

Some Recent and Upcoming Developments at ECMWF

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ECMWF



Thanks to Ivan Tsonevsky, Richard Forbes, ...

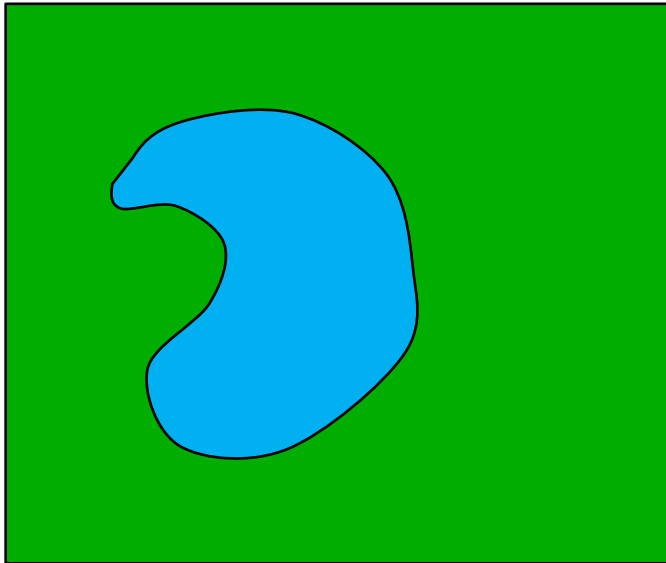
Recent Developments

New Model Cycle

- A new ECMWF model version became operational on May 12th 2015 (cycle 41R1)
- First new cycle since Nov 2013
- Verification measures for new cycle vs old show positive impacts in many areas:
 - For weather parameters total cloud cover and precipitation show the biggest improvements
 - For example light rain / drizzle over-prediction is reduced
- A lake model was introduced (includes sub grid lakes)
- The auxiliary files (e.g. land-sea mask) were updated
- Forecast products have been updated also - *later*
- Documentation (comprehensive yet user-oriented) is here:

<http://www.ecmwf.int/en/forecasts/documentation-and-support/changes-ecmwf-model/cycle-41r1>

Lake Model



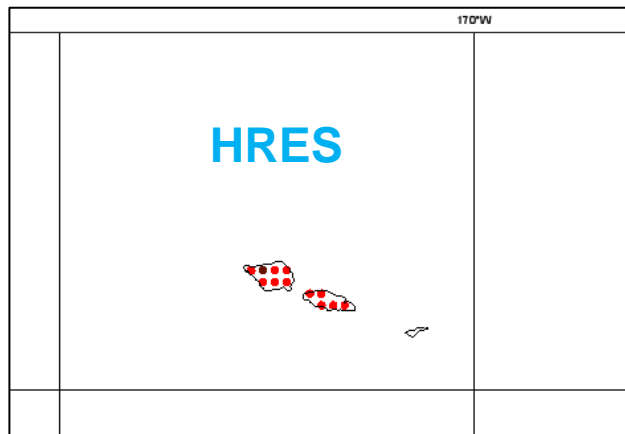
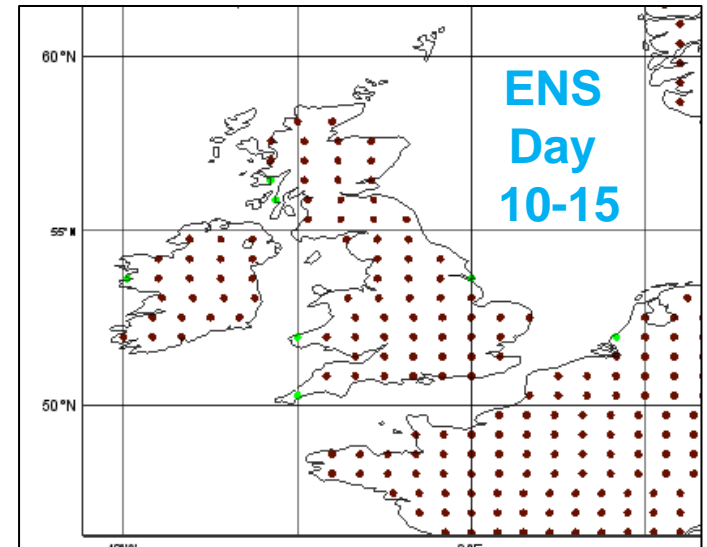
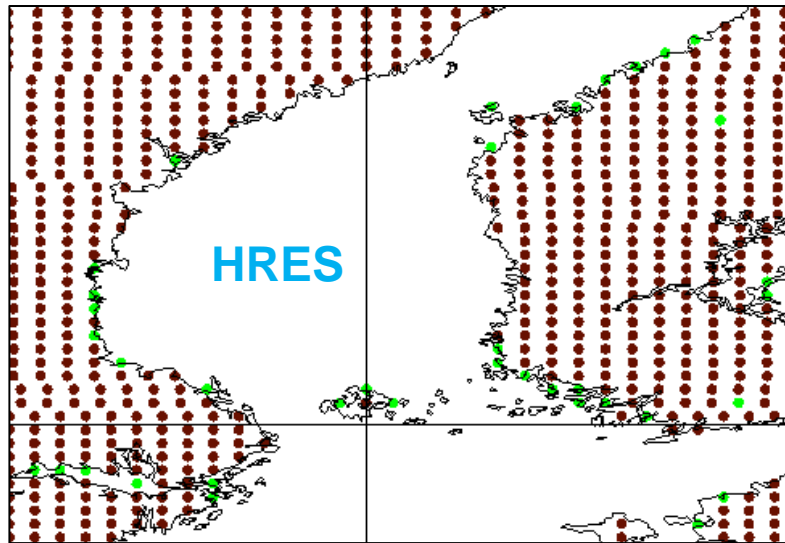
> Model gridboxes with lake(s) in

2m temperature output is now the weighted average of values over the lake(s) and over the land, in each gridbox

This strategy might give the 'false' impression that there are 2m temperature errors when verifying against observations over land.

It is however better for overall model behaviour

New Land-Sea Mask



Green dot = land point added in new cycle
Red dot = land point removed in new cycle

- More land points around Europe, all resolutions
- Some 'disappearing island' problems in the Pacific, eg Tahiti, Samoa, will be fixed next year

SUMMARY SLIDE FROM LAST YEAR'S PRESENTATION: “upcoming improvements”

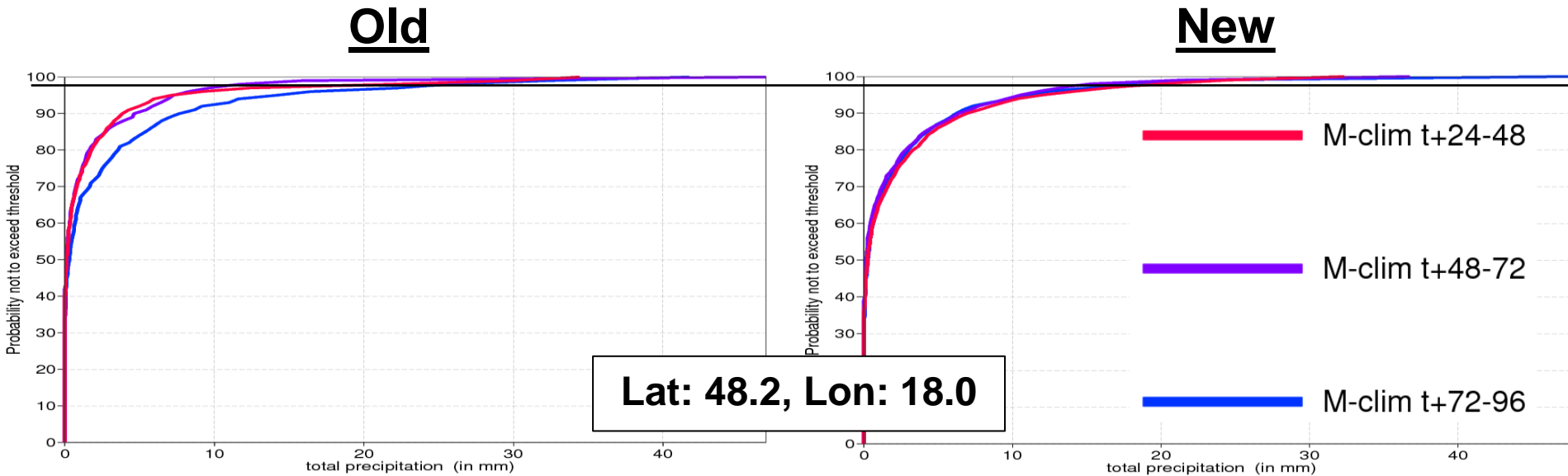
- 1. Better / more stable EFI/SOT due to improved model climate ✓
- 2. EFI/SOT products for the day 10-15 range ✓
- 3. New EFI for Convection (CAPE, or CAPE*SHEAR, or..) ✓
- 4. New Freezing Rain forecasting capability ✓
- 5. Clickable Dalmatian charts (in the cyclone tracking suite) ✗
- 6. New Precipitation Rate and Fog/Vis diagnostics ✓
- 7. **NEW:** work in progress – estimating sub-grid variability in rainfall as a function of model variables – flash flood and other applications – looks very promising...

New Model Cycle

- All the ✓ improvements on the previous slide tied in with the new May 2015 ECMWF model version (cycle 41R1)

1. “Better / more stable EFI/SOT due to improved model climate”

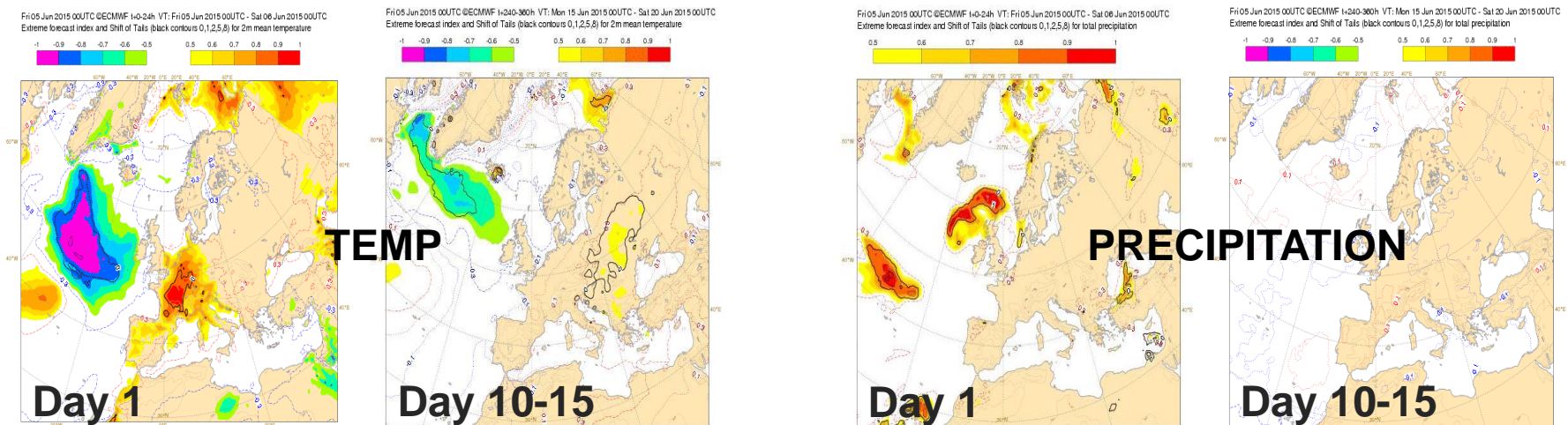
Example model climate profiles for 24h Ppn, at one point in Europe



- This increased stability means also that set differences between the forecast and the M-Climate have a greater significance than they did previously

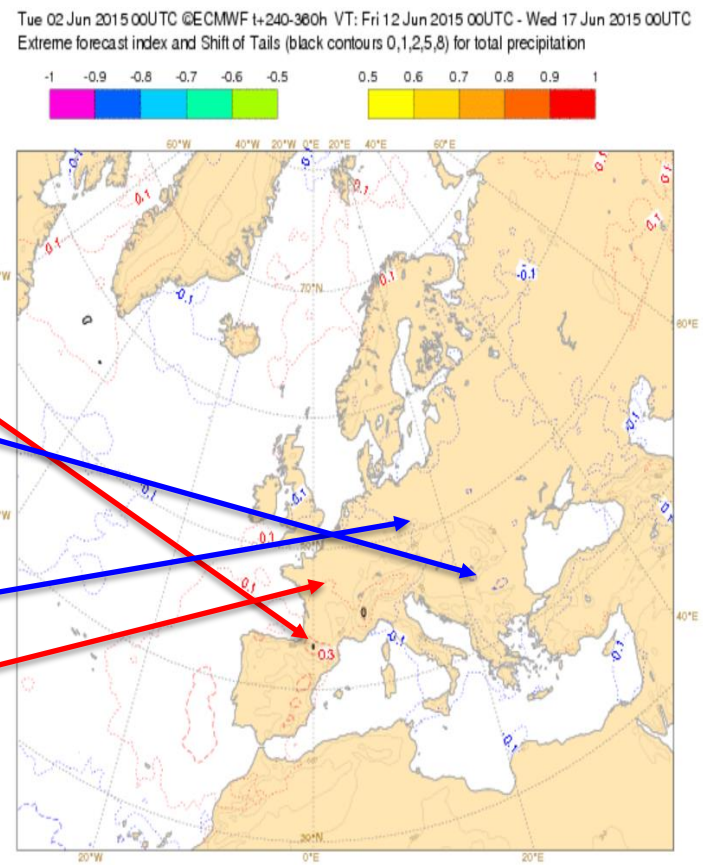
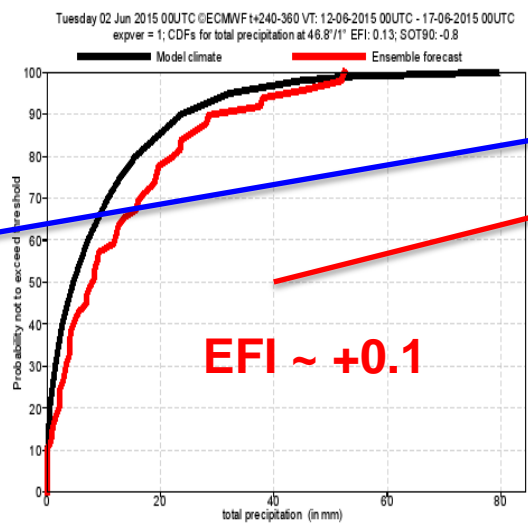
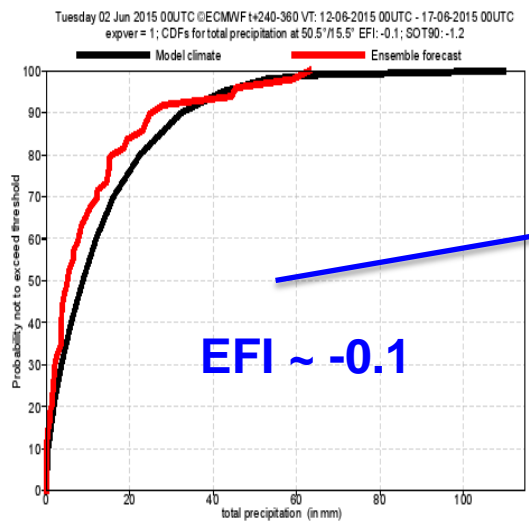
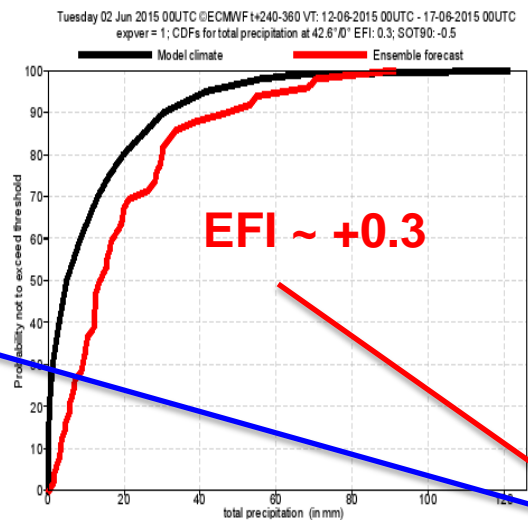
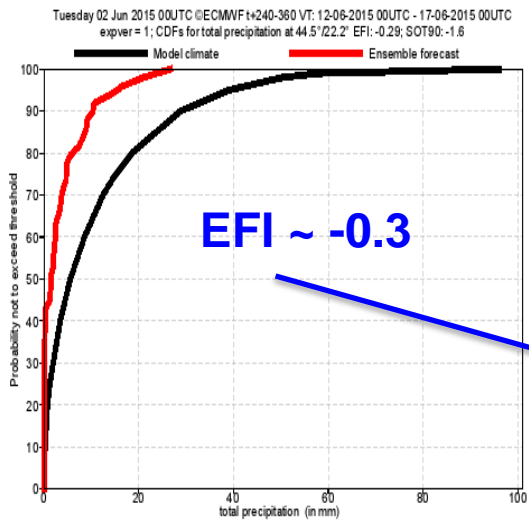
2. “EFI/SOT products for the day 10-15 range”

- To extend ECMWF guidance regarding severe/anomalous weather beyond day 10 new lead times were added to the EFI/SOT product suite at the end of May
- These are for: **Day 10-15**, and **Day 1-15**
- They are available for: **2m Temperature**, **Wind Speed** (not gust), **Total Ppn**
- Because ensemble spread increases with lead time, getting strong signals of extreme weather beyond day 10 is difficult and rare (example plots below)
- Therefore EFI maps for Day 10-15 often look empty, especially for precipitation.
- So to provide some extra information regarding how the distribution compares with climatology we plot also contours for EFI values of +0.1 and -0.1



So how might small magnitude EFI values be interpreted?

Example cdf profiles for day 10-15 precipitation



The difference between forecast and M-Climat is statistically significant in all 4 examples

What does this mean for the user, for the day 10-15 range?

- **EFI values are commonly small, and therefore not so indicative of extreme weather**
- **Nonetheless even small values (~0.1) do provide statistically significant pointers to the likelihood of relatively wet or relatively dry conditions (or indeed relatively warm/cold or relatively windy/calm)**

3. “New EFI for Convection (CAPE, or CAPE*SHEAR, or..)”

- Convective Available Potential Energy (CAPE) – MUCAPE in the lowest 350 hPa:

$$CAPE = \int_{z_{LFC}}^{z_{EL}} g \left(\frac{\theta_{e,up} - \bar{\theta}_{e,sat}}{\bar{\theta}_{e,sat}} \right) dz$$

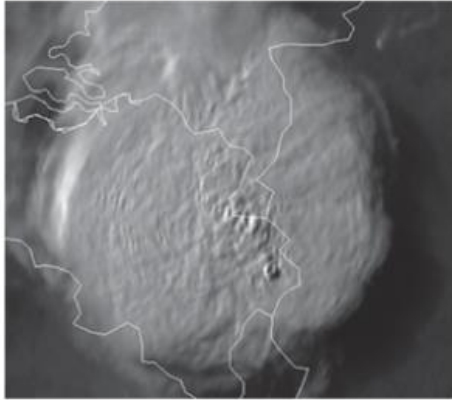
- CAPE-SHEAR Parameter (CSP):

$$CSP = WS_{l_1}^{l_2} \sqrt{CAPE}$$

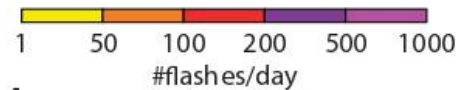
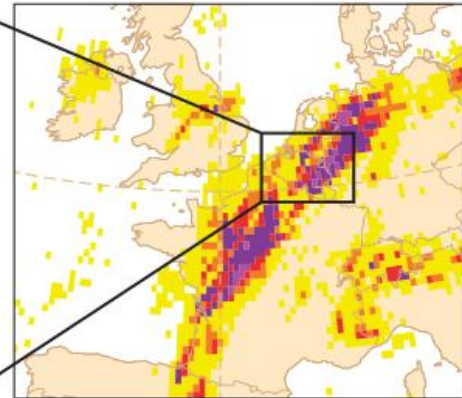
- $WS_{l_1}^{l_2}$ - wind shear between $l_1=925$ hPa and $l_2=500$ hPa;
- $w_{max} = \sqrt{2CAPE}$ is the maximum vertical velocity in convective updraughts.
- Four values for each 24-hour period are considered and the maximum of these is retained.
- To avoid noise in the high latitudes, CAPE less than 10 J/kg is filtered out.

Severe convection, 9 June 2014

a Satellite

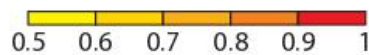
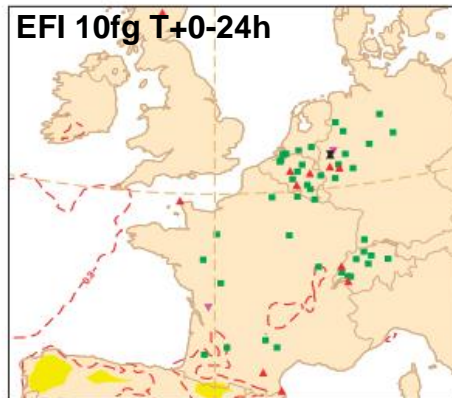


b Lightning



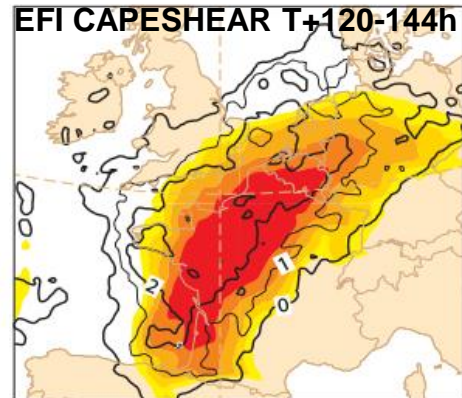
- Strong wind gusts were reported in France, Belgium, the Netherlands and Germany.
- The maximum wind gust at Düsseldorf airport was 42 m/s.
- The EFI gave no indication of severe wind gusts even in the short range.
- The EFI for CAPESHEAR reached values close to 1 six days in advance.

c Wind gusts



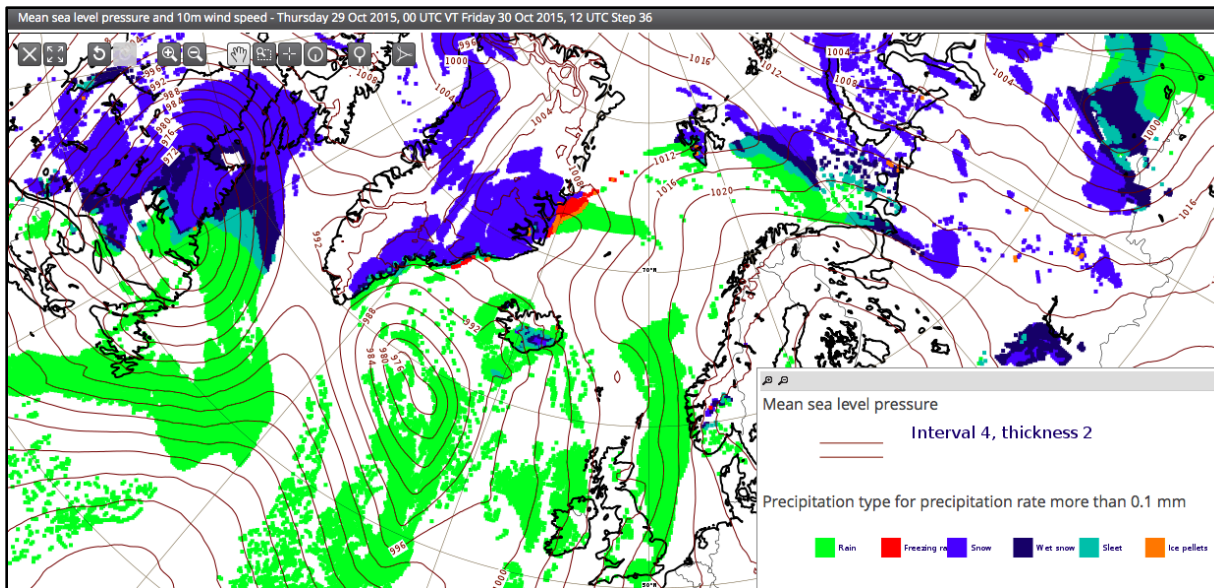
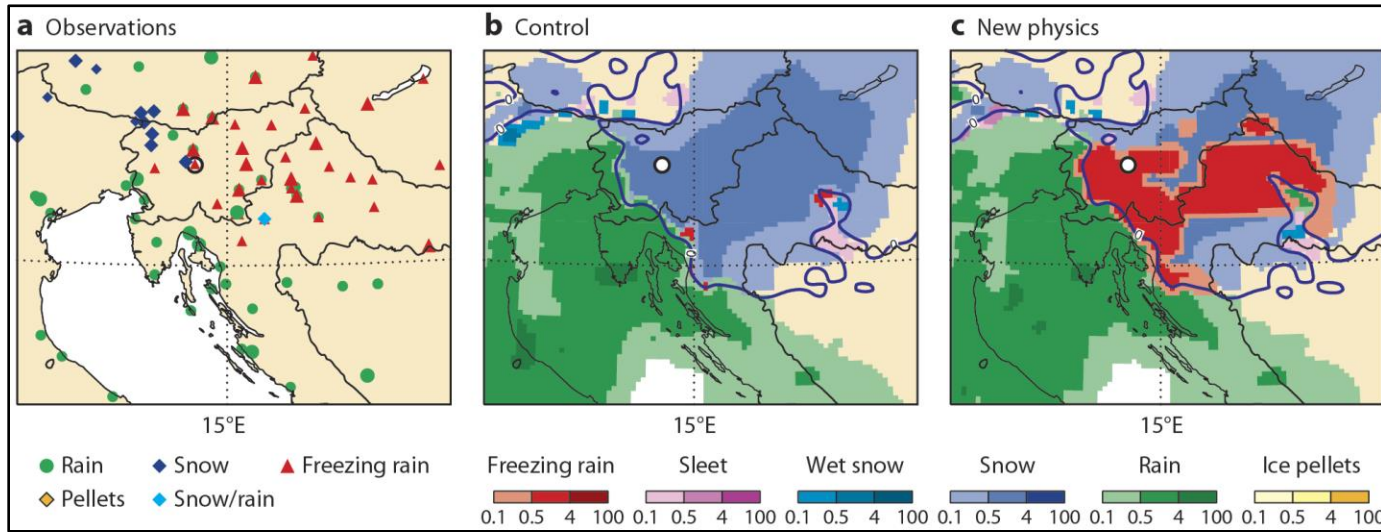
■ 20-25 ▲ 25-30 ▼ 30-40 ■ 40-50
Observations (m/s)

d CSP



EFI values

4. "New Freezing Rain forecasting capability"

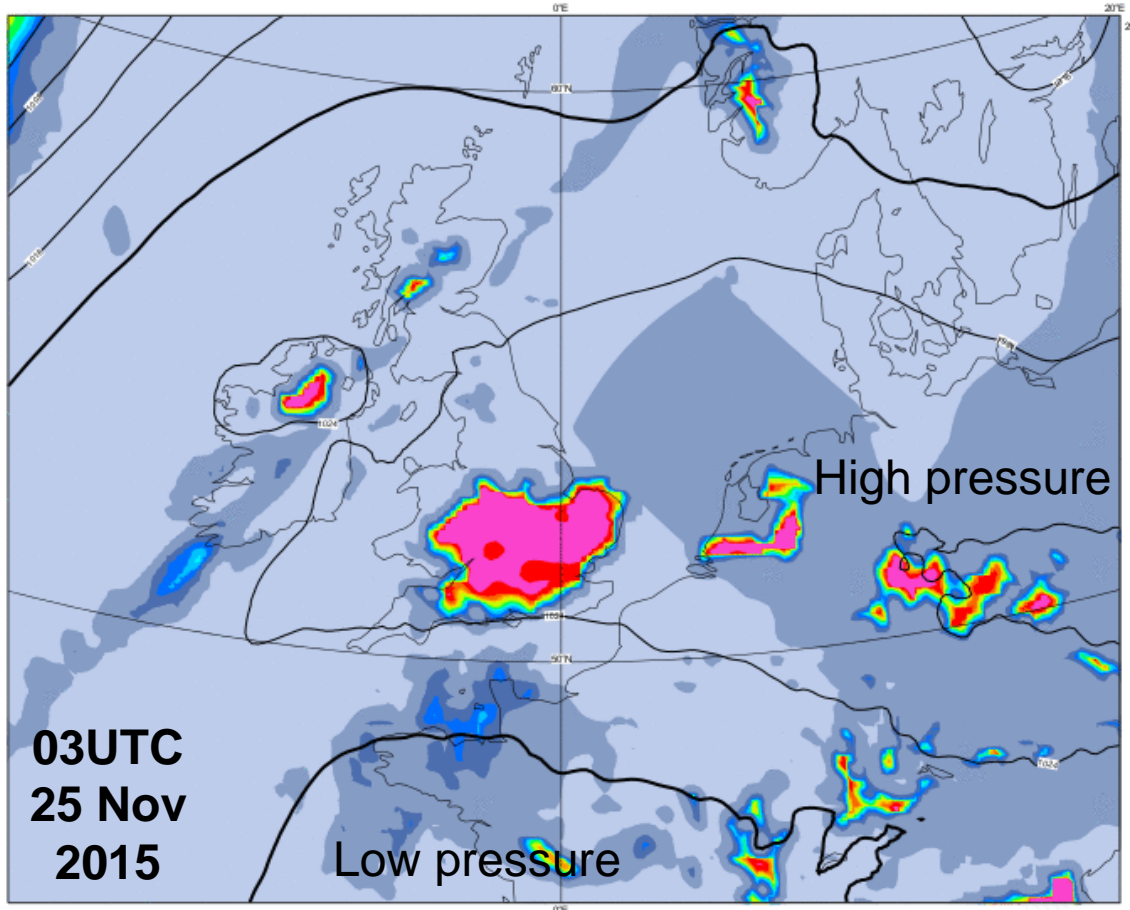


Slovenia/Croatia event in 2014

Ppn Type option now in ecCharts

6. “New Precipitation Rate and Fog/Vis diagnostics”

Metres

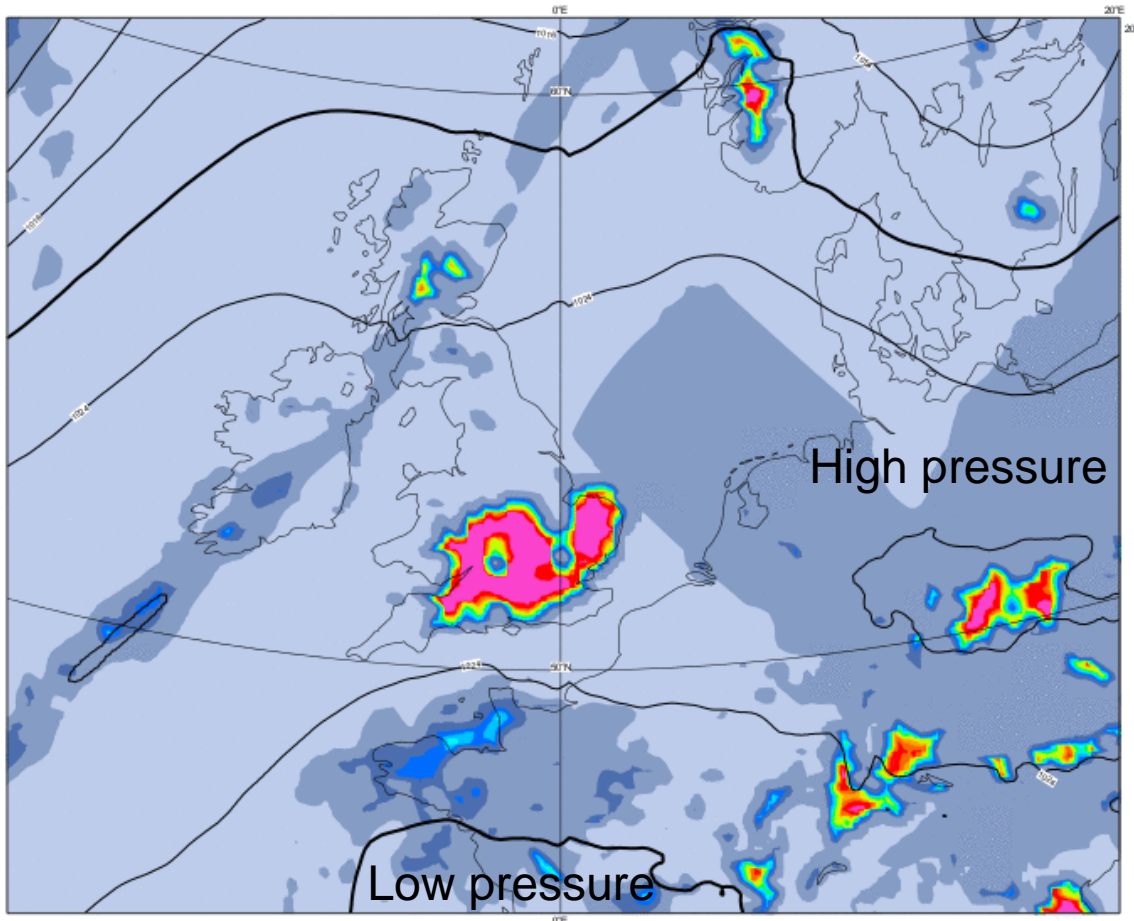


Visibility is new model parameter

- Introduced on 13 May (41R1)
- Bug fix (droplet size) was introduced in June
- Example (left) is with this fix
- Shows Obs & 3h HRES forecast
- Bright colours are fog
- Agreement quite good generally
- But will be worse at longer leads
- In fog situations in particular visibility is intrinsically very difficult to forecast
- For example aerosol emissions and the physics/chemistry of droplet interaction with aerosols, of varying concentrations, are both important but are not used

Metres

0 100 200 300 400 500 1000 1500 2000 3000 5000 10000 30000 100000



Visibility is a new model parameter

- Example shows how visibility evolves in HRES at 1h intervals, T+0 to T+12, 00-12UTC (Nov 25 2014). MSLP also shown.
- **3 factors are illustrated:**
- **Fog formation**, synoptically reasonable, focussed on anticyclonic light wind regions
- **Reduction in ppn**, e.g. with cyclone moving N from France
- **Background climatology**, e.g. causes straight lines in N Sea
- Other analysis suggests that instances of dense hill fog may be substantially underestimated

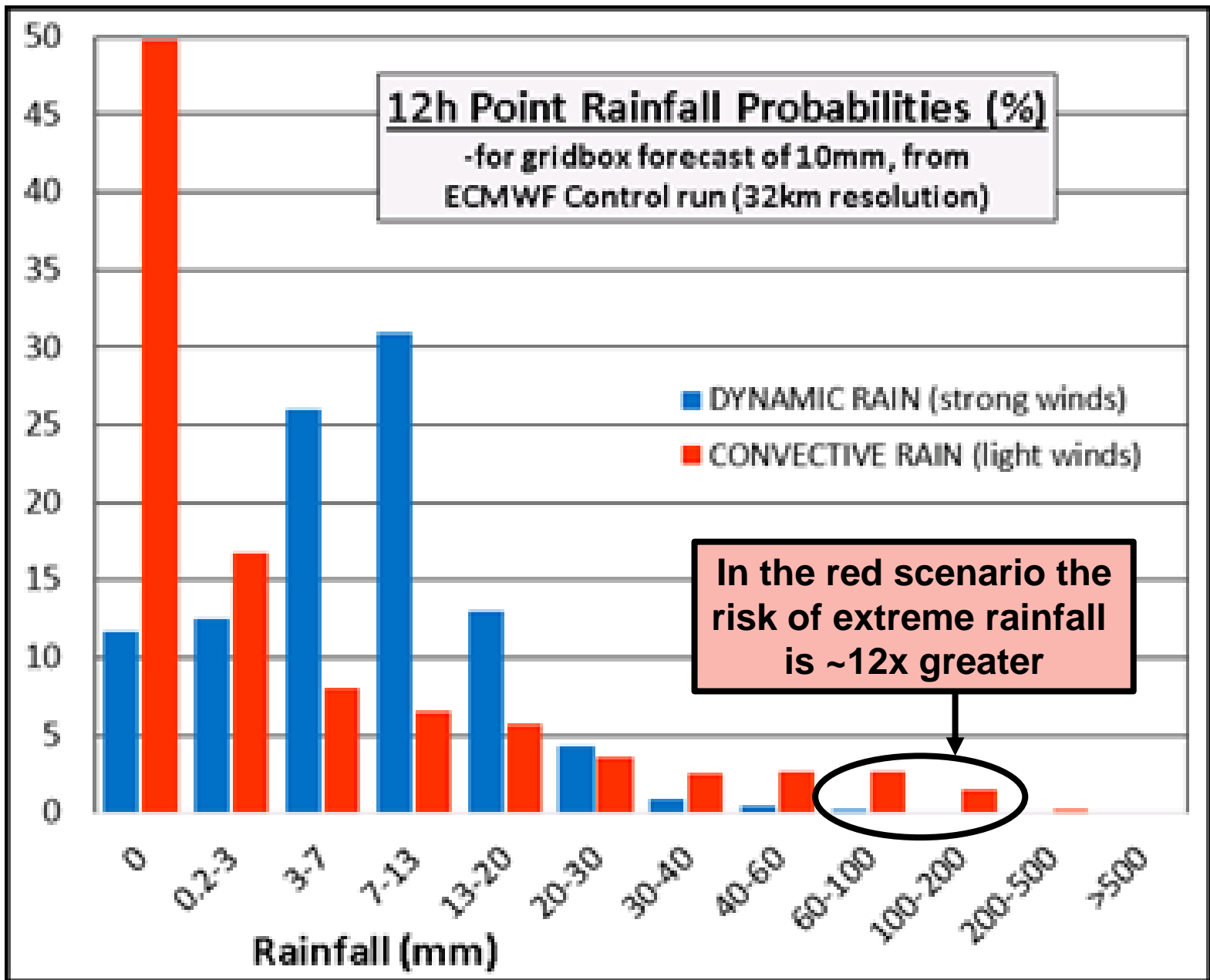
Upcoming Developments

Some upcoming developments (not exhaustive!)

- Old website switch off (Dec), new location for CDB
- Next cycle 41R2 – Mar 2016 (?)
 - Incorporates model resolution upgrade ☺
 - Incorporates numerous other model changes
 - Verification scores very positive in tests!
 - Will include freezing rain accumulation
 - Will include height of wet bulb fz level (following French request)
 - Will probably include more PV-related diagnostics (Swiss request)
- Flash flood initiative *
- Looking into improved representation of Monthly Forecasts *
 - EFI for different weeks ?
 - Making CDFs (for a given week) available via clickable option ?
 - Introducing other parameters ?

Flash Flood prediction with a global model ensemble

(part of EFAS/GLOFAS)



Anticipating sub-grid variability in ppn totals using model parameters

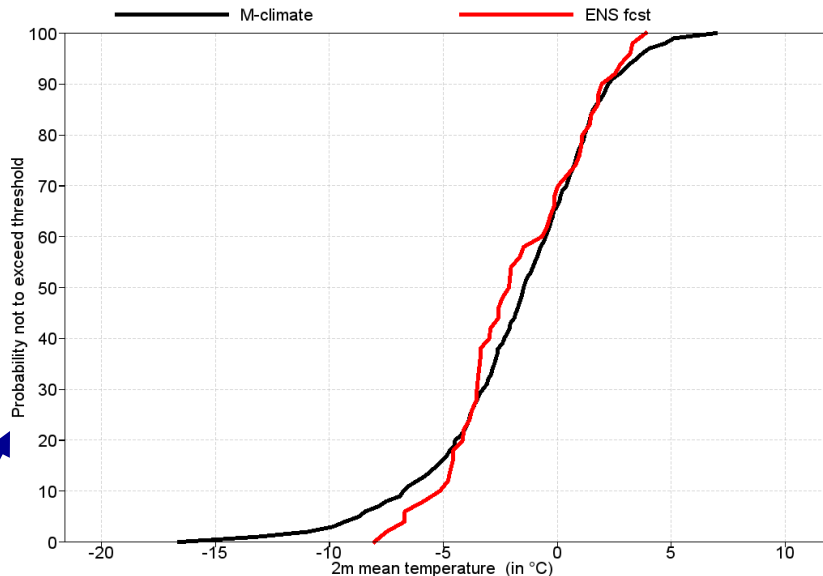
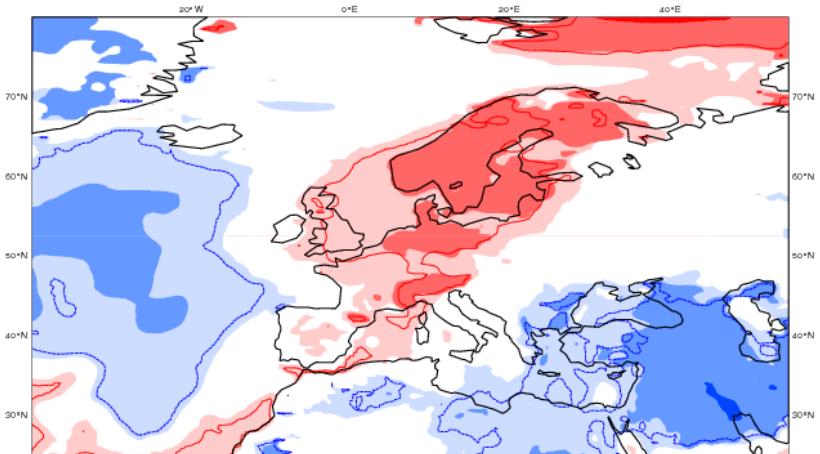
Rainfall Totals: O = Raingauges M = High resolution model R = Radar-derived

 = gridbox of a global model

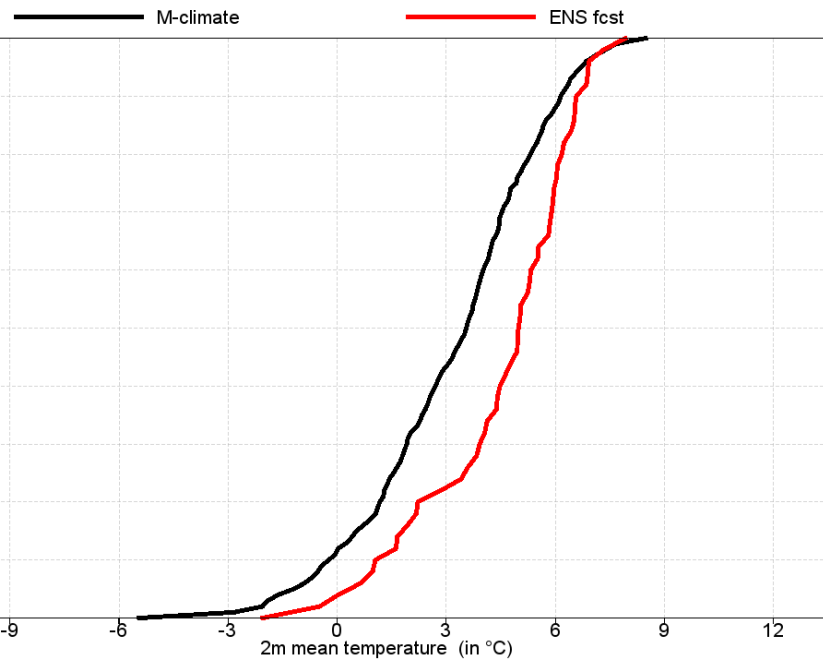
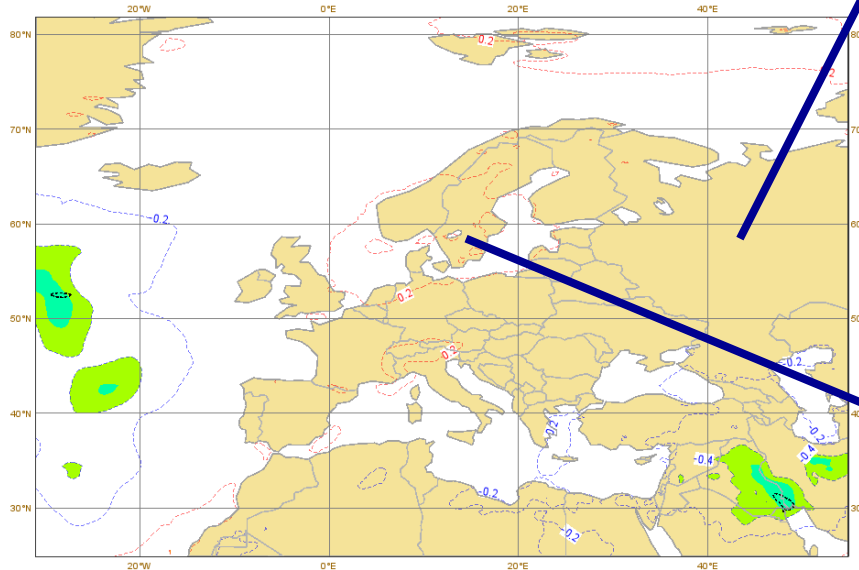
Monthly Forecast

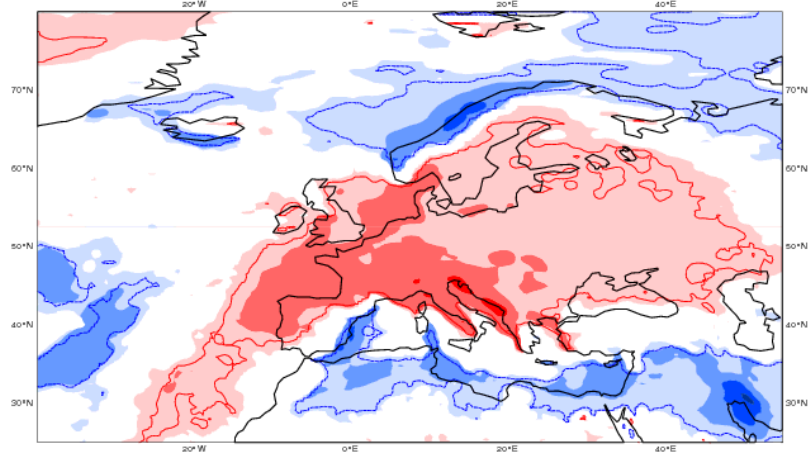
- Member states have often complained about ‘no signal’ forecasts, for weeks 3 and 4 especially
- Question arises: could we provide more information on the DISTRIBUTION of the forecast outcomes?
- Make use of EFI/SOT and CDF concepts ?
- Work in progress
- No decisions made as yet
- Whatever we decide to provide, verification work would be needed to support the use of any new products...

- Input/comments welcome

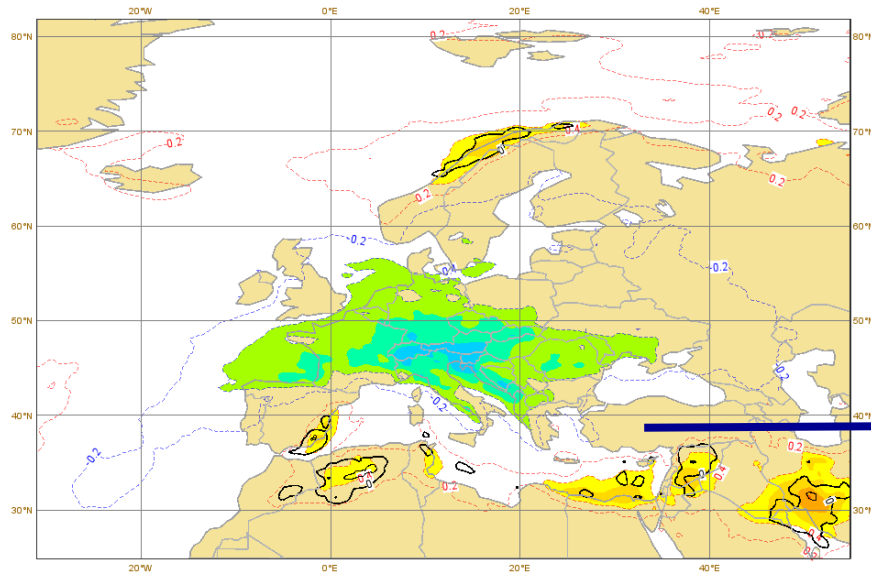


Mon 26 Oct 2015 00UTC ©ECMWF VT: Mon 09 Nov 2015 00UTC - Mon 16 Nov 2015 00UTC 336-504h
 Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: 2m mean temperature

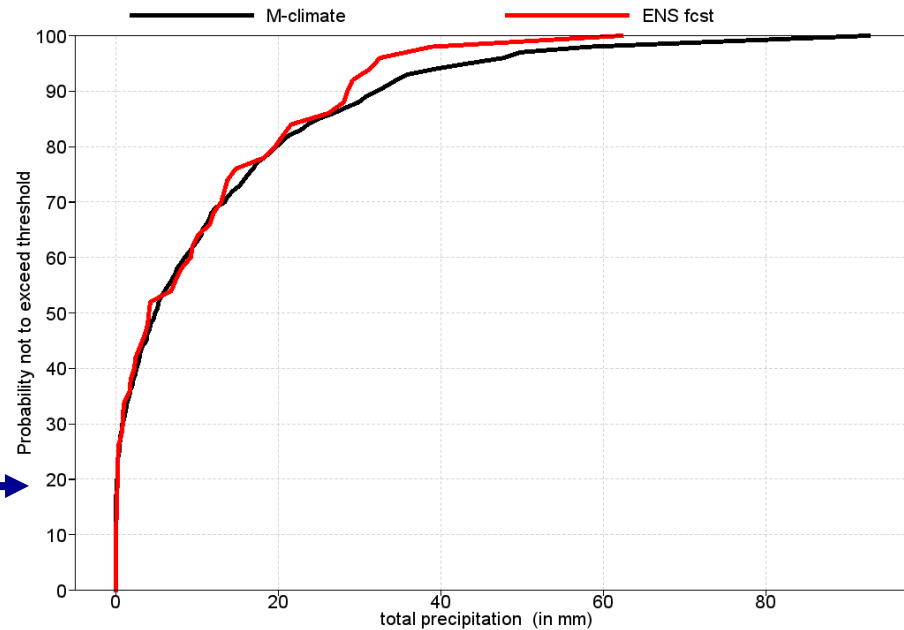




Mon 26 Oct 2015 00UTC @ECMWF VT: Mon 02 Nov 2015 00UTC - Mon 09 Nov 2015 00UTC 168-336h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: total precipitation



Monday 26 Oct 2015 00UTC @ECMWF t+168-336 VT: 02-11-2015 00UTC - 09-11-2015 00UTC
expper = 0001; Cumulative Distribution Functions for total precipitation at 38°/31°



And finally..

- Please remember the “forecast_user” web pages provided by ECMWF !
- These have recently been opened up to the world, and so can be examined without logging in (though to add comments a login is needed)
- Key Components:
 - 1. Severe weather case studies (please contribute material via email - e.g. high density observations / reports of impacts)
 - 2. Model issues (regularly updated list of known issues with ECMWF forecasts - short range through to seasonal – written especially for forecasters)

Types of severe weather and current status..

- Extreme rainfall		
▪ Long period	✓	
▪ Short period	~	R
- Windstorms		
▪ Cyclone-related	✓	
▪ Topography-related	~	R
▪ Convection-related	x	R
- Snowstorms		
▪ Large-scale snowfall	✓	
▪ Convection-related	x	R
- Freezing rain	x	
- Fog	x	
- Extreme cold	✓	
- Extreme heat	✓	
- Drought	~	
- Tropical cyclones	~	R
- Hail and thunderstorms	x	R
- Air Quality	~	

How good are ECMWF forecasts currently?

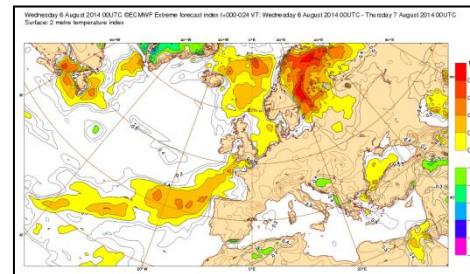
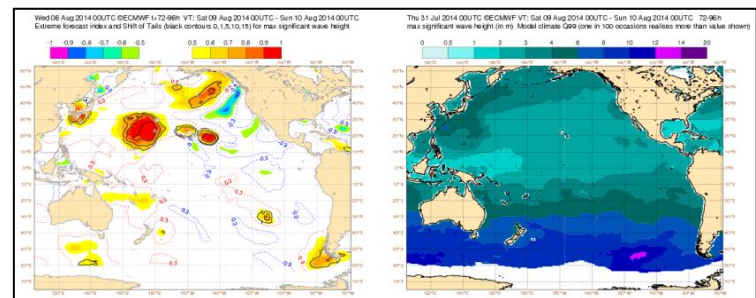
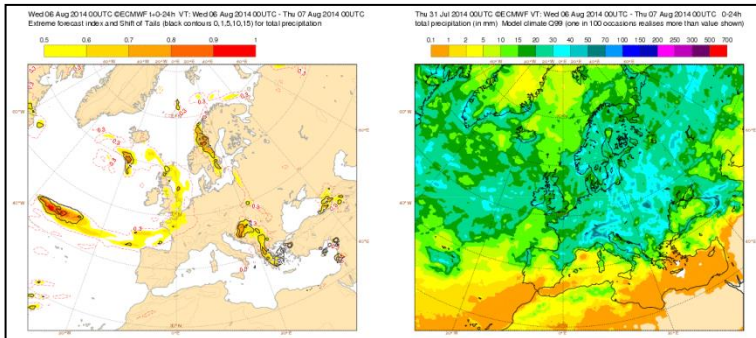
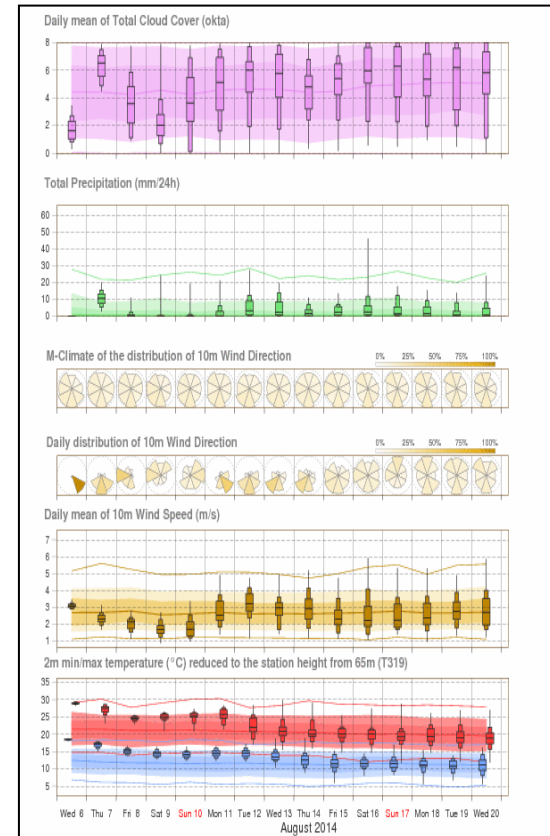
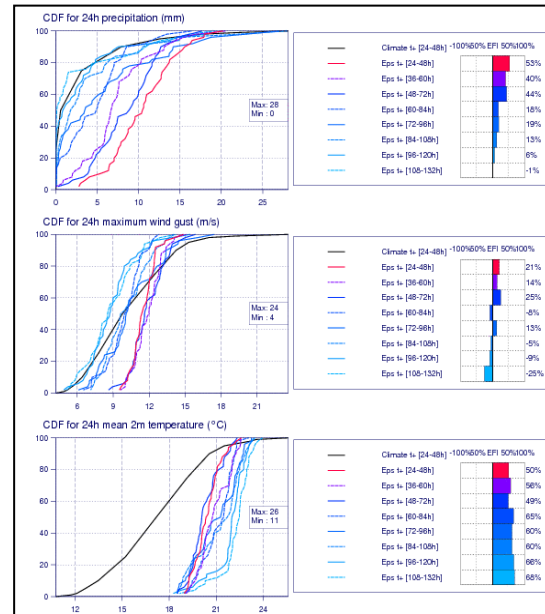
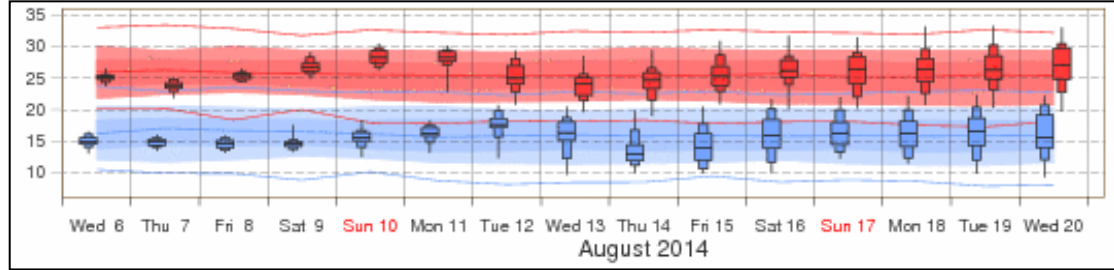
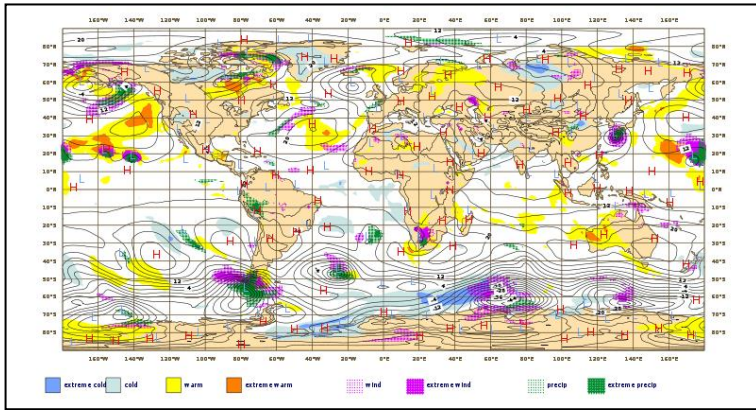
R=
clearcut
resolution
dependence

Layout

- **1. *Impact-related developments***
 - Extreme forecast index (EFI) and Shift-Of-Tails (SOT)
 - Return periods
- **2. *Tailored output***
 - Extra-tropical cyclone products
- **3. *Targetted model improvements***
 - Freezing rain example
- **4. *New IFS Output***
 - Fog/Visibility and Precipitation Rate

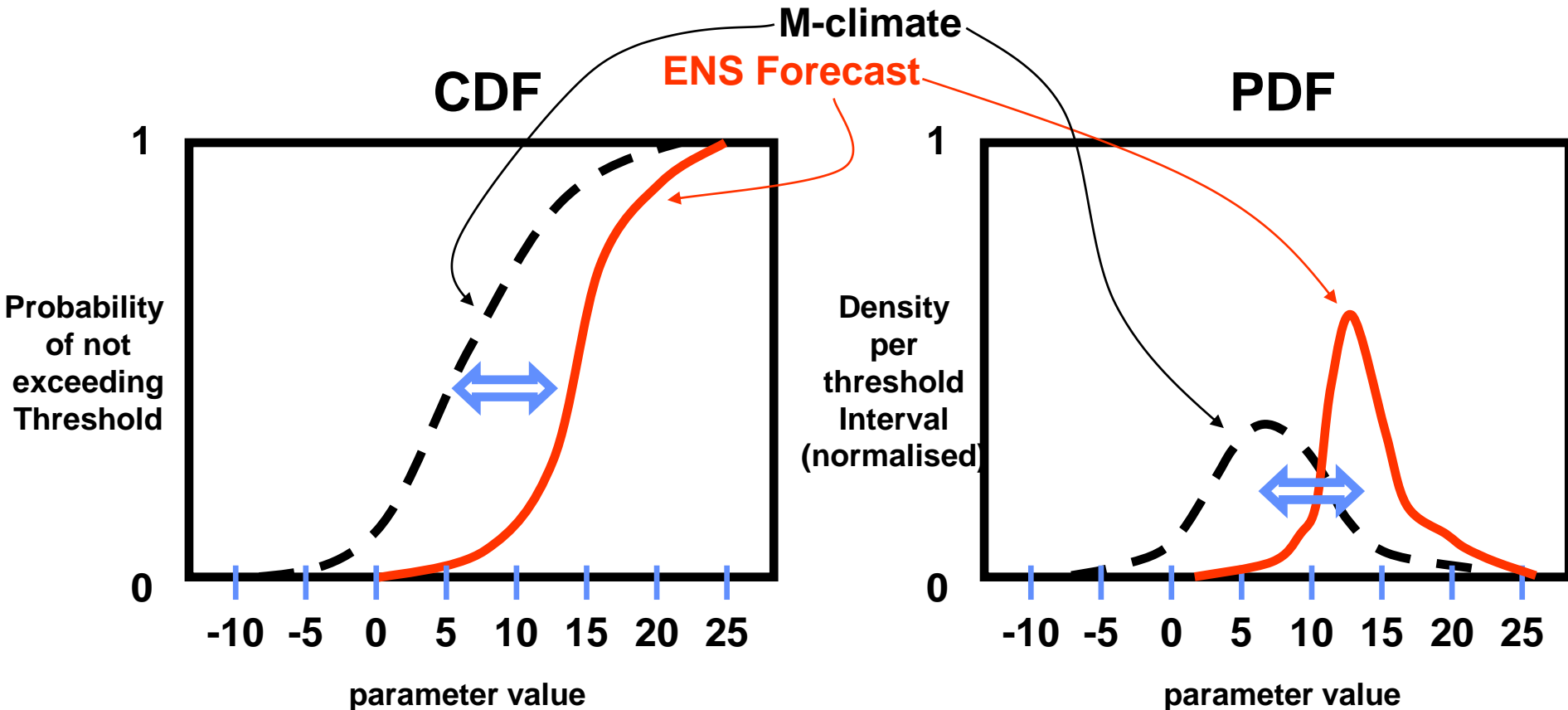
1. Impact-related – EFI / SOT

Some products related to EFI / SOT / M-Climate



Extreme Forecast Index (EFI)

- EFI is defined on the basis of Cumulative Distribution Functions (CDF). The unusualness of the ensemble is assessed according to the relative positions and shapes of the distributions.



Limitations

- Clearly both EFI and SOT depend critically on the structure of the M-Climate
- So we want a stable, reliable M-climate, especially near the extremes
- Without this we would get **jumpy EFI and SOT** values, between consecutive ENS forecasts, even if those consecutive forecasts were no different!
- A Nov/Dec 2014 upgrade aims to improve M-Climate stability, and thus EFI and SOT reliability...

New developments!

A

- Currently the M-Climate comprises **500** realisations (20 years of re-runs * 5 dates * 5 ENS members)
- The Nov/Dec 2014 upgrade will have **1980** realisations (20 years * 11 dates * 9 ENS members)

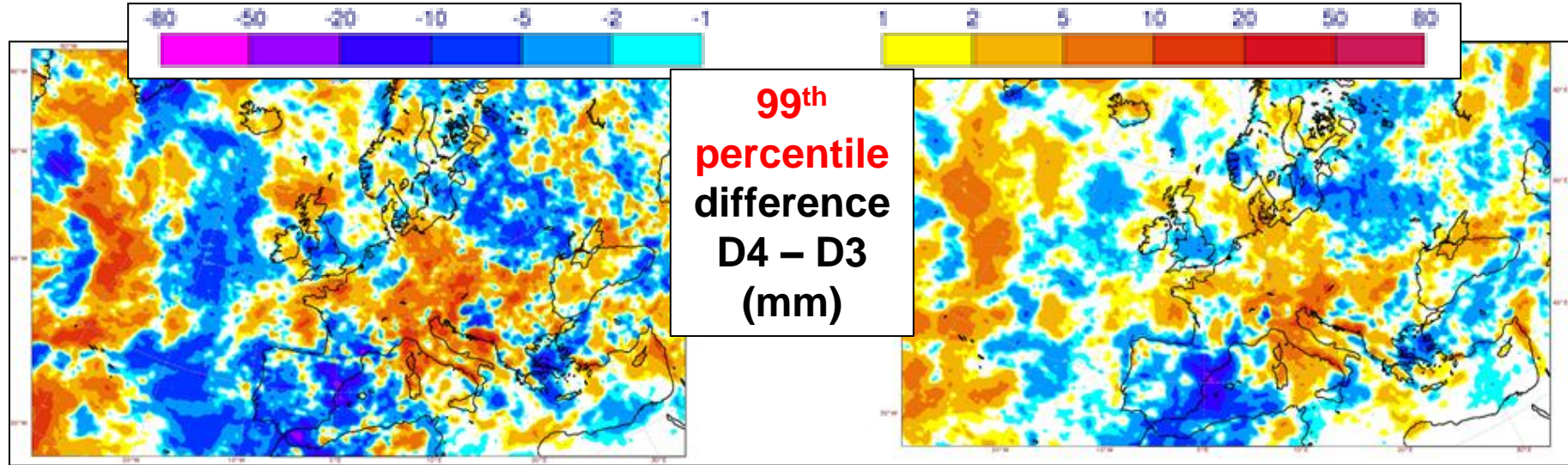
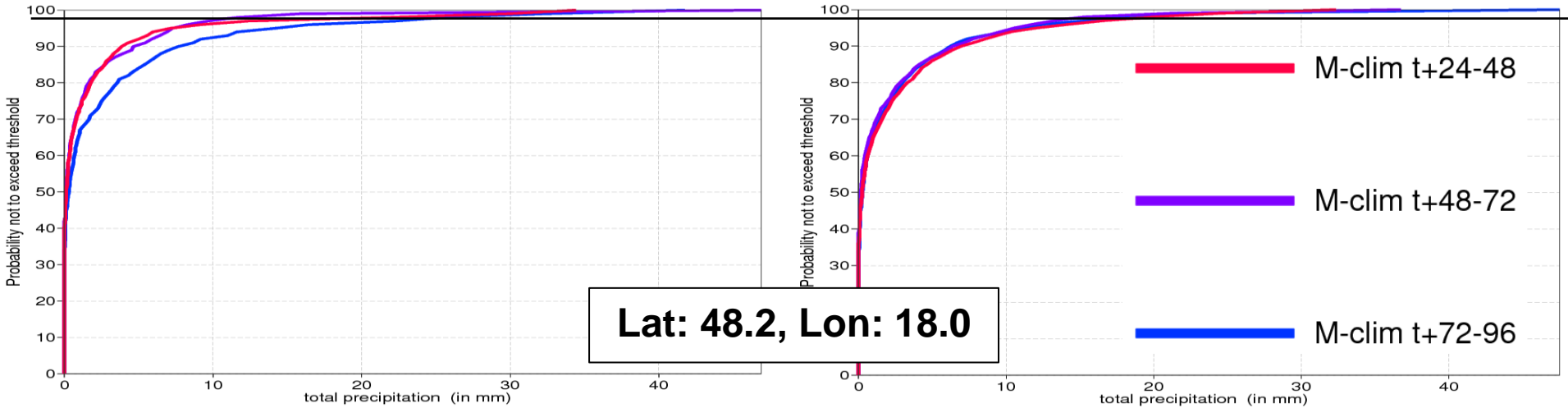
A

More realisations mean M-Climate stability will improve

Operational

24h PPN

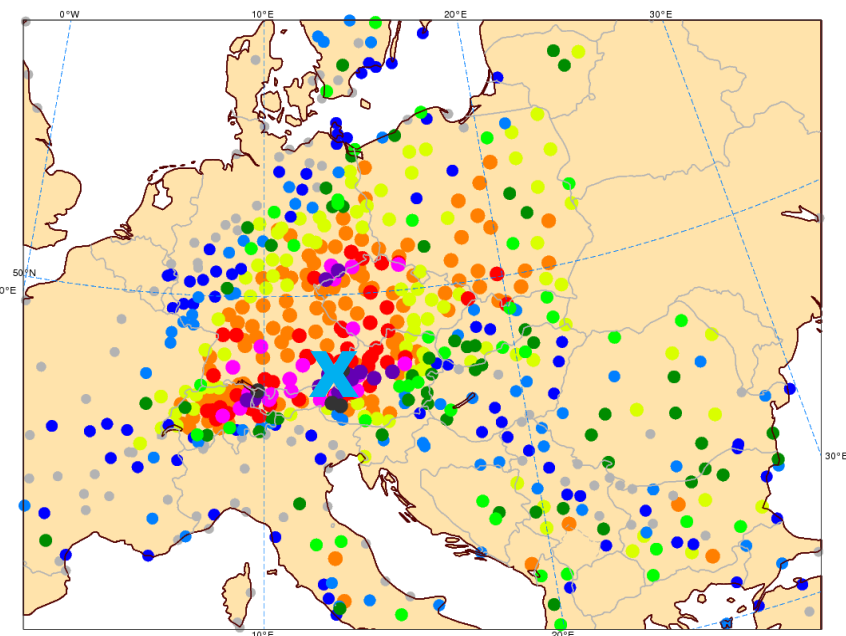
New



Longer lead times – eg EFI & SOT for total ppn, T+240-360h

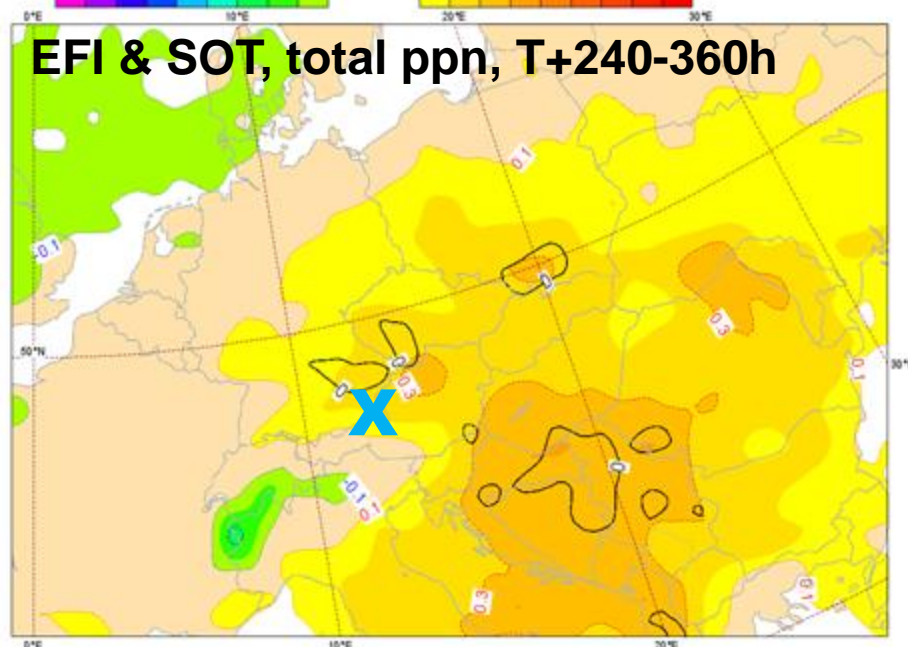
Observed total rainfall
from 31/05/2013 00UTC to 05/06/2013 00UTC

0.5 5 10 15 20 25 40 80 120 150 200 400



Tue 21 May 2013 00UTC @ECMWF VT: Fri 31 May 2013 00UTC - Wed 05 Jun 2013 00UTC 240-360h
Extreme forecast index and Shift of Tails (black contours 0.1, 5, 10, 15) for: total precipitation

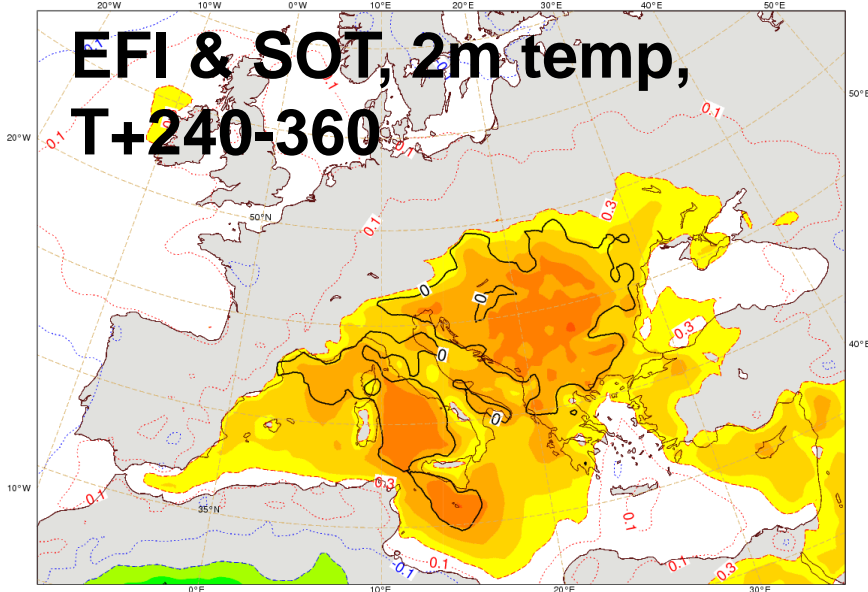
-1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1



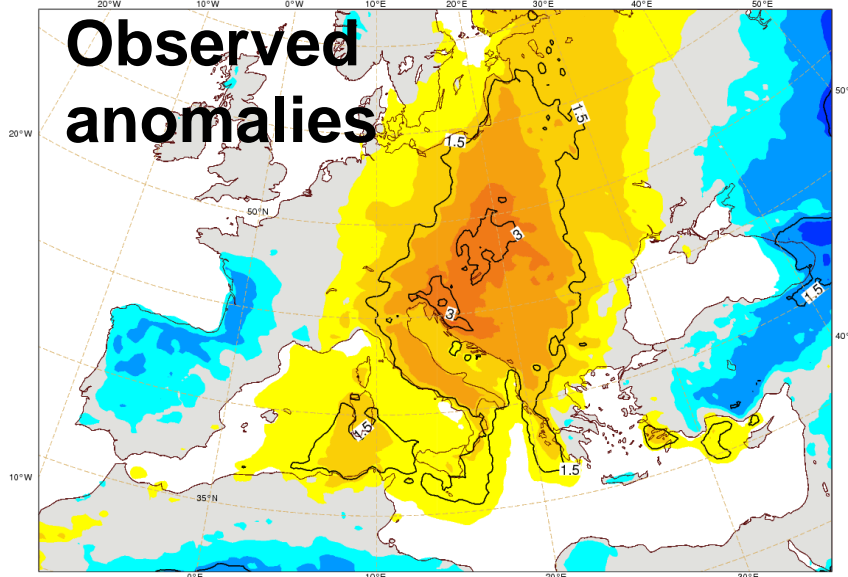
- Several days of heavy rain led to severe flooding in Central Europe at the end of May and beginning of June 2013.
- An early signal of extreme precipitation appeared in the EFI and SOT forecast for T+240-360 lead time.

EFI & SOT for temperature, T+240-360h

Fri 26 Jul 2013 00UTC @ECMWF VT: Mon 05 Aug 2013 00UTC - Sat 10 Aug 2013 00UTC 240-360h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: 2m mean temperature

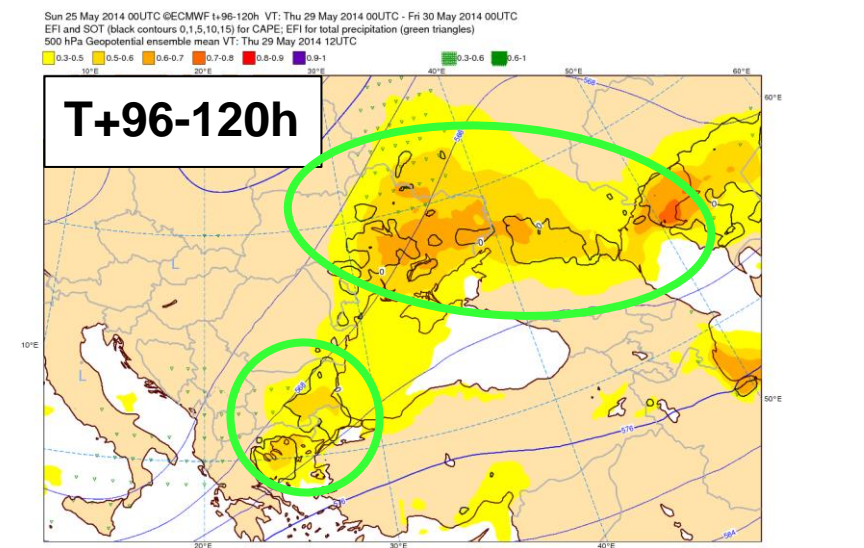
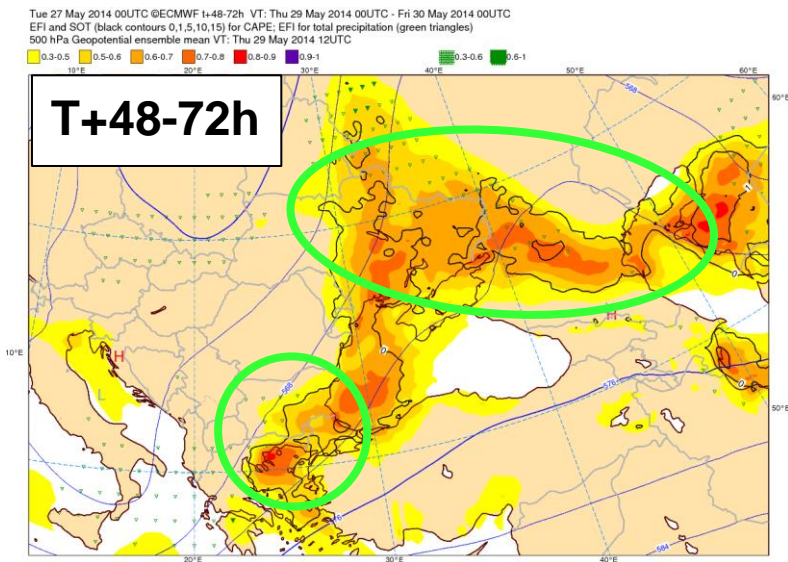
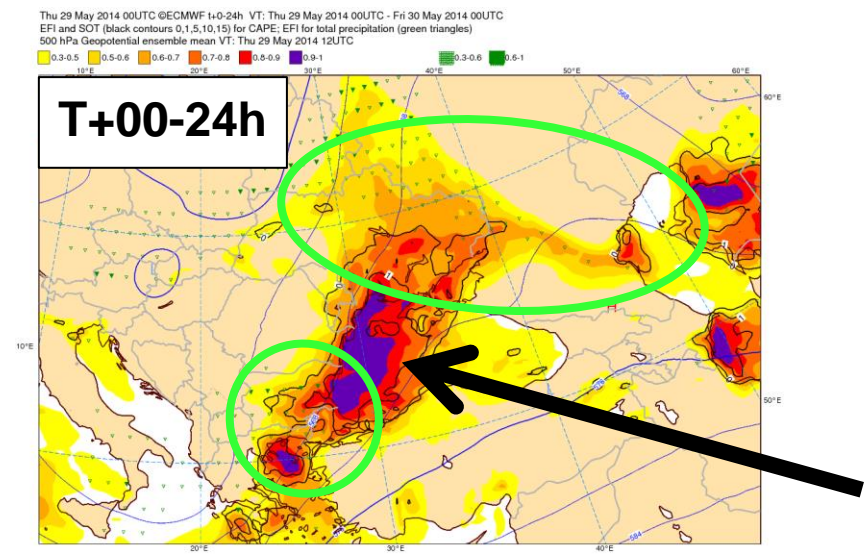
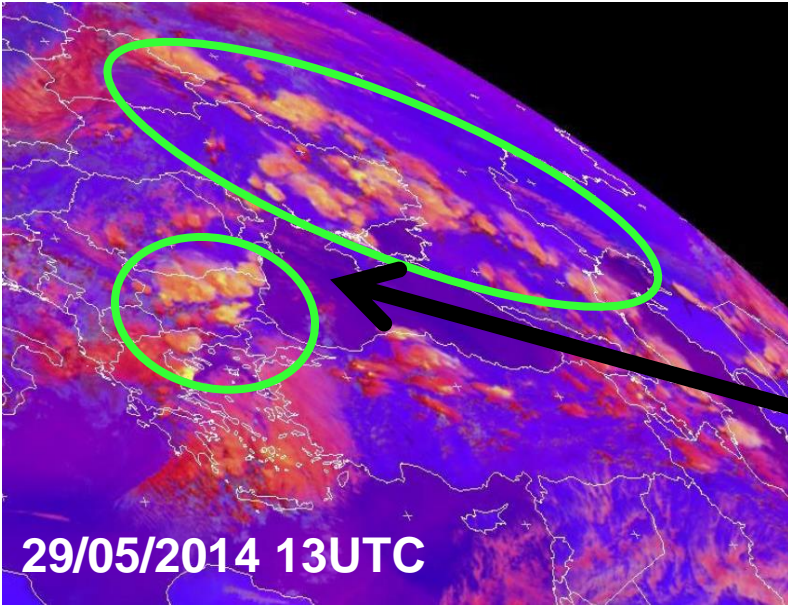


2-metre mean temperature anomalies VT: 05/08/2013 00UTC - 10/08/2013 00UTC



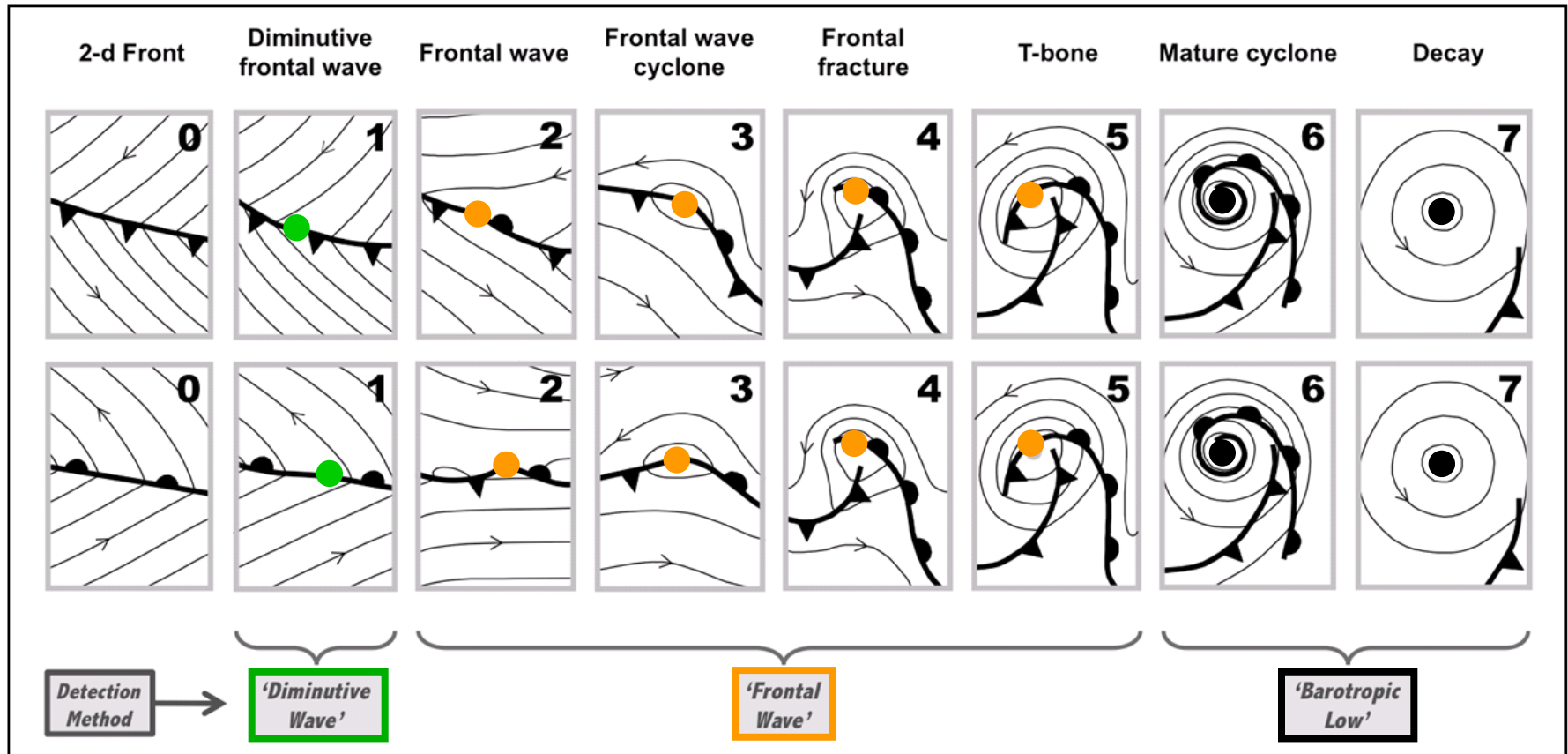
- A heatwave affected many countries from the Mediterranean northwards to Scandinavia in **early August 2013**. Austria set a new high temperature record when temperatures in two locations in eastern Austria exceeded 40°C on 8th August.
- EFI gave an early signal of the likelihood of exceptionally hot weather .

Severe convection, 29/05/2014, CAPE EFI/SOT



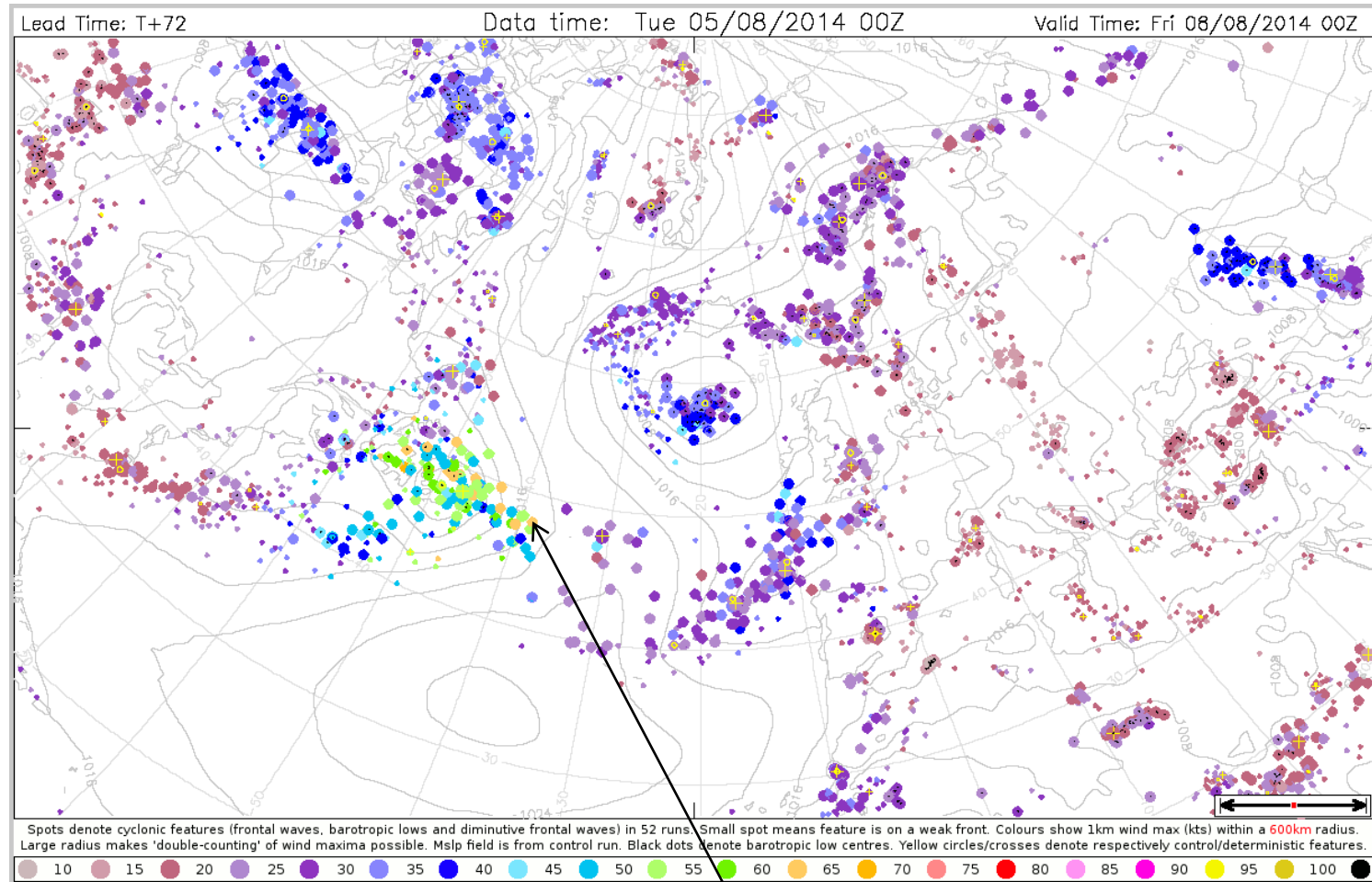
2. Tailored Output – Fronts / Cyclones

- Automated identification methods broadly based around this conceptual model of extra-tropical cyclone development (but aren't constrained by it)
- Tracking is also performed to 'join the dots' between successive times



After Shapiro and Keyser (1990) and Hewson and Tittley (2010)

New functionality – clickable dalmatian charts



User will be able to select a feature with the mouse, view which run it comes from, run an animation from that run, see other characteristics of the cyclone, etc... (any requests?!)

3. Targeted model improvements

New Initiatives to predict Freezing Rain...

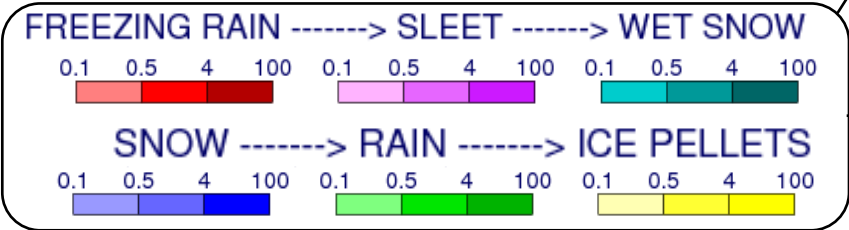
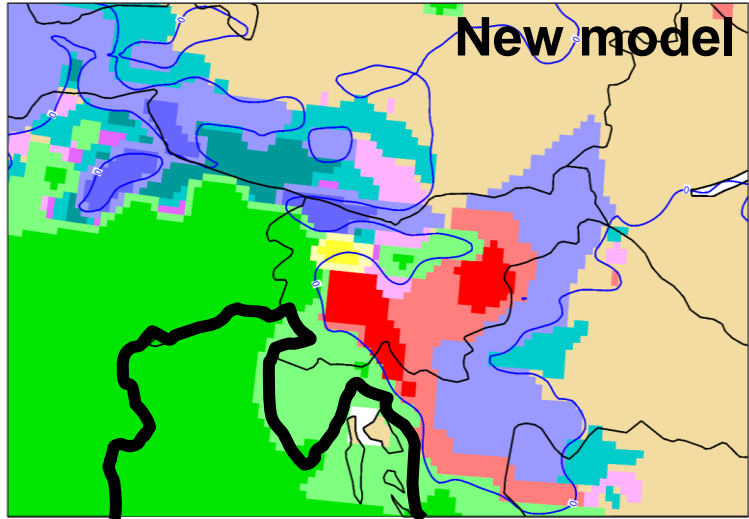
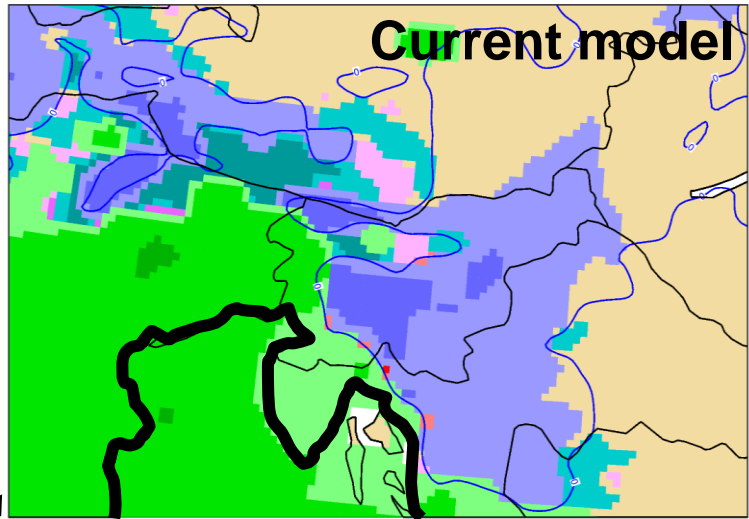
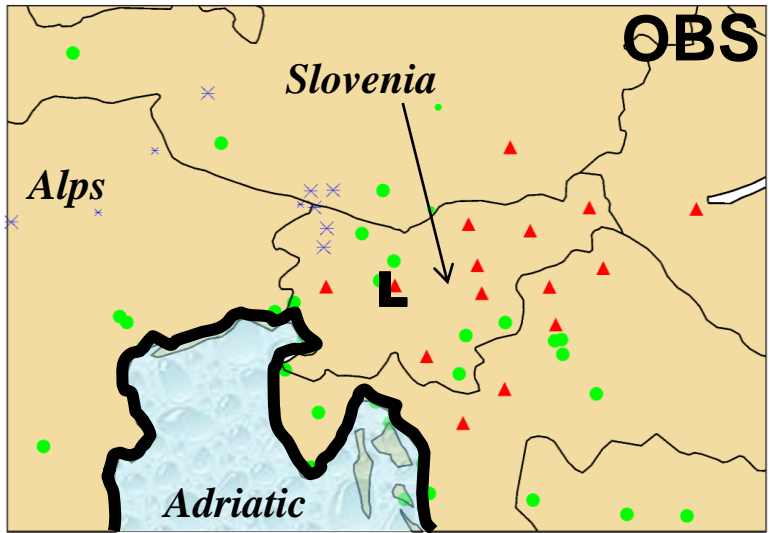
Photos are from Postojna, SW Slovenia, 3rd February 2014



In Slovenia

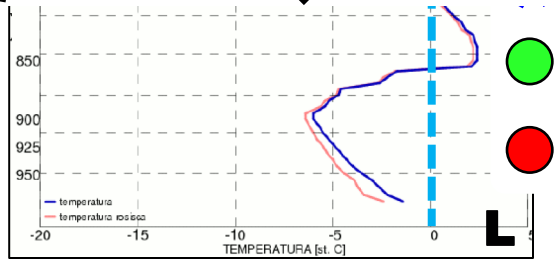
- An ice storm hit at the beginning of February 2014
- More than 40% of Alpine forests were damaged
- One in four homes left without electricity.

● drizzle ● rain ▲ freezing rain ◆ snow and rain ◆ ice pellets ✕ snow

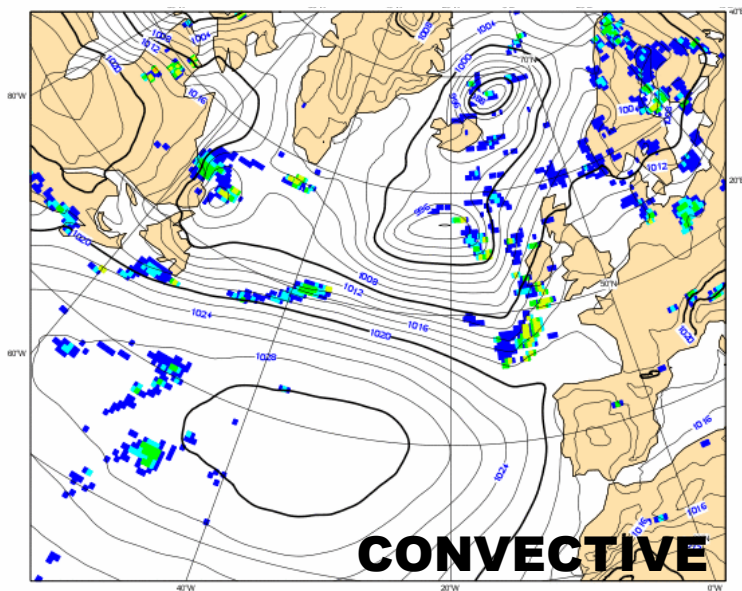
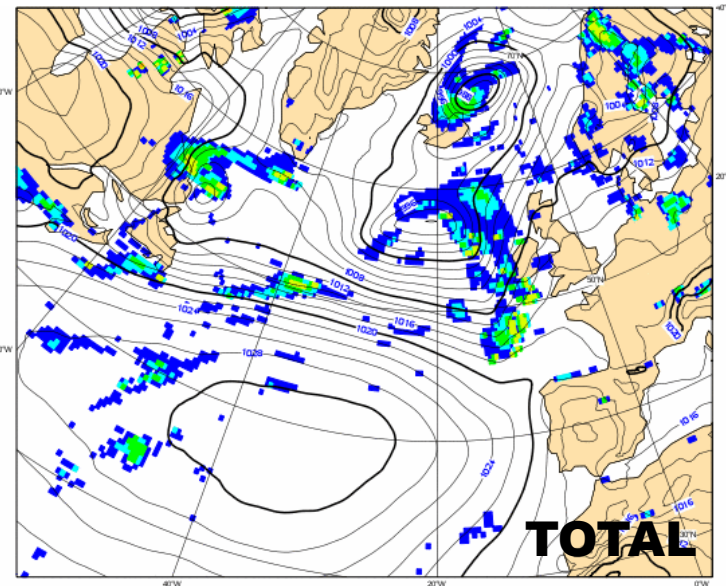
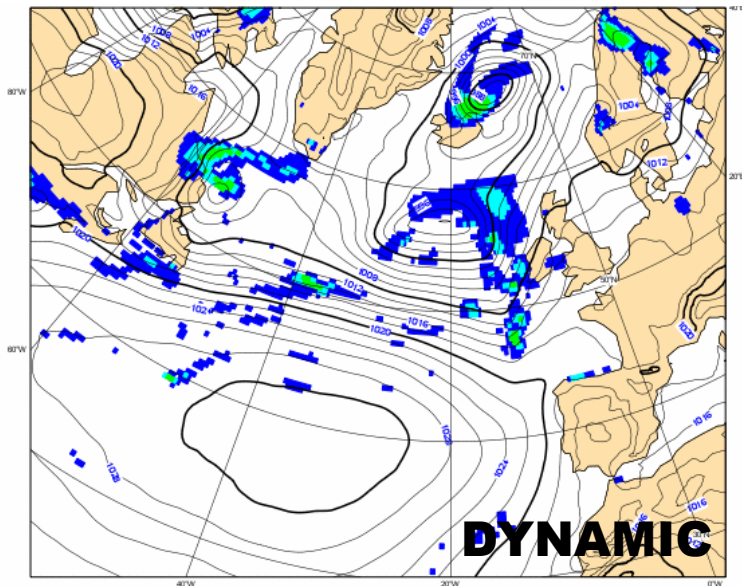


Two new ECMWF developments:

- Precip type/rate diagnosis/diagnostics
- Model physics changes to markedly slow down the re-freezing of melted precipitation



4. New IFS Output



Precipitation rates

- Example run (at T511) from July 2013
- Output looks sensible
- For dynamic ppn that should be a given, for convective there could have been issues
- Maximum convective rate in this domain = 8-16mm/hr