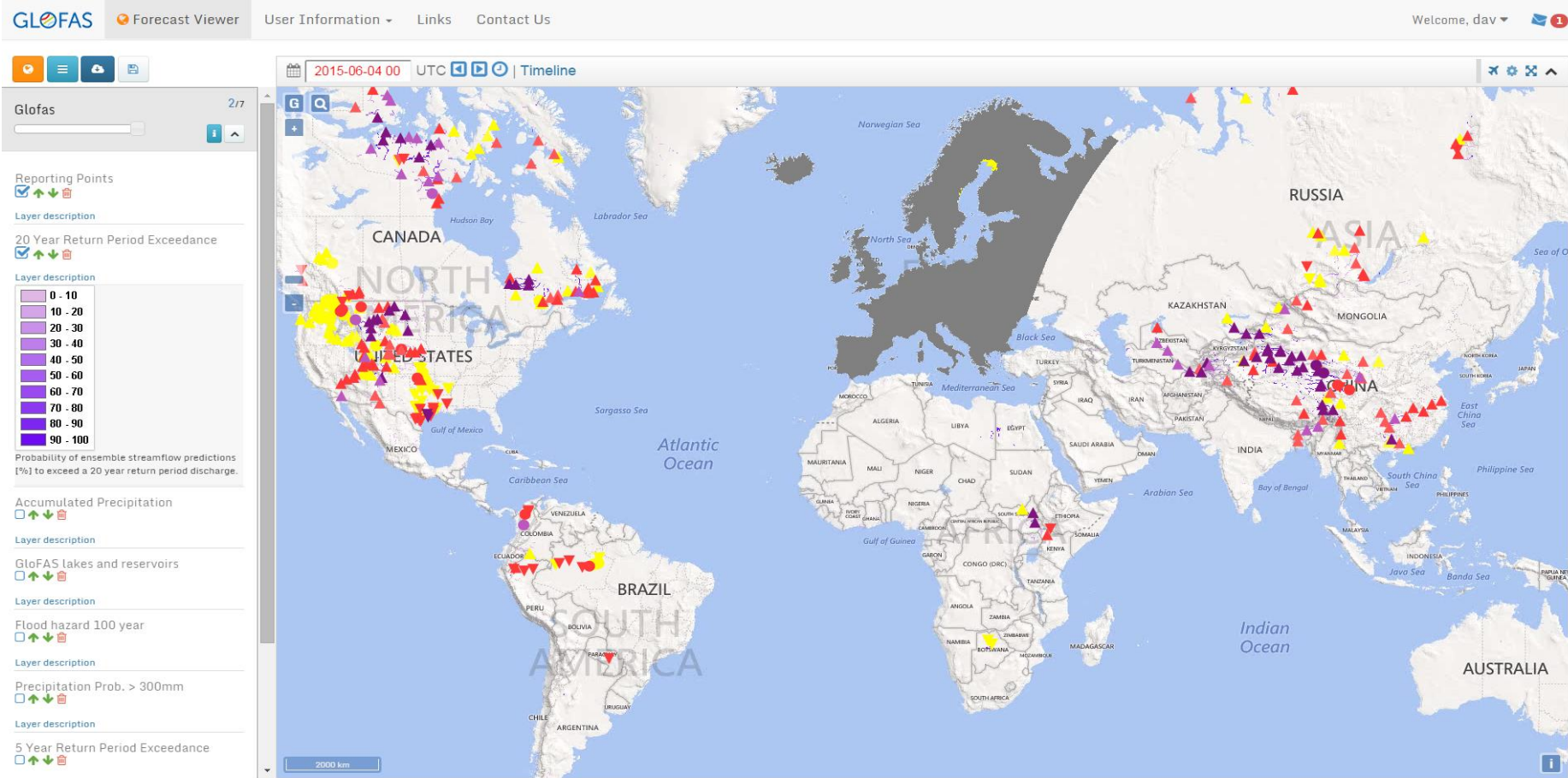


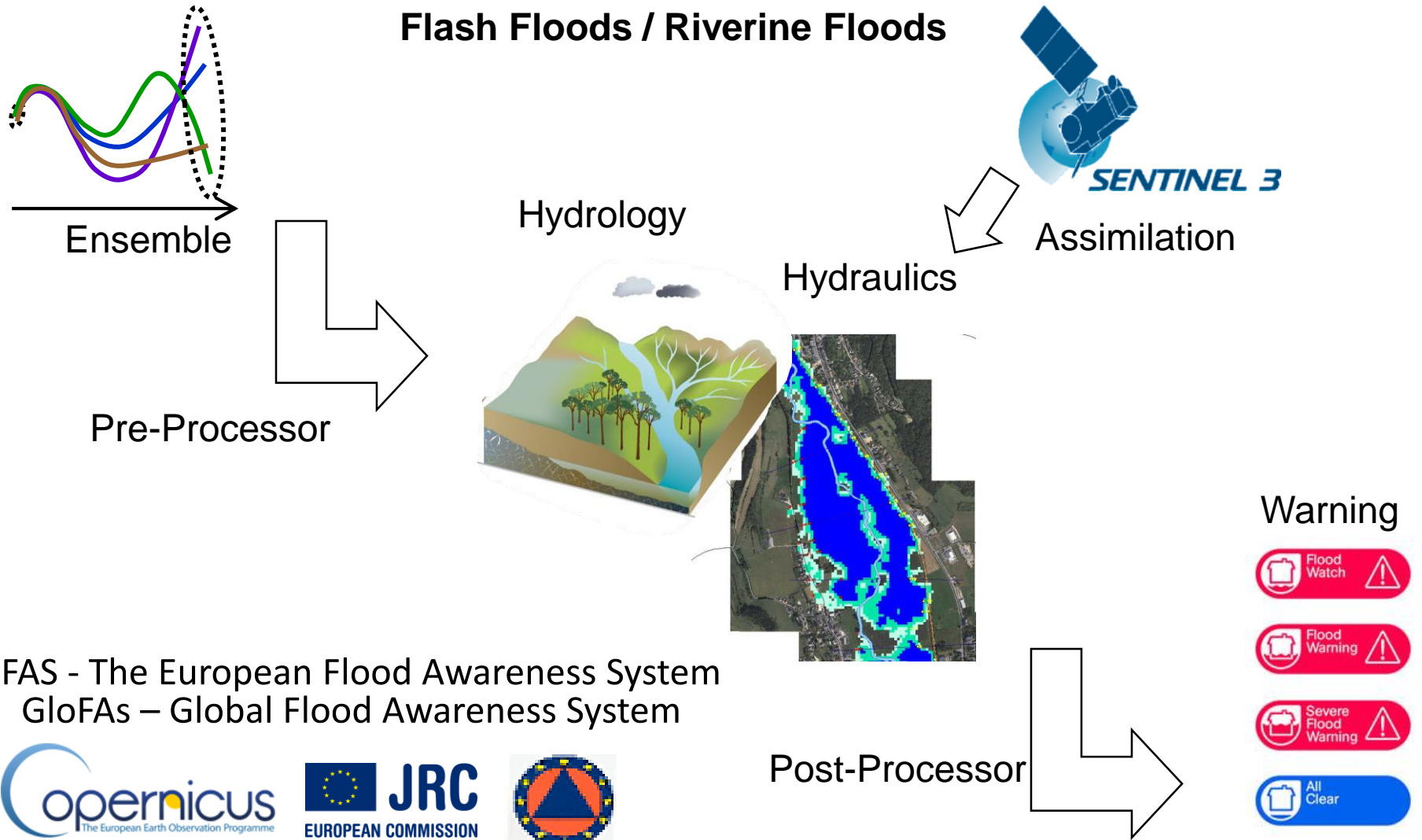
David Muraro, Gabriele Mantovani and *Florian Pappenberger*

www.globalfloods.eu



Forecasting chain using Ensemble Numerical Weather Predictions

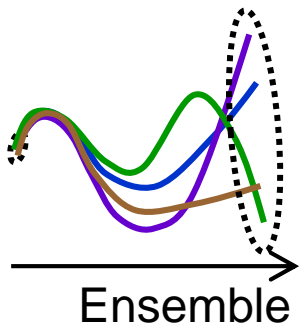
Flash Floods / Riverine Floods



EFAS - The European Flood Awareness System
GloFAs – Global Flood Awareness System



Forecasting chain using Ensemble Numerical Weather Predictions



Flash Floods / Riverine Floods

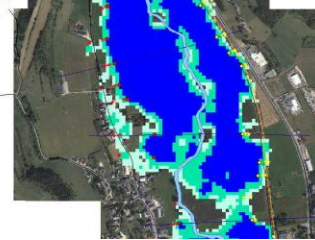


Assimilation

Hydrology

Hydraulics

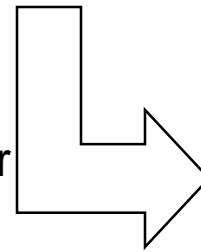
Pr **232 Forecasts a day**



Warning



Post-Processor



EFAS - The European Flood Awareness System
GloFAs – Global Flood Awareness System



Objectives of Global Flood Awareness System

Novel products for international aid

- Early flood warning information for preparation of aid assistance in the case of major floods
- Worldwide comparable information



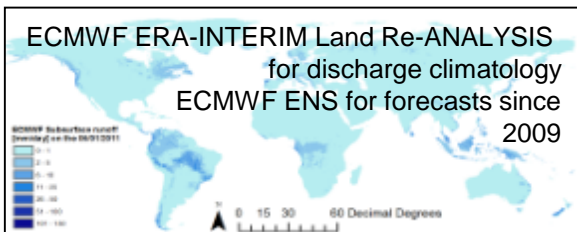
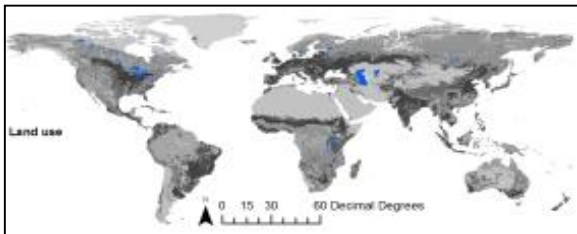
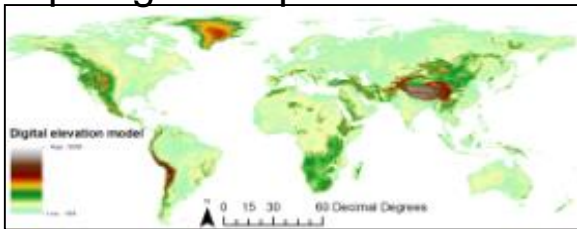
Added value for National Hydrological Services

- Catchment based information with 10-30 days lead-time
- Probabilistic information (ensemble predictions)

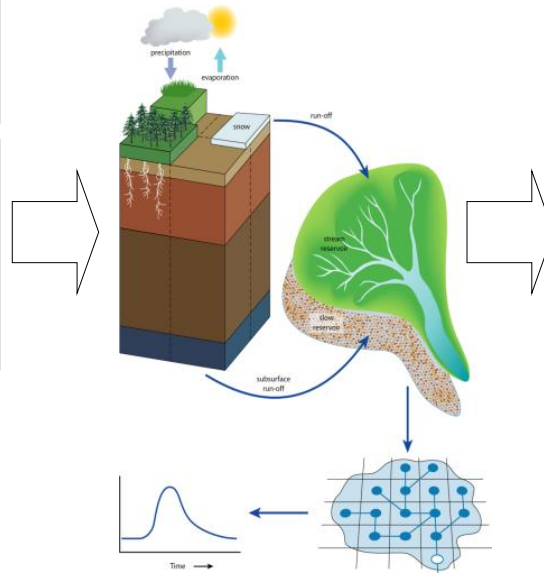


Global Flood Awareness System Set-up

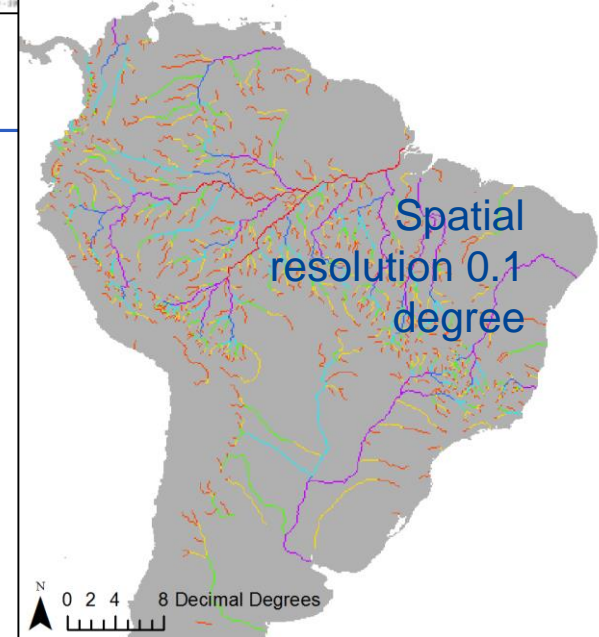
Input: global spatial data



Hydro-Meteo model

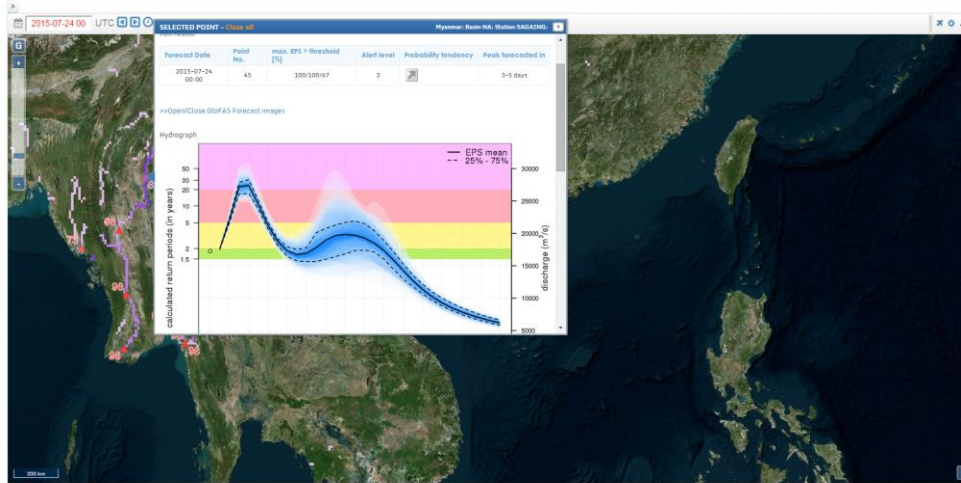


Output: global daily discharge



How does GloFAS work – Finding simple ways to communicate complex information!

Easy and fast access to flood forecast via:

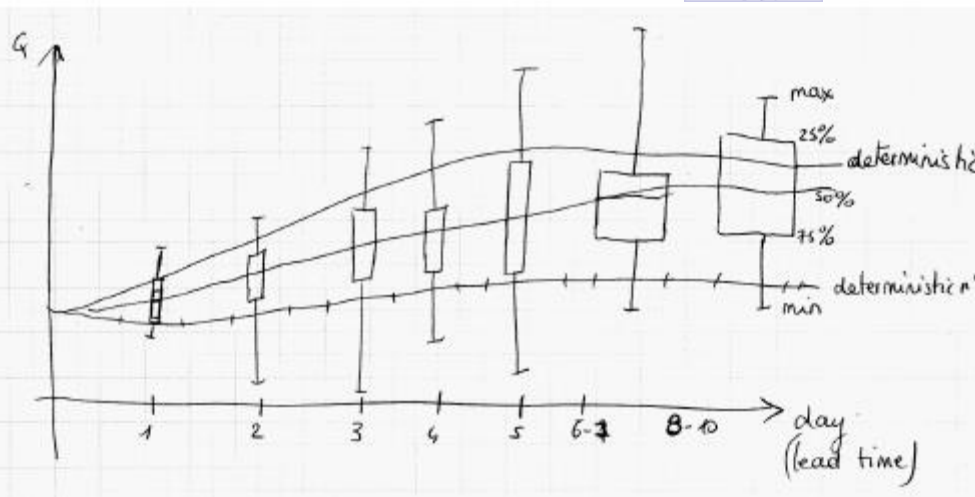
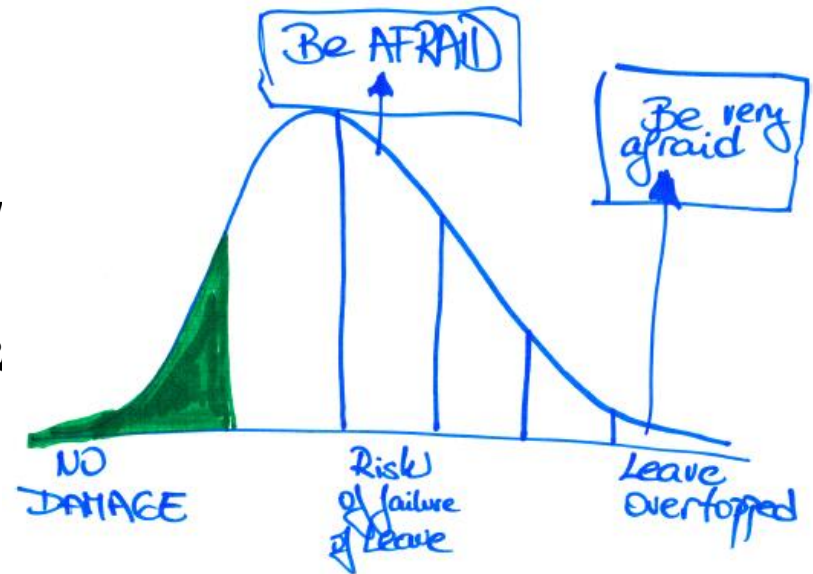


- Updates every day
- Easy understandable hotspot maps, flood probability maps, flood threshold exceedance, persistence plots
- Hydrologically relevant meteo information
- **Almost 7 years of forecast available with 1 click!**
- Cross-browser and multi-devices
- Possibility to include external OGC:WMS (Nov 2015)
- GloFAS YouTube Channel

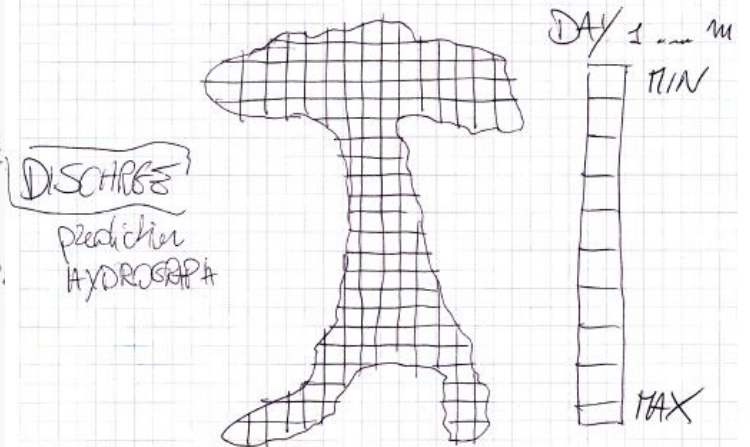


A Frontier: Communicating probabilistic information between experts

- Inter-expert \neq Public
- Difficult cause experts assume they know (quite arrogant 😊)
- 10 years of European Flood forecasting & numerous workshops later
- Many small changes
- Visualisation: mainly Magics



HOW TO communicate probabilistic FORECAST



GloFAS Persistence Plots

Colour: Warning level

Day Forecast is Valid

Medium Alert Level

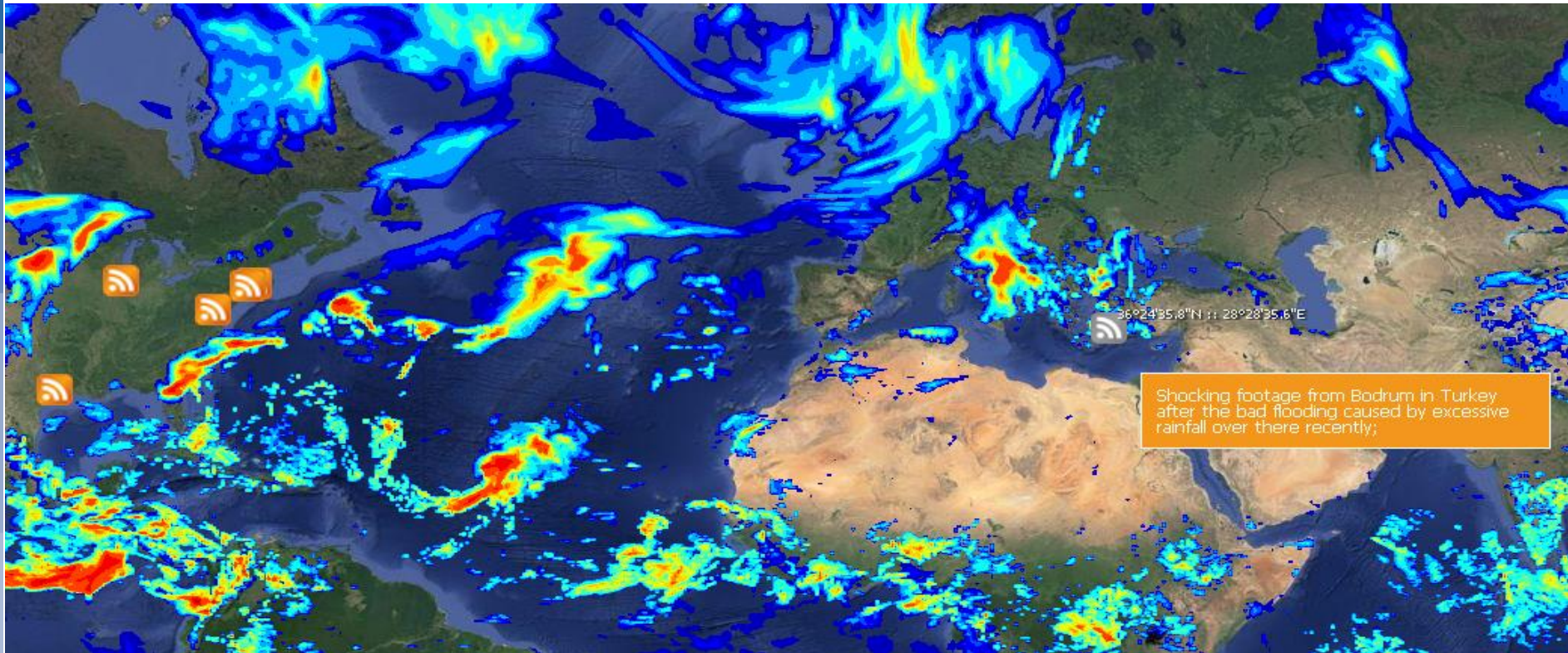
| Forecast Day | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|--------------|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 17/07/2015 | | | | | | | 2 | 16 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | | |
| 18/07/2015 | | | | | | | 2 | 24 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | |
| 19/07/2015 | | | | | | | 2 | 25 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | |
| 20/07/2015 | | | | | | | | 27 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| 21/07/2015 | | | | | | | | 16 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Easy to analyse persistence

Number is percentage of ensembles exceeding warning threshold

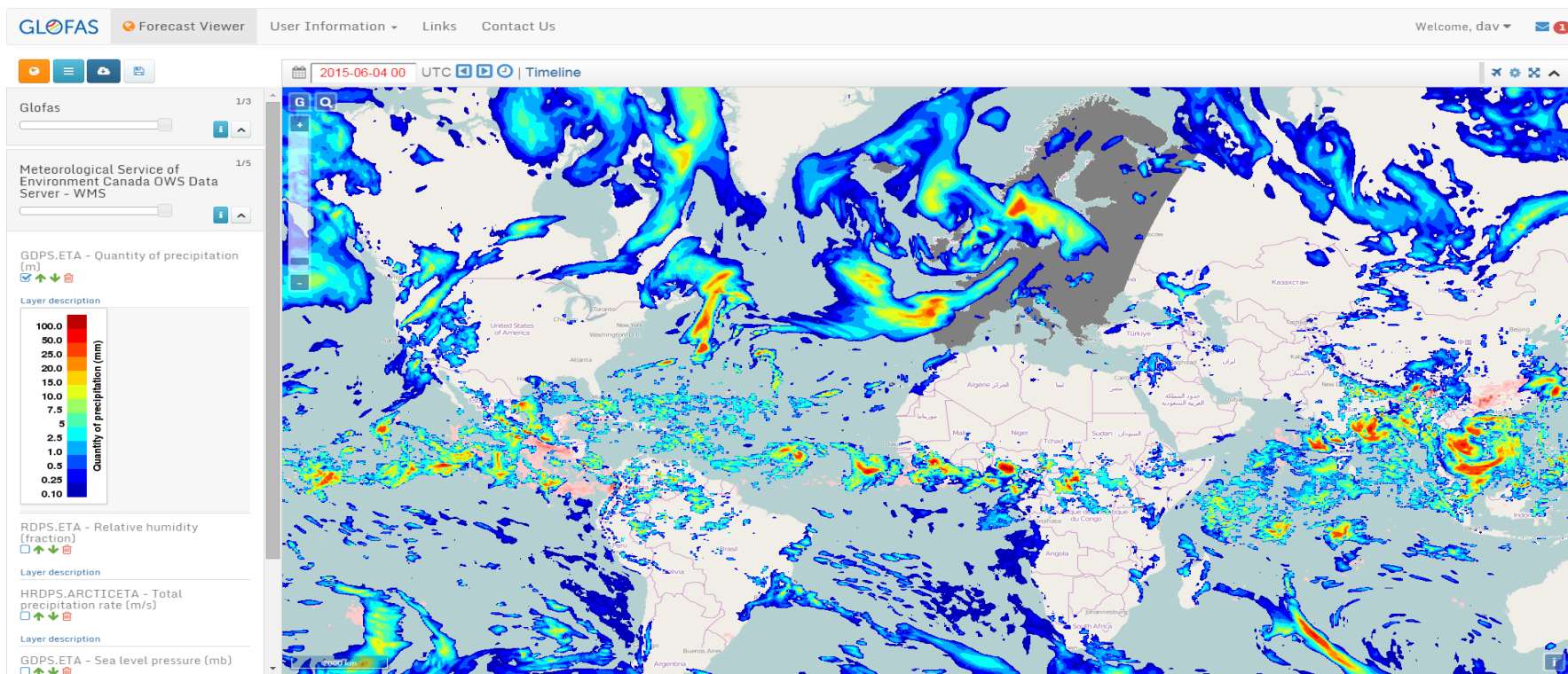
Day Forecast is issued

Including and combining OGC services with GloFAS



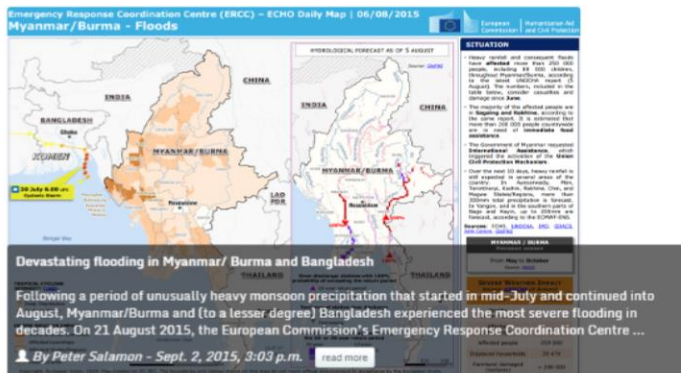
New GloFAS release will allow combining any OGC standard service (e.g. GeoRSS, OGC:WMS, etc) with GloFAS information. In the figure we see the GeoRSS from globalfloodsystem.com.

Possibility to include any OGC:WMS (Nov 2015)



GloFAS layer called Precipitation Prob. > 300mm which (probability [%] of exceeding 300 mm of accumulated rainfall over the forecast range of 10 days for the ensemble ECMWF forecast) and a single layer from an external service the Meteorological Service of Environment Canada OWS Data Server - WMS called GDPS.ETA - Quantity of precipitation (m)

www.globalfloods.eu and Twitter



- Devastating flooding in Myanmar/ Burma and Bangladesh
Sept. 2, 2015, 3:03 p.m.
- Science helps to reduce flood risk around the world
July 24, 2015, 4:46 p.m.
- GloFAS at the Third Space for Hydrology Workshop 15-17 September 2015
July 7, 2015, 2:38 p.m.
- GloFAS Webinar channel available!
April 22, 2015, 10:45 a.m.

A dedicated floods news Twitter channel where various RSS feeds (Google news, Yahoo news, Floodlist, EC EMM, Satellite activations, etc.) are filtered based on a combination of bigrams*.

Bigrams: two keywords appearing most often in proper flood message based on analysis of 3 months twitter communication e.g. “disastrous flooding”.

Twitter View @globalfloods_eu on Twitter

Tweets

globalfloods @globalfloods_eu
Flash flood kills 8 in Utah-Arizona towns known as polygamist stronghold: A wall of water... cbc.ca/news/world/fla...
pic.twitter.com/8oH8vGtbyl

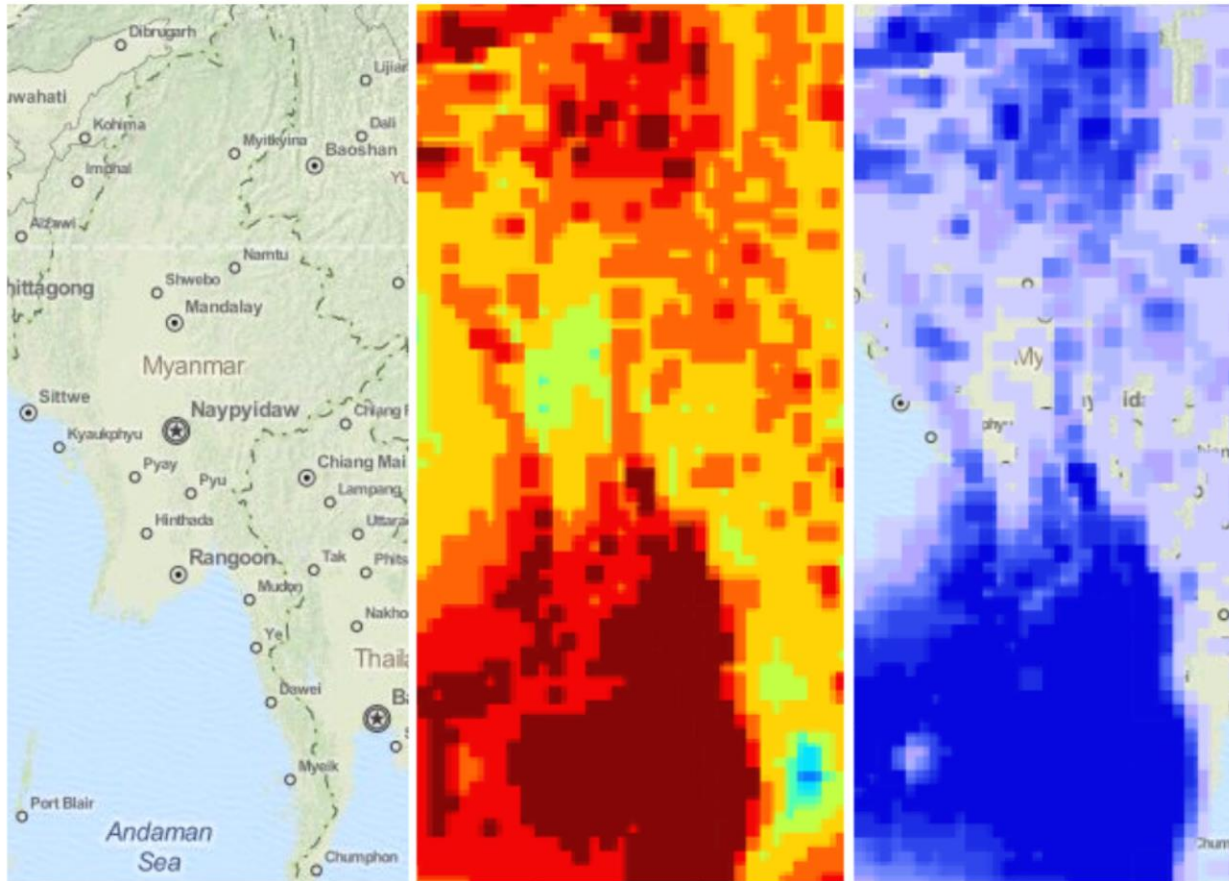


Prototype for social media analysis for flood events

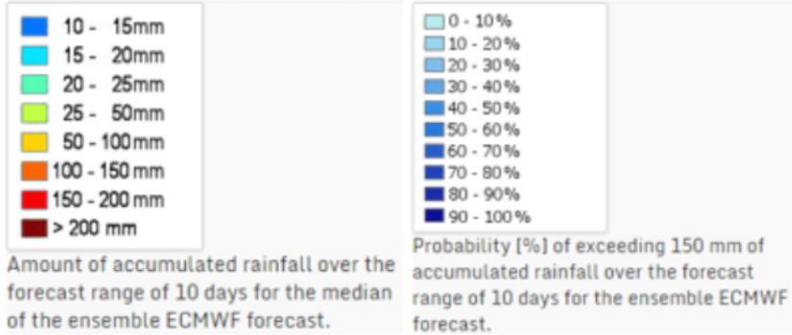
This example shows an aggregated 24 hours filtered flood signal from Twitter for

This map shows an aggregated 24 hours filtered flood signal from Twitter for 24th of July 2013 in form of a heat map (read color=high signal). It is considered as a valid signal if Twitter messages containing top 25 bigrams extracted from Twitter streaming over the last 10 days prior to the day of 24 hourly analysis.

Myanmar floods August 2015



GloFAS forecast:
2015-08-04 00 UTC

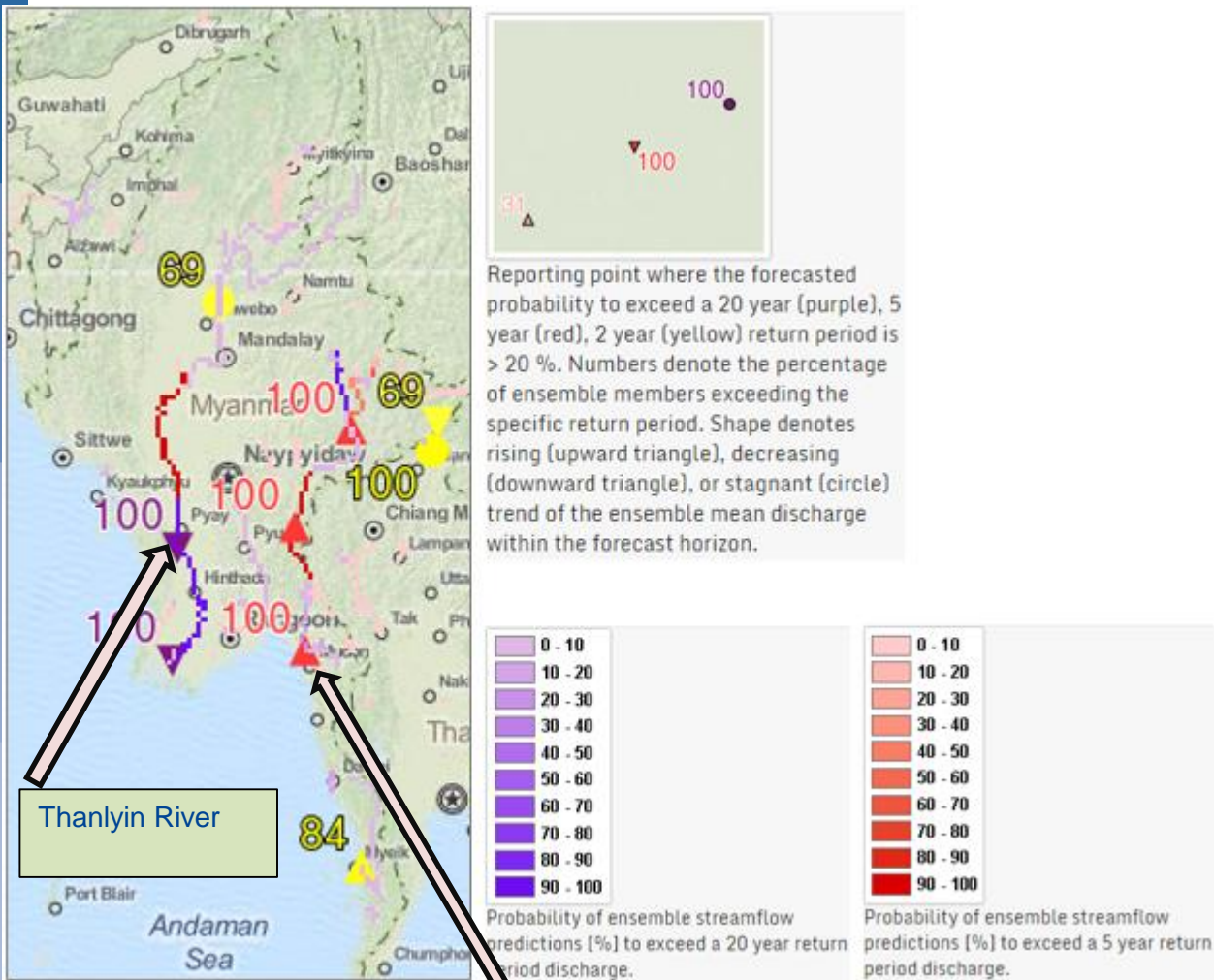


According to the precipitation forecast of the ECMWF (Figure 1), Myanmar is expecting very high amounts of precipitation during the next 10 days based on the 2015-08-04 00 UTC forecast.

In the North and South of the country precipitation is expected to exceed 200 mm, while in the center of the country precipitation will stay below 100 mm.

South of Rangoon precipitation is likely to exceed 300 mm during the next 10 days.

Myanmar 2015 floods, GloFAS hydrological forecast



Thanlyin River

Ayeyarwady River

GloFAS forecast:
2015-08-04 00 UTC

In the Ayeyarwady River discharges are currently very high above 20 years GloFAS return period, but are predicted to drop rapidly during the next 3-5 days (dropping below the GloFAS 5 year return period); after that they are expected to decrease slower.

Also in the Thanlyin River (Figure 1 next slide) discharges are currently high. In the upstream part (close to Mong Pan) discharges are presently stagnate and are expected to decrease from now on.

But, in the downstream part of the river discharges **are predicted to increase** during the next days due to the water coming from the upstream river sections, plus the large amount of precipitation that is expected for that area.

The **peak** at the river outlet is expected for 8 August.

In the south tip of the country discharges are currently not high, but are predicted to **increase significantly** during the next days. (Figure 2)

Myanmar 2015 floods, GloFAS Hydrographs

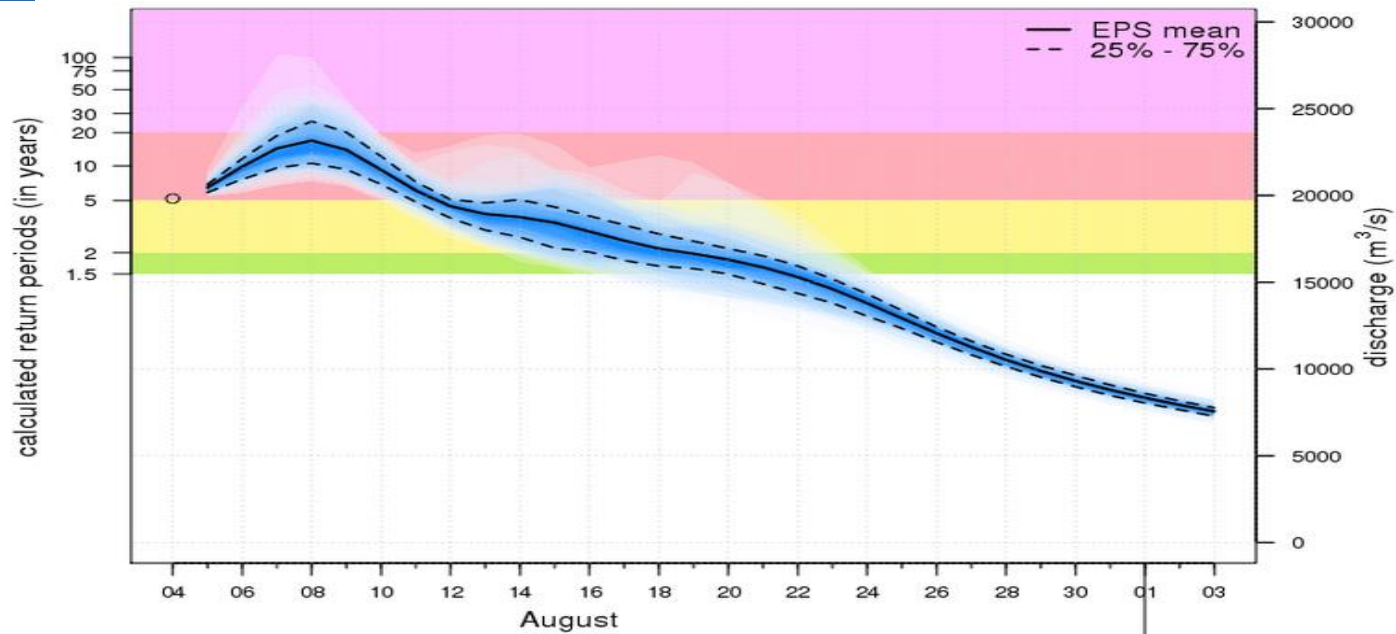


Figure 1
GloFAS forecast for the Thanlyin River at Mawlamyine (river outlet)

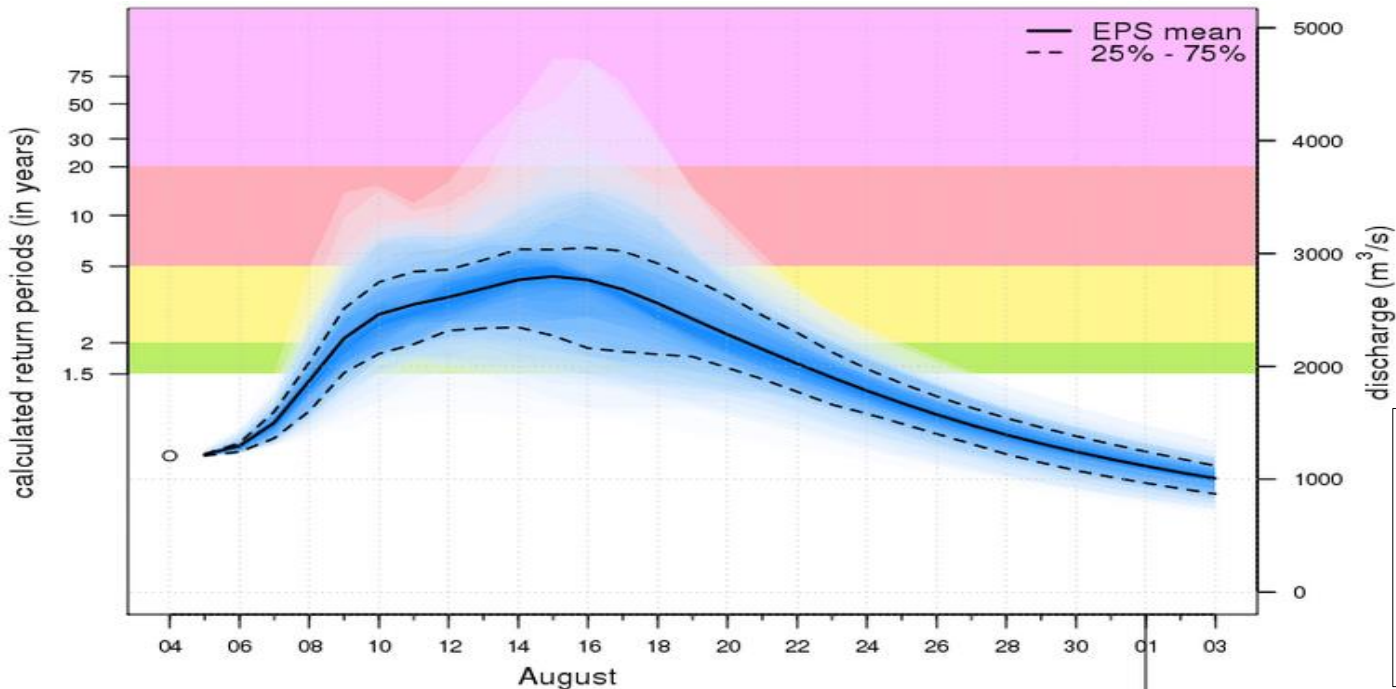


Figure 2
GloFAS forecast for the Tanintharyi River at Mergui

On 31 July, the President of the Union of Myanmar issued a statement declaring natural disaster zones in Chin and Rakhine states and in the Sagaing and Magway regions, stating “the following regions which are hugely affected by natural disasters.

GloFAS Persistence Plots

Medium Alert Level

| Forecast Day | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|--------------|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 17/07/2015 | | | | | | | 2 | 16 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | | |
| 18/07/2015 | | | | | | | 2 | 24 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | |
| 19/07/2015 | | | | | | | 2 | 25 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | |
| 20/07/2015 | | | | | | | | 27 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| 21/07/2015 | | | | | | | | 16 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

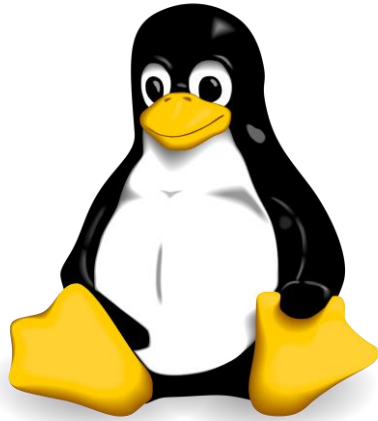
High Alert Level

| Forecast Day | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| 17/07/2015 | | | | | | | | | 2 | 2 | 2 | 2 | 6 | 18 | 27 | 43 | 57 | 69 | 80 | 88 | | | | |
| 18/07/2015 | | | | | | | | | | | | | | 6 | 18 | 31 | 45 | 57 | 61 | 69 | 86 | | | |
| 19/07/2015 | | | | | | | | | | | | | | 2 | 6 | 16 | 33 | 49 | 69 | 84 | 88 | 90 | | |
| 20/07/2015 | | | | | | | | | | | | 4 | 8 | 10 | 10 | 22 | 49 | 61 | 76 | 80 | 84 | 90 | 96 | |
| 21/07/2015 | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 14 | 25 | 51 | 80 | 88 | 96 | 100 | 100 | 100 |

Severe Alert Level

| Forecast Day | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|----|----|----|----|----|----|
| 17/07/2015 | | | | | | | | | | | | | | | | | 2 | 4 | 6 | 12 | | | | | |
| 18/07/2015 | | | | | | | | | | | | | | | | | | 2 | 6 | 10 | 24 | | | | |
| 19/07/2015 | | | | | | | | | | | | | | | | | | 2 | 2 | 8 | 10 | 25 | | | |
| 20/07/2015 | | | | | | | | | | | | | | | | | | | 2 | 8 | 10 | 20 | 27 | | |
| 21/07/2015 | | | | | | | | | | | | | | | | | | 2 | 2 | 6 | 8 | 12 | 20 | 37 | 47 |

GloFAS Technologies used



python

django



OGC™
Open Geospatial Consortium, Inc.



GloFAS exists thanks to them!

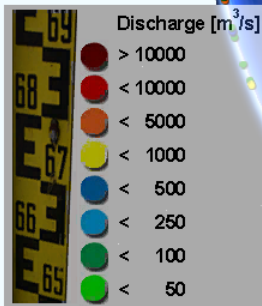
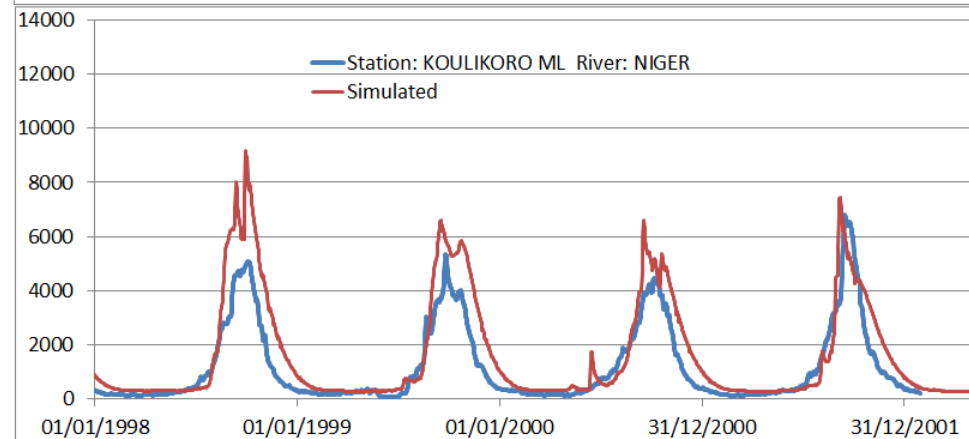
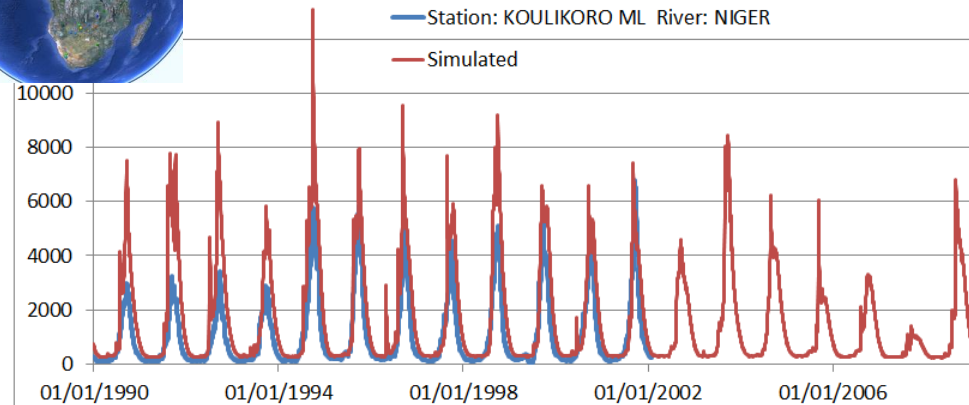
Simulation vs. Observation: Niger

River: NIGER
 Station: KOULIKORO
 Country: ML

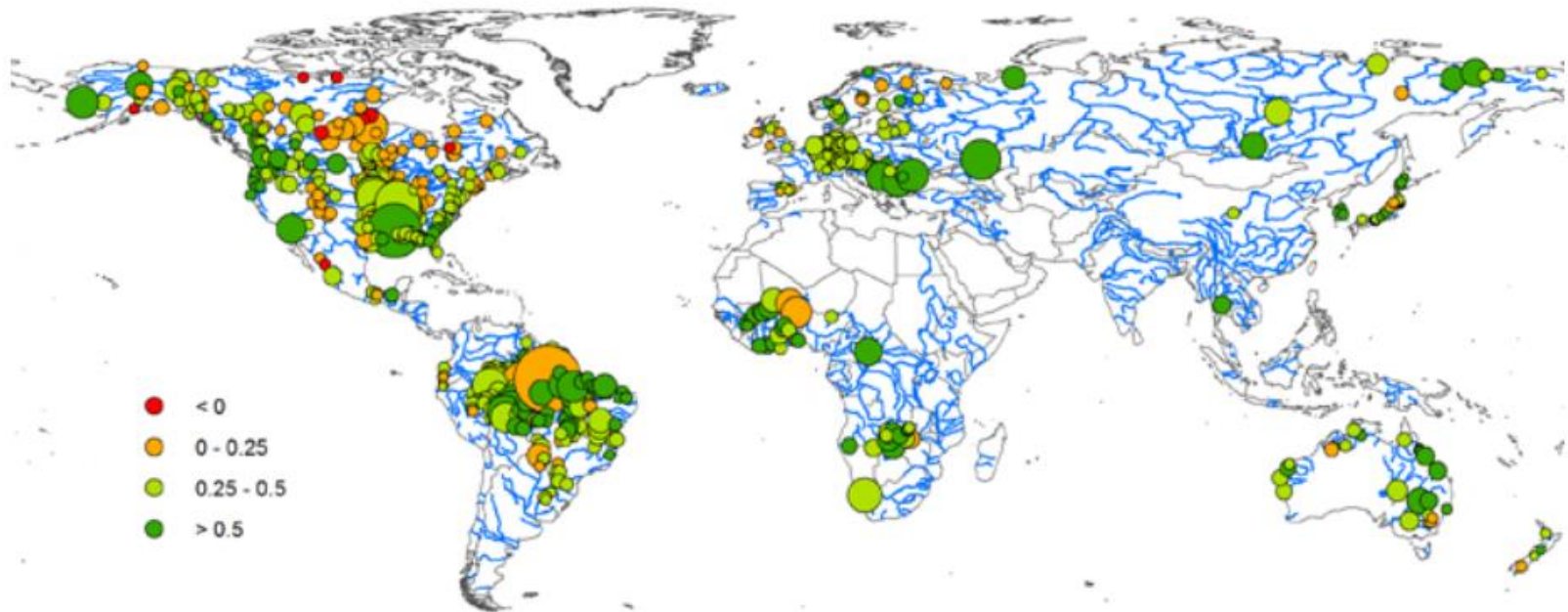
Min. flow [m³/s]: 61
 Mean flow [m³/s]: 1083
 Max. flow [m³/s]: 6800



GRDC-ID: 1134100
 Area [km²]: 120000
 290
 907 - 2006
 12.867 Lon.: -7.550



Skill score analysis



Pierce skill score of simulated versus observed discharge for 620 selected stations

For more information

www.globalfloods.eu

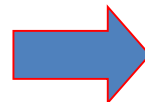
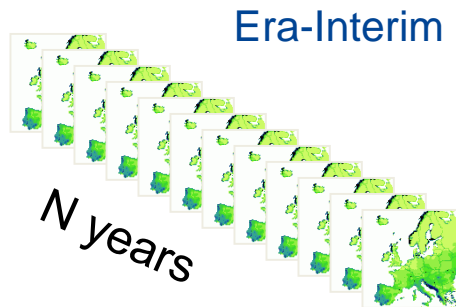
info@globalfloods.eu

florian.pappenberger@ecmwf.int

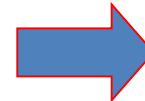
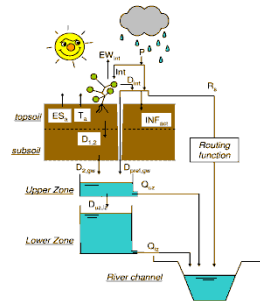
Thanks!

Alfieri, L., Burek, P., Dutra, E., Krzeminski, B., Muraro, D., Thielen, J., and Pappenberger, F.
GloFAS – global ensemble streamflow forecasting and flood early warning
Hydrol. Earth Syst. Sci., 17, 1161-1175, doi:10.5194/hess-17-1161-2013, 2013.

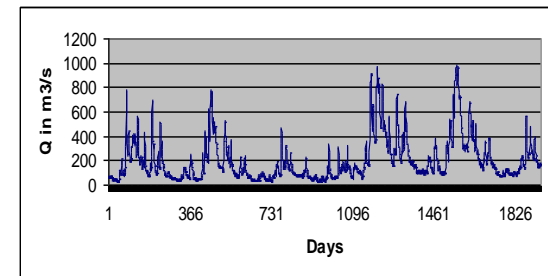
Estimating flood magnitude in GloFAS



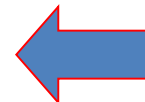
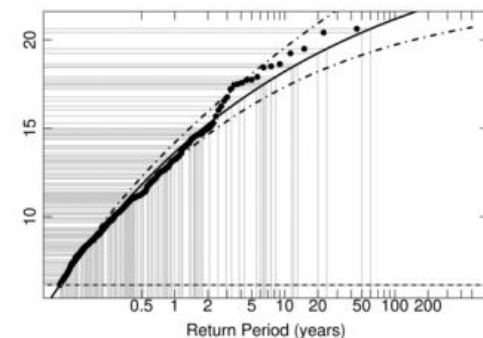
HTESSEL/Lisflood



Simulated discharge time series



Return period statistics

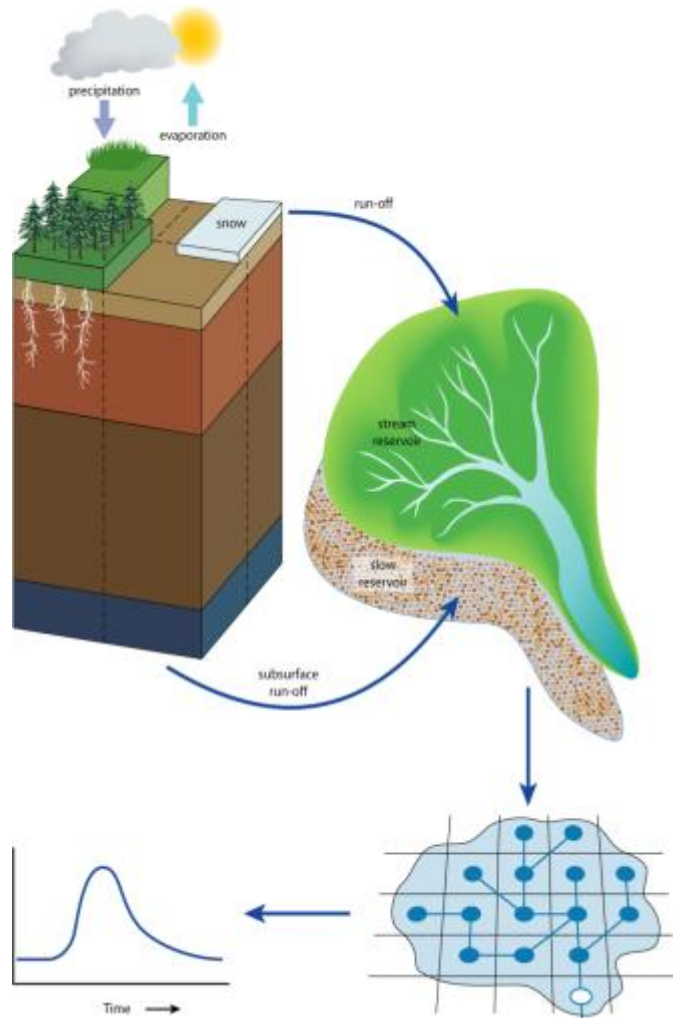


Thresholds

-  Q20
-  Q5
-  Q2
-  Q1.3

- Thresholds are derived from simulated time series
- The same model set-up and parameterisations are used in the forecasts to remain model consistent

GloFAS: Modelling framework



Output from global NWP land-surface scheme forecast: HTESEL (ECMWF)
(Hydrology Tiled ECMWF Scheme for Surface Exchange over Land)

- Surface heat & evaporation
- Soil water budget

Output: surface flux & subsurface flux



Routing model: Simplified LISFLOOD (JRC)

- Groundwater
- Routing (kinematic wave)



Post-processing for end users