

Forecasting Extreme Events



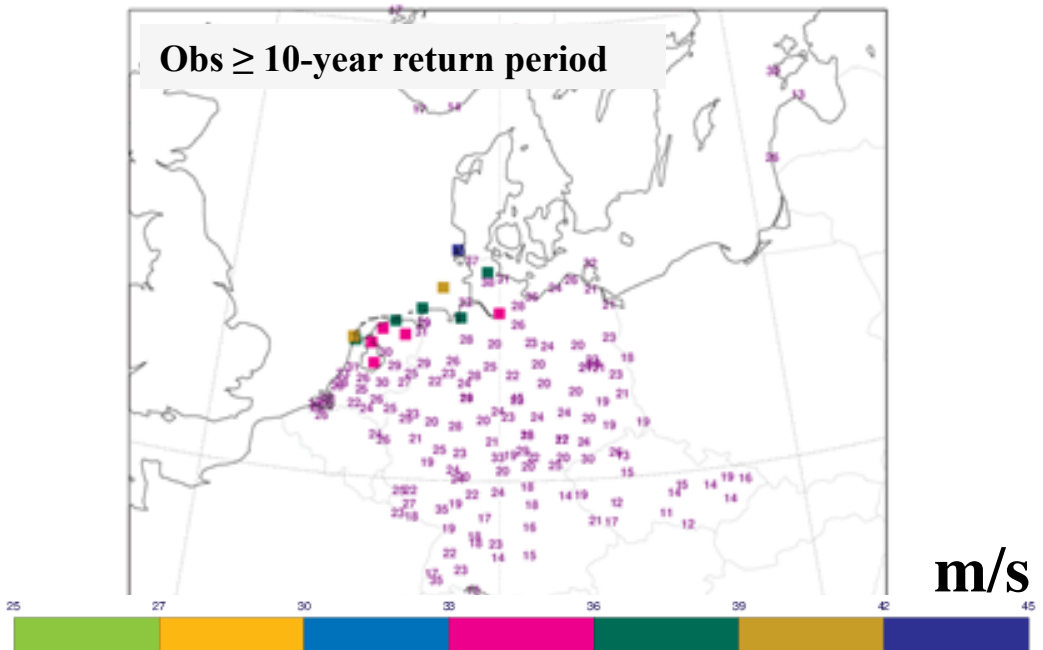
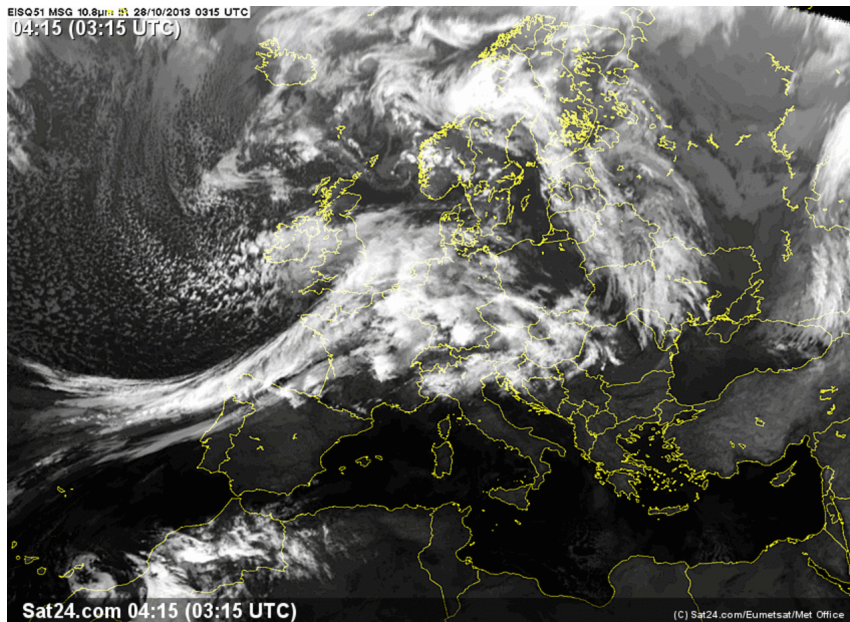
Ivan Tsonevsky,

ivan.tsonevsky@ecmwf.int

Outline

- **Example of severe weather – St. Jude Storm**
- **Extreme Forecast Index (EFI) and the Model climate (M-climate)**
- **Shift Of Tails (SOT) – an index to complement EFI**
- **Operational products and verification**
- **Case studies:**
 - **US cold snap, early January 2014**
 - **Central European floods, beginning of June 2013**
- **Return-period probabilities**
- **EFI for CAPE?**

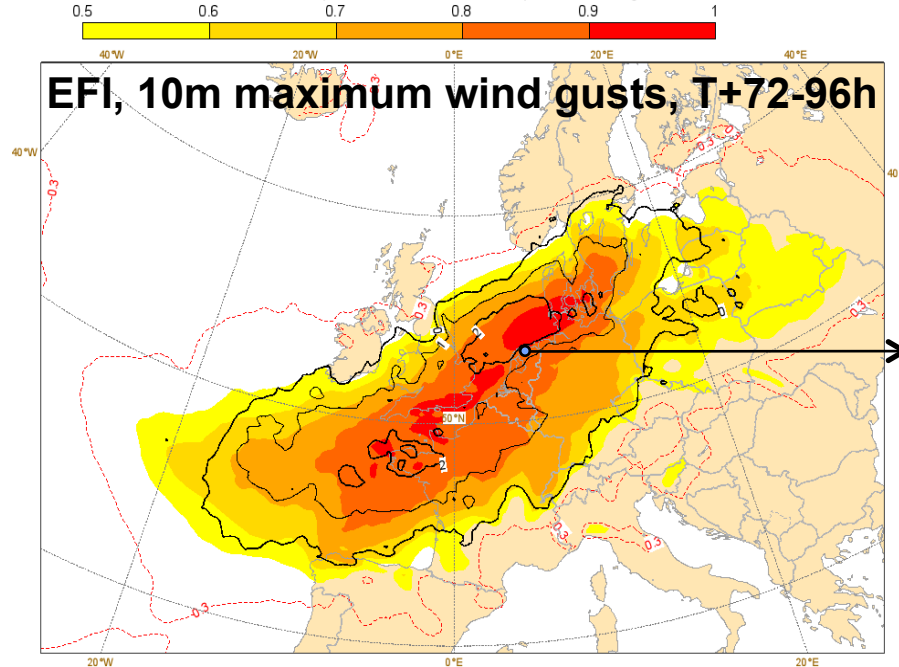
St Jude Storm, 27-28 Oct 2013



Daily maximum wind gust observations (m/s) exceeding the 10-year return period. Return values associated with the return periods are computed using the Extreme Value Theory for the base period 1991-2010 (from European Climate Assessment & Dataset, ECA&D project). Square symbols (■) represent the stations where the values exceeded the return values. Stations which not exceeded the return values are in numbers.

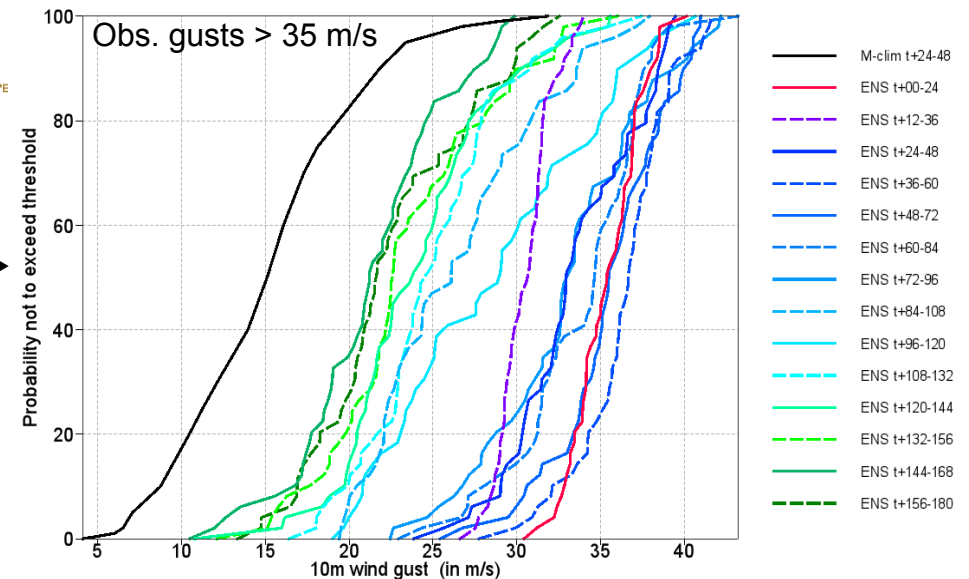
St Jude Storm, 27-28 Oct 2013

Fri 25 Oct 2013 00UTC @ECMWF expver = 1 VT: Mon 28 Oct 2013 00UTC - Tue 29 Oct 2013 00UTC 72-96h
Extreme forecast index and Shift of Tails (black contours 0, 1, 2, 5, 10, 15) for: 10m wind gust



Cumulative Distribution Functions (CDF)

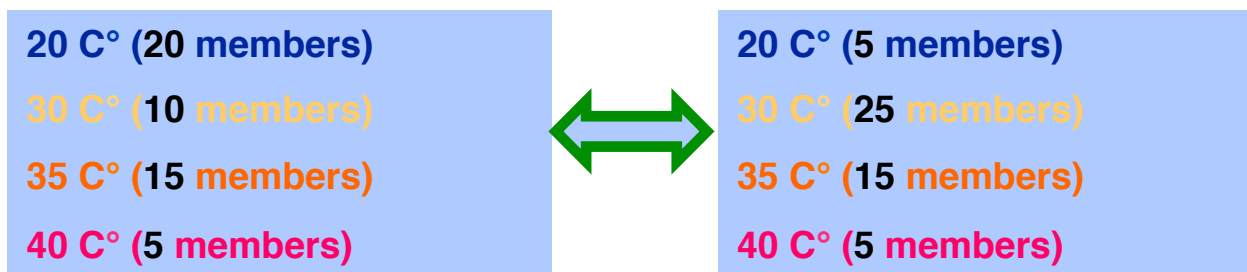
Cumulative Distribution Functions for 10m wind gust at 53.25°/5.34° VT: 28/10/2013 00UTC - 29/10/2013 00UTC



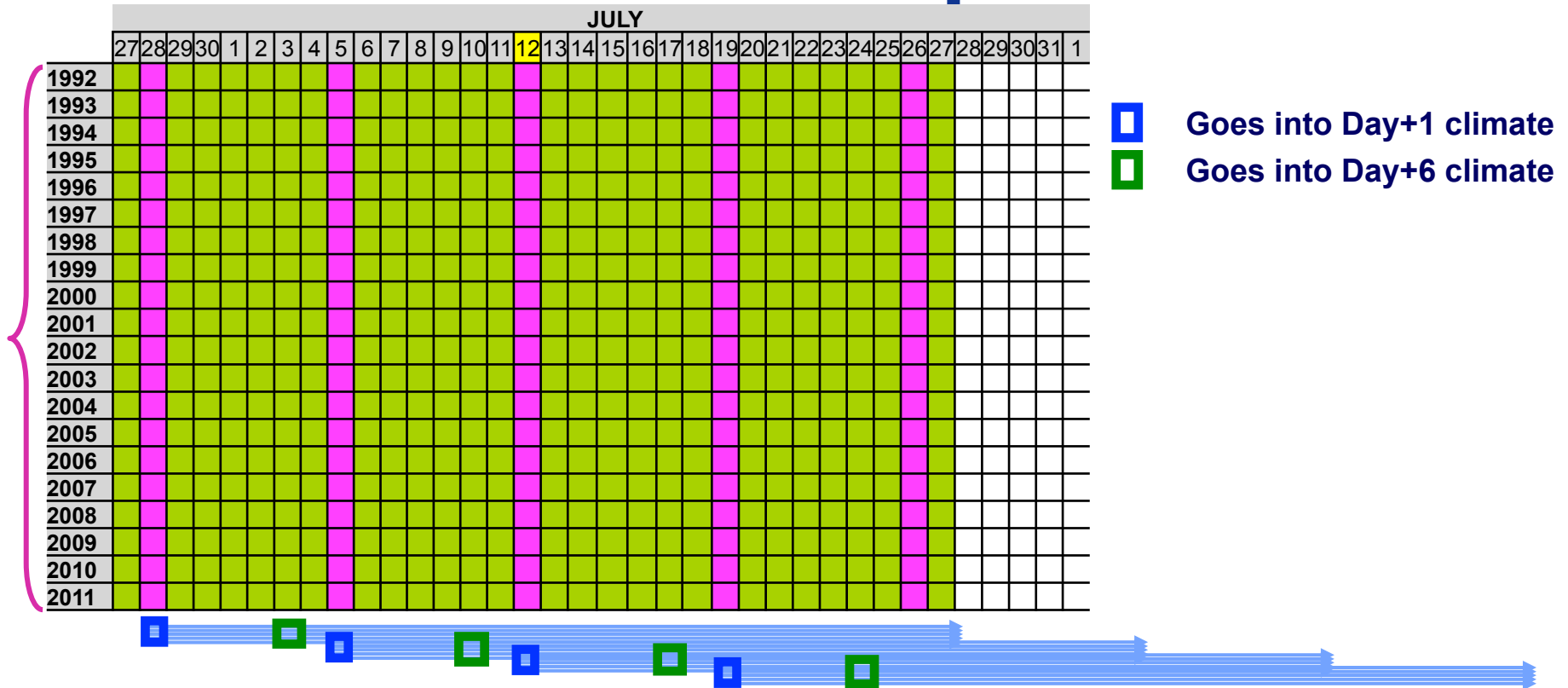
- **EFI indicated a risk of windstorm in the medium range. Positive SOT (black contours) showed that an exceptionally strong windstorm was likely.**
- **There was a sign of windier-than-normal conditions 7 days in advance with the last 7 runs predicting extreme wind (see CDF).**

Extreme Forecast Index (EFI)

- **Extreme Forecast Index (EFI)** is designed to measure how extreme a given ensemble forecast is.
- EFI is a measure of the difference between the ensemble forecast distribution and a reference distribution - **model climate (M-climate)**.
- EFI delivers model-climate-related information, therefore it can be used as an **“alarm bell”** for extreme weather situations over any area without defining different space- and time-dependent thresholds.
- Simple probabilities (eg. $> 32^{\circ}\text{C}$) will not highlight the differences in the distributions below. EFI will, by accounting for **the distribution of all the ensemble members**.



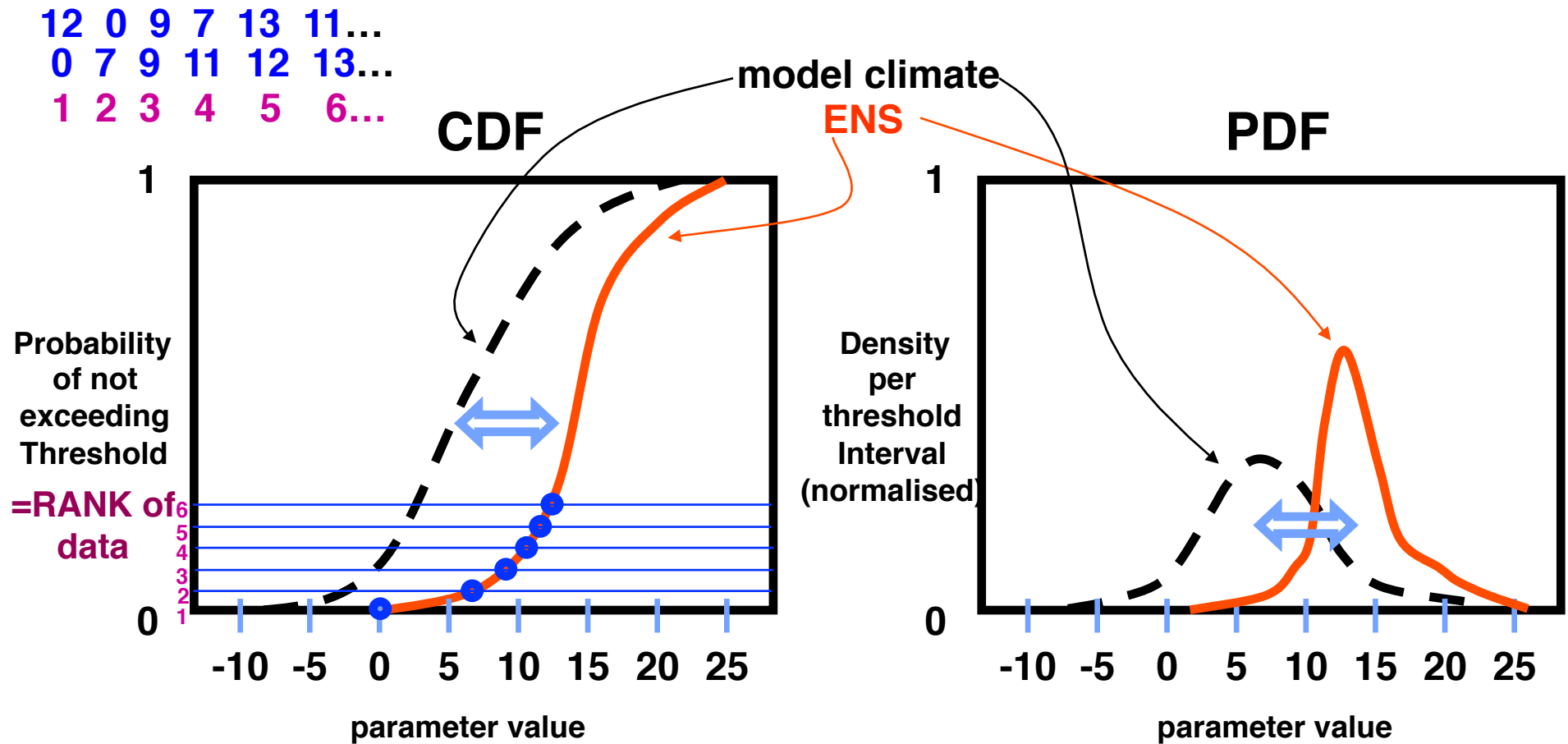
M-Climate – schematic representation



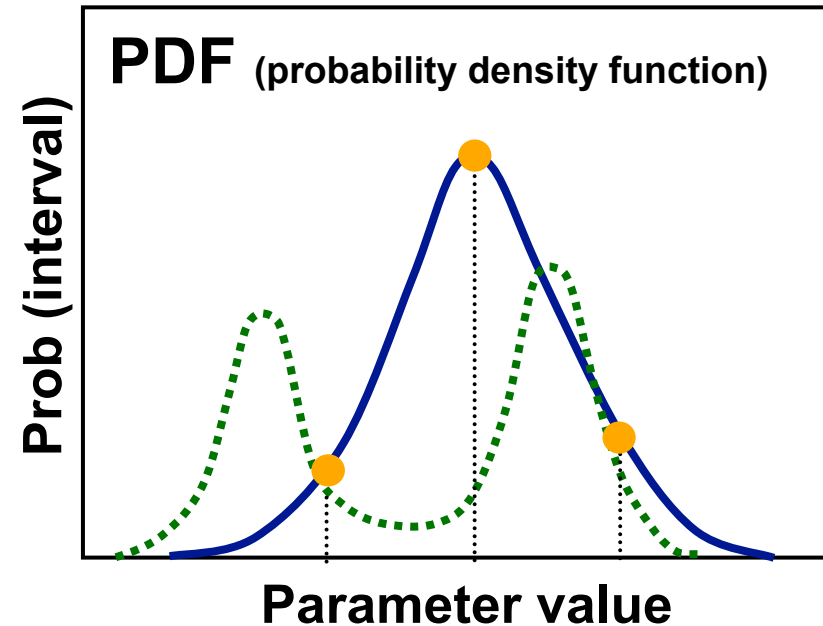
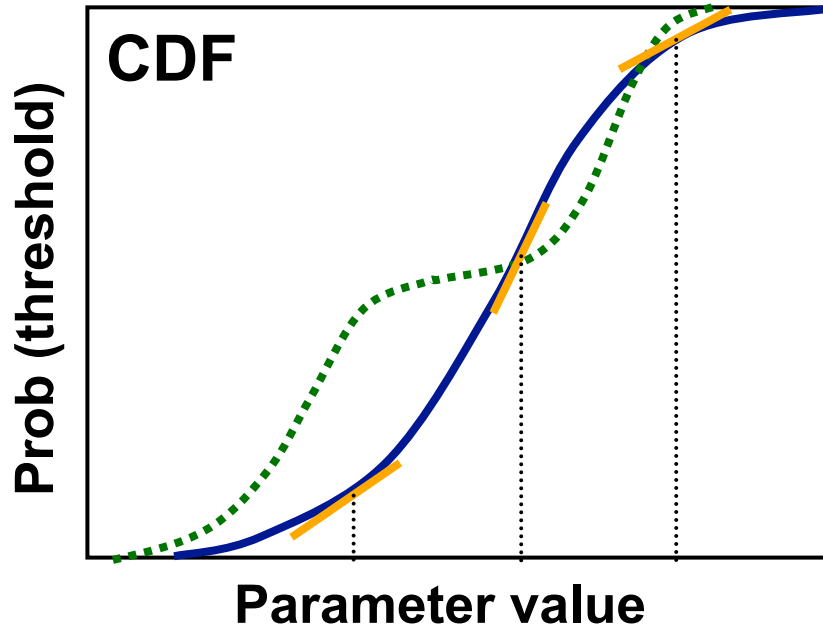
- To provide a robust, less noisy M-Climate, we don't use just one set of re-forecasts, but five sets centred on the week in question (increasing the sample size by a factor of 5)...
- The M-climate sample size is: $20 \text{ years} * 5 \text{ ensemble members} * 5 \text{ weekly runs} = 500$ re-forecast fields
- As the M-climate consists of 500 realisations, the M-climate extreme values correspond, approximately, to 16-year return periods (for month-long time windows)

Extreme Forecast Index (EFI)

- The EFI is defined on the basis of the Cumulative Distribution Functions (CDF). The abnormality level in the ensemble is determined based on the position and shape of the distributions.



How do CDFs and PDFs relate?

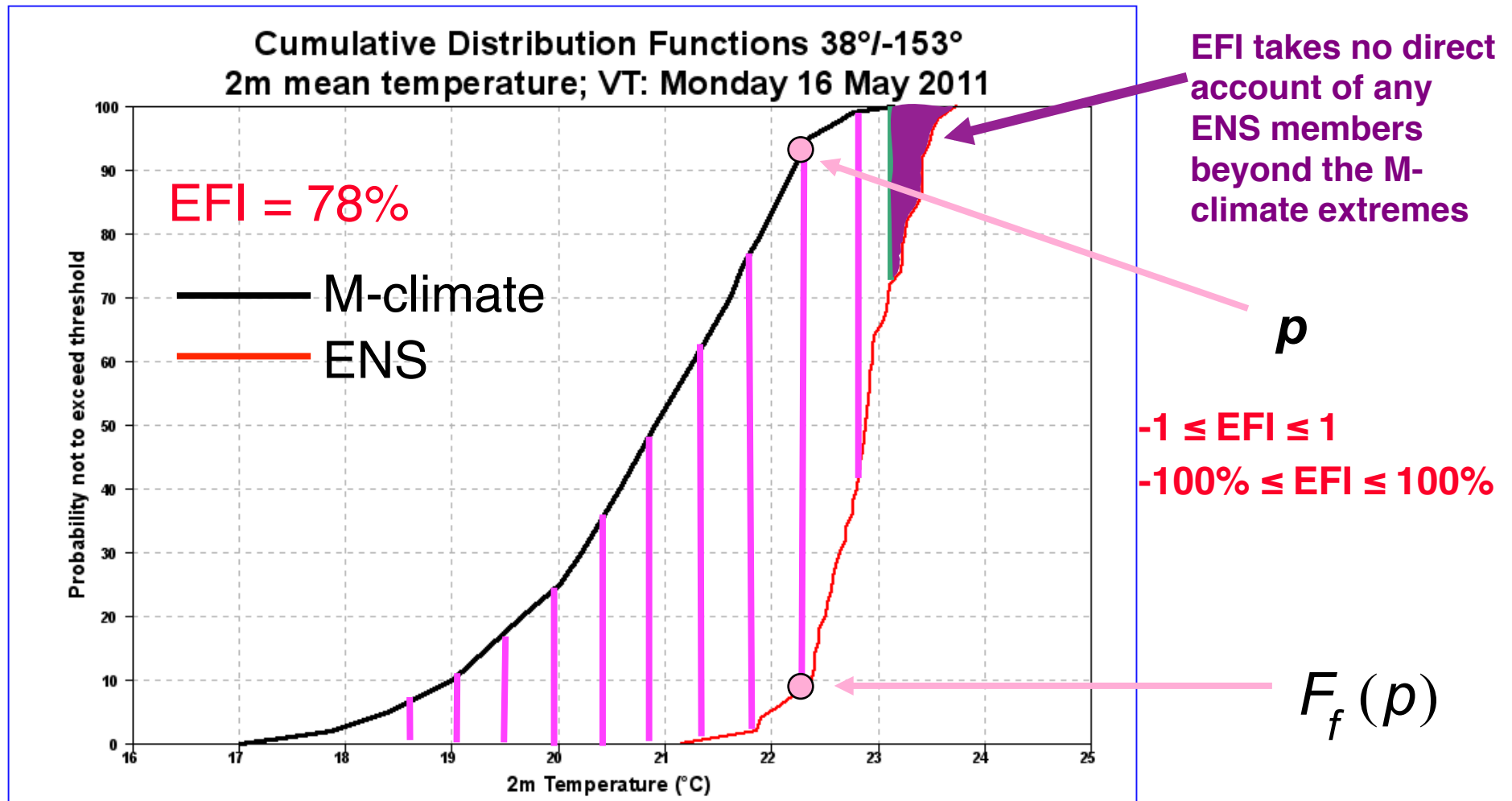


- The PDF (y-axis) value equals the slope of the CDF
- **Steeper CDF = narrower PDF = higher confidence in the forecast**
- A **step** in the CDF means a bimodal PDF

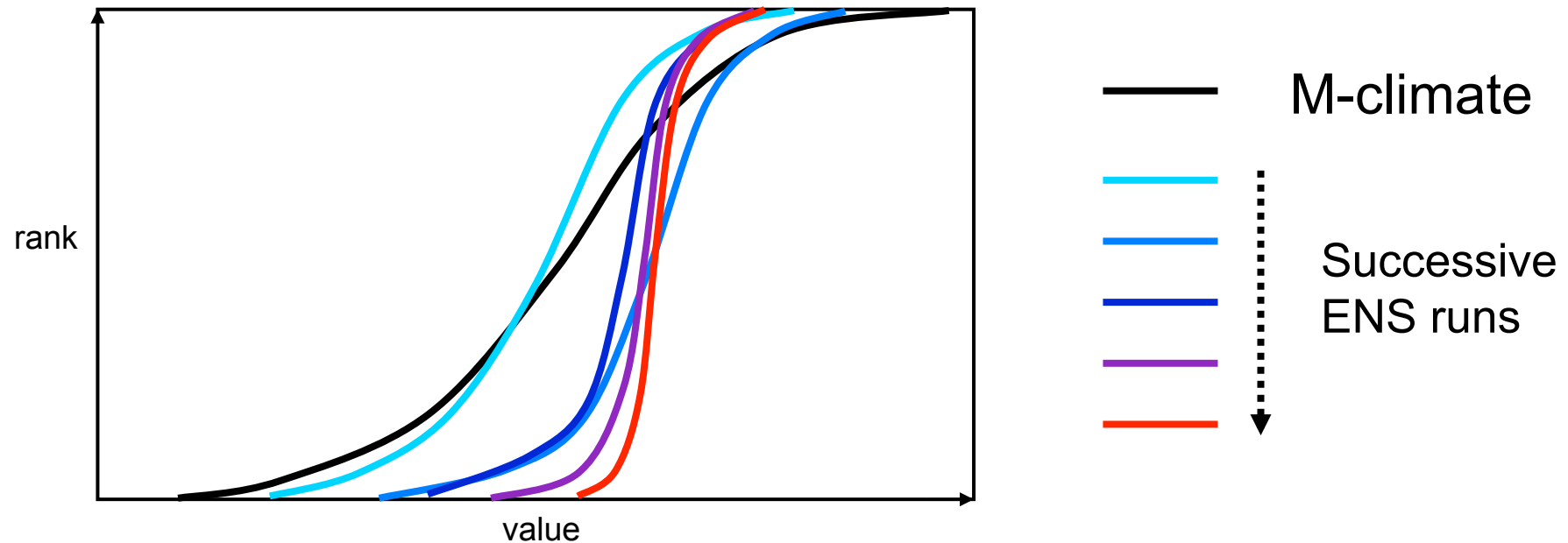
$$EFI = \frac{2}{\pi} \int_0^1 \left(\frac{p - F_f(p)}{\sqrt{p(1-p)}} \right) dp$$

Represented by pink lines below

More weight to extremes of M-climate



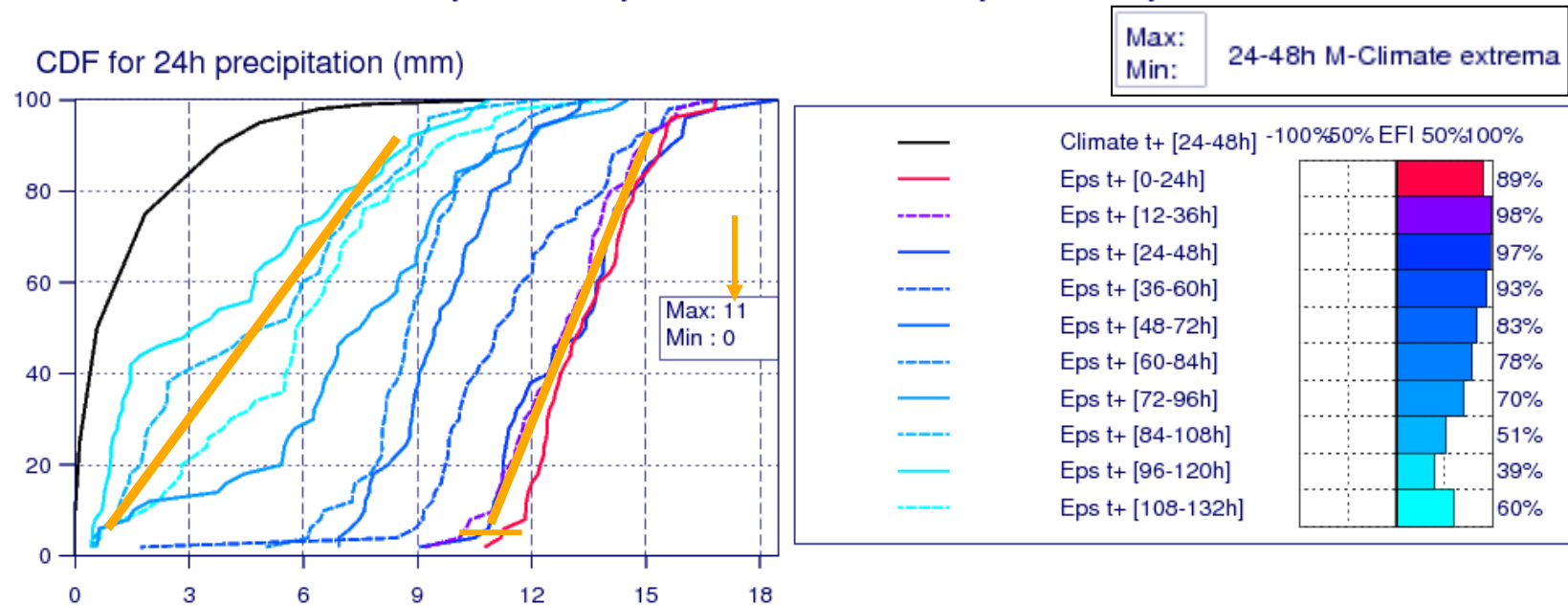
How 'should' CDFs behave in successive ENS runs?



- At long lead times forecast CDF may be similar to the M-climate.
- Lateral variations in CDF position between successive runs should, mostly, become less (with time).
- CDF will tend to become steeper (with time), implying higher confidence.

Example

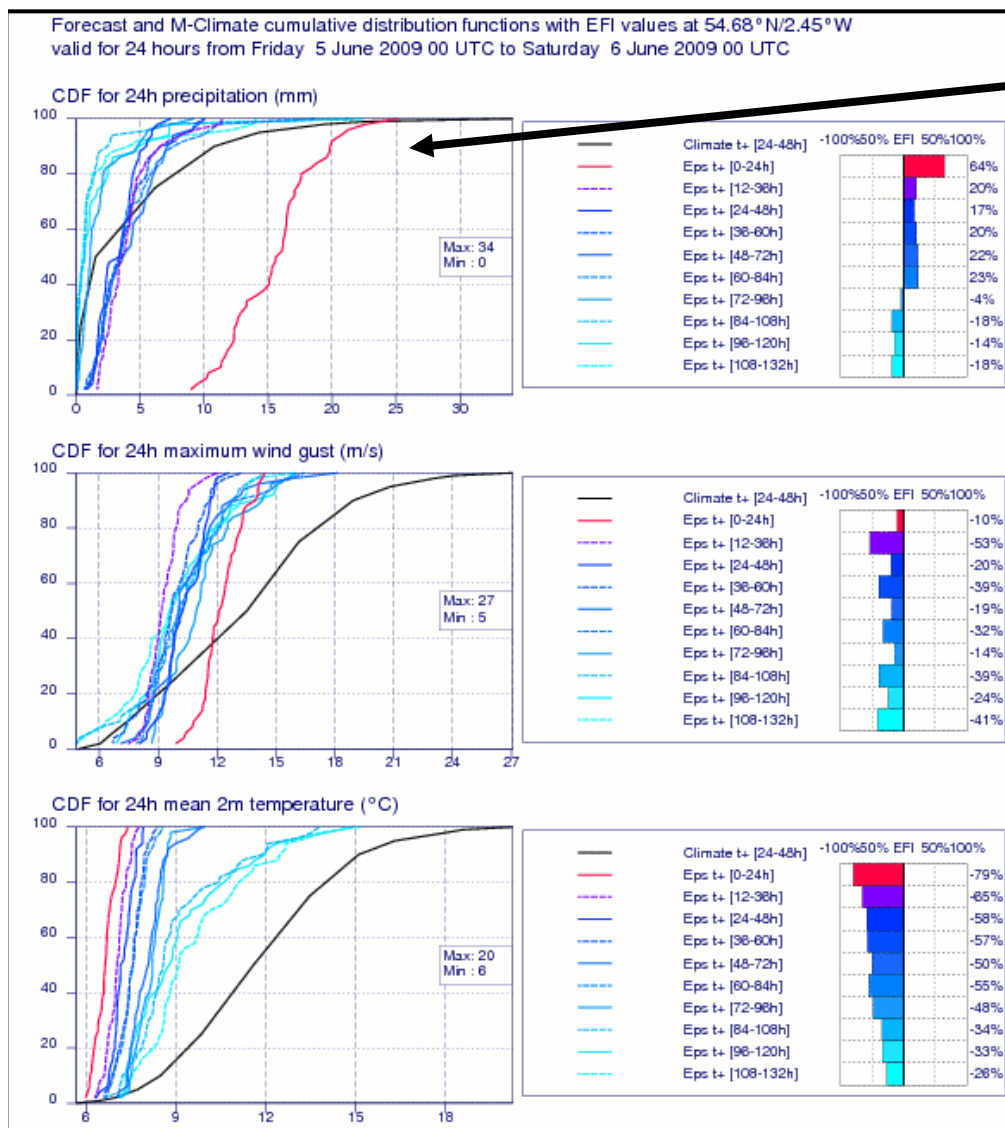
Forecast and M-Climate cumulative distribution functions with EFI values at 59.09°N/41.69°E valid for 24 hours from Monday 4 February 2013 00 UTC to Tuesday 5 February 2013 00 UTC



- The 16-year return period value of 24h precipitation for ~February is 11 mm (M-climate).
- ~ 95% probability of >11mm (blue line; t+24-48h)
- Steeper CDF slope on more recent forecasts signifies increasing confidence

Counter example

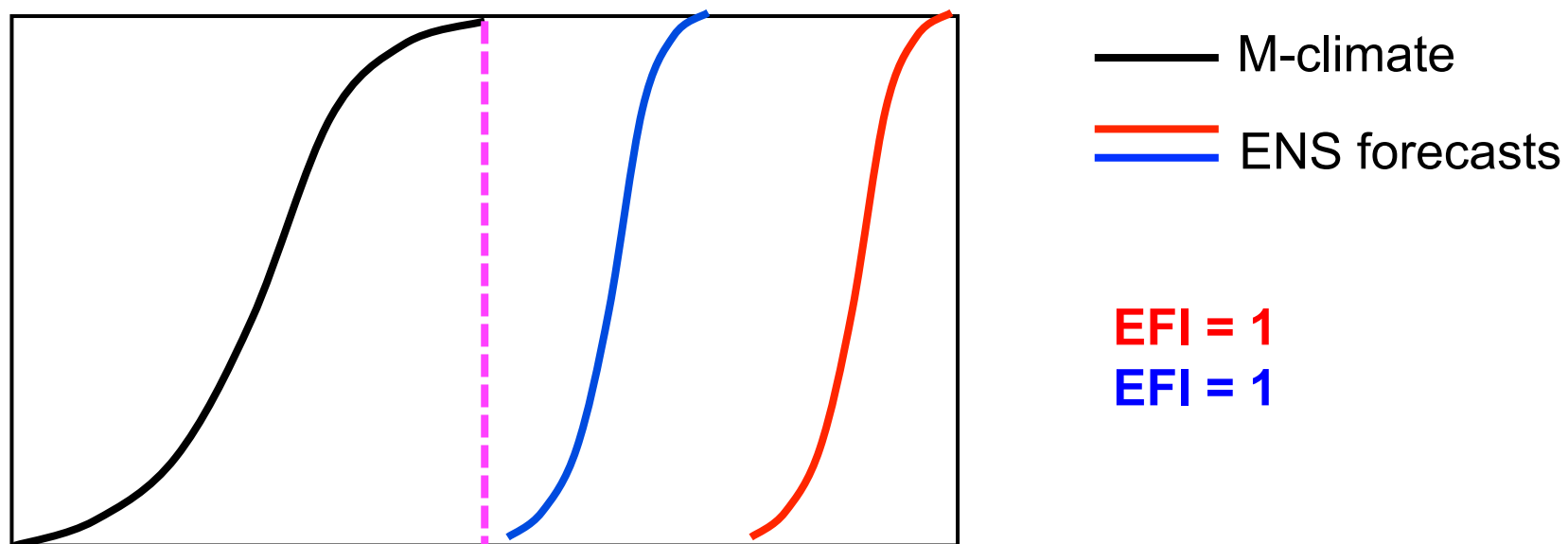
- N England rain – June '09 - low prob alternative became likely at short range. **If rare this is OK.**



Some limitations

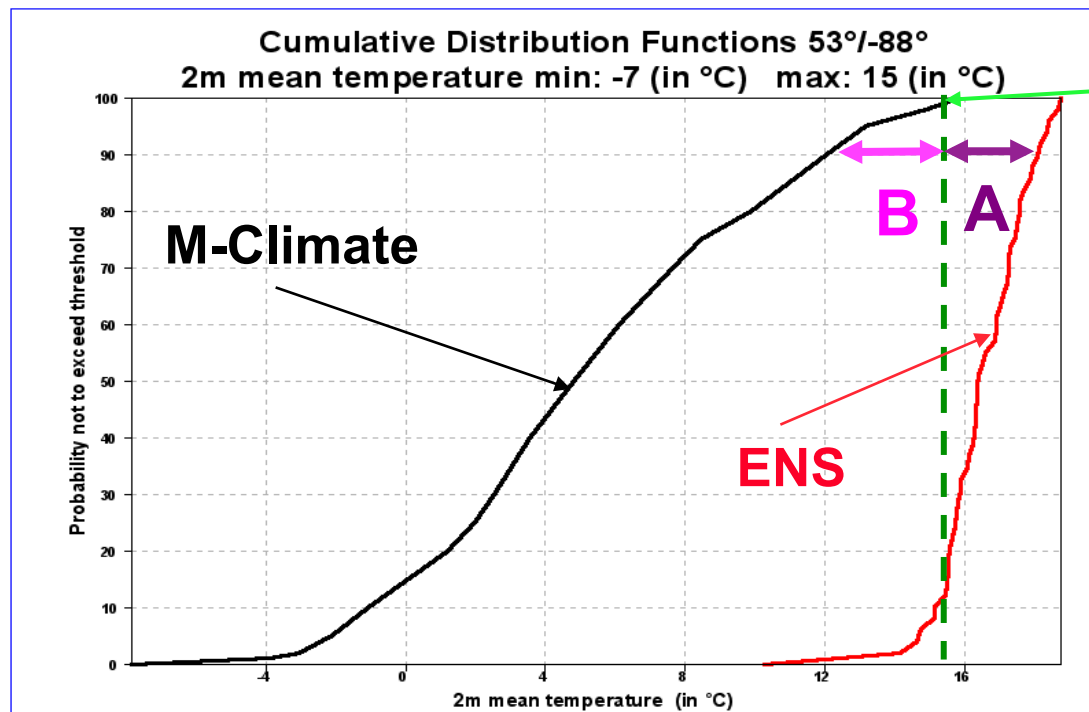
- Extreme does not *necessarily* mean high impact (eg 2mm rain in the desert)
- Past history also important but not directly accounted for (eg heavy rain when ground saturated)
- Windstorm impact can depend on whether trees are in leaf, whether ground is saturated...
- Products are only as good as the model output, e.g.:
 - Tropical cyclone representation is limited by resolution
 - Threat from intense, *very localised* convection unlikely to be fully captured
- Some severe weather parameters – e.g. blizzard, sandstorm, freezing rain – remain to be incorporated

Shift Of Tails (SOT)



- As EFI does not take direct account for members which are beyond the M-climate, once EFI reaches its maximum value of 1 or minimum value of -1, it does not provide further information about the magnitude of extremity.
- Shift Of Tails (SOT) has been introduced since 19 June 2012 to complement EFI by providing information about how extreme an extreme event might be.

Shift Of Tails (SOT)

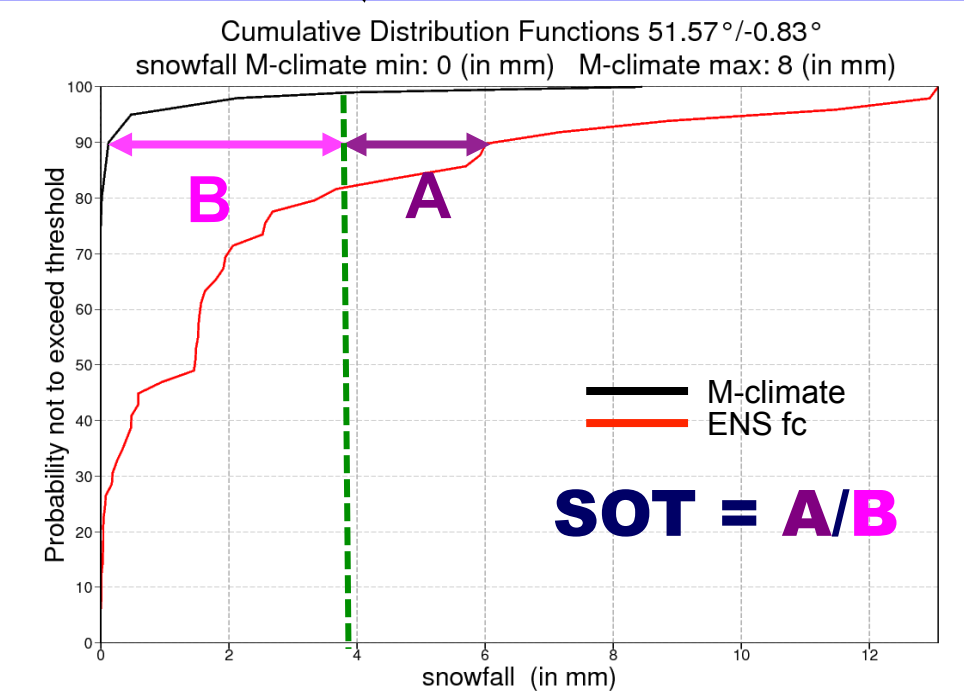
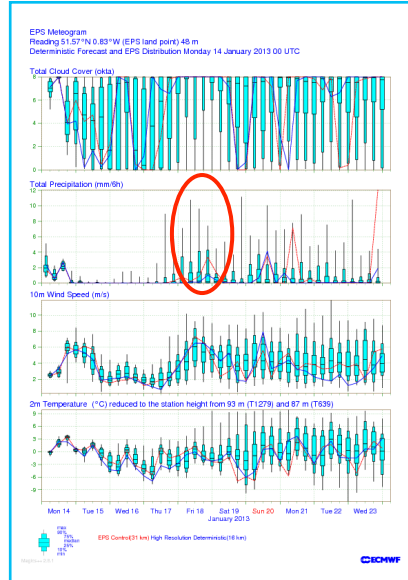
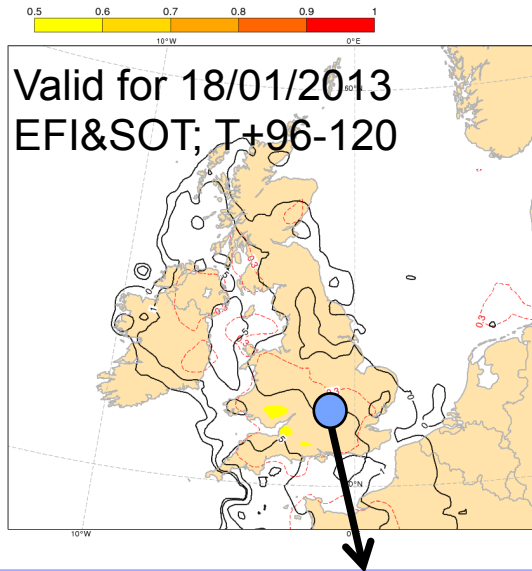


$$\text{SOT} = A/B$$

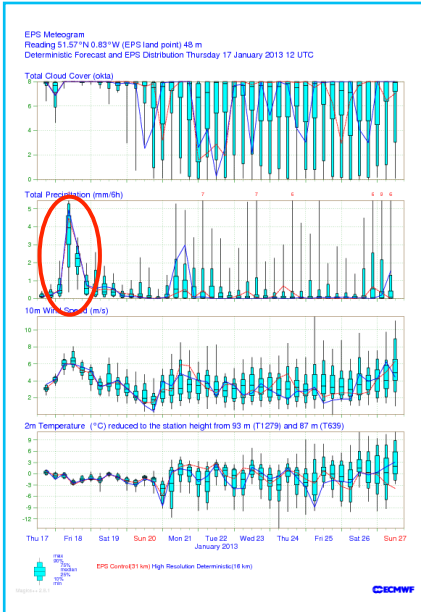
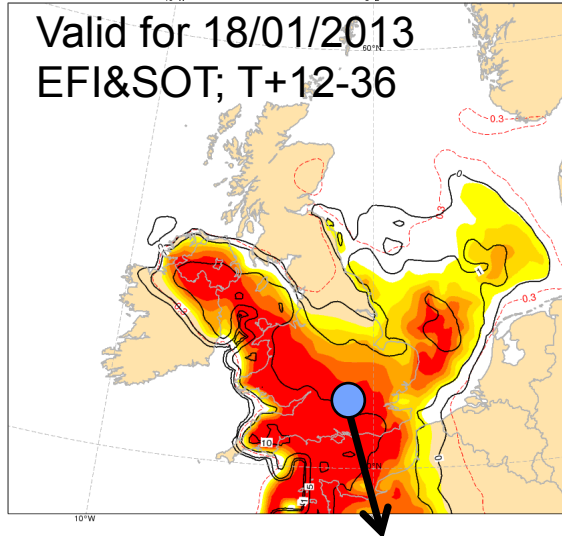
$$A = Q_f(90) - Q_c(99)$$

$$B = Q_c(99) - Q_c(90)$$

- SOT compares the tails of both distributions M-climate and ENS.
- SOT is based on 90th (upper tail) and 10th (lower tail for temperature only) M-climate percentiles
- SOT > 0 → extreme event is likely



- **SOT > 0** → at least 10% of the ensemble members are above the 99th percentile M-climate
- The higher the SOT value is, the further this top 10% of the ensemble forecast is beyond Q99 of the M-climate.
- In the example (Reading):
 - **EFI = 0.36**
 - **SOT = 0.8**
- EFI positive → forecast suggests some snow
- SOT > 0 → there are ENS members predicting extreme snowfall but the forecast is still uncertain (low EFI)



Fri

Provided by
Met Office

United Kingdom

Snow

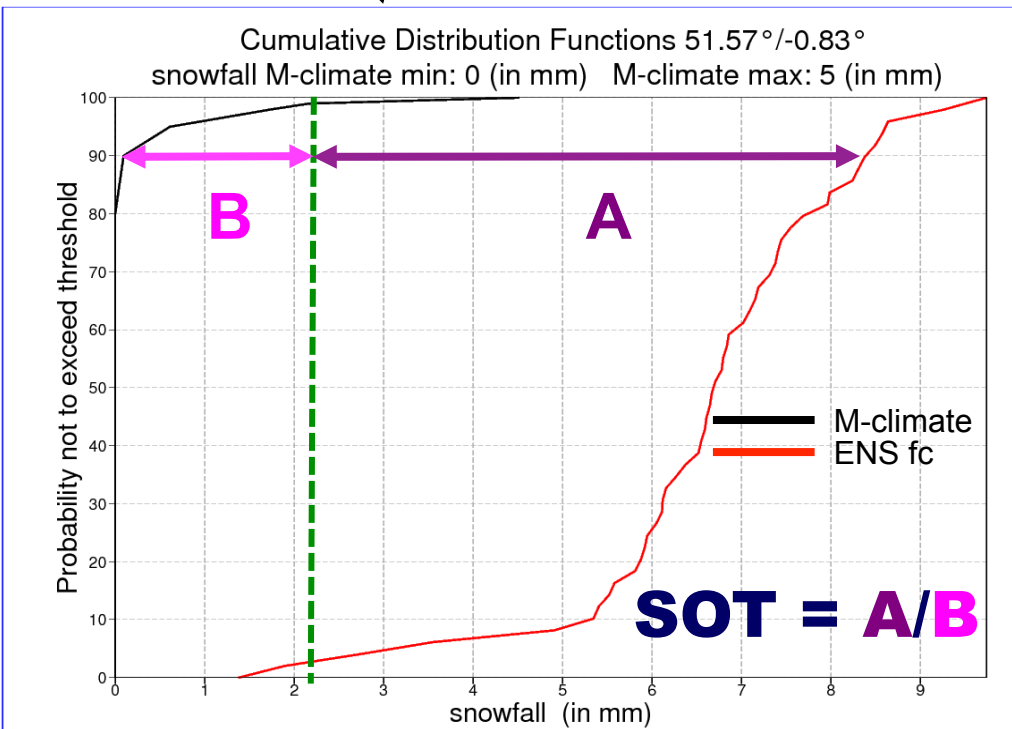
Issued at: 1230 on Thu 17 Jan 2013
Valid from: 0300 on Fri 18 Jan 2013
Valid to: 2100 on Fri 18 Jan 2013

A band of snow, heavy in places, will spread northeastwards across Wales and the southwestern half of England, during Friday morning, lasting through the afternoon and evening across much of Wales, the Midlands, southern and parts of southeast England. Winds will strengthen, leading to drifting of lying snow.

Many parts of the Red Warning area are likely to have 20-30 cm of snow with strong southeasterly winds causing blizzards, severe drifting of lying snow and thus severe disruption. The public should avoid all non-essential journeys.

Elsewhere, accumulations of more than 5-10 cm of snow will occur quite widely, with 15 cm in some western parts of the Amber area, falling within 3-6 hours. The public should be prepared for disruption, including altering travel plans.

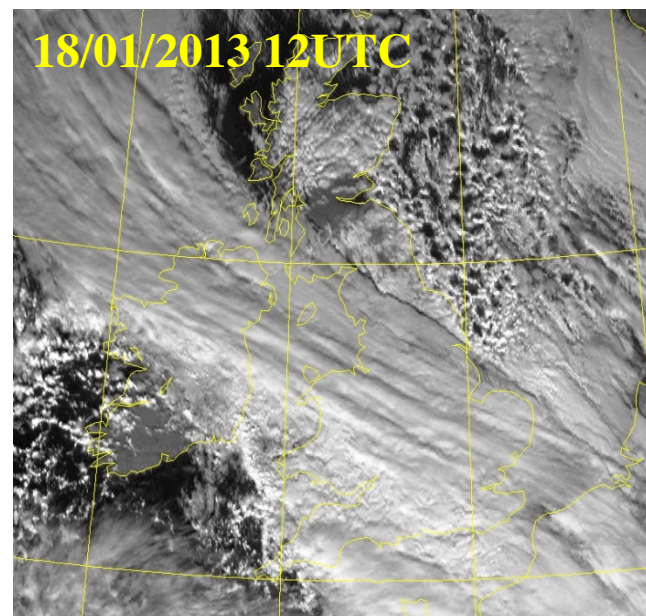
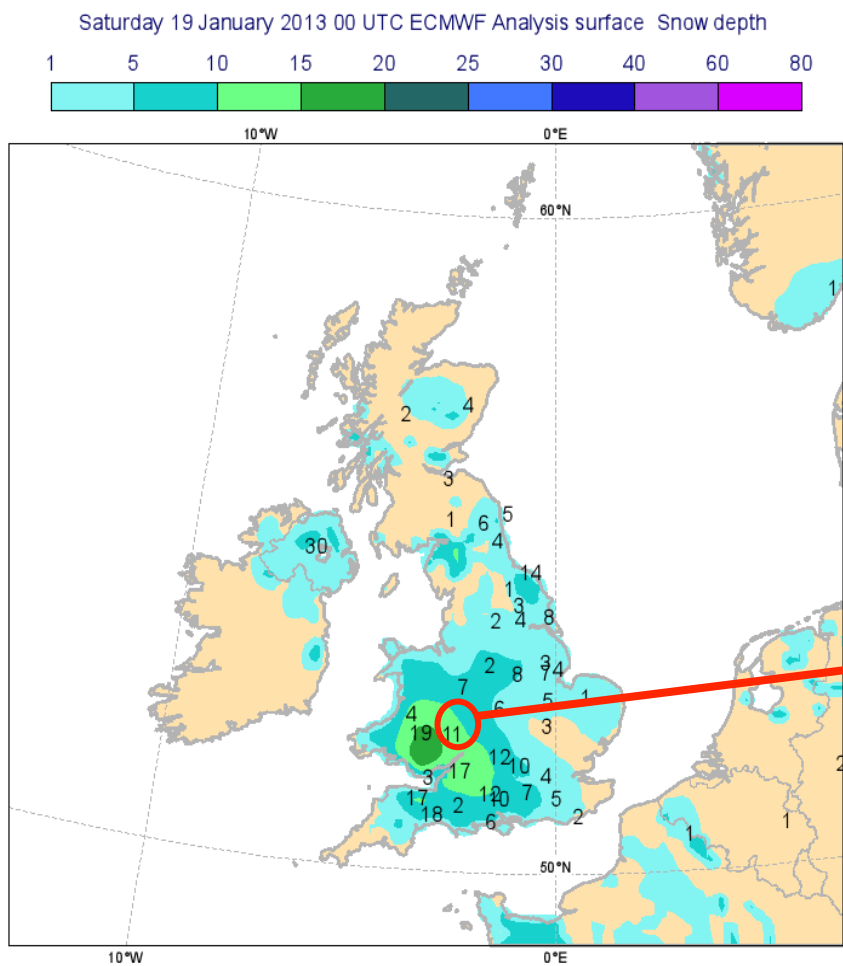
Please watch for updates to these



- Reading:**
- **EFI = 0.96**
 - **SOT = 3.5**
 - **High values of the EFI imply high confidence that extreme snowfall may happen**
 - **Higher SOT values indicate where the most exceptional snowfall amounts might occur (relative to climate)**

What happened

ECMWF snow depth analysis and observations representing the new snow depth for 24-h period from 18/01/2013 00UTC to 19/01/2013 00UTC

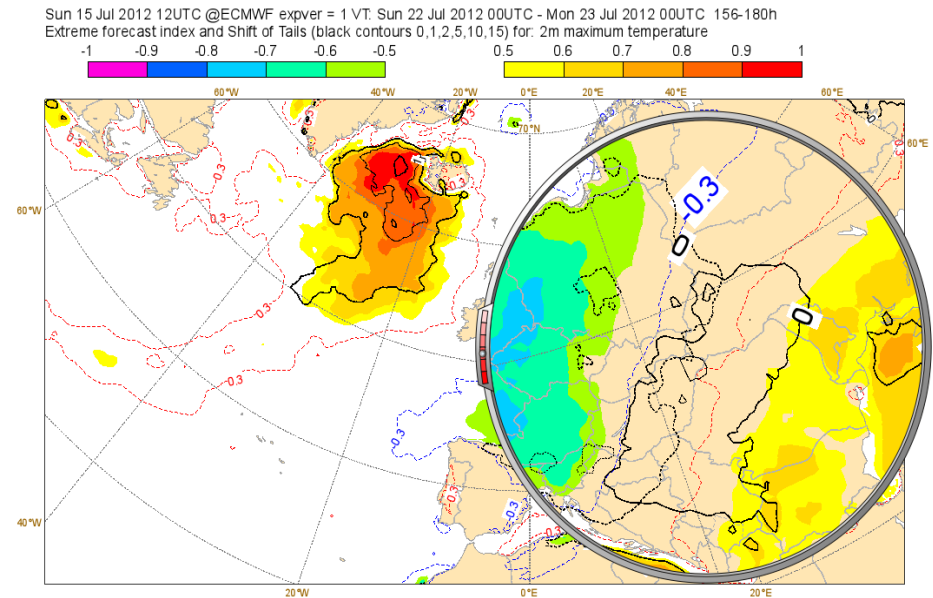
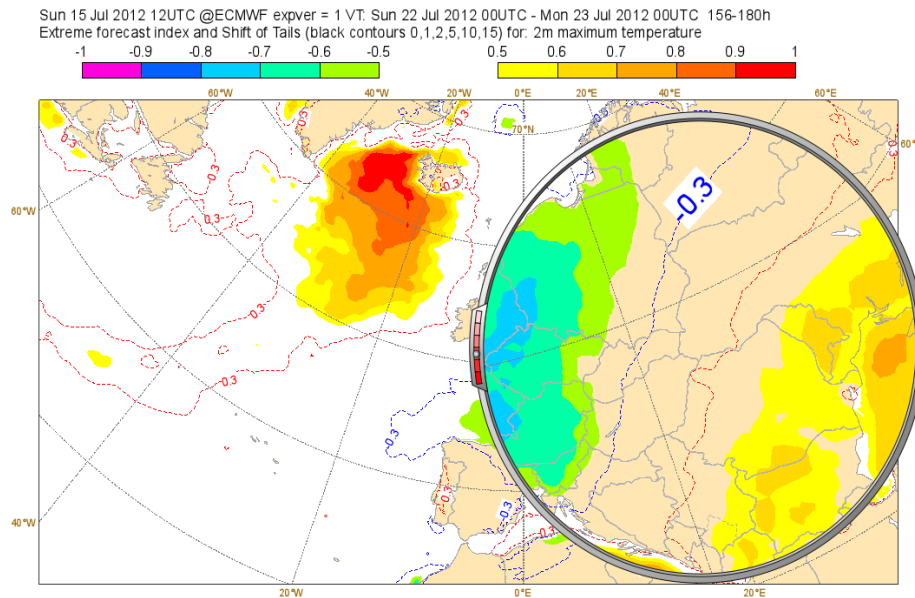


Bromsgrove, near Birmingham, UK



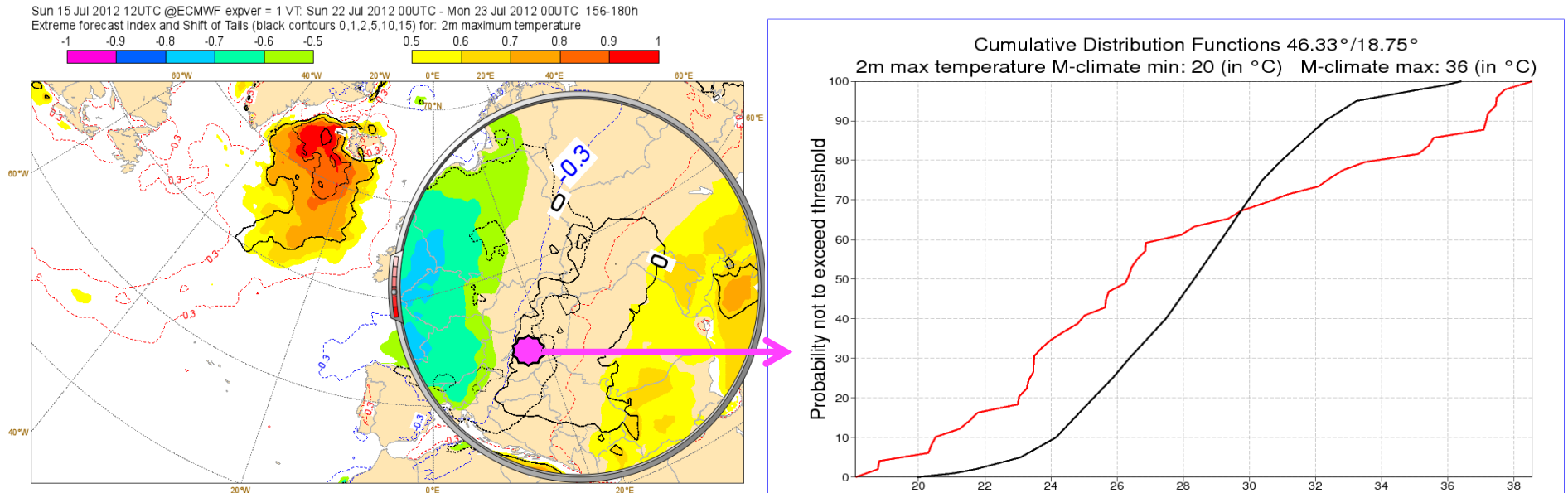
A beer garden in Bromsgrove. Credit: Sue Eden

A case of large uncertainty

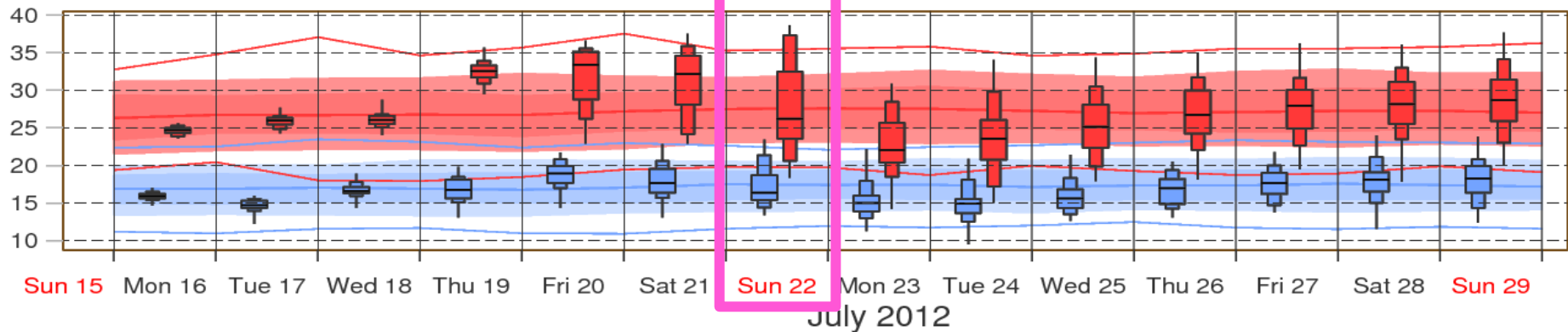


- **EFI forecast shows cold conditions over Central Europe and hot weather to the east over the Balkans.**
- **SOT gives additional information. In the area between the cold and hot weather SOTs overlap. This is a signal of very uncertain forecast – over that area extremely low and extremely high temperatures are possible at the same time.**

A case of large uncertainty



2m min/max temperature (°C) reduced to the station height from 129m (T319)

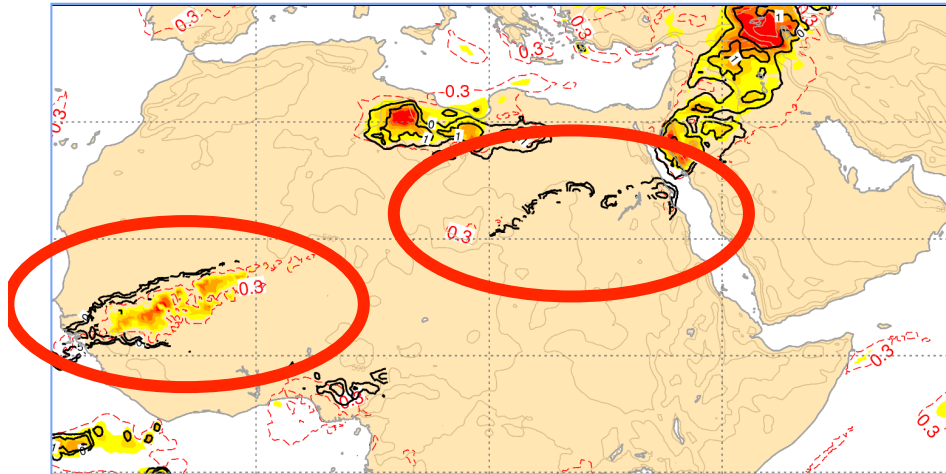


- Some ENS members predict maximum temperature below the M-climate minimum, but some – above the M-climate maximum!

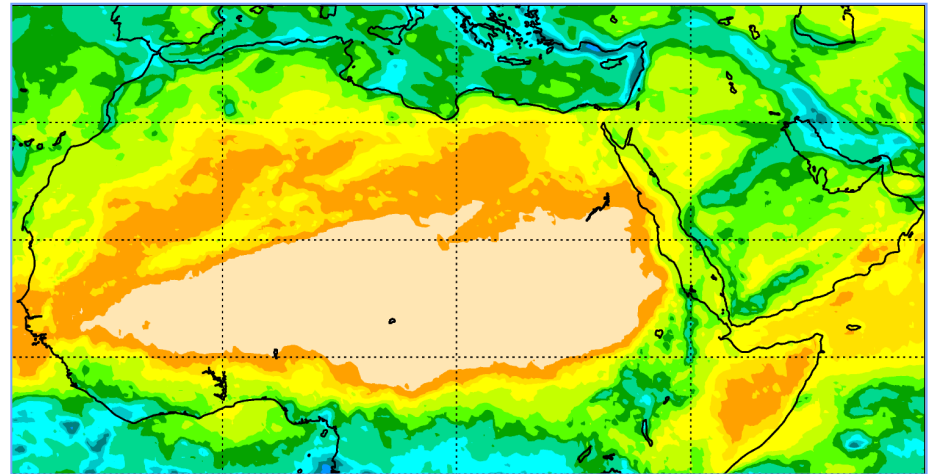
Use and interpretation of ECMWF Products, 27 Jan - 07 Feb 2014

Some limitations

EFI & SOT; precipitation



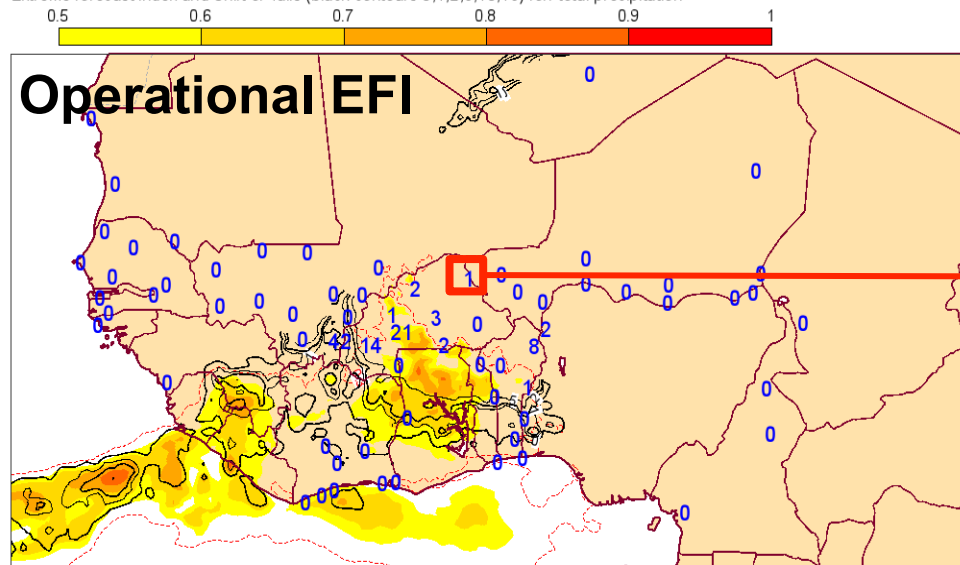
M-climate Q99



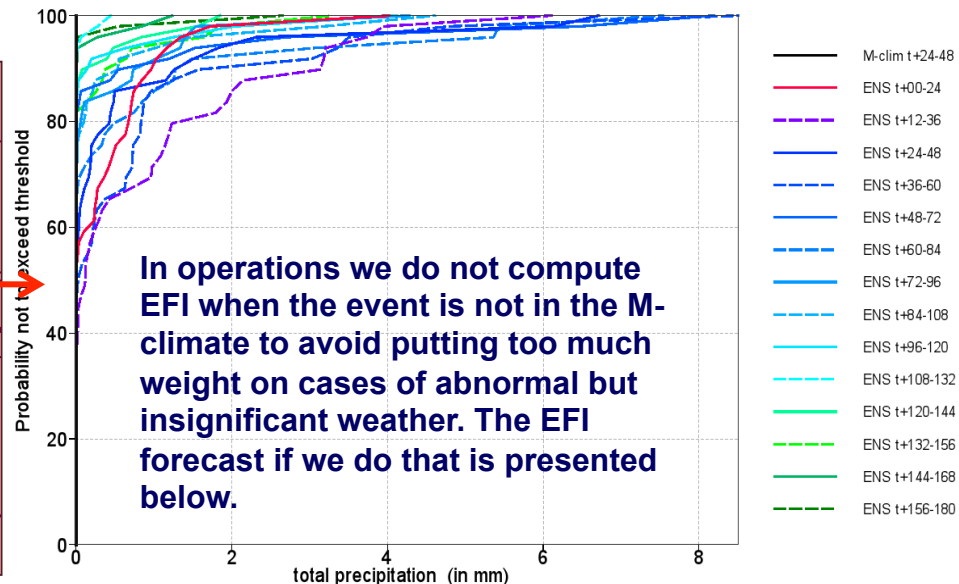
- SOT is not defined when M-climate $Q_c(90) = Q_c(99)$ (division by 0). This leads to some noise on plots. To avoid this and to close SOT contours for snowfall, SOT is artificially set to -1 where not defined only for plotting purposes.

Some limitations – a case of very rare rainfall

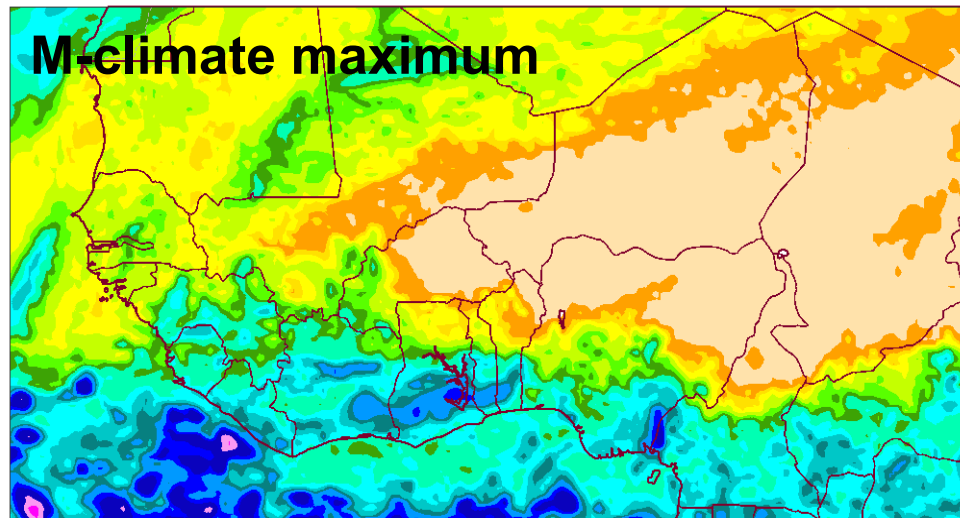
Sat 18 Jan 2014 00UTC @ECMWF expver = 1 VT: Sat 18 Jan 2014 00UTC - Sun 19 Jan 2014 00UTC 0-24h
 Extreme forecast index and Shift of Tails (black contours 0, 1, 2, 5, 10, 15) for: total precipitation



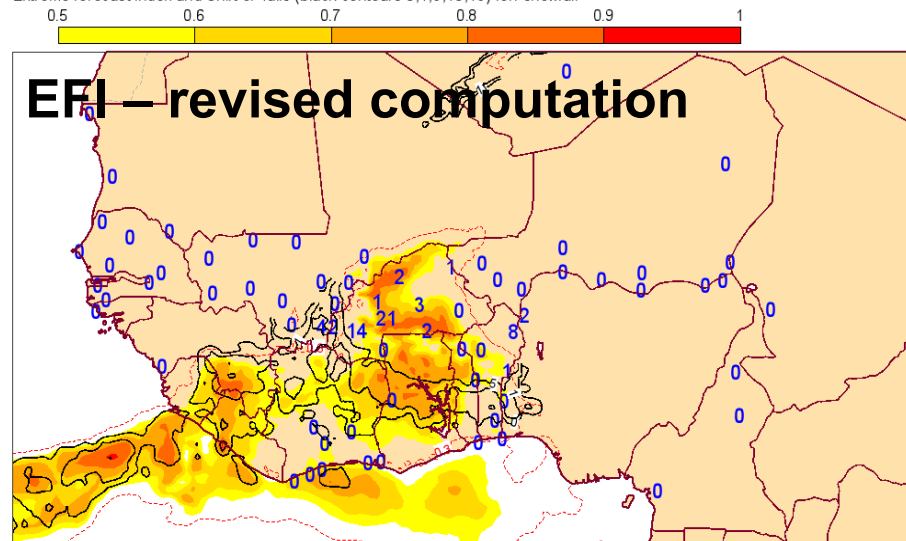
Cumulative Distribution Functions for total precipitation at 14.03°/-0.03° VT: 18/01/2014 00UTC - 19/01/2014 00UTC



Model climate Q100 (climate maximum) for total precipitation (in mm)
 0.1 1 2 5 10 15 20 30 40 50 60 80 100 150 200 250 300 500 700 1000



Sat 18 Jan 2014 00UTC @ECMWF VT: Sat 18 Jan 2014 00UTC - Sun 19 Jan 2014 00UTC 0-24h
 Extreme forecast index and Shift of Tails (black contours 0, 1, 5, 10, 15) for: snowfall



Operationally available EFI fields

- In the current operational system every EFI field is based on a forecast range of 24 hours or longer.
- Since each meteorological parameter is valid for a period the content is either an accumulated value (e.g. precipitation), a mean over a period (e.g. temperature or mean wind) or an extremum (maximum or minimum) over that period (e.g. wind gust).
- Each 24-hour period variable is worked out as a post-processed value based on four 6-hourly forecast time steps. E.g. a mean over a 00-00 UTC period is a mean of the 06-12-18 and the ending 00 UTC fields.
- *Importantly*, for **wind gusts**, the 6 hourly wind gust values used are maxima within the preceding 6 hours (diagnosed by interrogating the model run at every time step).

Operationally available EFI fields

- **EFI and SOT parameters:**
 - 2-metre mean temperature index (2ti)
 - total precipitation index (tpi)
 - 10-metre mean wind speed index (10wsi)
 - 10-metre maximum wind gusts index (10fgi)
 - **2-metre minimum temperature index (mn2ti)**
 - **2-metre maximum temperature index (mx2ti)**
 - **total snowfall index (sfi)**
 - **maximum significant wave height index (maxswhi)**

* Parameters in red available since 19th June 2012

Operationally available EFI fields

- **24h interval: parameters 2ti, tpi, 10swi, 10fgi, mn2ti, mx2ti, sfi, maxswi**
 - **00 UTC: 00-24, 24-48, 48-72, 72-96, 96-120, 120-144, 144-168**
 - **12 UTC: 12-36, 36-60, 60-84, 84-108, 108-132, 132-156, 156-180**
- **72h interval: parameters 2ti, tpi, 10swi**
 - **00 UTC: 00-72, 24-96, 48-120, 72-144, 96-168, 120-192, 144-216**
 - **12 UTC: 12-84, 36-108, 60-132, 84-156, 108-180, 132-204, 156-228**
- **120h interval: parameters 2ti, tpi, 10swi**
 - **00UTC: 00-120 (only for tpi before), 24-144 (only for tpi before), 48-168, 72-192, 96-216**
 - **12UTC: 12-132, 36-156, 60-180, 84-204, 108-228**
- **240h interval: parameters 2ti, tpi, 10swi**
 - **00UTC: 000-240 (only for tpi before)**
 - **12UTC: 000-240 (only for tpi before)**

http://www.ecmwf.int/products/forecasts/d/charts/medium/eps/

The screenshot displays the ECMWF website interface. On the left, a navigation menu includes sections for Tropical cyclones, Epsgrams (WMO Members), Special, Chart catalogue, Page overview, Find charts, Your room, and Add all products. The main content area features several product categories:

- temperature at 850 hPa, and geopotential at 500 hPa**: 10-day forecasts from the ECMWF 'Ensemble Prediction System (EPS)'
- Probabilities**: Forecast probabilities are computed from the 50 members of the Ensemble Prediction System for different parameters and relevant thresholds.
- Probabilities day 10-15**: Forecast probabilities are computed for different parameters and relevant thresholds over the period from day 10 to day 15.
- Extreme forecast index - Standard**: The Extreme Forecast Index (EFI) up to five days ahead for 10-metre wind (daily mean), 10-metre wind gusts (daily maximum), 2-metre temperature (daily mean), precipitation (daily accumulations). The precipitation EFI is also shown for some longer period accumulations: days 1-5, 2-6 and 1-10.
- Extreme forecast index - Extended**: The Extreme Forecast Index (EFI) extended to show more parameters and more time ranges, together with the Shift Of Tails (SOT) index, and also maps of model climate quantiles.
- Extreme forecast index (Interactive chart)**: This interactive web page provides access to a range of EPS products. The main page is an 'Anomalous weather' chart that summarises EFI information for wind, temperature and precipitation. Click on the chart to find more detailed information for a specific location, including EPSgrams and the distribution of EPS values for each EFI parameter.

Three detailed views are shown on the right, each with a blue arrow pointing from the 'Extreme forecast index - Standard' section:

- EFI 12m**: A map showing the Extreme Forecast Index for 10-metre wind. The forecast base time is Tuesday 22 Jan 2013 00UTC. The map displays EFI values over Europe and surrounding regions, with a color scale from 0.0 to 1.0.
- EFI 2m temperature**: A map showing the Extreme Forecast Index for 2-metre temperature. The forecast base time is Tuesday 22 Jan 2013 00UTC. The map displays EFI values over Europe and surrounding regions, with a color scale from 0.0 to 1.0.
- Global EFI all parameters (interactive chart)**: A map showing the Extreme Forecast Index for all parameters. The forecast base time is Tuesday 22 Jan 2013 00UTC. The map displays EFI values over Europe and surrounding regions, with a color scale from 0.0 to 1.0. The chart includes a legend for parameters: wind, temperature, precipitation, and SOT.

At the bottom of the page, there is a blue banner with the text: **Use and interpretation of ECMWF Products, 27 Jan - 07 Feb 2013**. The ECMWF logo is visible in the bottom right corner.

New web plots – available for all member states

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Home > Products > Forecasts > Medium range forecast > Ensemble Prediction System > EFI 2m temperature >

Show guide **EFI 2m temperature**

Parameter: **EFI 2m temperature**

Forecast base time: Tue 22 Jan 2013 00UTC

EFI & SOT **M-climate**

Tue 22 Jan 2013 00UTC ©ECMWF t+48-72h VT: Thu 24 Jan 2013 00UTC - Fri 25 Jan 2013 00UTC
 Extreme forecast index and Shift of Tails (black contours 0, 1,5,10,15) for 2m mean temperature

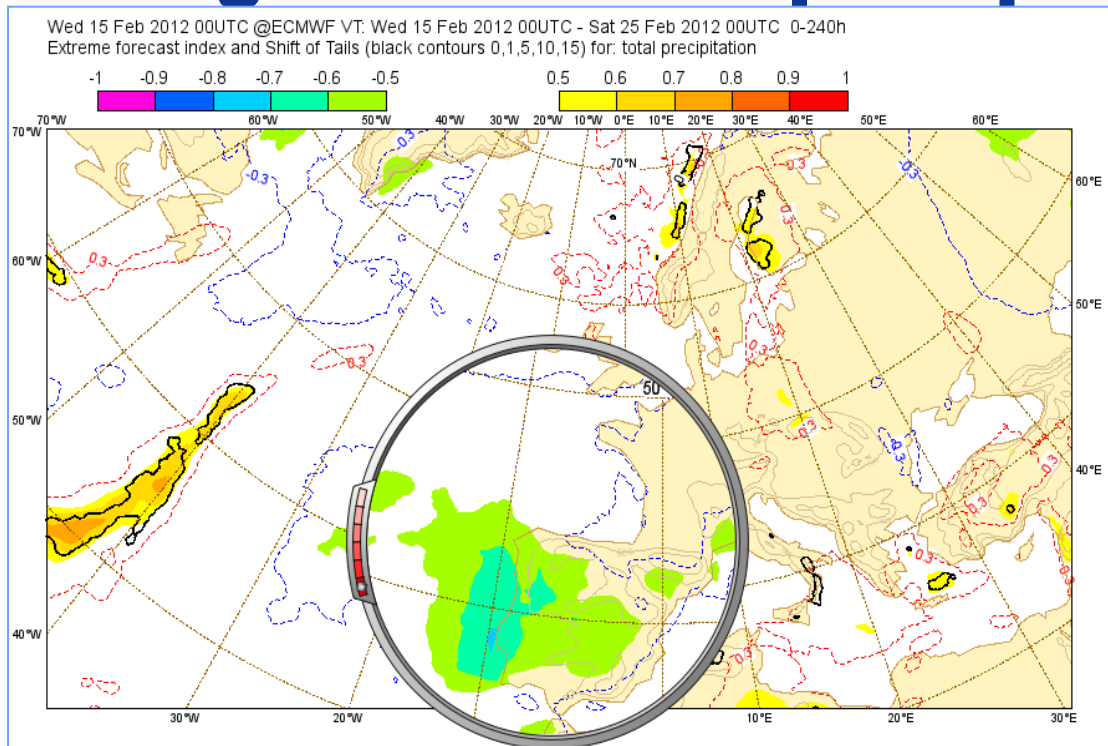
Thu 17 Jan 2013 00UTC ©ECMWF VT: Thu 24 Jan 2013 00UTC - Fri 25 Jan 2013 00UTC 48-72h
 2m mean temperature (in °C) Model climate Q50 (climate median)

Day: 3

Quantile: 1, 10, 50, 90, 99

Area: Europe, North America, South America, Asia, Australia, Africa

Negative EFI for precipitation



Severe drought in Portugal

- For 24-hour accumulations negative EFI for precipitation does not make sense because precipitation is bounded by 0.
- For accumulations over longer periods negative EFI does make sense. It shows the likelihood of dry weather.

EFI fields available for all WMO members

Home > Products > Forecasts > Medium range forecast > Ensemble Prediction System > EFI t2m

Show guide

Parameter

- EFI t2m
- EFI 10m wind speed
- EFI 10m wind gusts
- Precipitations

Forecast base time ▲▼

Tue 22 Jan 2013 00UTC ▼

Selected parameters and time ranges

Tuesday 22 January 2013 00UTC ©ECMWF Extreme forecast index t+000-024 VT: Tuesday 22 January 2013 00UTC - Wednesday 23 January 2013 00UTC
Surface: 2 metre temperature index

Day ▲▼

- 1
- 2
- 3
- 4
- 5

Area ▲▼

- Europe
- North America
- South America
- Asia
- Australia
- Africa

Your Room

Add this product

Show overview

Day
Area
Forecast base time

80°W 40°W 20°W 0°E 20°E 40°E 60°E

20°W 0°E 20°E

“Anomalous weather” map

Home > Products > Forecasts > Medium range forecast > Ensemble Prediction System > Global EFI all parameters (Interactive chart)>

Show guide

Global EFI all parameters (Interactive chart)

This chart is ...
 Clickable
 Day
 1
 2
 3
 4
 5

Area
 Global
 Europe
 North America
 South America
 Asia
 Africa
 Australia

Interactive point
 10 days
 15 days
 10 days wave
 15 days with clim
 efi distribution

Your Room
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 PDF
 Postscript

Forecast base time
 Tue 22 Jan 2013 00UTC

Anomalous weather predicted by EPS: Tuesday 22 January 2013 at 00 UTC
 1000 hPa Z ensemble mean (Tuesday 22 January 2013 at 12 UTC)
 and EFI values for Total precipitation,maximum 10m wind gust and mean 2m temperature (all 24h)
 valid for 24hours from Tuesday 22 January 2013 at 00 UTC to Wednesday 23 January 2013 at 00 UTC

Click anywhere

extreme cold cold warm extreme warm wind extreme wind precip extreme precip

22-01-2013 © ECMWF

“Anomalous weather” map

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Latitude: 51.72
Longitude: -1.22
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51.72/-1.22 (15c)
51.72/-1.22 (10)

Show guide

This chart is ...
Clickable

Day
1
2
3
4
5

Area
Global
Europe
North America
South America
Asia
Africa
Australia

Interactive point
10 days
15 days
10 days wave
15 days with clim
efi distribution

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22-01-2013

Global EFI all parameters (Interactive chart)

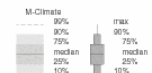
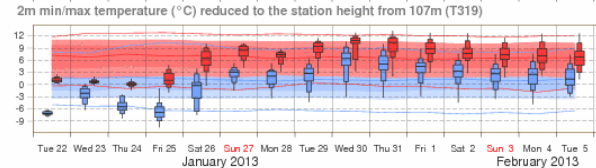
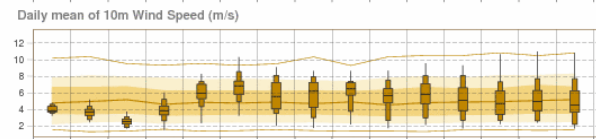
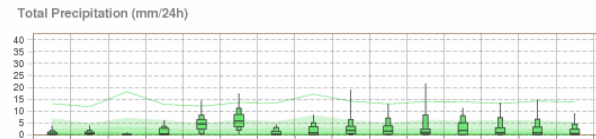
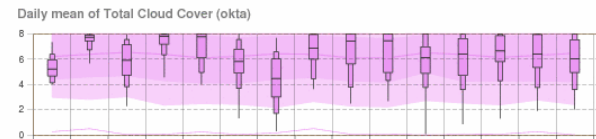
Forecast base time
Tue 22 Jan 2013 00UTC

Anomalous weather predicted by EPS: Tuesday 22 January 2013 at 00 UTC
1000 hPa Z ensemble mean (Tuesday 22 January 2013 at 12 UTC)
and EFI values for Total precipitation, maximum 10m wind gust and mean 2m temperature (all 24h)
valid for 24hours from Tuesday 22 January 2013 at 00 UTC to Wednesday 23 January 2013 at 00 UTC

Legend:
extreme cold, cold, warm, extreme warm, wind, extreme wind, precip, extreme precip

15 days with clim for 51.72 and -1.22 (Selected/clicked point)

EPS Meteogram
51.95° N 0.83° W (EPS land point) 83 m (T639)
Extended Range Forecast based on EPS Distribution Tuesday 22 January 2013 00 UTC



M-Climate: this stands for "Model Climate". It is a function of lead time, date (+/-15days), and model version. It is derived by rerunning a 5 member ensemble over the last 20 years, once per week (500

“Anomalous weather” map

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Global EFI all parameters (Interactive chart)

Forecast base time
Tue 22 Jan 2013 00UTC

Anomalous weather predicted by EPS: Tuesday 22 January 2013 at 00 UTC
1000 hPa Z ensemble mean (Tuesday 22 January 2013 at 12 UTC)
and EFI values for Total precipitation, maximum 10m wind gust and mean 2m temperature (all 24h)
valid for 24hours from Tuesday 22 January 2013 at 00 UTC to Wednesday 23 January 2013 at 00 UTC

Interactive point
10 days
15 days
10 days wave
efi distribution

Your Room
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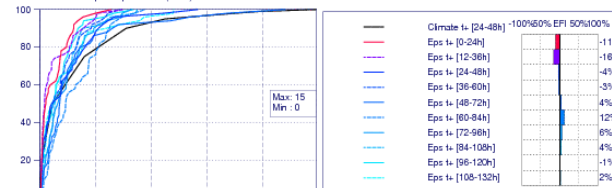
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Postscript

22-01-2013

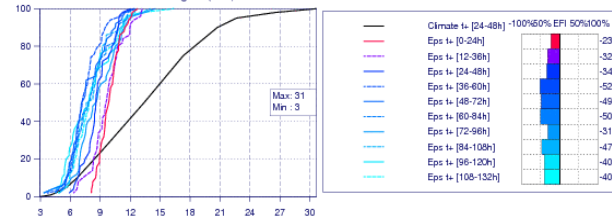
new efi distribution for 51.84 and -1.22 (Selected/clicked point)

Forecast and M-Climate cumulative distribution functions with EFI values at 51.84 °N/1.22°W valid for 24 hours from Tuesday 22 January 2013 00 UTC to Wednesday 23 January 2013 00 UTC

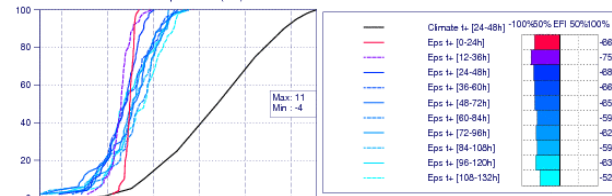
CDF for 24h precipitation (mm)



CDF for 24h maximum wind gust (m/s)



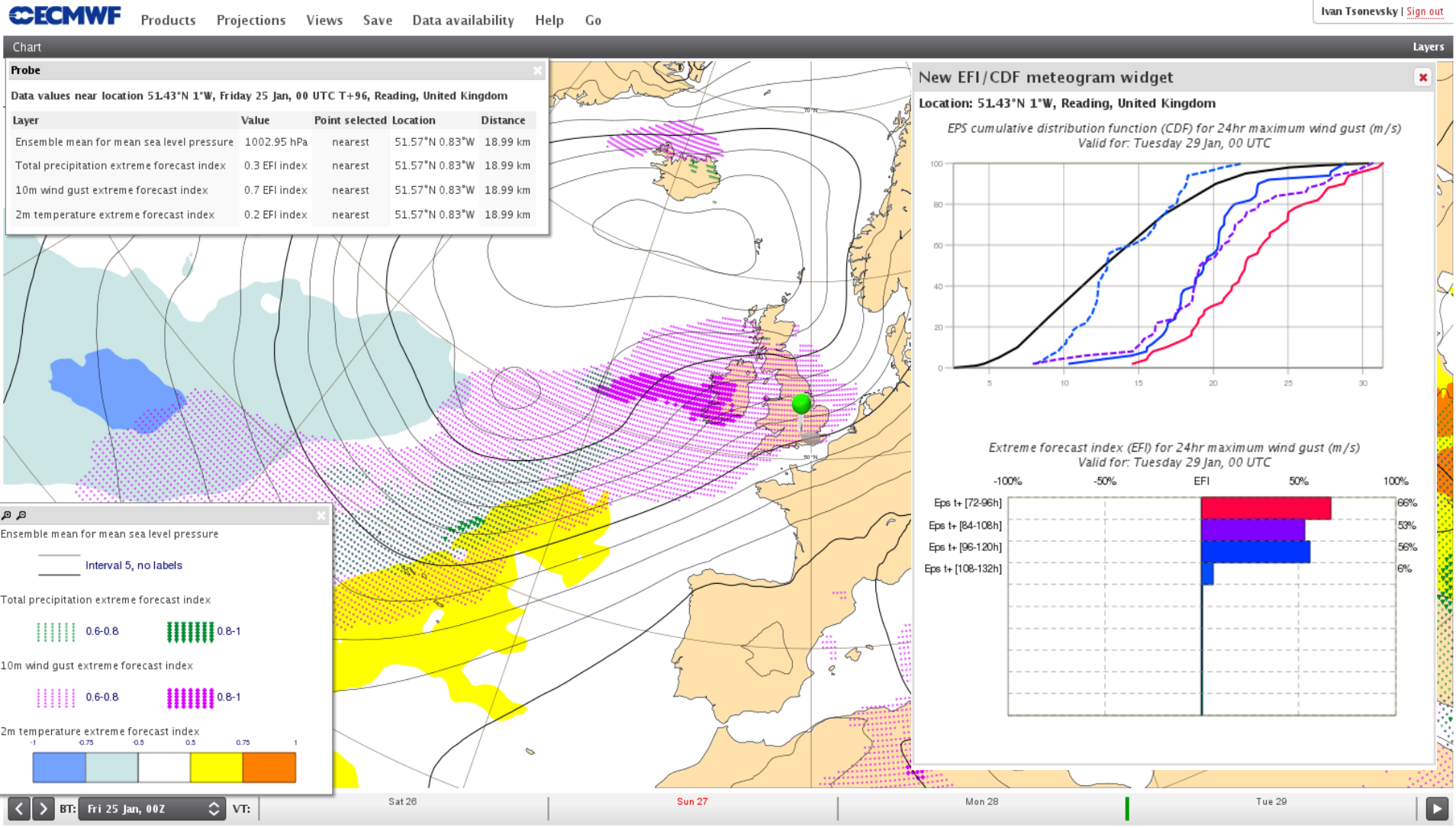
CDF for 24h mean 2m temperature (°C)



Max: 24-48h M-Climate extrema
Min:

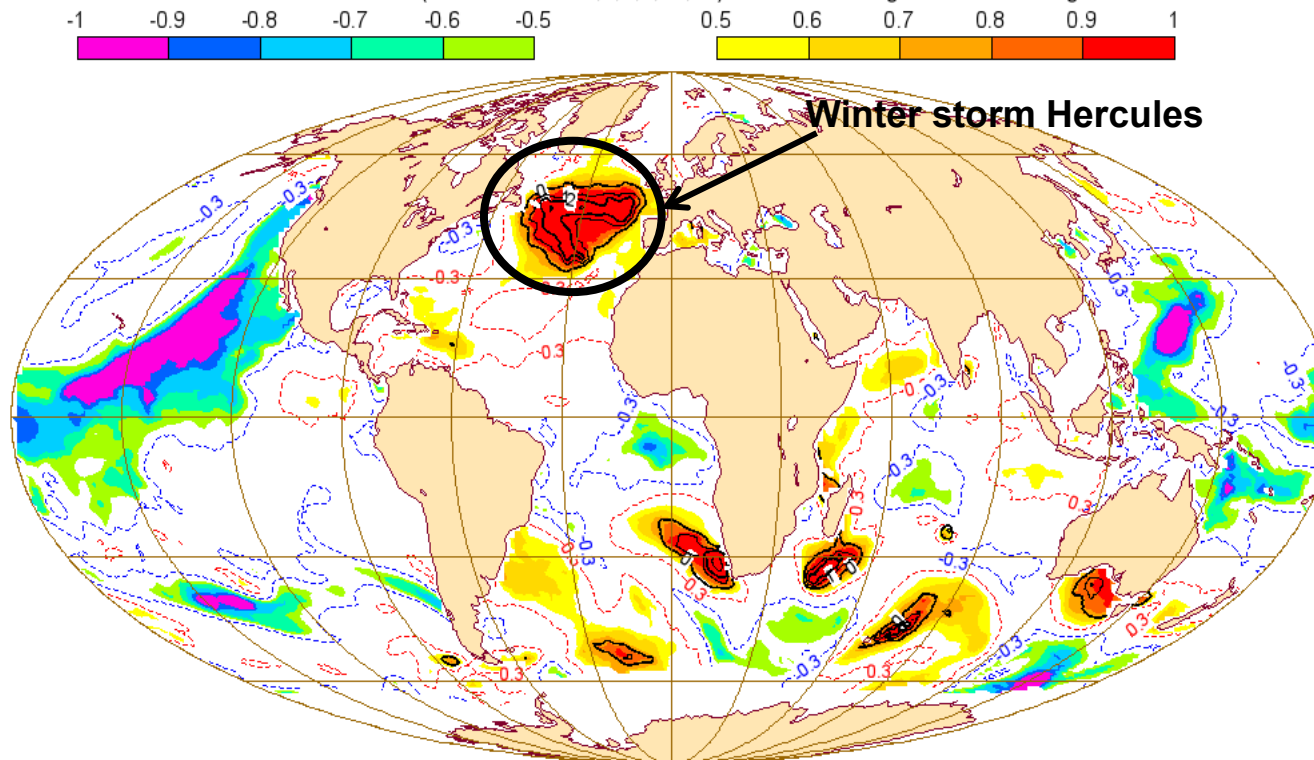
M-Climate: this stands for "Model Climate". It is a function of lead time, date (+/- ~15 days), and model version. It is derived by running a 5 member ensemble, over the last 20 years, once a week (500 realisations). M-Climate is always from the same

EFI products on ecCharts



EFI for waves

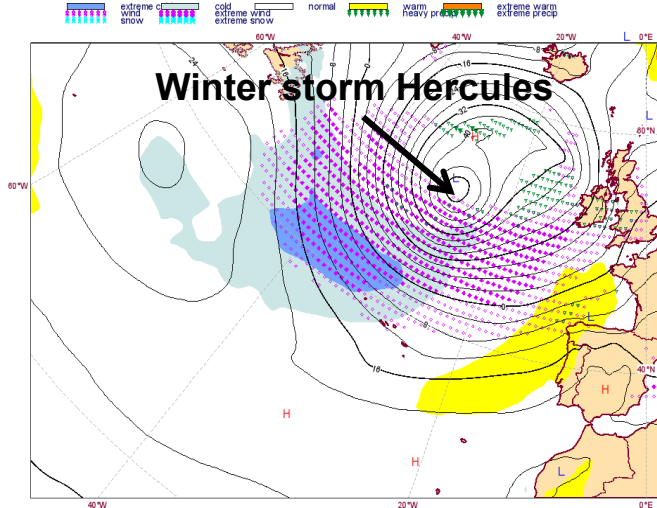
Sun 05 Jan 2014 00UTC @ECMWF expver = 1 VT: Sun 05 Jan 2014 00UTC - Mon 06 Jan 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: maximum significant wave height



- Negative EFI (calm sea) also plotted on the web.
- The winter storm Hercules generated waves up to 20 m in height on 5 and 6 January 2014.

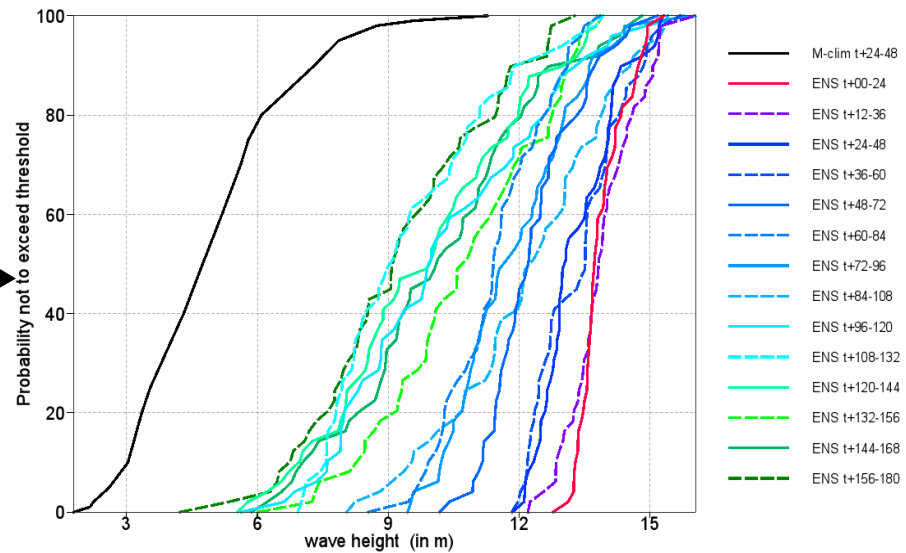
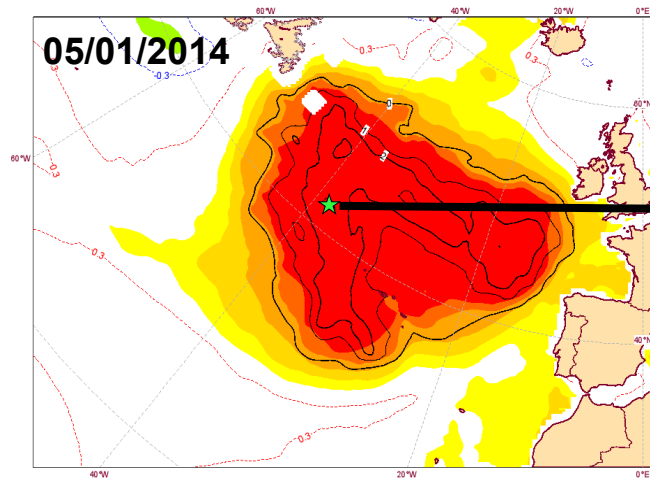
Historic swell – Storm Hercules

Weather anomalies predicted by EPS: 20140105 00 UTC
 1000 hPa Z ensemble mean VT: Sunday 05 January 2014 12 UTC
 and EFI values for 24h Total precipitation, snowfall, 10m wind gust and 2m temperature
 VT: Sunday 05 January 2014 00 UTC - Monday 06 January 2014 00 UTC



Cumulative Distribution Functions for wave height at 42.03°N-38.43°W: 05/01/2014 00UTC - 06/01/2014 00UTC

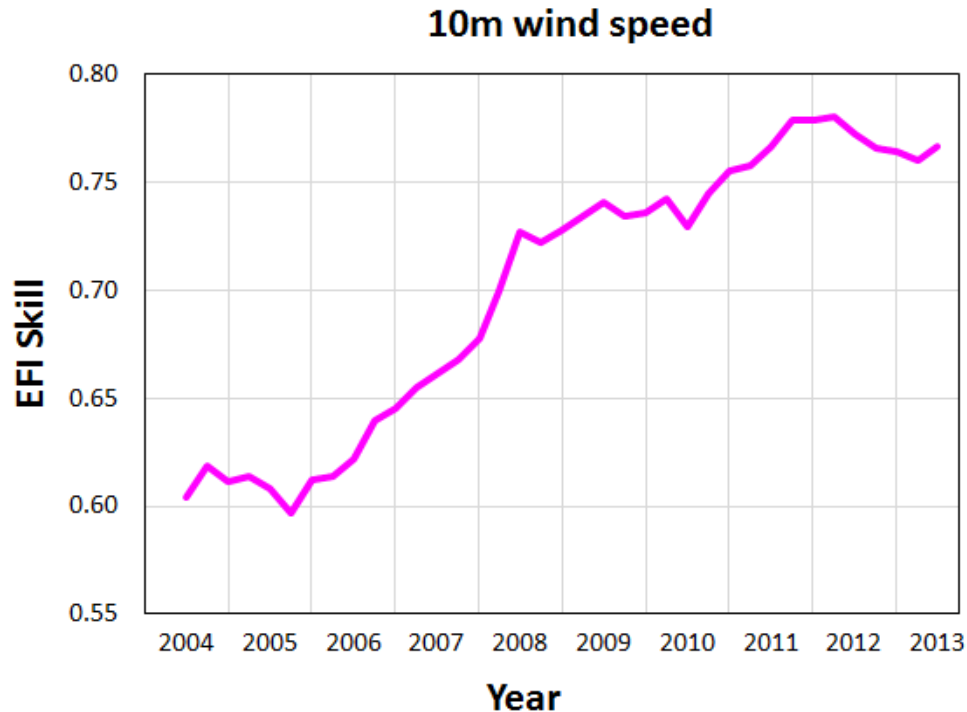
Sun 05 Jan 2014 00UTC @ECMWF expver = 1 VT: Sun 05 Jan 2014 00UTC - Mon 06 Jan 2014 00UTC 0-24h
 Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for maximum significant wave height



EFI Verification

- Verification of the EFI has been done using synoptic observations over Europe available on the GTS.
- An extreme event is taken as occurring if the observation exceeds the 95th percentile of the observed climate for that station (calculated from a 15-year sample).
- The ability of the EFI to detect extreme events is assessed using the Relative Operating Characteristic area (ROCA).
- $EFI\ Skill = 2ROCA - 1$;
0 → no skill, 1 → perfect score
- The verification is done for 3 parameters: 2m mean temperature, 10m mean wind speed and total precipitation

EFI Verification



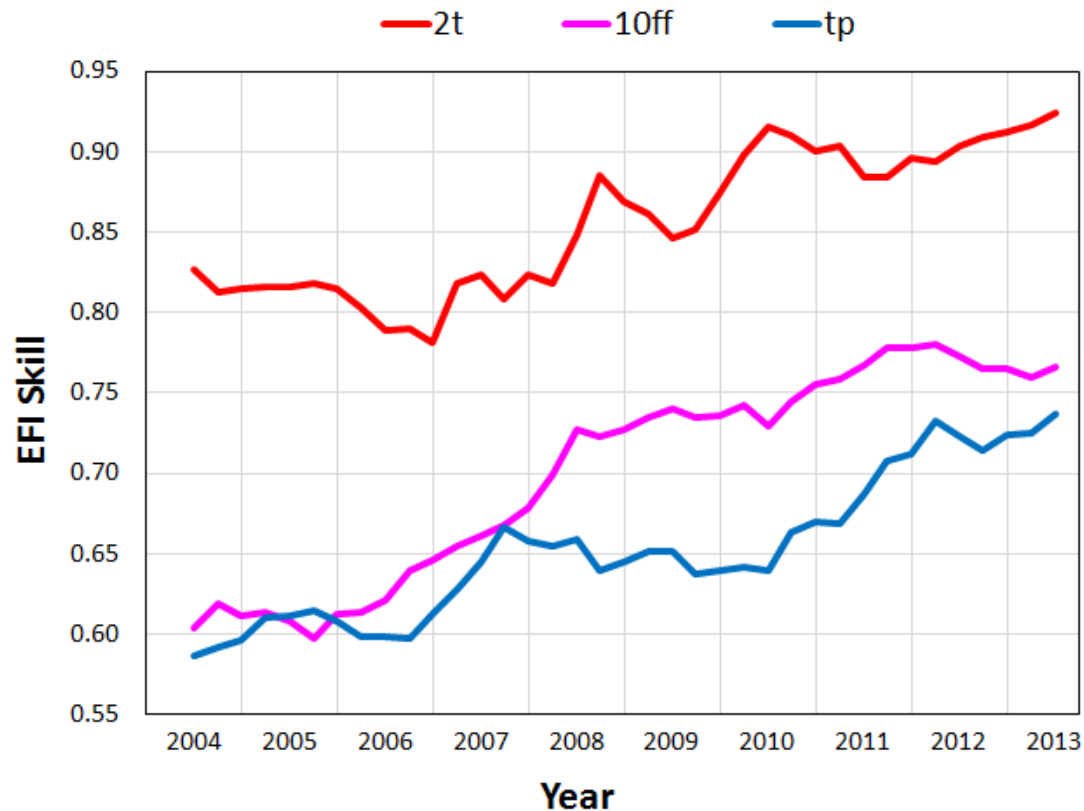
EFI Skill = $2 \cdot \text{ROCA} - 1$

EFI Skill = 0 no skill

EFI Skill = 1 perfect score

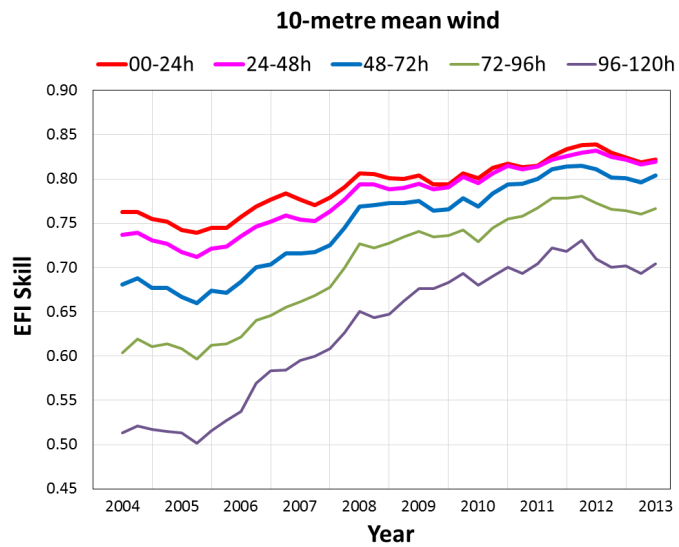
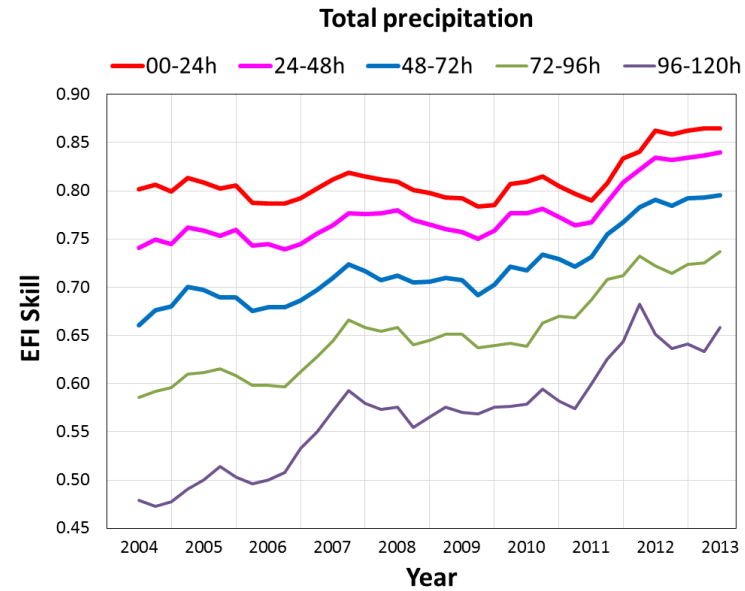
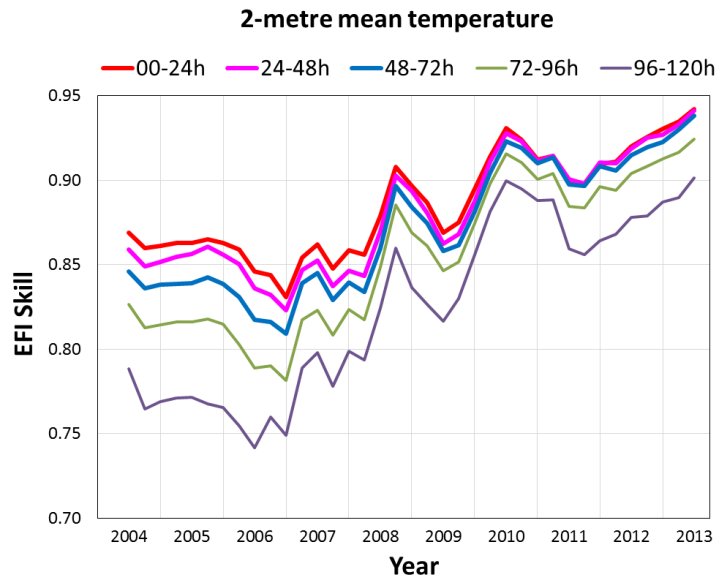
- The plot shows the skill of the EFI for 10-metre wind speed (a supplementary headline score adopted by the ECMWF Council) at forecast day 4 (t+72-96h for 00UTC).
- The curve shows a four-season running mean.

EFI Verification



- Curves show a four-season running mean of the EFI skill score for **2m mean temperature (2t)**, **10 metre mean wind speed (10ff)** and **total precipitation (tp)**.
- The EFI for 2m temperature is more skilful than EFI for the other two parameters.

EFI Verification



● **EFI skill as a function of the lead time**

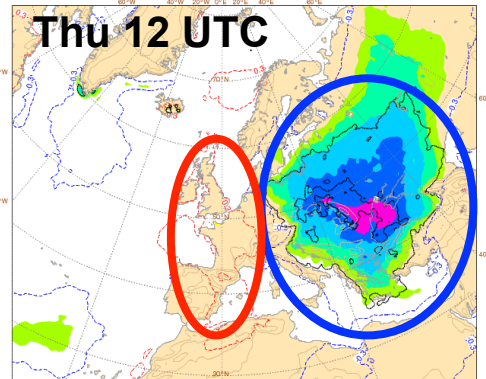
Known issues

- **Re-forecast sample size is still not sufficient for providing robust climate:**
 - Noise, especially in the tails of the climate distribution
 - Jumpiness in the EFI and especially in Shift Of Tails (SOT)
- **M-climate is computed only once a week (every Thursday):**
 - Sudden jumps in the EFI forecasts when changing the M-climate on Fridays due to the seasonal trend
- **M-climate is not perfect. It may be affected by model biases:**
 - Jumpiness in the M-climate for different lead times

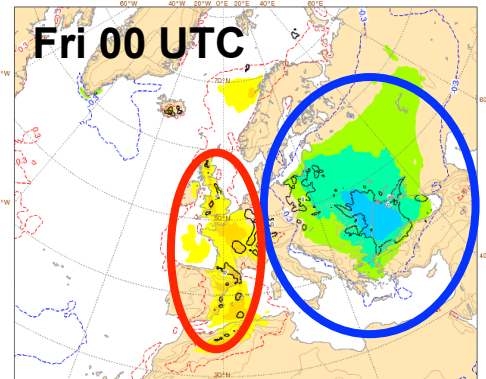
Known issues – example of a cold wave, Europe, beginning of October 2013

EFI

Thu 26 Sep 2013 12UTC ©ECMWF t-156-180h VT: Thu 03 Oct 2013 00UTC - Fri 04 Oct 2013 00UTC
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for 2m mean temperature

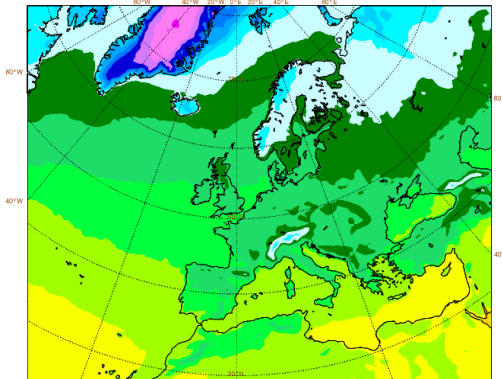
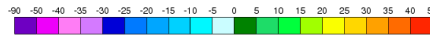


Fri 27 Sep 2013 00UTC ©ECMWF t-144-168h VT: Thu 03 Oct 2013 00UTC - Fri 04 Oct 2013 00UTC
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for 2m mean temperature

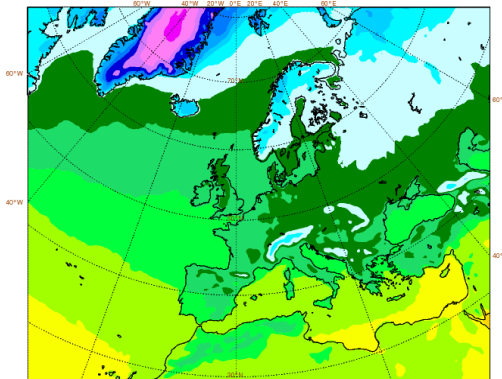
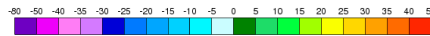


M-climate

Thu 19 Sep 2013 00UTC ©ECMWF VT: Thu 03 Oct 2013 00UTC - Fri 04 Oct 2013 00UTC 156-180h
2m mean temperature (in °C) Model climate Q1 (one in 100 occasions realises less than value shown)



Thu 26 Sep 2013 00UTC ©ECMWF VT: Thu 03 Oct 2013 00UTC - Fri 04 Oct 2013 00UTC 144-168h
2m mean temperature (in °C) Model climate Q1 (one in 100 occasions realises less than value shown)



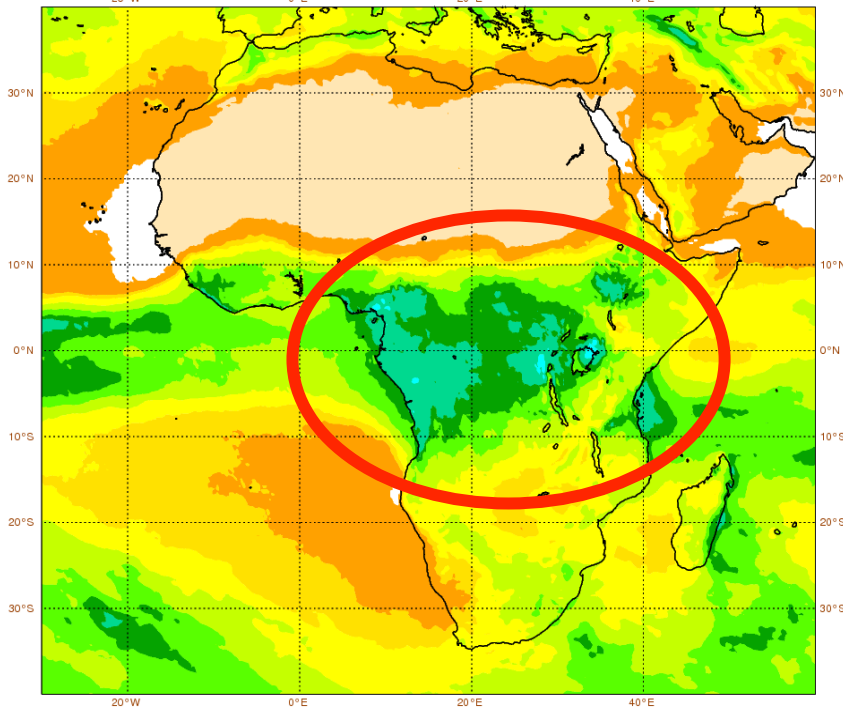
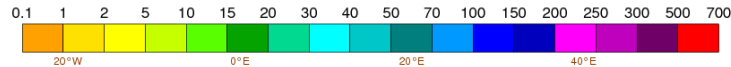
● **M-climate is computed only once a week (every Thursday):**

- Sudden jumps in the EFI forecasts when changing the M-climate on Fridays due to the seasonal trend

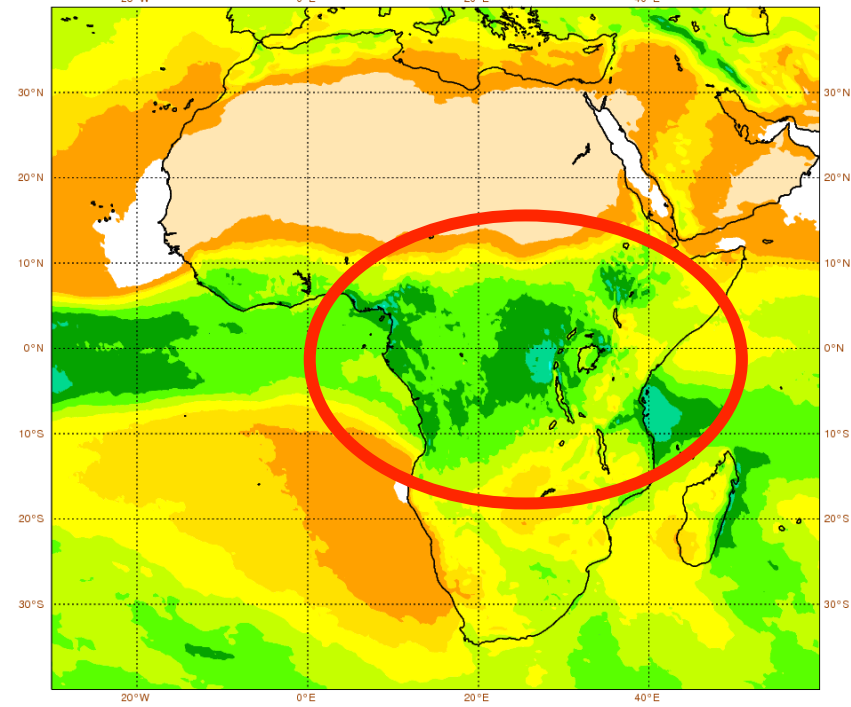
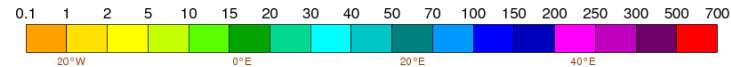
Example: two consecutive forecast runs. The signal of extremely cold weather is less prominent in the Friday's run because of the different climate though the forecasts are similar.

Known issues – example tropical Africa

Thu 11 Apr 2013 00UTC ©ECMWF VT: Thu 18 Apr 2013 00UTC - Fri 19 Apr 2013 00UTC 0-24h total precipitation (in mm) Model climate Q90 (one in 10 occasions realises more than value shown)



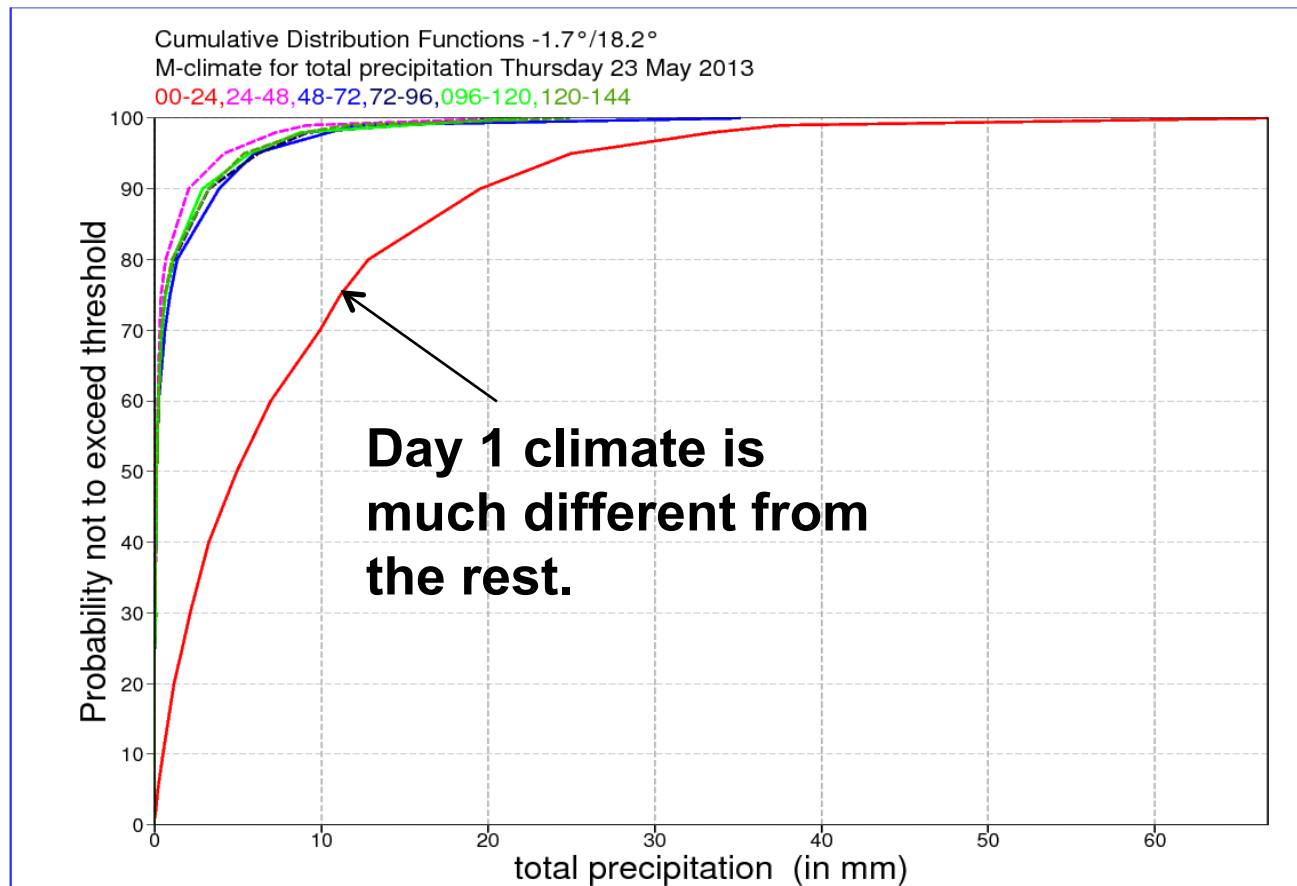
Thu 11 Apr 2013 00UTC ©ECMWF VT: Fri 19 Apr 2013 00UTC - Sat 20 Apr 2013 00UTC 24-48h total precipitation (in mm) Model climate Q90 (one in 10 occasions realises more than value shown)



The striking difference between t+00-24h and t+24-48h climate is noticeable on these charts which represent 90th model climate percentile. Precipitation amounts corresponding to Q90 for 00-24h are much bigger than those for 24-48h.

Known issues – example tropical Africa

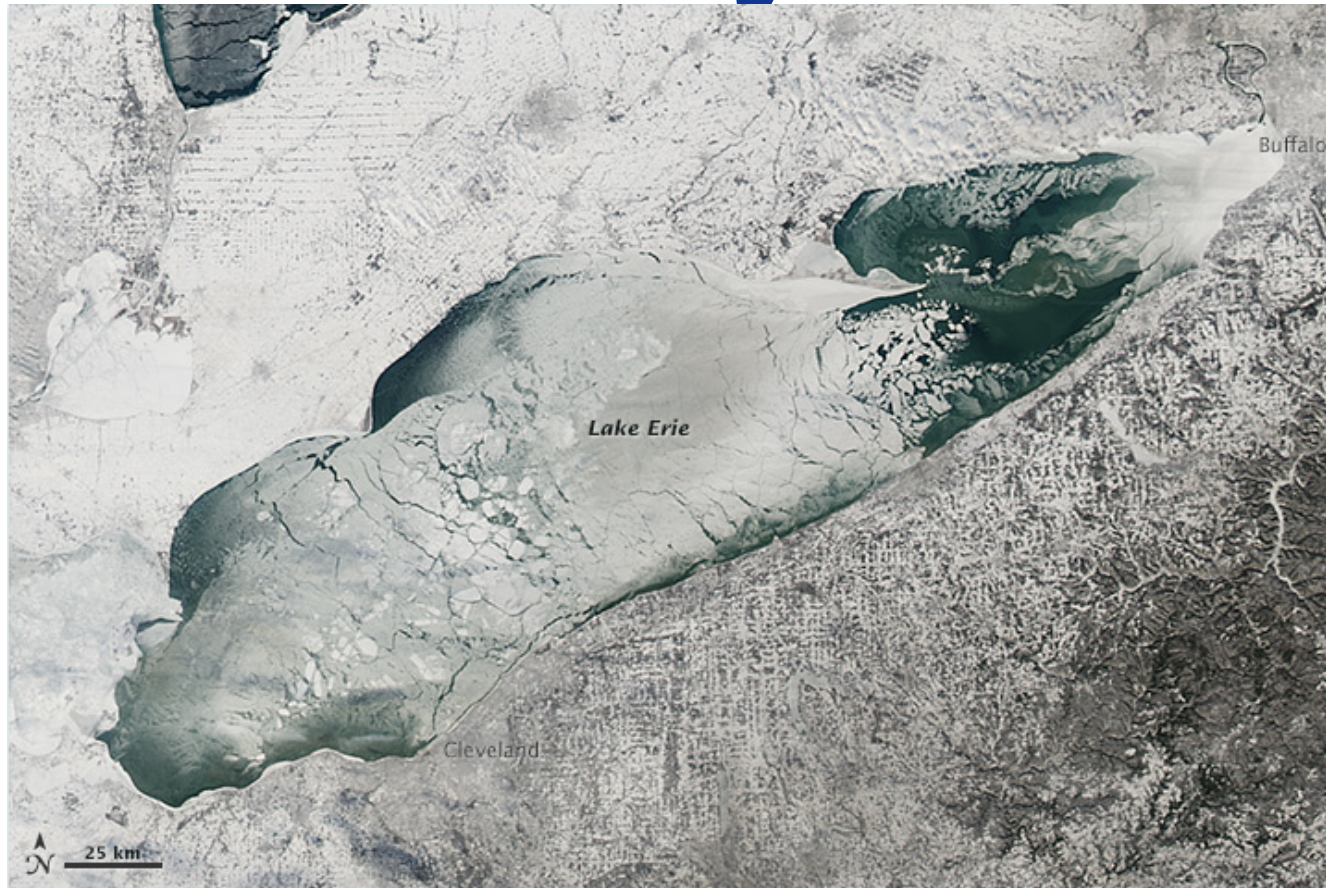
- M-climate is not perfect. It may be affected by model biases:
 - Jumpiness in the M-climate for different lead times



Proposed changes in the M-climate

- **To increase the number of the ensemble members in the re-forecasts from 5 (now) to 11:**
 - The sample size will considerably increase from 500 to $11*5*20=1100$
 - Still not enough in the first 2 days of the forecast as the ensemble spread is not big enough to cover the whole range of the possible outcomes
- **To run re-forecast suite twice a week (every Monday and Thursday) instead of being run once a week (Thursdays)**
 - It will better account for the seasonal trend, hence less jumpy forecasts due to the seasonal trend when the M-climate changes

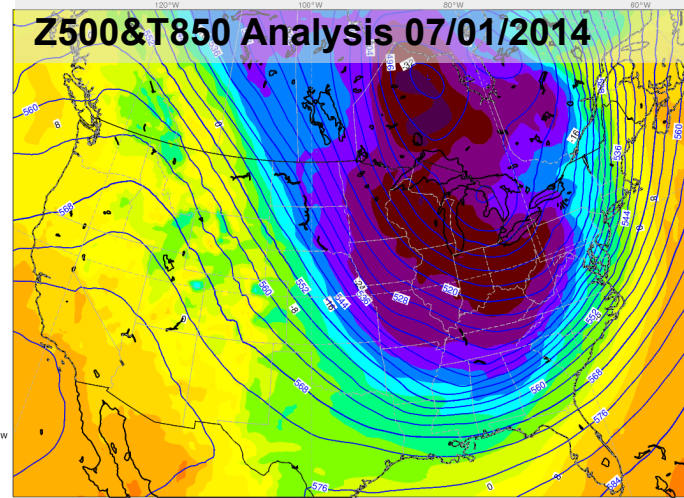
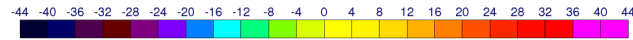
US cold snap January 2014



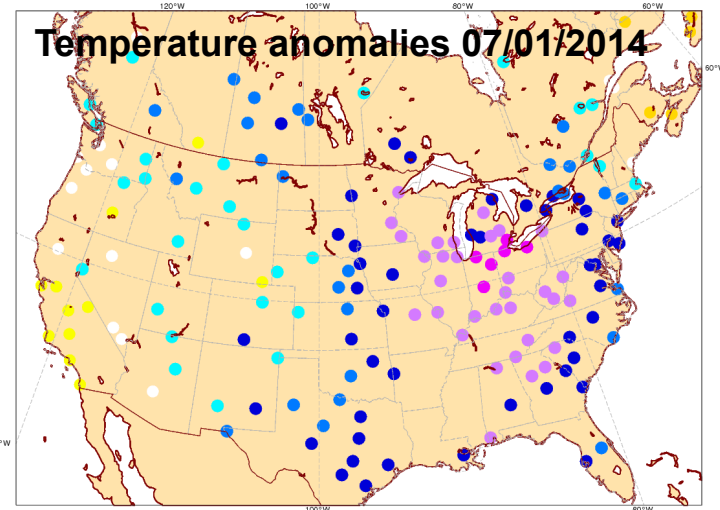
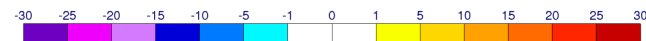
Great Lakes frozen

US cold snap, January 2014

07 January 2014 00 UTC ECMWF t+0 VT: 07 January 2014 00 UTC
500 hPa Height/850 hPa Temperature



Temperature anomalies VT: 07/01/2014

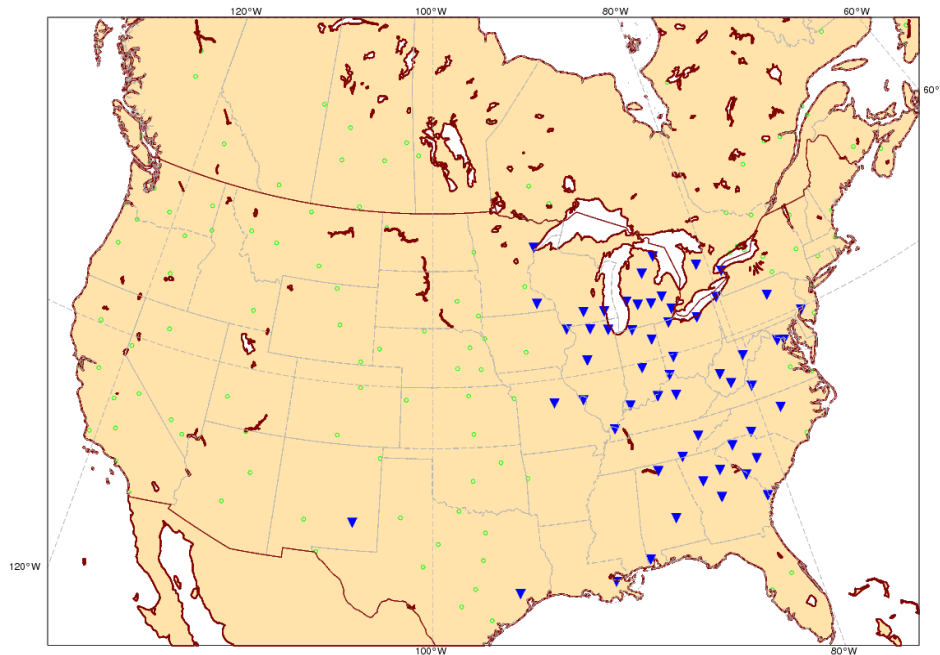


- An extremely cold airmass from the Arctic region dropped the temperatures in the US January 5-7, 2014.
- Record freezing temperatures (15 to 22C below normal) brought many cities to a standstill. Over a dozen deaths were attributed to the cold wave.
- It was the coldest weather since early February 1996.

US cold snap, January 2014

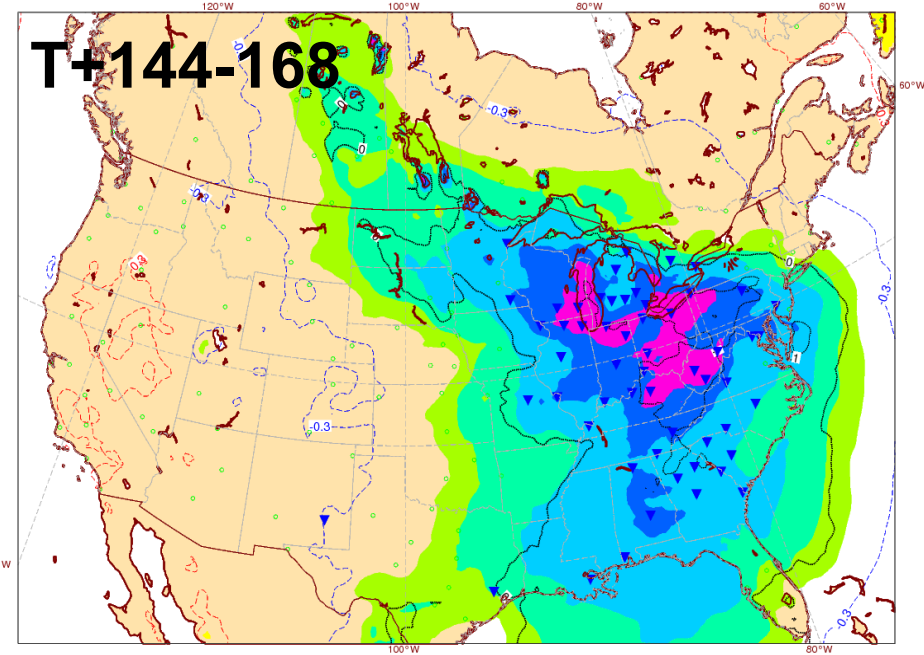
Temperature extremes compared to 15-year observed climate
VT: 07/01/2014

▲ OBS>Q99 ● Q1<OBS<Q99 ▼ OBS<Q1



Wed 01 Jan 2014 00UTC @ECMWF expver = 1 VT: Tue 07 Jan 2014 00UTC - Wed 08 Jan 2014 00UTC 144-168h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 2m mean temperature

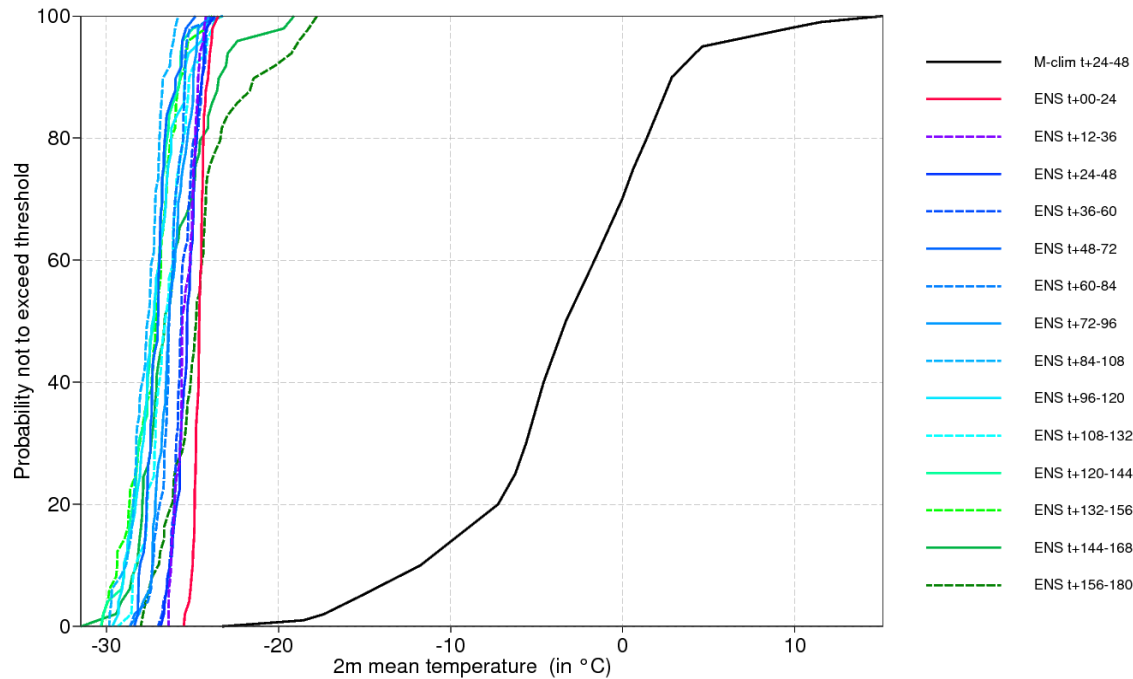
-1 -0.9 -0.8 -0.7 -0.6 -0.5 0.5 0.6 0.7 0.8 0.9 1



- Blue triangles denote extremely low temperatures below 1st percentile of the 15-year climatology from observations.
- Positive SOT (black contours) and high negative EFI match very well the areas of extremely low temperatures even 7 days in advance.

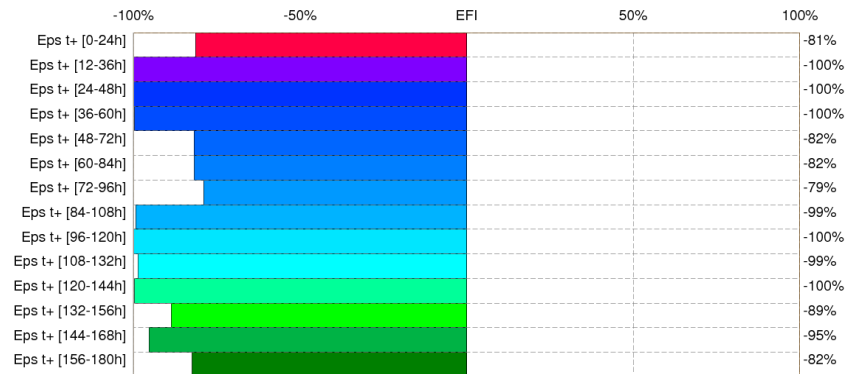
US cold snap, January 2014

Cumulative Distribution Functions for 2m mean temperature at 41.98°/-87.9° VT: 07/01/2014 00UTC - 08/01/2014 00UTC



- CDFs and EFI forecast for Chicago
- All the forecast CDFs are closely packed.
- Near vertical CDFs imply high confidence in the forecast.

Extreme Forecast Index for 2m mean temperature at 41.98N -87.9W
Tuesday 7 January 2014



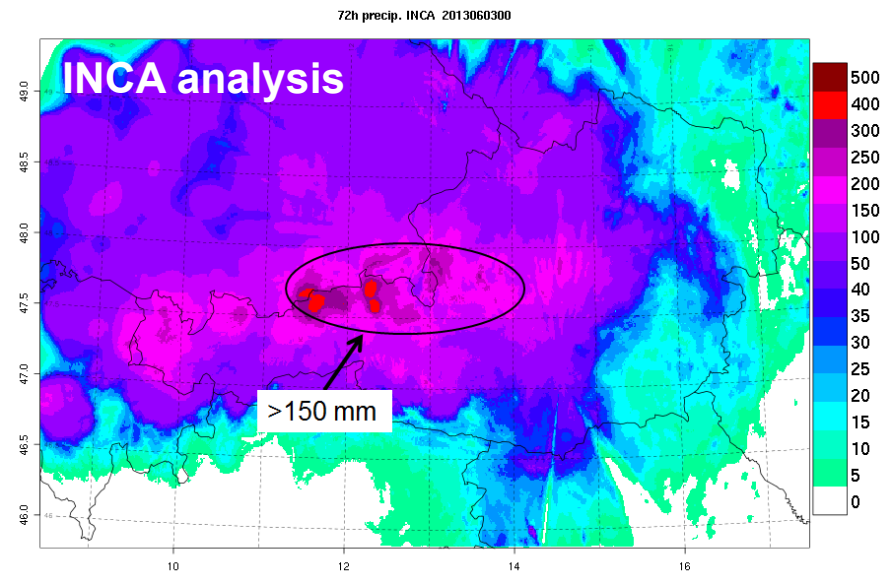
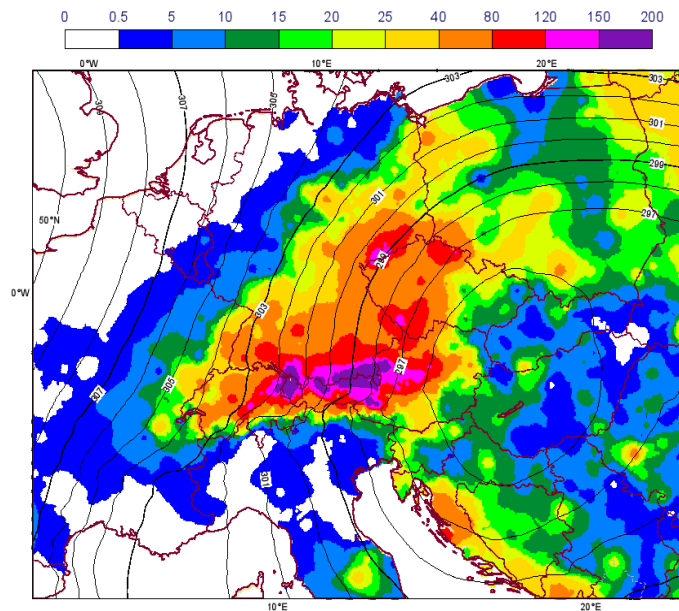
Floods in Central Europe

June 2013



Analysis

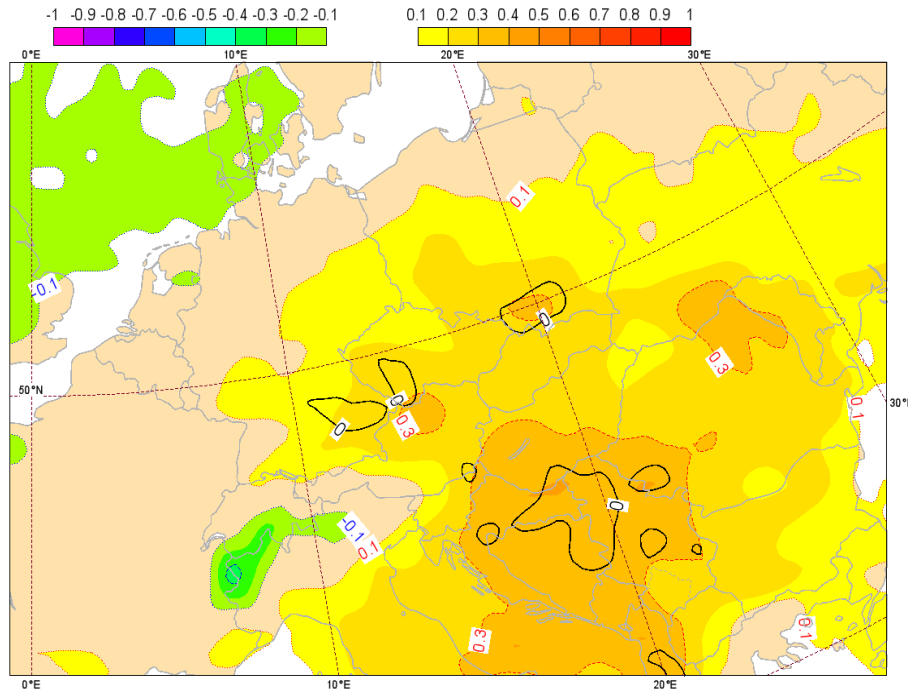
Observed rainfall interpolated on a grid and
Z700 (mean over the period) ECMWF analysis
VT: 31/05/2013 06 UTC – 03/06/2013 06UTC



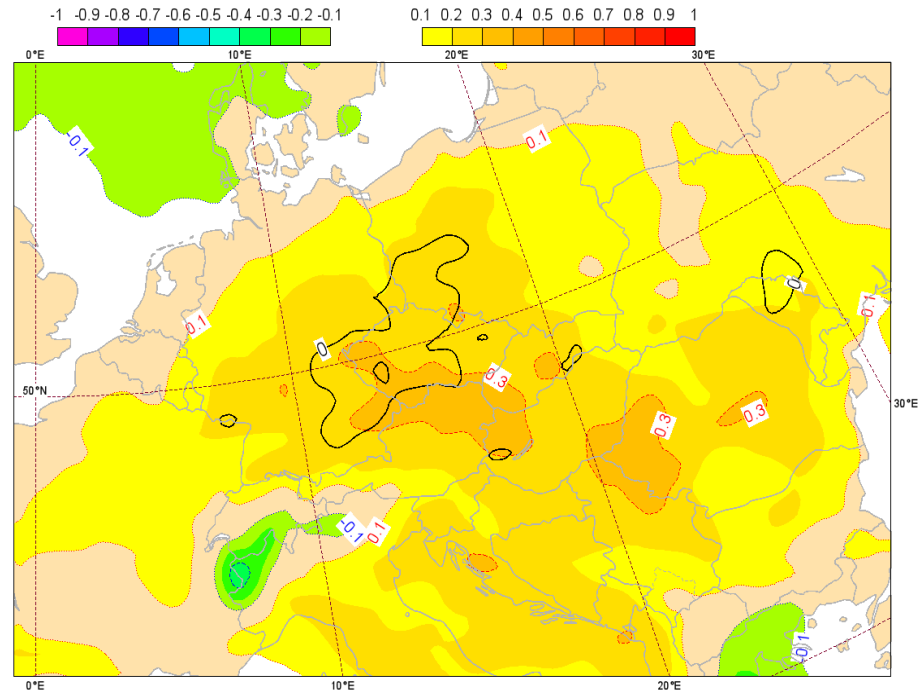
- A quasi-stationary low pressure system brought moist, warm air from the east and northeast into Central Europe causing massive amounts of rain in southern Germany and western Austria.
- Orographic enhancement of precipitation along the northern side Alps played an important role.

EFI & SOT, total precipitation, T+240-360

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



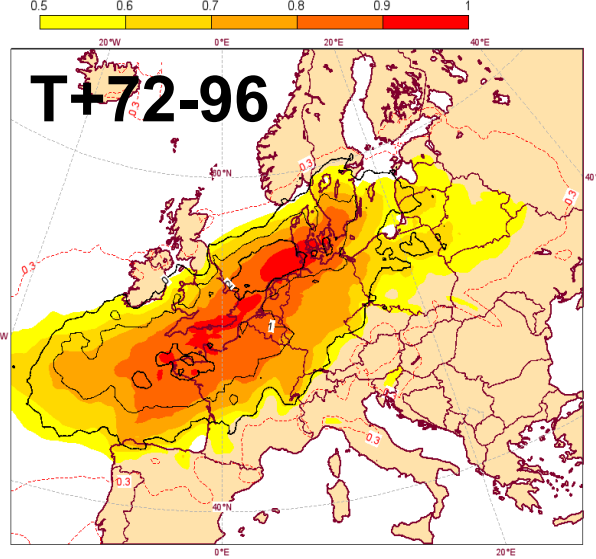
Wed 22 May 2013 00UTC @ECMWF VT: Sat 01 Jun 2013 00UTC - Thu 06 Jun 2013 00UTC 240-360h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: total precipitation



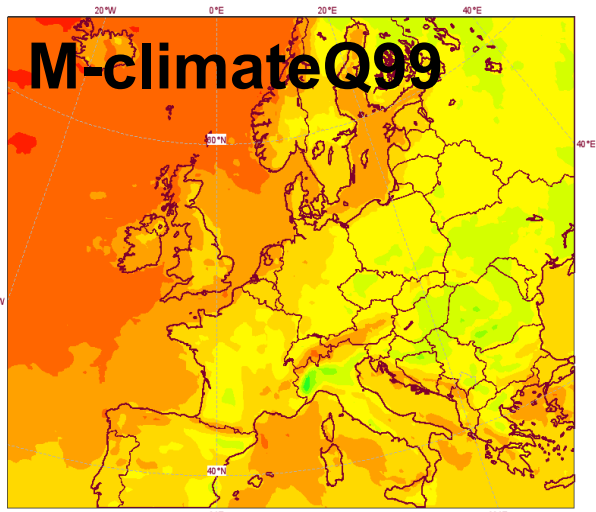
- A remarkably strong signal in the EFI.
- Positive SOT marks the areas where the forecast system predicts exceptionally heavy rain.

St. Jude storm case

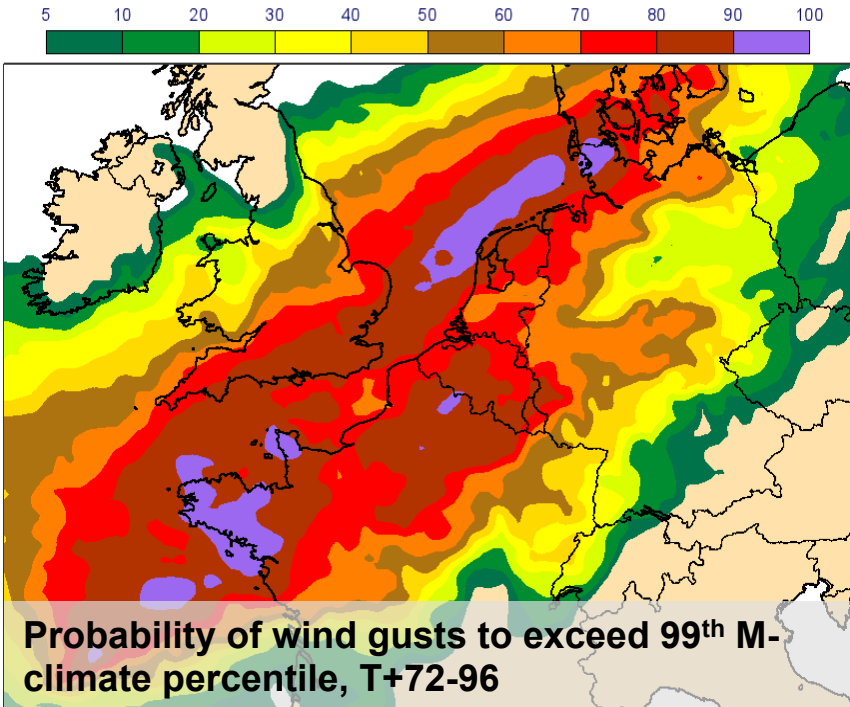
Fri 25 Oct 2013 00UTC @ECMWF expver = 1 VT: Mon 28 Oct 2013 00UTC - Tue 29 Oct 2013 00UTC 72-96h
 Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 10m wind gust



Model climate Q99 (one in 100 occasions realises more than value shown) for 10m wind gust (in m/s)

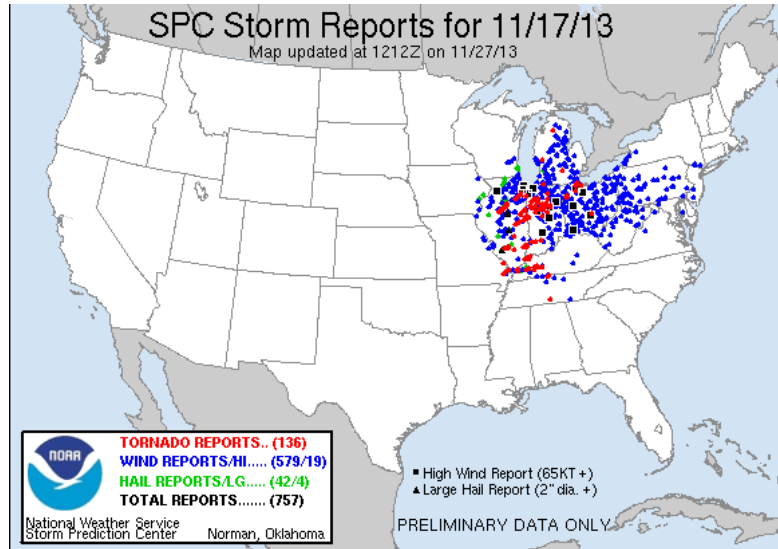


25/10/2013 00 UTC ECMWF T+72-96h VT: 28/10/2013 00 UTC - 29/10/2013 00 UTC
 Probability of 10-metre wind gusts to exceed 99-th M-climate percentile

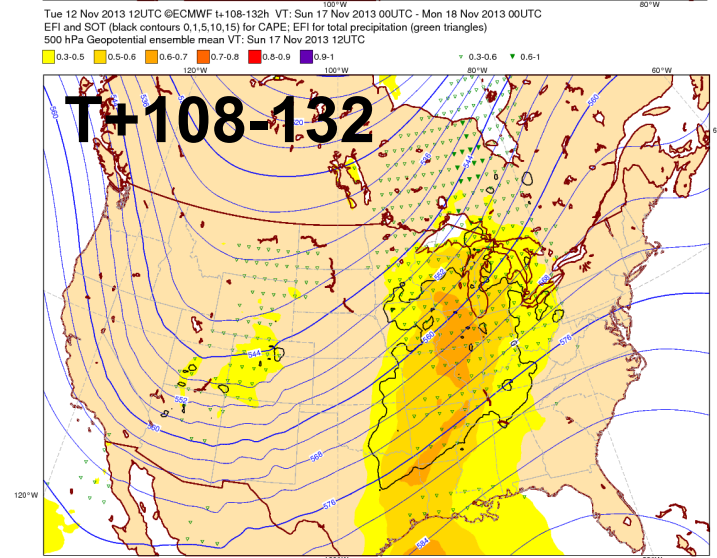
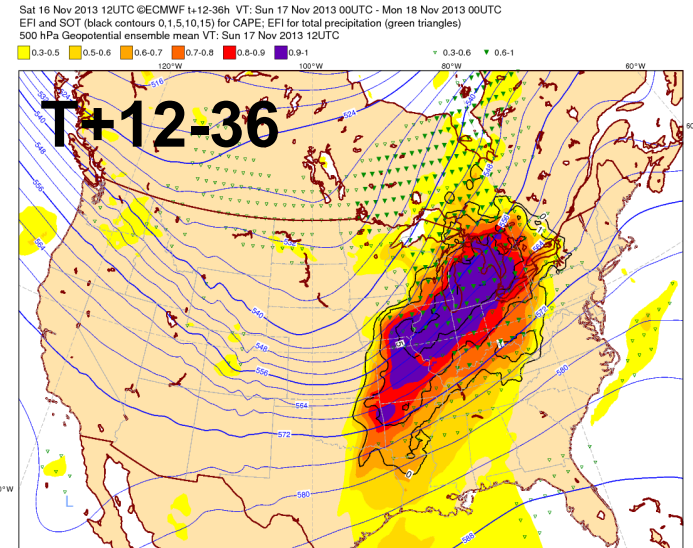


- **M-climate can be used to compute probabilities of exceeding/not exceeding certain M-climate percentiles.**

EFI and SOT for CAPE (experimental)



- Several sates in Midwest of the USA were affected by severe convection and tornadoes that killed at least six people on the 17th Nov 2013.
- EFI warned of abnormally high values of CAPE several days in advance.





Further Reading:

- “Application of the new EFI products to a case of early snowfall in Central Europe”, *ECMWF Newsletter* No. 133 – Autumn 2012, p. 4
- “Early warnings for severe weather” at http://www.ecmwf.int/newsevents/meetings/forecast_products_user/Presentations2012/