Assessment of the impact of climate change on the global water cycle using multiple climate and hydrological models

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1. Introduction

21st century climate change is likely to have an intensified influence on the hydrological cycle and thus has the potential to impose additional water stress in some region. Here, the study focuses on the assessment of the implication of climate change for global hydrological regimes and related water resources states for the 21st century. Because different climate and hydrological models show quite different projected change with a large uncertainty for the future climate and water fluxes, multiple climate and hydrological models were used within the European project "Water and Global Change" (WATCH). Climate projections from three coupled atmosphere-ocean general circulation models (GCMs) (see Table 1) with A2 and B1 emission scenarios were used to assess the hydrological response to climate change to predict the future state of global and large scale water resources. Due to the systematic model errors of climate models, their output has been corrected by statistical bias correction method and then the corrected output was used directly as input for global hydrological models (GHMs) (see Table 2) to calculate the corresponding changes in hydrological fluxes (especially runoff, evapotranspiration and moisture storage). The hydrological cycle was evaluated and multiple-model based projections were produced for control period(1971-2000) and future decades(2071-2100). The analyses concentrate on the changes in the hydrological characteristics for twelve large, continental river basins (Fig. 1) without taking into account anthropogenic influences in the hydrological simulations.

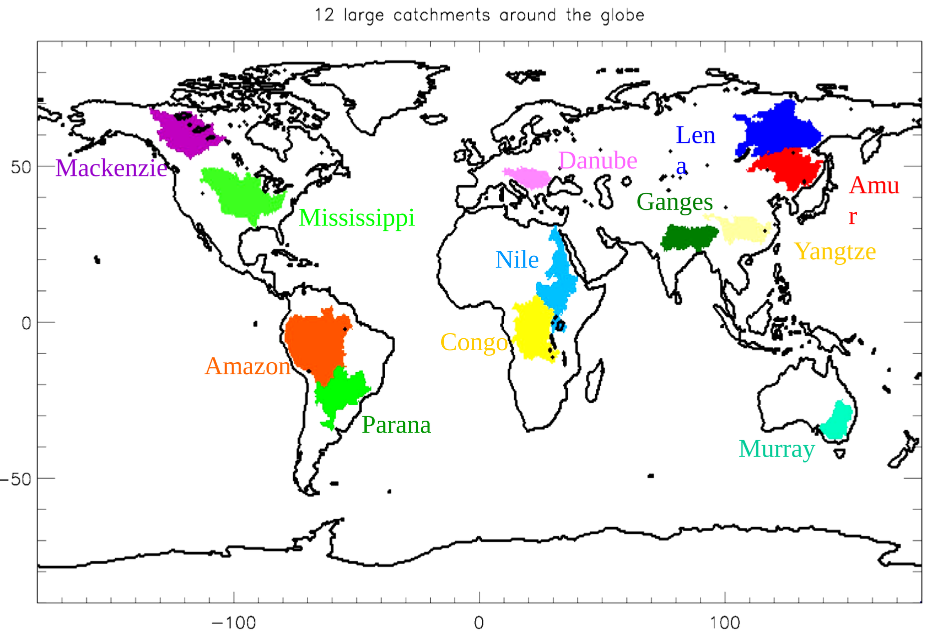

Figure 1: 12 large catchments around the globe

Table 1 and 2: Participated Global Circulation Models and Global Hydrological Models

Centre	GCMs	Ensemble members Horizontal resolution	Vert.
MPI-M	ECHAM5/MPIOM	C20, B1, A2	L31
CNRM	CNRM-CM3	C20 , B1, A2	L45
IPSL	LMDZ-4	C20, B1, A2	L19

GHMs	Model group
MPI-HM	Max-Planck Institute for meteorology, Hamburg, Germany
LPJmL	Potsdam Institute for Climate Impact Research, Germany
WaterGAP	University of Kassel, Germany
VIC	Norwegian Water Resources and Energe Directorate, Norway
MacPDM	University of Reading, UK
H08	University of Tokyo, Japan
Gwava	Centre for Ecology and Hydrology, UK
HTESSEL	University of Lissabon, Portugal
JULES	Met Office Hadley Centre, UK

2. Assessment of the results

Figure 2 and 3 show the model ensemble mean and standard deviation of precipitation, evapotranspiration and total runoff over global area for the control period and future decades. Here all GHMs were forced by ECHAM5 output with A2 emission scenario.

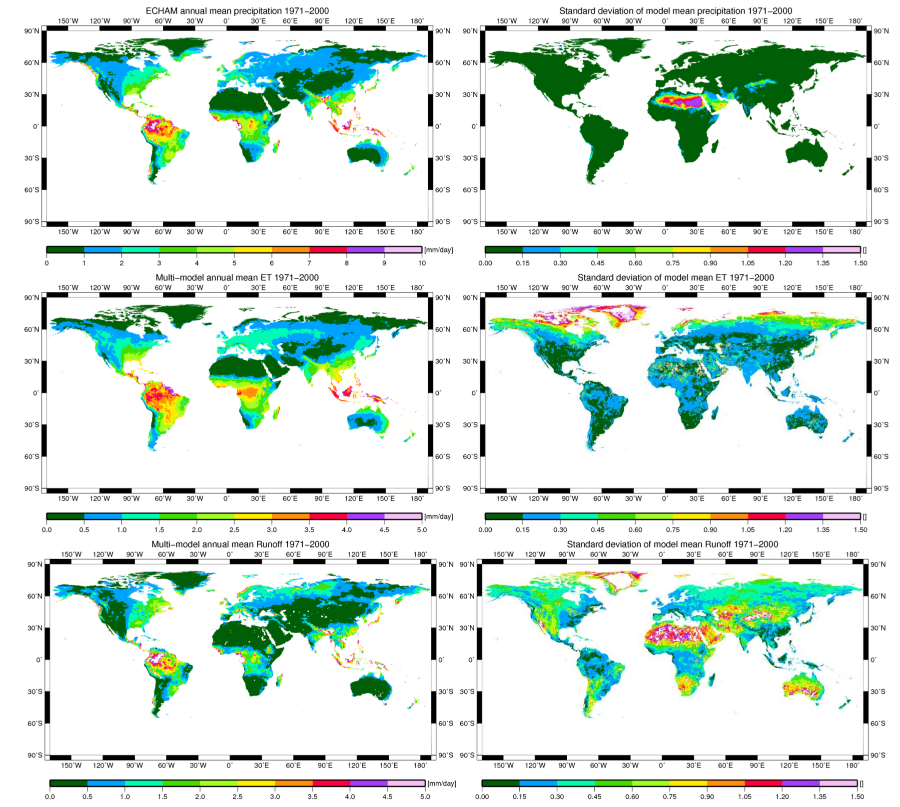

Figure 2: Multi-model mean annual results 1971-2000

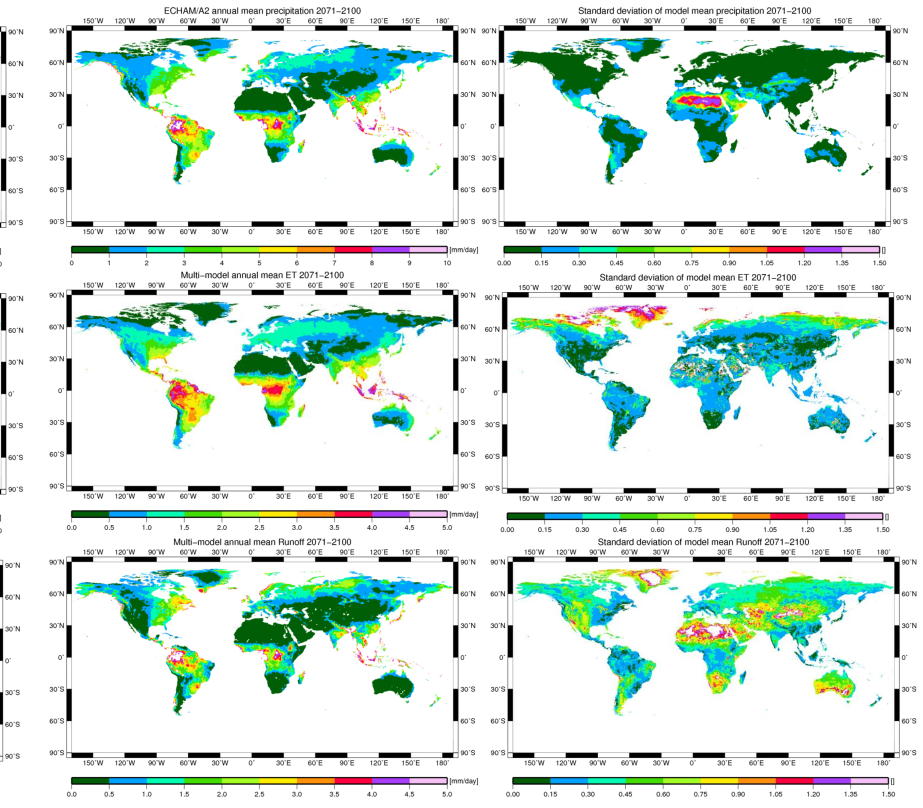

Figure 3: Multi-model mean annual results 2071-2100

Figure 4 and 5 show the monthly mean value of evapotranspiration and runoff of sample basins for the control period (1971-2000) and the change signal in 2071-2100 compared to 1971-2000. All models were forced by ECHAM output with A2 scenario.

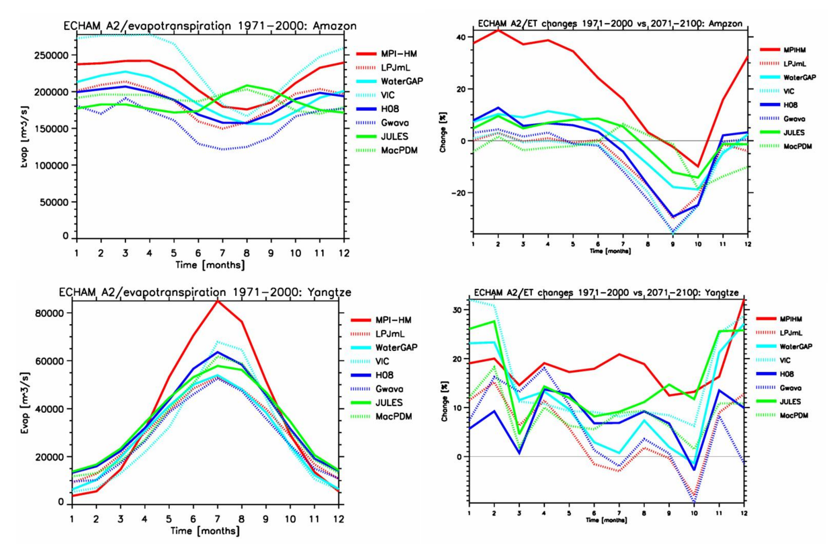

Figure 4: Monthly mean and changes of ET from 8 GHMs

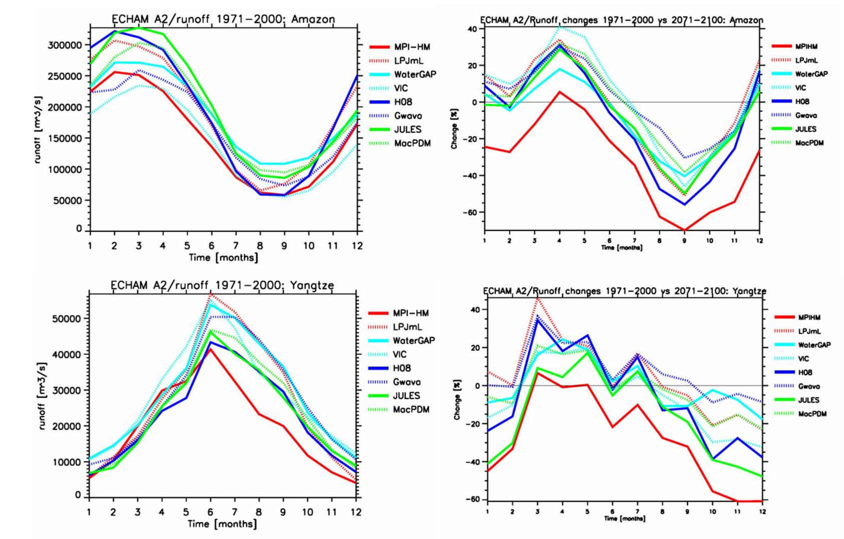

Figure 5: Monthly mean and changes of Runoff from 8 GHMs

Figure 6 and 7 show mean value and standard deviation of current period, absolute and relative changes in 2071-2100 compared to 1971-2000 for different GCM forcing.

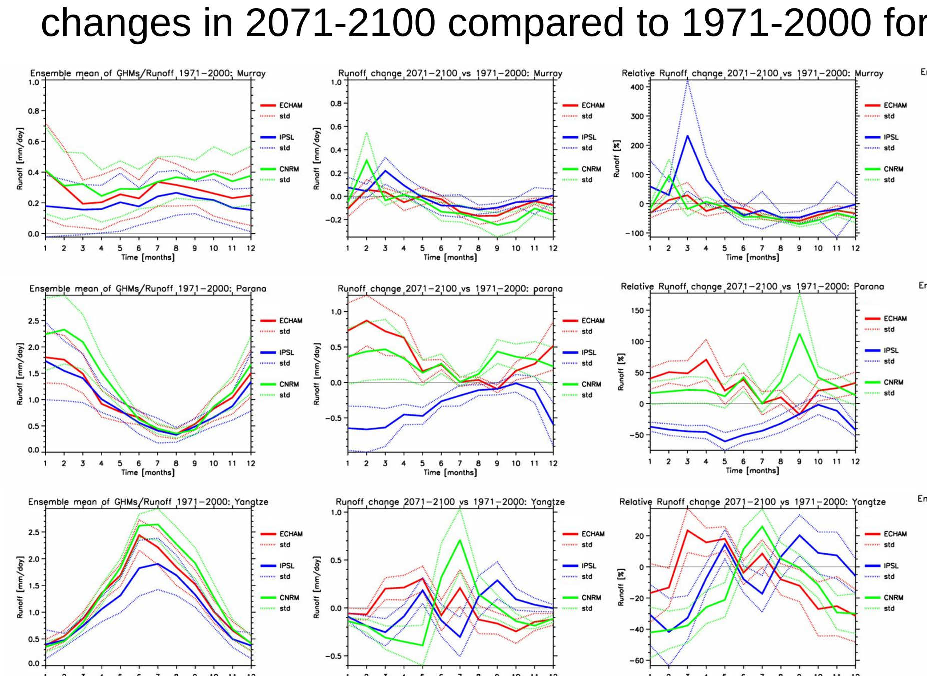

Figure 6: Spread of ensemble mean and standard deviation for runoff

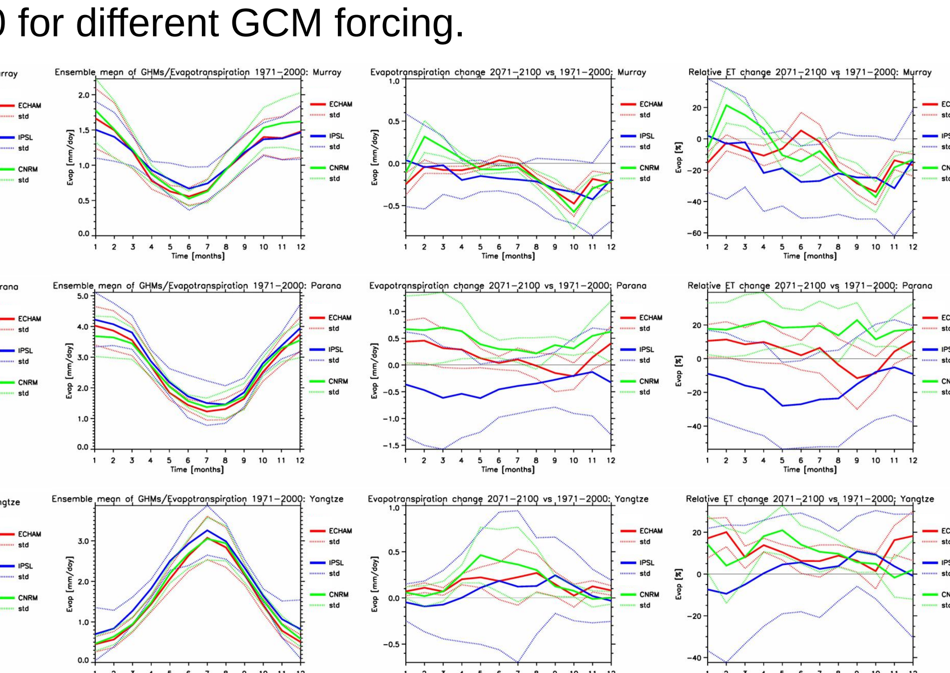

Figure 7: Spread of ensemble mean and standard deviation for ET

Figure 8 and 9 show the uncertainty spread for several sample basins with standard deviation in period 1971-2000 and standard deviation of the changes in 2071-2100 compared to 1971-2000 due to the choice of GHM.

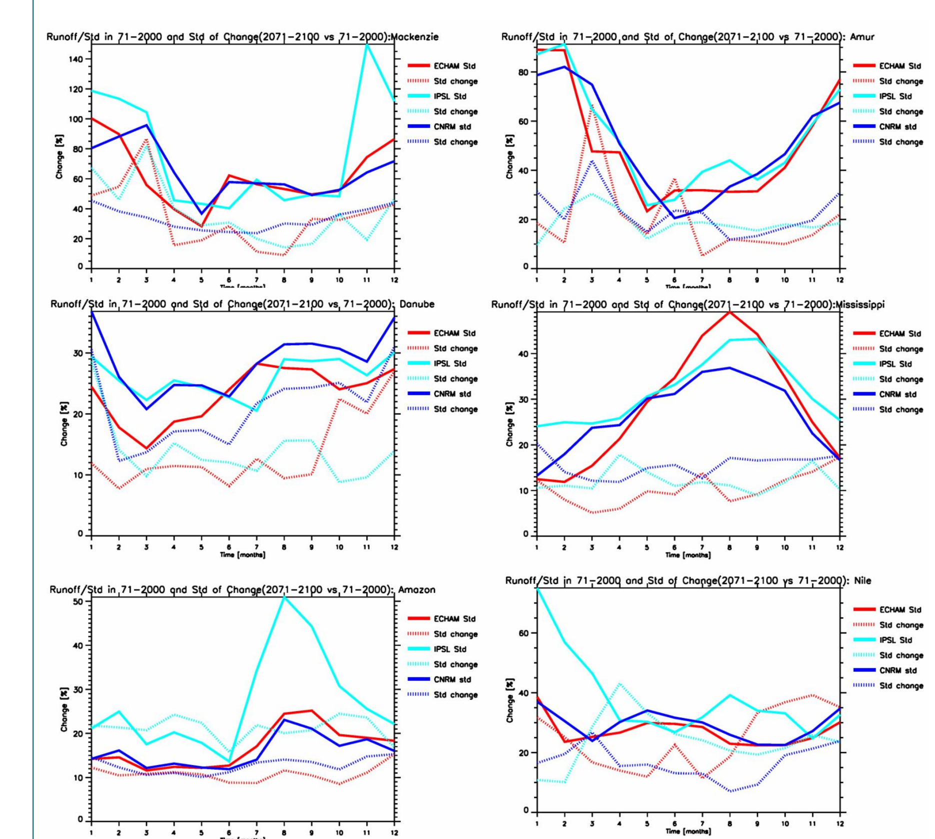

Figure 8: Comparison of standard deviation of Runoff mean and change

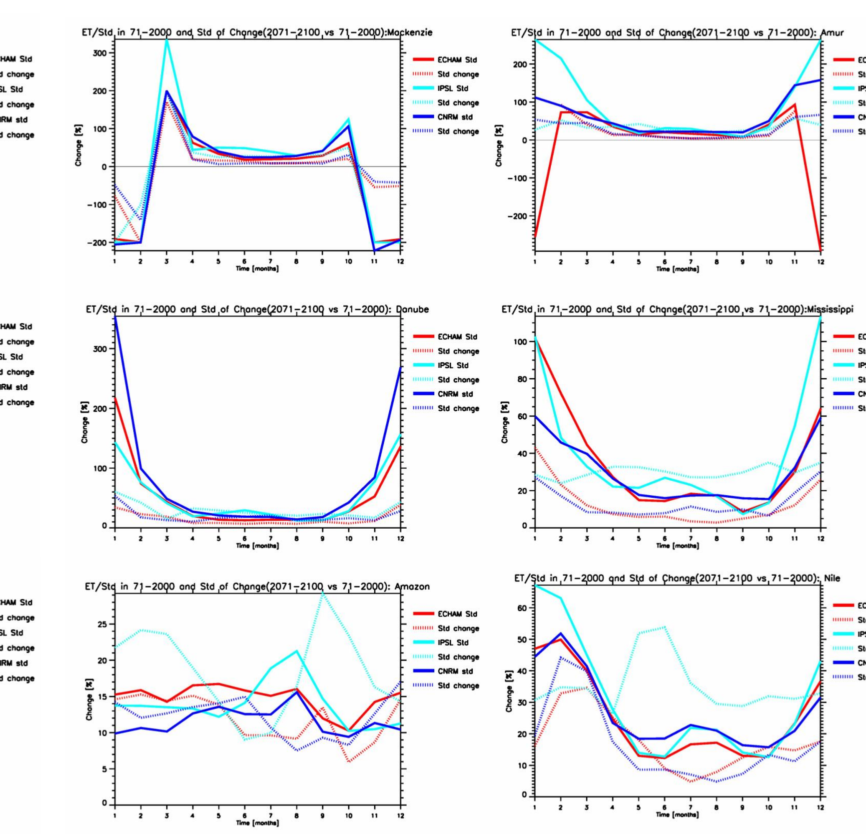

Figure 9: Comparison of standard deviation of Runoff mean and change

3. Discussion and outlook

1. Here are the current status and first results for the analysis of future water resources using multiple GCMs and GHMs.
2. Generally, the uncertainties due to the choice of GCM are larger than those due to the choice of GHM, especially for the change signal in the future period
3. The standard deviation of the change signal is smaller than the model spread of the mean value in current period.
4. Soil moisture and other hydrological components will be taken into account in the future work.
5. Water use/availability will be considered for the future water resources analysis.

4. Acknowledgement

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