Rivers and lakes monitoring from space

The HYDROWEB water levels database.
Example of an operational use over the Congo basin.

Jean-François CRETAUX, Muriel BERGÉ NGUYEN – CNES/LEGOS

Stéphane CALMANT – IRD/LEGOS

Adrien PARIS, Lionel ZAWADZKI, Nicolas TABURET – CLS Toulouse

Philippe PACHOLCZYK, Philippe MAISONGRANDE,

Nicolas PICOT, Alice ANDRAL, Selma CHERCHALI - CNES

LEGOS

French National Research Institute for Sustainable Development
IRD

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CENTRE NATIONAL D'ÉTUDES SPATIALES

Theia
Pôle Thématique Surfaces Continentales

Context

Demography ↑
➔ demand on freshwater

Water scarcity and non-uniform distribution

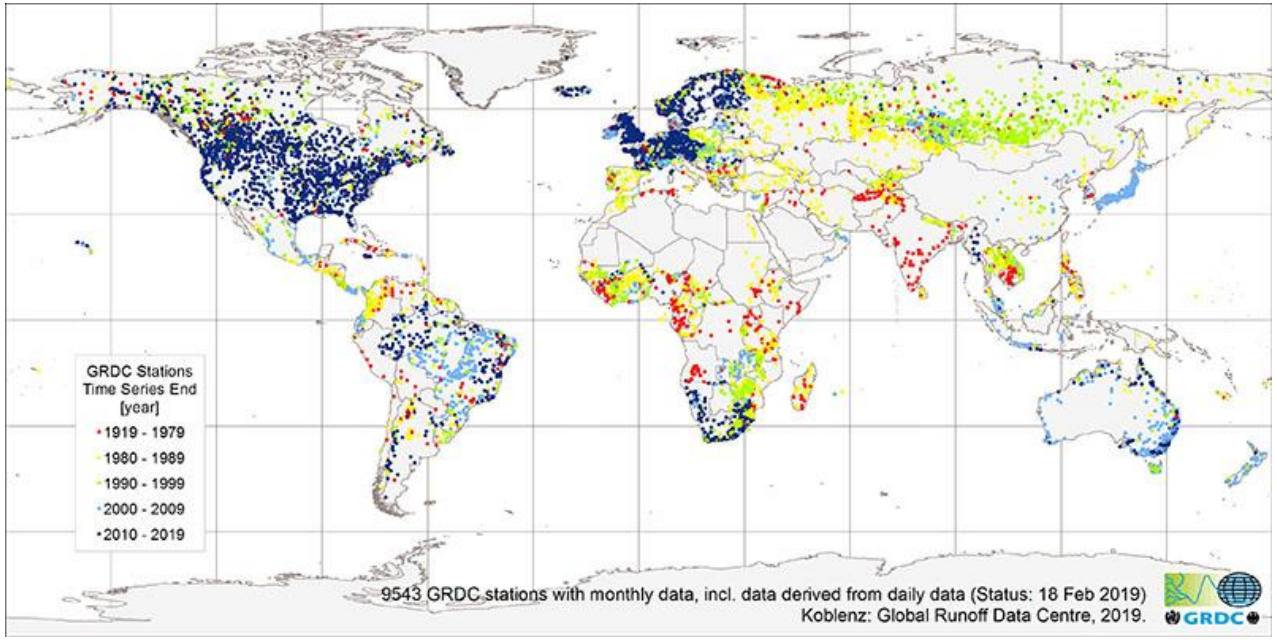
Transboundary river basin
➔ availability of data

In-situ network ↓
homogeneity, quality ?

Climate change : impacts, mitigation, adaptation ?

Need of an integrated water resources management

Source : Showeet

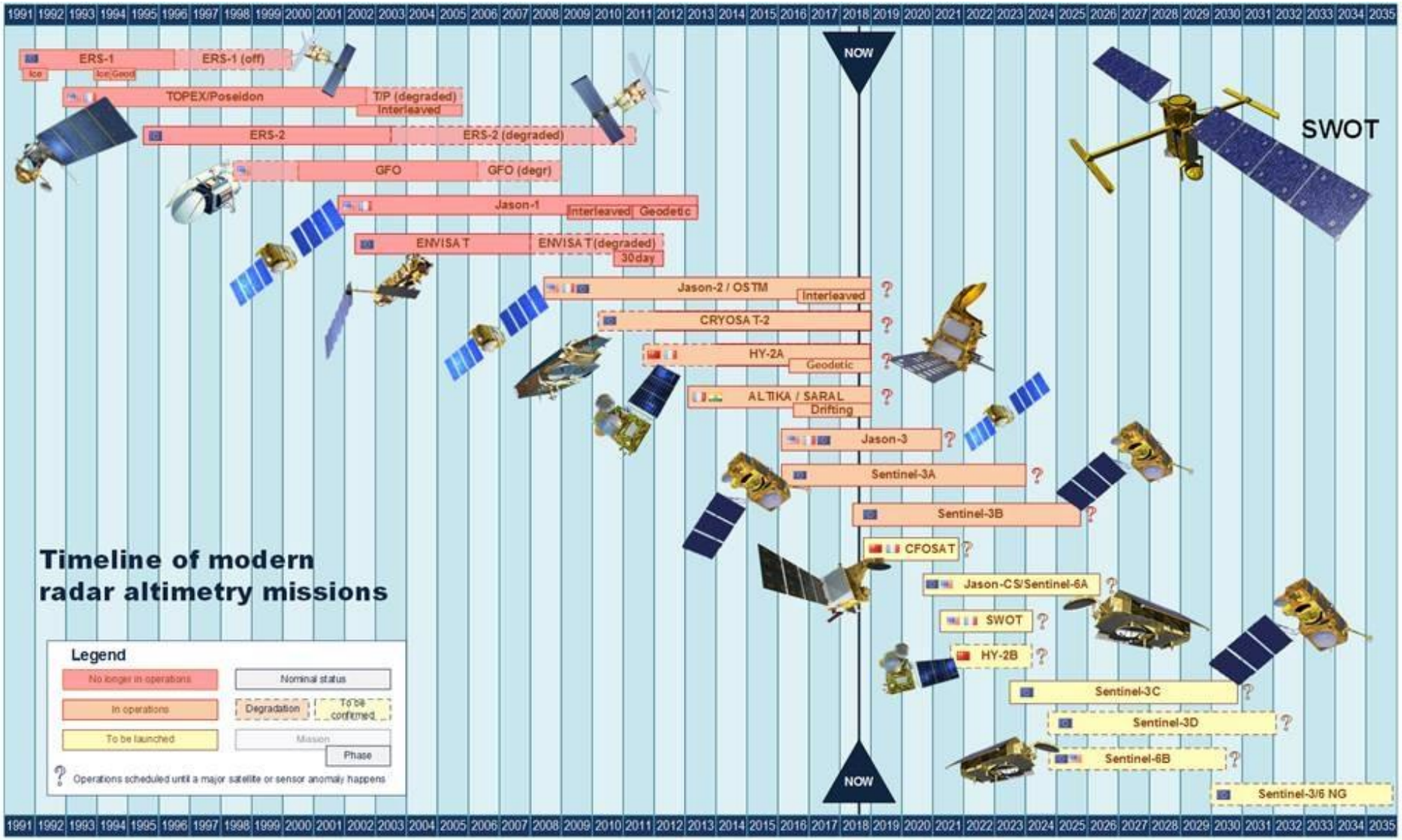


- Innovative water elevation from space :
  from local to global, homogeneity of data,
  free data access, time series since 1992

- Altimetry data, as a complement of the in-situ network

➔ What is the spatial and temporal variability of inland water at global scale?

A long-term constellation of altimeters

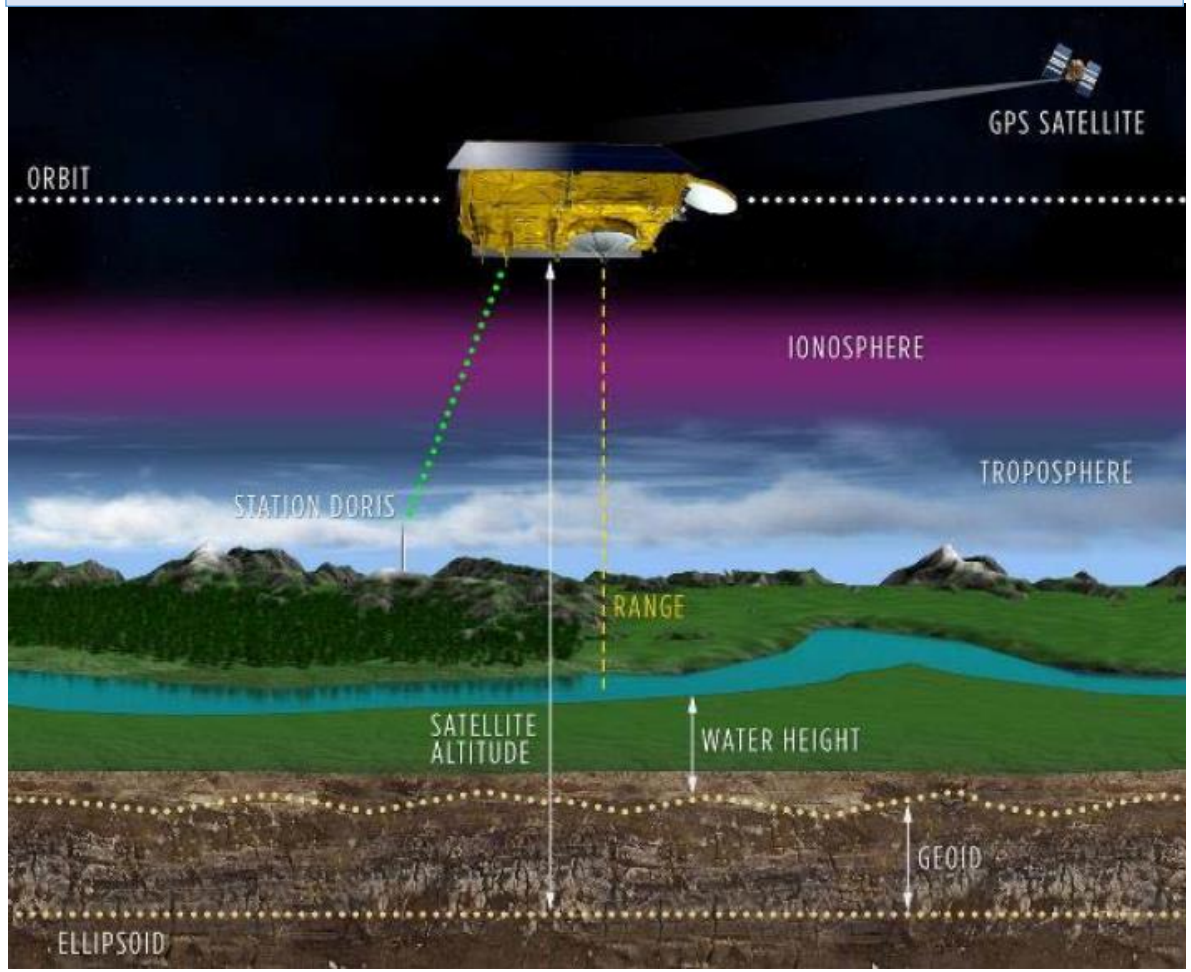


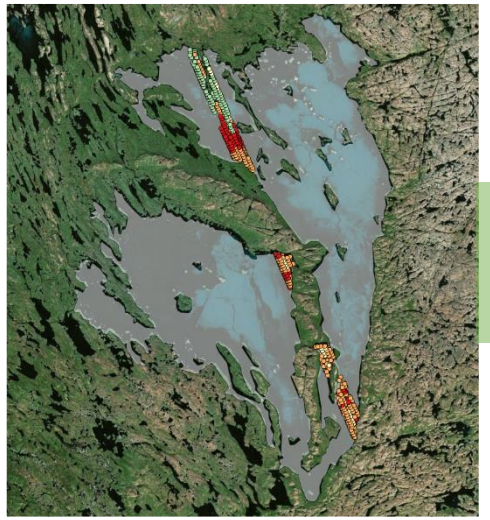
Continuity guaranteed after 2030

⇒ Long times series

Principles of radar altimetry

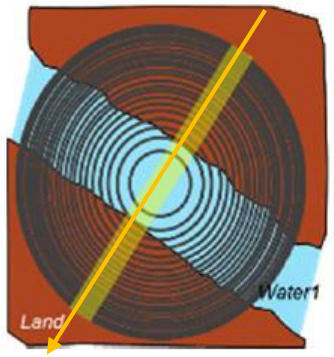
Water height = Satellite altitude - Range- Geoid



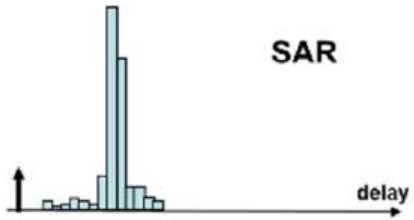


Sentinel-3a raw data
over the reservoir of Manicuagan (Canada)
➔ **Virtual station**

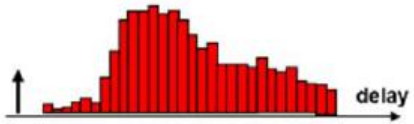
Footprint size ➔ land contamination ➔ river width limit



Sentinel 3



Jason



Smaller water bodies

Large water bodies

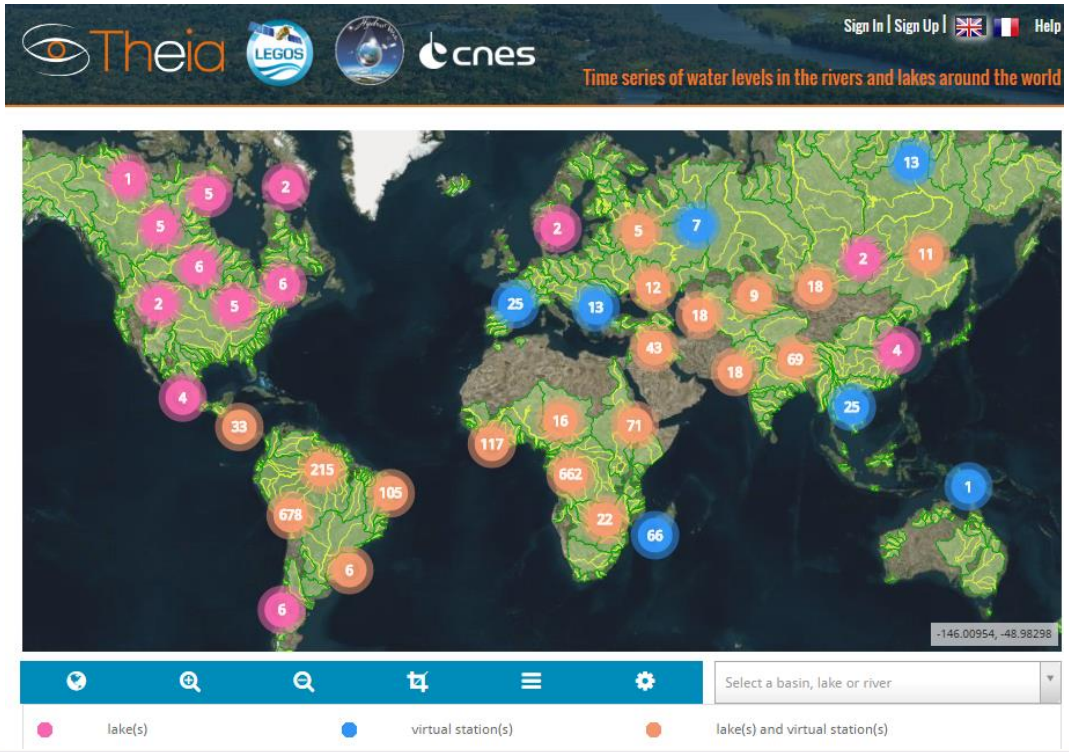
Principles of conventionnal radar altimetry

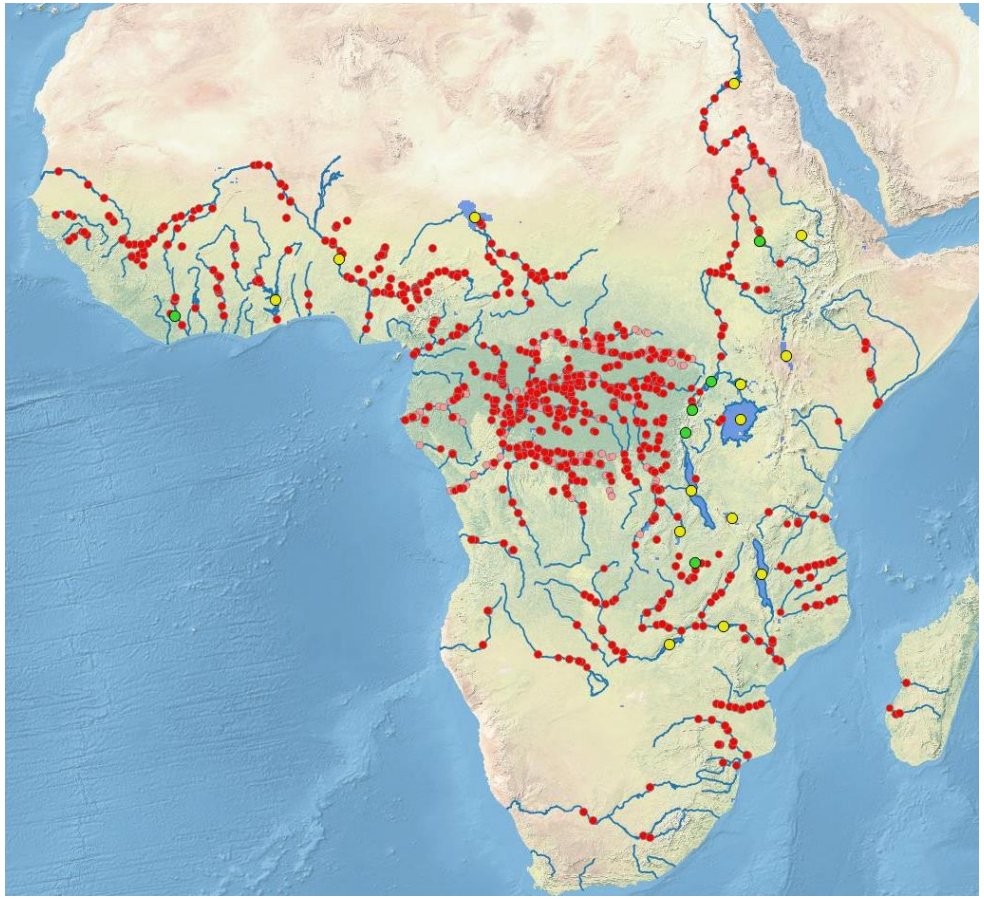
The HYDROWEB water levels database

http://hydroweb.theia-land.fr

Rivers : **962** operational virtual stations and **1 218** in research mode
Lakes : **64** operational lakes and **91** in research mode.

- **Time series since 1992**
  Specific product for lakes : surface + lake volume variation
- In **2019 : massive densification** over rivers in Europe, Asia, South America and over lakes worldwide.



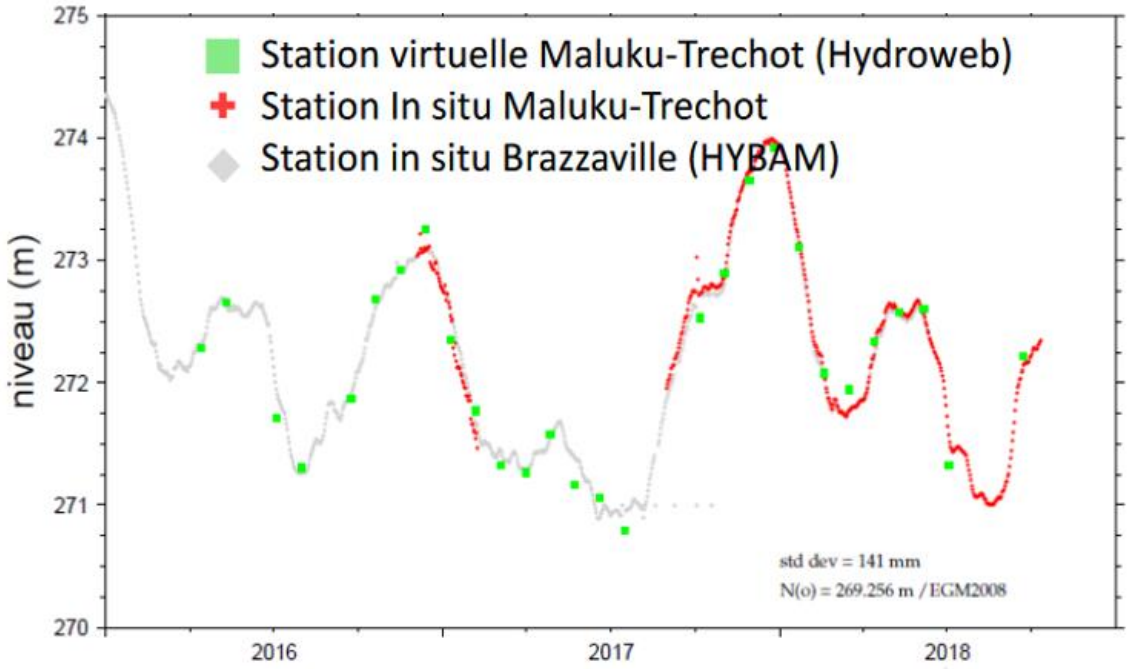


Included in the **Copernicus** Land Monitoring Service and soon in the Climate Change Service

opernicus Europe's eyes on Earth
Land Monitoring Service
Climate Change Service

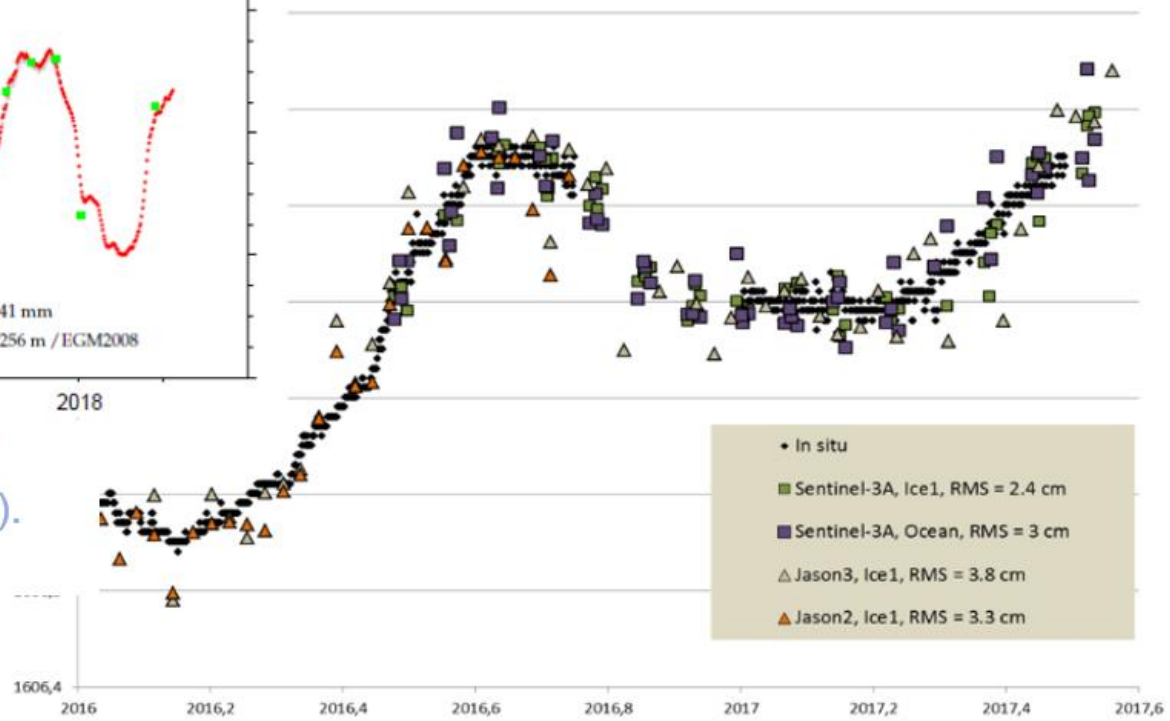
The HYDROWEB water levels database

http://hydroweb.theia-land.fr



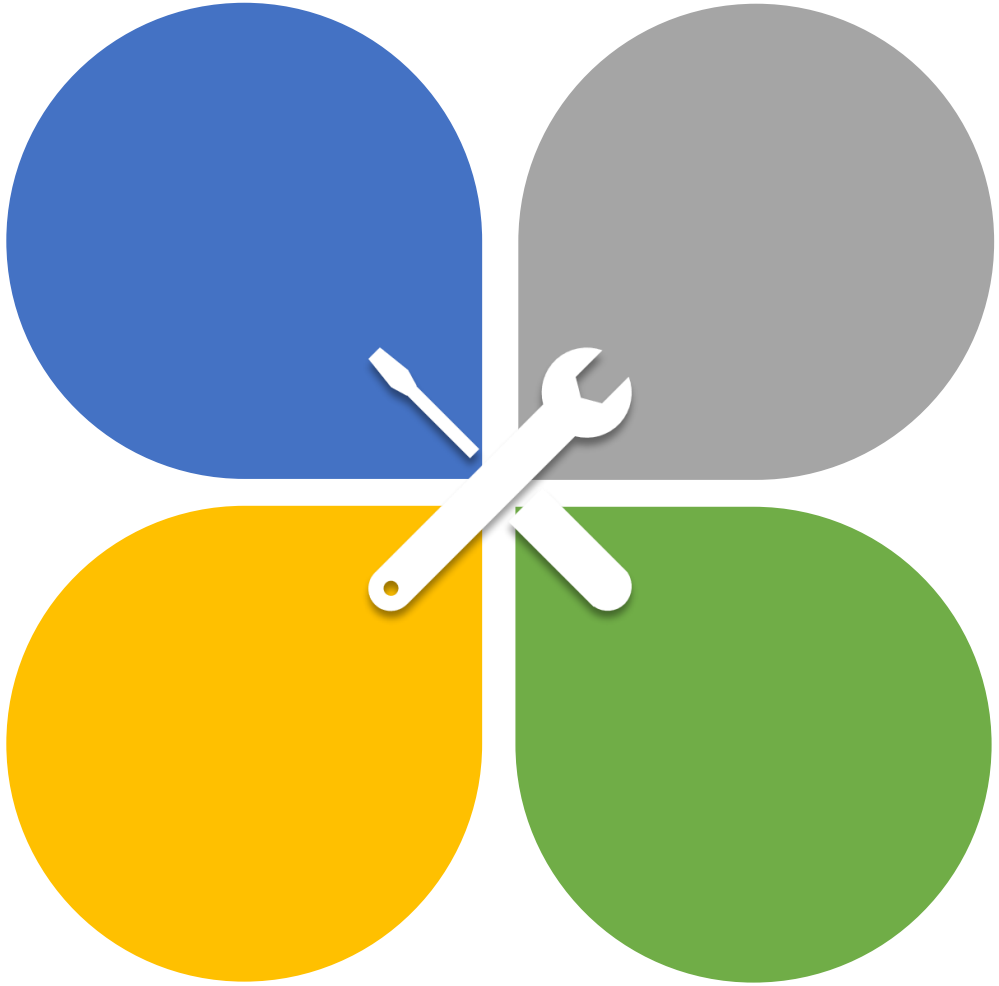
Comparison btwn water elevation from HYDROWEB and an in-situ gauge at Maluku-Trechot (Congo river).
Source S. Calmant – IRD/LEGOS

Comparison btwn water elevation from HYDROWEB and an in-situ gauge at Issyk-Kul lake (Kirghizistan).
Source J-F Crétaux– CNES/LEGOS



Open up avenues to an operational altimetry

Temporal resolution

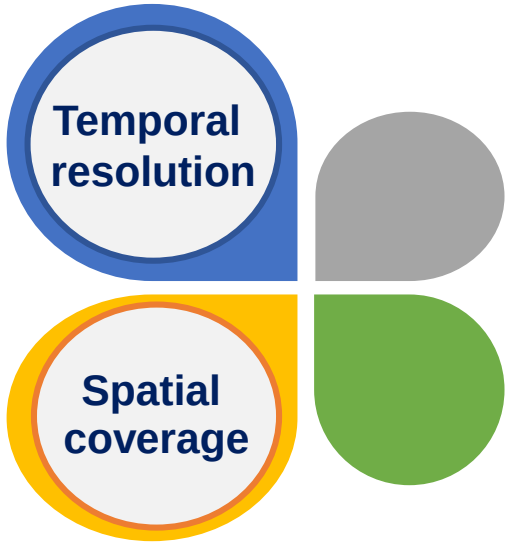


Accuracy

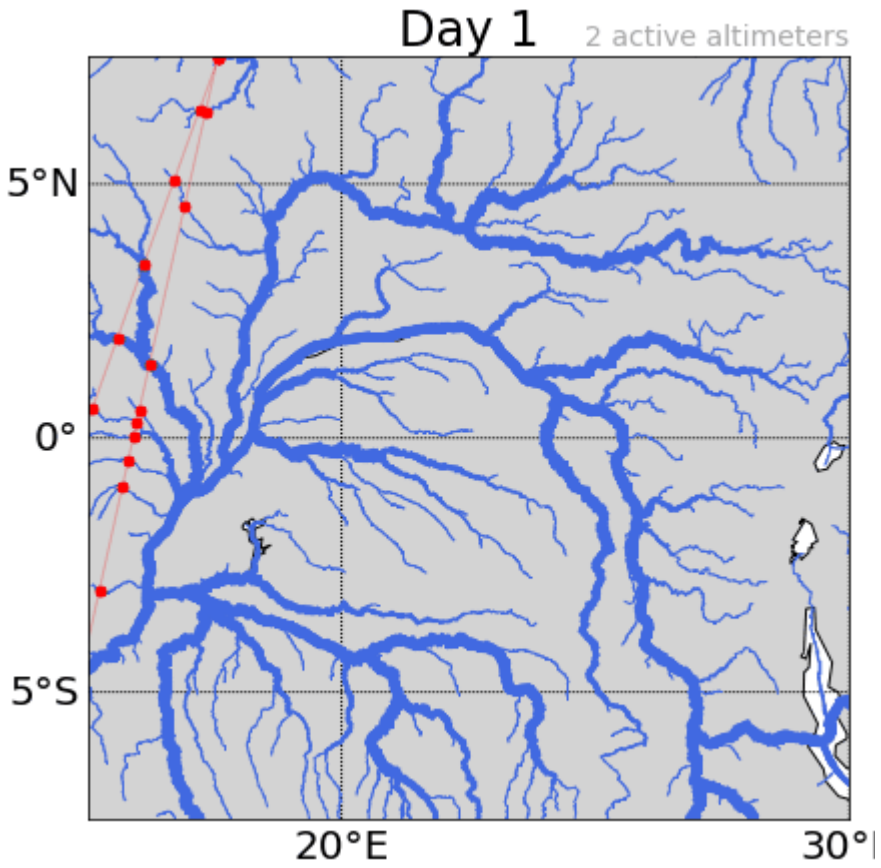
Spatial coverage

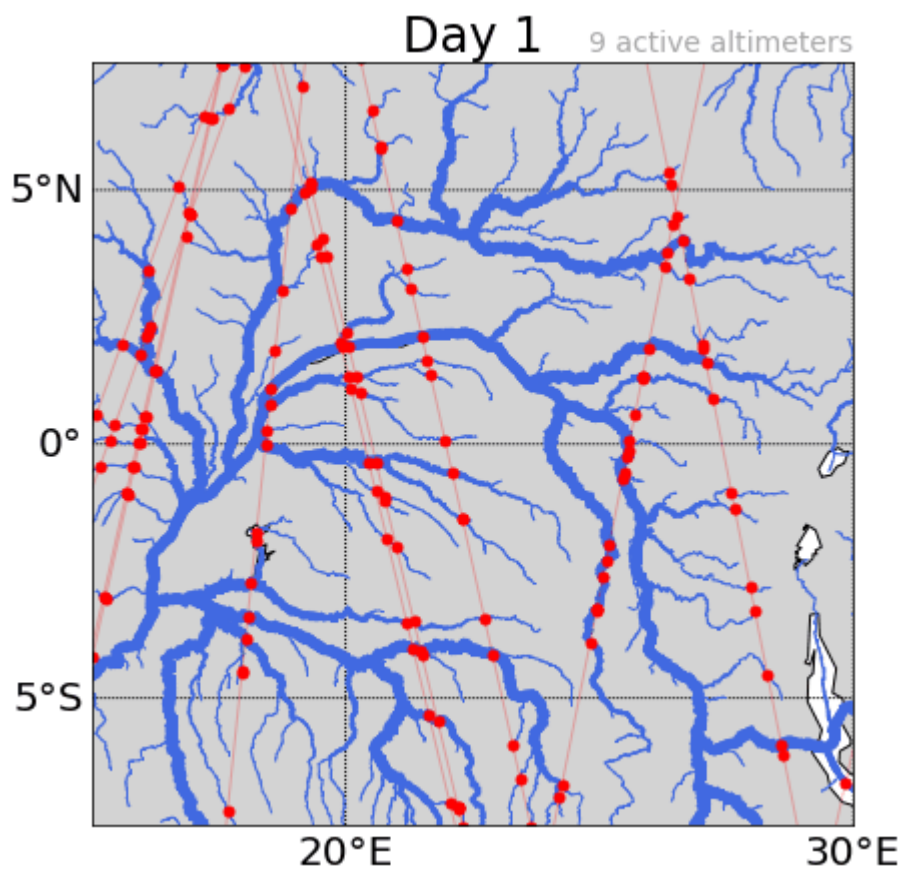
Size of water bodies

Open up avenues to an operational altimetry



➔ **COMBINATION OF ALL AVAILABLE ALTIMETERS**

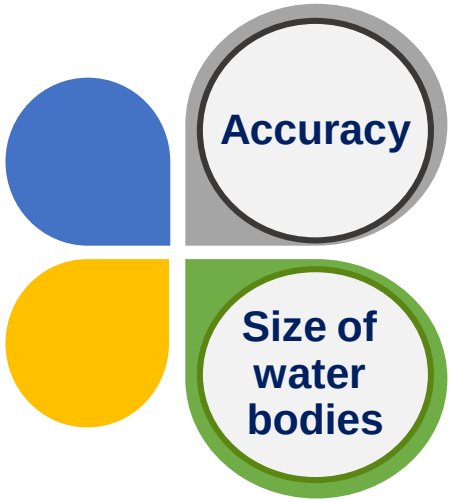




Example of altimetry data available every day over the Congo basin

10 days : Jason series
27 days : Sentinel 3

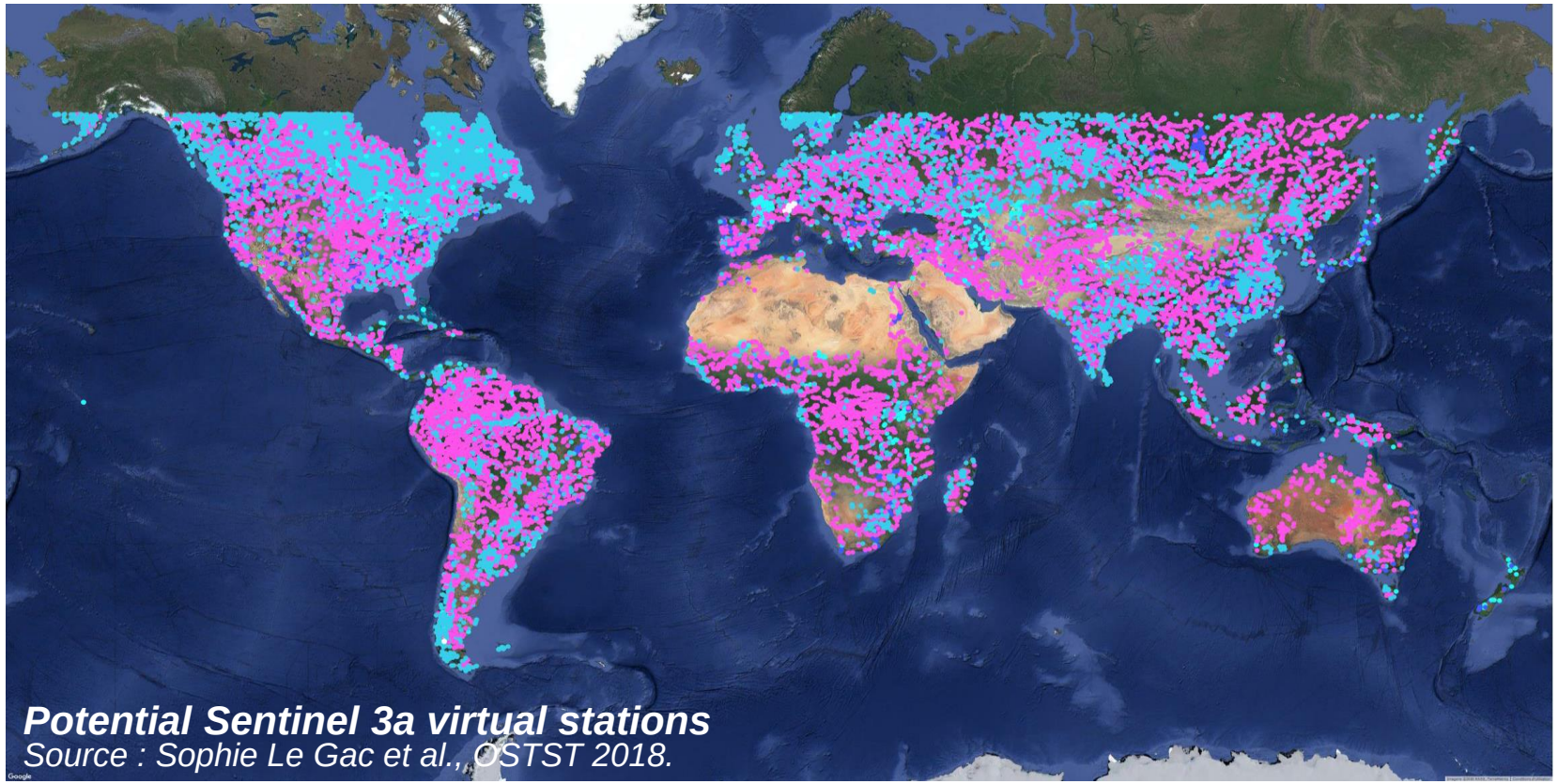
Open up avenues to an operational altimetry



NEW PROCESSING FOR THE LATEST ALTIMETERS

- Open Loop tracking mode for Jason 3 and Sentinel 3
- **~65 000 potential virtual stations worldwide.** On-going work to qualify each of them

➔ key to inland waters observation and small lakes & rivers



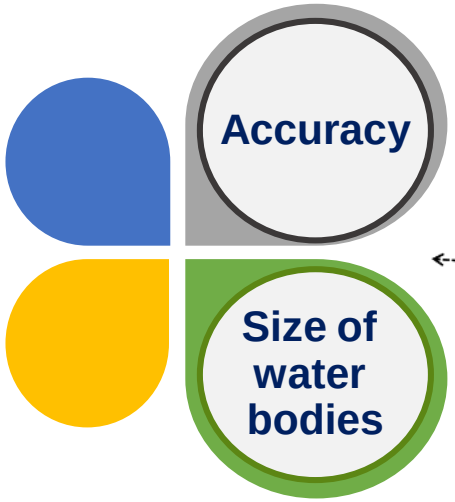
Potential Sentinel 3a virtual stations
Source : Sophie Le Gac et al., OSTST 2018.

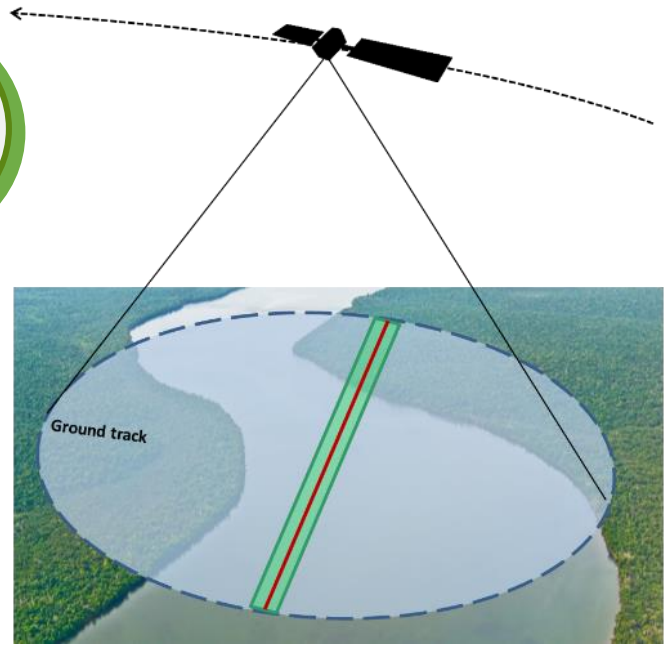
Open up avenues to an operational altimetry

NEW PROCESSING FOR SAR ALTIMETERS

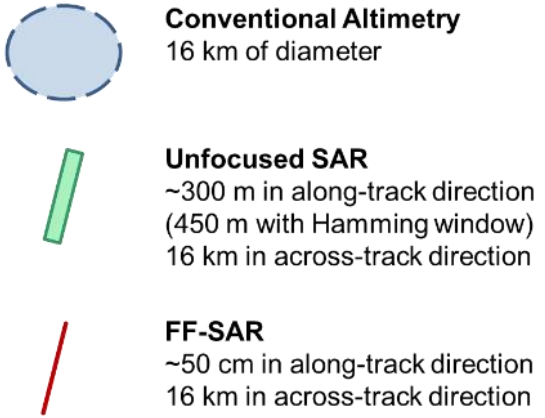
Fully-Focused SAR (FF-SAR) for Sentinel 3 and future Sentinel 6 / Jason CS:

- Increase in the azimuthal resolution (**up to 0.5m**)
- Detection of very small water bodies with a **good accuracy**

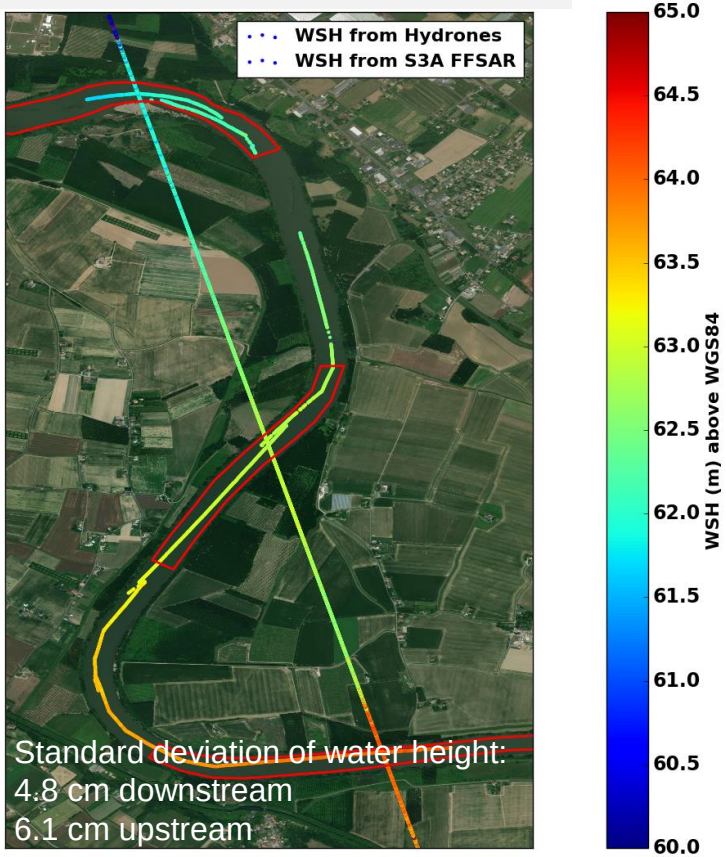




Source : Sophie Le Gac et al., OSTST 2018.



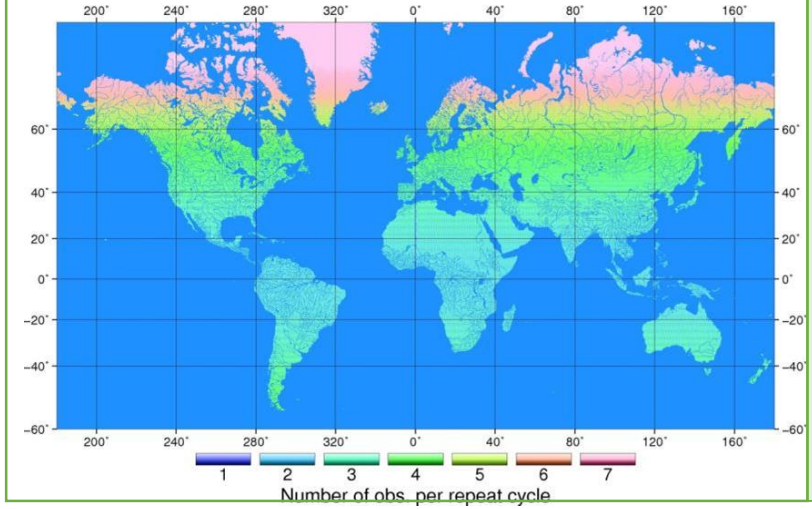
https://www.hydrones.fr



A breakthrough in the altimetry: the SWOT Mission

Surface Water and Ocean Topography

- NASA–CNES–CSA mission ; **dedicated to inland water** and oceans.
- Ka-band SAR interferometric system with 2 swaths, 50km each + Nadir altimeter (Jason class)
- **21 days repeat-cycle**, Launch **Sept. 2021**
- **Co-registrated all weather 2D imagery of water levels** rivers (width >100m) and lakes, reservoirs and wetlands (surface > (250 m)²)
- Height vertical **accuracy of 10 cm** (100m/ 10km) for rivers



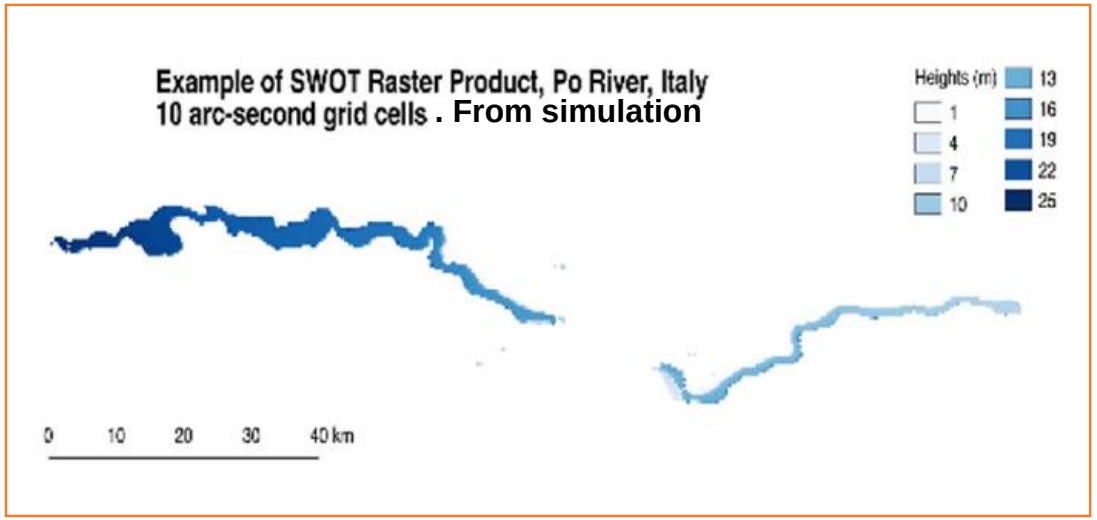
Global coverage :

➔ First global inventory of all terrestrial water bodies

➔ Global **storage change**

➔ Global change in **river discharge**

FREE ACCESS to all data and products



Operational use of altimetry data: the Congo basin

Congo basin = 2nd world largest basin

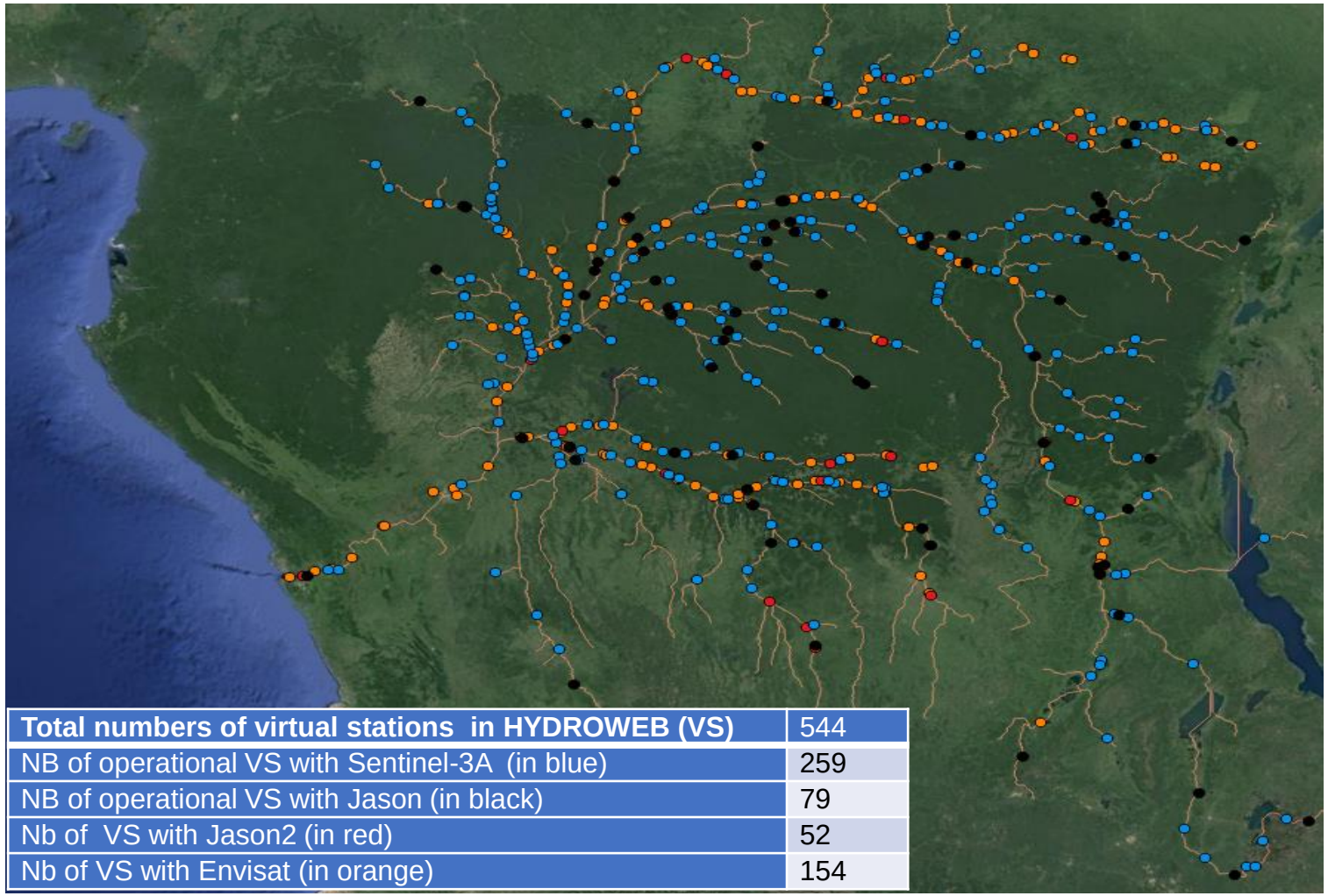
- 3.8 Mkm²
- 10 countries

~30 in-situ station

- Integrated water resources management?
- Water available for agriculture, navigation, fishing, drinking water, hydropower, ecology ?

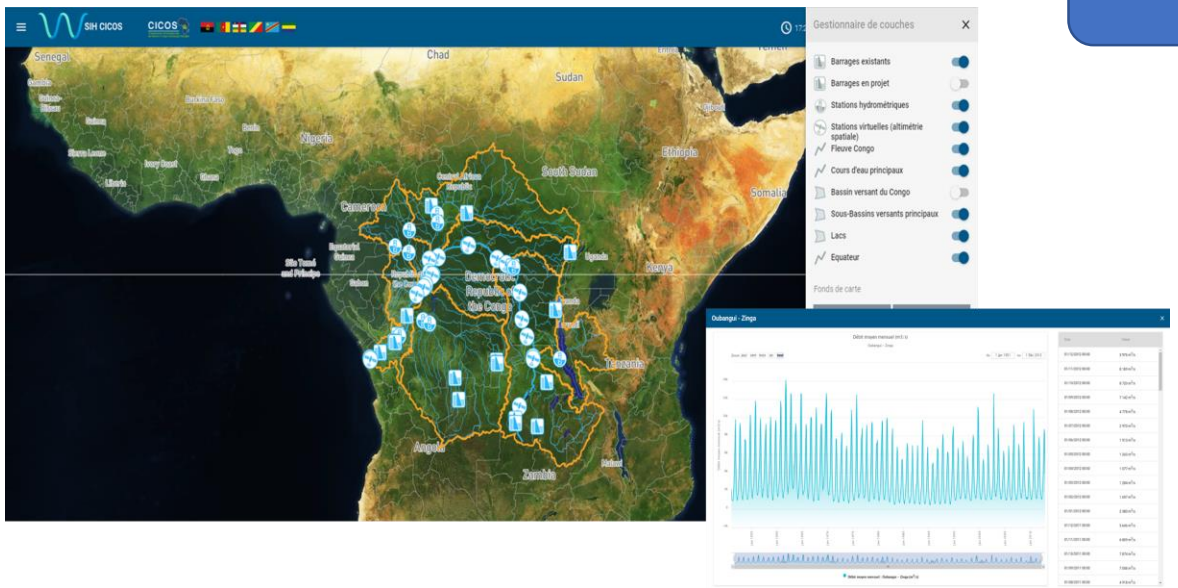
544 virtual stations from altimetry

- Satellite data as a complement to the in-situ network
- Available for all



Total numbers of virtual stations in HYDROWEB (VS)	544
NB of operational VS with Sentinel-3A (in blue)	259
NB of operational VS with Jason (in black)	79
Nb of VS with Jason2 (in red)	52
Nb of VS with Envisat (in orange)	154

Operational use of altimetry data: the Congo basin

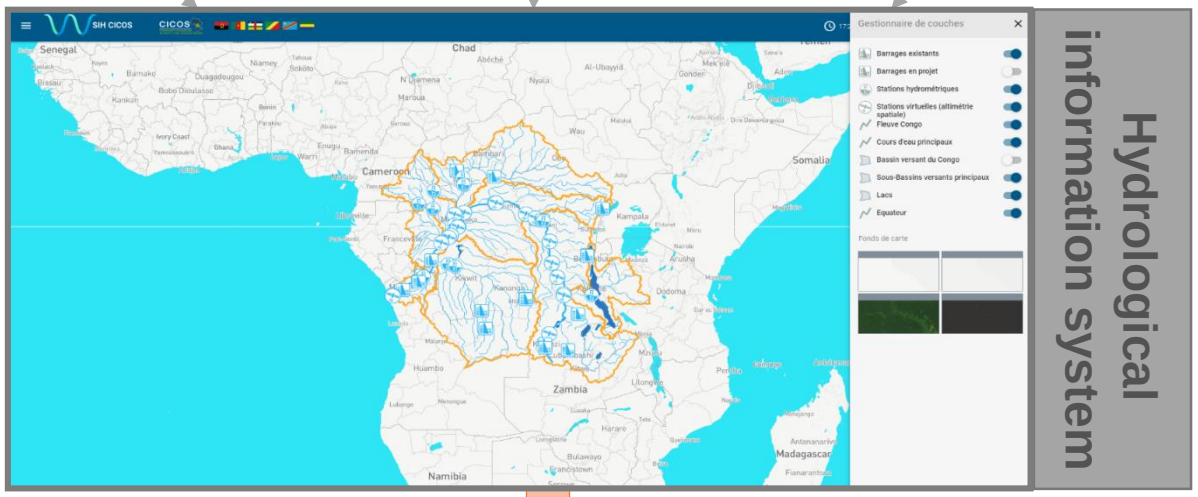


HYDROWEB

Water elevation from altimetry data

Discharge estimation

In-situ water elevation and discharge measurement from NHS

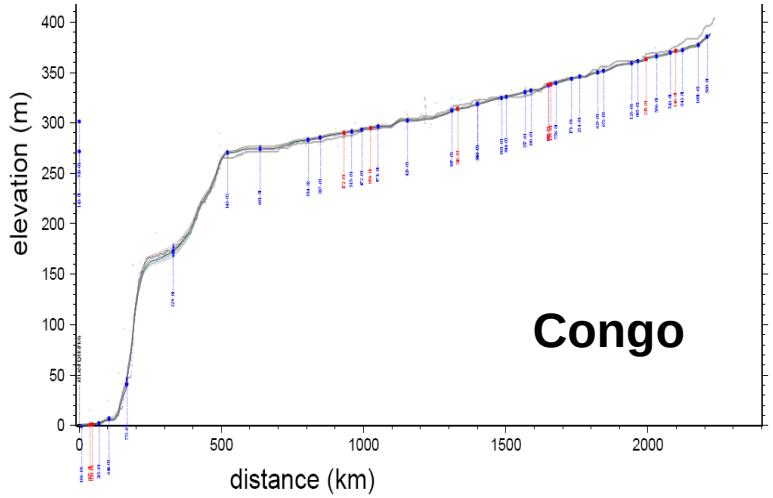


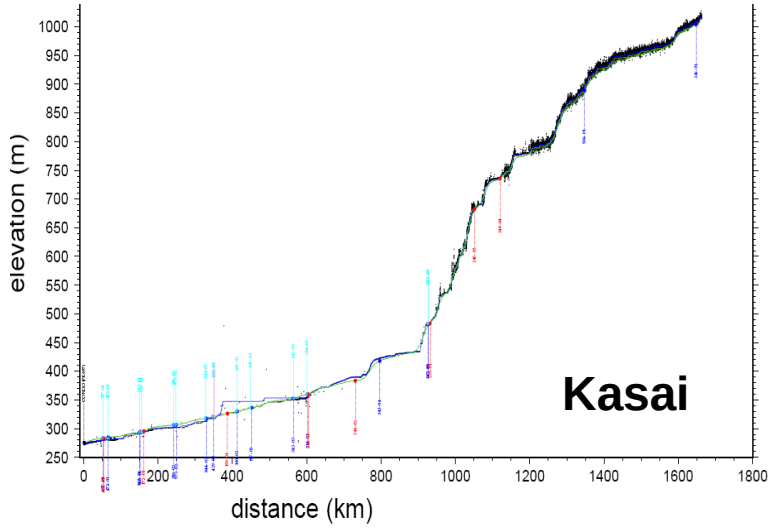
Hydrological information system

Applications and services :

navigation, integrated water resources management, hydropower.

Operational use of altimetry data: the Congo basin

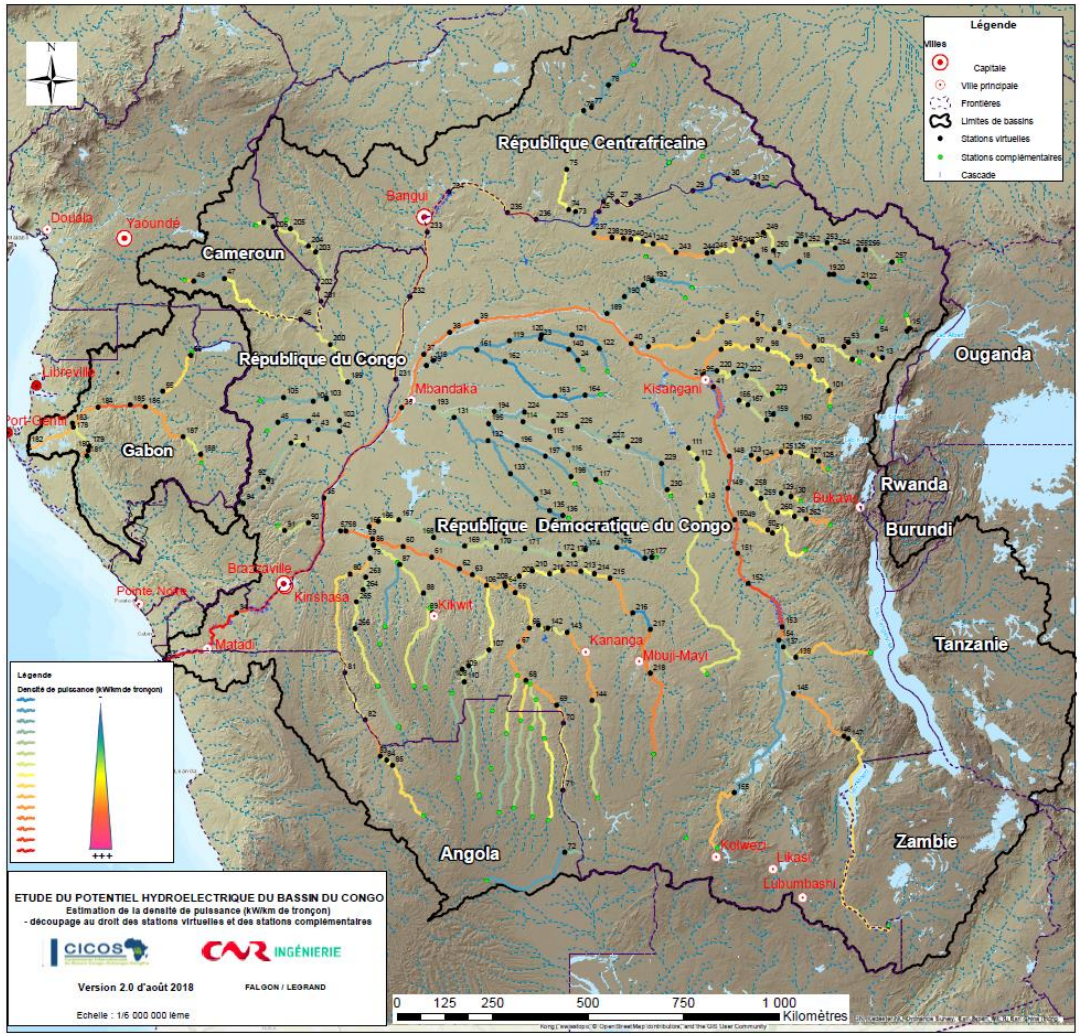




CICOS
Commission Internationale du Bassin Congo-Oubangui-Sangha

ETUDE DU POTENTIEL HYDROELECTRIQUE DU BASSIN DU CONGO

ESTIMATION DE LA DENSITE DE PUISSANCE (kW/km) - DECOUPAGE AU DROIT DES STATIONS VIRTUELLES

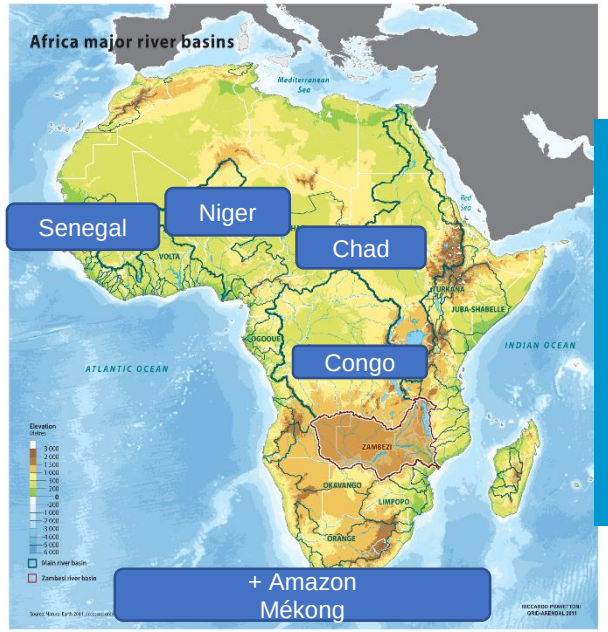


Summary and perspectives

Importance of in-situ data :

- Needed for calibration and validation purposes
- Can be installed almost everywhere
- Satellite data as a complement to the in-situ network

Continuous improvement in water elevation from altimetry: accuracy, processing, size of water bodies



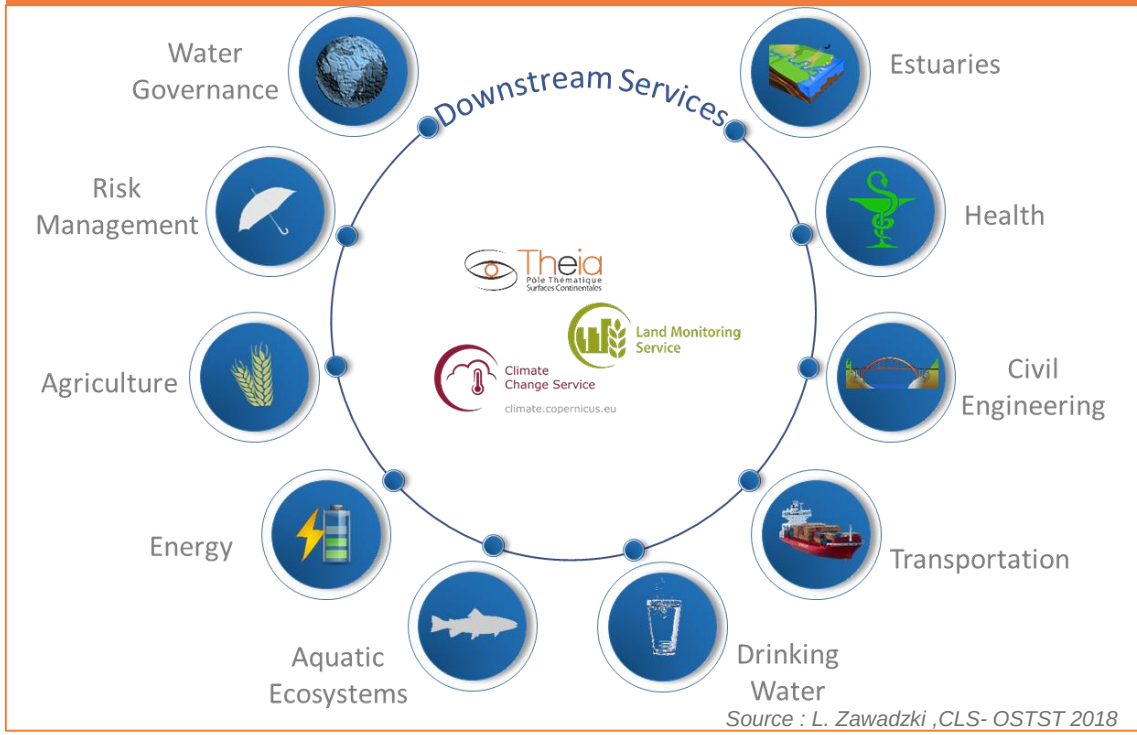
Operational use of altimetry data now possible.

Proof of concept made over the Congo basin : great satisfaction from local authorities

In development in other large basin (Niger, Chad, Senegal).

The SWOT users preparatory program:

- To ease the use of spatial data in hydrology *land use, water bodies surface, soil moisture, snow cover, water quality, etc.*
- To leverage new services and applications



Source : L. Zawadzki ,CLS- OSTST 2018

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jean-francois.cretaux@cnes.fr

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