Assessing vulnerability and adaptation of river systems

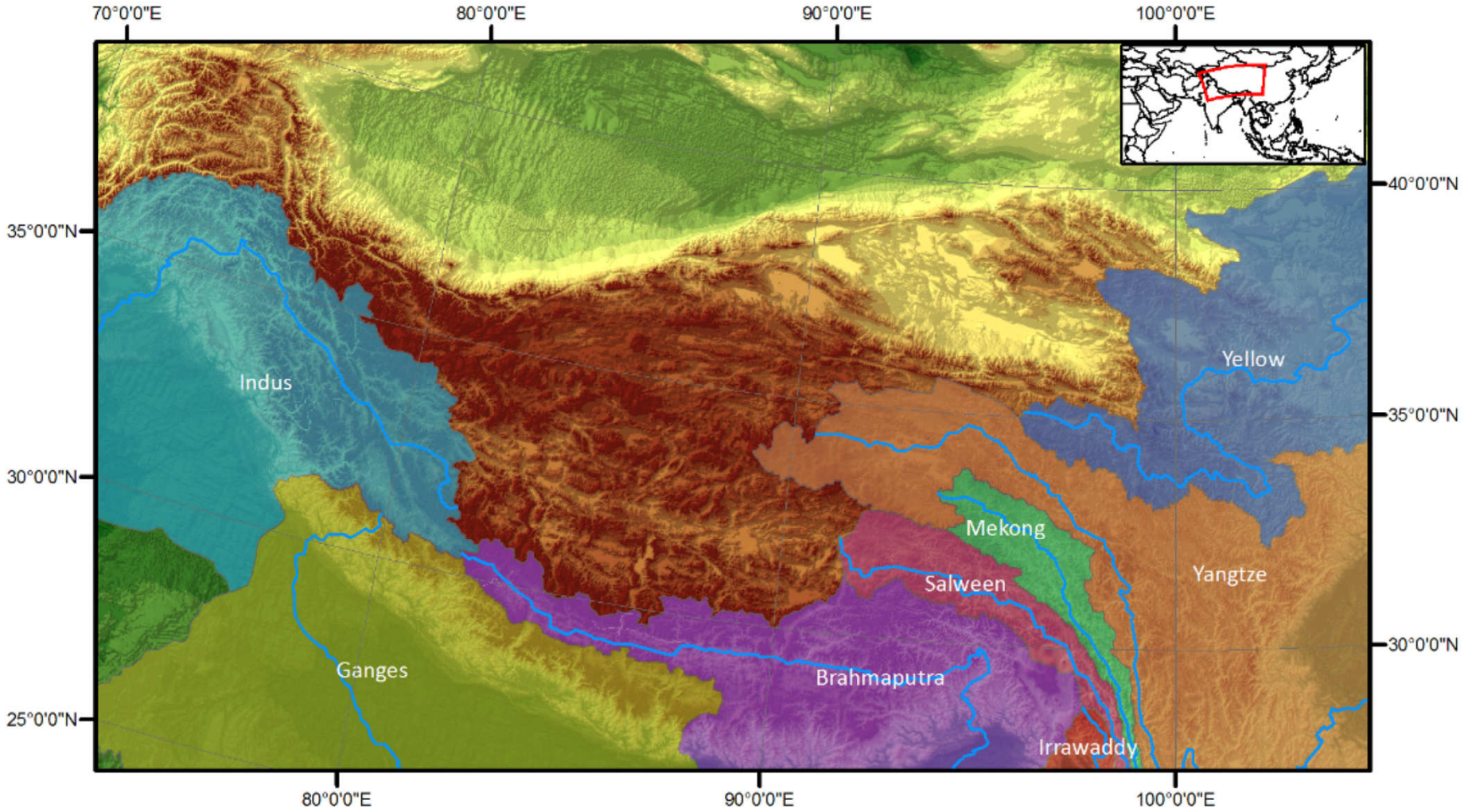
Massimo Menenti

Delft University of Technology

Climate Change Adaptation

- hydrological observations, analyses and predictions
- mitigate the impacts of climate change
- remove the underlying causes of vulnerability to climate change
- Themes:
  - Short- and long-term hydrological variability and climate change
  - Resilience versus vulnerability of hydrologic systems
  - Resilience of hydrological systems to climate variability
  - Identifying and removing the causes of the vulnerability of hydrological systems to climate change
  - Reconstruction of adaptation mechanisms to hydrological variability in the recent past
- GEWEX / HAP Working Group?
- Need to integrate very diverse data and models river-wise

Water Balance Model domain



CEOP-AEGIS

EU Project

Collaborative
Project / Small or medium-scale focused research project – Specific International Co-operation Action

ENV.2007.4.1.4.2
Improving observing systems for water resource management

Period: May 2008 – May 2012

Coordinated Asia-European long-term Observing system of Qinghai–Tibet Plateau hydro-metOeorological processes and the Asian-monsoon systEm with Ground satellite Image data and numerical Simulations

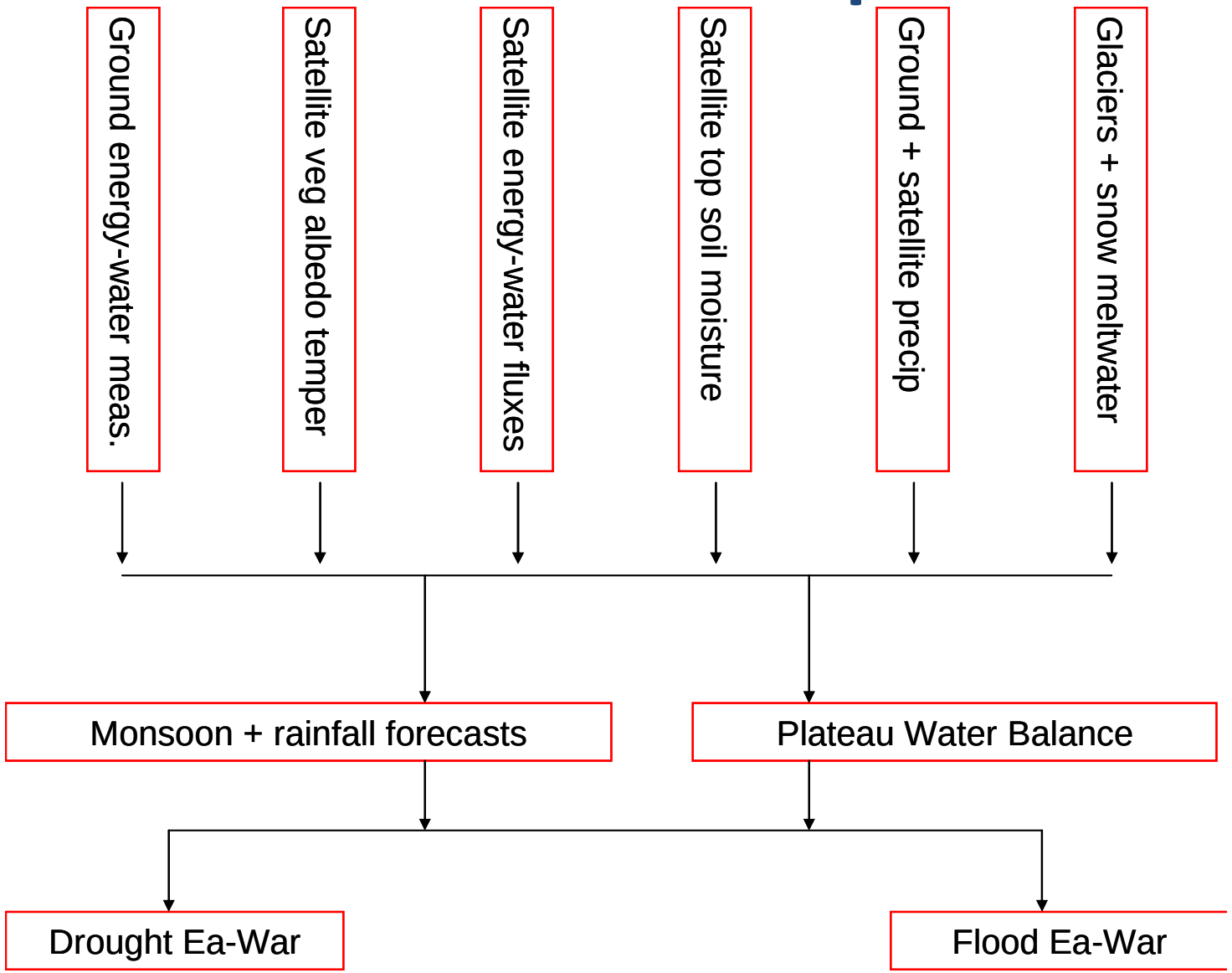
An international cooperation project between Europe and Asia to improve knowledge on hydrology and meteorology of the Tibetan Plateau and its role in climate, monsoon and extreme meteorological events

- To construct out of existing ground measurements and current / future satellites an observing system to determine and monitor the water yield of the Plateau, i.e. how much water is finally going into the seven major rivers of SE Asia
- To monitor the evolution of snow, vegetation cover, surface wetness and surface fluxes and analyze the linkage with convective activity, (extreme) precipitation events and the Asian Monsoon.

19 beneficiaries from 8 european and asian countries

www.ceop-aegis.org

CEOP AEGIS concept



Climate elasticity of streamflow

(Zheng et al., 2009)

$$Q = f(P, E_0, V)$$

Q = streamflow

P = precipitation

E_0 = potential evapotranspiration

V = land use / land cover

$$\Delta Q = f'_P \Delta P + f'_{E_0} \Delta E_0 + f'_V \Delta V$$

$$\varepsilon = \frac{dQ/Q}{dX/X}$$

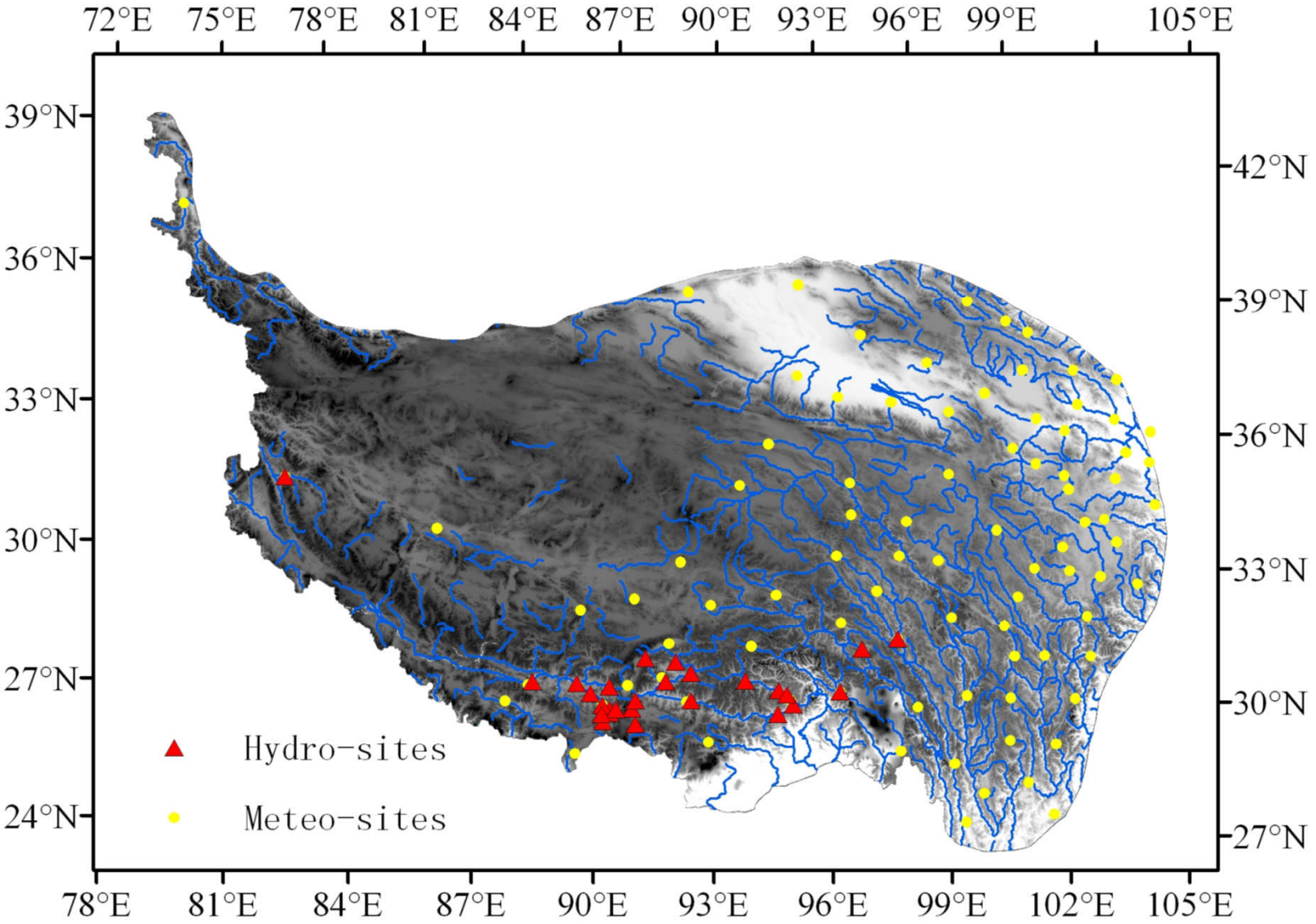
climate elasticity of streamflow to X

case study on the Headwaters of the Yellow River Basin (HYRB)

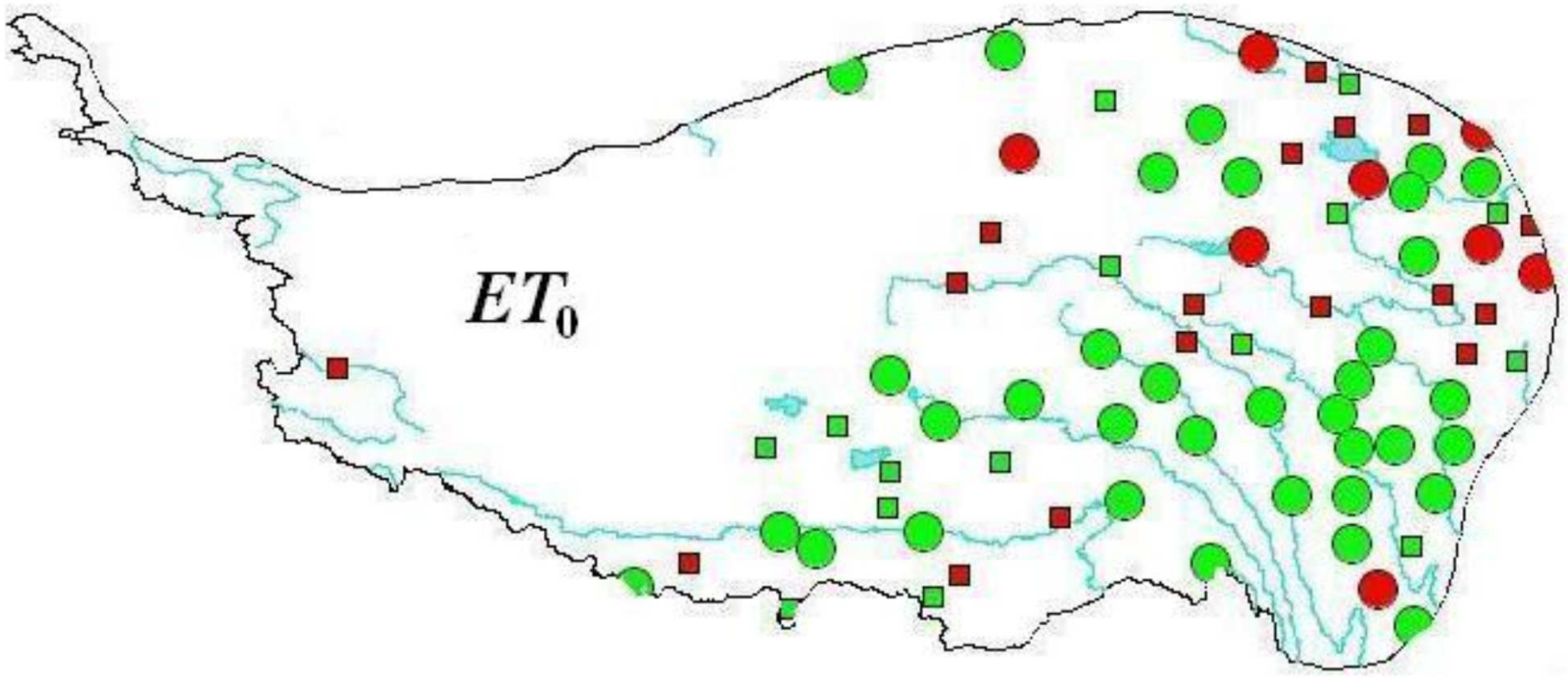
land use change: about 74.6% of the streamflow reduction in the 1990s

climate change 25.4% of the reduction

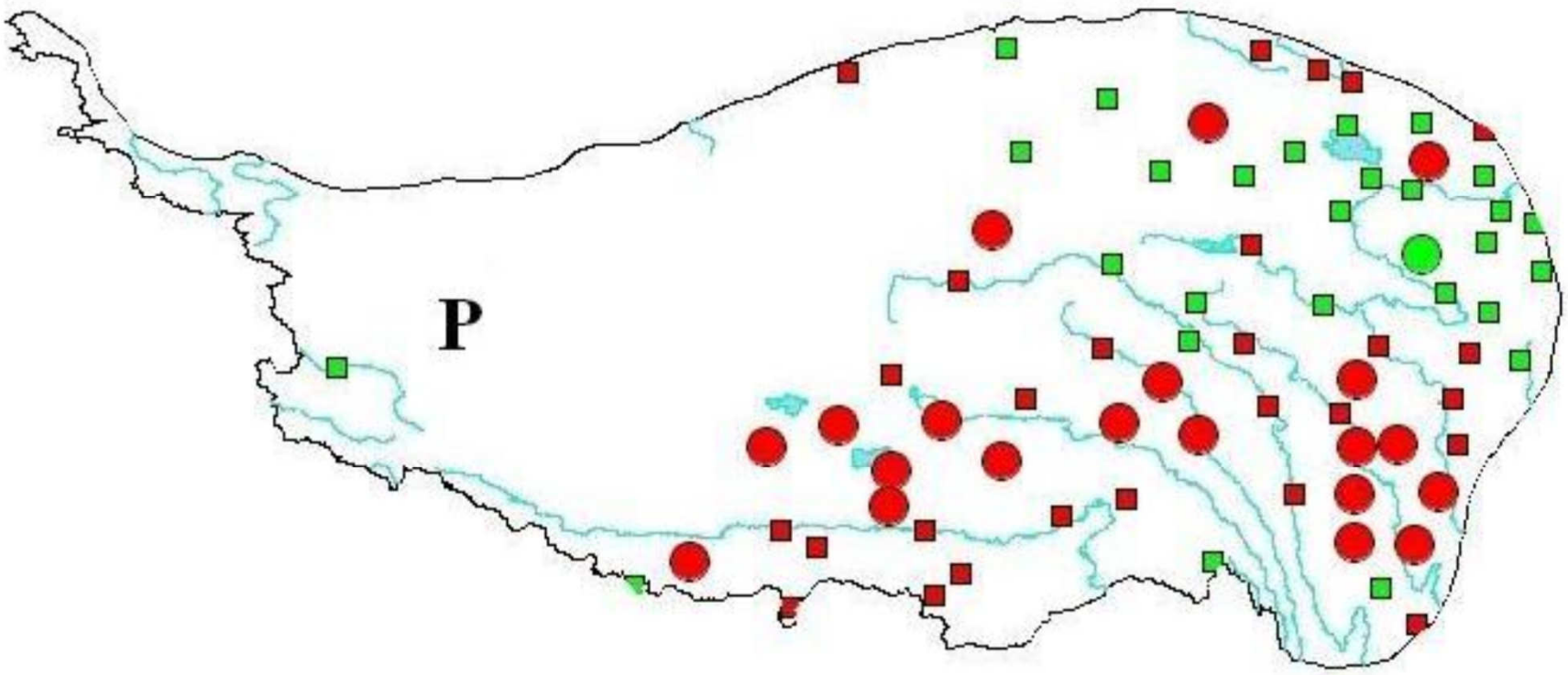
Observed trends Qinghai – Tibet Plateau 1960 - 2000



Potential ET

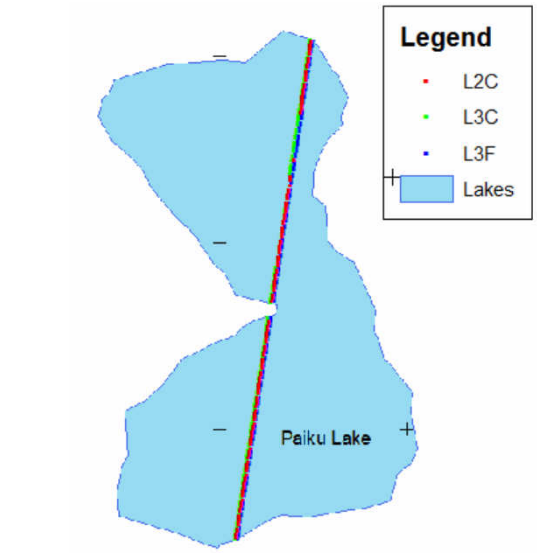


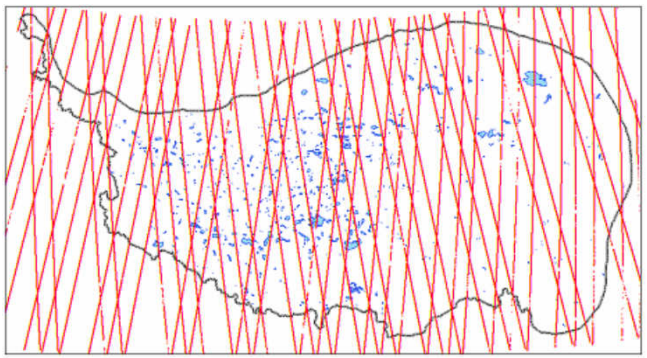
Precipitation

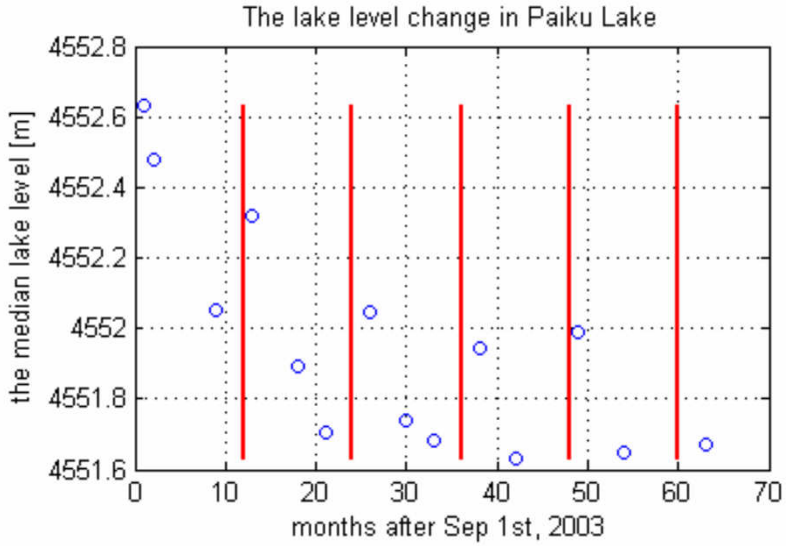


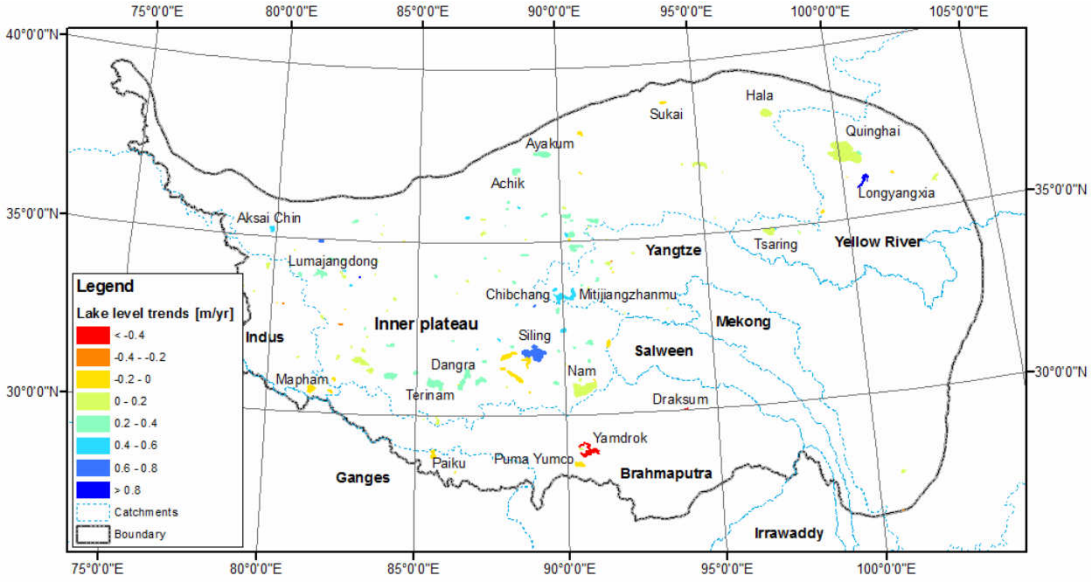
Lake level changes from ICESAT/GLAS 2003 - 2009

(Phan Hien et al., 2010)

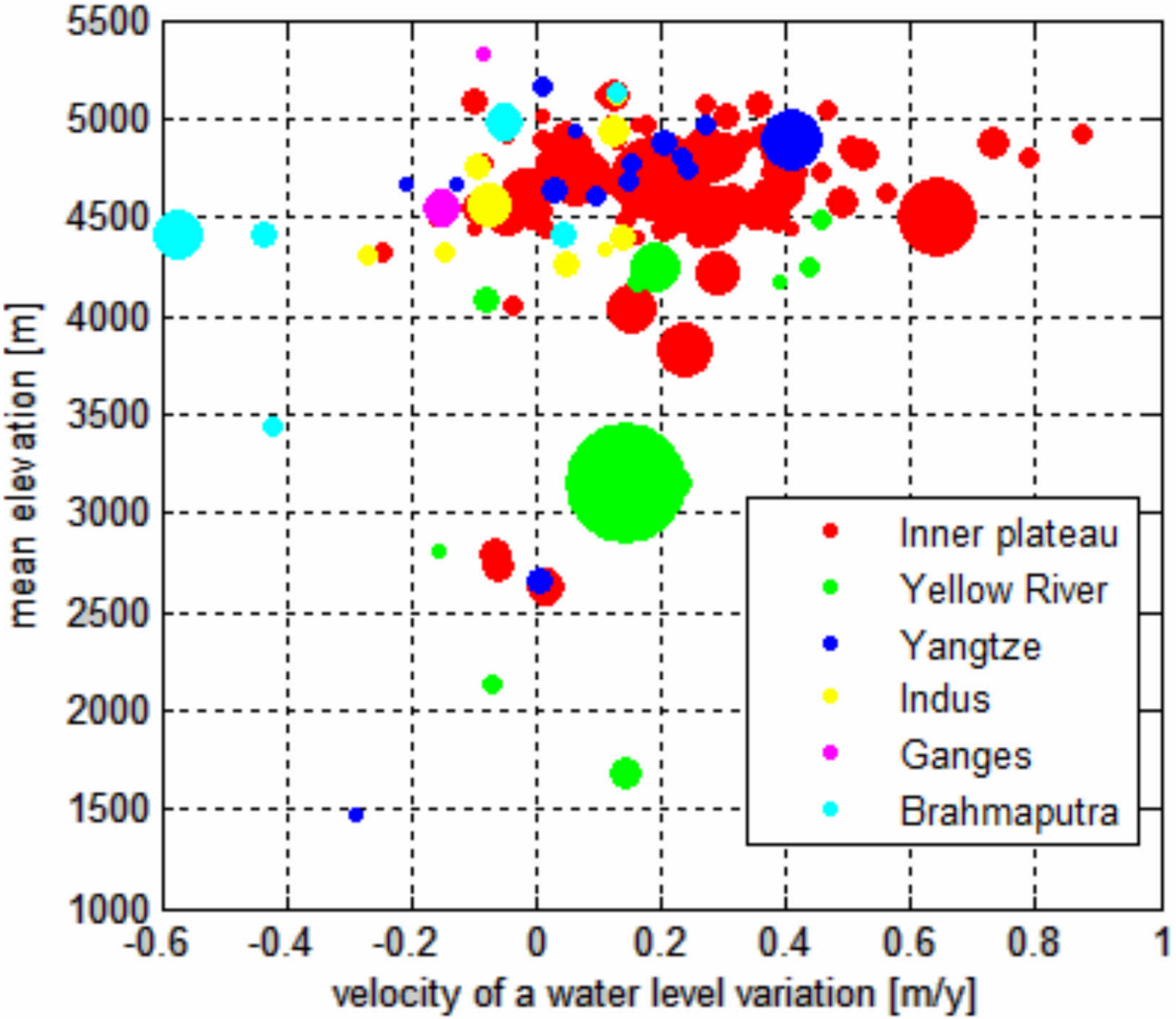








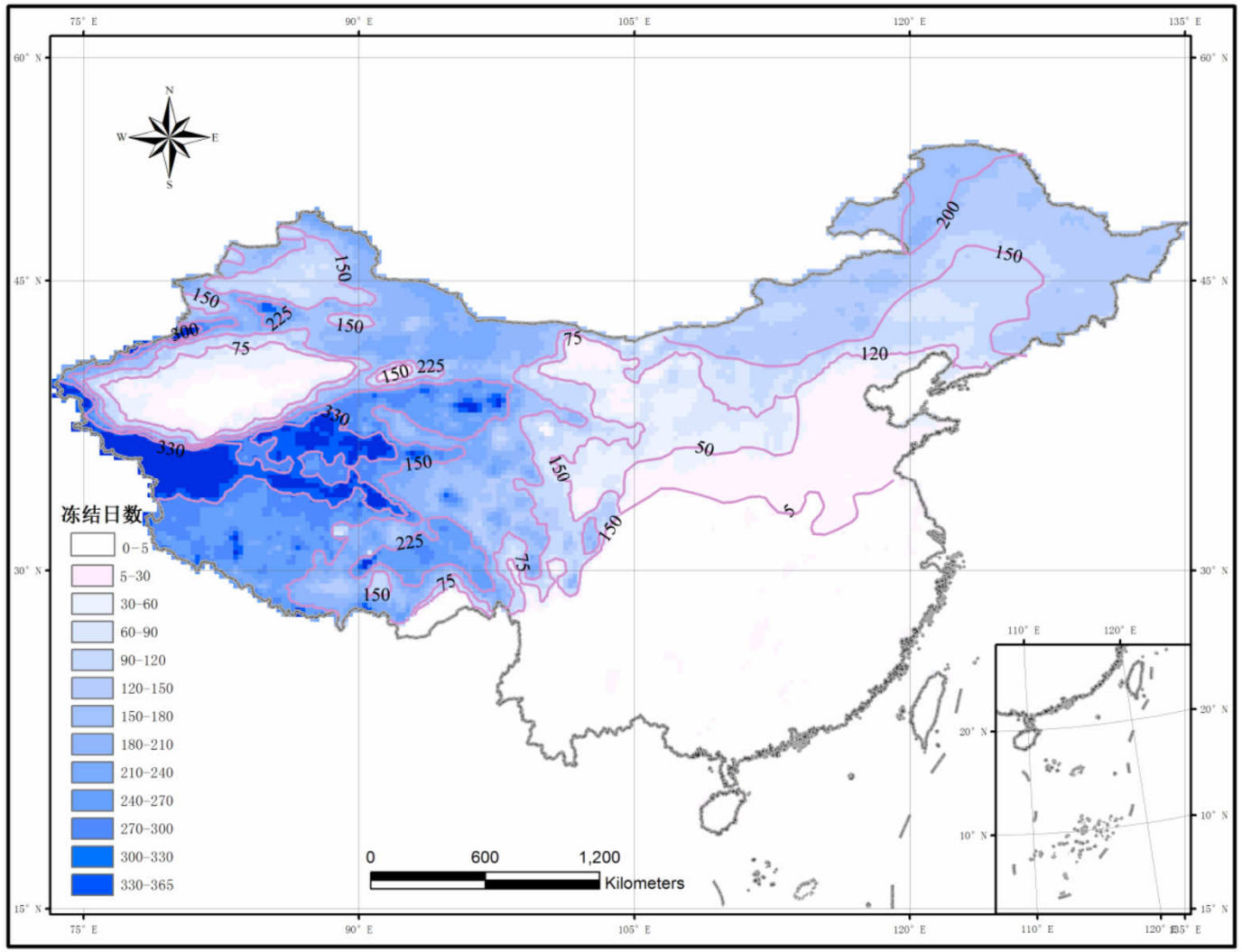
Regional variability of trends



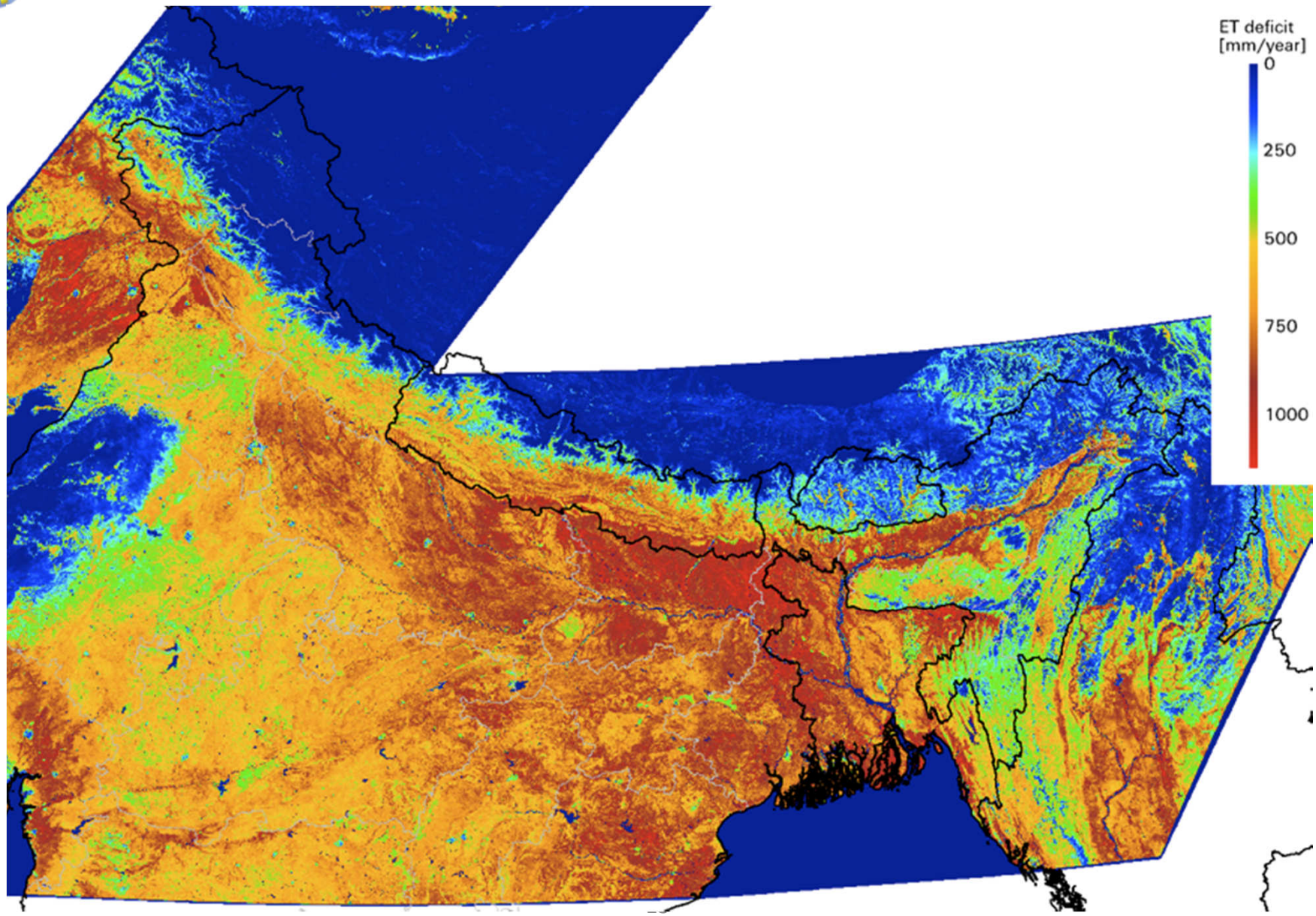
Number of frozen days in China
(Oct. 1, 2002 ~ Sep. 31, 2003)

Sensor:
SSM/I

Method:
Decision Tree



ET deficit year 2009



PBL response to land surface forcing

GRAPES = Global / Regional Assimilation and PrEdiction System

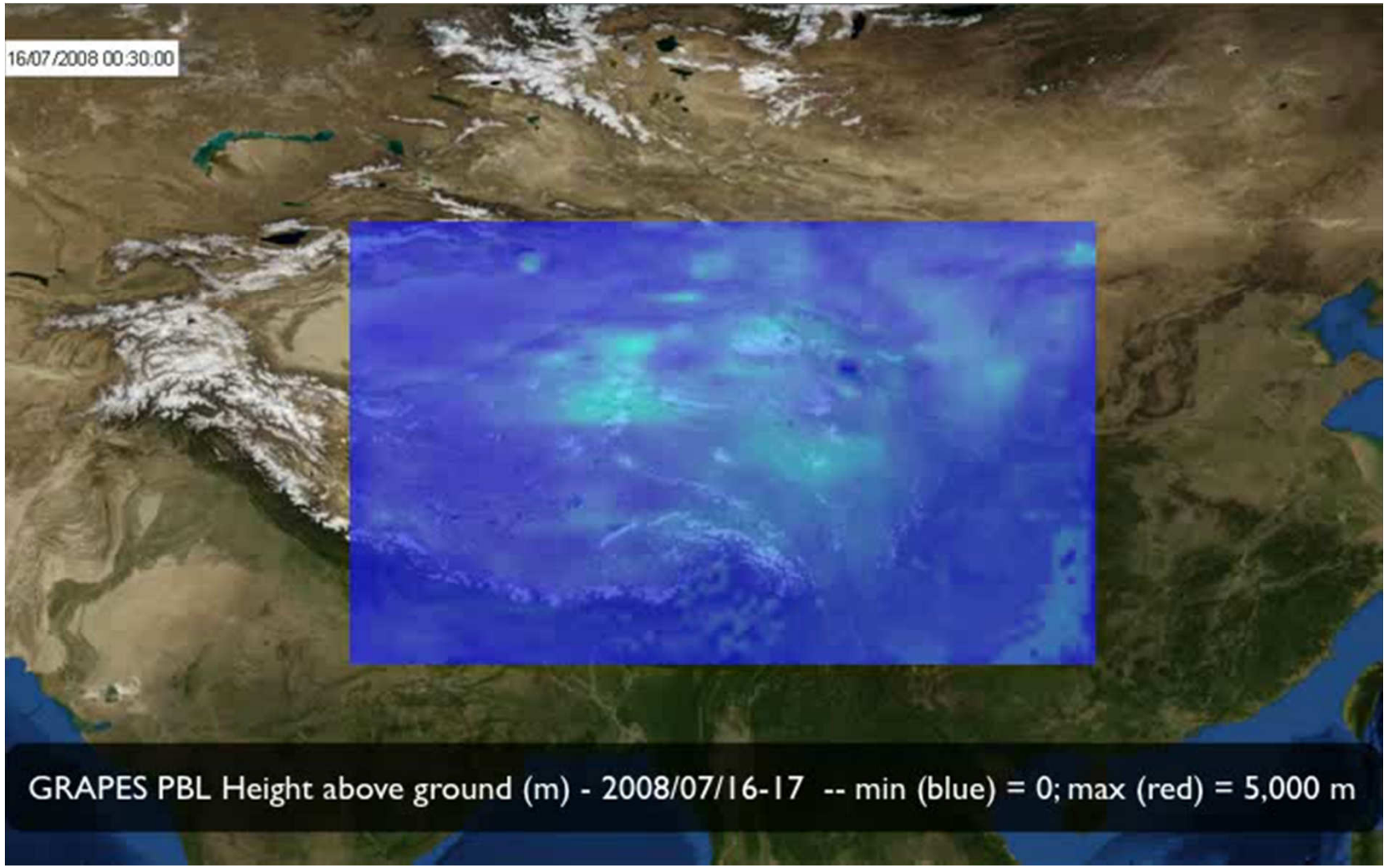
unified NWP model with 3/4DVAR data assimilation system under development by Shen et al. at CMA / CAMS, China.

GRAPES_Meso with 15 km x 15 km horizontal resolution

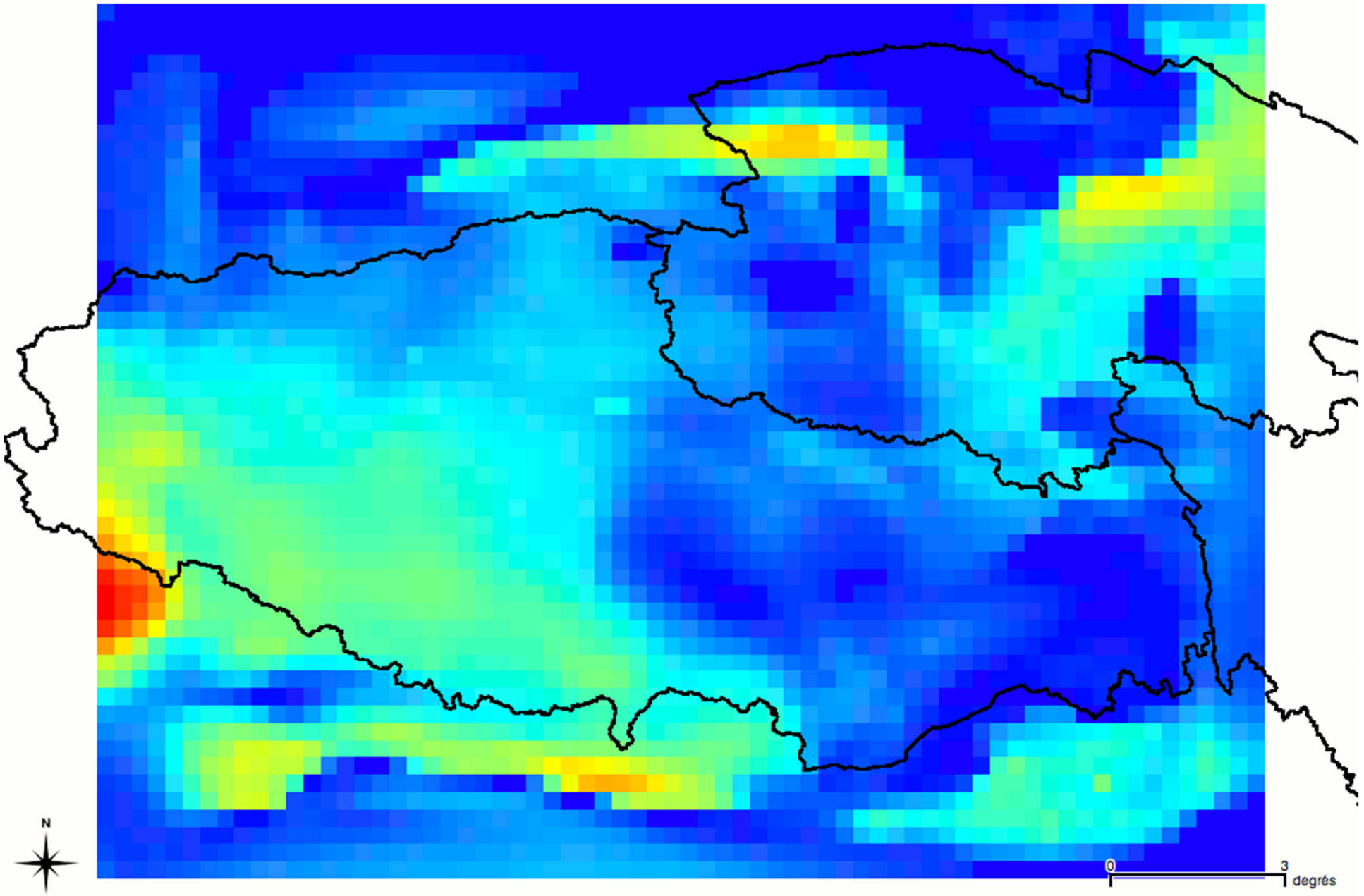
Dynamics	Flux-form equations of water substances
	Piece-wise rational method + volume-remapping SL for scalar advection
	Reference atmosphere based on the initial field
	Effective topography
Physics	NOAH LSM + Simple initialization
	Xu and Randall Diagnostic cloud
	Betts-Miller-Janjic Cumulus
	CAMS mixed-phase microphysics
	Effect of slope on surface radiation

Describing the ABL of the Plateau

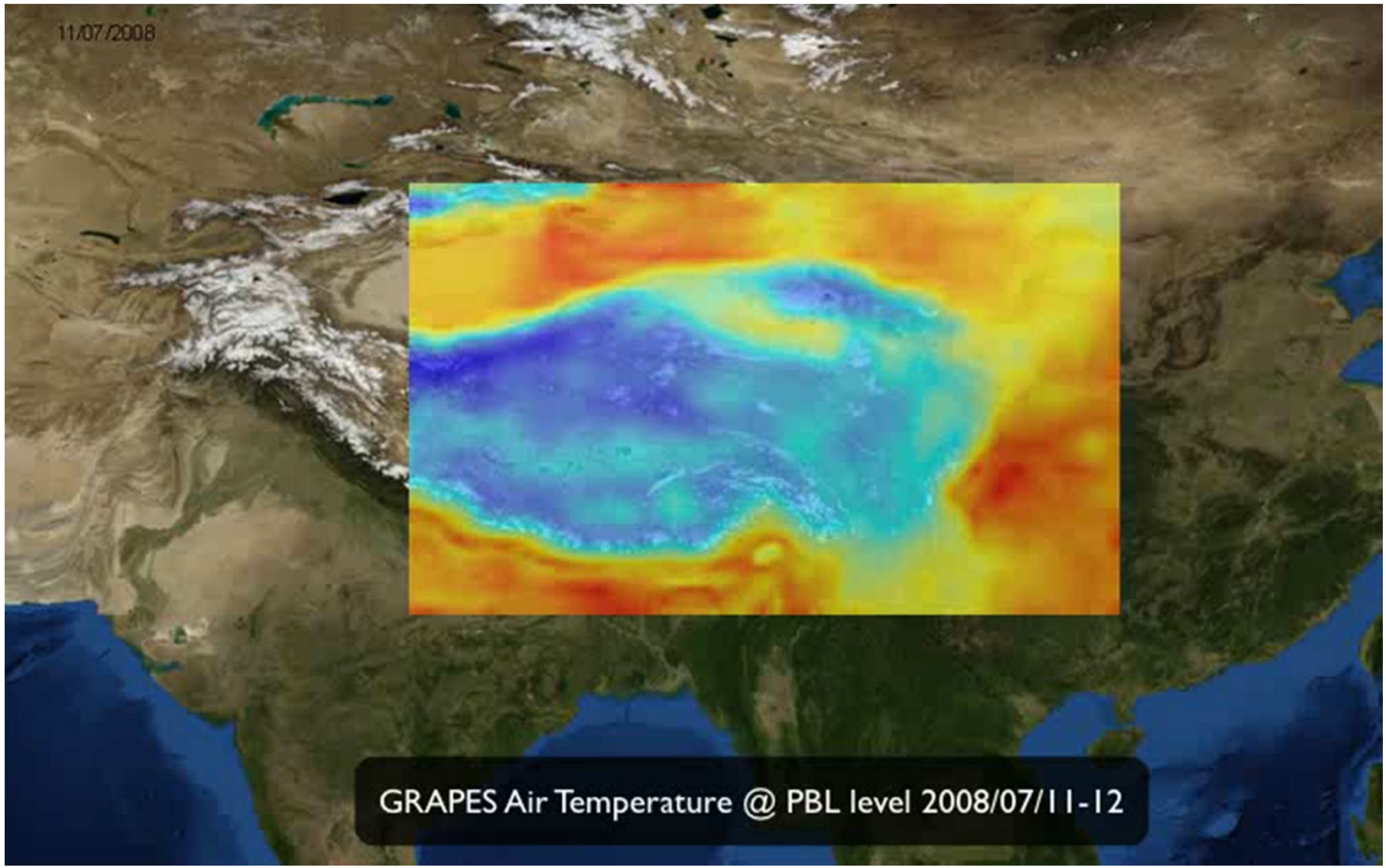
30km simulation, 30’ step, 48h runs – Ta, q, u, v, p, Global, IRa



ABL height daily cycle



Describing the ABL of the Plateau



Generalize the Energy Balance mapping on the Plateau

- SEBI based (Menenti and Choudhury, 1993)
- Physical calculation of the extreme boundaries following the SEBS approach (Su, 2000)
- 2D ABL forcing & calculation grid size for stability functions depending on the ABL development (MSSEBS, Colin 2006)
- Expected results:
  - **1km resolution Surface Energy Balance** components
  - **Time series** on a week to 10 days basis
  - Automated processing chain, including interface with data providers & results repositories

Meso-scale Atmospheric Forcing grid [15-100 km]

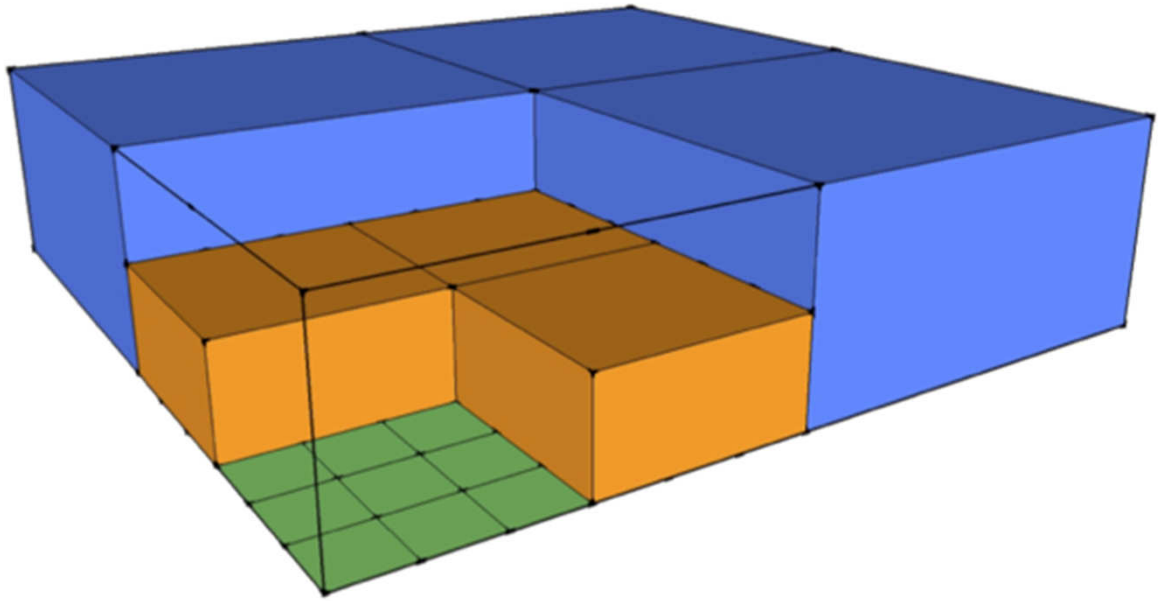
Ta, q, u, v, p

Sw, Lw incoming radiance

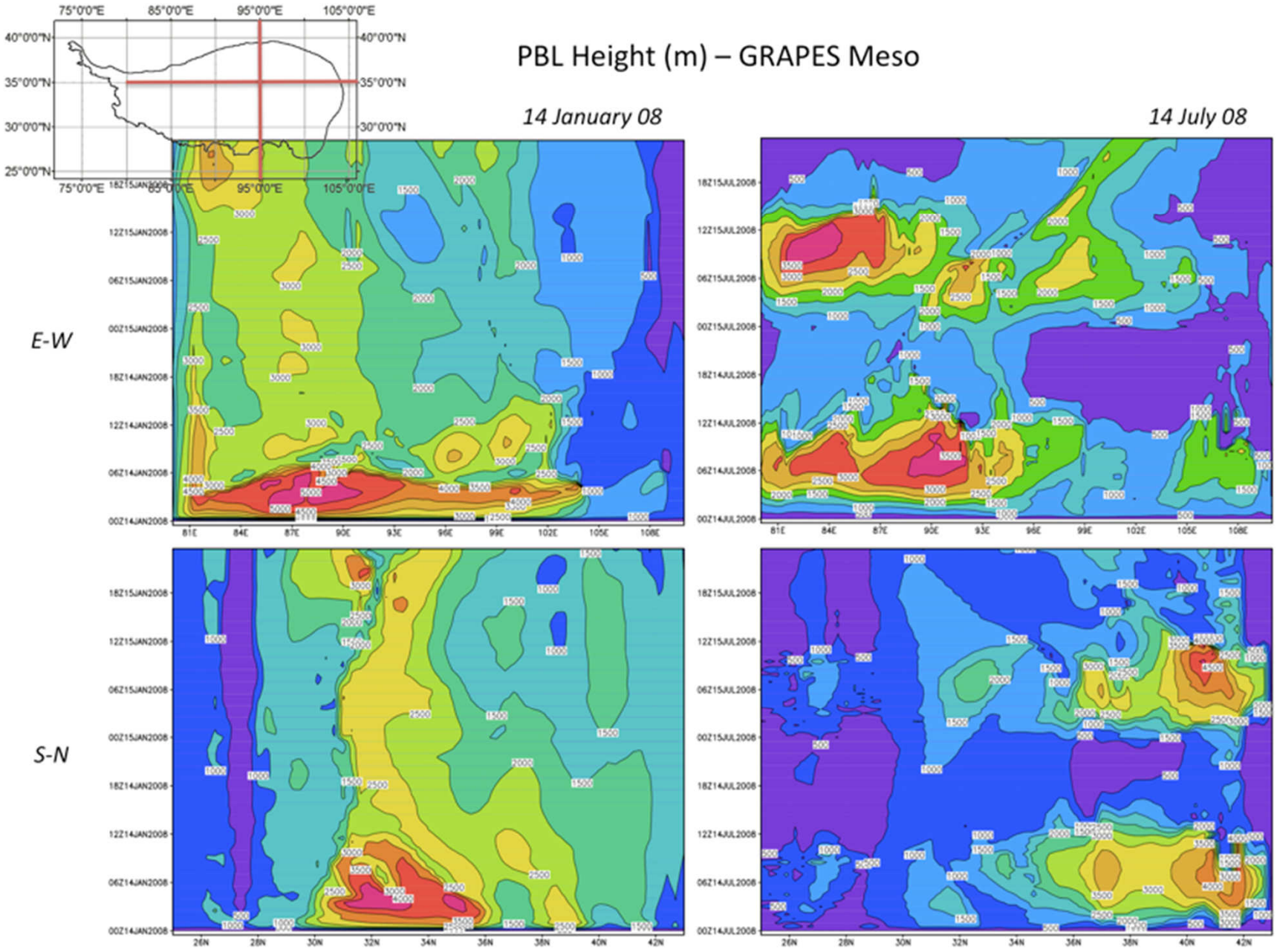
ABL Calculation grid [10 x $\overline{\text{ABL height}}$]

Full resolution calculation grid [TIR Resolution]

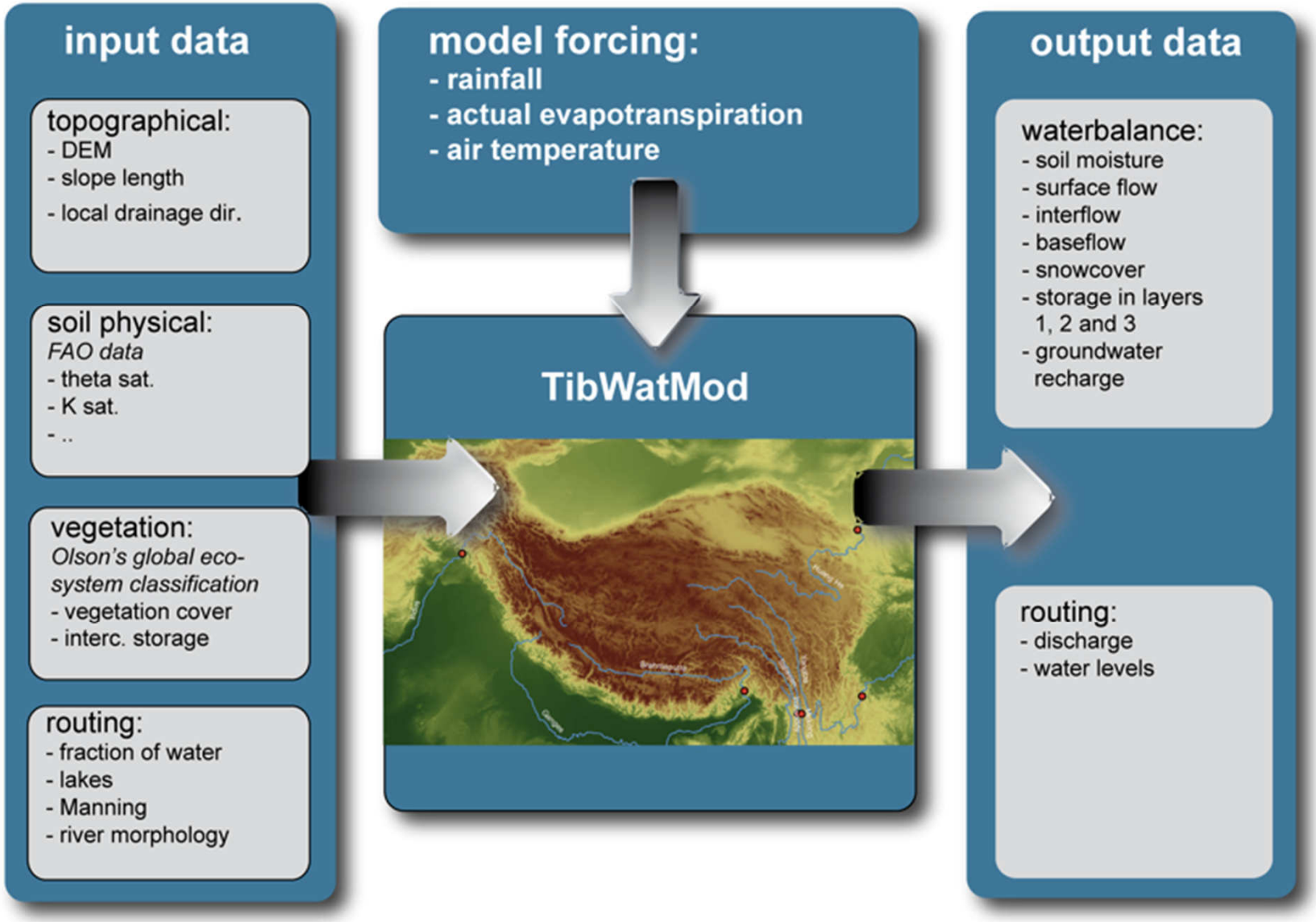
LST, albedo, fc, LAI, emissivity, DEM



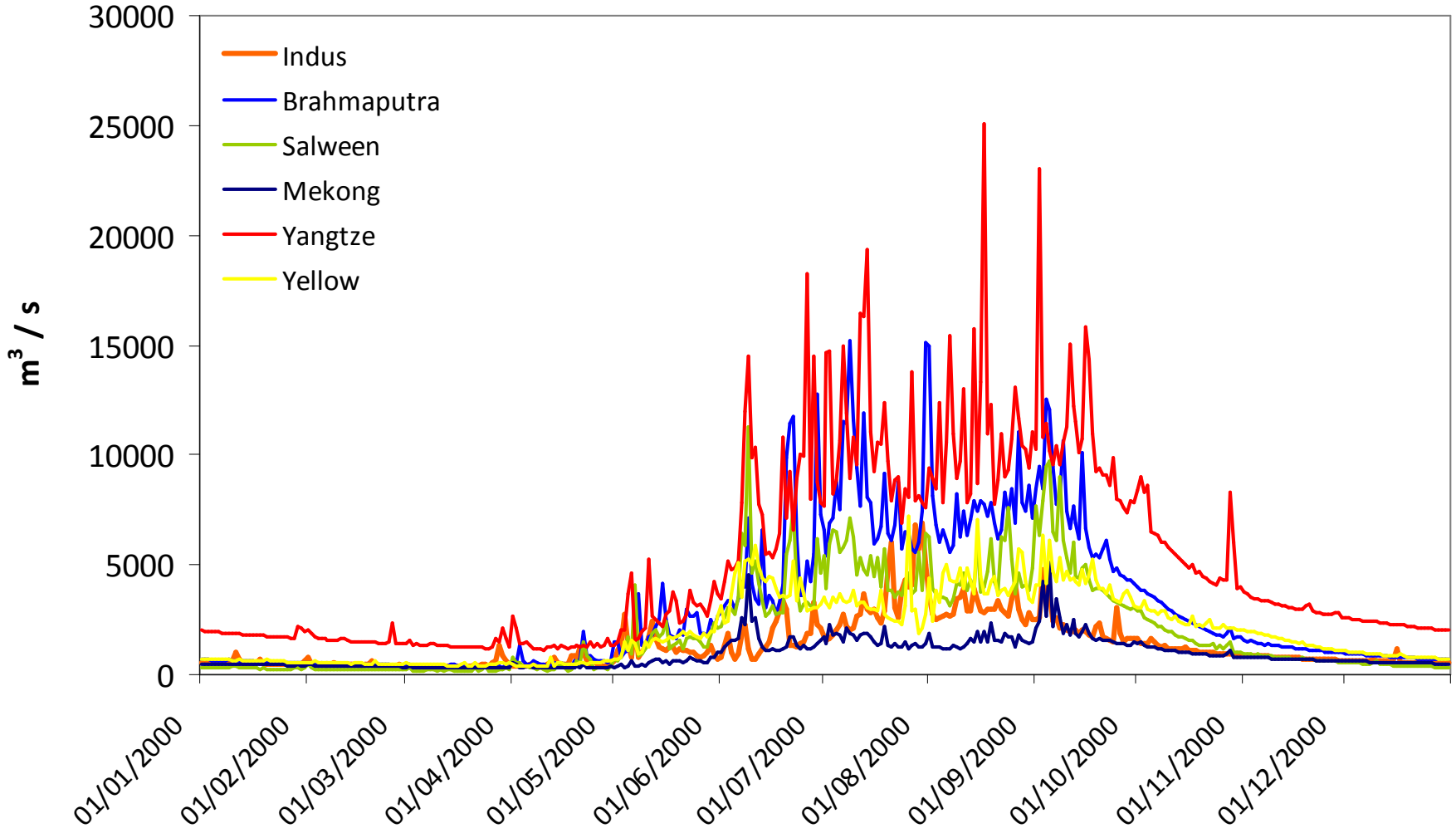
Spatial and temporal variability PBL height



Plateau Water Balance: Data Requirements

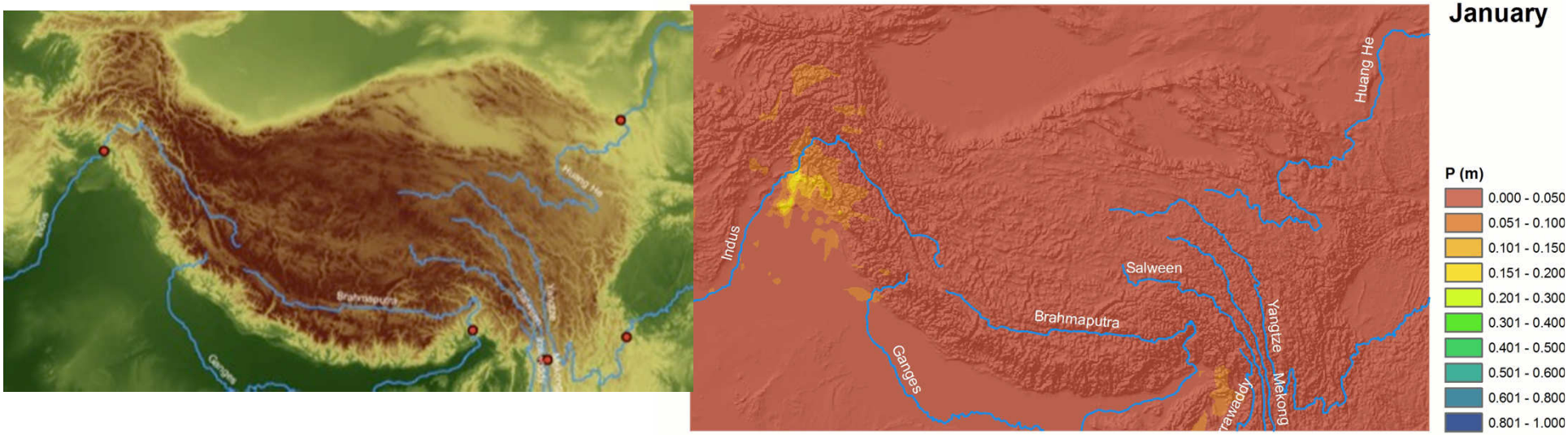


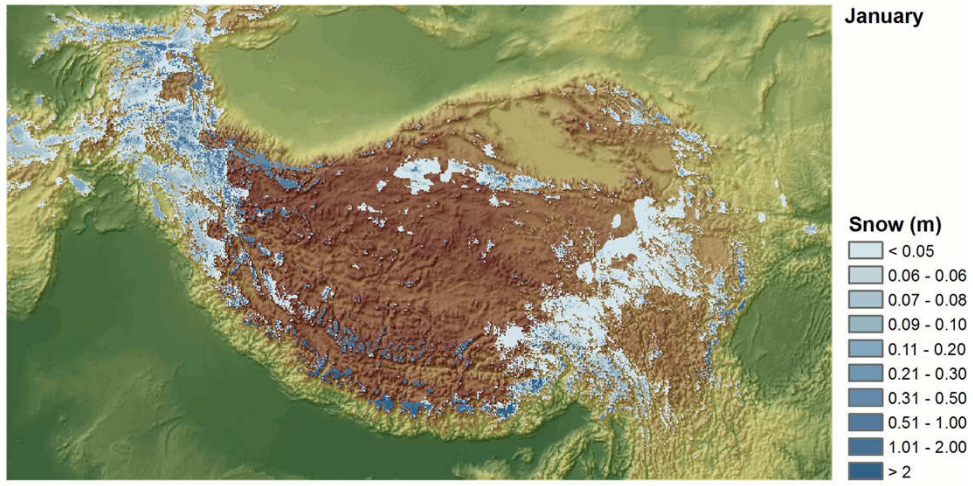
First results: routed discharge

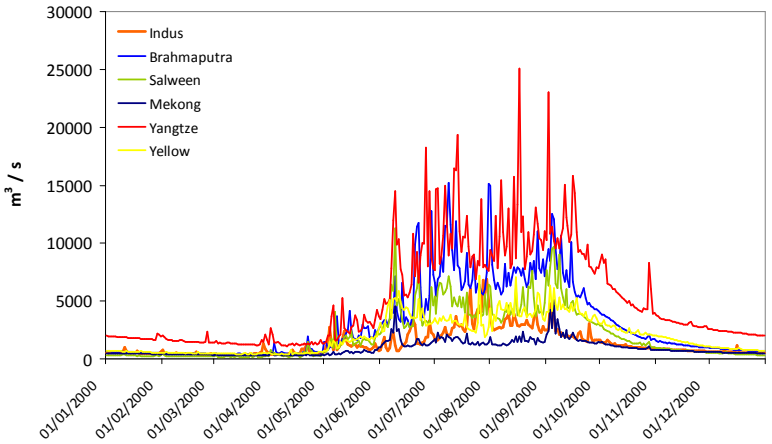


Immerzeel at al., 2010. Science

Large fluctuations of regional and local water cycles

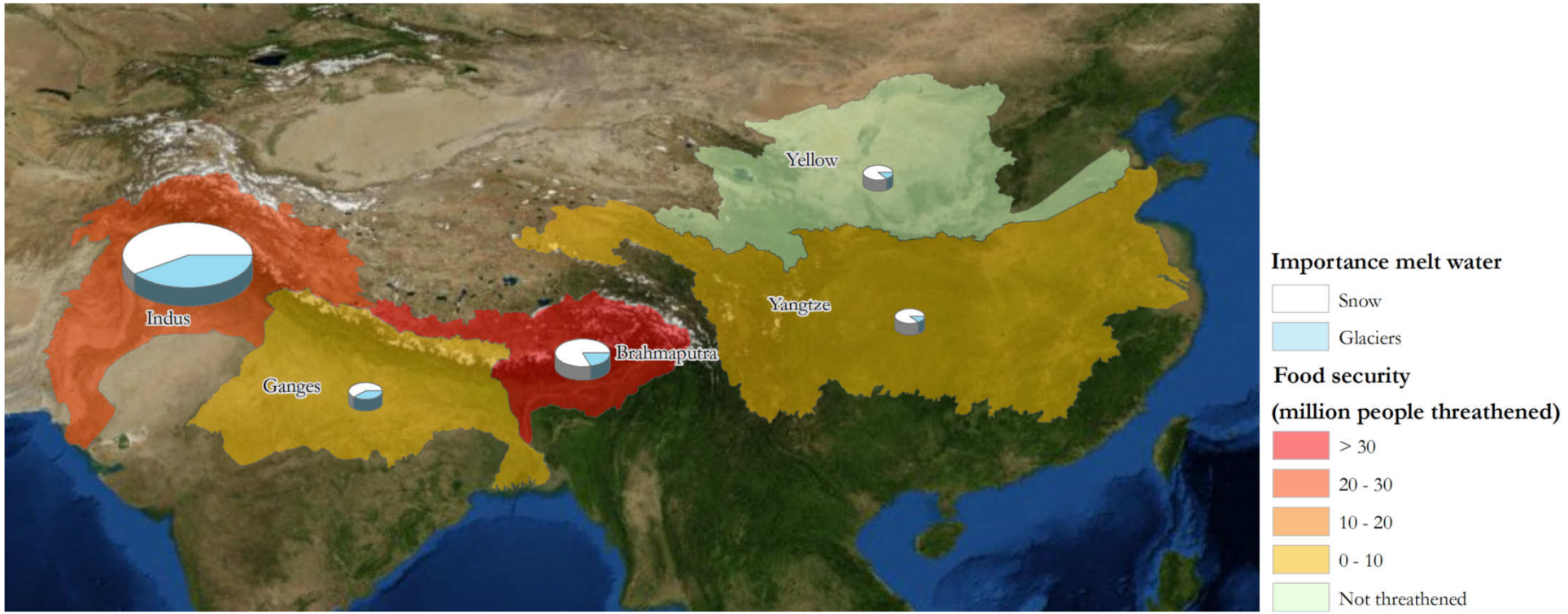






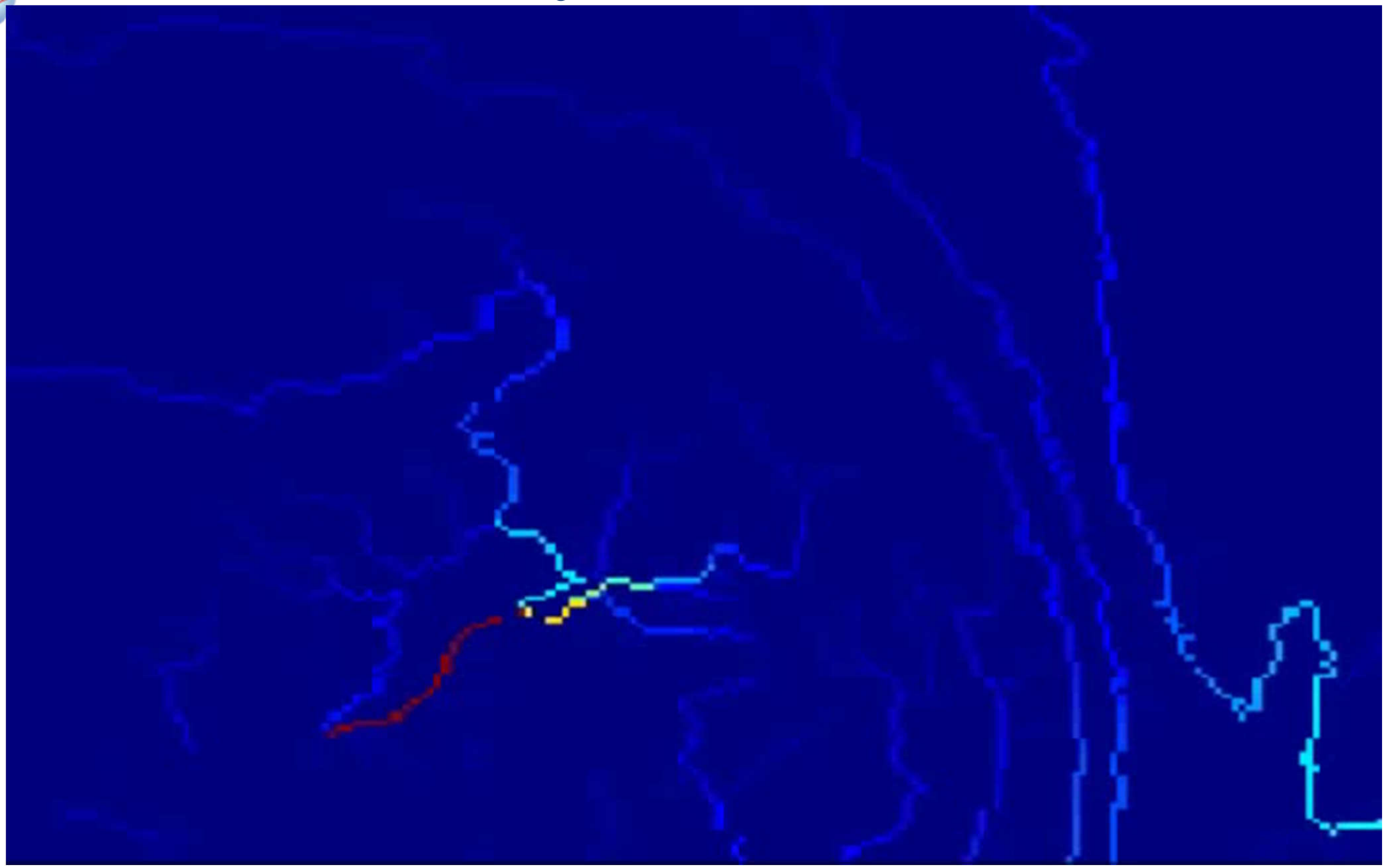
Climate Change Will Affect the Asian Water Towers

Immerzeel et al., 2010



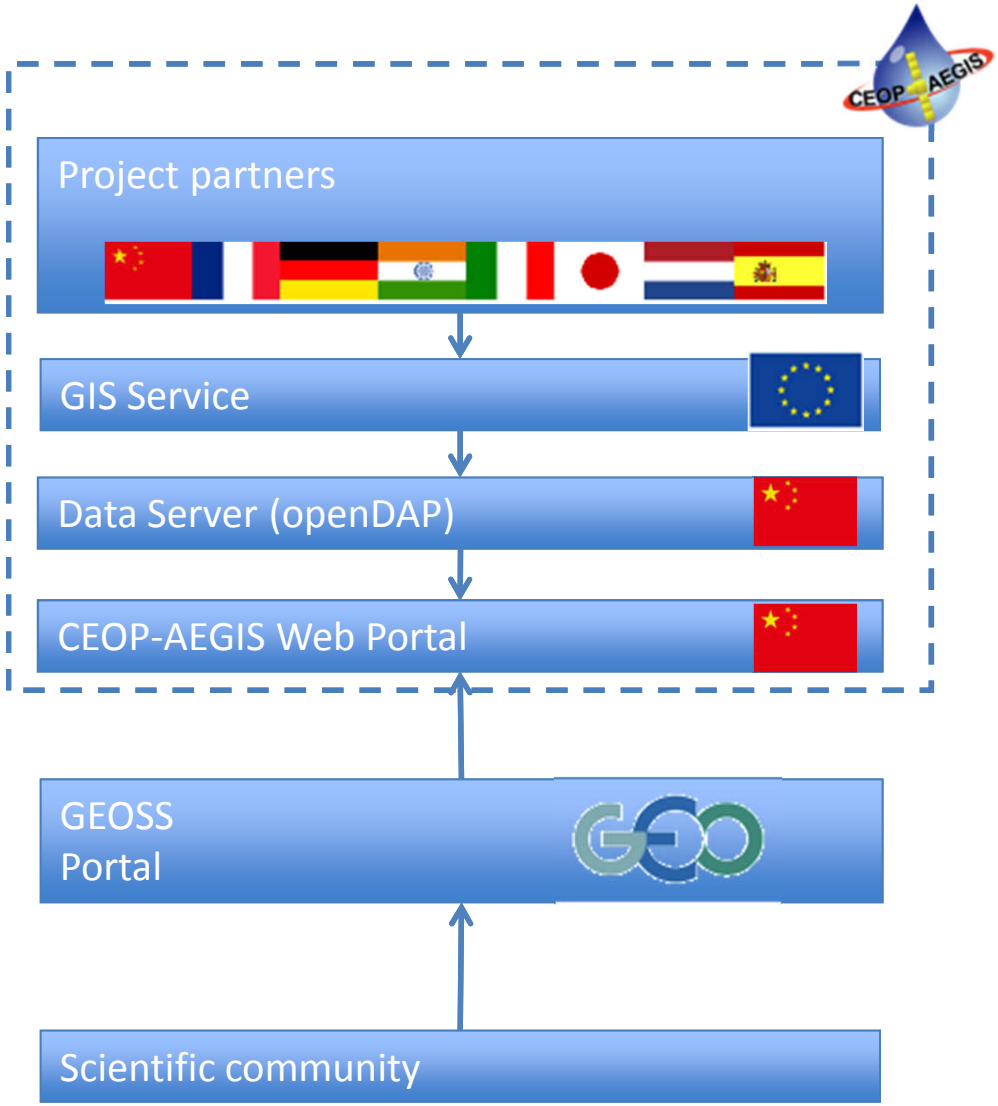
The map shows the importance of melt water to downstream areas (pie charts) and the number of people threatened in their food security due to reduction in upstream flow due to climate change

Daily streamflow



CEOP-AEGIS Database

- Principles
  - all project products in one single entry point
  - web-based user-friendly interface
  - registered as a contribution to GEOSS
  - open access to the scientific community



List of datasets

D1.4	Final 3 years dataset on aerodynamic and thermodynamic variables over the different land surfaces of the Tibetan Plateau
D2.5	Data set vegetation cover, surface albedo, LAI, aerosol optical depth, precipitable water vapour, soil/foliage component and land surface emissivity/temperatures for a 3 years period.
D3.2	Generalize SEB calculation at a high spatial resolution and on a regional extent
D3.4	Validated complete time-series maps of fluxes over 3 years, with a target frequency of one week
D4.1	Collection of consistent continuous in-situ soil moisture measurements at regional scale
D4.3	Estimation of soil moisture from Geostationary Satellite (GS) data
D4.4	A data product of the plateau using different sensors simultaneously
D4.5	Validation results and documentation of uncertainties
D5.3	Provide 3-years 3-D gridded radar data for case studies
D5.4	Provide high space and temporal resolution precipitation data retrieved from radar, satellite (both VIS-IR and MW) and ground rain gauge data for case studies
D6.4	Validated data set (include snow cover area, SWE, glacier area and storage from satellite data, and assimilation data sets) from 2008 to 2010
D8.2	Time series analysis of water balance data
D9.1	Vegetation dynamic maps over a long-term period
D9.2	Maps of drought vulnerability zones in the study area
D9.5	Anomalies maps of rainfall, vegetation response
D10.3	Flood inundation, flood hazard and flood risk zone maps based on the hydraulic modelling and analysis of satellite data
D10.4	Real time forecasting of flood inundation, depth, areal extent and return period of flooding
D10.5	Case studies on flood events in the period 1999-2010

List of datasets partially or totally available

D2.5	Data set vegetation cover, surface albedo, LAI, aerosol optical depth, precipitable water vapour, soil/foliage component and land surface emissivity/temperatures for a 3 years period.
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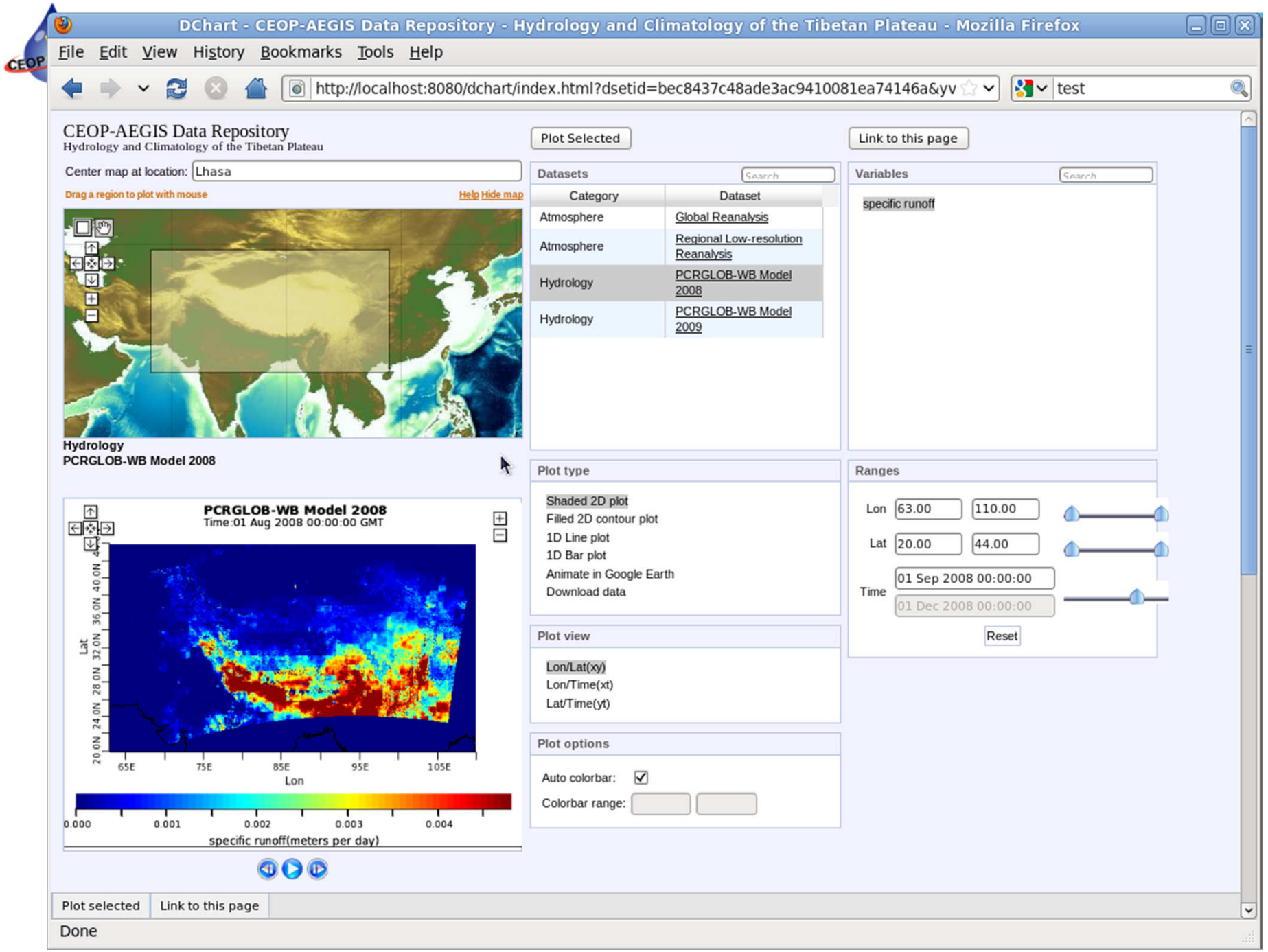
DChart - CEOP-AEGIS Data Repository - Hydrology and Climatology of the Tibetan Plateau - Mozilla Firefox
File Edit View History Bookmarks Tools Help
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CEOP-AEGIS Data Repository
Hydrology and Climatology of the Tibetan Plateau
Plot Selected
Link to this page
Center map at location: Lhasa
Drag a region to plot with mouse
Help Hide map
Hydrology
PCRGLOB-WB Model 2008
Datasets
Search
Category
Dataset
Atmosphere
Global Reanalysis
Atmosphere
Regional Low-resolution Reanalysis
Hydrology
PCRGLOB-WB Model 2008
Hydrology
PCRGLOB-WB Model 2009
Variables
Search
specific runoff
PCRGLOB-WB Model 2008
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95E
105E
Lon
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0.003
0.004
specific runoff(meters per day)
Plot type
Shaded 2D plot
Filled 2D contour plot
1D Line plot
1D Bar plot
Animate in Google Earth
Download data
Ranges
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Lat 20.00 44.00
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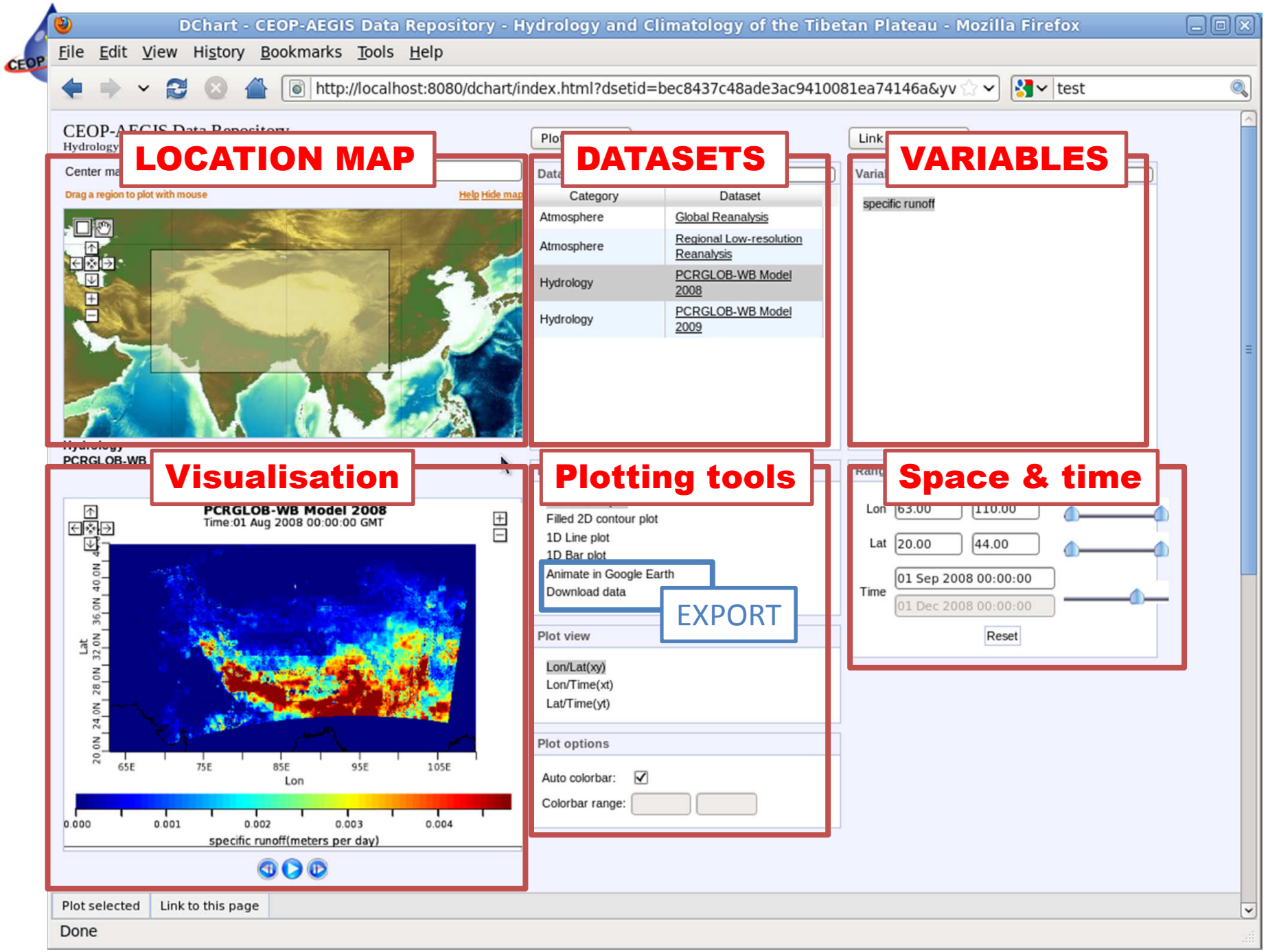
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CEOP-AEGIS Data Repository
Hydrology
LOCATION MAP
Drag a region to plot with mouse
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DATASETS
Category
Dataset
Atmosphere
Global Reanalysis
Atmosphere
Regional Low-resolution Reanalysis
Hydrology
PCRGLOB-WB Model 2008
Hydrology
PCRGLOB-WB Model 2009
VARIABLES
specific runoff
Visualisation
PCRGLOB-WB Model 2008
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0.003
0.004
specific runoff(meters per day)
Plotting tools
Filled 2D contour plot
1D Line plot
1D Bar plot
Animate in Google Earth
Download data
EXPORT
Plot view
Lon/Lat(xy)
Lon/Time(xt)
Lat/Time(yt)
Plot options
Auto colorbar:
Colorbar range:
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01 Dec 2008 00:00:00
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Data analysis and integration

- Merge radiometric data optical systems
- Cross calibration “family” imaging radiometers
- Develop generic algorithms
- Analysis of time series of satellite observations to get statistics on anomalies (when, where, how large) on droughts and floods
- 30+ years AVHRR , microwave radiometers
- Access to data bases of different initiatives: Third Pole Environment (China, Nepal…), PAPRIKA (Pakistan, Italy, France)

Acknowledgements

- This study is jointly supported by the **ESA Dragon II** program under proposal no.5322: “Key Eco-Hydrological Parameters Retrieval and Land Data Assimilation System Development in a Typical Inland River Basin of China’s Arid Region” and by the **European Commission** (Call FP7-ENV-2007-1 Grant nr. 212921) as part of the **CEOP-AEGIS** project (http://www.ceop-aegis.org) coordinated by the University of Strasbourg.
- **WATER** is jointly supported by the Chinese Academy of Science Action Plan for West Development Program (grant KZCX2-XB2-09) and Chinese State Key Basic Research Project (grant 2007CB714400).