ATLAS OF ISOTOPE HYDROLOGY

ASIA AND THE PACIFIC

IAEA
International Atomic Energy Agency

ATLAS OF ISOTOPE HYDROLOGY
— ASIA AND THE PACIFIC

IAEA

Water Resources Programme

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CONTENTS

FOREWORD

At the core of all efforts for sustainable human development lies an adequate supply of freshwater. With increasing population numbers and economic growth, it is imperative that we reach a balance between demand and the availability of freshwater, protect available resources in rivers, lakes and aquifers, and prevent disputes over shared resources. Although a significant portion of the Earth's freshwater is renewed by the hydrological cycle, freshwater is still a finite resource and, unlike many other strategic resources, it has no substitute in most of its uses. Nearly half of all freshwater used for drinking and irrigation worldwide is groundwater, on which irrigation and the world's food supply are dependent. Yet, the world's groundwater resources are not well understood.

Water resources management and related policy development require widely acceptable scientific information on the hydrology of water bodies. Naturally occurring isotopes in water provide unique hydrological information and the associated techniques are highly cost effective. The applications of isotopes in hydrology have from the very beginning been part of the IAEA's programmes related to the peaceful applications of nuclear energy. The focus of the IAEA's work has been to develop appropriate methods for use in water resources management and to assist its Member States in using those methods.

The IAEA has helped create a large body of isotope data on the world's rivers, lakes and aquifers that can be used for resource assessment and management on a local, regional and continental scale. I am pleased to see that a number of isotope hydrology atlases are now being produced using these data from nearly one hundred countries. By making the data easily available to scientists worldwide, I hope that the IAEA can facilitate the integration of isotope hydrology into the practice of water resources management.

Vienna, September 2008

Mohamed ElBaradei

Director General
International Atomic Energy Agency

PREFACE

Despite the importance of groundwater for many societies, there is a lack of corresponding public concern about its protection, perhaps because the extent and availability of groundwater are not easily measured. The impact of increasing degrees of temporal and spatial climatic variability on water resources is also an important consideration, and groundwater to some extent provides an opportunity to mitigate the impacts of climate change.

Applications of isotopes in hydrology are based on the general concept of "tracing", in which naturally occurring or environmental isotopes (either radioactive or stable) are used to study hydrological processes on large temporal and spatial scales through their natural distribution in a hydrological system. Thus, environmental isotope methodologies are unique in regional studies of water resources to obtain integrated characteristics of groundwater systems. The most frequently used environmental isotopes include those of the water molecule, hydrogen (^{2}H or D, also called deuterium, and ^{3}H, also called tritium) and oxygen (^{18}O), as well as of carbon (^{13}C and ^{14}C, also called radiocarbon or carbon-14) occurring in water as constituents of dissolved inorganic and organic carbon compounds. ^{2}H, ^{13}C and ^{18}O are stable isotopes of the respective elements, whereas ^{3}H and ^{14}C are radioactive isotopes.

Among the most important areas where isotopes are useful in groundwater applications are aquifer recharge and discharge processes, flow and interconnections between aquifers, and the sources, fate and transport of pollutants. In particular, under arid and semi-arid climatic conditions, isotope techniques constitute virtually the only approach for the identification and quantification of groundwater recharge. Pollution of shallow and deep aquifers by anthropogenic contaminants is one of the central problems in the management of water resources. Environmental isotopes can be used to trace the pathways and predict the spatial distribution and temporal changes in pollution patterns for assessing pollution migration scenarios and in planning for aquifer remediation.

This isotope hydrology atlas focuses on projects in IAEA Member States in the Asia and Pacific region, where environmental isotopes were used to assess water resources in terms of quantity or quality. It presents location maps of study areas, summary statistics and relevant data plots. Nearly 16 000 isotope records from 105 projects carried out between 1973 and 2007 in 16 Member States are included. For each country, a physiographic map is provided that shows major water bodies, locations of stations in the IAEA/WMO Global Network of Isotopes in Precipitation (GNIP) and the project study areas. For each project, a map of the study area is provided, together with data tables and plots for median and mean values of $\delta^{18}O$ and $\delta^{2}H$, average annual precipitation and air temperature, tritium and radiocarbon values.

The Isotope Hydrology Information System (ISOHIS), maintained by the IAEA, is the source of the hydrological and isotope information used in the compilation of this atlas. Isotope data and relevant information of GNIP stations in Asia and the Pacific are available through the on-line application WISER at www.iaea.org/water.

The following IAEA staff were involved in the preparation of this atlas: P.K. Aggarwal, M.A. Choudhry, S. Eder, S. Hofko, E. Izewski, T. Kurttas and S. Terzer. The technical officers responsible for this publication were K.M. Kulkarni and L. Araguás-Araguás of the Division of Physical and Chemical Sciences.

STRUCTURE OF THE ATLAS

DESCRIPTION OF PLATES

The countries in this atlas are listed alphabetically. The projects are arranged chronologically: first national projects and then regional projects, with each country having a group of plates in the atlas. The first plate in each group contains a map of the country showing the project areas. This plate also includes a brief background of each project. The following plates provide maps of each project area, a summary table of isotope data, and relevant isotope plots.

Physiographical maps for countries and study areas were taken from commercial GIS software [1]. Country boundaries have been taken from the United Nations Geographical Information Working Group [2].

Project types and codes

Each IAEA technical cooperation project as well as research contract has a unique code number that appears on the plates of the atlas. National projects include investigations at the national or local level, whereas regional projects comprise investigations in a group of Member States. Research contracts form a part of more focused coordinated research projects (CRPs) on selected research themes.

The codes for the three categories of projects mentioned above are described below.

Interagency projects: Projects implemented by other UN agencies in cooperation with the IAEA are represented by the code of the respective agencies and the original number/code (e.g. UNDP/FAO–AFG–10). Multiple study areas investigated in a project are shown on different plates with details. In such cases, a letter is placed after the project code, for example, UNDP–IND–73–008H and UNDP–IND–73–008W.

National projects: The code consists of a three letter string for the country, followed by the number 8, which stands for the thematic field of the project (i.e. water resources and industrial applications). Finally, a three digit sequential code is assigned (e.g. BGD8016, CPR8014, etc.). These codes are used in the plates describing national projects. Multiple study areas investigated in a project are shown in different plates with details. In such cases, a letter is placed after the project code, for example, MAL8008K and MAL8008P.

Regional projects: The code consists of a three letter string RAS, followed by the thematic field area number (8) and a three digit sequential code (e.g. RAS8084, RAS8104, etc.). A three letter code identifying the participating country is added after this code. The regional project plates show a code such as, for example, RAS8092–MAL or RAS8084–SRL, etc. When multiple study areas are investigated in a given country, they are shown on different plates with details. In such cases a letter is placed after the project code, for example, RAS8104L–PAK and RAS8104P–PAK.

Research contracts: The research contract code consists of a three letter country code, followed by the assigned number of the contract (e.g. VIE–5840). When multiple study areas are investigated in a given country, they are shown on different plates with details. In such cases an arbitrary letter is placed after the project code, for example, IND–10802B and IND–10802J.

Combined projects: Whenever different projects are combined in one plate, their codes are shown in the heading.

Study areas

The approximate spatial distribution of the study areas of all the projects is shown in Fig. 1. Project codes and study areas are listed in Table 1.

FIGURE 1. Map of the Asia and Pacific region showing areas covered by the IAEA projects on water resources that are included in this atlas.

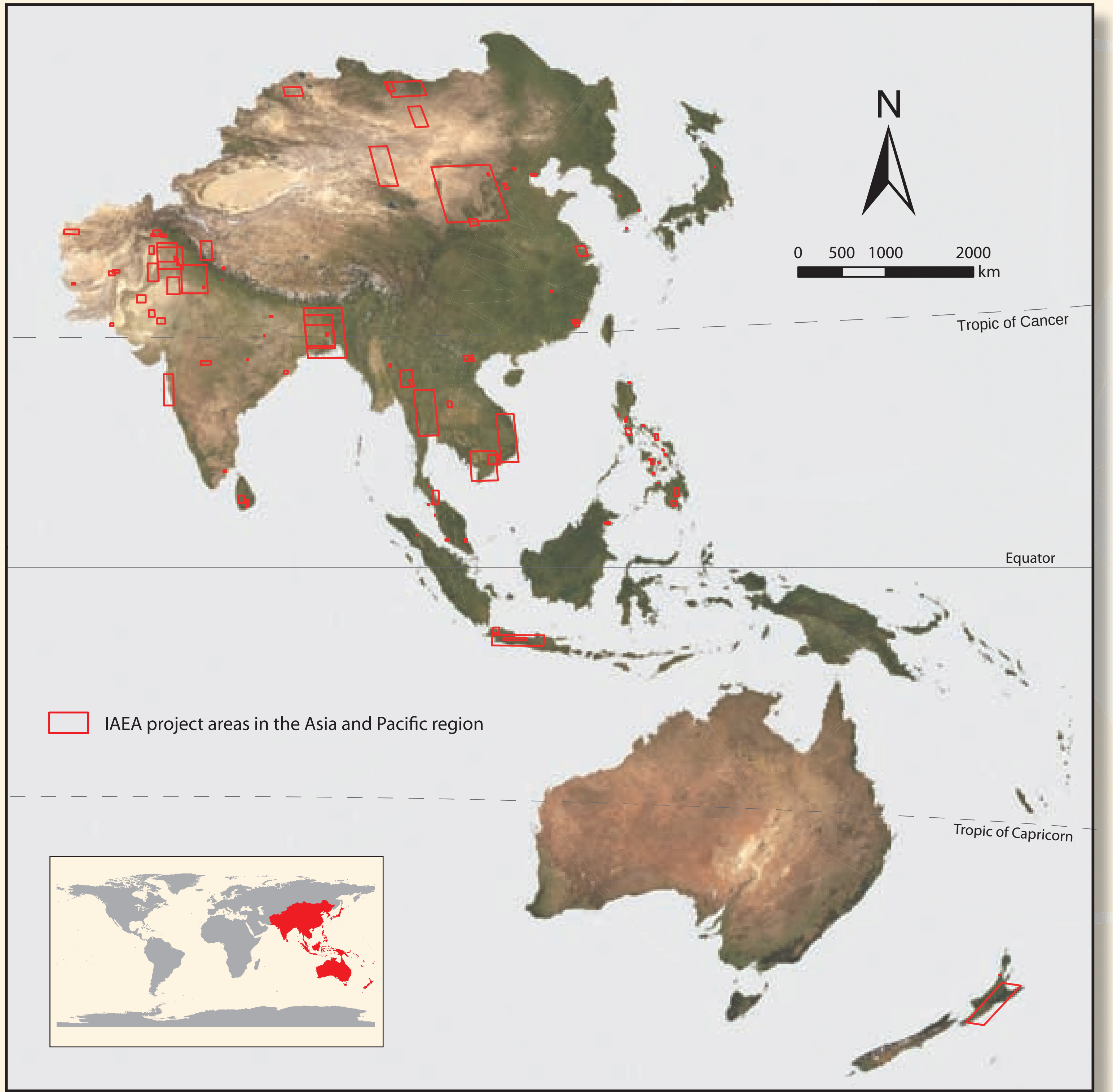


TABLE 1. Summary table showing the list of projects with their codes and study areas.

Country	Project	Study Area
Afghanistan	UNDP/FAO-AFG-10	Hari River aquifers
Bangladesh	UNDP-BGD-74-009-01	Alluvial aquifers of Bangladesh
	BGD8016	Alluvial aquifers of Bangladesh
	BGD8018	Alluvial aquifers of Bangladesh
	RAS8097-BGD	Urban aquifers in Dhaka, Narayanganj and Tungi areas
	BGD-10068	Dupi Tila aquifer, Dhaka
China	CPR8014	Black River basin
	CPR8017	Erdos basin
	RAS8084-CPR	Shijiazhuang basin
	RAS8097D-CPR	Datong basin
	RAS8097Y-CPR	Yangtze River deltaic aquifers
	CPR-4850 CPR-9180Z	Zhangzhou geothermal area
	CPR-7277	Xiangshan ore field
	CPR-8199	Beijing urban aquifers
	CPR-9180H	Hebei Plain geothermal area
	CPR-11730	Guanzhong basin
India	UNDP-IND-73-008H	Northwestern Himalayan springs
	UNDP-IND-73-008W	West coast springs
	UNDP/FAO-IND-81-010	Alluvial aquifers, Haryana State
	RAS8084R-IND	Urban aquifers, Raipur city
	RAS8084P-IND	Purna River basin
	RAS8092-IND	Tattapani geothermal area
	RAS8097D-IND	Landfill areas, Delhi
	RAS8097B-IND	Alluvial aquifers, Ghazipur area
	RAS8104T-IND	Tiruvadanai aquifers
	RAS8104S-IND	Sasthamkotta Lake
	IND-6234	Tapoban and Badrinath geothermal areas
	IND-7746	Lake Naini area, Nainital
	IND-7904B IND-10802B	Bhadka–Bheemda area, Barmer
	IND-7904J	Kishangarh–Ghotaru area, Jaisalmer
	IND-7904I	Indira Gandhi Canal Scheme, Rajasthan
	IND-8398	Delang–Puri Sector, Orissa
	IND-10283	Alluvial aquifers, Kolkata city
	IND-10802J	Arid zone aquifers, Jalore area
Indonesia	RAS8092-INS	Lahendong geothermal area, Sulawesi
	RAS8097-INS	Jakarta city area
	INS-5306W	Western Java geothermal areas
	INS-5306E	Central and Eastern Java geothermal areas
	INS-9717	Sibajak geothermal area, Sumatra
Japan	JPN-10230	Onikobe geothermal area
Korea, Republic of	RAS8084-ROK	Chojeong area
	RAS8092-ROK	Pusan geothermal areas
	RAS8097-ROK	Yuseong aquifers
	ROK-11323	Cheju Island coastal aquifers
Malaysia	MAL8008K	Kuala Rompin aquifers
	MAL8008P	Kuala Perlis area
	MAL8008L	Langkawi island
	MAL8018	Taiping area
	RAS8084-MAL	Langat basin
	RAS8092-MAL	Tawau geothermal area, Northern Borneo
	RAS8097-MAL	Pulau Burung area
Mongolia	MON8002G	Gobi desert aquifers
	MON8002T	Tsambagarav area, Western Mongolia
	MON8004	Tuul and Khangal River basins
	MON8006	Orkhon River basin
Myanmar	MYA8003	Lake Inle
New Zealand	NZE-5961	Northern Island geothermal systems
	NZE-10232	Auckland area
Pakistan	RAS8084-PAK	Sheikhupura area
	RAS8092-PAK	Koh Sultan volcano area, Chagi
	RAS8097M-PAK	Multan area
	RAS8097L-PAK	Lahore area
	RAS8104P-PAK	Peshawar area
	RAS8104R-PAK	Rechna Doab
	RAS8104C-PAK	Chashma Nuclear Power Plant area
	RAS8104T-PAK	Tarbela dam area
	RAS8104Q-PAK	Quetta area
	PAK-3620	Mardan area
	PAK-4255	Chaj Doab
	PAK-4794	Haripur area
	PAK-8591	Ziarat area
	PAK-9826 PAK-11516	Kasur area
	PAK-11322	Karachi coastal aquifer

TABLE 1. Summary table showing the list of projects with their codes and study areas (continued).

Country	Project	Study Area
Philippines	PHI8011M	Metro Manila area
	PHI8011D RAS8084-PHI RAS8097-PHI	Davao city area
	PHI8011C	Cebu city
	PHI8016L PHI-9719L	Leyte geothermal field
	PHI8016S RAS8092-PHI PHI-9719S	Southern Negros geothermal area
	PHI8018	Laguna Lake basin
	PHI8022 RAS8097-PHI RAS8093-PHI	La Mesa, Rodriguez–Montalban and Angat dam sites
	PHI8025	Bacolod area
	RAS8075Mo-PHI RAS8075Ma-PHI	Montelago–Mabini geothermal areas
	PHI-6019MB PHI-6019BM PHI-9719BM	Mount Bulusan–BacMan area
	PHI-6019MA	Mount Ampiro geothermal area
	PHI-6019MC	Mount Cagua geothermal area
	PHI-6019MP	Mount Parker geothermal area
	PHI-6019Pi	Mount Pinatubo geothermal area
	PHI-6019Bi	Mount Biliran geothermal area
	PHI-6019ML	Mount Labo geothermal area
	PHI-6019NN	Northern Negros geothermal area
Sri Lanka	SRL8018	Kukuleganga–Victoria–Randenigla dam areas
	RAS8084-SRL	Hambantota area
	RAS8093-SRL	Samanalawewa reservoir area
	RAS8097-SRL	Nanu Oya and Bomburella basins
Thailand	THA8011	Khon Kaen area
	RAS8075-THA RAS8092-THA	Fang and Mae Hong Son geothermal areas
	RAS8084-THA	Ronphibun mining area
	RAS8097-THA THA-4803H	Hat Yai basin
	THA-4803C	Chao Phraya basin
	THA-6233	Chiang Mai basin
Vietnam	VIE8003 RAS8084-VIE	Mekong Delta aquifers
	VIE8008 VIE8012 VIE8016 RAS8097M-VIE	Ho Chi Minh City area
	RAS8084-VIE RAS8097H-VIE RAS8104H-VIE	Hanoi city area
	RAS8093-VIE RAS8104D-VIE	Dong Mo dam area
	VIE-5840	Trungbo geothermal area

UNITS OF MEASUREMENT

Oxygen-18 and deuterium

Oxygen-18 and deuterium contents in water samples are expressed as δ values ($\delta^{18}O$, $\delta^{2}H$), which are permil deviations from an internationally accepted standard. The δ unit is defined as:

$$\delta(‰) = \frac{R_{sample} - R_{VSMOV}}{R_{VSMOV}} \times 10^3$$

where, R is the isotope ratio $^{2}H/^{1}H$ or $^{18}O/^{16}O$.

In the case of water, the internationally accepted standard is called Vienna Standard Mean Ocean Water (VSMOW) [3, 4]. The ^{2}H and ^{18}O isotope ratios are determined by mass spectrometric methods. The measurements reported in this atlas generally have a precision of about ±0.1‰ for $\delta^{18}O$ and ±1‰ for $\delta^{2}H$ at one standard deviation level.

Tritium

Tritium concentration is expressed in tritium units (TU). One TU is defined as one atom of ^{3}H per 10^{18} atoms of ^{1}H, which is equivalent to an activity of 0.118 Bq or 3.193 pCi per litre of water. The half-life of tritium is 12.32 years (4500 days) [5]. Due to this relatively short half-life, tritium has been used in hydrogeology as an excellent environmental tracer to identify modern recharge in aquifer systems. Tritium content is measured by counting its radioactive decay, using liquid scintillation spectrometers. Due to very low levels of tritium in natural waters, electrolytic enrichment of tritium is done before counting the radioactive decay. The analytical uncertainty for tritium analysis is usually reported with each measurement. Current analytical methods involving electrolytic enrichment followed by liquid scintillation counting provide uncertainty values of the order of ±0.3 TU for tritium levels lower than 5 TU.

Carbon-14

For hydrogeological applications, radiocarbon or carbon-14 activity is expressed as a percentage of modern carbon (pMC). The activity of modern carbon is 95% of the specific activity of the carbon of NBS oxalic acid supplied by the US National Institute of Standards and Technology (NIST). One hundred per cent modern carbon corresponds to a carbon-14 specific activity of 13.56 ± 0.07 disintegrations per minute per gram of carbon. Measurement of carbon-14 activity is generally carried out by decay counting using liquid scintillation spectrometry or, more recently, by measurement of atoms using accelerator mass spectrometry (AMS) methods. Carbon-14 is a key dating tool for groundwaters between 5000 and 40 000 years before present (B.P.).

STABLE ISOTOPES IN PRECIPITATION OVER ASIA AND THE PACIFIC

The analysis of temporal and spatial variations of isotope contents in the different components of the water cycle is required for the characterization of different sources of recharge for aquifers, springs, lakes, rivers, reservoirs, etc.

Ultimately, precipitation is the source of all recharge. Therefore, definition of the isotope signals (^{2}H, ^{18}O and ^{3}H) in precipitation is required for proper assessment of location and mechanism of recharge. In other cases, isotopes in precipitation can aid in identifying fossil groundwater (complementary to the use of carbon-14 dating of groundwater) because of the isotopic contrast between modern and past precipitation.

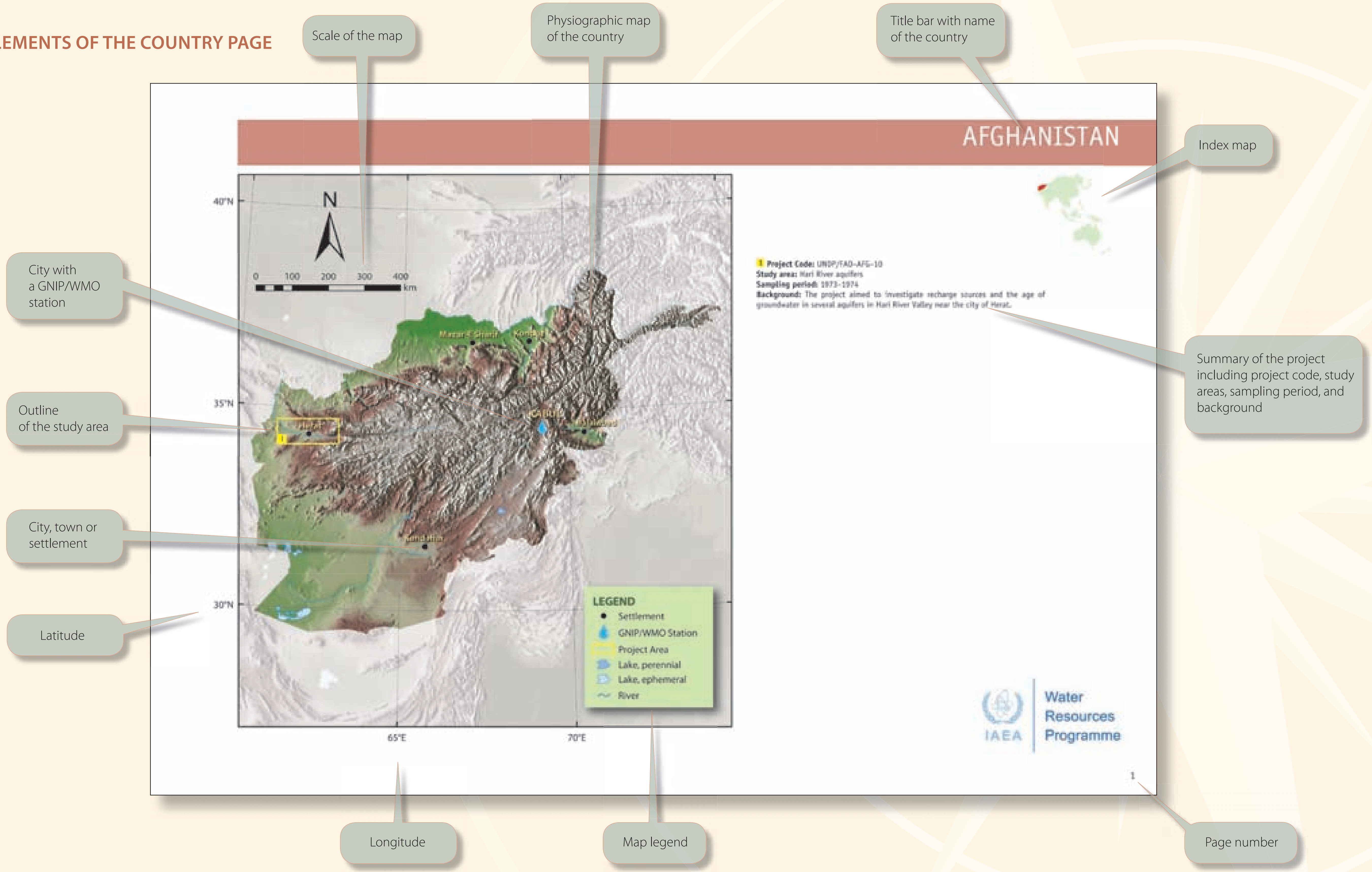
GNIP is one of the main sources of information on isotope signals of precipitation worldwide. This global monitoring programme has been in operation since 1961 through a joint collaboration between the IAEA and the World Meteorological Organization (WMO).

The GNIP database, which is also accessible through WISER (http://www.iaea.org/water), provides basic isotope data for the application of isotopes in hydrological sciences.

The isotope contents of precipitation over Asia and the Pacific have been monitored at more than 100 stations for the last 40 years. The raw isotope data, as well as the summary information (statistical treatment of meteorological and isotope data), are available at: http://www.iaea.org/water.

The locations of GNIP stations in Asia are shown in Fig. 2 and are listed in Table 2. The long term weighted mean $\delta^{18}O$ and $\delta^{2}H$ values of precipitation calculated for the nearest GNIP station for each study area have been included in the summary table for each project.

ELEMENTS OF THE COUNTRY PAGE



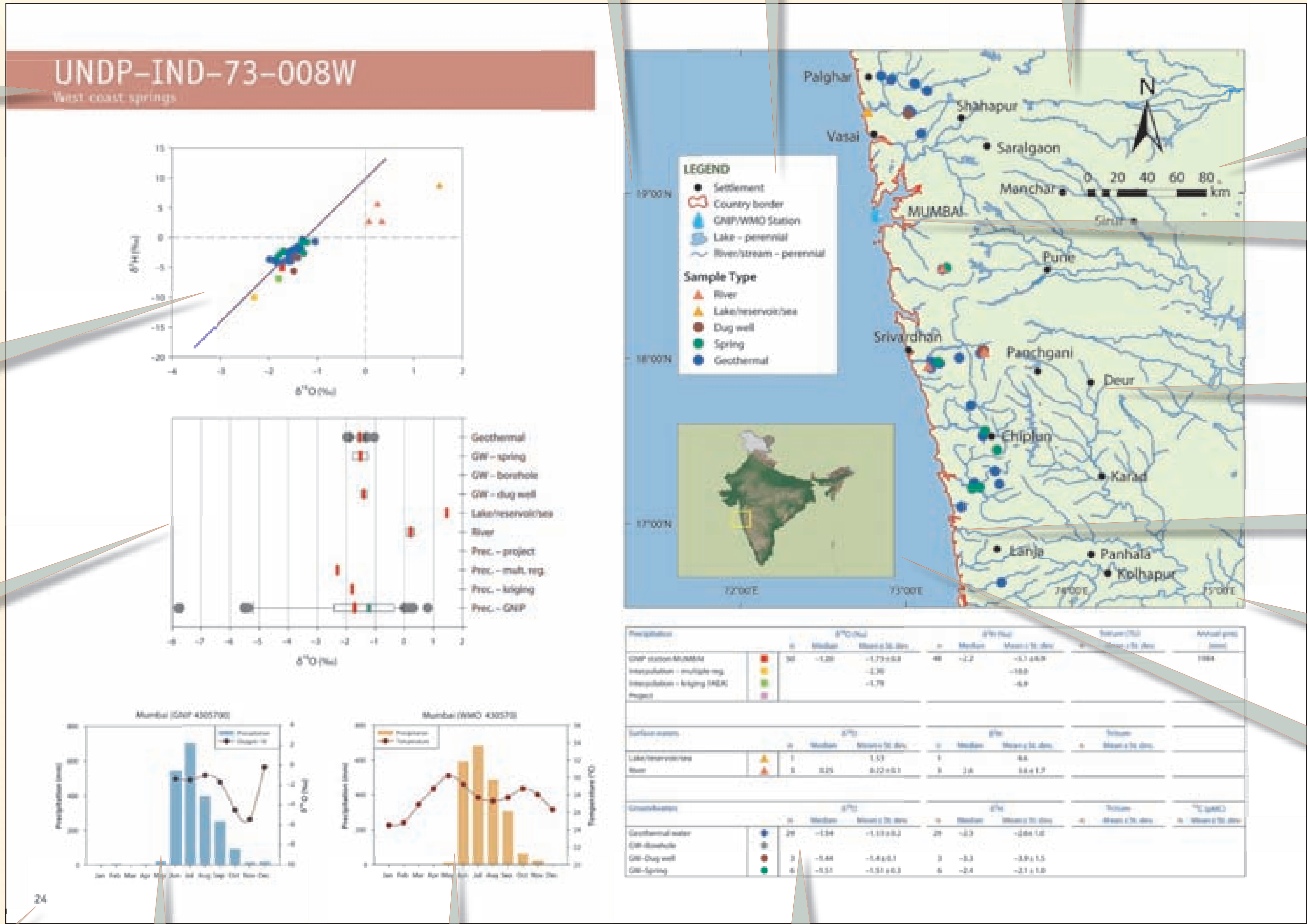
ELEMENTS OF THE PROJECT PAGE

Latitude

Map legend

Study area map showing the location and water types sampled for isotopes

Title bar with the project codes and name of study area



Scale of the map

City with a GNIP/WMO station

Scatter plot showing ^{2}H versus ^{18}O of samples analysed in the project. Different water types are shown in the legend of the map and in the summary table. The Global Meteoric Water Line [3], $\delta^{2}H = 8 \times \delta^{18}O + 10$, is included for reference. See the following page for an explanation of units.

City, town or settlement

Box-and-whisker plot showing the range of ^{18}O values for different water types. The central box shows the range of the middle 50% of the data values, between the lower and upper quartiles. The central line shows the value of the median. The red line indicates the mean and the green line shows the long term amount weighted mean. The "whiskers" extend out of the extremes (minimum and maximum values) within 1.5 times the interquartile range. Outliers are plotted as separate points.

International border of the country

Longitude

Index map

Page number

The oxygen-18 (permil) in precipitation and mean monthly values of precipitation (mm) from the nearest GNIP station. See page ix for an explanation of units.

The distribution of mean monthly values of precipitation (mm) and temperature (°C) is presented from the WMO station closest to the study area [6].

Summary table providing basic statistics of the isotopes in each project. These statistics include the number of isotope measurements, the mean and median of the ^{18}O, deuterium, tritium and carbon-14 values and standard deviations. Long term weighted annual means for ^{18}O, deuterium, and the amount of precipitation estimated from the nearest GNIP station are shown. For short term isotope records in the GNIP database, the median is also provided. Estimates of the mean isotope contents of precipitation by interpolation were calculated at the IAEA using multiple regression [7] and kriging [8, 9] methods. Mean values of precipitation samples collected in the project are also listed. Similar statistics for surface water (e.g. rivers, lakes and reservoirs) and groundwater (e.g. shallow dug wells, deep boreholes, springs and geothermal waters) are presented.

FIGURE 2. Locations of selected GNIP stations in the Asia and Pacific region.

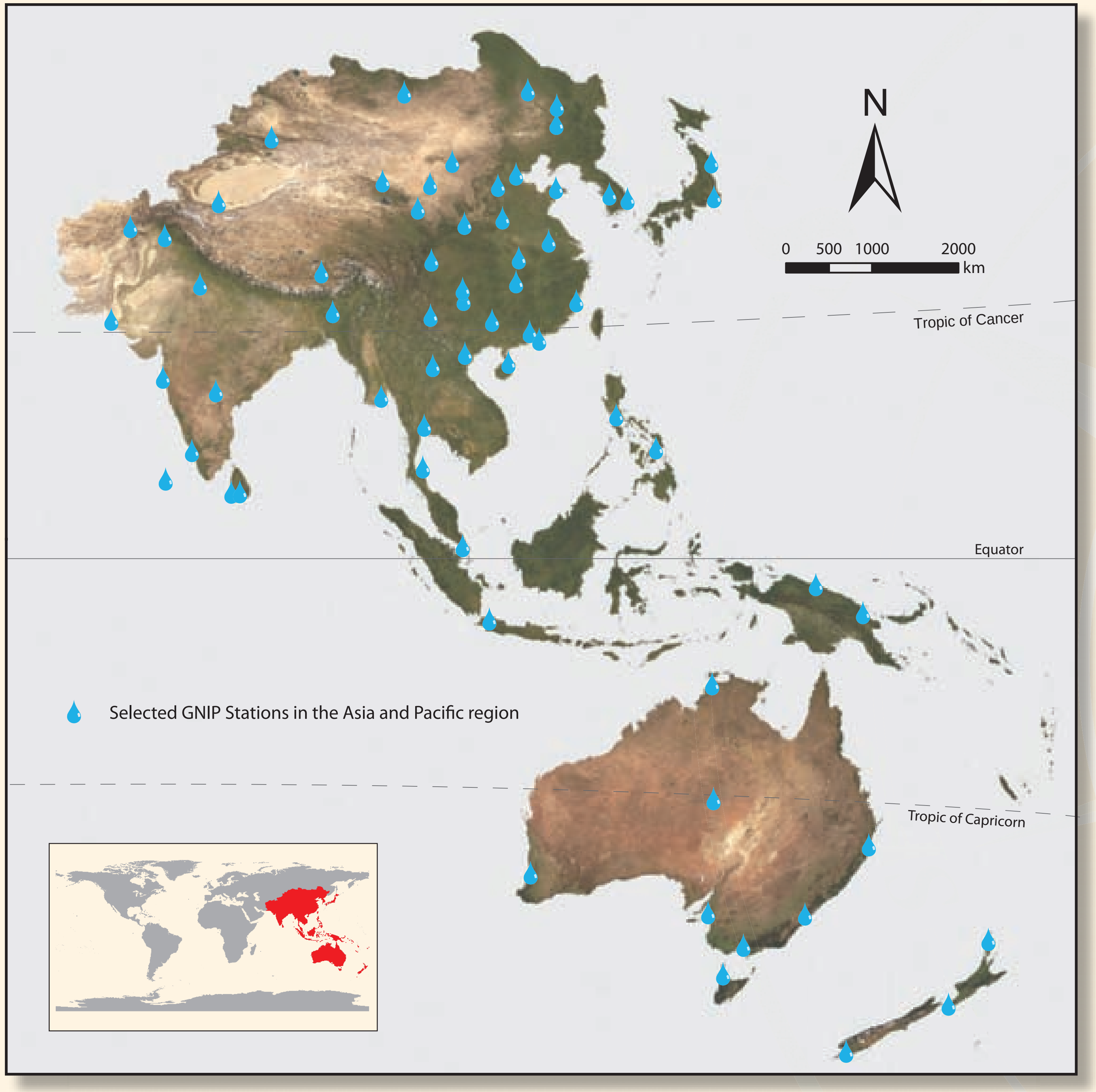


TABLE 2. Selected GNIP stations in the Asia and Pacific region.

GNIP code	Station name	Latitude	Longitude
4094900	Kabul, Afganistan	34° 34′ N	69° 13′ E
4157101	Nilore/Islamabad, Pakistan	33° 39′ N	73° 16′ E
4178000	Karachi, Pakistan	24° 54′ N	67° 08′ E
4218200	New Delhi, India	28° 35′ N	77° 12′ E
4251600	Shillong, India	25° 34′ N	91° 53′ E
4305700	Mumbai, India	18° 54′ N	72° 49′ E
4312800	Hyderabad, India	17° 27′ N	78° 28′ E
4331400	Kozhikode, India	11° 15′ N	75° 47′ E
4336900	Minicoy Island, India	08° 18′ N	73° 00′ E
4346600	Colombo, Sri Lanka	06° 54′ N	79° 52′ E
4347300	Nuwara Eliya, Sri Lanka	06° 58′ N	80° 46′ E
4429200	Ulaanbaatar, Mongolia	47° 56′ N	106° 59′ E
4500400	Hong Kong, China	22° 19′ N	114° 10′ E
4713101	Cheongju, Republic of Korea	36° 37′ N	127° 28′ E
4713800	Pohang, Republic of Korea	36° 02′ N	129° 23′ E
4751300	Ryori, Japan	39° 02′ N	141° 49′ E
4766200	Tokyo, Japan	35° 41′ N	139° 46′ E
4809700	Yangon, Myanmar	16° 46′ N	96° 10′ E
4845500	Bangkok, Thailand	13° 44′ N	100° 30′ E
4855000	Ko Samui, Thailand	09° 28′ N	100° 03′ E
4869400	Singapore, Singapore	01° 21′ N	103° 54′ E
4882001	Hanoi, Vietnam	21° 03′ N	105° 48′ E
4893000	Luang-Prabang, Lao People's Democratic Republic	19° 53′ N	102° 08′ E
5074500	Qiqihar, China	47° 23′ N	123° 55′ E
5095300	Harbin, China	45° 41′ N	126° 37′ E
5182800	Hetian, China	37° 08′ N	79° 56′ E
5182801	Wulumuqi, China	43° 47′ N	87° 37′ E
5265200	Zhangye, China	38° 56′ N	100° 26′ E
5288900	Lanzhou, China	36° 03′ N	103° 53′ E
5361400	Yinchuan, China	38° 29′ N	106° 13′ E
5369800	Shijiazhuang, China	38° 02′ N	114° 25′ E
5369801	Yantai, China	37° 32′ N	121° 24′ E
5416101	Changchun, China	43° 54′ N	125° 13′ E

GNIP code	**Station name**	**Latitude**	**Longitude**
5452700	Tianjin, China	39° 06′ N	117° 10′ E
5452701	Baotou, China	40° 40′ N	109° 51′ E
5559100	Lhasa, China	29° 42′ N	91° 08′ E
5629400	Chengdu, China	30° 40′ N	104° 01′ E
5677800	Kunming, China	25° 01′ N	102° 41′ E
5703600	Xian, China	34° 18′ N	108° 56′ E
5708300	Zhengzhou, China	34° 43′ N	113° 39′ E
5749400	Wuhan, China	30° 37′ N	114° 08′ E
5767900	Changsha, China	28° 12′ N	113° 04′ E
5771300	Zunyi, China	27° 42′ N	106° 53′ E
5781600	Guiyang, China	26° 35′ N	106° 43′ E
5823800	Nanjing, China	32° 11′ N	118° 11′ E
5884700	Fuzhou, China	26° 05′ N	119° 17′ E
5904600	Liuzhou, China	24° 21′ N	109° 24′ E
5928700	Guangzhou, China	23° 08′ N	113° 19′ E
5975800	Haikou, China	20° 02′ N	110° 21′ E
9301100	Kaitaia, New Zealand	35° 04′ S	173° 17′ E
9341701	Kaitoke, New Zealand	41° 06′ S	175° 10′ E
9384400	Invercargill, New Zealand	46° 25′ S	168° 19′ E
9401400	Madang, Papua New Guinea	05° 13′ S	145° 48′ E
9412000	Darwin, Australia	12° 26′ S	130° 52′ E
9432600	Alice Springs, Australia	23° 48′ S	133° 53′ E
9457600	Brisbane, Australia	27° 26′ S	153° 05′ E
9460800	Perth, Australia	31° 57′ S	115° 58′ E
9467500	Adelaide, Australia	34° 56′ S	138° 35′ E
9476500	Campbelltown, Australia	34° 24′ S	150° 00′ E
9486800	Melbourne, Australia	37° 49′ S	144° 58′ E
9495400	Cape Grim, Australia	40° 41′ S	144° 41′ E
9674500	Jakarta, Indonesia	06° 11′ S	106° 50′ E
9769800	Jayapura, Indonesia	02° 32′ S	140° 43′ E
9842900	Manila, Philippines	14° 31′ N	121° 00′ E
9855003	Alto Peak, Philippines	11° 06′ N	124° 44′ E

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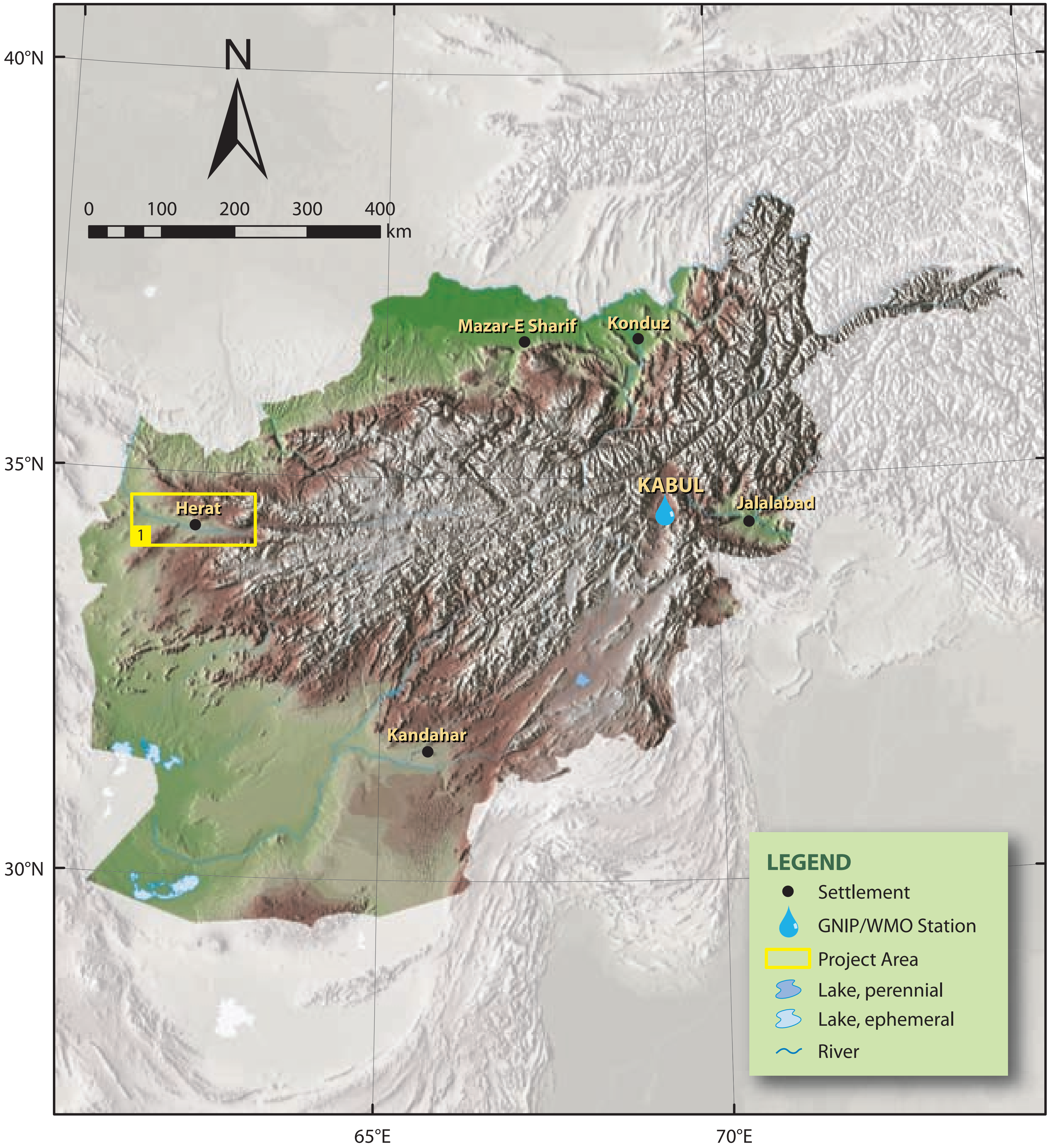
PLATES

AFGHANISTAN

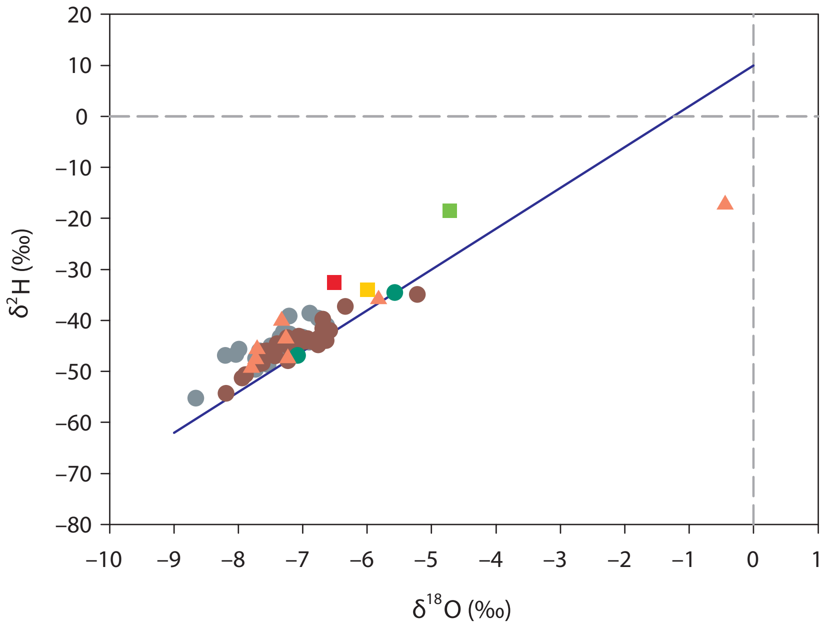


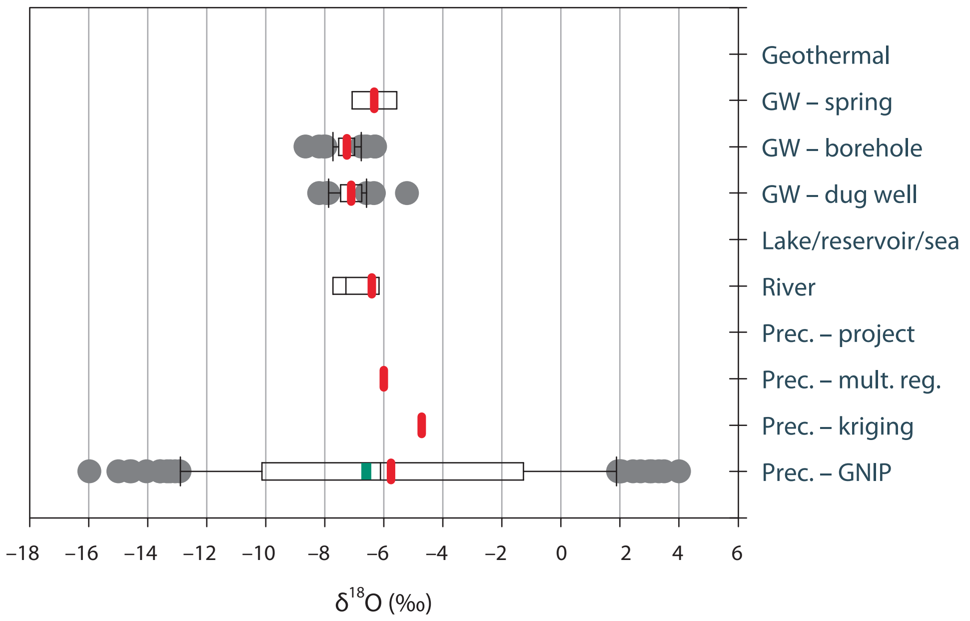
1 **Project Code:** UNDP/FAO–AFG–10
Study area: Hari River aquifers
Sampling period: 1973–1974
Background: The project aimed to investigate recharge sources and the age of groundwater in several aquifers in Hari River Valley near the city of Herat.

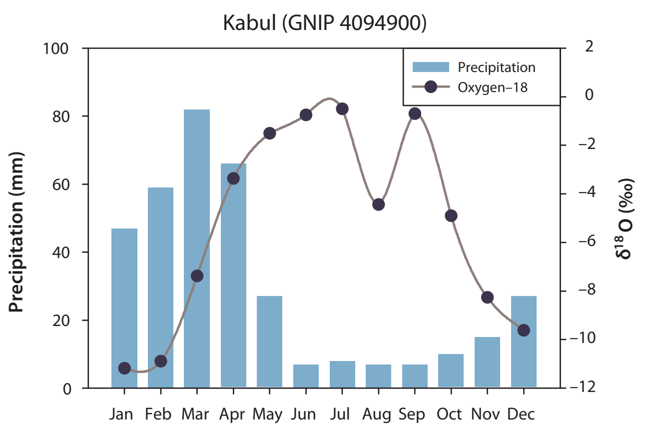
IAEA Water Resources Programme

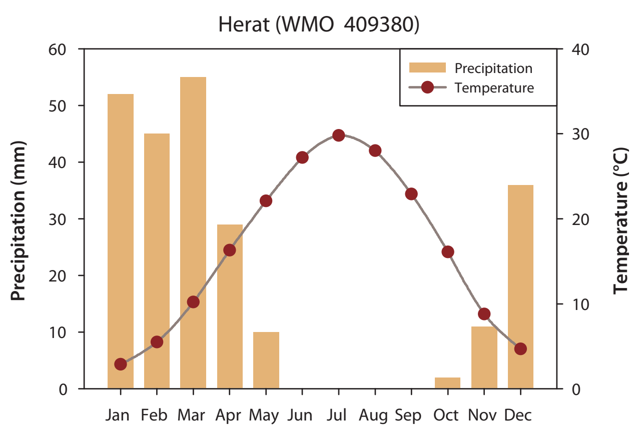
UNDP/FAO-AFG-10

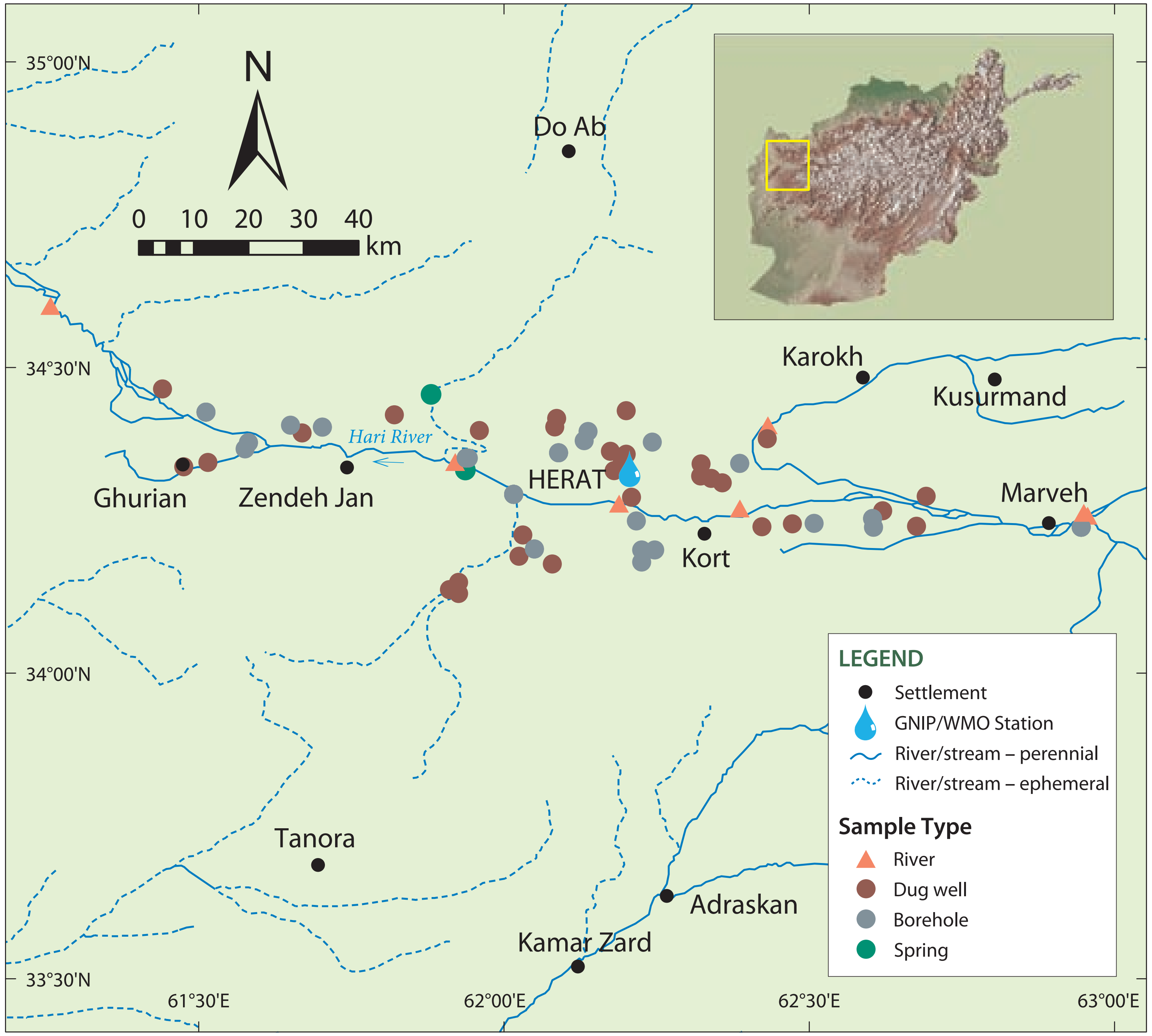
Hari River aquifers



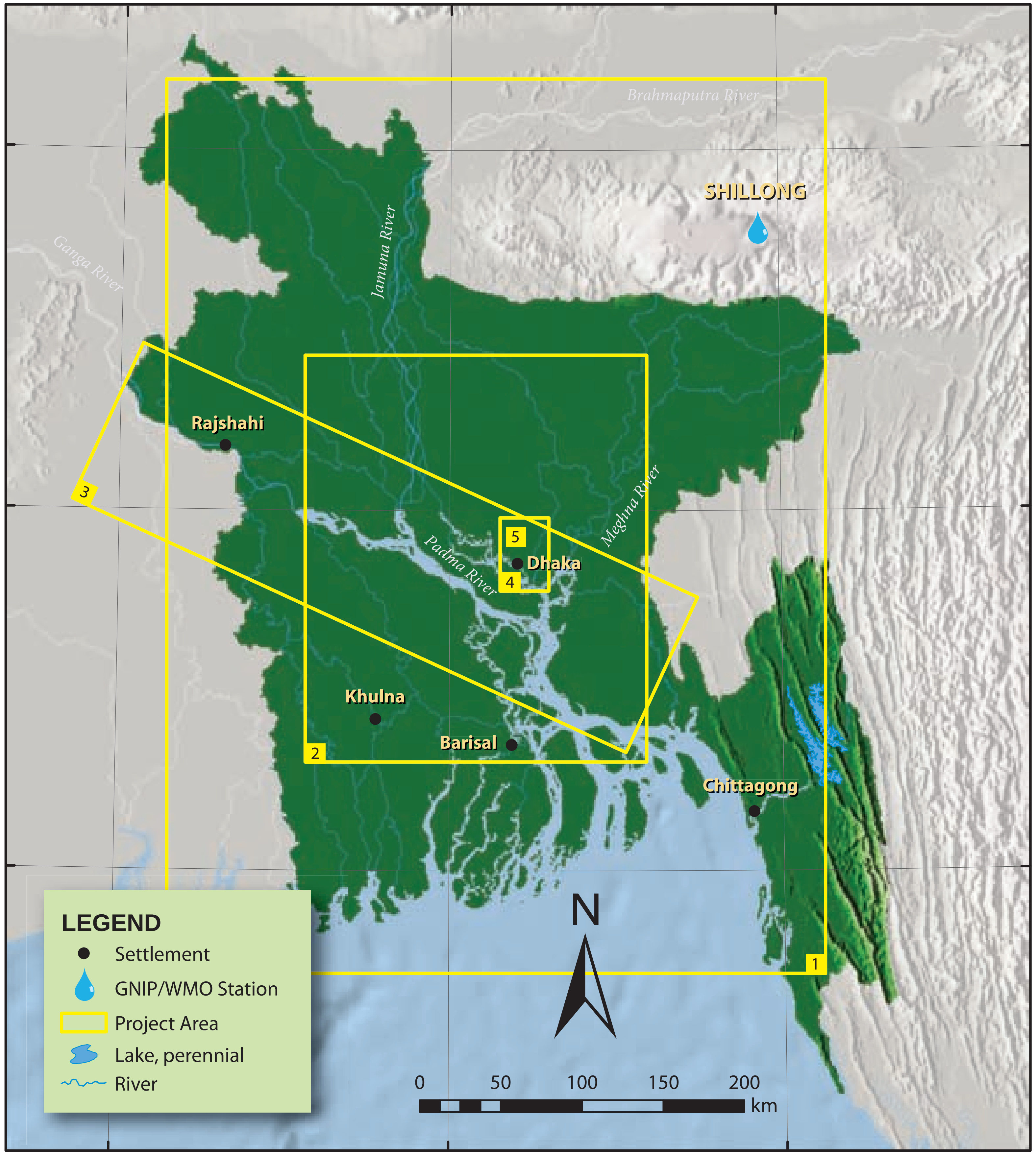








Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station KABUL		109	−6.23	−6.51 ± 2.4	86	−28.2	−32.5 ± 7.7			329	
Interpolation – multiple reg.				−6.00			−34.0				
Interpolation – kriging (IAEA)				−4.72			−18.46				
Project											
Surface waters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea											
River		8	−7.30	−6.42 ± 2.5	8	−44.6	−40.85 ± 10.5	4	85.6 ± 62.7		
Groundwaters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**¹⁴C (pMC)** n	Mean ± St. dev.
Geothermal water											
GW–Borehole		51	−7.21	−7.25 ± 0.5	25	−44.3	−44.75 ± 3.6	32	82.7 ± 75.4		
GW–Dug well		30	−7.12	−7.10 ± 0.6	30	−44.4	−44.78 ± 3.8	26	73.9 ± 73.2		
GW–Spring		2	−6.33	−6.33 ± 1.1	2	−40.8	−40.75 ± 8.7	2	135.6 ± 106.7		



1 **Project Code:** UNDP–BGD–74–009–01
Study area: Alluvial aquifers of Bangladesh
Sampling period: 1979–1981
Background: To investigate groundwater dynamics in alluvial aquifers of Bangladesh through isotope techniques.

2 **Project Code:** BGD8016
Study area: Alluvial aquifers of Bangladesh
Sampling period: 1999–2000
Background: To identify the mechanism of arsenic mobilization in groundwater and to investigate deeper aquifers as alternate sources of safe drinking water through isotopic characterization of hydrological conditions in selected areas.

3 **Project Code:** BGD8018
Study area: Alluvial aquifers of Bangladesh
Sampling period: 2002–2005
Background: An assessment of environmental isotope contents of rivers and groundwaters in different regions of the country for determination of groundwater origin, levels of arsenic contamination and mitigation options.

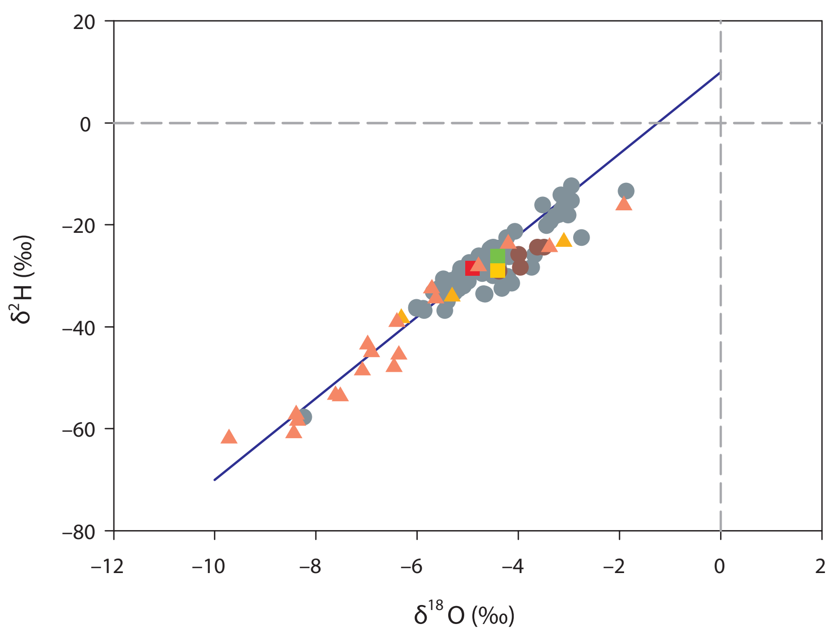
4 **Project Code:** RAS8097–BGD
Study area: Urban aquifers in Dhaka, Narayanganj and Tungi areas
Sampling period: 2004–2006
Background: To use environmental isotopes in studying pollutant behaviour and interaction of river and groundwater as well as to establish baseline data on pollutants in surface water and groundwater systems in Dhaka city and other urban areas.

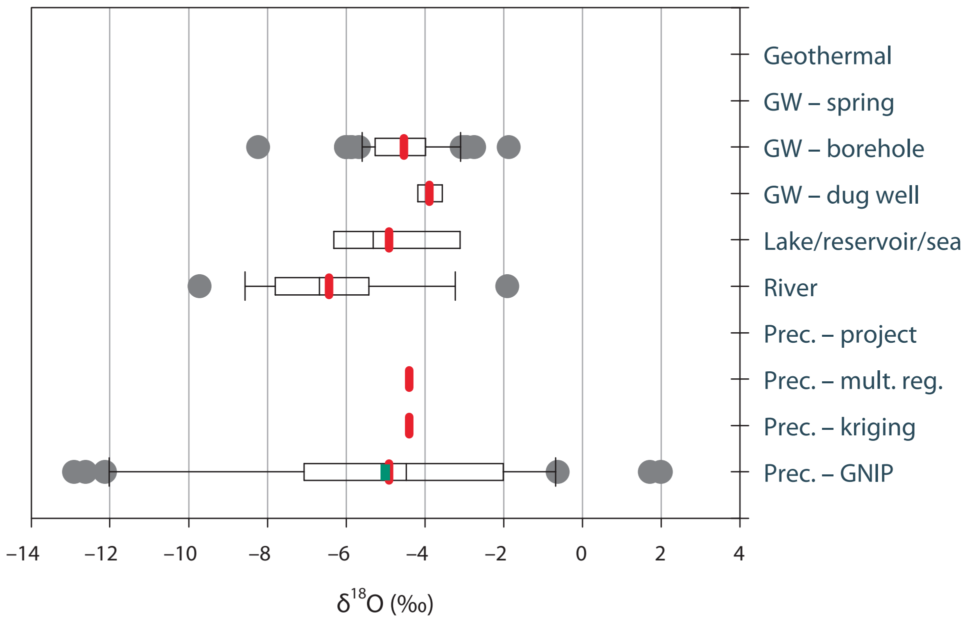
5 **Project Code:** BGD–10068
Study area: Dupi Tila aquifer, Dhaka
Sampling period: 2000
Background: Dupi Tila multilayer alluvial aquifer was investigated to understand surface water–groundwater interactions for assessment of groundwater recharge and contamination.

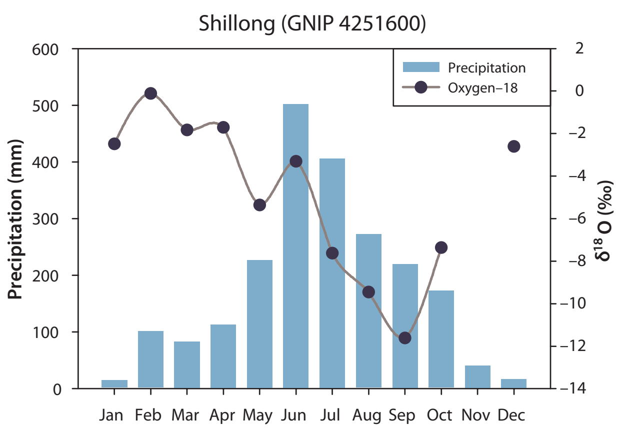
IAEA
Water Resources Programme

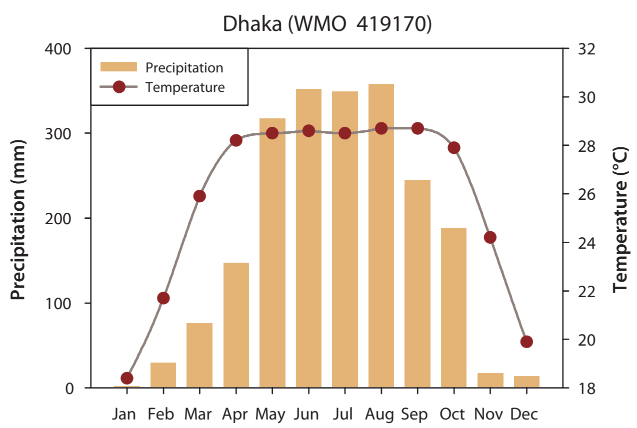
UNDP–BGD–74–009–01

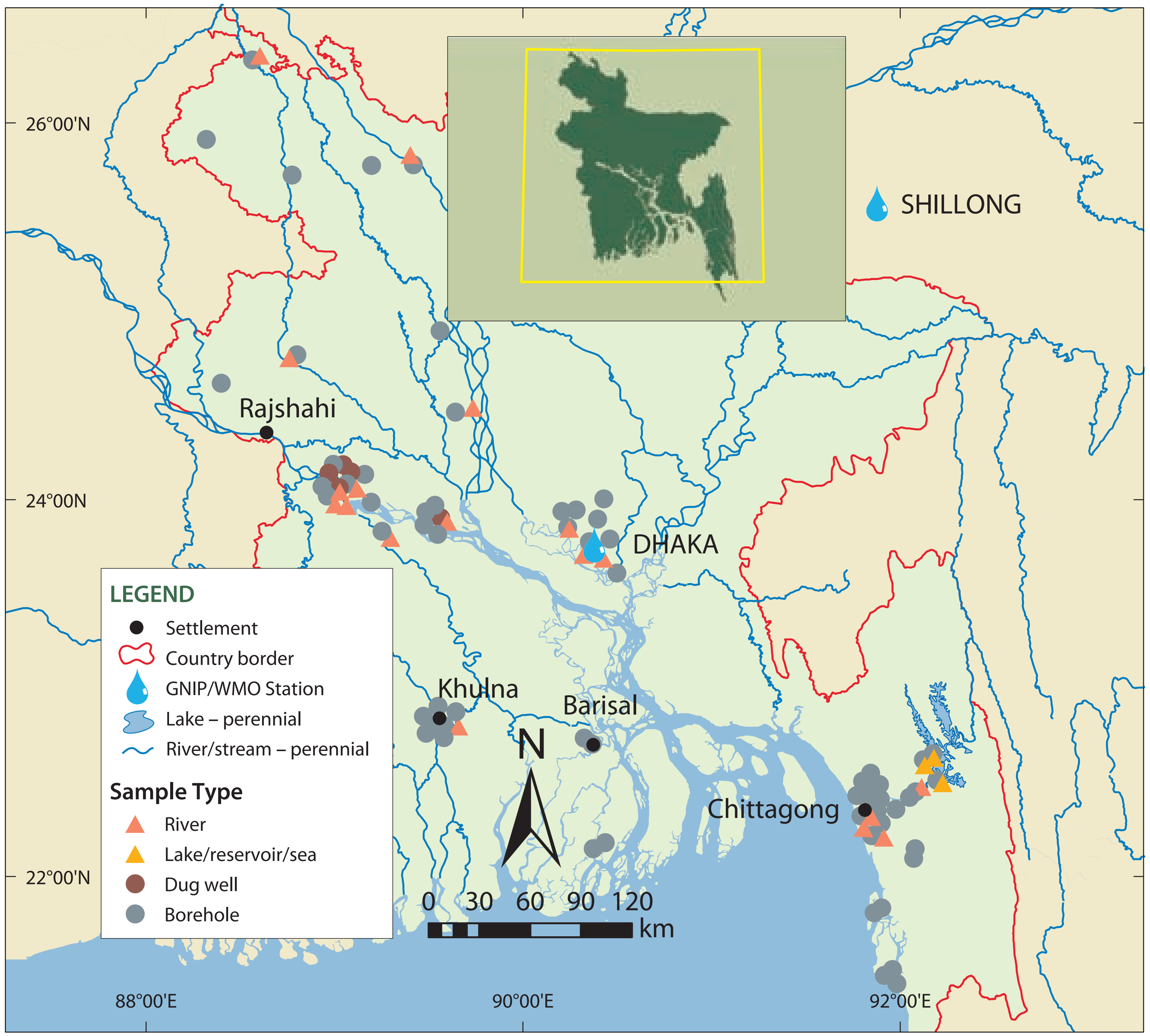
Alluvial aquifers of Bangladesh



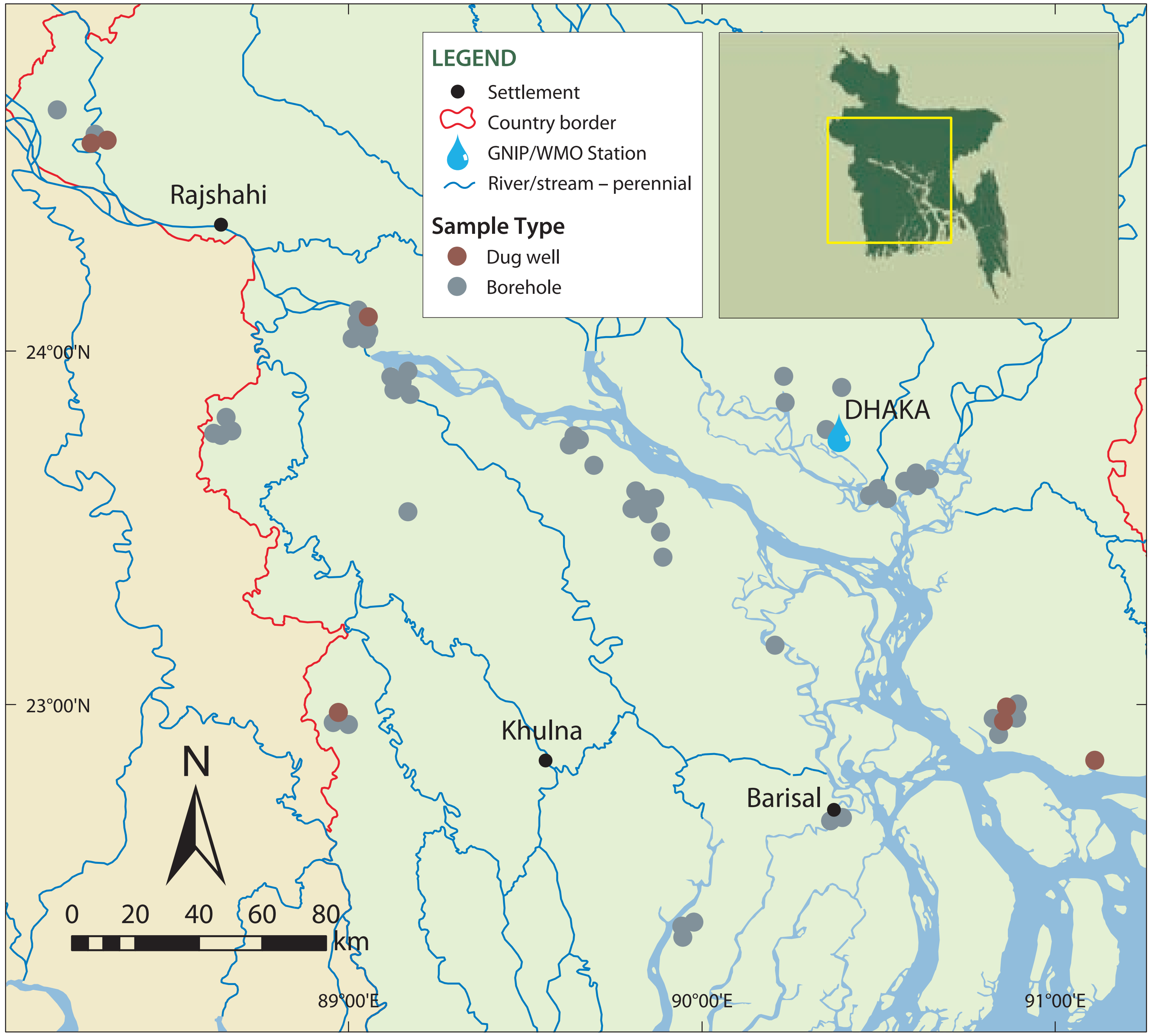


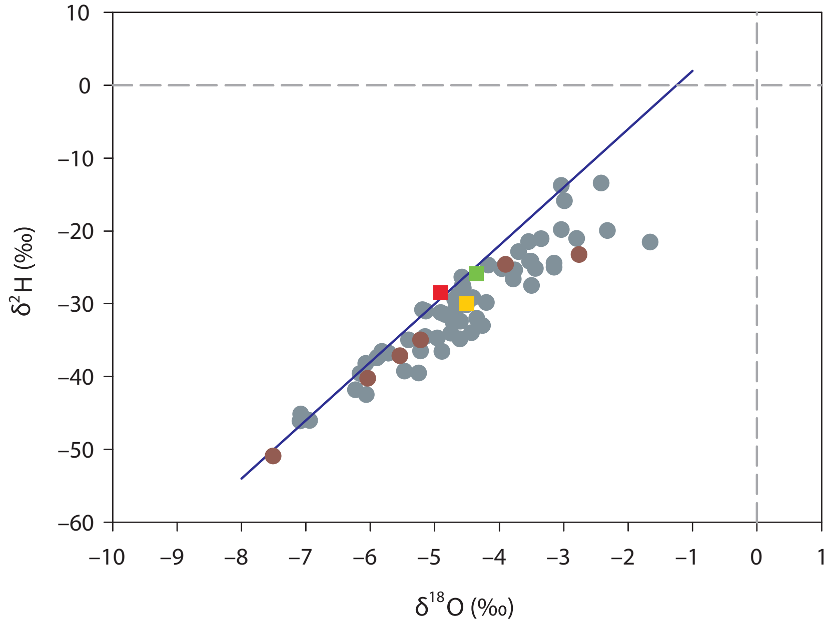


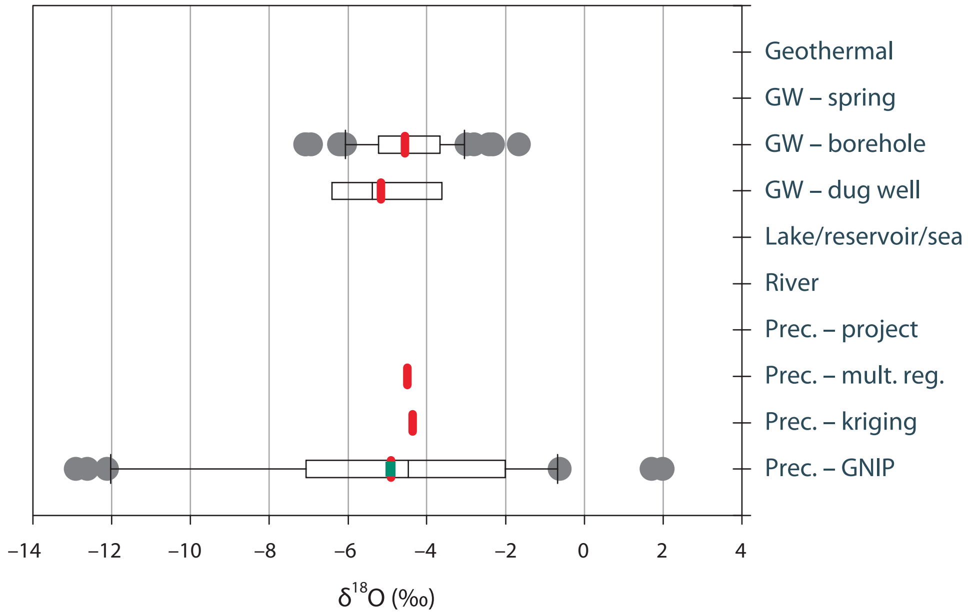




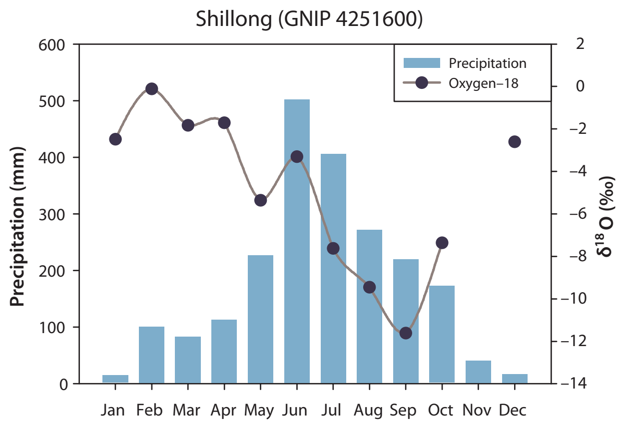
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SHILLONG		30	−4.48	−4.91 ± 4.1	30	−25.6	−28.5 ± 18.9				1825
Interpolation – multiple reg.				−4.40			−29.0				
Interpolation – kriging (IAEA)				−4.40			−26.1				
Project											
Surface waters		δ¹⁸O			δ²H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea		3	−5.31	−4.91 ± 1.6	3	−34.1	−31.9 ± 7.7	3	13.4 ± 2.5		
River		18	−6.68	−6.44 ± 2.0	18	−45.2	−43.0 ± 13.8	18	20.8 ± 7.0		
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water											
GW–Borehole		66	−4.55	−4.53 ± 1.0	66	−28.3	−27.6 ± 7.4	63	4.2 ± 9.5	41	63 ± 34
GW–Dug well		5	−3.96	−3.89 ± 0.4	5	−25.8	−26.4 ± 2.2	5	35.4 ± 19.6		
GW–Spring											

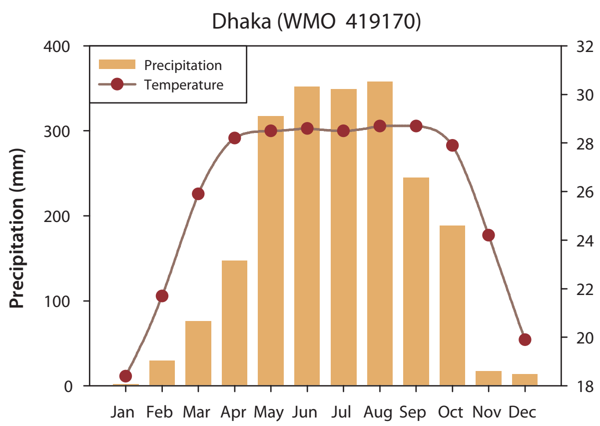






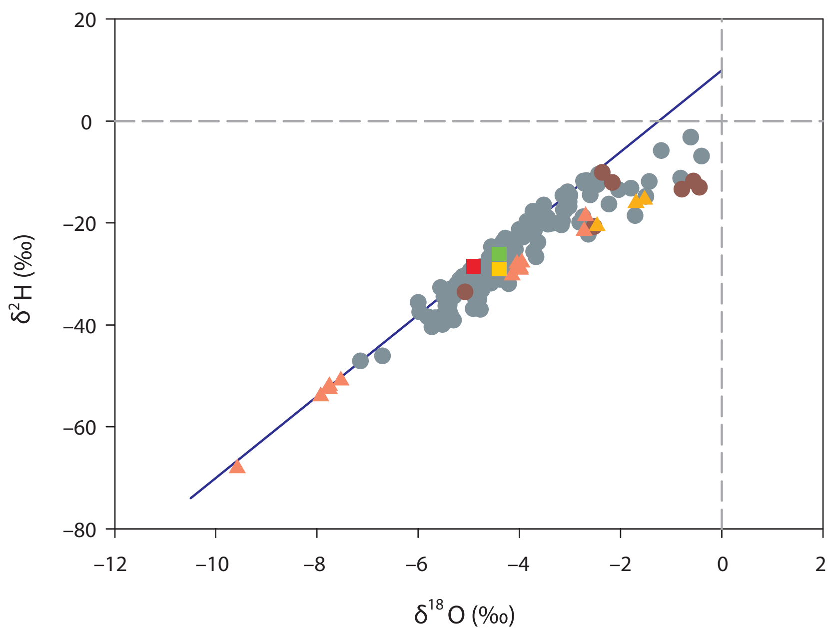
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SHILLONG	red square	30	−4.48	−4.91 ± 4.1	30	1.0	−28.5 ± 18.9			1825	
Interpolation – multiple reg.	yellow square			−4.50			−30.0				
Interpolation – kriging (IAEA)	green square			−4.36			−25.8				
Project	pink square										
Surface waters		**δ18O**			**δ2H**			**Tritium**			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	orange triangle										
River	light red triangle										
Groundwaters		**δ18O**			**δ2H**			**Tritium**		**14C (pMC)**	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	62	−4.61	−4.55 ± 1.2	62	−30.7	−30.5 ± 7.5	32	2.2 ± 2.4	7	45 ± 29
GW–Dug well	brown circle	6	−5.38	−5.16 ± 1.7	6	−36.1	−35.2 ± 10.3	3	6.2 ± 1.9		
GW–Spring	green circle										

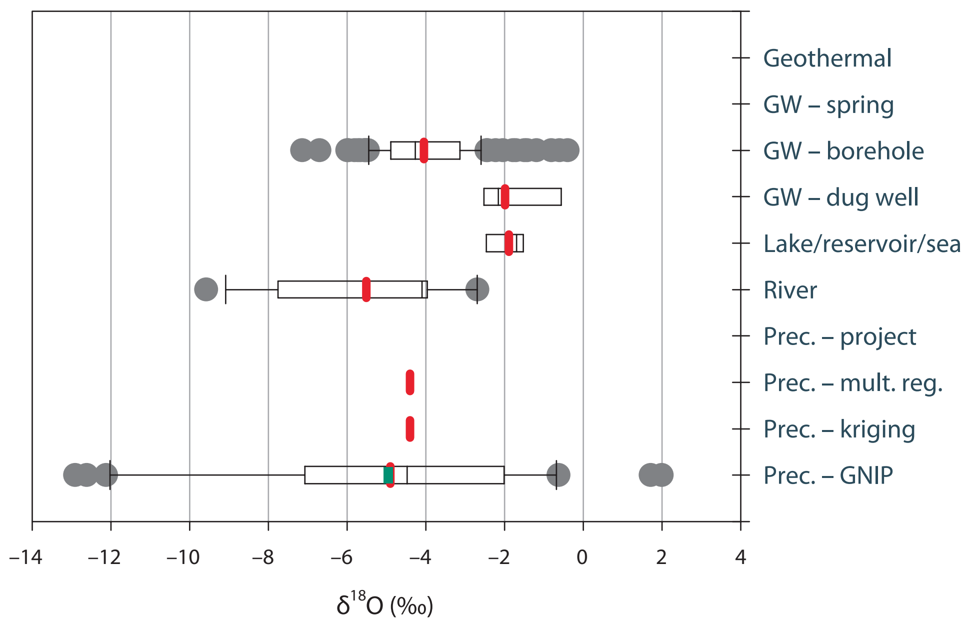


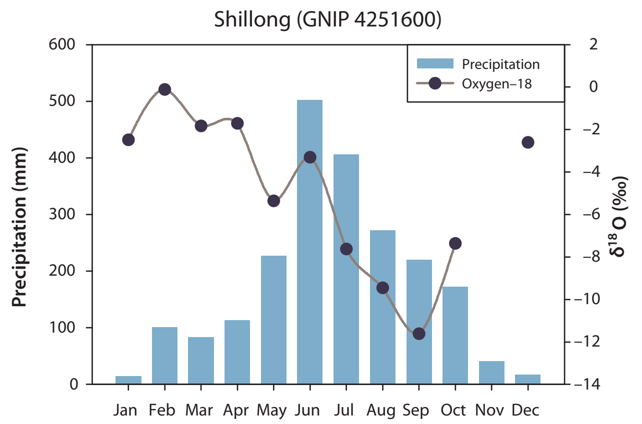


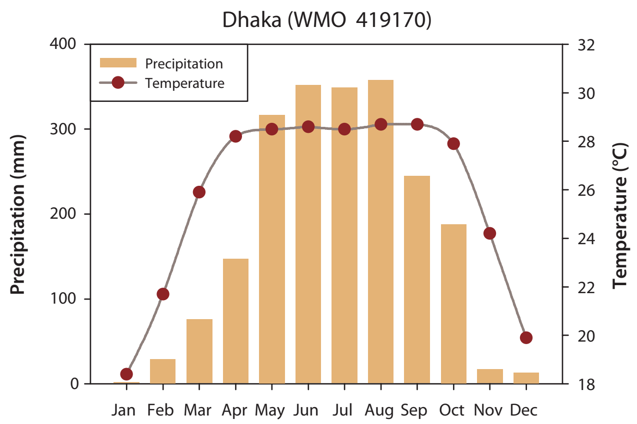
BGD8018

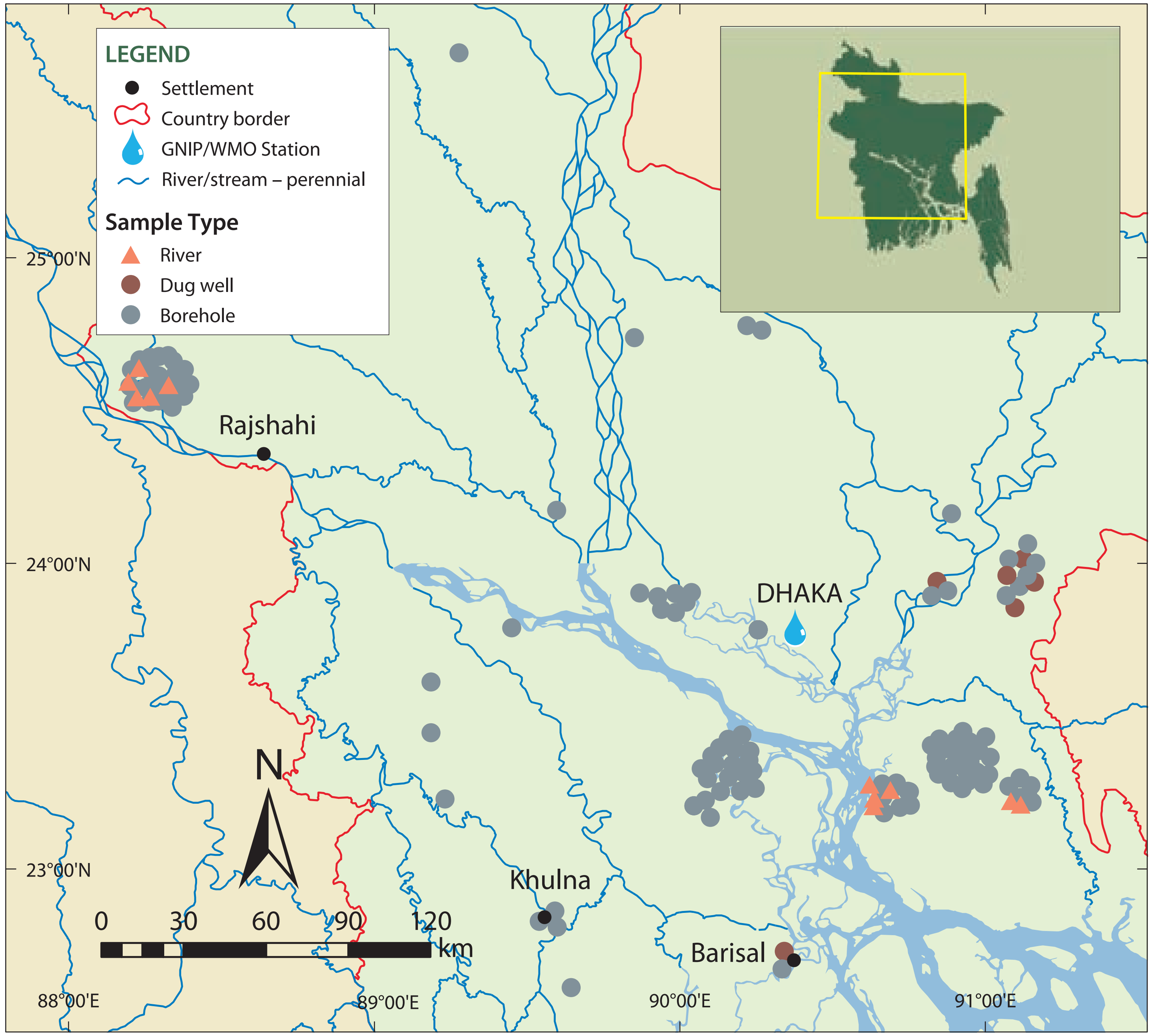
Alluvial aquifers of Bangladesh







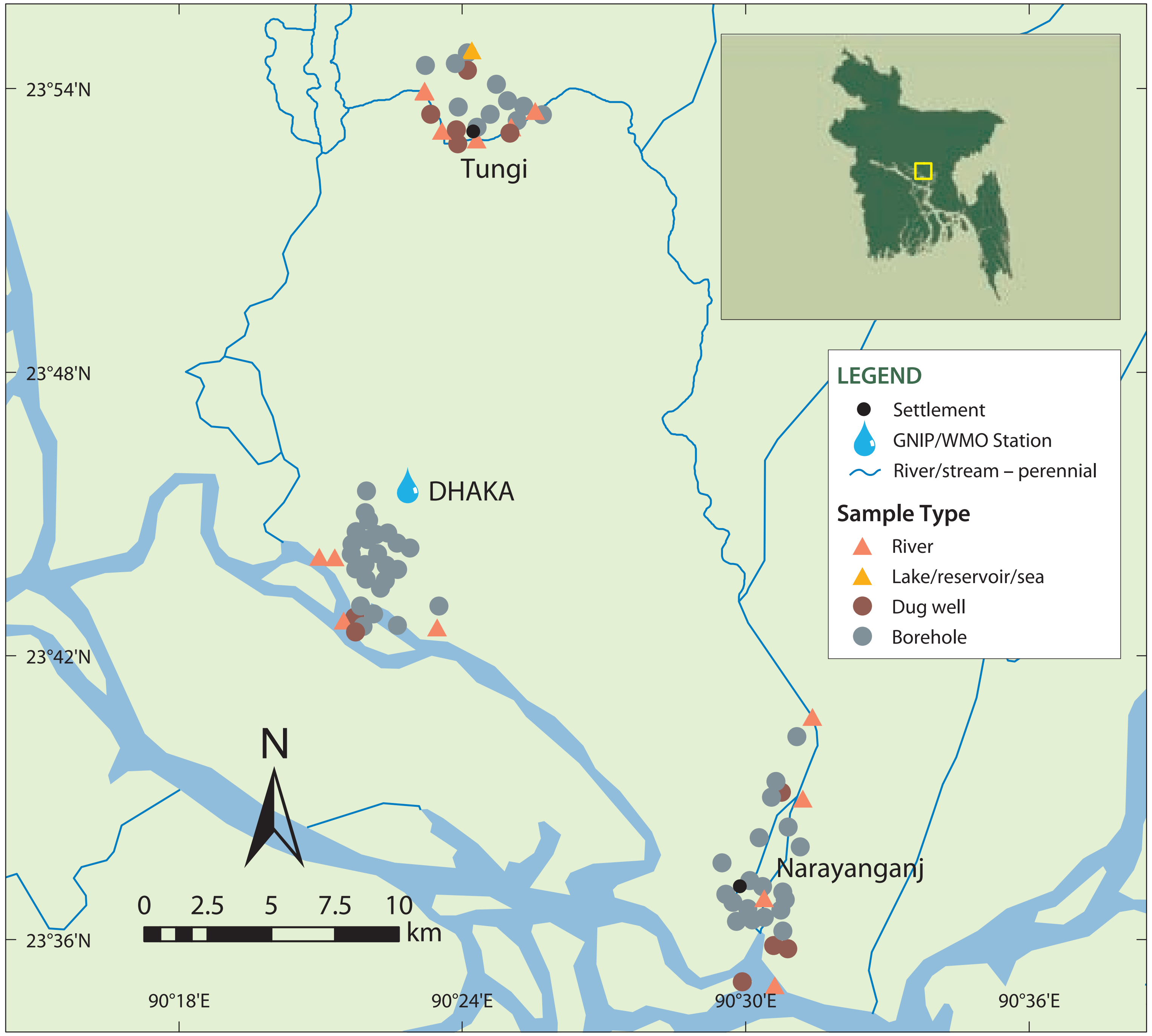




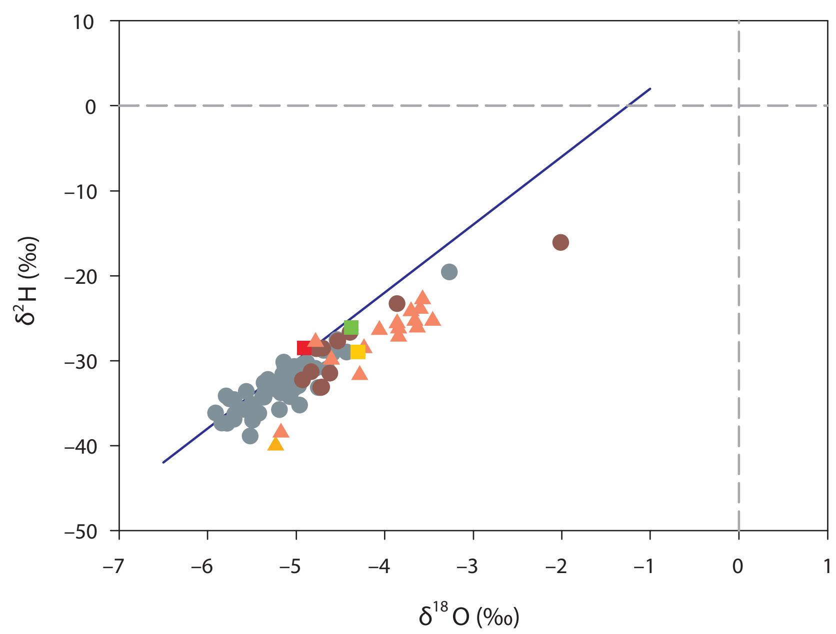
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SHILLONG		30	−4.48	−4.91 ± 4.1	30	−25.6	−28.5 ± 18.9				1825
Interpolation – multiple reg.				−4.40			−29.0				
Interpolation – kriging (IAEA)				−4.40			−26.1				
Project											
Surface waters		δ18O			δ2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea		3	−1.69	−1.89 ± 0.5	3	−16.1	−17.4 ± 2.8				
River		12	−4.10	−5.51 ± 2.4	12	−29.8	−38.5 ± 16.0	5	3.9±0.1		
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water											
GW–Borehole		129	−4.27	−4.05 ± 1.2	129	−26.0	−25.4 ± 8.8	59	1.8 ± 2.0	33	44 ± 30
GW–Dug well		7	−2.16	−1.99 ± 1.6	7	−13.0	−16.4 ± 8.3	1			
GW–Spring											

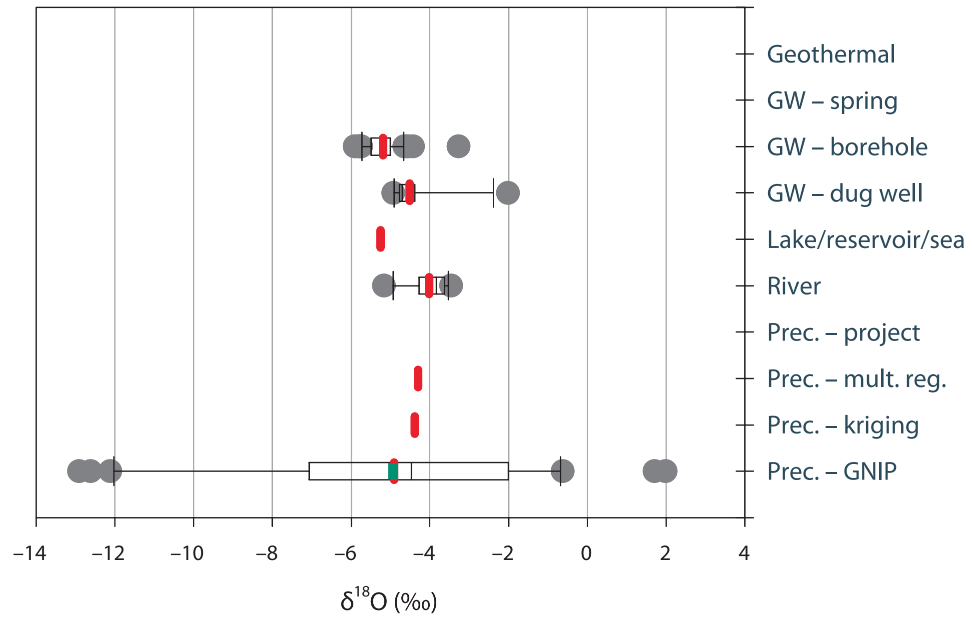
RAS8097–BGD

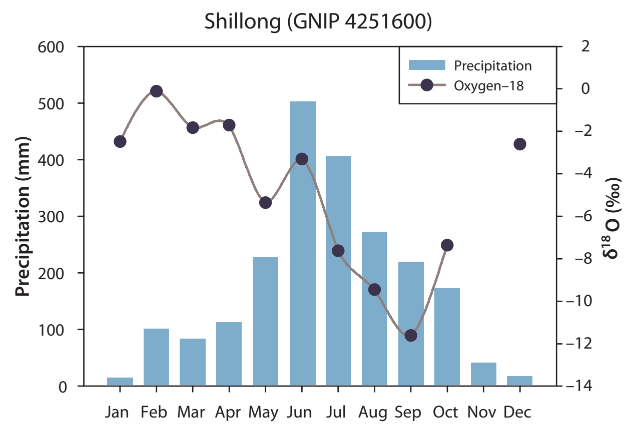
Urban aquifers in Dhaka, Narayanganj and Tungi areas

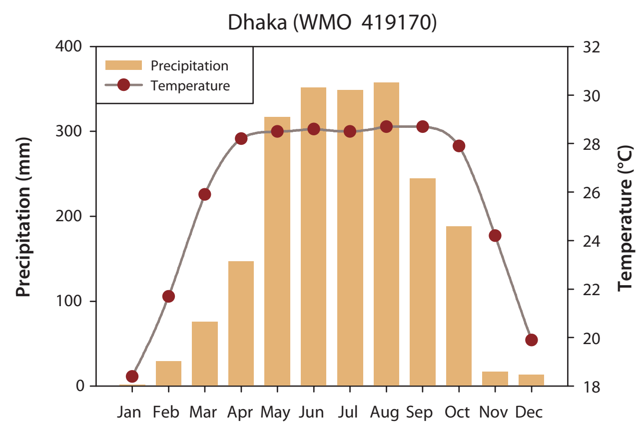


Precipitation		$\delta^{18}O$ (‰)			$\delta^{2}H$ (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SHILLONG		30	−4.48	−4.91 ± 4.1	30	−25.6	−28.5 ± 18.9				1825
Interpolation – multiple reg.				−4.30			−29.0				
Interpolation – kriging (IAEA)				−4.38			−26.1				
Project											
Surface waters		$\delta^{18}O$			$\delta^{2}H$			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea		1	−5.23		1	−40.0					
River		15	−3.84	−4.02 ± 0.5	15	−26.2	−27.3 ± 3.9	9	3.5 ± 0.9		
Groundwaters		$\delta^{18}O$			$\delta^{2}H$			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water											
GW–Borehole		54	−5.18	−5.18 ± 0.4	54	−33.3	−33.1 ± 3.1	39	2.8 ± 1.6	14	85 ± 28
GW–Dug well		11	−4.70	−4.37 ± 0.8	11	−28.6	−28.4 ± 5.1	10	3.3 ± 1.7		
GW–Spring											



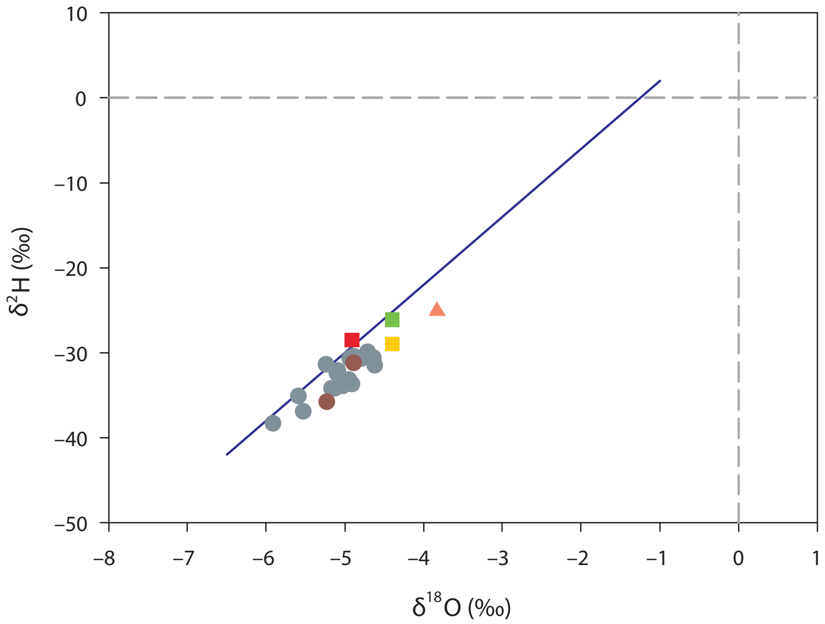


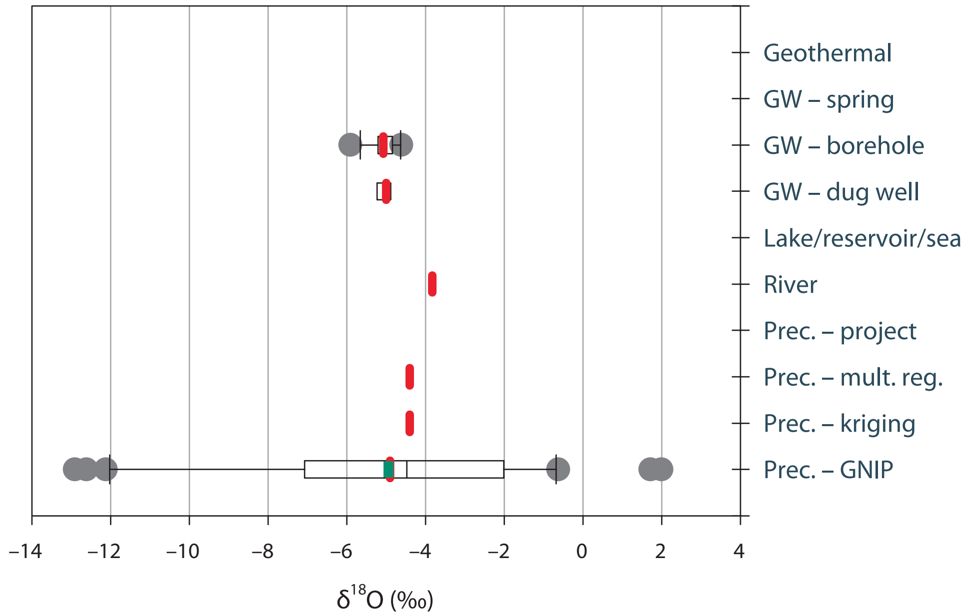


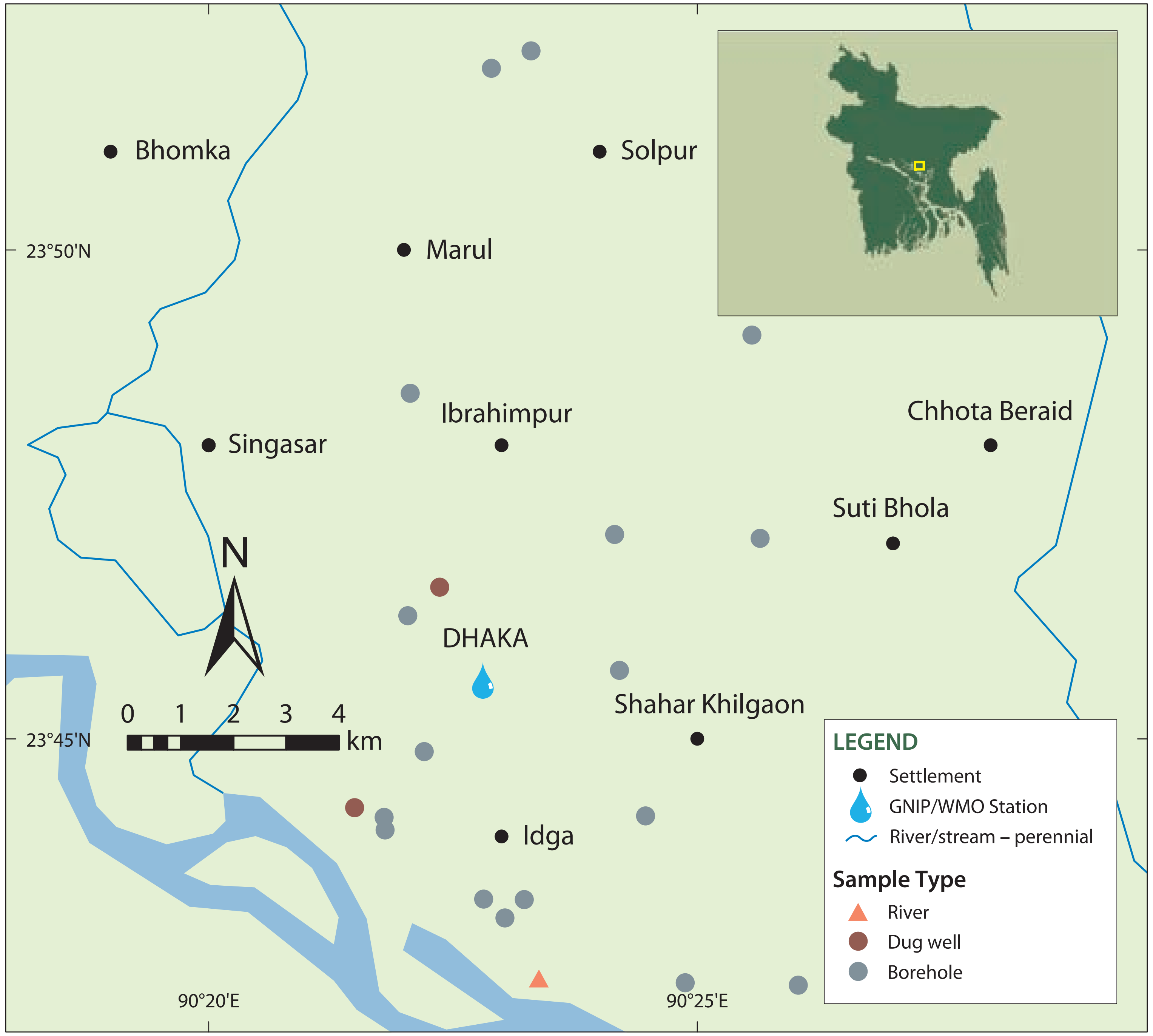


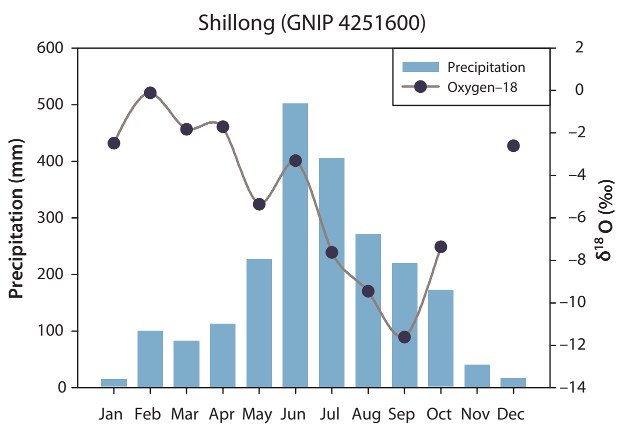
BGD-10068

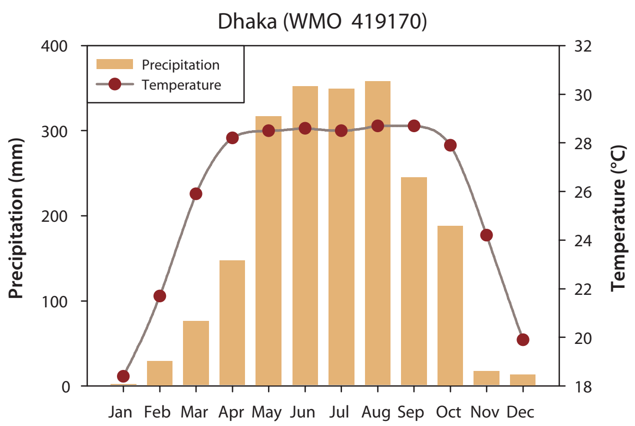
Dupi Tila aquifer, Dhaka



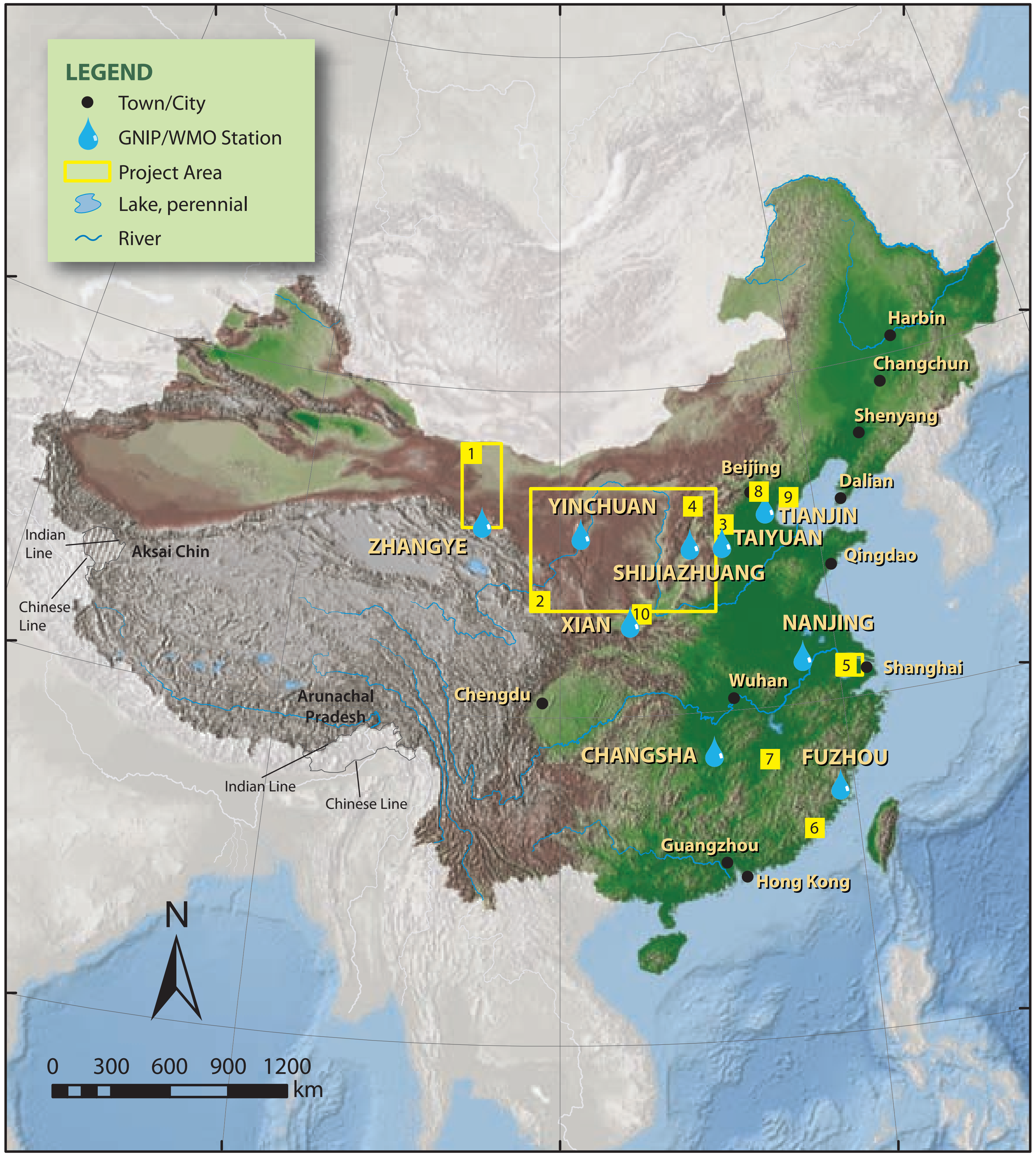








Precipitation		$\delta^{18}O$ (‰)			$\delta^{2}H$ (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station SHILLONG	■ (red)	30	−4.48	−4.91 ± 4.1	30	−25.6	−28.5 ± 18.9			1825
Interpolation – multiple reg.	■ (yellow)			−4.40			−29.0			
Interpolation – kriging (IAEA)	■ (green)			−4.40			−26.1			
Project	■ (pink)									
Surface waters		$\delta^{18}O$			$\delta^{2}H$			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	▲ (yellow)									
River	▲ (red)	1		−3.83	1		−25.1			
Groundwaters		$\delta^{18}O$			$\delta^{2}H$			Tritium		^{14}C (pMC)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n Mean ± St. dev.
Geothermal water	● (blue)									
GW–Borehole	● (grey)	17	−5.03	−5.07 ± 0.4	17	−32.4	−32.9 ± 2.4			
GW–Dug well	● (brown)	2	−5.06	−5.06 ± 0.2	2	−33.5	−33.5 ± 3.2			
GW–Spring	● (green)									



1 Project Code: CPR8014
Study area: Black River basin
Sampling period: 2002–2003
Background: The Black River basin project was implemented to determine the nature and extent of groundwater exchange with the river using isotope techniques, and to develop management strategies that will optimize availability and security of water resources in the Black River basin. Under the project, along with the field sampling, a guidelines document for integration of isotope techniques in water resources studies in northwest China was developed.

2 Project Code: CPR8017
Study area: Erdos basin
Sampling period: 2000–2004
Background: This project was undertaken to assess the potential of deep groundwater resources in the Erdos basin for sustainable exploitation. The hydrodynamic relationship between different subsystems in the karstic groundwater system, circulation paths of groundwater in the artesian basin, groundwater recharge mechanism, and origin of brackish groundwater were studied.

3 Project Code: RAS8084–CPR
Study area: Shijiazhuang basin
Sampling period: 2001–2002
Background: Isotope techniques were used to assess hydrological settings and groundwater dynamics in the aquifers of this basin. Isotopes were also used for studying the extent and geometry of groundwater contamination.

4 Project Code: RAS8097D–CPR
Study area: Datong basin
Sampling period: 2005
Background: The area was investigated to understand groundwater conditions for the delineation of arsenic contamination of aquifers. Development of a conceptual model by using hydrochemistry and isotopes for environmental impact was also undertaken.

5 Project Code: RAS8097Y–CPR
Study area: Yangtze River deltaic aquifers
Sampling period: 2004
Background: These aquifers were studied for identification of sources, flowpaths and extent of contamination of groundwater for appropriate management decisions in the region.

IAEA

Water Resources Programme

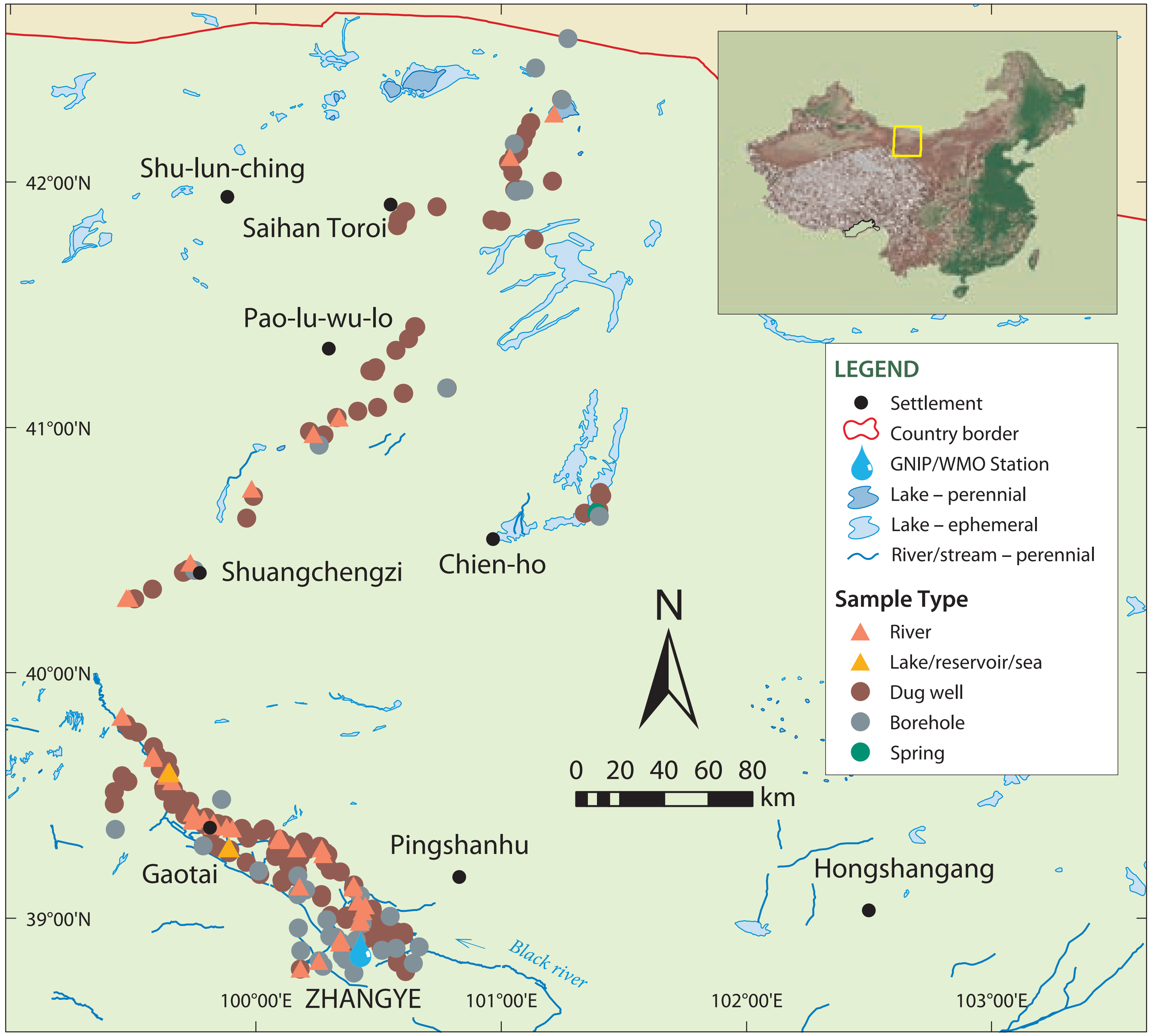
6 **Project Code:** CPR–4850 & CPR–9180Z
Study area: Zhangzhou geothermal area
Sampling period: 1985–1989, 1996
Background: Isotopic composition of meteoric water, seawater, springs, and geothermal sources was measured for determination of mixing ratios of waters from different origins and to investigate geothermal reservoir temperatures using isotope geothermometry.

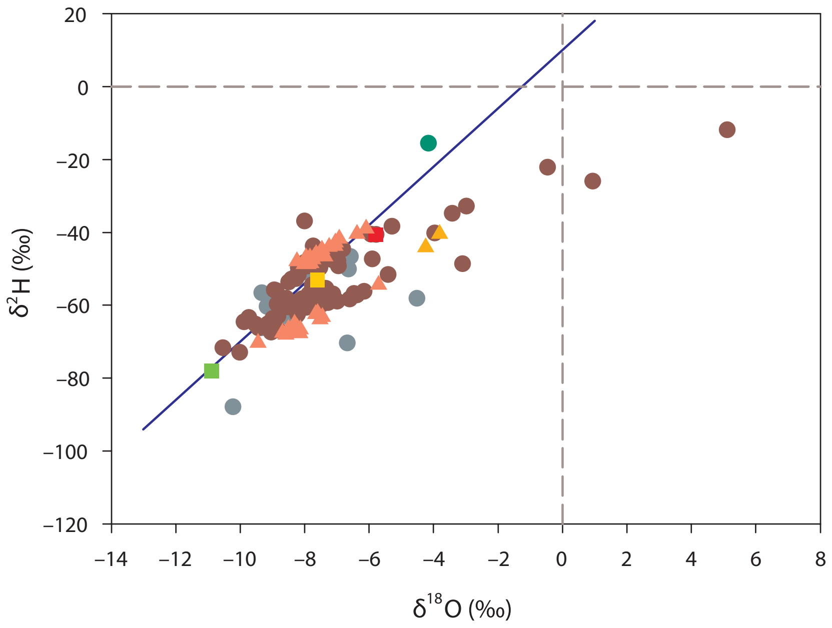
7 **Project Code:** CPR–7277
Study area: Xiangshan ore field
Sampling period: 1994–1998
Background: Isotopes were used to determine the origin, recharge conditions, and contamination of groundwater around the Xiangshan Uranium Mine.

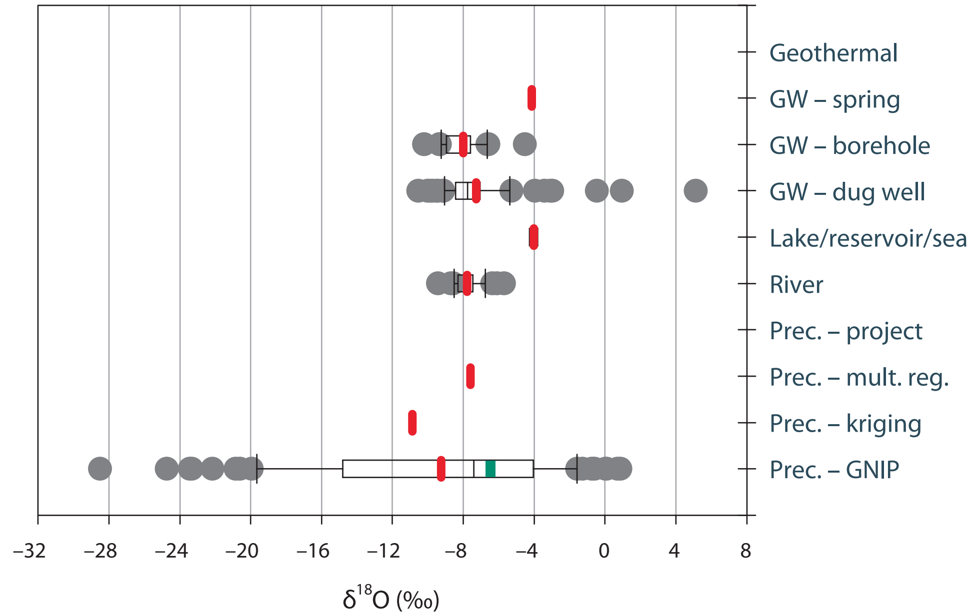
8 **Project Code:** CPR–8199
Study area: Beijing urban aquifers
Sampling period: 1997 (incl. 1975)
Background: Assessment of impact of industrial pollutants and domestic sewage irrigation on the groundwater quality in the suburbs of the old Beijing City using environmental isotopes was carried out.

9 **Project Code:** CPR–9180H
Study area: Hebei Plain geothermal area
Sampling period: 1998
Background: Main objectives of this study were: to study the origin of dissolved sulphate and equilibrium fractionation of oxygen isotopes in dissolved sulphur species and thermal waters; to test SO_4–H_2O isotope geothermometry in low temperature geothermal environments; and to measure the residence time of geothermal fluids using environmental isotopes.

10 **Project Code:** CPR–11730
Study area: Guanzhong basin
Sampling period: 2002
Background: In order to adopt management decisions, identification of sources and processes involved in the formation of saline groundwater in the northeast of the Guanzhong basin was undertaken in this research.



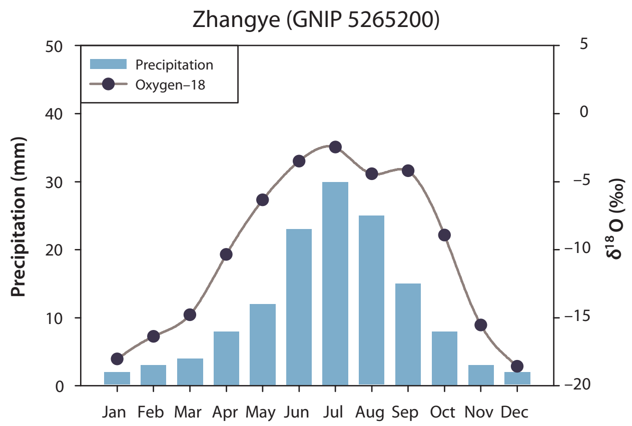


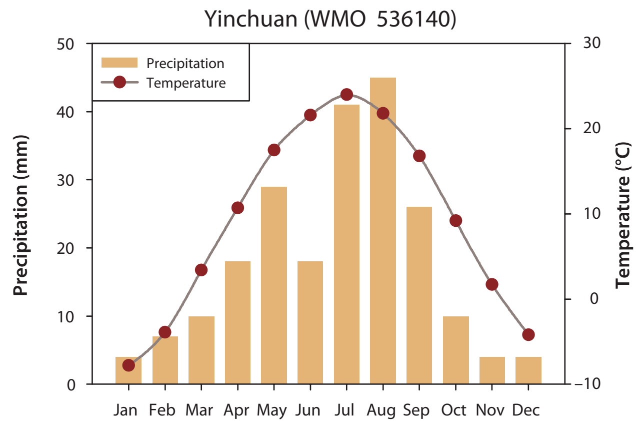


Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station ZHANGYE	■ (red)	86	−7.41	−5.80 ± 3.7	86	−51.9	−40.7 ± 25.4			104
Interpolation – multiple reg.	■ (yellow)			−7.60			−53.0			
Interpolation – kriging (IAEA)	■ (green)			−10.88			−78.1			
Project	■ (pink)									

Surface waters		δ18O			δ2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)	2	−4.03	−4.03 ± 0.3	2	−42.2	−42.2 ± 2.6		
River	▲ (orange)	36	−7.84	−7.78 ± 0.7	36	−51.6	−55.4 ± 10.6	16	24.5 ± 9.5

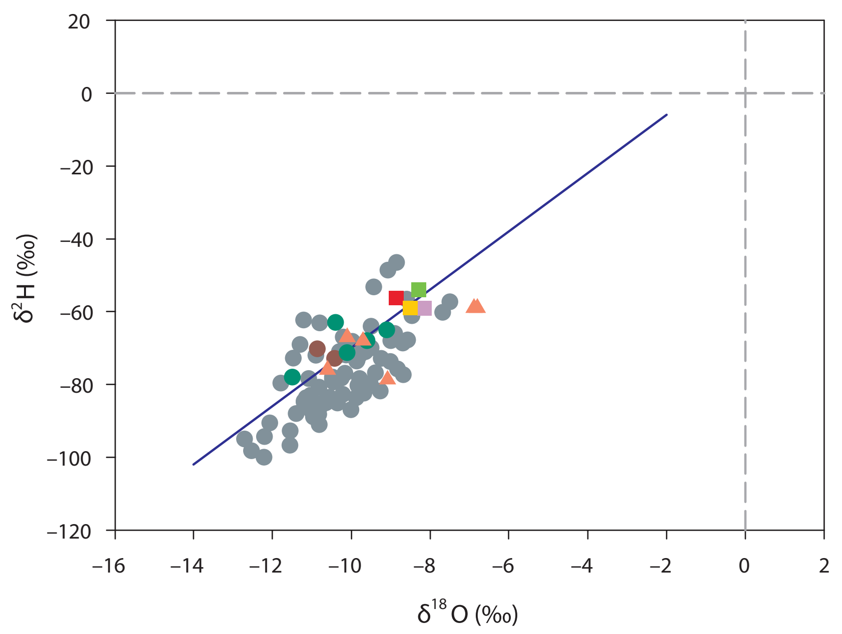
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	34	−7.94	−8.01 ± 1.0	34	−57.8	−57.4 ± 8.1	29	15.3 ± 10.3		
GW–Dug well	● (brown)	86	−7.75	−7.29 ± 2.3	86	−56.1	−53.3 ± 10.4	86	21.3 ± 9.2		
GW–Spring	● (green)	1	−4.16		1	−15.6		1			

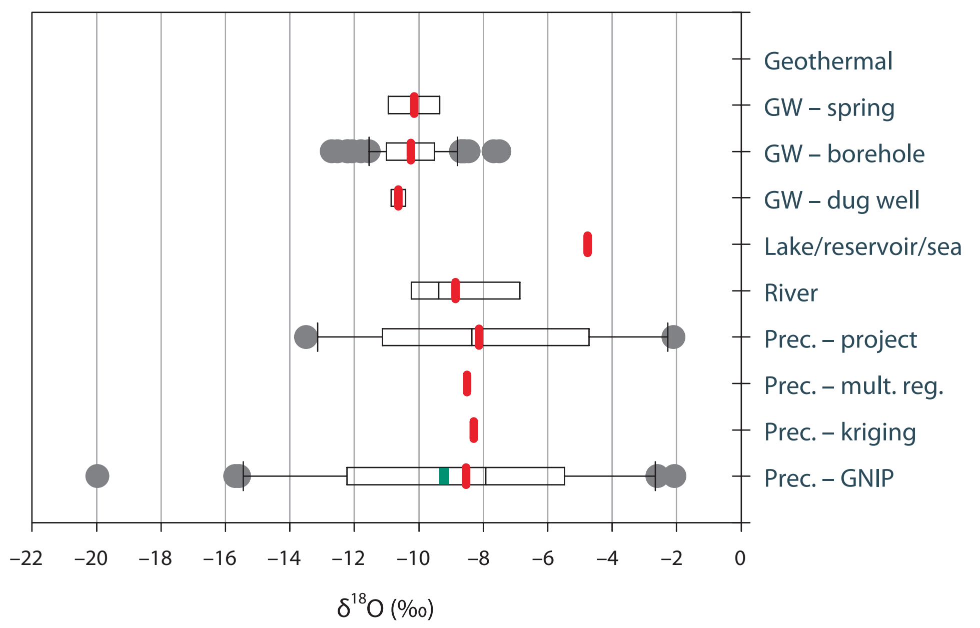


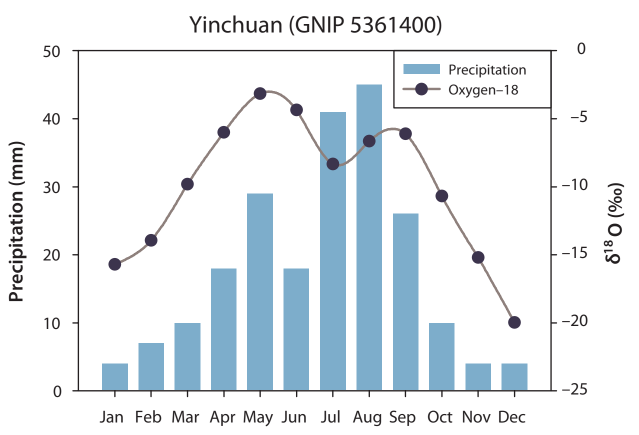


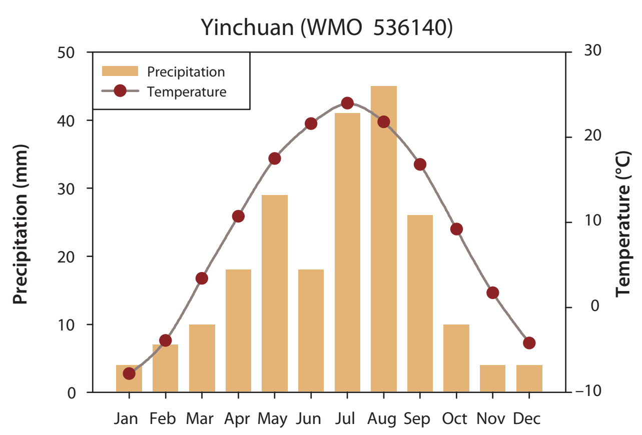
CPR8017

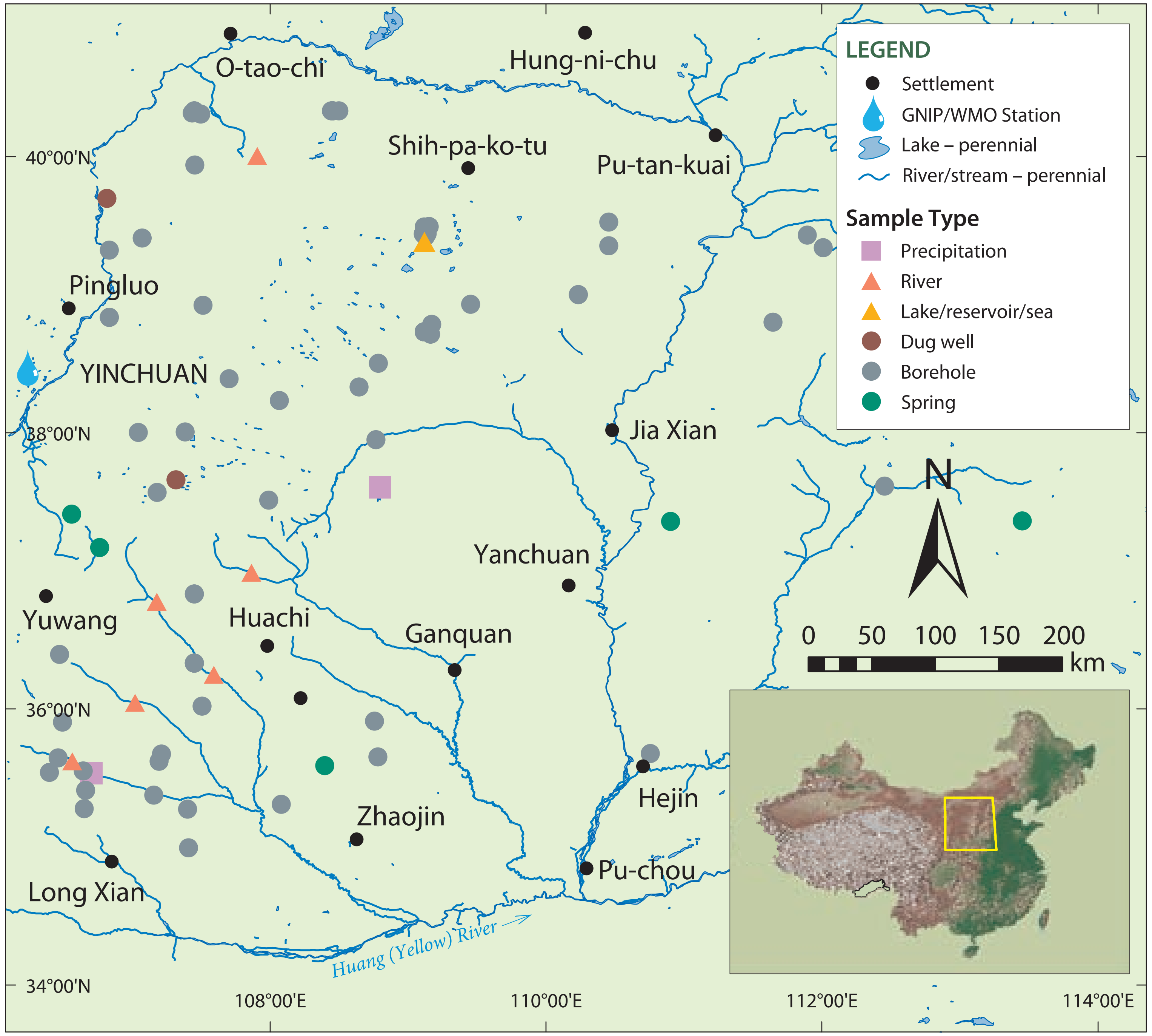
Erdos basin





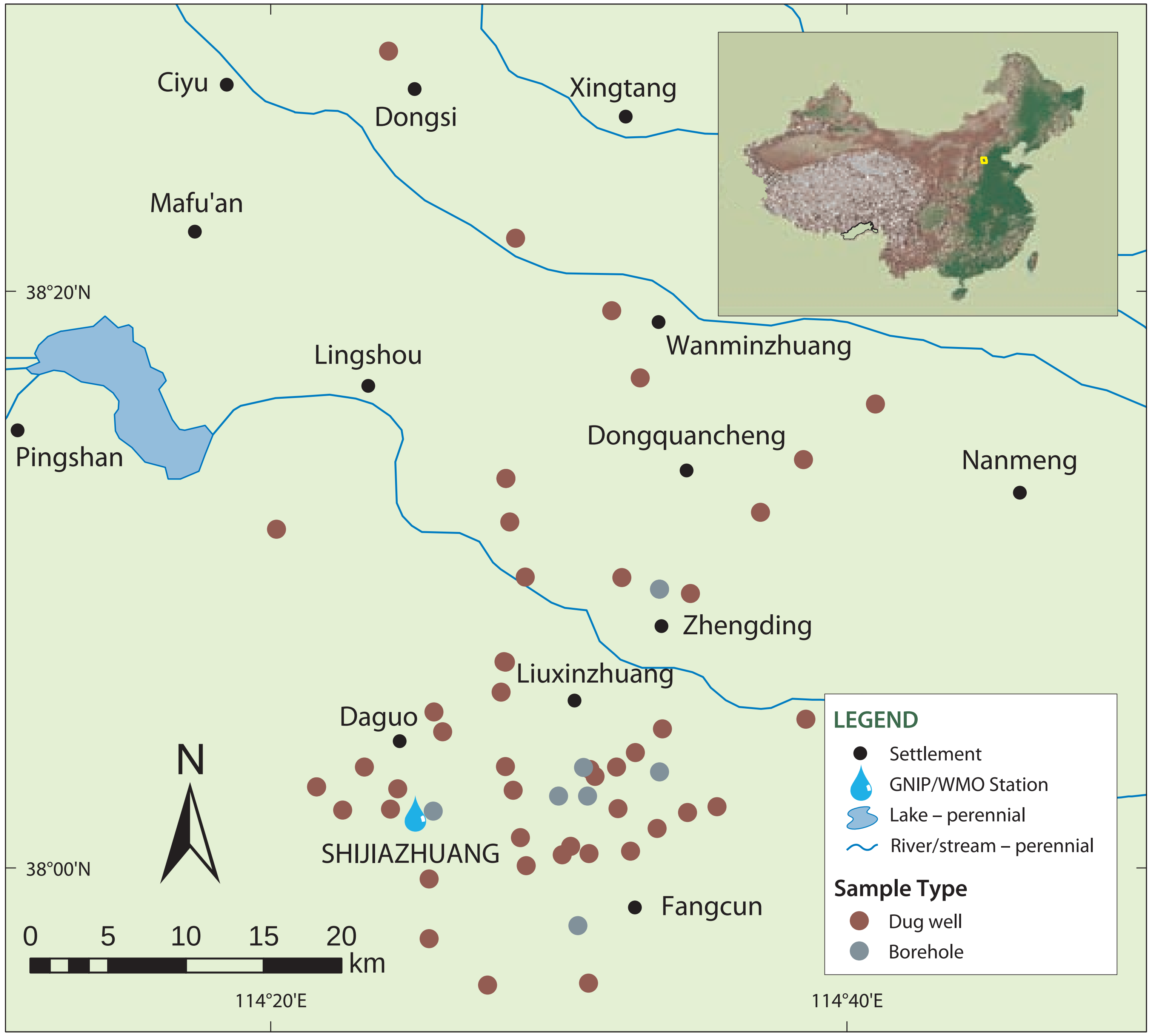


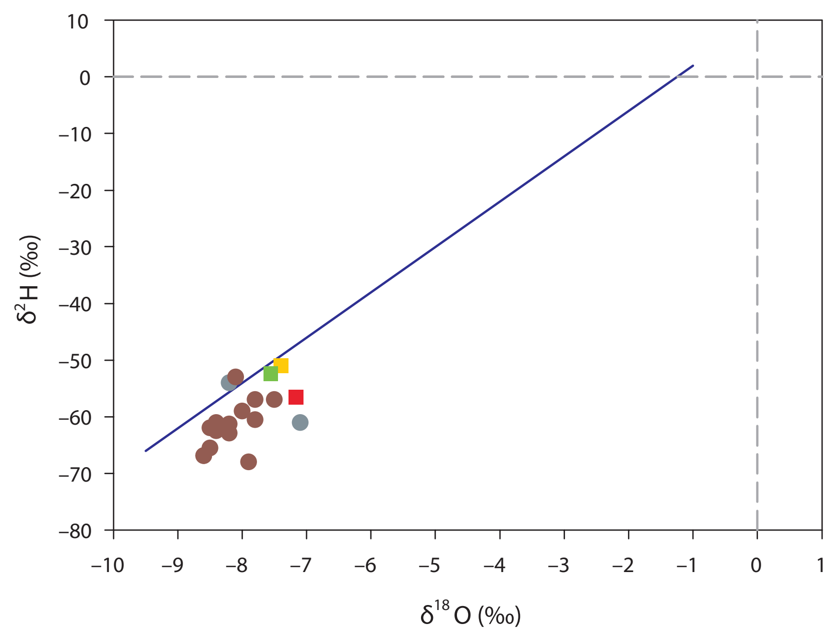


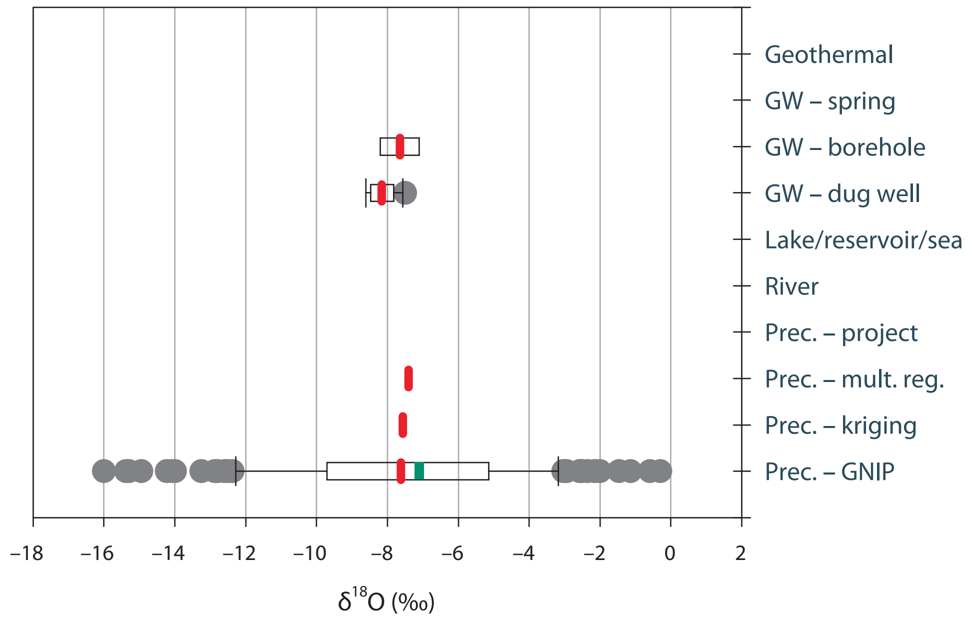


Precipitation	δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
	n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station YINCHUAN	30	−7.92	−8.85 ± 2.1	30	−53.2	−56.3 ± 13.3				195
Interpolation – multiple reg.			−8.50			−59.0				
Interpolation – kriging (IAEA)			−8.29			−54.0				
Project	18	−8.35	−8.14 ± 3.8	18	−59.0	−59.1 ± 24.7				
Surface waters	δ¹⁸O			δ²H			Tritium			
	n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	1		−4.76	1		−47.3	1	16.5		
River	6	−9.39	−8.86 ± 1.6	6	−67.5	−67.9 ± 8.3				
Groundwaters	δ¹⁸O			δ²H			Tritium		^{14}C (pMC)	
	n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water										
GW–Borehole	77	−10.25	−10.24 ± 1.1	77	−78.3	−77.0 ± 11.1	43	1.0 ± 2.4	31	45 ± 30
GW–Dug well	2	−10.64	−10.64 ± 0.3	2	−71.6	−71.6 ± 1.8				
GW–Spring	5	−10.11	−10.14 ± 0.9	5	−68.0	−69.5 ± 5.9			3	54 ± 18

RAS8084–CPR
Shijiazhuang basin



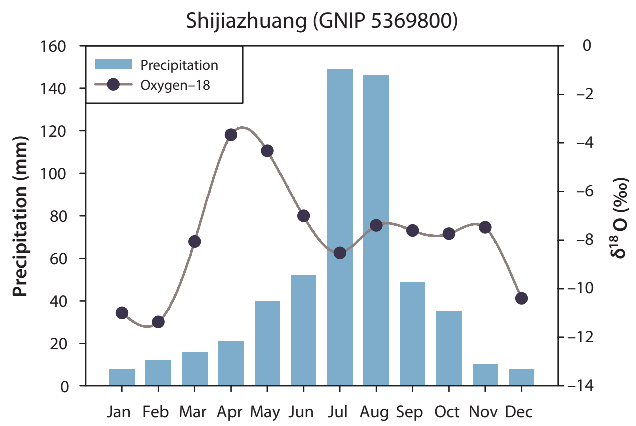


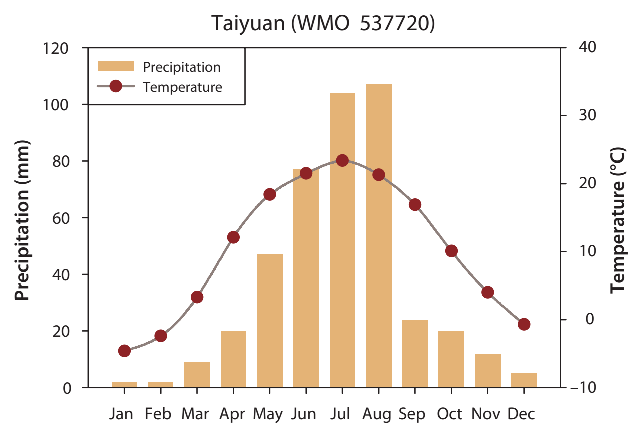


Precipitation	$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station SHIJAZHUANG	146	–7.63	–7.16 ± 1.1	148	–52.1	–56.5 ± 8.0			456
Interpolation – multiple reg.			–7.40			–51.0			
Interpolation – kriging (IAEA)			–7.56			–52.5			
Project									

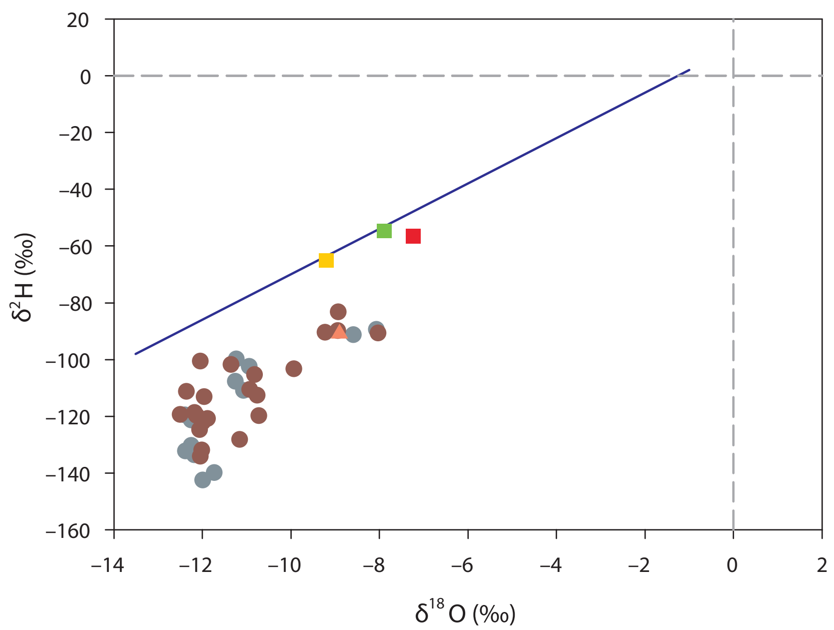
Surface waters	$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea								
River								

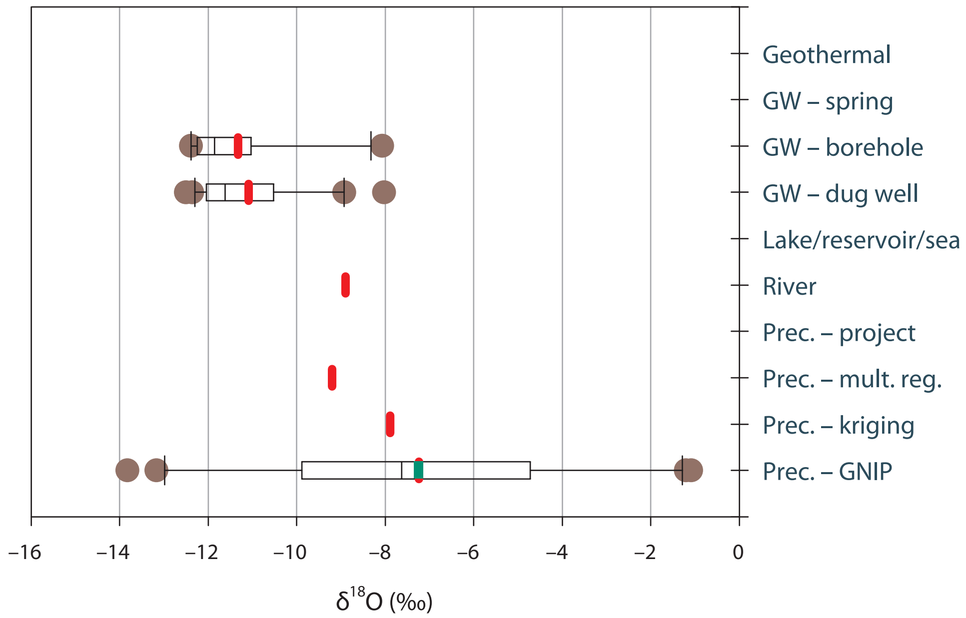
Groundwaters	$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	2	–7.65	–7.65 ± 0.8	2	–57.5	–57.5 ± 5.0	1	28.3		
GW–Dug well	16	–8.20	–8.16 ± 0.4	15	–61.3	–61.6 ± 4.1	13	33.4 ± 15.1		
GW–Spring										

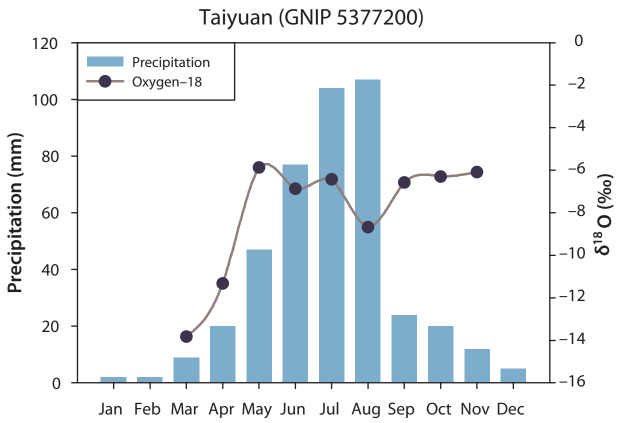


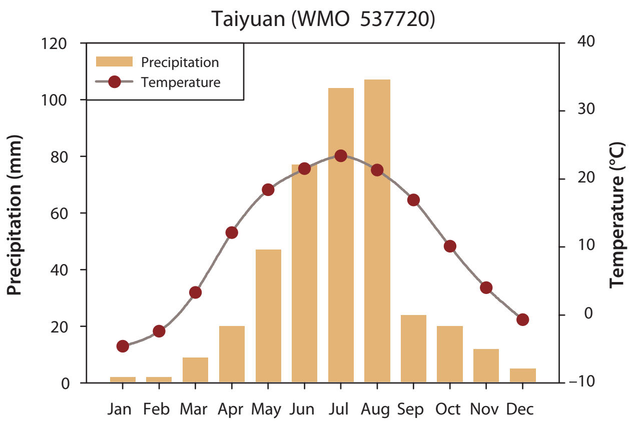


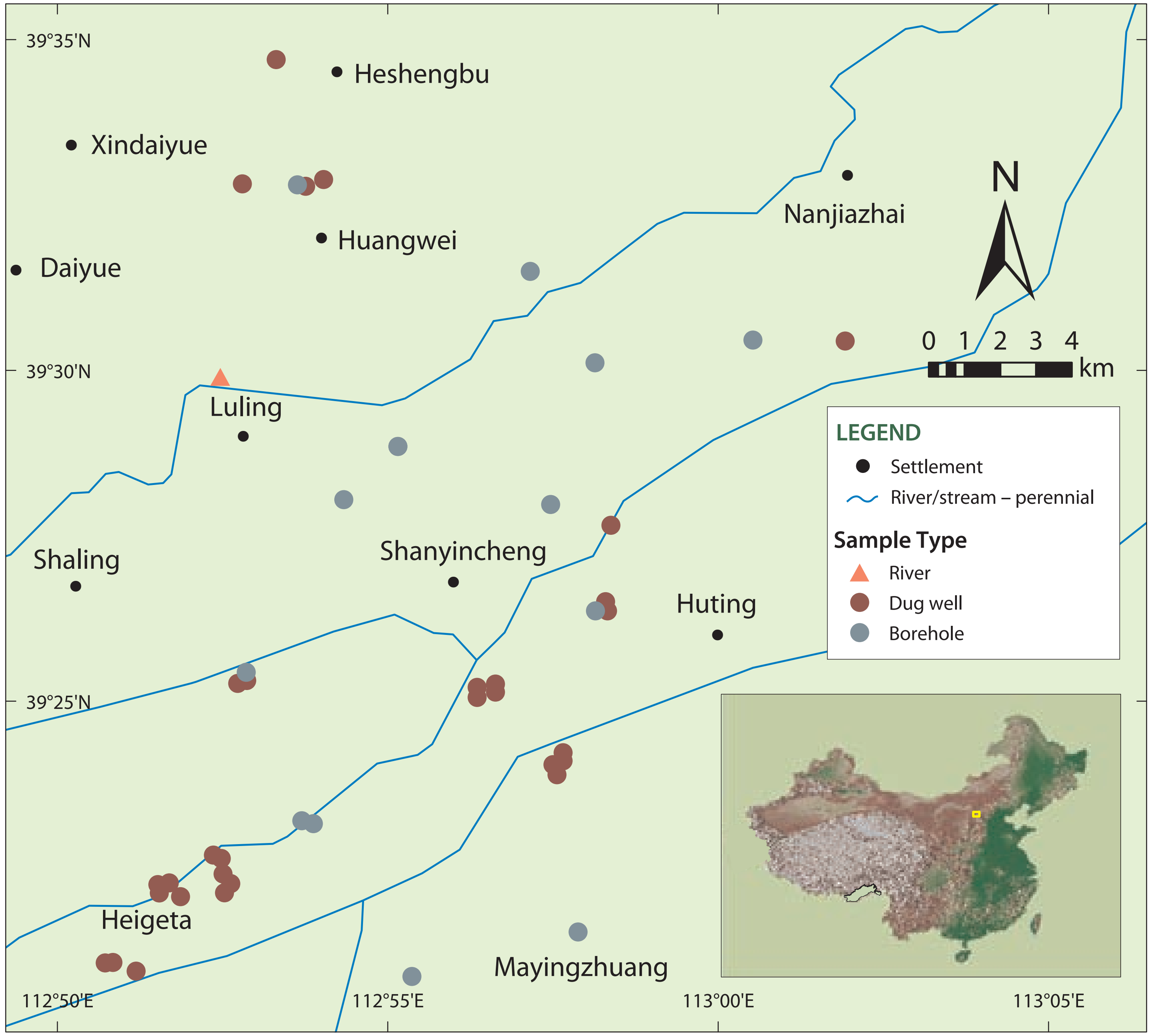
RAS8097D-CPR
Datong basin







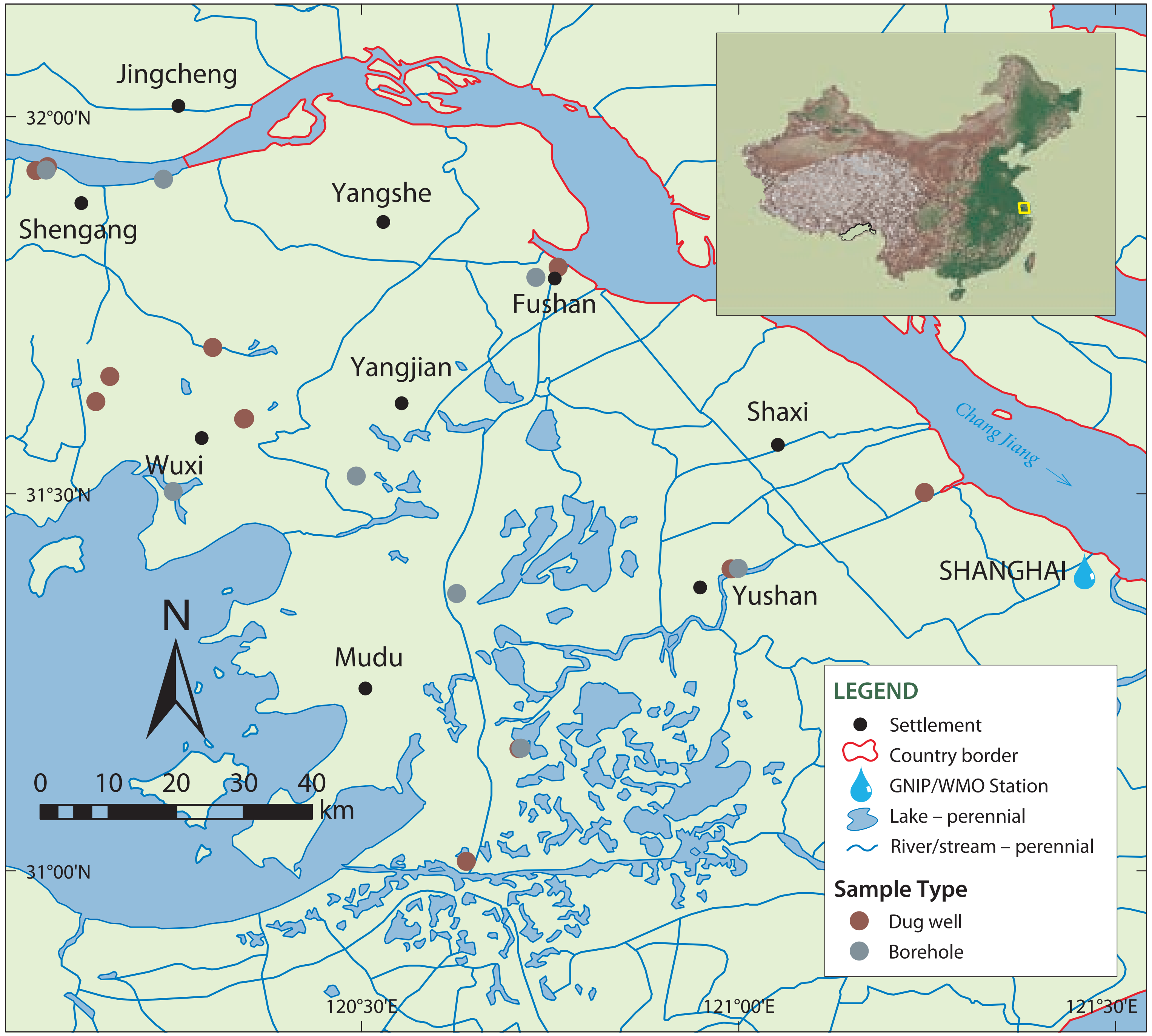


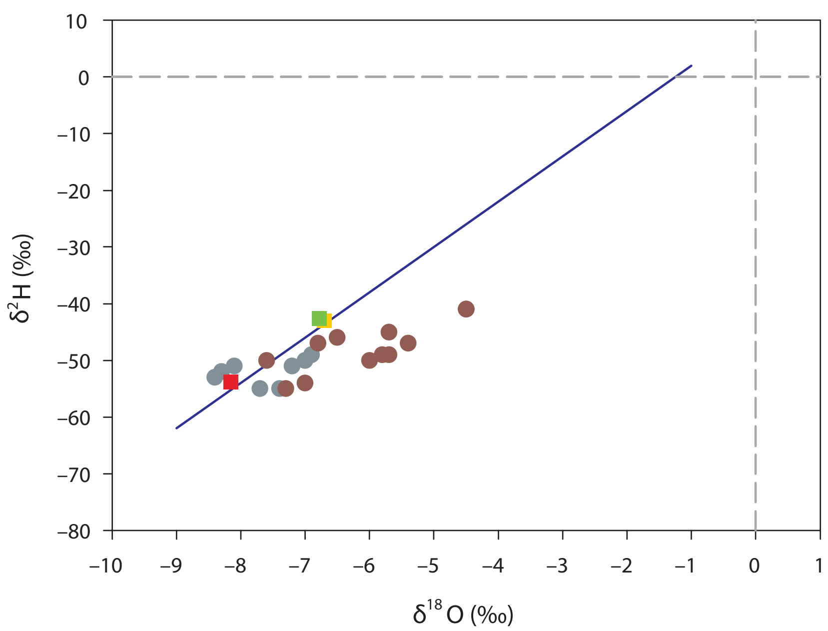


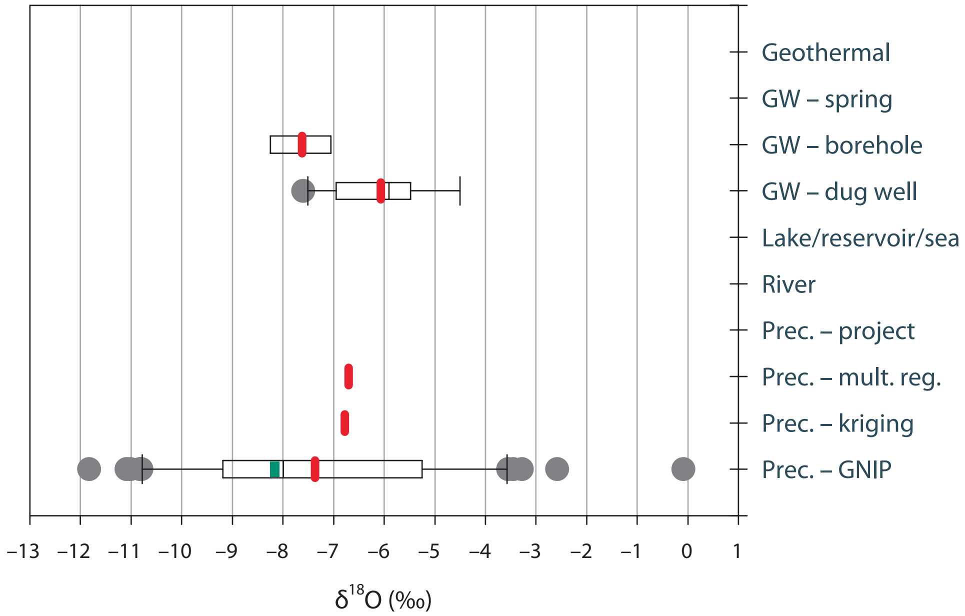
Precipitation	δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station TAIYUAN	20	−7.63	−7.24 ± 1.4	20	−49.6	−56.5 ± 8.2			415
Interpolation – multiple reg.			−9.20			−65.0			
Interpolation – kriging (IAEA)			−7.89			−54.7			
Project									

Surface waters	δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea								
River	1		−8.90	1		−90.9		

Groundwaters	δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	14	−11.86	−11.32 ± 1.4	14	−119.8	−117.2 ± 17.4				
GW–Dug well	22	−11.62	−11.09 ± 1.3	22	−112.8	−111.4 ± 14.3				
GW–Spring										



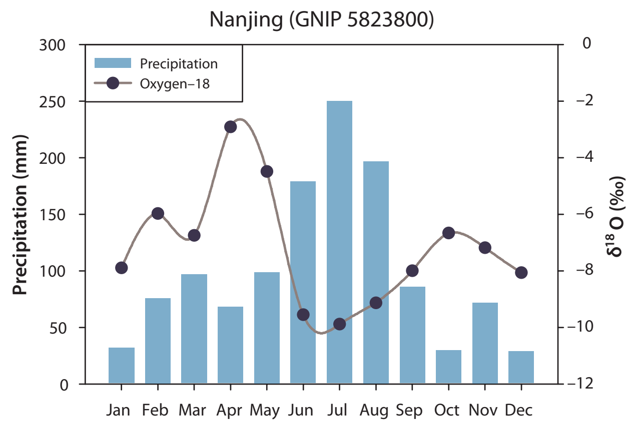


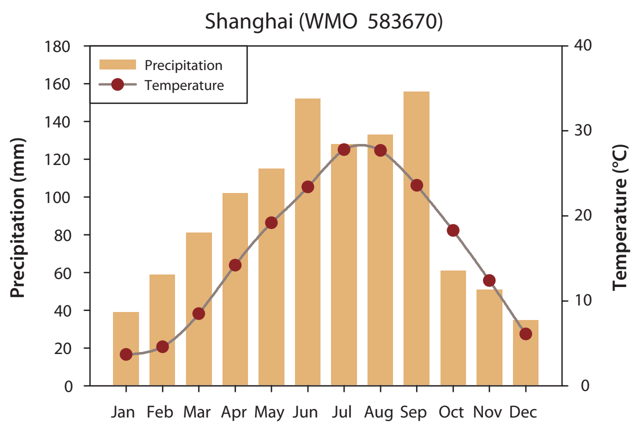


Precipitation		$\delta^{18}O$ (‰)			δ^2H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station NANJING	■ (red)	58	−7.99	−8.15 ± 1.5	58	−46.8	−53.8 ± 5.8			1176
Interpolation – multiple reg.	■ (yellow)			−6.70			−43.0			
Interpolation – kriging (IAEA)	■ (green)			−6.78			−42.6			
Project	■ (pink)									

Surface waters		$\delta^{18}O$			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)								
River	▲ (red)								

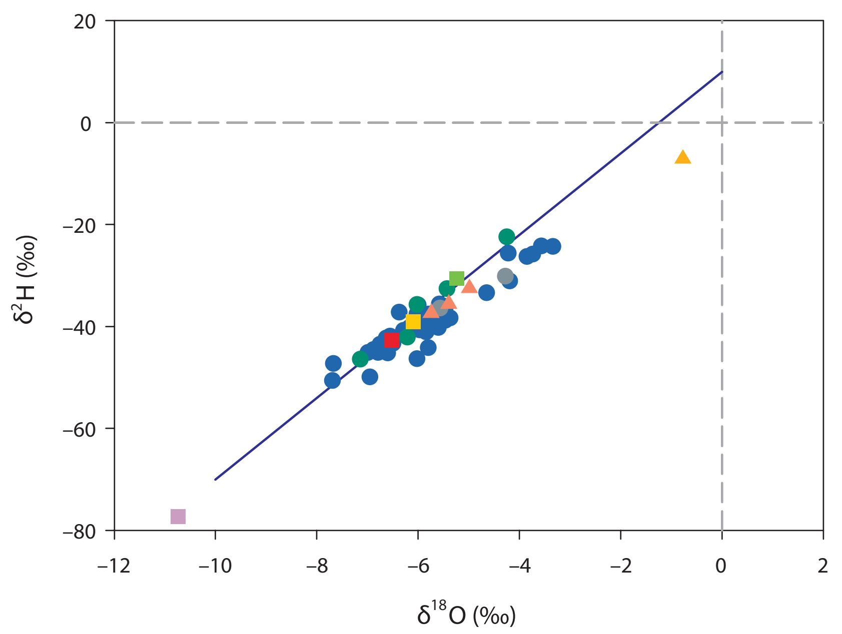
Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	8	−7.55	−7.63 ± 0.6	8	−51.5	−52.0 ± 2.2				
GW–Dug well	● (brown)	12	−5.90	−6.07 ± 1.0	12	−48.0	−47.8 ± 4.3				
GW–Spring	● (green)										

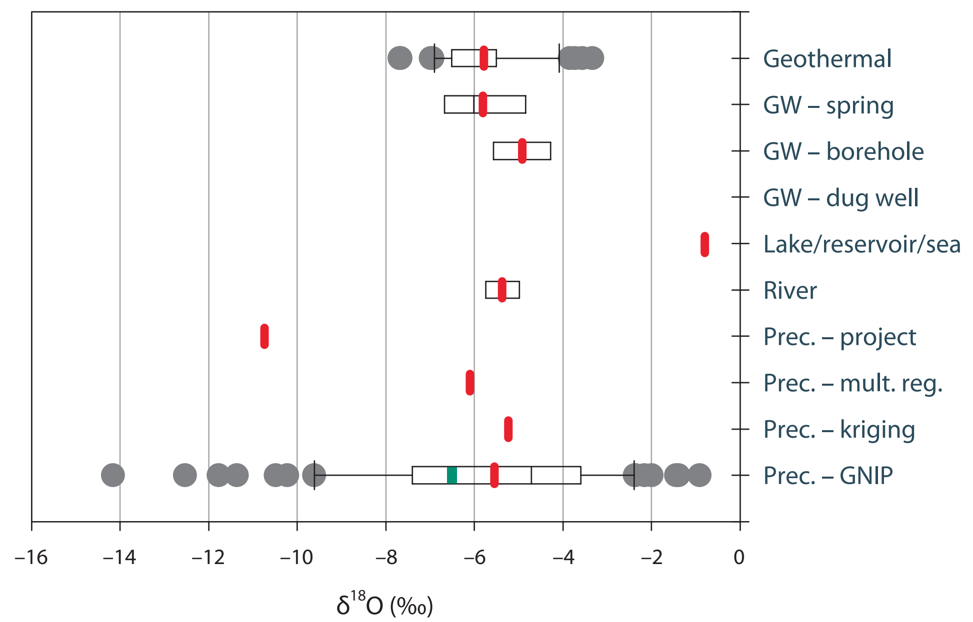


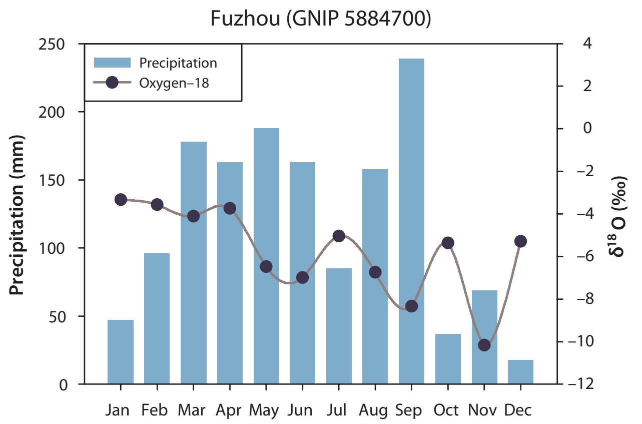


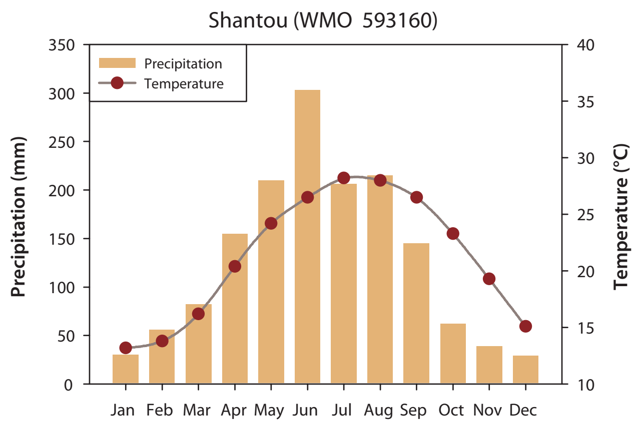
CPR-4850; CPR-9180Z

Zhangzhou geothermal area





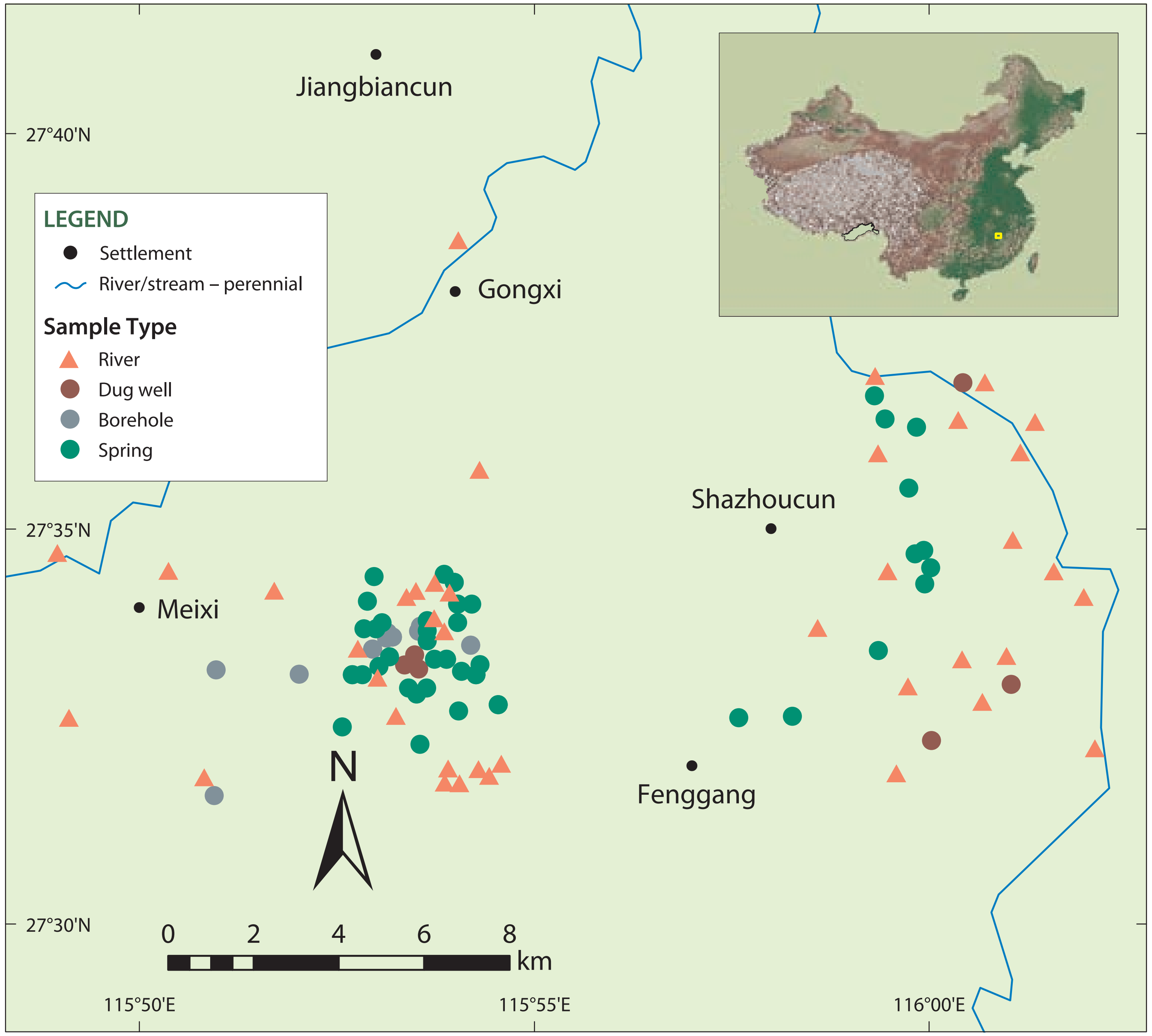


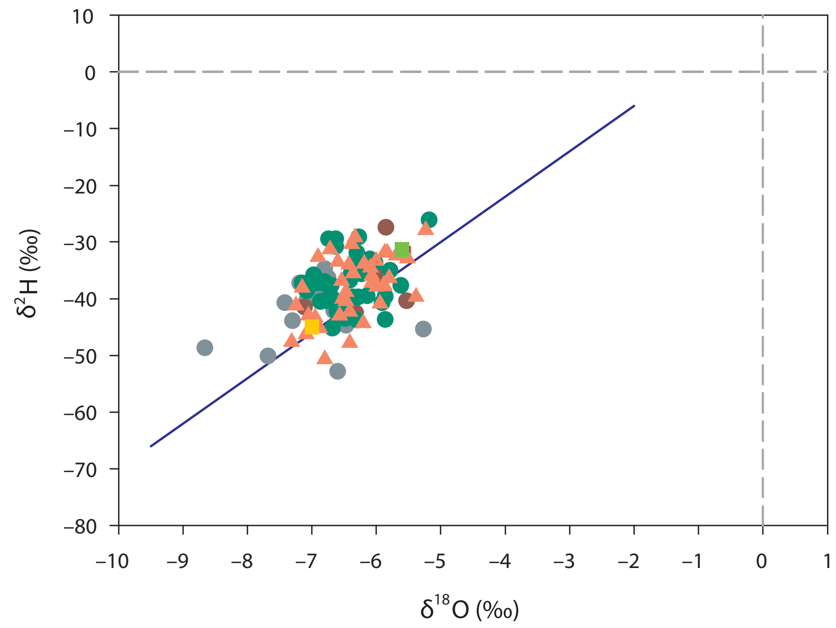


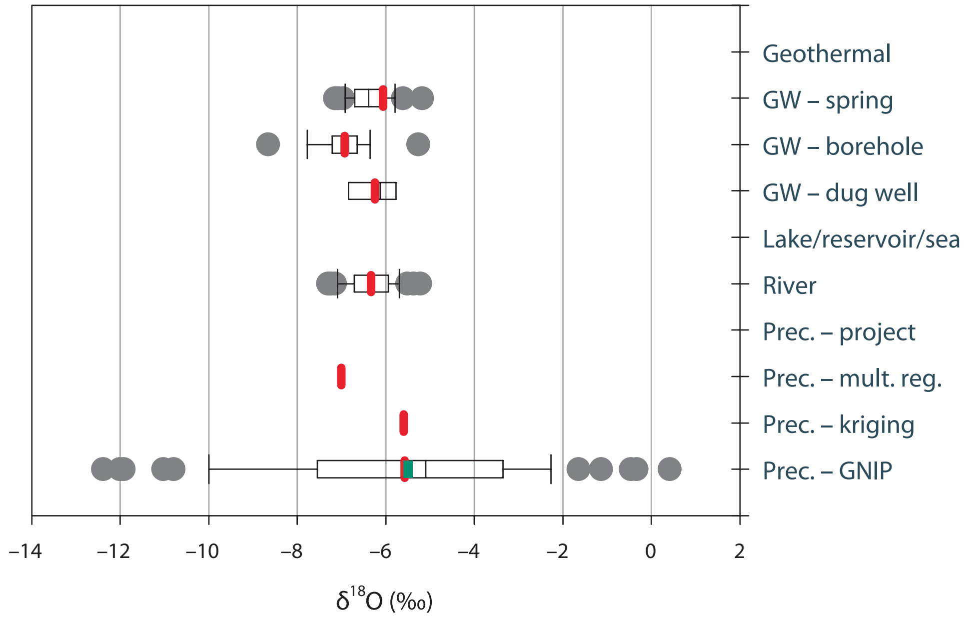
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station FUZHOU	red square	71	−4.71	−6.52 ± 1.2	72	−23.7	−42.7 ± 10.0			1224
Interpolation – multiple reg.	yellow square			−6.10			−39.0			
Interpolation – kriging (IAEA)	green square			−5.24			−30.6			
Project	pink square	1		−10.74	1		−77.3	1	17.2	

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	1		−0.72	1		−6.9	1	5.7
River	orange triangle	3	−5.39	−5.37 ± 0.4	3	−35.6	−35.2 ± 2.5	3	11.5 ± 2.9

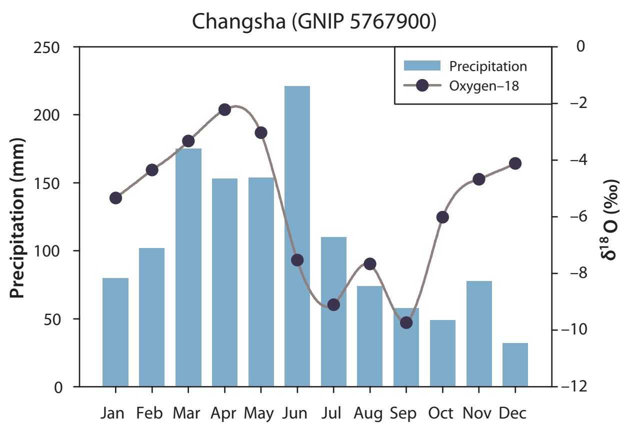
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle	46	−5.80	−5.81 ± 1.1	44	−38.4	−38.7 ± 6.4	17	5.0 ± 2.1	1	154
GW–Borehole	grey circle	2	−4.93	−4.93 ± 0.9	2	−33.2	−33.2 ± 4.4				
GW–Dug well	brown circle										
GW–Spring	green circle	5	−6.02	−5.81 ± 1.1	5	−35.7	−35.8 ± 9.2	4	9.3 ± 3.1	1	34

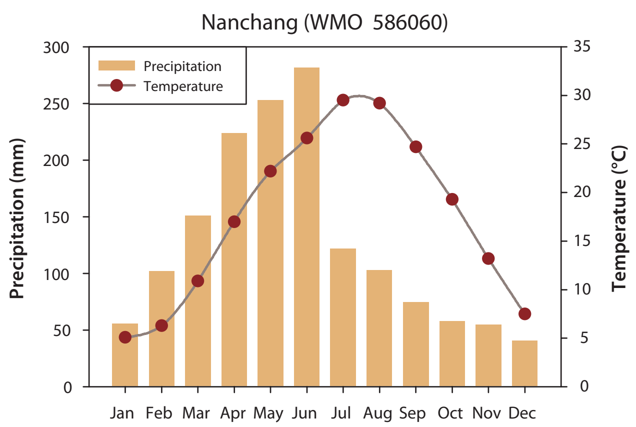




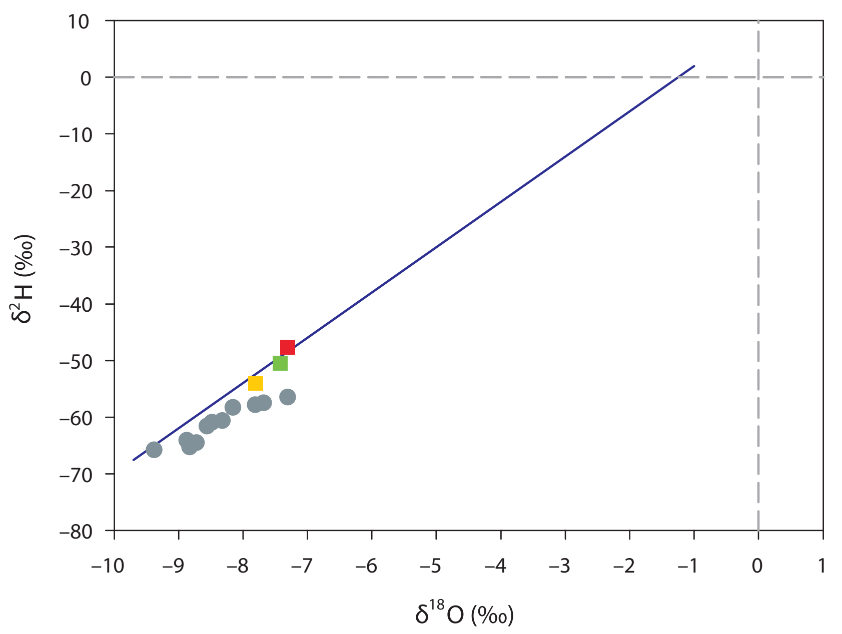


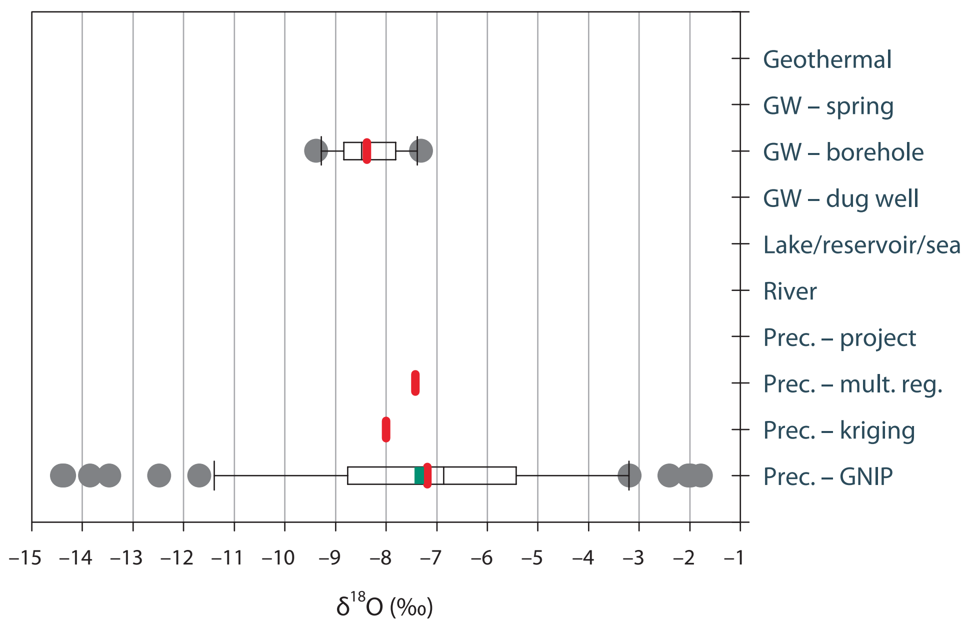
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station CHANGSHA	red	57	–5.10	–5.58 ± 1.4	57	–24.6	–32.0 ± 11.3			1271	
Interpolation – multiple reg.	yellow			–7.00			–45.0				
Interpolation – kriging (IAEA)	green			–5.60			–31.3				
Project	pink										
Surface waters		$\delta^{18}O$			δ^2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲										
River	▲	39	–6.38	–6.34 ± 0.5	39	–37.6	–37.9 ± 5.6	12	32.5 ± 38.8		
Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	18	–6.85	–6.93 ± 0.7	18	–41.4	–42.1 ± 5.1	13	20.1 ± 20.7		
GW–Dug well	●	6	–6.13	–6.25 ± 0.6	6	–40.2	–38.0 ± 5.6	3	20.6 ± 14.1		
GW–Spring	●	39	–6.39	–6.07 ± 2.2	39	–37.3	–37.1 ± 4.5	32	31.3 ± 30.6		

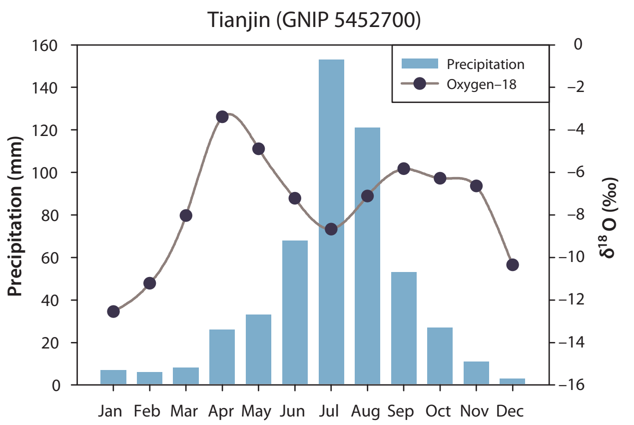


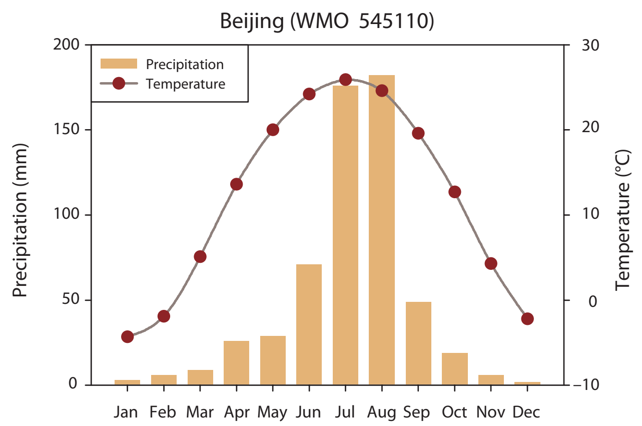


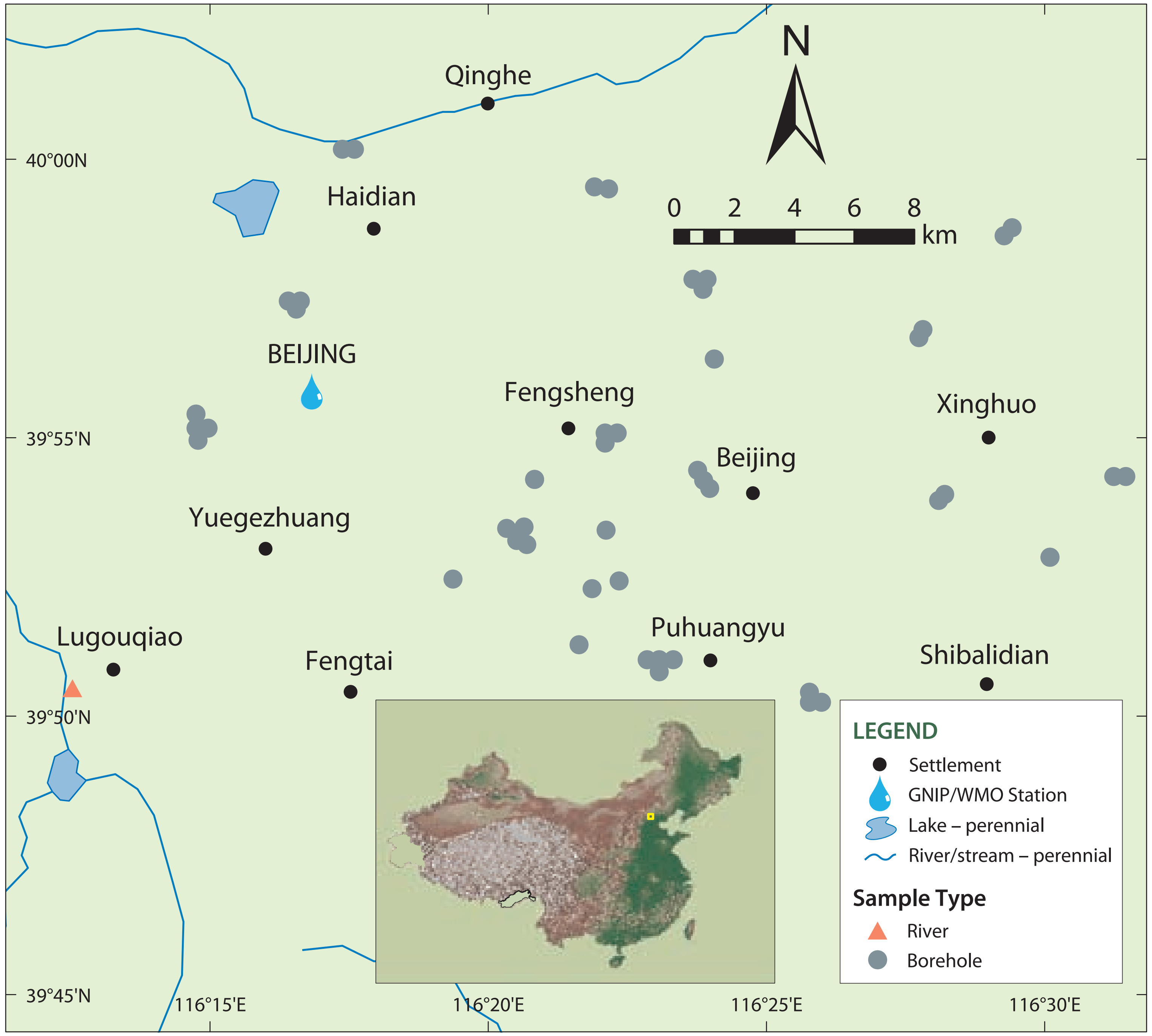
CPR–8199
Beijing urban aquifers







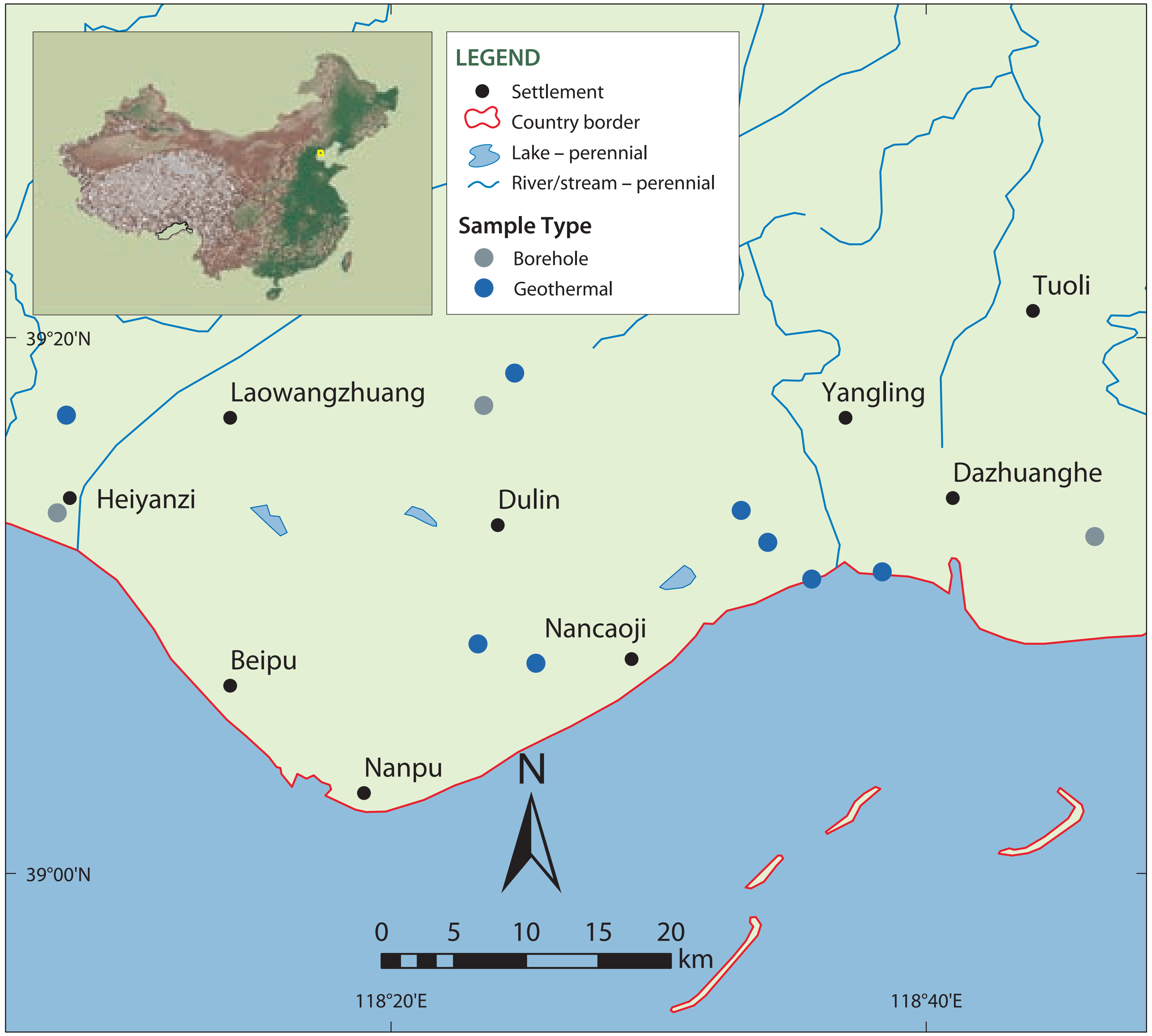




Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station TIANJIN	■ (red)	64	−6.86	−7.31 ± 0.4	64	−44.1	−47.7 ± 3.7			496
Interpolation – multiple reg.	■ (yellow)			−7.80			−54.0			
Interpolation – kriging (IAEA)	■ (green)			−7.42			−50.5			
Project	■ (pink)							1		

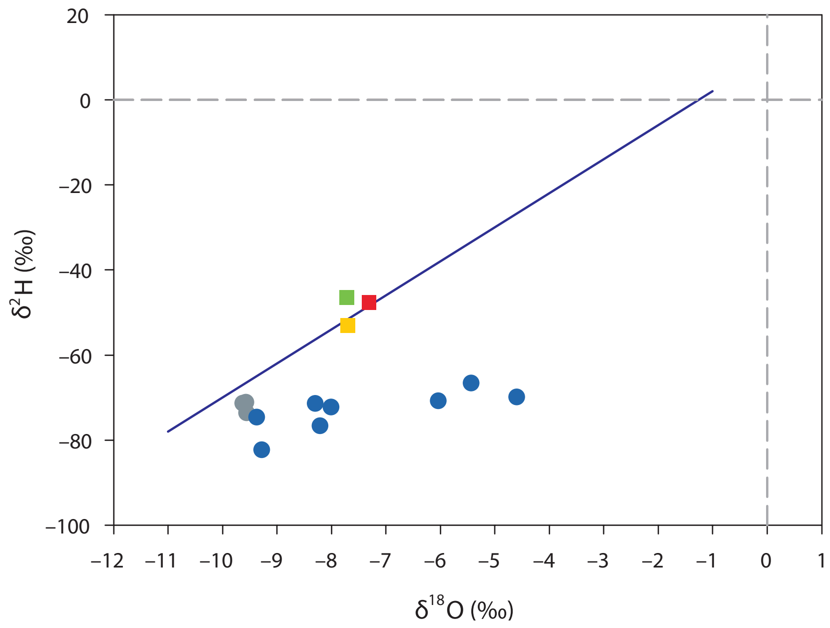
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)								
River	▲ (red-orange)							2	62.7 ± 52.8

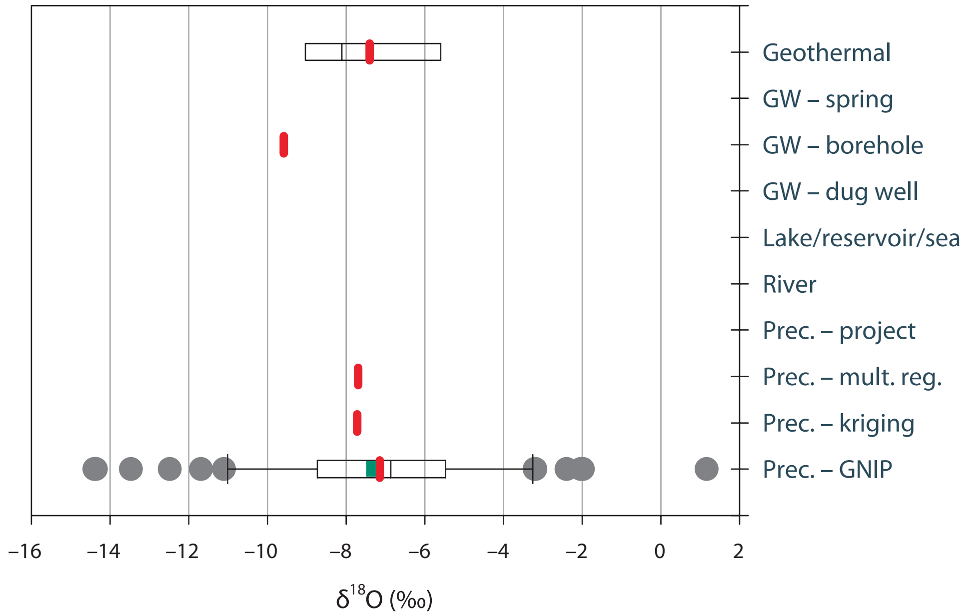
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	11	−8.48	−8.37 ± 0.6	14	−59.4	−59.1 ± 6.2	43	65.0 ± 57.9		
GW–Dug well	● (brown)										
GW–Spring	● (green)										



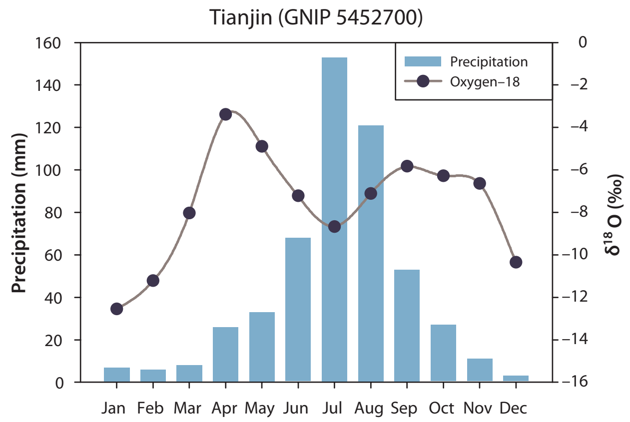
CPR–9180H

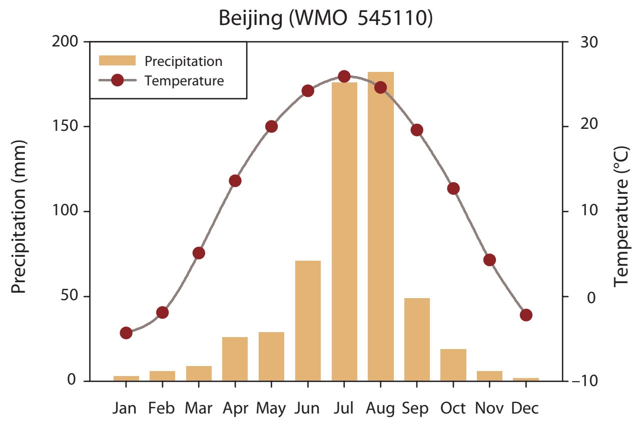
Hebei Plain geothermal area





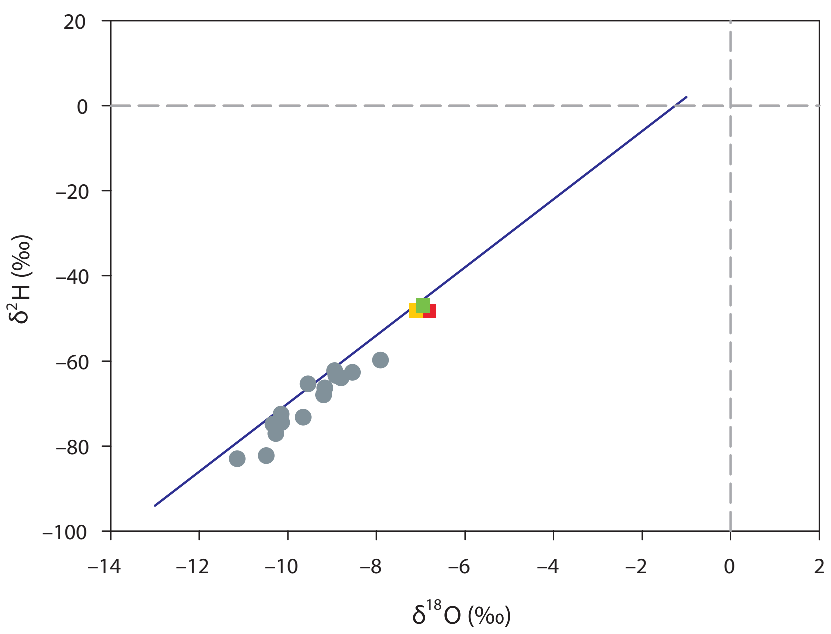
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station TIANJIN		61	−6.86	−7.31 ± 0.4	61	−44.3	−47.7 ± 3.7			496	
Interpolation – multiple reg.				−7.70			−53.0				
Interpolation – kriging (IAEA)				−7.72			−46.4				
Project											
Surface waters		δ¹⁸O			δ²H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea											
River											
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		8	−8.11	−7.41 ± 1.8	8	−71.8	−73.0 ± 4.9				
GW–Borehole		3	−9.57	−9.59 ± 0.1	3	−71.3	−72.0 ± 1.4				
GW–Dug well											
GW–Spring											

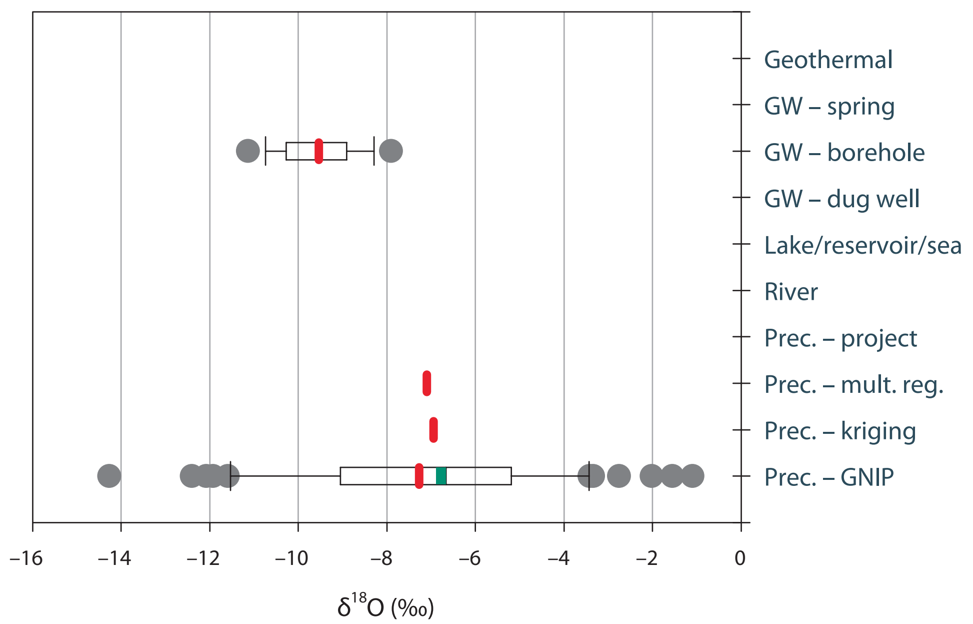


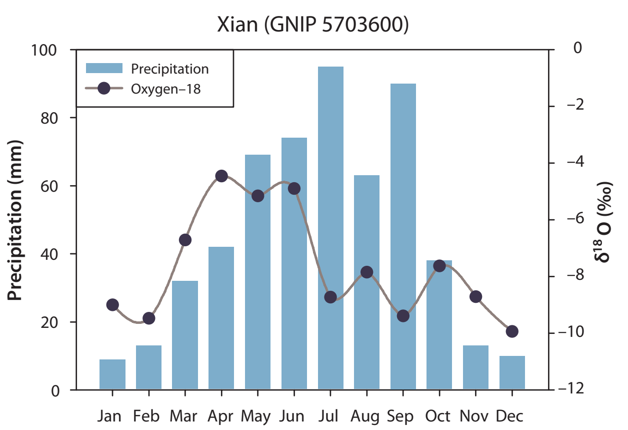


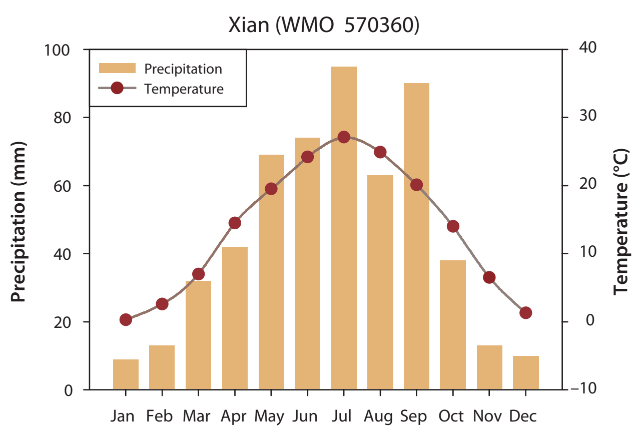
CPR–11730

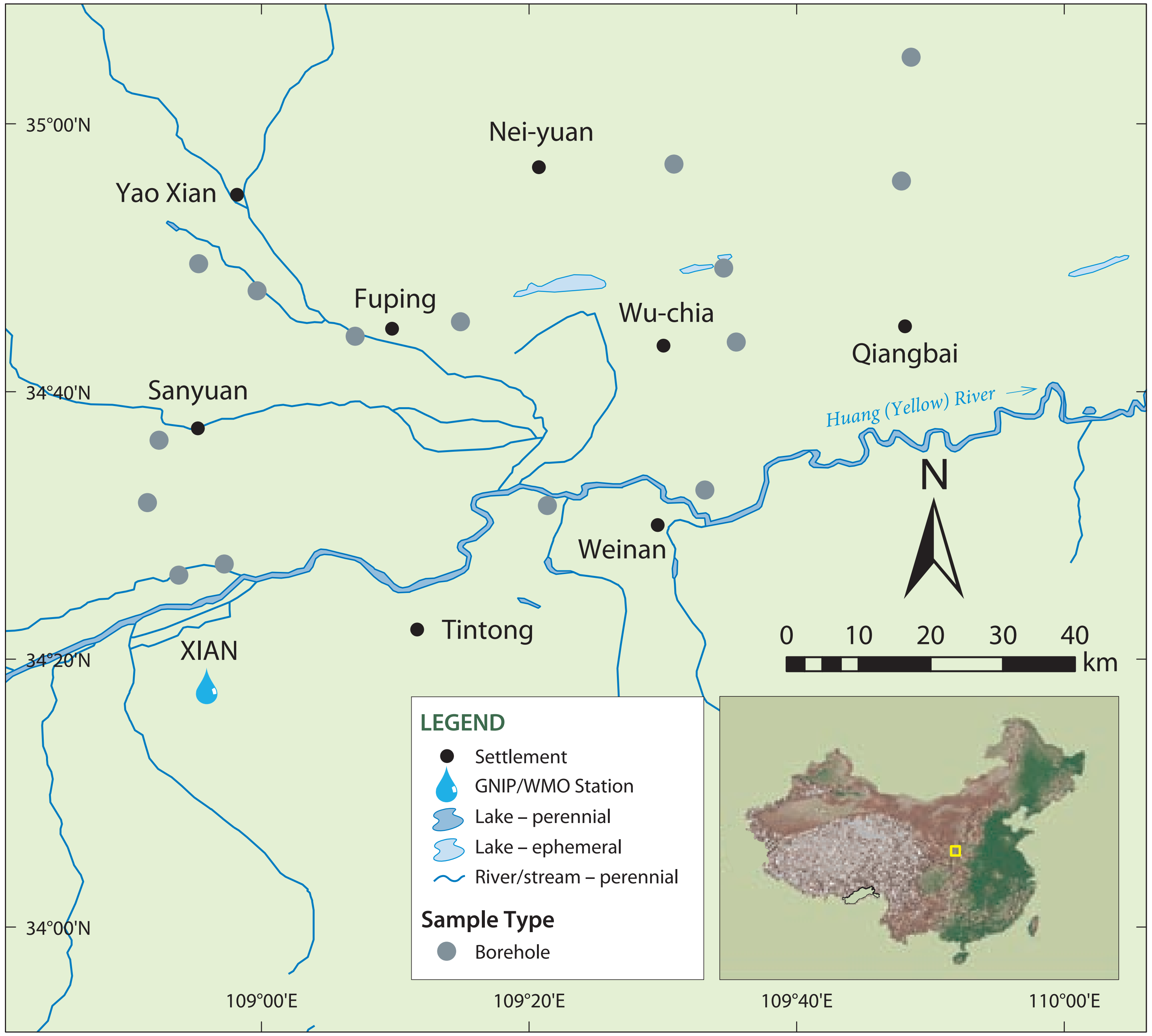
Guanzhong basin







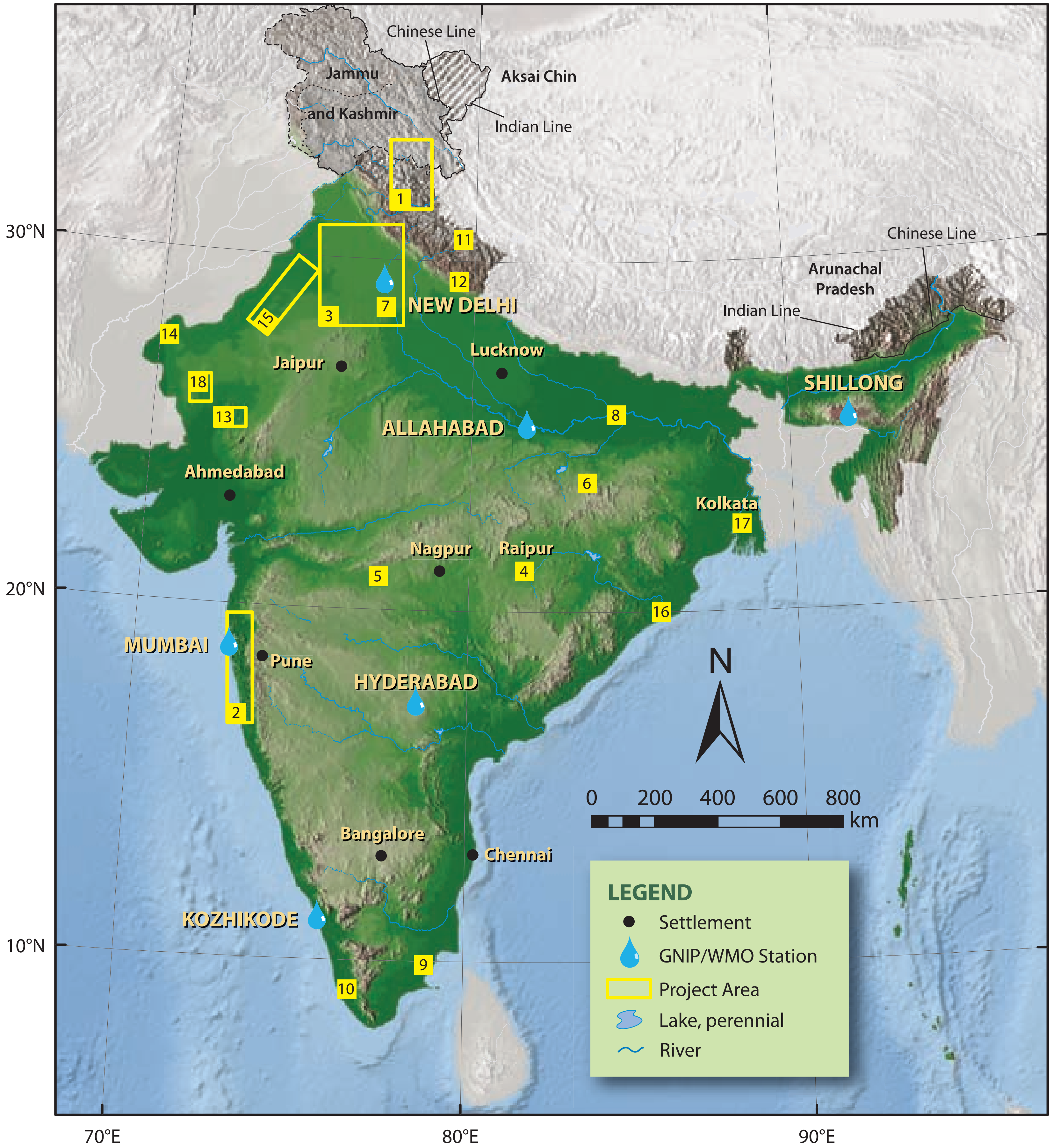




Precipitation	δ¹⁸O (‰) n	δ¹⁸O (‰) Median	δ¹⁸O (‰) Mean ± St. dev.	δ²H (‰) n	δ²H (‰) Median	δ²H (‰) Mean ± St. dev.	Tritium (TU) n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station XIAN	60	−6.67	−6.82 ± 1.7	60	−43.9	−48.3 ± 14.9			336
Interpolation – multiple reg.			−7.10			−48.0			
Interpolation – kriging (IAEA)			−6.95			−46.9			
Project									

Surface waters	δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea								
River								

Groundwaters	δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C (pMC) Mean ± St. dev.
Geothermal water										
GW–Borehole	15	−9.54	−9.54 ± 0.9	15	−68.0	−67.0 ± 7.4				
GW–Dug well										
GW–Spring										



1 **Project Code:** UNDP–IND–73–008H
Study area: Northwestern Himalayan springs
Sampling period: 1976–1977
Background: Isotope investigation under this project aimed at assessing the dynamics of the geothermal springs in the Himalayan valleys and studying their suitability for energy production.

2 **Project Code:** UNDP–IND–73–008W
Study area: West coast springs
Sampling period: 1976–1977
Background: Isotope investigation was carried out to study the dynamics of geothermal springs in the West coast region of Maharashtra State and to find out their suitability for energy production.

3 **Project Code:** UNDP/FAO–IND–81–010
Study area: Alluvial aquifers, Haryana State
Sampling period: 1983
Background: There is a serious constraint on exploitation of groundwater in Haryana State, which is over 60 % brackish and very saline in quality. Rising groundwater levels are threatening agricultural productivity of the area. The scope of this isotope study was to evaluate the dynamics of groundwater in order to explore mitigation options to prevent further water-logging as well as groundwater and soil salinization.

4 **Project Code:** RAS8084R–IND
Study area: Urban aquifers, Raipur city
Sampling period: 1998
Background: Karstic aquifers in Raipur city were investigated using isotope techniques to identify potential spots such as landfill sites which may cause groundwater contamination.

5 **Project Code:** RAS8084P–IND
Study area: Purna River basin
Sampling period: 1998
Background: About 40% of the river basin is underlain by brackish and saline groundwater. In this investigation isotope geochemical techniques were employed to study origin and mechanisms of groundwater salinization by employing a multidisciplinary approach including isotopic and geochemical techniques.

6 **Project Code:** RAS8092–IND
Study area: Tattapani geothermal area
Sampling period: 2002
Background: This isotope geochemical investigation was carried out to understand the origin of thermal and non-thermal waters, water-rock interactions, mixing of thermal water with cold water and to estimate subsurface reservoir temperatures.

The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations and the International Atomic Energy Agency. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

IAEA Water Resources Programme

INDIA

7 **Project Code:** RAS8097D–IND
Study area: Landfill areas, Delhi
Sampling period: 2003–2004
Background: This isotopic study was aimed at the identification of recharge sources and recharge zones near landfill sites as well as scale and geometry of spread of contaminants into groundwater.

8 **Project Code:** RAS8097B–IND
Study area: Alluvial aquifers, Ghazipur area
Sampling period: 2004–2006
Background: Recharge and dynamics of groundwaters in the alluvial aquifers were investigated using isotope and geochemical techniques for assessment of mobilization of arsenic under prevailing conditions.

9 **Project Code:** RAS8104T–IND
Study area: Tiruvadanai aquifers
Sampling period: 2002–2006
Background: Study of recharge and dynamics of groundwater in the Tiruvadanai coastal aquifers using environmental isotopes and hydrochemistry was undertaken in this project.

10 **Project Code:** RAS8104S–IND
Study area: Sasthamkotta Lake
Sampling period: 2001
Background: Situated in Kollam district, Sasthamkotta Lake is the largest freshwater lake in Kerala State. The lake is the major source of drinking water. It is seriously affected by anthropogenic activities resulting in accelerated reservoir sedimentation. In this investigation, isotope techniques were used for estimation of sedimentation rate and interaction of lake water with the groundwater in the vicinity.

11 **Project Code:** IND–6234
Study area: Tapoban and Badrinath geothermal areas
Sampling period: 1990
Background: This isotope geochemical investigation was carried out in the Himalayan ranges of Uttarakhand State to understand the origin of thermal and non-thermal springs, water-rock interactions, mixing of thermal water with cold water and to estimate subsurface reservoir temperatures.

12 **Project Code:** IND–7746
Study area: Lake Naini area, Nainital
Sampling period: 1994–1995
Background: Modelling of lake water dynamics and lake water–groundwater interactions in the vicinity of Lake Naini was undertaken in this isotope study.

13 **Project Code:** IND–7904B & IND–10802B
Study area: Bhadka–Bheemda area, Barmer
Sampling period: 1987, 1996–2000
Background: Deep groundwater in the area is extensively exploited for the municipal drinking water supply and agriculture. Lowering of groundwater levels and consequent deterioration of water quality has been reported at many locations in the area in the recent years. In order to evaluate sustainability of these aquifers, an environmental isotope study was carried out.

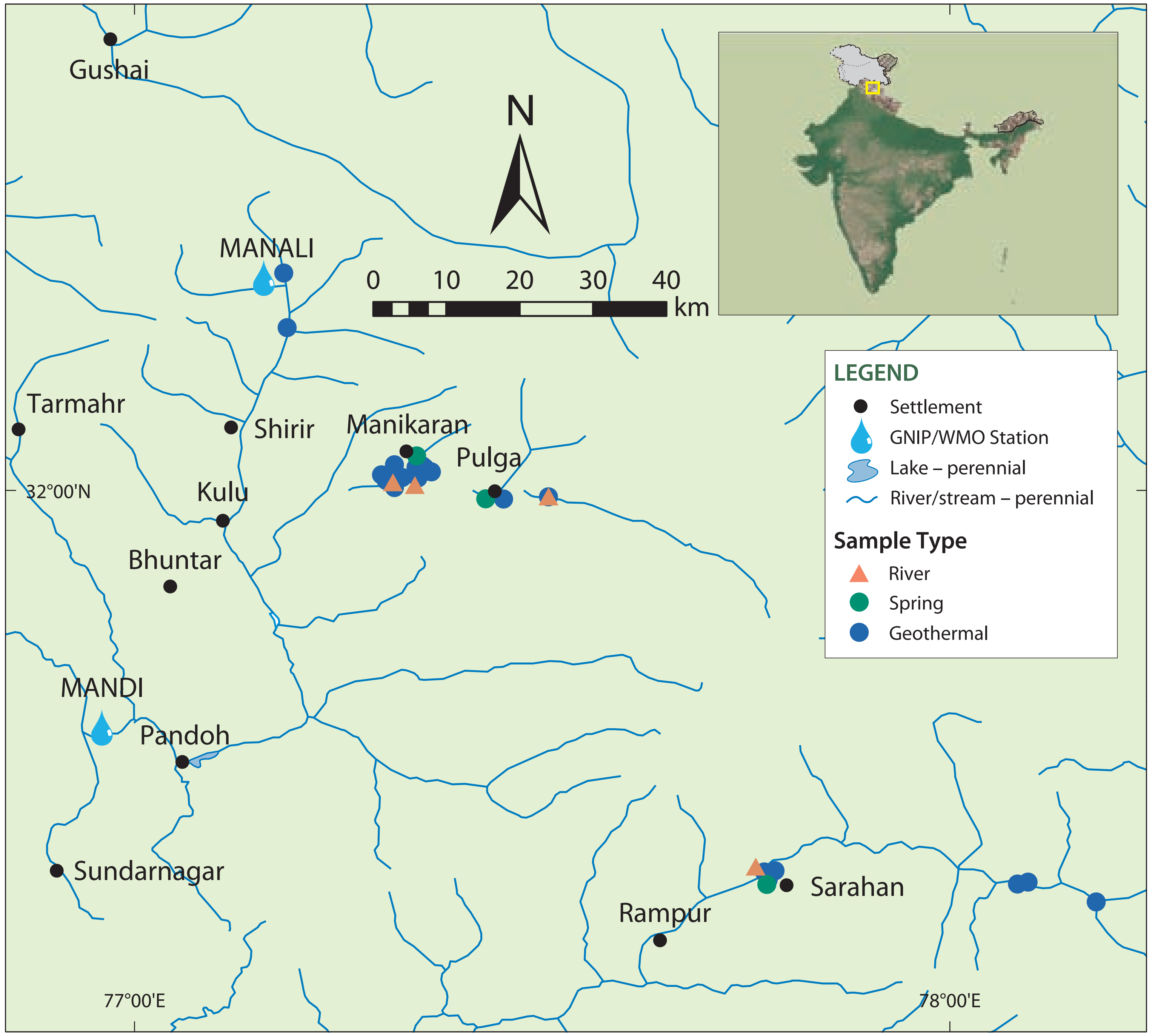
14 **Project Code:** IND–7904J
Study area: Kishangarh–Ghotaru area, Jaisalmer
Sampling period: 1987
Background: In the heart of the Thar Desert, fresh groundwater was found in the old alluvial channels buried under the desert sands. Sustainability and recharge conditions of groundwater were evaluated using isotope techniques in this aquifer located in Jaisalmer district.

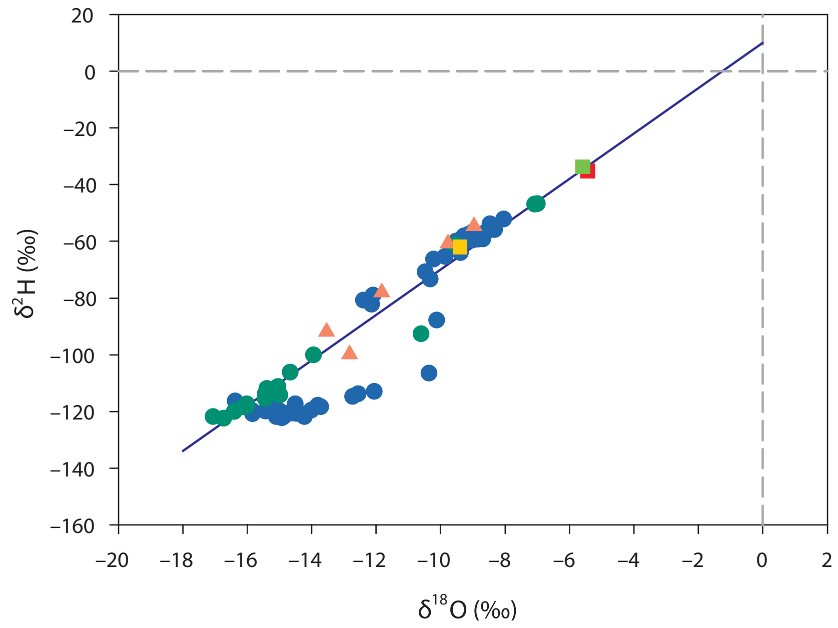
15 **Project Code:** IND–7904I
Study area: Indira Gandhi Canal Scheme, Rajasthan
Sampling period: 1987
Background: Contribution of canal waters and irrigation return flows as well as related groundwater problems in the canal command area of this large irrigation project were studied in this isotope study.

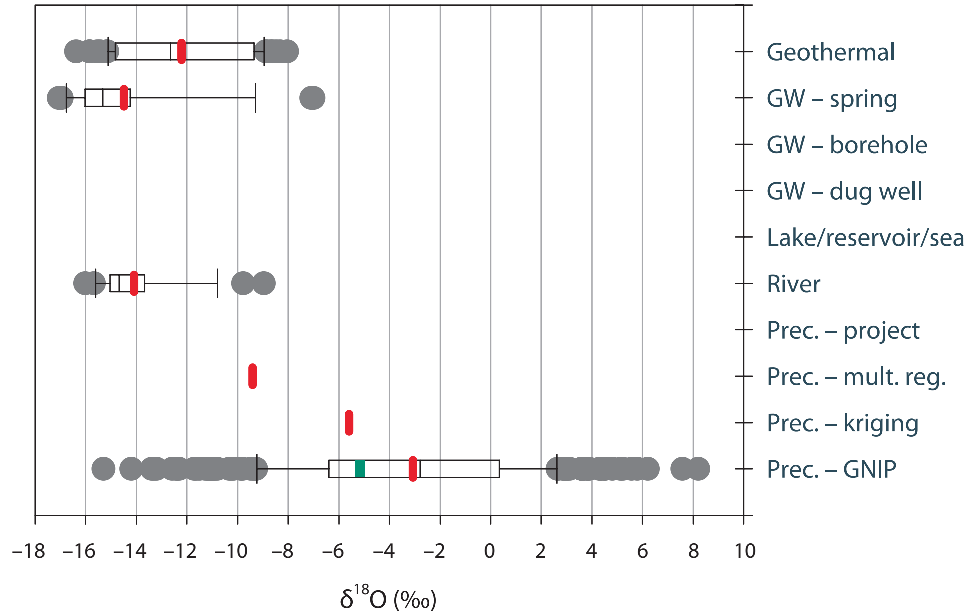
16 **Project Code:** IND–8398
Study area: Delang–Puri Sector, Orissa
Sampling period: 1995
Background: As part of a drinking water supply project, thousands of wells were drilled in the coastal areas of Orissa State. Many of them quickly became unacceptable because of deterioration in water quality. This isotope geochemical investigation was launched which aimed at determining the origin of salinity and at evaluating groundwater recharge conditions.

17 **Project Code:** IND–10283
Study area: Alluvial aquifers, Kolkata city
Sampling period: 1998–2000
Background: Kolkata city in West Bengal State is one of the biggest cities in the world. Difficulties are being faced in supplying safe drinking water due to expansion of urban complexes, industrial development and population growth. To keep demand–supply in balance, groundwater has been exploited extensively. This study was undertaken to understand the impact of overexploitation of groundwater on arsenic contamination of the alluvial aquifers.

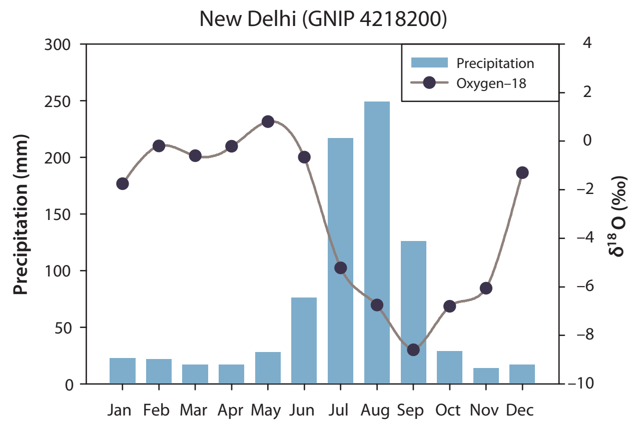
18 **Project Code:** IND–10802J
Study area: Arid zone aquifers, Jalore area
Sampling period: 1983–2000
Background: Groundwater sustainability and recharge conditions of the aquifers in this arid region were studied by applying environmental isotope techniques.

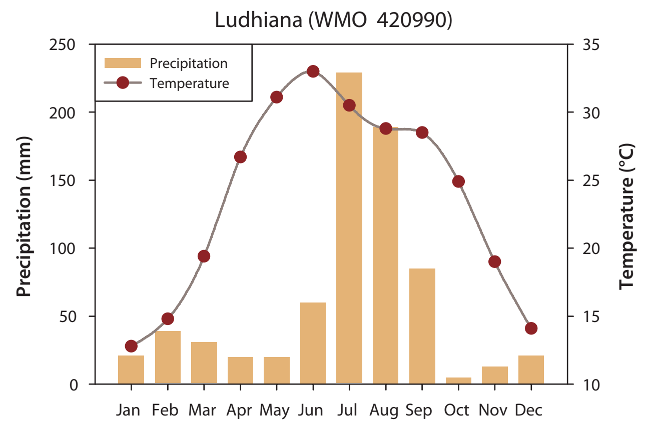






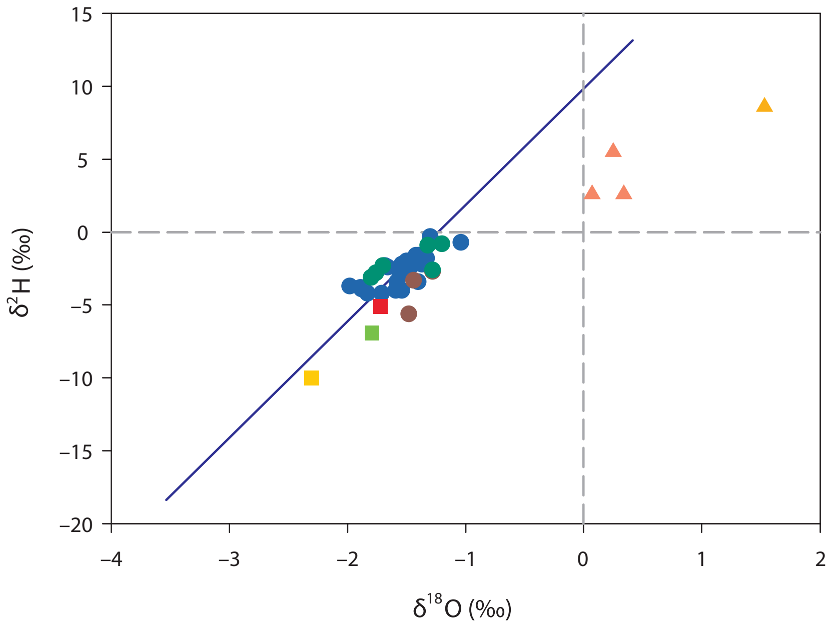
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station NEW DELHI		324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3				764
Interpolation – multiple reg.				−9.40			−62.0				
Interpolation – kriging (IAEA)				−5.59			−33.6				
Project											
Surface waters		δ18O			δ2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea											
River		24	−14.67	−14.09 ± 1.7	5	−78.0	−77.0 ± 19.4				
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		76	−12.65	−12.22 ± 2.7	60	−72.0	−86.0 ± 28.6	6	0.4 ± 0.4		
GW–Borehole											
GW–Dug well											
GW–Spring		28	−15.32	−14.49 ± 2.7	17	−113.8	−102.2 ± 25.5	8	30.6 ± 42.1		

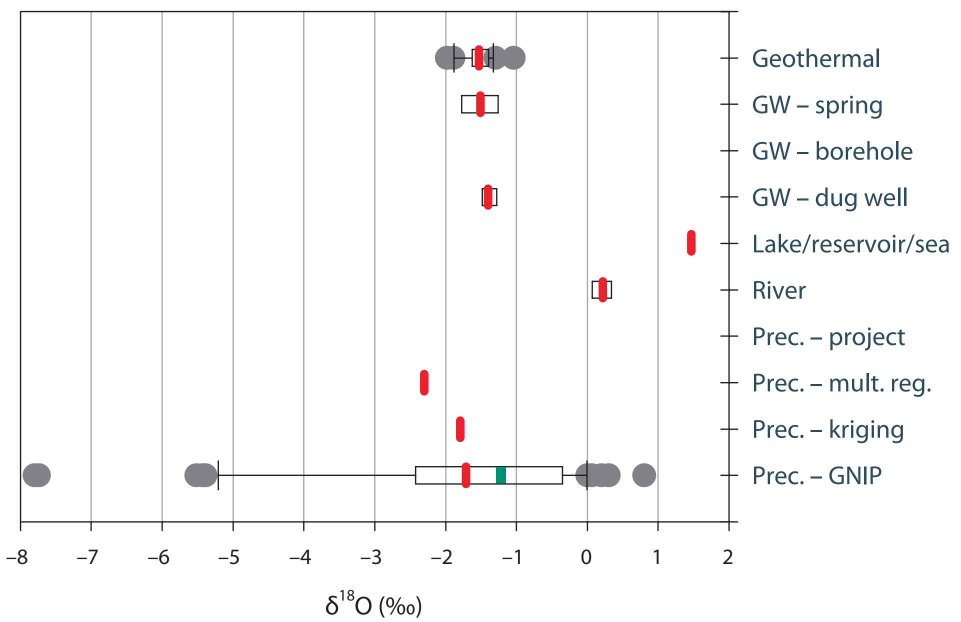


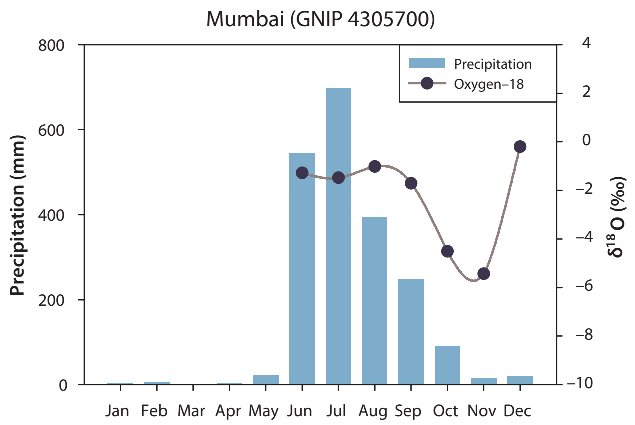


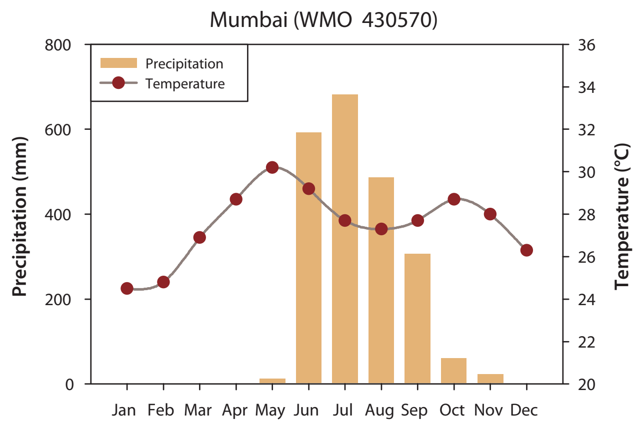
UNDP-IND-73-008W

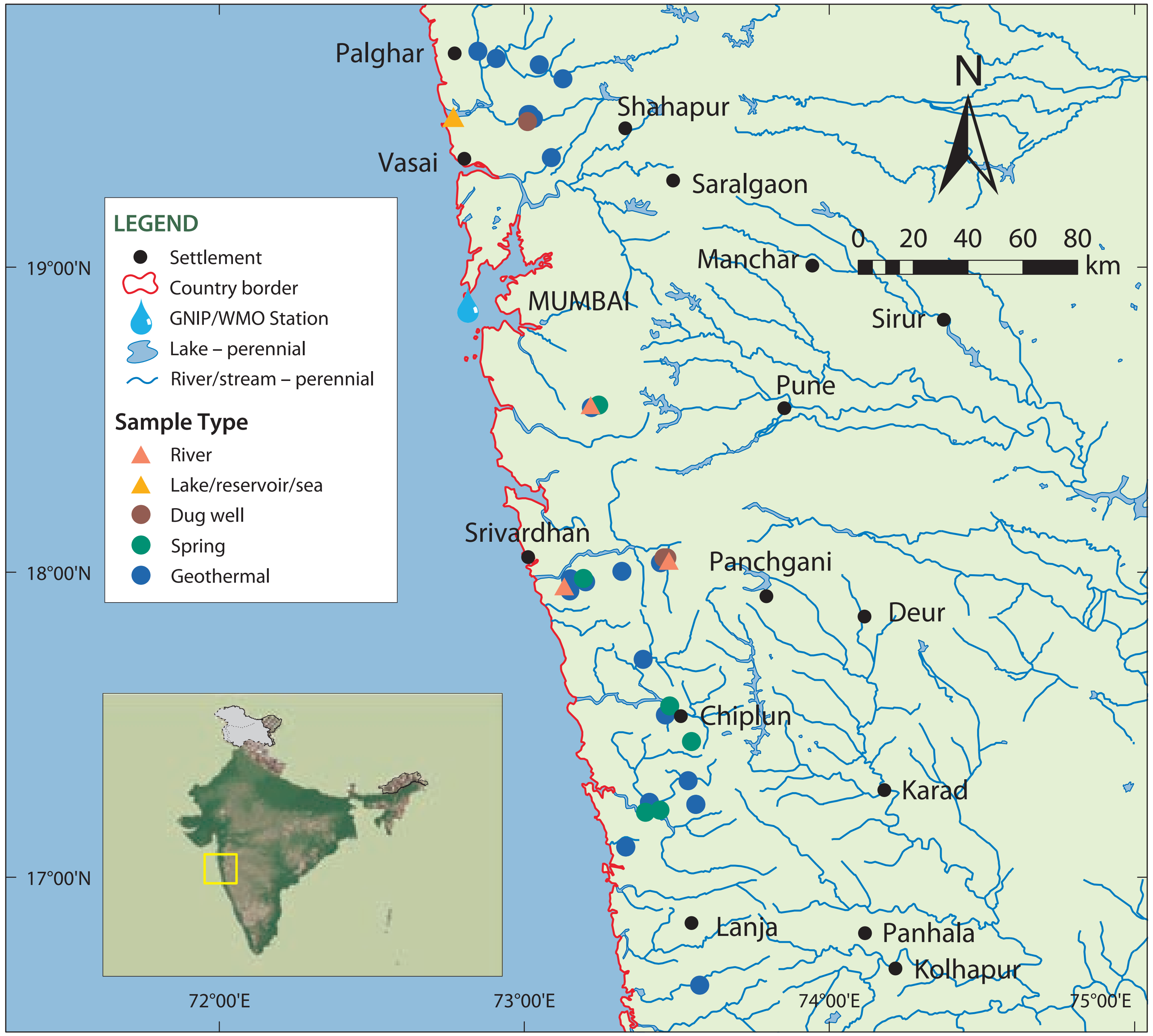
West coast springs











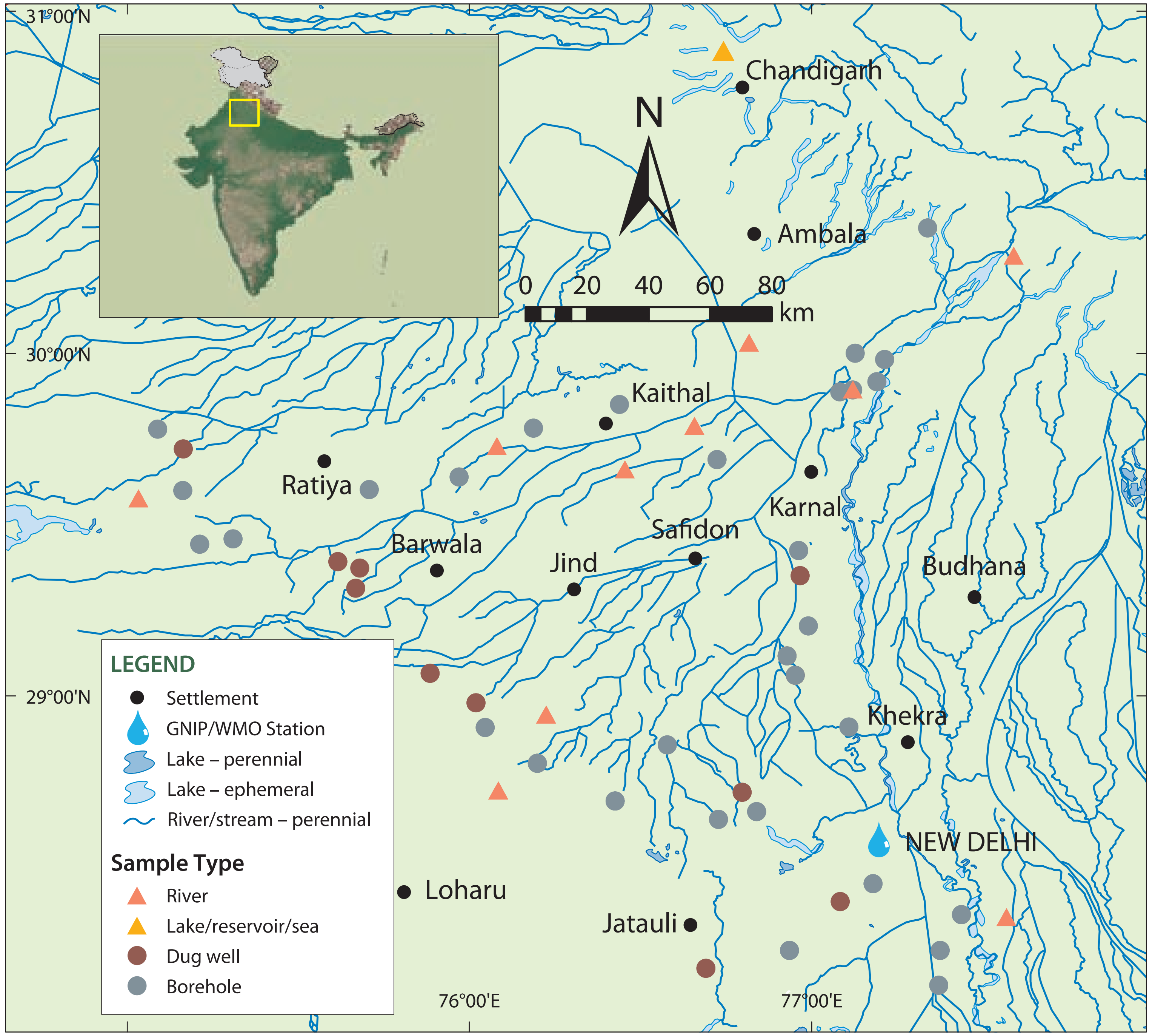
Precipitation		δ¹⁸O (‰) n	δ¹⁸O (‰) Median	δ¹⁸O (‰) Mean ± St. dev.	δ²H (‰) n	δ²H (‰) Median	δ²H (‰) Mean ± St. dev.	Tritium (TU) n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station MUMBAI		50	−1.20	−1.73 ± 0.8	48	−2.2	−5.1 ± 6.9			1984
Interpolation – multiple reg.				−2.30			−10.0			
Interpolation – kriging (IAEA)				−1.79			−6.9			
Project										

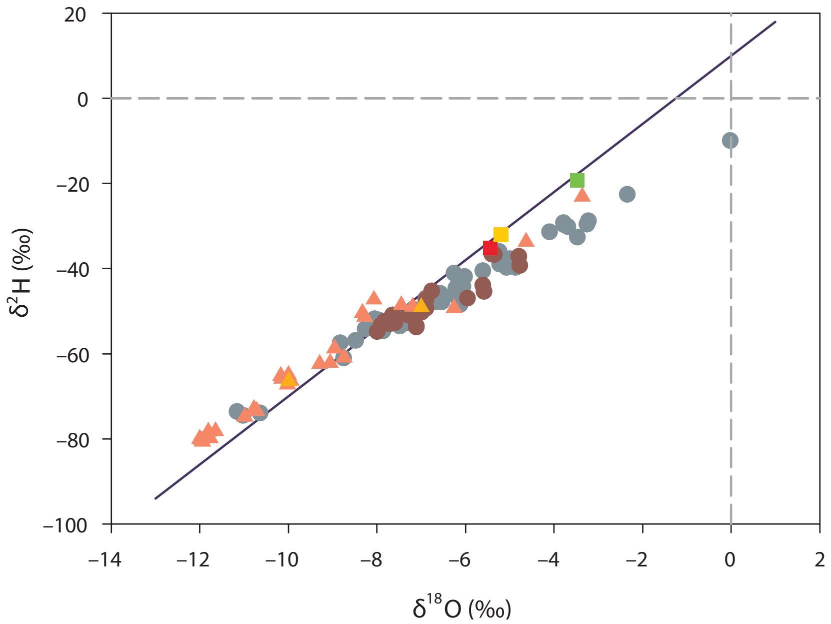
Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea		1		1.53	1		8.6		
River		3	0.25	0.22 ± 0.1	3	2.6	3.6 ± 1.7		

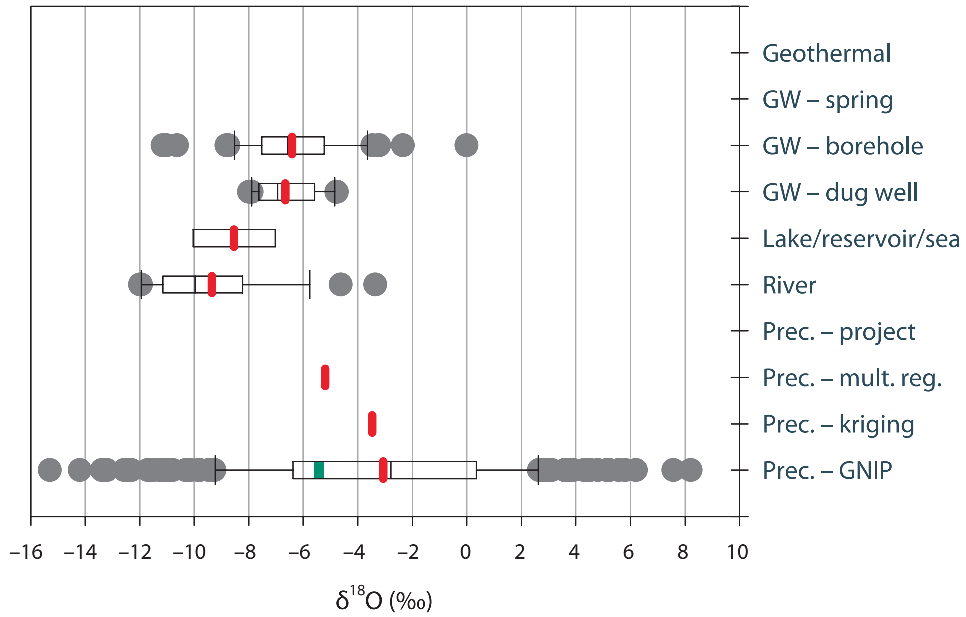
Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C (pMC) Mean ± St. dev.
Geothermal water		29	−1.54	−1.53 ± 0.2	29	−2.3	−2.6 ± 1.0				
GW–Borehole											
GW–Dug well		3	−1.44	−1.4 ± 0.1	3	−3.3	−3.9 ± 1.5				
GW–Spring		6	−1.51	−1.51 ± 0.3	6	−2.4	−2.1 ± 1.0				

UNDP/FAO–IND–81–010

Alluvial aquifers, Haryana State



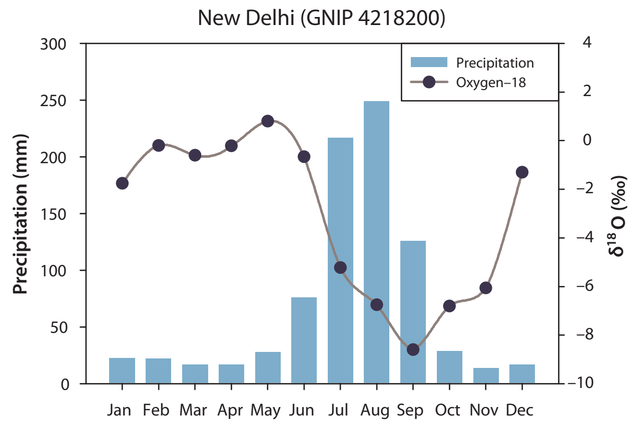


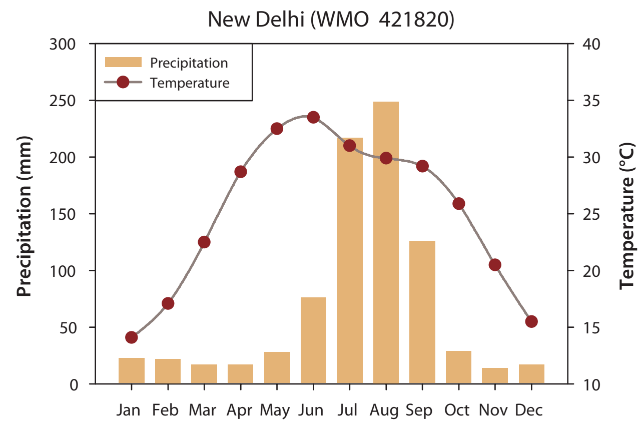


Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station NEW DELHI	■	324	–2.79	–5.44 ± 1.7	291	–12.2	–35.1 ± 13.3			764	
Interpolation – multiple reg.	■			–5.20			–32.0				
Interpolation – kriging (IAEA)	■			–3.47			–19.3				
Project	■										

Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲	2	–8.54	–8.54 ± 2.1	2	–57.7	–57.7 ± 12.2	2	22.9 ± 25.4
River	▲	26	–9.97	–9.36 ± 2.2	26	–65.1	–62.5 ± 15.0	21	28.4 ± 9.9

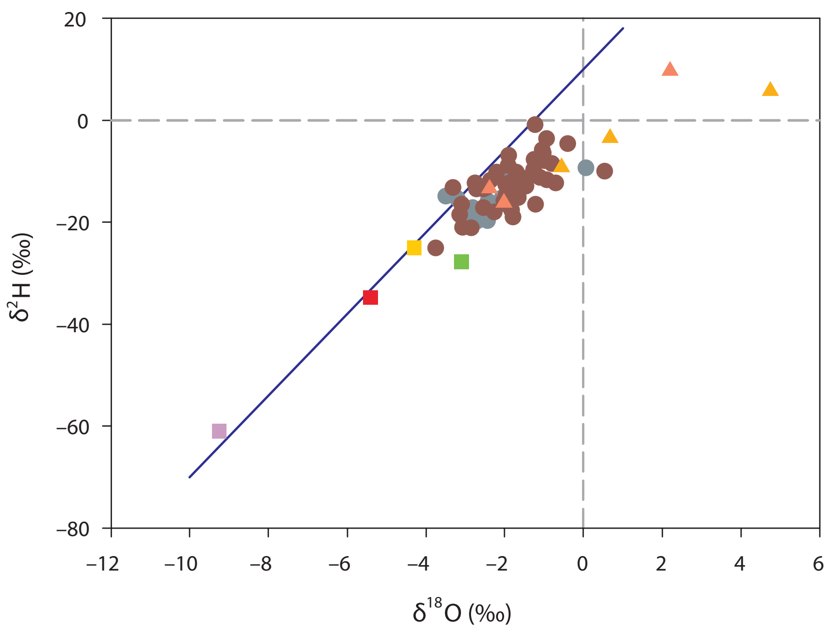
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	57	–6.57	–6.41 ± 2.0	56	–47.4	–46.1 ± 11.8	56	16.5 ± 17.6	4	35 ± 12
GW–Dug well	●	20	–6.94	–6.66 ± 1.1	20	–49.8	–47.7 ± 6.1	19	22.6 ± 25.7		
GW–Spring	●										

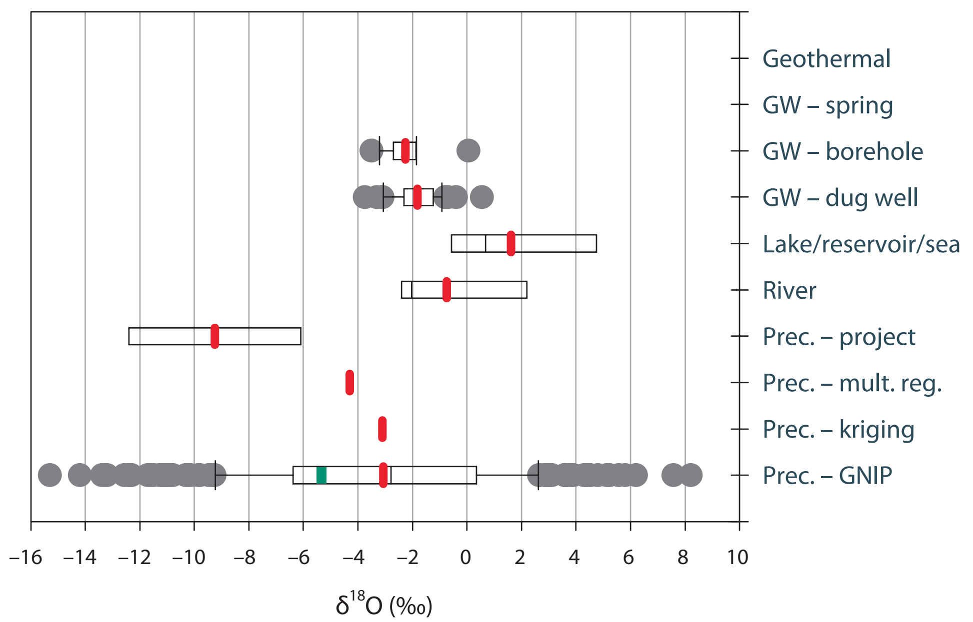


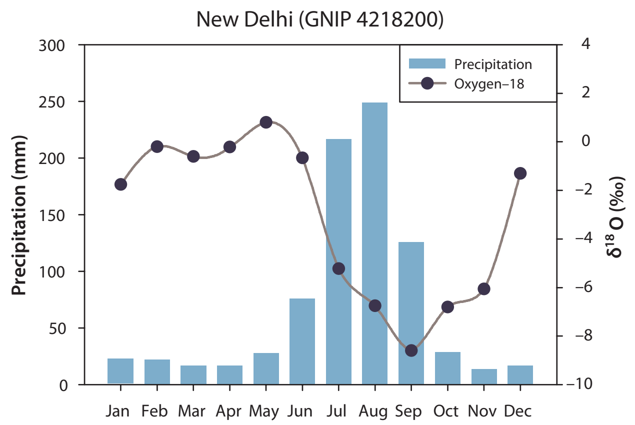


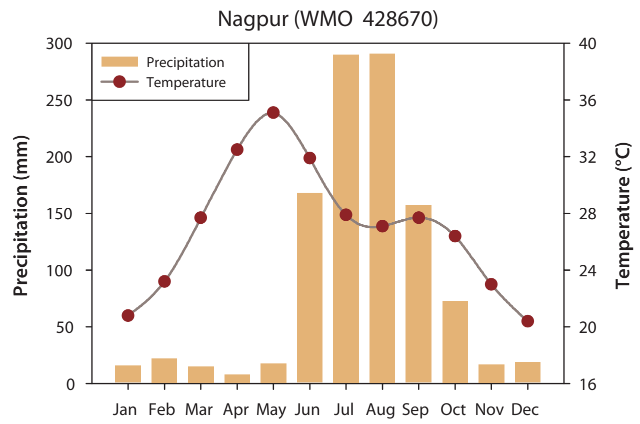
RAS8084R-IND

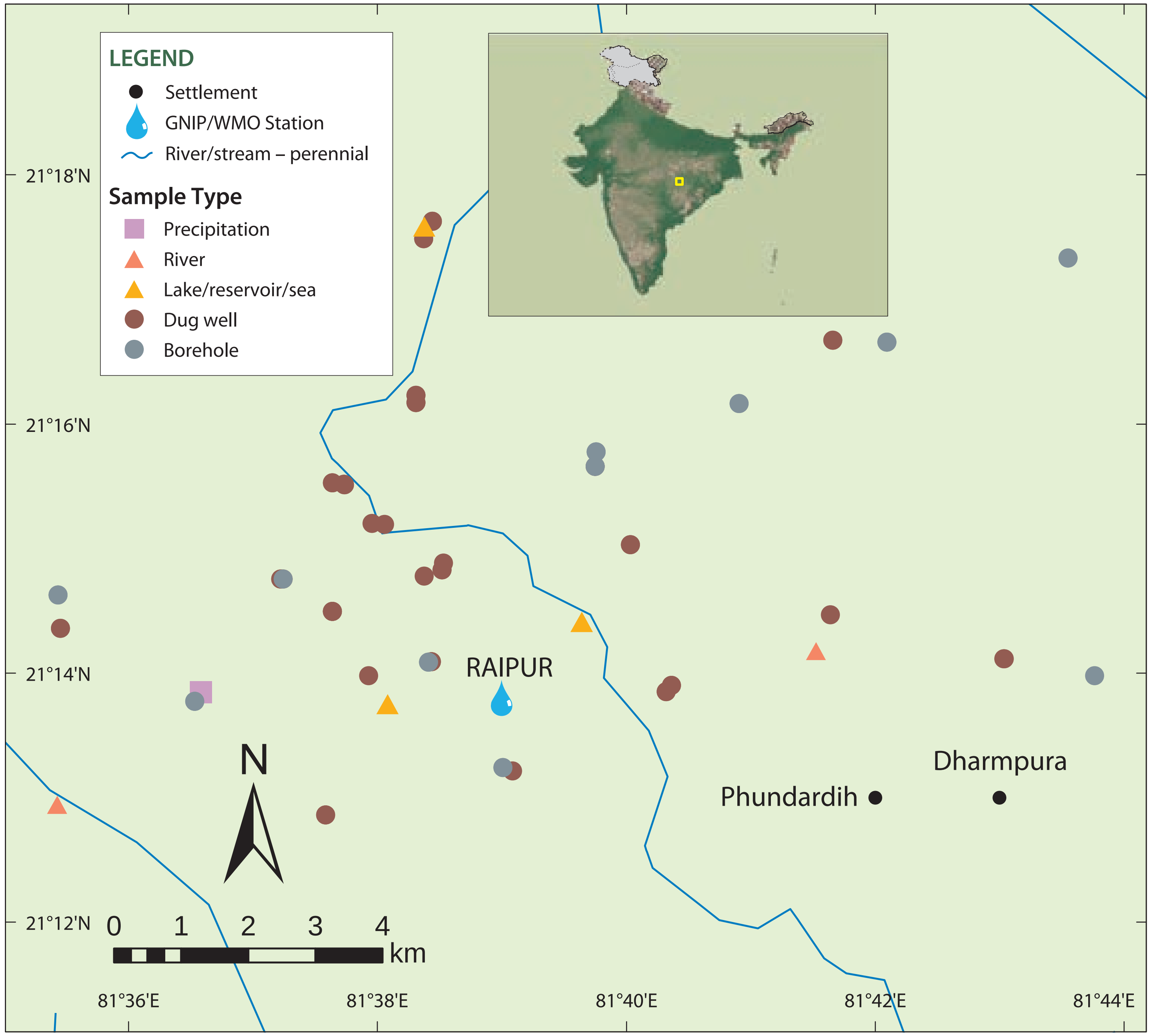
Urban aquifers, Raipur city









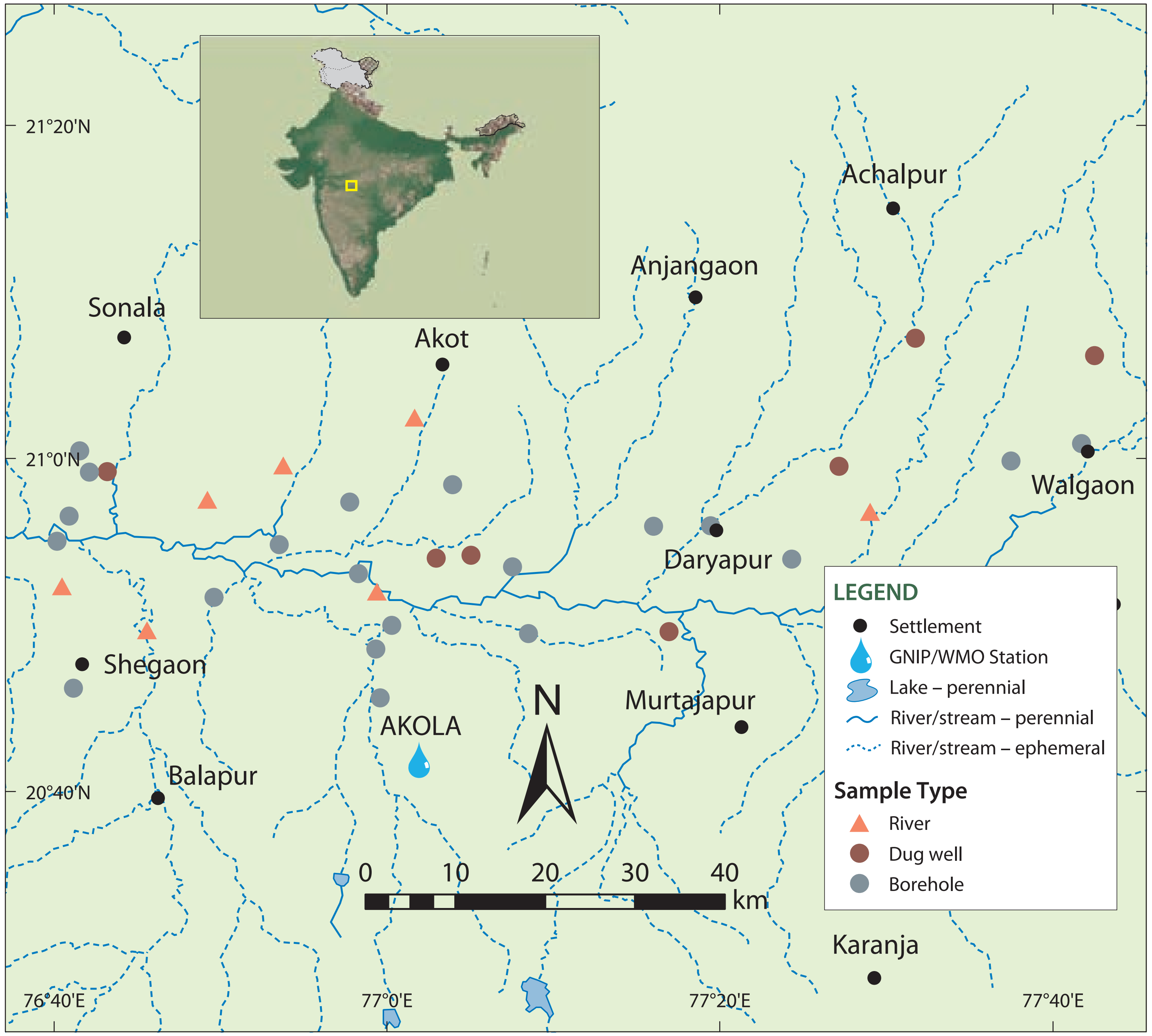


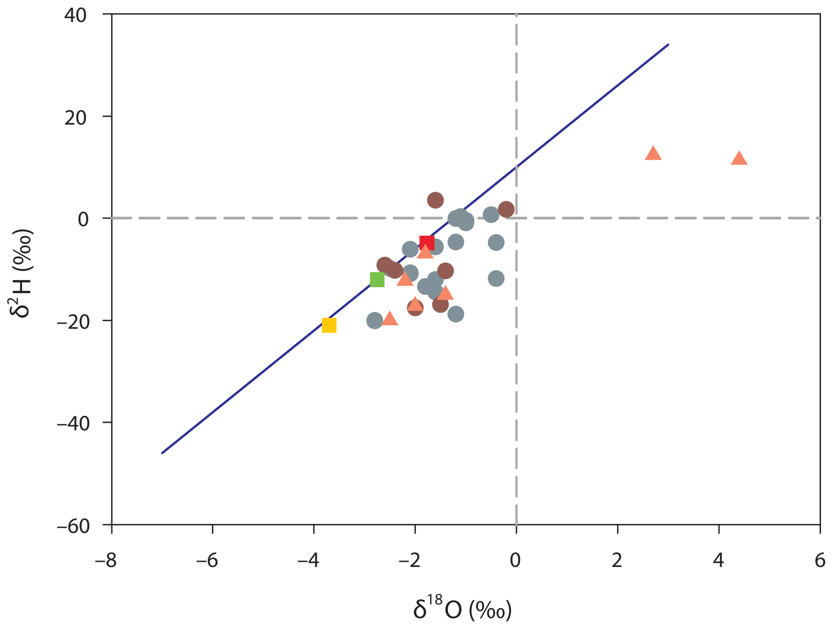
Precipitation	δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.			−4.30			−25.0			
Interpolation – kriging (IAEA)			−3.10			−27.7			
Project	2	−9.25	−9.25 ± 4.5	2	−61.0	−61.0 ± 43.1			

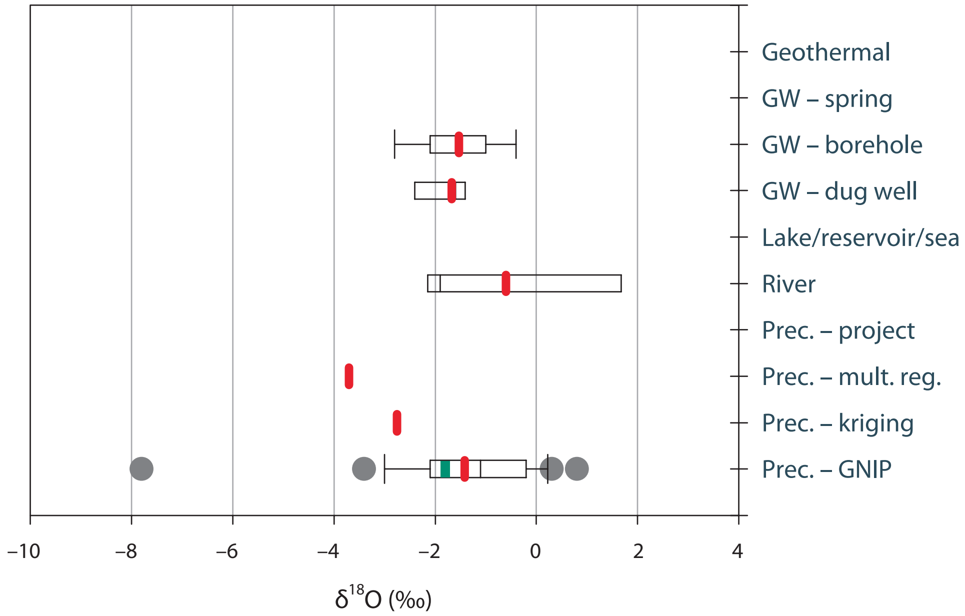
Surface waters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	3	0.68	1.62 ± 2.8	3	−3.5	−2.3 ± 7.5	3	10.1 ± 0.5
River	3	−2.02	−0.74 ± 2.6	3	−13.4	−6.6 ± 14.2	3	7.8 ± 0.7

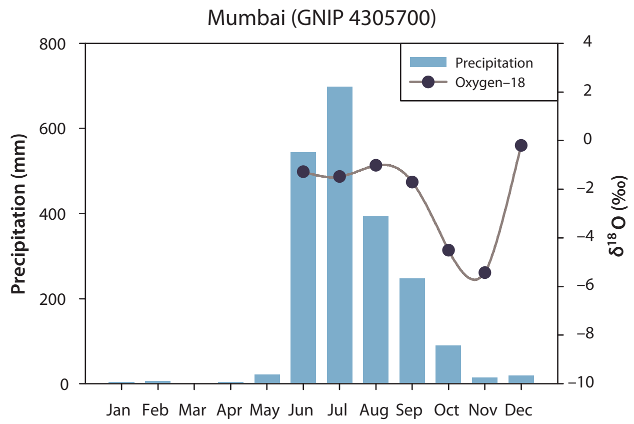
Groundwaters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	19	−2.16	−2.26 ± 0.8	19	−15.4	−16.1 ± 3.9	20	5.4 ± 2.2		
GW–Dug well	49	−1.79	−1.81 ± 0.8	48	−13.0	−12.8 ± 4.7	47	6.9 ± 2.2		
GW–Spring										

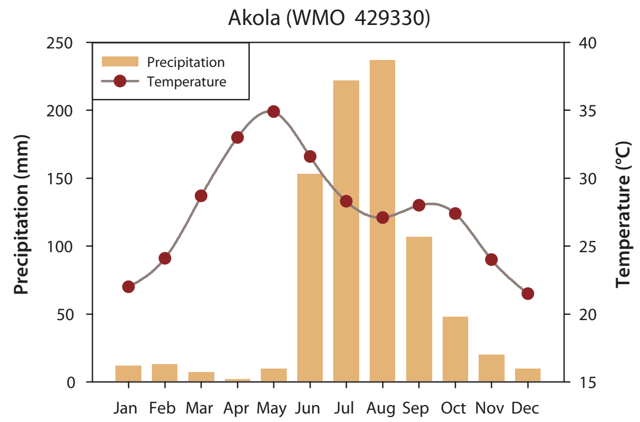
RAS8084P-IND
Purna River basin











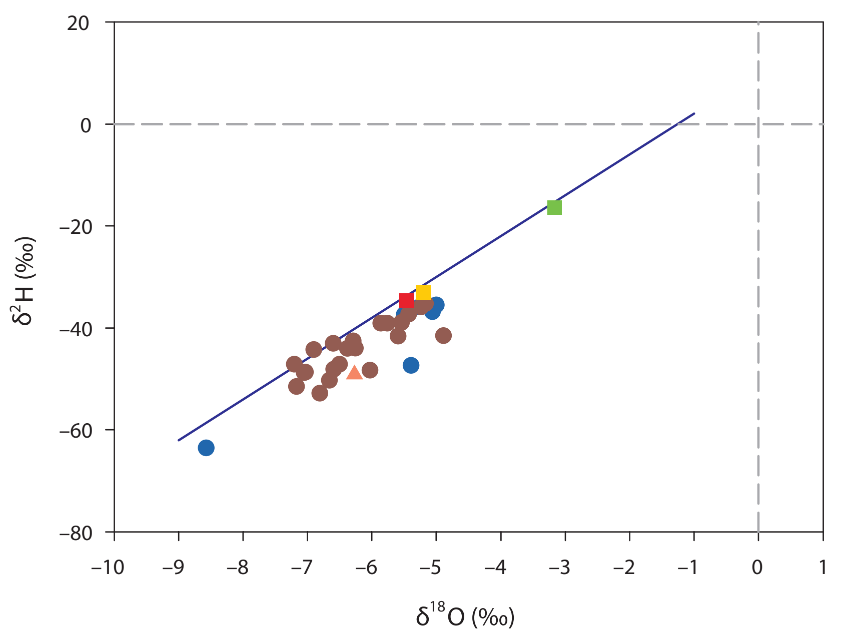
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station MUMBAI	■ (red)	50	−1.20	−1.73 ± 0.8	48	−2.2	−5.1 ± 6.9			1984
Interpolation – multiple reg.	■ (yellow)			−3.70			−21.0			
Interpolation – kriging (IAEA)	■ (green)			−2.75			−12.1			
Project	■ (pink)									

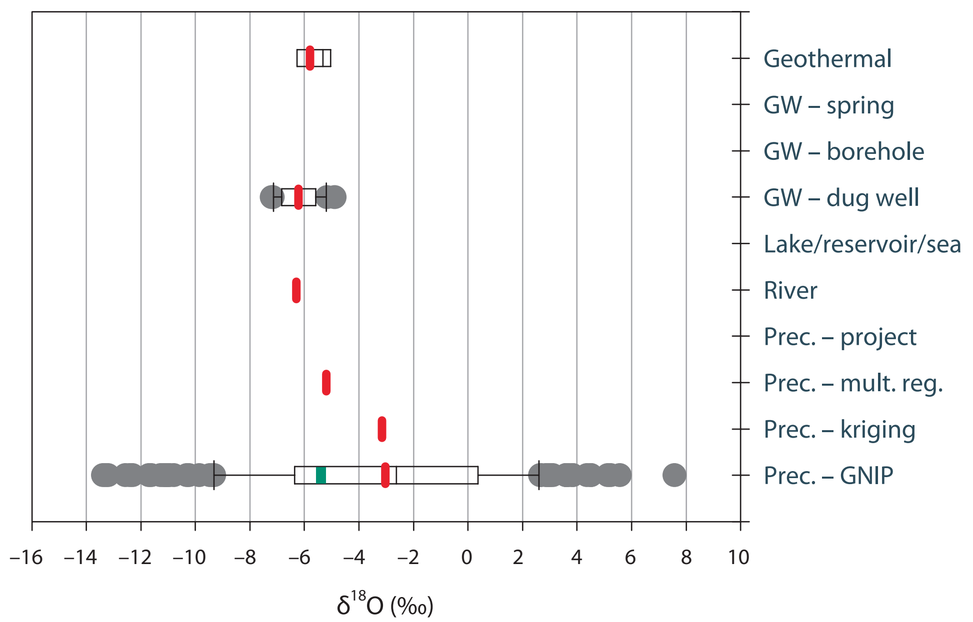
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)								
River	▲ (red)	8	−1.90	−0.6 ± 2.6	7	−12.3	−6.8 ± 13.4	7	4.1 ± 2.7

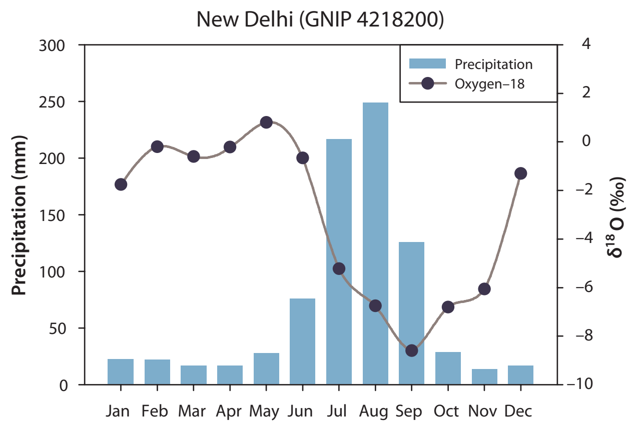
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	19	−1.60	−1.53 ± 0.7	19	−9.9	−8.6 ± 6.9	17	1.1 ± 1.4		
GW–Dug well	● (brown)	7	−1.60	−1.67 ± 0.8	7	−10.2	−8.4 ± 8.2	2	2.5 ± 3.4		
GW–Spring	● (green)										

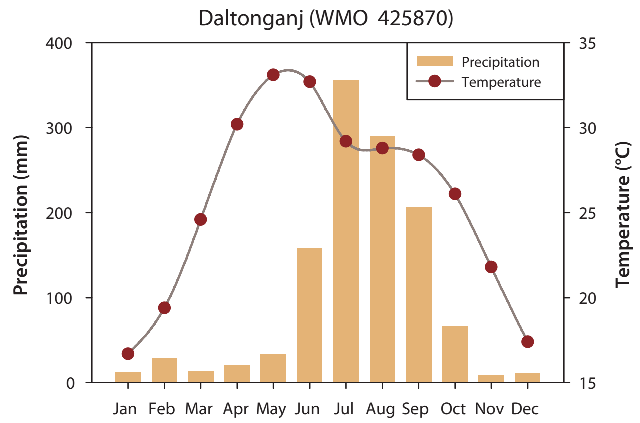
RAS8092–IND

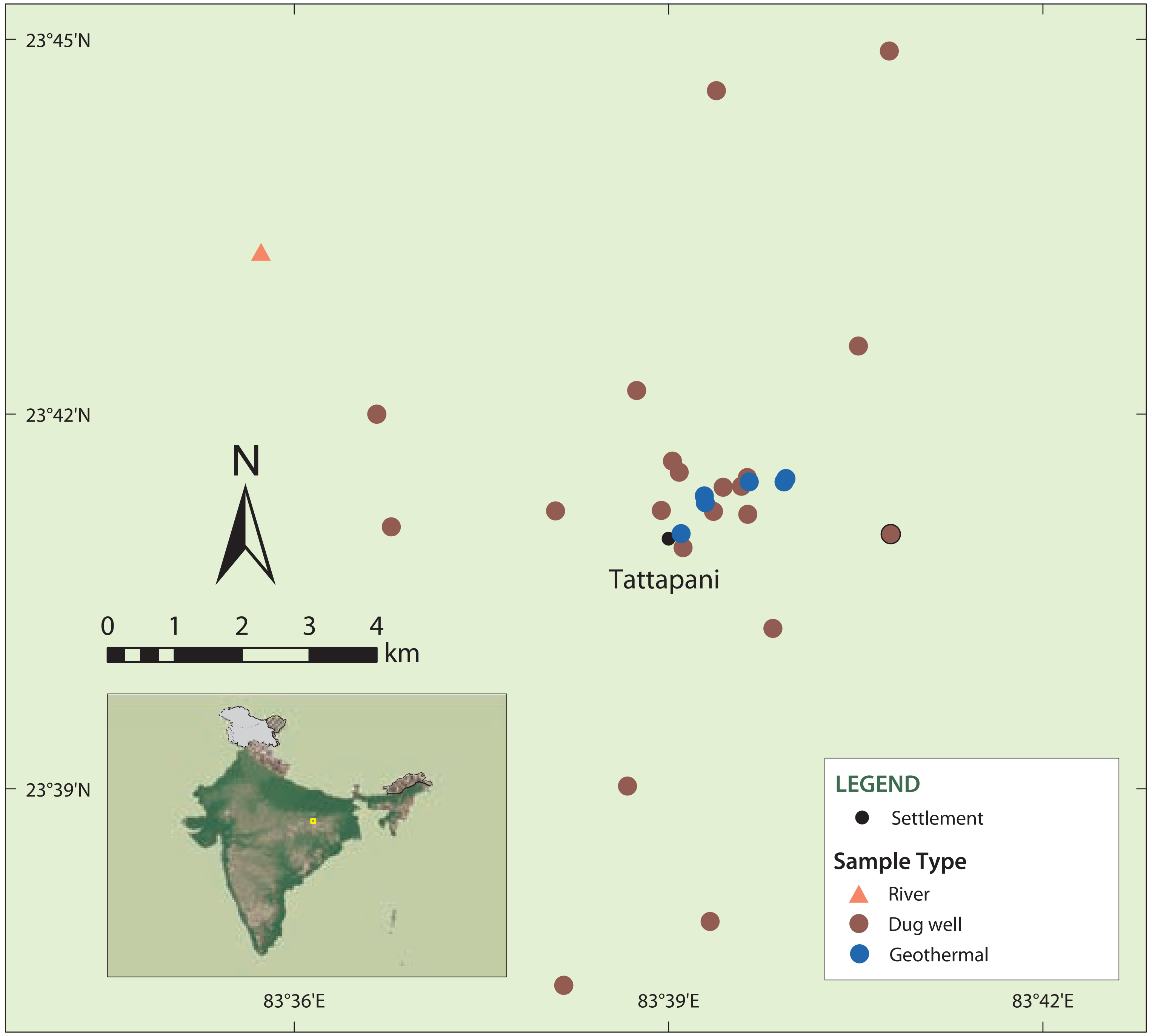
Tattapani geothermal area







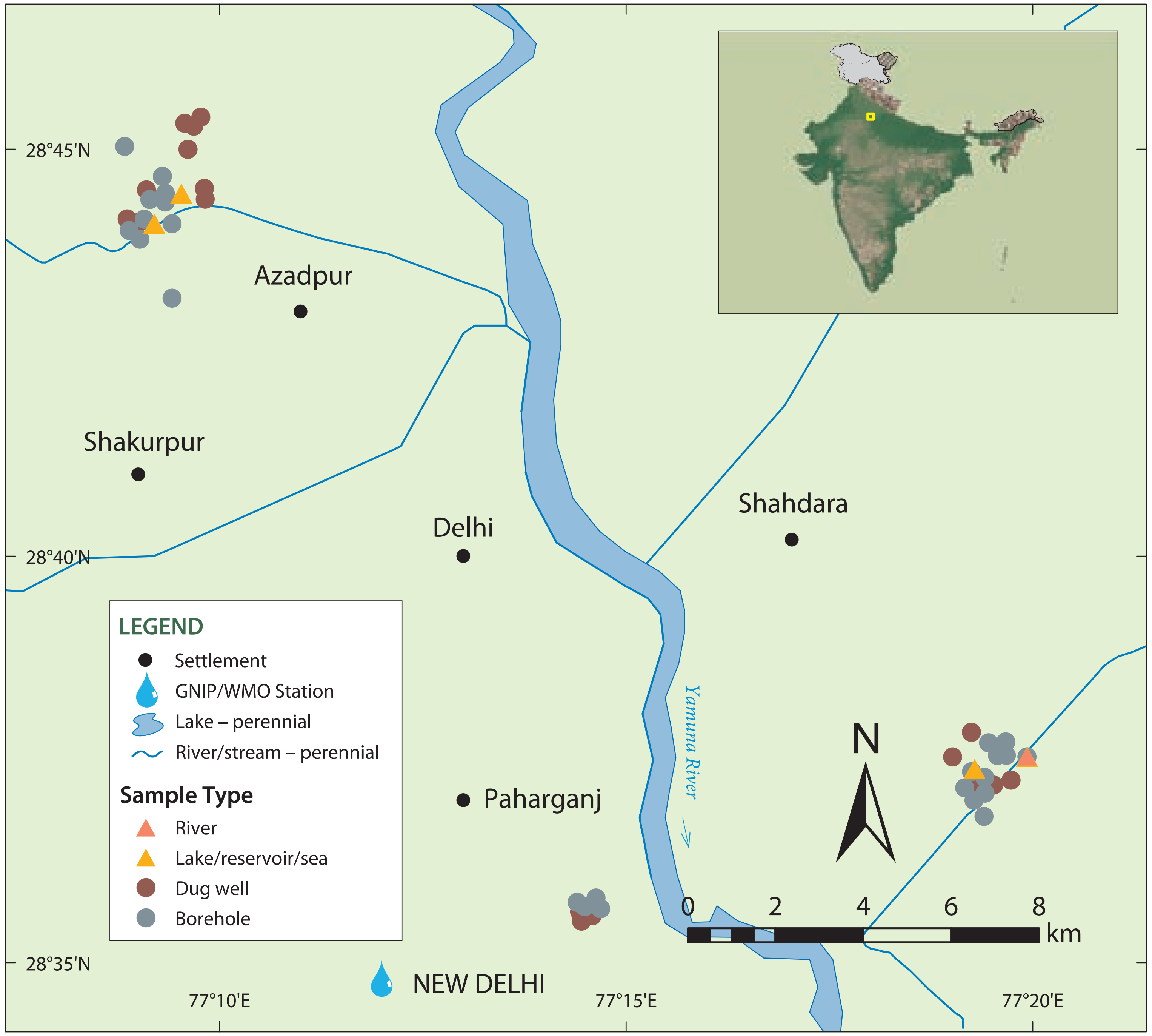


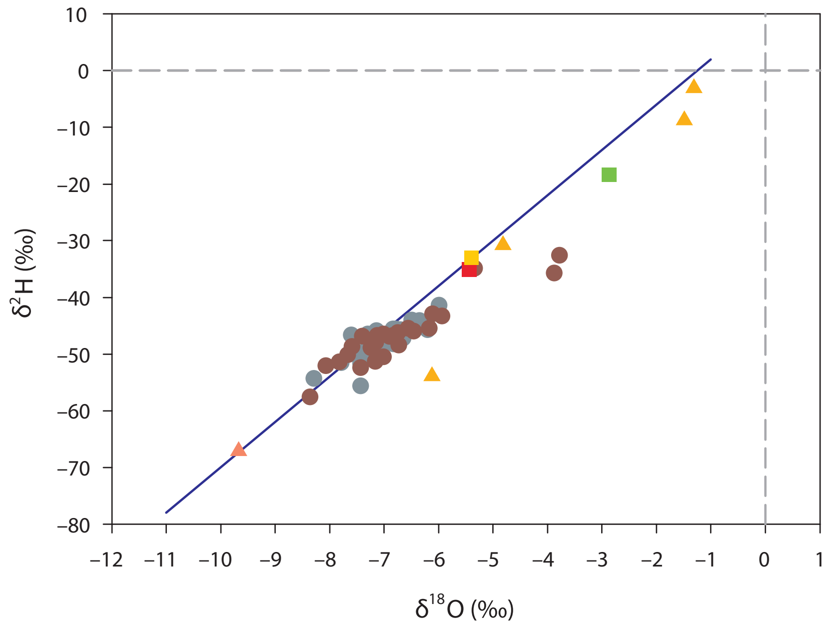


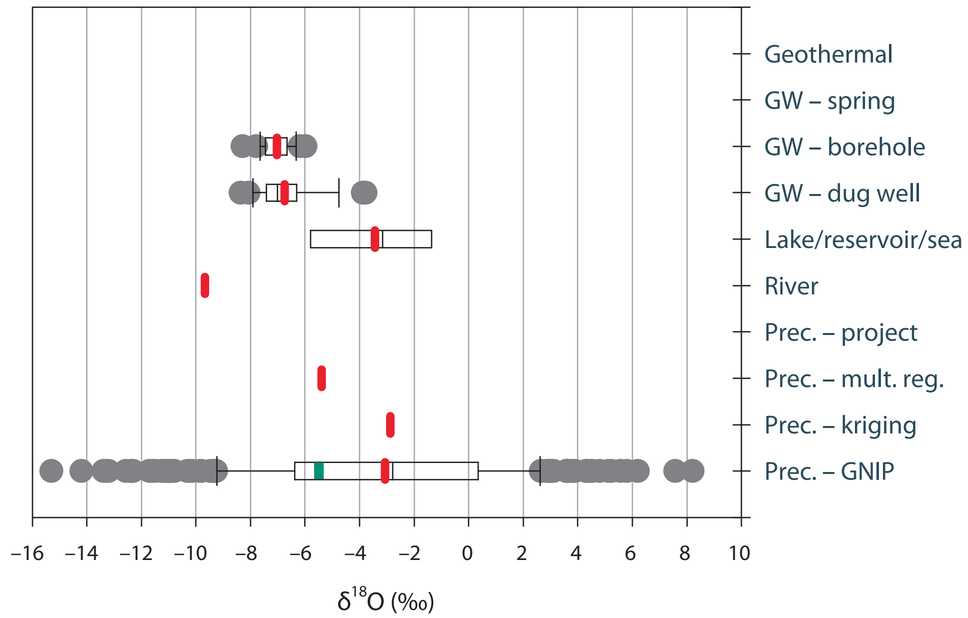
Precipitation	δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.			−5.20			−33.0			
Interpolation – kriging (IAEA)			−3.16			−16.4			
Project									

Surface waters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea								
River	1		−6.27	1		−49.1	1	

Groundwaters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	6	−5.33	−5.80 ± 1.4	6	−37.1	−42.7 ± 11.1	5	1.0 ± 0.7		
GW–Borehole										
GW–Dug well	22	−6.34	−6.23 ± 0.7	23	−44.0	−44.3 ± 5.2	18	5.7 ± 2.3		
GW–Spring										



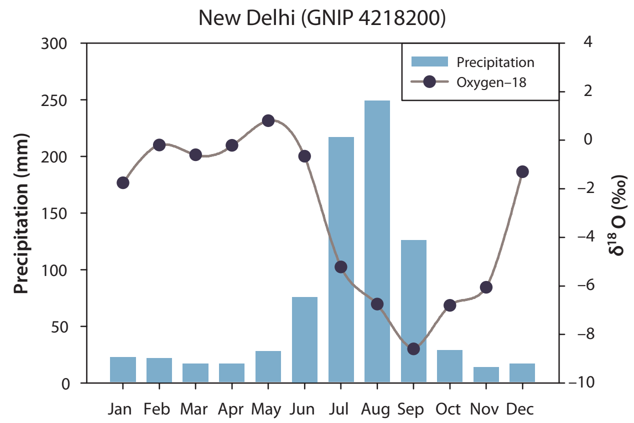


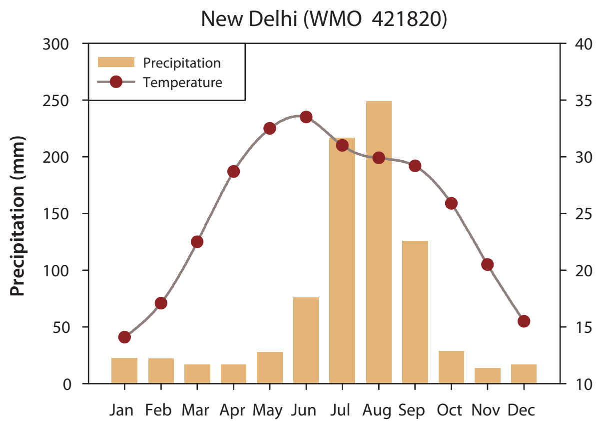


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station NEW DELHI		324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.				−5.40			−33.0			
Interpolation – kriging (IAEA)				−2.87			−18.3			
Project										

Surface waters		δ¹⁸O			δ²H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea		4	−3.16	−3.44 ± 2.4	4	−19.8	−24.1 ± 23.2	3	133.7 ± 36.1	
River		1		−9.67	1		−67.1	1	14.4	

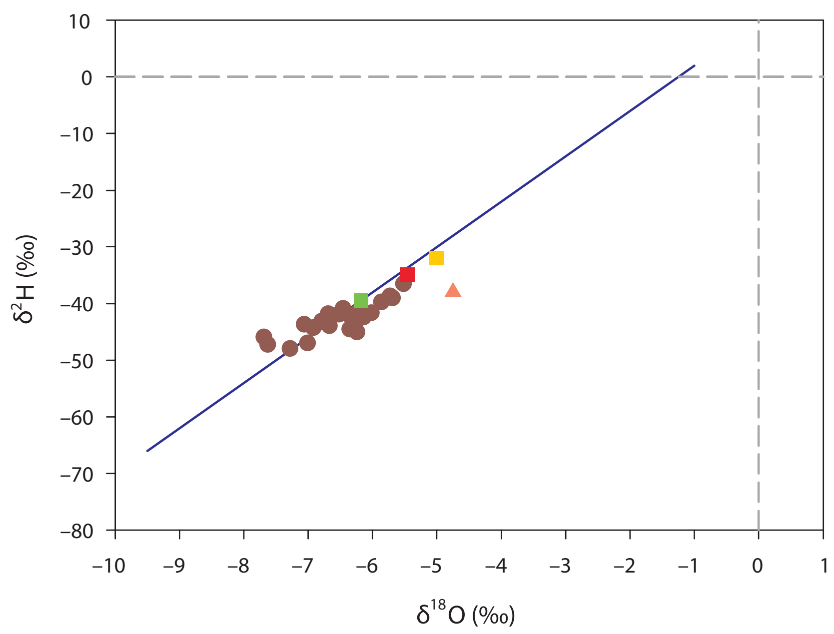
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water											
GW–Borehole		28	−6.96	−7.04 ± 0.5	28	−47.1	−47.7 ± 3.2	28	8.3 ± 6.0		
GW–Dug well		25	−7.01	−6.74 ± 1.1	25	−46.9	−46.6 ± 5.6	24	9.8 ± 5.1		
GW–Spring											

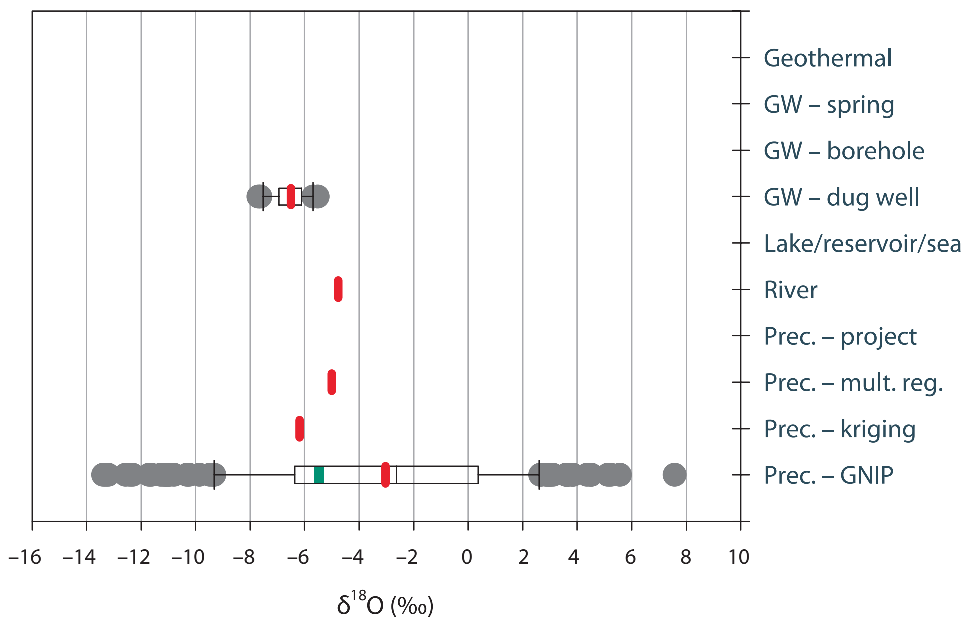


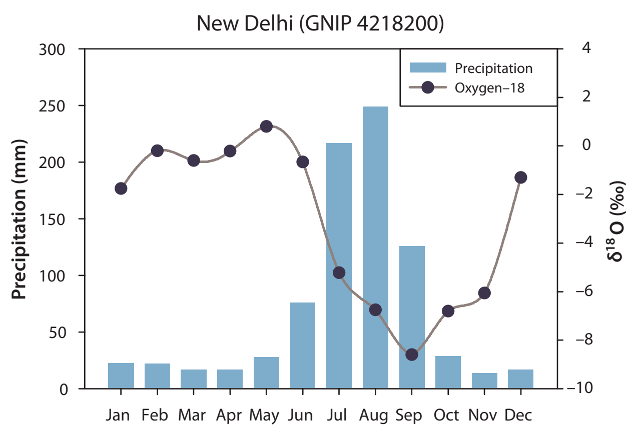


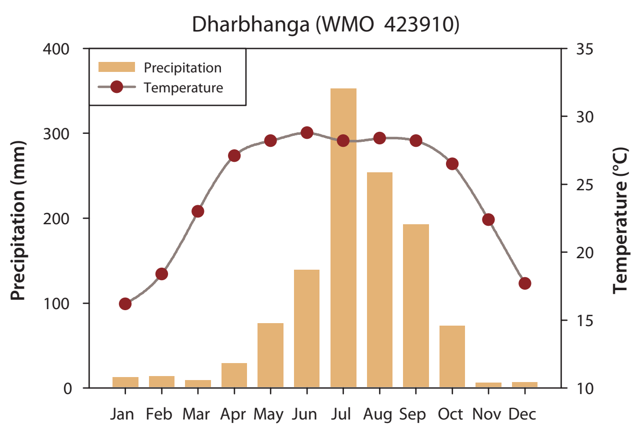
RAS8097B-IND

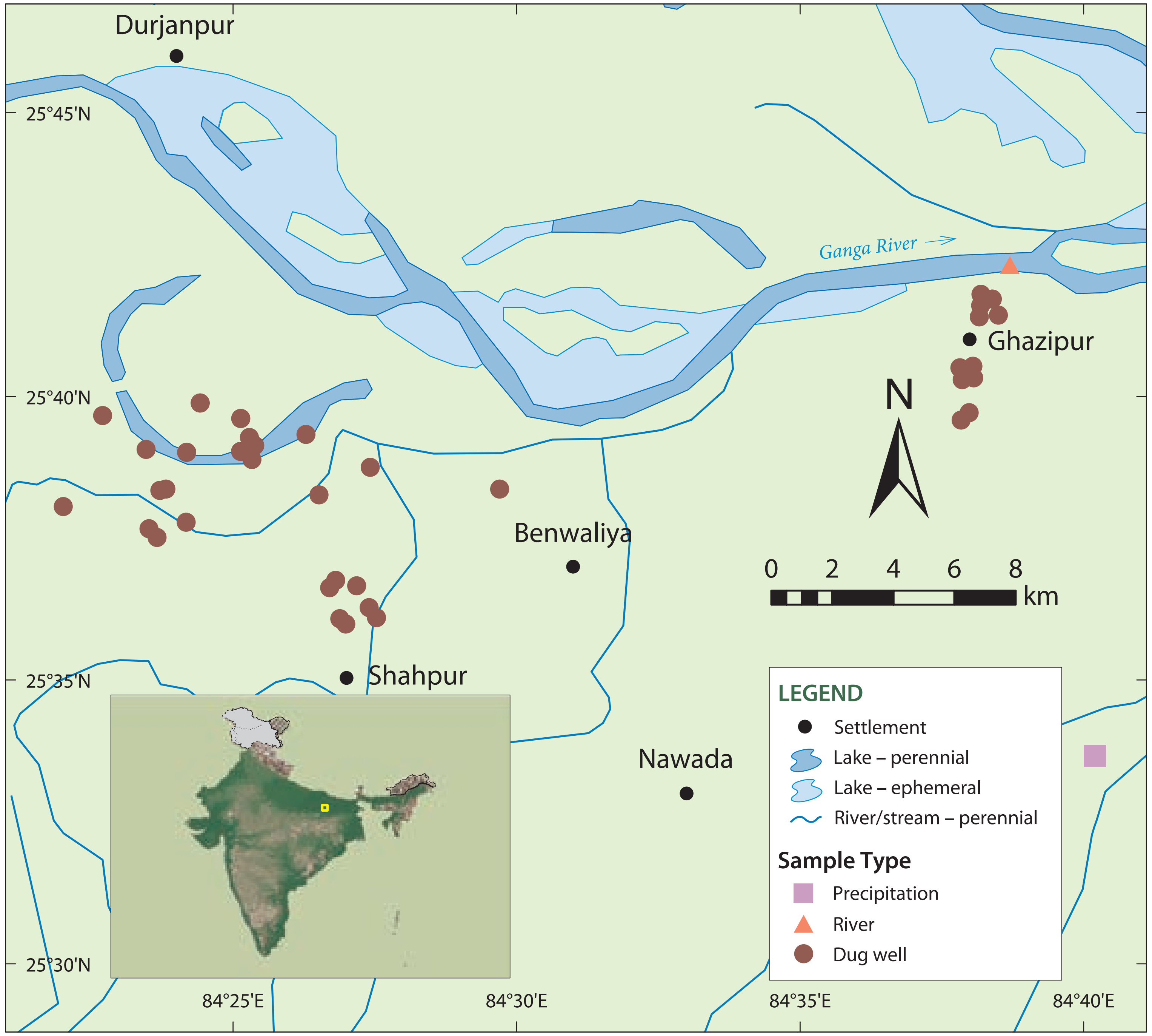
Alluvial aquifers, Ghazipur area







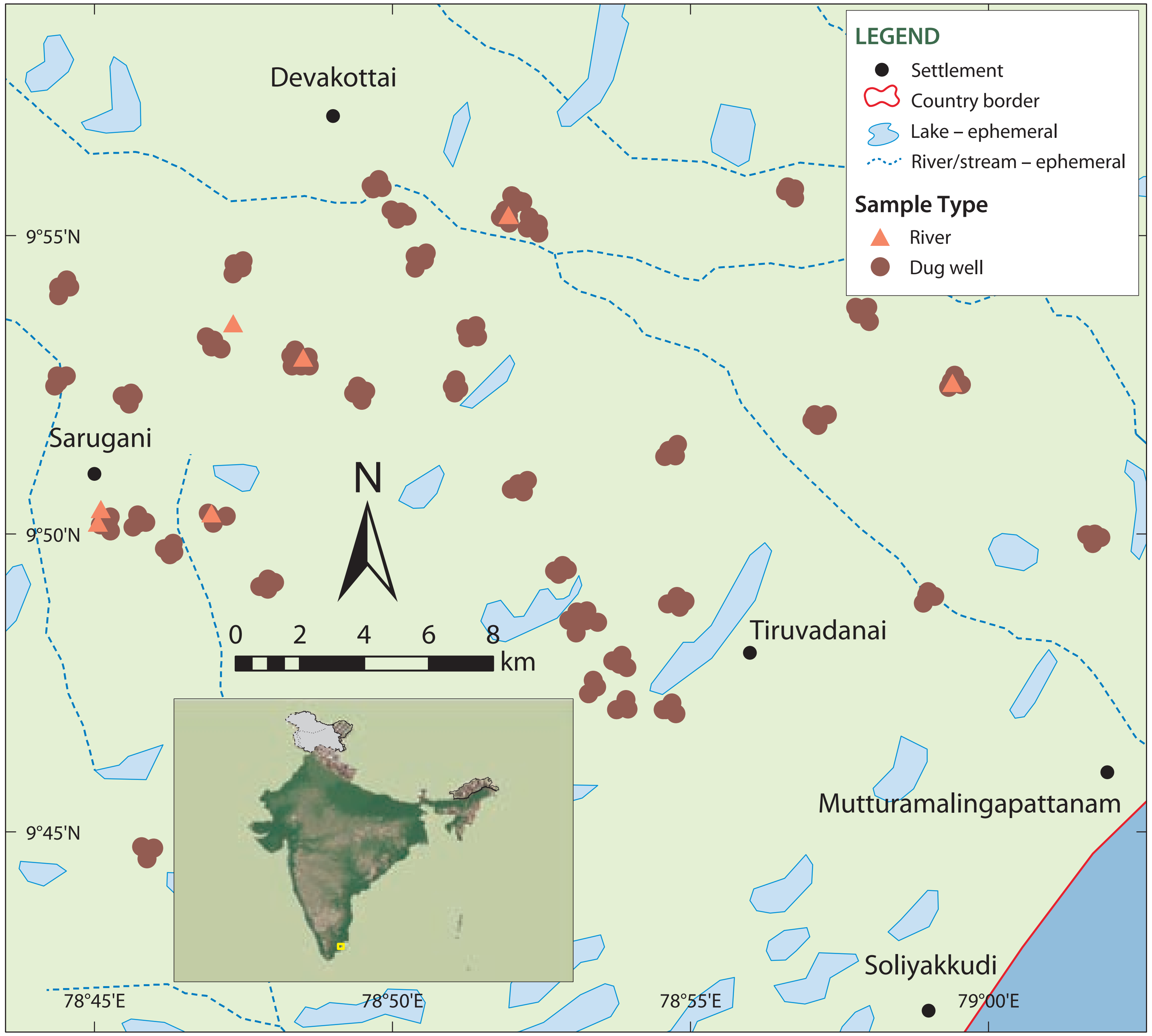


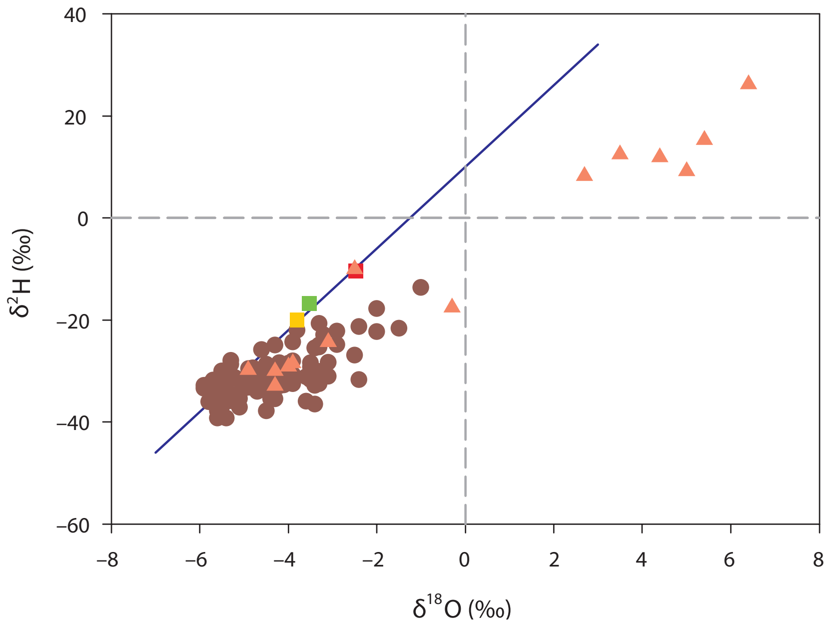


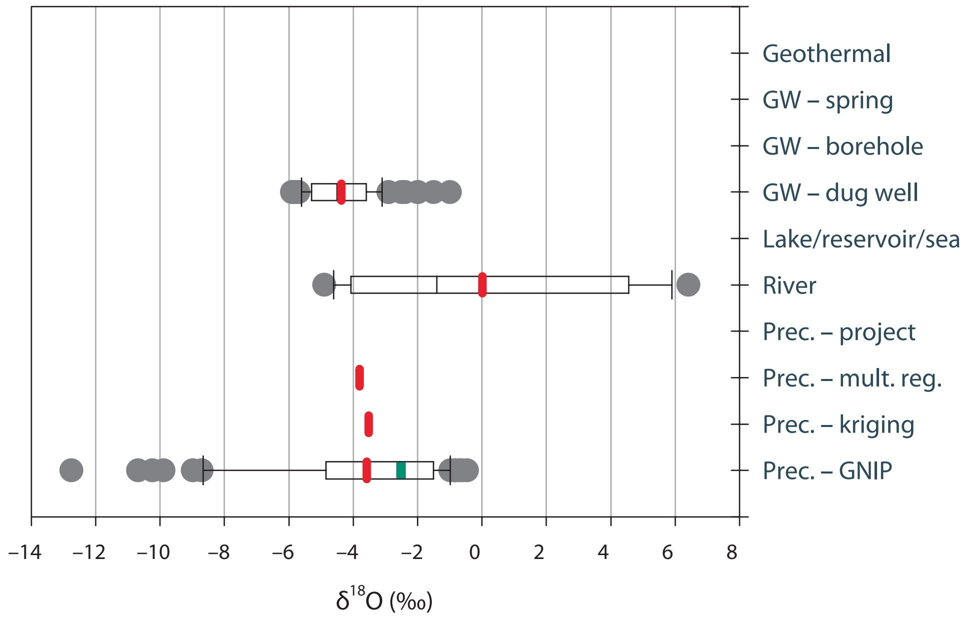
Precipitation	$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.			−5.00			−32.0			
Interpolation – kriging (IAEA)			−6.18			−39.5			
Project							1	8.4	

Surface waters	$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea								
River	1		−4.75	1		−37.8	1	15.4

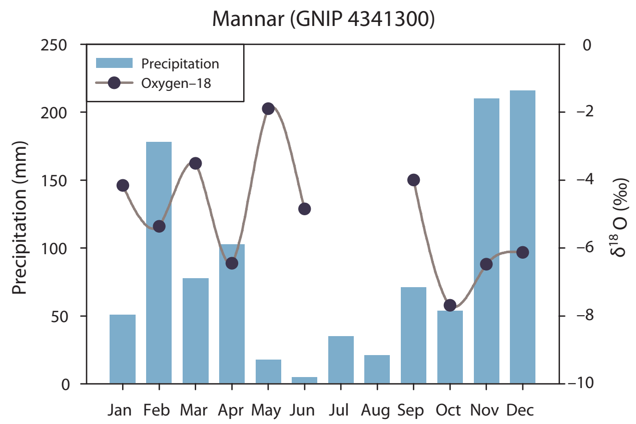
Groundwaters	$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole										
GW–Dug well	22	−6.42	−6.51 ± 0.6	22	−42.8	−42.8 ± 2.9	39	5.2 ± 2.8	13	138 ± 46
GW–Spring										

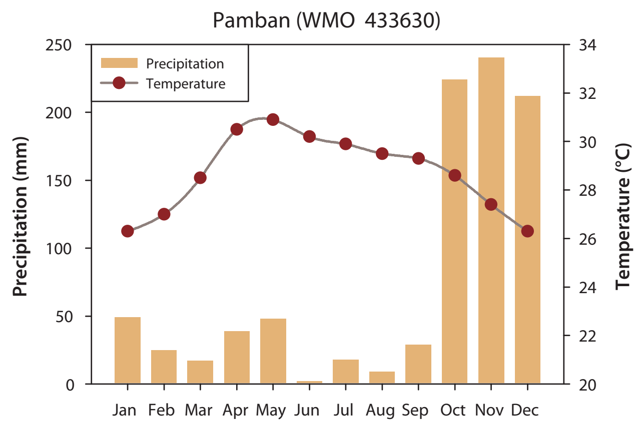


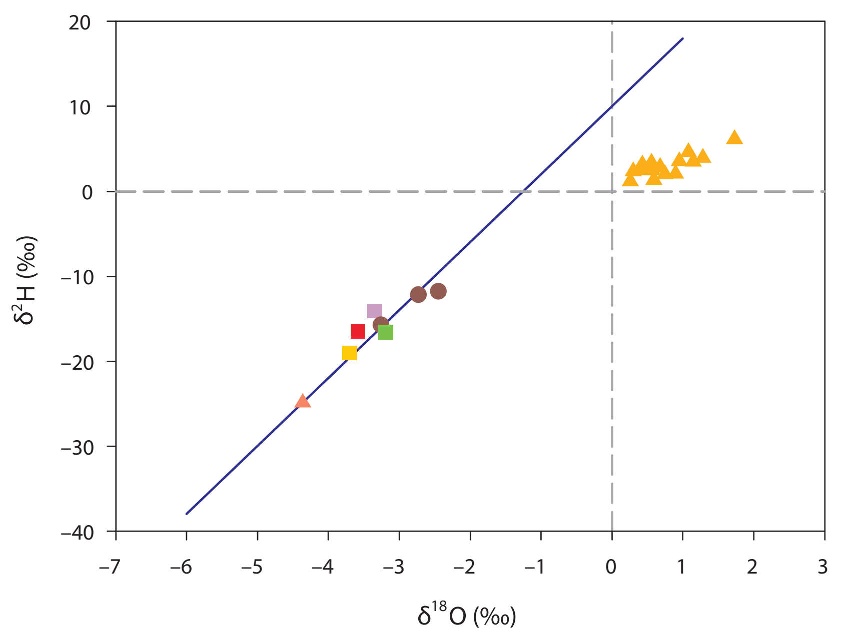


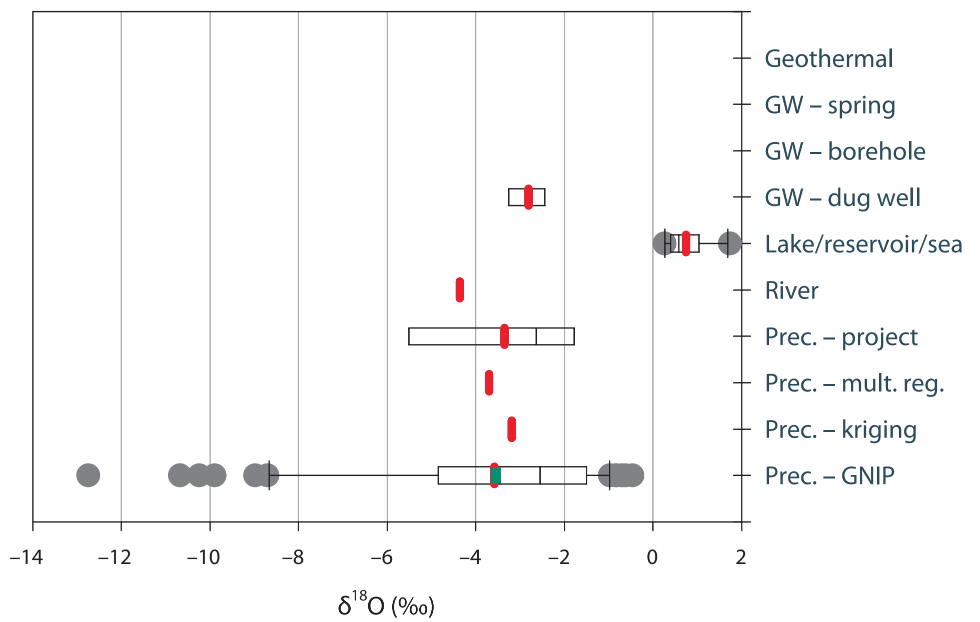


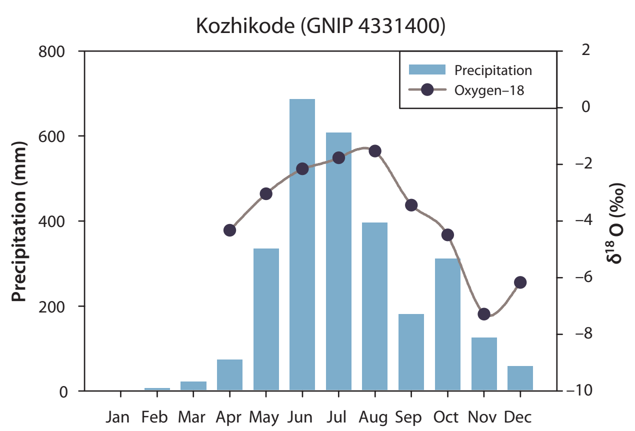
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station MANNAR	■ (red)	19	−4.70	−6.33 ± 1.2	19	−26.6	−40.8 ± 7.5			2715
Interpolation – multiple reg.	■ (yellow)			−3.80			−20.0			
Interpolation – kriging (IAEA)	■ (green)			−3.52			−16.8			
Project	■ (pink)									
Surface waters		δ¹⁸O			δ²H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	▲ (orange)									
River	▲ (salmon)	14	−1.40	0.01 ± 4.3	14	−13.8	−8.5 ± 21.2	4	5.1 ± 0.3	
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n / Mean ± St. dev.
Geothermal water	● (blue)									
GW–Borehole	● (grey)									
GW–Dug well	● (brown)	103	−4.50	−4.37 ± 1.1	101	−31.6	−30.8 ± 4.6	40	1.8 ± 1.1	15 / 4 ± 27
GW–Spring	● (green)									

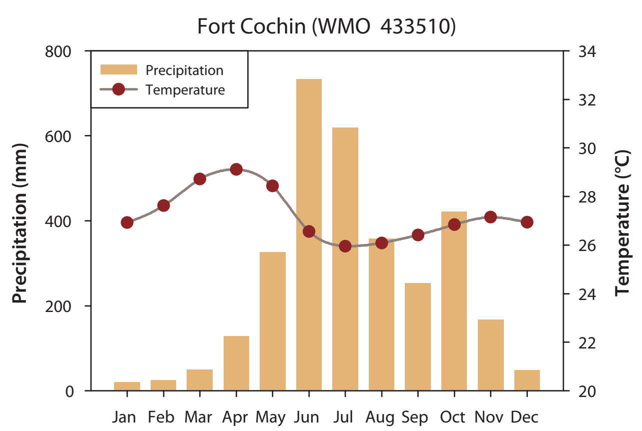


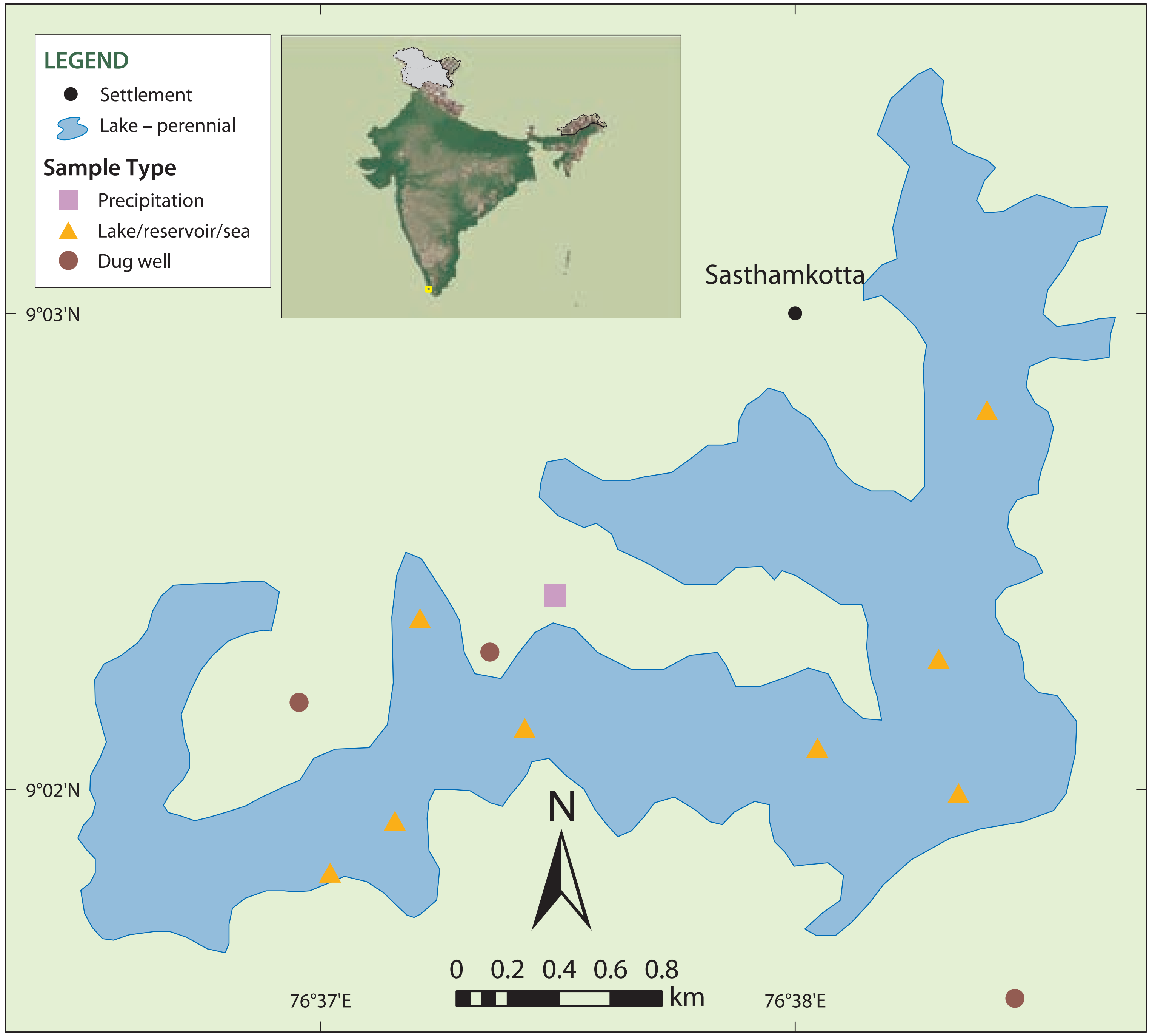








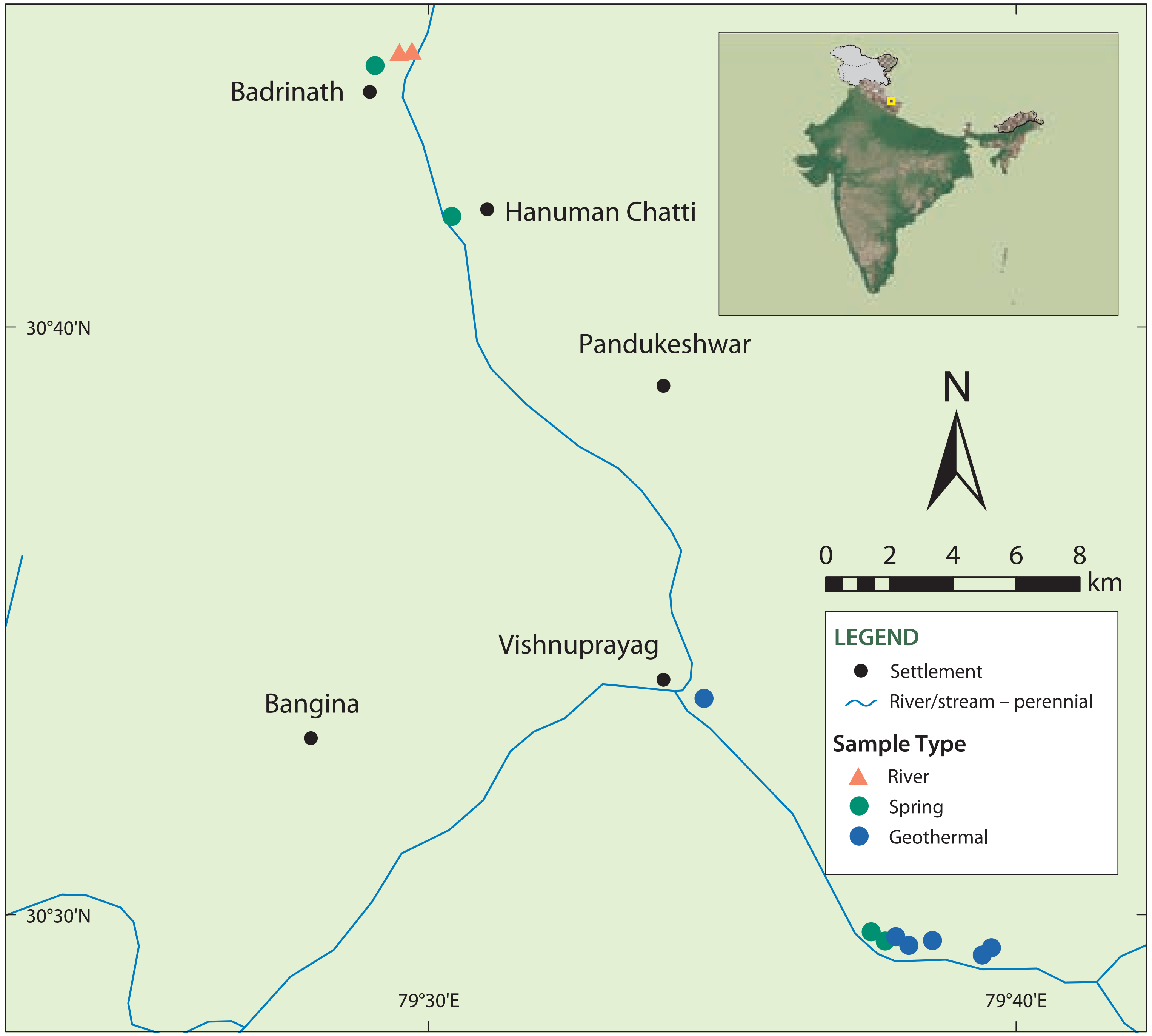


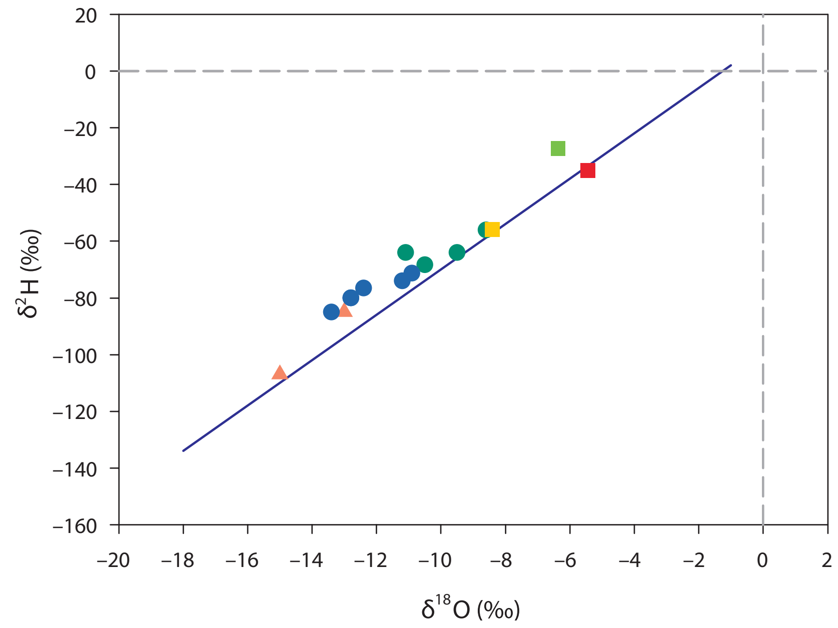


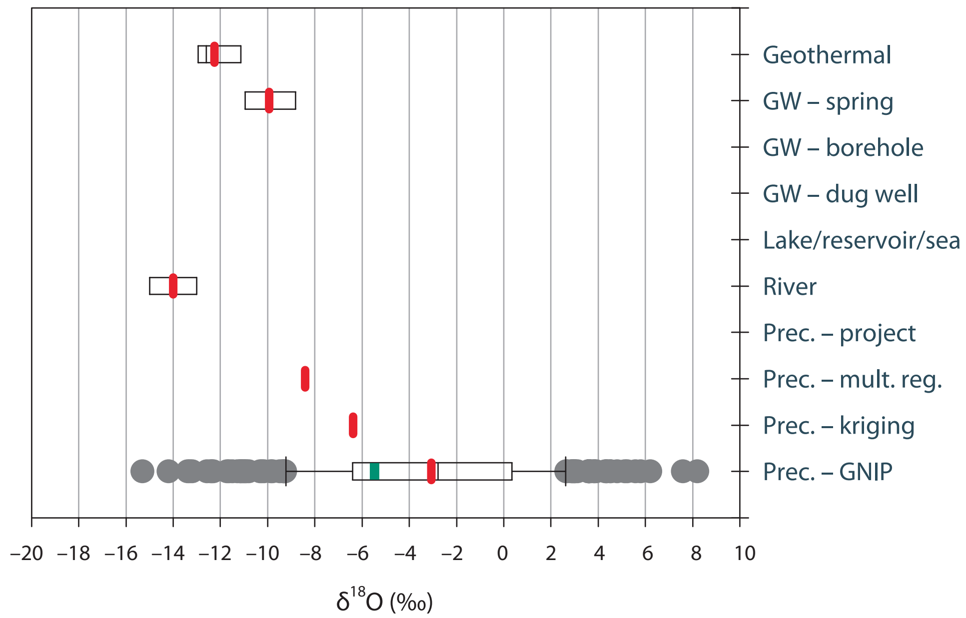
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station KOZHIKODE	red square	61	−2.55	−3.58 ± 3.0	59	−8.0	−16.5 ± 22.0			2715
Interpolation – multiple reg.	yellow square			−3.70			−19.0			
Interpolation – kriging (IAEA)	green square			−3.19			−16.6			
Project	pink square	11	−2.60	−3.35 ± 1.9	11	−7.9	−14.2 ± 15.3			

Surface waters		δ18O			δ2H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	orange triangle	15	0.68	0.78 ± 0.4	20	2.7	2.9 ± 1.1			
River	salmon triangle	1		−4.36	1		−24.9			

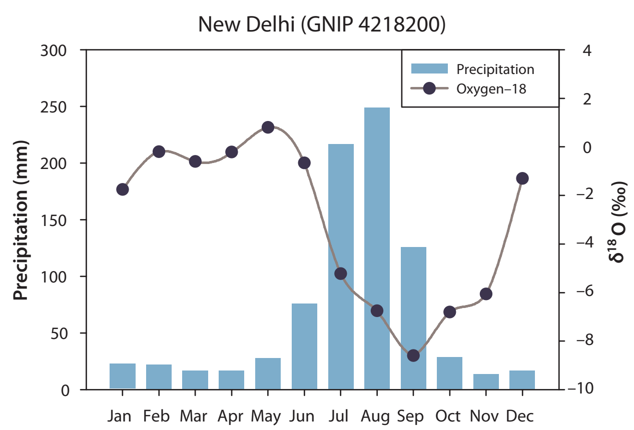
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle										
GW–Dug well	brown circle	3	−2.70	−2.81 ± 0.4	3	−12.2	−13.2 ± 2.2				
GW–Spring	green circle										

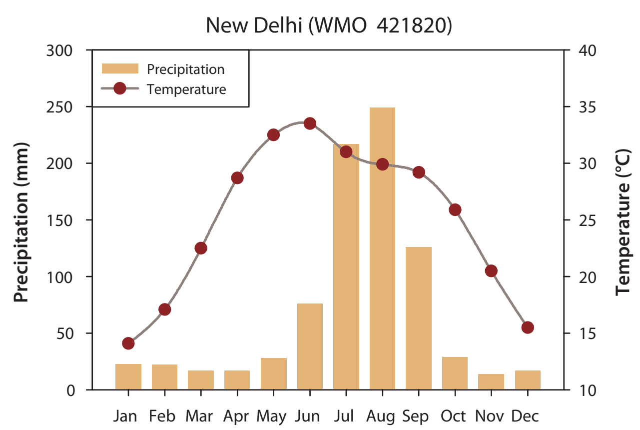






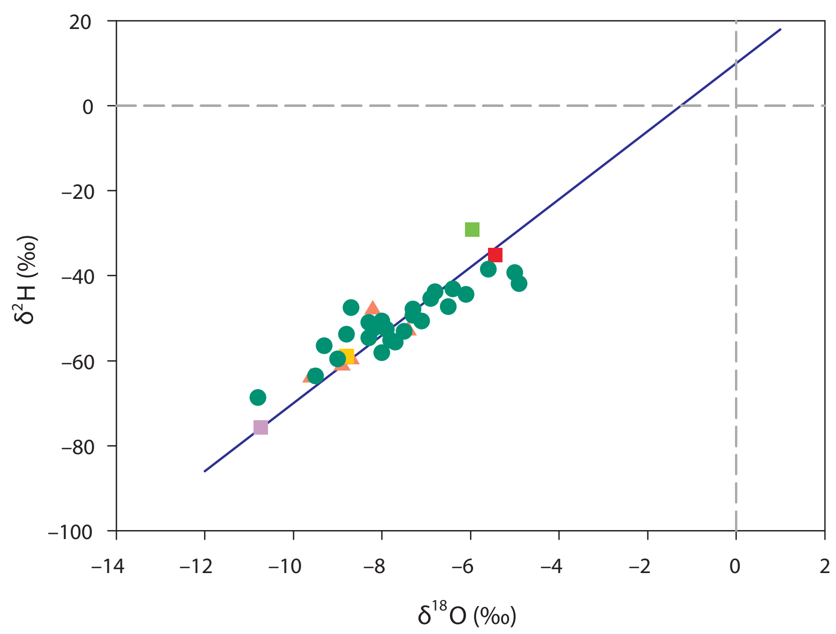
Precipitation		δ^{18}O (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.		Annual prec. (mm)
GNIP station NEW DELHI	red	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3				764
Interpolation – multiple reg.	yellow			−8.40			−56.0				
Interpolation – kriging (IAEA)	green			−6.37			−27.4				
Project	pink										
Surface waters		**δ^{18}O** n	Median	Mean ± St. dev.	**δ^2H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea											
River		2	−14.00	−14.00 ± 1.4	2	−96.0	−96.0 ± 15.6	2	16.7 ± 3.0		
Groundwaters		**δ^{18}O** n	Median	Mean ± St. dev.	**δ^2H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**^{14}C (pMC)** n	Mean ± St. dev.
Geothermal water		6	−12.60	−12.25 ± 0.99	6	−78.2	−77.8 ± 4.9	5	20.5 ± 7.7		
GW–Borehole											
GW–Dug well											
GW–Spring		4	−10.00	−9.93 ± 1.1	4	−64.0	−63.1 ± 5.1	3	19.6 ± 3.4		

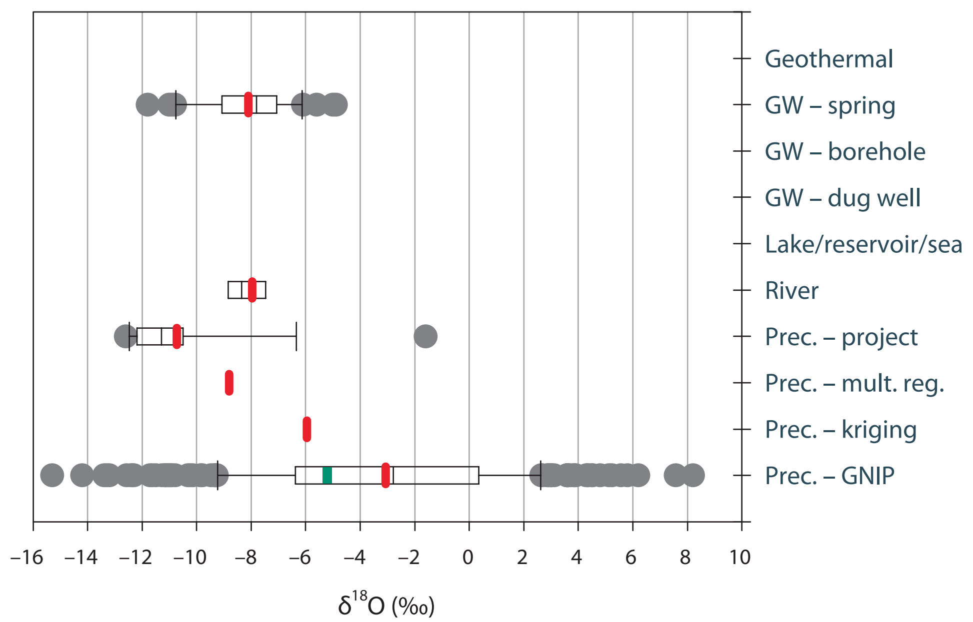


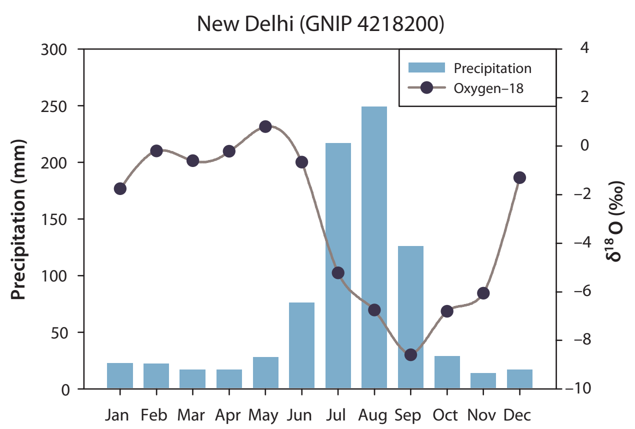


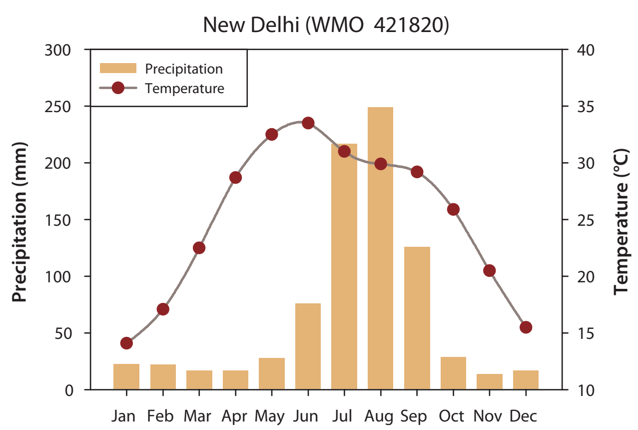
IND-7746

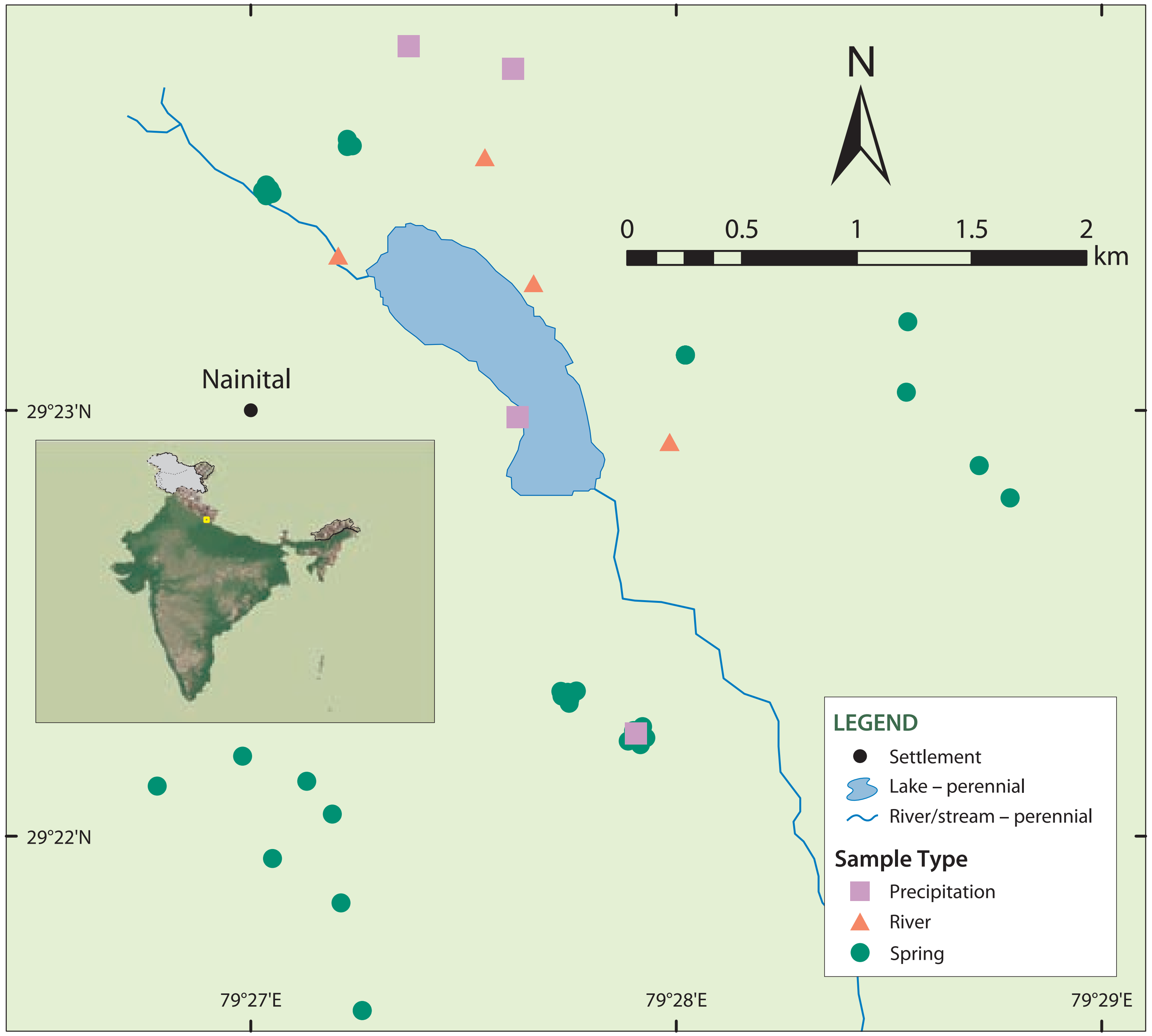
Lake Naini area, Nainital









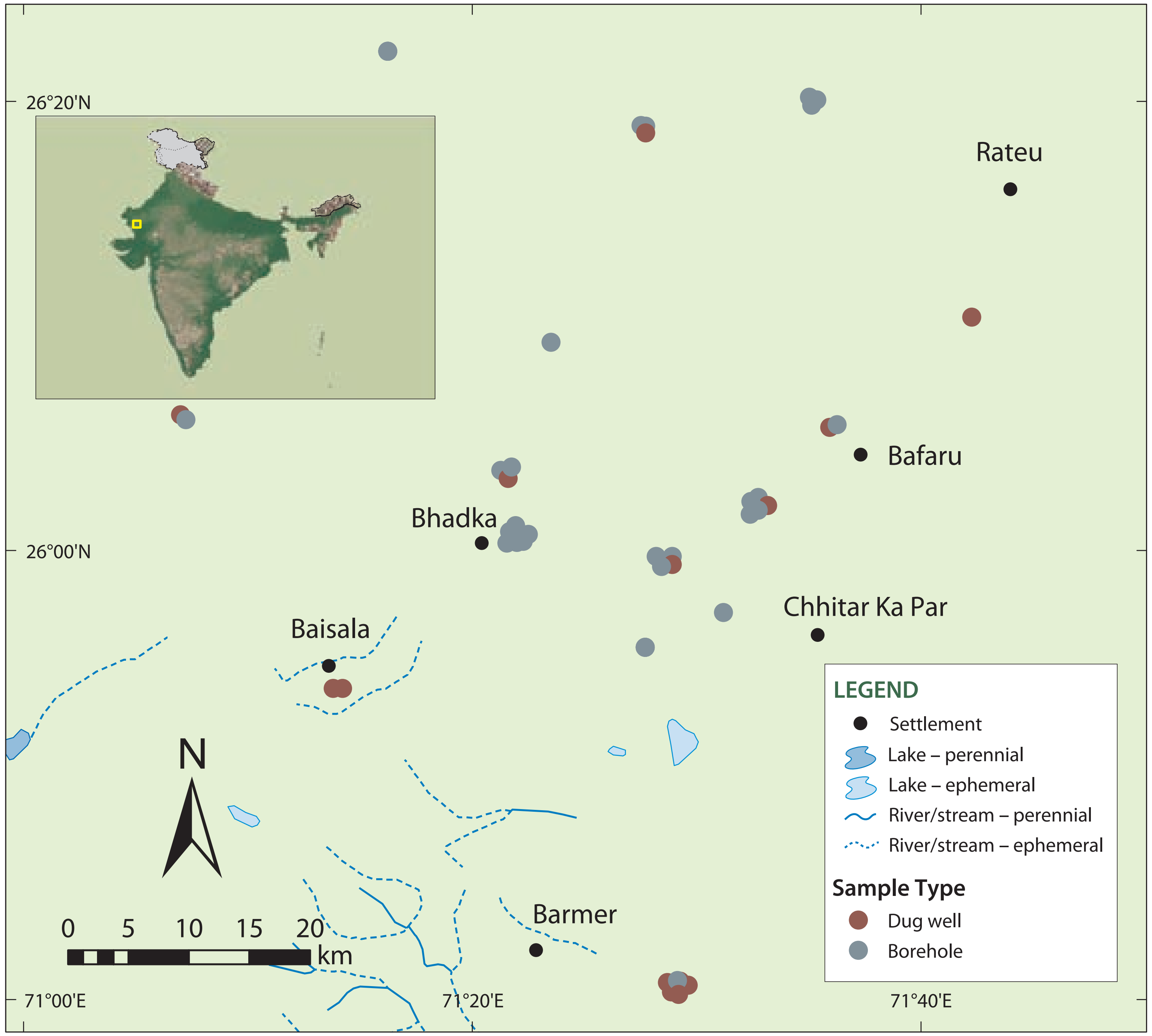


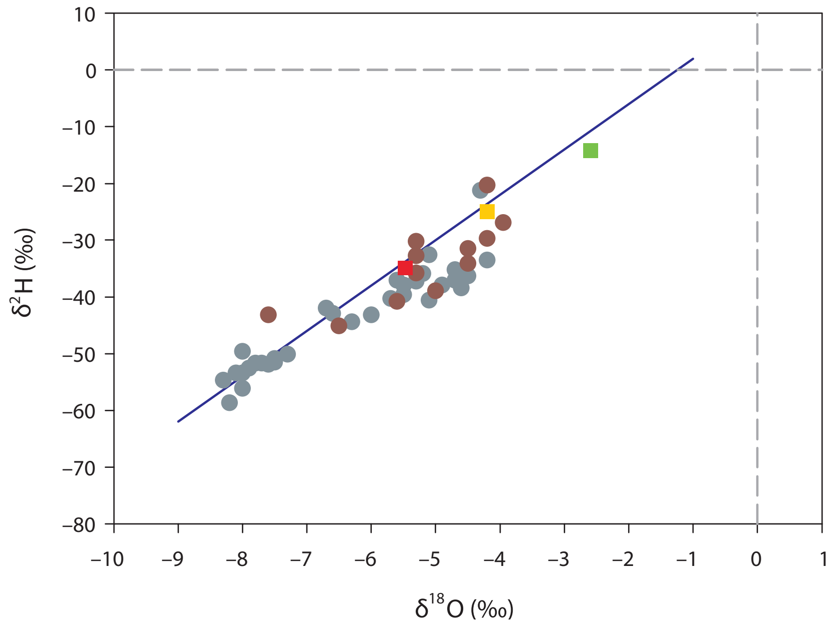
Precipitation		δ¹⁸O (‰) n	δ¹⁸O (‰) Median	δ¹⁸O (‰) Mean ± St. dev.	δ²H (‰) n	δ²H (‰) Median	δ²H (‰) Mean ± St. dev.	Tritium (TU) n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	■	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.	■			−8.80			−59.0			
Interpolation – kriging (IAEA)	■			−5.96			−29.12			
Project	■	15	−11.30	−10.73 ± 2.7u	15	−80.0	−75.72 ± 20.3			

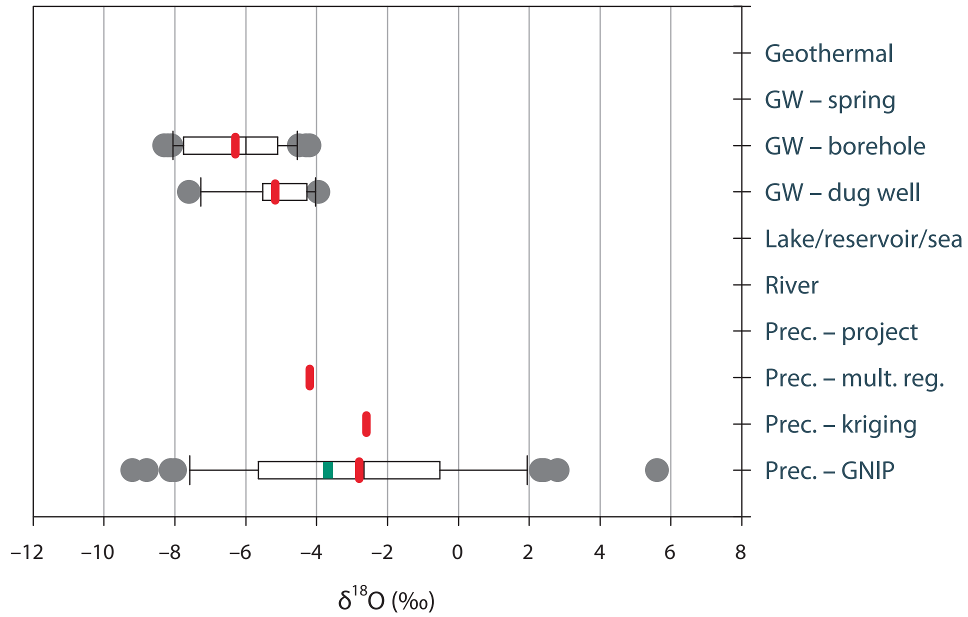
Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	▲								
River	▲	8	−8.35	−7.96 ± 1.5	8	−54.6	−53.69 ± 7.9		

Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C (pMC) Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●										
GW–Dug well	●										
GW–Spring	●	42	−7.80	−8.1 ± 1.7	28	−50.8	−51.33 ± 7.3				

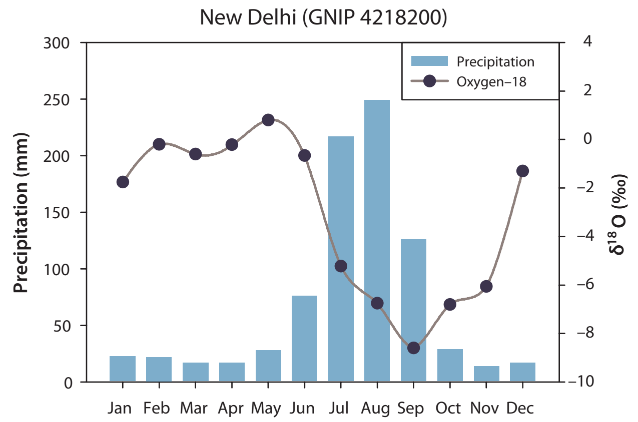
IND-7904B; IND-10802B
Bhadka–Bheemda area, Barmer

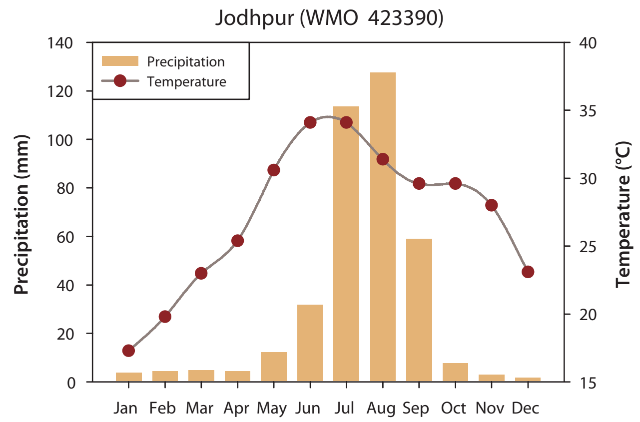






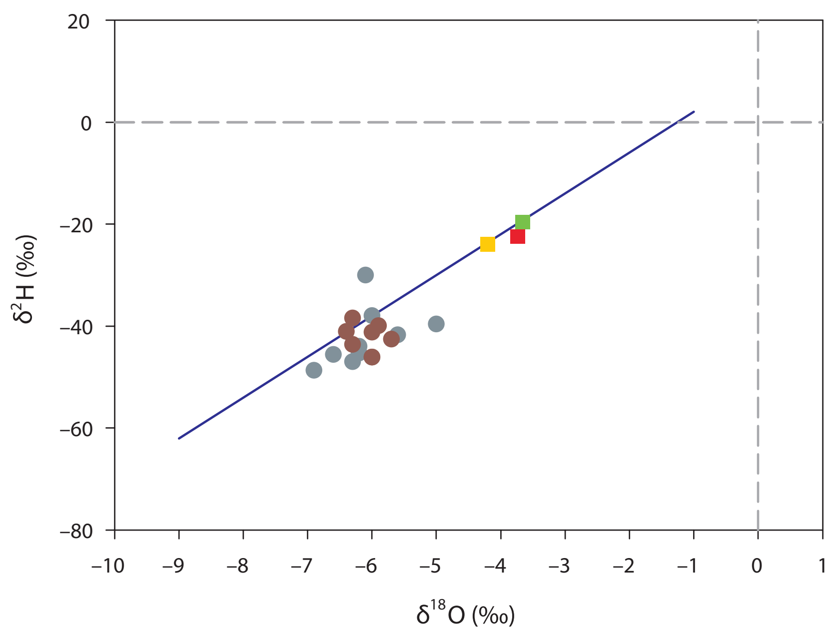
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station NEW DELHI		324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.				−4.20			−24.0			
Interpolation – kriging (IAEA)				−3.66			−19.6			
Project										
Surface waters		δ¹⁸O			δ²H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea										
River										
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n / Mean ± St. dev.
Geothermal water										
GW–Borehole		33	−6.00	−6.29 ± 1.4	32	−42.4	−43.7 ± 8.7	28	0.8 ± 0.5	21 / 42 ± 17
GW–Dug well		12	−5.15	−5.16 ± 1.1	12	−33.4	−34.1 ± 7.1	9	4.7 ± 6.4	3 / 44 ± 30
GW–Spring										

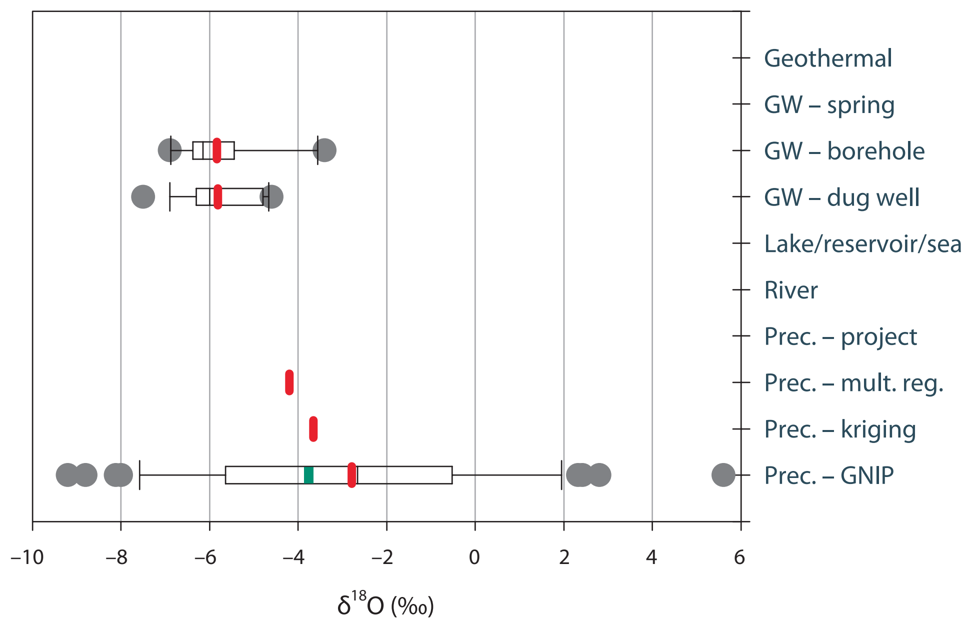


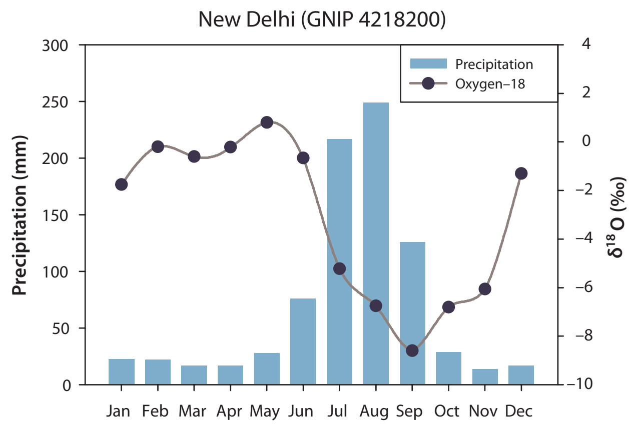


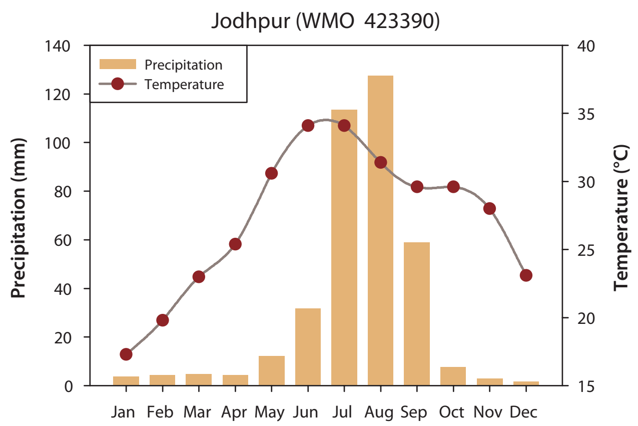
IND-7904J

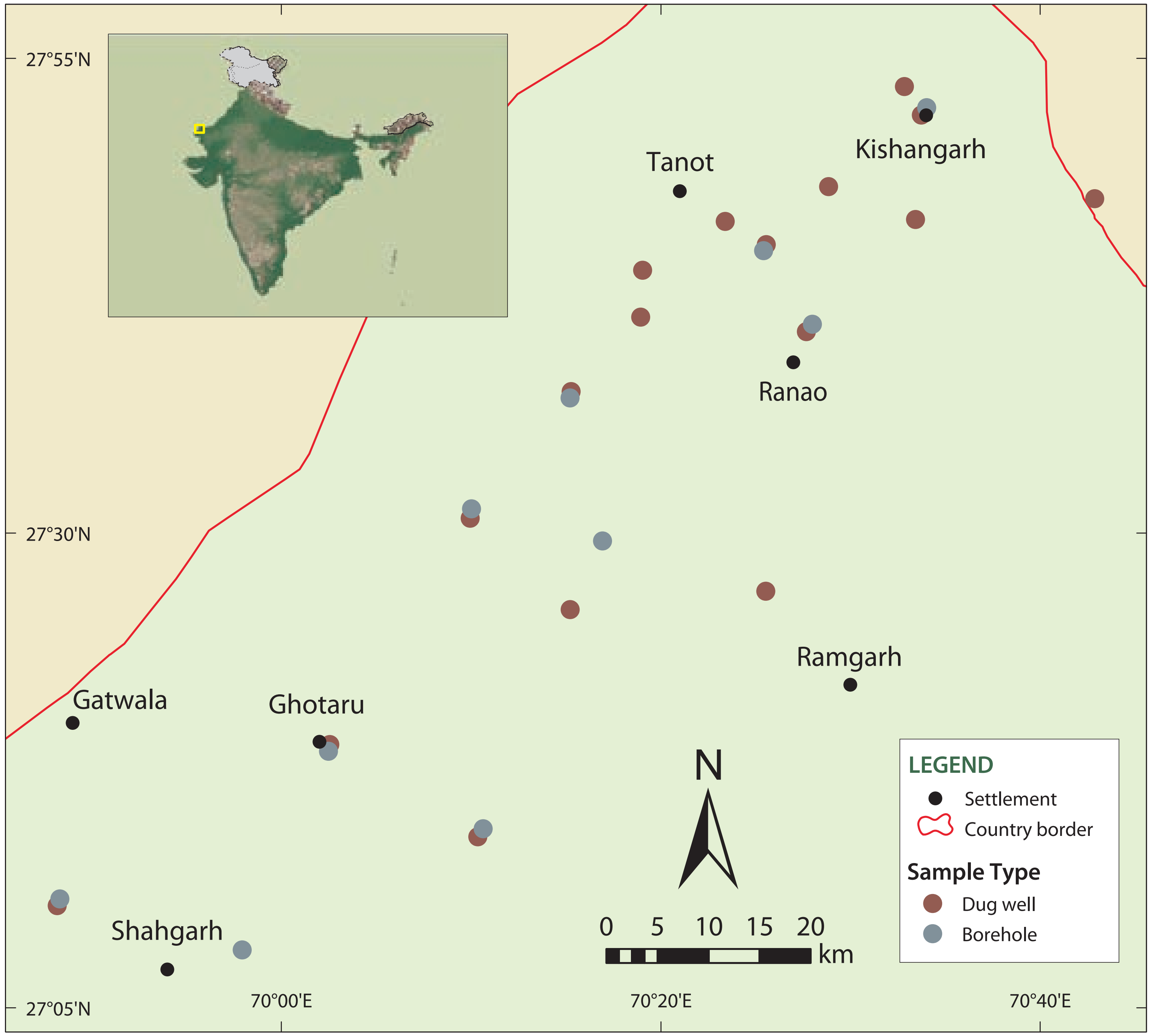
Kishangarh–Ghotaru area, Jaisalmer











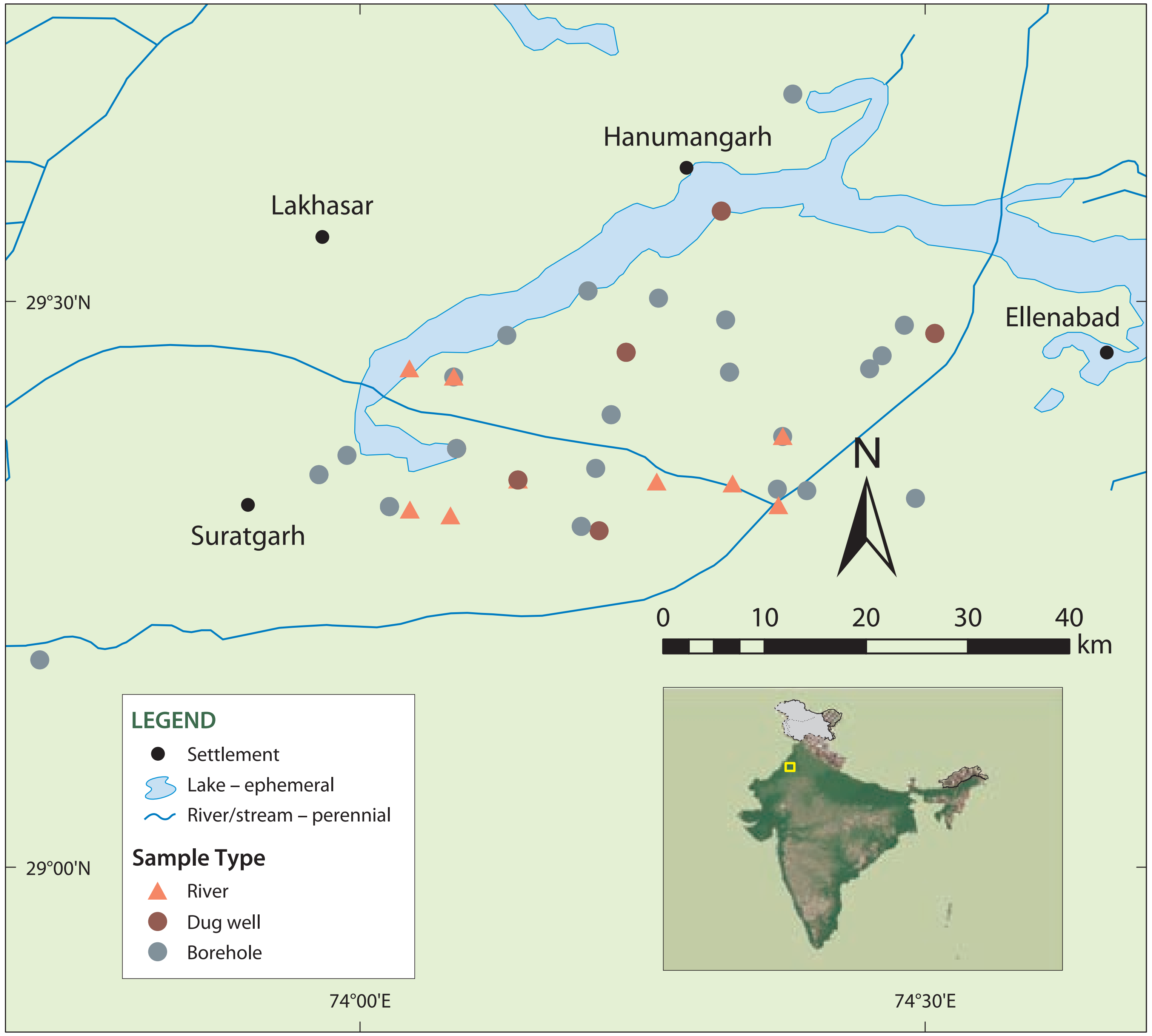
Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI		324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.				−4.20			−24.0			
Interpolation – kriging (IAEA)				−3.66			−19.6			
Project										

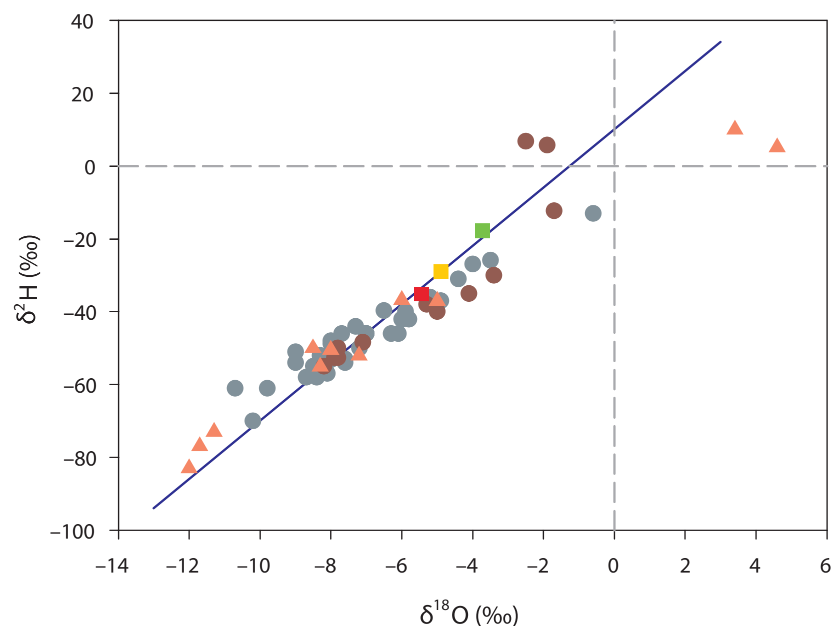
Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea									
River									

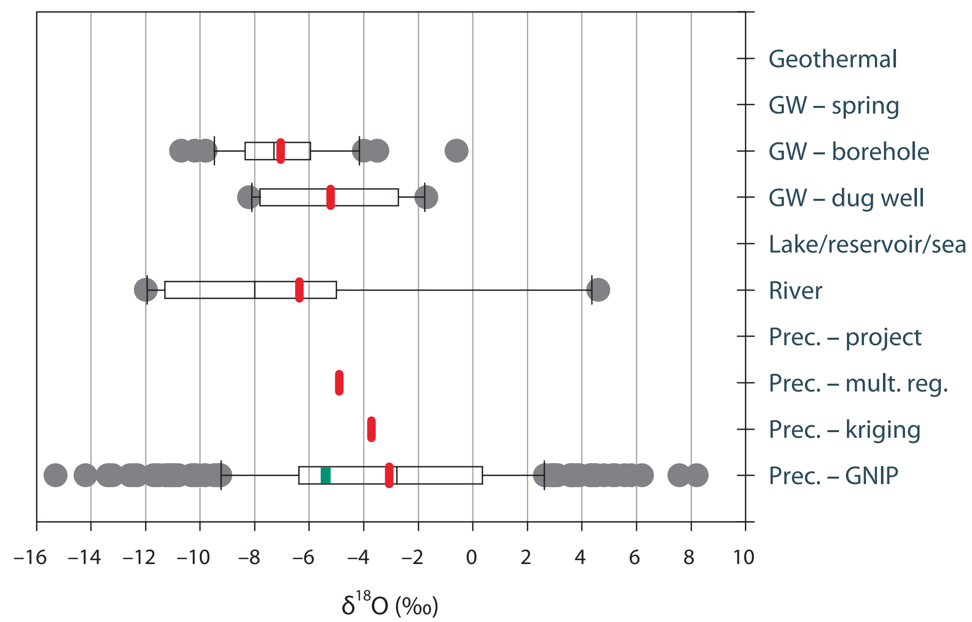
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		10	−6.15	−5.83 ± 1.0	9	−44.0	−42.2 ± 5.7	10	0.4 ± 0.1	8	34 ± 21
GW–Dug well		15	−6.00	−5.81 ± 0.8	9	−41.2	−42.2 ± 2.6	15	1.0 ± 0.6	10	645 ± 12
GW–Spring											

IND-7904I

Indira Gandhi Canal Scheme, Rajasthan



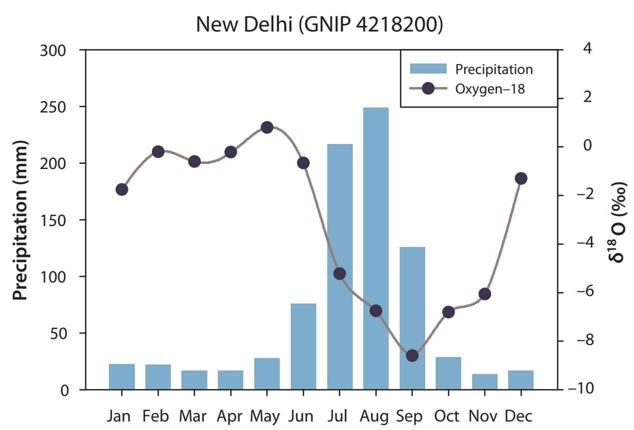


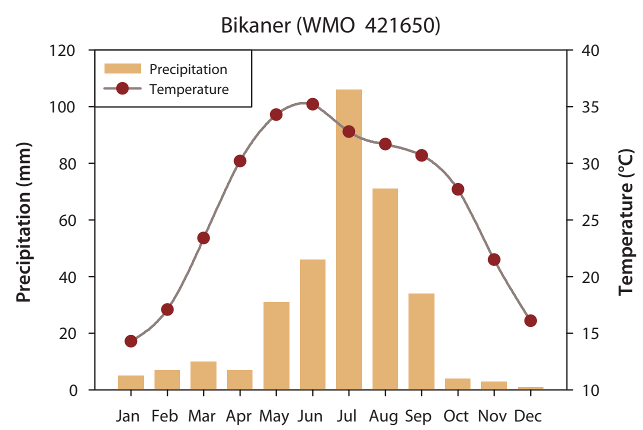


Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.		Annual prec. (mm)
GNIP station NEW DELHI		324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3				764
Interpolation – multiple reg.				−4.90			−29.0				
Interpolation – kriging (IAEA)				−3.72			−17.8				
Project											

Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea									
River		11	−8.00	−6.36 ± 5.6	11	−50.5	−45.4 ± 30.2	5	11.0 ± 4.0

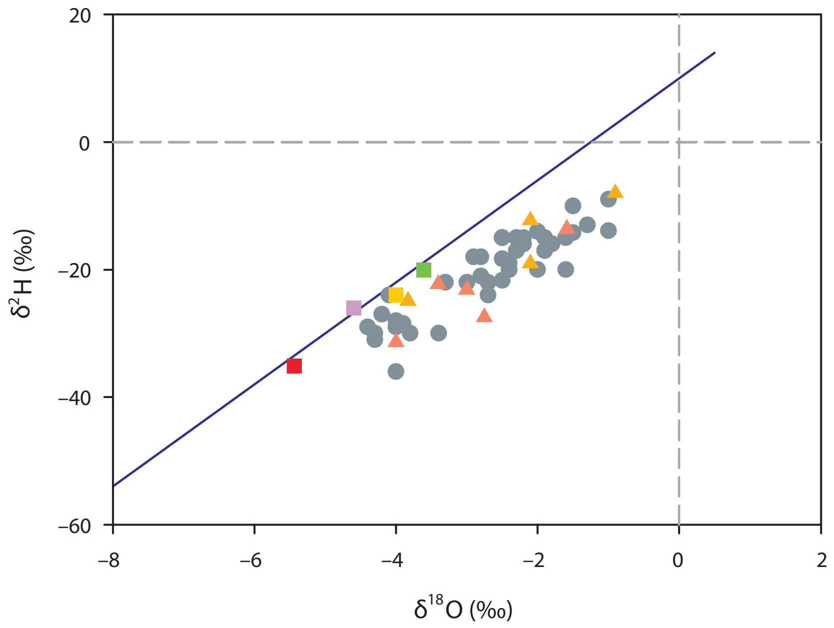
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		33	−7.30	−6.69 ± 3.0	33	−46.0	−46.6 ± 11.5	19	12.4 ± 13.2	3	73 ± 6
GW–Dug well		12	−5.15	−5.23 ± 2.5	12	−39.0	−33.4 ± 22.1	9	9.4 ± 6.0	2	64 ± 18
GW–Spring											

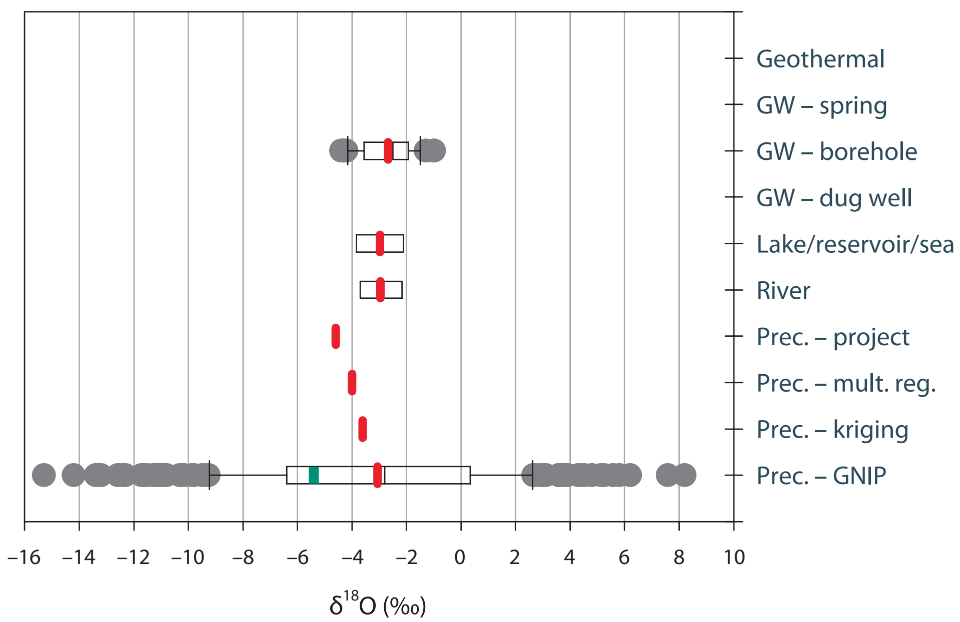


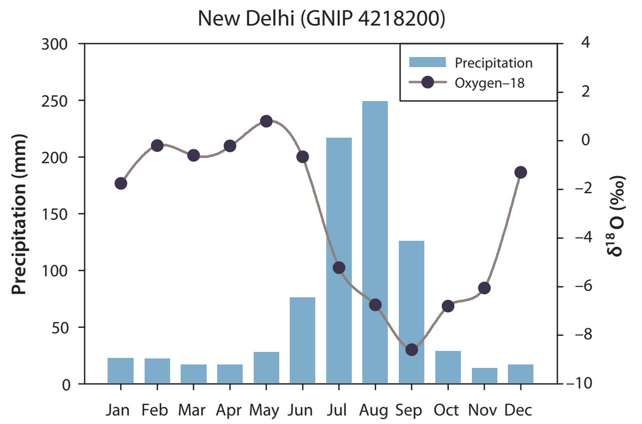


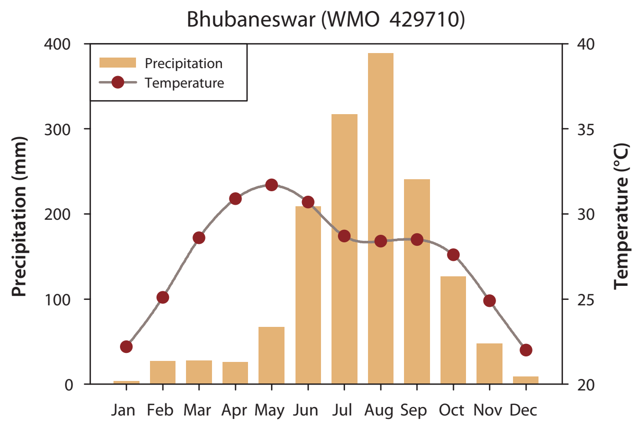
IND-8398

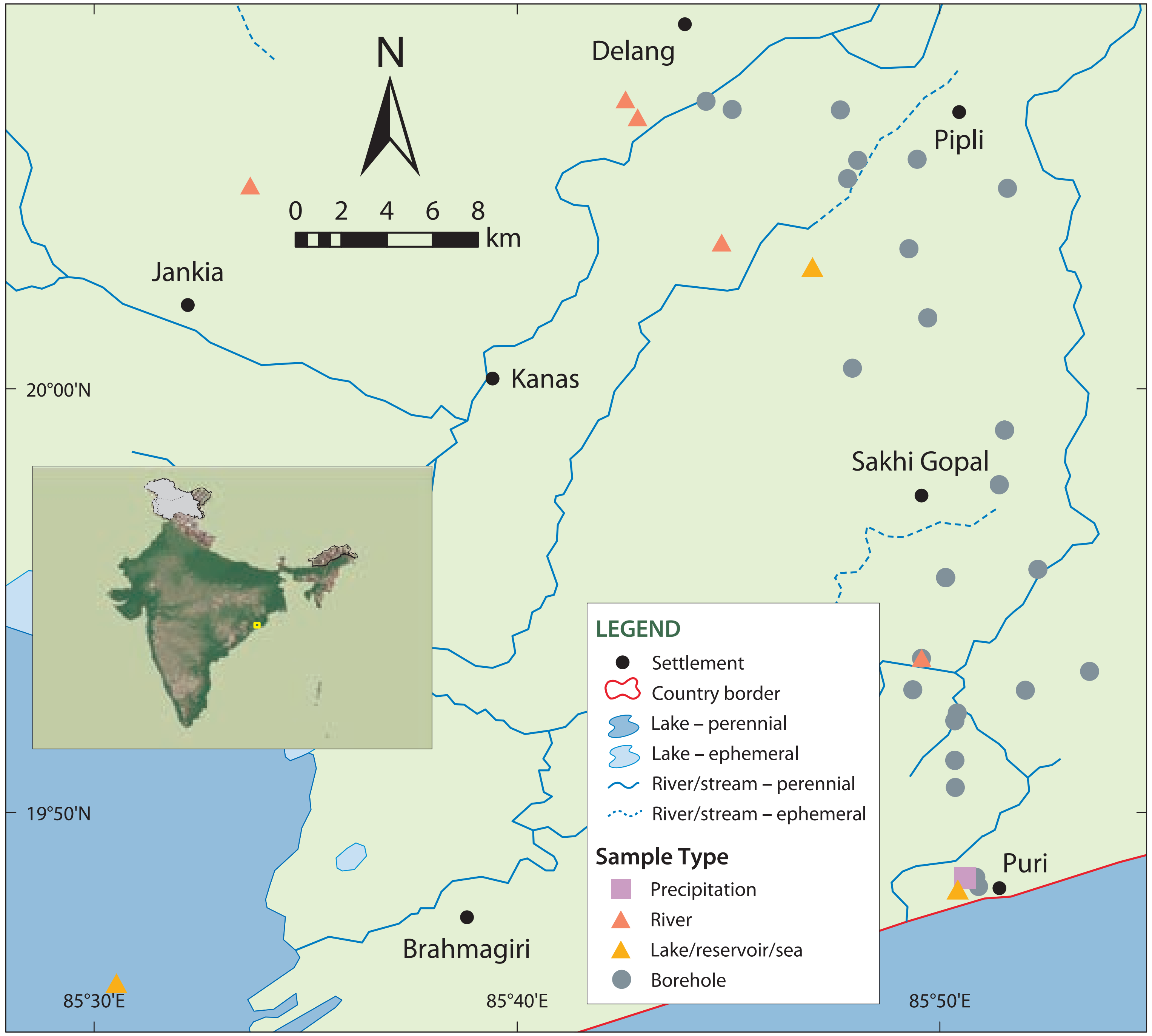
Delang–Puri Sector, Orissa











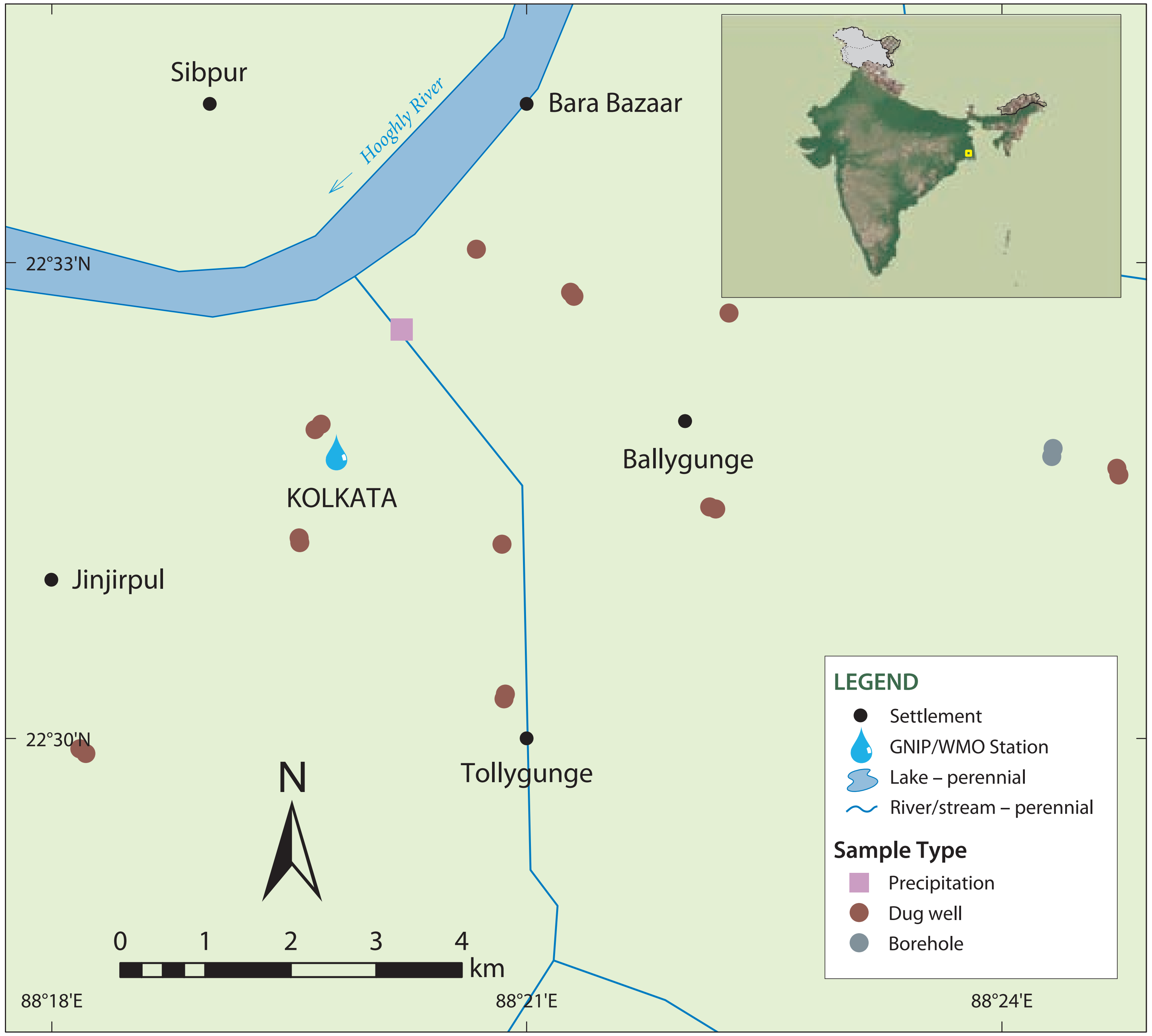
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	■	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.	■			−4.00			−24.0			
Interpolation – kriging (IAEA)	■			−3.61			−20.1			
Project	■	1		−4.60	1		−26.0	1	7.0	

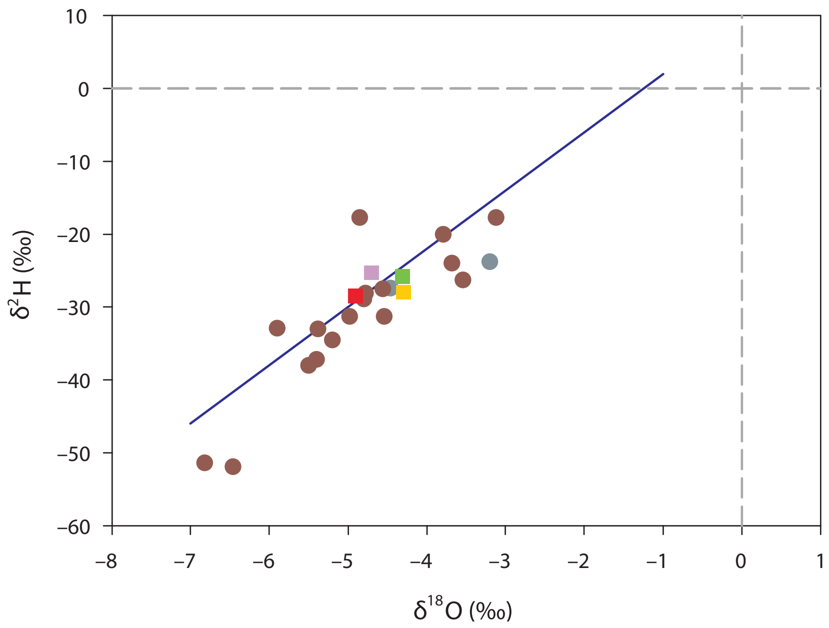
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲	4	−2.10	−2.23 ± 1.2	4	−15.6	−16.0 ± 7.4	4	4.8 ± 1.2
River	▲	5	−3.00	−2.95 ± 0.9	5	−23.2	−23.6 ± 6.7	1	7.1

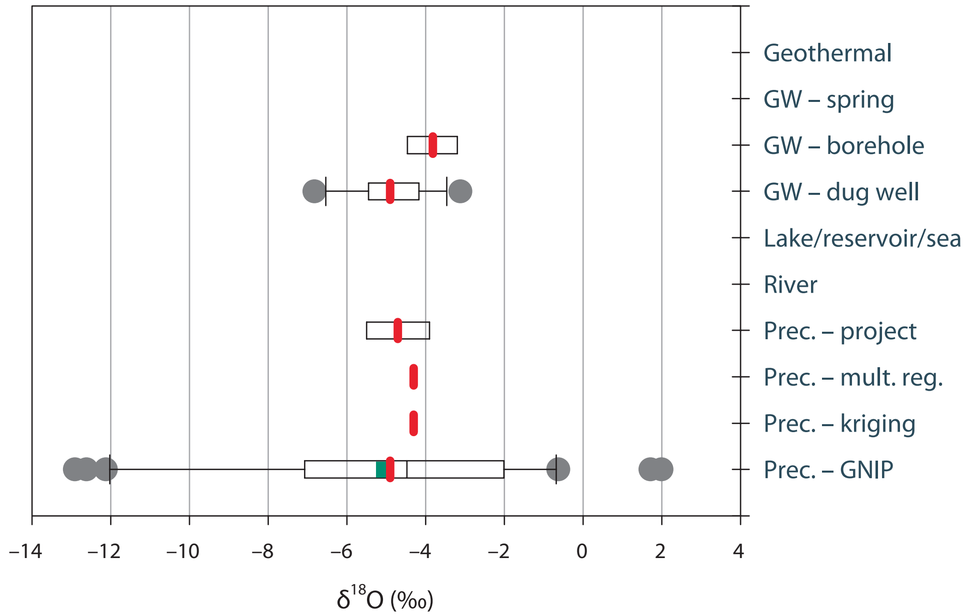
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	44	−2.50	−2.68 ± 1.0	43	−19.0	−20.2 ± 6.4	40	2.2 ± 2.0		
GW–Dug well	●										
GW–Spring	●										

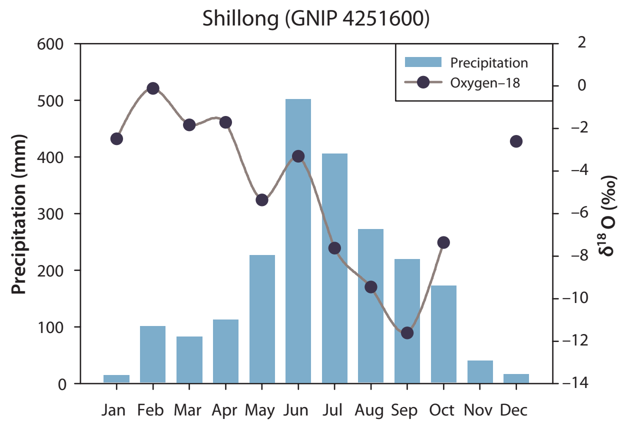
IND-10283

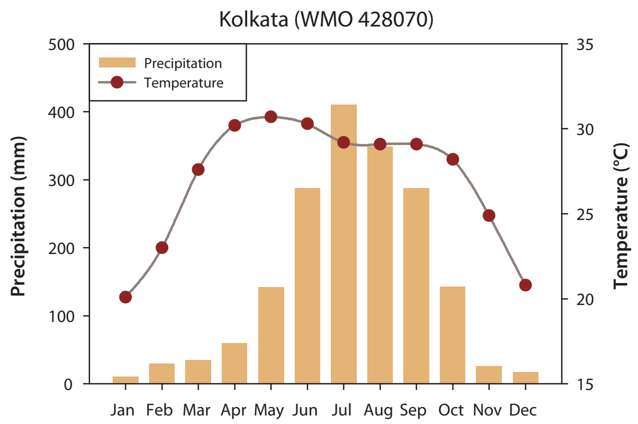
Alluvial aquifers, Kolkata city











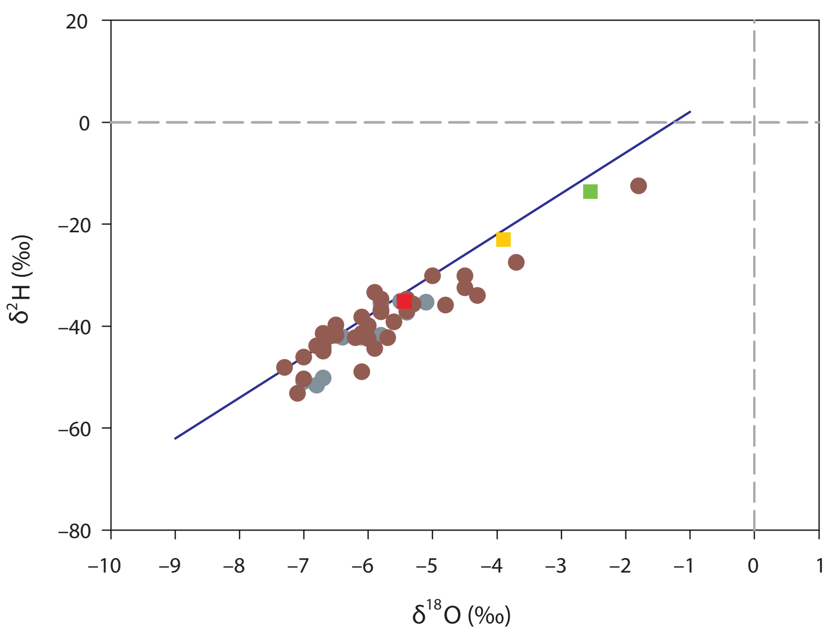
Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station SHILLONG	red	30	–4.48	–4.91 ± 4.1	30	–25.6	–28.5 ± 18.9			1825
Interpolation – multiple reg.	yellow			–4.30			–28.0			
Interpolation – kriging (IAEA)	green			–4.31			–25.8			
Project	pink	2	–4.70	–4.70 ± 1.1	2	–25.3	–25.3 ± 6.9	2	7.2 ± 1.2	

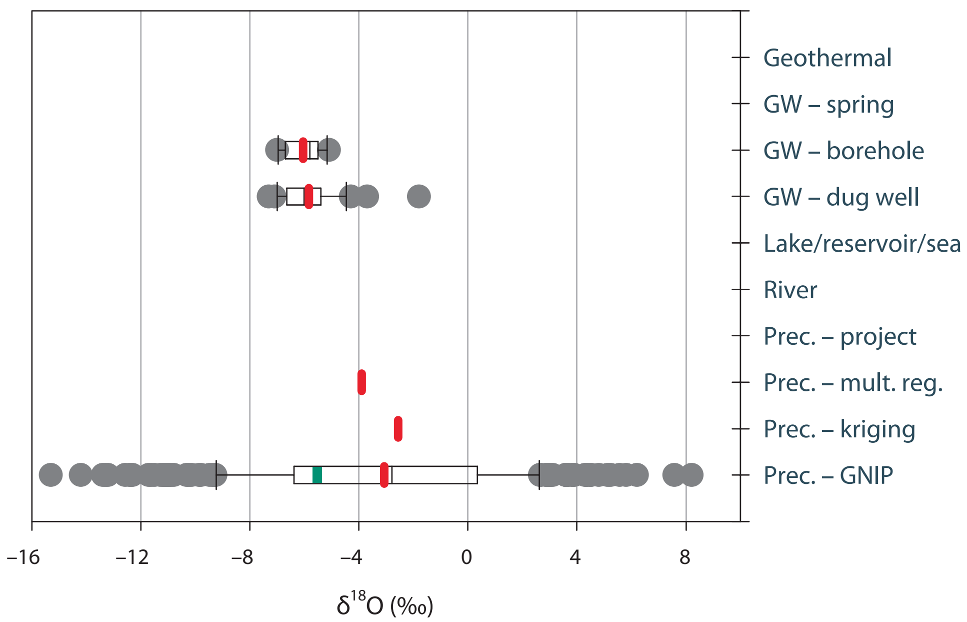
Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea									
River									

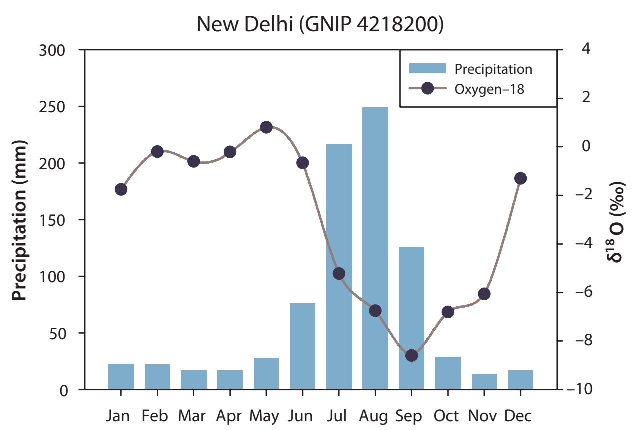
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		2	–3.83	–3.83 ± 0.9	2	–25.6	–25.6 ± 2.6	2	1.2 ± 1.7	1	23
GW–Dug well		17	–4.85	–4.90 ± 1.0	17	–31.3	–31.3 ± 9.8	17	2.4 ± 2.8	3	41 ± 24
GW–Spring											

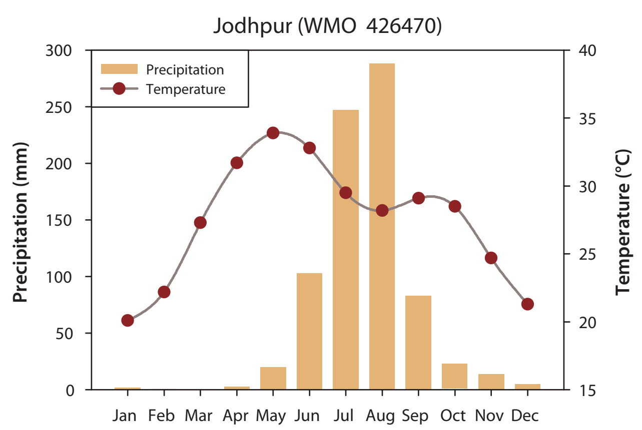
IND–10802J

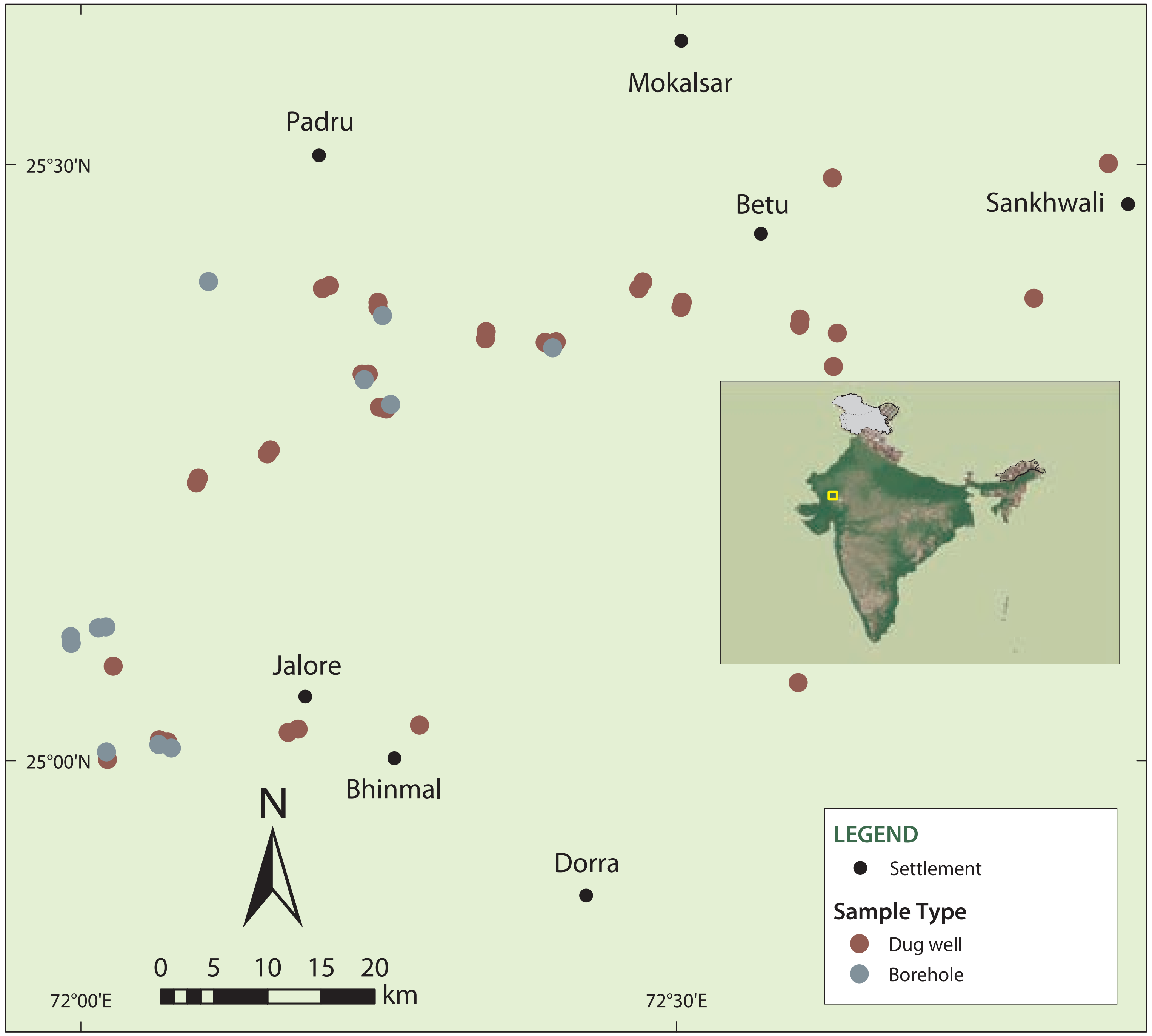
Arid zone aquifers, Jalore area







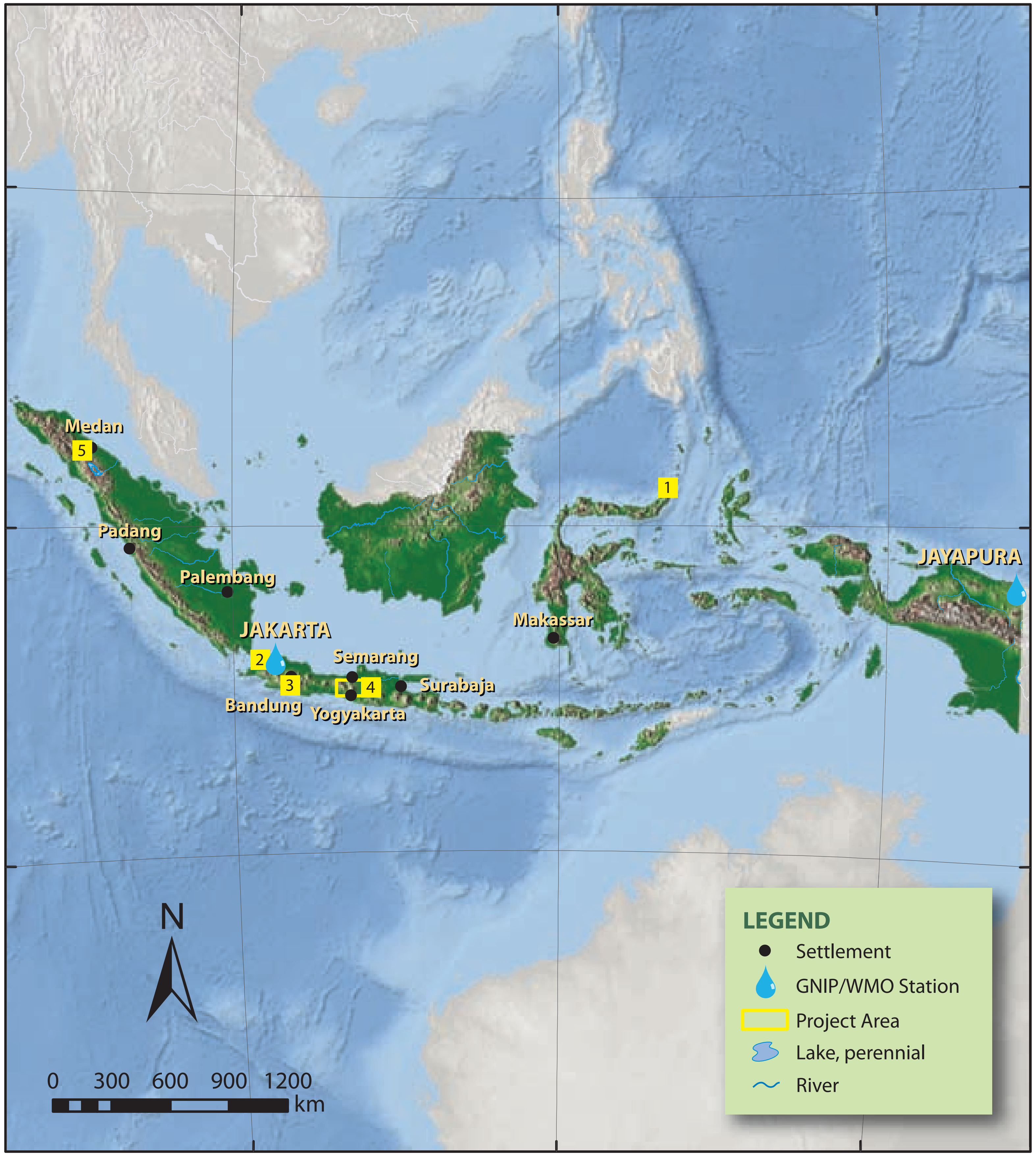




Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NEW DELHI	■ red	324	−2.79	−5.44 ± 1.7	291	−12.2	−35.1 ± 13.3			764
Interpolation – multiple reg.	■ yellow			−3.90			−23.0			
Interpolation – kriging (IAEA)	■ green			−2.55			−13.6			
Project	■ pink									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲								
River	▲								

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	11	−5.80	−6.04 ± 0.6	11	−41.8	−41.6±6.7	10	1.6 ± 1.03	7	62 ± 25
GW–Dug well	●	37	−6.00	−5.83 ± 1.1	37	−39.9	−39.2 ± 7.4	32	4.6 ± 4.8	4	83± 8
GW–Spring	●										



1 **Project Code:** RAS8092–INS
Study area: Lahendong geothermal area, Sulawesi
Sampling period: 2004
Background: In this regional project, the origin of geothermal fluids, reservoir temperatures and interactions between the juvenile water from volcanic system and the fluids from geothermal reservoir in the Lahendong area of Sulawesi were studied using isotope techniques.

2 **Project Code:** RAS8097–INS
Study area: Jakarta city area
Sampling period: 2003–2004
Background: The urban aquifers in the vicinity of Jakarta city were studied for understanding of contamination levels of shallow groundwater and its interaction with local surface waters.

3 **Project Code:** INS–5306W
Study area: Western Java geothermal areas
Sampling period: 1990
Background: Investigations of the geothermal resources of Java Island for exploitation for production of electricity were carried out using isotope geochemical tools.

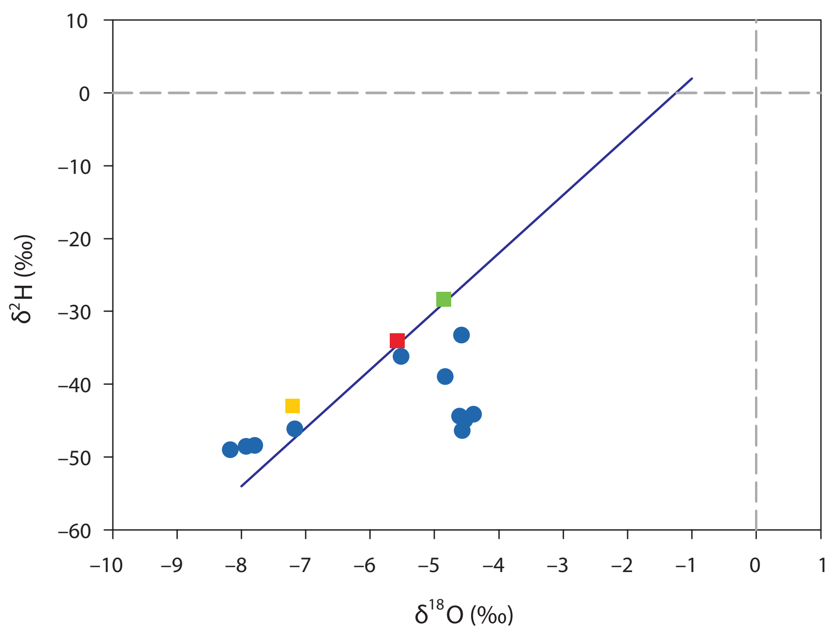
4 **Project Code:** INS–5306E
Study area: Central and Eastern Java geothermal areas
Sampling period: 1990
Background: Investigations of the geothermal resources of Java Island for exploitation for production of electricity were carried out using isotope geochemical tools.

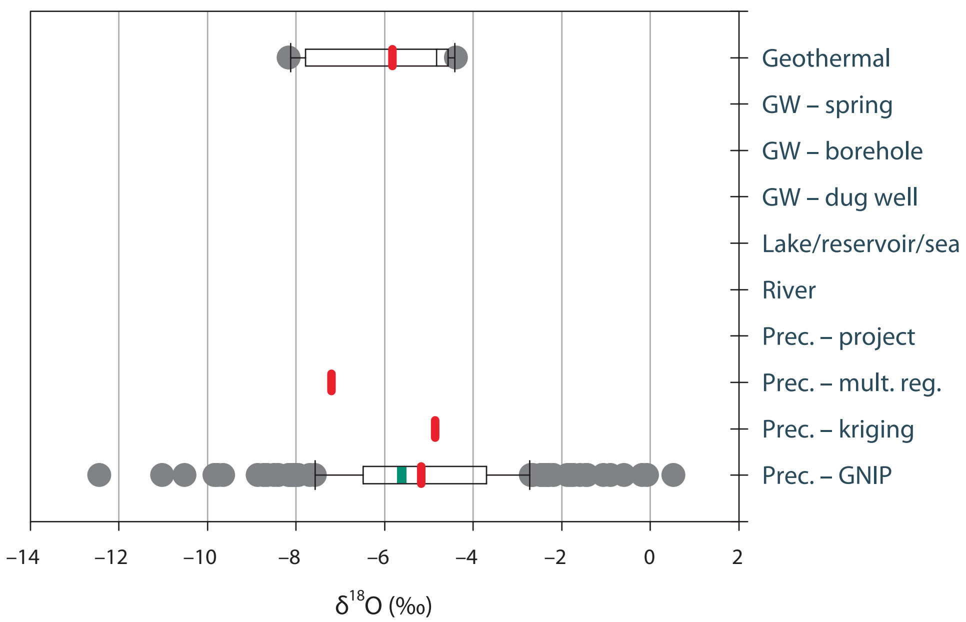
5 **Project Code:** INS–9717
Study area: Sibajak geothermal area, Sumatra
Sampling period: 1997–1998
Background: This isotope geochemical investigation was carried out in the Sibajak area of Sumatra to understand the origin of thermal waters, water-rock interactions, mixing of thermal water with cold water and to estimate subsurface reservoir temperatures.

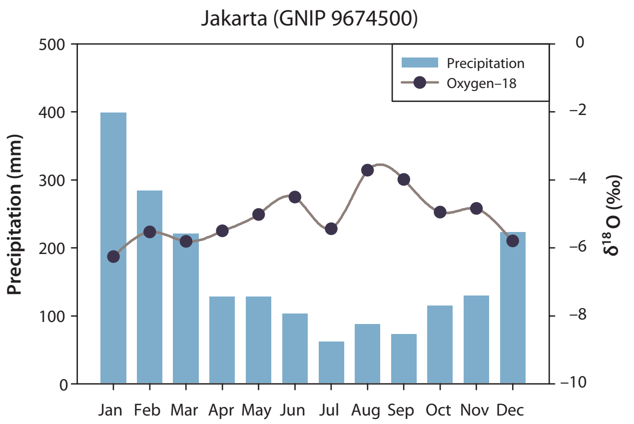
IAEA Water Resources Programme

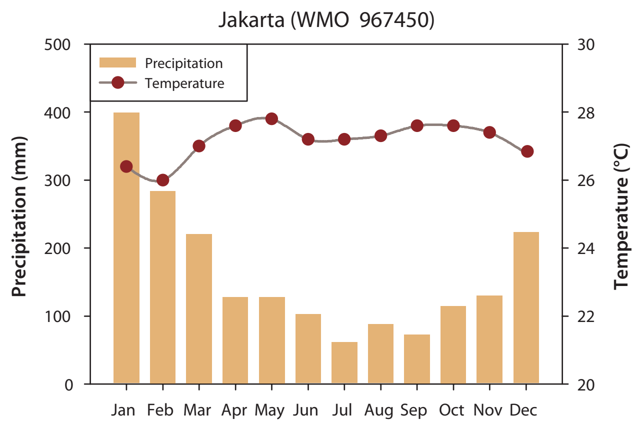
RAS8092-INS

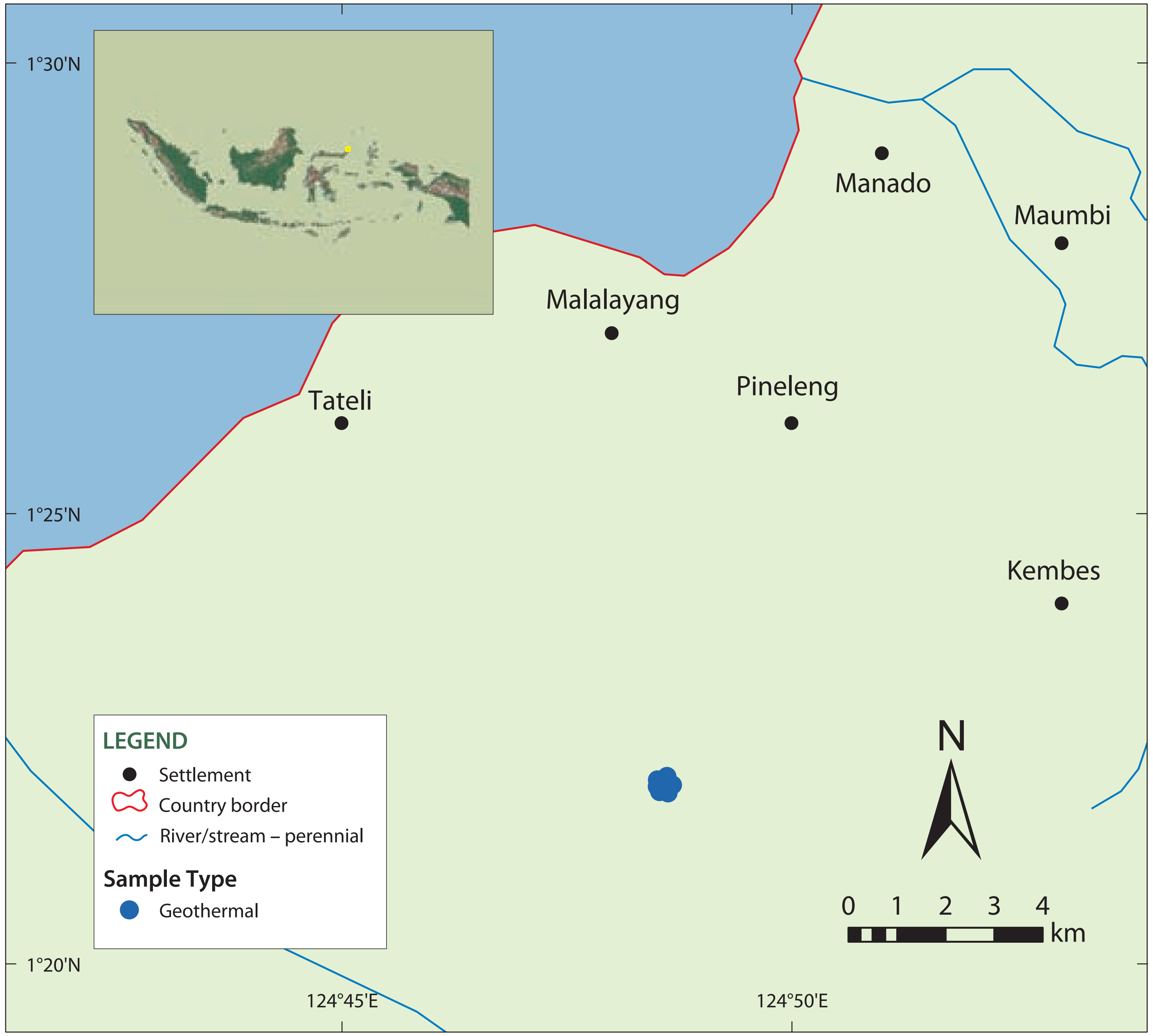
Lahendong geothermal area, Sulawesi









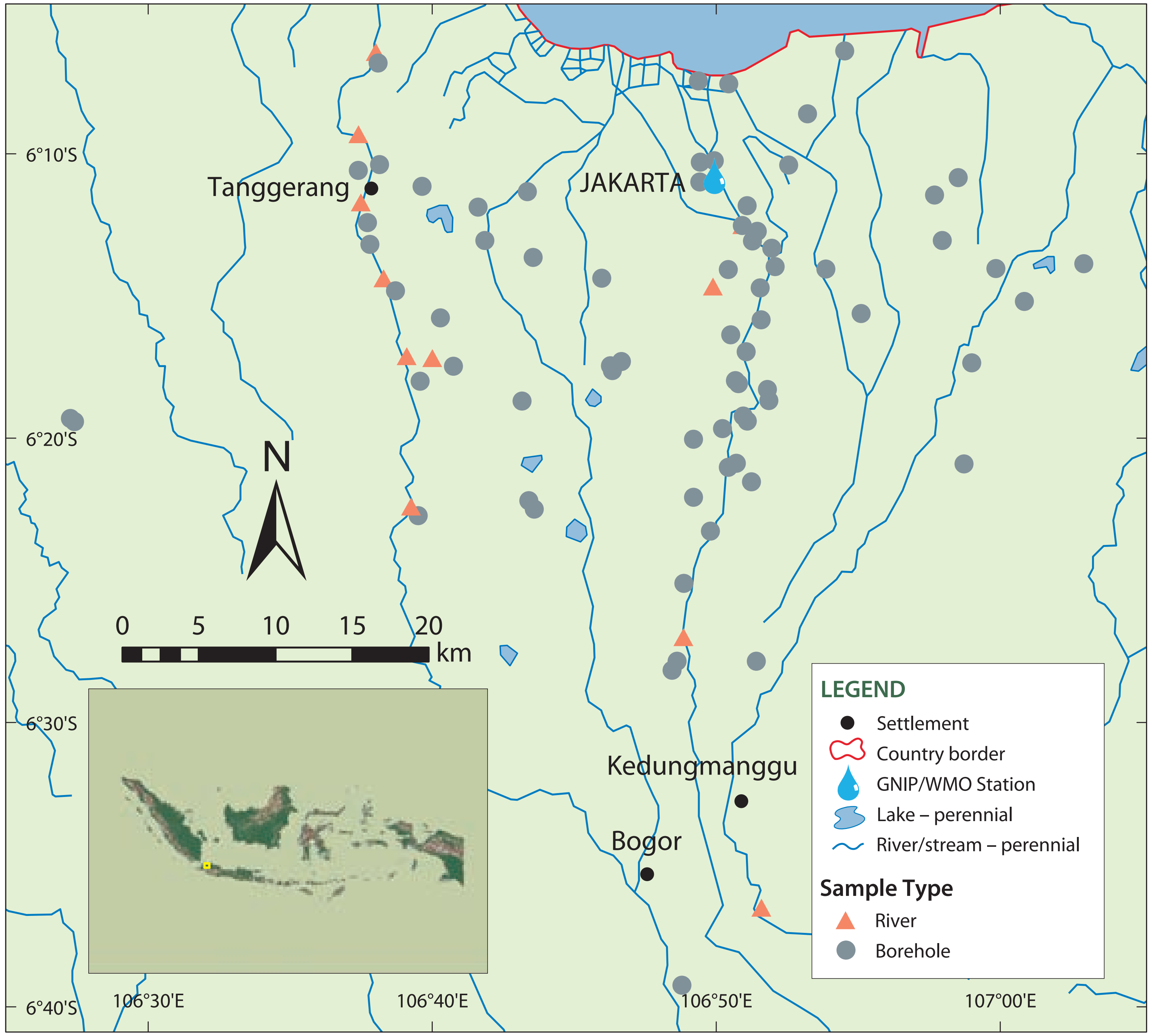


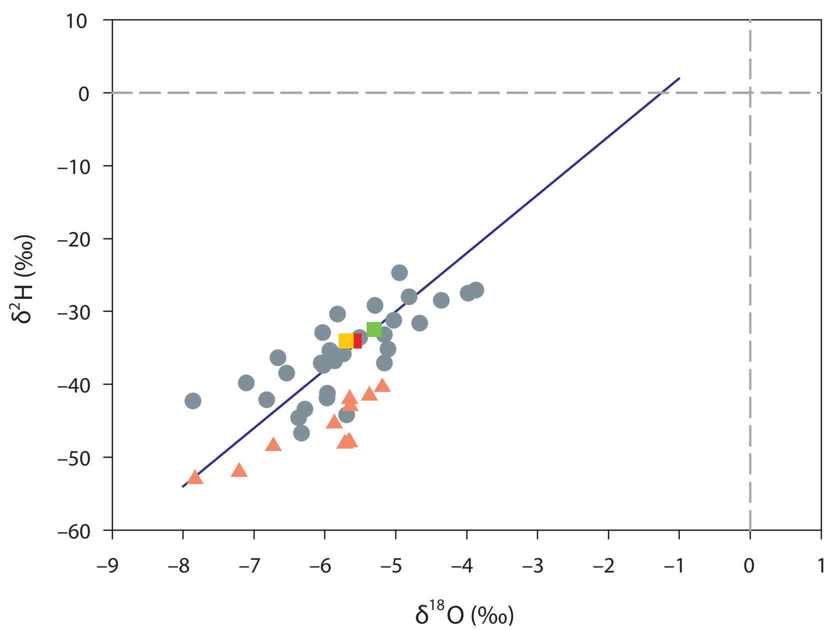
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station JAKARTA	red square	228	−5.10	−5.58 ± 1.3	228	−30.5	−34.0 ± 7.6			1735
Interpolation – multiple reg.	yellow square			−7.20			−43.0			
Interpolation – kriging (IAEA)	green square			−4.86			−28.4			
Project	pink square									

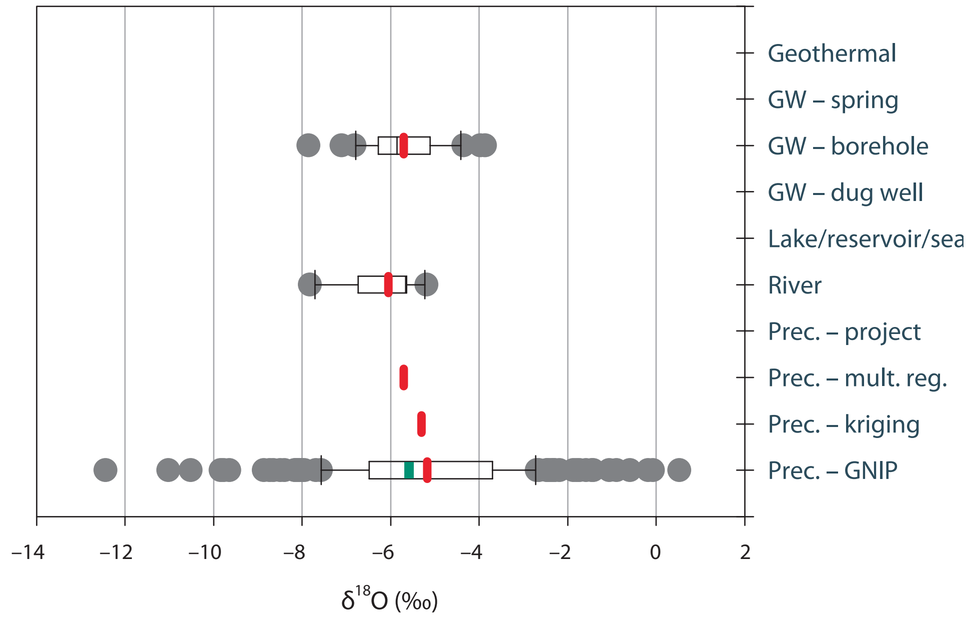
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	orange triangle								
River	salmon triangle								

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle	11	−4.83	−5.83 ± 1.6	11	−44.9	−43.7 ± 5.3				
GW–Borehole	grey circle										
GW–Dug well	brown circle										
GW–Spring	green circle										

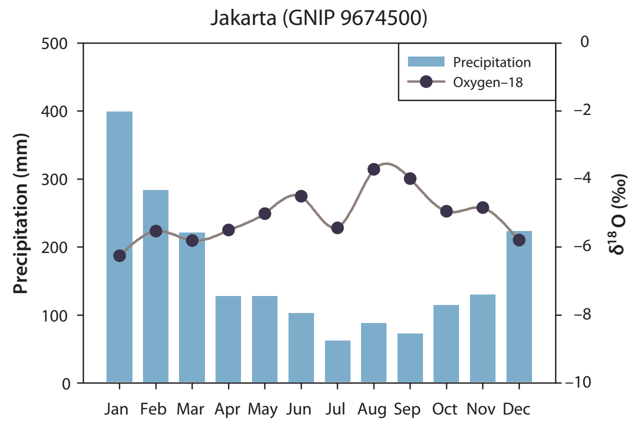
RAS8097-INS
Jakarta city area

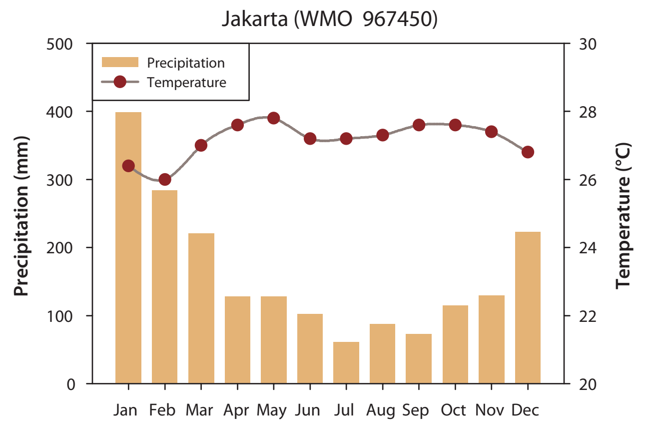






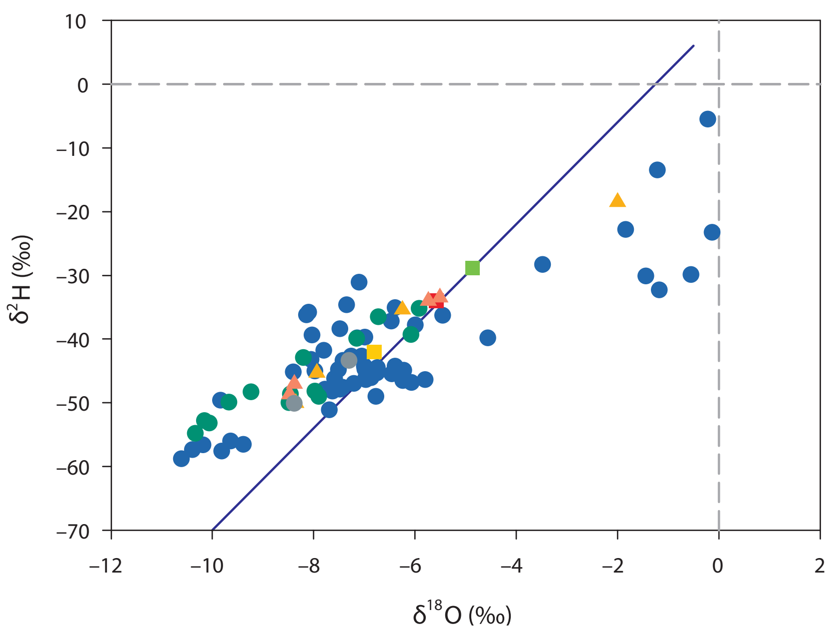
Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station JAKARTA	■ (red)	228	−5.10	−5.58 ± 1.3	228	−30.5	−34.0 ± 7.6			1735	
Interpolation – multiple reg.	■ (yellow)			−5.70			−34.0				
Interpolation – kriging (IAEA)	■ (green)			−5.30			−32.4				
Project	■ (pink)										
Surface waters		**δ18O** n	Median	Mean ± St. dev.	**δ2H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea	▲ (yellow)										
River	▲ (orange)	11	−5.66	−6.05 ± 0.8	11	−47.9	−46.3 ± 4.2				
Groundwaters		**δ18O** n	Median	Mean ± St. dev.	**δ2H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**14C (pMC)** n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	31	−5.86	−5.71 ± 0.9	37	−35.4	−34.7 ± 6.3			29	22 ± 31
GW–Dug well	● (brown)										
GW–Spring	● (green)										

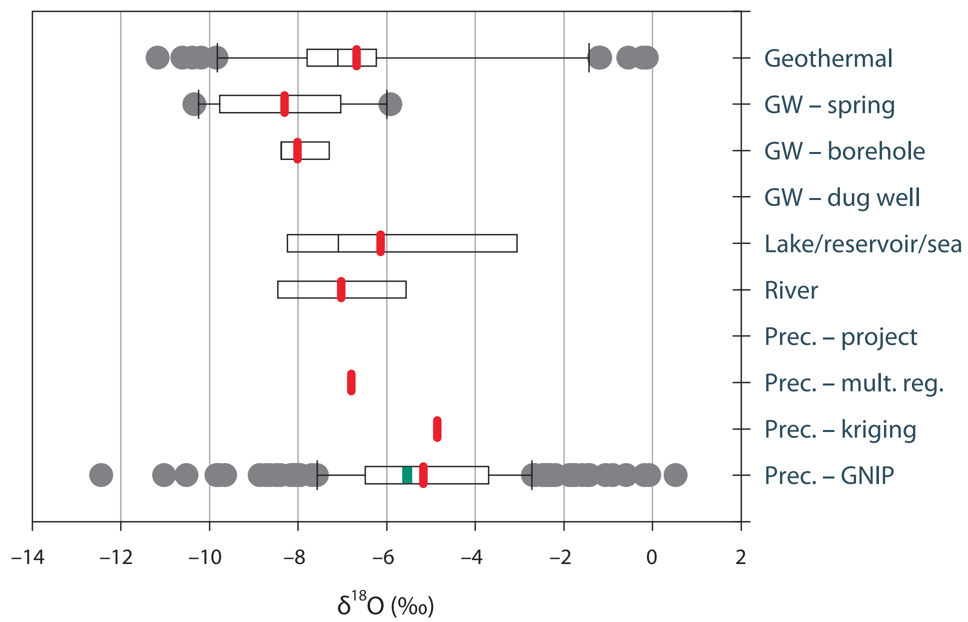


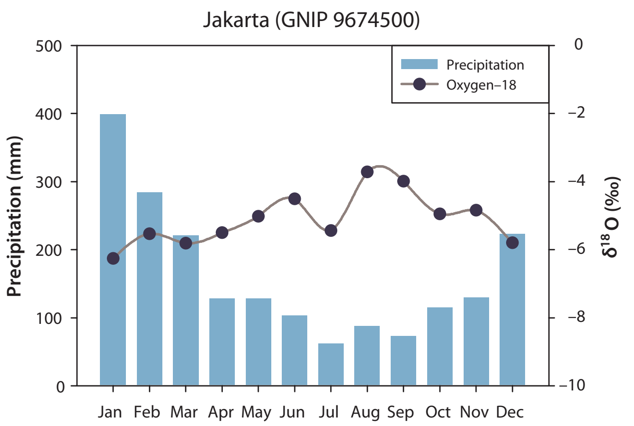


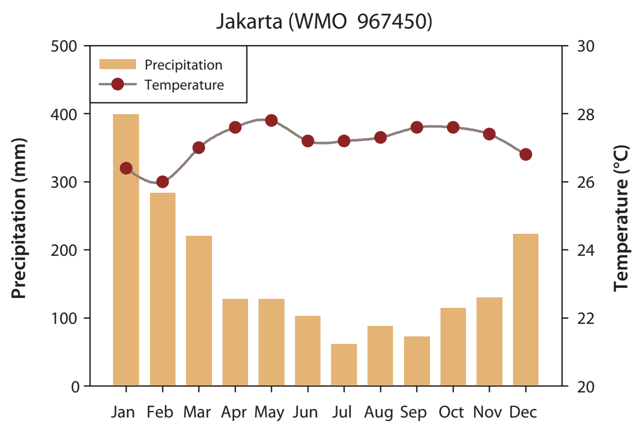
INS–5306W

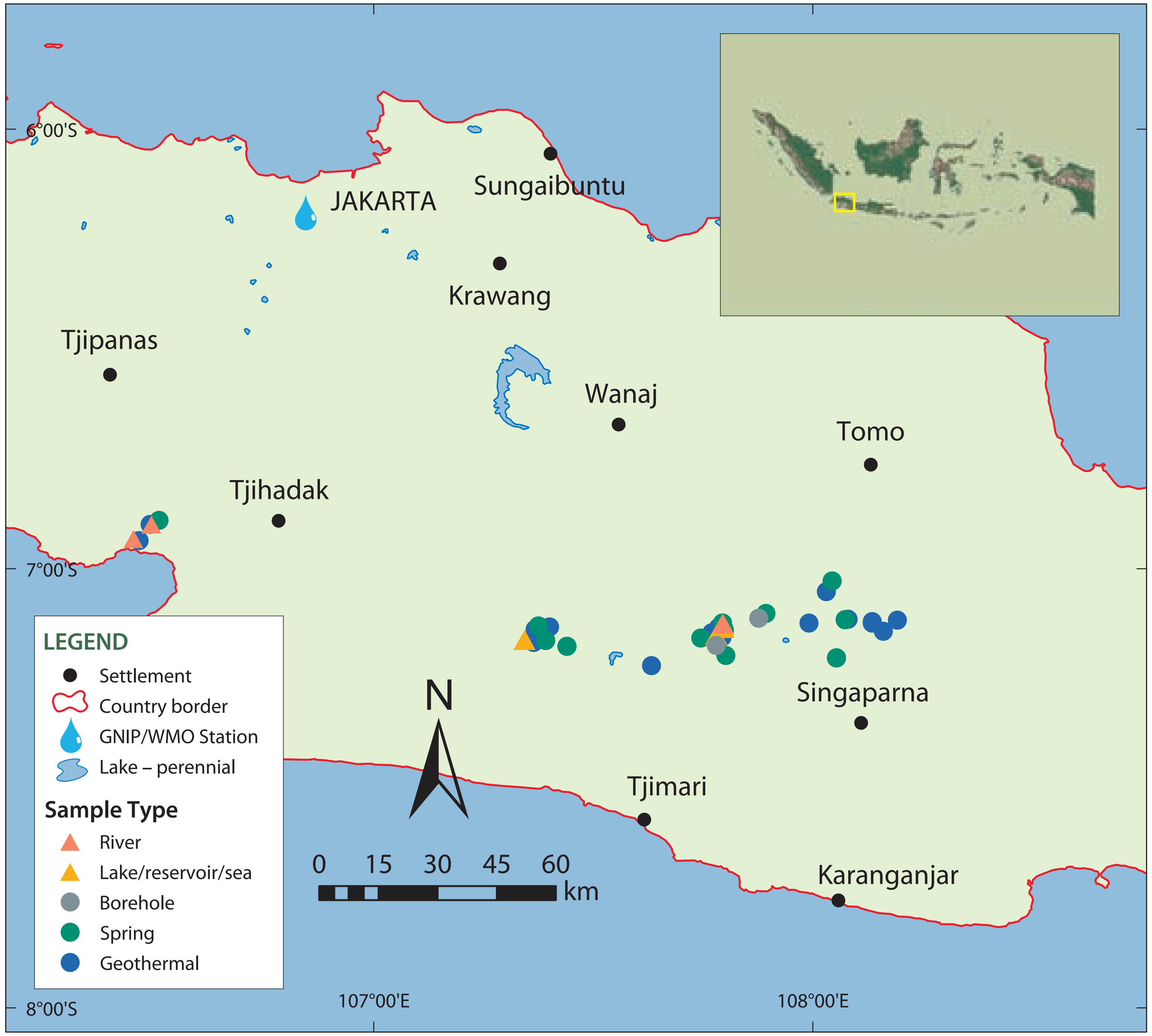
Western Java geothermal areas







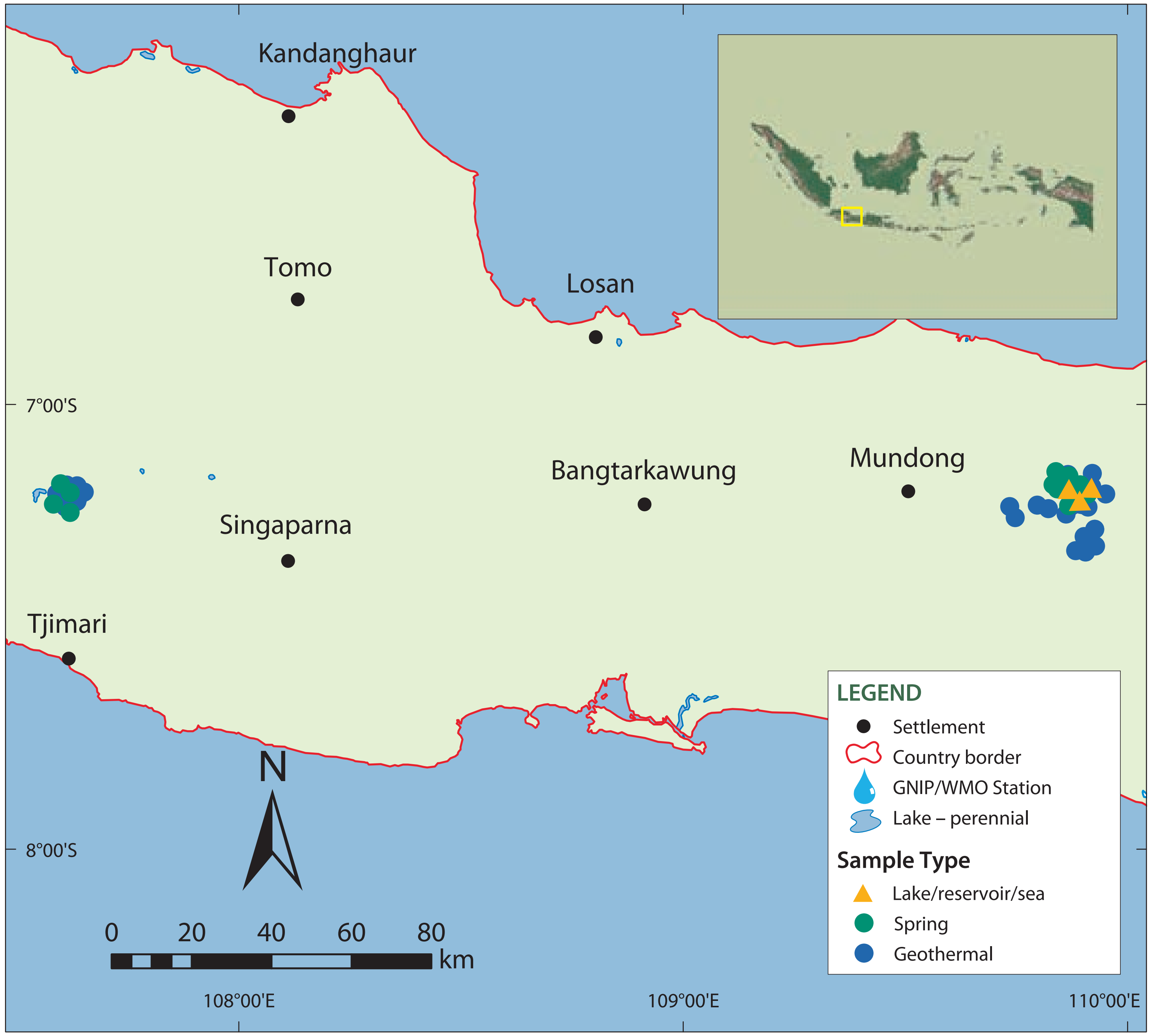




Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station JAKARTA	■	228	−5.10	−4.45 ± 1.3	228	−30.5	−31.8 ± 7.6			1735
Interpolation – multiple reg.	■			−6.80			−42.0			
Interpolation – kriging (IAEA)	■			−4.86			−28.8			
Project	■									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲	5	−6.25	−5.28 ± 3.2	4	−40.4	−37.3 ± 13.9	5	2.0 ± 1.8
River	▲	4	−7.06	−7.03 ± 1.6	4	−40.5	−40.8 ± 8.2	3	3.0 ± 1.0

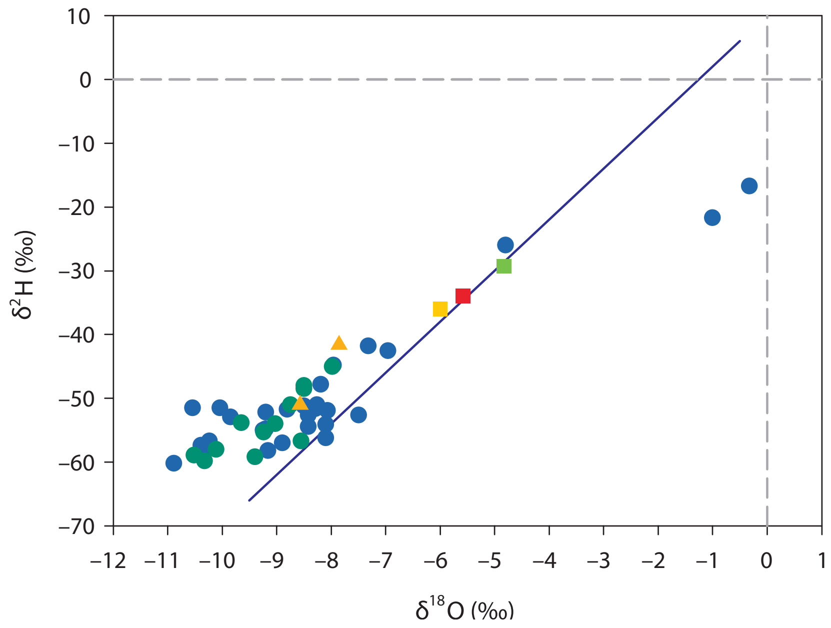
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●	59	−7.10	−6.68 ± 2.5	65	−44.3	−41.5 ± 10.7	62	2.7 ± 4.3		
GW–Borehole	●	2	−7.84	−7.84 ± 0.8	2	−46.8	−46.8 ± 4.7				
GW–Dug well	●										
GW–Spring	●	14	−8.33	−8.31 ± 1.5	15	−48.3	−42.7 ± 15.3	13	2.7 ± 1.7		

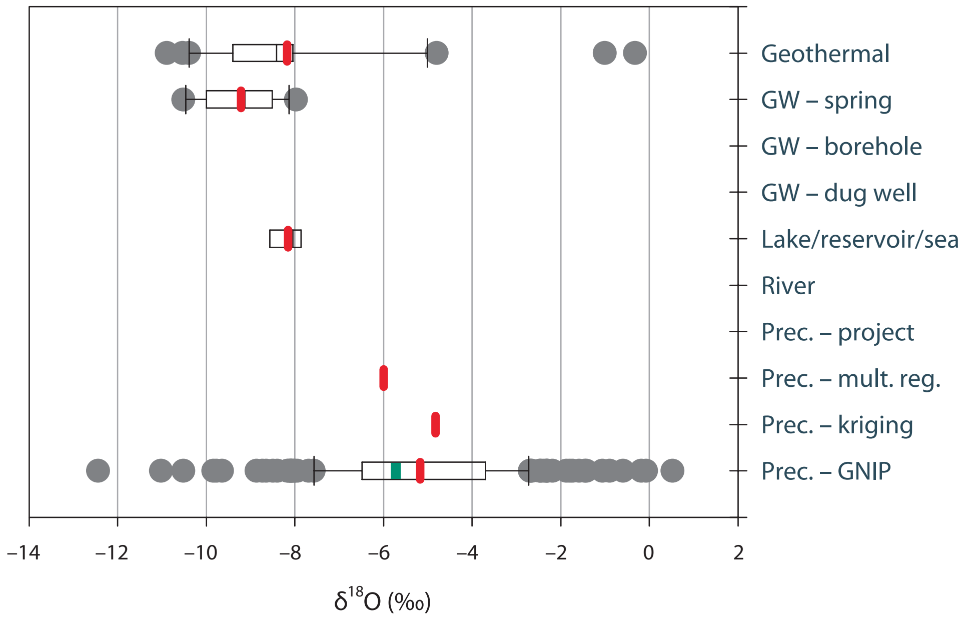


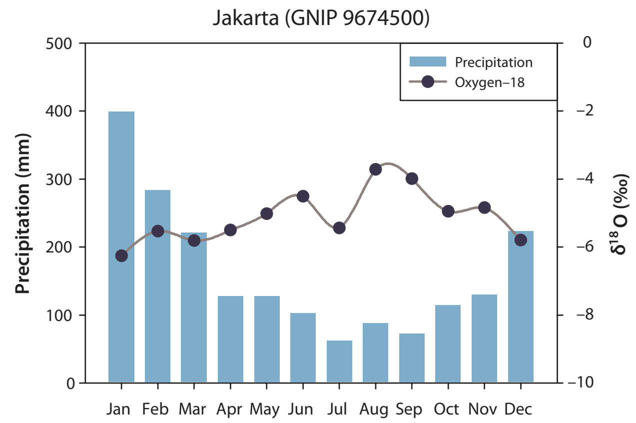
Precipitation		$\delta^{18}O$ (‰)			$\delta^{2}H$ (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station JAKARTA	■ (red)	228	−5.10	−5.58 ± 1.3	228	−30.5	−34.0 ± −7.6			1735
Interpolation – multiple reg.	■ (yellow)			−6.00			−36.0			
Interpolation – kriging (IAEA)	■ (green)			−4.83			−29.3			
Project	■ (pink)									

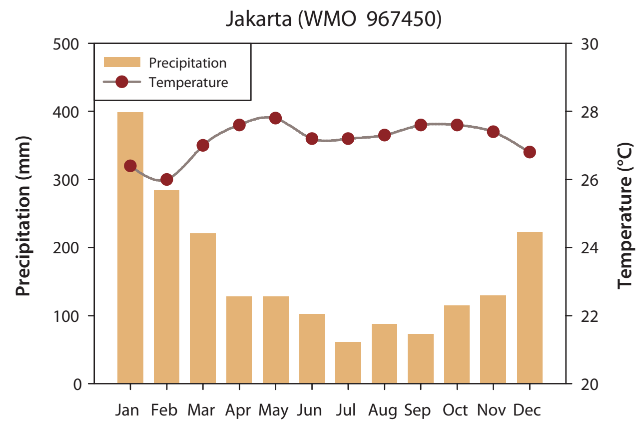
Surface waters		$\delta^{18}O$			$\delta^{2}H$			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)	2	−8.22	−8.22 ± 0.5	3	−41.6	−42.9 ± 7.5	2	4.3 ± 2.3
River	▲ (light orange)								

Groundwaters		$\delta^{18}O$			$\delta^{2}H$			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)	30	−8.42	−8.18 ± 2.4	37	−51.7	−47.9 ± 11.4	24	1.7 ± 1.3		
GW–Borehole	● (grey)										
GW–Dug well	● (brown)										
GW–Spring	● (green)	12	−9.14	−9.21 ± 0.8	12	−54.6	−54.0 ± 4.9	10	2.2 ± 1.3		



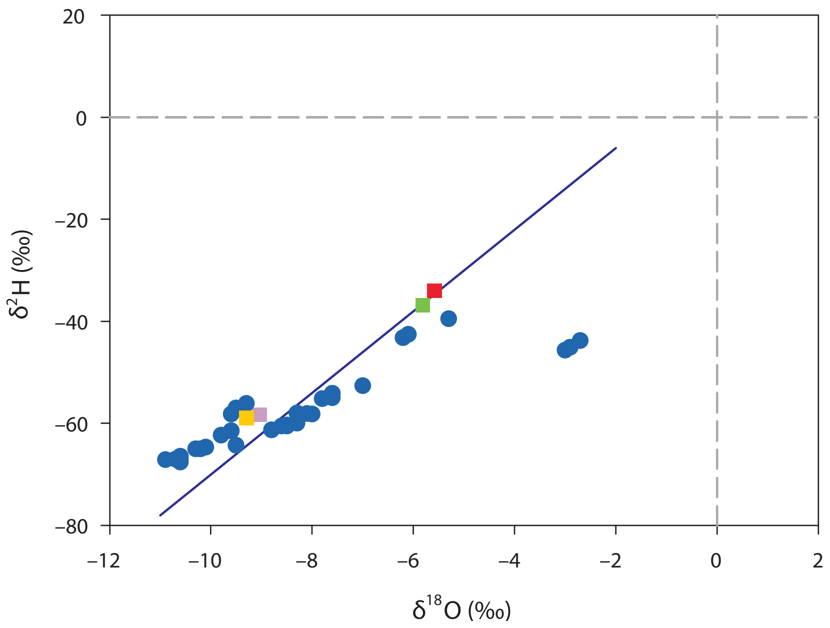


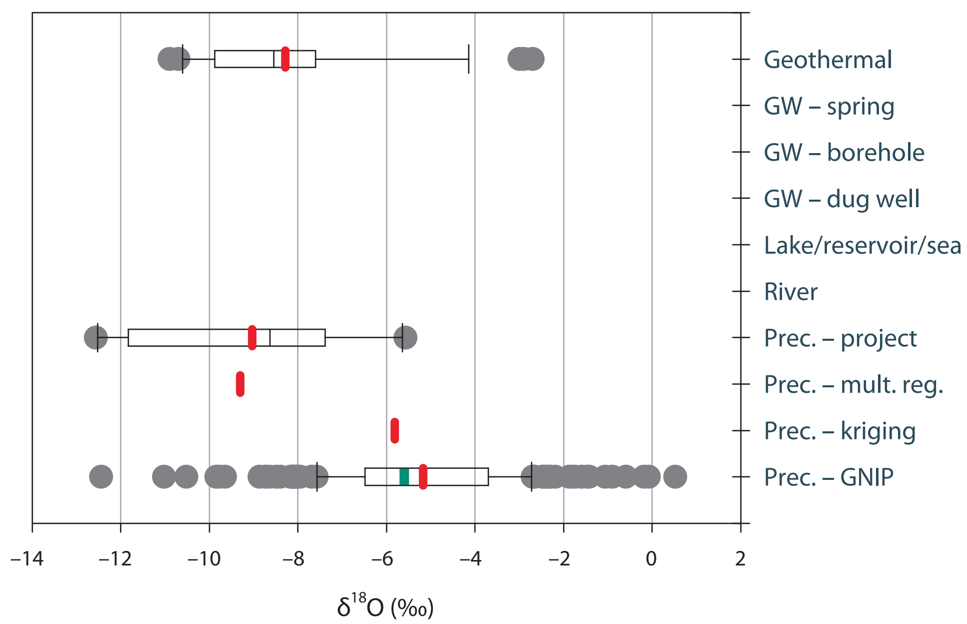


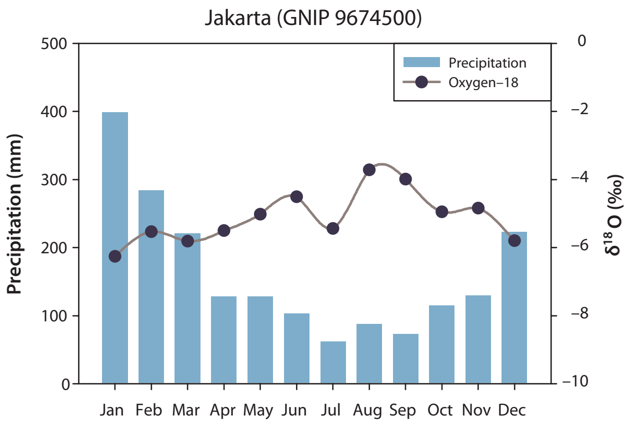


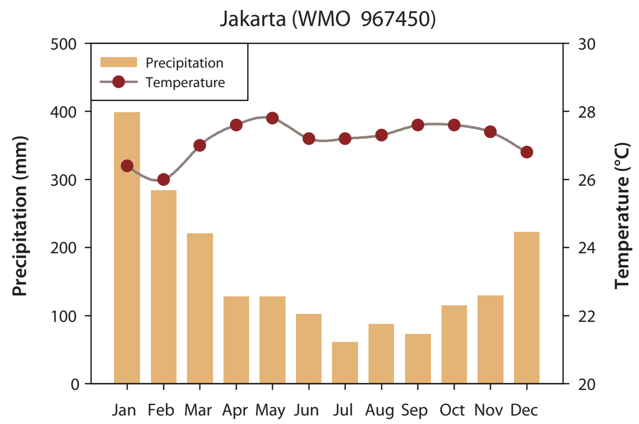
INS–9717

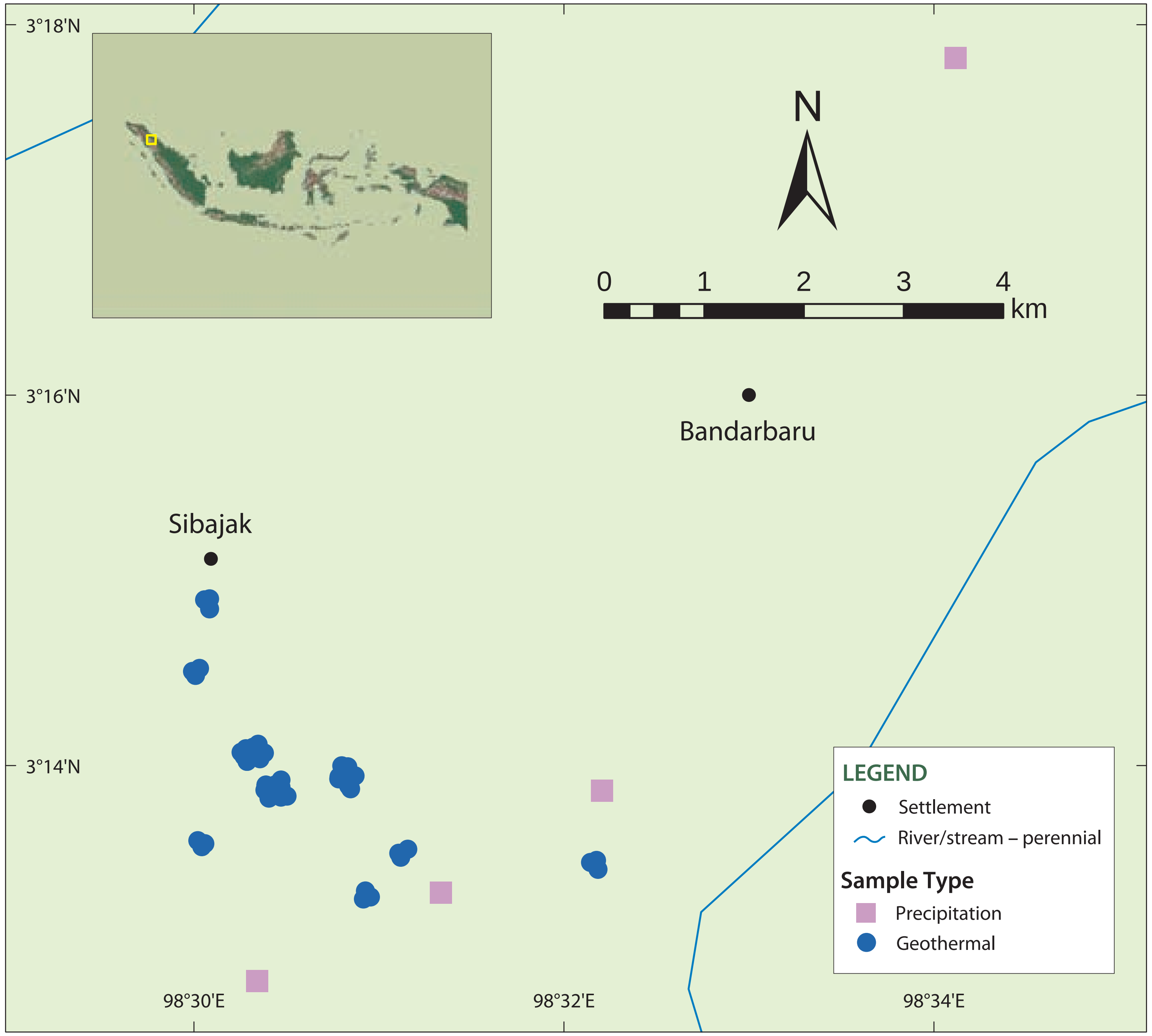
Sibajak geothermal area, Sumatra







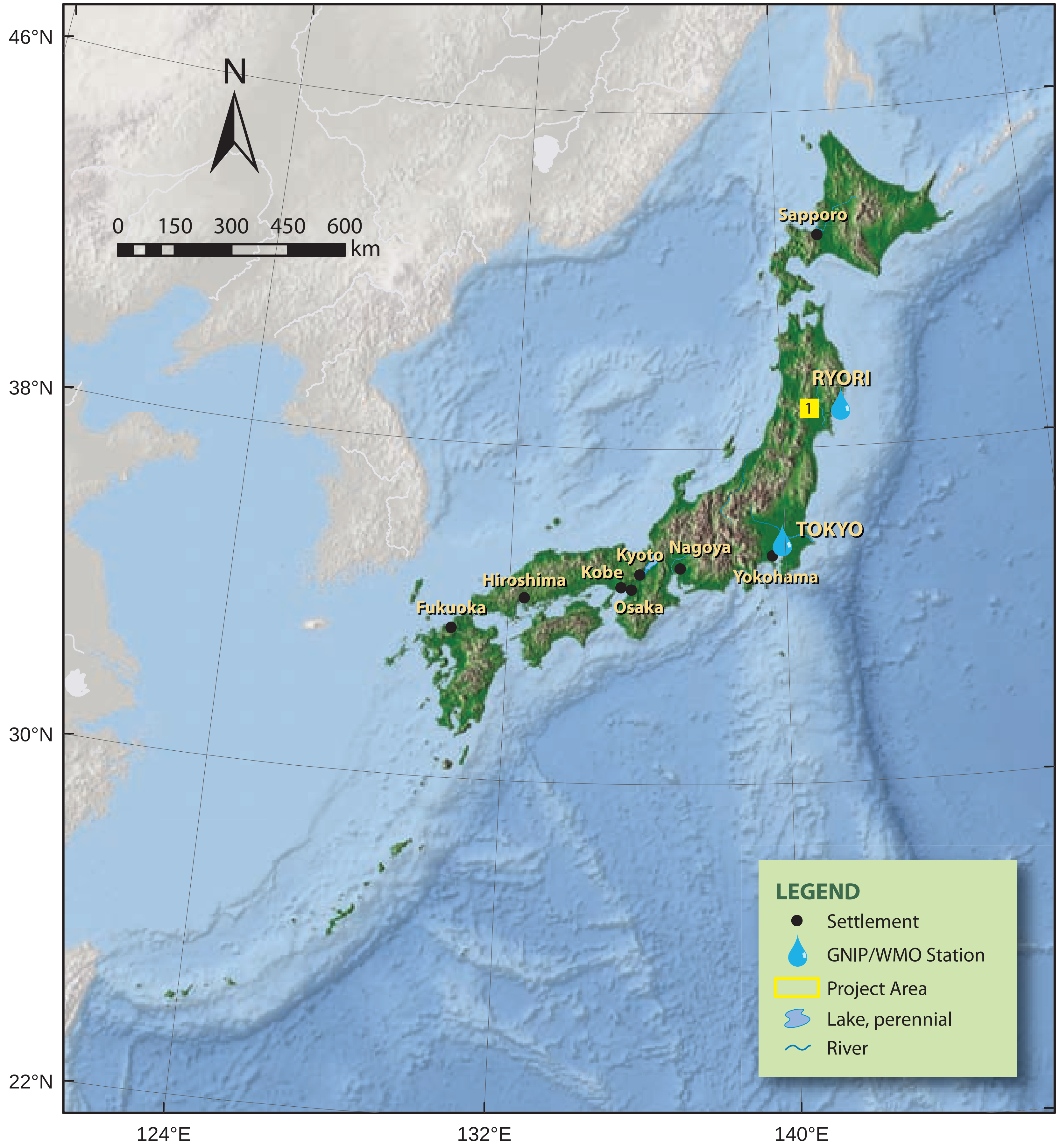




Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station JAKARTA	■ (red)	228	−5.10	−5.58 ± 1.3	228	−30.5	−34.0 ± 7.6			1735
Interpolation – multiple reg.	■ (yellow)			−9.30			−59.0			
Interpolation – kriging (IAEA)	■ (green)			−5.81			−36.84			
Project	■ (pink)	12	−8.63	−9.04 ± 2.5	12	−56.2	−58.3 ± 18.7			

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲								
River	▲								

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●	34	−8.55	−8.29 ± 2.2	34	−59.1	−57.6 ± 7.9				
GW–Borehole	●										
GW–Dug well	●										
GW–Spring	●										

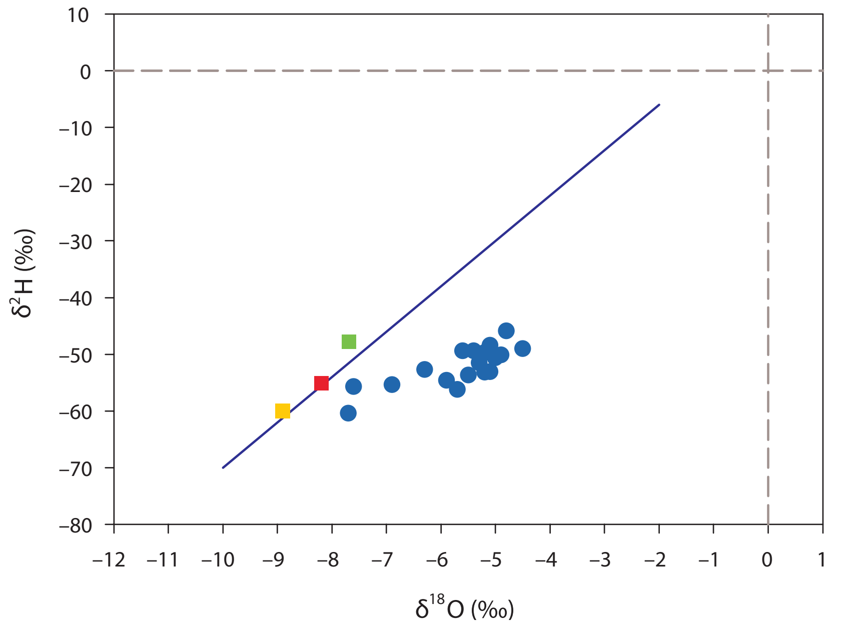


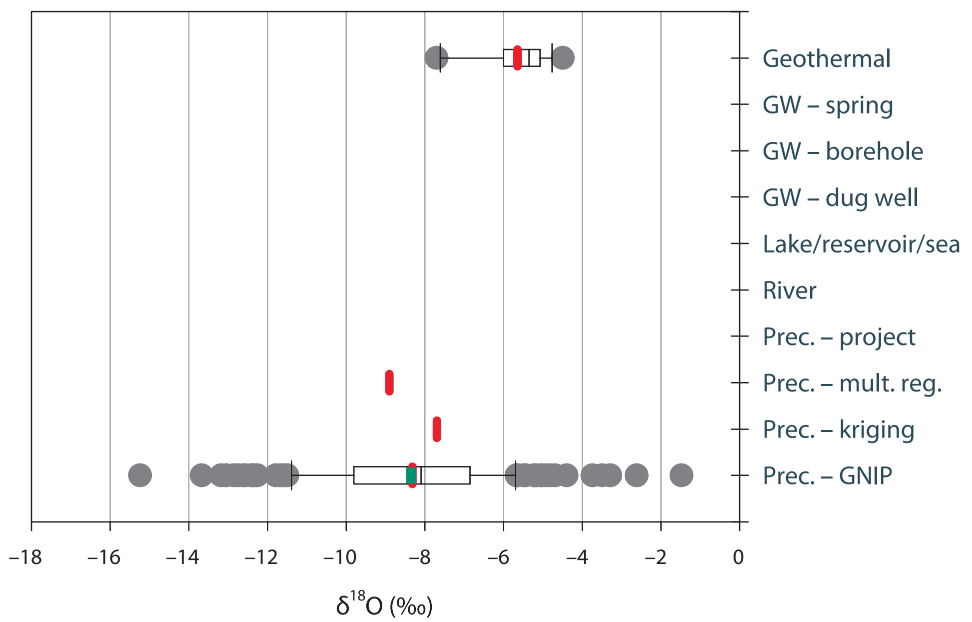
1 **Project Code:** JPN-10230
Study area: Onikobe geothermal area
Sampling period: 1984-1998
Background: Interaction of injected fluids with geothermal fluids was studied in the operative Onikobe geothermal reservoir area for the sustainability of the production plant.

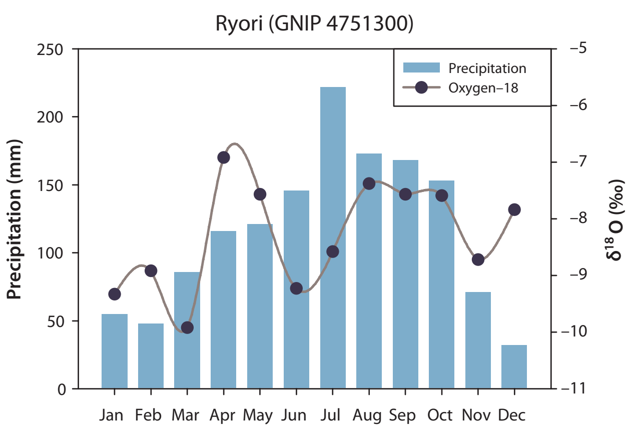
IAEA Water Resources Programme

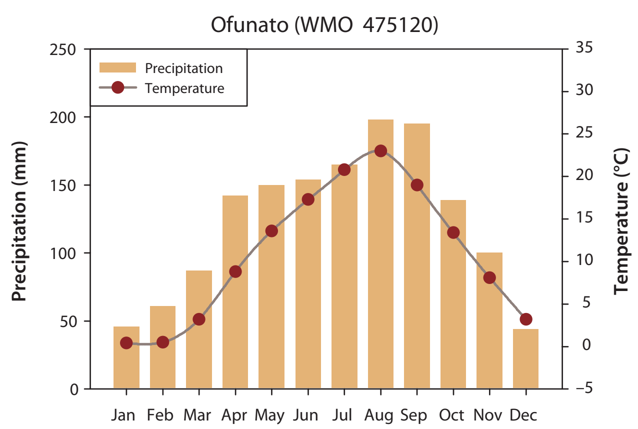
JPN-10230

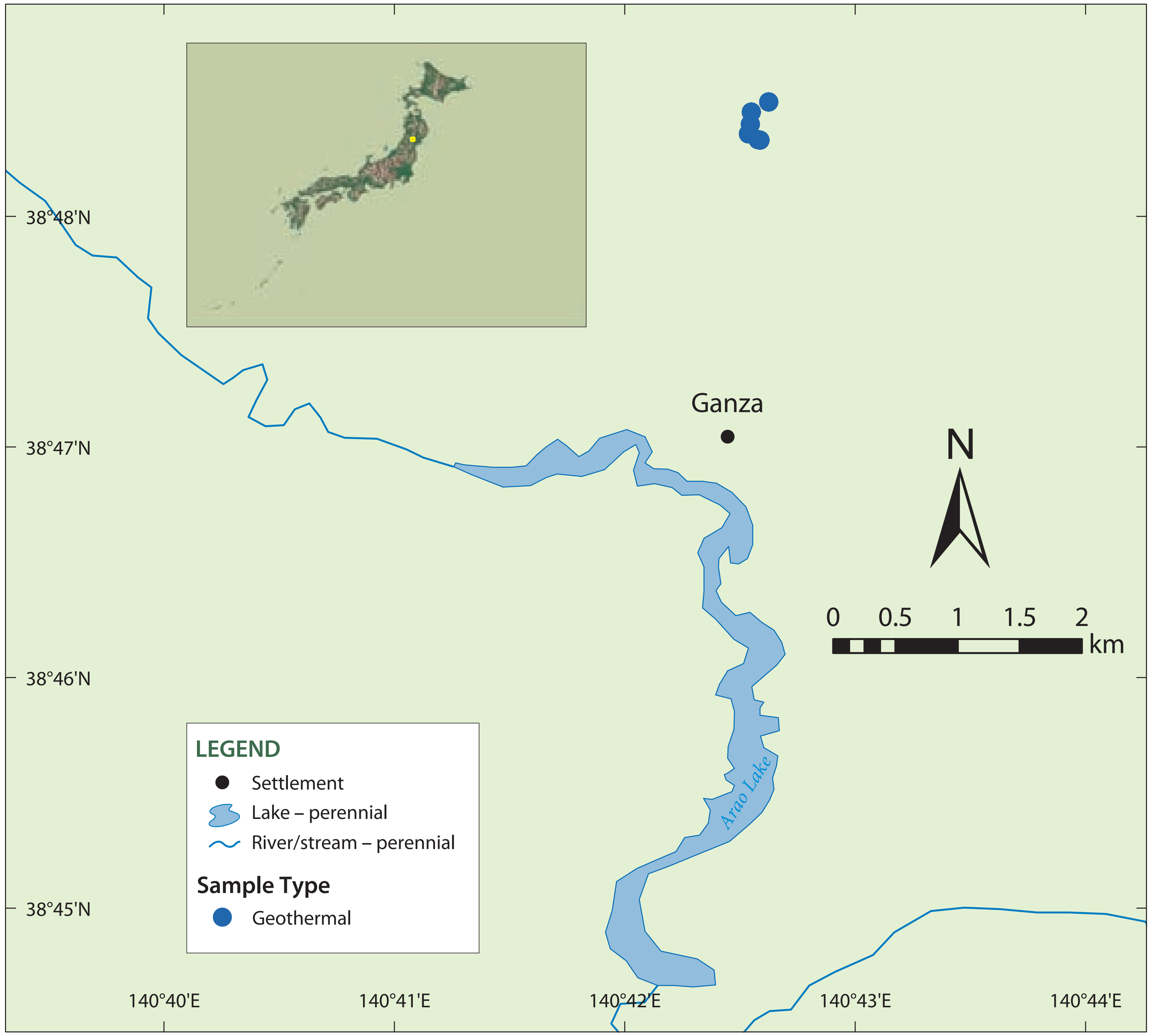
Onikobe geothermal area







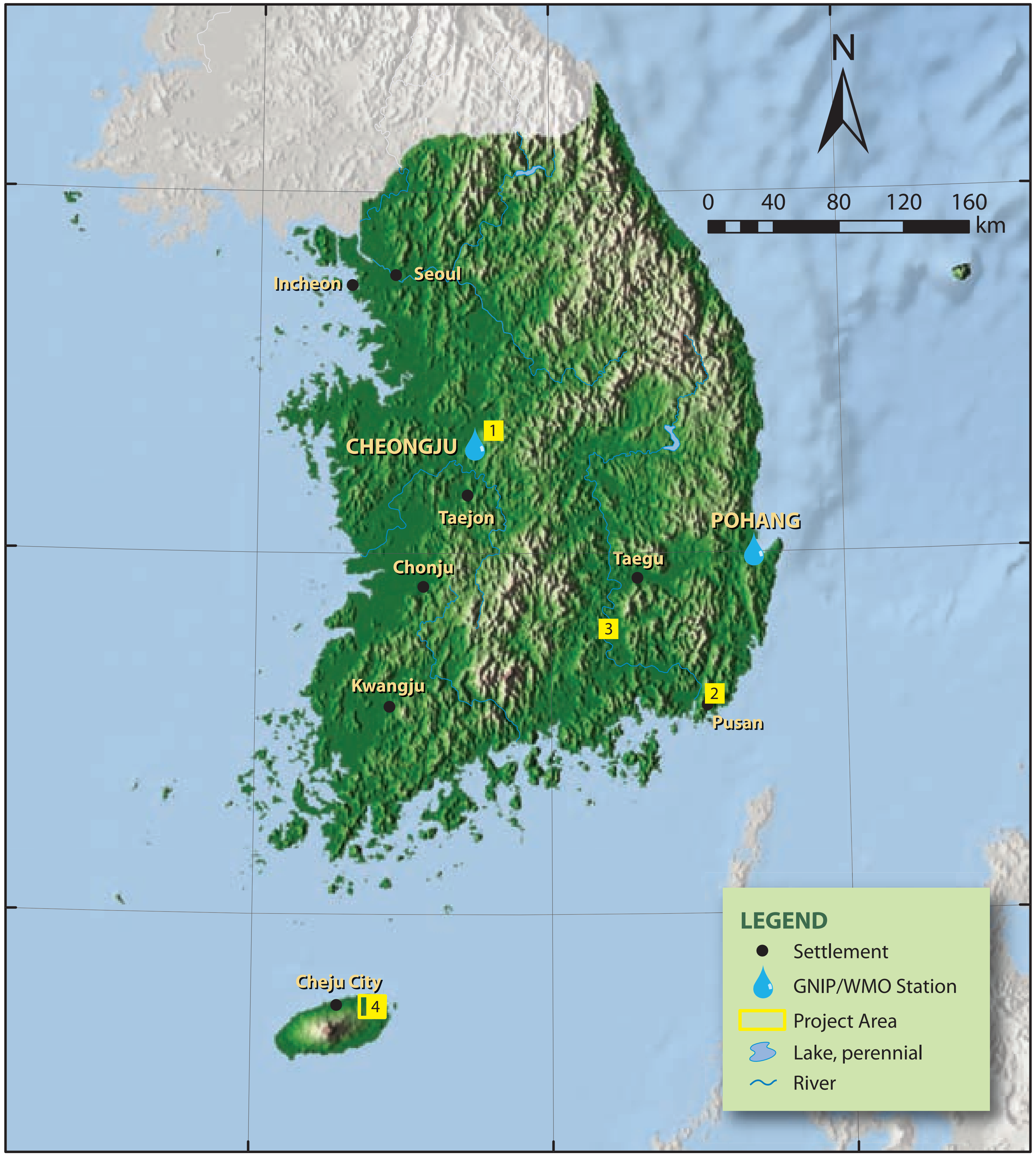




Precipitation		δ¹⁸O (‰) n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H (‰) n	δ²H Median	δ²H Mean ± St. dev.	Tritium (TU) n	Tritium Mean ± St. dev.	Annual prec. (mm)
GNIP station RYORI	red square	183	−8.10	−8.19 ± 1.2	186	−52.6	−55.1 ± 8.2			1228
Interpolation – multiple reg.	yellow square			−8.90			−60.0			
Interpolation – kriging (IAEA)	green square			−7.69			−47.8			
Project	pink square									

Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	orange triangle								
River	salmon triangle								

Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C Mean ± St. dev.
Geothermal water	blue circle	18	−5.35	−5.65 ± 0.9	18	−52.1	−52.2 ± 3.5				
GW–Borehole	grey circle										
GW–Dug well	brown circle										
GW–Spring	green circle										



1 **Project Code:** RAS8084–ROK
Study area: Chojeong area
Sampling period: 1998
Background: The objective of the study was to understand the geochemical evolution of carbonate waters. Hydrochemical information and isotope parameters were used as a confidence building tool for the development of a conceptual groundwater model of local aquifers.

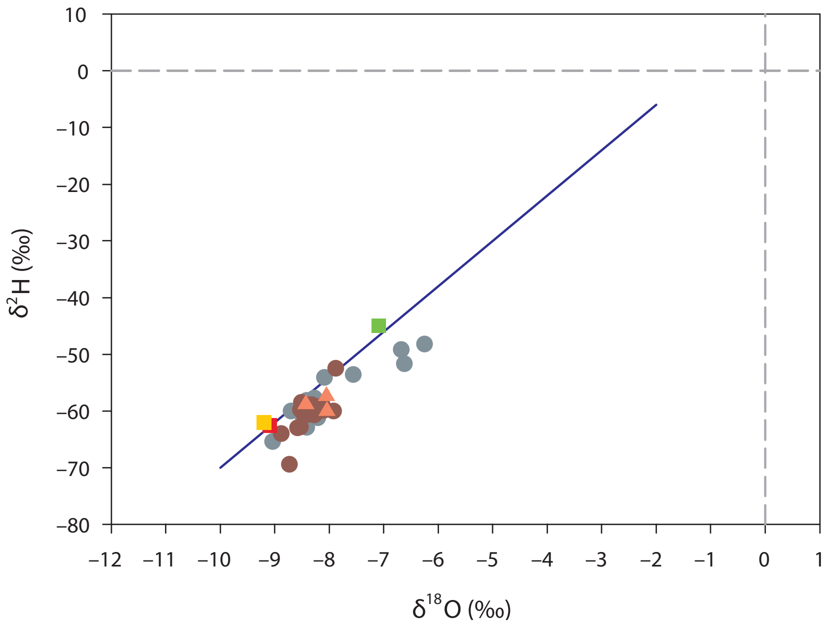
2 **Project Code:** RAS8092–ROK
Study area: Pusan geothermal areas
Sampling period: 1999–2003
Background: The geochemical and isotopic characteristics of the geothermal waters were studied for understanding the origin of thermal springs, water-rock interactions, mixing of thermal water with cold meteoric water as well as for estimation of geothermal reservoir temperatures.

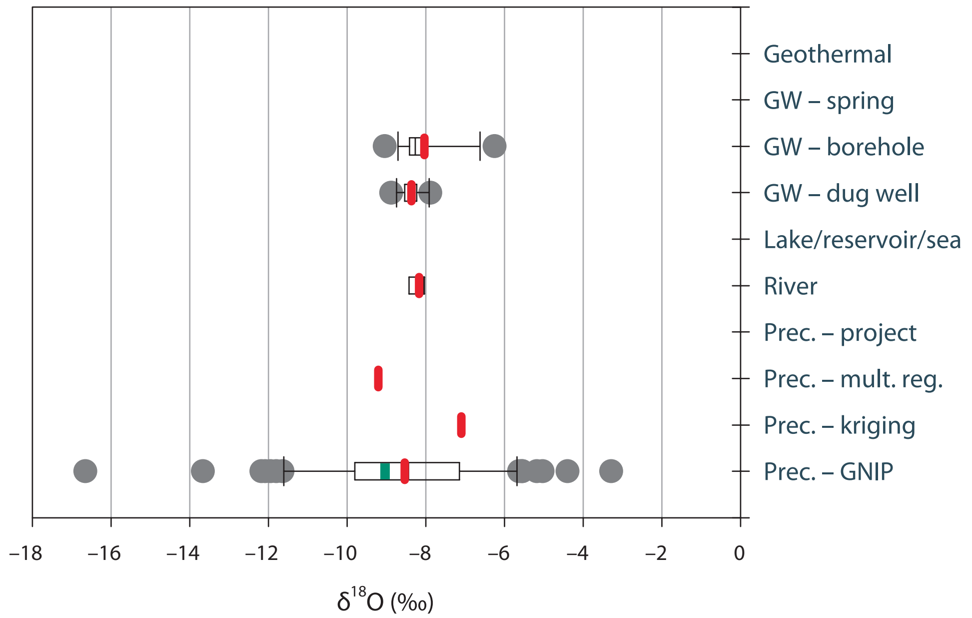
3 **Project Code:** RAS8097–ROK
Study area: Yuseong aquifers
Sampling period: 2005–2006
Background: Groundwater dynamics was studied using isotope geochemical tools for characterizing origin and pathways of fluorine in groundwater in the hard rock aquifers of Yuseong area.

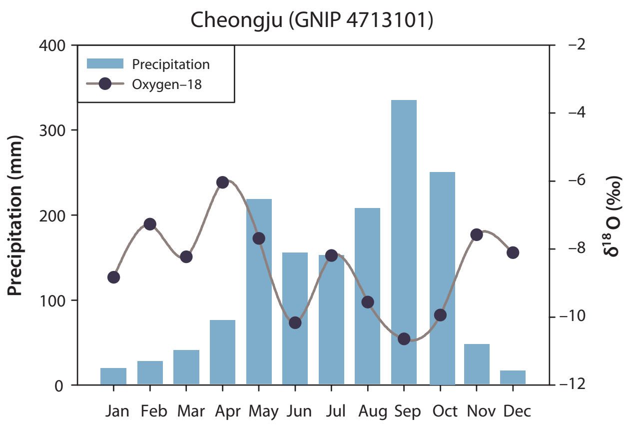
4 **Project Code:** ROK–11323
Study area: Cheju Island coastal aquifers
Sampling period: 2001
Background: Multi-isotope fingerprinting approach was employed in this study for understanding groundwater salinization and water-rock interactions in coastal aquifers of Cheju Island.

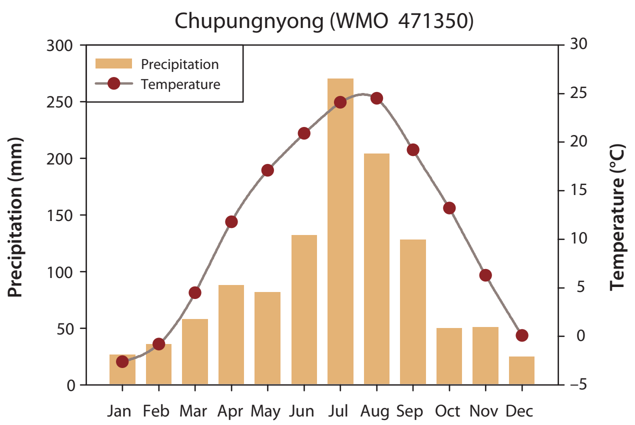
IAEA Water Resources Programme

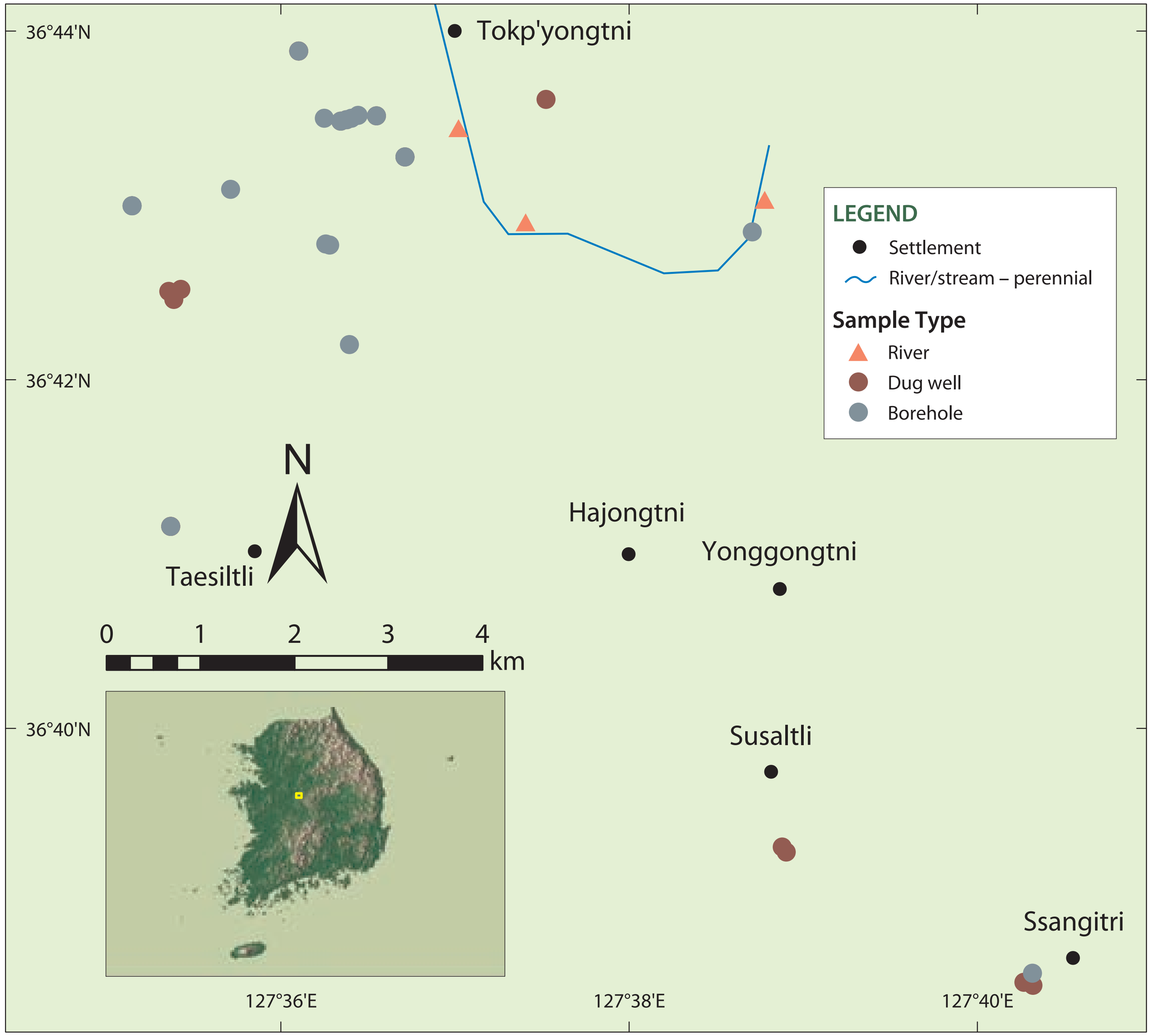
RAS8084–ROK
Chojeong area







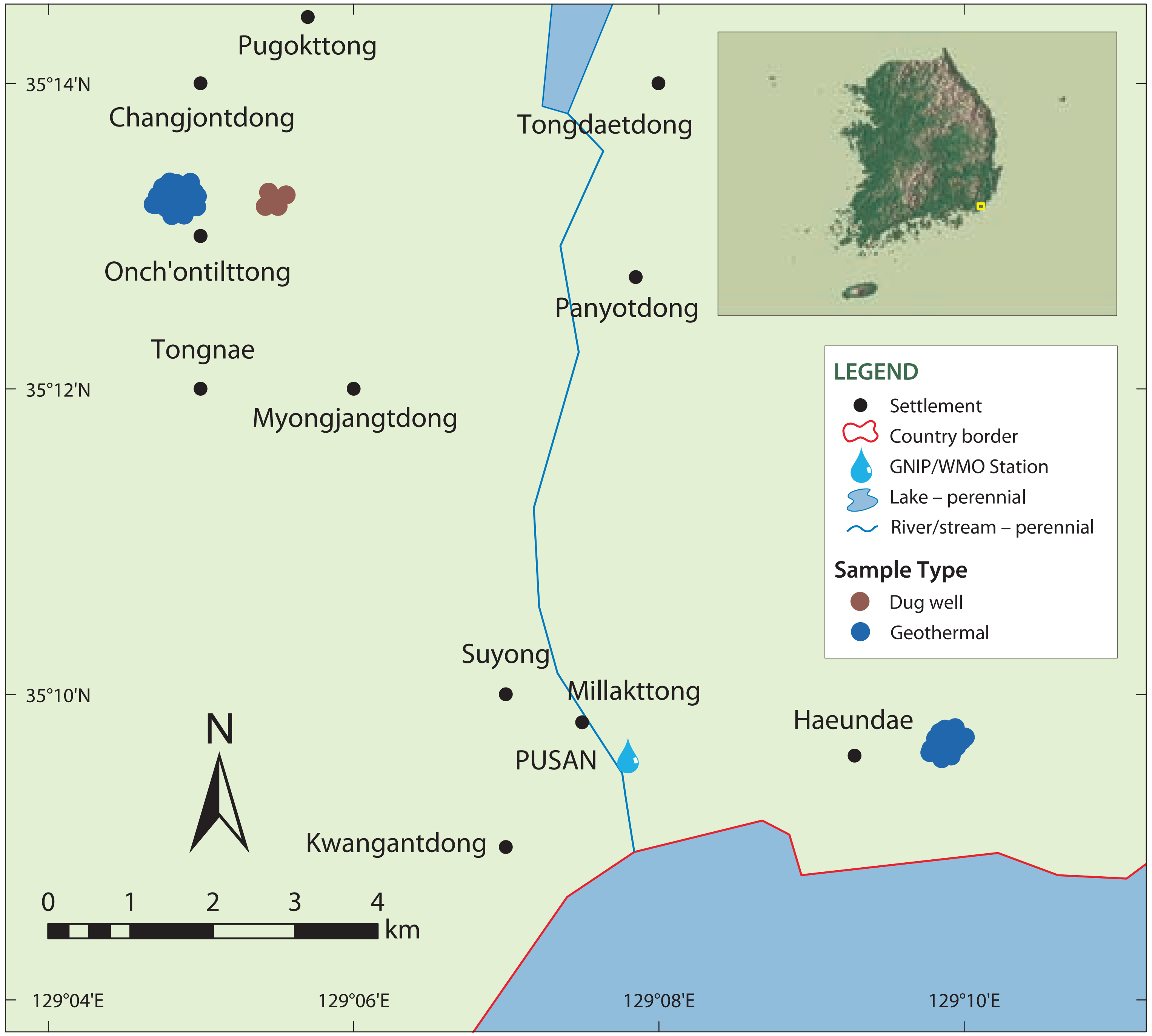


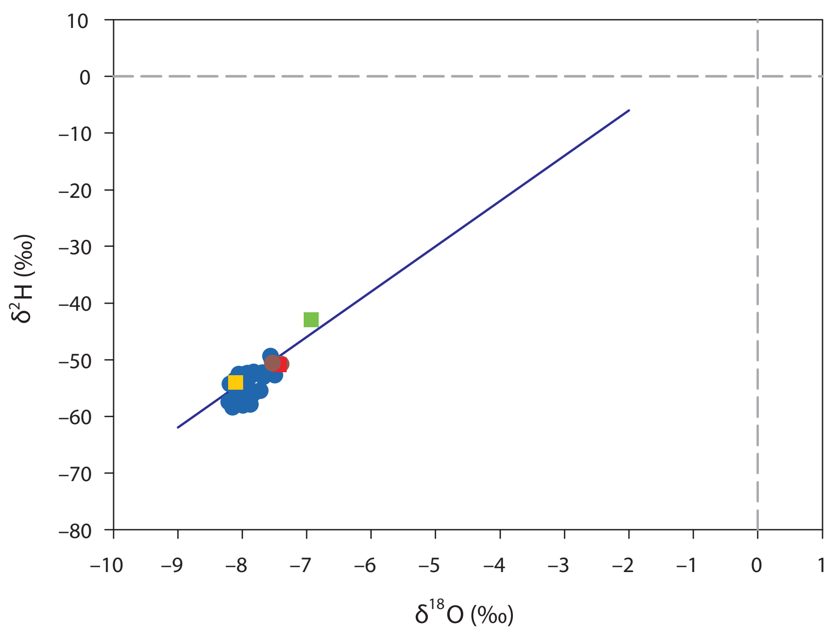


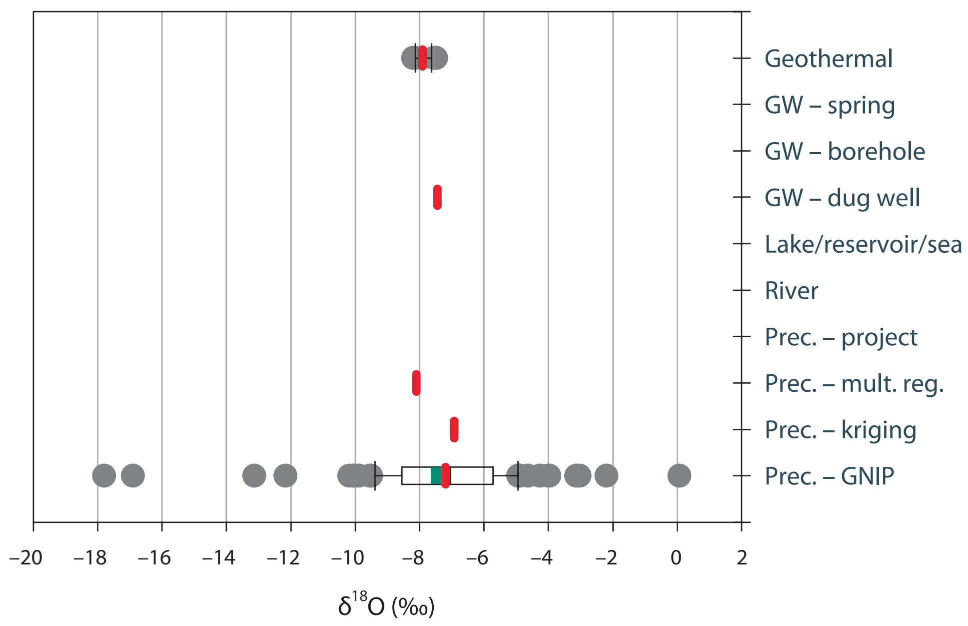
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station CHENGJU	red square	73	−8.44	−9.09 ± 3.0	73	−54.5	−62.5 ± 6.2			1244
Interpolation – multiple reg.	yellow square			−9.20			−62.0			
Interpolation – kriging (IAEA)	green square			−7.09			−44.9			
Project	pink square									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle								
River	orange triangle	3	−8.05	−8.17 ± 0.2	3	−58.8	−58.7 ± 1.3	3	10.3 ± 3.0

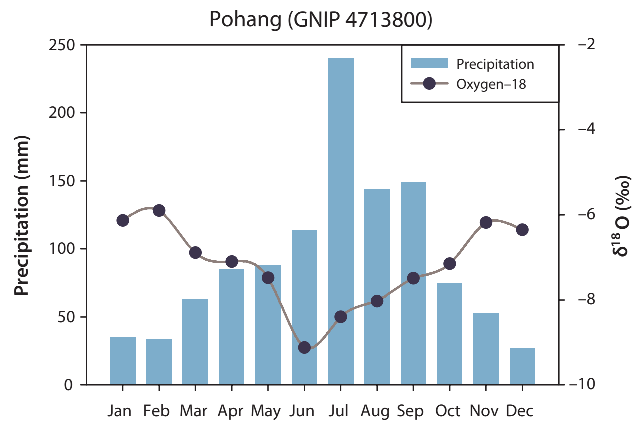
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	19	−8.27	−8.04 ± 0.7	19	−59.0	−57.8 ± 4.5	17	8.4 ± 3.5		
GW–Dug well	brown circle	18	−8.36	−8.36 ± 0.3	18	−60.0	−60.4 ± 3.3	16	6.4 ± 3.7		
GW–Spring	green circle										

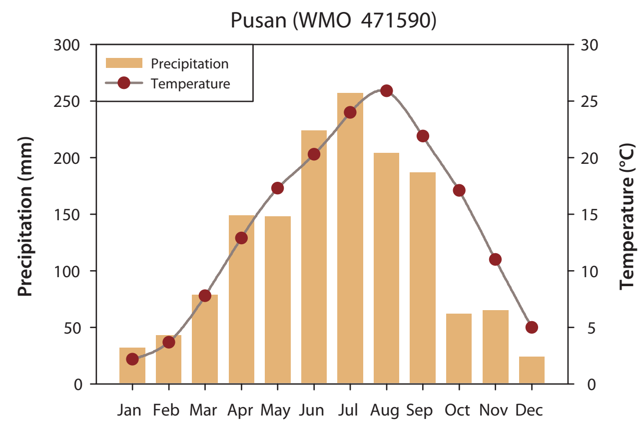






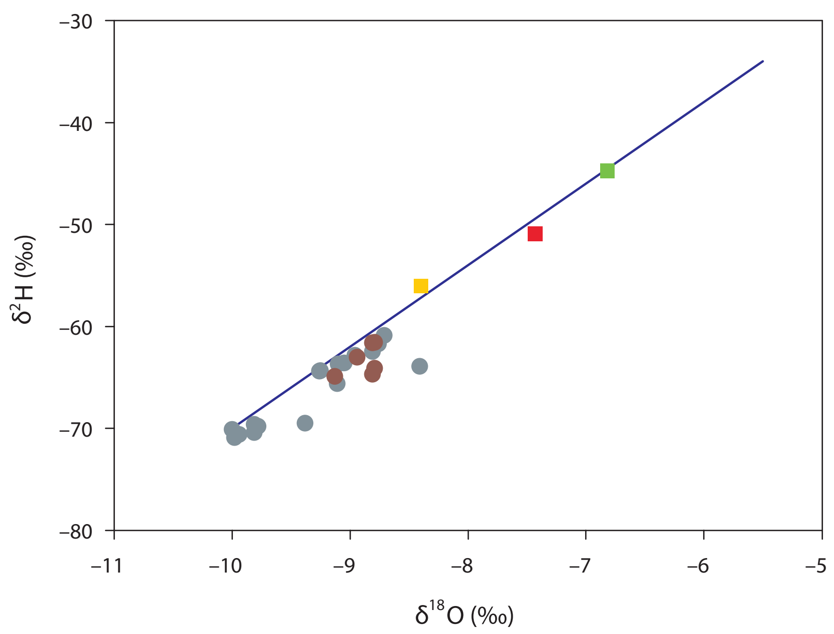
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec.	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)	
GNIP station POHANG		110	−7.05	−7.43 ± 2.4	118	−43.4	−50.9 ± 9.6			1106	
Interpolation – multiple reg.				−8.10			−54.0				
Interpolation – kriging (IAEA)				−6.93			−43.0				
Project											
Surface waters		δ18O			δ2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea											
River											
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		38	−7.96	−7.92 ± 0.2	43	−55.0	−54.6 ± 2.1	48	2.1 ± 2.0	5	93 ± 19
GW–Borehole											
GW–Dug well		2	−7.47	−7.47 ± 0.1	2	−50.7	−50.7 ± 0.2	5	6.3 ± 2.1		
GW–Spring											

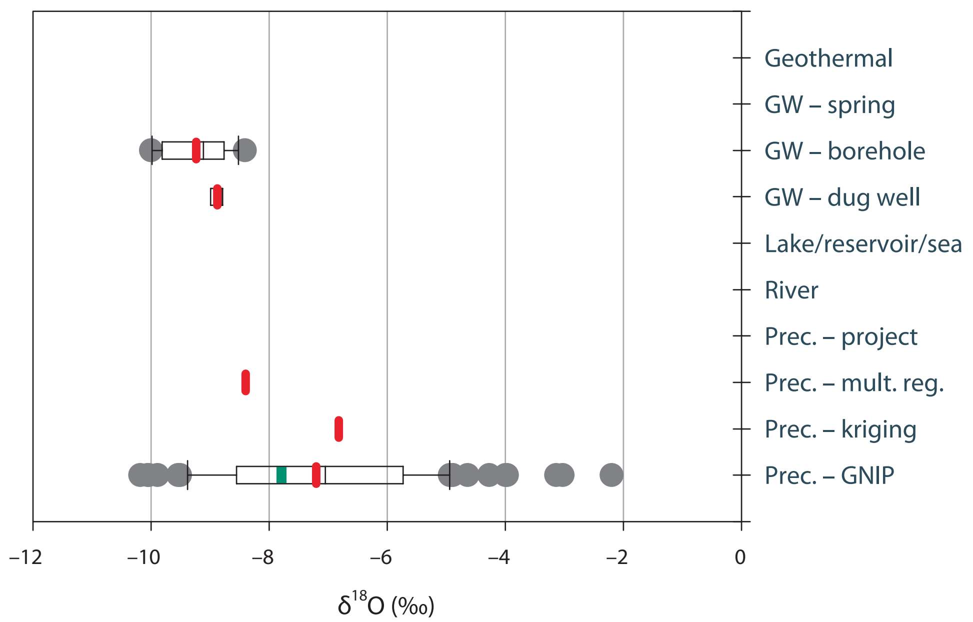


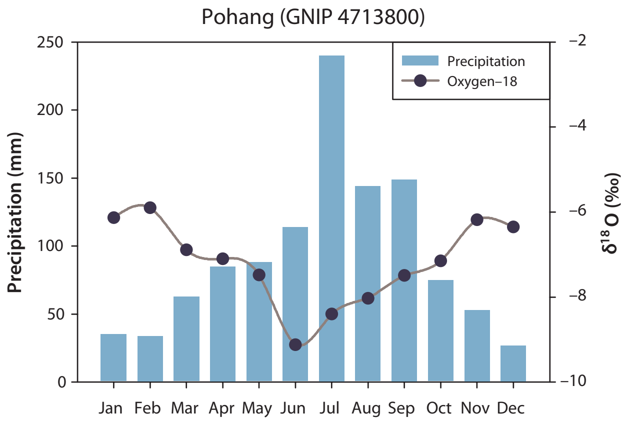


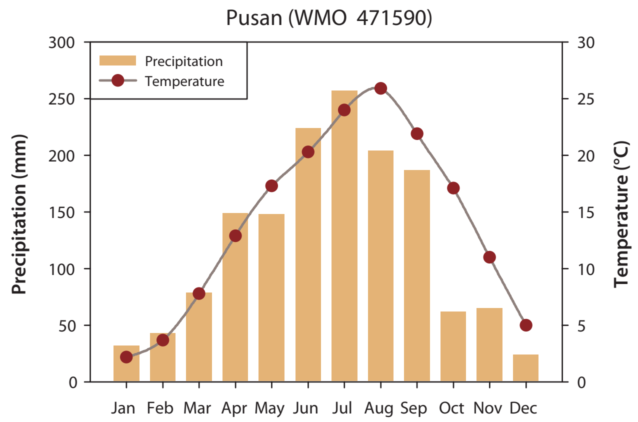
RAS8097-ROK

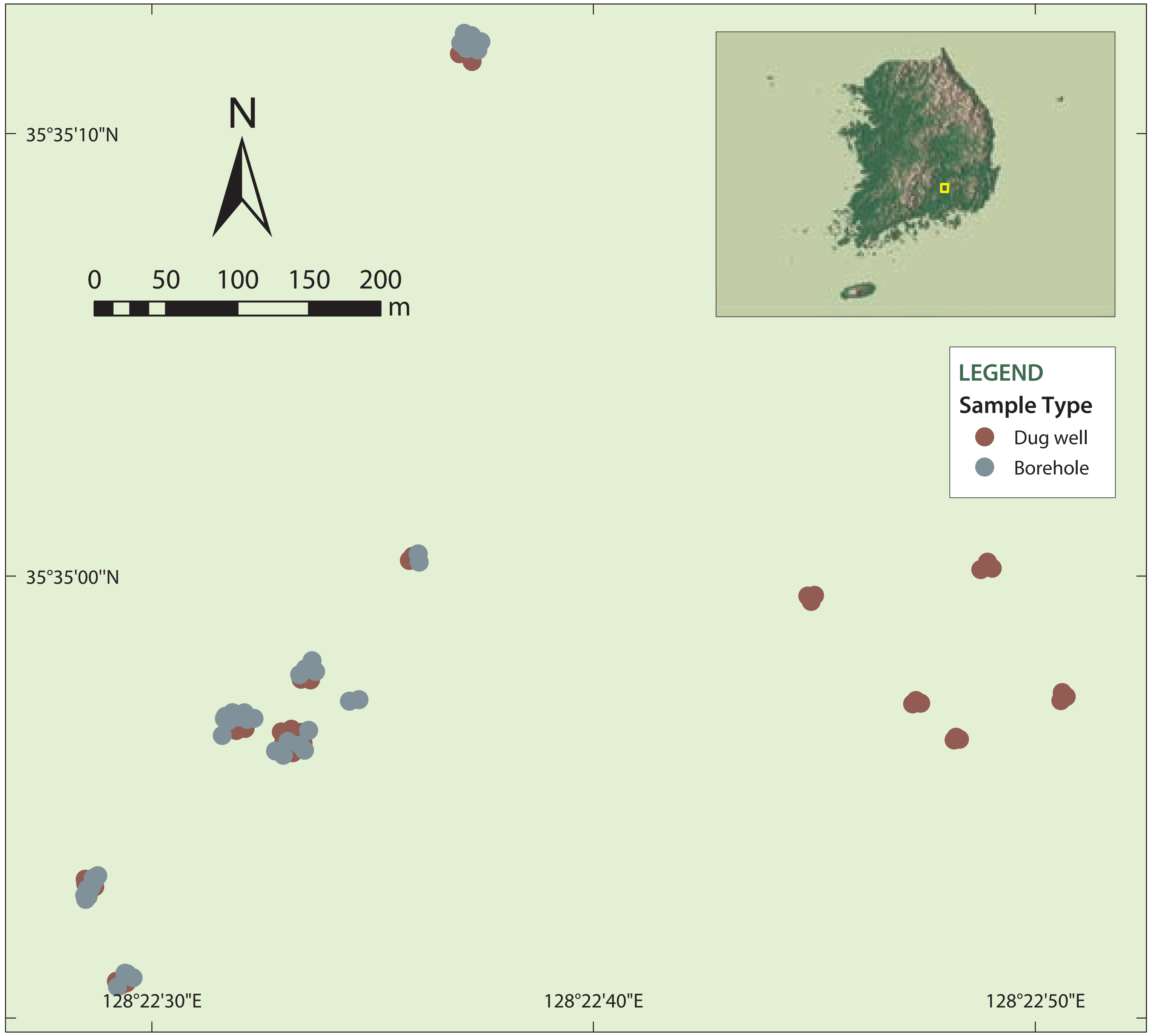
Yuseong aquifers











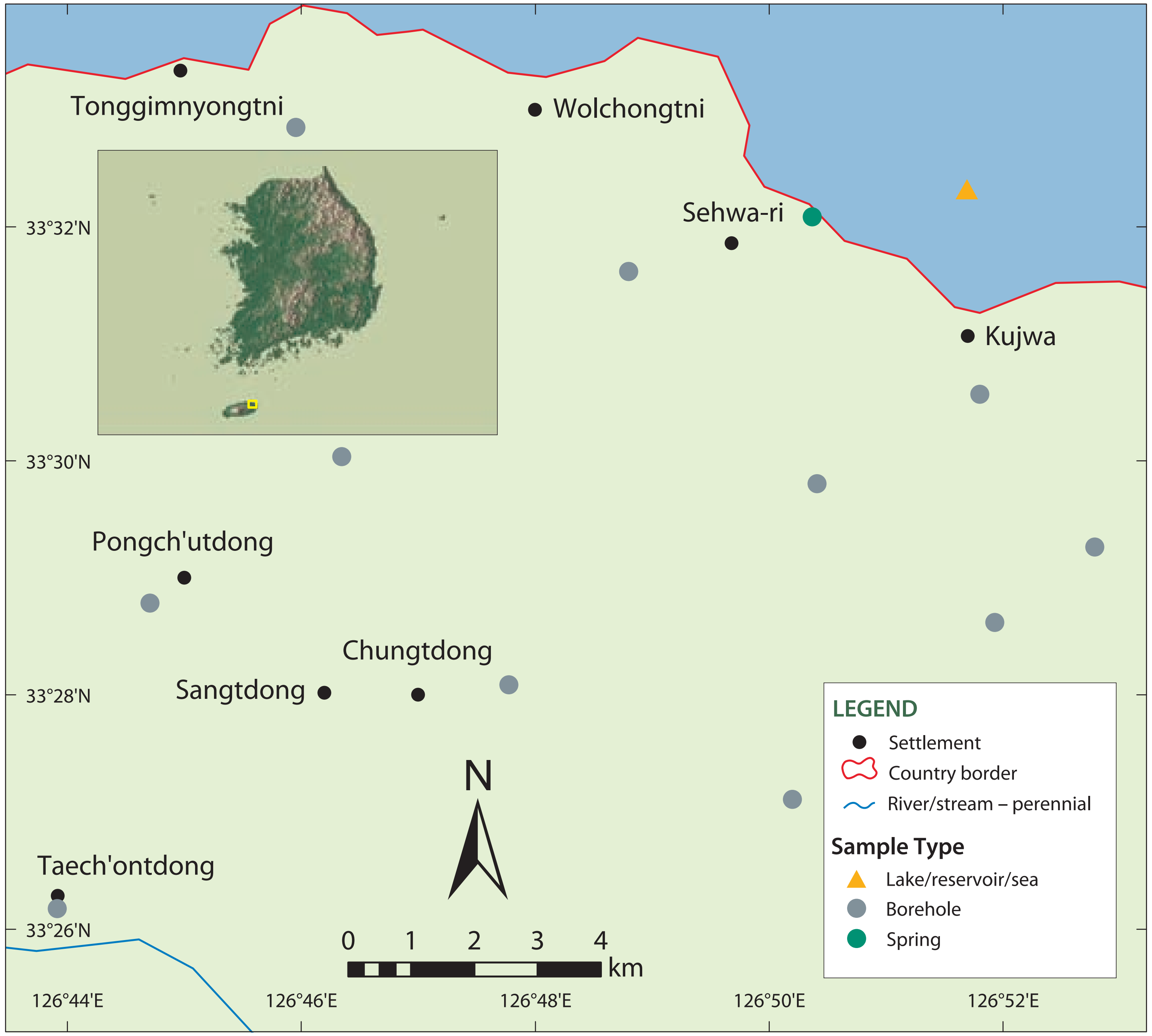
Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station POHANG	red square	110	−7.05	−7.43 ± 2.4	118	−43.4	−50.9 ± 9.6			1106
Interpolation – multiple reg.	yellow square			−8.40			−56.0			
Interpolation – kriging (IAEA)	green square			−6.82			−44.7			
Project	pink square									

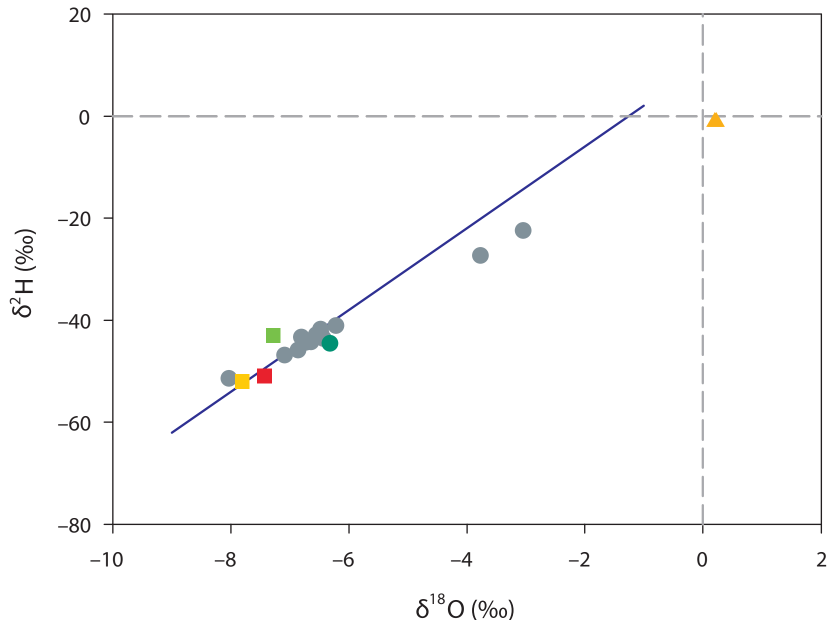
Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle								
River	orange triangle								

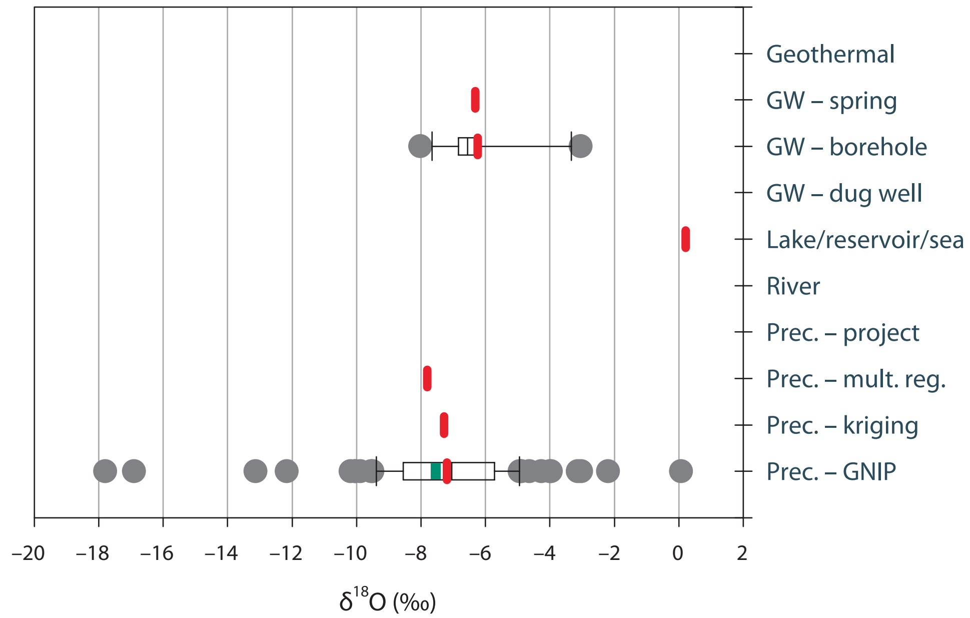
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	19	−9.11	−9.23 ± 0.5	18	−64.4	−65.9 ± 3.7	19	5.4 ± 4.4		
GW–Dug well	brown circle	6	−8.81	−8.88 ± 0.1	6	−63.6	−63.3 ± 1.5	6	13.2 ± 8.8		
GW–Spring	green circle										

ROK–11323

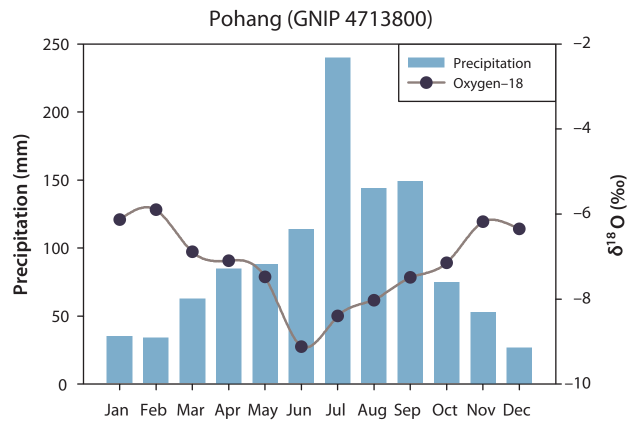
Cheju Island coastal aquifers

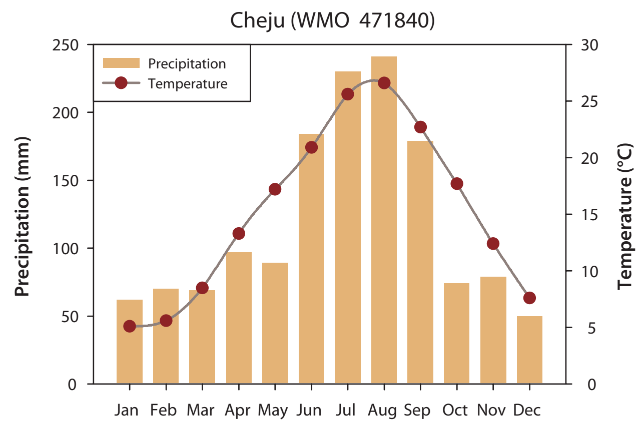




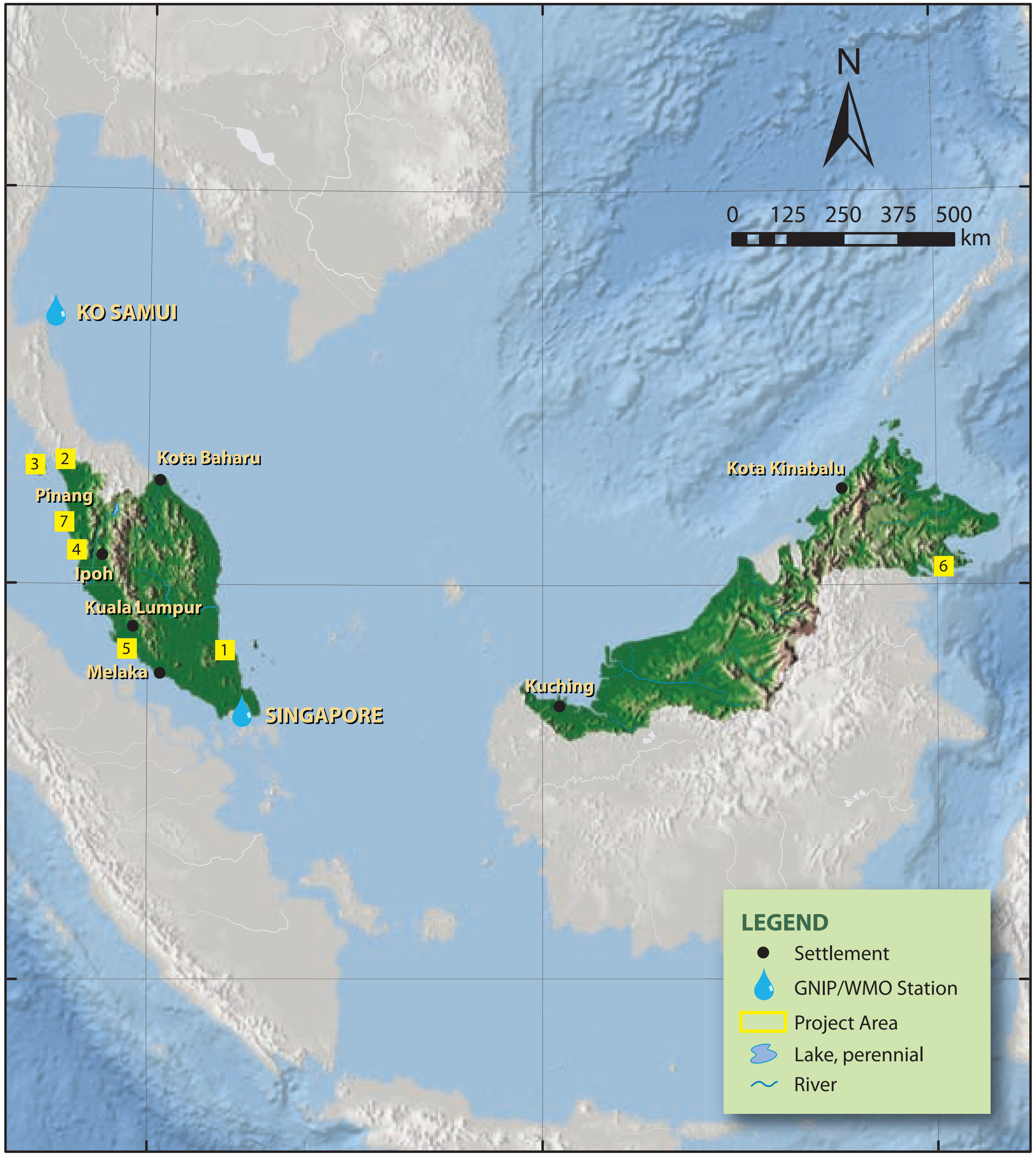


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station POHANG	■ (red)	110	−7.05	−7.43 ± 2.4	118	−43.4	−50.9 ± 9.6			
Interpolation – multiple reg.	■ (yellow)			−7.80			−52.0			
Interpolation – kriging (IAEA)	■ (green)			−7.28			−43.0			
Project	■ (pink)									
Surface waters		δ¹⁸O			δ²H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	▲ (orange)	2	0.21	0.21 ± 0.0	2	−1.1	−1.1 ± 0.0			
River	▲ (pink)									
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n Mean ± St. dev.
Geothermal water	● (blue)									
GW–Borehole	● (grey)	13	−6.55	−6.24 ± 1.3	13	−43.3	−41.4 ± 7.9			
GW–Dug well	● (brown)									
GW–Spring	● (green)	1		−6.32	1		−44.5			





MALAYSIA



1 **Project Code:** MAL8008K
Study area: Kuala Rompin aquifers
Sampling period: 1987–1988
Background: Isotope techniques along with conventional methods were used in the assessment of hydrogeological problems concerning genesis, flow dynamics and salt water intrusion processes in the aquifer system around Kuala Rompin.

2 **Project Code:** MAL8008P
Study area: Kuala Perlis area
Sampling period: 1990
Background: Isotope techniques along with conventional methods were used in the assessment of hydrogeological problems concerning genesis, flow dynamics and salt water intrusion processes in the aquifer system around Kuala Perlis.

3 **Project Code:** MAL8008L
Study area: Langkawi island
Sampling period: 1985–1989
Background: Origin of saline groundwater and geothermal fluids as well as salt water intrusion processes were investigated using isotope techniques in the aquifers of the Langkawi island.

4 **Project Code:** MAL8018
Study area: Taiping area
Sampling period: 2004
Background: In this project, assessment of the impact of industrial and municipal landfill operations on groundwater and surface water resources in the Taiping city area was carried out using isotope and geochemical techniques.

5 **Project Code:** RAS8084–MAL
Study area: Langat basin
Sampling period: 1999–2002
Background: Isotopes were employed to understand groundwater dynamics and to verify saline water intrusion into the aquifers of the area.

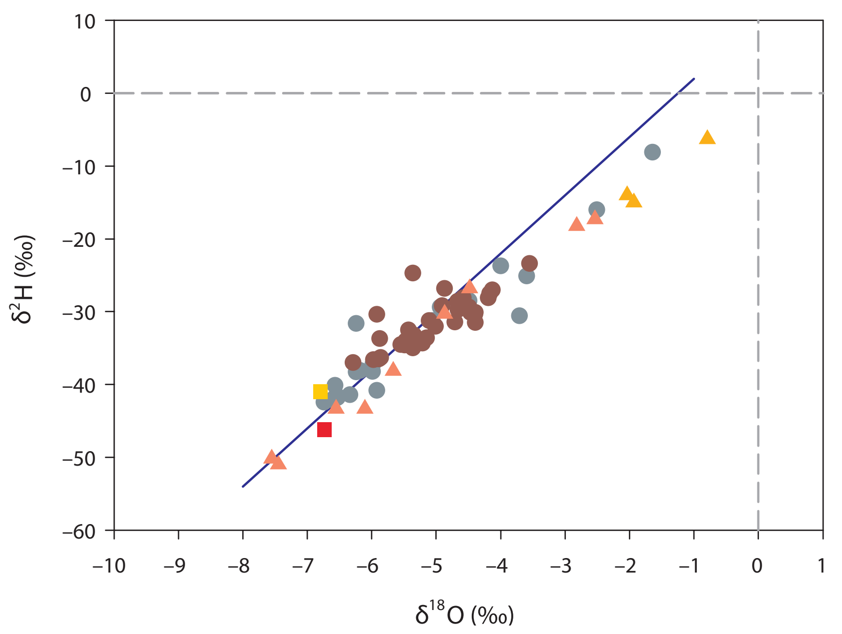
6 **Project Code:** RAS8092–MAL
Study area: Tawau geothermal area, Northern Borneo
Sampling period: 2002–2003
Background: Isotope techniques were used to investigate the origin, circulation, and subsurface history of geothermal waters of the Tawau region.

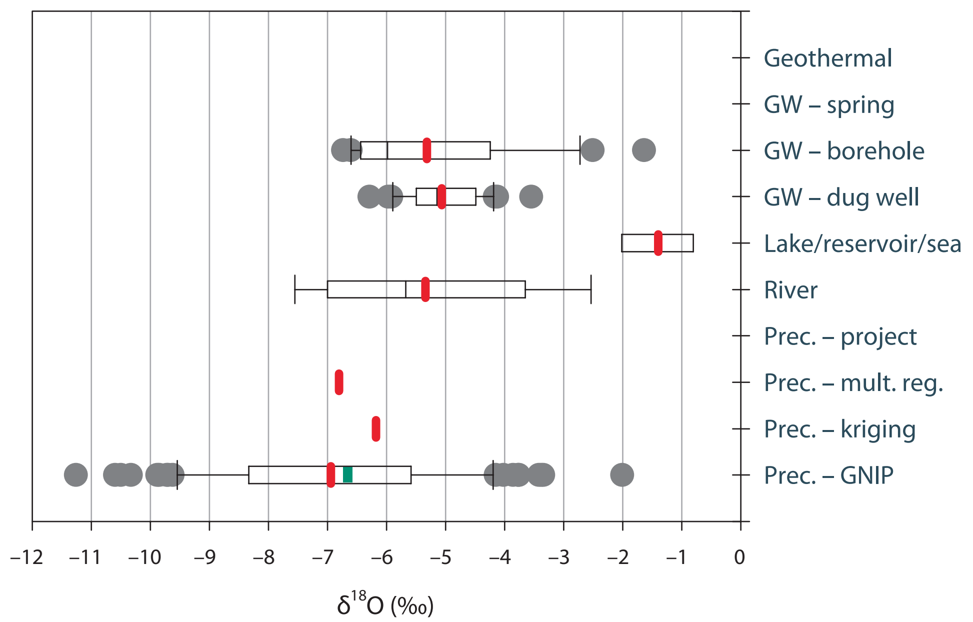
7 **Project Code:** RAS8097–MAL
Study area: Pulau Burung area
Sampling period: 2004–2005
Background: In the multi-disciplinary approach, isotopes were used to assess the impact of the Pulau Burung Sanitary Landfill operation on groundwater and surface water resources for formulation of appropriate national groundwater management policy.

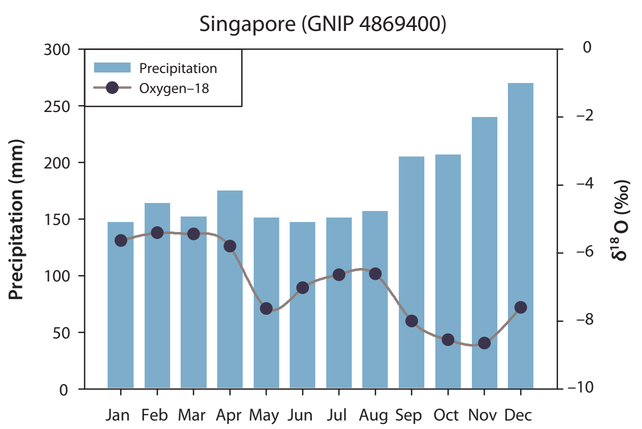
IAEA | Water Resources Programme

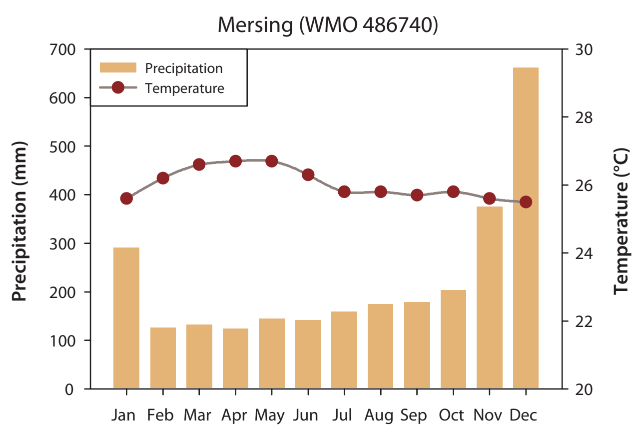
MAL8008K

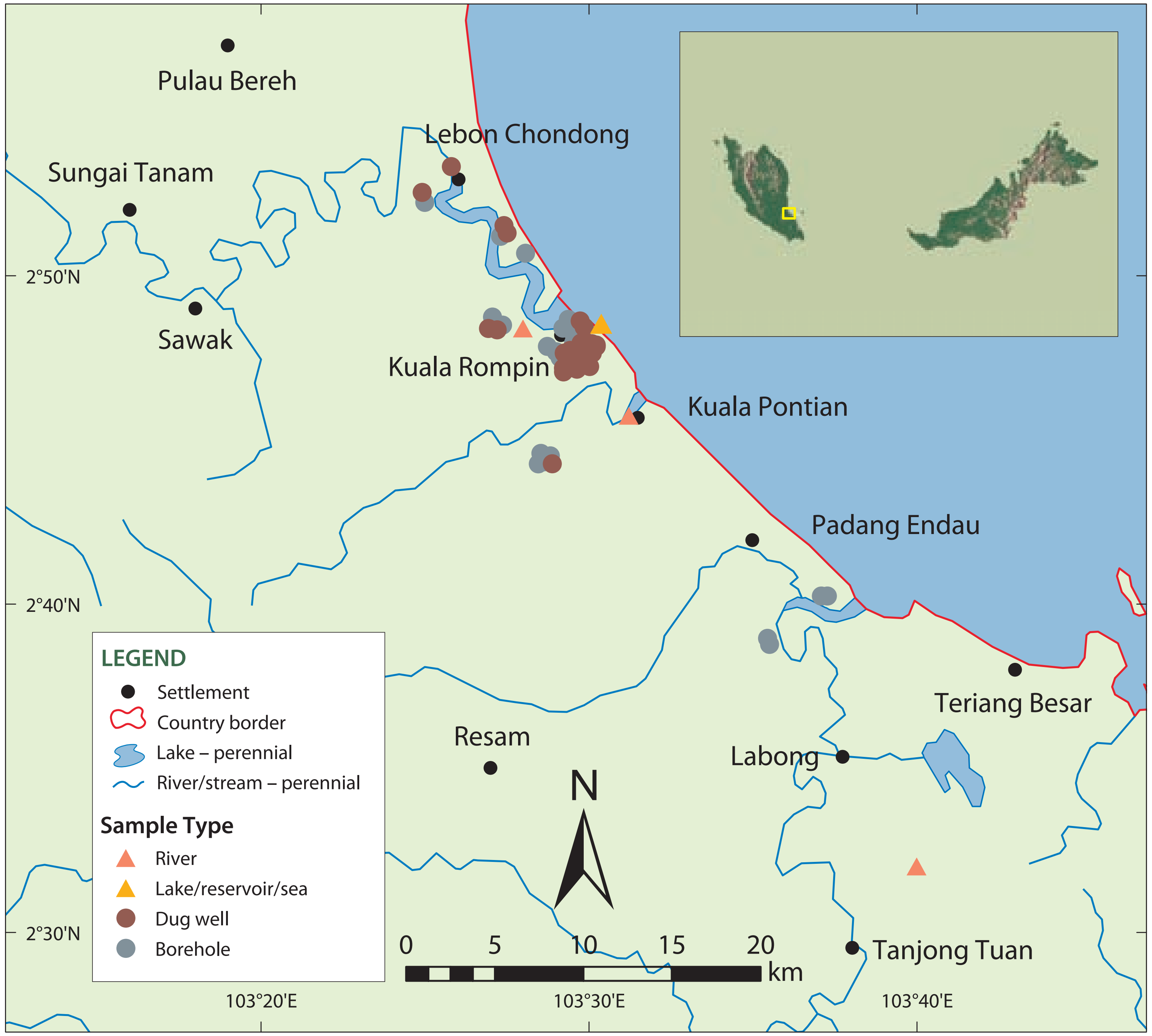
Kuala Rompin aquifers







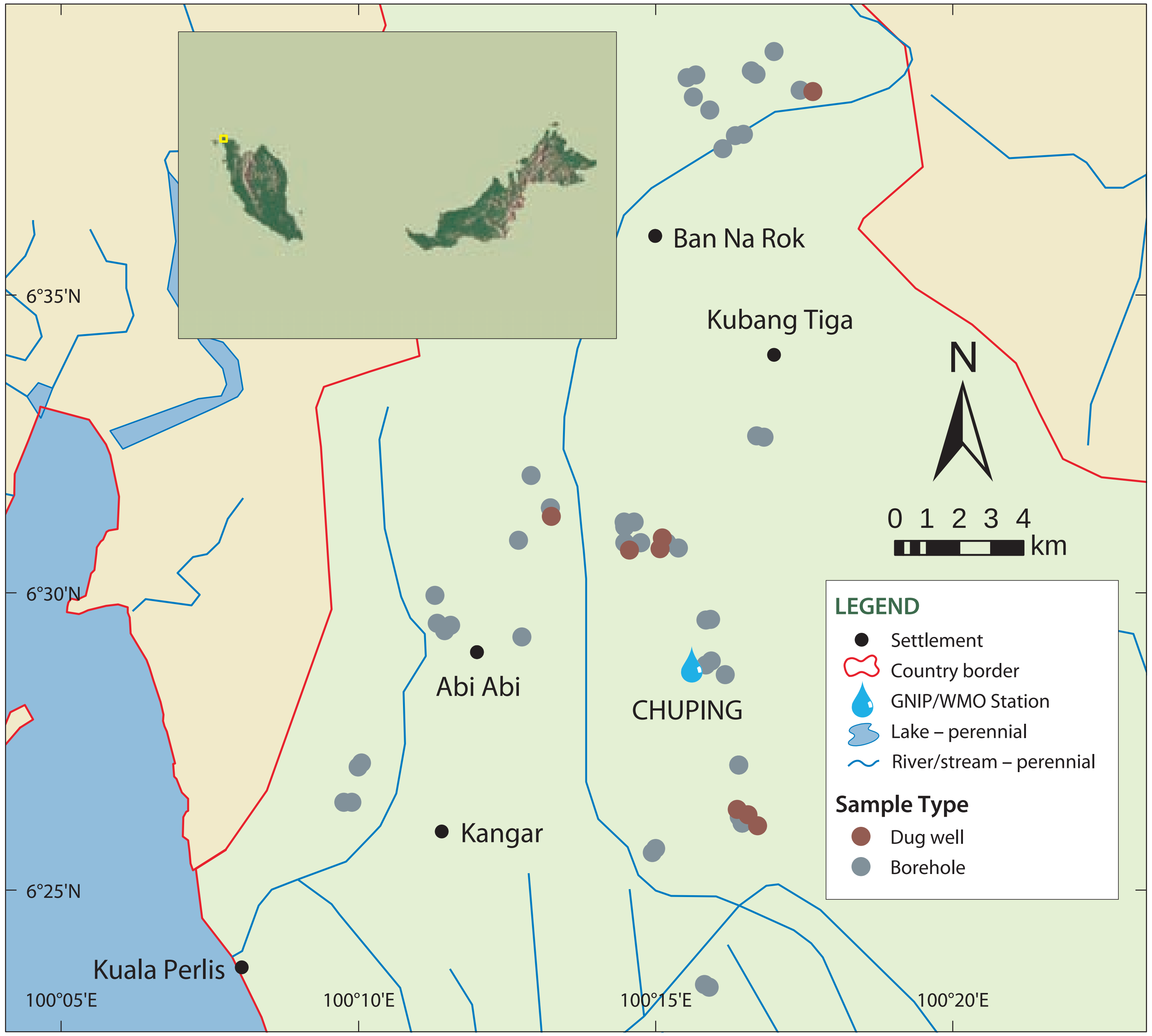


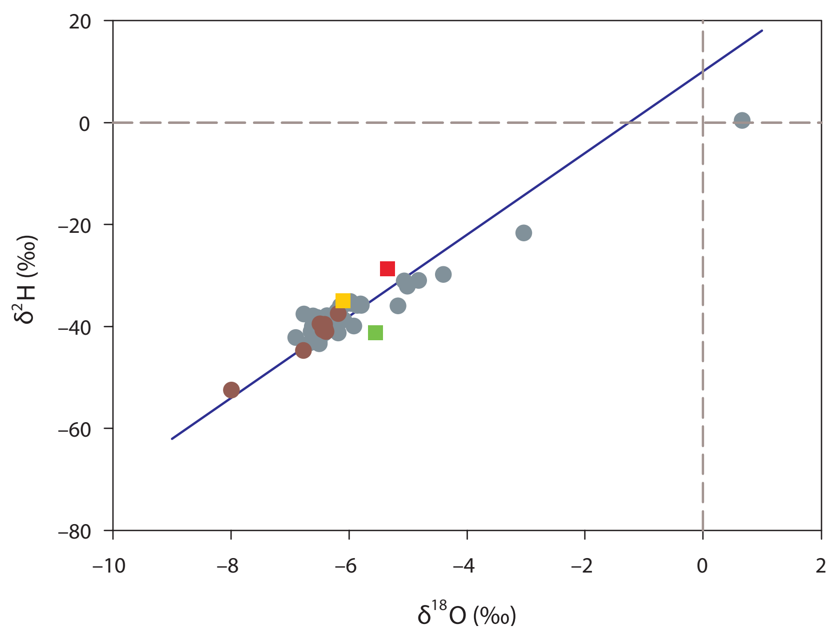


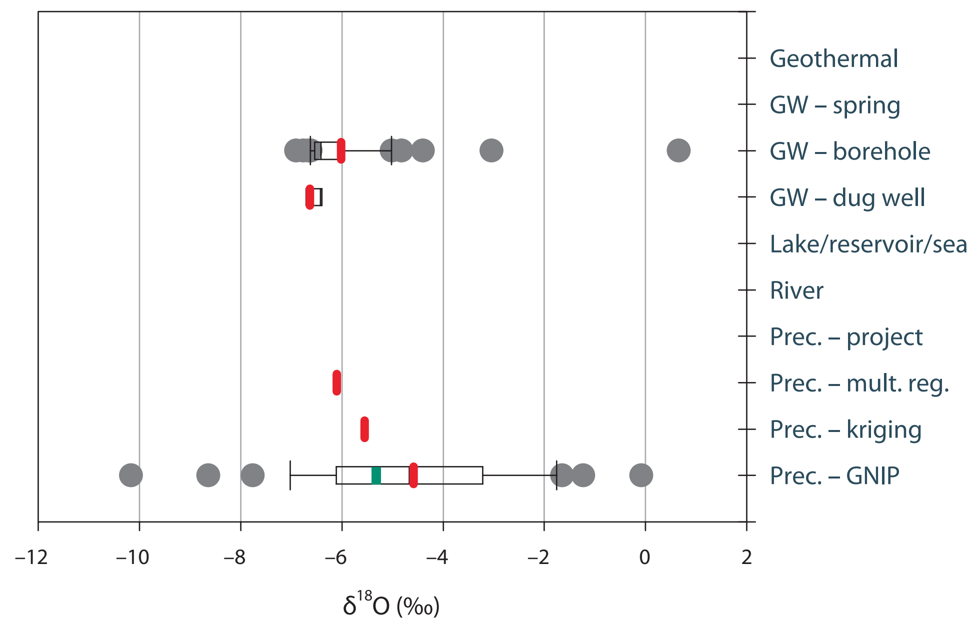
Precipitation		$\delta^{18}O$ (‰)			δ^2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SINGAPORE	■	97	−7.00	−6.73 ± 0.9	52	−46.0	−46.2 ± 1.6			2164	
Interpolation – multiple reg.	■			−6.80			−41.0				
Interpolation – kriging (IAEA)	■			−6.18			−39.5				
Project	■										

Surface waters		$\delta^{18}O$			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲	4	−1.39	−1.40 ± 0.7	3	−14.0	−11.8 ± 4.8	3	3.1 ± 0.3
River	▲	9	−5.67	−5.34 ± 1.8	9	−38.1	−35.4 ± 12.8	7	3.6 ± 0.6

Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	21	−5.98	−5.32 ± 1.5	20	−37.6	−33.3 ± 9.5	16	1.2 ± 1.2		
GW–Dug well	●	37	−5.15	−5.07 ± 0.6	37	−31.5	−31.6 ± 3.5	34	3.6 ± 0.8		
GW–Spring	●										



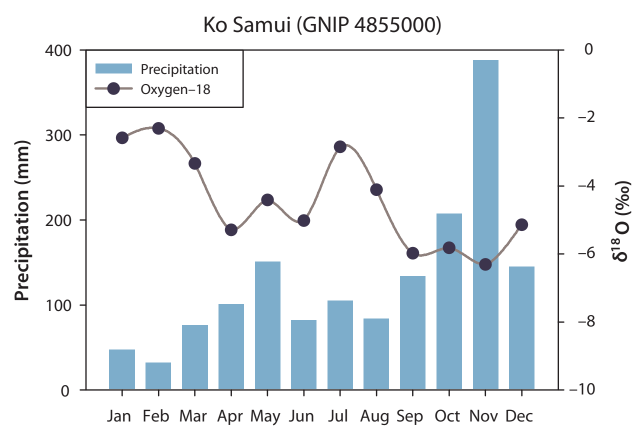


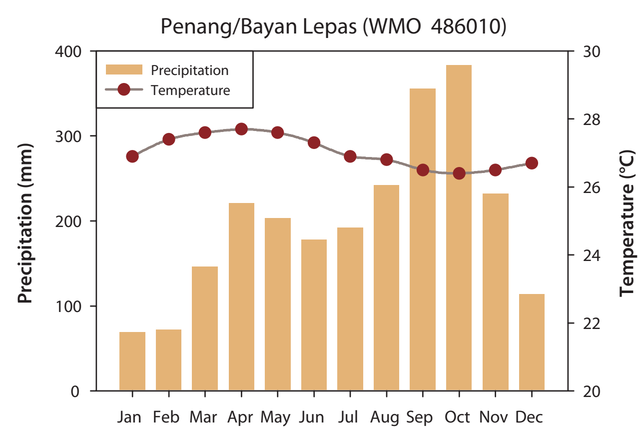


Precipitation		δ¹⁸O (‰) n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H (‰) n	δ²H Median	δ²H Mean ± St. dev.	Tritium (TU) n	Tritium Mean ± St. dev.	Annual prec. (mm)
GNIP station KO SAMUI	red square	36	−4.67	−5.35 ± 2.2	29	−23.1	−28.7 ± 10.1			1265
Interpolation – multiple reg.	yellow square			−6.10			−35.0			
Interpolation – kriging (IAEA)	green square			−5.55			−41.2			
Project	pink square									

Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	orange triangle								
River	light red triangle								

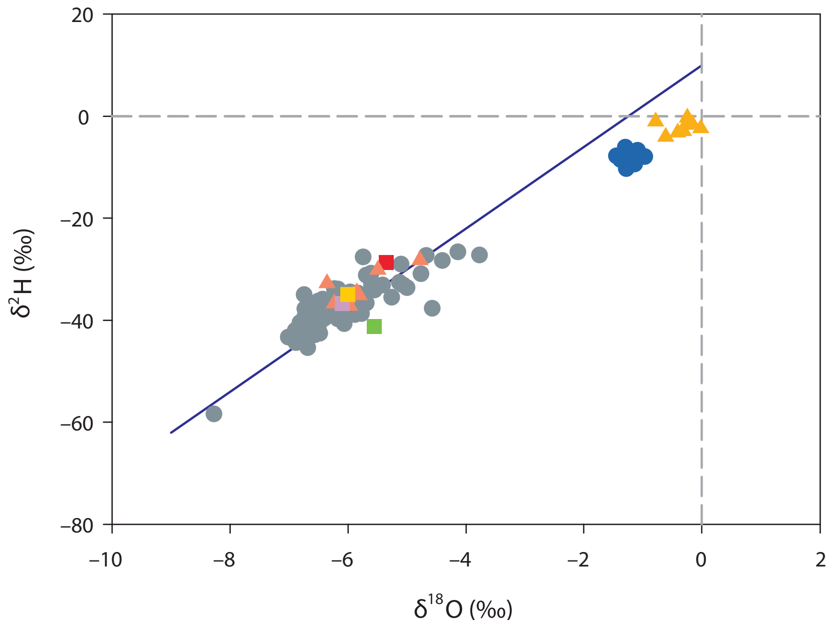
Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	51	−6.41	−6.01 ± 1.2	51	−38.9	−37.4 ± 6.6	52	3.0 ± 1.6	3	32 ± 6
GW–Dug well	brown circle	8	−6.43	−6.63 ± 0.6	8	−40.6	−42.0 ± 4.7	8	2.1 ± 1.1		
GW–Spring	green circle										

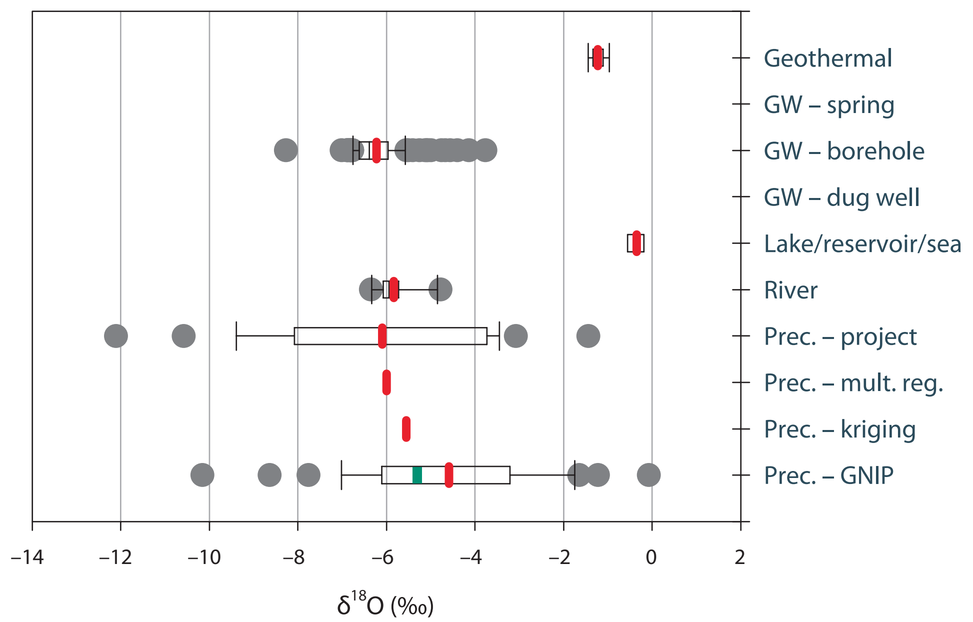


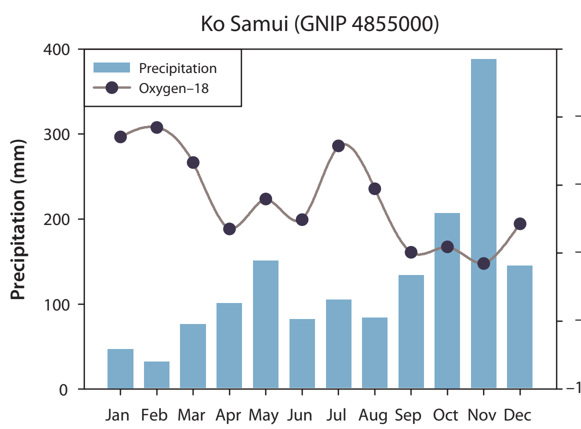


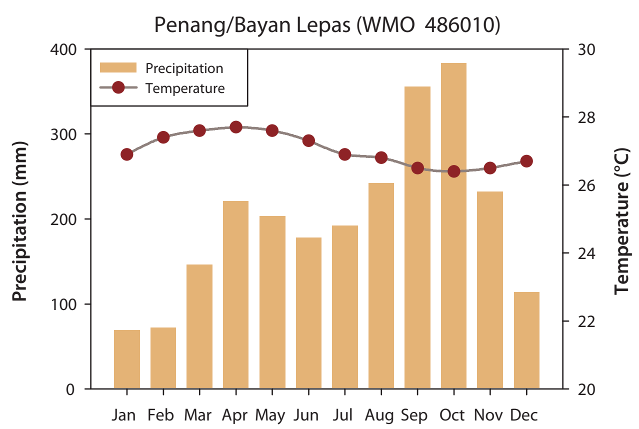
MAL8008L

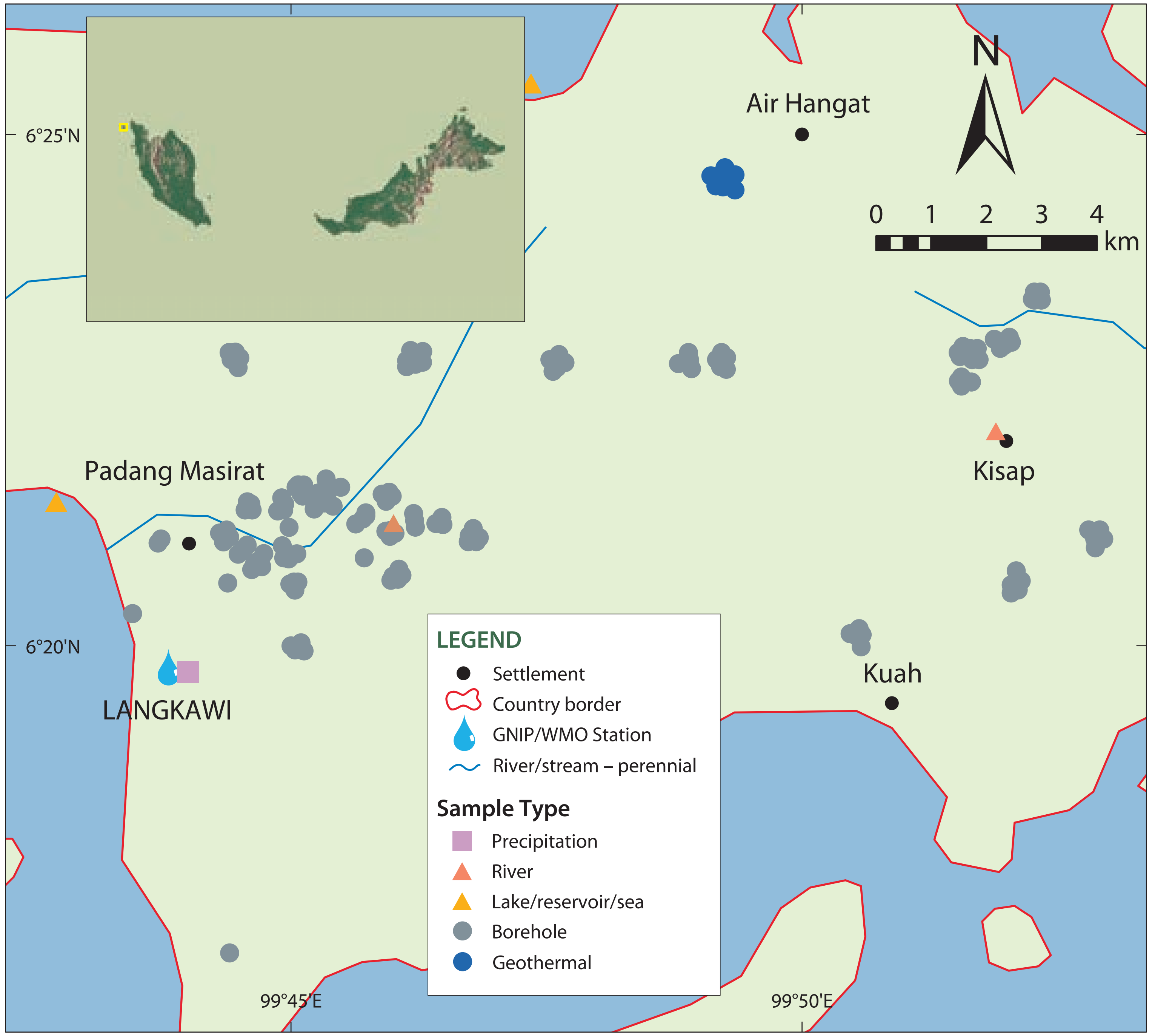
Langkawi island





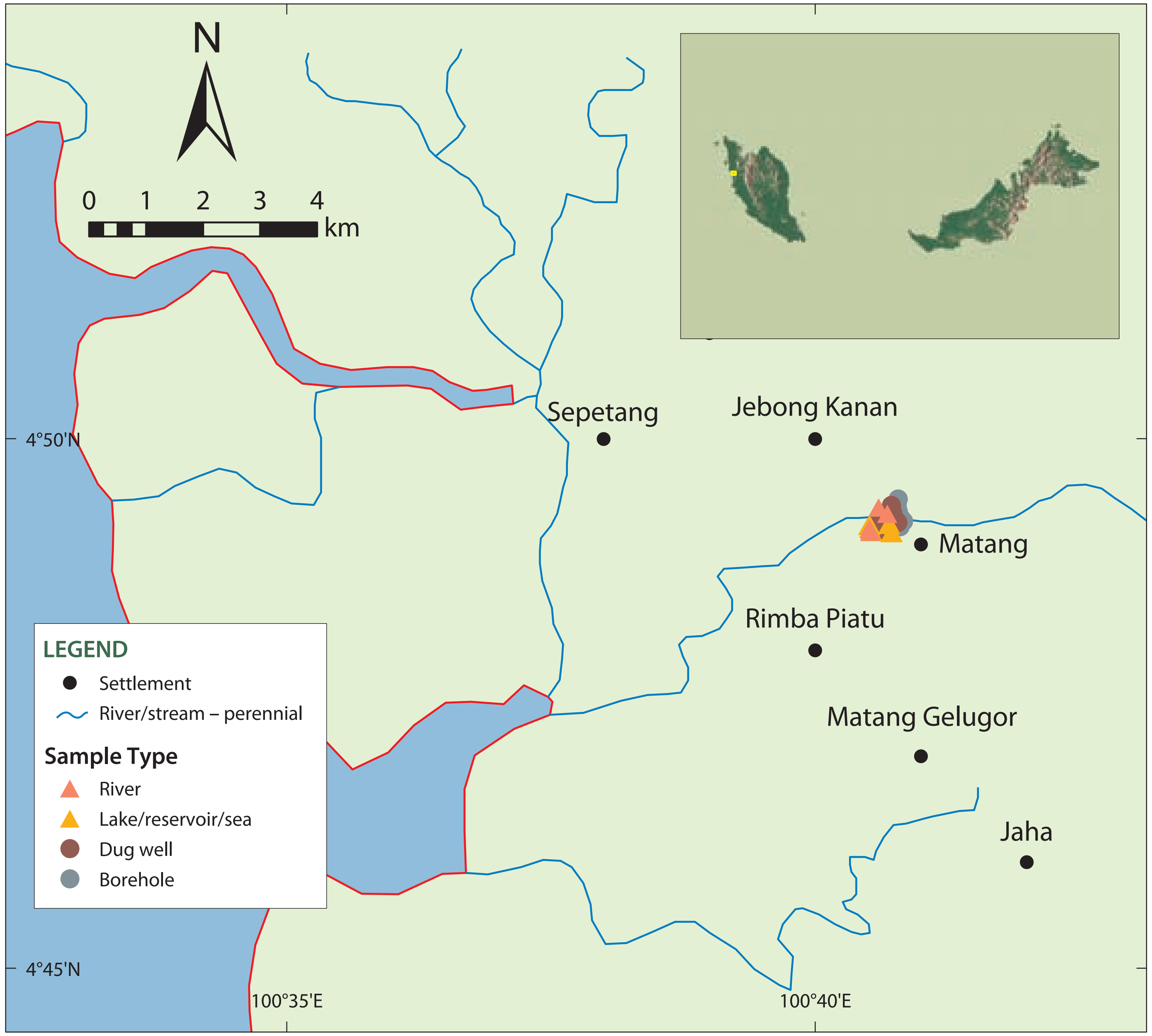


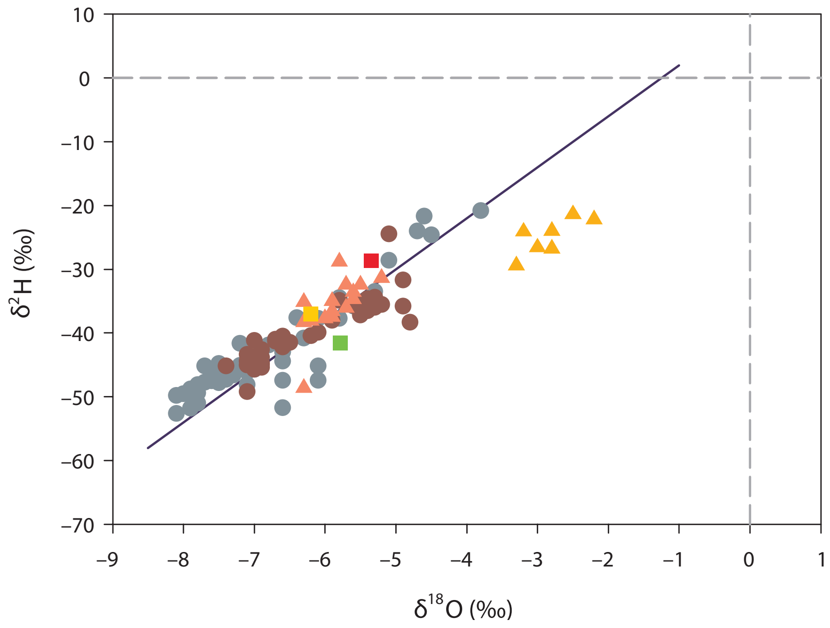


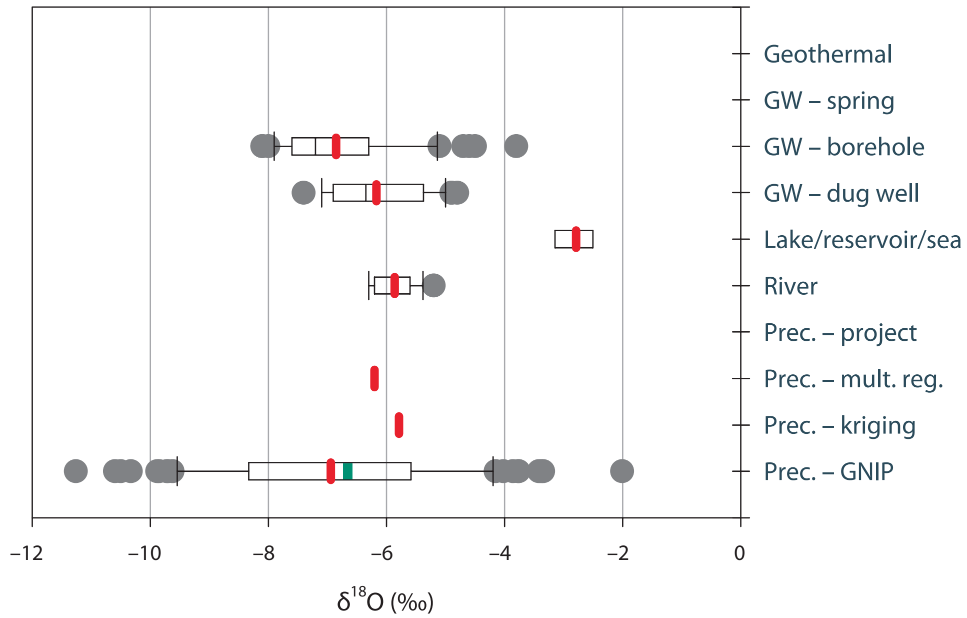


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station KO SAMUI		36	−4.67	−5.35 ± 2.2	29	−23.1	−28.7 ± 10.1			1265	
Interpolation – multiple reg.				−6.00			−35.0				
Interpolation – kriging (IAEA)				−5.55			−41.2				
Project		27	−6.10	−6.1 ± 2.5	27	−36.7	−36.0 ± 18.6	14	5.7 ± 3.1		
Surface waters		δ¹⁸O			δ²H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea		8	−0.29	−0.35 ± 0.2	8	−2.1	−2.1 ± 1.2	6	4.1 ± 0.8		
River		10	−5.94	−5.84 ± 0.4	10	−35.1	−34.1 ± 2.9	9	4.7 ± 1.6		
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		9	−1.24	−1.23 ± 0.2	9	−8.5	−8.3 ± 1.3	7	2.7 ± 1.4	1	1.7
GW–Borehole		147	−6.39	−6.22 ± 0.6	147	−38.4	−38.1 ± 4.0	135	2.7 ± 1.9	6	69 ± 20
GW–Dug well											
GW–Spring											

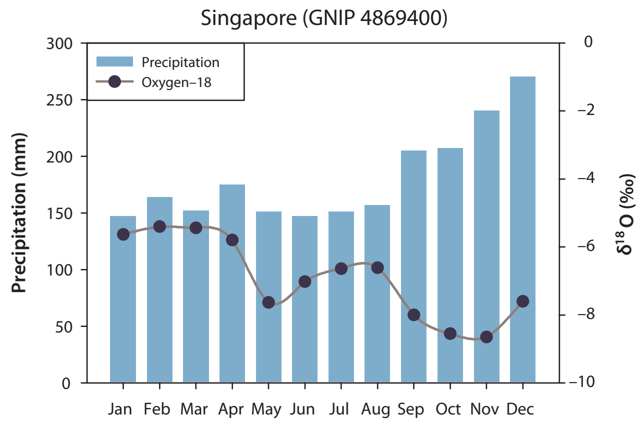
MAL8018
Taiping area

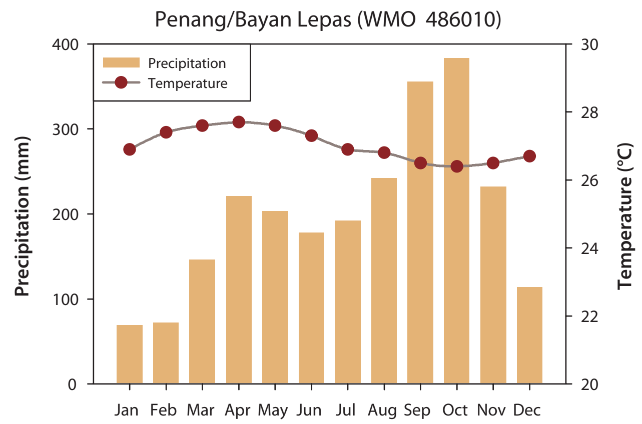






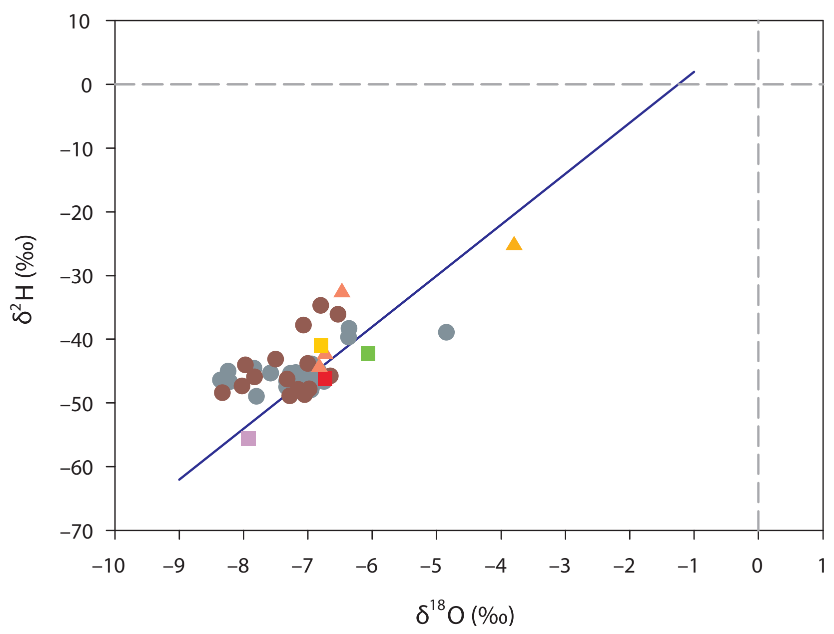
Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station SINGAPORE	■	97	−7.00	−6.73 ± 0.9	52	−46.0	−46.2 ± 1.6			2164	
Interpolation – multiple reg.	■			−6.20			−37.0				
Interpolation – kriging (IAEA)	■			−5.79			−41.6				
Project	■										
Surface waters		δ18O			δ2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲	8	−2.79	−2.80 ± 0.4	8	−24.0	−24.5 ± 2.9	8	6.4 ± 0.5		
River	▲	15	−5.90	−5.86 ± 0.3	15	−35.1	−35.8 ± 4.5	16	7.1 ± 1.0		
Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	51	−7.20	−6.86 ± 1.0	51	−45.8	−41.4 ± 15.0	50	6.2 ± 0.8		
GW–Dug well	●	34	−6.35	−6.16 ± 0.8	34	−40.4	−39.6 ± 5.0	39	6.1 ± 0.8		
GW–Spring	●										

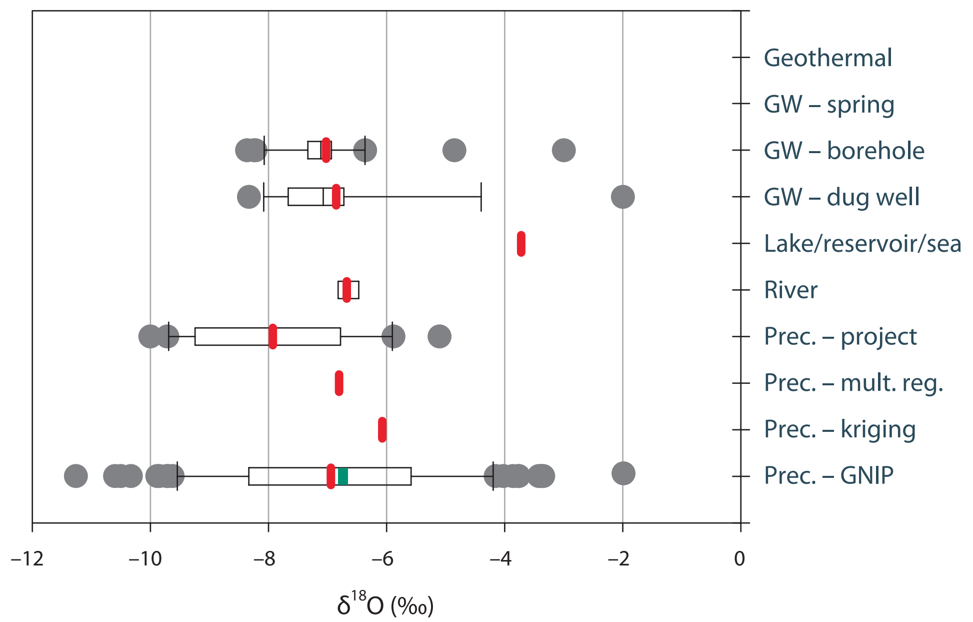


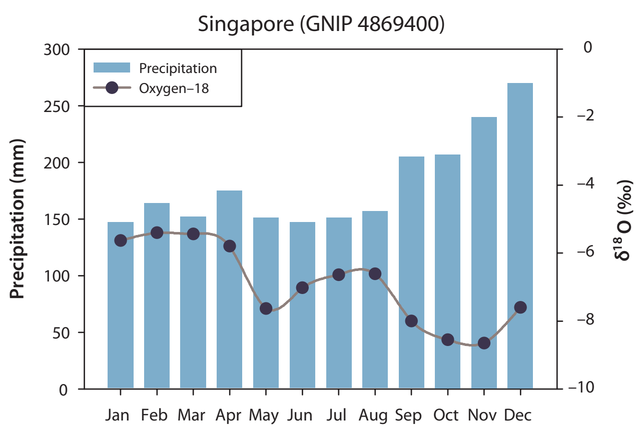


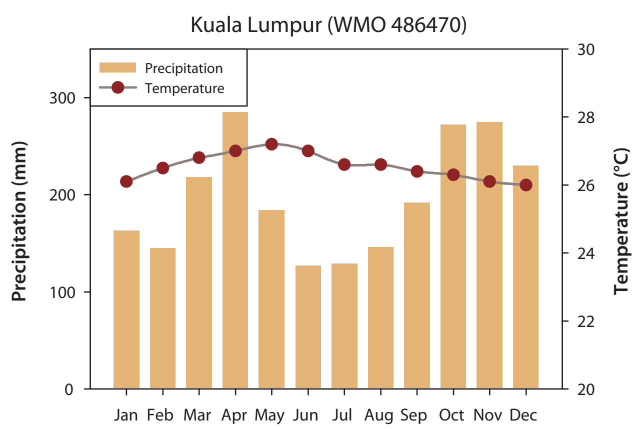
RAS8084–MAL

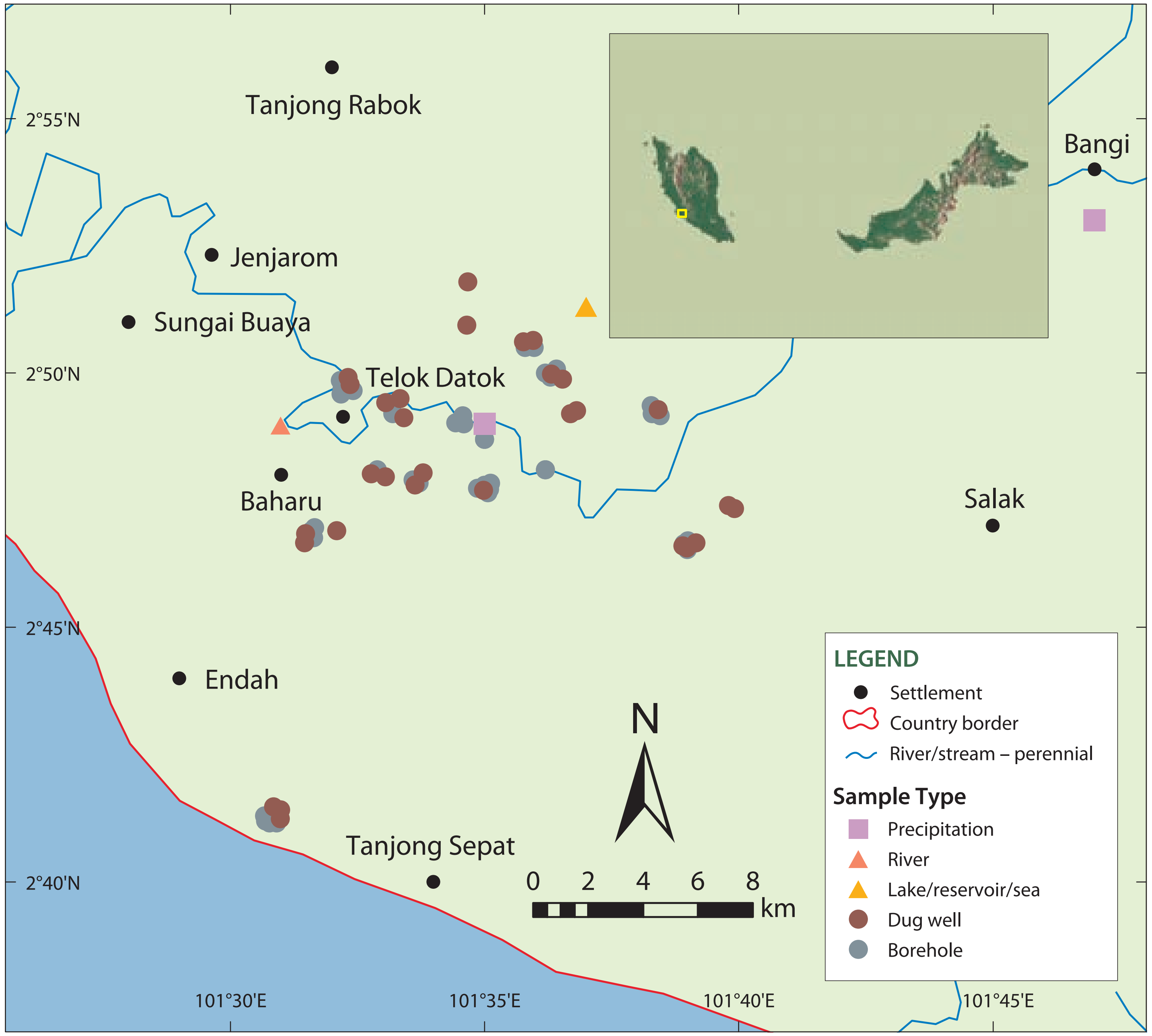
Langat basin











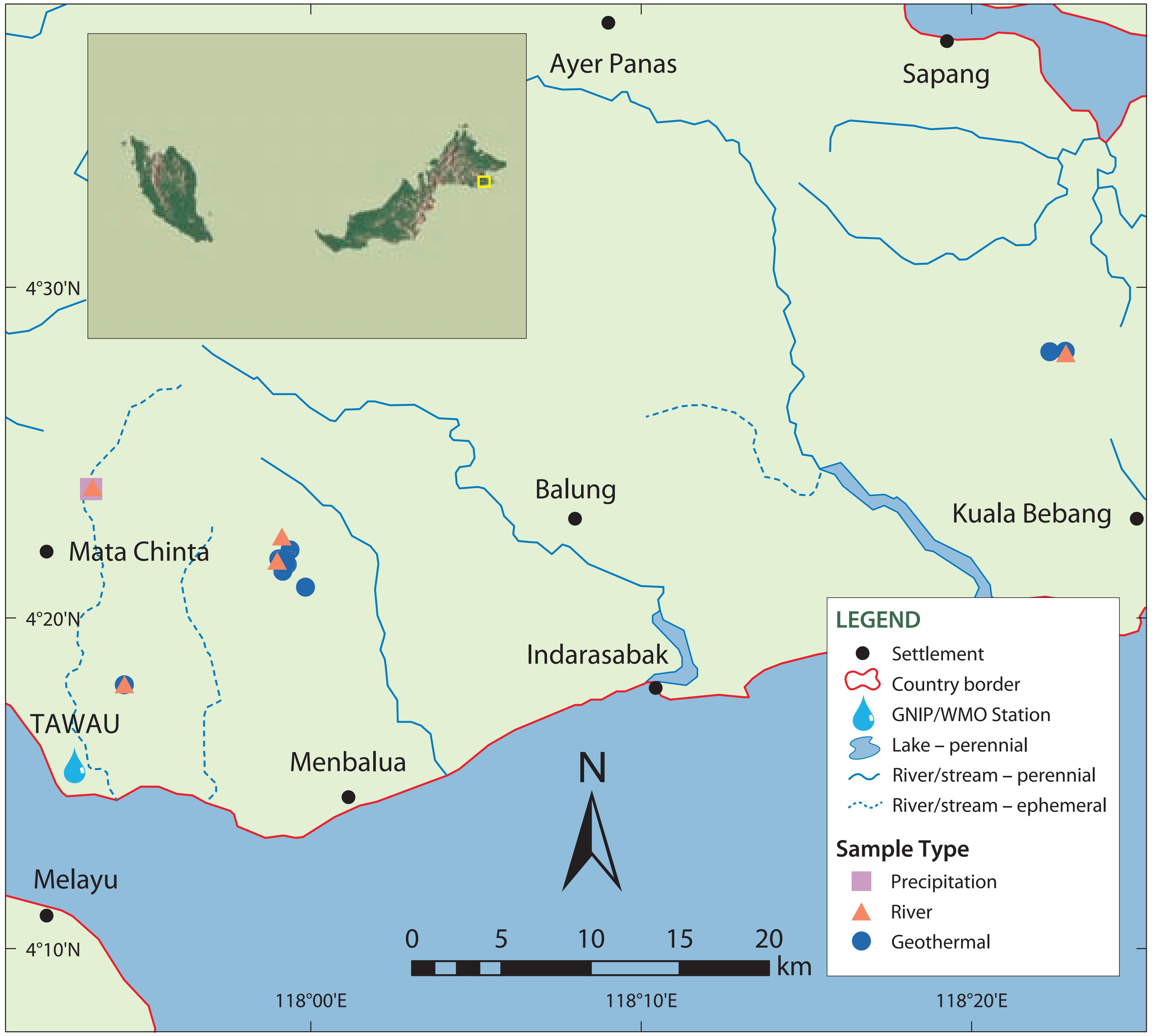
Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station SINGAPORE		97	−7.00	−6.73 ± 0.9	52	−46.0	−46.2 ± 1.6			2164
Interpolation – multiple reg.				−6.80			−41.0			
Interpolation – kriging (IAEA)				−6.07			−42.3			
Project		20	−7.93	−7.93 ± 1.4	20	−53.8	−55.6 ± 12.2	4	8.5 ± 1.4	

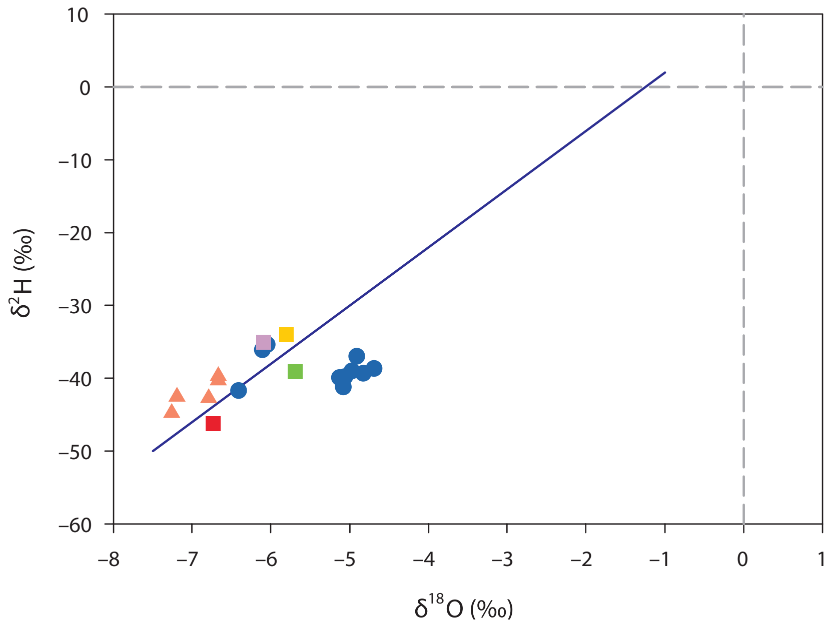
Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea		1		−3.85	1		−25.34		
River		3	−6.73	−6.67 ± 0.1	3	−42.4	−39.8 ± 6.3	1	17.1

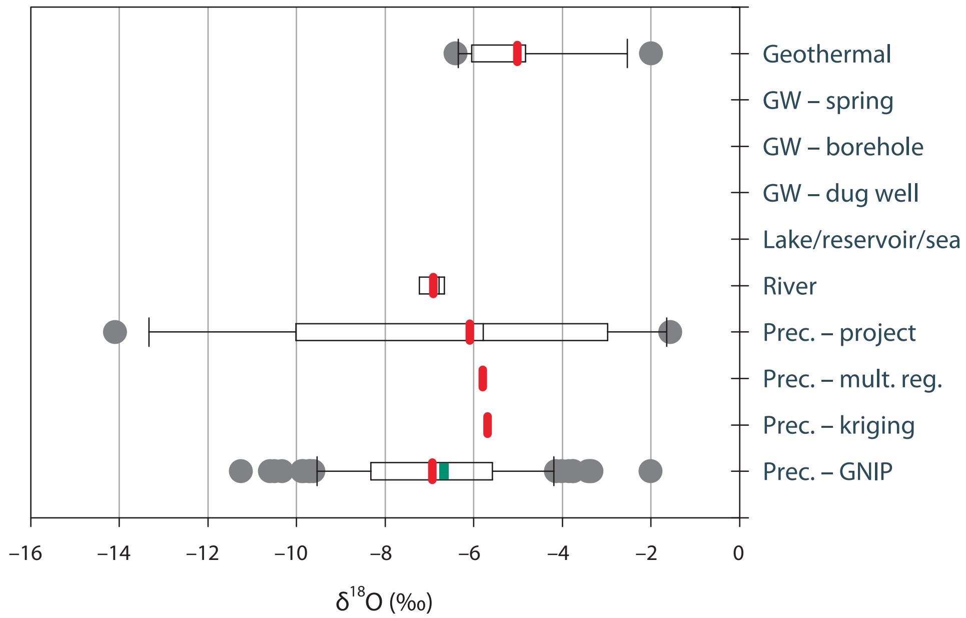
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		32	−7.12	−7.15 ± 0.6	32	−45.6	−45.5 ± 2.4	18	9.4 ± 4.5		
GW–Dug well		15	−7.15	−7.3 ± 0.5	15	−45.9	−44.4 ± 4.6	7	5.9 ± 1.6		
GW–Spring											

RAS8092–MAL

Tawau geothermal area, Northern Borneo

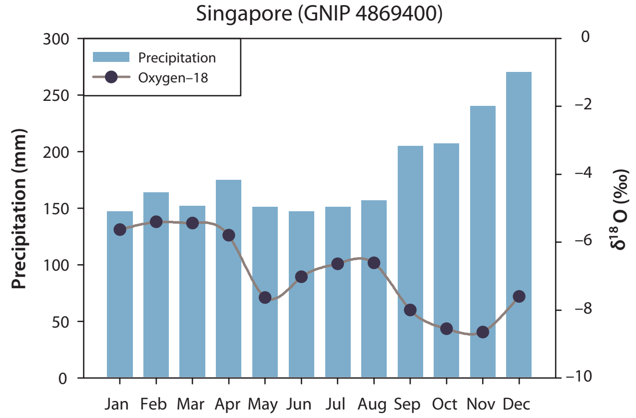




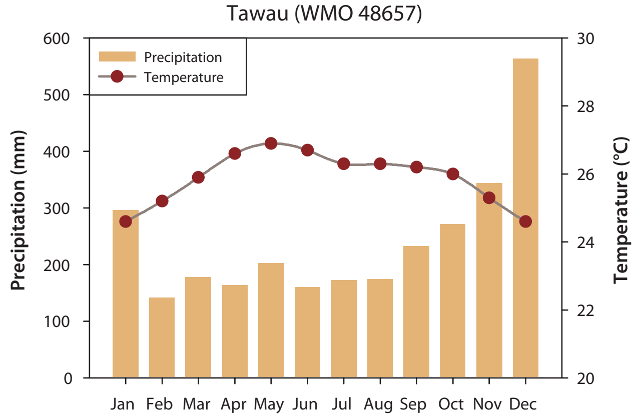


Precipitation	δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station SINGAPORE	97	−7.00	−6.73 ± 0.9	52	−46.0	−46.2 ± 1.6			2164	
Interpolation – multiple reg.			−5.80			−34.0				
Interpolation – kriging (IAEA)			−5.69			−39.1				
Project	11	−5.79	−6.09 ± 3.9	11	−31.3	−35.1 ± 31.3	2	4.5 ± 4.4		
Surface waters	**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea										
River	5	−6.79	−6.92 ± 0.3	5	−42.5	−42.0 ± 2.1	5	1.2 ± 0.3		
Groundwaters	**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**¹⁴C (pMC)** n	Mean ± St. dev.
Geothermal water	10	−5.07	−5.32 ± 0.6	10	−39.2	−38.8 ± 2.1	10	0.1 ± 0.2	5	4 ± 25
GW–Borehole										
GW–Dug well										
GW–Spring										

Singapore (GNIP 4869400)

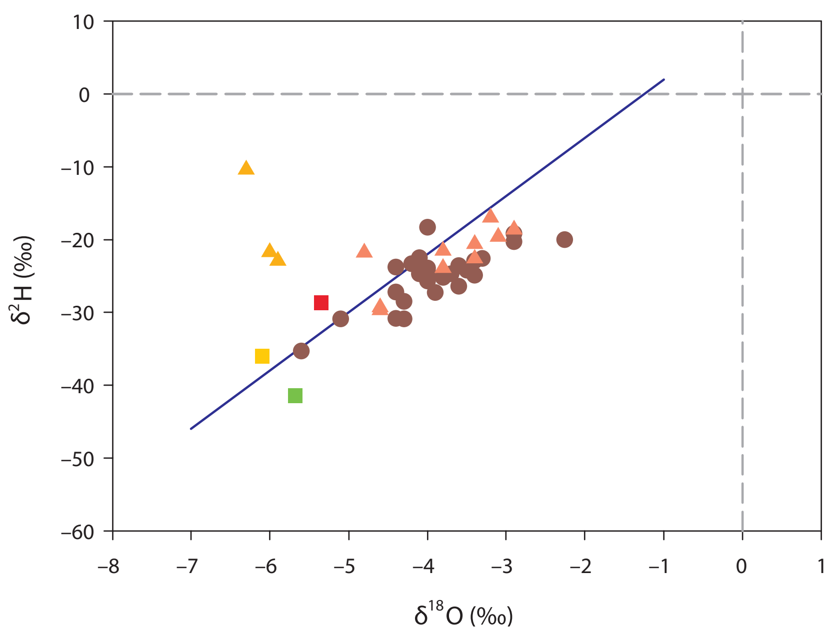


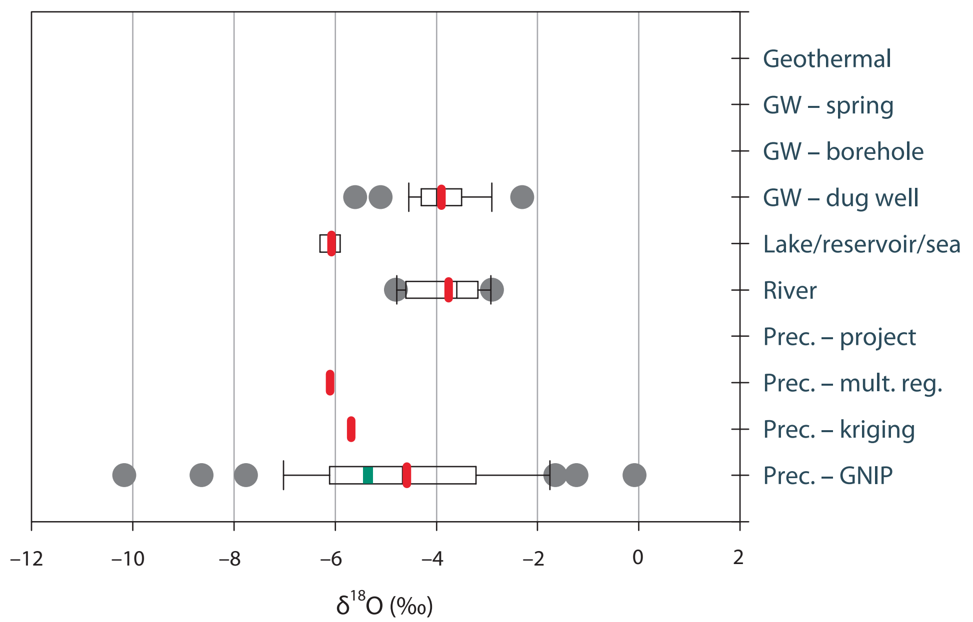
Tawau (WMO 48657)

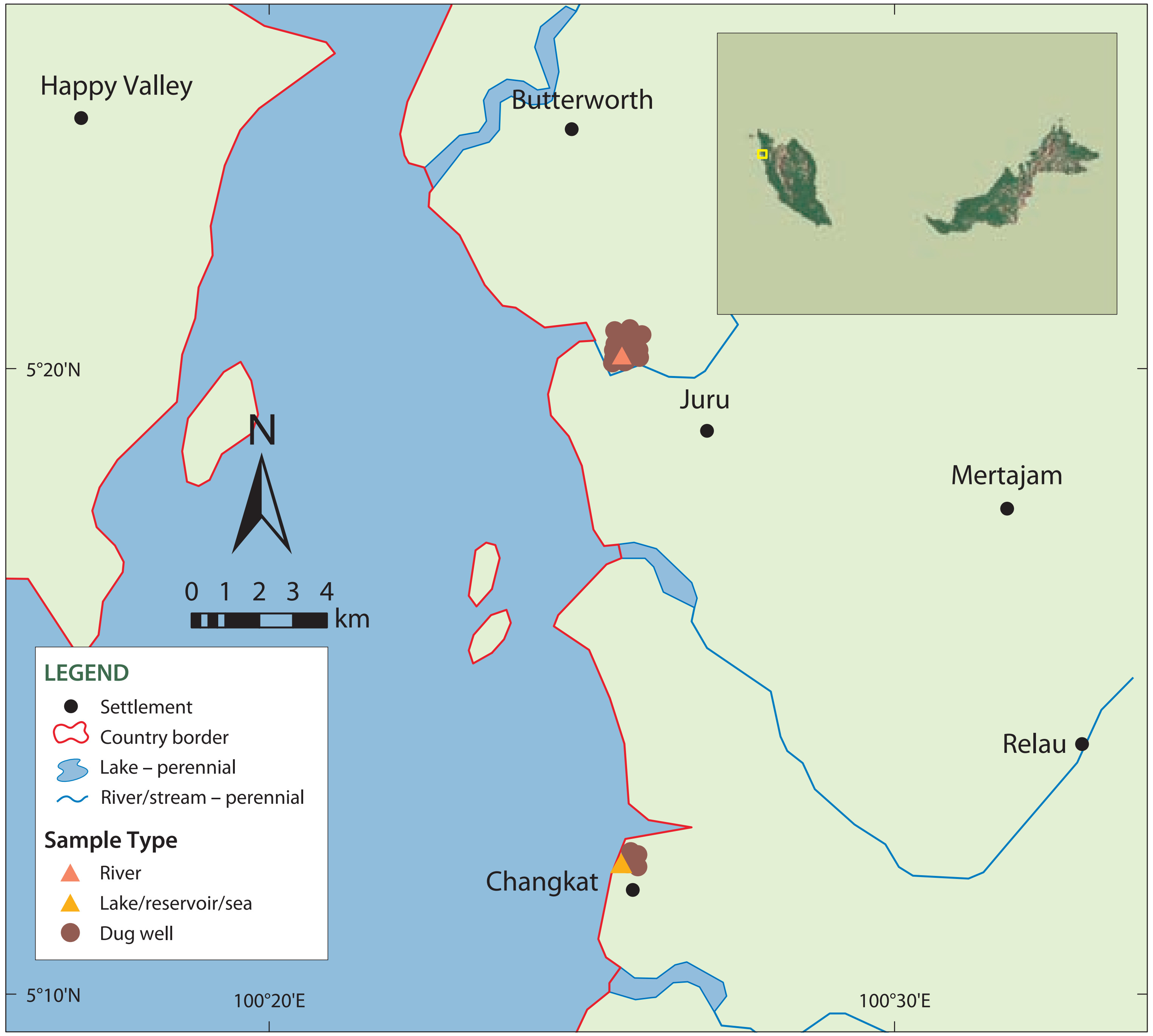


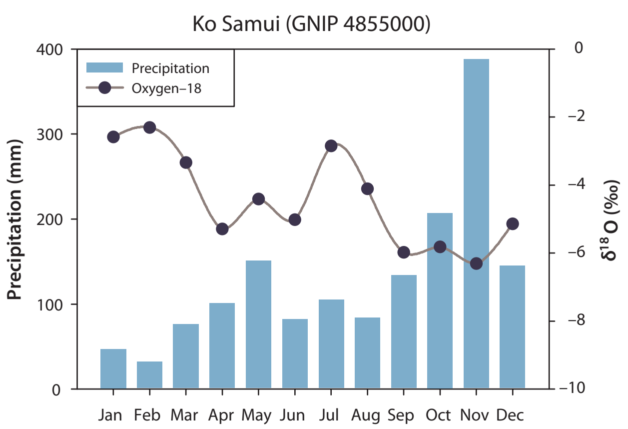
RAS8097–MAL

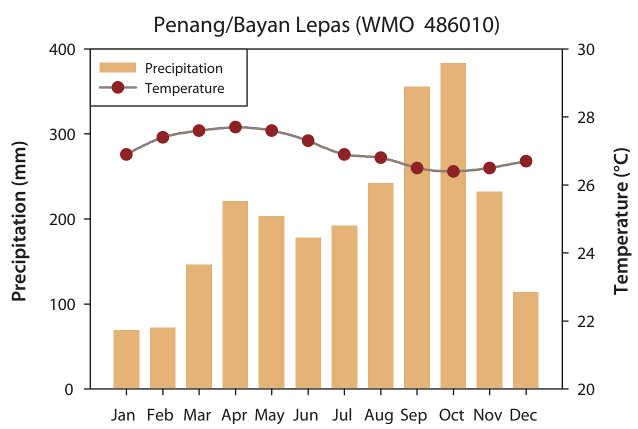
Pulau Burung area







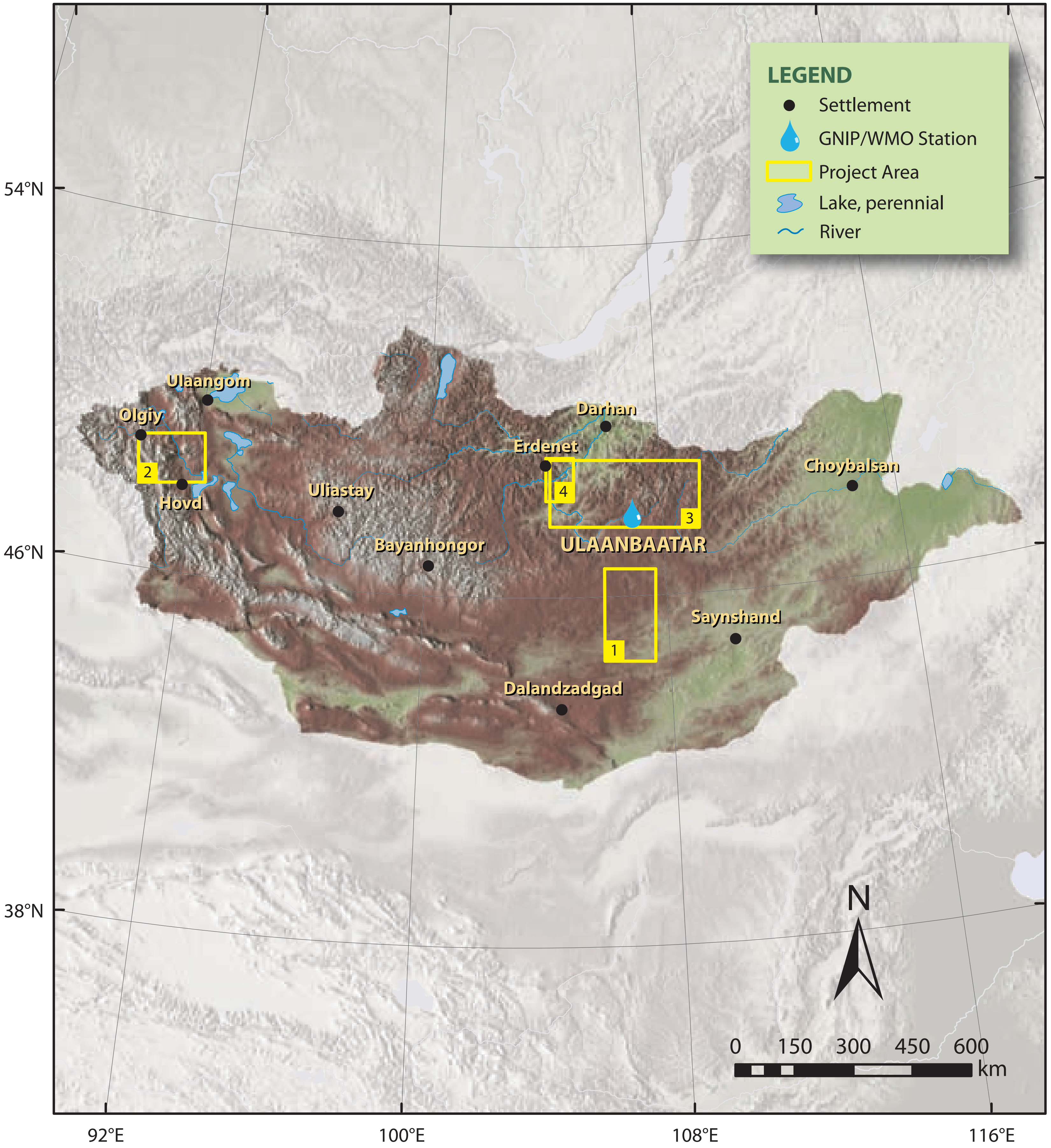




Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KO SAMUI	red square	36	−4.67	−5.35 ± 2.2	29	−23.1	−28.7 ± 10.1			1265
Interpolation – multiple reg.	yellow square			−6.10			−36.0			
Interpolation – kriging (IAEA)	green square			−5.68			−41.4			
Project	pink square									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	3	−6.00	−6.07 ± 0.2	3	−21.7	−18.3 ± 6.9	3	5.7 ± 0.1
River	orange triangle	10	−3.60	−3.76 ± 0.7	10	−21.6	−22.5 ± 4.2	12	8.0 ± 0.5

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle										
GW–Dug well	brown circle	27	−4.00	−3.9 ± 0.7	27	−24.7	−25.1 ± 3.82	27	6.2 ± 0.6		
GW–Spring	green circle										



1 **Project Code:** MON8002G
Study area: Gobi desert aquifers
Sampling period: 1988-1990
Background: Groundwater sustainability and recharge conditions of the aquifers in the arid regions of the Gobi Desert were studied using isotope techniques.

2 **Project Code:** MON8002T
Study area: Tsambagarav area, Western Mongolia
Sampling period: 1991
Background: Isotopic characterization of surface water and groundwater resources in the pristine environments, and studies of snow and ice in glaciers were made in western Mongolia.

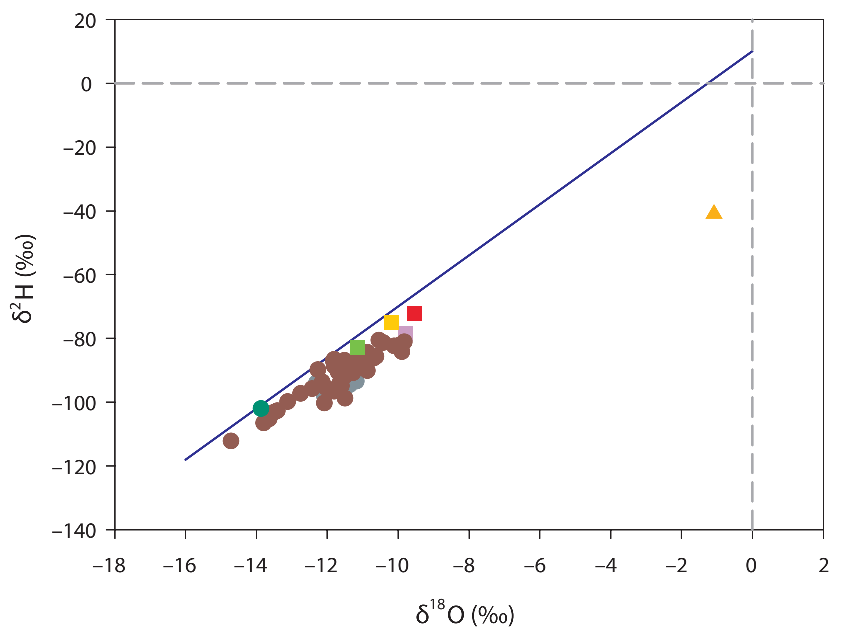
3 **Project Code:** MON8004
Study area: Tuul and Khangal River basins
Sampling period: 1999–2000
Background: Assessment of water resources in Tuul and Khangal River basins was undertaken to understand groundwater dynamics, surface water–groundwater interactions and groundwater contamination due to various industrial activities.

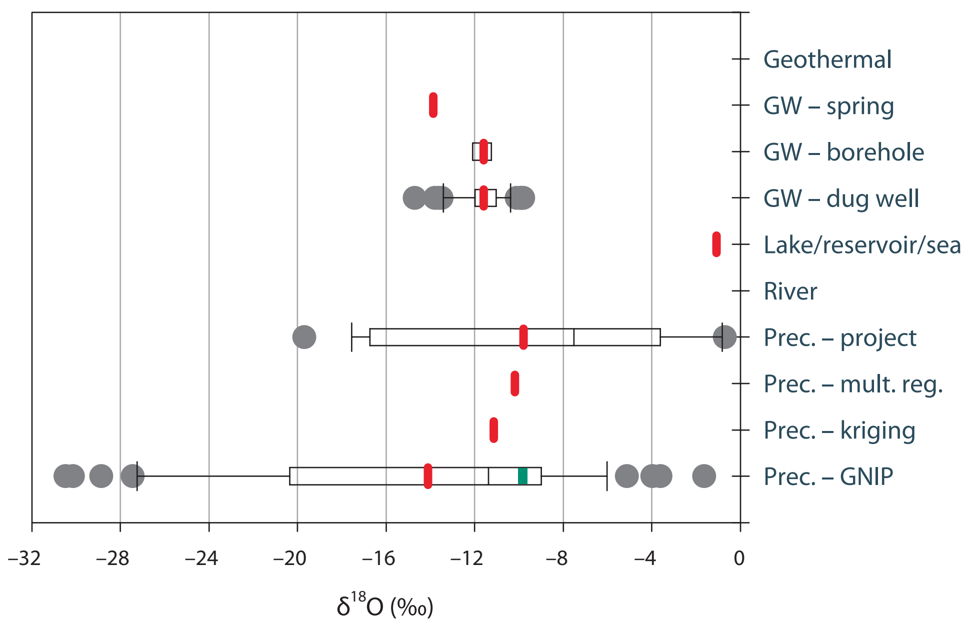
4 **Project Code:** MON8006
Study area: Orkhon River basin
Sampling period: 2005–2006
Background: Isotope techniques in combination with hydrochemical techniques were used for assessing the degradation of water quality in the Orkhon River basin.

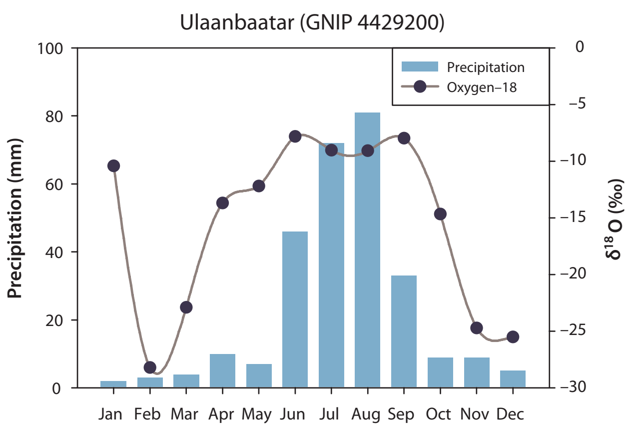
IAEA
Water Resources Programme

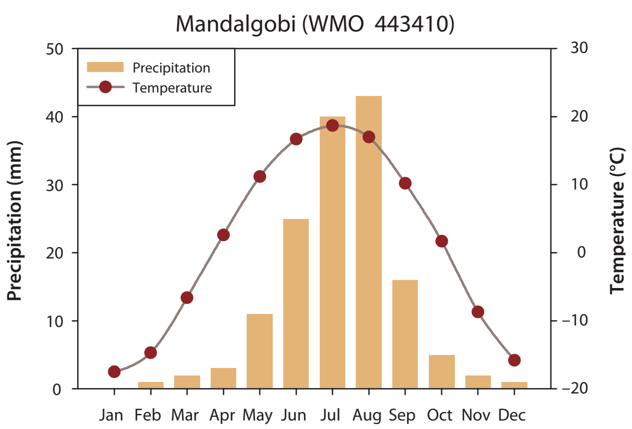
MON8002G

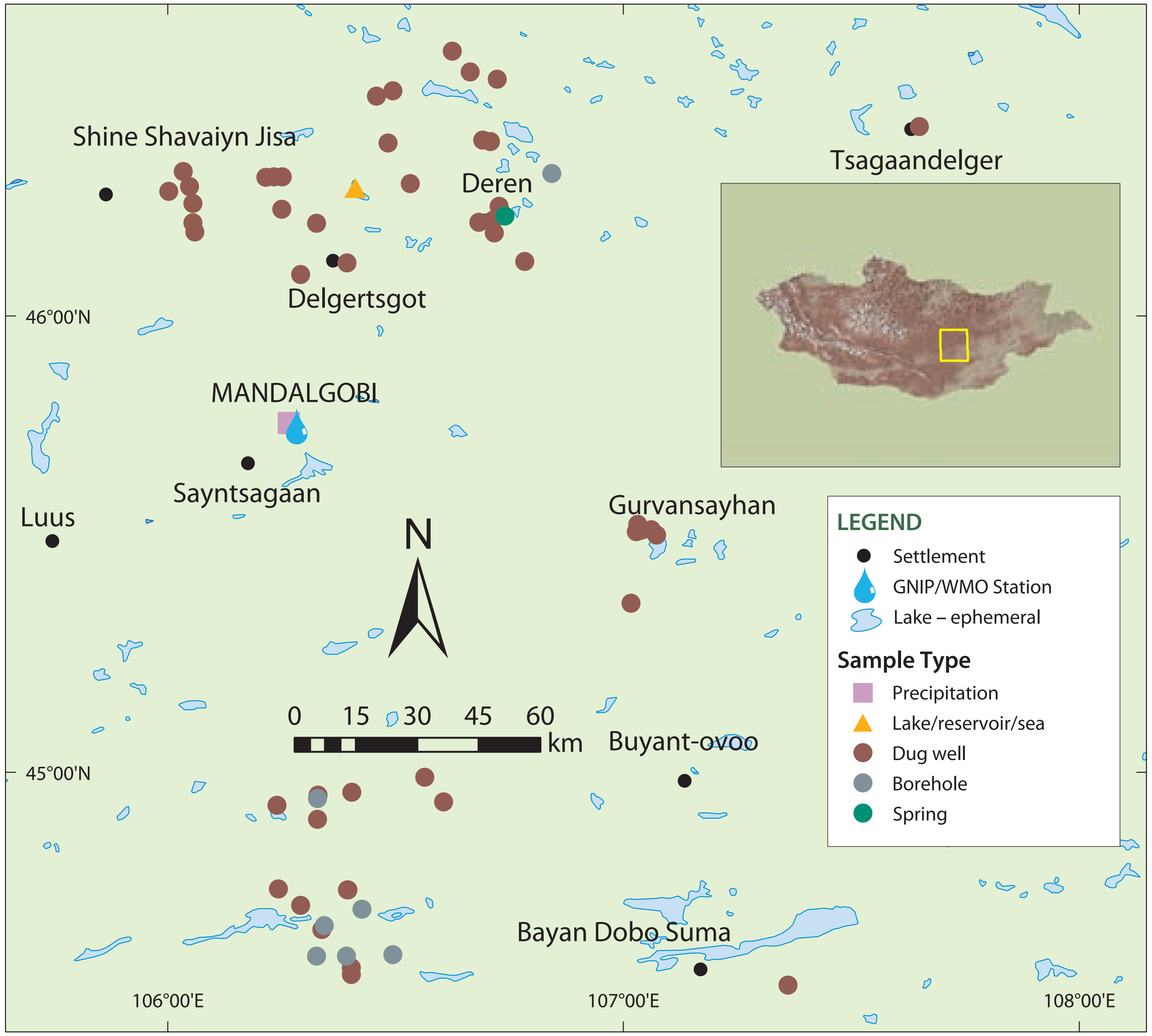
Gobi desert aquifers











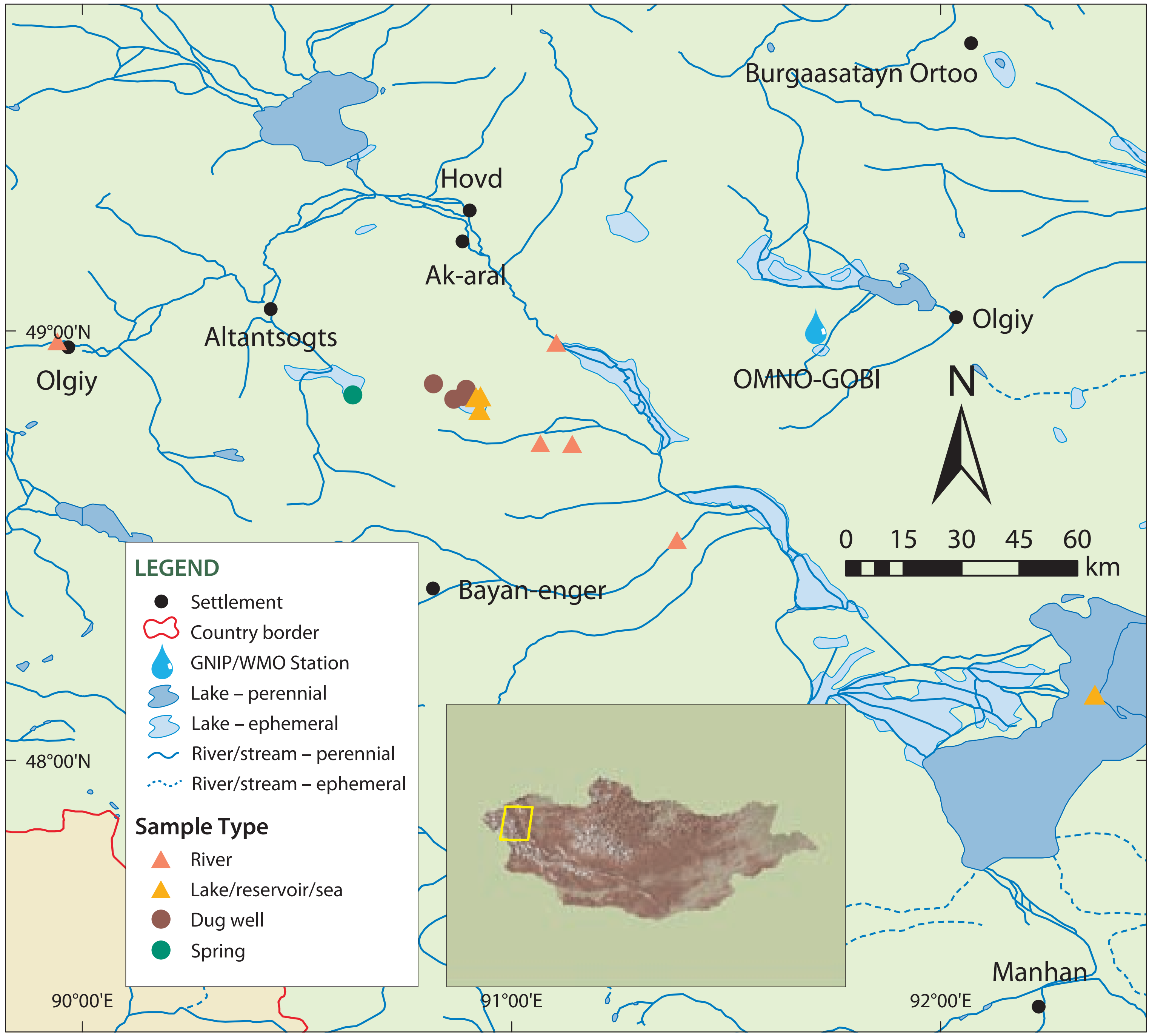
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station ULAANBAATAR	■ (red)	44	−11.38	−9.54 ± 3.3	44	−83.1	−72.0 ± 7.9			255
Interpolation – multiple reg.	■ (yellow)			−10.20			−75.0			
Interpolation – kriging (IAEA)	■ (green)			−11.15			−82.8			
Project	■ (pink)	18	−7.53	−9.80 ± 6.5	18	−66.1	−78.3 ± 43.1	17	72.8 ± 14.8	

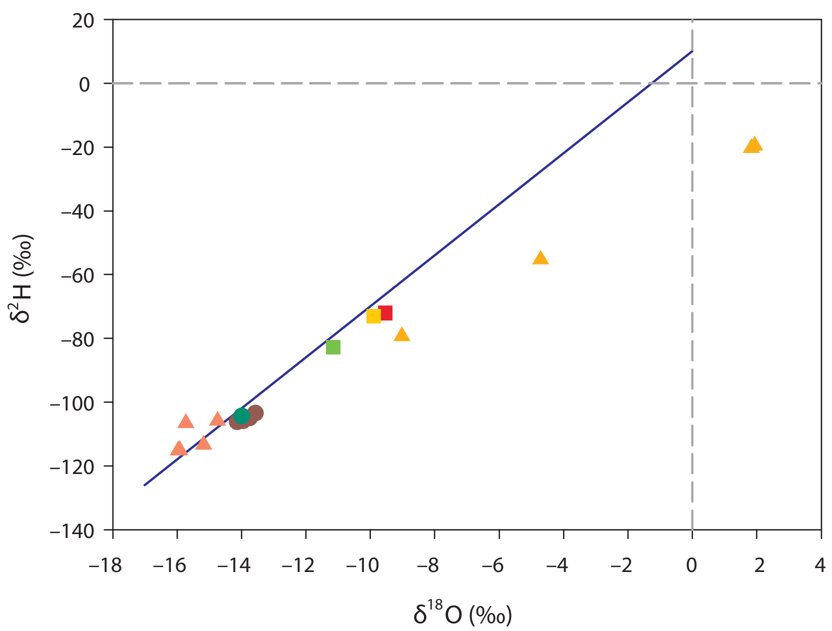
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲	1		−1.09	1		−41.0	1	6.7
River	▲								

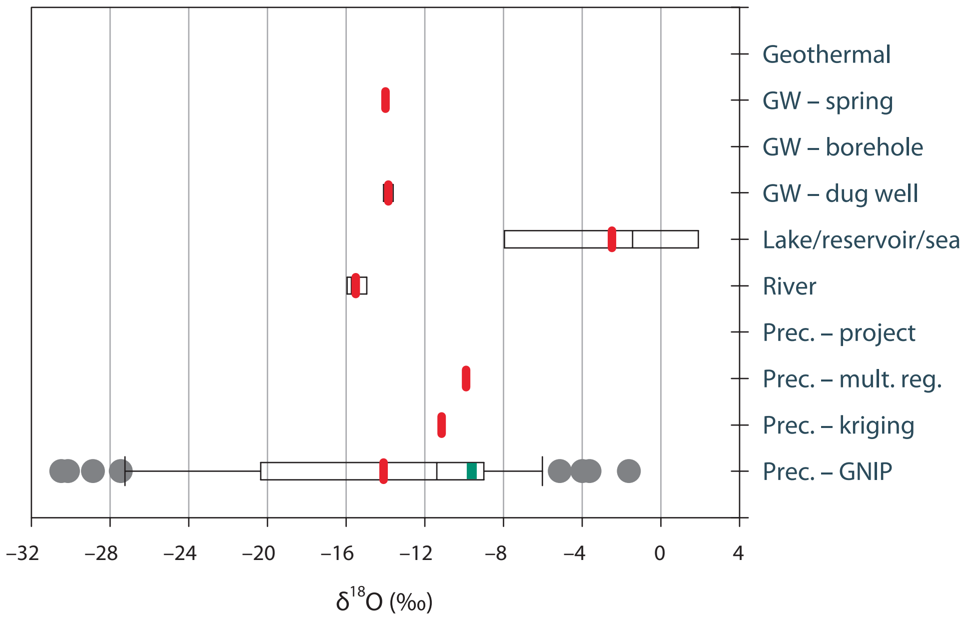
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	7	−11.51	−11.6 ± 0.4	7	−94.6	−95.0 ± 1.6	7	0.1 ± 0.1	4	0 ± 0
GW–Dug well	●	48	−11.46	−11.6 ± 1.0	48	−89.3	−91.1 ± 7.0	47	27.5 ± 44.9	11	73 ± 25
GW–Spring	●	1	−13.87		1	−102.0		1	0.2		

MON8002T

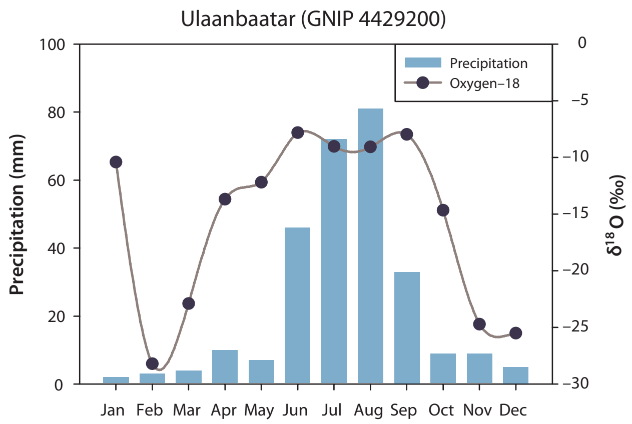
Tsambagarav area, Western Mongolia

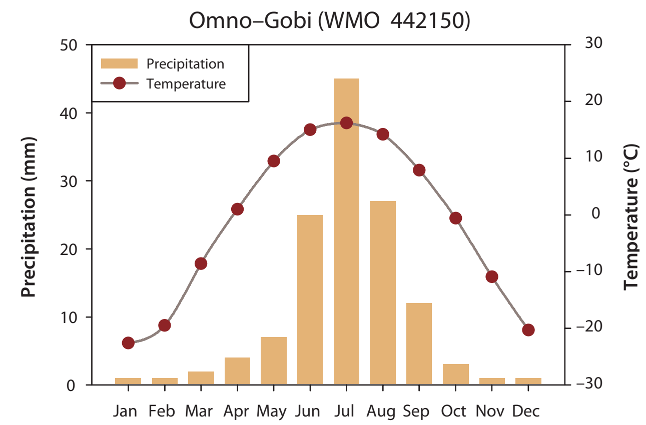






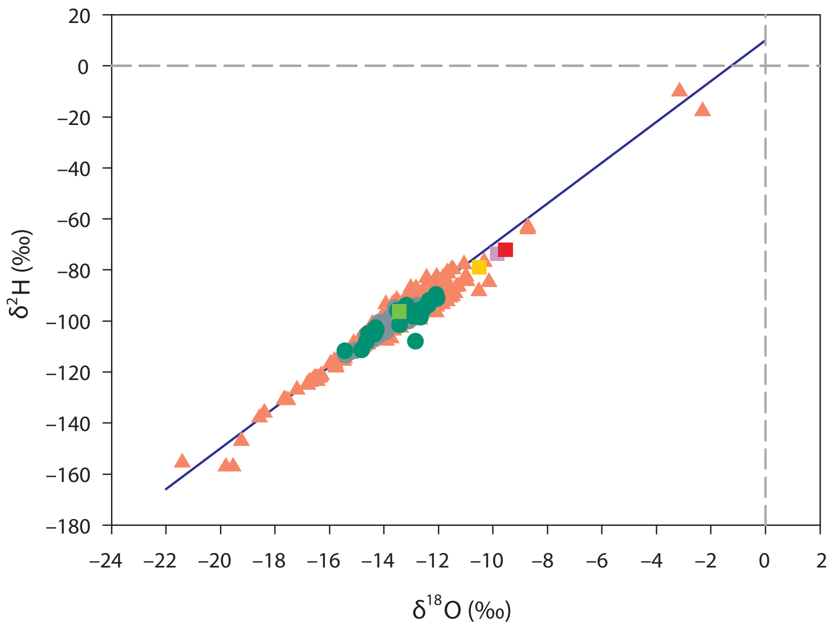
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station ULAANBAATAR	red square	44	−11.38	−9.54 ± 3.3	44	−83.1	−72.0 ± 7.9			255	
Interpolation – multiple reg.	yellow square			−9.90			−73.0				
Interpolation – kriging (IAEA)	green square			−11.15			−82.8				
Project	pink square										
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.		
Lake/reservoir/sea	yellow triangle	4	−1.45	−2.5 ± 5.4	4	−37.8	−43.6 ± 29.0	4	69.7 ± 53.6		
River	orange triangle	5	−15.72	−15.5 ± 0.5	5	−113.4	−111.2 ± 4.6	5	48.1 ± 9.9		
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle										
GW–Dug well	brown circle	4	−13.85	−13.85 ± 0.2	4	−105.4	−105.1 ± 1.2	4	53.2 ± 8.4		
GW–Spring	green circle	1		−13.99	1		−104.4	1	51.5		

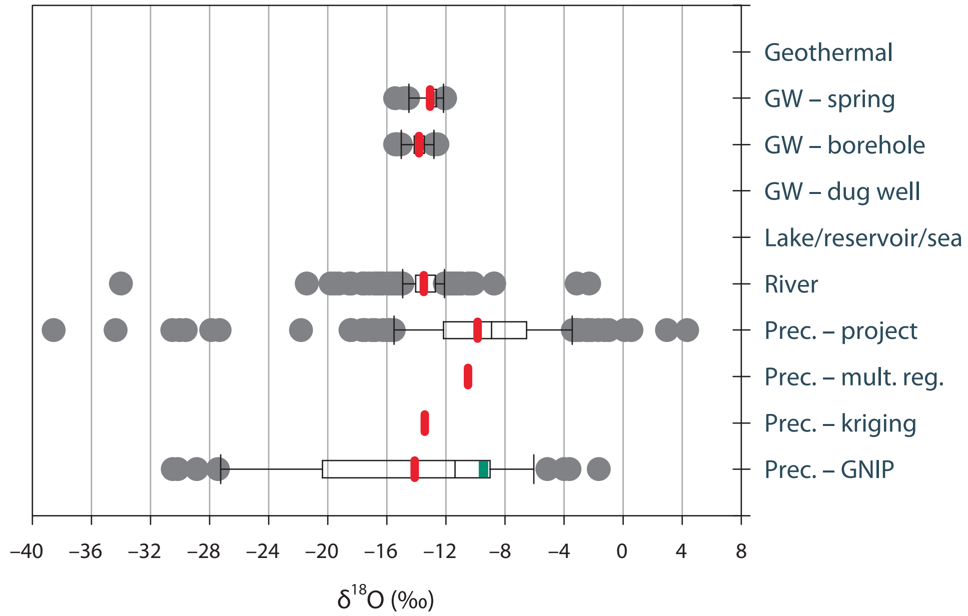


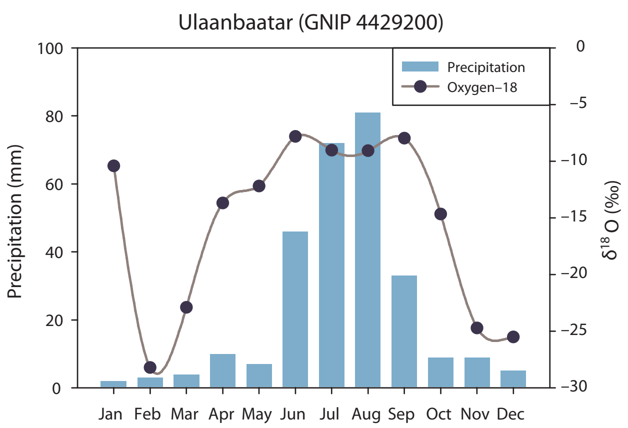


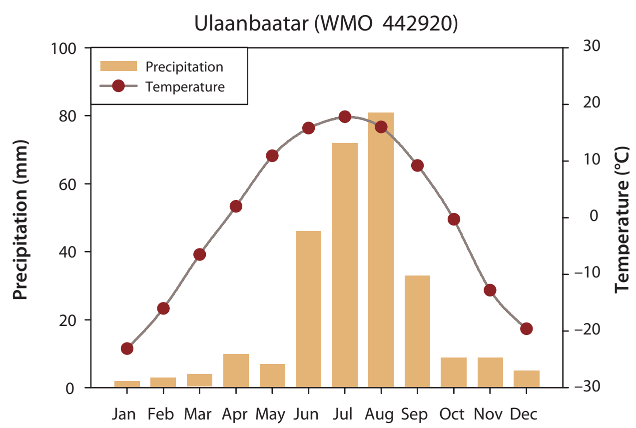
MON8004

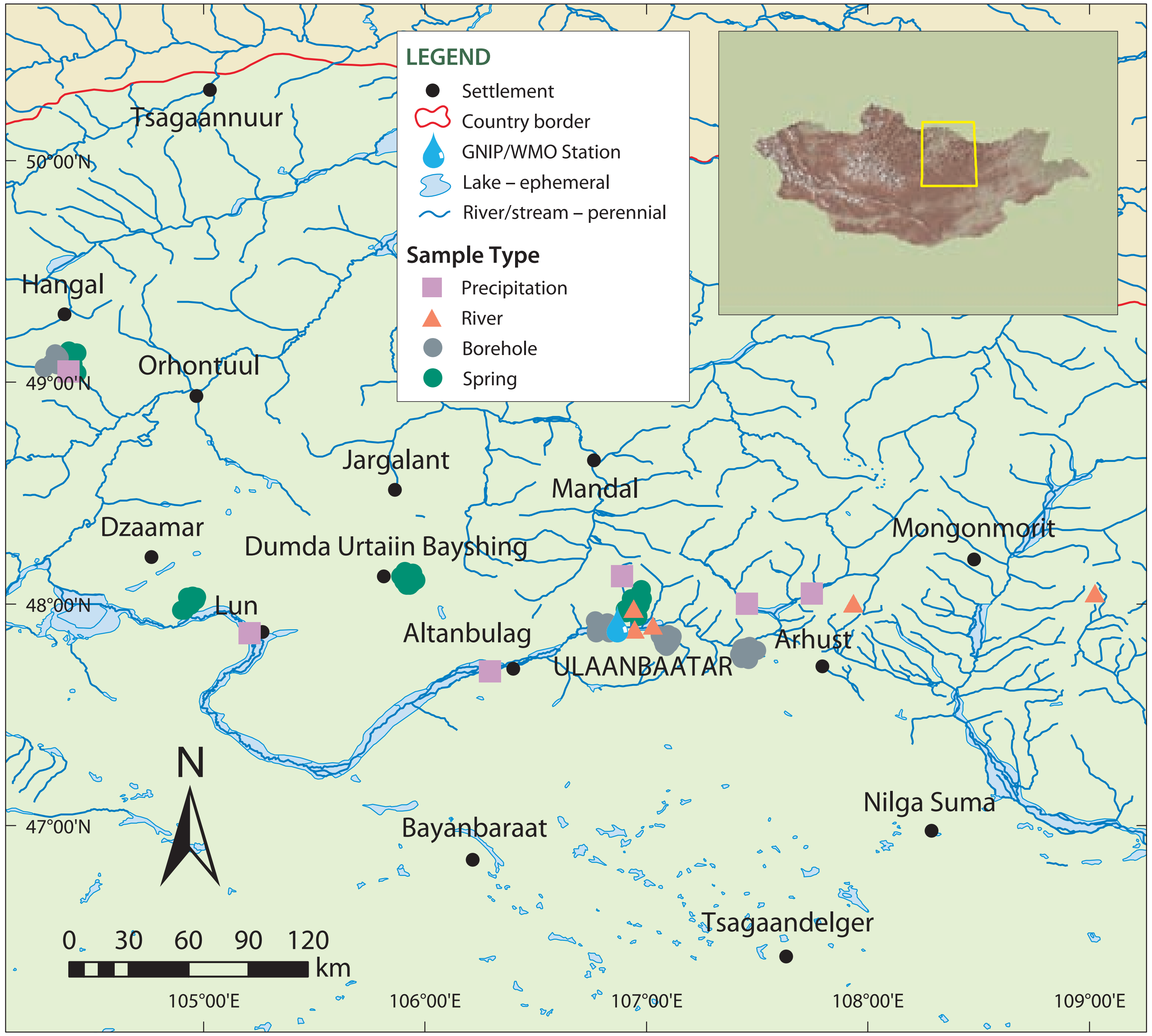
Tuul and Khangal River basins







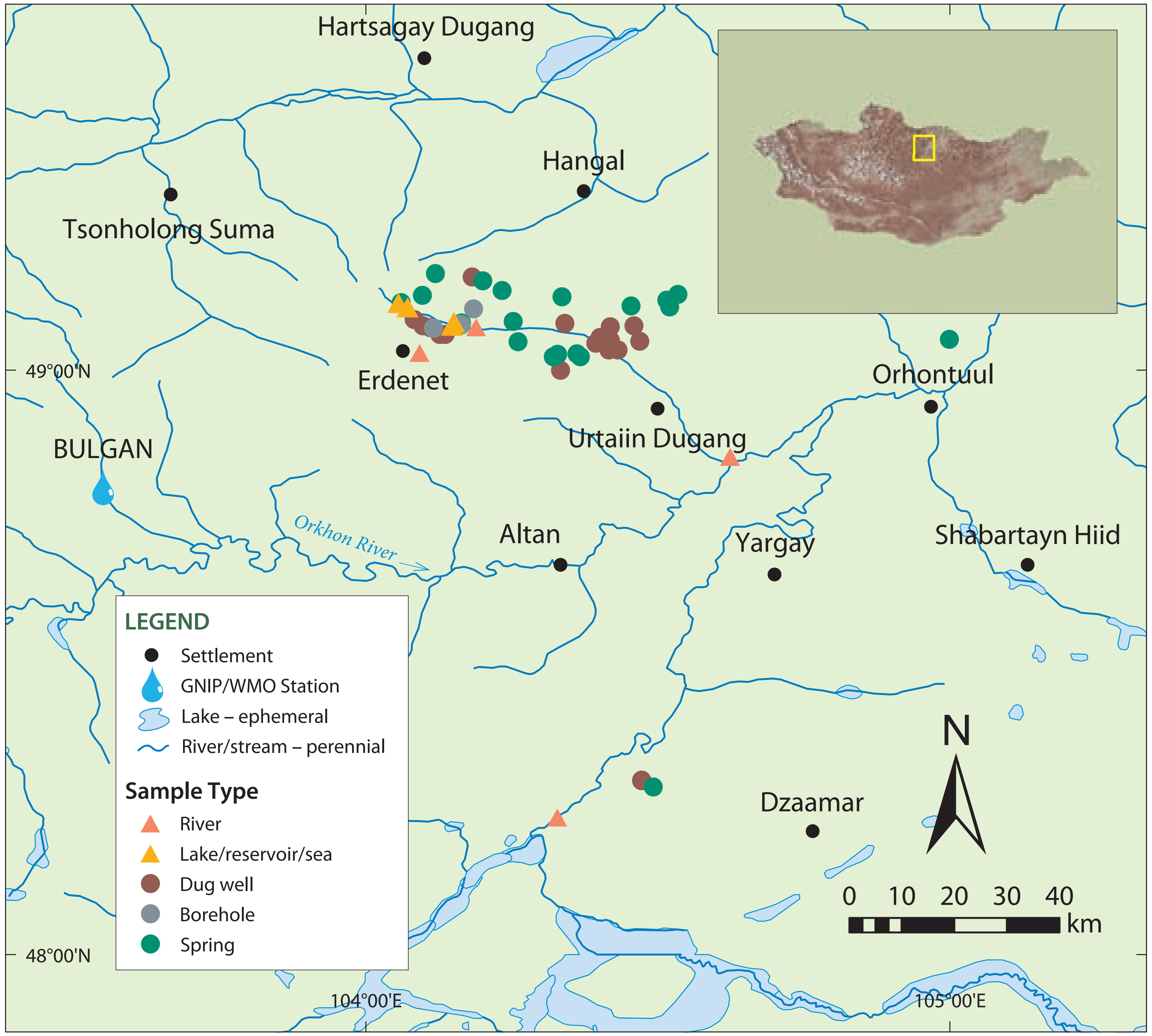


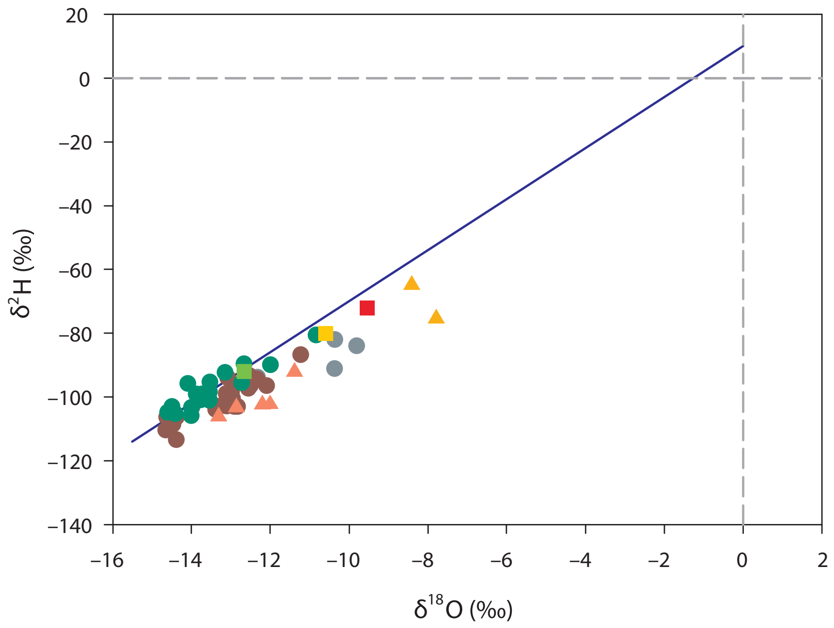


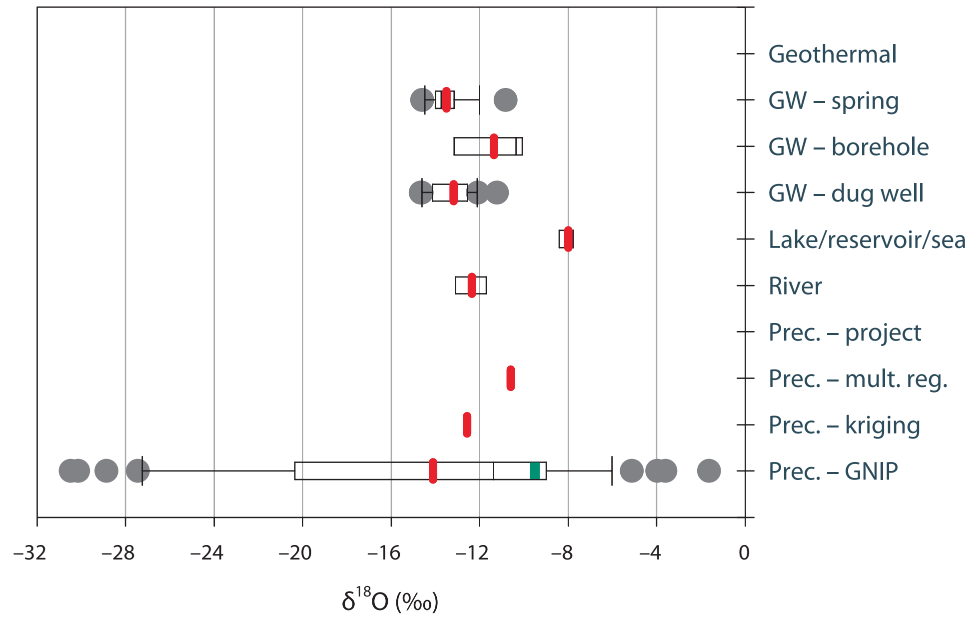
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station ULAANBAATAR	■	44	−11.38	−9.50 ± 3.3	44	−83.1	−72.0 ± 7.9			255
Interpolation – multiple reg.	■			−10.50			−79.0			
Interpolation – kriging (IAEA)	■			−13.44			−96.14			
Project	■	192	−8.90	−9.80 ± 5.9	192	−65.0	−73.8 ± 43.8	27	36.1 ± 3.5	

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲								
River	▲	434	−13.44	−13.50 ± 1.8	426	−97.6	−98.5 ± 17.7	68	37.3 ± 9.0

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	47	−13.77	−13.80 ± 0.7	47	−100.4	−101.3 ± 5.1	16	36.9 ± 4.3		
GW–Dug well	●										
GW–Spring	●	42	−12.84	−13.10 ± 0.8	41	−97.2	−98.2 ± 5.3	14	42.2 ± 8.4	1	93



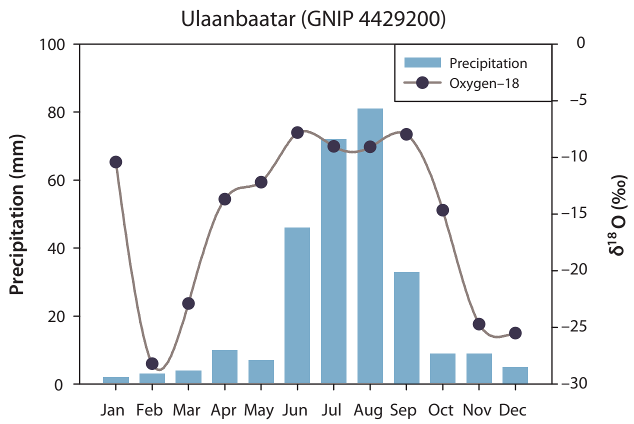


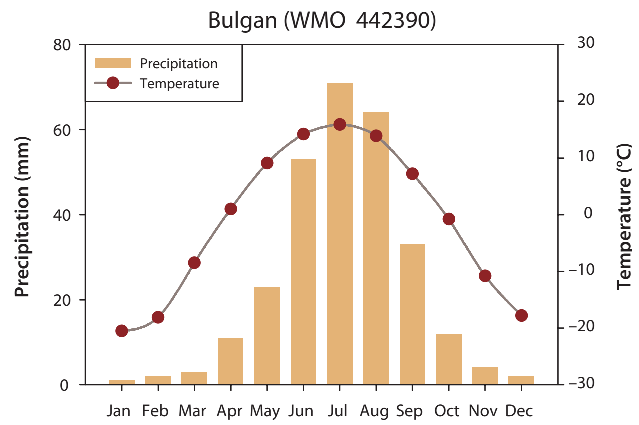


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station ULAANBAATAR	red square	44	−11.38	−9.54 ± 3.3	44	−83.1	−72.0 ± 7.9			255
Interpolation – multiple reg.	yellow square			−10.60			−80.0			
Interpolation – kriging (IAEA)	green square			−12.58			−93.0			
Project	pink square									

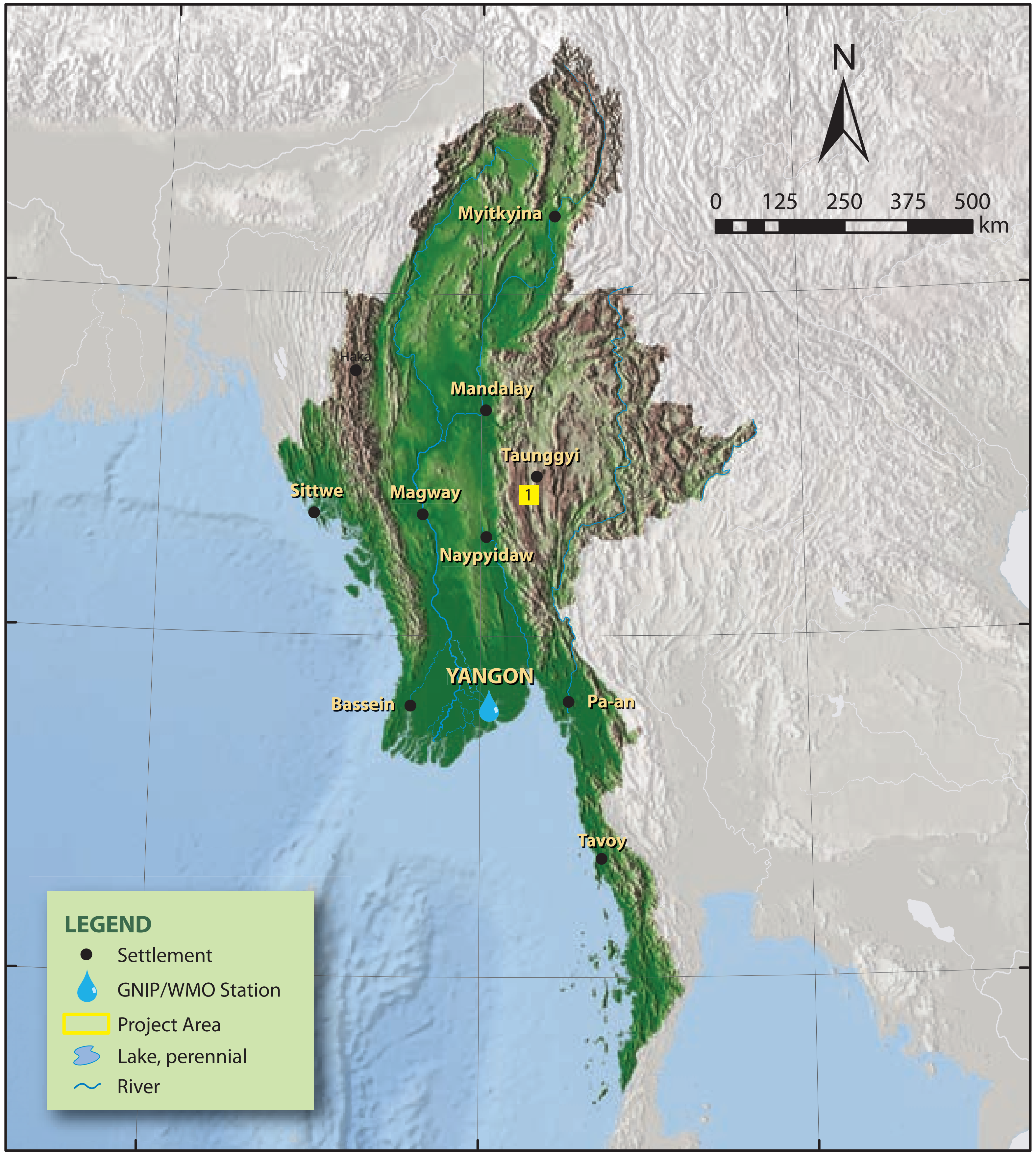
Surface waters		δ¹⁸O			δ²H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	2	−8.10	−8.1 ± 0.4	2	−70.1	−70.1 ± 7.4	1	28.5
River	orange triangle	5	−12.20	−12.35 ± 0.8	5	−102.3	−101.2 ± 5.3	5	28.1 ± 5.6

Groundwaters		δ¹⁸O			δ²H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	5	−10.37	−11.37 ± 1.8	5	−91.1	−90.8 ± 8.5	2	19.8 ± 7.6		
GW–Dug well	brown circle	20	−13.03	−13.17 ± 0.9	20	−101.6	−100.8 ± 6.5	16	13.9 ± 8.3	3	82 ± 3
GW–Spring	green circle	19	−13.74	−13.5 ± 0.9	19	−99.1	−97.9 ± 6.4	1	27.5		





MYANMAR

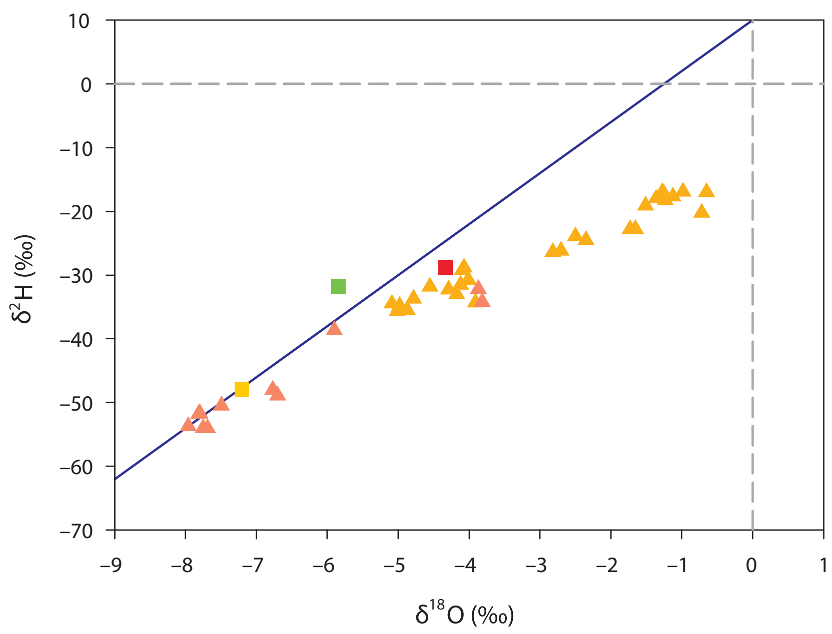


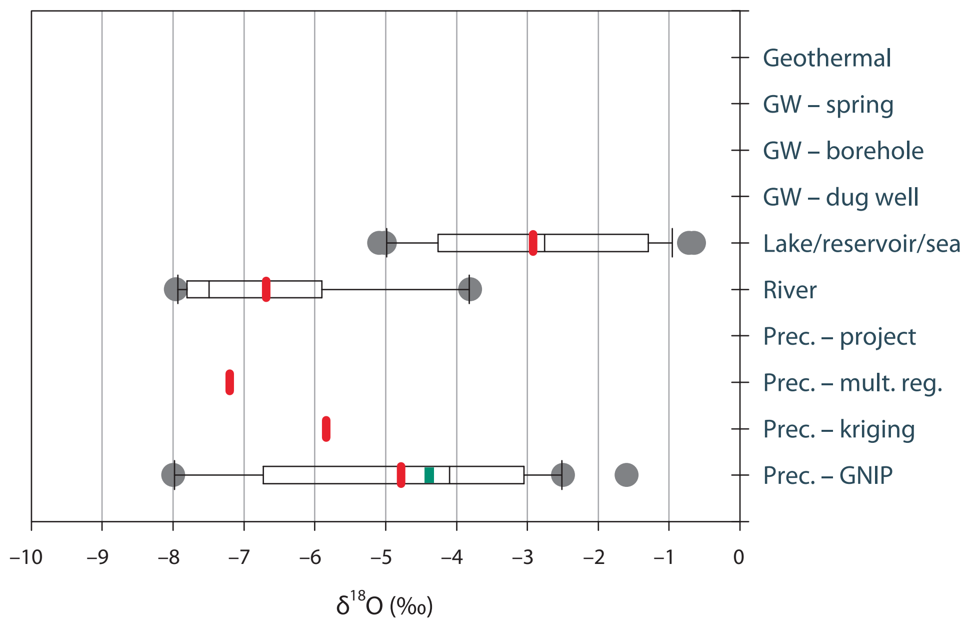
1 **Project Code:** MYA8003
Study area: Lake Inle
Sampling period: 1993
Background: Lake water dynamics and sedimentation rates in Lake Inle in Central Myanmar were studied using isotope techniques.

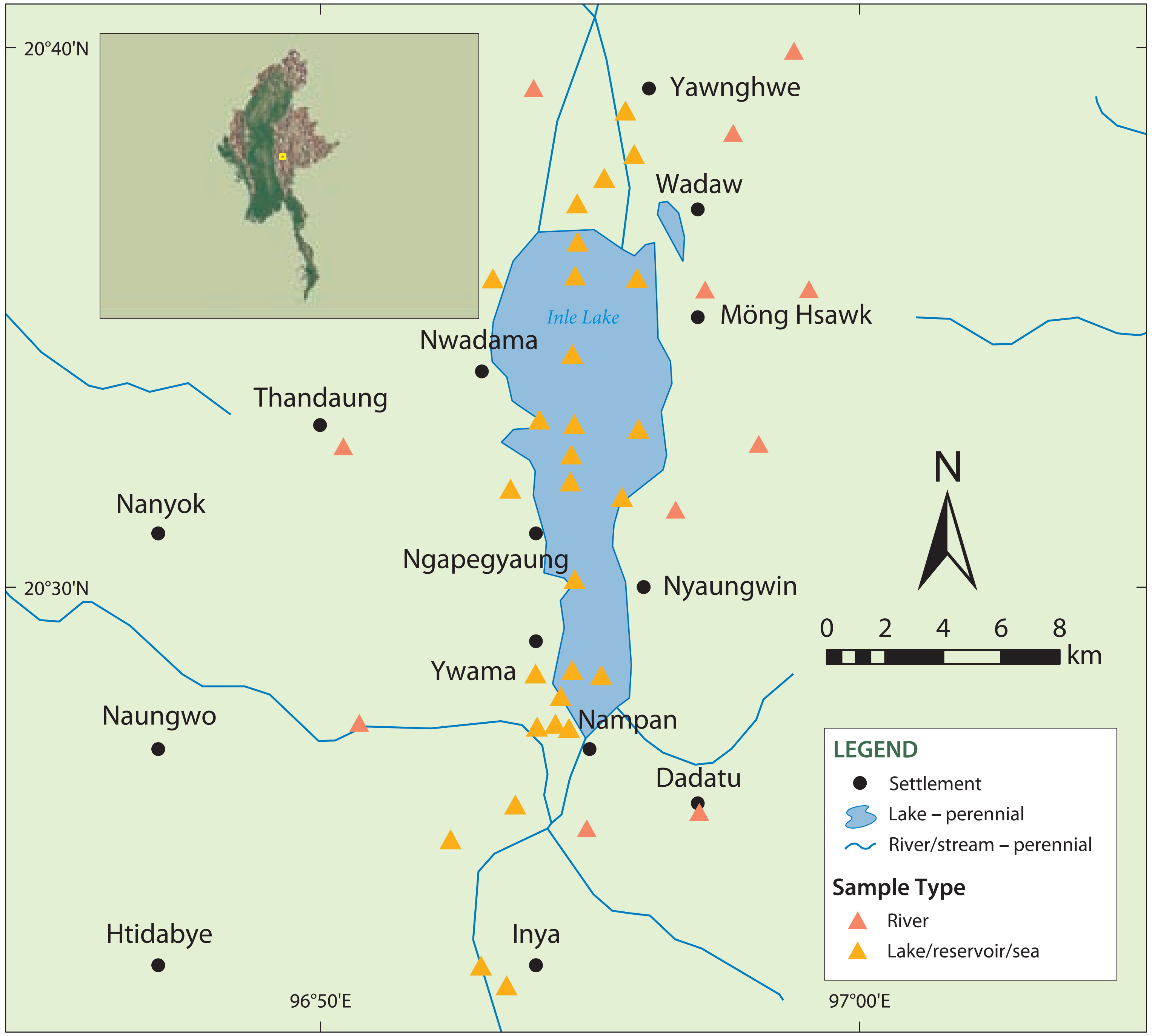
IAEA Water Resources Programme

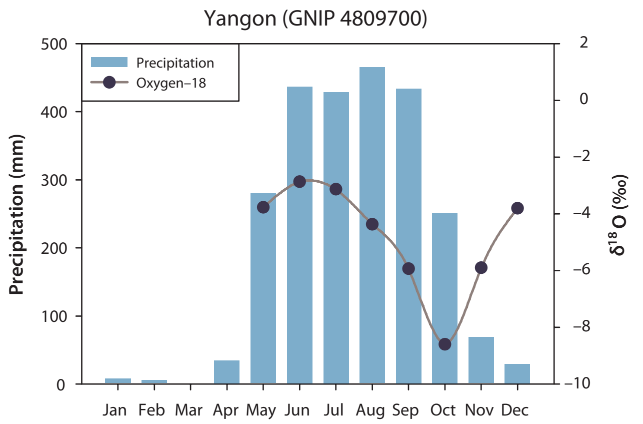
MYA8003

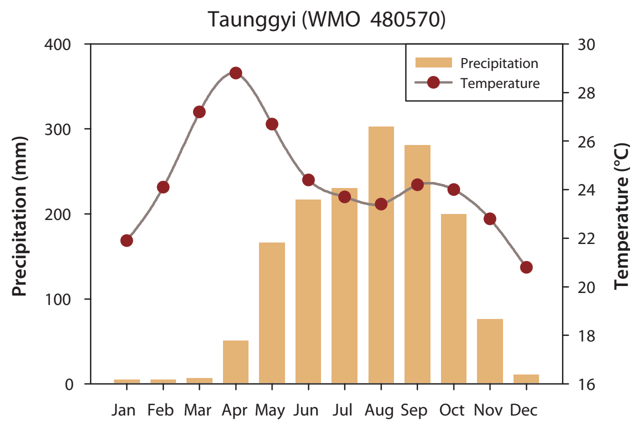
Lake Inle







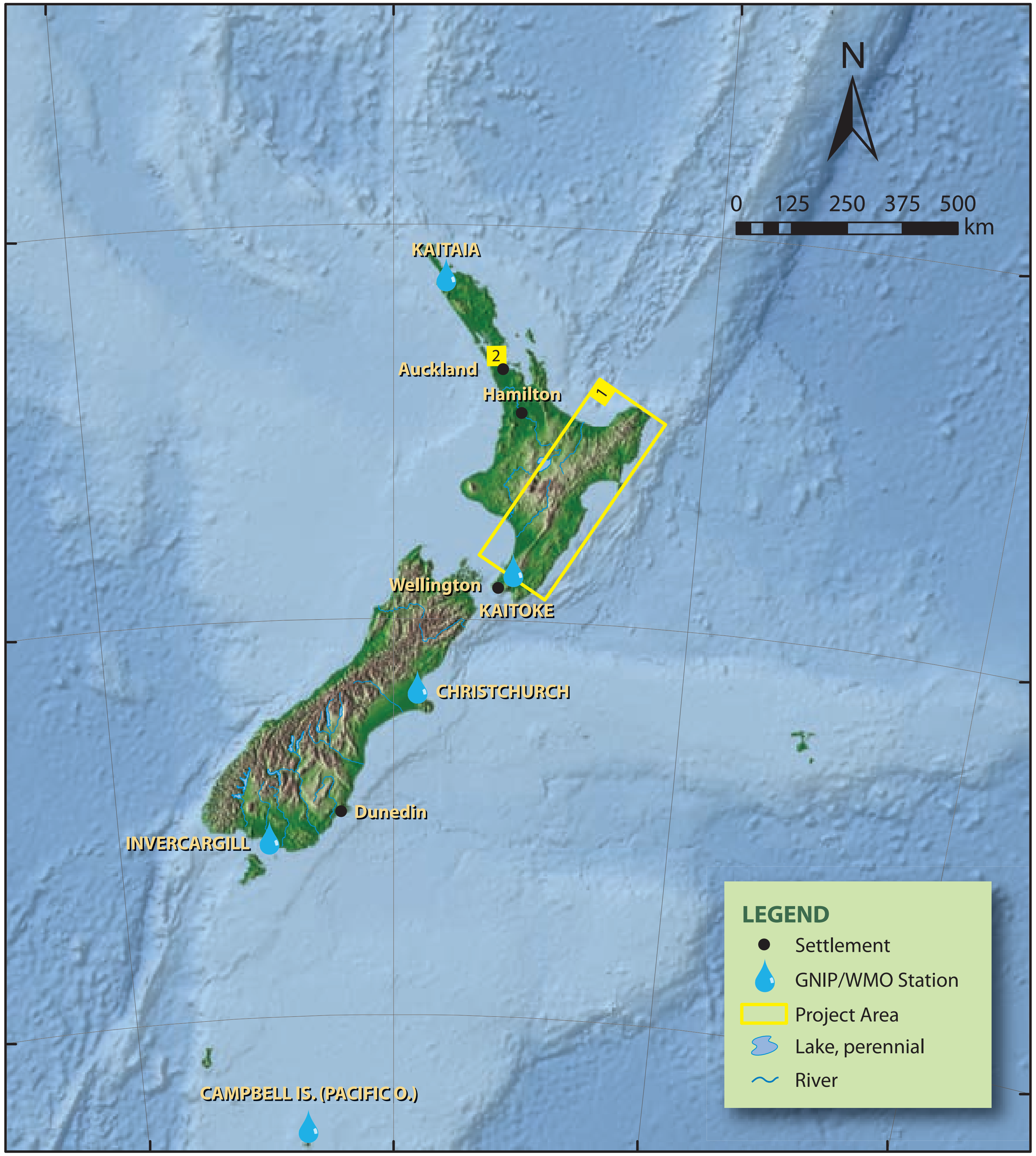




Precipitation		δ¹⁸O (‰) n	δ¹⁸O (‰) Median	δ¹⁸O (‰) Mean ± St. dev.	δ²H (‰) n	δ²H (‰) Median	δ²H (‰) Mean ± St. dev.	Tritium (TU) n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station YANGON	■	20	−4.10	−4.33 ± 0.4	20	−25.2	−28.8 ± 2.9			2189
Interpolation – multiple reg.	■			−7.20			−48.0			
Interpolation – kriging (IAEA)	■			−5.84			−31.7			
Project	■									

Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	▲	28	−2.76	−2.92 ± 1.6	28	−26.3	−26.2 ± 6.9		
River	▲	11	−7.49	−6.69 ± 1.5	11	−50.5	−47.1 ± 8.1		

Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C (pMC) Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●										
GW–Dug well	●										
GW–Spring	●										



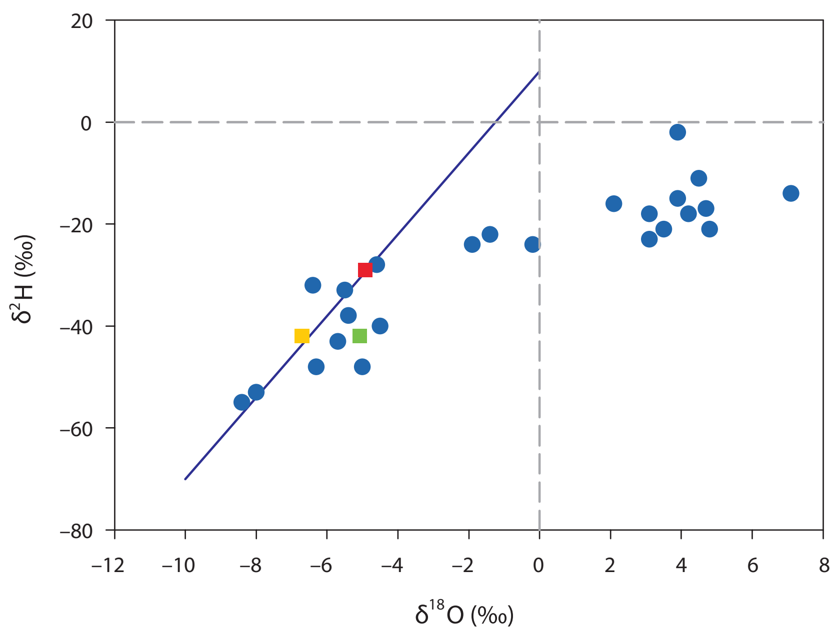
1 **Project Code:** NZE–5961
Study area: Northern Island geothermal systems
Sampling period: 1977–1992
Background: The isotope study was carried out to investigate the evolution of geothermal fluids within an active accretionary prism associated with andesitic magmatism where marine sediments and seawater subduct along the convergent plate margins.

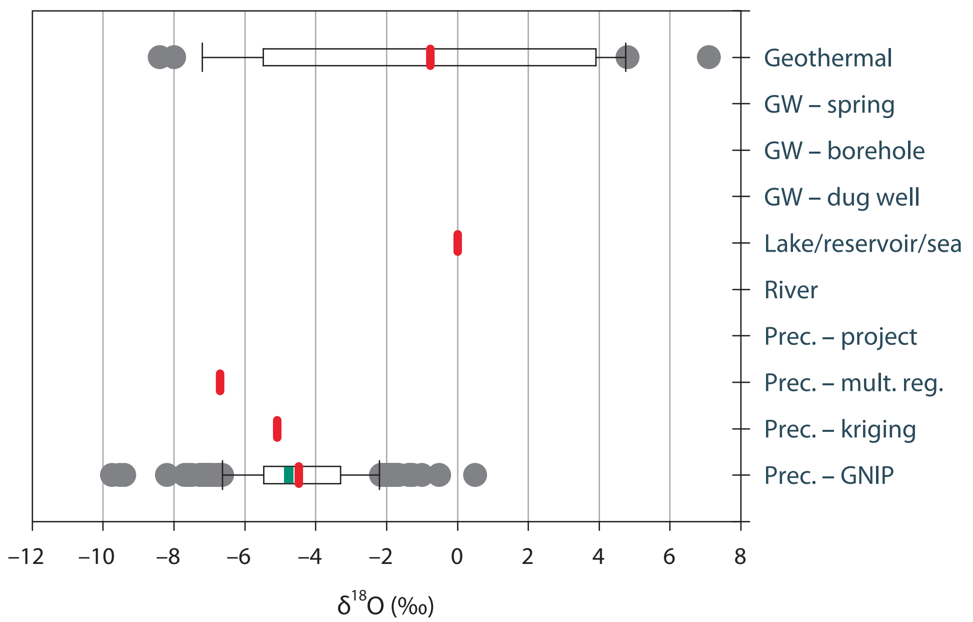
2 **Project Code:** NZE–10232
Study area: Auckland area
Sampling period: 1998–1999
Background: Disposal of storm water in the Mt. Eden area of Auckland, New Zealand is via 'soak holes' drilled directly into the fractured basalt. The objective of this study was to use geochemical and isotopic results as inputs for modelling.

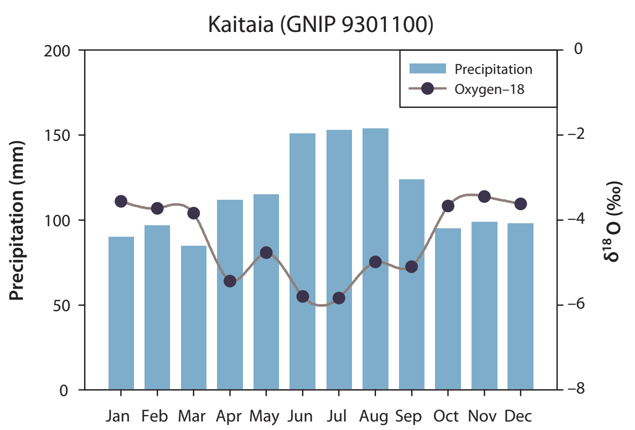
IAEA
Water Resources Programme

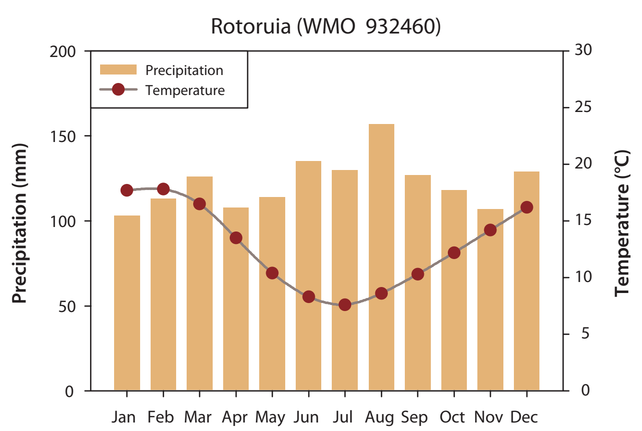
NZE–5961

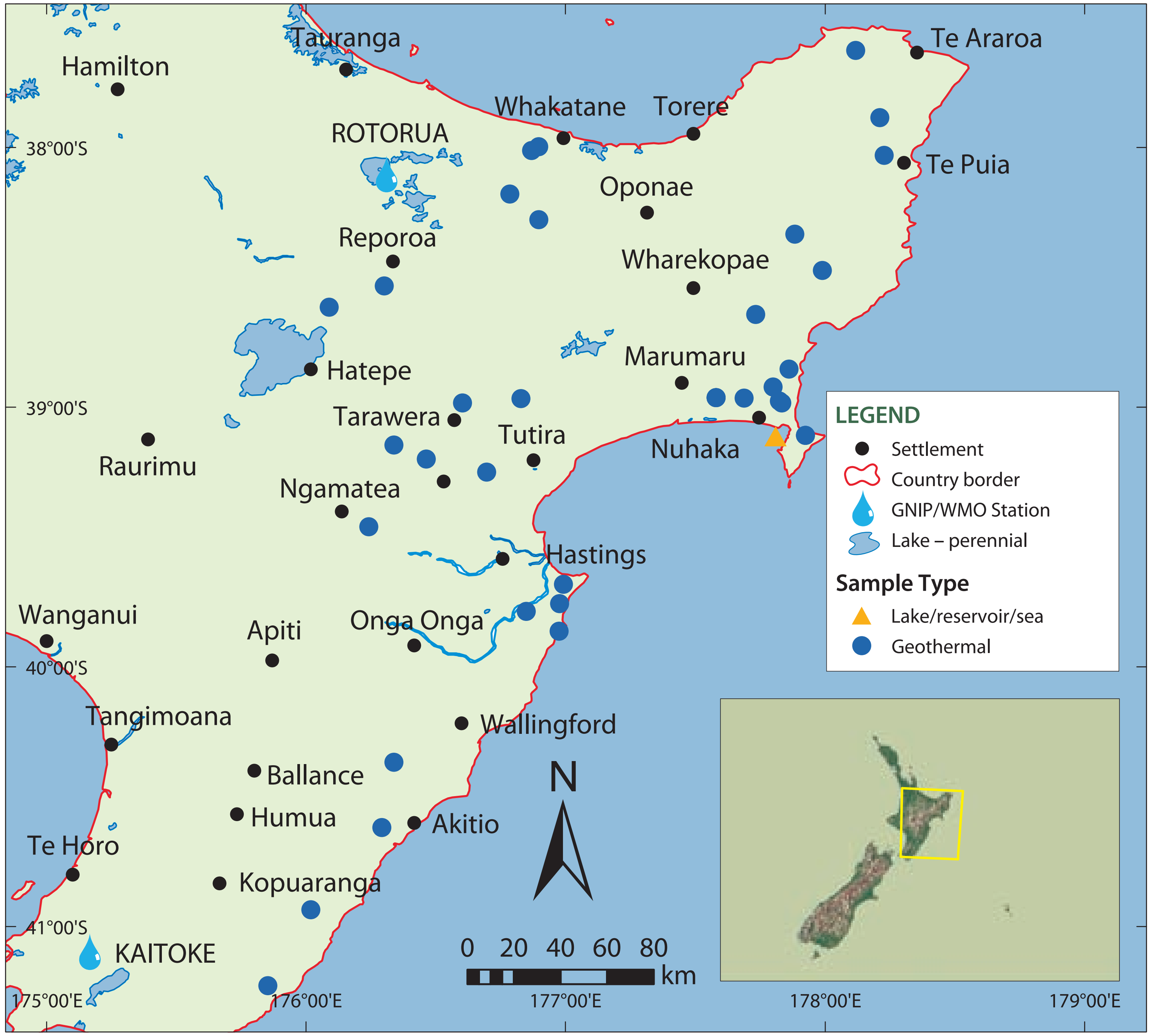
Northern Island geothermal systems







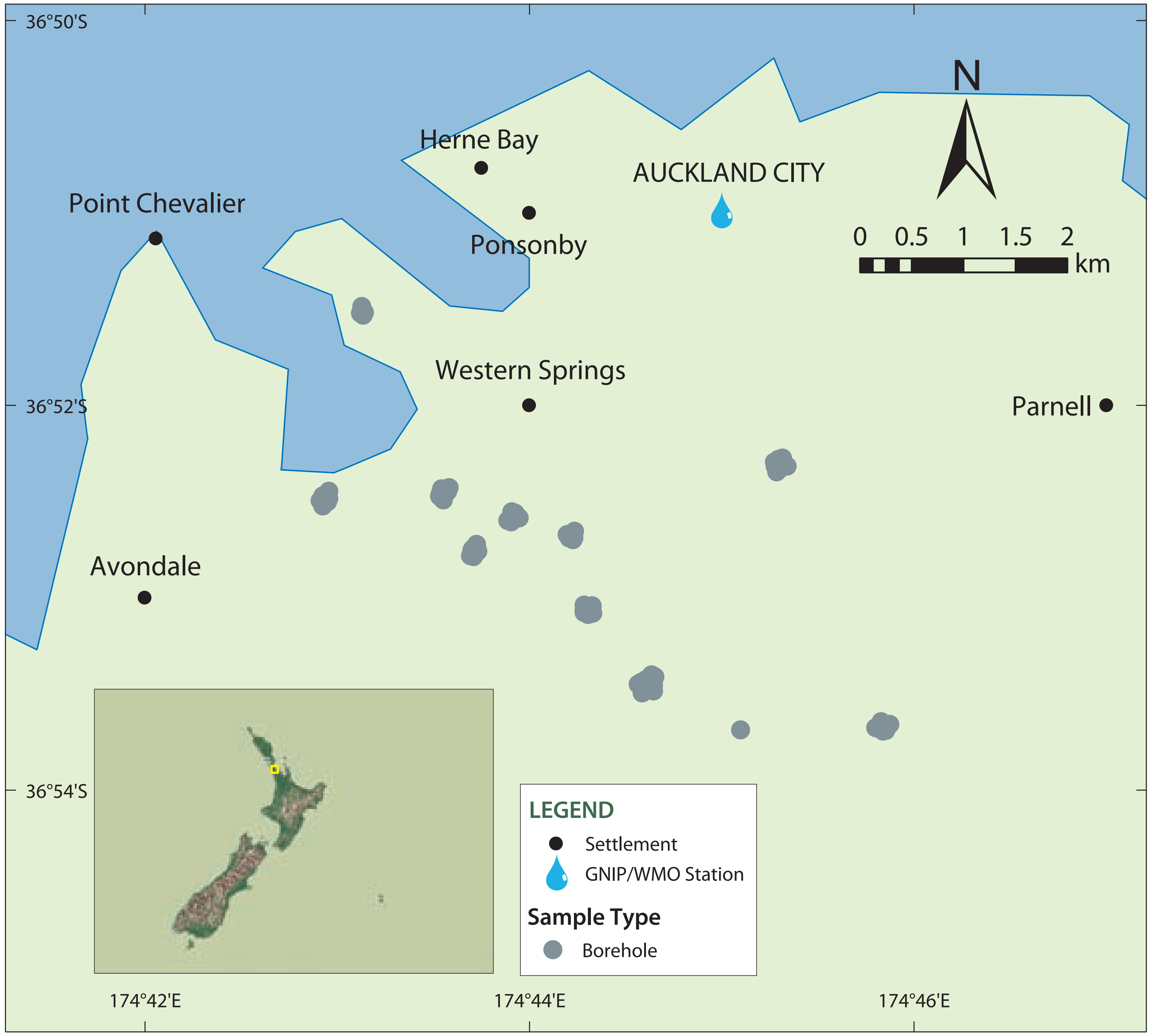


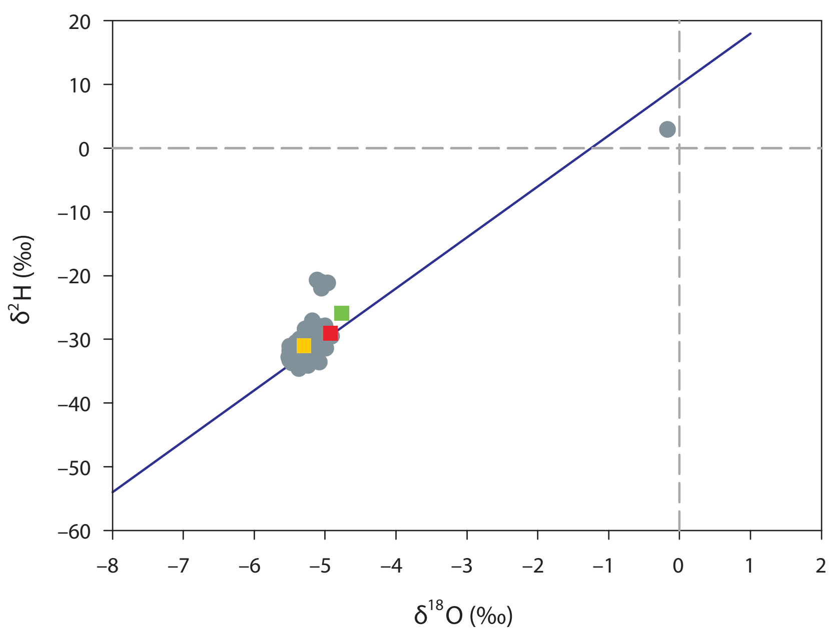


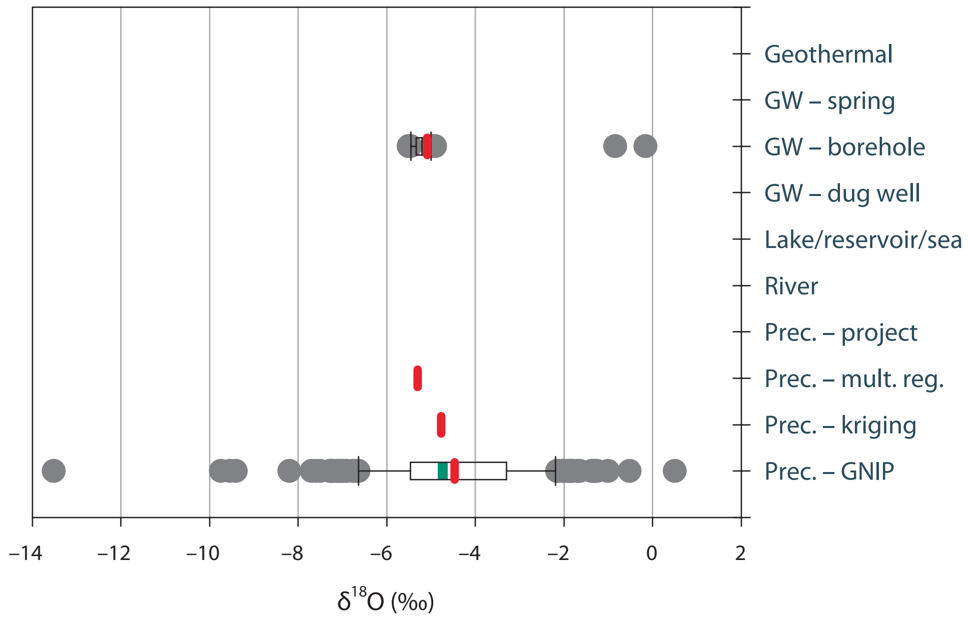
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KAITAIA	■ (red)	241	−4.42	−4.92 ± 1.6	228	−23.4	−29.0 ± 3.6			1353
Interpolation – multiple reg.	■ (yellow)			−6.70			−42.0			
Interpolation – kriging (IAEA)	■ (green)			−5.08			−30.2			
Project	■ (pink)									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)	1		0.0	1		0.0		
River	▲ (salmon)								

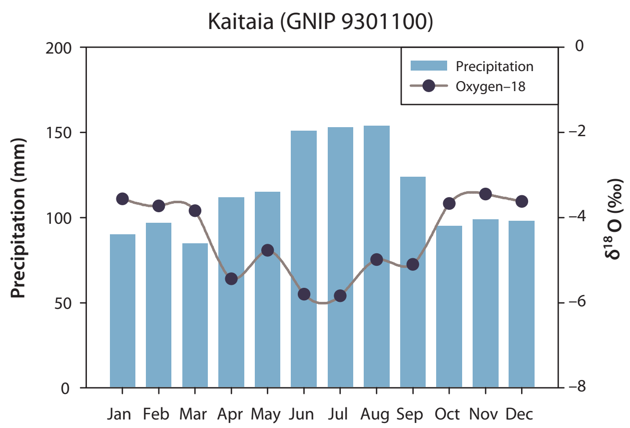
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)	24	−0.80	−0.77 ± 5.0	24	−23.5	−27.7 ± 14.2				
GW–Borehole	● (grey)										
GW–Dug well	● (brown)										
GW–Spring	● (green)										

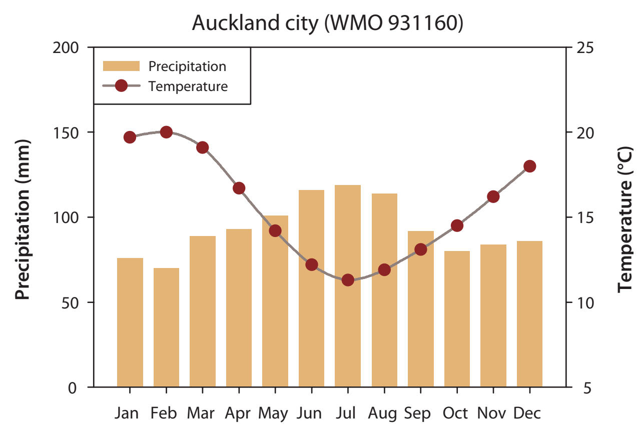


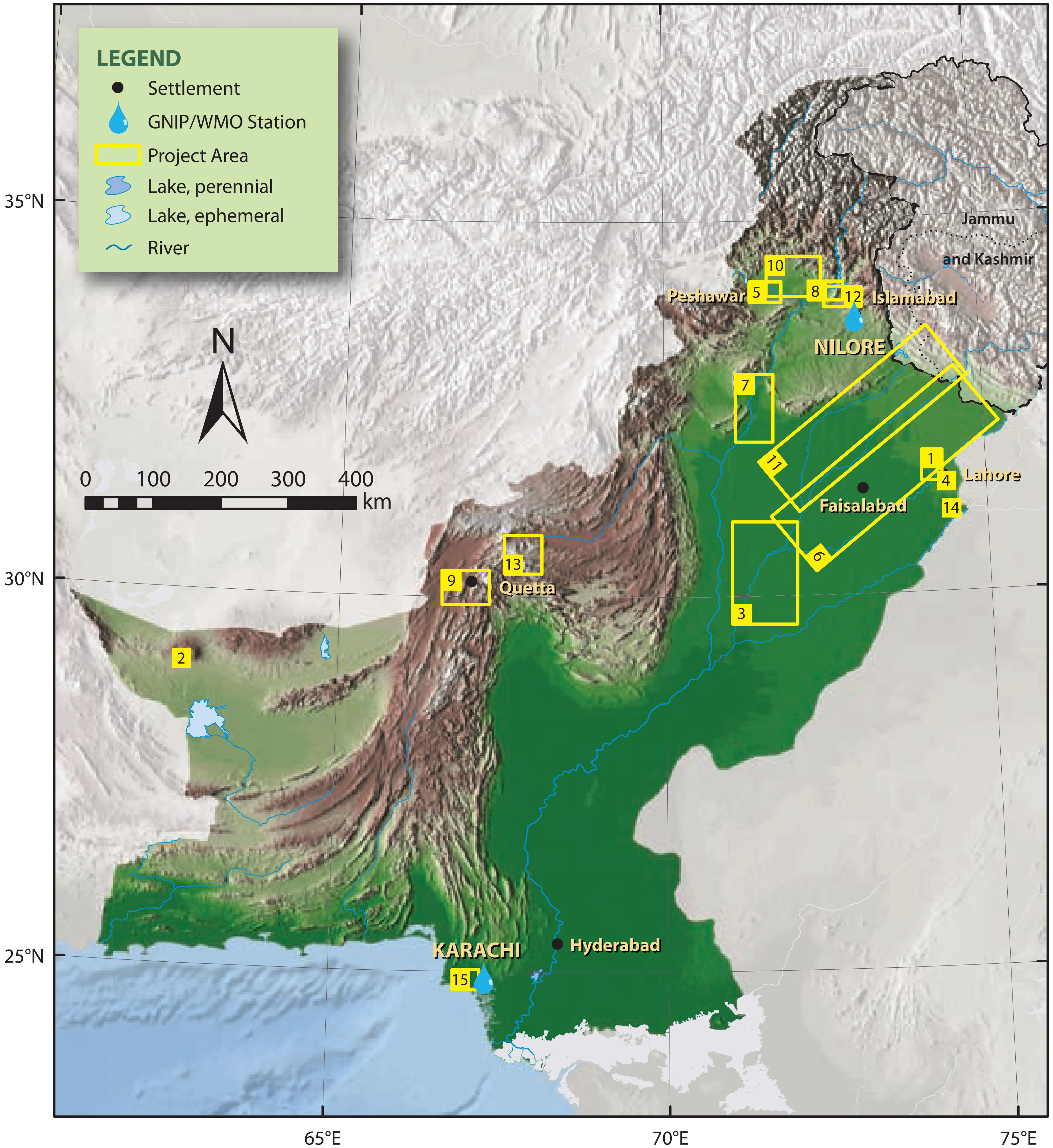




Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station KAITAIA	■ (red)	241	−4.48	−4.92 ± 1.6	228	−23.4	−29.0 ± 3.6			1353
Interpolation – multiple reg.	■ (yellow)			−5.30			−31.0			
Interpolation – kriging (IAEA)	■ (green)			−4.77			−26.0			
Project	■ (pink)									
Surface waters		δ¹⁸O			δ²H			Tritium		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	▲									
River	▲									
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n Mean ± St. dev.
Geothermal water	●									
GW–Borehole	●	68	−5.21	−5.08 ± 0.8	67	−30.0	−29.6 ± 5.0	4	1.6 ± 0.9	
GW–Dug well	●									
GW–Spring	●									







1 Project Code: RAS8084–PAK
Study area: Sheikhupura area
Sampling period: 1998–1999
Background: The study area has numerous surface drains carrying untreated domestic wastes and industrial effluent, which cause a threat to the quality of surface water and groundwater. The objectives of the project were: to investigate pollution levels, sources of recharge and pollutants, aquifer vulnerability to pollution, and to develop groundwater flow and pollutant transport model for sustainable management of the aquifer.

2 Project Code: RAS8092–PAK
Study area: Koh Sultan volcano area, Chagi
Sampling period: 2003–2004
Background: Koh Sultan is the youngest volcano in Pakistan and has some geothermal springs around its crater. For preliminary investigation of geothermal potential, isotope and chemical techniques were used to identify the source of recharge, subsurface processes, residence time, and reservoir temperatures of geothermal fluids.

3 Project Code: RAS8097M–PAK
Study area: Multan area
Sampling period: 2002
Background: Due to an increase in abstraction rate, the hydrodynamics of groundwater is changing and, as a result, the quality of groundwater is deteriorating in the Multan area. This isotope geochemical study was carried out for the assessment of groundwater recharge and pollution for safe and sustainable exploitation of the aquifer.

4 Project Code: RAS8097L–PAK
Study area: Lahore area
Sampling period: 2004–2006
Background: In Lahore, the second largest city of Pakistan, as a result of heavy withdrawal of groundwater and reduction in recharge, the water table is lowering at an alarming rate and the aquifer is vulnerable to pollution due to induced infiltration of polluted surface waters and hydraulic gradients favouring saline water intrusion from nearby zones. This investigation focused on identification of sources and study of mobilization processes of groundwater pollutants, including arsenic for sustainable management of the resources.

PAKISTAN

5 **Project Code:** RAS8104P–PAK
Study area: Peshawar area
Sampling period: 1982–1985
Background: Peshawar valley in the North West Frontier Province forms a part of the Kabul River basin. The problem of water logging and salinity considerably affected the agricultural activities in the valley. This isotope study was undertaken to assess the groundwater recharge and salinization as well as to understand the extent of surface water–groundwater interactions.

6 **Project Code:** RAS8104R–PAK
Study area: Rechna Doab
Sampling period: 1986–1990
Background: Rechna Doab comprises the interfluvial area between the Chenab and Ravi Rivers. Isotope investigations were made with the objectives to: identify different recharge sources of groundwater; estimate the relative contribution of recharge sources; determine residence time of groundwater; and investigate groundwater salinization processes.

7 **Project Code:** RAS8104C–PAK
Study area: Chashma Nuclear Power Plant area
Sampling period: 1992–1994
Background: Investigation of groundwater dynamics on a regional scale is a prerequisite for the evaluation of a nuclear power plant site. This isotope investigation was carried out as a part of the safety report of the Chashma Nuclear Power Plant. Major objectives were to investigate recharge mechanism, flow paths, and residence time of groundwater.

8 **Project Code:** RAS8104T–PAK
Study area: Tarbela dam area
Sampling period: 1992–1993, 1994–1995
Background: Tarbela Dam, the giant multi-purpose dam, was built on the River Indus in 1976. It was observed that the water table rises in the downstream areas when the reservoir attains its highest level in the monsoon season. The main objectives of this isotopic study were to: fingerprint different water masses; ascertain the hydraulic connections, if any, between the Tarbela reservoir and the groundwater monitoring wells and springs downstream.

9 **Project Code:** RAS8104Q–PAK
Study area: Quetta area
Sampling period: 2003–2004
Background: In the arid areas of Quetta City in Balochistan, groundwater is the main source of drinking water supply. In order to meet the increasing demand, hard rock aquifers were explored. As a part of the larger project, the isotope study of groundwater in hard rocks and alluvium in the Quetta valley was carried out for determining interconnections between hard rock and alluvial aquifers and the age of groundwater.

10 **Project Code:** PAK–3620
Study area: Mardan area
Sampling period: 1982–1986
Background: The low lying areas of the Mardan valley face water logging problems due to rise in groundwater levels. The shallow and deep aquifers are separated by varying thickness of a clay layer. In order to help plan remedial measures, an isotope study was carried out with the aim of studying groundwater recharge and interconnections between the shallow and deep aquifers.

11 **Project Code:** PAK–4255
Study area: Chaj Doab
Sampling period: 1985–1988
Background: This interfluvial tract of land between the Chenab and Jhelum Rivers is a part of the Indus basin. Extensive agricultural practices depend on intricate canal irrigation systems in the area. Large tracts of irrigated land have been adversely affected by salinity and water logging. Isotopic and hydrochemical studies were carried out to understand the recharge mechanism of groundwater, surface water–groundwater interactions and salinization processes in the Chaj Doab.

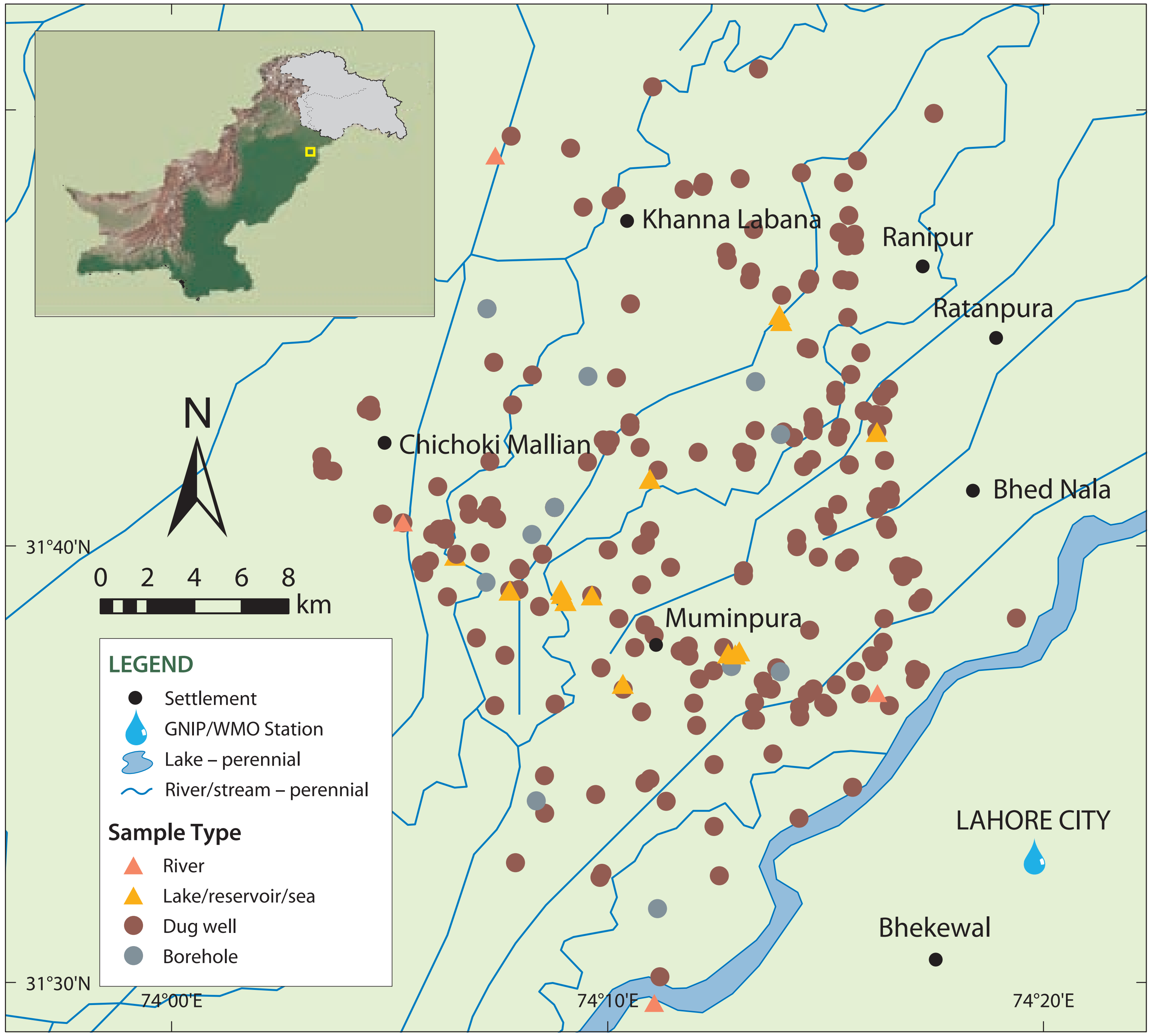
12 **Project Code:** PAK–4794
Study area: Haripur area
Sampling period: 1987–1989
Background: The study area is located around Haripur town close to Tarbela reservoir. Isotope techniques were used to investigate groundwater recharge and surface water–groundwater interactions.

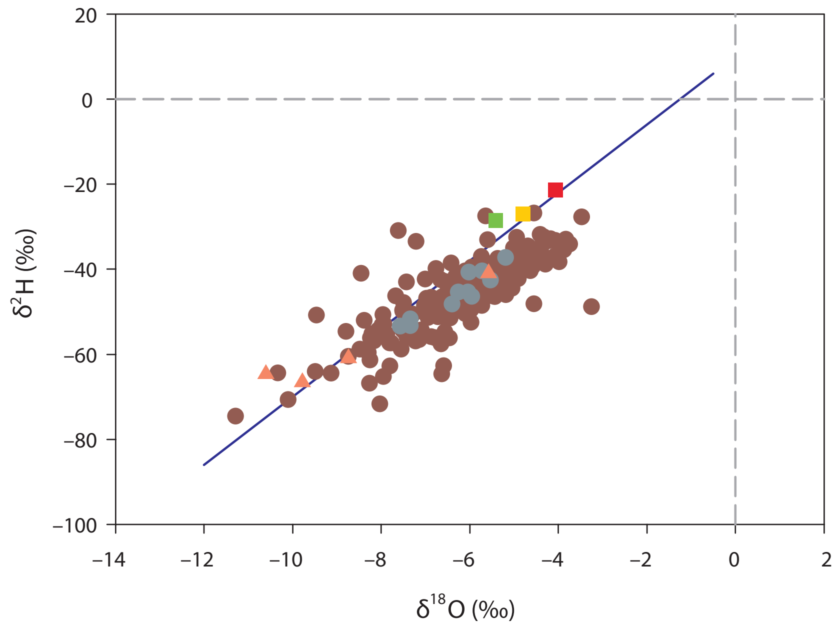
13 **Project Code:** PAK–8591
Study area: Ziarat area
Sampling period: 1995–1998
Background: Ziarat is an arid area with meagre precipitation and high evaporation. In order to augment groundwater recharge, many storage structures called delay action dams were constructed on the alluvial fans for the storage of runoff to facilitate percolation. The focus of this isotope investigation was to evaluate efficacy of artificial recharge measures.

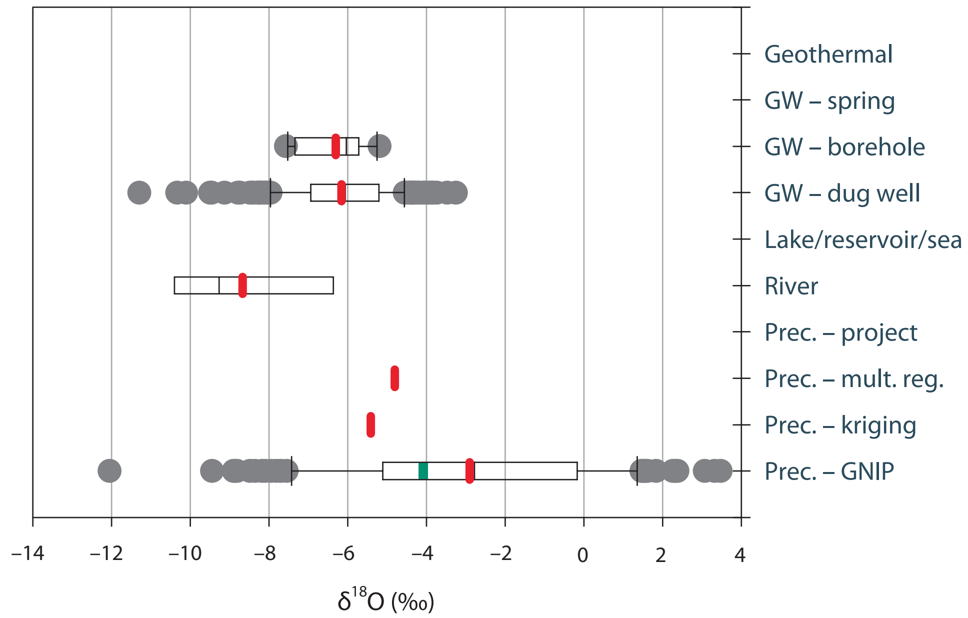
14 **Project Code:** PAK–9826, PAK–11516
Study area: Kasur area
Sampling period: 1997–1998, 2001–2004
Background: Domestic waste and effluent of about 300 tanneries are discharged into an open pond close to Kasur town. Possible movement of contaminants to the groundwater is a threat to its quality. The first study was carried out to monitor the movement of contaminants through unsaturated zone. The second investigation focused on the source of groundwater recharge as well as the scale and geometry of nitrate contamination.

15 **Project Code:** PAK–11322
Study area: Karachi coastal aquifer
Sampling period: 2002
Background: In the Karachi area, the coastal aquifers are generally very saline with a few freshwater pockets. The main objectives of this study were to investigate the sources of recharge, extent of seawater encroachment due to groundwater withdrawal along the coastal belt and salinization of interconnected aquifers.

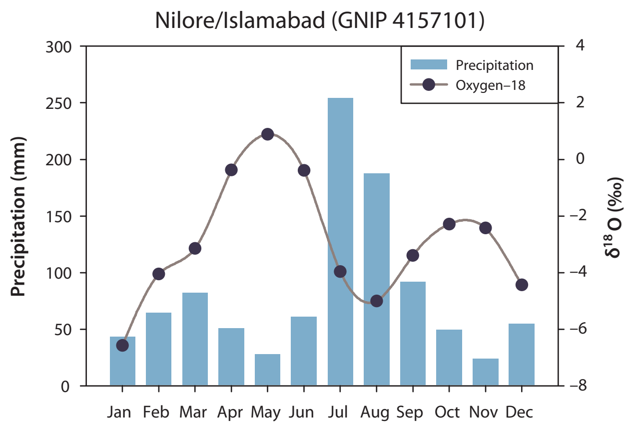
RAS8084–PAK
Sheikhupura area

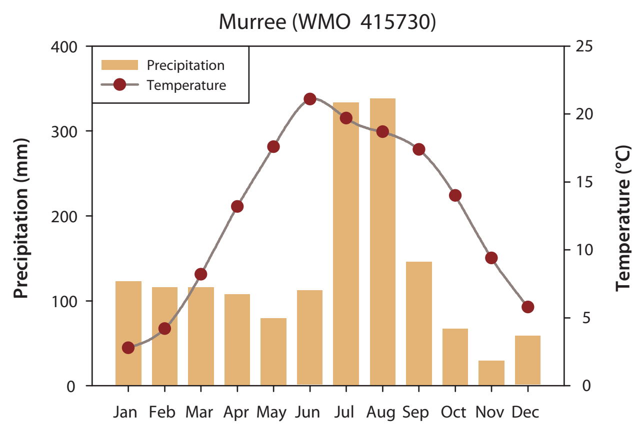






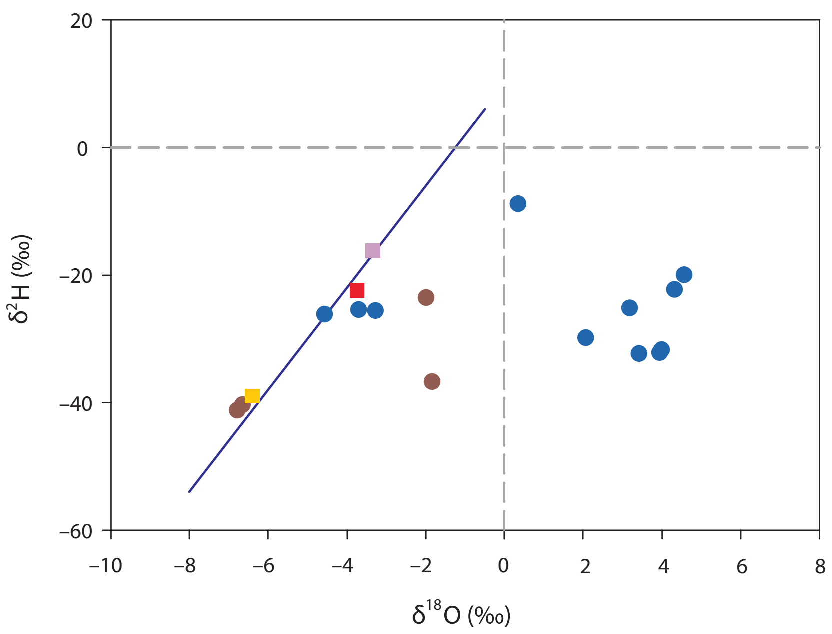
Precipitation	δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station NILORE/ISLAMAB.	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993	
Interpolation – multiple reg.			−4.80			−27.0				
Interpolation – kriging (IAEA)			−5.41			−28.5				
Project										
Surface waters	**δ18O n**	**Median**	**Mean ± St. dev.**	**δ2H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**		
Lake/reservoir/sea										
River	4	−9.26	−8.67 ± 2.2	4	−62.8	−58.3 ± 11.8	1	18.6		
Groundwaters	**δ18O n**	**Median**	**Mean ± St. dev.**	**δ2H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**	**14C (pMC) n**	**Mean ± St. dev.**
Geothermal water										
GW–Borehole	11	−6.04	−6.31 ± 0.8	11	−45.4	−45.9 ± 5.4				
GW–Dug well	223	−6.06	−6.16 ± 1.3	223	−44.6	−45.7 ± 8.5	27	9.8 ± 4.1		
GW–Spring										

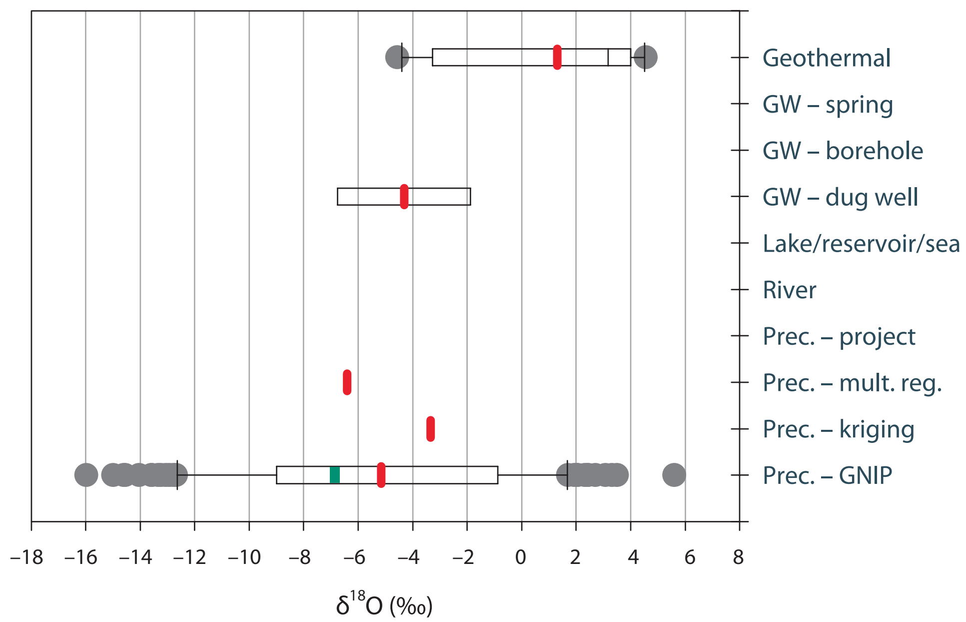


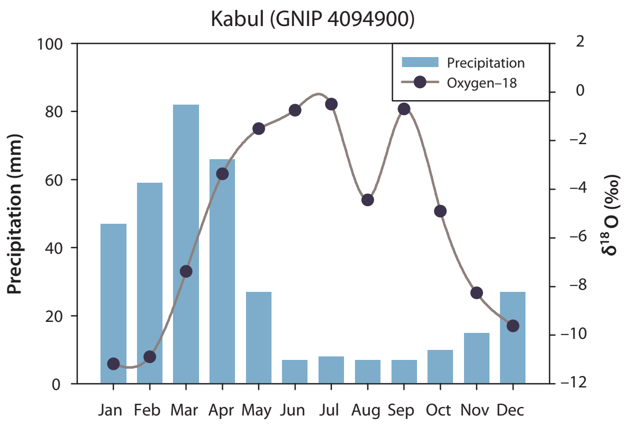


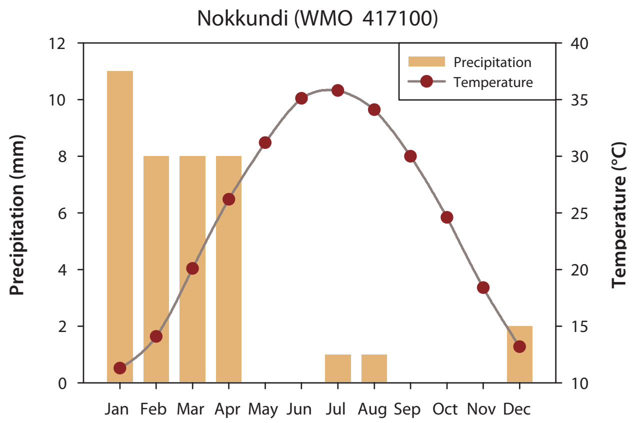
RAS8092–PAK

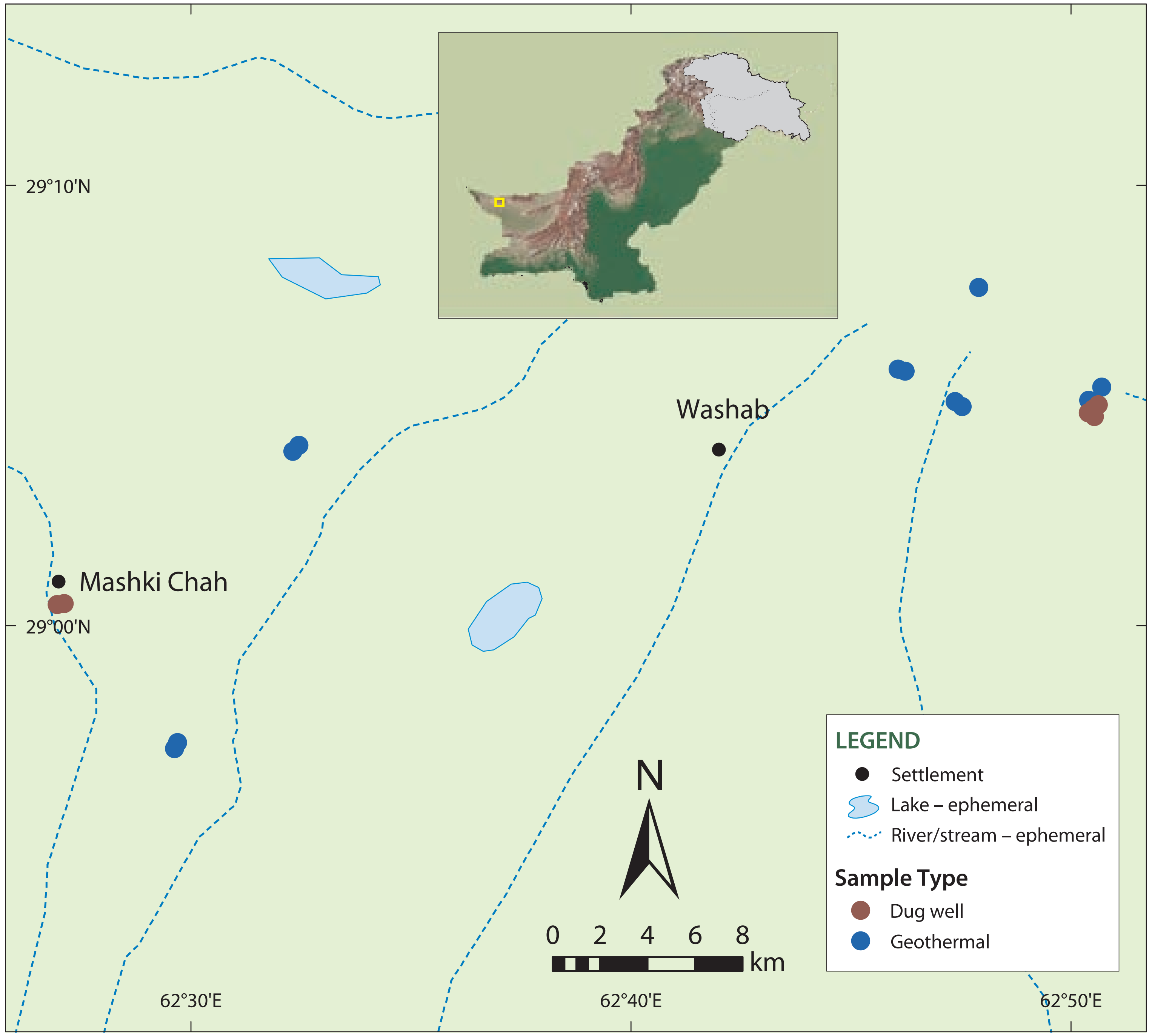
Koh Sultan volcano area, Chagi







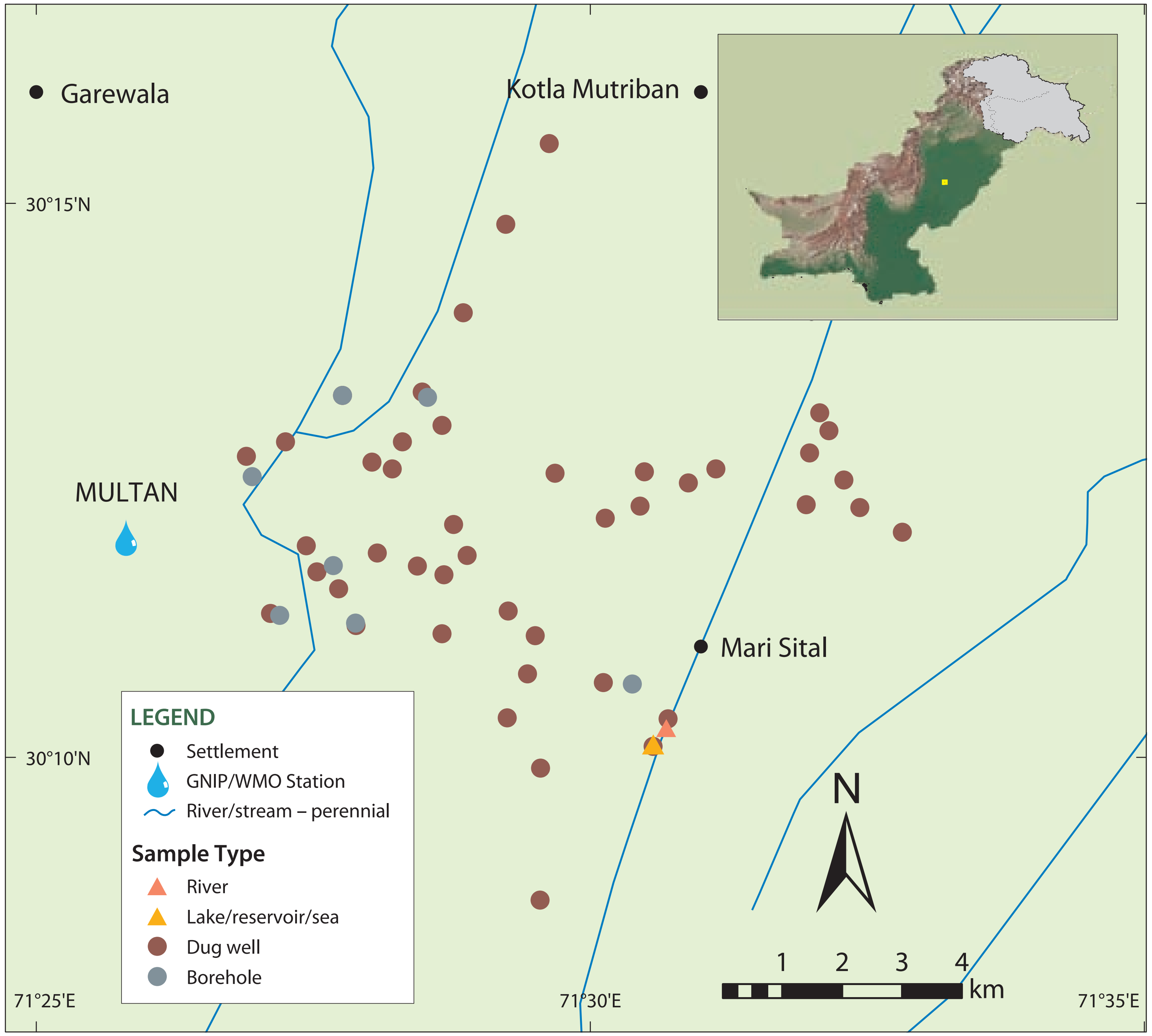


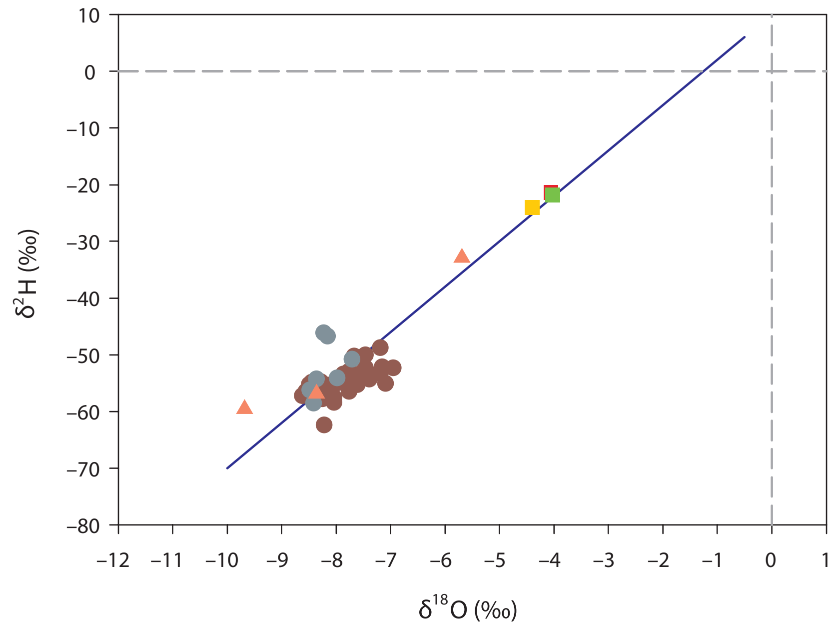


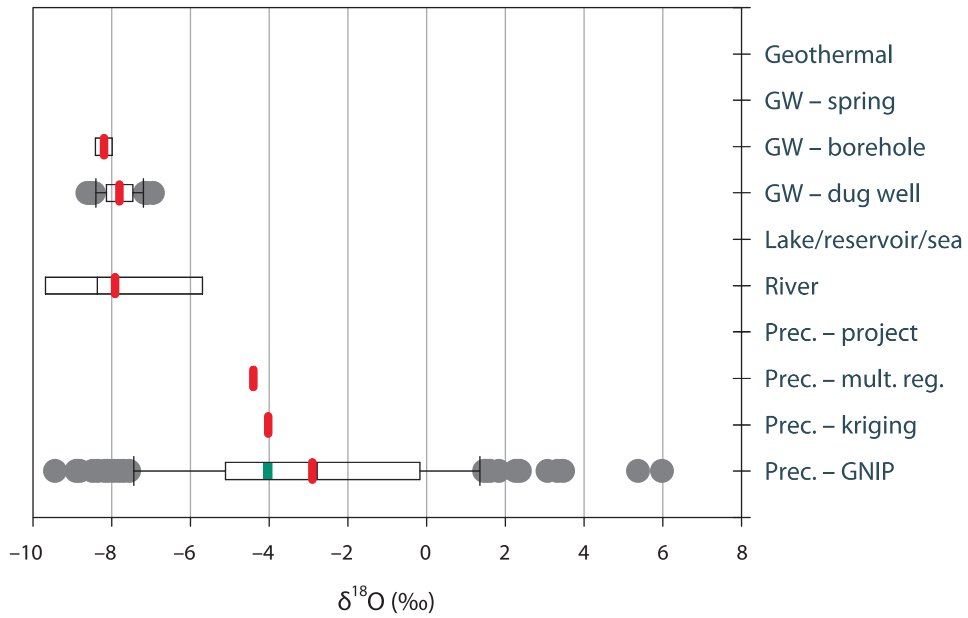
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station KABUL	■	109	−6.23	−6.51 ± 2.4	86	−28.2	−32.5 ± 7.7				329
Interpolation – multiple reg.	■			−6.40			−39.0				
Interpolation – kriging (IAEA)	■			−3.34			−16.2				
Project	■										
Surface waters		**δ¹⁸O**			**δ²H**			**Tritium**			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲										
River	▲										
Groundwaters		**δ¹⁸O**			**δ²H**			**Tritium**		**¹⁴C (pMC)**	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●	11	3.18	1.3 ± 3.5	11	−25.6	−25.4 ± 6.8	11	1.0 ± 0.9		
GW–Borehole	●										
GW–Dug well	●	4	−4.32	−4.32 ± 2.8	5	−36.7	−35.0 ± 7.1	4	1.5 ± 1.7		
GW–Spring	●										

RAS8097M–PAK

Multan area



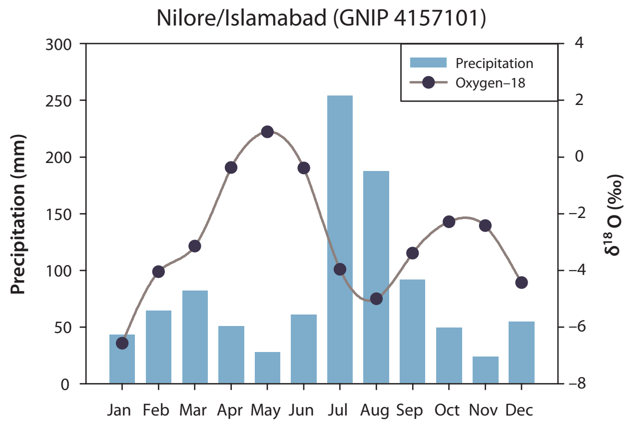


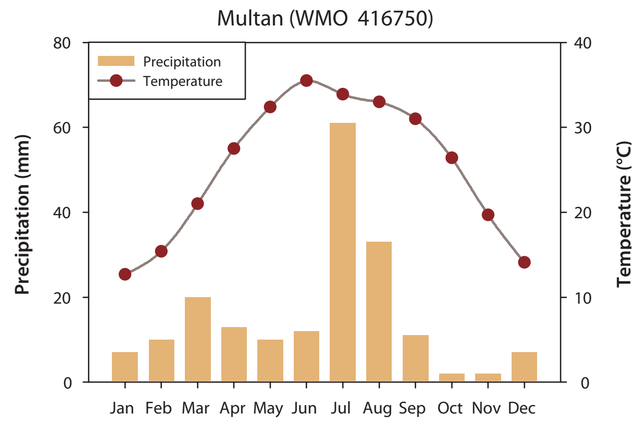


Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	red square	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.	yellow square			−4.40			−24.0			
Interpolation – kriging (IAEA)	green square			−4.02			−21.8			
Project	pink square									

Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	orange triangle	1		−6.97	1		−48.7	1	2.0
River	salmon triangle	3	−8.36	−7.91 ± 2.0	3	−569	−49.8 ± 14.7	3	13.5 ± 1.9

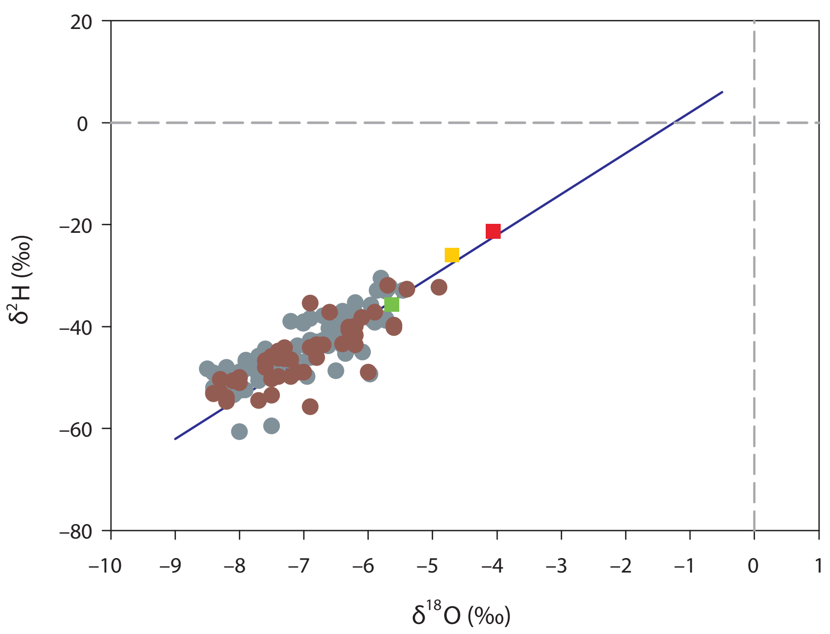
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	7	−8.23	−8.19 ± 0.3	7	−54.1	−52.4 ± 4.7	7	6.8 ± 10.7		
GW–Dug well	brown circle	42	−7.79	−7.8 ± 0.4	44	−54.8	−54.6 ± 2.4	44	5.9 ± 7.2		
GW–Spring	green circle										

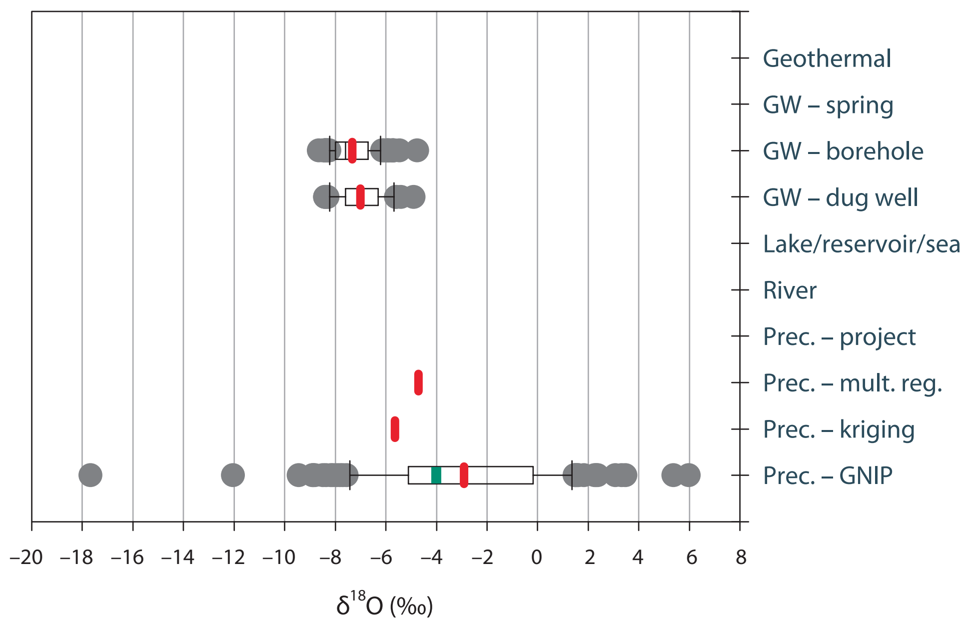


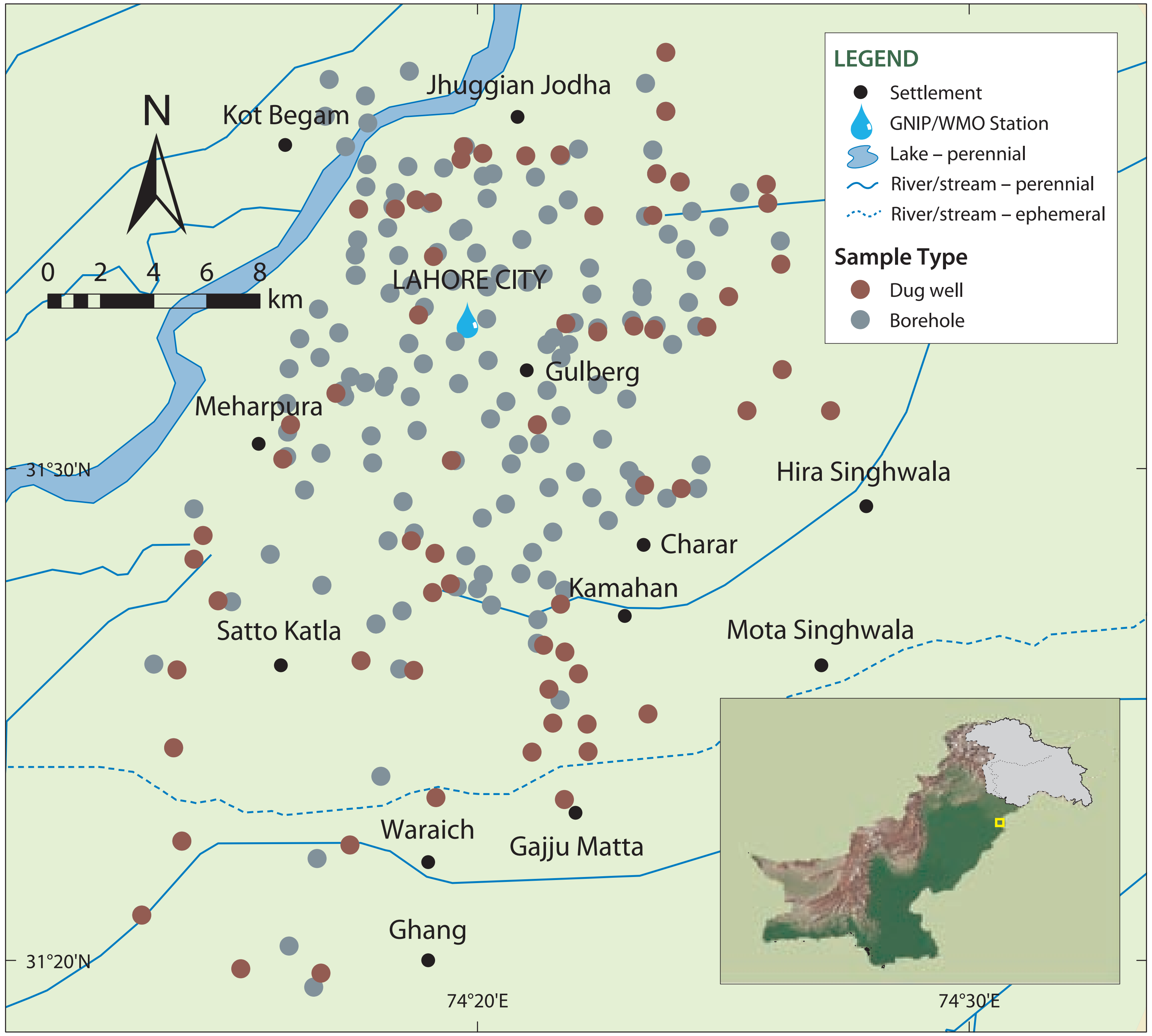


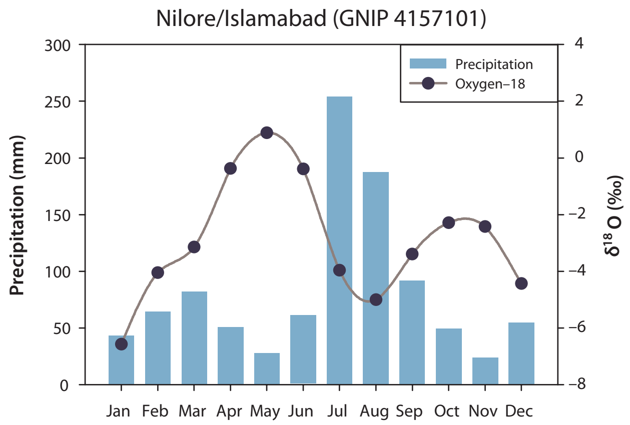
RAS8097L–PAK

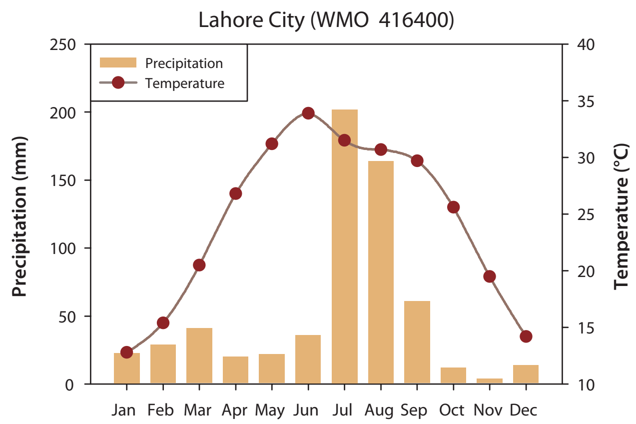
Lahore area











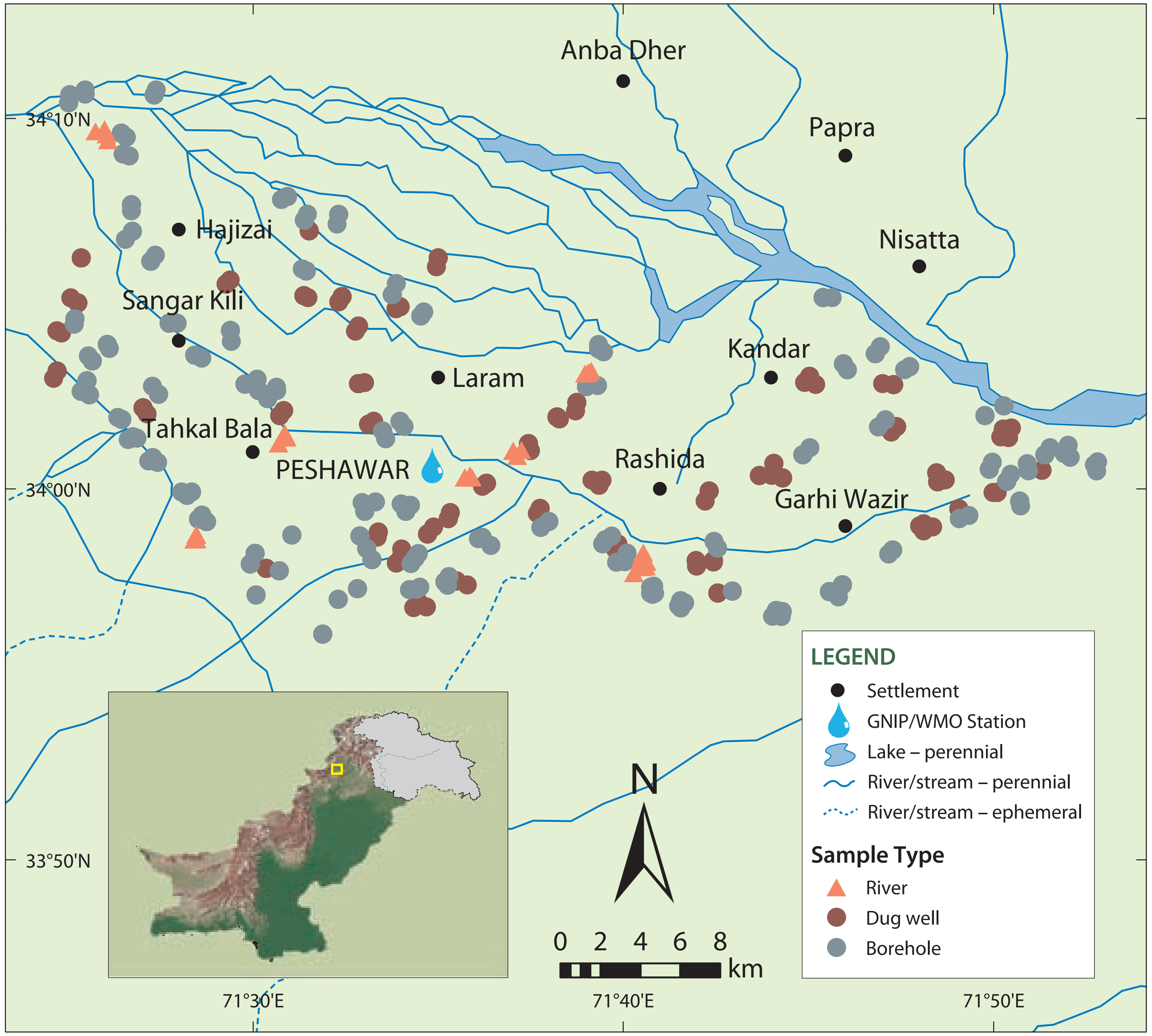
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station NILORE/ISLAMAB.	■ (red)	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.	■ (yellow)			−4.70			−26.0			
Interpolation – kriging (IAEA)	■ (green)			−5.63			−35.7			
Project	■ (pink)									

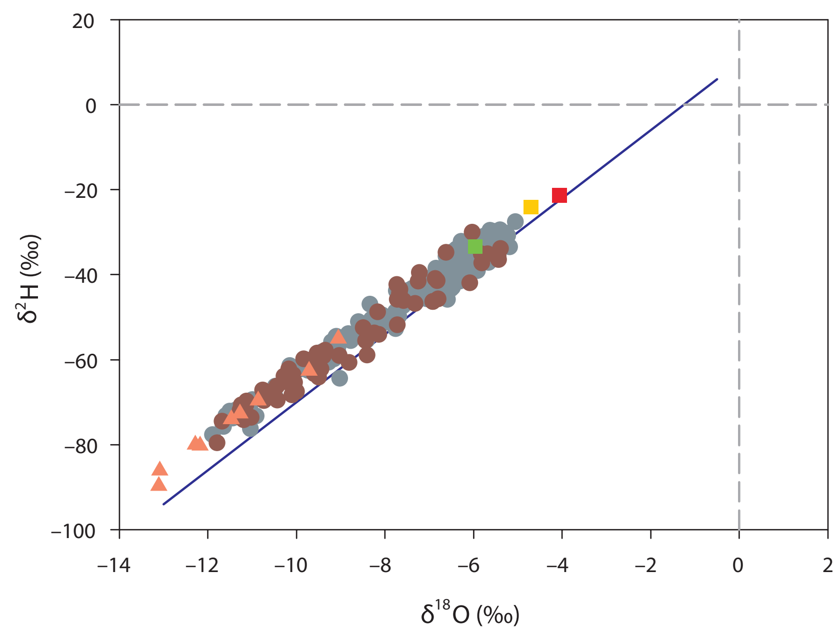
Surface waters		δ¹⁸O			δ²H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲								
River	▲								

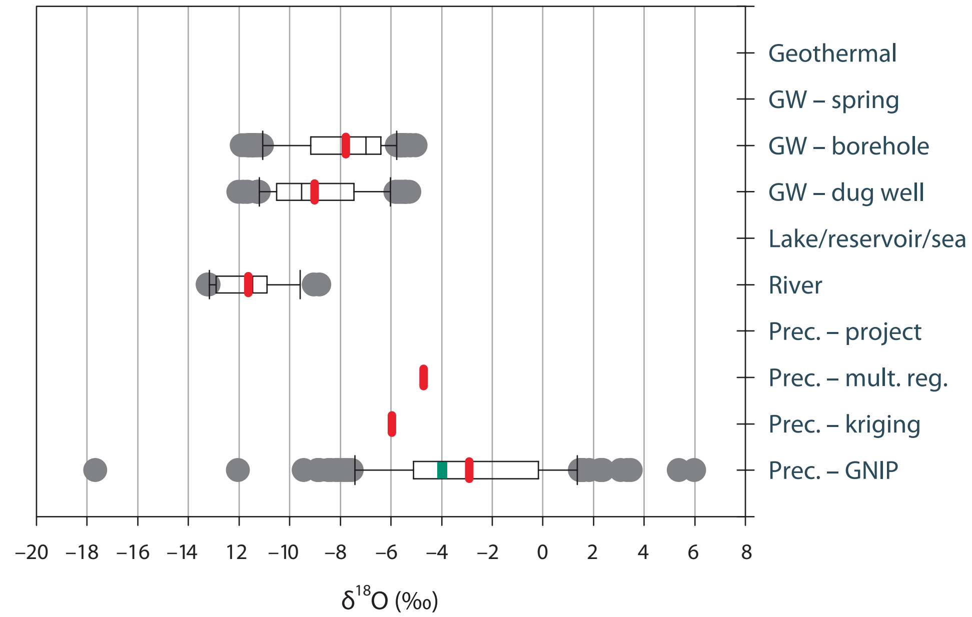
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	183	−7.60	−7.33 ± 0.8	93	−46.7	−45.2 ± 6.0	21	7.9 ± 3.2		
GW–Dug well	●	47	−7.10	−7.00 ± 0.9	48	−46.0	−45.5 ± 6.2	21	10.4 ± 4.0		
GW–Spring	●										

RAS8104P–PAK

Peshawar area





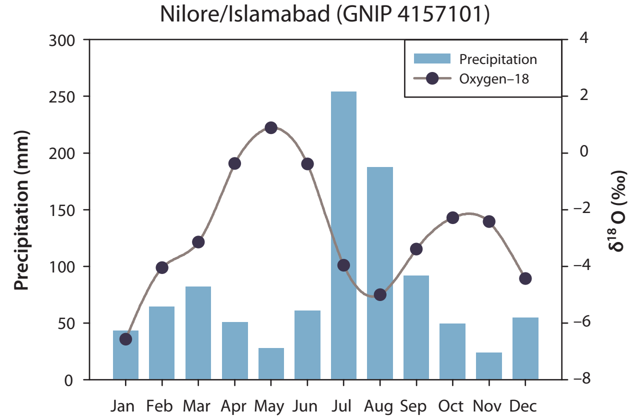


Precipitation		δ18O (‰)			δ2H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station NILORE/ISLAMAB.	■ (red)	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.	■ (yellow)			−4.70			−24.0			
Interpolation – kriging (IAEA)	■ (green)			−5.96			−33.4			
Project	■ (pink)									

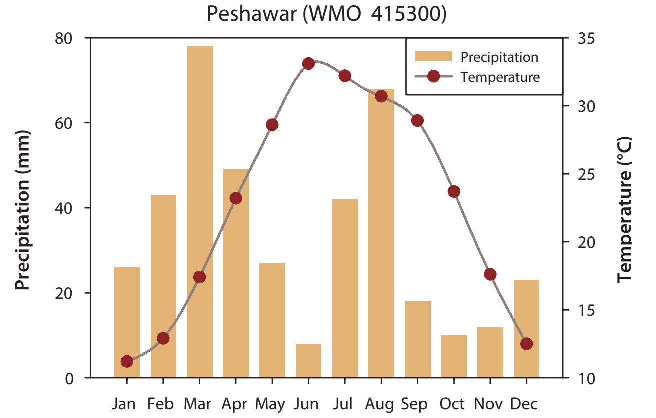
Surface waters		δ18O			δ2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)								
River	▲ (orange)	27	−11.47	−11.63 ± 1.3	9	−74.0	−74.43 ± 11.04	14	64.0 ± 14.2

Groundwaters		δ18O			δ2H			Tritium		14C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	270	−6.99	−7.78 ± 1.9	179	−42.4	−46.4 ± 12.8	149	66.1 ± 35.6		
GW–Dug well	● (brown)	118	−9.52	−9.01 ± 1.9	68	−59.1	−55.9 ± 13.1	42	79.4 ± 31.5		
GW–Spring	● (green)										

Nilore/Islamabad (GNIP 4157101)

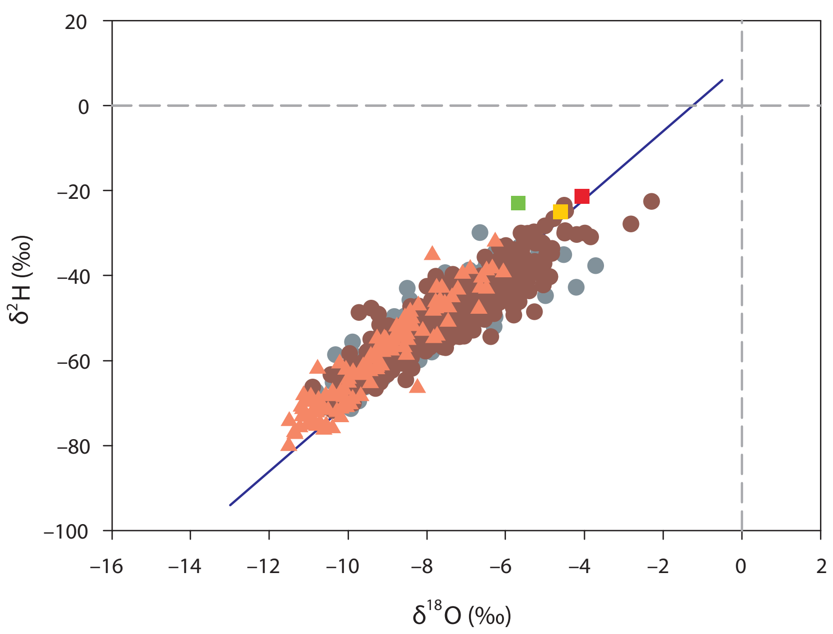


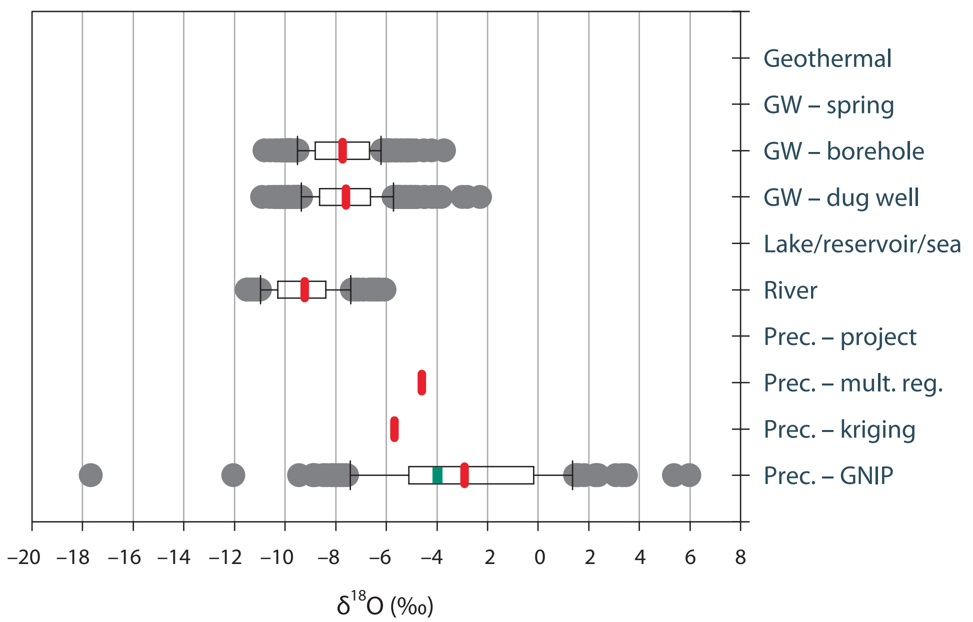
Peshawar (WMO 415300)

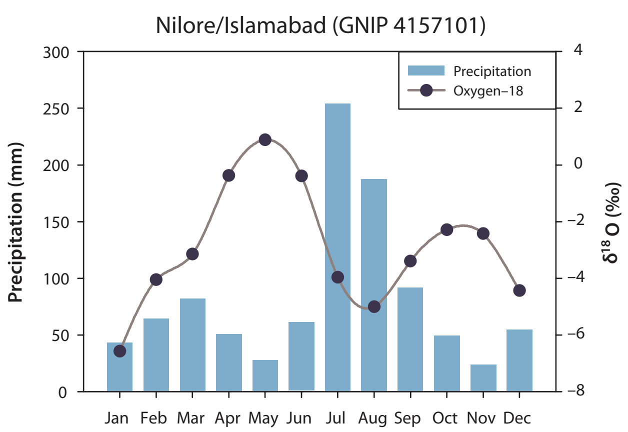


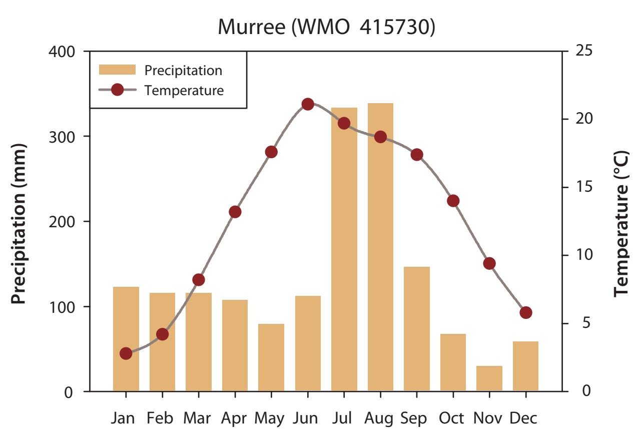
RAS8104R–PAK

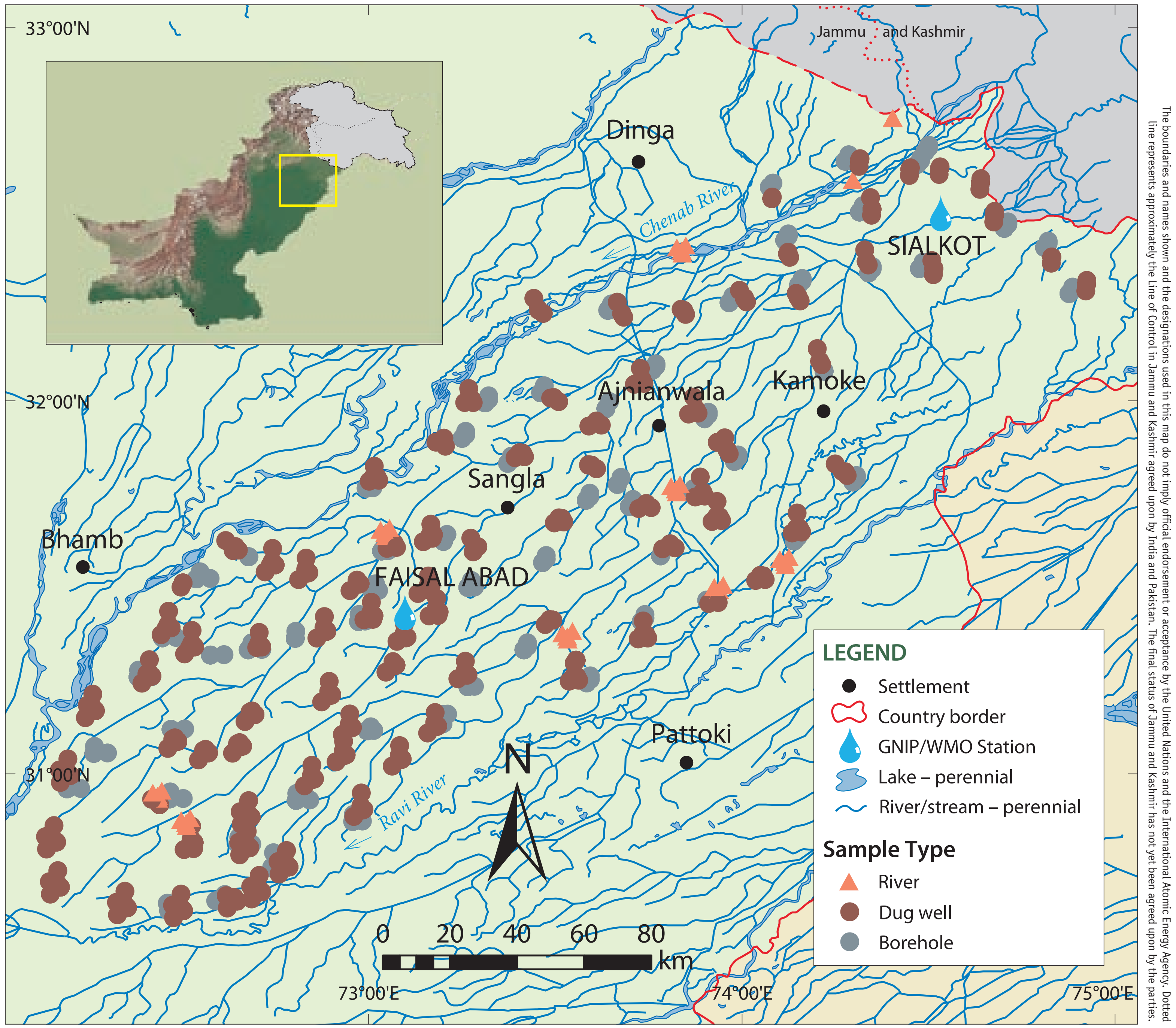
Rechna Doab











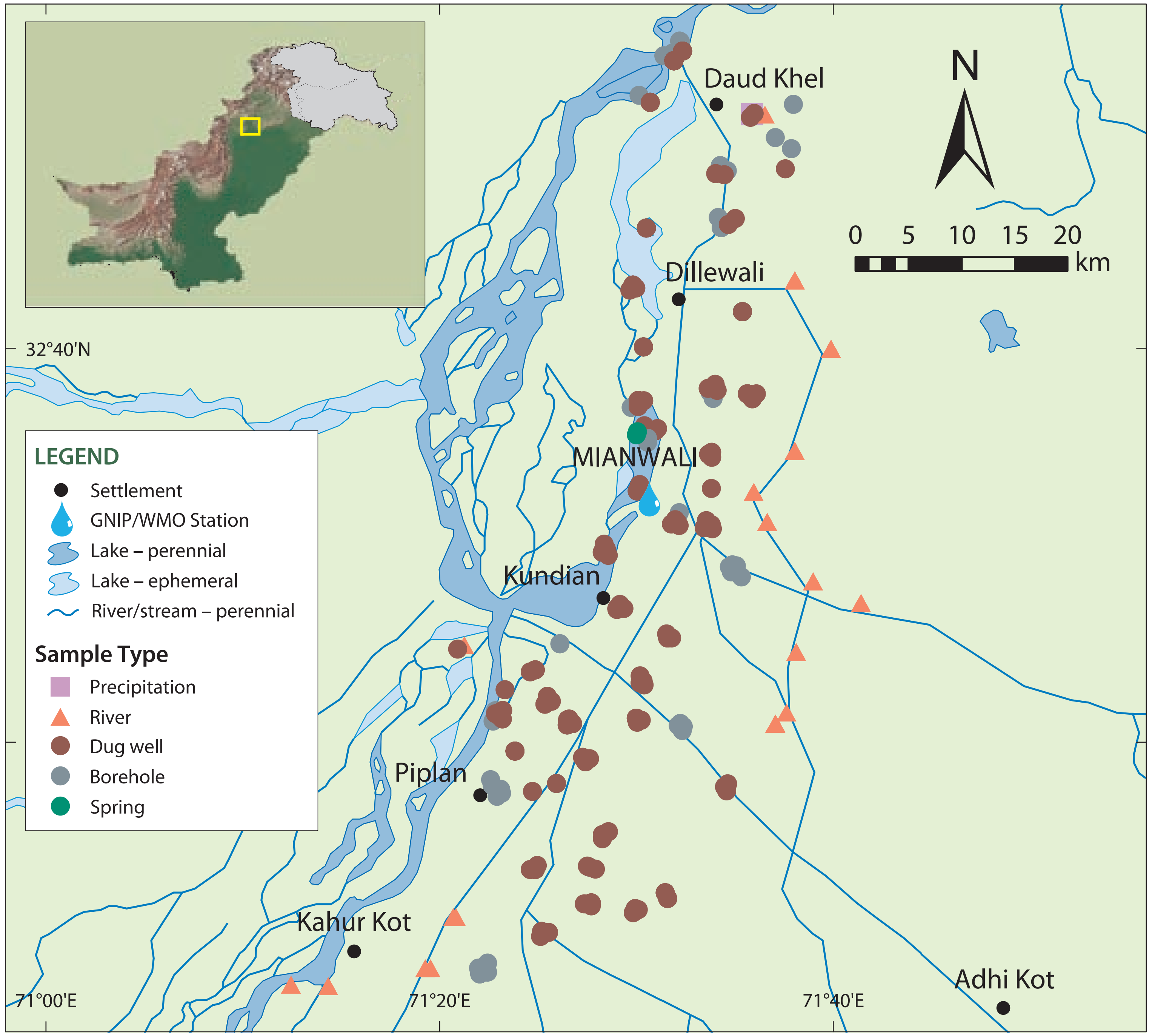
Precipitation	n	$\delta^{18}O$ (‰) Median	Mean ± St. dev.	n	$\delta^{2}H$ (‰) Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	115	−2.77	−4.06 ± 1.5	114	−11.9	−21.4 ± 12.7			993
Interpolation – multiple reg.			−4.60			−25.0			
Interpolation – kriging (IAEA)			−5.68			−22.88			
Project									

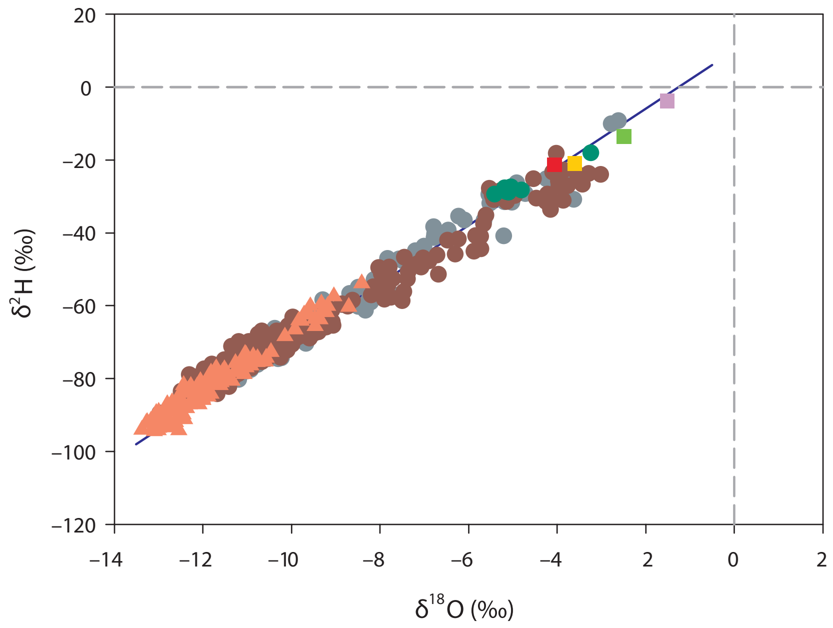
Surface waters	n	$\delta^{18}O$ Median	Mean ± St. dev.	n	$\delta^{2}H$ Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea								
River	124	−9.26	−9.22 ± 1.4	126	−60.9	−59.7 ± 11.2	3	24.7 ± 2.2

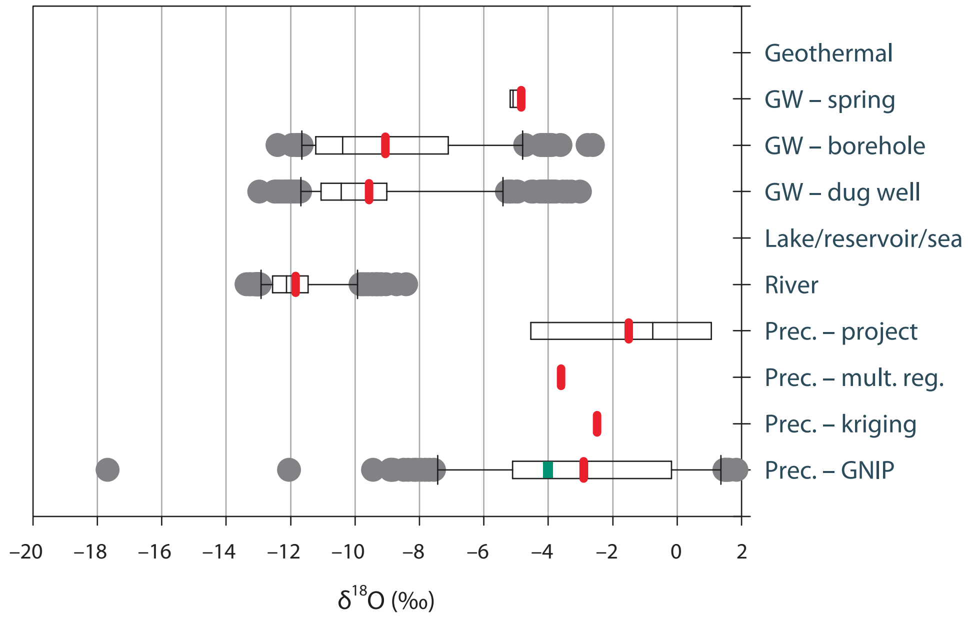
Groundwaters	n	$\delta^{18}O$ Median	Mean ± St. dev.	n	$\delta^{2}H$ Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	340	−7.65	−7.72 ± 1.3	359	−48.7	−50.5 ± 8.2	65	9.2 ± 14.9		
GW–Dug well	599	−7.70	−7.61 ± 1.4	627	−49.4	−50.0 ± 8.7	100	13.3 ± 12.1		
GW–Spring										

RAS8104C–PAK

Chashma Nuclear Power Plant area

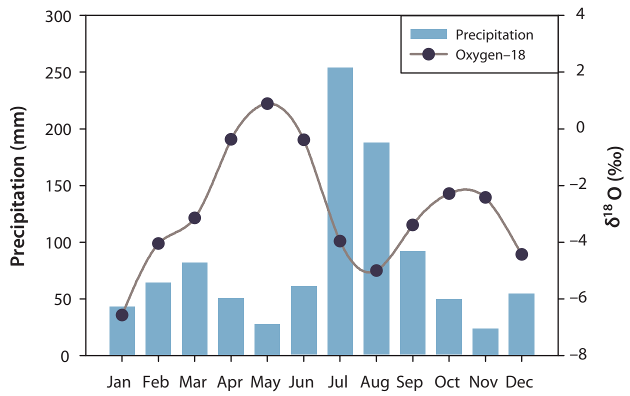




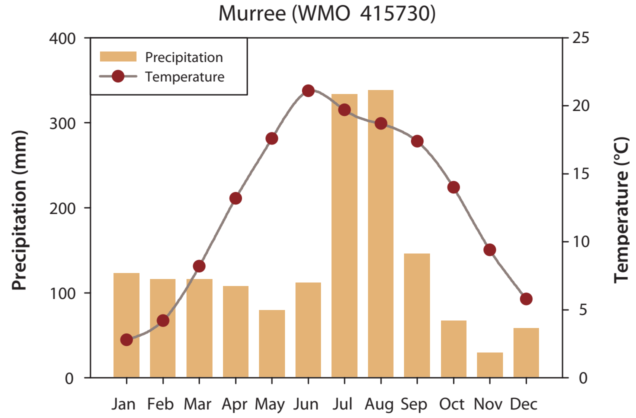


Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station NILORE/ISLAMAB.	■ (red)	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993	
Interpolation – multiple reg.	■ (yellow)			−3.60			−21.0				
Interpolation – kriging (IAEA)	■ (green)			−2.49			−13.5				
Project	■ (pink)	6	−0.75	−1.51 ± 3.2	6	−3.7	−3.8 ± 24.2	3	18.9 ± 2.2		
Surface waters		**δ¹⁸O n**	**Median**	**Mean ± St. dev.**	**δ²H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**		
Lake/reservoir/sea	▲ (orange)										
River	▲ (salmon)	159	−12.12	−11.84 ± 1.0	159	−83.4	−81.8 ± 8.7	35	22.2 ± 2.5		
Groundwaters		**δ¹⁸O n**	**Median**	**Mean ± St. dev.**	**δ²H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**	**¹⁴C (pMC) n**	**Mean ± St. dev.**
Geothermal water	● (blue)										
GW–Borehole	● (grey)	113	−10.38	−9.06 ± 2.7	113	−72.6	−60.9 ± 20.1	65	12.8 ± 17.9	5	117 ± 28
GW–Dug well	● (brown)	258	−10.44	−9.56 ± 2.3	258	−70.5	−64.9 ± 16.1	146	20.9 ± 24.7	11	104 ± 26
GW–Spring	● (green)	7	−5.10	−4.85 ± 0.7	7	−28.3	−26.9 ± 3.9	4	5.4 ± 3.6		

Nilore/Islamabad (GNIP 4157101)

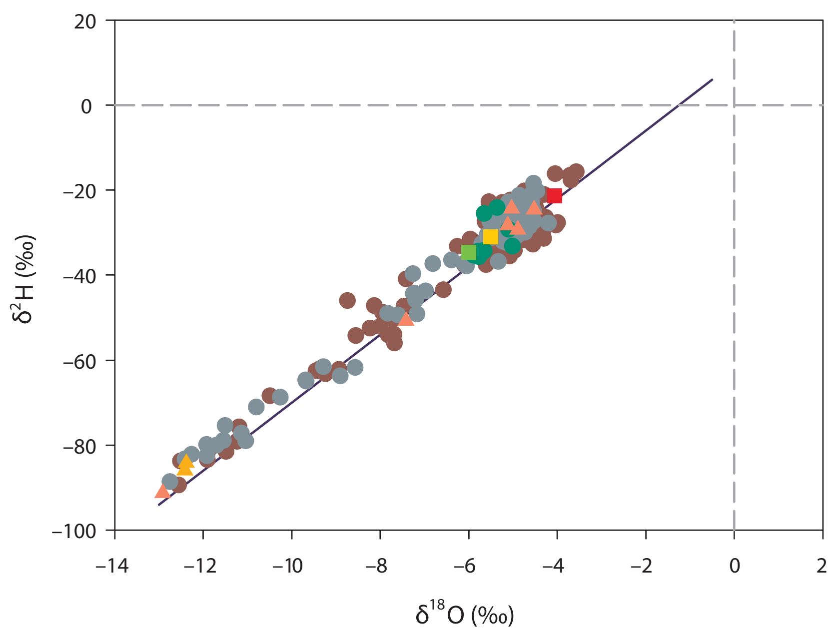


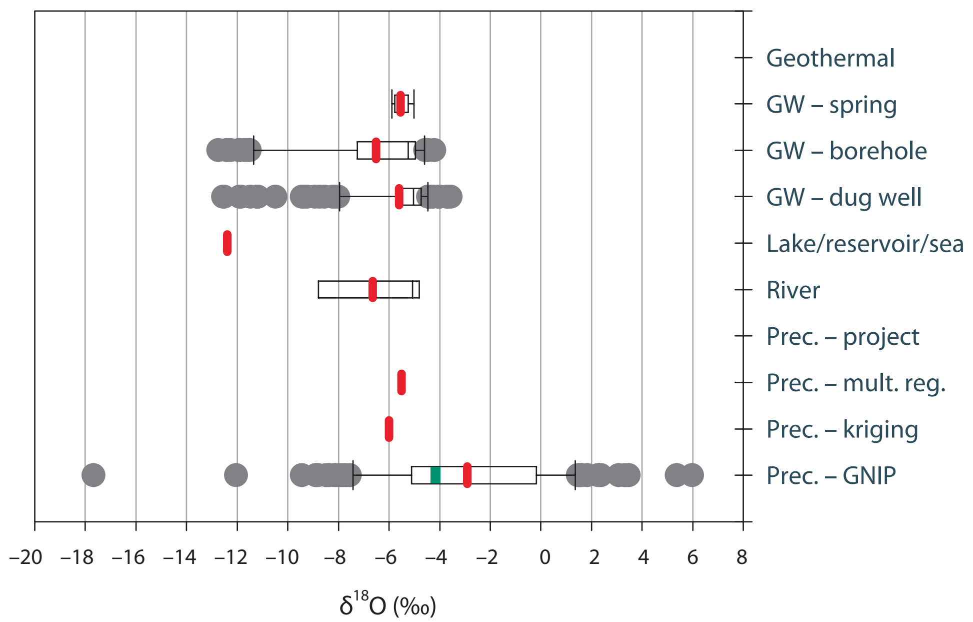
Murree (WMO 415730)

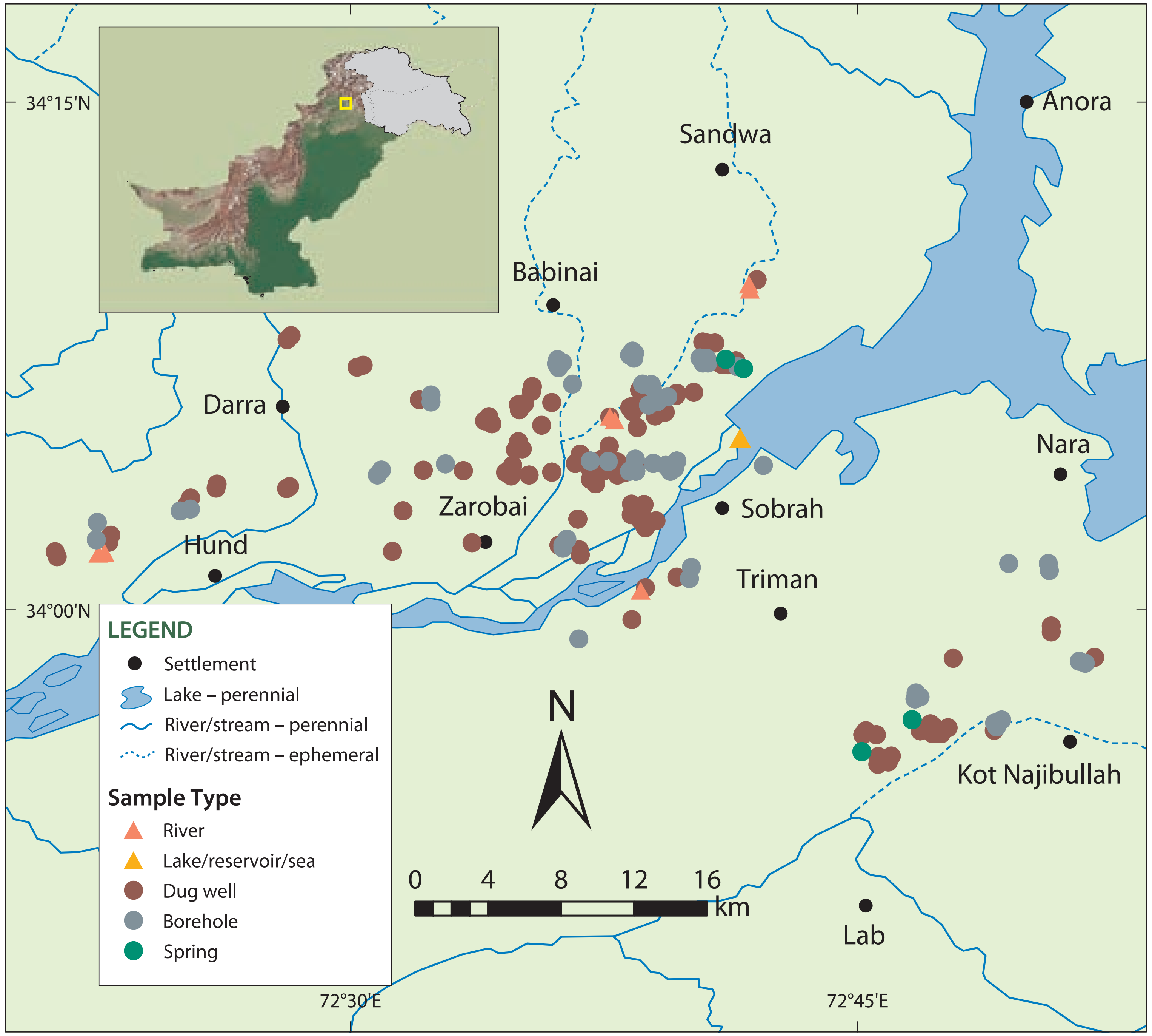


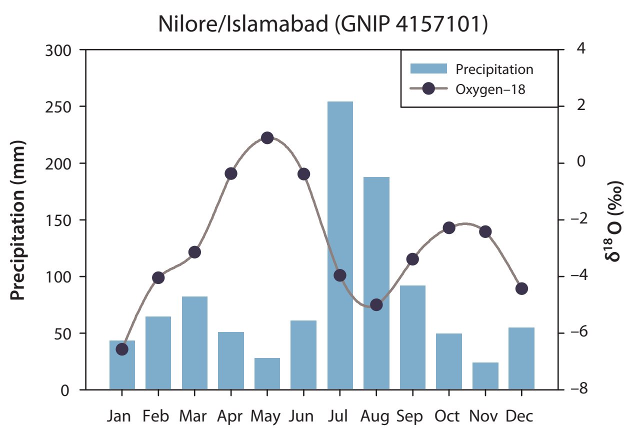
RAS8104T–PAK

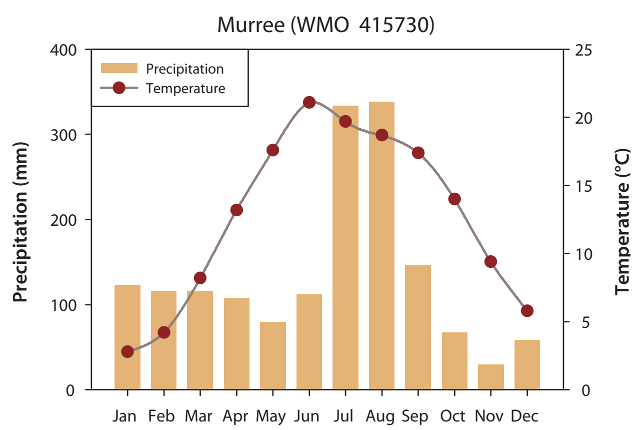
Tarbela dam area







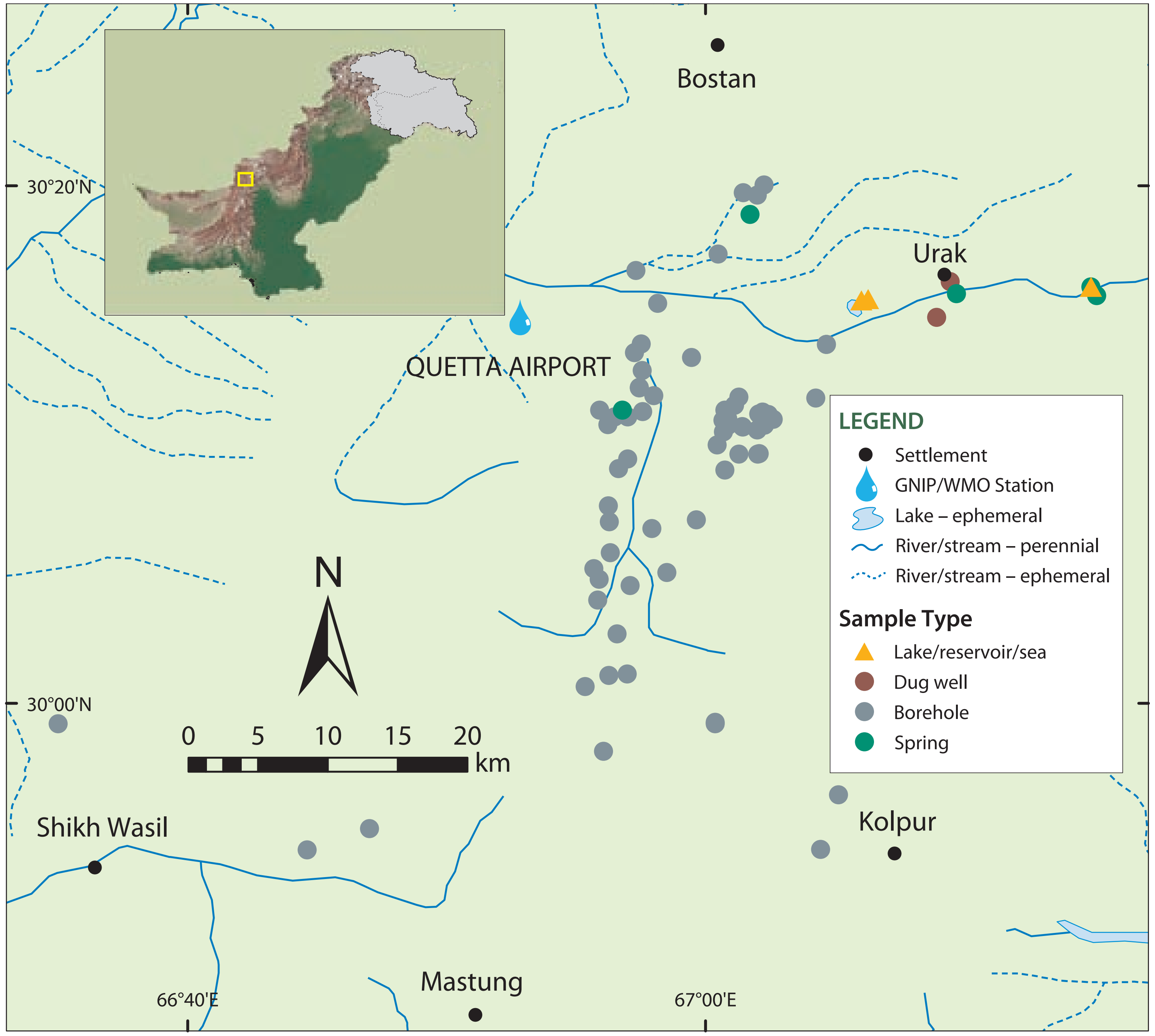




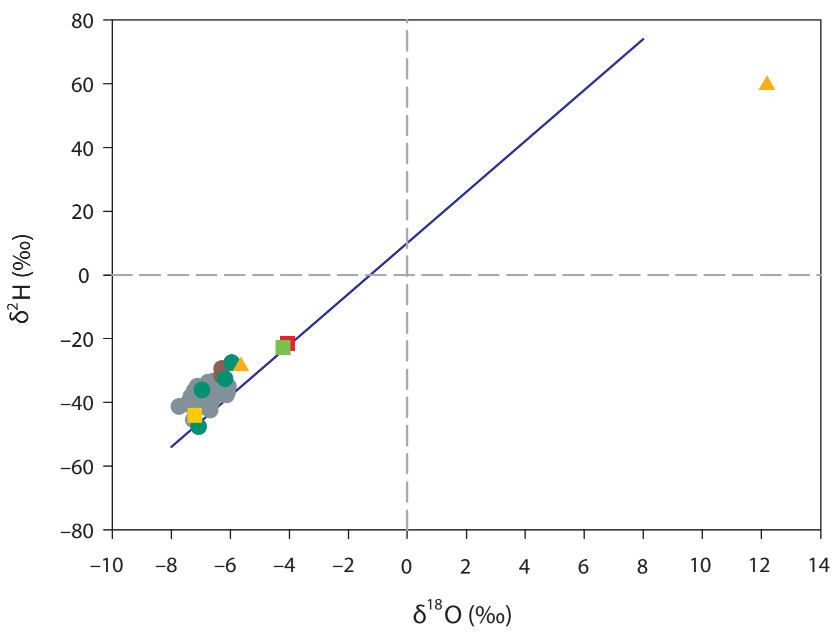
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	■ (red)	145	−2.78	−4.06 ± 1.5	143	−11.3	−21.4 ± 12.7			993
Interpolation – multiple reg.	■ (yellow)			−5.50			−31.0			
Interpolation – kriging (IAEA)	■ (green)			−6.00			−34.6			
Project	■ (pink)									

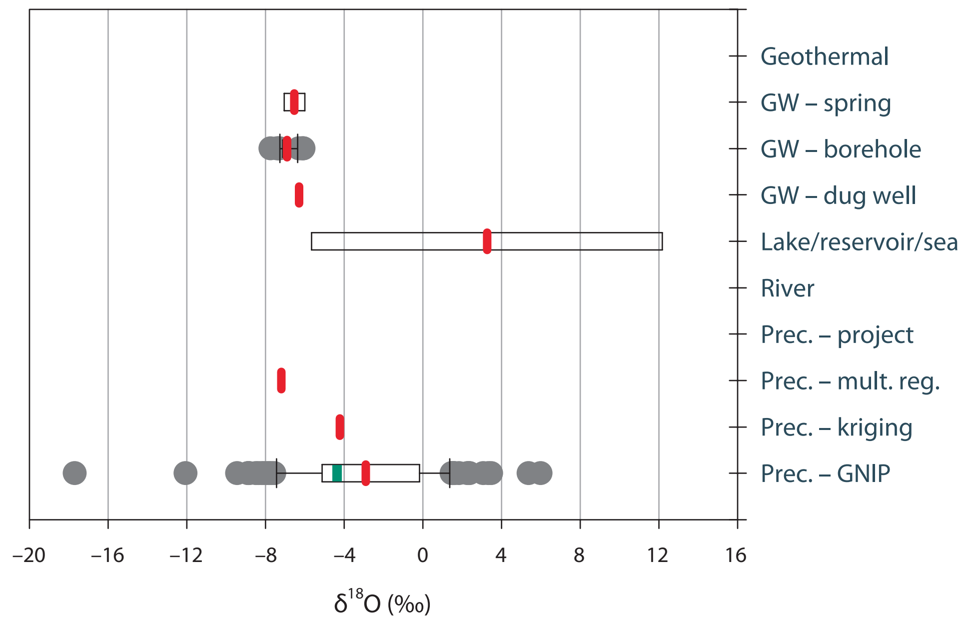
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲	2	−12.40	−12.40 ± 0.0	2	−85.1	−85.1 ± 1.3	2	31 ± 0.0
River	▲	6	−5.08	−6.65 ± 3.2	6	−28.8	−41.4 ± 26.3	4	18.5 ± 4.5

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	82	−5.23	−6.53 ± 2.4	82	−30.1	−38.9 ± 20.7	55	17.2 ± 7.4		
GW–Dug well	●	187	−5.03	−5.59 ± 1.7	187	−28.6	−32.8 ± 13.6	106	28.0 ± 97.5		
GW–Spring	●	9	−5.65	−5.54 ± 0.3	9	−34.2	−31.8 ± 4.4	7	11.0 ± 4.6		



RAS8104Q–PAK
Quetta area

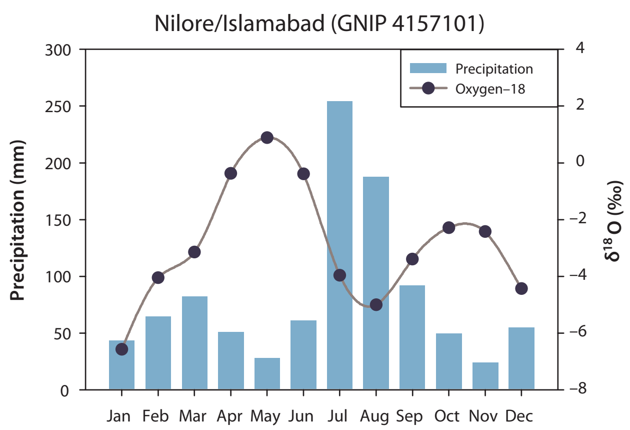


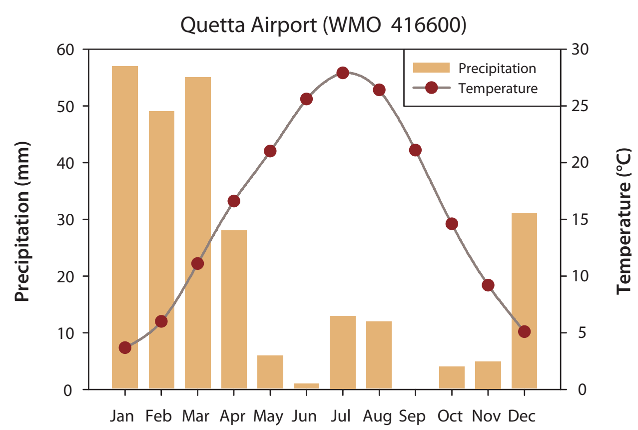


Precipitation	n	$\delta^{18}O$ (‰) Median	Mean ± St. dev.	n	δ^2H (‰) Median	Mean ± St. dev.	n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.			−7.20			−44.0			
Interpolation – kriging (IAEA)			−4.21			−22.8			
Project									

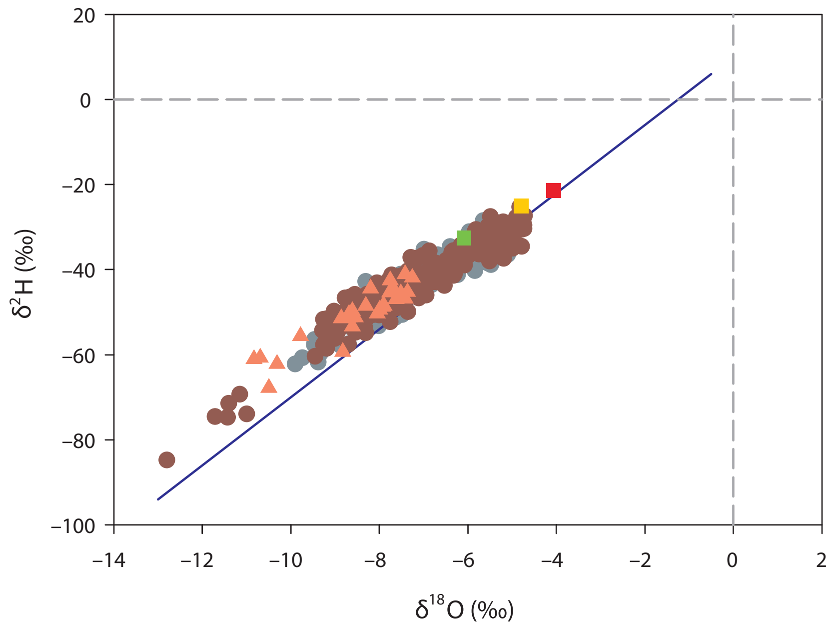
Surface waters	n	$\delta^{18}O$ Median	Mean ± St. dev.	n	δ^2H Median	Mean ± St. dev.	n	Tritium Mean ± St. dev.
Lake/reservoir/sea	2	3.27	3.27 ± 2.6	2	15.6	15.6 ± 62.1		
River								

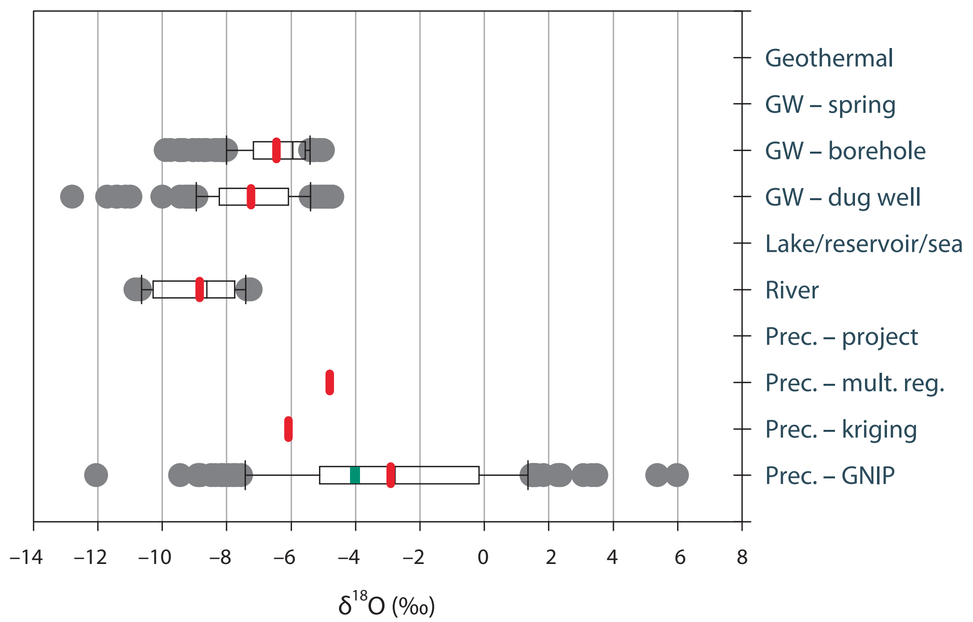
Groundwaters	n	$\delta^{18}O$ Median	Mean ± St. dev.	n	δ^2H Median	Mean ± St. dev.	n	Tritium Mean ± St. dev.	n	^{14}C (pMC) Mean ± St. dev.
Geothermal water										
GW–Borehole	57	−6.92	−6.9 ± 0.4	57	−38.6	−38.6 ± 2.4	38	1.5 ± 1.5		
GW–Dug well	2	−6.29	−6.29 ± 0.0	2	−30.6	−30.6 ± 1.6	1	6.5		
GW–Spring	4	−6.56	−6.54 ± 0.6	4	−34.4	−36.0 ± 8.5	5	3.6 ± 2.1		

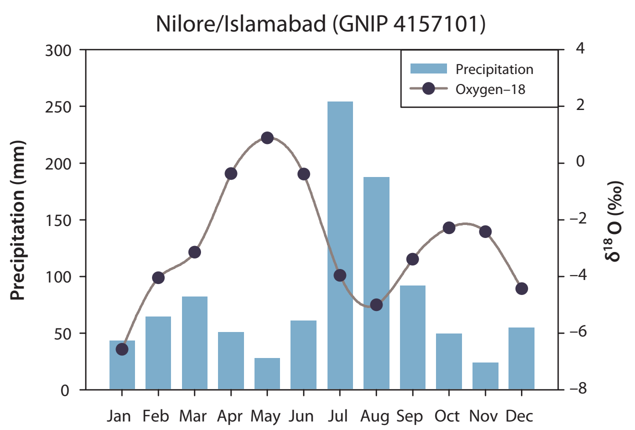


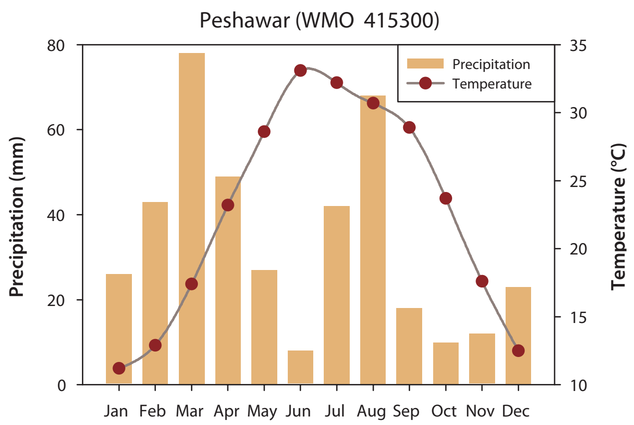


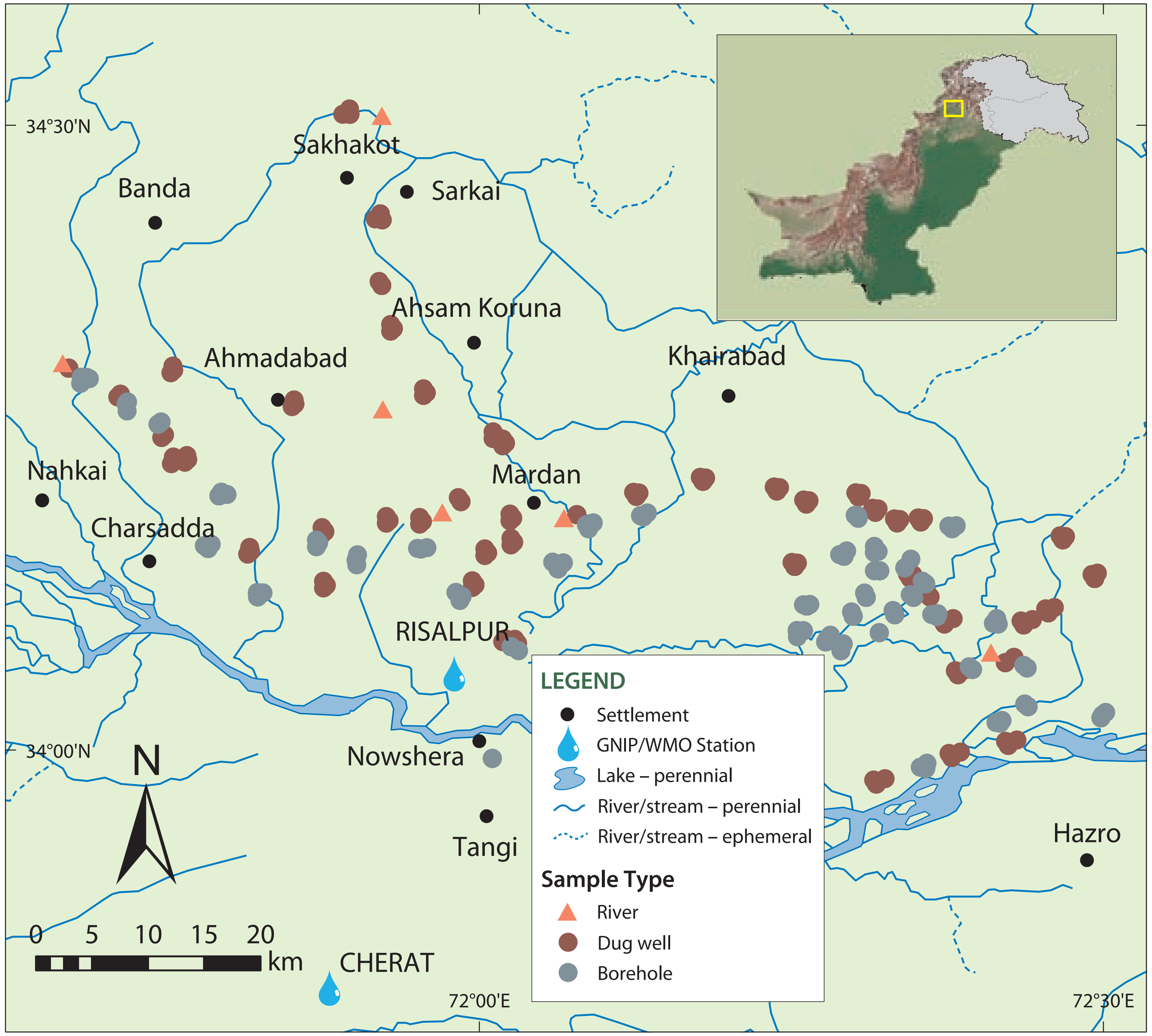
PAK–3620
Mardan area







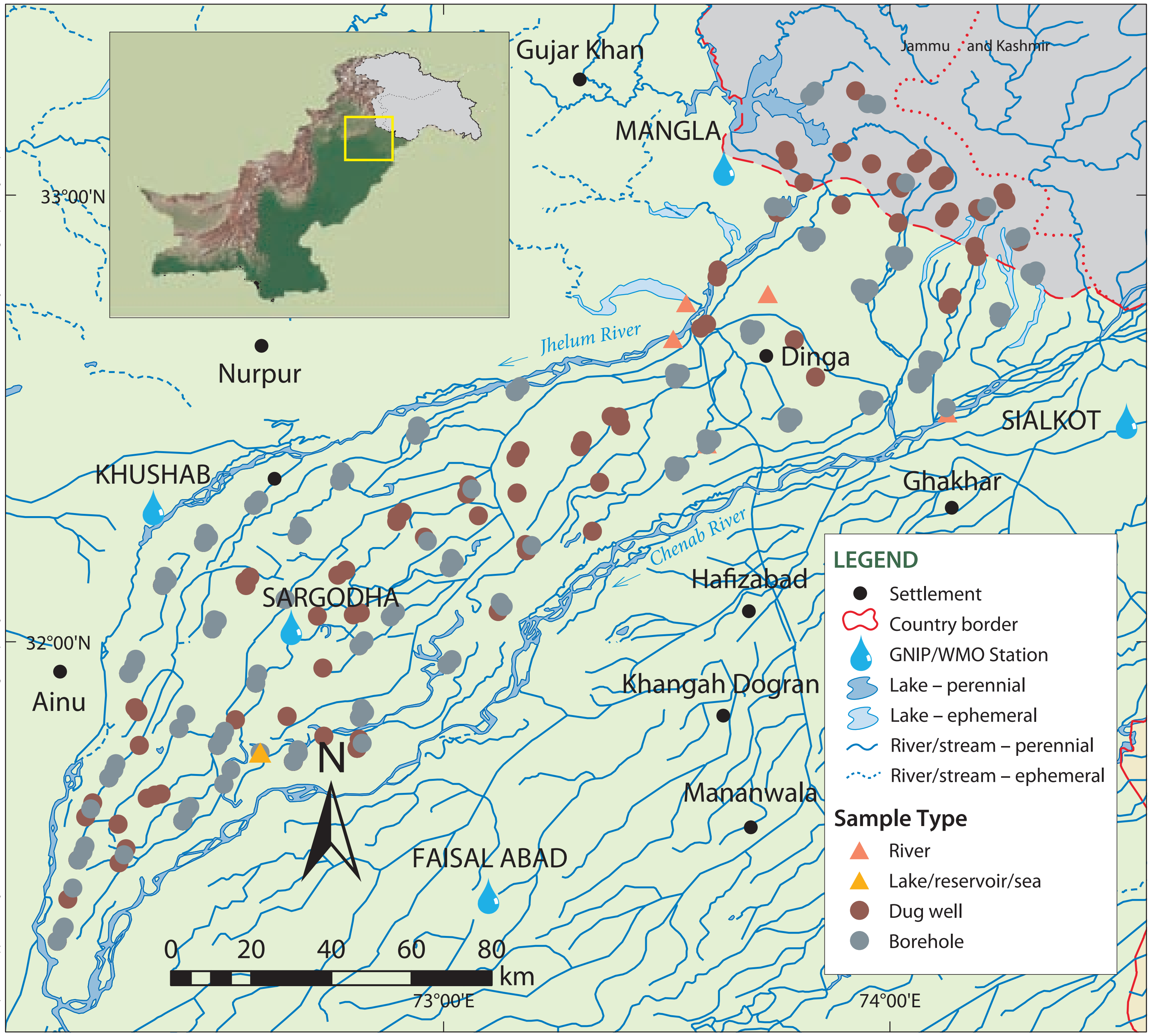




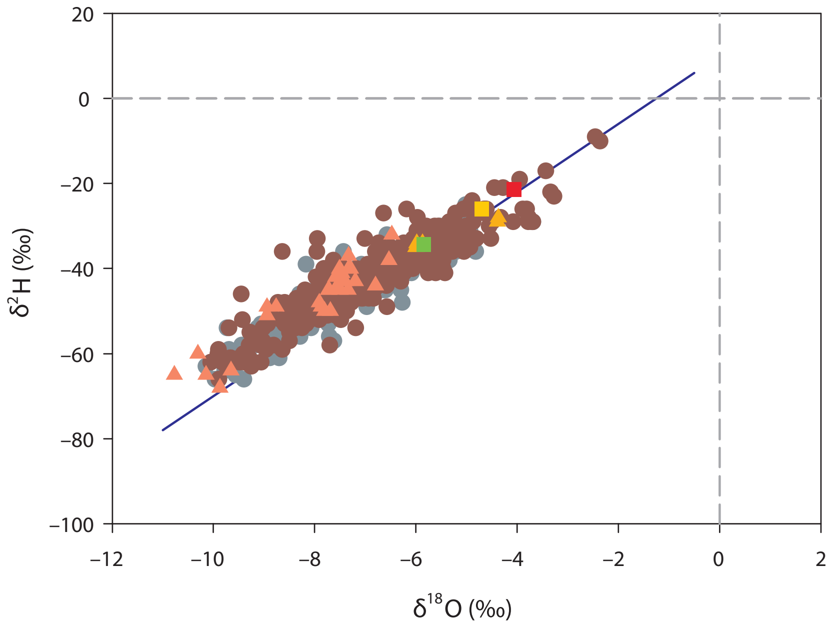
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.		145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.				−4.80			−25.0			
Interpolation – kriging (IAEA)				−6.08			−32.6			
Project										

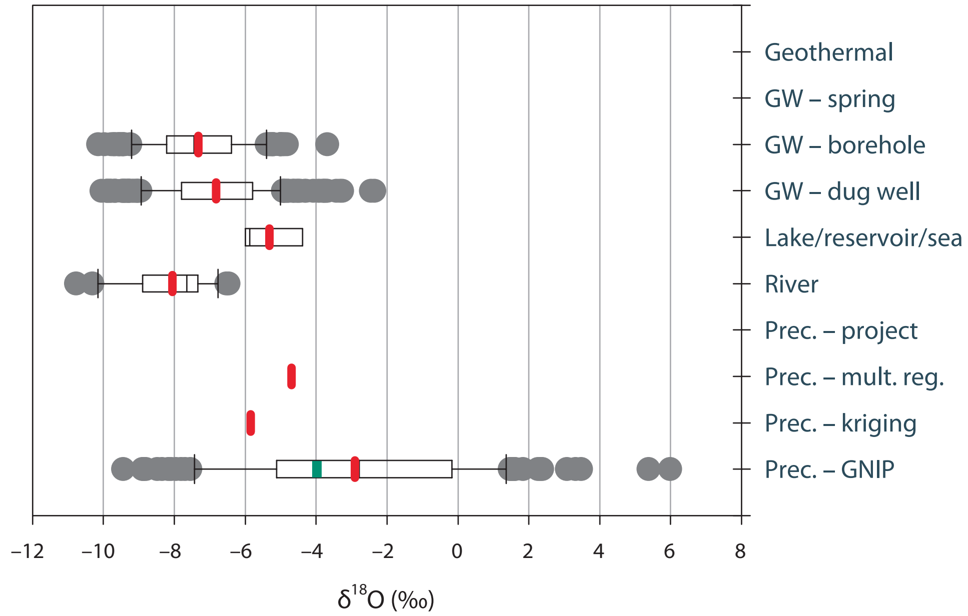
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea									
River		33	−8.61	−8.83 ± 1.2	28	−49.6	−50.9 ± 6.9	4	47.3 ± 5.1

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		188	−5.90	−6.42 ± 1.1	183	−36.5	−38.9 ± 7.2	62	23.8 ± 41.1		
GW–Dug well		215	−7.57	−7.42 ± 1.5	203	−44.5	−44.3 ± 9.3	60	51.0 ± 24.1		
GW–Spring											



The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations and the International Atomic Energy Agency. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

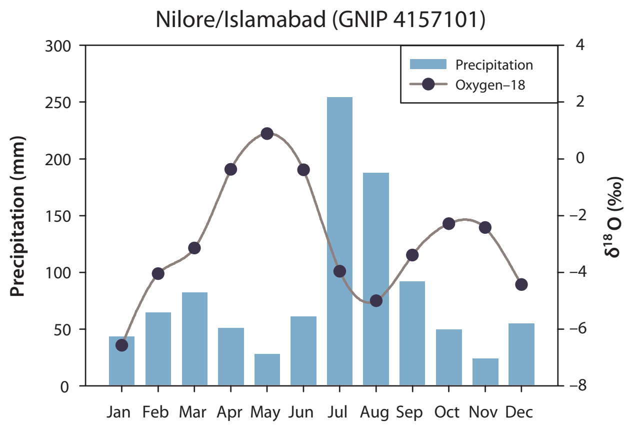


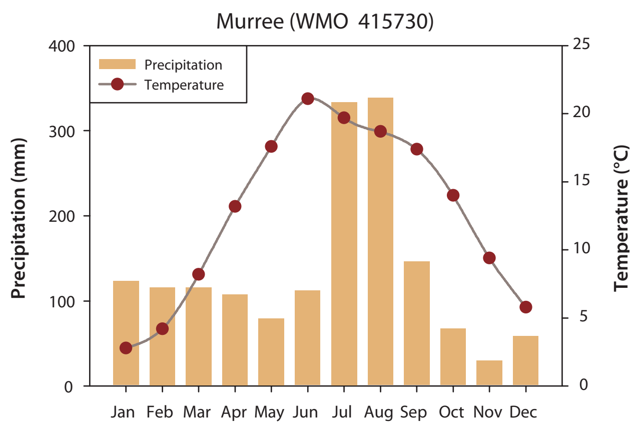


Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	red square	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.	yellow square			−4.70			−26.0			
Interpolation – kriging (IAEA)	green square			−5.85			−34.4			
Project	pink square									

Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	5	−5.87	−5.32 ± 0.9	5	−34.0	−32.0 ± 3.2	5	11.0 ± 1.9
River	orange triangle	28	−7.64	−8.05 ± 1.2	28	−45.0	−47.6 ± 9.2	28	32.1 ± 6.6

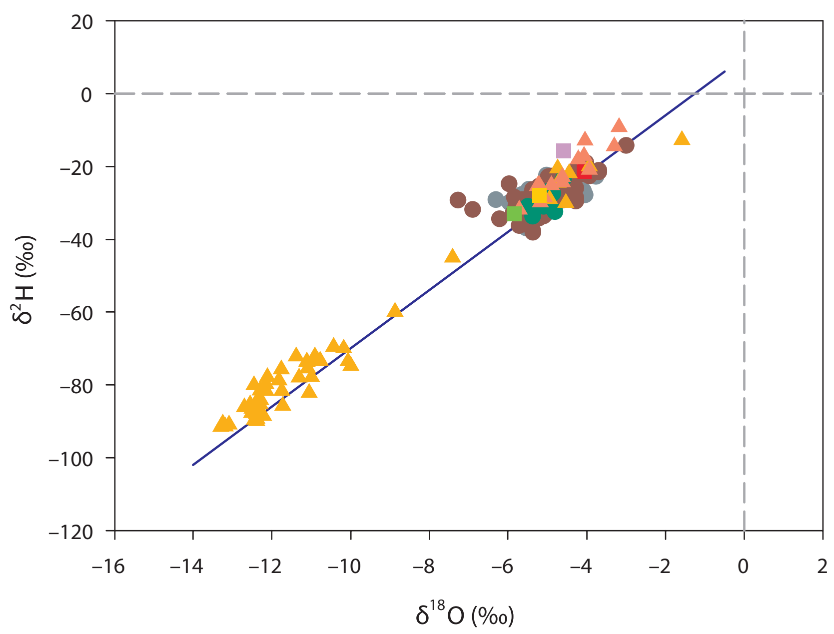
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	187	−7.46	−7.34 ± 1.3	187	−46.0	−45.8 ± 9.2	187	18.6 ± 17.7		
GW–Dug well	brown circle	258	−6.84	−6.89 ± 1.4	258	−42.0	−42.5 ± 9.4	258	31.3 ± 33.5		
GW–Spring	green circle										

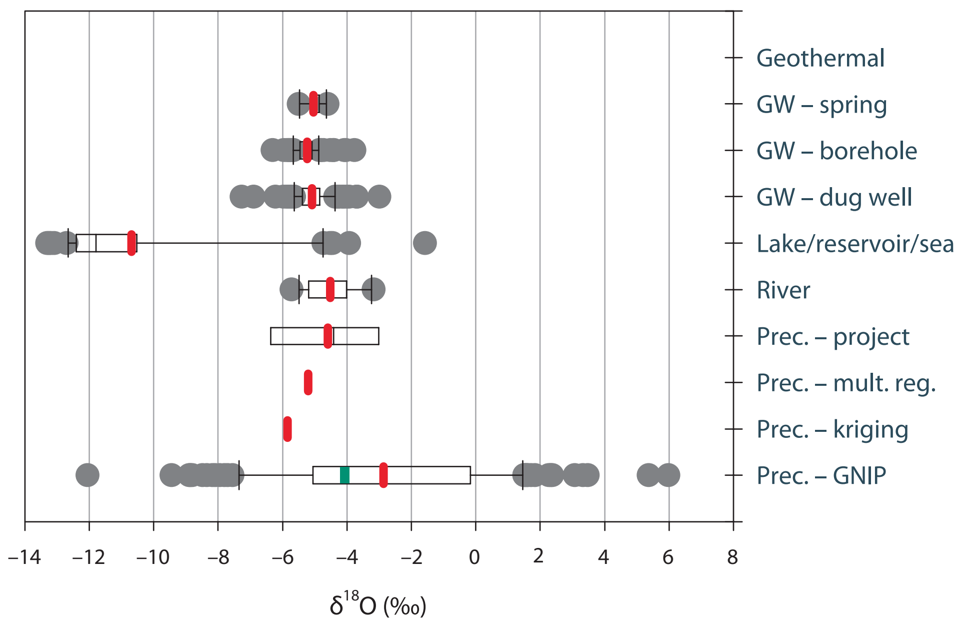


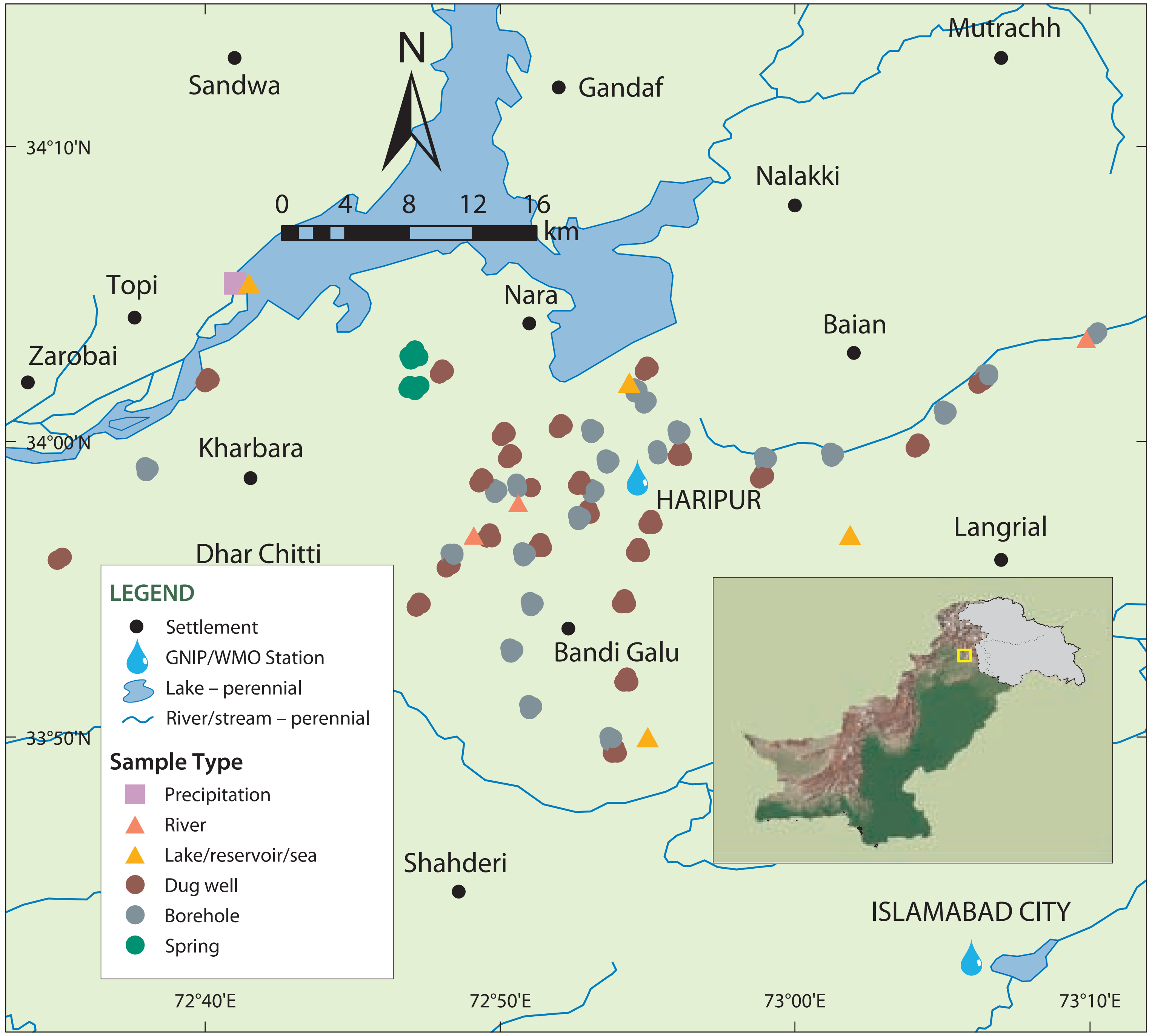


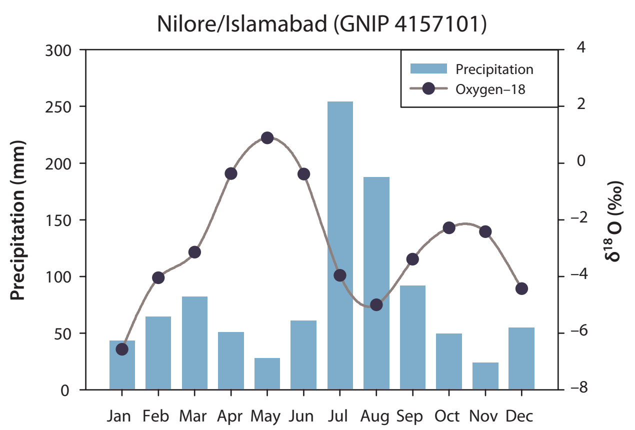
PAK–4794

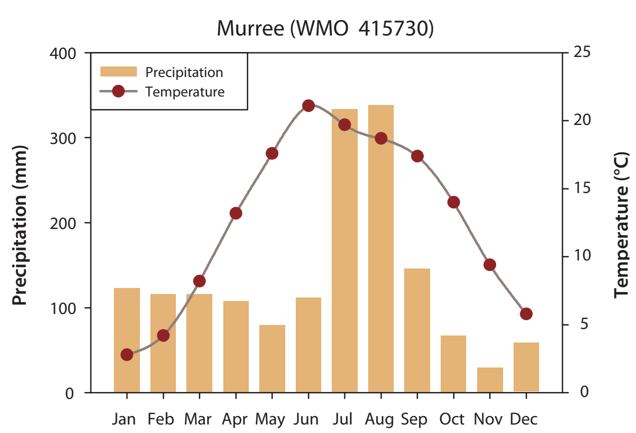
Haripur area



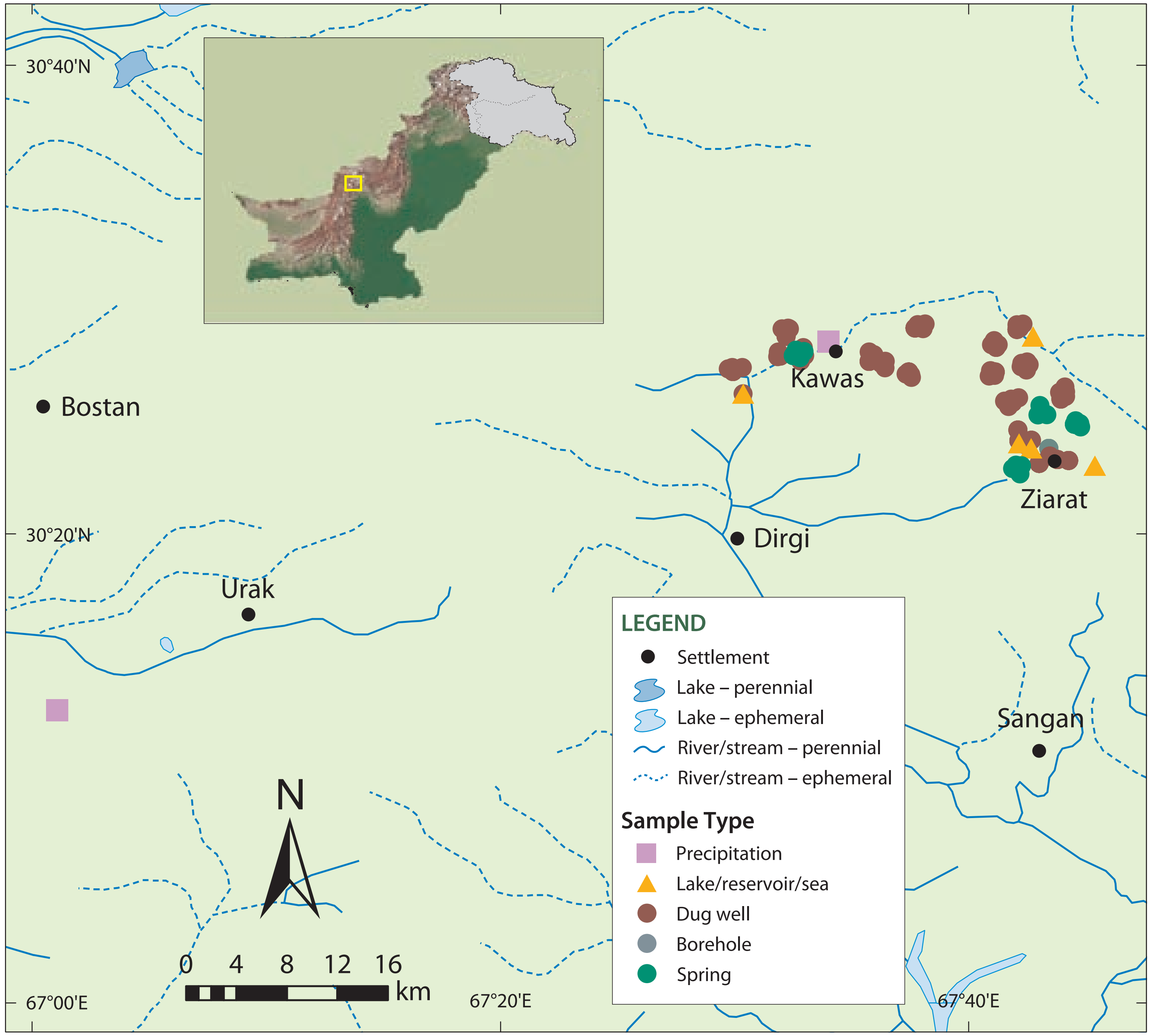


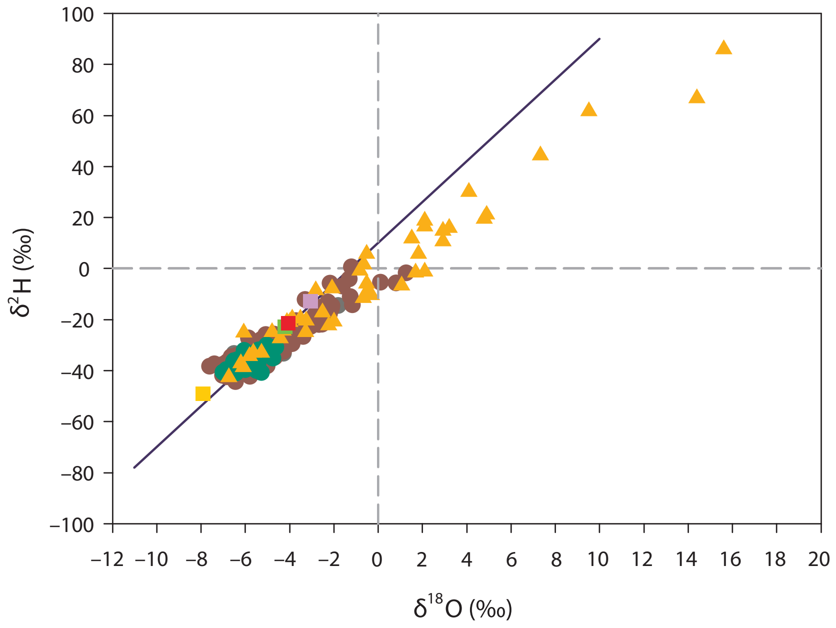


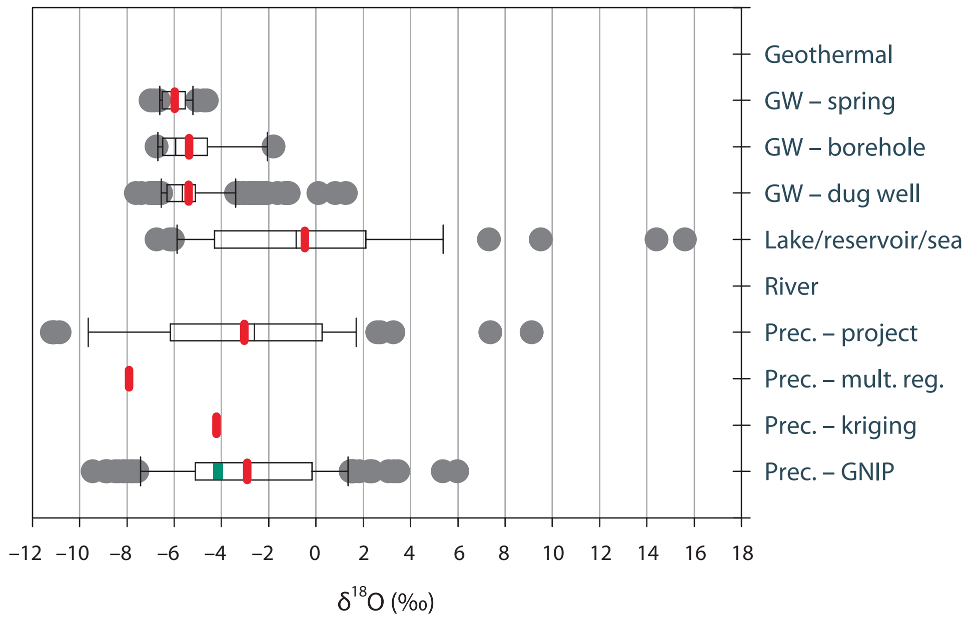




Precipitation		$\delta^{18}O$ (‰)			$\delta^{2}H$ (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station NILORE/ISLAMAB.	■	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7				993
Interpolation – multiple reg.	■			−5.20			−28.0				
Interpolation – kriging (IAEA)	■			−5.84			−33.1				
Project	■	3	−4.41	−4.59 ± 1.7	3	−13.6	−15.8 ± 12.1				
Surface waters		$\delta^{18}O$			$\delta^{2}H$			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲	52	−11.80	−10.69 ± 2.9	53	−80.1	−73.1 ± 21.7	3	24.1 ± 1.6		
River	▲	14	−4.62	−4.52 ± 0.8	14	−23.6	−21.8 ± 6.7	6	40.4 ± 4.9		
Groundwaters		$\delta^{18}O$			$\delta^{2}H$			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	107	−5.23	−5.23 ± 0.4	108	−29.2	−29.4 ± 2.8	33	25.5 ± 12.7		
GW–Dug well	●	131	−5.15	−5.08 ± 0.6	131	−29.2	−28.8 ± 3.9	41	26.4 ± 14.2		
GW–Spring	●	11	−5.05	−5.04 ± 0.3	11	−29.5	−29.2 ± 2.91	4	31.1 ± 6.2		



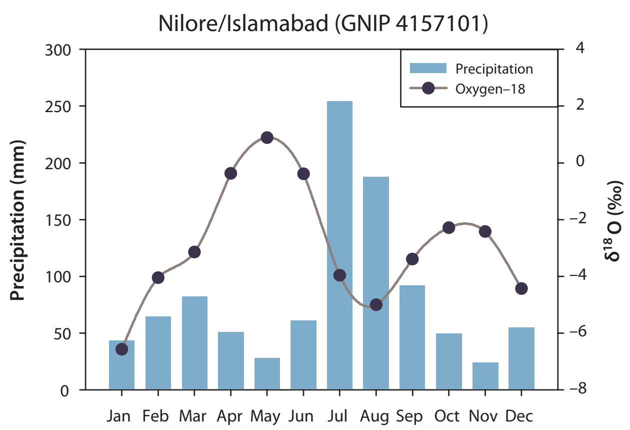


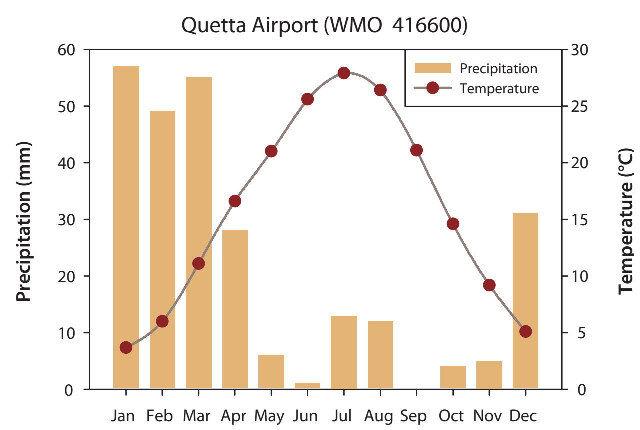


Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.		145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.				−7.90			−49.0			
Interpolation – kriging (IAEA)				−4.21			−22.8			
Project		57	−2.60	−3.04 ± 4.7	59	−5.5	−12.7 ± 36.7	8	8.7 ± 2.1	

Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea		47	−0.83	−0.48 ± 5.1	45	−8.5	−3.1 ± 28.4	19	14.0 ± 6.2
River									

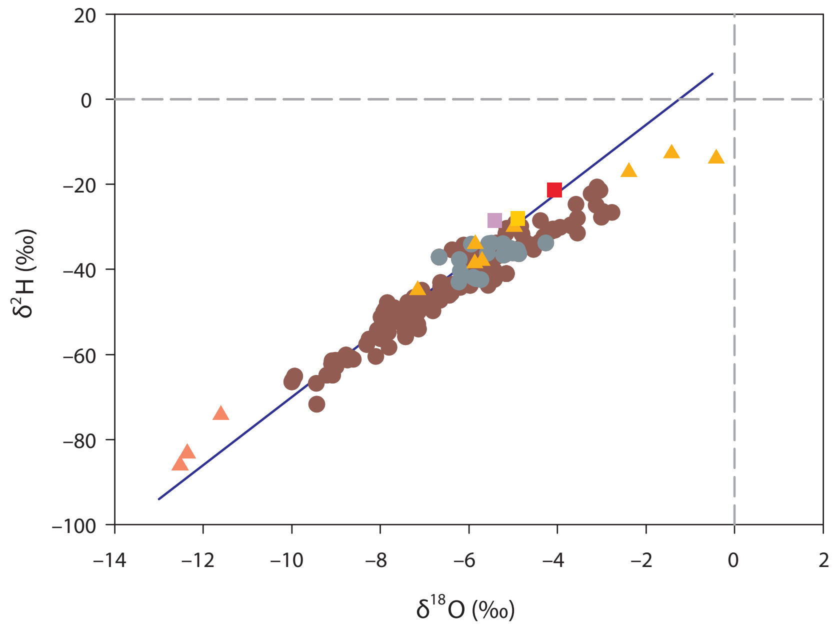
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		12	−5.95	−5.38 ± 1.6	12	−34.5	−32.1 ± 7.5	5	9.6 ± 0.9		
GW–Dug well		260	−5.66	−5.39 ± 1.4	262	−34.0	−32.1 ± 7.4	104	11.0 ± 3.7		
GW–Spring		36	−6.00	−5.98 ± 0.6	35	−36.1	−36.4 ± 3.1	12	9.8 ± 3.6		

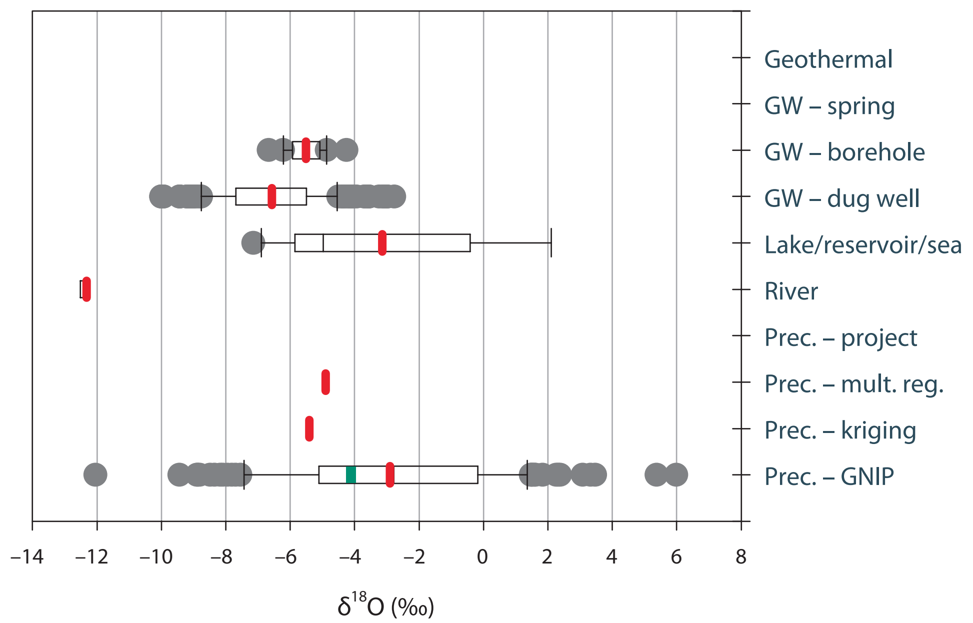


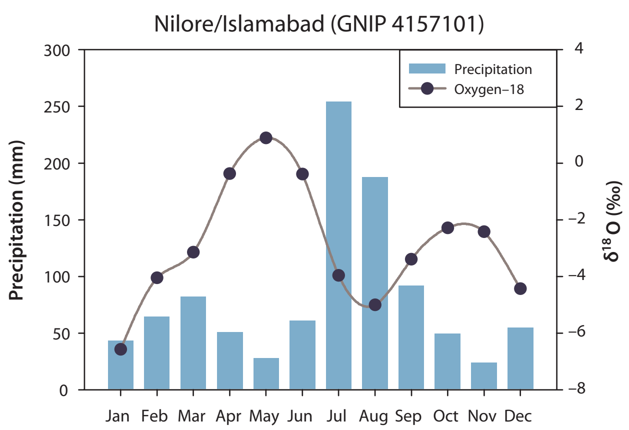


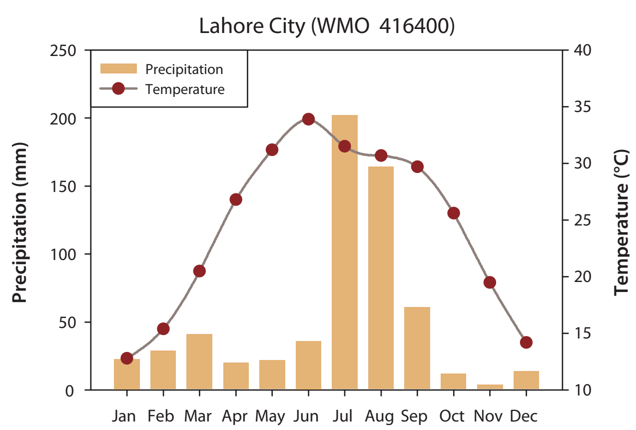
PAK–9826; PAK–11516

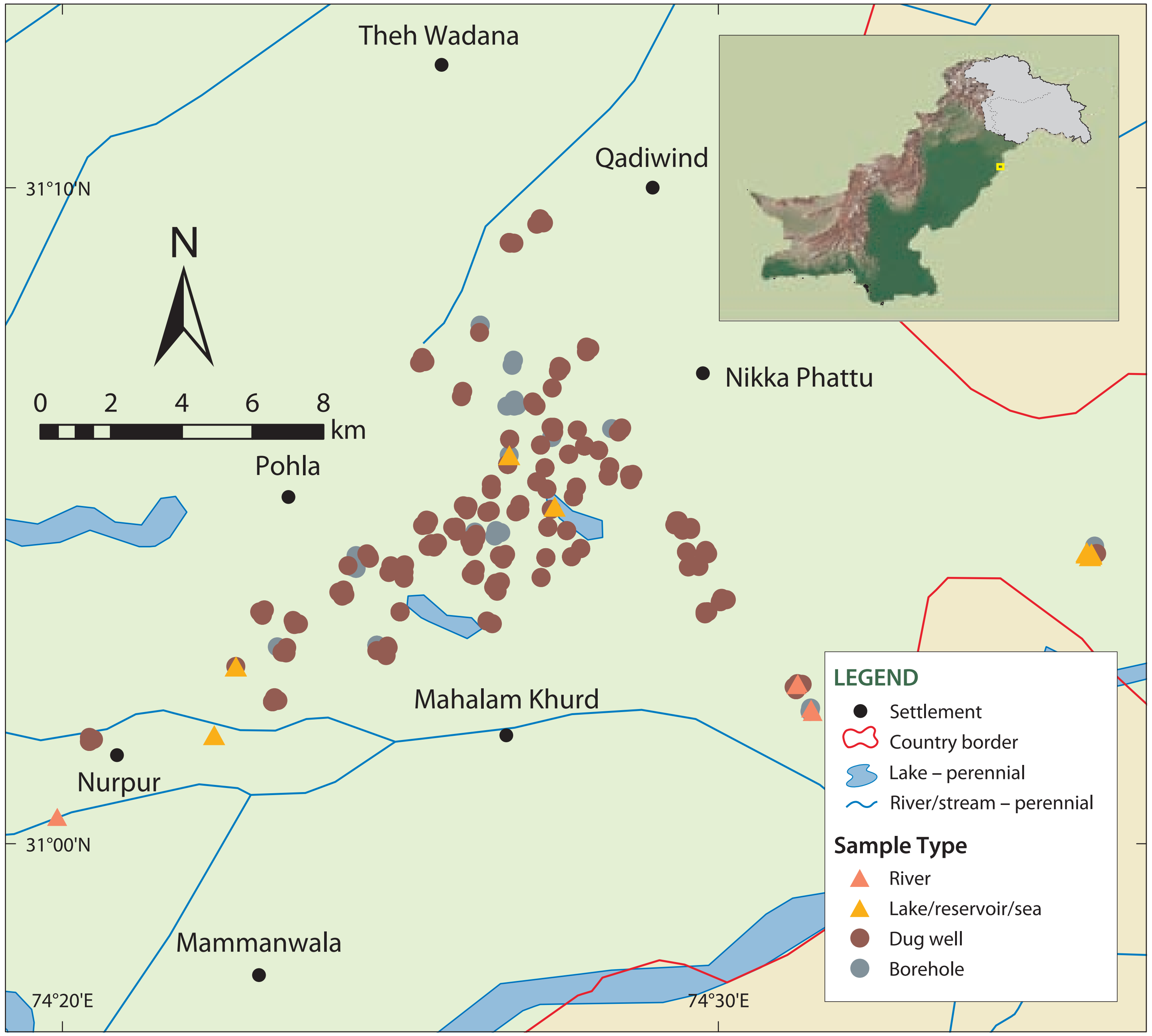
Kasur area











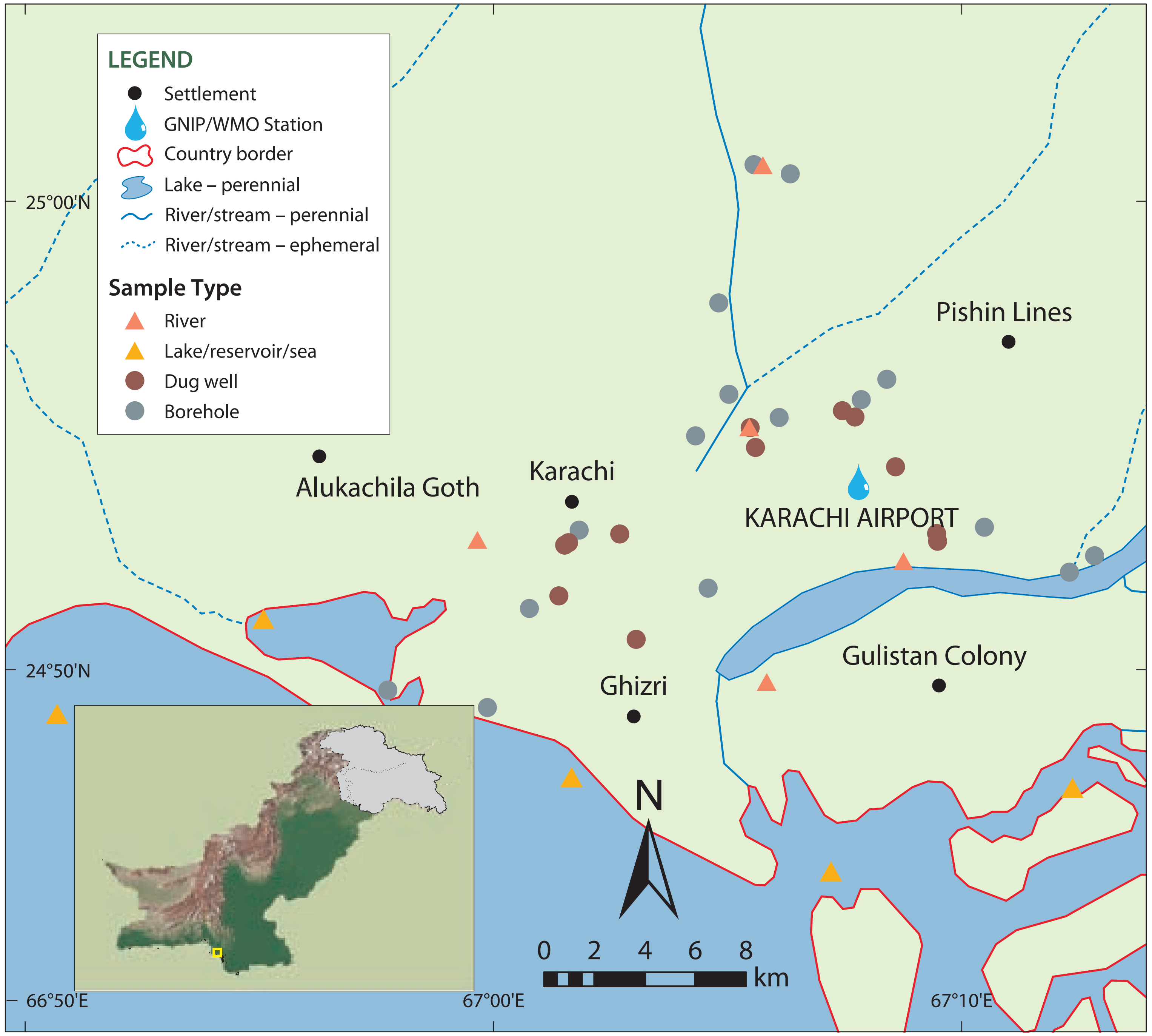
Precipitation		δ¹⁸O (‰) n	δ¹⁸O (‰) Median	δ¹⁸O (‰) Mean ± St. dev.	δ²H (‰) n	δ²H (‰) Median	δ²H (‰) Mean ± St. dev.	Tritium (TU) n	Tritium (TU) Mean ± St. dev.	Annual prec. (mm)
GNIP station NILORE/ISLAMAB.	red square	145	−2.78	−4.06 ± 1.5	143	−11.7	−21.4 ± 12.7			993
Interpolation – multiple reg.	yellow square			−4.90			−28.0			
Interpolation – kriging (IAEA)	green square			−5.41			−28.5			
Project	pink square									

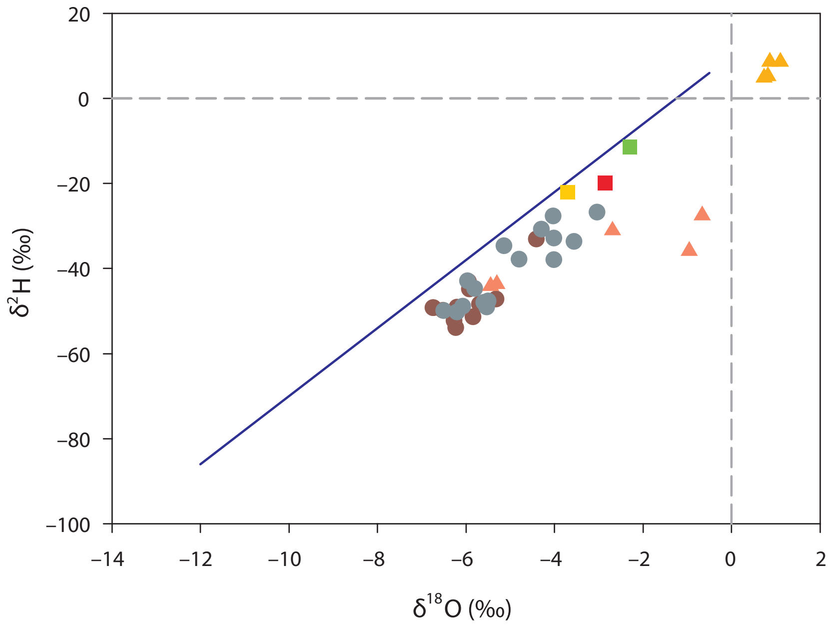
Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	orange triangle	11	−4.18	−3.14 ± 3.3	11	−30.0	−21.7 ± 8.8	1	7.4
River	salmon triangle	7	−12.36	−12.32 ± 0.3	7	−83.3	−83.2 ± 4.2		

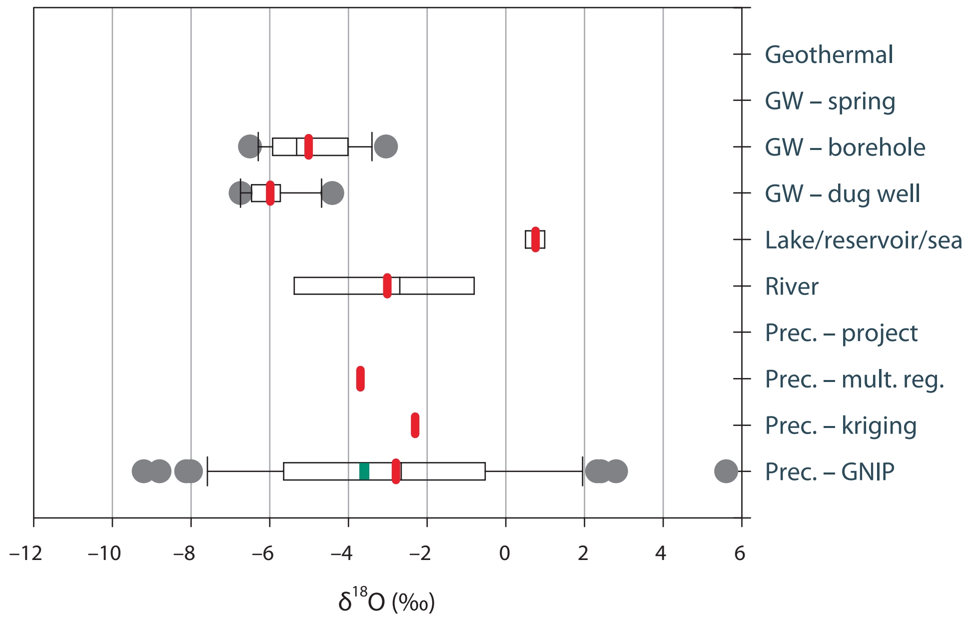
Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C (pMC) Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	20	−5.52	−5.51 ± 0.6	20	−36.2	−37.0 ± 3.2	3	5.0 ± 1.5		
GW–Dug well	brown circle	251	−6.50	−6.57 ± 1.6	251	−45.6	−45.2 ± 10.5	29	6.7 ± 3.8		
GW–Spring	green circle										

PAK–11322

Karachi coastal aquifer



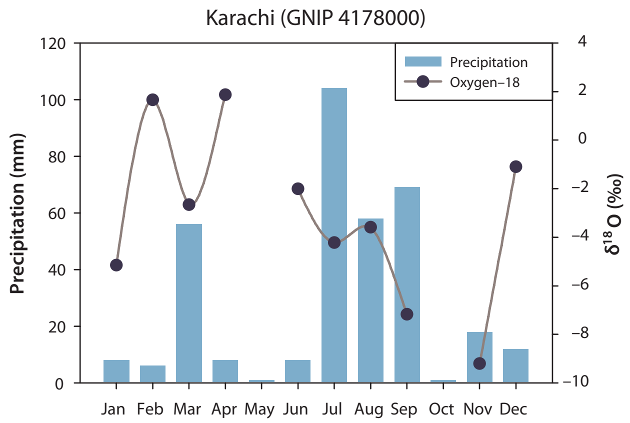


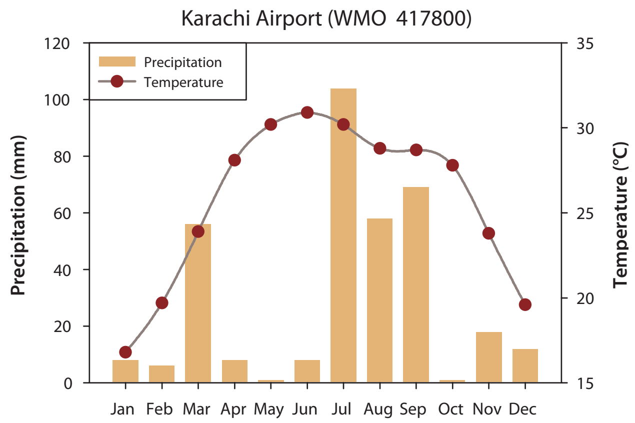


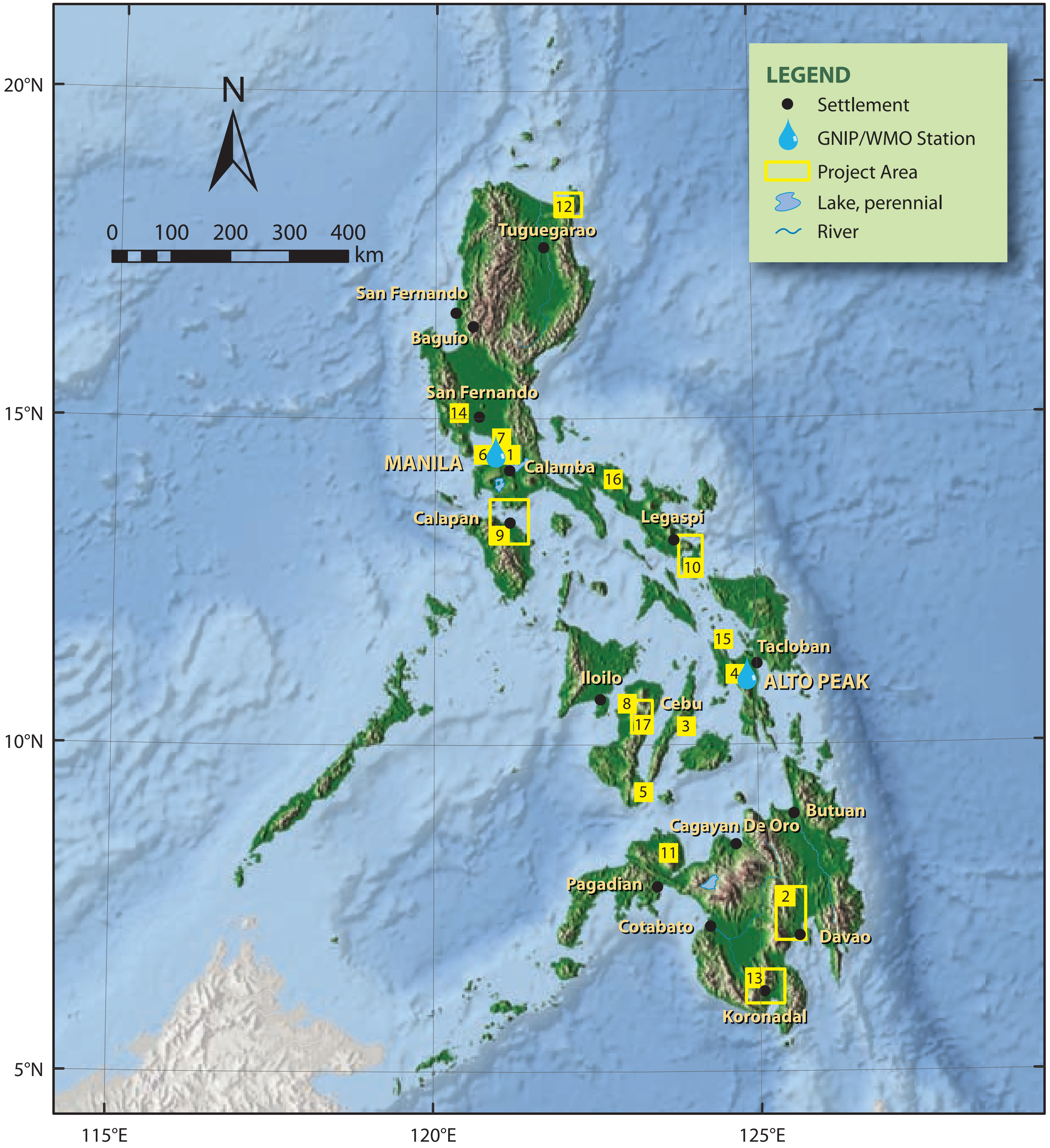
Precipitation		δ^{18}O (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KARACHI	red square	45	−2.66	−3.74 ± 2.0	43	−12.0	−22.4 ± 18.5			195
Interpolation – multiple reg.	yellow square			−3.70			−22.0			
Interpolation – kriging (IAEA)	green square			−2.30			−11.4			
Project	pink square									

Surface waters		δ^{18}O n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	5	0.82	0.76 ± 0.3	4	6.9	6.9 ± 2.0		
River	orange triangle	5	−2.69	−3.01 ± 2.3	5	−31.1	−35.1 ± 8.2		

Groundwaters		δ^{18}O n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	16	−5.32	−5.00 ± 1.1	16	−42.8	−41.1 ± 7.7				
GW–Dug well	brown circle	12	−6.07	−5.98 ± 0.6	12	−49.1	−48.4 ± 3.4				
GW–Spring	green circle										







1 **Project Code:** PHI8011M
Study area: Metro Manila area
Sampling period: 1986–1987
Background: This isotope study aimed at assessment of groundwater recharge and salinization as well as determination of the extent of salt water intrusion into the aquifers in Metro Manila for sustainable water resources management.

2 **Project Code:** PHI8011D, RAS8084–PHI, RAS8097–PHI
Study area: Davao city area
Sampling period: 1988, 1998–2002, 2003–2004
Background: In these projects, isotope studies aimed at understanding the groundwater origin, dynamics and salinization, including the extent of salt water intrusion into the aquifers, in Davao city for sustainable water supply for the city.

3 **Project Code:** PHI8011C
Study area: Cebu city
Sampling period: 1986–1988
Background: This isotope study aimed at understanding the groundwater dynamics and extent of saline intrusion into the aquifers in Cebu city area.

4 **Project Code:** PHI8016L, PHI–9719L
Study area: Leyte geothermal field
Sampling period: 1974–1990, 1995
Background: The aim of these isotope investigations was the assessment of the deleterious effects of the reinjection of cold fluids into geothermal fields and determination of dilution factors as well as chemical/physical changes in the geothermal reservoir for improving electrical power production.

5 **Project Code:** PHI8016S, RAS8092–PHI, PHI–9719S
Study area: Southern Negros geothermal area
Sampling period: 1982–1992, 1999–2001, 1995
Background: The aim of these isotope investigations was the assessment of the deleterious effects of the reinjection of cold fluids into geothermal fields and determination of dilution factors as well as chemical/physical changes in the geothermal reservoir for improving electrical power production.

6 **Project Code:** PHI8018
Study area: Laguna Lake basin
Sampling period: 1995–1996
Background: This project focused on the groundwater systems of the Laguna Lake basin in order to study their recharge and origin, and the hydraulic interrelationships between different aquifer systems.

IAEA Water Resources Programme

PHILIPPINES

7 **Project Code:** PHI8022, RAS8097–PHI, RAS8093–PHI
Study area: La Mesa, Rodriguez–Montalban and Angat dam sites
Sampling period: 2002–2003, 2003–2005, 2003
Background: These projects were carried out with the aim of fingerprinting different water masses to ascertain the hydraulic connections between reservoirs, landfills and groundwater.

8 **Project Code:** PHI8025
Study area: Bacolod area
Sampling period: 2005–2006
Background: The Bacolod city water supply network was under the second phase of expansion. This isotope study was carried out to understand the recharge zones of aquifers for delineating the areas that will need concentrated effort for forest cover preservation and restoration.

9 **Project Code:** RAS8075Mo–PHI, RAS8075Ma–PHI
Study area: Montelago–Mabini geothermal areas
Sampling period: 1989–1997, 1981–1998
Background: A significant amount of geothermal resources remains untapped in certain areas because of a lack of exposure to various technologies of geothermal exploration and exploitation. In order to support the use of geothermal resources for energy production in the region through the application of isotope and geochemical techniques, this regional project was implemented to obtain benchmark isotopic and chemical data for understanding the dynamics of the geothermal fluids and reservoir temperatures. The Montelago and Mabini areas were investigated under this project.

10 **Project Code:** PHI–6019MB, PHI–6019BM, PHI–9719BM
Study area: Mount Bulusan–BacMan area
Sampling period: 1986–1990, 1983–1984, 1990–1991, 1995
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under the research contracts.

11 **Project Code:** PHI–6019MA
Study area: Mount Ampiro geothermal area
Sampling period: 1991–1992
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

12 **Project Code:** PHI–6019MC
Study area: Mount Cagua geothermal area
Sampling period: 1991
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

13 **Project Code:** PHI–6019MP
Study area: Mount Parker geothermal area
Sampling period: 1992
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

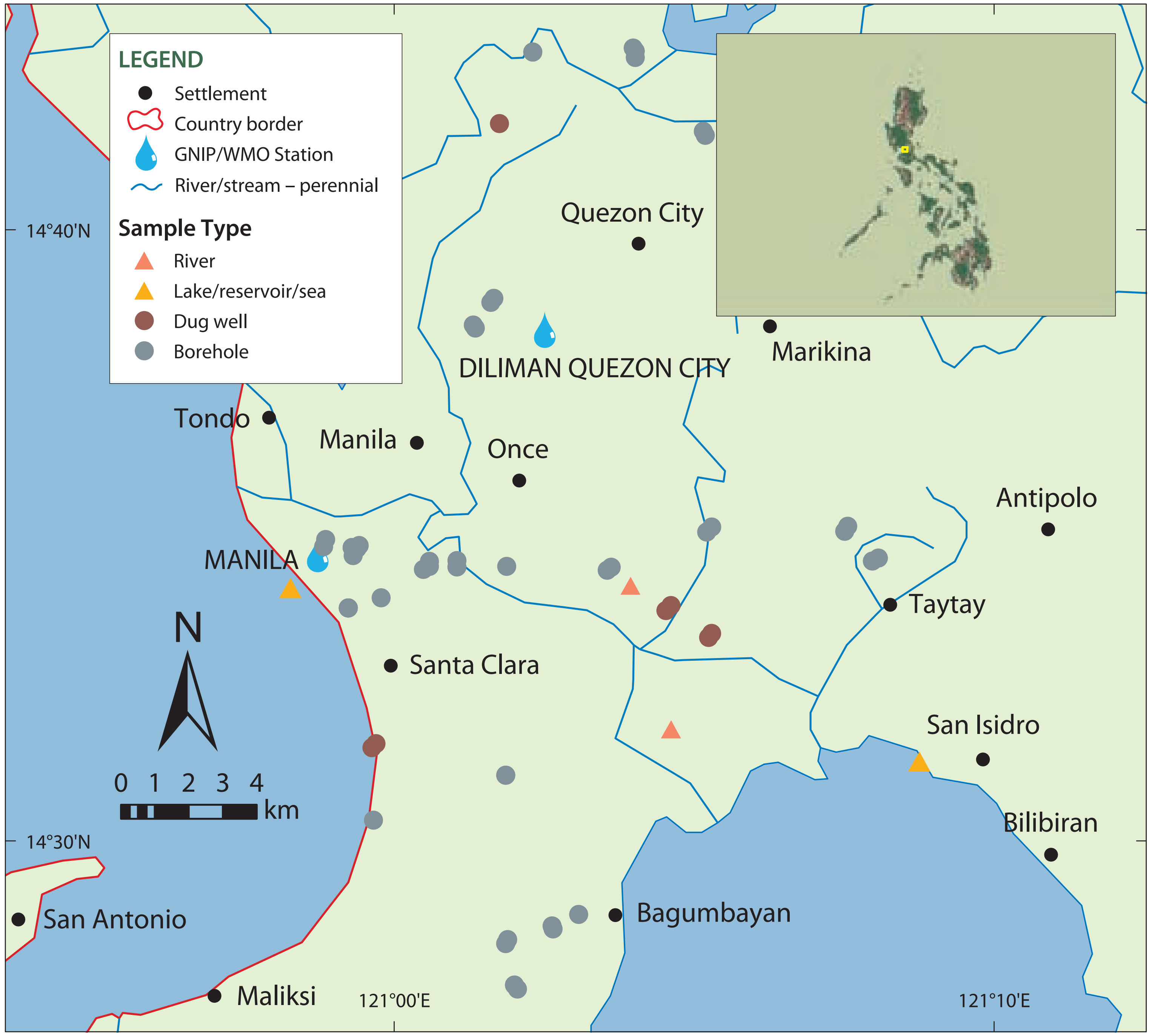
14 **Project Code:** PHI–6019Pi
Study area: Mount Pinatubo geothermal area
Sampling period: 1981–1983, 1989–1990
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

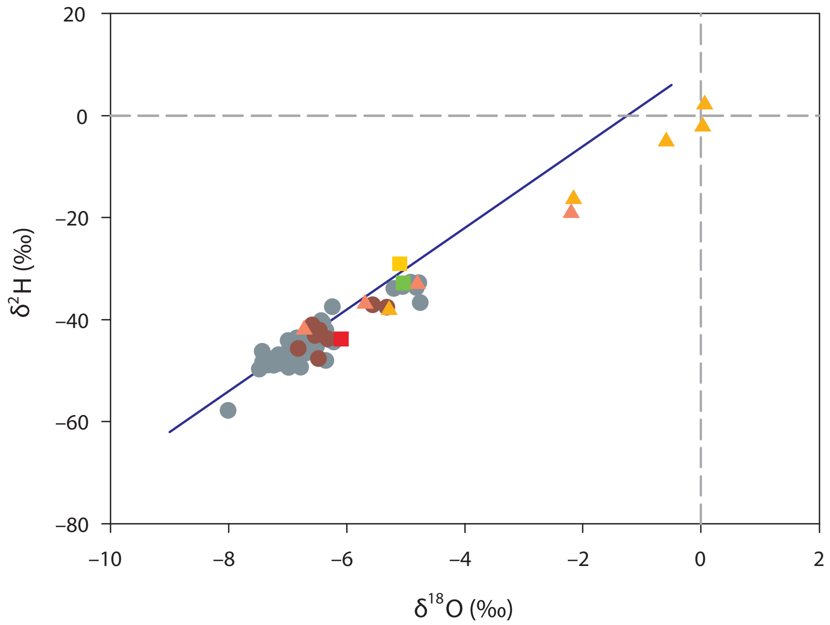
15 **Project Code:** PHI–6019Bi
Study area: Mount Biliran geothermal area
Sampling period: 1982–1992
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

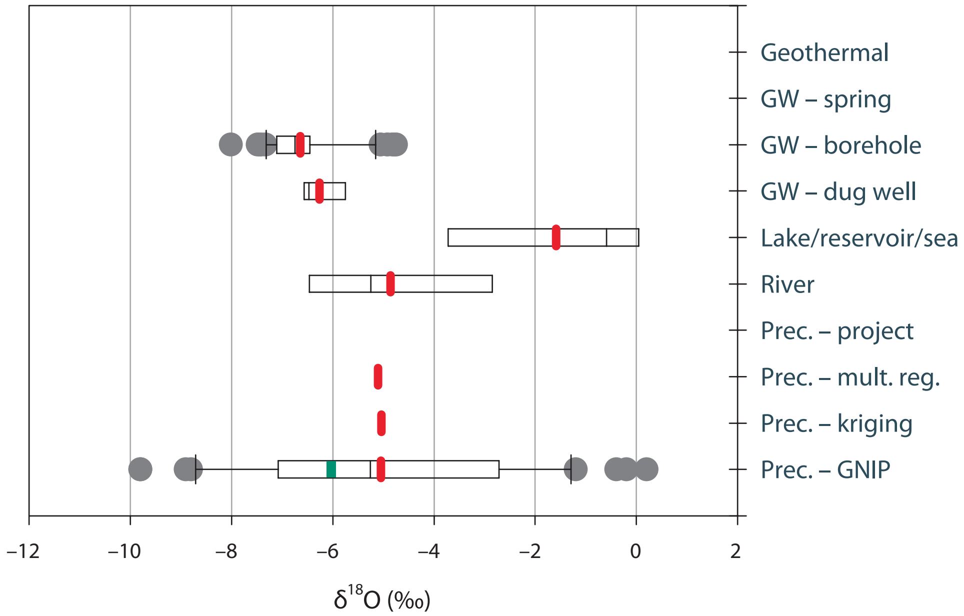
16 **Project Code:** PHI–6019ML
Study area: Mount Labo geothermal area
Sampling period: 1990–1993
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

17 **Project Code:** PHI–6019NN
Study area: Northern Negros geothermal area
Sampling period: 1979, 1989–1992
Background: The study was designed to determine the hydrological characteristics of geothermal areas in the Philippines through the use of environmental isotopes and to utilize isotopic data alongside chemical and geological data as tools in geothermometry and reservoir management. Several areas were investigated under this research contract.

PHI8011M
Metro Manila area



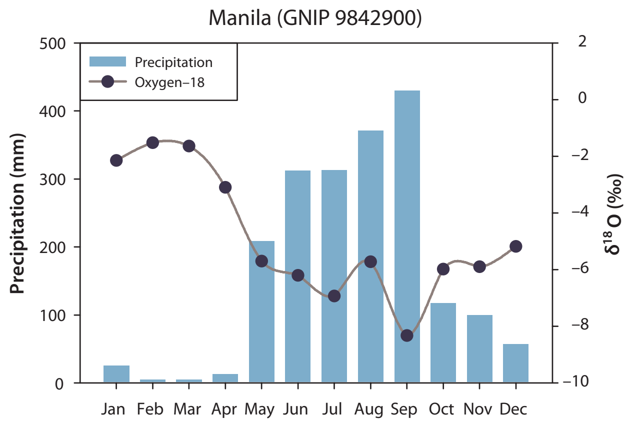


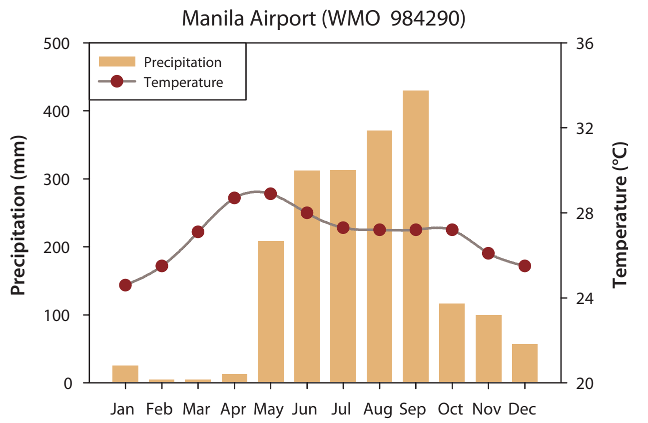


Precipitation	δ^{18}O (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station MANILA	48	−5.25	−6.09 ± 2.9	46	−38.2	−43.8 ± 1.2			907
Interpolation – multiple reg.			−5.10			−29.0			
Interpolation – kriging (IAEA)			−5.04			−32.8			
Project									

Surface waters	δ^{18}O n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	5	−0.59	−1.59 ± 2.2	5	−5.1	−11.9 ± 16.2	2	2.7 ± 0.1
River	4	−5.25	−4.85 ± 1.9	4	−35.0	−32.8 ± 9.8	2	4.8 ± 0.6

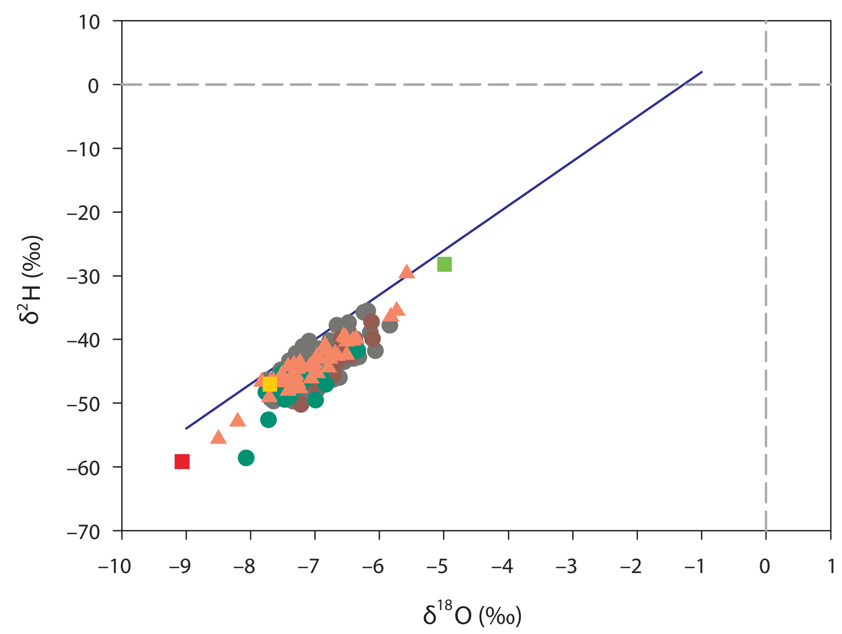
Groundwaters	δ^{18}O n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	56	−6.74	−6.64 ± 0.7	56	−46.1	−45.0 ± 4.8	21	0.6 ± 0.9	14	55 ± 31
GW–Dug well	8	−6.47	−6.26 ± 0.5	8	−42.6	−42.3 ± 3.6	4	4.9 ± 1.0		
GW–Spring										

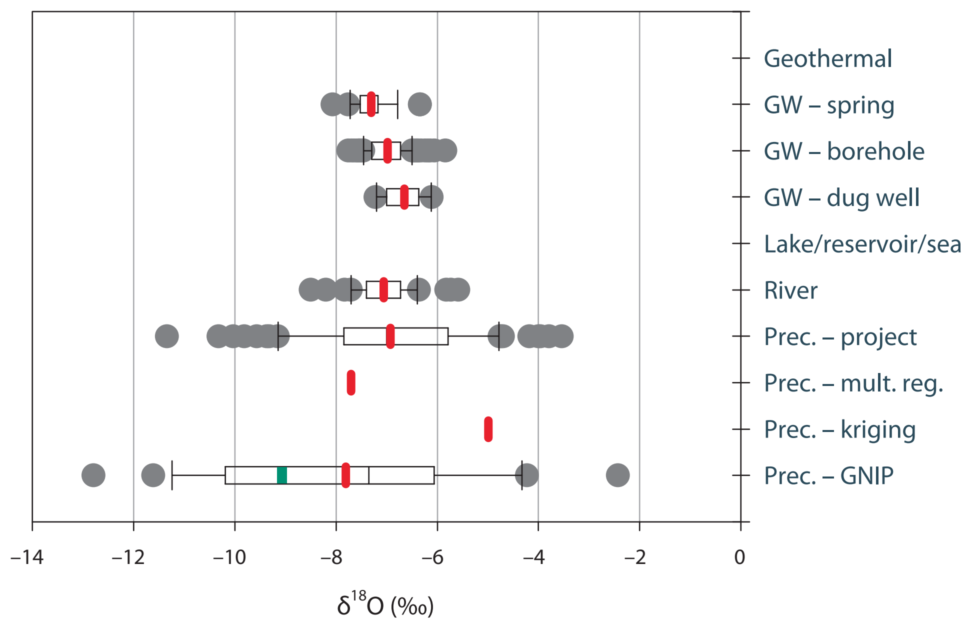


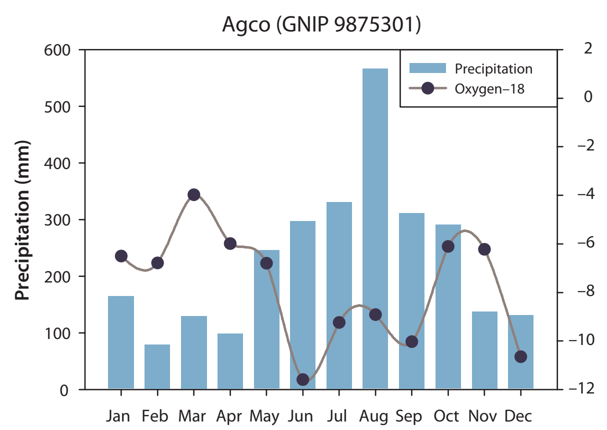


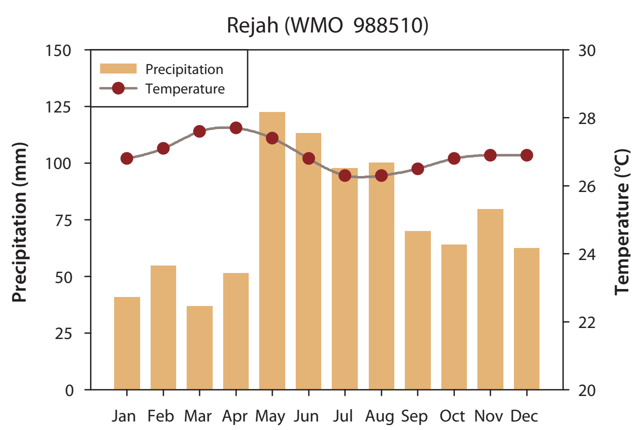
PHI8011D; RAS8084–PHI; RAS8097–PHI

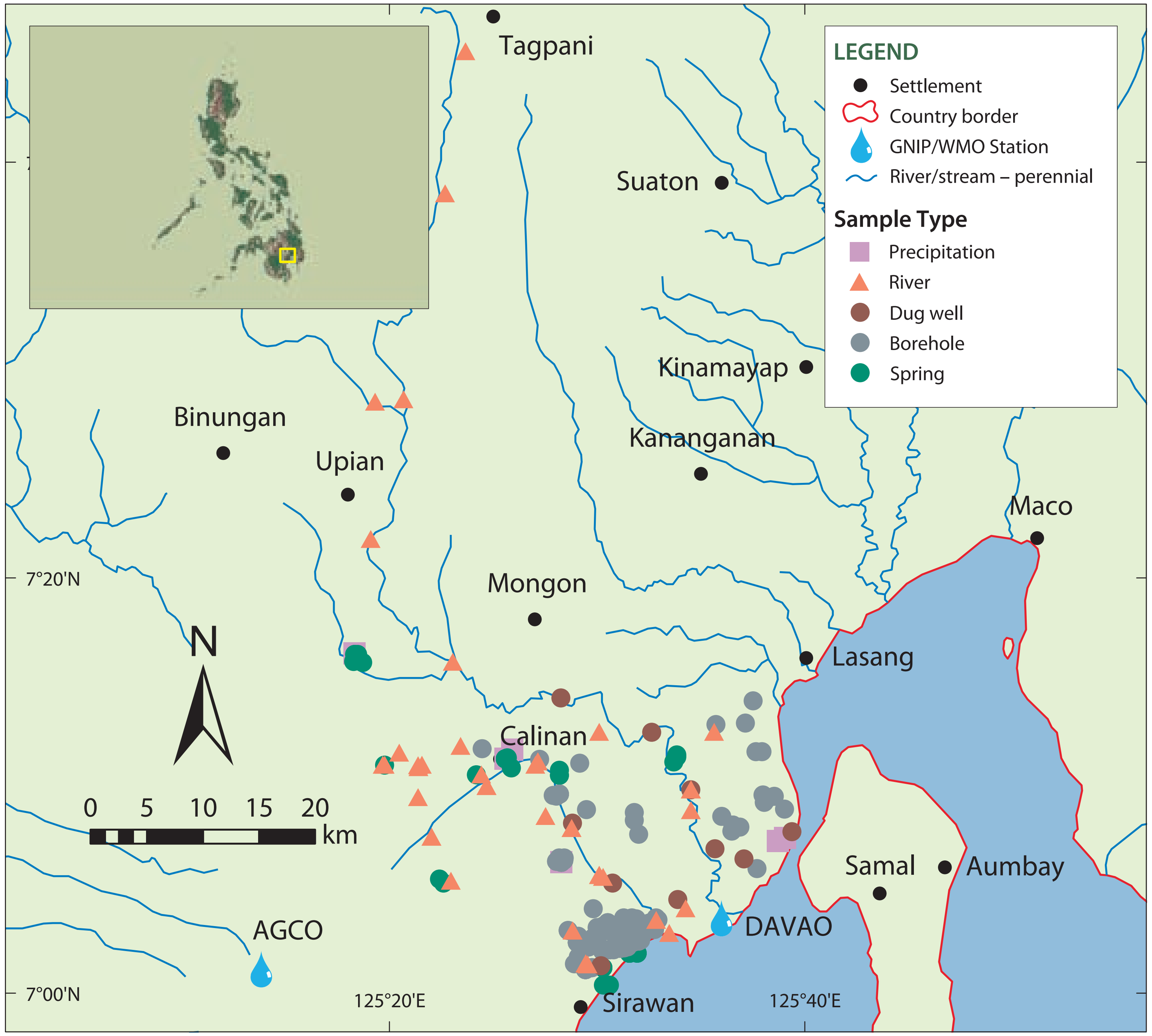
Davao city area





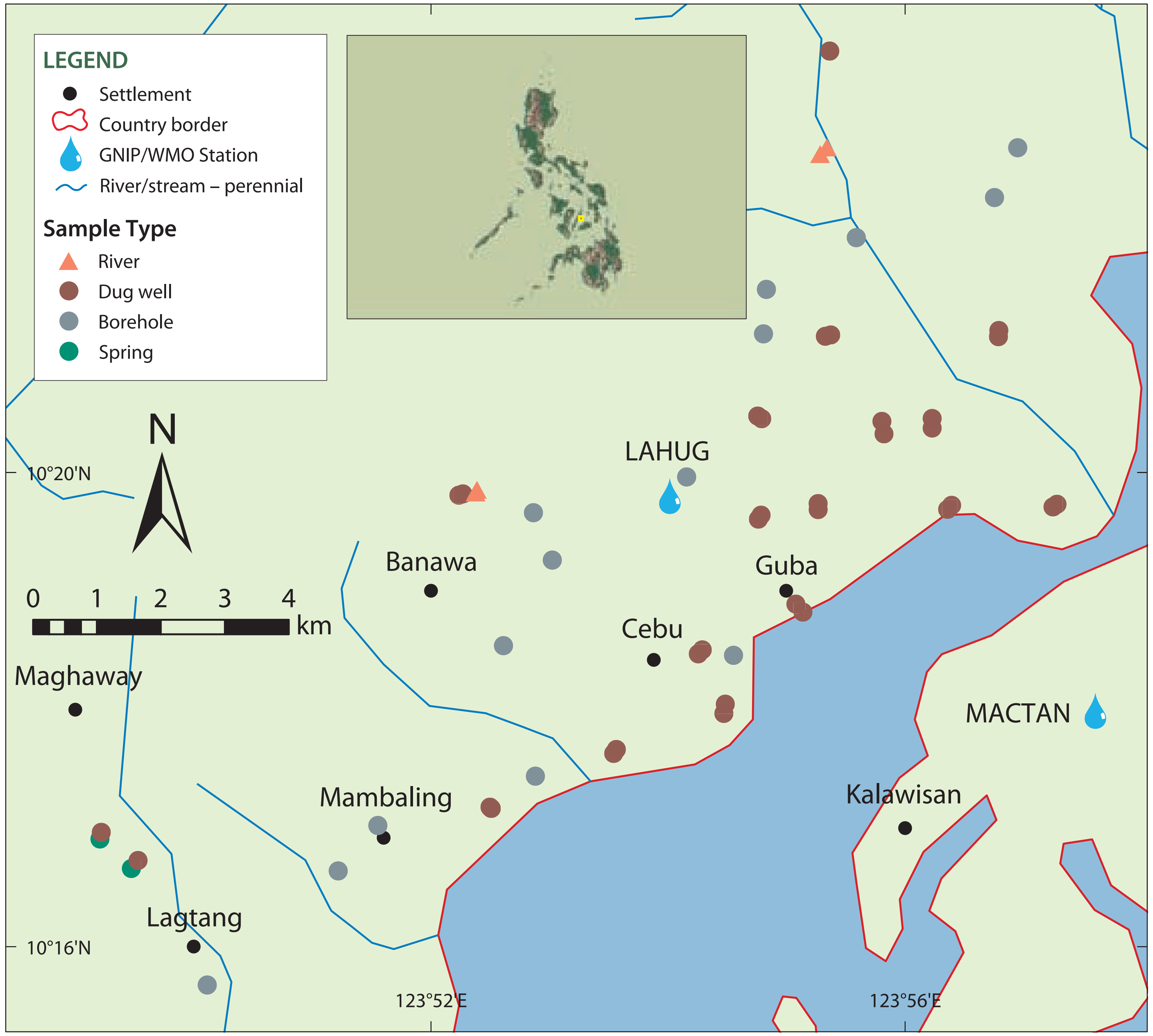


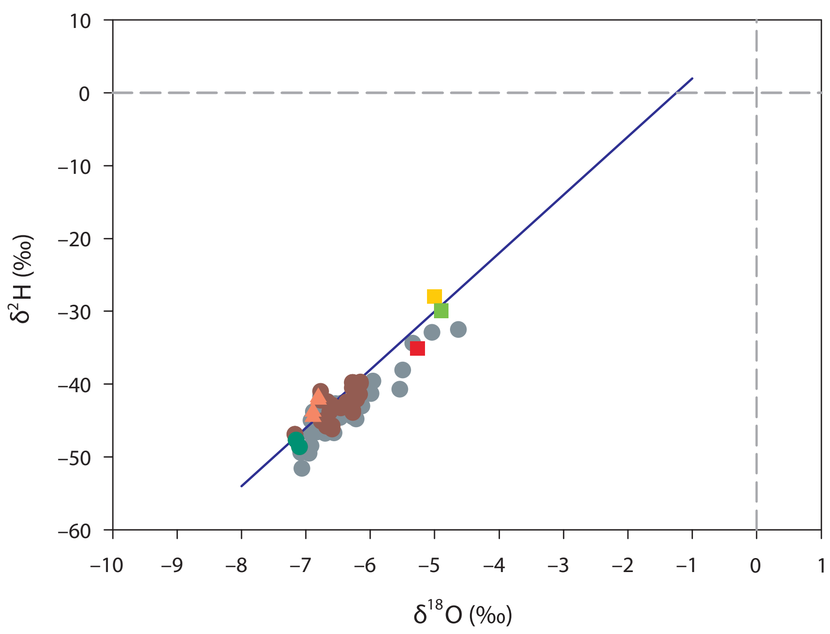


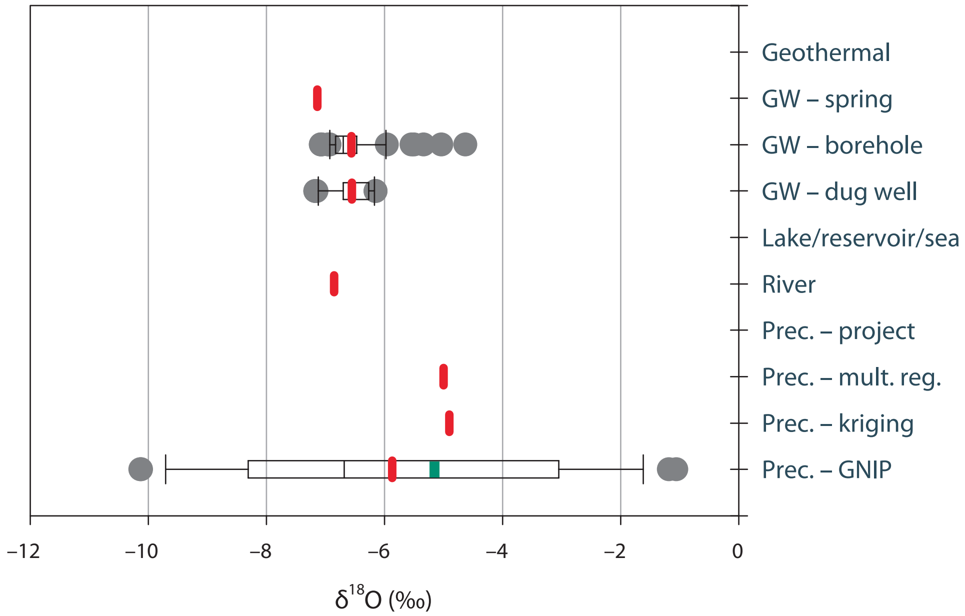


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station AGCO	■ (red)	28	−7.35	−9.06 ± 1.1	27	−45.3	−59.2 ± 7.2				1546
Interpolation – multiple reg.	■ (yellow)			−7.70			−47.0				
Interpolation – kriging (IAEA)	■ (green)			−4.99			−28.2				
Project	■ (pink)	80	−7.00	−6.93 ± 1.6	80	−45.0	−45.2 ± 13.5	96	4.1 ± 1.9		
Surface waters		δ¹⁸O			δ²H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲ (orange)										
River	▲ (salmon)	45	−7.08	−7.06 ± 0.6	45	−44.3	−44.0 ± 4.2	9	3.3 ± 1.9		
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	189	−6.98	−6.98 ± 0.4	190	−44.3	−44.2 ± 2.6	95	1.7 ± 1.2		
GW–Dug well	● (brown)	10	−6.63	−6.64 ± 0.4	10	−43.0	−43.3 ± 3.9	9	2.3 ± 0.7		
GW–Spring	● (green)	28	−7.34	−7.30 ± 0.4	28	−46.5	−47.1 ± 3.1	19	3.2 ± 1.3		

PHI8011C
Cebu city





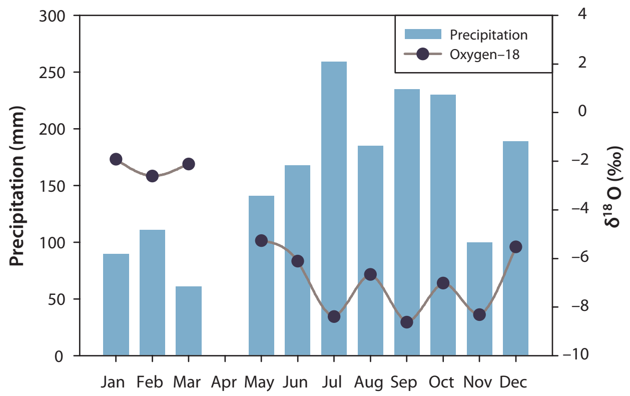


Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station TICALA	red	22	−6.68	−5.27 ± 2.1	22	−42.6	−35.1 ± 17.6			1026
Interpolation – multiple reg.	yellow			−5.00			−28.0			
Interpolation – kriging (IAEA)	green			−4.90			−29.9			
Project	pink									

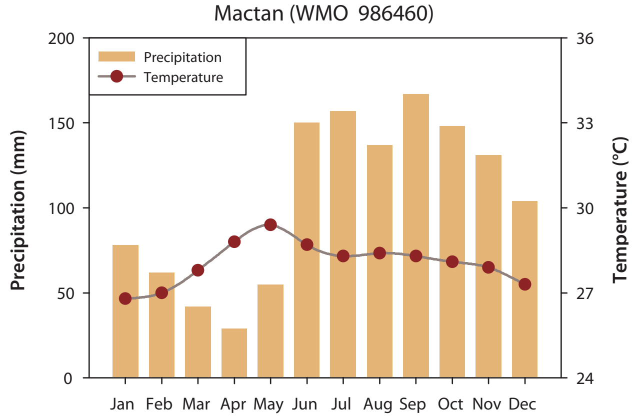
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea									
River		4	−6.85	−6.85 ± 0.1	4	−43.0	−43.1 ± 1.3	2	3.9 ± 1.3

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		64	−6.70	−6.56 ± 0.5	64	−44.9	−44.3 ± 3.4	17	4.0 ± 1.6		
GW–Dug well		34	−6.60	−6.55 ± 0.3	34	−42.9	−43.3 ± 2.5	18	3.6 ± 1.6		
GW–Spring		2	−7.13	−7.13 ± 0.0	2	−48.2	−48.2 ± 0.6				

Ticala (GNIP 9864203)

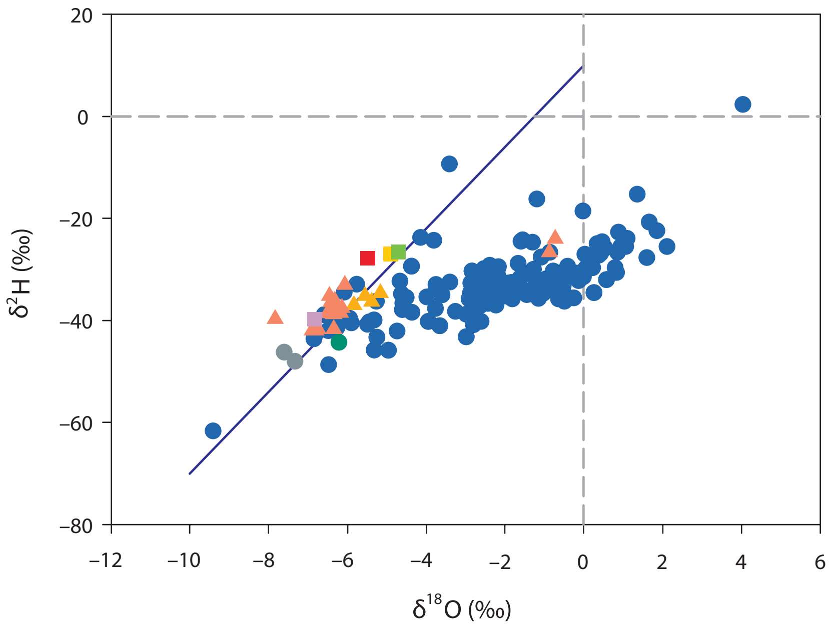


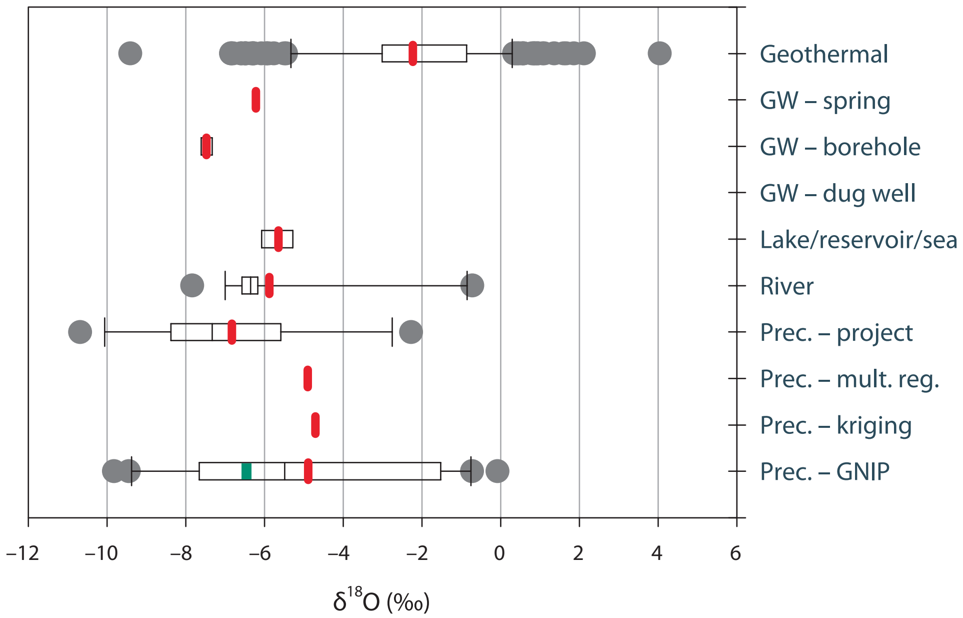
Mactan (WMO 986460)

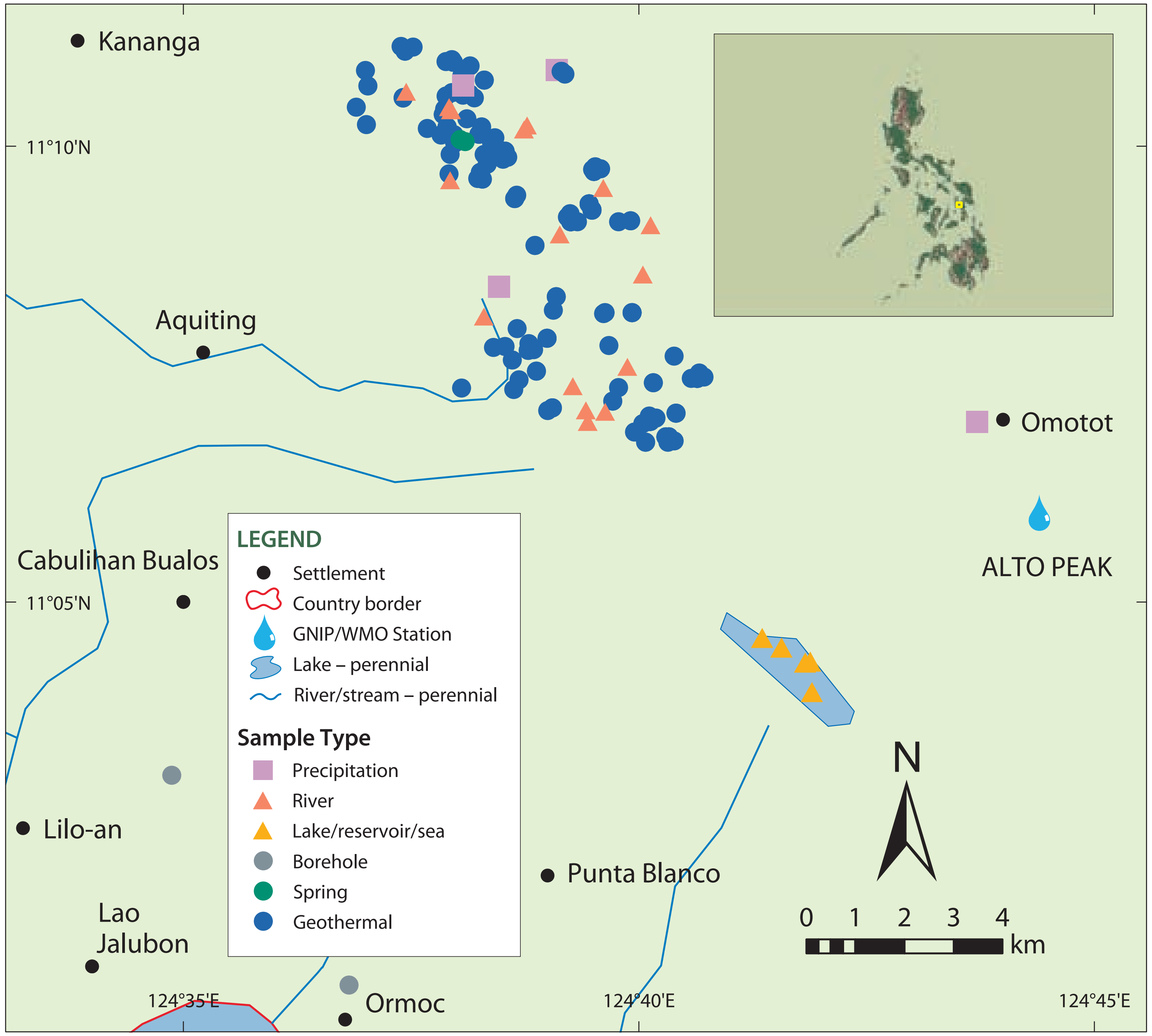


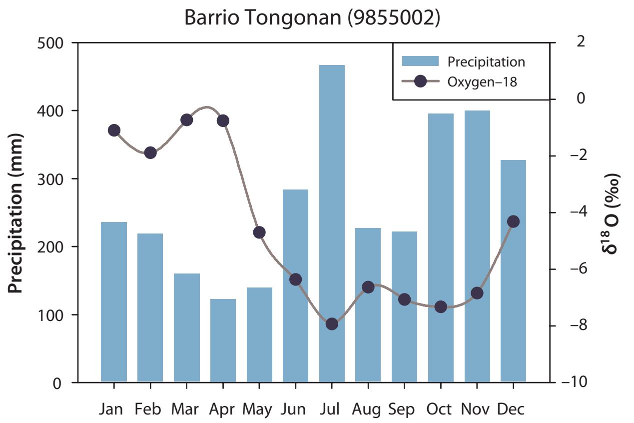
PHI8016L; PHI–9719L

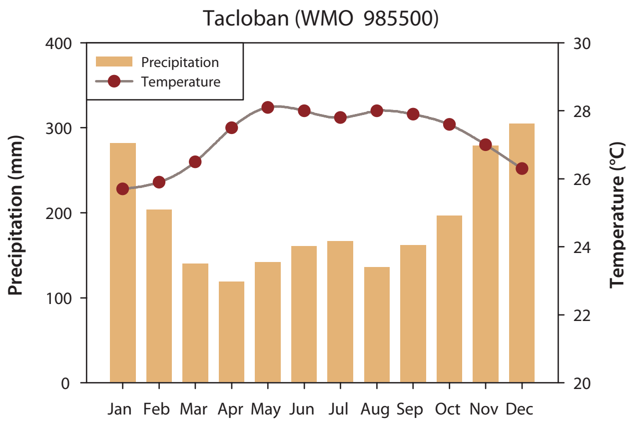
Leyte geothermal field











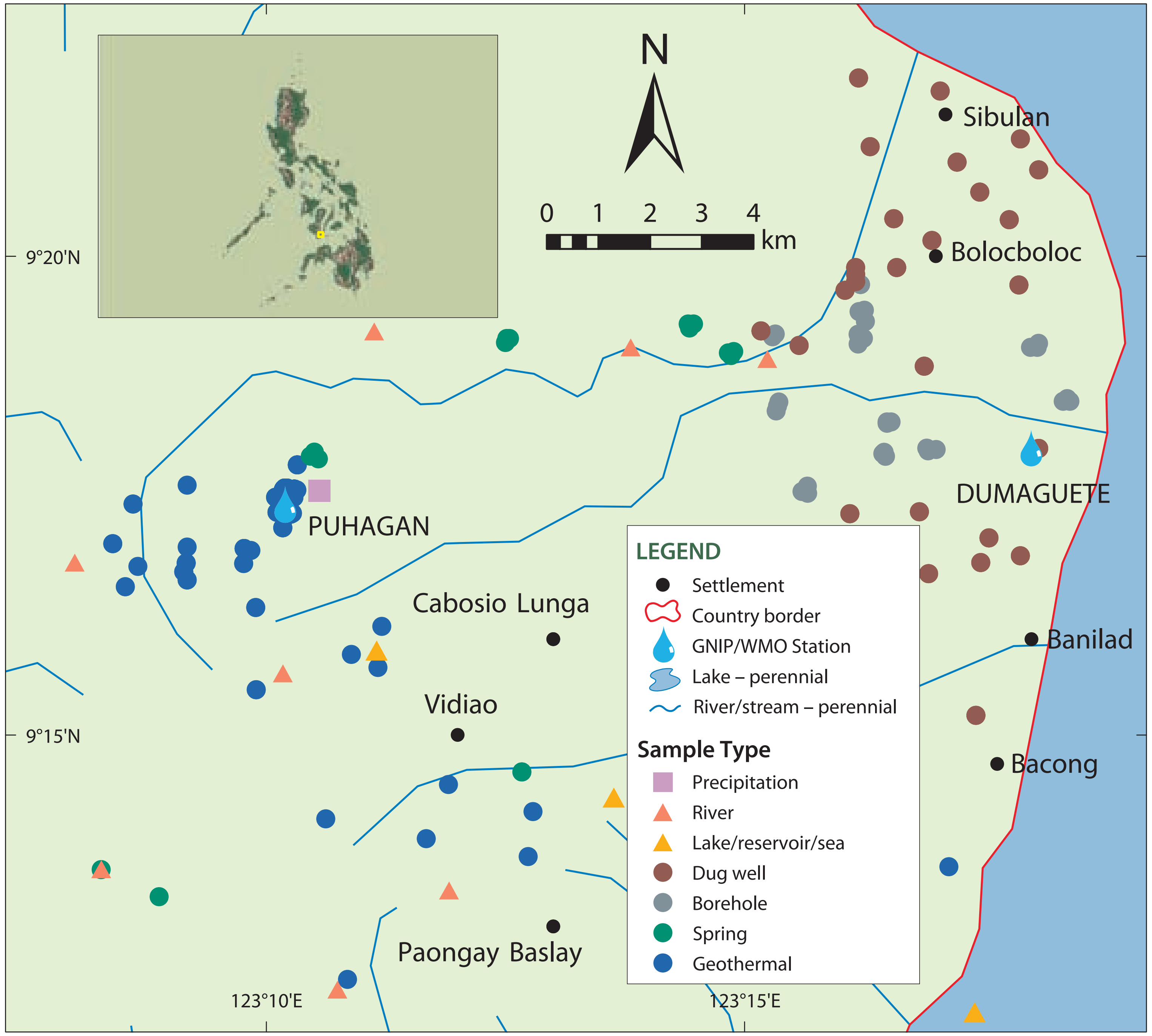
Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	$\delta^{2}H$ (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station BARRIO TONGON.	red square	21	−5.49	−6.29 ± 2.3	21	−31.0	−38.1 ± 16.5			1622
Interpolation – multiple reg.	yellow square			−4.90			−27.0			
Interpolation – kriging (IAEA)	green square			−4.70			−26.6			
Project	pink square	14	−7.33	−6.83 ± 2.3	14	−40.1	−39.8 ± 18.0			

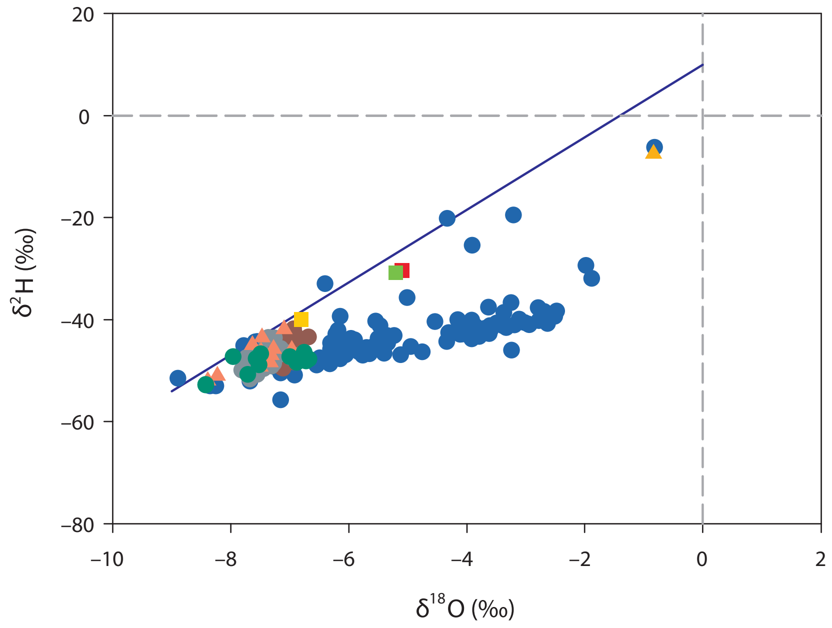
Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	orange triangle	5	−5.56	−5.65 ± 0.4	5	−36.3	−36.1 ± 1.2		
River	salmon triangle	18	−6.36	−5.87 ± 1.9	18	−38.5	−37.0 ± 4.9		

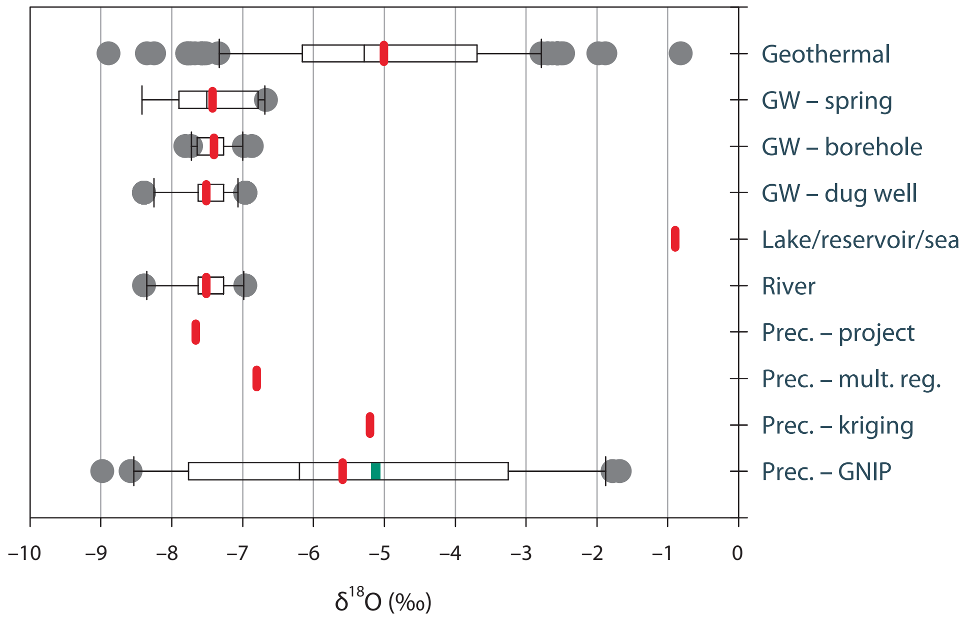
Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	$\delta^{2}H$ n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle	215	−2.19	−2.22 ± 2.1	208	−34.1	−33.6 ± 6.5				
GW–Borehole	grey circle	2	−7.47	−7.47 ± 0.2	2	−47.1	−47.1 ± 1.3				
GW–Dug well	brown circle										
GW–Spring	green circle	1		−6.21	1		−44.3				

PHI8016S; RAS8092–PHI; PHI–9719S

Southern Negros geothermal area



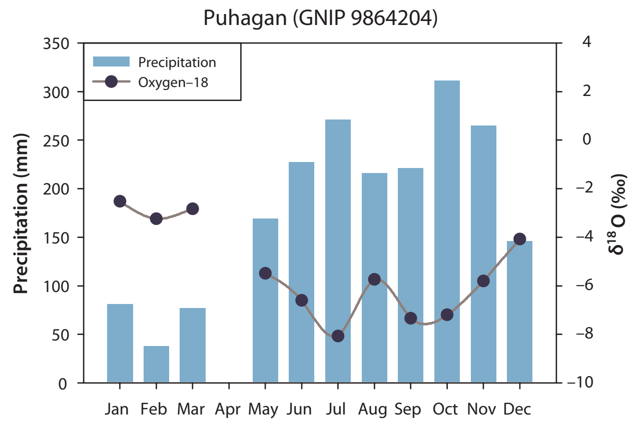


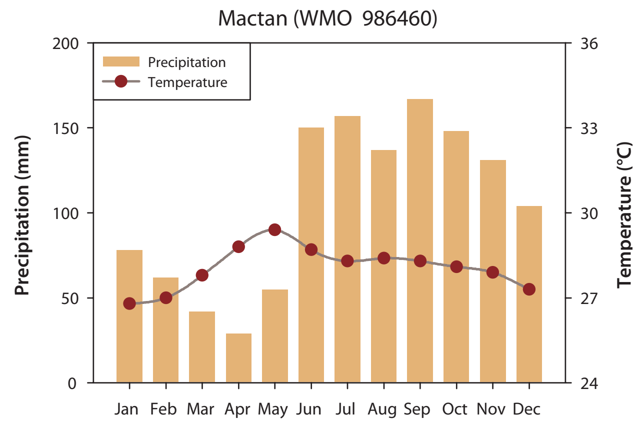


Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station PUHAGAN	■ (red)	25	−6.20	−5.10 ± 2.5	25	−35.5	−30.4 ± 20.6			1215
Interpolation – multiple reg.	■ (yellow)			−6.80			−40.0			
Interpolation – kriging (IAEA)	■ (green)			−5.20			−30.8			
Project	■ (pink)	1		−7.66	1		−48.1			

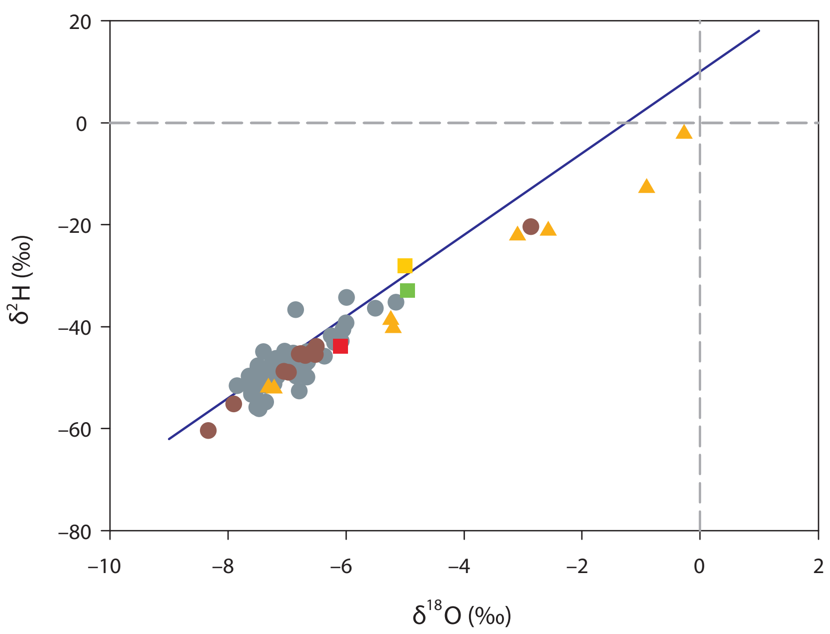
Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)	1		−0.82	1		−6.2		
River	▲ (salmon)	11	−7.47	−7.51 ± 0.4	11	−46.3	−46.9 ± 3.1		

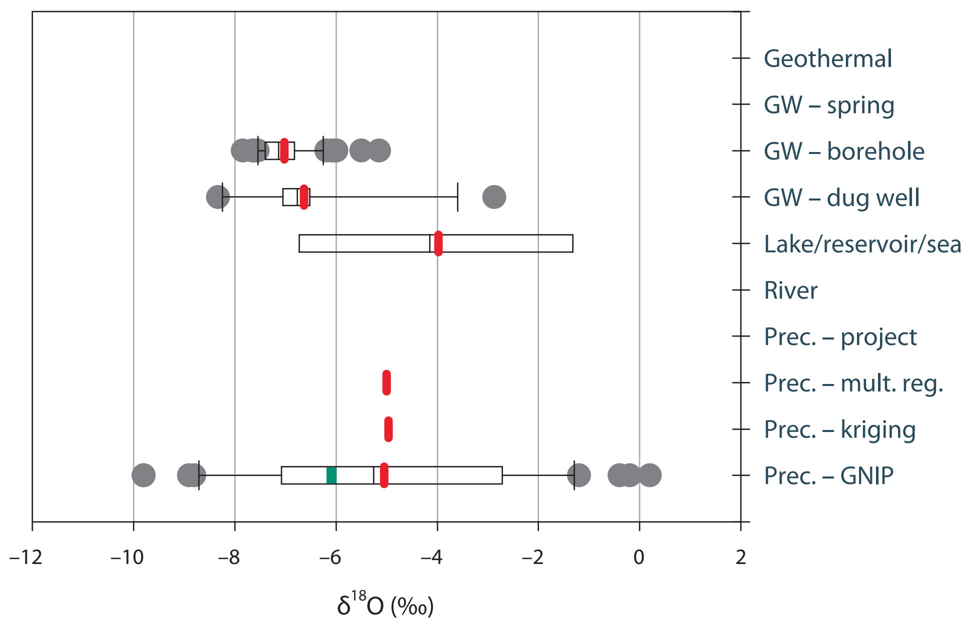
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)	131	−5.28	−5.01 ± 1.6	103	−43.1	−42.61 ± 6.8				
GW–Borehole	● (grey)	28	−7.43	−7.41 ± 0.2	28	−47.6	−47.6 ± 1.9	4	2.2 ± 1.9		
GW–Dug well	● (brown)	77	−7.47	−7.51 ± 0.4	50	−45.9	−45.72 ± 1.8	2	2.4 ± 0.2		
GW–Spring	● (green)	12	−7.51	−7.43 ± 0.6	12	−47.9	−48.74 ± 2.2	1	3.1		

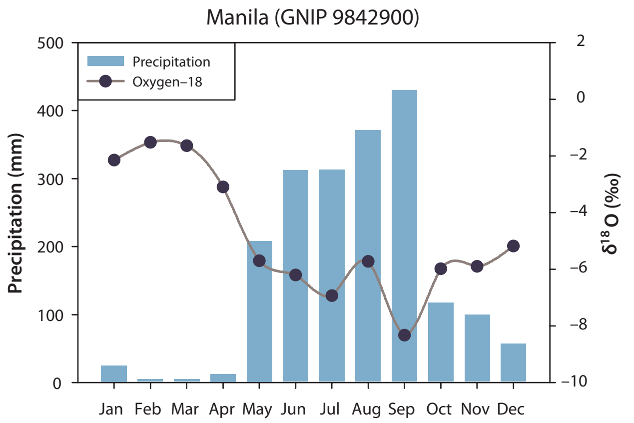


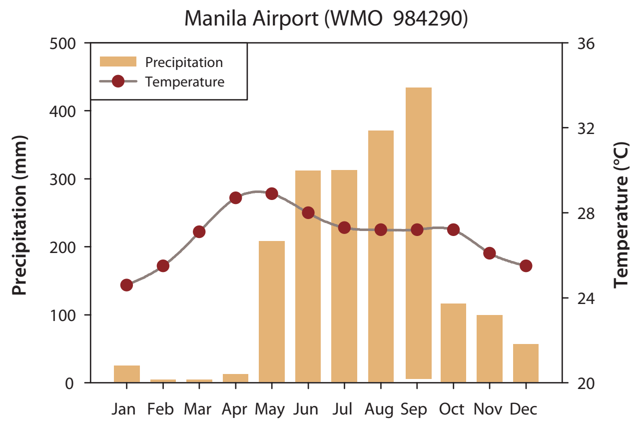


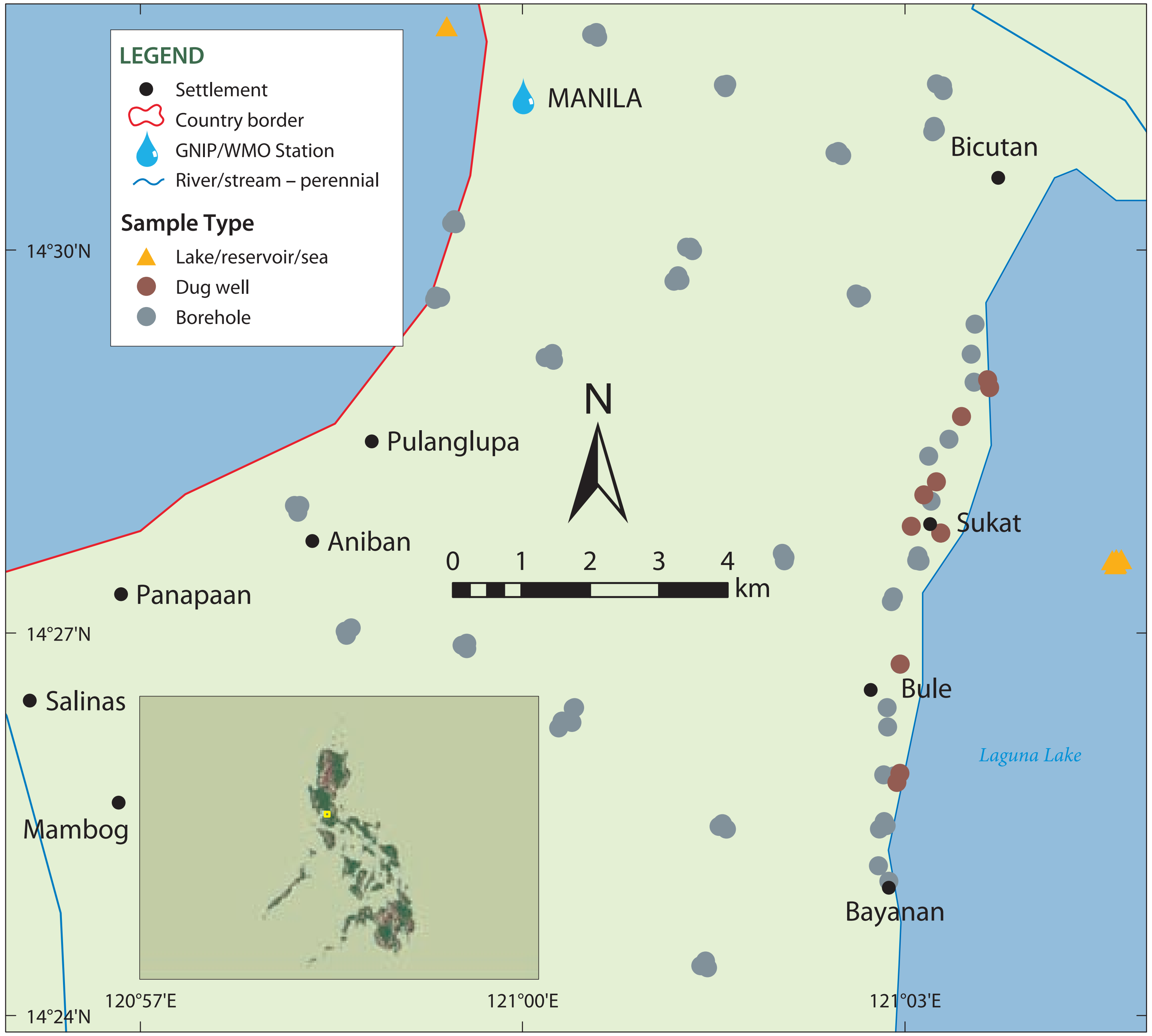
PHI8018
Laguna Lake basin







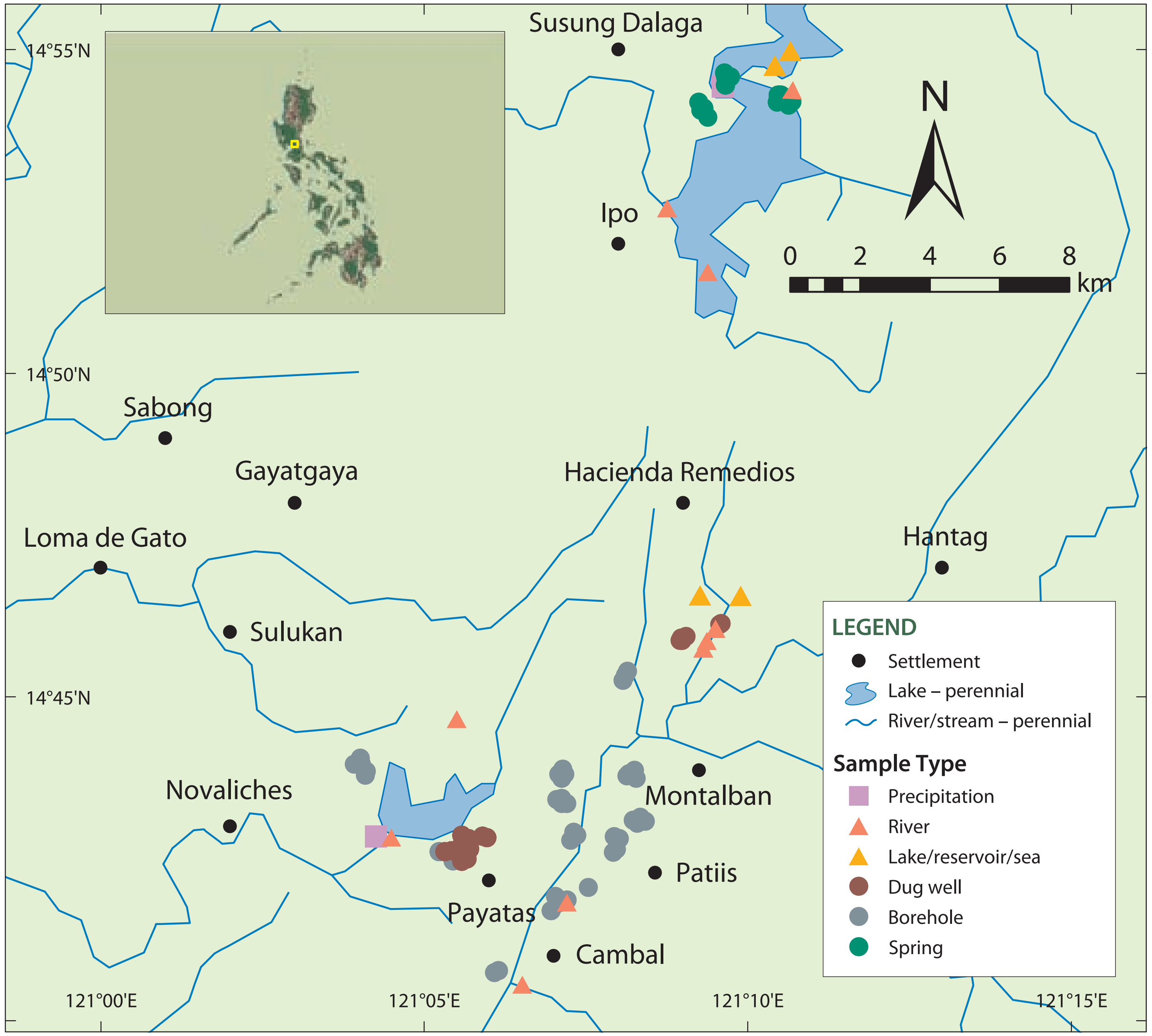


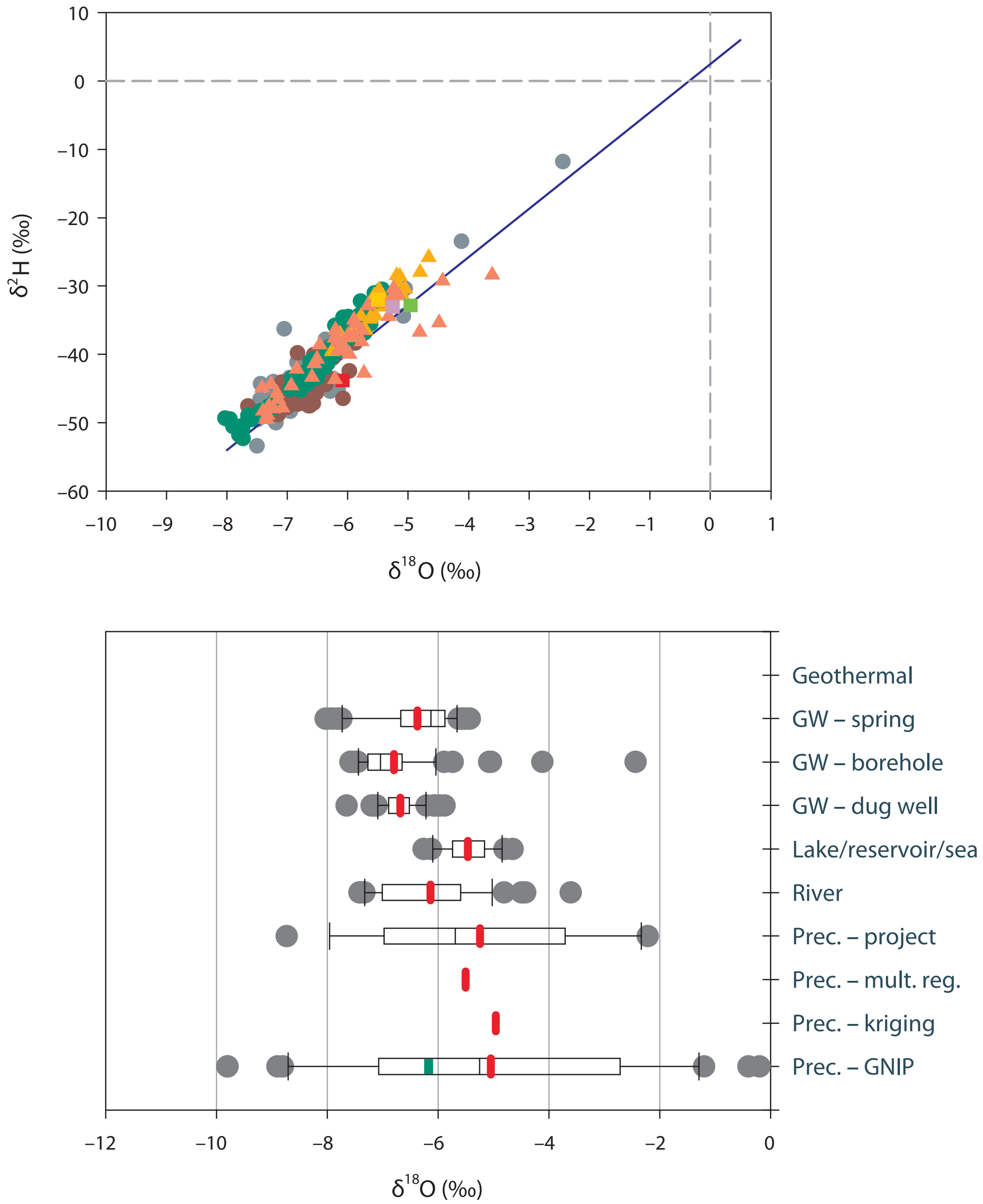


		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
GNIP station MANILA	■	48	−5.25	−6.09 ± 2.9	46	−38.2	−43.8 ± 1.2				907
Interpolation – multiple reg.	■			−5.00			−28.0				
Interpolation – kriging (IAEA)	■			−4.96			−32.9				
Project	■										
Surface waters		δ¹⁸O			δ²H			Tritium			
Lake/reservoir/sea	▲	8	−4.15	−3.98 ± 2.7	8	−30.4	−30.2 ± 18.4	4	2.18 ± 0.46		
River	▲										
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
Geothermal water	●										
GW–Borehole	●	79	−7.13	−7.02 ± 0.5	79	−48.2	−47.5 ± 4.1	33	0.7 ± 0.7		
GW–Dug well	●	11	−6.76	−6.63 ± 1.4	11	−45.5	−45.9 ± 9.8				
GW–Spring	●										

PHI8022; RAS8097–PHI; RAS8093–PHI

La Mesa, Rodriguez–Montalban and Angat dam sites

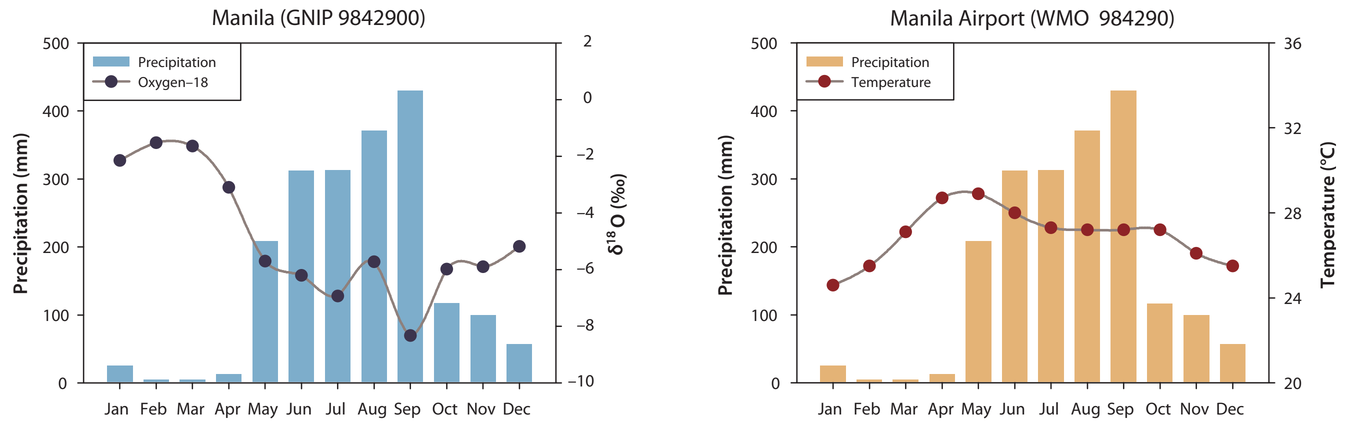




Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station MANILA		48	−5.25	−6.09 ± 2.9	46	−38.15	−43.8 ± 1.2			907
Interpolation – multiple reg.				−5.50			−32.0			
Interpolation – kriging (IAEA)				−4.96			−32.9			
Project		14	−5.69	−5.24 ± 2.0	14	−35.8	−32.7 ± 15.6			

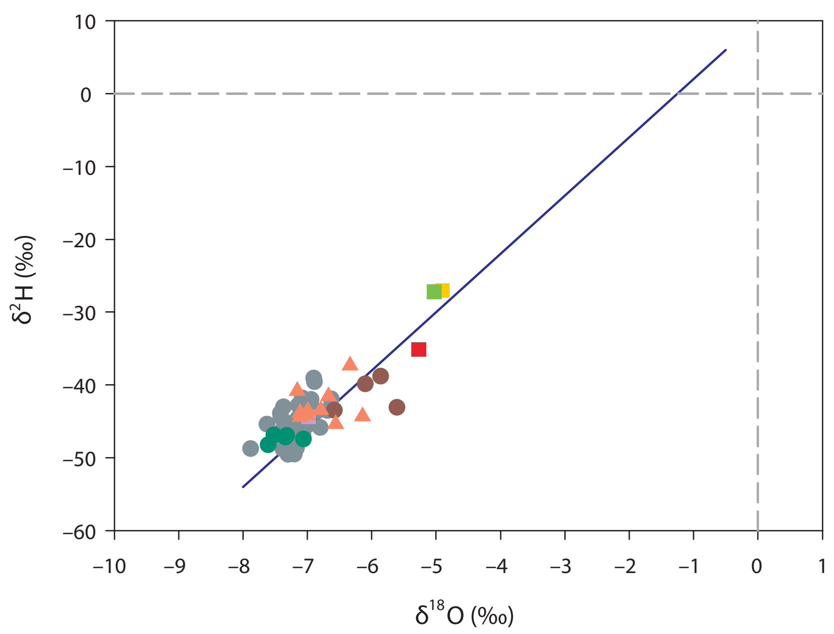
Surface waters		δ¹⁸O			δ²H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea		21	−5.48	−5.46 ± 0.4	21	−31.42	−32.6 ± 3.6		
River		45	−6.08	−6.13 ± 0.9	45	−38.62	−39.3 ± 5.9	13	2.5 ± 3.1

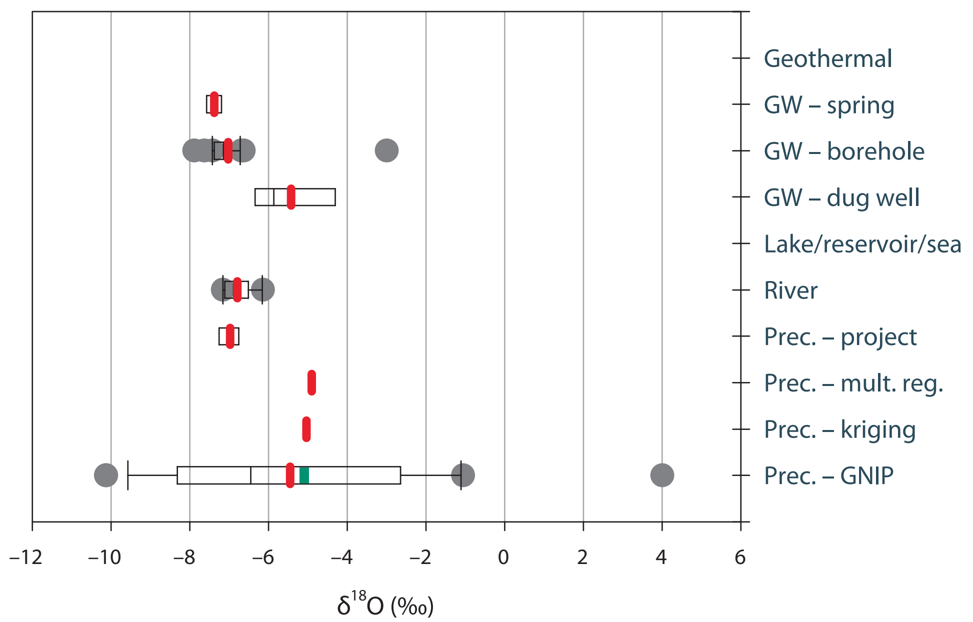
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water											
GW–Borehole		69	−7.04	−6.8 ± 0.8	70	−46.27	−44.4 ± 6.3	5	2.6 ± 0.7		
GW–Dug well		51	−6.67	−6.68 ± 0.3	51	−44.86	−44.3 ± 2.6	9	2.8 ± 0.8		
GW–Spring		87	−6.13	−6.38 ± 0.7	87	−38.44	−39.9 ± 5.6				

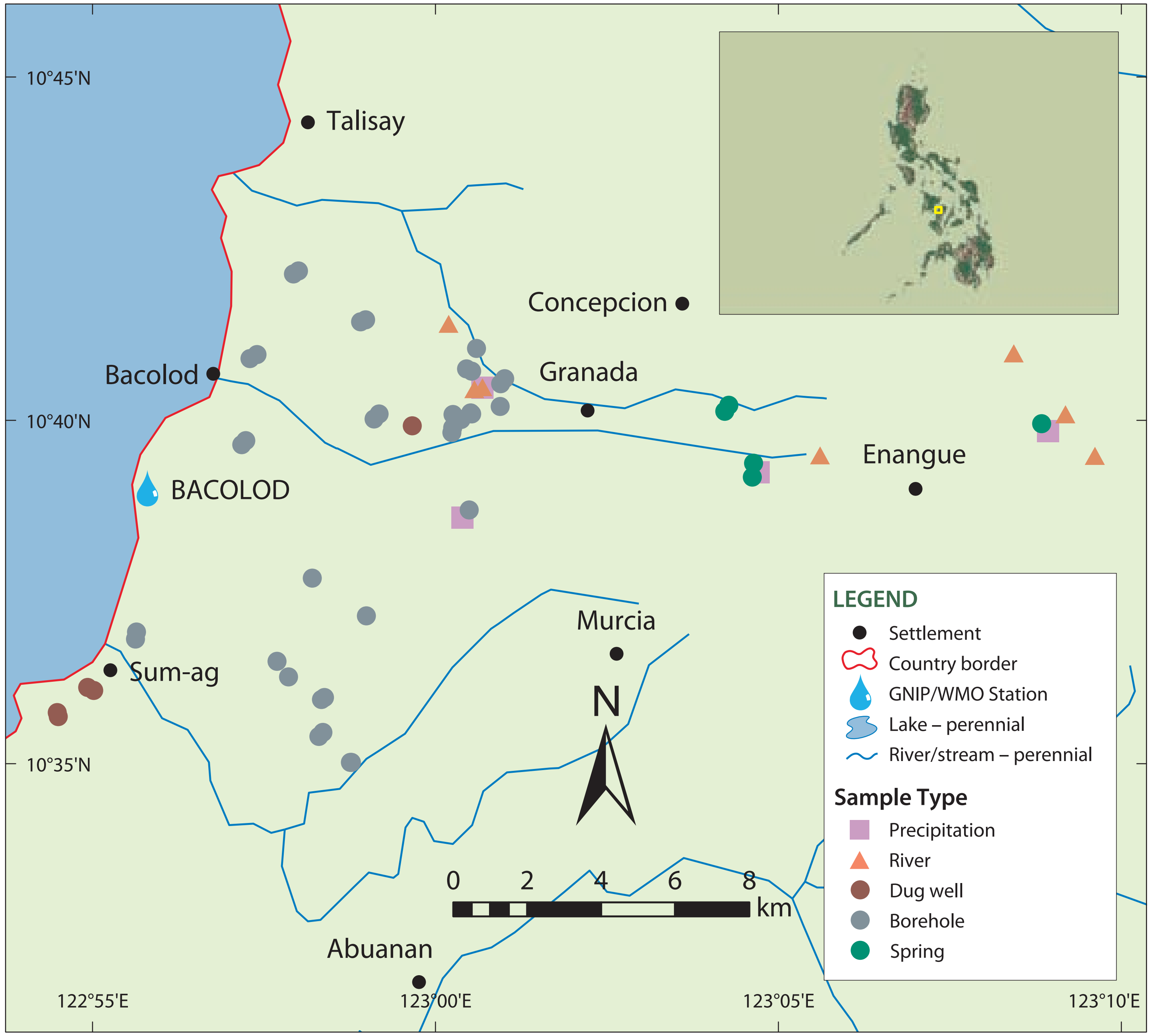


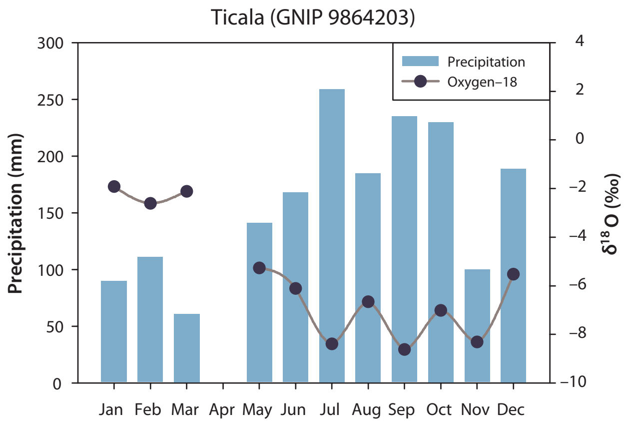
PHI8025

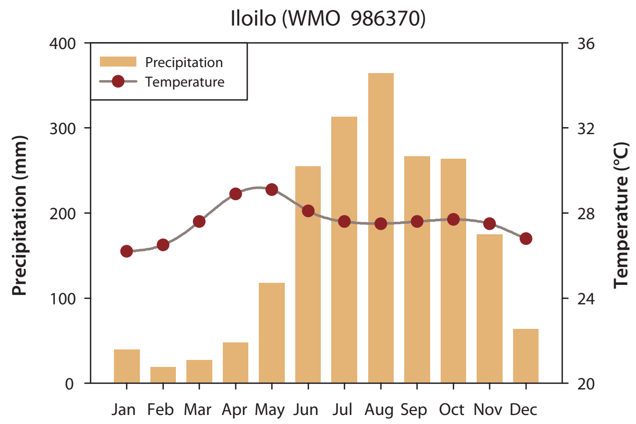
Bacolod area







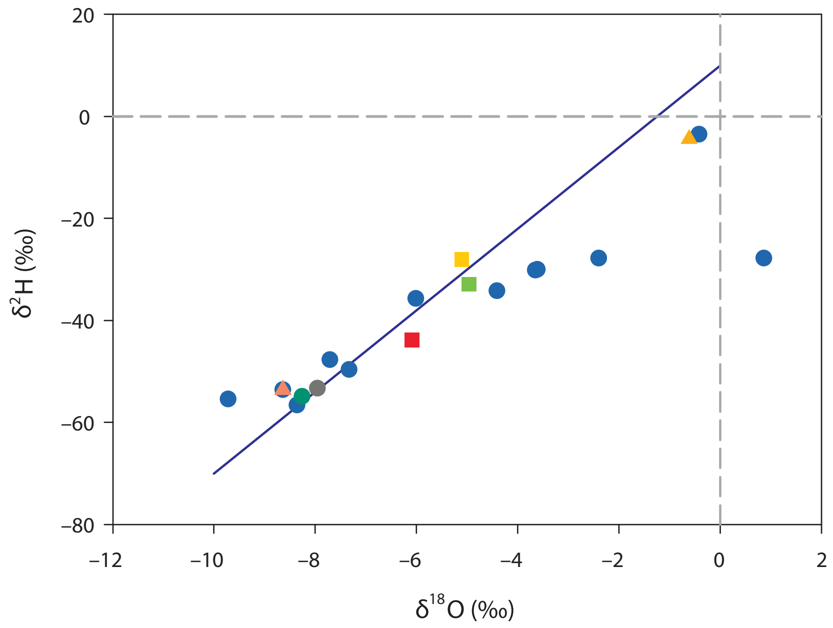


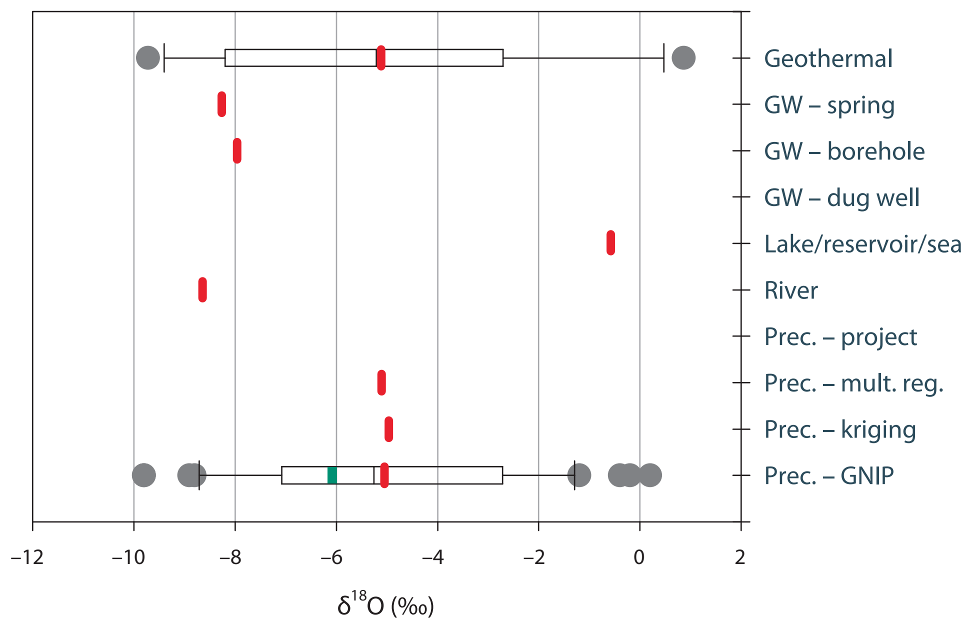


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station TICALA	■ (red)	22	−6.68	−5.27 ± 2.1	22	−42.6	−35.1 ± 17.6			1026
Interpolation – multiple reg.	■ (yellow)			−4.90			−27.0			
Interpolation – kriging (IAEA)	■ (green)			−5.03			−27.2			
Project	■ (pink)	4	−6.92	−6.98 ± 0.3	4	−44.5	−44.4 ± 2.2			
Surface waters		**δ¹⁸O**			**δ²H**			**Tritium**		
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
Lake/reservoir/sea	▲ (yellow)									
River	▲ (orange)	10	−6.89	−6.79 ± 0.4	10	−43.7	−42.9 ± 2.4	4	1.5 ± 0.1	
Groundwaters		**δ¹⁸O**			**δ²H**			**Tritium**		**¹⁴C (pMC)**
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n Mean ± St. dev.
Geothermal water	● (blue)									
GW–Borehole	● (grey)	30	−7.14	−7.15 ± 0.3	30	−45.0	−44.9 ± 2.7	17	0.4 ± 0.1	
GW–Dug well	● (brown)	4	−5.98	−6.04 ± 0.4	4	−41.4	−41.3 ± 2.3	2	1.6 ± 0.4	
GW–Spring	● (green)	5	−7.34	−7.37 ± 0.2	5	−47.2	−47.3 ± 0.6	3	1.4 ± 0.2	

RAS8075Mo–PHI; RAS8075Ma–PHI

Montelago–Mabini geothermal areas

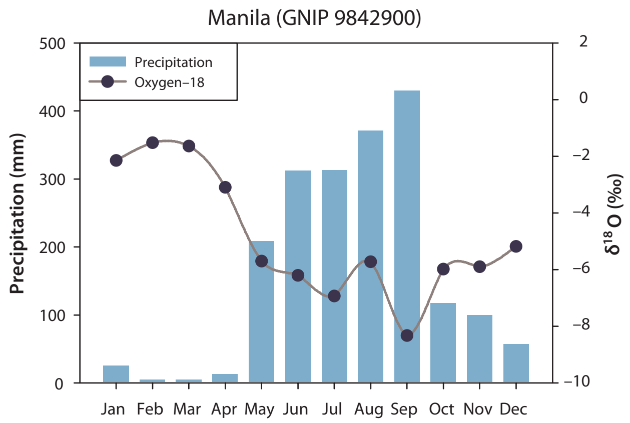


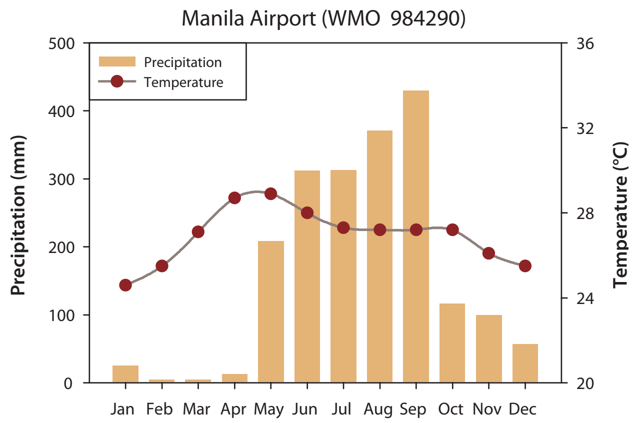


Precipitation		$\delta^{18}O$ (‰)			δ^2H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station MANILA		48	−5.25	−6.09 ± 2.9	46	−38.2	−43.8 ± 1.2			907
Interpolation – multiple reg.				−5.10			−28.0			
Interpolation – kriging (IAEA)				−4.96			−32.9			
Project										

Surface waters		$\delta^{18}O$			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea		1		−0.59	1		−4.3		
River		2	−8.64	−8.64 ± 0.0	2	−53.6	−53.6 ± 0.1		

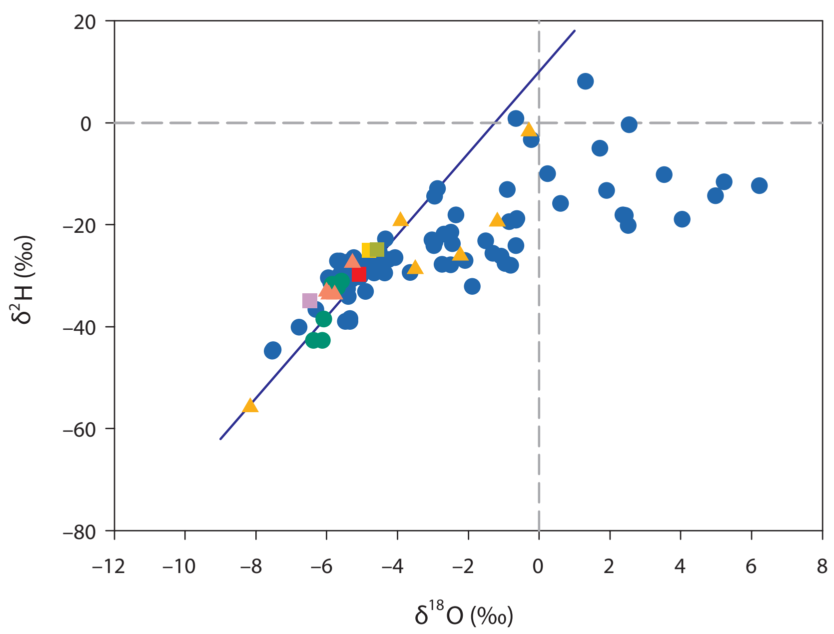
Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		12	−5.21	−5.10 ± 3.4	12	−34.9	−37.7 ± 15.6				
GW–Borehole		1		−7.96	1		−53.3				
GW–Dug well											
GW–Spring		1		−8.26	1		−54.9				

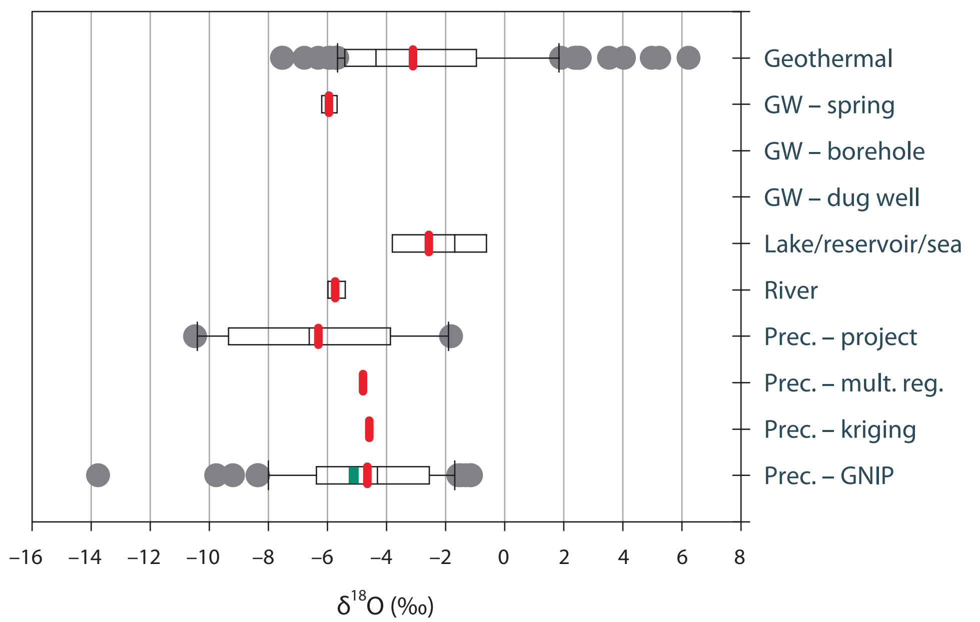


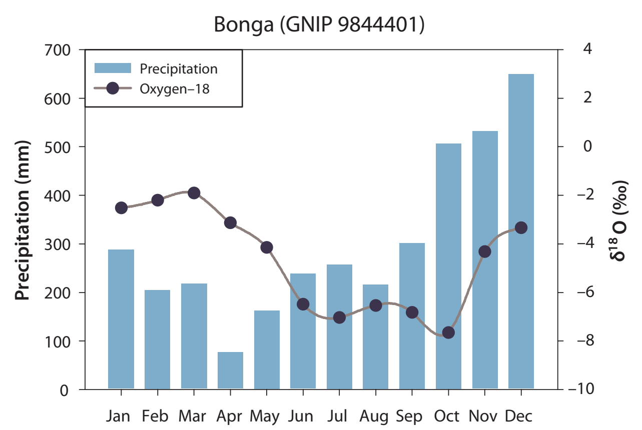


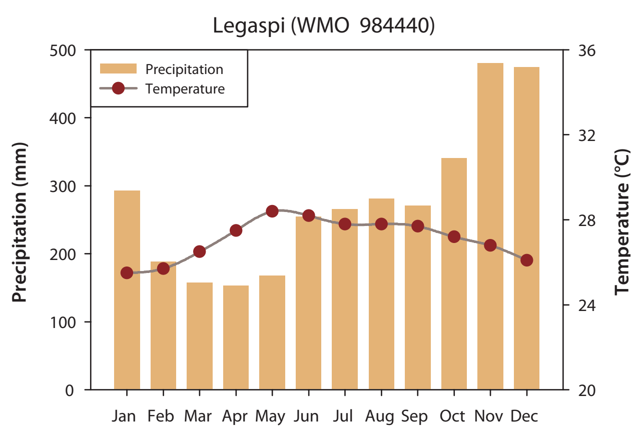
PHI–6019MB; PHI–6019BM; PHI–9719BM

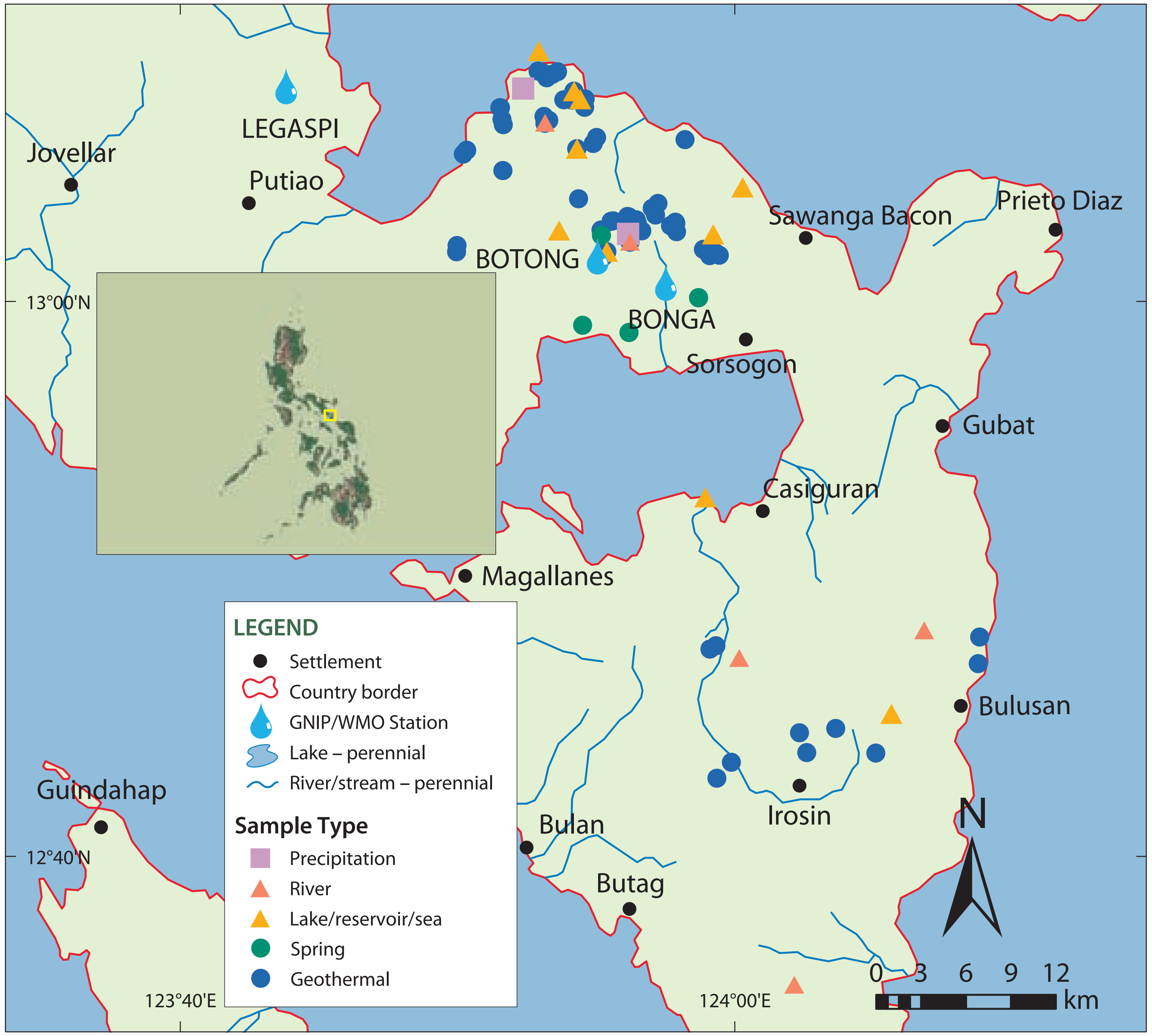
Mount Bulusan–BacMan area





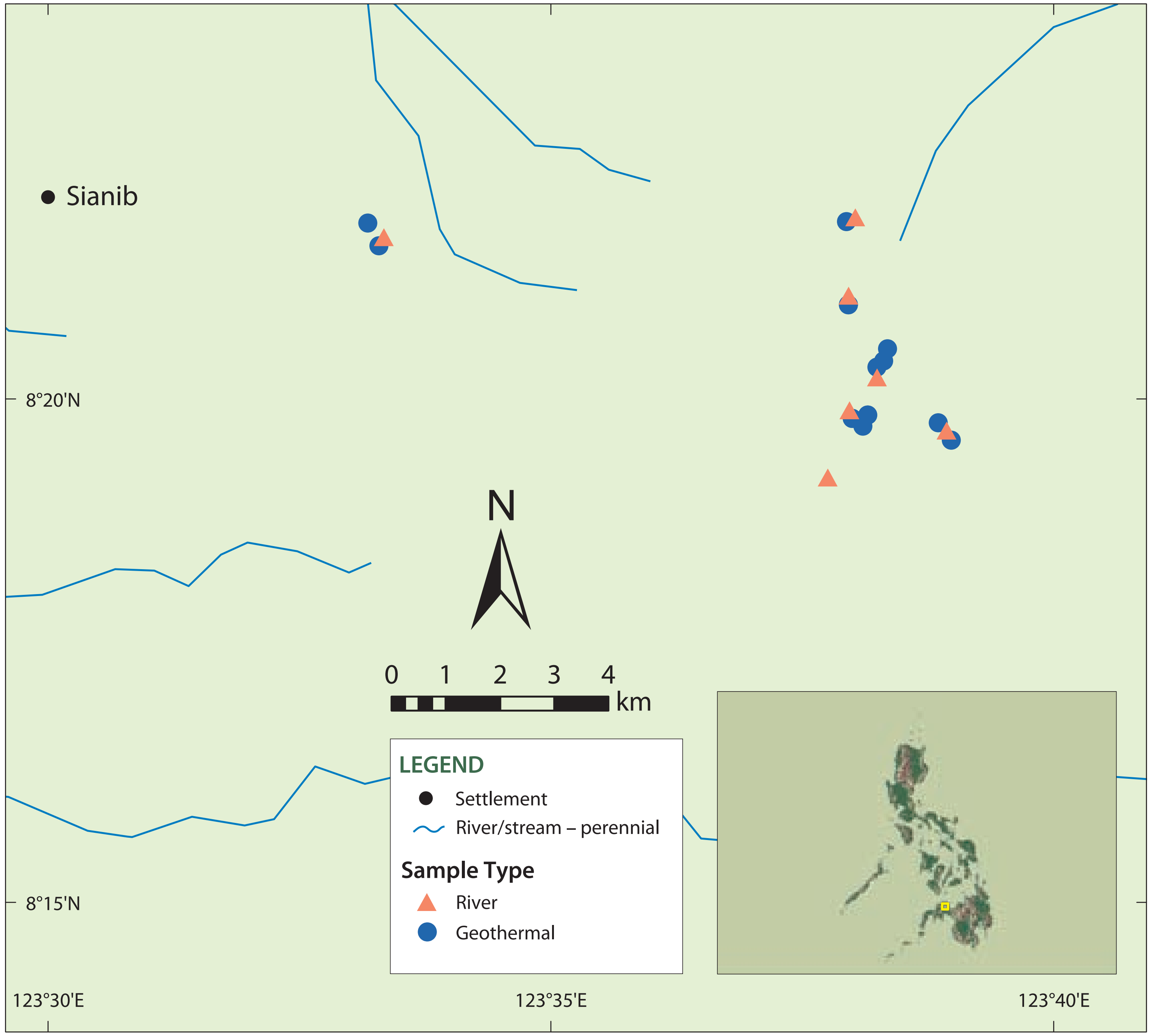


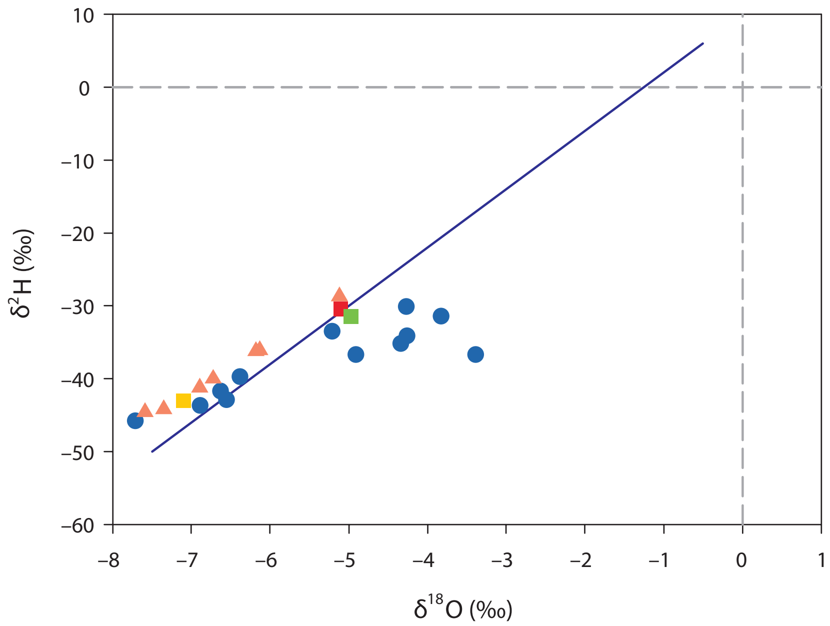


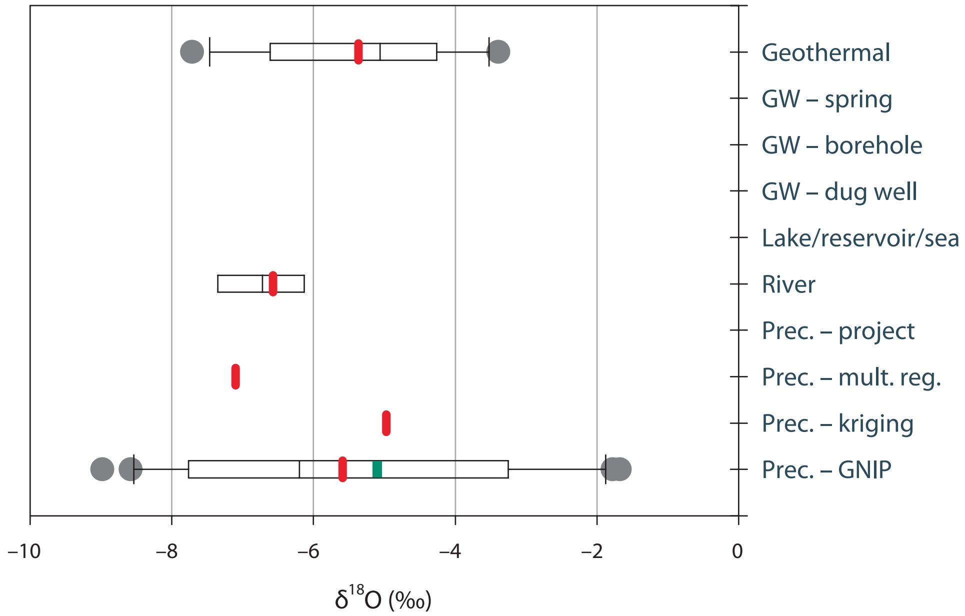


Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)	
GNIP station BONGA	■	54	−4.31	−5.08 ± 1.2	54	−23.1	−29.7 ± 9.6				1051
Interpolation – multiple reg.	■			−4.80			−25.0				
Interpolation – kriging (IAEA)	■			−4.58			−24.9				
Project	■	10	−6.62	−6.31 ± 3.0	10	−38.9	−36.3 ± 23.4	3	1.9 ± 0.5		
Surface waters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea	▲	8	−1.70	−2.56 ± 2.6	6	−22.8	−25.2 ± 17.7	1	1.3		
River	▲	4	−5.85	−5.74 ± 0.3	4	−33.4	−32.0 ± 3.0				
Groundwaters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**¹⁴C (pMC)** n	Mean ± St. dev.
Geothermal water	●	103	−4.36	−3.10 ± 3.0	97	−27.8	−25.3 ± 9.1	4	2.1 ± 1.3		
GW–Borehole	●										
GW–Dug well	●										
GW–Spring	●	6	−5.96	−5.95 ± 0.3	6	−35.4	−36.5 ± 5.5				

PHI-6019MA
Mount Ampiro geothermal area



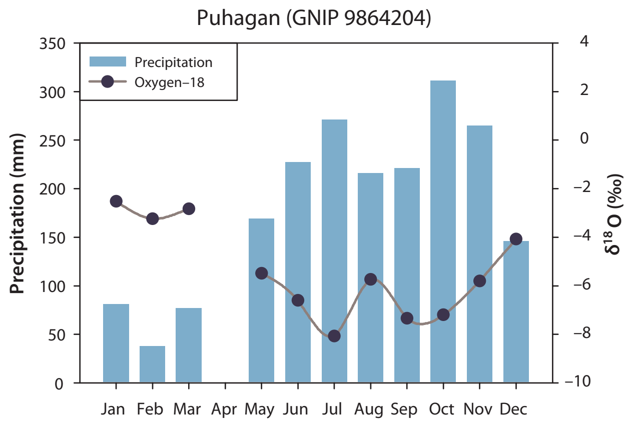


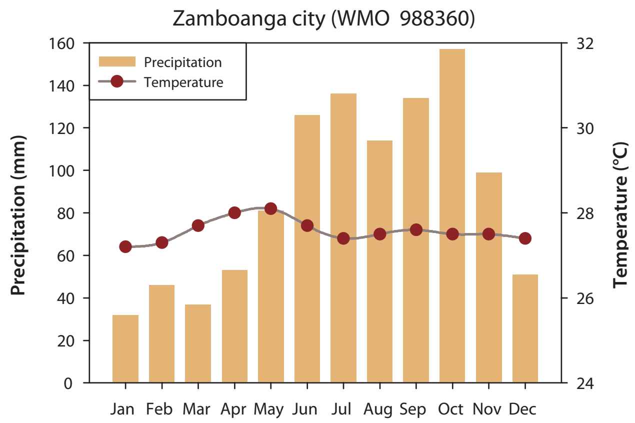


Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station PUHAGAN	■ (red)	25	−6.20	−5.10 ± 2.5	25	−35.5	−30.4 ± 20.6			1215
Interpolation – multiple reg.	■ (yellow)			−7.10			−43.0			
Interpolation – kriging (IAEA)	■ (green)			−4.97			−31.44			
Project	■ (pink)									

Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)								
River	▲ (orange)	7	−6.72	−6.57 ± 0.8	7	−40.0	−38.71 ± 5.6		

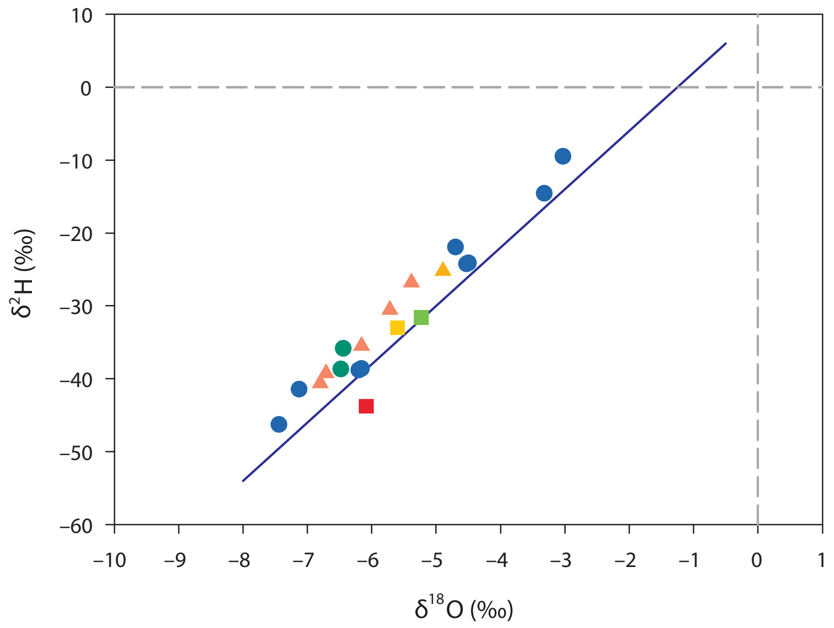
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)	12	−5.06	−5.36 ± 1.4	12	−36.7	−37.63 ± 5.1				
GW–Borehole	● (grey)										
GW–Dug well	● (brown)										
GW–Spring	● (green)										

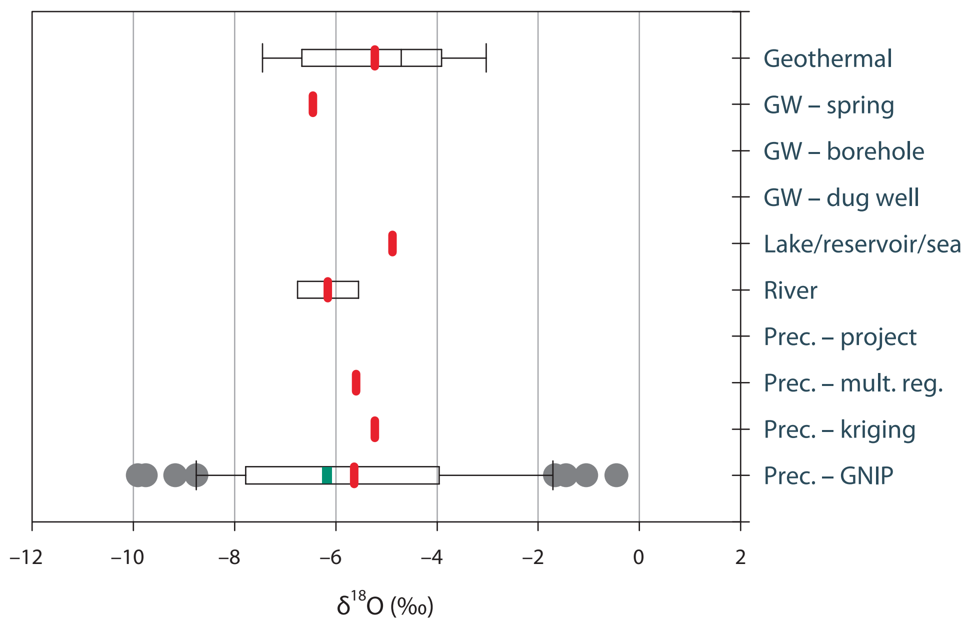


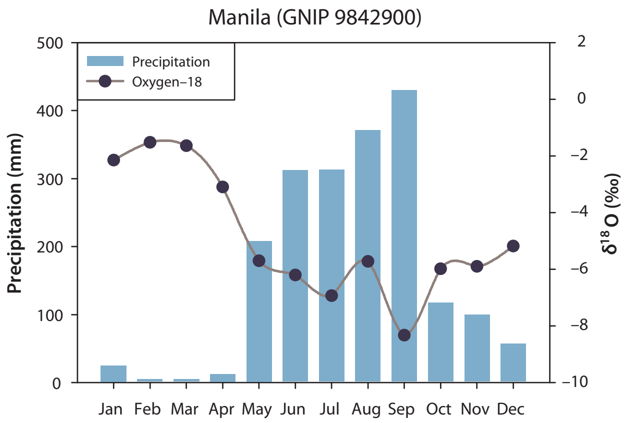


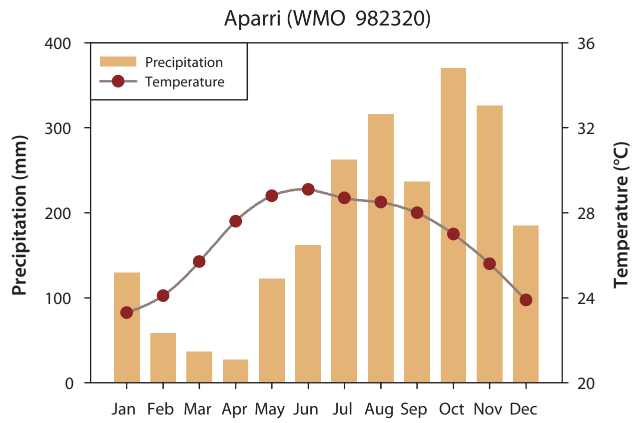
PHI–6019MC

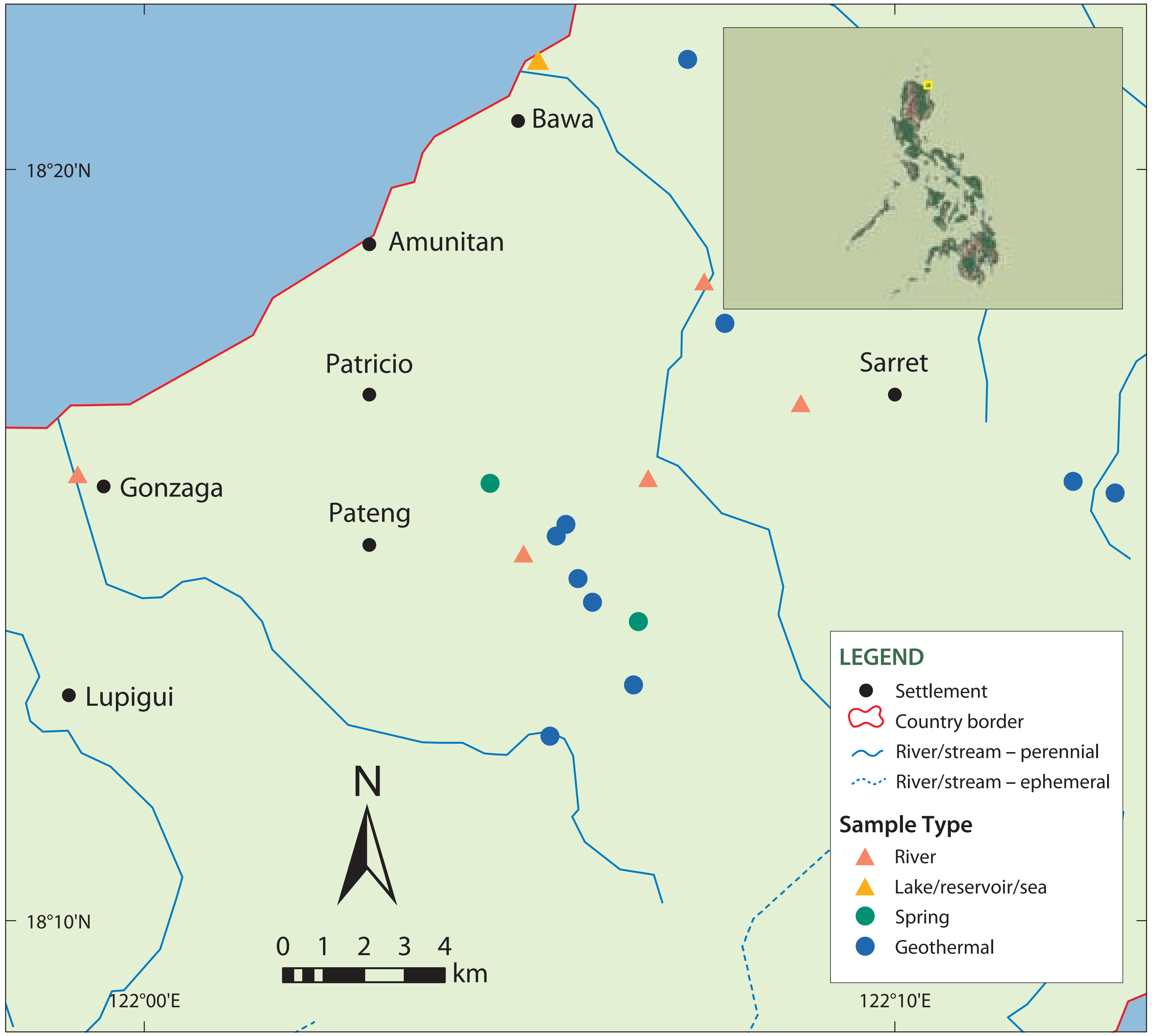
Mount Cagua geothermal area







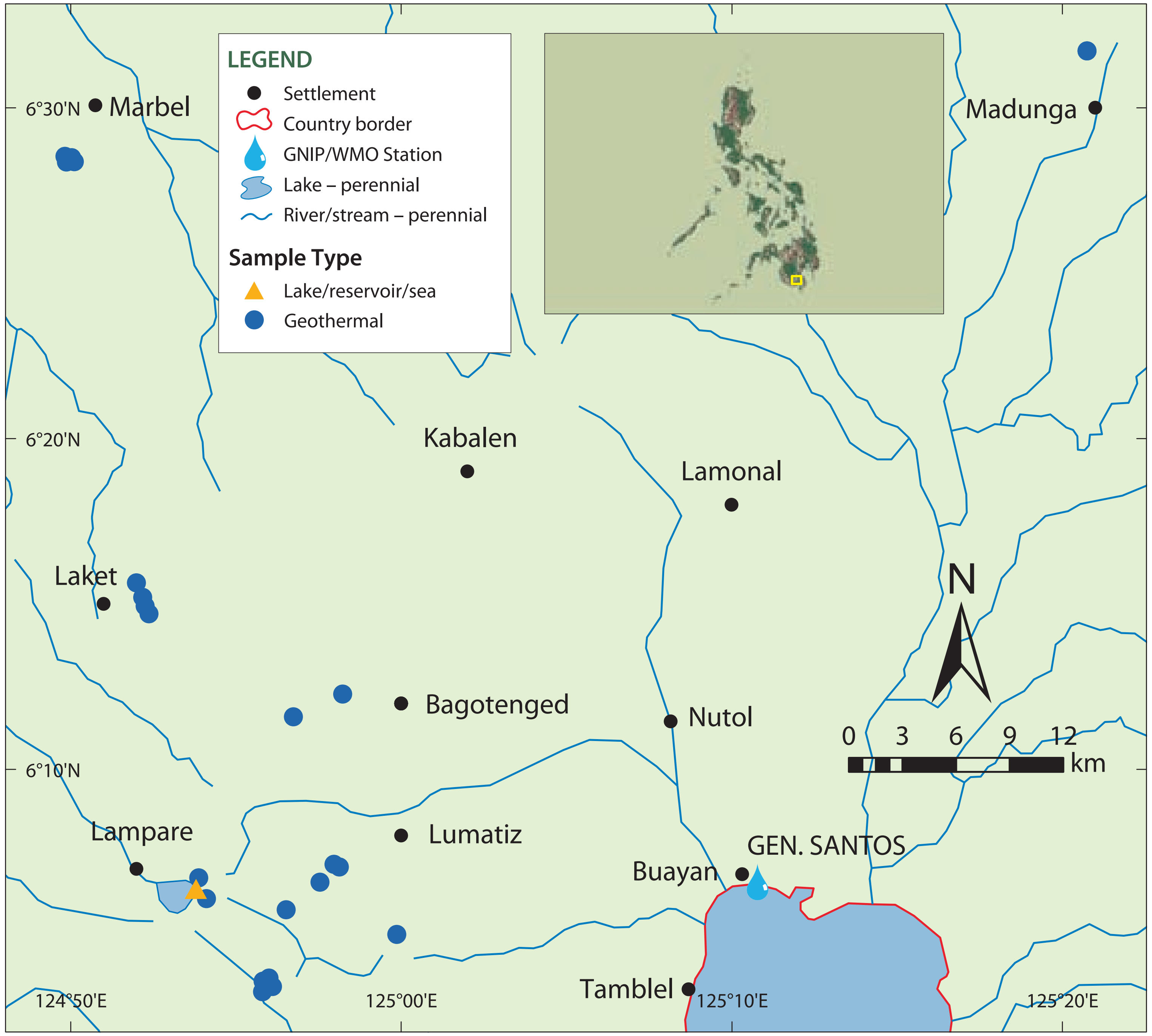


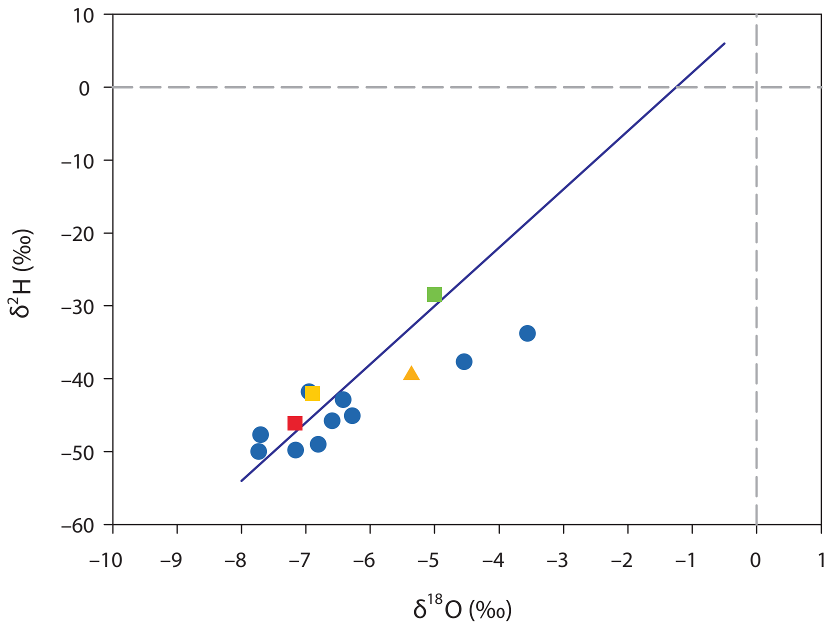


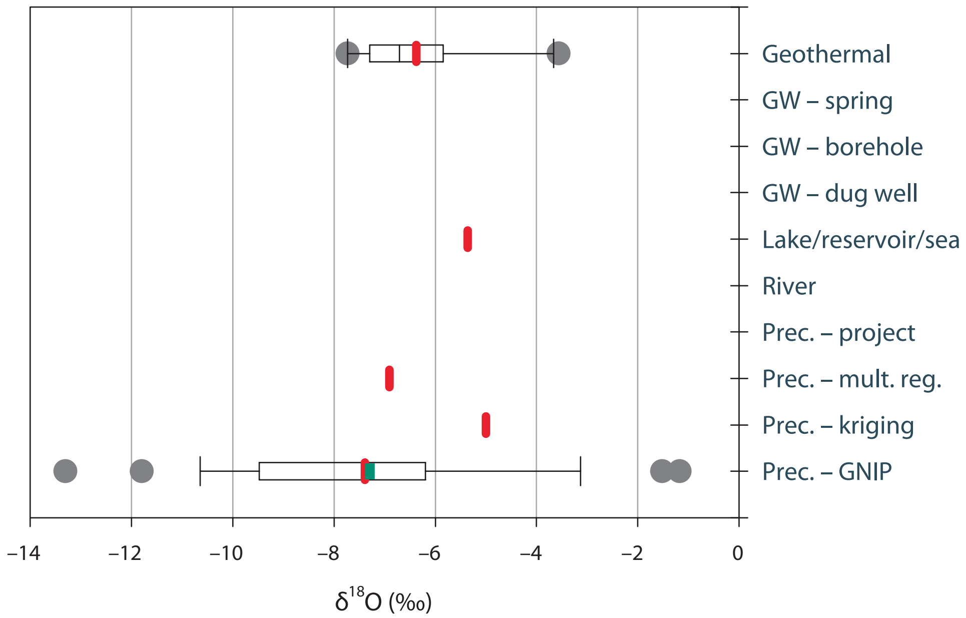
Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station MANILA	■ (red)	48	−5.25	−6.09 ± 2.9	46	−38.2	−43.8 ± 1.2			907	
Interpolation – multiple reg.	■ (yellow)			−5.60			−33.0				
Interpolation – kriging (IAEA)	■ (green)			−5.23			−31.6				
Project	■ (pink)										
Surface waters		**δ¹⁸O**			**δ²H**			**Tritium**			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲ (orange)	1		−4.86	1		−26.4				
River	▲ (salmon)	5	−6.16	−6.15 ± 0.6	5	−35.5	−34.6 ± 5.8				
Groundwaters		**δ¹⁸O**			**δ²H**			**Tritium**		**¹⁴C (pMC)**	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)	9	−4.70	−5.22 ± 1.6	9	−24.2	−28.8 ± 12.9				
GW–Borehole	● (grey)										
GW–Dug well	● (brown)										
GW–Spring	● (green)	2	−6.46	−6.46 ± 0.0	2	−37.2	−37.2 ± 2.0				

PHI-6019MP

Mount Parker geothermal area



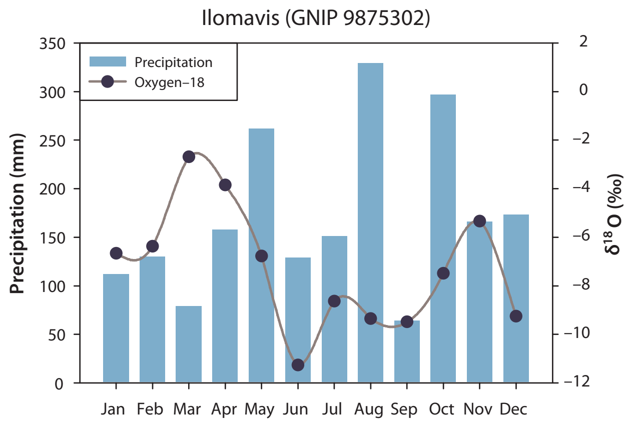


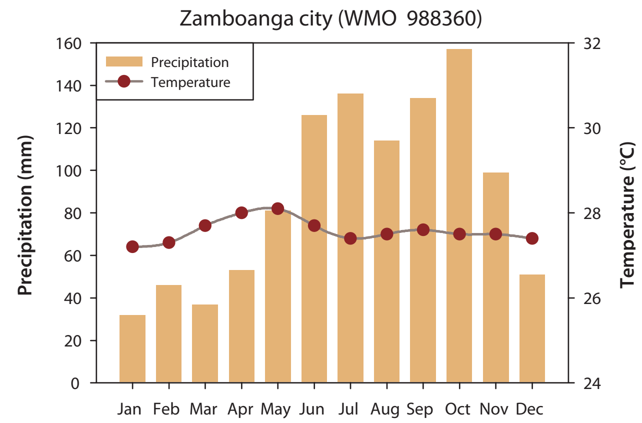


Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station ILOMAVIS	■ (red)	25	–7.32	–7.17 ± 0.9	25	–41.5	–46.1 ± 5.0			1051
Interpolation – multiple reg.	■ (yellow)			–6.90			–42.0			
Interpolation – kriging (IAEA)	■ (green)			–5.00			–28.4			
Project	■ (pink)									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)	1		–5.36	1		–39.5		
River	▲ (salmon)								

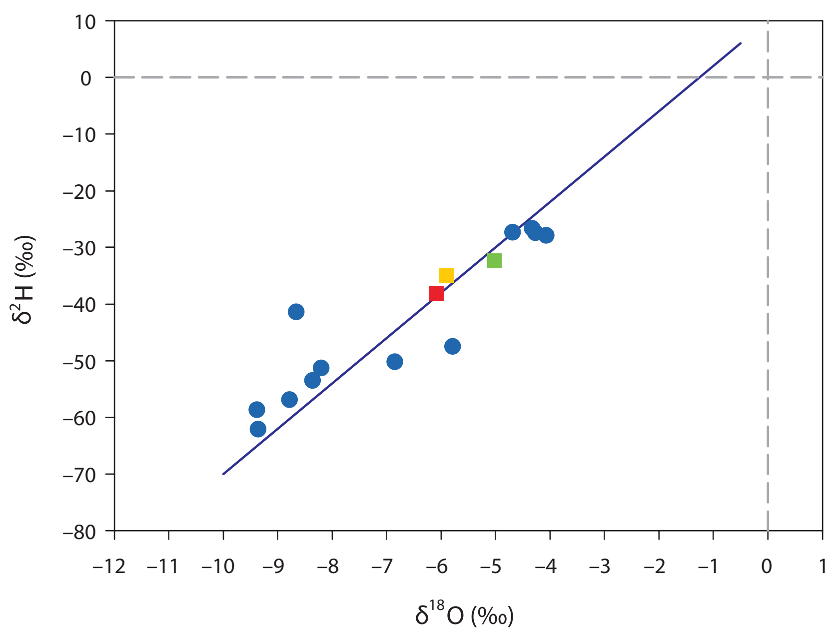
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)	10	–6.70	–6.37 ± 1.3	10	–45.4	–44.4 ± 5.4				
GW–Borehole	● (grey)										
GW–Dug well	● (brown)										
GW–Spring	● (green)										

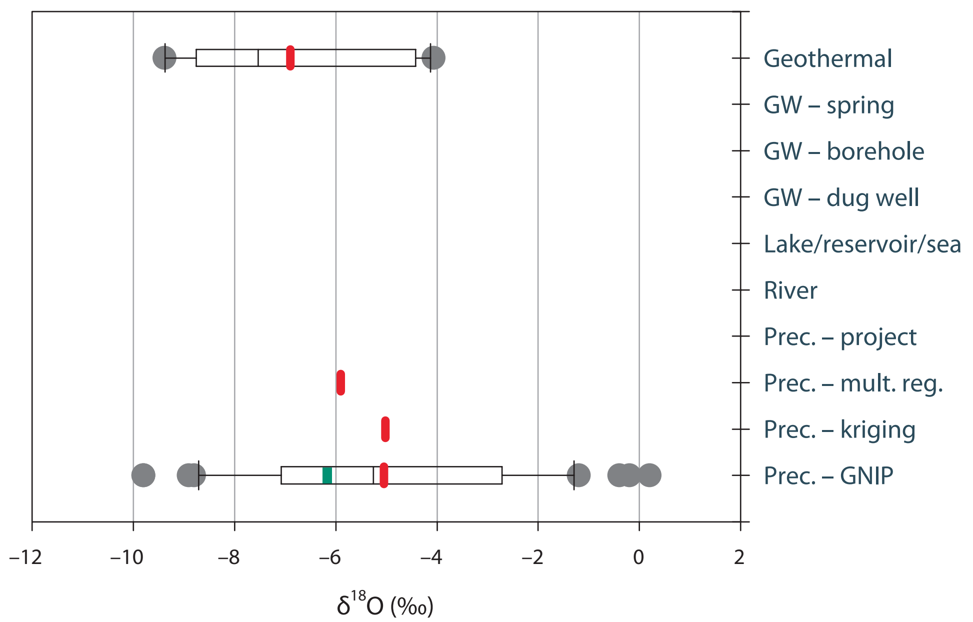


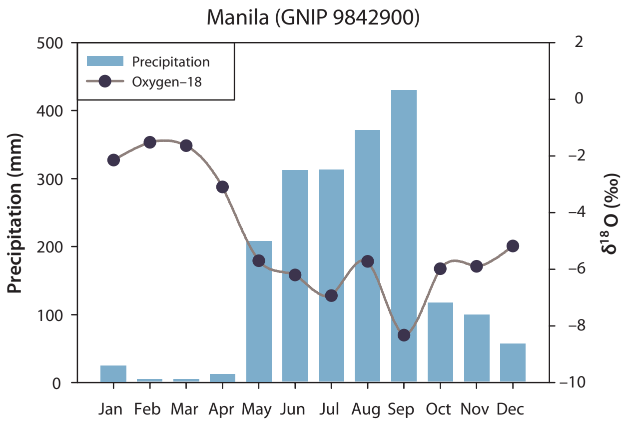


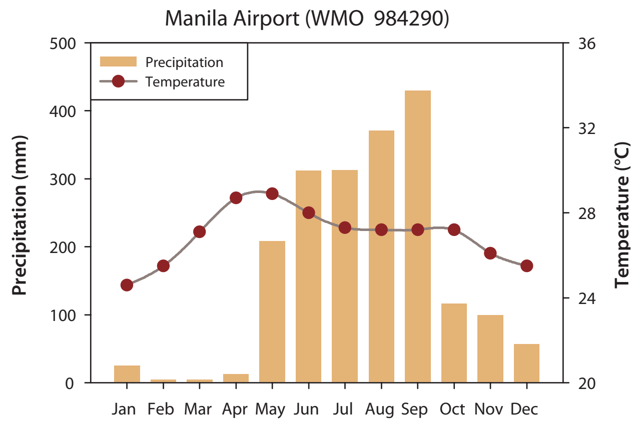
PHI–6019Pi

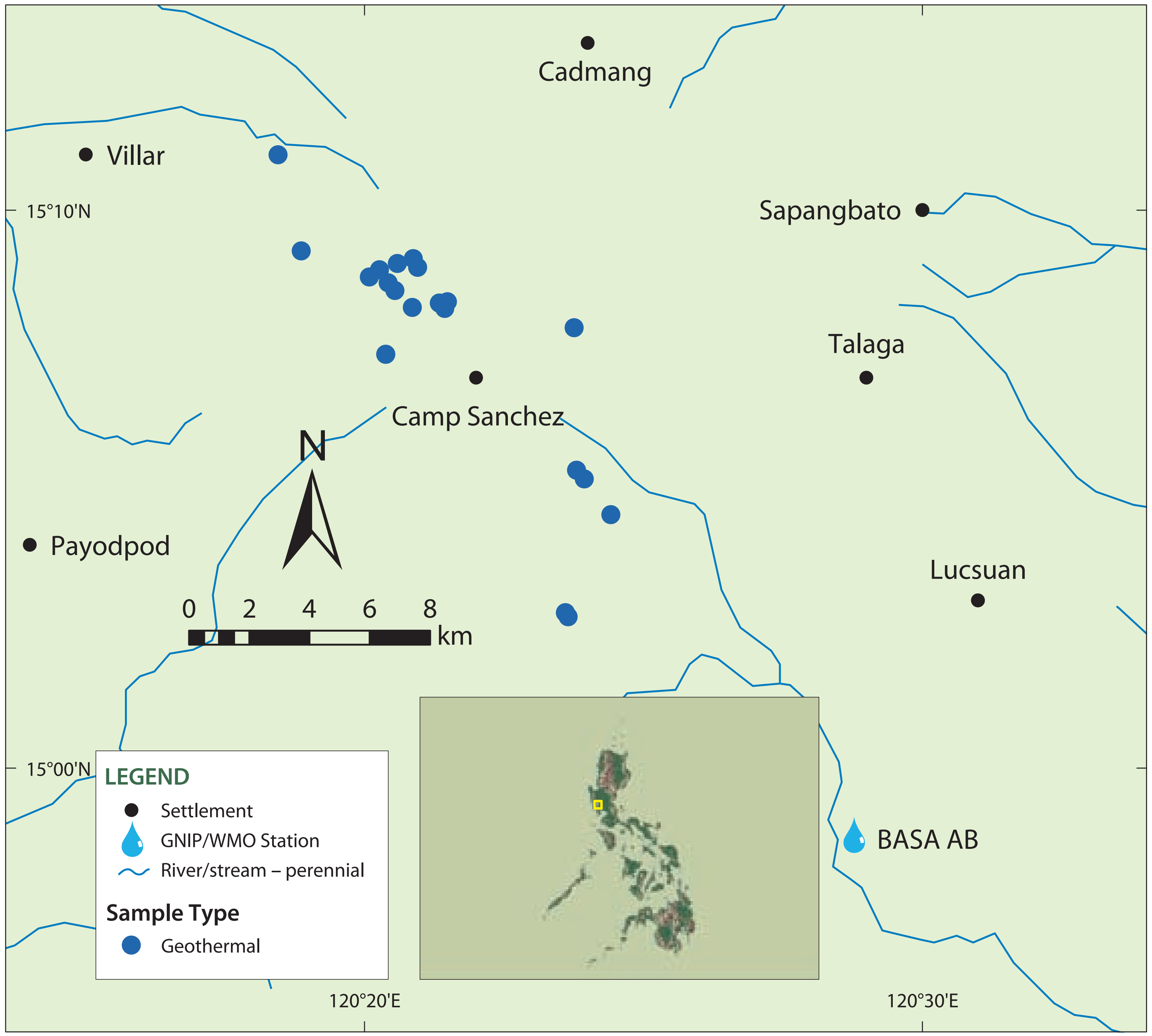
Mount Pinatubo geothermal area











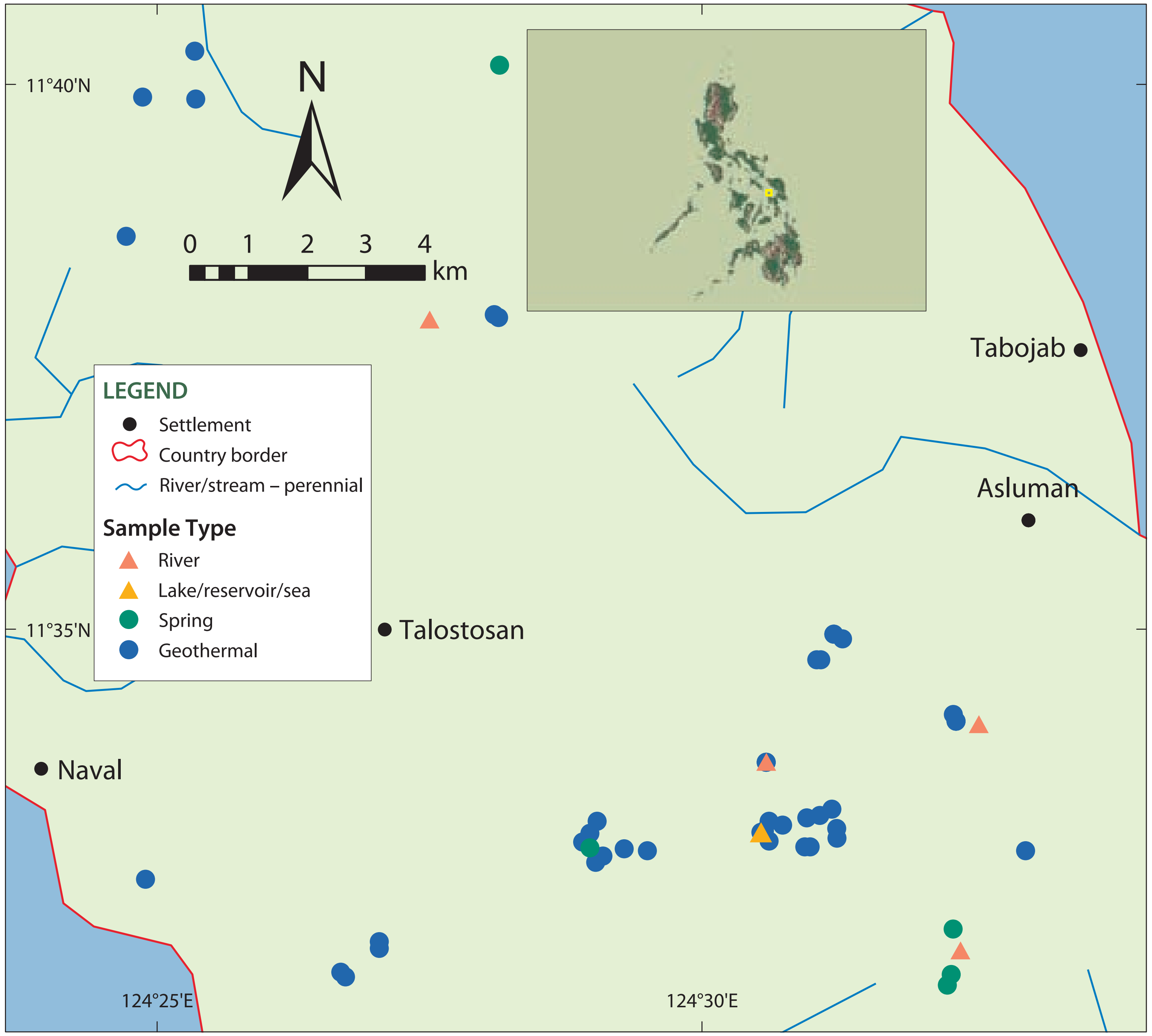
Precipitation	δ¹⁸O (‰) n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H (‰) n	δ²H Median	δ²H Mean ± St. dev.	Tritium (TU) n	Tritium Mean ± St. dev.	Annual prec. (mm)
GNIP station MANILA	48	−5.25	−6.09 ± 2.9	46	−38.2	−43.8 ± 1.2			907
Interpolation – multiple reg.			−5.90			−35.0			
Interpolation – kriging (IAEA)			−5.02			−32.4			
Project									

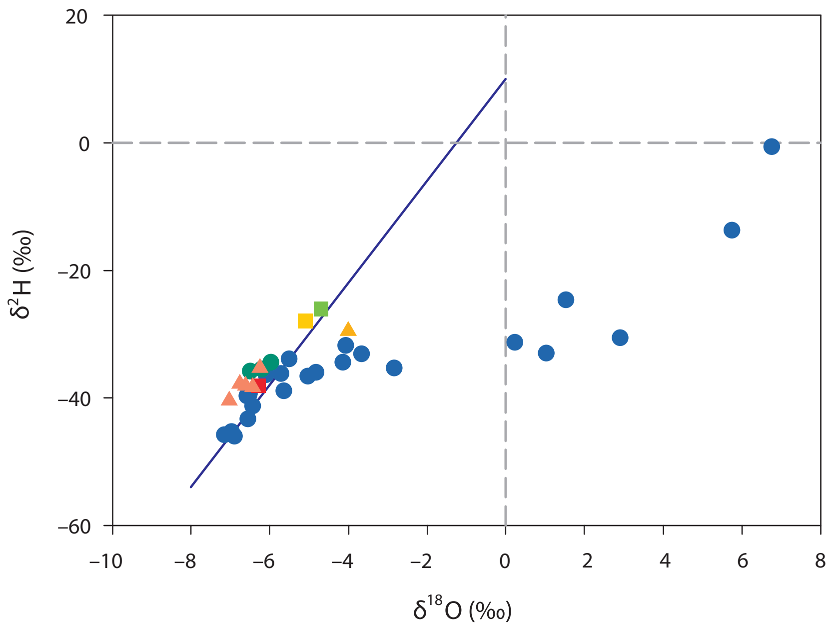
Surface waters	δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea								
River								

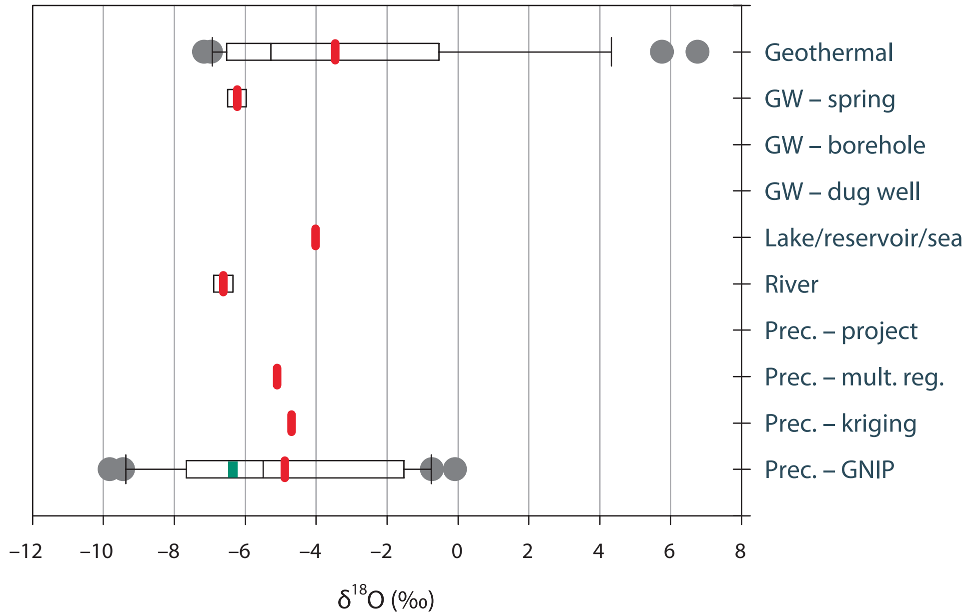
Groundwaters	δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C Mean ± St. dev.
Geothermal water	12	−7.53	−6.9 ± 2.1	12	−48.8	−44.2 ± 13.6	7	2.4 ± 1.6		
GW–Borehole										
GW–Dug well										
GW–Spring										

PHI–6019Bi

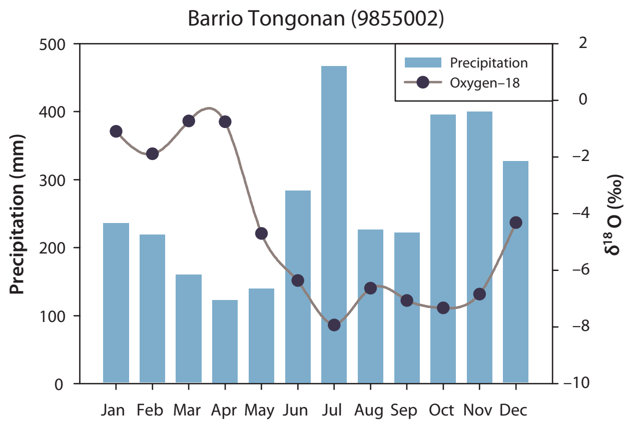
Mount Biliran geothermal area

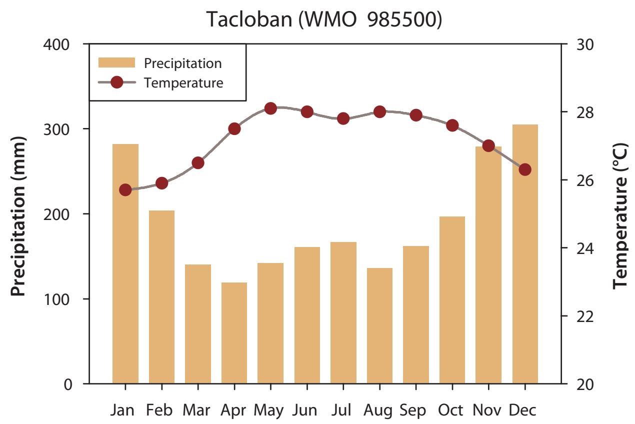






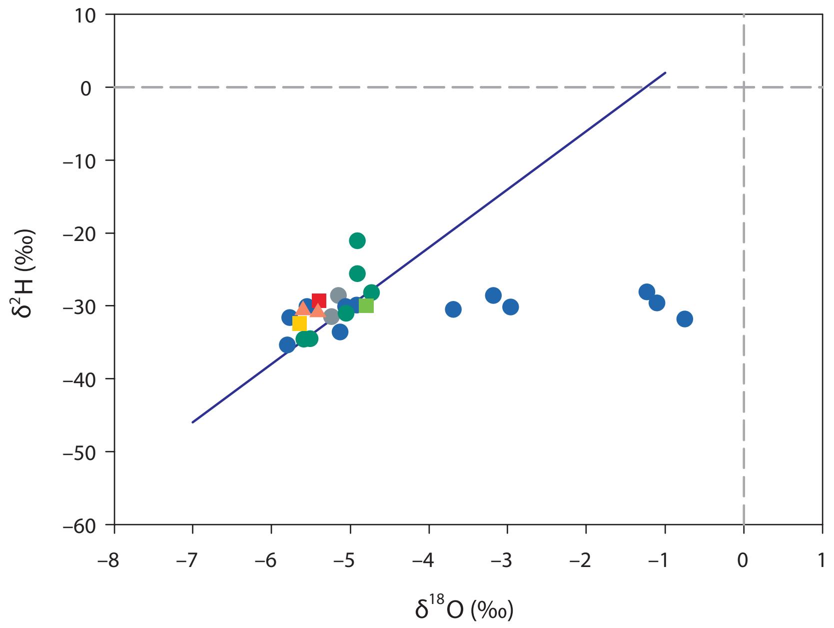
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.		Annual prec. (mm)
GNIP station BARRIO TONGON.	■	21	−5.49	−6.29 ± 2.3	21	−31.0	−38.1 ± 16.5				1622
Interpolation – multiple reg.	■			−5.10			−28.0				
Interpolation – kriging (IAEA)	■			−4.70			−26.0				
Project	■										
Surface waters		**δ¹⁸O n**	**Median**	**Mean ± St. dev.**	**δ²H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**		
Lake/reservoir/sea	▲	1		−4.01	1		−29.5				
River	▲	5	−6.61	−6.62 ± 0.3	5	−38.1	−38.0± 1.8				
Groundwaters		**δ¹⁸O n**	**Median**	**Mean ± St. dev.**	**δ²H n**	**Median**	**Mean ± St. dev.**	**Tritium n**	**Mean ± St. dev.**	**¹⁴C (pMC) n**	**Mean ± St. dev.**
Geothermal water	●	24	−5.27	−3.46 ± 4.2	24	−36.1	−34.4 ± 10.1				
GW–Borehole	●										
GW–Dug well	●										
GW–Spring	●	3	−6.20	−6.22 ± 0.3	3	−35.5	−35.2 ± 0.7				

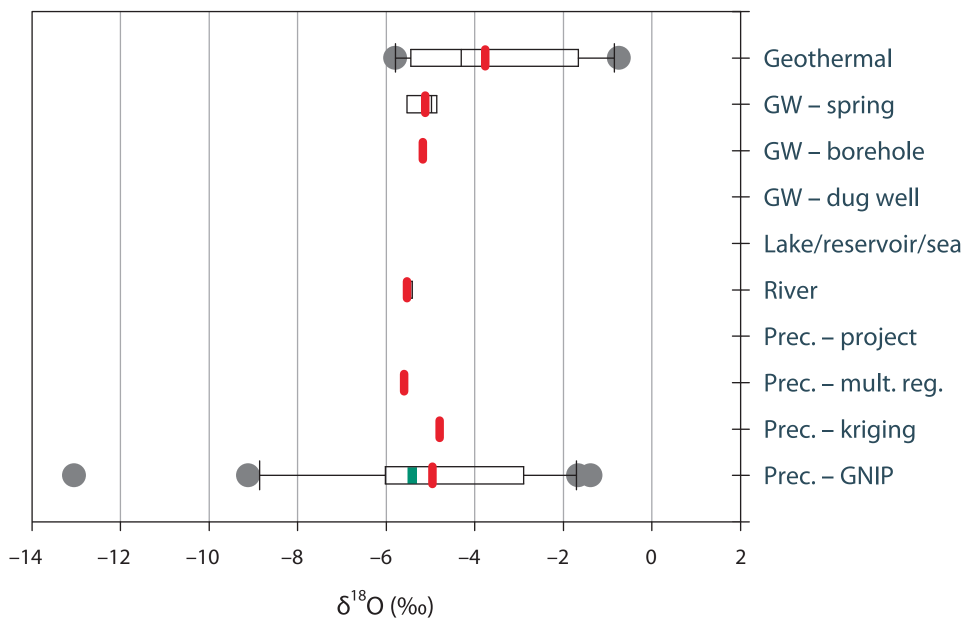


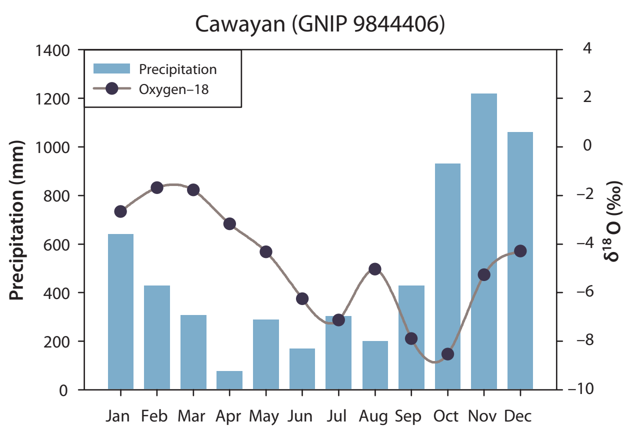


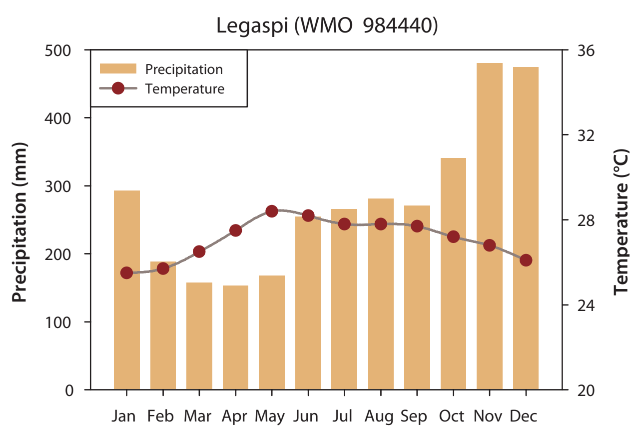
PHI–6019ML

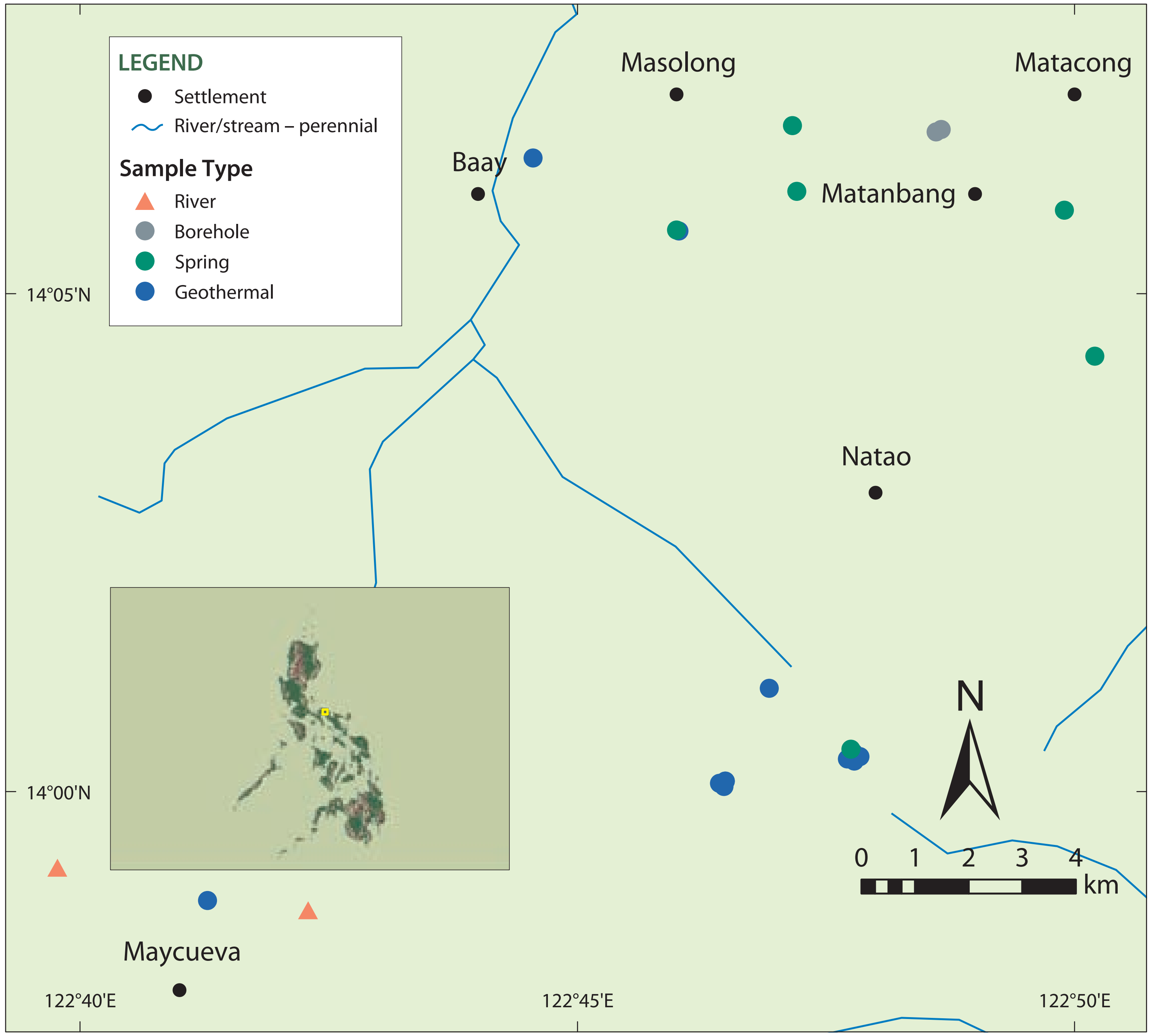
Mount Labo geothermal area







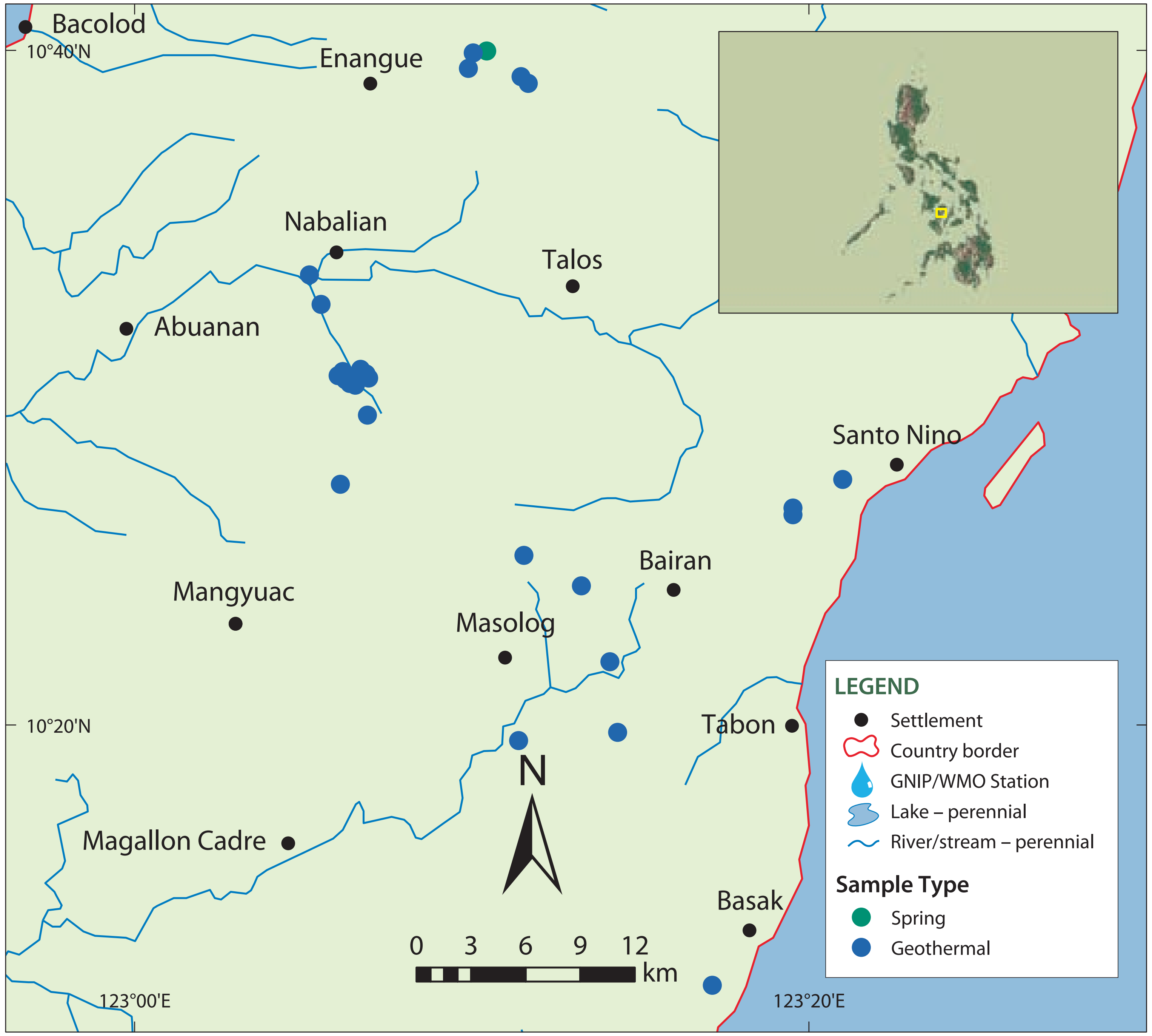


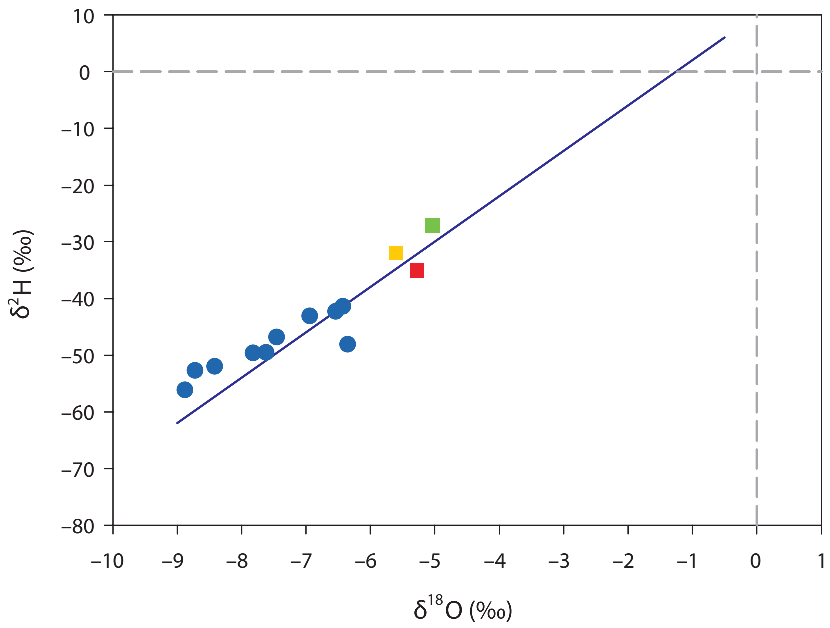


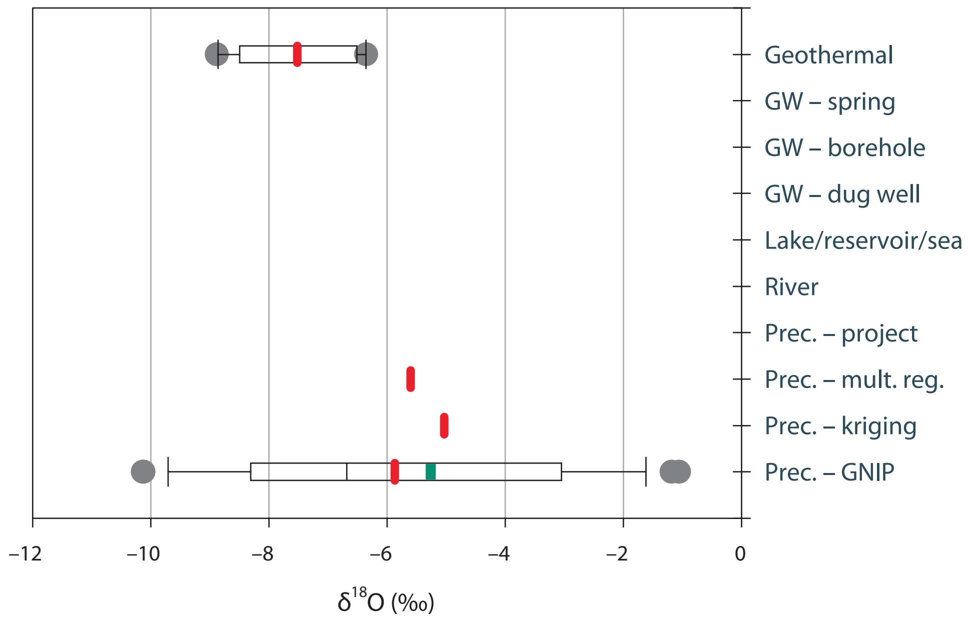
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station CAWAYAN	■ (red)	23	−4.89	−5.4 ± 1.8	23	−25.9	−29.3 ± 13.0			5899
Interpolation – multiple reg.	■ (yellow)			−5.60			−32.0			
Interpolation – kriging (IAEA)	■ (green)			−4.80			−30.0			
Project	■ (pink)									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)								
River	▲ (salmon)	2	−5.51	−5.51 ± 0.1	2	−30.8	−30.8 ± 0.2		

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)	12	−4.31	−3.76 ± 1.9	12	−30.2	−30.8 ± 2.1	4	1.4 ± 0.7		
GW–Borehole	● (grey)	2	−5.20	−5.20 ± 0.1	2	−30.1	−30.1 ± 2.1				
GW–Dug well	● (brown)										
GW–Spring	● (green)	6	−4.98	−5.12 ± 0.4	6	−29.6	−29.2 ± 5.3	6	2.6 ± 0.5		



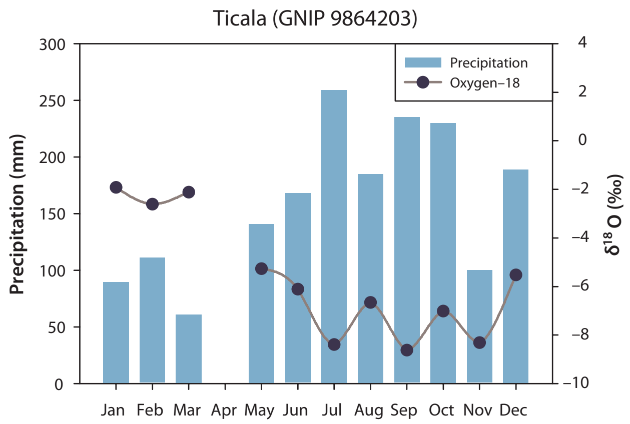


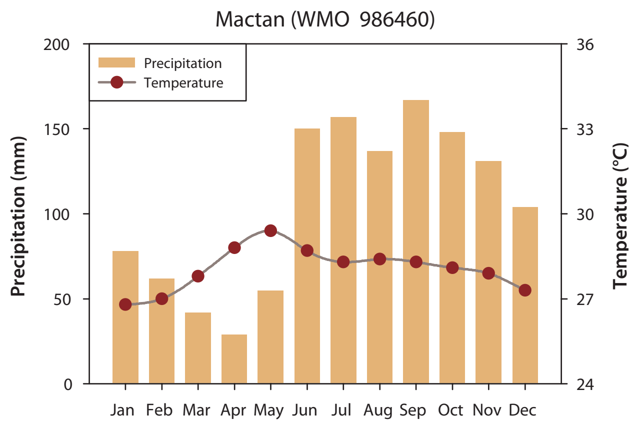


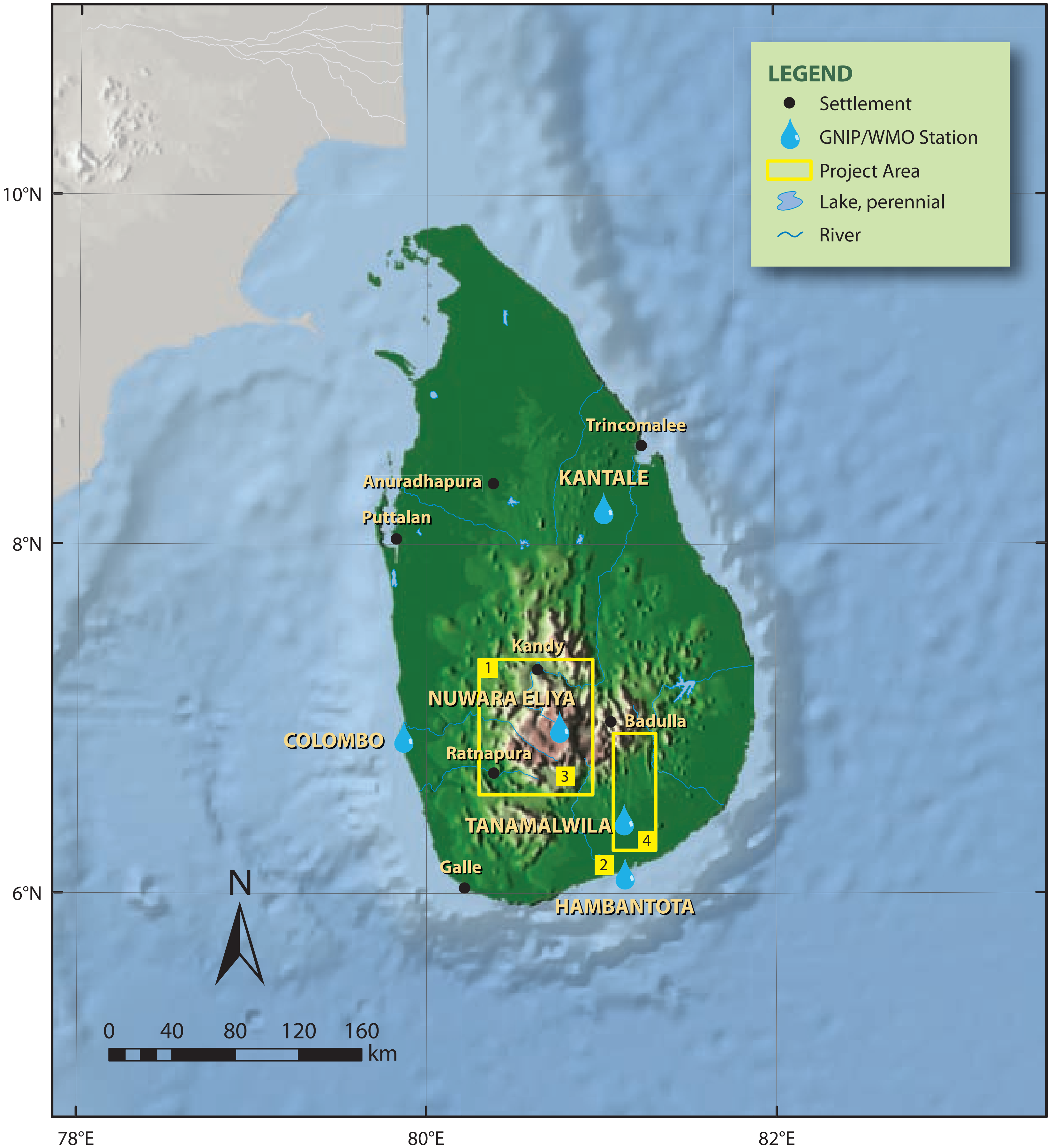
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station TICALA	red square	22	−6.68	−5.27 ± 2.1	22	−42.6	−35.1 ± 17.6			1026
Interpolation – multiple reg.	yellow square			−5.60			−32.0			
Interpolation – kriging (IAEA)	green square			−5.03			−27.2			
Project	pink square									

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	orange triangle								
River	red triangle								

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle	10	−7.54	−7.52 ± 1.0	10	−48.8	−48.2 ± 4.8				
GW–Borehole	grey circle										
GW–Dug well	brown circle										
GW–Spring	green circle										







1 Project Code: SRL8018
Study area: Kukuleganga–Victoria–Randenigla dam areas
Sampling period: 2004–2005
Background: This project was implemented to assist in the detection of seepage and leakage paths at the selected dams by using isotope techniques and to develop the national capabilities for using isotope techniques for dam safety.

2 Project Code: RAS8084–SRL
Study area: Hambantota area
Sampling period: 2000
Background: In the study, isotopes were used to understand groundwater recharge and dynamics in the coastal area between Ridiyagama Tank and Ambalantota.

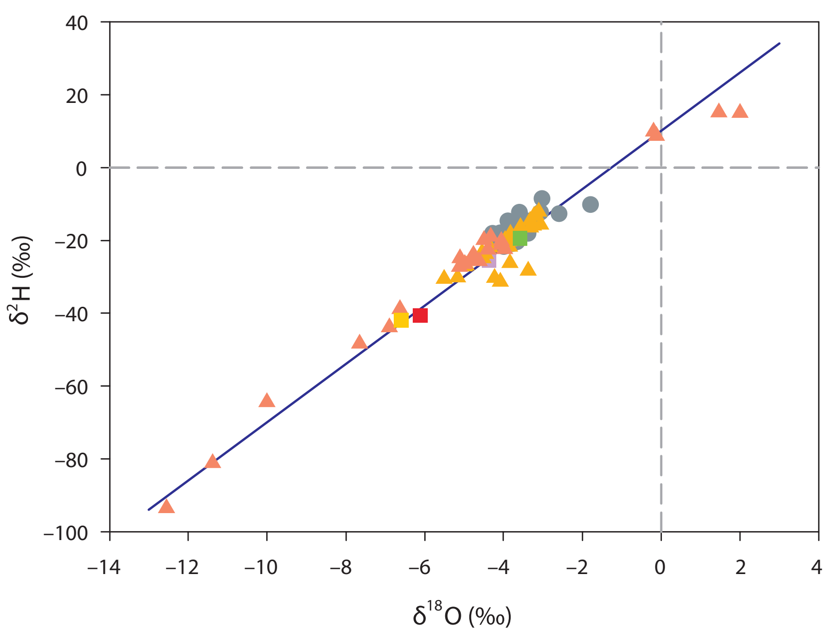
3 Project Code: RAS8093–SRL
Study area: Samanalawewa reservoir area
Sampling period: 2001–2002
Background: In this isotope investigation, detection of seepage and leakage paths in the vicinity of Samanalawewa reservoir, one of the large reservoirs in Sri Lanka, was undertaken.

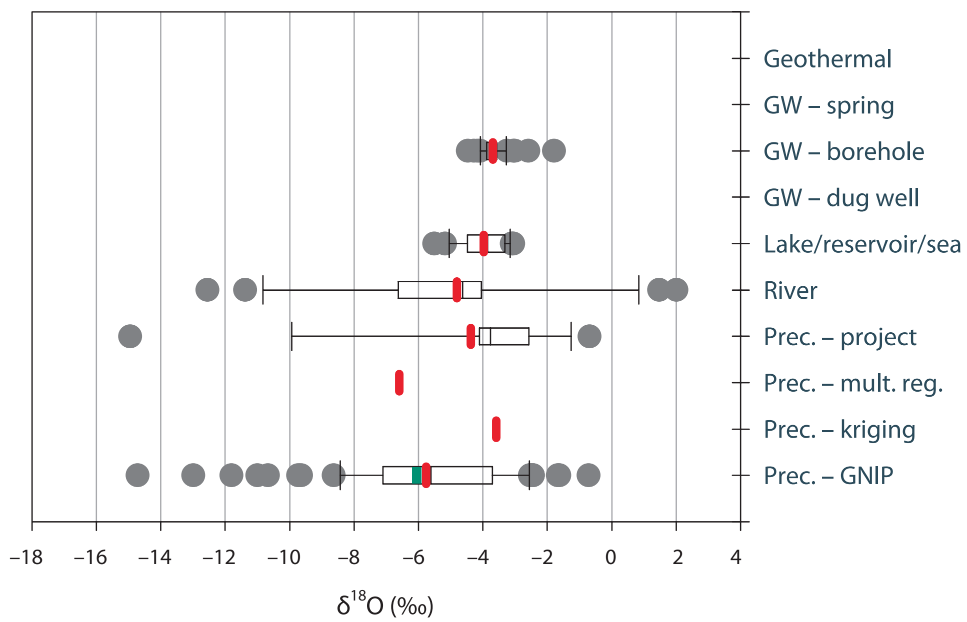
4 Project Code: RAS8097–SRL
Study area: Nanu Oya and Bomburella basins
Sampling period: 2005
Background: In the framework of this project, interactions between two well fields as well as the impact of extraction of groundwater from deep aquifers on the shallow aquifers were studied.

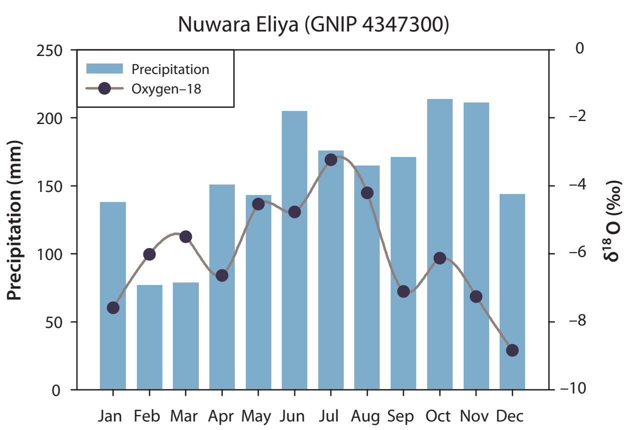
IAEA Water Resources Programme

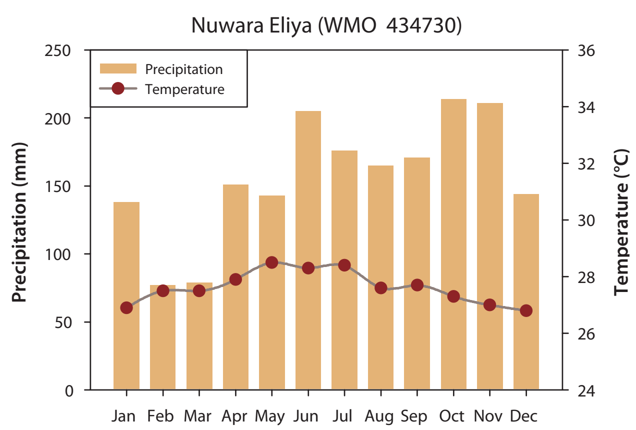
SRL8018

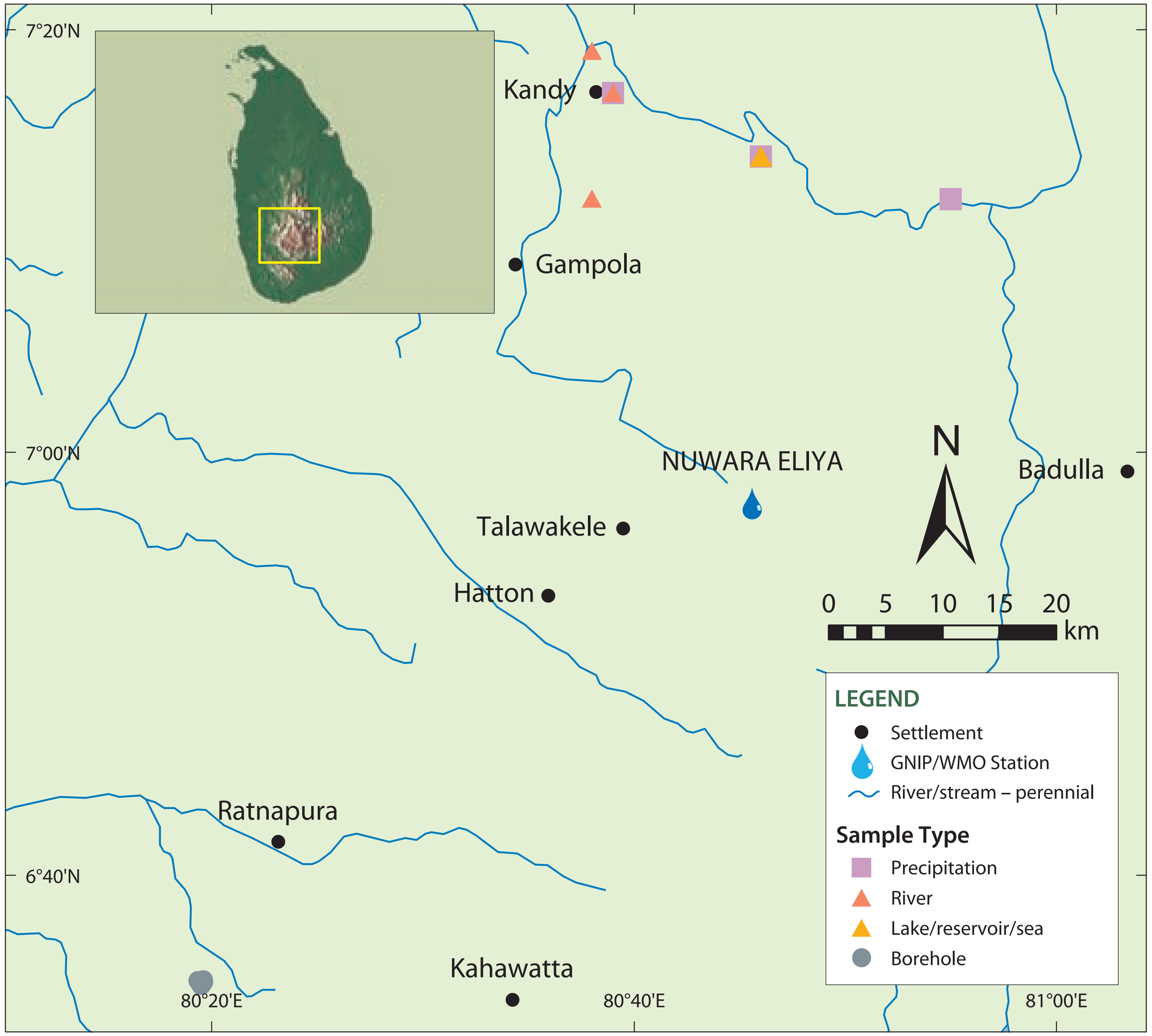
Kukuleganga–Victoria–Randenigla dam areas









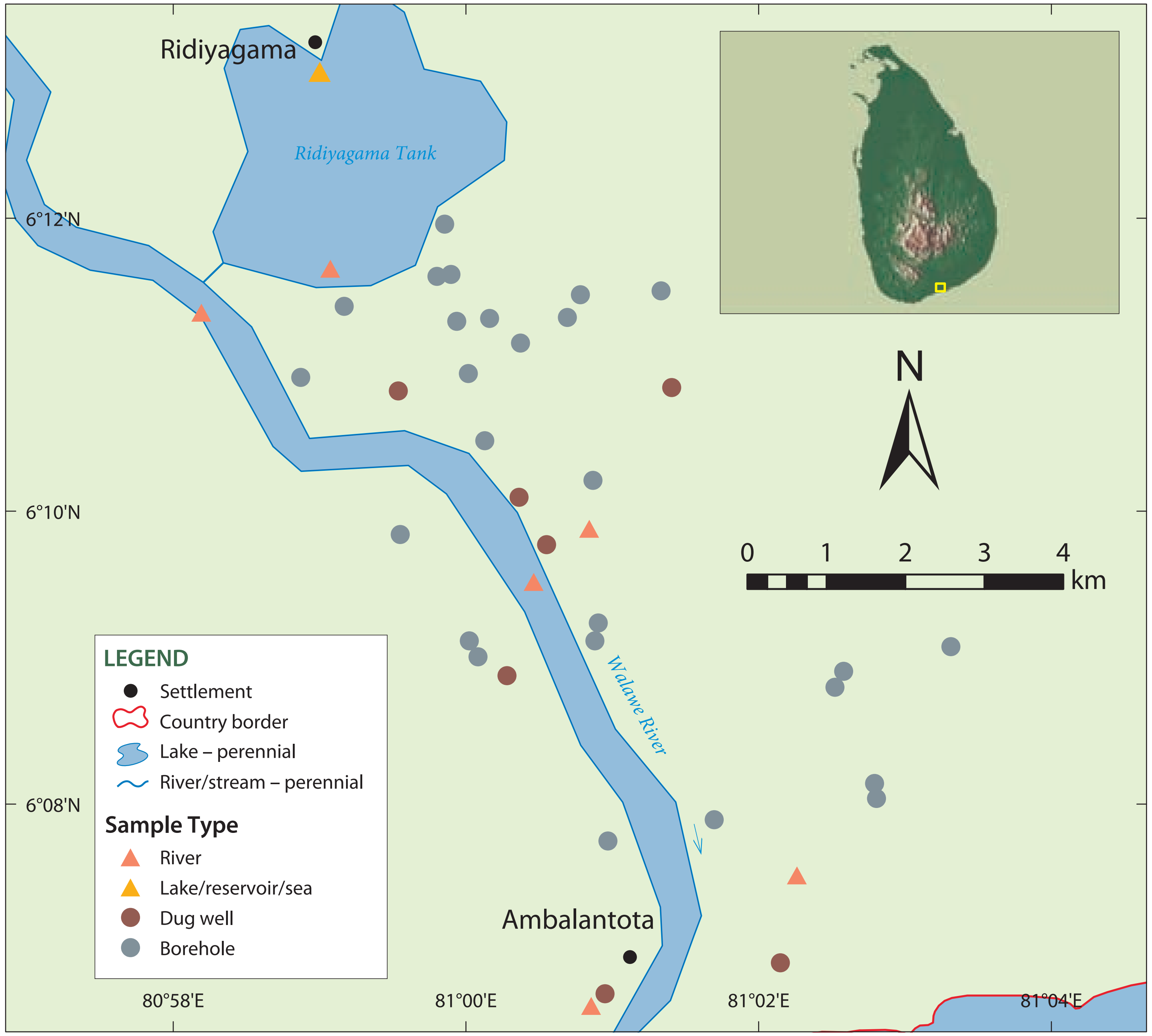


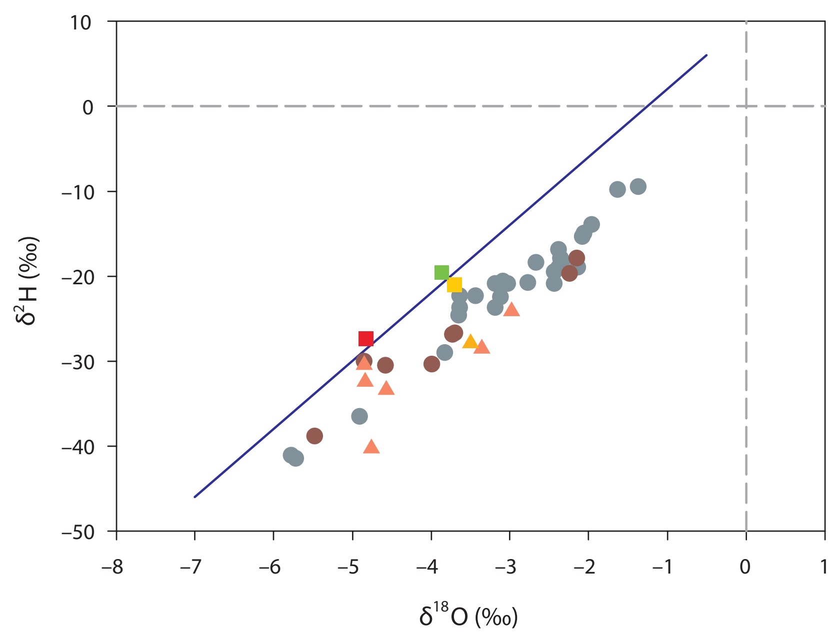
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station NUWARA ELIYA	■ (red)	83	−5.61	−6.11 ± 1.7	71	−32.7	−40.6 ± 8.3			2556
Interpolation – multiple reg.	■ (yellow)			−6.60			−42.0			
Interpolation – kriging (IAEA)	■ (green)			−3.58			−19.49			
Project	■ (pink)	16	−3.77	−4.37 ± 3.4	16	−21.4	−25.4 ± 26.5	15	2.2 ± 1.2	

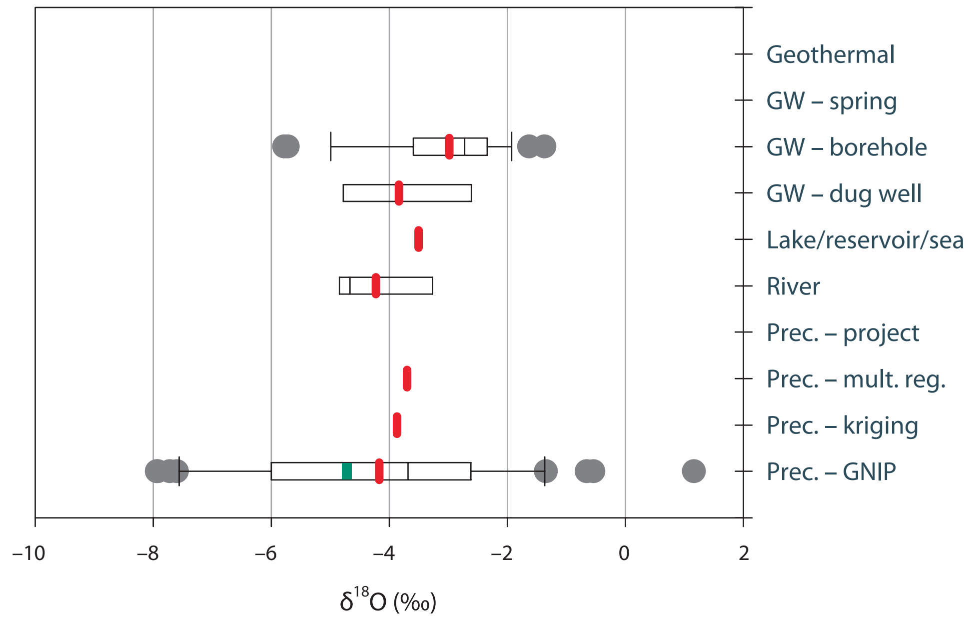
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)	26	−3.86	−3.97 ± 0.7	26	−21.3	−21.7 ± 6.0	24	1.8 ± 1.1
River	▲ (orange)	23	−4.62	−4.81 ± 3.6	23	−23.9	−27.0 ± 27.0	23	2.1 ± 1.2

Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	50	−3.77	−3.69 ± 0.4	50	−17.9	−17.5 ± 2.8	50	1.2 ± 0.3		
GW–Dug well	● (brown)										
GW–Spring	● (green)										

RAS8084–SRL
Hambantota area



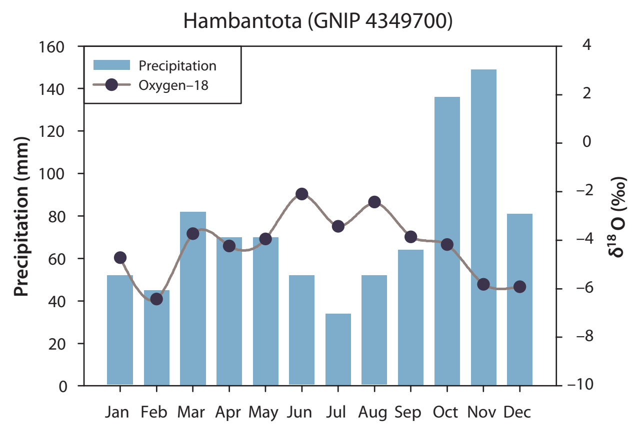


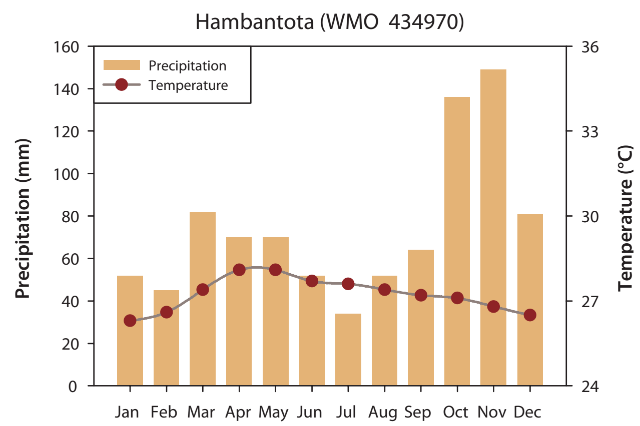


Precipitation		δ^{18}O (‰)			δ^2H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station HAMBANTOTA	■ (red)	40	−3.69	−4.83 ± 2.0	29	−13.8	−27.4 ± 16.3			831
Interpolation – multiple reg.	■ (yellow)			−3.70			−21.0			
Interpolation – kriging (IAEA)	■ (green)			−3.87			−19.6			
Project	■ (pink)									

Surface waters		δ^{18}O			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)	1		−3.56	1		−28.1		
River	▲ (orange)	6	−4.67	−4.23 ± 0.8	6	−31.4	−31.5 ± 5.4		

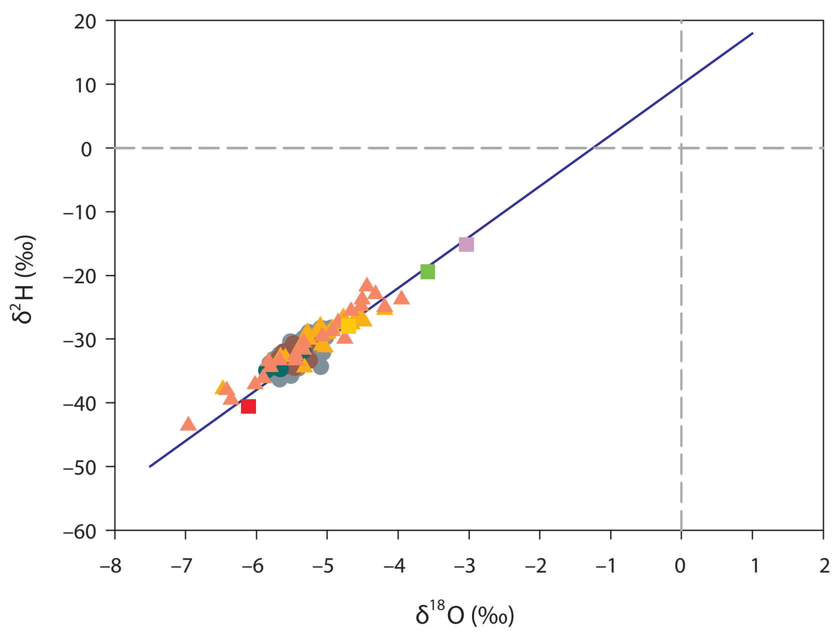
Groundwaters		δ^{18}O			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	28	−2.72	−2.99 ± 1.1	28	−20.7	−21.5 ± 7.7	9	2.2 ± 0.9		
GW–Dug well	● (brown)	8	−3.86	−3.84 ± 1.2	8	−28.4	−27.6 ± 6.6				
GW–Spring	● (green)										

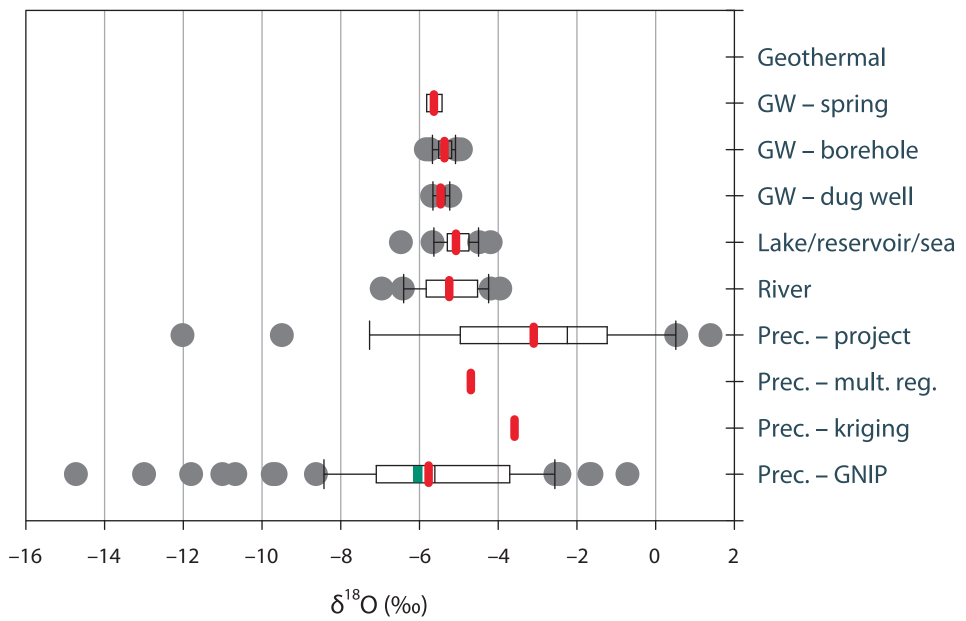


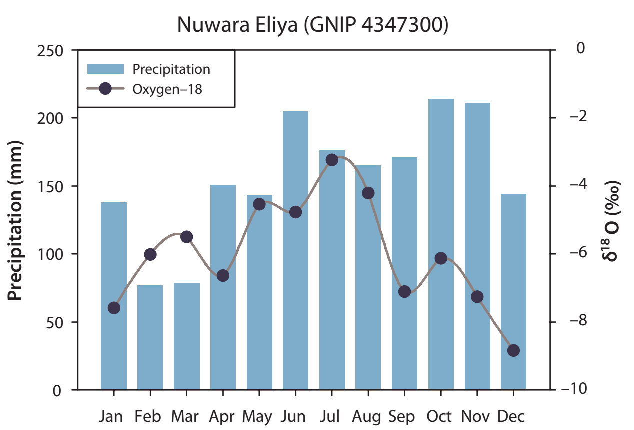


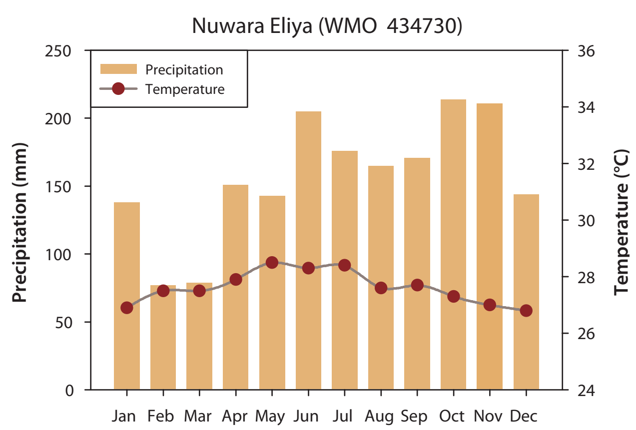
RAS8093–SRL

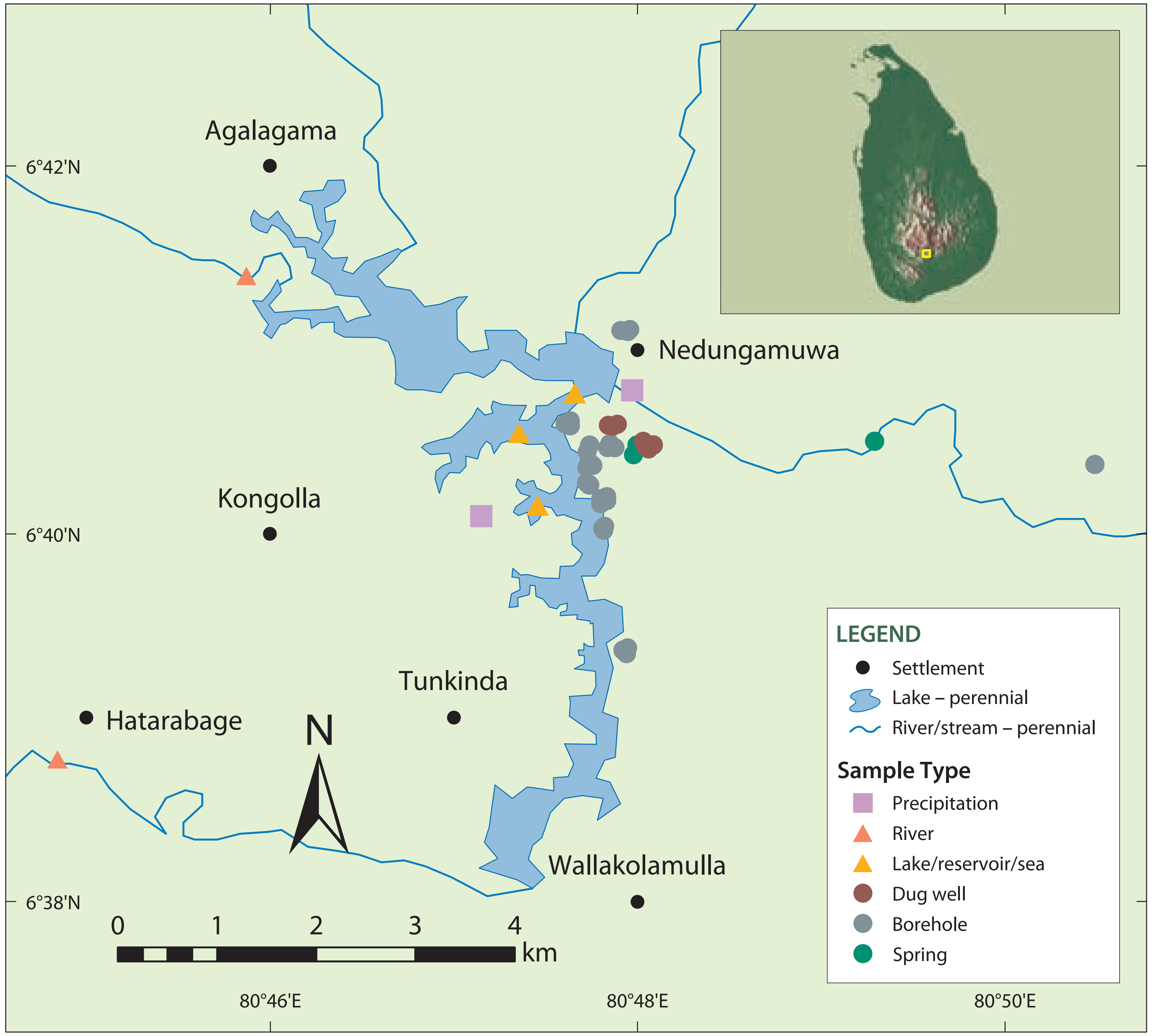
Samanalawewa reservoir area







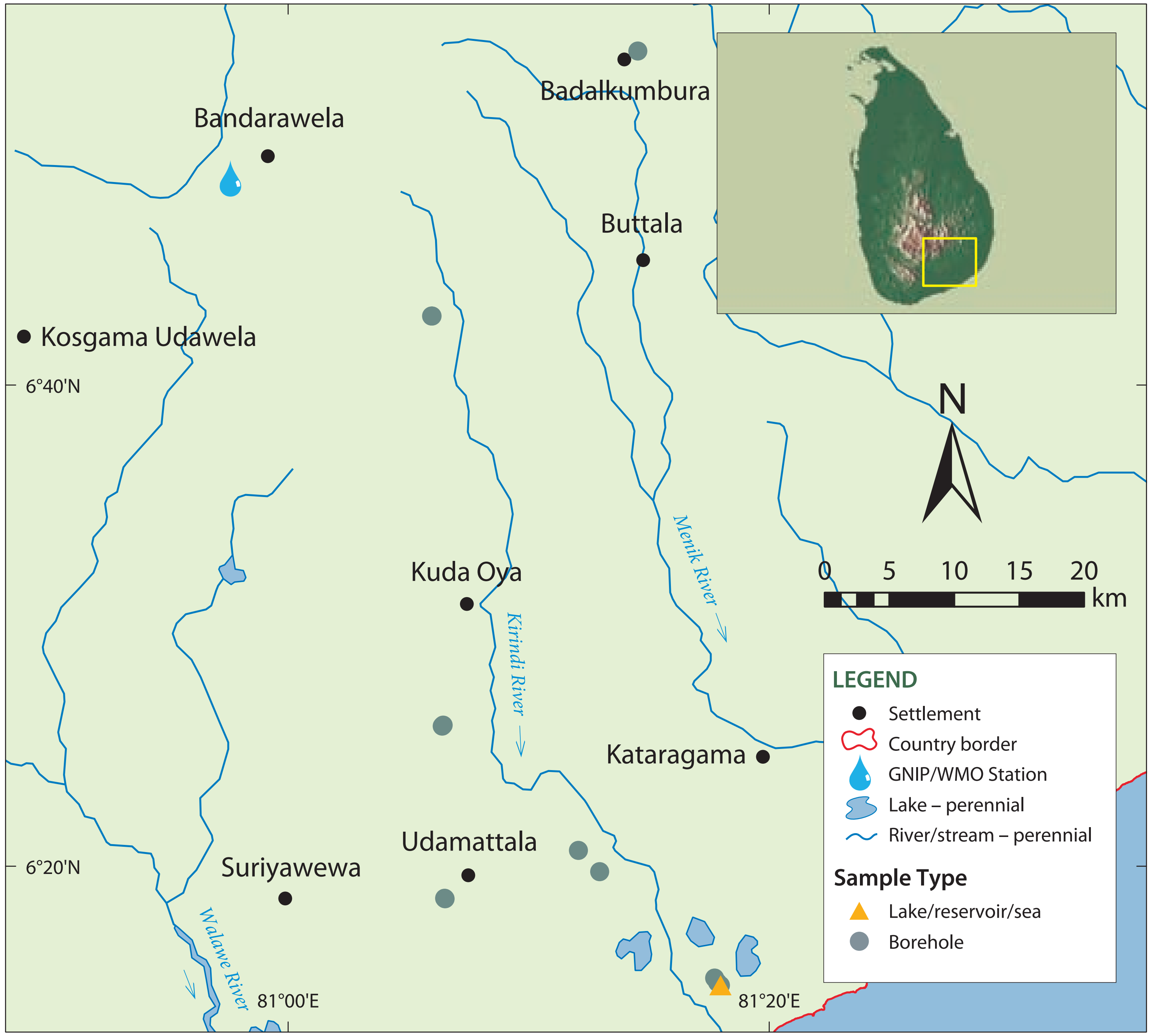


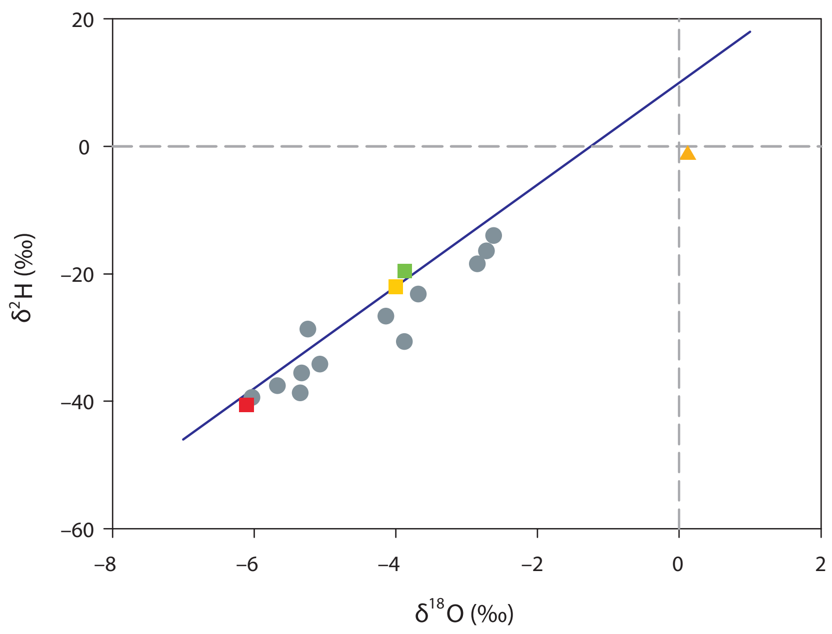


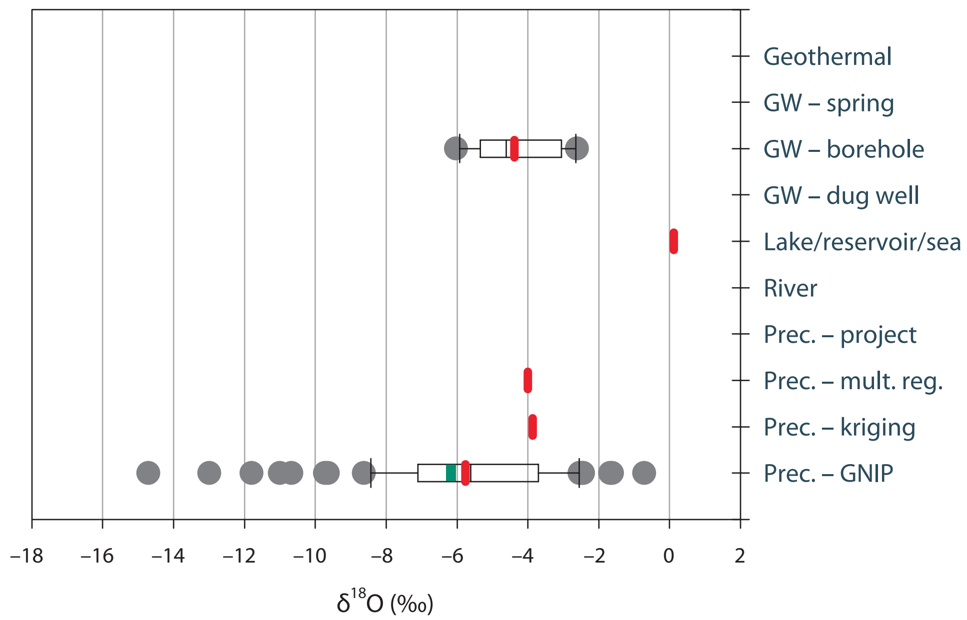
Precipitation		δ¹⁸O (‰) n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H (‰) n	δ²H Median	δ²H Mean ± St. dev.	Tritium (TU) n	Tritium Mean ± St. dev.	Annual prec. (mm)
GNIP station NUWARA ELIYA	red square	83	−5.61	−6.11 ± 1.7	71	−32.7	−40.6 ± 8.3			2556
Interpolation – multiple reg.	yellow square			−4.70			−28.0			
Interpolation – kriging (IAEA)	green square			−3.58			−19.5			
Project	pink square	29	−2.24	−3.09 ± 3.0	29	−10.7	−16.2 ± 22.9	2	6.3 ± 0.4	

Surface waters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.
Lake/reservoir/sea	yellow triangle	22	−5.07	−5.07 ± 0.5	22	−29.1	−29.6 ± 3.0	3	4.7 ± 1.0
River	orange triangle	23	−5.33	−5.25 ± 0.8	23	−30.6	−30.7 ± 5.8	1	4.8

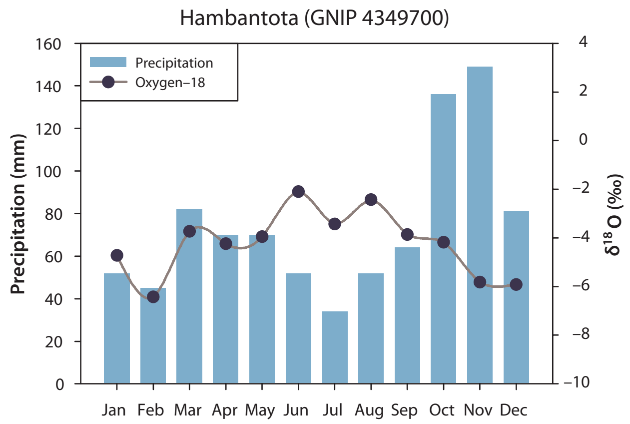
Groundwaters		δ¹⁸O n	δ¹⁸O Median	δ¹⁸O Mean ± St. dev.	δ²H n	δ²H Median	δ²H Mean ± St. dev.	Tritium n	Tritium Mean ± St. dev.	¹⁴C (pMC) n	¹⁴C Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	58	−5.36	−5.36 ± 0.2	58	−31.5	−31.7 ± 1.9	10	4.5 ± 1.5		
GW–Dug well	brown circle	12	−5.50	−5.47 ± 0.1	12	−31.9	−32.2 ± 1.3	4	2.3 ± 0.6		
GW–Spring	green circle	4	−5.68	−5.64 ± 0.2	4	−34.6	−34.0 ± 1.4	4	3.4 ± 1.0		

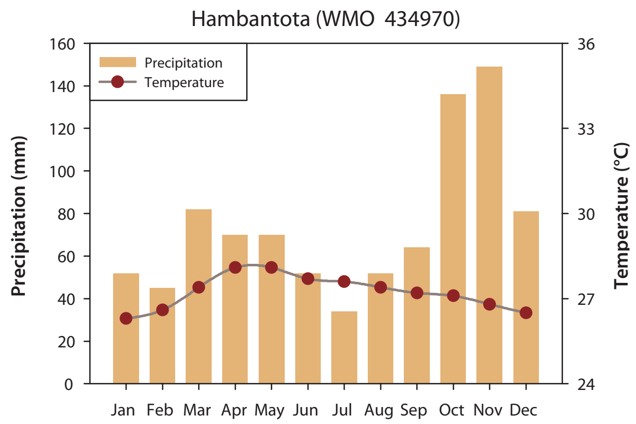


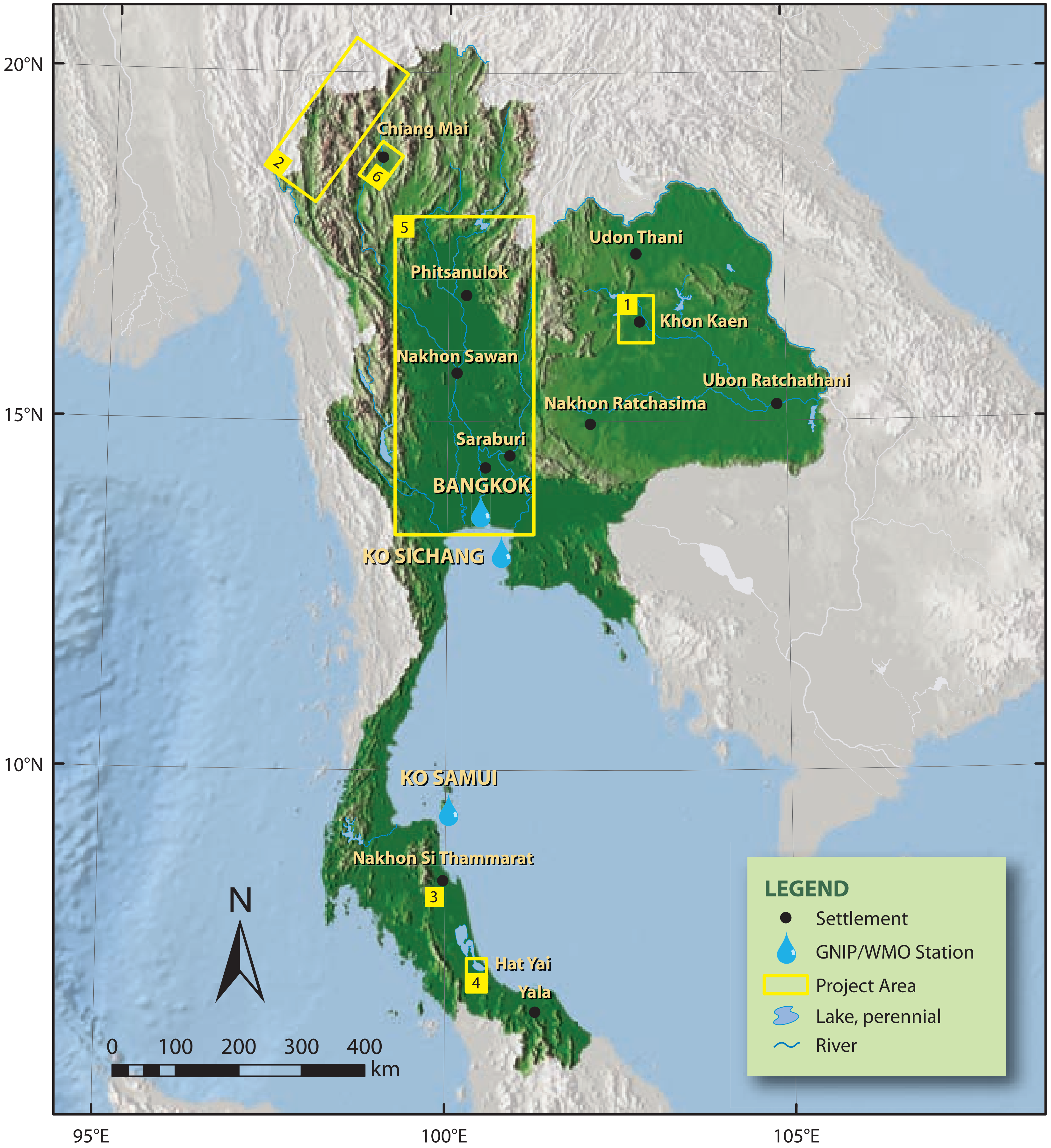




Precipitation		$\delta^{18}O$ (‰)			δ^2H (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station HAMBANTOTA	■ (red)	83	−5.61	−6.11 ± 1.7	71	−32.7	−40.6 ± 8.3			2556	
Interpolation – multiple reg.	■ (yellow)			−4.00			−22.0				
Interpolation – kriging (IAEA)	■ (green)			−3.87			−19.6				
Project	■ (pink)										
Surface waters		$\delta^{18}O$			δ^2H			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲ (orange)	1		0.12	1		1.36	1	5.3		
River	▲ (light red)										
Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	12	−4.61	−4.38 ± 1.2	12	−29.6	−28.6 ± 8.9	12	5.1 ± 1.2		
GW–Dug well	● (brown)										
GW–Spring	● (green)										







1 Project Code: THA8011
Study area: Khon Kaen area
Sampling period: 1994–1996
Background: The objective of this isotope investigation was to obtain information on origin and dynamics of groundwater in various aquifers of Khon Kaen area.

2 Project Code: RAS8075–THA, RAS8092–THA
Study area: Fang and Mae Hong Son geothermal areas
Sampling period: 1997–1999, 2002–2003
Background: A significant amount of geothermal resources remains untapped in certain areas because of a lack of exposure to various technologies of geothermal exploration and exploitation. In order to support the use of geothermal resources for energy production in the region through the application of isotope and geochemical techniques, these regional projects were implemented to obtain benchmark isotopic and chemical data for understanding the dynamics of the geothermal fluids and reservoir temperatures. In Thailand, Fang and Mae Hong Son areas were investigated.

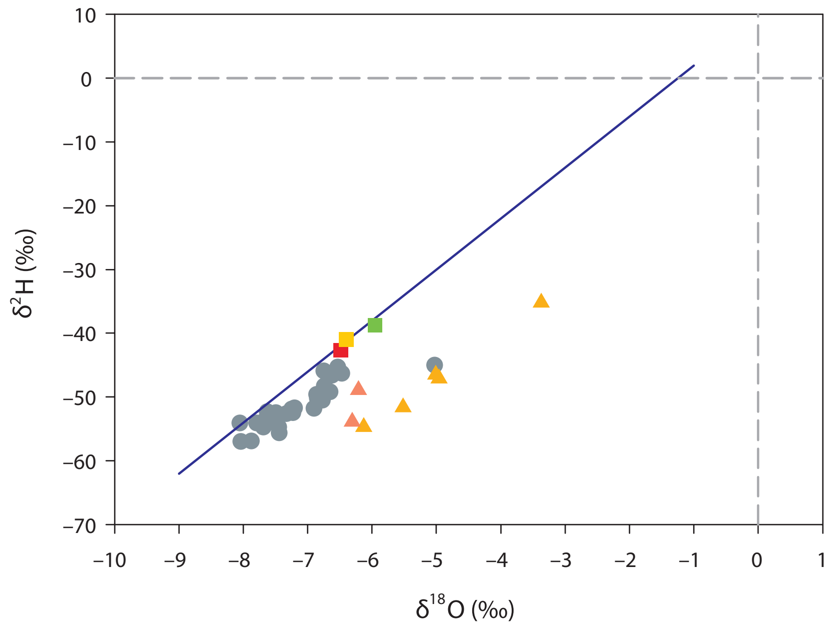
3 Project Code: RAS8084–THA
Study area: Ronphibun mining area
Sampling period: 1999–2001
Background: Isotope techniques were employed to understand the groundwater recharge and dynamics for studying arsenic poisoning of groundwater in the vicinity of tin mining areas.

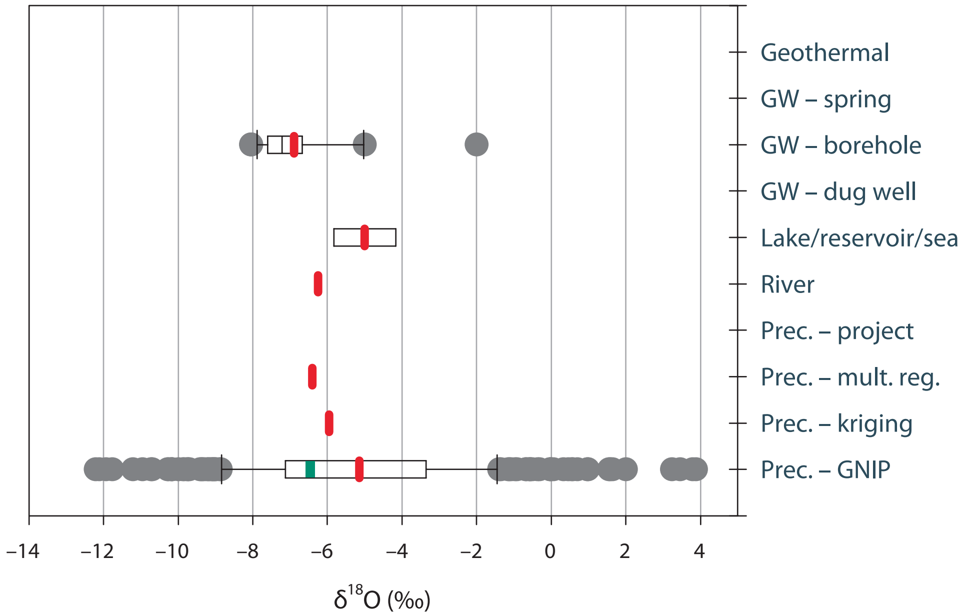
4 Project Code: RAS8097–THA, THA–4803H
Study area: Hat Yai basin
Sampling period: 2004–2006, 1988–1989
Background: The objectives of these isotope investigations were to: obtain information on origin, age, flow, and recharge mechanism of groundwater as well as surface water–groundwater interactions; develop a flow and transport model for groundwater management; and identify the sources and types of contamination in Hat Yai basin.

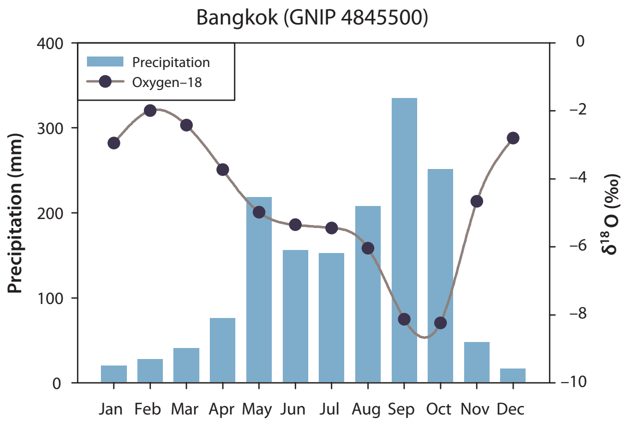
5 Project Code: THA–4803C
Study area: Chao Phraya basin
Sampling period: 1980–1982, 1987–1989
Background: Under this research project, the origin, dynamics and age of groundwater in the Chao Phraya basin were studied using isotope techniques for calibration of a mathematical model.

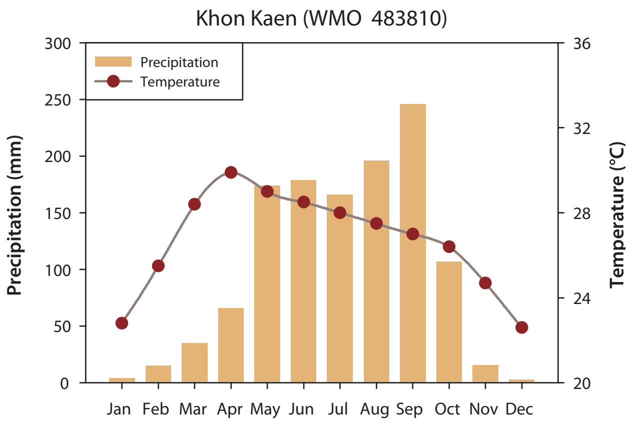
6 Project Code: THA–6233
Study area: Chiang Mai basin
Sampling period: 1991
Background: In this research contract, the origin of groundwater, groundwater movement and age of groundwater in the Chiang Mai basin were studied using isotope geochemical techniques.

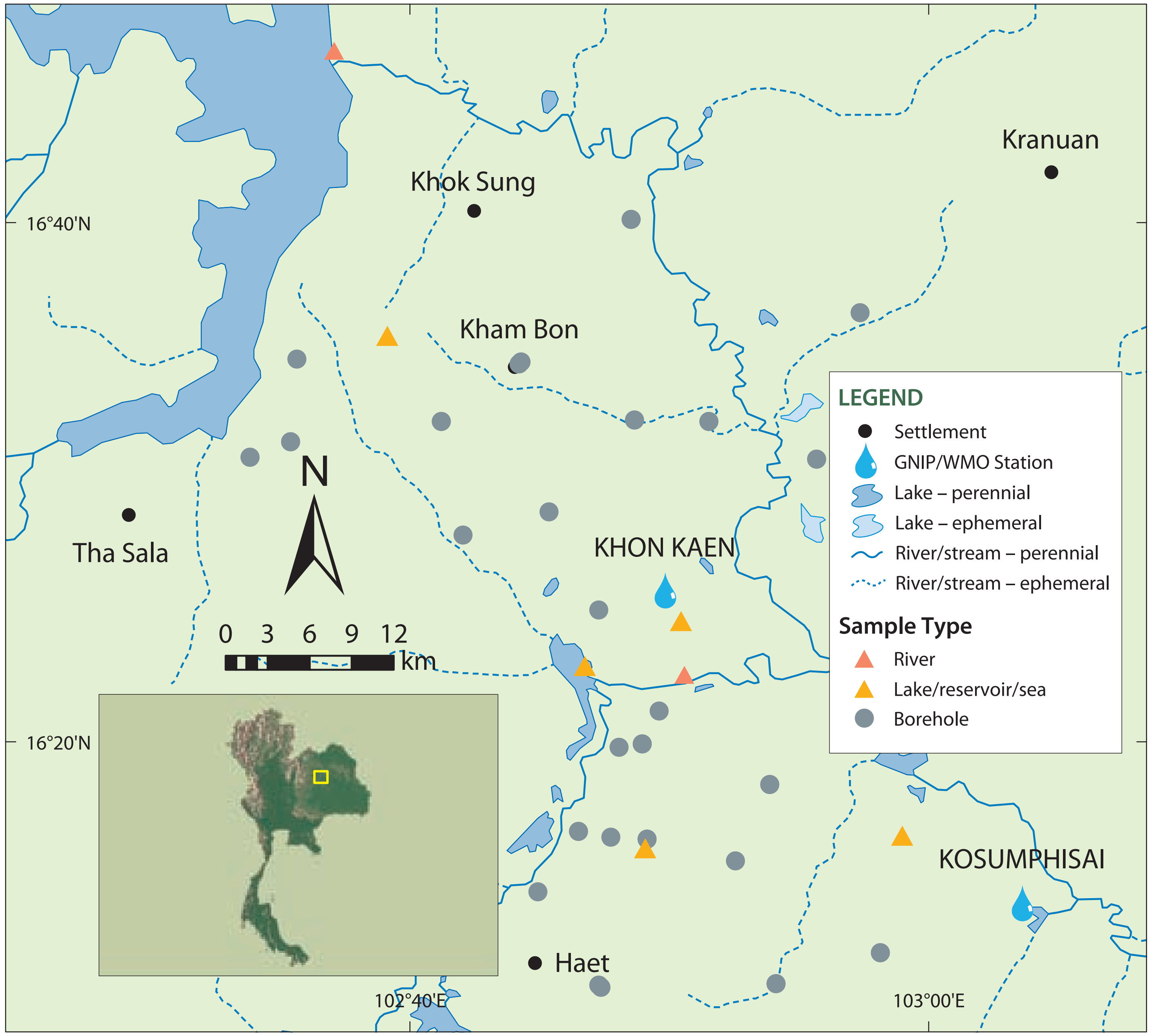
THA8011
Khon Kaen area











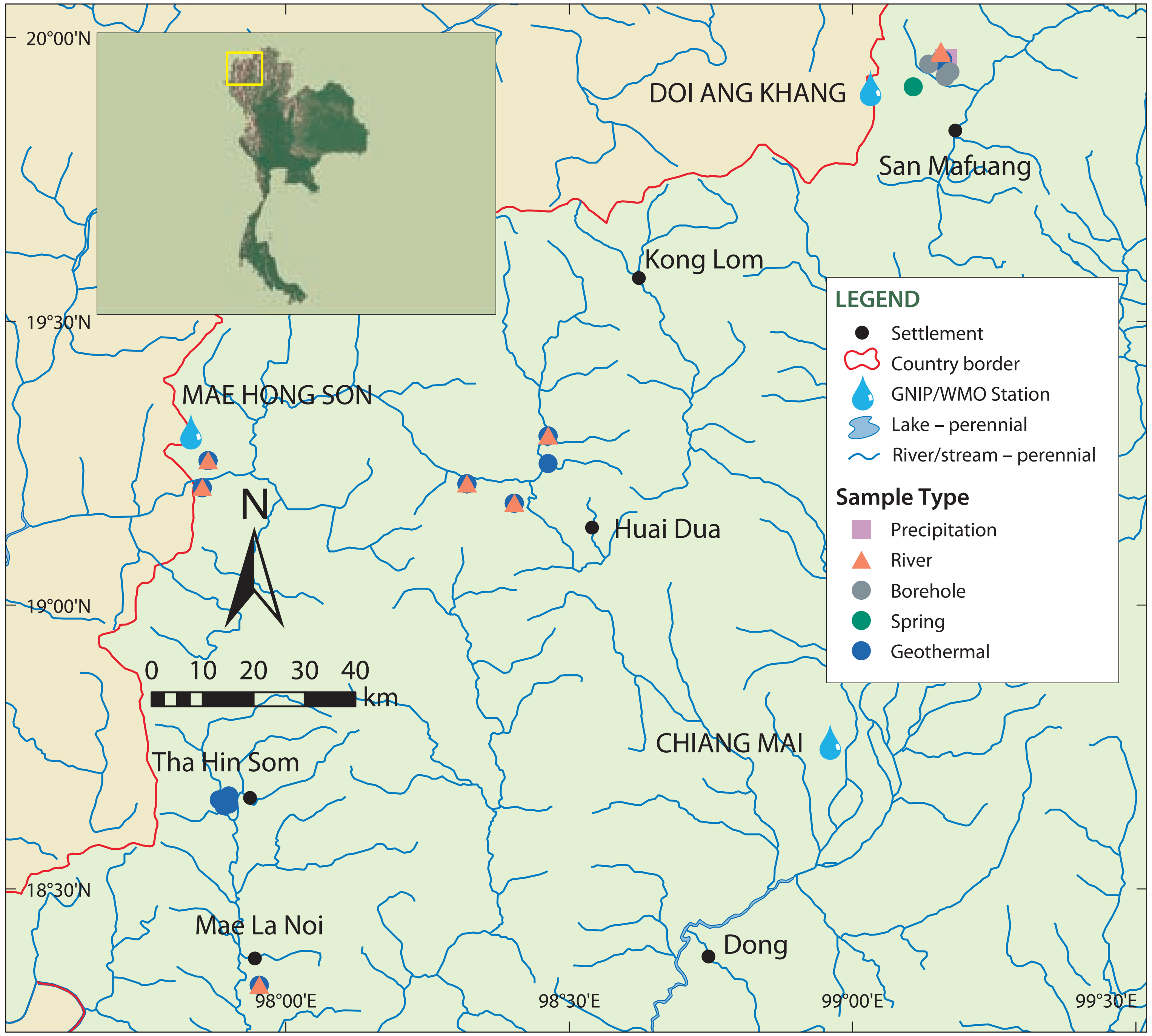
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station BANGKOK	red square	346	−5.15	−6.48 ± 1.51	318	−33.6	−42.7 ± 10.1			1498
Interpolation – multiple reg.	yellow square			−6.40			−41.0			
Interpolation – kriging (IAEA)	green square			−5.95			−38.8			
Project	pink square									

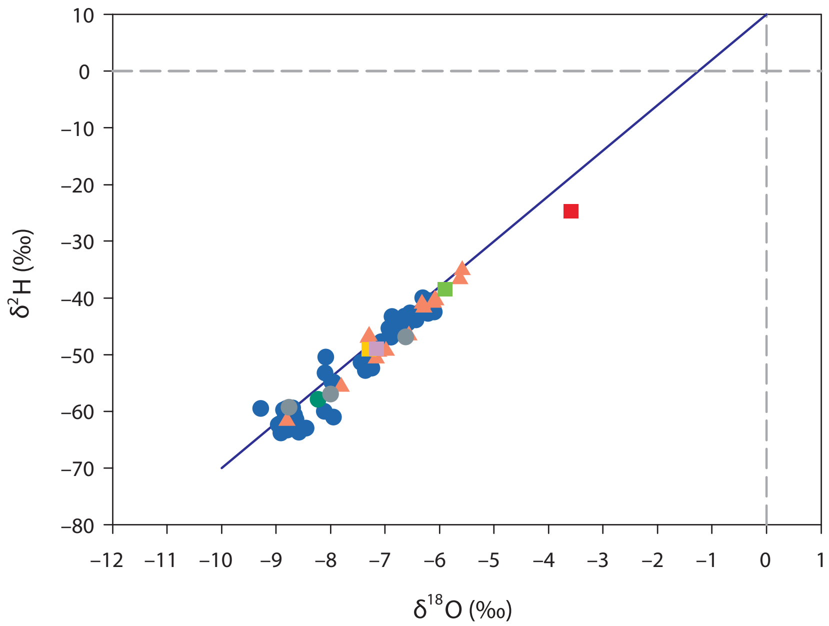
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	orange triangle	5	−5.01	−5 ± 1.03	5	−47.1	−47.0 ± 7.4	5	2.8 ± 0.2
River	light-red triangle	2	−6.26	−6.26 ± 0.07	2	−51.4	−51.4 ± 3.5	2	3.1 ± 0.1

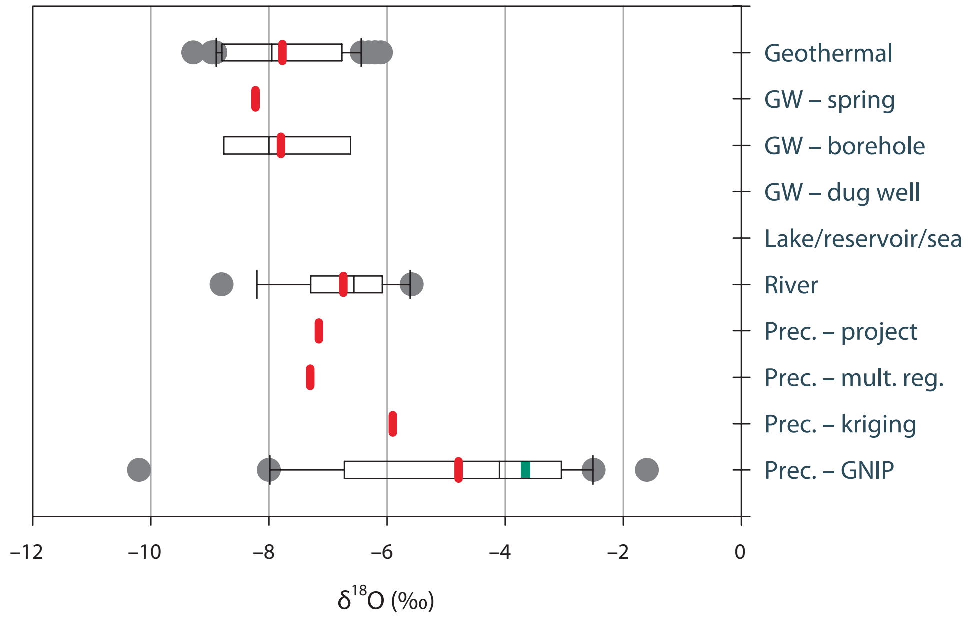
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	blue dot										
GW–Borehole	grey dot	26	−7.24	−7.14 ± 0.64	26	−52.1	−51.4 ± 3.5	23	1.6 ± 1.4	24	83.9 ± 28.3
GW–Dug well	brown dot										
GW–Spring	green dot										

RAS8075–THA; RAS8092–THA

Fang and Mae Hong Son geothermal areas



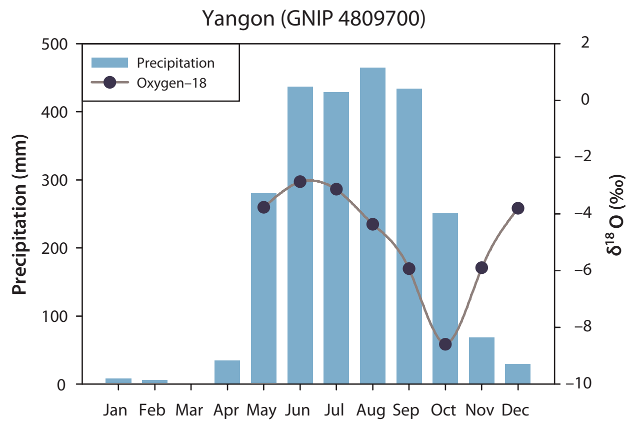


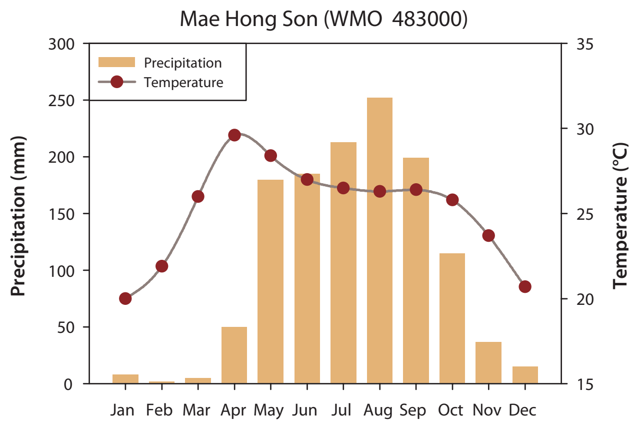


Precipitation		δ¹⁸O (‰)			δ²H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station YANGON		20	−4.10	−3.59 ± 0.4	20	−25.2	−24.7 ± 2.9			2189
Interpolation – multiple reg.				−7.30			−49.0			
Interpolation – kriging (IAEA)				−5.90			−38.4			
Project		1		−7.15	1		−48.3	1	3.8	

Surface waters		δ¹⁸O			δ²H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea									
River		15	−6.56	−6.74 ± 0.9	15	−46.6	−45.6 ± 7.2	9	2.8 ± 1.1

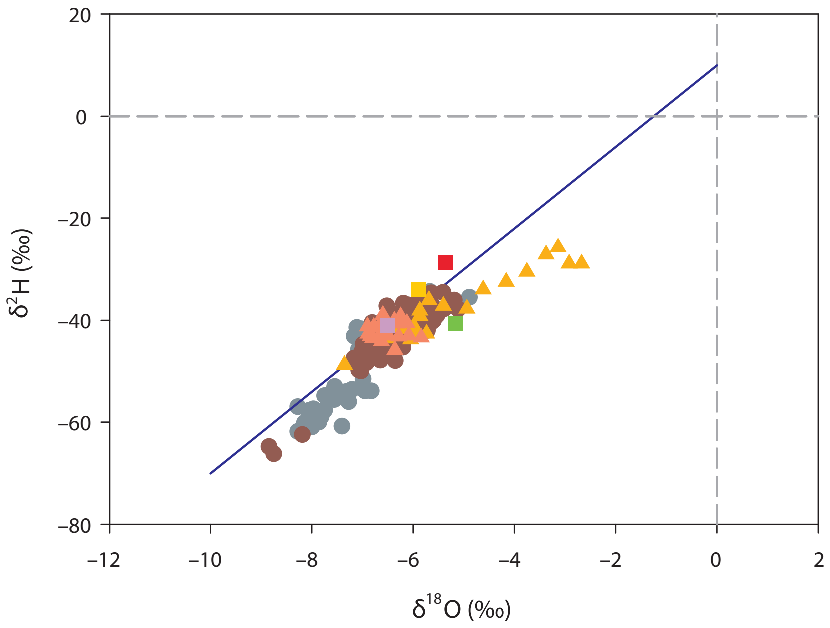
Groundwaters		δ¹⁸O			δ²H			Tritium		¹⁴C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		53	−7.95	−7.77 ± 1.0	53	−53.2	−53.7 ± 8.1	39	0.3 ± 0.4		
GW–Borehole		3	−8.00	−7.79 ± 1.1	3	−57.0	−54.4 ± 6.6	3	3.1 ± 2.0		
GW–Dug well											
GW–Spring		1		−8.23	1		−58.0	1	3.6		

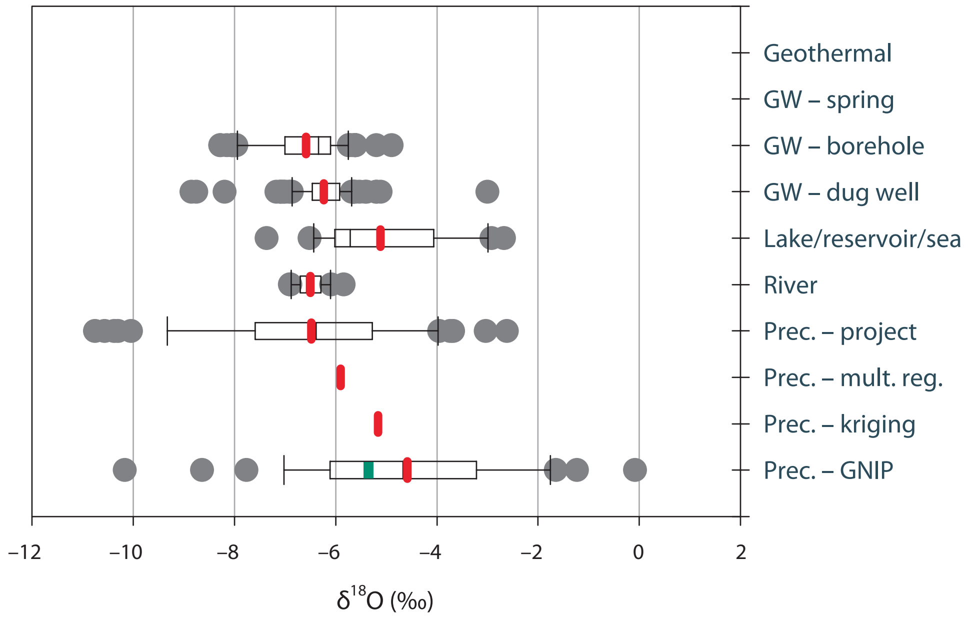


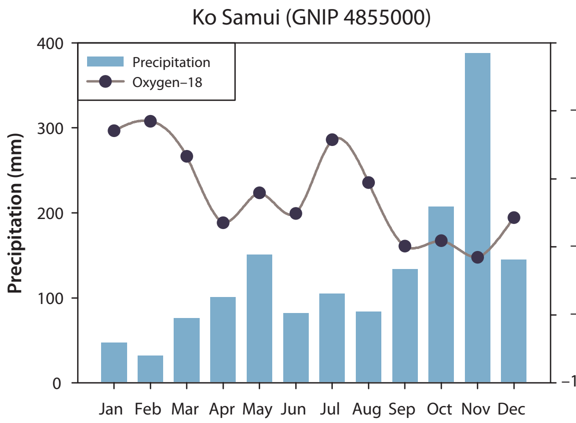


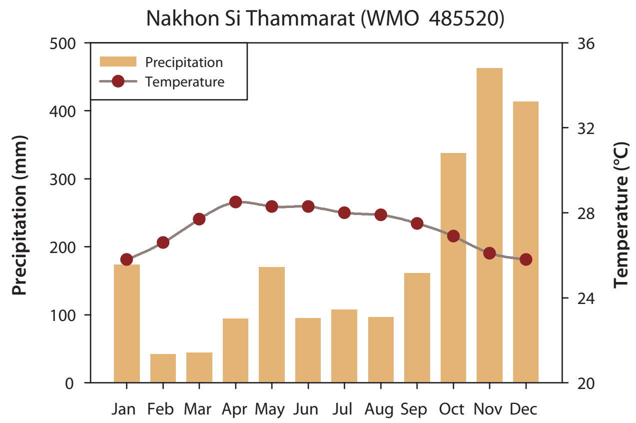
RAS8084–THA

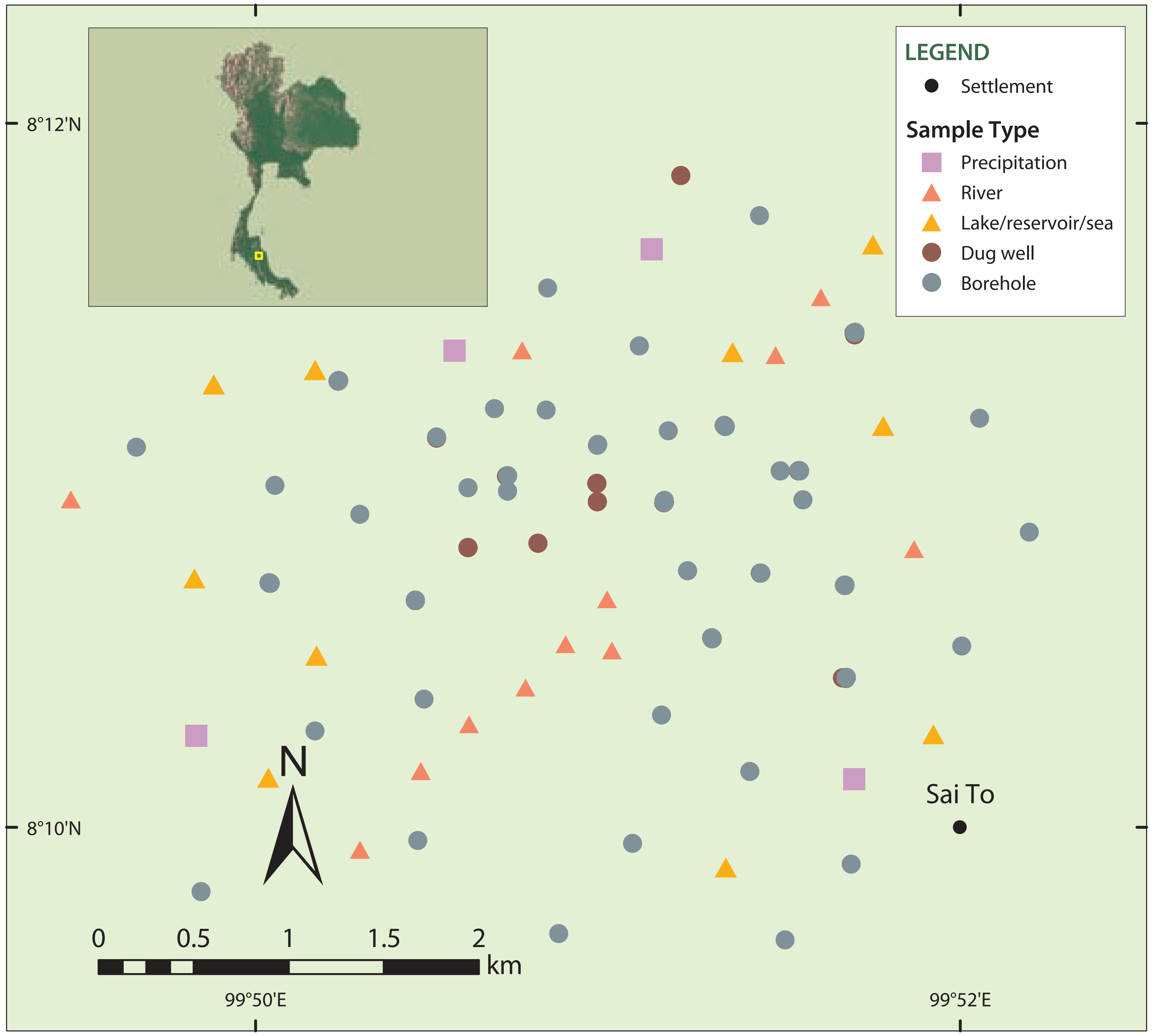
Ronphibun mining area











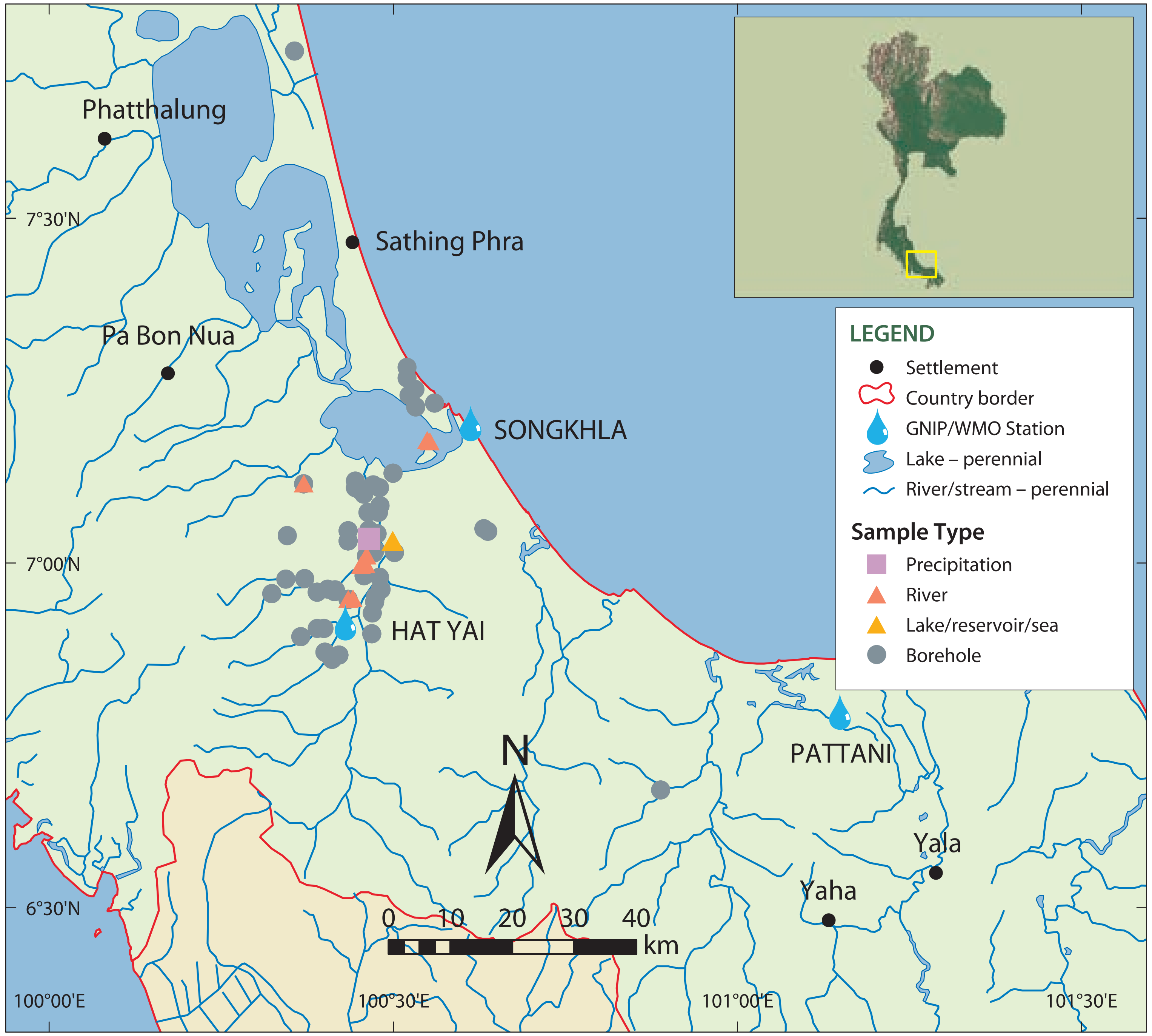
Precipitation		δ18O (‰) n	Median	Mean ± St. dev.	δ2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KO SAMUI		36	−4.67	−5.35 ± 2.2	29	−23.1	−28.7 ± 10.1			1265
Interpolation – multiple reg.				−5.90			−34.0			
Interpolation – kriging (IAEA)				−5.16			−40.6			
Project		59	−6.38	−6.47 ± 1.9	59	−41.1	−41.2 ± 15.8			

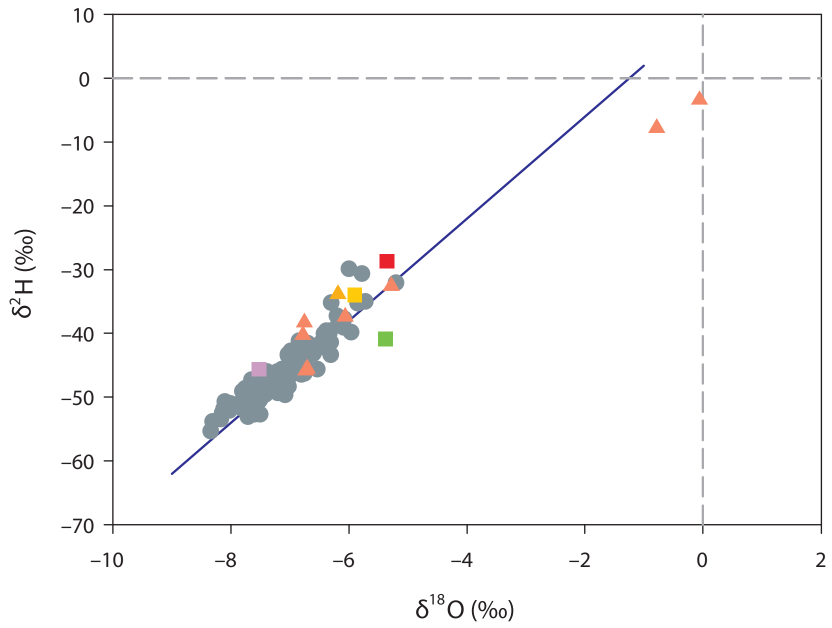
Surface waters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea		22	−5.71	−5.12 ± 1.3	22	−38.0	−37.3 ± 6.3		
River		22	−6.57	−6.50 ± 0.3	22	−42.1	−42.0 ± 1.7		

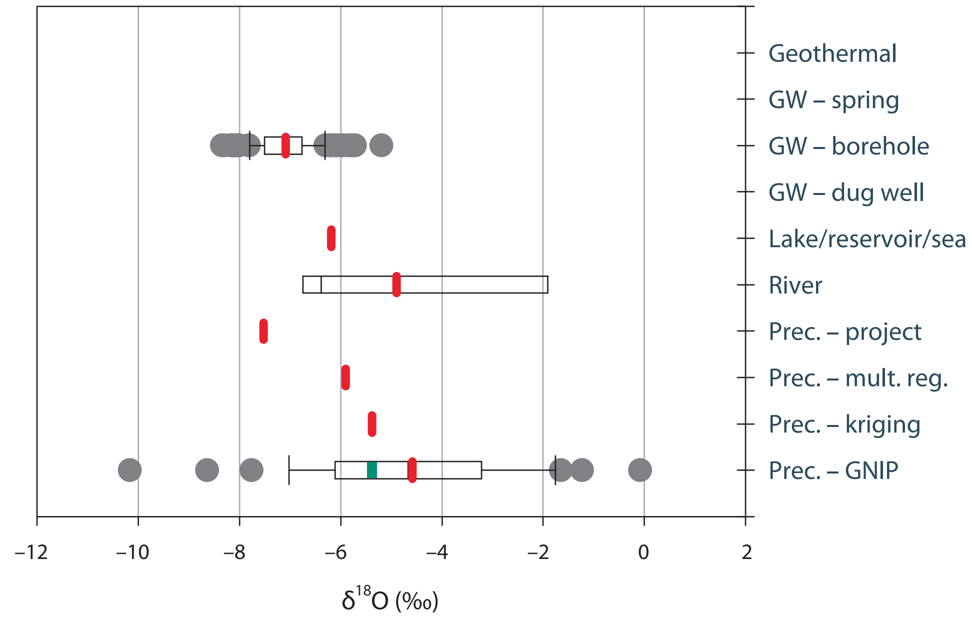
Groundwaters		δ18O n	Median	Mean ± St. dev.	δ2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	14C (pMC) n	Mean ± St. dev.
Geothermal water											
GW–Borehole		113	−6.34	−6.59 ± 0.8	113	−41.8	−45.0 ± 7.2				
GW–Dug well		129	−6.19	−6.26 ± 0.6	129	−41.0	−41.8 ± 4.6				
GW–Spring											

RAS8097-THA; THA-4803H

Hat Yai basin



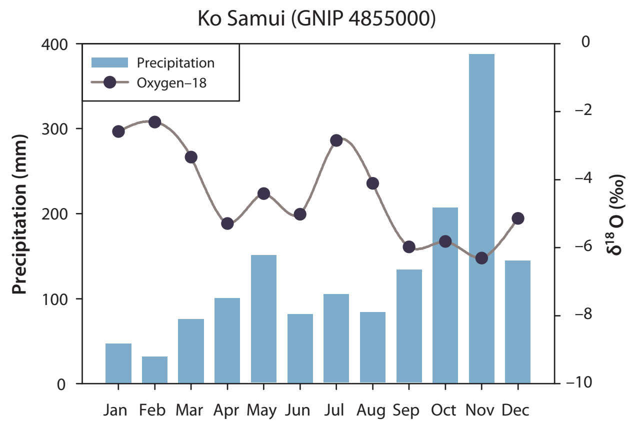


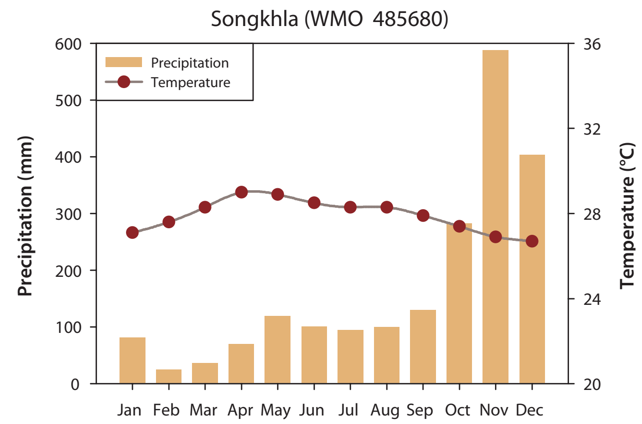


Precipitation	δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KO SAMUI	36	−4.67	−5.35 ± 2.2	29	−23.1	−28.7 ± 10.1			1265
Interpolation – multiple reg.			−5.90			−34.0			
Interpolation – kriging (IAEA)			−5.38			−40.9			
Project	2	−7.52	−7.52 ± 0.0	2	−45.6	−45.6 ± 1.1	2	1.5 ± 0.7	

Surface waters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	1		−6.18	1		−33.9	1	1.1
River	8	−6.38	−4.89 ± 2.8	8	−37.8	−31.4 ± 16.5	8	1.9 ± 0.6

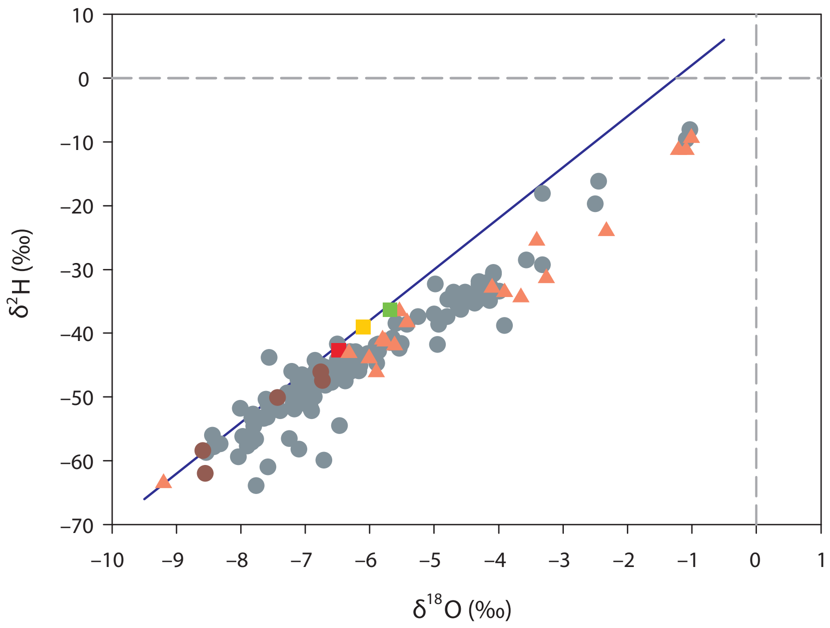
Groundwaters	δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water										
GW–Borehole	117	−7.08	−7.08 ± 0.6	117	−46.4	−45.8 ± 5.0	70	0.9 ± 1.0	34	36 ± 40
GW–Dug well										
GW–Spring										

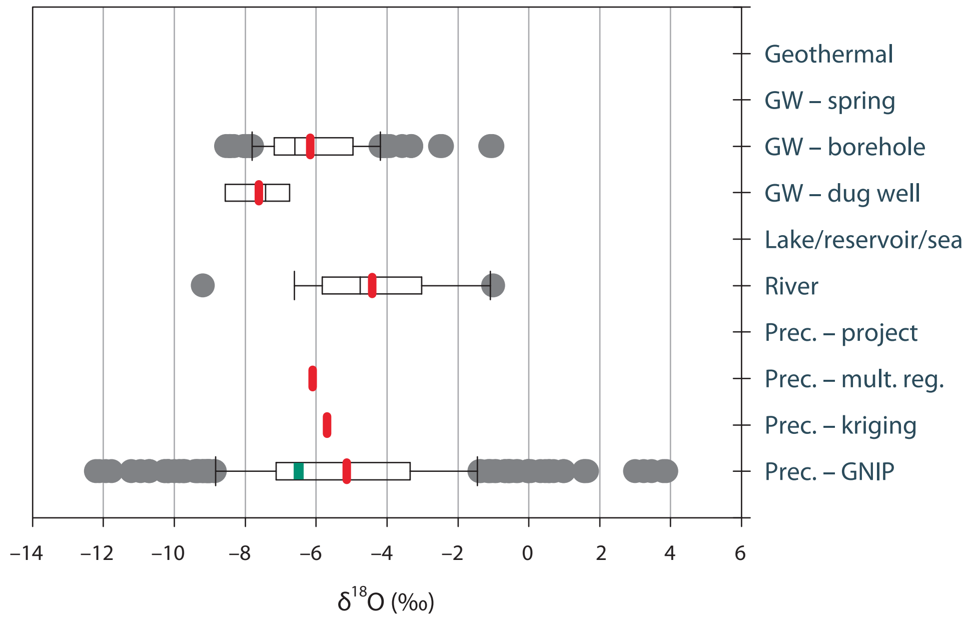


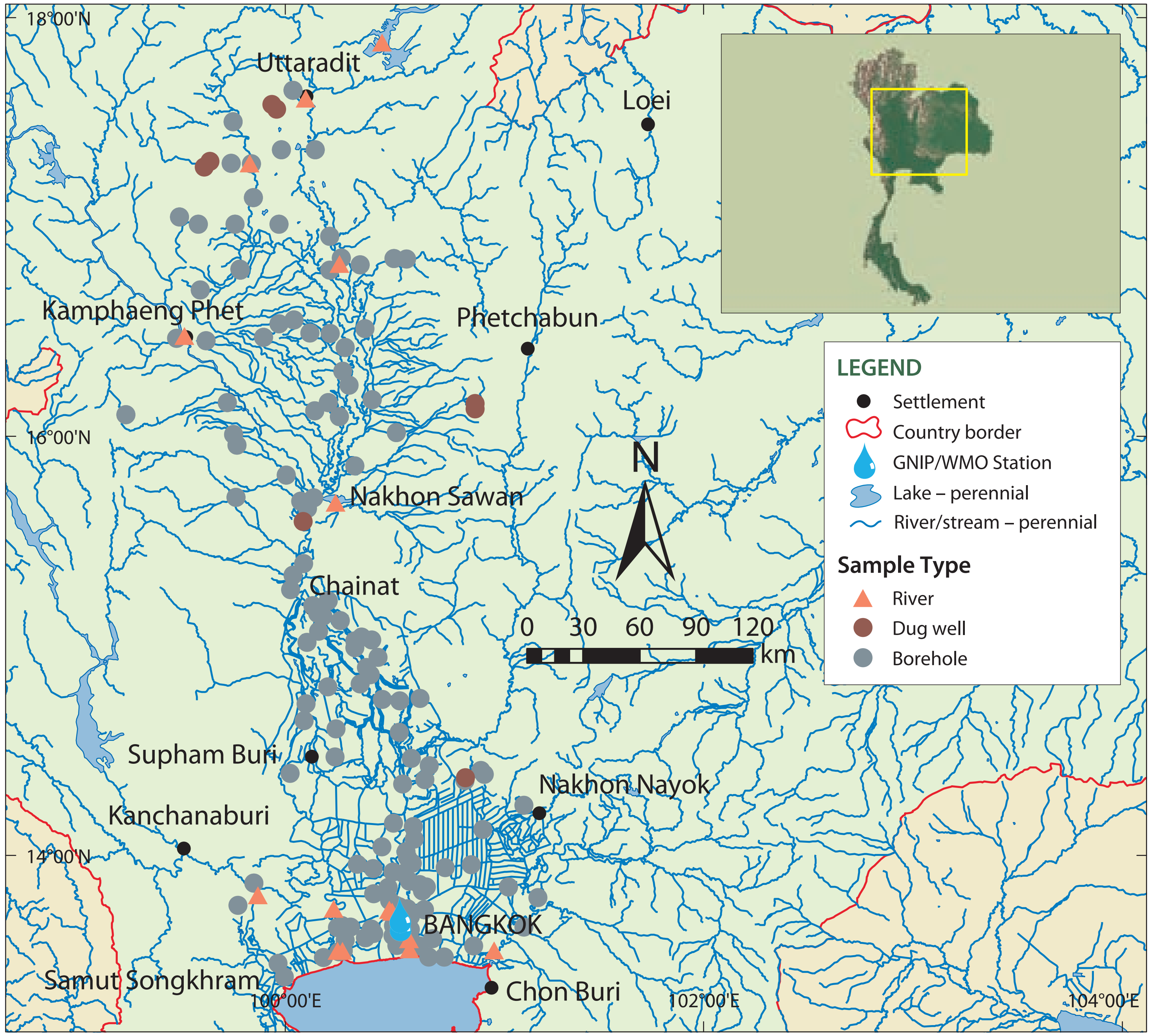


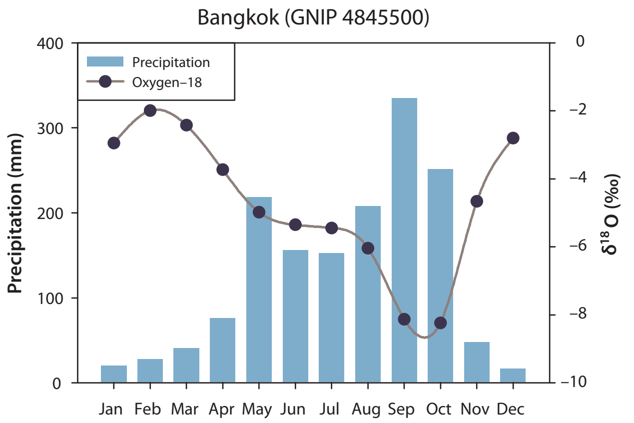
THA-4803C

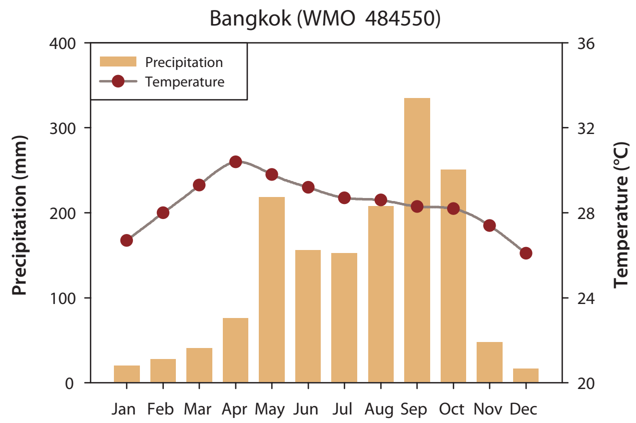
Chao Phraya basin





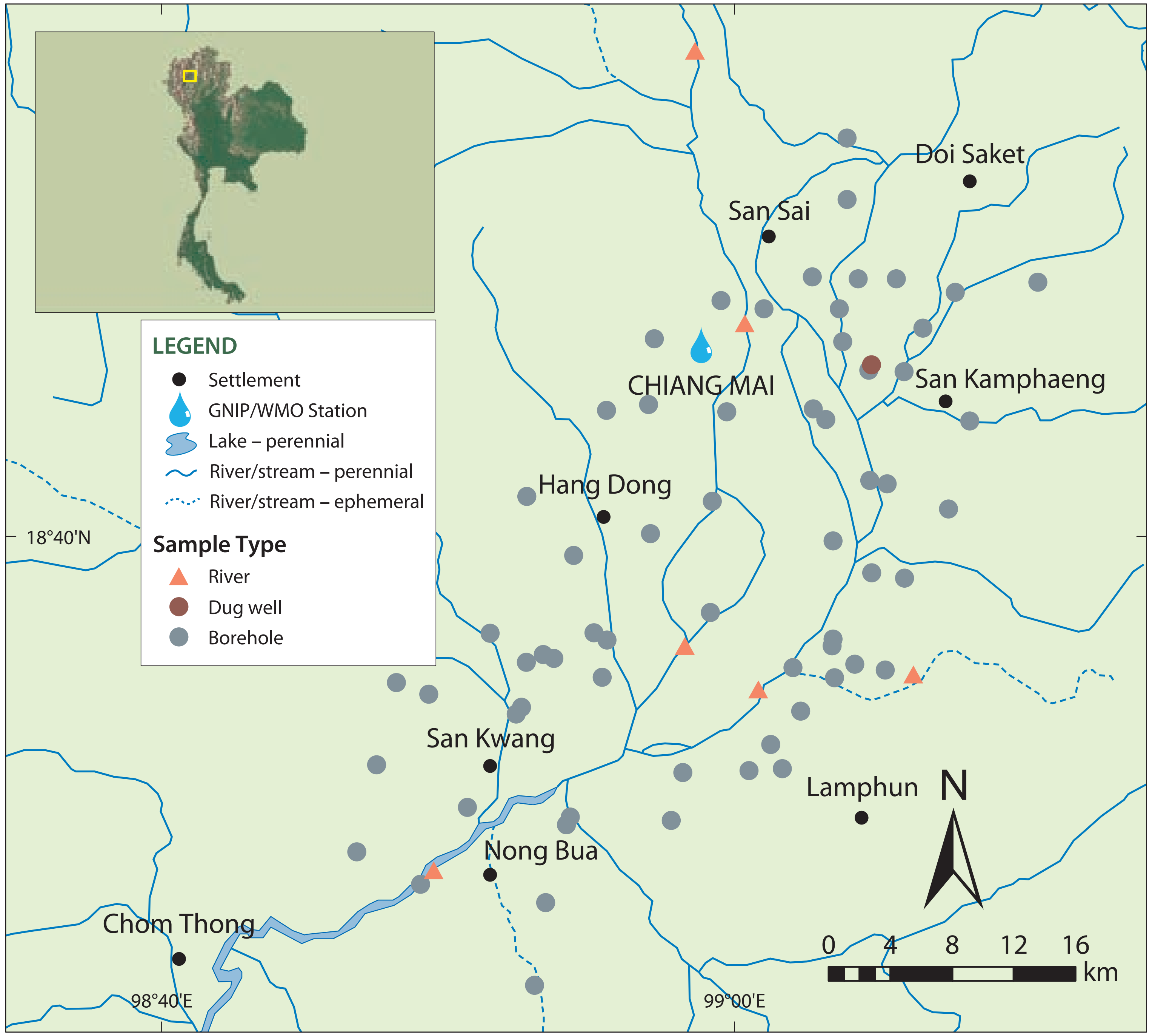


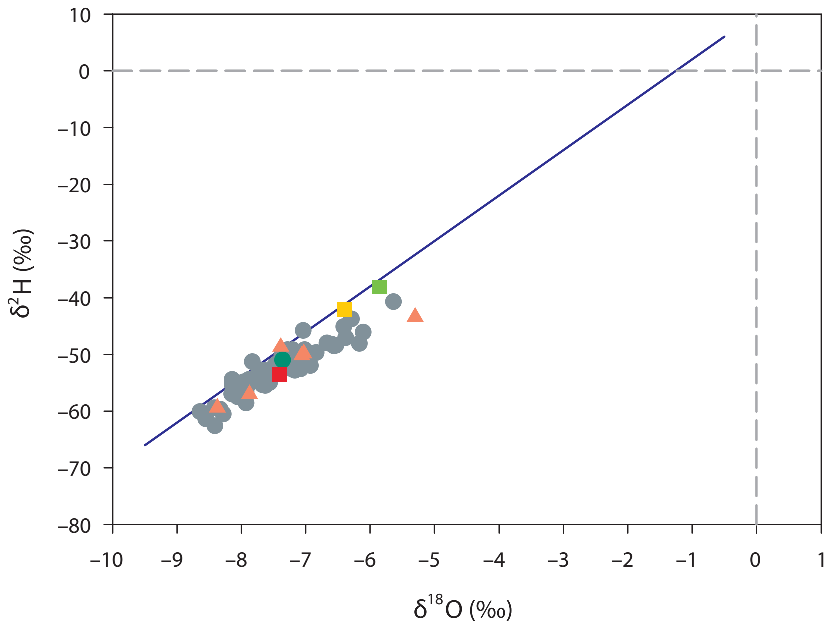


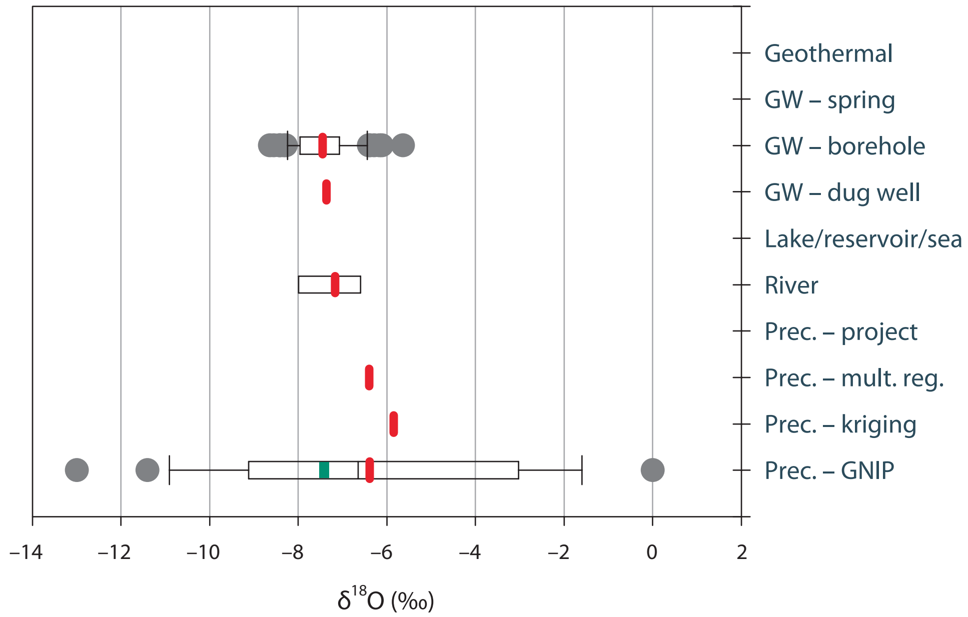


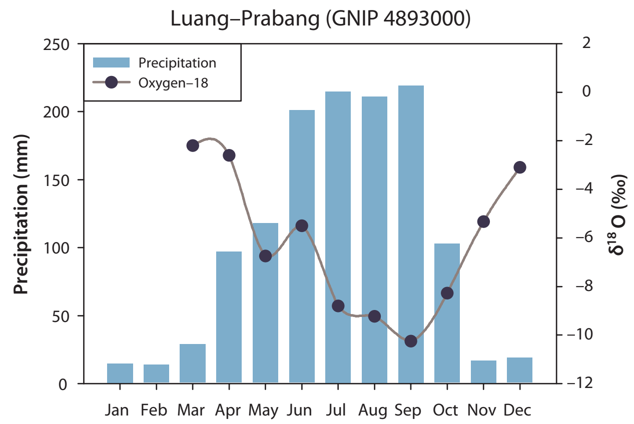
Precipitation		$\delta^{18}O$ (‰)			$\delta^{2}H$ (‰)			Tritium (TU)		Annual prec. (mm)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
GNIP station BANGKOK	■	346	−5.15	−6.48 ± 1.5	318	−33.6	−42.7 ± 10.1				1498
Interpolation – multiple reg.	■			−6.10			−39.0				
Interpolation – kriging (IAEA)	■			−5.69			−36.4				
Project	■										
Surface waters		$\delta^{18}O$			$\delta^{2}H$			Tritium			
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.		
Lake/reservoir/sea	▲										
River	▲	18	−4.76	−4.42 ± 2.2	18	−35.5	−33.9 ± 13.7	10	4.8 ± 1.4		
Groundwaters		$\delta^{18}O$			$\delta^{2}H$			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	●										
GW–Borehole	●	140	−6.60	−6.17 ± 1.5	137	−46.0	−44.2 ± 9.8	47	1.2 ± 1.9	117	18 ± 38
GW–Dug well	●	5	−7.43	−7.61 ± 0.9	5	−50.1	−52.8 ± 7.0	4	2.5 ± 3.3	6	86 ± 10
GW–Spring	●										

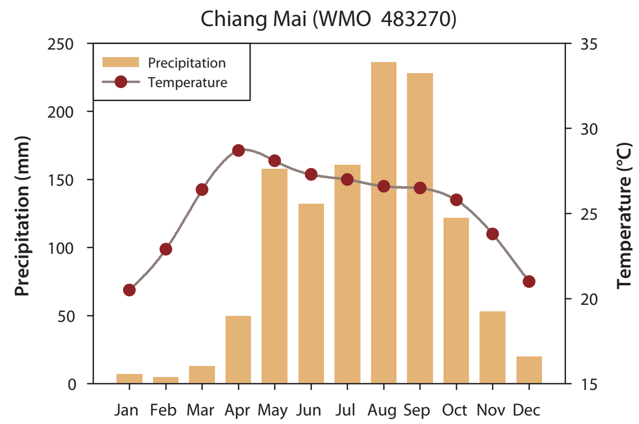
THA-6233
Chiang Mai basin







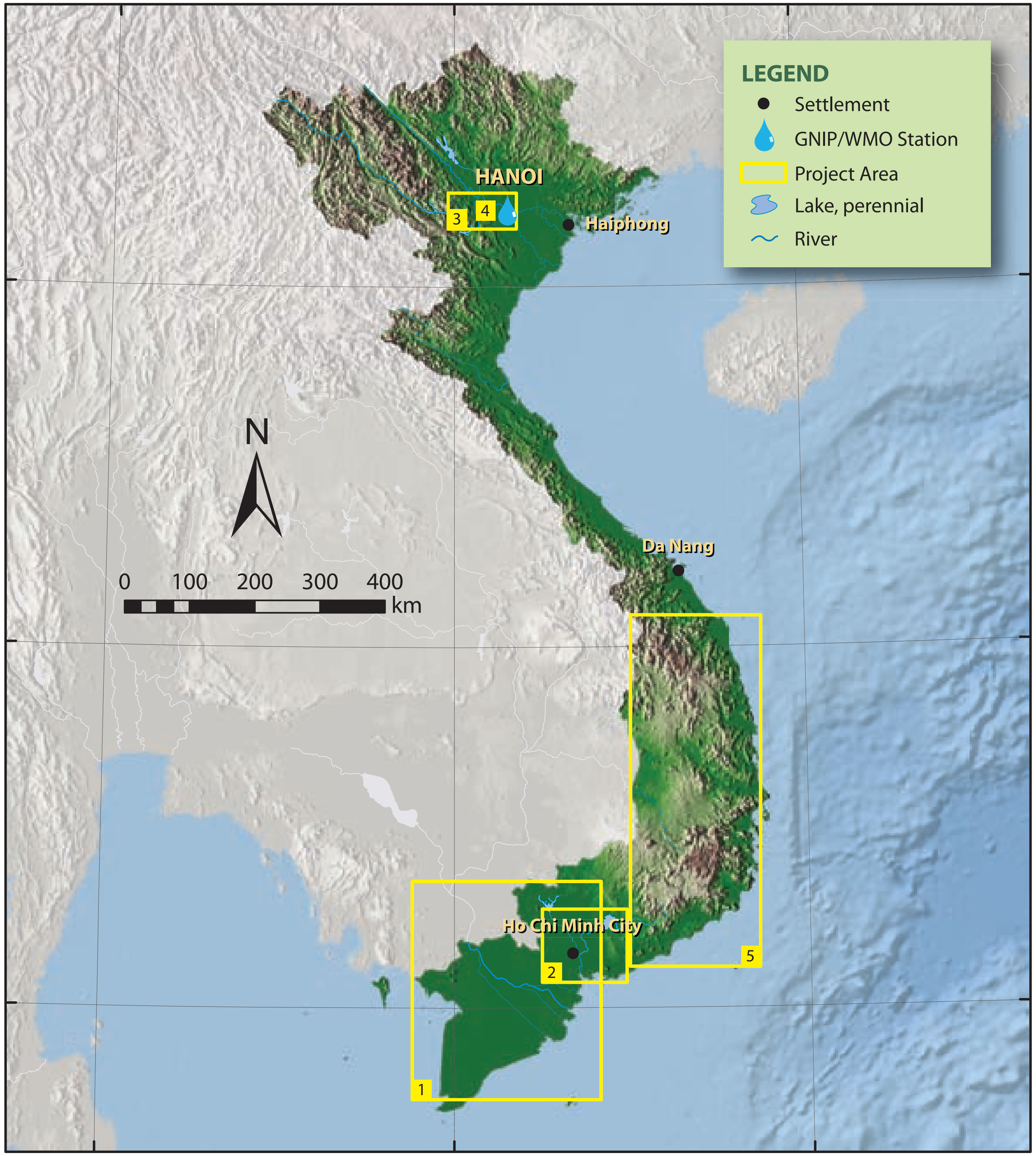




Precipitation		$\delta^{18}O$ (‰) n	Median	Mean ± St. dev.	δ^2H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station LUANG-PRABANG	red square	26	−6.65	−7.41 ± 2.8	26	−43.9	−53.6 ± 10.8			1229
Interpolation – multiple reg.	yellow square			−6.40			−42.0			
Interpolation – kriging (IAEA)	green square			−5.85			−38.1			
Project	pink square									

Surface waters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	yellow triangle								
River	orange triangle	6	−7.23	−7.17 ± 1.1	6	−50.0	−51.4 ± 5.8		

Groundwaters		$\delta^{18}O$ n	Median	Mean ± St. dev.	δ^2H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	^{14}C (pMC) n	Mean ± St. dev.
Geothermal water	blue circle										
GW–Borehole	grey circle	62	−7.49	−7.45 ± 0.7	62	−52.6	−52.9 ± 4.4	36	1.8 ± 2.4	31	63 ± 37
GW–Dug well	brown circle	1		−7.36	1		−51.0	1	1.6		
GW–Spring	teal circle										



1 **Project Code:** VIE8003, RAS8084-VIE
Study area: Mekong Delta aquifers
Sampling period: 1982–1983, 1986–1990, 1999–2002
Background: The deltaic aquifers present a challenge to water managers due to their complex hydrogeological structure. In Mekong delta, isotope investigations were carried out to understand the origin, dynamics, and age of groundwater in this complex aquifer system. The problems of salinity and extent of saline intrusions were also addressed using isotope techniques.

2 **Project Code:** VIE8008, VIE8012, VIE8016, RAS8097M-VIE
Study area: Ho Chi Minh City area
Sampling period: 1994–1995, 1999–2004
Background: The coastal aquifers of the Ho Chi Minh City area form the main source of domestic water supply. The aquifers are subjected to overexploitation and are under the threat of pollution and salinization. Isotope studies were undertaken to understand the recharge and dynamics of groundwater. Mechanism of salinization, vulnerability to pollution, and modelling the extent of pollution/saline intrusions into the aquifers over the period of time were also studied.

3 **Project Code:** RAS8084-VIE, RAS8097H-VIE, RAS8104H-VIE
Study area: Hanoi city area
Sampling period: 1999–2001
Background: Parts of Hanoi city area are facing problems of arsenic poisoning of groundwater. The problem is compounded at some places due to nitrate contamination. The isotope studies aimed at understanding recharge mechanism of groundwater, vulnerability of aquifers to pollution as well as studying extent of river water–groundwater interactions for assessing arsenic mobilization in the aquifers.

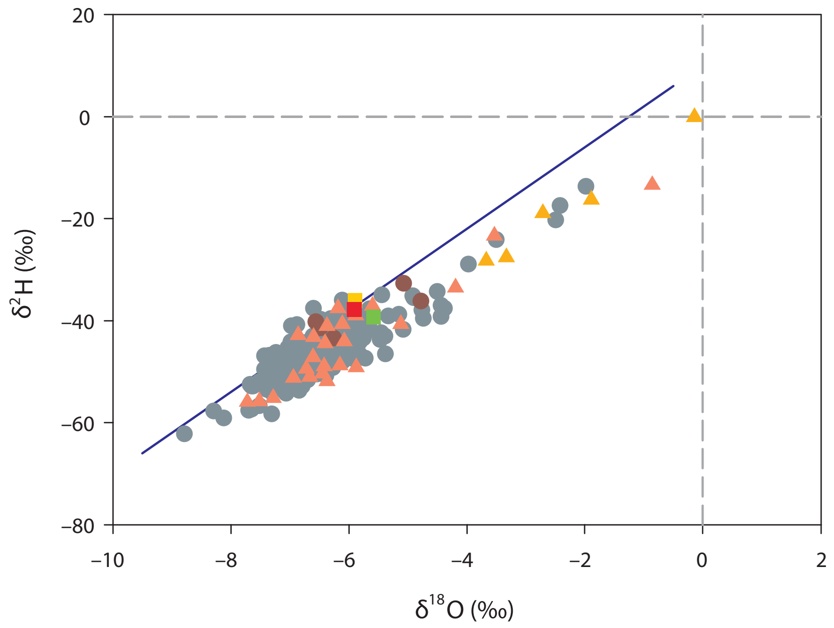
4 **Project Code:** RAS8093-VIE, RAS8104D-VIE
Study area: Dong Mo dam area
Sampling period: 2002, 2005–2007
Background: These projects were implemented to assist the authorities in the detection of seepage and leakage paths at the Dong Mo dam area as well as for determining extent of recharge in aquifers downstream.

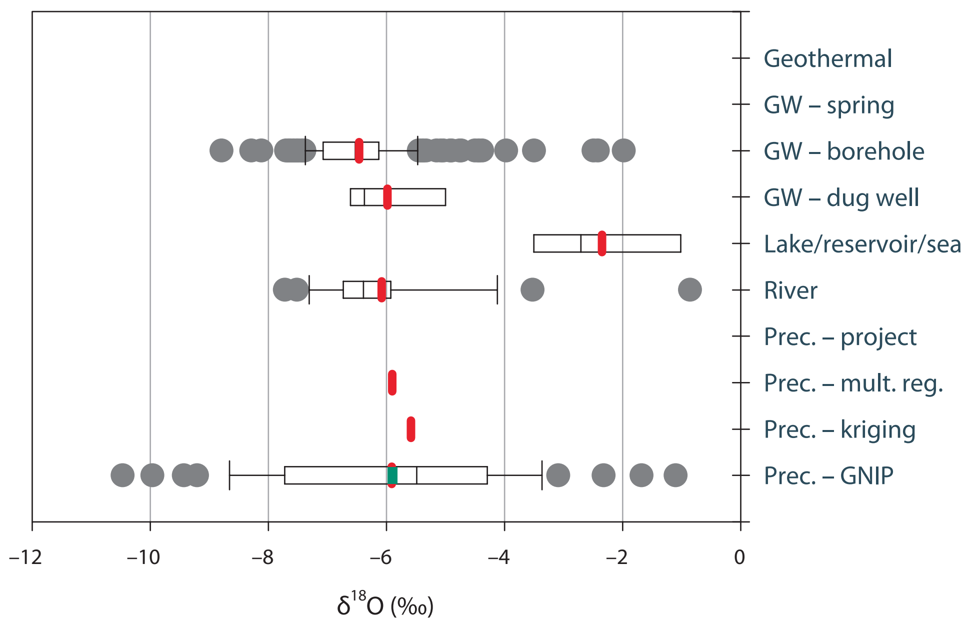
5 **Project Code:** VIE-5840
Study area: Trungbo geothermal area
Sampling period: 1990–1991
Background: Under this research contract, isotope investigation was carried out in Trungbo geothermal area to study the dynamics and geothermometry of thermal springs in the coastal region of southern Vietnam to find out their suitability for energy production.

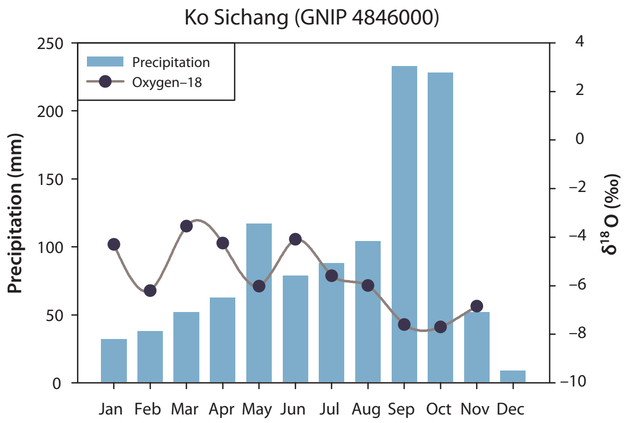
IAEA Water Resources Programme

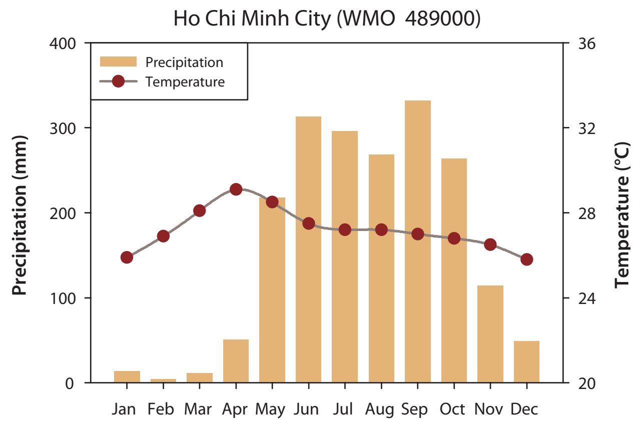
VIE8003; RAS8084-VIE

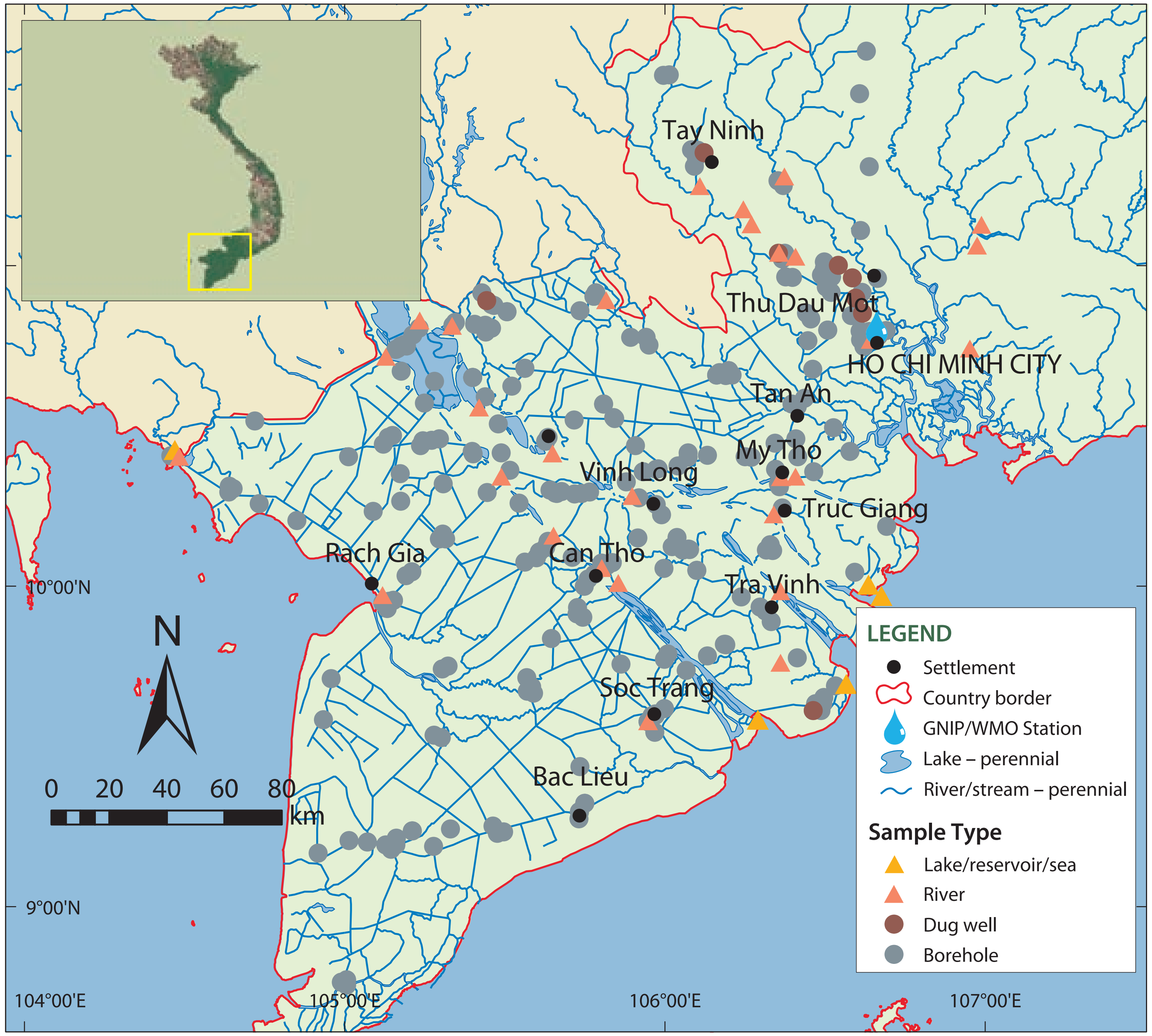
Mekong Delta aquifers











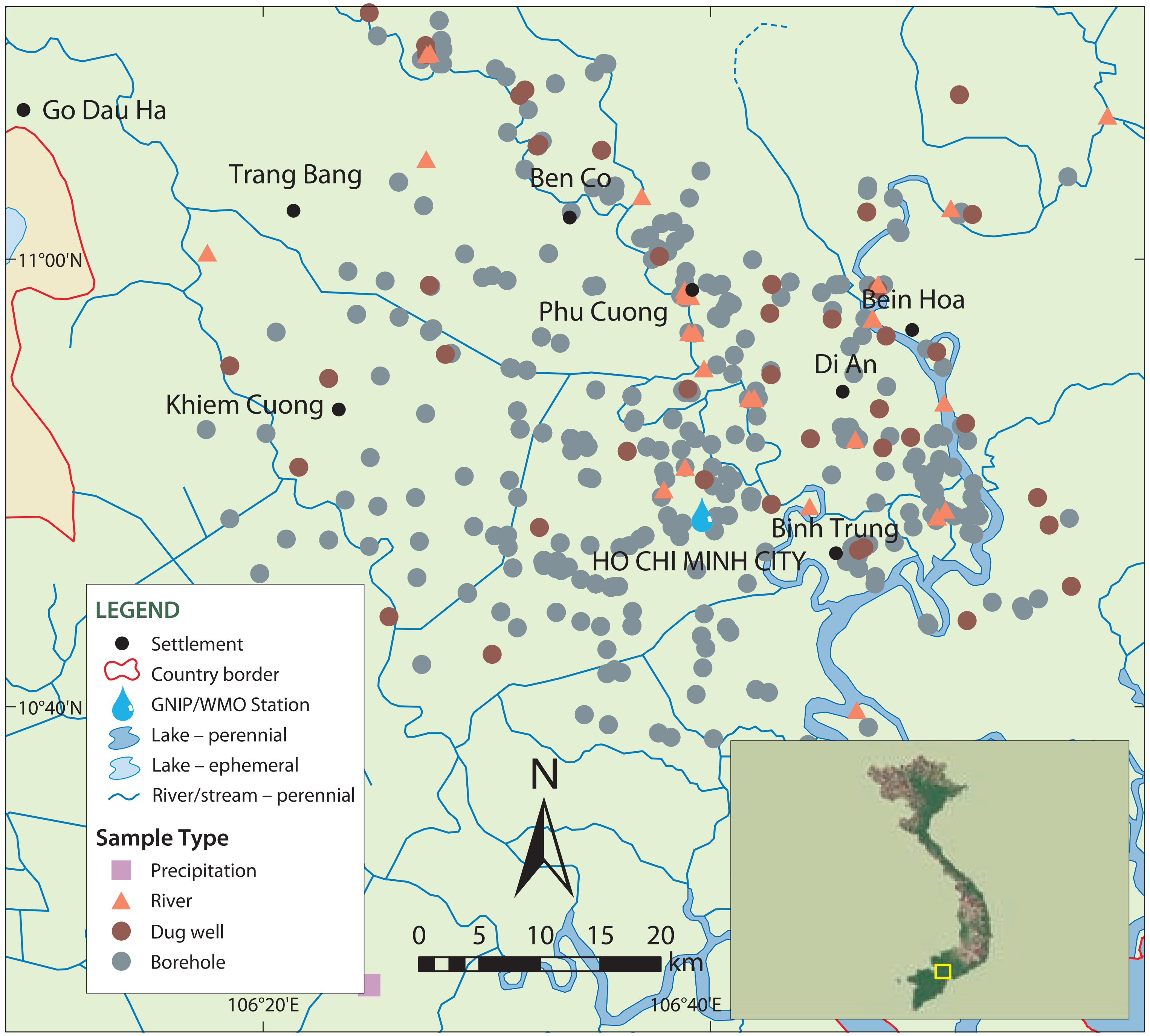
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station KO SICHANG	■ (red)	46	−5.49	−5.91 ± 1.4	45	−35.0	−37.8 ± 6.2			877
Interpolation – multiple reg.	■ (yellow)			−5.90			−36.0			
Interpolation – kriging (IAEA)	■ (green)			−5.58			−39.3			
Project	■ (pink)									

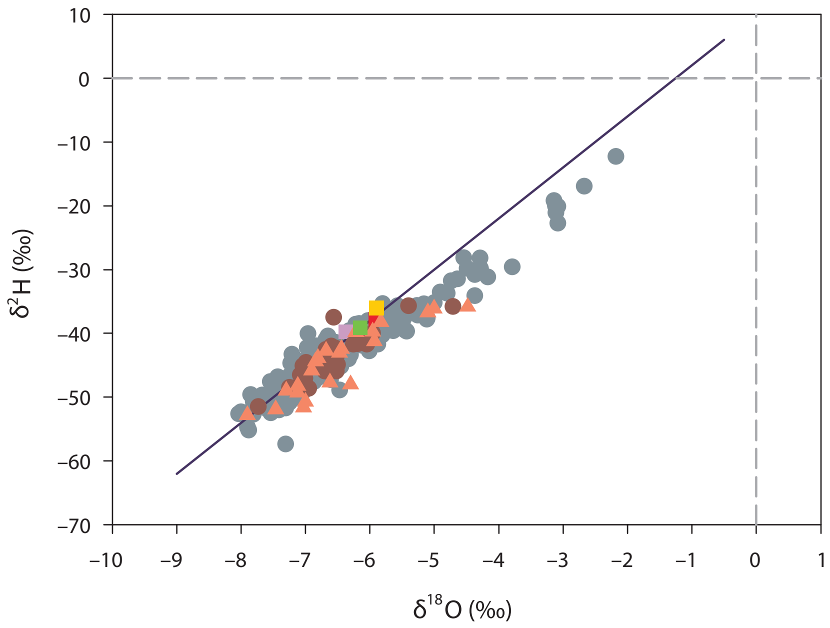
Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ (orange)	5	−2.71	−2.35 ± 1.4	5	−18.9	−18.2 ± 11.4	1	1.5
River	▲ (salmon)	28	−6.39	−6.08 ± 1.4	25	−44.4	−43.8 ± 9.9	13	6.5 ± 4.0

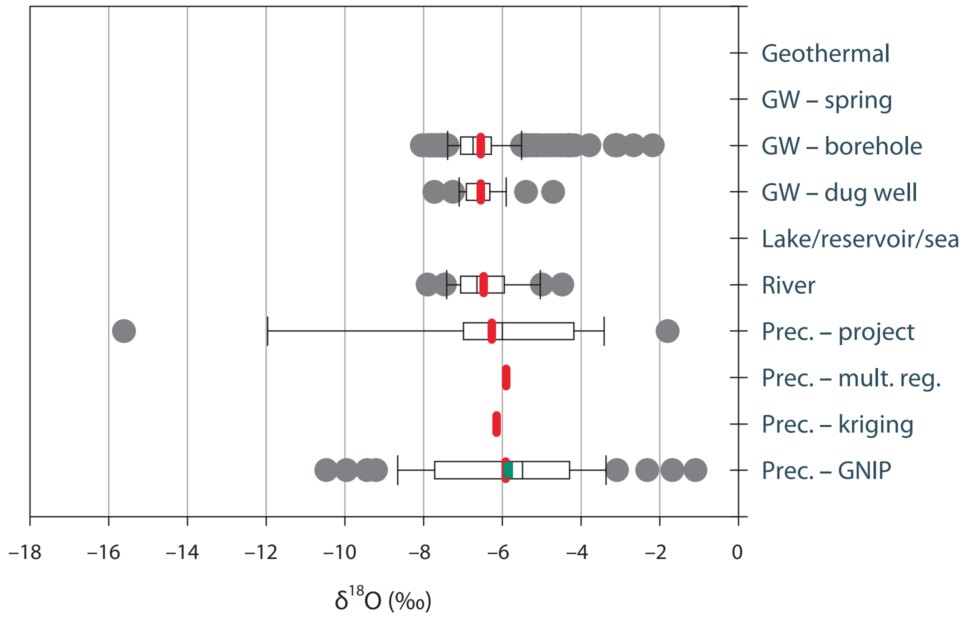
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	218	−6.53	−6.47 ± 0.9	197	−46.8	−45.3 ± 9.6	30	1.7 ± 2.8	138	13 ± 23
GW–Dug well	● (brown)	6	−6.38	−5.98 ± 0.8	5	−40.2	−38.8 ± 4.3	4	4.9 ± 3.0	2	96 ± 2
GW–Spring	● (green)										

VIE8008; VIE8012; VIE8016; RAS8097M–VIE

Ho Chi Minh City area



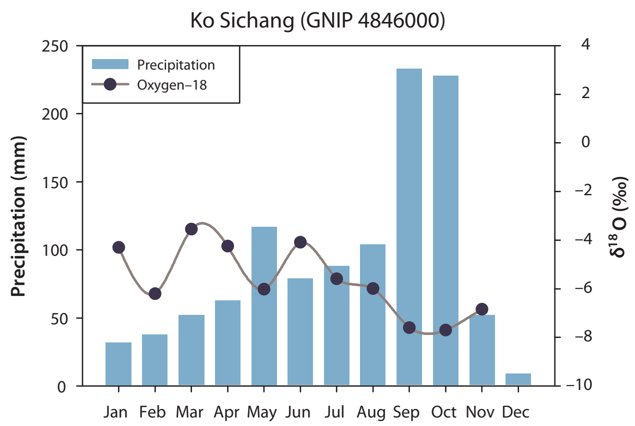


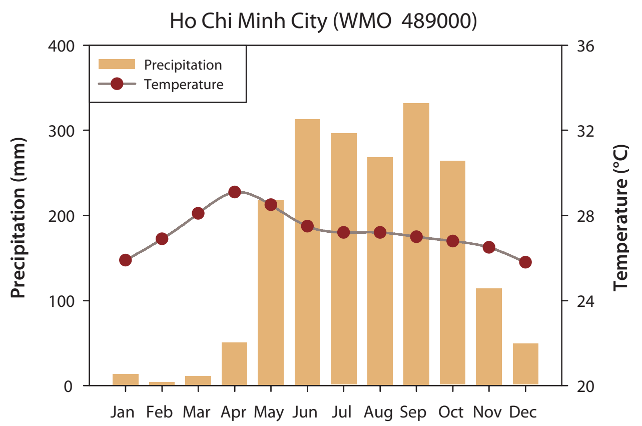


Precipitation		δ^{18}O (‰)			δ^2H (‰)			Tritium (TU)		Annual prec. (mm)
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	
GNIP station KO SICHANG	■ (red)	46	−5.49	−5.91 ± 1.4	45	−35.0	−37.8 ± 6.2			877
Interpolation – multiple reg.	■ (yellow)			−5.90			−36.0			
Interpolation – kriging (IAEA)	■ (green)			−6.15			−39.1			
Project	■ (pink)	18	−6.01	−6.27 ± 3.2	18	−33.5	−39.7 ± 25.6	18	3.1 ± 1.4	

Surface waters		δ^{18}O			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea	▲ (yellow)								
River	▲ (orange)	22	−6.65	−6.48 ± 0.8	22	−44.1	−44.5 ± 5.4	10	2.2 ± 0.9

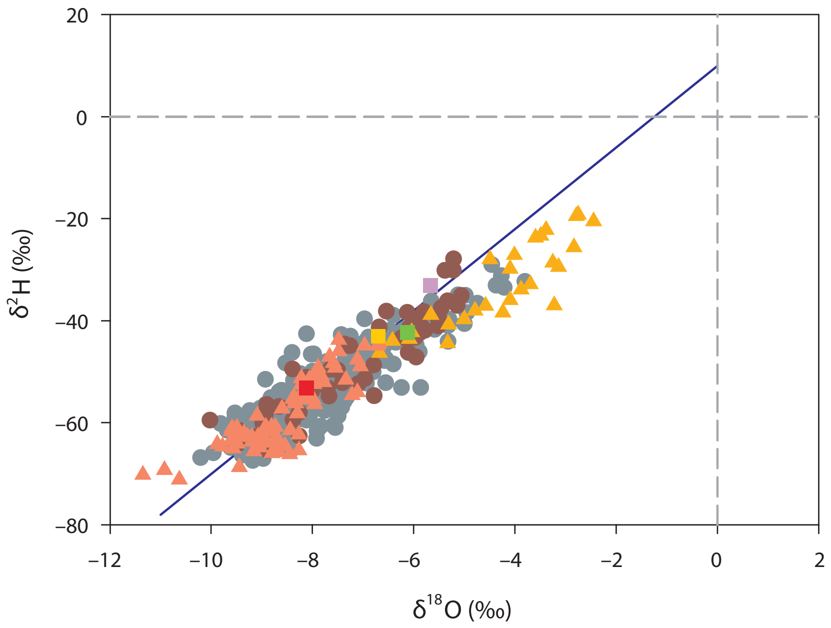
Groundwaters		δ^{18}O			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water	● (blue)										
GW–Borehole	● (grey)	378	−6.74	−6.55 ± 0.9	378	−43.8	−43.3 ± 5.7	174	1.0 ± 1.4	6	67 ± 27
GW–Dug well	● (brown)	28	−6.59	−6.55 ± 0.6	28	−43.4	−43.4 ± 3.6	8	2.3 ± 0.5		
GW–Spring	● (green)										

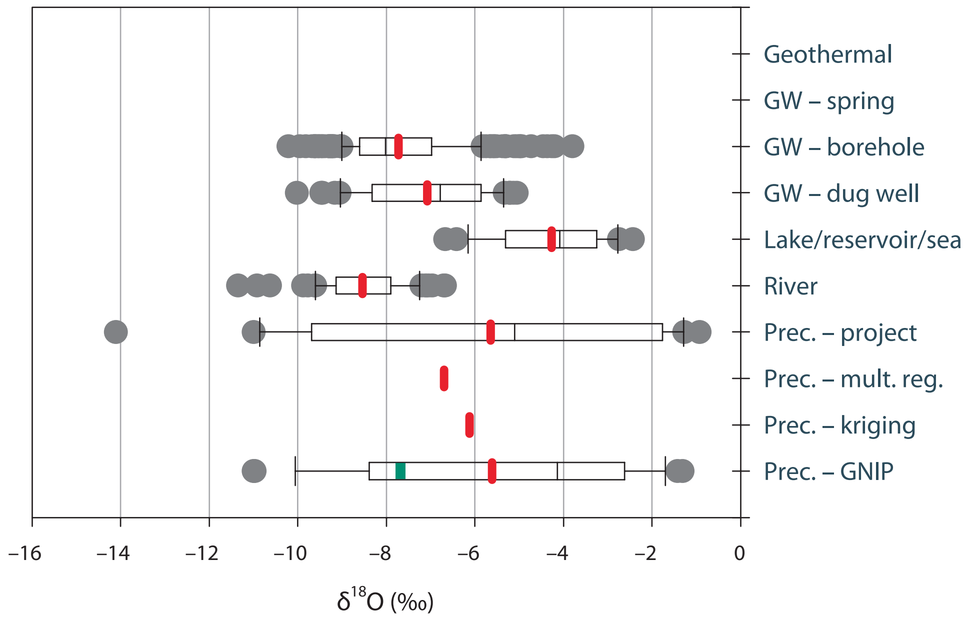


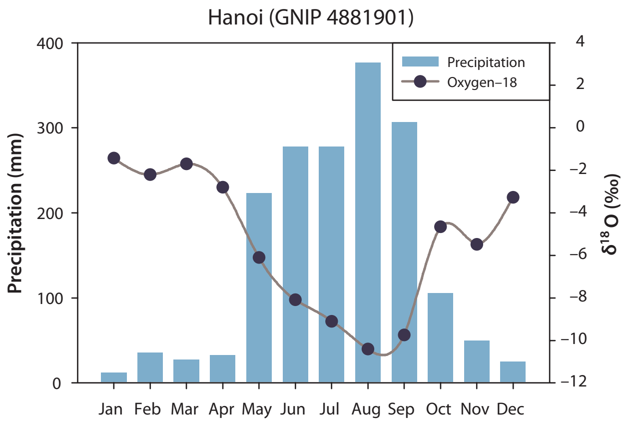


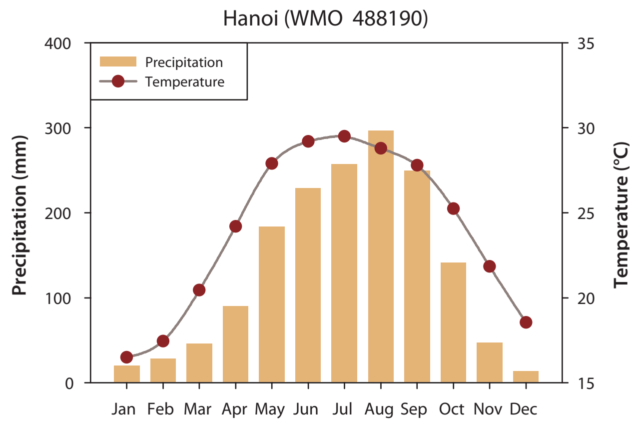
RAS8084–VIE; RAS8097H–VIE; RAS8104H–VIE

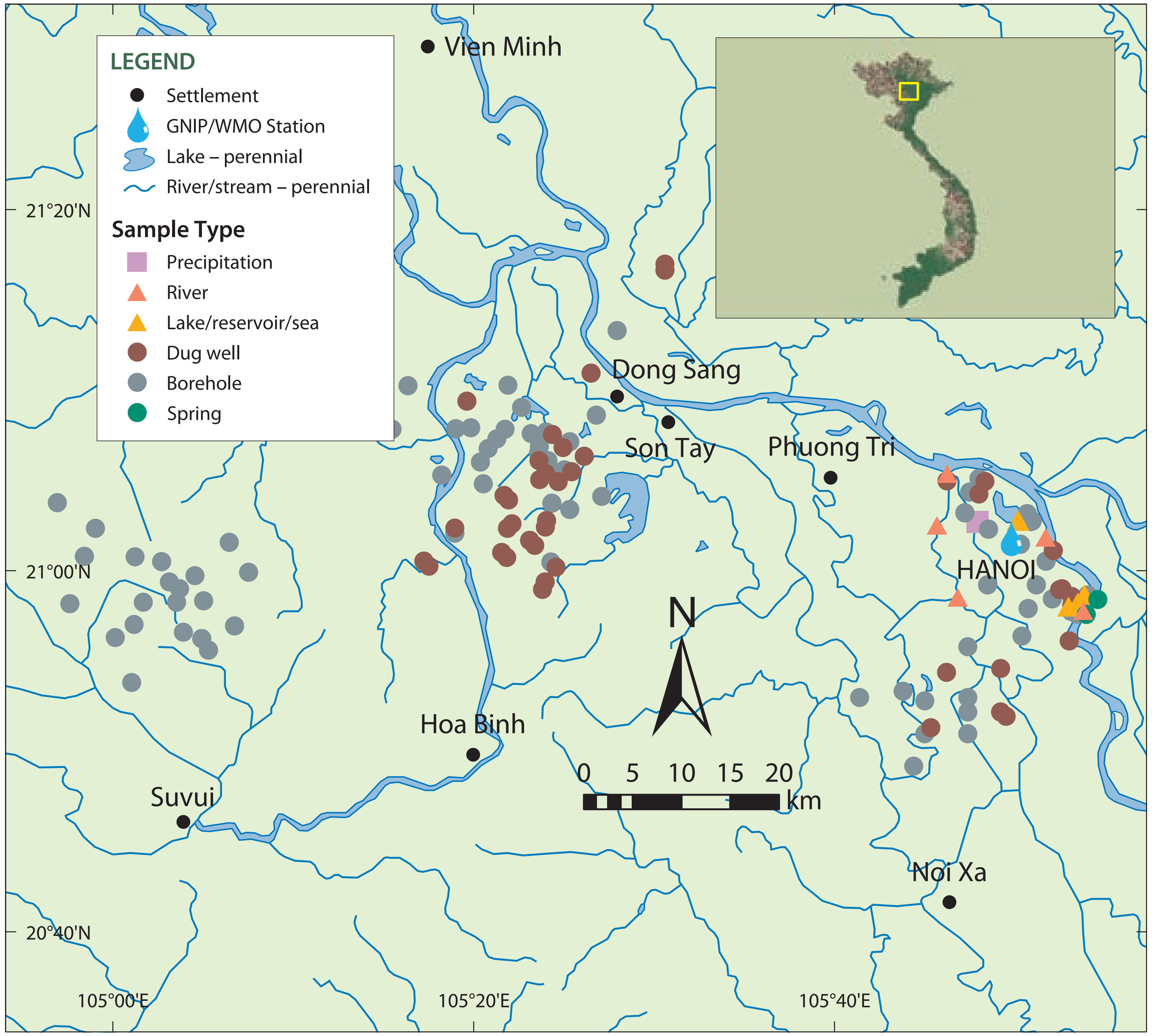
Hanoi city area







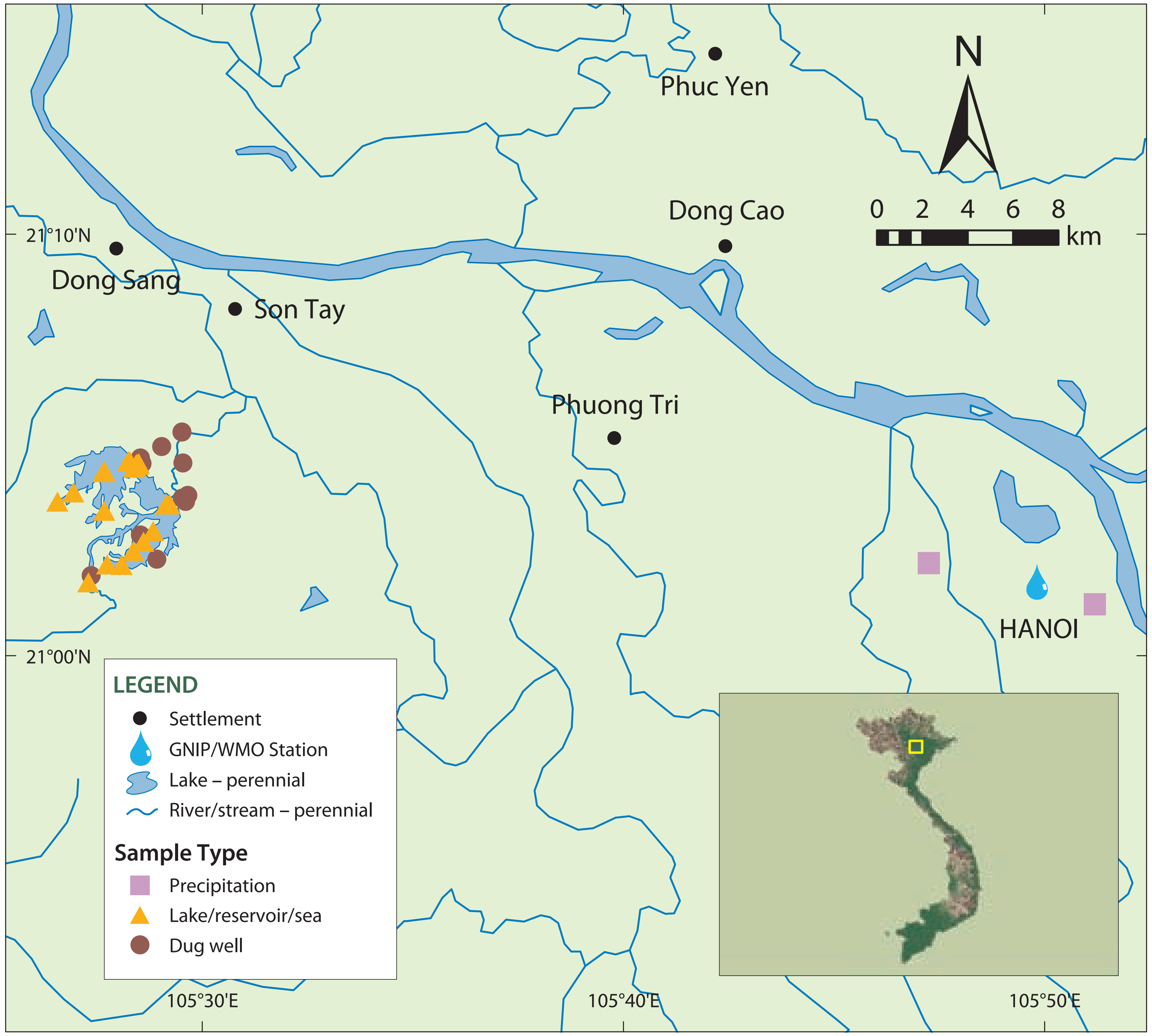


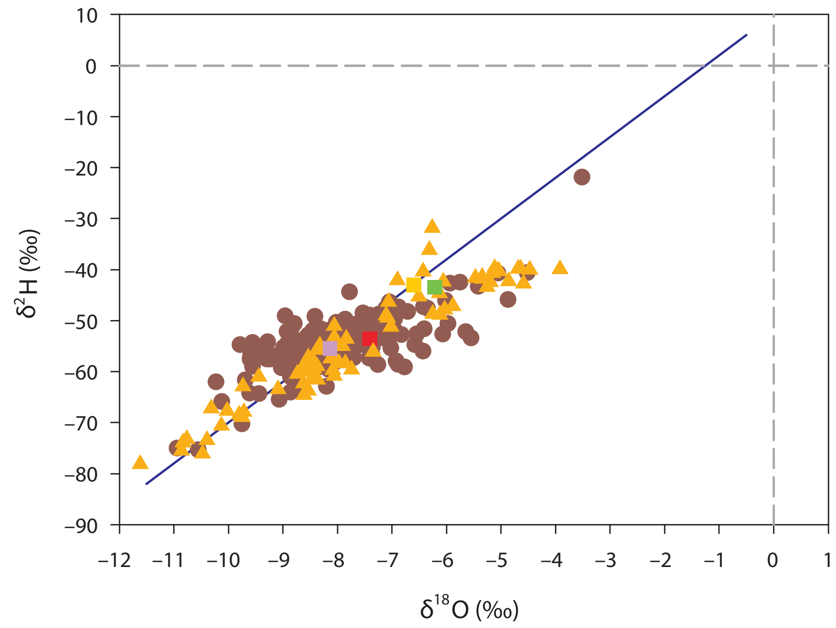


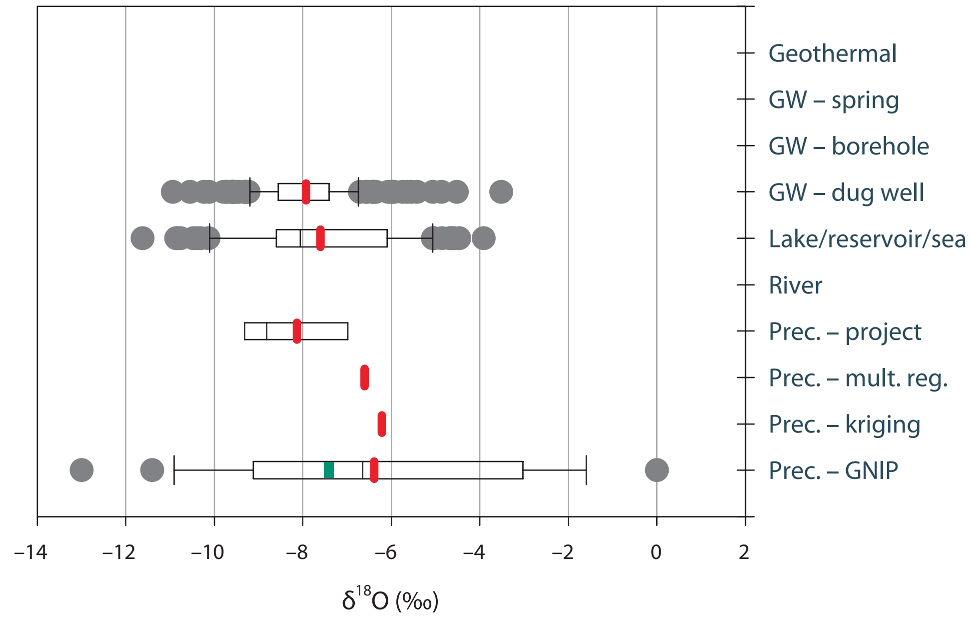
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.	Annual prec. (mm)
GNIP station HANOI	■ red	27	–4.14	–7.78 ± 0.4	27	–23.2	–50.7 ± 3.0			1752
Interpolation – multiple reg.	■ yellow			–6.70			–43.0			
Interpolation – kriging (IAEA)	■ green			–6.12			–42.3			
Project	■ pink	23	–5.11	–5.65 ± 3.9	23	–28.6	–32.8 ± 31.3			

Surface waters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.
Lake/reservoir/sea	▲ yellow	27	–4.09	–4.27 ± 1.2	27	–33.8	–33.0 ± 8.4		
River	▲ orange	72	–8.50	–8.54 ± 0.9	72	–60.8	–58.2 ± 7.1		

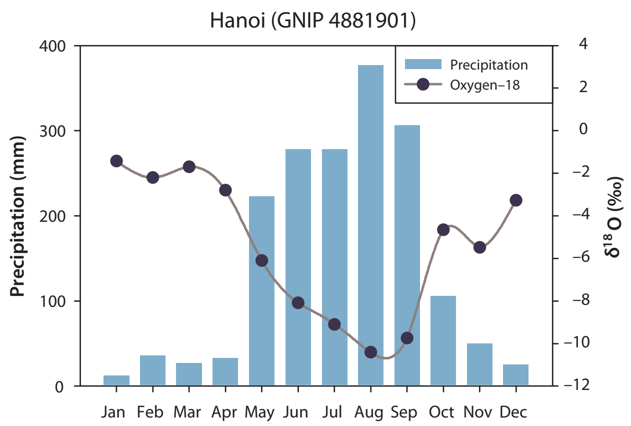
Groundwaters		δ¹⁸O n	Median	Mean ± St. dev.	δ²H n	Median	Mean ± St. dev.	Tritium n	Mean ± St. dev.	¹⁴C (pMC) n	Mean ± St. dev.
Geothermal water	● blue										
GW–Borehole	● grey	244	–8.02	–7.72 ± 1.2	244	–55.5	–52.8 ± 8.1	20	2.2 ± 1.3	138	
GW–Dug well	● brown	53	–6.79	–7.08 ± 1.4	53	–48.7	–48.2 ± 9.9	1	2.9		
GW–Spring	● green										

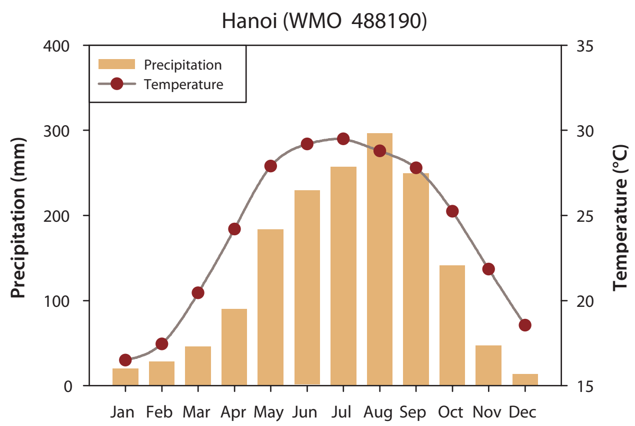






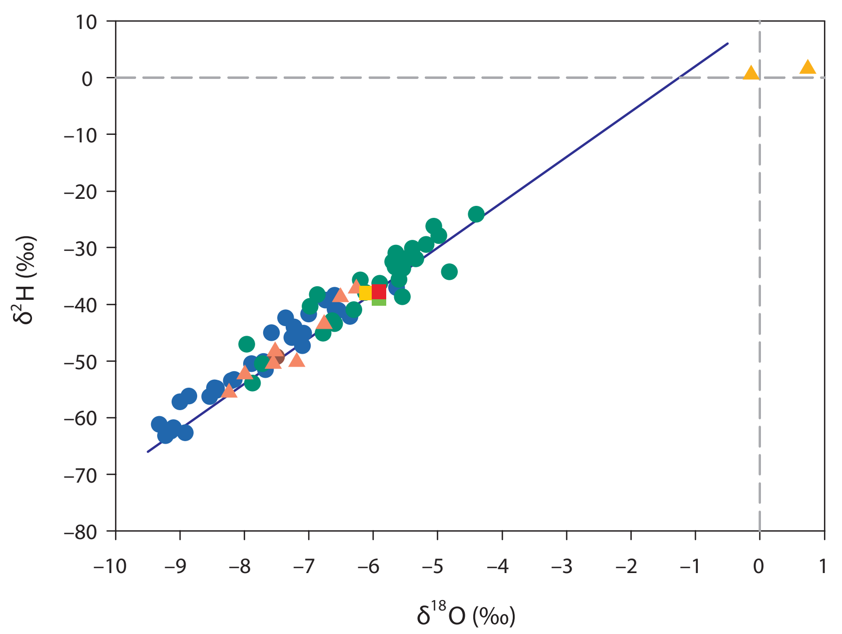
Precipitation		δ¹⁸O (‰) n	Median	Mean ± St. dev.	δ²H (‰) n	Median	Mean ± St. dev.	Tritium (TU) n	Mean ± St. dev.		Annual prec. (mm)
GNIP station HANOI	■	27	−4.14	−7.78 ± 0.4	27	−23.2	−50.7 ± 3.0				1752
Interpolation – multiple reg.	■			−6.60			−43.0				
Interpolation – kriging (IAEA)	■			−6.21			−43.42				
Project	■	6	−8.82	−8.14 ± 1.8	6	−63.0	−55.9 ± 14.2				
Surface waters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.		
Lake/reservoir/sea	▲	81	−8.06	−7.61 ± 1.8	81	−56.8	−54.4 ± 11.0	18	3.6 ± 1.9		
River	▲										
Groundwaters		**δ¹⁸O** n	Median	Mean ± St. dev.	**δ²H** n	Median	Mean ± St. dev.	**Tritium** n	Mean ± St. dev.	**¹⁴C (pMC)** n	Mean ± St. dev.
Geothermal water	●										
GW-Borehole	●										
GW-Dug well	●	194	−7.97	−7.93 ± 1.1	194	−53.7	−54.0 ± 5.4	3	3.6 ± 1.2		
GW-Spring	●										

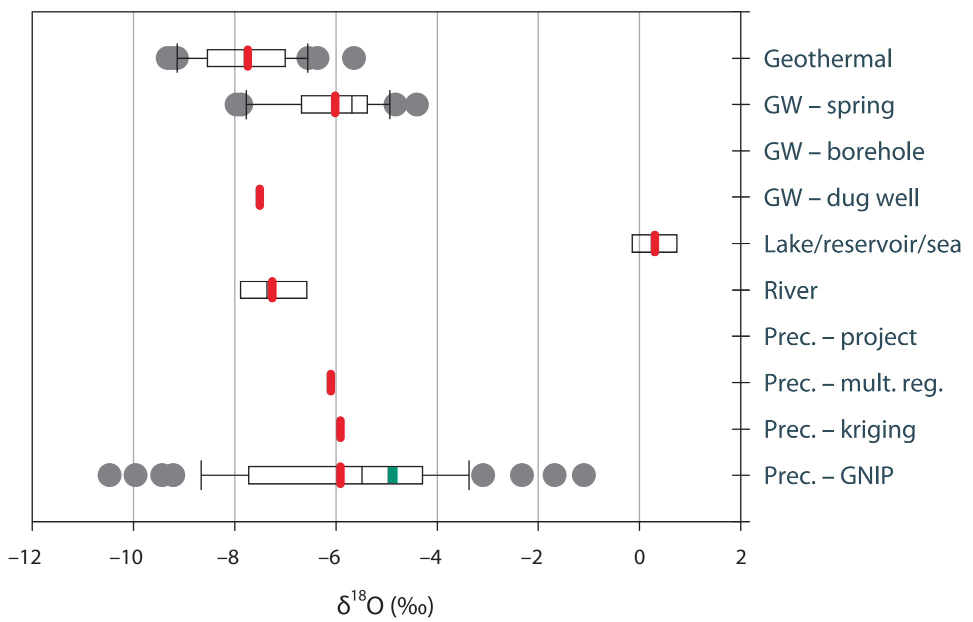


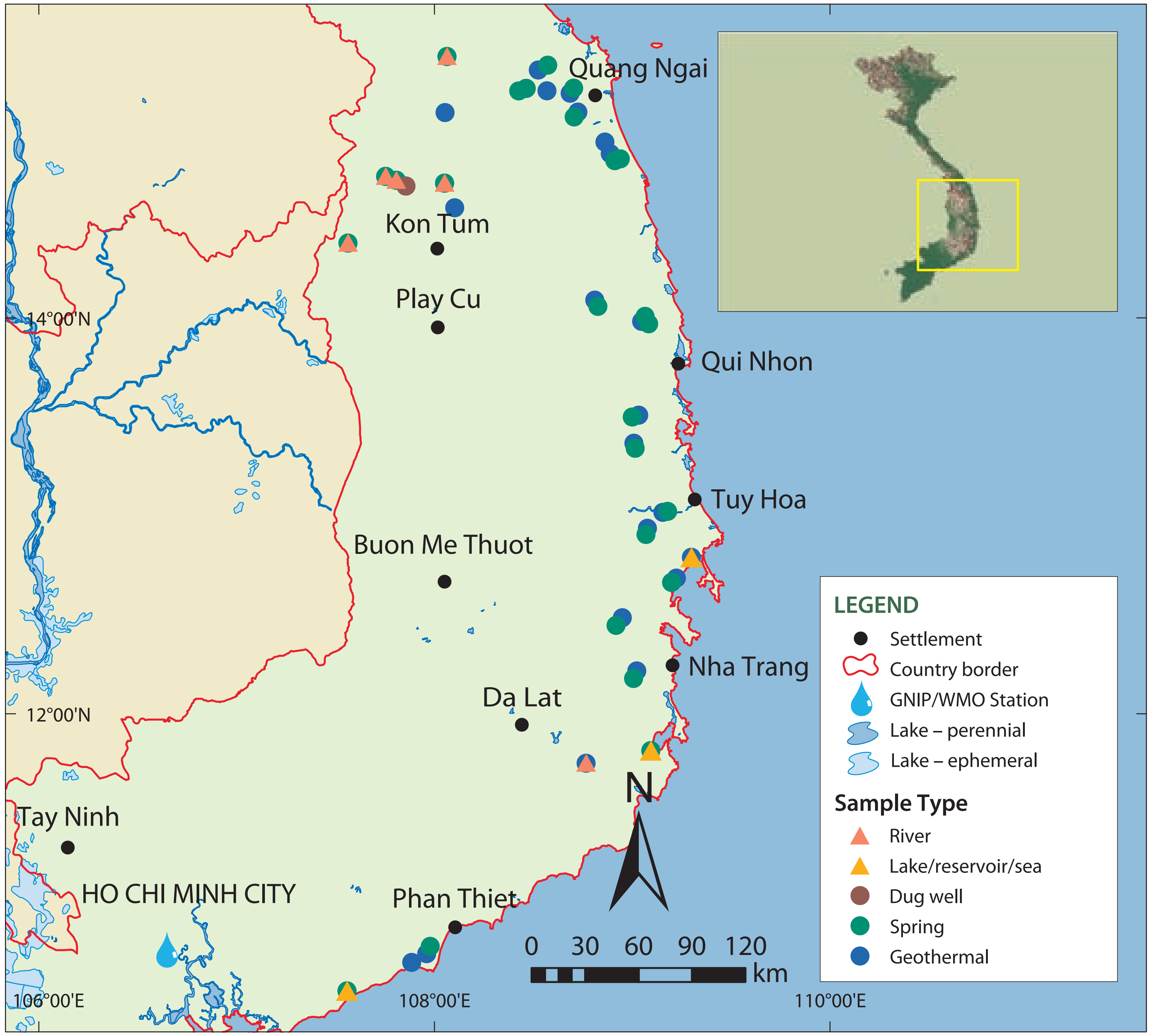


VIE-5840

Trungbo geothermal area



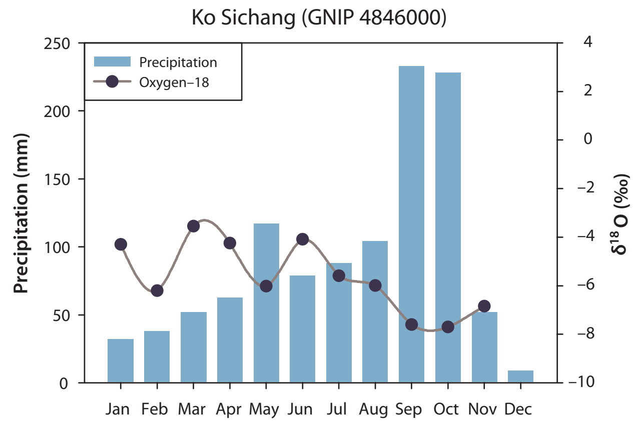


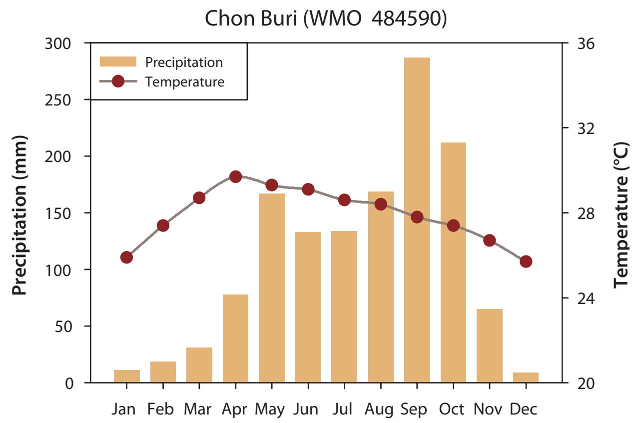


Precipitation		$\delta^{18}O$ (‰)			δ^2H (‰)			Tritium (TU)		Annual prec.
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	(mm)
GNIP station KO SICHANG		46	−5.49	−5.91 ± 1.4	45	−35.0	−37.8 ± 6.2			877
Interpolation – multiple reg.				−6.10			−38.0			
Interpolation – kriging (IAEA)				−5.91			−38.9			
Project										

Surface waters		$\delta^{18}O$			δ^2H			Tritium	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.
Lake/reservoir/sea		2	0.30	0.30 ± 0.6	2	1.1	1.1 ± 0.7		
River		8	−7.36	−7.25 ± 0.7	8	−49.2	−47.1 ± 6.6		

Groundwaters		$\delta^{18}O$			δ^2H			Tritium		^{14}C (pMC)	
		n	Median	Mean ± St. dev.	n	Median	Mean ± St. dev.	n	Mean ± St. dev.	n	Mean ± St. dev.
Geothermal water		31	−7.67	−7.74 ± 1.0	30	−50.3	−49.8 ± 8.2				
GW–Borehole											
GW–Dug well		1		−7.50	1		−49.3				
GW–Spring		26	−5.68	−6.01 ± 0.9	26	−35.6	−36.7 ± 7.4				





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