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GloFAS products: medium range forecast

UN-SPIDER / DLR / ZFL International Training Workshop
“Space technologies for flood management”

UN Bonn – 20 February 2023

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GloFAS scope and essential concepts – a reminder!

GloFAS scope and limitations

GloFAS provides **COMPLEMENTARY**, **PROBABILISTIC**, **EARLY WARNING** information on upcoming and ongoing flood events at the global scale.

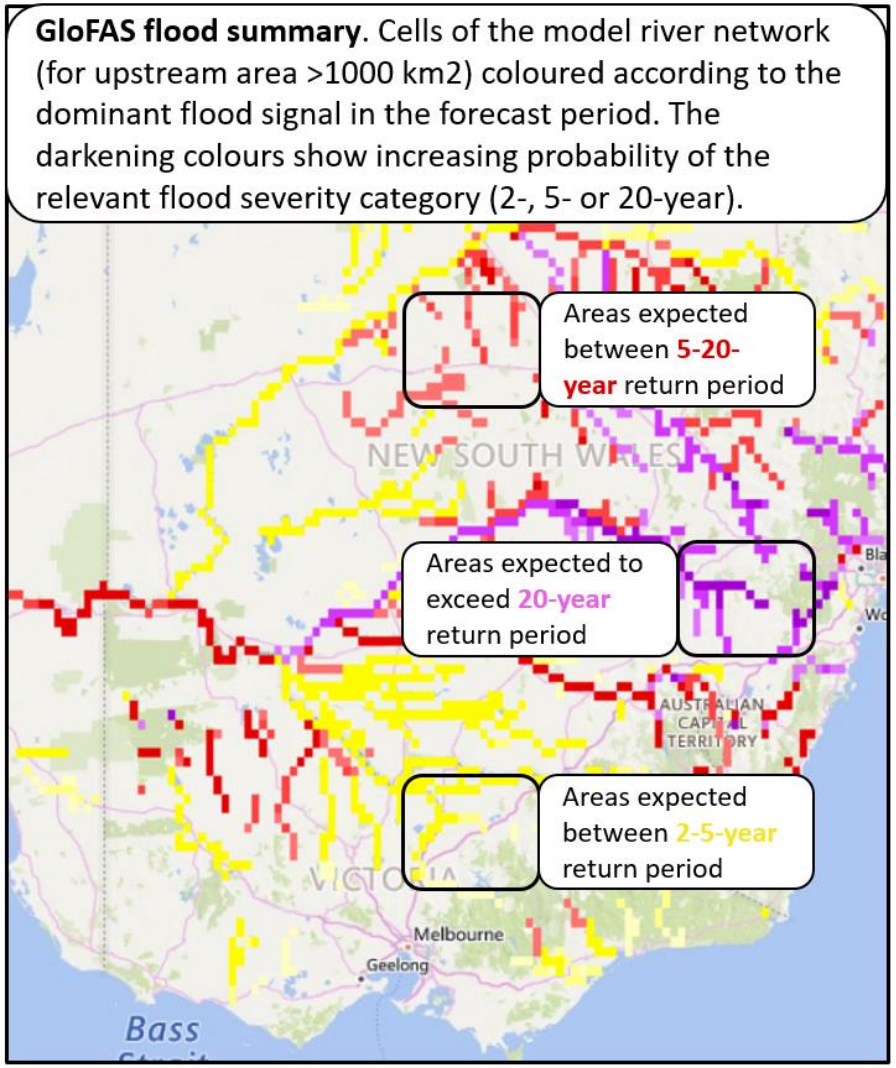
GloFAS is specifically relevant for **large**, transboundary catchments affected by **riverine** flooding.

As of today, GloFAS cannot model flash floods, coastal floods, urban floods.

- If available, always use national/regional forecasts and information to complement and evaluate GloFAS forecasts.

GloFAS products: Medium range forecast

Flood Early Warning: Flood Summary Layers



- River sections which are forecasted to have high discharge levels.
- The flood summary layers are available for different lead times,
  - ❖ 1-3 days,
  - ❖ 4-10,
  - ❖ 11-30
  - ❖ and for the whole forecast period, i.e. 1-30 days.
- The user has to choose which lead times are most relevant.

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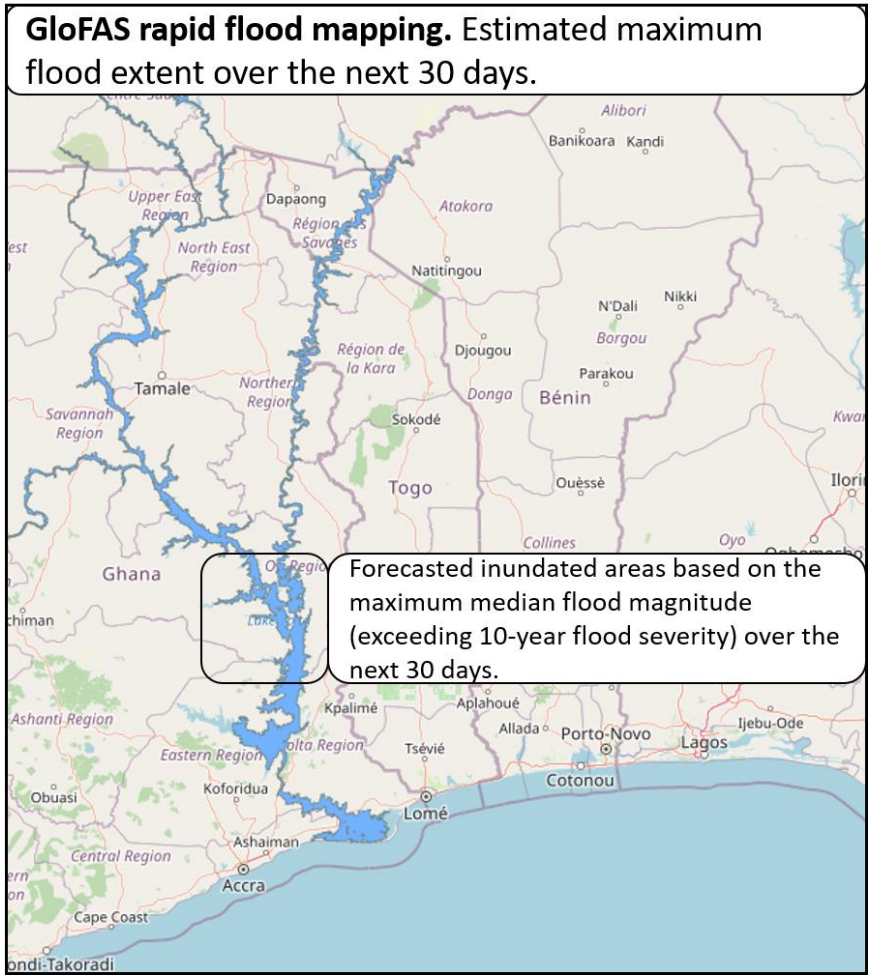
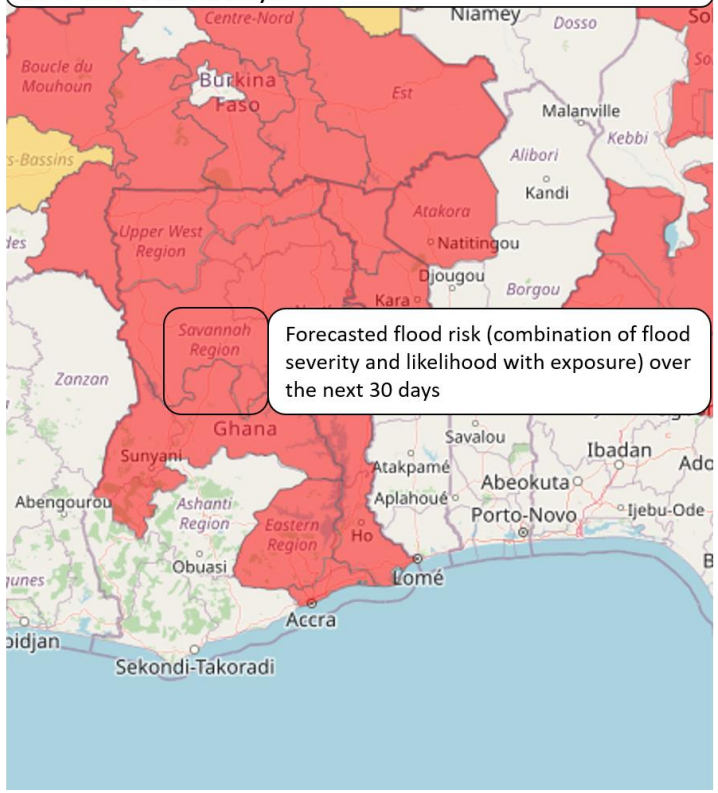
Flood Early Warning: Rapid Flood mapping



- Estimated flood extent at **1km resolution (late 2023: 100 m resolution!)** based on the matching of return periods from the GloFAS streamflow forecast and a catalogue of modelled inundation extents.
- Basins greater than **5000 km²** and where the maximum return period is greater than **10 years**.
- The role of flood defenses is not considered.

Flood Early Warning: Rapid Impact Assessment Layer

GloFAS rapid flood mapping. Estimated flood risk level over the next 30 days.



Forecasted flood risk (combination of flood severity and likelihood with exposure) over the next 30 days

GloFAS risk matrix. Table showing the flood likelihood level and impact categories and associated combined impact. Results are aggregated over NUTS administration units.

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

Impact levels. Defined according to the total population exposure

Flood likelihood levels. Based on the maximum median forecast over the next 30 days.

GloFAS impact tables. Tables showing exposure information and the maximum forecast flood characteristics over the next 30 days and expected associated impacts. Results are aggregated over NUTS administration units.

Exposure Information	Protected	Unprotected
Population affected [No. of people]	70100	70100
Population within floodplain affected [%]	69	69
Cities affected (% area affected)	N/A	N/A
Health facilities affected (No. of facilities)	3	3
Education facilities affected (No. of facilities)	3	3
Airport affected (No. of facilities)	N/A	N/A
Artificial surfaces affected [ha]	N/A	N/A
Agricultural surfaces affected [ha]	258	258
Forest and semi-natural surfaces affected [ha]	3061	3063

Flood Event Information	Protected	Unprotected
Estimated mean return period [yr]	200	200
Estimated protection levels [yr]	6	6
Estimated peak time [d]	1	1
Estimated flooding duration (day)	13	13
Estimated flooded area (km2)	4024	4026
Mean probability of exceeding 2-years threshold	100	100
Mean probability of exceeding 5-years threshold	100	100
Mean probability of exceeding 20-years threshold	100	100

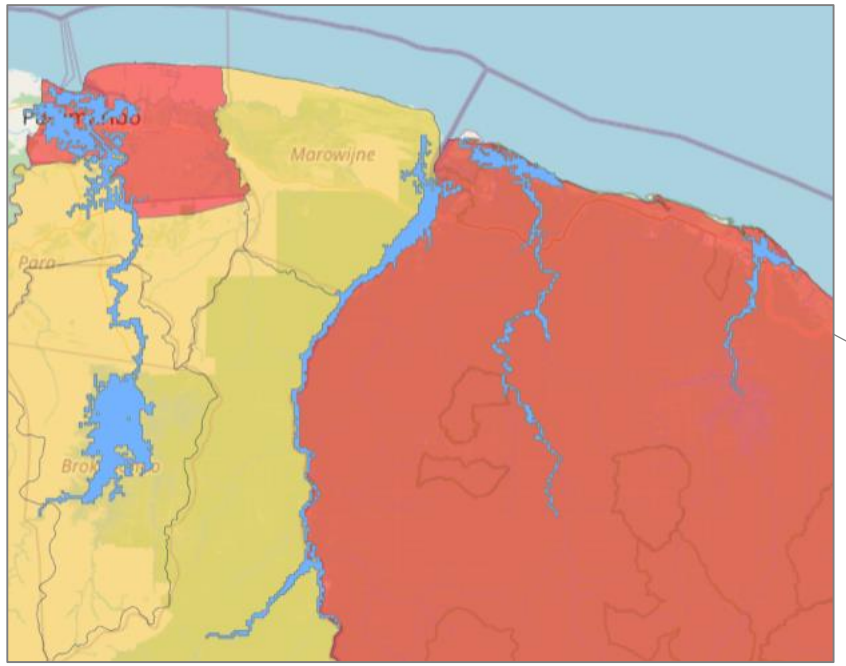
Flood characteristics. Based on the maximum forecast median over the next 30 days.

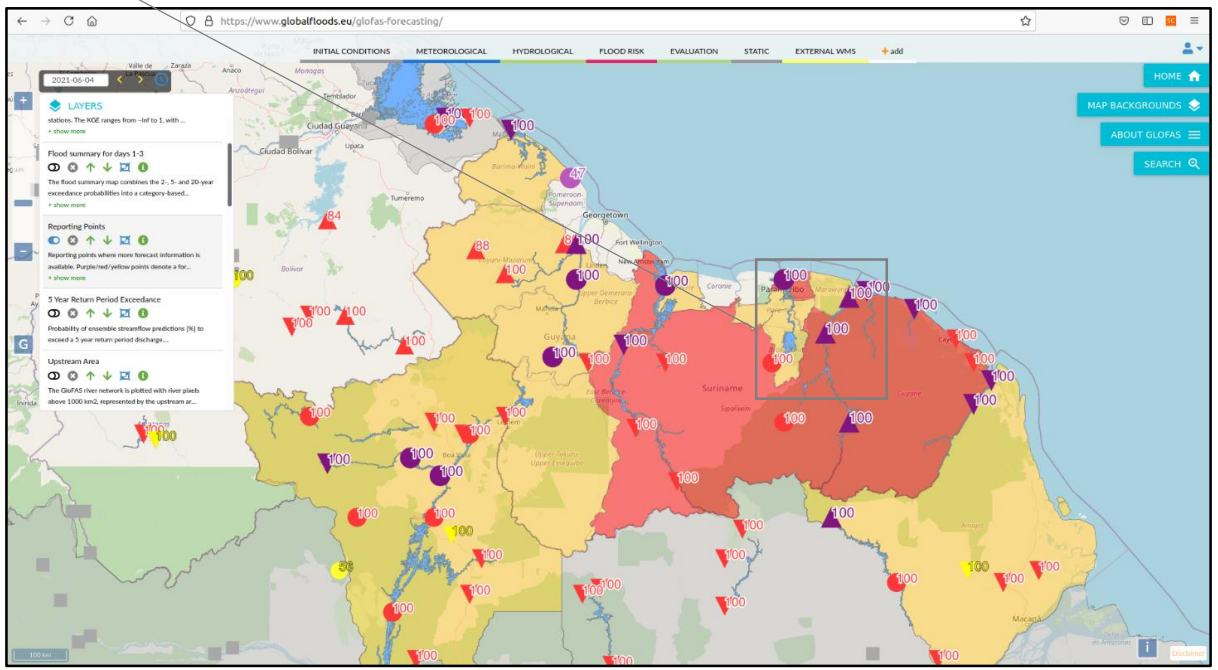
Impact estimates. Defined by overlaying the inundation area with exposure data, aggregated over NUTS admin units.

Exposure information. Potential impact of floods on population and land use (e.g. agriculture, urban).

Protected. Flood defenses accounted for in inundation extent estimates.

Unprotected. Inundation extent estimates assuming no flood defense.





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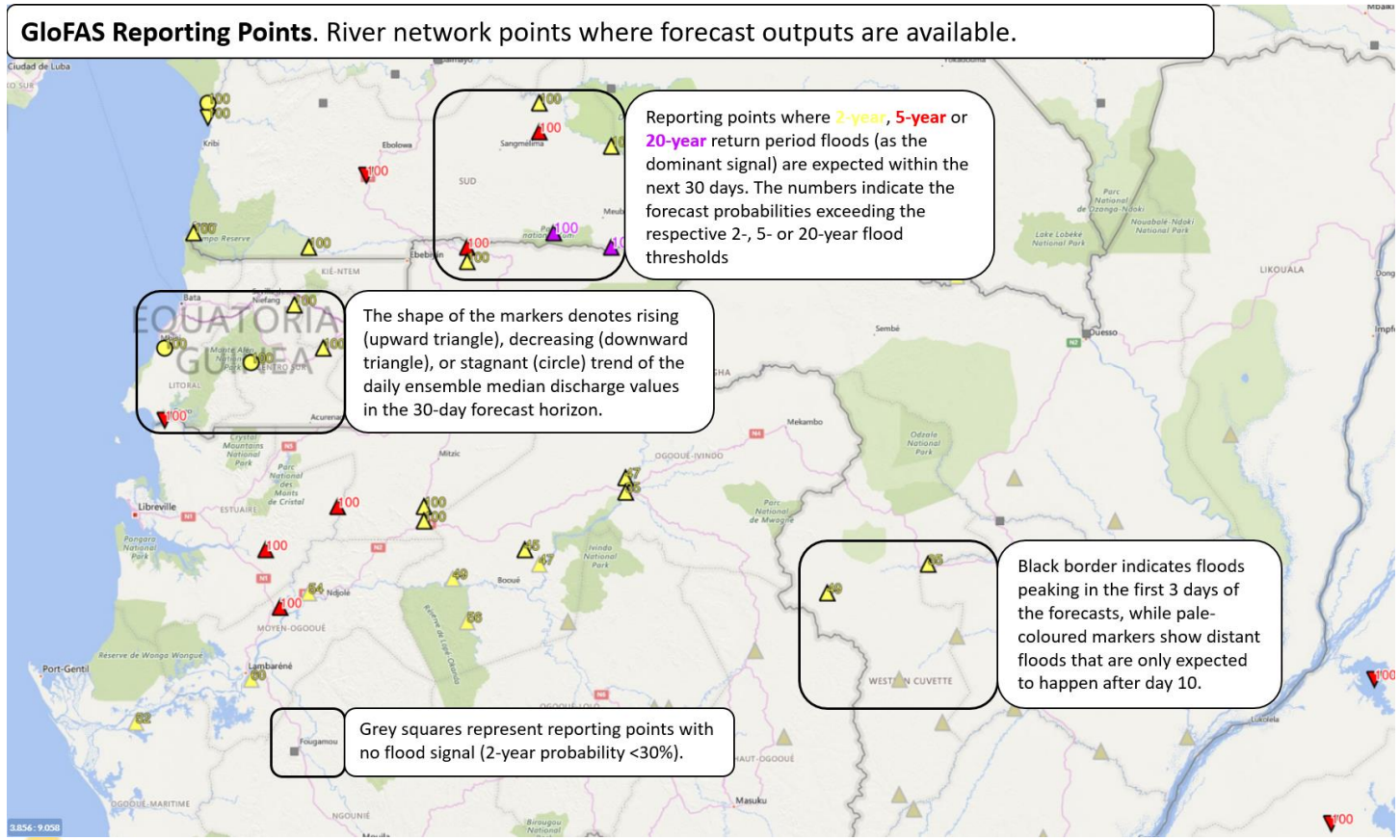
Flood Early Warning: Reporting points layer

- Static and dynamic reporting points
- Triangles (upward/downward), circles. Black/grey border.



No flood

2-, 5-, 20-year flood, rising flow, days 1-3 peak

2-, 5-, 20-year flood, stagnating flow, days 1-3 peak

2-, 5-, 20-year flood, falling flow, days 1-3 peak

2-, 5-, 20-year flood, rising flow, peak after day 3

2-, 5-, 20-year flood, stagnating flow, peak after day 3

2-, 5-, 20-year flood, falling flow, peak after day 3

2-, 5-, 20-year flood, rising flow, peak after day 10

2-, 5-, 20-year flood, stagnating flow, peak after day 10

2-, 5-, 20-year flood, falling flow, peak after day 10

100 100 100 ECMWF-ENS probability of the 2-, 5-, 20-year flood

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Flood Early Warning: Reporting points layer

- Pop-up window (click on the point of interest): forecasted discharge hydrographs.

Reporting Points

Reporting Points

Station ID	Country	Basin	River	Station Name	Point ID	Drainage Area [km2]	Longitude [Deg]	Latitude [Deg]	LISFLOOD Drainage Area [km2]	LISFLOOD X [Deg]	LISFLOOD Y [Deg]
G1649	South Africa	Limpopo	Krokodil	Krokodil River At Haakdoringdrift	SI003717	22,270	27.41	-24.7	22,053.2	27.45	-24.75

Point Forecast

Forecast Date	Maximum probability (2 yr / 5 yr / 20 yr)	Alert level	Max probability step	Discharge tendency	Peak forecasted
2023-02-15 00:00	8 / 2 / 0	Inactive	No Data		in 2 days (on 2023-02-17)

Flood Early Warning: Reporting points layer

- Pop-up window (click on the point of interest): forecasted discharge hydrographs.

Reporting Points

Reporting Points

Station ID	Country	Basin	River	Station Name	Point ID	Drainage Area [km2]	Longitude [Deg]	Latitude [Deg]	LISFLOOD Drainage Area [km2]	LISFLOOD X [Deg]	LISFLOOD Y [Deg]
NA	NA	NA	NA	Not a station	DM001997	NA	4.15	100.95	9,930	100.95	4.15

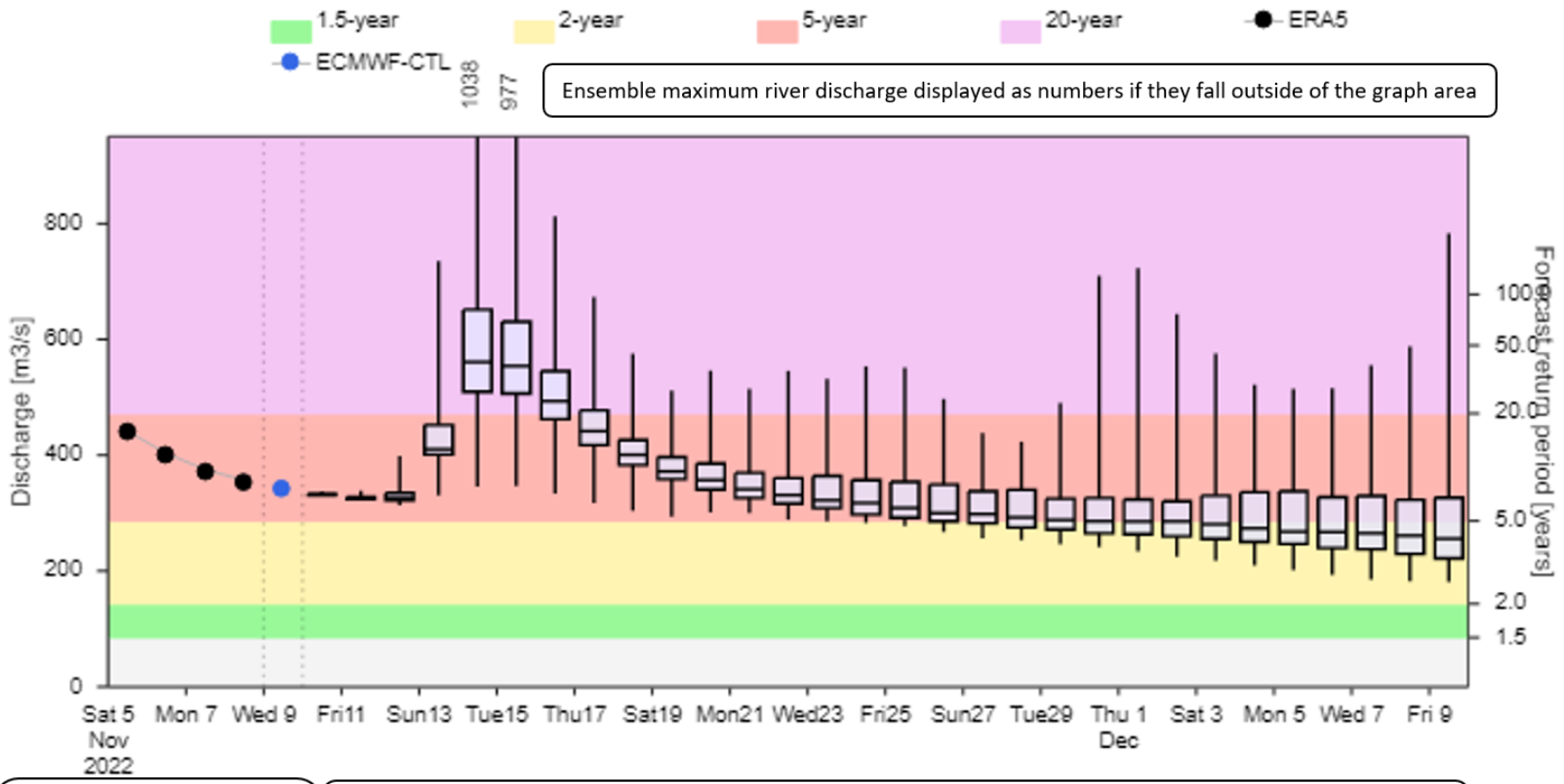
Point Forecast

Forecast Date	Maximum probability (2 yr / 5 yr / 20 yr)	Alert level	Max probability step	Discharge tendency	Peak forecasted
2022-12-07 00:00	41 / 14 / 8	Medium	in 14-20 days (on 2022-12-23)		in 14-20 days (on 2022-12-23)

Flood Early Warning: Reporting points layer

- Pop-up window (click on the point of interest): forecasted discharge hydrographs.
- Analysis of onset, severity (return period) as well as uncertainty of the event (spread of the boxplots)

GloFAS discharge hydrograph. Time series plot of the daily discharge values in the previous 5 days and over the next 30 days, compared against the flood severity thresholds (coloured return periods on the y-axis, right hand side). The 30-day forecast indicates potential upcoming floods over the forecast window. The plot is linearly scaled, based on river discharge (left hand side).



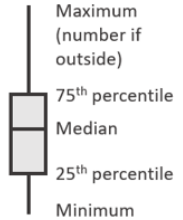
Initial condition period
Simulations from ERA5 (black dots) and ENS-Control fill-up (blue dots).

Forecast period. Starts at the second vertical dotted line. Shows the ensemble forecast for days 1 to 30 (box plots)

Severity thresholds

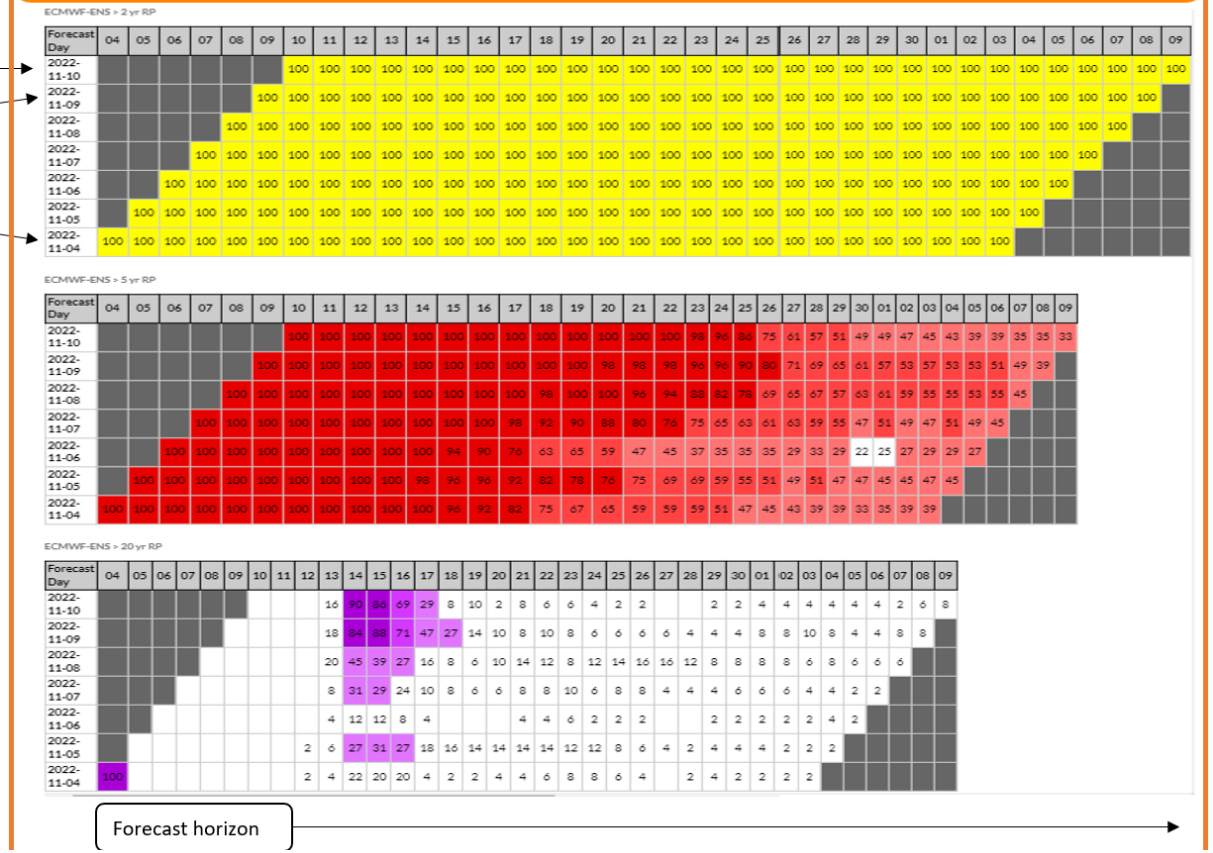
Return periods (green to purple colours) derived from the long-term reanalysis run of the model

Ensemble forecast boxplot

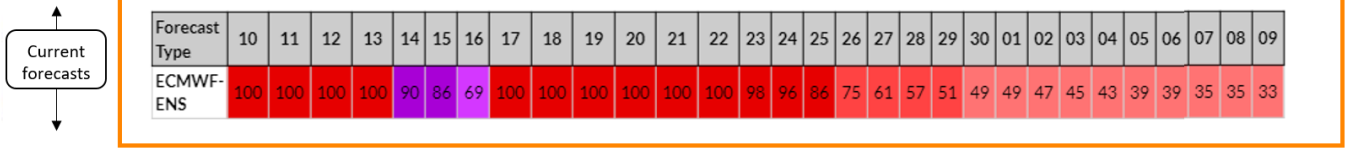


Flood Early Warning: Reporting points layer

GloFAS consistency diagram. Consistency diagrams of the probability of exceeding each of the three return-period thresholds: 2-year (yellow), 5-year (red), and 20-year (purple) severity levels for the most recent seven forecasts (rows), with the current forecast in the top row, for all 30 days of the forecast horizon (columns).
The same colours are used in this table as in the Forecast Overview table and the Flood Summary maps.



Forecast overview. Plot of the highest threshold exceedance (as shown by the colours) for all 30 days of the forecast horizon (columns), with the day of the dates in the first row (the first column is the first forecast day). The plot shows an overview, following the dominant severity (2-, 5- or 20-year) and the probabilities represented by white (no flood) or one of the 9 colours showing expected floods.

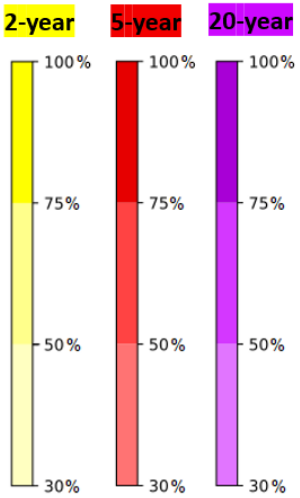


Analysis of onset, severity (return period) as well as uncertainty of the event.

Probabilistic forecast legend

The numbers and the colour intensity show the percentage of ensemble members above a given return period thresholds

The cells with 0-25% probability values are left blank



PERSISTENCY!

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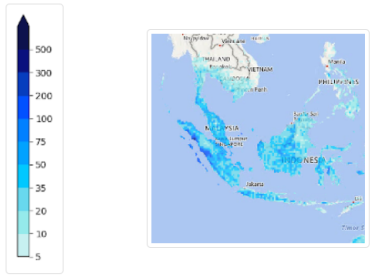
GloFAS products: Supporting layers

Forecast interpretation – Initial conditions

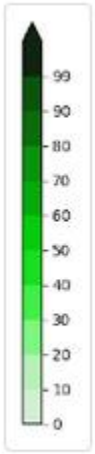
- Precipitation, snowmelt of 3 days preceding the forecast and initial snow cover, soil moisture and 2m temperature
- Absolute values and anomaly maps

Initial 3-day precipitation



Accumulated precipitation (mm) from meteorological forcing input over the 3-day period before the date of the forecast run.

Initial soil moisture

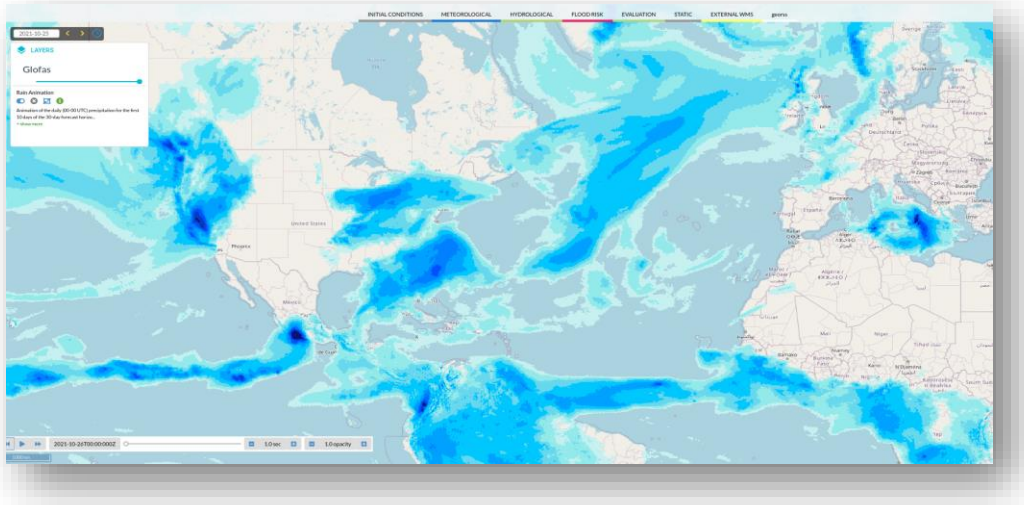


Soil moisture (%) from meteorological forcing input at initial time (00 UTC) on the day of the forecast run.

https://confluence.ecmwf.int/display/COPSRV/GloFAS+products

Forecast interpretation – Meteorological forecast

- 10-day probability precipitation forecast
- Probability [%] of exceeding 50/150/300 mm of accumulated precipitation over the first 10 days of the 30-day forecast horizon in the ECMWF ensemble forecast.
- Amount of accumulated precipitation over the first 10 days of the 30-day forecast horizon, computed as the mean of the ECMWF ensemble forecast.
- Animated daily precipitation maps of next 10 days ensemble mean forecast to follow meteorological system evolution



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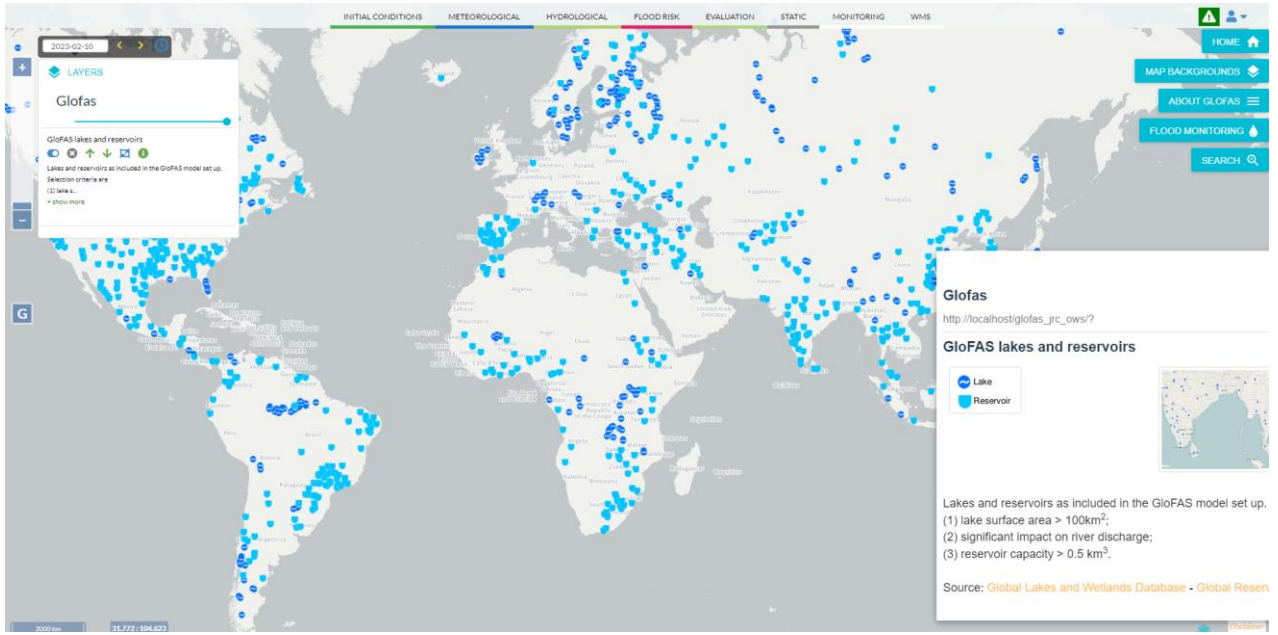
Forecast interpretation – Static layers

- Lakes (463) and reservoirs (667) as included in the GloFAS model set up. Selection criteria are:
  (1) lake surface area > 100km^2;
  (2) significant impact on river discharge;
  (3) reservoir capacity > 0.5 km^3.
- Hydrological model network



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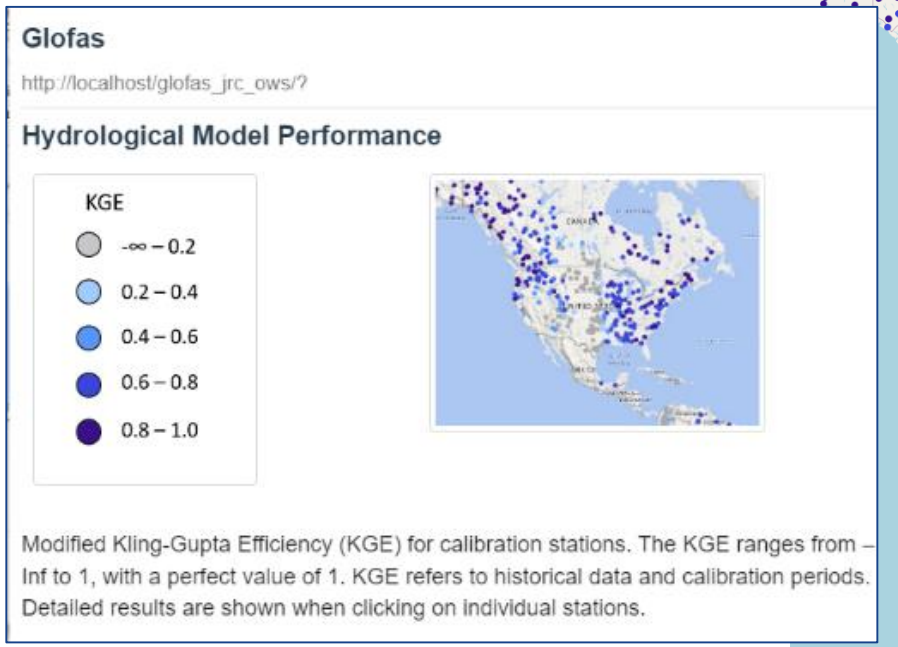
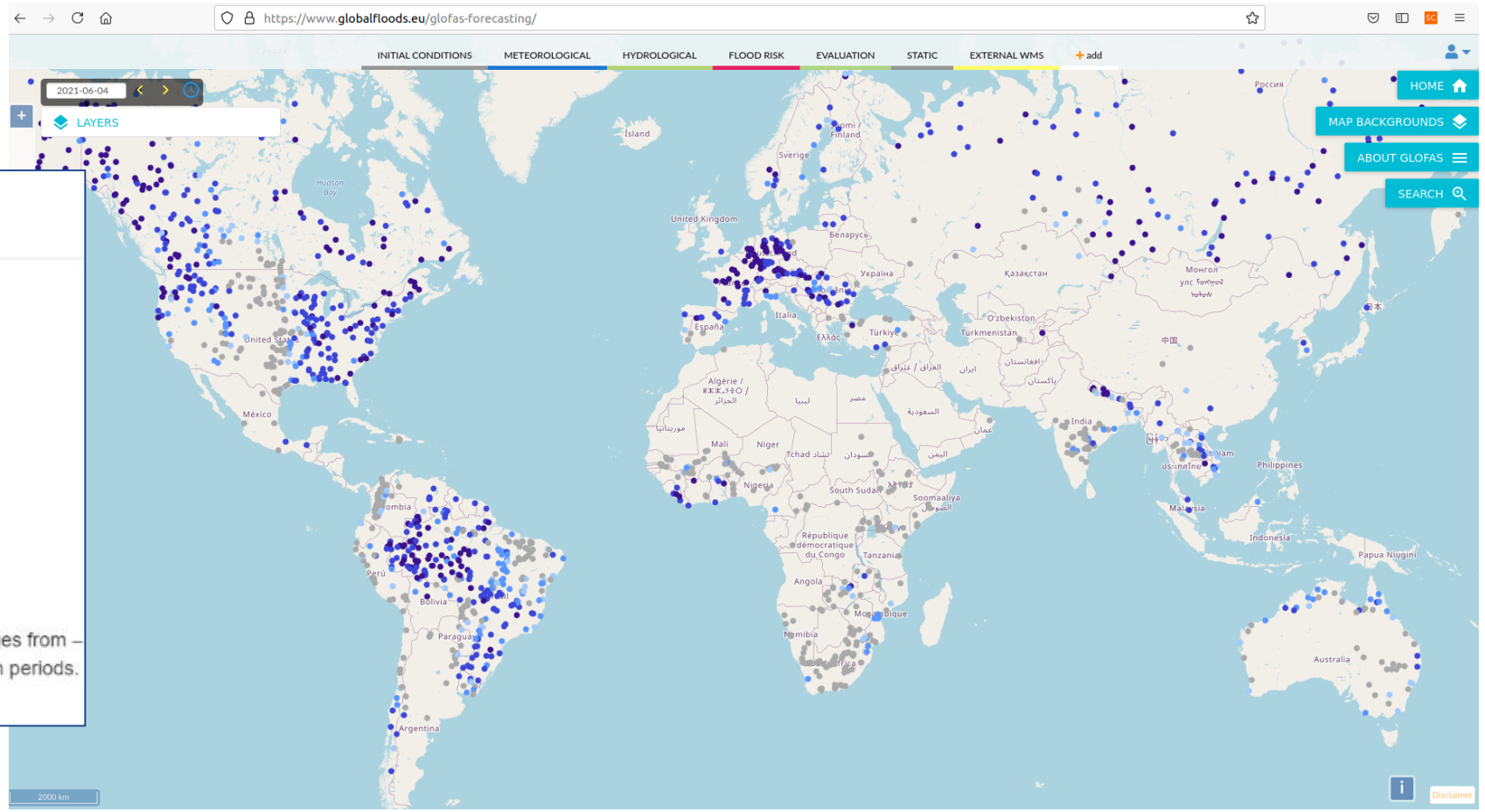
Forecast interpretation – Hydrological performance

General goodness of fit of the hydrological model for the region of interest.





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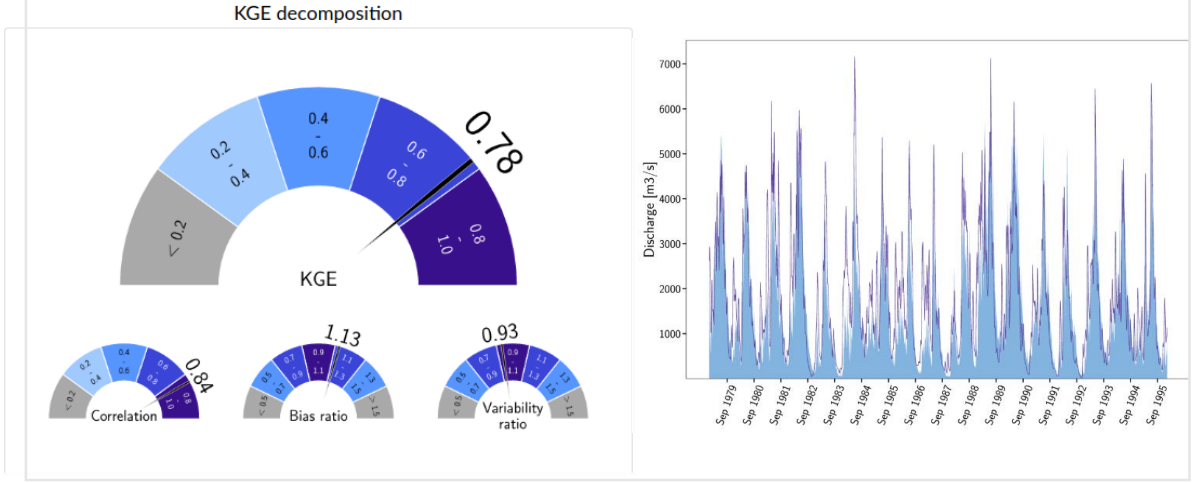
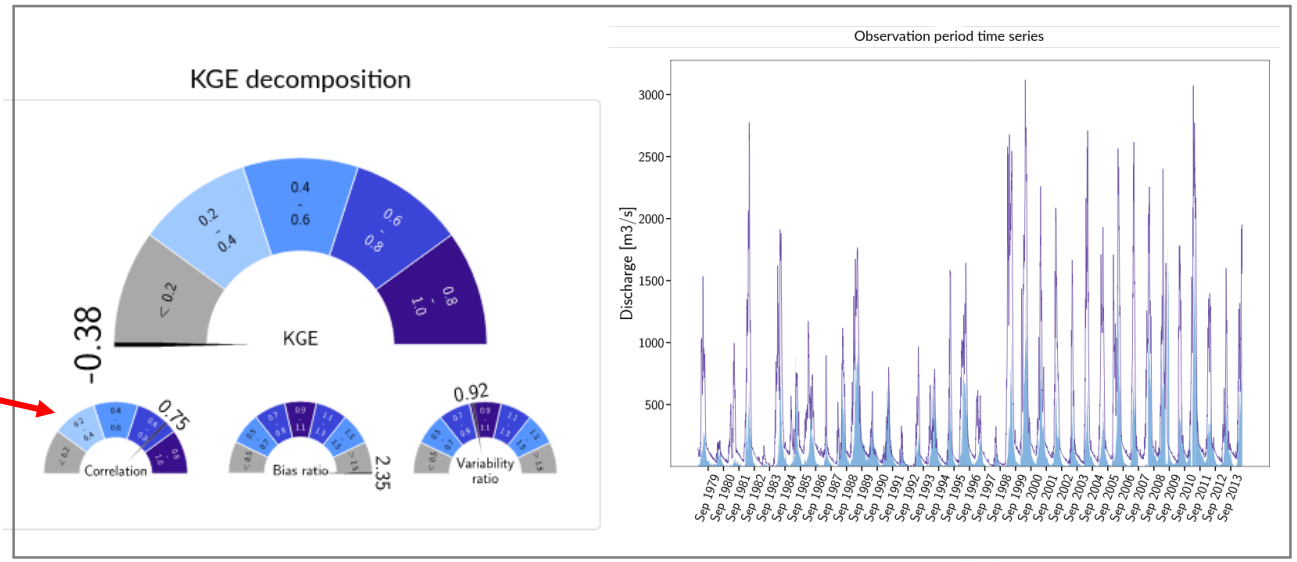
Forecast interpretation – Hydrological performance

Calibrated	KGE	Correlation	Bias	Spread	NSE
Yes	0.78	0.84	1.13	0.93	0.63





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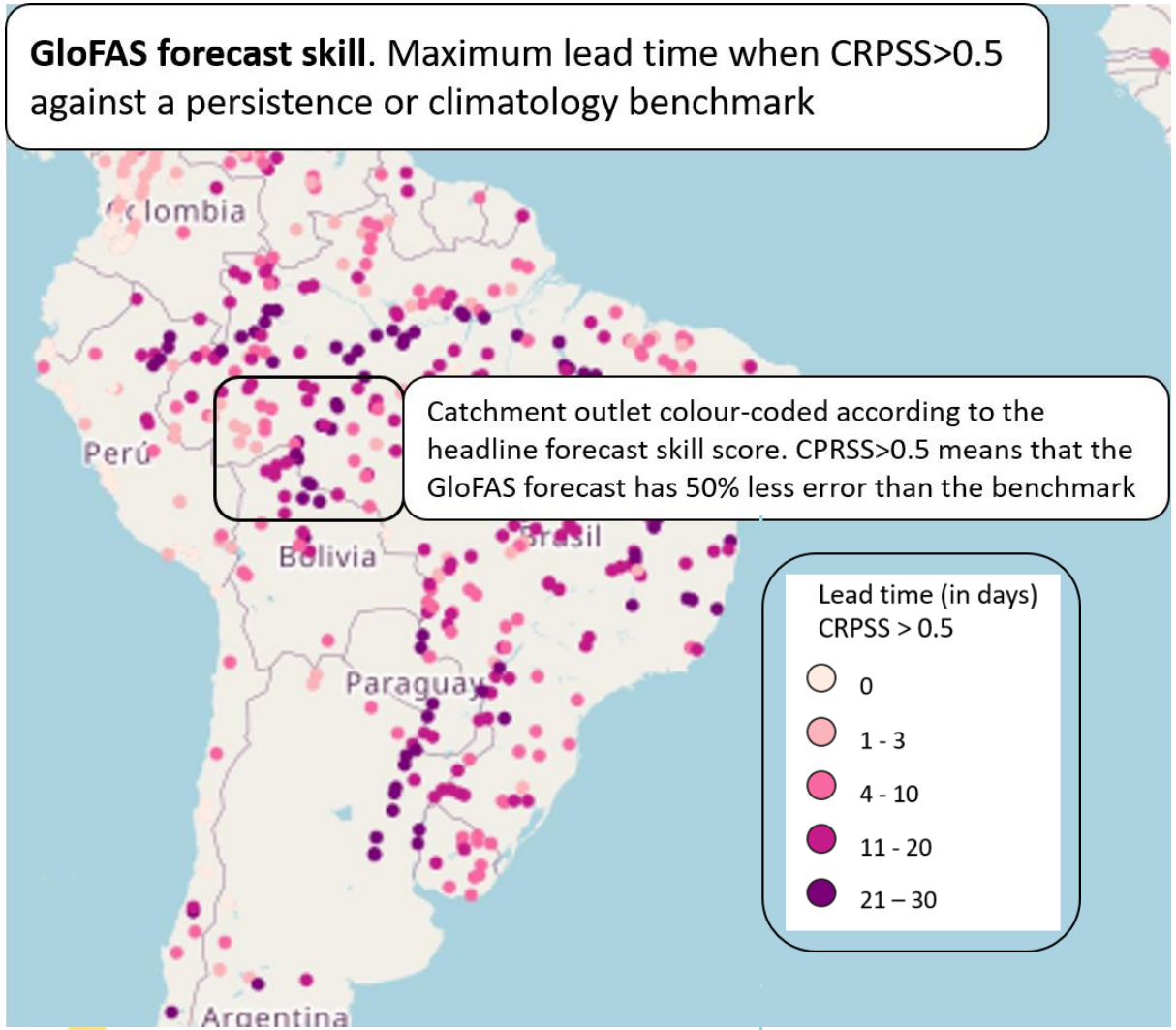
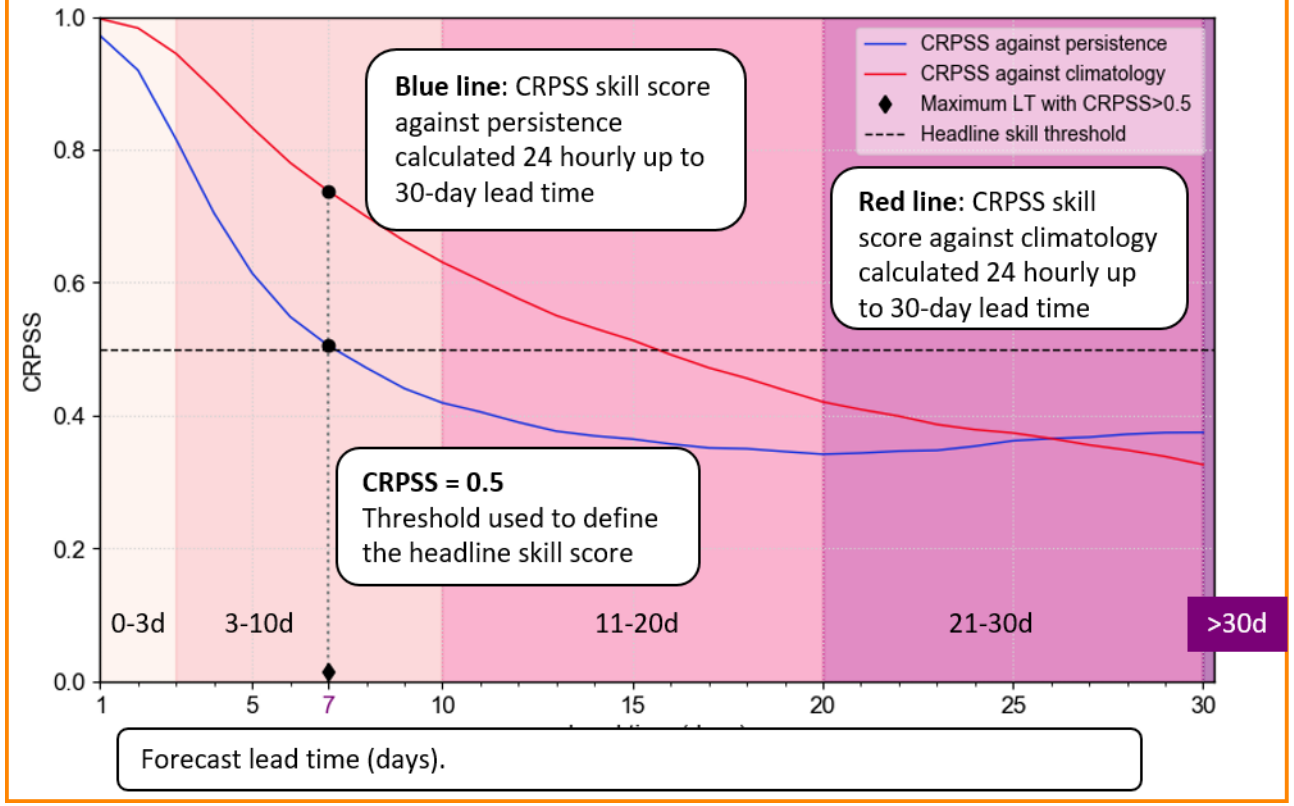
Forecast interpretation – Forecast skill

GloFAS forecast skill. Maximum lead time when CRPSS>0.5 against a persistence or climatology benchmark



GloFAS forecast skill. Time series plot of CRPSS as a function of the forecast lead time. CRPSS is calculated against persistence and climatology benchmarks



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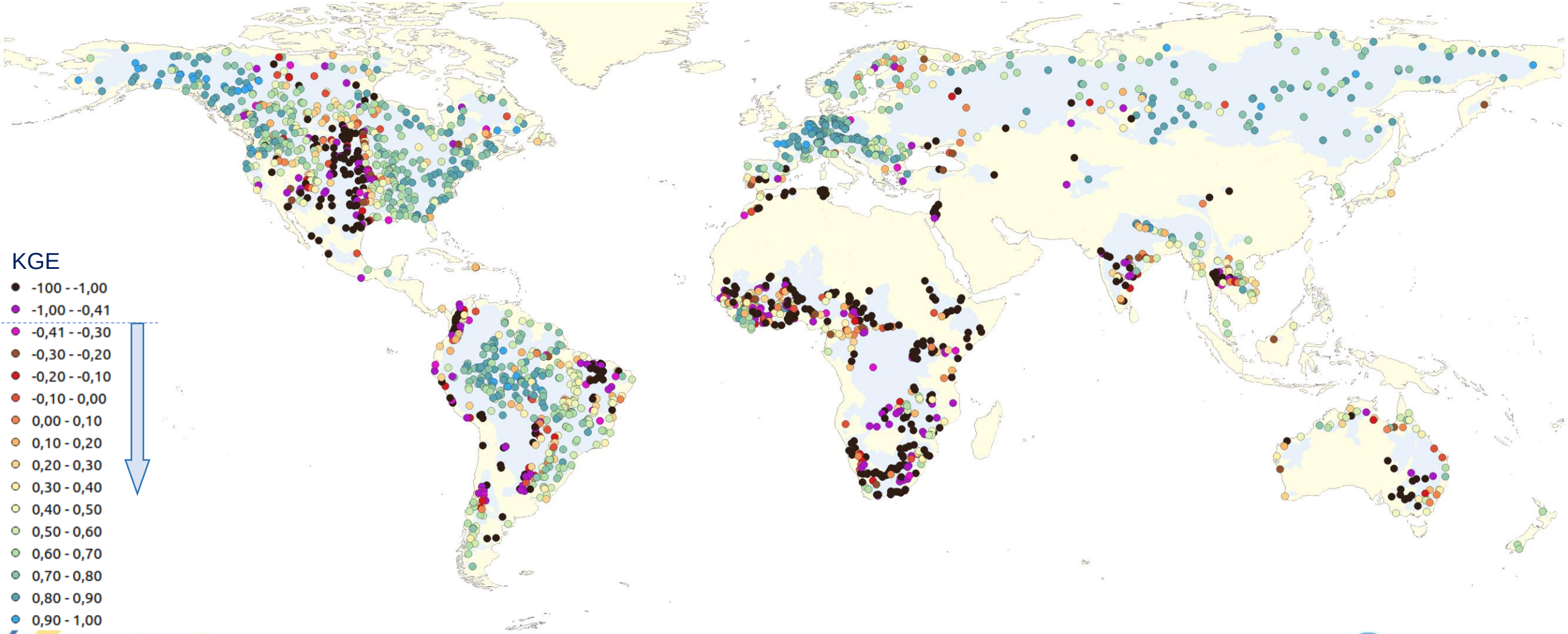
GloFAS next release (late 2023)

GloFAS “now” – Hydrological performance

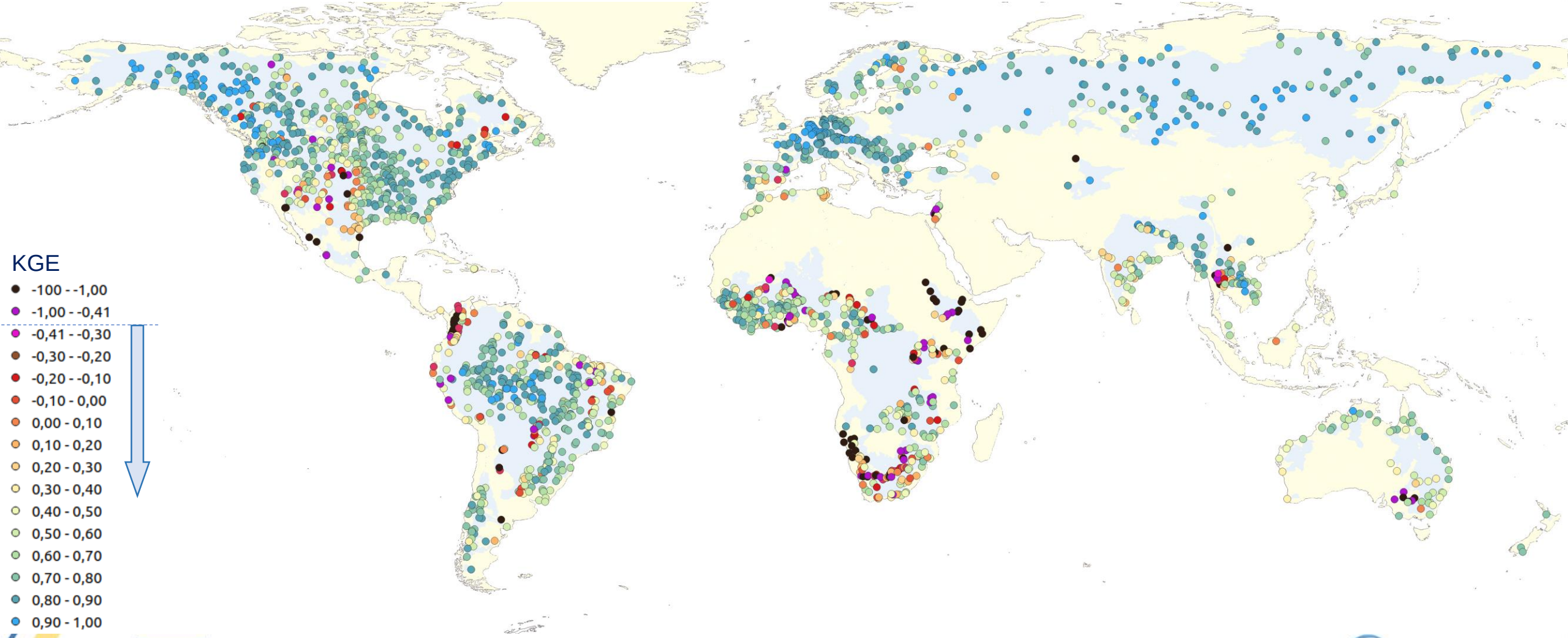
GloFAS 3.2: KGE = index to evaluate the accuracy of the model, optimum 1. Figure: all the available observations.



Calibration of GloFAS 3.2: Alfieri et al., 2020,
https://www.sciencedirect.com/science/article/pii/S2589915519300331?via%3Dihub

GloFAS next release – Hydrological performance

GloFAS NEXT: KGE = index to evaluate the accuracy of the model, optimum 1. Figure: all the available observations.



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