What's new in EFAS 4.0?

Model improvements, 6-hourly calibration, new evaluation layers & reporting points

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Cinzia Mazzetti and Shaun Harrigan

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LISFLOOD model improvements for EFAS 4.0

In LISFLOOD code:

- Sub-daily steps (6-hourly)
- Improved channel routing
- Improved handling of restart from existing state files (warm start)
- Open Source LISFLOOD
- New model documentation and test cases

In EFAS 4.0:

- 6-hourly model steps now used everywhere
- Improved simulations in small-medium catchments
- Some corrections to the model river network
- Improved location of river gauges on the model river network
- More strictly physical ranges for calibration parameters

Open Source LISFLOOD

GitHub https://ec-jrc.github.io/lisflood/

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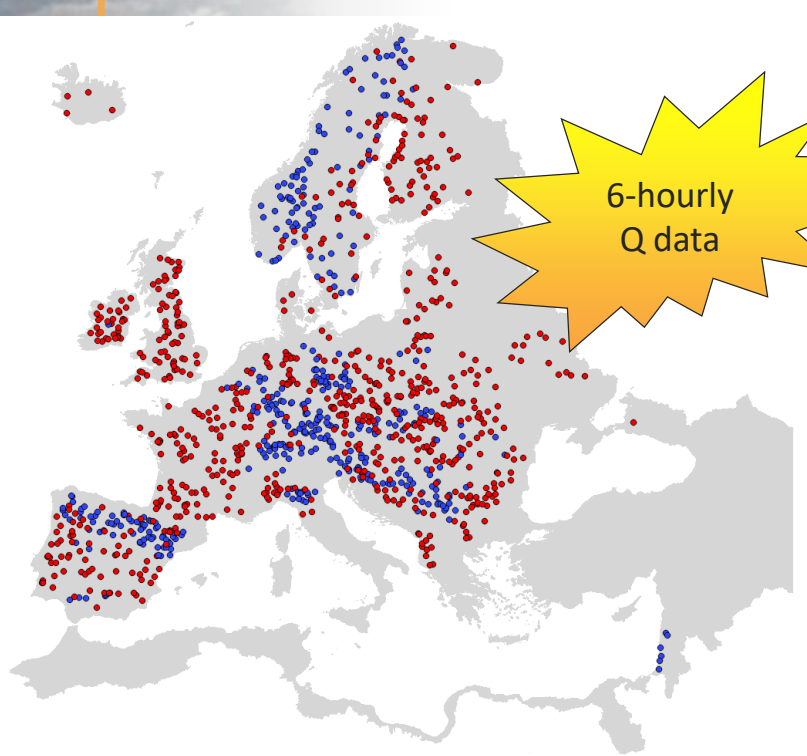
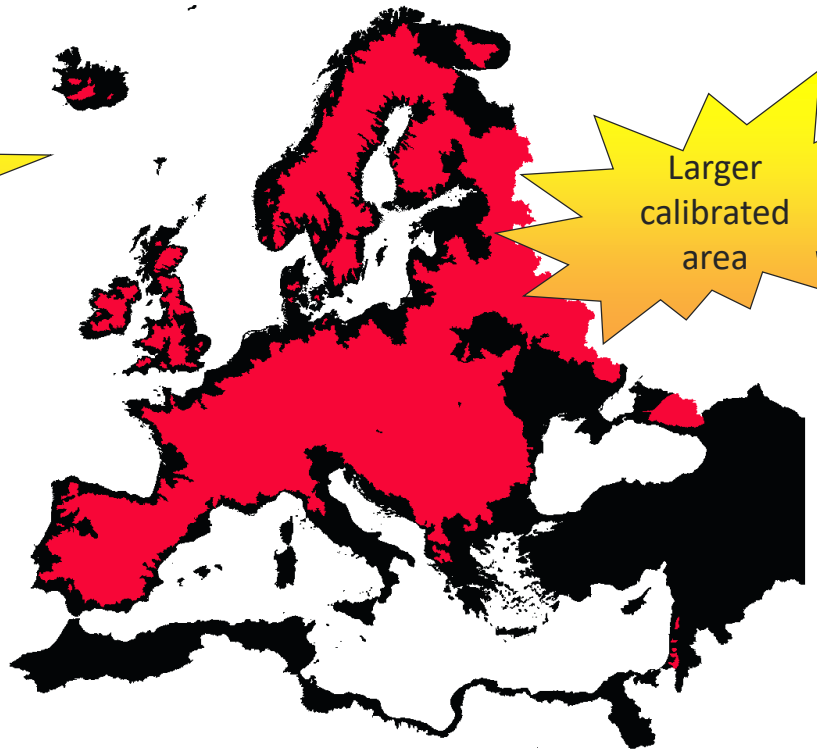
New 6-hourly calibration

- Calibration performed at **6-hourly steps** for the first time
- **1137 stations** in 215 different catchments (up from 717)
- 406 with **6-hourly discharge data (~35%)** and 731 with daily discharge data
- **~50 % of EFAS domain** area belongs to a calibrated catchment (~4 millions km^2 over ~9 millions km^2)
- Catchments area of calibration stations varying from 468 km^2 (Ishem catchment, AL) to 807'000 km^2 (Danube catchment, RO), with a median area of 3000 km^2.



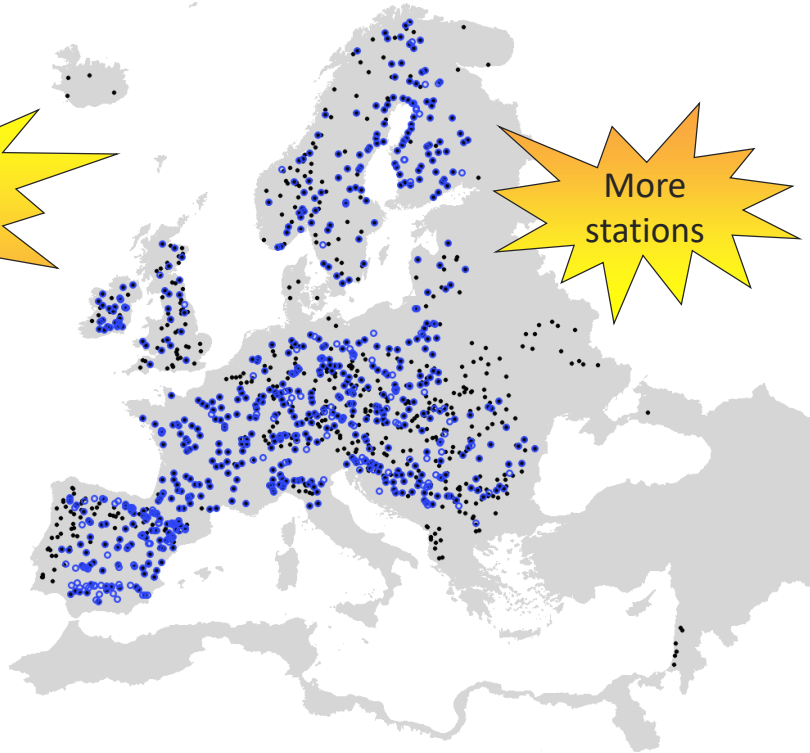
6-hourly (blue) and daily (red) calib points

6-hourly Q data



Calibrated area (red)

Larger calibrated area



EFAS3 (blue) and EFAS4 (black) calib points

More stations

New 6-hourly calibration

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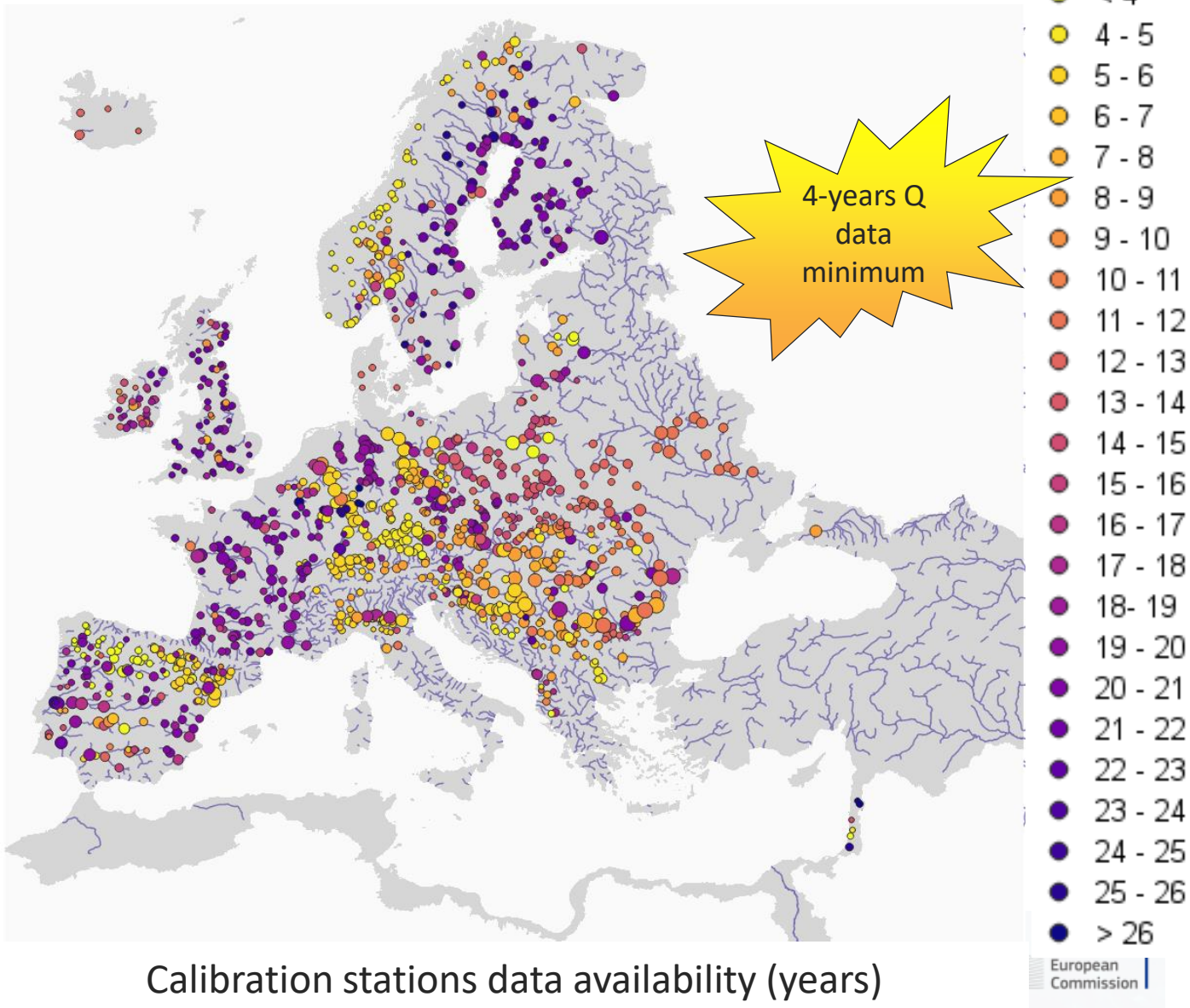
- Observed discharge data for the **period 1990-2017** were considered for the calibration
- **Minimum 4 years** of discharge data are used for calibration.
- **Privileged 6-hourly data** at stations where daily data are also available
- Performed on **14 LISFLOOD parameters** with 6-hourly modelling steps
- Used **modified KGE** as objective function

All details on **EFAS Wiki**:

https://confluence.ecmwf.int/display/COPSRV/European+Flood+Awareness+System



Calibration stations data availability (years)

Hydrological model performance

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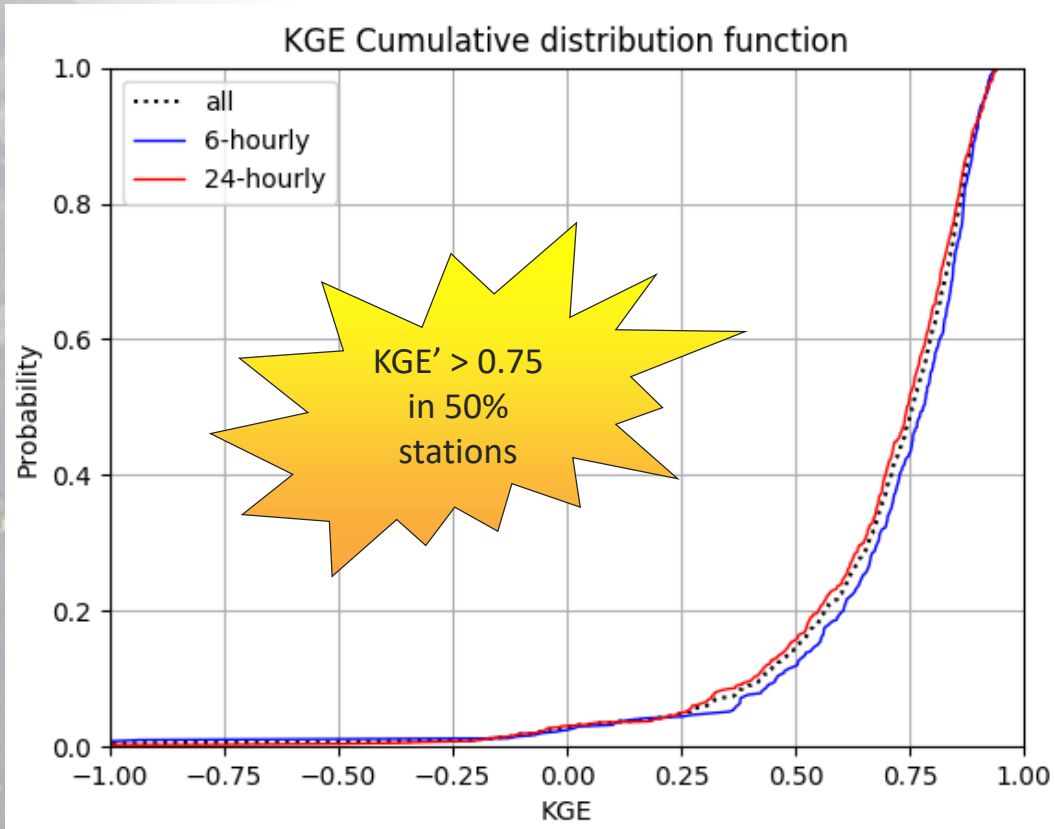
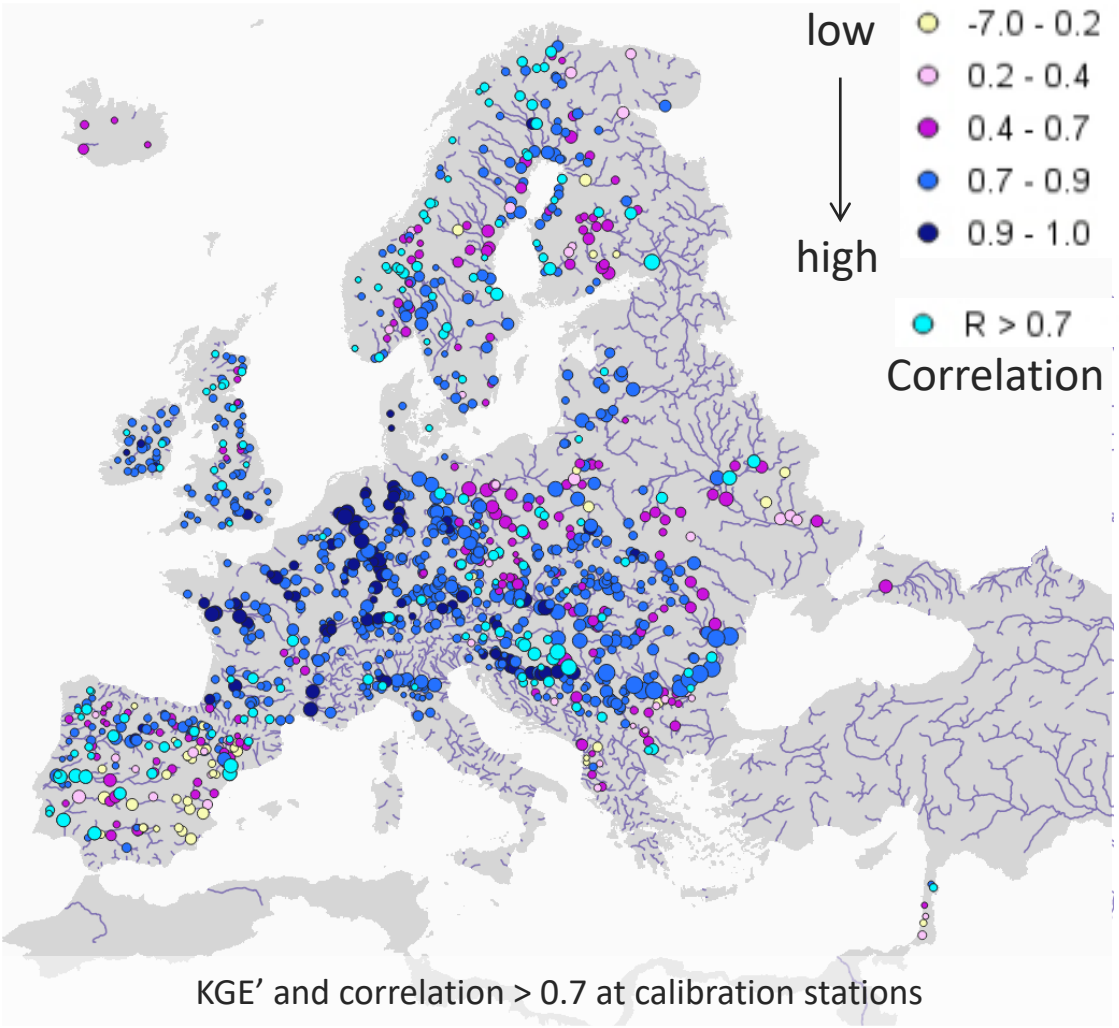
- Median **KGE' = 0.75** across Europe (1991-2017)
- Similar performance for stations with **6-hourly** and **24-hourly** observations



KGE decomposition and full results on the **EFAS wiki**



KGE' and correlation > 0.7 at calibration stations

KGE' is generally uniformly distributed

Higher skills in Central Europe and main European rivers

Lower skill in catchments with strongly regulated rivers

Model performance: EFAS4 vs EFAS3

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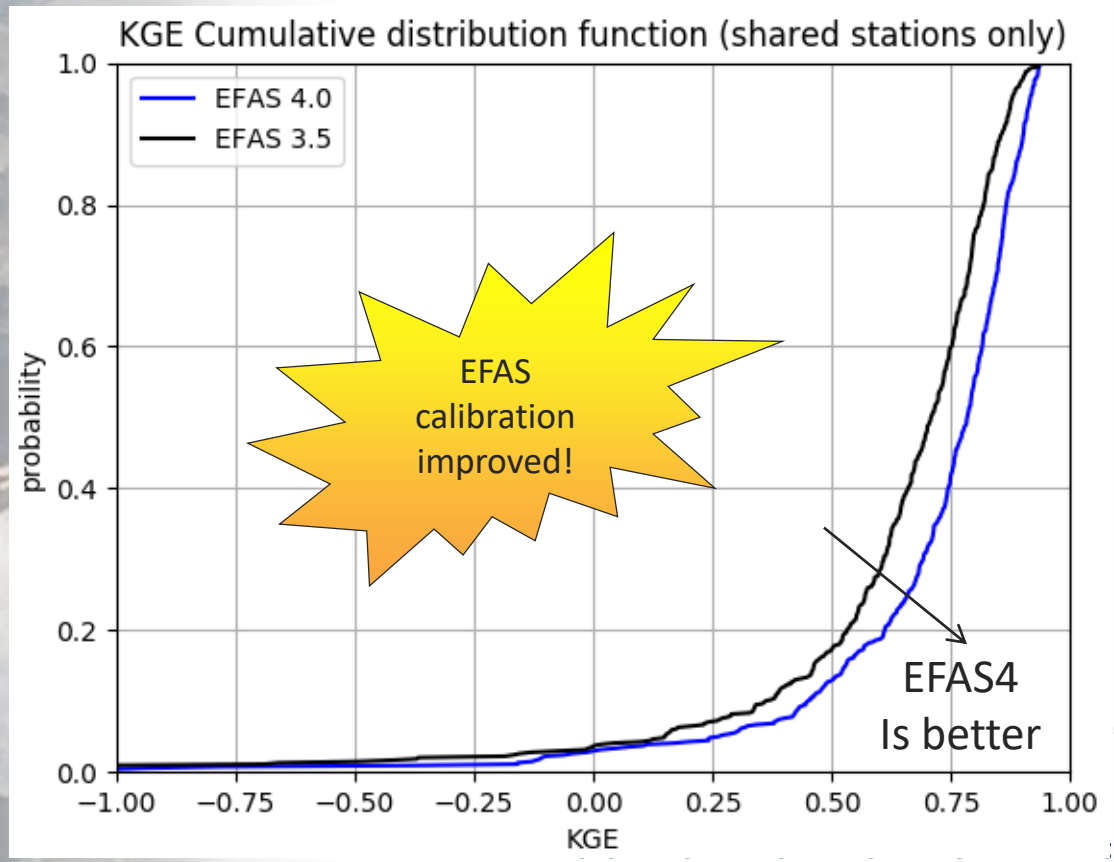
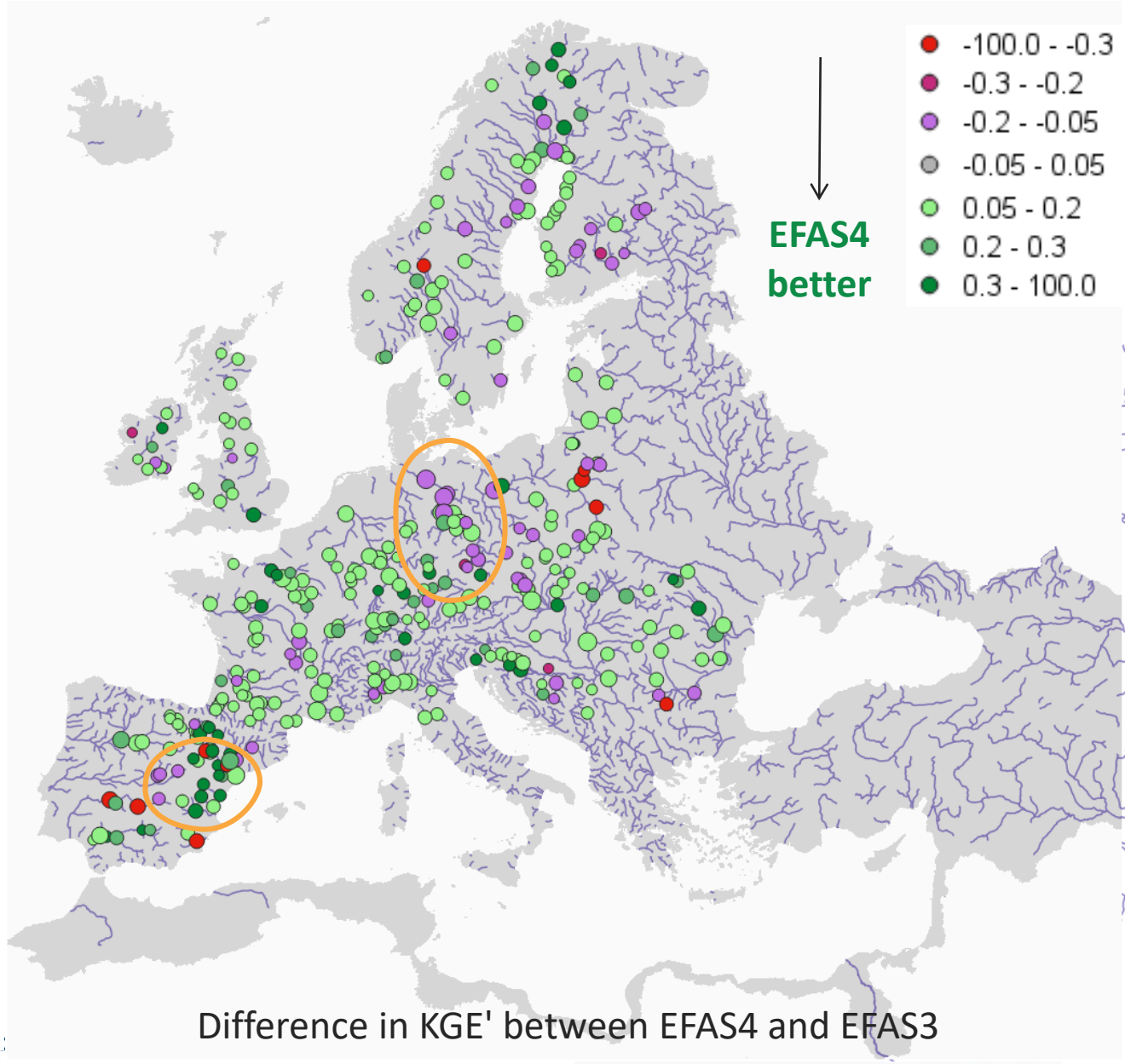
Comparison on 1991-2017 at daily time steps

- **6hrs steps** in EFAS4 vs **24hrs steps** in EFAS3
- **1137** calib stations in EFAS4 vs **718** in EFAS3
- **Shorter calib period** in EFAS4 vs EFAS3





Difference in KGE' between EFAS4 and EFAS3

Hydrological Simulations

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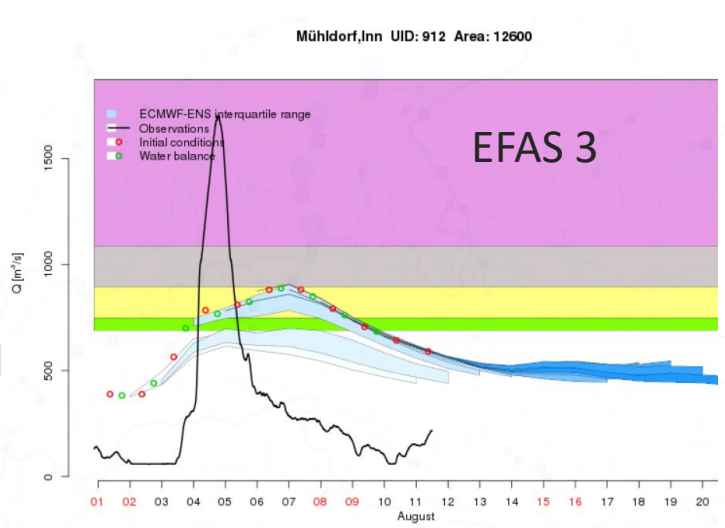
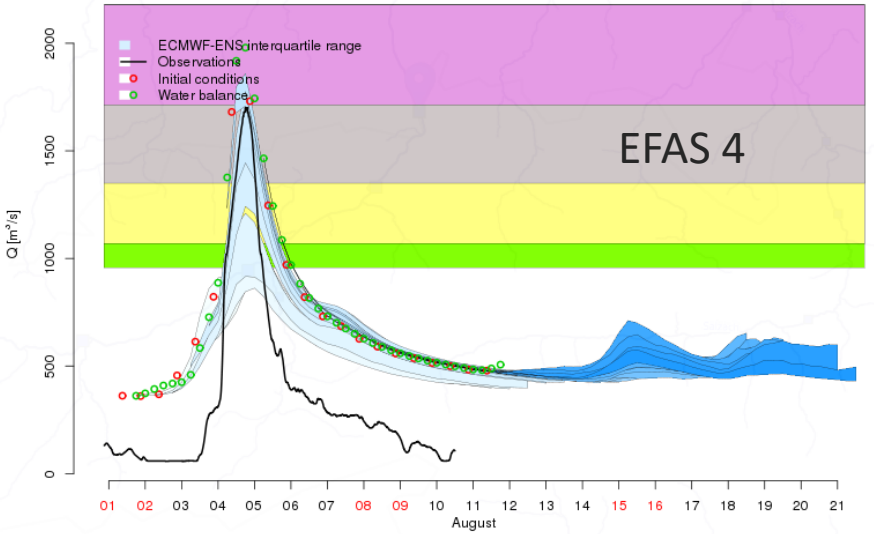
- Water Balance layer is now showing 6-hourly LISFLOOD hydrographs
- Number of stations up to 1387
- New thresholds based on recalibrated model climatology

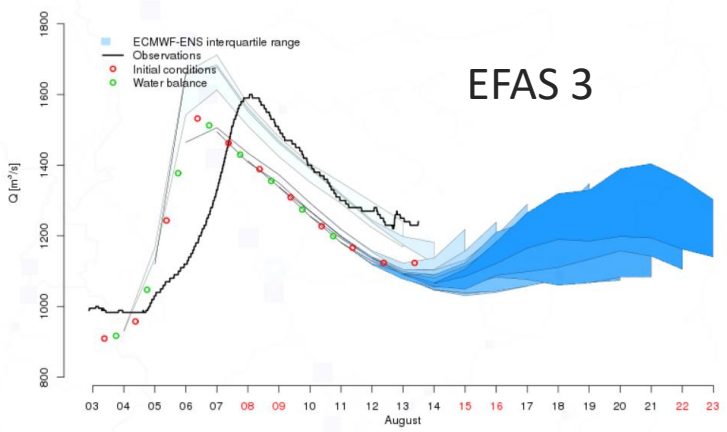
Compare Qsim and Qobs in WB layer

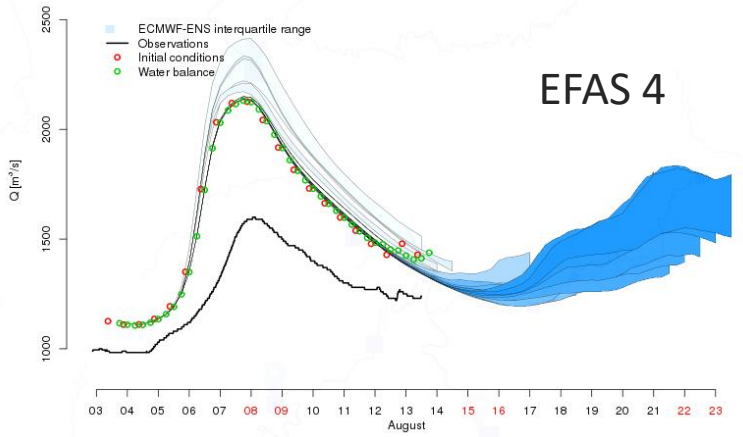
Inn@Muehldorf (Area=12600km^2)





Rhine@Bonn (Area=140775km^2)





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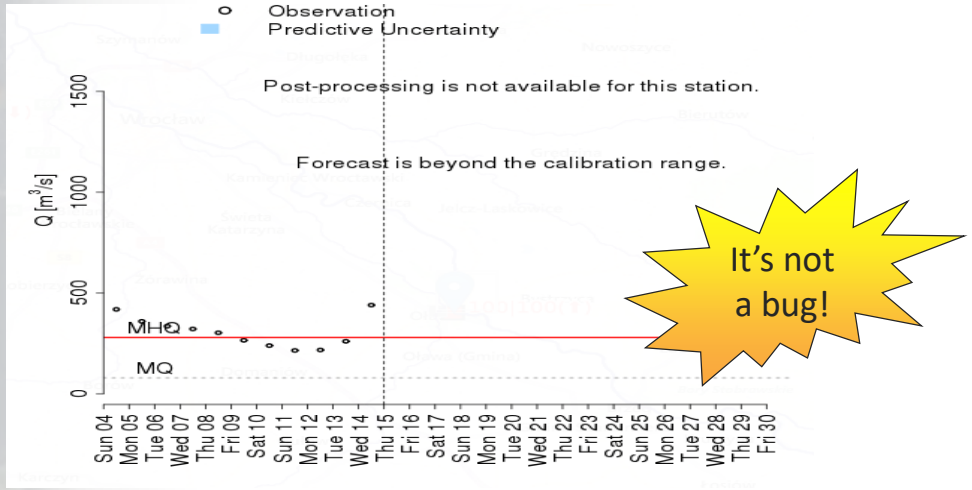
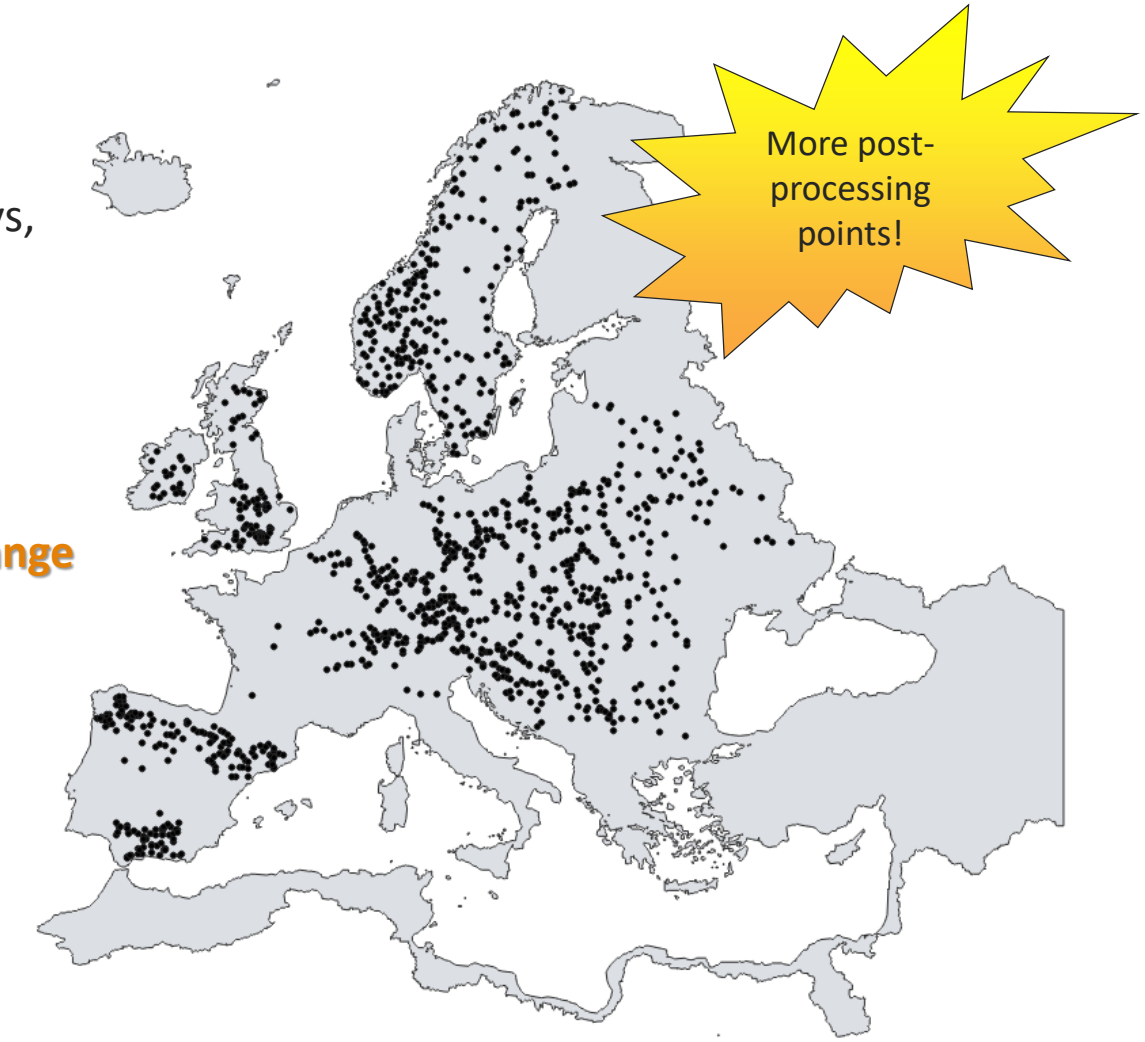
New post-processing points

- Post-processing is **trained with past observations and simulations**
- It blends the available observations over the last 40 days, LISFLOOD water balance and forecasts
- It gives the **probability distribution of the future observations**
- It's now **available at 1183 stations**
- It can be missing if forecast is **beyond the calibration range**



It's not a bug!



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Medium-range forecast skill

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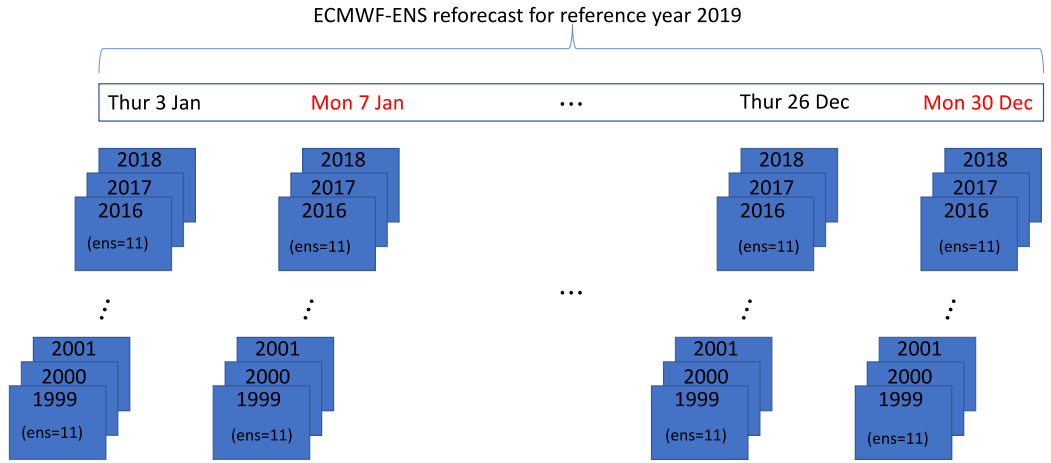
- Generation of long-term large-sample **reforecasts**
  - ECMWF-ENS for reference year 2019
  - 2 per week; 11 ensemble members
  - 20-years (1999-2018), 6-hourly; 46 day lead time



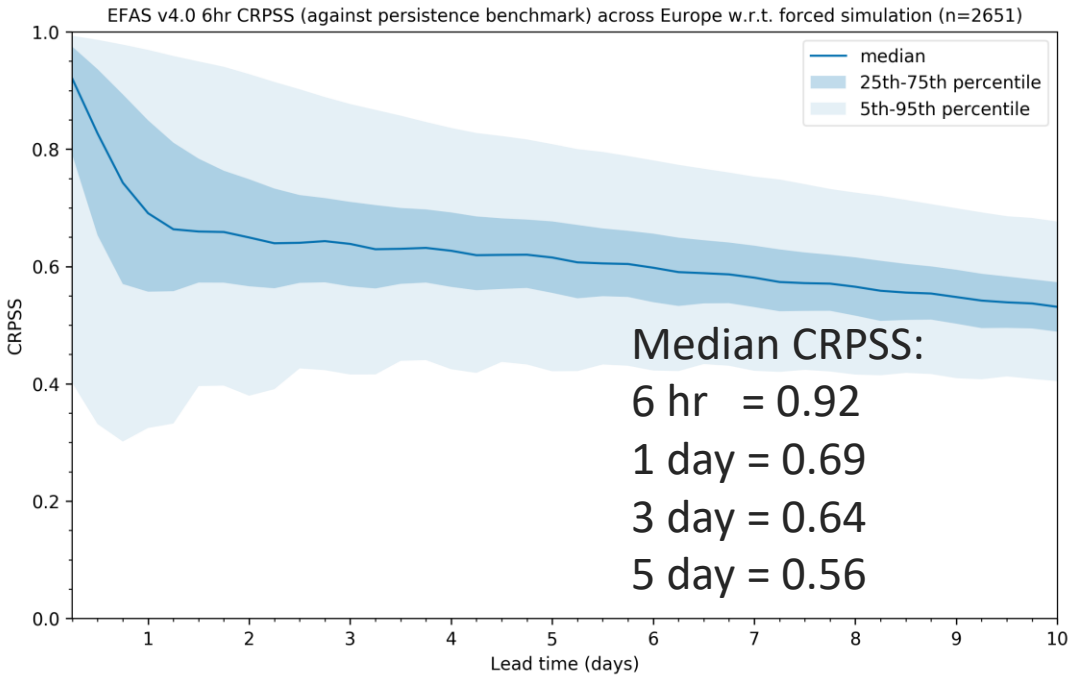
- **Persistence benchmark forecast** = 6 hr river discharge from previous time step

- Evaluated against **proxy observations (**EFAS 4.0 **forced simulation (sfo))** at n=2651 fixed reporting points

- **Continuous Ranked Probability Skill Score:**

$$\mathbf{CRPSS} = 1 - \frac{\overline{\mathbf{CRPS_{fc}}}}{\overline{\mathbf{CRPS_{bench}}}}$$

No Skill=0; Perfect skill=1



New 'Evaluation' tab

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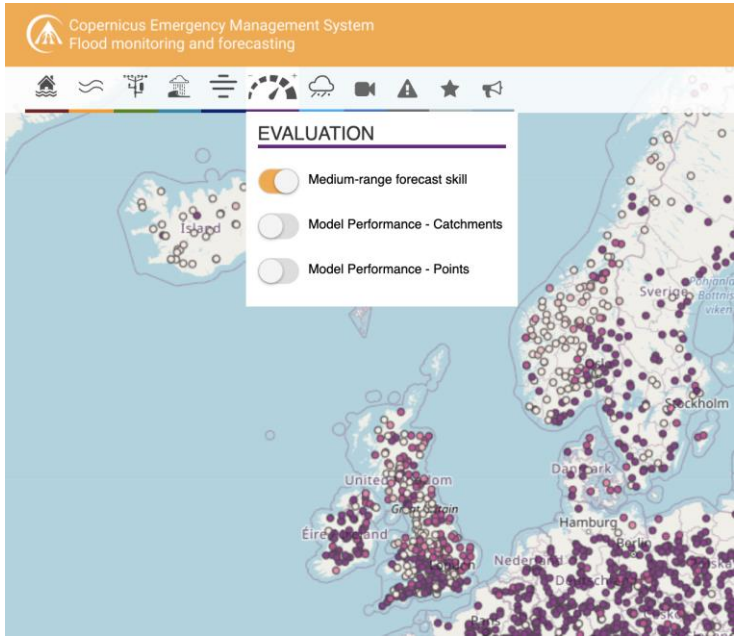
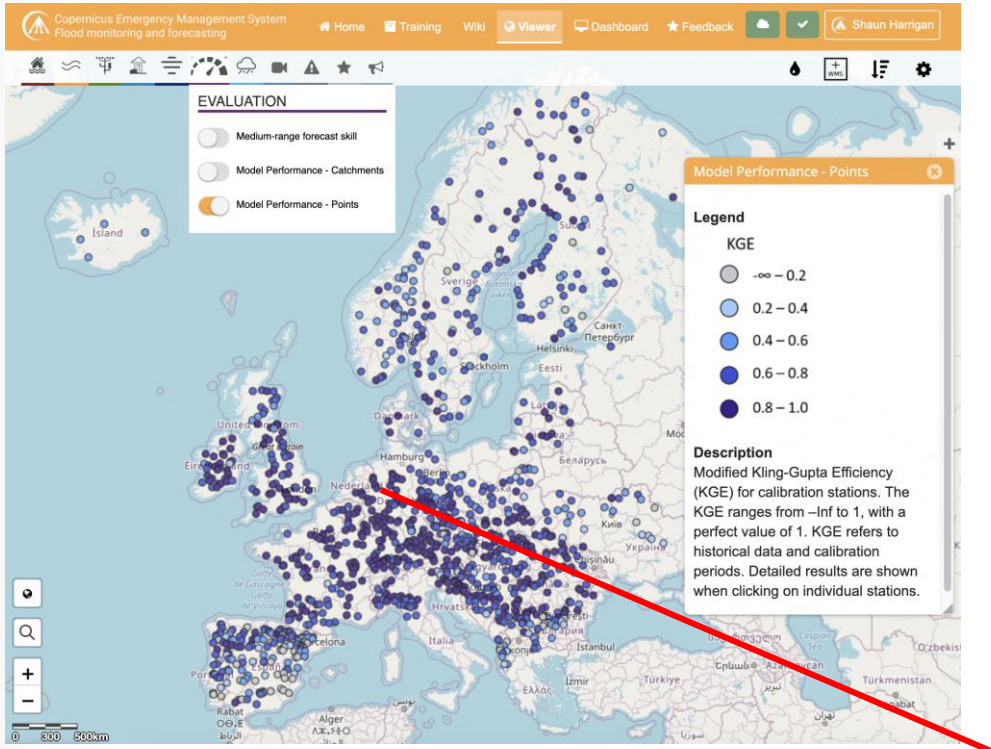
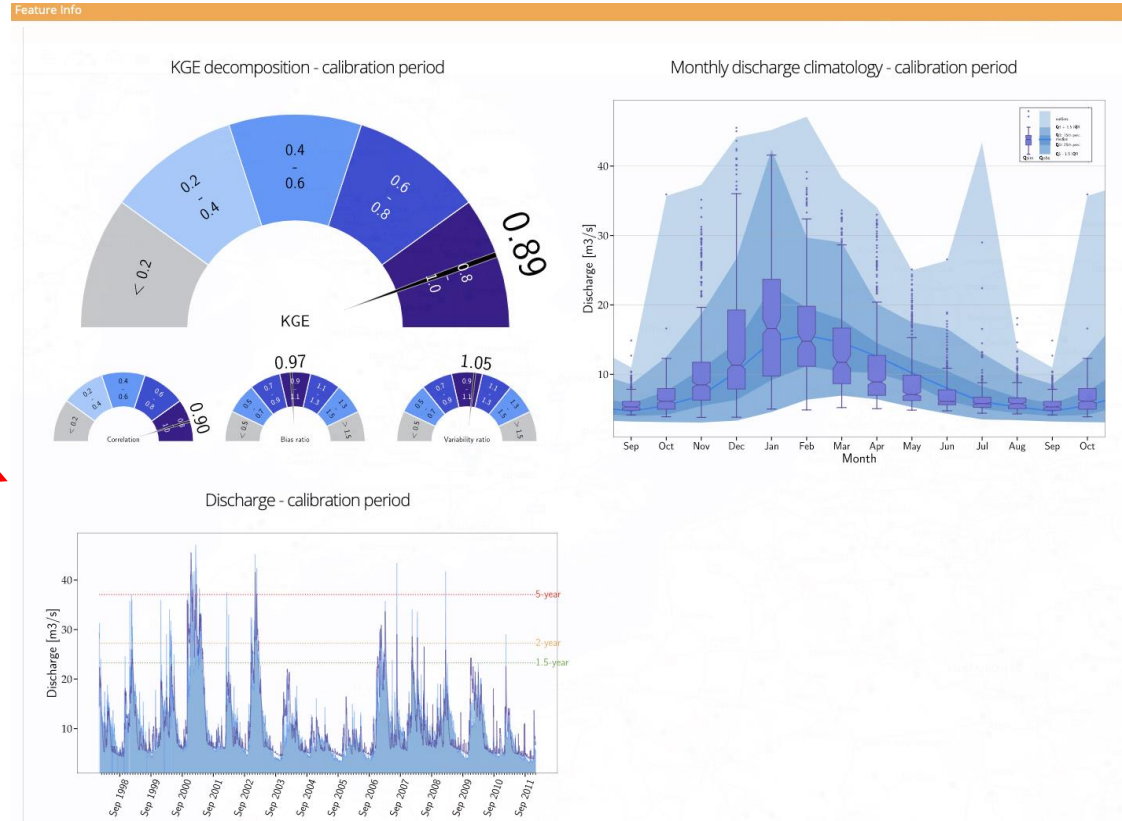
- **Three layers in new Evaluation tab :**
  - **1.)** Model performance – Points
  - **2.)** Model performance – Catchments
  - **3.)** Medium-range forecast skill



- **Full method details and results on the wiki:**
  - Hydrology model performance: https://confluence.ecmwf.int/display/COPSRV/EFAS+hydrological+model+performance
  - Medium-range forecast skill: https://confluence.ecmwf.int/display/COPSRV/EFAS+medium-range+forecast+skill

1.) Model performance - Points





Summary: Kling Gupta-Efficiency (KGE)
Decomposed into:
- Correlation
- Bias errors
- Variability errors

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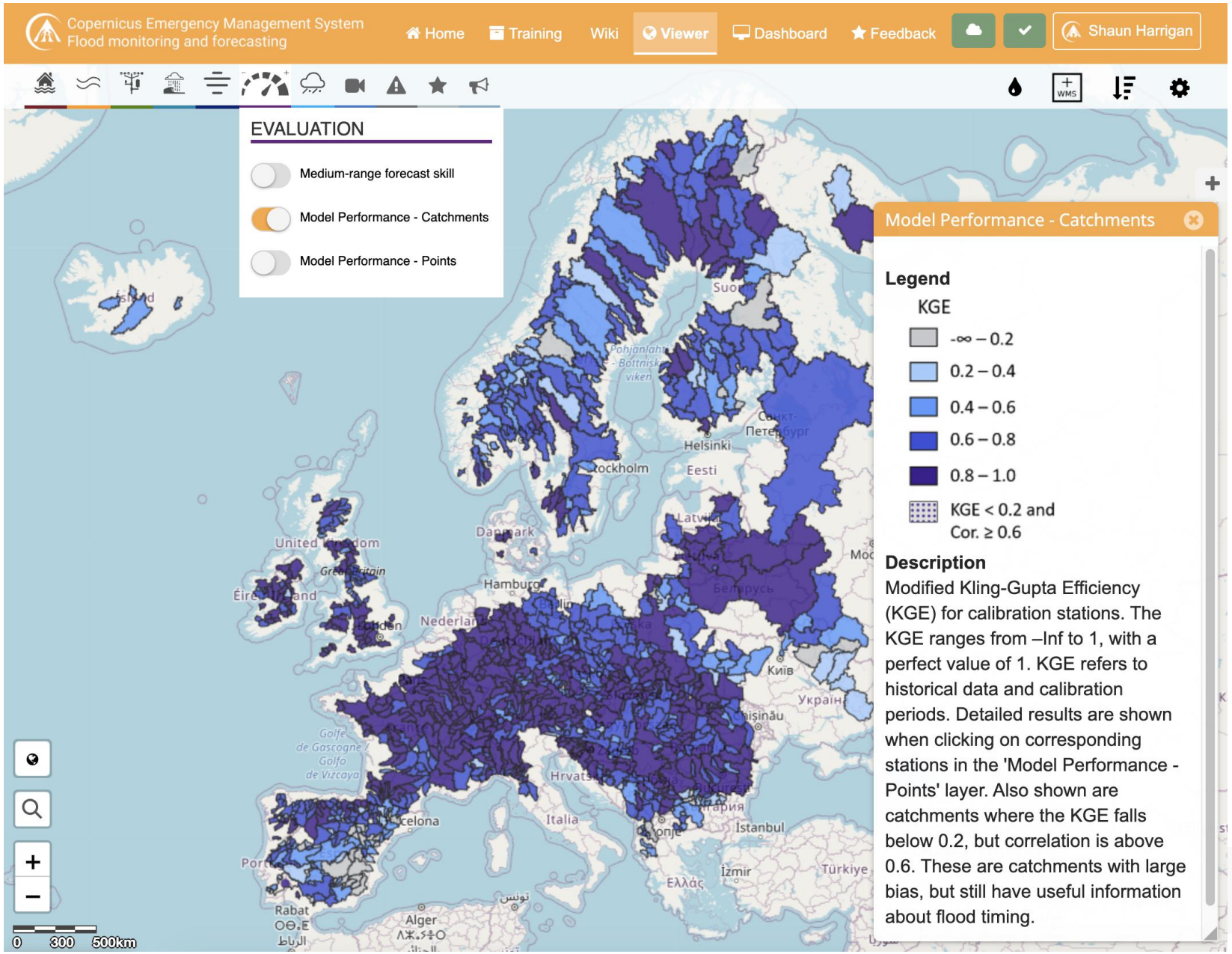
2.) Model performance - catchments



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3.) Medium-range forecast skill

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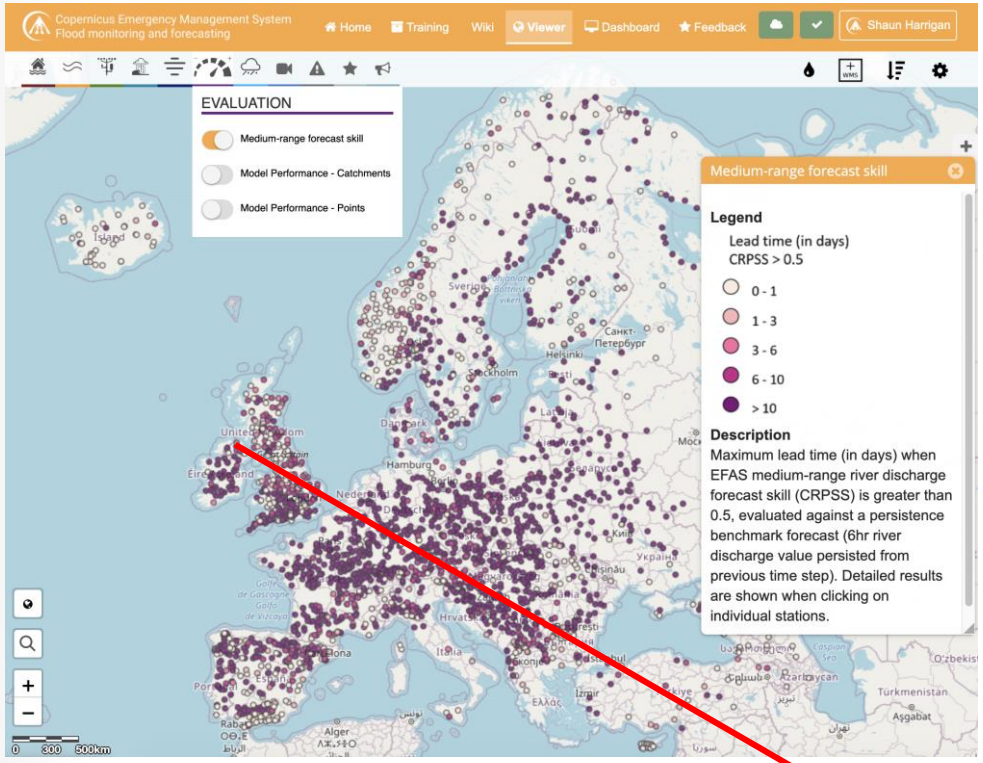
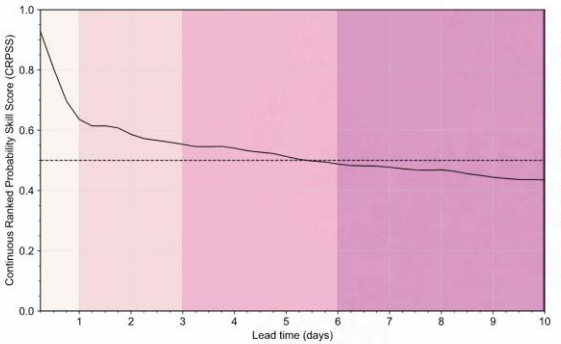


Continuous Ranked Probability Skill Score (CRPSS)

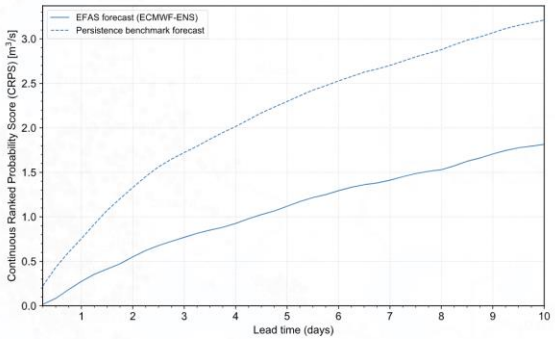
Medium-range forecasts skill layer

ID	StationName	Country	Catchment	Forecast evaluation period	Benchmark forecast	Lead time (in days) CRPSS > 0.5
2282	Seneirl Bridge	UK	North Eastern	03/01/1999 06:00 - 30/12/2018 00:00	Persistence	5.25

Forecast skill (ECMWF-ENS)



Individual CRPS (ECMWF-ENS and persistence)



Headline medium-range forecast skill score

Max lead time (in days), up to 10-days ahead, in which the CRPSS > 0.5, when compared to a simple persistence benchmark forecast

Q & A - 1

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Q1 (Nuno Moreira, IPMA, Portugal): ***I was wondering in regards to the latest map on the CRPSS score, for a higher value of the score closer to 1. There could also be an extra map for the number of days because of the short rain forecast. What do you think about this option of having higher scores for setting the number of days where you have the score higher than thresholds for the short rains?***

A1a (Shaun Harrigan, COMP): We had so many different ideas on different ways we could display the score. We wanted to have a few summary layers that describe the basic kind of skill in the model performance. We have decided for a threshold 0.5, which means that a forecast is twice skillful as the benchmark.

A1b (Peter Salamon, JRC): I think we're doing really a bit of pioneering work, because for hydrology it is not a common bizniss to use these types of headline scores. It is also the learning process needed on the user's side and for sure over time we need to finetune and maybe we find some other headlines scores. This is definitely work in the progress.

Q & A - 2

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Q2 (Maik Renner, LfU, Germany): ***Are model simulations and forecasts directly accessible? For example to be used in our local forecasting system, e.g. for comparison with our own forecasts?***

A2 (Christel Prudhomme, COMP): Yes, the hydrological simulations and forecasts are made available after 30 days for the forecasts through the Copernicus Data Store (CDS), but you can request access in real-time to COMP. We are also now publishing all reforecasts through the CDS, so that partners can do their own evaluation (https://cds.climate.copernicus.eu/cdsapp#!/dataset/efas-reforecast?tab=overview).

Q3 (Oliver Nicholson, OPW, Ireland): ***Is it possible that the improvements that are available in EFAS 4 will lead to a smaller minimum catchment size for EFAS Formal Flood Notifications?***

A3a (Cinzia Mazzetti, COMP): Yes, it is possible that new EFAS developments could lead to a smaller minimum catchment size for EFAS Formal Flood Notifications. We'll carry out further investigations before doing that.

A3b: (Shaun Harrigan, COMP): While the catchment size has not yet changed for formal notifications, the new way the fixed reporting points is implemented means you will be able to monitor any station that is available for Ireland (including if EFAS thresholds are triggered).