Challenges for the HEPEX community in the coming years

An example from EFAS and GloFAS

Fredrik Wetterhall

ECMWF

H SAF HEPEX workshop 2014

Participants in the H SAF/HEPX workshop in Reading 3-7 November 2014

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Outcomes from the workshop in 2014

- Remotely sensed snow, precipitation and soil moisture potentially very useful for the hydrological forecasting community
- Training and communication needed
- User-friendly and user-targeted products will help uptake
- No consistent picture on the impact on discharge, except when discharge is directly assimilated (updating, post-processing)
- Uncertainty estimation and ensemble assimilation techniques were hot topics
- Satellite anomaly products would be very useful

What was hot in 2014, and what is hot now?

Most common words removed

Abstracts in 2014

Abstracts in 2019

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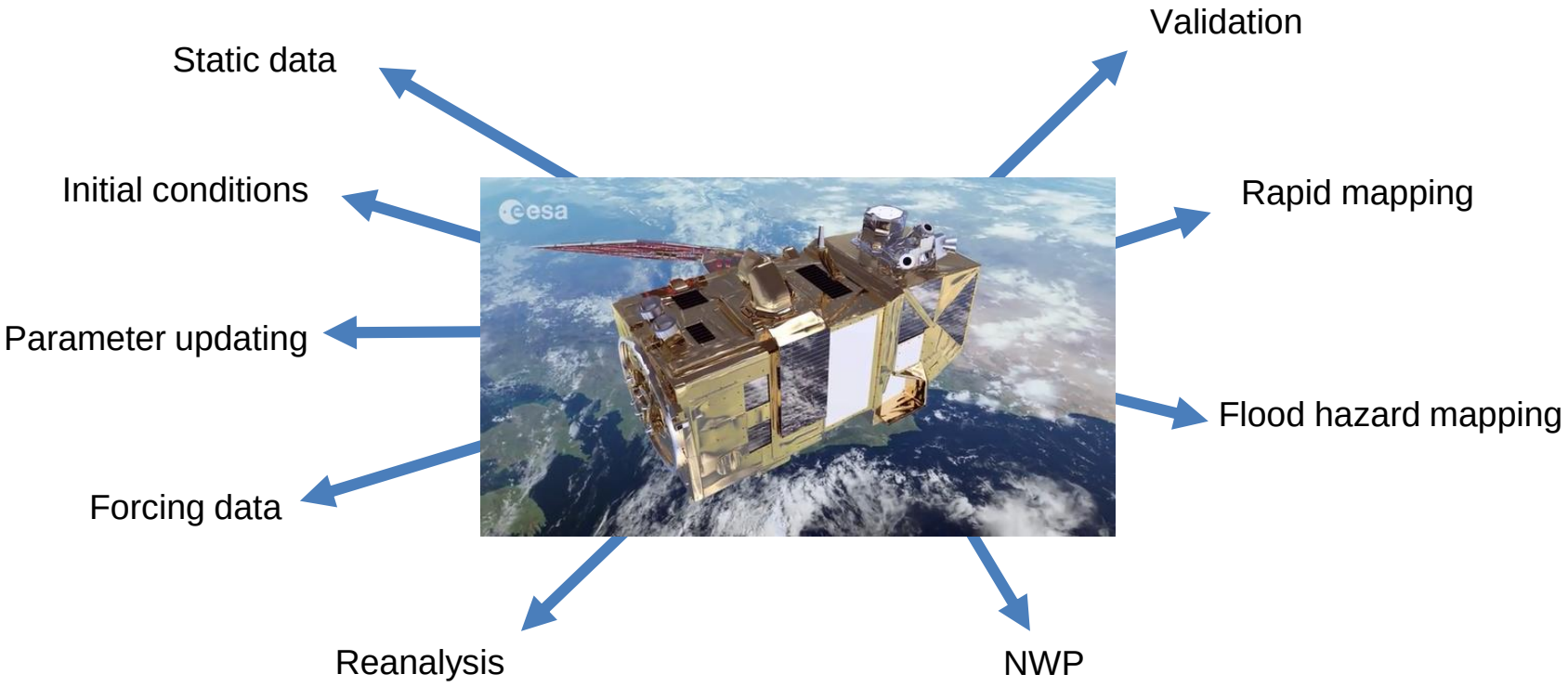
Where are satellite information used in hydrometeorological forecasts?



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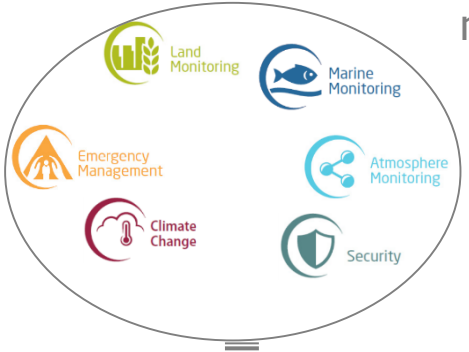
Satellite data in operational flood forecasting (example from EFAS)

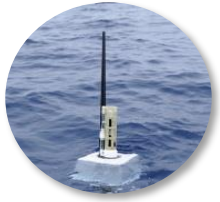
Copernicus
Europe's eyes on Earth

6 services use Earth Observation data to deliver …

Sentinels & Contributing Satellite Missions



In-situ measurements



… added value products

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Satellite data in operational flood forecasting (example from EFAS)

European Commission

COPERNICUS

Emergency Management Service

Copernicus Europe's eyes on Earth

LATEST NEWS : 2018-08-31 | The Copernicus EMS Monitors Forest Fires in Germany

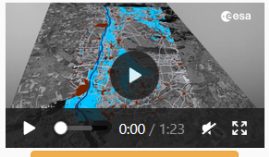
Copernicus Emergency Management Service

Copernicus Emergency Management Service (Copernicus EMS) provides information for emergency response in relation to different types of disasters, including meteorological hazards, geophysical hazards, deliberate and accidental man-made disasters and other humanitarian disasters as well as prevention, preparedness, response and recovery activities. The Copernicus EMS is composed of an on-demand mapping component providing rapid maps for emergency response and risk & recovery maps for prevention and planning and of the early warning and monitoring component which includes systems for floods, droughts and forest fires:

Copernicus EMS - Mapping

The Copernicus EMS - Mapping addresses, with worldwide coverage, a wide range of emergency situations resulting from natural or man-made disasters. Satellite imagery is used as the main datasource. The service covers in particular:

- Floods
- Severe Storms
- Tsunamis
- Volcanic eruptions
- Earthquakes
- Technol. disasters
- Landslides
- Humanitarian crises
- Fires

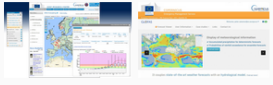


Copernicus EMS - Mapping

European & Global Flood Awareness System

The European and Global Flood Awareness Systems (EFAS & GloFAS) provide complementary flood forecast information to relevant stakeholders supporting flood risk management at national, regional and global level.

The forecasts are derived using in-situ and satellite data as well as hydro-meteorological models and aim at facilitating users with a wide range of added value (medium-range lead time, probabilistic, river basin wide, flash flood indicators etc.) flood forecast products.



EFAS GloFAS

European Forest Fire Information System (EFFIS)

The European Forest Fire Information System (EFFIS) monitors forest fire activity in near-real time and in Europe, Middle East and North Africa and supports wildfire management at national and regional scales.

At the global scale, the JRC leads the development of the Group on Earth Observations (GEO) Global Initiative for the development of a Global Wildfire Information System (GWIS), supported by EU Copernicus and NASA programs.

EFFIS

Drought Observatory

The EMS Drought Observatory (DO) provides drought-relevant information and early-warnings for Europe (EDO) and the globe (GDO). Short analytical reports (Drought News) are published in case of imminent droughts.

EDO and GDO build on open web services and connect drought data providers and users from global to regional levels.

EDO GDO

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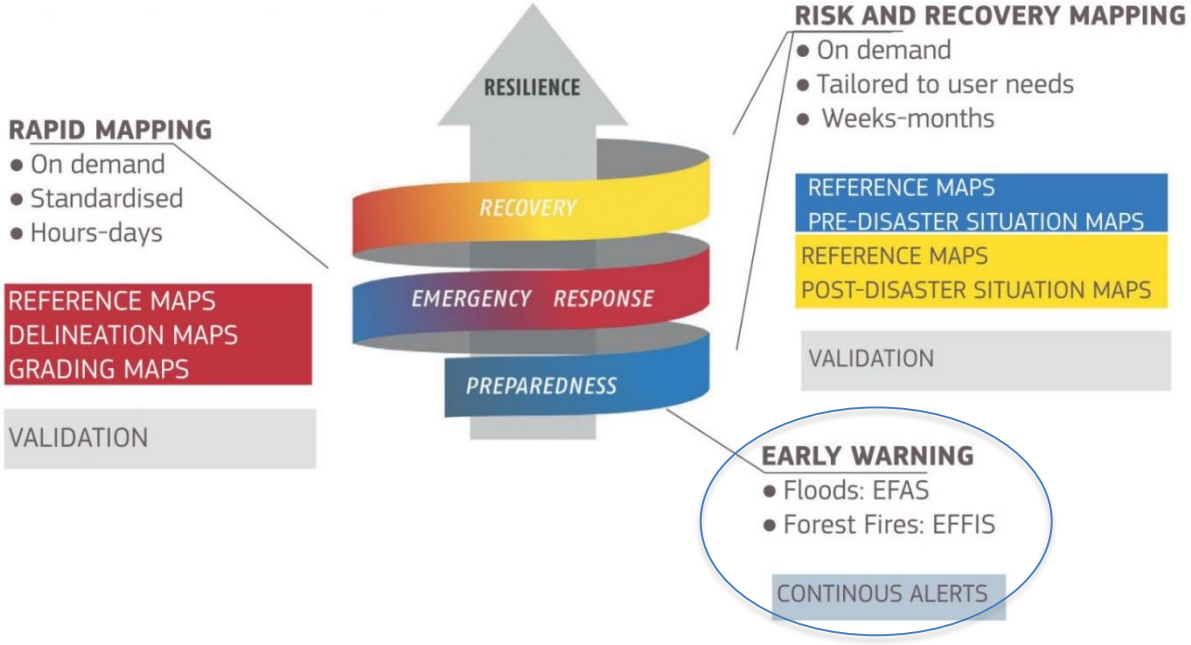
Copernicus Emergency Management Service @ECMWF

EC Copernicus Emergency Management Service CEMS set-up to "*Provide information for emergency response in relation to different types of disasters as well as prevention, preparedness, response and recovery activities*."

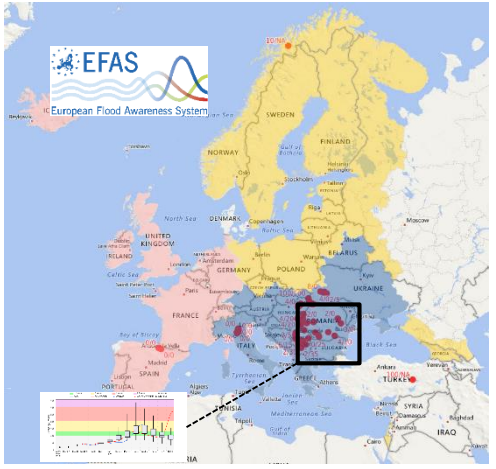


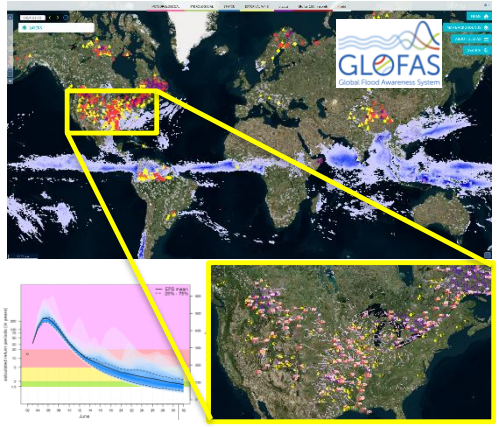
EFAS/GloFAS at a glance

- Early probabilistic flood warnings (restricted in Europe)
- Transboundary system

- In Europe (EFAS), ~ 70 partners (restricted) who provide:
  - Observations
  - Feedback on warning performance
  - Service delivered by the JRC and 4 centres
  - Operational since 2012 (pre-operational 2003)

- In the world (GloFAS)
  - Over 4000 registered users
  - Special partners providing data
  - Service delivered by JRC and ECMWF
  - Operational since 2018 (pre-operational since 2011)





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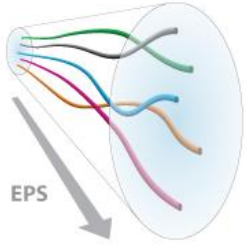
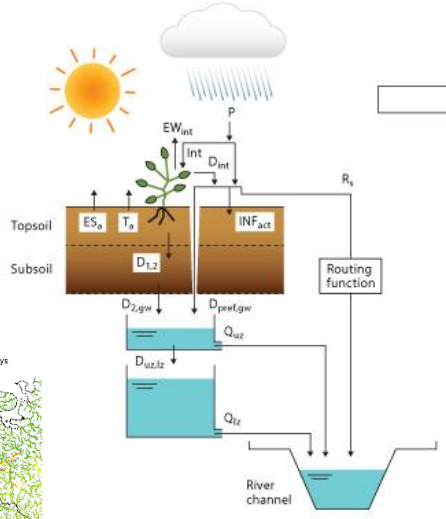
Hydrological forecasting modelling overview

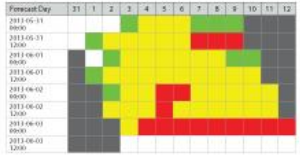


Pre-processing

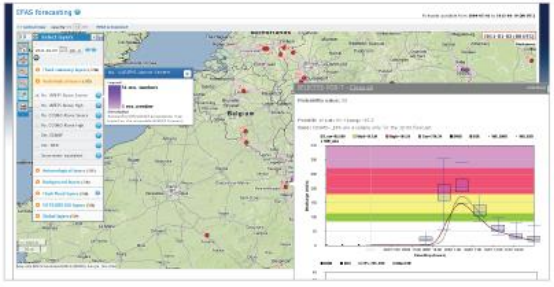
Hydrological model



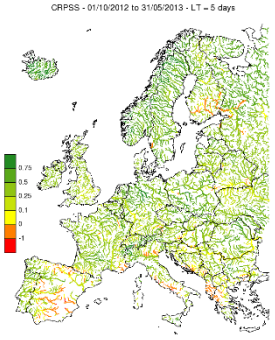
Post-processing



Warning



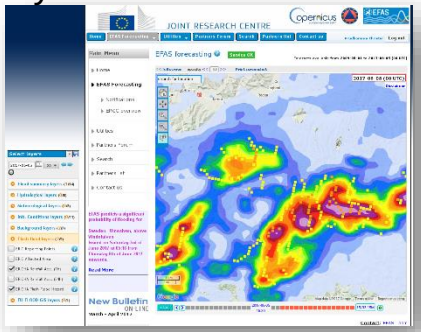
Verification

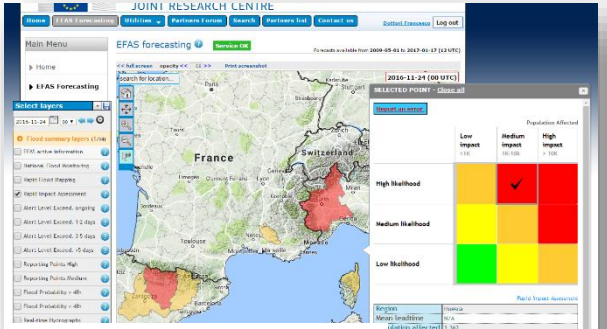


ECMWF

EFAS products

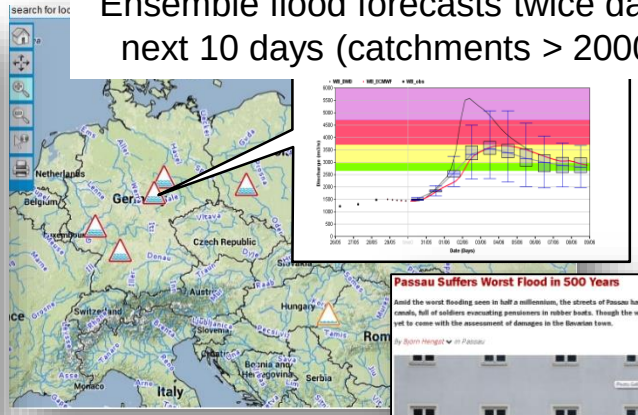
Radar-based flash-flood ‘nowcast’ every 15 minutes for next 3 hours



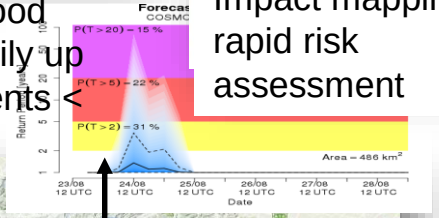


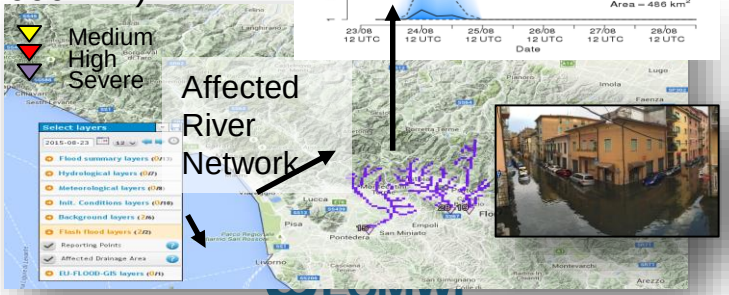
Impact mapping for rapid risk assessment

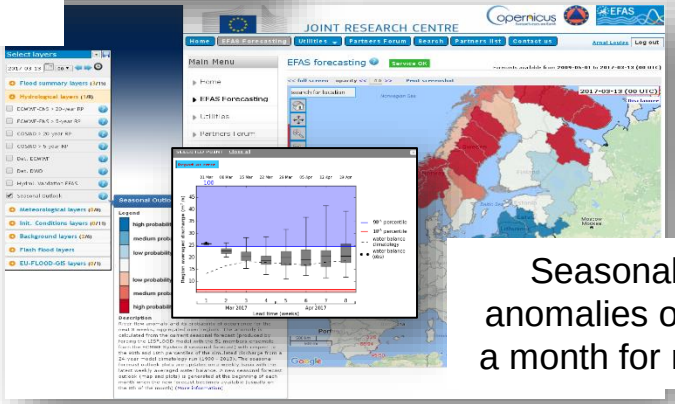
Ensemble flood forecasts twice daily for next 10 days (catchments > 2000km2)



Ensemble Flash-flood forecasts Twice daily up to 5 days (catchments < 2000km2)



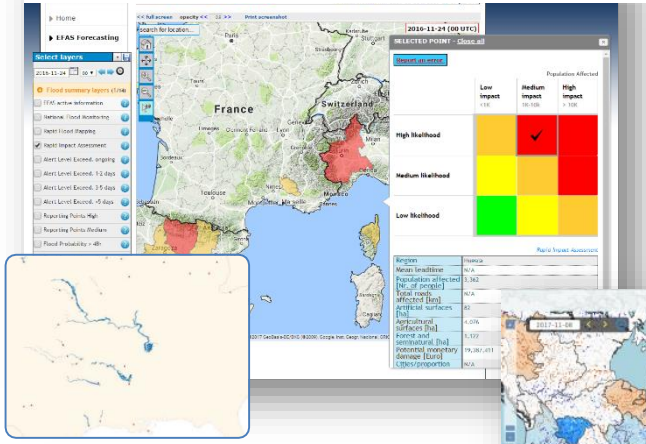




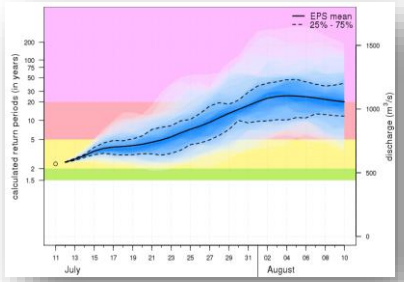
Seasonal hydrological anomalies outlooks once a month for next 8 weeks

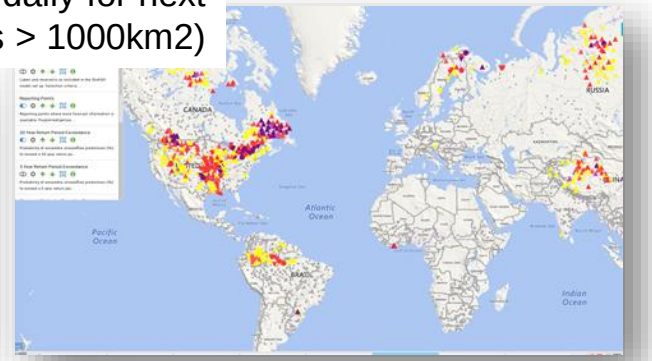
GloFAS products

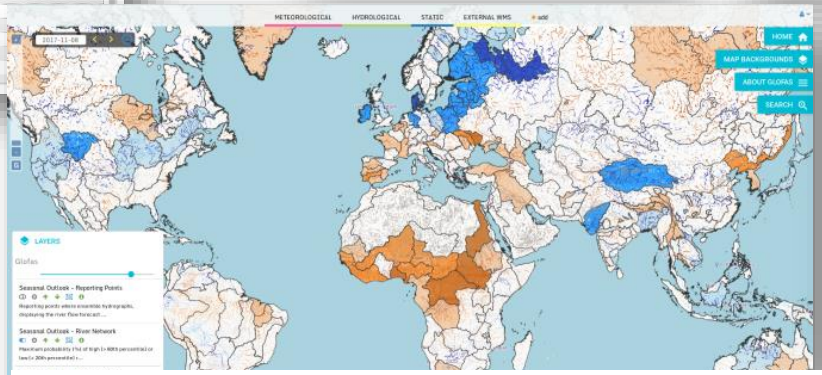
Impact mapping for rapid risk assessment, once daily for next 10 days

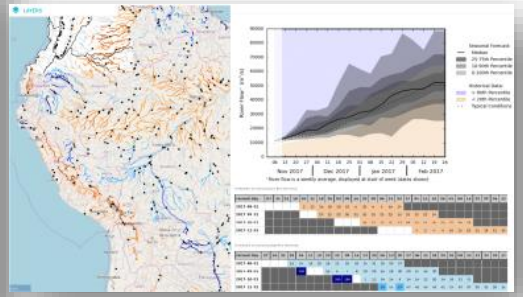


Ensemble flood forecasts daily for next 30 days (catchments > 1000km2)









Seasonal hydrological anomalies outlooks once a month for next 12 weeks

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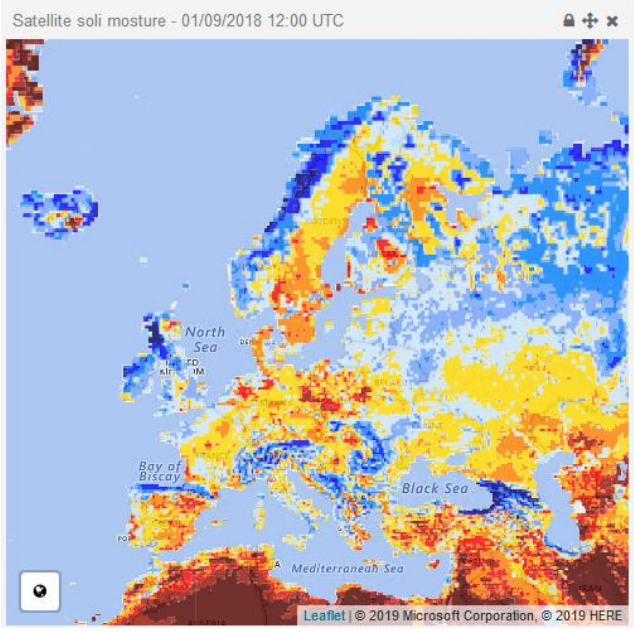
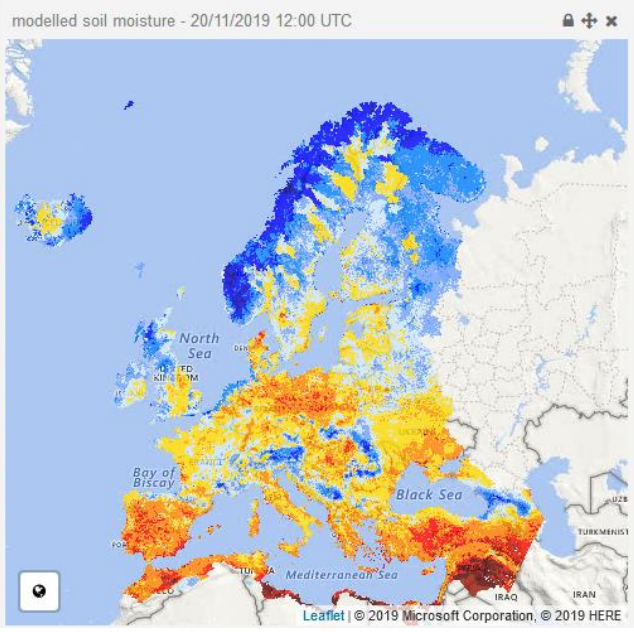
EFAS and HSAF data soil moisture



H SAF H08



Modelled with EFAS

Comparing model and satellite rel. soil moisture in near real time

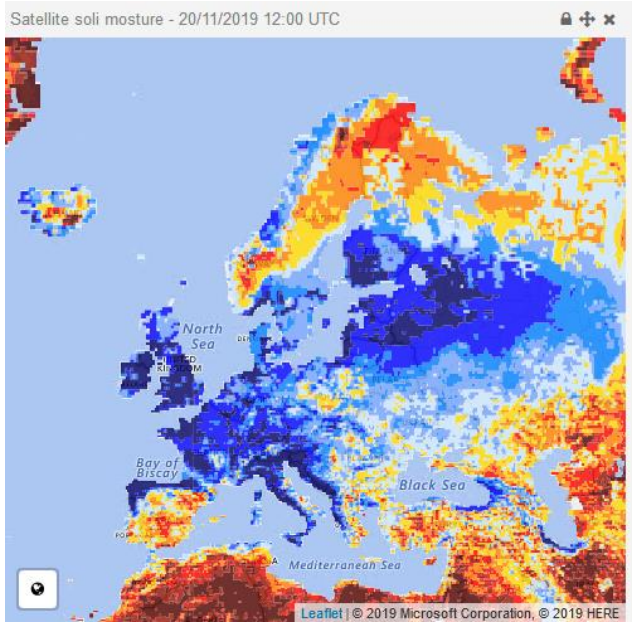
- Purpose I: added value information for the forecaster
- Purpose II: model validation in near real time

- Available since May 2014 for EFAS users

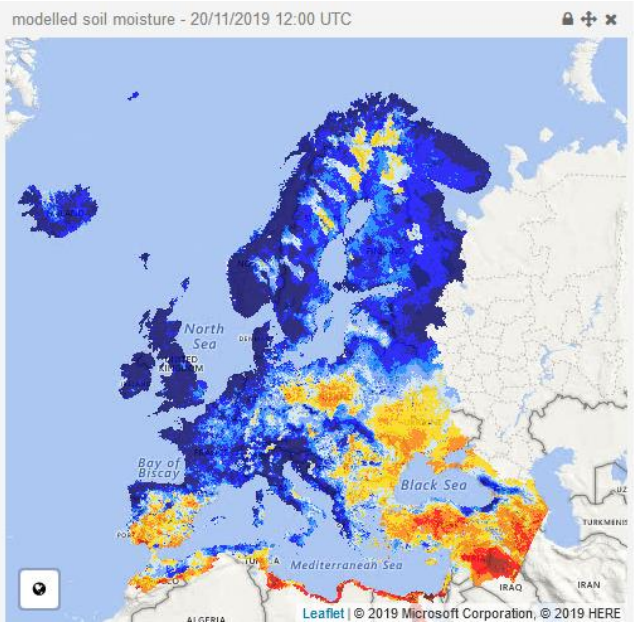
- Example 15 August 2018

ECMWF

EFAS and HSAF data – soil moisture



H SAF H08



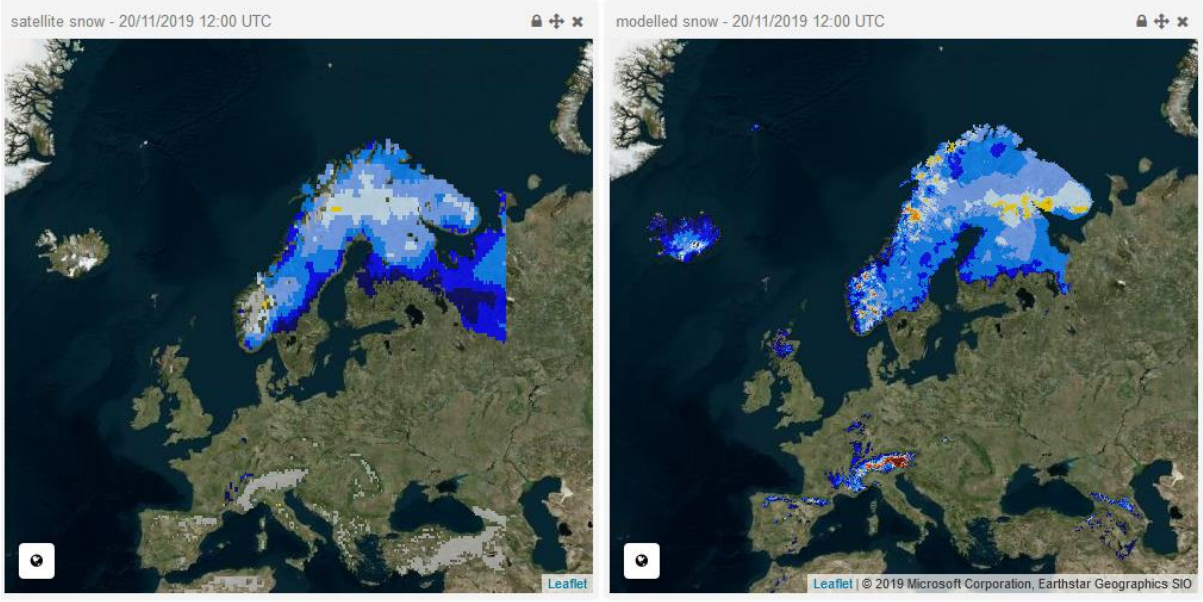
Modelled with EFAS

Comparing model and satellite rel. soil moisture in near real time

- Problem: Soil moisture ≠ soil moisture – products need to be made comparable first (parameterisation of soil layers)
- Masking out non-reliable data

ECMWF

EFAS and HSAF data -snow



H SAF H13

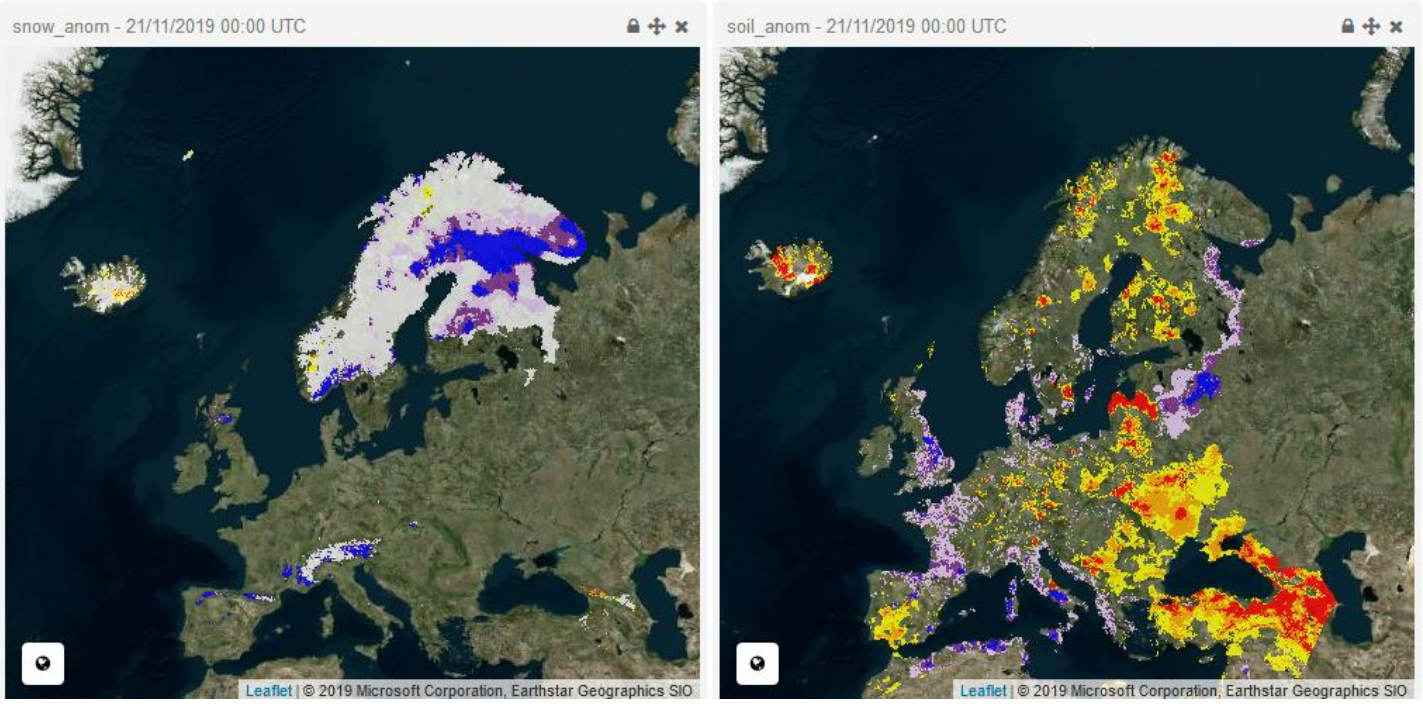
Modelled with EFAS

Comparing model and satellite SWE

Problem: accuracy of satellite SWE (tentatively 20 mm)–quality of the product is dependent on the surface characteristics

ECMWF

What would be very useful – comparable anomalies



Modelled snow and soil moisture anomalies compared with a climatological run (1991-2016)

ECMWF

Satellite data assimilation in EFAS forecasts – case studies

- **Snow**: Assimilation of snow cover data into LISFLOOD using particle filter. MODIS snow cover data was transformed to SWE. Tested in the Morava river basin in 2013:
  - **Main findings: improvements for simulated snow cover in all cases but only improvements in discharge for smaller upstream basins –larger basins showed only limited improvements –effect on forecasts not tested**
- **Soil moisture:** Assimilation SMOS/ASCAT/AMSR-E soil moisture and 7 discharge stations using Ensemble Kalman filter in the Upper Danube in 2014
  - **Main findings: Most positive results from discharge assimiliation, which improved forecasting skill (35%). Soil moisture contributed with a 10% increase**
- **New study on using SMOS ongoing, see talk on Wednesday**

ECMWF

Pros and cons for use of remotely sensed data in hydrology

- Satellite products provide invaluable information in NRT
- Can be used for validation and diagnosis of model errors
- Improves hydrological variables
- Improves meteorological forecasts
- Data from areas with no station data
- Monitoring and mapping of events during a crisis
- Post-event and recovery

- Not always available in real-time
- No clear-cut improvement of discharge forecasts
- Representativeness of the data
- Not always available in all areas
- Computational intensive
- Preference for traditional observations
- Long time series needed for hydrological calibration

ECMWF

Challenges and opportunities ahead

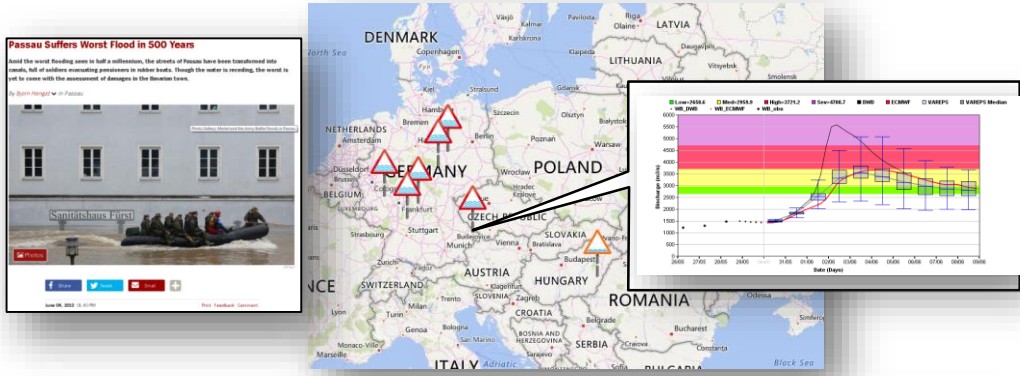
- Better use of machine learning and AI
- Probabilistic inundation forecasting
- Novel ways of using satellite data: not necessarily as proxy for observations
- Ensemble assimilation techniques including the uncertainty
- New satellite missions: SWOT – a game changer for hydrology?
- Assimilating “soft data”, crowd sourced information
- Event-based assimilation and rapid flood risk assessment

www.hepex.org www.efas.eu www.globalfloods.eu

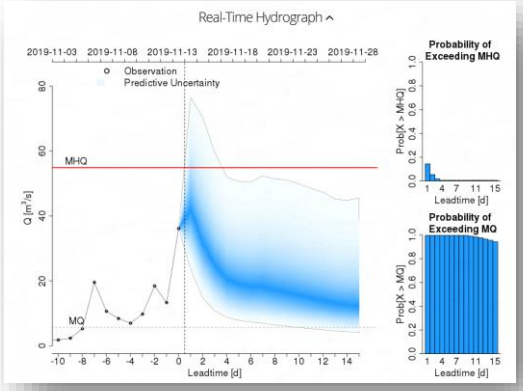
EFAS Medium Range - Flood Warning and Alerts

Donau at Passau, Germany 30 May 2013

- **Flood summary layers**
  - European coverage; Twice daily up to 15 days
  - 4 Meteorological forecasts
  - Different flood probability
  - EFAS active information/notifications (activated by EFAS duty forecaster)

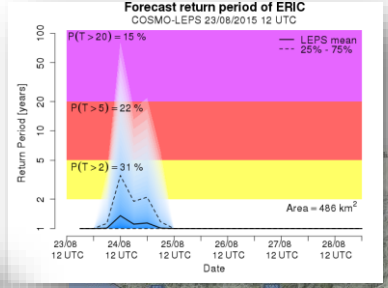


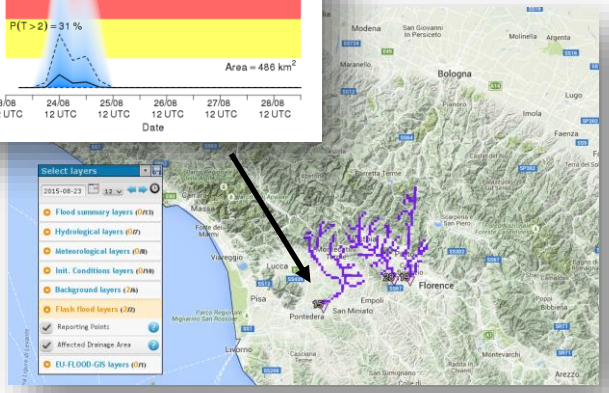
- **Post-processed flood forecasts layers**
  - Over 500 points over Europe; produced twice daily up to 15 days
  - Statistical correction where real-time observed discharge is provided



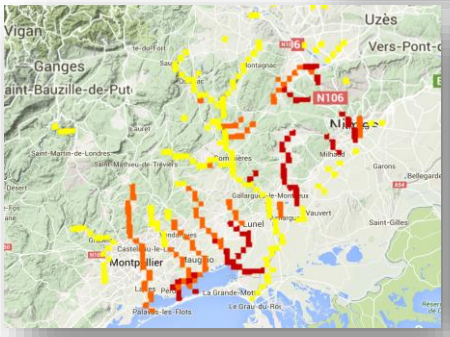
EFAS Short Range – Flash floods

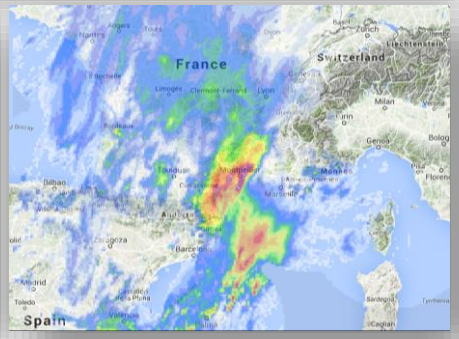
- **Flash Flood alert layer**
  - European coverage; Daily up to 5 days
  - Probabilistic forecasts for given return periods, affected areas and accumulated runoff
  - Catchment size up to 2000km^2





- **Nowcasting layer**
  - Opera radar coverage; every 15min up to 3 hours
  - Precipitation field image and flash flood indices on 1-km river network

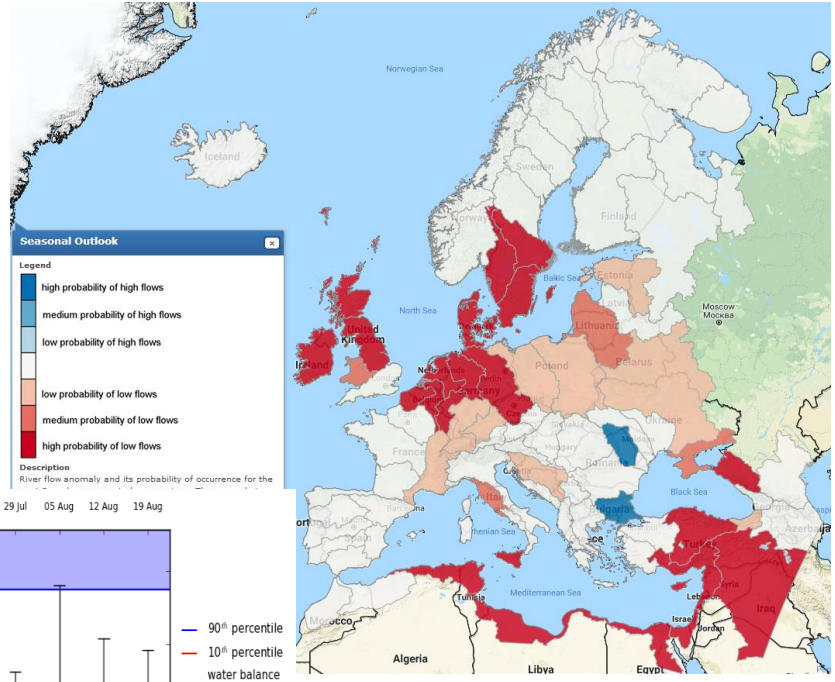


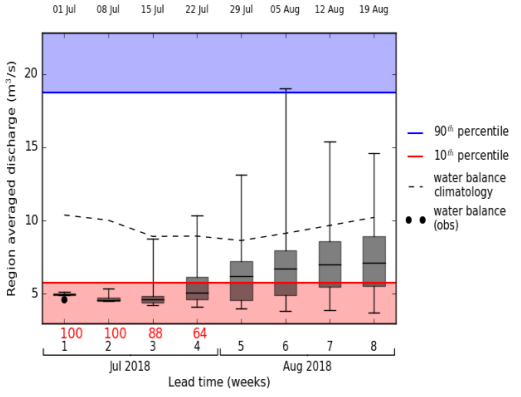


ECMWF

EFAS Seasonal Range - EFAS-Seasonal

- **Seasonal outlook layers**
  - European coverage, issued once a month lead-time of 8 weeks
  - Catchment-based probability of high/low flow occurrence
  - Weekly averaged hydrographs with ensemble prediction
- **Sub-seasonal to seasonal outlook layers**
  - European coverage, issued twice weekly lead-time of 8 weeks
  - Catchment-based probability of high/low flow occurrence
  - Weekly averaged hydrographs with ensemble prediction



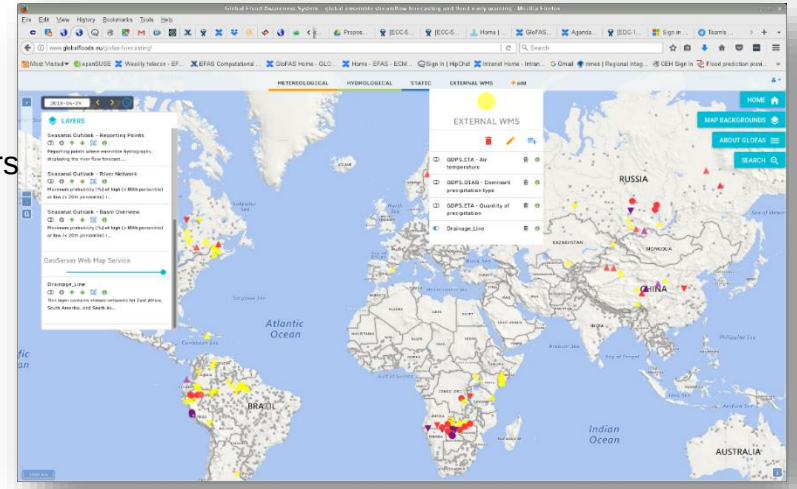


Web interface & Data Access

- Web Interface
  - Forecast viewer for registered users (for all GloFAS; eligible partners EFAS)
  - Quick overview of hydro-meteorological outlooks, multiple layers
  - Search and zoom on locations
  - Web services for users to import/export layers to viewer
  - Background information, case studies and video tutorials
  - In-focus news and twitter feeds

    https://www.efas.eu

    www.globalfloods.eu



- Data Access
  - Real-time forecasts, climatology, past-forecasts (all GloFAS; eligible partners EFAS)
  - On-demand ftp service
  - EFAS available in MARS archive and CDS with 30-day delay
  - GloFAS data available in real-time in CDS