EGU General Assembly 2022 | 23-27 May 2022 | Vienna, Austria
"Water Level, Storage and Discharge from Remote Sensing and Assimilation in Hydrodynamic Models"

Congo Basin Water Resources Research Center

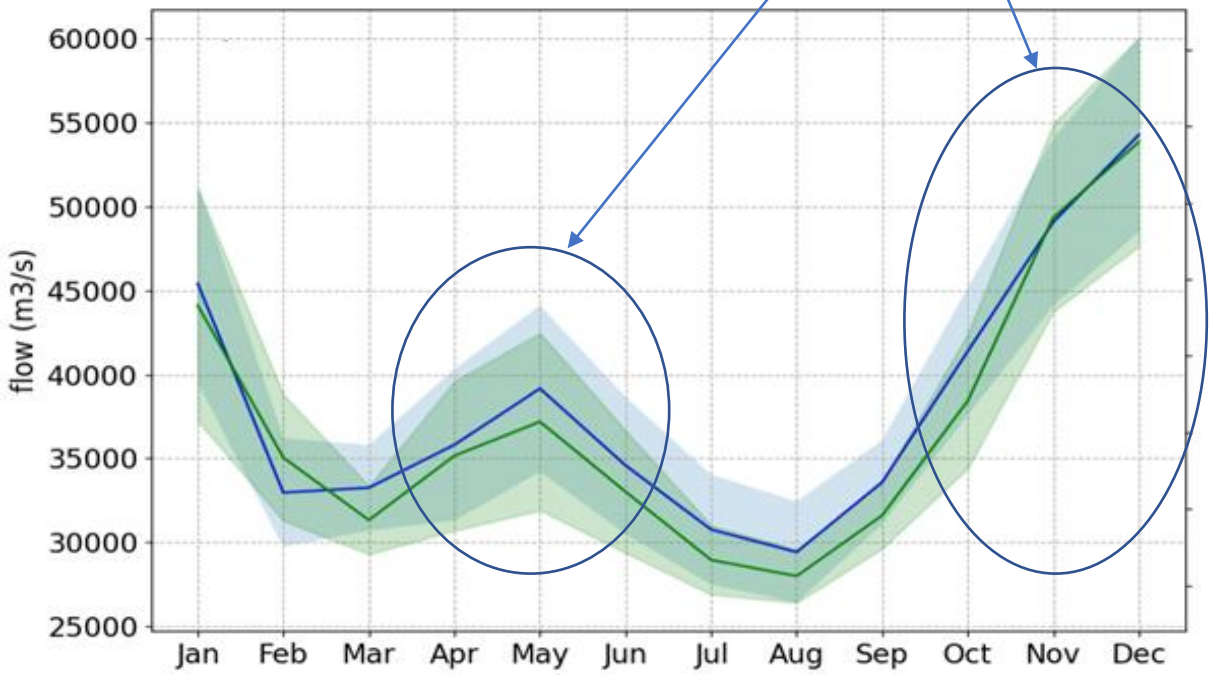
# Large-scale spatio-temporal variability of the Congo Basin surface hydrologic components from space

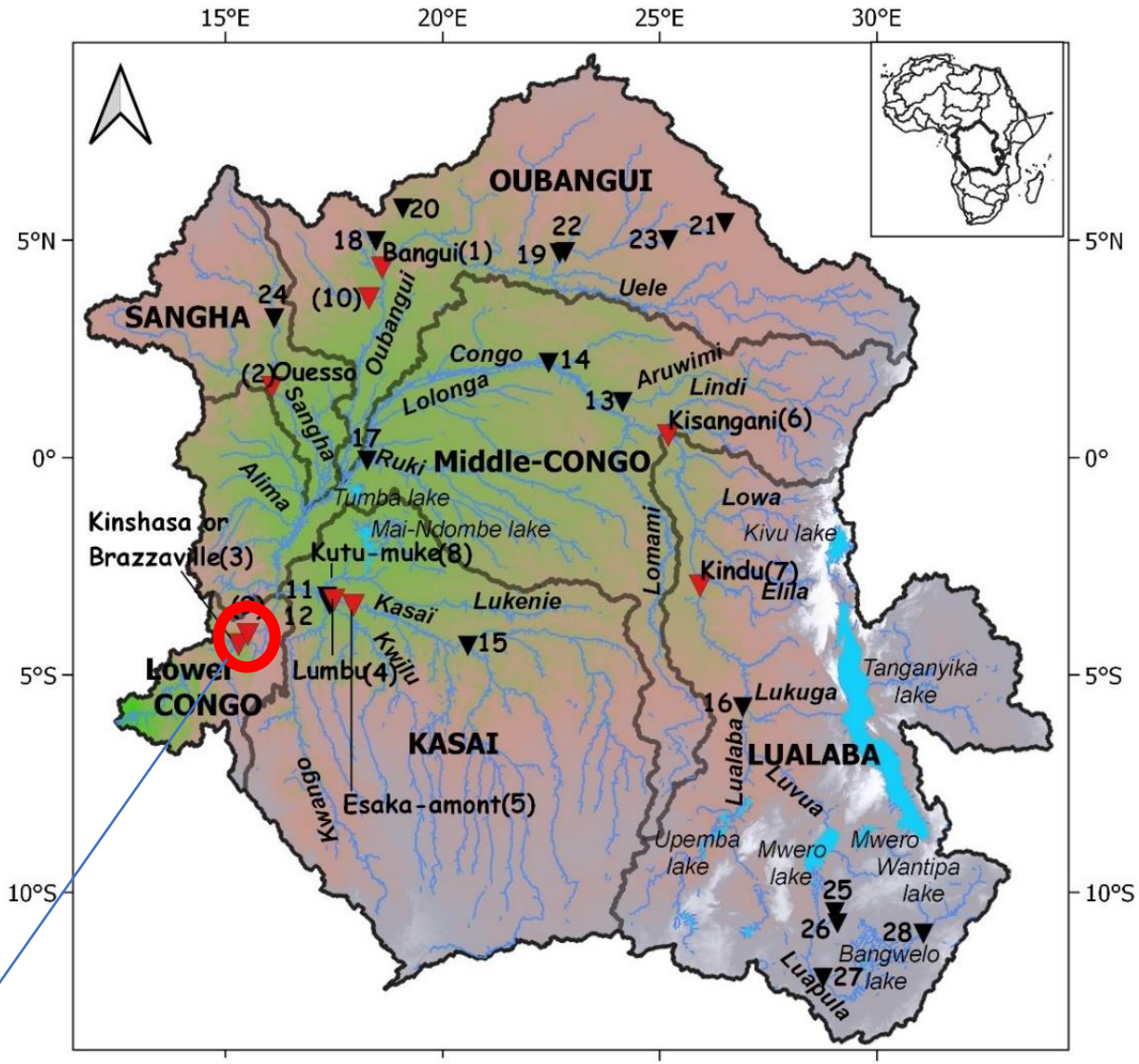
Benjamin Kitambo[1,4], Fabrice Papa[1,2], Adrien Paris[3,1], Raphael Tshimanga[4], Frédéric Frappart[5] and Stephane Calmant[1,2]

*Laboratoire d'Etudes en Géophysique et Océanographie Spatiales[1] (LEGOS)*
*Institut de Recherche pour le développement[2] (IRD)*
*Hydro Matters[3]*
*Congo Basin Water Resources Research Center[4] (CRREBaC)*
*Institut National de Recherche pour l'Agriculture, l'alimentation et l'Environnement[5] (INRAE)*

# Study area : Congo River Basin (CRB) - context- rationale

- Second largest river system in the world
  - ➢ Drainage area: ~3.7 × $10^6$ $km^2$
  - ➢ Mean water discharge: ~40.500 $m^3s^{-1}$
- Flow marked by its <u>bimodal hydrological regime</u>



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➡ Understanding, monitoring, management, forecasting CRB large freshwater systems

- Limited understanding of the large-scale variability of the surface hydrologic components and their link with climate (*Munzimi et al., 2019*)
- Less in-situ records to understand and monitor water availability (*Laraque et al., 2020*)
- Yet an increasing quantity of long-term earth observation datasets to complement and extend in-situ records (*Alsdorf et al., 2016*)

# Scientific questions

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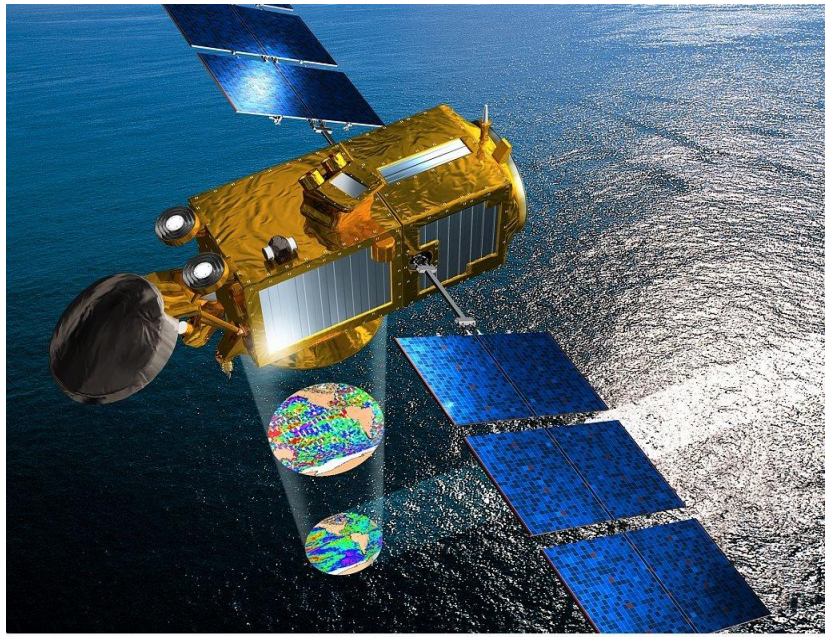

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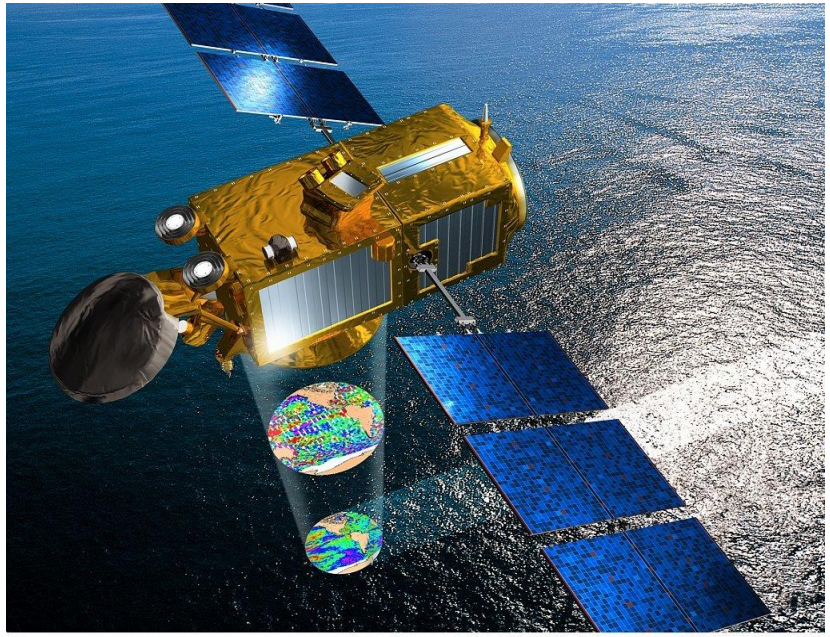


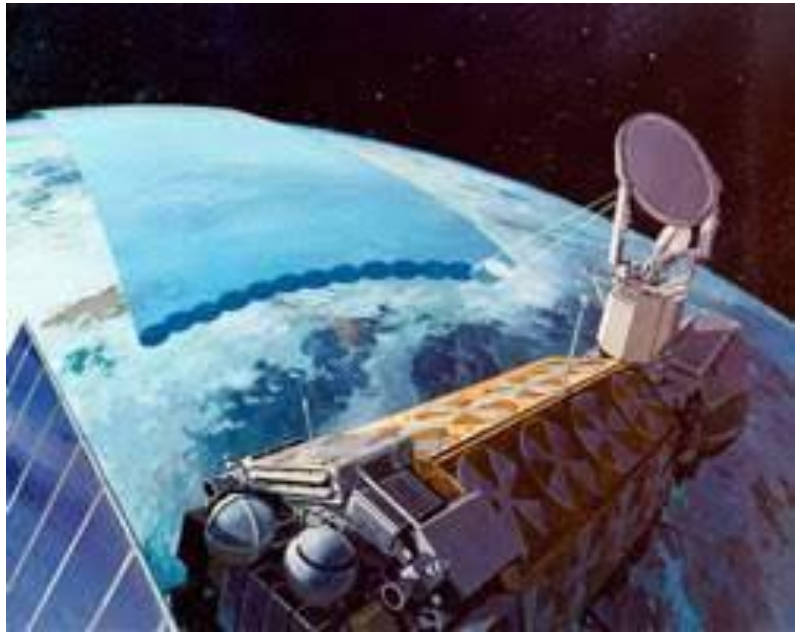

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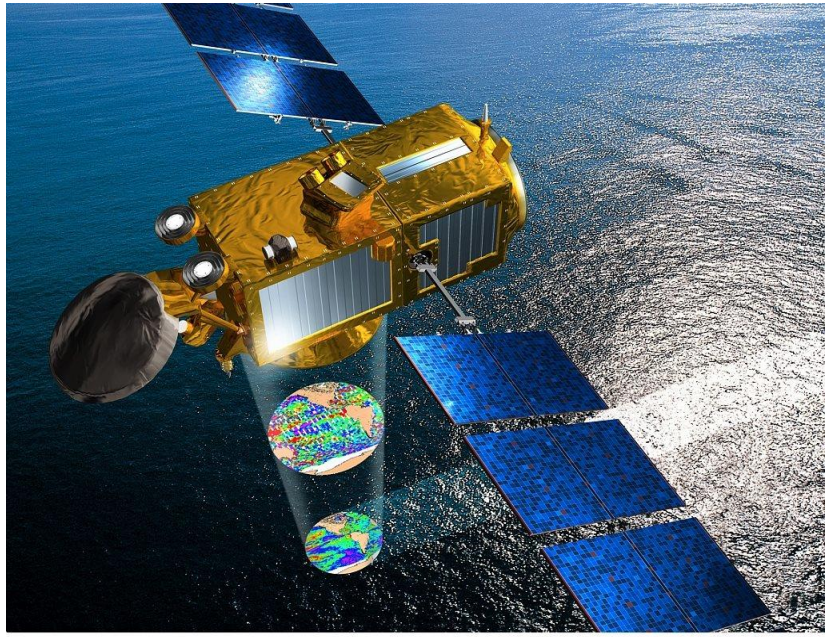
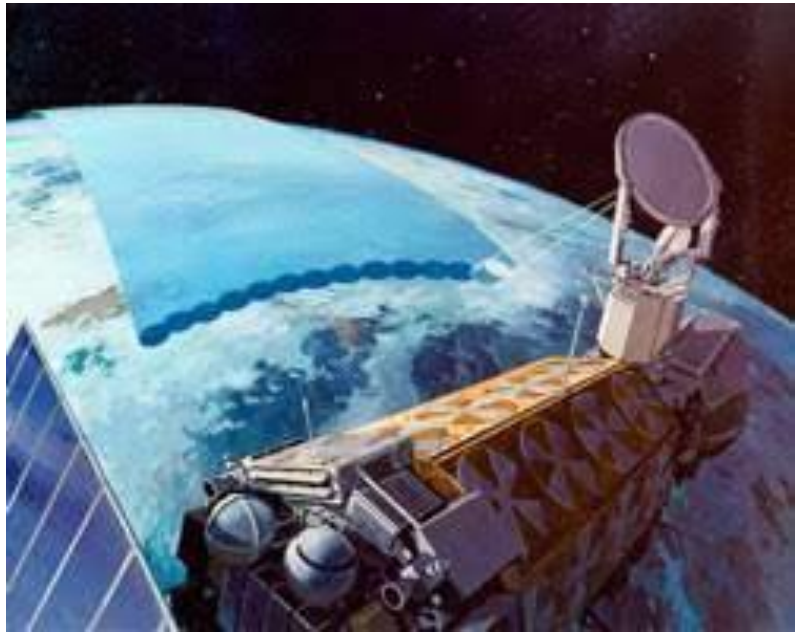
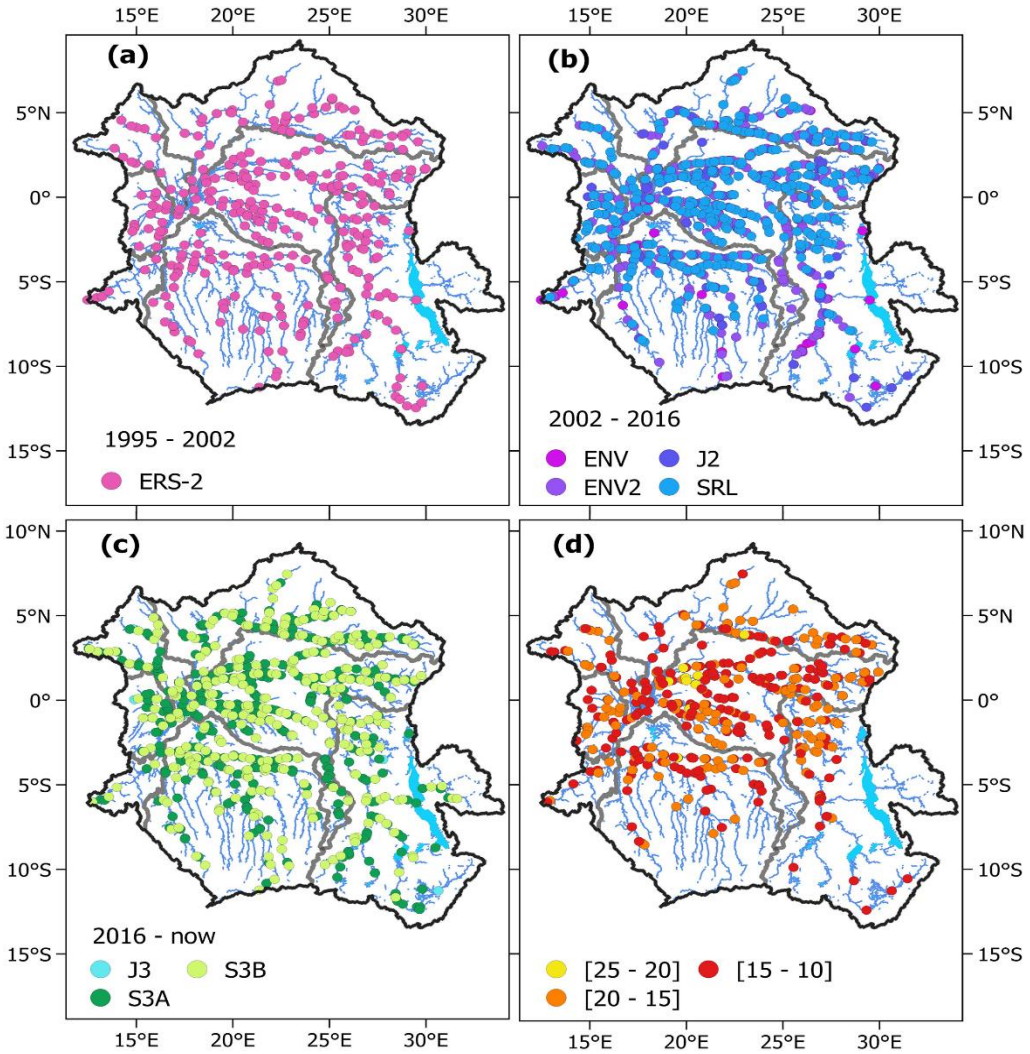


# Surface water height (SWH) dataset from radar altimetry




*Locations of **~2,311** VSs from multi-satellite missions. (d) actual long time series*

*VSs covering the **1995-2020** period were used in our research*

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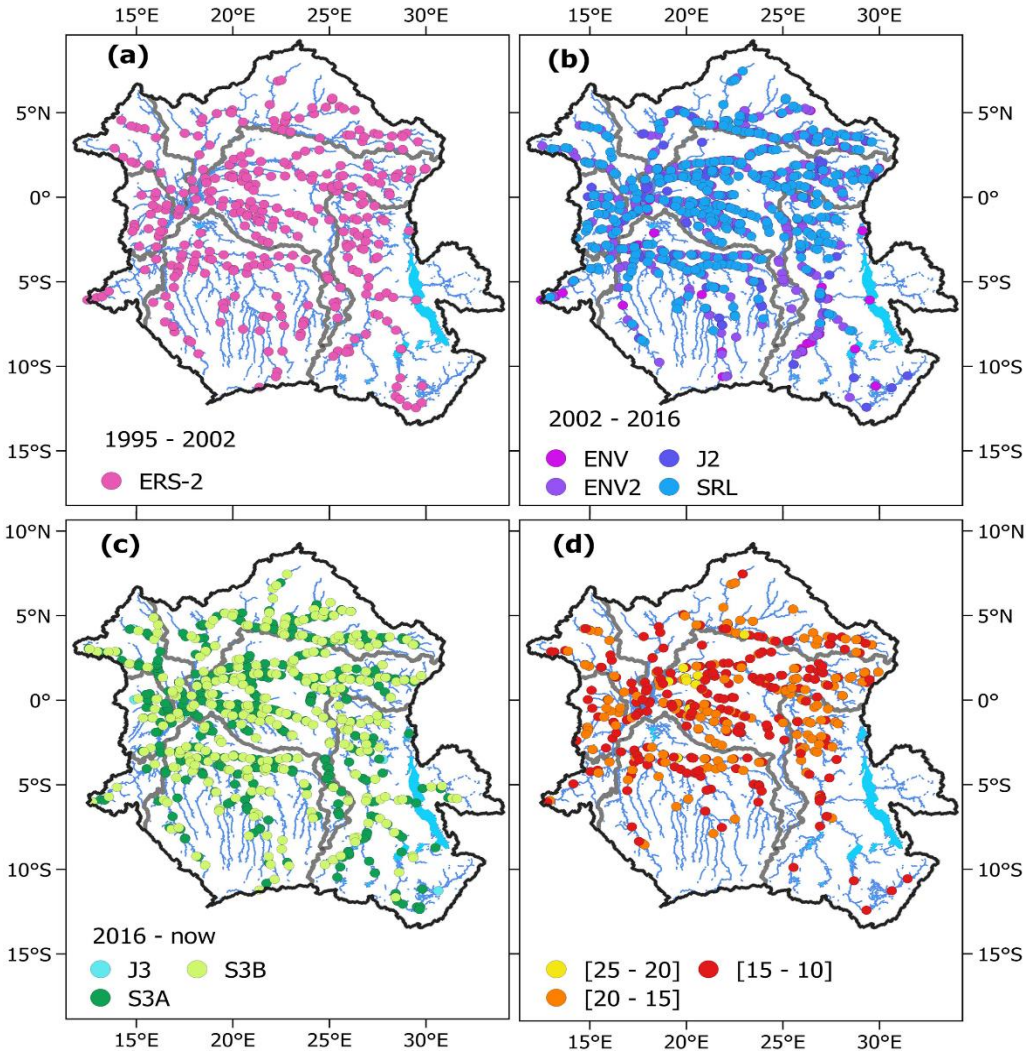


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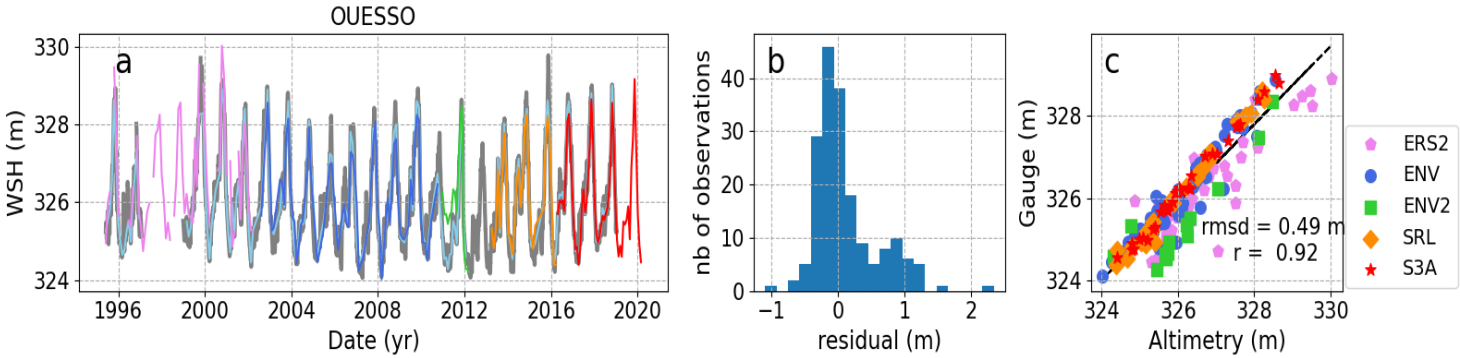


*Comparison of in-situ water levels and altimeter-derived SWH*

*Good agreement between in-situ water levels and altimeter-derived SWH*

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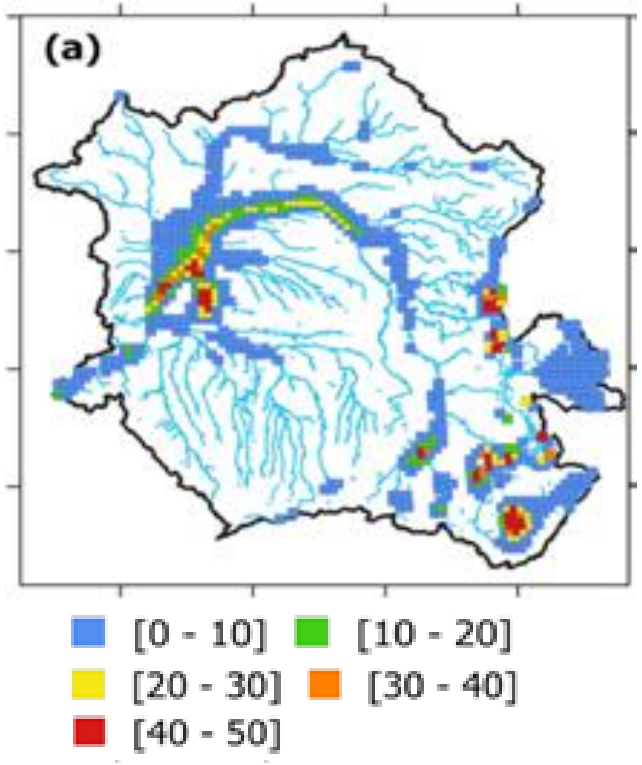
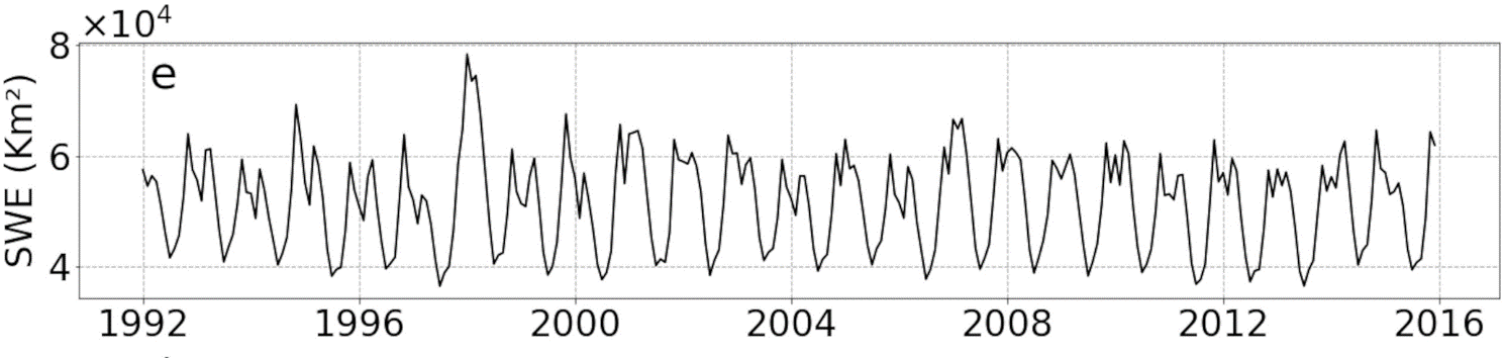



*Mean extent*




*Time series of surface water extent (SWE)*

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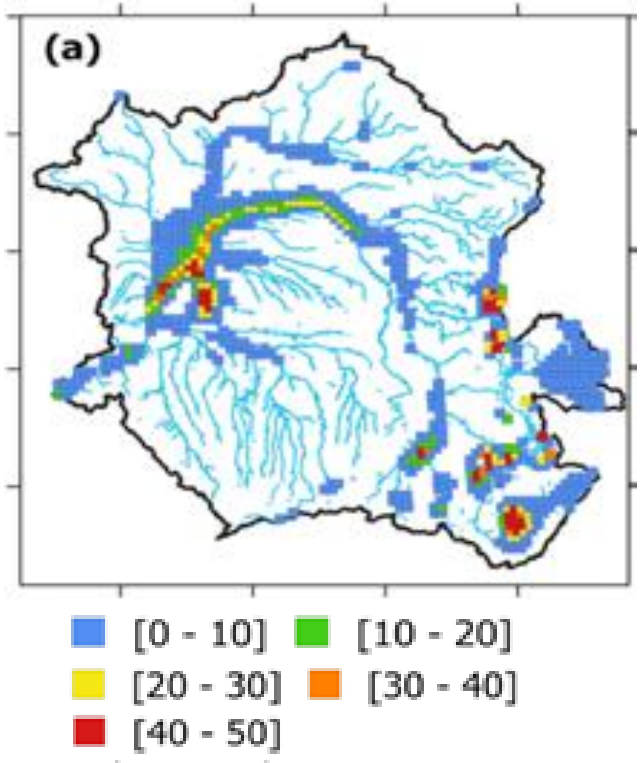


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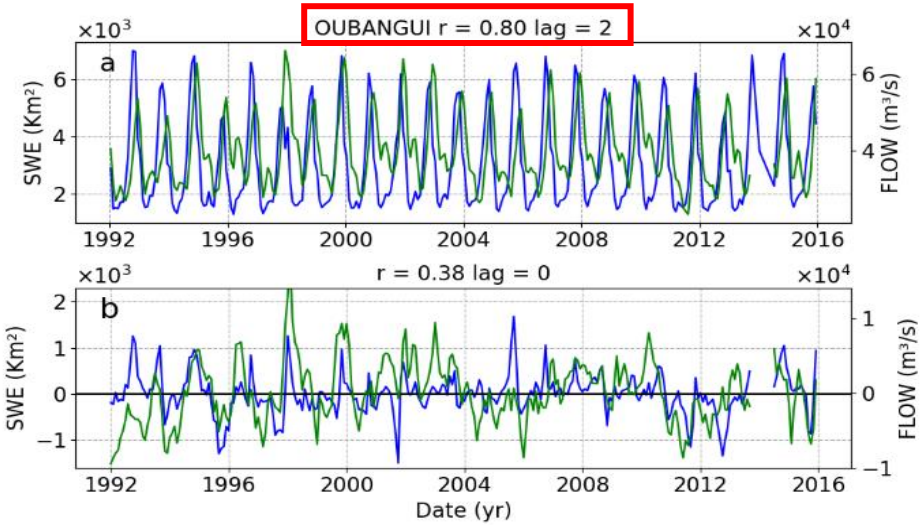
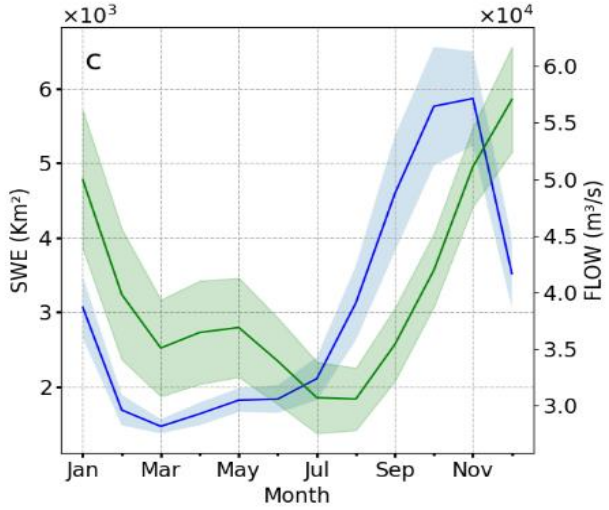
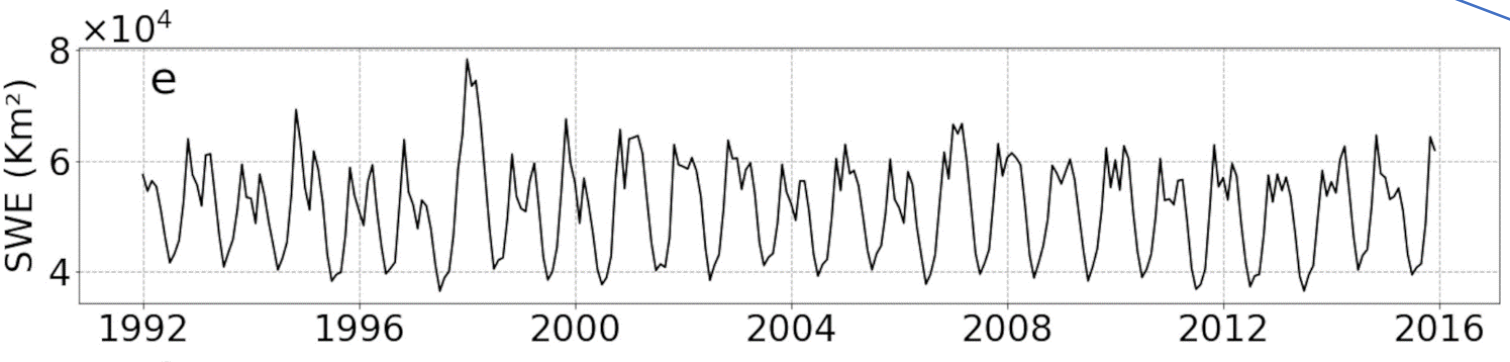



*Correlation between SWE$_{sub-basin}$ versus discharge at Brazzaville/Kinshasa station*

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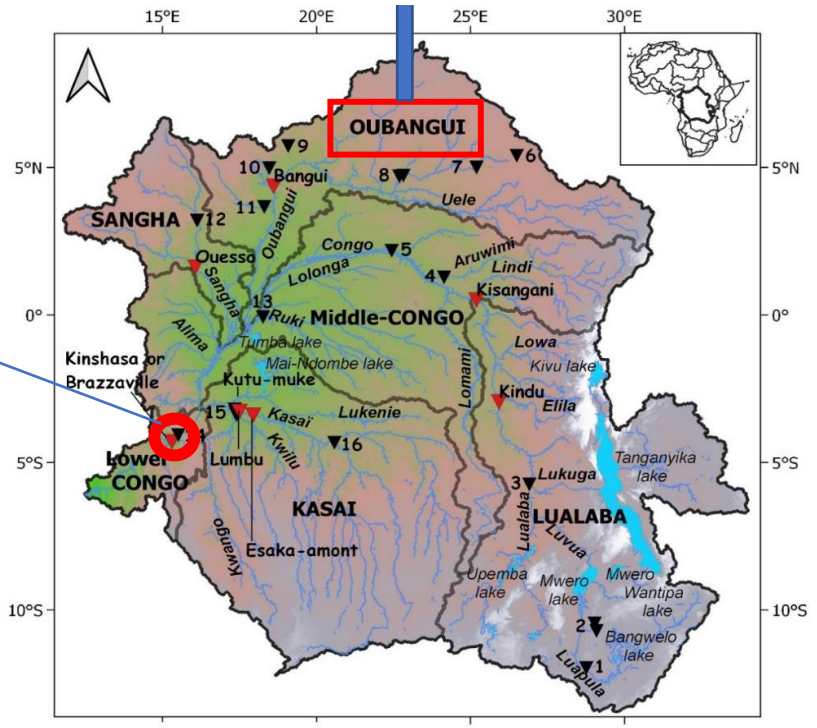

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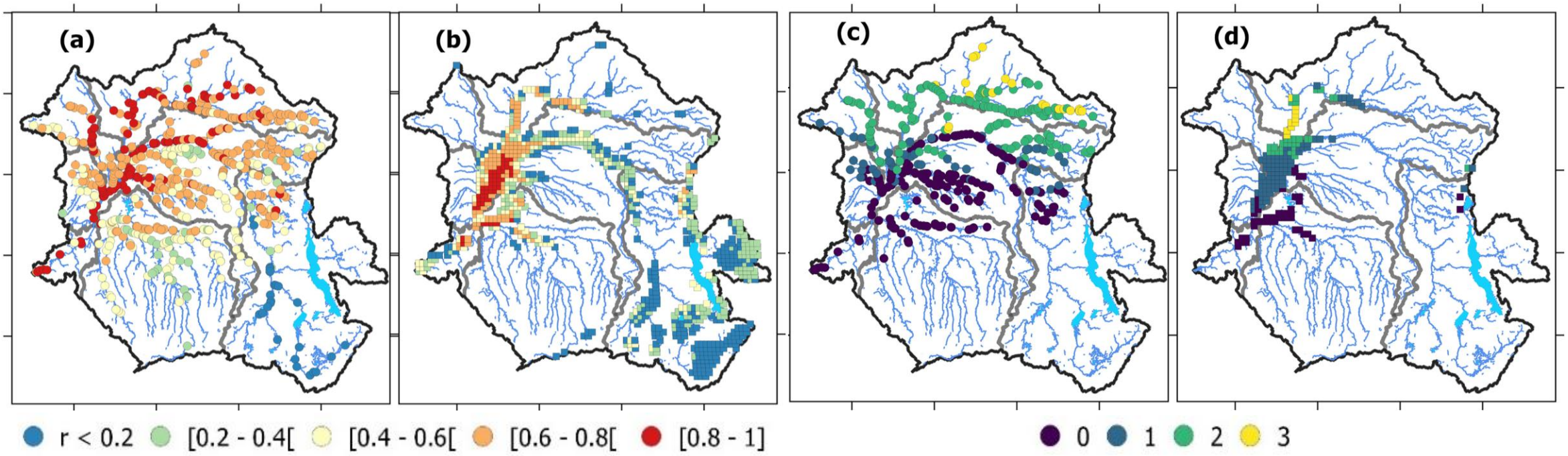


*Maximum correlation between SWH(a)/SWE(b) versus height/river discharge at Brazzaville/Kinshasa station and the associated lag (in month, SWH(c) and SWE(d))*

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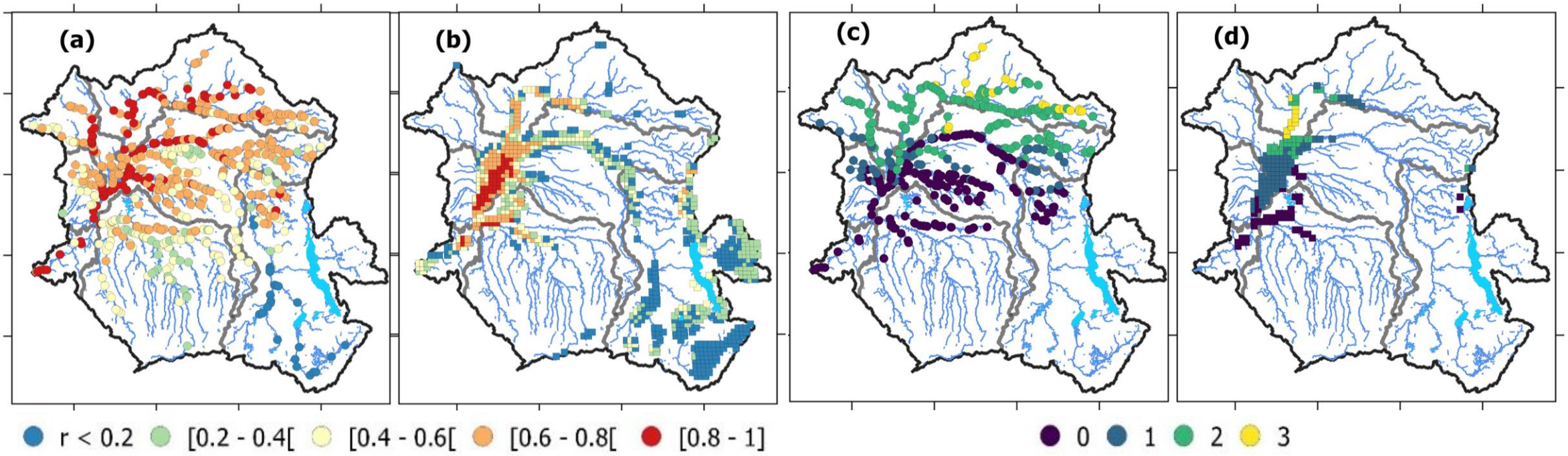
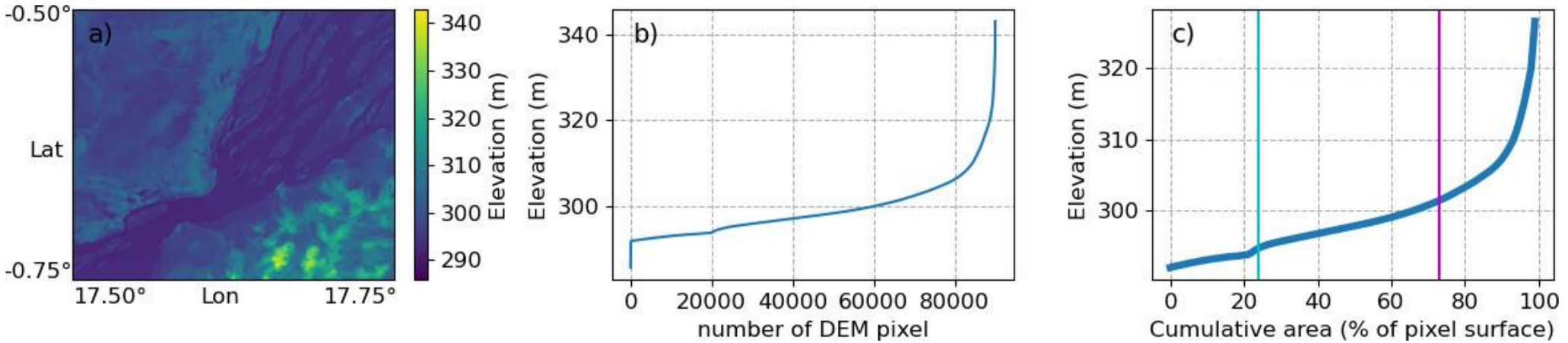



*Maximum correlation between SWH(a)/SWE(b) versus height/river discharge at Brazzaville/Kinshasa station and the associated lag (in month, SWH(c) and SWE(d))*

- *High correlation for the Middle-Congo and northern sub-basins*
- *Travel time ranges from 0-1 month (Middle-Congo, Kasai) to 2-3 months (Oubangui, Sangha, remote areas)*

# Surface water storage (SWS) estimate

- ***First methodology*** *: hypsometric curve (HC) approach consisting in combination of the surface water extent (SWE) (GIEMS-2) products with a global digital elevation model (DEM)* *Papa et al. (2013)*




*Relationship between surface water elevation from Hypsometric curves (MERIT DEM) and the inundated area of a 773 km$^2$ pixel from GIEMS-2*

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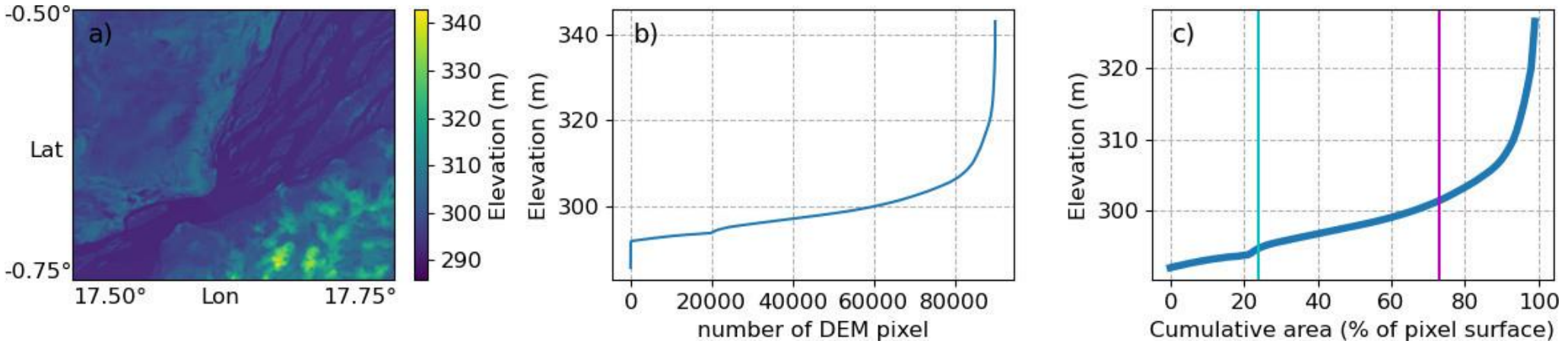


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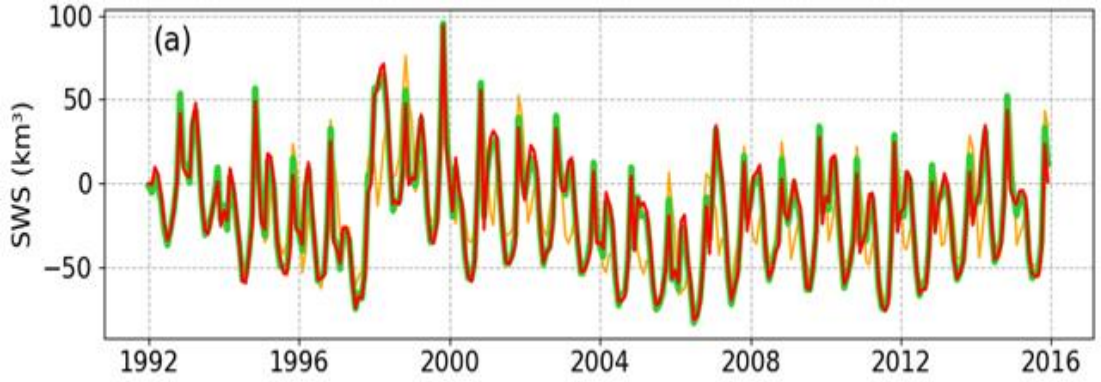
- ***Second methodology*** *: combination of the surface water extent (SWE) (GIEMS-2) with the altimeter-derived surface water heights (SWH) (as in Becker et al. [2018])*

  *using* ***159 virtual stations*** *from the combined multi-satellite missions covering 1995-2015 (****+ 20 years****)*

# Spatial and temporal variability of surface water storage

**25-year** SWS time series




1st methodology using MERIT DEM

1st methodology using FABDEM

2nd methodology using SWE + SWH

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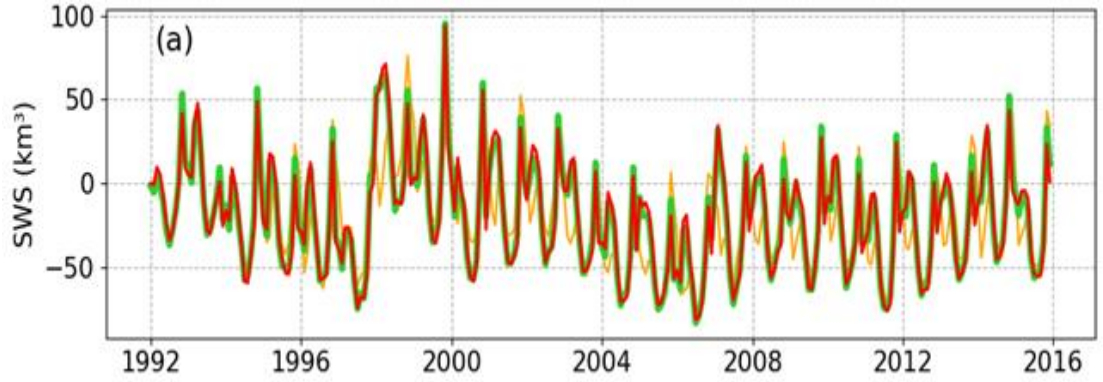
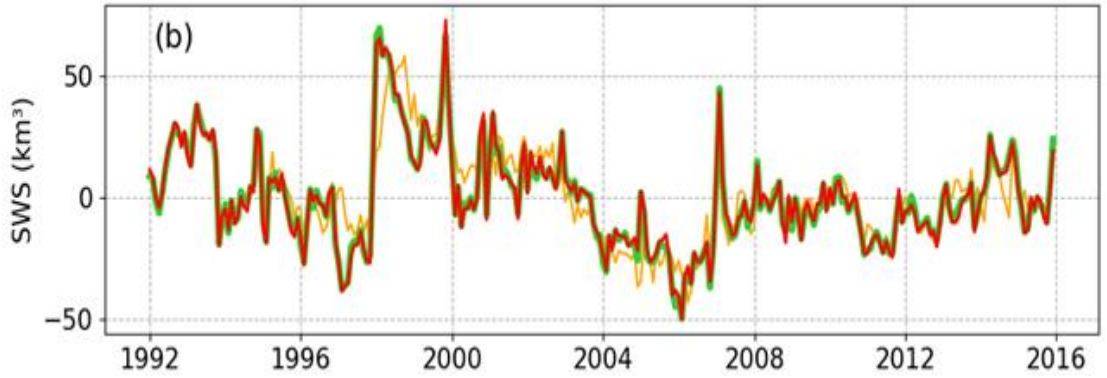



Deseasonalized anomalies

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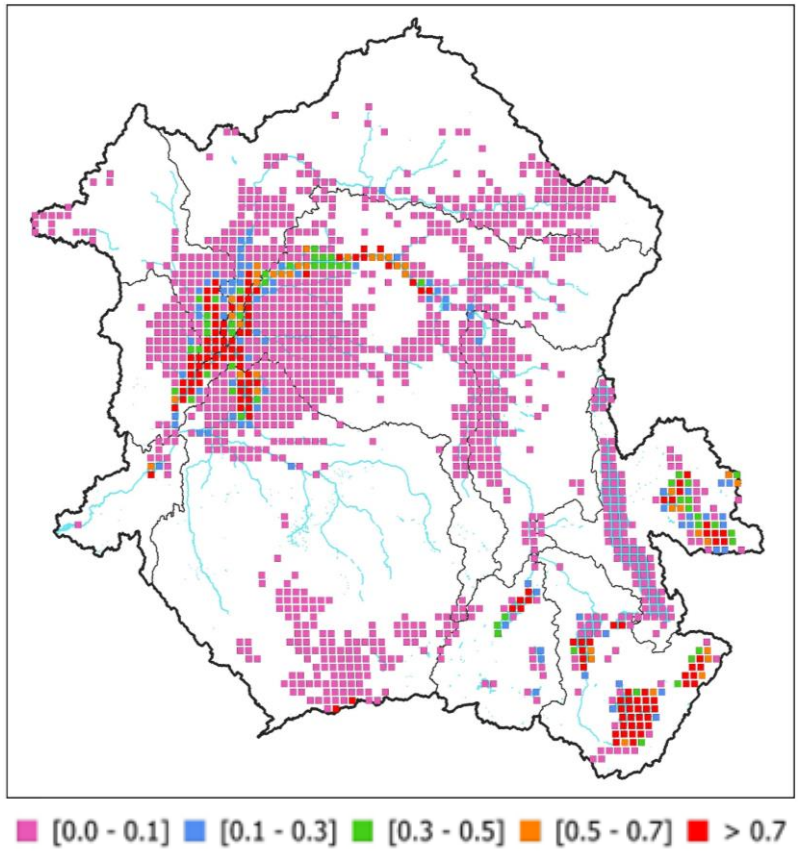


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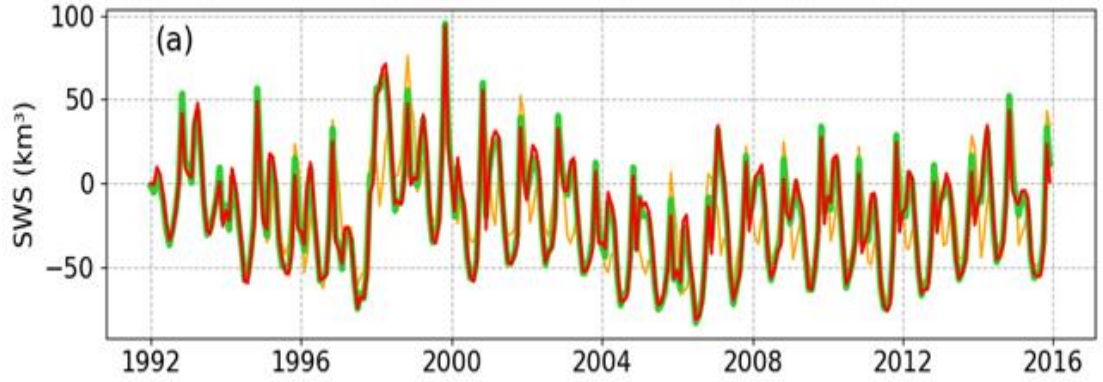


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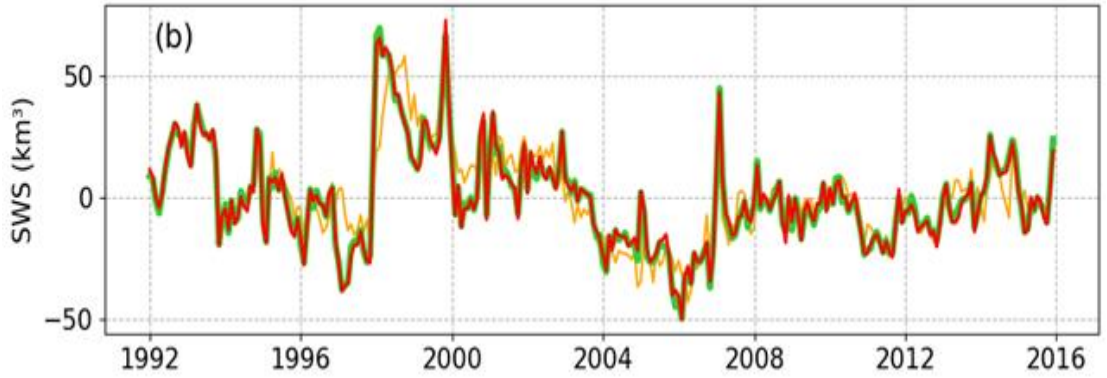


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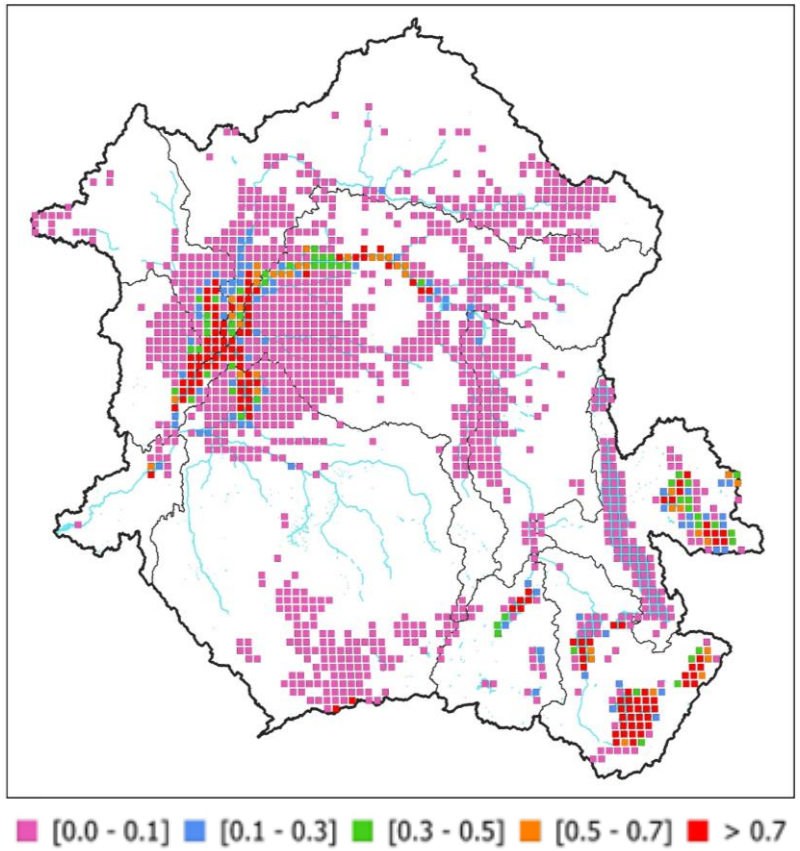
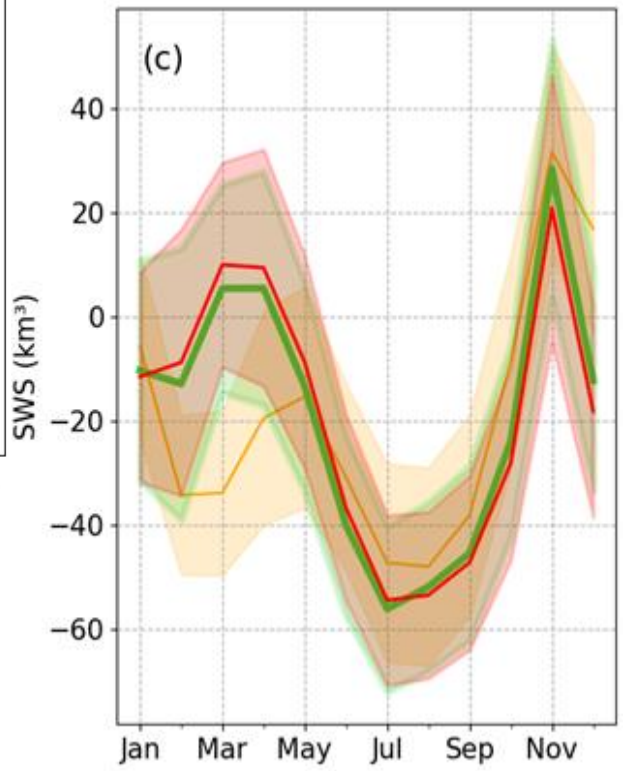



Mean seasonal cycle

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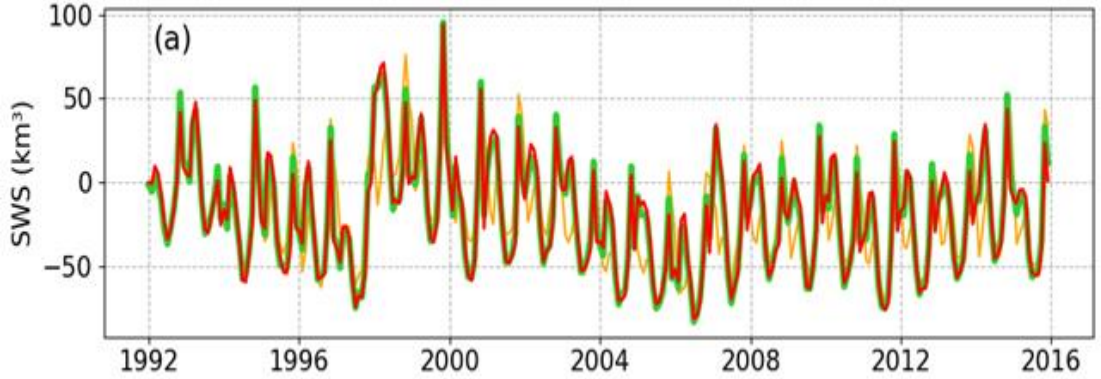


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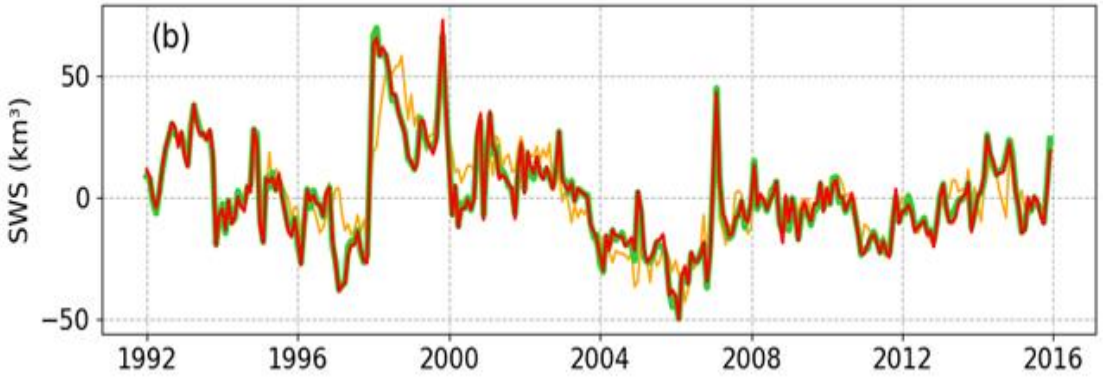


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2nd methodology using SWE + SWH

*CRB mean annual amplitude* ***~ 80 Km³***

# Conclusions

- Very first-time in-depth analysis; consistency; small scale differences between methods
- Highlight local non-linear processes; overbank vs rainfall flooding; cuvette centrale; gap for investigating local phenomena
- Great contribution to CICOS integrated water resources management thanks to EO data; CREBBAC next research themes

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# Perspectives

Dataset on SWS over CRB soon available to the scientific community

Very important :

- To understand extreme events, climate variability in the CRB
- To derive groundwater variations of the CRB
- To develop hydrological modeling in the CRB

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# Thank you for your attention

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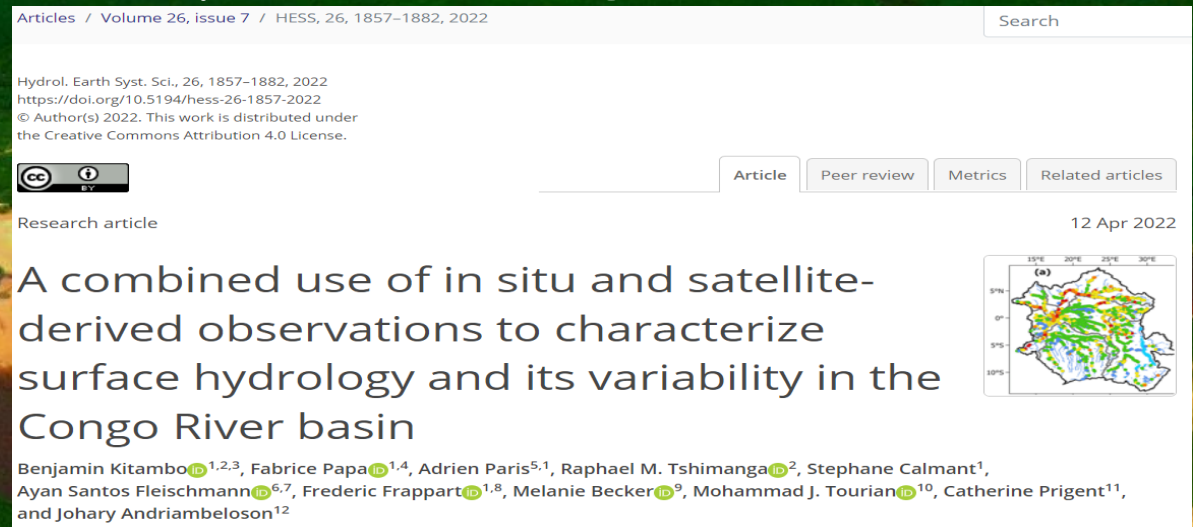

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Research article 12 Apr 2022

A combined use of in situ and satellite-derived observations to characterize surface hydrology and its variability in the Congo River basin


Benjamin Kitambo[1,2,3], Fabrice Papa[1,4], Adrien Paris[5,1], Raphael M. Tshimanga[2], Stephane Calmant[1], Ayan Santos Fleischmann[6,7], Frederic Frappart[1,8], Melanie Becker[9], Mohammad J. Tourian[10], Catherine Prigent[11], and Johary Andriambeloson[12]