



# Earth Observation for water resources management

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for the SWOT downstream Team



# Observing water resources from space : WHY?

Demography ↑  
→ demand on freshwater

Water scarcity and non-uniform distribution

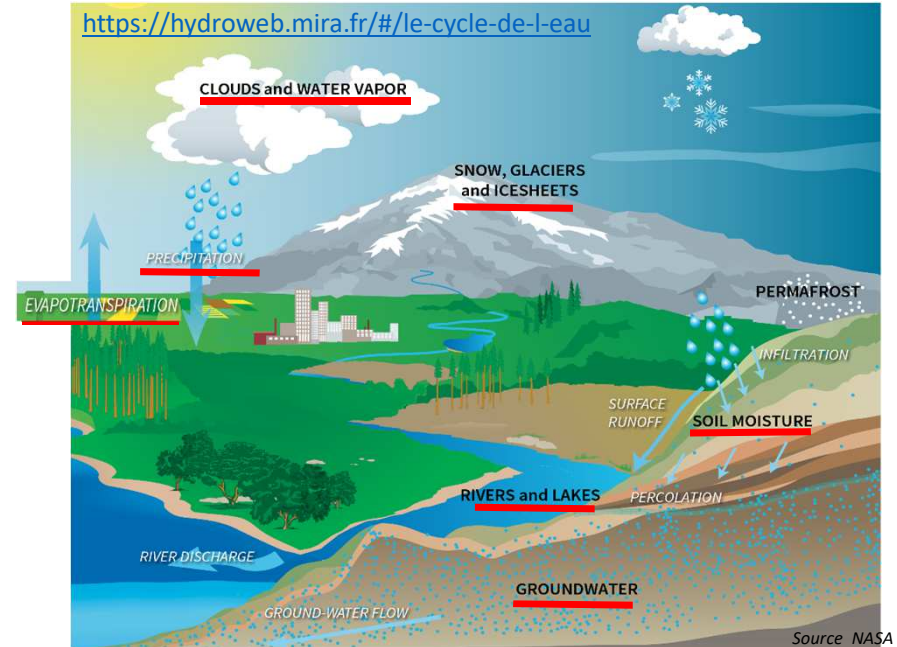
Transboundary river basin  
→ availability of data

Climate change : impacts, mitigation, adaptation ?

In-situ network ↓  
homogeneity, quality ?

Need of an integrated water resources management

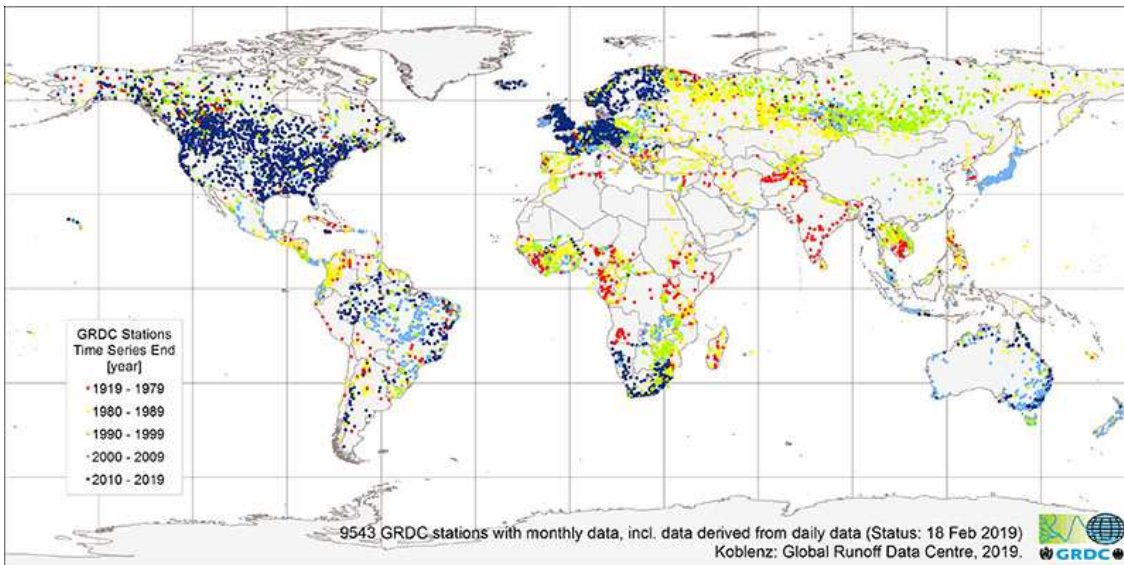
<https://hydroweb.mira.fr/#/le-cycle-de-l-eau>



## What SPACE OBSERVATIONS are bringing in to water cycle ?

- Global data, no borders
- Homogeneous
- Open access, operational services and data continuum (>2030)
- All components of the water cycle seen by satellites (!! spatial and temporal resolution + accuracy)

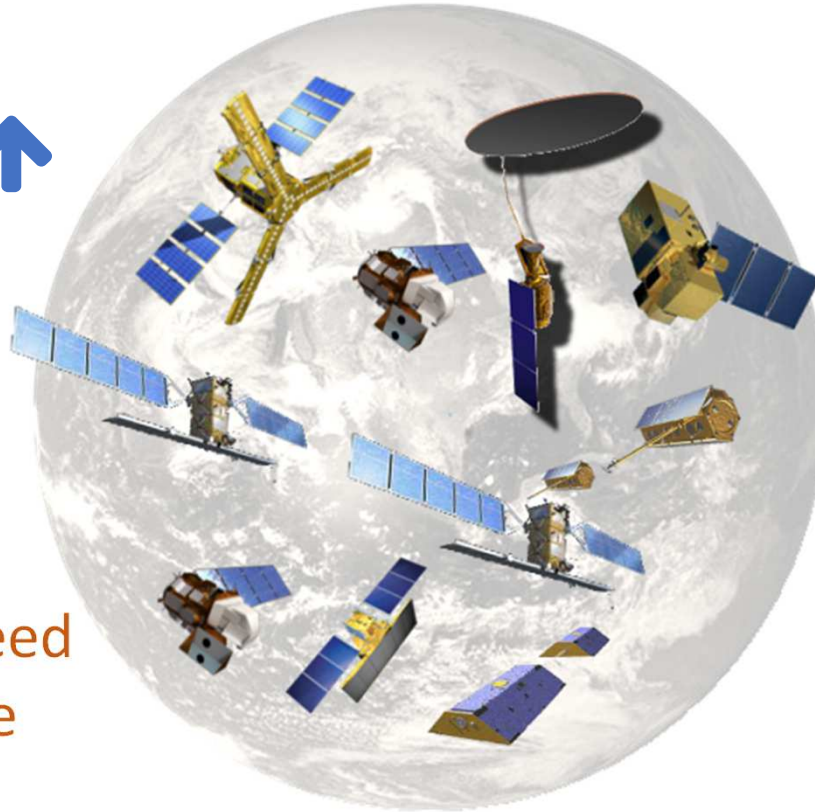
→ Satellite data as a complement of in-situ network



# Open up avenues to operational hydrology



Temporal resolution ↑



Smaller water bodies  
and global coverage

Data continuity guaranteed  
& freely, easily accessible

Accuracy improved

→ Golden age of spatial data

# The SWOT Mission : a booster for hydrology from space



## 1<sup>st</sup> satellite mission dedicated to inland water



- Surface Water and Ocean Topography - NASA-CNES-CSA mission
- Launch February 2022

## 2D images of water level with high vertical accuracy

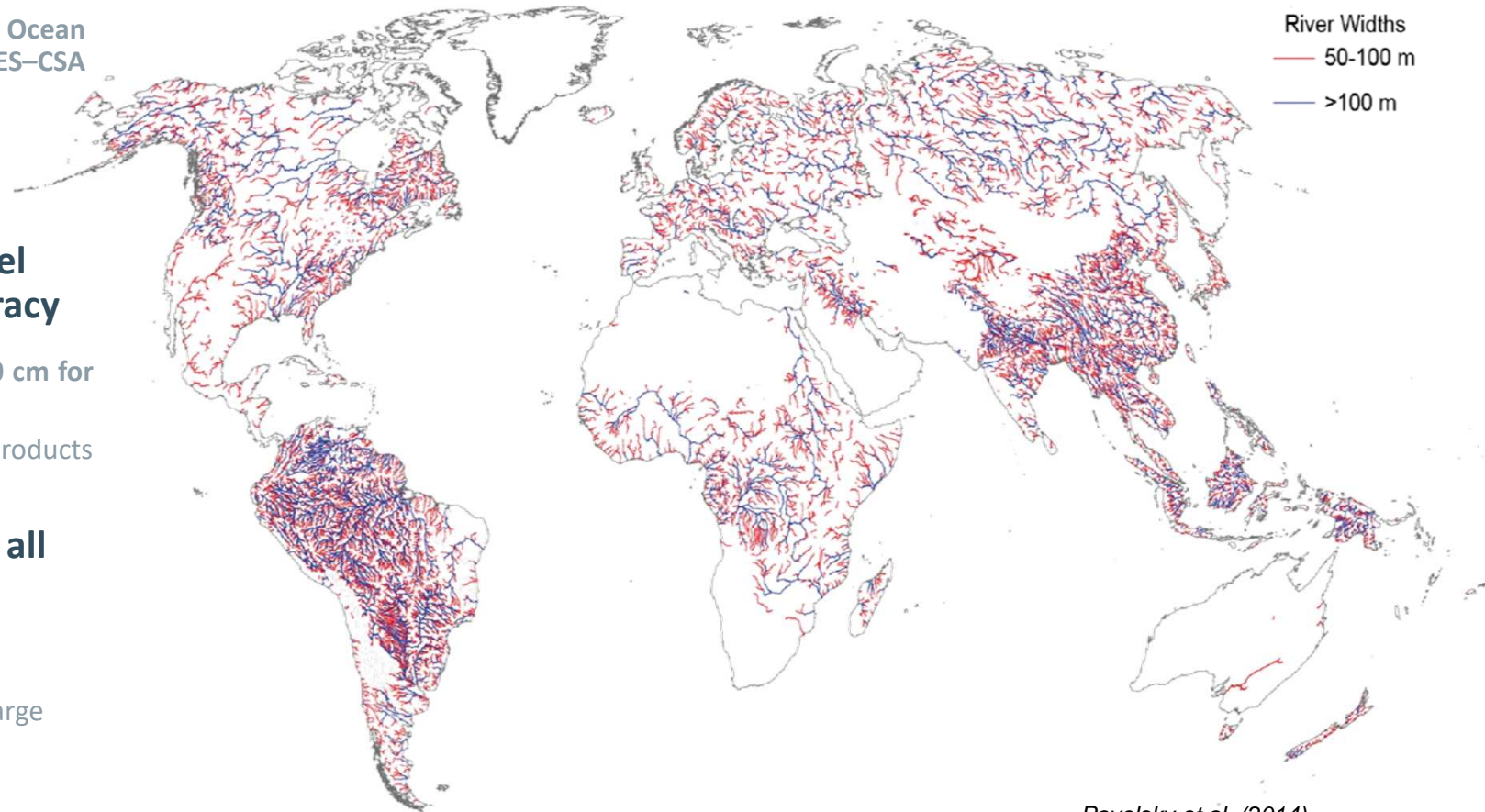


- Height vertical accuracy of 10 cm for rivers
- **FREE ACCESS** to all data and products

## First global inventory of all terrestrial water bodies



- Global storage change
- Global change in river discharge

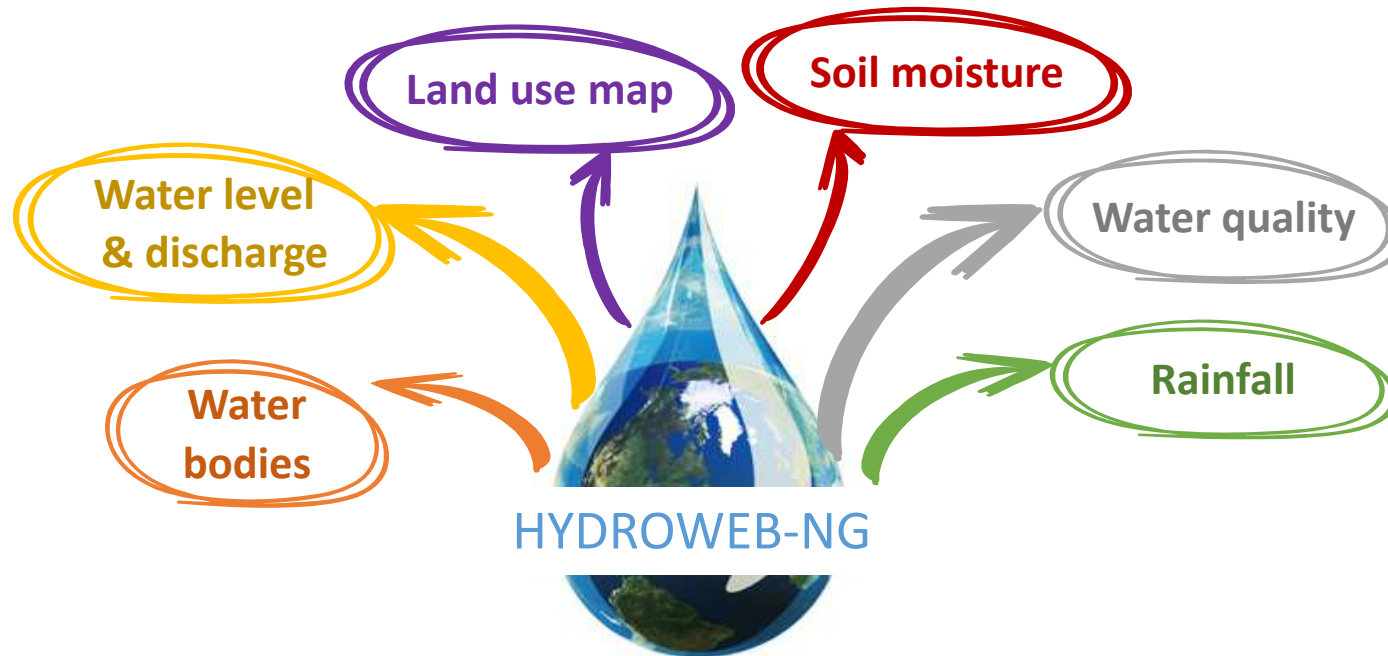


River Widths  
— 50-100 m  
— >100 m

Pavelsky et al. (2014)



# The SWOT downstream program : targeted variables



- ✓ Single access point for hydrology products from EO
- ✓ Multi-sensors, multi-variables approach
- ✓ Global scale targeted when possible
- ✓ Appropriate spatial and temporal resolutions
- ✓ Free access to data for all users
- ✓ Standardization of data, interoperability, data quality

➔ Facilitate the use of satellite-based data

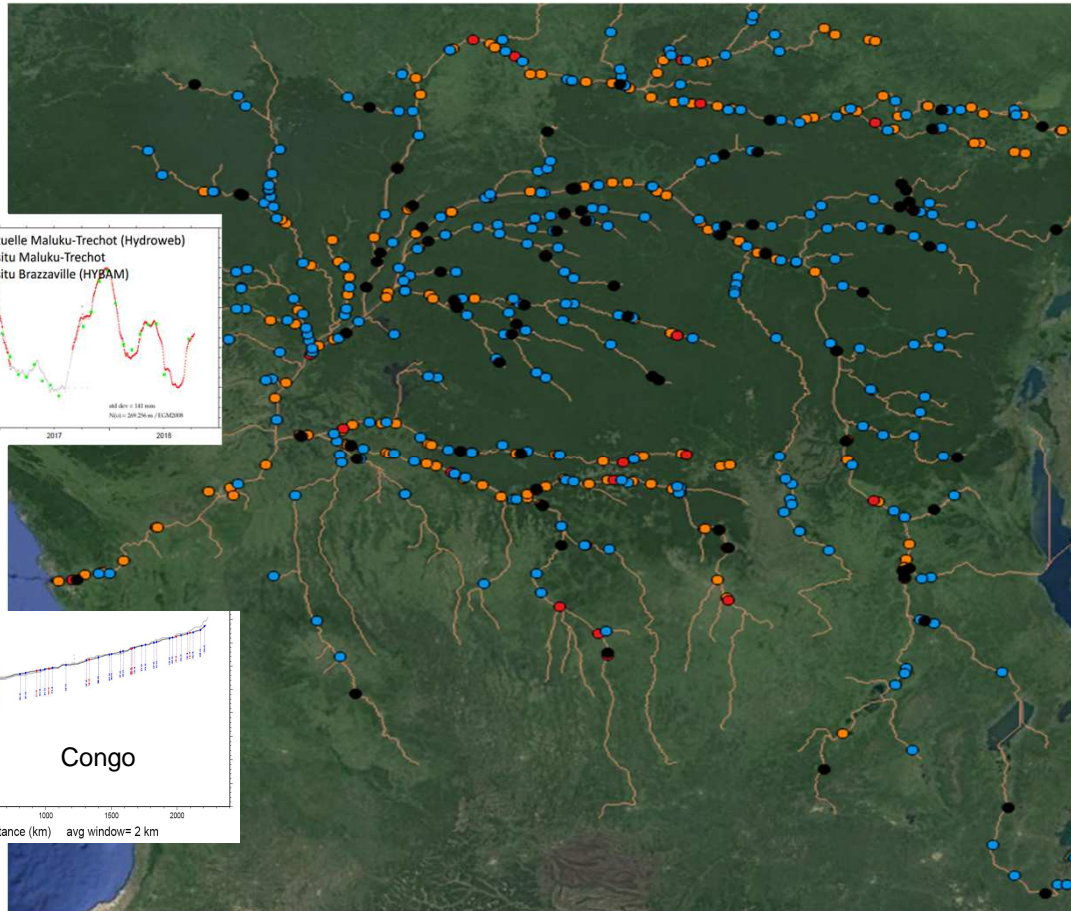
➔ Set up of pilot sites to evaluate the added-value of Earth Observation



# Examples of applications



# 1- Improve knowledge of hydrological status- Congo basin



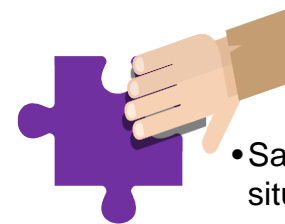
Congo basin = 2nd world largest basin

- 3.8 Mkm<sup>2</sup>
- 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

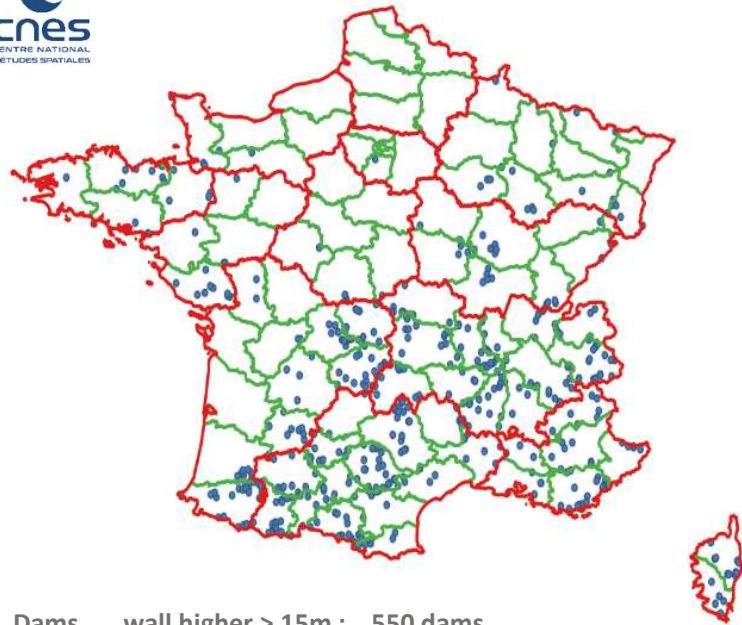
- Satellite data as a complement to the in-situ network
- Available for all on the HYDROWEB portal : <http://hydroweb.theia-land.fr>



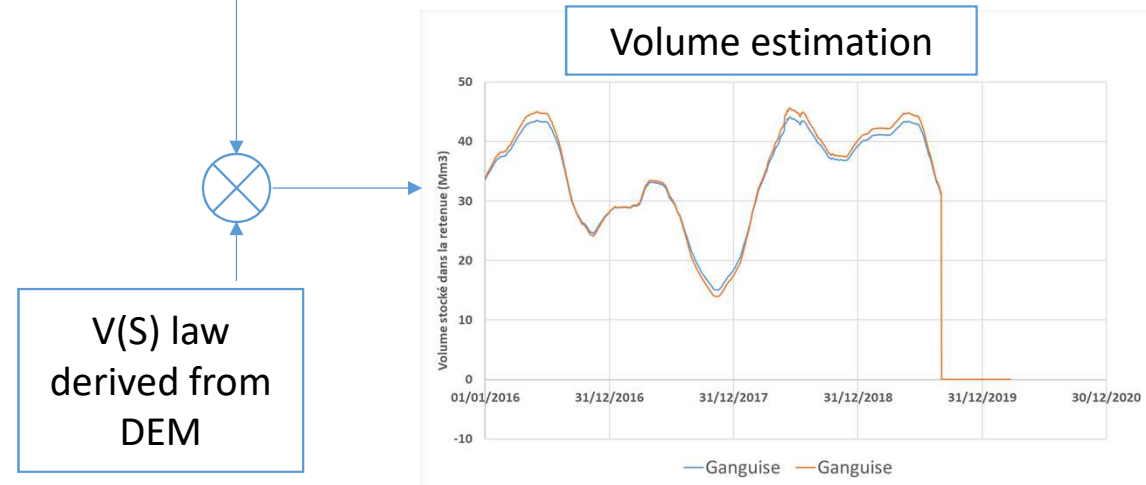
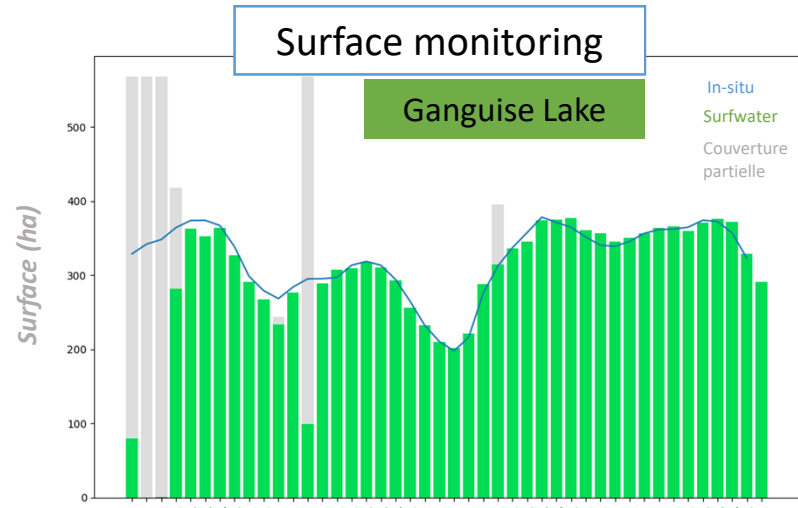
# 2- Monitoring of reservoirs volume variations



**Ongoing project:**  
Towards operational monitoring of  
dams/reservoirs



Dams wall higher > 15m : 550 dams  
surface > 40 ha : 226 dams where 154 classical morphology



V(S) law  
derived from  
DEM



# 3- Water quality of Lake Chad

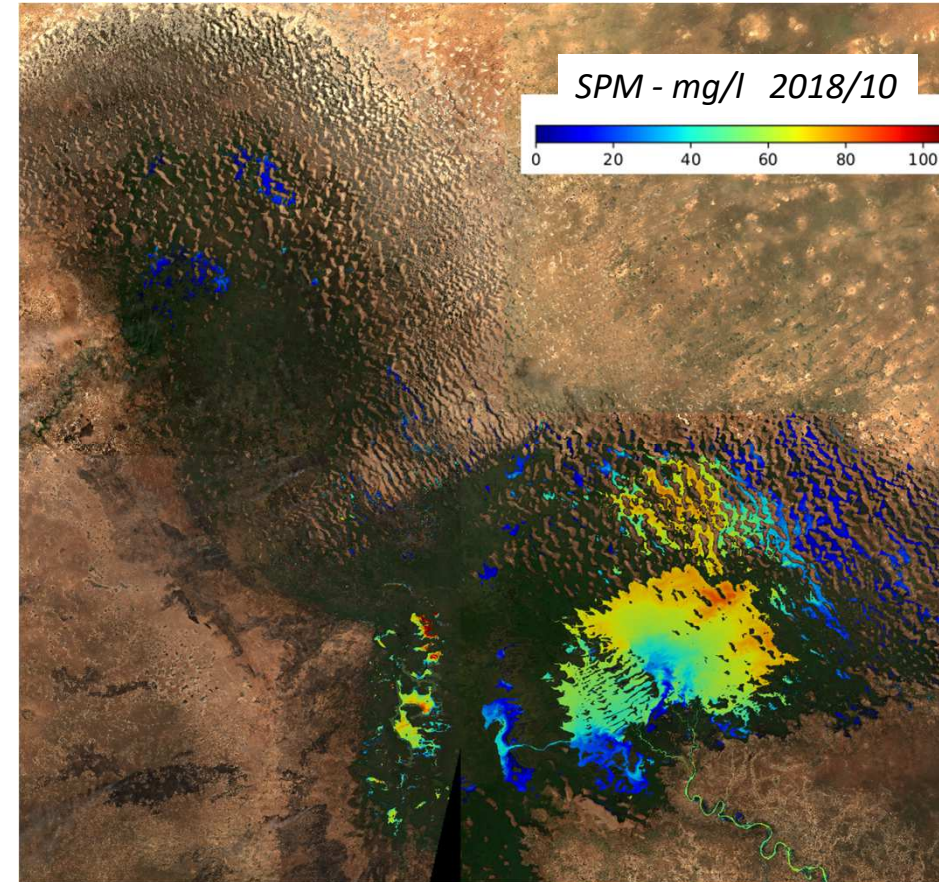
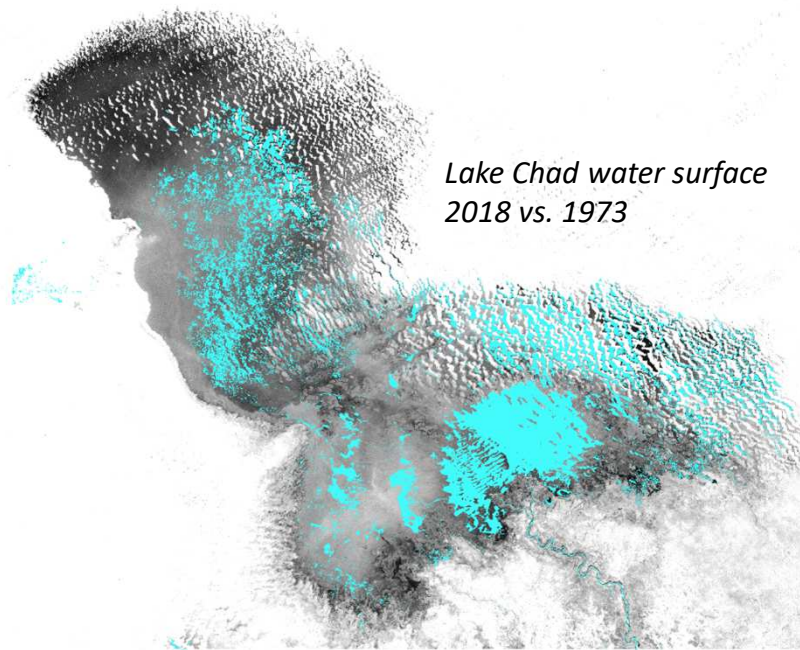


United Nations  
Educational, Scientific and  
Cultural Organization

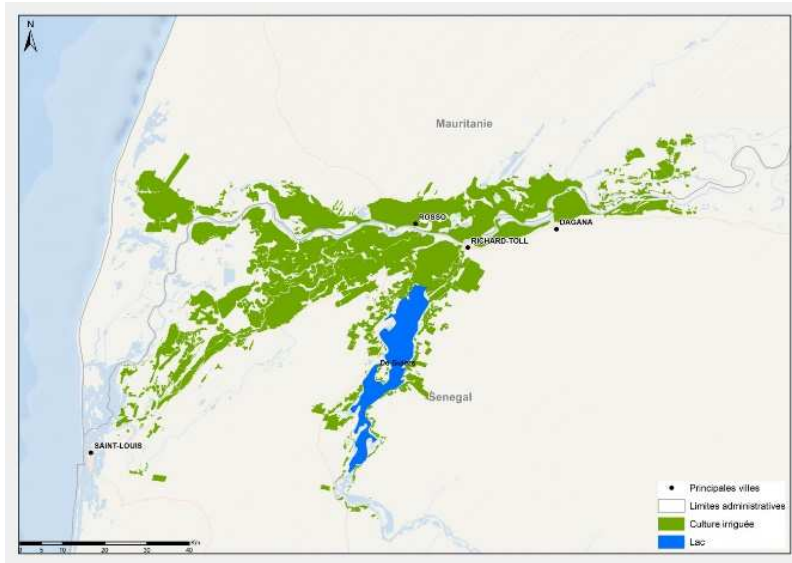
## On-going project : Biosphere and heritage of Lake Chad (BIOPALT):

5 to 10 years monitoring of :

- Surface
- Temperature,
- Turbidity, Suspended matter, Chl-a, algal bloom
- Water elevation (Hydroweb)



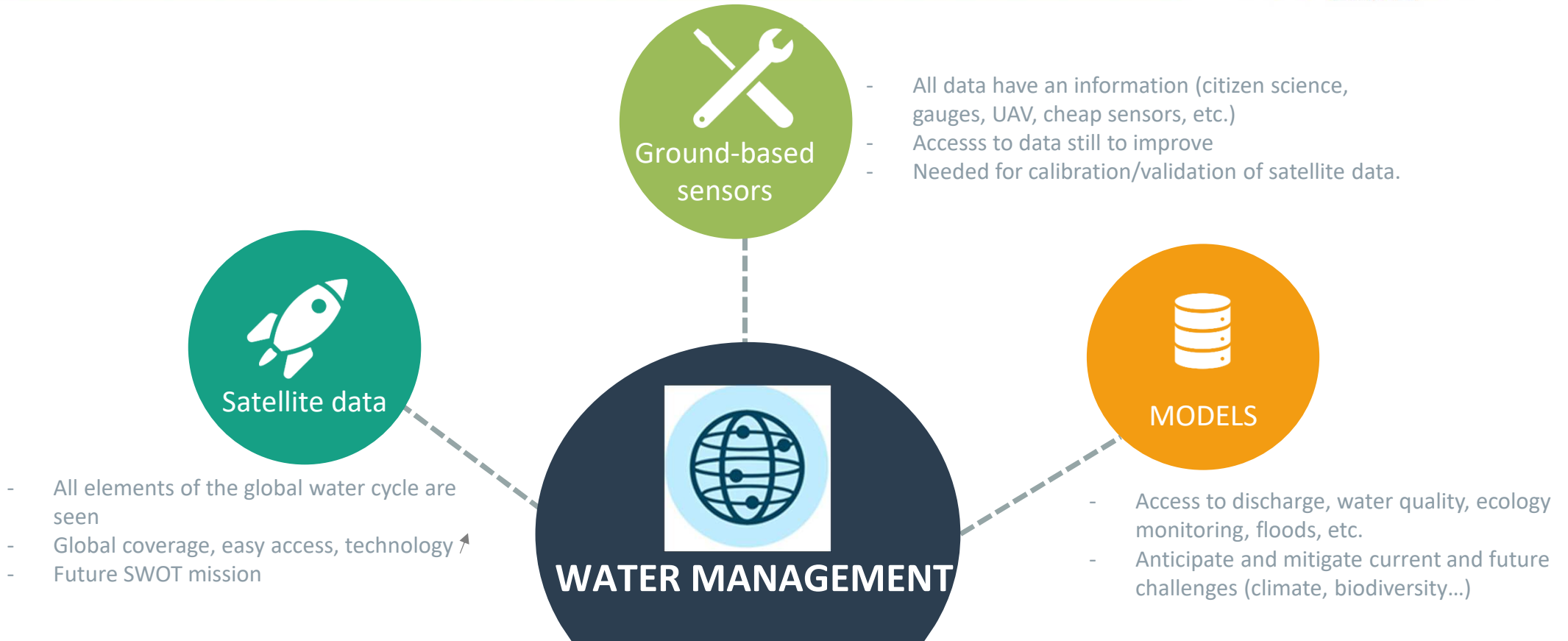
# 4- Monitoring and survey of irrigated systems (MoSIS) on Senegal River



## KEY ISSUES

- Continuous monitoring of irrigated surfaces and vegetation status using satellite data
- Evaluation of surface prone to royalties and comparison to the declaration of the beneficiaries
- Development of an Information system with a Web-GIS interface

# Summary and perspectives



**Toward a real-time inventory of the world's water and its changes over space and time**





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# Observing water resources from space : HOW?

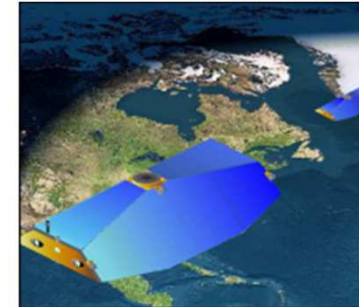
Some space techniques used for hydrology :



Radar altimetry  
Jason 2, 3, CS, Saral,  
Sentinel 3, SWOT



Microwave imaging radiometer  
SMOS, SMAP, *SMOS Next*



Gravimetry  
Grace 1, 2



Synthetic Aperture Radar (SAR)



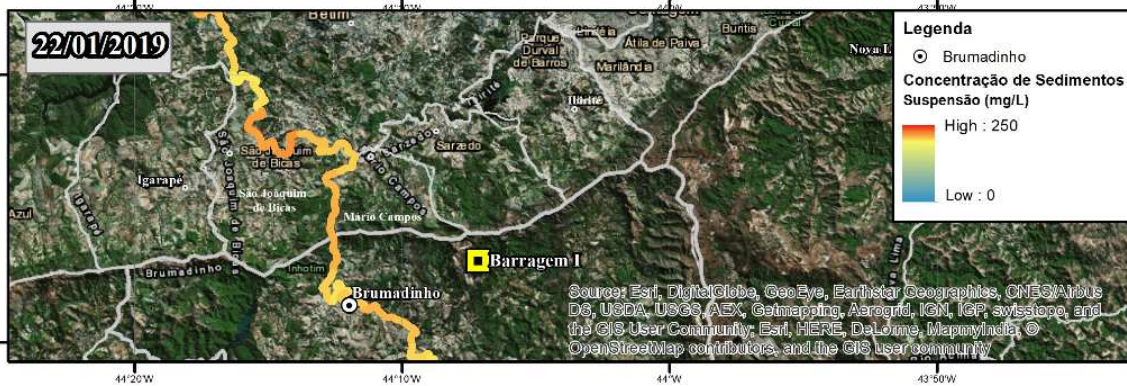
Optical imaging radiometer  
SPOT 5, 6, 7, *Landsat 8*  
Pléiades 1, 2, Sentinel 2  
Metop, Météosat



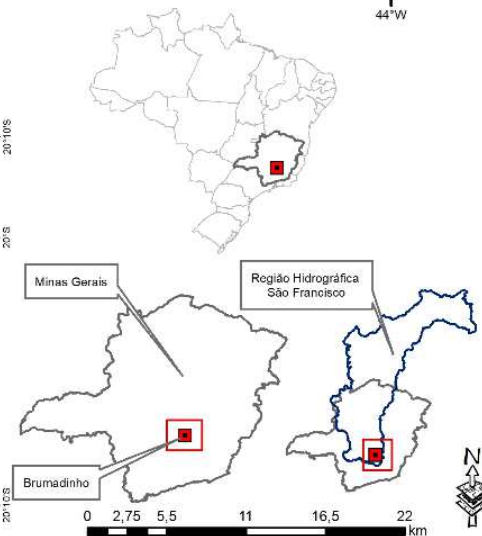
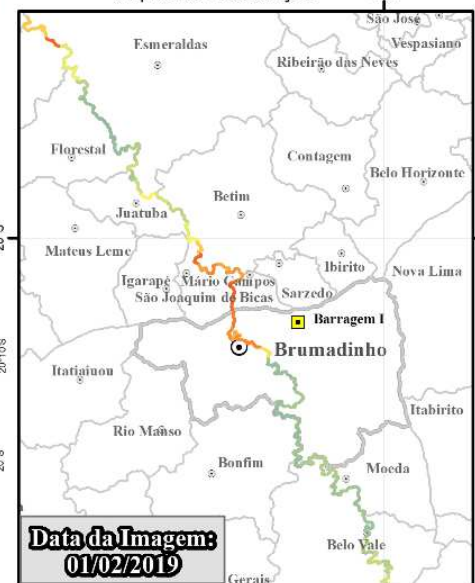
Infrared imaging  
radiometer  
*Sentinel-3,*



Variação da Concentração de Sedimentos em Suspensão  
Rio Paraopeba visto por satélite (Sentinel 2)



Mapas de Localização



## Disaster monitoring

### Brumadinho dam failure

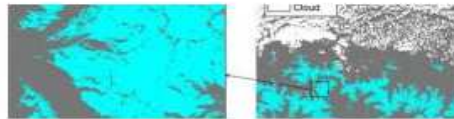
- 25 Jan 2019 (+300 casualties)
- IRD and Brazilian water agency
- Sentinel 2 & Landsat 8 Images

### Turbidity changes of Paraopeba river



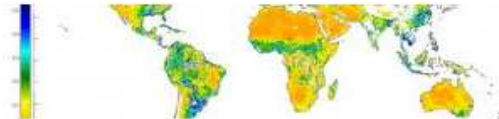
<https://www.theia-land.fr/en/products/>

## Snow



Zone: Alps, Pyrenees, High Atlas  
 Period: July 2016 - present  
 Access: All users  
[theia.cnes.fr](http://theia.cnes.fr)

## Soil moisture



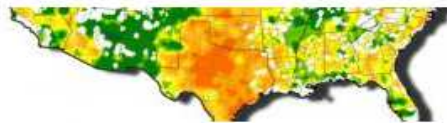
Zone: Global  
 Period: 2002 - present  
 Access: All users  
[ftp.ifremer.fr](http://ftp.ifremer.fr)

## Soil moisture in the root zone



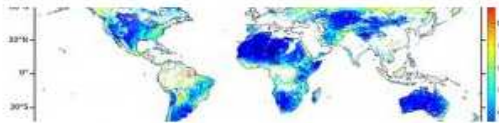
Zone: Global  
 Period: 2010 - present  
 Access: All users  
[ftp.ifremer.fr](http://ftp.ifremer.fr)

## Drought index



Zone: Global  
 Period: 2010 - 2017  
 Access: All users  
[ftp.ifremer.fr](http://ftp.ifremer.fr)

## Surface roughness



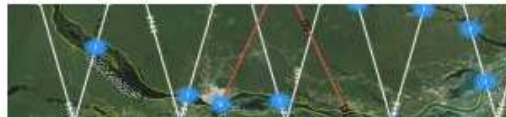
Zone: Global  
 Period: 2010 - présent  
 Access: All users  
[ftp.ifremer.fr](http://ftp.ifremer.fr)

## Soil moisture map with very high spatial resolution



Zone: Occitanie  
 Period: Sept. 2016 à mai 2017  
 Access: All users  
[ids.equipepex-geosud.fr](http://ids.equipepex-geosud.fr)

## Water levels of rivers and lakes (Hydroweb)



Zone: Global  
 Period:  
 Access: All users  
[hydroweb.theia-land.fr](http://hydroweb.theia-land.fr)

## Water cycle variables (Postel)



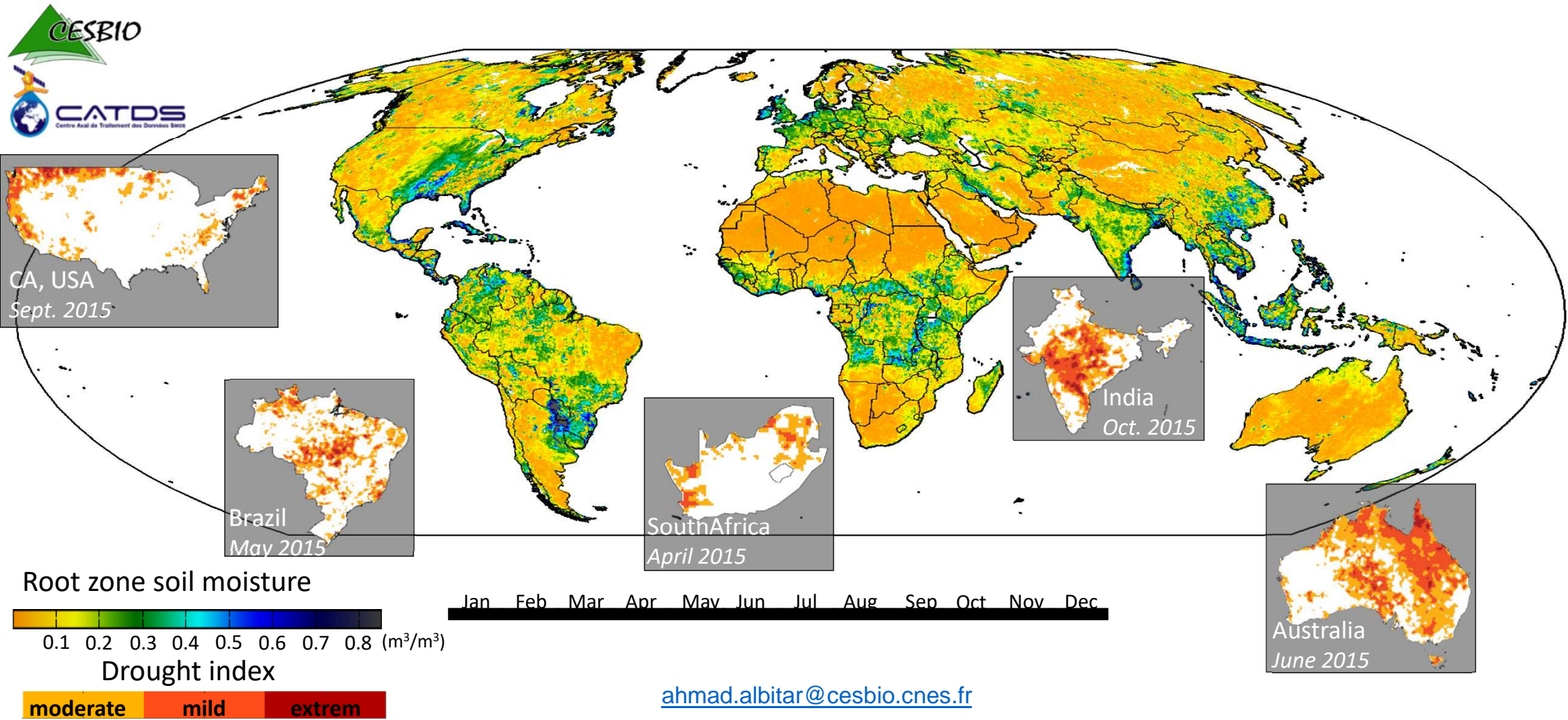
Zone: Continental to Global  
 Period: 1992-2005  
 Access: All users  
[theia-landsat.cnes.fr](http://theia-landsat.cnes.fr)

## Land cover map



Zone: Metropolitan France  
 Period: 2016  
 Access: All users  
[osr-cesbio.ups-tlse.fr](http://osr-cesbio.ups-tlse.fr)

# Soil moisture





# MOSIS - Mid to long term prospects

- Real ways of deploying and exploiting this tool exist in the Senegal River and why not in other territories....  
..... or for other services and for different users

Geographic domains

## OMVS

- Anticipating the effects of climate change
- Monitoring the environment and the proliferation of invasive plant species
- Estimate references of moisture or drought hazards
- Follow operating and risk management instructions

## SOGED

- Implementation of a regulatory certification procedure
- Follow the most exploited areas to coordinate maintenance
- Plan and optimize dam and infrastructures
- Support end users cooperation

## Partners & relay

- Monitoring the reality of farm operations: farm credit, banks, SAED, SONADER, regional delegations, etc.
- Decision-making aid for financing and carrying out maintenance work on hydraulic axes

## Beneficiaries & Irrigants

- Support for efficient and water-efficient management
- Monitoring of leased areas