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water resources management" hosted in Accra, Ghana



Congo Basin
Water Resources
Research Center

The signature of the Congo basin's 2005-2006 drought revealed from space

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Hydro Matters³

Congo Basin Water Resources Research Center⁴ (CRREBaC⁴)



Presentation outline

- General context
- Study area: Congo River Basin (CRB)
- Evaluation of satellite-derived surface hydrology products and main characteristics
 - Altimetry-derived Surface Water Height (SWH)
 - Surface Water Extent (SWE) from Global Inundation Extent from Multi-Satellite (GIEMS-2)
- Spatial signature of the 2005-2006 drought event over the CRB
- Perspectives



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General context

- African continent hosts largest freshwater systems but unevenly distributed and limited
- Threatened by the combined effect of climate change and anthropogenic pressure in the sub-Saharan and tropical Africa region
- African basins experience extreme events such as **droughts** and floods

➔ Understanding, monitoring, management, forecasting of water systems in the major African basins





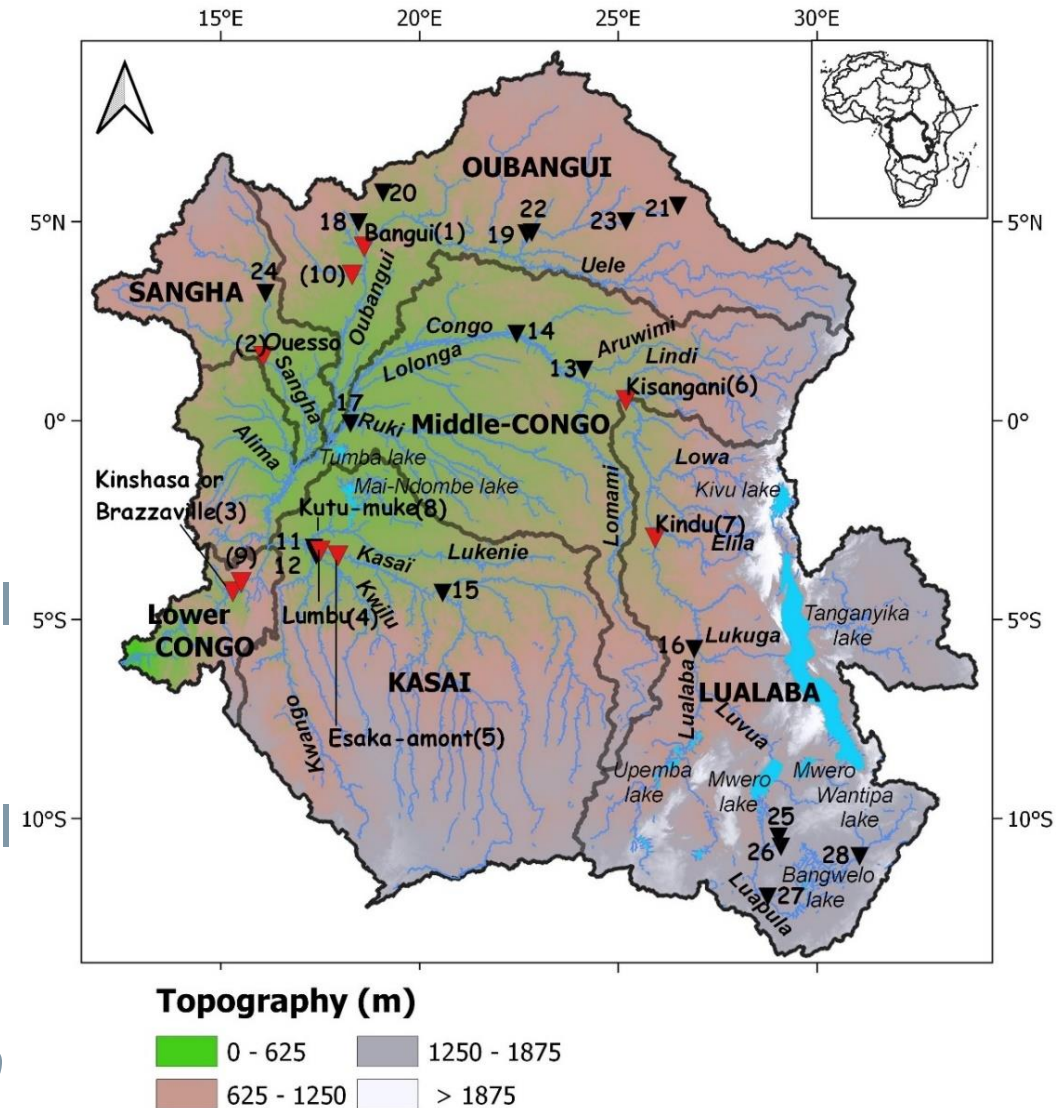
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Study area: Congo River Basin (CRB)

- Second largest river system in the world
 - Drainage area: $\sim 3.7 \times 10^6 \text{ km}^2$
 - Mean water discharge: $\sim 40.500 \text{ m}^3\text{s}^{-1}$
 - Highest flow: $\sim 65.000 \text{ m}^3\text{s}^{-1}$
- Flow marked by its bimodal hydrological regime
- $\sim 45\%$ of the CRB land area is covered by tropical forest
- CRB hosts large biodiversity
- CRB plays a crucial role for regional and global scale climate



Runge, 2007; Verhegghen et al., 2012; Laraque et al., 2020

Rationale

- Highly dependence of the CRB population to the water resources availability (*Bele et al., 2010*)
- CRB is subject to anthropic pressure and climate change (*Tshimanga and Hughes, 2012*)
- CRB experienced a long-term drying trend over the past decades (*Hua et al., 2016*)
- Limited understanding of the large-scale variability of the hydrologic components and their link with climate (*Munzimi et al., 2019*)
- Less in-situ records to understand and monitor water availability in the CRB (*Laraque et al., 2020*)
- Yet an increasing quantity of long-term earth observation from space datasets to complement and extend in-situ records (*Alsdorf et al., 2016*).





Tackled problem in our research

- Poor knowledge at the basin scale of the spatio-temporal distribution and characterization of extreme climate events such as droughts and floods from surface hydrologic variables

Scientific question

- What is the spatial signature and distribution of the major drought that occurred in the end of 2005 and early 2006 on the dynamics of surface water across the CRB?



The following datasets will help to cater to this question:

- Spatial altimetry dataset
- Global Inundation Extent from Multi-Satellite (GIEMS-2) dataset
- In-situ database

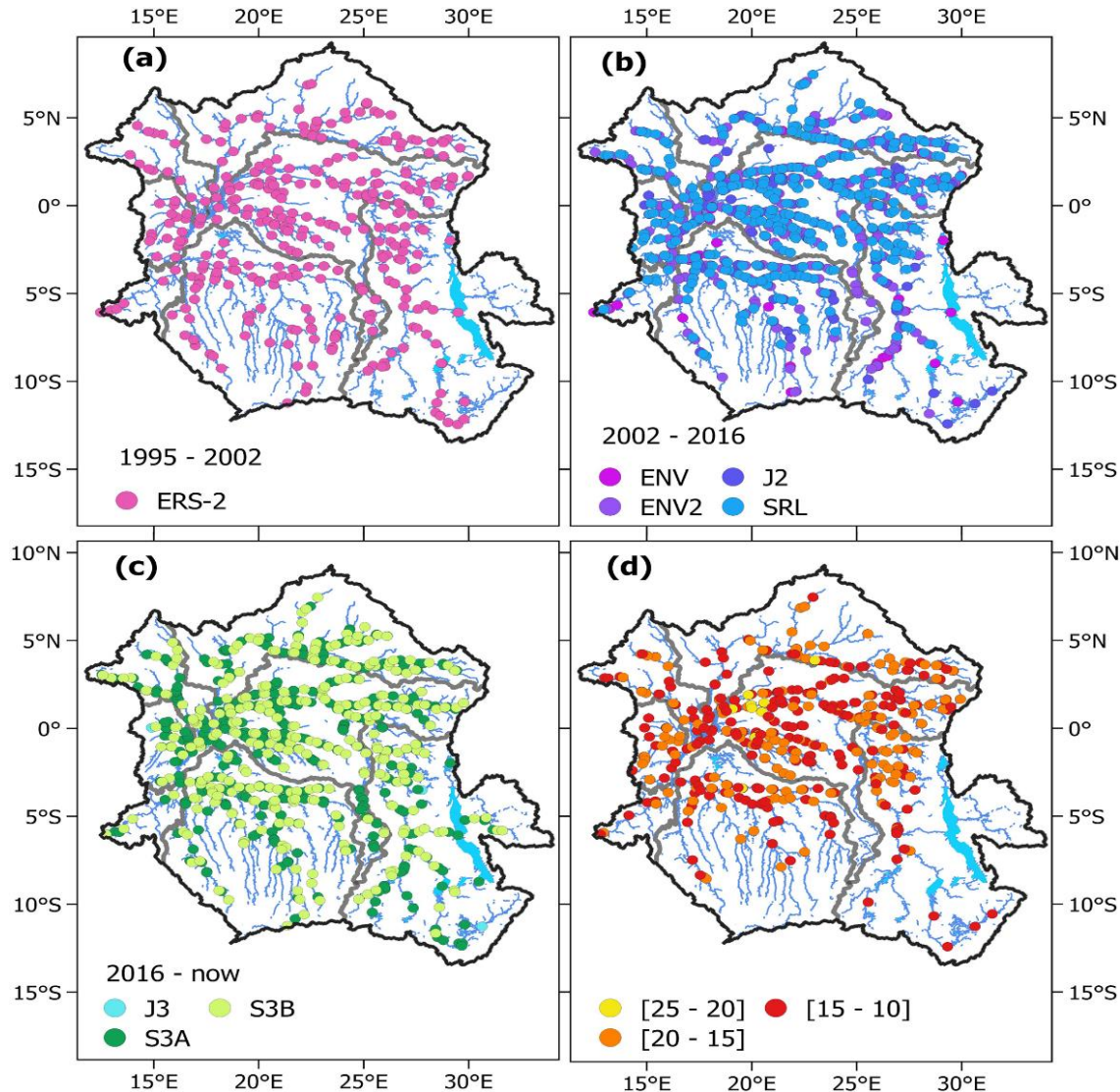


Presentation outline

- General context
- Study area: Congo River Basin (CRB)
- **Validation of satellite-derived surface hydrology products and main characteristics**
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Surface water height (SWH) dataset from radar altimetry



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

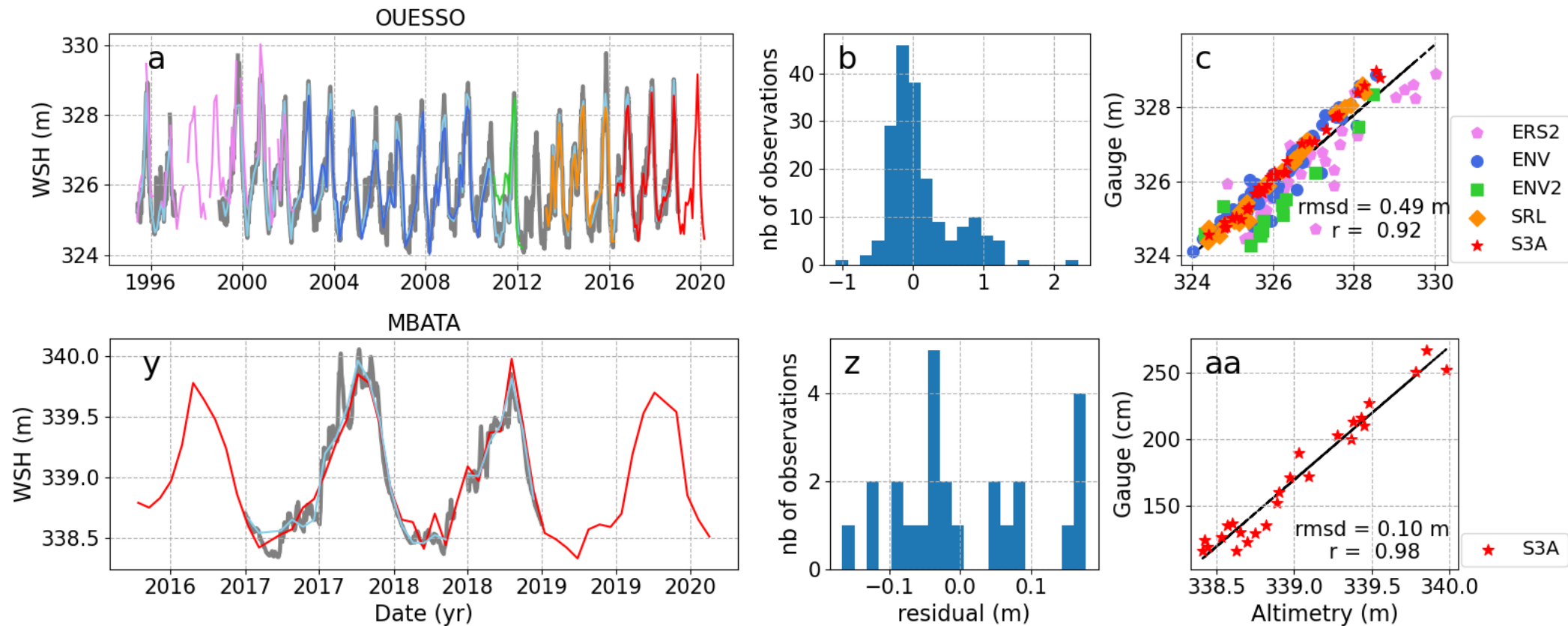


VSs covering period of **1995-2020** (more than 20 years)



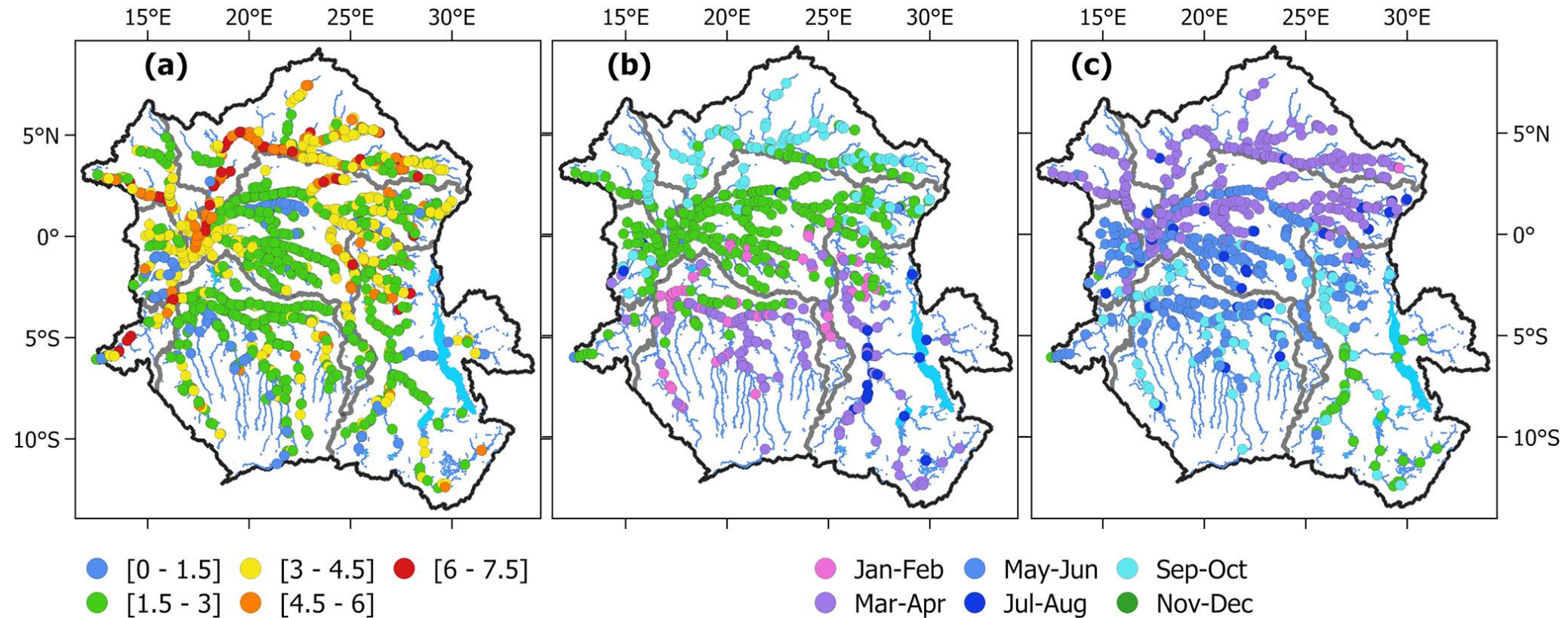
Validation with in-situ dataset

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



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

Spatio-temporal variability of SWH over the CRB



Hydrological dynamics of SWH (a) **maximum amplitude in m**, (b) **mean month of the maximum of SWH**, and (c) **mean month of the minimum of SWH**

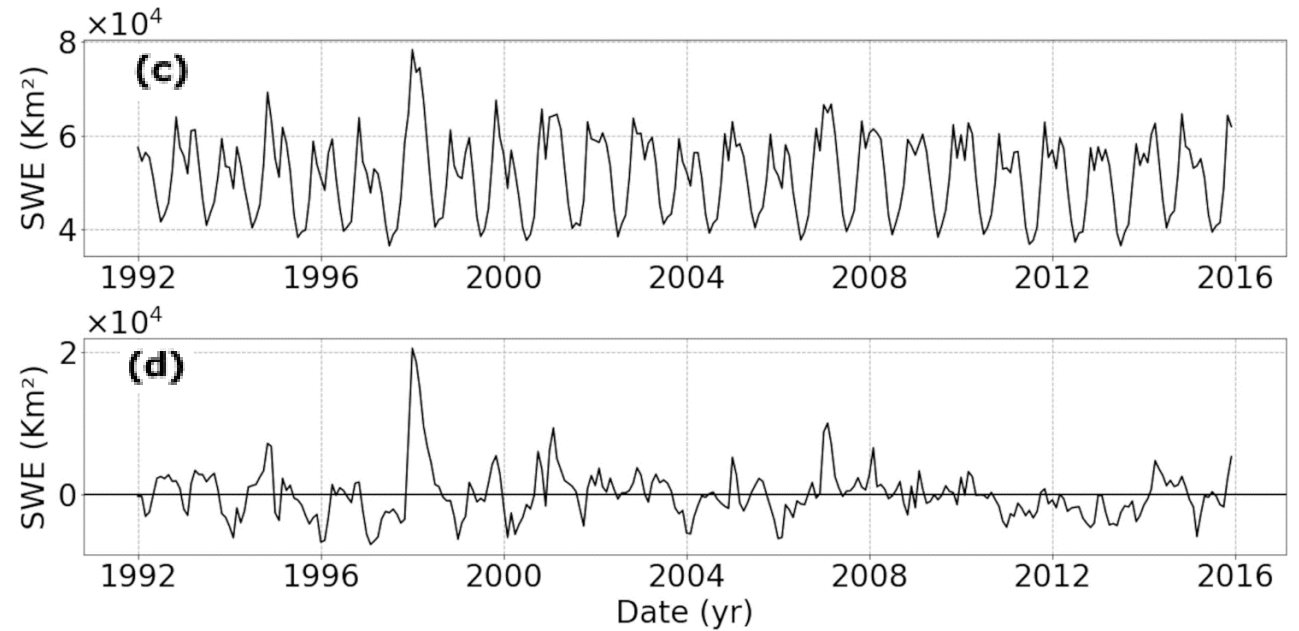
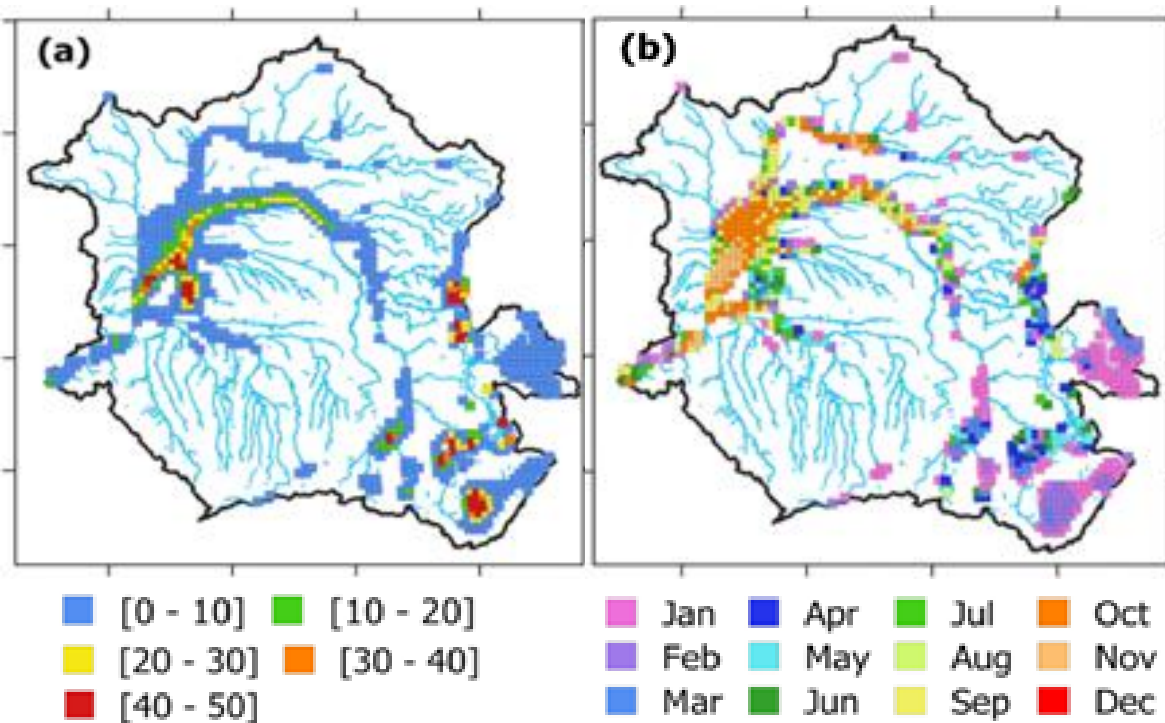


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Global Inundation Extent from Multi-Satellite (GIEMS-2) dataset

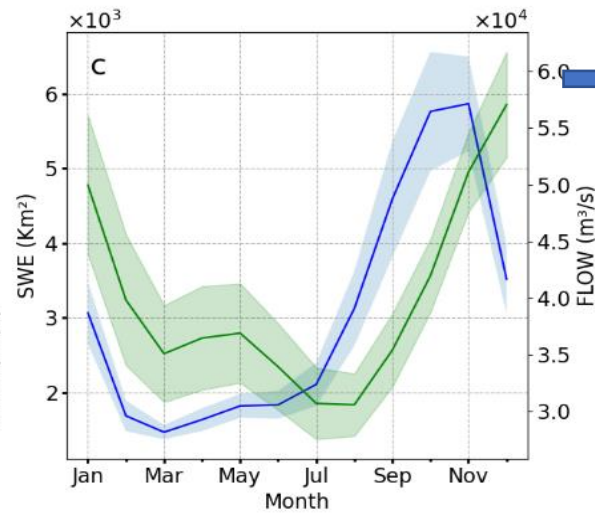
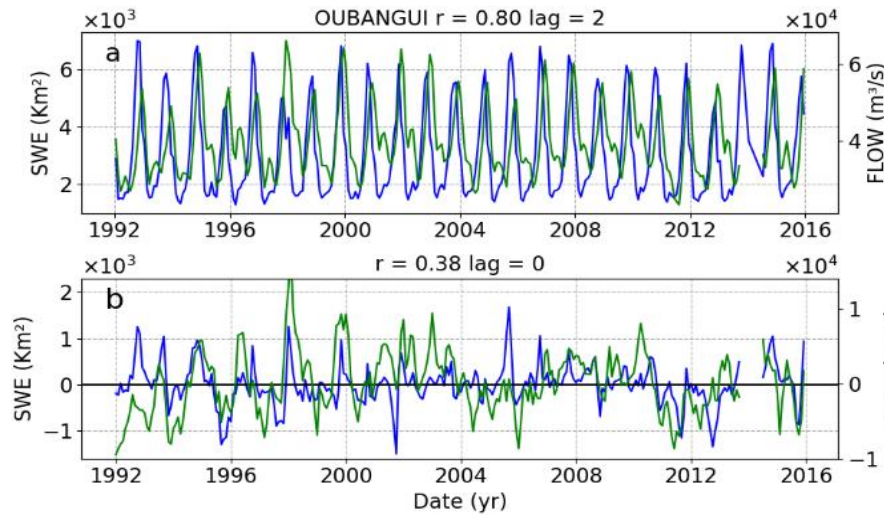


Characterization of GIEMS-2 (1992-2015)

- (a) Mean extent,
- (b) Average month of maximum surface water extent (SWE),
- (c) Time series,
- (d) Deseasonalized Anomaly

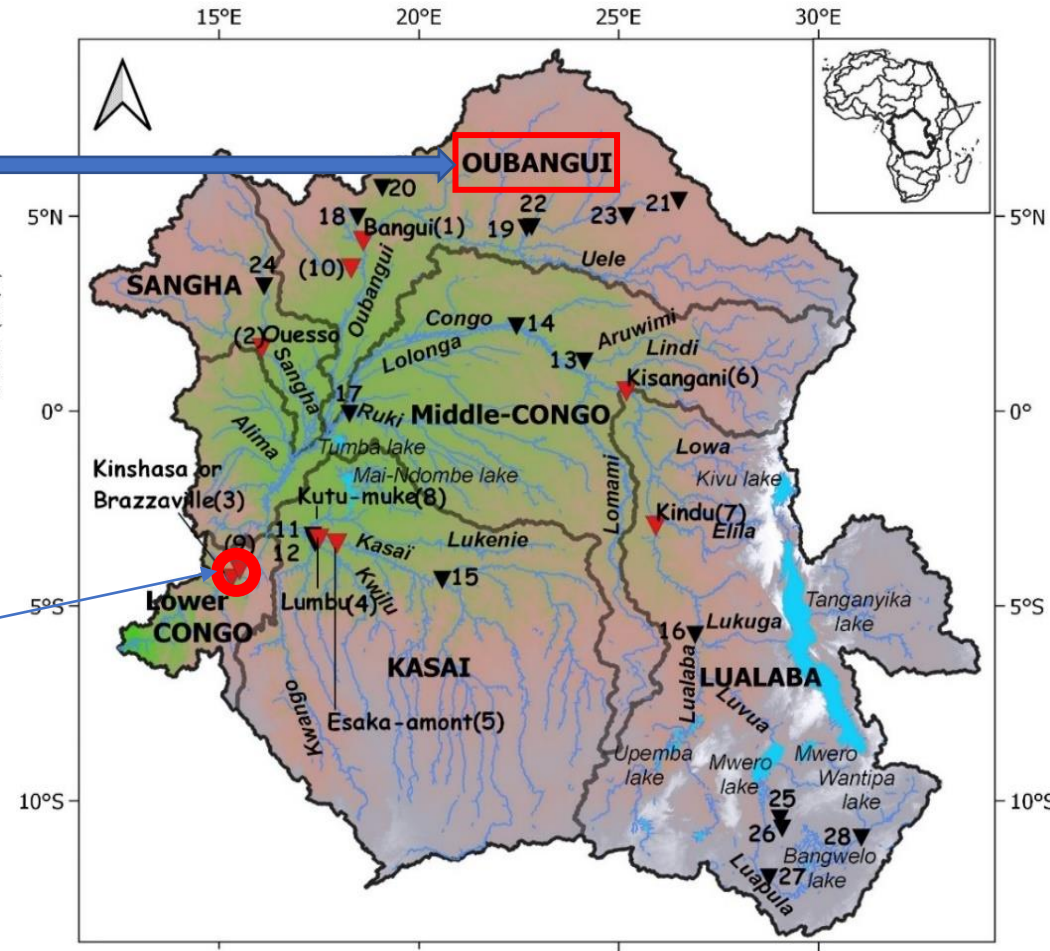


Evaluation of GIEMS-2 against in-situ data



Correlation between $SWE_{sub-basin}$ versus discharge at Brazzaville/Kinshasa station

- *Good agreement between in-situ water discharge and surface water extent*





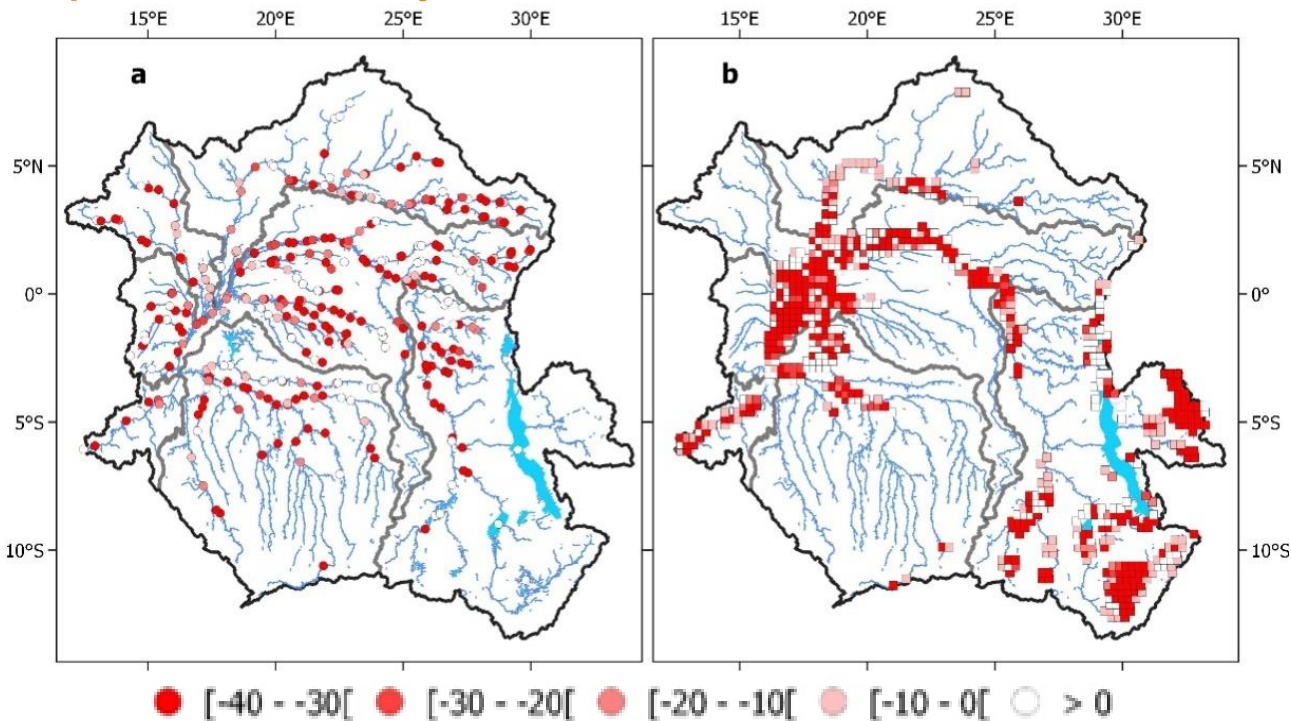
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- **Spatial signature of the 2005-2006 drought event over the CRB: main results**
- Perspectives

Spatial signature and distribution of the major 2005-2006 drought event

Spatial altimetry dataset

GIEMS-2 dataset



- Less decreased of both SWH and SWE in Oubangui and Kasai sub-basin ($> -10\%$ of the mean maximum for SWH and SWE, less affected)
- Severe decreased of SWE in cuvette centrale and Lualaba sub-basin (southeastern wetlands, $< -40\%$ of the mean maximum for SWE, more affected)

Anomaly of the maximum $SWH_{(a)}/SWE_{(b)}$ over October 2005-January 2006 as compared to the 2002-2010 mean maximum anomaly



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- **Recommendations and Perspectives**



Recommendations

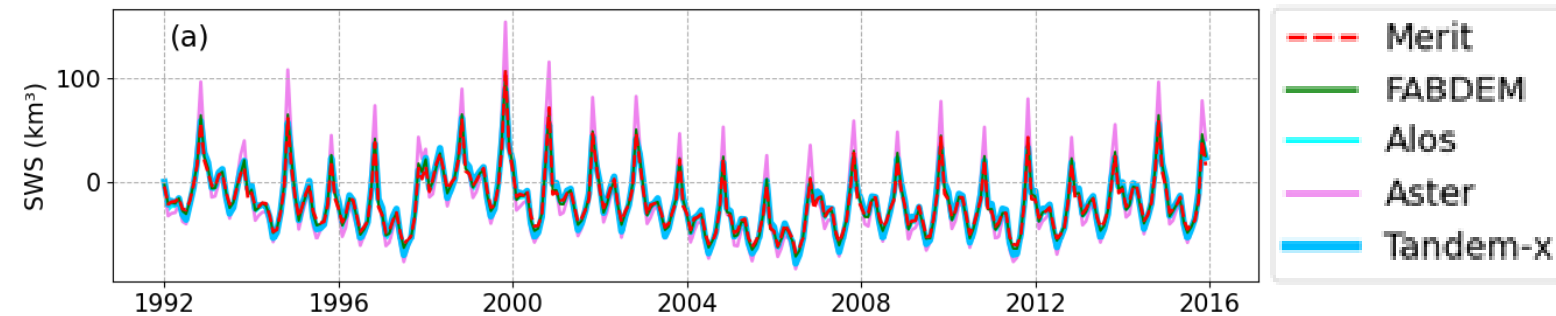
- Better understand the long seasonal and interannual spatio-temporal variability of the Congo freshwater volume and their links with climate dynamics, especially during exceptional **drought/flooding** events and how the latter affect the water resources availability.



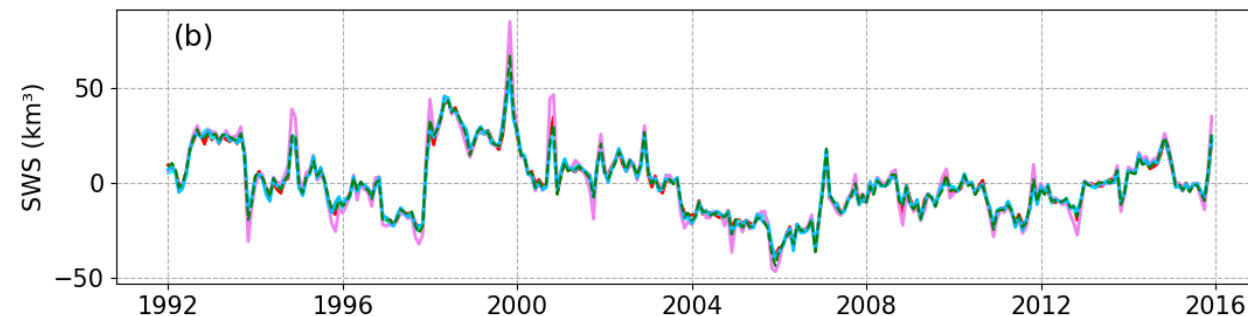
Perspectives

- Analyze the seasonal and interannual variability of the Congo freshwater volume stored in surface and their link with extreme events (**drought/flood**) from the **25-year long-term surface water storage** dataset developed by combining the variation of the monthly SWE from GIEMS-2 dataset and the hypsometric curve from the digital elevation model

25-year surface water volume time series



Deseasonalized anomalies



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Thank you for your attention

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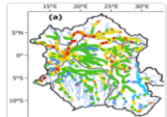
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A combined use of in situ and satellite-derived observations to characterize surface hydrology and its variability in the Congo River basin 

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