Third Workshop on Water Resources in Developing Countries: Planning and Management in Face of Hydroclimatological Extremes and Variability
Trieste, 2015

"CHyM around the world" Climate change impact on water resources for several river basins: a European, Asian and African case study

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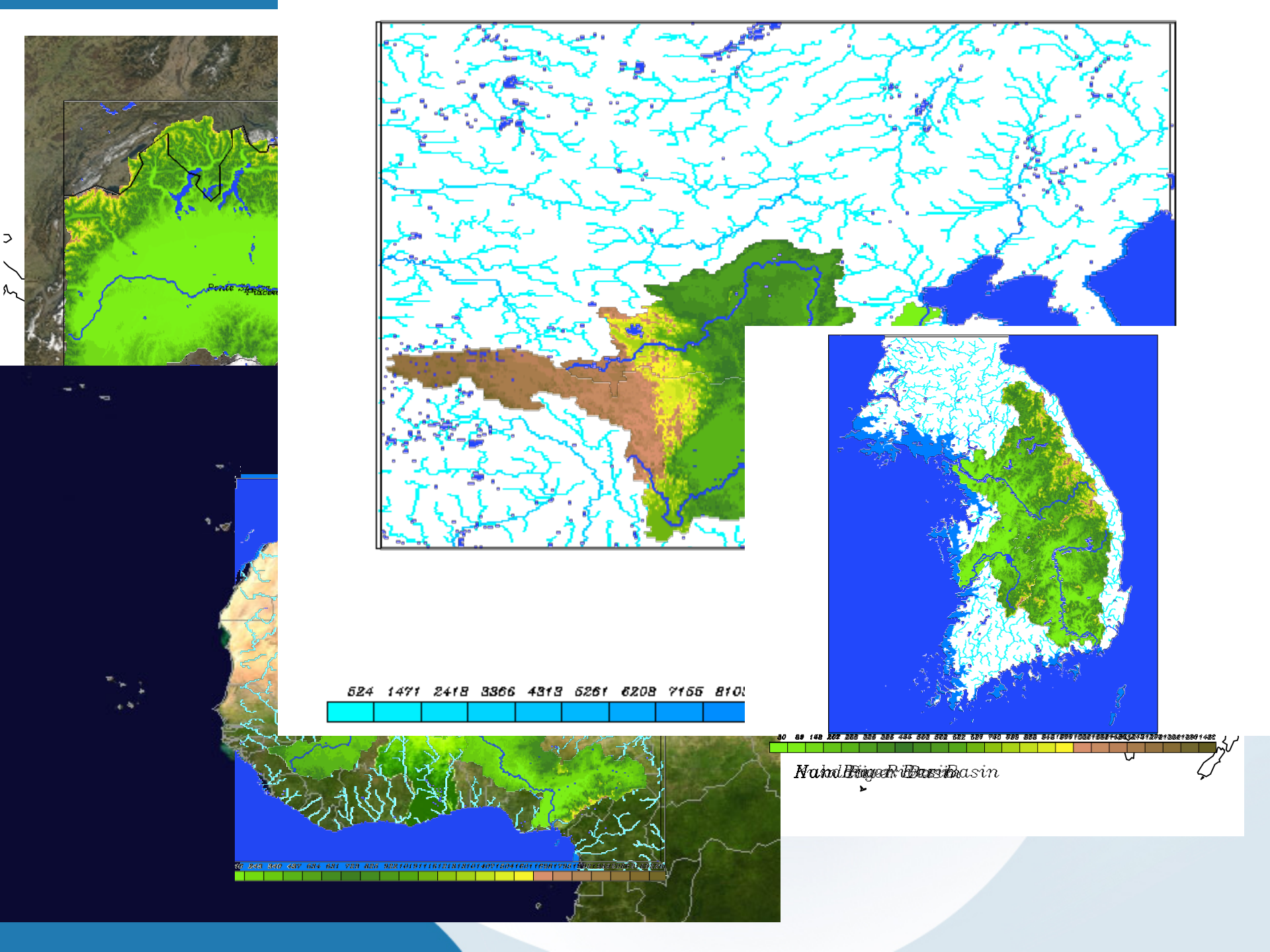
(mariotti@ictp.it)


524 1471 2418 3366 4313 5261 6208 7155

Case studies

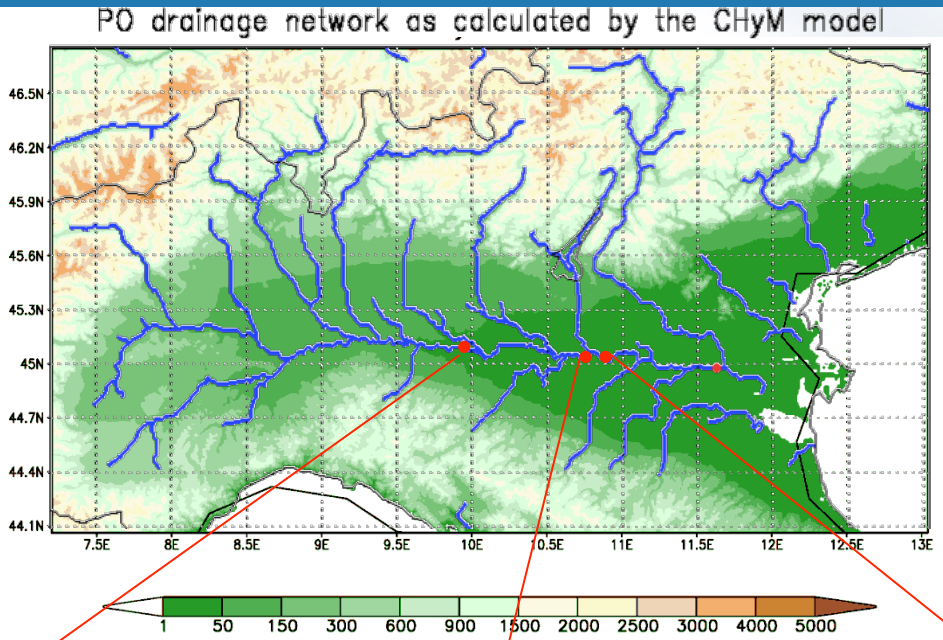
Po river (Italy) (1 km resolution; 110945.0 km^2 drained area)
5 years RegCM-ERA40 simulation 1995-2000
3 years RegCM-ECHAM5 A1B scenario simulation 1980/82 -2080/82

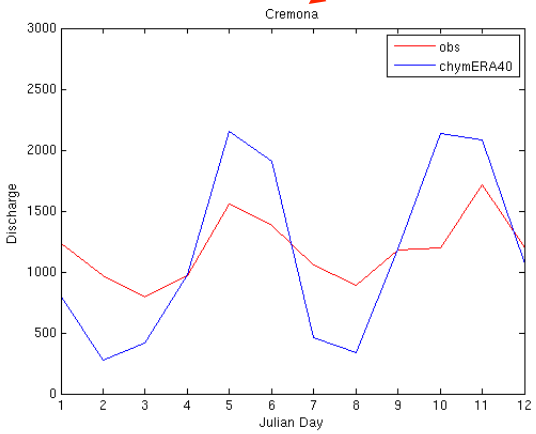
Han-Kum (Geum)-Nakdong rivers (Korea)(740 m; Han 19678 km^2, Nakdong 15848 km^2, Kum 6769 km^2 drained area)
3 years RegCM-ECHAM5 A1B scenario simulation 1980/82 -2080/82

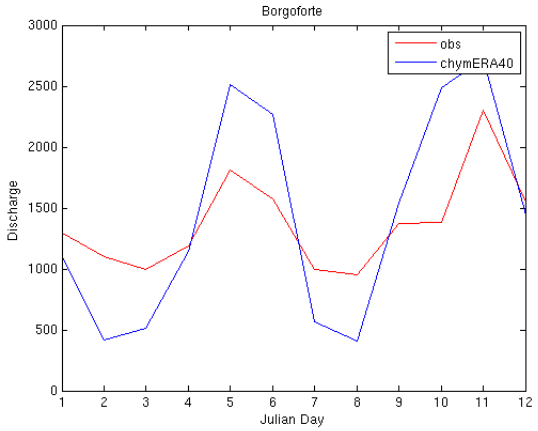
Yellow – Yangtze rivers (China)(5.7 km, Yellow river 360431km^2, Yangtze 564594 km^2)
1 years RegCM-fvGCM A2 scenario simulation 1961- 2071

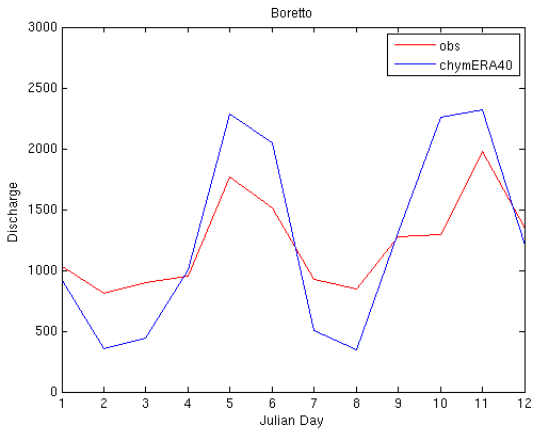
Niger - Volta rivers (West-Africa)
(7.7km, Niger 2494084 km^2 drained area; 5km, Volta 434235 km^2 drained area)
121 years RegCM-ECHAM5 A1B scenario simulation 1980 -2100

RegCM-ERA40



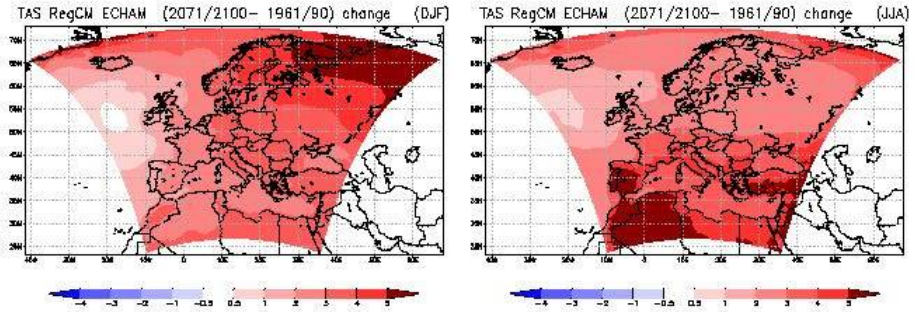




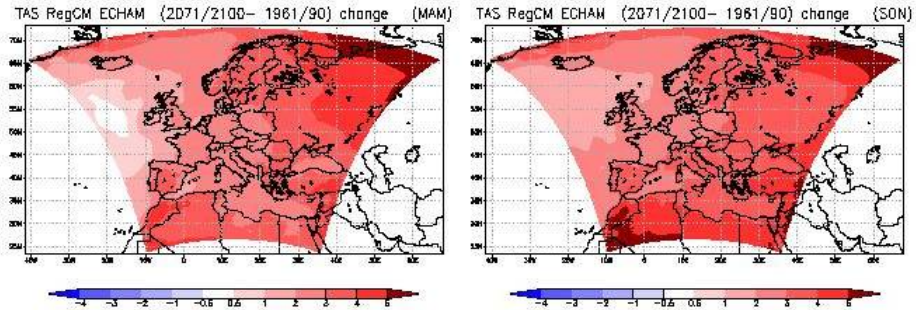


Avg. discharge 1540 m³/s

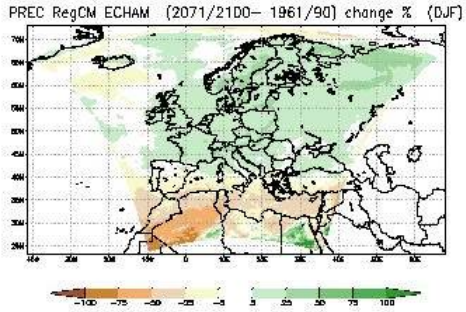
RegCM-ECHAM 25km A1B scenario 1950-2100

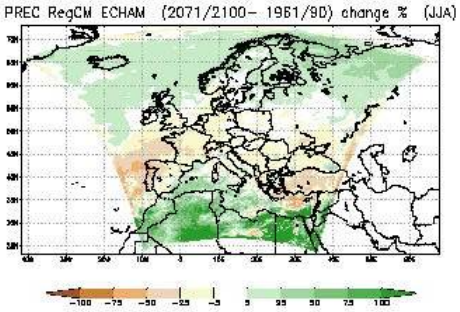


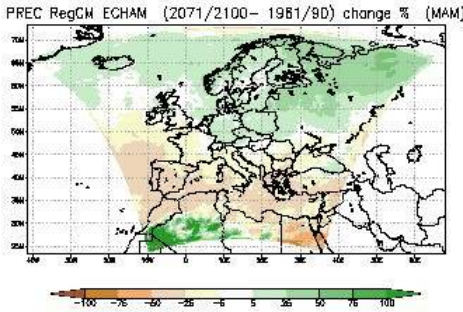
Temperature

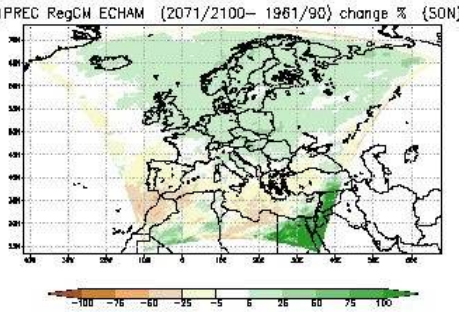


Precipitation



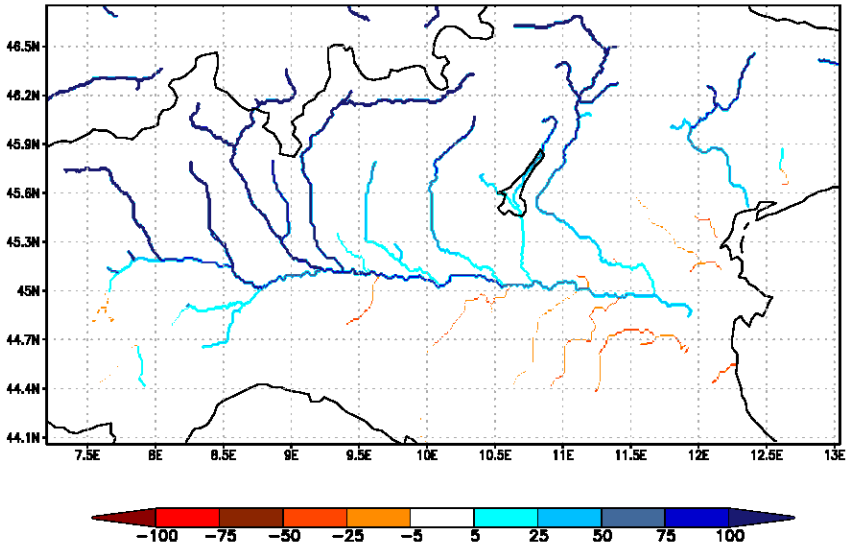




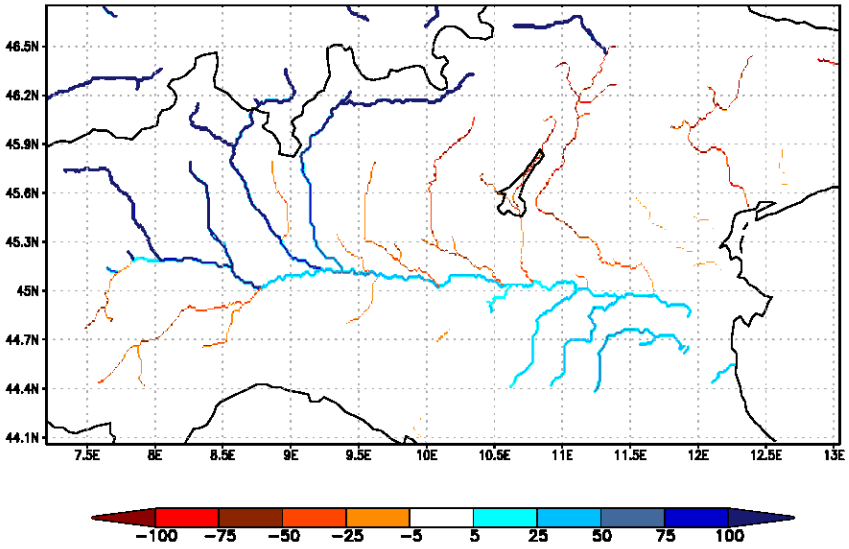


A1B scenario simulation

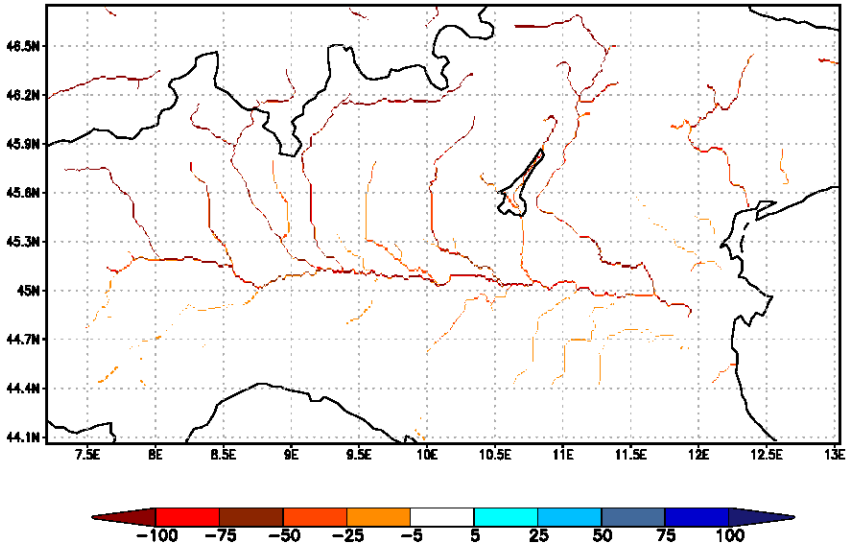
DJF runoff change (2080/2082)−(1980/1982)



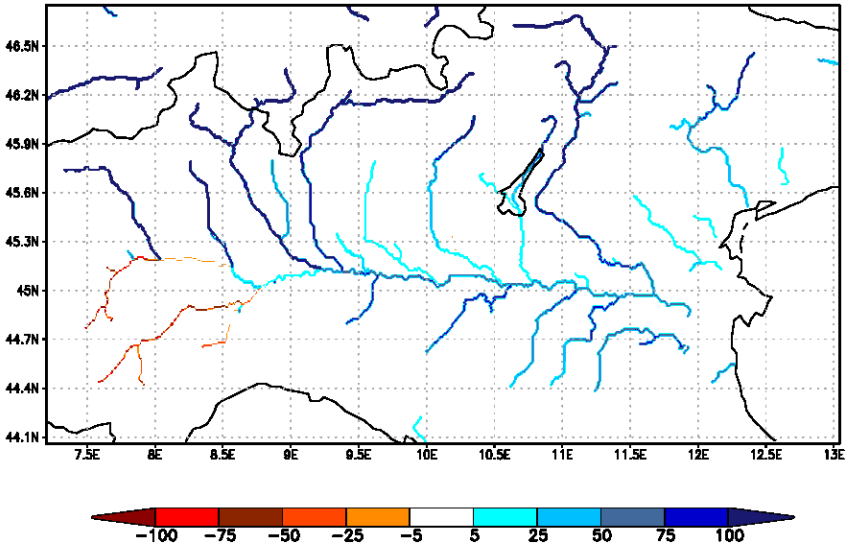
MAM runoff change (2080/2082)−(1980/1982)



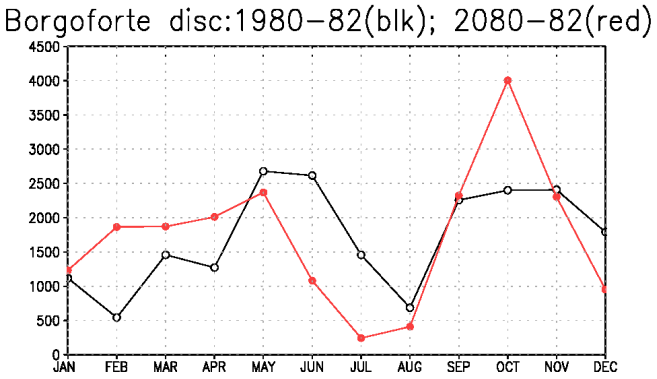
JJA runoff change (2080/2082)−(1980/1982)

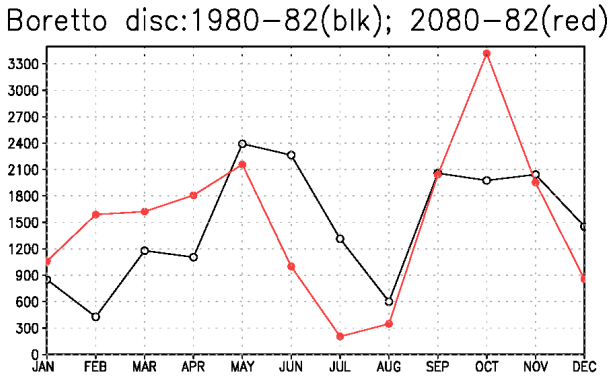


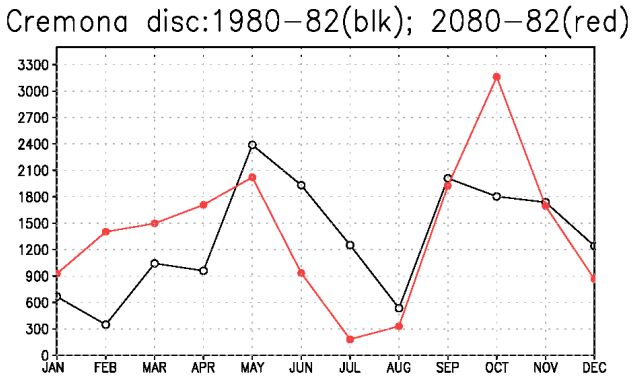
SON runoff change (2080/2082)−(1980/1982)



Station annual discharge cycle



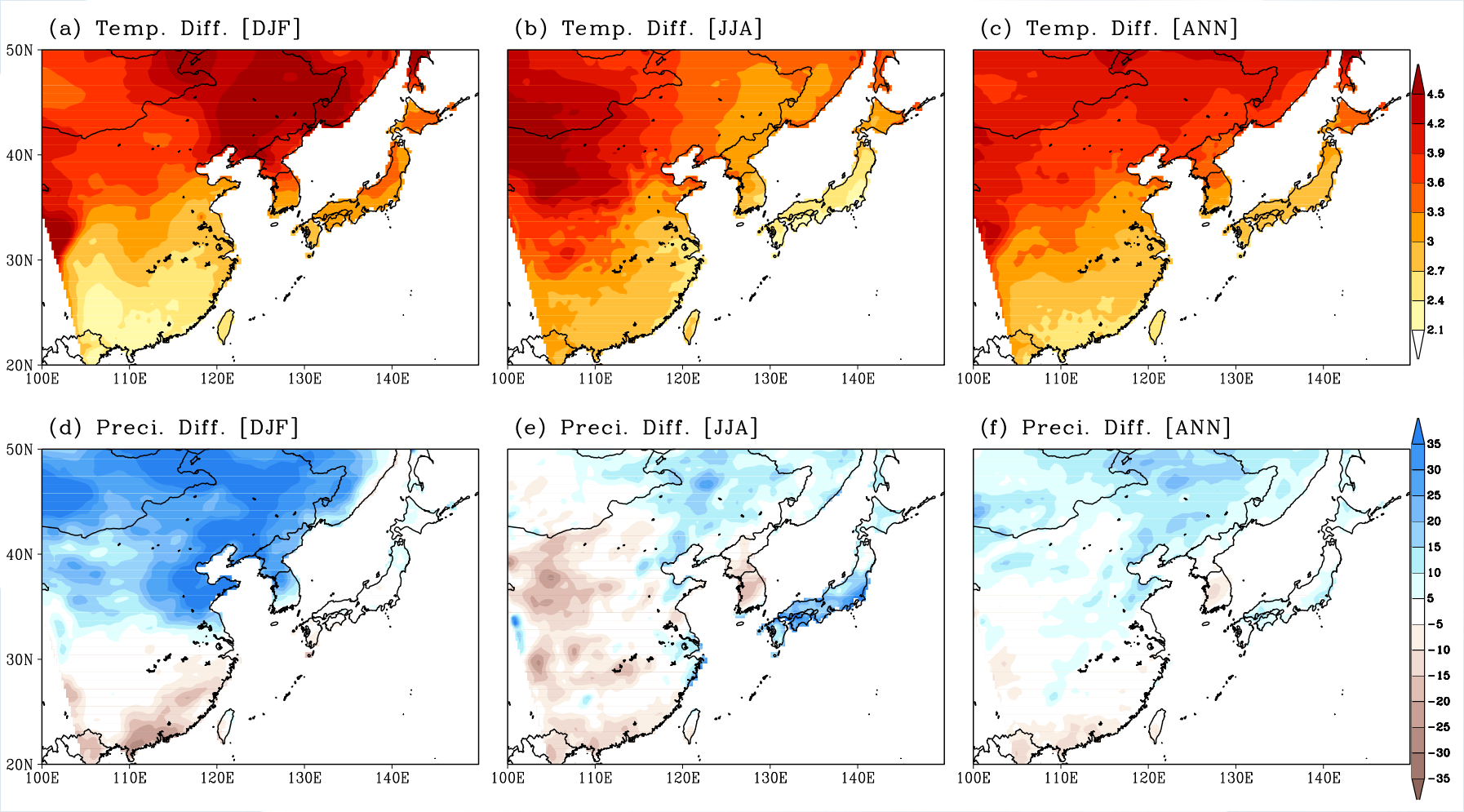




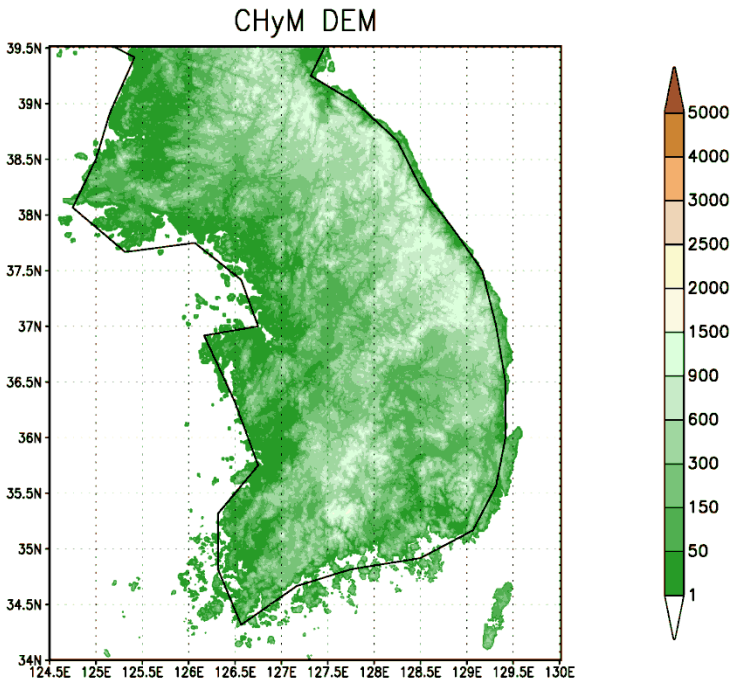
- **Shift of the spring peak toward the early part of the season**
- **Decrease of runoff during the summer months (Jul. and Aug.)**
- **Increase of the autumn runoff**

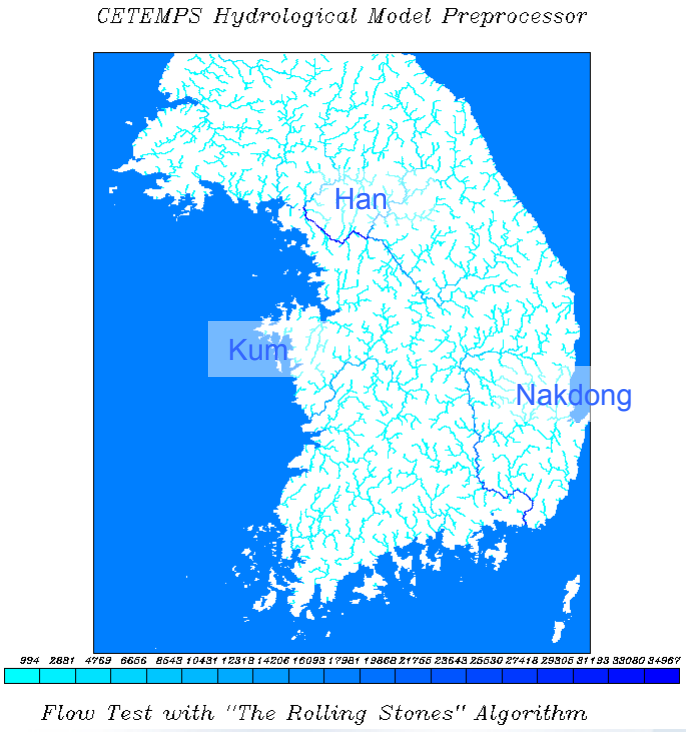
RegCM-ECHAM 20km A1B scenario 1950-2100

Korea

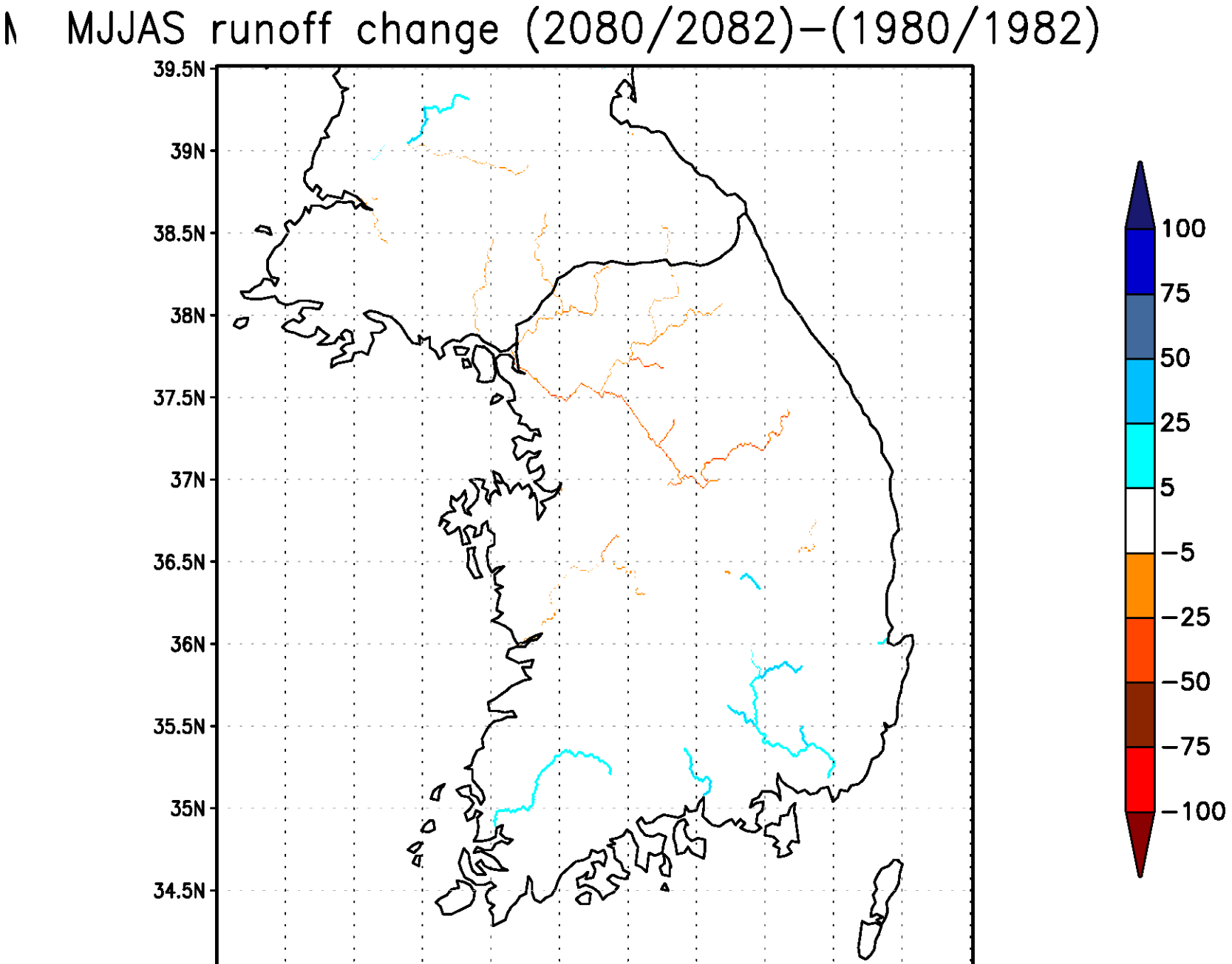


A1B scenario simulation

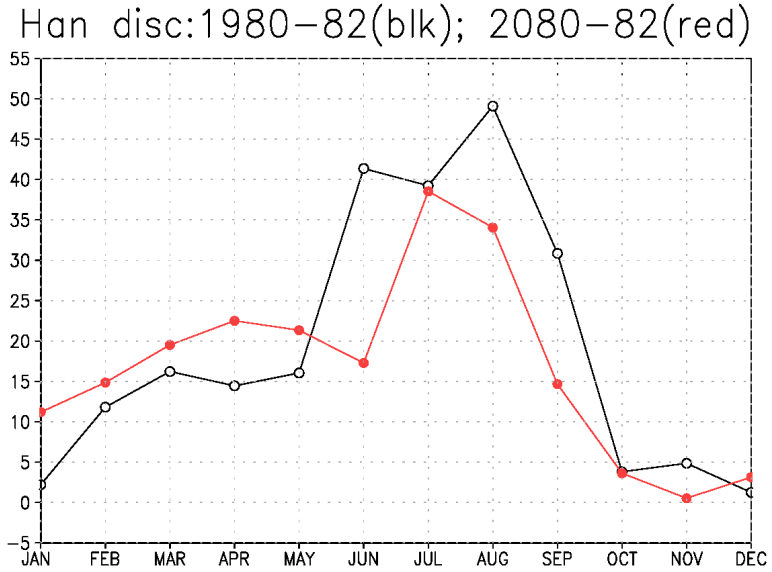


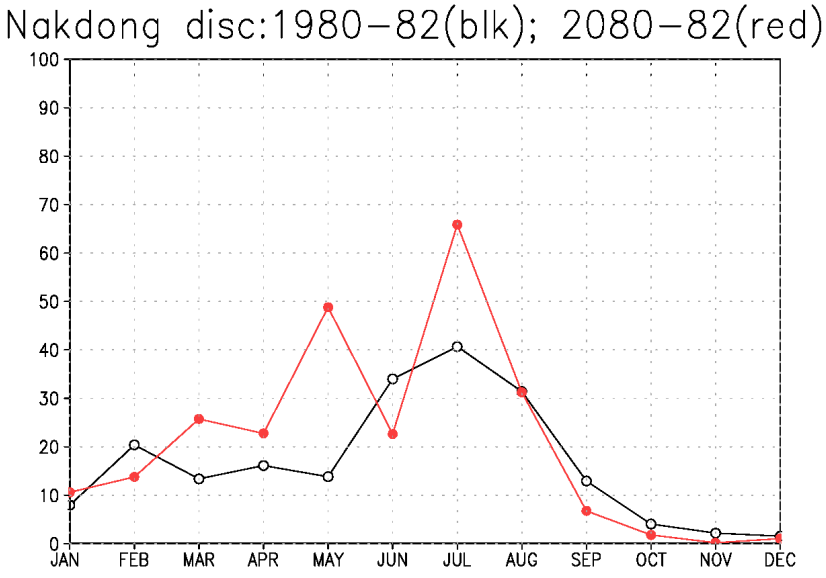


A1B scenario simulation



Annual discharge cycle at the river mouth

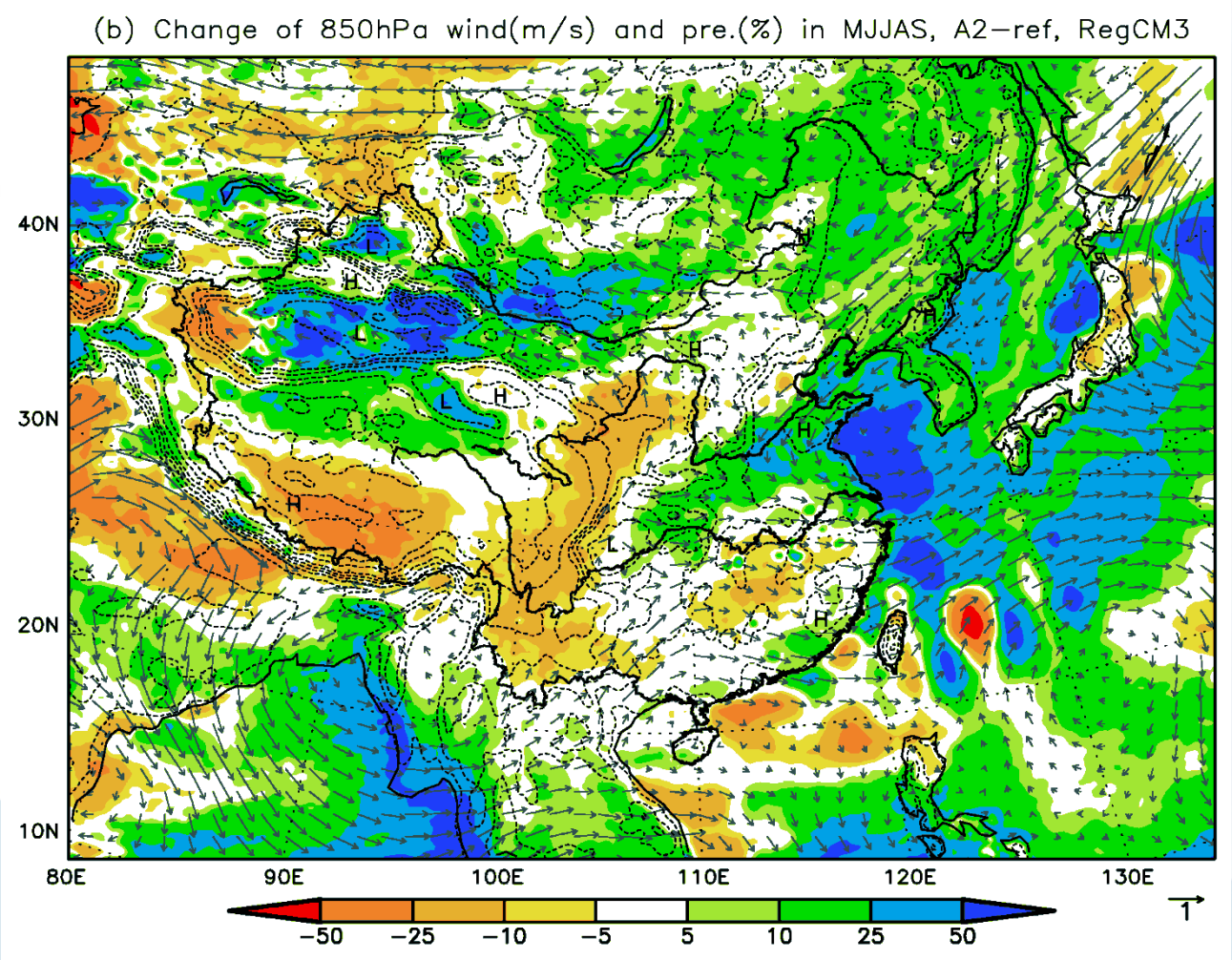




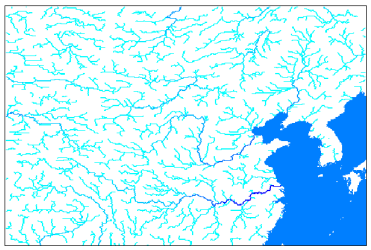
No big change is found neither in the annual mean discharge nor in the discharge timing

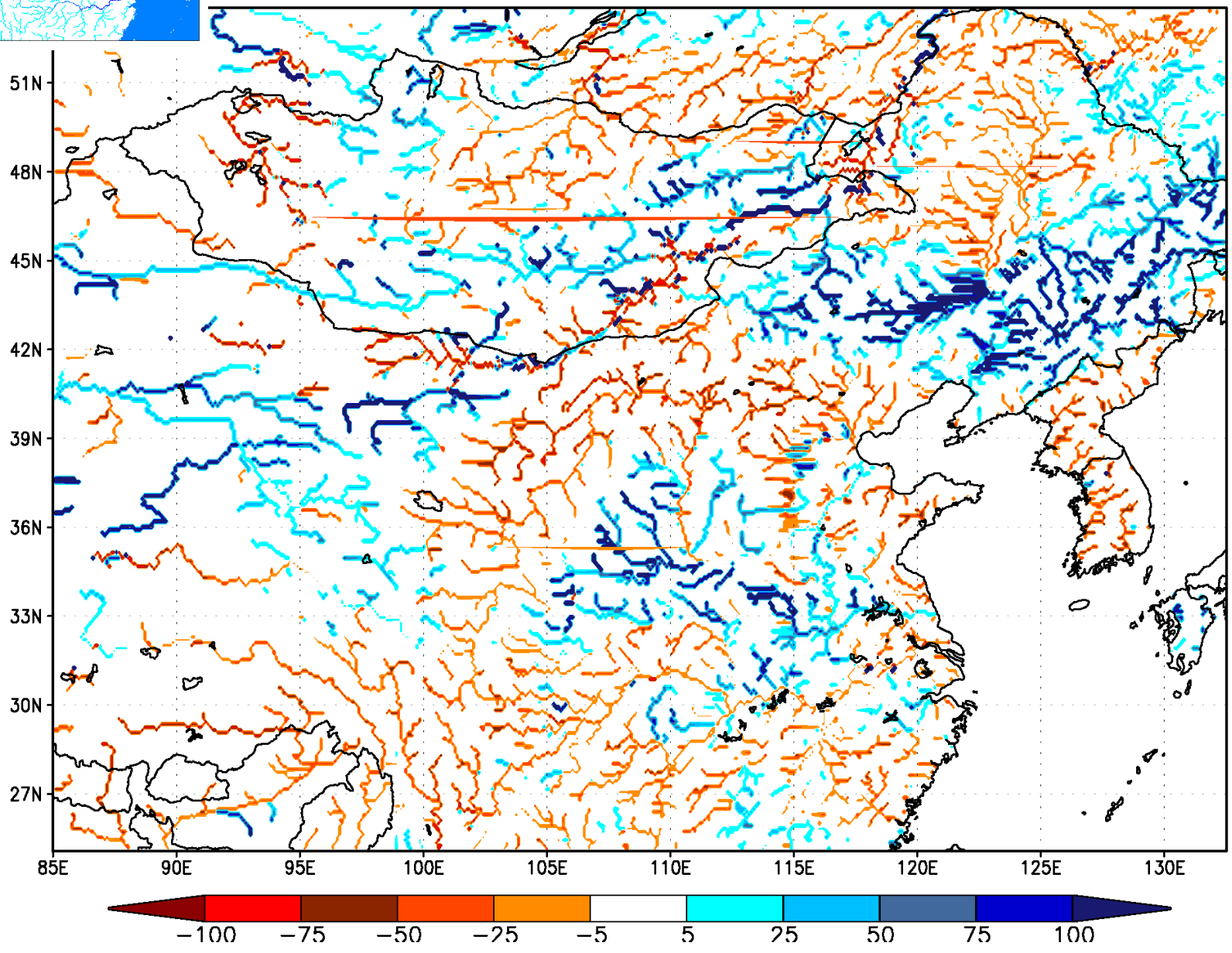
RegCM-fvGCM 20km A2 scenario 1950-2100

China

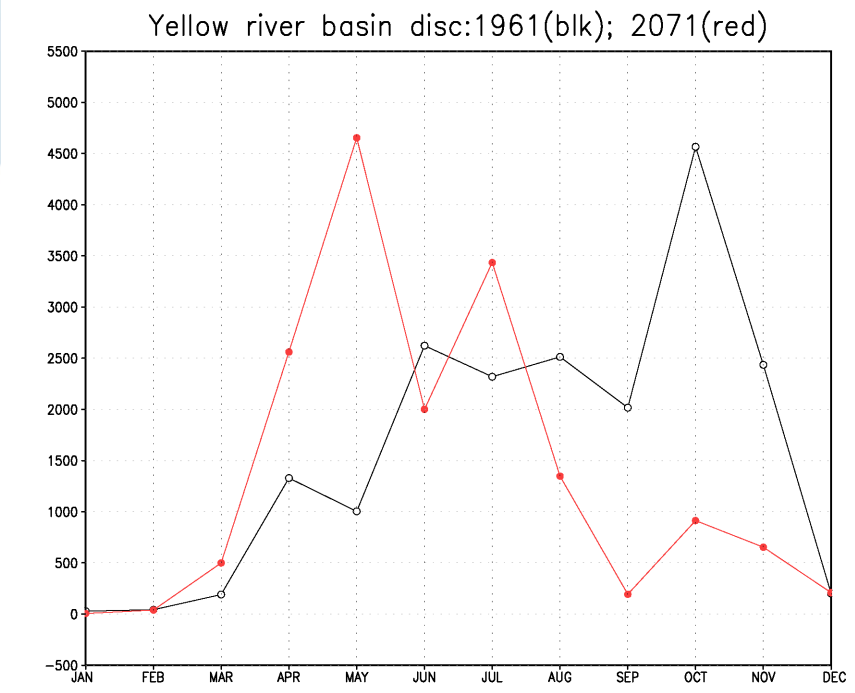


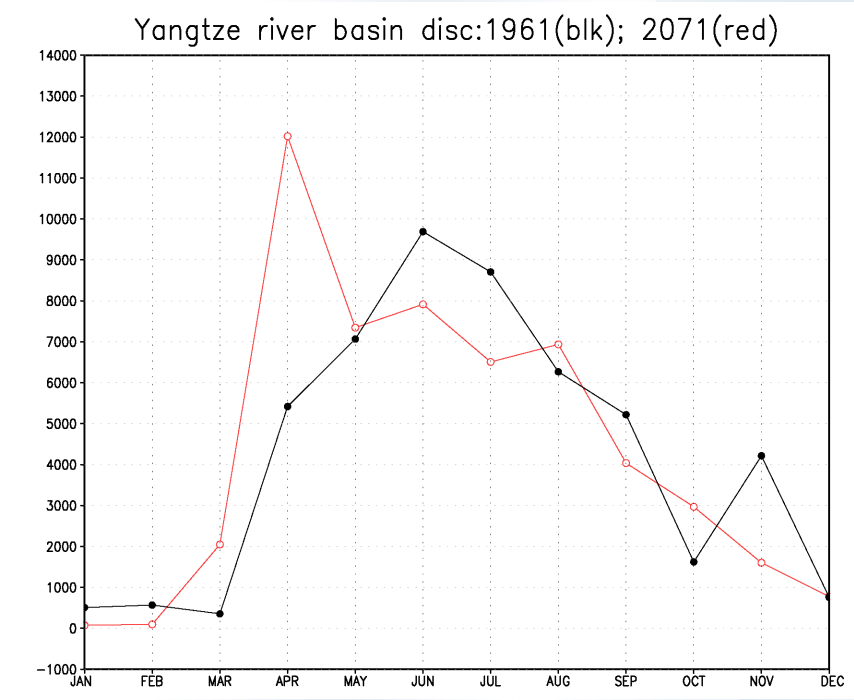
A2 scenario simulation





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

Runoff change in monsoon regions like Korea is weak

AFRICA- Experiment Description

Two simulations have been done using the Regional Climate Model RegCM3:

- *Control simulation using ERA-Interim as boundary conditions (1990-2007) [Sylla et al. 2009]*
- *Scenario simulations using ECHAM5-GCM A1B (1980-2100) [Mariotti et al 2011]*

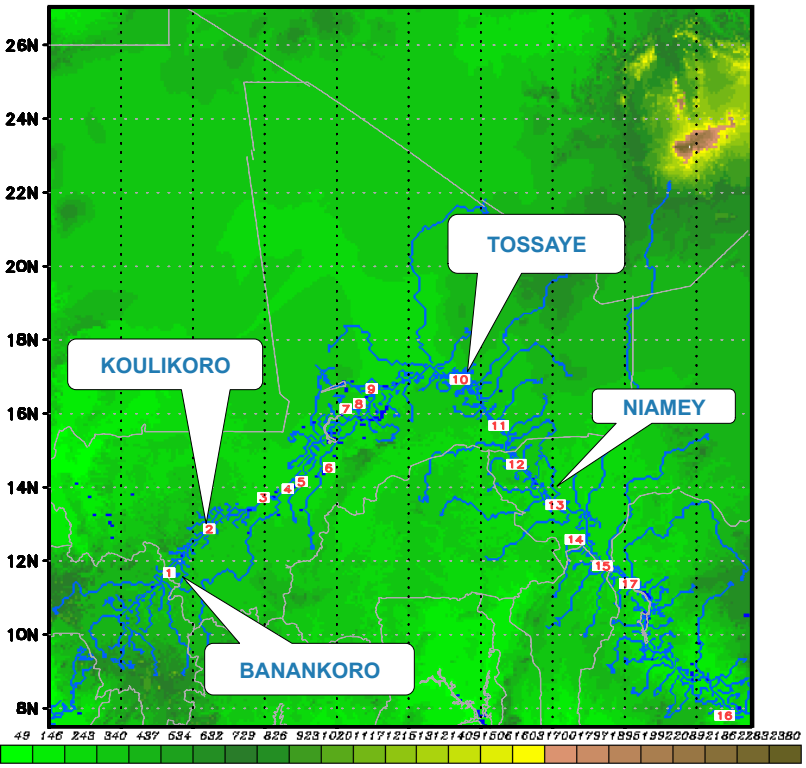
From these results, the Cetemps Hydrological Model **CHYM** [*Coppola et al. 2007*] has been coupled with the regional climate model to study two basins in West Africa:

Niger and Volta

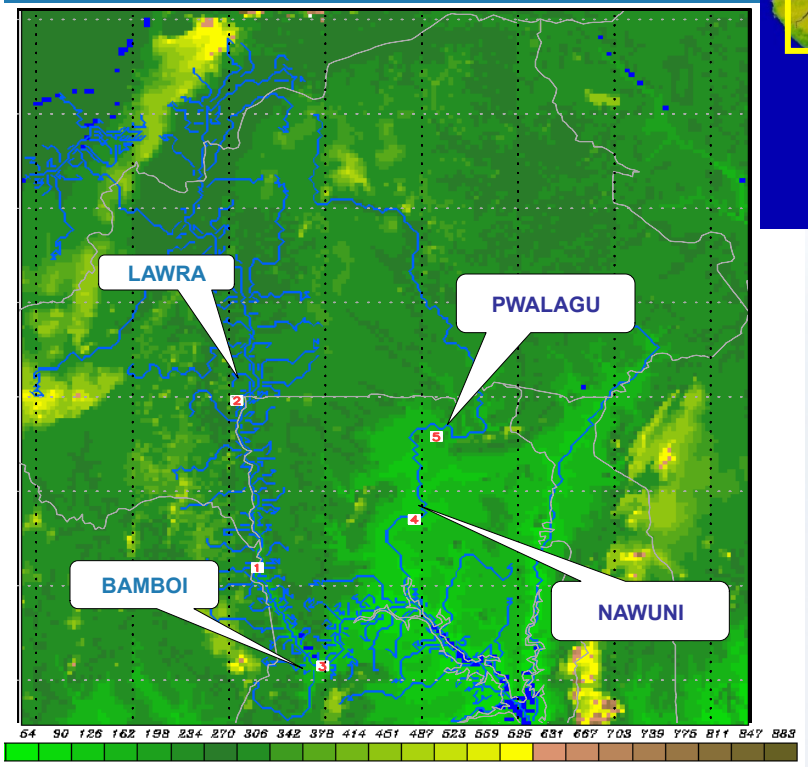
Two different kind of simulations are done for each basin separately:

- *Calibration hydrological run using the regional model perfect boudary output as input (1990-2005)*
- *Transient hydrological scenario simulations using as input the regional climate model output from the A1B transiet simulation (1980-2100)*

Niger River



Volta River



Niger:

- Length 4180 km , it s the third-longest river in Africa, after the Nile and the Congo/Zaire Rivers, and the longest and largest river in West Africa.
- The catchment area covers 7.5% of the continent and spread over 10 countries.
- **The water is partially regulated through dams mainly used for hydropower and for irrigation.**

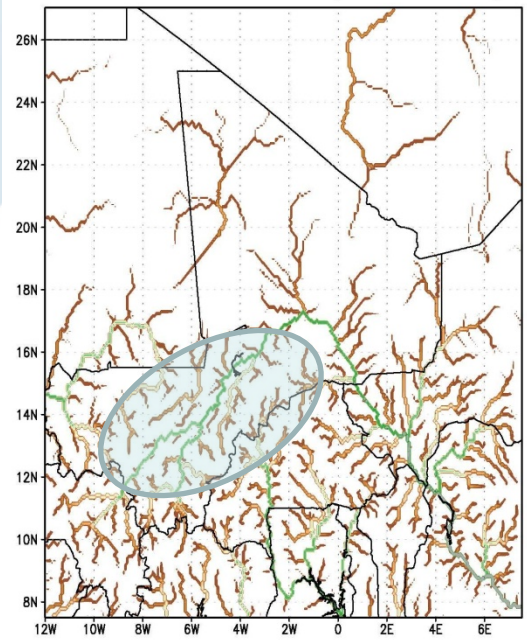
Volta:

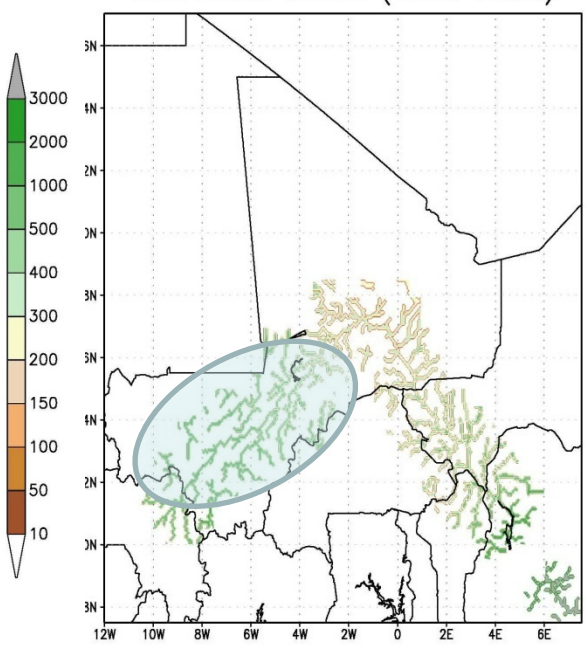
- Length 1600 km
- **The catchment area stretches over approximately 400 000 km^2, making it the ninth most important river basin in Sub-Saharan Africa.**
- **Situated in a very arid region, this is one of the poorest regions of the world.**
- **There is extensive use of the water resources for electricity generation and irrigation.**
- The Akosombo dam in Ghana generates 80% of the power produced in the country.

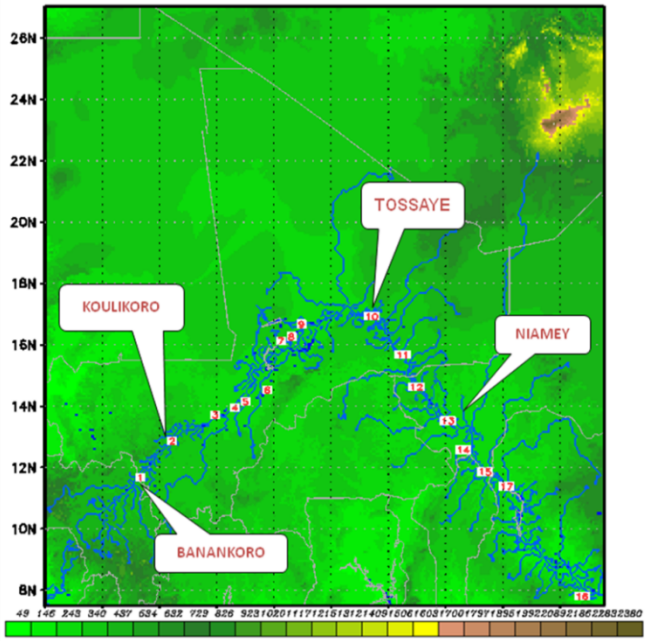
1 > Calibration Runs

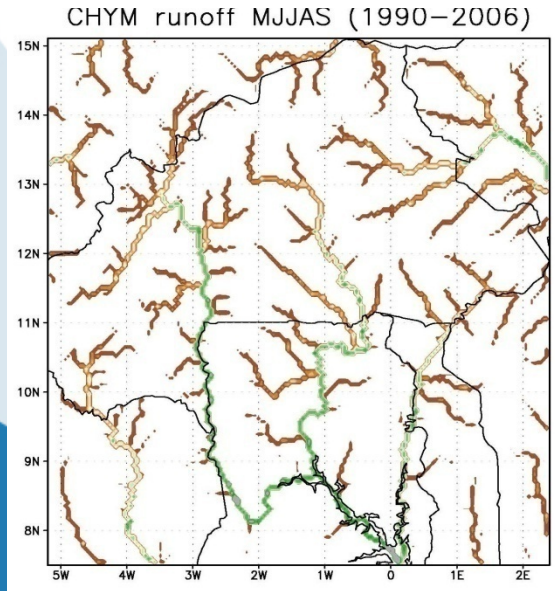
2 > Transient Scenario Simulations

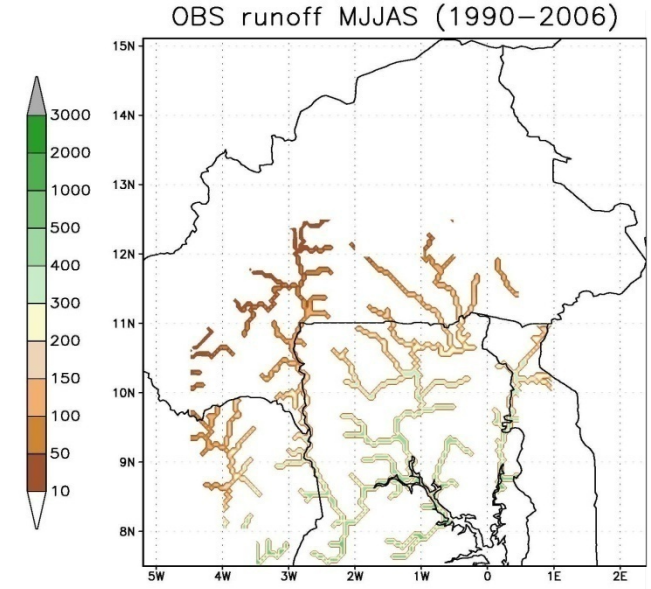
Seasonal Runoff for MJJAS

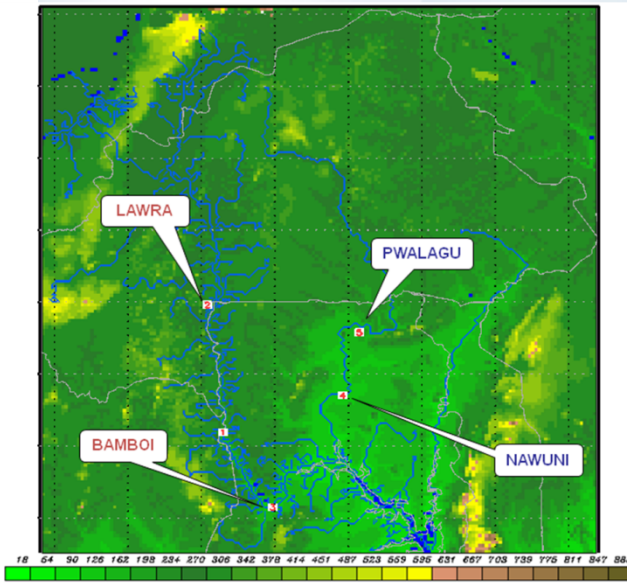








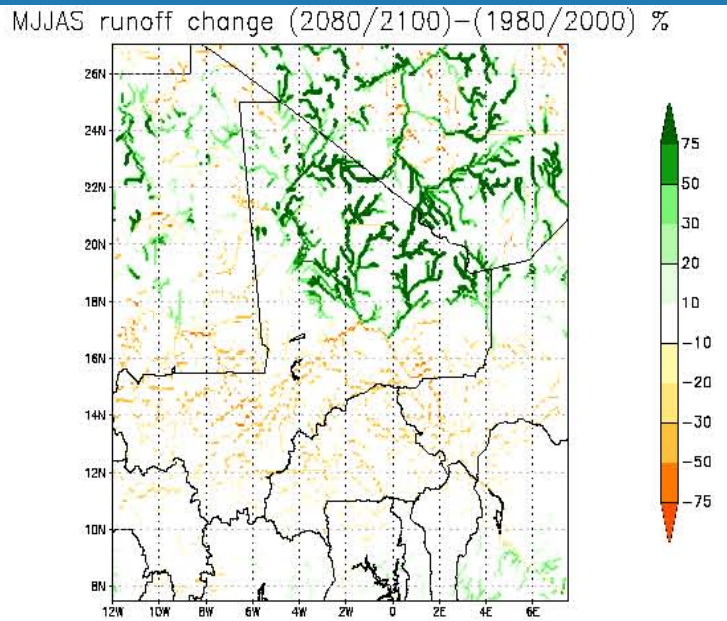


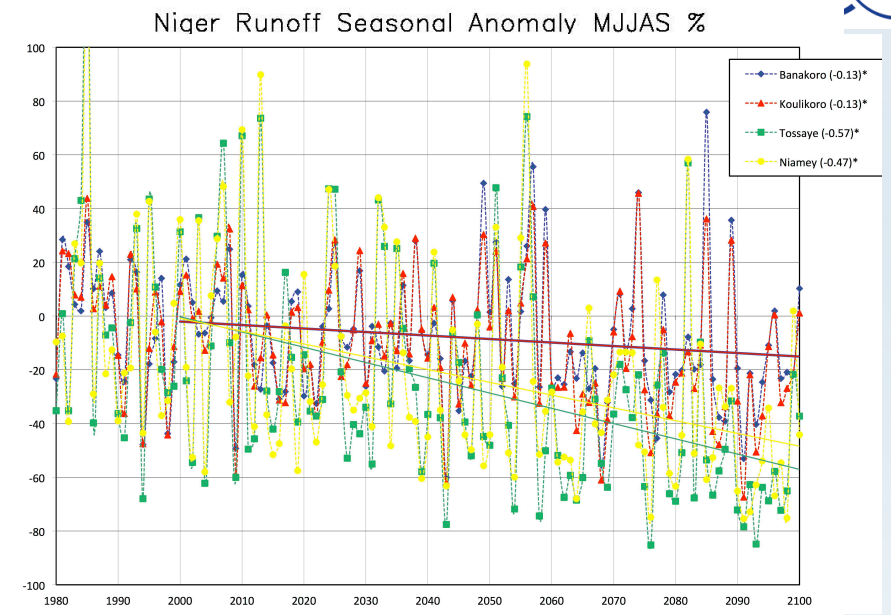


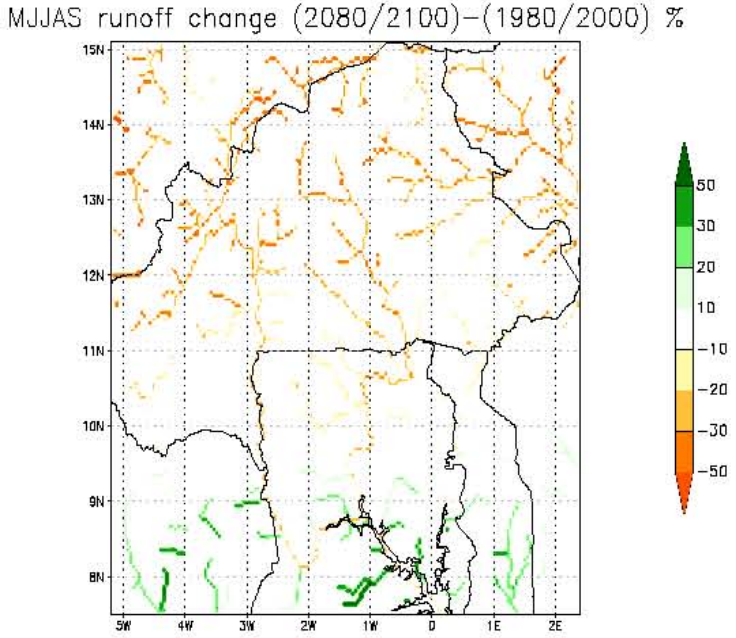
1 > Calibration run

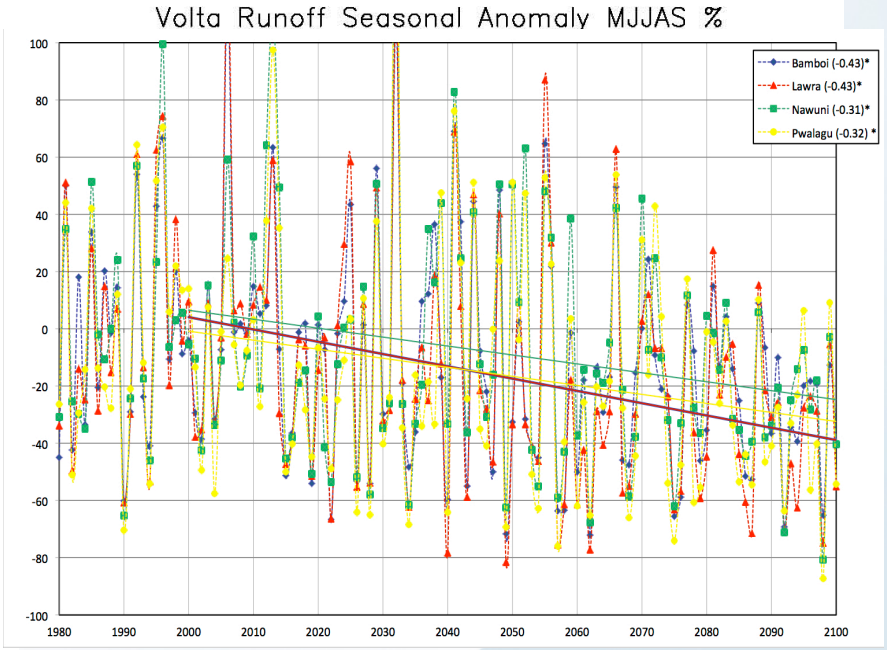
2 > Scenario climate change simulation

Runoff Seasonal Change

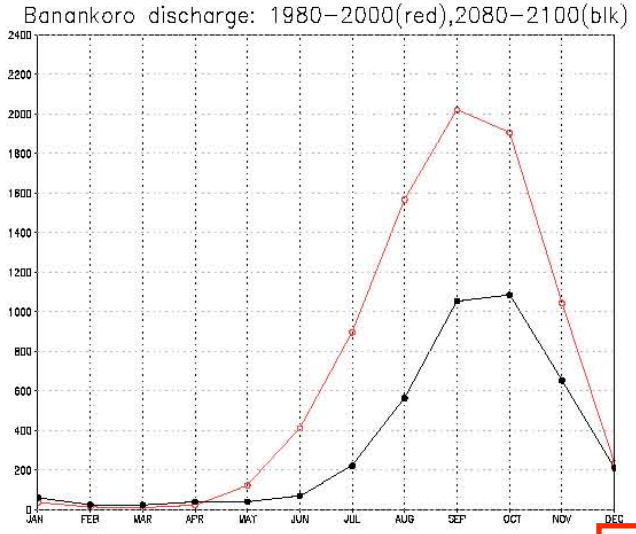




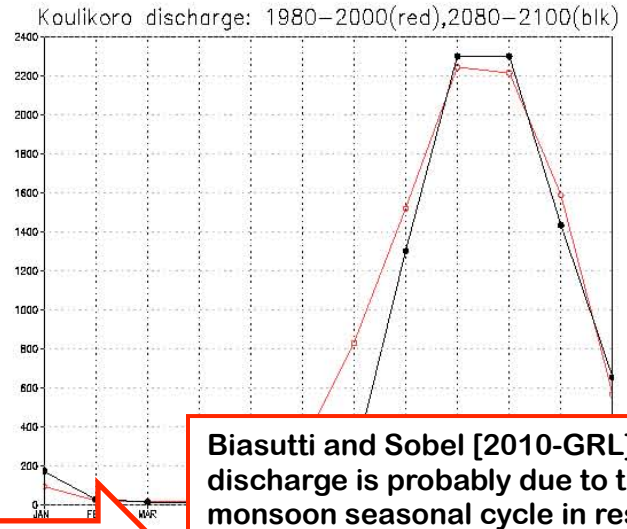




Niger – Mean Annual Cycle

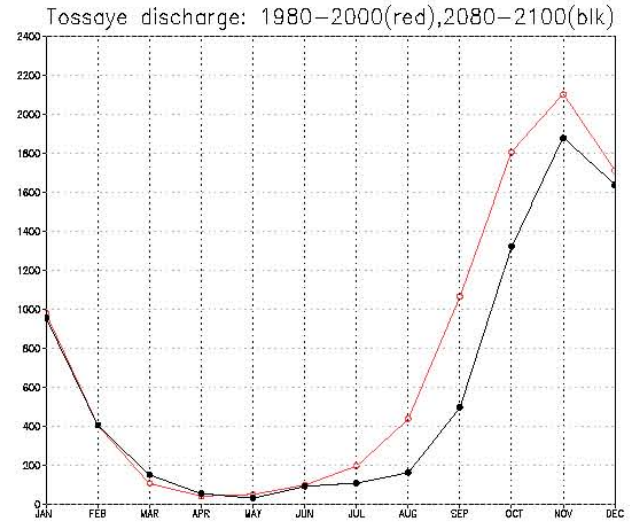


(a)



SHIFT

Biasutti and Sobel [2010-GRL] The shift of the discharge is probably due to the shift of the monsoon seasonal cycle in response to increasing greenhouses gases.
In particular, the rainy season of the semi-arid African Sahel is projected to start later and become shorter.



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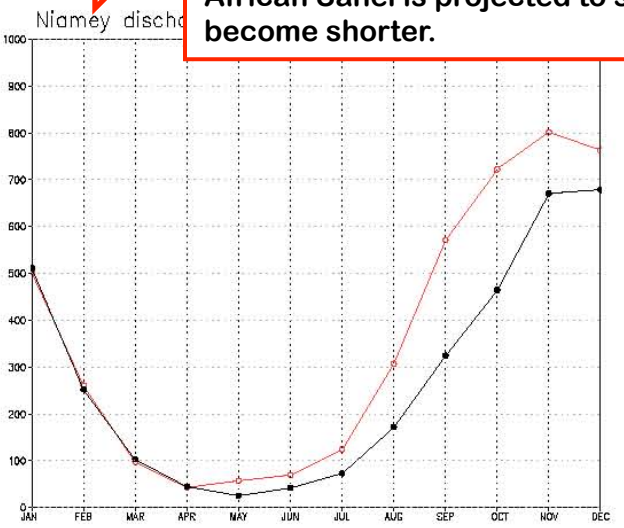
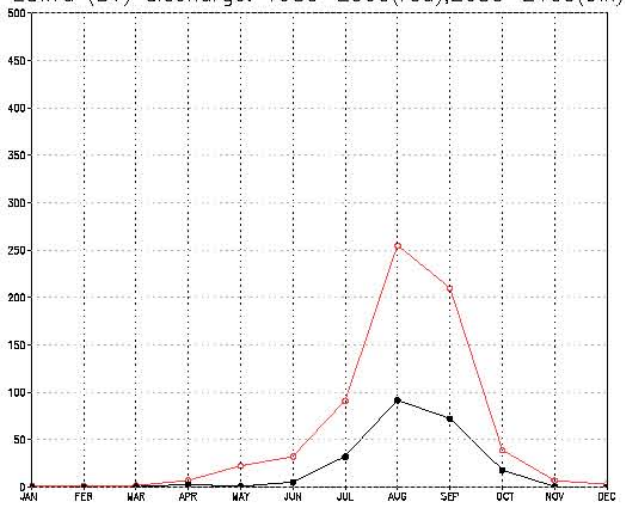


(d)

Volta – Mean Annual Cycle



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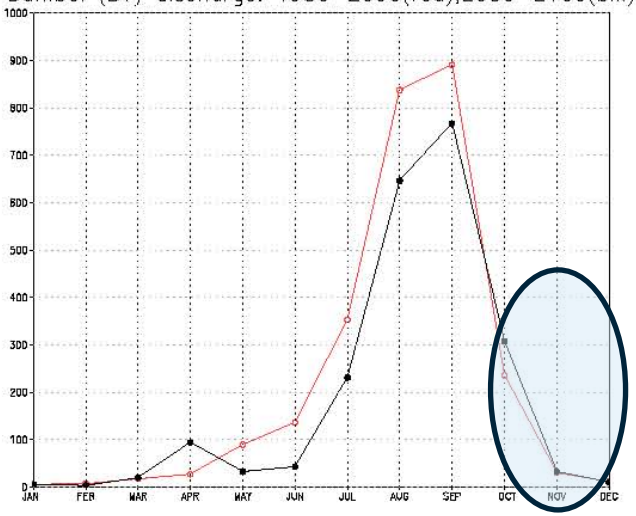

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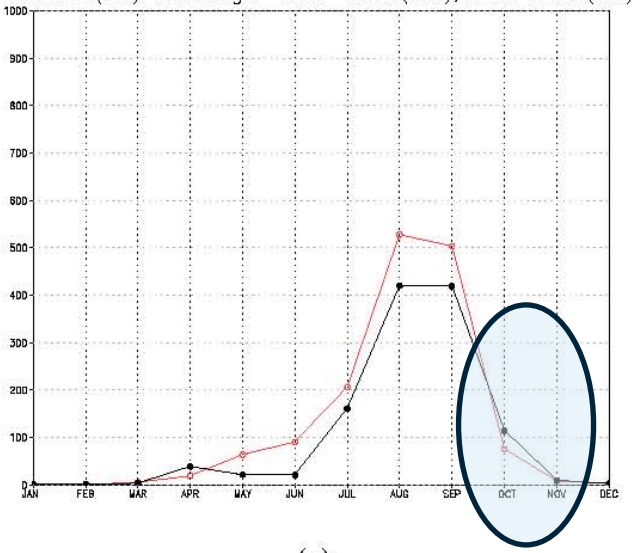
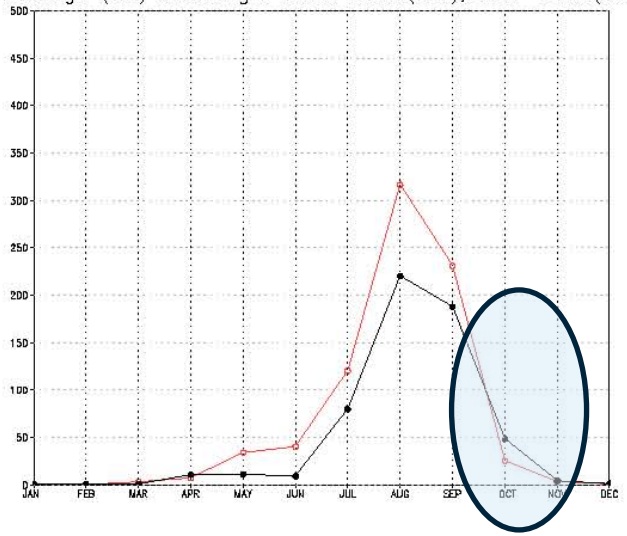


(c)



(d)

Conclusions

CHyM model has been validated in a coupled simulation with a perfect boundary regional model simulation using ERA-interim as boundary conditions (BC).

- The monthly distribution of the discharge value is well represented. For the two basins the overestimation/underestimation tendency is not univocal but rather station dependent.

The transient hydrological scenario simulation for the two basin is done using as input the regional climate model output from the A1B transient simulation.

- The Runoff change for the MJJAS season shows a decrease in discharge up to 40% for the Volta river and up to 60% for the Niger river.
- For all stations is possible to see a decrease of the peak flow for the future scenario and a slightly change in the timing of the annual cycle with a shift towards the end of the rainy season.
- The shift of the discharge is probably due to the shift of the monsoon seasonal cycle in response to increasing greenhouses gases. [Biasutti and Sobel 2010]

Thank you
for your attention