The potential use of passive microwave satellite data within the Copernicus Emergency Management Service - Floods

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With contributions from the EFAS team

Outline

1. What is CEMS?
   - Flood forecasting service: EFAS/GloFAS
2. Hydrological Modelling
   - Hydrological model vs LSM
3. How can satellite data help?
   - Parameterisation
   - Assimilation

CEMS Branches

European Commission

COPERNICUS

Emergency Management Service

Copernicus Europe's eyes on Earth

LATEST NEWS : 2017-11-20 | Copernicus EMS Monitors the Impact of Floods in Attika, Greece

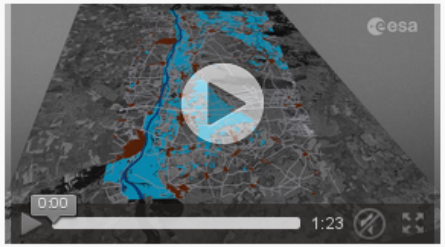
Copernicus Emergency Management Service

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. Three modules constitute the Copernicus EMS:

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
- Tsunamis
- Earthquakes
- Landslides
- Fires
- Severe Storms
- Volcanic eruptions
- Technological disasters
- Humanitarian crises



Copernicus EMS - Mapping

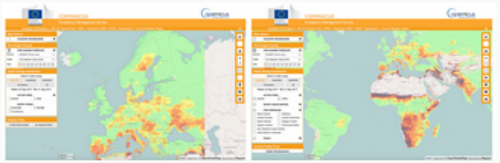
European Flood Awareness System

The European Flood Awareness System (EFAS) is the first operational system that monitors and forecasts flood events across Europe. It provides its partners (national/regional authorities, as well as the European Commission's Emergency Response Coordination Centre) with a wide range of complementary, added value flood early warning information including related risk assessments up to 10 days in advance.

European Flood Awareness System

European Forest Fire Information System (EFFIS) and Global Wildfire Information System (GWIS)

The European Forest Fire Information System (EFFIS) monitors forest fire activity in near-real time and archives historical information on forests fires in Europe, Middle East and North Africa. The Global Wildfire Information System (GWIS) is a joint initiative of the Copernicus EMS and the Group on Earth Observations (GEO) work programs aiming at monitoring wildfire occurrence and impact at the global level. Both, EFFIS & GWIS, support wildfire management at national, regional and global levels.



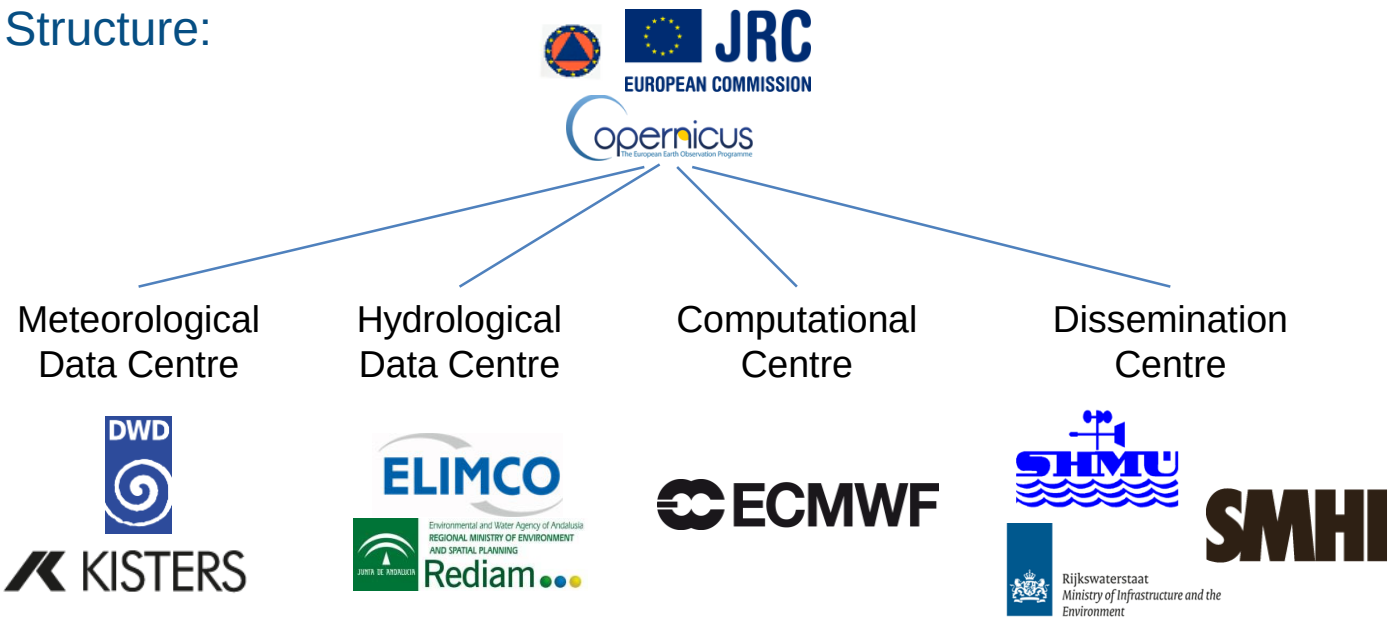
Access to EFFIS and GWIS application are available at:

EFFIS and GWIS Systems

EFAS - European Flood Awareness System

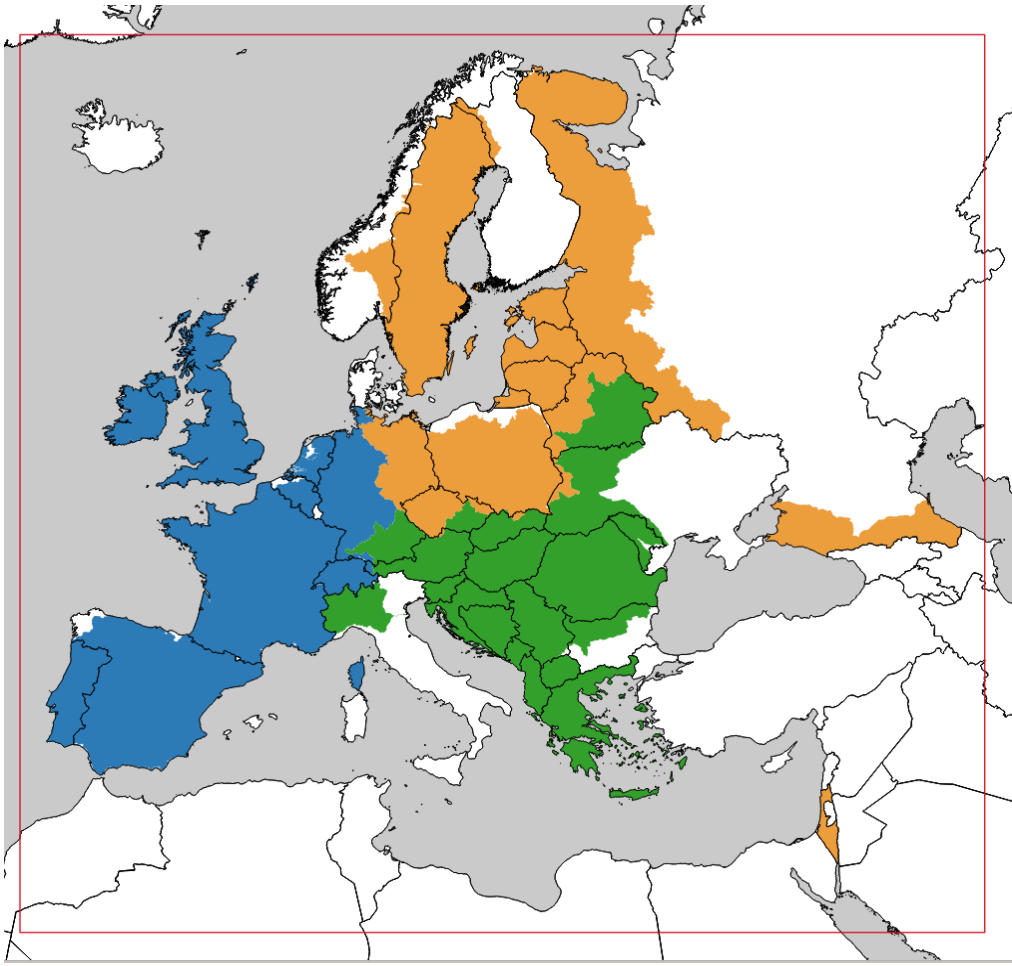
Copernicus Emergency Management Service - Floods

Structure:



EFAS – European Flood Awareness System

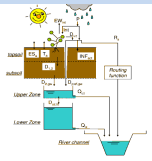
- Registered user only
- National hydro-met services
  - Regional cross-border dimension
  - Lead time up to 15 days (8 weeks) through probabilistic information
  - Network of operational service
  - Novel tools/ techniques/ data (e.g. satellite data)
- European commission
  - Comparable information across Europe
  - Tool for anticipation of crisis management:
  - Civil Protection aid assistance during crisis
  - COPERNICUS Mapping Service



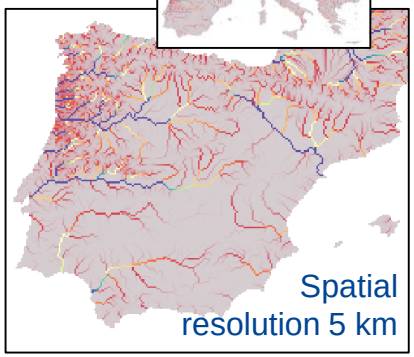
EFAS Schematic Overview

2 - Model

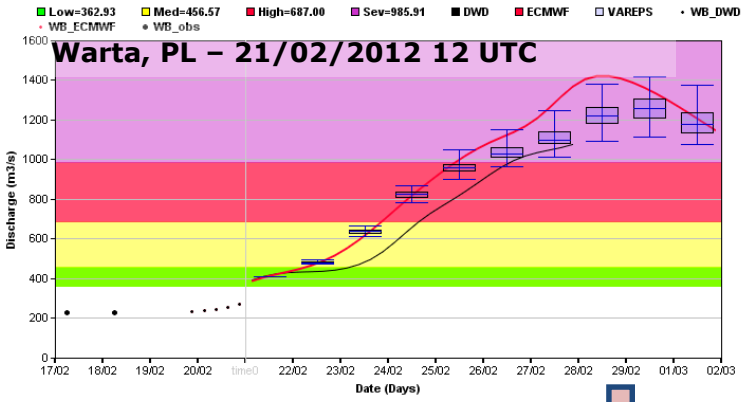
LISFLOOD



European twice daily discharge



3 – Products



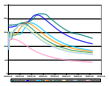
EFAS user interface

Alert email

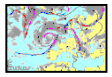
4 – Alerts

1- Data (obs and NWP)

Real-time data (EU-FLOOD-GIS/ETN-R)



Historical Data



Static Data

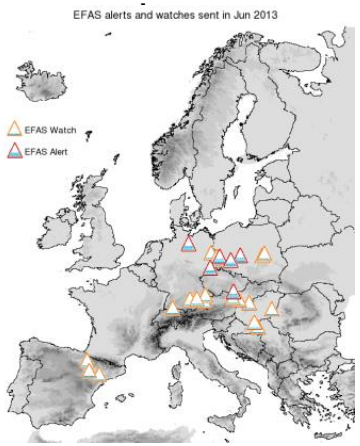
Europ. Data Layers

Meteo – Data / forecasts

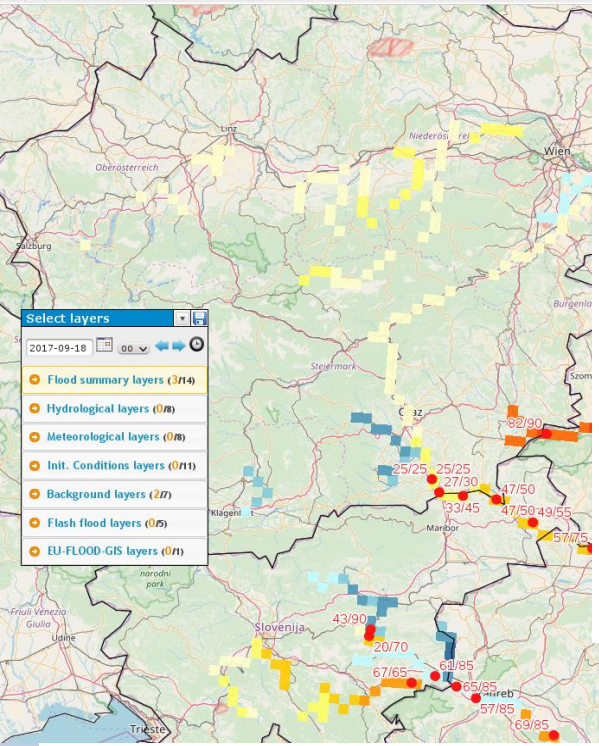
Expert Knowledge of Member States

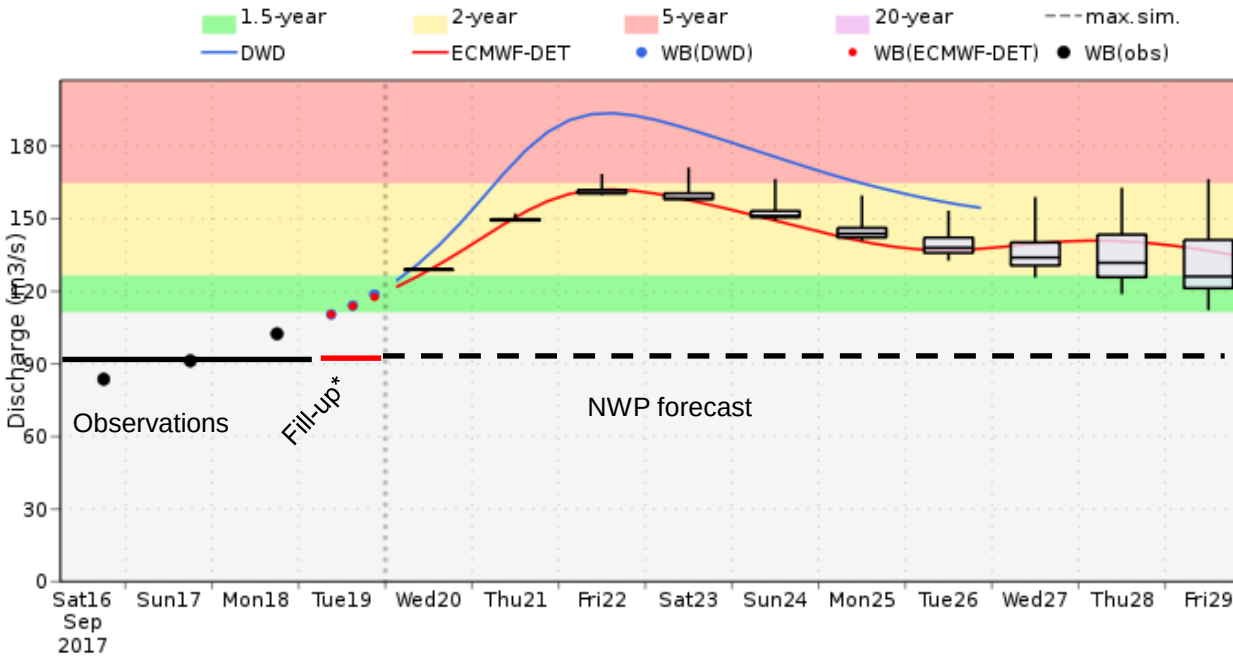
5 – Possible actions

EFAS partner



How EFAS Forecasts are Produced





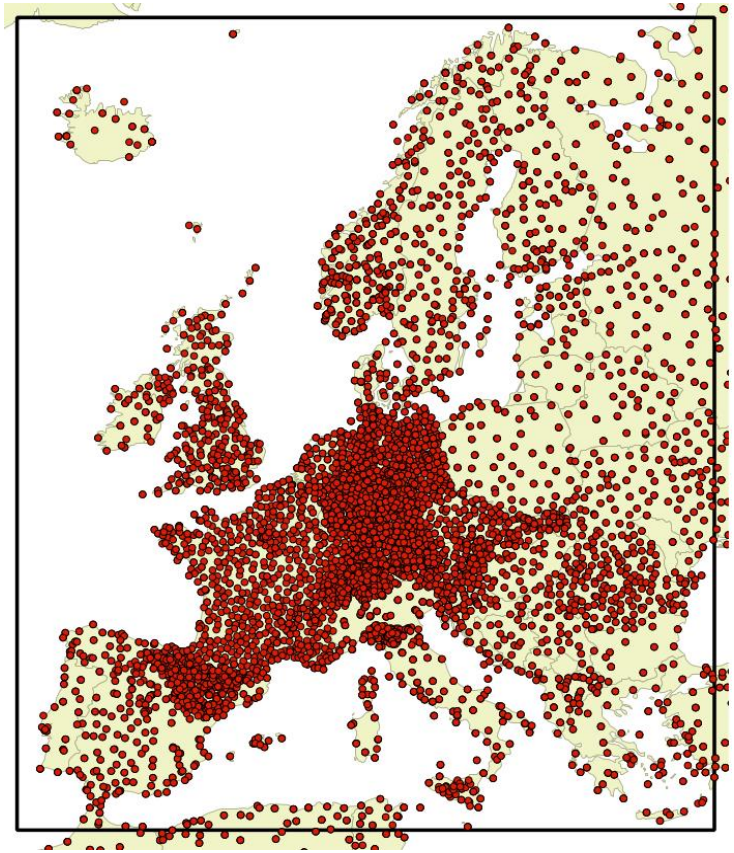
*ECMWF High Res

EFAS: Input Data - Observations

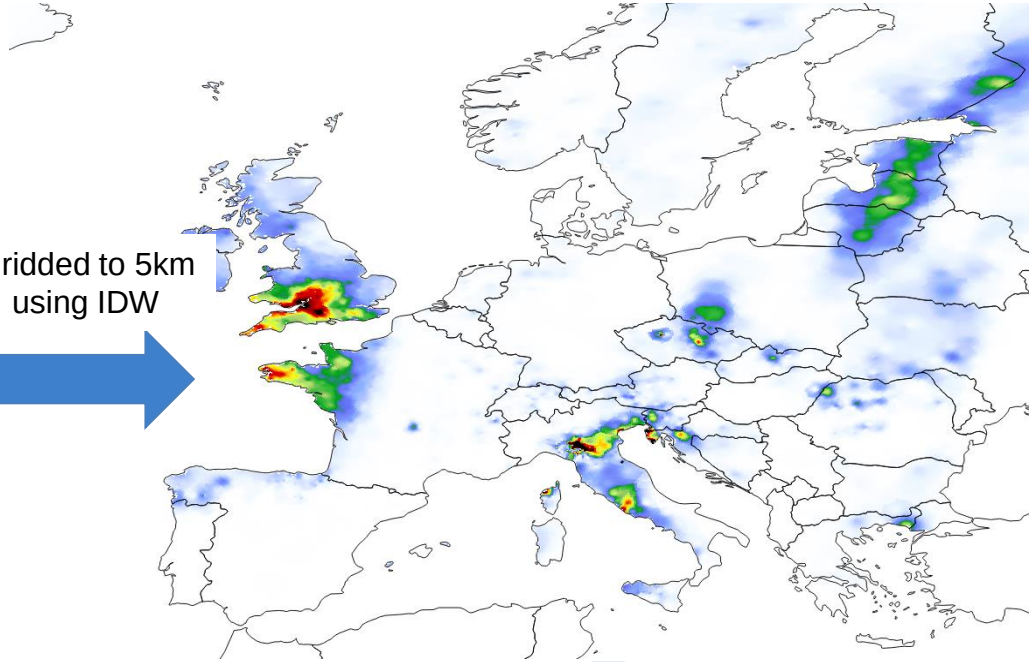
Observations: Precipitation and Temperature

Processed by Meteorological Data Centre partner

- >800 observations
- Aggregated daily



Gridded to 5km using IDW



Transferred to ECMWF by FTP

EFAS: Input Data – NWP Forecasts

NWP Forecast Data:

4 different NWP systems

Product	Spatial Resolution (km)	Time step (hours)	Vertical layers	Maximum lead time (days)	Number of members
ECMWF-HRES	9km	6	137	10	1
ECMWF-ENS	18km	24	91	15	51
DWD	7km up to day3 then ~30km	6	40	7	1
COSMO-LEPS	7km	6	40	5.5	20

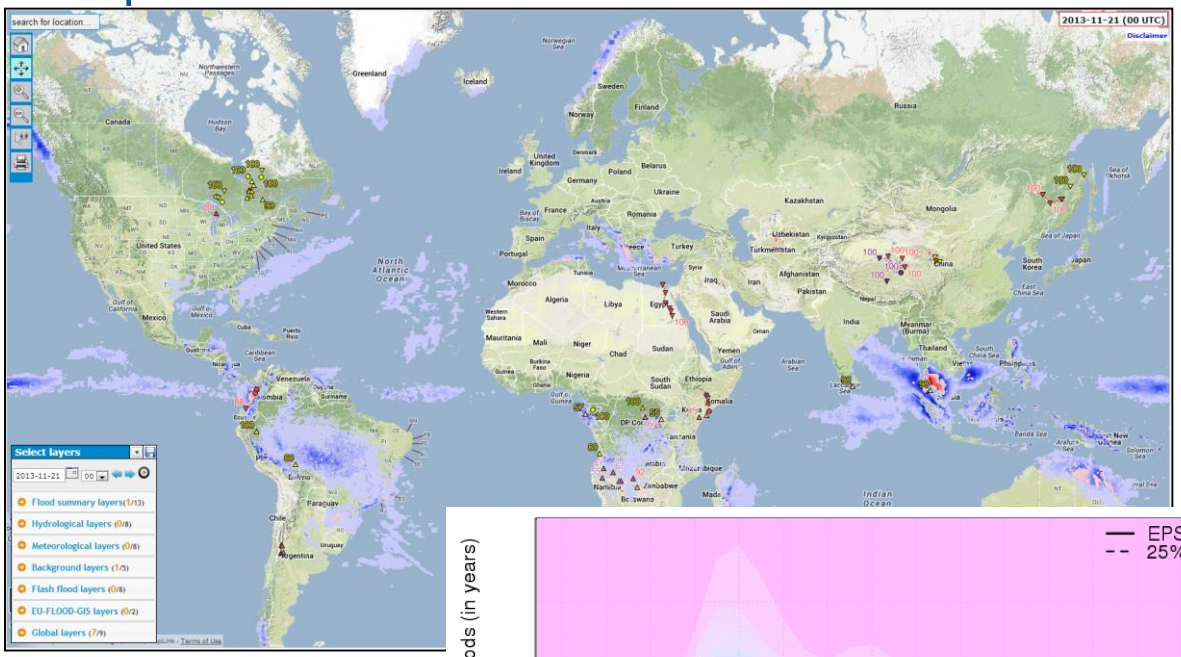
Run twice daily using 00 & 12 UTC forecasts

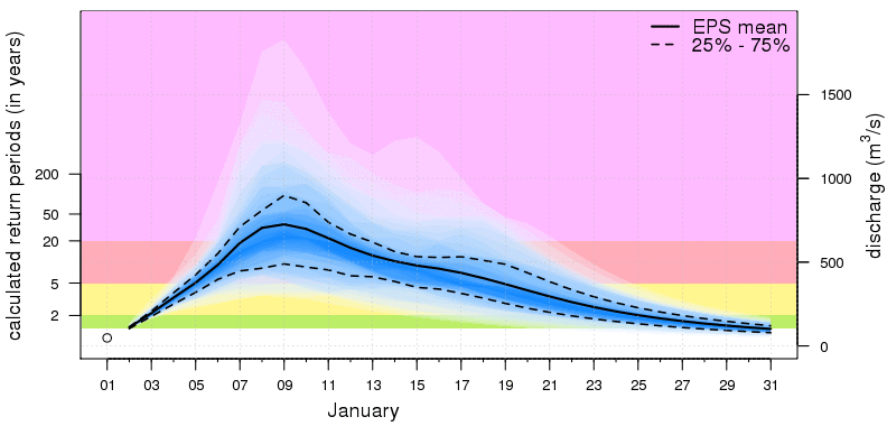
GloFAS: Global Flood Awareness System

Global-scale ensemble-based flood forecasting system

A collaboration product between the JRC and ECMWF

Pre-operational since 2011





Forecast frequency:
Updated daily

Forecast lead time:
Up to 30 days
(+new seasonal product up to 4 months)

Forecast variable:
River Flow

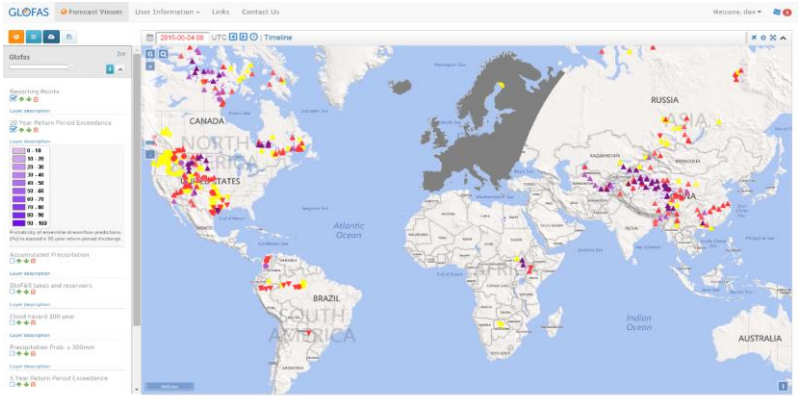
Forecast type:
Probabilistic

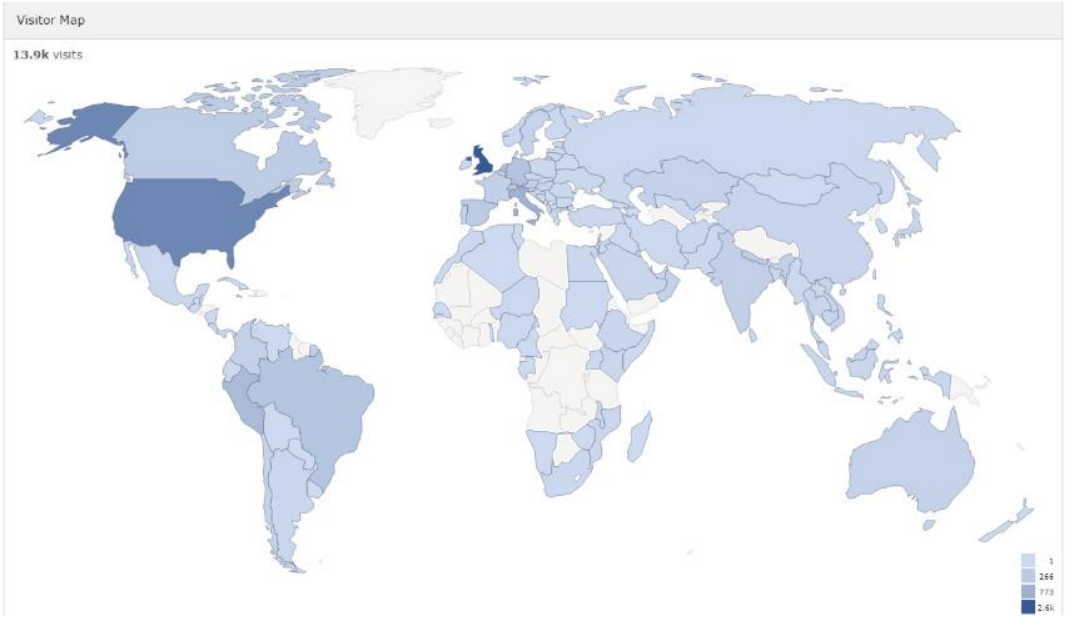
Forecast resolution:
Daily and 0.1 degree

Who?

European Commission

- GloFAS has >1600 registered users from:
  - Public authorities
  - NGOs
  - Private sector
  - Academic/training/research institutions





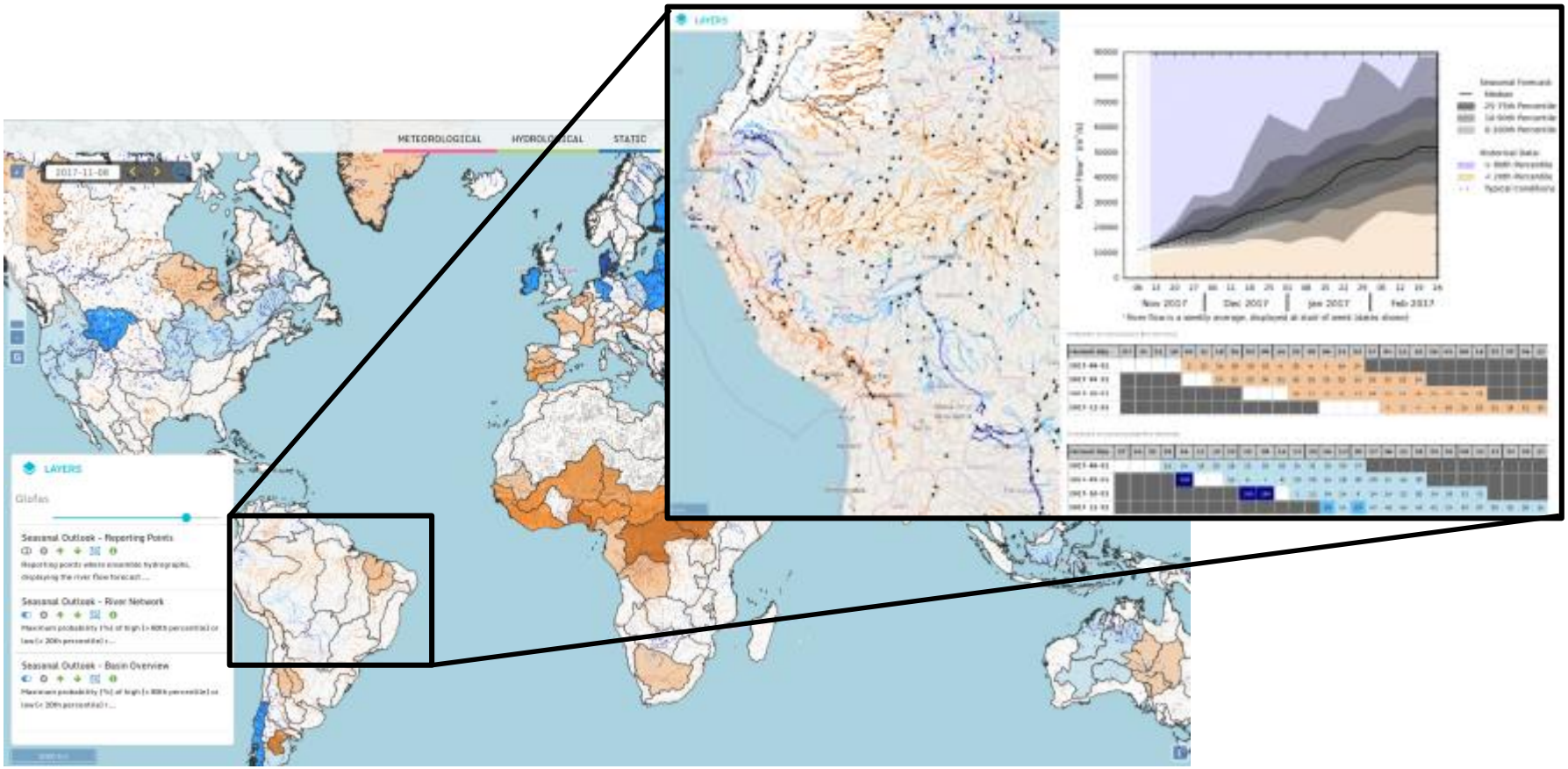
ECMWF
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

GLOFAS
Global Flood Awareness System

Copernicus
Europe's eyes on Earth

GloFAS-Seasonal: 3 New GloFAS "Seasonal Outlook" Layers

- Basin Overview
- River Network
- Reporting Points (Hydrographs & Persistence Diagrams)



Hydrological modelling within EFAS and GloFAS

EFAS
European Flood Awareness System

GLOFAS
Global Flood Awareness System

Raster based hydrological model (**LISFLOOD**)

1D flow routing (**LISFLOOD**)

5Km grid – **Extended Europe**

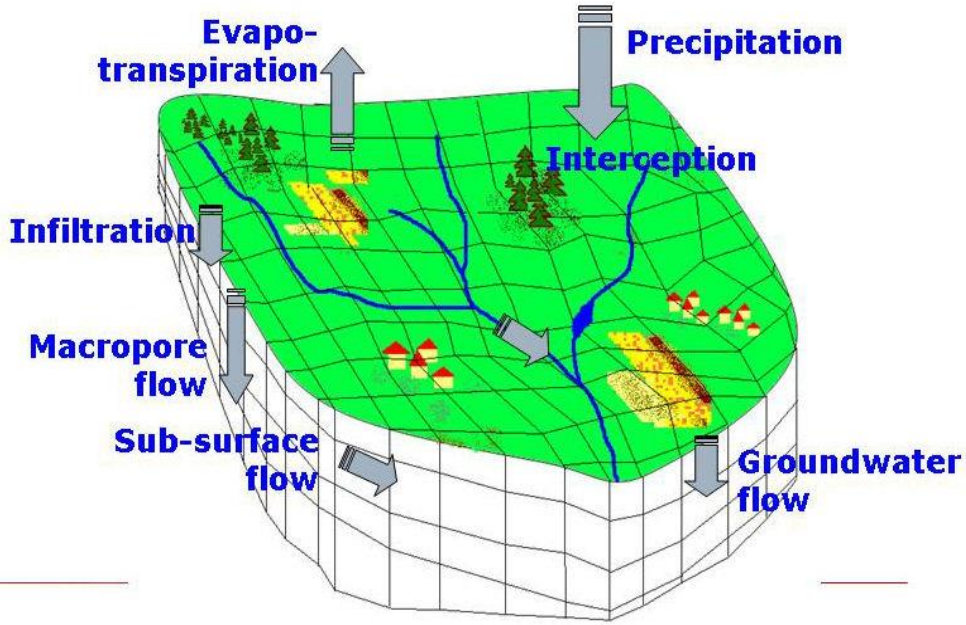
Runoff generated by the grid based land surface model (**HTESSEL**)

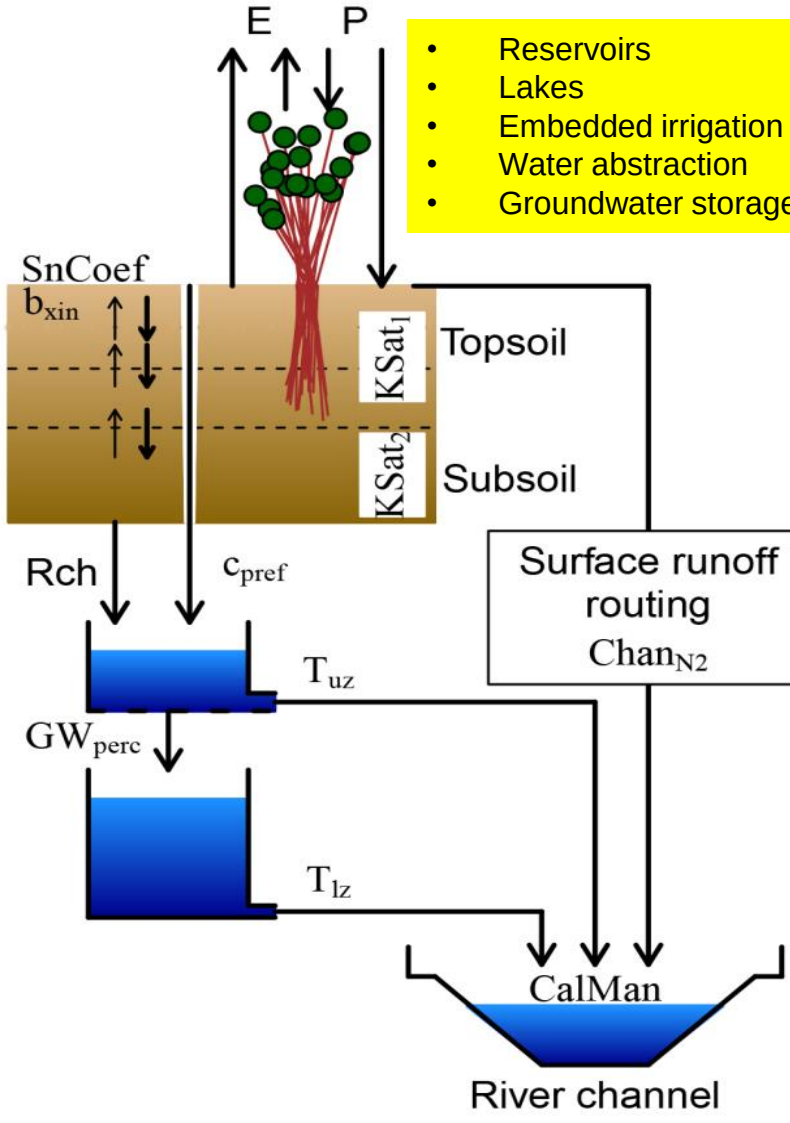
1D flow routing (**LISFLOOD**)

~10Km grid - **Global**

EFAS: Hydrological Model - LISFLOOD

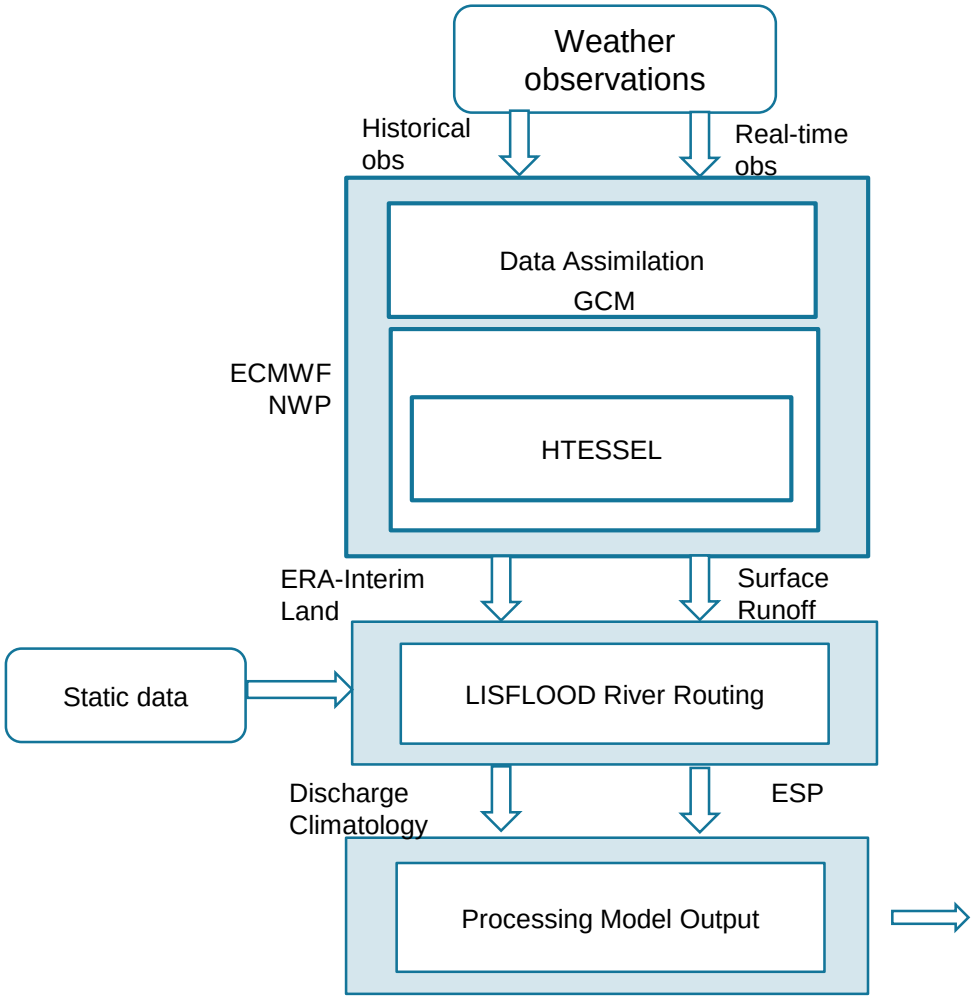
- Run in Python using PCRaster Framework
- Calibrated at 693 locations (1994-2002)
- Validated from 2003-2012
- 12 parameters calibrated using NSE
- Explanatory power in 90% of catchments



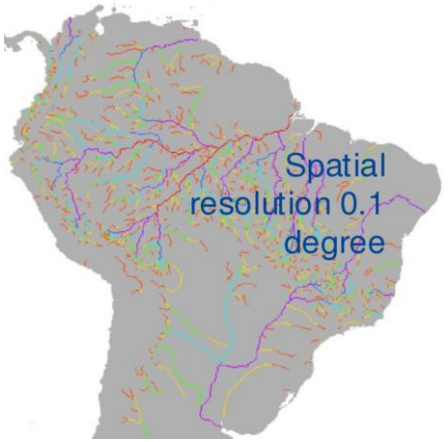


- Reservoirs
- Lakes
- Embedded irrigation
- Water abstraction
- Groundwater storage

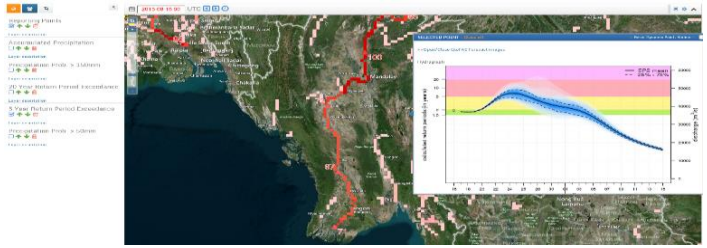
GloFAS: Hydrological Modelling - HTESSEL



Outputs

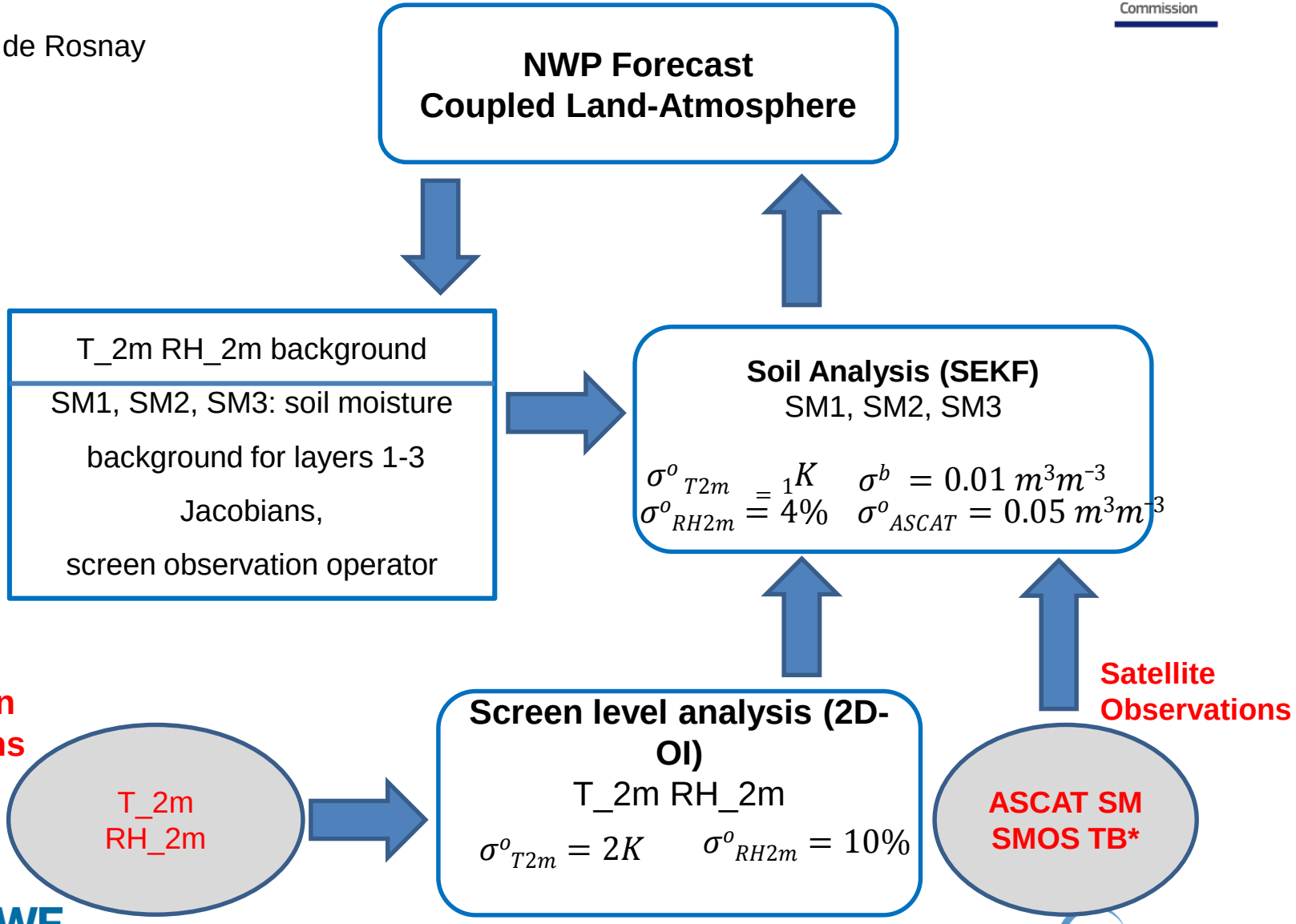


River discharge up to 30 days on 0.1 degree Probabilistic forecasts



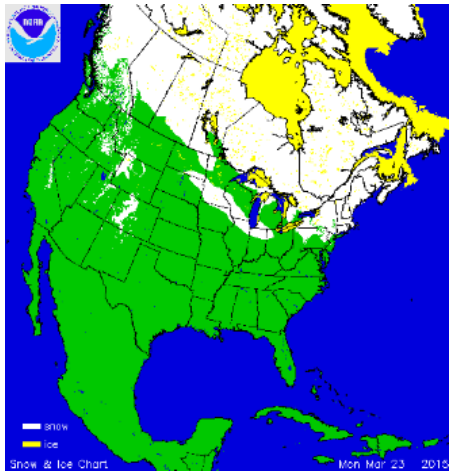
HTESSEL + Soil Moisture Data Assimilation

slide from P. de Rosnay



HTESSEL + Snow Cover Data Assimilation

- Snow cover data from NOAA NESDIS/IMS at 4km
  - Constructed from SSM/I, AVHRR and in-situ data
- Operationally no SWE assimilation into NWP



Next Steps for Global Hydrological Modelling

(Global) LISFLOOD

- Set up and run LISFLOOD globally
- Required data:
  - Soil properties, channel geometries, lakes/reservoirs, water usage
- Requires extensive calibration
  - Does sufficient data exist?

and/or

HTESSEL

- Already set up globally
- Data assimilation already built-in
- Bring hydrology within earth-system modelling framework
- Need to account for lateral movement of surface & sub-surface flow

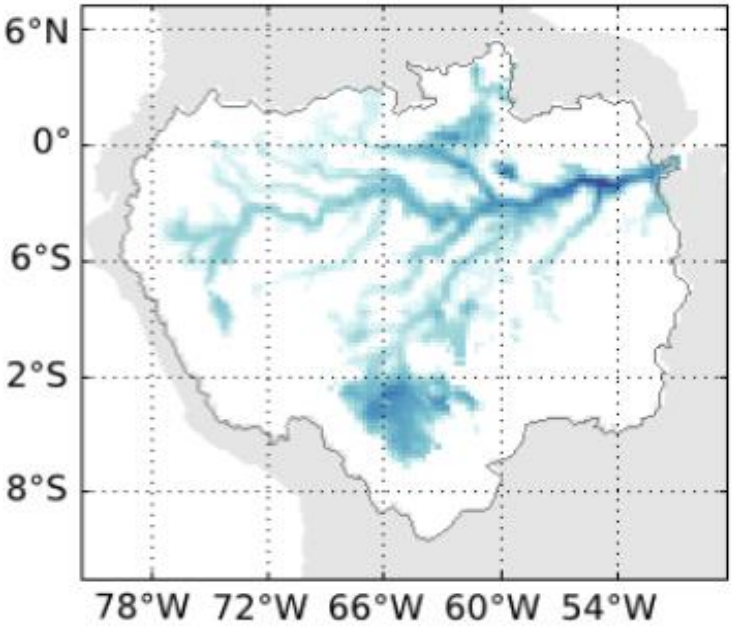
Availability of hydrological data from satellite sensors could influence the direction taken (i.e. if DA offers significant improvements)

How could passive microwave sensors help?

1. Flood extent

- Flooded/non-flooded state could be used as switch in soil moisture scheme
- A volumetric application?

1km work of Pekel *et al.,* 2016 could give fascinating insight into hydraulic functioning of floodplains

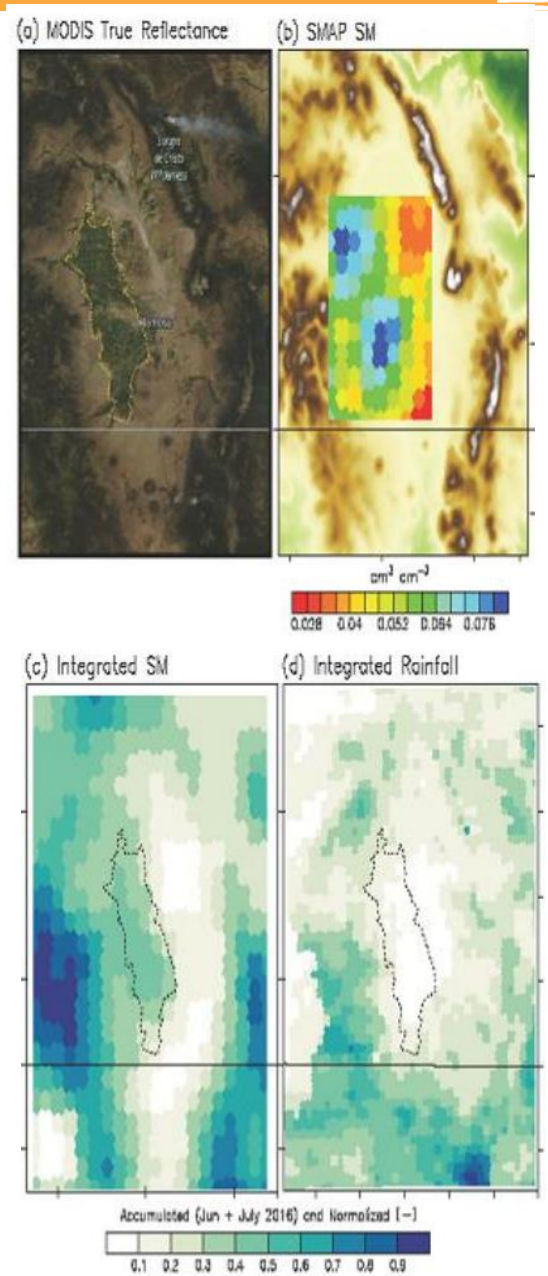


Parrens *et al.,* 2017

How could passive microwave sensors help?

2. Irrigation / Water Use

- Currently GloFAS assumes rivers are mostly naturally flowing
  - Some reservoirs are included, with limited representation
  - Means flows can be over-estimated
- Assessing deviation of SM from precipitation trends to identify irrigation patterns [Lawston *et al.*, 2017]
  - Could build up a global irrigation 'climatology' used as an input in hydrological model



Lawston *et al.*, 2017

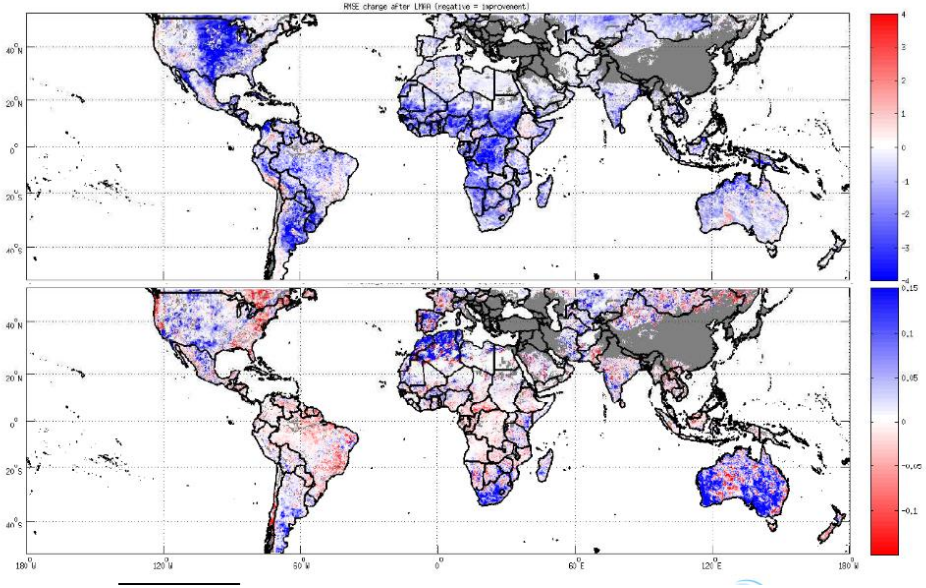
How could passive microwave sensors help?

3. Rainfall

- Work of Pellarin *et al.,* to use SMOS SM to correct GPM / IMERG rainfall estimates
- Could be used instantaneous flash flood threat product
  - Similar to WMO FFGS
  - Use rainfall as input to river routing module

ΔRMSE

ΔR²



Pellarin *et al.,*

Summary

Current passive microwave satellite usage in GloFAS:

- HTESSEL assimilation of soil moisture and snow cover

Possibilities for future use

- Flooded fraction
- Irrigation/water use
- Rainfall

Requirements of passive microwave data

- If using for data assimilation then NRT availability
- Spatial resolution – future move towards 10 km would match the current GloFAS resolution
- Legacy – security of follow-on missions?

More on EFAS/GloFAS

- http://www.globalfloods.eu
- http://www.efas.eu

@globalfloods_eu

GLOFAS

Global Flood Awareness System