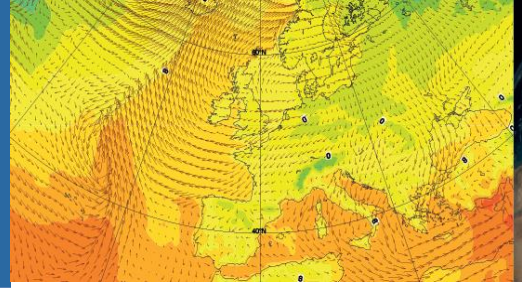




ECMWF plans & product development

Florian Pappenberger
Tim Hewson

ECMWF

ECMWF 2016-2025 strategy: overview

ECMWF's purpose is to develop a capability for medium-range weather forecasting and to provide such weather forecasts to the Member and Co-operating States

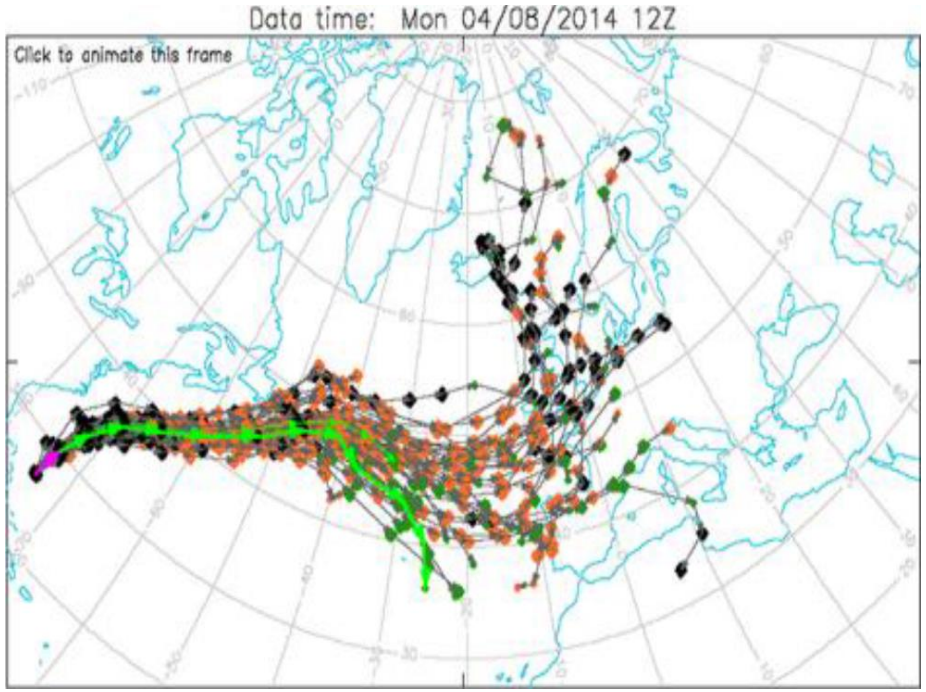
ECMWF is complementary to the National Meteorological Services and works with them in research, numerical weather predictions, supercomputing and training.

- Focus on high-impact weather, regime transitions and global-scale anomalies
- Integrated ensemble at high resolution at 5km by 2025
- Earth-System model and analysis
- Scalable computation
- Environmental information services: Copernicus

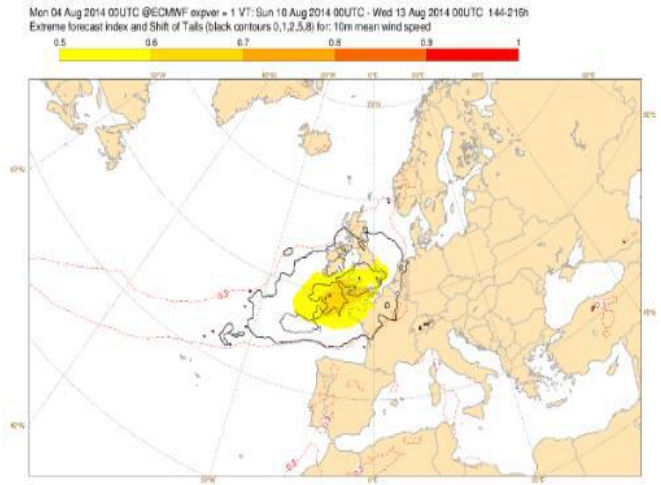
ECMWF 2016-2025 strategy: the challenge

The challenge: prediction of high-impact weather 2 weeks ahead.

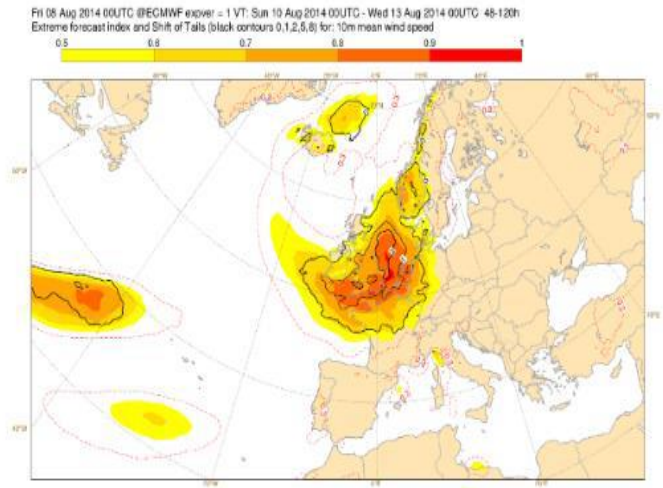
High-impact weather: Hurricane Bertha



The difficulty: sharp ensembles 2 weeks ahead



6-9 days

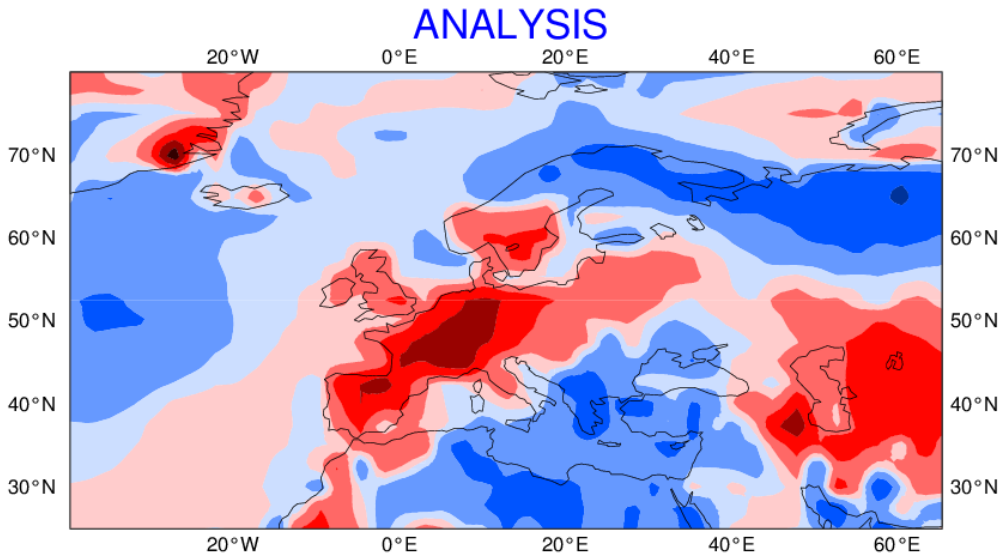


2-5 days

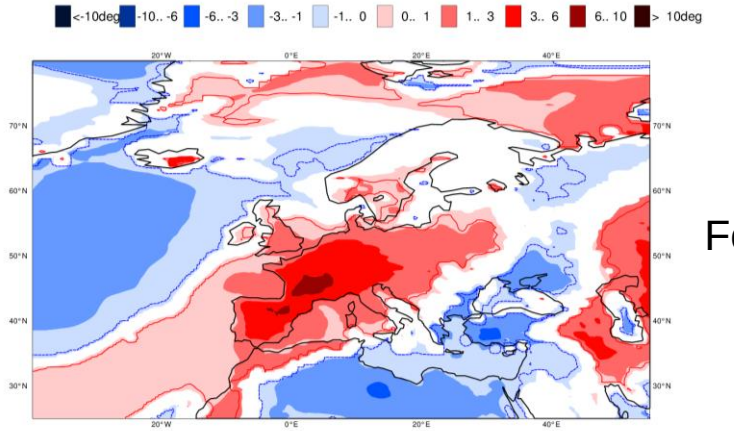
ECMWF 2016-2025 strategy: the challenge

The prediction of regional anomalies and regime transitions 4 weeks ahead.

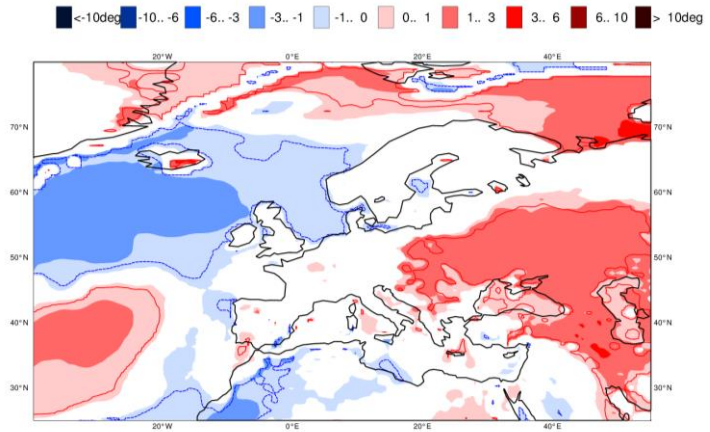
European heat wave - 29 June – 5 July 2015



The difficulty: extracting a signal 3-4 weeks ahead



Forecast week 1.5



Forecast week 2.5

The operational forecasting system

High resolution deterministic forecast (HRES) :

- twice per day **9 km** 137 levels, to 10 days ahead

Ensemble forecast (ENS):

- twice per day 51 members, **18 km** 91 levels, to 15 days ahead
- Monday/Thursday 00 UTC extended to 1 month ahead (**Monthly Forecast, 18/36 km**)

Ocean waves: twice per day

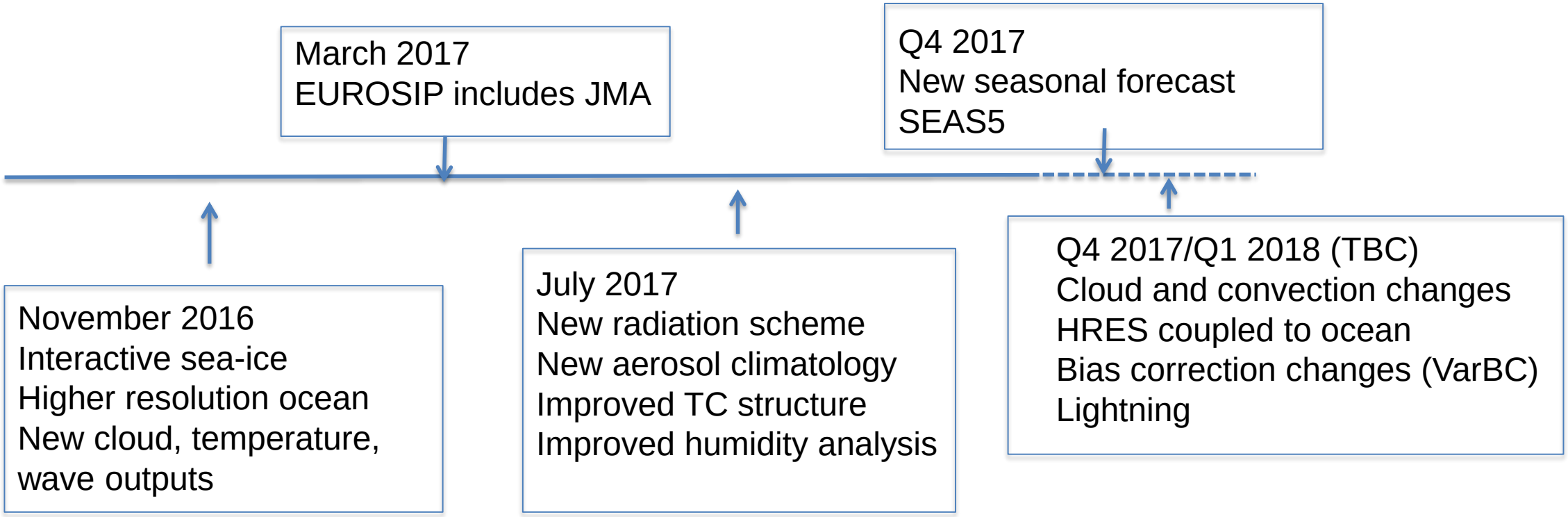
- **HRES-WAM**: 10 days ahead at **14 km** (coupled)
- **HRES Stand Alone Wave (SAW) model** : 10 days ahead at **11 km**
- **ENS-WAM:** 15 days ahead at **28 km** (coupled)

Seasonal forecast: once a month

- 51-members, **~80 km** 91 levels, to 7 months ahead
- sub-set of 15 members is run for 13 months every quarter (**30 years of hindcasts**)

IFS cycles

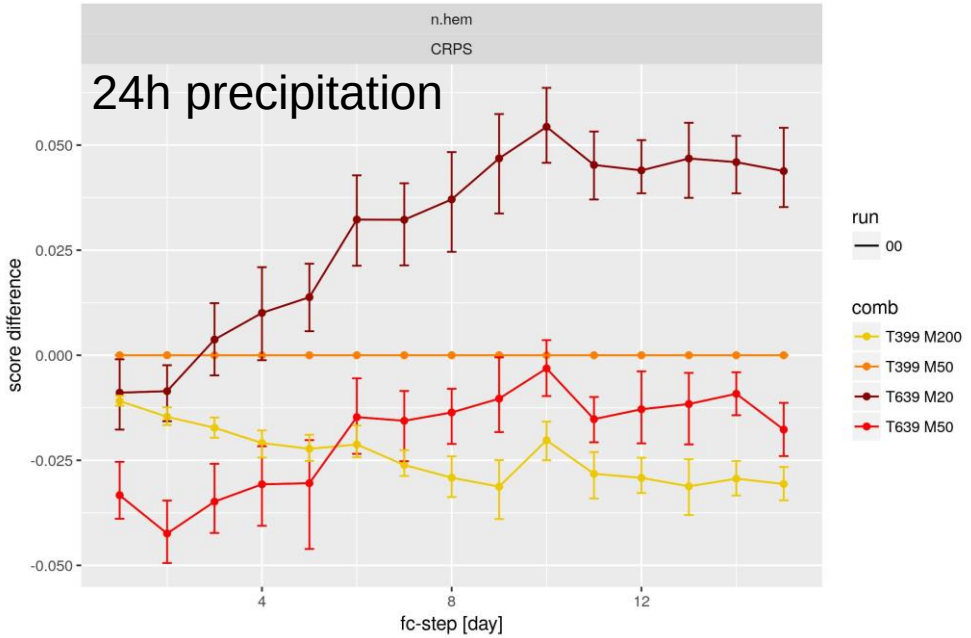
November 2016 and beyond …….

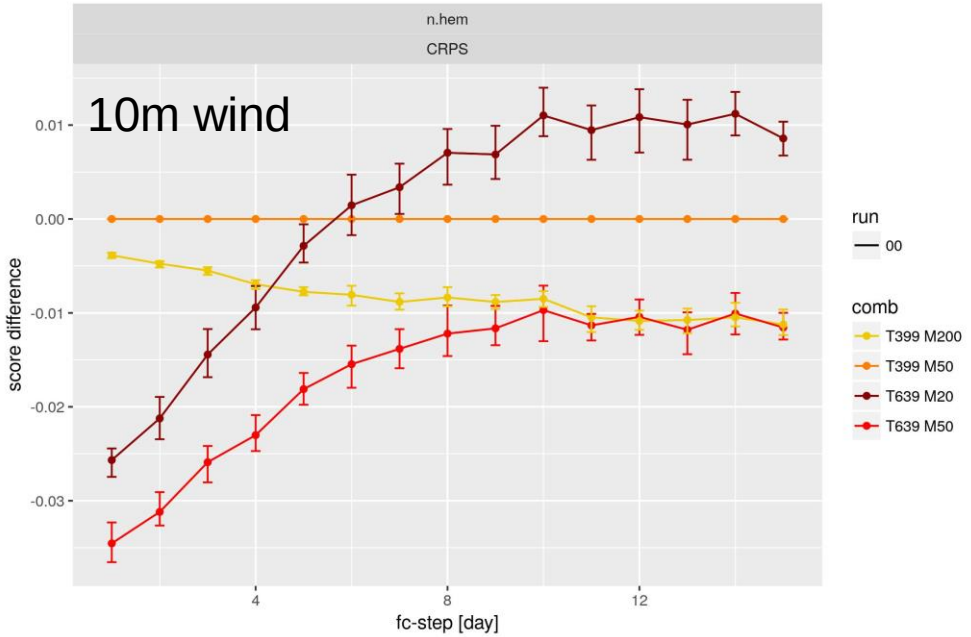


ENS configurations

What are relative benefits of increasing spatial resolution versus increasing ensemble size?

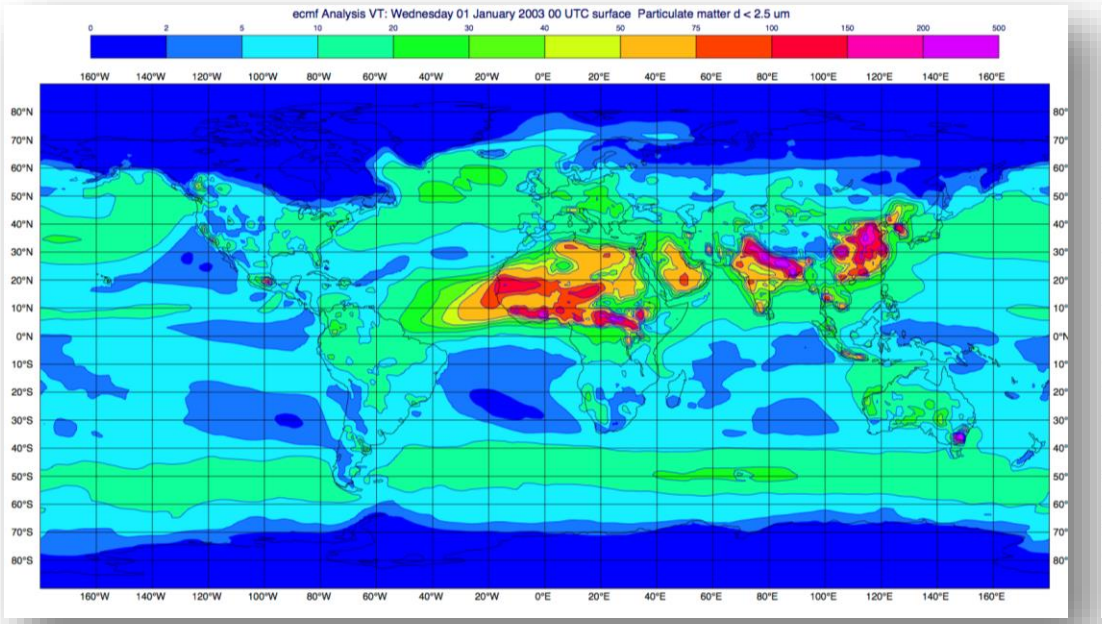
- two configurations with similar costs:
  - 50 members at18-km resolution
  - 200 members at 29-km resolution
- Depends on parameter, forecast range, …
- Dual resolution ENS configuration?

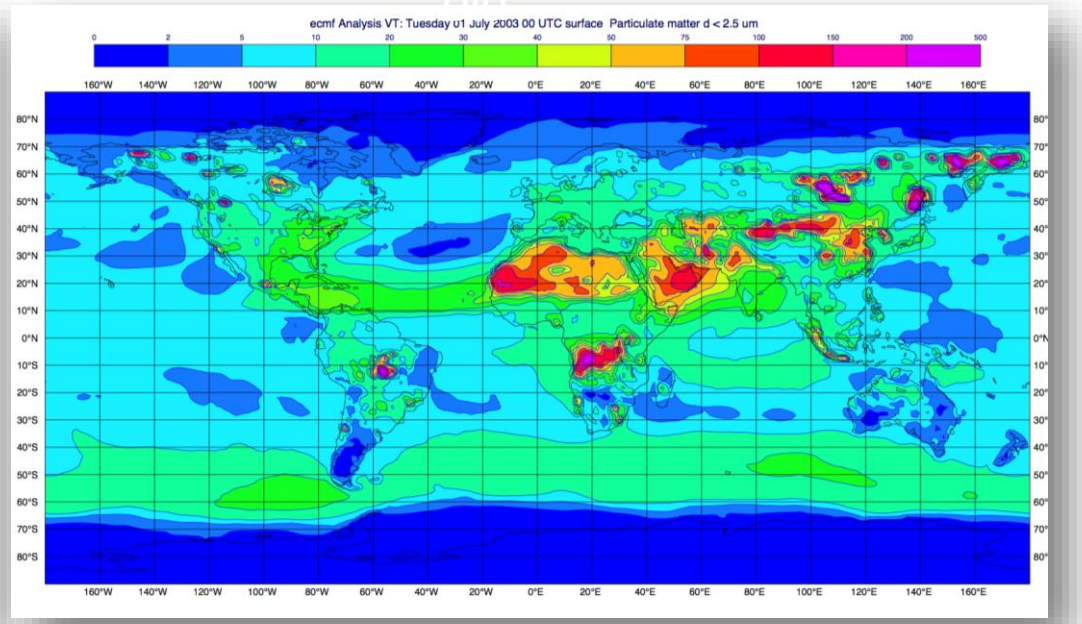




Long term research plans shown by Irina Sandu

CAMS REANALYSIS 2003-present





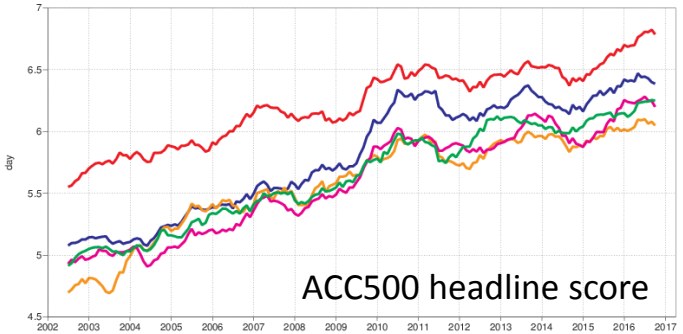
A new CAMS reanalysis of atmospheric composition has started running (Jan, top and July 2003, bottom) and first results are promising.

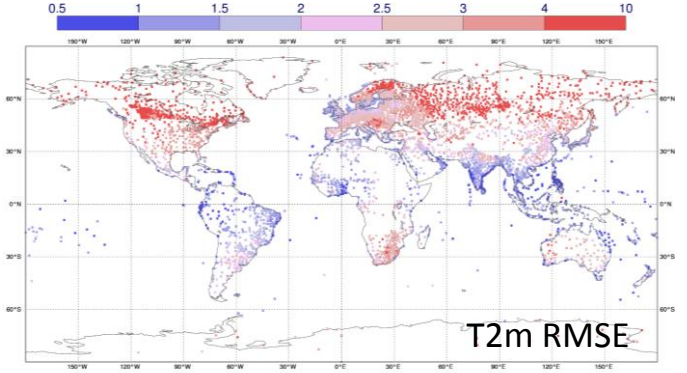
1st release (2003-2008) to users expected in Q3-Q4. The previous reanalysis (MACC) has now over 2600 users worldwide.

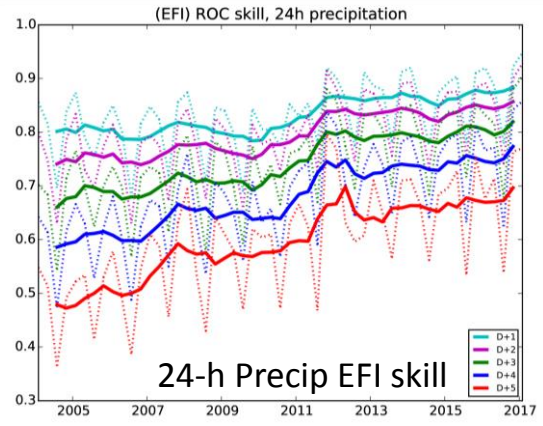
ECMWF

Assessing the quality of our forecasts

- Headline scores
- Comparison with reference forecasts (ERA-Interim, ERA5) and other centres
- Daily monitoring of forecast quality (Daily Report)
- Severe event catalogue
- In-depth analysis of specific issues
- Model diagnostics and relaxation experiments

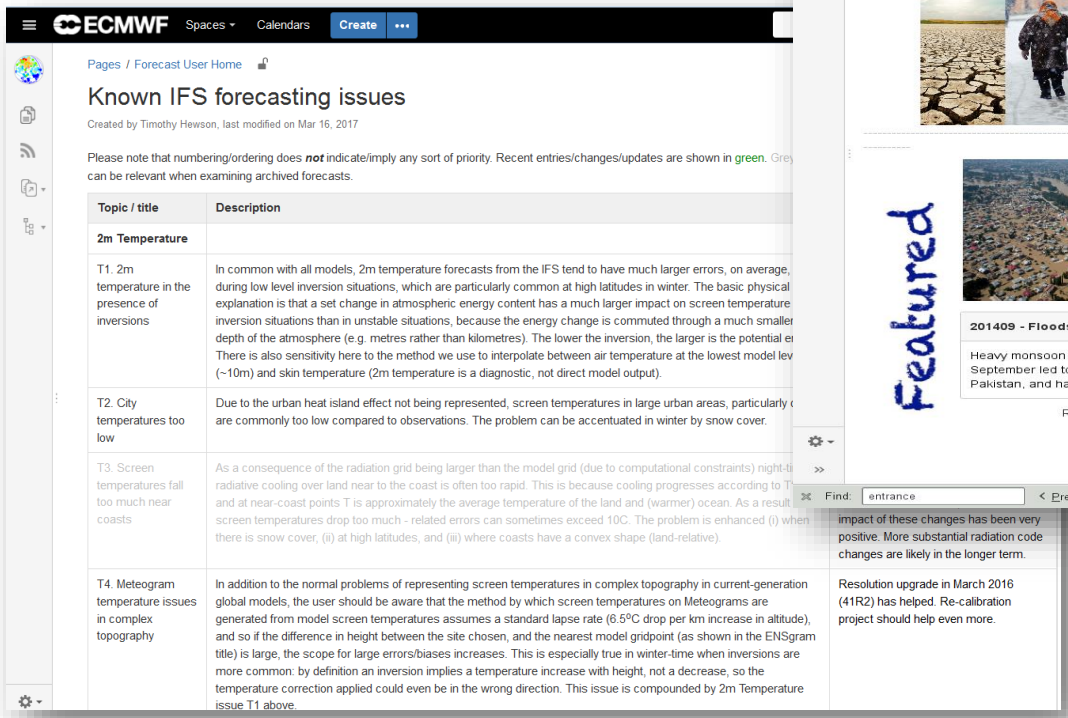


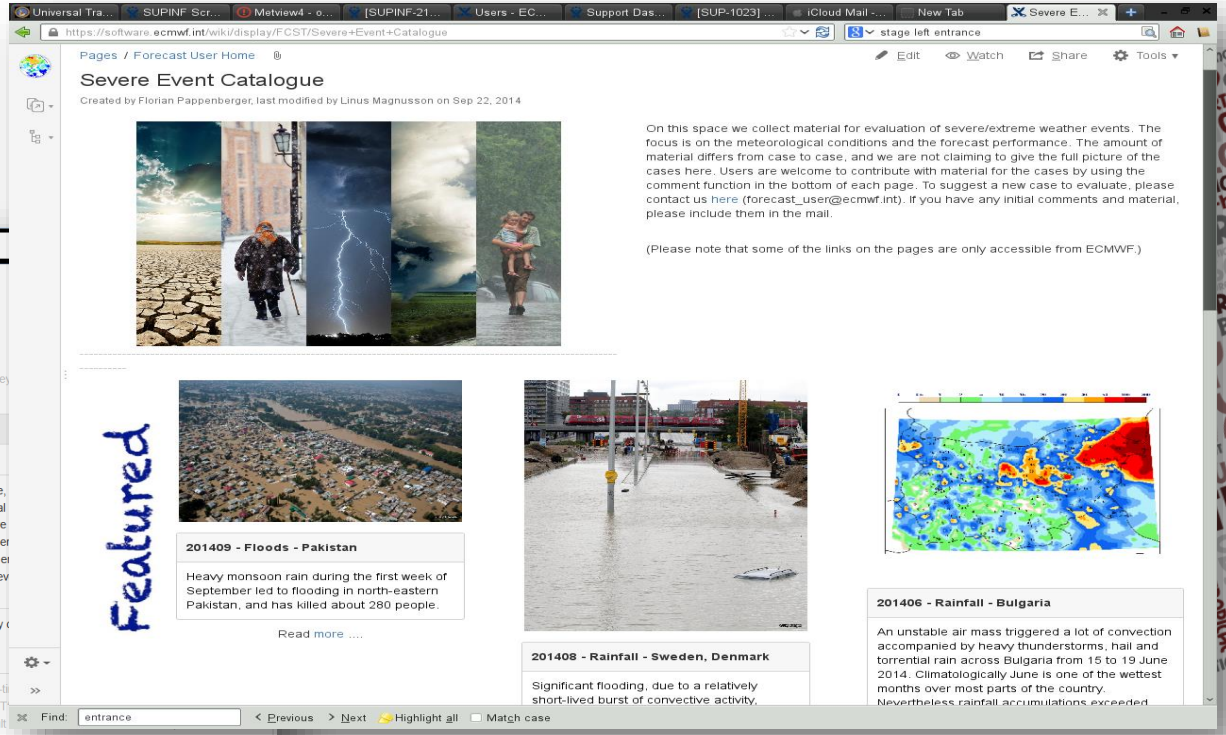




See later talks by David Richardson and Thomas Haiden

Sharing knowledge





https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues

https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue

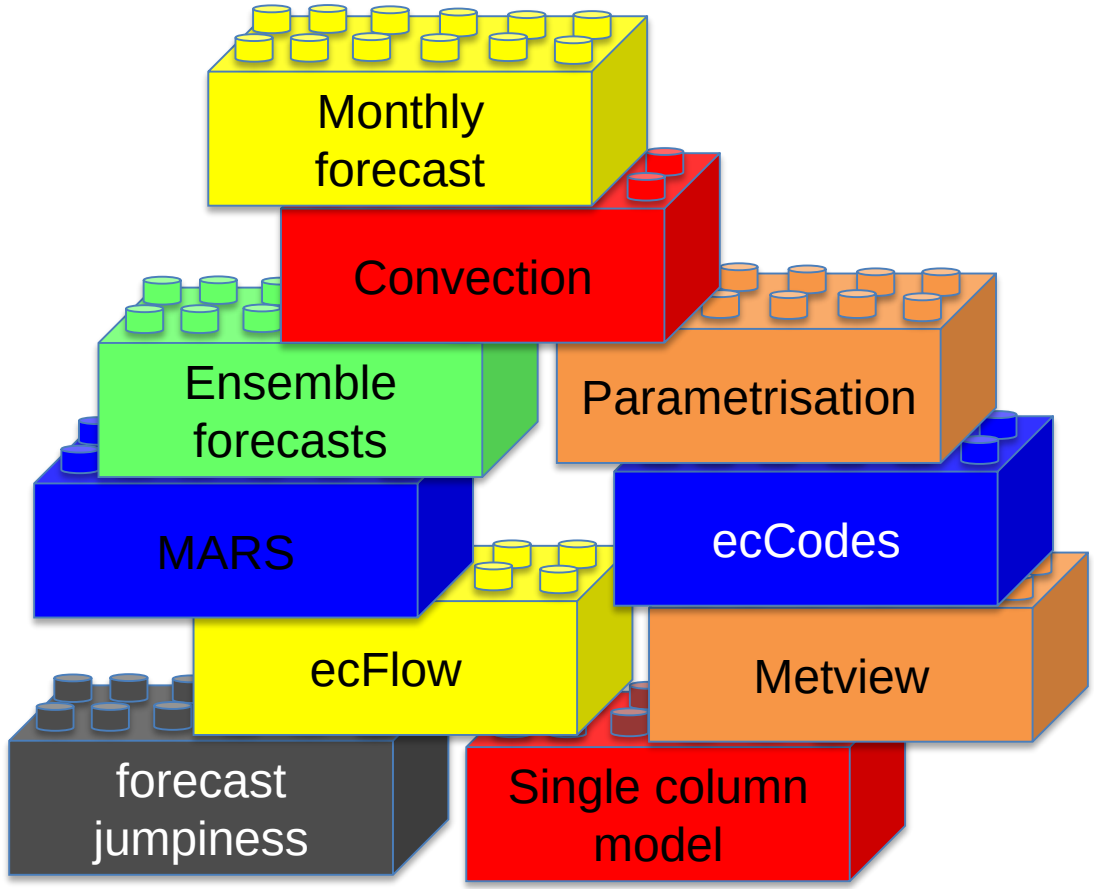
eLearning @ECMWF

Self-contained modules to be used either stand-alone or as part of blended courses (eLearning combined with face to face)

Freely available

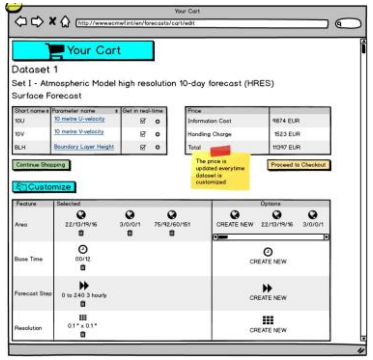
Learner-tailored approach to allow for different knowledge levels and learning styles

The project has funds for about 24 modules (11 by August 2017, and the rest before summer 2018)

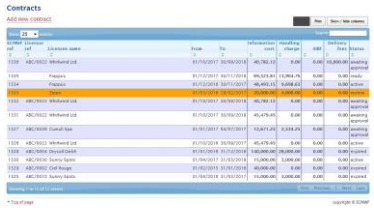


New Software

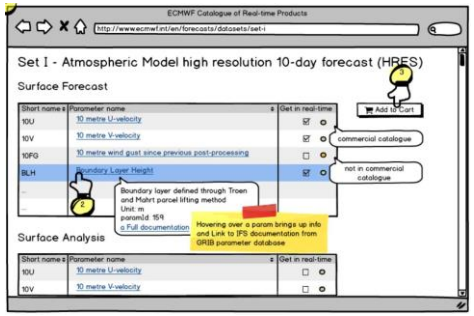
- **MIR**: New interpolation replacing EMOSLIB; Introduction in operations (MARS, Product Generation etc) next year initially in parallel to the current package; There will be differences as we remove bugs and update the algorithms
- **Product Delivery:** Interfaces to browse, select, price, install and manage data requirements
- **Python Framework**: Offer Python version of Metview Macro; High level field and observation functions (differences, cross sections, regridding, etc) integrated with powerful user interface for plotting / data inspection



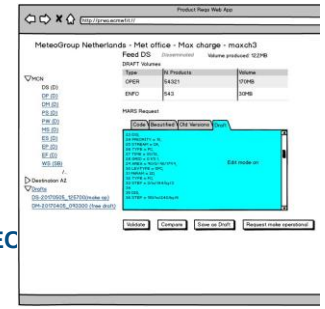
Pricing Management



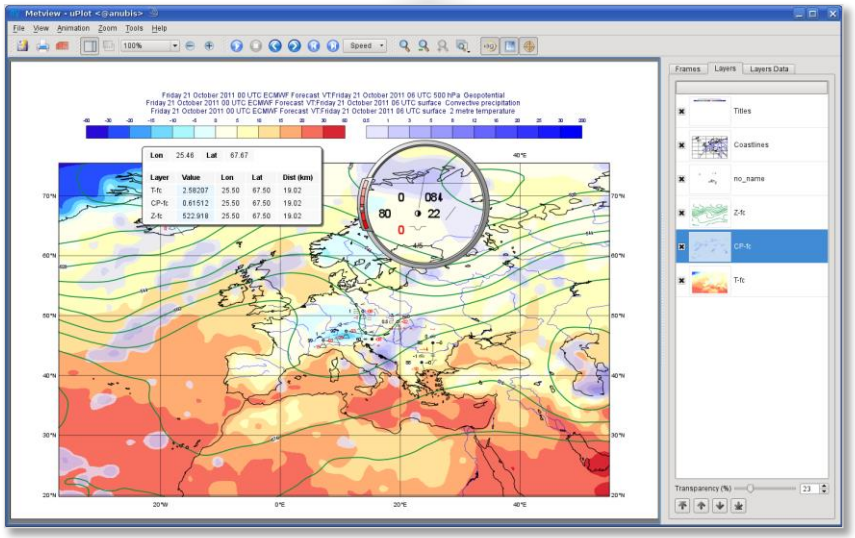
Licences Management



Web Catalogue



Requirements Management



Special Projects

A maximum of 10% of the computing resources available to Member States may be allocated to Special Projects

For 2018:

HPCF: 825 million units (1 CPU hour = ~16 units)

Data Storage: 4610 terabytes

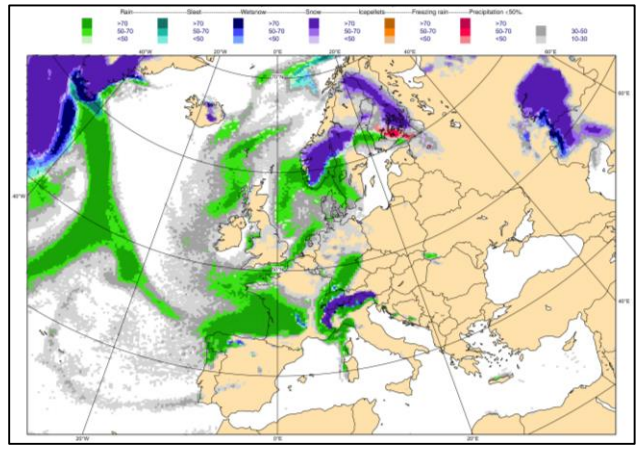
Applications must be done via one of the ECMWF Member States

Questions? Talk to Umberto!

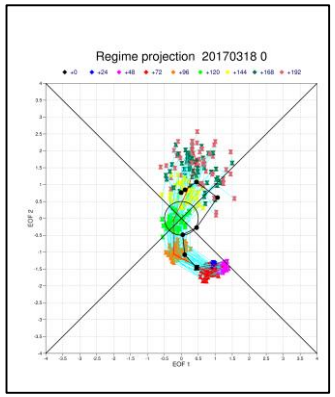
User requests for forecast products

- ECMWF provides forecast products to meet the requirements of its Member and Co-operating States
  - Selected ECMWF products used by NMHSs of other WMO members, commercial customers and the public
- Requests for new products
  - annual users' meetings: "Using ECMWF's Forecasts"
  - ECMWF visits to the Member and Co-operating States
  - reports from Member and Co-operating States
  - Training courses
- Consolidated list of requests for new forecast products reviewed by TAC each October
- Some constraints e.g. on data policy set by Member States

Some upcoming ECMWF Products



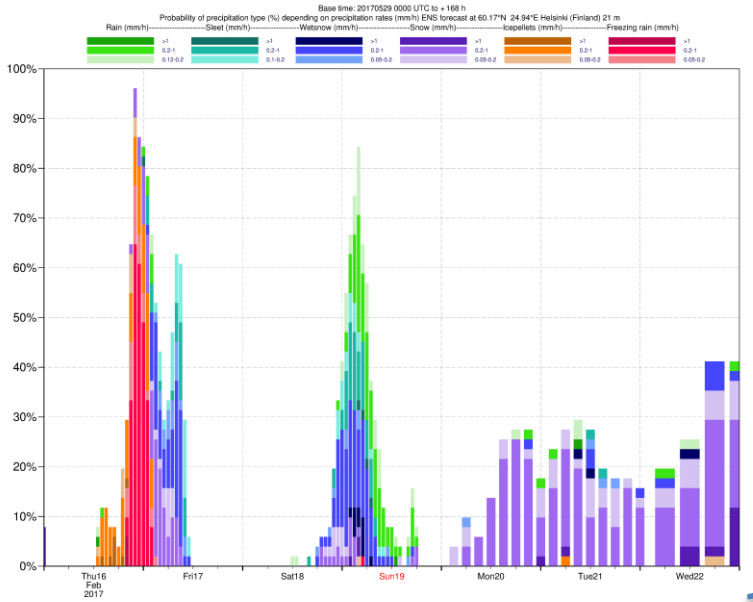
- At various stages of development, all from the ENS
- Intrinsically all have two uses:
  - General forecasting
  - Application(s) regarding severe weather
- Four products
  1. Precipitation Type (snow/fz rain) [Estíbaliz Gascón – weather wall later]
  2. Point Rainfall (flash floods) [Fatima Pillosu – poster later]
  3. Distributions in the monthly forecast (various) [Ivan Tsonevsky]
  4. Moisture Flux (orographic rainfall extremes) [David Lavers, poster/pico later]
  5. Regime Transitions (various) [Laura Ferranti, Linus Magnusson]



- Final products may look a bit different to what will be shown here

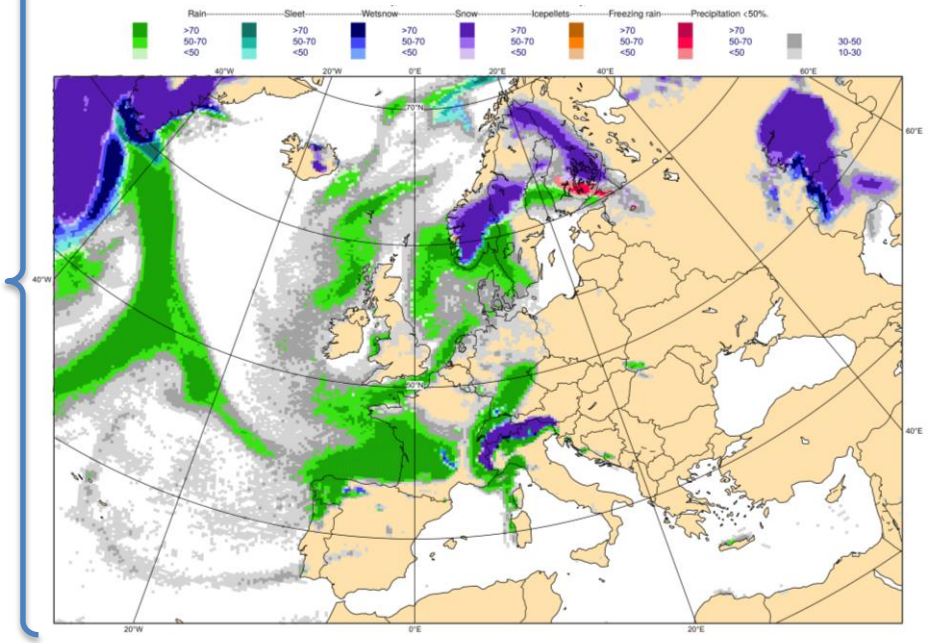
1. Precipitation Type

Precipitation type Probabilities



- The ECMWF Precipitation type probability focusses on the type of precipitation falling (at the surface) at the valid time: rain, snow, wet snow, sleet, freezing rain, ice pellets, dry
- Precipitation **rate is denoted by "lightness"** of the colour shades, e.g. to provide indication of potential substantial freezing rain events. Ranges are: <V mm/h, V → 1mm/h, >1mm/h (darkest).
- "V" is the threshold of minimum precipitation rate for each precipitation type, used to define "precipitation occurring" (by enforcing bias=1).

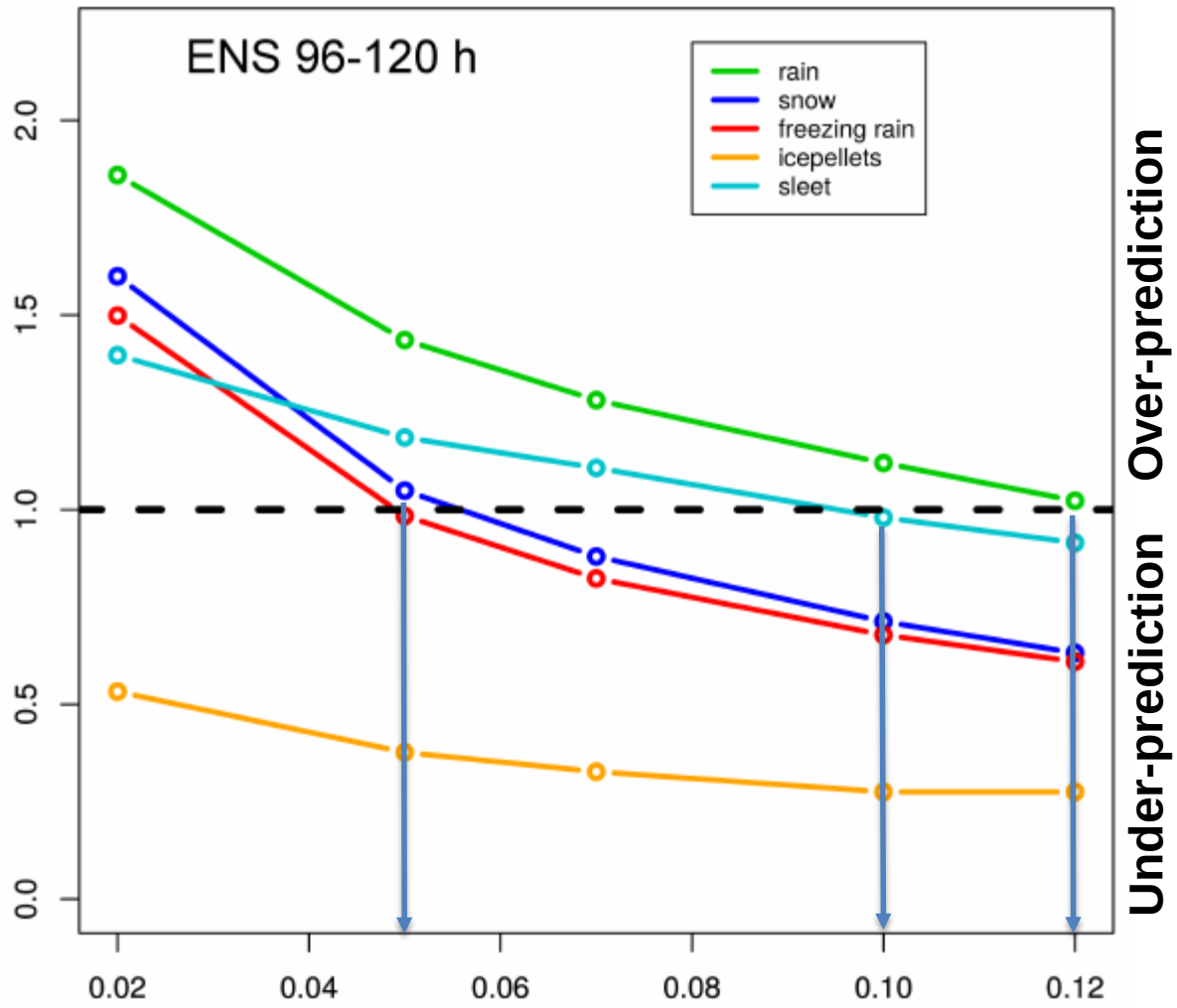
Most probable Precipitation type

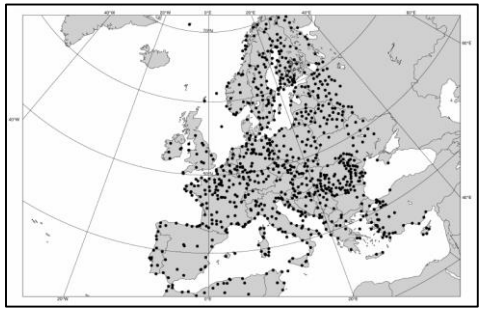


- Shows the most probable precipitation type according to ENS distribution
- **Greys** denote dry is most likely, but equally show probability of there being any falling precipitation (PPF) when that lies between 10 and 50%.
- **Colours** are for when precipitating is most likely (PPF>50%); **"lightness" shows type probability** in three bands: <50%, 50→70%, >70% (darkest).
- Minimum rates employed (V) are:

  rain: 0.12mm/h, sleet: 0.1mm/h, all others: 0.05mm/h

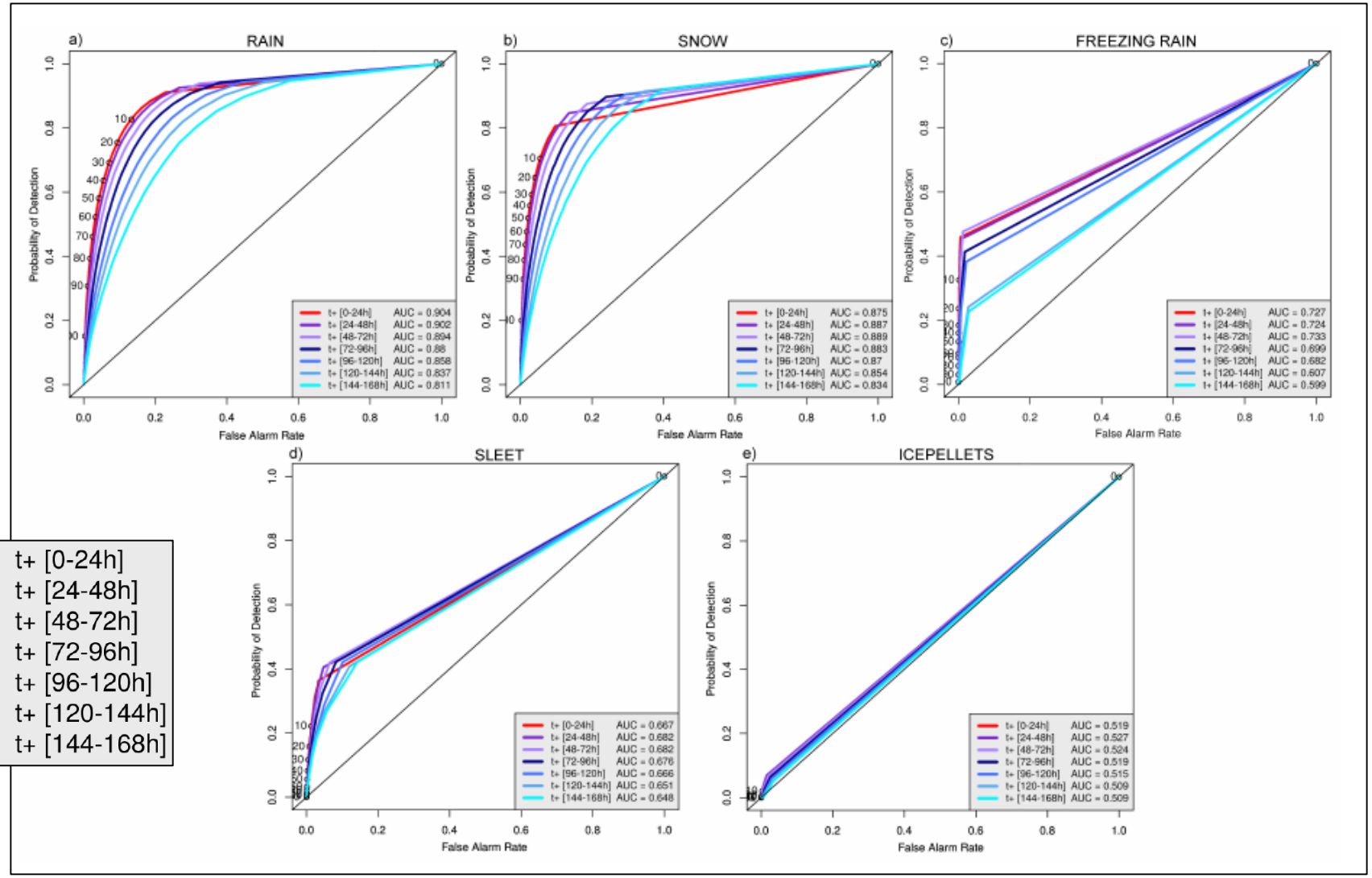
BIAS adjustment





versus SYNOPS

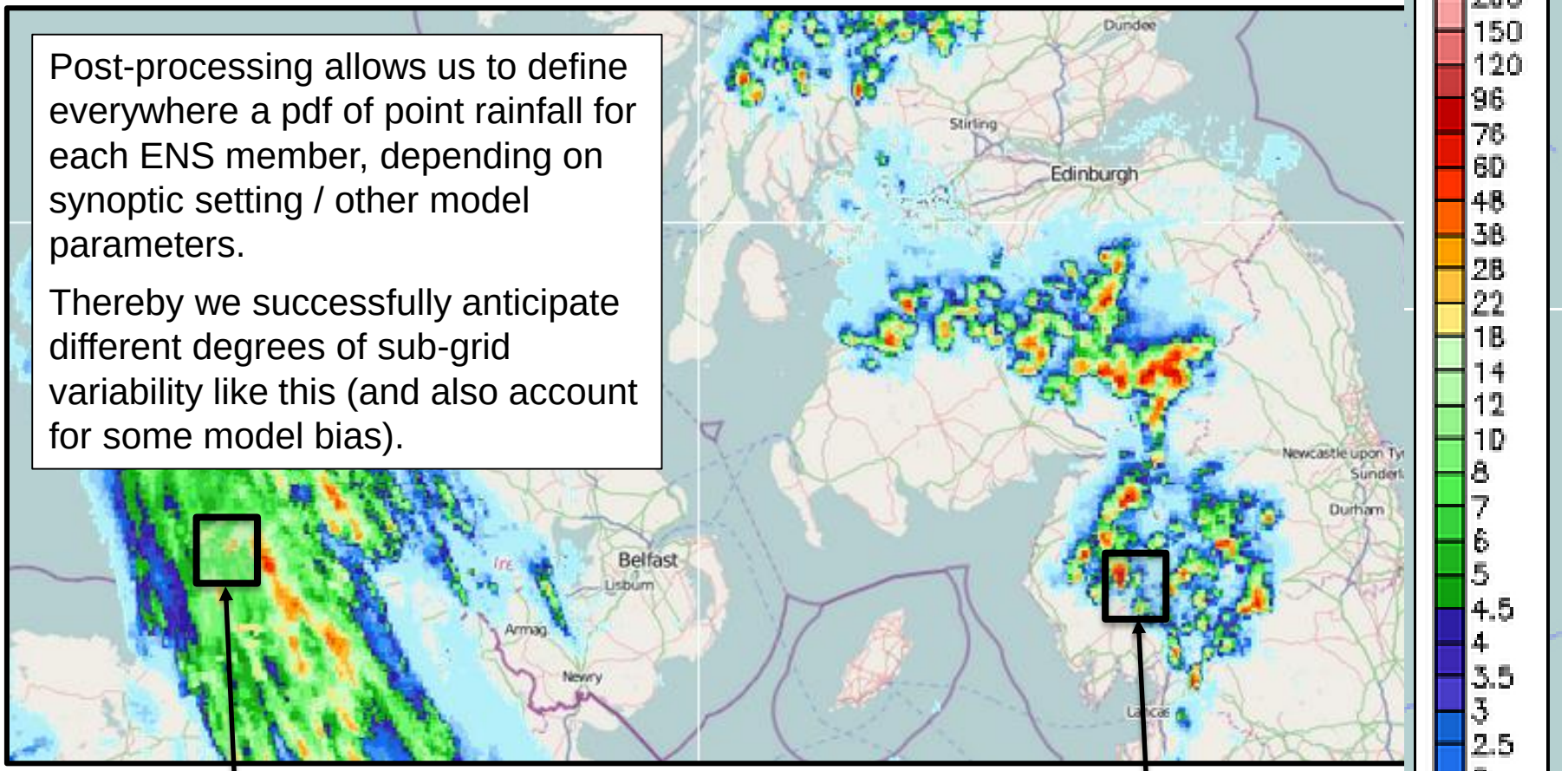
ENS Precipitation Type Verification – ROC curves



2. Point Rainfall

Post-processing allows us to define everywhere a pdf of point rainfall for each ENS member, depending on synoptic setting / other model parameters.

Thereby we successfully anticipate different degrees of sub-grid variability like this (and also account for some model bias).

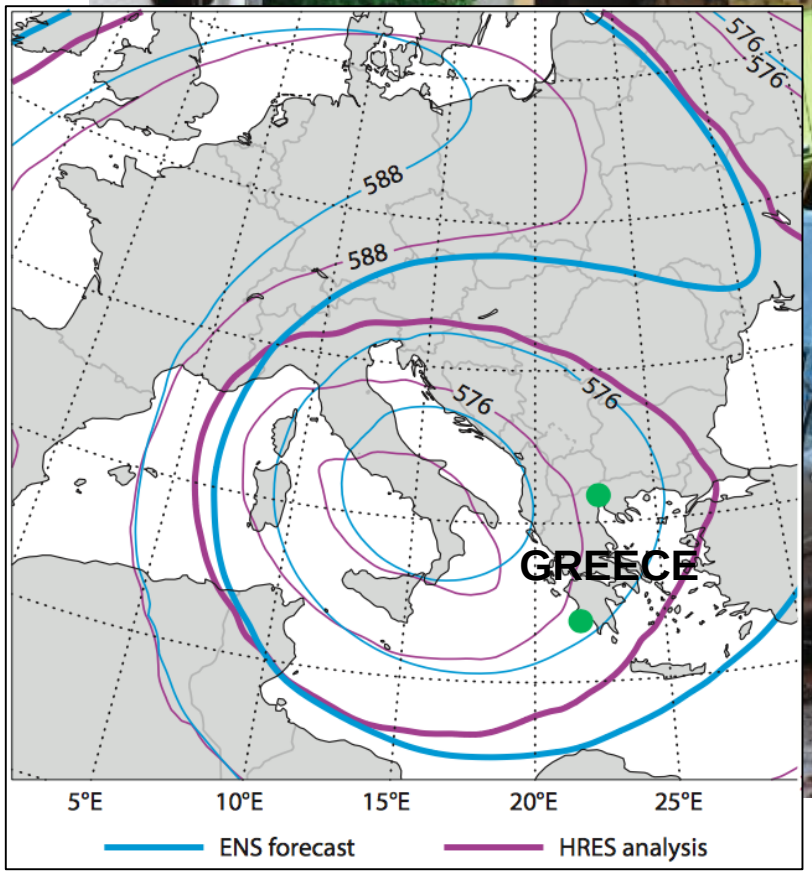


12h radar-derived totals

10-25mm
Mean ~ 13mm

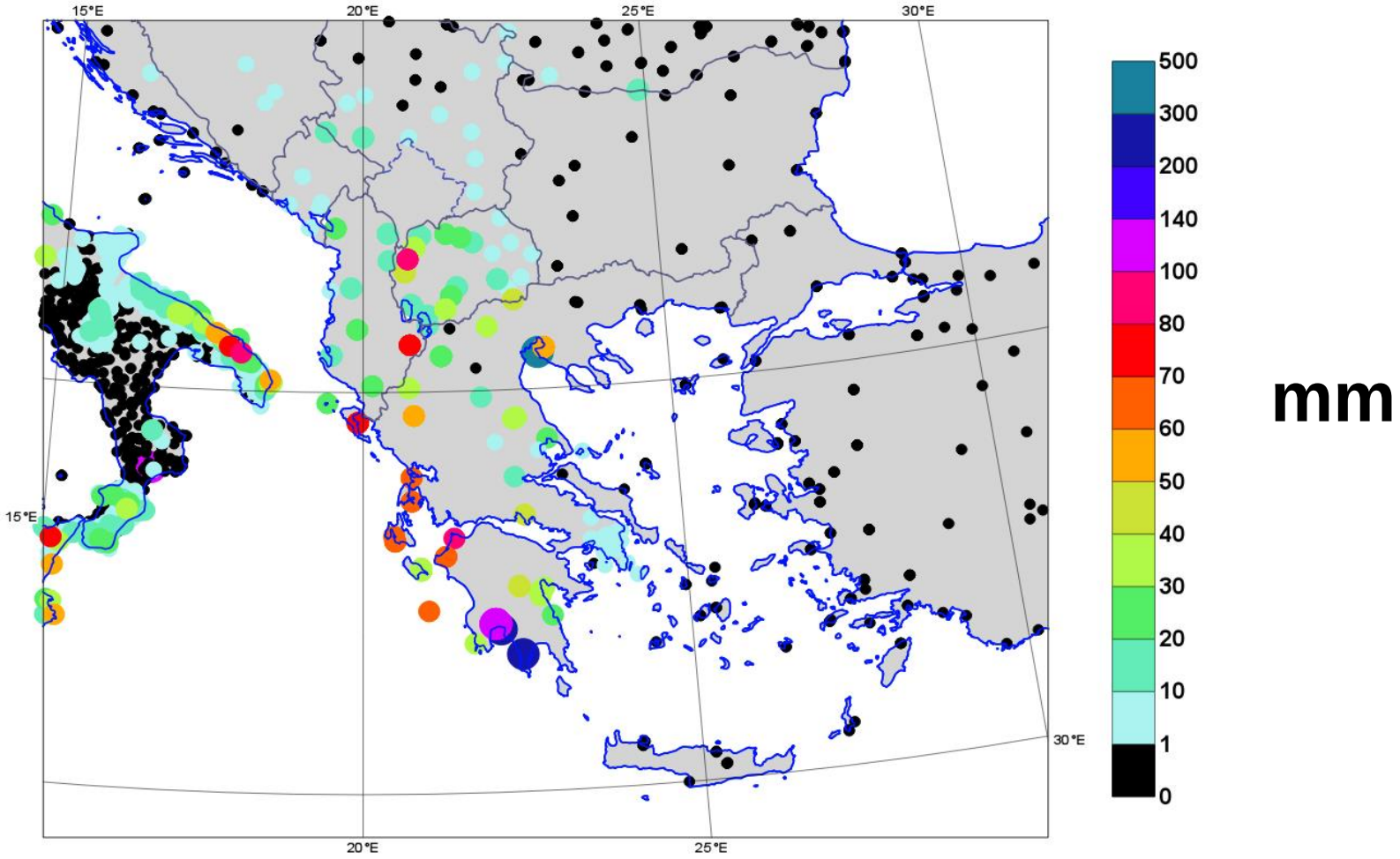
0-80mm
Mean ~ 6mm

Case Study – Flash Floods in Greece Sep 2016



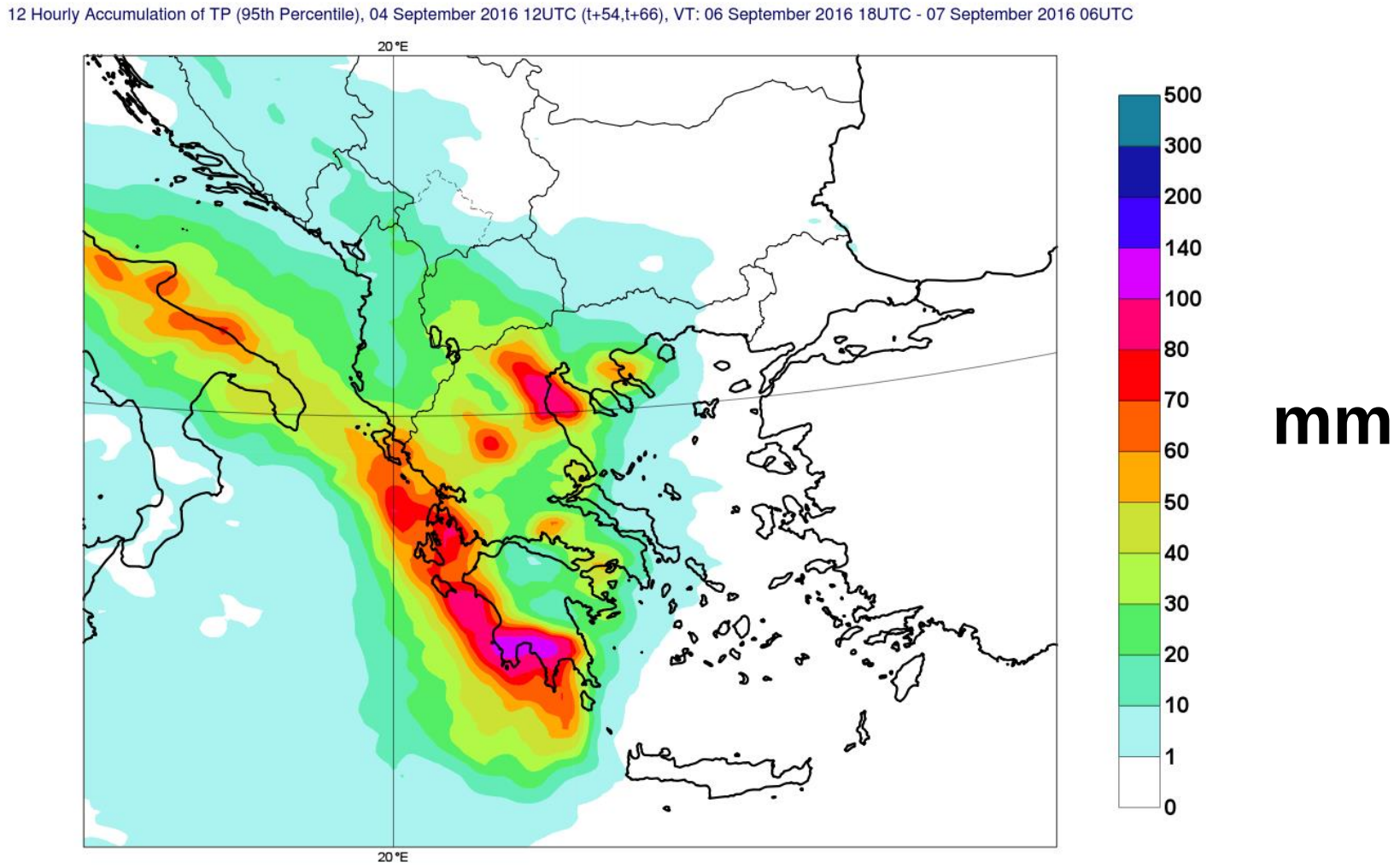
EPA/Nikitas Kotsiaris

Observations – official and unofficial



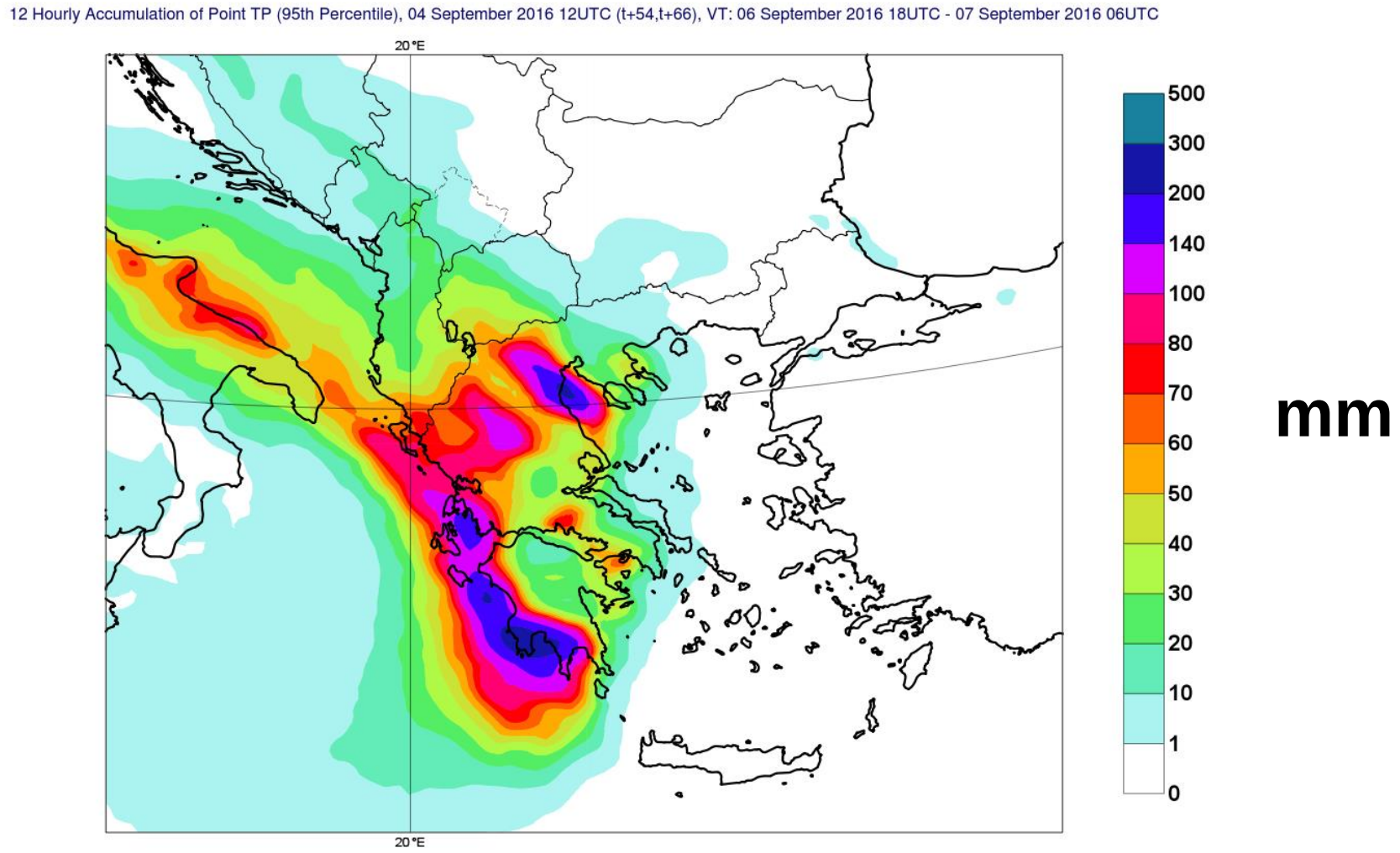
RAW ENS forecast – Day 3 - 95th Percentile

=1 in 20 chance of exceedance!

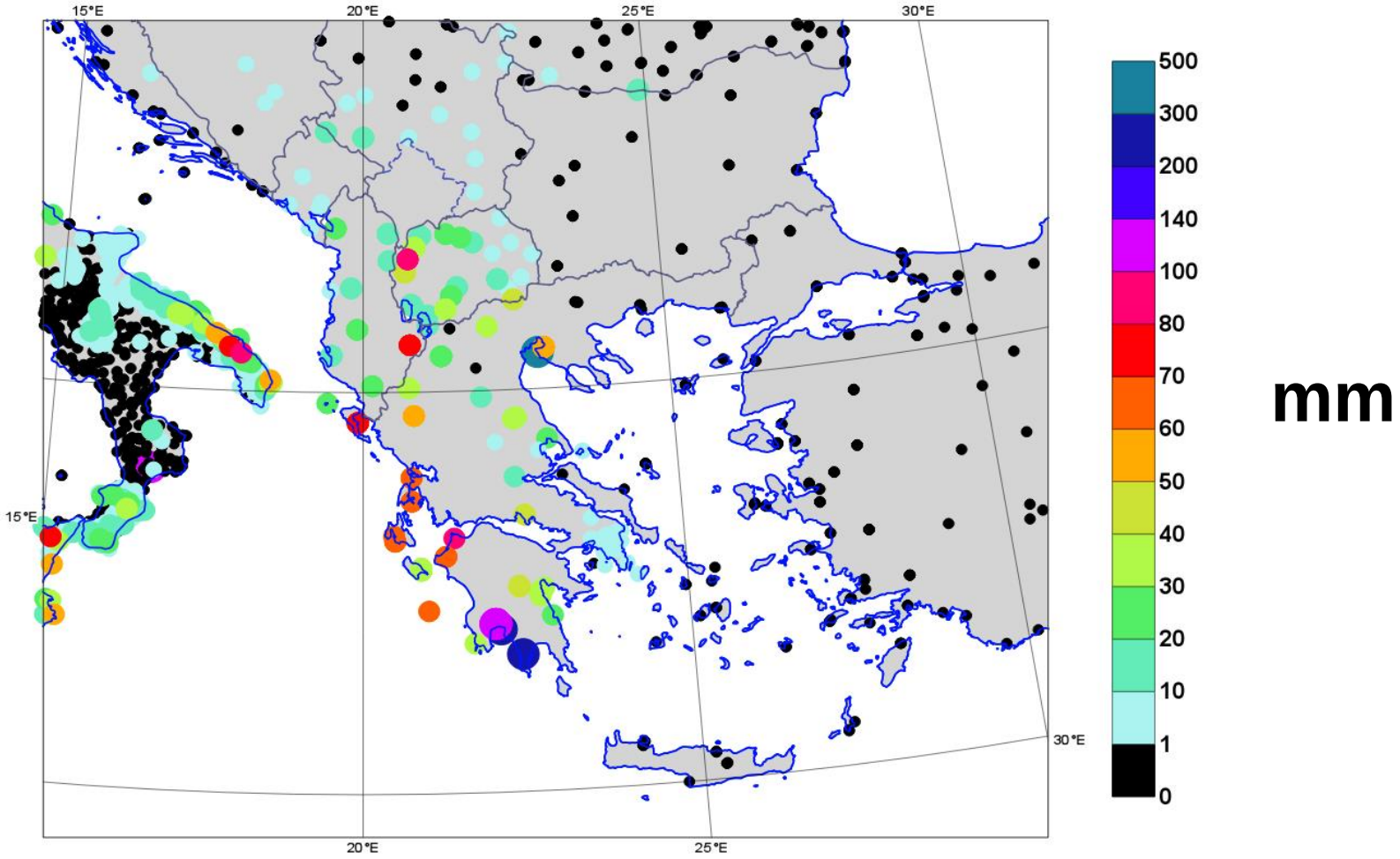


ENS Point Forecast – Day 3 - 95th Percentile

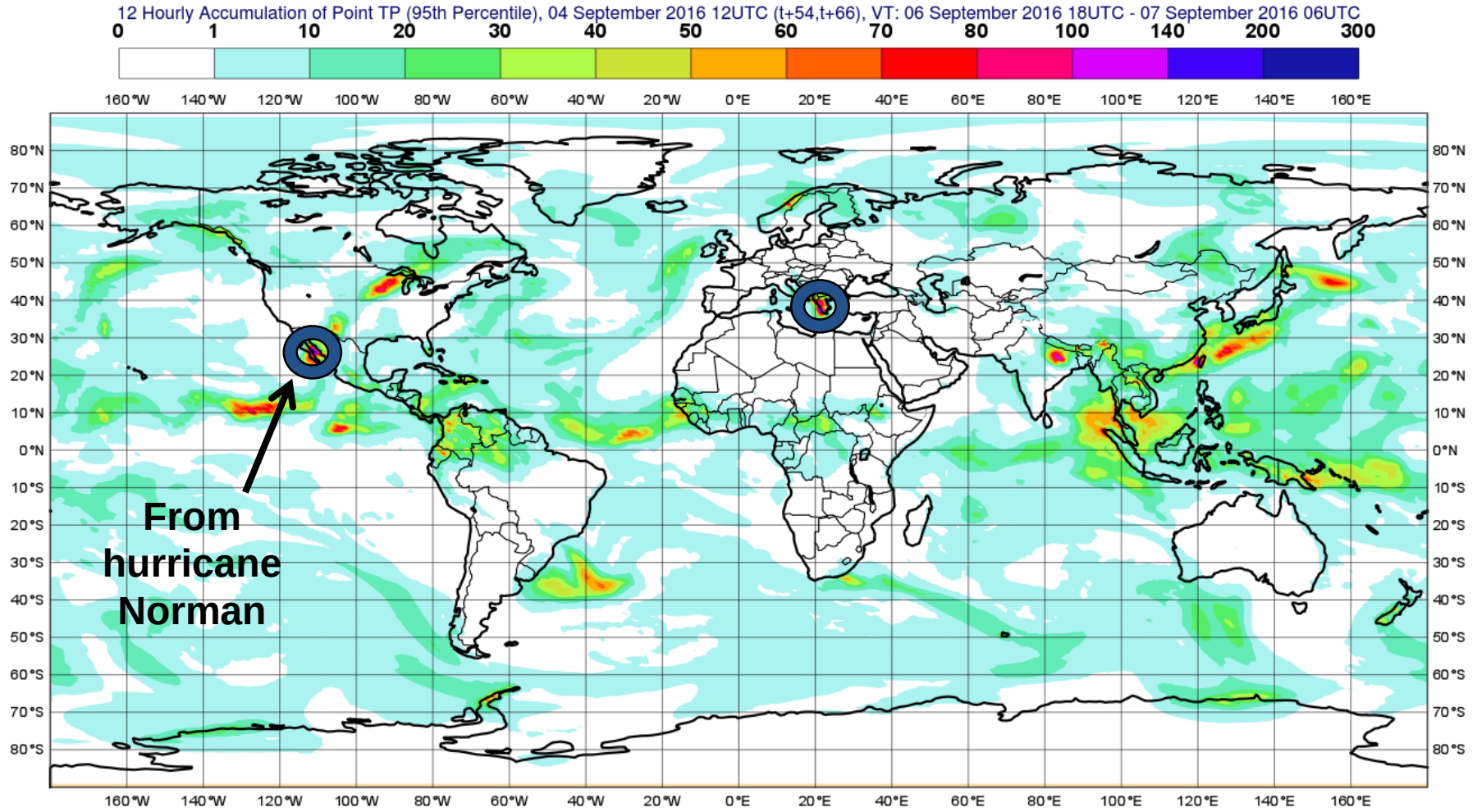
=1 in 20 chance of exceedance!



Observations – official and unofficial



Same Point forecast – Global – Day 3



Wettest places in this forecast by this metric

Verification – ROC area, Raw ENS versus Point Rain product

1 year, Global, raingauge observations

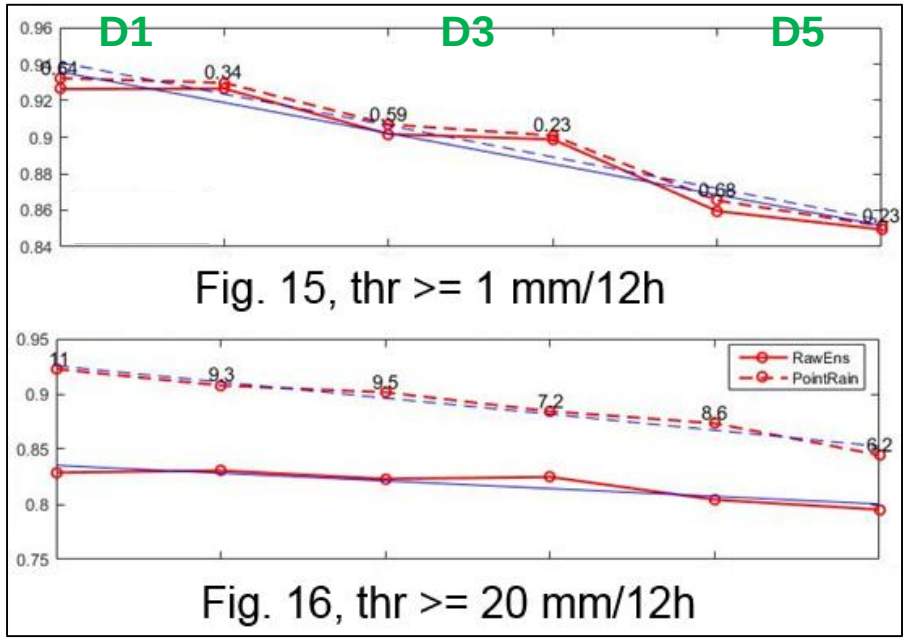


Fig. 15, thr >= 1 mm/12h

Fig. 16, thr >= 20 mm/12h

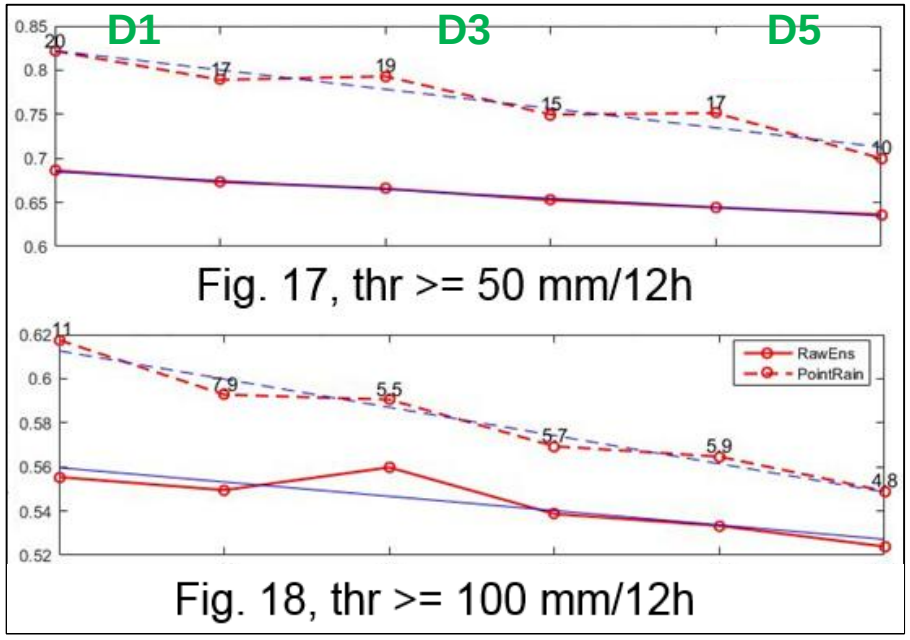


Fig. 17, thr >= 50 mm/12h

Fig. 18, thr >= 100 mm/12h

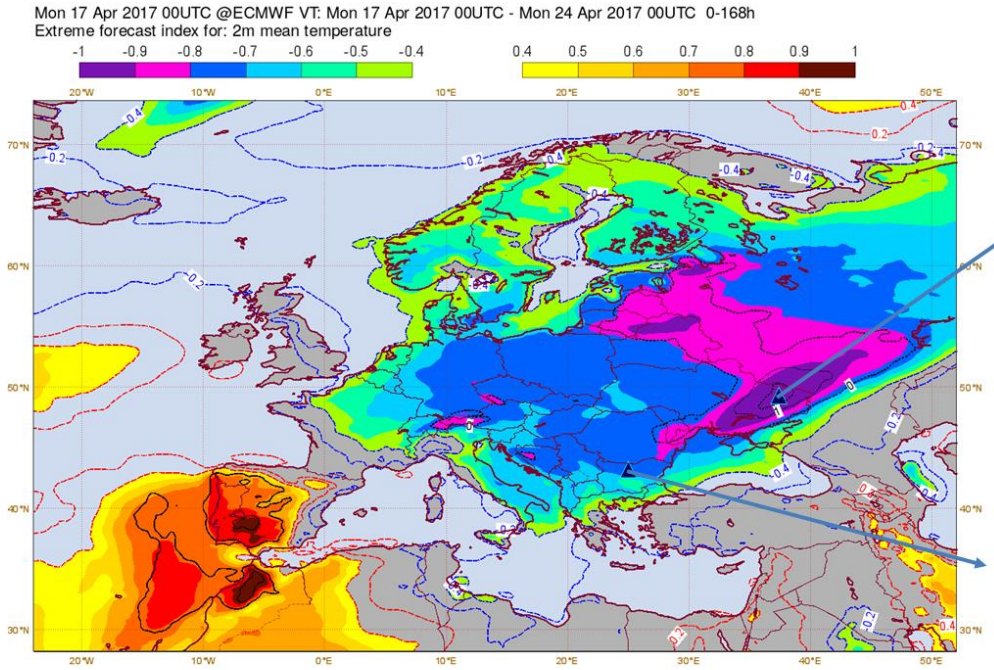
By this metric, for “large” totals the Point Rain product is ~ as skilful at day 5 as the Raw ENS is at day 1

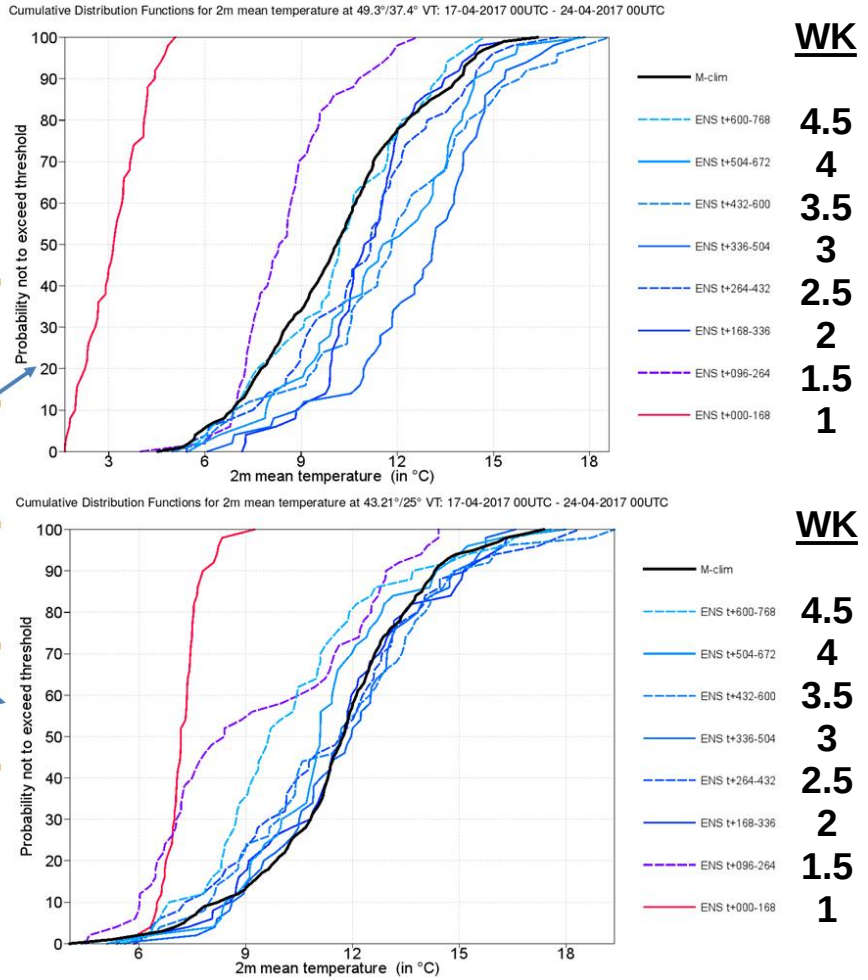
=> Much better probabilistic flash flood predictions

We are working on further improvements

3. Distributions for the Monthly Forecast

Week 1 EFI for 2m Temp



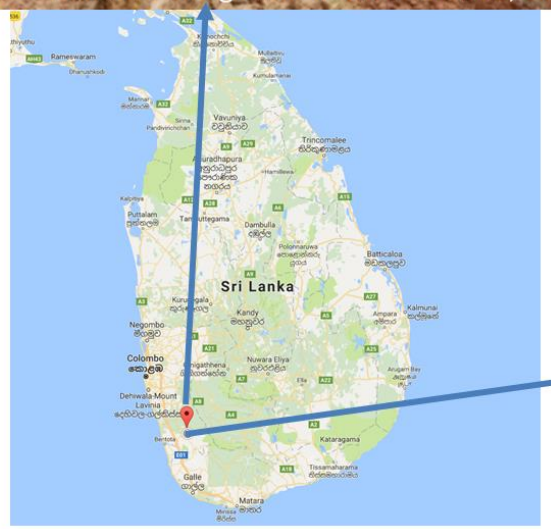


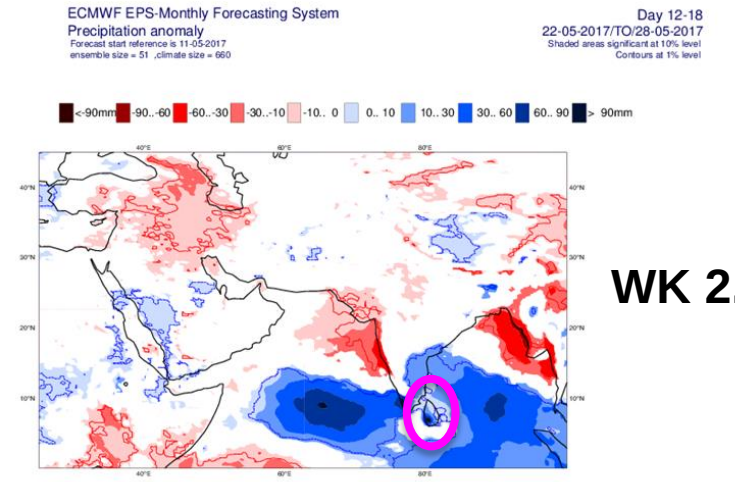
WK

ENS t+600-768	4.5
ENS t+504-672	4
ENS t+432-600	3.5
ENS t+336-504	3
ENS t+264-432	2.5
ENS t+168-336	2
ENS t+096-264	1.5
ENS t+000-168	1

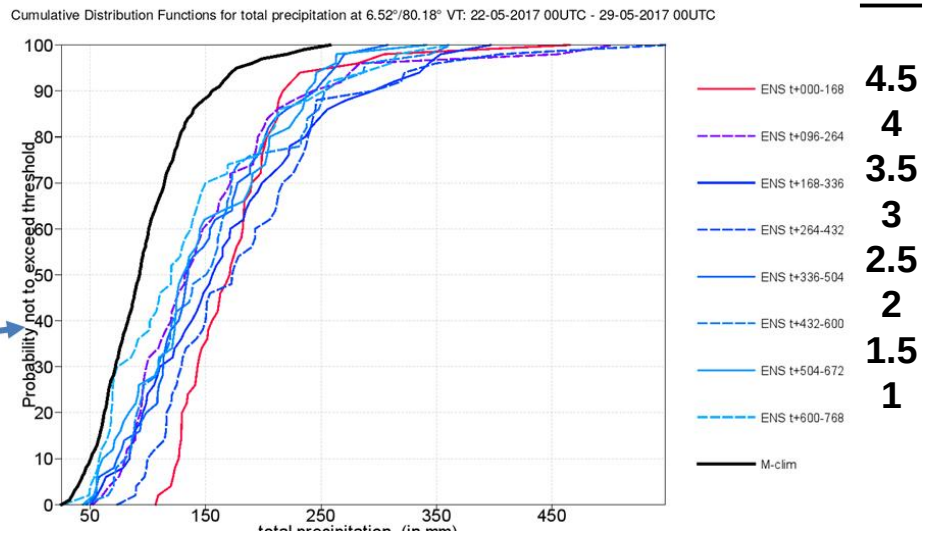
For week 3, 4 lead times there are risks:

- EFI plots may be very bland
- EFI/CDF signals may be unreliable
- There may be many “forecast busts”





WK 2.5



WK

4.5
4
3.5
3
2.5
2
1.5
1

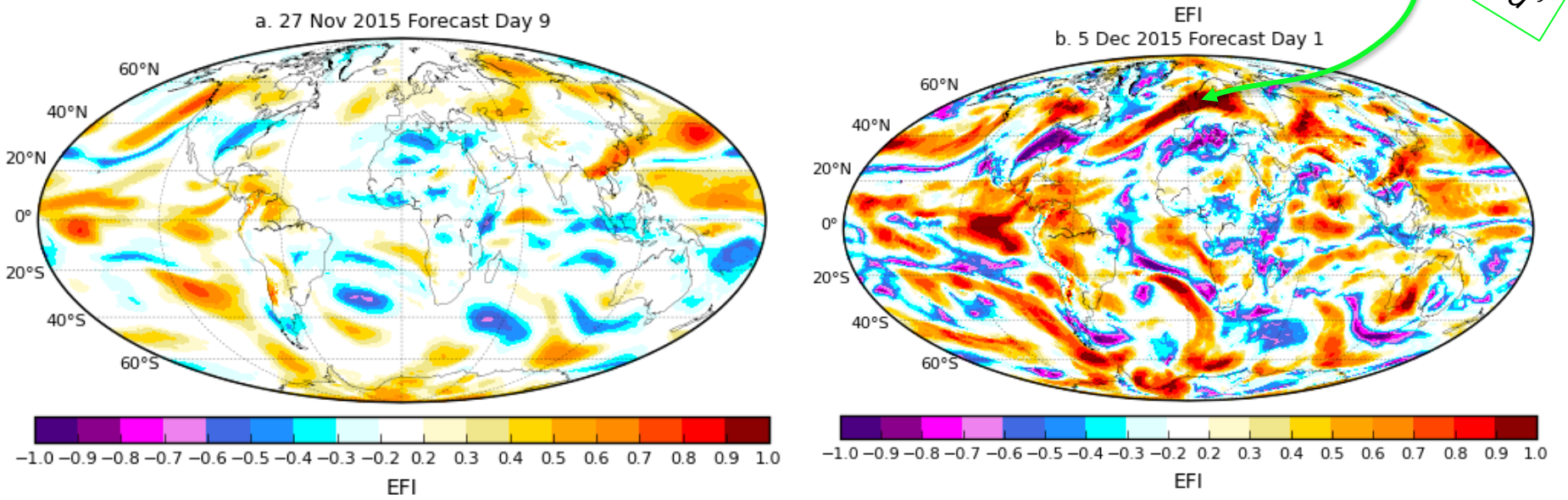
But sometimes, in some areas, we have a useable signal several weeks in advance…

Verification

- Regional EFI verification needed – work well underway
- Reliability of extremes in the forecast needs to be quantified
- Much scope for new parameters (e.g. “max 1 day rainfall in a 7 day period”)
- If verification suggests difficulties in weeks 3 and 4, should ECMWF promulgate forecast charts for weeks 5 and 6?

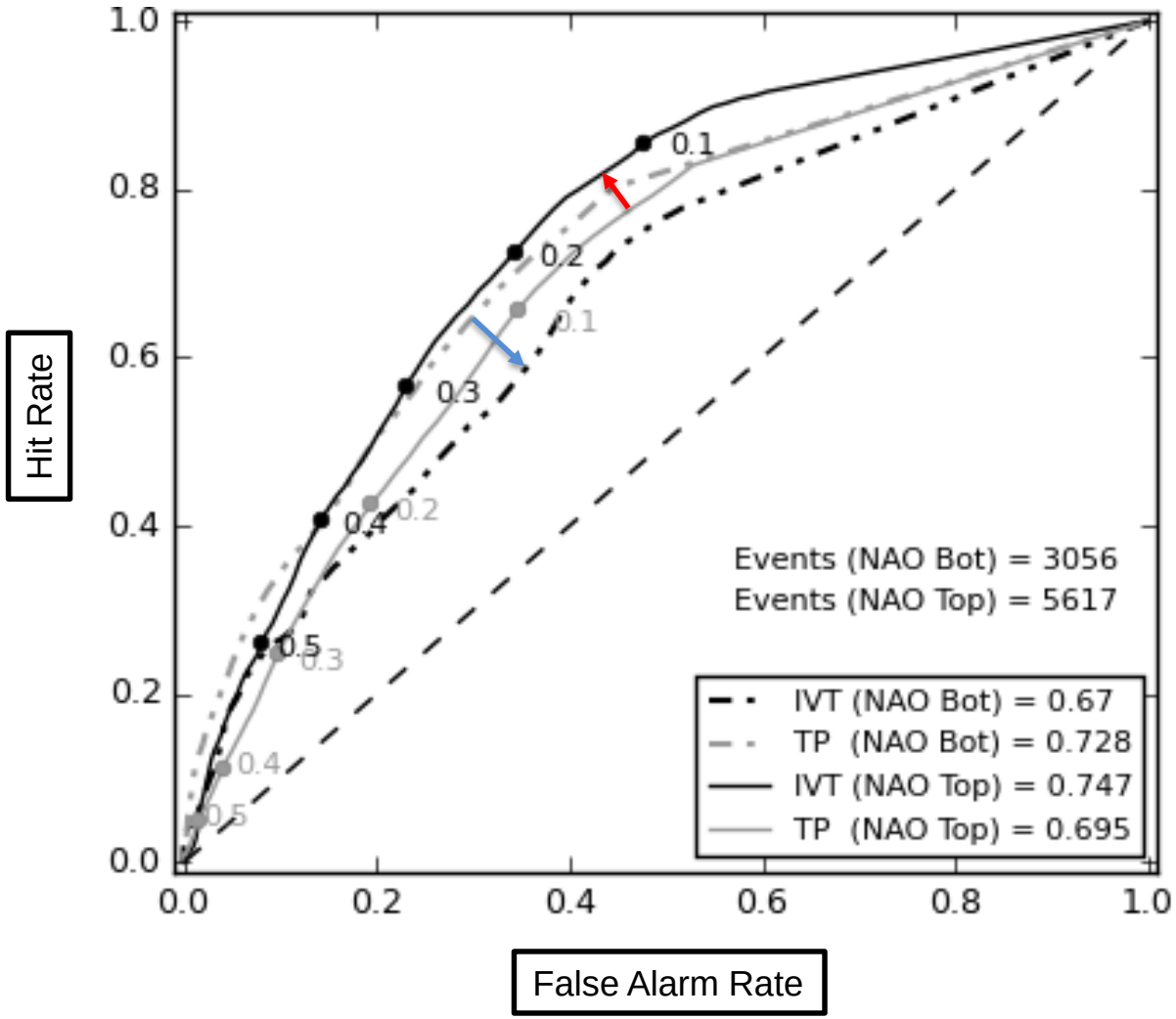
4. Moisture Flux

Extreme Forecast Index (EFI) for moisture flux



Strong positive moisture fluxes in regions of elevated topography deliver heavy orographic rain

Verification



Precipitation (grey)
IVT (black)

Solid lines (NAO+)
Dashed (NAO-)

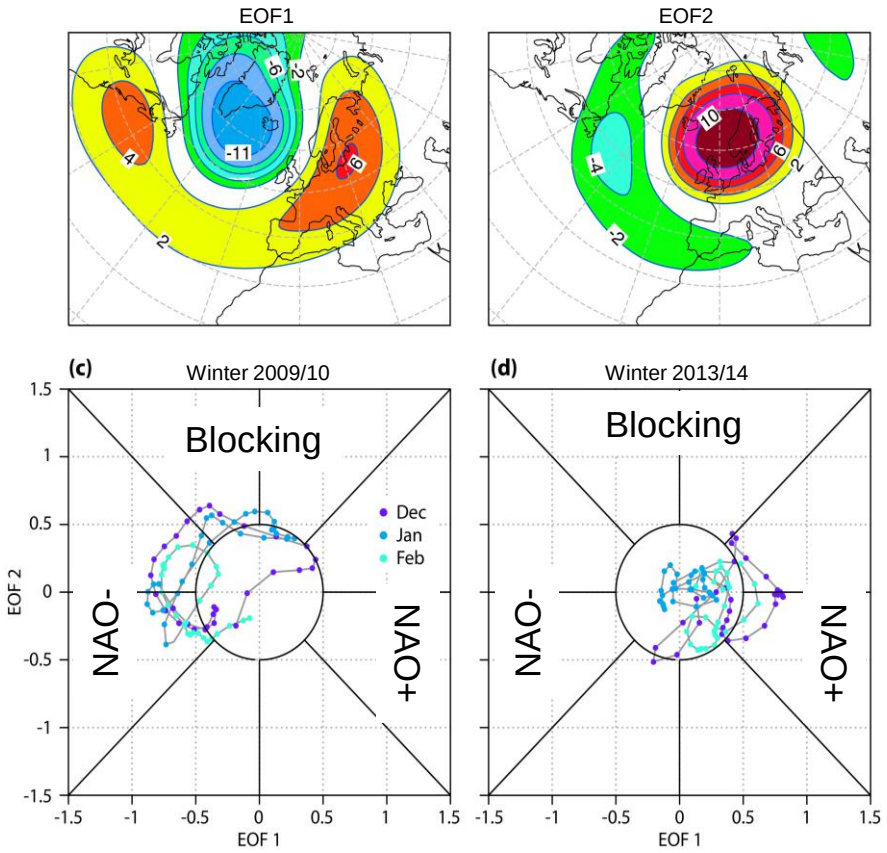
(NAO phase at Day 0)

For NAO+ the IVT EFI performs better than the Rainfall EFI

5. Regime transitions

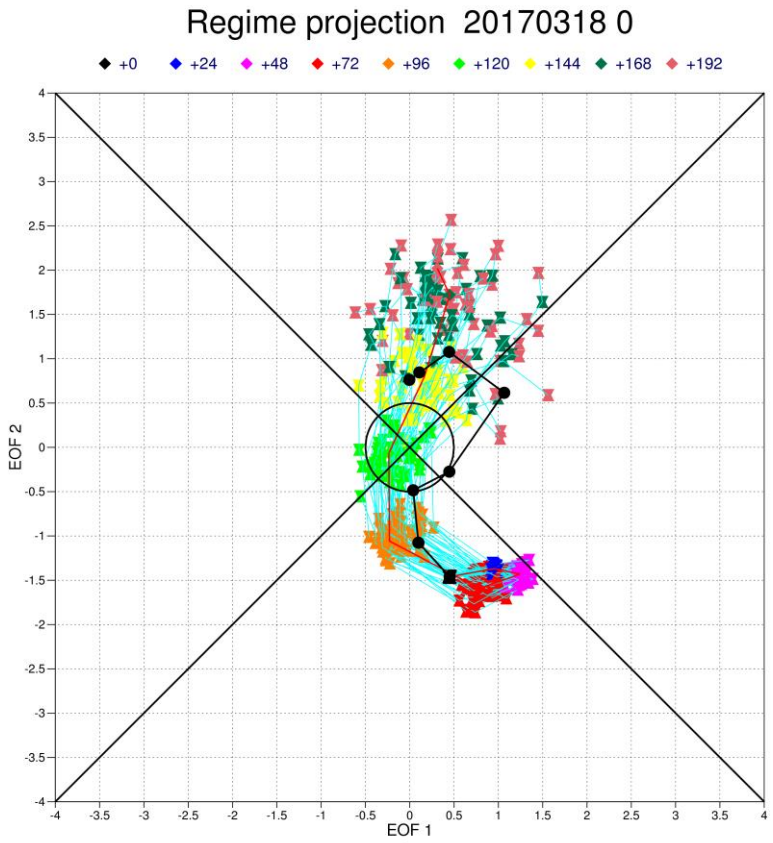
- ±EOF1 and +EOF2 represent quite well ±NAO and BL
- Trajectories in phase space summarise regime evolution

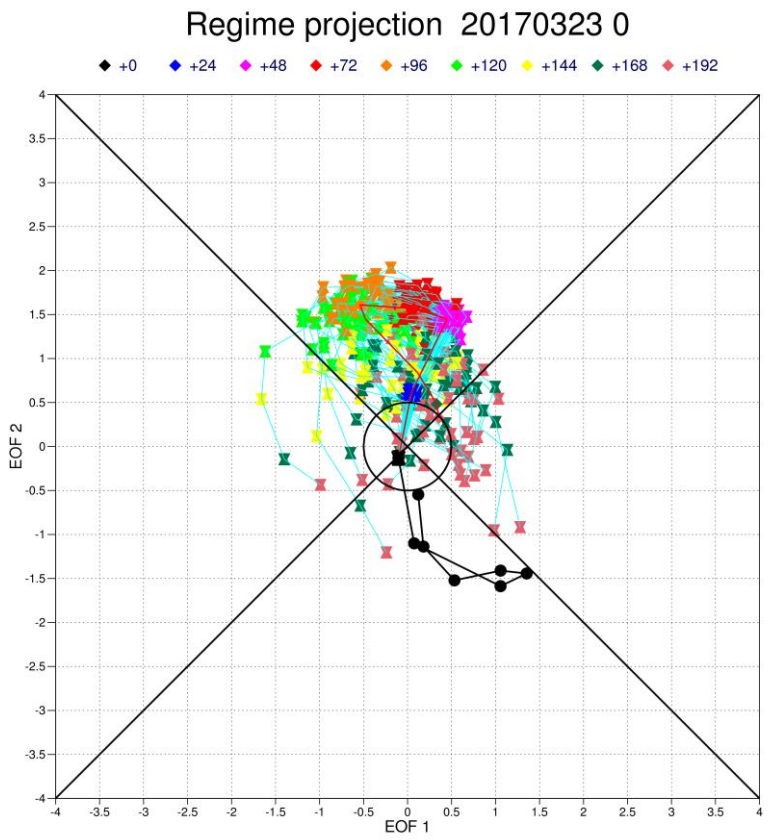
Record-breaking cold temperatures over Europe



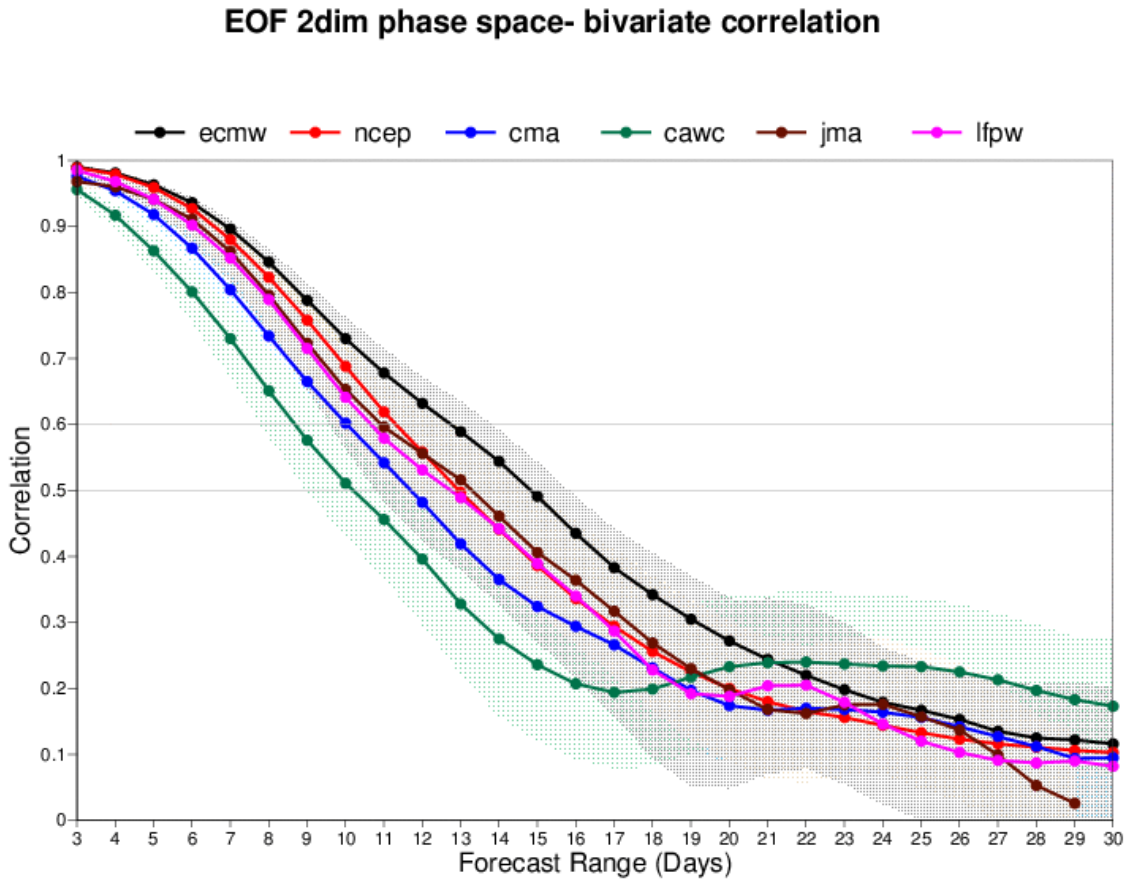
Exceptional storminess, but mild temperatures over Europe

Forecast Examples (D1-8)





Verification (to 1 month)



Current Status

1. Precipitation Type (snow/fz rain) [Estíbaliz Gascón – weather wall later]

2017: Provide layer and meteogram in ecCharts

2. Point Rainfall (flash floods) [Fatima Pillosu – poster later]

2017: Provide layer and point meteogram in ecCharts, + GLOFAS/EFAS layers

3. Distributions in the monthly forecast (various) [Ivan Tsonevsky]

2017: Verification work, 2018?: Web products

4. Moisture Flux (orographic rainfall extremes) [David Lavers, poster/pico later]

2017-2018: Web product to D15

5. Regime Transitions (various) [Laura Ferranti, Linus Magnusson]

Under consideration: Web charts of Regime projections, 15-day and monthly ENS

Tim Hewson

Some upcoming ECMWF Products

- At various stages of development, all from the ENS
- Five products

1. Precipitation Type [Estíbaliz Gascón – weather wall later]
2. Point Rainfall [Fatima Pillosu – poster later]
3. Extremes in the monthly forecast
4. Moisture Flux (EFI for Atmospheric Rivers) [David Lavers - presentation]
5. Regime Transitions