

Forecasting Extreme Events



Ivan Tsonevsky,

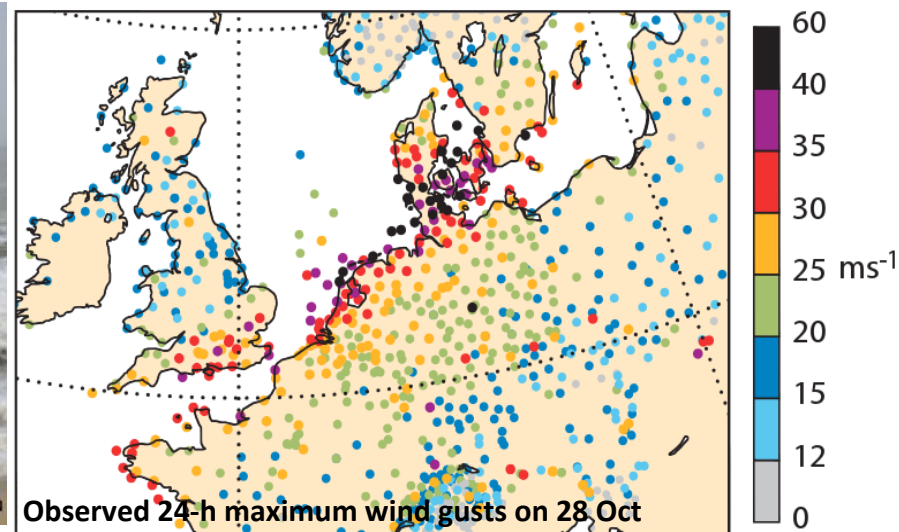
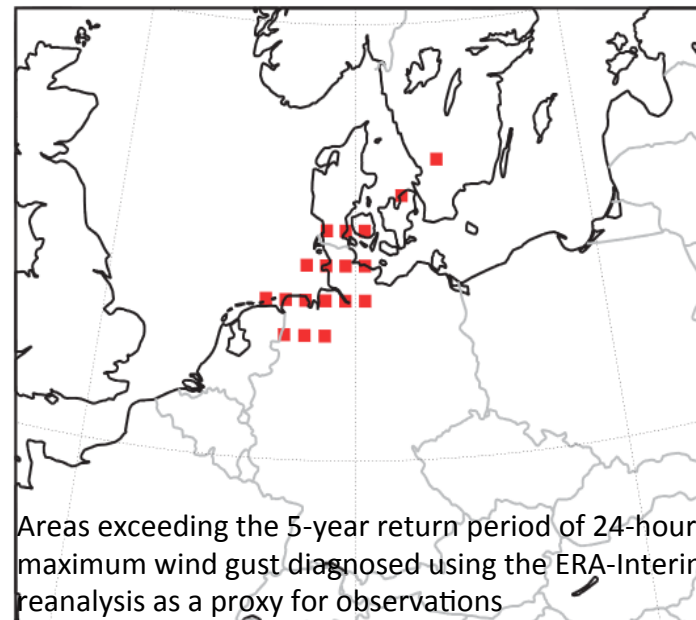
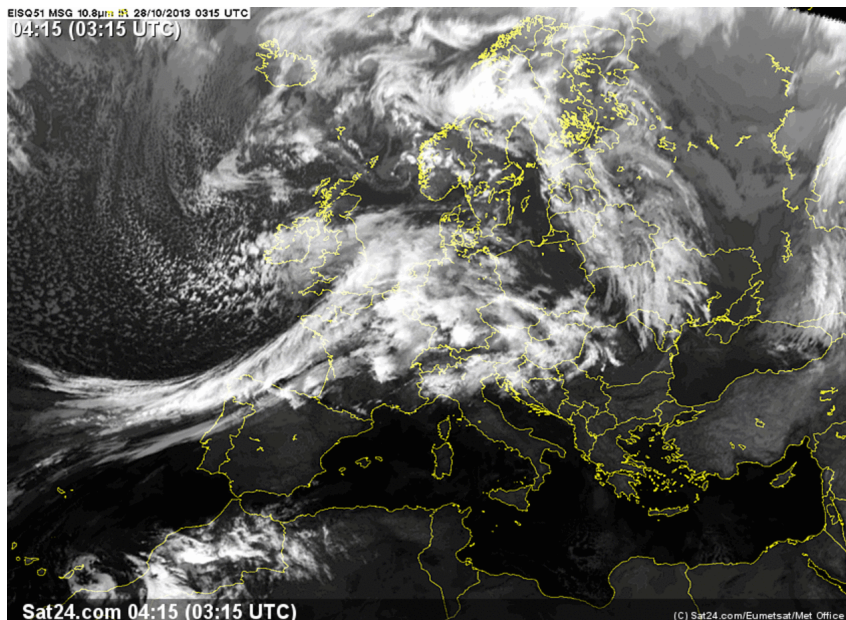
ivan.tsonevsky@ecmwf.int

Use and interpretation of ECMWF products, Jan-Feb 2015

Outline

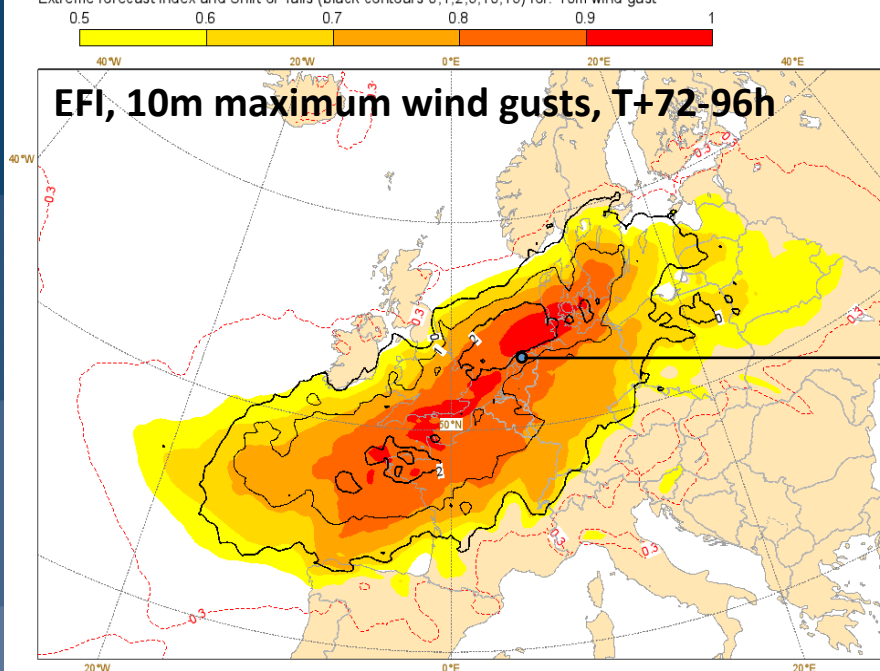
- **An example of severe weather – St. Jude Storm**
- **Extreme Forecast Index (EFI) and the Model climate (M-climate)**
- **Shift Of Tails (SOT) – an index to complement EFI**
- **A case study: extreme cold, US**
- **Operational products and verification**
- **Forthcoming changes**
- **Recent development - EFI for convection**

St Jude Storm, 27-28 Oct 2013



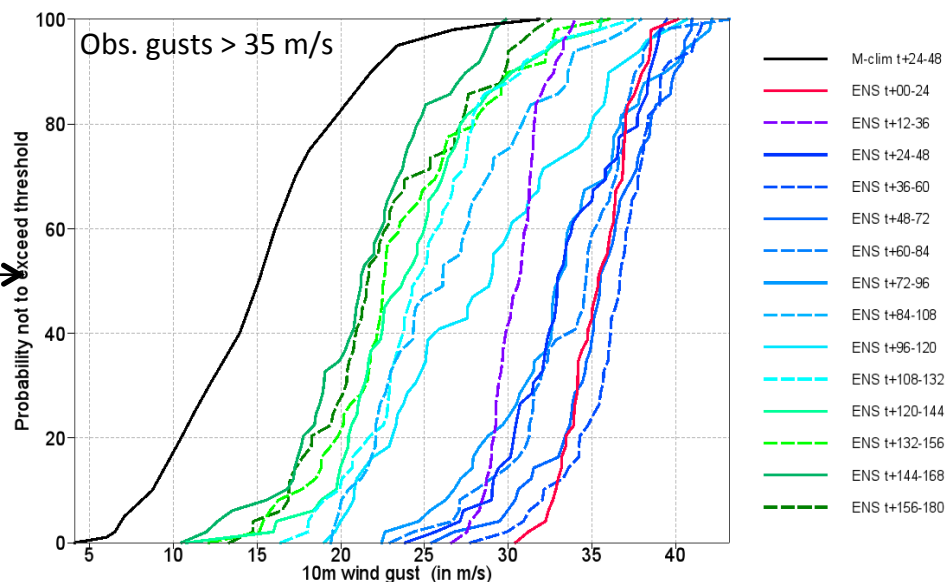
St Jude Storm, 27-28 Oct 2013

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

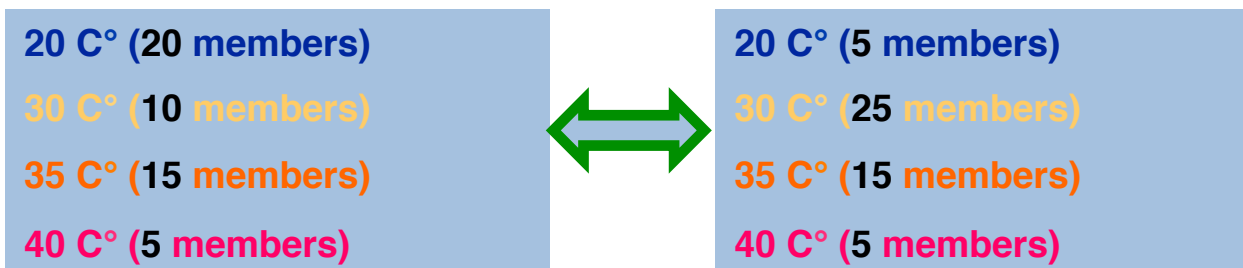


- EFI indicated a risk of a windstorm in the medium range. Positive SOT (black contours) showed that an exceptionally strong windstorm was likely.
- There was a sign of windier-than-normal conditions 7 days in advance with the last 7 runs predicting extreme wind (see CDF).

Windstorms in northwest Europe in late 2013, *ECMWF Newsletter No. 139*, 22-28

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.



The Model Climate (M-Climate)

For climate related products like the EFI a reliable model climate is essential.

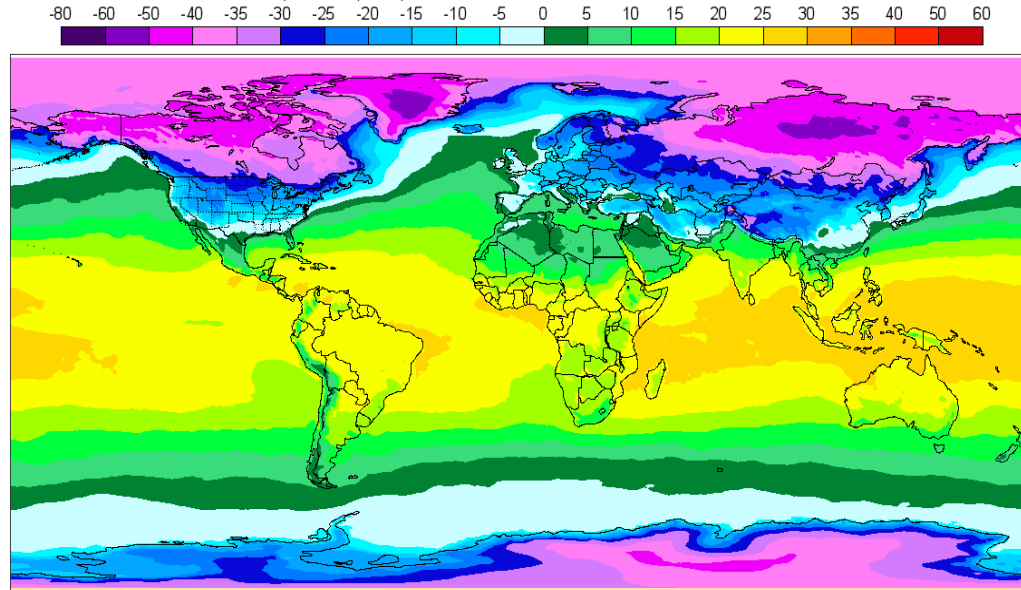
Ideally the model climate (M-Climate) is a large set of ensemble re-forecasts with the latest model configuration (used operationally) for a long enough period (e.g. 30 years).

The current M-climate in use:

- Running an ensemble re-forecast suite with 4 perturbed ensemble members and the Control
- Always for the most recent 20 years with initial conditions taken from the ECMWF global atmospheric reanalysis ERA-Interim
- Currently runs every Thursday (therefore climate files are available only for Thursdays. For days in between Thursdays the closest preceding Thursday's files are taken)
- Model run for 32 days, post-processed fields as for ENS (data every 6 hours)
- Uses the latest model cycle (resolution/ physics / etc.)
- Allows an immediate adaptation of the EFI and other model climate related products to any upgrade of ENS

Model climate (M-climate)

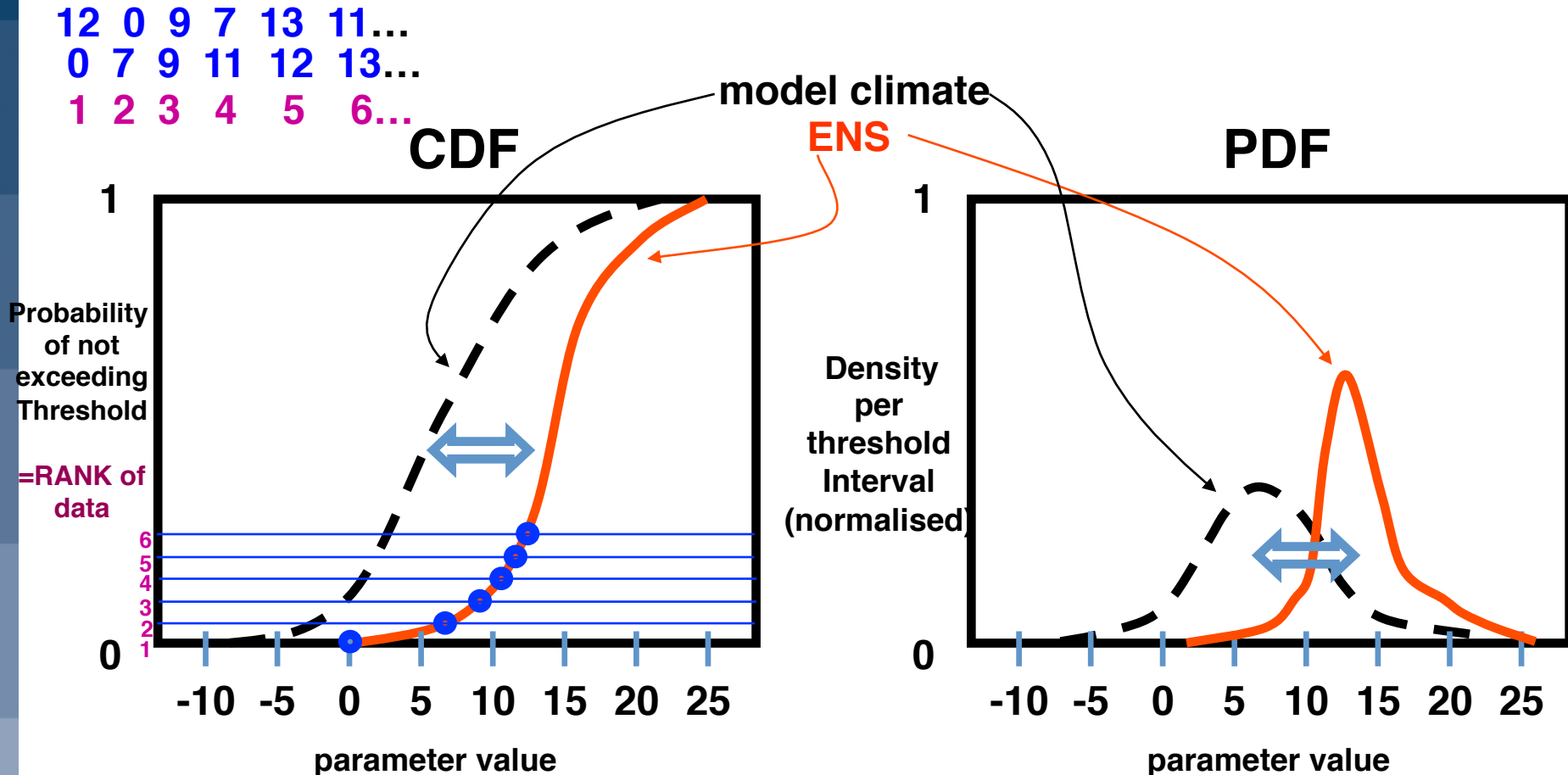
Thu 15 Jan 2015 00UTC: ©ECMWF lead time: 00-24h
Model climate Q1 for 2m mean temperature (in °C)



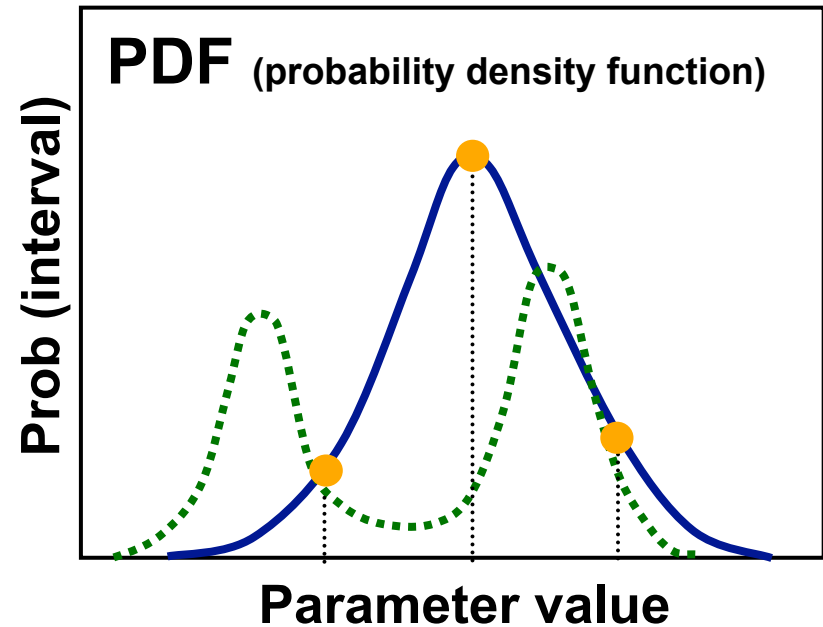
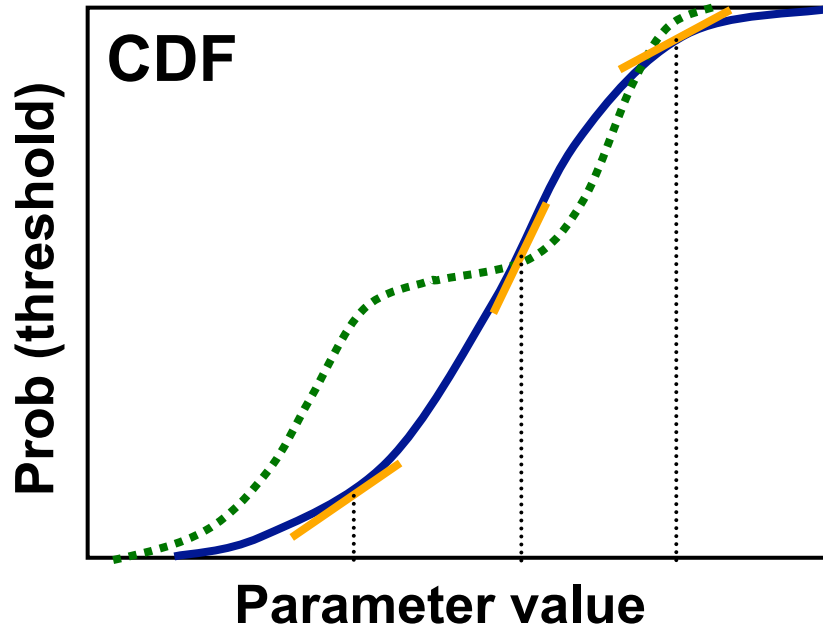
- To provide a robust, less noisy M-Climature, we do not use just one set of re-forecasts, but five sets centred on the week in question (increasing the sample size by a factor of 5)...
- M-climate sample size is: 20 years * 5 ensemble members * 5 weekly runs = 500 re-forecast fields
- As the M-climate 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?

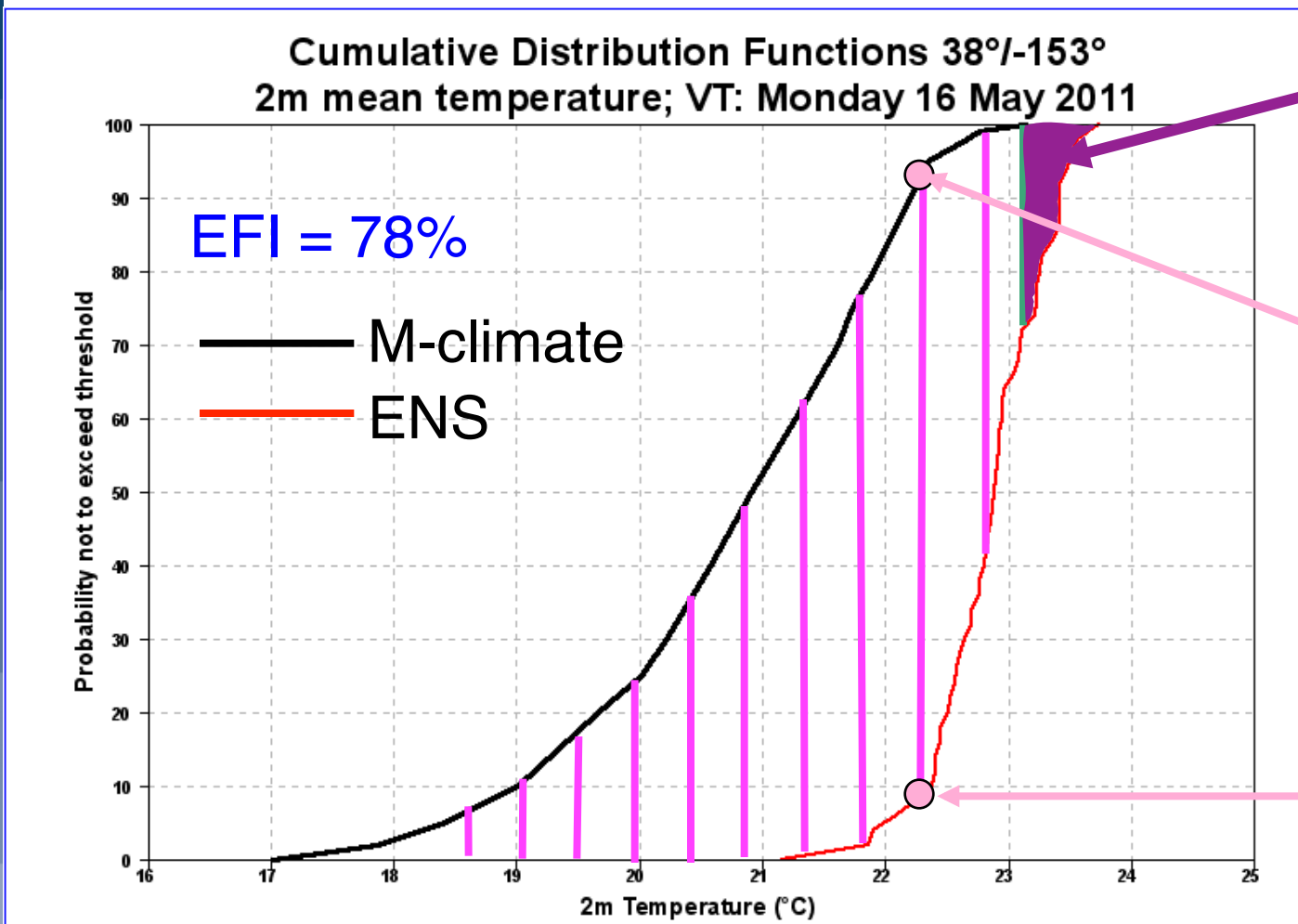


- The PDF (y-axis) value equals the slope of the CDF
- **Steeper CDF = narrower PDF = higher confidence in the forecast**
- A step in the CDF means a bimodal PDF

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

Represented by pink lines below

More weight to extremes of M-climate



EFI takes no direct account of any ENS members beyond the M-climate extremes

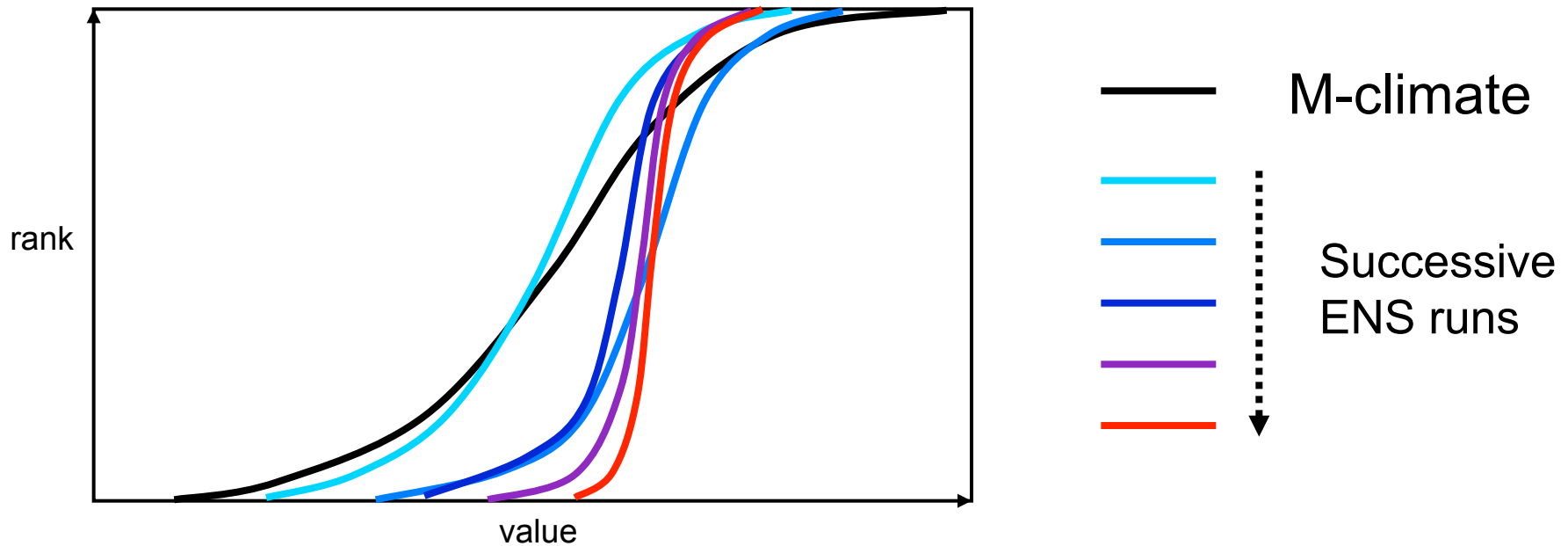
p

$-1 \leq EFI \leq 1$

$-100\% \leq EFI \leq 100\%$

$F_f(p)$

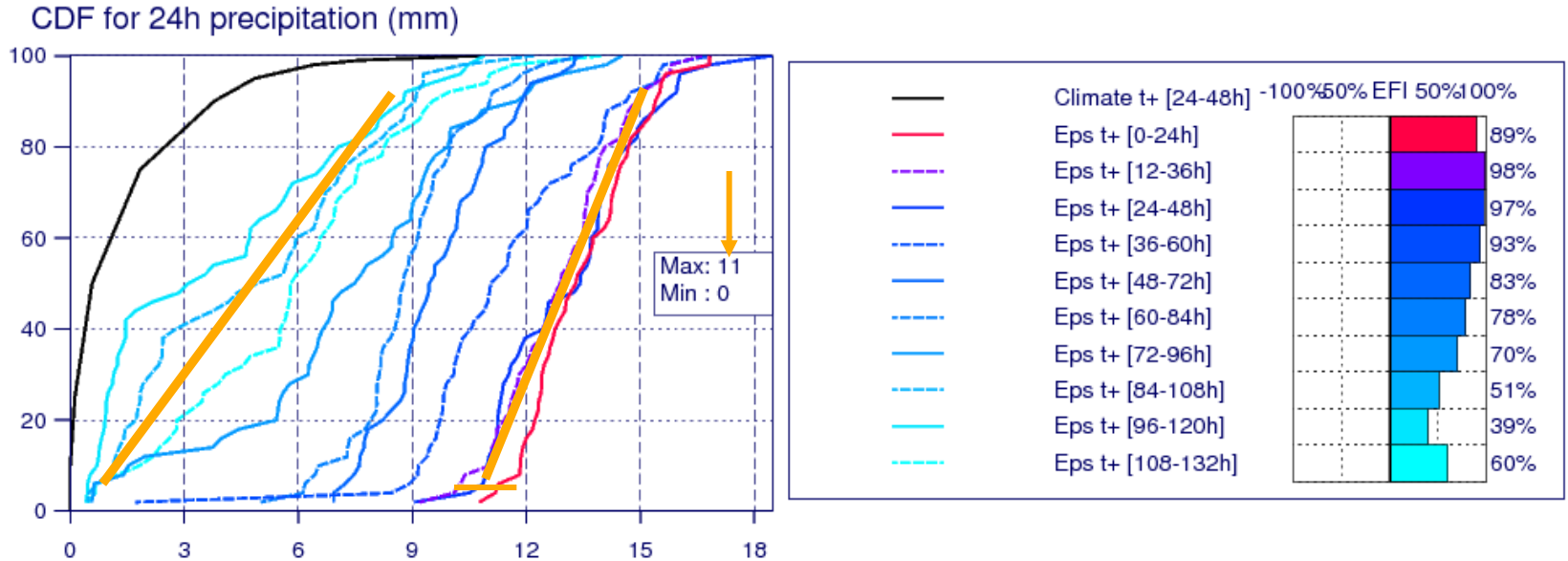
How 'should' CDFs behave in successive ENS runs?



- 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.

An example

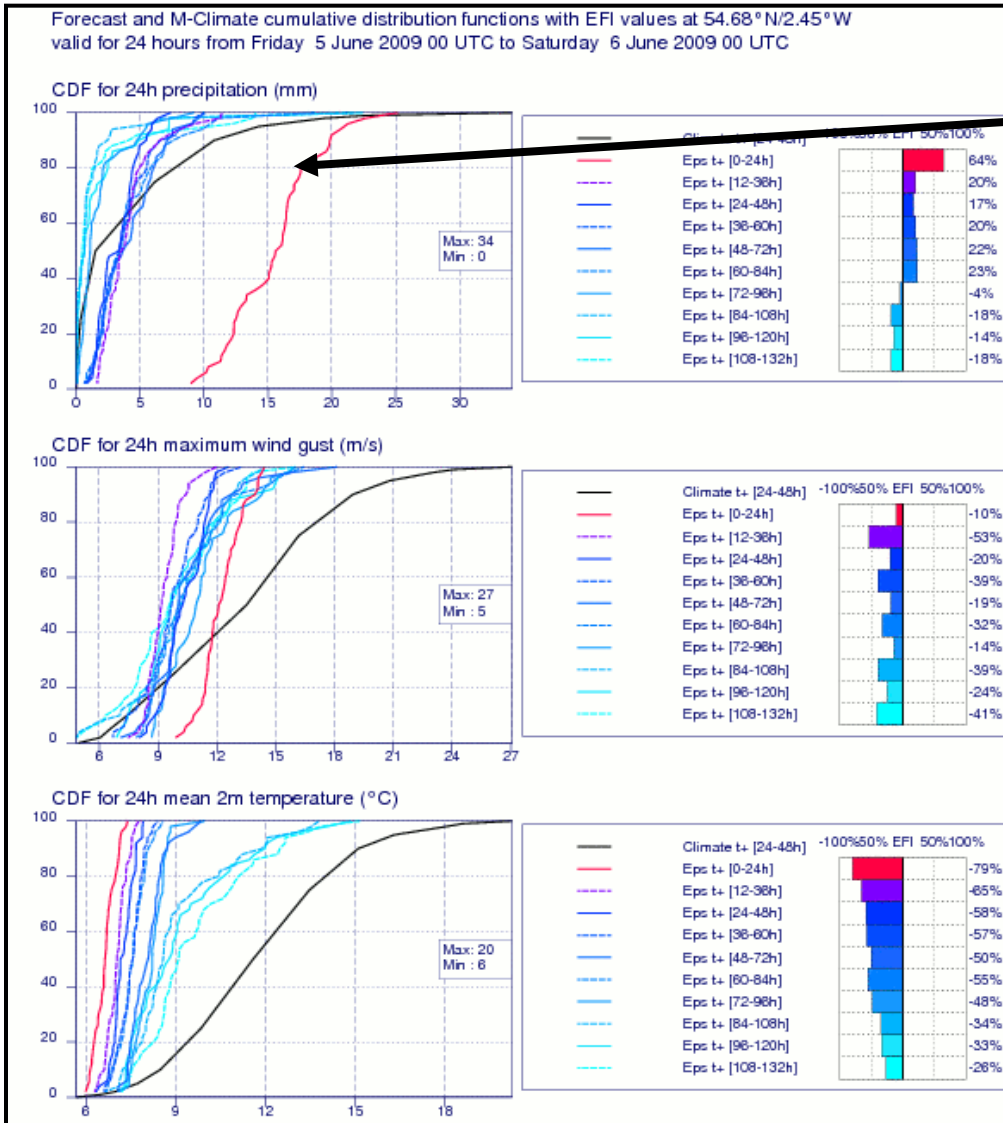
Forecast and M-Climate cumulative distribution functions with EFI values at 59.09°N/41.69°E valid for 24 hours from Monday 4 February 2013 00 UTC to Tuesday 5 February 2013 00 UTC



- 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

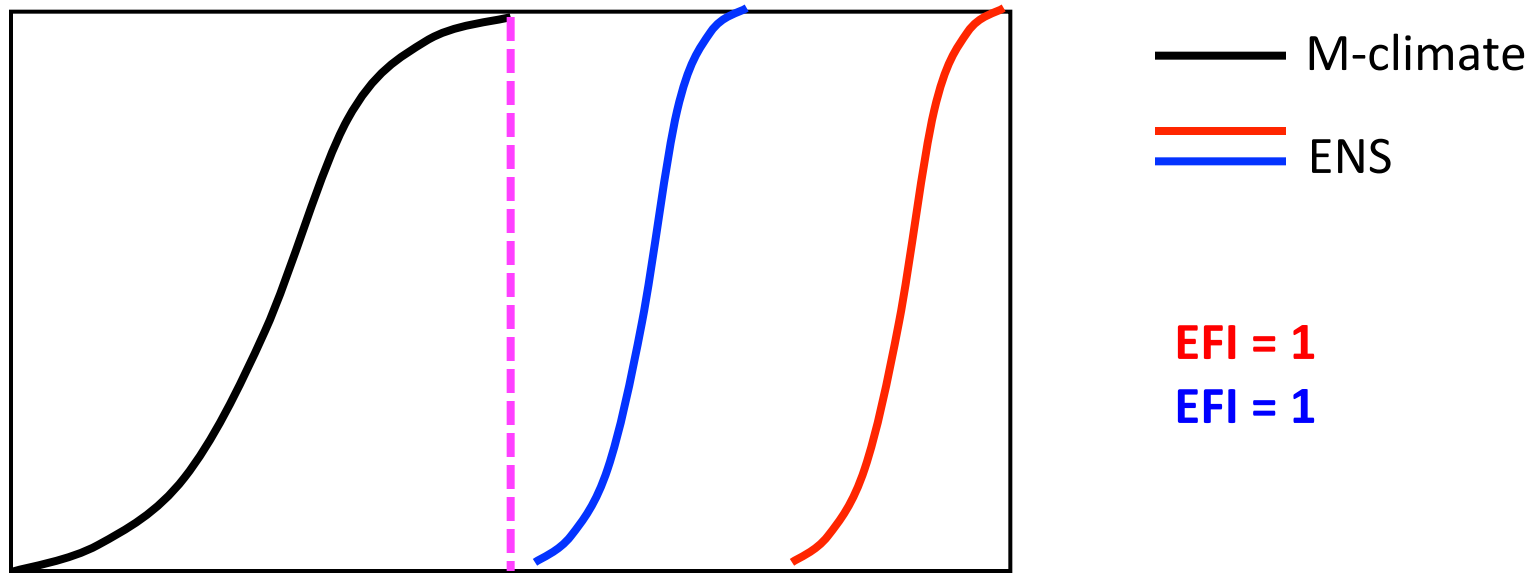
- N England rain – June '09 - low prob alternative became likely at short range.



Some limitations

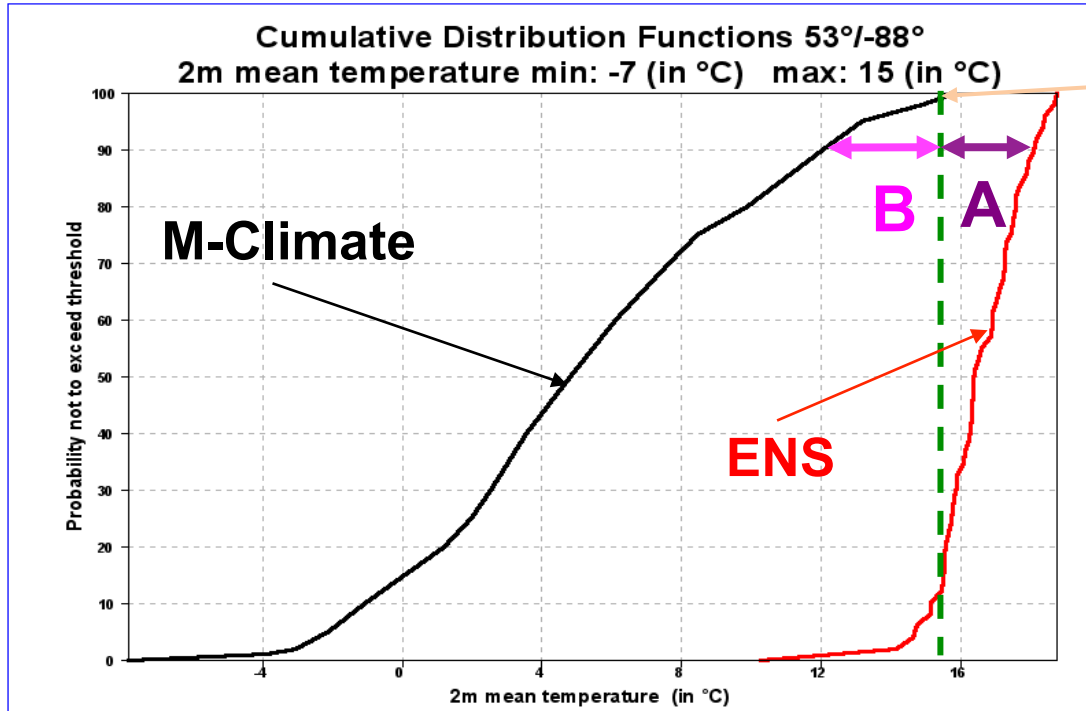
- Extreme does not *necessarily* mean high impact (eg 2mm rain in the desert)
- Past history also important but not directly accounted for (eg heavy rain when ground saturated)
- Windstorm impact can depend on whether trees are in leaf, whether ground is saturated...
- Products are only as good as the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

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)



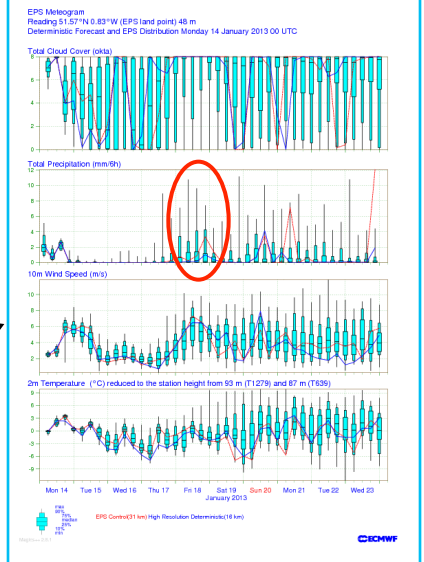
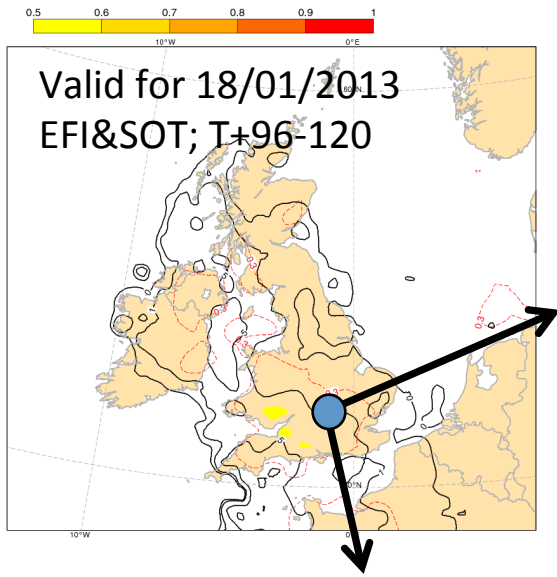
$Q_c(99)$

$$SOT = A/B$$

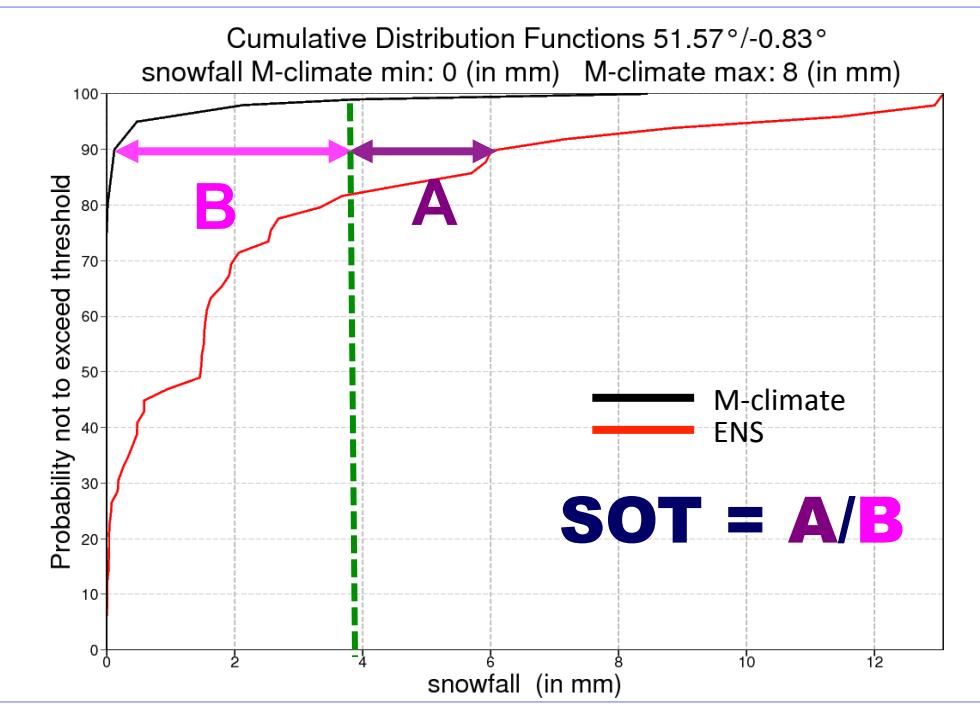
$$A = Q_f(90) - Q_c(99)$$

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

- 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
- $SOT > 0 \rightarrow$ 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):

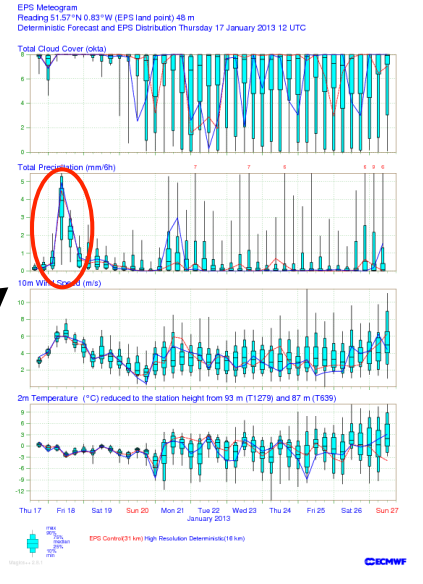
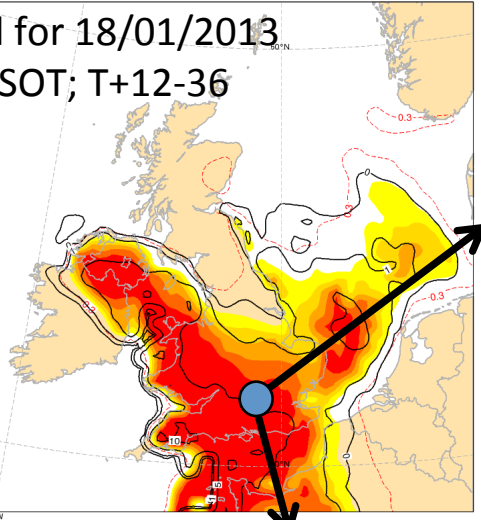
- ✓ EFI = 0.36
- ✓ SOT = 0.8

EFI positive → forecast suggests some snow

SOT > 0 → there are ENS members predicting extreme snowfall but the forecast is still uncertain (low EFI)



Valid for 18/01/2013
 EFI&SOT; T+12-36



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

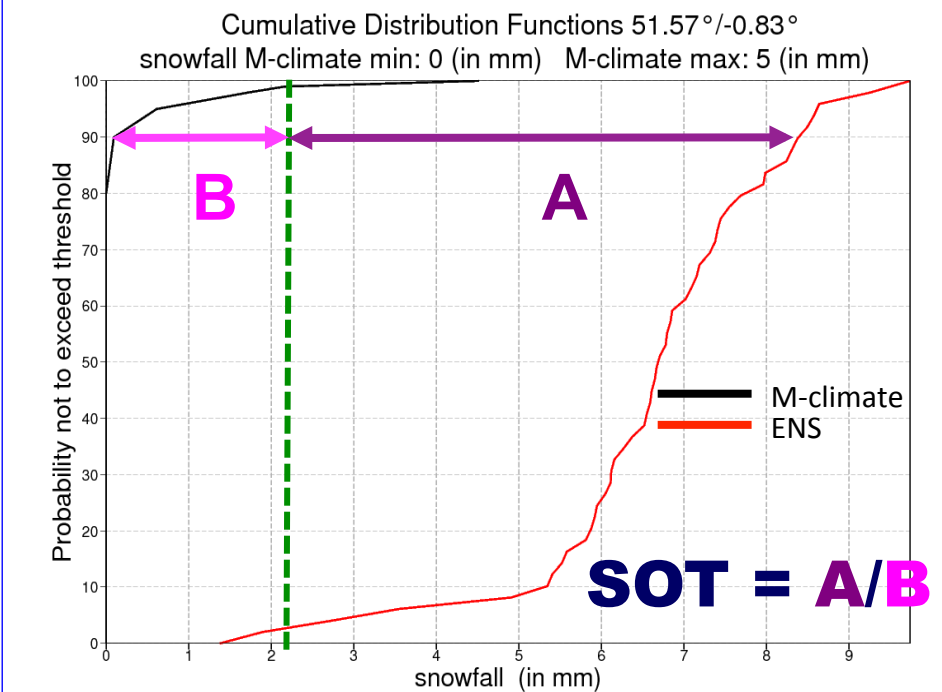
A band of snow, heavy in places, will spread northeastwards across Wales and the south western half of England, during Friday morning, lasting through the afternoon and evening across much of Wales, the Midlands, southern and parts of southeast England. Winds will strengthen, leading to drifting of lying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

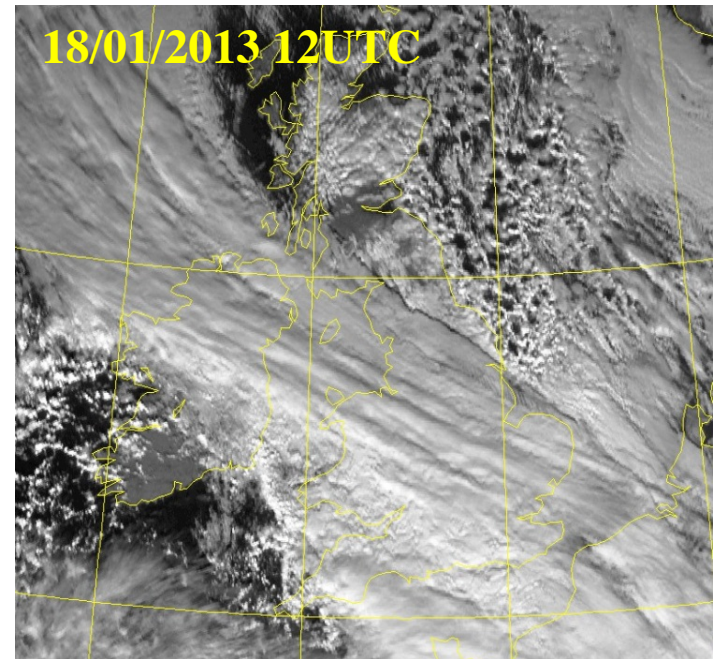
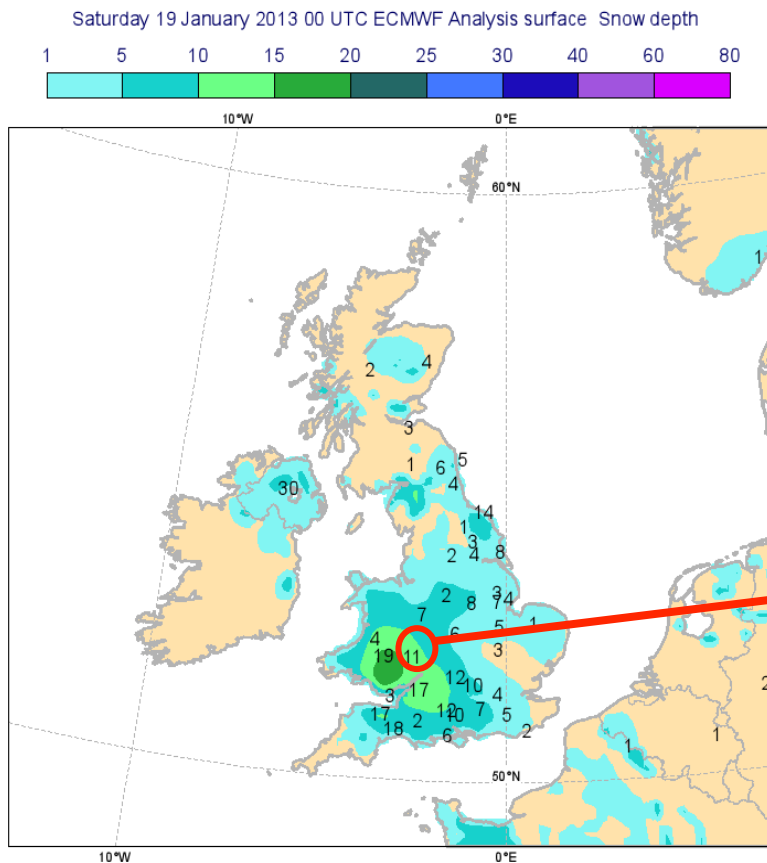
Provided by
 Met Office



- 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).

The outcome

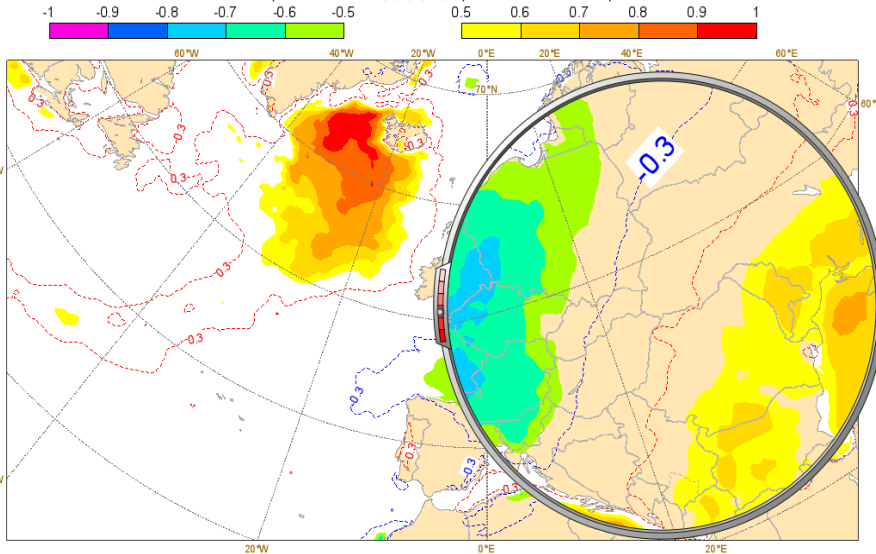
ECMWF snow depth analysis and observations representing the new snow depth for 24-h period from 18/01/2013 00UTC to 19/01/2013 00UTC



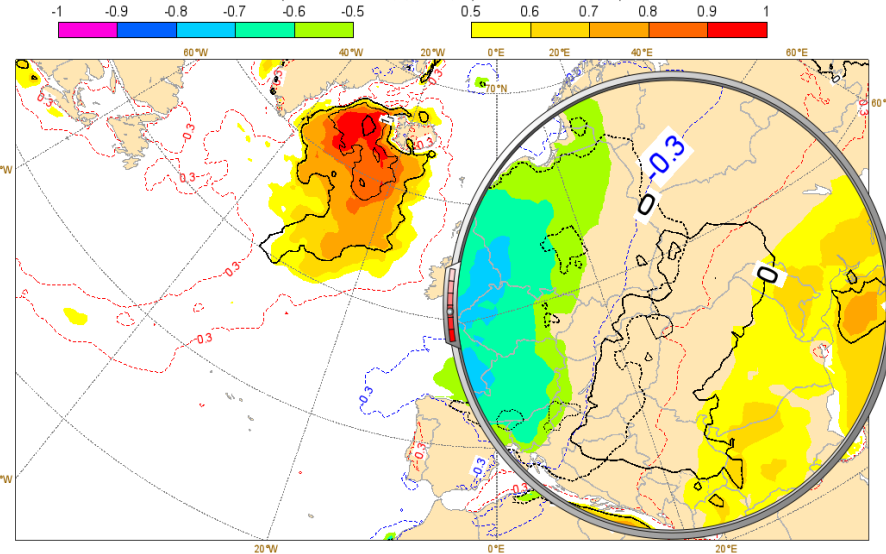
A beer garden in Bromsgrove. Credit: Sue Eden

A case of large uncertainty

Sun 15 Jul 2012 12UTC @ECMWF expver = 1 VT: Sun 22 Jul 2012 00UTC - Mon 23 Jul 2012 00UTC 156-180h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 2m maximum temperature



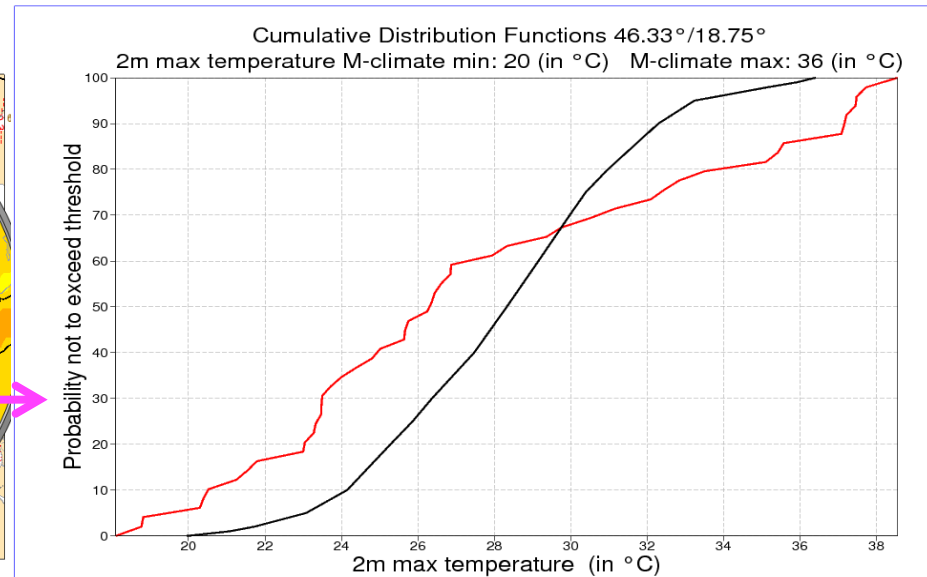
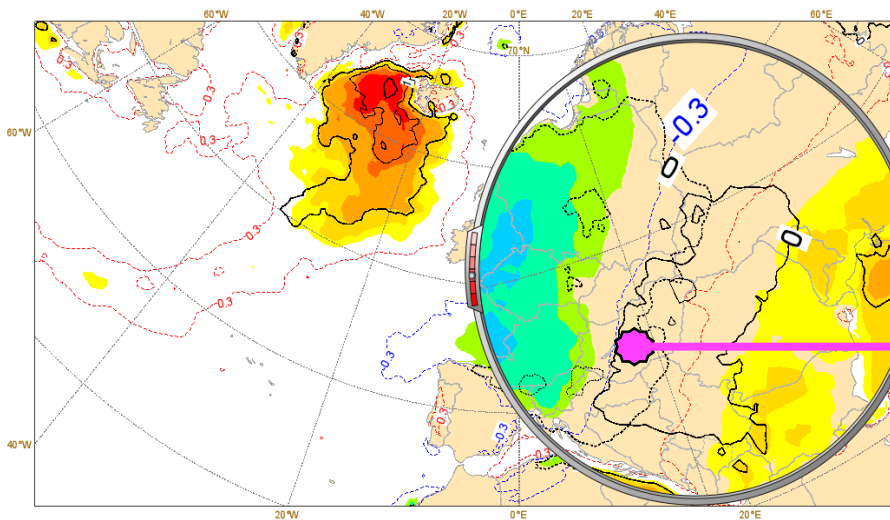
Sun 15 Jul 2012 12UTC @ECMWF expver = 1 VT: Sun 22 Jul 2012 00UTC - Mon 23 Jul 2012 00UTC 156-180h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 2m maximum temperature



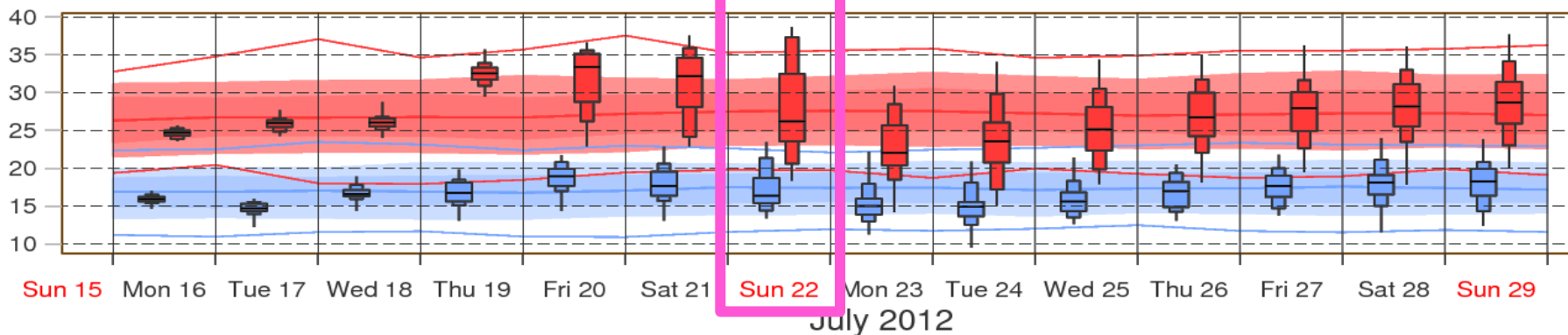
- EFI forecast shows cold conditions over Central Europe and hot weather to the east over the Balkans.
- SOT gives additional information. In the area between the cold and hot weather SOTs overlap. This is a signal of very uncertain forecast – over that area extremely low and extremely high temperatures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

A case of large uncertainty

Sun 15 Jul 2012 12UTC @ECMWF expver = 1 VT: Sun 22 Jul 2012 00UTC - Mon 23 Jul 2012 00UTC 156-180h
 Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 2m maximum temperature



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

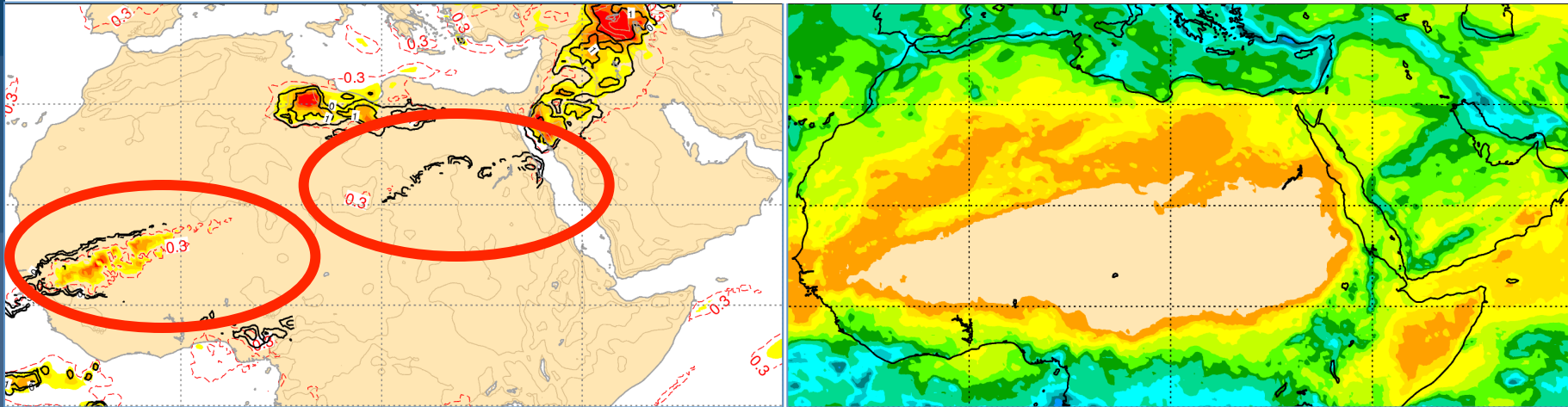
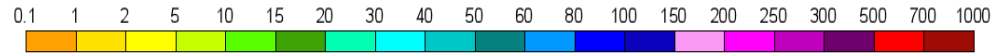


Some ENS members predict maximum temperature below the M-climate minimum, but some – above the M-climate maximum!

Some limitations

EFI & SOT for 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 arbitrarily set to -1 where not defined only for plotting purposes.

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, maxswhi

- 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

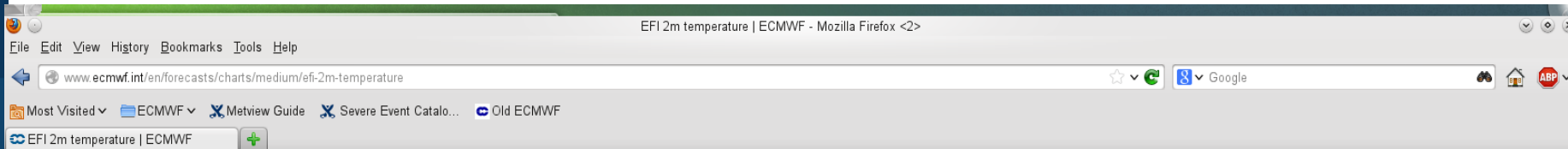
- 00 UTC: 00-72, 24-96, 48-120, 72-144, 96-168, 120-192, 144-216
- 12 UTC: 12-84, 36-108, 60-132, 84-156, 108-180, 132-204, 156-228

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)



About Forecasts Computing Research Learning **OFF** Ivan Tsonevsky Search site Go

EFI 2m temperature

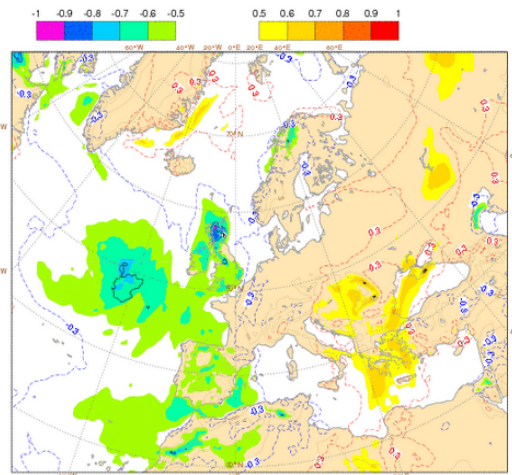
- Charts
- Datasets
- Quality of our forecasts
- Software and tools
- Documentation and support
- Accessing forecasts
- Back to charts

Forecast base time Area Quantile Day

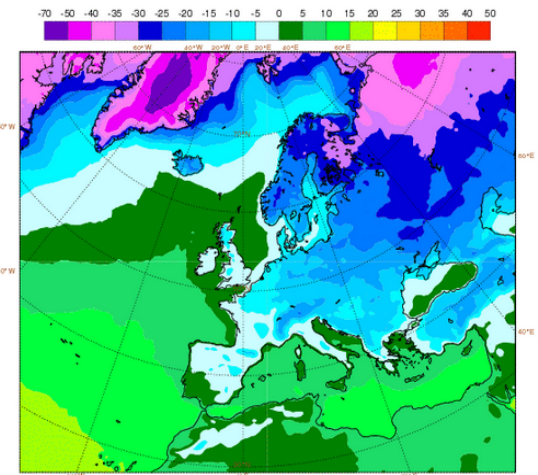


- Extreme forecast index**
- EFI 2m temperature
- EFI 2m minimum temperature
- EFI 2m maximum temperature
- EFI wind gust
- EFI wind speed
- EFI precipitation
- EFI significant wave height
- EFI snow fall
- Global EFI - multiple parameters

Mon 19 Jan 2015 00UTC @ECMWF t+0-24h VT: Mon 19 Jan 2015 00UTC - Tue 20 Jan 2015 00UTC
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for 2m mean temperature

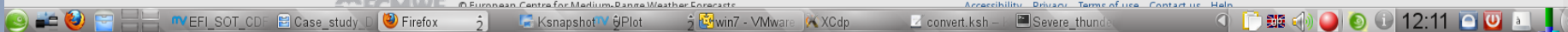


Thu 15 Jan 2015 00UTC @ECMWF VT: Mon 19 Jan 2015 00UTC - Tue 20 Jan 2015 00UTC 0-24h
2m mean temperature (in °C) Model climate Q1 (one in 100 occasions realises less than value shown)

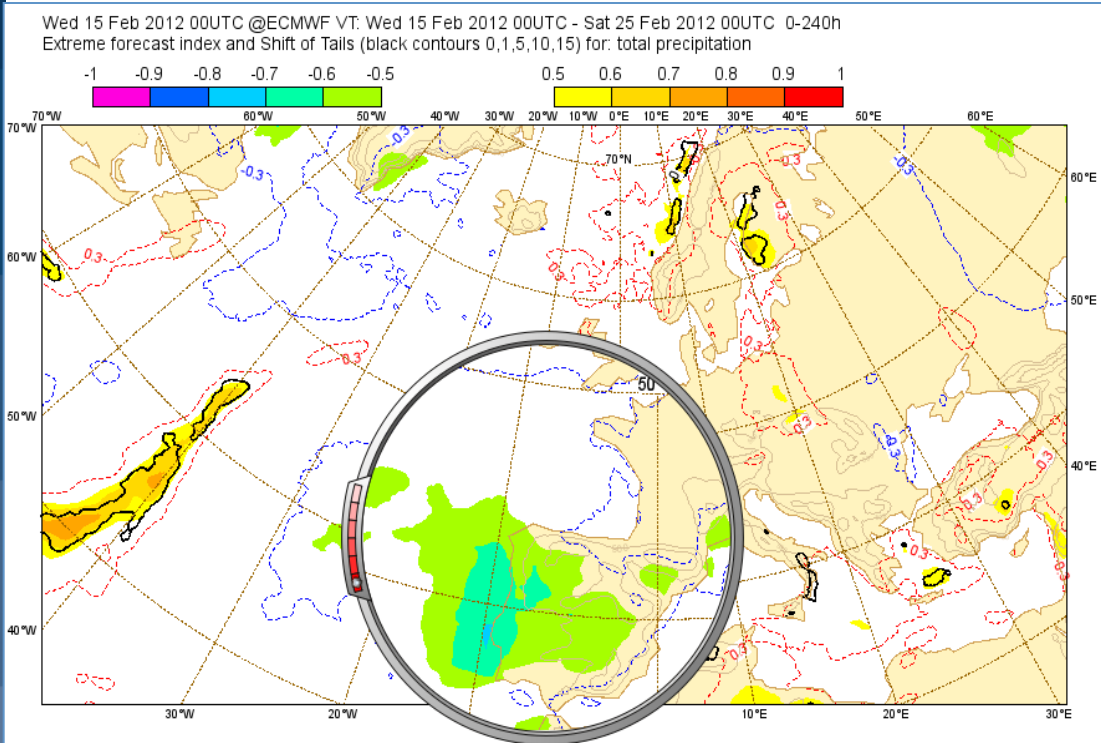


- Plot structure
- Extreme forecast index (EFI)
- Shift of tails (SOT)
- Model Climate (M-climate)
- Negative EFI values

help pages



Negative EFI for precipitation

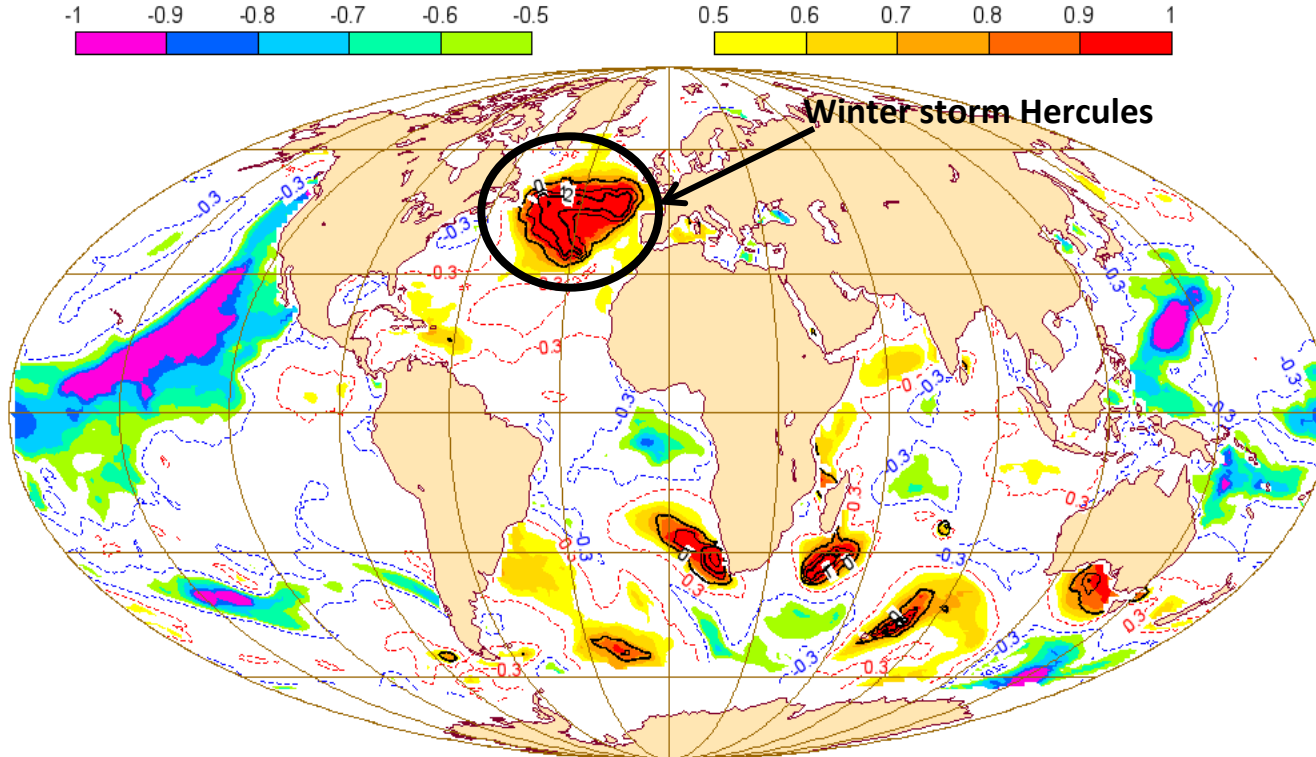


Severe drought in Portugal

- 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 risk of dry weather.

EFI for waves

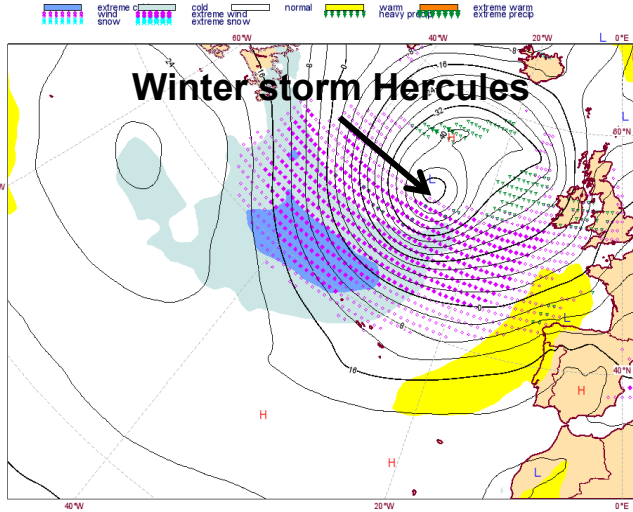
Sun 05 Jan 2014 00UTC @ECMWF expver = 1 VT: Sun 05 Jan 2014 00UTC - Mon 06 Jan 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: maximum significant wave height



- 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.

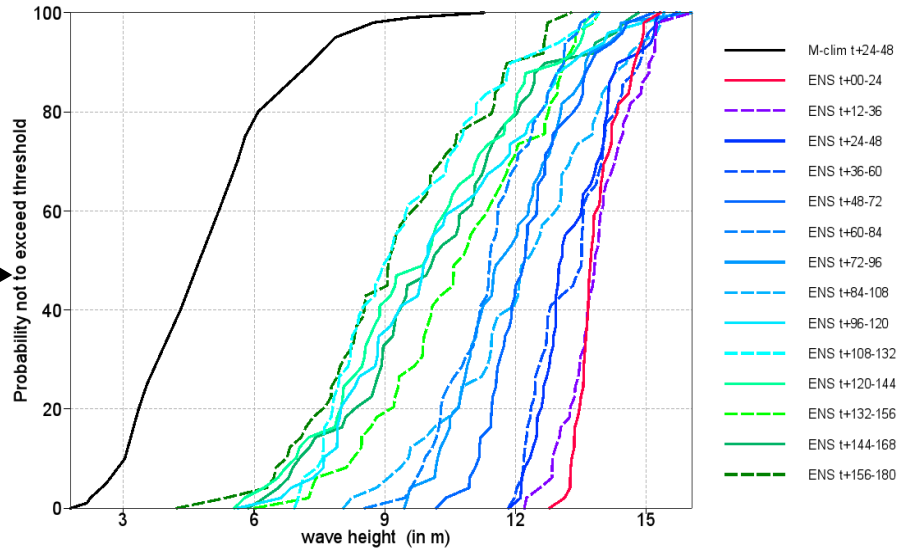
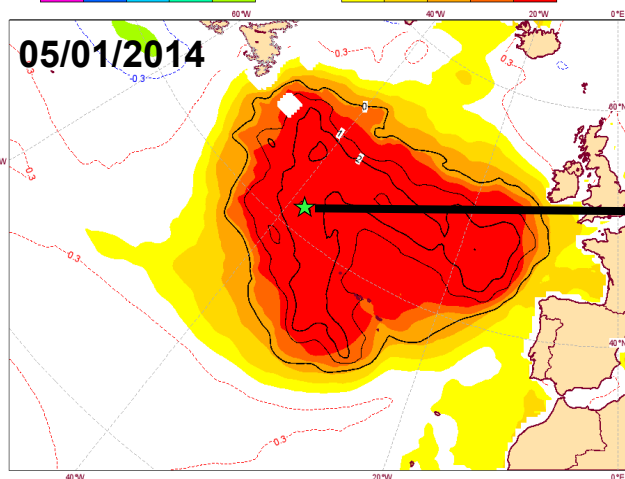
Historic swell – Storm Hercules

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 00UTC - Monday 06 January 2014 00UTC

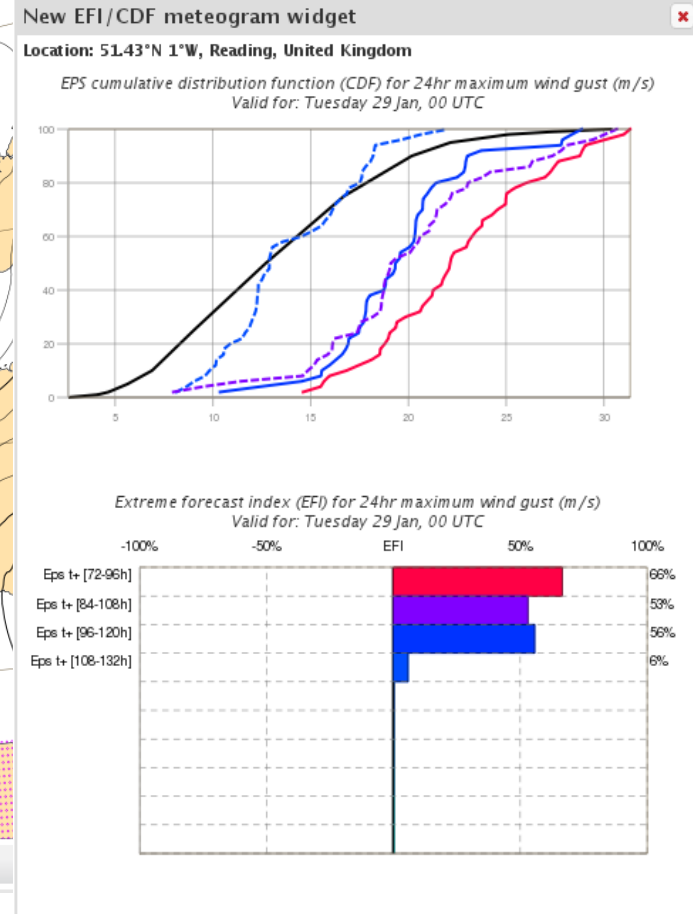
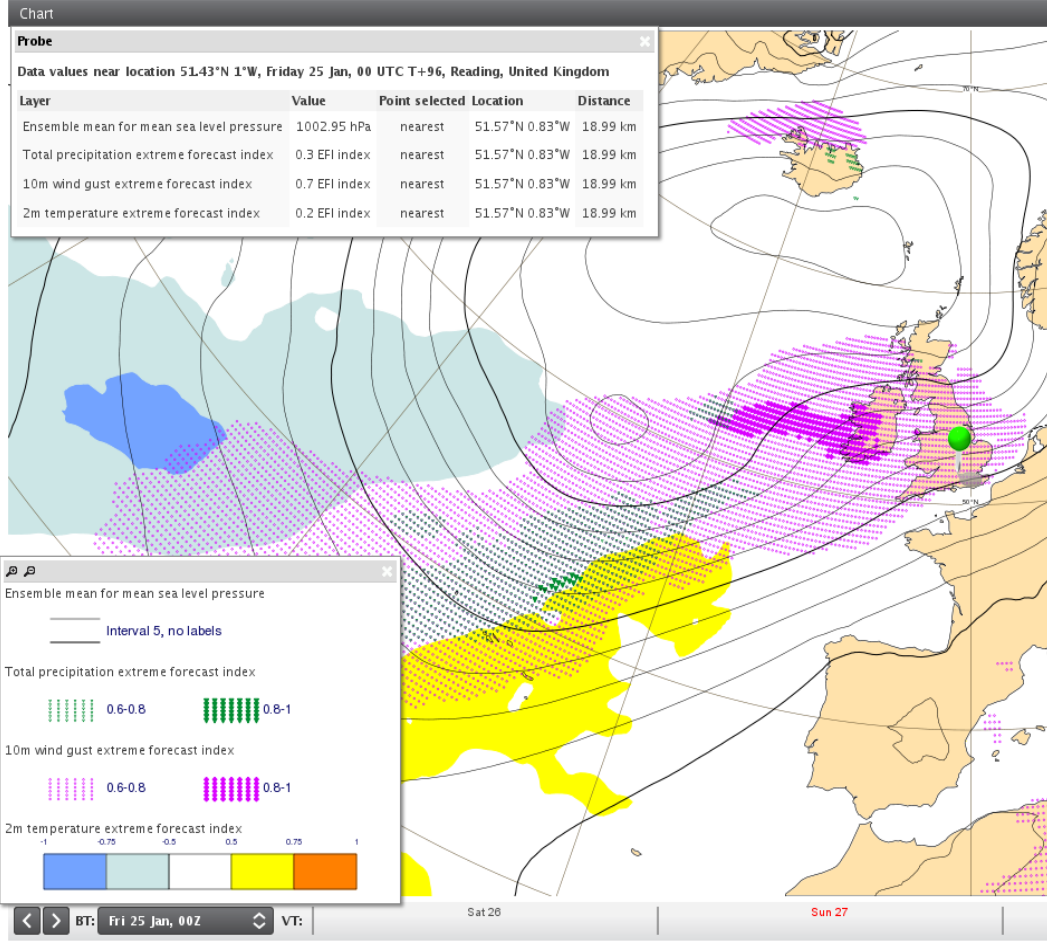


Cumulative Distribution Functions for wave height at 42.03°N-38.43° W: 05/01/2014 00UTC - 06/01/2014 00UTC

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 on the ecCharts



“Anomalous weather” map (old web)

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
Add this product

Download ...
 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

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

22-01-2013 ©ECMWF

“Anomalous weather” map (old web)

ECMWF Home Your Room Login Contact Feedback Site Map Search

About Us Overview Getting here Committees
Products Forecasts Order Data Order Software
Services Computing Archive PreplFS
Research Modelling Reanalysis Seasonal
Publications Newsletters Manuals Library
News Calendar Employ Open Te

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

Show guide

This chart is ...
Clickable

Day
 1
 2
 3
 4
 5

Area
 Global
 EUR ODS
 North America
 South America
 Asia
 Africa
 Australia

Interactive point
 10 days
 15 days
 10 days wave
 efi distribution

Your Room
 Add this product

Download ...
 PDF
 Postscript

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

Download ...
 PDF
 Postscript

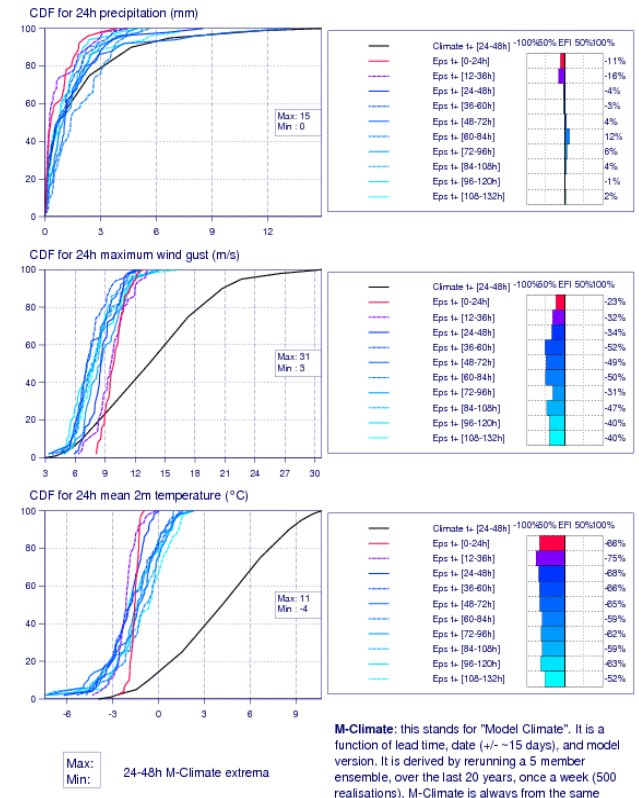
Recent clicks ...
 51.84;-1.22 (efi)
 51.84;-0.66 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (efi)
 51.72;-1.22 (15c)
 51.72;-1.22 (10)

Legend:
 extreme cold, cold, w arm, extreme w arm, wind, extreme w ind, precip, extreme pre

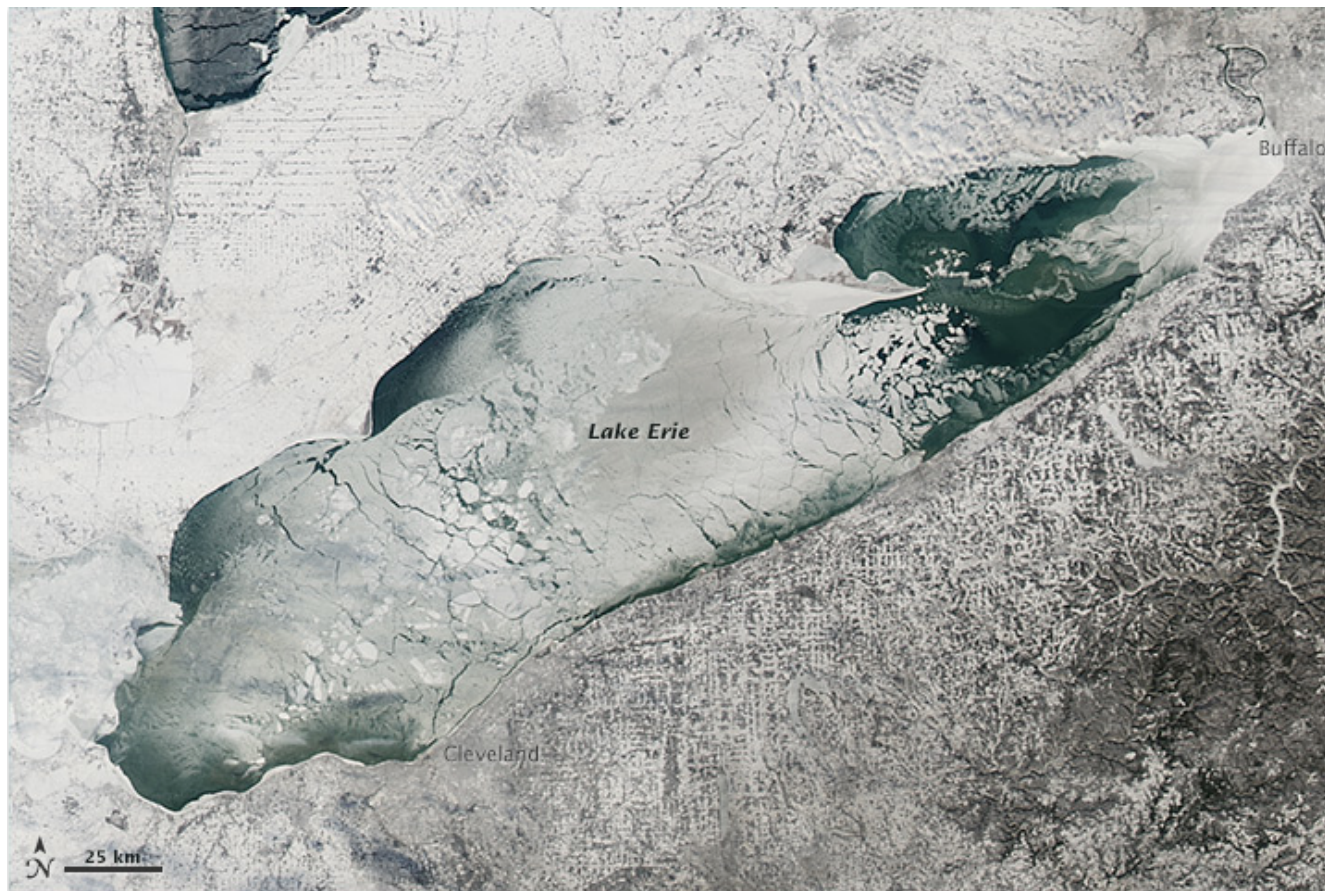
22-01-2013

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



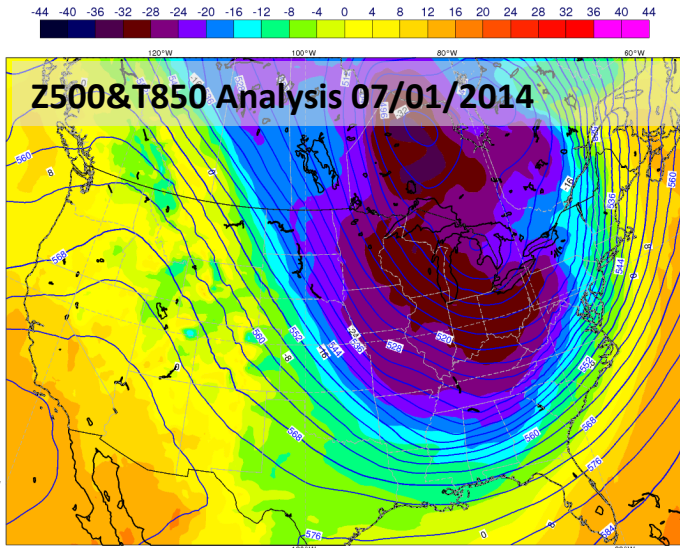
US cold snap January 2014



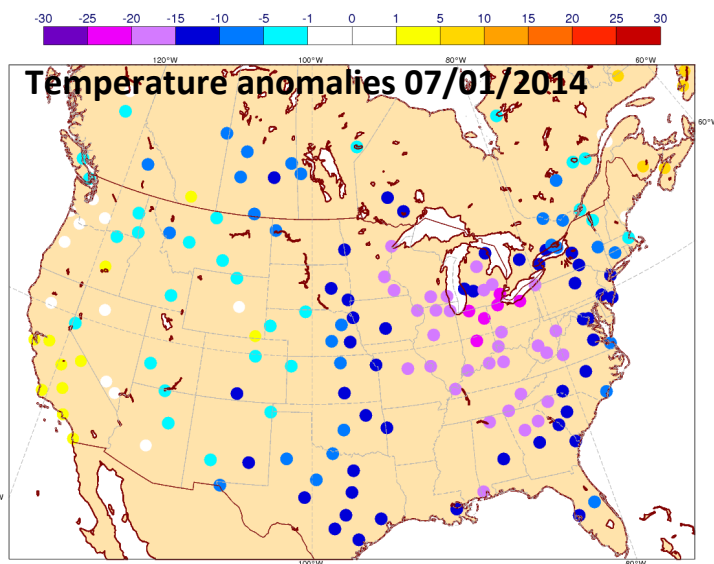
Great Lakes frozen

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

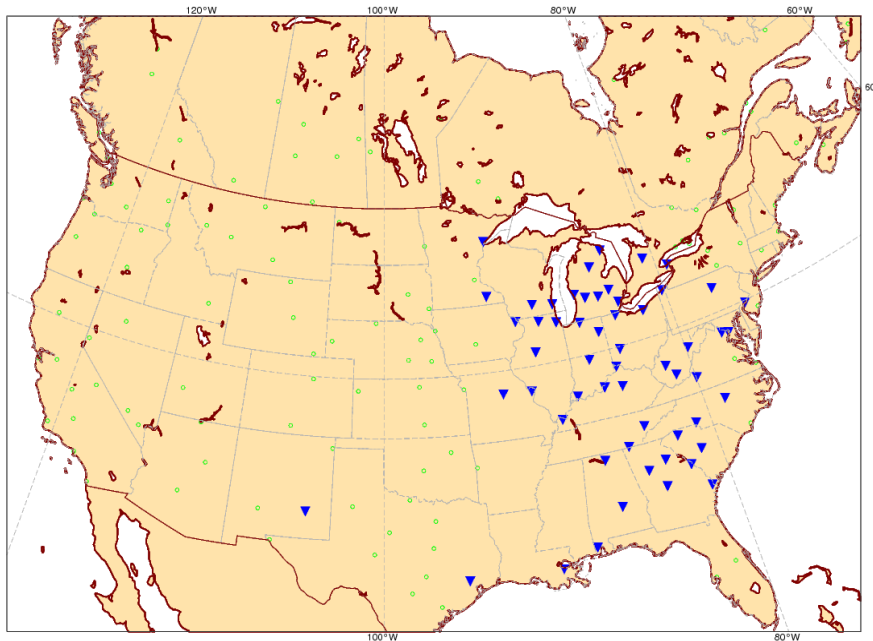


- An extremely cold airmass from the Arctic region dropped the temperatures in the US January 5-7, 2014.
- Record freezing temperatures (15 to 22C below normal) brought many cities to a standstill. Over a dozen deaths were attributed to the cold wave.
- It was the coldest weather since early February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

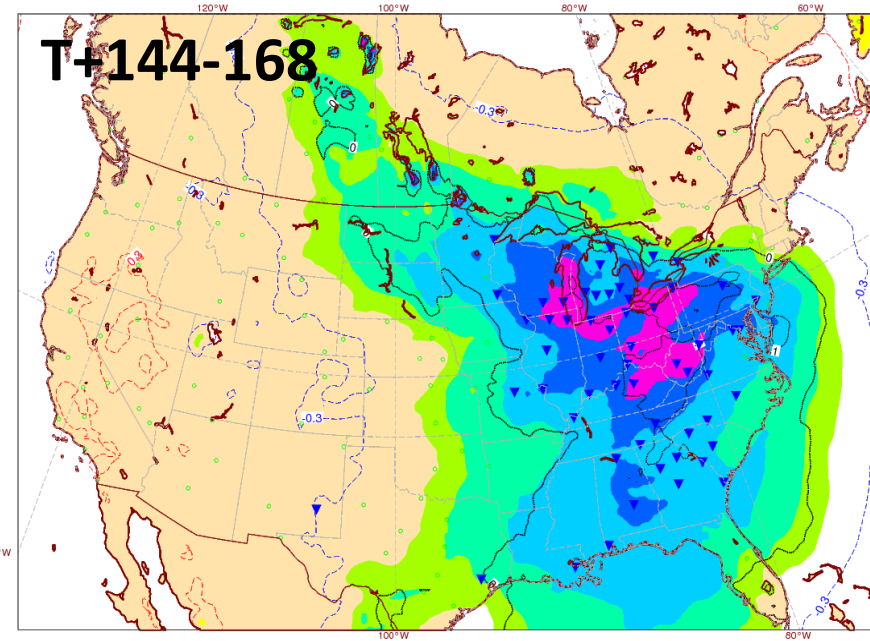
US cold snap, January 2014

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

▲ OBS>Q99 ● Q1<OBS<Q99 ▼ OBS<Q1



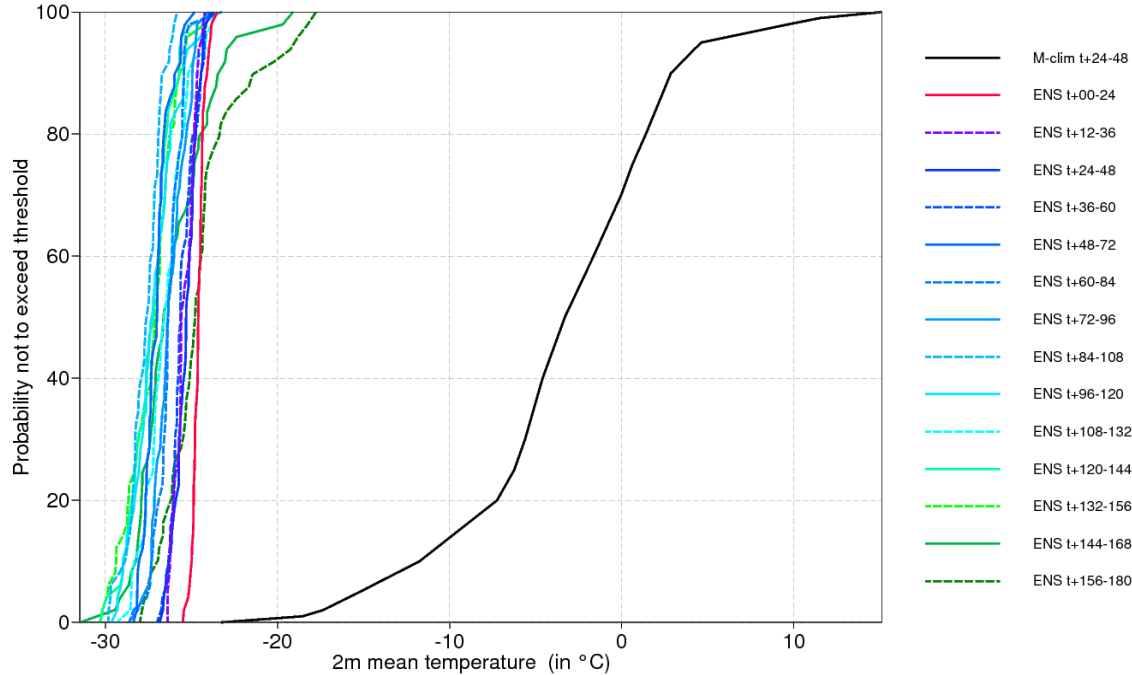
Wed 01 Jan 2014 00UTC @ECMWF expver = 1 VT: Tue 07 Jan 2014 00UTC - Wed 08 Jan 2014 00UTC 144-168h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 2m mean temperature



- 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.

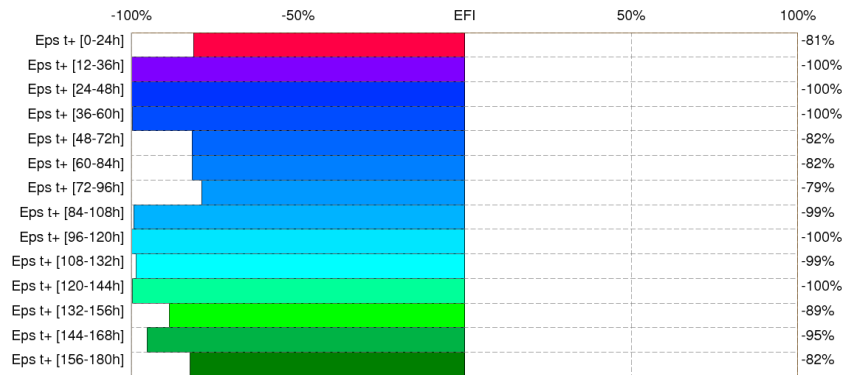
US cold snap, January 2014

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.

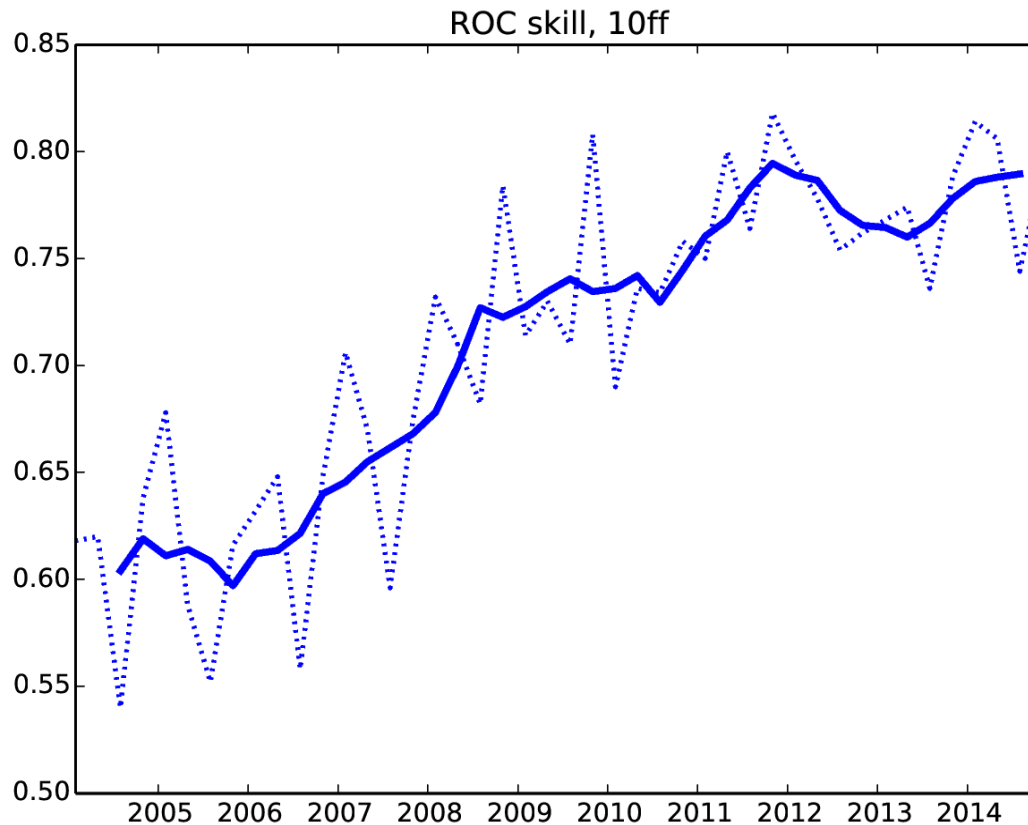
Extreme Forecast Index for 2m mean temperature at 41.98N -87.9W
Tuesday 7 January 2014



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



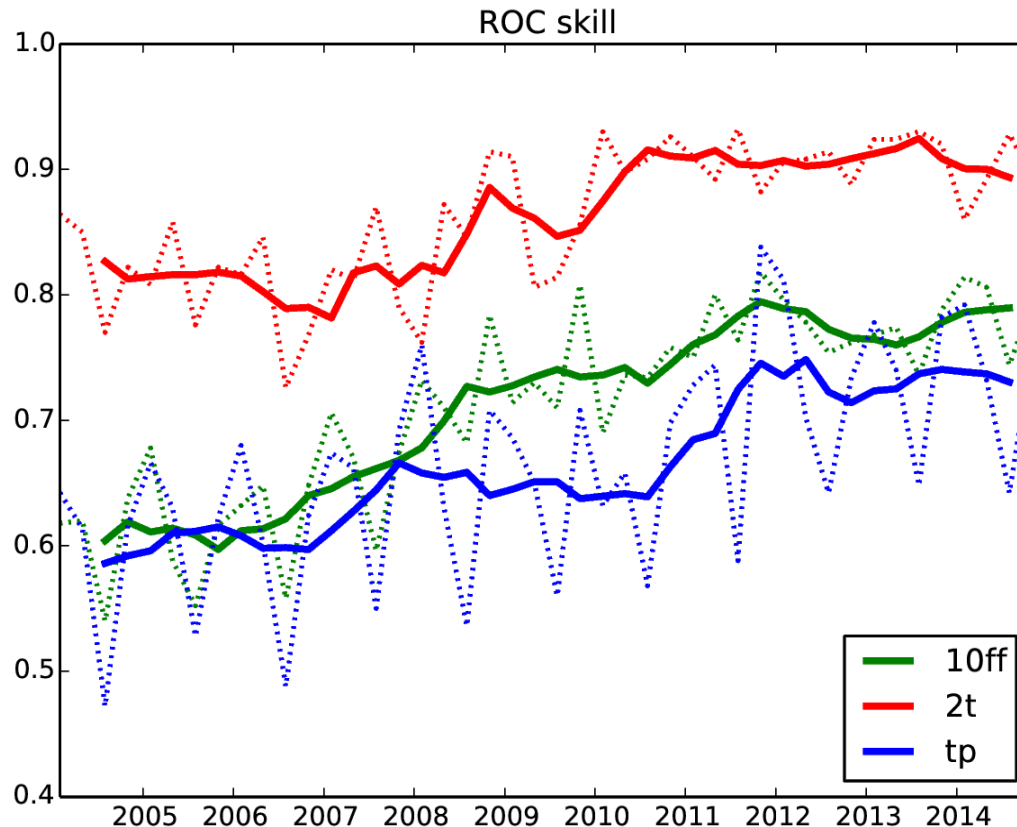
EFI Skill = $2 \times \text{ROCA} - 1$

EFI Skill = 0 no skill

EFI Skill = 1 perfect score

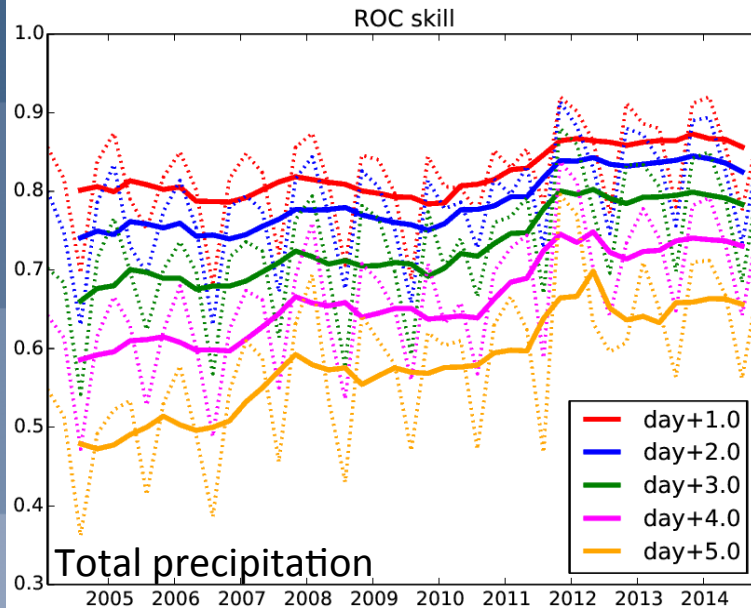
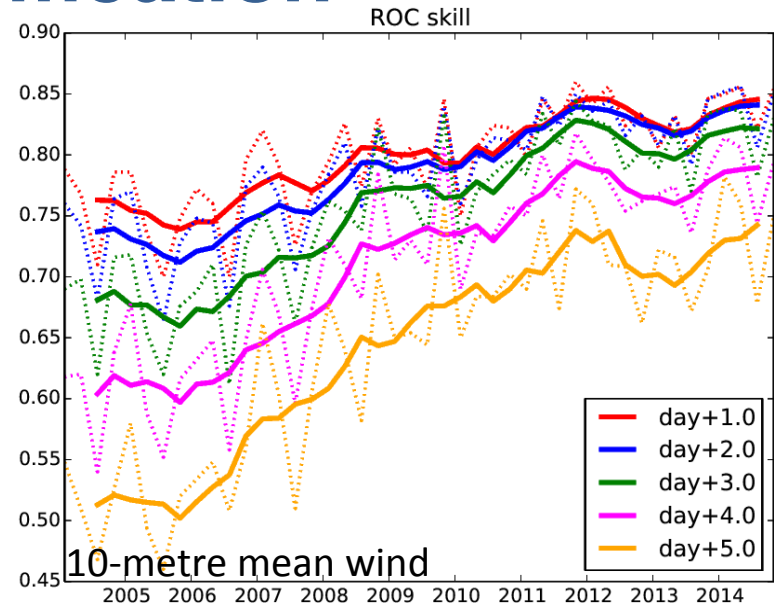
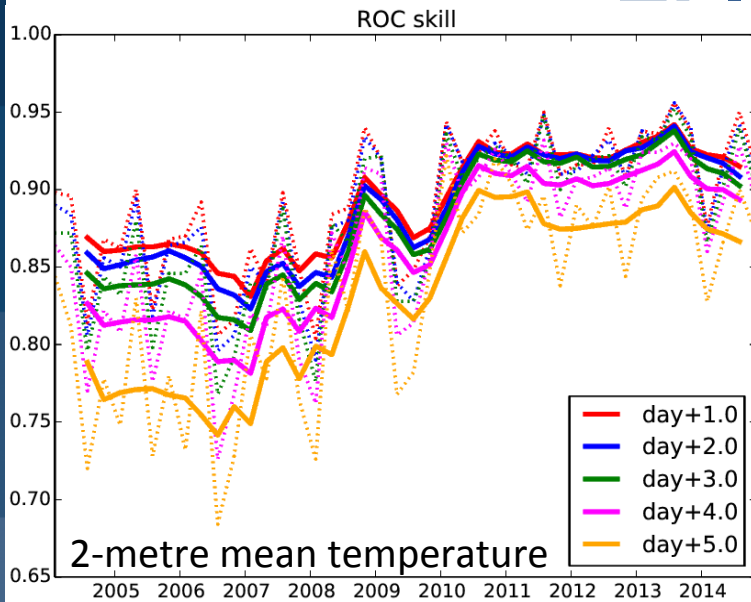
- **The plot shows the skill of the EFI for 10-metre wind speed (a supplementary headline score adopted by the ECMWF Council) at forecast day 4 (t+72-96h for 00UTC).**
- **The solid curve shows a four-season running mean.**

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)** for day 4 (t+72-96h for 00UTC).
- 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

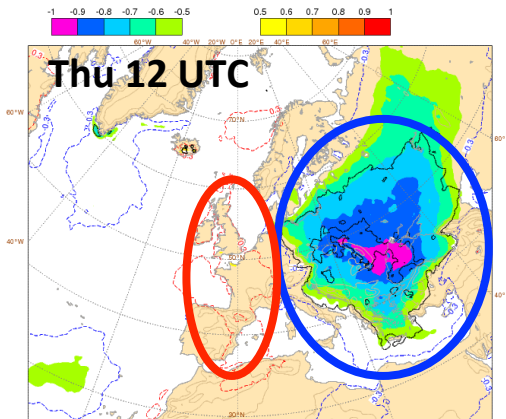
Known issues

- **Re-forecast sample size is 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 a strong seasonal trend
- **M-climate is affected by model biases:**
 - ✓ Jumpiness in the M-climate for different lead times
 - ✓ This does not affect the EFI/SOT

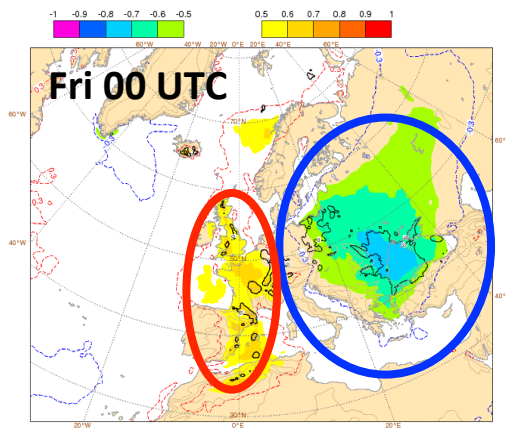
Known issues – an example of a cold wave, Europe, beginning of October 2013

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

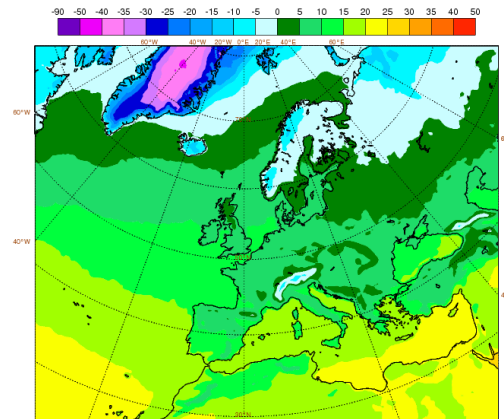


Fri 27 Sep 2013 00UTC ©ECMWF t+144-168h VT: Thu 03 Oct 2013 00UTC - Fri 04 Oct 2013 00UTC
Extreme forecast index and Shift of Tails (one in 100 occasions realises less than value shown)

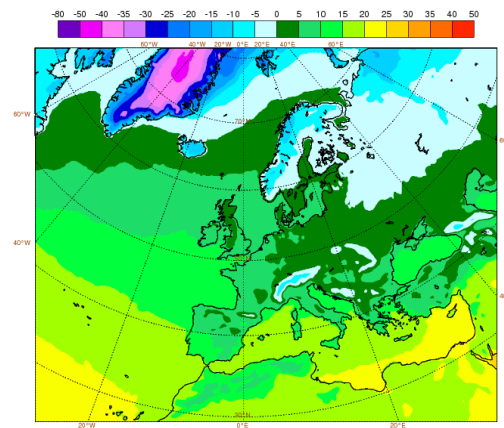


M-climate

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):

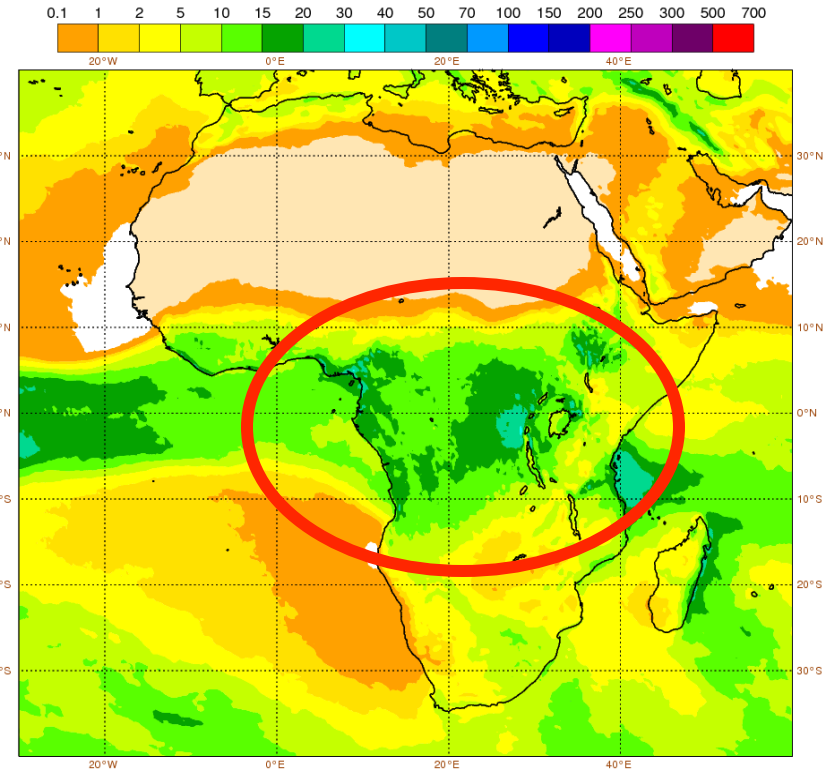
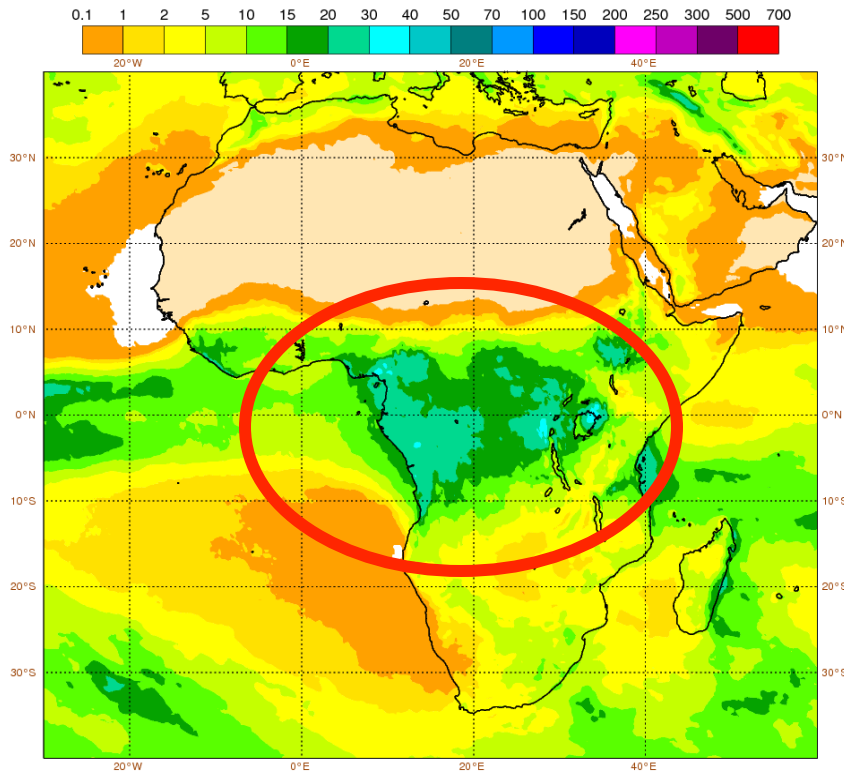
- Sudden jumps in the EFI forecasts when changing the M-climate on Fridays due to the seasonal trend

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 – an example, tropical Africa

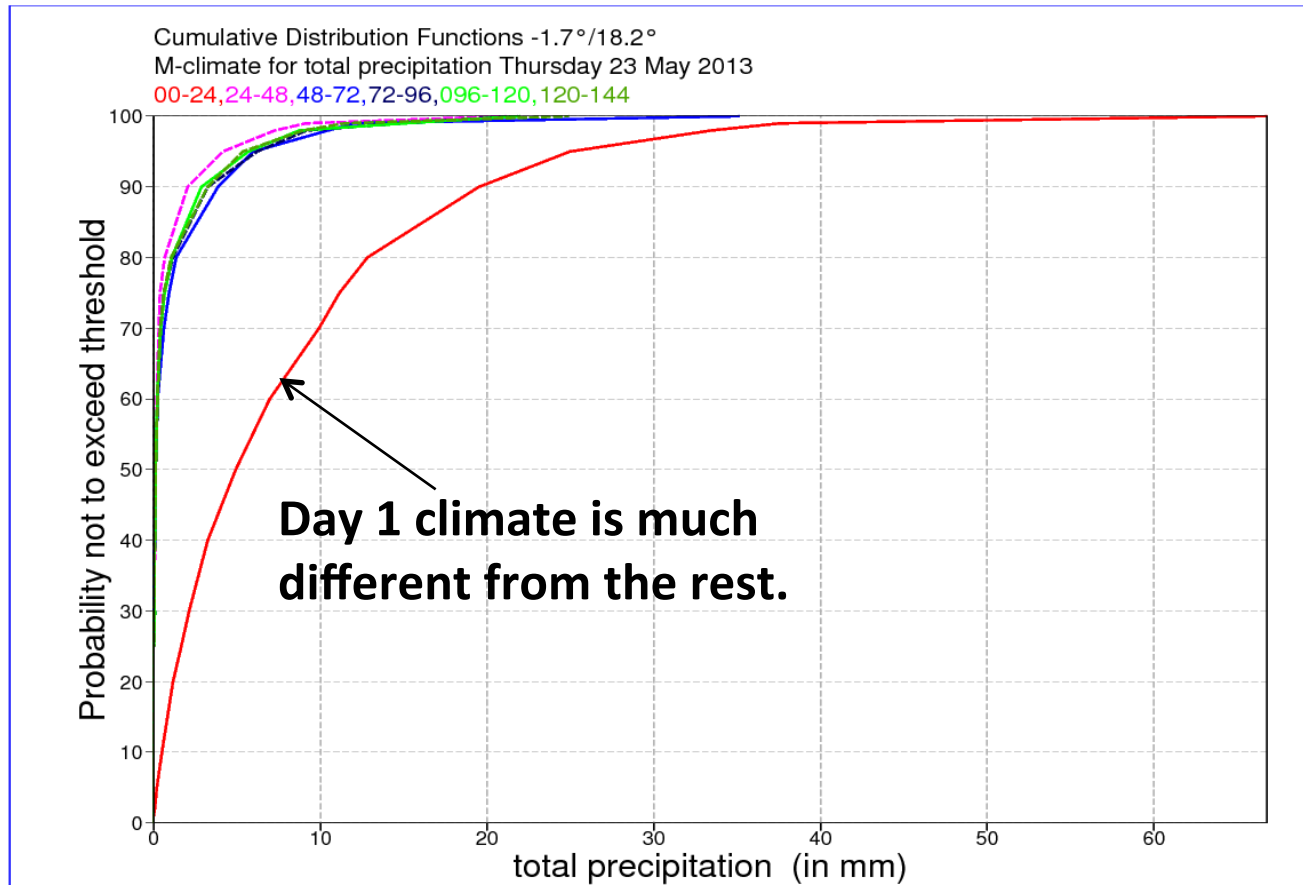
Thu 11 Apr 2013 00UTC ©ECMWF VT: Thu 18 Apr 2013 00UTC - Fri 19 Apr 2013 00UTC 0-24h total precipitation (in mm) Model climate Q90 (one in 10 occasions realises more than value shown)

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 – an example, tropical Africa



M-climate is not perfect. It is affected by model biases and therefore it depends on the lead time:

- Jumpiness in the M-climate for different lead times
- Ideally, this shouldn't affect the EFI

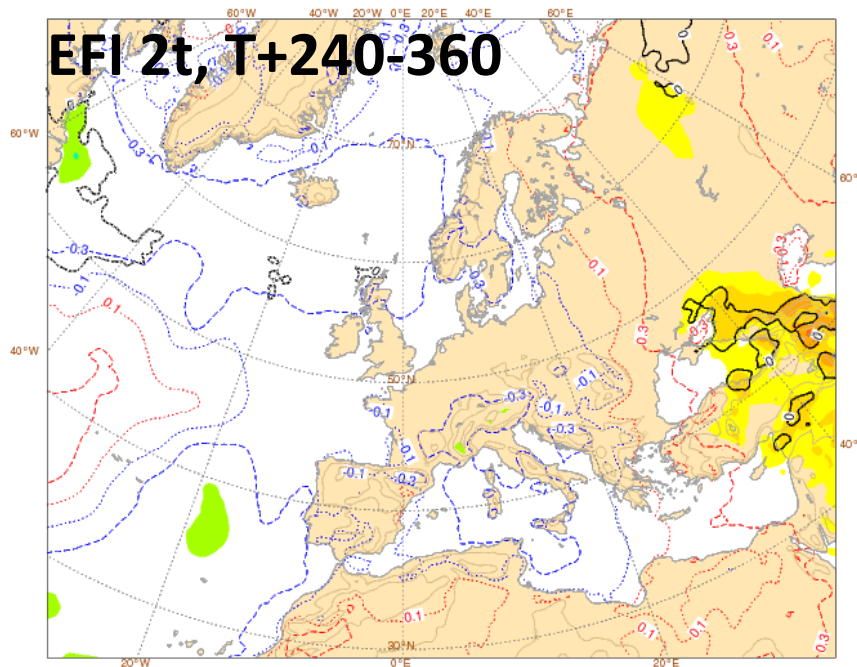
Forthcoming changes in the M-climate (next model cycle)

- Increase in the number of the ensemble members in the re-forecasts from 5 (now) to 11.
- Re-forecast suite will run twice a week (every Monday and Thursday) instead of once a week (Thursdays).
- M-climate will still use 5 weeks but it will be updated twice a week, every Monday and Thursday.
- M-climate will use all the runs in the 5-week period, e.g. the M-climate on a given Thursday will consist of all Thursday's runs in a 5-week period (2 weeks before and 2 weeks after the Thursday of interest) and all Monday's runs in between, in total 9 re-forecast runs.
- Climate sample size will increase considerably from 500 values to 11 members X 20 years X 9 runs = 1980 values.
- These changes will:
 - ✓ Decrease of the noise in the tails of the M-climate distribution and will increase considerably the consistency of SOT;
 - ✓ Decrease of the jumpiness due to the seasonal trend.

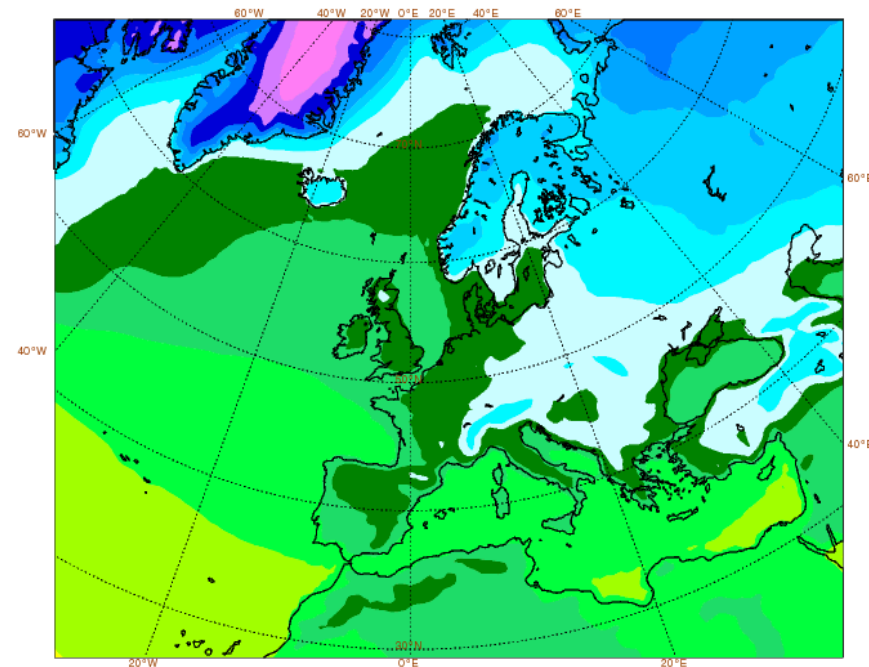
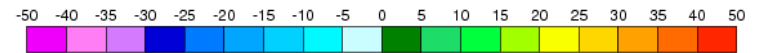
Forthcoming changes in the EFI/SOT (next model cycle)

- Two new time ranges will be added to EFI/SOT for 2t, 10fg and tp: **T+000-360h** and **T+240-360h**
- The EFI computational code will be replaced with a new more robust code. This won't change the EFI significantly.

Thu 22 Jan 2015 00UTC ©ECMWF t+240-360h VT: Sun 01 Feb 2015 00UTC - Fri 06 Feb 2015 00UTC
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for 2m mean temperature



Mon 19 Jan 2015 00UTC ©ECMWF VT: Sun 01 Feb 2015 00UTC - Fri 06 Feb 2015 00UTC 240-360h
2m mean temperature (in °C) Model climate Q50 (climate median)



Floods in Central Europe

June 2013



TECHNICAL MEMORANDUM

723

ECMWF forecast performance
during the June 2013 flood
in Central Europe

T. Haiden, L. Magnusson, I. Tsonevsky,
F. Wetterhall, L. Alfieri, F. Pappenberger,
P. de Rosnay, J. Muñoz-Sabater,
G. Balsamo, C. Albergel, R. Forbes,
T. Hewson, S. Malardel, D. Richardson

Forecast and Research Departments

June 2014

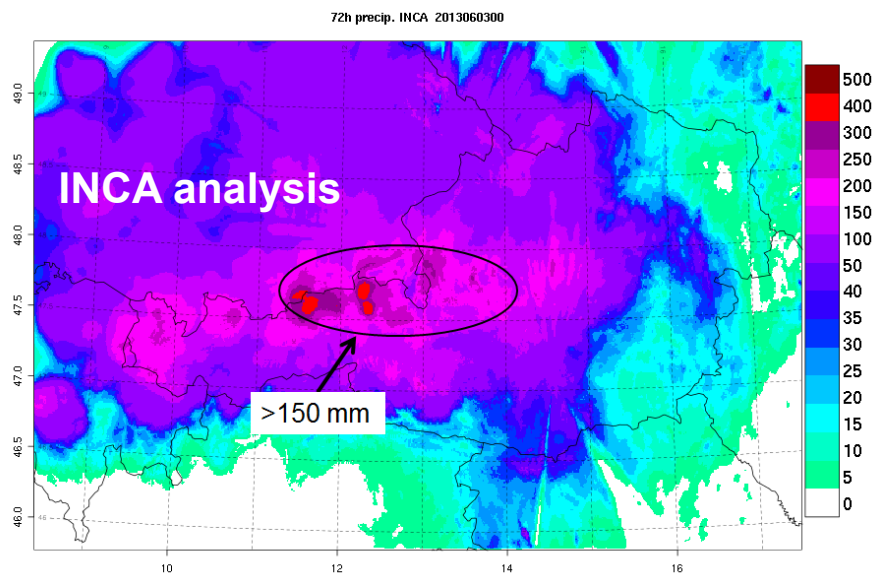
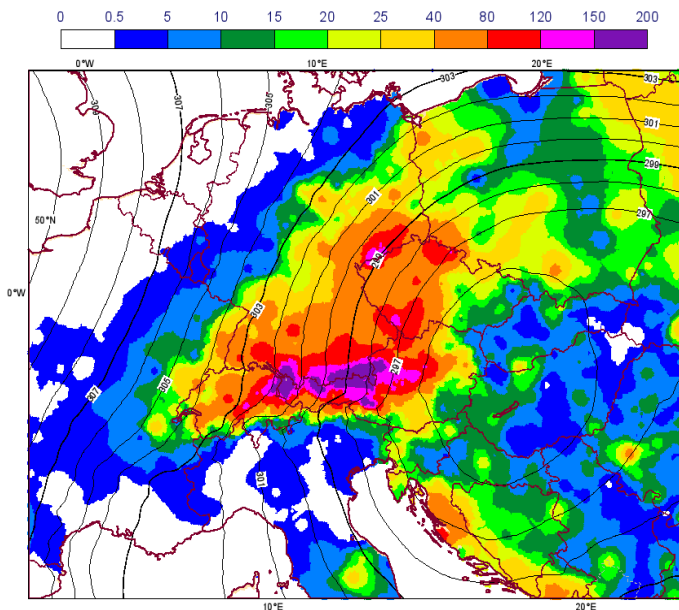
This paper has not been published and should be regarded as an Internal Report from ECMWF.
Permission to quote from it should be obtained from the ECMWF.



European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
Centre européen pour les prévisions météorologiques à moyen

Analysis

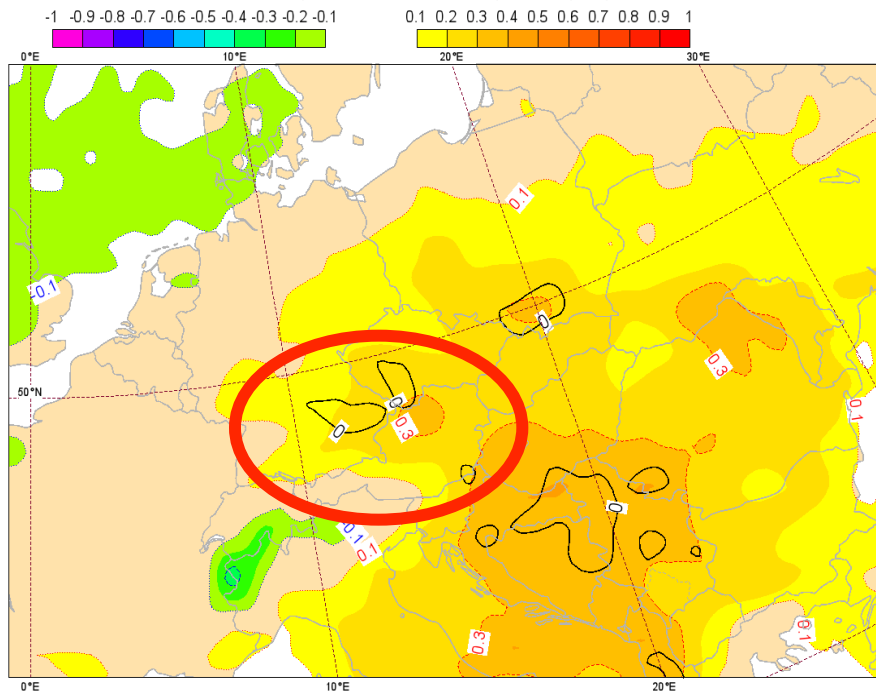
Observed rainfall interpolated on a grid and Z700
(mean over the period) ECMWF analysis
VT: 31/05/2013 06 UTC – 03/06/2013 06UTC



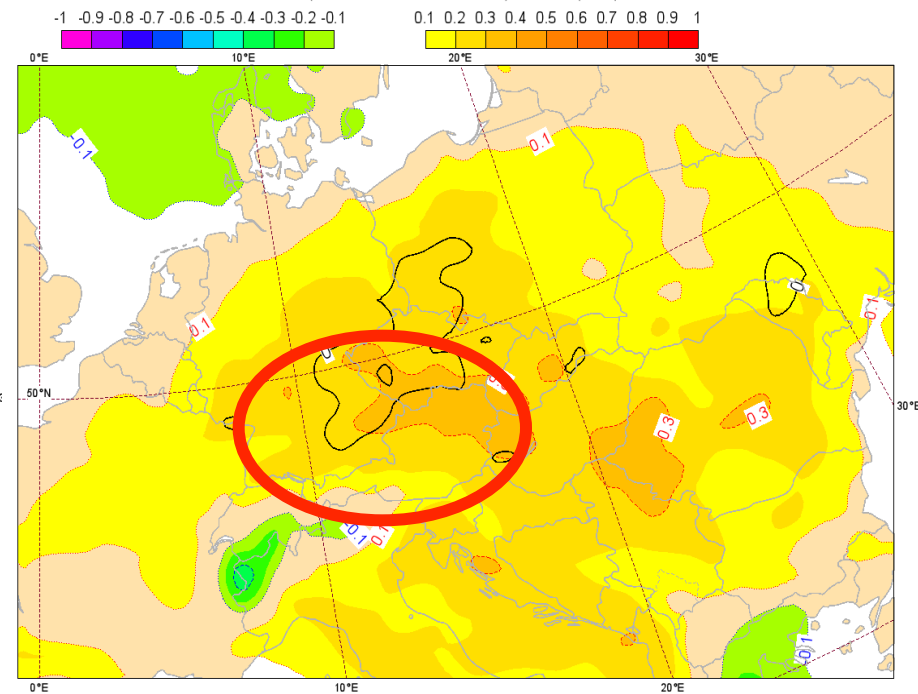
- A quasi-stationary low pressure system brought moist, warm air from the east and northeast into Central Europe causing massive amounts of rain in southern Germany and western Austria.
- Orographic enhancement of precipitation along the northern side Alps played an important role.

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.

EFI/SOT for convection (summer 2015?)

Motivation:

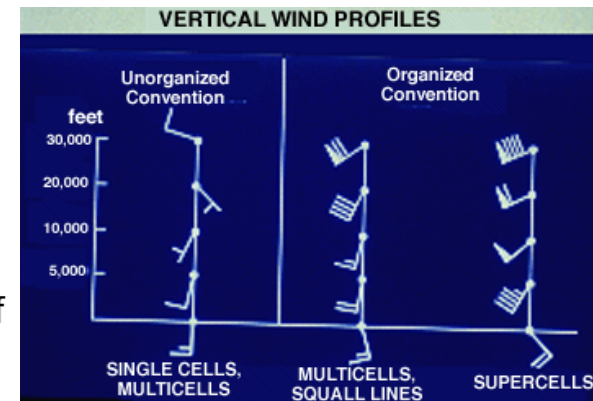
- A substantial number of severe weather events are related to deep convection, especially in the warm season.
- EFI/SOT does not cover convection so far and EFI/SOT for precipitation and wind gusts are less skilful in case of severe convection; moreover, deep convection is not just heavy rain/snow and strong wind gusts but also large hail, damaging lightning, etc.
- Significant improvements of convection in the model recently (see *ECMWF Newsletter No. 136 – Summer 2013*)
- Many and continuing user requests for guidance about forecasting severe convection.

CAPE SHEAR parameter used to highlight the possibility of extreme convection:

$$CAPE SHEAR = [WS]_{L1}^{L2} * \sqrt{CAPE}$$

where WS is the wind shear between levels L1 and L2. The dimension of CAPE SHEAR is m^2s^{-2} (energy).

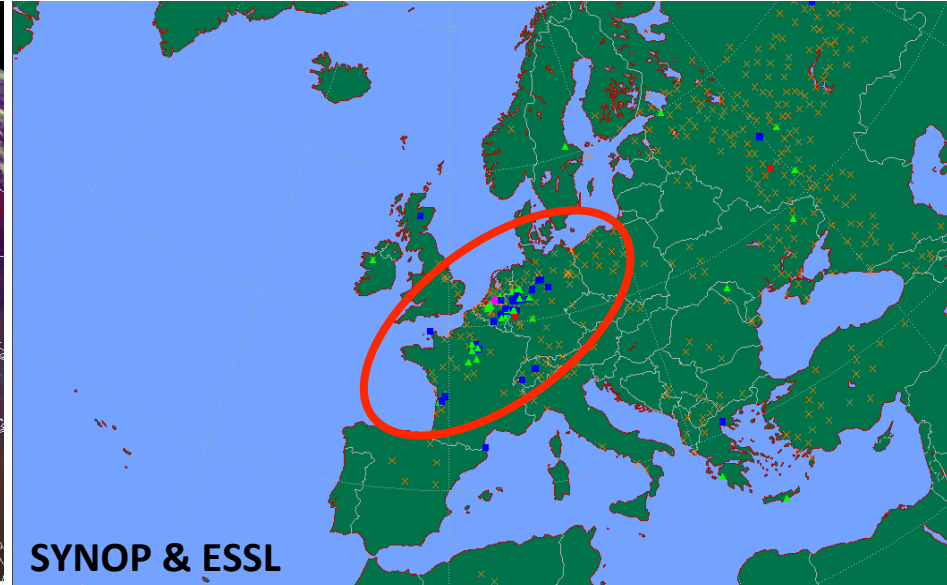
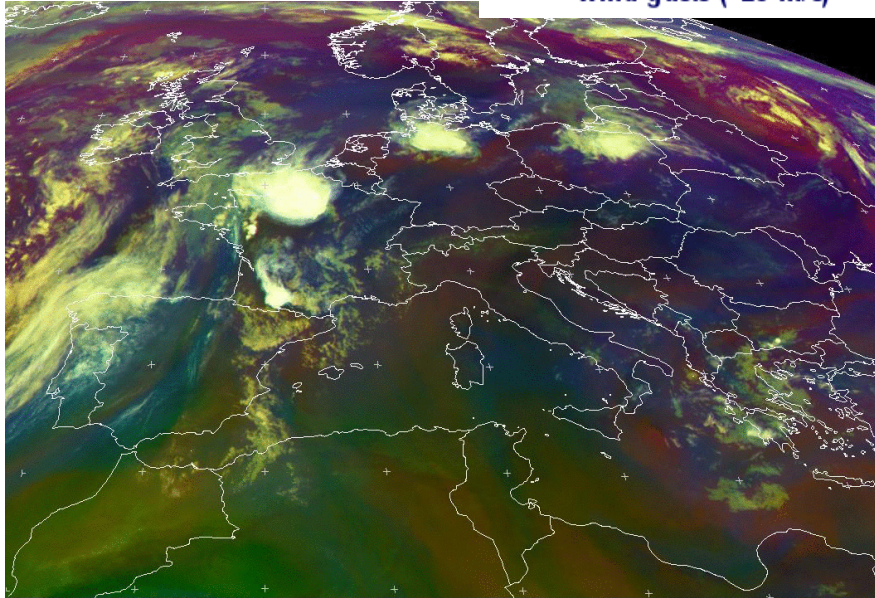
- CAPE is a key ingredient of deep moist convection.
- Large vertical wind shear favours the organised convection.
- Supercells occur where strong shear is combined with large instability
- The EFI was computed using the maximum value for CAPE SHEAR out of every four values during a 24-hour period (the standard output from the ensemble model is every 6 hours so there are 4 values every 24 hours).
- CAPE values of less than 10 J/kg are filtered out to emphasise convection rather than anomalous but insignificant CAPE SHEAR.
- **Limitations:** CIN not taken into account.



Severe convection, 9 June 2014

Severe weather reports for 09/06/2014

TS wind gusts (>25 m/s) hail heavy precip (> 50 mm) squalls tornadoes



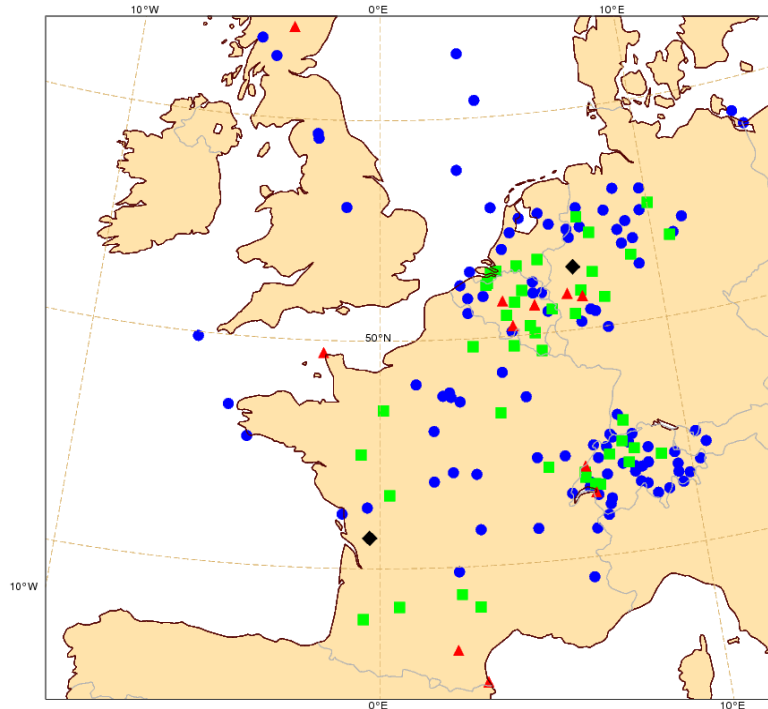
- Severe convection affected Western Europe on 9 June 2014.
- Deep moist convection developed along the western fringe of a hot air mass.
- Many weather reports of severe wind gusts and large hail.

Severe convection. 9 June 2014

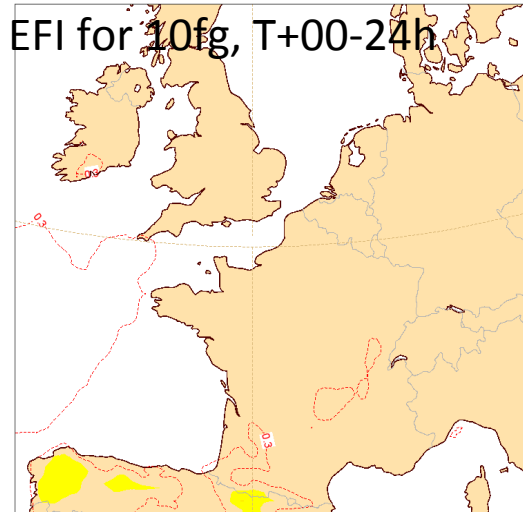
Mon 09 Jun 2014 00UTC @ECMWF exper = 1 VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 10m wind gust

Observed maximum wind gusts on 09 June 2014

◆ 35-40 ▼ 30-35 ▲ 25-30 ■ 20-25 ● 15-20

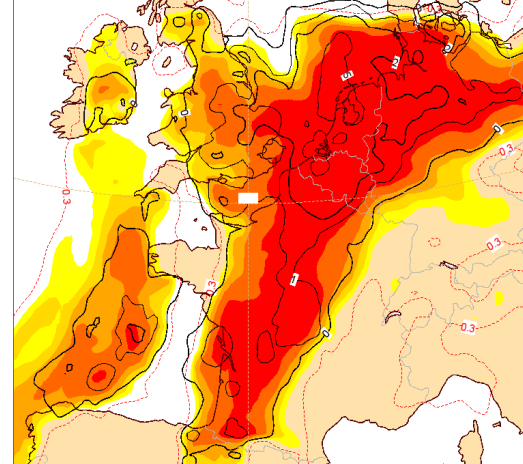


EFI for 10fg, T+00-24h



Mon 09 Jun 2014 00UTC @ECMWF VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: SCI
M-CLIMATE (5 members X 20 years every Thursday X 5 weeks)

EFI for CAPESHEAR, T+00-24h

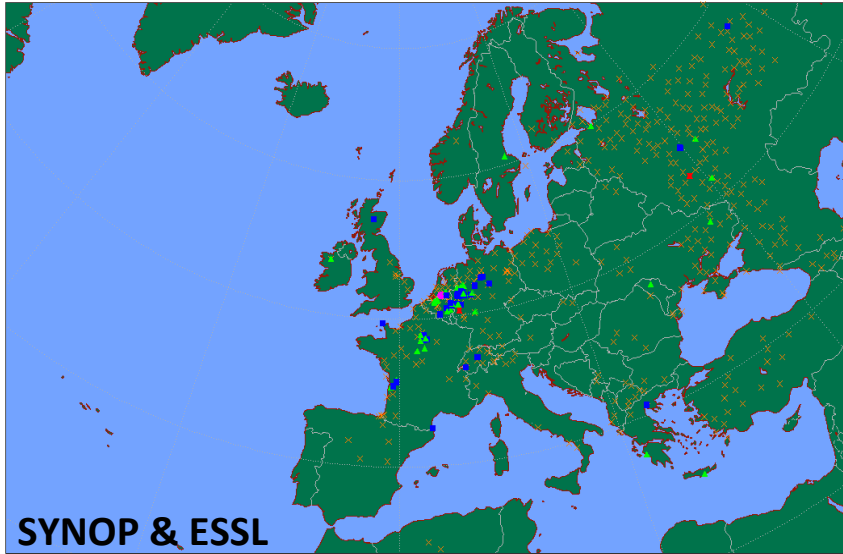


- Strong wind gusts were reported in France, Belgium, the Netherland and Germany.
- The maximum wind gust at Düsseldorf airport was 42 m/s.

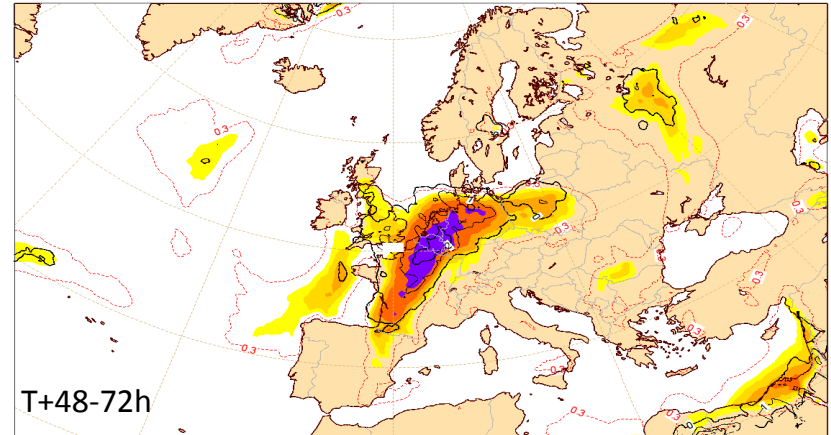
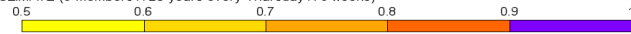
EFI for CAPE-SHEAR

Severe weather reports for 09/06/2014

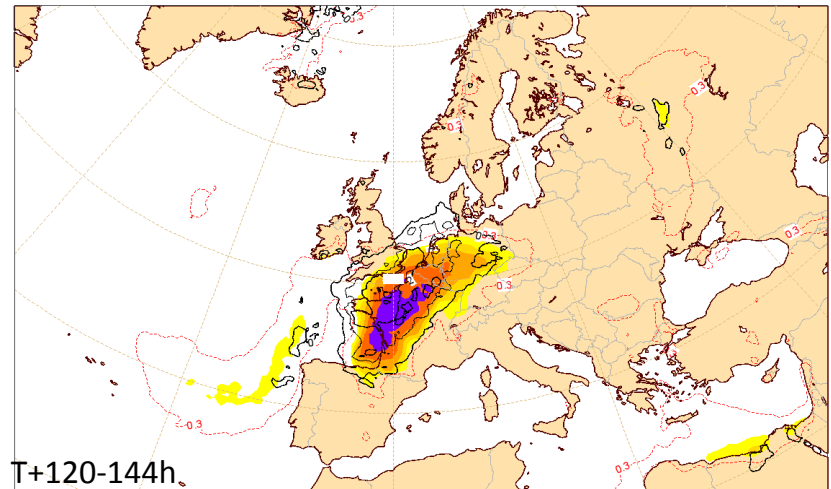
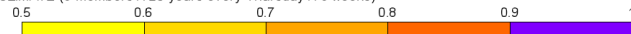
× TS wind gusts (>25 m/s)
 ▲ hail heavy precip (> 50 mm)
 ✘ squalls
 ▲ tornadoes



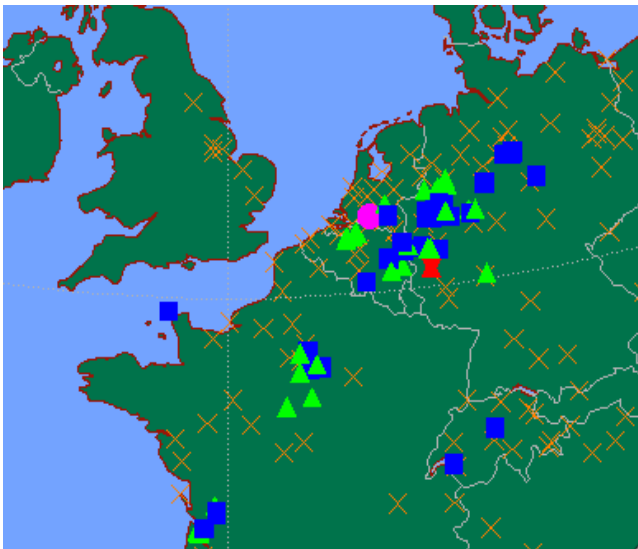
Sat 07 Jun 2014 00UTC @ECMWF VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 48-72h
 Extreme forecast index and Shift of Tails (black contours 0, 1, 5, 10, 15) for: SCI
 M-CLIMATE (5 members X 20 years every Thursday X 5 weeks)



Wed 04 Jun 2014 00UTC @ECMWF VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 120-144h
 Extreme forecast index and Shift of Tails (black contours 0, 1, 5, 10, 15) for: SCI
 M-CLIMATE (5 members X 20 years every Thursday X 5 weeks)

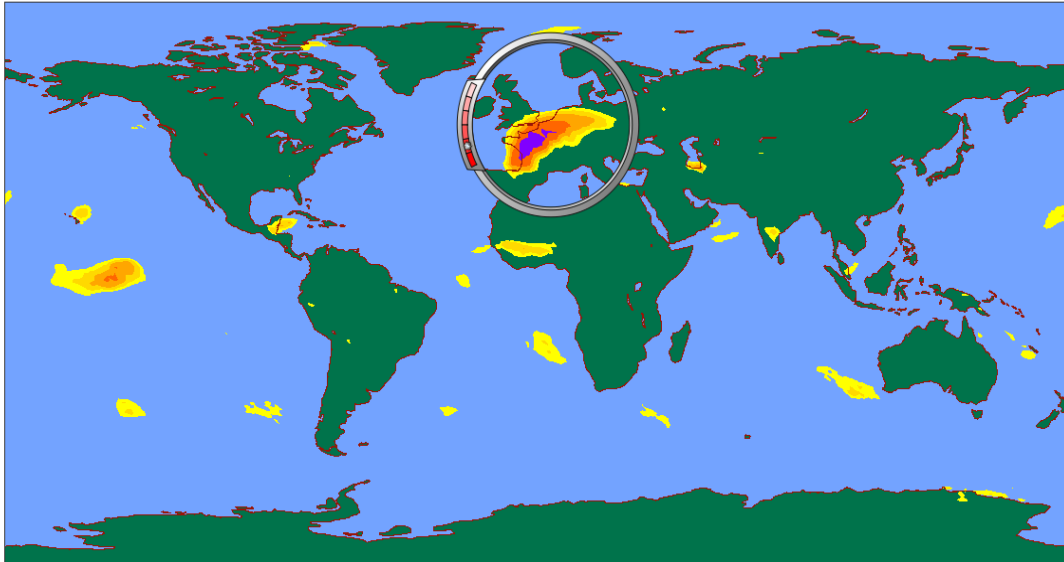


× TS wind gusts (>25 m/s)
 ▲ hail heavy precip (> 50 mm)
 ✘ squalls
 ▲ tornadoes



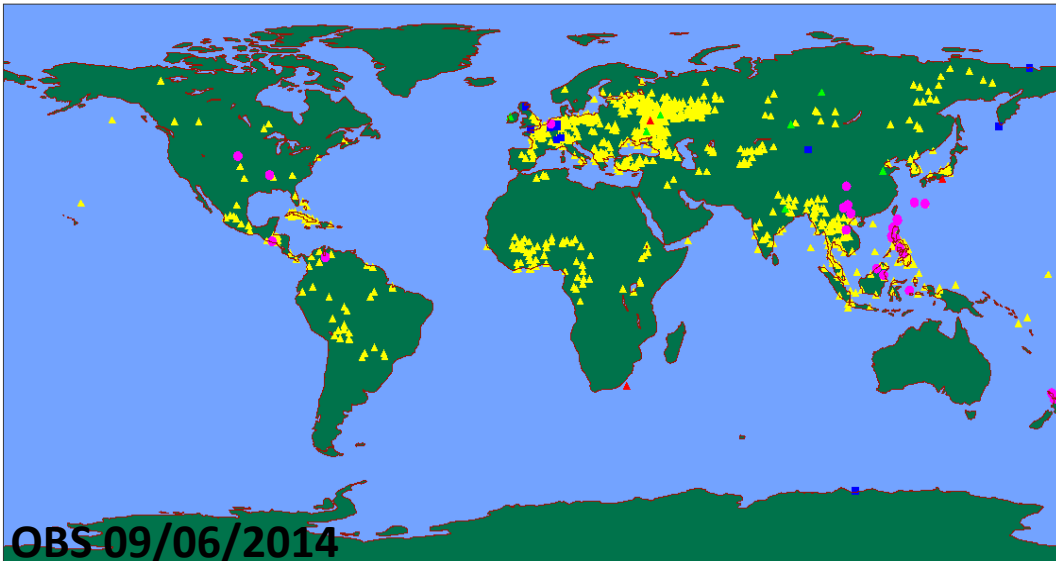
➤ A strong signal of anomalous weather 5 days in advance.

EFI for CAPESHEAR, T+120-144 VT: 09/06/2014



- The strongest signal of anomalous CAPESHEAR over Western Europe.

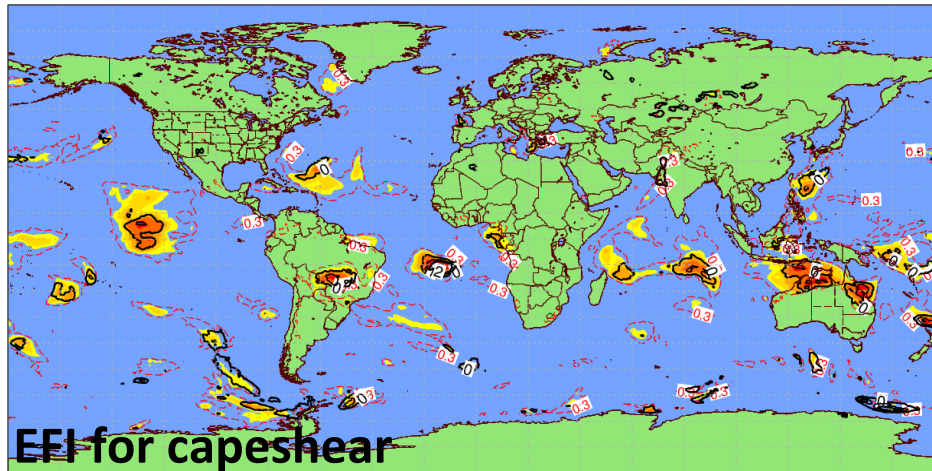
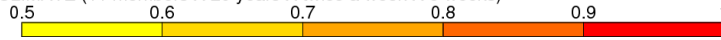
▲ TS ▲ hail ▲ tornadoes/squalls ■ high winds (>25 m/s) ● heavy rain (> 50 mm)



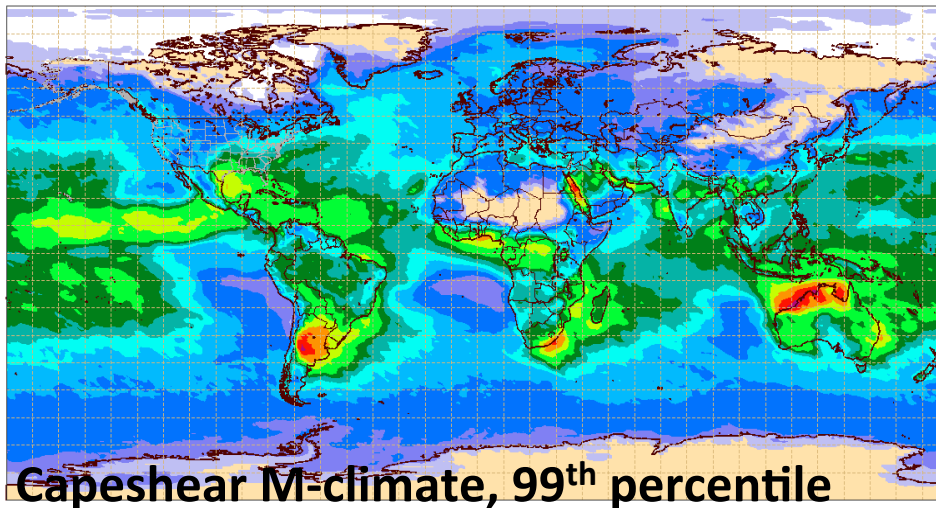
OBS 09/06/2014

EFI for capeshear and M-climate

Tue 20 Jan 2015 00UTC @ECMWF VT: Wed 21 Jan 2015 00UTC - Thu 22 Jan 2015 00UTC 24-48h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: CAPESHEAR
M-CLIMATE (11 members X 20 years X twice a week X 5 weeks)

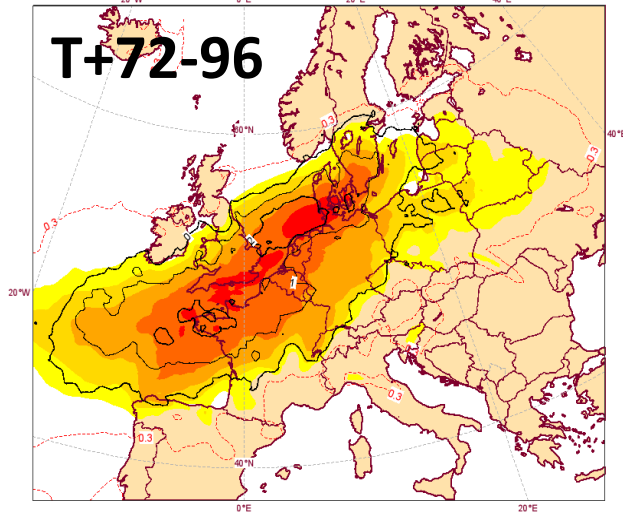


- M-climate helps to assess the significance of the anomalous capeshear index.

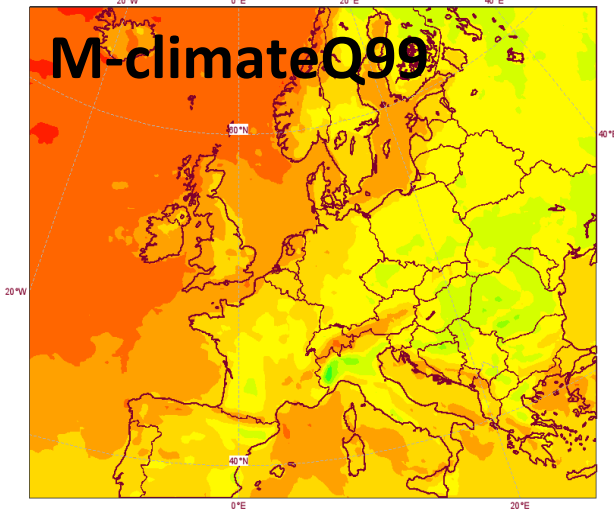


St. Jude storm case

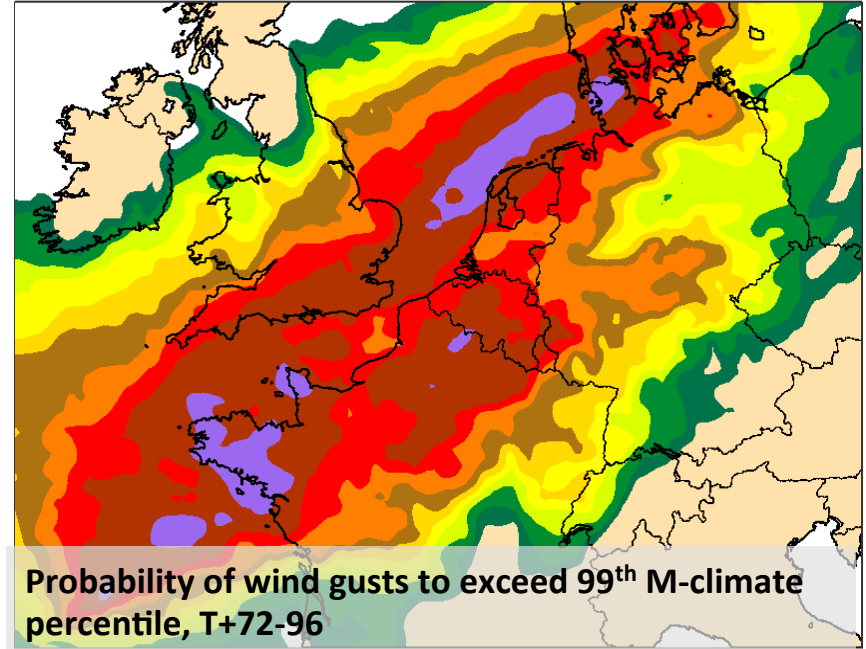
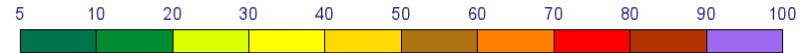
Fri 25 Oct 2013 00UTC @ECMWF expver = 1 VT Mon 28 Oct 2013 00UTC - Tue 29 Oct 2013 00UTC 72-96h
 Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 10m wind gust



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.



Further Reading:

- ✓ User Guide to ECMWF forecast products, http://old.ecmwf.int/products/forecasts/guide/user_guide.pdf
- ✓ “Application of the new EFI products to a case of early snowfall in Central Europe”, *ECMWF Newsletter* No. 133 – Autumn 2012, 4