

GloFAS v4.0

2nd Global Flood Forecasting and Monitoring Meeting

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COPERNICUS
EMERGENCY
MANAGEMENT
SERVICE

What is new in GloFAS v4.0?

GloFAS v4.0 spatial resolution: **0.05 degrees**, 4 times **higher** than the current operational set-up!

HIGHER SPATIAL RESOLUTION

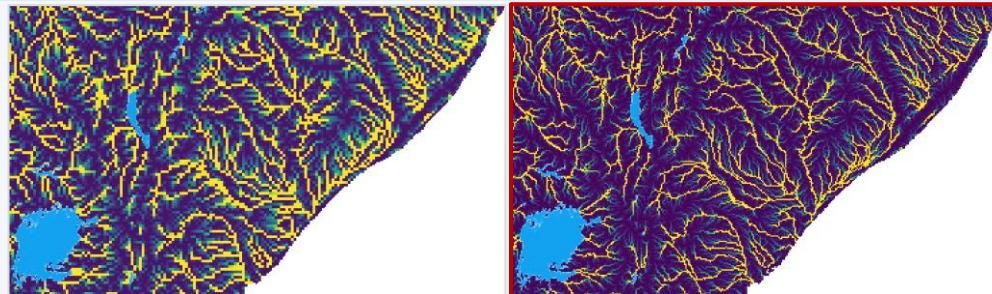
The **increased resolution** (from **0.1 degrees** to **0.05 degrees**) allows for:

- more accurate representation of the spatial variability of catchments' properties;
- more accurate representation of river network.

LATEST RESEARCH AND DATA SETS

The 0.1 degrees set-up was prepared in ~2010.
10+ years of

- **research;**
- **technological development;**
- **data collection.**



Shebelle, Tana Basins, Upstream area map, derived from local drainage network map : 0.1 (left), 0.05 degrees (right)

Example:

Digital Elevation Model:

- 0.1 degree: Hydro SHEDS¹ (Lehner et al., 2008¹)
- 0.05 degrees: Merit-DEM (Yamazaki et al., 2019²)

More accurate representation of **the rainfall-runoff** processes →
more accurate modelling and forecasts of
- **river flow**,
- **soil moisture**.

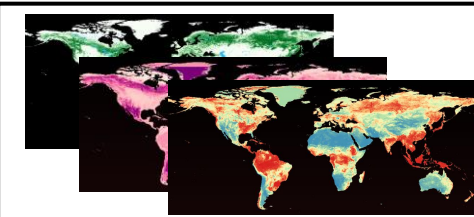
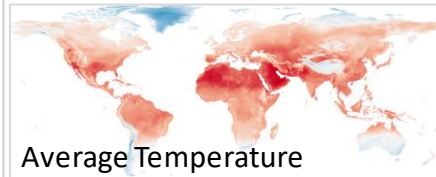
The pathway to GloFAS v4.0

GloFAS v4.0 major upgrade required 3 major changes:

(1) the use of entirely revamped input maps with **0.05 degree (~5km)** resolution;



METEO FORCINGS:
Daily time steps
ERA5

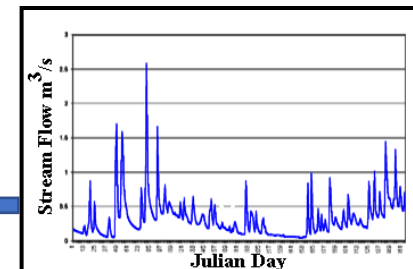


Information on
catchments physical
properties

(2) an **upgraded** version
of LISFLOOD-OS model,
imperative to run the high
resolution set-up.

HYDROLOGICAL MODEL
LISFLOOD-OS:
Semi-distributed,
physically based
model

(3) a new **calibration**

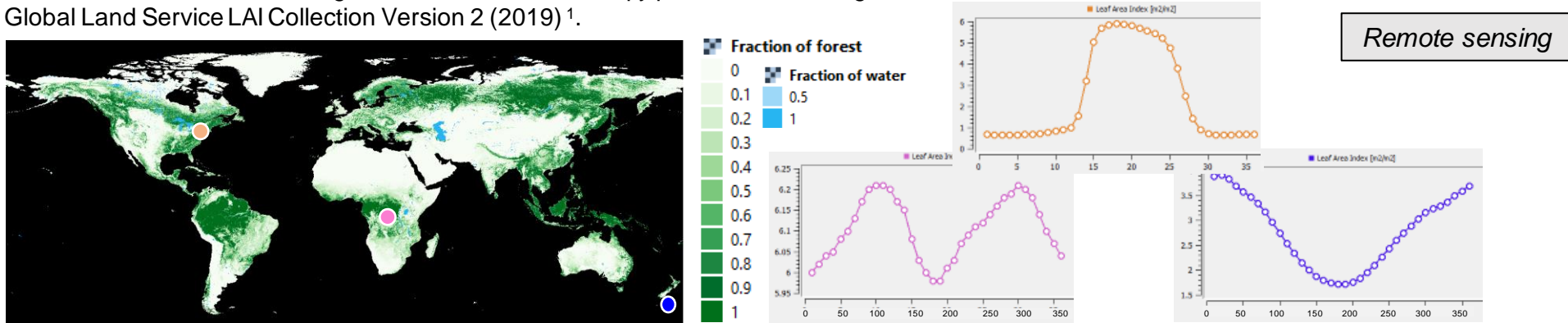


OBSERVED DISCHARGE
TIME SERIES

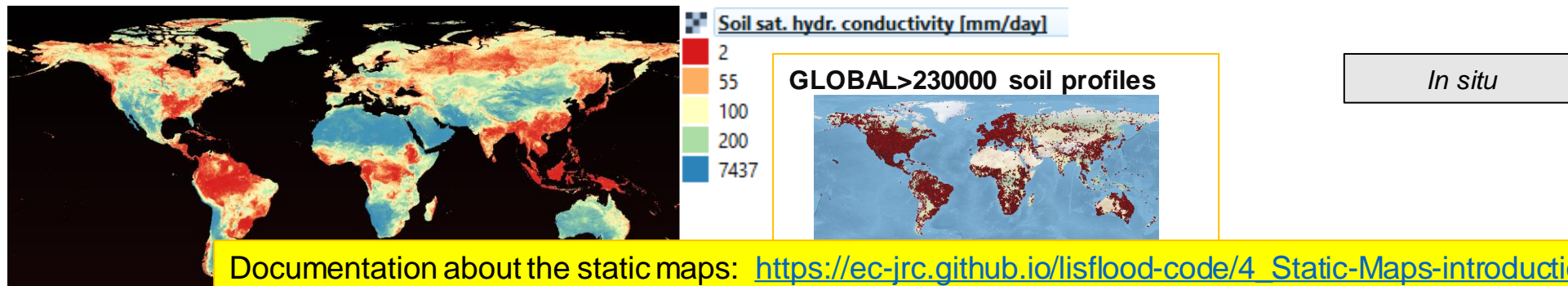
(1) Static maps dataset

~100 maps providing information on catchments' morphology, land cover and land use, soil properties, water demand for human use (Collaborative effort: JRC and ECMWF).

❖ **Leaf area index:** half the total area of green elements of the canopy per unit horizontal ground area m^2/m^2 .
Copernicus Global Land Service LAI Collection Version 2 (2019) ¹.



❖ **Soil properties:** hydraulic conductivity, saturated and residual water content, Van Genuchten parameters.
International Soil Reference and Information Centre (ISRIC) – SoilGrids™ (2020) ² and pedotransfer equations by Toth et al. (2015) ³.



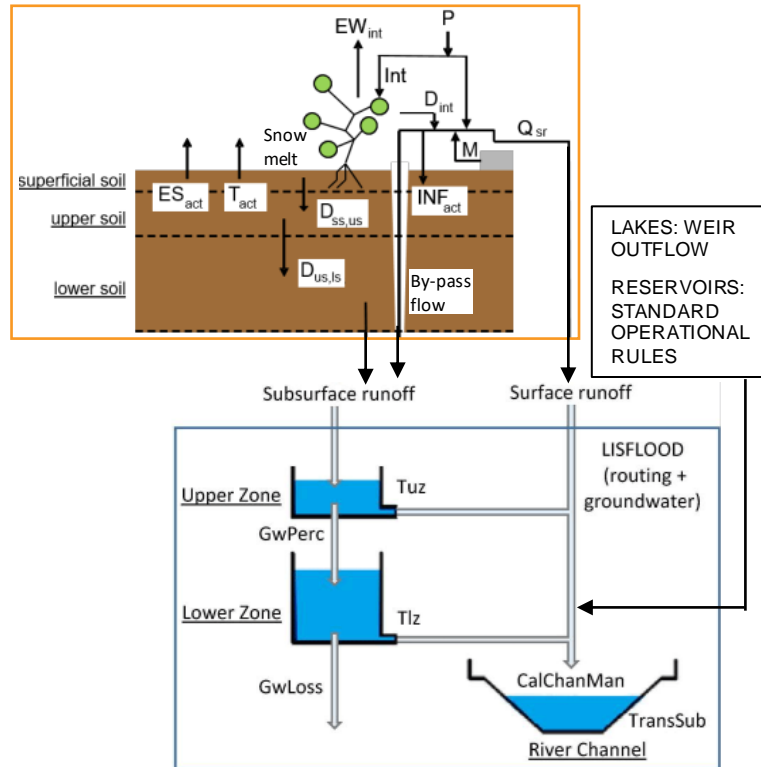
Documentation about the static maps: https://ec-jrc.github.io/lisflood-code/4_Static-Maps-introduction/
Scientific publication and release of the data set: work in progress!

¹<https://land.copernicus.eu/global/products/LAI>;

²<https://www.isric.org/> ;

³<https://esdac.jrc.ec.europa.eu/themes/soil-hydraulic-properties>

(2) OS LISFLOOD hydrological model



LISFLOOD-OS: Semi-distributed, physically based model

- 6 land cover fractions within a pixel;
- 3 soil layers;
- 2 groundwater storages;
- kinematic wave routing in channels and floodplains;
- lakes and dams;
- water abstraction for anthropogenic use.

INCREASED COMPUTATIONAL EFFICIENCY, imperative to run GloFAS v4.0!

- **Optimal** management of large input.
- **Parallel** computations.

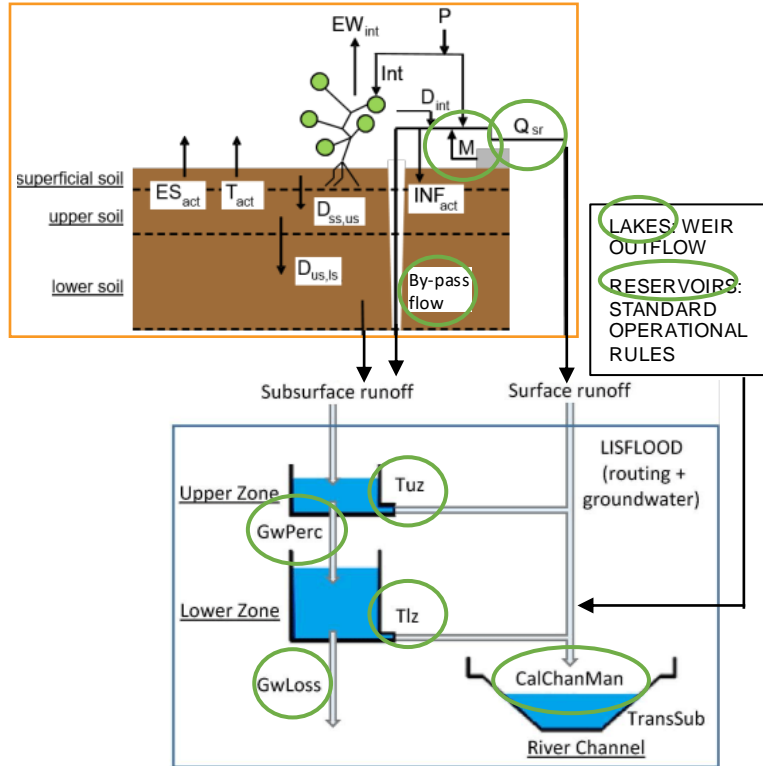
Open Source code and documentation:

<https://github.com/ec-jrc/lisflood-code>

<https://ec-jrc.github.io/lisflood-model/>

Would you like to know more about OS LISFLOOD?
Please join the **Gather.Town** session!

(3) Calibration

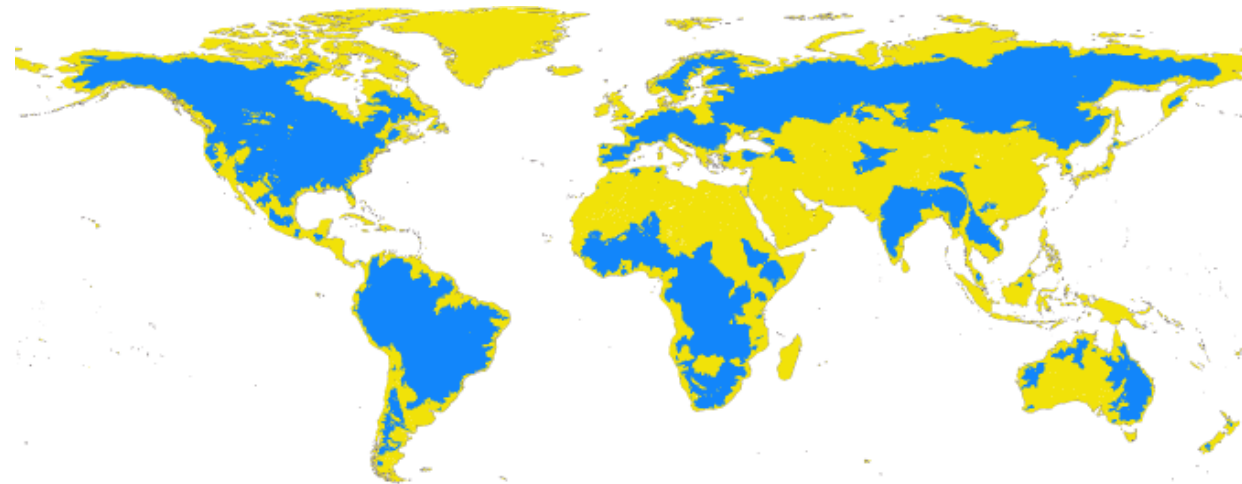


WHAT IS CALIBRATION AND WHY DO WE NEED IT?

- Every model is an approximate representation of reality.
- Tuning of the parameters to improve the model capability to represent local processes.
- 14 parameters.

HOW DID WE CALIBRATE GloFAS v4.0?

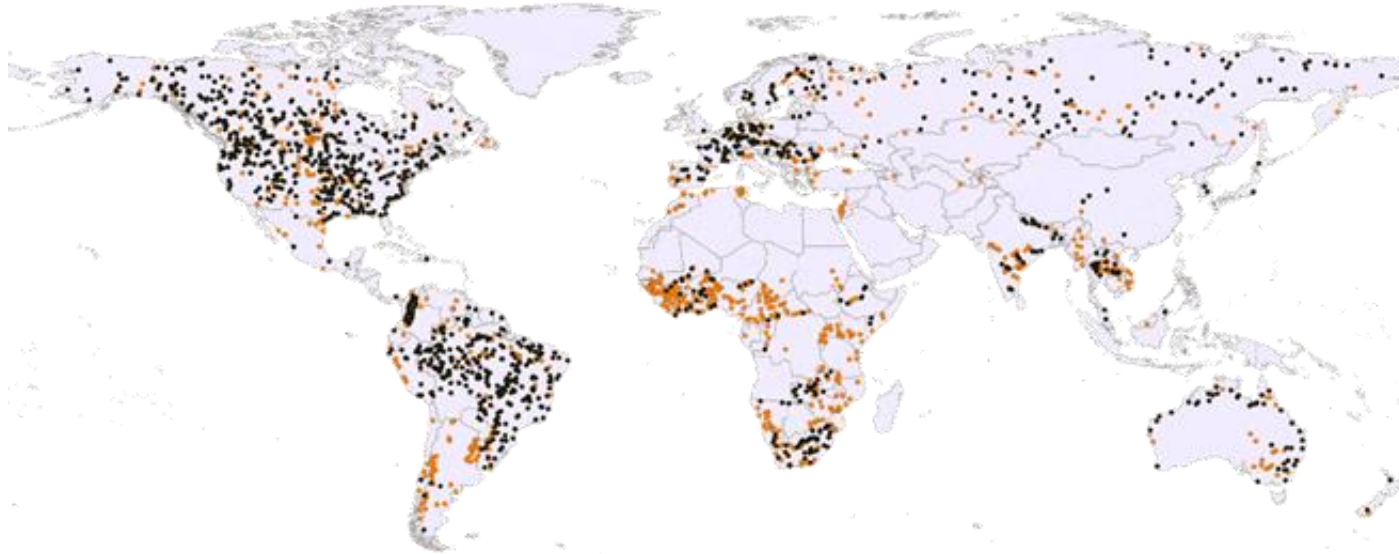
- Comparison of model results with observations.
- GloFAS v4.0 observations: in situ discharge measurements.



■ Discharge measurements available

■ Discharge measurements **NOT** available

(3.a) Available discharge data



Black: GloFAS 3.1¹, 1226 stations

Orange: GloFAS v4.0, **1996 stations!**

- *Catchment area > 500 km² (GloFAS 3.1 at 0.1 degree resolution: 5000 km²).*
- *At least 365x4 daily observations from 1982 (with exceptions for critical locations).*
- *Quality checks: outliers, general pattern.*

Would you like to **contribute** to the discharge data base?

Please join the **Gather.Town** session!

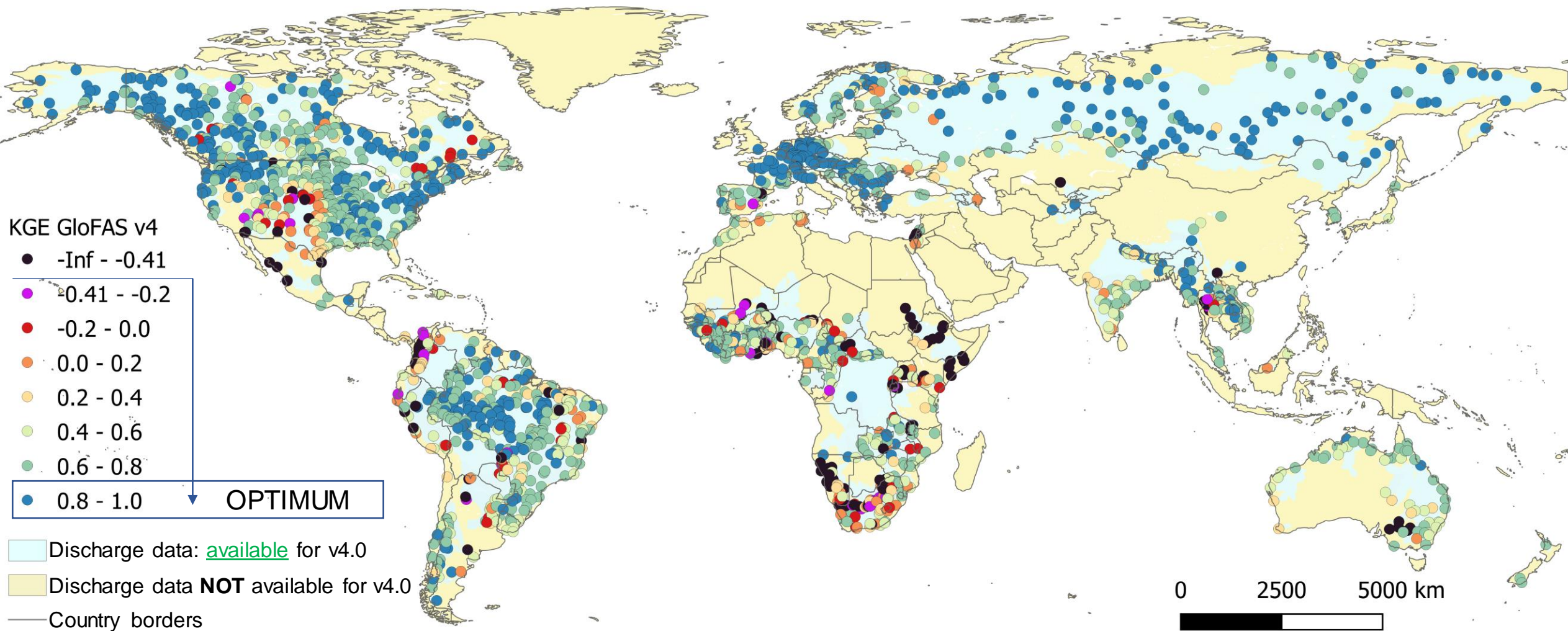
- Distributed Evolutionary Algorithm for Python (DEAP, Fortin et.al 2012).
- Kling Gupta Efficiency (KGE) objective function.

Open source, developed by JRC and ECMWF: [ec-jrc/lisflood-calibration: Lisflood OS \(Calibration tool\) \(github.com\)](https://ec-jrc/lisflood-calibration)

Would you like to know more about OS LISFLOOD?

Please join the **Gather.Town** session!

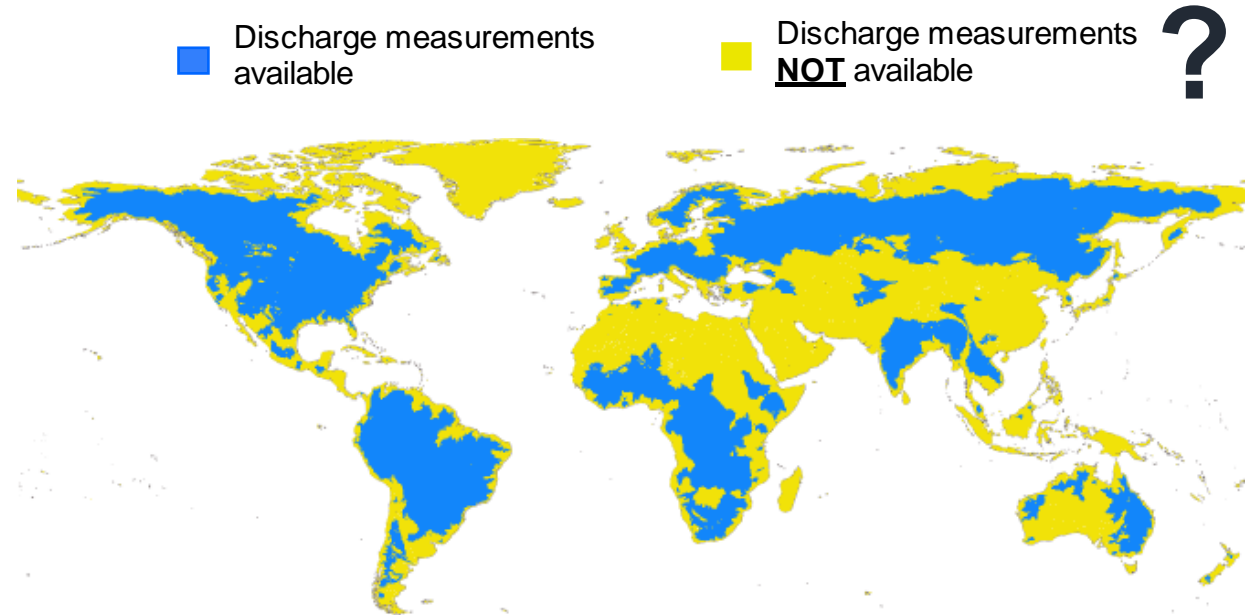
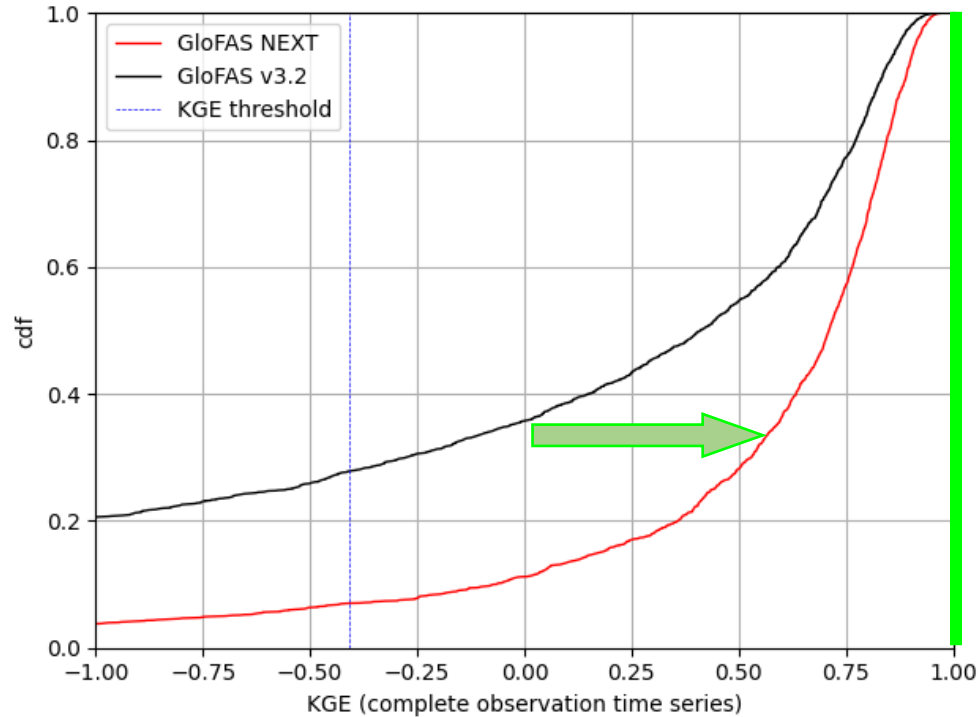
(3.a) Available discharge data: results (KGE)



(3.a) Available discharge data: results

GloFAS v4.0 vs GloFAS 3.1, calibration points of GloFAS v4.0

This graph compares the performances of the two versions (i.e. the graph does NOT compare the two calibrations).



How do we improve model performances where we do not have in-situ observations?

Regionalization approach.

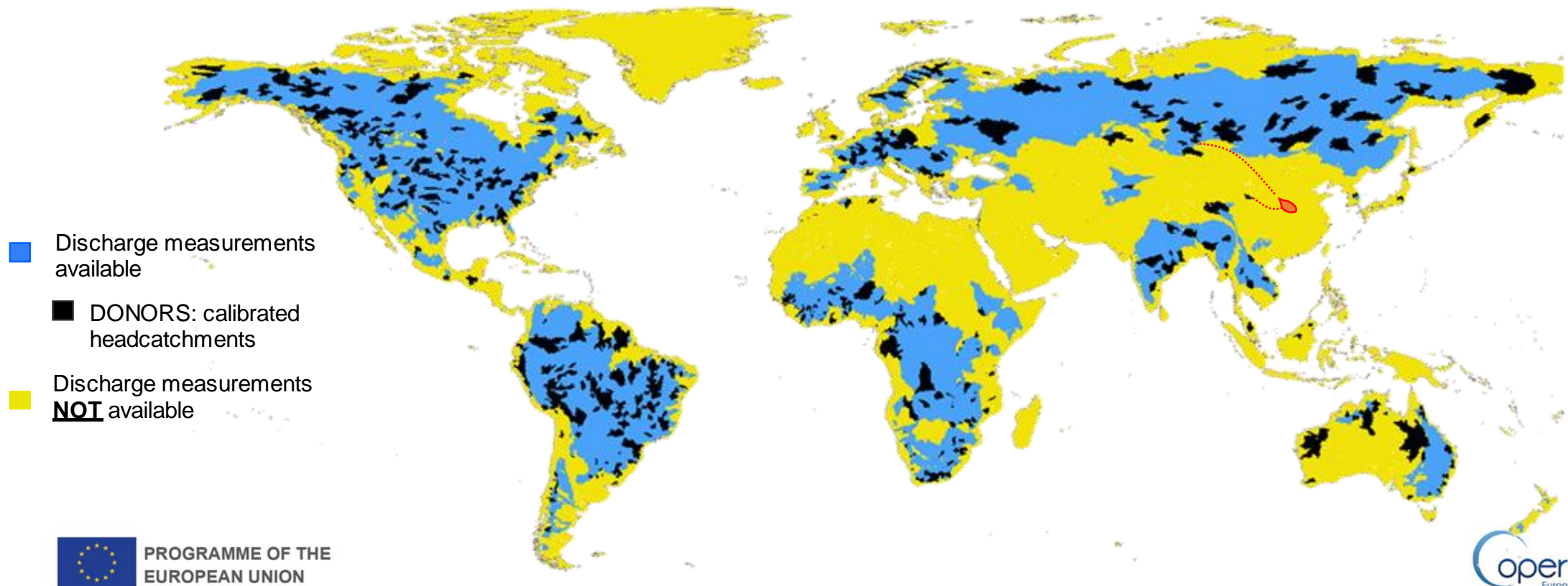
(3.b) Discharge data NOT available: parameters regionalization

❖ **Pragmatic regionalization** approach:

Transfer of the complete parameter set from a donor (calibrated) catchment to a target (uncalibrated) catchment.

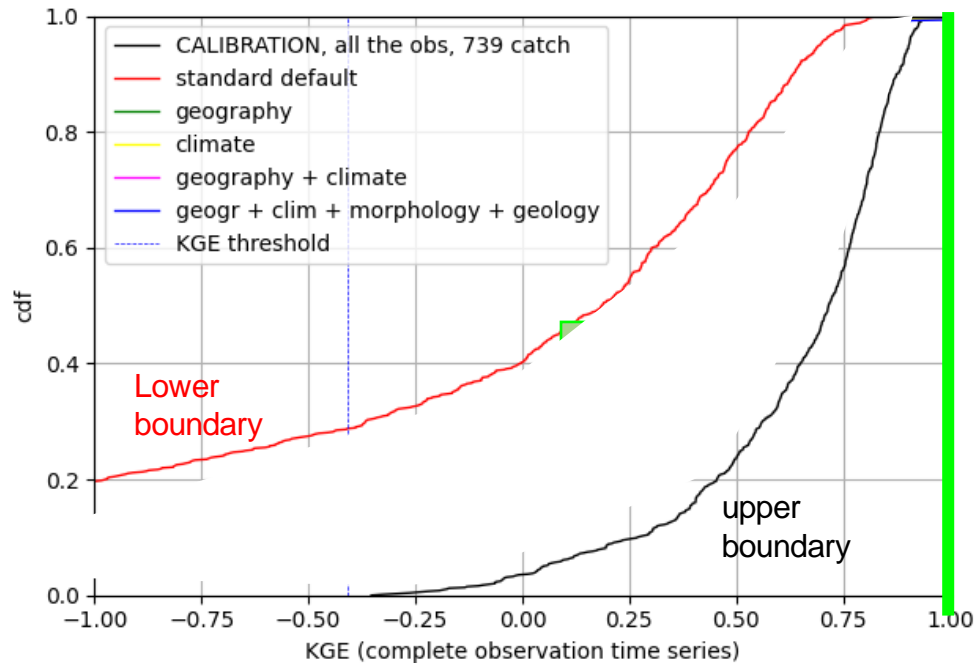
❖ Identification of the donor catchment according to:

- ✓ **Spatial** proximity: geographical distance between the centroids of the donors and of the target catchments, **AND**
- ✓ **Physical** proximity: similarity of the donor and the target catchments according to *Climate, Morphology, Geology*

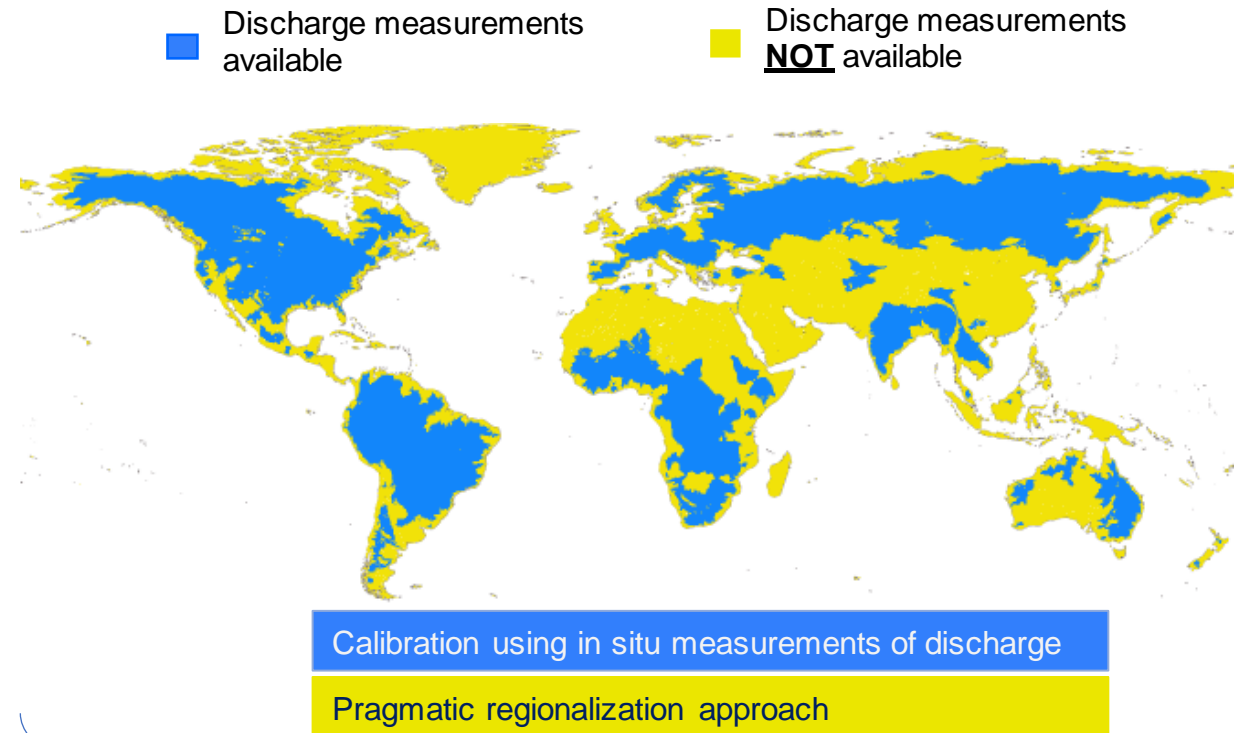


(3.b) Discharge data NOT available: parameters regionalization

❖ Leave one out cross validation experiment. Transfer of snow, runoff, infiltration, routing parameters.



Selected criteria for GloFAS NEXT:
climate and geographic proximity.



GloFAS reanalysis data set with 0.05 degrees resolution!

GloFAS v4.0 DISCHARGE REANALYSIS 1980-2022

DATA <https://cds.climate.copernicus.eu/cdsapp#!/dataset/cems-glofas-historical?tab=overview>

DOCUMENTATION

<https://confluence.ecmwf.int/display/CEMS/GloFAS+v4.0+hydrological+reanalysis>

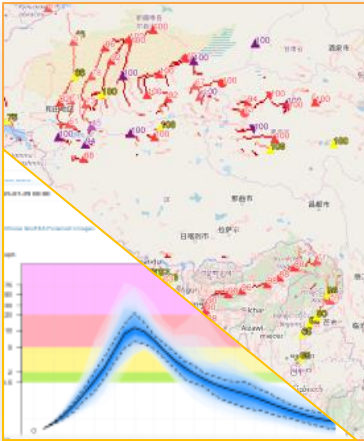
The screenshot shows the Copernicus portal interface for the GloFAS v4.0 dataset. At the top, there are logos for the European Union, Copernicus, ECMWF, and the Climate Change Service. Below the navigation bar, the title "River discharge and related historical data from the Global Flood Awareness System" is displayed. A warning message states: "Please note that accessing this dataset via CDS for time-critical operation is not advised or supported. We suggest checking the list of known issues on the GloFAS wiki here before downloading the dataset (last updated 28/03/22). Please note the legacy version of GloFAS (v2.1) was decommissioned on 11/09/22 and no longer produces new data (see announcement)." The main content area has three tabs: "Overview", "Download data", and "Documentation". The "Overview" tab is active, showing a description of the dataset and a "System version" section. The "System version" section has two expandable options: "Operational" (containing "Version 3.1" with an unchecked checkbox) and "Pre-release" (containing "Version 4.0" with a checked checkbox). To the right of the version selection, there is a world map titled "Mean daily river discharge from 1979-2018 for GloFAS v3.1 reanalysis" with a color scale from 0 to 15,000 m³/s.

The screenshot shows the documentation page for GloFAS v4.0 hydrological reanalysis on the Confluence platform. The page title is "GloFAS v4.0 hydrological reanalysis" and it is created by Karen O'Leary. The "Summary" section states: "The GloFAS v4.0 hydrological reanalysis dataset is the new generation of the ERA5-based hydrological reanalysis produced within the Copernicus Emergency Management Service which includes daily maps of discharge (in m³/s) with quasi-global extent (-180 180S-90) at 0.05 degree (1-km) grid resolution. The GloFAS v4.0 hydrological reanalysis dataset features several updates in comparison to the previous version of the GloFAS hydrological reanalysis, that is GloFAS v3.1, released on 2021-05-26. These updates include a higher spatial resolution, a complete new set of input mass for the catchment physical properties, major improvements to the open-source hydrological model USRLOOD, and a new calibration. This page provides a concise description of the features of the GloFAS v4.0 hydrological reanalysis dataset." The "1. Higher resolution, entirely new set of input maps" section explains that accurate representation of rainfall-runoff processes requires a set of maps showing morphological, pedological, vegetation, and land use characteristics. It notes that the spatial resolution of the GloFAS v4.0 hydrological reanalysis dataset is 0.05 degrees, which is four times higher than the previous 0.1 degree GloFAS v3.1 hydrological reanalysis. It also mentions that the latest research findings, remote sensing, and in-situ datasets were used to produce the 0.05 degree resolution input maps. The "2. Meteorological input variables" section states that ERA5 and the open-source processor USWAP were used to prepare the meteorological input variables for both 0.1 degree GloFAS v3.1 hydrological reanalysis and 0.05 degree GloFAS v4.0 hydrological reanalysis. The "3. Updated version of USRLOOD model" section explains that the GloFAS v4.0 hydrological reanalysis dataset was generated using the open-source hydrological model USRLOOD. USRLOOD is a semi-distributed, physically based hydrological model which has been developed by the Joint Research Centre (JRC) of the European Commission since 1997. Specifically, the GloFAS v4.0 hydrological reanalysis dataset was generated using USRLOOD v4.1.0. Compared to the USRLOOD version used to produce the previous version of GloFAS v3.1 hydrological reanalysis, USRLOOD v4.1.0 features updates in the hydrological routines, such as:

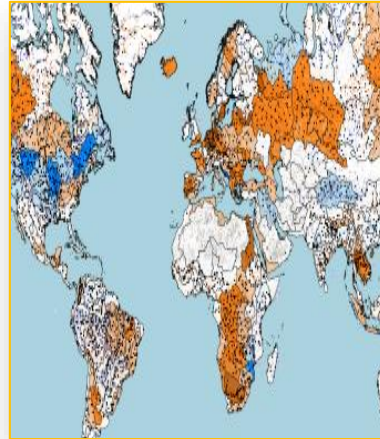
Figure 1 shows two maps of a river network. The left map is at 0.1 degree resolution and the right map is at 0.05 degree resolution. Both maps show a dense network of rivers with discharge values represented by colors from blue (low) to yellow (high). The 0.05 degree map shows a much more detailed and complex network of smaller tributaries compared to the 0.1 degree map.

Work in progress and next steps

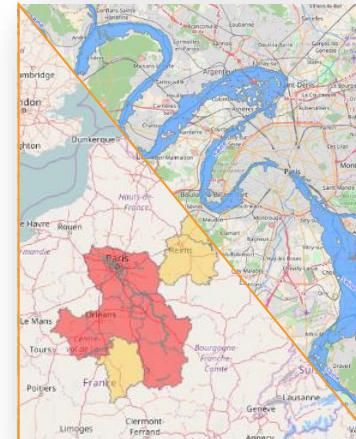
Riverine flood forecast (hazard)



Seasonal outlook (4 months)



Riverine flood forecast (impact)



Flood extent maps recomputed with 100 m resolution!!

Pre-operational release of some products during Q2.

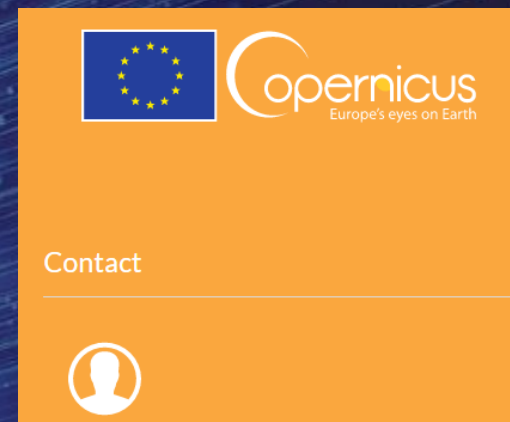
STAGE environment <https://stage.globalfloods.eu/accounts/signup/>

Operational release, tentative timeline: end of Q3.

Shape the future of GloFAS!

- ❖ See you in Gather.Town!
- ❖ Fill the GloFAS and GFM 2022 annual survey
- ❖ Get in touch

<https://www.globalfloods.eu/>



STAY CONNECTED

EVENTS, ONLINE, and MAP VIEWERS



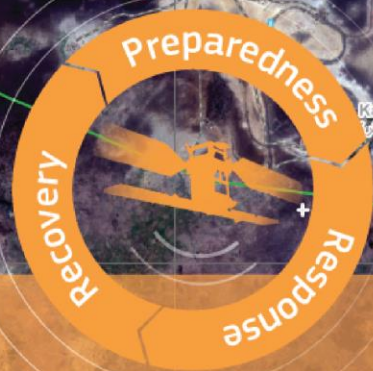
@CopernicusEMS



emergency.copernicus.eu



activations.emergency.copernicus.eu



Rapid Mapping



Risk & Recovery Mapping



Floods



Fires



Droughts



Population



Built-up areas



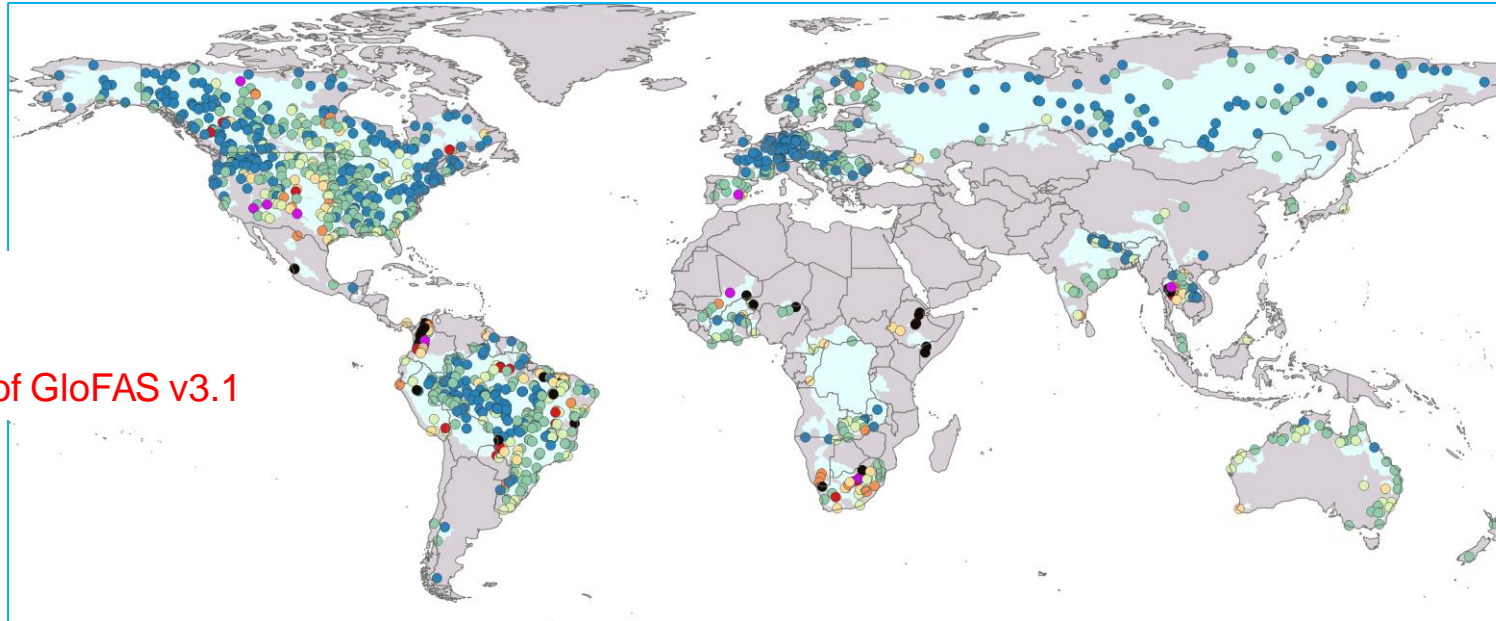
PROGRAMME OF THE
EUROPEAN UNION

Back up slides

(3.a) Available discharge data: results

GloFAS v4.0

SELECTION:
Calibration points of GloFAS v3.1



KGE

- -Inf - -0.41
- -0.41 - -0.20
- -0.20 - 0.00
- 0.00 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00

□ Discharge data:
available for v3.1

□ Discharge data:
NOT available for
v3.1

GloFAS v3.1

