Fukushima University Institute of Environmental Radioactivity

Karlsruhe Institute of Technology

Assessment and Prognosis in Response to a Nuclear or Radiological Emergency

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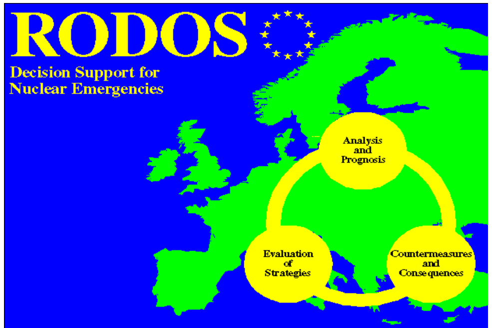
Vienna, Austria

IAEA

Prognosis and Assessment of the Consequences of the Fukushima Daiichi Accident Provided by the models of the Decision Support System RODOS

M.Zheleznyak (1), (2), W.Raskob (3), S.Kivva (1),(2), I. Kovalets (2), V. Maderich (2), K.Nanba (1), R.Bezhenar (2), I. Ievdin (2), D.Trybushnyi (3)

1) Institute Environmental Radioactivity (IER), Fukushima University, Japan
2) Institute of Mathematical Machines and Systems (IMMS), NAS of Ukraine
3) Karlsruhe Institute of Technologies (KIT), Germany



Key features of RODOS
Real-time On-line Decision Support system

- ***Multi-user operation in national/regional emergency centres for off-site nuclear emergency management***

- ***Provision of information for decision-making***

  - **on local / national / regional / European scales,**

  - **in the early and later phases of an accident,**

  - **for all relevant emergency actions and countermeasures.**

- ***Wide IT applicability - HP-UX and Linux (RODOS), Microsoft Windows, Linux and Mac OS (JRodos)***

Historical development

- 1988-2002 RESY (Germany) / RODOS (Europe)
  - until end of 1998: RESY for emergency management in the near range of German NPPs; funded by German BMU
  - Since 1990: RODOS as comprehensive system, with RESY as integral part, but designed also for far range and late phase applications; funded by the EC with the involvement of FSU Institutes within EC Chernobyl Program since 1992
- 2003-2008 Reorganisation, as part of European project EURANOS
  - User wishes: Cheaper hardware, more simple use, maintenance, and customisation, modern look-and-feel of user interface
- Since 2009 Newly organized JAVA based JRodos
  - For operation on modern IT - platforms (Microsoft Windows, Linux, Mac OS)

JRodos: Tasks, input data, output

Meteorology and Release (Measurements / Prognoses / User specified)

Geo-referenced data (orographical data, population, land use, ...); nuclide data, dose factors etc.; intervention criteria and levels; Scenarios for exercises

Radiological Situation
real-time diagnoses + prognoses

→ **Contamination of air, ground, and vegetation, food- and feedstuffs; potential doses**

Countermeasures
actions and consequences

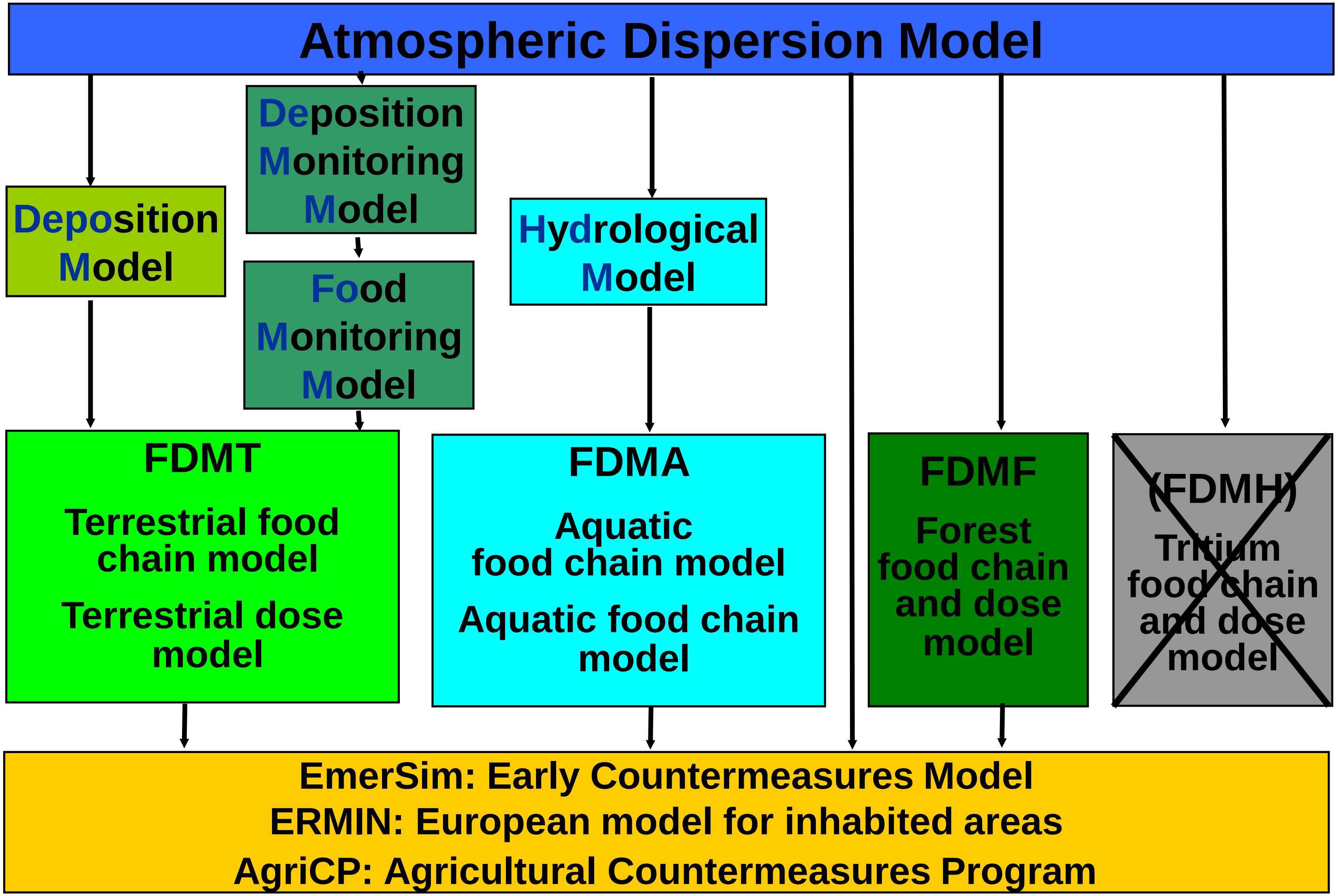
→ **Potential areas with actions; organ doses, health effects , effort and costs**

JRodos Emergency and EmergencyLite-model chains

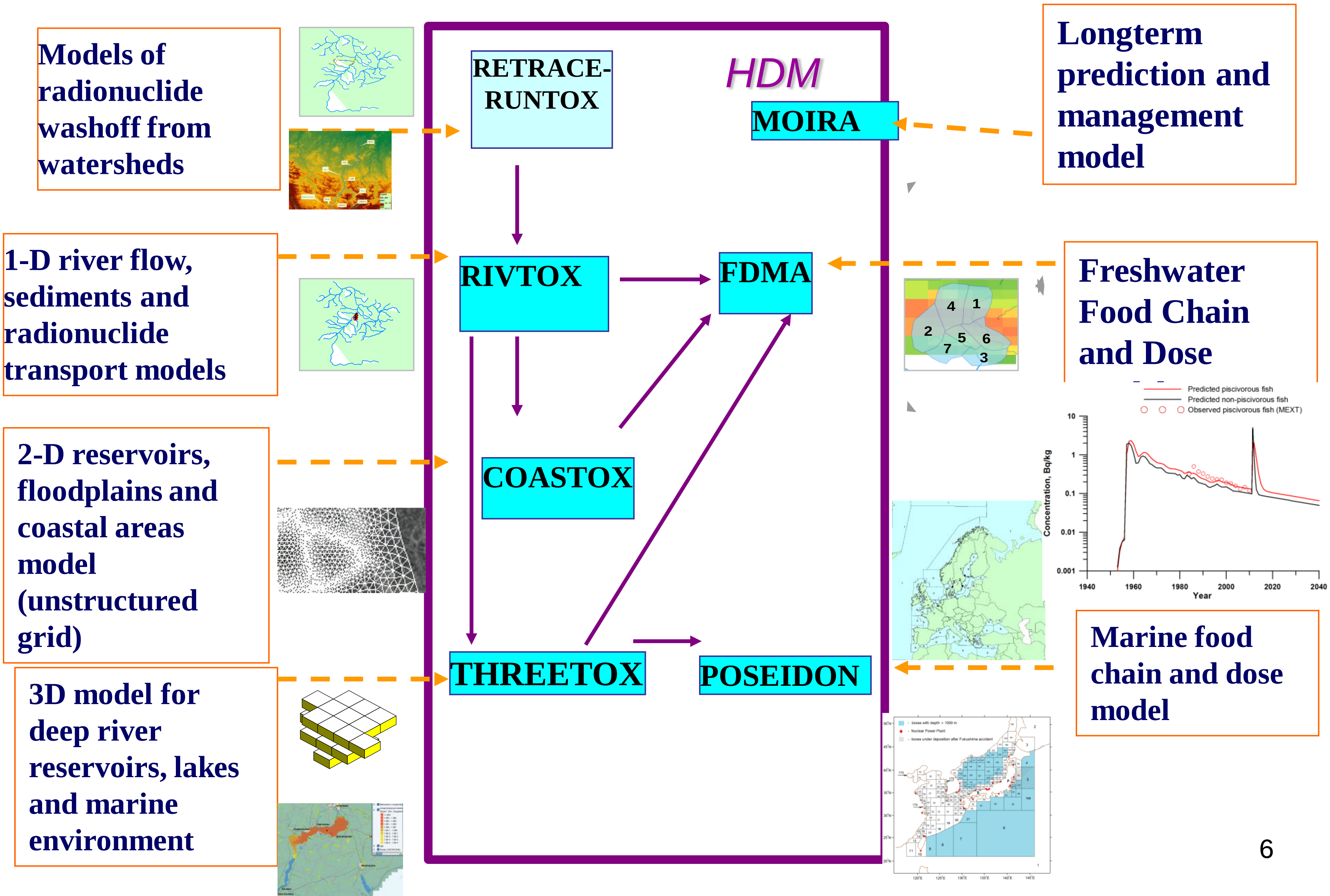
Evaluation
of action sequences

→ **Ranked list of possible strategies (Multi Attribute Value Theory)**

Task: Assessment of radiological situation – JRodos models

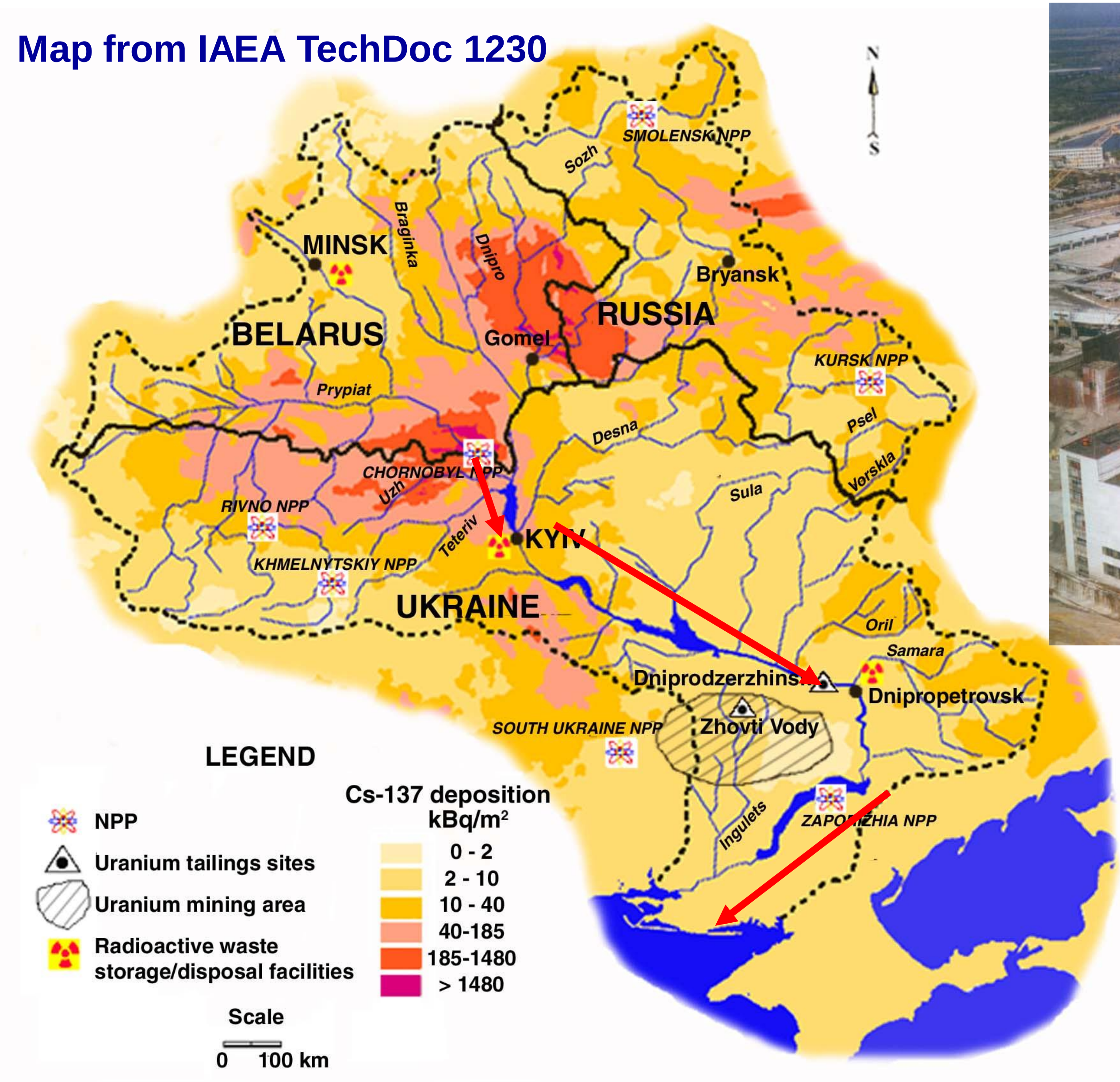


Hydrological Dispersion Models (HDM) of EC Decision Support System for Nuclear Emergency- RODOS



Basis of RODOS Hydrological Models – the models implemented after the Chernobyl Accident

Map from IAEA TechDoc 1230

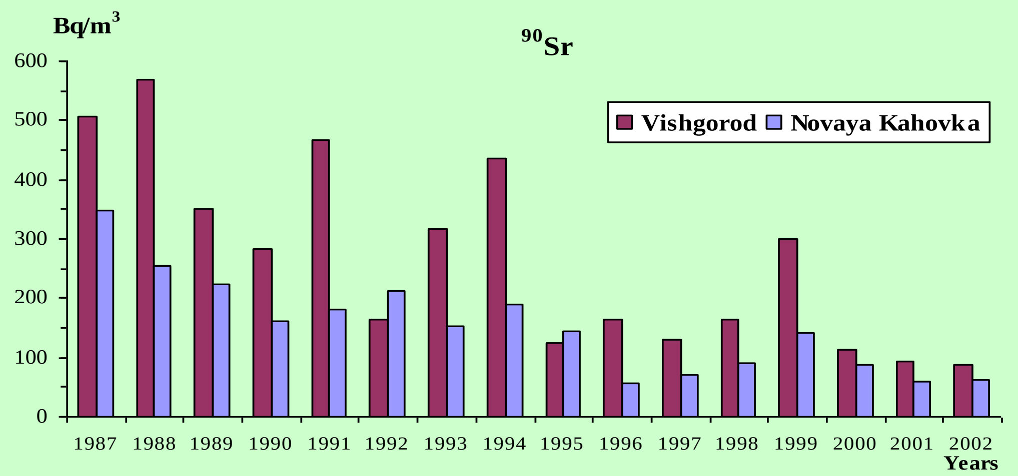


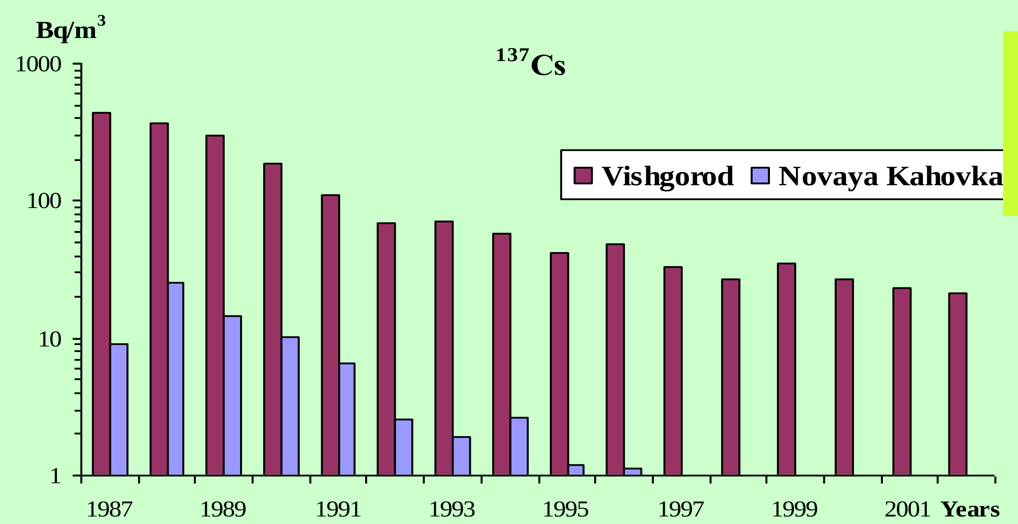
Chernobyl-1986

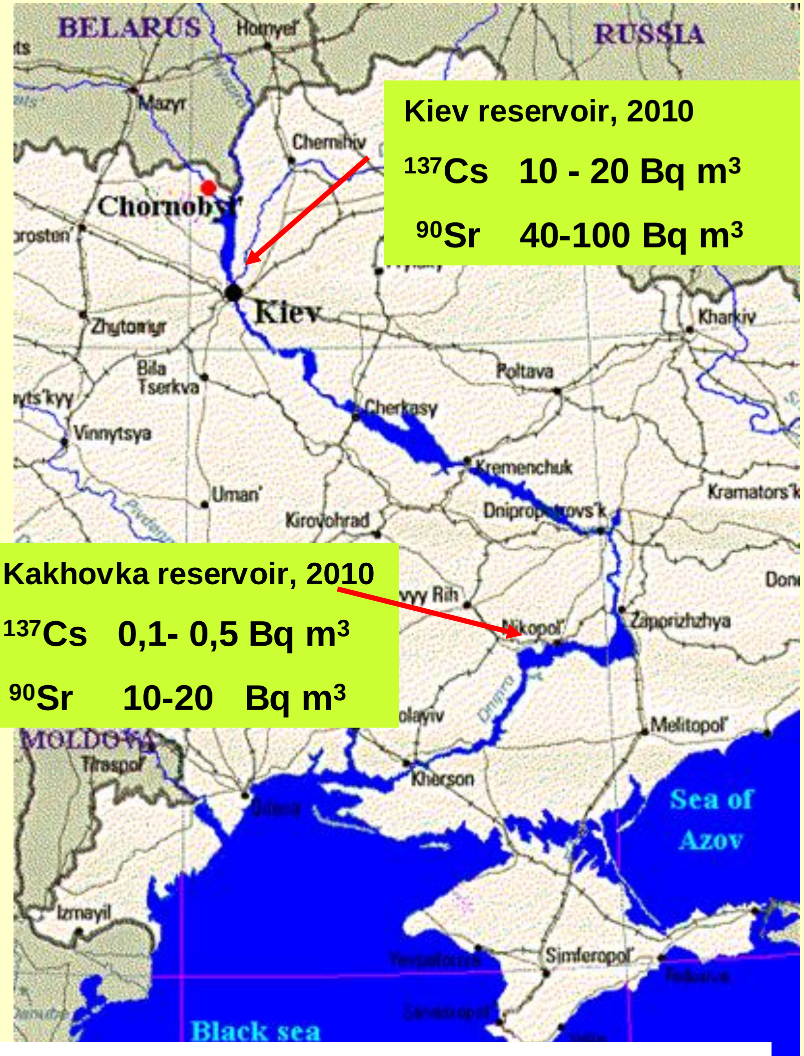
^{90}Sr and ^{137}Cs in the waters of the Dnieper's reservoirs

^{90}Sr in the reservoirs of the Dnieper cascade is still above of its pre-accidental levels

^{137}Cs activity concentration in the water at the lowest reservoir returned to its pre-accidental level still in 1996-1998.

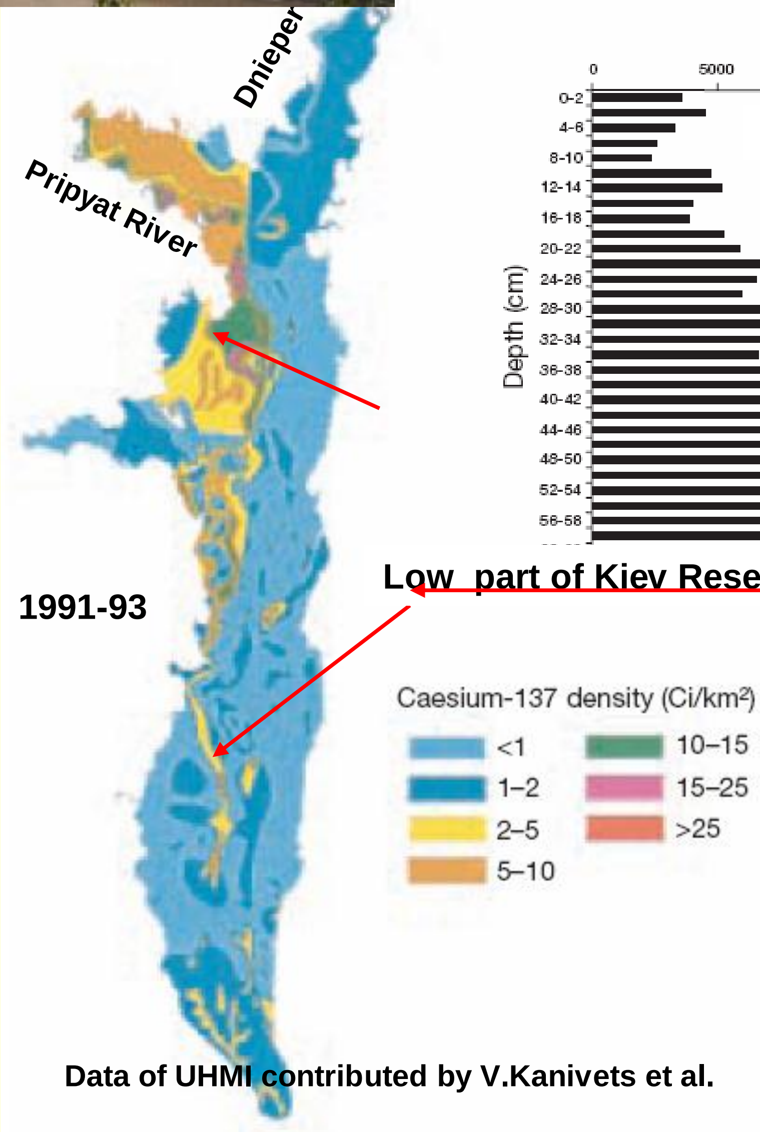


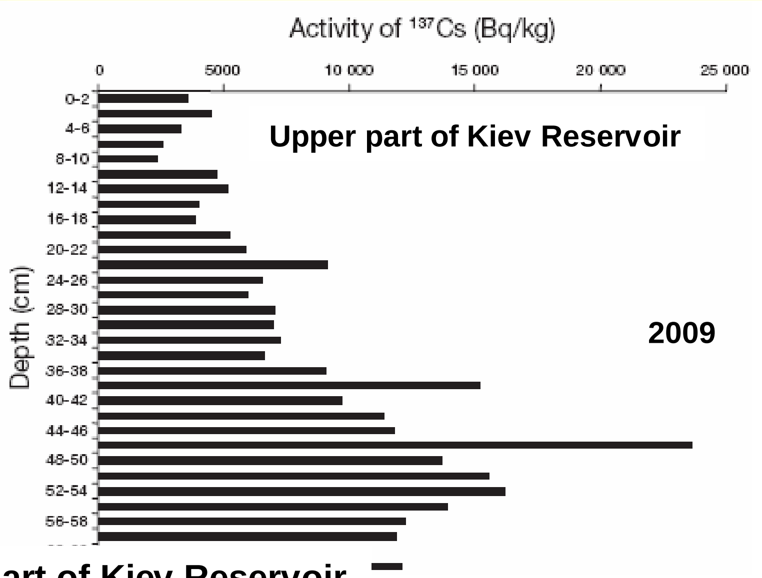




Slide presented by Oleg Voistekhovich (UHMI)

^{137}Cs in the bottom sediments of Reservoirs



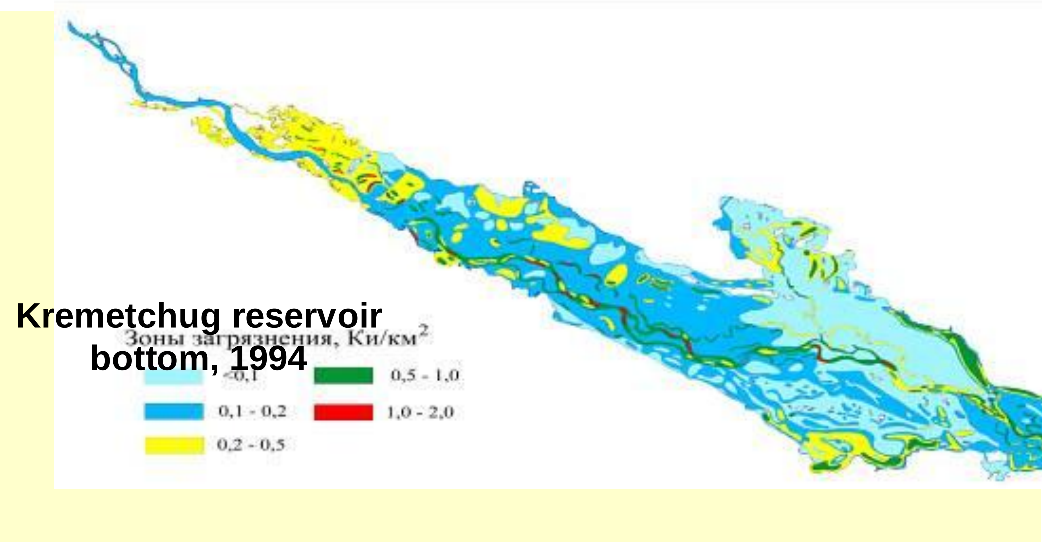


Upper part of Kiev Reservoir

2009

Low part of Kiev Reservoir

1991-93



Kremetchug reservoir bottom, 1994

Data of UHMI contributed by V.Kanivets et al.

Modeling system for watersheds- rivers –reservoirs has been developed after the Chernobyl accident

Why modeling?

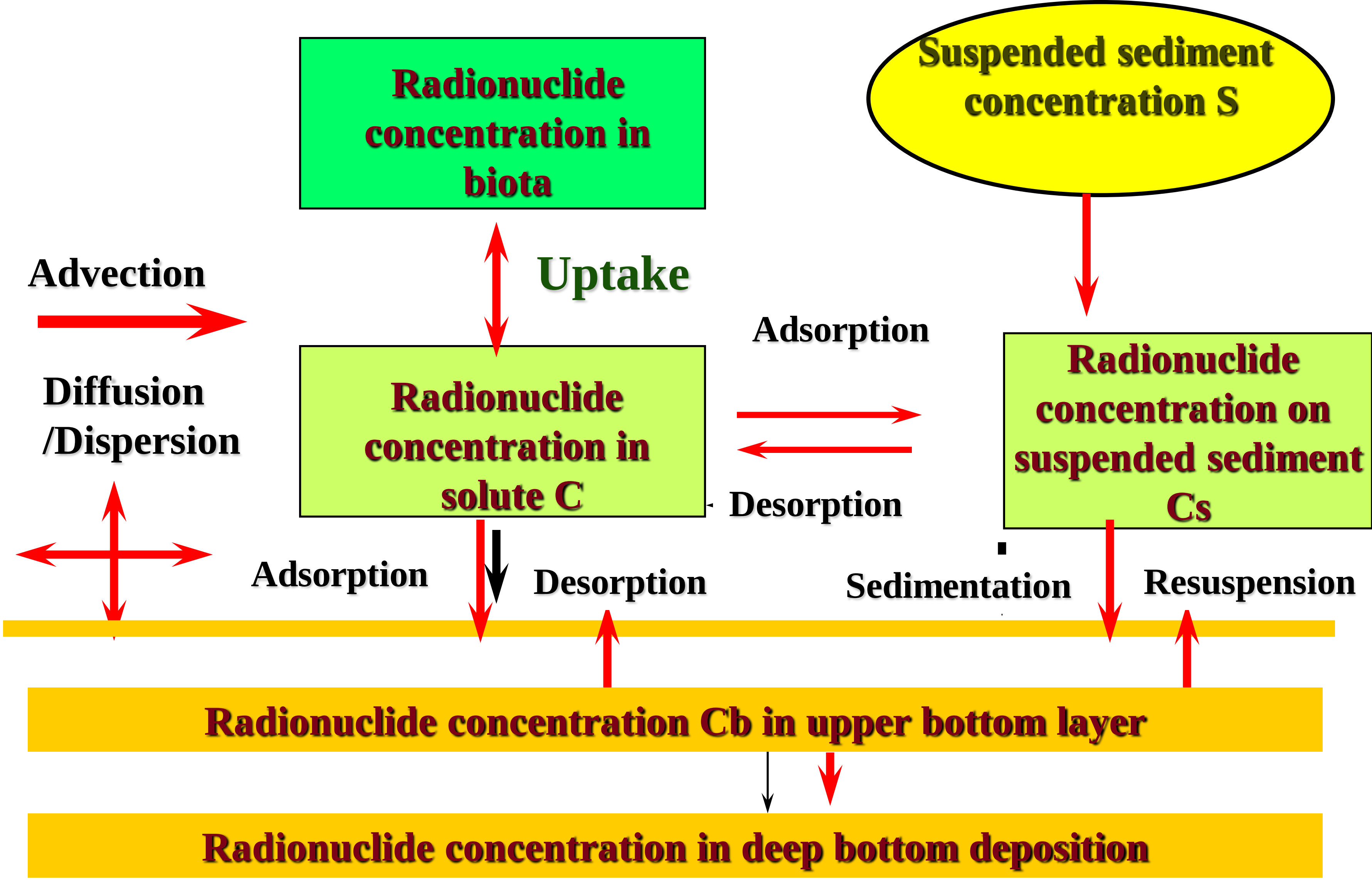
The models are the tools for :

- **Prediction** and long term assessment of the temporal dynamics of the radionuclide concentration in water bodies
- **Risk assessment** for the potential emergency (extreme floods, dam breaks)
- Analyses of the efficiency and **justification of the countermeasures** diminishing water fluxes of radionuclides
- Supporting of the **post accidental communications with the population** and mass media

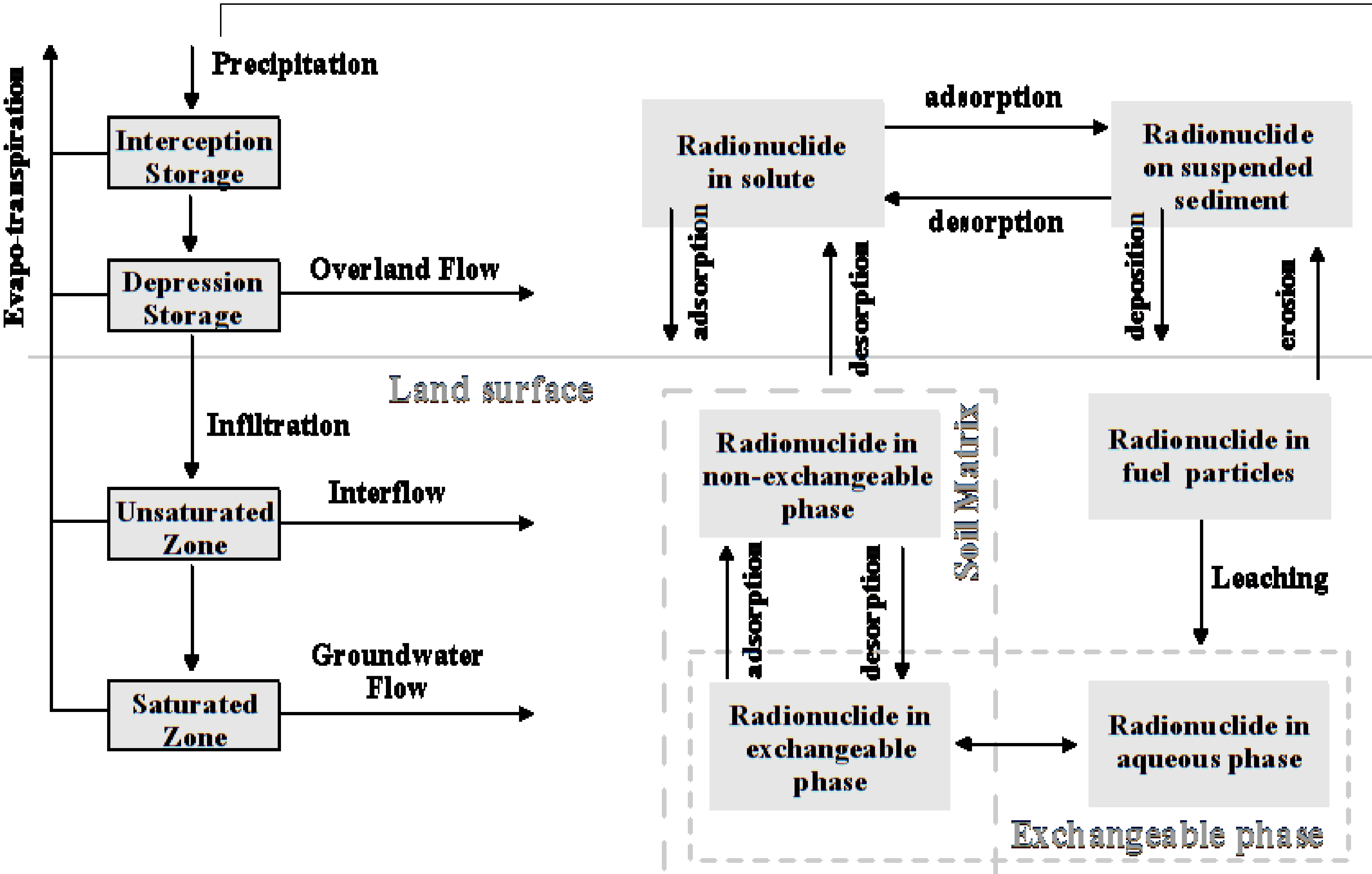
The developed in Ukraine the set of the hydrodynamics – sediment transport- radionuclide transport models includes:

- Watershed models RETRACE-R and RUNTOX
- 3D Model- THREETOX (hydrodynamics hydrostatic model similar to POM)
- 2D Model – COASTOX (hydrodynamics – shallow water equations)
- 1D Model – RIVTOX (hydraulics – Saint Venant Equations)

Radionuclide transport in solute and on suspended sediment modules : advection diffusion equations including the exchange rates between liquid and solid phases on the basis of adsorption- desorption kinetic equations based on “distribution coefficient” – Kd and exchange rate coefficients parameterizations (similar to Prof. Yasuo Onishi’s models, TODAM, FETRA, SERATRA)

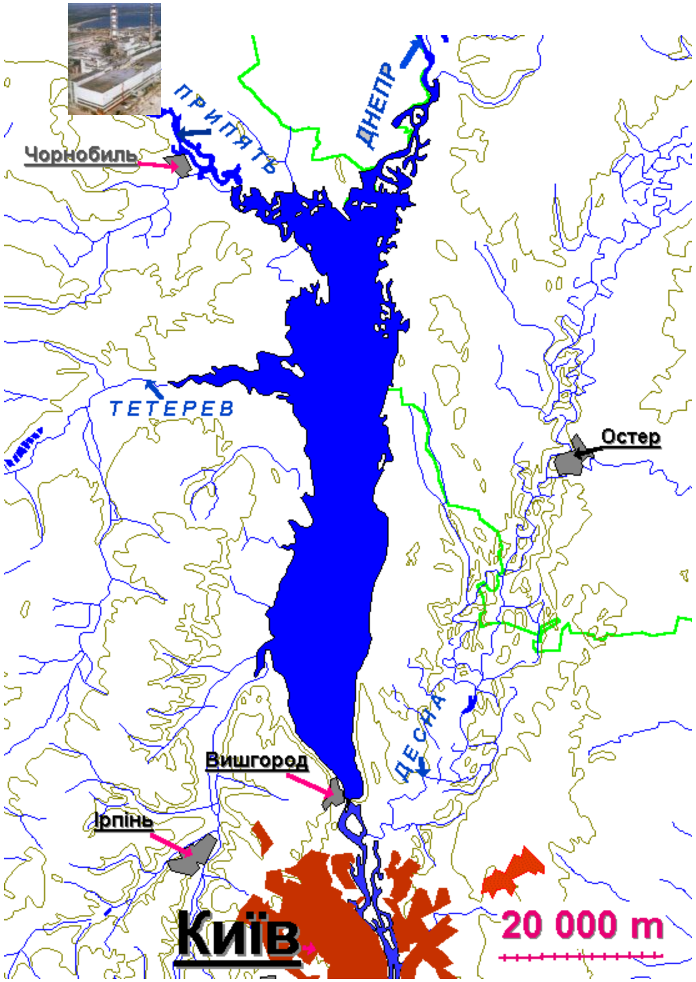


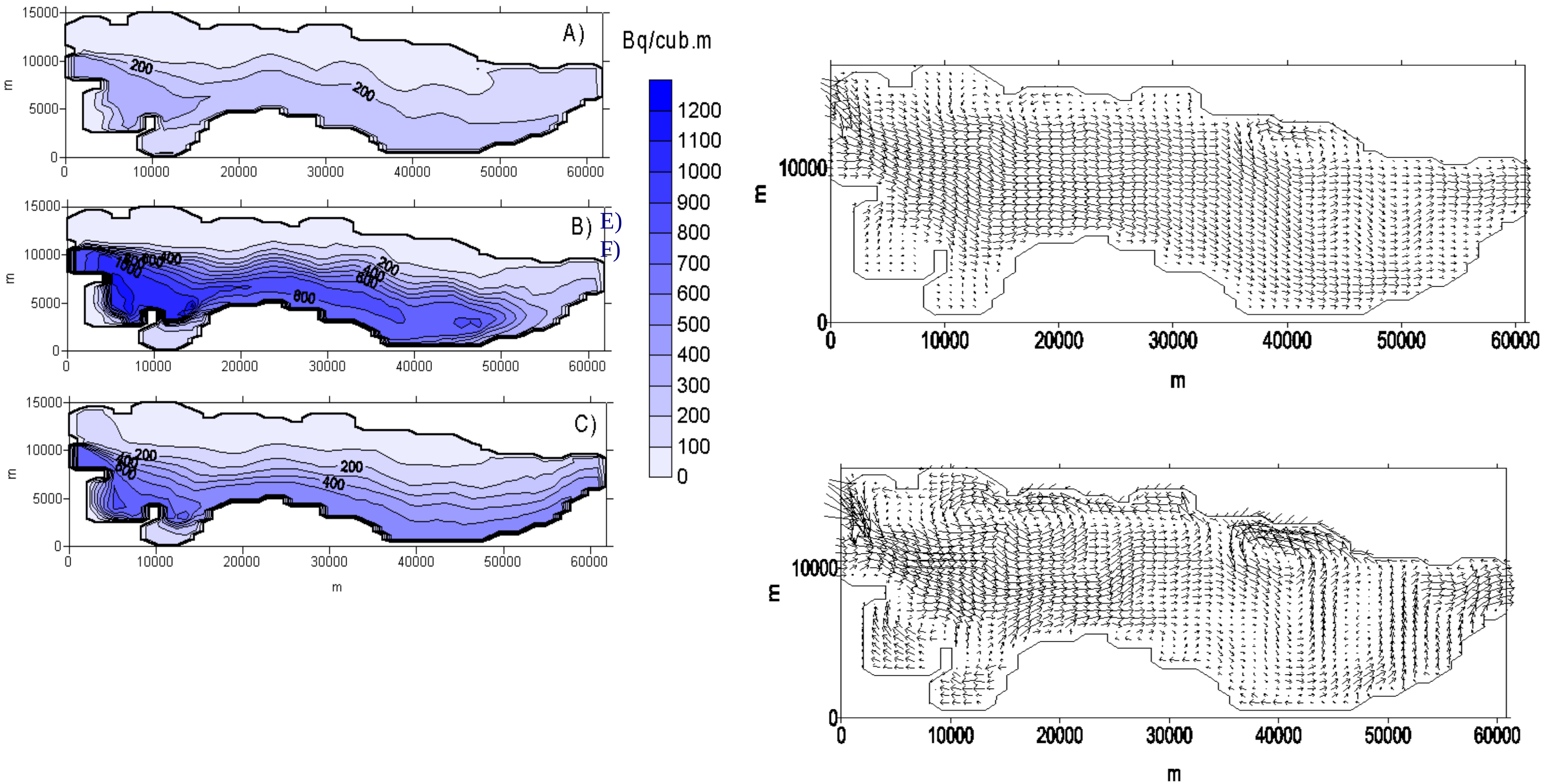
Processes to be modeled for simulation radionuclide fate in surface water – rivers, reservoirs



Processes to be modeled pn watersheds

Radionuclide transport from the Chernobyl site through the Kiev Reservoir – ^{90}Sr flux is increased during each high flood.
Last high flood - 1999





Simulated by 3-D model concentration of ^{90}Sr a the surface of Kiev Reservoir in A) 5 March, B) 25 March and C) 15 April 1999 and simulated currents at the bottom E) and at the surface for the conditions of N-W wind, wind velocity |W|=5.3 м/s, maximum currents velocity |U|max=16 cm/s, Q=1100 m^3/s.

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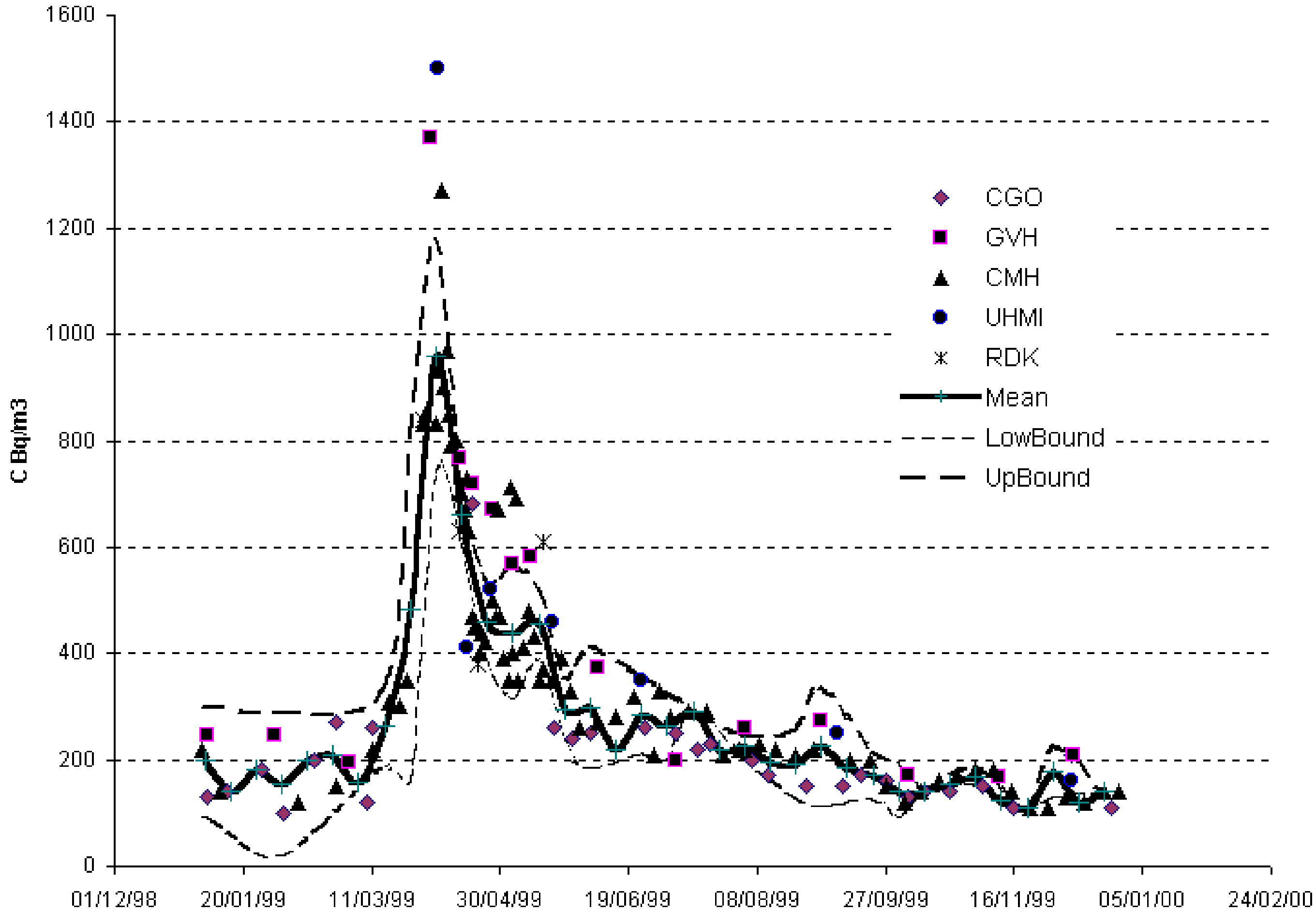


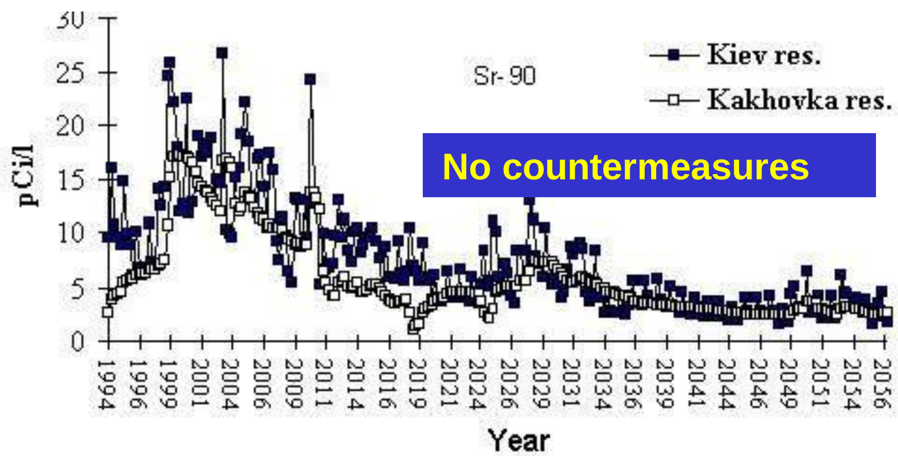
Concentration of ^{90} Sr in Kiev Reservoir at dam of Hydro Power Plant in 1999 measured by different institutions and results of the statistical processing of these data – mean value, upper and lower bounds of the confidential band.

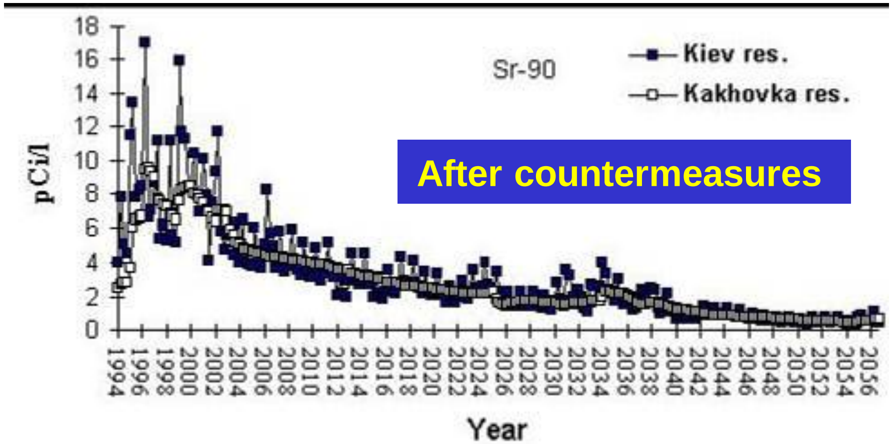
Fukushima University
INSTITUTE OF ENVIRONMENTAL RADIOACTIVITY

Chernobyl modeling

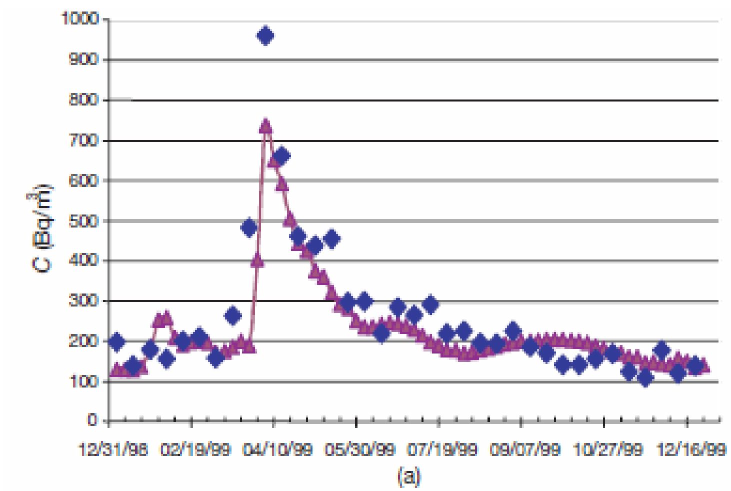
Model based forecasting of radionuclides fate in water systems

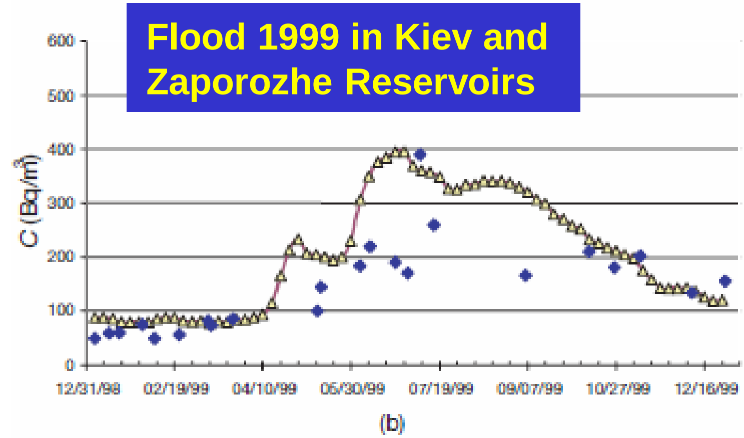
Long term (scenario based) forecasting for dose assessment

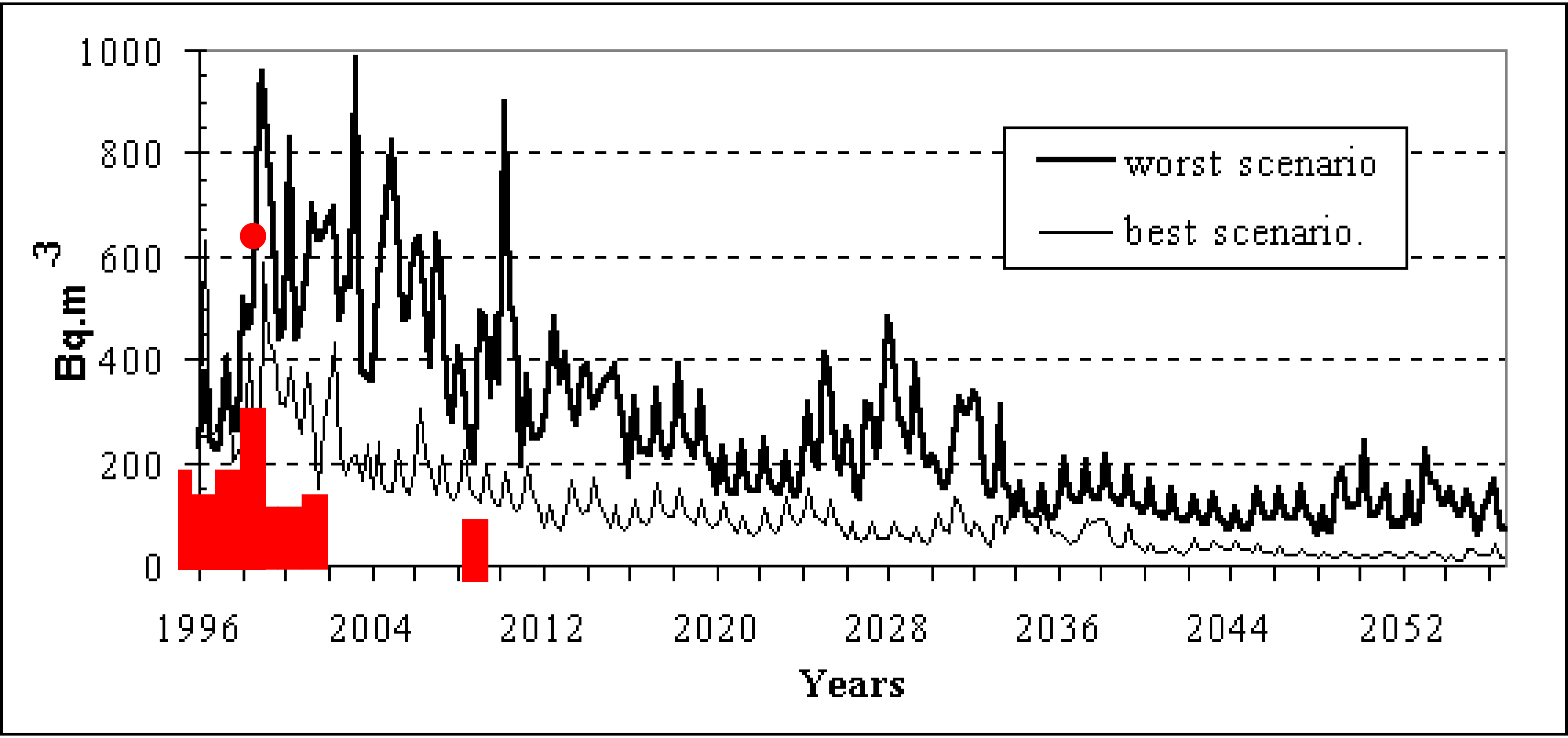




Seasonal (flood events) forecasting





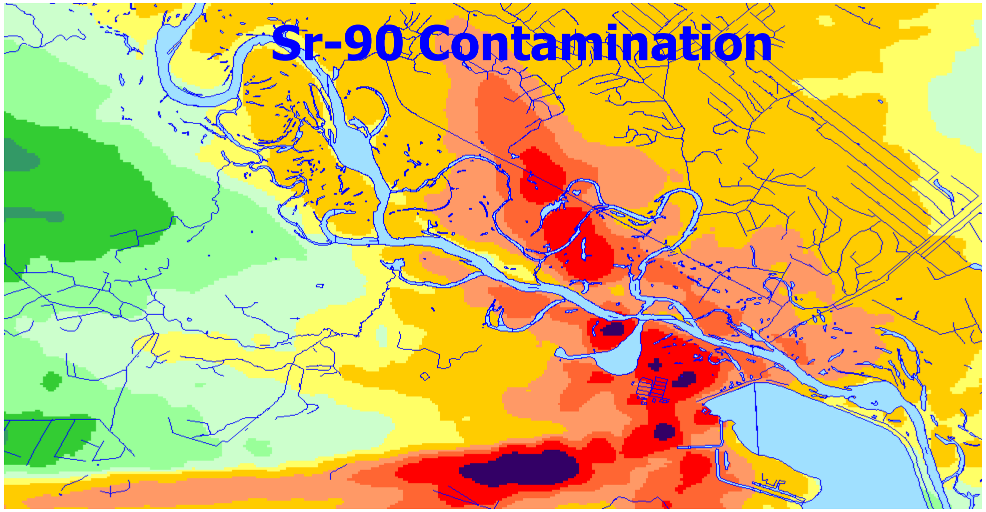


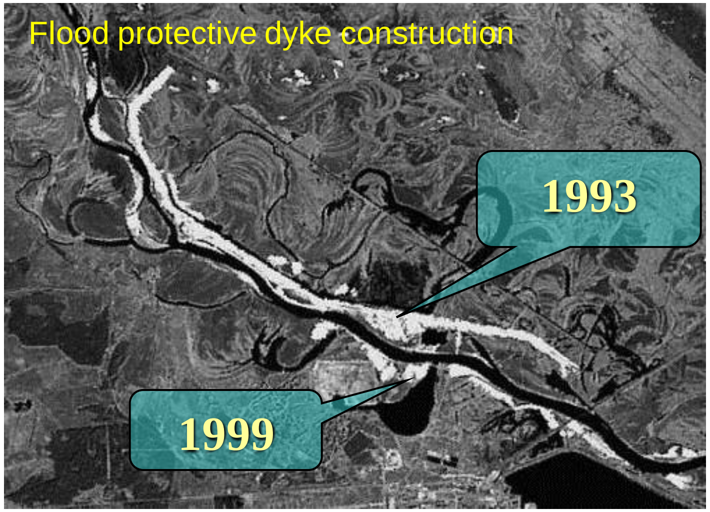
Simulation of long-term fate of ^{90}Sr in Kiev Reservoir

Input scenarios of low- and high- water hydrological years in assumptions of absence of emergency situations in Chernobyl zone .Simulation has been done in 1995. The measured data are close to the avaraging of the "best" scenario

Pripyat River Floodplain around Chernobyl NPP was severe contaminated after the accident

Pripyat river floodplain was the most significant source of ^{90}Sr secondary contamination in Dnieper system. No significant impact of ^{137}Cs,





The most efficient water protection was to control water level and to mitigate inundation of the most contaminated floodplains **by the flood protection sandy dams** constructed at left and right banks of the Pripyat river

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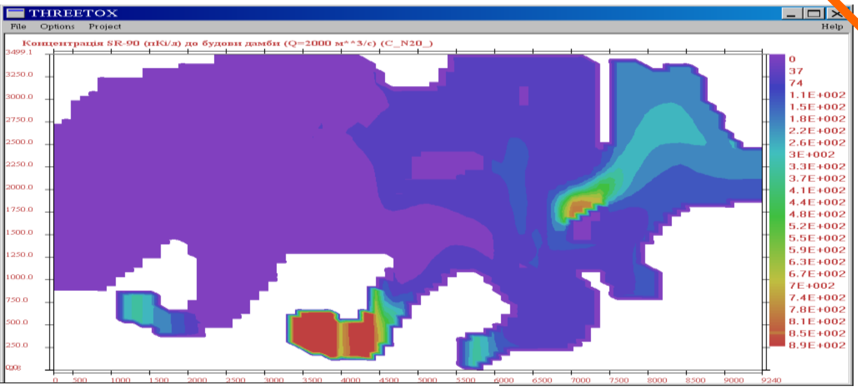
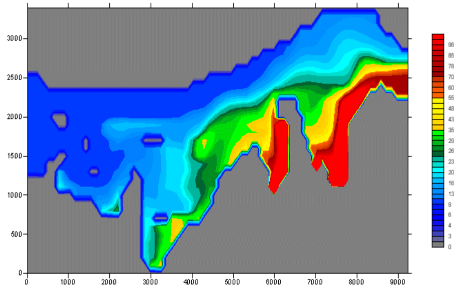
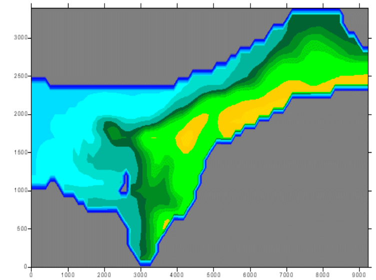
2D modeling predicted the efficiency of special dams for the reducing of radionuclide wash-off from the heavy contaminated floodplain of the Pripyat River at the city of Pripyat,

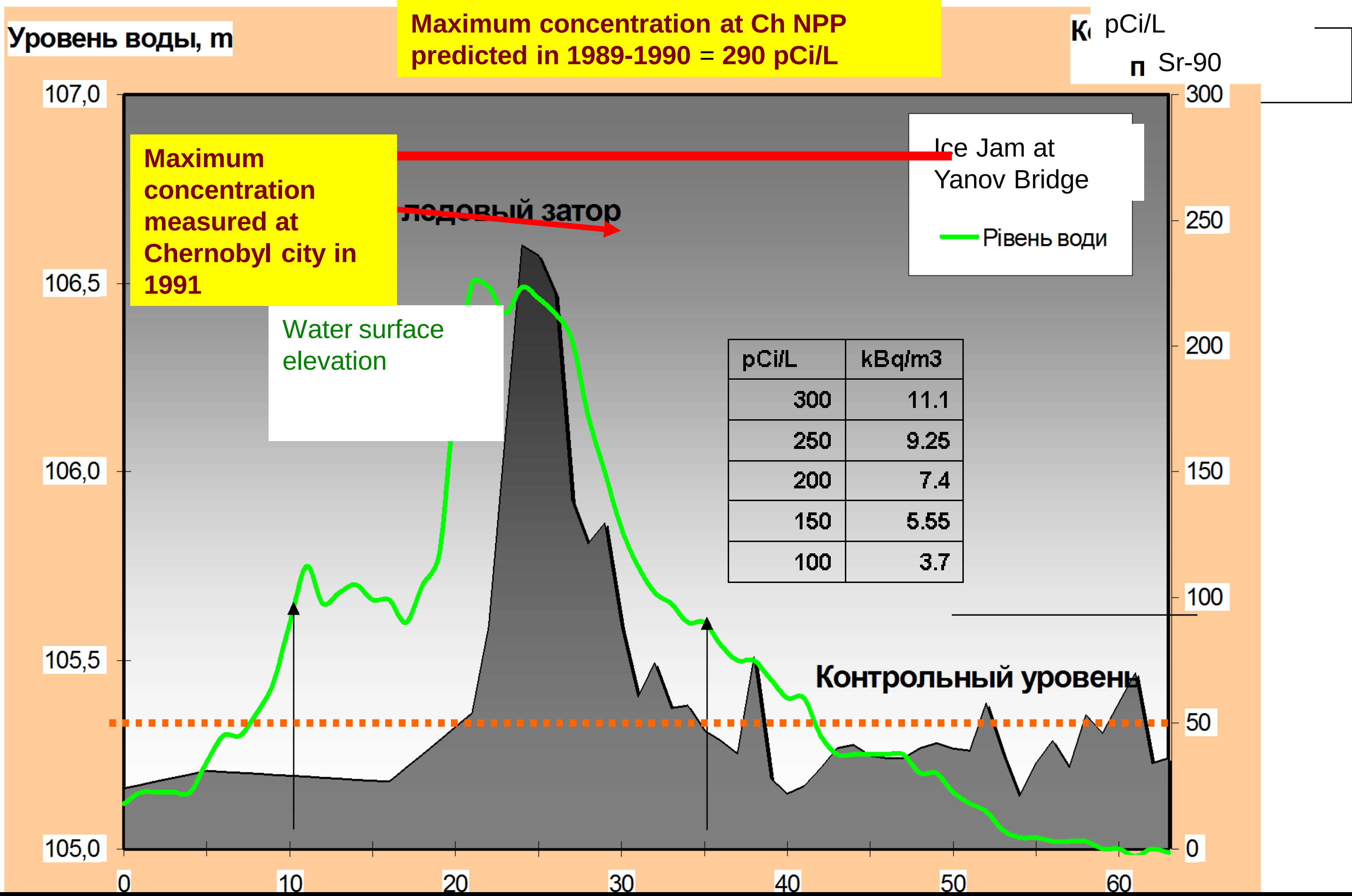




Прогнозные концентрации Sr-90 в воде(пКи/л) на затопленной пойме р.Припять. Водоохранные мероприятия:левобережная дамба. Паводок 25% обеспеченности.



Прогнозные концентрации Sr-90 в воде(пКи/л) на затопленной пойме р.Припять. Водоохранные мероприятия:левобережная и укороченная правобережная дамбы. Паводок 25 % обеспеченности.

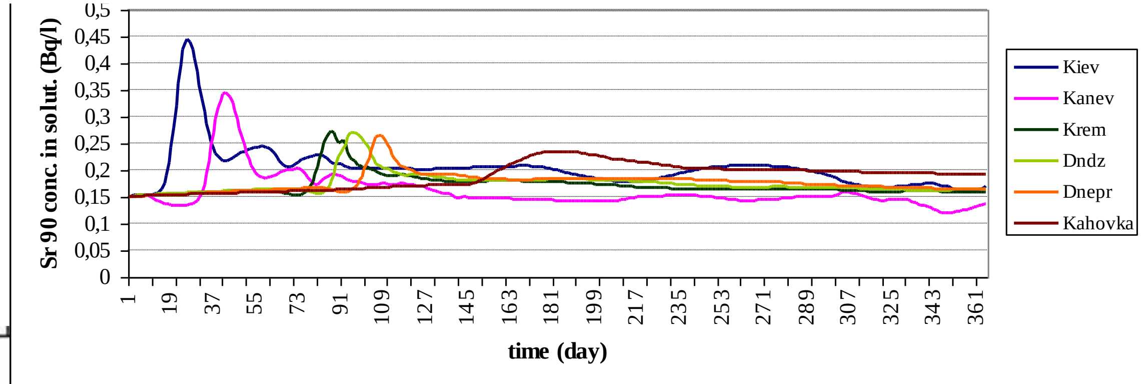


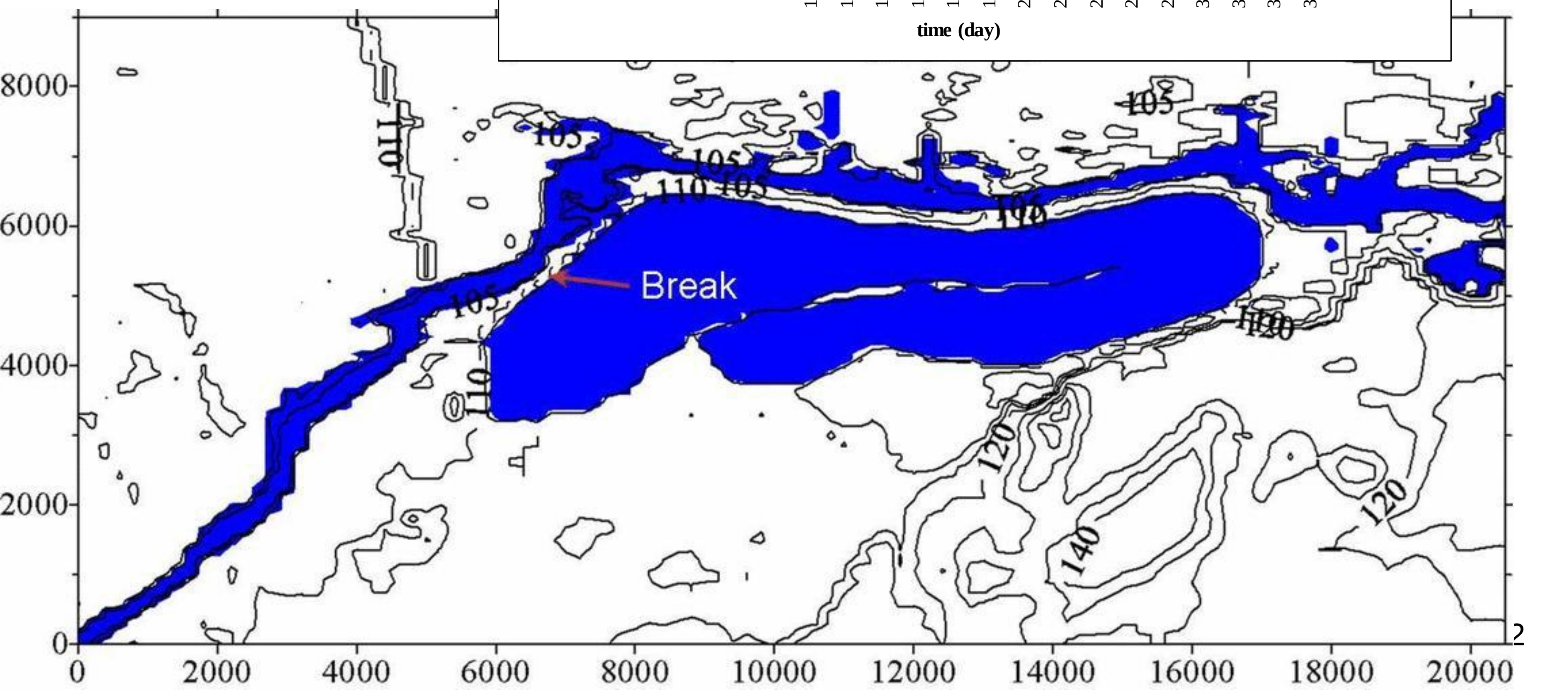
pCi/L	kBq/m3
300	11.1
250	9.25
200	7.4
150	5.55
100	3.7

Measured Sr-90 concentration and water elevation in Pripyat River in January 1991 at Chernobyl ! The forecast of 1990 was confirmed by the monitoring data of 1991 !!!

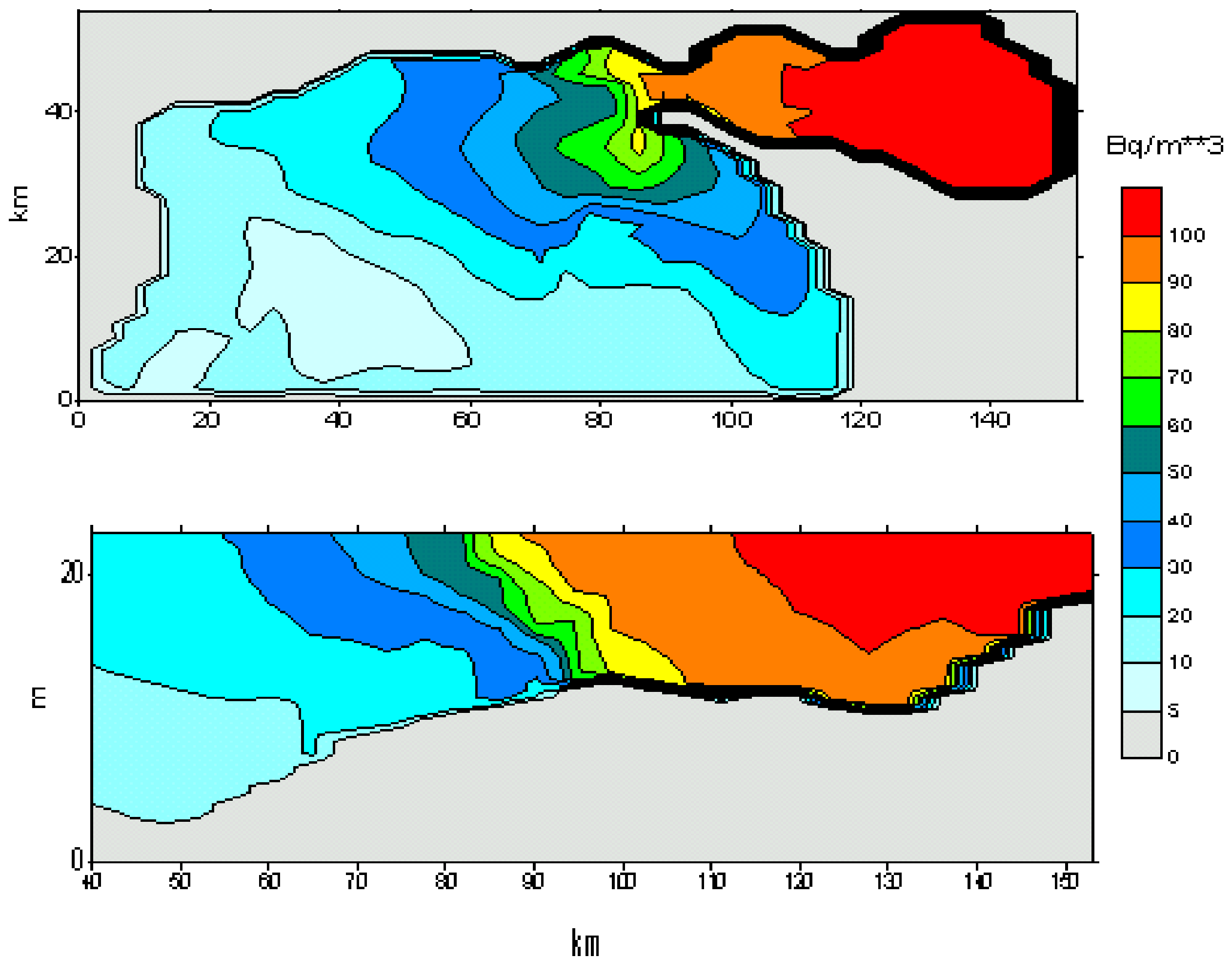
2-D modeling of the inundation zones in a case of the dam break at the Chernobyl Cooling Pond

Crossectionally averaged concentration of Sr-90 downstream the Cooling Pond after dam break

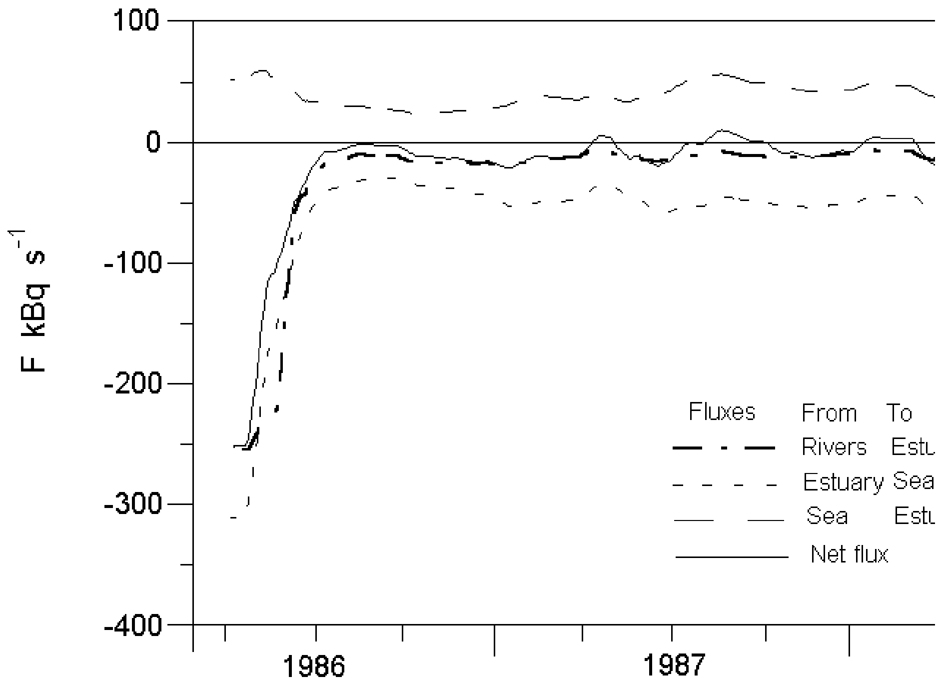


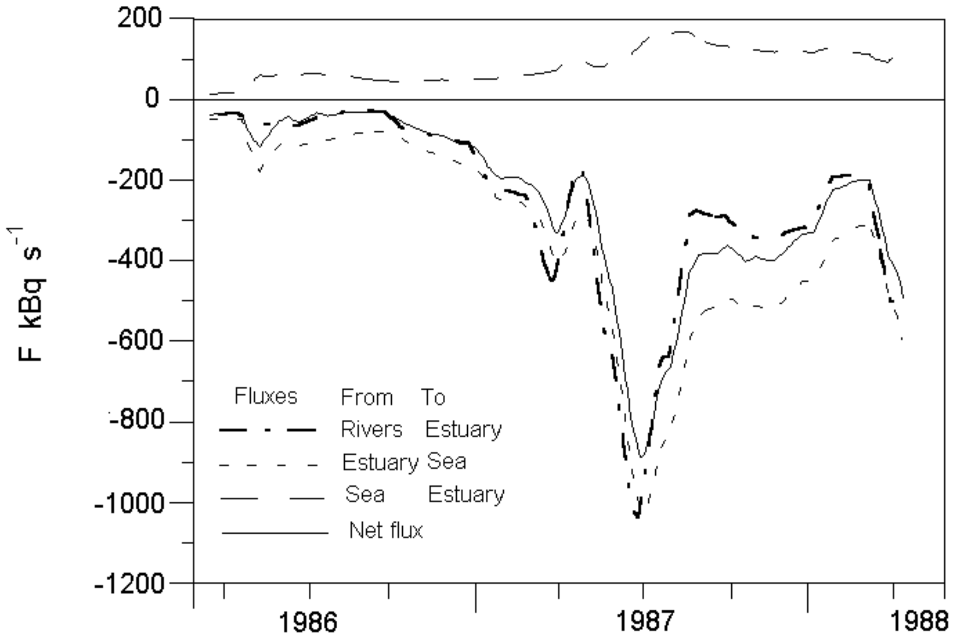


Simulation of Sr-90 release from the Dnieper-Boog Estuary to the Black sea



Simulated fluxes of Cs-137 and Sr-90 from DBE into the Black Sea in first post accidental period

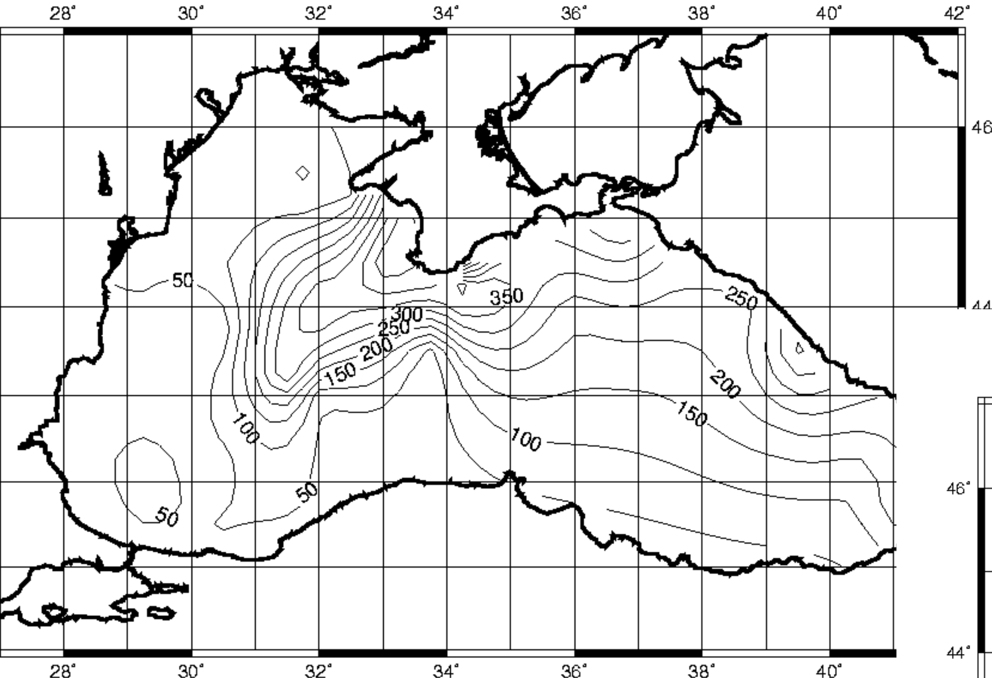




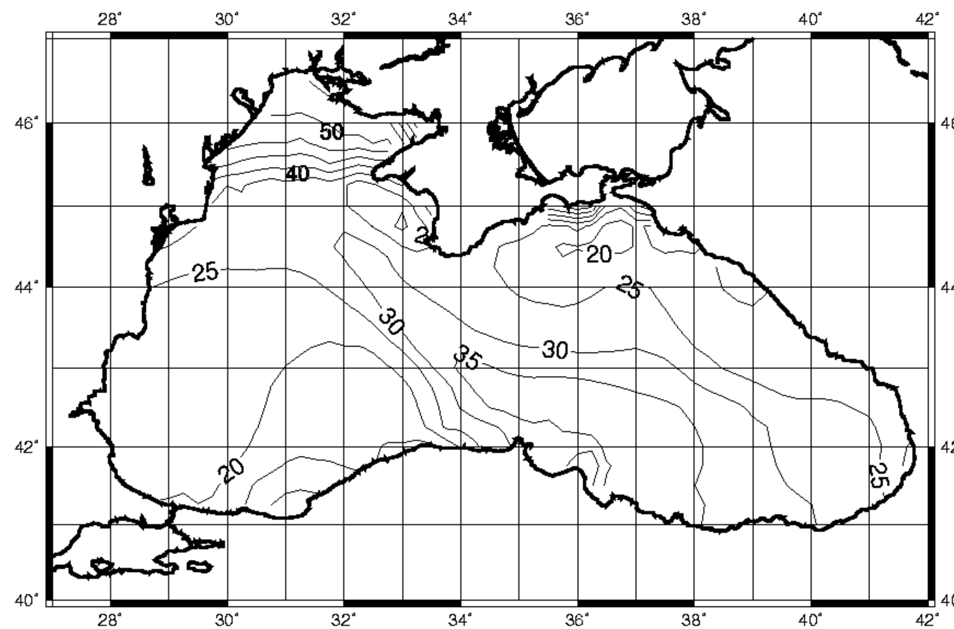
Fluxes of ^{137}Cs
through the Kinbourn strait

Fluxes of ^{90}Sr
through the Kinbourn strait

Calculated by 3-D model THREETOX fields of ^{137}Cs surface concentrations (Bq/m^3) in the Black Sea

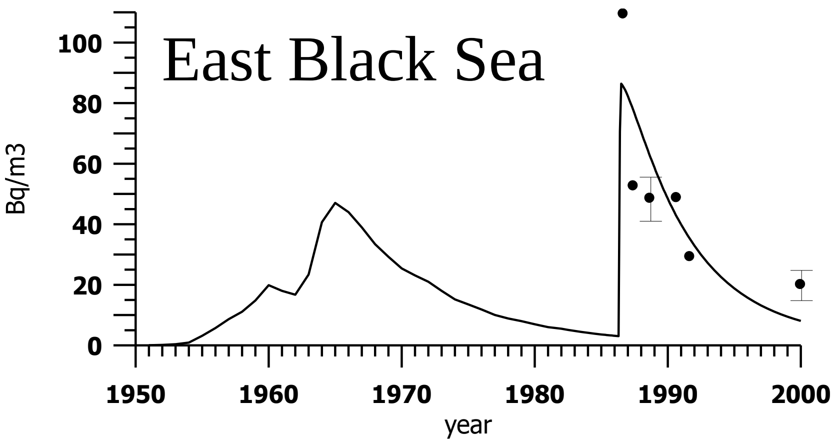


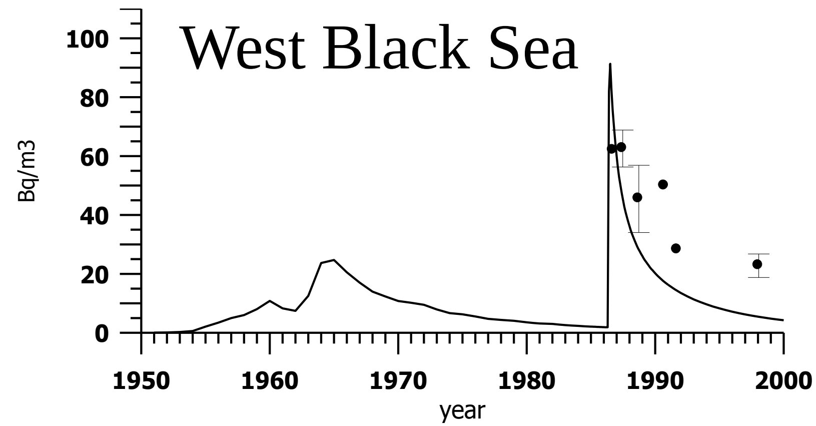
June 1986



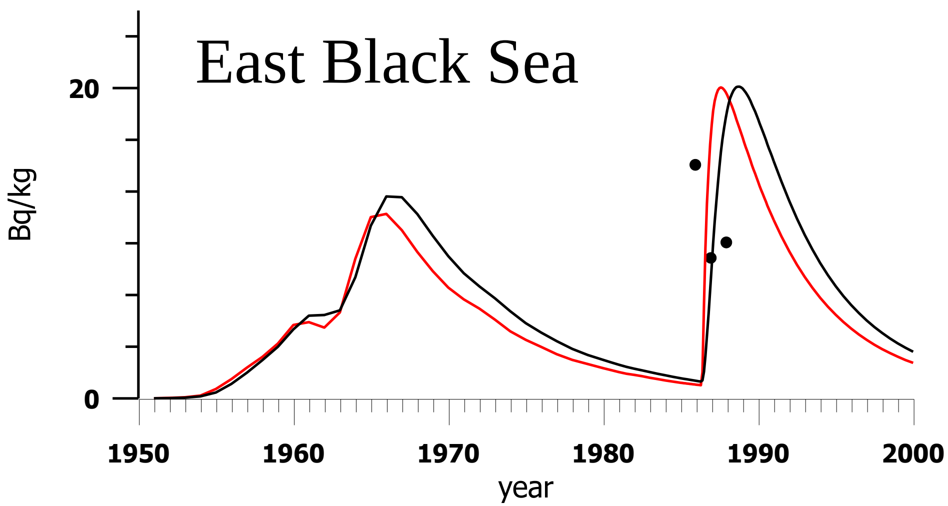
September 1988

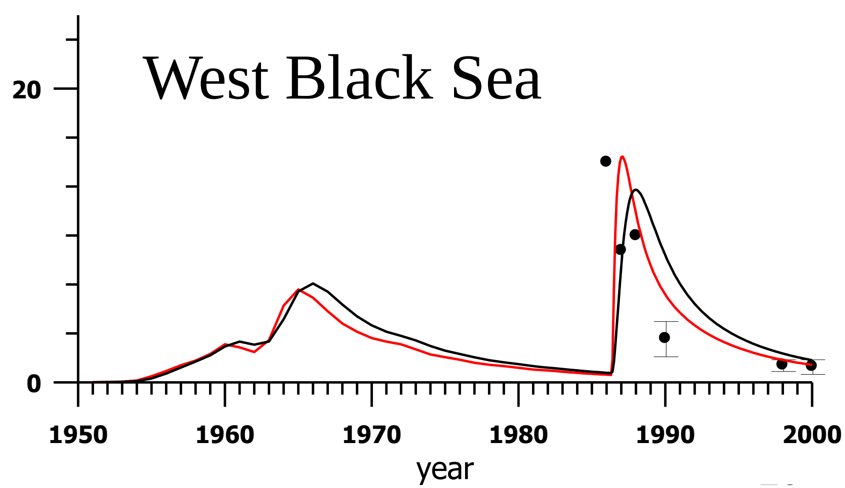
^{137}Cs concentration in surface compartments vs. measurements





^{137}Cs concentration in piscivorous and non-piscivorous fish vs. measurements (box model Poseidon)

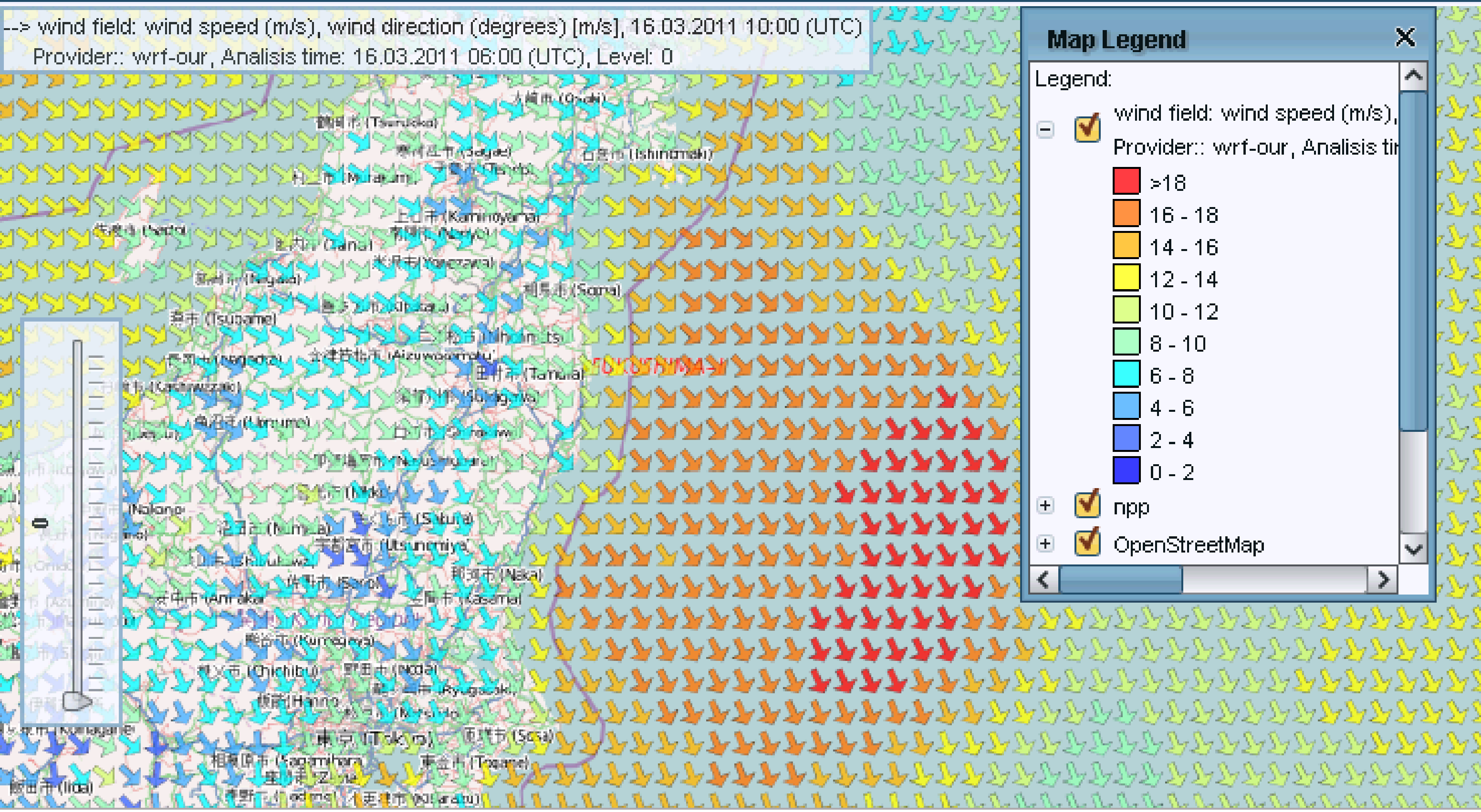




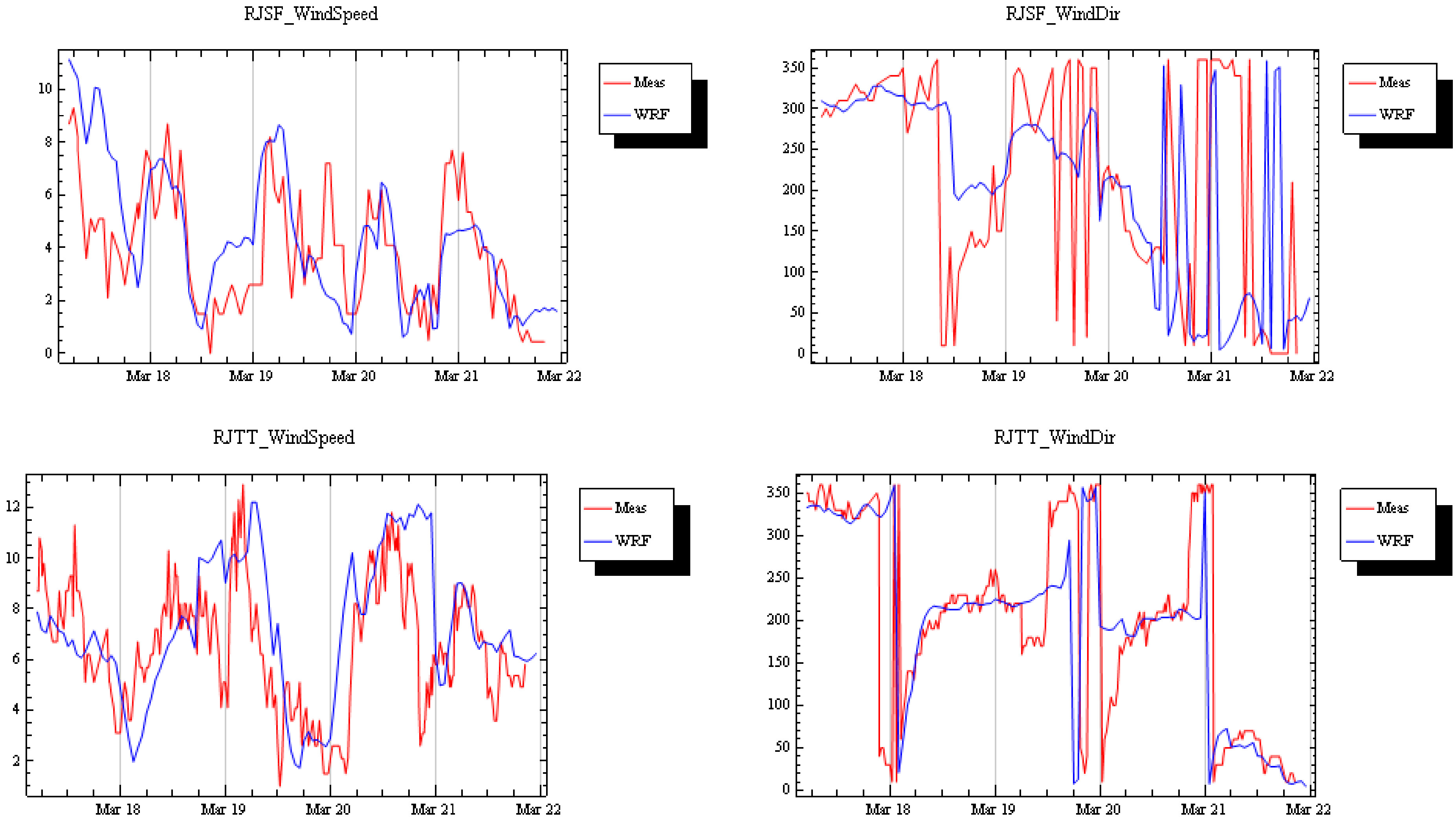
RODOS implementation in EC for Fukushima Dai-ichi NPP (March-April, 2011)

What have we done for atmospheric modelling of Fukushima releases?

- **Adaptation of RODOS to Japan (topography, land use from open sources)**
- **The Meteorological Institute of KIT and IMMSP/UCEWP have provided meteorological forecast data based on the American global model GFS (50 – 100 km) adapted with the model WRF for local application (10-20 km)**
- **The Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) has provided potential source terms for our calculations**



Visualization of numerical weather prediction data from WRF model: wind field at 10m near Fukushima in JRODOS window



Comparison of wind speed and wind direction with observation data from Fukushima Airport (upper pictures), Tokyo Airport (lower pictures)

Release scenarios

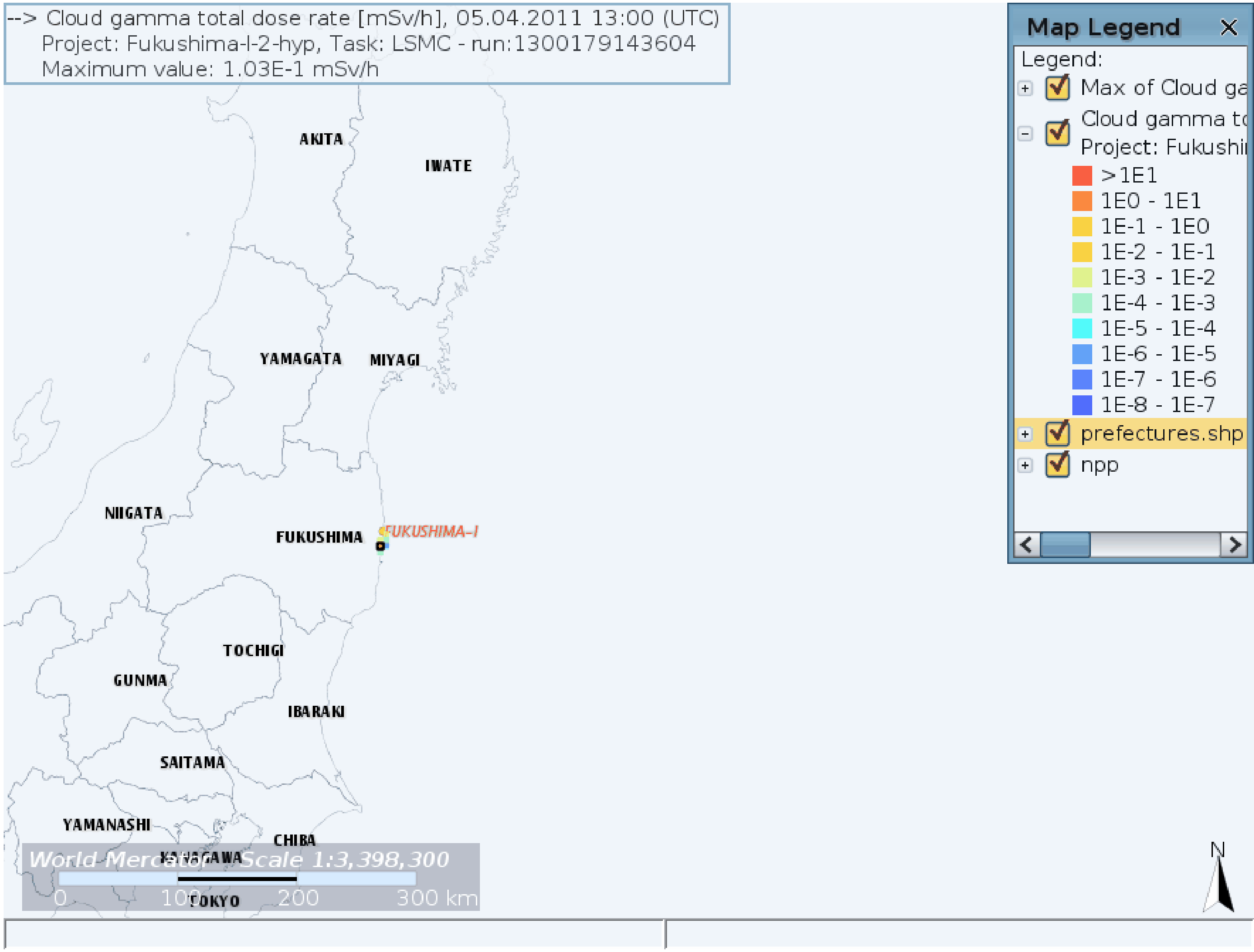
- GRS provided two source terms
  - Release from some fuel rods (lower estimation – gap release)
  - Release assuming a core melt (upper estimation – core melt)
- Estimated activit released (Bq)

	gap release	core melt	core melt max.
– Xe-133	4.E14	3.E18	3.E18
– I-131	4.E13	4.E16	4.E17
– Cs-137	2.E13	3.E15	3.E16
– Pu241	0.E00	9.E11	9.E12

- On 12.04.2011 the Nuclear and Industrial Safety Agency (NISA) estimated the release (in Bq) as follows
  - I-131 1.3E17
  - Cs-137 6.1E15
  - I-131 equivalent 3.7E17 (sum of I-131 + Cs-137)
- On 06.06 source term has been raised by factor of two

Daily calculations based on weather predictions- the results were presented online on the web site of Karsruhe Institute of Technologies, Germany

- Using the core melt release scenario calculations were performed to predict the contamination for the next 24 hours

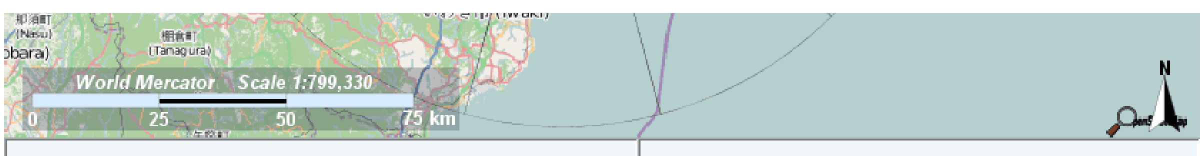


RODOS simulation with RIMPUFF

- Calculation for 3 days

TABLE 1. Estimated source terms (in Bq), provided by GRS in the beginning of the accident, by NISA after the initial phase of the accident and by other authors.

	Gap release (GRS)	Core melt, (GRS)	Conserva-tive estimates, (GRS)	Estimates from NISA (by 06 June 2011)	Estimates from Sugiyama, et al., (2012)	Estimates from Stohl, et al., (2011)
^{133}Xe	$4\cdot10^{14}$	$3\cdot10^{18}$	$3\cdot10^{18}$	-	$3.7\cdot10^{17}$	$1.5\cdot10^{19}$
^{131}I	$4\cdot10^{13}$	$4\cdot10^{16}$	$4\cdot10^{17}$	$2.6\cdot10^{17}$	$7.4\cdot10^{16}$	-
^{137}Cs	$2\cdot10^{13}$	$3\cdot10^{15}$	$3\cdot10^{16}$	$1.2\cdot10^{16}$	$3.7\cdot10^{15}$	$3.66\cdot10^{16}$
^{241}Pu	0	$9\cdot10^{11}$	$9\cdot10^{12}$	-	-	-



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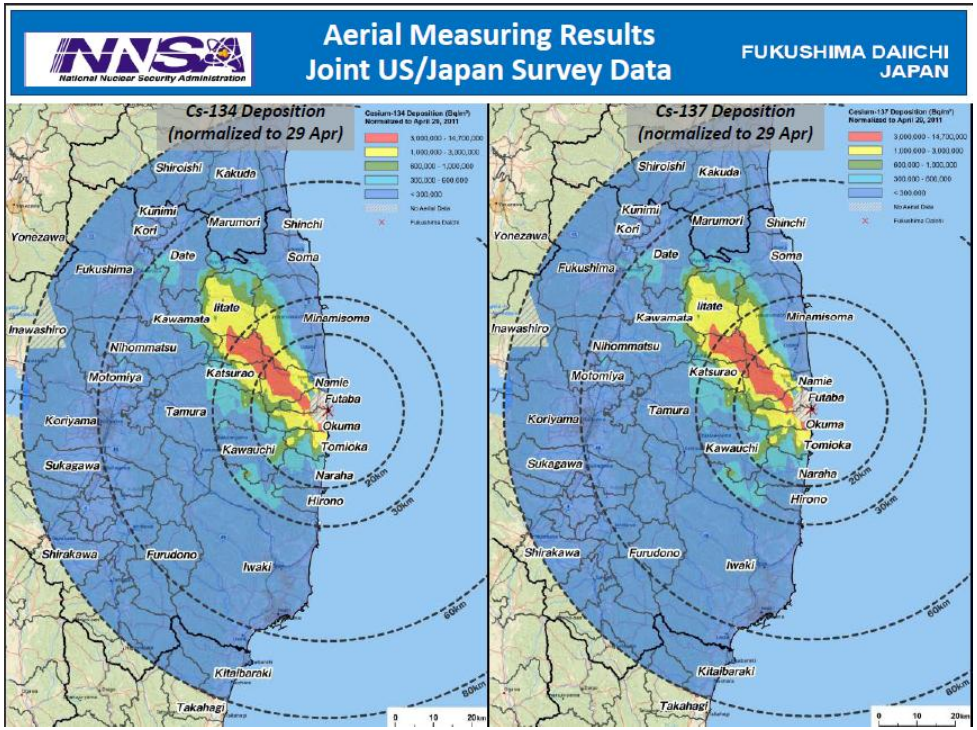
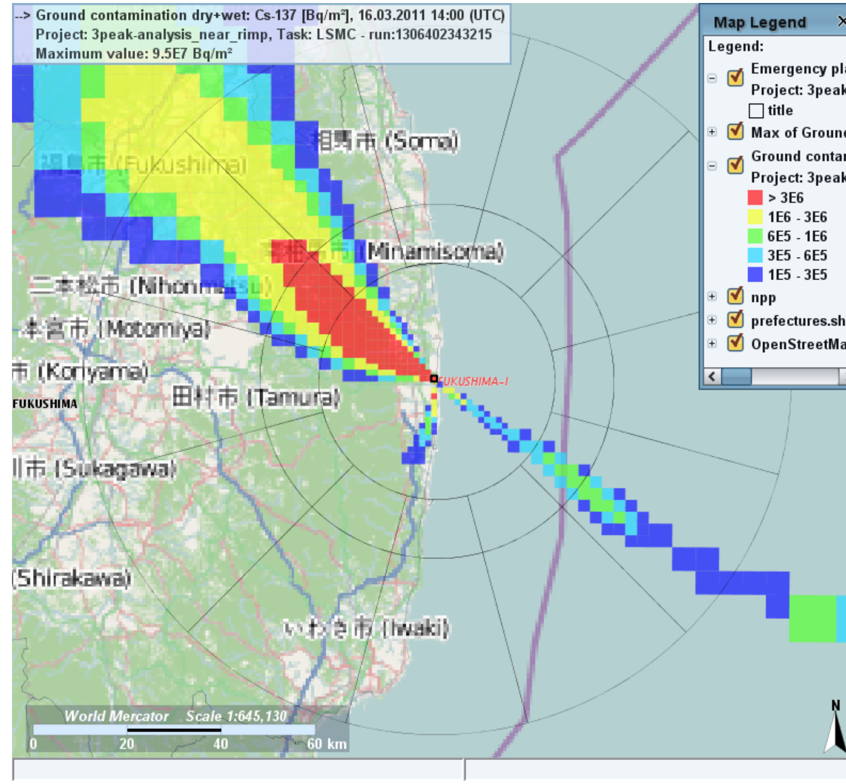
^{137}Cs	$2 \cdot 10^{13}$	$3 \cdot 10^{15}$	$3 \cdot 10^{16}$	$1.2 \cdot 10^{16}$	$3.7 \cdot 10^{15}$	$3.66 \cdot 10^{16}$
^{241}Pu	0	$9 \cdot 10^{11}$	$9 \cdot 10^{12}$	-	-	-

The total amount of radionuclides following the NISA data (Table 1) has been manually distributed in time so the release had three peaks between March 13 and 16 (GRS, internal communication). The simulation scenario started on March, 14, 14:00 UTC. The first peak release occurred during the first hour and the released activity of ^{137}Cs was set to $2.5 \cdot 10^{15}$ Bq. The second peak occurred between the 19th and the 20th hour of calculation, the released activity of ^{137}Cs was set to $5.0 \cdot 10^{15}$ Bq. The third peak occurred between the 30th and the 31st hour, the released activity of ^{137}Cs was set to $2.5 \cdot 10^{15}$ Bq.

Comparison of monitoring and simulation





U.S. Department of Energy

http://energy.gov/news/10194.htm

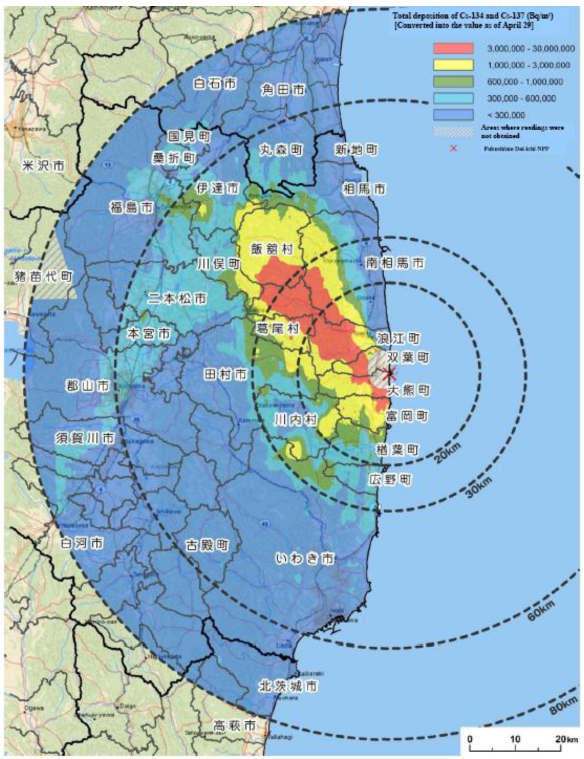
Estimation with RODOS

Source term: ~ 1.0E16 Bq Cs-137

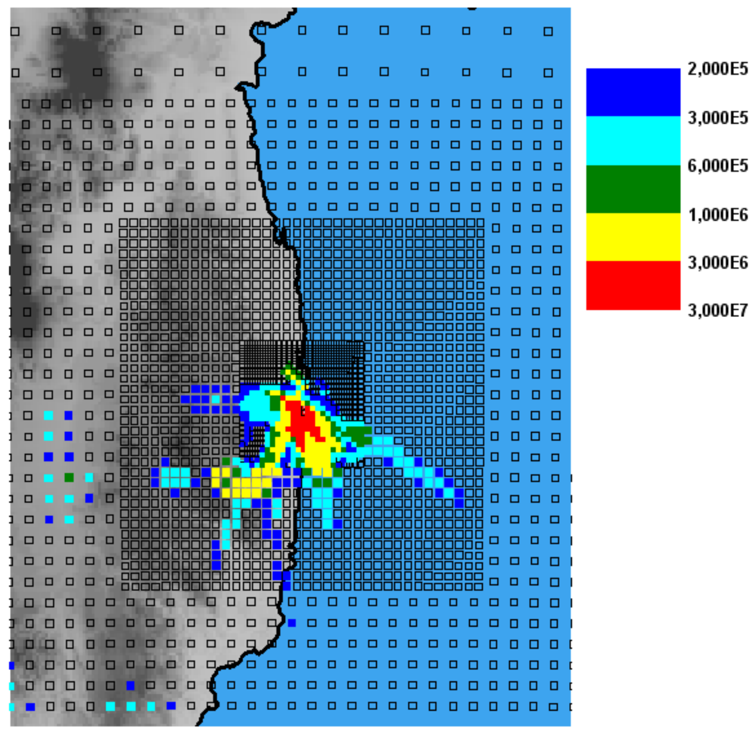
4 days duration, 3 peaks

Comparison of station data with Numerical Weather Prediction Data

- Source term as before, but weather data only from station near Fukushima (RODOS mit ATSTEP)



Monitoring total Cs



Calculations total Cs

Structure of Information flow for HDM

JRODOS – ADM

↓

JRODOS – HDM

Hydrological Dispersion Module

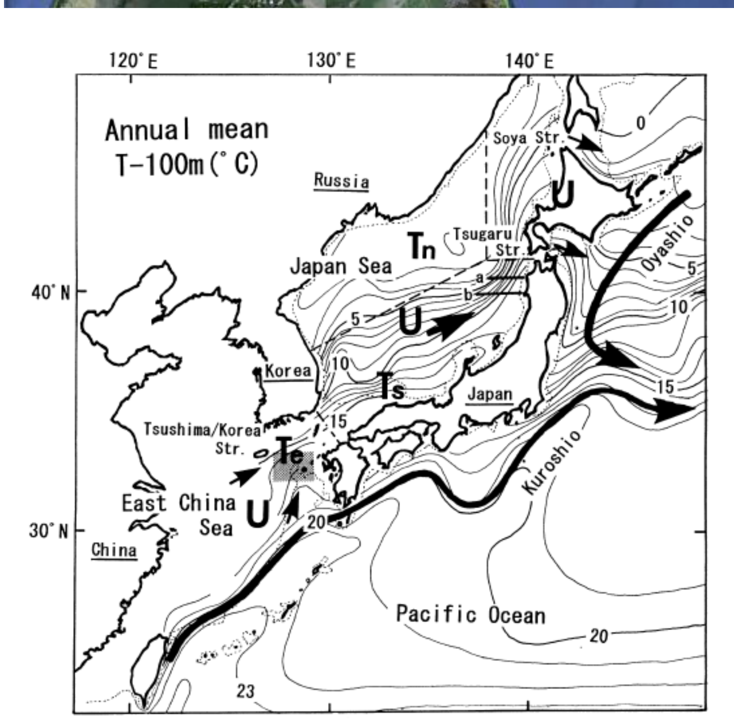
3D Marine Hydrodynamics and Radionuclide Transport Model THREETOX

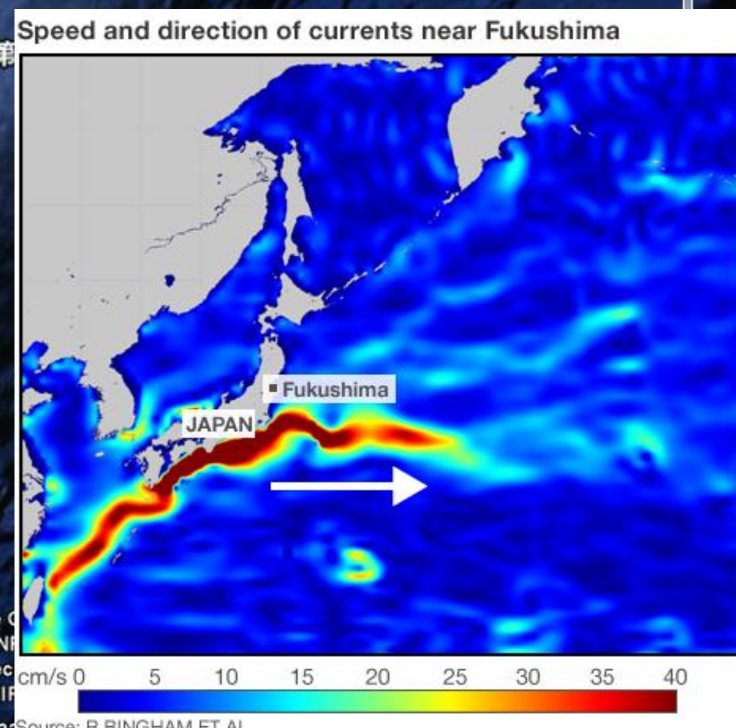
THREETOX:

- Hydrodymics Module (temperature, salinity, currents)
- Sediment Transport Module
- Radionuclide transport in 3 phases (in solute, on suspended sediments, contamination of upper bottom sediment layer)

Adaptation of the RODOS_HDM to Japan

Complicated flow structure due to abrupt changes in bathymetry and dynamic changes in ocean circulation





Boundary conditions for the release scenarios

Direct water release from NPP

Water 4.3 m³/h.

Concentration ^{137}Cs

1.8 GBq/L

2 - 6 April 2011

Total 0.95 PBq

(0.95 x 10^{15} Bq)

NISA estimate based on TEPCO data (presented on IAEA Web Site)

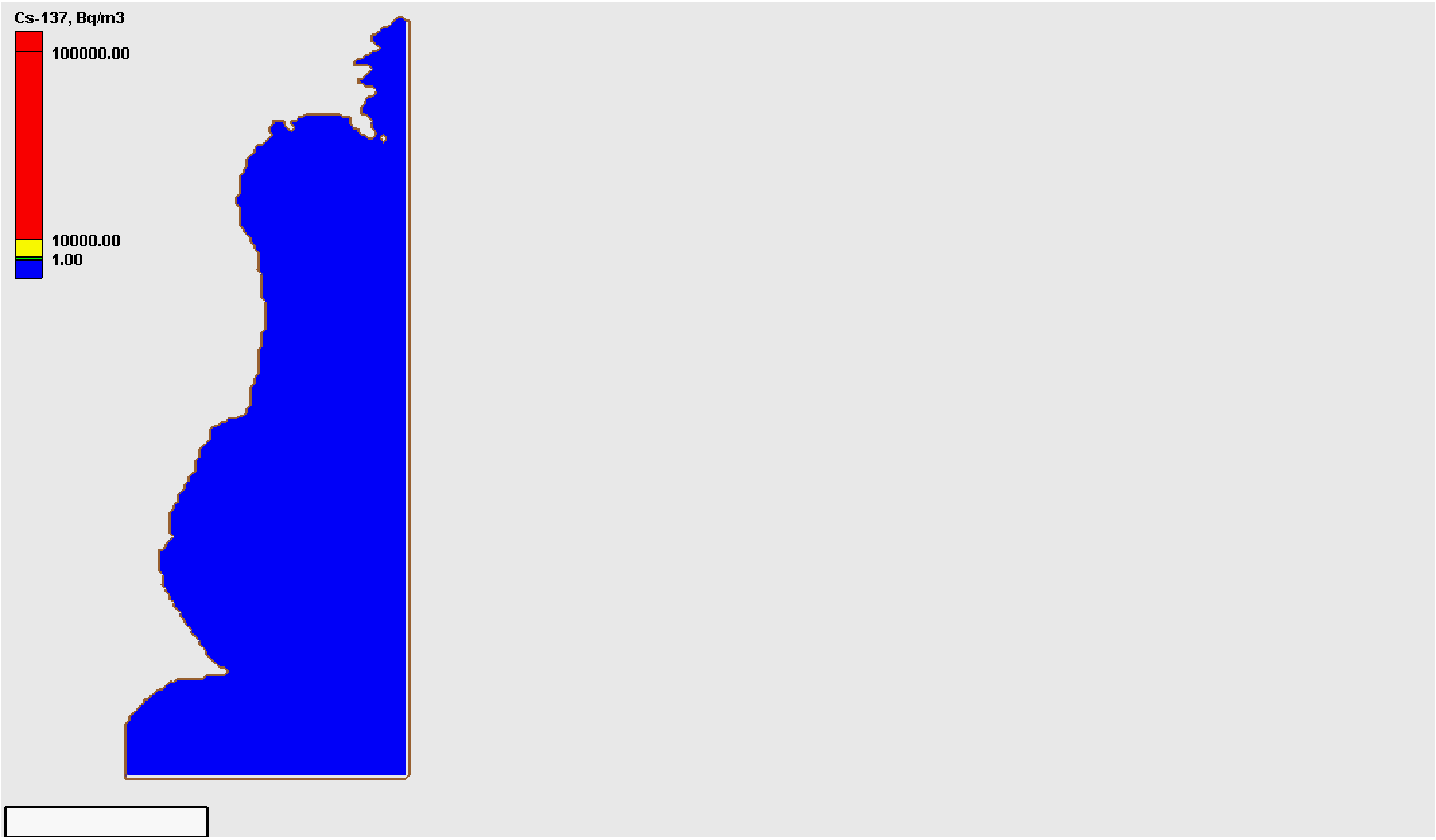
Atmospheric Fallout from RODOS ADM

Meteorological Data from US Final Reanalysis

Oceanographical

Boundary Conditions from Korean KORDI Pacific Ocean Model MOM

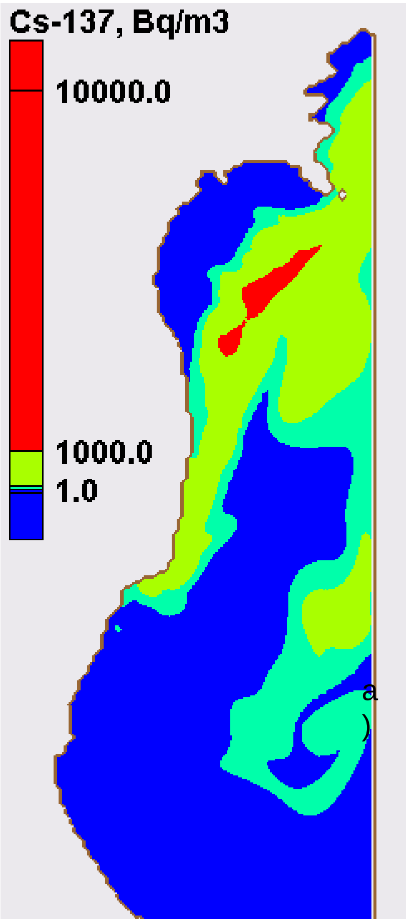
^{137}Cs concentration (Bq/m^3) in upper water layer due to atmospheric fallout 12-24 March 2011



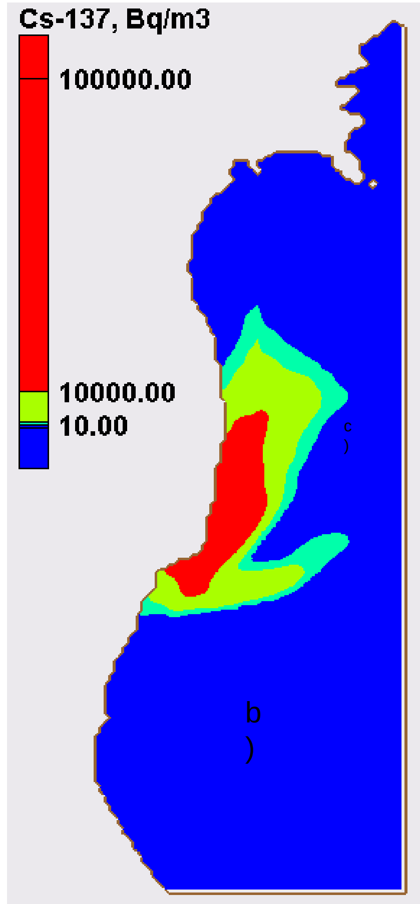
^{137}Cs concentration (Bq/m^3) in upper water layer due to direct water release 2 - 6 April 2011

Simulations from 7-15 April

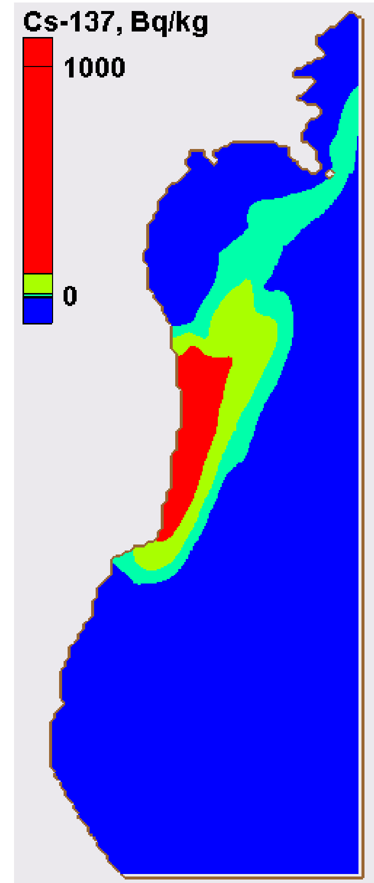
Concentrations in water and sediments



23 March

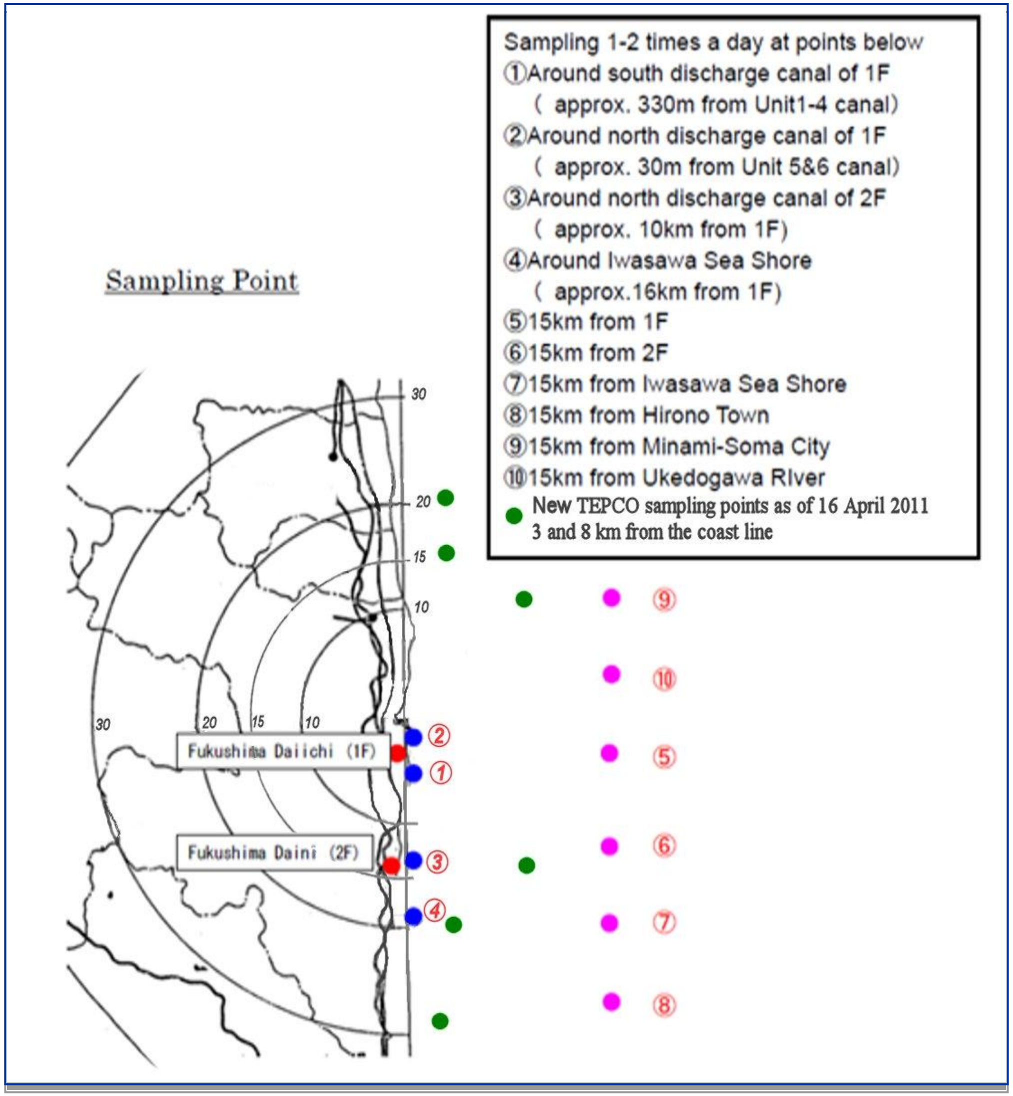


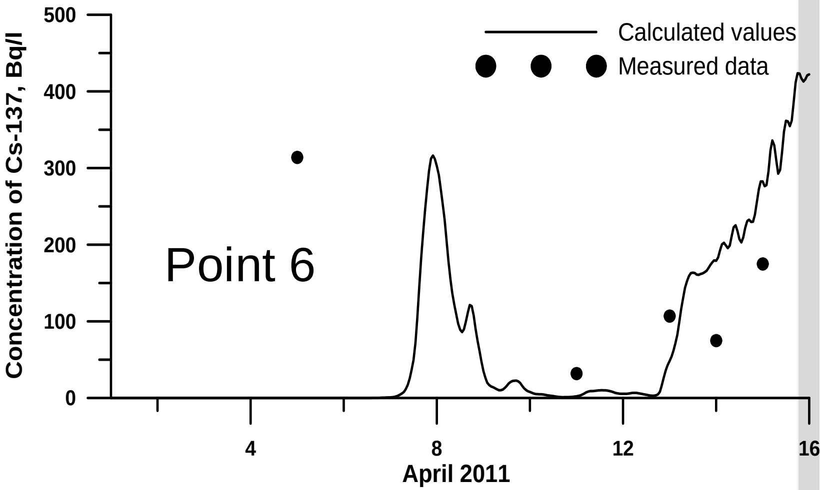
18 April

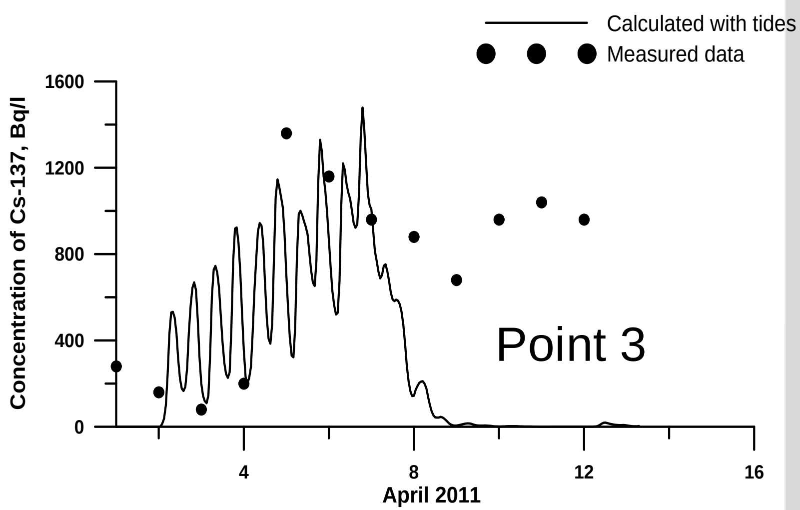


^{137}Cs concentrations in the bottom 18 April

Comparison of measured and calculated data





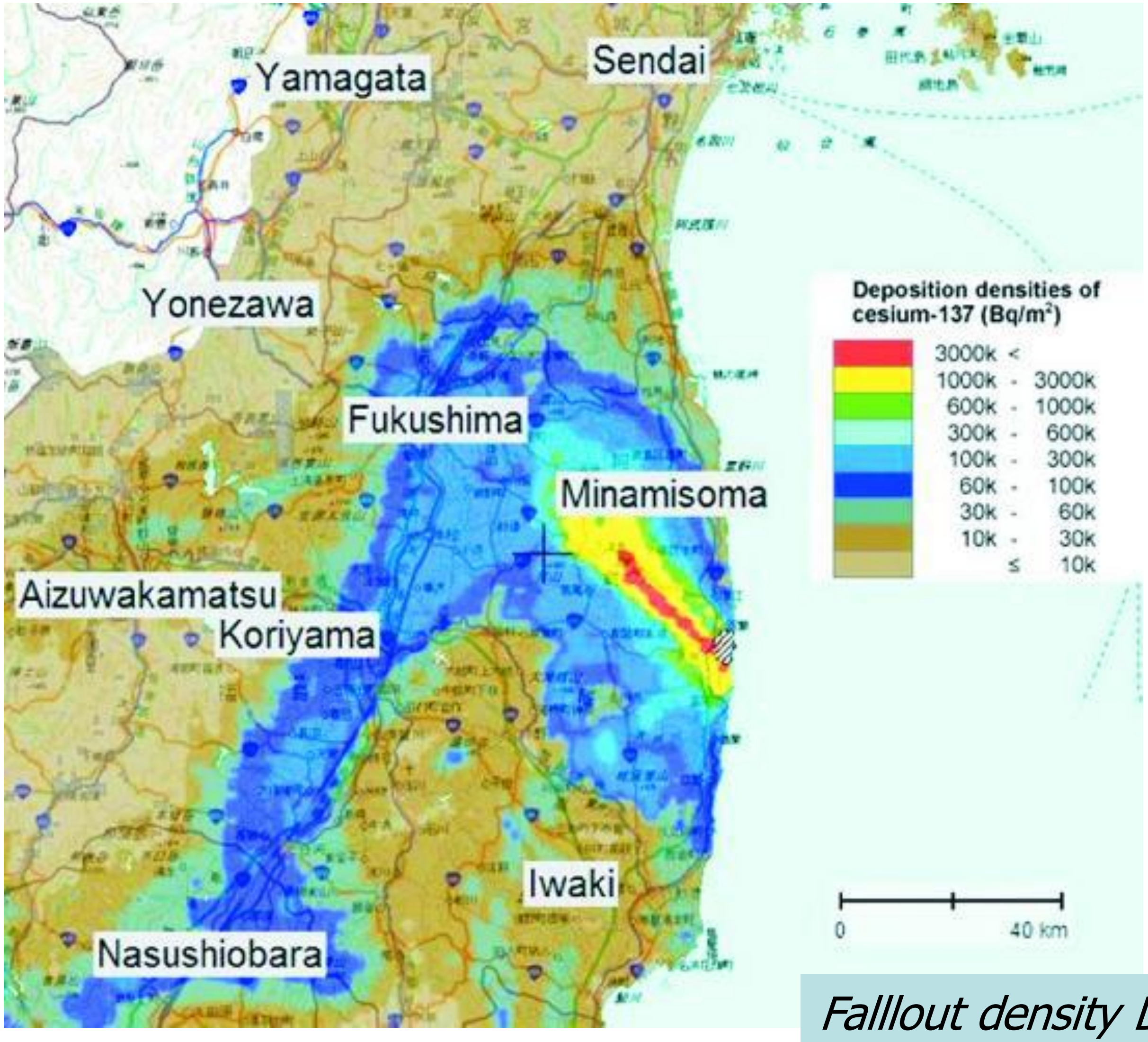


Water systems of Chernobyl and Fukushima regions:

Common problems = rivers/reservoirs as pathways of radionuclide transport from the most contaminated zones to the populated areas:

Water systems of Fukushima regions:

Common with Chernobyl problems = rivers/reservoirs as pathways of radionuclide transport from the most contaminated zones to the populated areas:

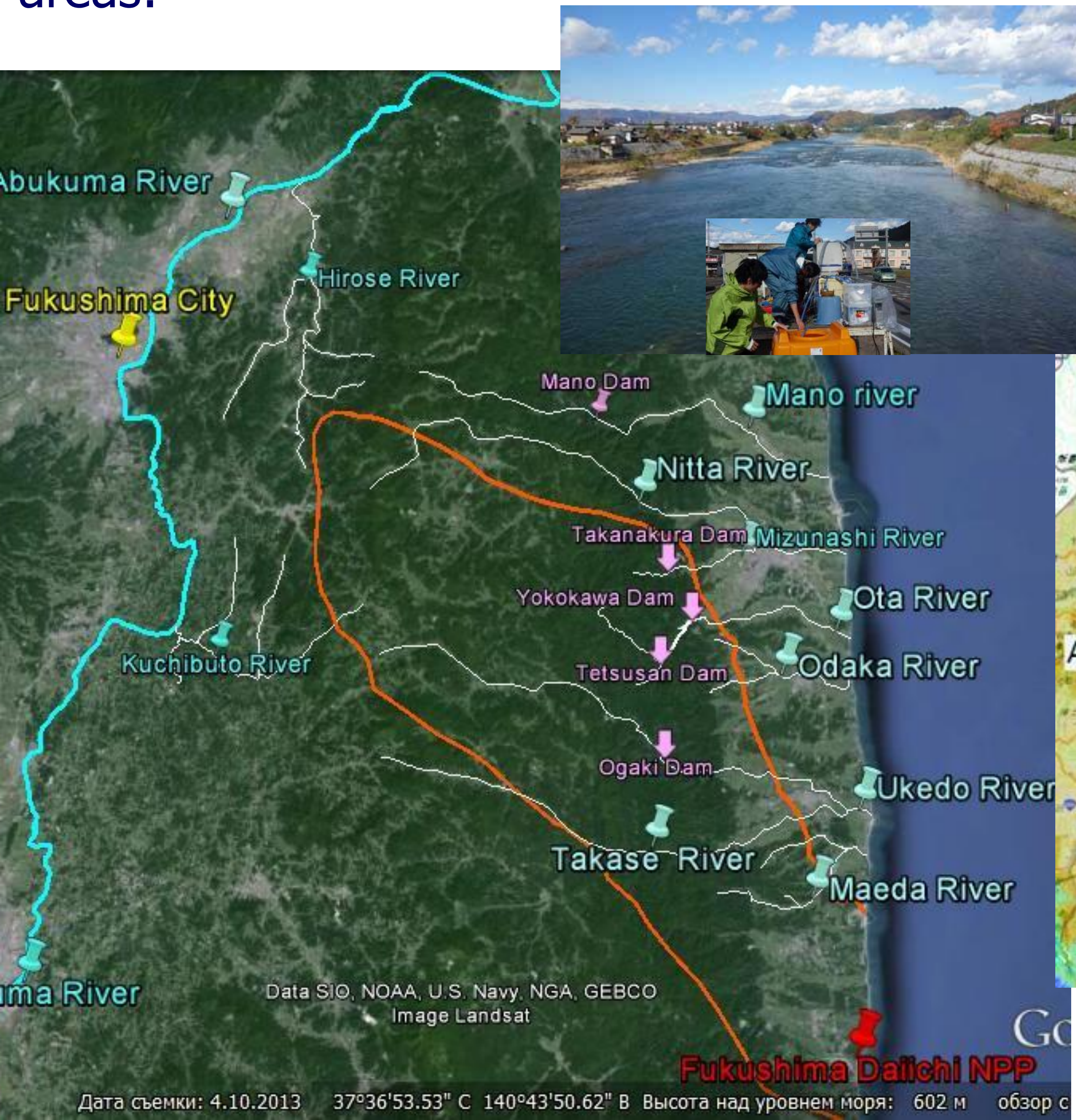


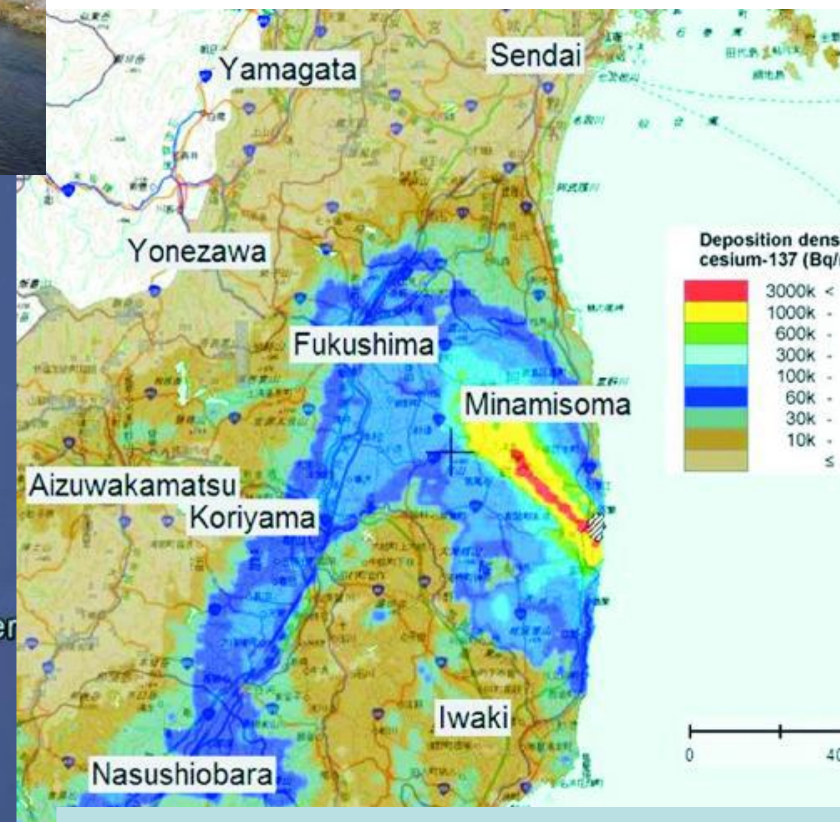
Falllout density December 2012

http://ramap.jmc.or.jp/map/eng/

Water systems of Fukushima regions:

Common with Chernobyl problems = rivers/reservoirs as pathways of radionuclide transport from the most contaminated zones to the populated areas:





Fallout density December 2012

http://ramap.jmc.or.jp/map/eng/

Water systems of Chernobyl and Fukushima regions-: differences:

Fukushima Region: Mountainous watersheds - steep slopes, high erosion

High amount of precipitations, rain seasons, typhoons

Volcanic soils

Chernobyl Region:

Plain watersheds- mild slopes, small erosion

Mild amount of precipitations, no rain season

Monitoring radioactive cesium in Abukuma River in Fukushima Prefecture

Kenji NANBA

Date	Sediment Concentration g/L	Dissolved Cs-137 (Bq/L)	Cs-137 on Suspended Sediment (Bq/L)	Total Cs-137 in River Water (Bq/L)	Dissolved/Total (%)
5/8/2012	0.0268	5.42E-02	2.00E-01	2.54E-01	21.31
6/5/2012	0.021035	1.19E-02	1.24E-01	1.36E-01	8.75
6/26/2012	0.008126	1.26E-02	5.49E-02	6.75E-02	18.67
7/10/2012	0.011275	1.61E-02	1.26E-01	1.42E-01	11.33
7/30/2012	0.013214	1.84E-02	5.99E-02	7.83E-02	23.50
9/4/2012	0.00991	1.73E-02	1.46E-01	1.63E-01	10.62
9/11/2012	0.007573	2.12E-02	8.69E-02	1.08E-01	19.60
9/25/2012	0.017388	2.73E-02	2.92E-01	3.19E-01	8.56
10/9/2012	0.008278	1.58E-02	7.90E-02	9.48E-02	16.67
10/29/2012	0.01169	1.36E-02	1.68E-01	1.81E-01	7.50
11/13/2012	0.006408	1.27E-02	6.81E-02	8.08E-02	15.73
12/5/2012	0.020319	2.27E-02	6.10E-01	6.33E-01	3.58
12/11/2012	0.002451	1.37E-02	5.58E-02	6.96E-02	19.74
12/18/2012	0.003274	9.78E-03	3.42E-02	4.40E-02	22.22
12/25/2012	0.002347	1.22E-02	2.67E-02	3.89E-02	31.36

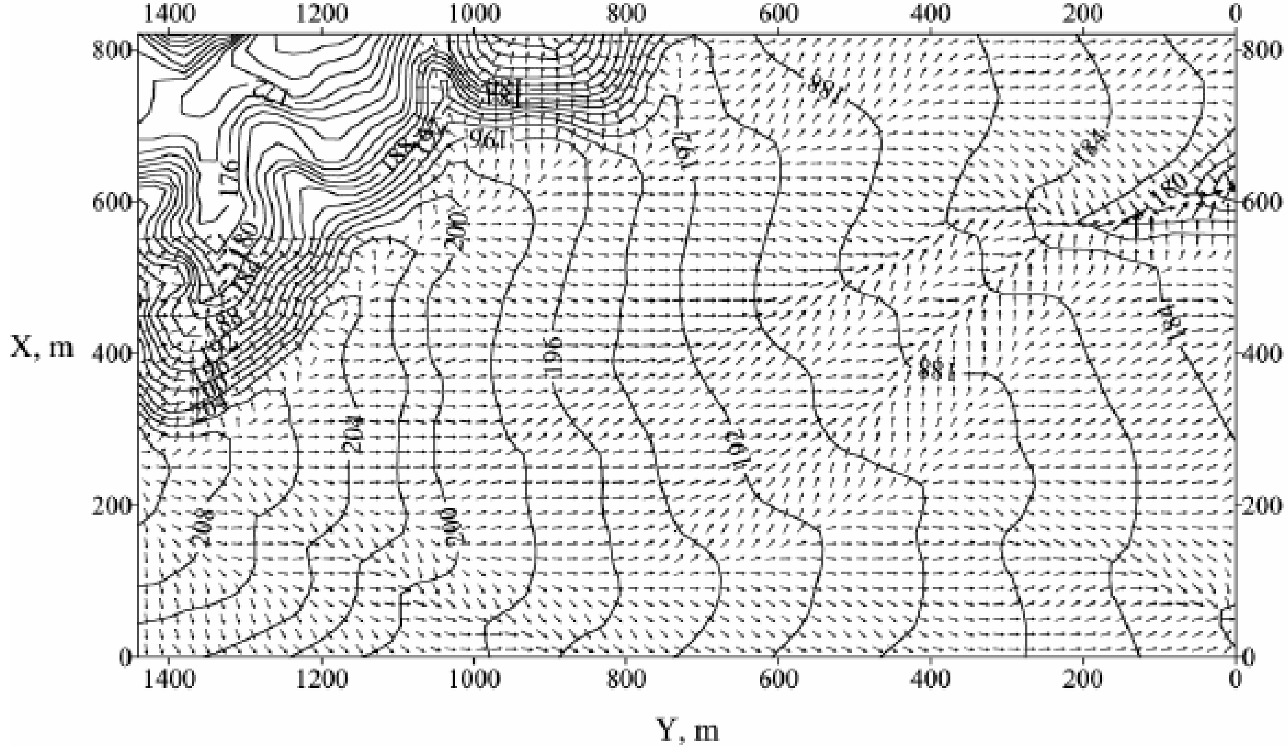
5-35% of Cs-137 in solute, up to 95% on sediments

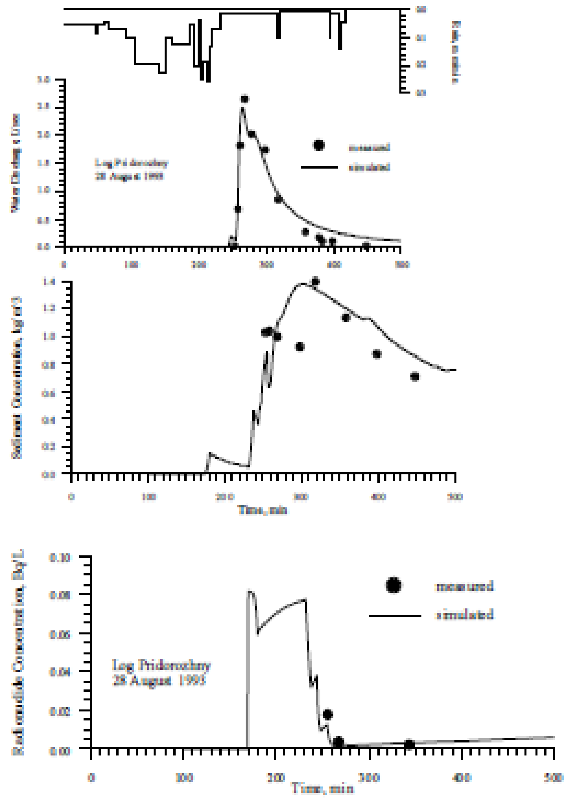
At 90%-95% of Cs-137 at Fukushima is transported by sediments in river water.

At Chernobyl – only up to 50% in initial period, than less, why?? What are the reasons and with which weight for such difference??

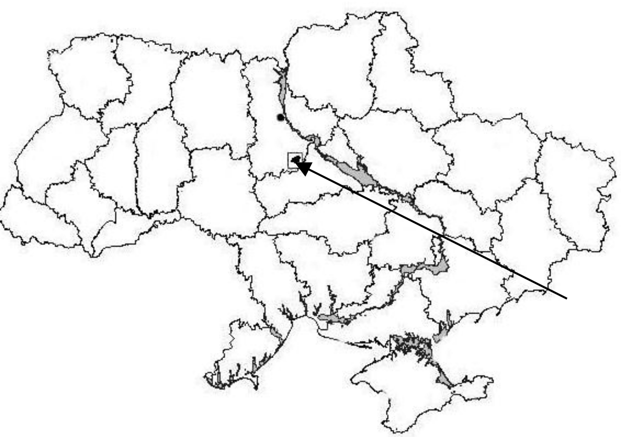
1) Steep mountain slopes vs mild or small plain slopes ???
2) Volcanic Fukushima soils vs soils of the Ukrainian- Byelorussian Poles'ye , i.e difference in Kd?
3) Typhoon generated higher amount of precipitations?

Implementations in Ukraine

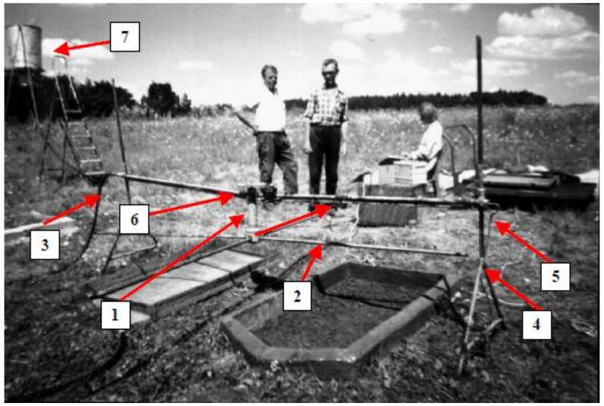




Watersheds at Boguslav / Kiev oblast, RUNTOX testing within EC SPARATCUS Projevt (M van der Perk, Kivva Korobova et al



Butenya River watershed



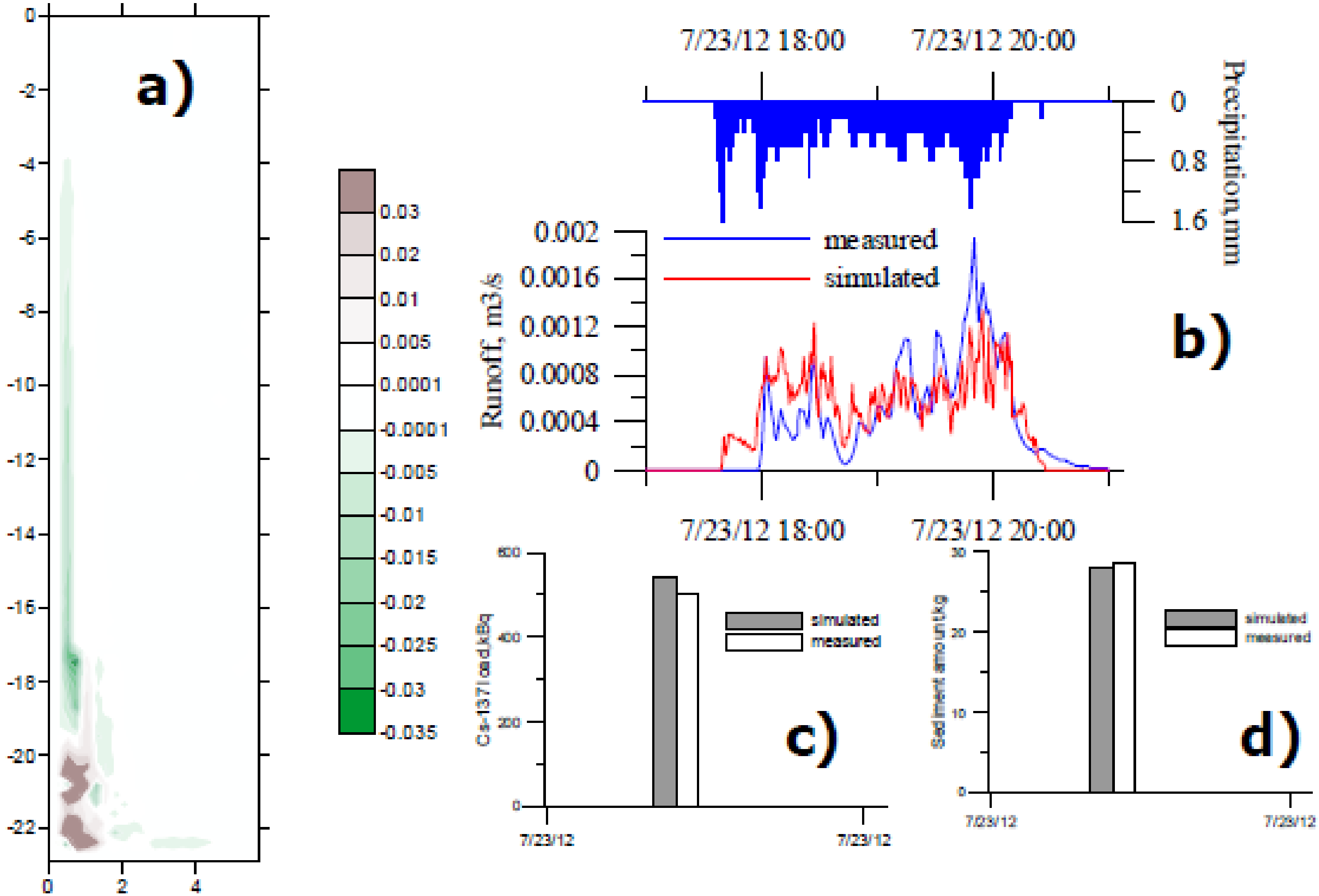
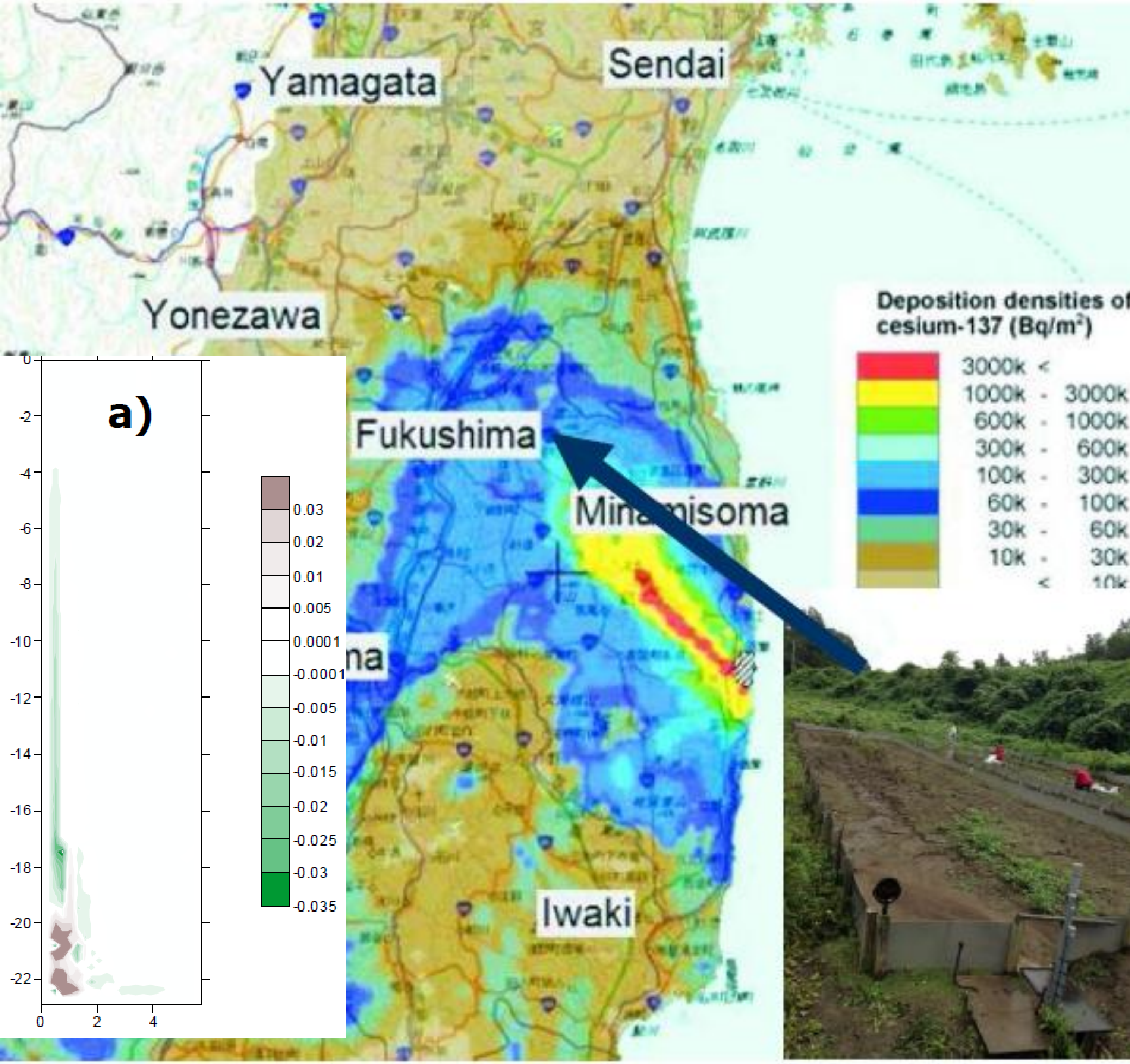


Fig.5 DHSVM-R testing versus the data from the "Farmland A1" plot measured during heavy rainstorm 23.07.2012: a) simulated zones of erosion and accretion, b) precipitation and simulated water discharge; c) total weight of the eroded sediments; d) total amount of ^{137}Cs washed out on sediments,



Yamagata
Sendai
Yonezawa
Fukushima
Minamisoma
Iwaki
na
Deposition densities of cesium-137 (Bq/m²)
3000k <
1000k - 3000k
600k - 1000k
300k - 600k
100k - 300k
60k - 100k
30k - 60k
10k - 30k
< 10k
a)
0.03
0.02
0.01
0.005
0.0001
-0.0001
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
-0.035
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
0
2
4

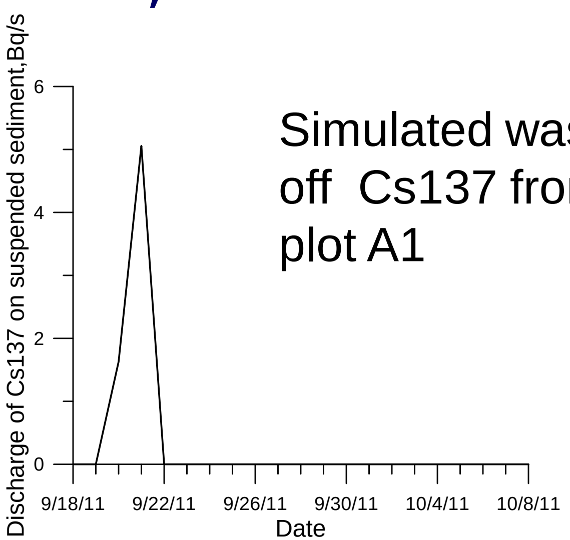
DHSMV- RUNTOX model preliminary testing for Fukushima experimental plots

Site specific : **Steep slopes**

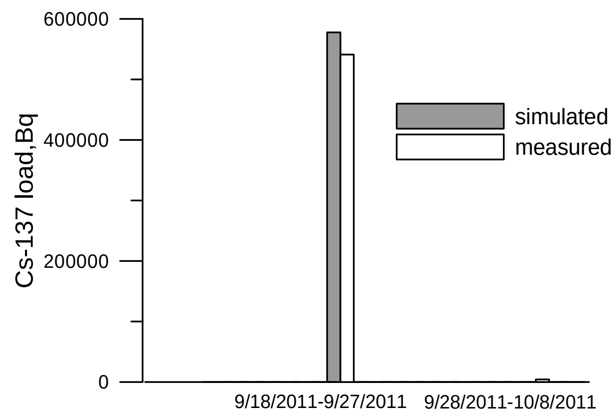
e.g. site A1 –slope =4.36 degree (7.36%)

In Chernobyl zone experimental plots (Konoplev et al. 1998) – slope 2.29 degree (4%)

Heavy precipitations: at Fukushima city day maximum – 165 mm, hour maximum 69 mm



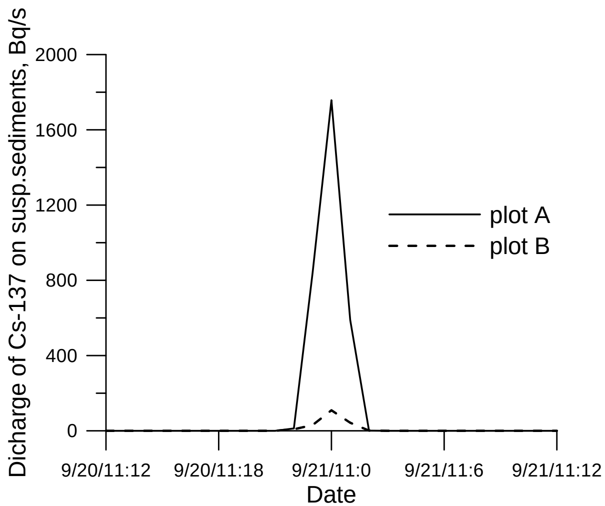
Simulated wash off Cs137 from plot A1



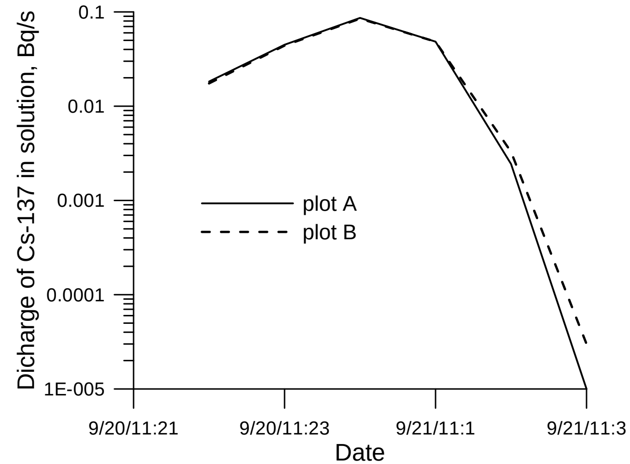
Comparison of the simulated and measured total wash off Cs137 from plot A1 during rainstorm

simulations of the influence of the watershed slope on the fluxes of the washed out Cs-137 in solute and with the eroded soil during extreme rainstorm

Simulated wash off Cs137 from two plots with the eroded soil (sediments)



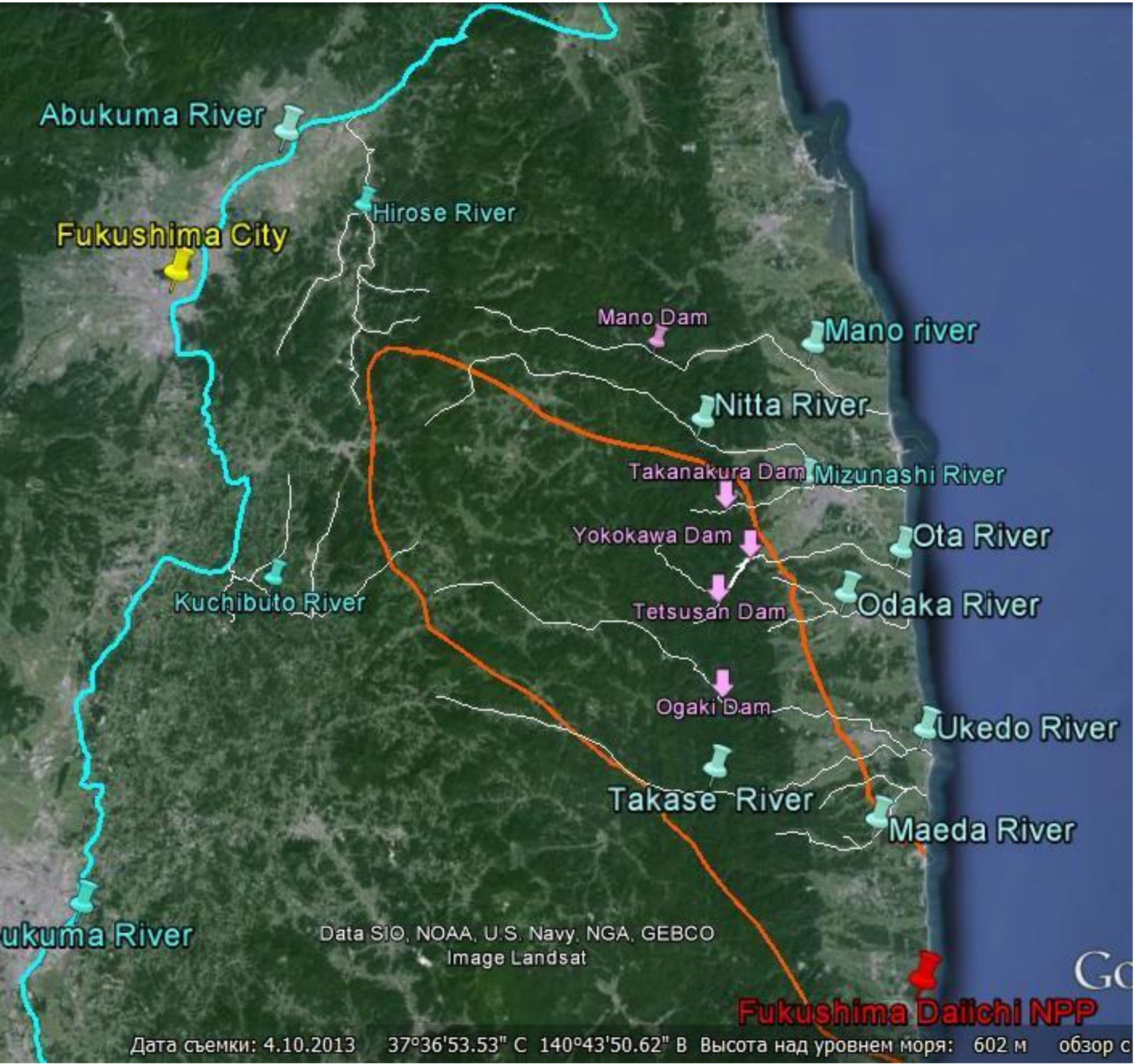
Simulated wash off Cs137 in solute



Plot description	Total amount of washed out Cs-137 during one rainstorm
Plot A – parameters of A1 plot of Tsukuba Univ. Slope 7.36%	11 530. Bq
Plot B– parameters of A1 plot of Tsukuba Univ., However smaller slope 4% as in Chernobyl sites	690 Bq

For the same Kd the twice steeper slope provides 20 times higher amount of Cs-137 on sediments – only due the higher amount of the precipitation !

RODOS models implementation in Fukushima area



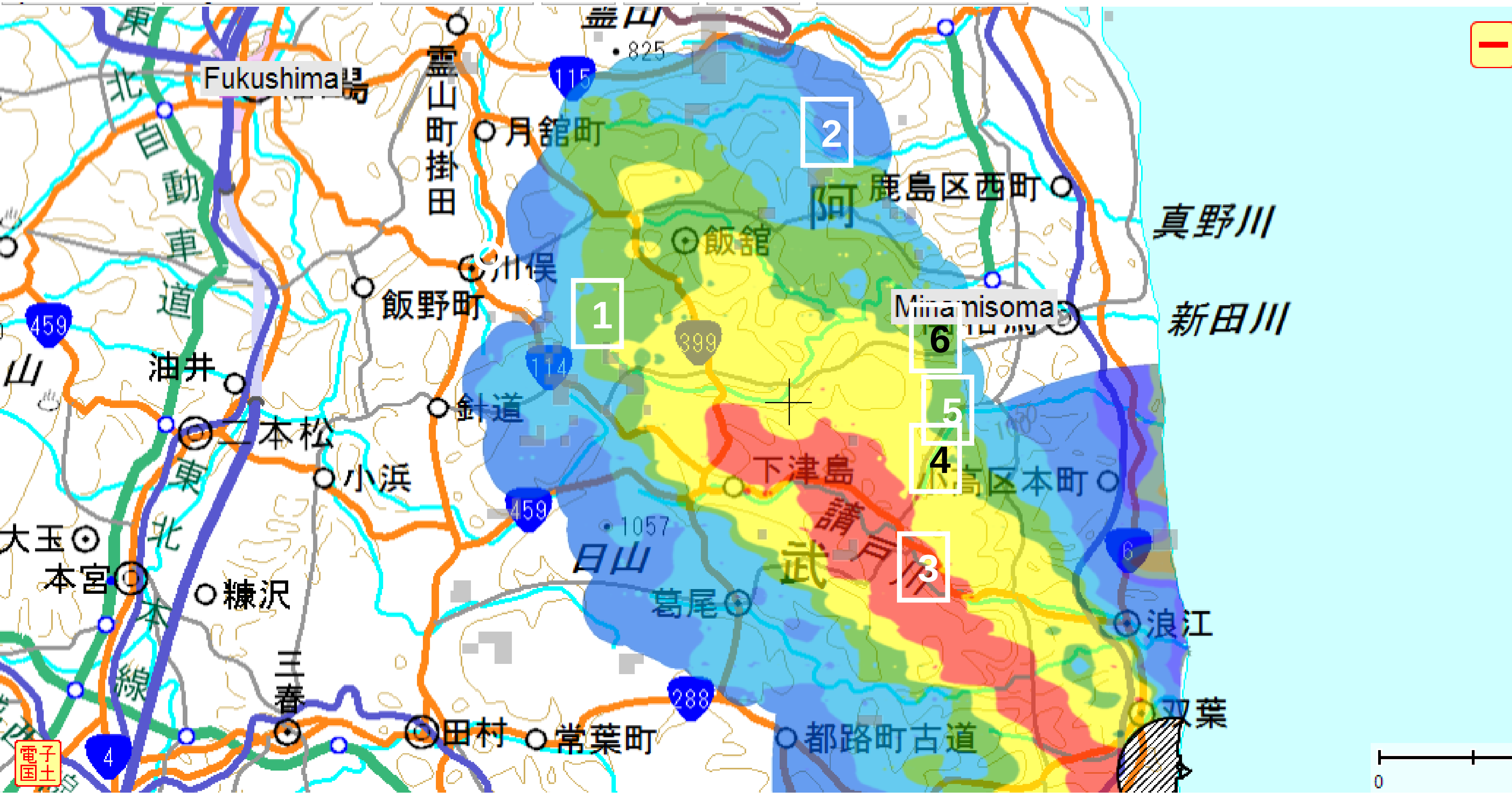
1 RIVERS

Annual amounts of sediment and ^{137}Cs exported into the ocean by the ruvers at Fukushima

River	Basin area (km^2)	Sediment discharge to ocean (t/y)	^{137}Cs discharge to ocean (Bq/y)	^{137}Cs to ocean/sediment to ocean (Bq/kg)
Abukuma	5423	2.4×10^5	3.0×10^{12}	1.2×10^4
Ukedo	420	2.7×10^4	2.0×10^{12}	7.2×10^4
Niida	261	1.6×10^4	1.1×10^{12}	6.5×10^4
Maeda	48	1.6×10^3	4.0×10^{11}	2.5×10^5
Kuma	74	2.5×10^3	2.8×10^{11}	1.1×10^5
Ota	79	1.7×10^3	2.7×10^{11}	1.6×10^5
Mano	167	5.5×10^3	2.0×10^{11}	3.7×10^4
Kido	260	1.5×10^4	1.4×10^{11}	9.0×10^3
Odaka	67	2.5×10^3	1.3×10^{11}	5.3×10^4
Tomioka	63	2.0×10^3	1.1×10^{11}	5.8×10^4
Natsui	685	4.2×10^4	1.1×10^{11}	2.6×10^3
Same	592	5.1×10^4	8.9×10^{10}	1.7×10^3
Ide	40	3.0×10^3	6.9×10^{10}	2.3×10^4
Uda	173	2.4×10^3	6.4×10^{10}	2.6×10^4
Total	8352	4.2×10^5	8.4×10^{12}	2.0×10^4

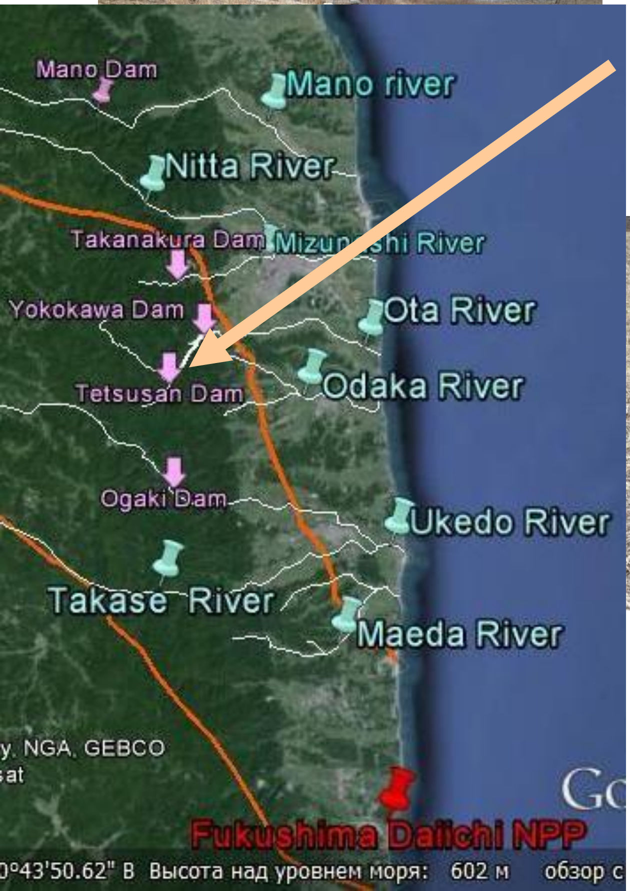
FROM: Kitamura, A., Yamaguchi, M., Kurikami, H., Yui, M., & Onishi, Y. (2014). Predicting sediment and cesium-137 discharge from catchments in eastern Fukushima. *Anthropocene*. Volume 5, March 2014, Pages 22–31

Contaminated reservoirs at Fukushima Daichi accident fallout zone



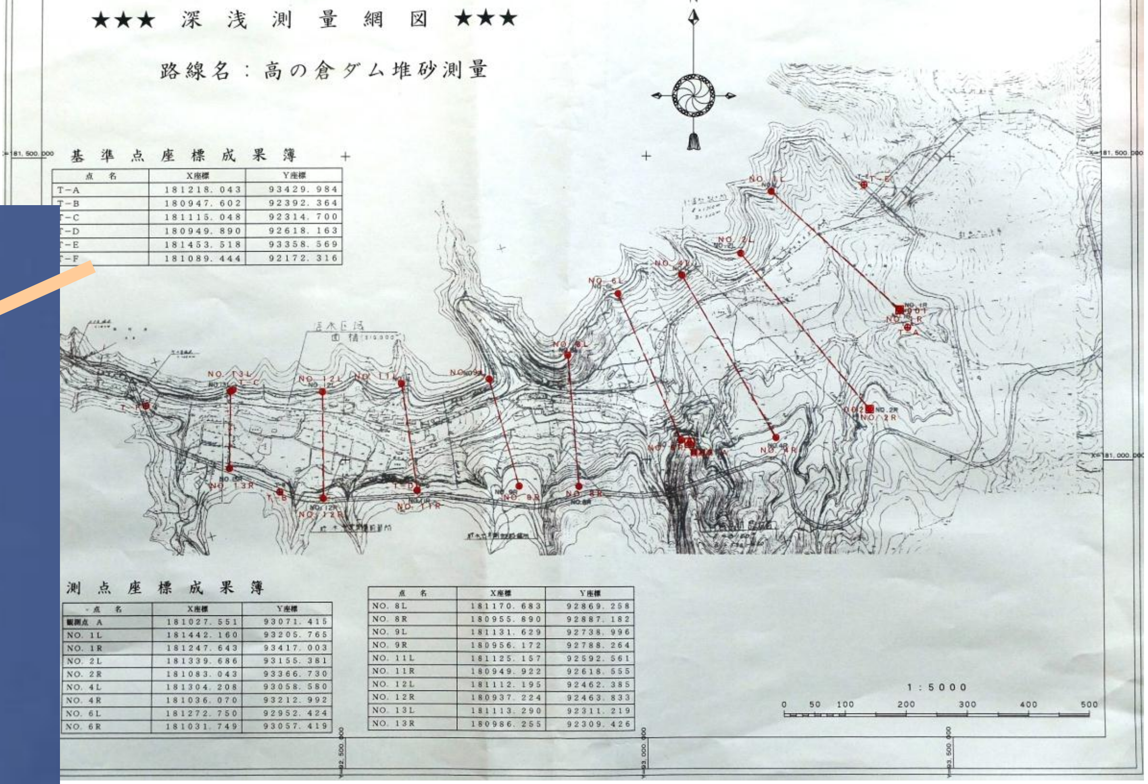
1-Ganbe (Iwabe) Dam at Ittoi- gawa River – the tributary of Nitta gawa
2-Mano Dam at Mano Gawa River
3- Ogaki Dam at Ukedo -gawa River
4 - Tetsuzan Dam and 5- Yokokawa Dam at Ota-gawa River
6- Takanakura Dam at Mizunashi Gawa River – tributary of Nitta Gawa River

2D COASTOX model implementation for simulation of Cs-137 transport in the reservoirs of Fukushima fallout Zone



Tetsuzan Dam destroyed by earthquake – now floodplain

Takanakura Dam



★★★ 深 浅 測 量 網 図 ★★★

路線名：高の倉ダム堆砂測量

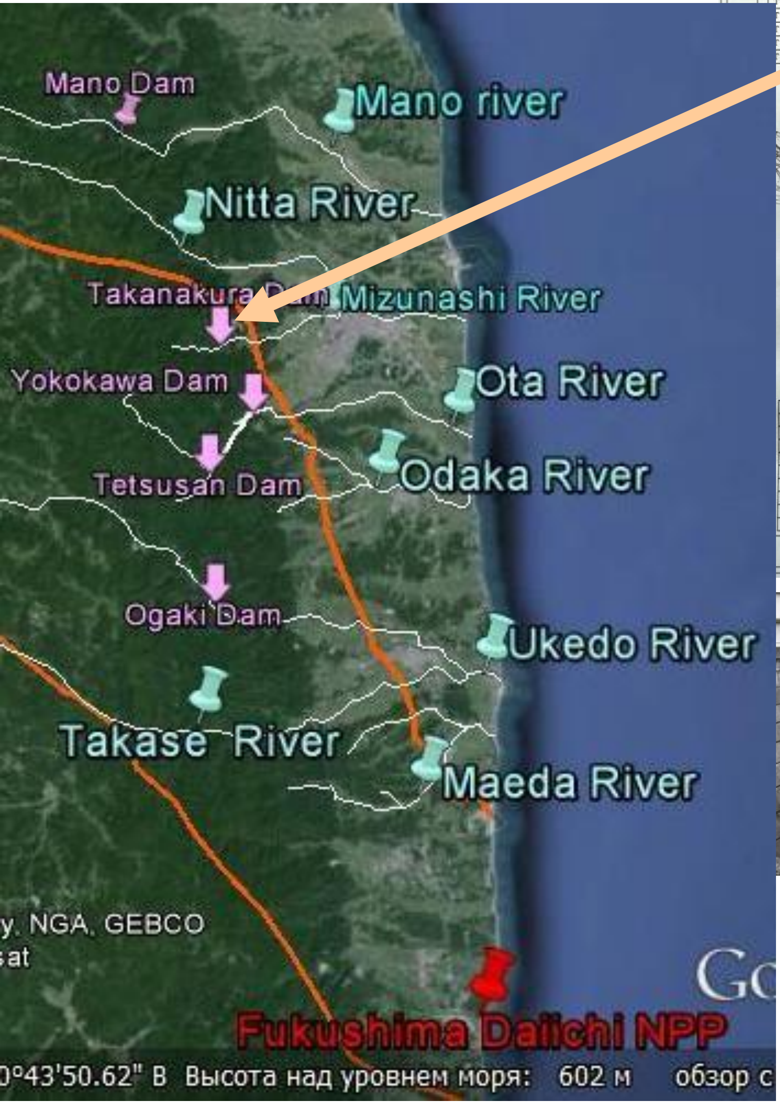
基 準 点 座 標 成 果 簿

点名	X座標	Y座標
T−A	181218.043	93429.984
T−B	180947.602	92392.364
T−C	181115.048	92314.700
T−D	180949.890	92618.163
T−E	181453.518	93358.569
T−F	181089.444	92172.316

測 点 座 標 成 果 簿

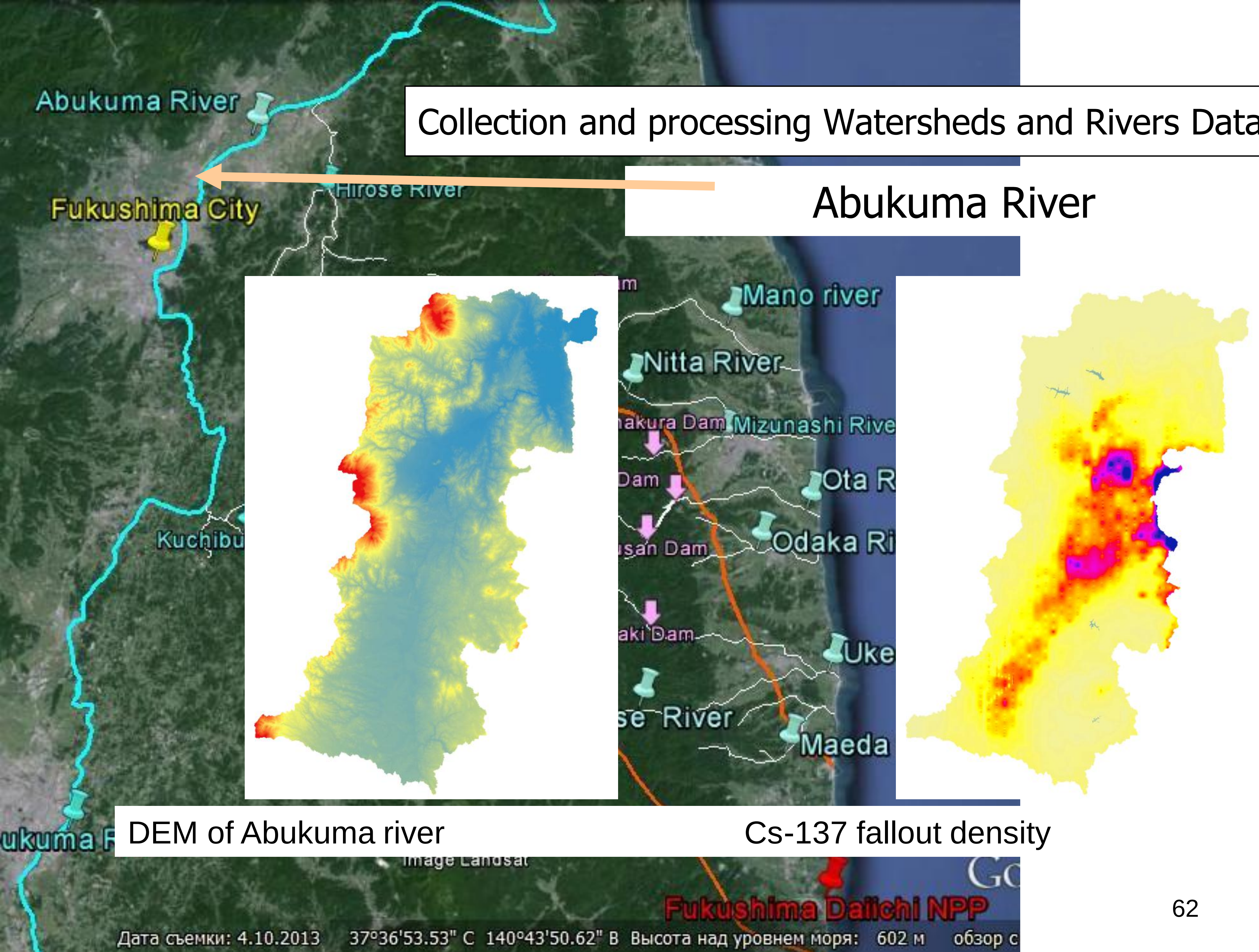
点名	X座標	Y座標
観測点 A	181027.551	93071.415
NO. 1L	181442.160	93205.765
NO. 1R	181247.643	93417.003
NO. 2L	181339.686	93155.381
NO. 2R	181083.043	93366.730
NO. 4L	181304.208	93058.580
NO. 4R	181036.070	93212.992
NO. 6L	181272.750	92952.424
NO. 6R	181031.749	93057.419

点名	X座標	Y座標
NO. 8L	181170.683	92869.258
NO. 8R	180955.890	92887.182
NO. 9L	181131.629	92738.996
NO. 9R	180956.172	92788.264
NO. 11L	181125.157	92592.561
NO. 11R	180949.922	92618.555
NO. 12L	181112.195	92462.385
NO. 12R	180937.224	92463.833
NO. 13L	181113.290	92311.219
NO. 13R	180986.255	92309.426



Collection and processing Watersheds and Rivers Data

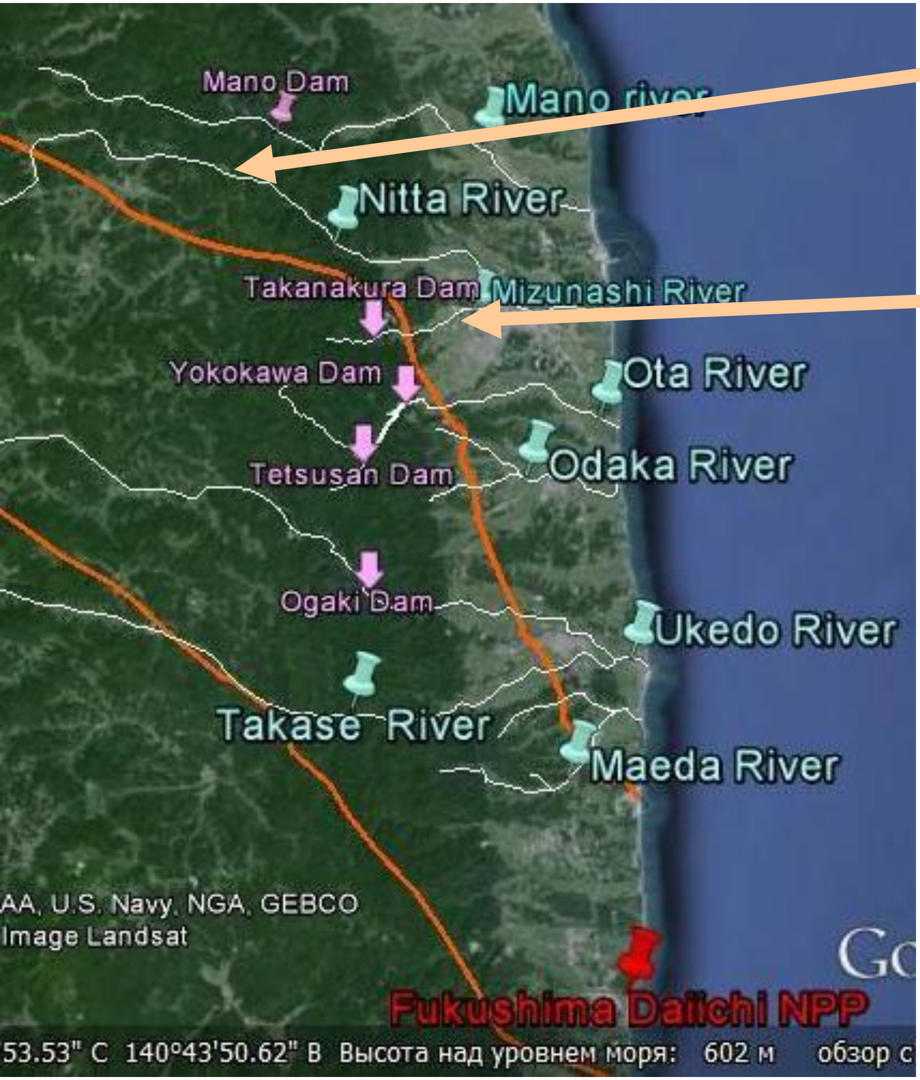
Abukuma River

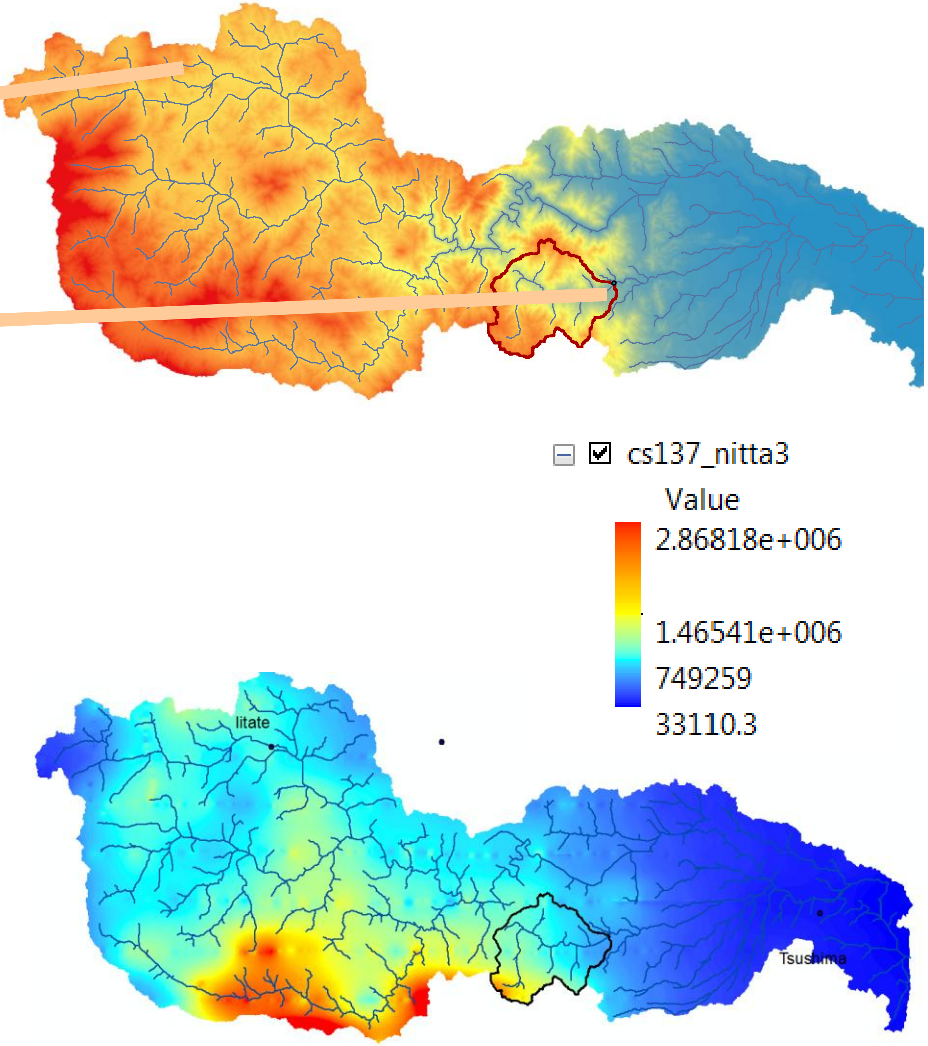


DEM of Abukuma river

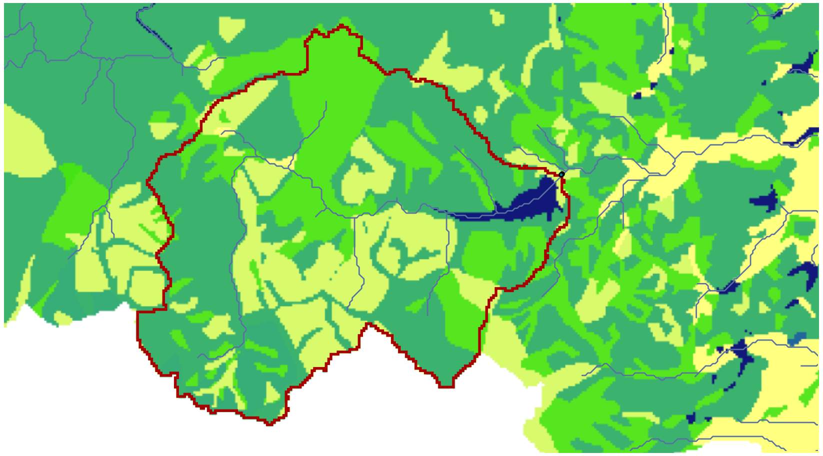
Cs-137 fallout density

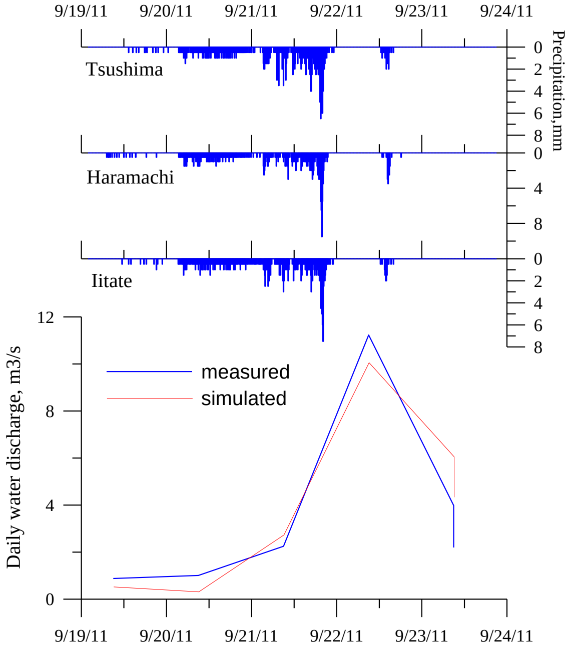
Nida (Nitta) River Watershed and sub-watershed of Takanokura Reservoir





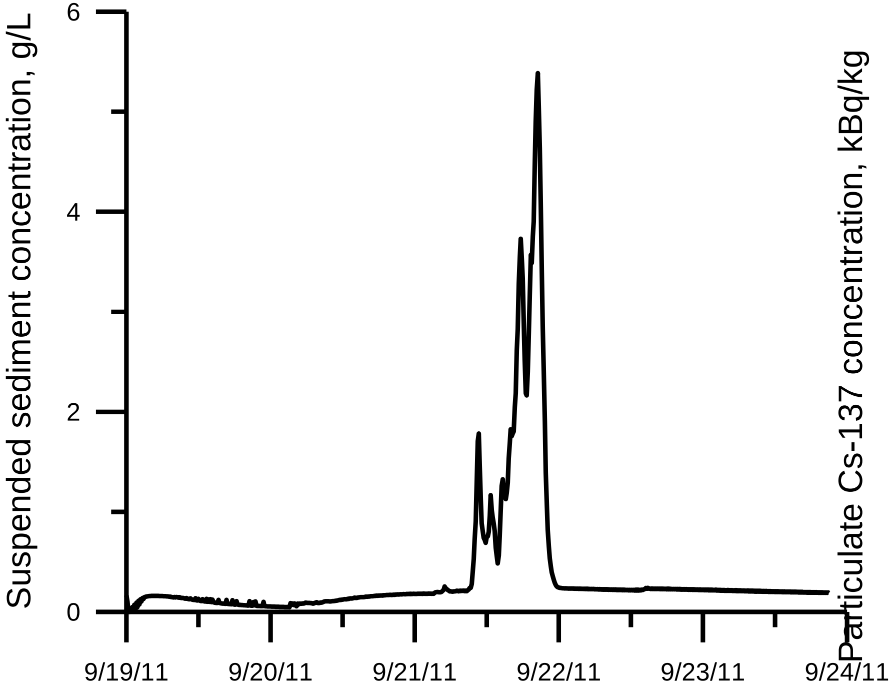
Modeling of watershed of Takanokura Reservoir

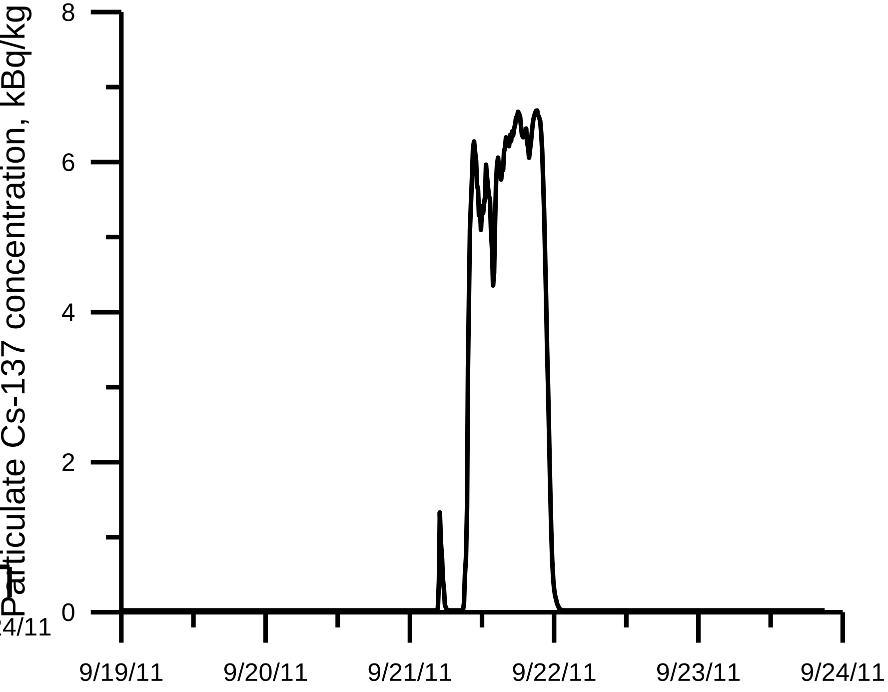




Modeling of water inflow to the Takanokura Reservoir by the distributed hydrological model DHSVM-R

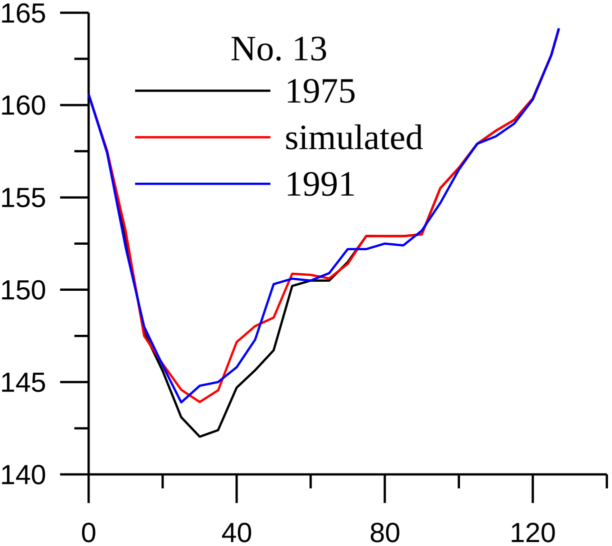
Modeling of suspended sediment transport and Cs-137 transport with sediments

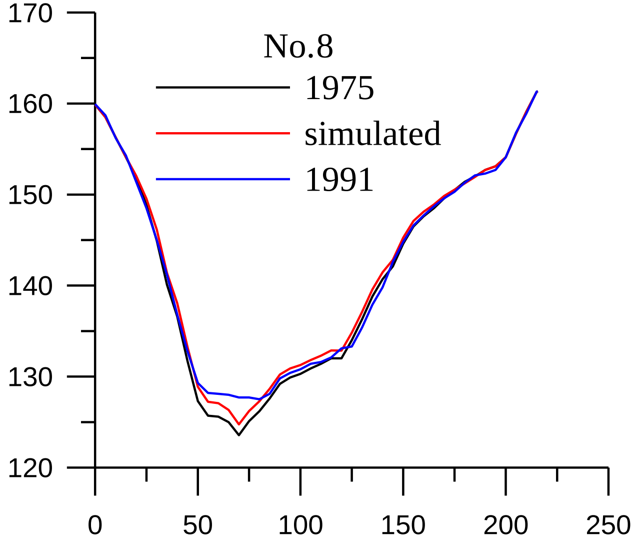


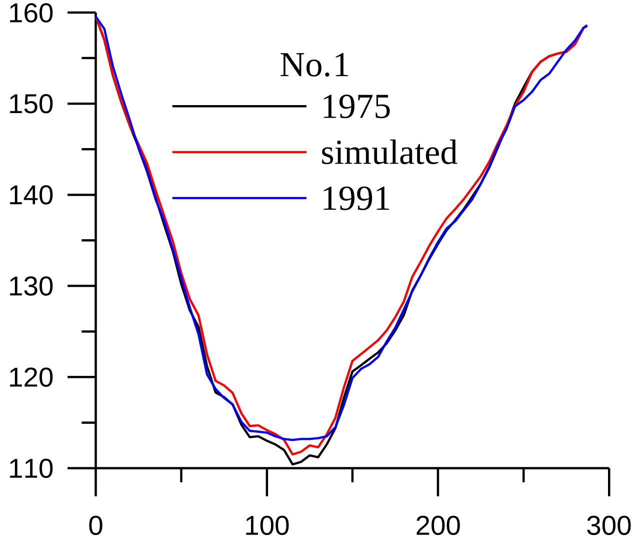


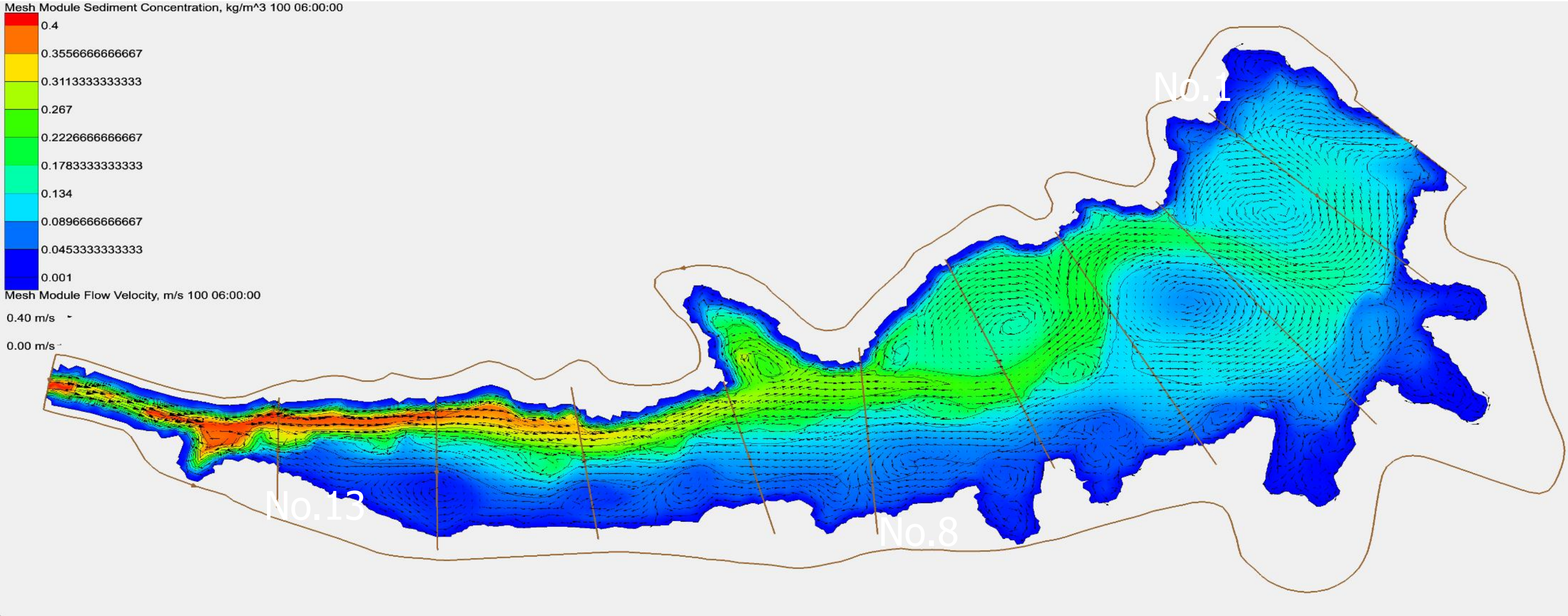
Susp sediment concentration and Cs-137 concentration on suspended sediments at the inflow to the Takanokura reservoir

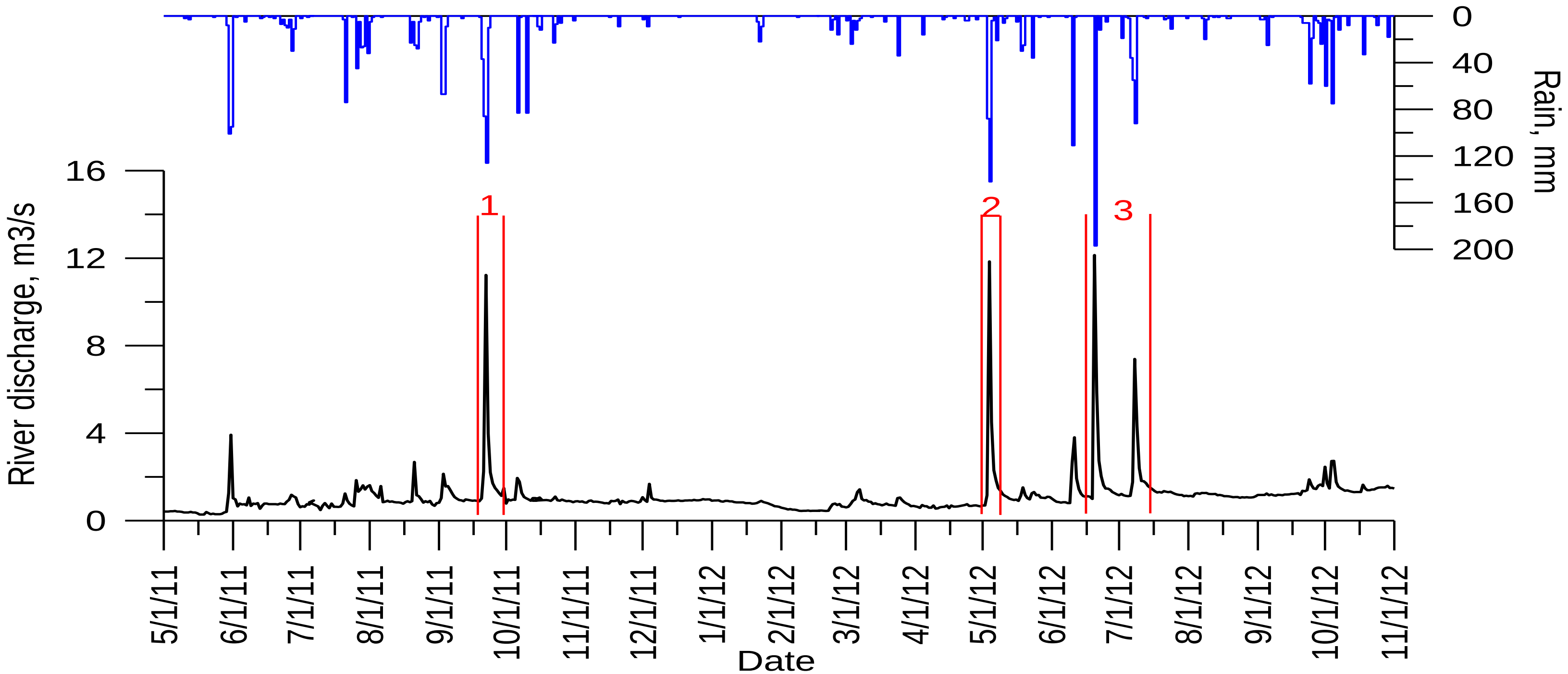
Takanokura Reservoir

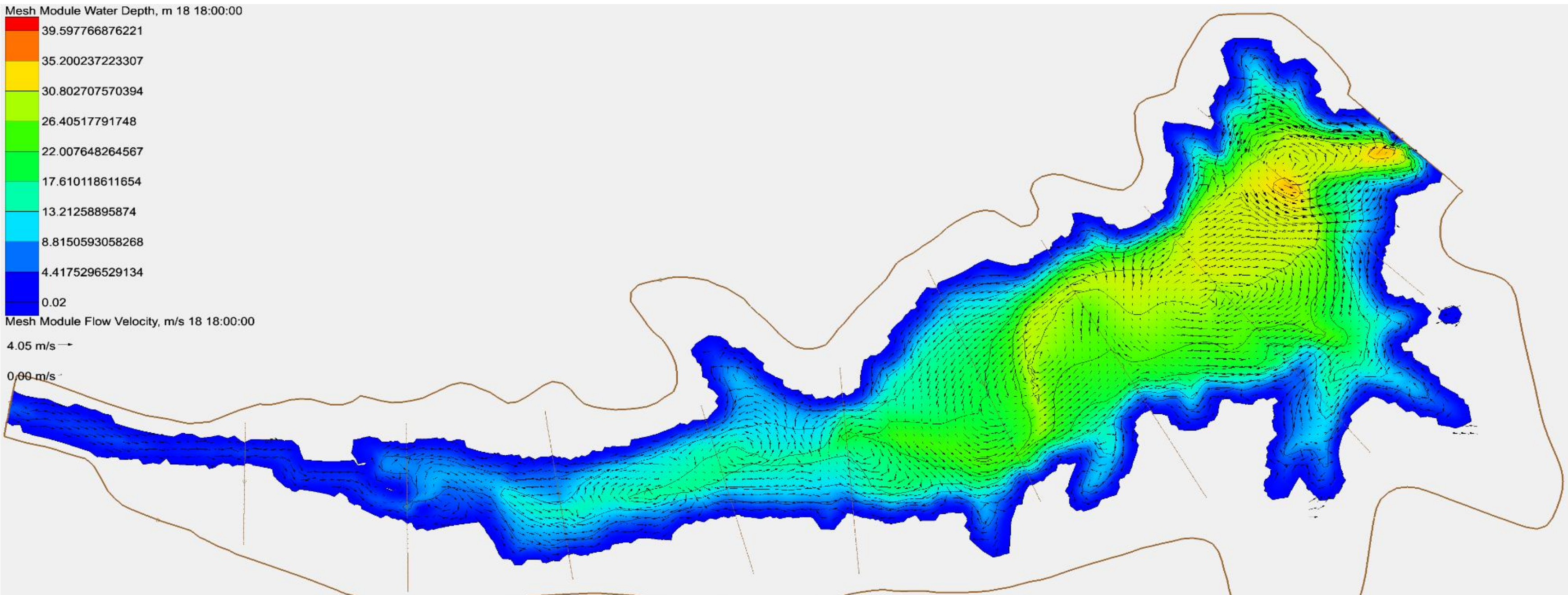






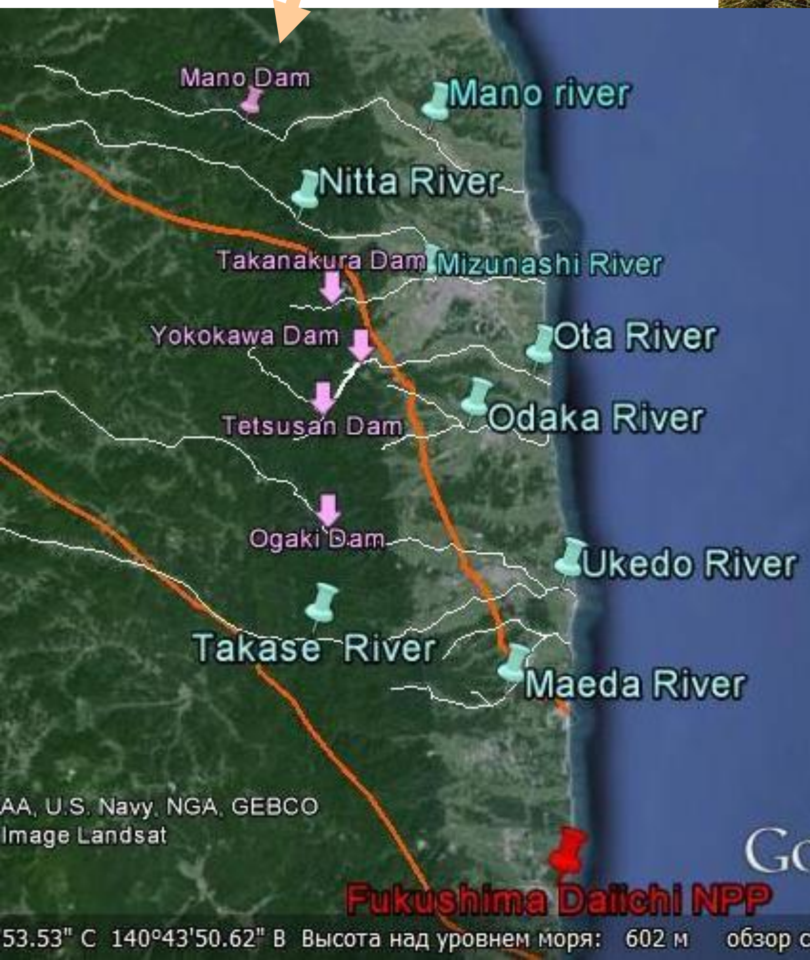


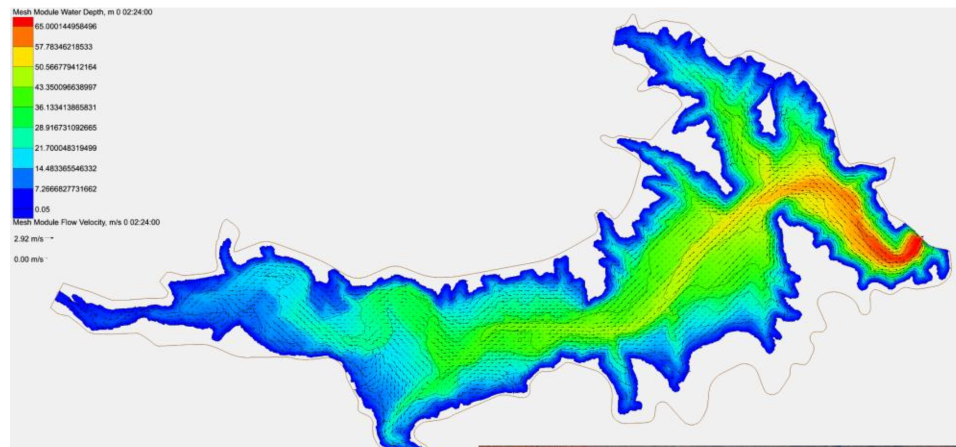




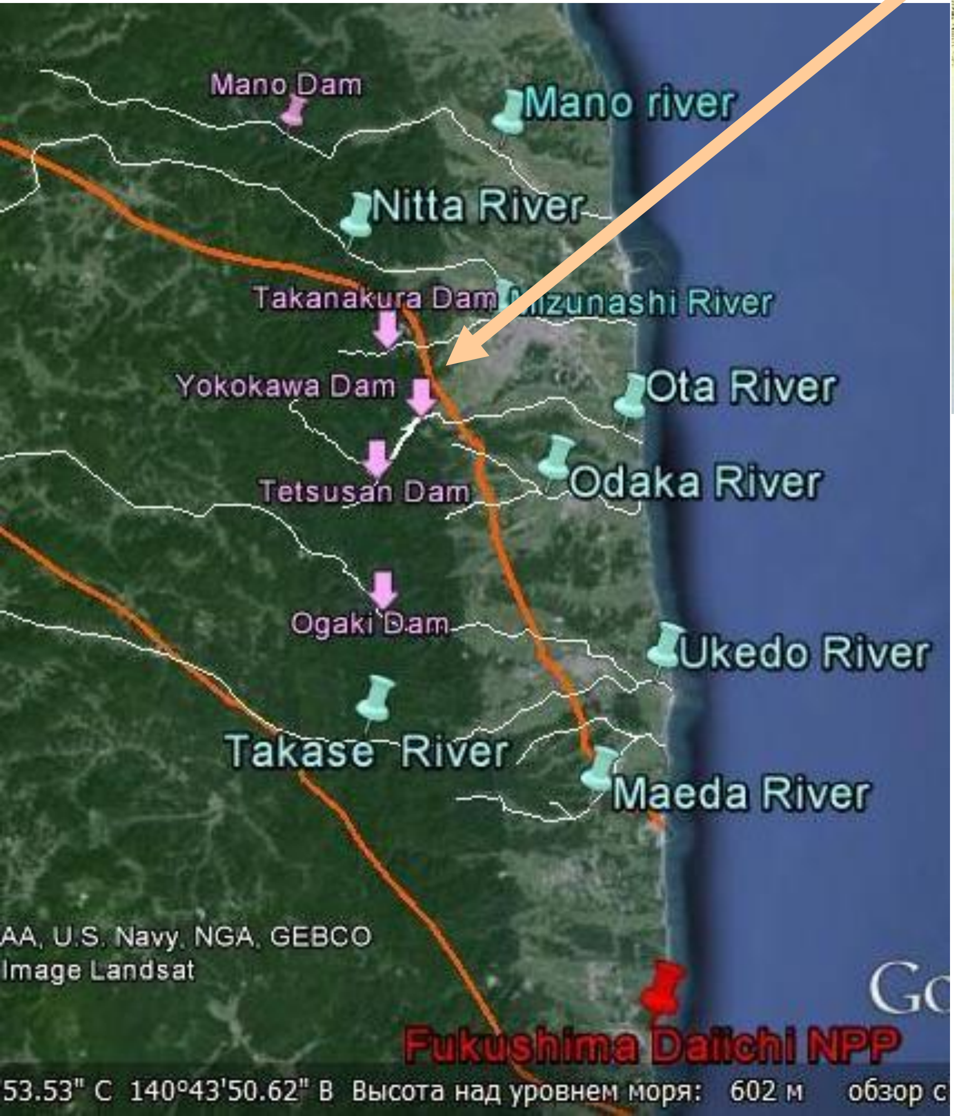
Water depth and water velocity field

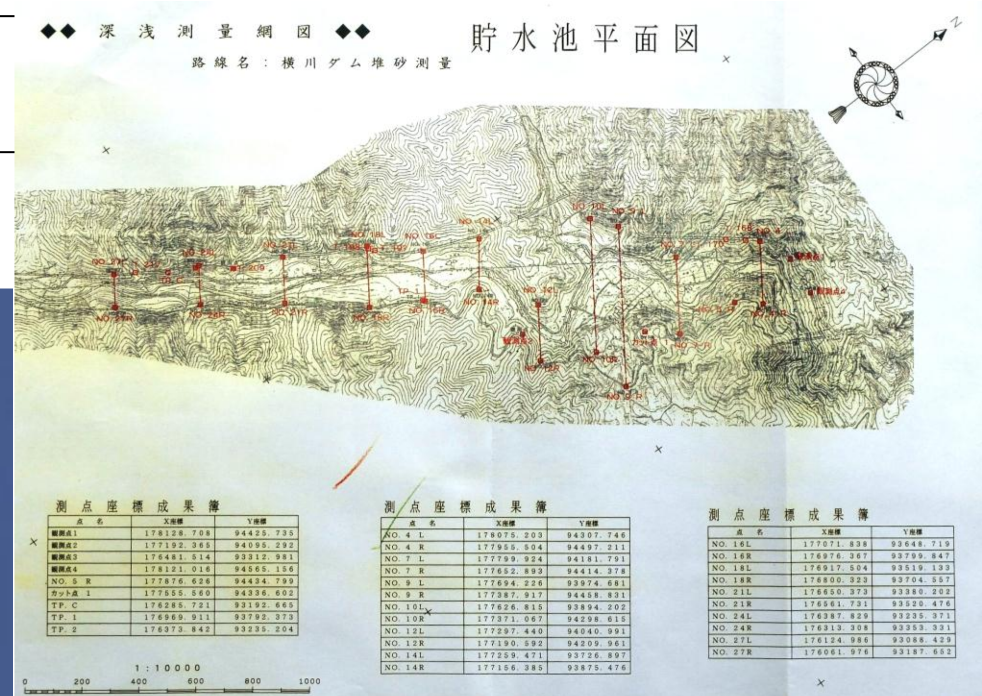
Mano Dam

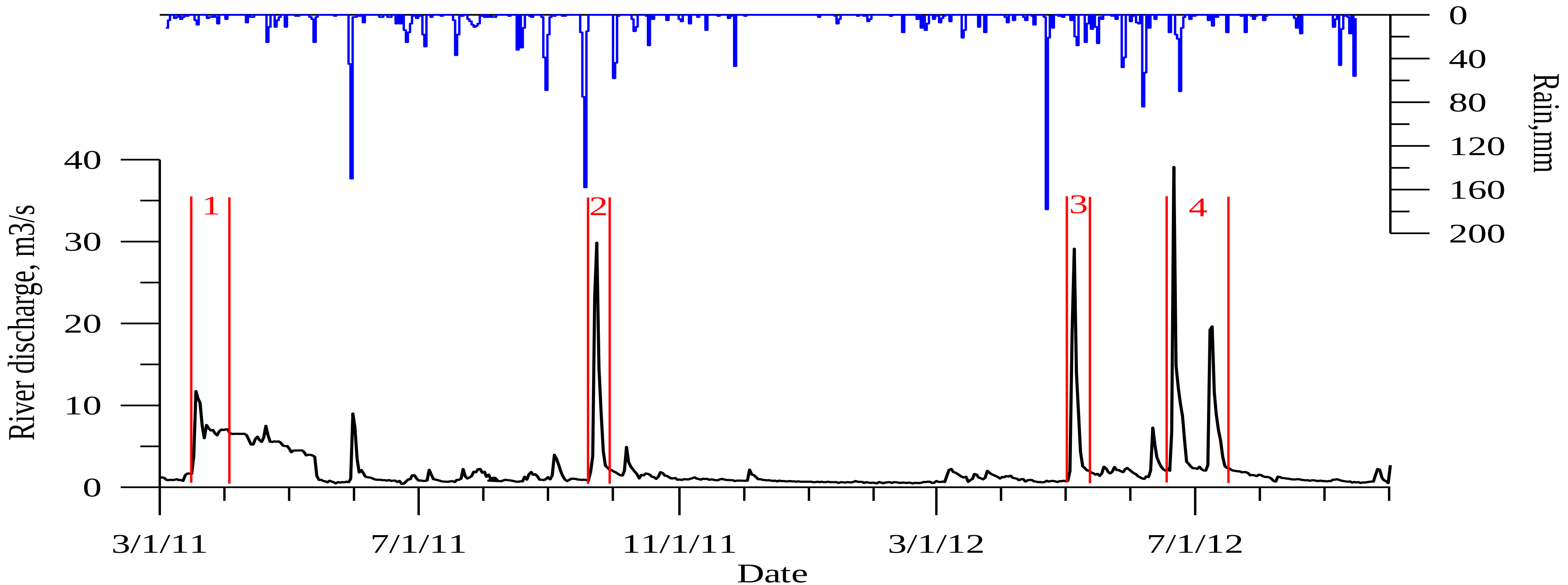

Mano Dam
Mano river
Nitta River
Takanakura Dam
Mizunashi River
Yokokawa Dam
Ota River
Tetsusan Dam
Odaka River
Ogaki Dam
Ukedo River
Takase River
Maeda River
AA, U.S. Navy, NGA, GEBCO
Image Landsat
Fukushima Daiichi NPP
53.53" С 140°43'50.62" В Высота над уровнем моря: 602 м обзор с

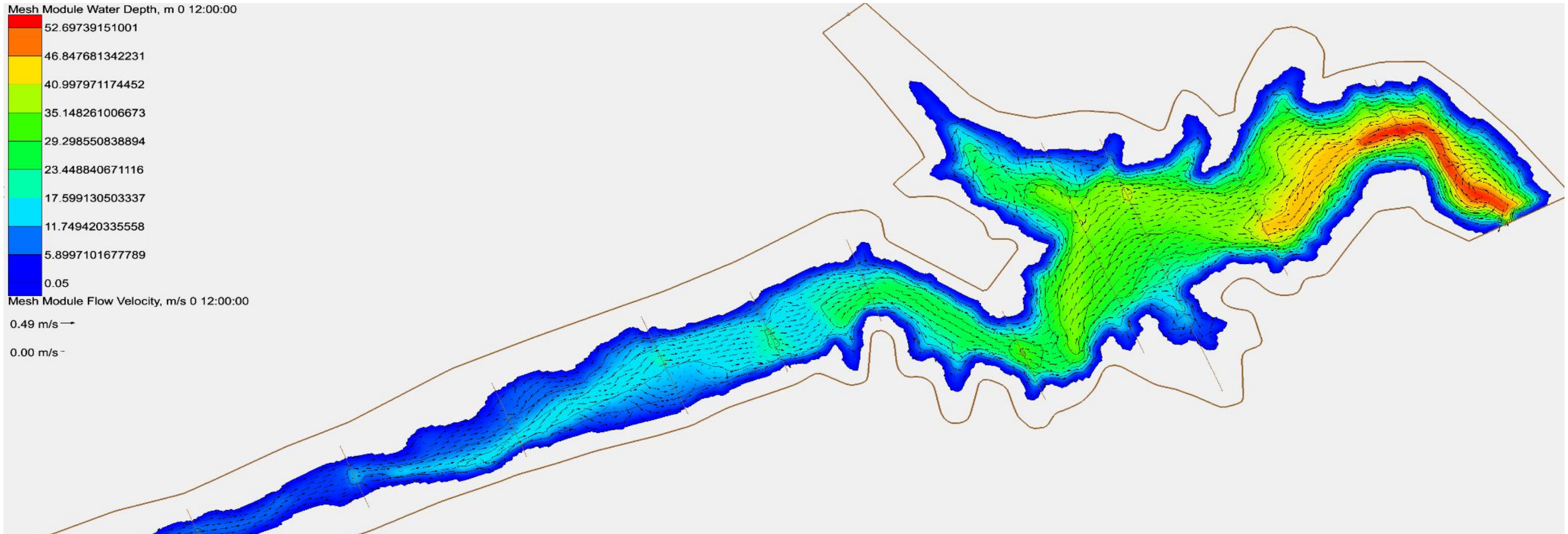

Mesh Module Water Depth, m 0 02:24:00
65.000144958496
57.78346218533
50.566779412164
43.350096638997
36.133413865831
28.916731092665
21.700048319499
14.483365546332
7.2666827731662
0.05
Mesh Module Flow Velocity, m/s 0 02:24:00
2.92 m/s
0.00 m/s

Yokokawa Dam



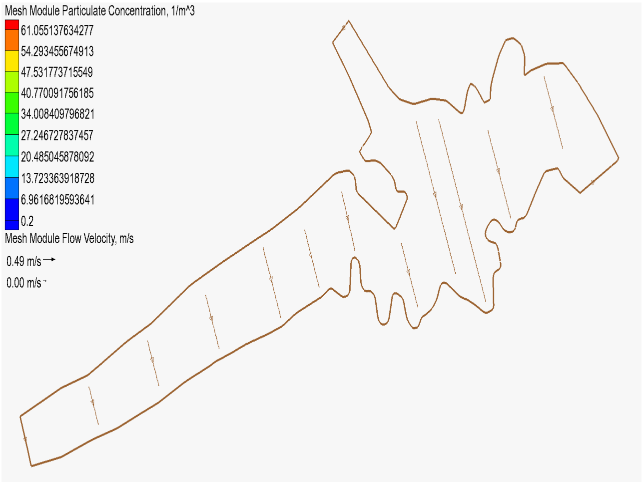


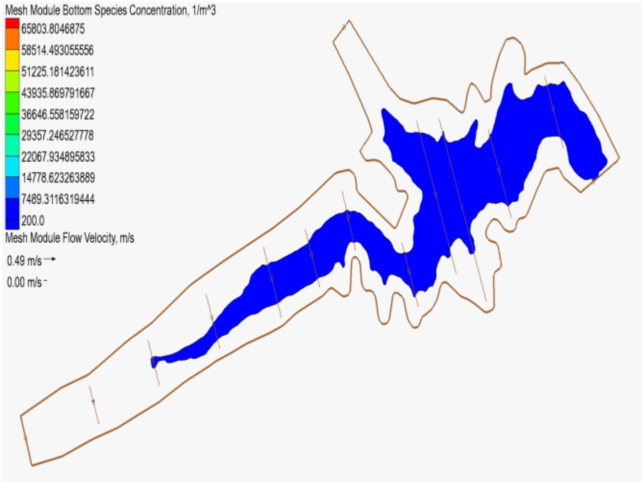




Water depth and water velocity field

COASTOX model is customized and preliminary tested for three reservoirs





Cs -137 concentration on the suspended sediments (left) and in the bottom deposition of the Yokokawa Dam during the high flood in the reservoir

Conclusions:

1 The modeling system that was implemented for Chernobyl site, validated within IAEA programs and integrated into the EC decision support system RODOS, starts to be implemented for the watersheds, rivers, reservoirs of Fukushima Prefecture

2 Reliable short term and long term forecasting of the future dynamics of Cs-137 in water bodies in different hydrometeorological scenarios and the quantization of the efficiency of the countermeasures can be provided using such modeling tools

2 Even in the initial post accidental period of the significant uncertainties of the source term the physically based well validated model can produce reasonable assessments of the radiological situation