Earth Observations as key elements in the development of Water Information Systems and Decision Support Tools

[3 - Water for Liveability and Resilience]

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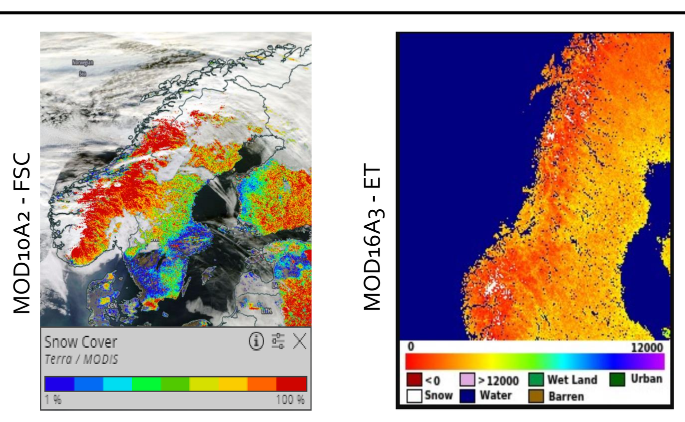
Introduction

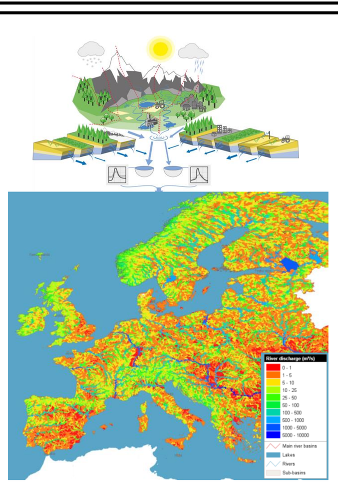
Freshwater resources are limited and face increasing pressures from drought, flooding, pollution, population growth, and competition from many uses. New water services perspective, integrating end-user dialogues in the water management process, play a decisive role in a number of water applications. Hydrological forecasting is a crucial aim in this process, since it allows predicting the available water resources, and therefore conditioning the final management decision to the end-user needs. Earth Observations (EOs) can provide an added value in hydrological services through the improvement of initial conditions for hydrological forecasting by their inclusion using Data Assimilation techniques. Therefore, the main aim of this study is to **improve hydrological modelling using EOs in a Data Assimilation scheme and consequently the initial hydrological state for hydrological forecasting.**

Methods

EARTH OBSERVATIONS



HYDROLOGICAL MODELLING
EHYPE

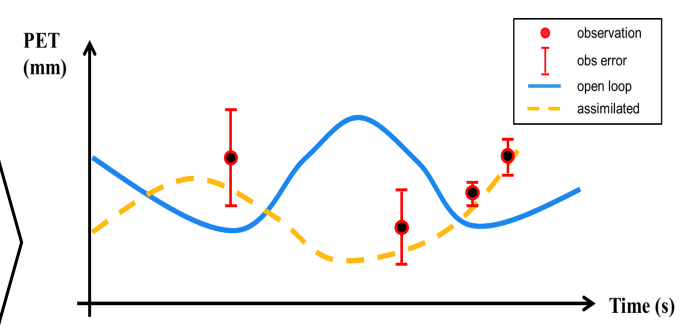


- **Semi-distributed** and process-based hydrological model (Lindström et al., 2010) applied across Europe
- The model resolution is given by **Hydrological Response Units** (HRUs)
- Each HRUs reflects an unique combination of **soil type/land cover** with specific set of parameters distributed all over the model domain (Hundecha et al., 2016)

DATA ASSIMILATION

Ensemble Kalman Filter, constitutes a stochastic formulation of the original Kalman Filter and simplifies the problem of the nonlinearity of the process thanks to the use of Monte Carlo simulations.

$$x^a = x^f + K(d - Hx^f)$$
$$K = P^f H^T\left(HP^f H^T + R\right)^{-1}$$

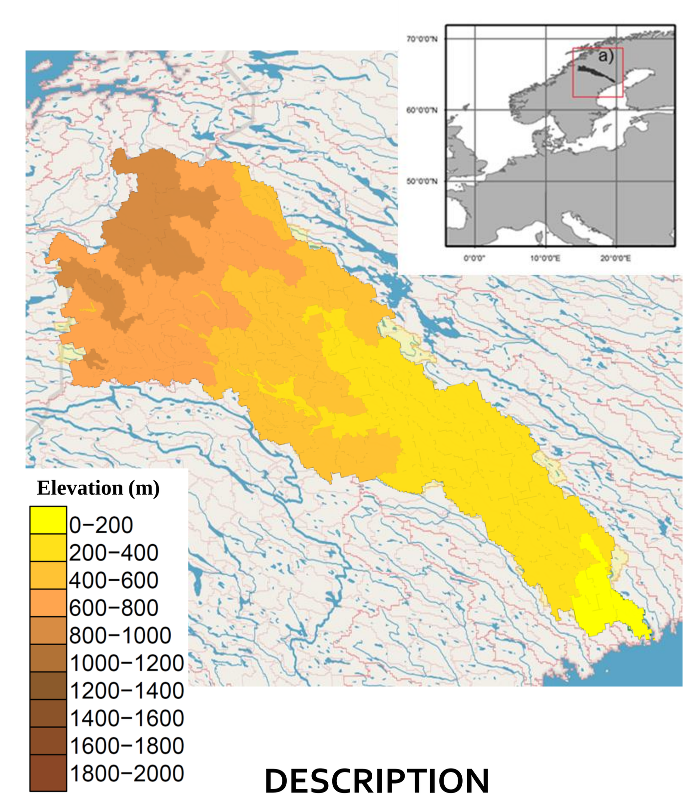


1) observation errors estimation : calculated based on the historical observation
2) model errors estimation
3) optimal ensemble size : sensitivity analysis

HYDROLOGICAL FORECAST

Study Sites

UMEÄLVEN



DESCRIPTION

Typical north European catchment highly influenced by snowmelt runoff
Two main branches (regulated and non-regulated)
High mountain and forest areas

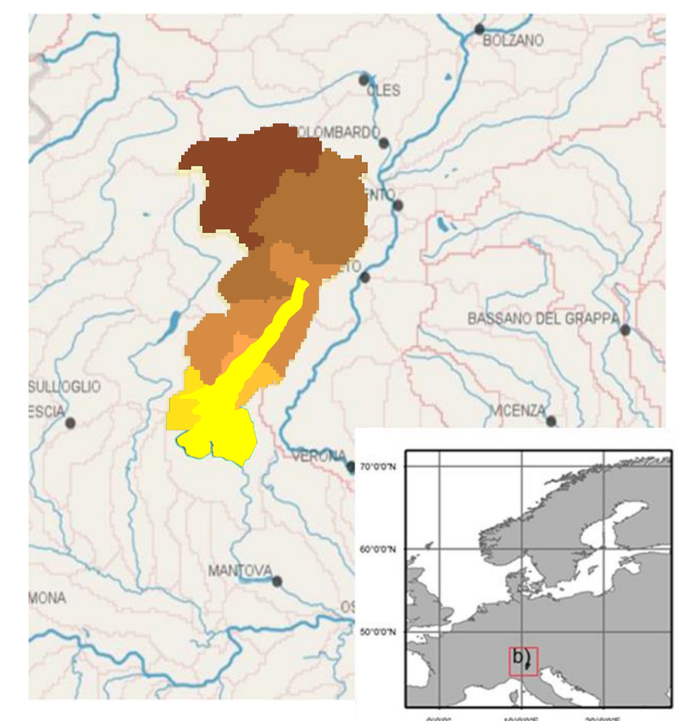
E-HYPE

121 subbasins – 15.000 km²
mean elevation– 400 m

Earth Observations

EO	Data source	Spatial res	Temporal res
FSC	Cryoland	500x500m	Daily
SWE	Cryoland	500x500m	Daily
ET	MODIS	1x1 km	Monthly
PET	MODIS	1x1 km	Monthly

LAKE GARDA



DESCRIPTION

Largest Italian lake (area – 368 km² and 49 hm³)
Alpine catchment
River Sarca is the main river flowing into the lake
Heterogenous land use distribution

E-HYPE

4 subbasins – 2.100 km²
mean elevation – 1050 m

Earth Observations

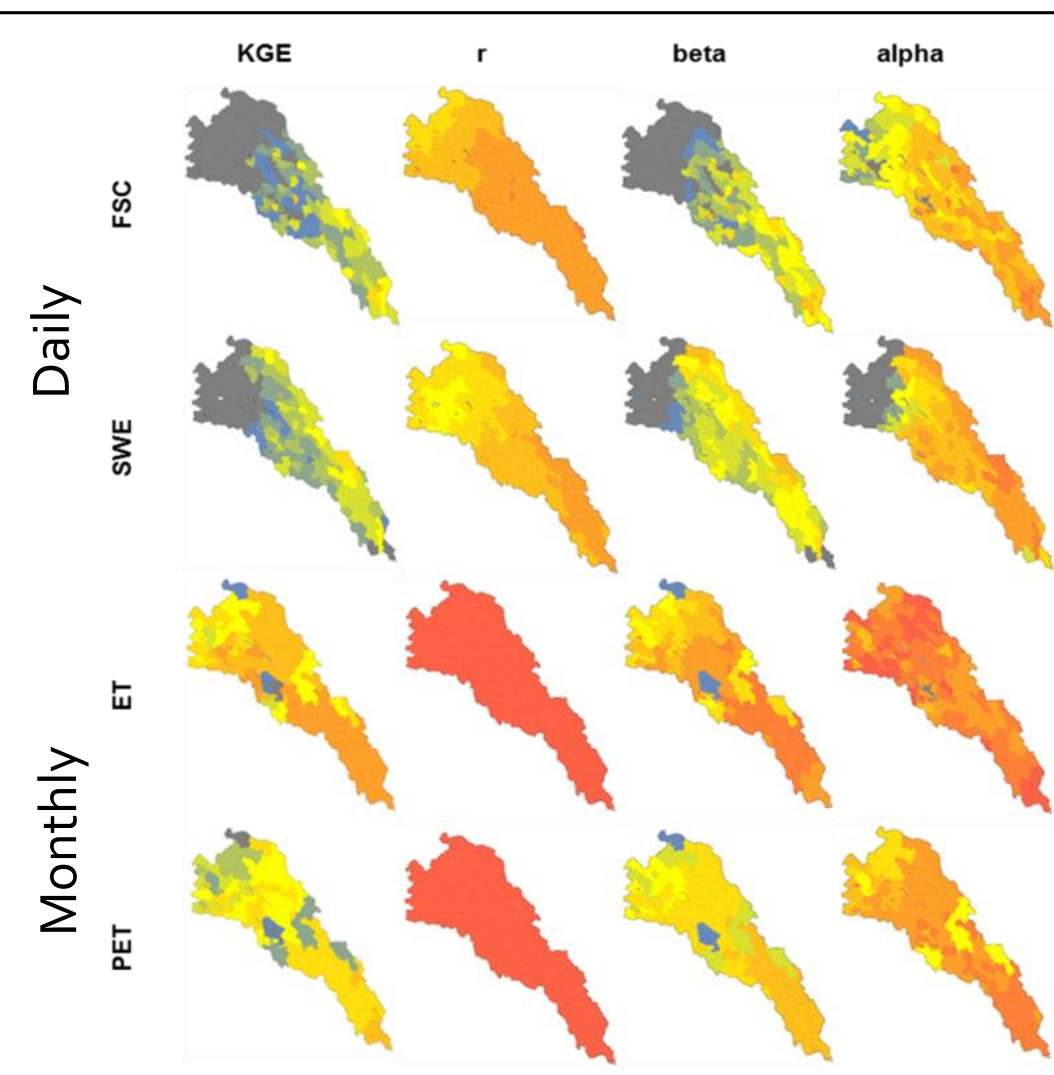
EO	Data source	Spatial res	Temporal res
FSC	EURAC	250x250 m	Daily
SWE	Cryoland	500x500m	Daily
ET	MODIS	1x1 km	Monthly
PET	MODIS	1x1 km	Monthly

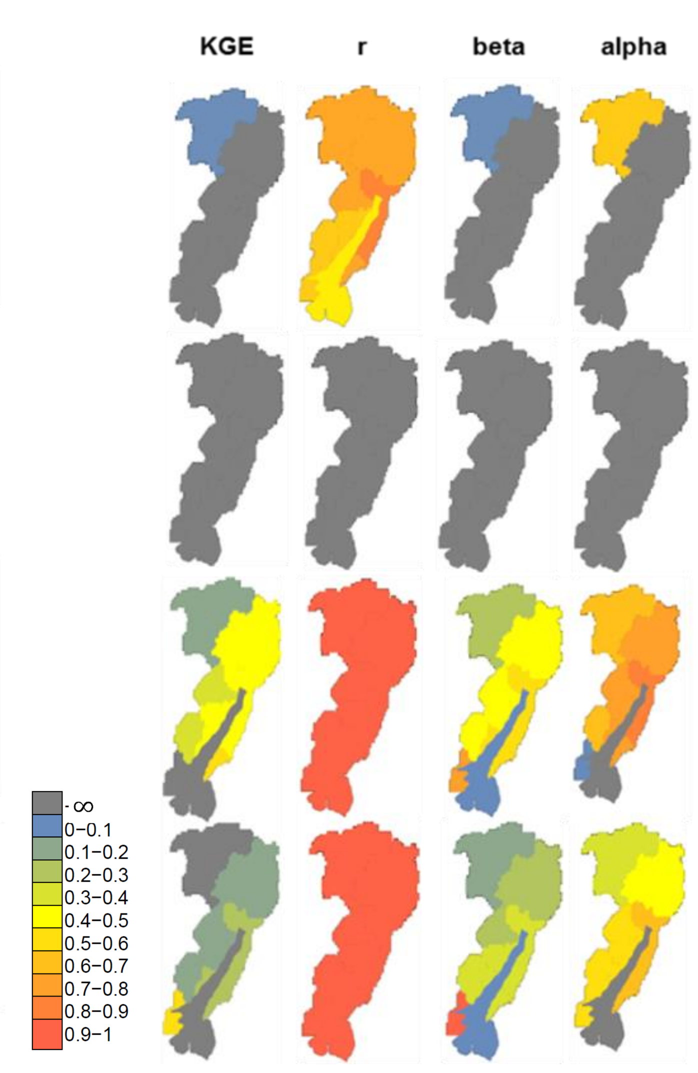
Results & Discussion

A) EHYPE vs EO

UMEÄLVEN

- The performance of snow variables presents a clear **decreasing trend related with the elevation**. The long gaps of information during winter due to short duration of the days is the main cause of this difference.
- Nevertheless, **the timing and the variability are well captured (correlation coefficient and alpha metrics)**.
- Evaporation variables are better represented by the model. Monthly scale helps to homogenize the variability in the simulations and allow achieving better performances in comparison to snow variables.



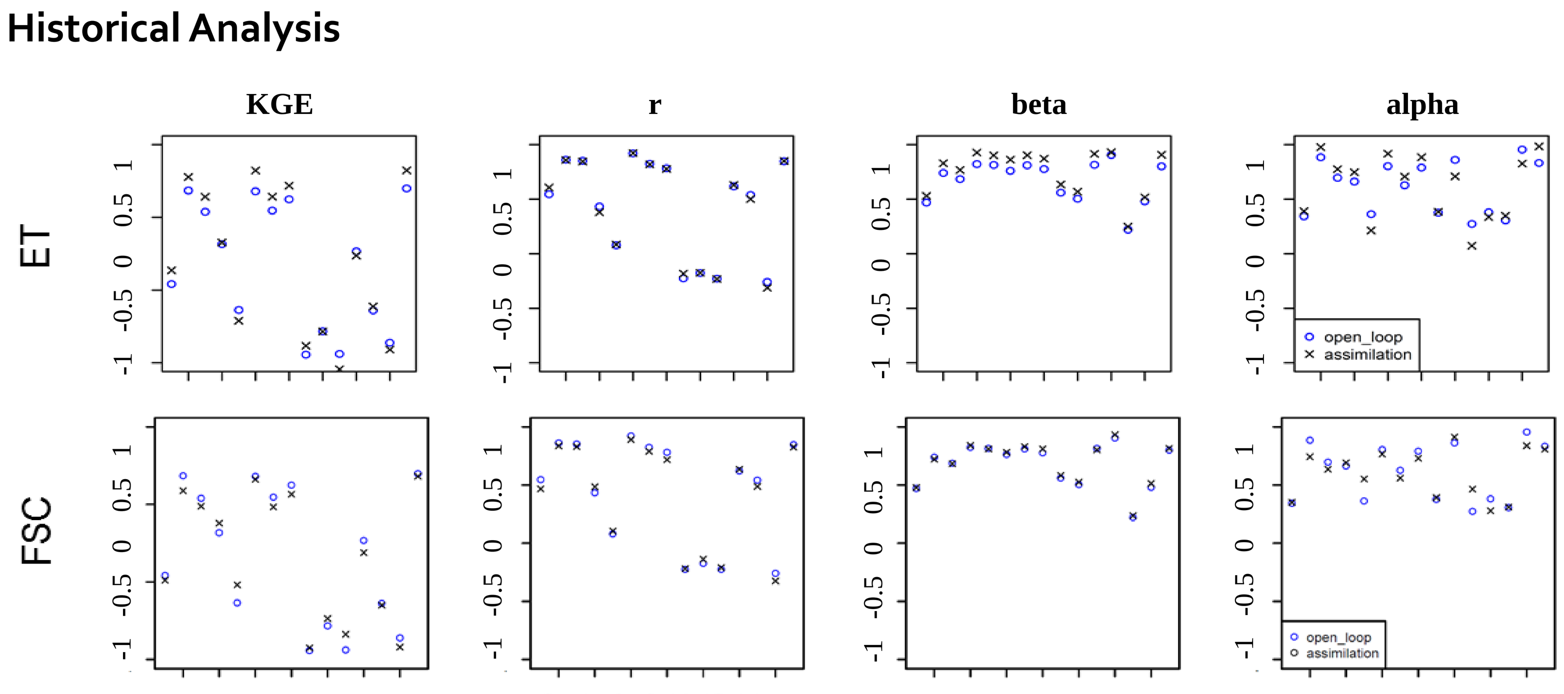


LAKE GARDA

- Snow is not adequately represented; only FSC in the high elevation sub-basin is captured. In general, the highly changeable snow conditions over this area make difficult its correct representation.
- Results for evaporation variables show a decreasing performance with elevation, this is due to the large elevation range in this catchment.

B) DATA ASSIMILATION

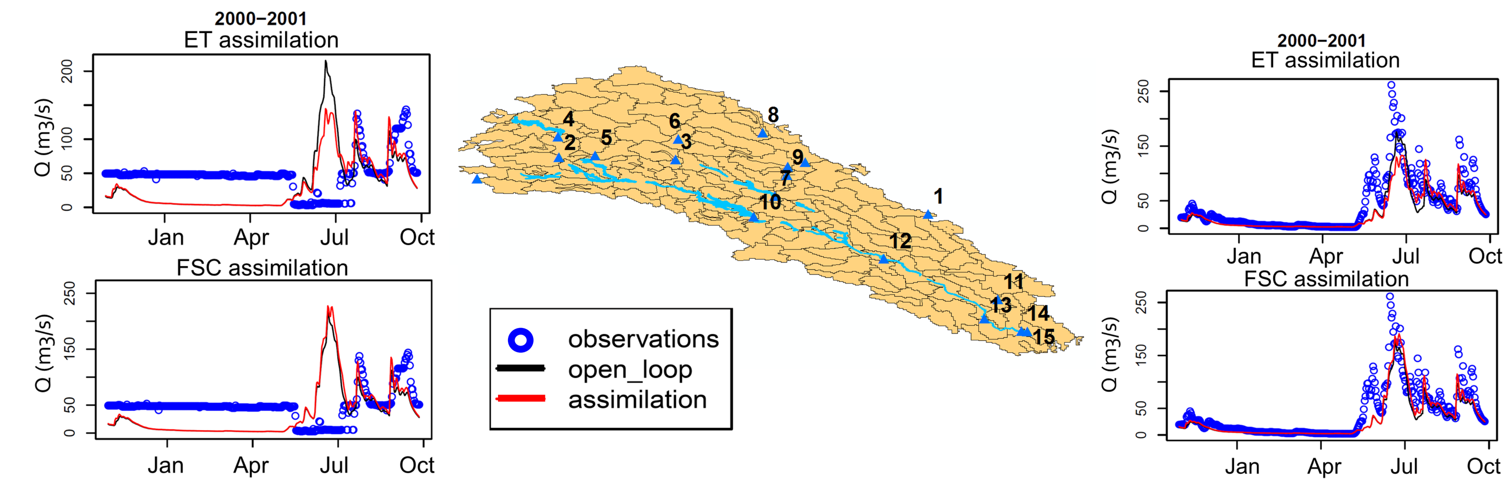
I) Historical Analysis



- The results **show higher improvements when ET is assimilated in comparison to FSC**, approximately 0.08 versus 0.005 in term of KGE for ET and FSC respectively
- The improvement is higher where the model already had a relatively good performance. This suggests that the model parameterization under certain conditions can limit the potential of assimilation to improve the streamflow predictions

II) Temporal evolution

- FSC assimilation only improves in certain catchments. The catchments with high improvements are those that are not regulated and therefore snow natural conditions have a clear impact on the river flows. When the catchments are regulated the impact of the snow on the outflow is completely reduced. It suggests that to evaluate the impact of assimilation of FSC in regulated watershed, the selected variable should be the input flow into the reservoirs and not the output one.



Conclusions

This study shows the potential of EOs to improve streamflow performance under certain conditions, and also point towards structural inconsistencies. The assimilation of EOs in hydrological modelling can also secure a right for the right reasons model. This opens the opportunity to produce water information systems and decision support tools based on near real-time EO products, setting a step forward in operational services.

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