PROGYSAT
Projet régional d'observation des Guyanes par satellite

WATER RESOURCES ON THE GUIANA SHIELD: SENSITIVITY AND EVOLUTION

COORDINATION : M.P BONNET & F SEYLER

Loic Marie-Louise, Adrien Paris, Daniela Junqueirac, Frederique Seyler, Henrique Roig, Thibault Catry, Marie-Line Gobinddass, Marie-Paule Bonnet

PRIMARY OBJECTIVES

Contribute to the assessment of the water resource on the Guiana Shield and its sensitivity to ongoing climate and anthropogenic changes

- Compile a **database** (surface water) by integrating available satellite and in situ data and a **documentary database** (including grey literature)
- Build an **integrated system of observation and forecasting of flows**, water levels and water bodies in the main rivers of the region
- Assess the sensitivity of surface water resources to anthropogenic and climatic pressures and determine possible changes

Geographical context: Guiana Shield

Basemap: OpenStreetMap, made with QGIS 3.16 , Mp.Bonnet

COMPLEMENTARY POSITIONNING

Link with ACTO

ACTO
Amazon Cooperation Treaty Organization

Bilateral agreements (ANA, CPRM, SENAMHI Peru, Bolivia, INAMHI Ecuador, Several universities in the basin countries

ACTO-IRD Memorandum of Understanding (MOU) was signed in 2020

A joint program with 4 tasks:

1. Support for compatibility and complementarity of hydrological and biodiversity information for the Amazon Regional Observatory (ORA).
2. Mercury in water bodies: information on the involvement of mercury in physical and biological processes, the presence of mercury in the atrophic chain from sediments, phytoplankton, to human health effects.
3. Environmental DNA
4. Calculation of ecological flow in the most representative sub-basins to determine ecosystem services

COMPLEMENTARY POSITIONNING

Collect, process, organize and disseminate comprehensive and internationally comparable official information among the Member Countries, providing information services agreed with the competent national public institutions through their foreign ministries, for the study and development of the Amazon region in the defined topics previously.

1. Support for compatibility and complementarity of hydrological and biodiversity information for the Amazon Regional Observatory (ORA).

Transfer of HYBAM observatory data and Amazonfish database

2. Mercury in water bodies: information on the involvement of mercury in physical and biological processes, the presence of mercury in the atrophic chain from sediments, phytoplankton, to human health effects.

Beginning of a joint work UnB-IRD to collect available information on mercury in the Amazon basin and create an atlas of vulnerability to mercury exposure. Capacity building is central in collaboration with ANA

COMPLEMENTARY POSITIONNING

Link with on-going research projects

OpHySE (**Op**erational **Hy**drology from **S**pace and mod**E**ls)

SAGUI (**S**ig d'**A**lerte pour la **G**uyane sur l'ea**U** et l'a**I**r)

Publics Partners:

COMPLEMENTARY POSITIONNING

Link with on-going research projects

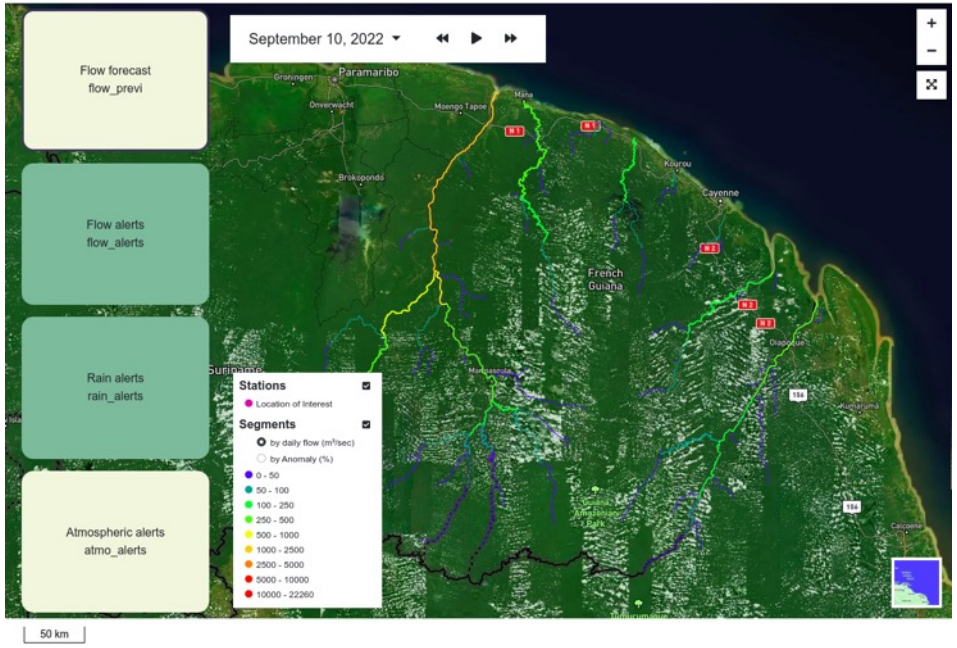
OpHySE (**Op**erational **Hy**drology from **S**pace and mod**E**ls)

SAGUI (**S**ig d'**A**lerte pour la **G**uyane sur l'ea**U** et l'a**I**r)

Publics Partners:

Setting up an operational alert plateform on all French Guiana's drainage basins with :

- Hydrological modeling
- Spatial data (e.g. Remote Sensing)
- Local public actors's expertise partners (e.g. DGTM, OEG).



COMPLEMENTARY POSITIONNING

Link with on-going research projects

OpHySE (**Op**erational **Hy**drology from **S**pace and mod**E**ls)

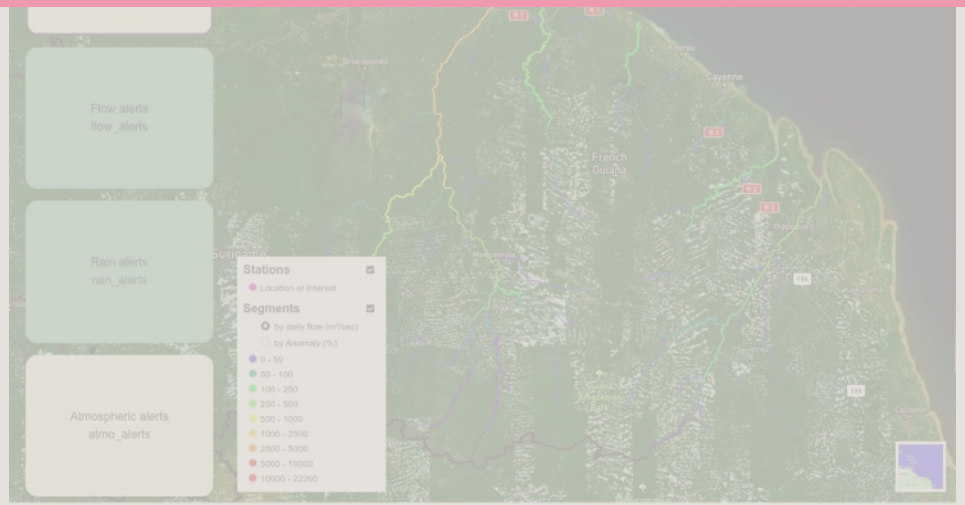
SAGUI (**S**ig d'**A**lerte pour la **G**uyane sur l'ea**U** et l'a**I**r)

Publics Partners:

Setting up an operational alert plateform on all French Guiana's drainage basins with :

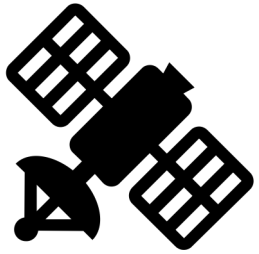
- Hydrological modeling
- Spatial data (e.g. Remote Sensing)
- Local public actors's expertise partners (e.g. DGTM, OEG).

STRONG SYNERGIES WITH THE WATER RESOURCE' AXIS – WORKING IN COLLABORATION WITH HYDROMATTERS TEAM



OVERALL METHODOLOGY

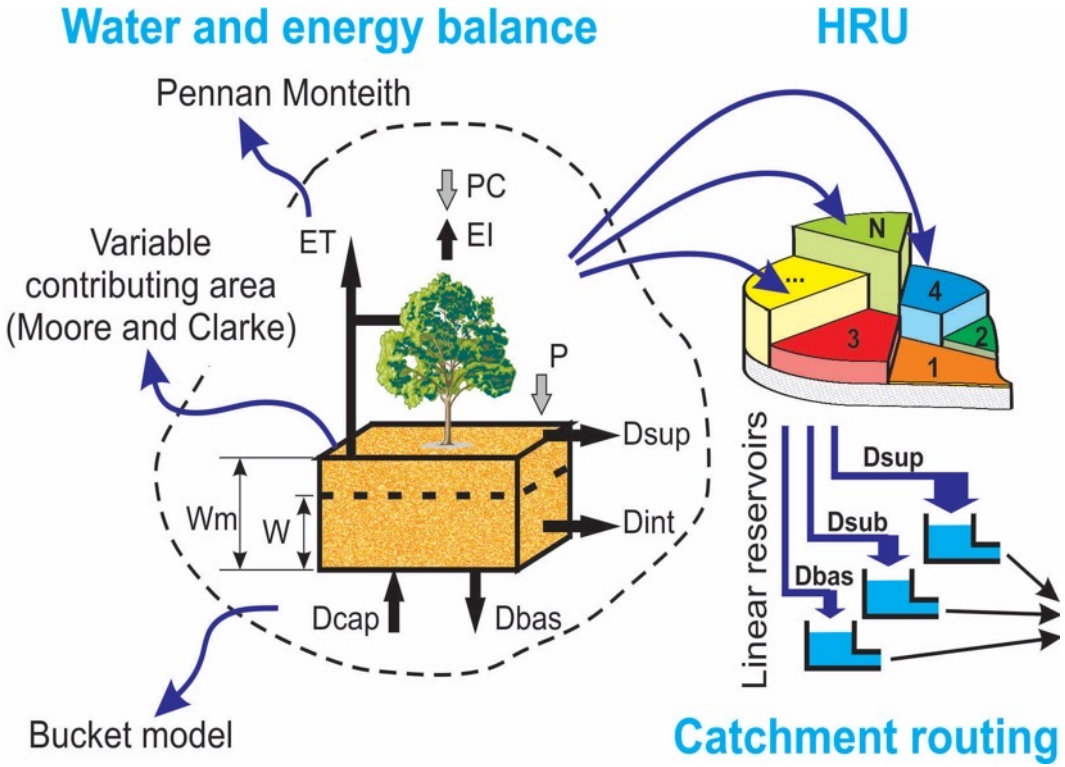
➡ Integrate remote sensing and in situ data with hydrological modelling



Topography
Rainfall
Land cover
Water level
Open Water Extent

Rainfall

Water level



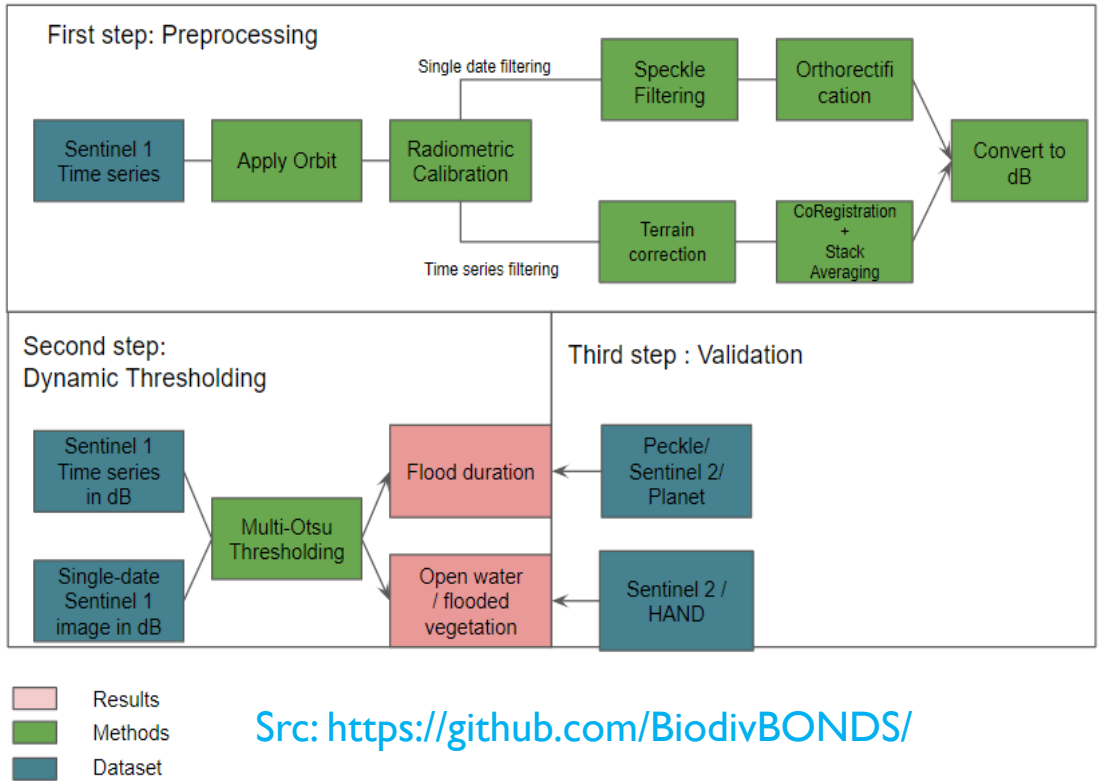
Semi-conceptual and spatialized model

Collischonn et al 2007

OPEN WATER EXTENT FROM S1

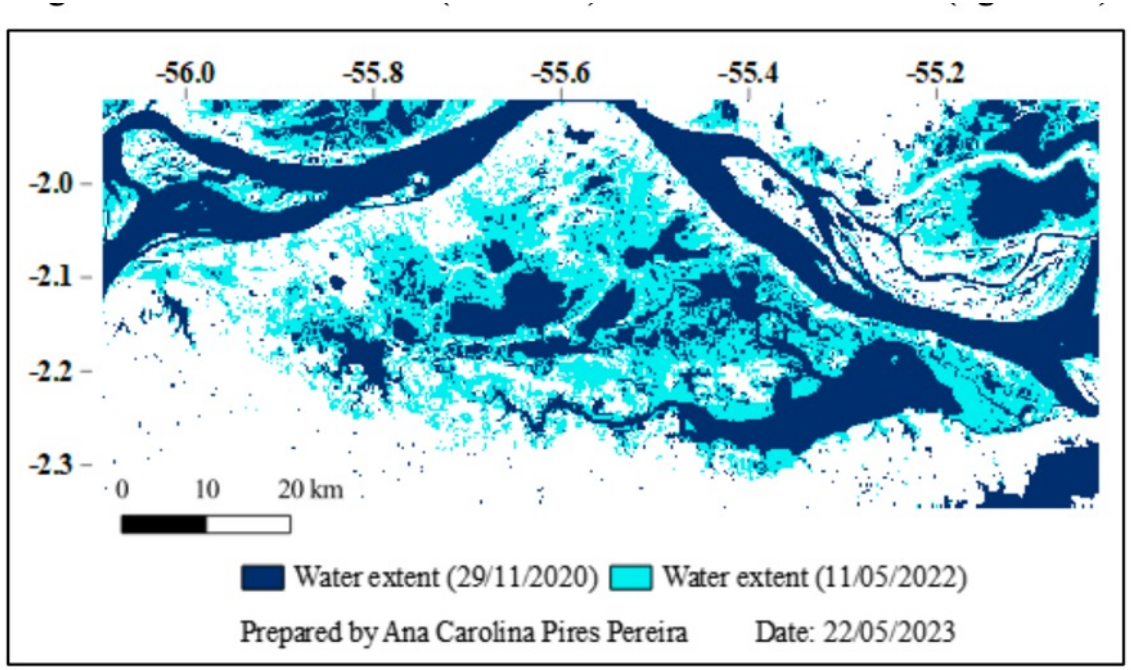
Automatic maping of open water extent (S1-FLOOD)

S1 processing workflow



Src: https://github.com/BiodivBONDS/

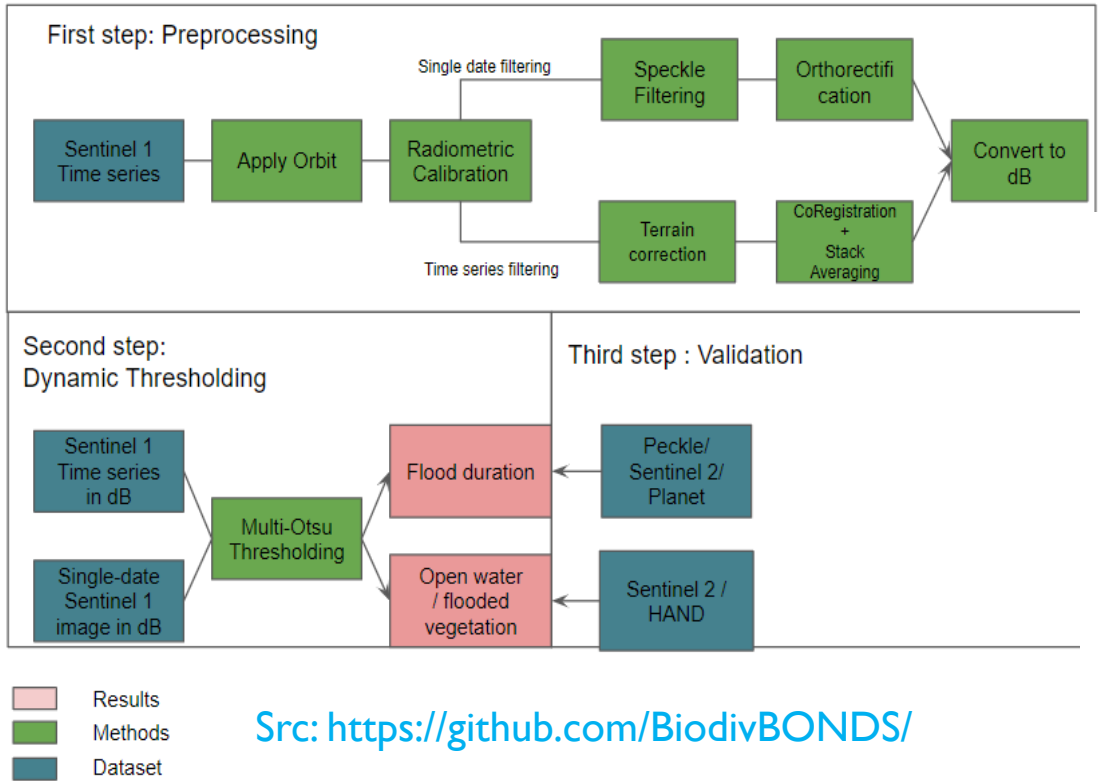
Developed for Amazonian wetlands



OPEN WATER EXTENT FROM S1

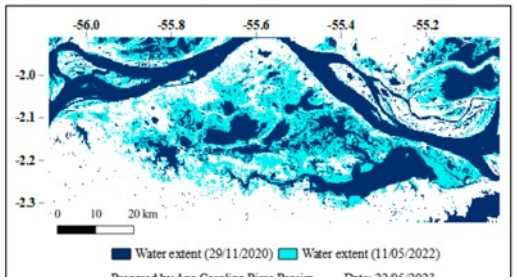
Automatic maping of open water extent (S1-FLOOD)

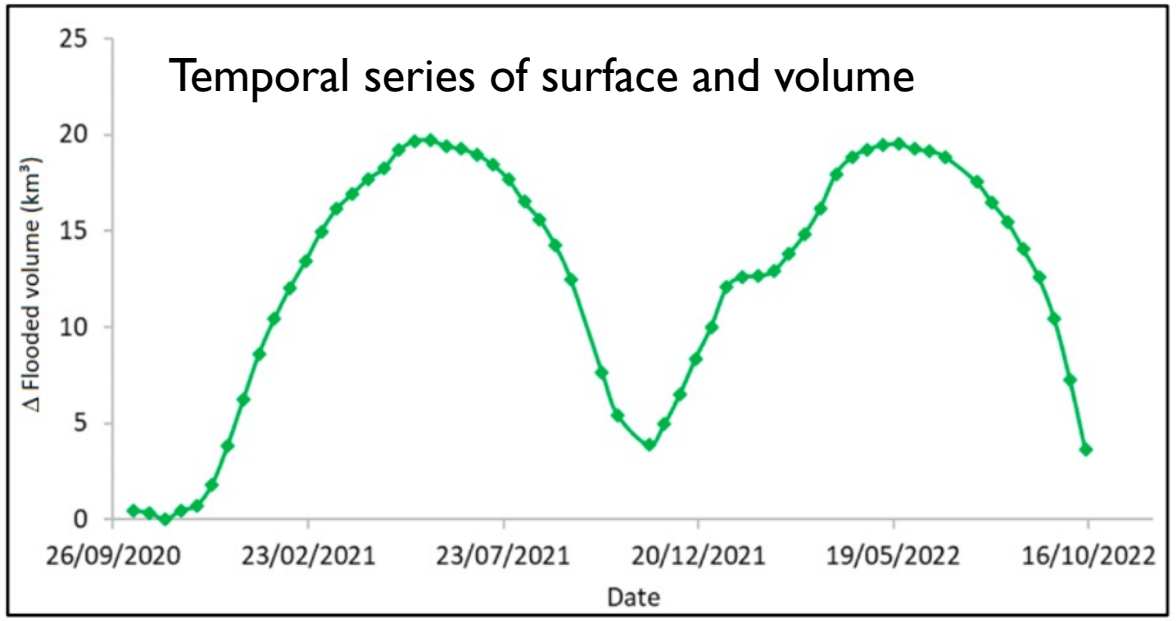
S1 processing workflow



Src: https://github.com/BiodivBONDS/

Developed for Amazonian wetlands

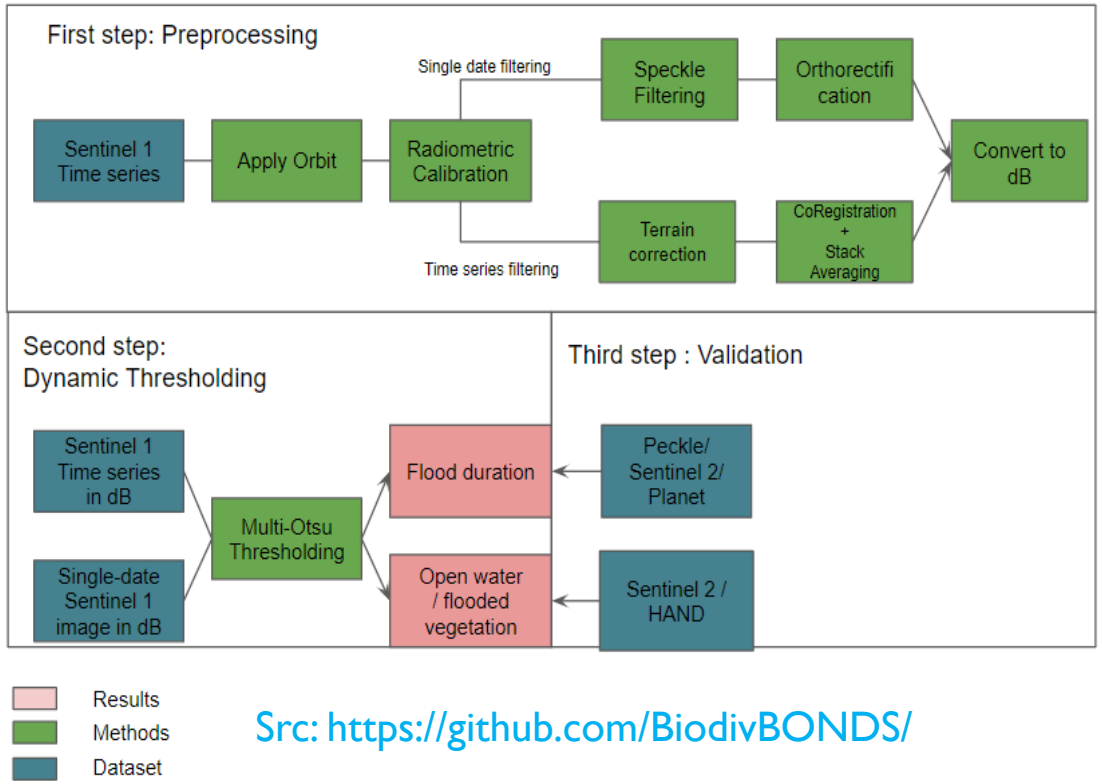




OPEN WATER EXTENT FROM S1

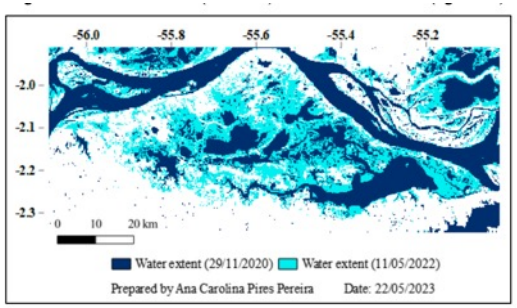
Automatic maping of open water extent (S1-FLOOD)

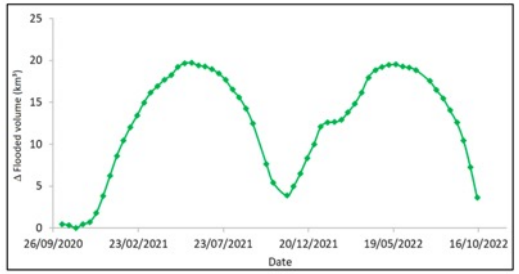
S1 processing workflow



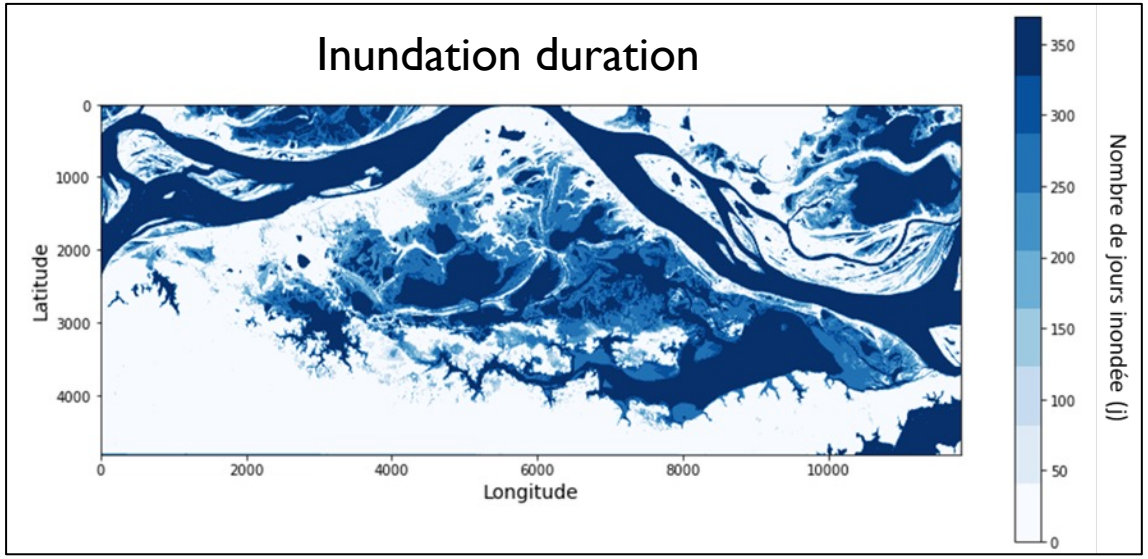
Src: https://github.com/BiodivBONDS/

Developed for Amazonian wetlands





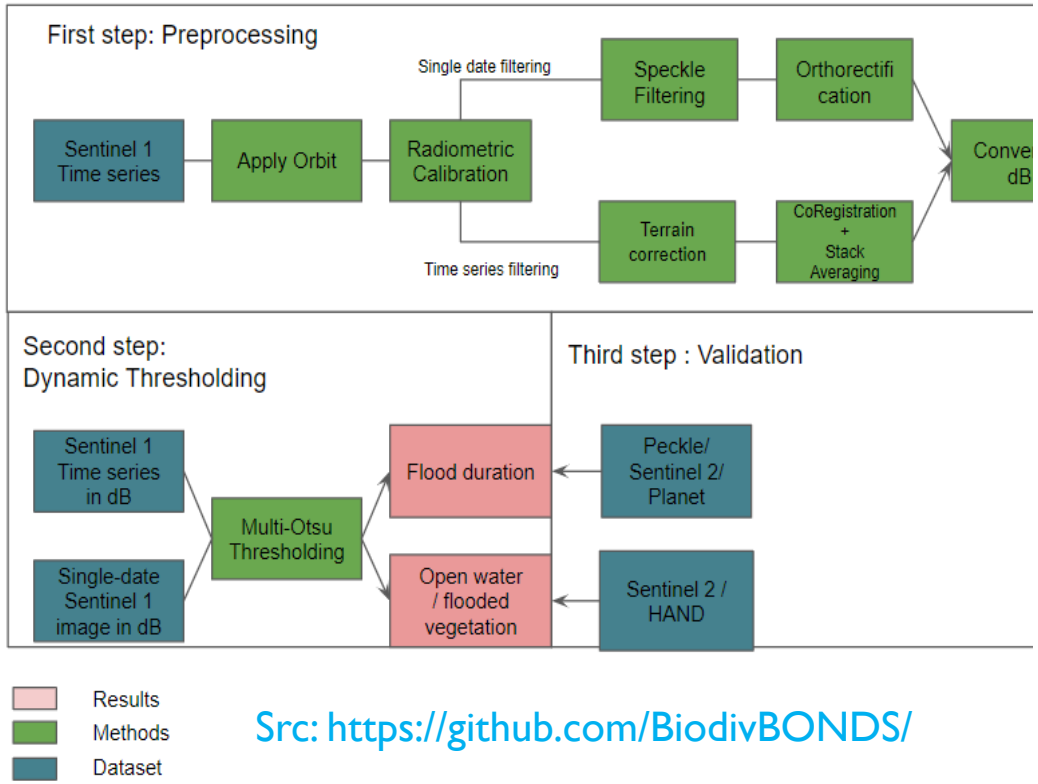
Inundation duration



OPEN WATER EXTENT FROM S1

➡ Automatic maping of open water extent (S1-FLOOD)

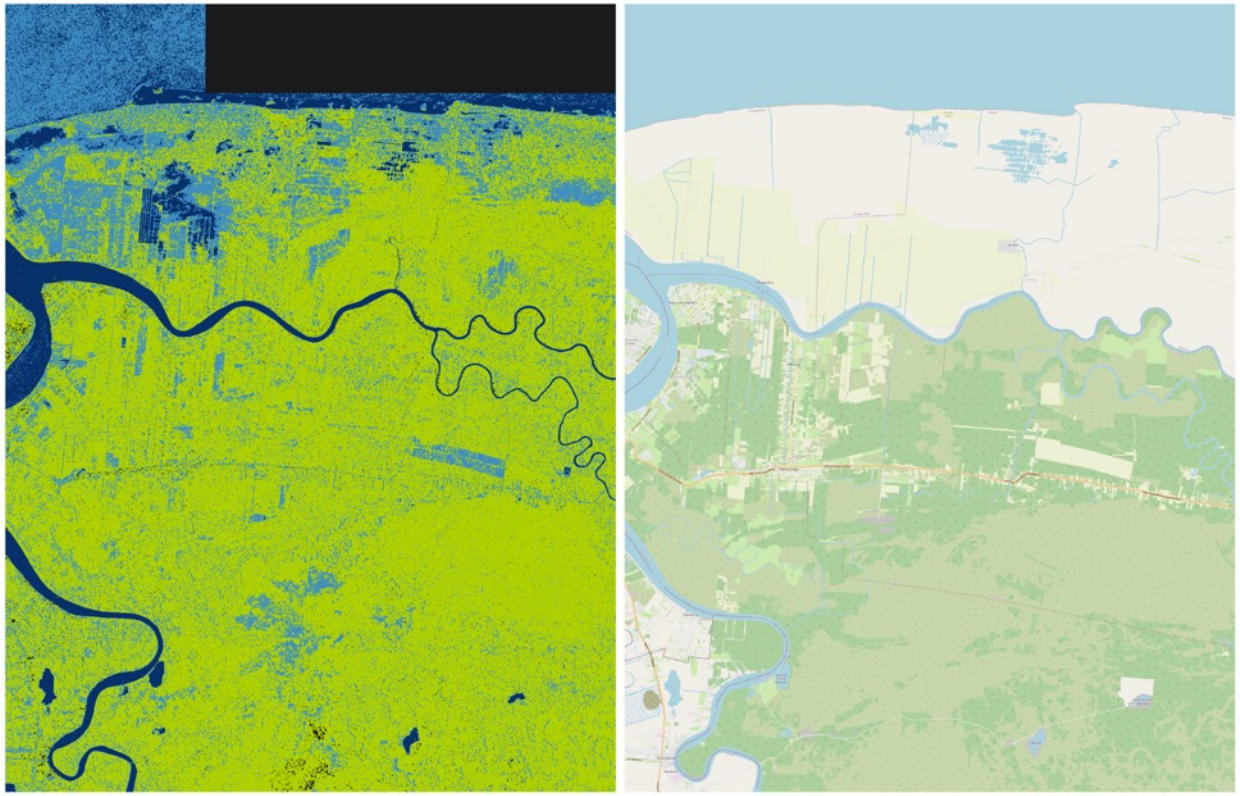
S1 processing workflow



Src: https://github.com/BiodivBONDS/

Operationalized for PROGYSAT

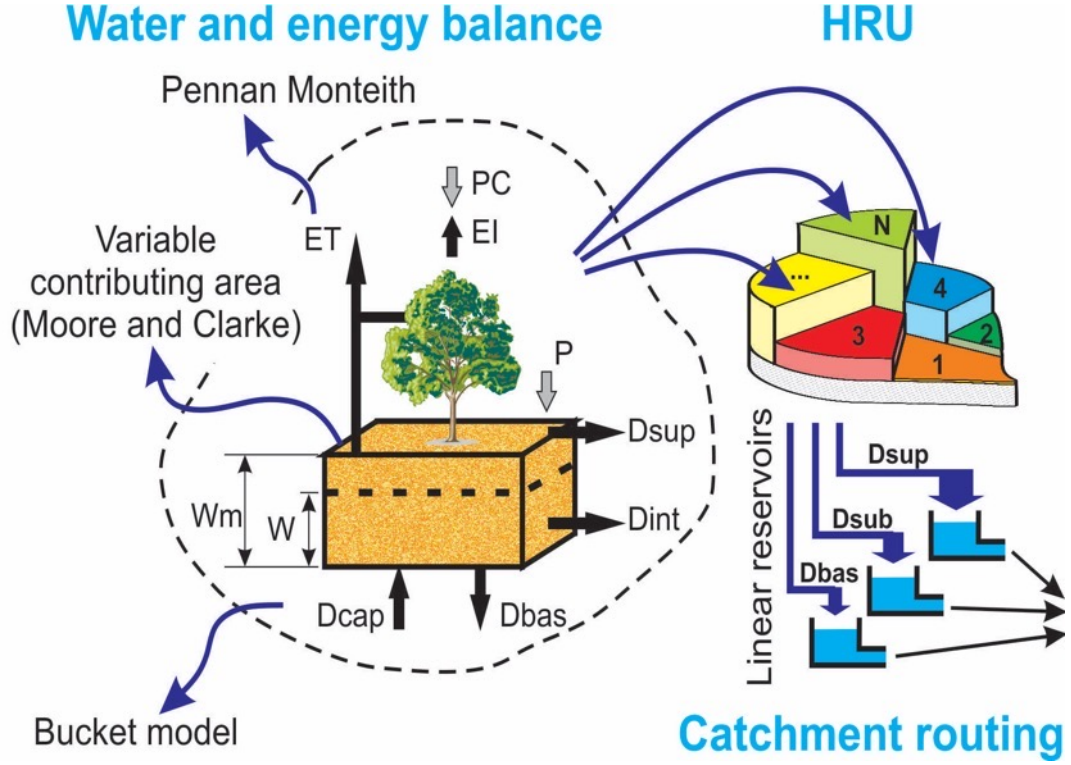
S1-Flood , open water detection in the city of Paramaribo



OPEN WATER EXTENT FROM S1

Hydrological modelling

Semi-conceptual and spatialized model



The MGB model was applied in the Amazon basin

It was used to evaluate the potential of the assimilation of radar altimetry water level (Paiva et al, 2013)

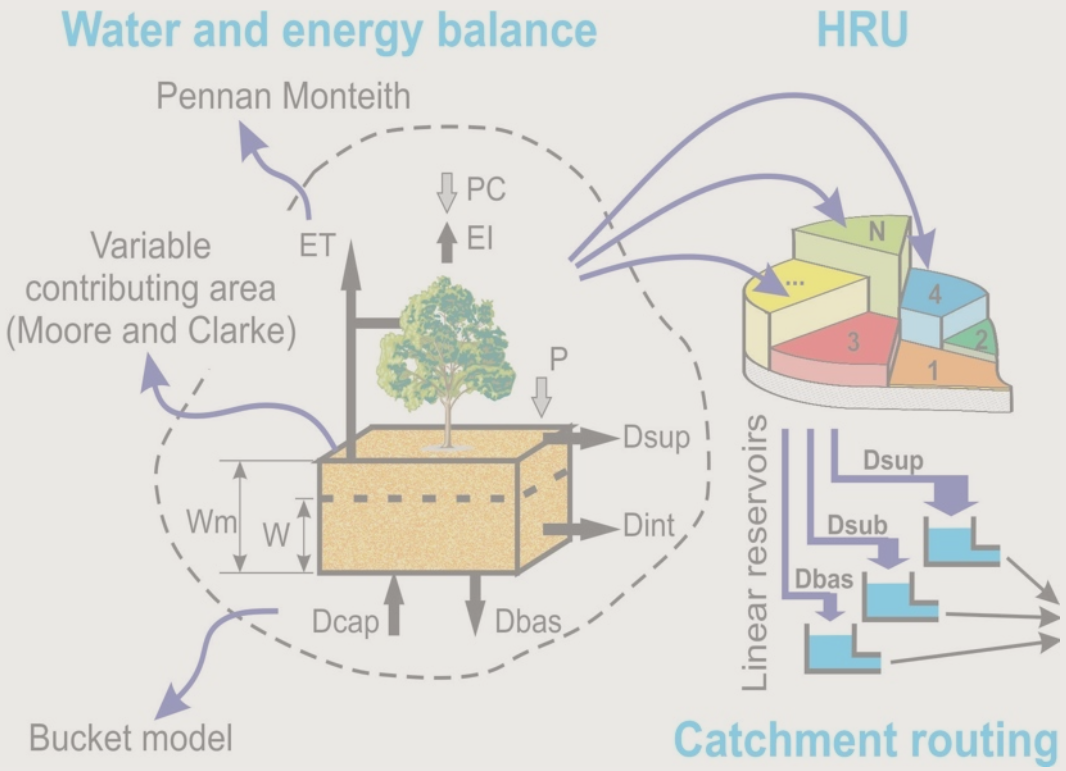
Simulated discharges were used to create rating curve at the radar altimetry virtual station (Paris et al, 2016)

It has been used to simulate discharge accros South America (Visqueira et al, 2018)

HYDROLOGICAL MODELLING

The used model

Semi-conceptual and spatialized model



The MGB model was applied in the Amazon basin

It was used to evaluate the potential of the assimilation of radar altimetry water level (Paiva et al, 2013)

A WELL SUITED MODEL FOR THE GUIANA SHIELD CONTEXT

It has been used to simulate discharge accros South America (Visqueira et al, 2018)

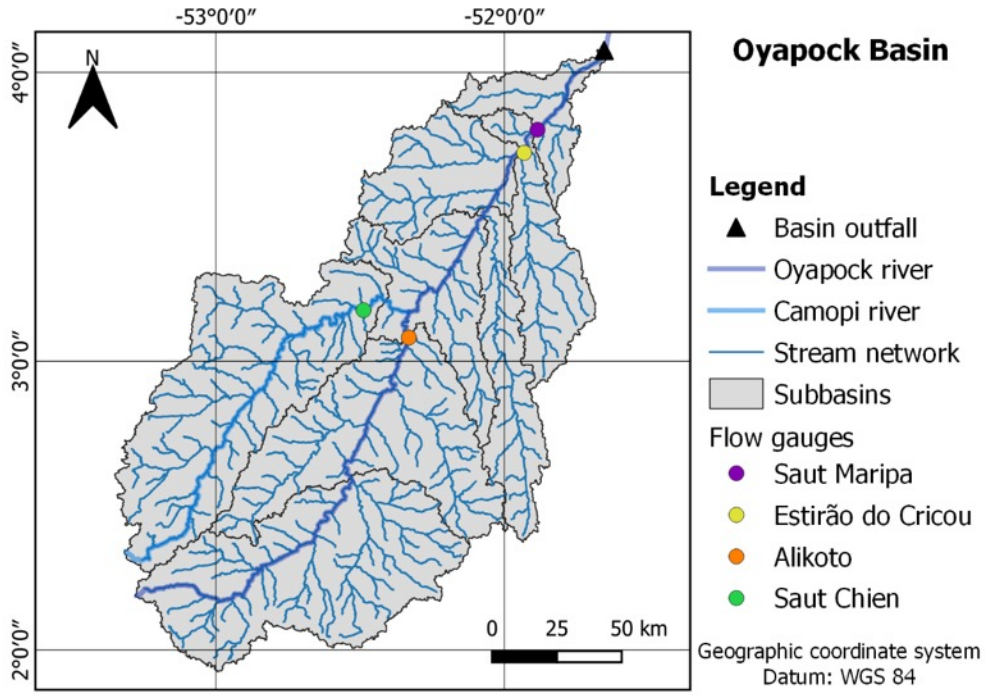
COMPILING DATA

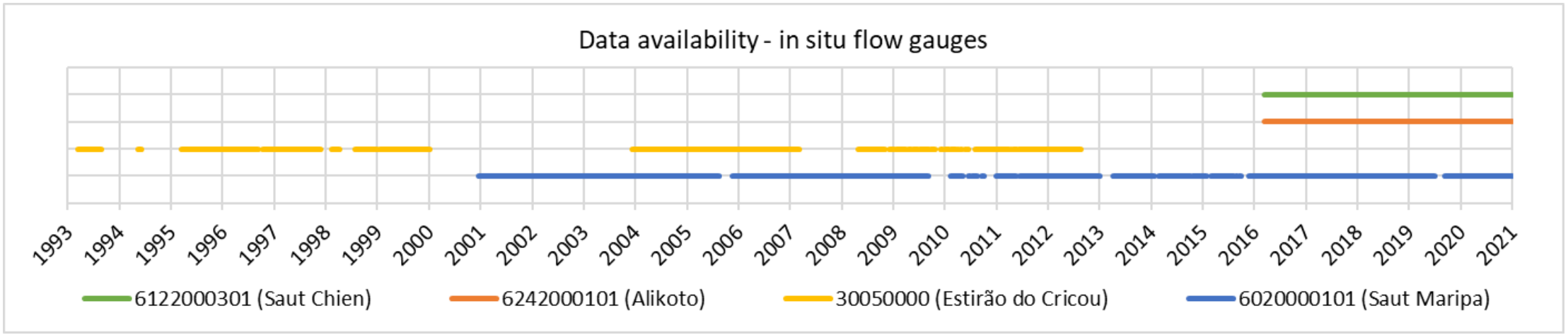
Compiling in situ and satellite products and prepare the MGB input data for the Guiana shield

DATA	PRODUCT	Source
Climate	ERA-5	ECMWF(1)
Daily water level and discharge	In situ data	Shapi / Hydroportail ANA/hidroweb(2)
Monthly water level	Altimetric data	Theia/Hydroweb(3)
Elevation and river width	DEM MERIT Hydro	Yamazaki et al, 2019 (4)
Soil type	SOTER	ISRIC/FAO/UNEP(5)
Land cover	Global cover 2019	Copernicus(6)
Hydrography	Stream network	BD Carthage(7)
River depth	A simple global river bankfull width and depth database	Andrealis et al, 2013 (8)
Precipitation	IMERG (0.01 degree) MSWEP GSMAP In situ daily data	GPM NASA(9,10,11)

SET UP THE MODEL FOR THE OYAPOCK BASIN

A basin with a reasonable amount of data

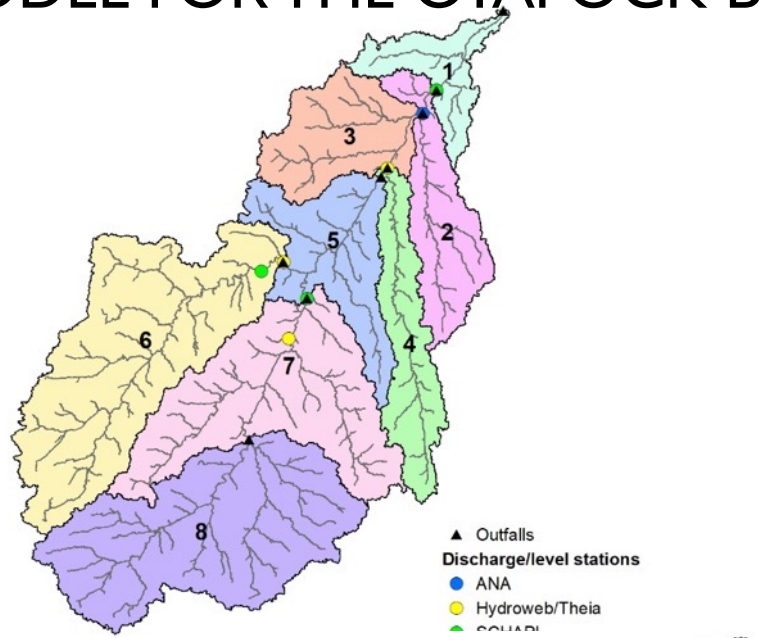




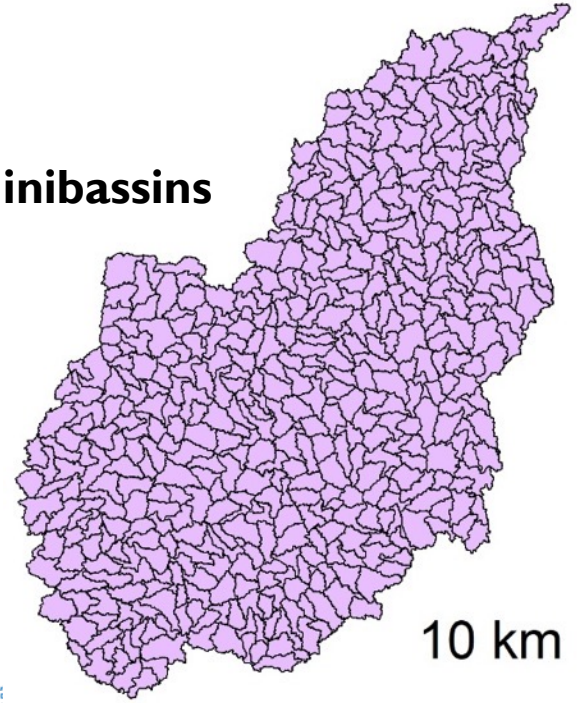
SET UP THE MODEL FOR THE OYAPOCK BASIN

Compiling in situ data and remote sensing data in order to prepare the MGB input data:

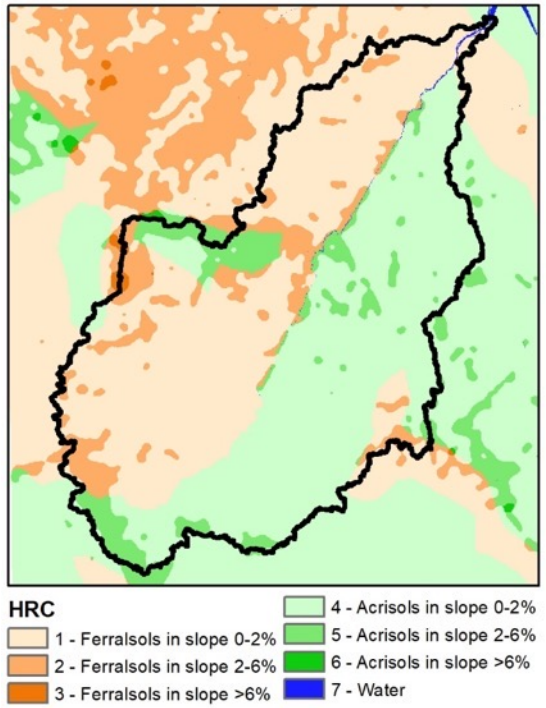
- Automated watershed delineation from DEM (90 m)
- 30 km² threshold for stream definition (a stream network compatible with BD Carthage data)
- Subbasin division in order to separate large contributing areas and the areas upstream of discharge/water level measuring stations
- Unit-catchments division with 5 and 10 km stream segmentation in order to compare model performance
- HRU based on land cover, slope and soil types
    - 7 classes were defined



Minibassins



HRU classes map



Made with QGIS 3.18

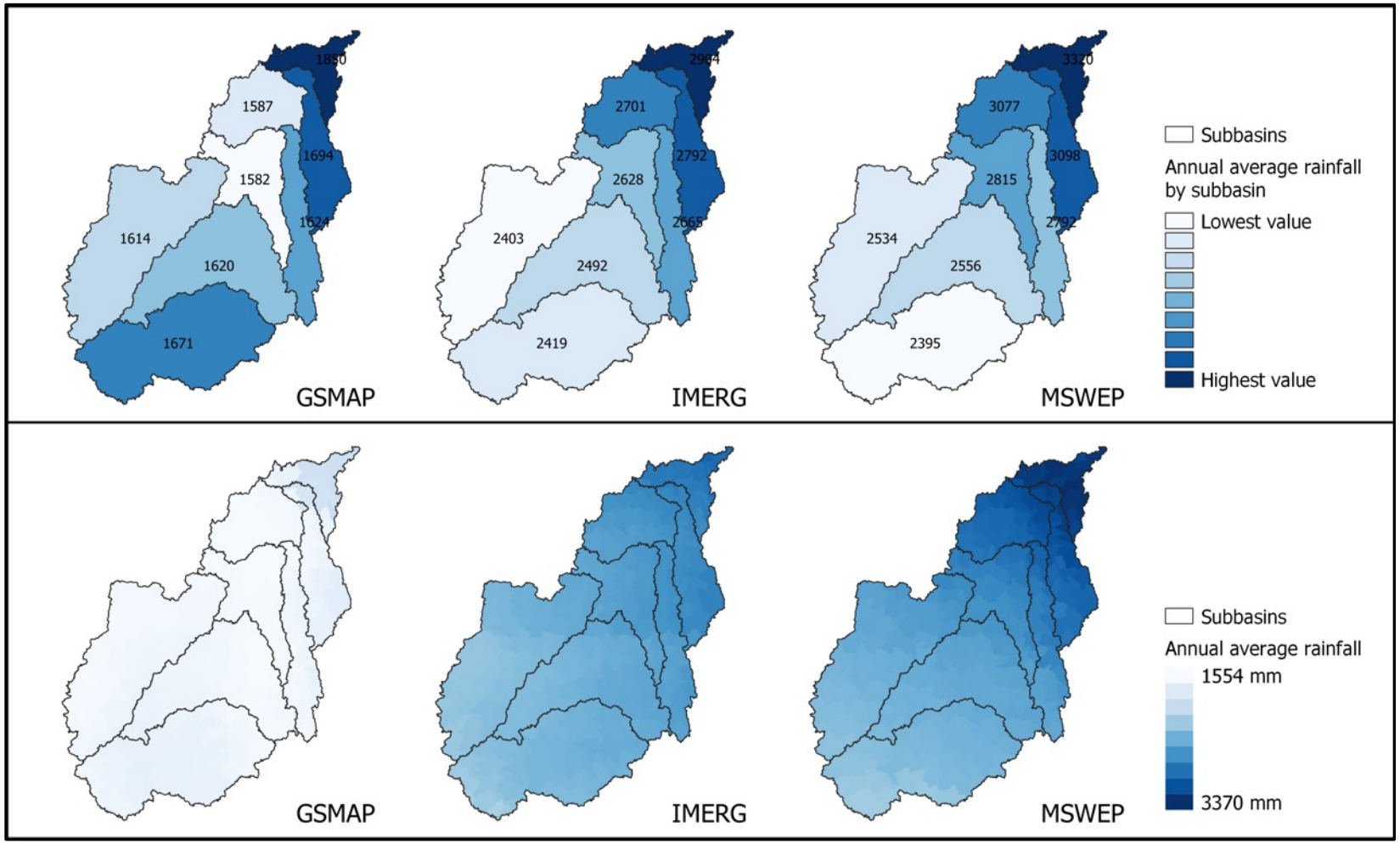
SET UP THE MODEL FOR THE OYAPOCK BASIN

Test different rainfall products

GSMaP: a multi-satellite product, resolution 0.1x0.1°, 3 hours

IMERG : fuses the precipitation estimates from TRMM satellite with precipitation estimates from the GPM satellite

MSWEP: merges gauge, satellite, and reanalysis data, 0.1x0.1°, 3 hours

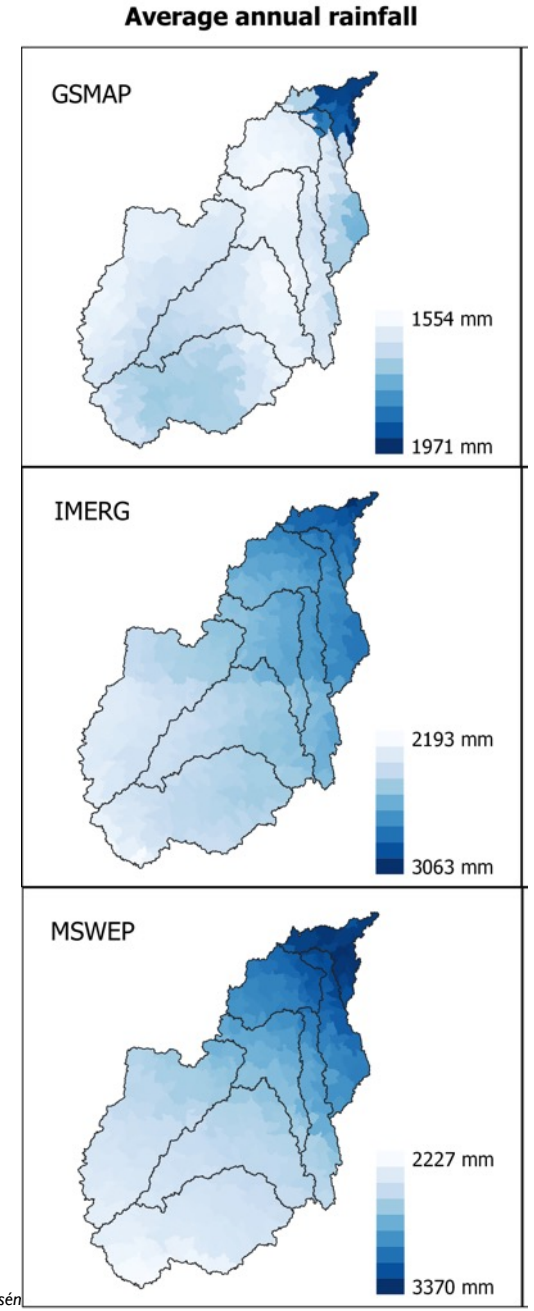


SET UP THE MODEL FOR THE OYAPOCK BASIN

Test different rainfall products

Some important discrepancies betwen the products

GSMaP rainfall estimation are lower than those from MSWEP;
IMERG provides intermediate values

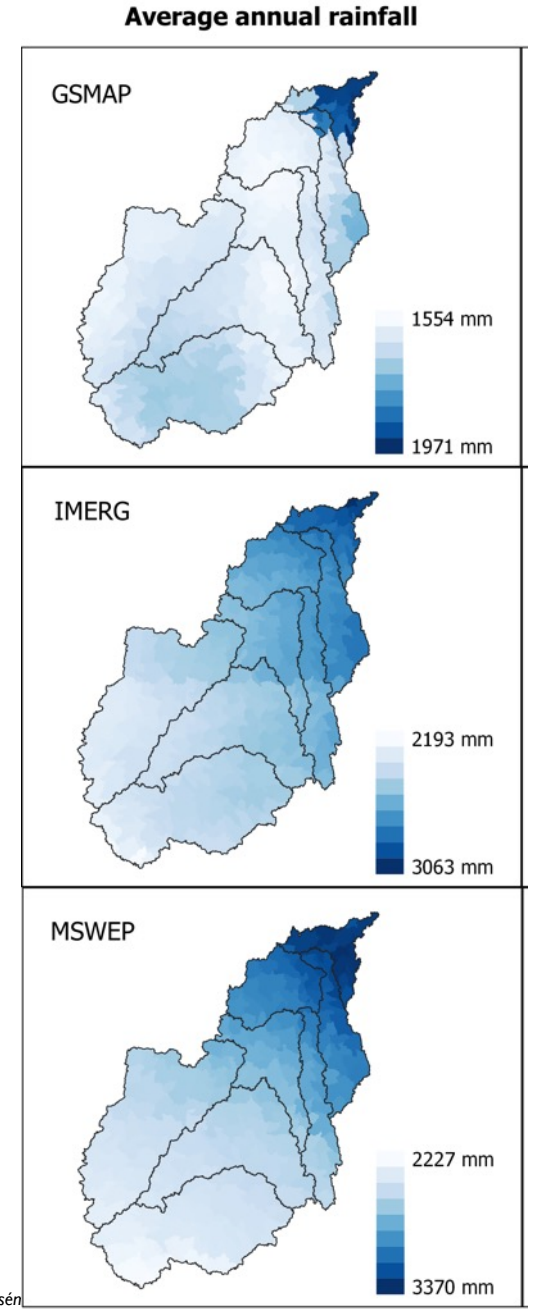


SET UP THE MODEL FOR THE OYAPOCK BASIN

Test different rainfall products

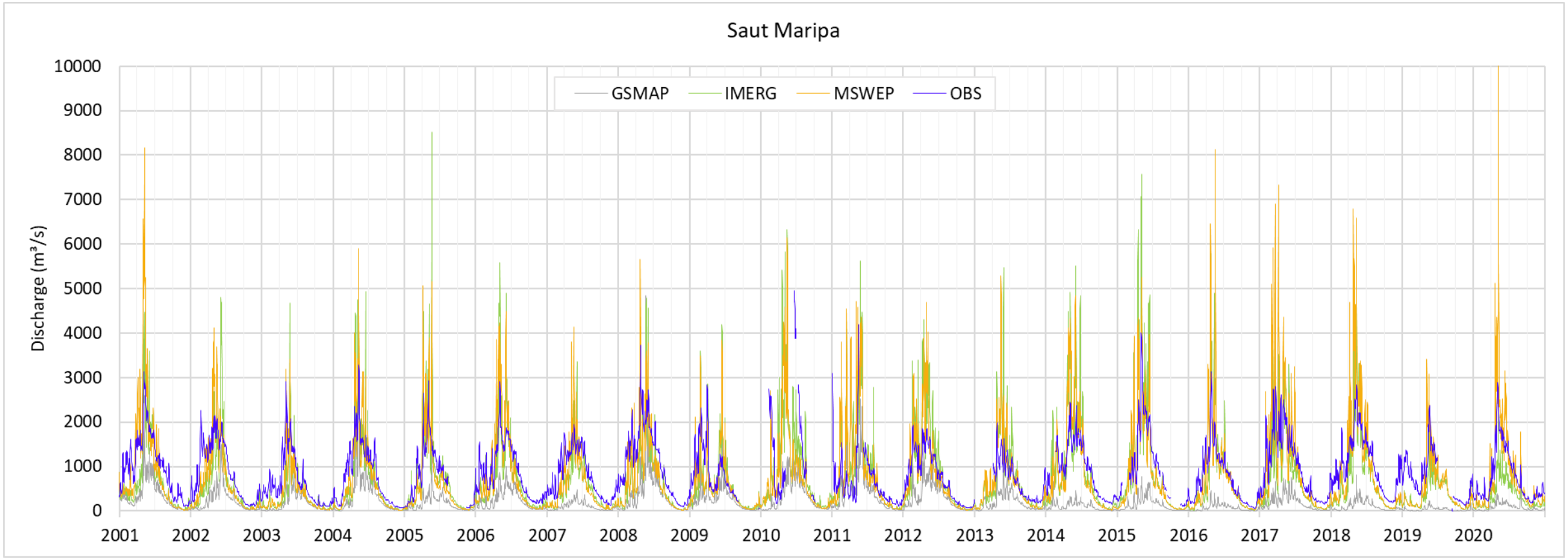
Some important discrepancies betwen the products

GSMaP rainfall estimation are lower than those from MSWEP;
IMERG provides intermediate values

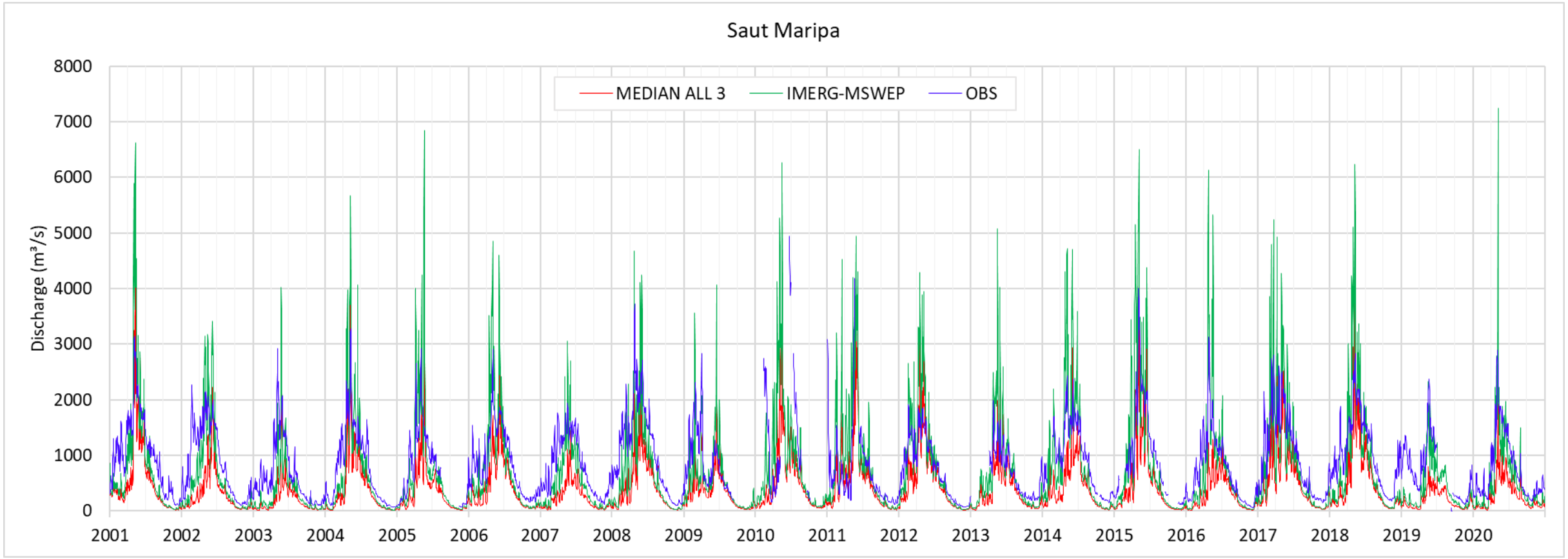


SET UP THE MODEL FOR THE OYAPOCK BASIN

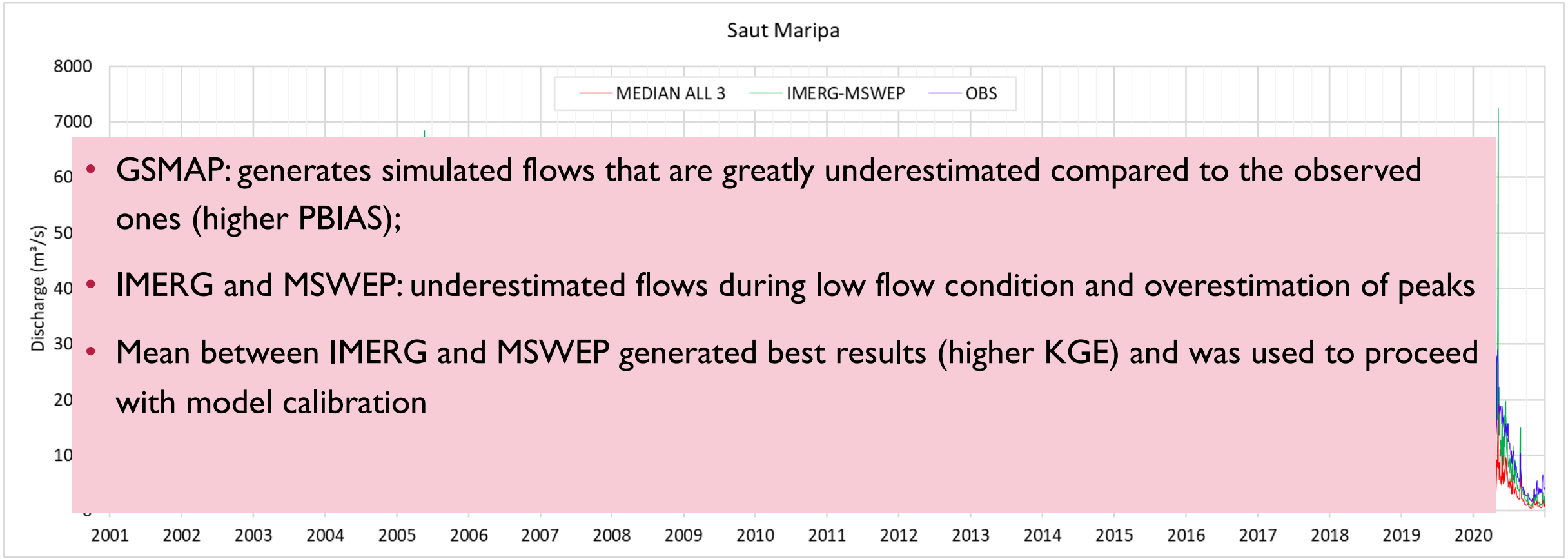
Test different rainfall products



SET UP THE MODEL FOR THE OYAPOCK BASIN

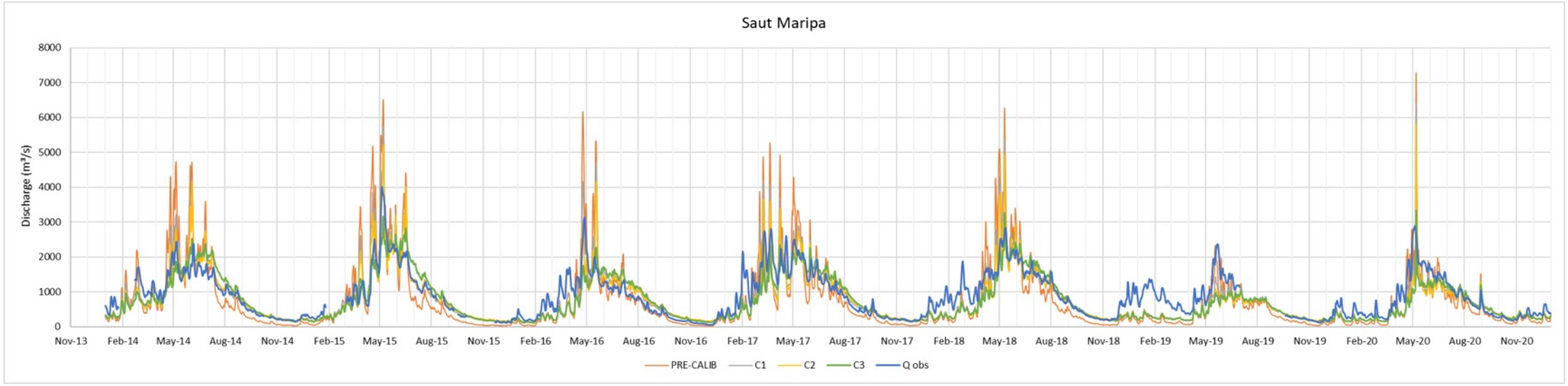


SET UP THE MODEL FOR THE OYAPOCK BASIN



- GSMAP: generates simulated flows that are greatly underestimated compared to the observed ones (higher PBIAS);
- IMERG and MSWEP: underestimated flows during low flow condition and overestimation of peaks
- Mean between IMERG and MSWEP generated best results (higher KGE) and was used to proceed with model calibration

SET UP THE MODEL FOR THE OYAPOCK BASIN



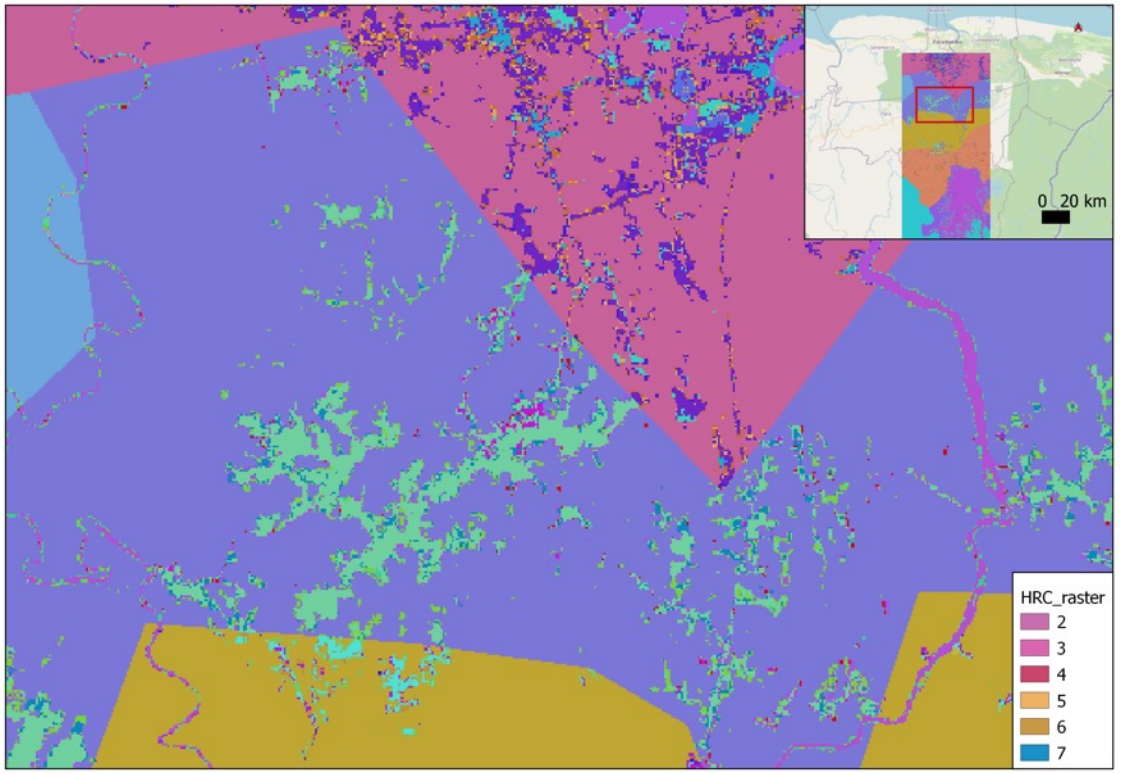
METRICS	FULL SIMULATION PERIOD	NOV-DEC-JAN	FEB-MAR-APR	MAY-JUN-JUL	AUG-SEP-OCT
NSE	0,65	0,04	0,17	0,22	0,17
KGE	0,79	0,14	0,55	0,59	0,75
PBIAS	-12,55	-40,50	-37,09	+1,92	+19,35
ΔVolume	-2,2E+10	-8,3E+09	-2,0E+10	+1,6E+09	+4,2E+09

SET UP THE MODEL FOR THE OTHERS BASINS

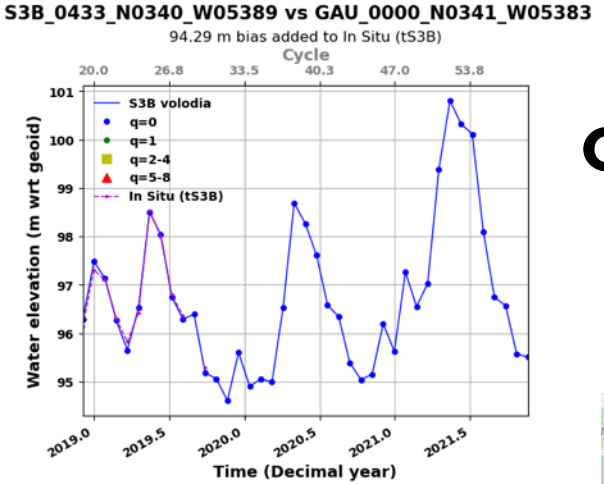
Still in progress

Once the model has been calibrated on the Oyapock basin, regionalization is relatively straightforward, assuming the same parameters for the HRUs.

HRU for the Suriname

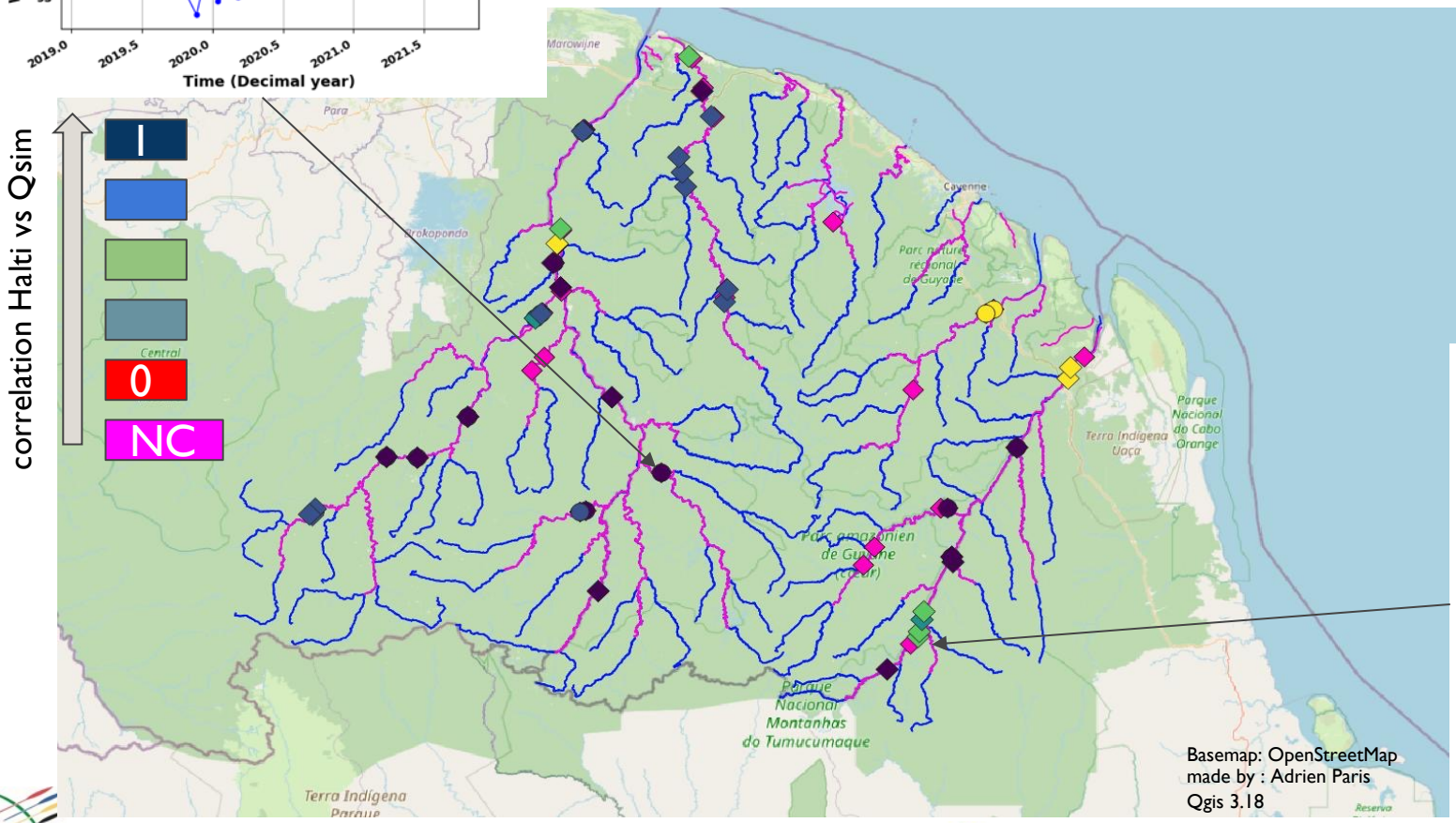


SET UP THE MODEL FOR THE OTHERS BASINS



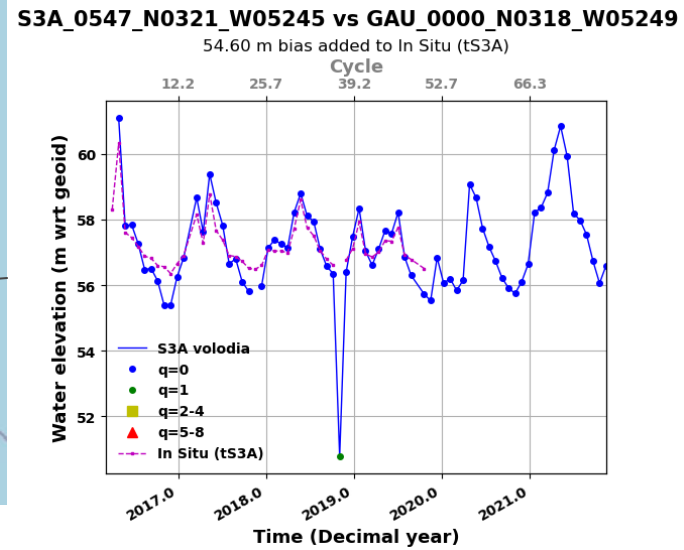
OPHYSE & SAGUI : French Guyana basins

Toward a monitoring of unmonitored small rivers and discharge basins of French Guiana (and Guiana Shield by extension) with altimetry and hydrological models



Virtual stations from Hydroweb

New virtual stations (HM)



DELIVRABLES & PRODUCTS

Scientific and technical activities

- Data processing chains, models, methods
  - ✓ S1-FLOOD https://github.com/BiodivBONDS/S1-pre-processing/blob/main/)
  - ✓ Oyapok hydrological simulation
- ✓ Articles, communications, conférences, posters…
  - ✓ 2 extended abstracts (Brazilian symposium of water resources (SBRH) Novembre 2023)

Activités de formation, transfert

- Students and University formation
  - 1 M2, Univ de Montpellier
- Training or reinforcement of professionals
  - 1 CDD at IRD
  - 1 CDD at UnB (master level)

Webography

(1) https://www.ecmwf.int/

(2) https://www.data.gouv.fr/

(3) https://www.snirh.gov.br/hidroweb/

(4) http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_Hydro/

(5) https://data.isric.org/

(6) https://land.copernicus.eu/global/products/lc

(7) https://geo.data.gouv.fr/

(8) https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/wrcr.20440

(9) https://gpm.nasa.gov/data/imerg

(10) http://www.gloh2o.org/mswep/

(11) https://smap.jpl.nasa.gov/