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Modeling the hydrological cycle of the Adige using the GEOframe system

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Session HS2.2.1: Incorporating novel data and hydrological process understanding into catchment models across spatio-temporal scales

Motivations

- Impact of climate change in an alpine region: Adige basin
- Effects on water resource and extreme events (droughts and floods)
- Anthropogenic effects and influences on the hydrological cycle in the region

nature climate change

ARTICLES

https://doi.org/10.1038/s41558-019-0676-5

More green and less blue water in the Alps during warmer summers

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ANSA.it › Veneto › Siccità: chiesta più acqua nell'Adige, ma bacini quasi vuoti

Siccità: chiesta più acqua nell'Adige, ma bacini quasi vuoti

Livelli bassi nelle dighe preoccupano Trento e Bolzano

CRONACA

Maltempo, è allerta anche per l'Adige. Bloccata la ferrovia del Brennero. In Alto Adige frane e allagamenti

La forte pioggia delle ultime ore sta creando molti problemi. La strada del Brennero è stata bloccata a causa di una frana e i vigili del fuoco sono al lavoro su tutto il territorio per mettere in sicurezza fiumi e torrenti

Outline

Obtaining necessary data:
Climatic data for the model
Land covers, dam data for anthropogenic

Hydrological model set-up and calibration / validation:
Using GEOframe famework

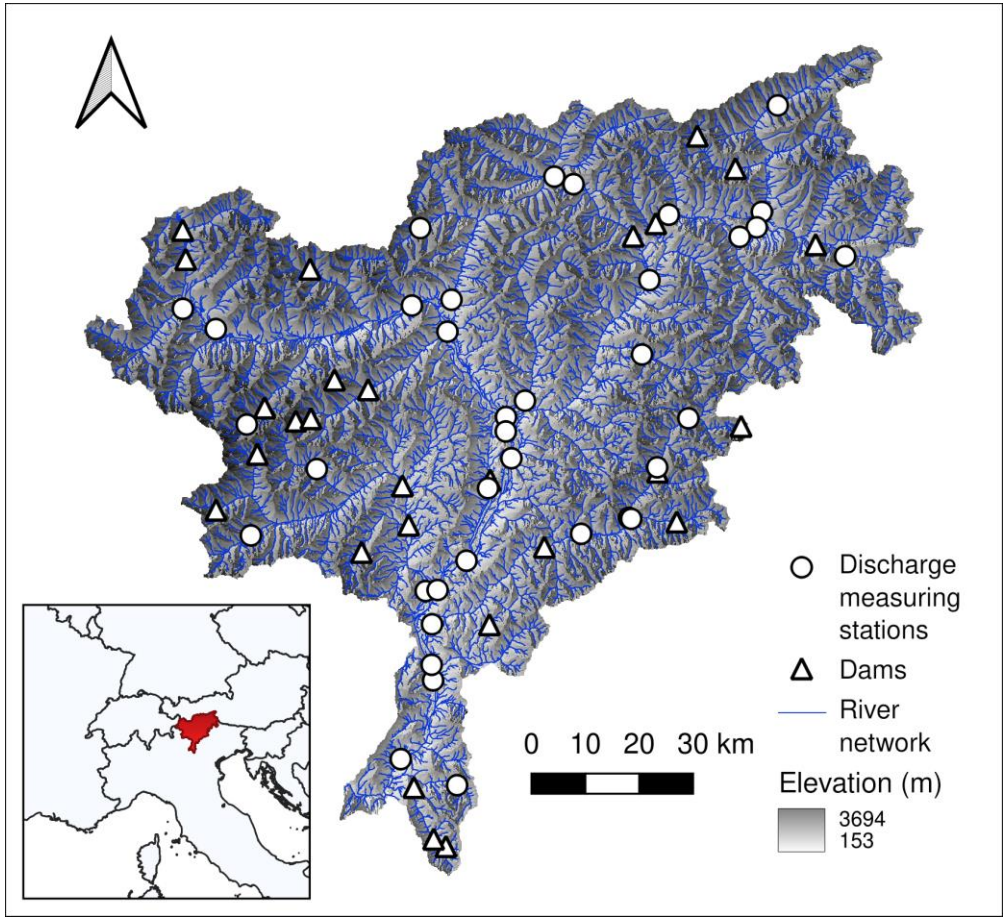
Verification of climatic historical scenarios: EuroCordex and CMIP6

Projections with the future climatic scenarios:
study of extremes occurrences (droughts and floods)

About GEOframe

- GEOframe is an open-source semi-distributed, component-based hydrological modeling system (Rigon et al., 2021; Formetta et al., 2014; Bancheri et al., 2020).
- Possibility of using different modules/components for different functions/methods depending on data available

Study area, challenges, data used

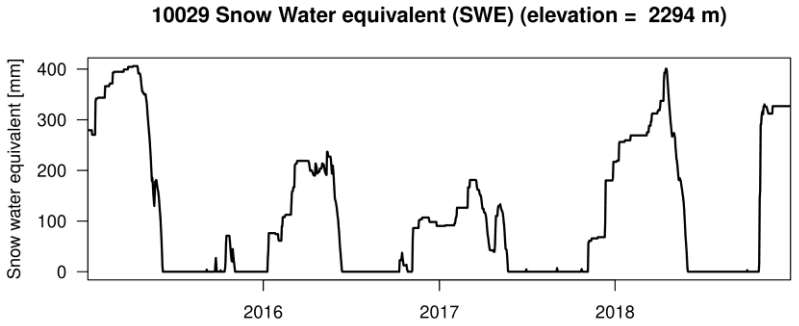


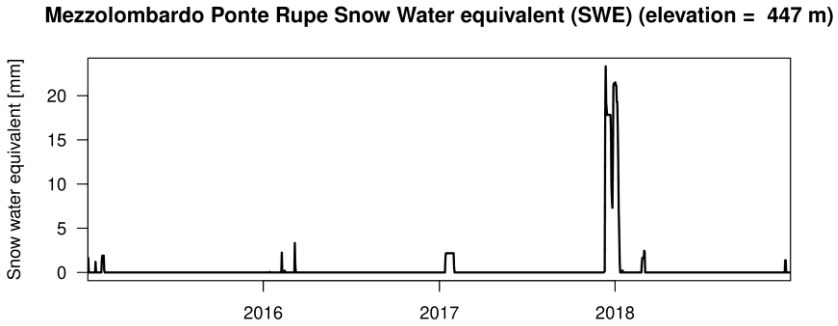
- Adige River basin: 10500km^2 (12,200km^2 in total)
- Challenges: heavy anthropization of the basin:
  - Land use changes
  - Dam and reservoirs
  - Diversions
  - Extensive modifications of the river channel including canals
- Data used:
  - Daily temperature and precipitation dataset for 1980 to 2018
  - Corine landcovers (1975, 1990, 2000, 2008, 2018)
  - Provincial and electrical companies' data with regards to dams, environmental flows and discharges
  - Discharge data from the provincial authorities.

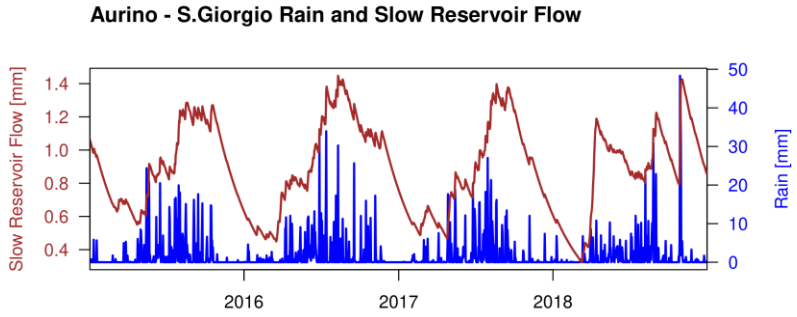
Methodology for the hydrological modelling of the Adige

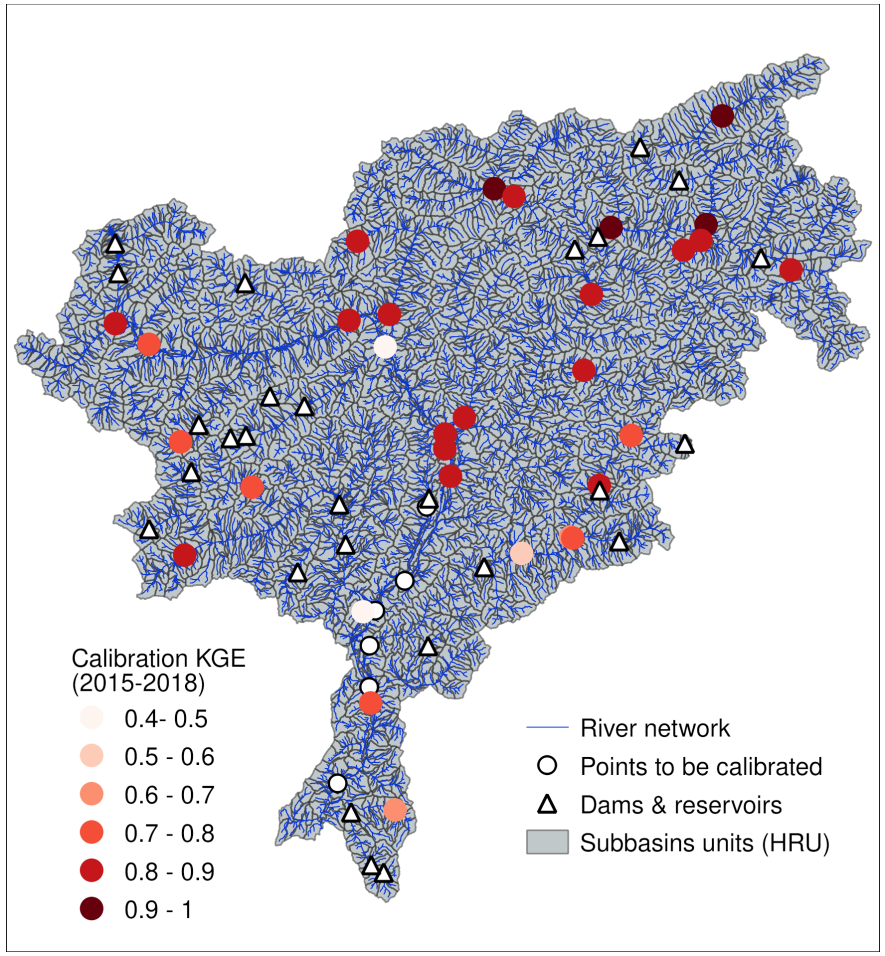
- Geomorphology analysis and topology set-up
  - Network carved-in to ensure the correct path of rivers
  - About 2000 subbasins, average size of 5km^2
- Different GEOframe standard module used:
  - Radiation
  - Evapotranspiration (Priestley-Taylor)
  - Snow model (Degree-day)
  - Hydrological model (HyMod) (Boyle, et al., 2003)
  - Routing (Muskingum)
- Novelties:
  - Correction of evapotranspiration based on landcovers (Nistor et al., 2017)
  - Diversions
  - Dam and reservoir module implementing different release strategies depending on the filling of the dam (Yassin et al., 2019)
- Multi-point calibration done at 35 observation points on the discharge

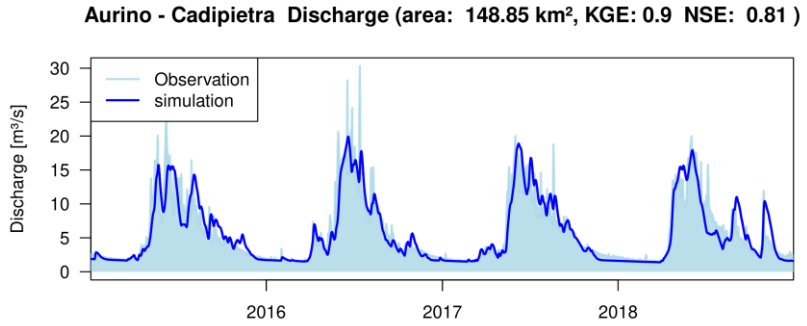
Results of calibration (hydrological modelling)

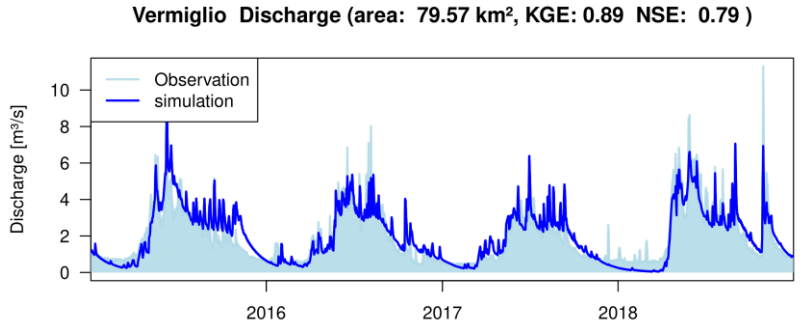


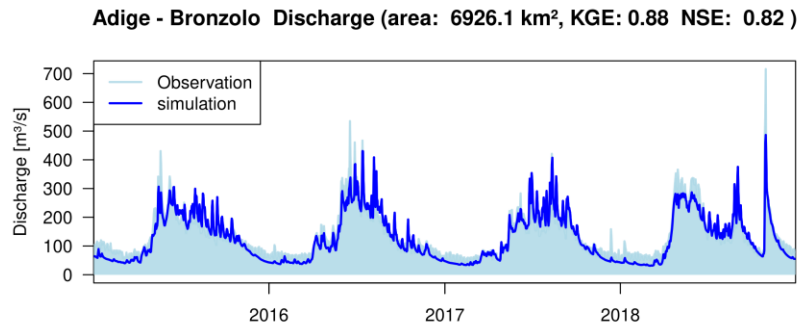




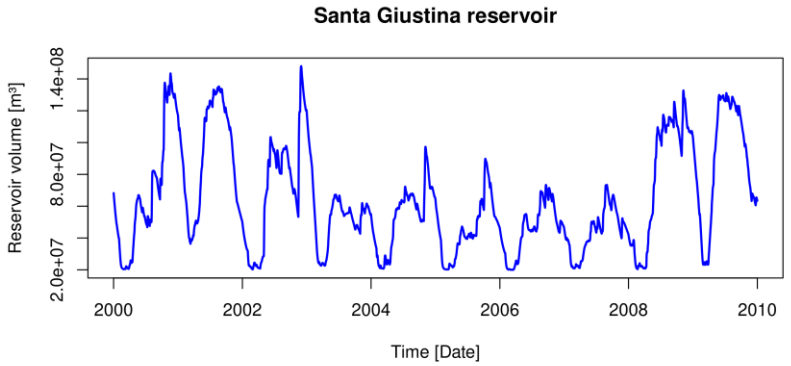


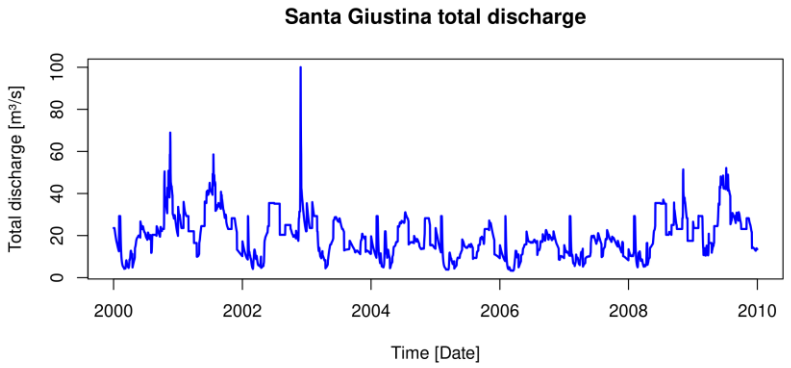


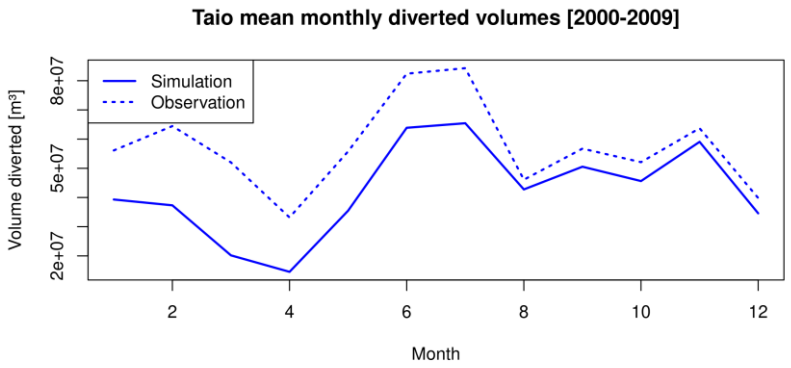


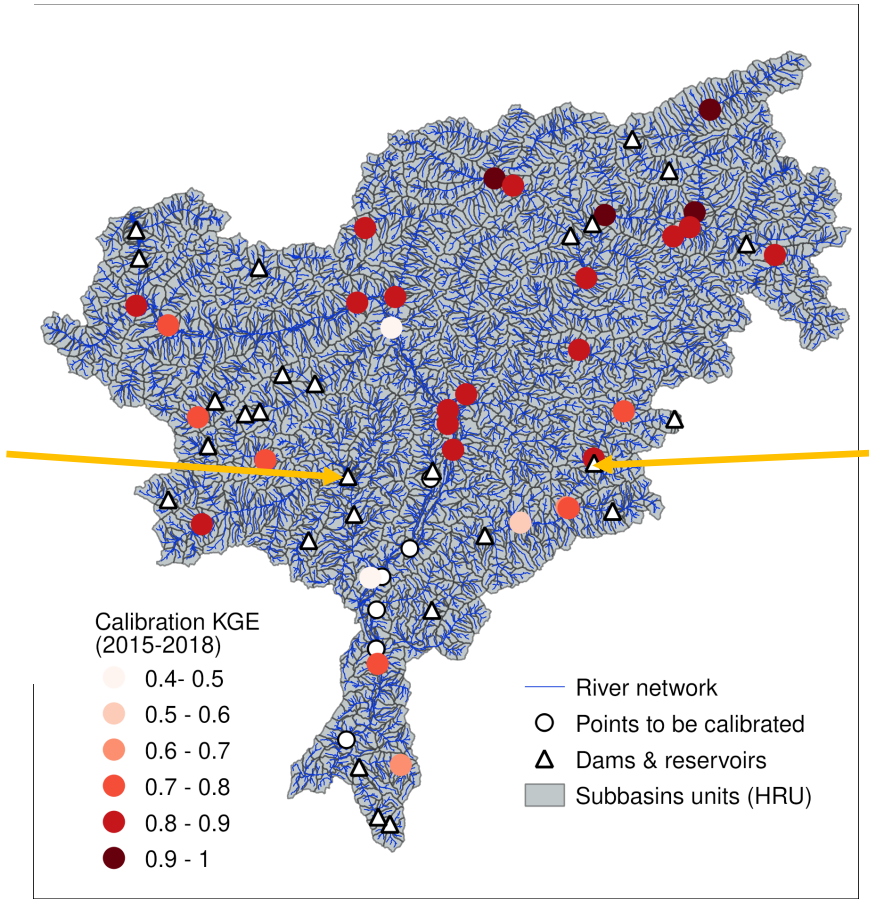


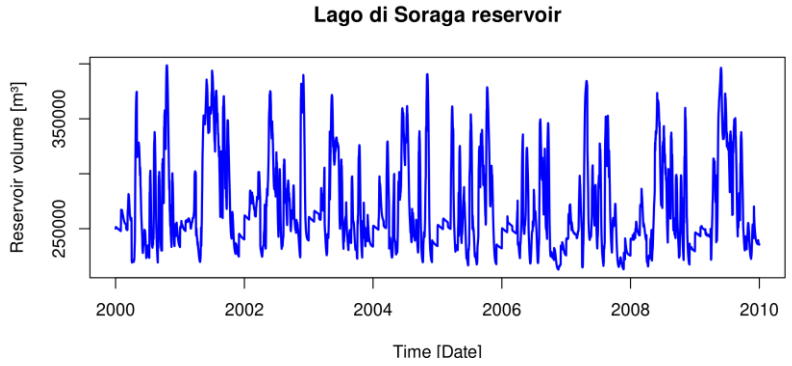
Results of calibration (dam modelling)

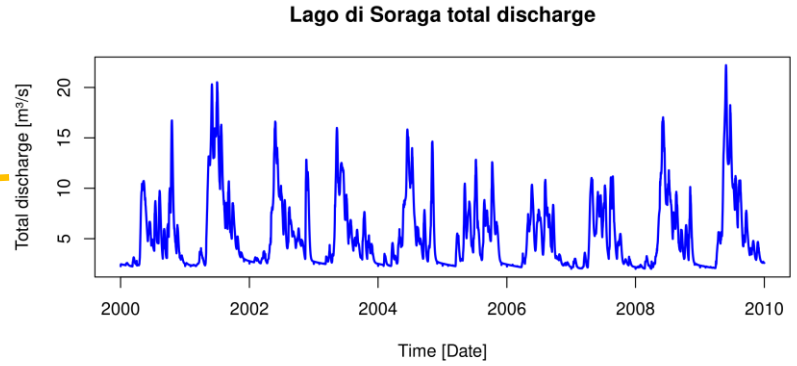


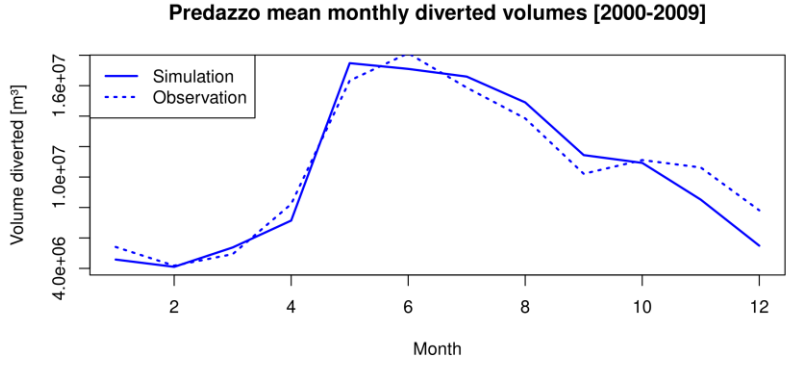












Conclusions and path ahead

Conclusions

- The model is calibrated against the discharge, able to mimic variation dynamic in discharge between low and high flows
- Different modules of the model allow to quantify components of the water cycle
- Makes it possible to model different types of droughts: Meteorological (precipitation), hydrological (River flows), Agricultural (soil moisture and groundwater)
- Dam modelling validated against pass diverted volumes; results are encouraging

- **Path ahead:**
- Implementation of irrigation
- EuroCordex / CMIP6: Verification of historical data results and fitting of future data
- Drawing findings regarding projection of extreme events (droughts / floods)

Thank you for listening!!!
Questions, feedback?

A special thanks to my supervisor Giuseppe Formetta

GEOframe essentials

GEOframe Summer School

GEOframe Winter School

OMS3 essentials

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Discussion Slide: KGE results