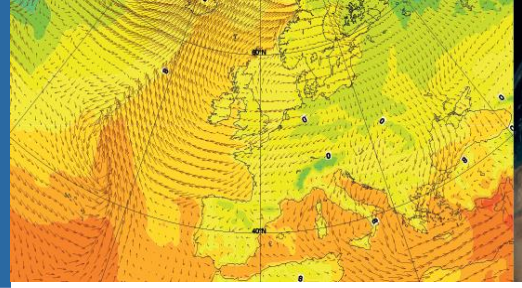



ECMWF and Copernicus outputs in support of multi-hazard Early Warning Systems in Member and Co-Operating States

David Richardson
Head of Evaluation Section, Forecast Department, ECMWF

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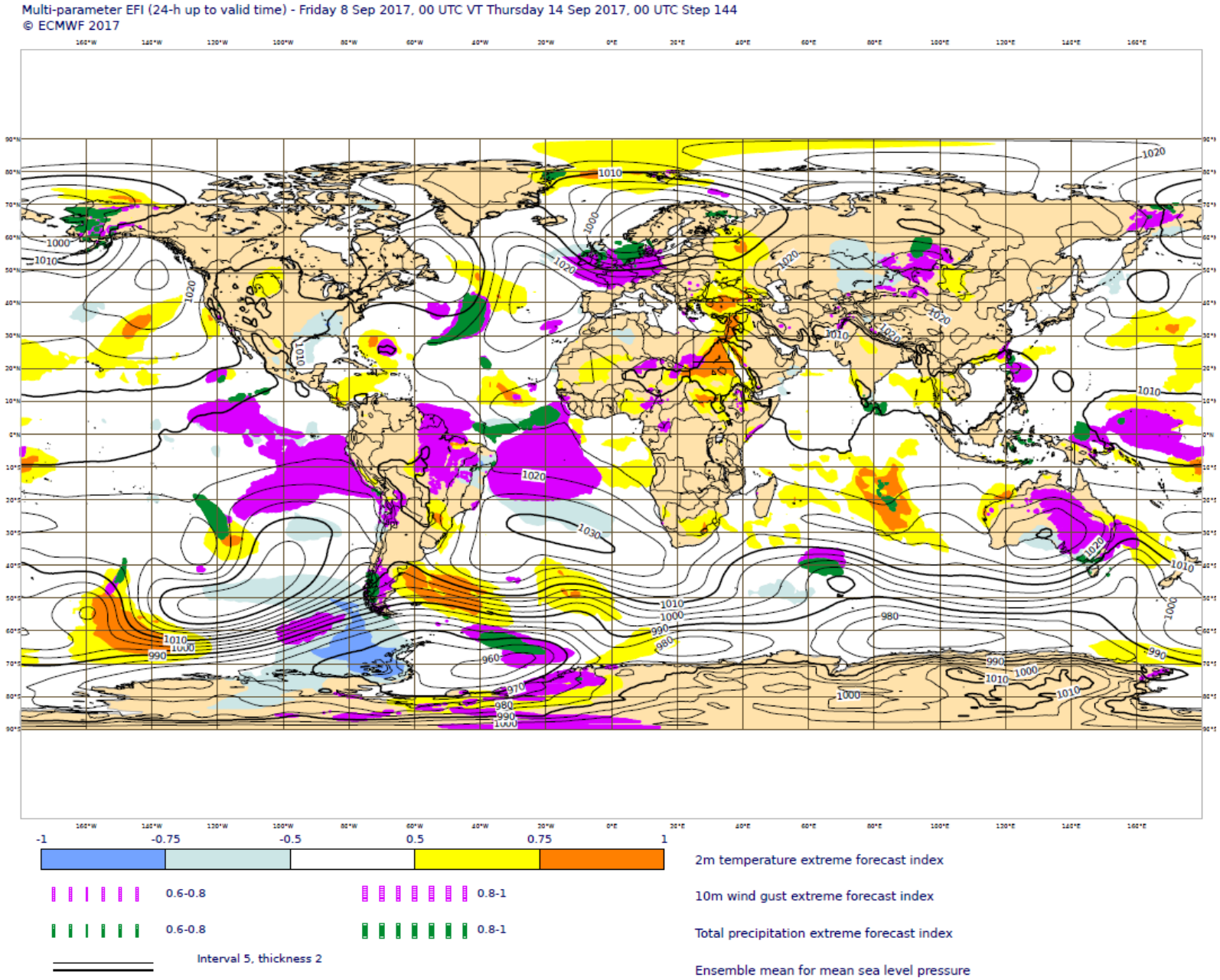
ECMWF

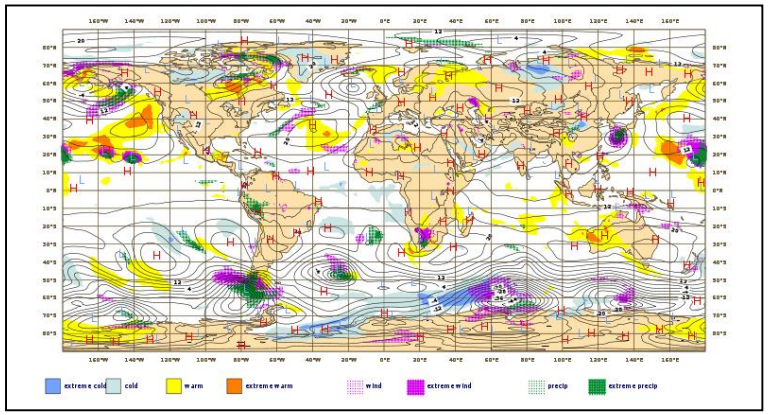
Outline

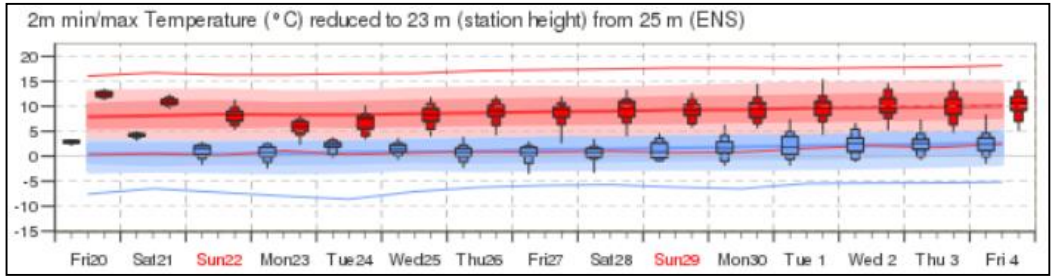
- What is available from ECMWF and Copernicus for MHEWS
- EFI, SOT, reforecast (model climate)
- Cyclone products (tracks, intensity)
- Large-scale flow, regime-based outputs
- Direct model output parameters
  - Precip type, Precip rate, lightning, …
  - Ocean waves, sea ice
- Copernicus products: floods, fire, air quality; reanalysis

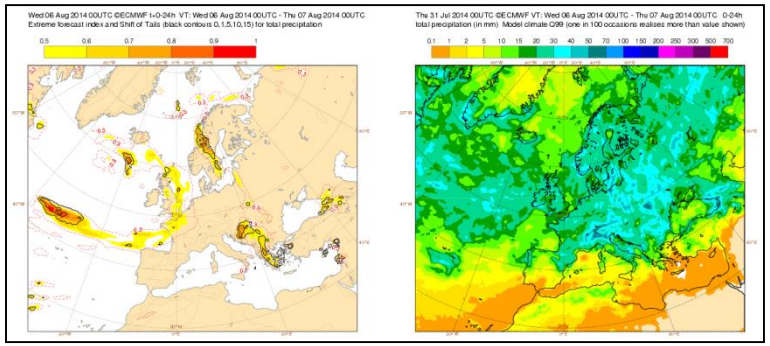
Global EFI map – highlights potential anomalous weather

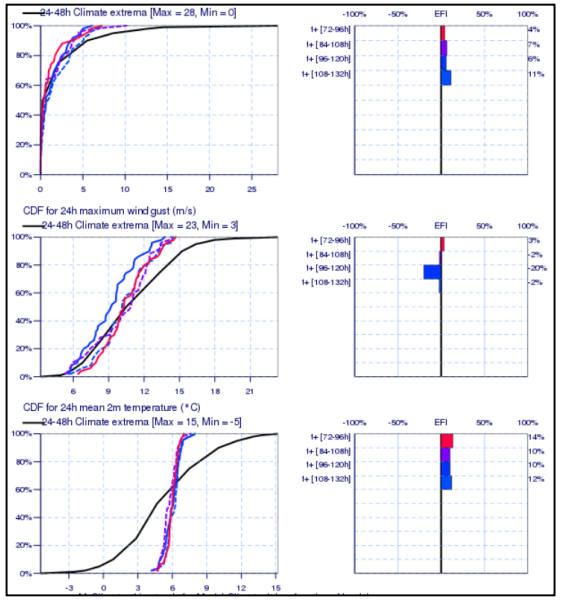


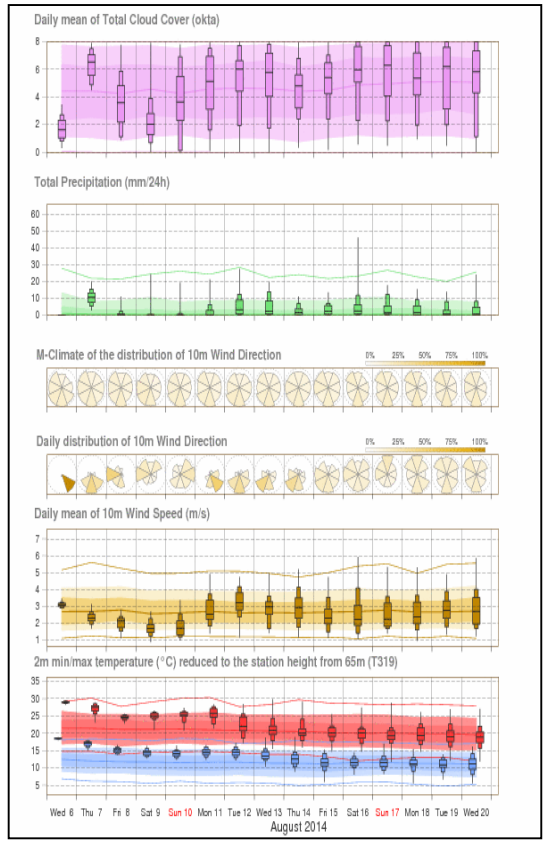
Some EFI and model climate-related products

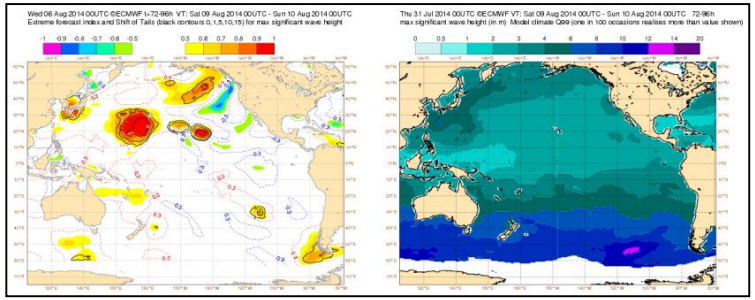


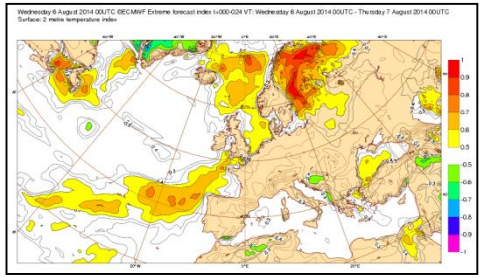




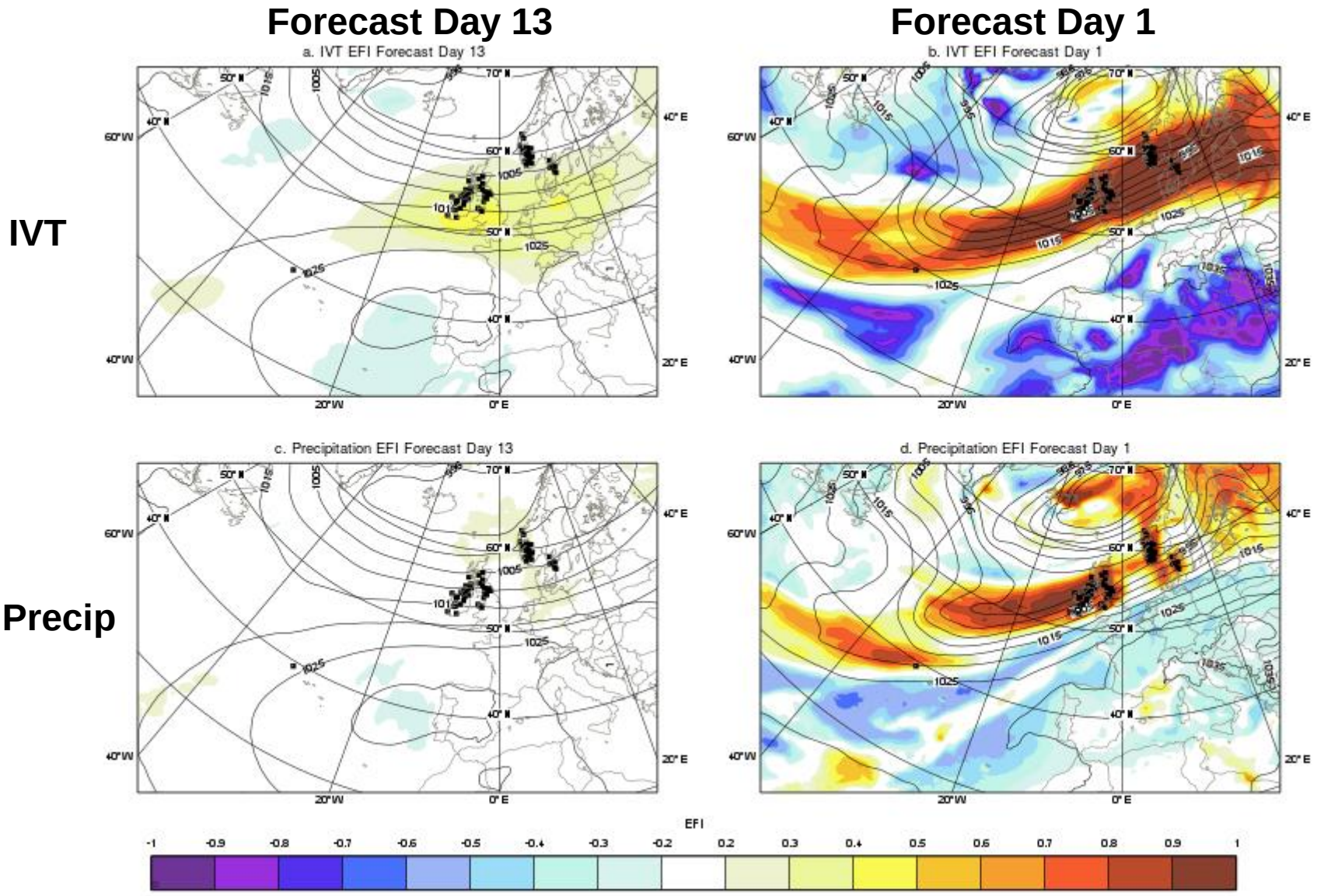




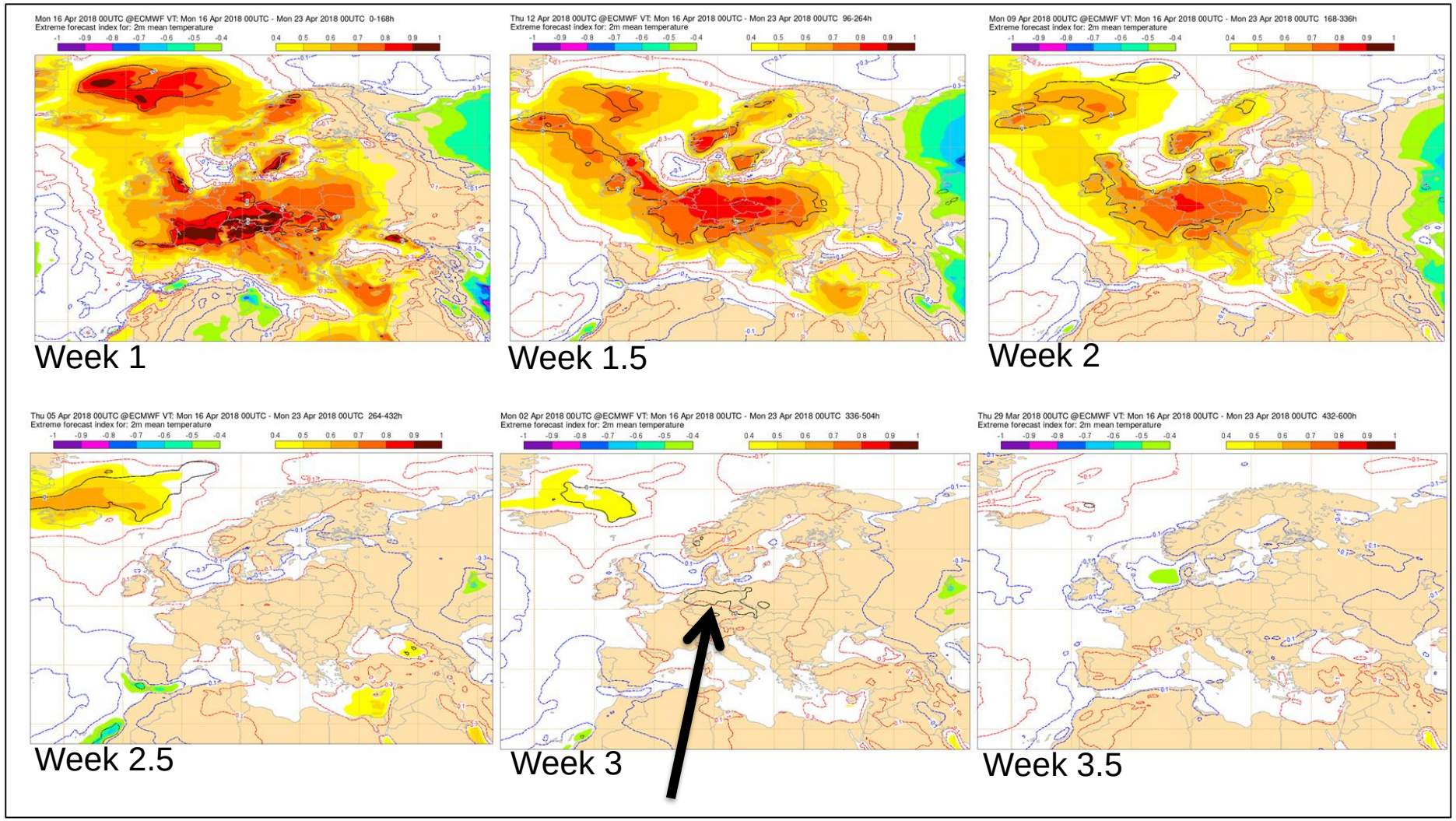




Atmospheric river EFI

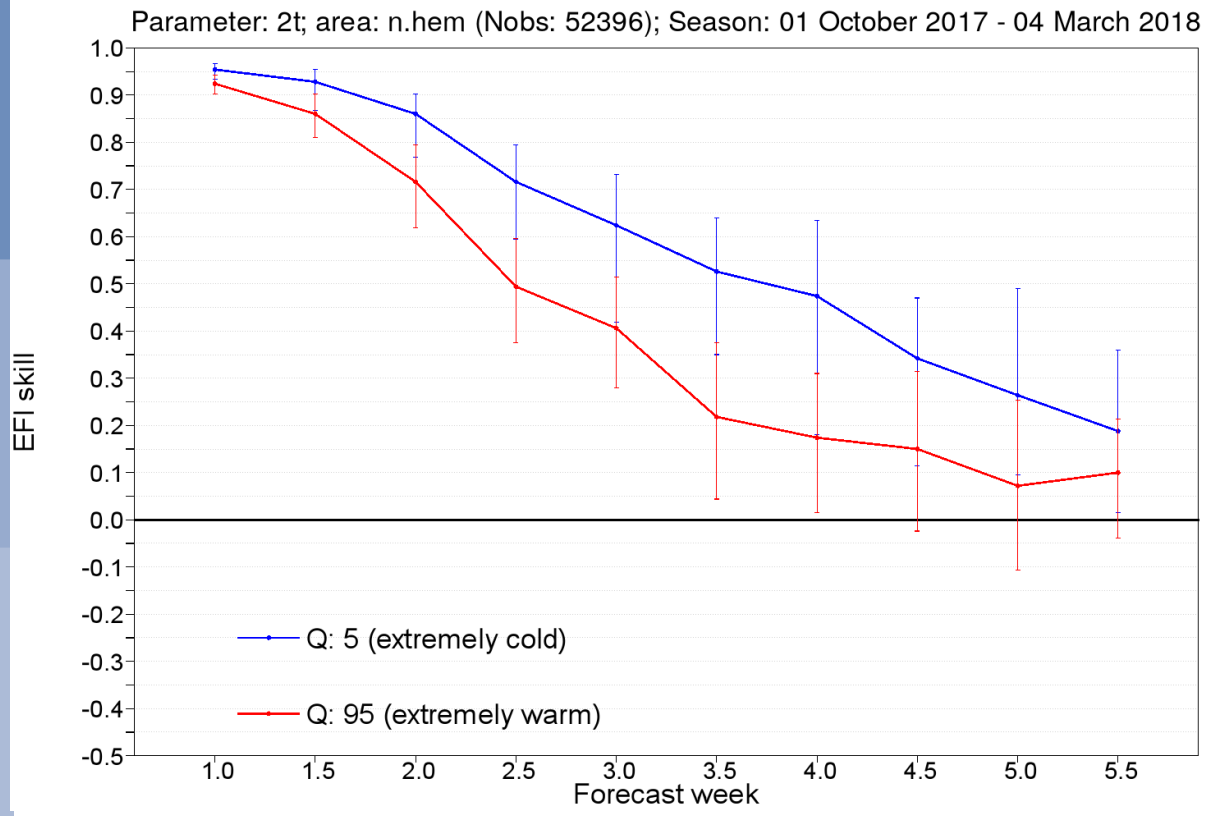


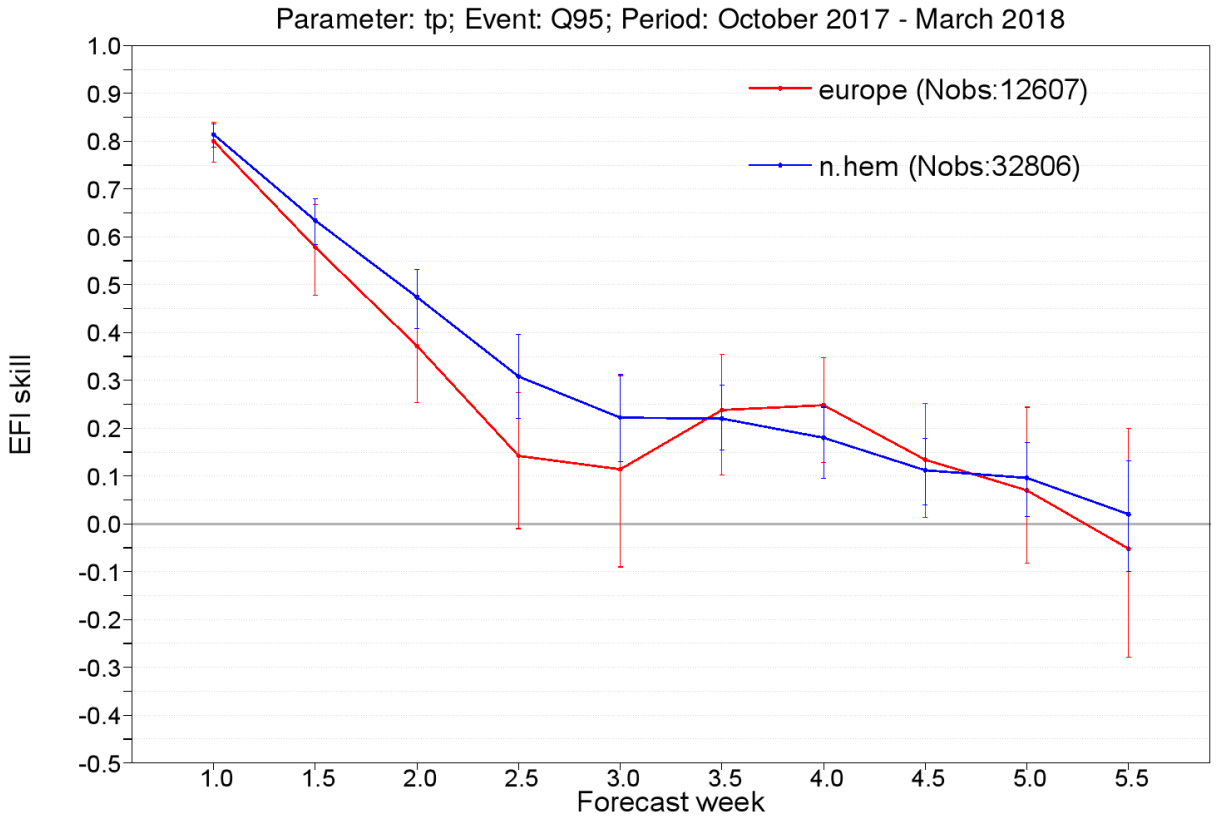
Extended-range EFI/SOT (under test)



2018 Spring Heatwave

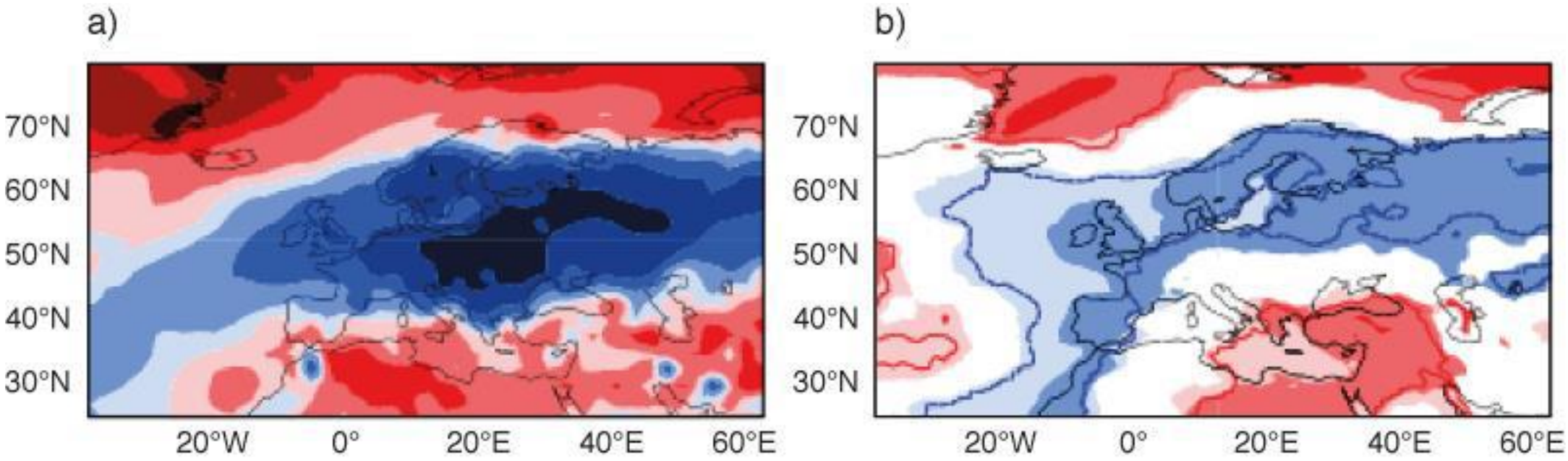
Extended-range EFI





Cold spell Europe Feb-Mar 2018

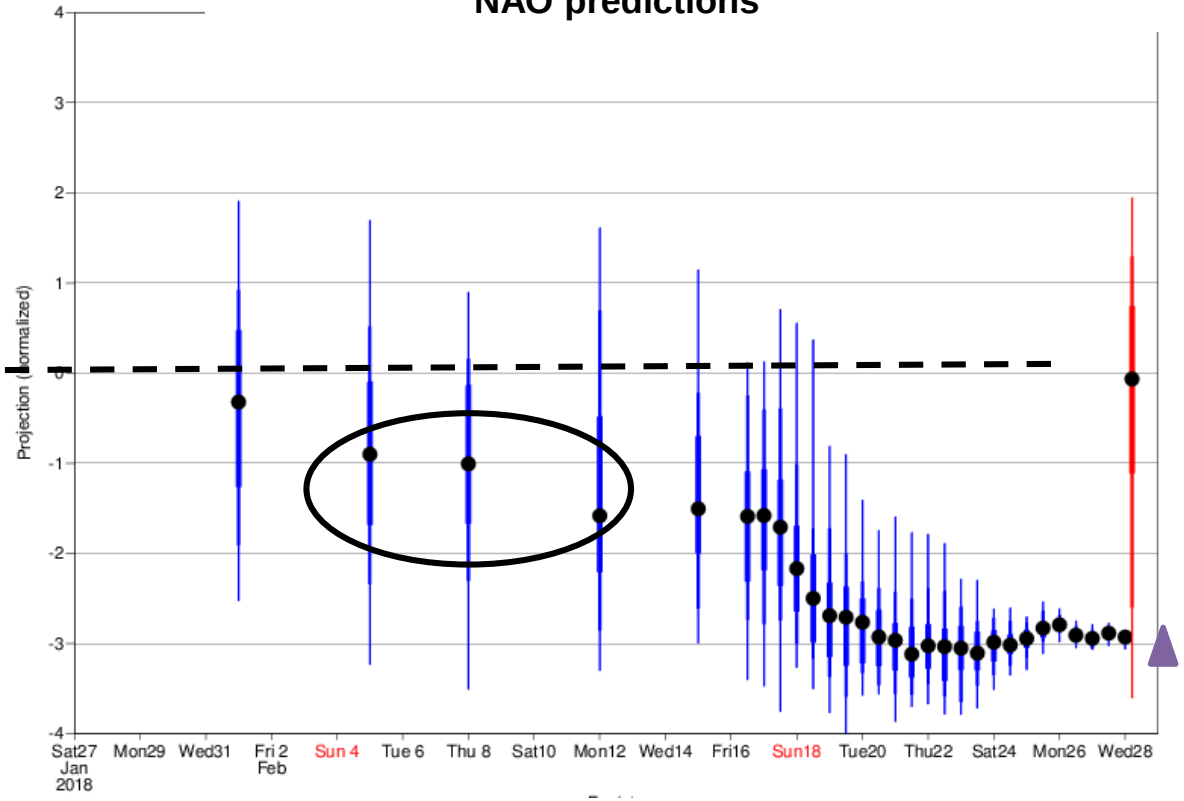
- Weekly mean temperature anomalies for 26 February – 4 March showing the verifying analysis (a) and the corresponding ECMWF forecast for days 22-28 (b)



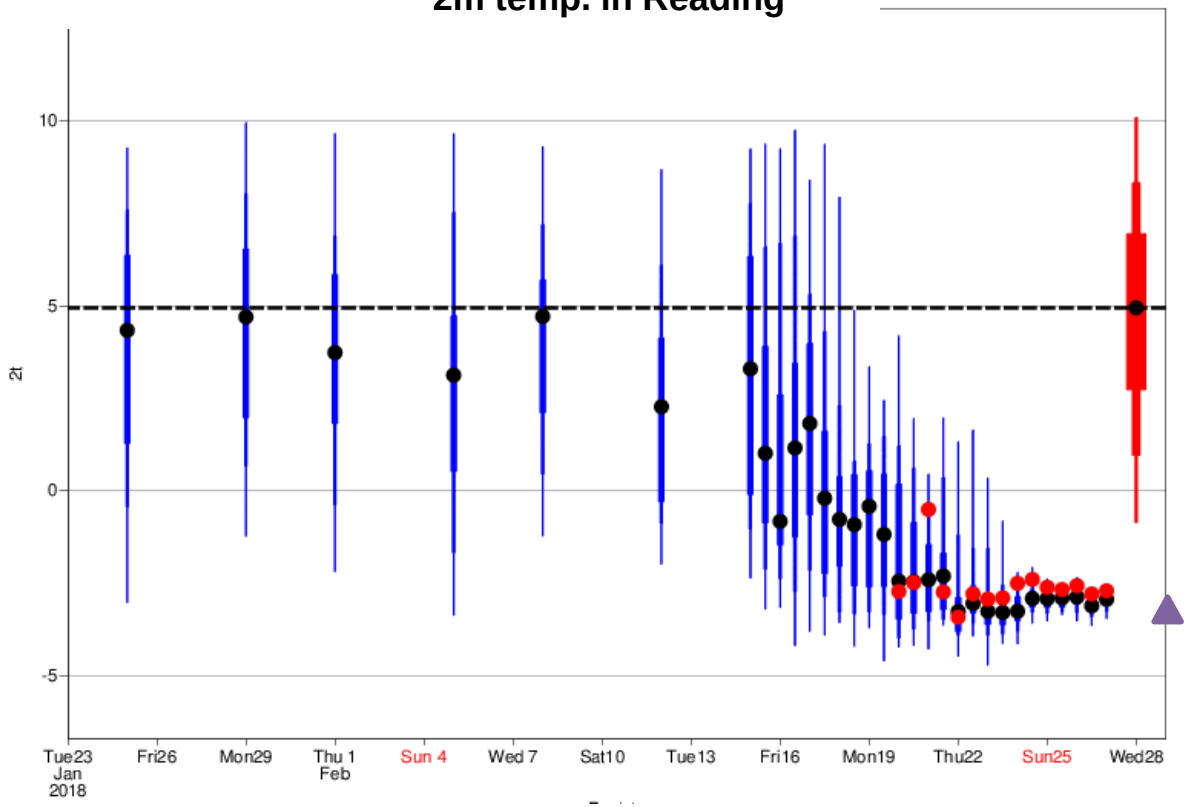
How far in advance could we predict this cold event?

Predictions initialized at different time and verifying the 3-days mean (27 Feb to 1 March)

NAO predictions



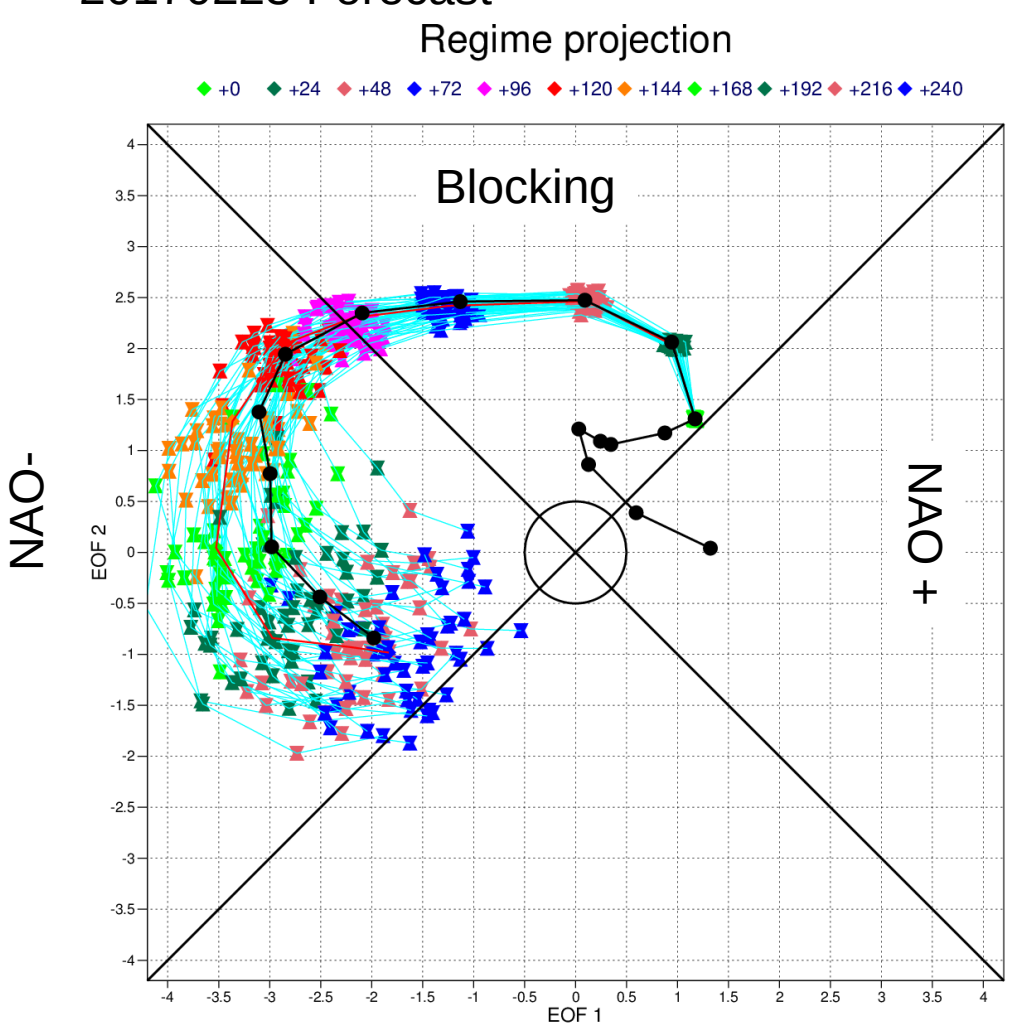
2m temp. in Reading

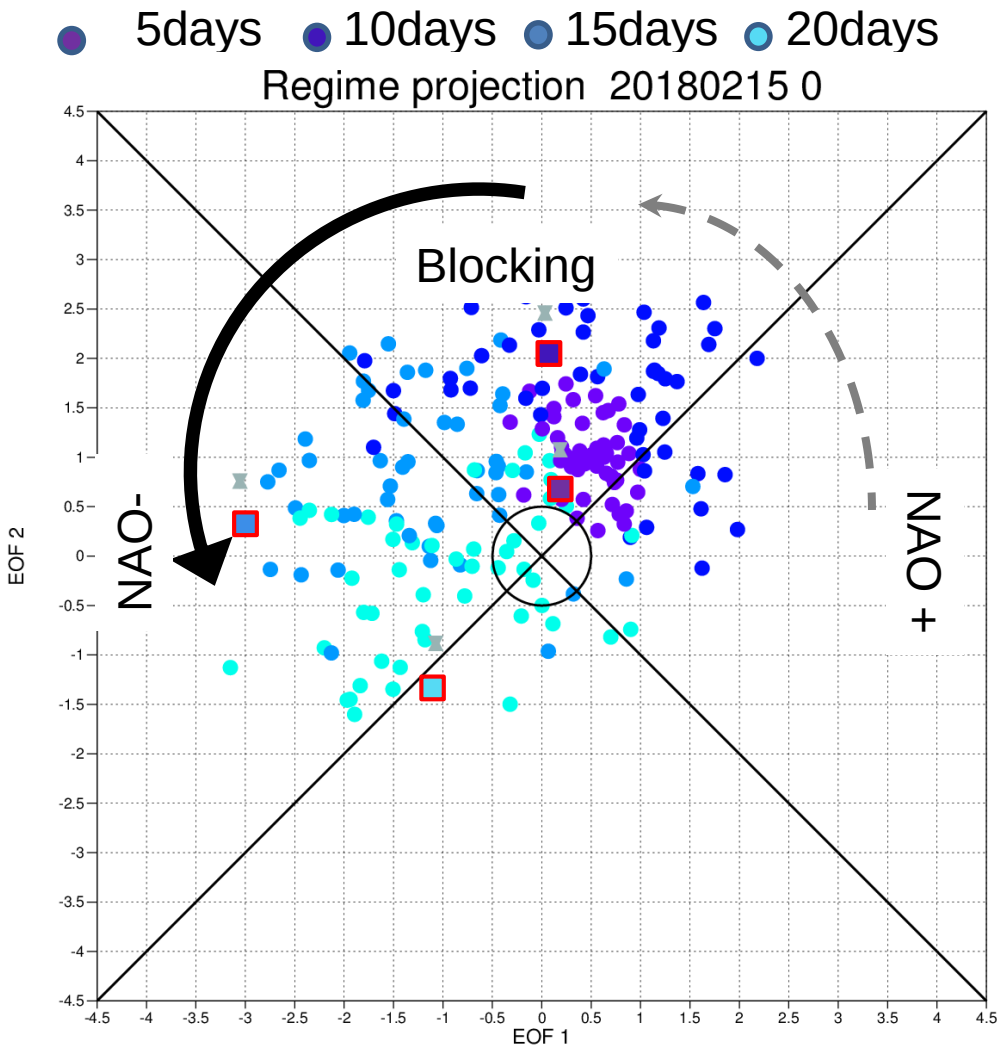


Thanks to Linus Magnusson

The ensemble evolution in the NAO-Blocking diagram

20170223 Forecast

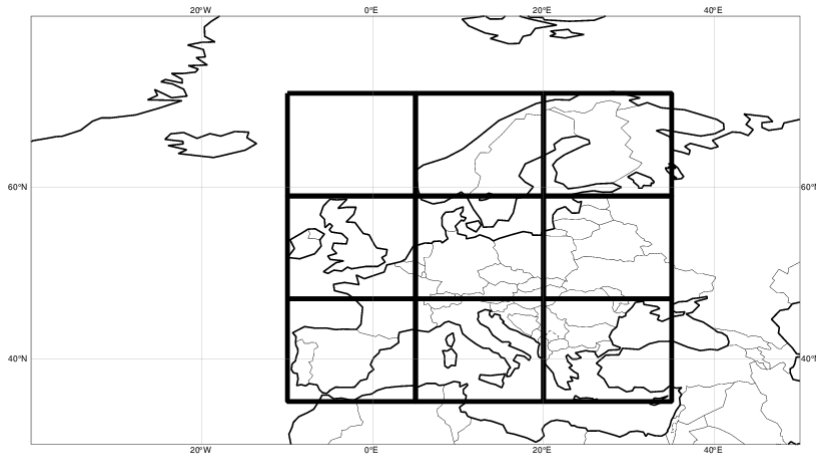


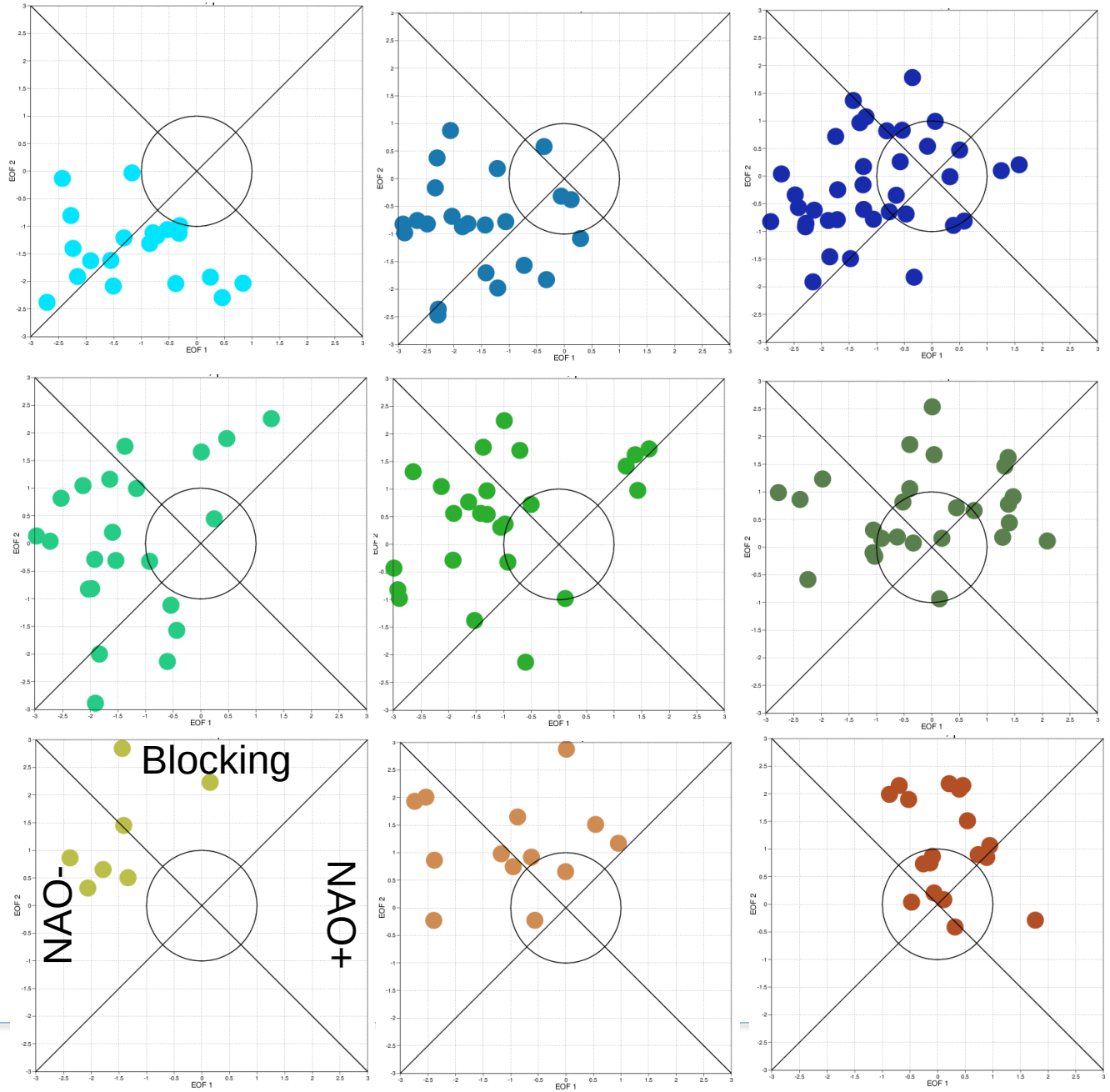


ECMWF

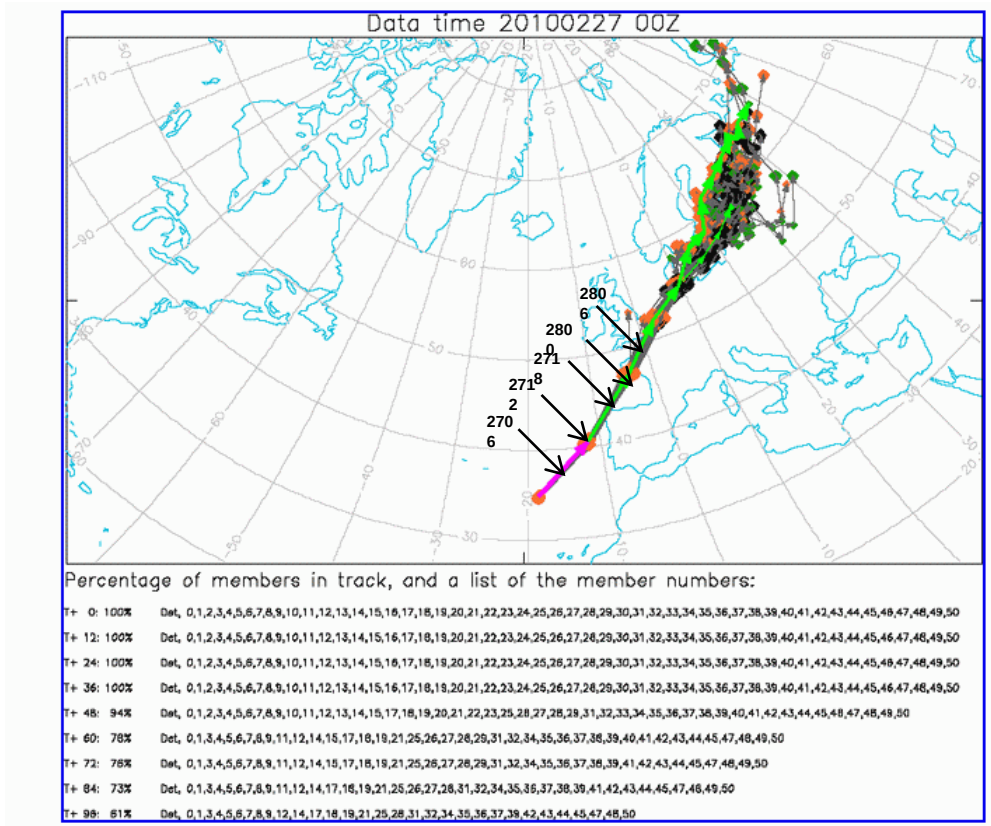
Distribution of severe winter (NDJF) events in era-interim (1980-2015)

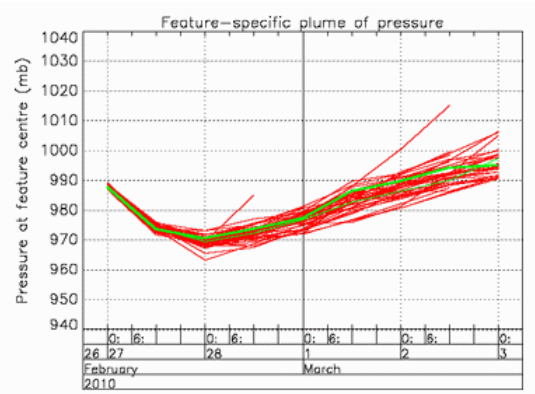
When for 60% grid points in each box the daily 2mt < 10th quantile of daily climate
for at least 4 consecutive days

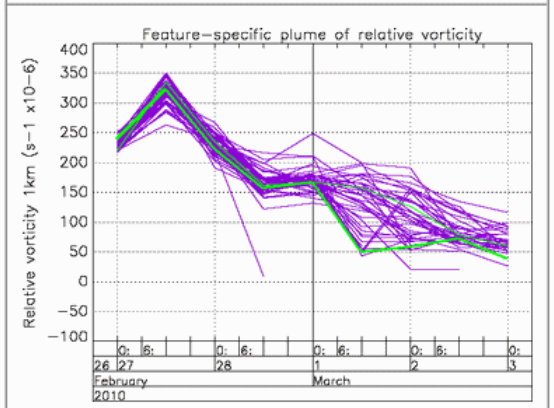


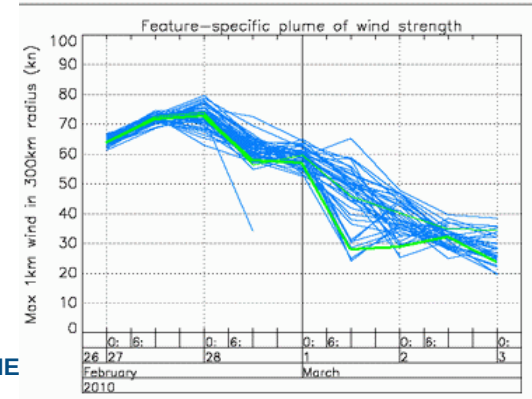


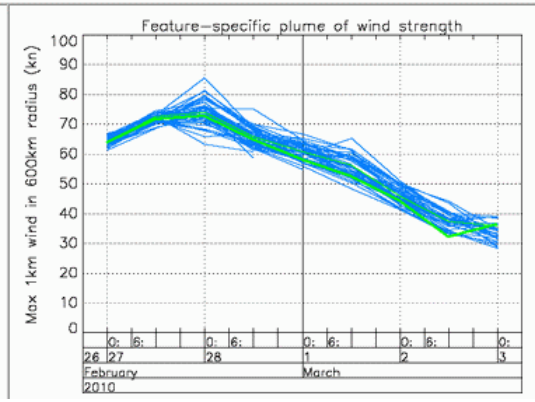
Extra-tropical cyclonic feature tracking

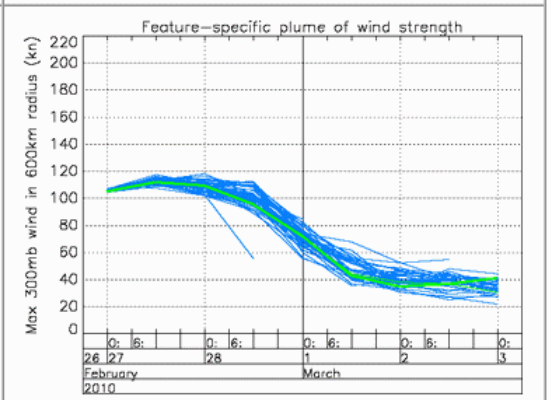








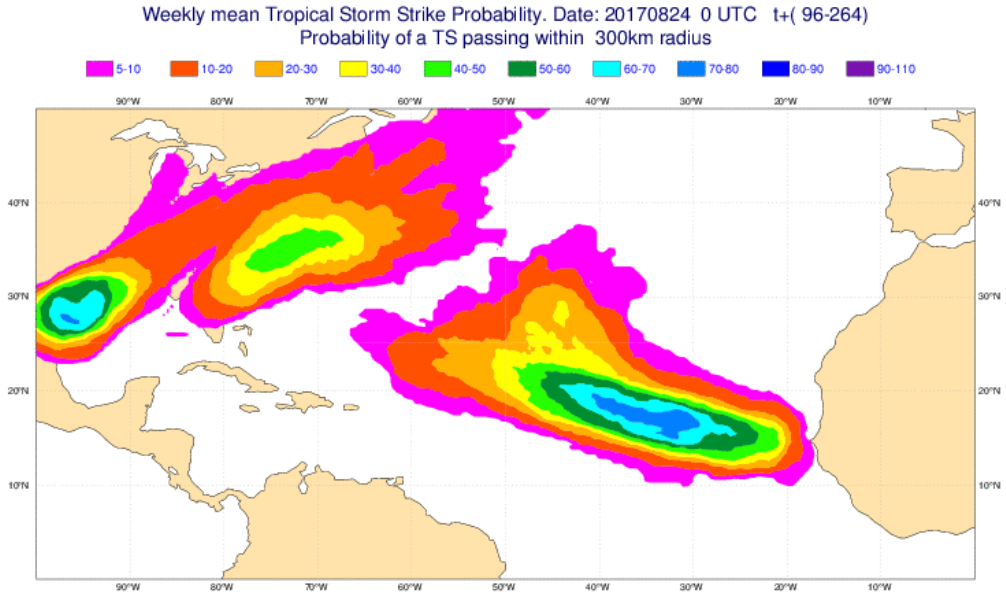


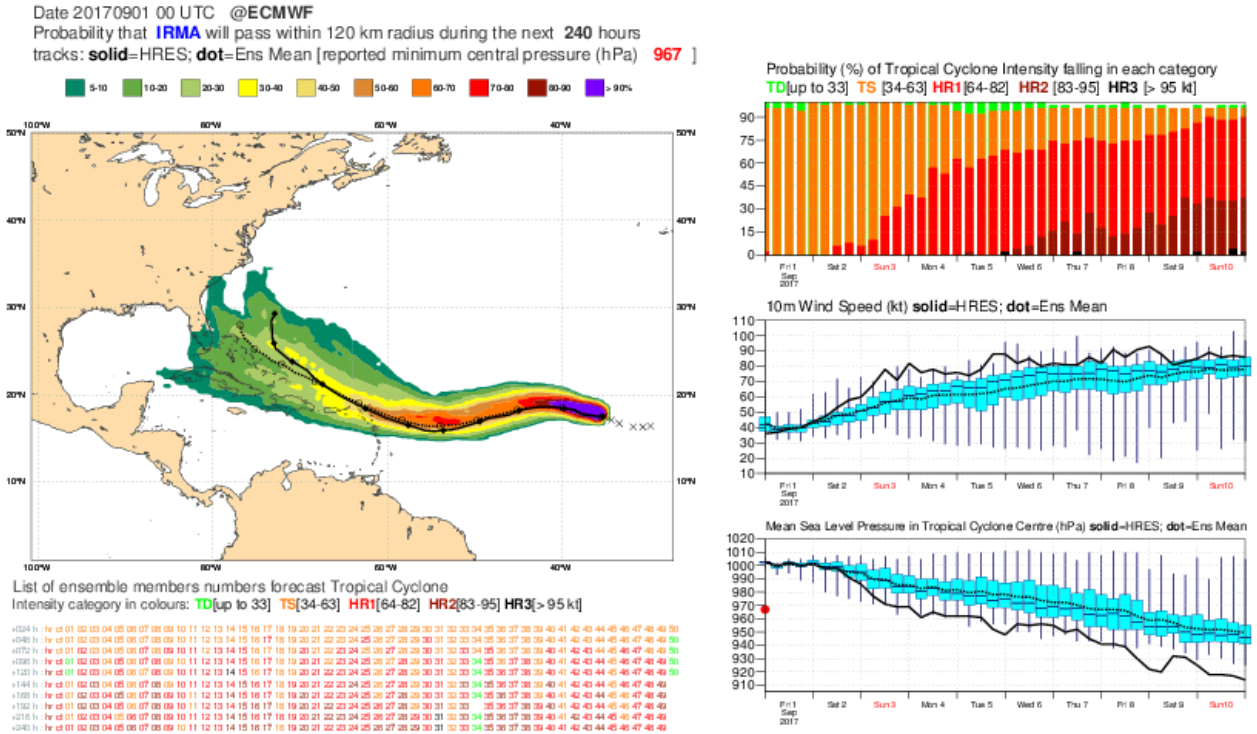


Tropical cyclones

Tracks of TCs present at start of forecast (HRES, control, ENS)

Probability for TCs to form during the forecast (genesis)





Hurricane Irma

Formed 31 August 2017

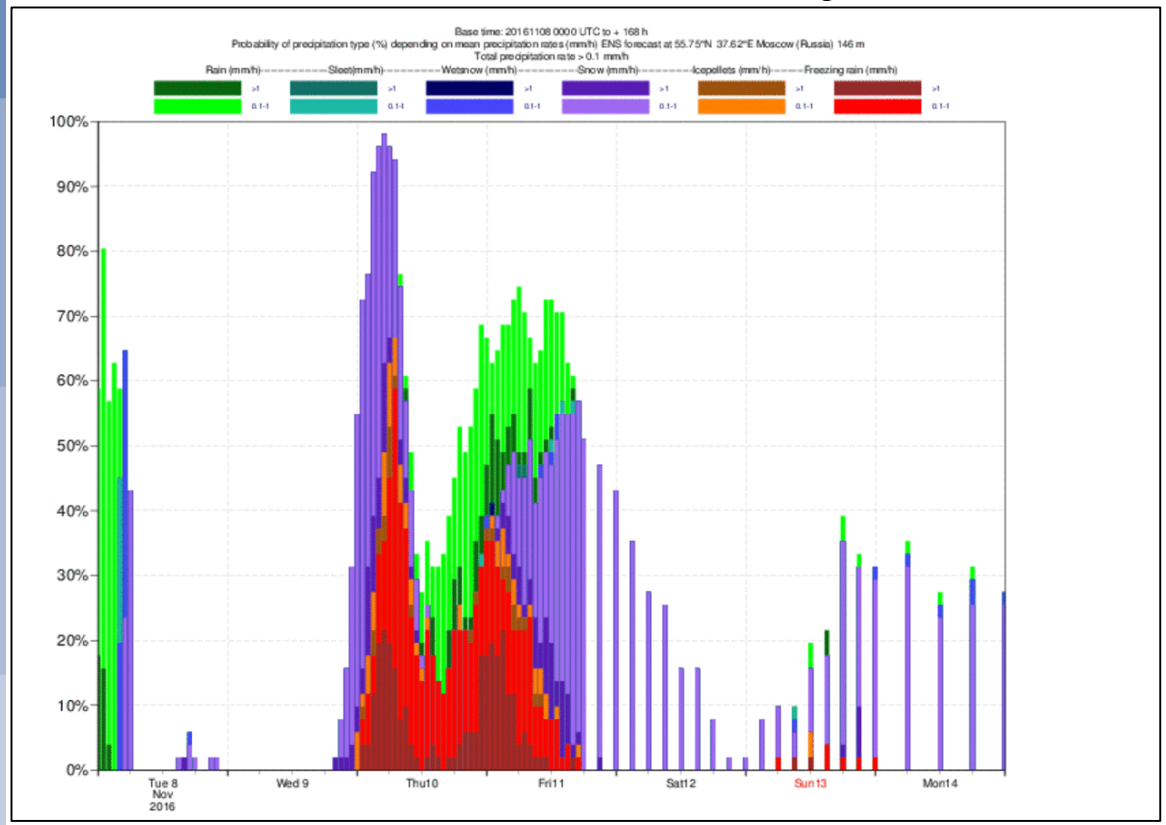
Precipitation type

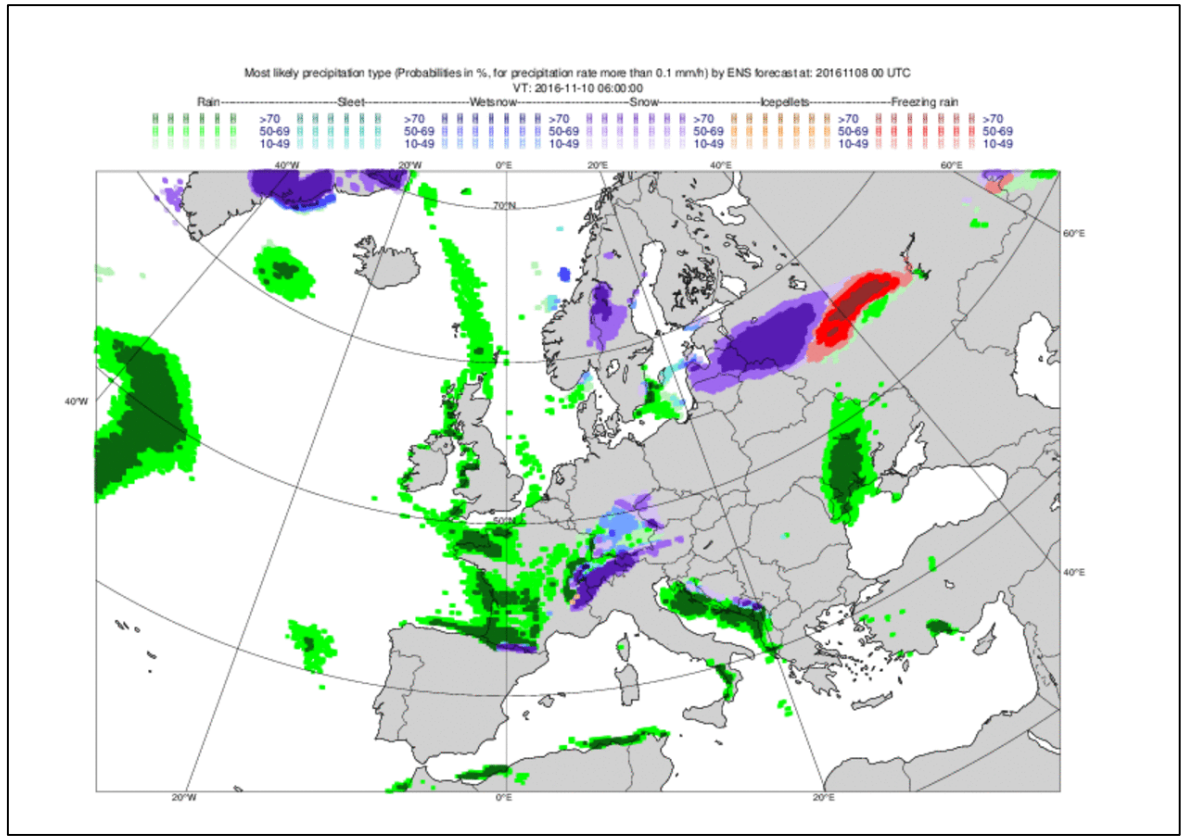
RAIN
SLEET
WET SNOW
SNOW
ICE PELLETS
FREEZING RAIN

What is the most probable precipitation type ?

- Precipitation diagnosed if: Instantaneous total rate > 0.1mm/hr
- On map show blank if Prob(dry) > 50%. Otherwise show most probable type.

Product based on an idea from the Hungarian Met Service

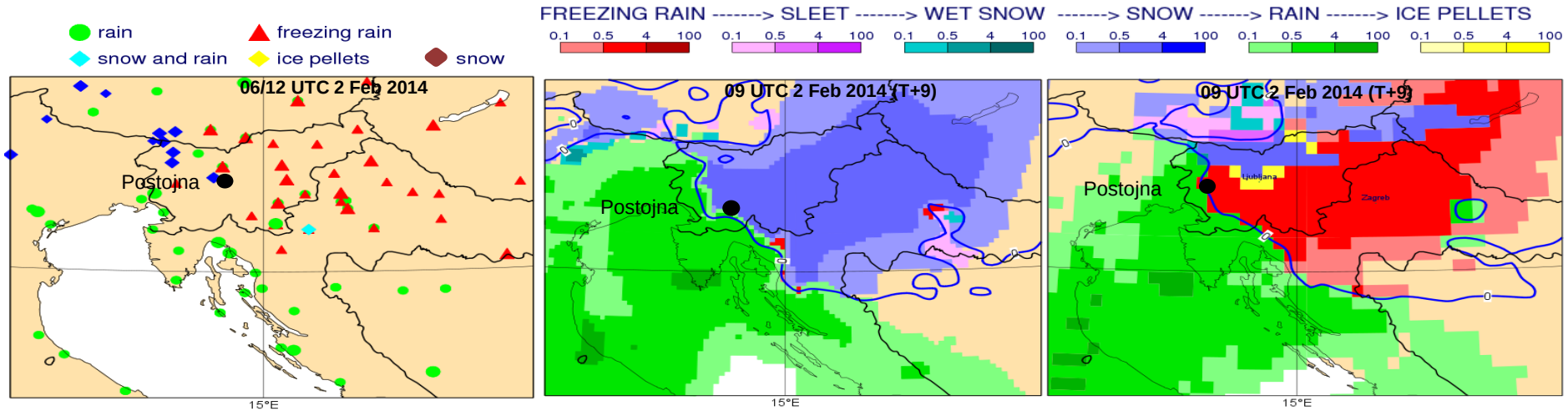




Freezing Rain – Major Hazard - Not really forecast by ECMWF before 2015

- Case Study: Slovenia/Croatia 02 Feb 2014
- Freezing rain caused severe disruption and damage, tranports/power/forests…
- IFS physics at the time (40r1) not able to predict
- New physics in 41r1 (operational from May 2015) enabled prediction of freezing rain
- Evaluation in HRES/ENS showed potential for useful forecasts
- Article in *ECMWF Newsletter Autumn 2014*

ECMWF Newsletter 141

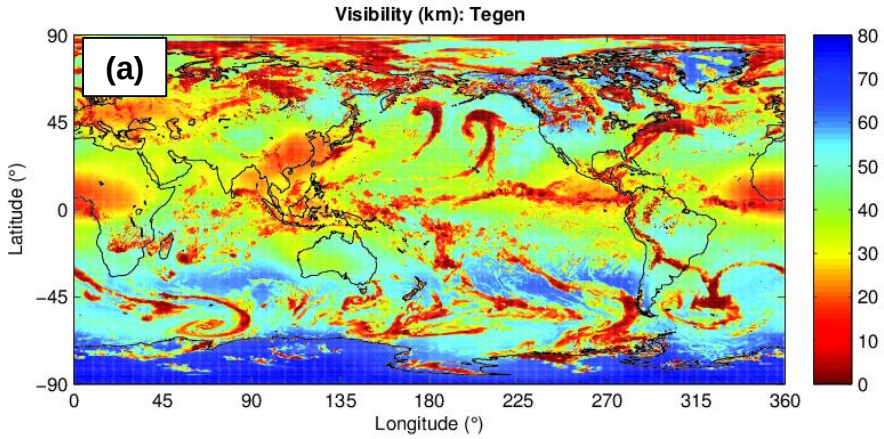


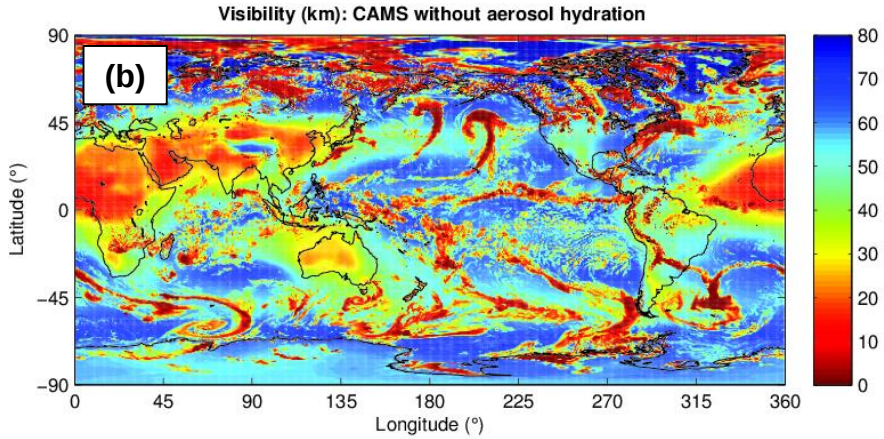
SYNOP Observations | **IFS HRES 40r1** | **IFS HRES 41r1**

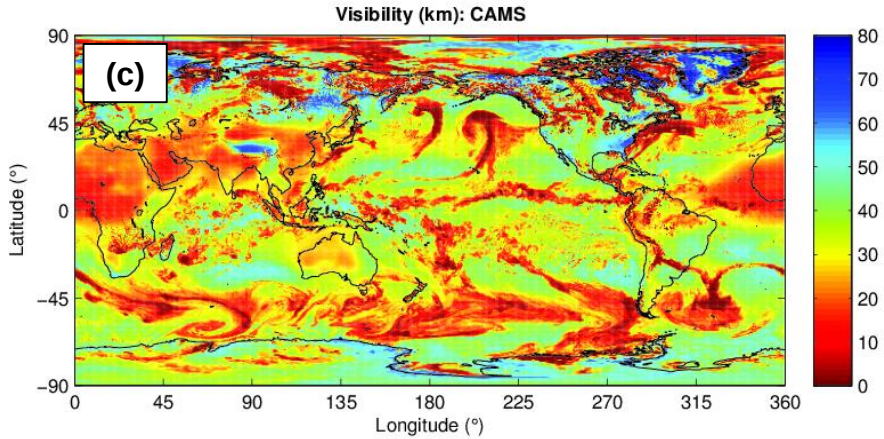
Visibility – revised July 2017 (43r3)

- New aerosol seasonally varying climatology based on CAMS aerosol re-analysis including dependence on relative humidity in 43r3
- Visibility clear sky calculation uses the new aerosol and will vary with relative humidity

Example snapshot of visibililty using:
(a) current Tegen aerosol climatology (**43r1**),
(b) new CAMS aerosol climatology with no hydration
(c) new CAMS aerosol climatology with hydration (**43r3**)

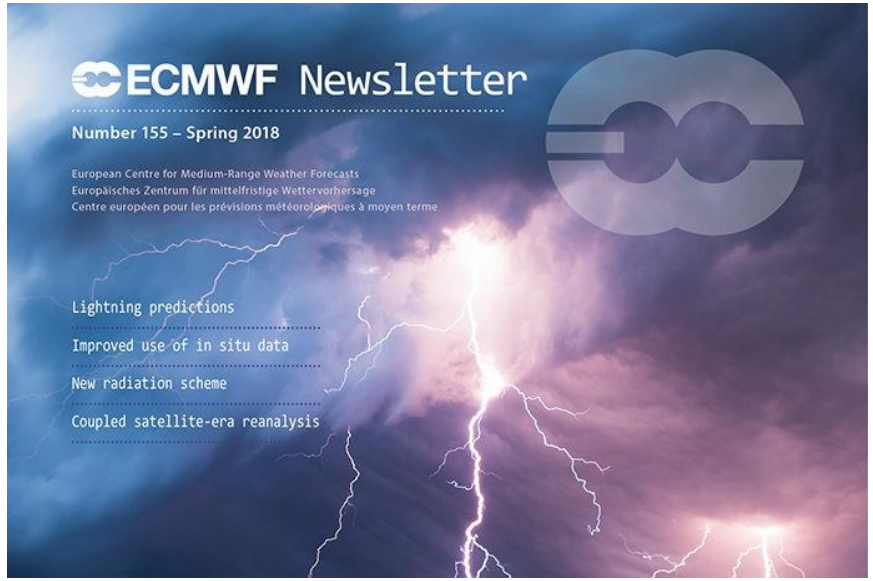






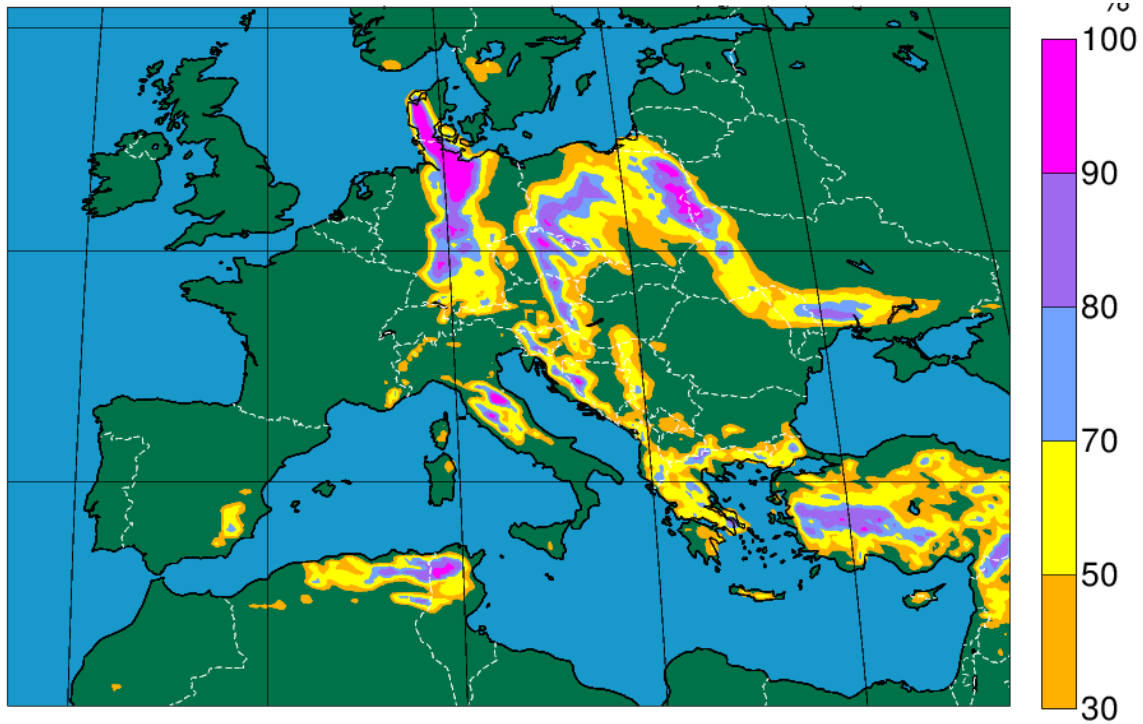
New lightning parameters (June 2018)

- Four lightning density parameters introduced with IFS cycle 45r1:
  - Instantaneous total lightning flash density (litoti)
  - Averaged total lightning flash density in the last hour (litota1)
  - Averaged total lightning flash density in the last 3 hours (litota3)
  - Averaged total lightning flash density in the last 6 hours (litota6)
- “Total” - cloud-to-ground and intra-cloud flashes
- Parametrization in IFS convective hydrometeor amounts, (CAPE) and convective cloud base height
- Instantaneous - flash density during one model time step of the model (so prone to larger errors)

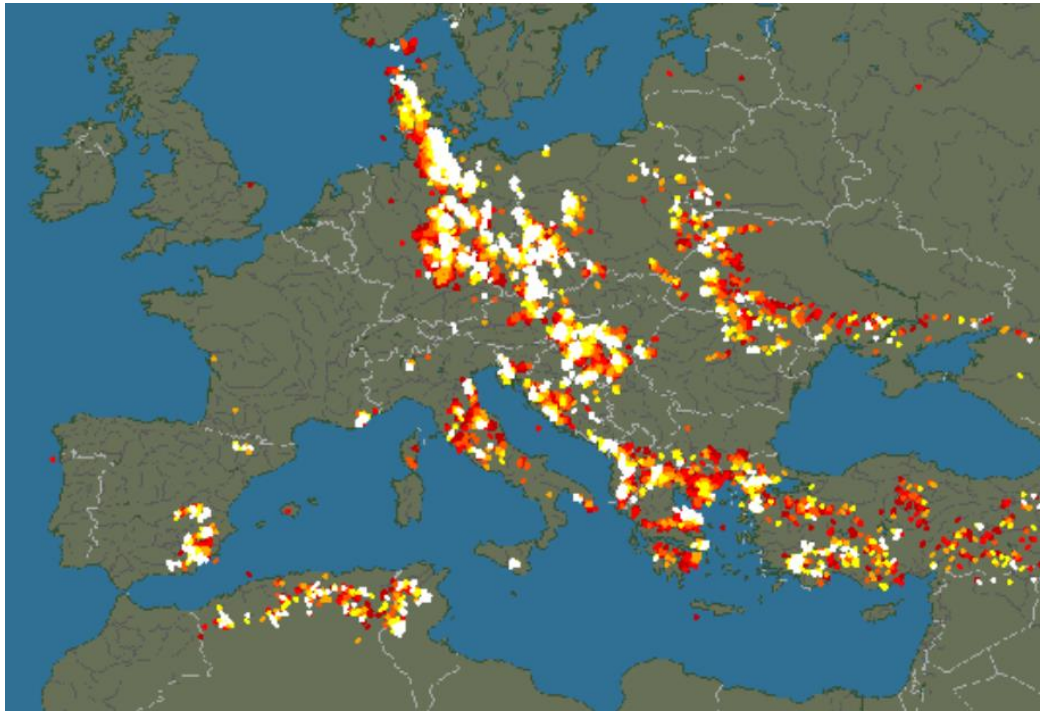


New lightning parameters (June 2018)

Ensemble forecast from 45r1 esuite
Prob(flash density) > 0.1 fl/100km2/h
10 May 2018 00 UTC, range: 12-15 hours

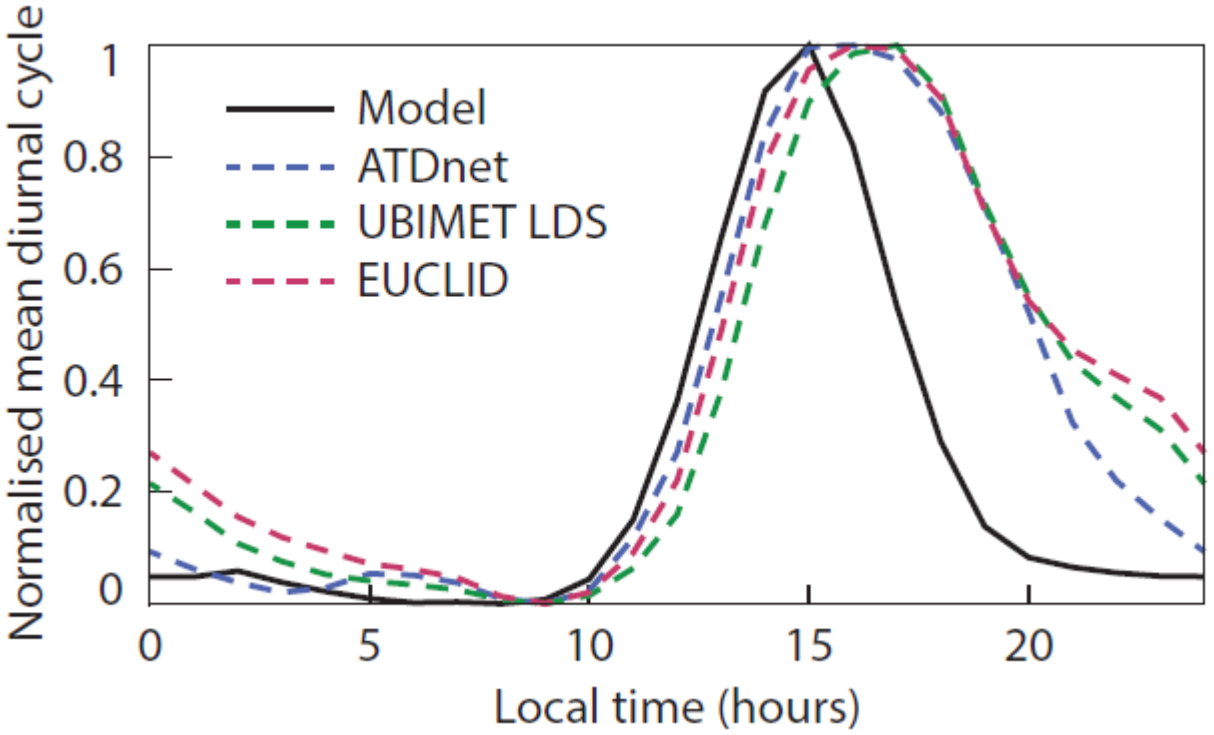


Observed lightning strikes (Blitzortung.org)
10 May 2018 12 to 15 UTC



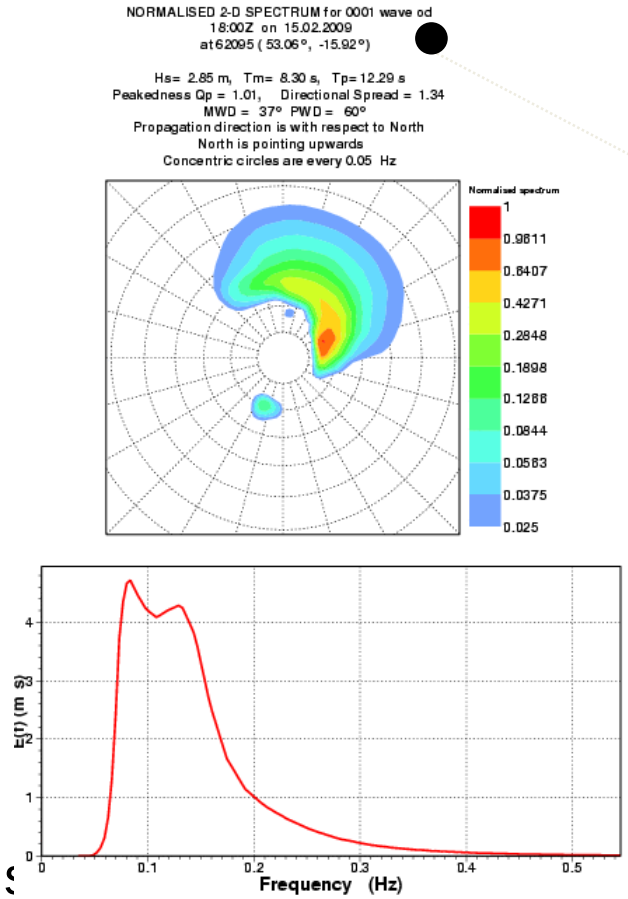
New lightning parameters (June 2018)

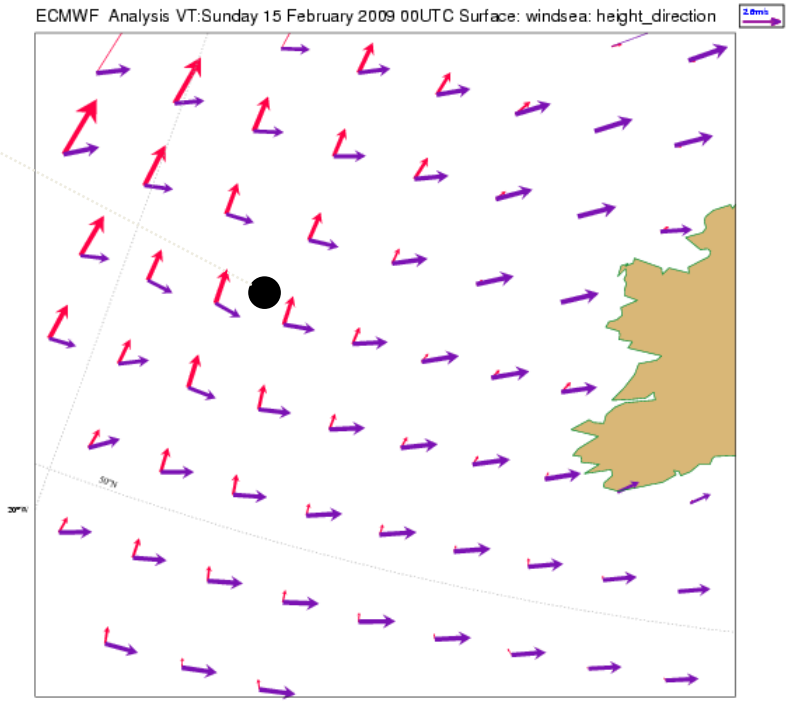
Mean diurnal cycle of lightning activity (normalised between 0 and 1) from IFS short-range forecasts at 18 km resolution and from three European ground-based networks of lightning sensors (ATDnet, EUCLID and UBIMET LDS) over the summer of 2015.



Ocean Wave Products

Windsea and swell: cross sea

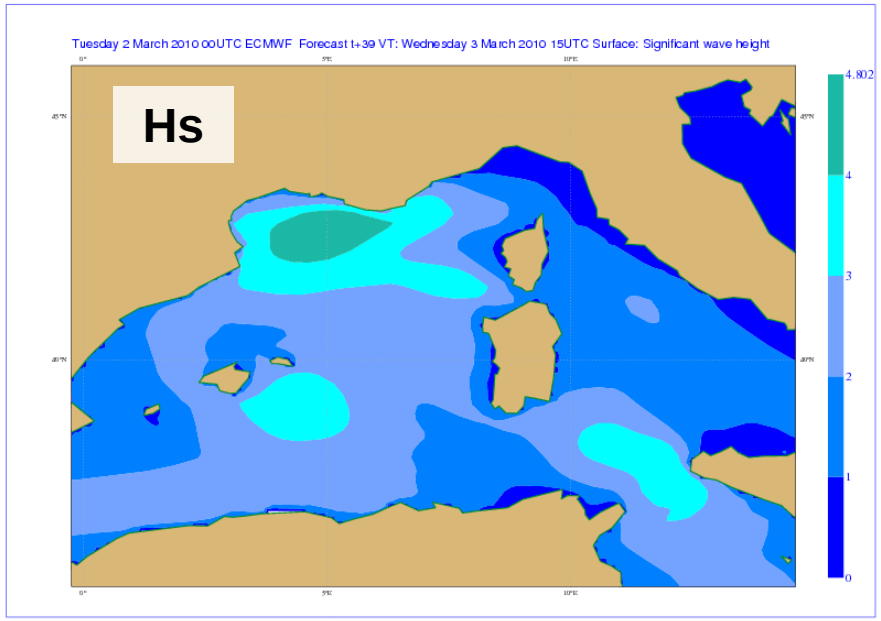


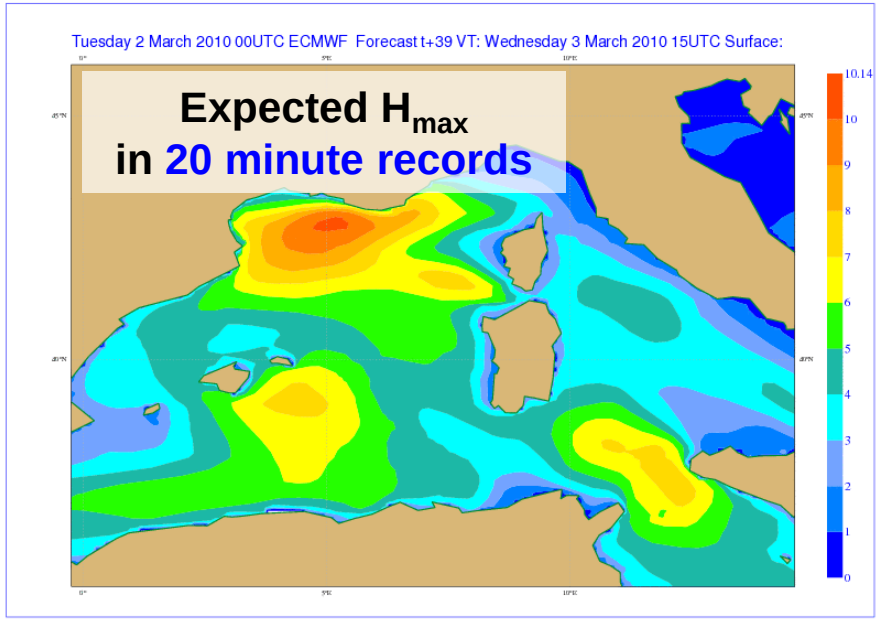


ECMWF

Wave Model Products: Extreme Waves

We have a parameter to estimate the height of the highest individual wave (H_{max}) one can expect. Its value can be derived from the 2d wave spectrum:

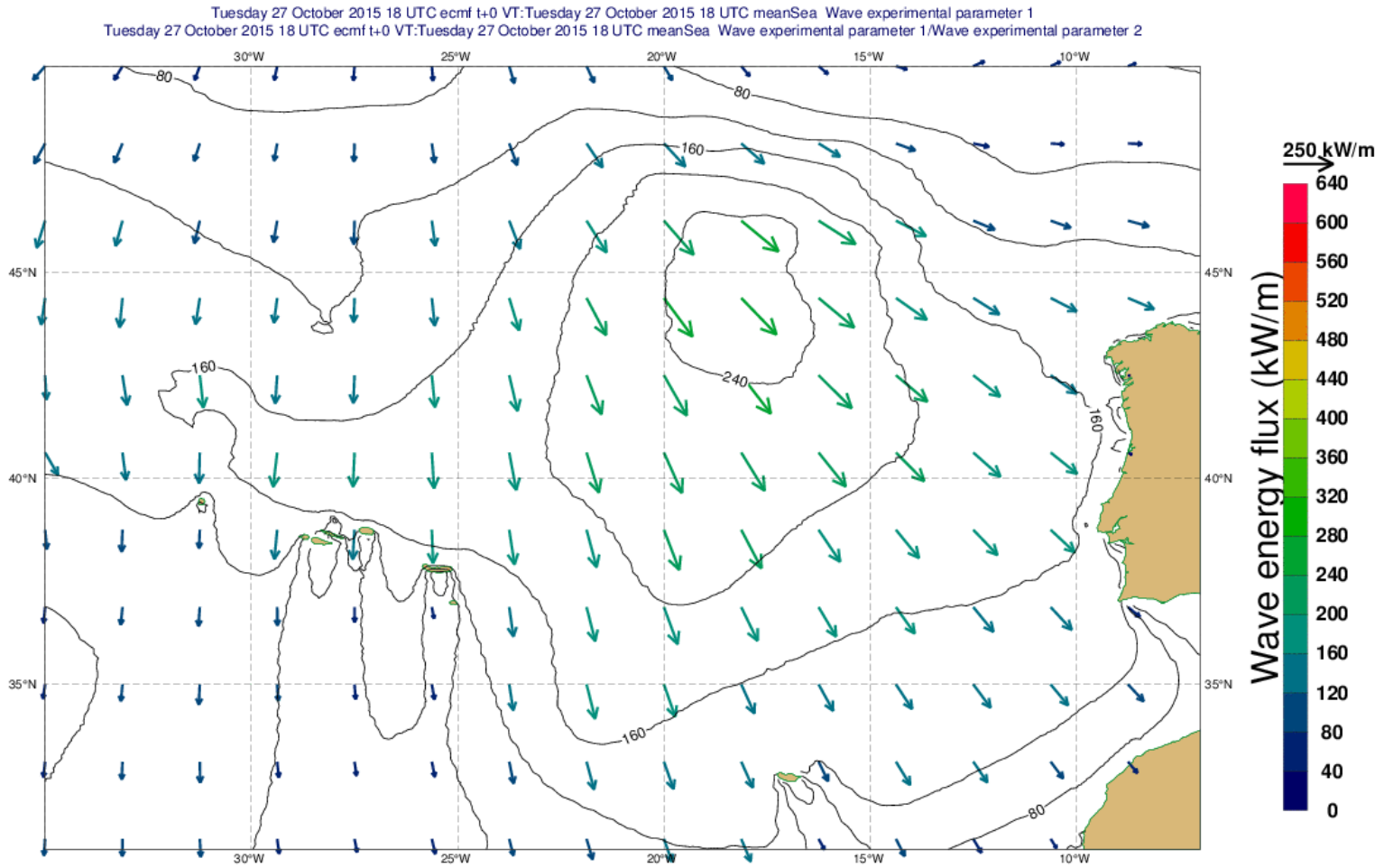




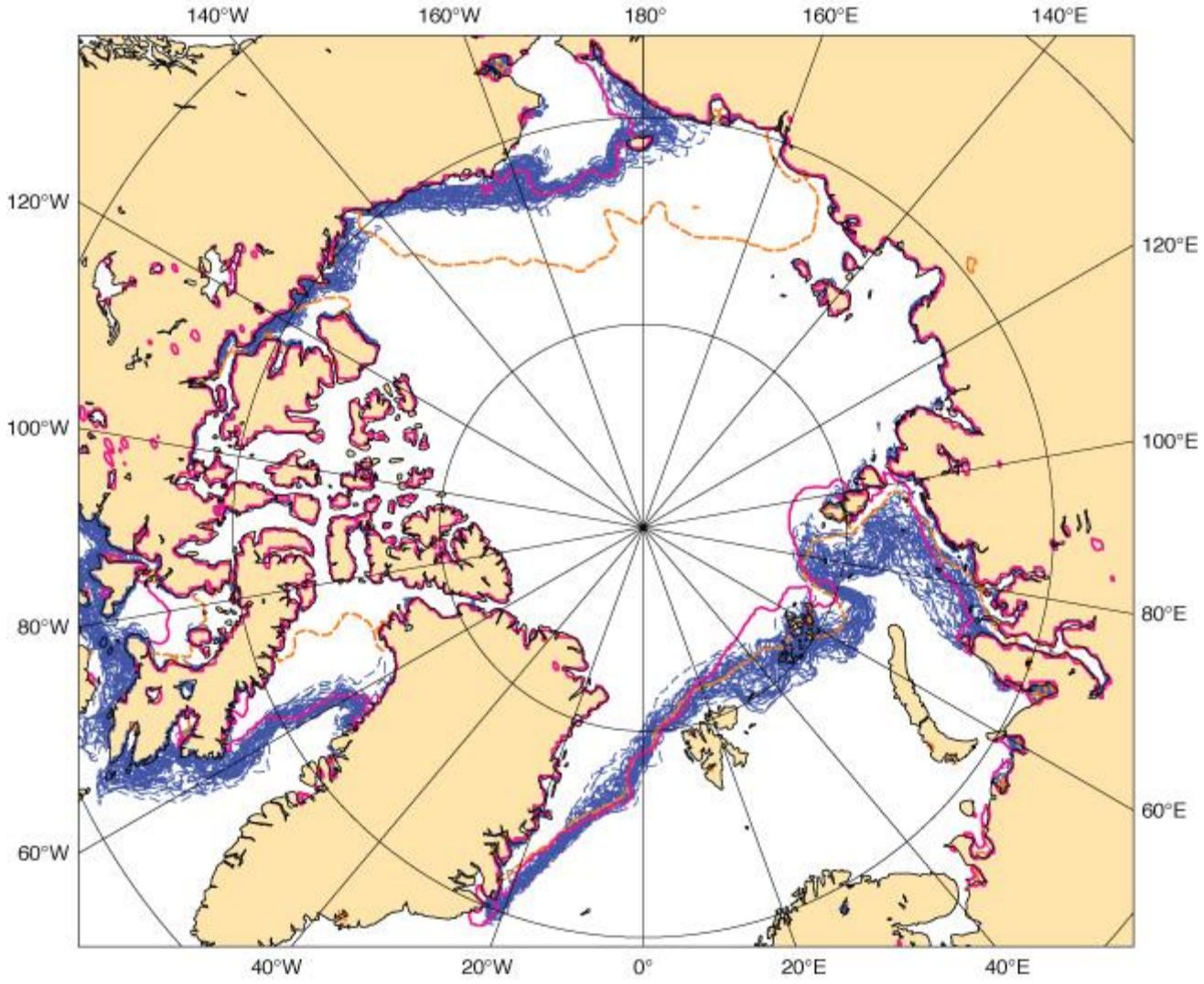
March 3, 2010, 15UTC
Forecasts fields from Friday 2 March, 2010, 0 UTC

New ocean wave outputs (November 2016)

- The magnitude and direction of the wave energy flux that is responsible for the impact of the waves on coastlines and offshore structures



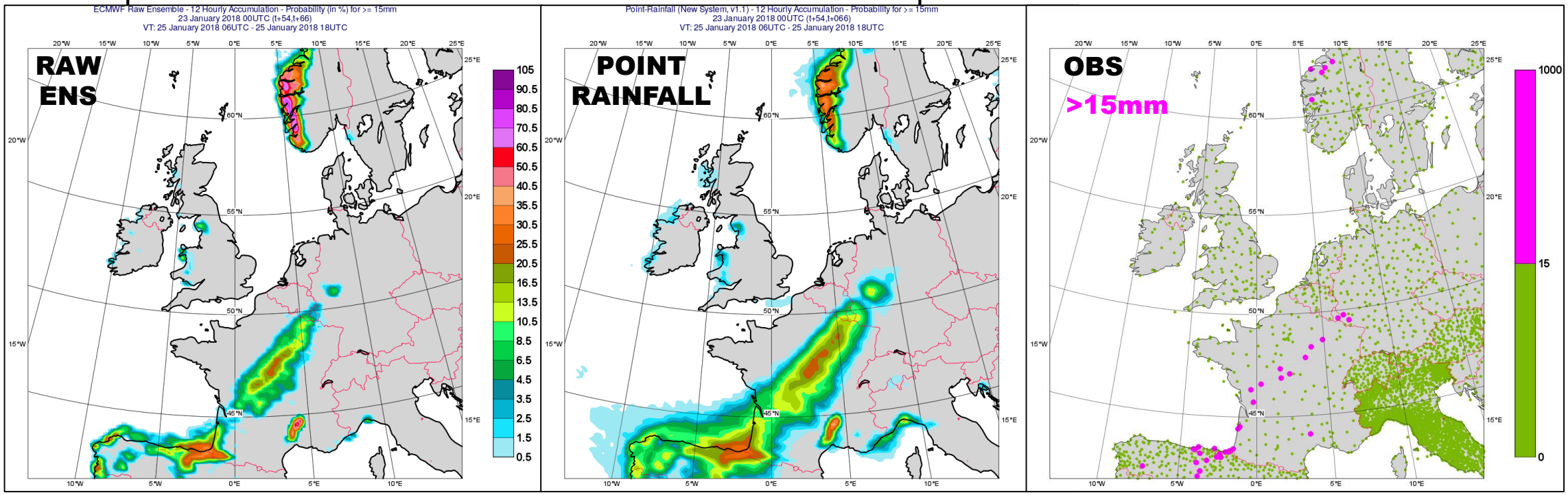
Sea ice


140°W
160°W
180°
160°E
140°E
120°W
100°W
80°W
60°W
120°E
100°E
80°E
60°E
40°W
20°W
0°
20°E
40°E

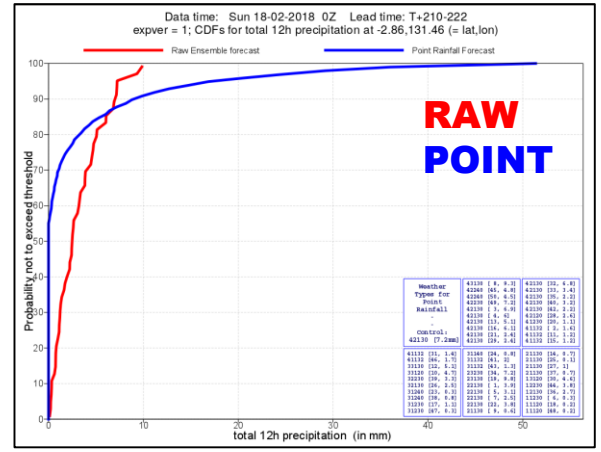
Point Rainfall (“ecPoint”) – new Experimental Global Product

- Post-processed fields delivering probabilities for rainfall at points and not for “gridbox averages”
- Situation-dependent adjustment of probabilities

Probabilities for **>15mm/12h** (D3, VT 25 Jan 2018)



Point Rainfall - Benefits for Users



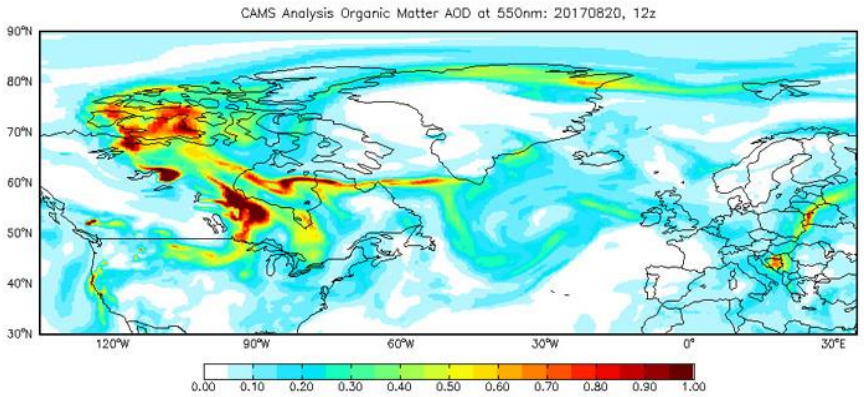
- Consistently better probabilistic forecasts of rainfall for individual sites
  - With larger spread than the raw ENS, which is under-dispersed (for sites)
- Bias correction of the PDF mean appropriate to the meteorological / geographical situation
  - Range of ~ x0.35 to x2.5
  - Could improve hydrological forecast inputs
- The probability distribution has a longer “wet tail” in most situations
  - Extremes predicted in convective situations can be much higher (very low probability) – flash flood applications
  - Extremes verifiy much better than for the raw ENS (e.g. for 50mm/12h D5 as good as D1 in Raw)
- Much more reliable forecasts of zero rainfall – again notably in convective situations

Point Rainfall - Status

- Will become an “Experimental product” in ecCharts during the summer – feedback welcome! Not yet in catalogue.
- Co-operation agreements reached with various NMHSs around the world to test this product out – (Ecuador, Canada, Hungary, Costa Rica,…). Regional point rainfall forecast grib files being provided via ftp in real time, in exchange for feedback reports (and also extra observations - precipitation totals, discharge - for non-European countries).

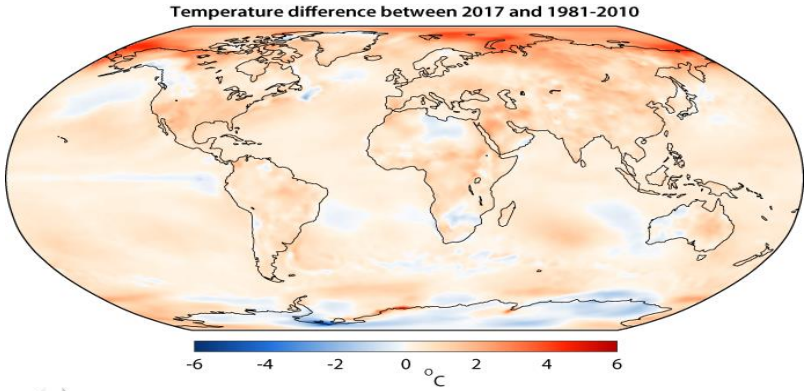
Working with the EU: Environmental information

Atmosphere Monitoring Service



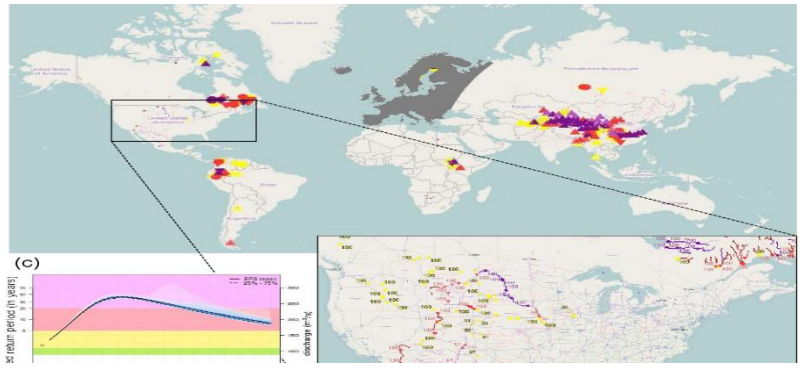
CAMS analysis organic matter AOD (fire emissions)

Climate Change Service



Reanalysis monitoring changes in global surface air temperature

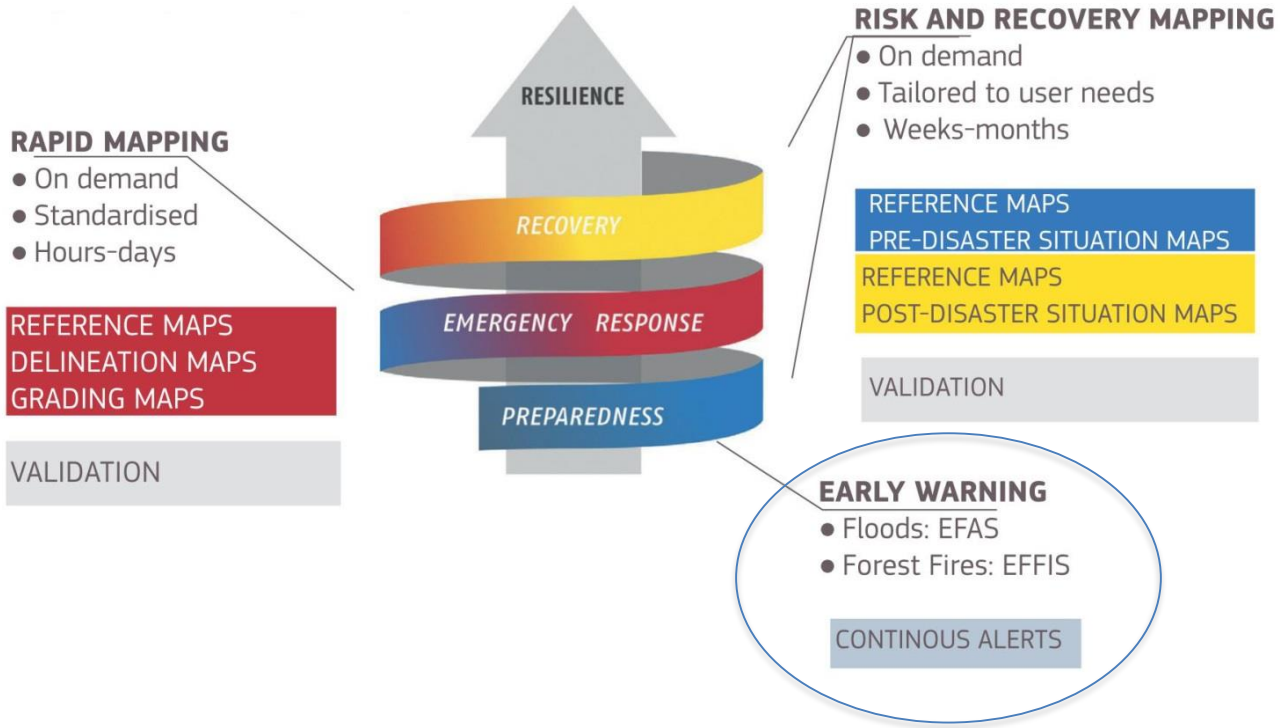
Emergency management Service Flood and Fire forecasting



Main GloFAS interface

Copernicus Emergency Management Service

- EC Copernicus Emergency Service set-up to "*Provides information for emergency response in relation to different types of disasters as well as prevention, preparedness, response and recovery activities*."
- ECMWF computational centre for Flood and Fire hazard of Early Warning service components
- EFAS, European domain operational since in 2012, pre-operational since 2003
- GloFAS, Global domain operational from March 2018, pre-operational since 2011
- EFFIS 2018



ECMWF

EFAS: European Flood Awareness System

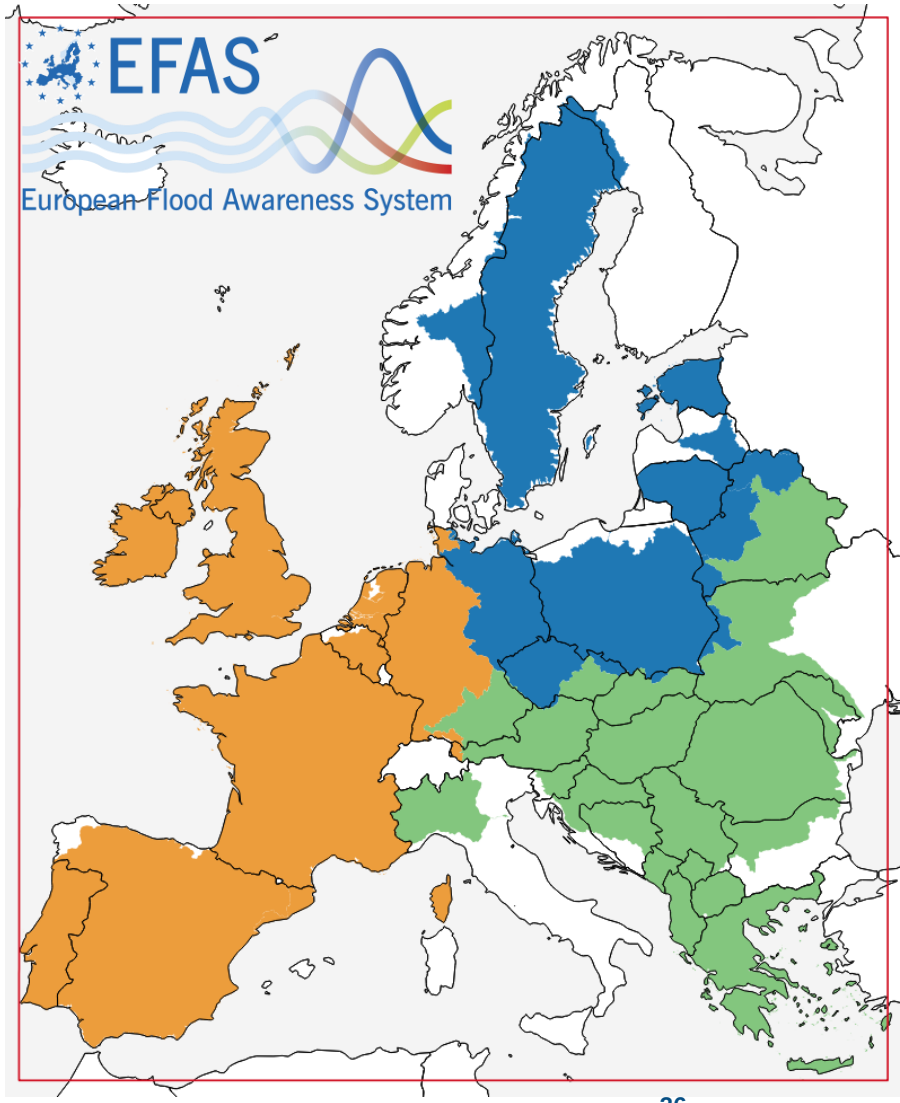
- Early probabilistic flood warnings across Europe
- Operational since October 2012, developed since 2003
- Transboundary
- 50 partners who provide:
  - Observations
  - Feedback on warning performance

Structure:

JRC EUROPEAN COMMISSION

opernicus

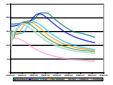
Meteorological Data Centre	Hydrological Data Centre	Computational Centre	Dissemination Centre
DWD, KISTERS	ELIMCO, Rediam	ECMWF	SHMU, SMHI, Rijkswaterstaat



Operational EFAS System

DATA

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



Historical Data

Static Data

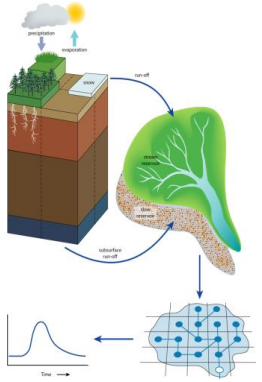
Europ. Data Layers

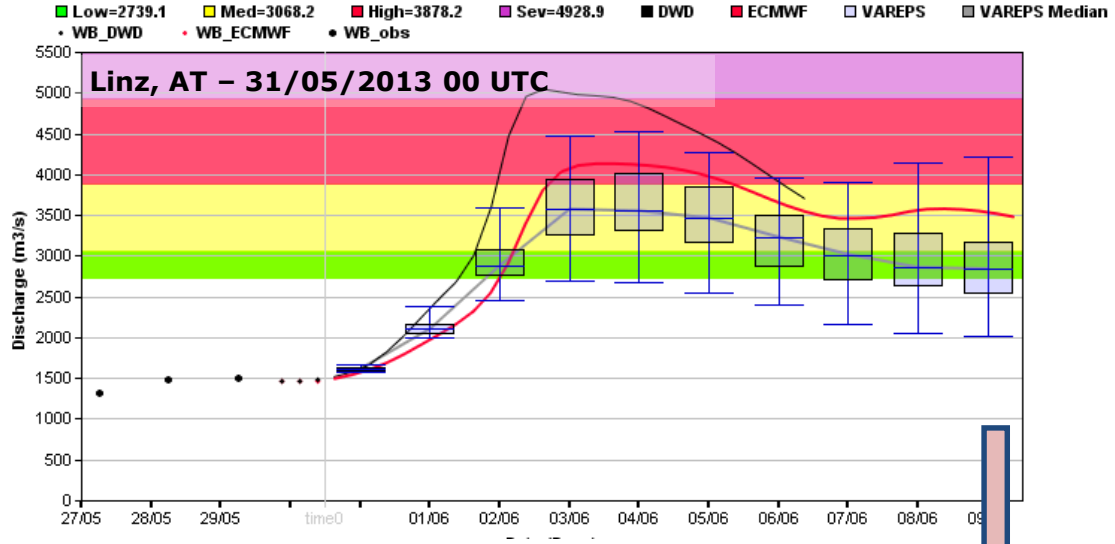
Meteo – Data / forecasts

Expert Knowledge of Member States

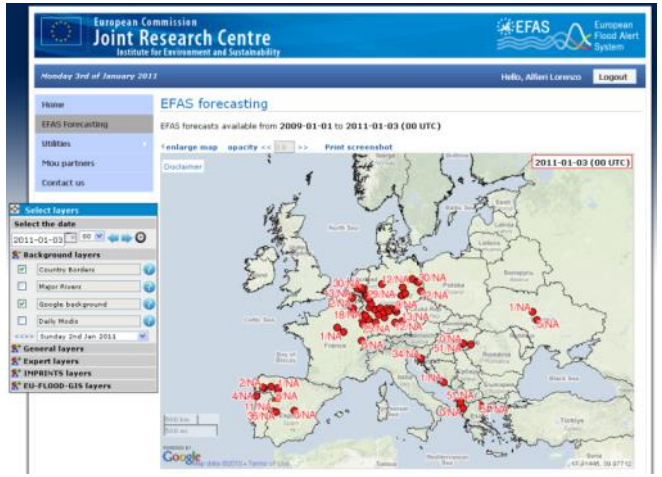
Hydrological modeling

LISFLOOD



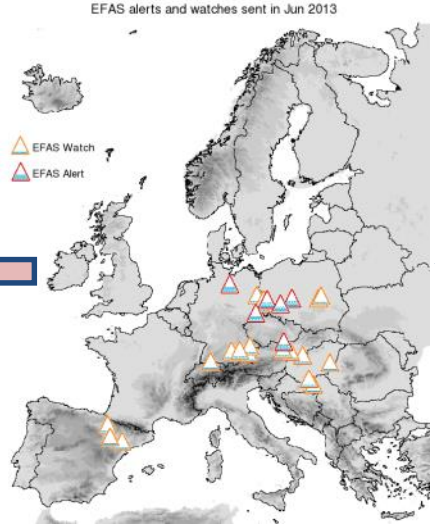


EFAS user interface

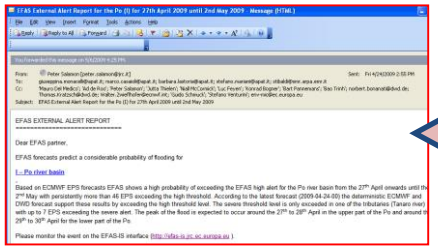


Generate Alerts

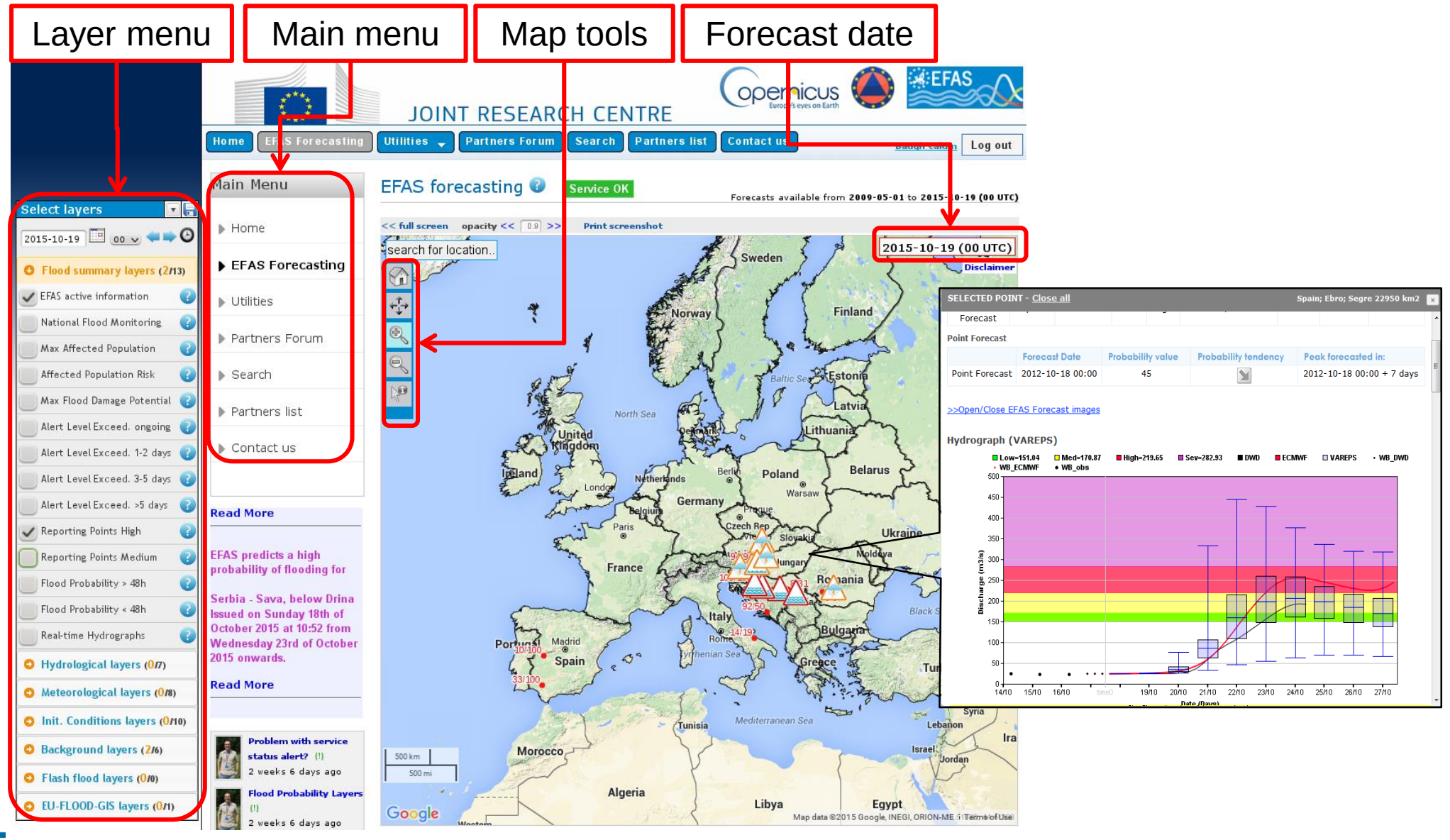
EFAS partner network



Alert email

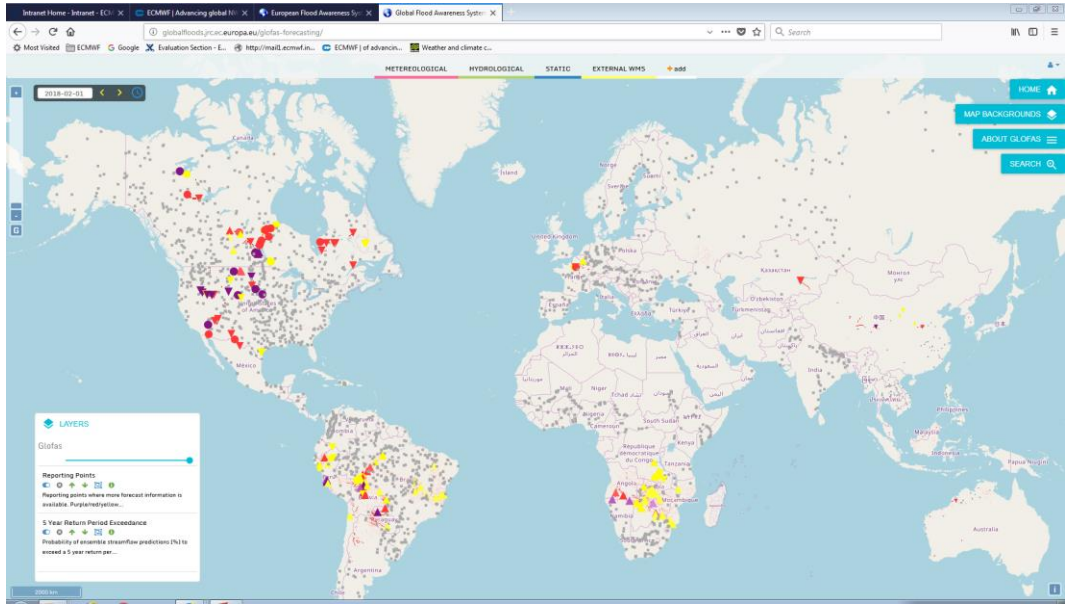


EFAS Web Interface



GloFAS: Global Flood Awareness System

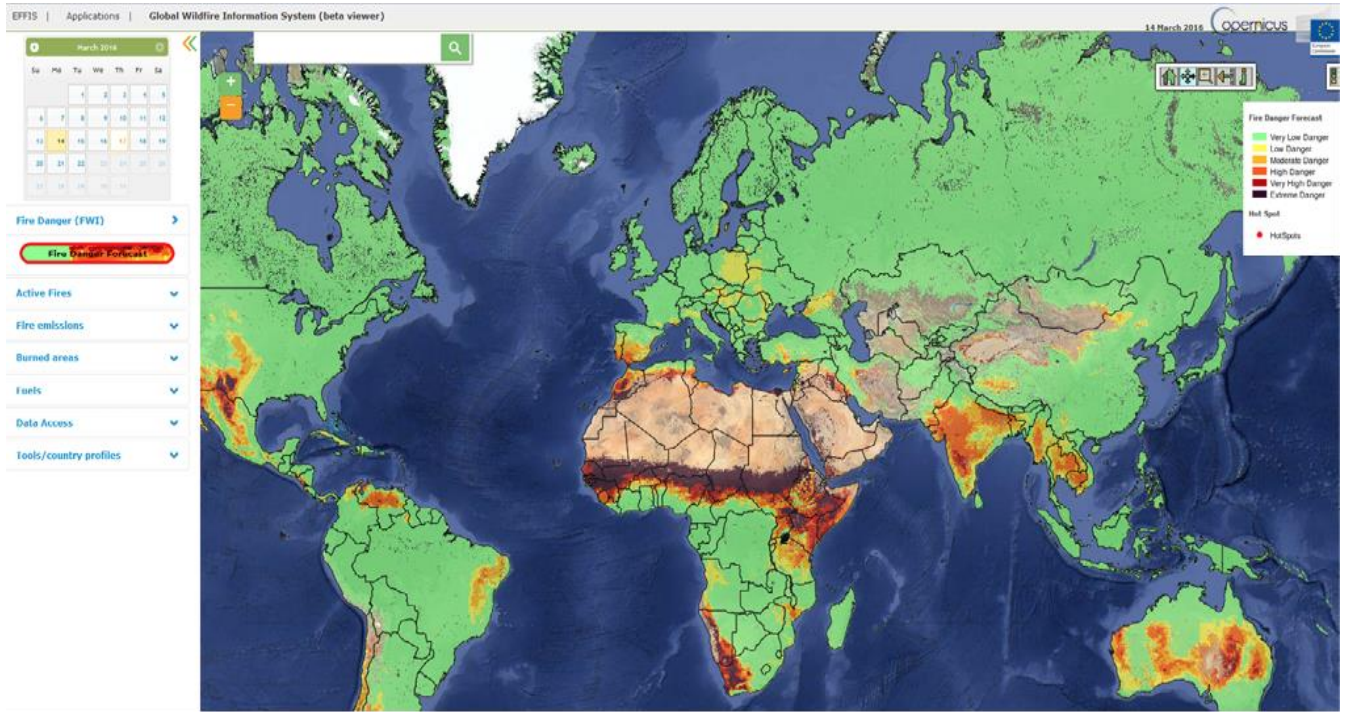
- Pre-operational since 2011
  - Producing medium range probabilistic flood forecasts
- Provides:
  - Global overviews of upcoming flood events in large river basins
  - Early warnings and info on upstream river conditions to downstream countries
- GloFAS has >1000 registered users from:
  - Public authorities
  - NGOs
  - Private sector
  - Academic/training/research institutions



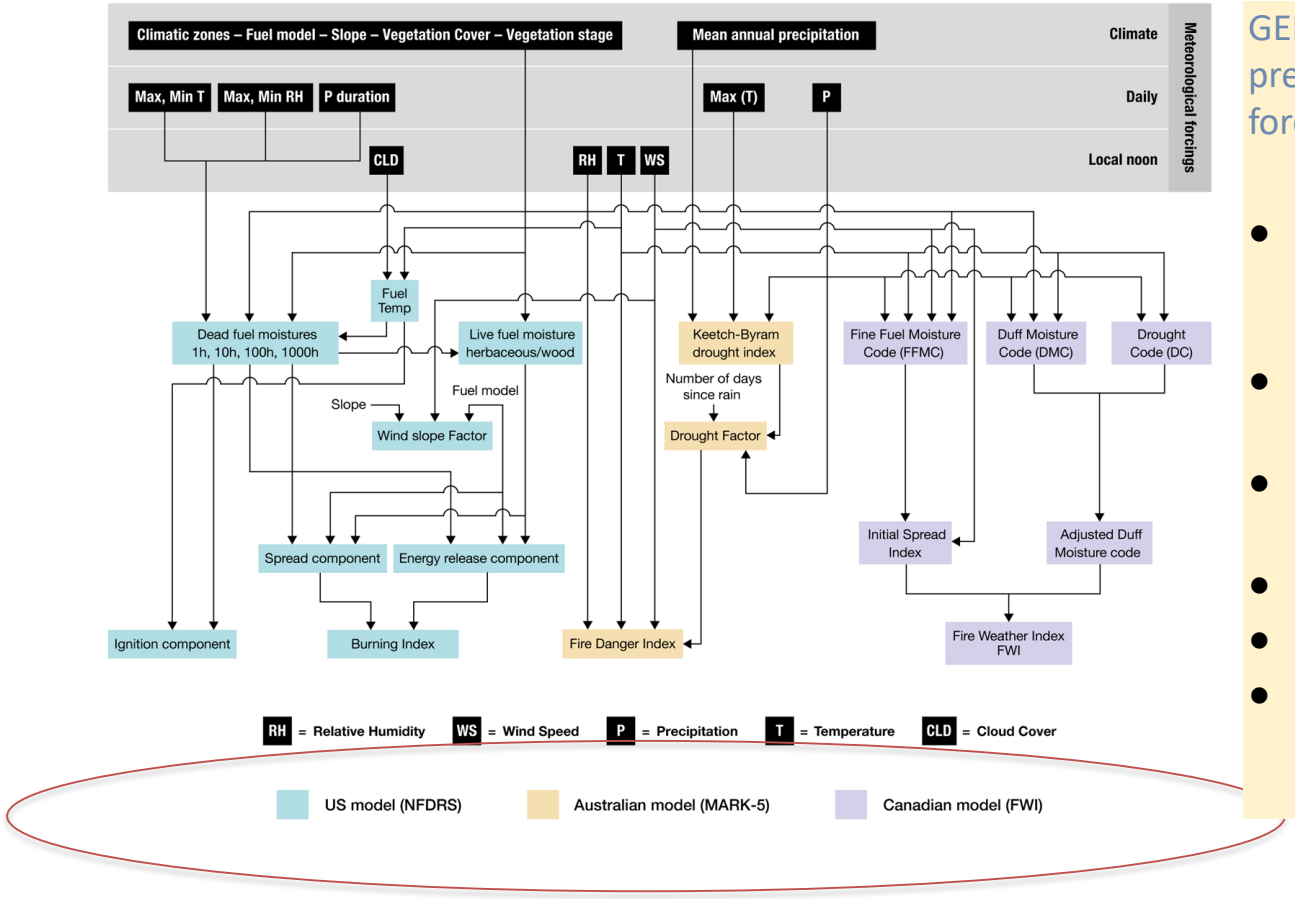
Fire forecast @ECMWF

The European Forest Fire Information System (EFFIS) is one of the products in support of natural disaster management provided by the Copernicus Emergency Management Service

The EFFIS platform is being expanded into the Global Wildfire Information System (GWIS) which aims at the creation of an integrated system that provides access to all fire related available information on a global scale.



The Global ECMWF Fire Forecast system



GEFF is a multi-model ensemble prediction system for fire danger forecast:

- 3 fire rating models: NFDRS (US),MARK-5 (Australia), FWI (Canada)
- 51 ensemble members at 18 km resolution
- 1 high resolution run at 9km resolution
- 10 days lead time
- Daily updates
- Uses the most recent ECMWF model cycle

GEFF –Reanalysis from ERA-Interim 1980-2017

GEFF –Extended rage [46 days]

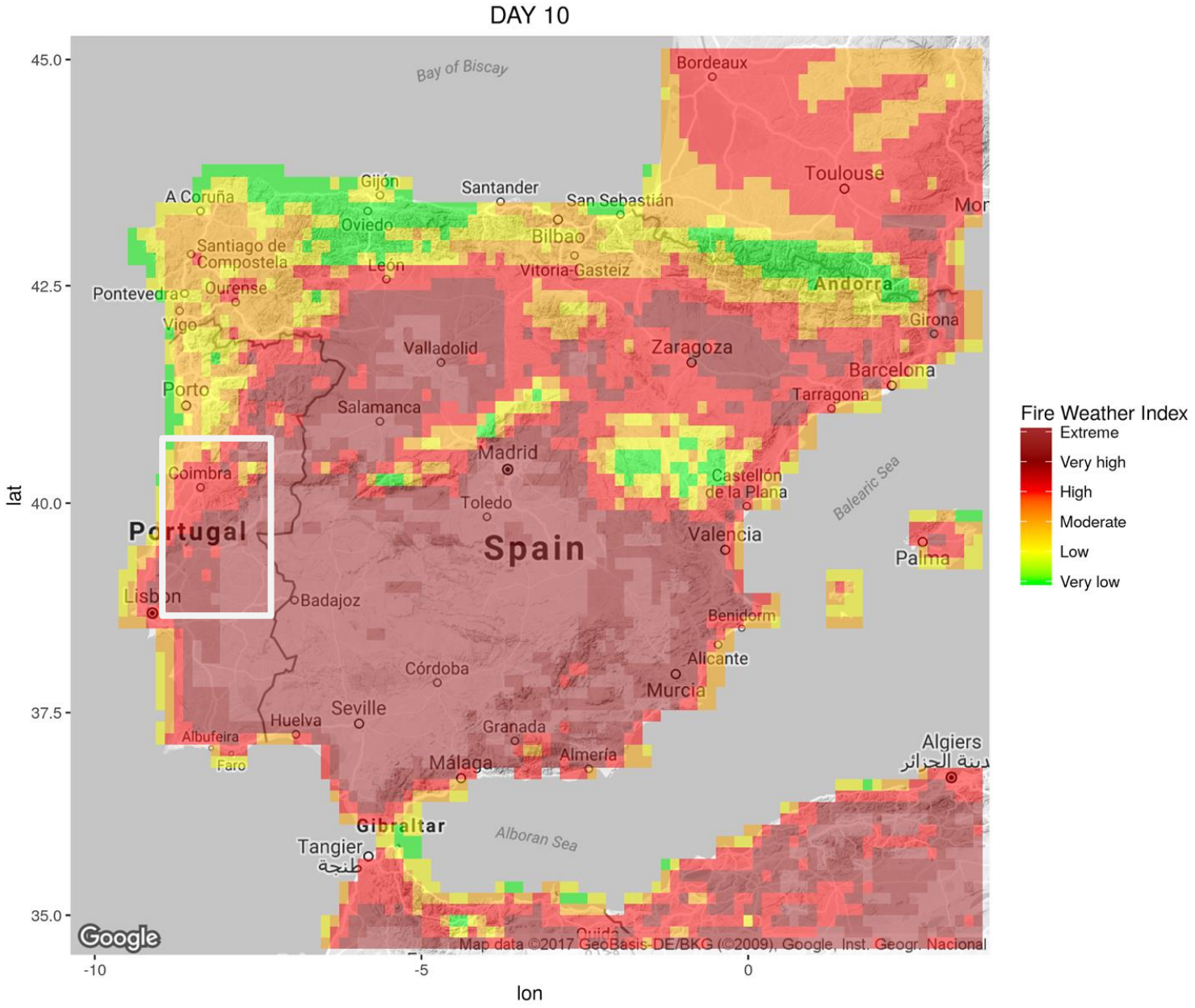
Di Giuseppe, Francesca, et al. "The potential predictability of fire danger provided by numerical weather prediction." Journal of Applied Meteorology and Climatology 55.11 (2016): 2469-2491.

Fire Danger Forecast @ECMWF: Coimbra - Portugal (17-18 June 2017)

A catastrophic forest fire in Portugal has claimed at least 62 lives. Most casualties in the Pedrógão Grande area, 50 km (30 miles) south-east of Coimbra

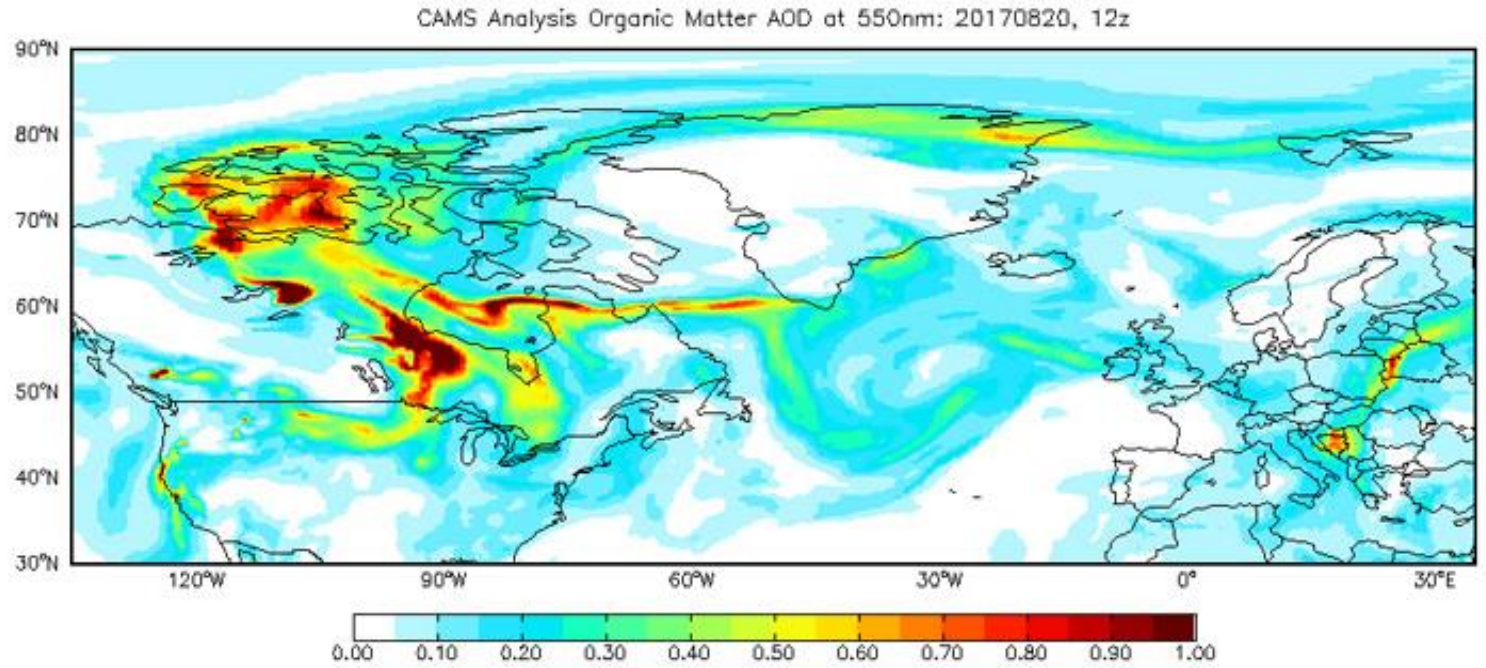
The fire is believed to have started ignited by a dry thunderstorm and has spread very quickly due to the heatwave which had affected the region with temperatures of more than 40C (104F)

ECMWF forecast had a clear signal for extreme (less the 2% of occurrence) fire danger conditions already 10 days before the event



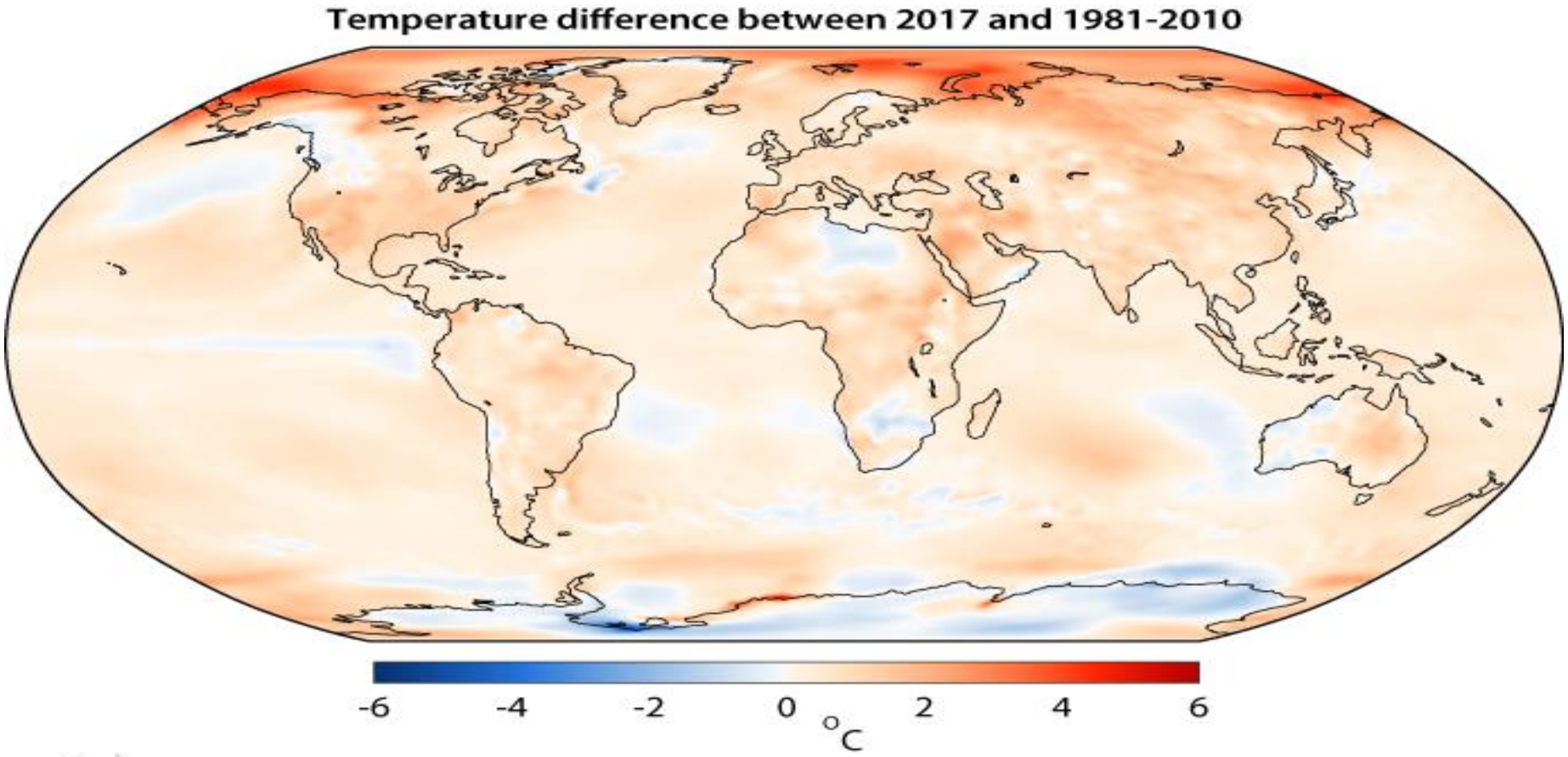
ECMWF working with the EU to forecast fires

Operating the Copernicus Atmosphere Monitoring Service



ECMWF working with the EU to monitor climate change

Operating the Copernicus Climate Change Service



What is new in ERA5?

	ERA-Interim	ERA5
Period	1979 – present	Initially 1979 – present, later addition 1950-1978
Streams	1979-1989, 1989-present	Parallel streams, one/two per decade
Assimilation system	2006, 4D-Var	2016 ECMWF model cycle (41r2), 4D-Var
Model input (radiation and surface)	As in operations, *(inconsistent sea surface temperature)*	***Appropriate for climate***, e.g., evolution greenhouse gases, volcanic eruptions, sea surface temperature and sea ice
Spatial resolution	79 km globally 60 levels to 10 Pa	***31 km globally*** 137 levels to 1 Pa
Uncertainty estimate		Based on a 10-member ***4D-Var ensemble*** at 62 km
Land Component	79km	ERA5L, 9km (separate, forced by ERA5)
Output frequency	6-hourly Analysis fields	***Hourly*** (three-hourly for the ensemble), ***Extended list of parameters*** ***~ 9 Peta Byte (1950 - timely updates)***
Extra Observations	Mostly ERA-40, GTS	Various ***reprocessed CDRs***, ***latest instruments***
Variational Bias correction	Satellite radiances, radiosondes predetermined	Also ozone, aircraft, surface pressure, newly predetermined for radiosondes.

Summary

- Overview of ECMWF and Copernicus outputs relevant for MHEWS
- EFI, SOT, reforecast (model climate)
- Cyclone products (tracks, intensity)
- Large-scale flow, regime-based outputs
- Increasing range of model output parameters in response to use requests
  - Lightning
  - Precip type, Precip rate
  - Waves, sea ice,
- Copernicus products: floods, fire, air quality; reanalysis