SWAT 2015
PULA / SARDINIA / ITALY
Thursday, June 25
Session G1 - Poster

Climate change effects in a Mediterranean basin with different hydrologic models

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Study Area

Our study site is the **Rio Mannu basin (RMB),** located in the southern Sardinia, Italy (Fig.1) and included within the CLIMB EU FP7 project (Ludwig et al., 2010):

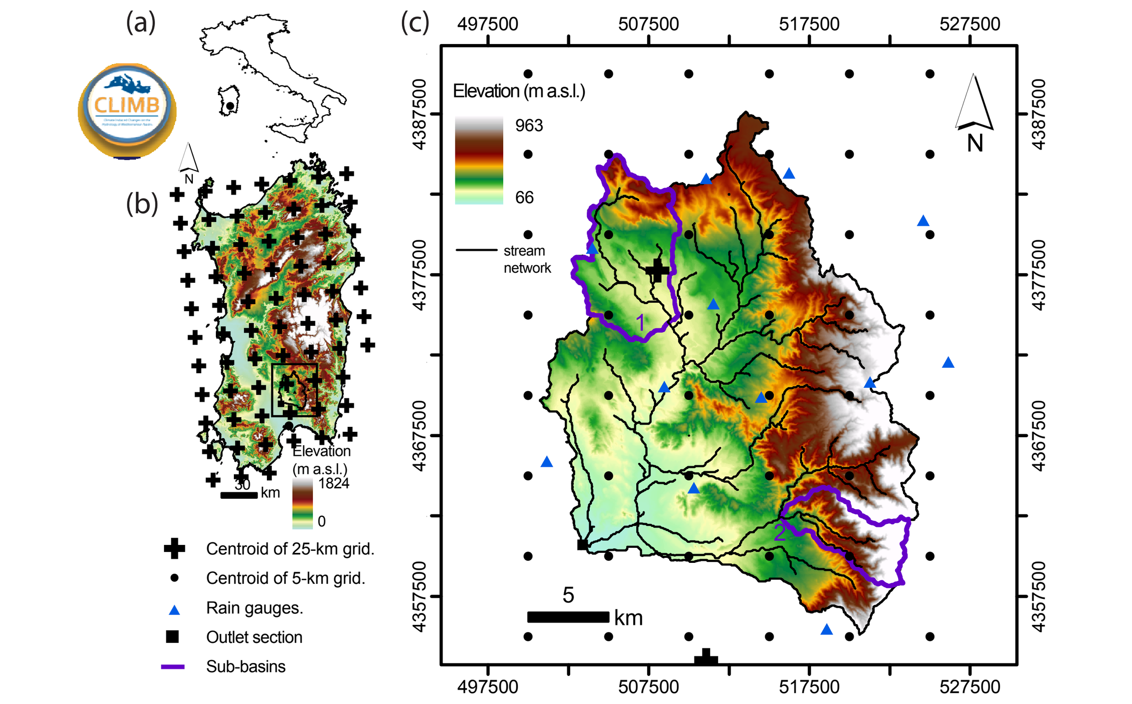


Fig. 1 - Location of the RMB within (a) Italy and (b) the island of Sardinia. (c) Digital elevation model (DEM) of the RMB including UTM coordinates. Panels (b) and (c) also report the centroids of the original and disaggregated climate model grids and (c) two sub-basins boundaries (violet lines).

Hydrologic Models

- Three hydrologic models (HMs) with different characteristics and schematizations are used to simulate the hydrological response due to climate change scenarios in RMB: SWAT, tRIBS and WASIM.

Soil and Water Assessment Tool, SWAT

- SWAT is a hydrological, semi-distributed model that functions on a continuous time step. Model components include weather, hydrology, channel and pond/reservoir routing. Fig 2 shows its performance when applied on the RMB (Marras et al., 2014).

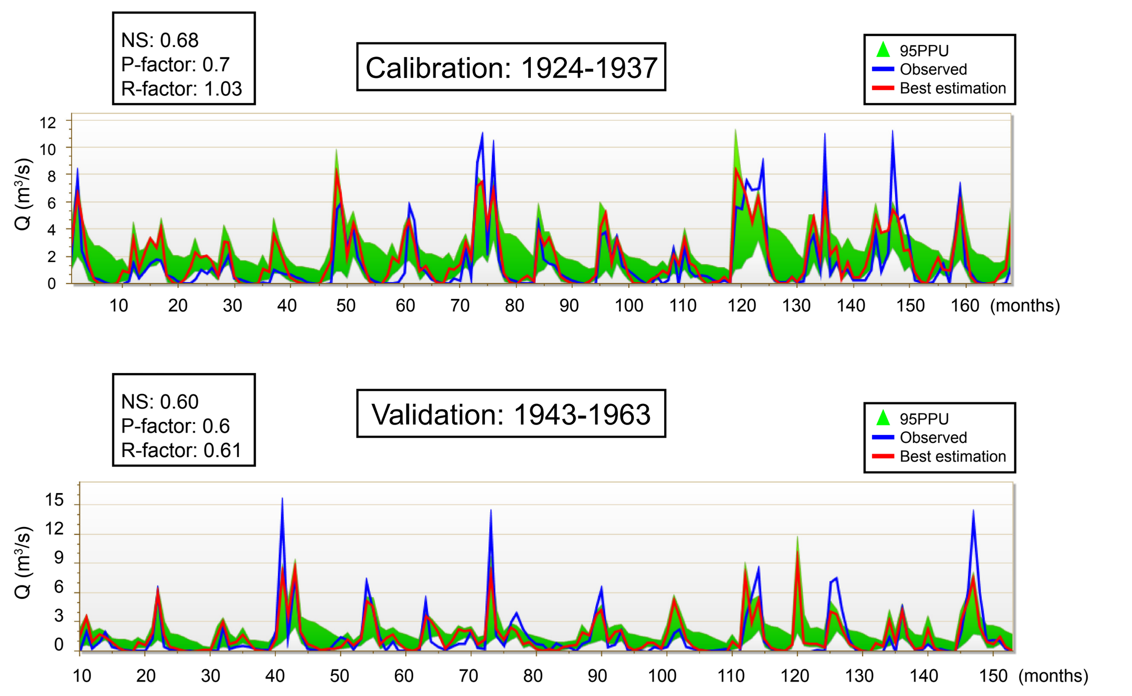
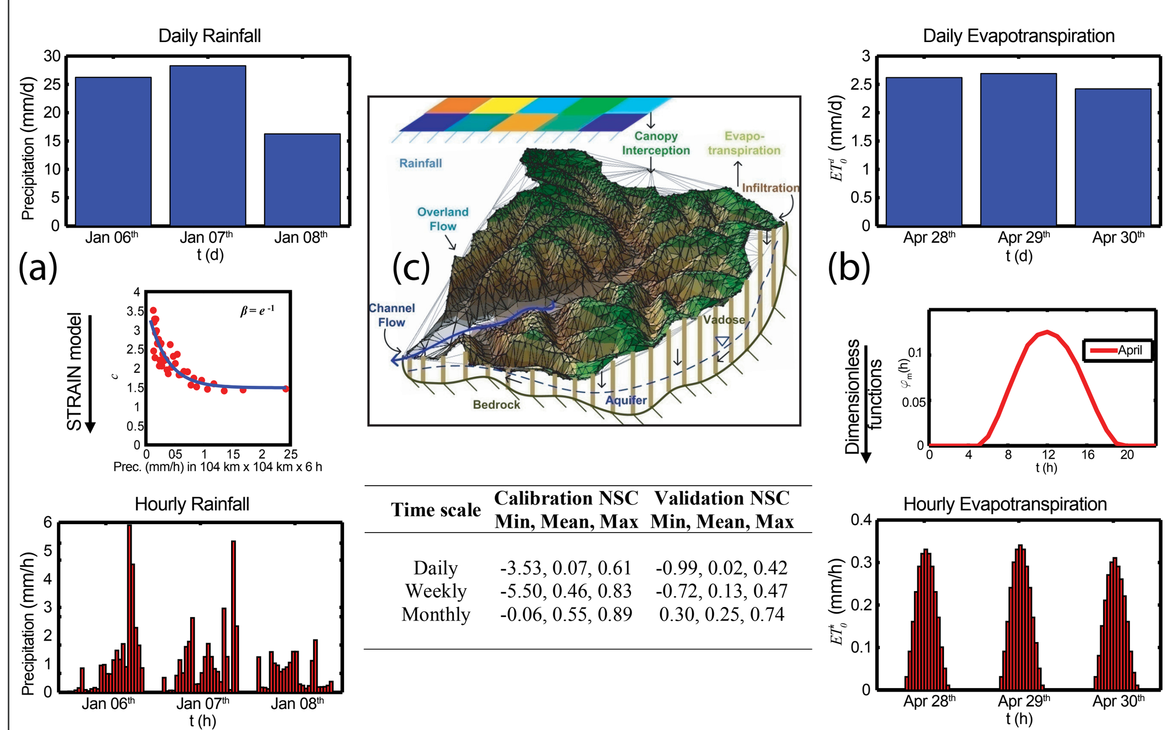


Fig. 2 - Results of calibration and validation of the SWAT HM in the RMB.

TIN-based Real Time Integrated Basin Simulator tRIBS

- tRIBS is a fully distributed, physically-based HM, using Triangulated Irregular Networks to represent topography (Fig. 3).



Time scale	Calibration NSC Min, Mean, Max	Validation NSC Min, Mean, Max
Daily	-3.53, 0.07, 0.61	-0.99, 0.02, 0.42
Weekly	-5.50, 0.46, 0.83	-0.72, 0.13, 0.47
Monthly	-0.06, 0.55, 0.89	0.30, 0.25, 0.74

Fig. 3 - tRIBS application scheme in the RMB (Mascaro et al., 2013): downscaling strategies and generation of hourly forcing for (a) precipitation, P, and (b) potential evapotranspiration, ET_p. (c) Hydrologic processes represented in tRIBS model over a complex triangulated terrain (Ivanov et al., 2004) and performances of tRIBS calibration and validation in RMB.

Water Flow and Balance Simulation Model (WaSiM)

- WaSiM-ETH, developed by Schulla and Jasper, is a process based and fully distributed hydrological model.
- The model is grid based and has a modular structure to represent the physical processes, as described in Fig. 4.
- The applied version uses the Richards equation for the water flow within the unsaturated soil zone.

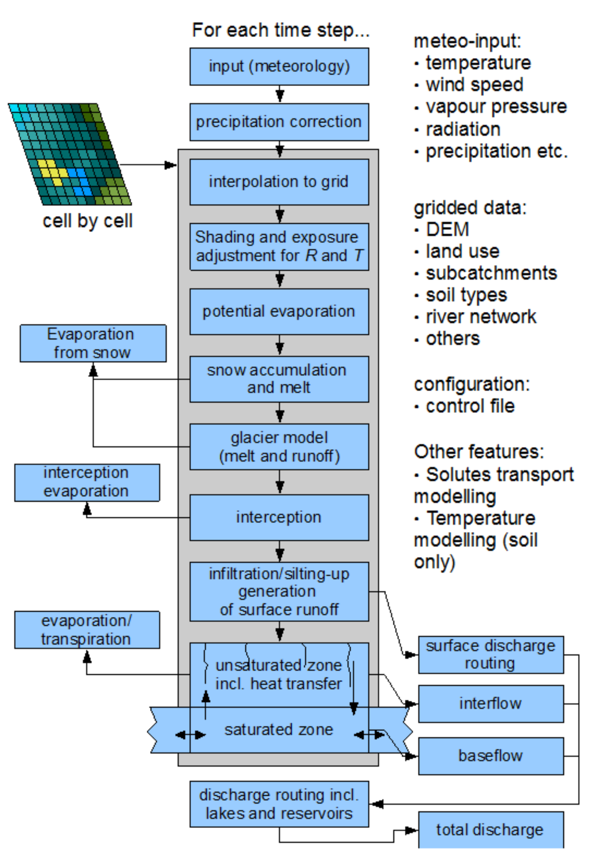


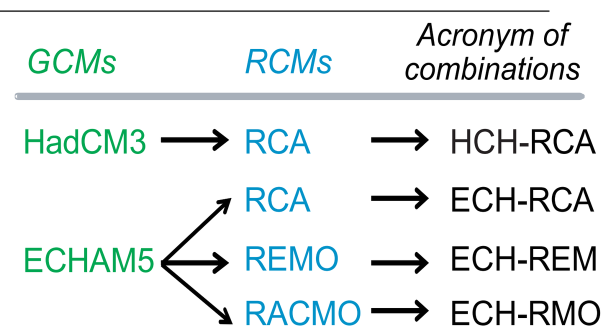
Fig. 4 - Model structure of the WaSiM-ETH (Schulla, 2015).

Climate Simulations

- Deidda et al. (2013) audited 14 combinations of general (GCM) and regional (RCM) climate models, based on the A1B emission scenario from the ENSEMBLES project (http://ensembles-eu.metoffice.com), for this study.

	Climatological center and model	Acronym	
GCMs	Hadley Centre for Climate Prediction, Met Office, UK HadCM3 Model (high sensitivity)	HadCM3	HCH
	Max Planck Institute for Meteorology, Germany ECHAM5 / MPI OM	ECHAM5	ECH
RCMs	Swedish Meteorological and Hydrological Institute (SMHI), Sweden RCA Model	RCA	RCA
	Max Planck Institute for Meteorology, Hamburg, Germany REMO Model	REMO	REM
	Koninklijk Nederlands Meteorologisch Instituut (KNMI), Netherlands RACMO2 Model	RACMO	RMO

- The four best performing combinations of two GCMs and three RCMs were selected, indicated as CMs.



- Two time slices: Reference (REF 1971-2000) and Future (FUT 2041-2070) periods.

Changes in climate forcing

- All CMs predict decreasing mean annual MAP (mean areal P), and increasing mean annual temperature T (Fig. 5 a,b) in FUT period.
- MAP is predicted to slightly increase in winter months (Fig. 5c) and decrease in the other seasons, while T is expected to increase throughout the year (Fig. 5d).
- HCH-RCA presents the largest variations for both P and T.

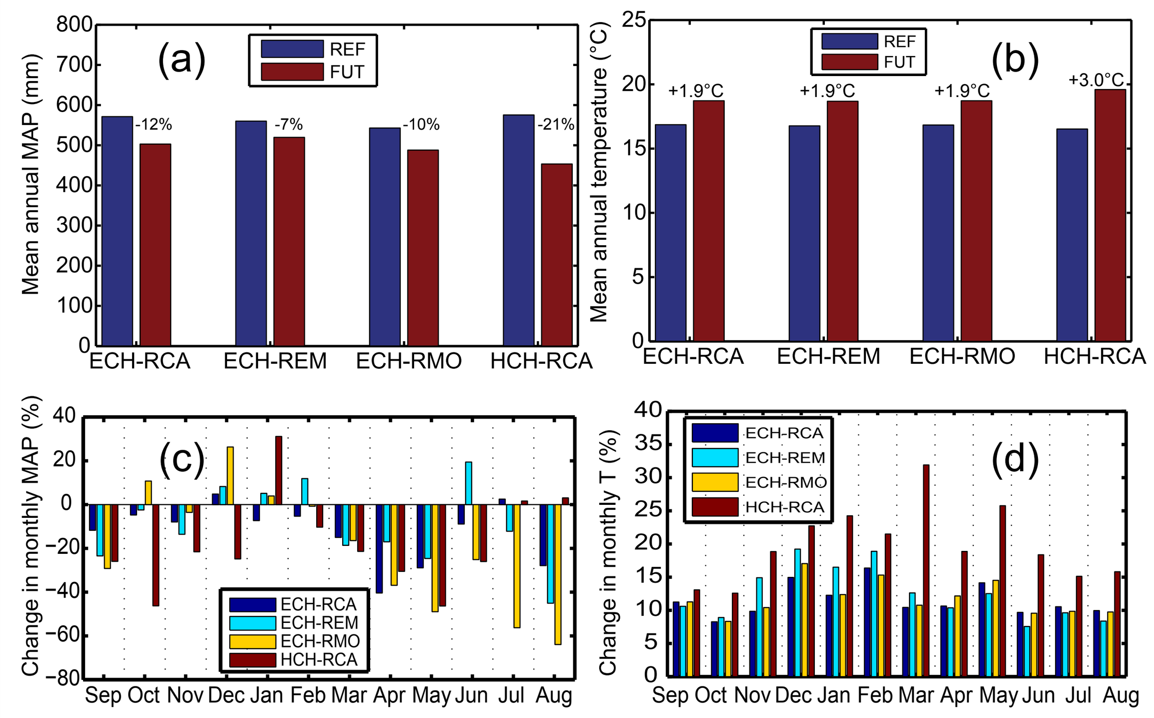


Fig. 5 - (a)-(b) Mean annual MAP (a) and T (b) in REF and FUT periods. (c)-(d) Relative change in monthly MAP (c) and T (d).

- High differences are found in the ETP estimations due to the different computational schemes. ETP is predicted to slightly increase in the FUT period, with the highest rise predicted by WaSiM model (Fig. 6). HCH-RCA presents the largest variations.

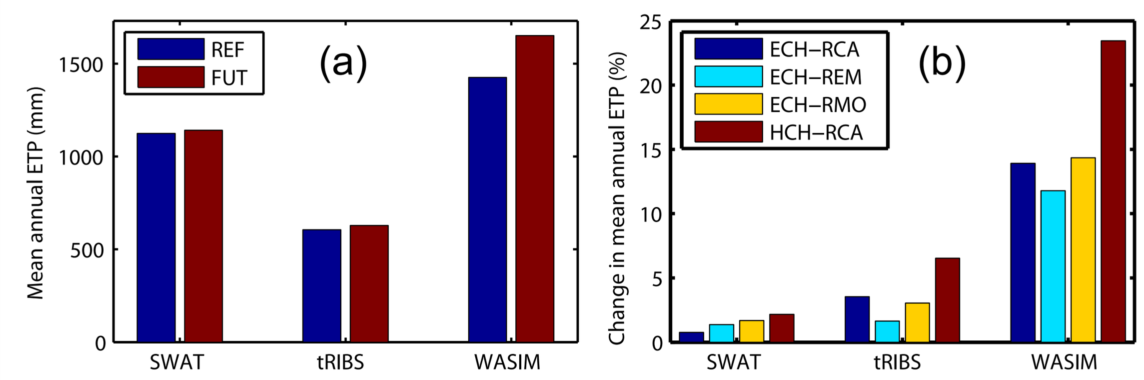


Fig. 6 - (a) Mean annual ETP in REF and FUT periods used in the 3 HMs. (b) Relative change in annual ETP specific for each CM.

Hydrologic Impacts

- The 3 HMs accordingly predict a decrease in mean annual discharge Q (Fig. 7a and b). Variation depends also on CMs.
- The real evapotranspiration ETR diminuishes in FUT according to the 3 HMs (Fig. 7c and d). Variation depends on CMs .
- Also the soil water content SWC is predicted to diminuish in FUT (Fig. 7e and f).
- The highest variations in Q, ETR and SWC are found for HCH-RCA.

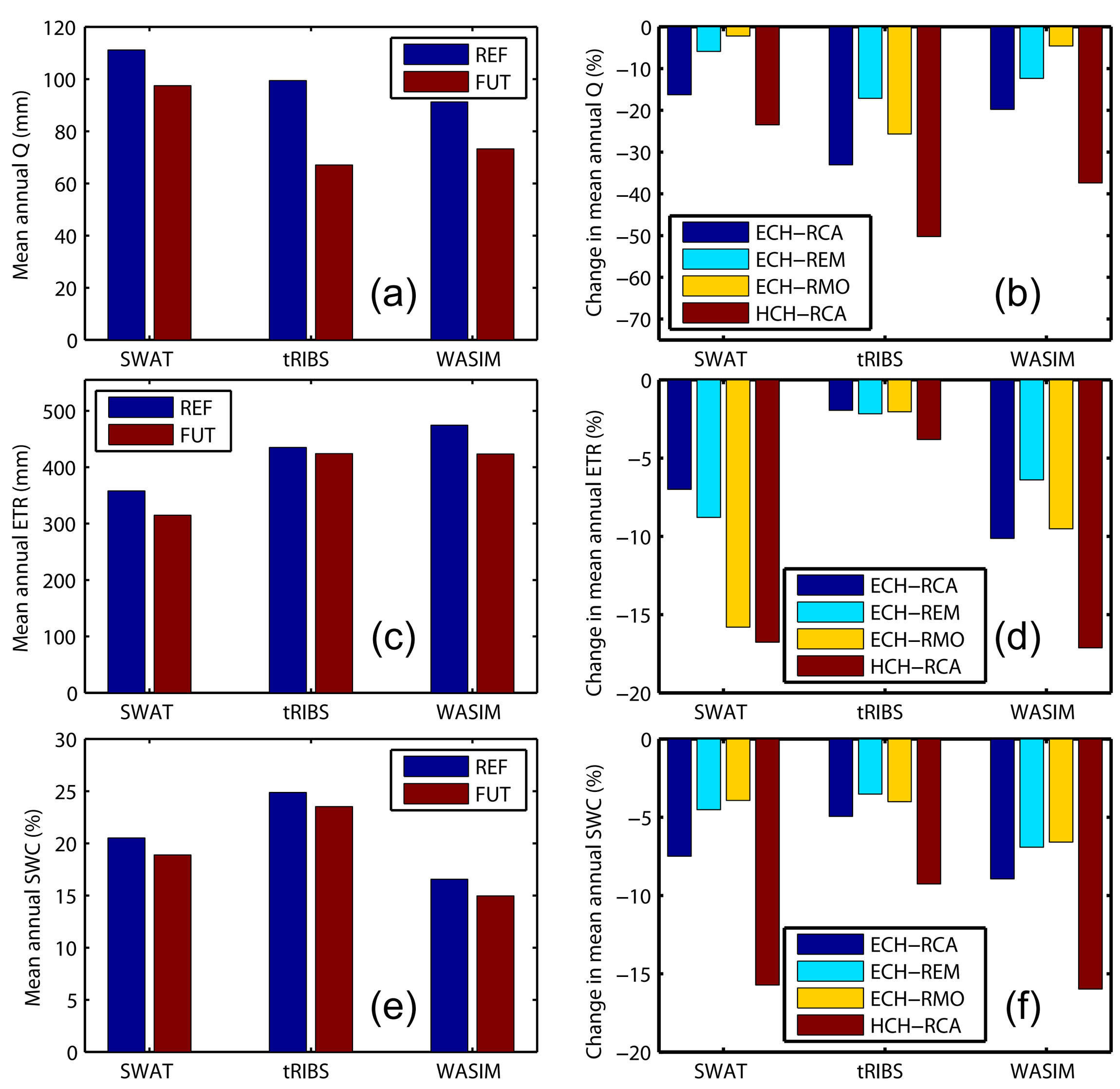


Fig. 7 - (a) Mean annual Q in REF and FUT periods simulated by the 3 HMs. (b) Relative change in annual Q specific for each CM. (c) and (d) Same as (a) and (b) for ETR. (e) and (f) Same as (a) and (b) for SWC.

Monthly variations

- The 3 HMs present larger variations considering the seasonal scale (Fig. 8) as compared to the annual scale (Fig. 7).
- Q is predicted to decrease in FUT in all months except for January and February (Fig. 8b).
- ETR increases only in December and January according to WaSiM. Largest descrease in summer months predicted by WaSiM (Fig. 8d).

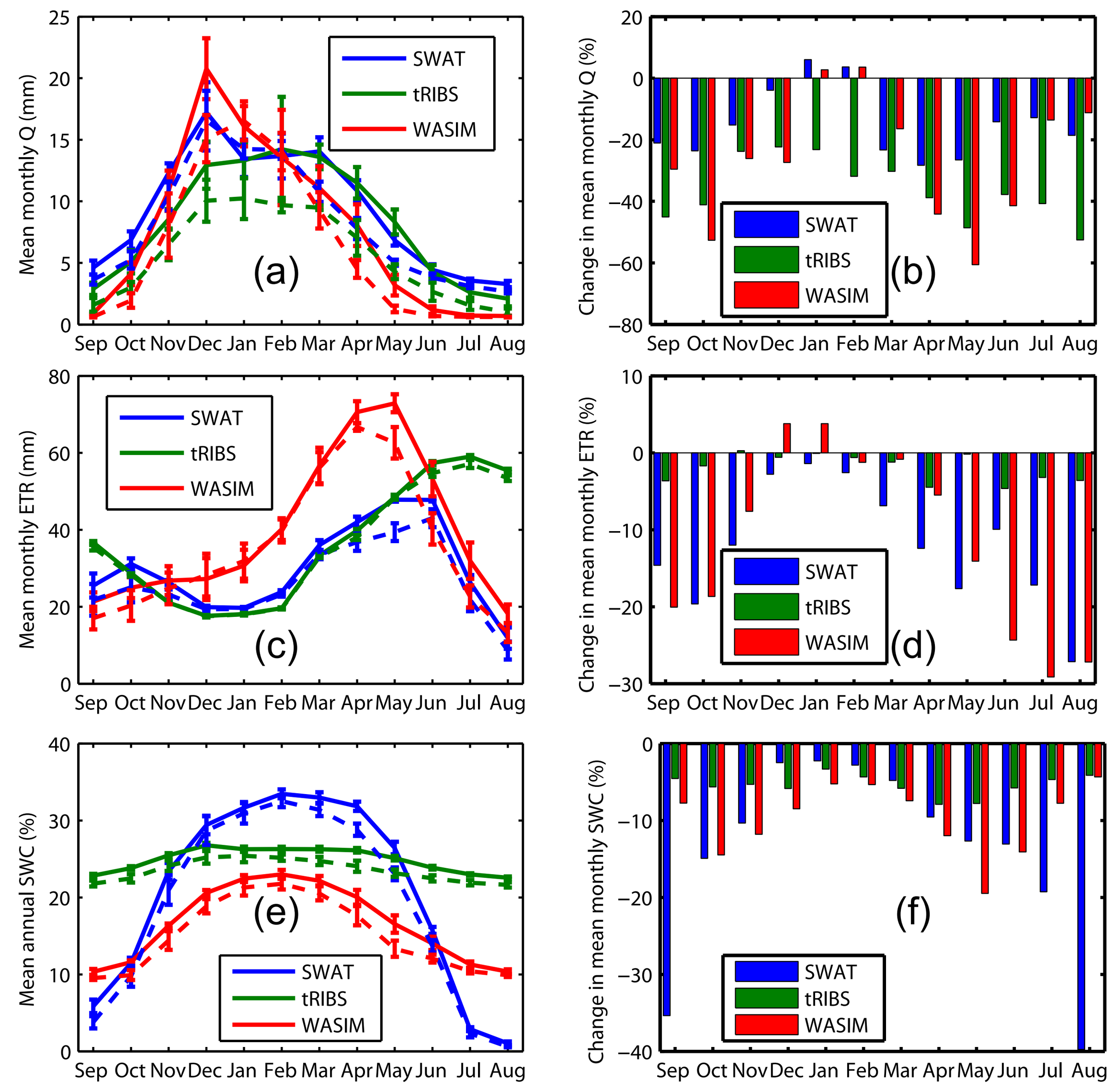


Fig. 8 - (a) Mean monthly Q in REF (solid lines) and FUT (dashed lines) periods simulated by the 3 HMs. (b) Relative change in mean monthly Q for each HM. (c) and (d) Same as (a) and (b) for ETR. (e) and (f) Same as (a) and (b) for SWC.

Sub-basins

- The mean monthly Q at the outlet section of two sub-basins with diverse terrain and soil properties (violet boundaries in Fig. 1c) shows different trends among the HMs (Fig. 9).

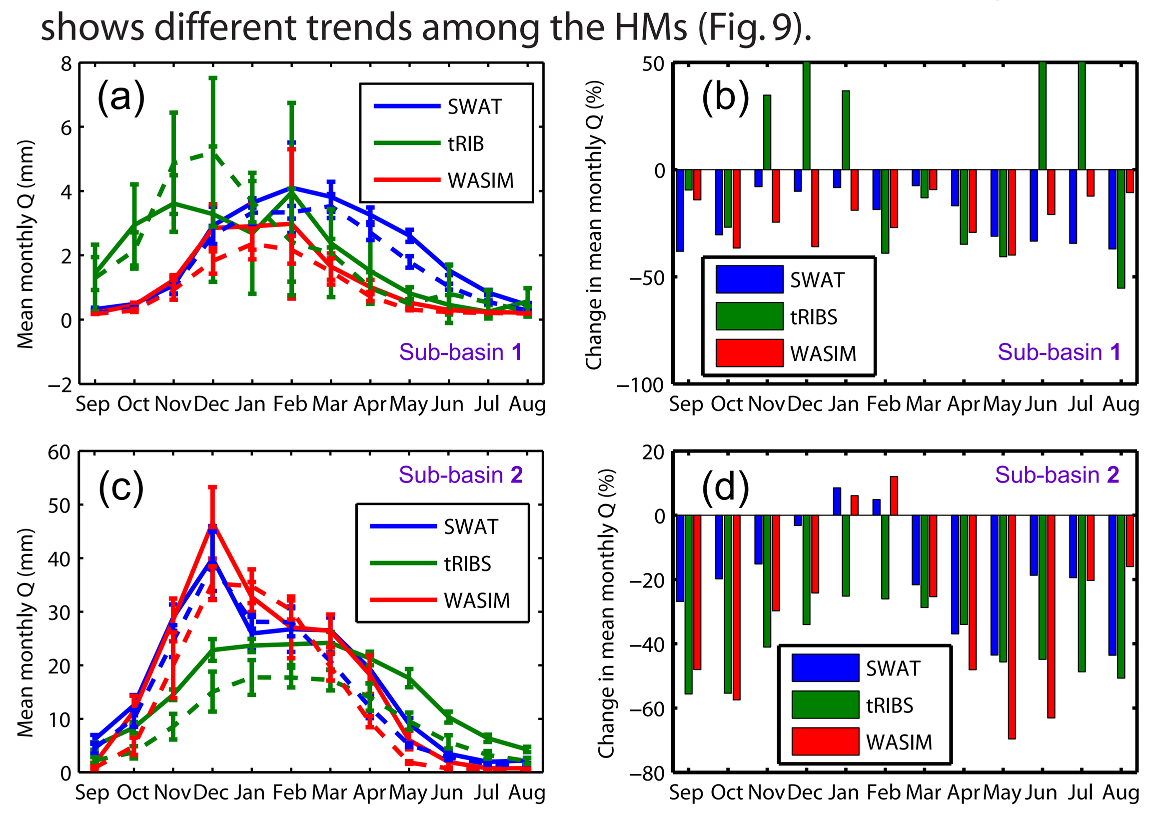


Fig. 9 - (a) Mean monthly Q in REF (solid lines) and FUT (dashed lines) periods simulated by the 3 HMs in sub-basin 1. (b) Relative change in mean monthly Q in sub-basin 1 for each HM. (c) and (d) Same as (a) and (b) for sub-basin 2.

Conclusions

Using 4 CM signals (coherently predicting lower mean annual precipitation and higher mean temperatures in the future period 2041-2070) as forcing of 3 HMs with different schematizations in the RMB leads to the following conclusions:

- All HMs indicate a negative trend of both mean annual discharge and mean annual real evapotranspiration (the latter likely due to drier soil moisture conditions), with minor differences across the HMs.
- Differences in the HMs outputs become more relevant when looking at higher time resolutions, e.g. at the monthly seasonal cycles, revealing the uncertainty of the hydrological component in climate change impact assessments.
- The analyses at sub-basin scale displays that, despite the different process schematization, all HMs were able to reliably represent the influence of terrain and soil properties in terms of basin response.

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