FACING CLIMATE CHANGE EFFECTS ON POTATO CULTIVATION: AN INTEGRATIVE APPROACH

P Monneveux, R Quiroz, A Posadas, U Kleinwechter

Centro International de la Papa, Lima, Perú

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

International Conference on Managing Soils for Food Security and Climate Change Adaptation and Mitigation (Vienna, Austria, 23-27 July 2012)

Outline

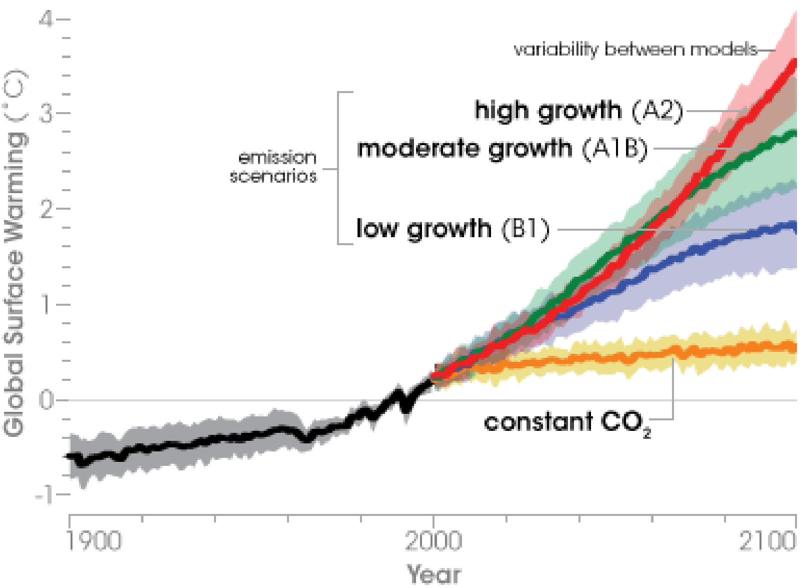
Prediction of climate change effects
Improvement of climatic data information
Modelling of climate change impact on potato yield

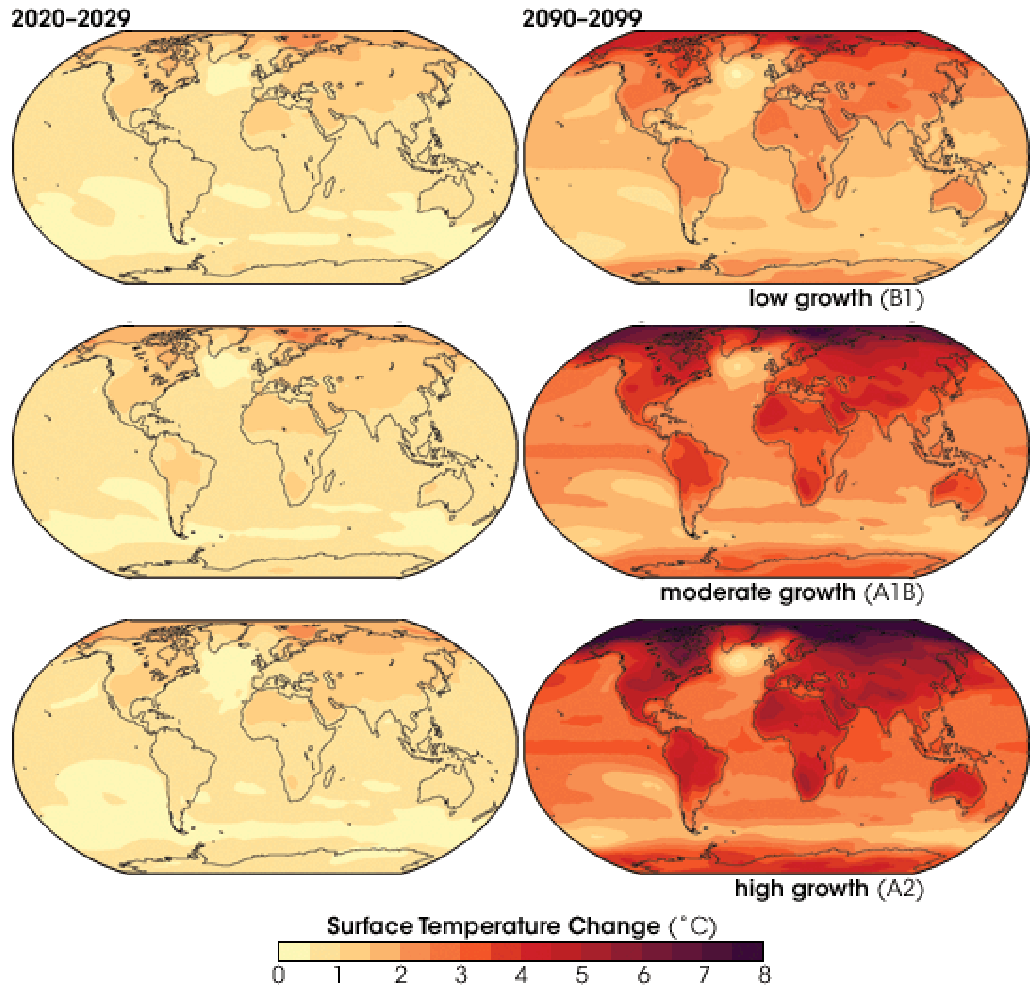
Mitigation of climate change: C sequestration and soil organic matter stabilization

Adaptation to climate change
Through irrigation: partial root-zone drying (PRD) irrigation method
Through breeding: drought and heat tolerance improvement

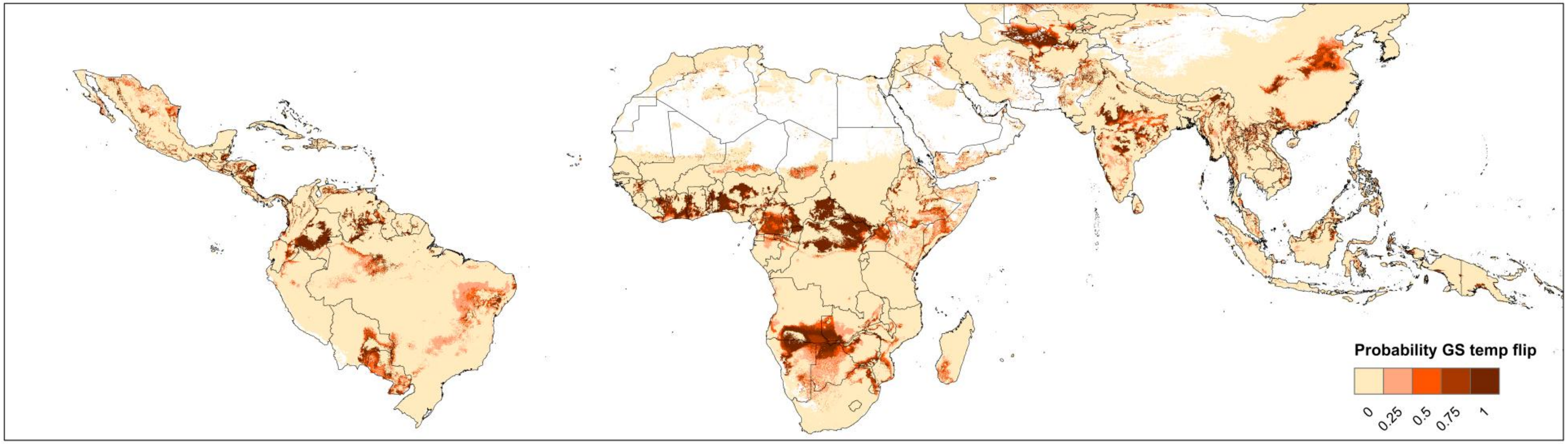
Ex-ante assessment of socio-economic impacts of potato technologies under climate change

Introduction

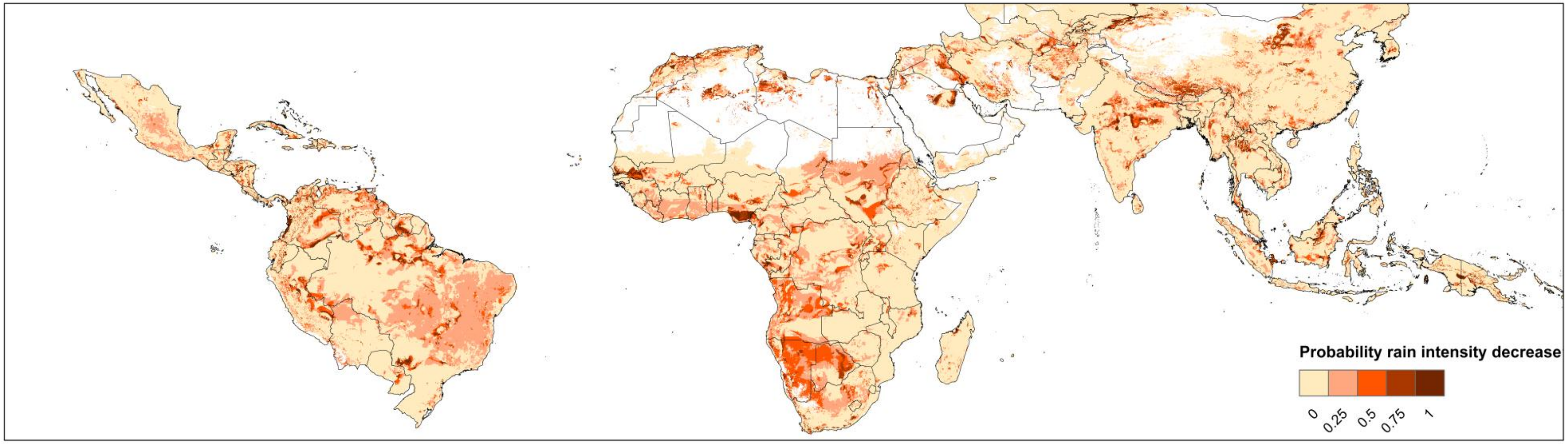




Areas where maximum temperature during the primary growing season is currently < 30° C but will flip to > 30° C by 2050

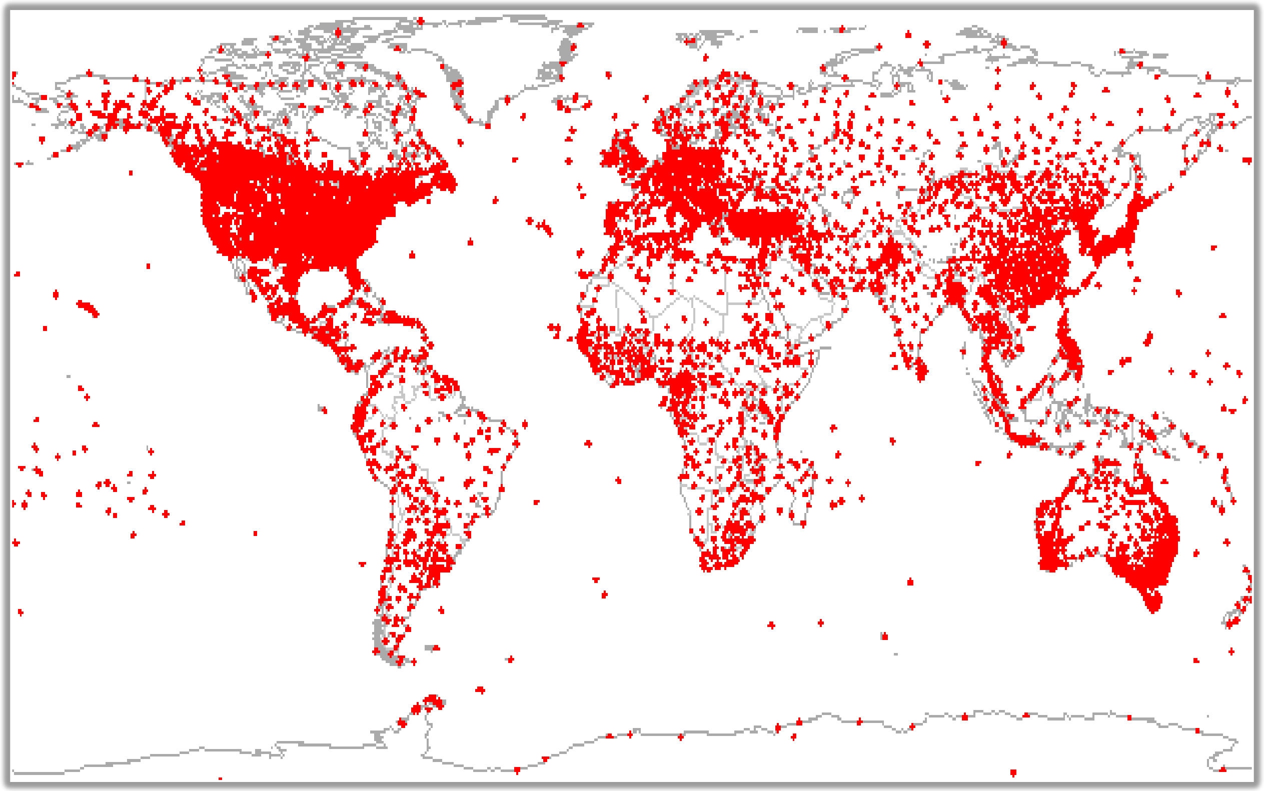


Areas where rainfall per day decreases by 10 % or more between 2000 and 2050

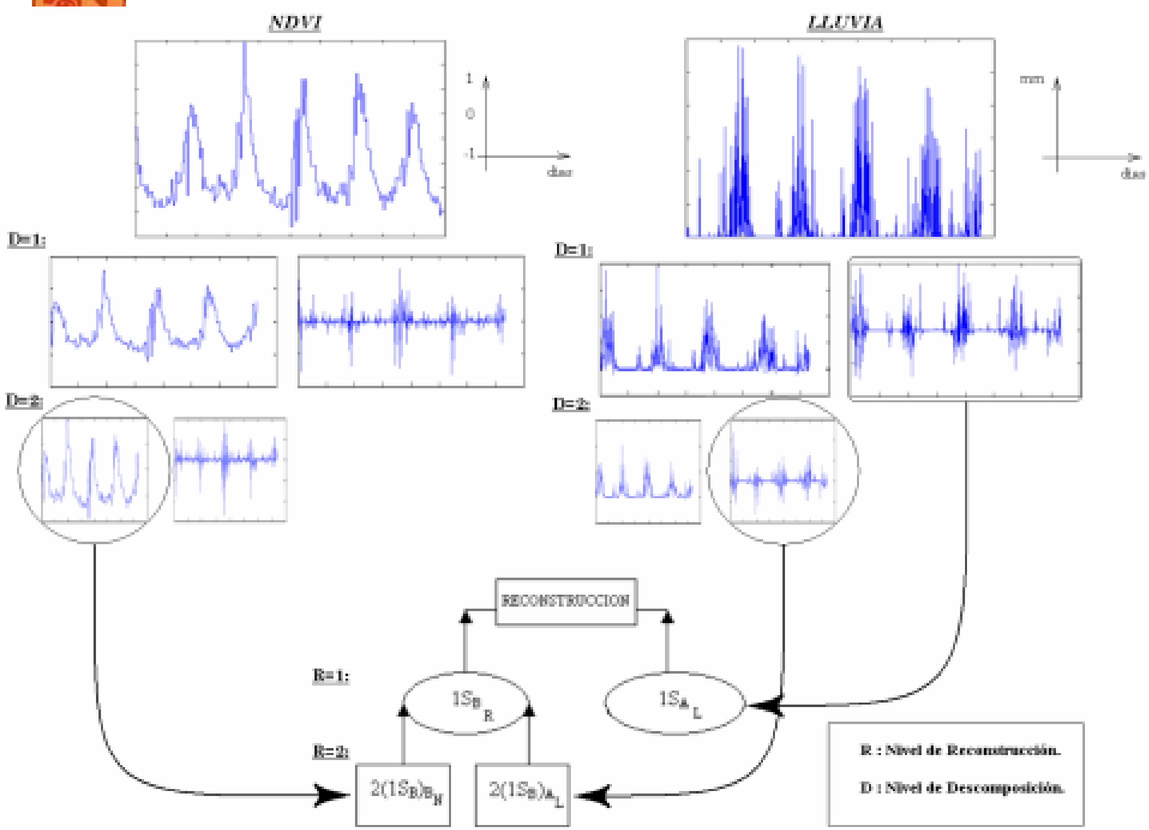


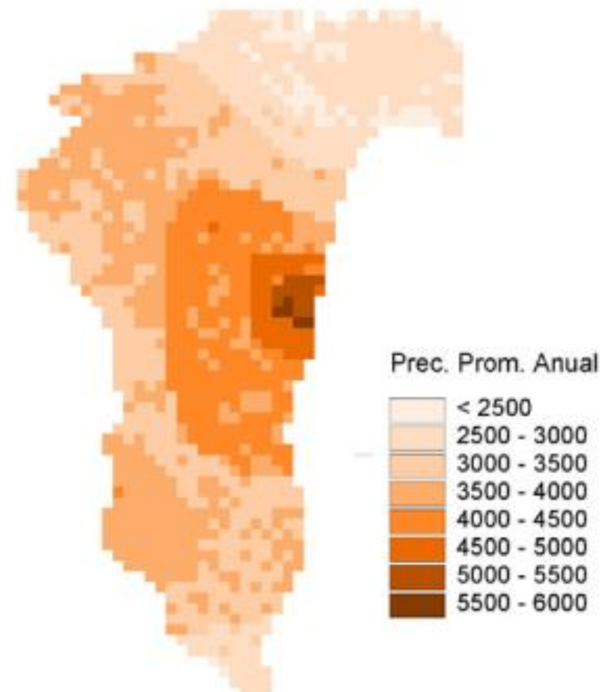
Prediction of climate change effects

Improvement of climatic data information



Importance of quantifying rainfall at spatial and temporal scales in regions where meteorological stations are scarce





- approach based on the wavelet transform (WT) and the multi-resolution analysis (MRA) developed at CIP to reconstruct daily rainfall from rain gauge data and the normalized difference vegetation index (NDVI) and to correct biased estimates generated by the NASA Tropical Rainfall Measuring Mission
- validation in the high Andean plateau of Peru (Heidinger et al., in press)

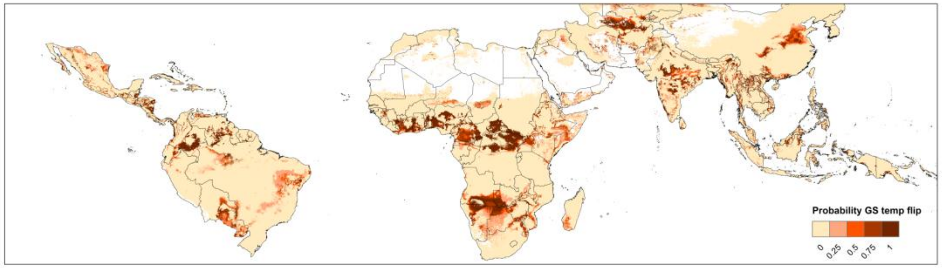
Modelling of climate change impact on potato yield

Temperature requirements

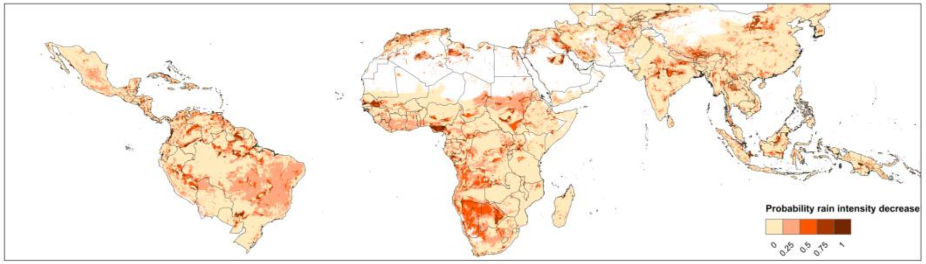
- mean daily temperatures 18 to 20°C
- night temperature below 15°C (required for tuber initiation)
- temperatures below 10°C and above 30°C (inhibit tuber growth)

Water Requirements

500 to 700 mm for a 120 to 150 days growing season

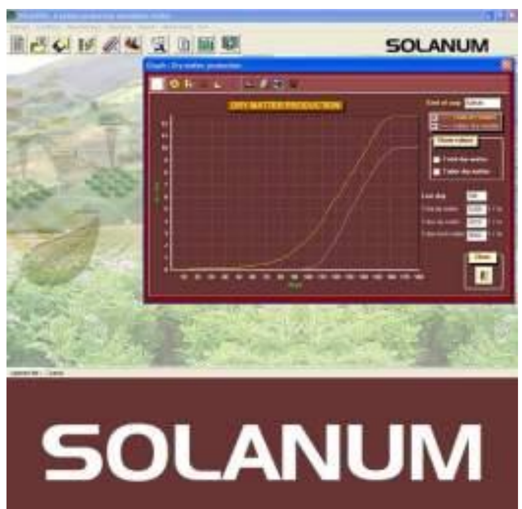


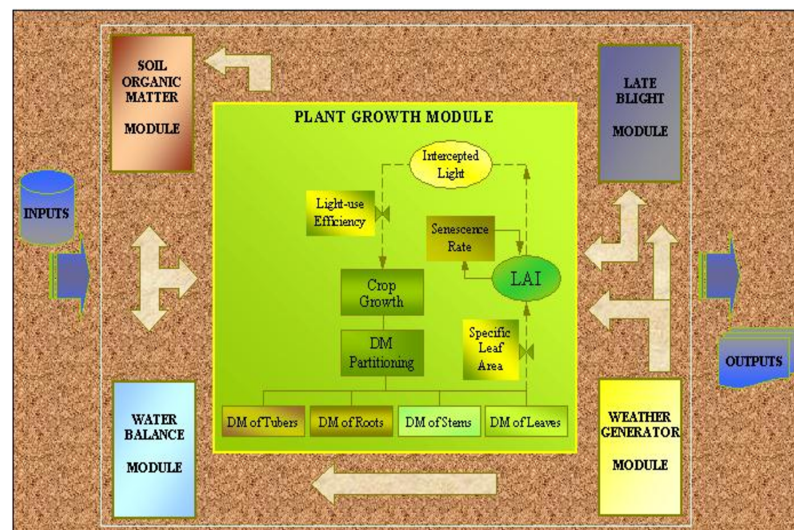
Areas where maximum temperature during the primary growing season is currently < 30° C but will flip to > 30° C by 2050

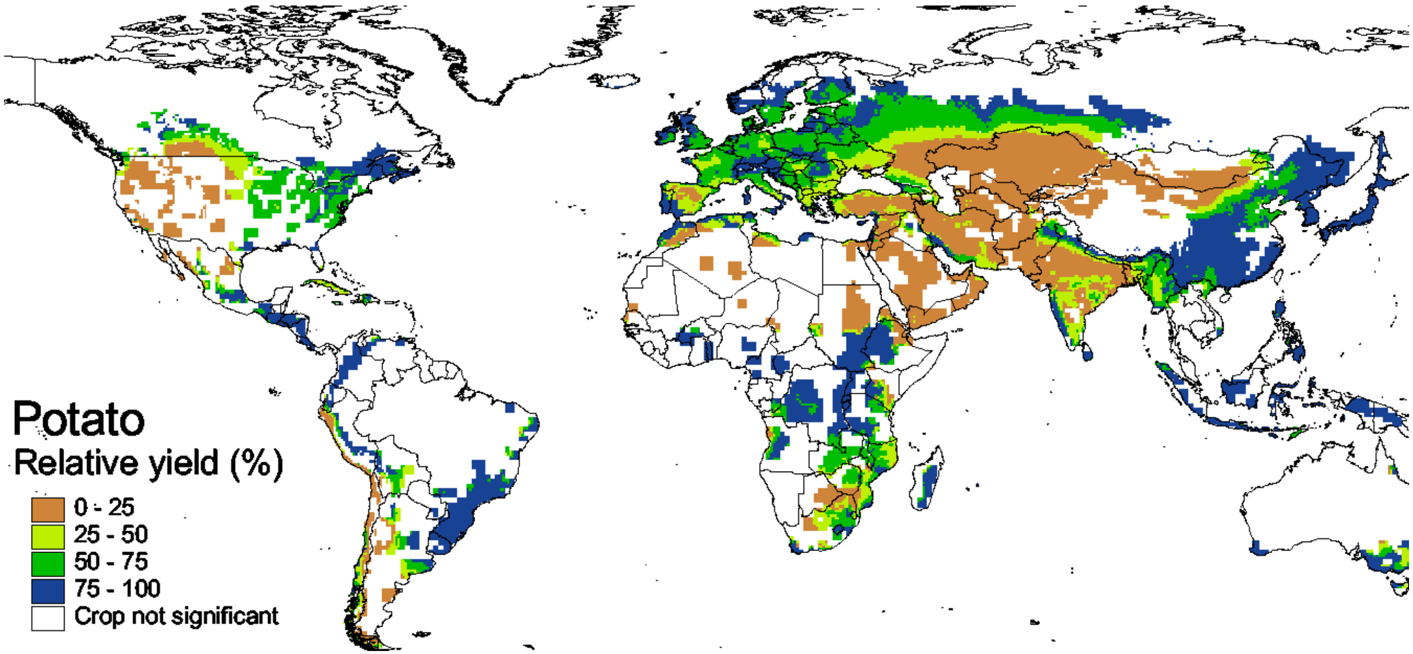


Areas where rainfall per day decreases by 10 % or more between 2000 and 2050

The effect of climate change on global potato production was assessed using a simulation model developed by CIP







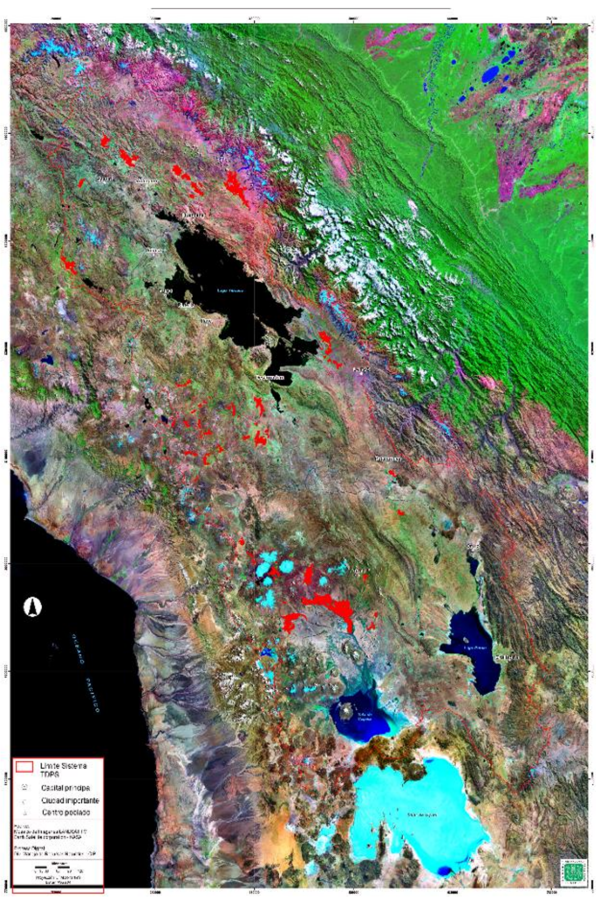
- until 2069, and depending on the climate scenario, potential potato yield is expected to decrease by 18% to 32% (without adaptation of planting time and cultivars) and by 9% to 18% (with adaptation)
- at high latitudes changes in potato yield are likely to be relatively small
- at low latitudes, shifting planting time or location is less feasible, and in these regions global warming could have a strong negative effect on potato production

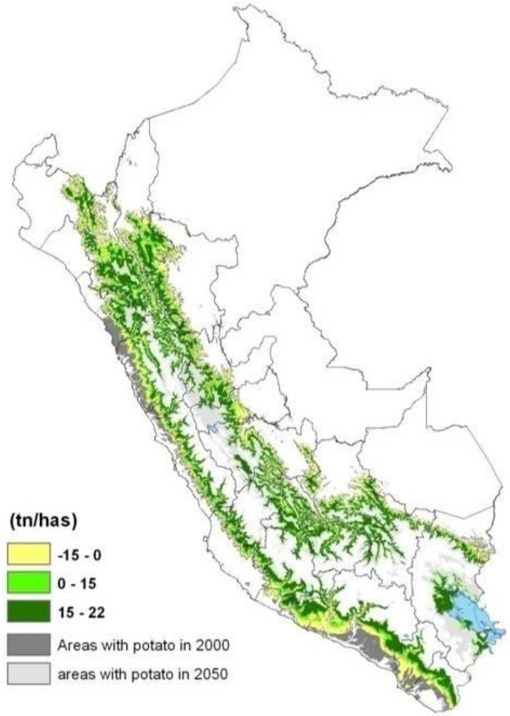
Mitigation of climate change: C sequestration and soil organic matter stabilization

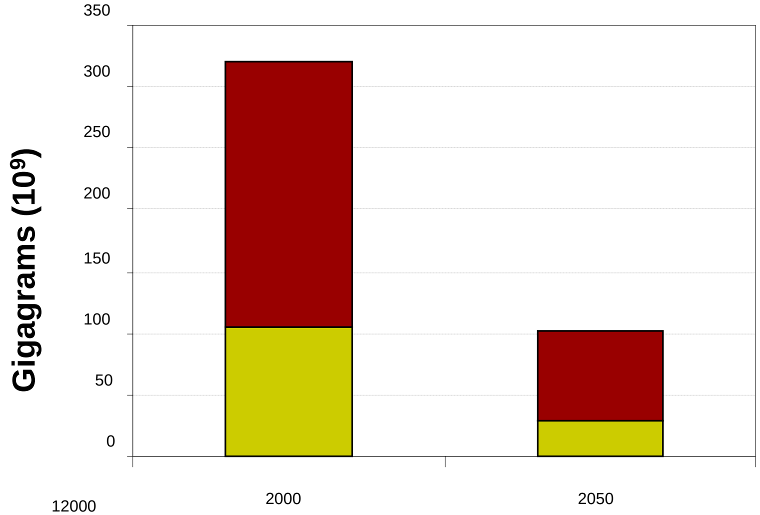
- soil organic matter (SOM) constitutes an essential atmospheric CO_2 sink in CO2 sequestration process
- analysis of its role needs quantitative assessment of humification degrees that reflects SOM stabilization
- different methods have been developed in collaboration with EMBRAPA to assess SOM and C stability: laser-induced fluorescence spectroscopy (LIFS), electron paramagnetic resonance (EPR) and 13C-NMR (Segnini et al., 2010)

SOC and C stability were assessed in different agro-ecologies of Peru

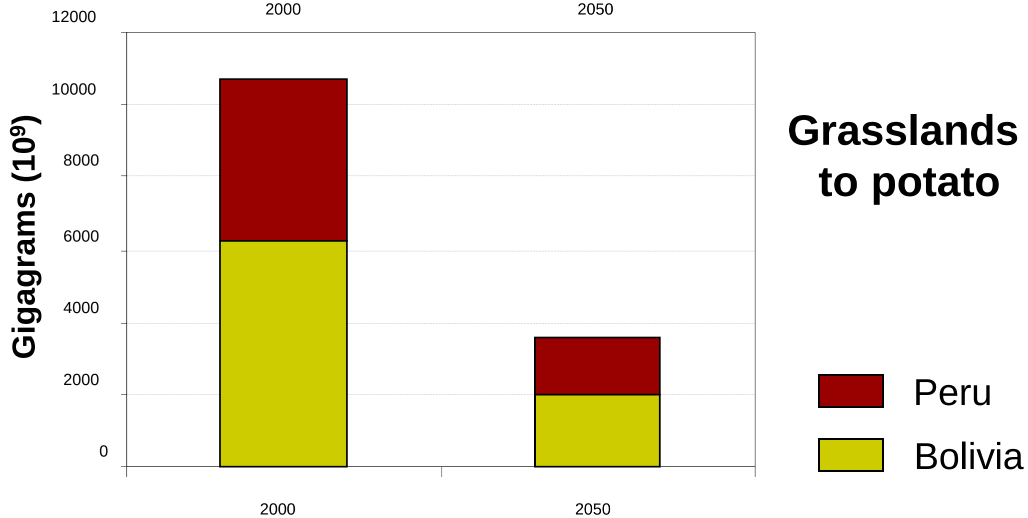
Soil use	Carbon stocks (Tons/ha^{-1})
Wet grasslands - high plateau	301.7
Peat lands — high plateau	228.9
Alfalfa (under irrigation)	91.9
Shaded coffee (Amazon)	91.3
Primary rainforest	75.2
Avocado (intercropping)	68.2
Grape	65.2
Potato	55.6
Maize	42.4
Olive	38.1







Peatlands to potato

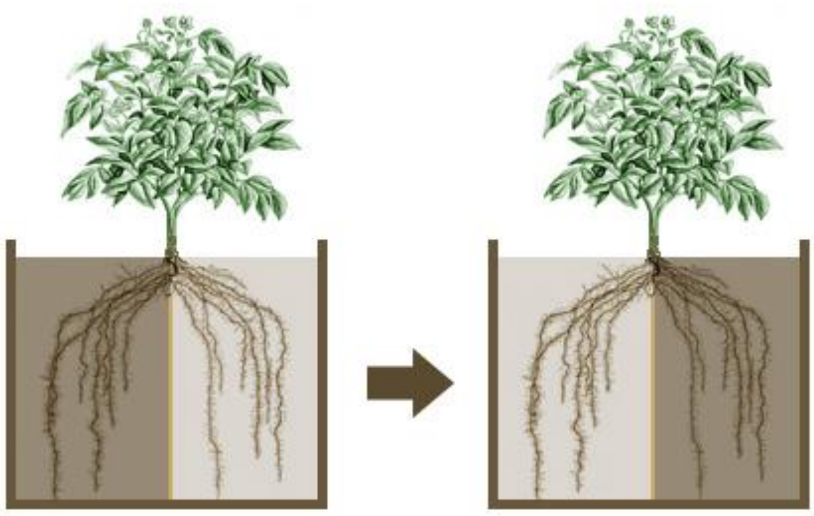


Grasslands to potato

- Soils with high C stocks are threatened by the encroachment of agriculture in rangelands, a process driven mainly by climate change
- Potato varieties adapted to variable environments are a must to reduce the incorporation of C-stocks rich soils into cropping

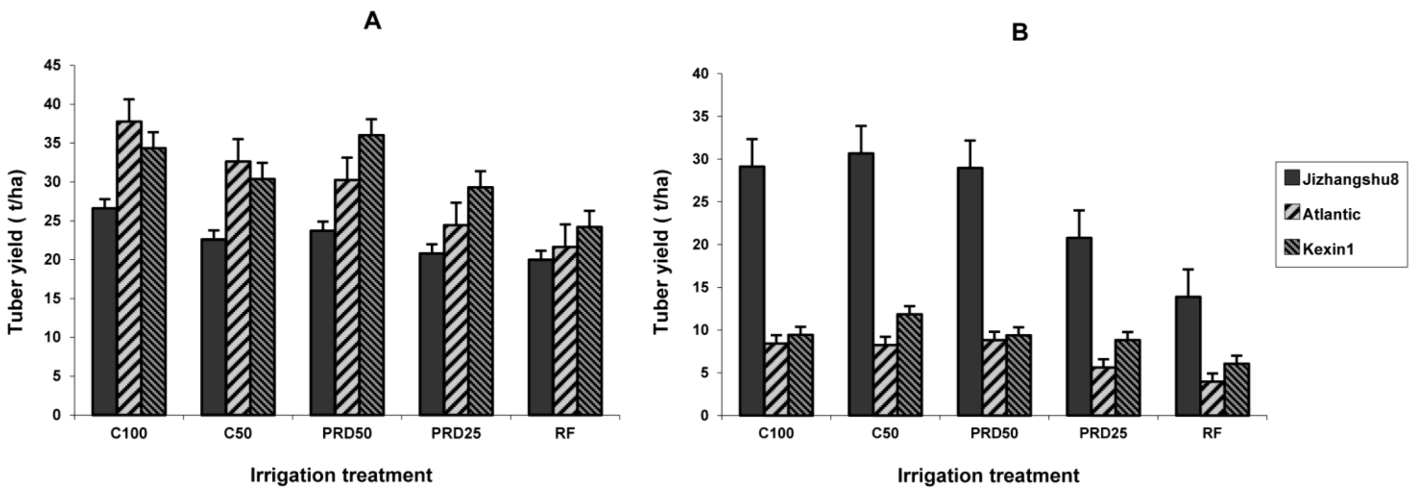
Adaptation to climate change

Through irrigation: partial root-zone drying (PRD) irrigation method



based on non-hydraulic signaling:
- exposure of roots to drying soil increases ABA concentration in the xylem what prompts stomata closure
- PRD uncouples the non-hydraulic signal from the hydraulic signal and the mixed signal leads to limited closure of stomata

effects on water use efficiency of partial root-zone drying (PRD) irrigation and plastic mulching evaluated by CIP in Inner Mongolia and Gansu (China)



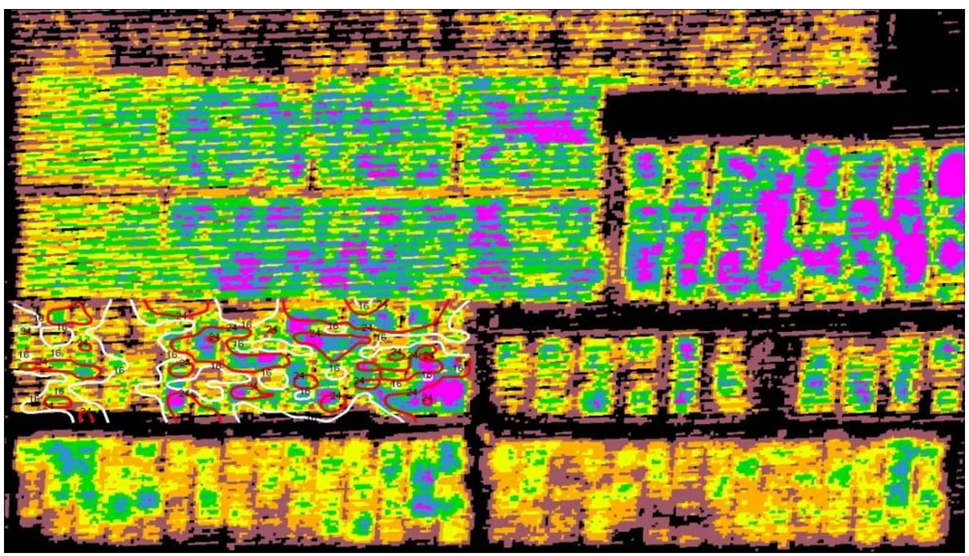
C100 = conventional full irrigation (4000 m3 ha-1)
C50 = conventional limited irrigation (2000 m3 ha-1)
PRD50 =Partial root-zone drying irrigation method (2000 m3 ha-1)
PRD25= Partial root-zone drying irrigation method (2000 m3 ha-1)
RF = rainfed conditions

- distribution of moisture in the soil improved, evaporation decreased due to the reduction of evaporative surface
- significant reduction of the quantity of water applied without yield reduction

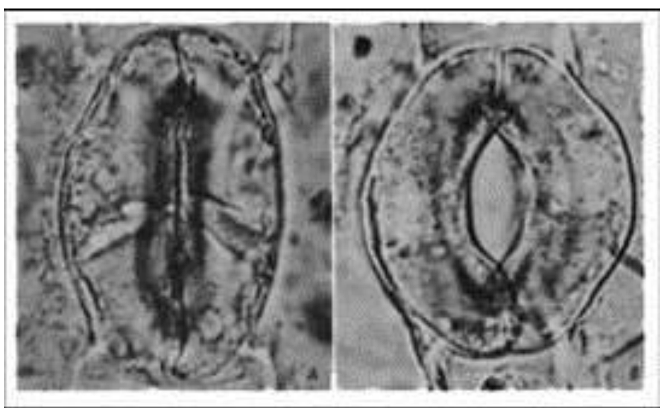
Through breeding: drought tolerance improvement

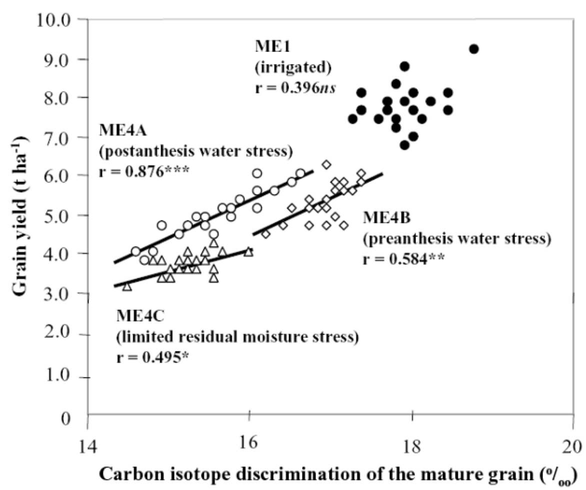
• large scale screening (desert coast of Peru) of 918 potato improved varieties, genetic stocks and landraces
• drought tolerant accessions identified, particularly in native potatoes

Development and use of new phenotyping tools (infrared thermometry, spectrometry)



carbon isotope discrimination, a trait successfully used in cereals to select for drought tolerance





Ex-ante assessment of socio-economic impacts of potato technologies under climate change

Integrated modelling of potato technologies promising for coping with climate change:

- global scale modelling of virtual crops with DSSAT crop modelling system to assess productivity impacts under alternative scenarios of CC by 2050
- economic assessment of socio-economic effects of productivity impacts with the IMPACT global agricultural sector model

Identification of promising technologies

Virtual crop modeling

IMPACT Economic modeling

Technology impacts

Cost-benefit ROI

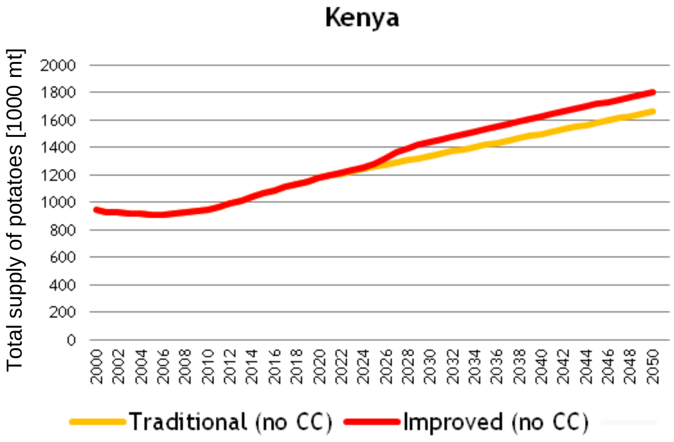
Economic welfare

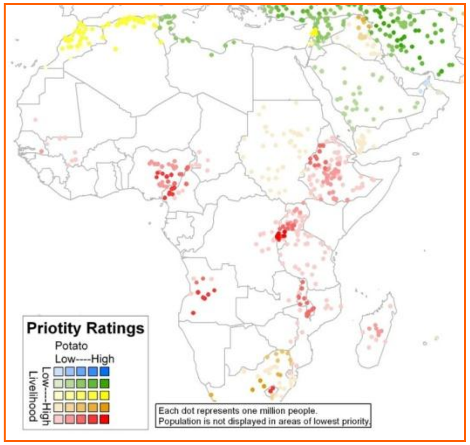
Food security

Production, consumption, prices, trade

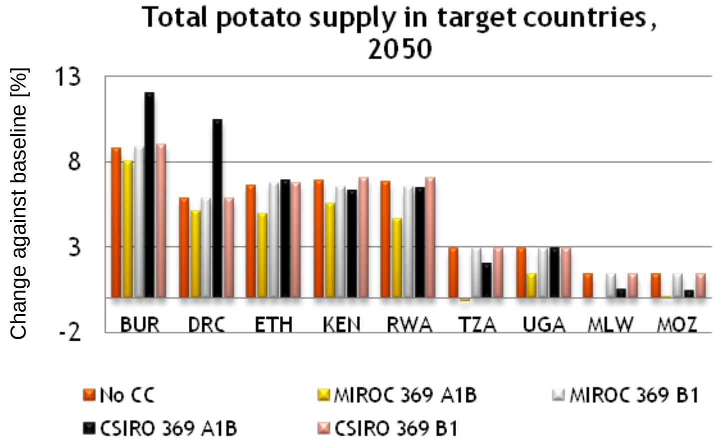
Example: Improved potato varieties for Sub Saharan Africa

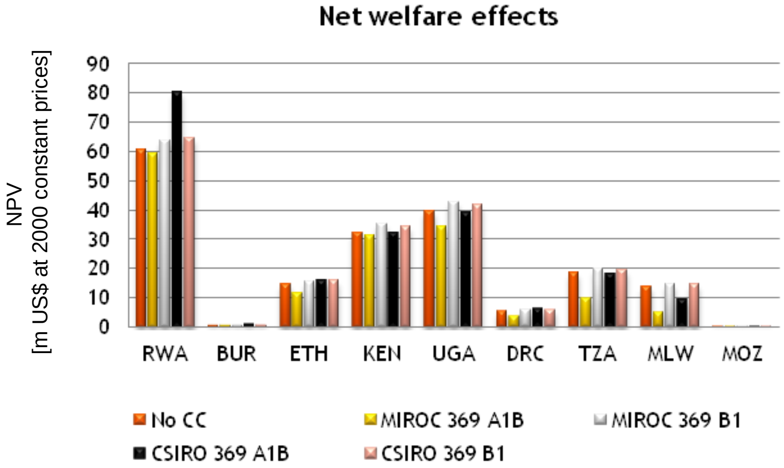
- higher yield potential
- late-blight and virus resistance
- heat tolerance
- nine target countries





Source: Theisen and Thiele (2008).






Thanks
for your
attention!