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Testing the hydrological coherence of high-resolution gridded precipitation and temperature data sets

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Assessing the accuracy of gridded datasets of precipitation and temperature obtained from the interpolation of in-situ measurements, satellite remote sensing or atmospheric reanalysis (e.g., *Michaelides et al., 2009* for precipitation and *Harris et al., 2014* for temperature) is highly relevant to climate change impact studies, since evaluation, bias correction and statistical downscaling of climate models commonly use these products as a reference. Among all impact studies those addressing hydrological fluxes are the most affected by errors and biases in these data. The error associated to gridded data is often unknown or, at least, difficult to quantify (*Isotta et al., 2015*). Measurement errors depend on local conditions and increase with the elevation. The interpolation method is an additional source of error, even when sophisticated geostatistical spatial analysis techniques are adopted. Moreover, the accuracy of gridded climate data derived by remote sensing techniques is closely linked to their spatio-temporal resolution (*Prein & Gobiet, 2017*). Applying hydrological modeling to different gridded meteorological datasets has received attention recently, particularly over relatively short time periods in the context of flood forecasting applications.

This work introduces an efficient methodology to rank gridded meteorological datasets according to their hydrological coherence with observed data and possibly reject them when their coherence is judged too low. We called this framework as HyCoT (Hydrological Coherence Test; *Laiti et al., 2018*). Coherence is evaluated by benchmarking streamflow, computed with a hydrological model fed by the selected datasets and applied in an inverse modeling framework against available measurements. The test allows, along a goal-oriented approach, to evaluate and rank the gridded datasets according to their hydrological coherence and provides a framework for excluding those not complying with hydrological observations, as function of the particular goal at hand.

HyCoT is applied to the Adige River Basin (northeast of Italy) for streamflow analysis, using a distributed hydrological model coupled with the HYPERstream routing scheme (*Piccolroaz et al., 2016*). HYPERstream routing scheme was designed in order to be coupled with gridded climate datasets and climate models, since it inherits the computational grid from the overlaying meteorological forcing, still preserving geomorphological dispersion caused by the river network irrespectively of the grid resolution. The parameters space was explored for optimality, as defined by the Nash-Sutcliffe (NSE) (*Nash & Sutcliffe, 1970*) and the Kling-Gupta (KGE) (*Gupta et al., 2009*) efficiency indexes, by using the Particle Swarming Optimization algorithm. In doing this, two of the eight gauging stations considered were used in a multi-site calibration framework, whereas the remaining six stations were used only for validation purposes. In order to verify whether a simple rainfall correction procedure can improve the performance of biased datasets a Linear Scaling (LS) (*Lenderink et al., 2007*) transformation of the gridded precipitations was also employed. LS is a simple multiplicative correction method generally applied to correct biases in meteorological forcing as derived from Regional Climate Models (RCMs) simulations. The comparison covers the period 1989-2008 and includes five daily meteorological gridded datasets: E-OBS, MSWEP, MESAN, APGD and ADIGE. They are characterized by relatively high nominal spatial resolutions (grid spacing < 25 km) and a daily temporal aggregation. For more details see *Laiti et al. (2018)*. The 1989-2008 period was identified as common time frame for the analysis.

The parameters of the hydrological model were inferred for each dataset by maximizing separately the average NSE and KGE of Trento and Bronzolo gauging stations (Figure 1).

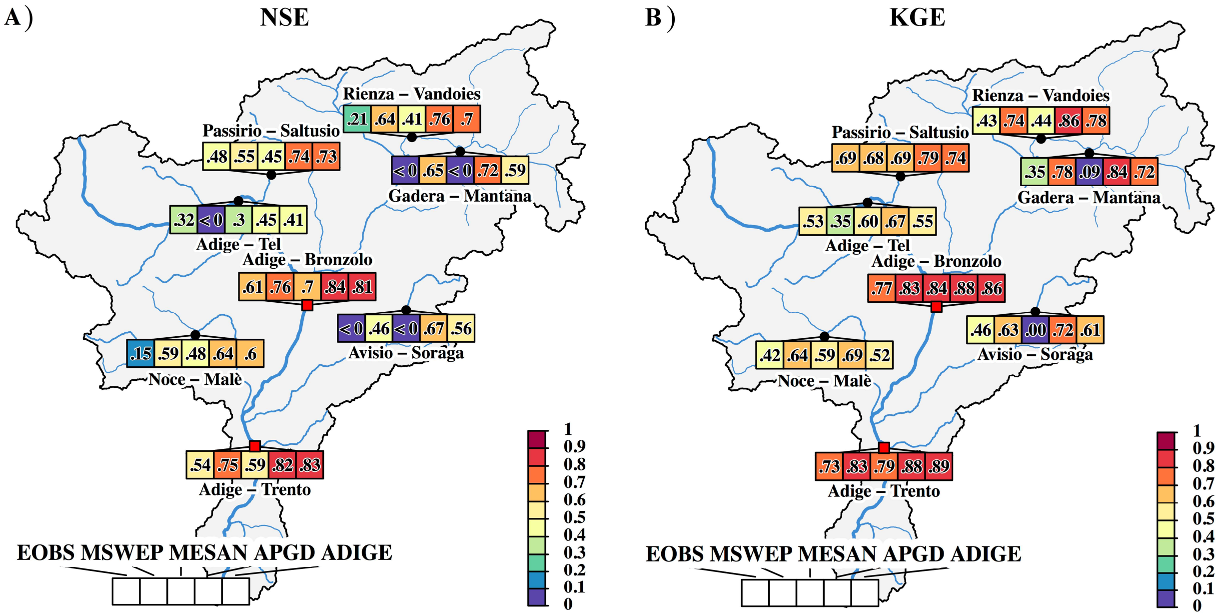

Figure 1. Maps of the (A) NSE values and (B) KGE values calculated at the gauging stations of the Adige River Basin. Simulated streamflow were obtained by calibrating HYPERstream such as to maximize the average NSE and KGE at the gauging stations of Trento and Bronzolo. The model has been calibrated separately for each dataset. Reproduced from Laiti et al. (2018).

In the Adige River Basin, APGD and ADIGE are the best candidates for hydrological applications. On the contrary, despite acceptable results at the larger basin scale, E-OBS, MESAN and MSWEP were found unable to correctly reproduce the observed streamflow at the smaller sub-catchments. Results of our analyses are relevant for climate change impact assessments in the Alpine region where available gridded products are in general characterized by low observational density (i.e., low effective spatial resolution and accuracy). HyCoT reveals deficiencies in the representation of spatio-temporal patterns, which cannot be corrected by simple rescaling of the meteorological forcing, as often done in bias correction of climate model output. We recommend this framework in the context of large-scale hydro-climatic studies for evaluating and selecting gridded climate datasets.

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