Improving river flow modeling with the integration of dams-reservoirs and the use of the future altimetry SWOT mission

Malak Sadki(1), Simon Munier(1), Aaron Boone(1)
(1) CNRM – Université de Toulouse, Météo-France/CNRS – Toulouse, France
malak.sadki@meteo.fr

Context

The management of water resources is considered to be a major challenge for the coming century, particularly in the context of climate change and increasing demographic pressure. Water resources are directly linked to the continental water cycle and its processes are mainly described by hydrological models. ISBA-CTRIP, developed at the CNRM, is an example of a coupled land surface – river routing model used for this purpose. However, anthropogenic impacts on water resources, and in particular the effects of dams and their associated reservoirs on river flows, are still poorly known and generally neglected in global hydrological models, including ISBA-CTRIP.

Objectives

- Improving the CTRIP river routing model by integrating the effects of dams-reservoirs

- Investigating the contribution of SWOT observations for the parametrization of the reservoir model

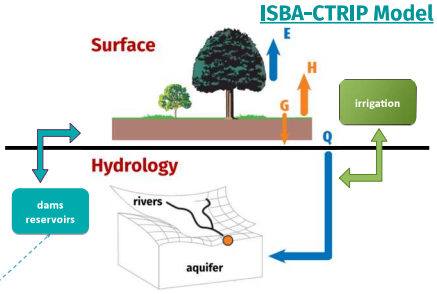
→ Better understand, through modeling, the impact of anthropisation on regional scale water resources.

Modeling chain

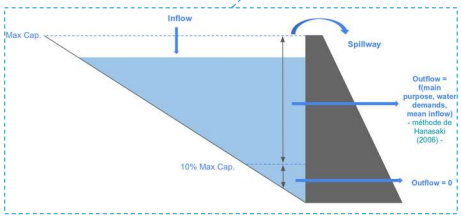
ISBA
Land Surface Model
Mass and energy balance at the soil-atmosphere interface

CTRIP
Routing Model
Water flow in rivers, aquifers and flood plains

ISBA-CTRIP Model



Reservoir Model



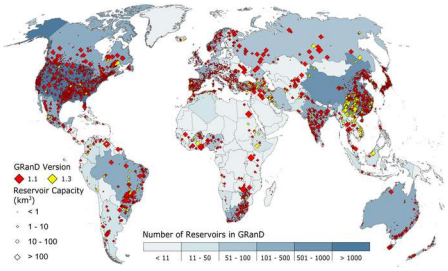
Parameterized reservoir model based on ***Hanasaki's scheme*** (*Hanasaki et al., 2006*) :

→ Difference between irrigation and non-irrigation reservoirs
→ Mass balance in the reservoir
→ Monthly releases based on **inflows** (**observed**) and **water demands** (**irrigation model**)

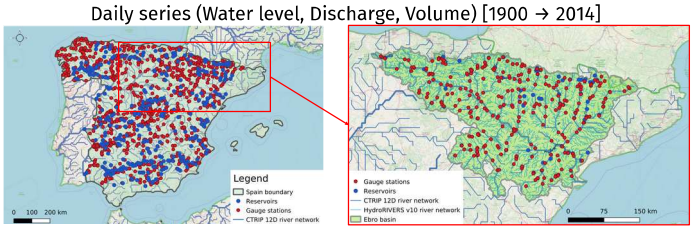
Observed Data

→ Global scale:
7320 referenced reservoirs
Storage capacity > 0.1 km³
(version v1.3, 2019) :
Georeferencing
+ Reservoir area
+ Attribute information

GRanD DataBase Lehner, B. et al., 2011



Spain DataBase
Daily series (Water level, Discharge, Volume) [1900 → 2014]



1119 gauging stations / **347** reservoirs

280 gauging stations / **68** reservoirs

Impact of the reservoir model (default parameters) on river flow modeling in Spain

Forcing
- Inflow
- Irrig. demand

Parameters (7) & Reservoirs characteristics (Main purpose, Max. Cap)

Reservoir Model

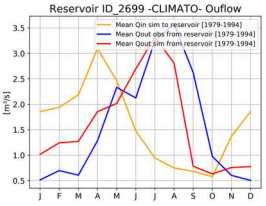
Observed data
- *Outflow*
- *Volume*

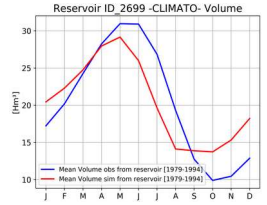
Output
- Outflow & Volume
- Performance indices

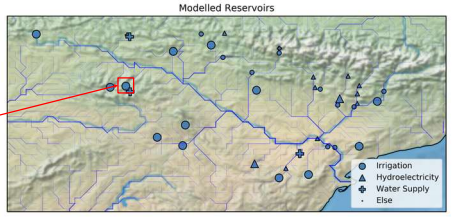
Reservoir modeling diagram

Ebro :

Irrigation reservoir 'Gonzalez lacasa'

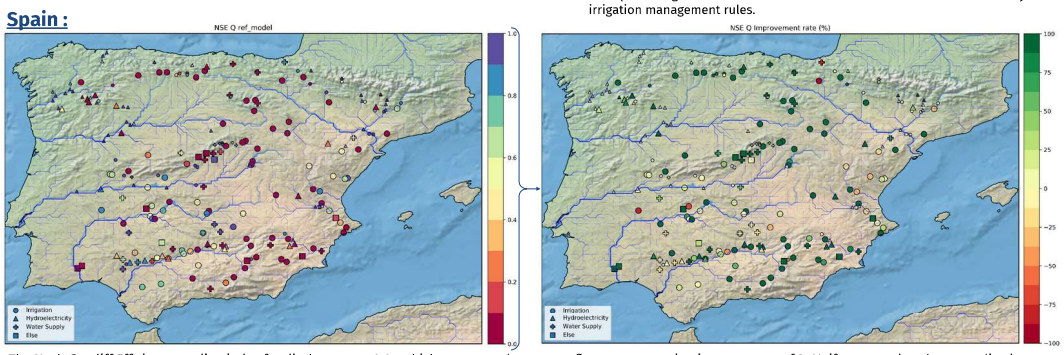






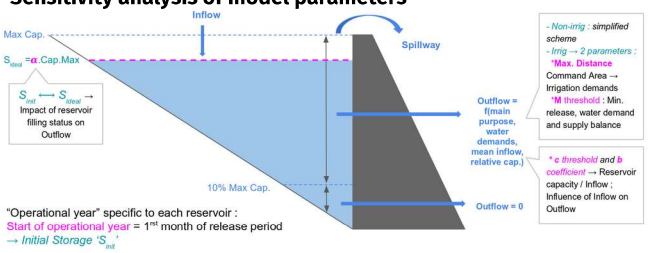
Improving the representation of the seasonal cycle of discharge and storage variation, specifically for irrigation large-storage capacity reservoirs
→ reproducing the seasonal shift between inflows and outflows caused by irrigation management rules.

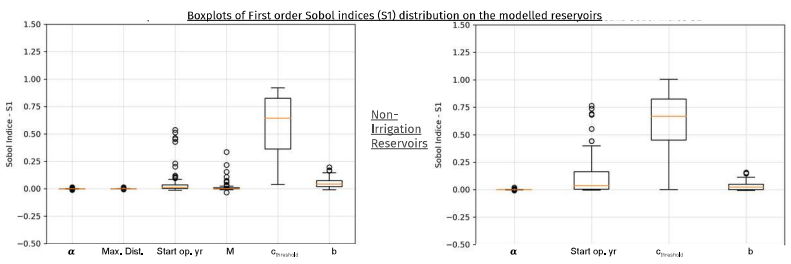
Spain :



The Nash-Sutcliff Efficiency median index for discharge was 0.67, which corresponds to an outflow representation improvement of 25%, if compared to the naturalized representation of river flows. For irrigation reservoirs, the improvement rate reaches 50% in the median.

Sensitivity analysis of model parameters





A sensitivity analysis has been conducted for the model parameters : *Sampling with Saltelli Method (size = 33 000 | 25 0000) (Saltelli A., 2002) / Computing first and total order Sobol indices*

Conclusions :

- Better representation of the seasonal cycle of discharge and storage variation for reservoirs
- Extensive sensitivity analysis based on different pools of reservoirs (irrig/non-irrig, small/large capacity)

Perspectives :

- Integration within the CTRIP model and coupling with ISBA (water supply for irrigation depending on dam releases and reciprocally) → Extension to other regions / global scale
- SWOT data assimilation : calibrating reservoir model parameters

References

- Decharme B., Delire C., Minvielle M., Colin J., Vergnes J.-P., Alias A., Saint-Martin D., Séférian R., Sénési S., Voldoire A. (2019). Recent changes in the ISBA-CTRIP land surface system for use in the CNRM-CM6 climate model and in global off-line hydrological applications. J. Adv. Model. Earth Syst., 11(5), 1207–1252.
- Hanasaki N., Kanae S., and Oki T. (2006). A reservoir operation scheme for global river routing models, J. Hydrol., 327, 22–41.
- Lehner, B., Liermann, C. R., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., Döll, P., Endejan, M., Frenken, K., Magome, J., Nilsson, C., Robertson, J. C., Rödel, R., Sindorf, N., and Wisser, D. (2011). High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management, Front. Ecol. Environ., 9, 494–502.
- Saltelli A. (2002). Making best use of model evaluations to compute sensitivity indices. Computer Physics Communications , 145(2),280–297.