Understanding the hydroclimatology of the world's largest tropical watersheds: The use of remote sensing and modeling in the Amazon and Congo basins

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1. Introduction

- The **Amazon (ARB)** and **Congo (CRB)** river basins are the largest in terms of drainage area (~6 and ~3.7 million km^2, respectively) and flow exported to the oceans with an annual average of 206x10^3 and 41x10^3 m^3 s^{-1} (Laraque et al., 2020).
- Home of a large percentage of the **world's tropical forests**, which plays a crucial role in the local, regional, and **global climate**, hydrological and biogeochemical cycles (Nogherotto et al., 2013).
- Guarantees fundamental **ecosystem services** to the population such as food provisioning, biodiversity conservation, climate and freshwater regulation, and mitigation of natural disasters. However, these regions are now facing risk under **climate and anthropogenic changes** (Casagrande et al., 2021).

2. Objectives

1. Study the spatio-temporal variability of flow and water levels over the past 30 years (Hydrological Reanalysis).
2. Analyze the potential effects of future climate on the hydrology (e.g., discharge and water level).
3. To understand the relationships between hydroclimatic variability and local-regional or global atmospheric and oceanic processes.

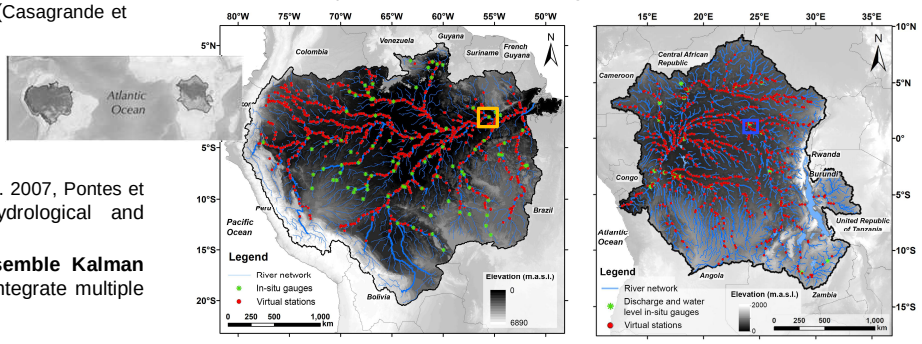
3. Data and methods

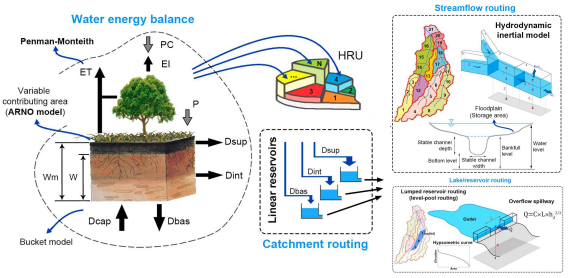
3.1. The MGB model and Data assimilation

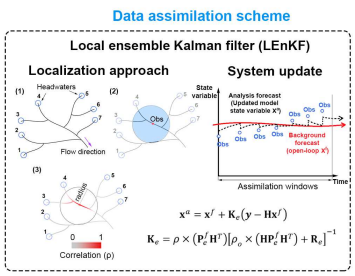
- The **hydrological-hydrodynamic MGB model** (Collischonn et al. 2007, Pontes et al., 2017) is a large-scale, distributed, process-based hydrological and hydrodynamic model.
- The sequential DA method, the **multi-observation local ensemble Kalman filter (MoLEnKF)**, is implemented and designed to effectively integrate multiple variables simultaneously (Wongchuig et al., 2024).

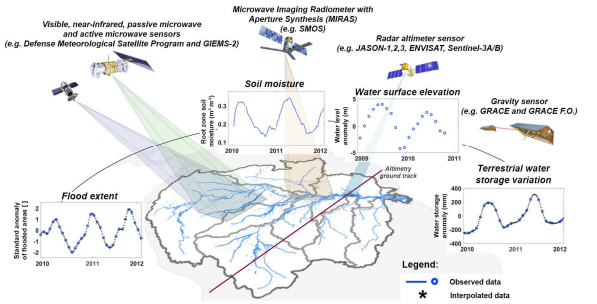
3.2. Study area and data

- We use information from **in-situ observations** and **remote sensing**, as well as atmospheric and oceanic **reanalysis data**.





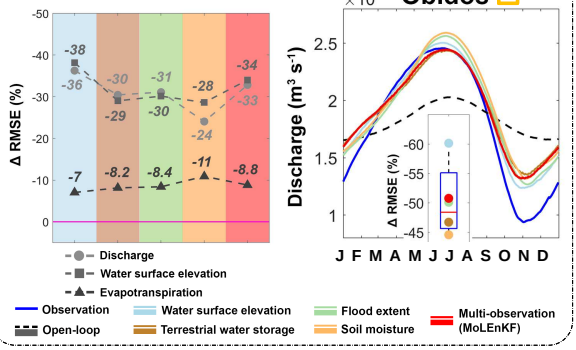




4. Ongoing results and conclusions

Amazon Hydrological Reanalysis (2000-2020)

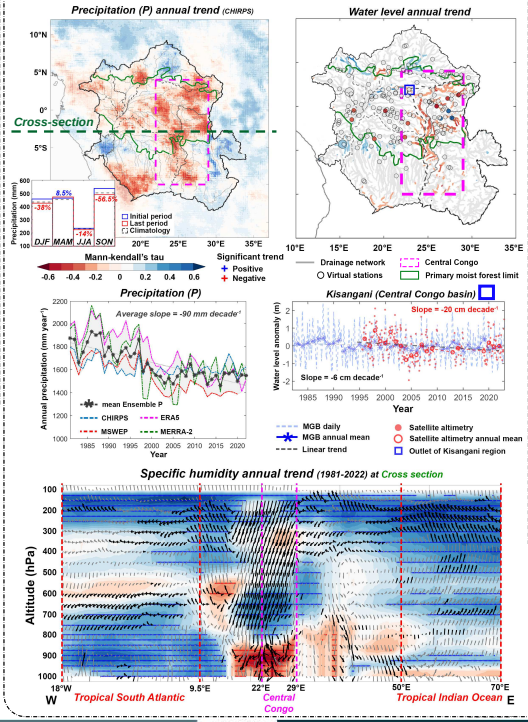
- **MoLEnKF** was able to improve the timing and amplitude of discharge (Q), water surface elevation (WSE) (not shown) and evapotranspiration (ET) (not shown) in a **weighted manner** among each individually assimilated observation (e.g. Óbidos station).
- **MoLEnKF** provides an **intermediate condition**, being able to holistically outperform univariate experiments. Its robustness ensures **replicability worldwide**, facilitating hydrological reanalysis and improved forecasting.



Drying of the central Congo (1981-2022)

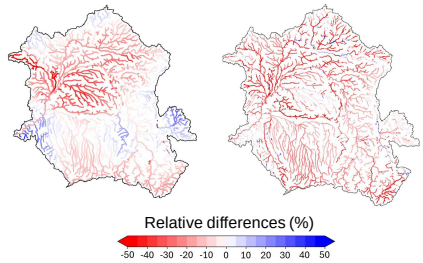
Meteorological and hydrological level:

- The central CRB (magenta rectangle) shows a decreasing trend in **P**, with an average of **-90 mm** per decade, and an increasing in **PET** (not shown) of **30 mm** per decade.
- **River discharges** (not shown) and **water levels** are significantly decreasing over the central CRB, around **-240 m^3 s^{-1}** and **-6 cm** (**-20 cm** from radar altimetry).



Projections of the Congo's hydrology (2070-2100)

- 14 out of 28 GCMs from **CMIP6** with the **ssp585 scenario** were chosen to force the **MGB model**, called as a multi-model ensemble (MME).
- The inter-period (2070-2100 and 1984-2014) analysis difference revealed mostly a **decrease in discharge** exceeding 25% in Sangha, Ubangui (northern regions) and Middle Congo regions by 2100.
- There is a systematic **increase of drought intensification** by about 30%.
- This pattern of decreasing discharge is mainly explained by the systematic **increase in surface temperature**, from 4°C to 5°C on average.



Potential drivers:

- A significant decrease in **specific humidity** at low levels, and a significant increase in **atmospheric subsidence** at different atmospheric levels over the central CRB.

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