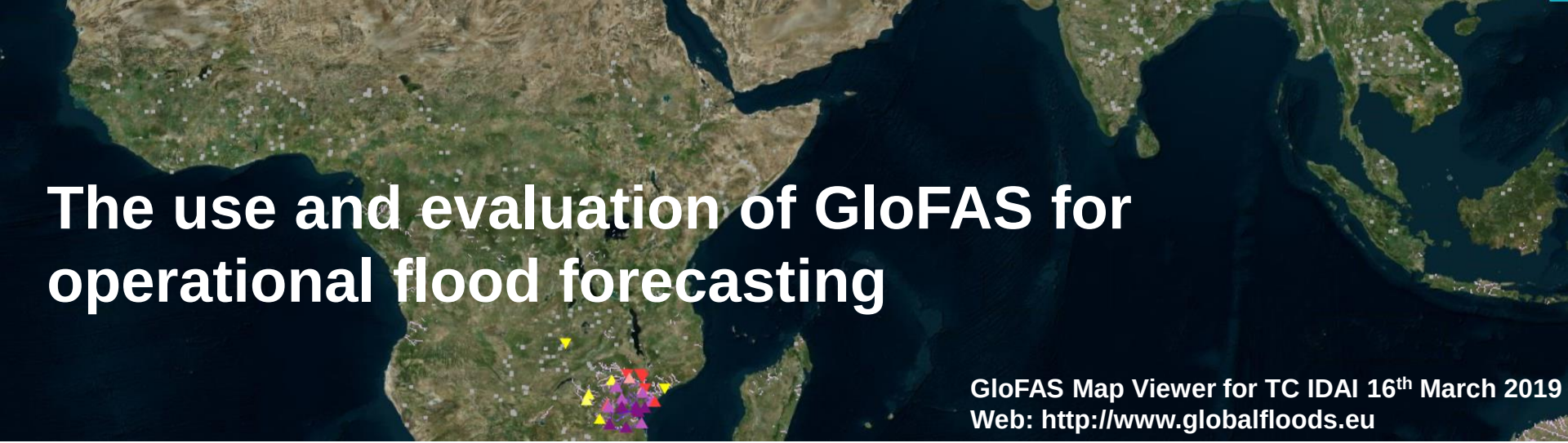


The use and evaluation of GloFAS for operational flood forecasting

Shaun Harrigan, Ervin Zsoter, Lorenzo Alfieri, Christel Prudhomme, Hannah Cloke, Peter Salamon, Elisabeth Stephens, and Florian Pappenberger

GLOFAS
Global Flood Awareness System

GFP Annual Meeting, Guangzhou, China
11th – 13th June 2019

ECMWF
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

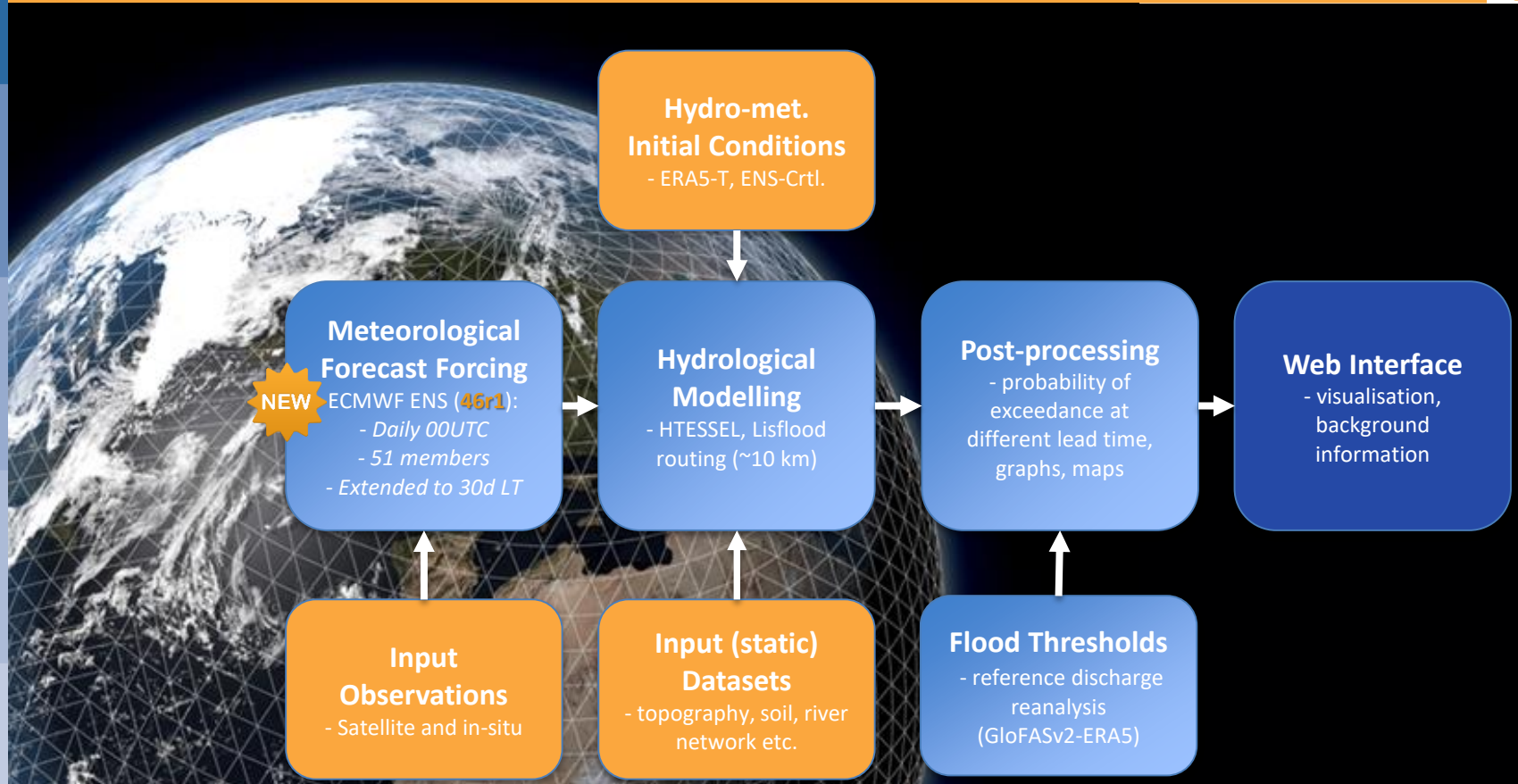
European Commission

opernicus
The European Earth Observation Programme

Emergency Management

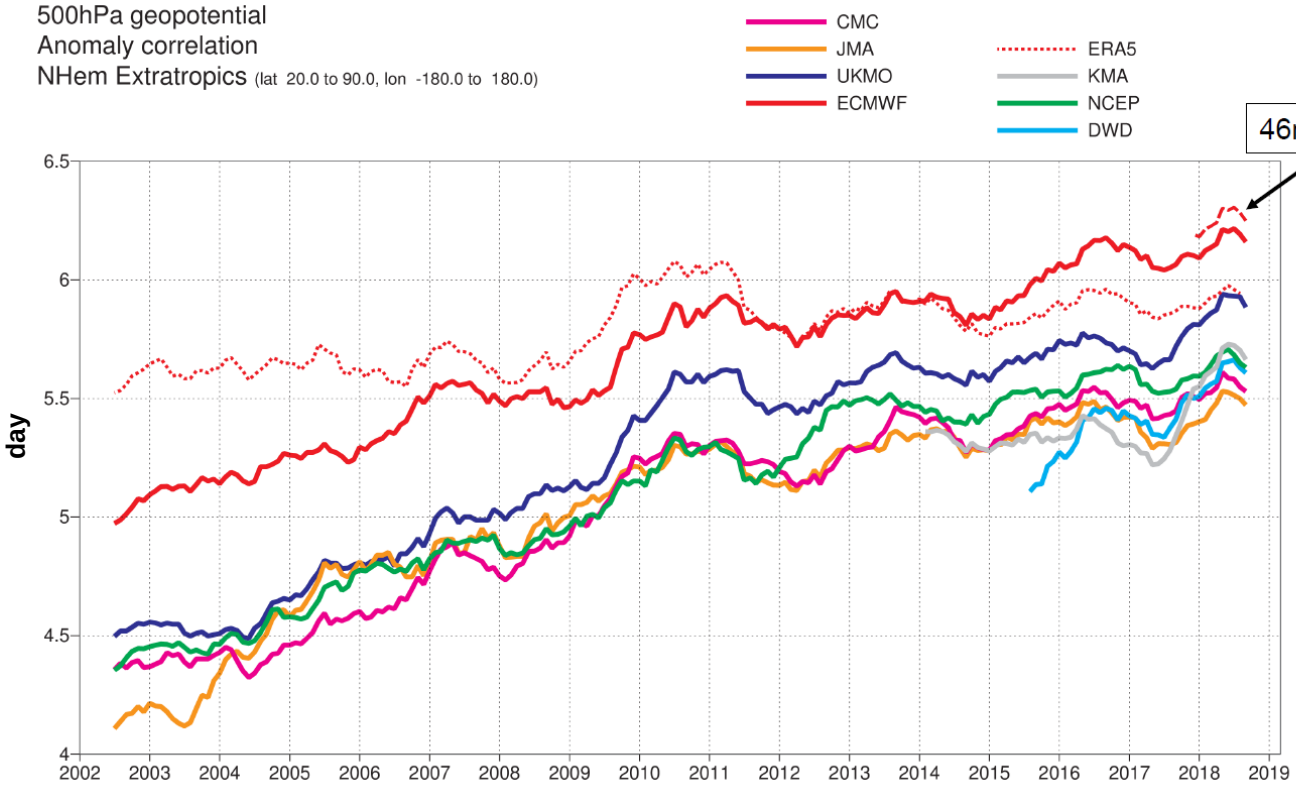
University of Reading

GloFAS operational chain (supported 24/7 since April 2018)



New meteorological model cycle (46r1) operational today!

Anomaly correlation of 500 hPa Geopotential reaching 85%



- Major data assimilation upgrade
- Many new products available (e.g. EFI Water Vapour Flux)
- Watch webinars here:

Scan me

GloFAS upgraded to v2 on 14 November 2018

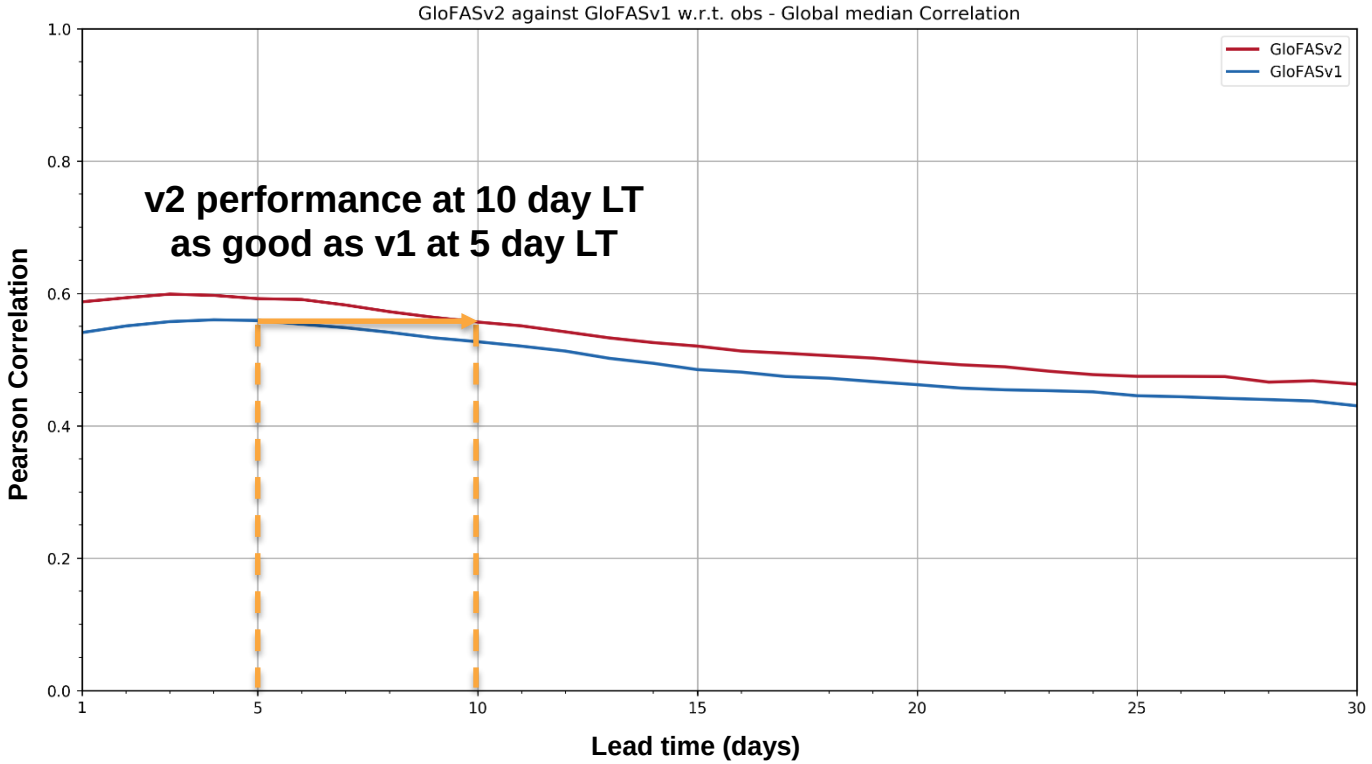
- **A.) Scientific developments:**
  - **1.)** Global calibration of Lisflood routing & GW (Hirpa et al., 2018, JoH)
  - **2.)** GloFASv2-ERA5 discharge reanalysis (1981 to NRT)
  - **3.)** Improved initialisation of real-time forecasts (ERA5-T, 2-5 day latency)

- **B.) User enhancements:**
  - **1.)** Version numbering system
  - **2.)** Availability of datasets (reforecasts and reanalysis) ahead of launch date
  - **3.)** More comprehensive documentation (see: http://www.globalfloods.eu/)

GloFASv2 Evaluation Datasets

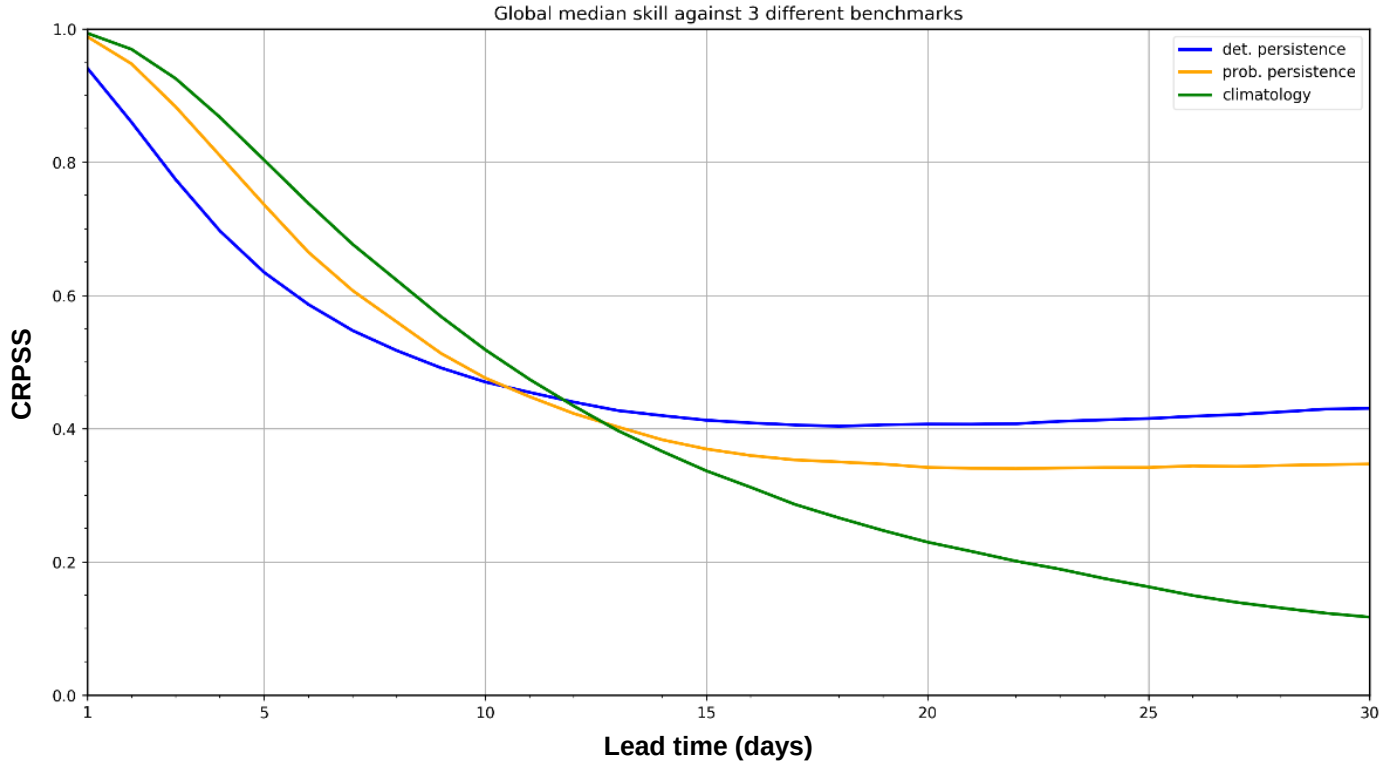
Datasets	GloFASv2	GloFASv1
Reforecasts (ECMWF IFS 43r1/43r3)	- 1997-2016 - Initialised 2 per wk. from ERA5 - 11 ens. members - Global 0.1° grid - **Calibrated**	- 1997-2016 - Initialised 2 per wk. from ERA-Interim/L - 11 ens. members - Global 0.1° grid - **Not calibrated**
Discharge reanalysis	GloFASv2-ERA5 (1981-2017)	Not used
Discharge observations	Yes	Yes

Forecast performance GloFAS v2 versus v1, w.r.t. obs.



Correlation(ensMean, obs.)
0=None; 1=Perfect

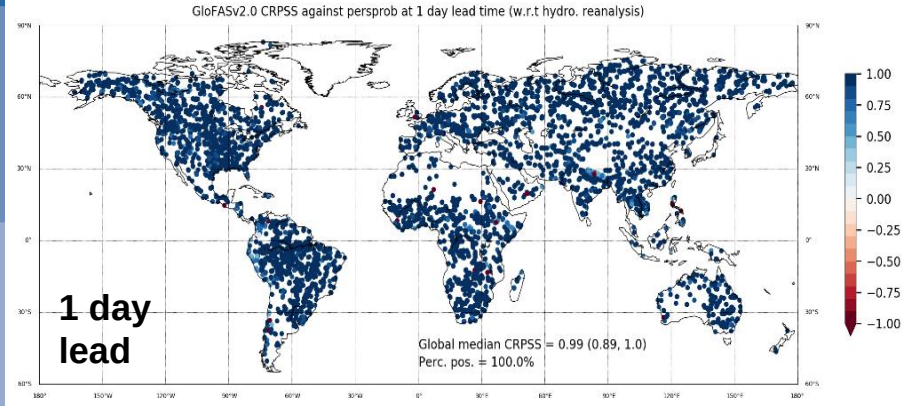
Overall ensemble forecast skill of GloFASv2

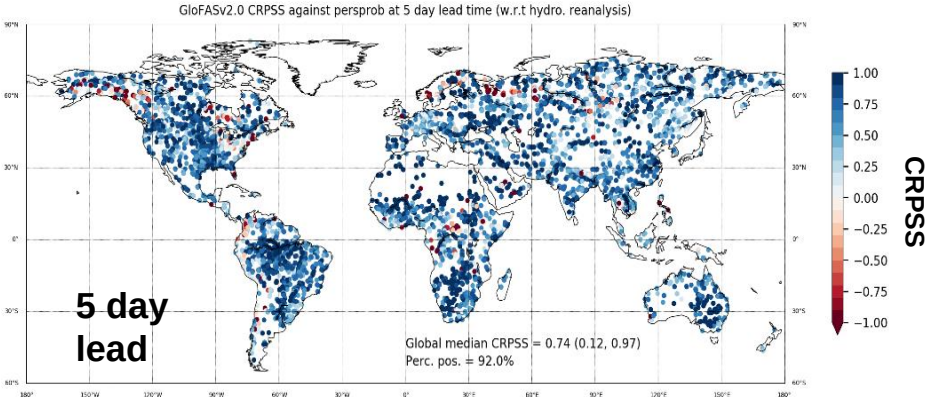


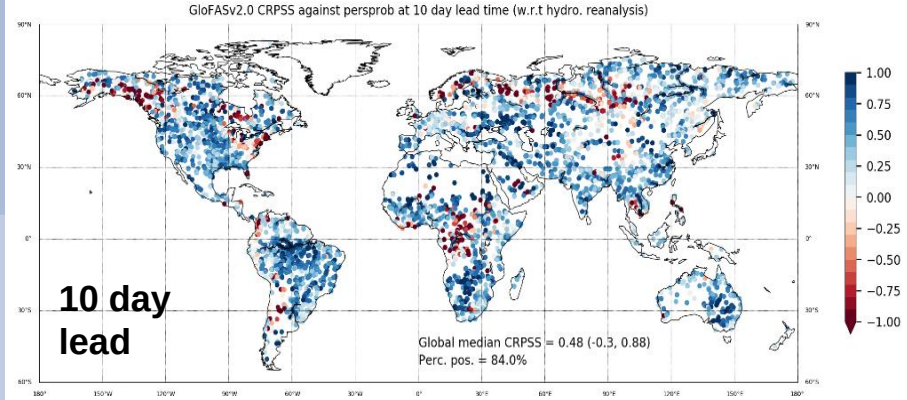
CRPSS = 1 – ($\overline{crps_fc}$)/($\overline{crps_bench}$)
(w.r.t. Reanalysis)
0=No Skill; 1=Perfect skill

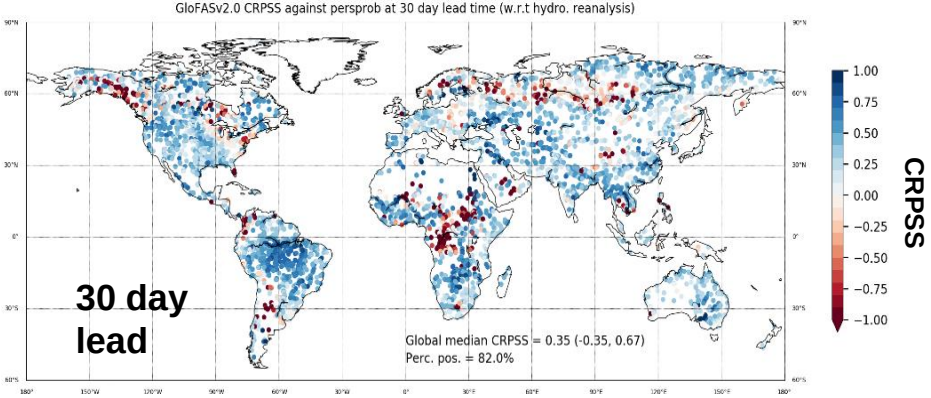
… spatial distribution of skill

CRPSS = 1 – $(\overline{crps_fc})/\overline{crps_persprob}$)
(w.r.t. Reanalysis)
0=No Skill; 1=Perfect skill



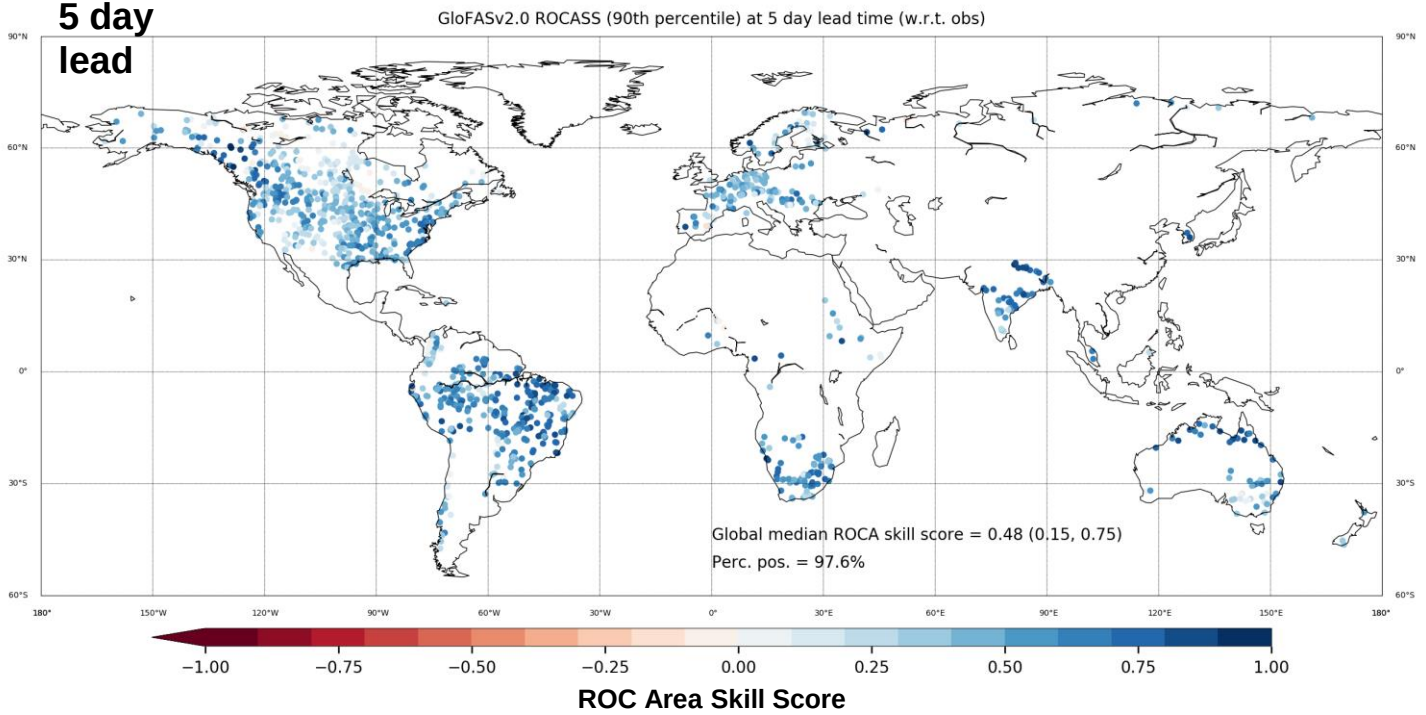




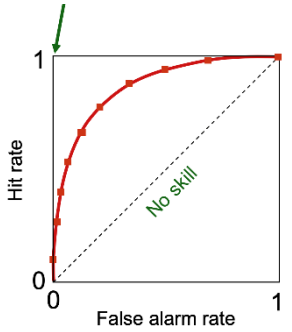


Ensemble skill for high flow events (Q10 threshold)

5 day lead



Perfect discrimination

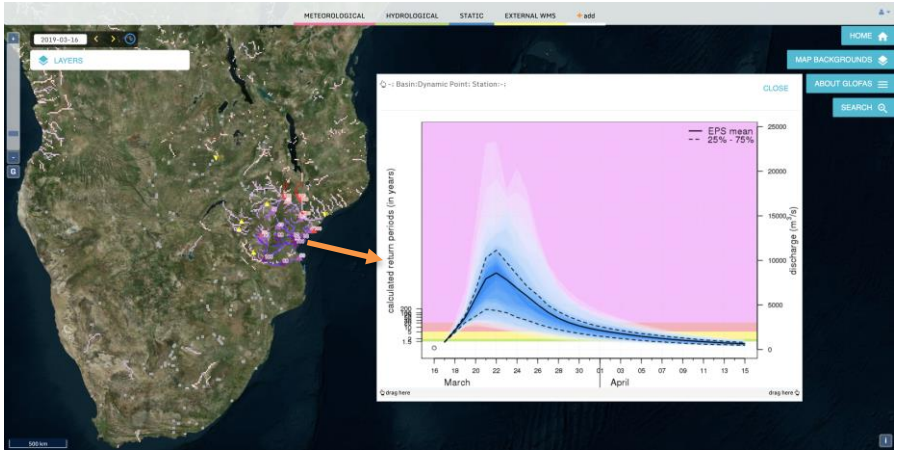


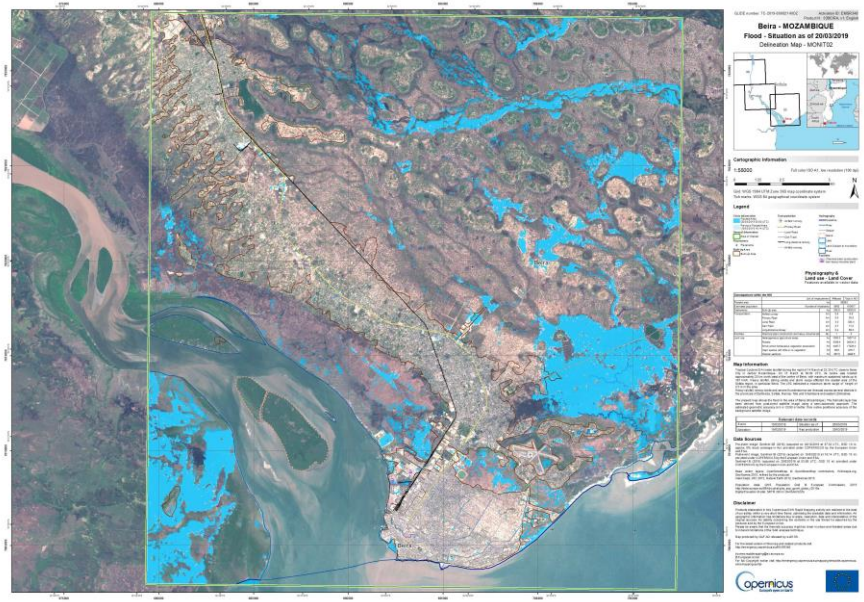
ROCSS = 2×ROCA–1
(w.r.t. obs.)
0=No Skill; 1=Perfect skill

CEMS in action during Malawi & Mozambique floods

Flood Forecast from GloFAS

CEMS Rapping Mapping





Copernicus
Europe's eyes on Earth

Using GloFAS forecasts to aid decision makers

- DfID (UK) requested emergency reports to aid response to TC Idai humanitarian disaster
- ECMWF, Uni. Reading, Uni. Bristol
- TC Idai (7 reports between 21st and 1st April):
- TC Kenneth (5 reports between 24th April and 3rd May)

GloFAS Emergency report

Flooding hazard briefing: Mozambique, Zimbabwe and Malawi

Details

Event start: 15 March 2019
Daily report finalized: 21 March 2019, 19:00 UTC

Briefing summary and background

Heavy rain and extreme floods are affecting several African
Malawi and Madagascar, since the beginning of March, causin
of fatalities is dramatically increasing, following the passage
central Mozambique, close to Beira city, on 14 March evening
of these flooding events (Tropical cyclone, heavy rainfall and s
days and are predicted to generally decrease. Thunderstorms
northern parts of Mozambique and Malawi at present. Over th
occur along the coast between Beira and Nampula, but they a

Flood hazard and risk Emergency report - Mozambique and Malawi

Event start: 15 March 2019 (Cyclone Idai, central Mozambique)

Report date (first issue): 21 March 2019, 19:00 UTC
Update #5: 1 April 2019, 12:00 UTC

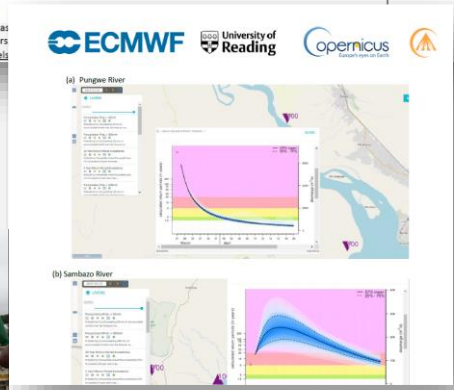
Key points

Meteorological forecast

- Precipitation forecasts (ECMWF) have been updated on 1 April and no significant rainfall event is expected over the affected areas in Mozambique and Malawi over the current week; more rainfall is predicted for northern/central Malawi but is not expected to impact significantly on flooding risk.

Flood forecast

- GloFAS forecas
for most rivers
- As water levels


(a) Pungwe River

(b) Sambazo River

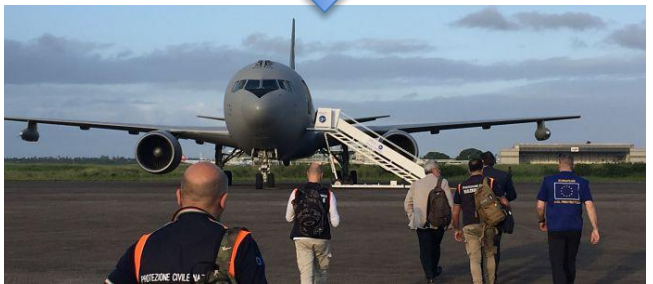
Global flood forecast guidance & impact going operational!

ARISTOTLE ENHSP

Aristotle multi-hazard activation

European Civil Protection

Likelihood of impact				
	High	monitor	prepare	act
	Medium	nil	monitor	prepare X
	Low	nil	nil	monitor
Required Resources		Sub-national	National	Inter-national



INGV INFP IPMA SMHI csem emsc GFZ Helmholtz Centre Potsdam cima Research Foundation METEO FRANCE KANDILLI ZAMG

ILMATIETEEN LAITOS METEOROLOGISKA INSTITUTET FINNISH METEOROLOGICAL INSTITUTE

Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Milieu

ECMWF

UK Research and Innovation

Met Office

Summary

GloFAS Map Viewer: http://www.globalfloods.eu/

1.) GloFASv2 operational since 14 November 2018 (Datasets freely available 😀)

2.) GloFASv2 more skilful than v1 in majority of catchments (extend lead time)

3.) GloFASv2 ensemble forecast evaluation, skilful against persistence + climatology

4.) GloFASv2 skilful during high flow events

5.) Flood forecast guidance & impact going operational at the global scale

6.) The road towards GloFAS 3.0 – Lorenzo Alfieri's talk tomorrow!

Questions?

Shaun Harrigan
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1000 km

GLOFAS
Global Flood Awareness System

ECMWF
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

European Commission

opernicus
The European Earth Observation Programme

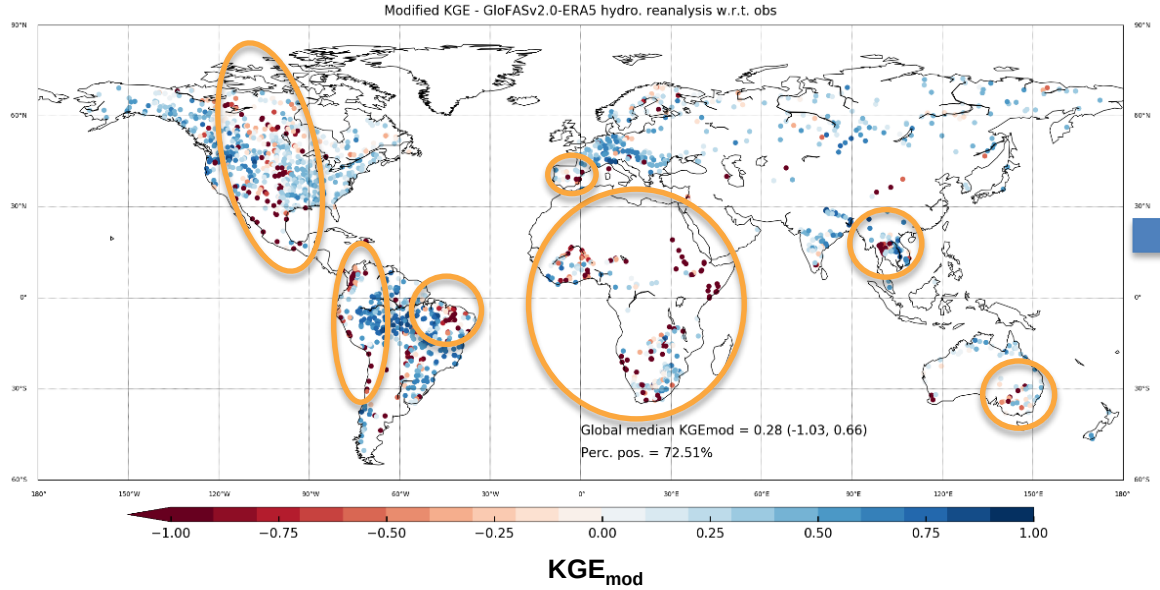
Emergency Management

University of Reading

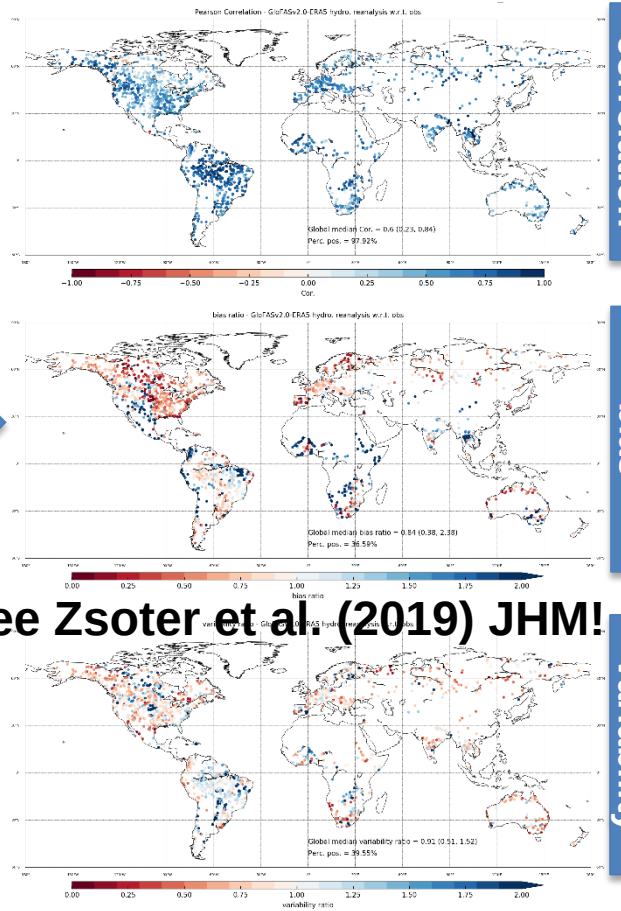
Extra slides…

Performance of GloFASv2-ERA5 discharge reanalysis

Hydrological performance with KGE_{mod}
(Gupta et al., 2009; Kling et al., 2012)



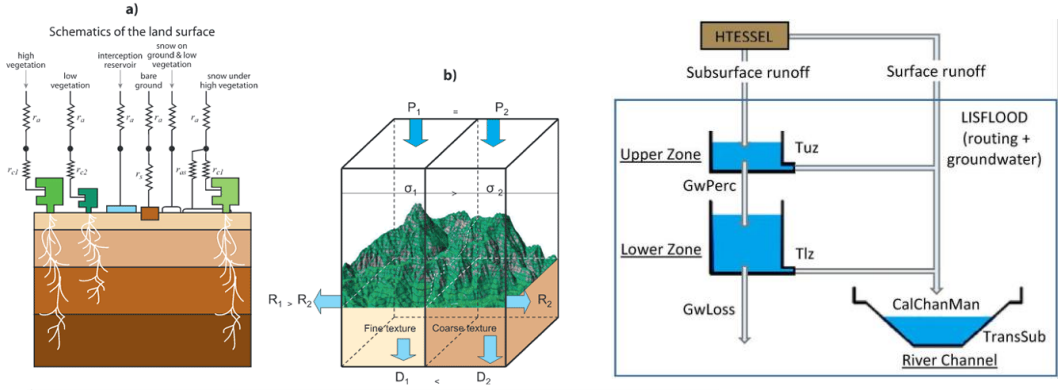
KGE_{mod}(sim., obs.)
0=No Skill; 1=Perfect skill

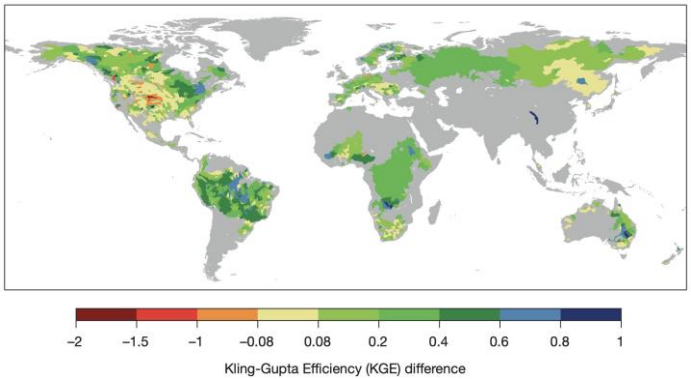


See Zsoter et al. (2019) JHM!

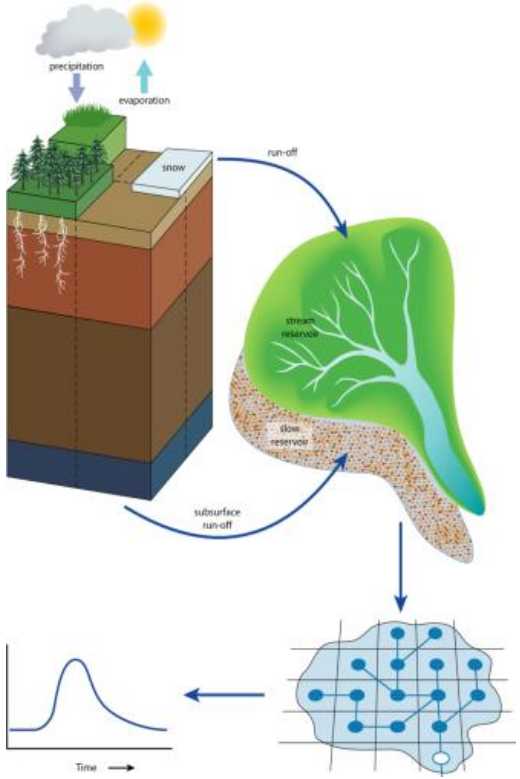
GloFAS Hydrological Model – HTESSEL + LISFLOOD routing

- Runoff from 18-km **H-TESSEL**
- 10-km resolution routing module
- Calibrated at ~1300 locations using KGE





Improvement KGE GloFAS v2 compared with GloFAS v1 (Hirpa et al., 2018, Journal of Hydrology)



Q3: GloFASv2 Evaluation: Best benchmark to use?

European Commission

Tougher to beat

Journal of Hydrology 522 (2015) 697–713

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

rps_fc)/crps_bench)
Reanalysis)
; 1=Perfect skill

How do I know if my forecasts are better? Using benchmarks in hydrological ensemble prediction

F. Pappenberger [a,f,g,*], M.H. Ramos [b], H.L. Cloke [d,e], F. Wetterhall [a], L. Alfieri [a,c], K. Bogner [a], A. Mueller [a,d], P. Salamon [c]

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1 da
lead

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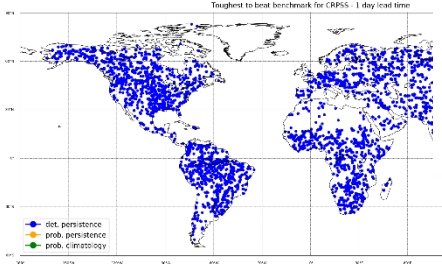
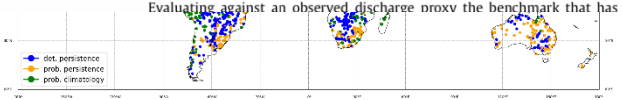
Evaluation

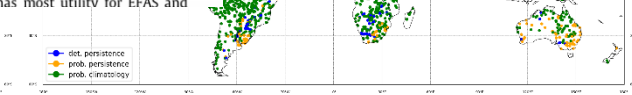
SUMMARY

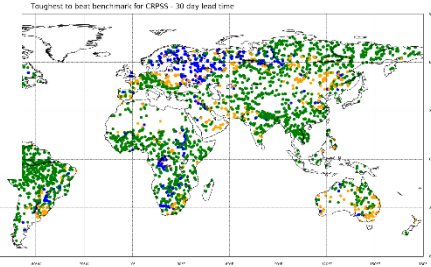
The skill of a forecast can be assessed by comparing the relative proximity of both the forecast and a *benchmark* to the observations. Example benchmarks include climatology or a naïve forecast. Hydrological ensemble prediction systems (HEPS) are currently transforming the hydrological forecasting environment but in this new field there is little information to guide researchers and operational forecasters on how benchmarks can be best used to evaluate their probabilistic forecasts. In this study, it is identified that the forecast skill calculated can vary depending on the benchmark selected and that the selection of a benchmark for determining forecasting system skill is sensitive to a number of hydrological and system factors. A benchmark intercomparison experiment is then undertaken using the continuous ranked probability score (CRPS), a reference forecasting system and a suite of 23 different methods to derive benchmarks. The benchmarks are assessed within the operational set-up of the European Flood Awareness System (EFAS) to determine those that are 'toughest to beat' and so give the most robust discrimination of forecast skill, particularly for the spatial average fields that EFAS relies upon.

Evaluating against an observed discharge proxy the benchmark that has most utility for EFAS and

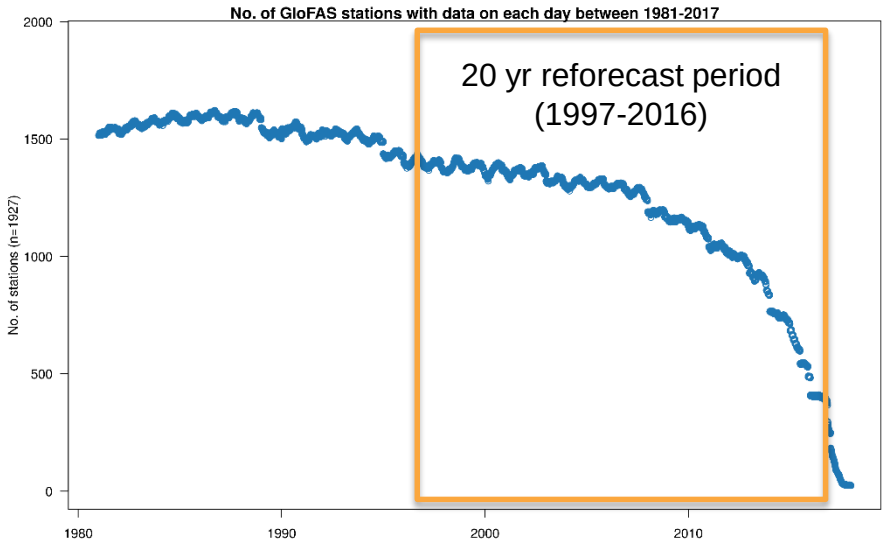


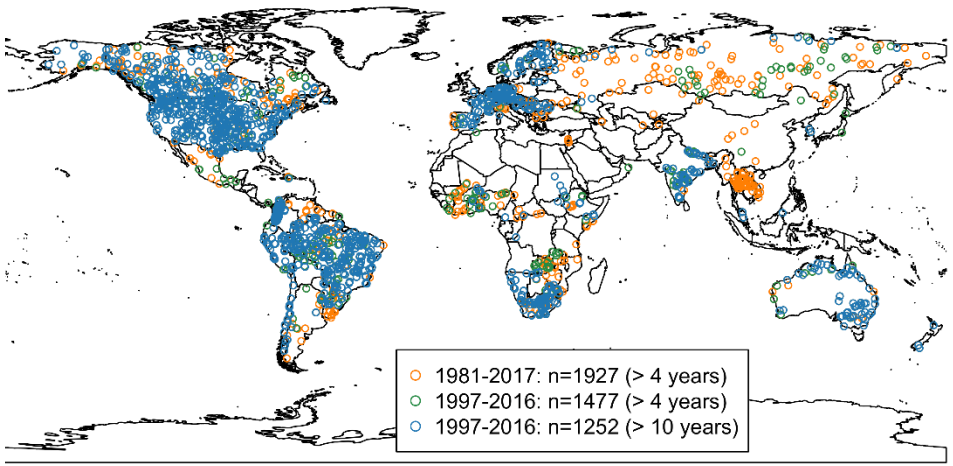






GloFAS discharge observations network



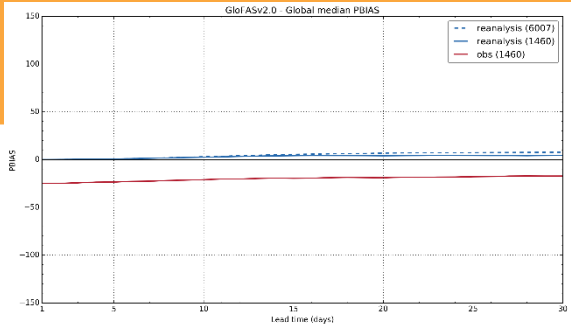


Observations maintained by Joint Research Centre (JRC) [2041 stations with at least 1 data entry]
Sources include: GRDC, National Hydro. Met. Services, GloFAS partners]

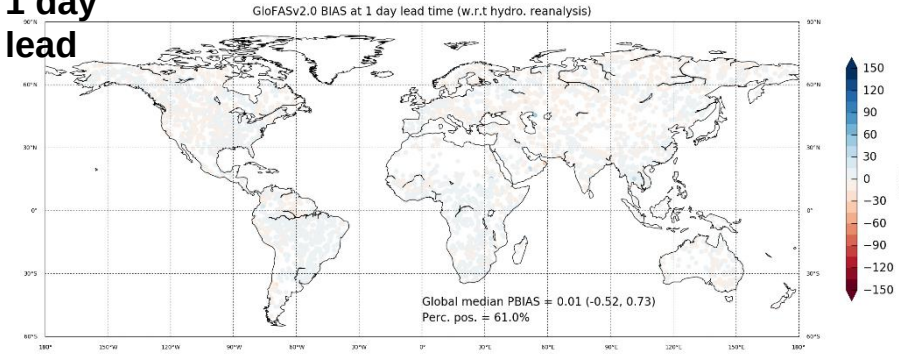
ECMWF

Copernicus
Europe's eyes on Earth

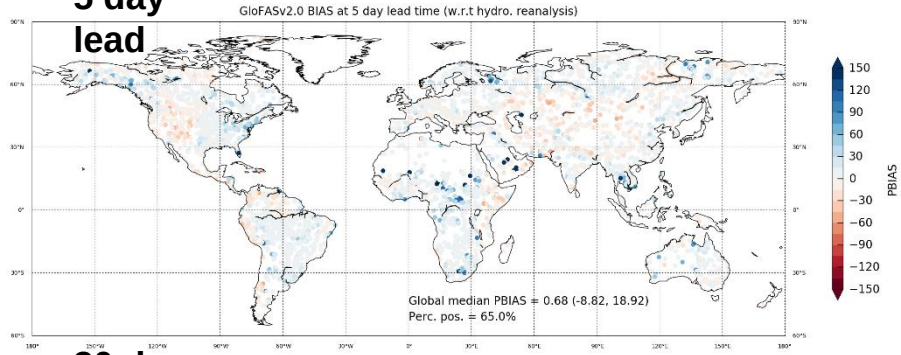
Forecast Bias (reanalysis)



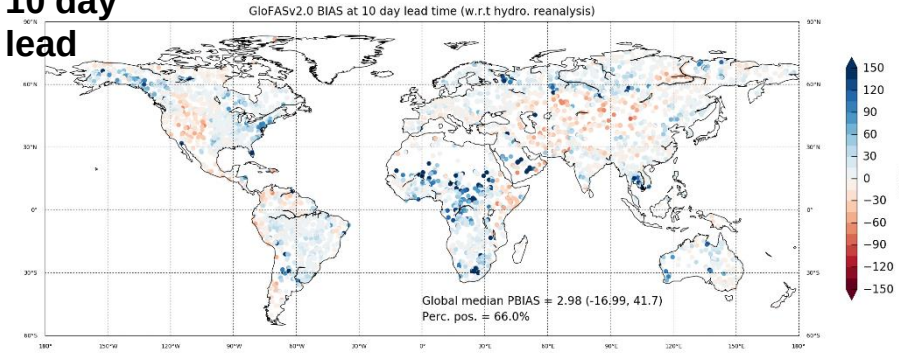
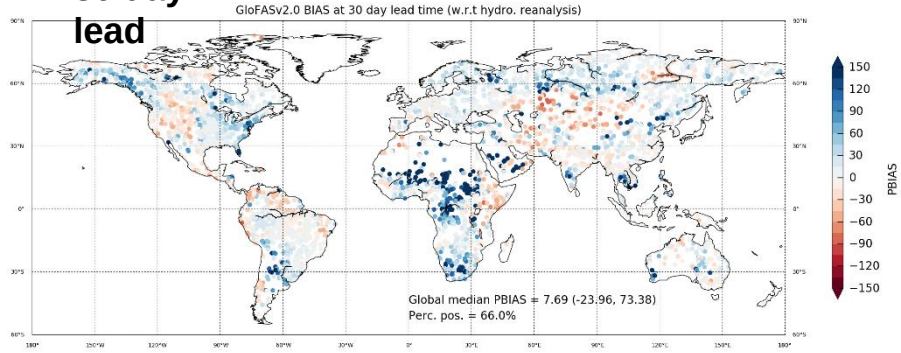
1 day lead



5 day lead



10 day lead



30 day lead