Intercomparison of terrestrial water budgets in EURO-CORDEX and TSMP evaluation runs

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Motivation and goals

Water is one of Earth's most important geo-ecosystem components. Water budgets provide means for evaluating the availability and sustainability of water supply. We present an evaluation of water cycle components (1996-2008) using 12 EURO-CORDEX Regional Climate Models (RCMs) and the Terrestrial Systems Modeling Platform (TSMP)[(1)(2)(3)] from ERA-Interim driven evaluation runs.

TSMP provides an integrated representation of the terrestrial water cycle by coupling the numerical weather prediction model COSMO, the land surface model CLM and the surface-subsurface hydrological model ParFlow, which explicitly simulates shallow groundwater states and fluxes.

The goal is to assess water budget components of EURO-CORDEX RCMs and compare them with the fully coupled TSMP and evaluate the models with independent datasets. In order to use the water budget components for vulnerability, impact and adaptation studies the water budget should to be closed.

Data and methods

Analysis strategy:

- Terrestrial water budget [(4)]:

$$\Delta S = pr - evspsbl - mrro$$

pr = precipitation, evspsbl = evapotranspiration, mrro = runoff, and ΔS = storage change

- Assessment of terrestrial water budget of 12 EURO-CORDEX RCMs (Tab. 2) and TSMP w.r.t. reference data (Tab. 1) for 20 river catchments over Europe (Fig. 1)
- Long-term (1996-2008) averages of water budget components annual sums: spatial distributions, empirical frequency distributions, annual cycles, taylor diagrams

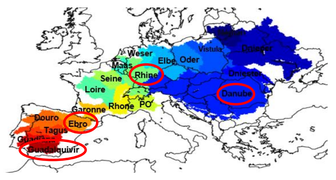

Fig. 1 Twenty major European river analysis; red circles: catchments considered in Fig 3 and 4

Tab. 1 List of the Reference datasets.

Source	Model	Parameter
ECA&D	E-OBS [(5)]	pr
ICDC	GLEAM[(6,7)]	evspsbl
PANGAEA	E-RUN[(8)]	mrro
ECMWF	ERA-5	pr, evspsbl, and mrro

Tab. 2 List of the EURO-CORDEX datasets.

Institute	Model	Parameter
ETH	CCLM	pr, evspsbl, and mrro
CLMcom	CCLM	
CNRM	ALADIN63, ALADIN53	
GERICS	REMO2015	
ICTP	RegCM4-6	
IPSL-INERIS	WRF	
KNMI	RACMO	
MOHC	HadREM3-GA7-05	
SHMI	RCA	
DMI	HIRHAM	
MPI-CSC	REMO	
FZJ-IBG3	TSMP	

Long-term averages of annual sum water budget components (1996-2008)

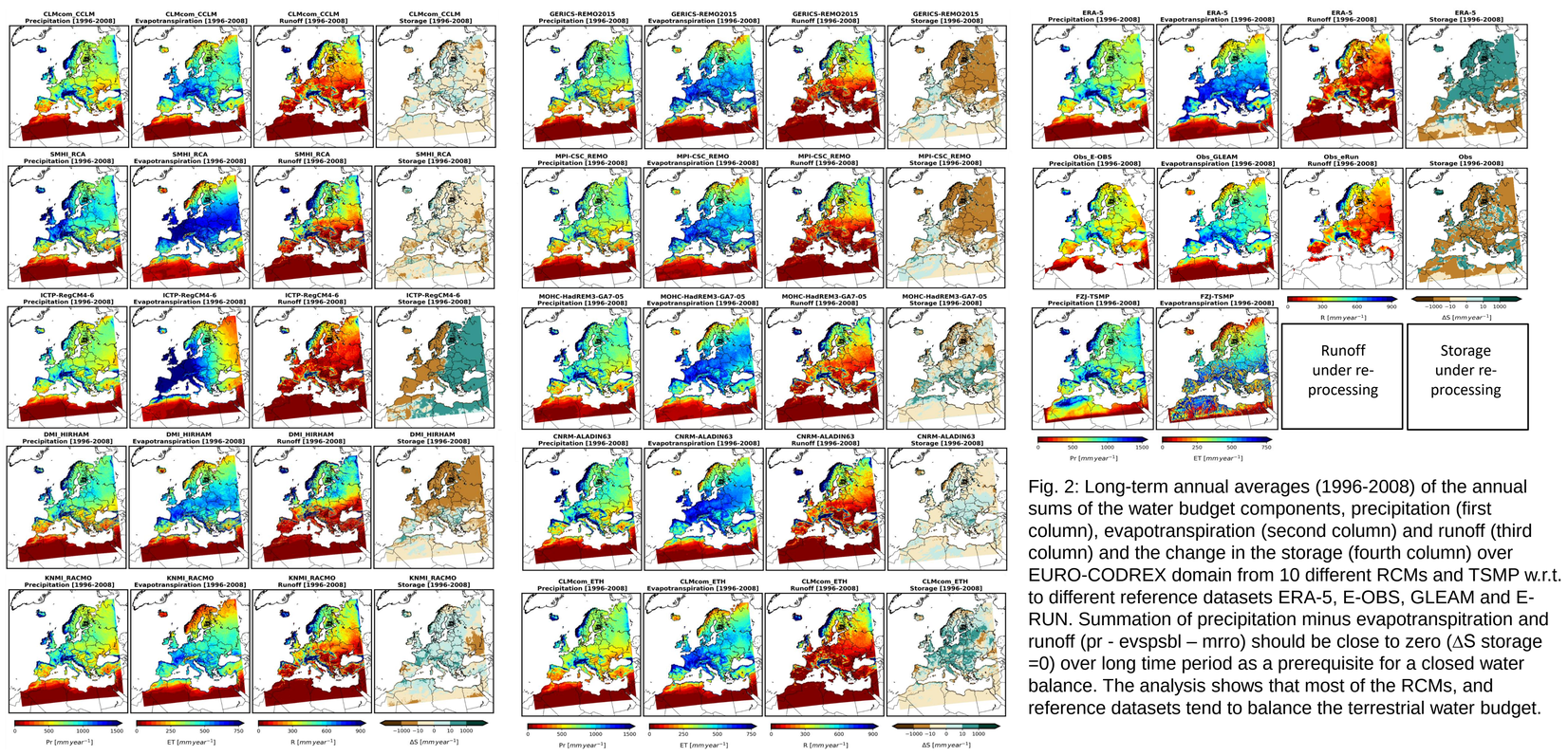

Fig. 2: Long-term annual averages (1996-2008) of the annual sums of the water budget components, precipitation (first column), evapotranspiration (second column) and runoff (third column) and the change in the storage (fourth column) over EURO-CODREX domain from 10 different RCMs and TSMP w.r.t. to different reference datasets ERA-5, E-OBS, GLEAM and E-RUN. Summation of precipitation minus evapotranspiration and runoff (pr - evspsbl – mrro) should be close to zero (ΔS storage =0) over long time period as a prerequisite for a closed water balance. The analysis shows that most of the RCMs, and reference datasets tend to balance the terrestrial water budget.

Empirical distributions

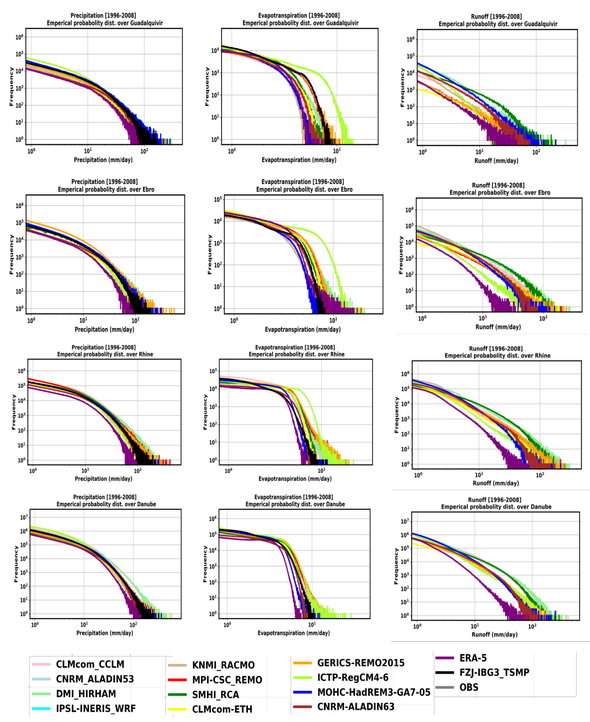

Fig. 3: Empirical distributions (1996-2008) of water budget components (pr, evspsbl and mrro) over (Guadalquivir, Ebro Danube, and Rhine).

Annual cycles

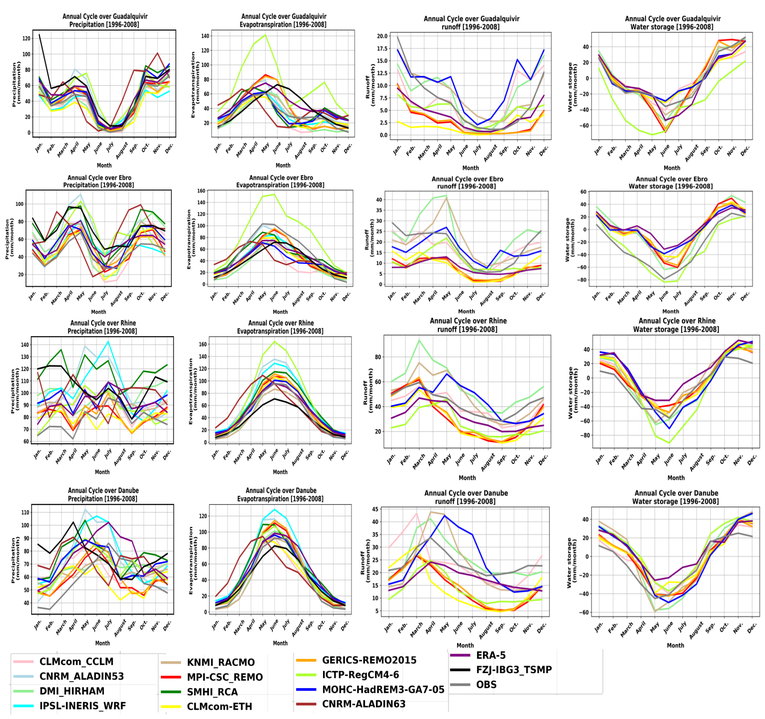

Fig. 4: Annual average (1996-2008) water budgets components (pr, evspsbl and mrro and ΔS) over Guadalquivir (56408.3, 388), Ebro (84619.2, 567), Rhine (163028.7, 1082) and Danube (786433.7, 5191) catchments. Number in brackets: catchments area [km2] and number of grid elements. Annual cycles are distinct and characteristic for climatic regions; RCMs show a large spread with similarity to observations epically for the evapotranspiration cycles.

Evaluation of annual cycles: Rhine and Guadalquivir rivers

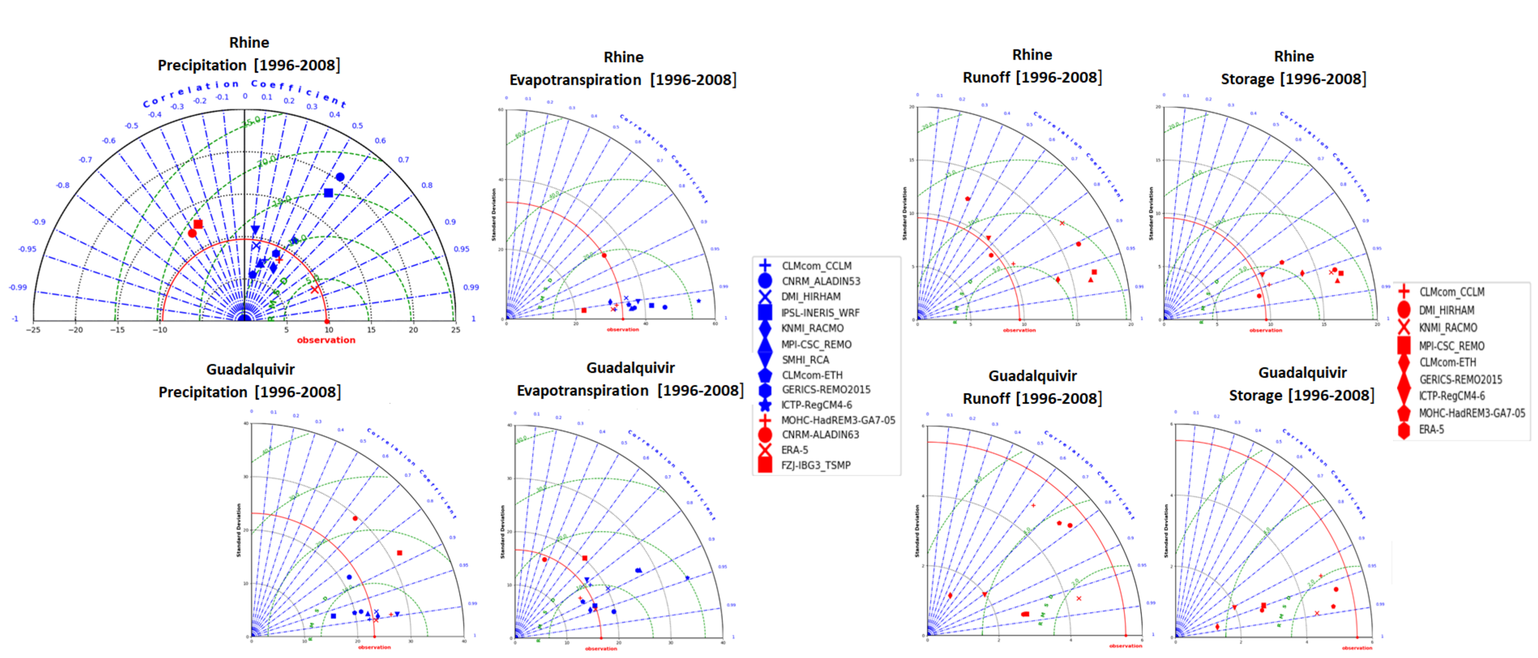

Fig. 5: Taylor diagrams of water budgets components over Rhine (first row) and Guadalquivir (second row) rivers which represent statistical indicators (standard deviation (Std), correlation coefficient (COR) and root mean square error (RMSE)) w.r.t. the reference data sets (E-OBS, GLEAM and E-RUN) of long term average (1996-2008) of annual sum for water budgets components pr (first column), evspsbl (second column), mrro (third column) and ΔS (fourth column).

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