Managing water levels and river flows requires detailed knowledge, in particular in the context of climate change. Yet in situ hydrologic stations are increasingly rare and financing their maintenance can be problematic. Calculations of “water elevation” (the altitude of rivers and lakes) based on data from Earth observation satellites provide a promising new source of information. Combined with other hydrological information from satellites, these altimetry data open up multiple perspectives for both scientific research and the operational management of water resources, in particular for large transboundary rivers.

**OBJECTIVES**

In 2014, a working group was created to bring together technical and scientific visions and user needs concerning satellite altimetry (estimation of river levels and discharges), and more generally, “multi-sensor” data (imagery, radars) useful for water management.

The spatial hydrology working group gathers French research, institutional, technical and operational stakeholders. It also works closely with potential users, like transboundary basin organisations, especially in Africa. The group members pool their research and champion the implementation of innovative technologies and knowhow.

The group works in particular on the **SWOT satellite programme** (Surface Water and Ocean Topography). By 2021, this Franco-American project featuring Earth observation satellites will provide spatio-temporal variations of the water levels of large rivers, lakes and streams, of the discharges of major rivers, and of sea levels.

**Group members**

The working group on spatial hydrology, coordinated by IOWater, involves the CNES, IRD, AFD, IRSTEA, BRLI, CNR and CLS.
**Overview of knowledge and requirements**

- Overview of the state-of-the-art on the use of spatial data in hydrology
- Continuous monitoring of progress in the field
- Analysis of the needs of transboundary basin organisations

**Creation of models using data from virtual stations**

These models are used to calculate:
- Water elevations in lakes and rivers
- Flows of watercourses
- Forecasts of future levels of water elevations and discharges

**Application for use:** navigation, hydroelectricity, flood forecasting, ecosystem maintenance, etc.

**Set up of an information system for users to collect, store, process, disseminate and exchange data**

**Training of beneficiaries to ensure successful adoption of tools**

**Availability of data**

- Collection and processing of spatial altimetry data received from different satellites (Saral, Envisat, Jason series, Sentinel 3)
- Comparison with data measured by stations on the field to estimate their precision
- Selection of pertinent virtual stations

**Virtual stations occur at the intersection between altimetry satellite ground tracks and the river network. They indicate the elevation of the water in relation to a reference: the ellipsoid.**

**Operational transfer**

- Application for use: navigation, hydroelectricity, flood forecasting, ecosystem maintenance, etc.
- Set up of an information system for users to collect, store, process, disseminate and exchange data
- Training of beneficiaries to ensure successful adoption of tools

**Determination of virtual stations operating on pilot basins**

- Time series of the water levels of rivers and lakes are available on the Hydroweb platform. These time series are continuous and cover a long period. They are produced from data supplied by different altimetry satellites. Cartographic visualisation and filters make it easier to access the available series.

http://hydroweb.theia-land.fr/

**Key dates**

- **2014**
  - Group creation

- **2015**
  - Signature of group agreement
  - 24 March 2017 COP 22 in Marrakech

- **2016**
  - Installation of two measurement stations aligned with a satellite track in the River Congo basin

- **2017**
  - Formalisation of partnership with the International Commission of the Congo-Oubangui-Sangha (CICOS) / Congo basin chosen as pilot basin
  - Delivery of a hydrologic information system to CICOS

- **2018**
  - Constitution of a base of altimetric database and reference virtual stations in the Niger basin (NBA)

- **2019**
  - Kick-off of activities on the Senegal basin (OMVS)
  - Collaboration with the Niger Basin Authority (NBA)
The Congo basin’s hydrological information system

The hydrological information system (HIS) developed for CICOS features:

- In situ measurements (water levels, discharges and rating curves)
- Water elevation from spatial altimetry.

The development of HIS is based on the WIMES platform produced by BRLI.

It is operated through services and applications used for navigation (water level forecasts) and for developing hydropower potential.

CICOS teams have been trained to use the tool.

**Applications and services:**
- Navigation
- Integrated water resources management
- Hydropower
544 time series of water levels produced by virtual stations on the Congo basin are freely available on Hydroweb. In addition, 163 time series from ENVISAT and 33 from Jason 2 are available from CICOS, IRD and on Hydroweb.

The data from these stations are used to feed into models and hydrological information systems in addition to in situ data.

M’Bata in Central African Republic, Maluku-Tréchot in Congo and Kollo in Niger

Measurements of pluviometry and water elevations

Maintenance of stations carried out by national hydrological services

Data used for comparison with data from virtual stations

CNR mapped an indicator of hydropower potential on the Congo and Ogooué basins, crossing flood and slope information useful for identifying hydropower projects. It is built from satellite altimetry, in situ discharges, precipitation data and a digital elevation model.

The second part of the project, relating to navigation, resulted in a forecasting service of water levels on the Sangha, a tributary of the Congo.

A new approach has been developed to forecast discharges, and in particular “red floods” (right-bank tributaries from Burkina), which can be devastating in Niamey. It integrates complementary tools i.e. satellite estimation of rains flowing into the river and the sometimes highly reactive lateral basins, a hydrological model to propagate the run-off and discharge, and satellite altimetry based on operational satellites (Jason, Sentinel 3) to monitor flood levels.

PERSPECTIVES

Continued activities on pilot transboundary basins of the Congo and Niger rivers:

- Extension of operational series to other satellites in orbit
- Operationalisation of other hydrological variables from spatial sources (water quality, soil moisture, water surfaces, land use, etc.)
- Spatial and temporal densification of the virtual station network, state of water resources on the entire basin, and forecast of floods and low waters
- Establishment of relations with the Space Climate Observatory piloted by the CNES

Activities are underway on rivers shared by Guiana. The group could extend its activities to other transboundary basins, e.g. Senegal, Lake Chad, Mekong and Nile rivers.

Training of final users and local experts along with citizens’ initiatives are vital to ensure the sustainability of action.

Contact - More information

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CNES - https://swot.cnes.fr/fr
NBA - http://www.abn.ne/
CICOS - https://www.cicos.int