

# ECMWF plans & product development

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# 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.

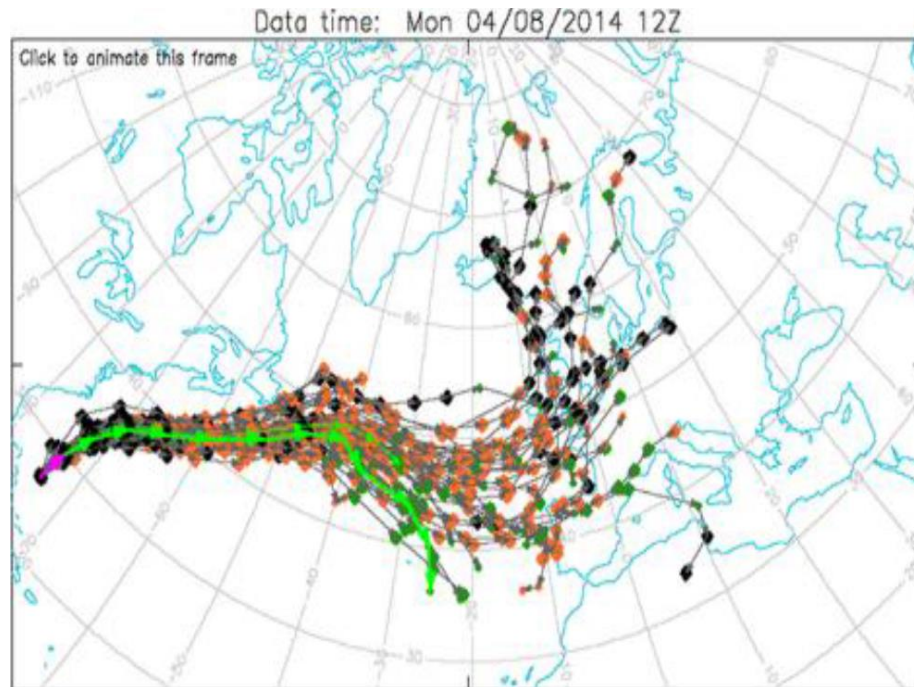
- Focus on high-impact weather, regime transitions and global-scale anomalies
- Integrated ensemble at high resolution at 5km by 2025
- Earth-System model and analysis
- Scalable computation
- Environmental information services: Copernicus



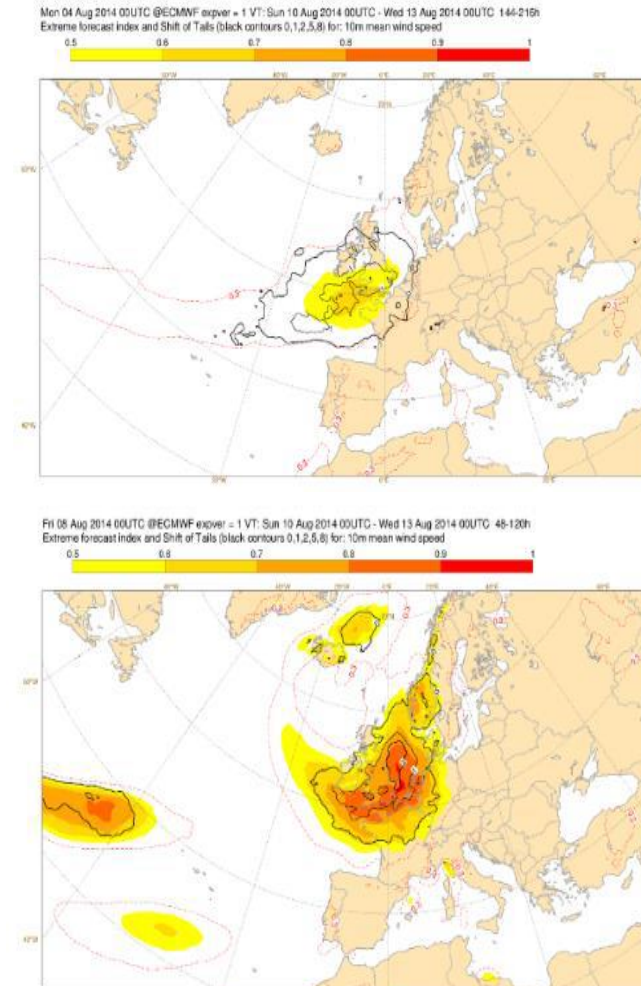
# ECMWF 2016-2025 strategy: the challenge

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

## High-impact weather: Hurricane Bertha



The difficulty: sharp ensembles 2 weeks ahead



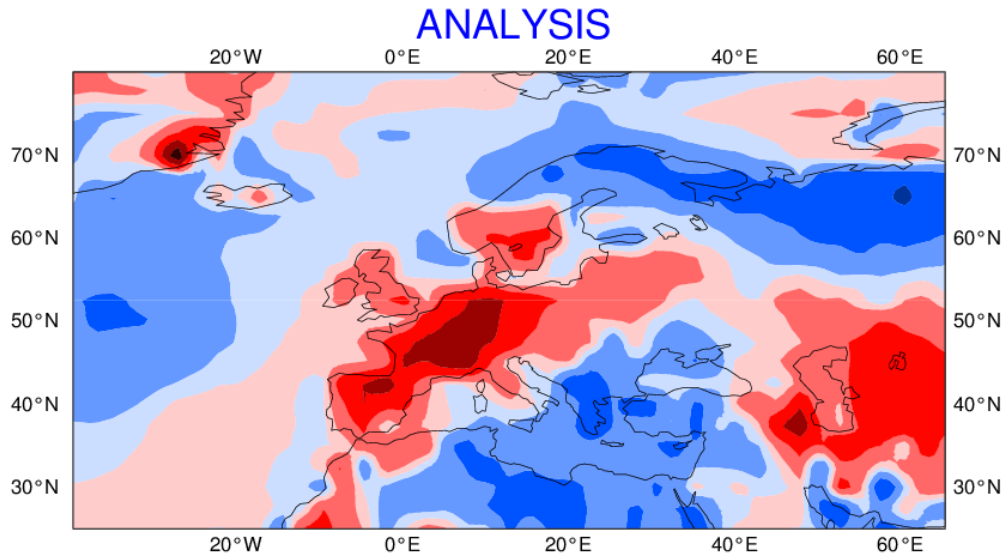
6-9 days

2-5 days

# ECMWF 2016-2025 strategy: the challenge

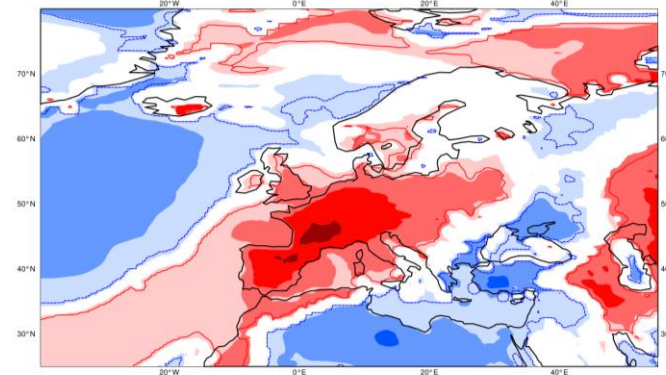
The prediction of regional anomalies and regime transitions 4 weeks ahead.

European heat wave - 29 June – 5 July 2015



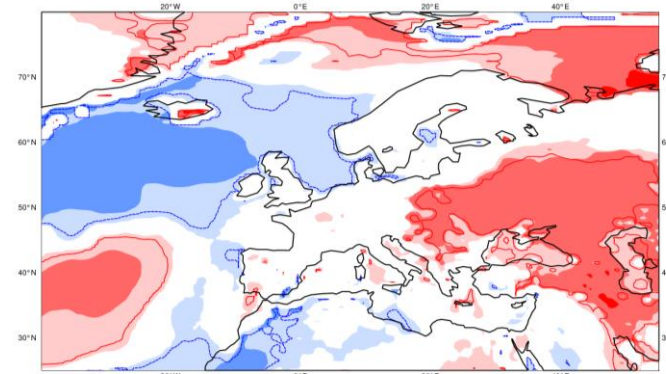
The difficulty: extracting a signal 3-4 weeks ahead

<math><-10\text{deg}</math> <math>-10..-6</math> <math>-6..-3</math> <math>-3..-1</math> <math>-1..0</math> <math>0..1</math> <math>1..3</math> <math>3..6</math> <math>6..10</math> <math>>10\text{deg}</math>



Forecast week 1.5

<math><-10\text{deg}</math> <math>-10..-6</math> <math>-6..-3</math> <math>-3..-1</math> <math>-1..0</math> <math>0..1</math> <math>1..3</math> <math>3..6</math> <math>6..10</math> <math>>10\text{deg}</math>



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

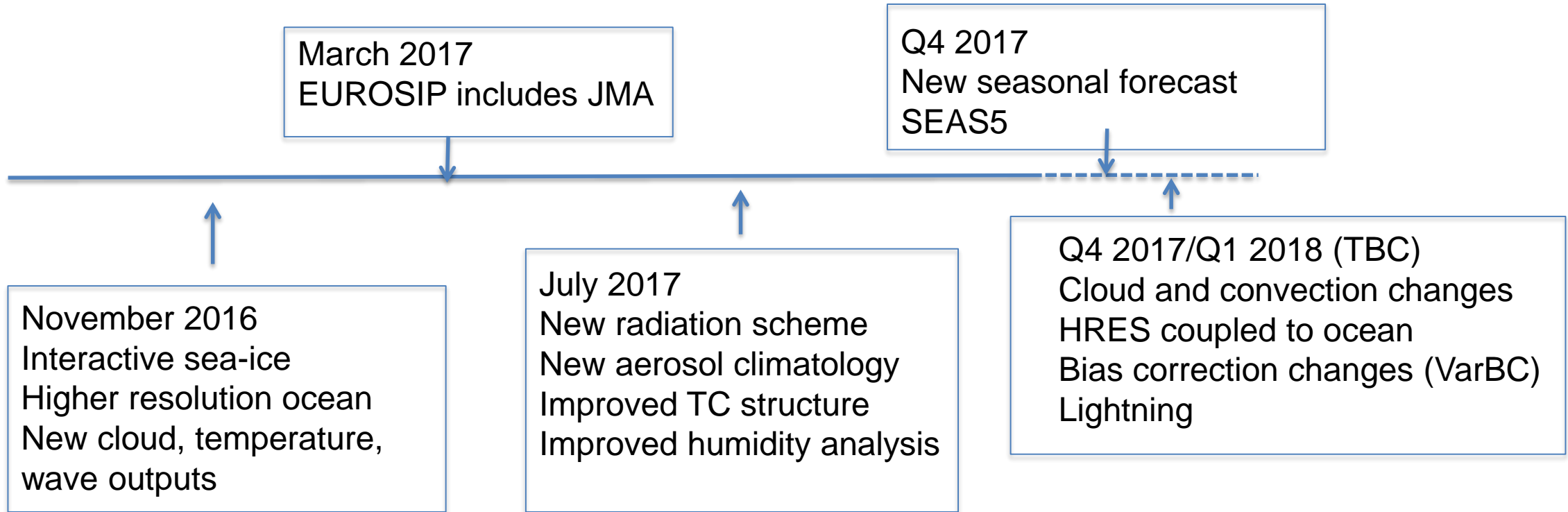
- **HRES-WAM**: 10 days ahead at **14 km** (coupled)
- **HRES Stand Alone Wave (SAW) model** : 10 days ahead at **11 km**
- **ENS-WAM**: 15 days ahead at **28 km** (coupled)

## 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 .....



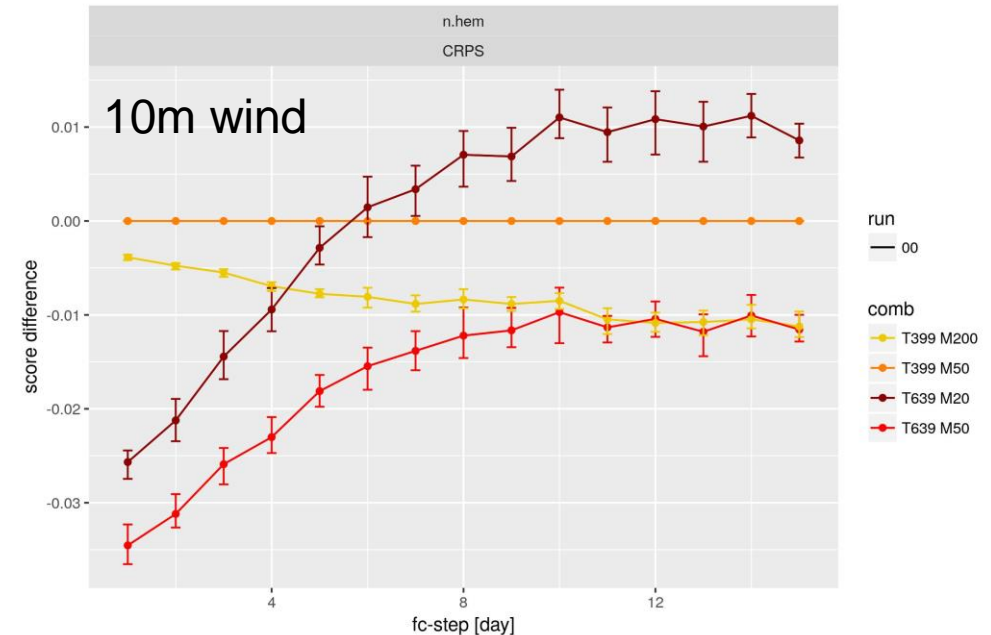
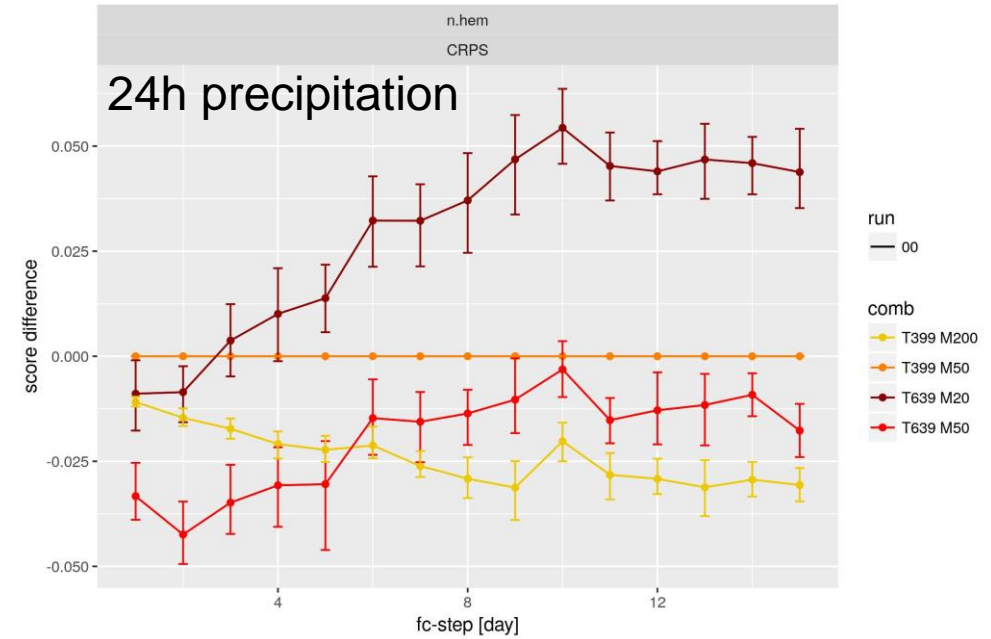
# ENS configurations

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

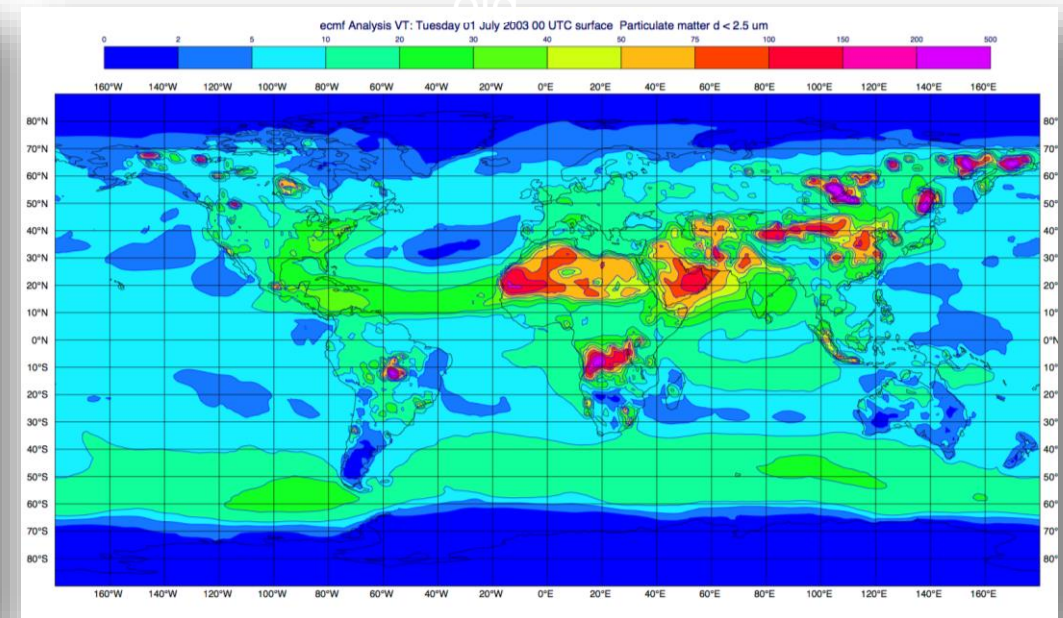
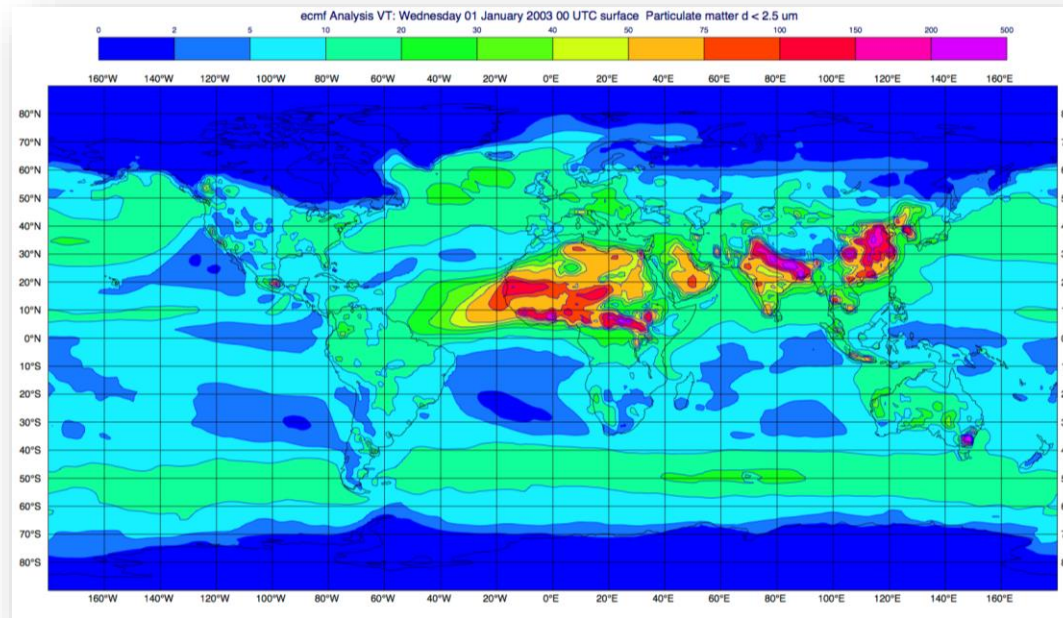
- two configurations with similar costs:
  - 50 members at 18-km resolution
  - 200 members at 29-km resolution
- Depends on parameter, forecast range, ...
- Dual resolution ENS configuration?



Long term research plans shown by Irina Sandu



# CAMS REANALYSIS 2003-present



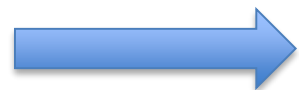
A new CAMS reanalysis of atmospheric composition has started running (Jan, top and July 2003, bottom) and first results are promising.

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

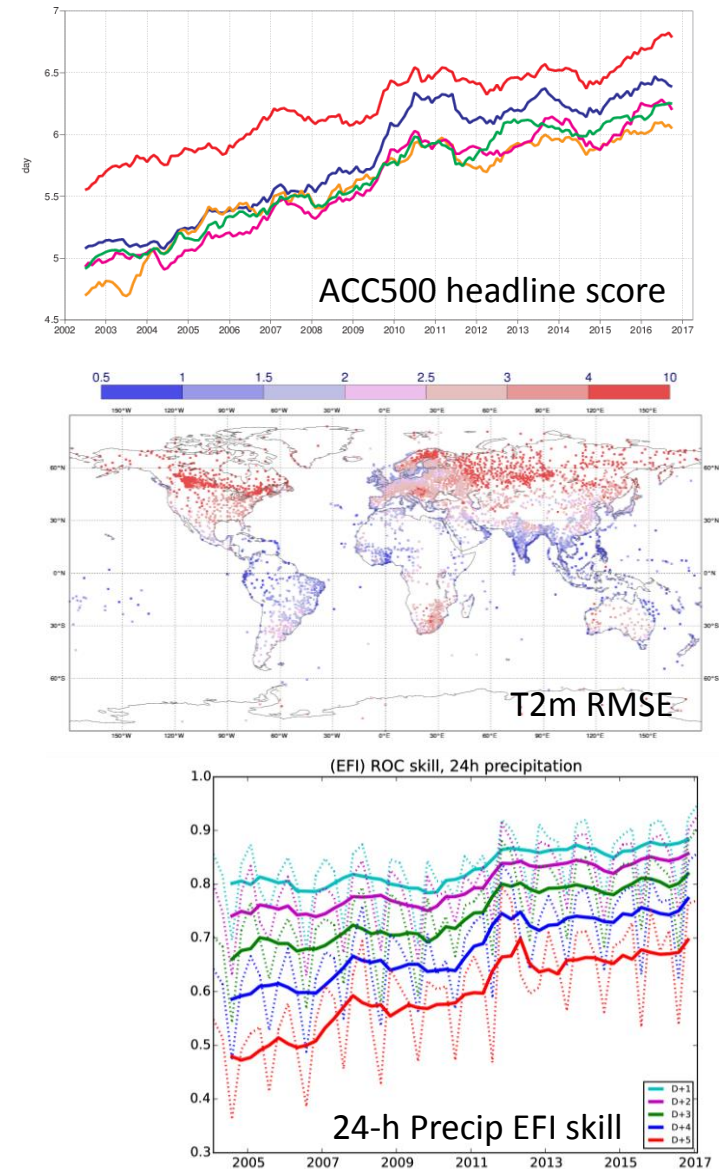


# Assessing the quality of our forecasts

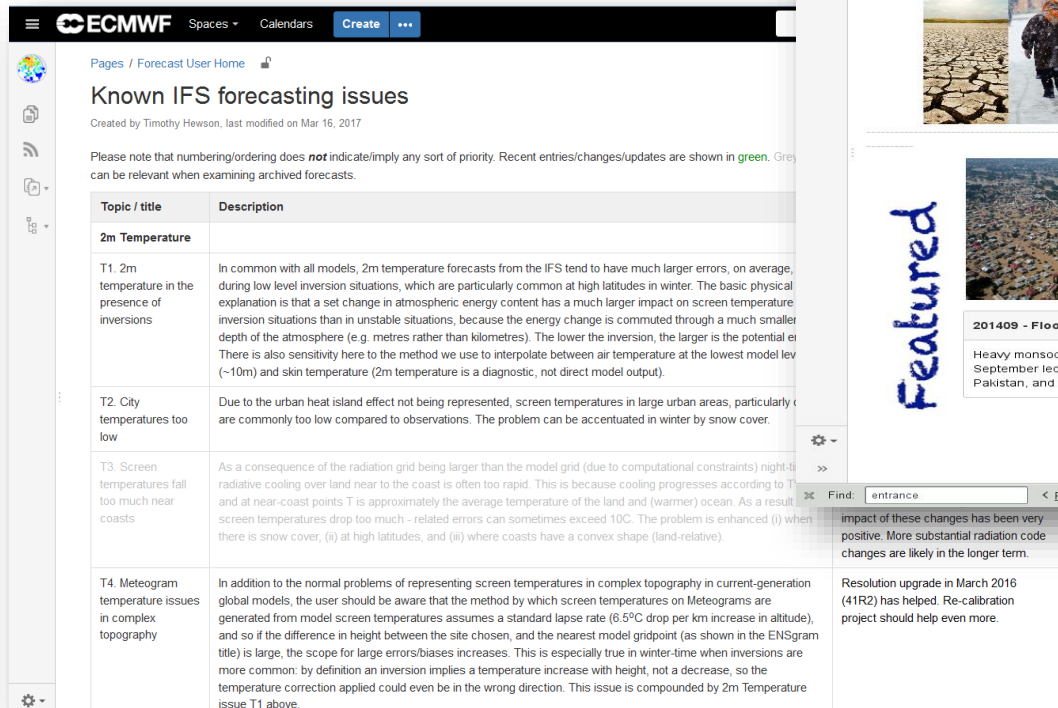
- Headline scores
- Comparison with reference forecasts (ERA-Interim, ERA5) and other centres
- Daily monitoring of forecast quality (Daily Report)
- Severe event catalogue
- In-depth analysis of specific issues
- Model diagnostics and relaxation experiments



See later talks by David Richardson and Thomas Haiden



# Sharing knowledge



**ECMWF** Spaces Calendars Create

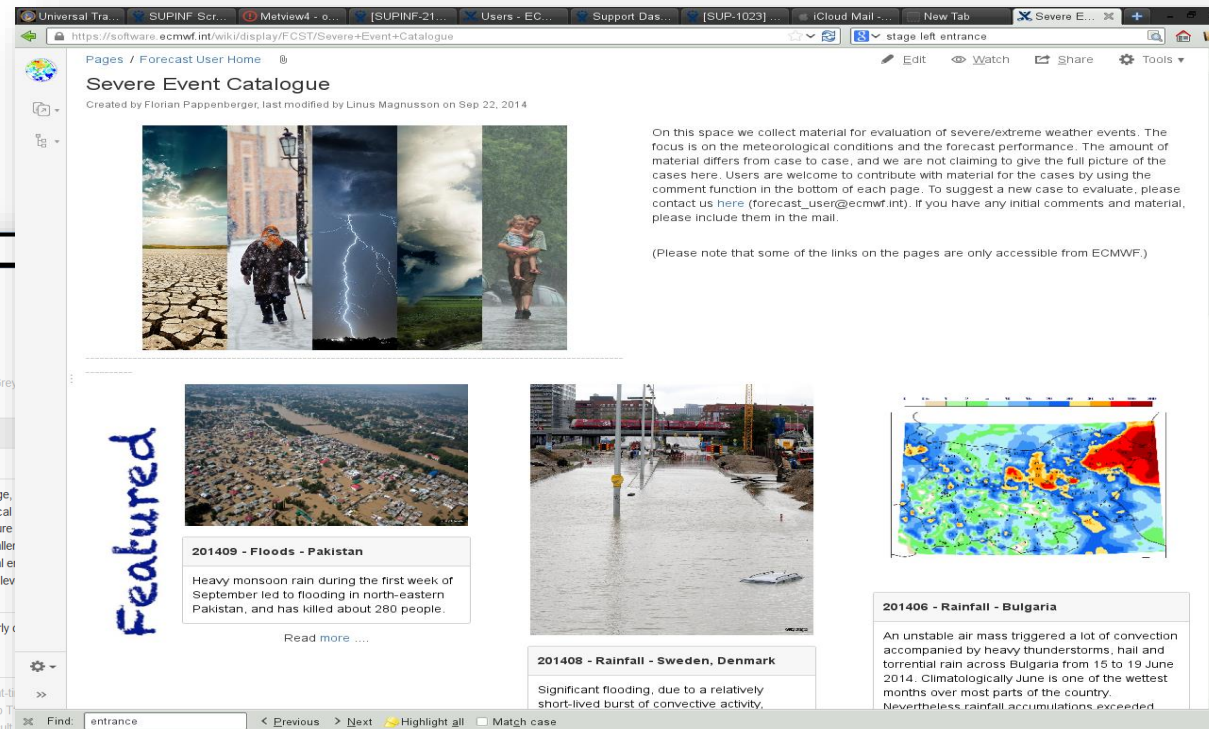
Pages / Forecast User Home

## Known IFS forecasting issues

Created by Timothy Hewson, last modified on Mar 16, 2017

Please note that numbering/ordering does **not** indicate/imply any sort of priority. Recent entries/changes/updates are shown in green. Grey can be relevant when examining archived forecasts.

Topic / title	Description
<b>2m Temperature</b>	
T1. 2m temperature in the presence of inversions	In common with all models, 2m temperature forecasts from the IFS tend to have much larger errors, on average, during low level inversion situations, which are particularly common at high latitudes in winter. The basic physical explanation is that a set change in atmospheric energy content has a much larger impact on screen temperature inversion situations than in unstable situations, because the energy change is commuted through a much smaller depth of the atmosphere (e.g. metres rather than kilometres). The lower the inversion, the larger is the potential error. There is also sensitivity here to the method we use to interpolate between air temperature at the lowest model level (~10m) and skin temperature (2m temperature is a diagnostic, not direct model output).
T2. City temperatures too low	Due to the urban heat island effect not being represented, screen temperatures in large urban areas, particularly in winter, are commonly too low compared to observations. The problem can be accentuated in winter by snow cover.
T3. Screen temperatures fall too much near coasts	As a consequence of the radiation grid being larger than the model grid (due to computational constraints) nighttime radiative cooling over land near to the coast is often too rapid. This is because cooling progresses according to the land and at near-coast points T is approximately the average temperature of the land and (warmer) ocean. As a result screen temperatures drop too much - related errors can sometimes exceed 10C. The problem is enhanced (i) when there is snow cover, (ii) at high latitudes, and (iii) where coasts have a convex shape (land-relative).
T4. Meteogram temperature issues in complex topography	In addition to the normal problems of representing screen temperatures in complex topography in current-generation global models, the user should be aware that the method by which screen temperatures on Meteograms are generated from model screen temperatures assumes a standard lapse rate (6.5°C drop per km increase in altitude), and so if the difference in height between the site chosen, and the nearest model gridpoint (as shown in the EN5gram title) is large, the scope for large errors/biases increases. This is especially true in winter-time when inversions are more common - by definition an inversion implies a temperature increase with height, not a decrease, so the temperature correction applied could even be in the wrong direction. This issue is compounded by 2m Temperature issue T1 above.




## Severe Event Catalogue

Created by Florian Pappenberger, last modified by Linus Magnusson on Sep 22, 2014

On this space we collect material for evaluation of severe/extreme weather events. The focus is on the meteorological conditions and the forecast performance. The amount of material differs from case to case, and we are not claiming to give the full picture of the cases here. Users are welcome to contribute with material for the cases by using the comment function in the bottom of each page. To suggest a new case to evaluate, please contact us here (forecast\_user@ecmwf.int). If you have any initial comments and material, please include them in the mail.

(Please note that some of the links on the pages are only accessible from ECMWF.)


**Featured**



### 201409 - Floods - Pakistan

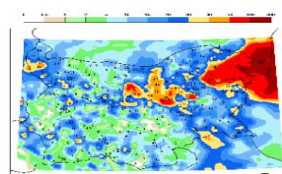
Heavy monsoon rain during the first week of September led to flooding in north-eastern Pakistan, and has killed about 280 people.

Read more .....



### 201408 - Rainfall - Sweden, Denmark

Significant flooding, due to a relatively short-lived burst of convective activity.



### 201406 - Rainfall - Bulgaria

An unstable air mass triggered a lot of convection accompanied by heavy thunderstorms, hail and torrential rain across Bulgaria from 15 to 19 June 2014. Climatologically June is one of the wettest months over most parts of the country. Nevertheless rainfall accumulations exceeded...



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

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

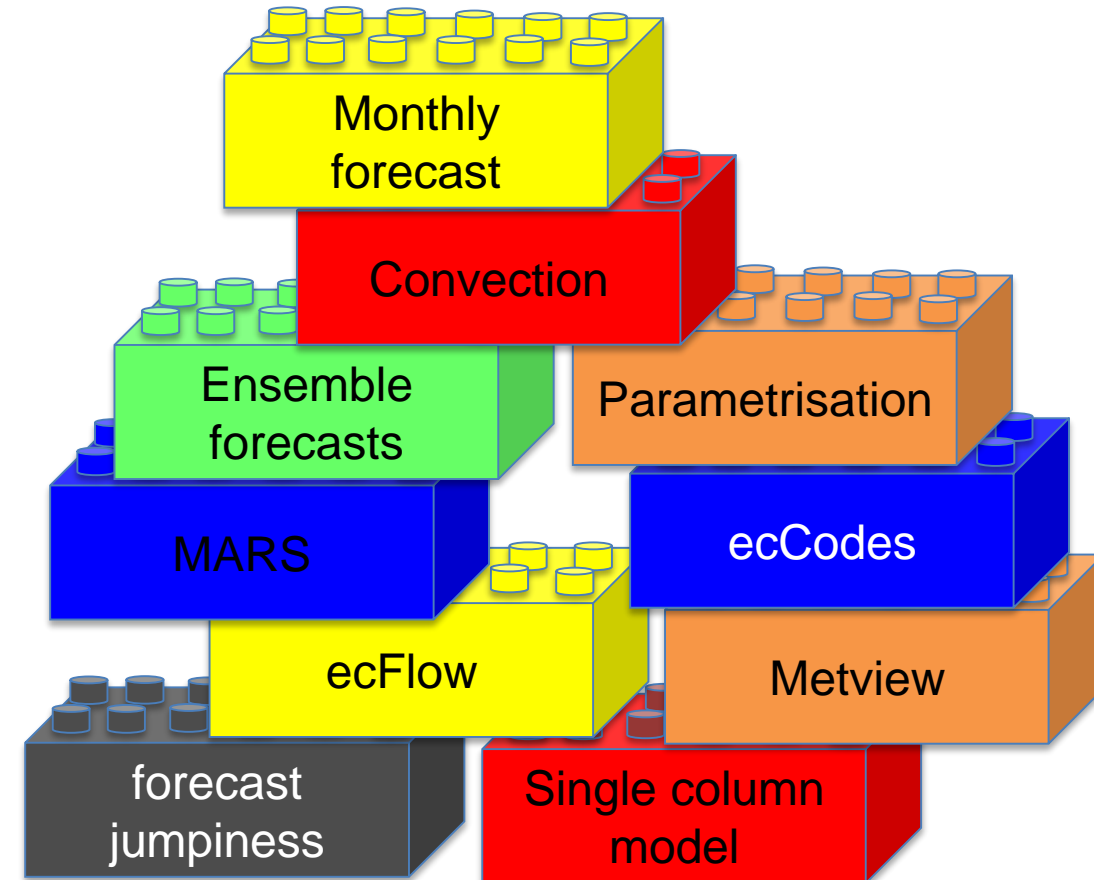
# eLearning @ECMWF

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

Freely available

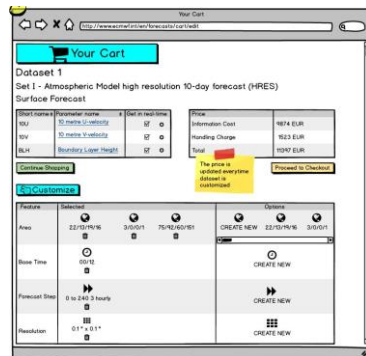
Learner-tailored approach to allow for different knowledge levels and learning styles

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



# New Software

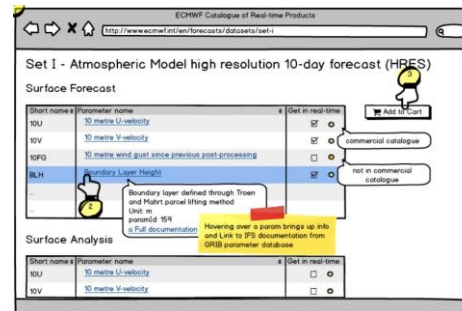
- **MIR:** New interpolation replacing EMOSLIB; Introduction in operations (MARS, Product Generation etc) next year initially in parallel to the current package; There will be differences as we remove bugs and update the algorithms
- **Product Delivery:** Interfaces to browse, select, price, install 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

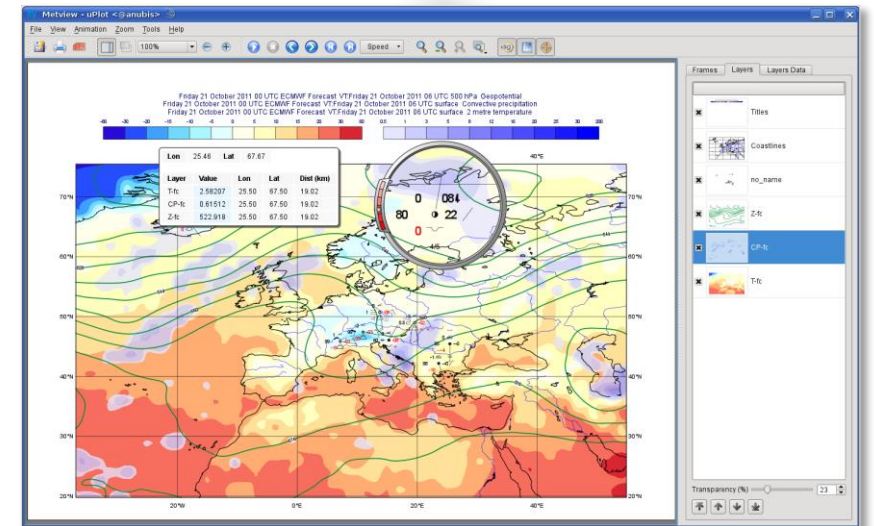
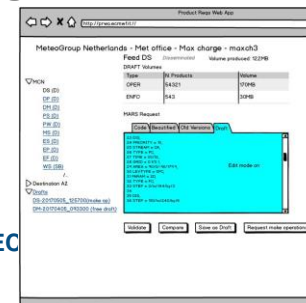
Contract	Product name	Start	End	Quantity	Unit	Price	Product name	Start	End	Quantity	Unit	Price
1234	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1235	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1236	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1237	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1238	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1239	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1240	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1241	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1242	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
1243	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
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1245	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
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1249	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00	ECMWF	2011-01-01	2011-12-31	1000	EUR	1000.00
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Licences Management



Web Catalogue

Requirements Management



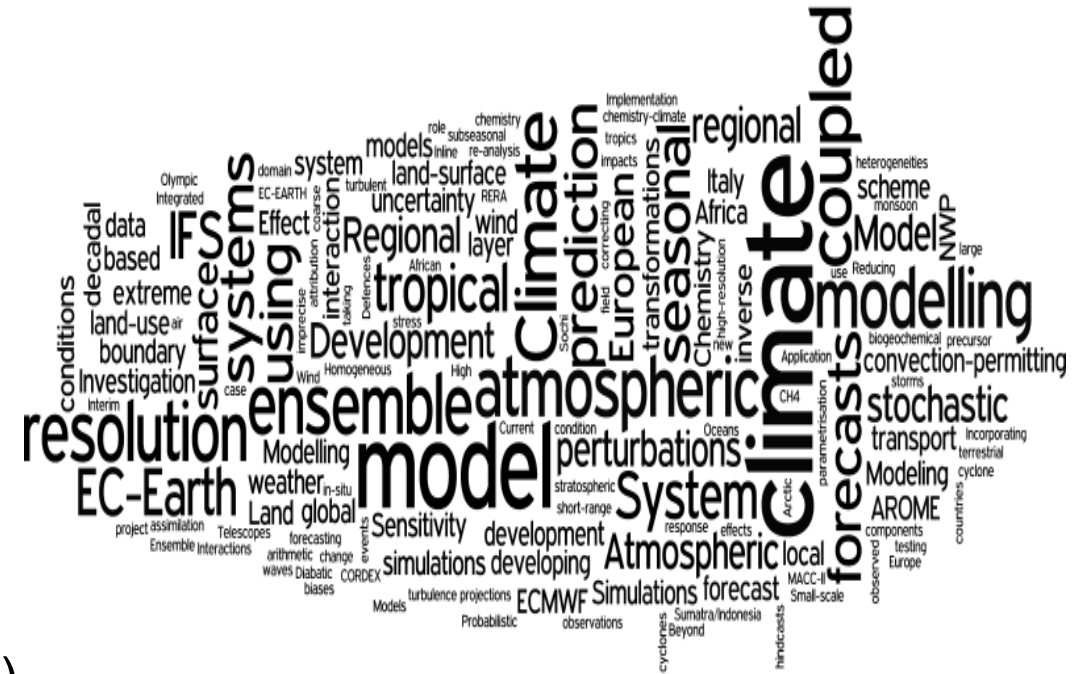
# Special Projects

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



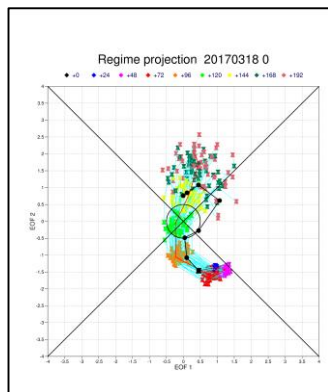
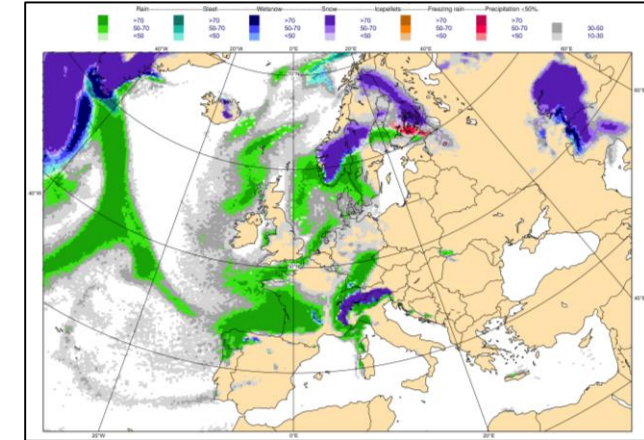
Questions? Talk to Umberto!

# User requests for forecast products

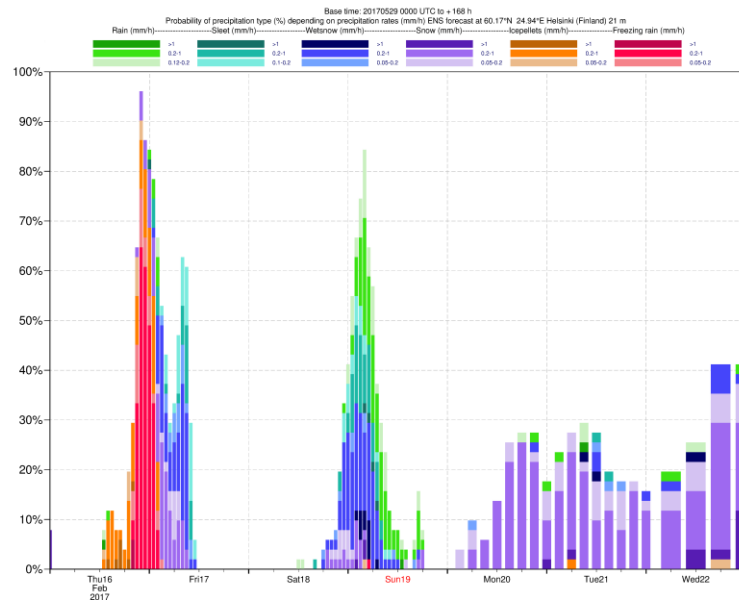
- ECMWF provides forecast products to meet the requirements of its Member and Co-operating States
  - Selected ECMWF products used by NMHSs of other WMO members, commercial customers and the public
- Requests for new products
  - annual users' meetings: "Using ECMWF's Forecasts"
  - ECMWF visits to the 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
- Intrinsicly 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



# Precipitation type Probabilities

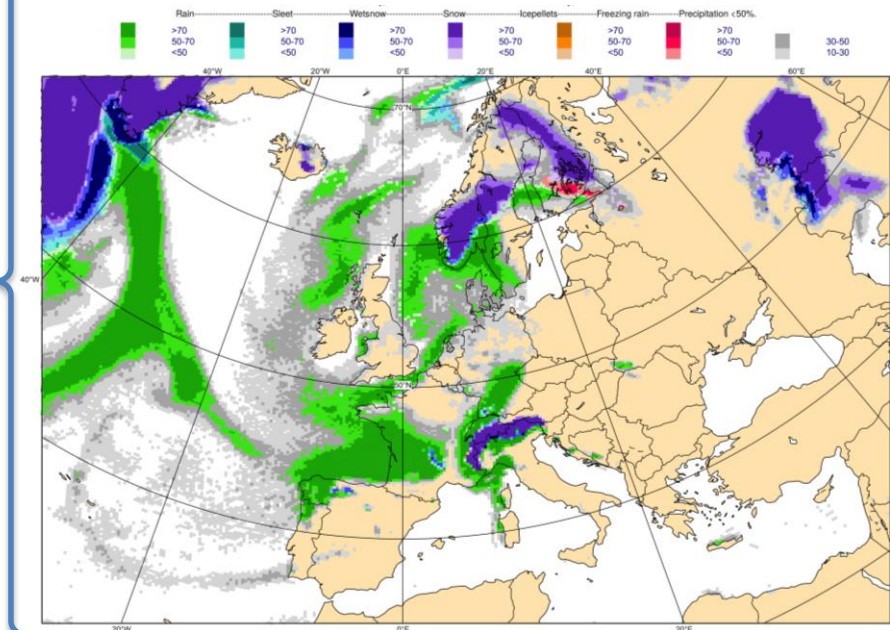


- Shows the most probable precipitation type according to ENS distribution
- **Greys** denote dry is most likely, but equally show probability of there being any falling precipitation (PPF) when that lies between 10 and 50%.
- **Colours** are for when precipitating is most likely (PPF>50%); "lightness" 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

# 1. Precipitation Type

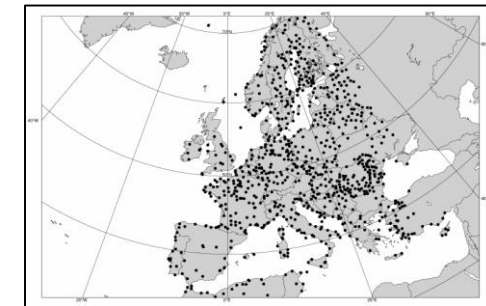
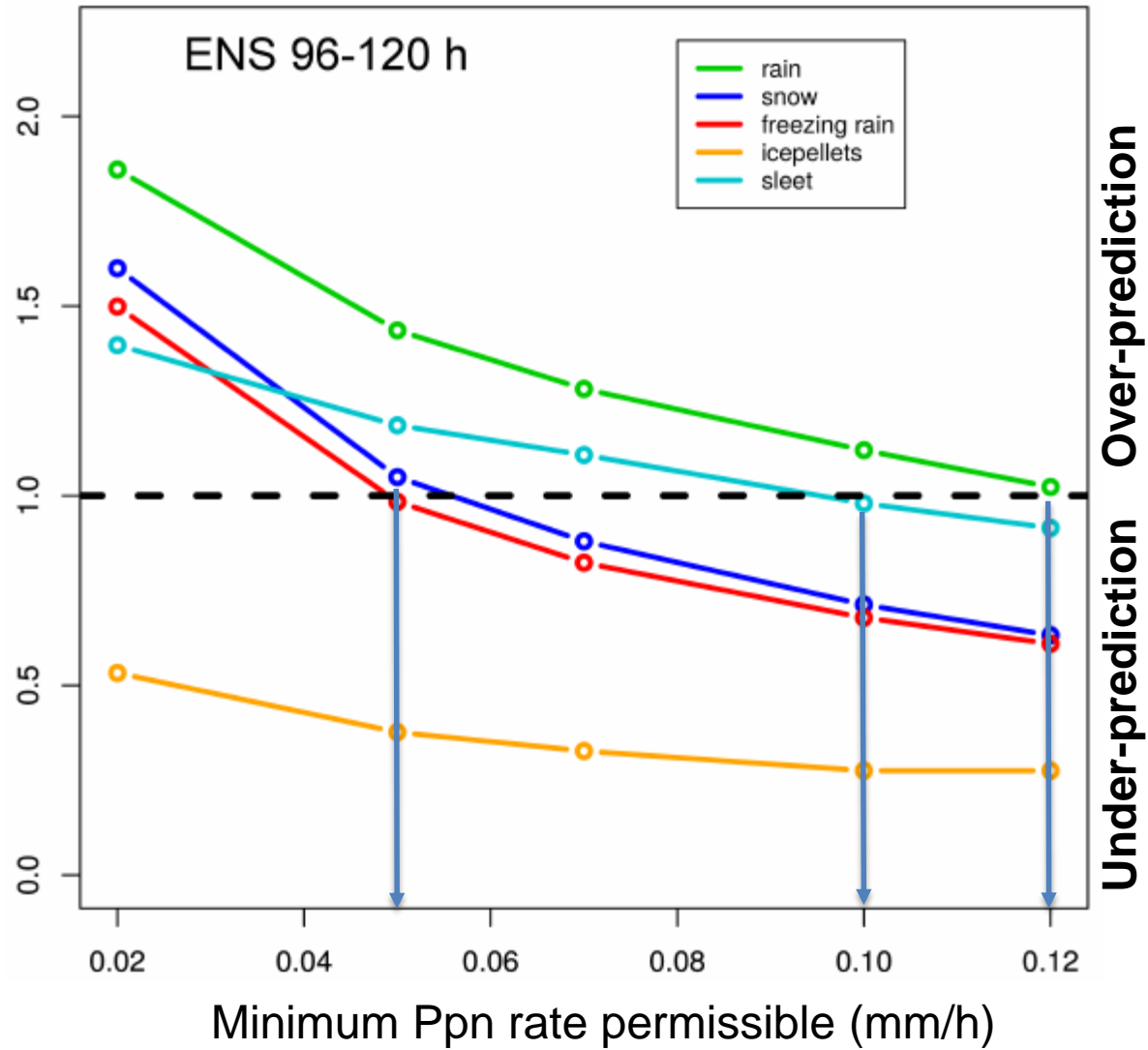
- The ECMWF Precipitation type probability focusses on the type of precipitation falling (at the surface) at the valid time: rain, snow, wet snow, sleet, freezing rain, ice pellets, dry
- Precipitation **rate is denoted by "lightness"** of the colour shades, e.g. to provide indication of potential substantial 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



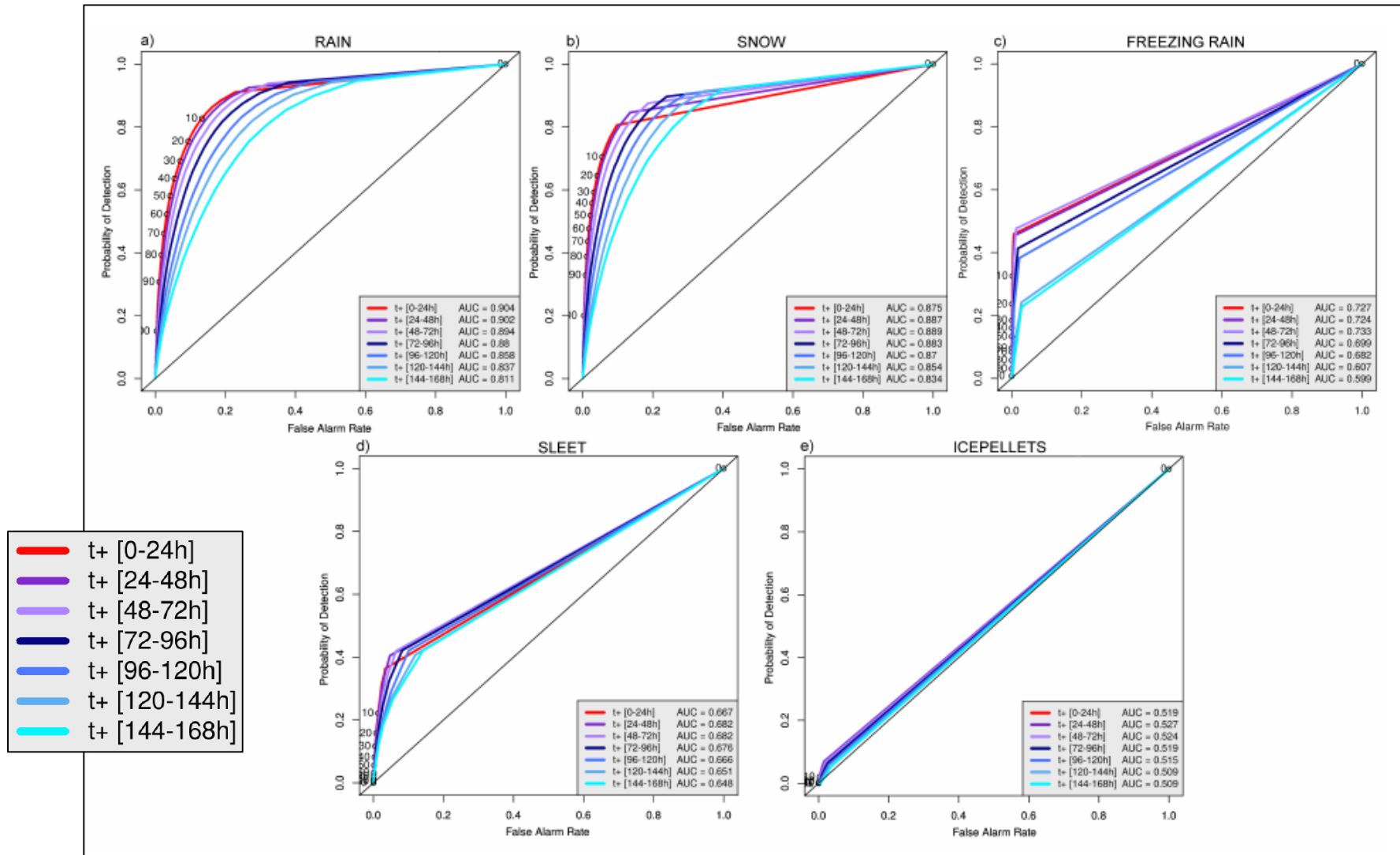


# BIAS adjustment



versus SYNOPS

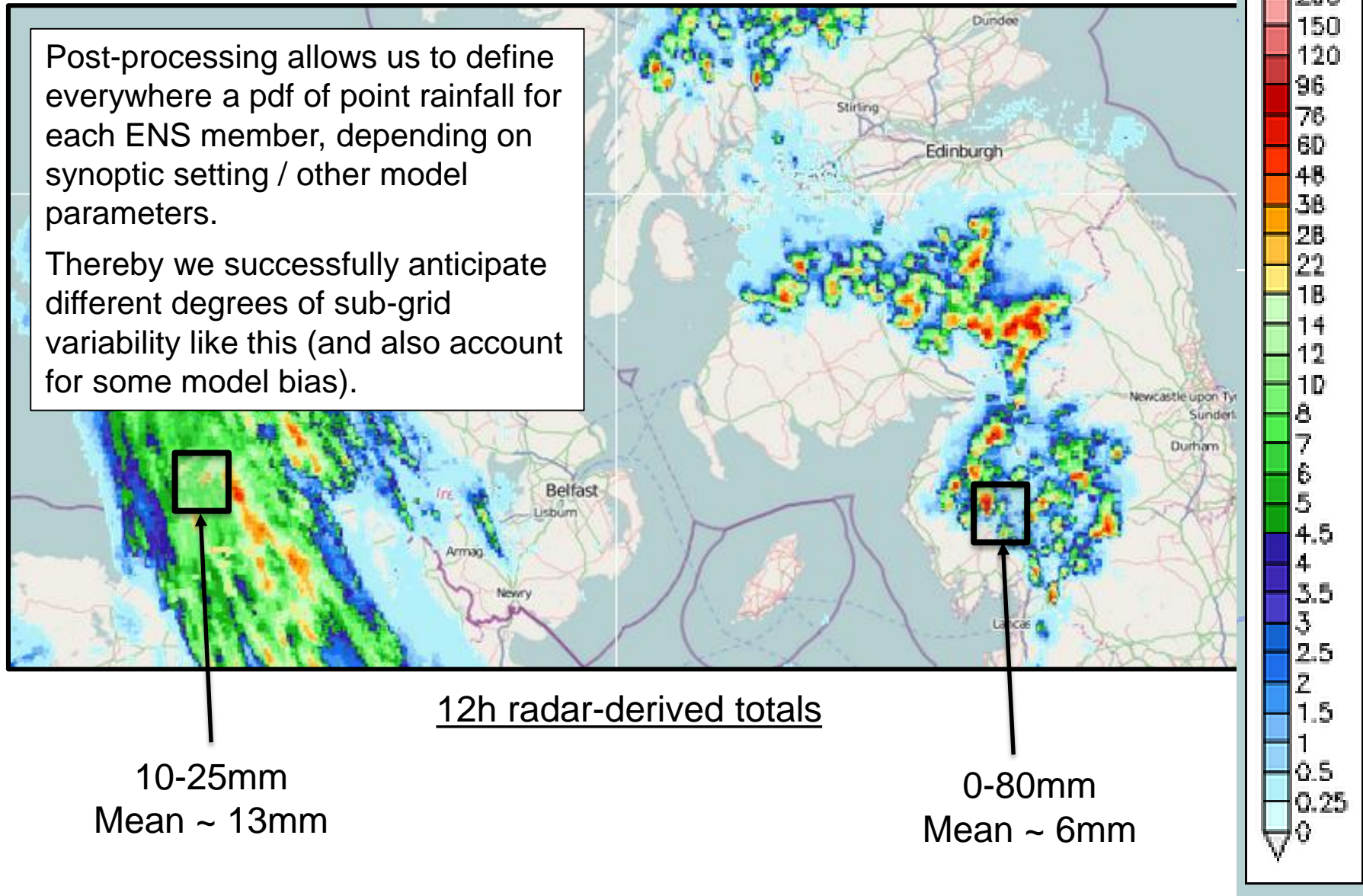
# ENS Precipitation Type Verification – ROC curves



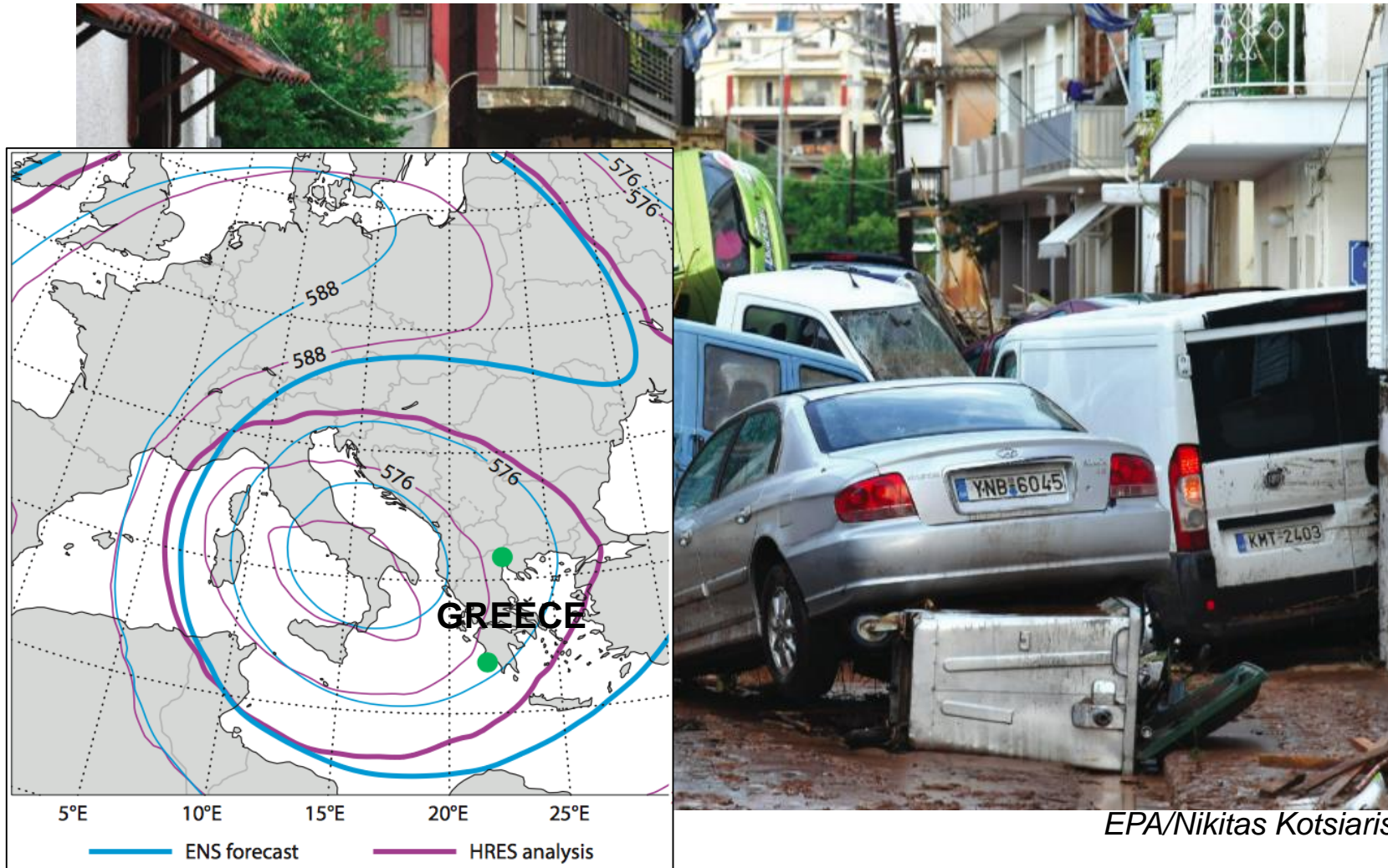
## 2. Point Rainfall

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

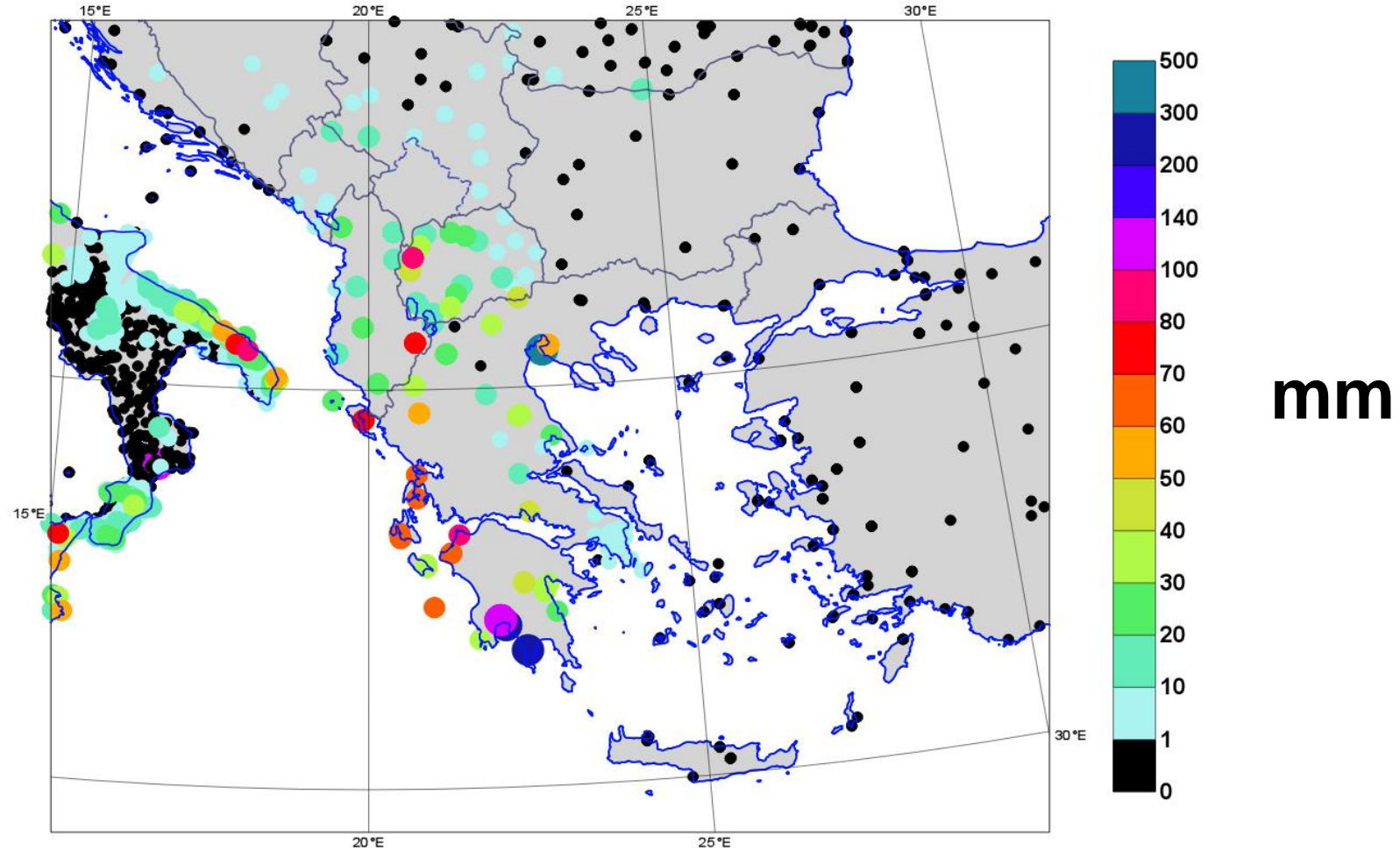
Thereby we successfully anticipate different degrees of sub-grid variability like this (and also account for some model bias).



# Case Study – Flash Floods in Greece Sep 2016



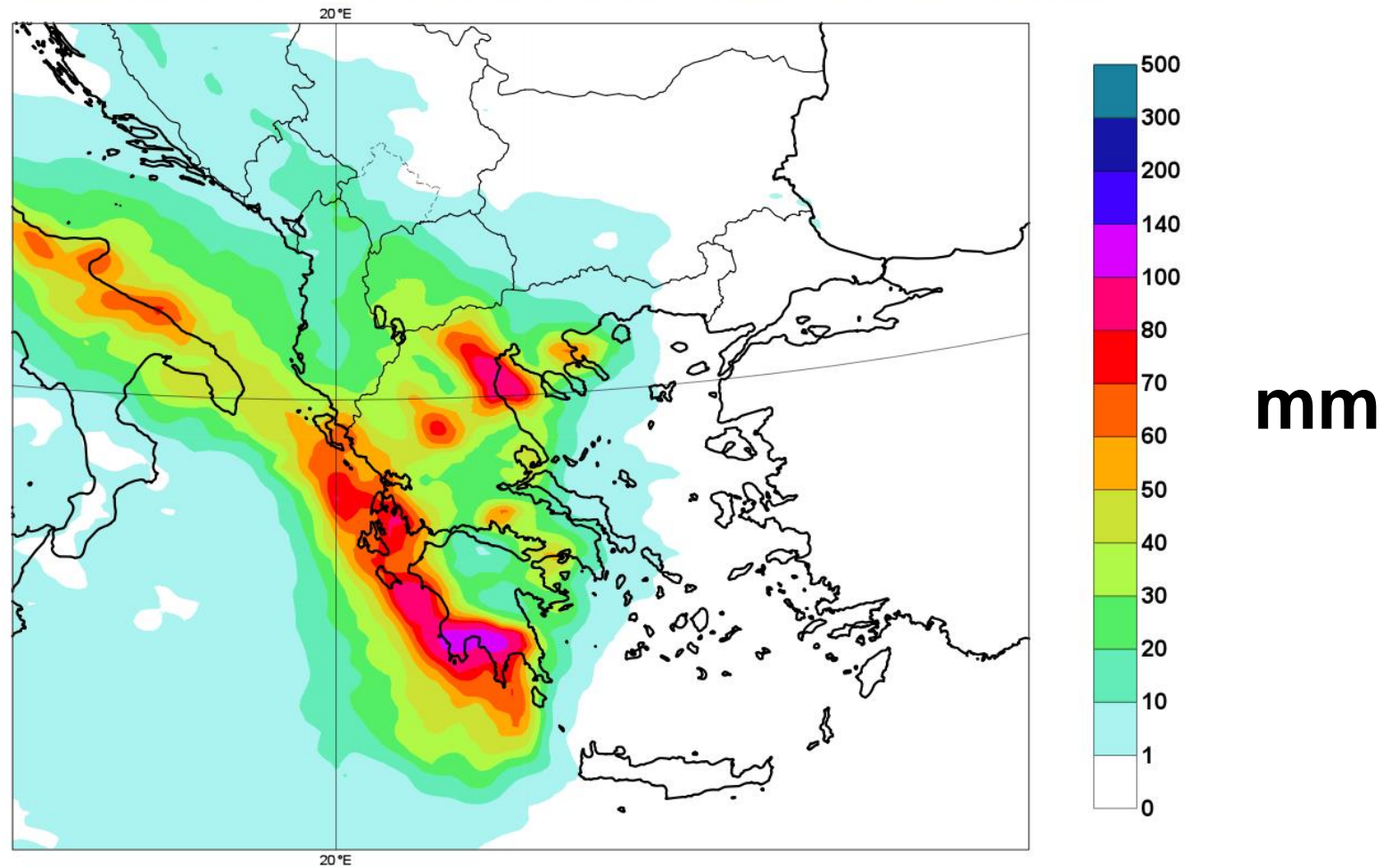
# Observations – official and unofficial



# RAW ENS forecast – Day 3 - 95<sup>th</sup> Percentile

*=1 in 20 chance of exceedance!*

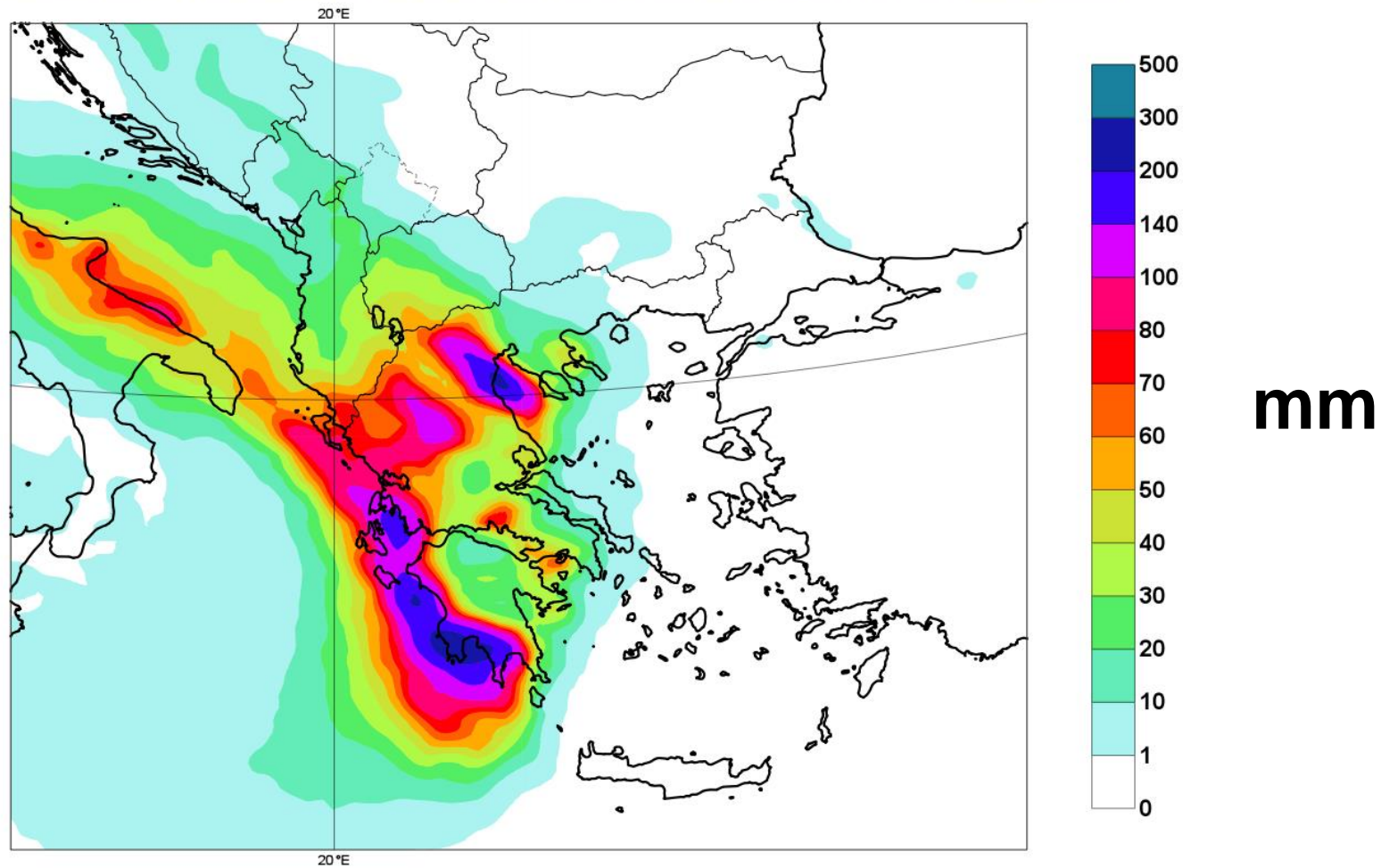
12 Hourly Accumulation of TP (95th Percentile), 04 September 2016 12UTC (t+54,t+66), VT: 06 September 2016 18UTC - 07 September 2016 06UTC



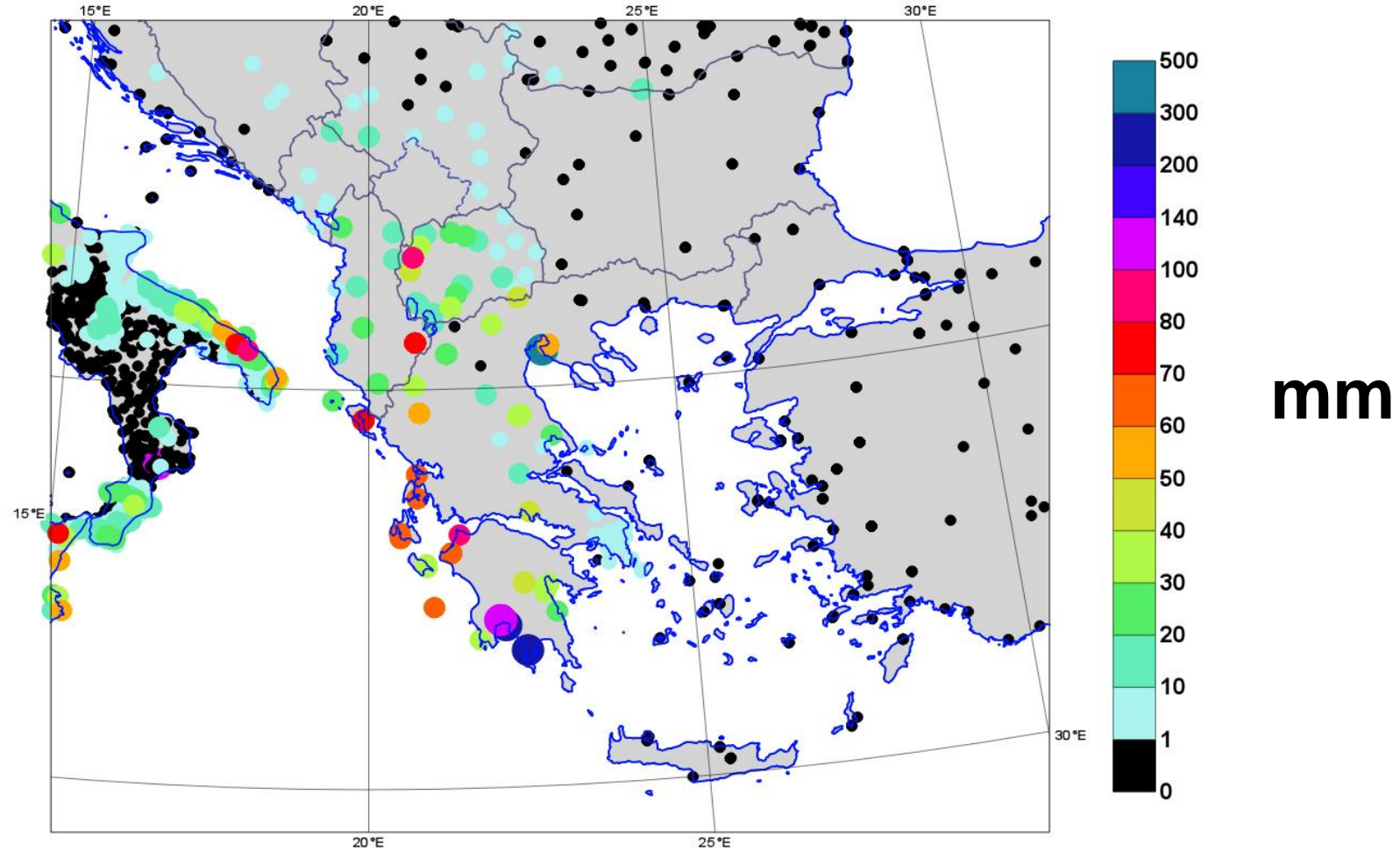
# ENS Point Forecast – Day 3 - 95<sup>th</sup> Percentile

*=1 in 20 chance of exceedance!*

12 Hourly Accumulation of Point TP (95th Percentile), 04 September 2016 12UTC (t+54,t+66), VT: 06 September 2016 18UTC - 07 September 2016 06UTC

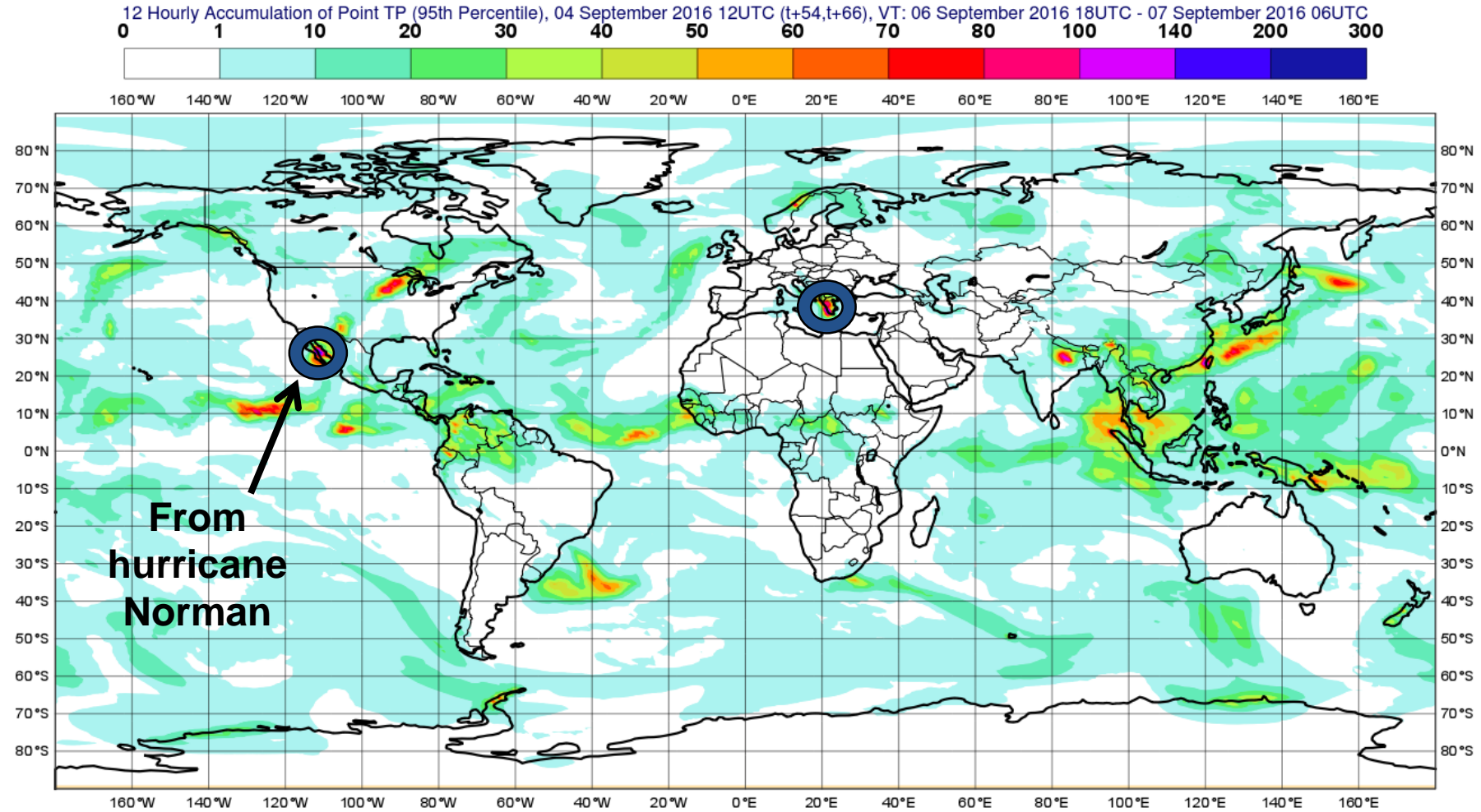


# Observations – official and unofficial





# Same Point forecast – Global – Day 3



From  
hurricane  
Norman



Wettest places in this forecast by this metric

# Verification – ROC area, Raw ENS versus Point Rain product

1 year, Global, raingauge observations

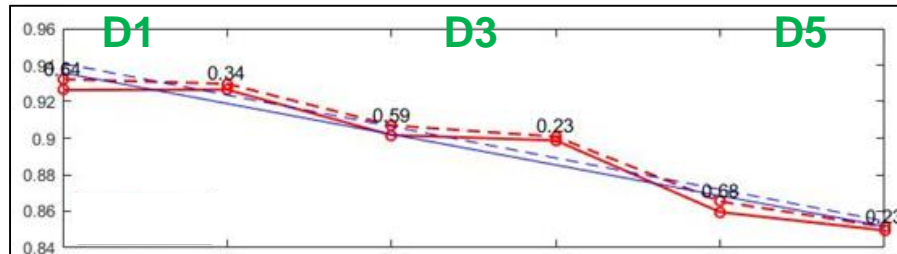


Fig. 15, thr  $\geq 1$  mm/12h

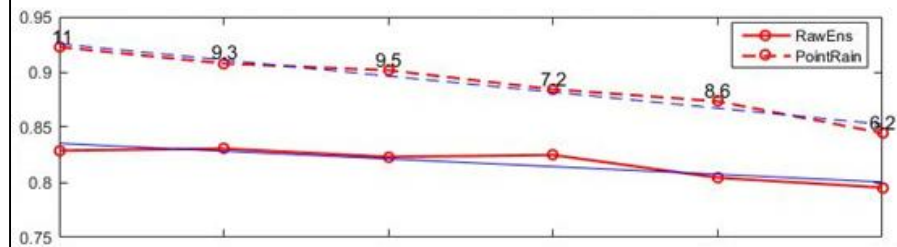


Fig. 16, thr  $\geq 20$  mm/12h

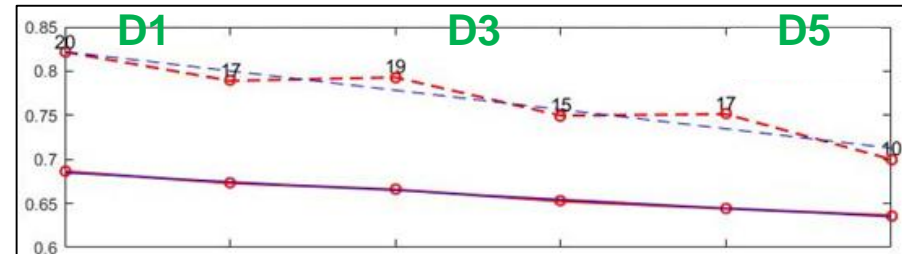


Fig. 17, thr  $\geq 50$  mm/12h

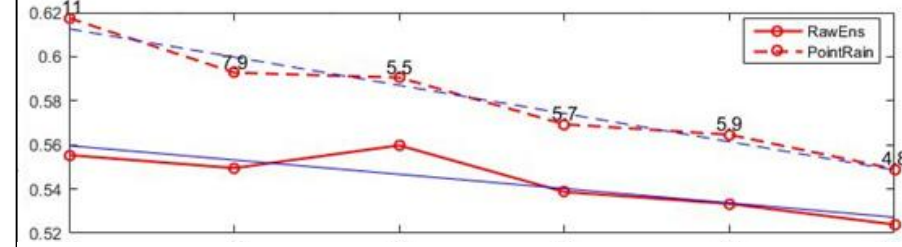


Fig. 18, thr  $\geq 100$  mm/12h

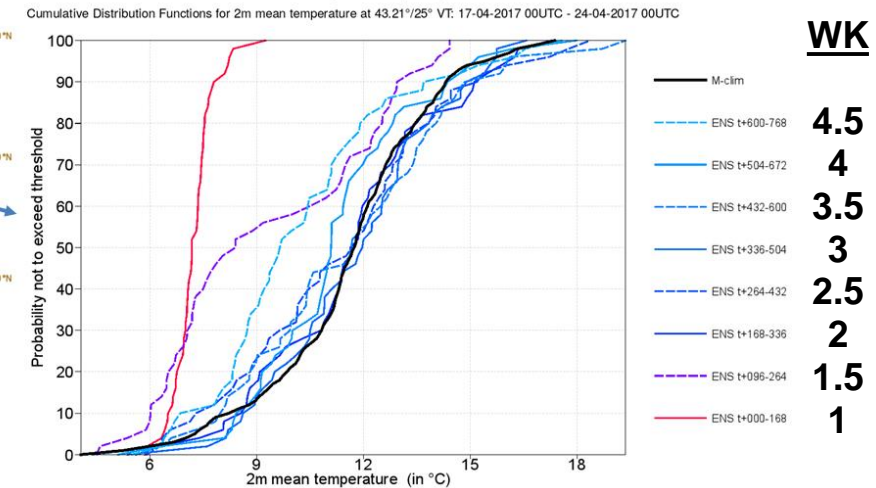
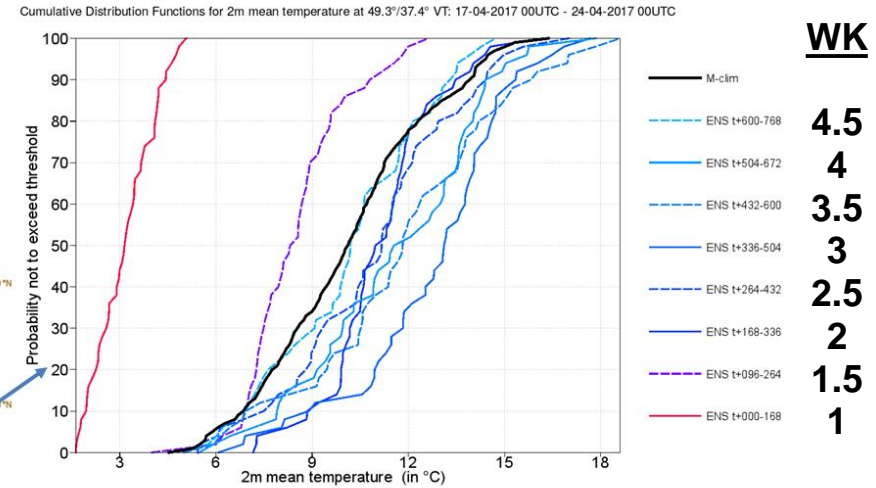
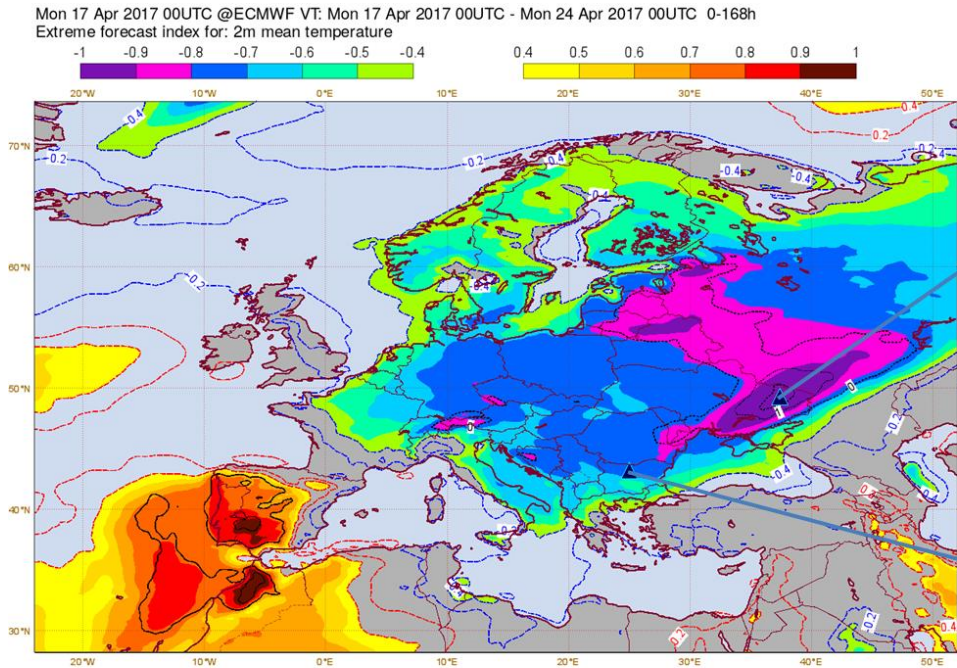
By this metric, for “large” totals the Point Rain product is ~ as skilful at day 5 as the Raw ENS is at day 1

=> Much better probabilistic flash flood predictions

We are working on further improvements

# 3. Distributions for the Monthly Forecast

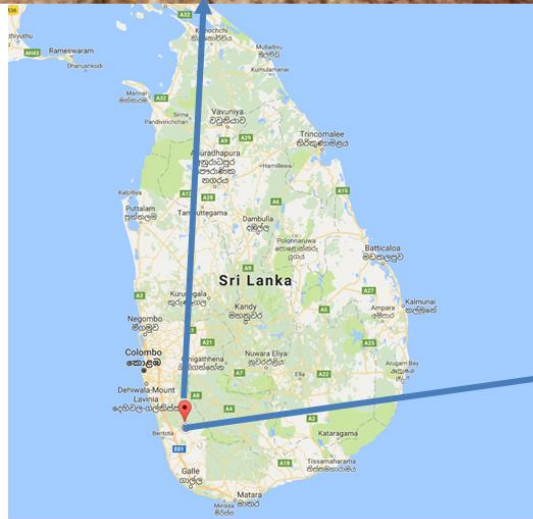
## Week 1 EFI for 2m Temp



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”



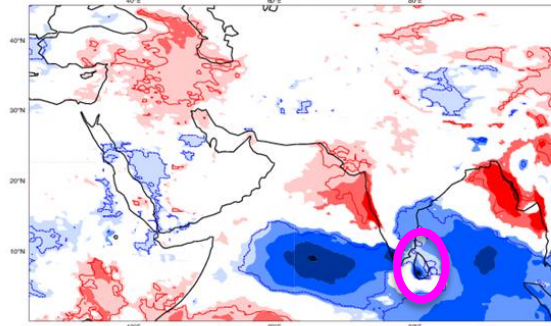
Bellana village in Kalutara district, Sri Lanka



ECMWF EPS-Monthly Forecasting System  
Precipitation anomaly  
Forecast start reference is 11-05-2017  
ensemble size = 51 , climate size = 660

Day 12-18  
22-05-2017/TO/28-05-2017  
Shaded areas significant at 10% level  
Contours at 1% level

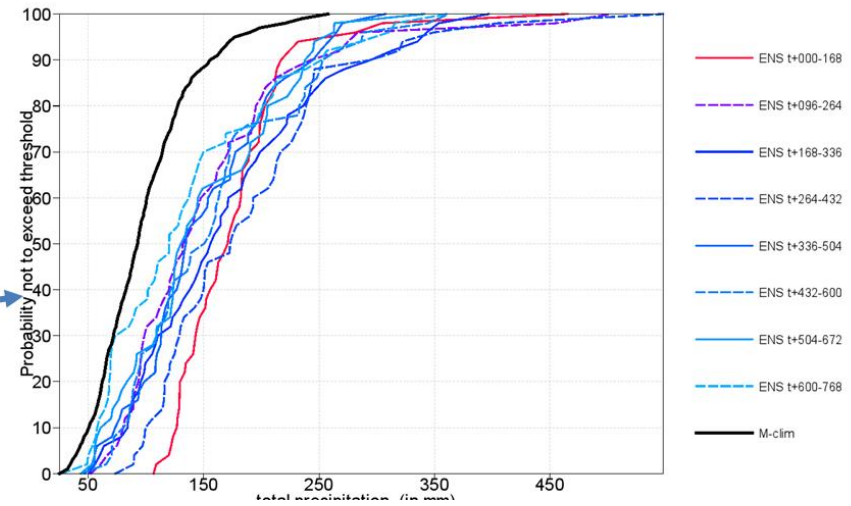
■ <-90mm ■ -90..-60 ■ -60..-30 ■ -30..-10 ■ -10.. 0 ■ 0.. 10 ■ 10.. 30 ■ 30.. 60 ■ 60.. 90 ■ > 90mm



**WK 2.5**

**WK**

Cumulative Distribution Functions for total precipitation at 6.52°/80.18° VT: 22-05-2017 00UTC - 29-05-2017 00UTC



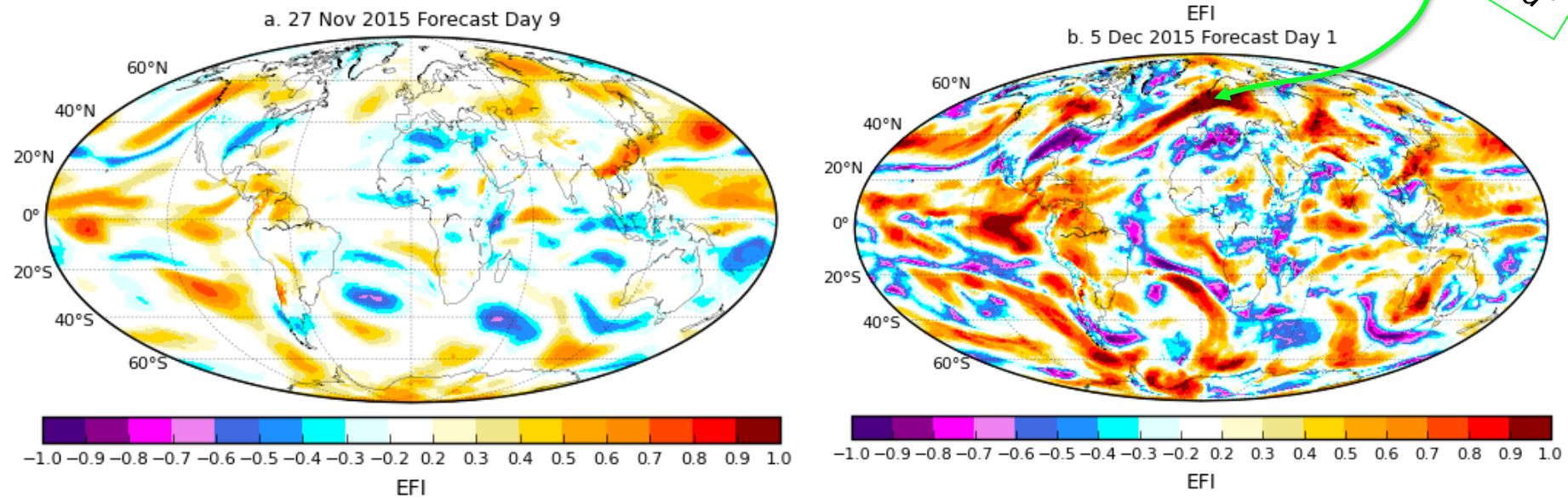
But sometimes, in some areas, we have a useable signal several weeks in advance...

# 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?

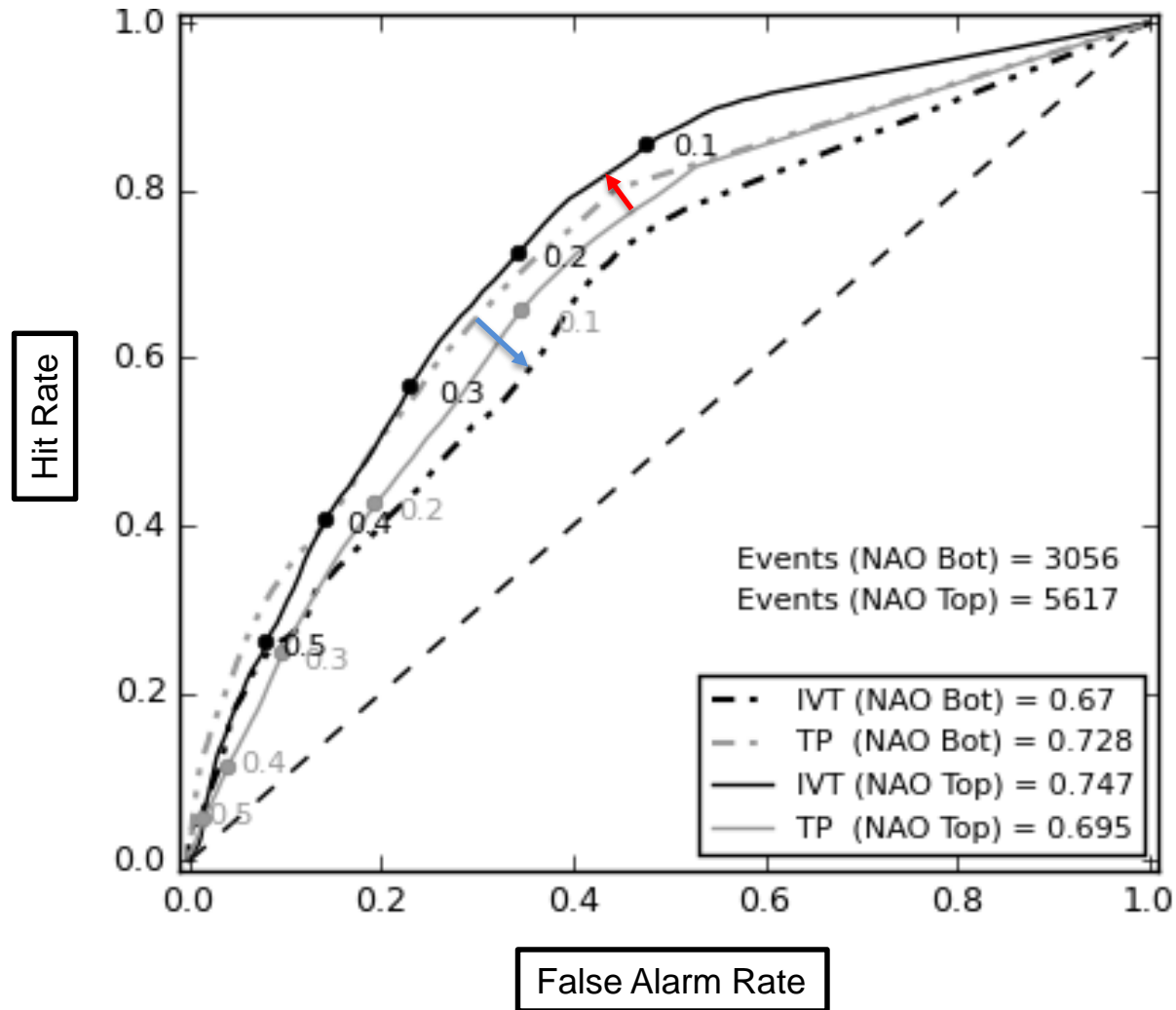
## 4. Moisture Flux

### 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)

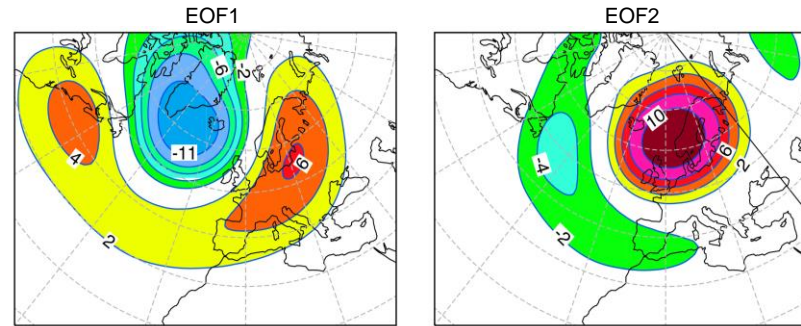
Solid lines (NAO+)  
Dashed (NAO-)

(NAO phase  
at Day 0)

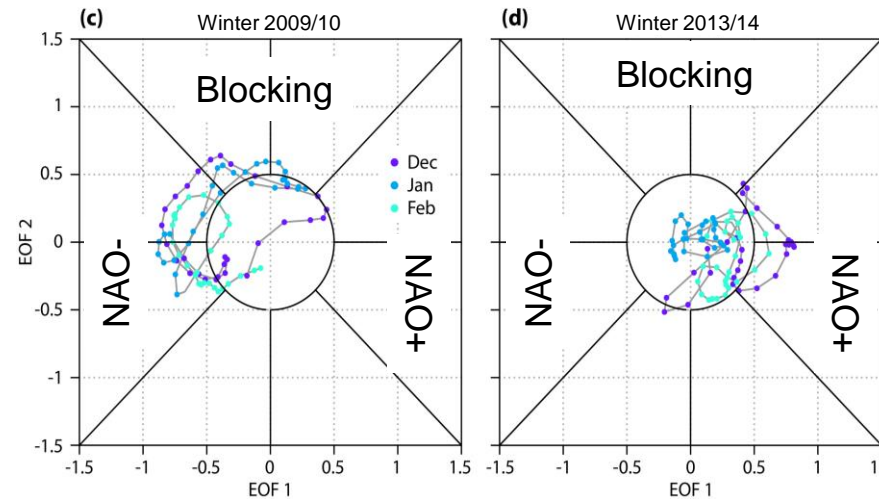
For NAO+ the IVT  
EFI performs better  
than the Rainfall EFI

## 5. Regime transitions

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



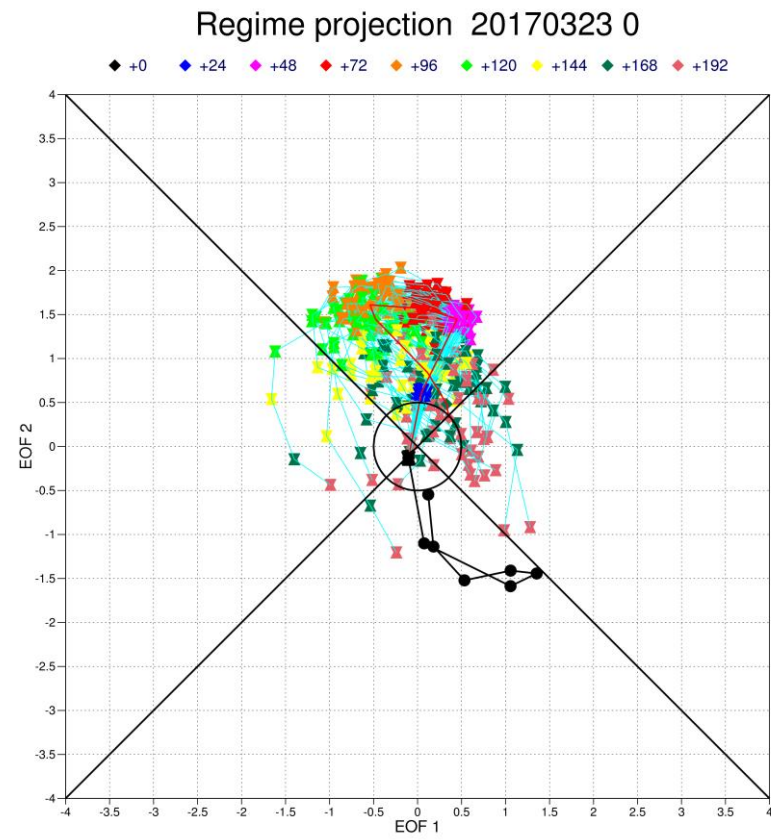
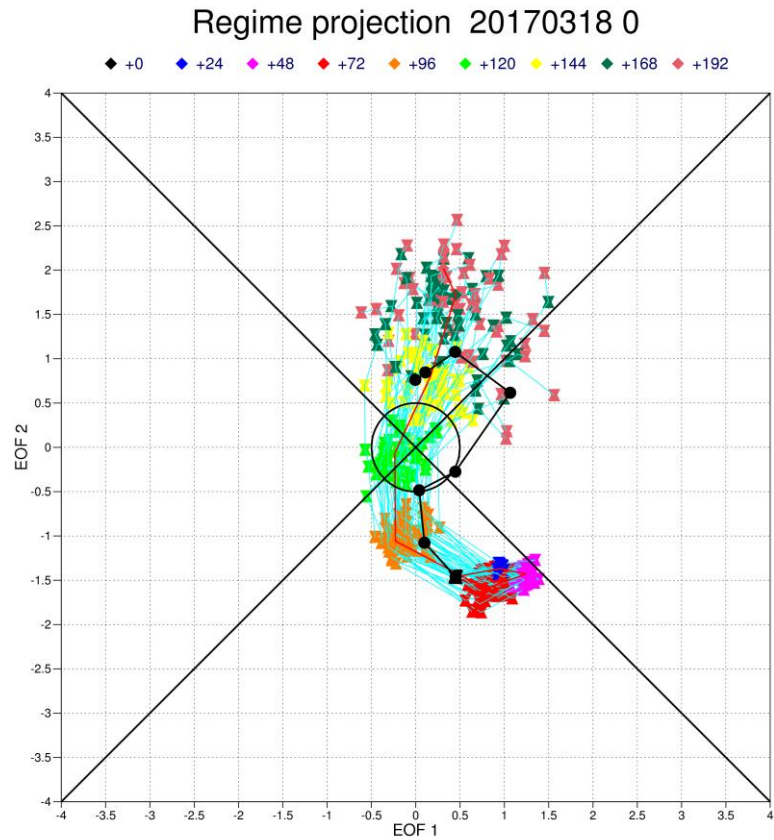
Record-breaking cold temperatures over Europe



Exceptional storminess, but mild temperatures over Europe

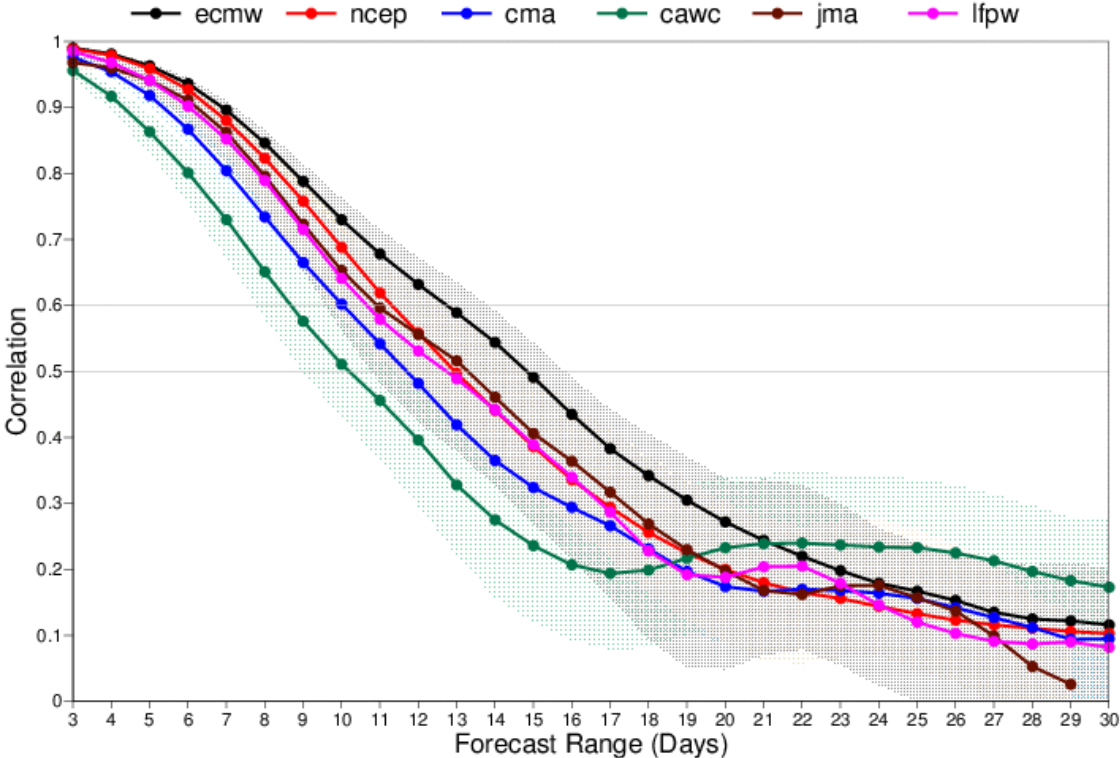


# Forecast Examples (D1-8)



# Verification (to 1 month)

EOF 2dim phase space- bivariate correlation



# 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

# 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