Climate change impact on water resources in several regions of the world. A European, Asian and African case study using CHyM hydrological model. Problems and challenges

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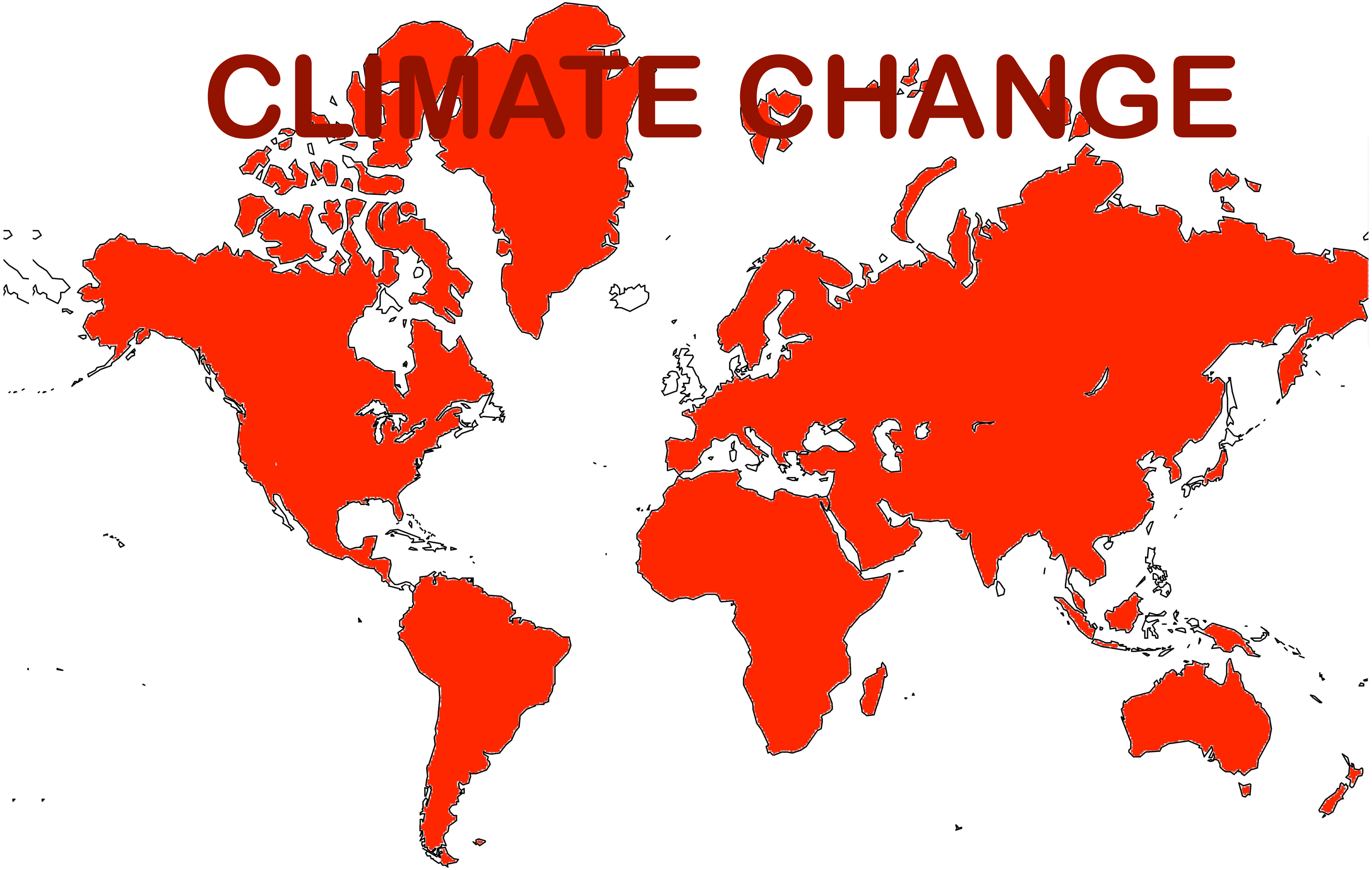
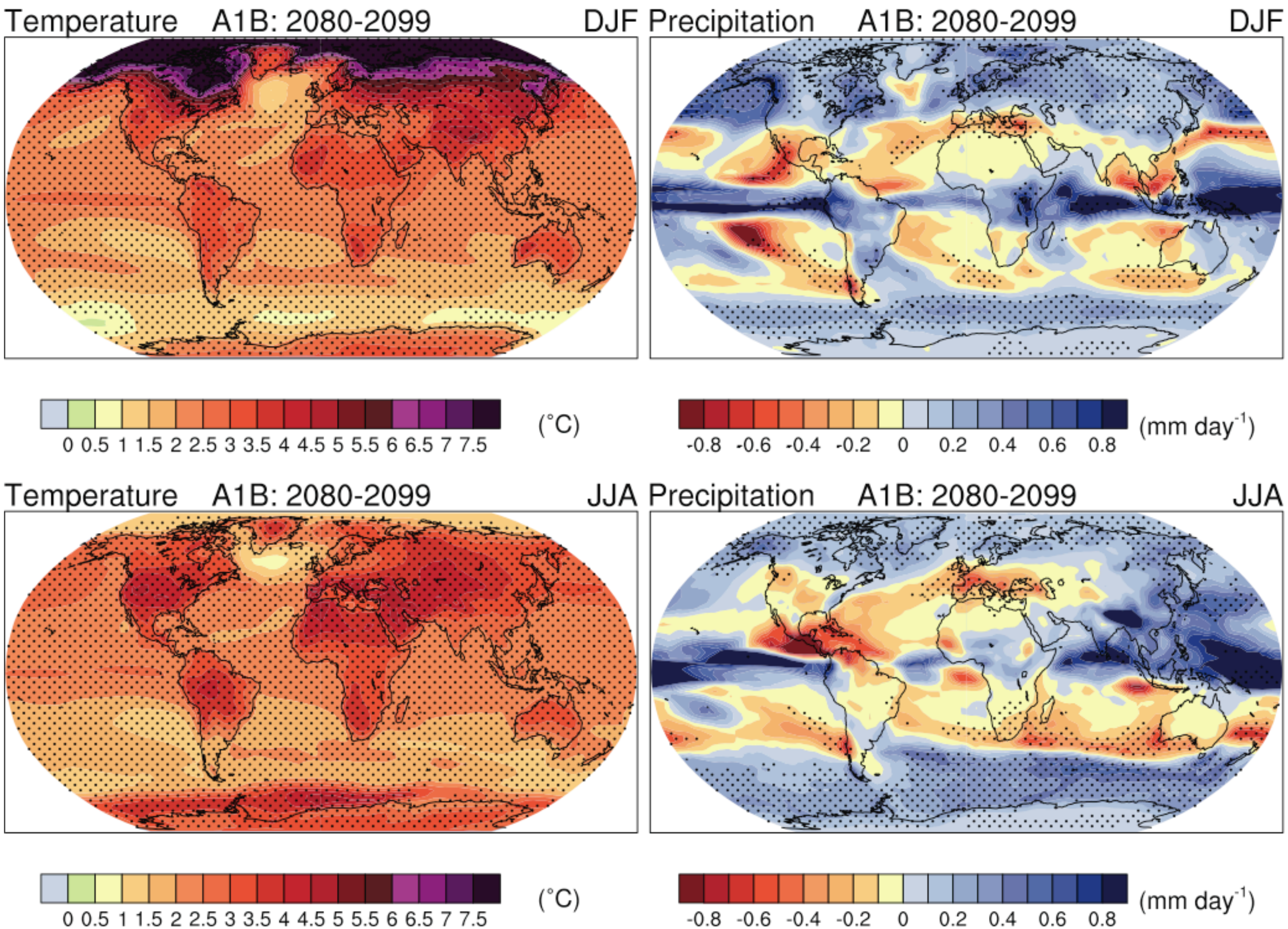
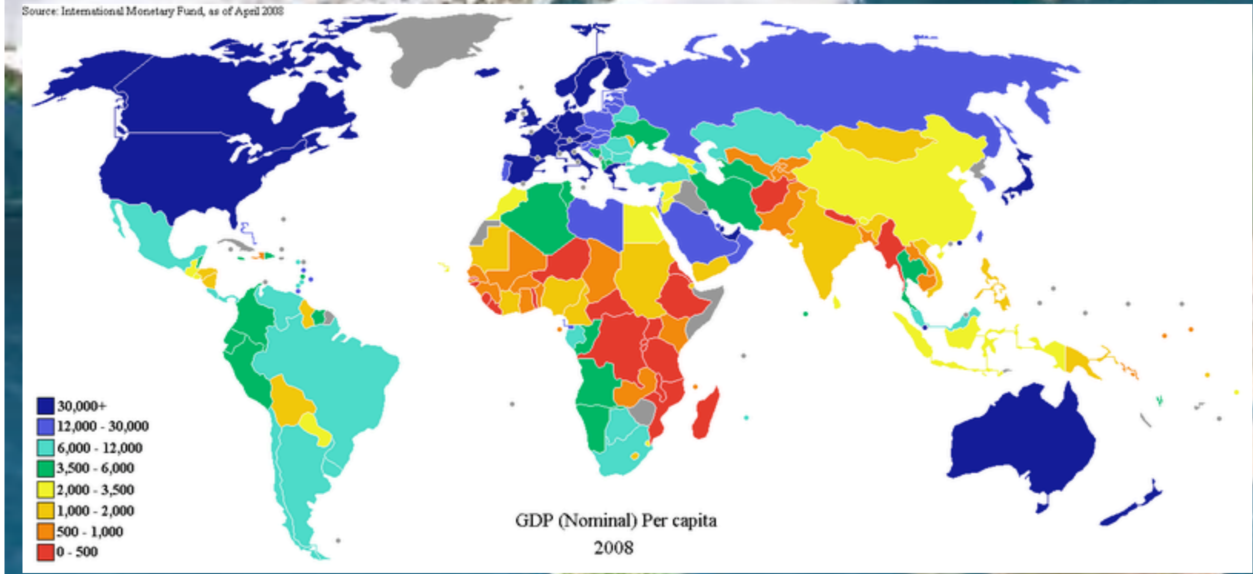
CLIMATE CHANGE



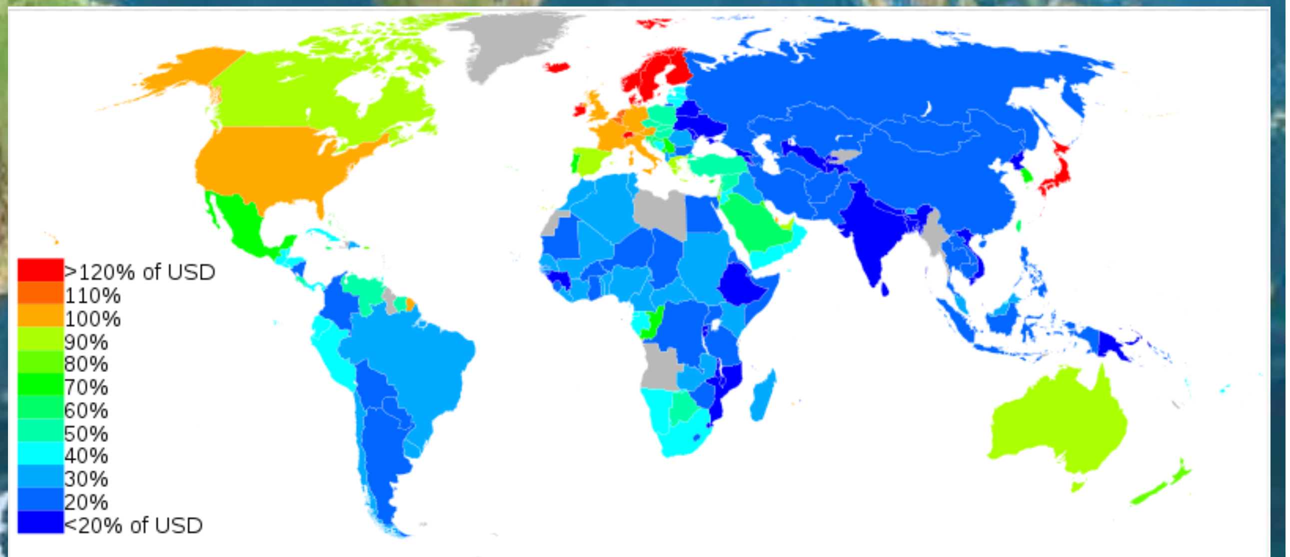
Temperature and Precipitation mean change



GDP = consumption + gross investment + government spending + (exports − imports)



Adjusted with the purchasing power parity (PPP)



What do we need?

Global information

↓

Local scale information

↓

Impact models

↓

Adaptation and mitigation policies

•Accurate assessment of the potential impacts of climate change on societies and ecosystems requires regional- to local-scale climate change information

•However, information about fine-scale climate change and its uncertainties is currently very sparse due to the lack of a coordinating framework

•Fine-scale climate factors (topography and land cover) modulate regional and local climate changes and dictate impacts on various sectors, including water resources

•We are starting the framework using the ICTP-based RegCNET network (Giorgi et al, 2006), the RegCM3 RCM (Pal et al. 2007), and the CMIP3 AOGCM ensemble (Meehl et al. 2007).
We cover the geographic uncertainty dimension with six continental-scale domains (North and Central America, South America, Europe, Africa, Central Asia, and South and East Asia) at 25 km grid spacing, a state-of-the-art resolution for long-term RCM experiments. Regional Climate Change (RCC) Hyper-Matrix framework (Giorgi et al., EOS, 2008)

DEM is available with a resolution of 300 m

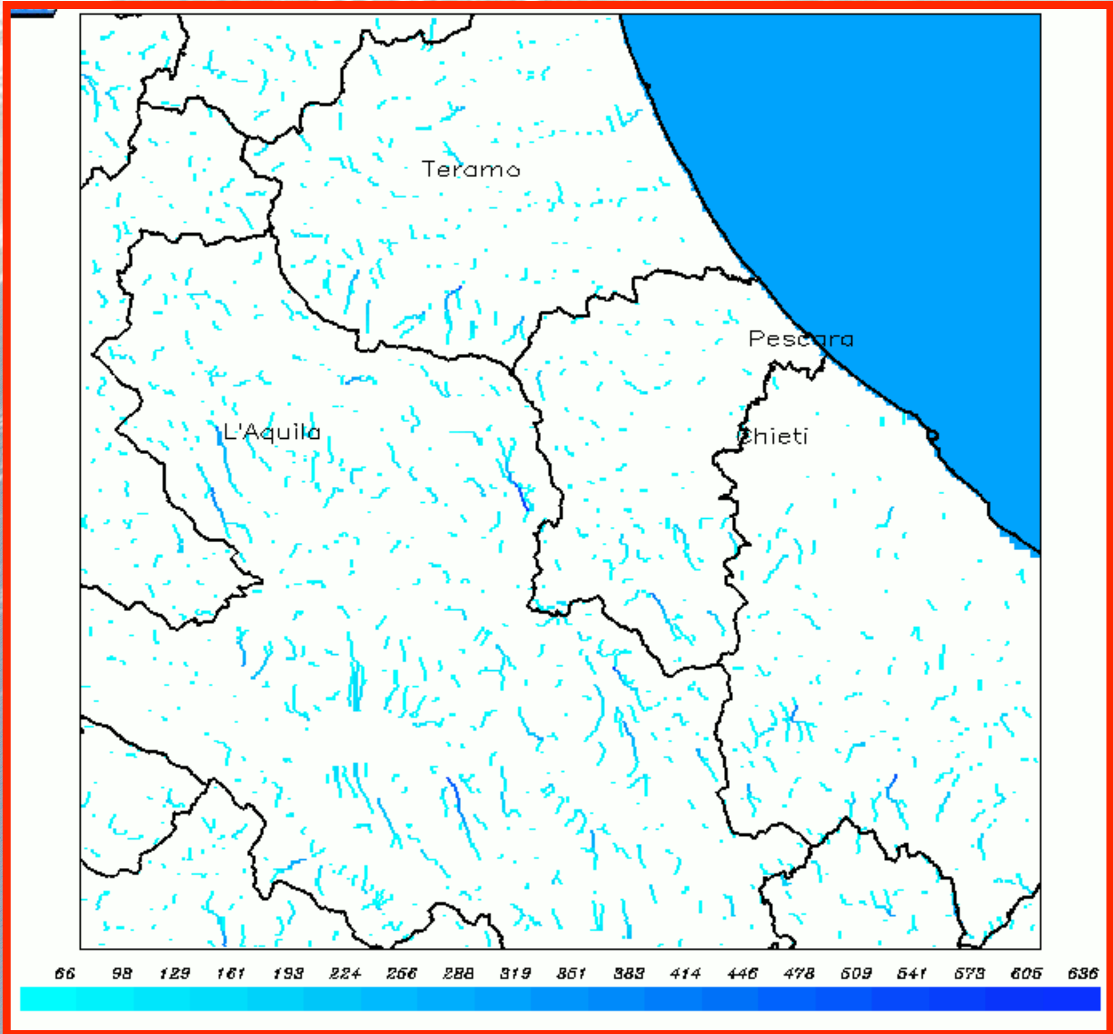
For each cell the slope is computed as: $\operatorname{atan}\frac{\Delta h}{\Delta x}$

Max slope

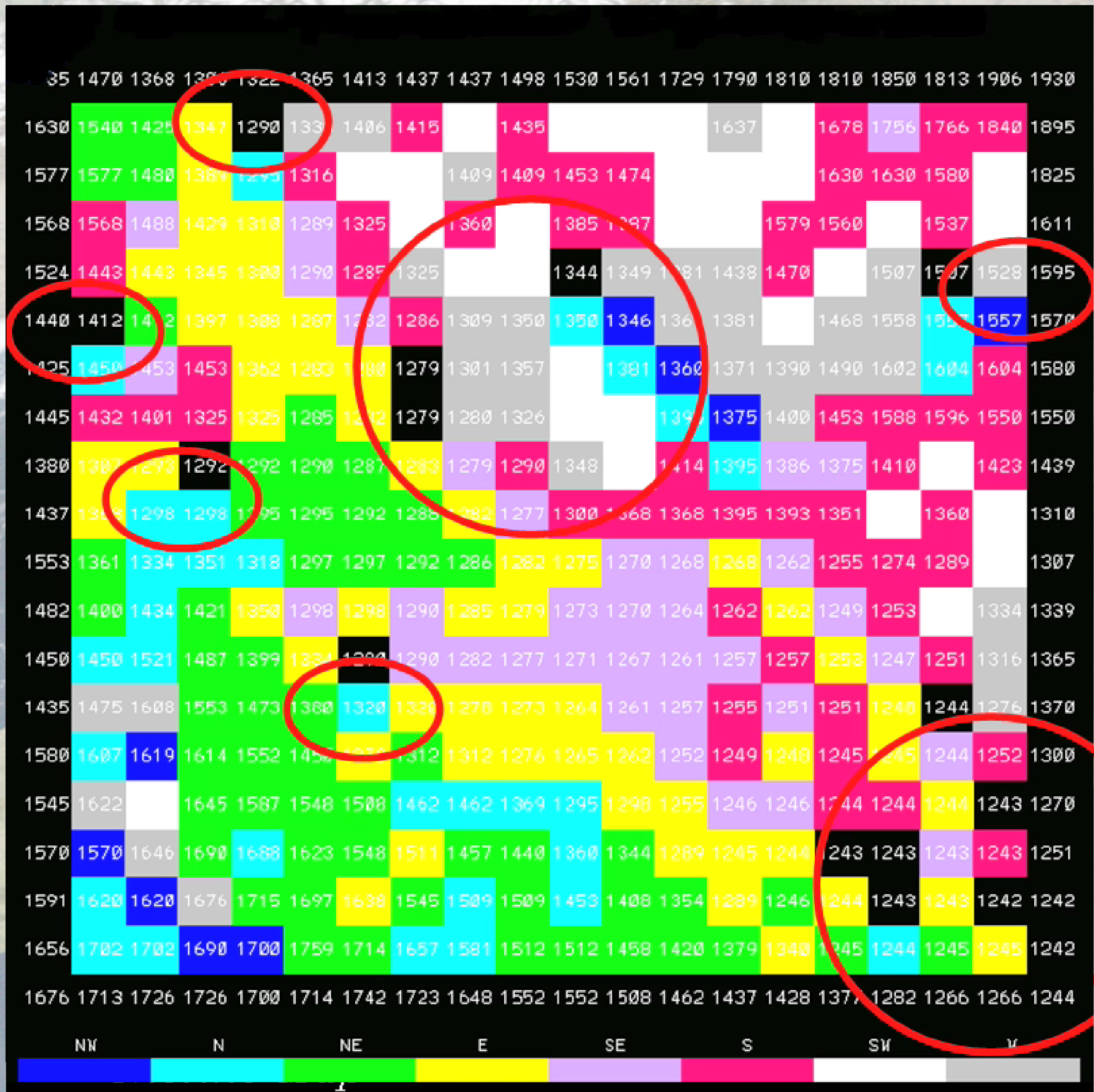
Runoff direction

movie

CHyM: Drainage network test

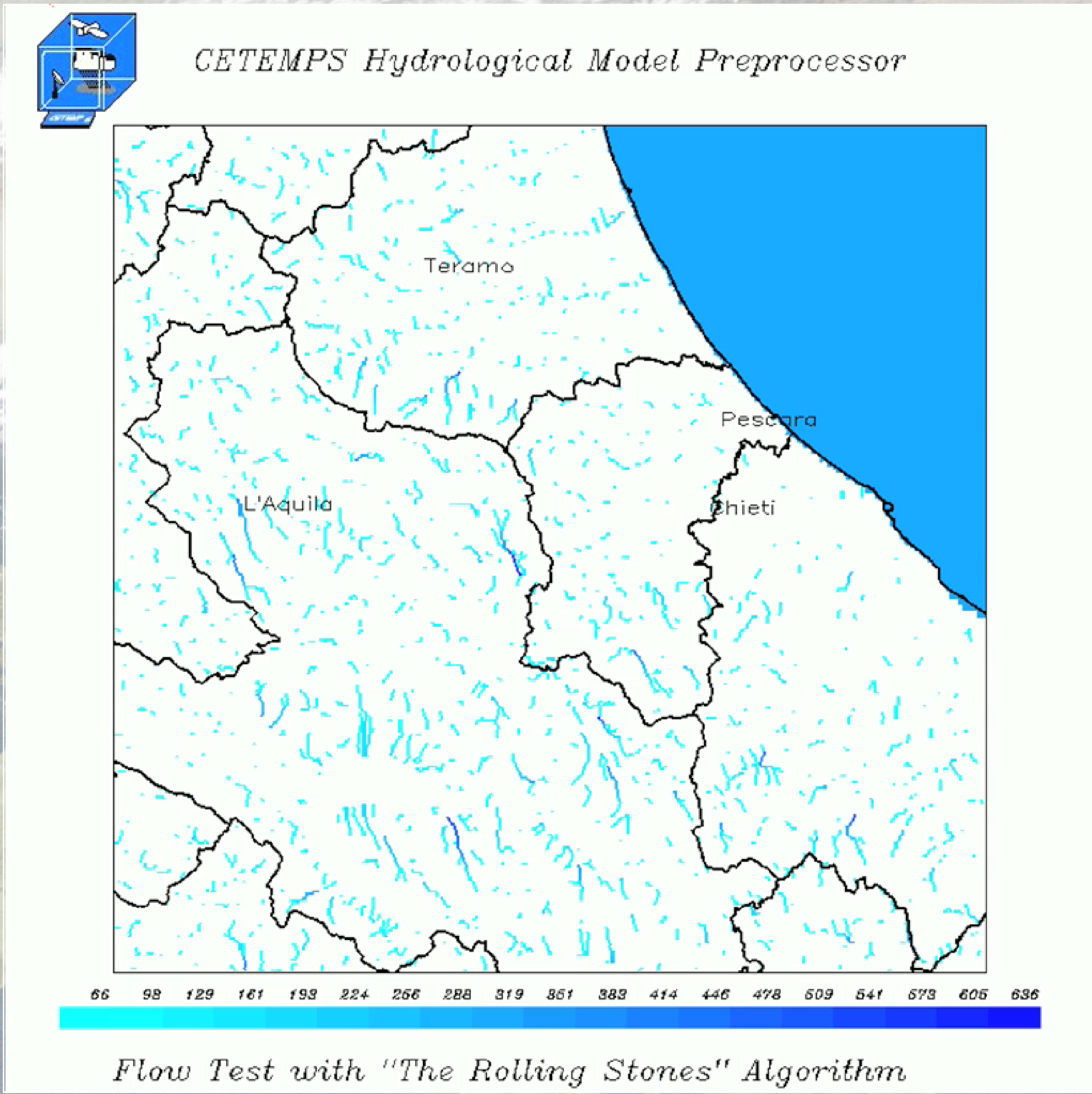


CHyM: Drainage network test



movie

CHyM: Drainage network test



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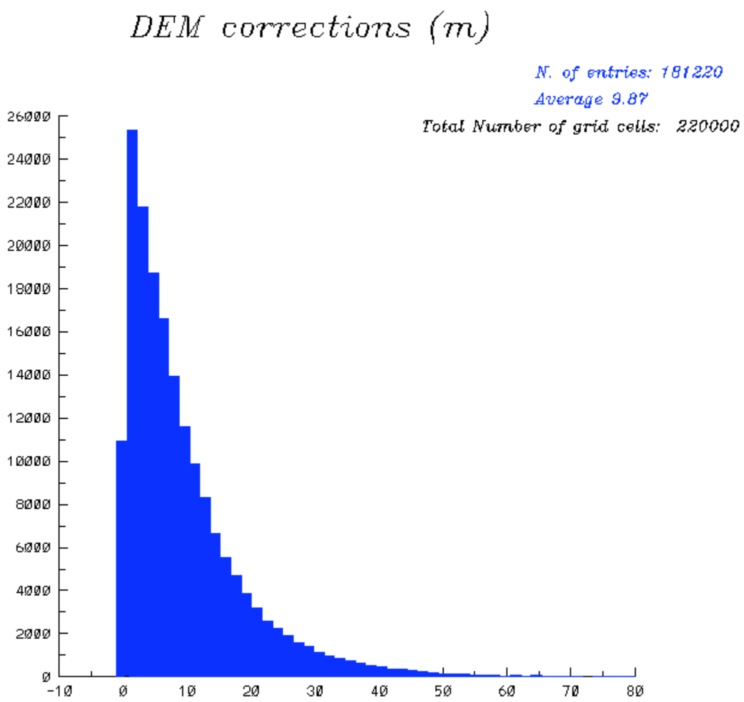
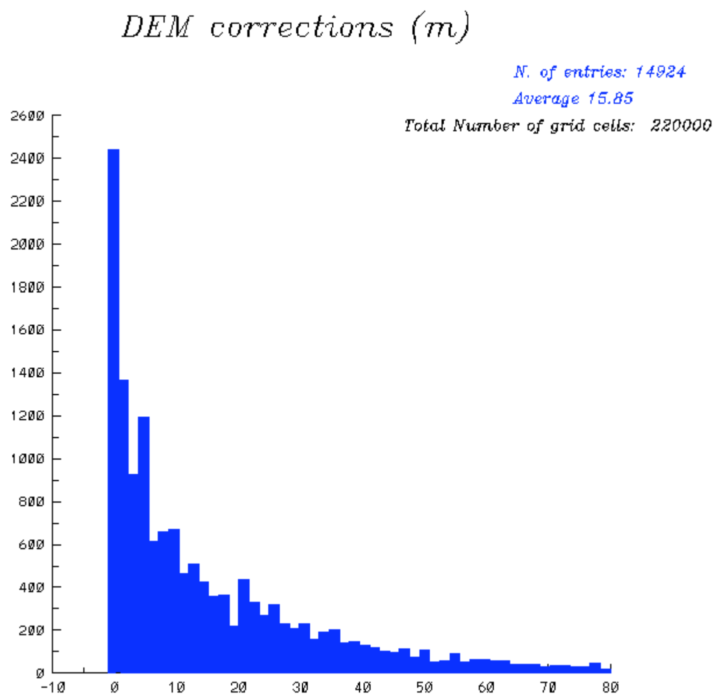
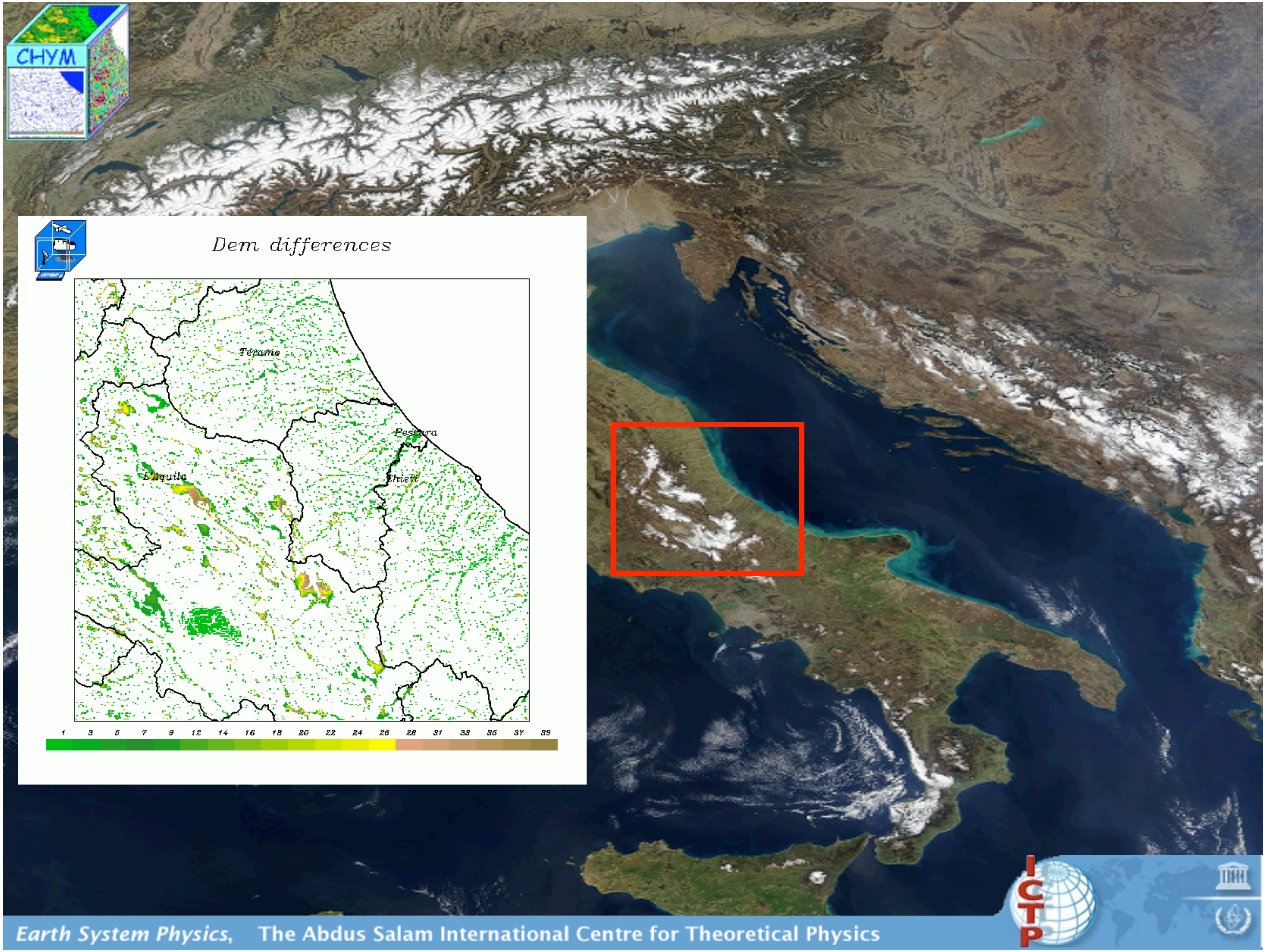


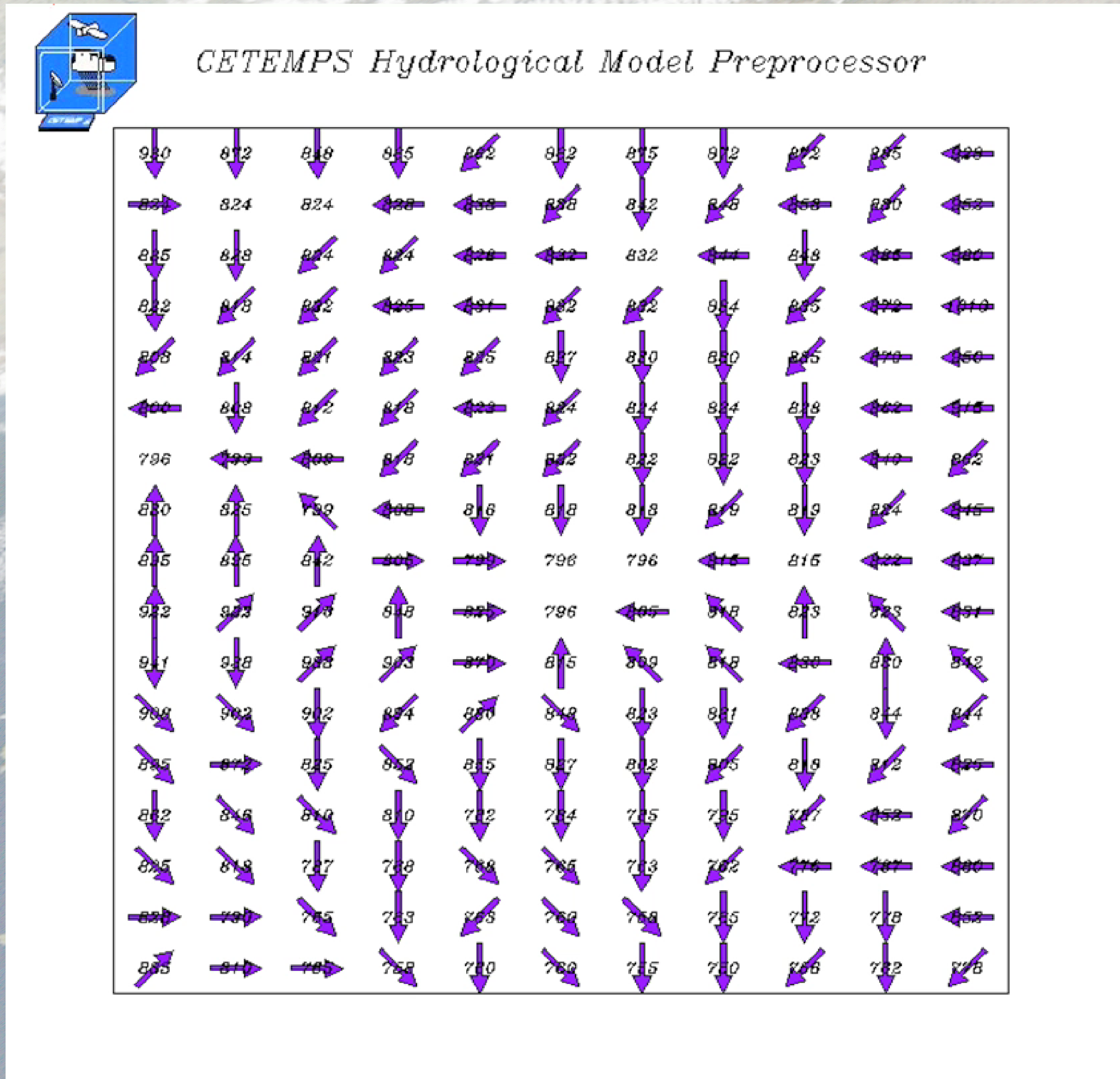
DEM Smooting Algorithm 1 (DSA1)



DEM Smooting Algorithm 2 (DSA2)


CHYM
Dem differences
Teramo
Pescara
L'Aquila
Chieti
1 3 5 7 9 12 14 16 18 20 22 24 26 28 31 33 36 37 39
ICTP
Earth System Physics, The Abdus Salam International Centre for Theoretical Physics

CHyM: DEM pit correction

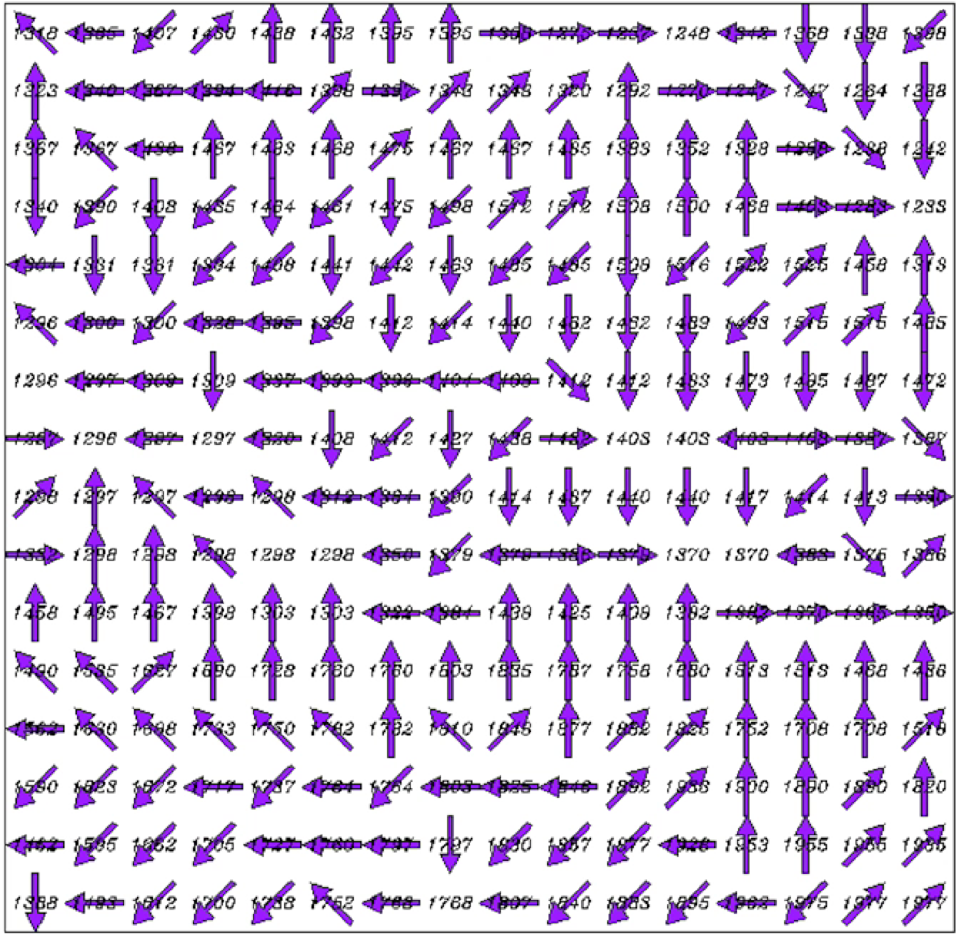


Flow Direction Map – 6633 of 6633 no-flow points were corrected.

movie

CHyM: DEM pit correction

CETEMPS Hydrological Model Preprocessor



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movie

CHyM: DEM pit correction

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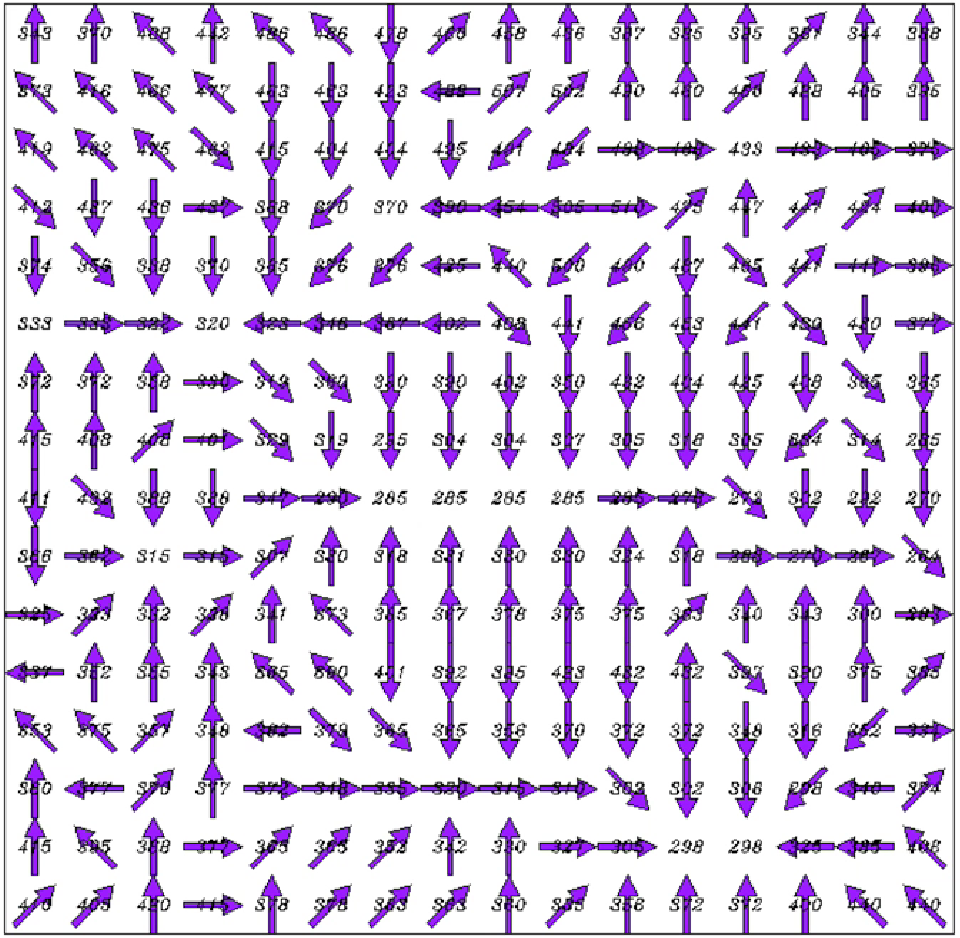

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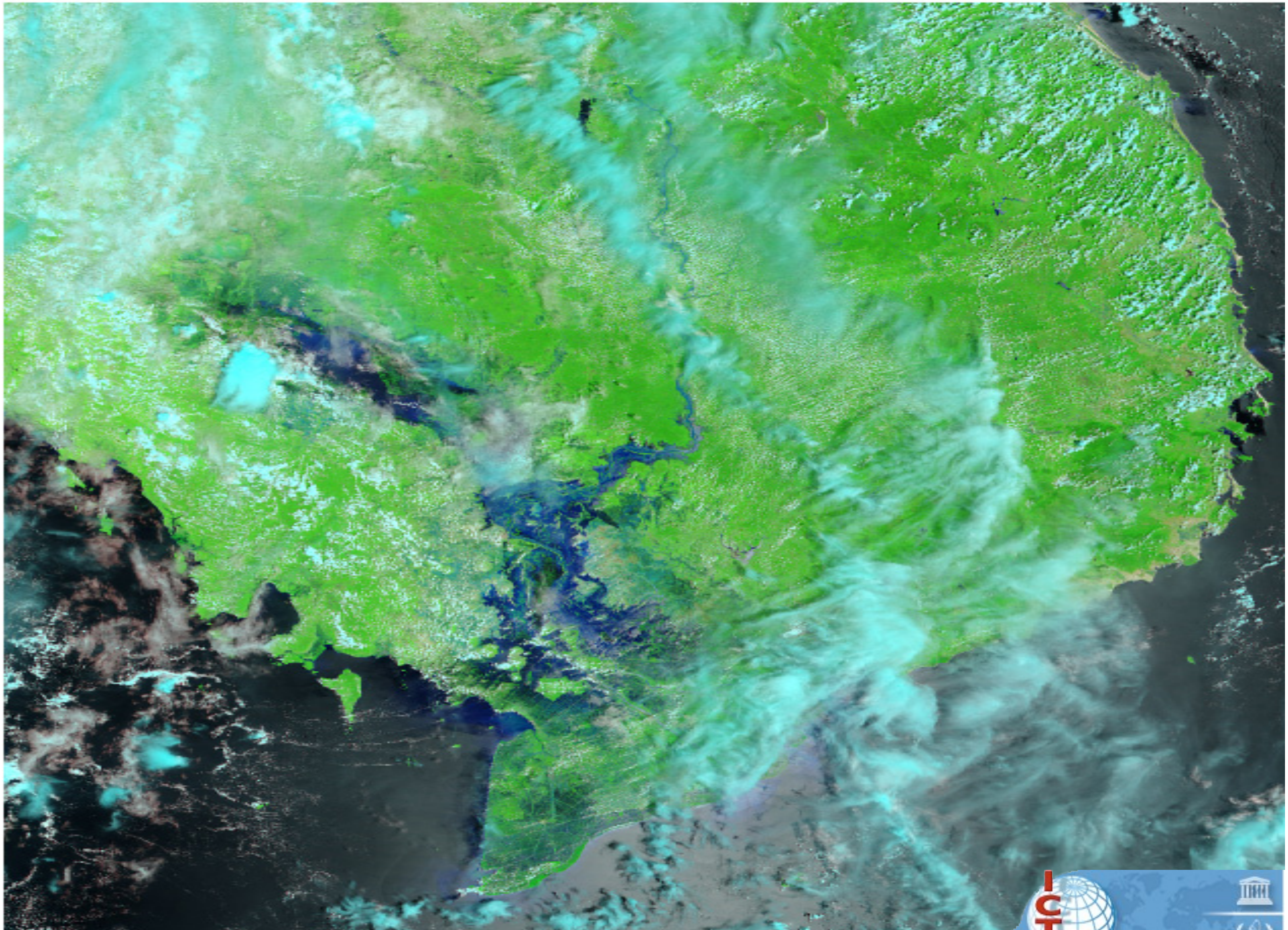
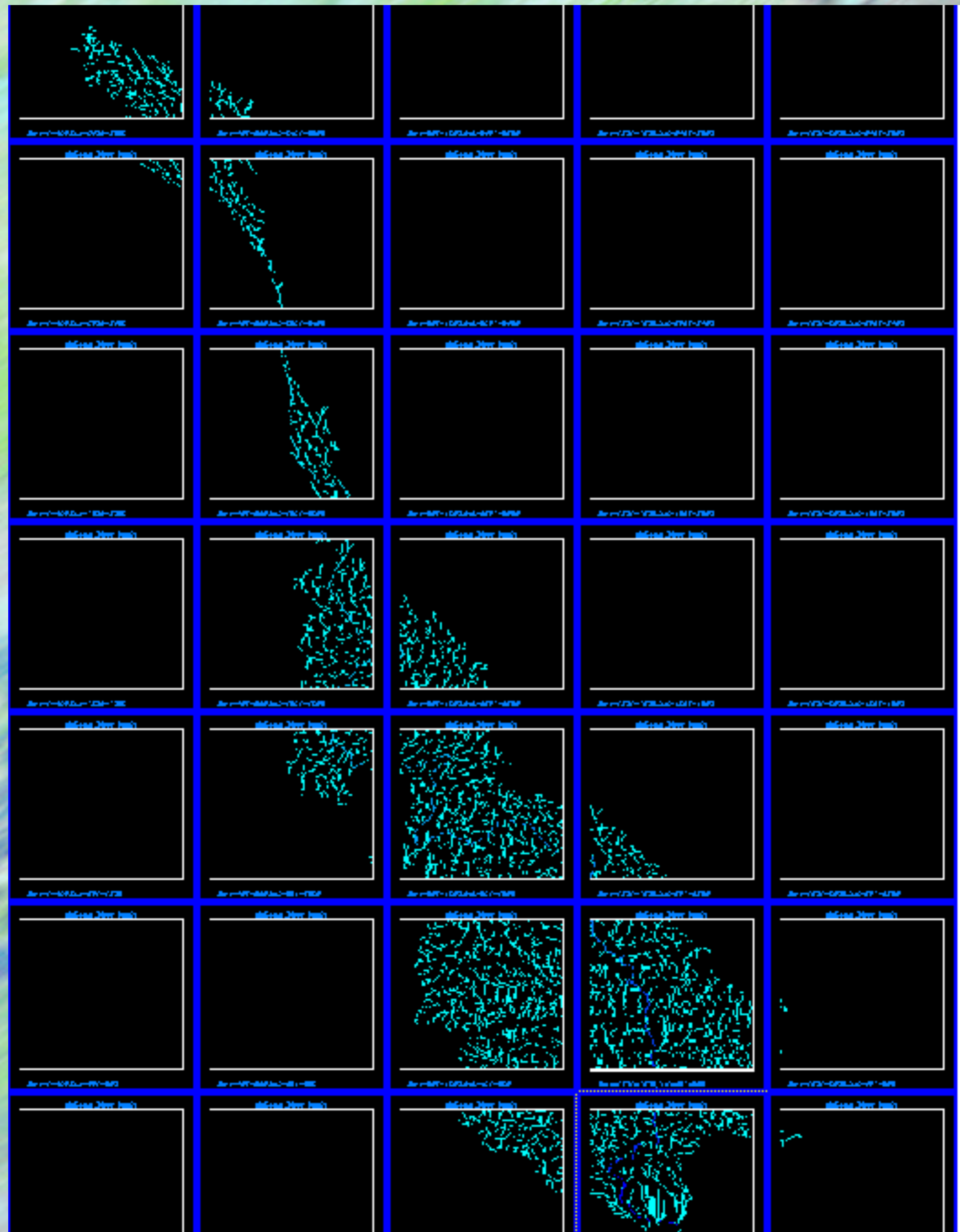
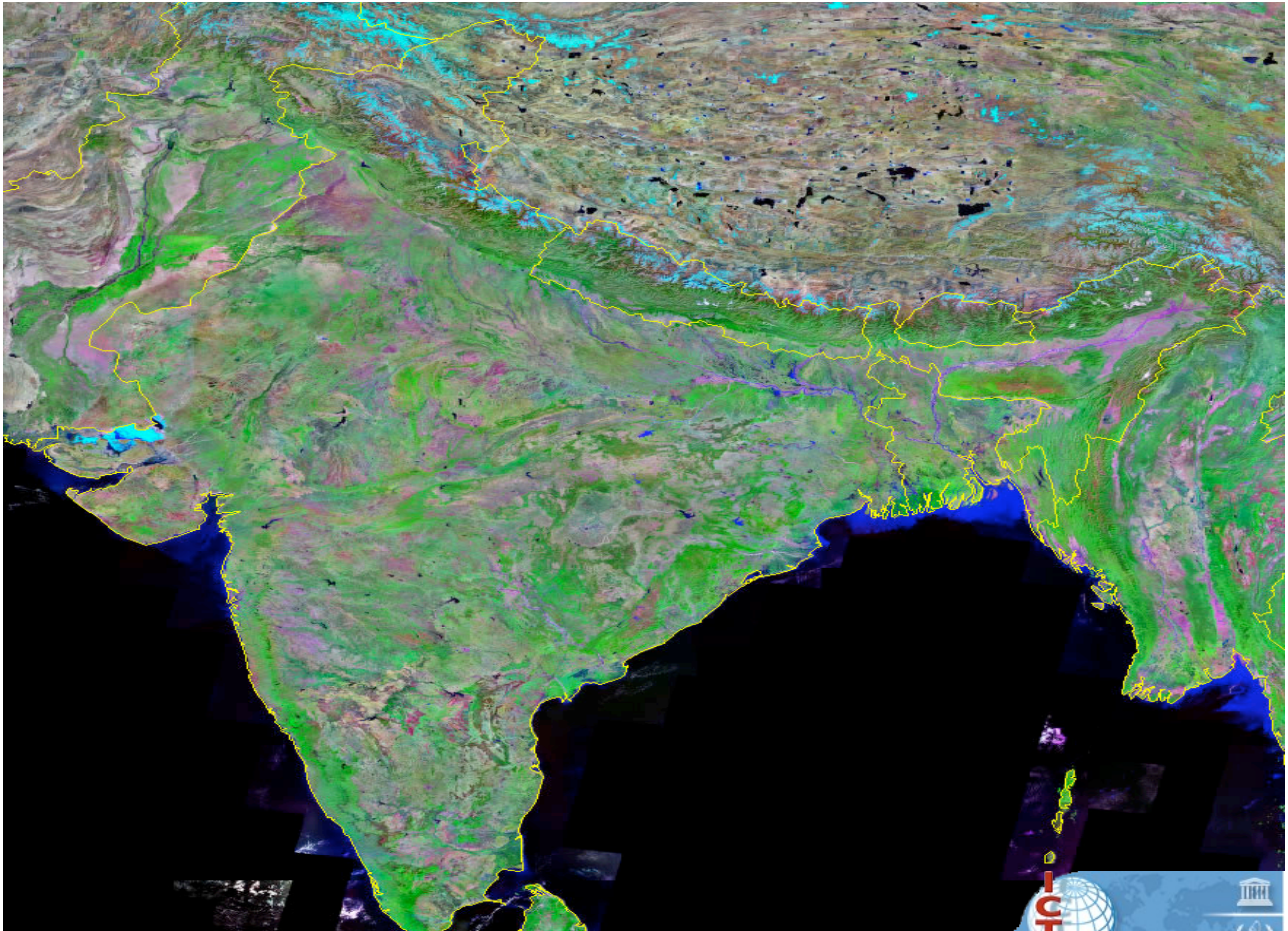
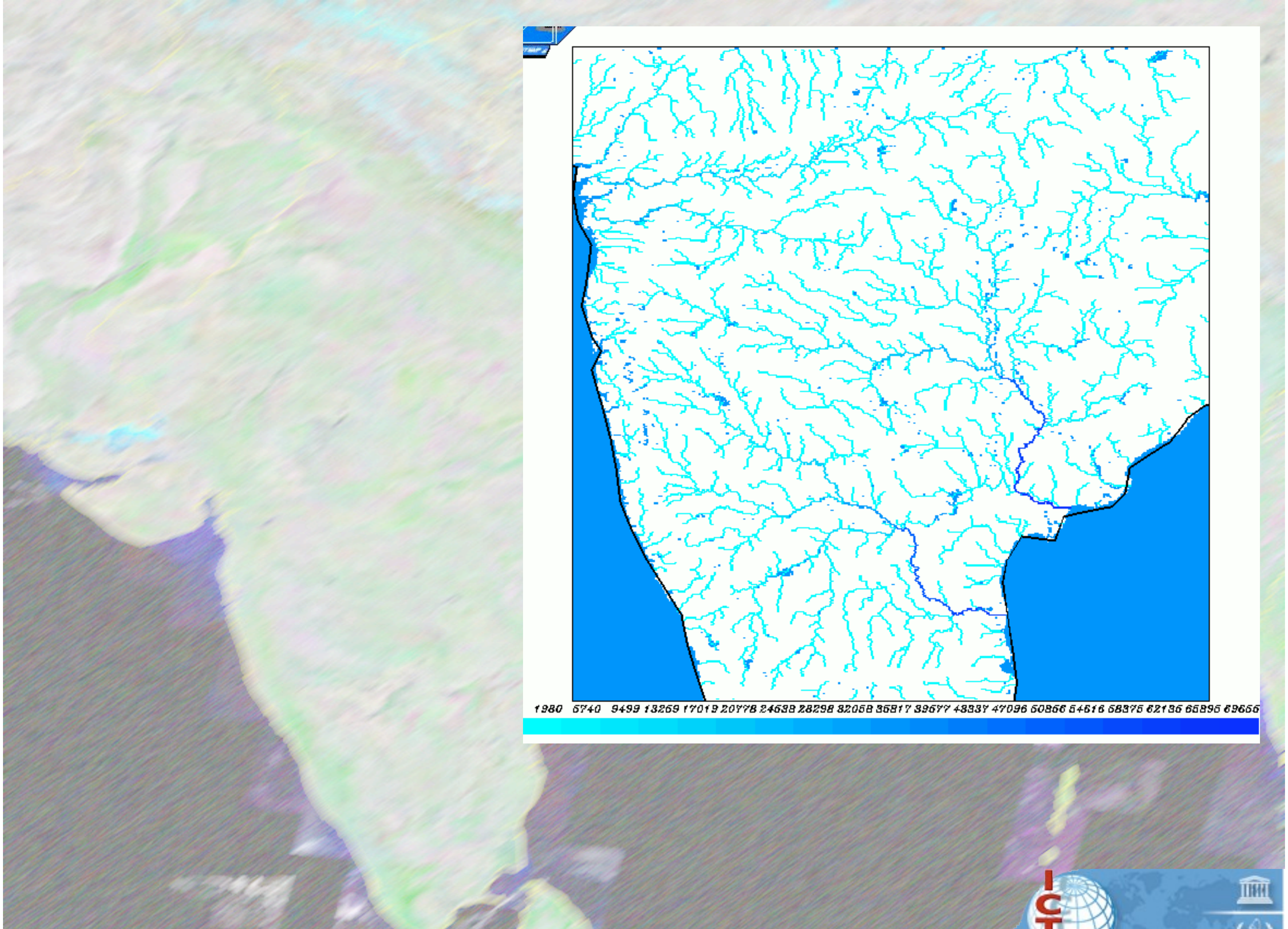
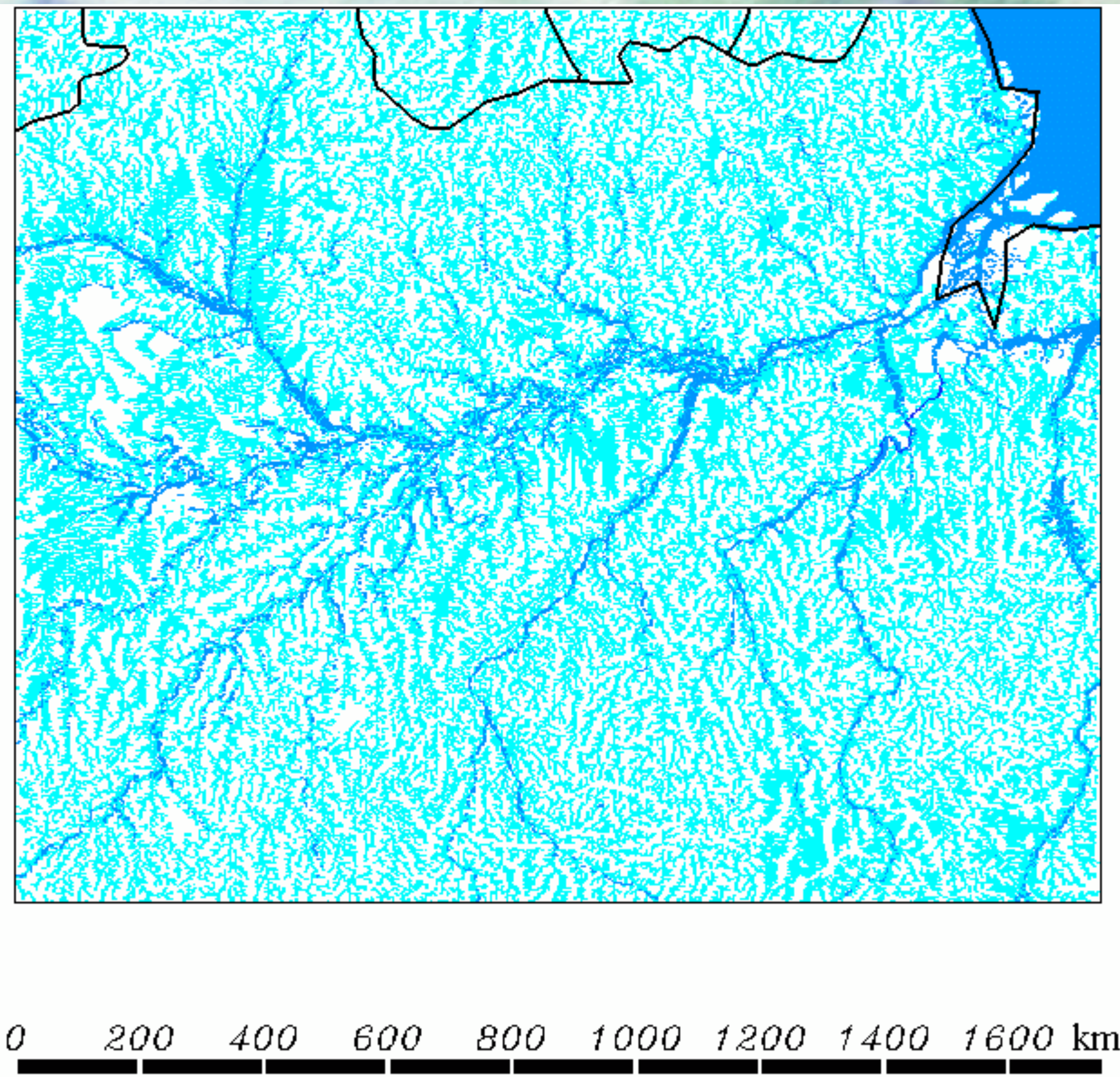
movie



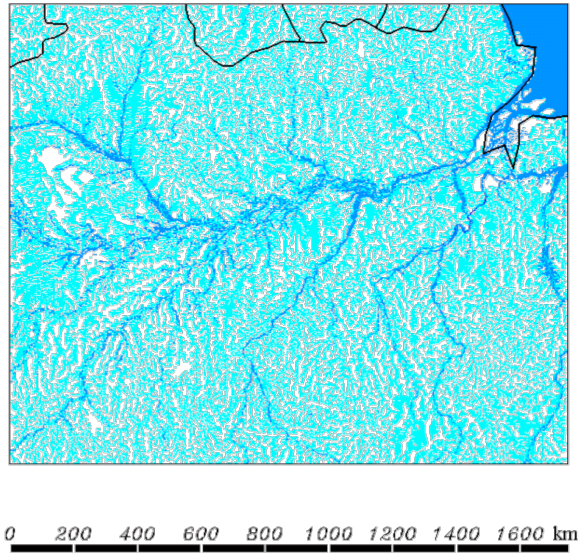





1980 6740 9499 13269 17019 20778 24638 28298 32068 36817 39677 43337 47096 50866 54616 58375 62136 65896 69666

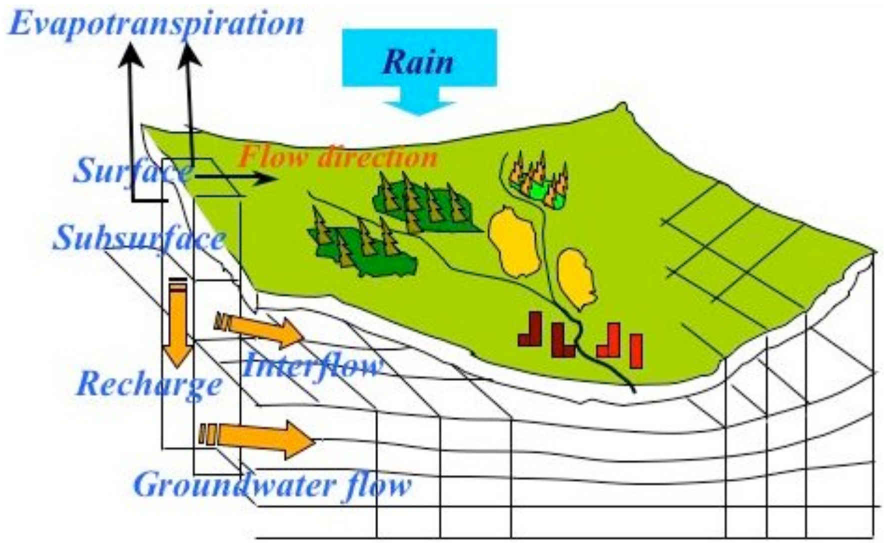

0 200 400 600 800 1000 1200 1400 1600 km

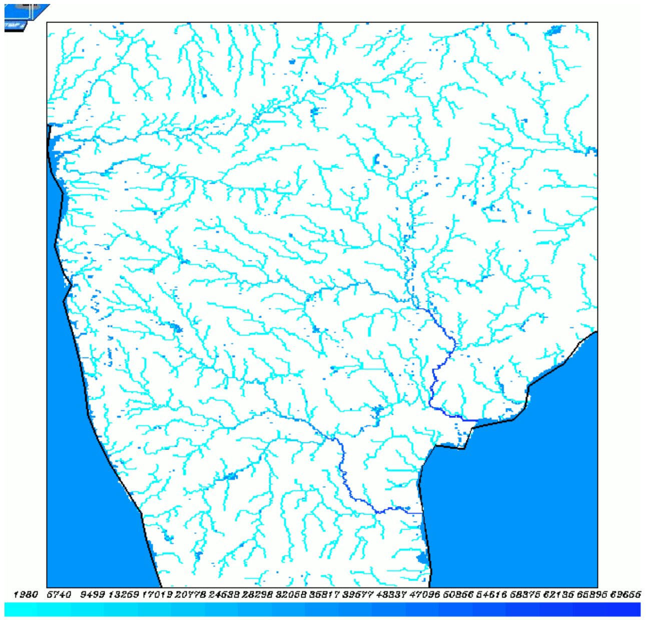
CHyM



Rain

Runoff
Evapotraspiration
Infiltration





E. Coppola, B. Tomassetti, L. Mariotti, M. Verdecchia and G. Visconti, Cellular automata algorithms for drainage network extraction and rainfall data assimilation, Hydrological Science Journal, 52(3), 2007

movie

Case studies

Po river (Italy) (1 km resolution; 110945.0 km2 drained area)
5 years RegCM-ERA40 simulation 1995-2000
3 years RegCM-ECHAM5 A1B scenario simulation 1980/82 -2080/82

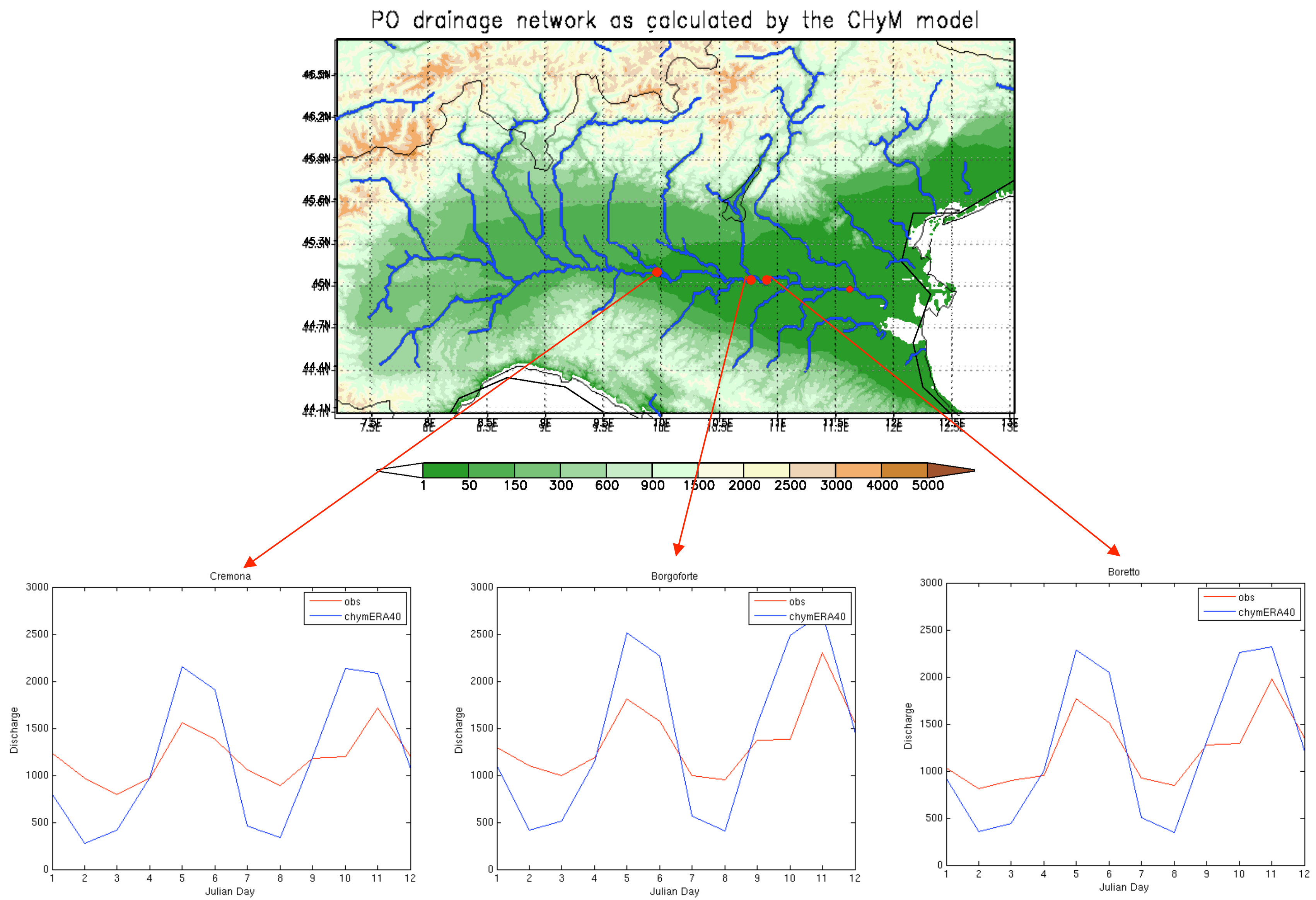
Niger - Volta river (West-Africa)(9.5 km; Niger 2494084 km2,
Volta 434235 km2 drained area)
3 years RegCM-ECHAM5 A1B scenario simulation 1980/82 -2080/82

Han-Kum-Nakdong river (Korea)(740 m; Han 19678 km2,
Nakdong 15848 km2, Kum 6769 km2 drained area)

3 years RegCM-ECHAM5 A1B scenario simulation 1980/82 -2080/82

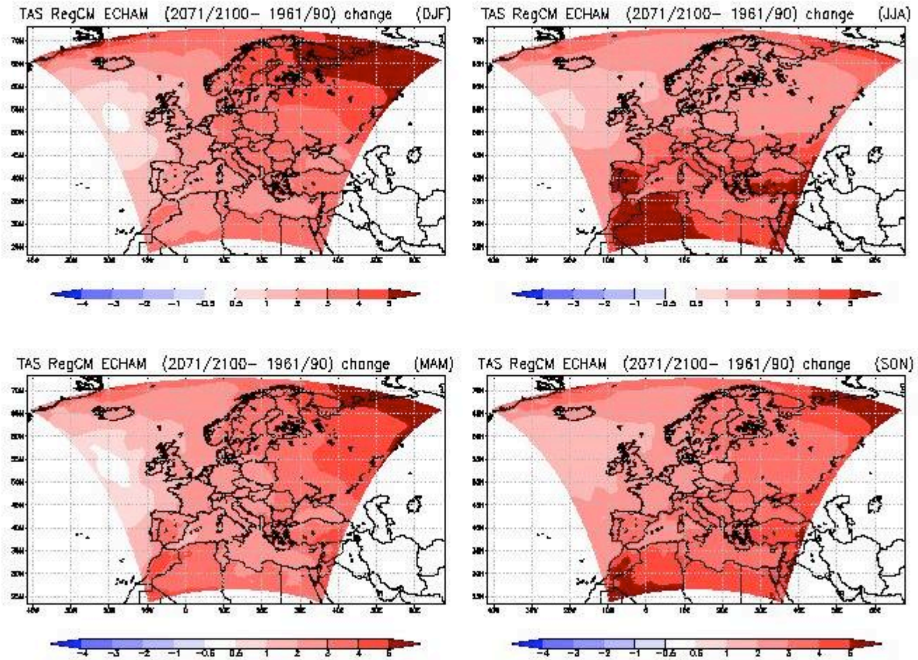
Yellow – Yangtze river (China)(5.7 km, Yellow river 360431km2,
Yangtze 564594 km2)
1 years RegCM-ECHAM5 A1B scenario simulation 1961- 2071

RegCM-ERA40



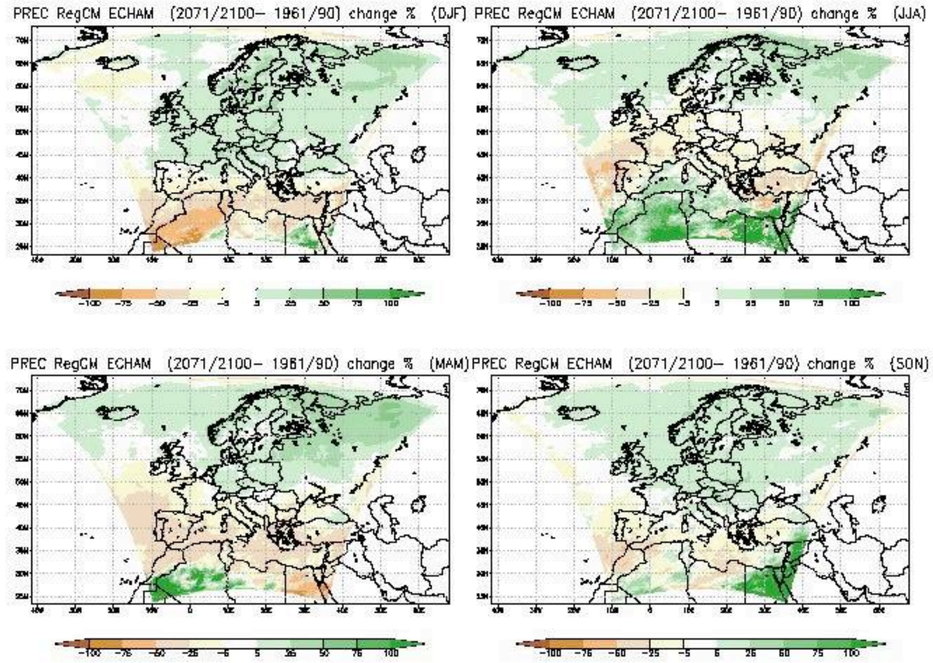
Avg. discharge1540 m³/s

RegCM-ECHAM 25km A1B scenario 1950-2100

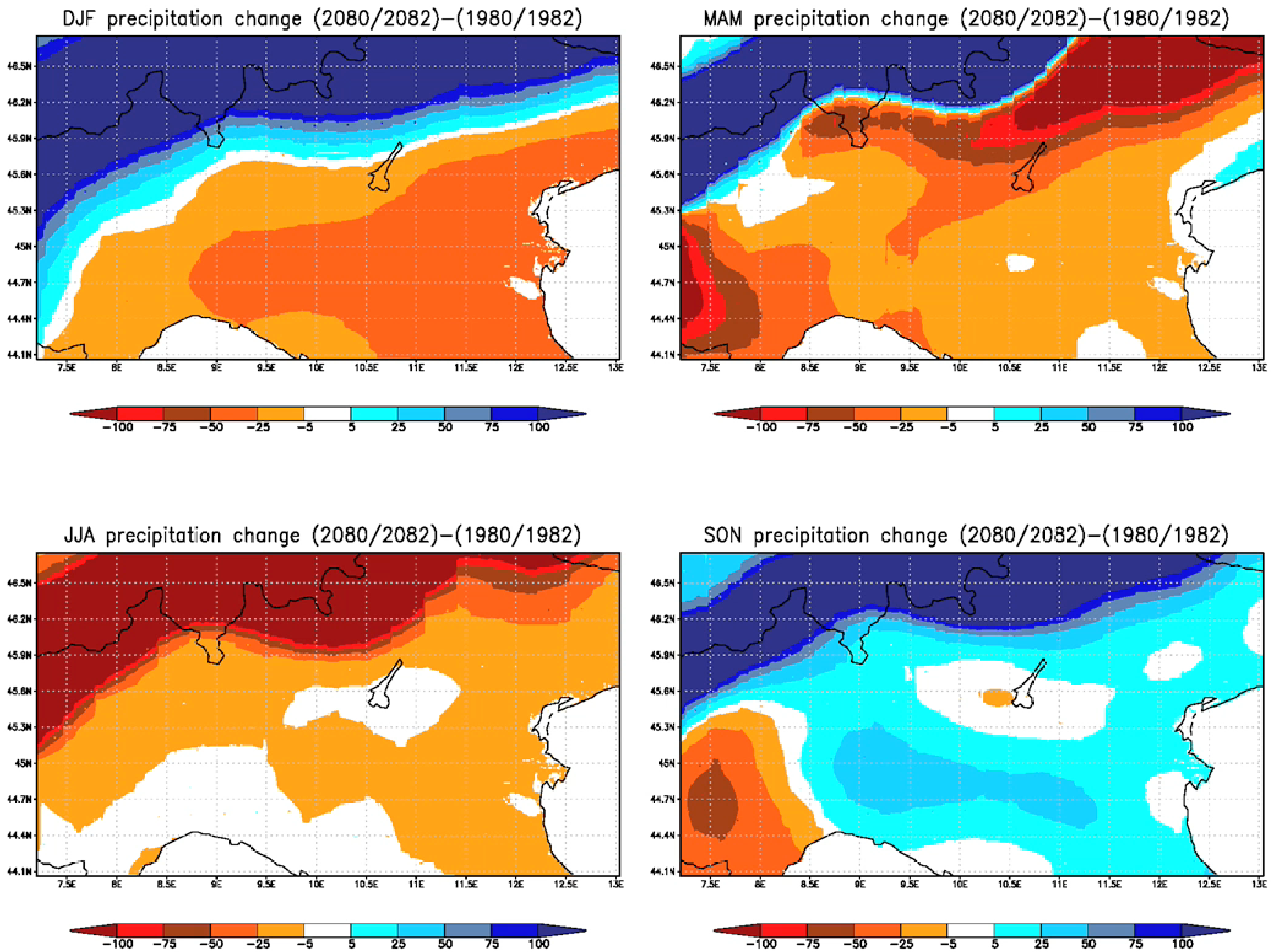


Temperature

Precipitation



A1B scenario simulation



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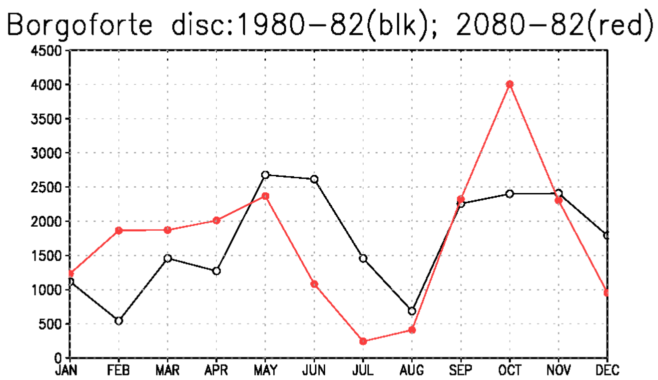
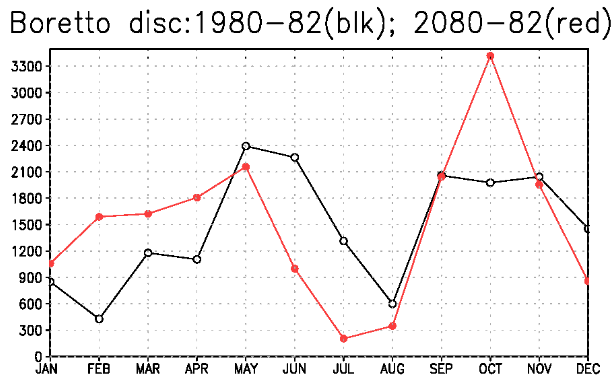
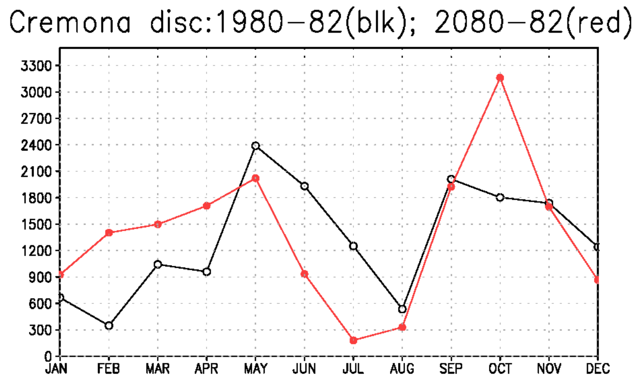


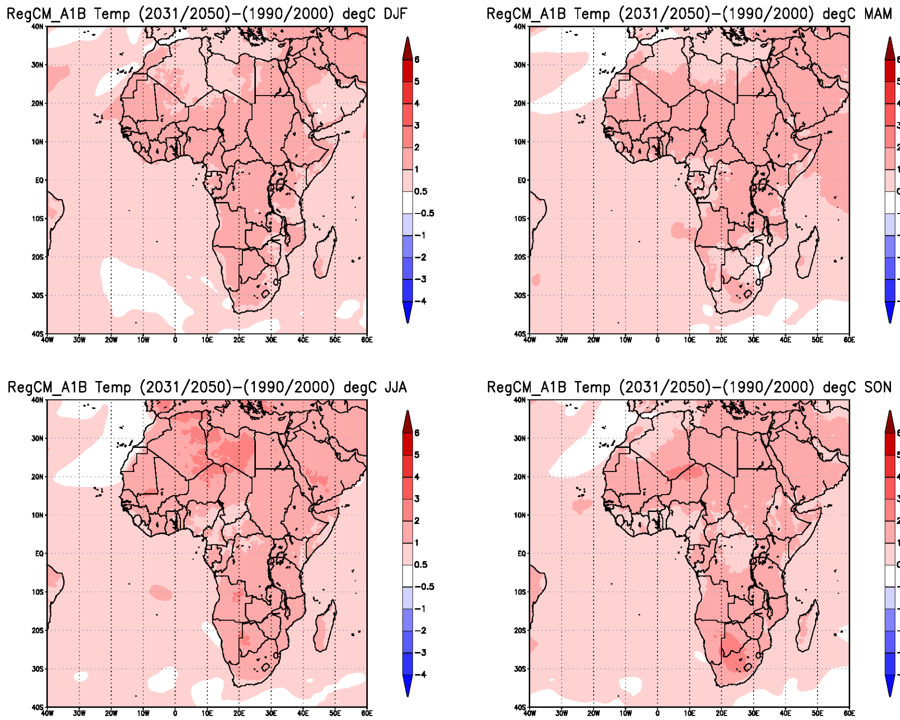
Station annual discharge cycle

- Shift of the spring peak toward the early part of the season
- Decrease of runoff during the summer months (Jul. and Aug.)
- Increase of the autumn runoff

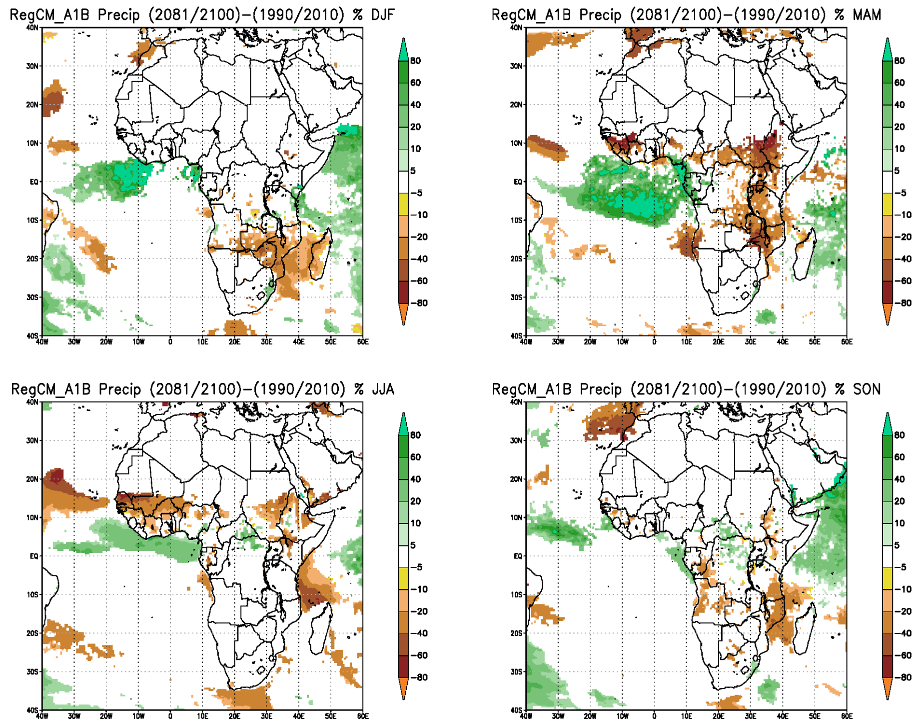




RegCM-ECHAM 50km A1B scenario 1950-2100

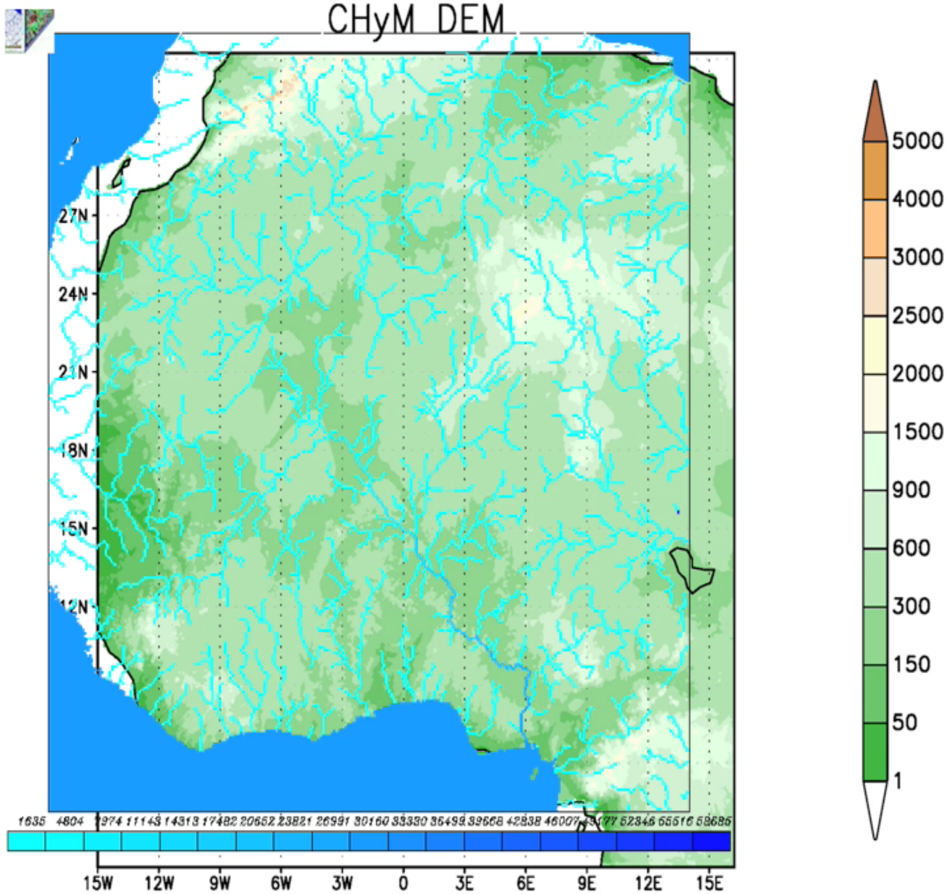


Temperature

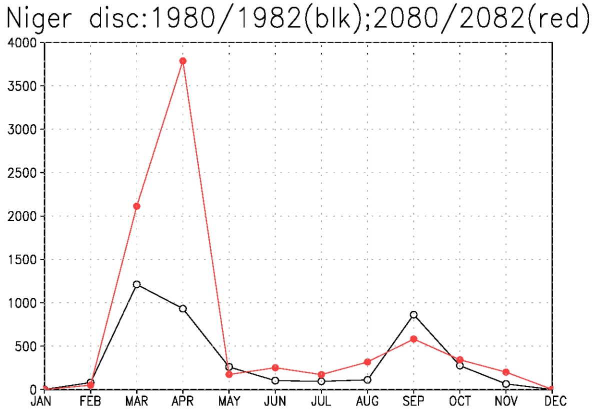


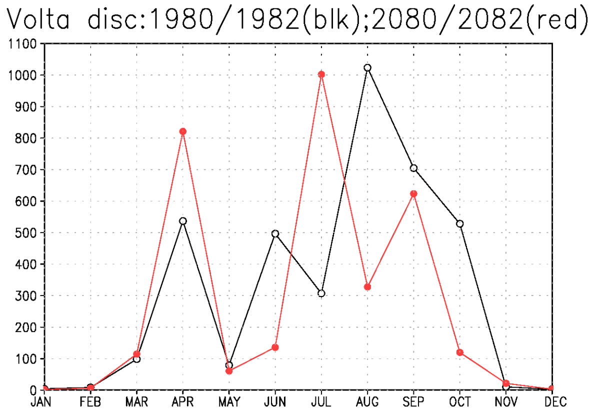
Precipitation

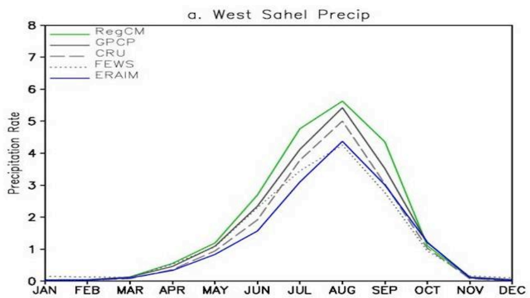
A1B scenario simulation

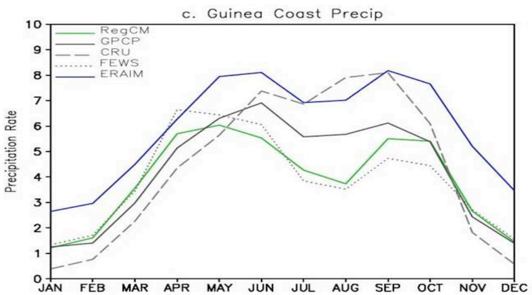


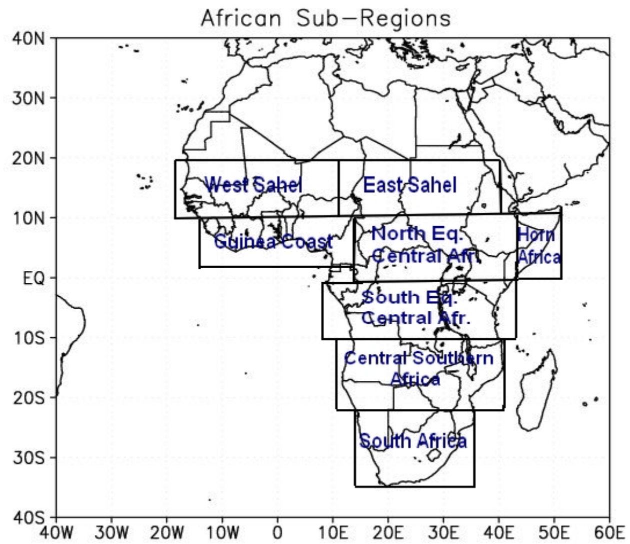
Annual discharge at the river mouth









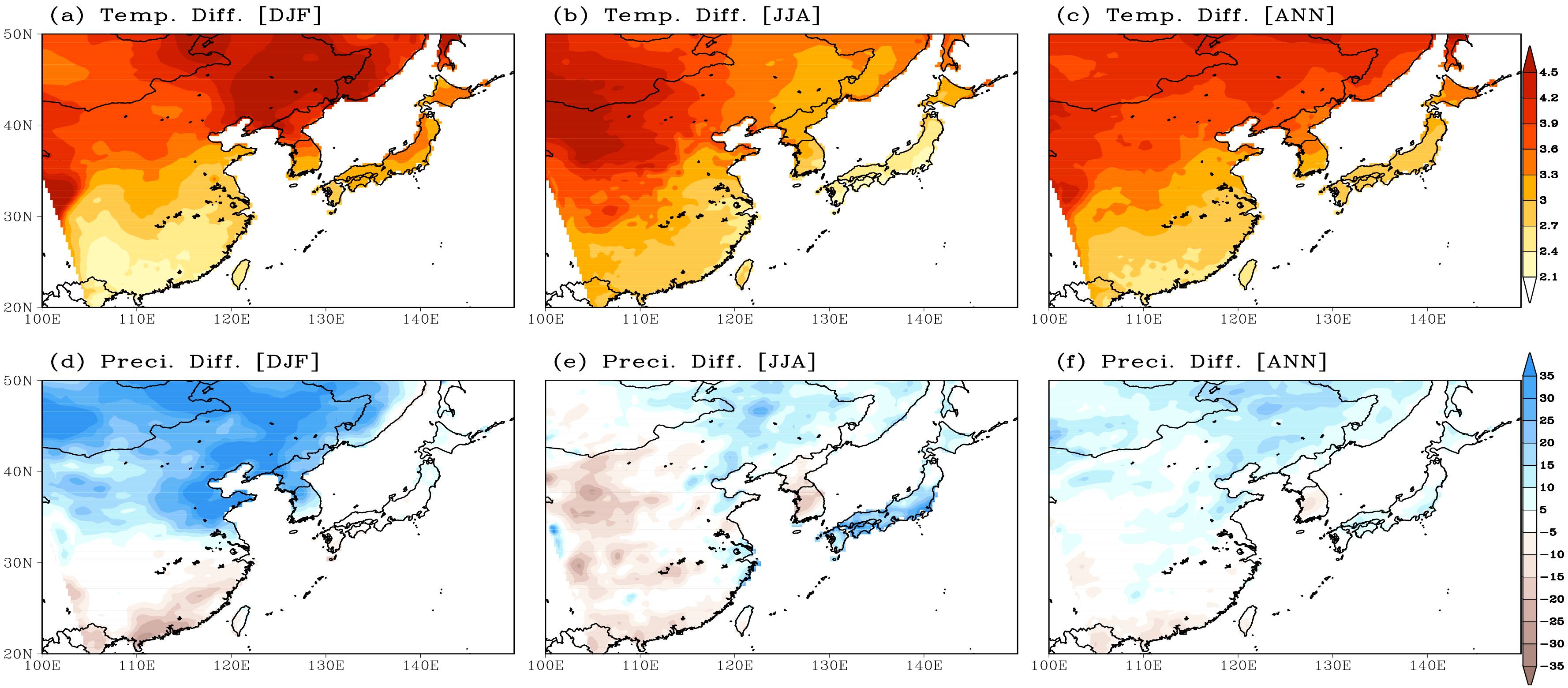


- **Increase of runoff in the first rainy season**

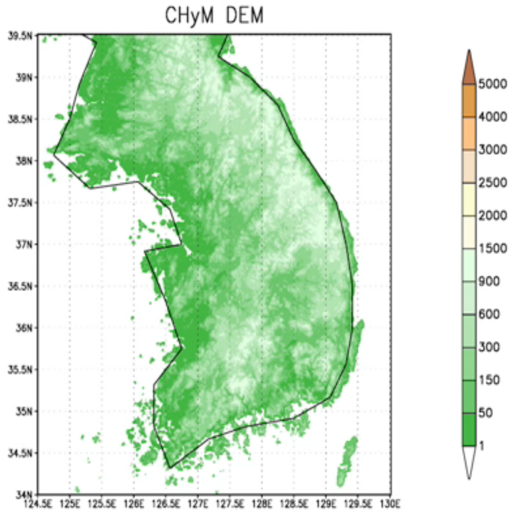
- **Decrease of runoff during in the second rainy season**

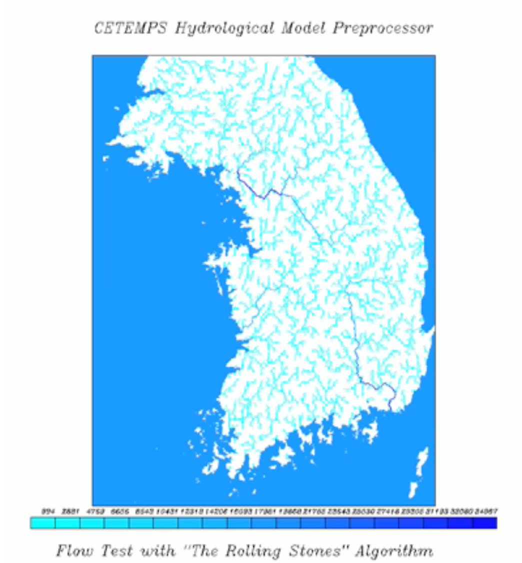
RegCM-ECHAM 20km A1B scenario 1950-2100

Korea



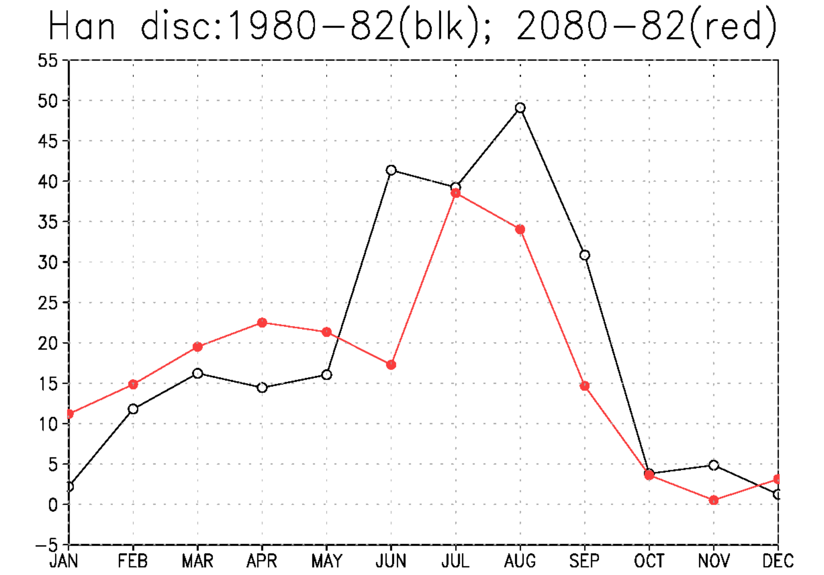
A1B scenario simulation



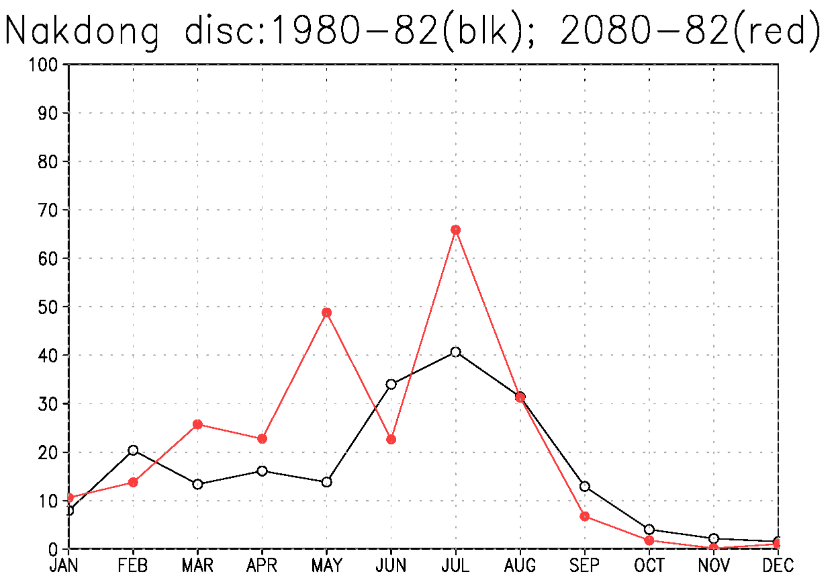


movie

Annual discharge cycle at the river mouth

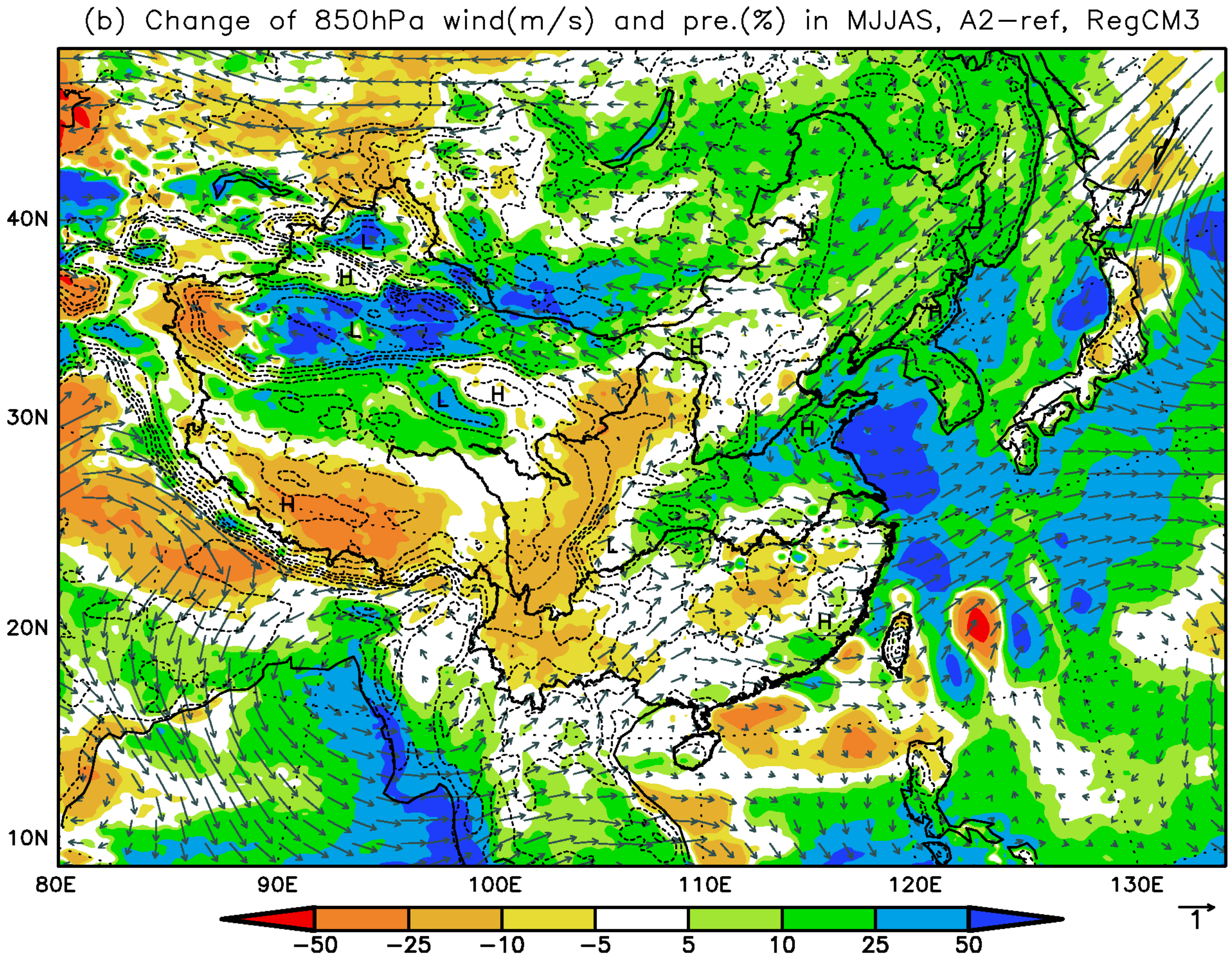


No big change is found neither in the annual mean discharge nor in the discharge timing

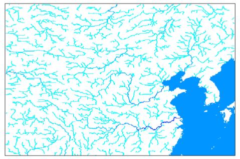


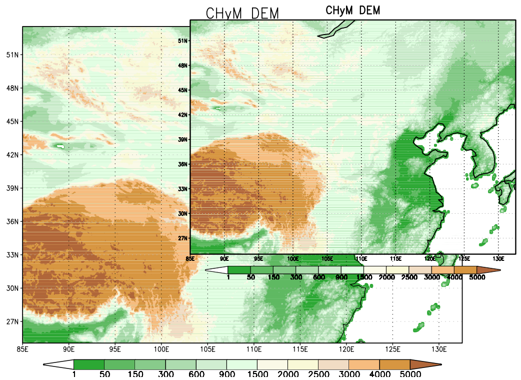
RegCM-fvGCM 20km A2 scenario 1950-2100

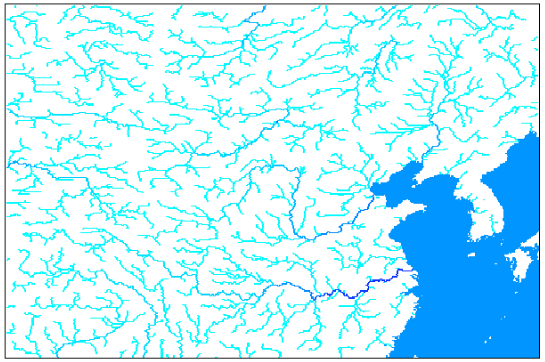
China

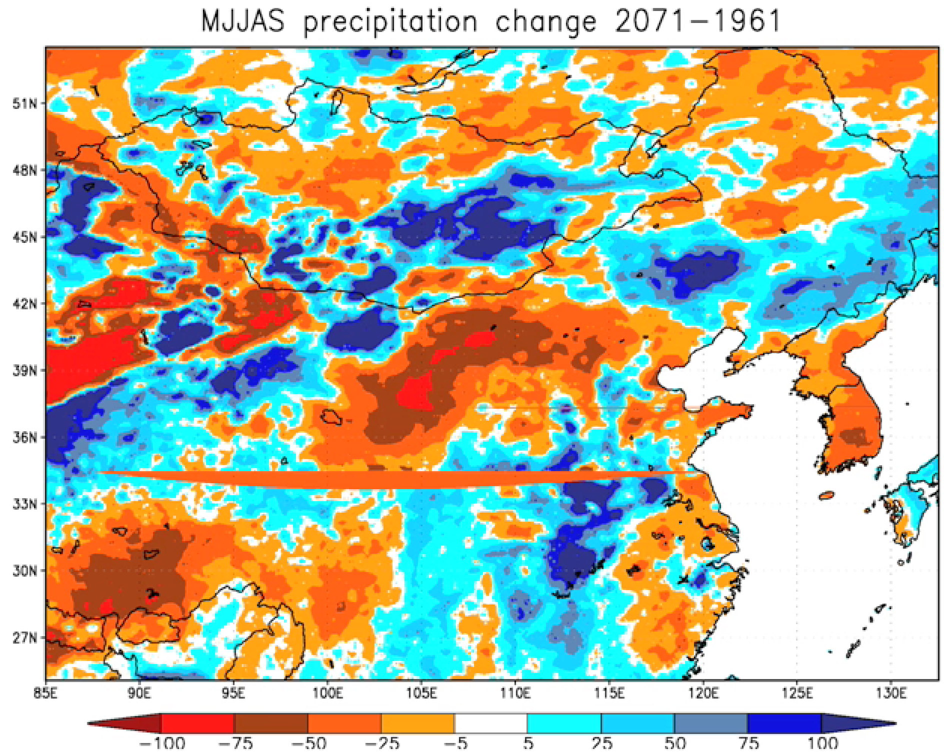


A2 scenario simulation









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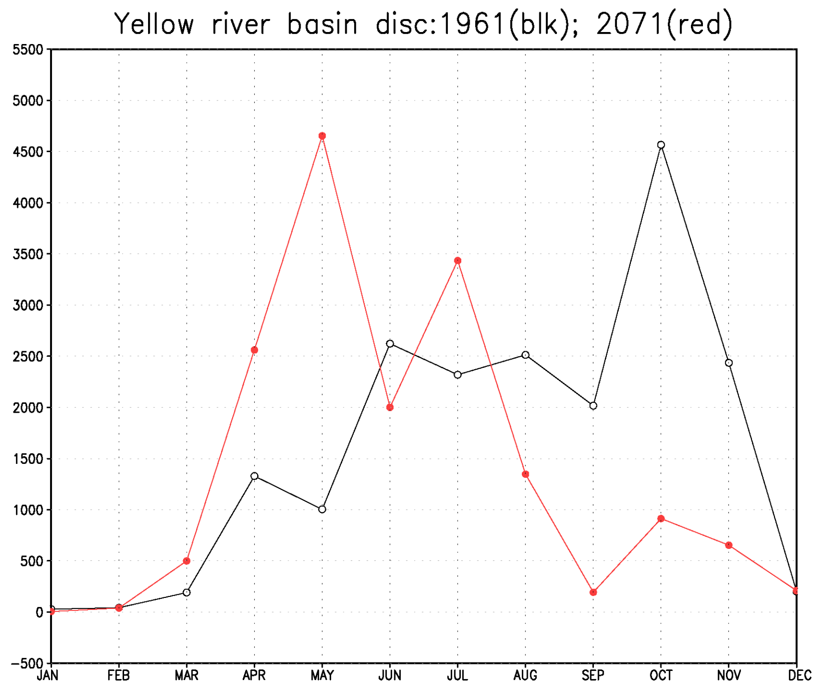
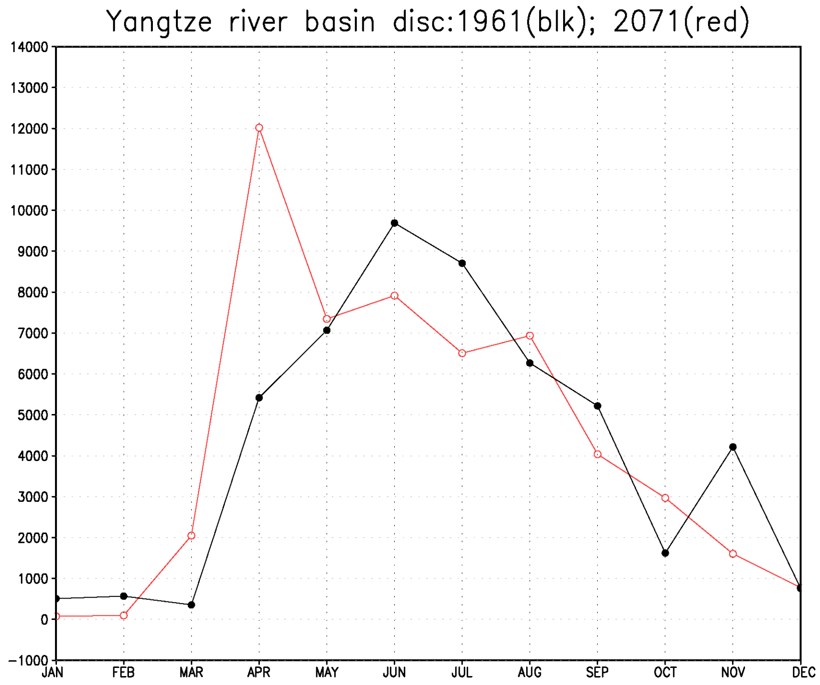
Annual discharge at the river mouth





Shift of the OCT-NOV peak toward the early part of the summer for the Yellow river and from summer to spring for the Yangtze river

Summary

Effects of climate change on precipitation are reflected in runoff changes in a highly non-linear way

Snow dominated climate change scenarios seem to show a shift in the peak discharge toward the early part of the year

Western African monsoon dominated areas seem to show an increase of runoff during the first rainy season

Runoff change in monsoon regions like Korea is weak

Thanks !