PROGRAMME OF THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

Implemented by
European Commission

Emergency Management

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The Global Flood Awareness System GloFAS of the Copernicus Emergency Management Service

A global flood forecasting tool

Peter Salamon, Stefania Grimaldi
Joint Research Center, European Commission
& many more

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Presenters:

Peter Salamon

Stefania Grimaldi

Outline:

An Introduction to GloFAS (30mins)

The GloFAS map viewer – intro & hands-on (30mins)

The Global Flood Monitoring product in GloFAS

- **Intro (10 mins)**
- **Hands-on (15mins)**


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An Introduction to GloFAS
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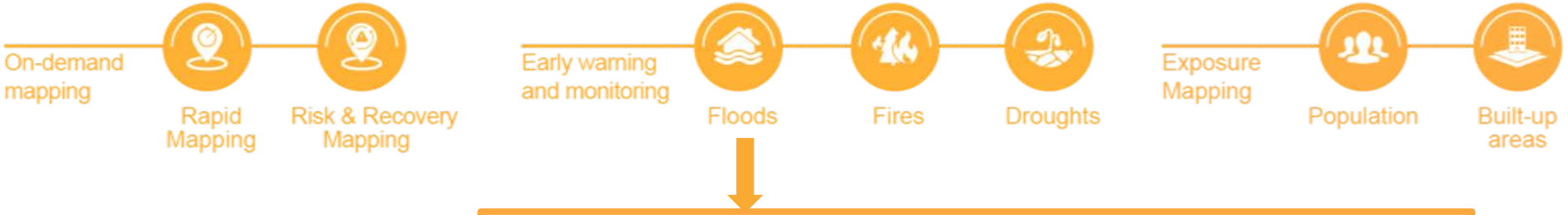
Copernicus Emergency Managment Service:

- Managed by the JRC and operational since 2012
- Provides timely and accurate geospatial info to support DRM

THE COPERNICUS EMERGENCY MANAGEMENT SERVICE



European Flood Awareness System (EFAS)

Global Flood Awareness System (GloFAS)

Global Flood Monitoring (GFM)

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Objective & History

Objective:

To support **flood preparedness and response** globally by providing **complementary** products from flood monitoring to flood forecasting.

History:

- Joint development between ECMWF & JRC in 2011
- **Pre-operational** since 2015
- Fully operational as part of the **Copernicus Emergency Management Service (CEMS)** since 2018
- JRC is the entrusted entity for CEMS (incl. GloFAS) and ECMWF is running GloFAS operationally as service provider for CEMS
- Integration of **Global Flood Monitoring** products since 2021 to provide seamless flood products from monitoring to predictions

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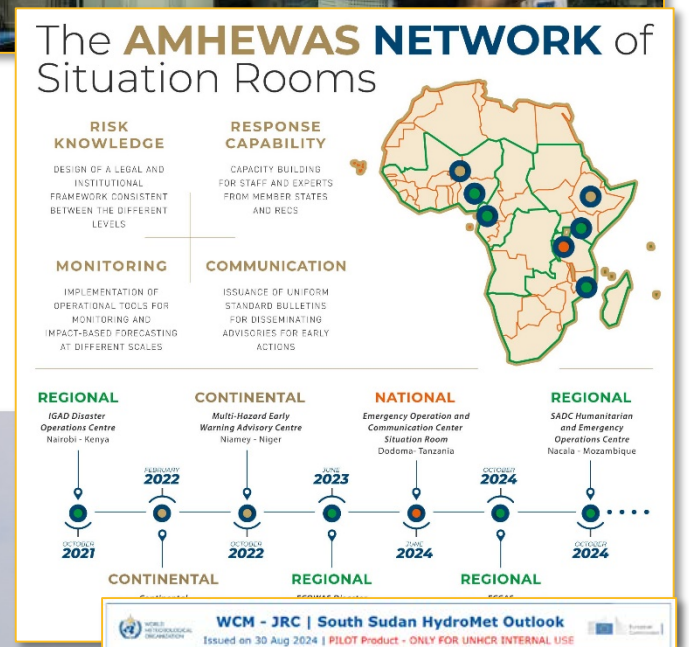
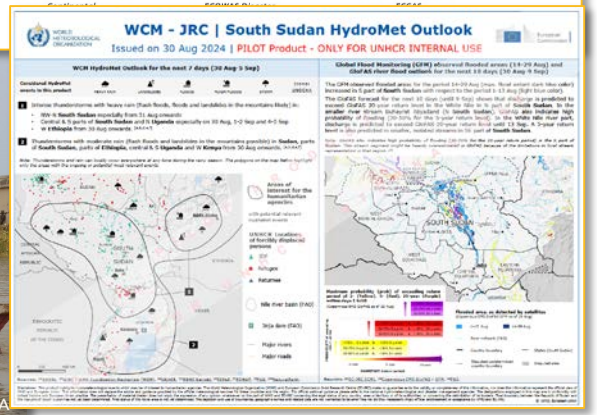
Main Users & requirements

- **Emergency Response Coordination Centre** (ERCC) of DG ECHO
  - *Impact & seasonal forecasts at global scale*
- **National/regional authorities**
  - Hydro-/meteo
    - *Medium-range forecasts at national/regional/river basin scale*
  - Civil Protection
    - *Impact forecasts at national/regional/river basin scale*
  - Water Resource Management
    - *Seasonal forecasts at national/regional/river basin scale*
- **International Aid Organizations**
  - Red Cross/Red Crescent, UN OCHA/WFP….
    - *Medium-range & impact forecasts at national/regional/river basin scale*



Source: *CIMA Foundation*



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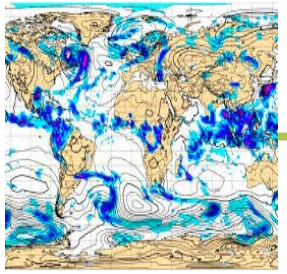
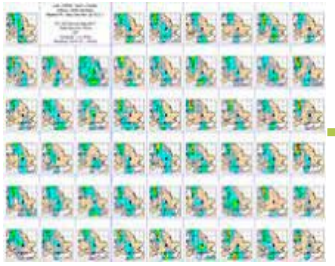
CEMS GloFAS processing chain

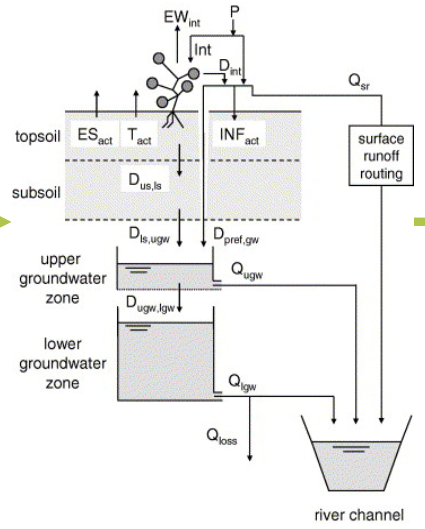


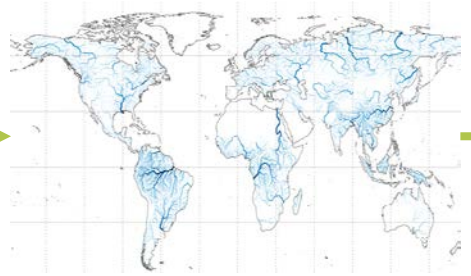
Weather ERA5T to forecast date



Weather forecasts

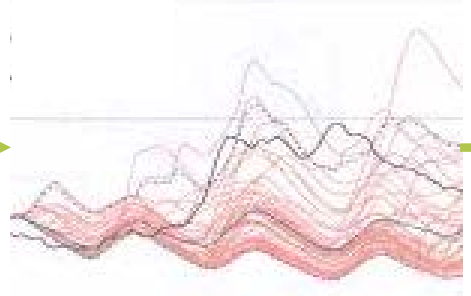
Spatially distributed, physically based hydrological model OS LISFLOOD





Hydrological status update

River discharge, Soil moisture, etc…



Ensemble hydrological forecast datasets

River discharge, soil moisture, etc..

Climatology

Flood thresholds

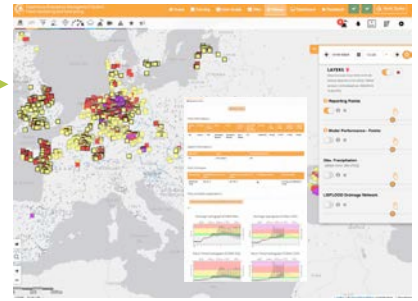
Hydrological forecast product generation

Flood hydrographs, seasonal outlooks, etc…

Data Service

EWDS

Reanalysis, forecasts, reforecast, seasonal forecasts and seasonal reforecasts



Web Service

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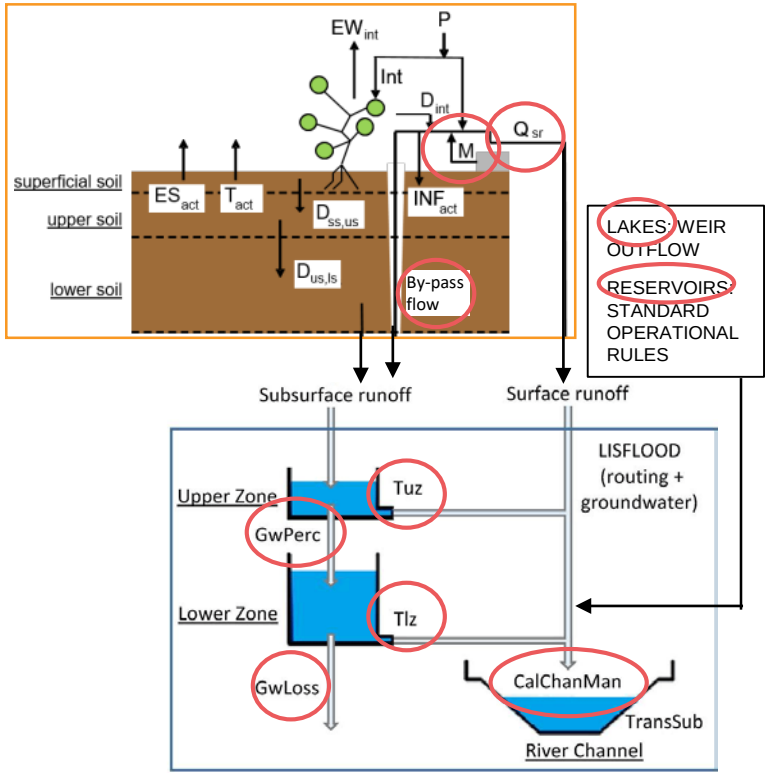
CEMS-Flood Open Source Hydrological Model



Open Source LISFLOOD
physically based and spatially distributed

- 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.

OUTPUT: all fluxes and states

Open Source code and ancillary tools; comprehensive documentation.

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

https://github.com/ec-jrc/lisflood-calibration

https://github.com/ec-jrc/lisflood-utilities

Open Source Implementation maps

https://data.jrc.ec.europa.eu/dataset/68050d73-9c06-499c-a441-dc5053cb0c86

https://doi.org/10.5194/hess-28-2991-2024

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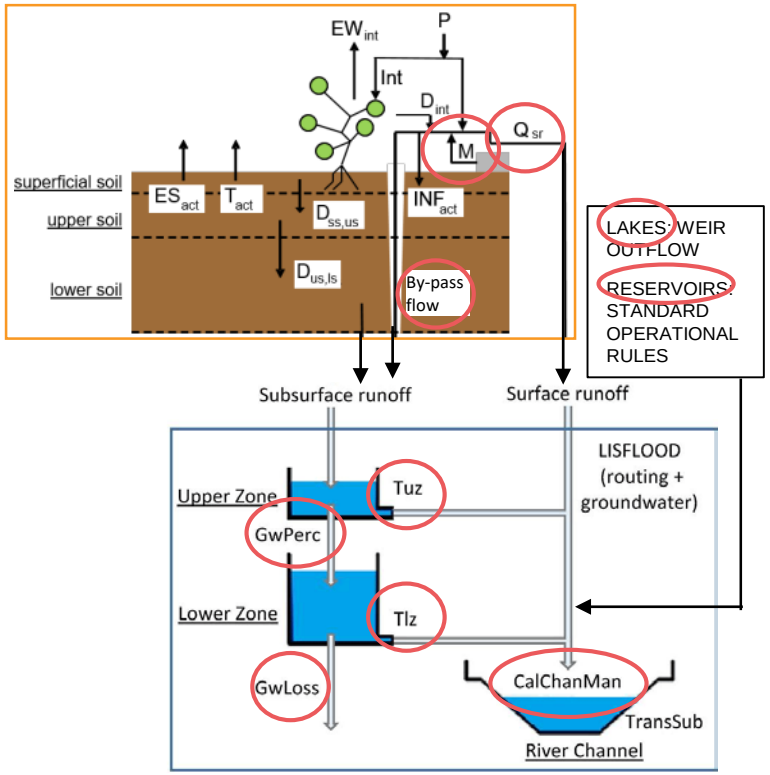
Model Calibration

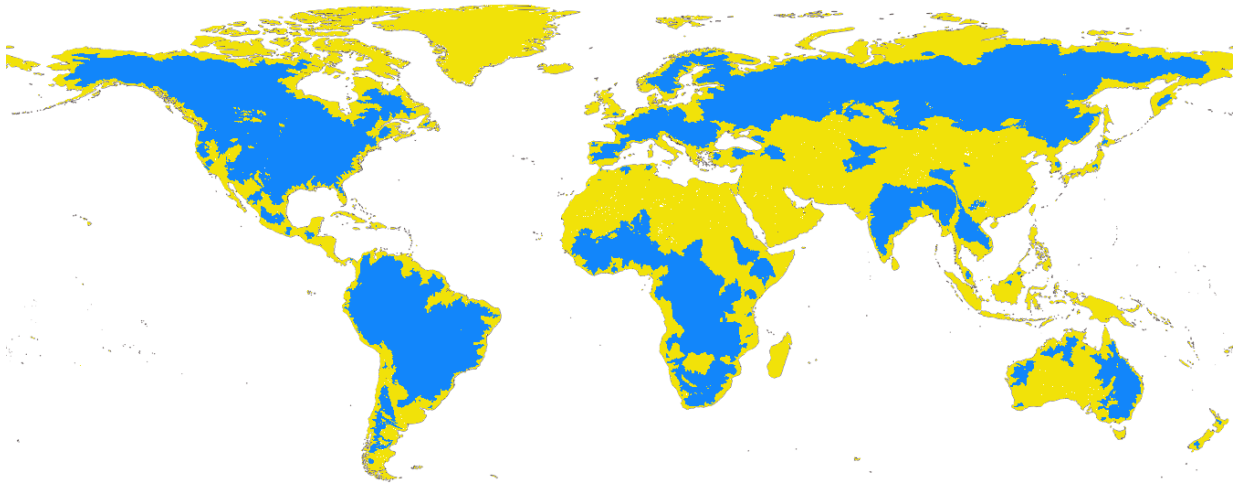


WHAT IS CALIBRATION AND WHY DO WE NEED IT?

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

HOW IS GloFAS CALIBRATED?

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



Discharge measurements available

Discharge measurements **NOT** available

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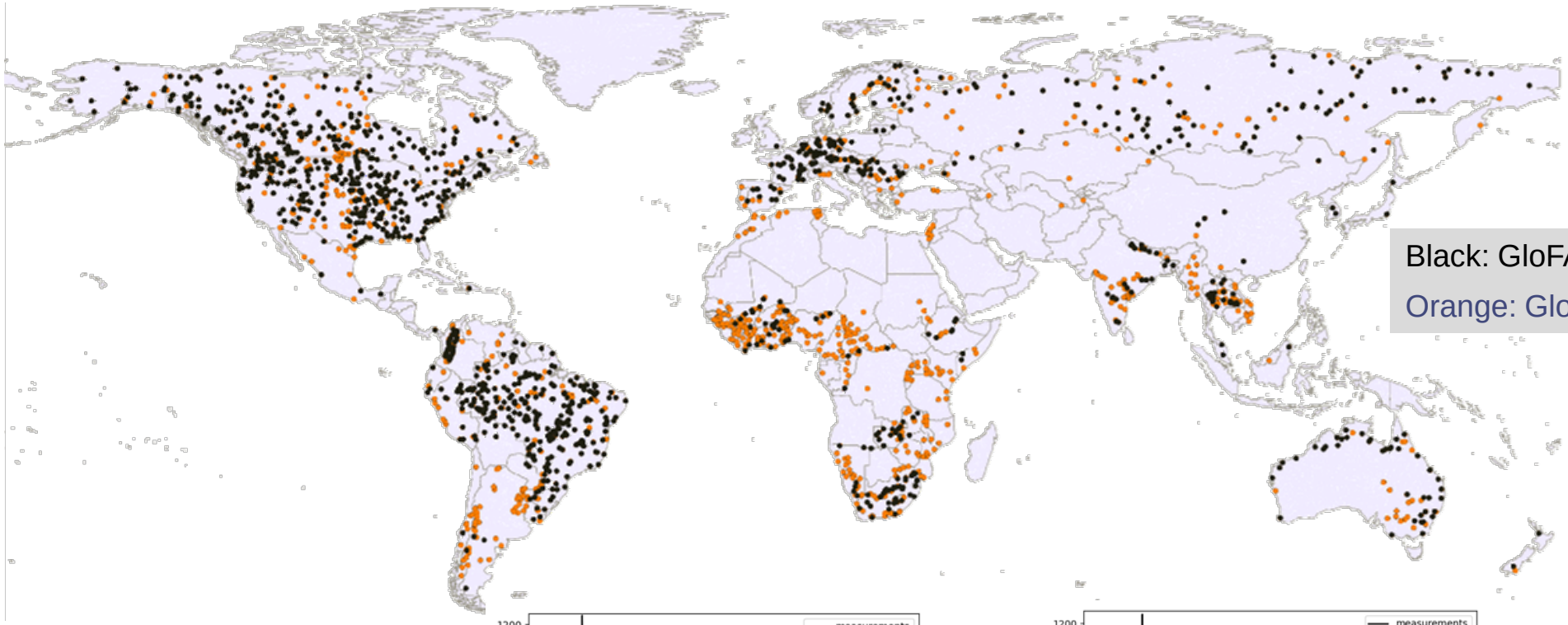
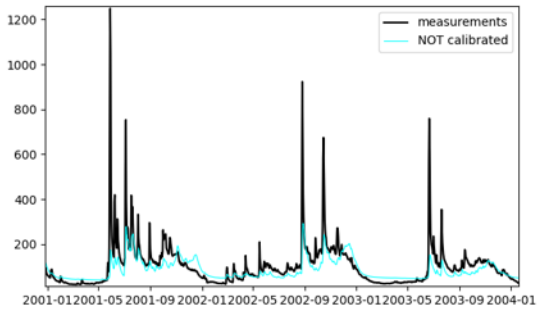
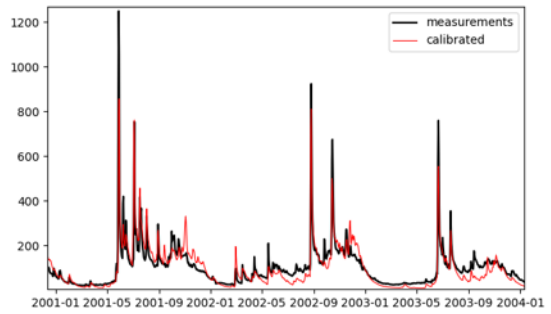
Available discharge data



Black: GloFAS 3.1 (2020), 1226 stations

Orange: GloFAS v4.0 (2023), **1996 stations**!





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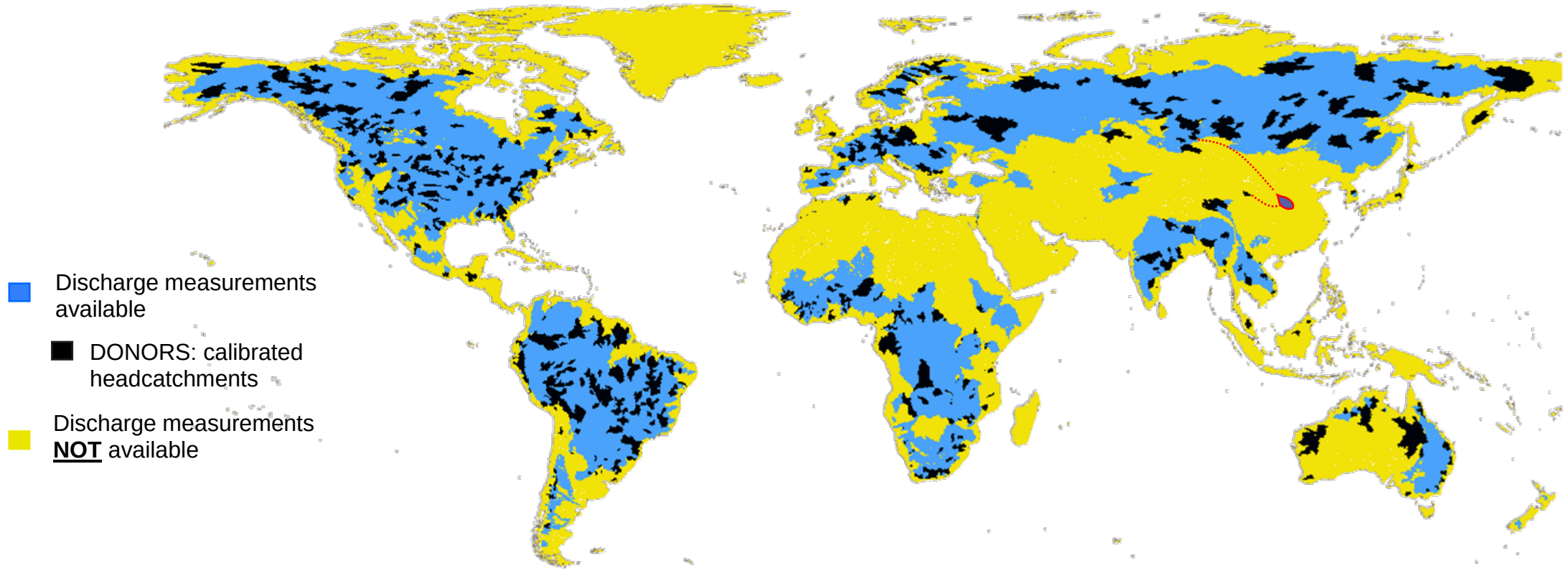
Parameter regionalization

❖ **Pragmatic regionalization** approach



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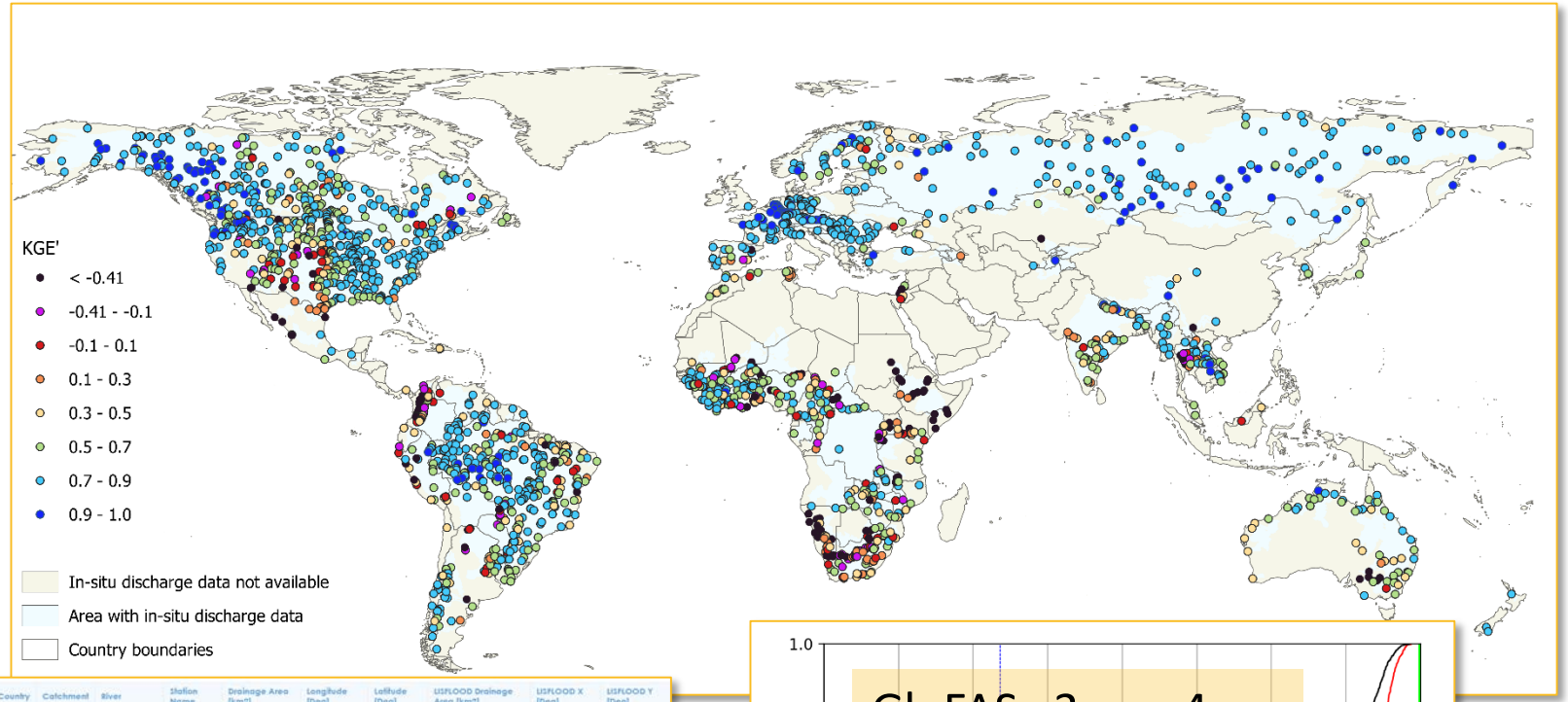
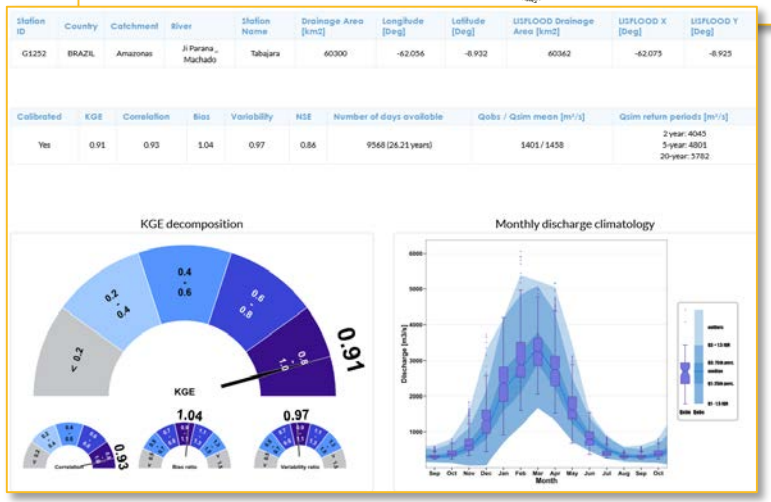
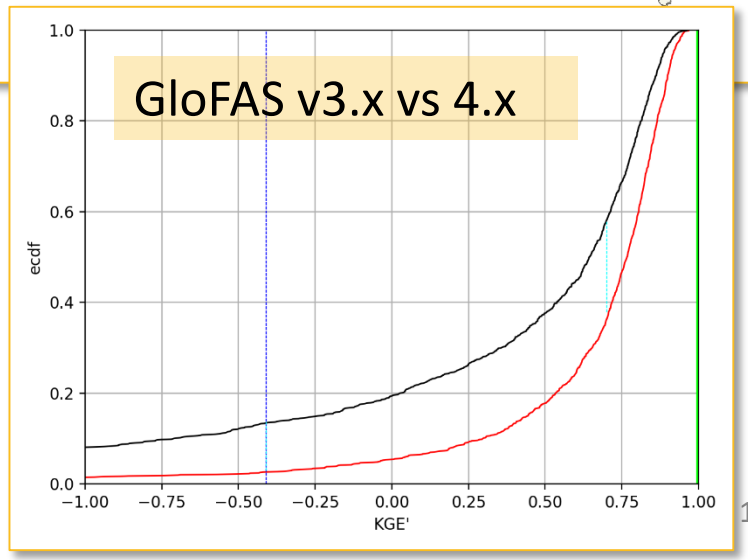
Hydrologic model performance

- Detailed hydrologic model performance on calibration and validation stations
- Comparisons against previous versions
- Individual station performance available in the map viewer (Speedometer plots)
- More details calibration: https://confluence.ecmwf.int/display/CEMS/GloFAS+v4+calibration+hydrological+model+performance
- More details validation: https://confluence.ecmwf.int/display/CEMS/GloFAS+v4+general+hydrological+model+performance







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How does it work?

GloFAS	V4.3
Meteorological forecasts	**ECMWF IFS 49r1:** • **Medium-range (day 1-15):** 1 p/d, 9 km, 51 ensemble members **ECMWF AIFS v1.1.0:** • **Medium-range (day 1-15):** 1 p/d, 28 km, deterministic
Meteorological re-analysis & initialization	• **ERA5 (reanalysis)** • **ERA5-T (initialization)**
Hydrological model	**Open-source LISFLOOD v4.3.1** (https://ec-jrc.github.io/lisflood/)
Horizontal & temporal resolution	• **0.05° (~5 km)** • **daily**
Hydrological Input Surface fields	• Catchment morphology, river network, land use, vegetation properties, soil properties, lakes, reservoirs, water demand, calibrated parameters (more info: Choulga et al., 2024) • **Freely available**: https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/CEMS-GLOFAS/LISFLOOD_static_and_parameter_maps_for_GloFAS/
Hydrologic model calibration & parameter regionalization	• **1995 stations** with **at least 4 years** of observations (v4.x) • Parameter regionalization using **climatic similarity and geographical proximity**
Real-time forecasts	• **GloFAS:** 15 days LT, run each day
Real-time ensembles	51 members plus 1 deterministic
Historical/Reanalysis	1979 to near-real-time (forcing from ERA5)
Reforecasts	• **GloFAS:** most recent 20 years, 2/pw, 11 ensemble members

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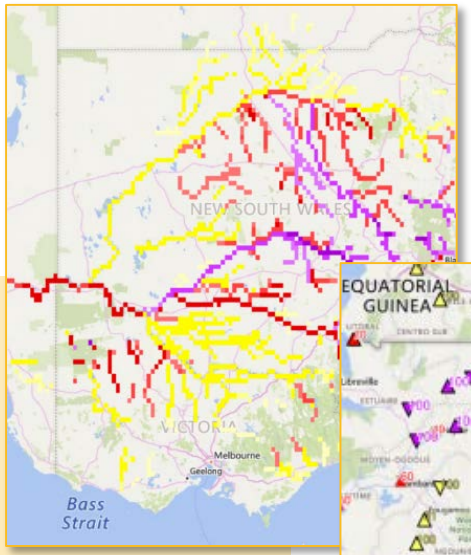
Products

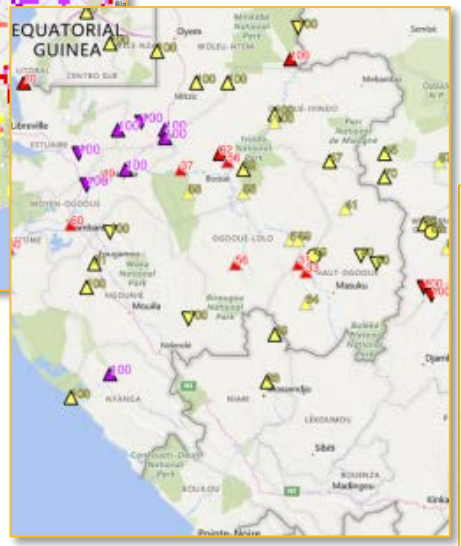
Flood forecasts (hazard)

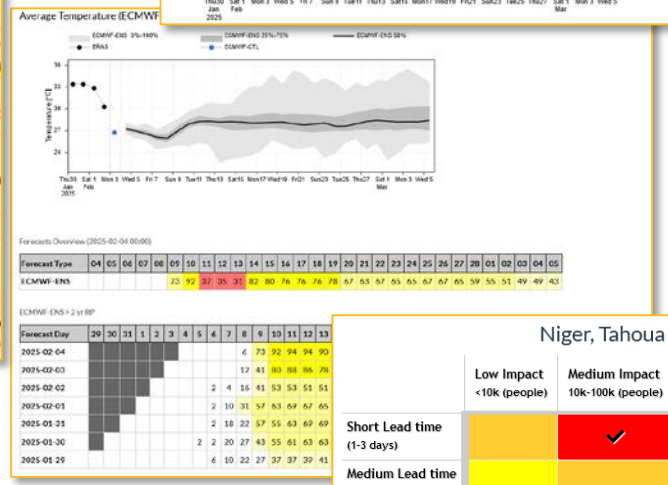
- Medium to long-range (up to 15 days)
- Exceedance probabilities
- Reporting points

Impact forecasts

- Rapid flood mapping (90m resolution)
- Rapid Risk Assessment (administrative region)







Niger, Tahoua

	Low Impact <10k (people)	Medium Impact 10k-100k (people)	High Impact >100k (people)
Short Lead time (1-3 days)		✓	
Medium Lead time (4-10 days)			
Long Lead time (>10 days)			

Exposure Information	Protected	Unprotected
Population affected [No. of people]	11200	11200
Population within floodplain affected [%]	NaN	NaN
Cities affected [% area affected]	N/A	N/A
Health facilities affected [No. of facilities]	0	0
Education facilities affected [No. of facilities]	0	0
Airport affected [No. of facilities]	0	0
Powerplant facilities affected [No. of facilities]	0	0
Artificial surfaces affected [ha]	34	34
Agricultural surfaces affected [ha]	5145	5145
Forest and semi-natural surfaces affected [ha]	8258	8258

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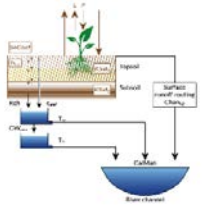
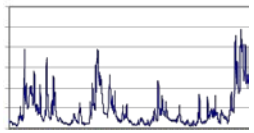
CEMS-Flood products generation principle

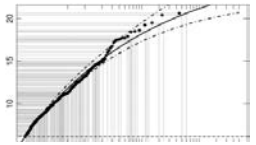
Historical met. observations



LISFLOOD



Discharge timeseries

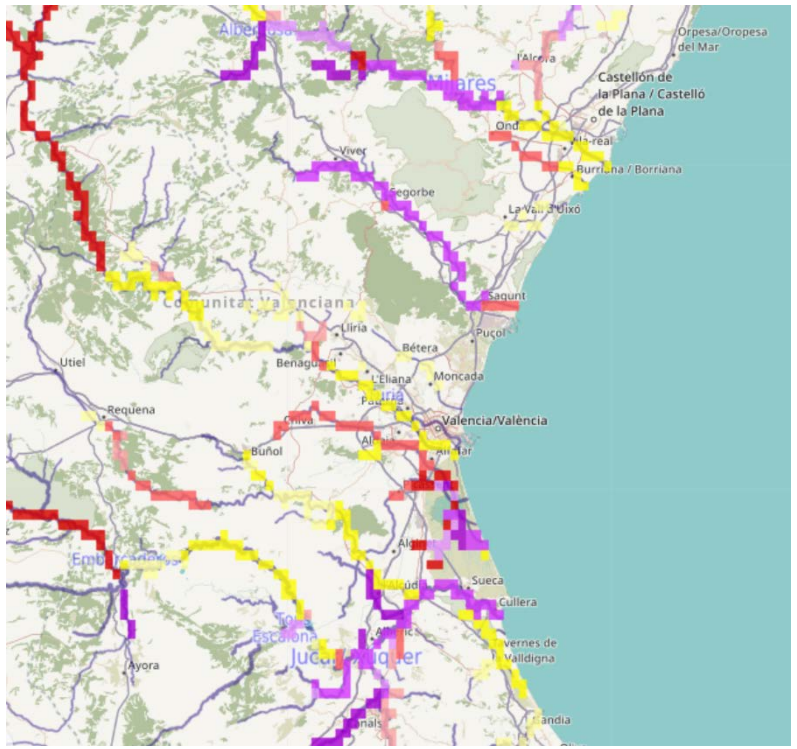


Return period statistics

Thresholds

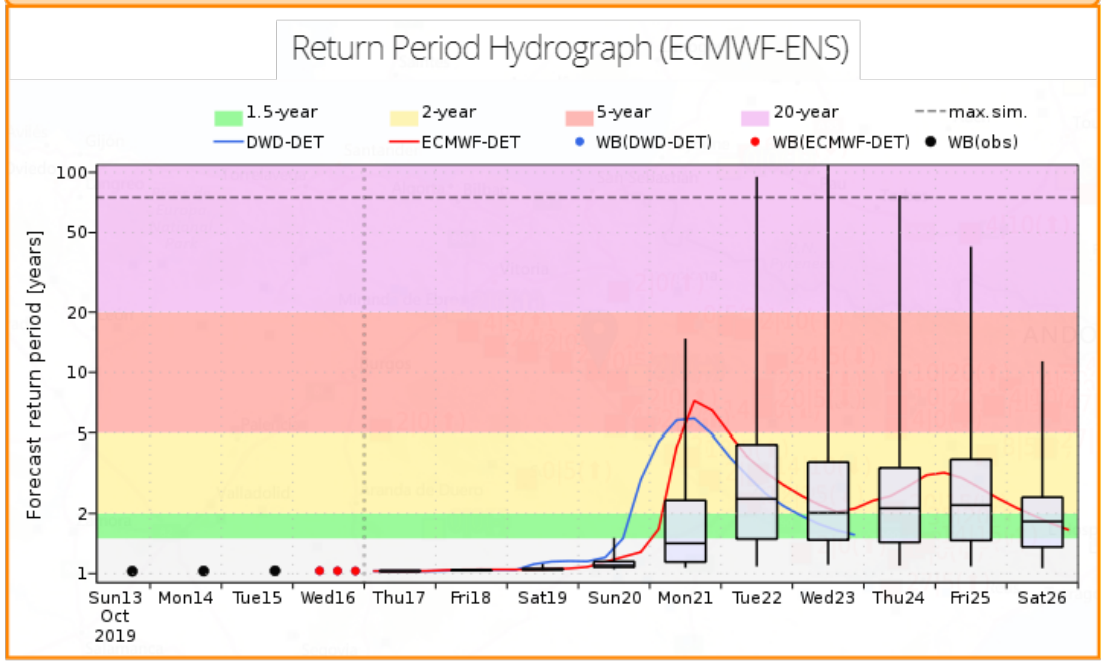
Reference thresholds calculated once at each major release

Comparison of forecast discharge data with reference threshold



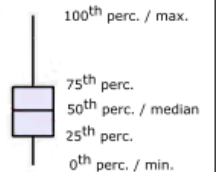
Maximum probability to exceed a flood threshold over the forecast horizon

Return period hydrograph. Time series plot of the (6-hourly deterministic and daily probabilistic) discharge forecasts over the next 10 days. Compared against the flood severity thresholds (coloured return periods on the y-axis), the forecast indicates potential upcoming floods over the forecast window.



Severity thresholds. Return periods (green to purple colours) and simulation maximum (dotted horizontal line) derived from the model climatology.

Ensemble forecast boxplot



Initial conditions period. Shows the simulations from observations (black dots; daily) and the fill-up (coloured dots; 6-hourly).

Forecast period. Starts at the vertical dotted line. Shows the two deterministic forecasts (single lines; 6-hourly) and ensemble forecast (daily boxplots; in this case ECMWF-ENS, as shown by the plot title).

Products created at each forecast update

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Products

Initial conditions

- 3-day precipitation & snowmelt
- Snow cover, soil moisture, temperature
- Anomalies for precip, snow, soil moisture and temperature

Meteorological forecasts

- Precipitation (accumulated & exceedance)
- Precipitation animation

Static

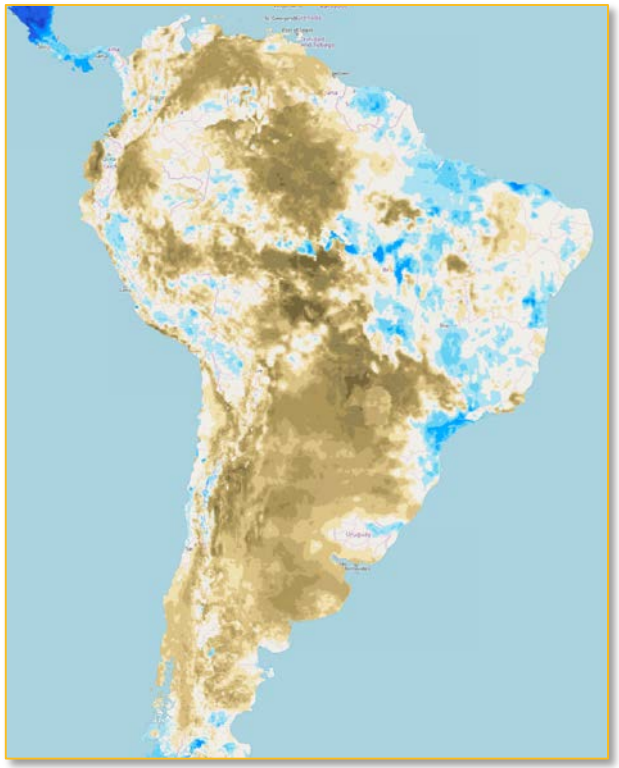
- Administrative regions, river basins, major rivers
- Hydrological model drainage network and reservoirs & lakes
- 100 year return period flood hazard map

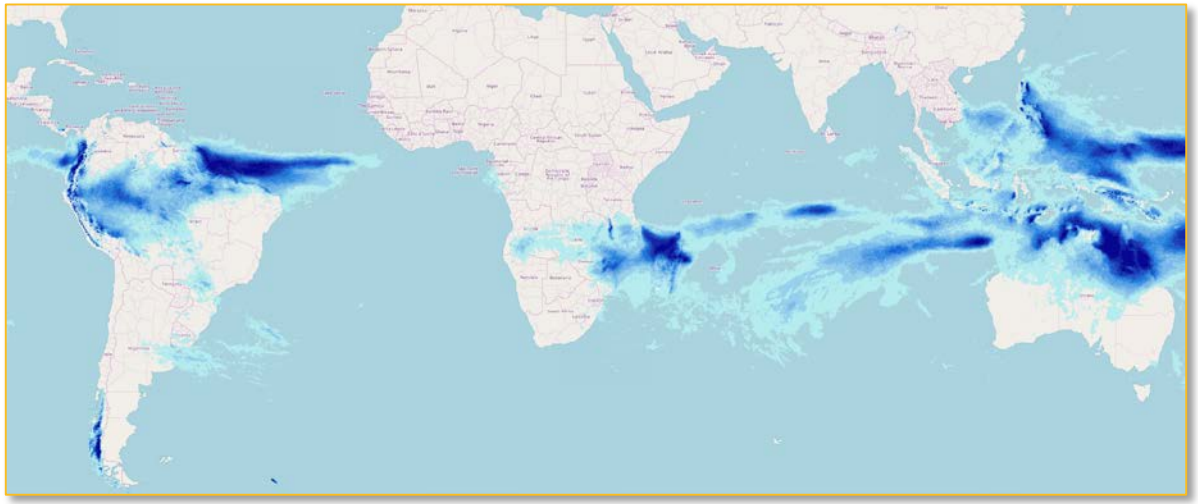
Evaluation

- See next slides

Flood Monitoring

- Not shown here





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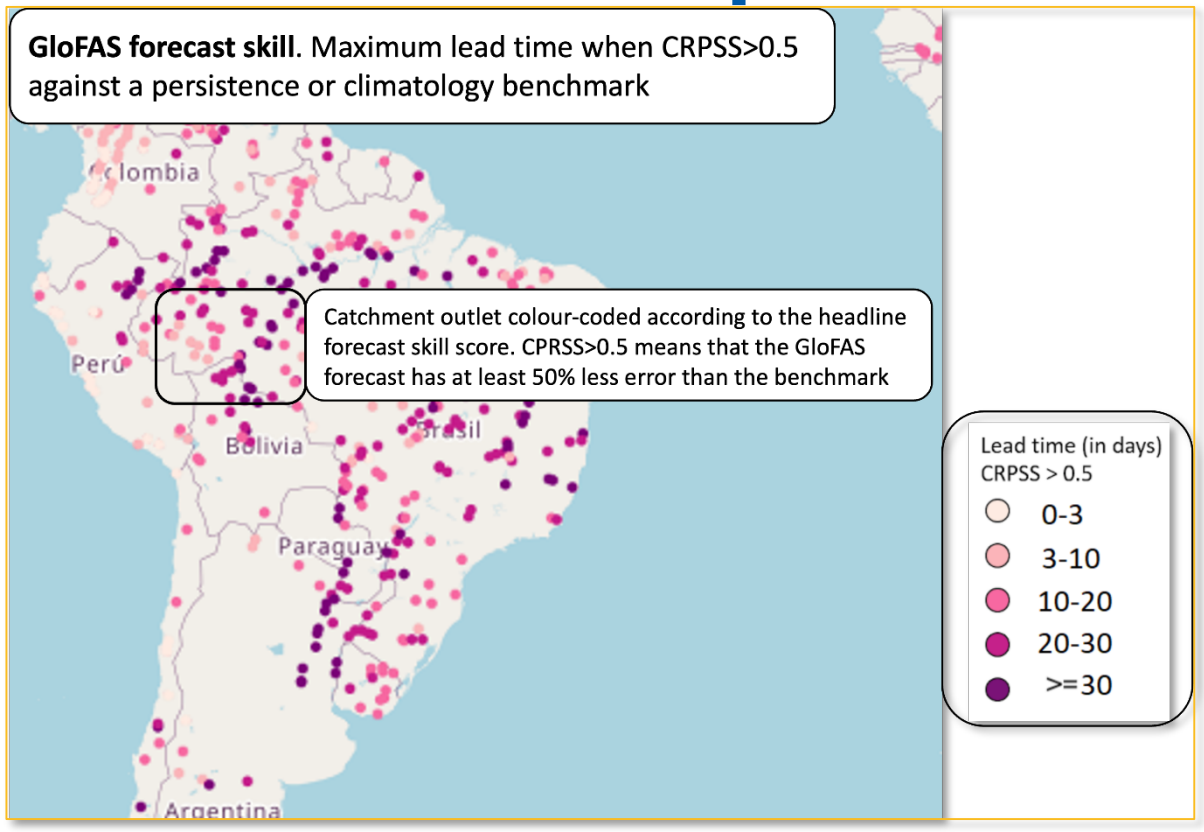
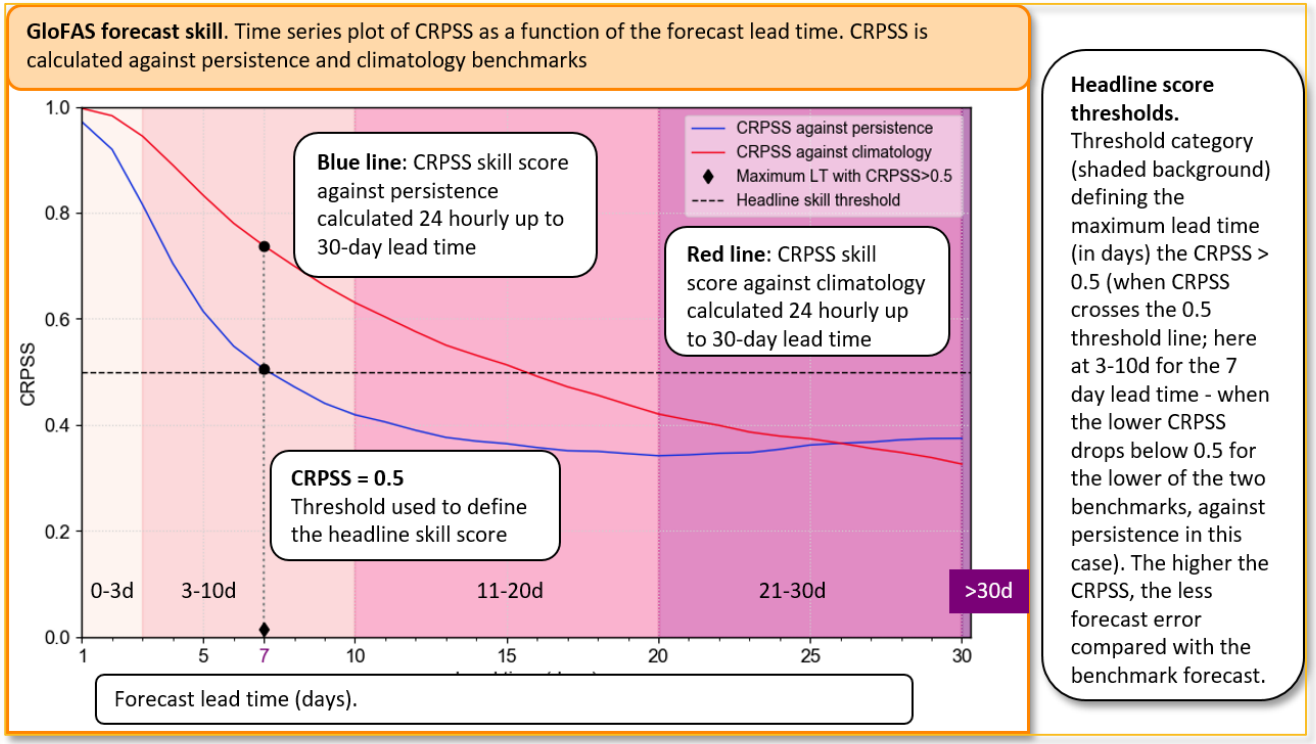
Forecast skill performance





- Headline score: Continuous Ranked Probability Skill Score (CRPSS) against persistence or climatology benchmark forecast
- Available as layer in the map viewer and for each individual station
- More details: https://confluence.ecmwf.int/display/CEMS/GloFAS+forecast+skill and https://confluence.ecmwf.int/display/CEMS/GloFAS+forecast+skill+product

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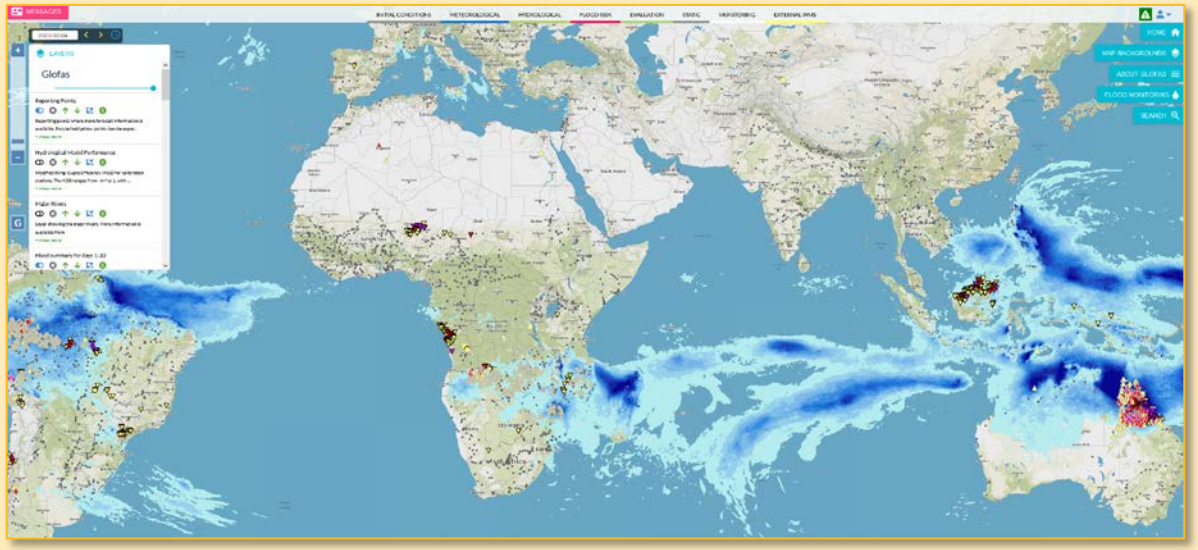
Access & dissemination

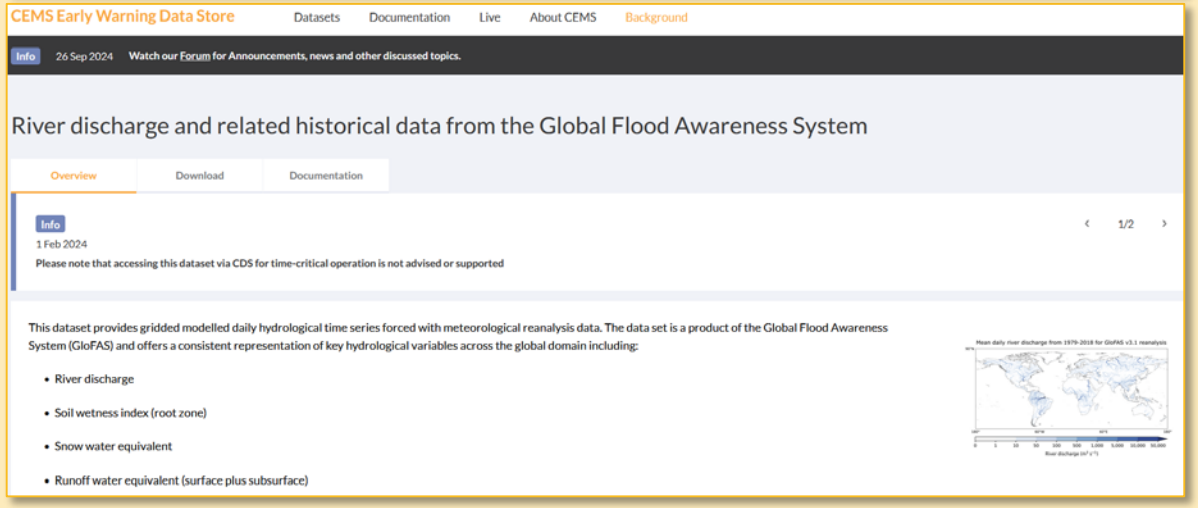
Map viewer

- **Easy & fast access**
- **customizable**



Early Warning Data Store, ECMWF MARS, ftp

- **Discharge, soil moisture, swe, surface runoff**
- **(re) forecasts, re-analysis**



Web Map Service (WMS-T)

- **Integration into OGC compliant web interface**

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User support

GloFAS Wiki:

- https://confluence.ecmwf.int/display/CEMS/Global+Flood+Awareness+System

GloFAS User Guide:

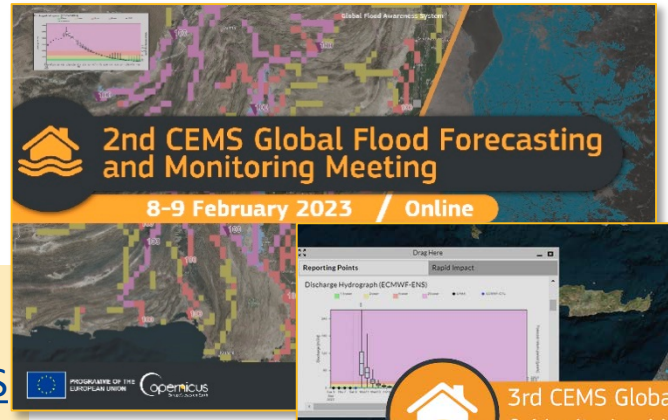
- https://confluence.ecmwf.int/display/CEMS/GloFAS+User+Guide

Webinars & trainings

Service desk

Events

User Surveys



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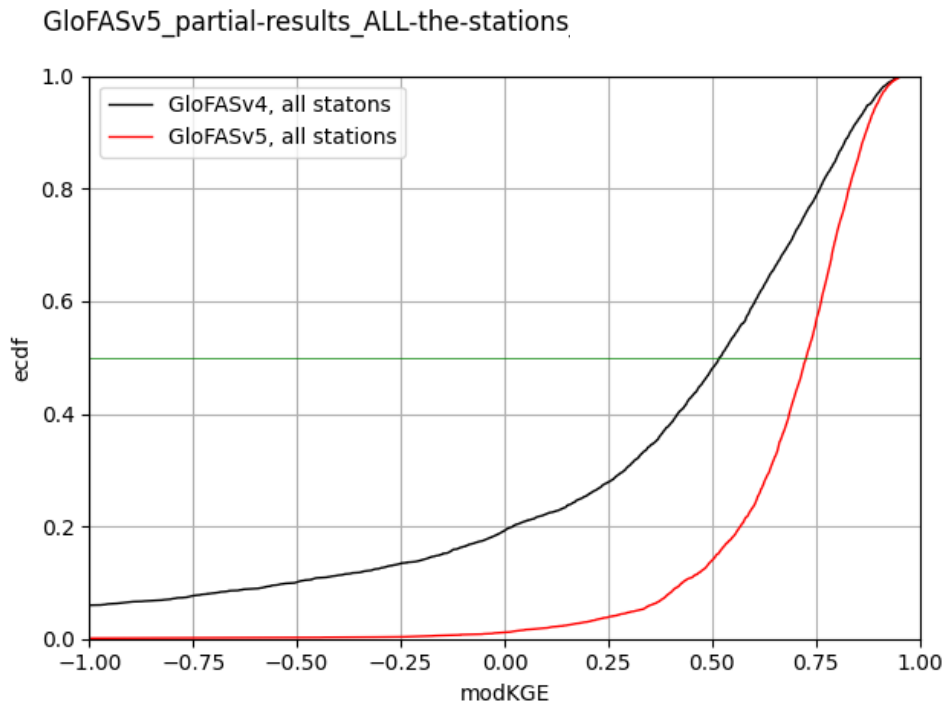
Outlook

Major release GloFAS v5.0 – Release date Q1/Q2 2026

- **Improvements in input data** (ERA-5 spurious precip correction, soil properties, LAI, water demand, lakes & reservoirs)
- **Improvements in the hydrological model** (initialization, Muskingum-Cunge-Todini routing, river leakage, reservoir module, bugfixes)
- **New calibration and regionalization** (increased no. of calibration stations – more than 5000!, performance improvements, parameter regionalization using DL)



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Find out more:

https://global-flood.emergency.copernicus.eu/