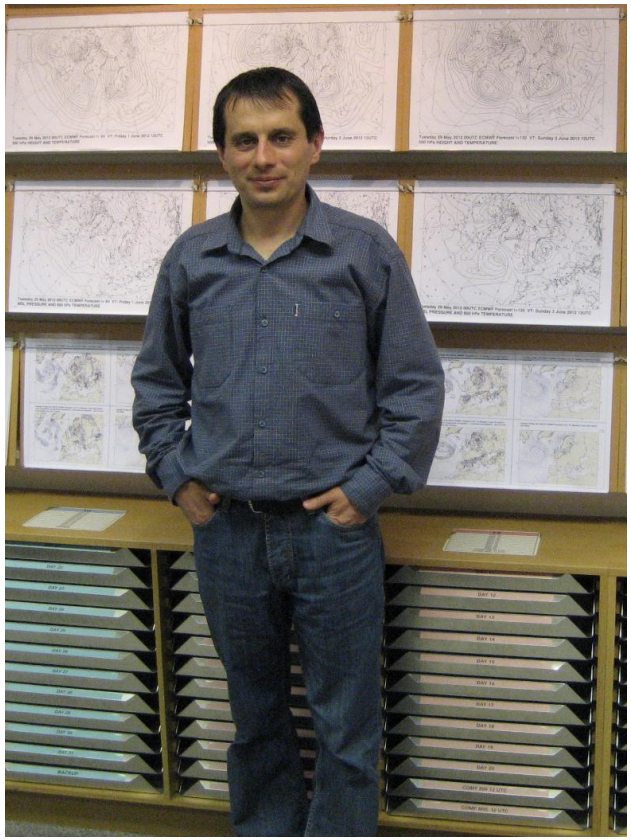
Forecasting Extreme Events



Ivan Tsonevsky,

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Outline

- Examples
- Extreme Forecast Index (EFI) and Model climate (M-climate)

  - how we define what is extreme (M-climate)

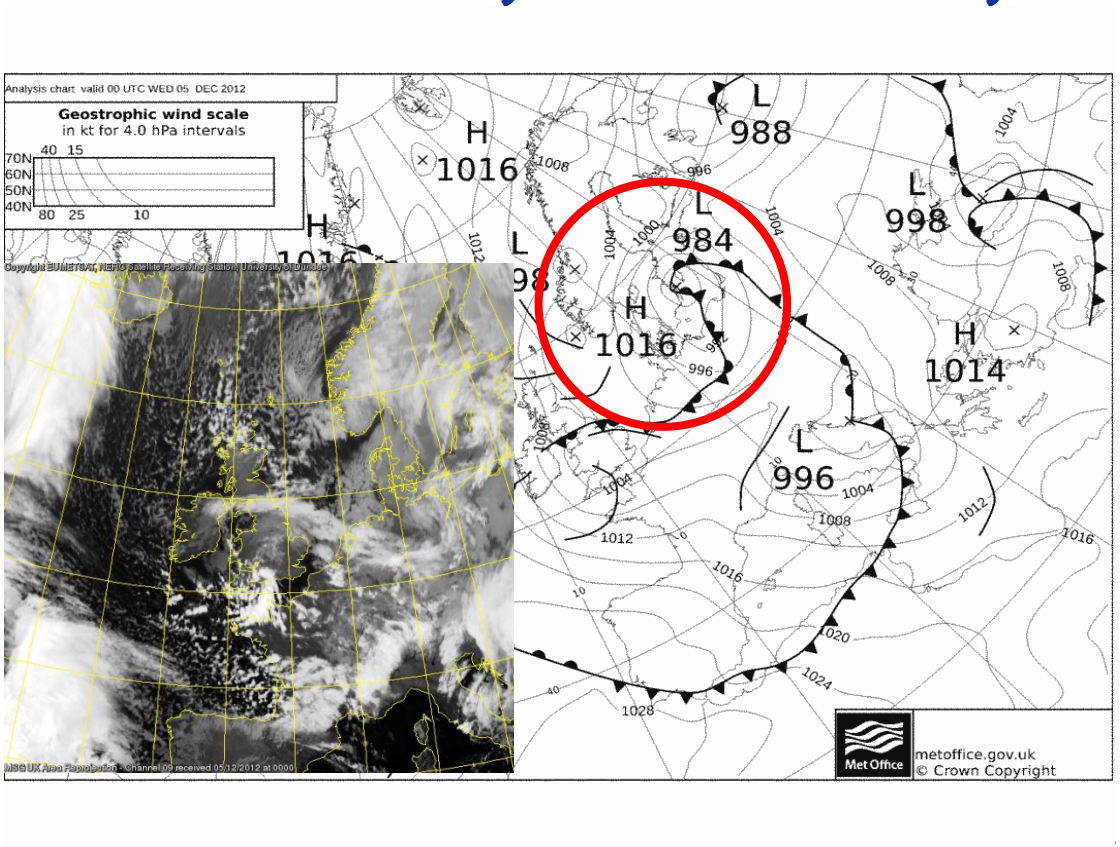
  - Shift Of Tails (SOT) – a new index to complement EFI

  - operational products
- Case studies:

  - heavy snowfall

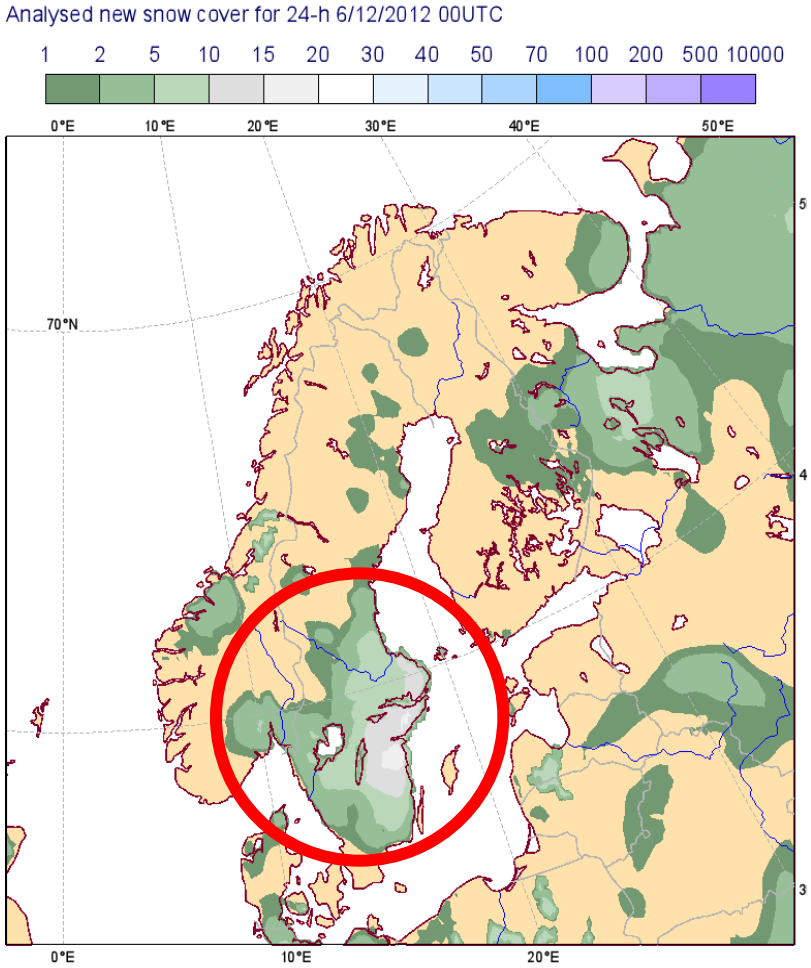
  - heat wave

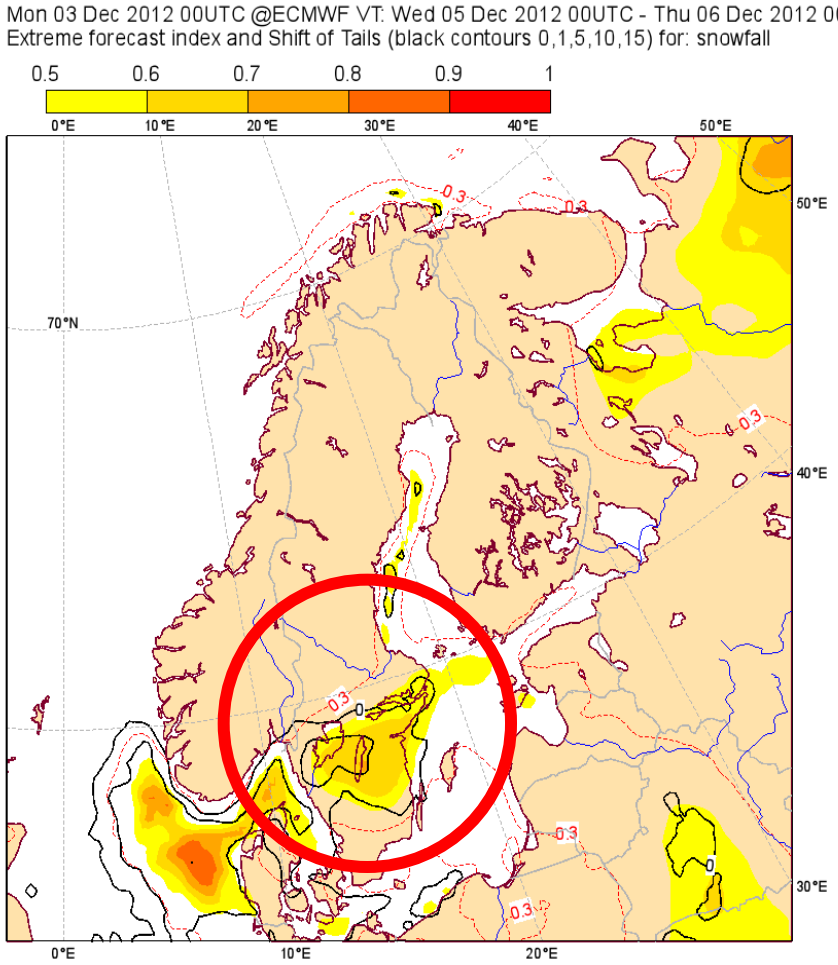
Snowstorm, Stockholm, Sweden, 5/12/2012



- **A deep cyclone from the Baltic Sea brought blizzard conditions to central and eastern parts of Sweden.**

EFI for snowfall

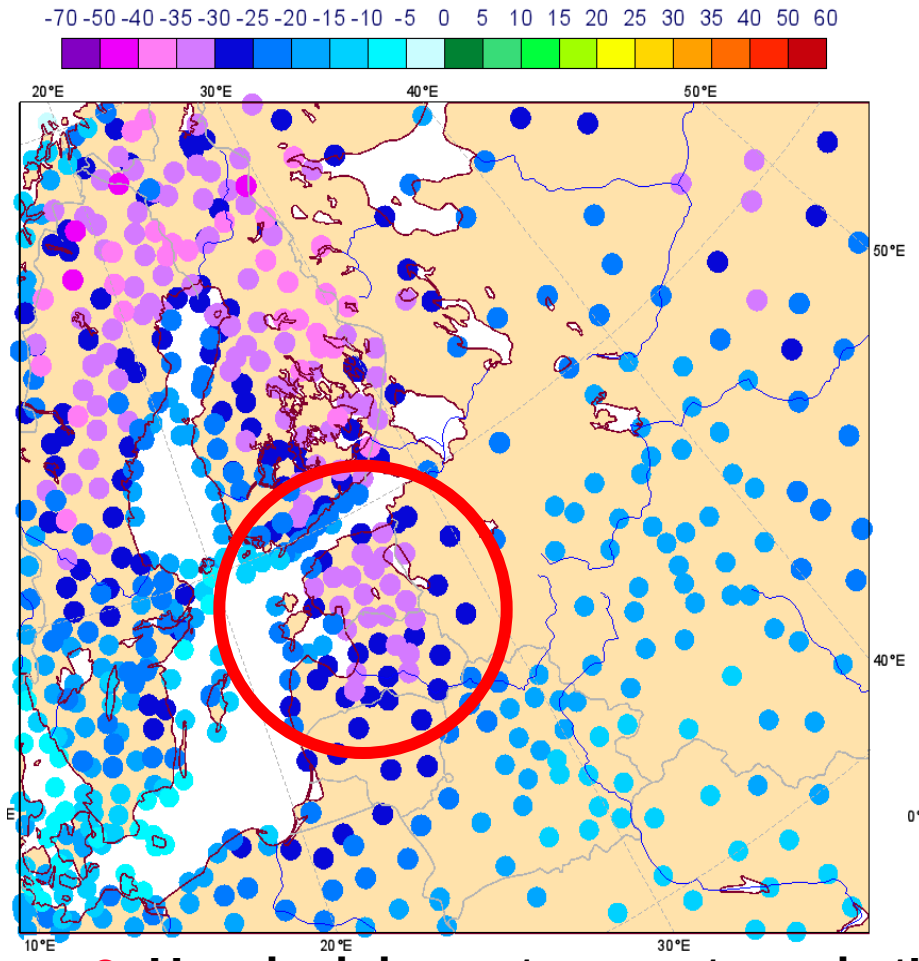




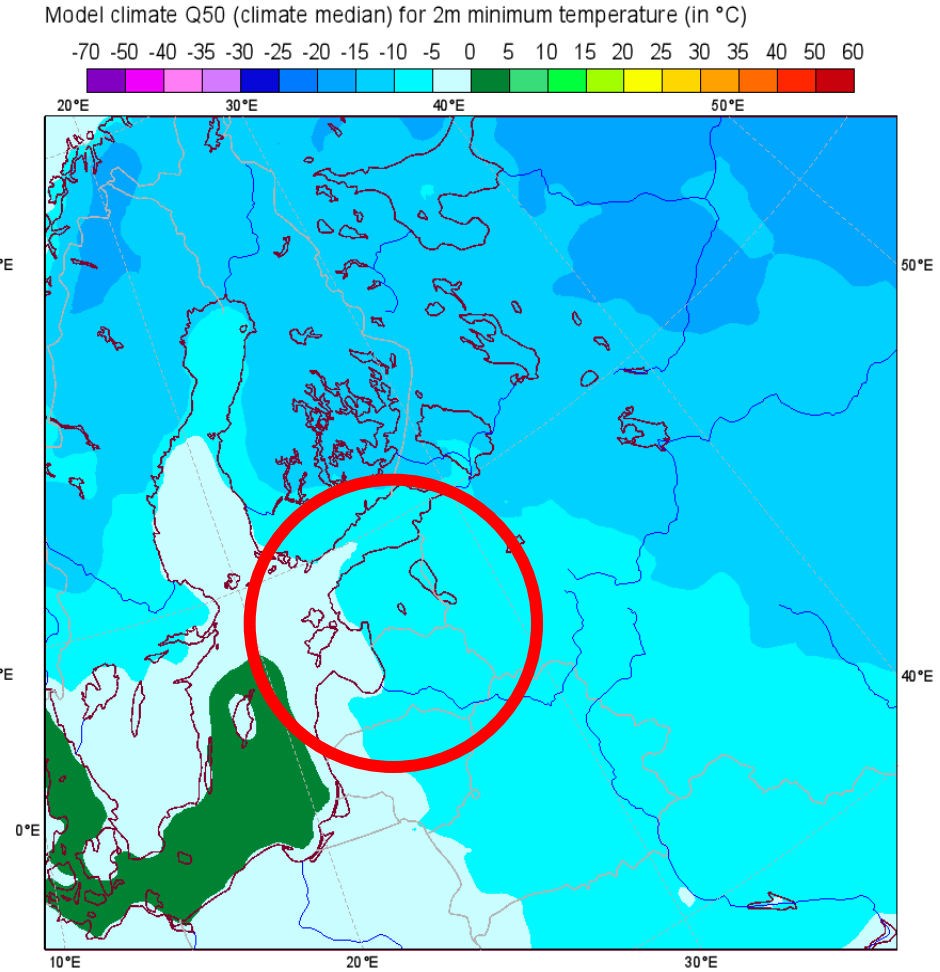
- **High values of EFI and positive SOT match pretty well the area of the heaviest snowfall.**

Observed 2m min T

5/2/2012 06UTC



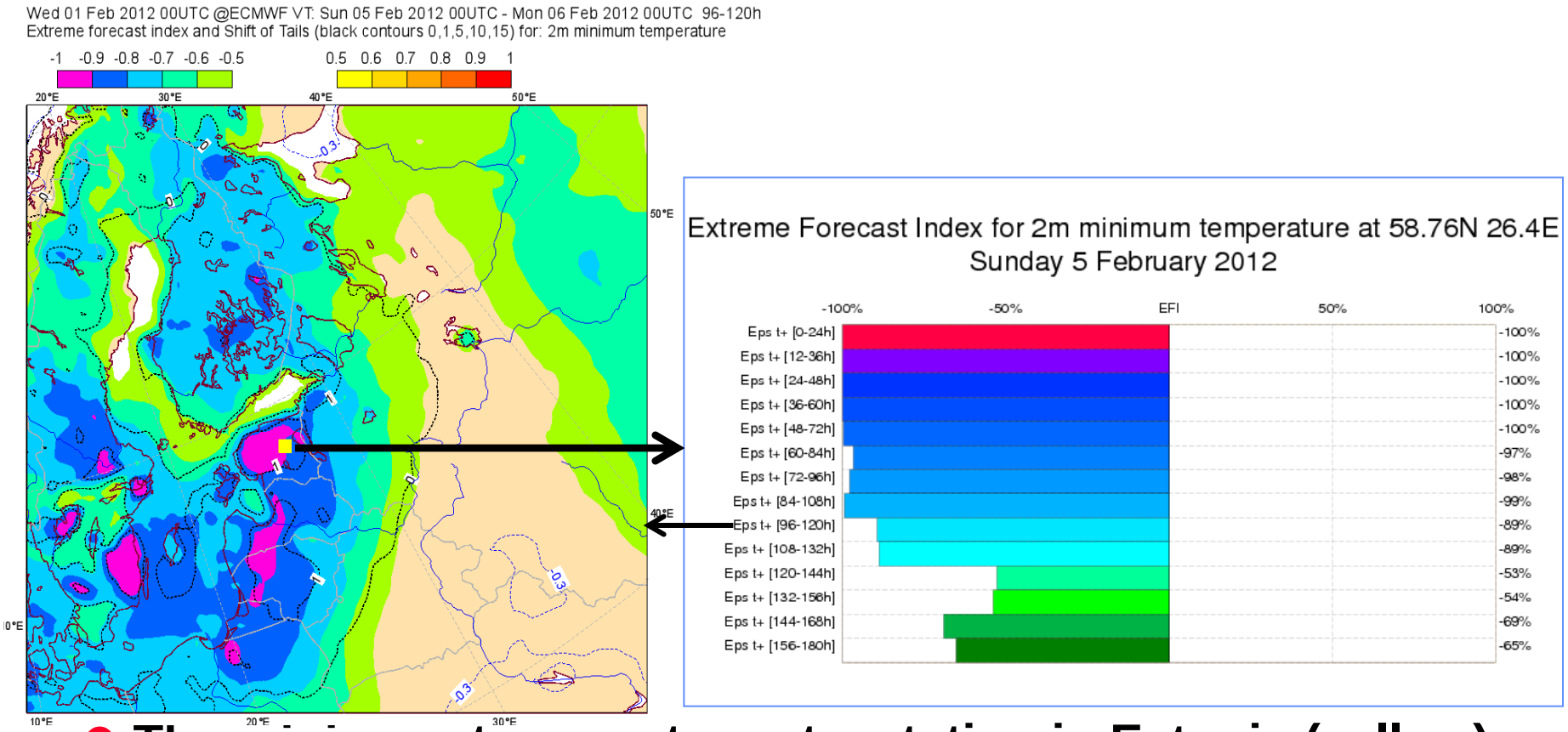
M-climate median of 2m min T



- Usual minimum temperatures in the Baltic states in February: -5 to -10° C
- Observed minimum temperatures: -30 to -35° C!

ECMWF

EFI for 2m minimum temperature

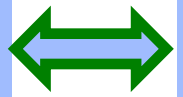


- **The minimum temperature at a station in Estonia (yellow) was -35 ° C!**
- **EFI indicated that abnormally cold weather may affect the region even 7 days in advance.**

Extreme Forecast Index (EFI)

- **Extreme Forecast Index (EFI)** is designed to measure the extremity of ensemble forecast.
- EFI is a measure of the difference between the ensemble forecast distribution and a **model climate (M-climate)** distribution.
- 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° C) will not highlight the differences in the distributions below. EFI will, by accounting for the distribution of all the ensemble members.

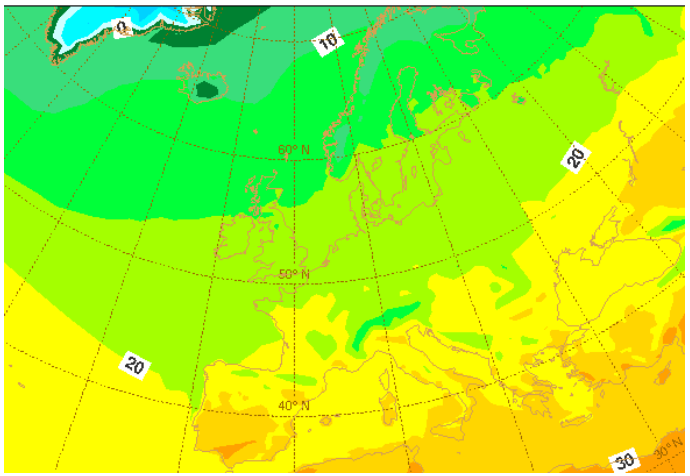
20 C°	(20 members)	20 C°	(5 members)
30 C°	(10 members)	30 C°	(25 members)
35 C°	(15 members)	35 C°	(15 members)
40 C°	(5 members)	40 C°	(5 members)

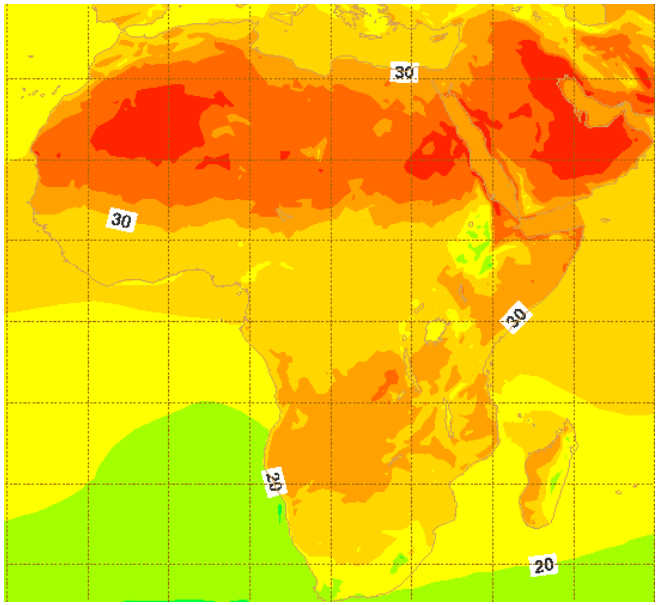


Model Climate

How can we define what is extreme?

- Definition of extreme weather is highly climate dependent, it varies in space and time.
- Maximum temperatures of 35° C are extreme in the UK in summer but in Sahara Desert they are not.
- Snowfall is normal in Central Europe in January but not in May.





What can be used to define ‘extreme’ across the globe?

- Particular Thresholds? NO
- Return Periods? YES
- We need reference threshold levels, for each weather parameter of interest, everywhere across the globe
- Return Periods from observational data are not available everywhere. However global model forecasts provide output everywhere.
- Therefore global model forecasts can be used to provide the climatology from which to extract Return-Period-type information

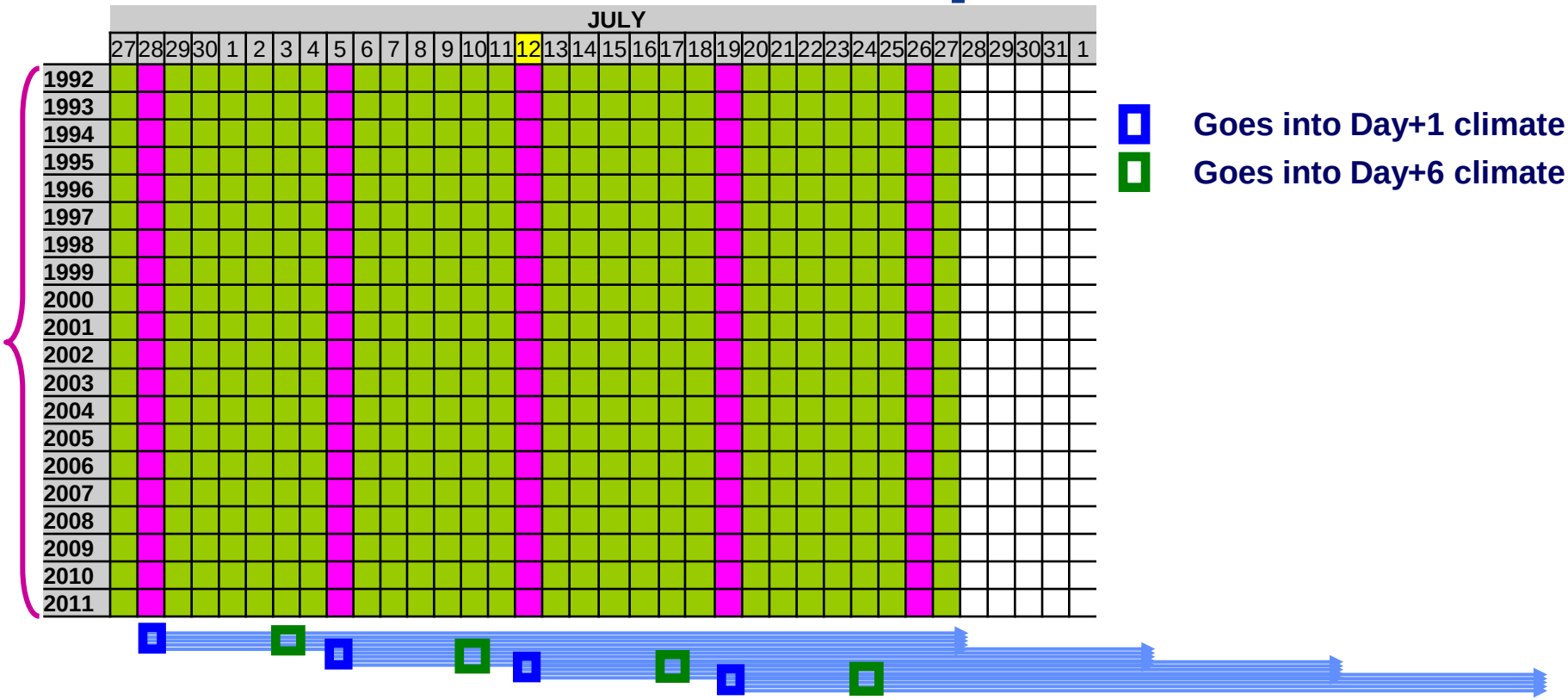
  - As many aspects of infrastructure are based on this, it should be very helpful for early warning provision

- Re-forecasts are performed each time a model is upgraded, to provide the relevant climatology.

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 ENS re-forecasts with the latest model configuration (used operationally) for a long enough period (e.g. 30 years).
- The current ENS M-climate in use:
  - ➔ Running an ENS re-forecast suite with 4 ENS members and the Control
  - ➔ Always for the most recent **20 years** with initial conditions taken from 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 latest model cycle (resolution/ physics / etc.)
  - ➔ Allows an immediate adaptation of EFI and other model climate related products to any ENS model upgrade

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 climate sample size is: 20 years * 5 members * 5 weekly runs = 500 re-forecast fields
- As the M-climate consists of 500 realisations, the M-climate extrema correspond, approximately, to 16-year return periods (for month-long time windows)

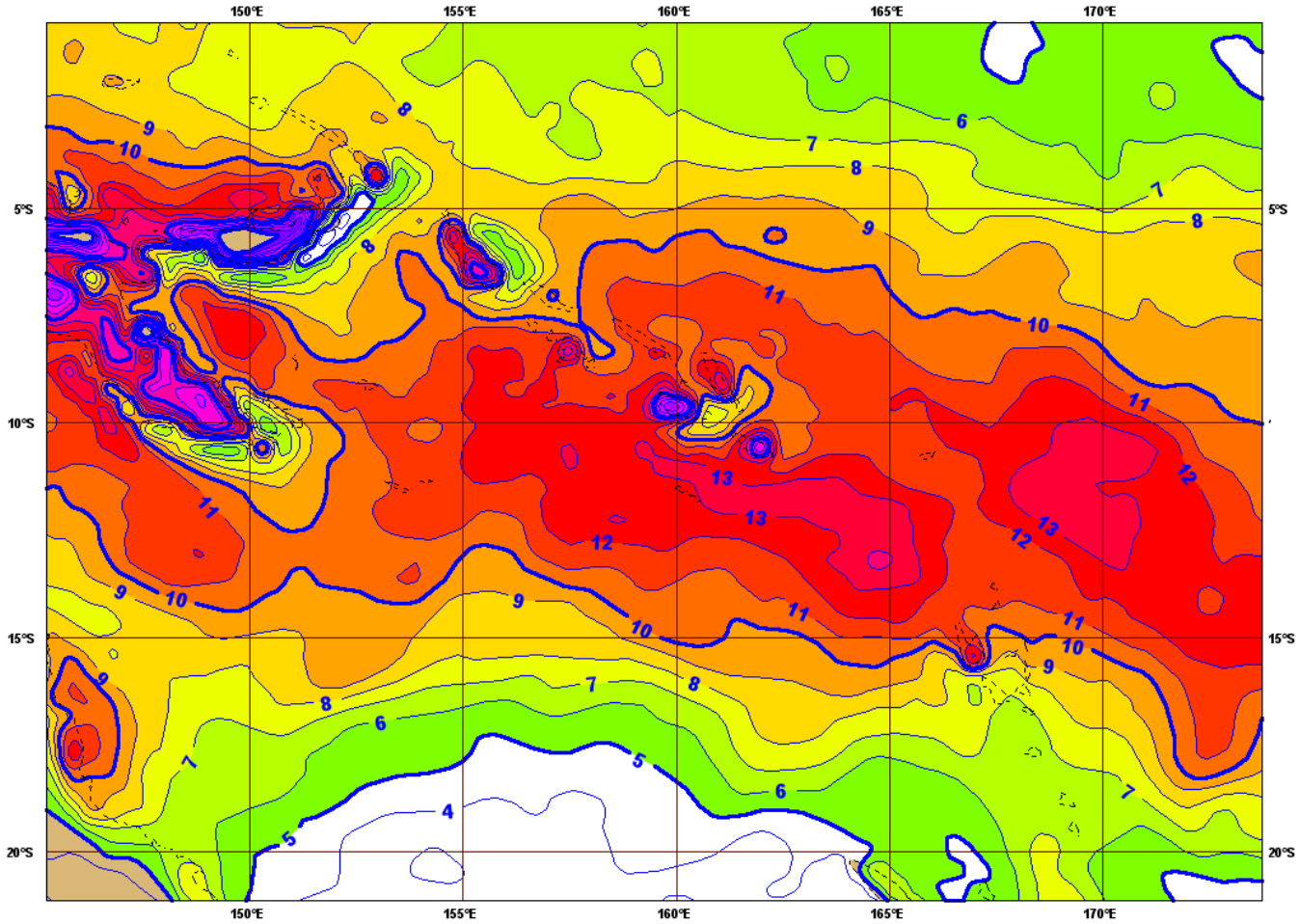
M-climate

- **M-Climate** is a function of 3 factors:
  - ➔ Location
  - ➔ Time of year, to take account of seasonal variations
  - ➔ Forecast lead time

But why forecast lead time?

Illustrate the need for this with an example…

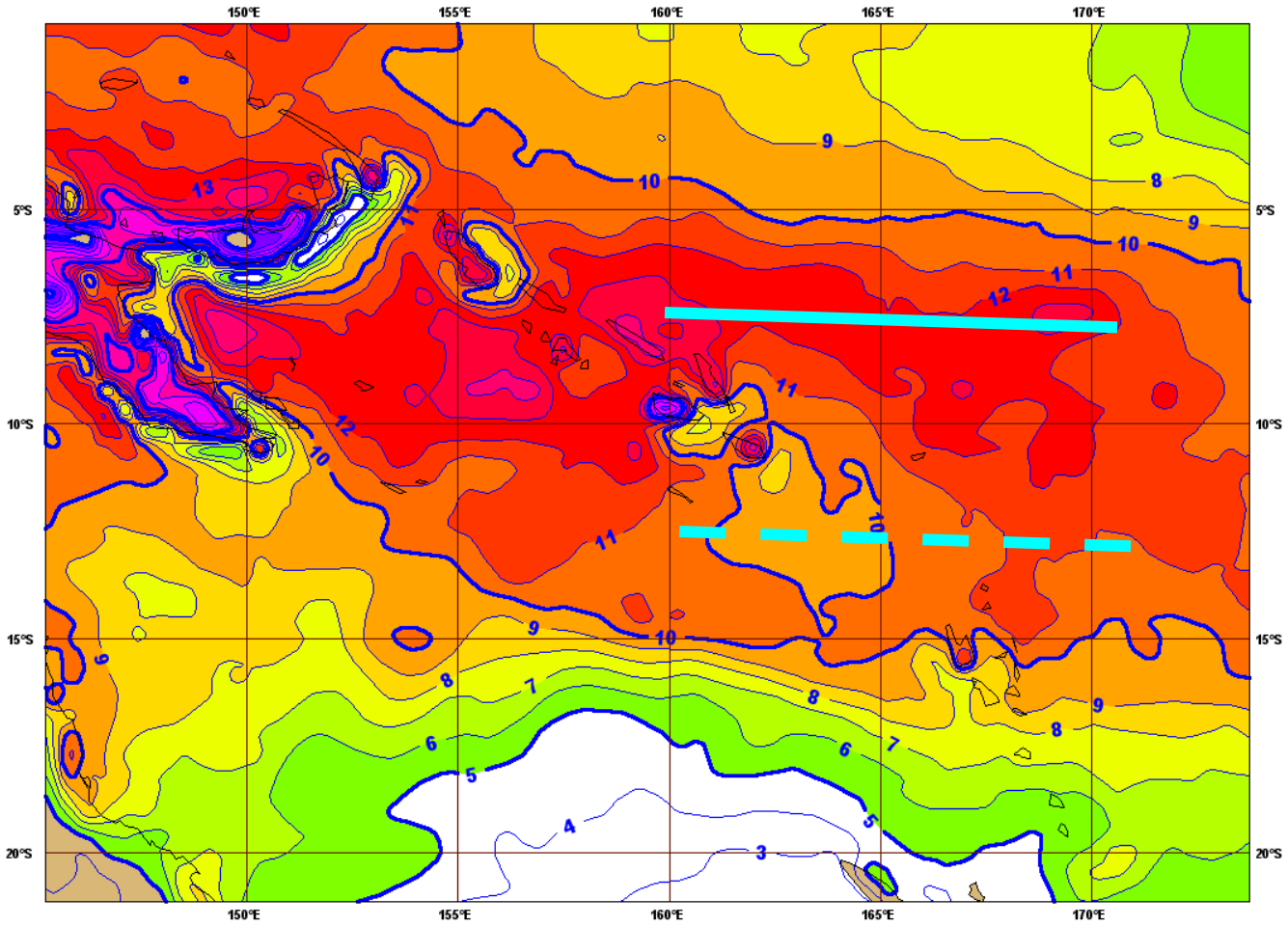
M-Climate e.g. Mean Daily Rainfall - SW Pacific – end of Jan



Day 2

ECMWF

M-Climate e.g. Mean Daily Rainfall - SW Pacific – end of Jan



Day 4

ECMWF

Model drift

- **The drift in rainfall in the SW Pacific is quite an extreme example**

  → **This relates to the difficulties the model has with handling tropical convection**

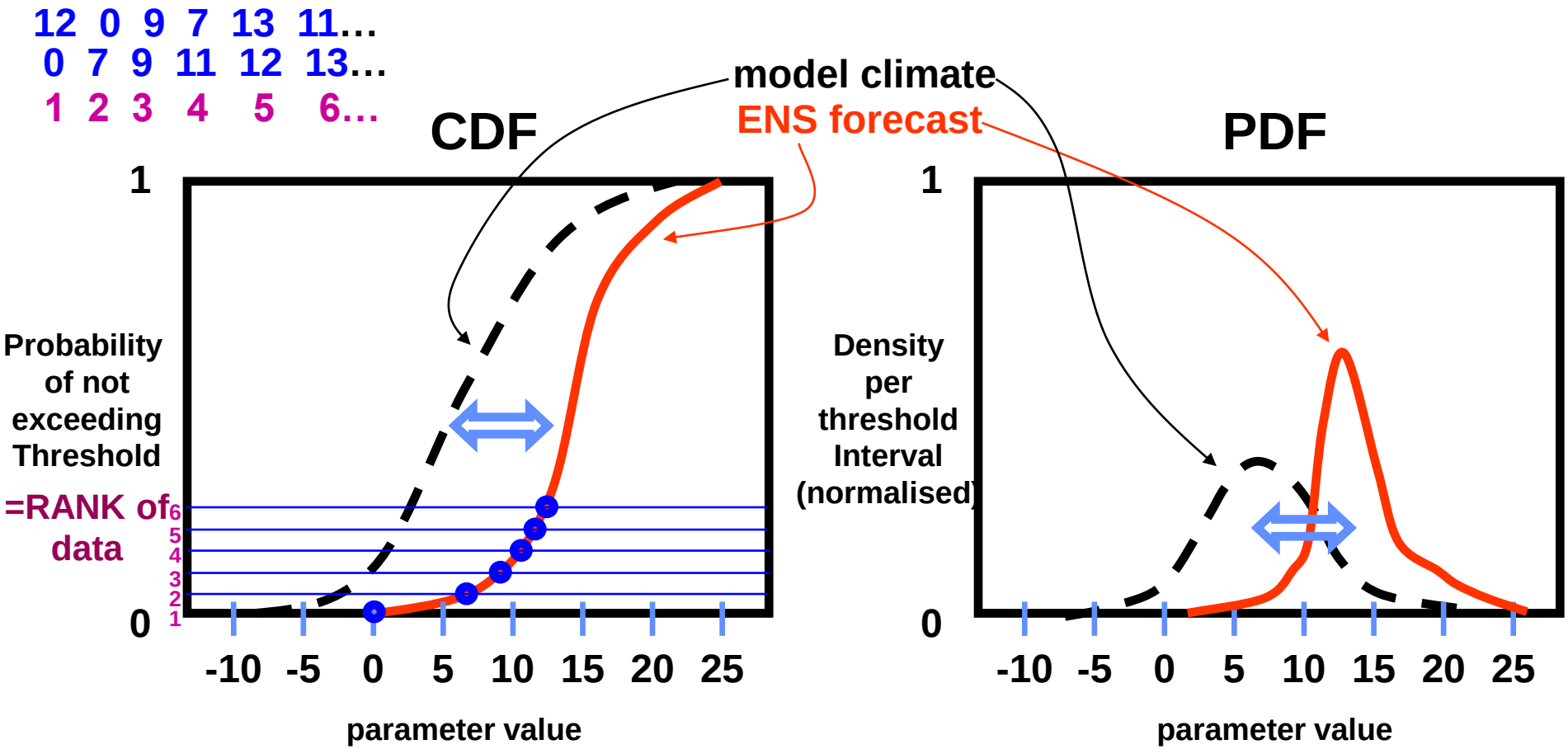
- **In other parts of the world such as Europe drift is generally much less. But it is still not zero.**

- **Anyway, the EFI needs to account for any drift, to see how extreme a particular set of forecasts are relative to what the forecast would 'ordinarily' produce at such lead times.**

Extreme Forecast Index

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.



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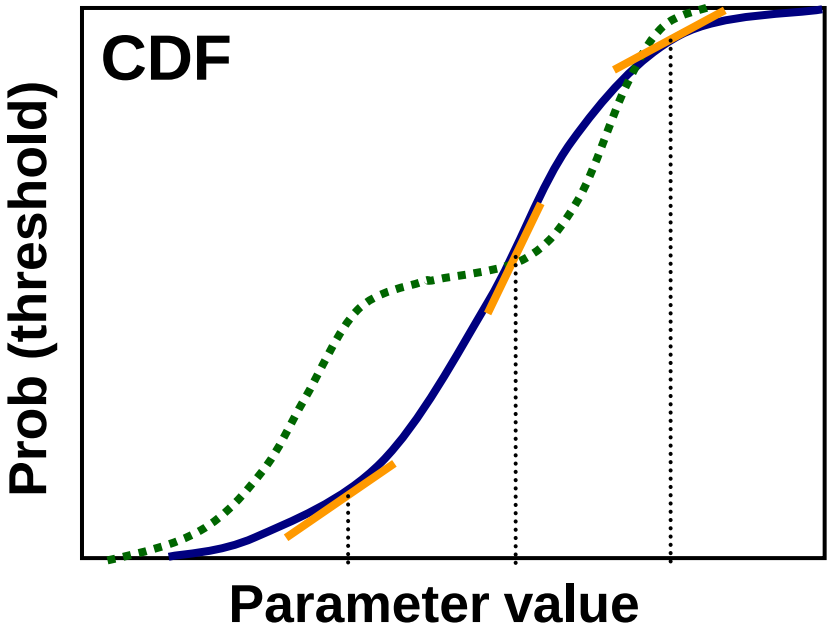
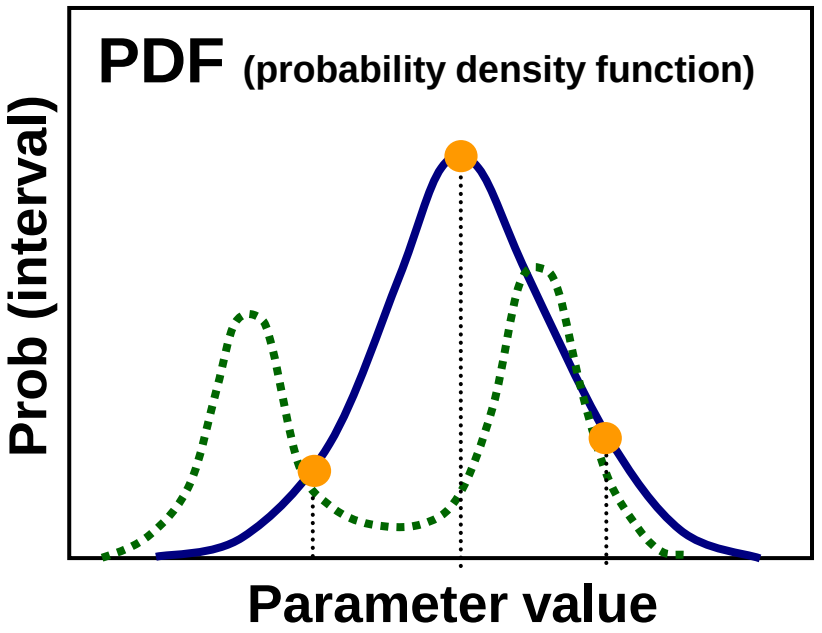
How do CDFs and PDFs relate?



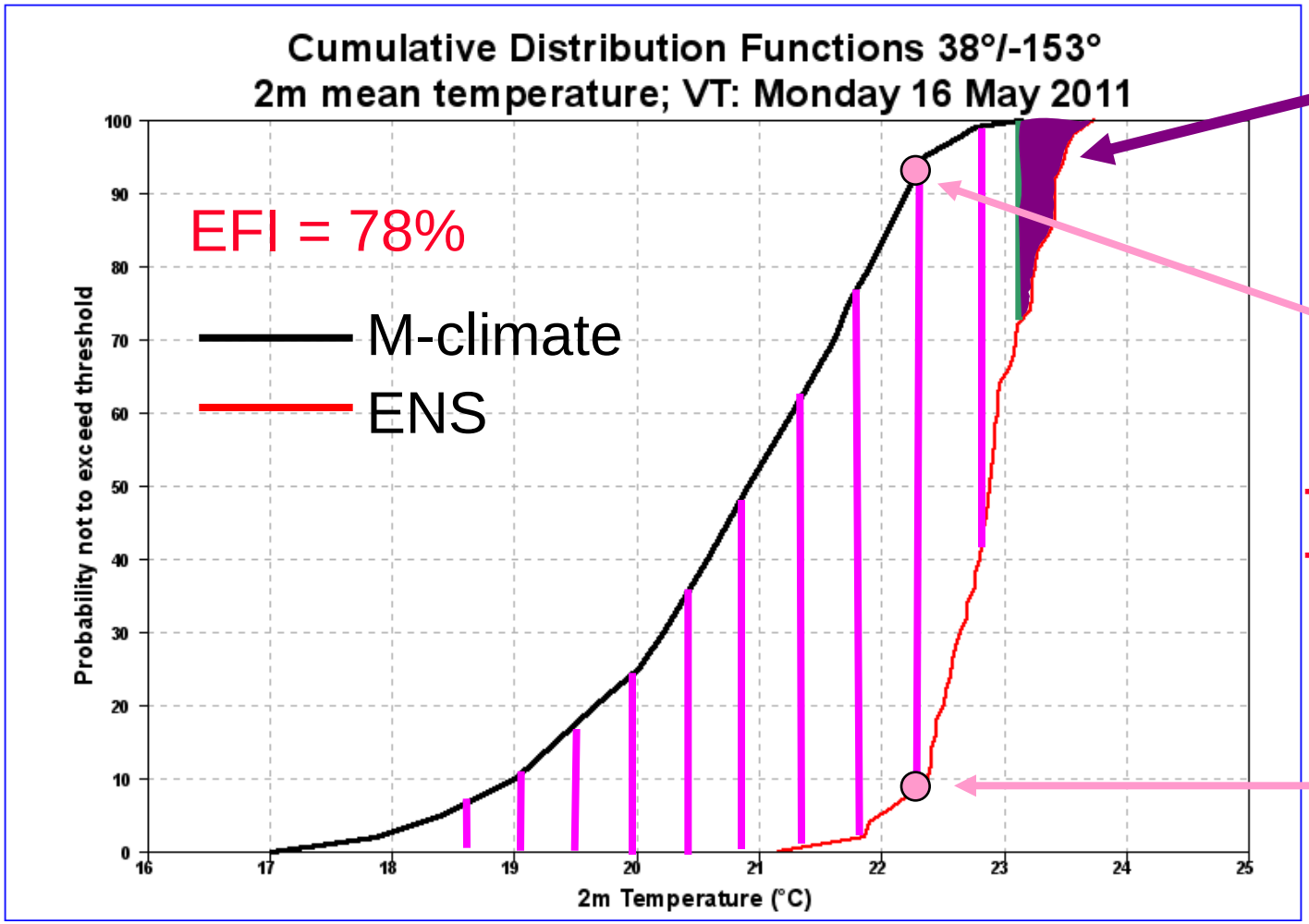


- The PDF (y-axis) value equals the slope of the CDF
- Steeper CDF = narrower PDF = higher confidence in the forecast
- A step in the CDF means a bimodal PDF

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

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

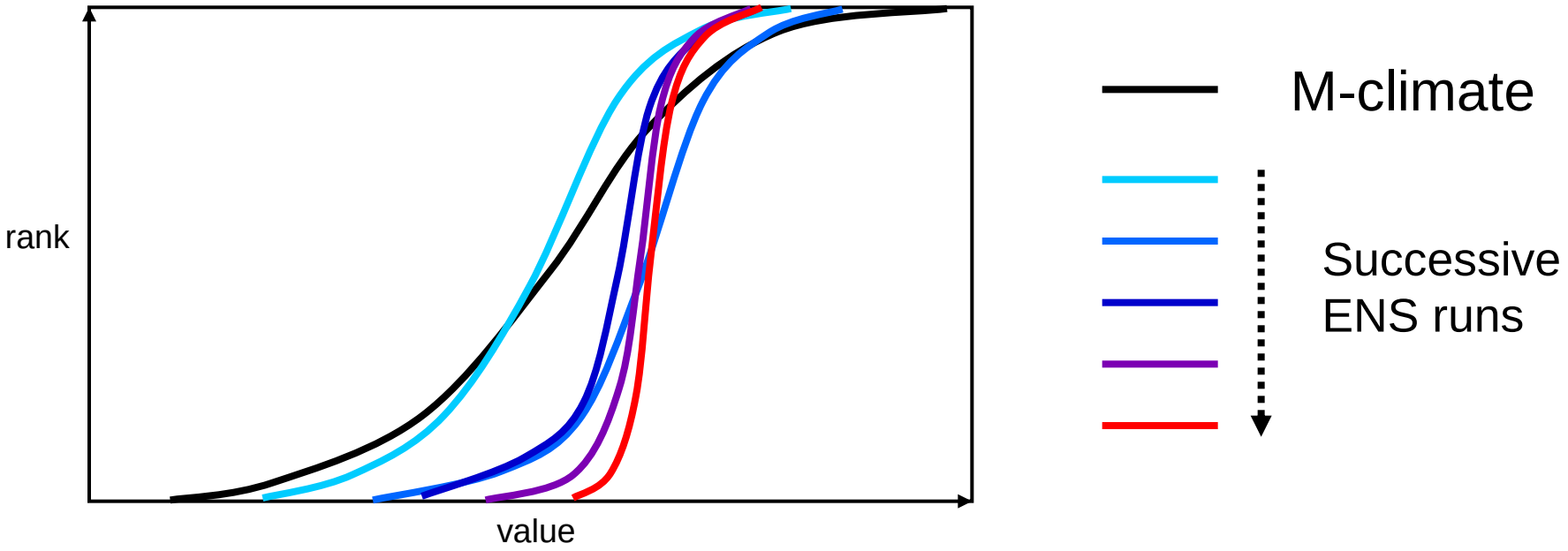
-1 ≤ EFI ≤ 1

-100% ≤ EFI ≤ 100%

$F_f(p)$

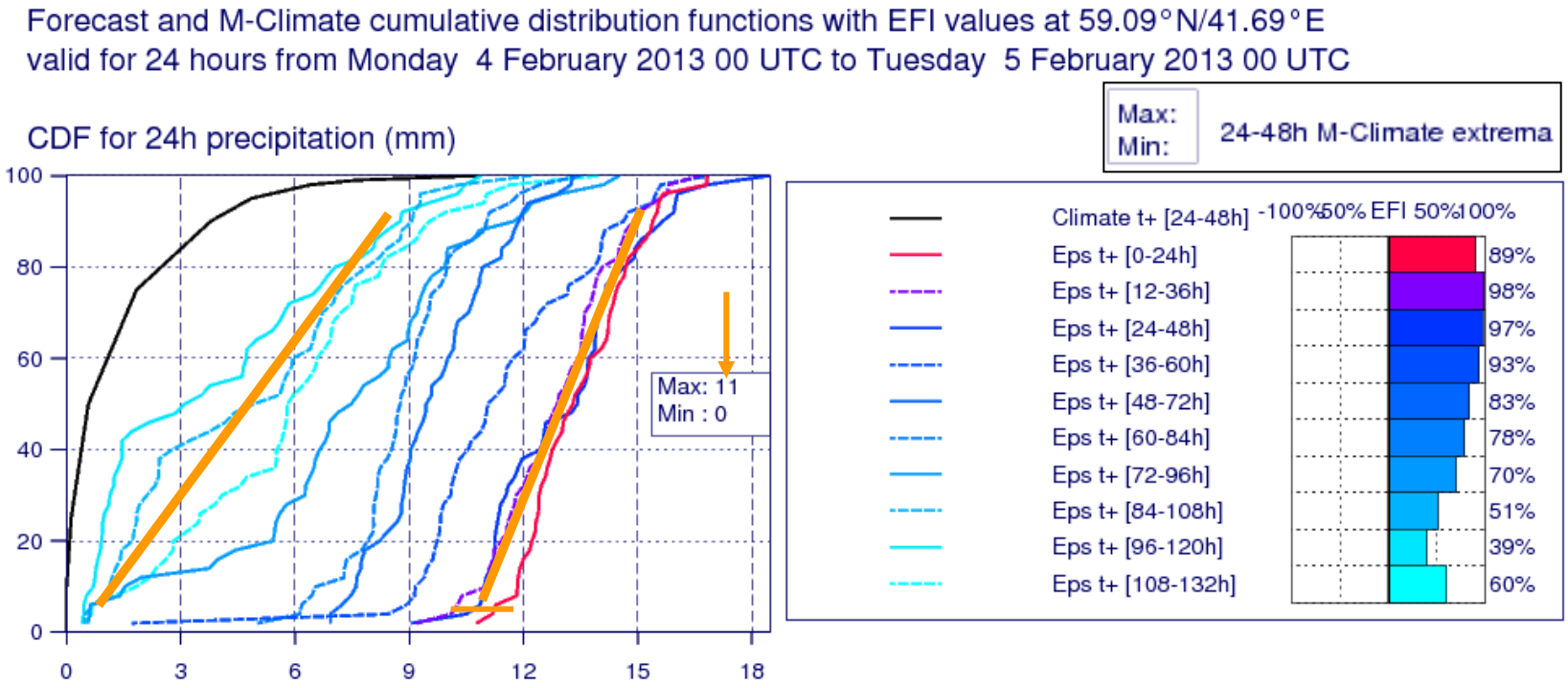
ECMWF

How 'should' CDFs behave in successive ENS runs?



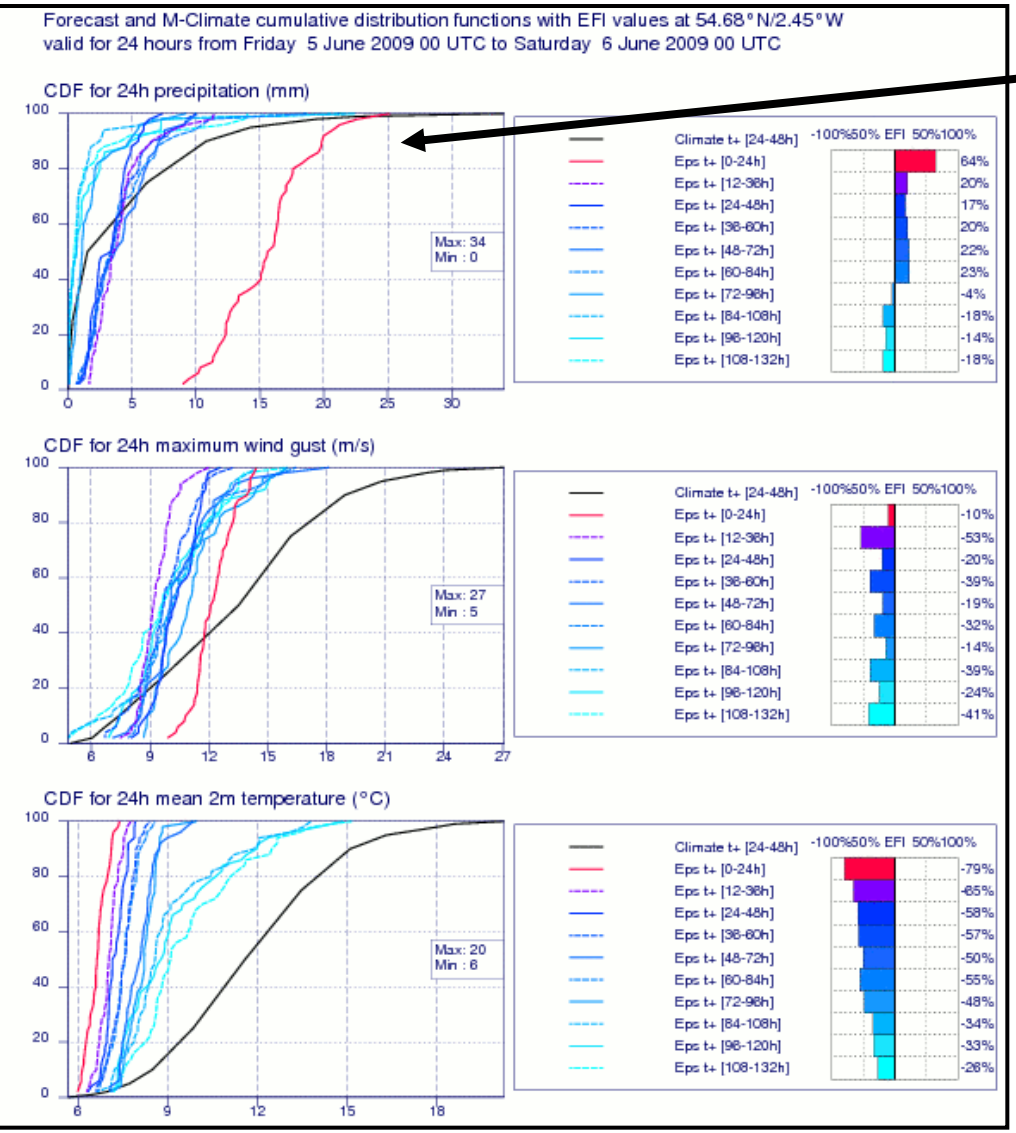
- At long lead times CDF may be similar to the M-climate.
- Lateral variations in CDF position between successive runs should, mostly, become less (with time).
- CDF will tend to become steeper (with time), implying higher confidence.

Example



- The 16-year return period 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

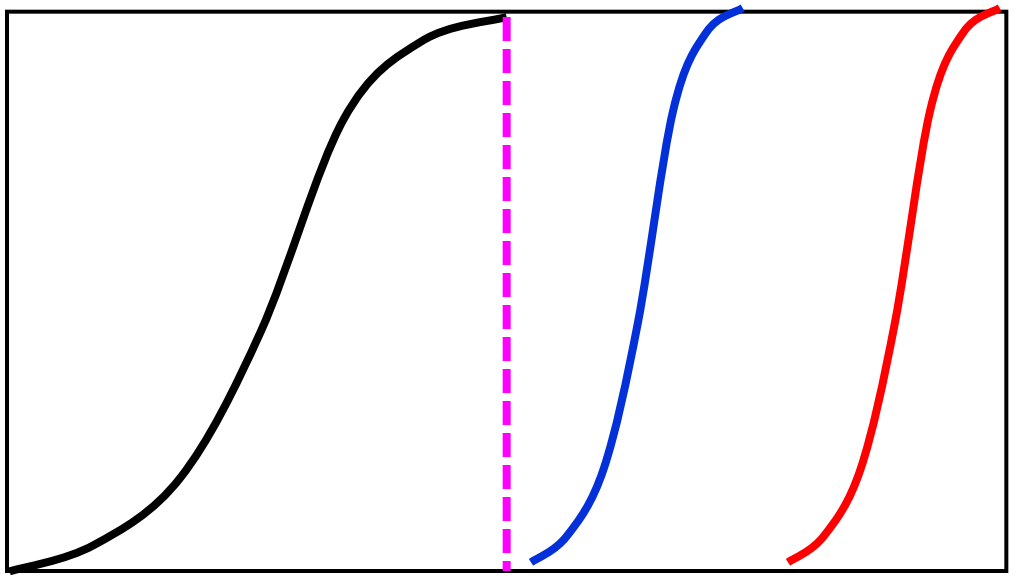


- N England rain – June ’09 - low prob alternative became likely at short range. If rare this is OK.

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

Some limitations



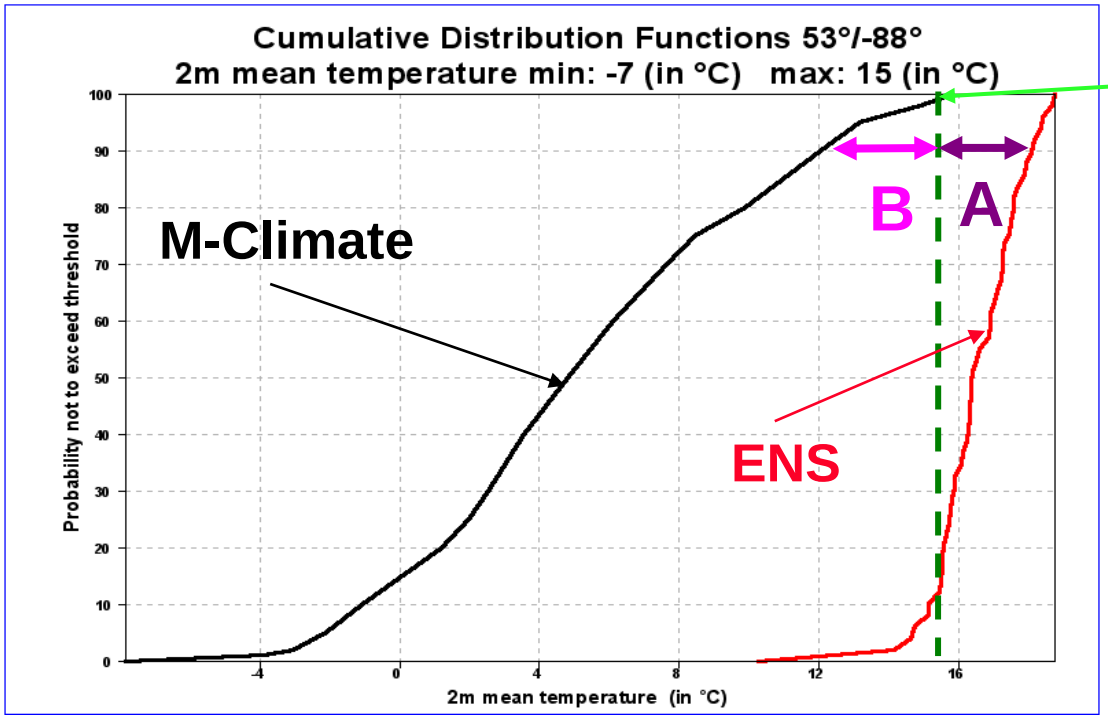
M-climate

ENS forecasts

EFI = 1
EFI = 1

- **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)

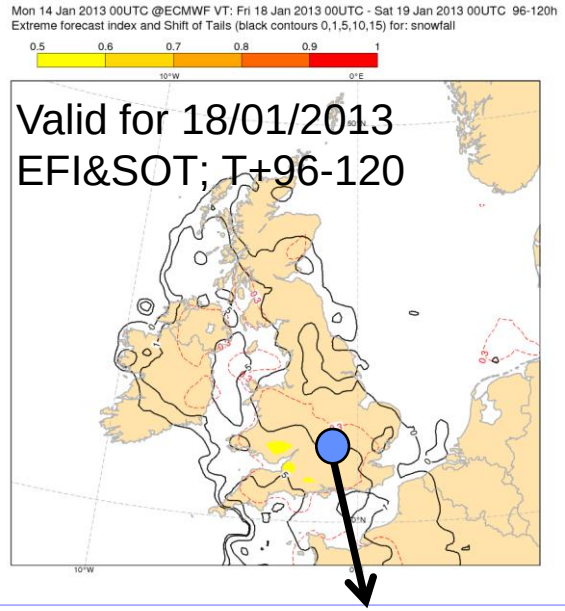


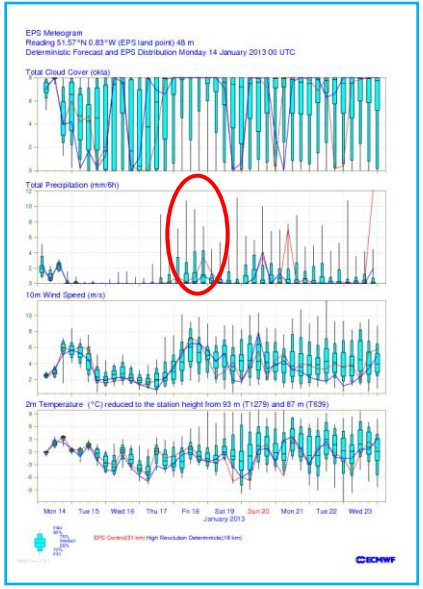
SOT = A/B

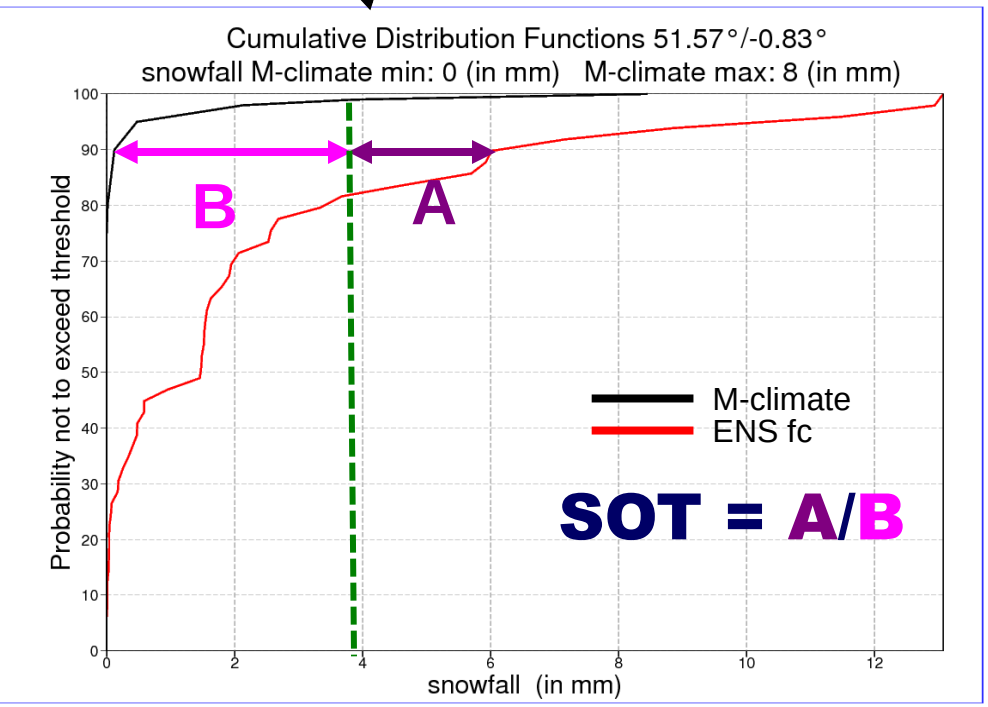
A = Qf(90) - Qc(99)

B = Qc(99) - Qc(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



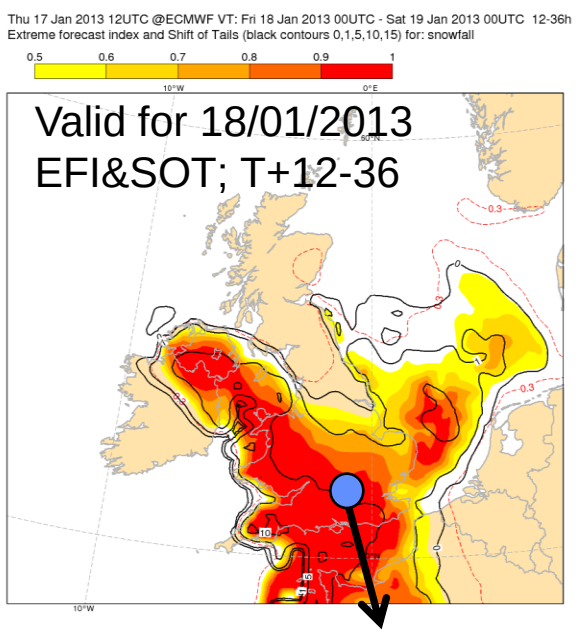


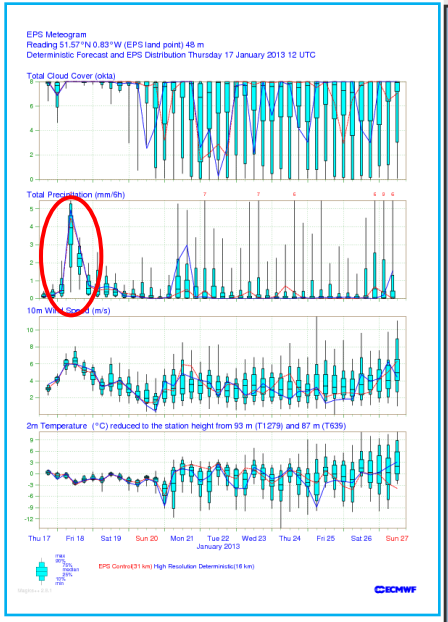


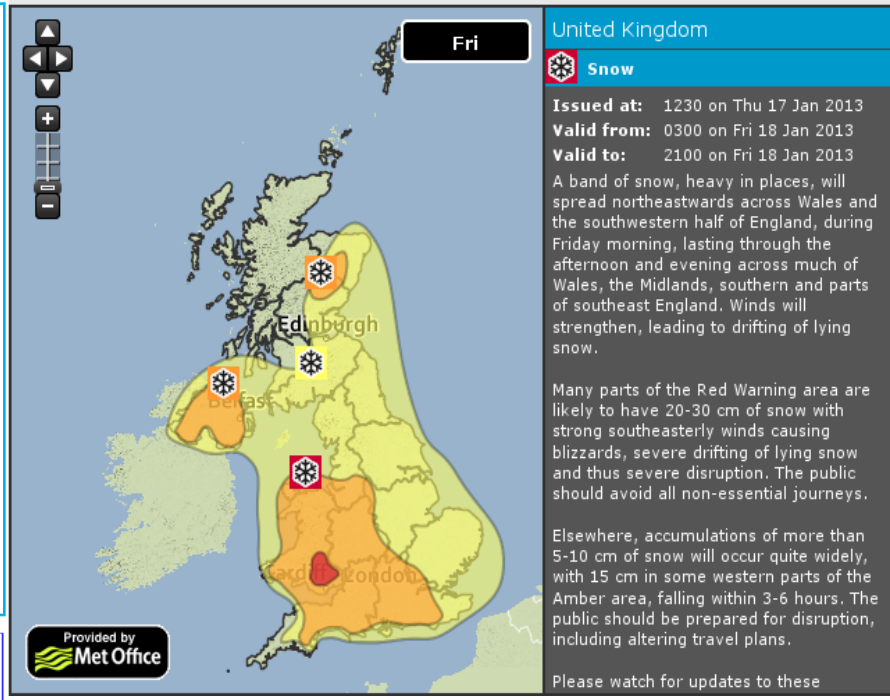
- **SOT > 0 → at least 10% of the ensemble members are above the 99th percentile M-climate**
- **The higher the SOT value is, the further this top 10% of the ensemble forecast is beyond Q99 of the M-climate.**
- **In the example (Reading):**
  - **EFI = 0.36**
  - **SOT = 0.8**

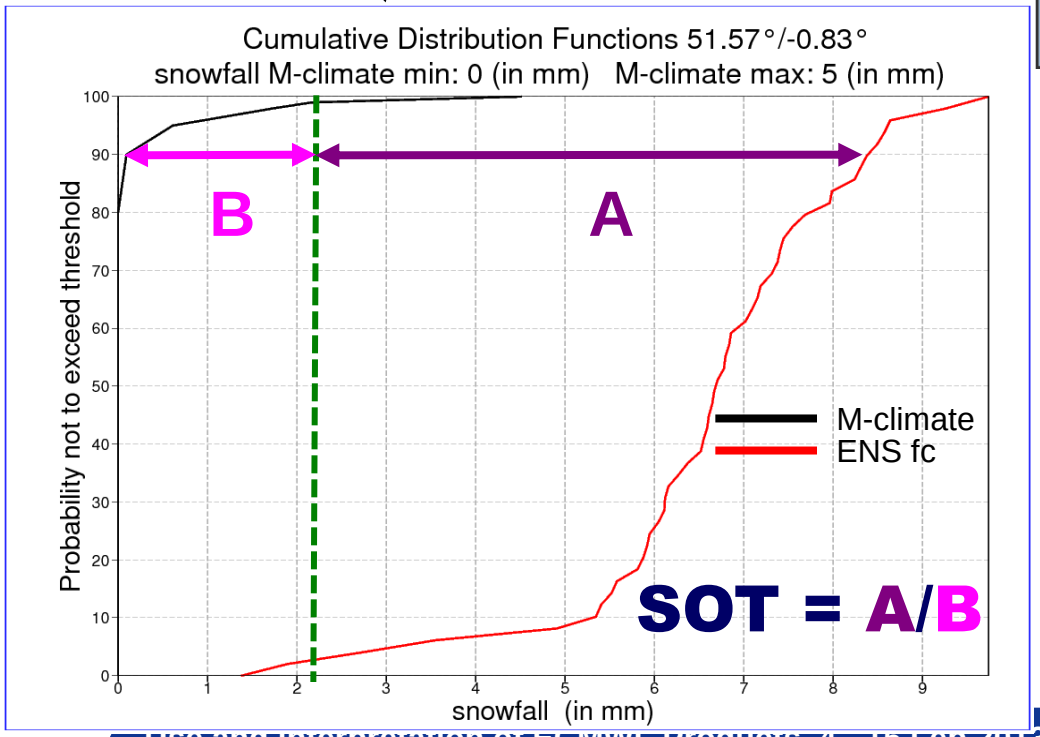
– **EFI positive → forecast suggests some snow**

– **SOT >0 → there are ENS members predicting extreme snowfall but the forecast is still uncertain**







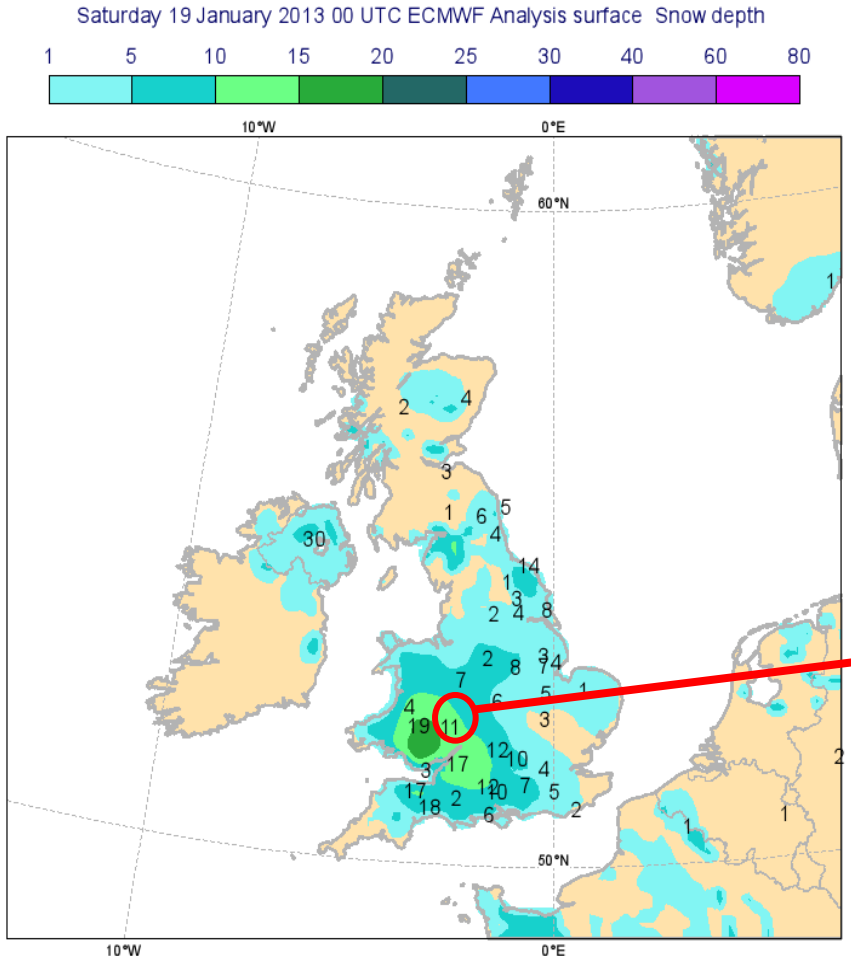


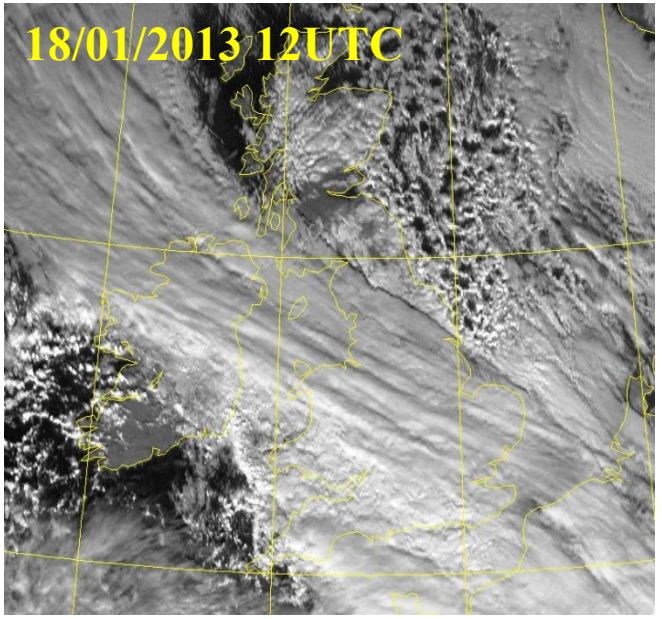
Reading:

- **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





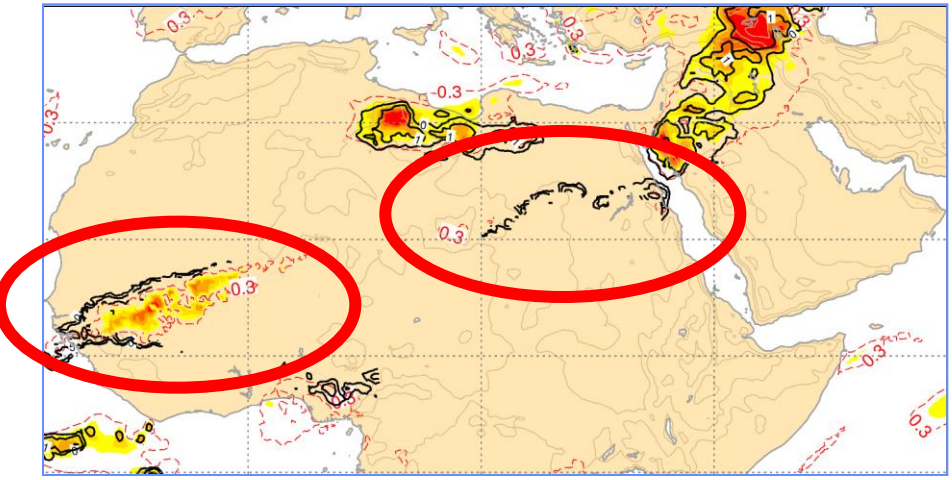
Bromsgrove, near Birmingham, UK

A beer garden in Bromsgrove. Credit: Sue Eden

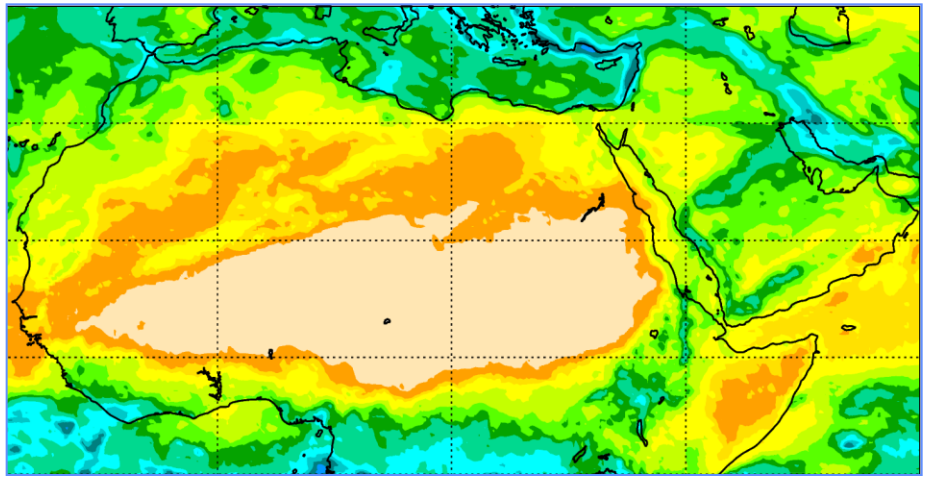
ECMWF

Some limitations

EFI &SOT; precipitation



M-climate Q99



- **SOT is not defined when M-climate Qc(90)= Qc(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.**

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)

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

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

Tropical cyclones
Epsgrams (WMO Members)
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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

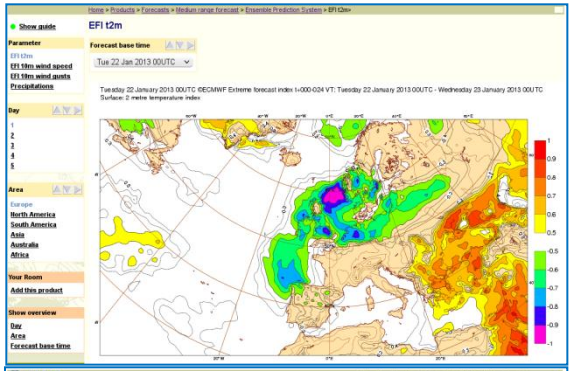
The Extreme Forecast Index (EFI) up to five days ahead for 10-metre wind (daily mean), 10-metre wind gusts (daily maximum), 2-metre temperature (daily mean), precipitation (daily accumulations). The precipitation EFI is also shown for some longer period accumulations: days 1-5, 2-6 and 1-10.

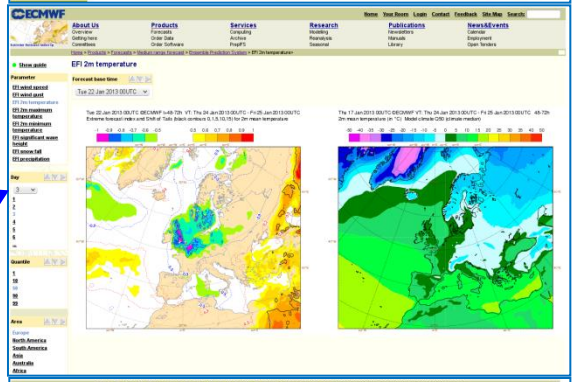
Extreme forecast index - Extended

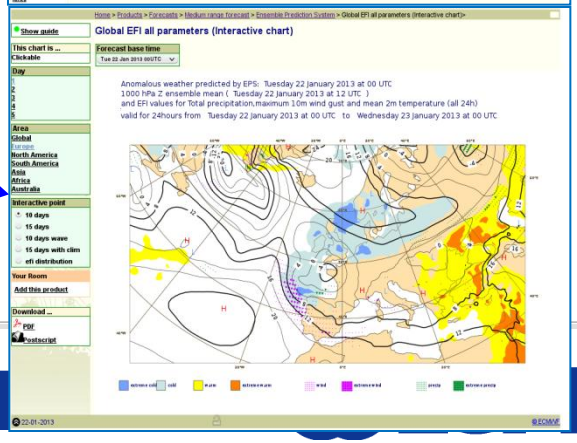
The Extreme Forecast Index (EFI) extended to show more parameters and more time ranges, together with the Shift Of Tails (SOT) index, and also maps of model climate quantiles.

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.







New web plots – available for all member states

ECMWF

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News&Events: Calendar, Employment, Open Tenders

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

Show guide

EFI 2m temperature

Parameter

- EFI wind speed
- EFI wind gust
- EFI 2m temperature
- EFI 2m maximum temperature
- EFI 2m minimum temperature
- EFI significant wave height
- EFI snow fall
- EFI precipitation

Forecast base time: Tue 22 Jan 2013 00UTC

Day: 3

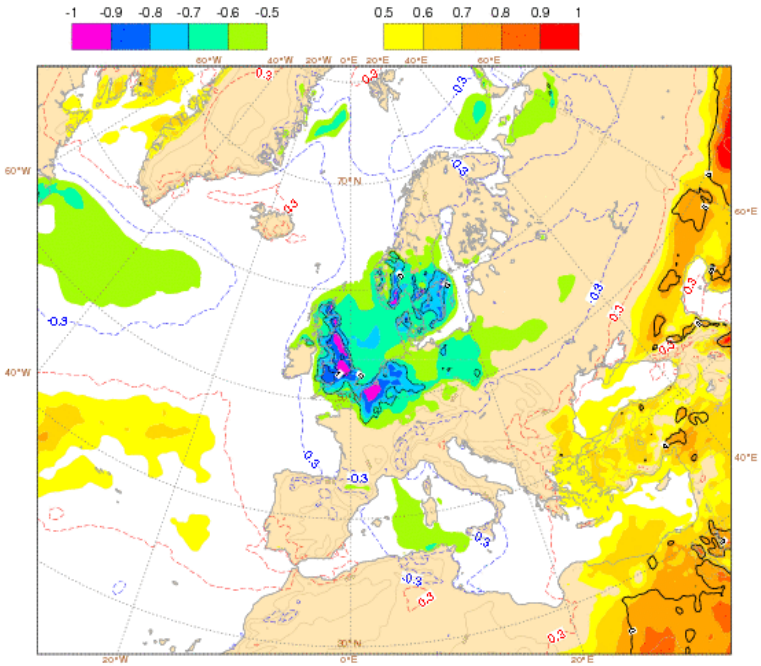
1 2 3 4 5 6 ...

Quantile: 1 10 50 90 99

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

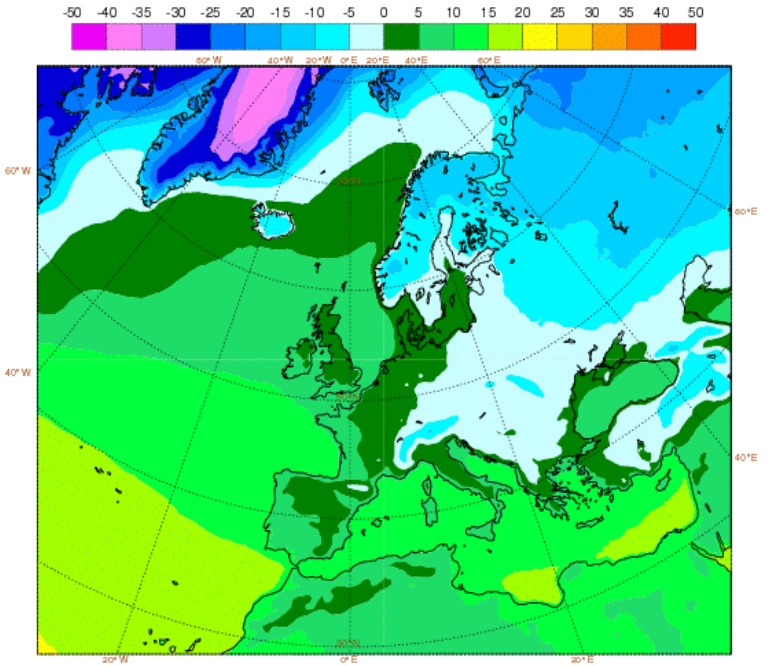
EFI & SOT

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



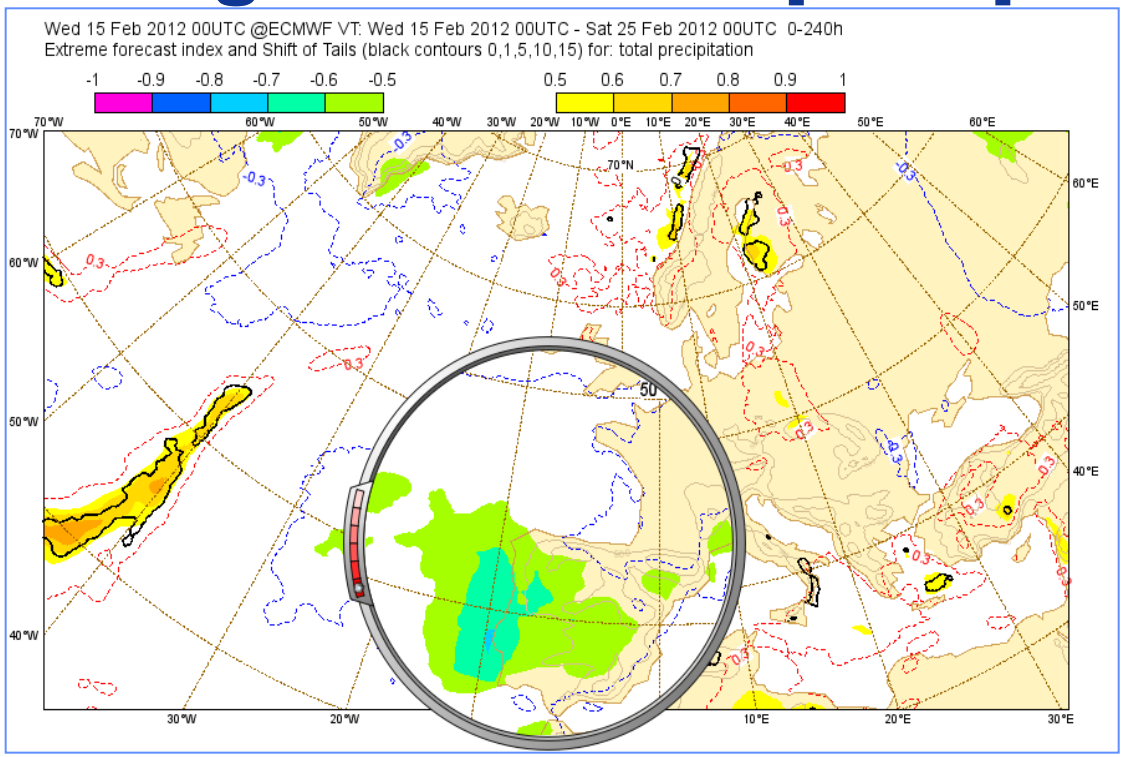
M-climate

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)



ECMWF

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

Day
- 1
- 2
- 3
- 4
- 5

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

Your Room
- Add this product

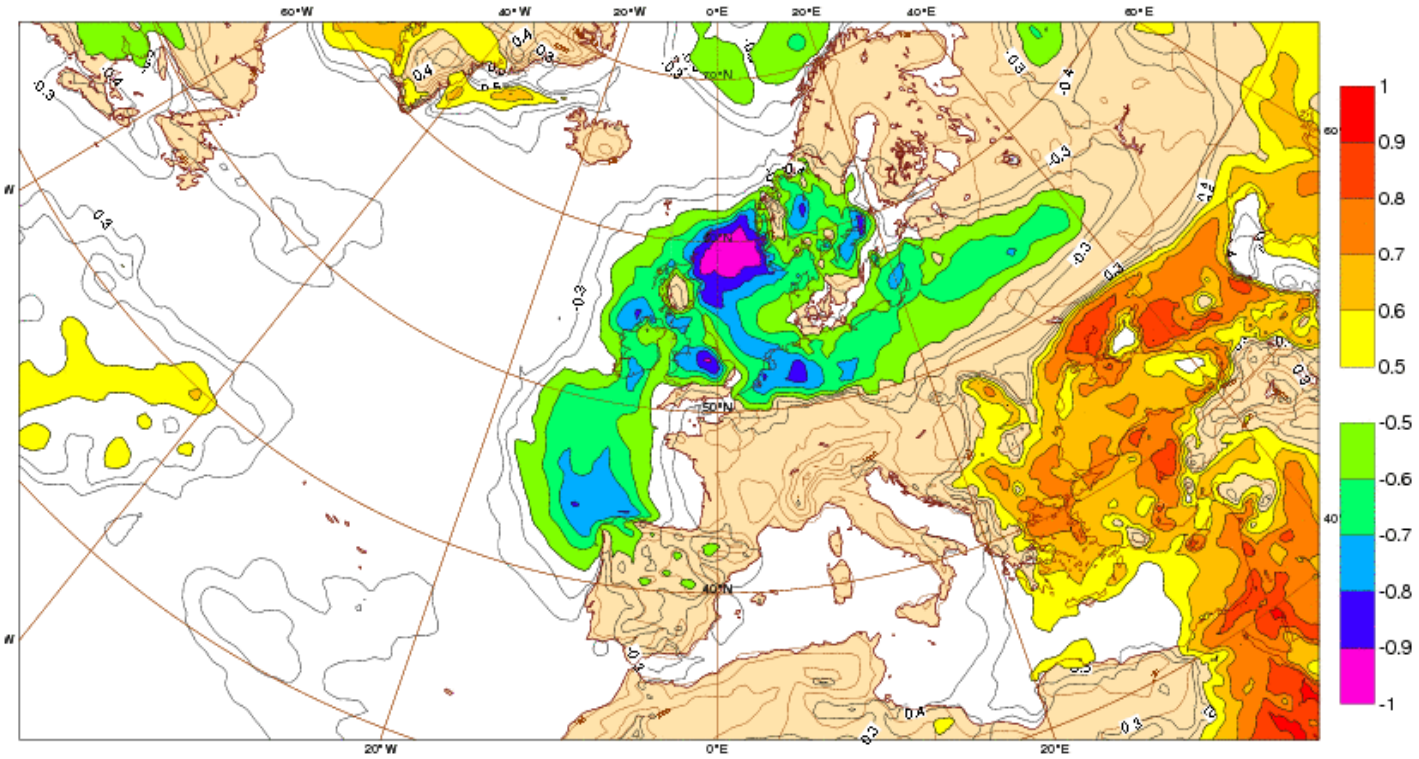
Show overview
- Day
- Area
- Forecast base time

EFI t2m

Forecast base time: Tue 22 Jan 2013 00UTC

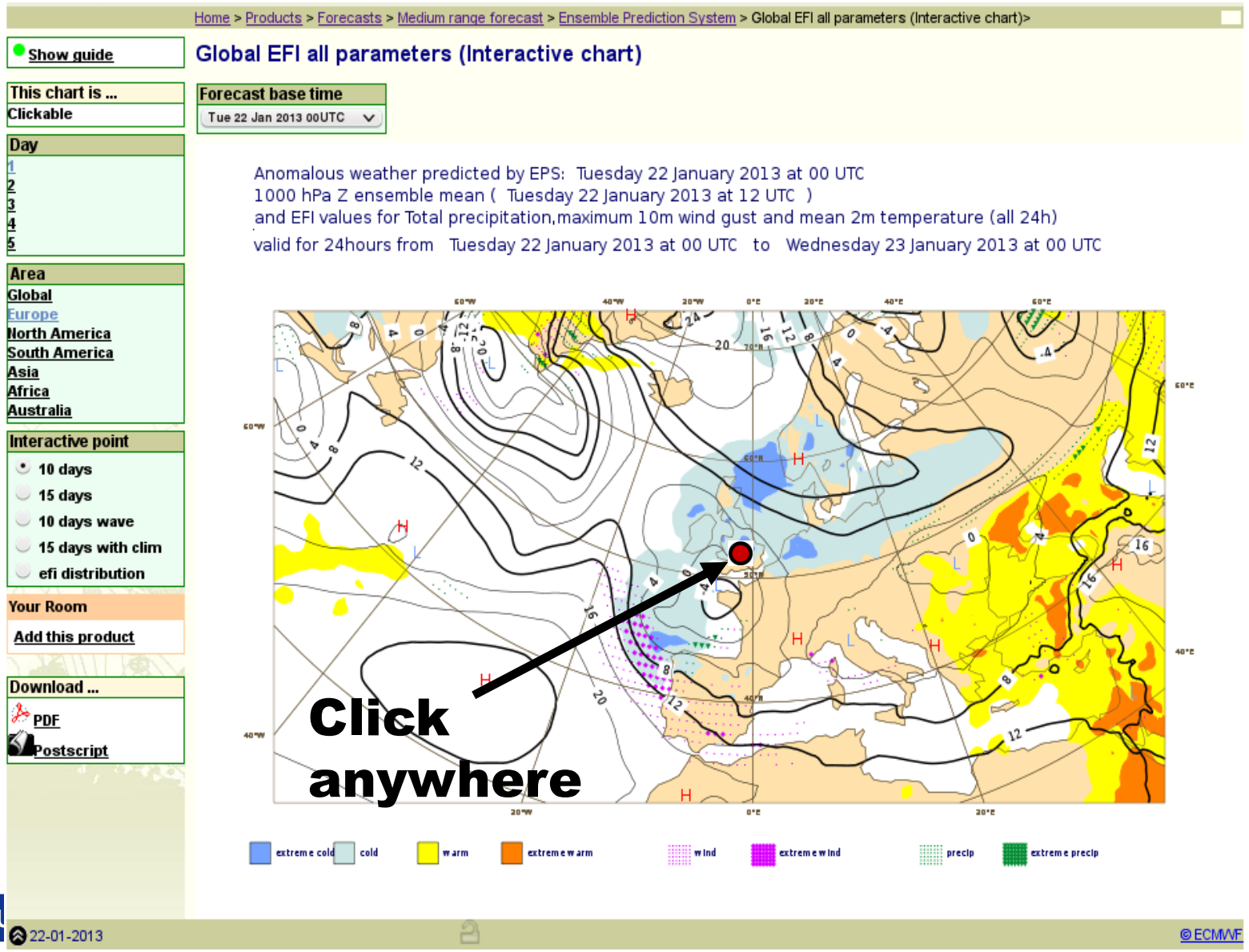
Selected parameters and time ranges

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

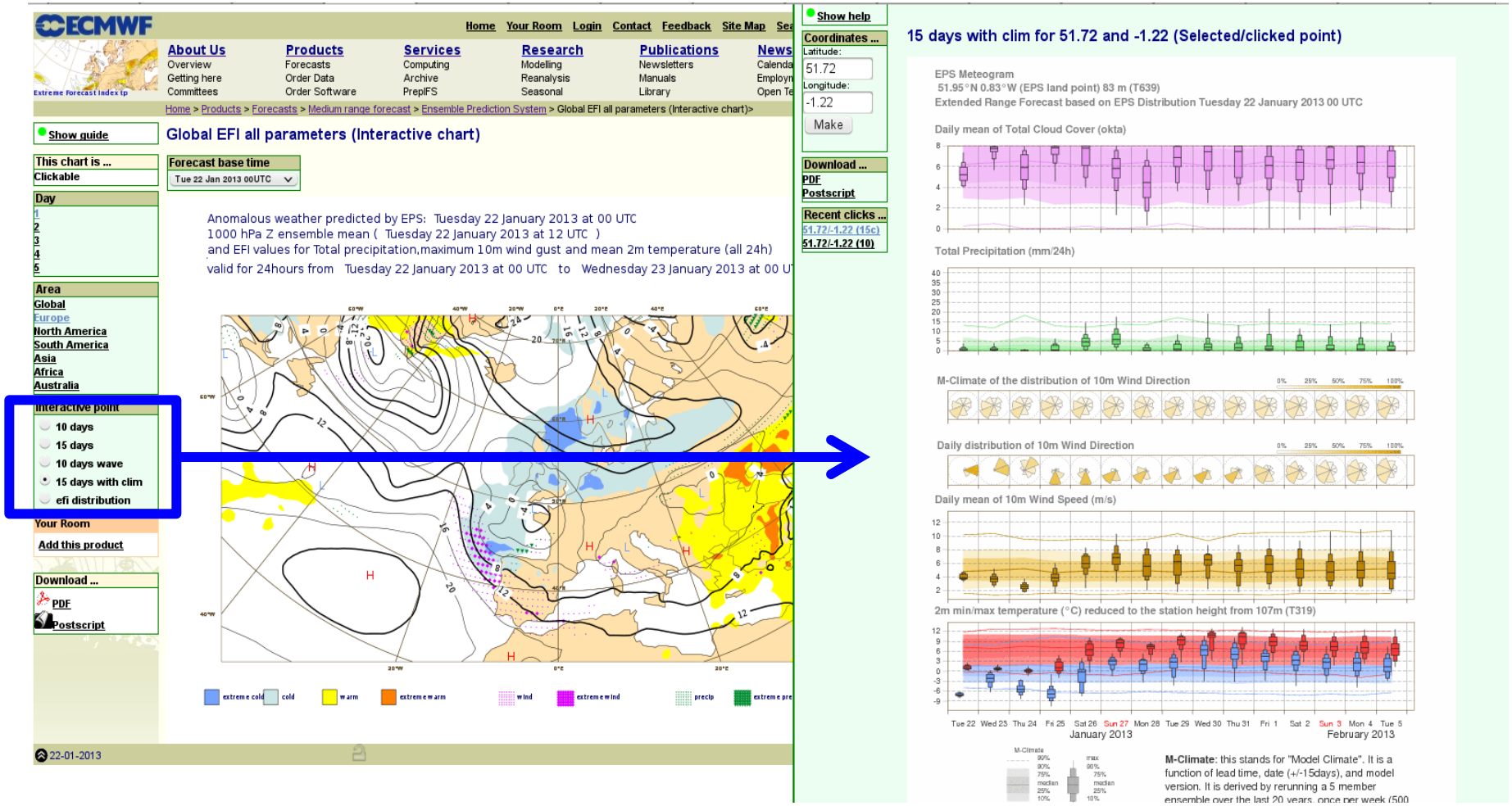


ECMWF

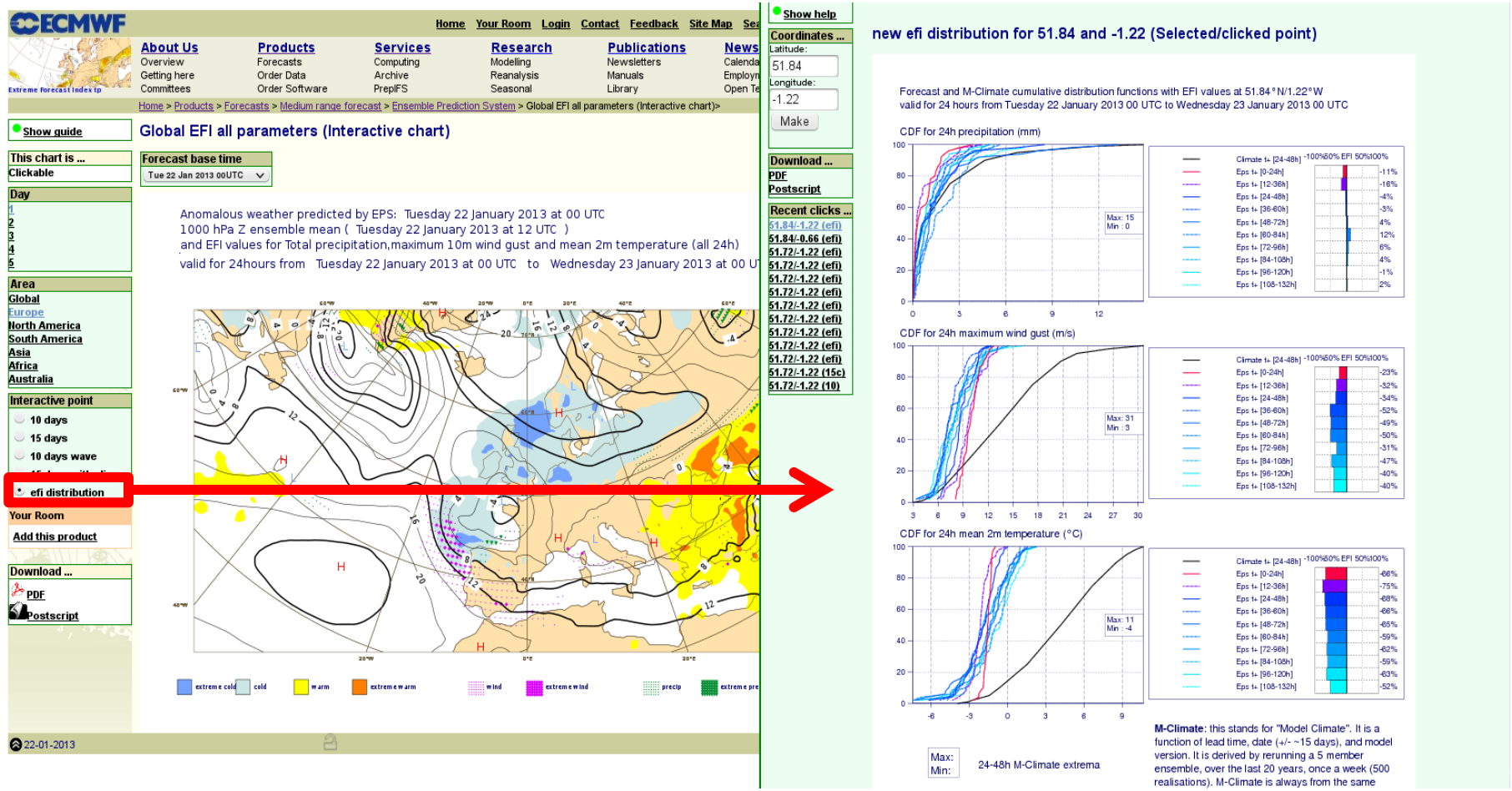
“Anomalous weather” map



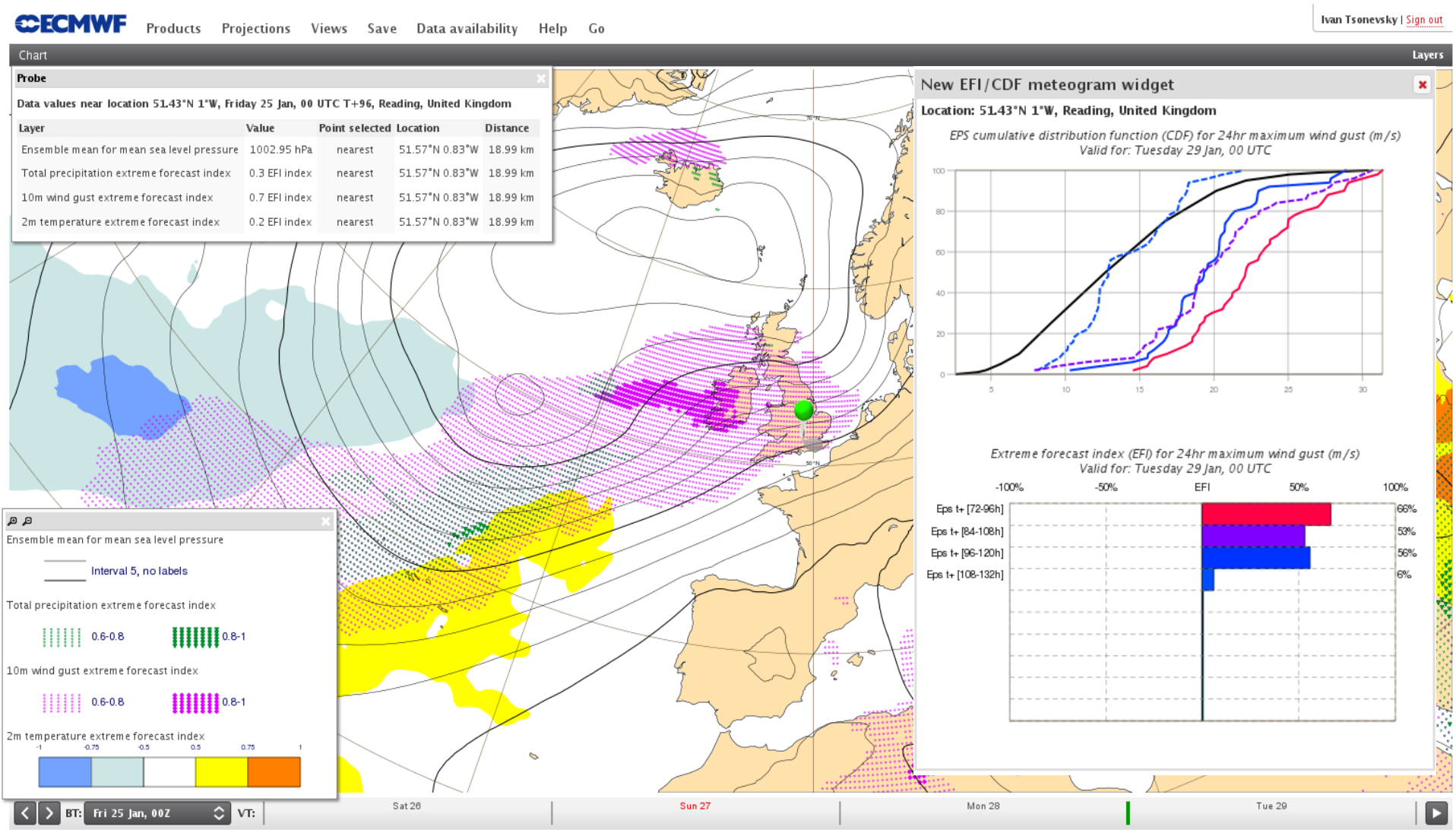
“Anomalous weather” map



“Anomalous weather” map

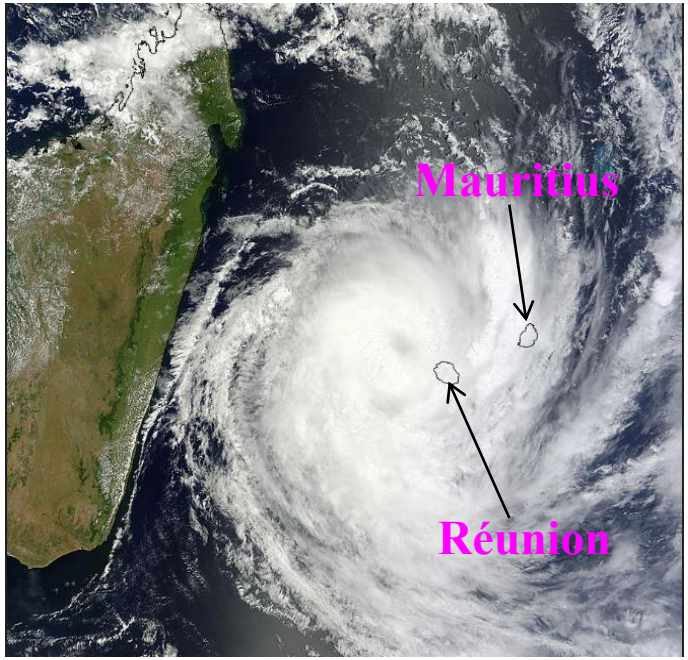


EFI products in ecCharts

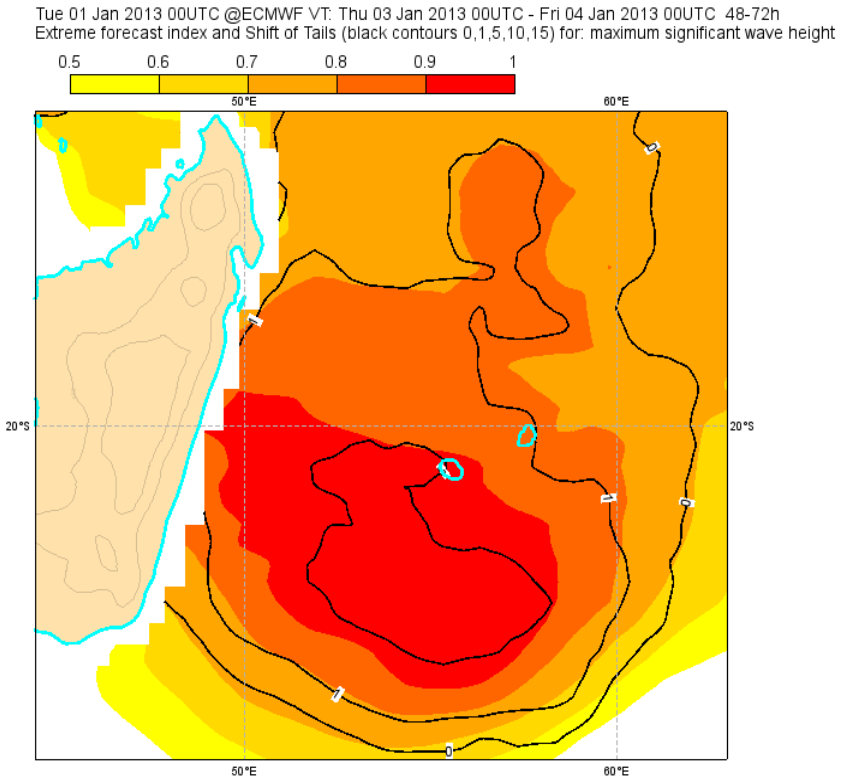


EFI for waves

NASA's Terra satellite on Jan. 3, 2013, at 0650 UTC



EFI for waves from 1/1/2013 00UTC valid for 3/1/2013



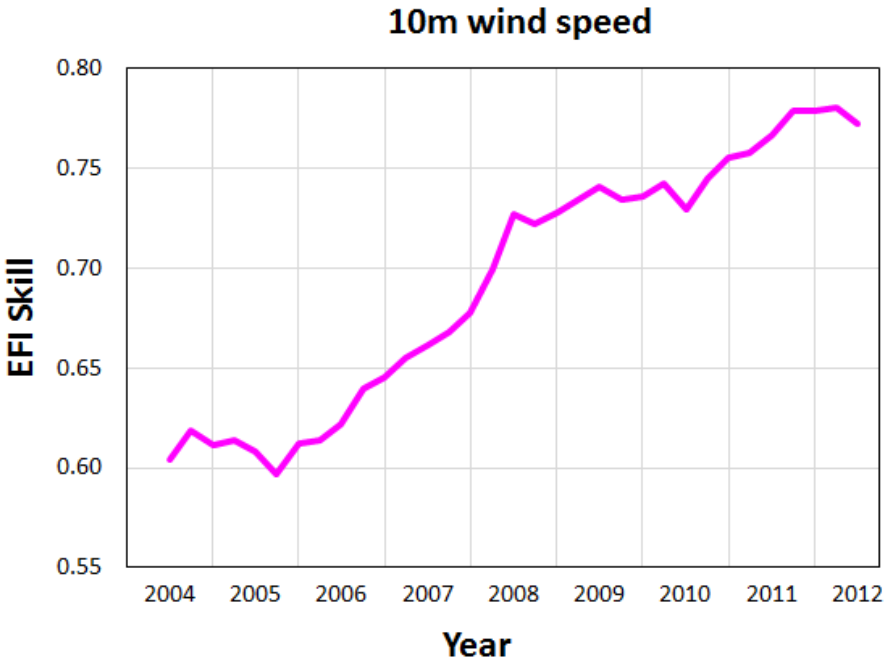
- Tropical cyclone Dumile passed near the French Island of La Réunion (~90 km to the west of the island). It caused exceptional waves and strong wind gusts (~ 120 km/h) leading to major power outages.
- Negative EFI (calm sea) also plotted on the web (not shown here).

EFI Verification

- Verification of the EFI has been made 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



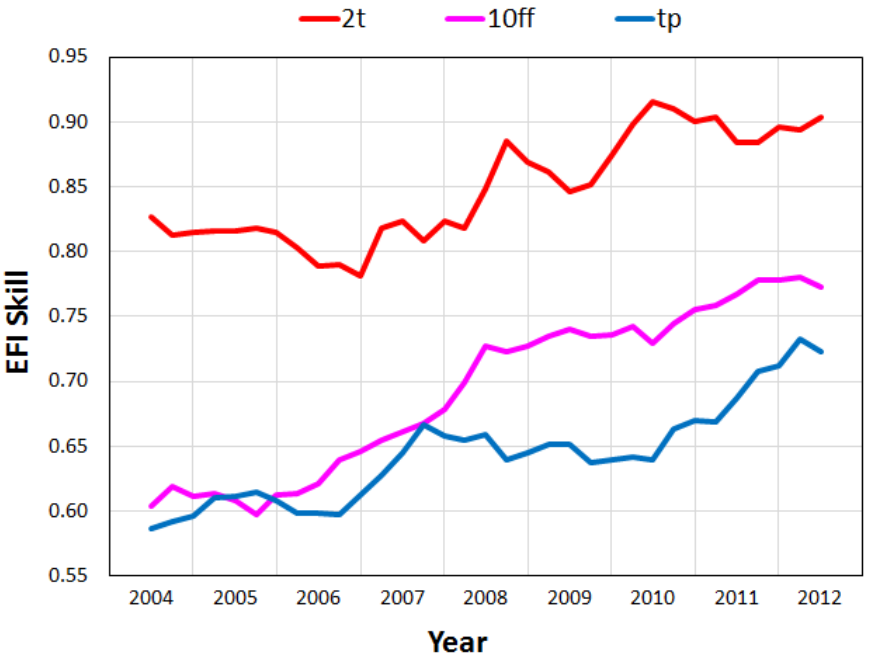
EFI Skill = 2*ROCA-1

EFI Skill = 0 no skill

EFI Skill = 1 perfect score

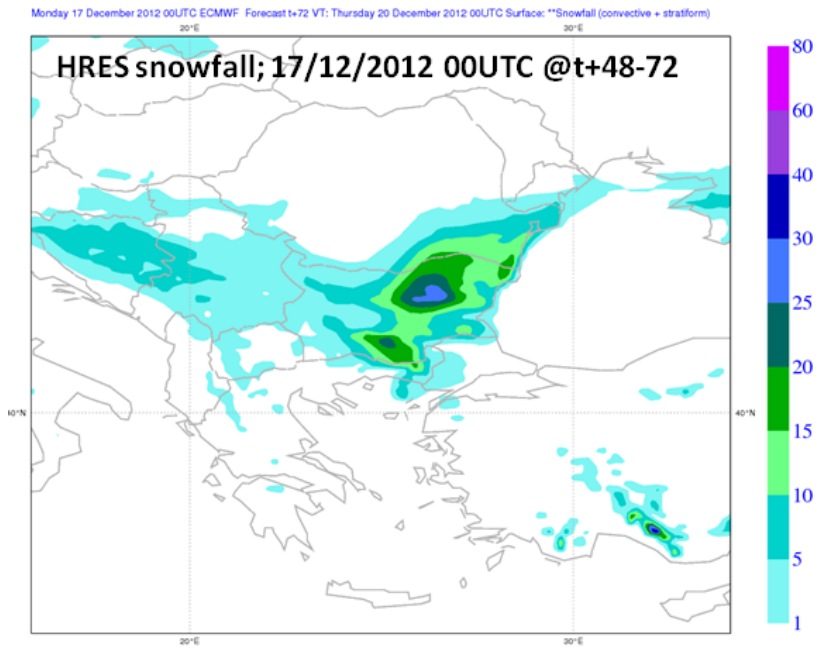
- **The plot shows the skill of the EFI for 10-metre wind speed** (a supplementary headline score adopted by the ECMWF Council) **at forecast day 4** (t+72-96h for 00UTC run and t+84-108h for 12UTC run)**.**
- **The curve shows a four-season running mean.**
- **It is noticeable a continually improving trend.**

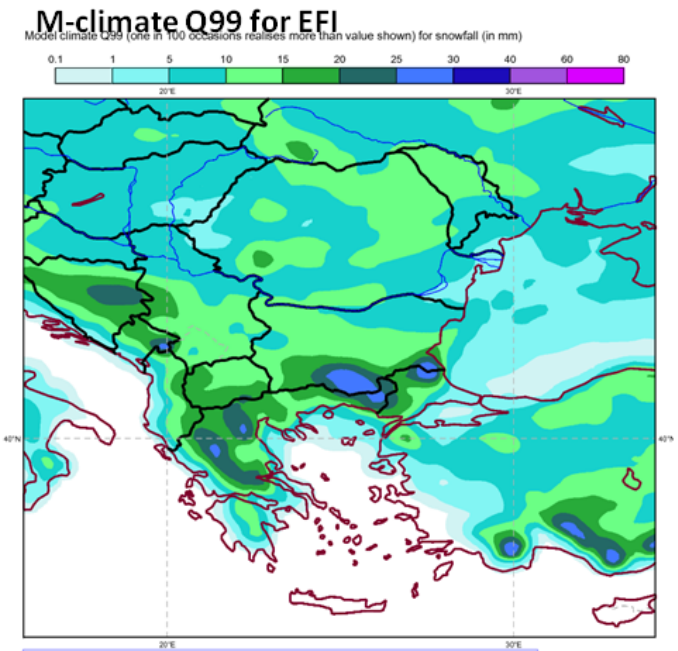
EFI Verification

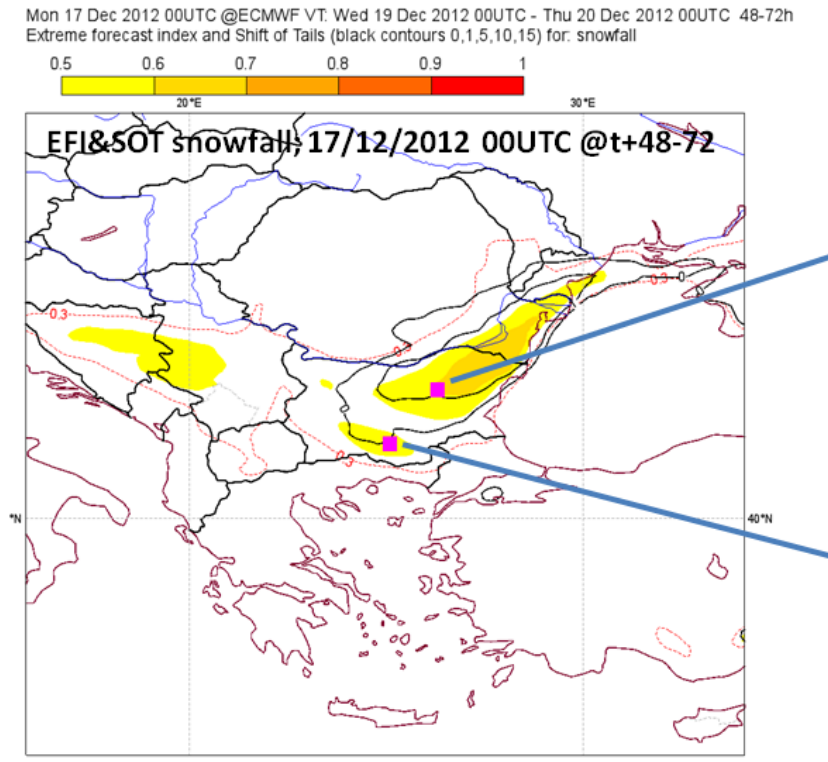


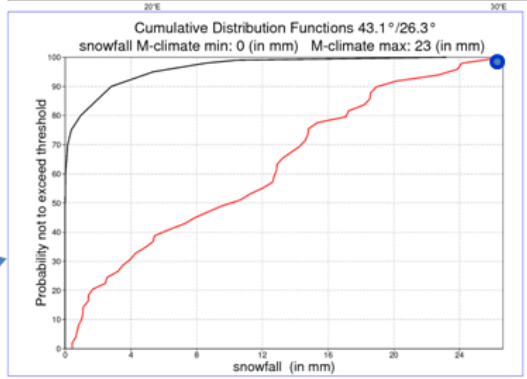
- Curves show a four-season running mean of the EFI skill score for 2m mean temperature (2t), 10 metre mean wind speed (10ff) and total precipitation (tp).
- The EFI for 2m temperature is more skilful than EFI for the other two parameters.
- For precipitation and wind speed, there has been a clear improvement since 2010 whilst for the temperature the EFI skill is maintained at a similar level.

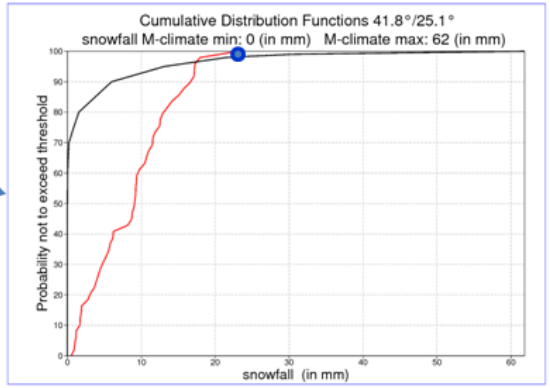
A CASE OF HEAVY SNOWFALL





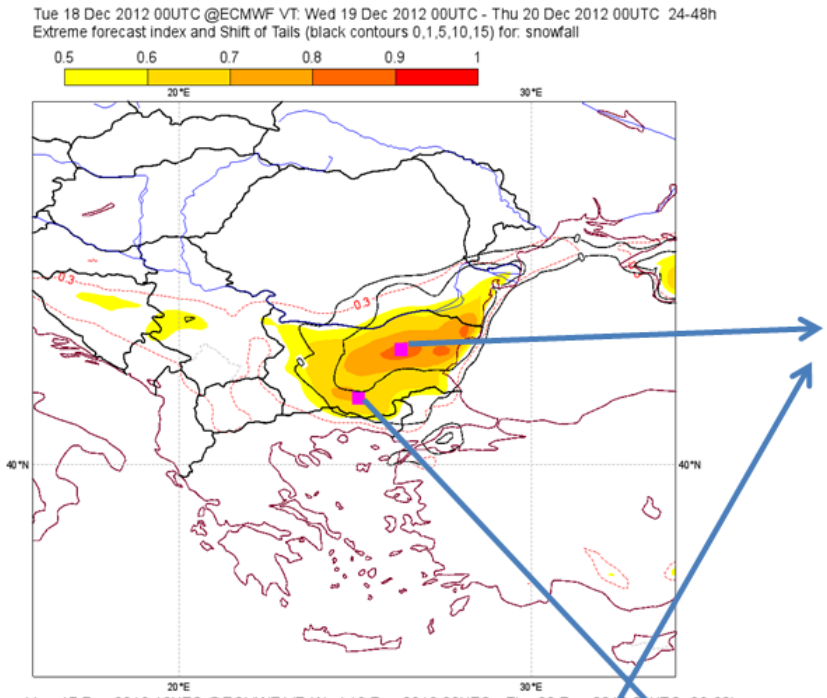


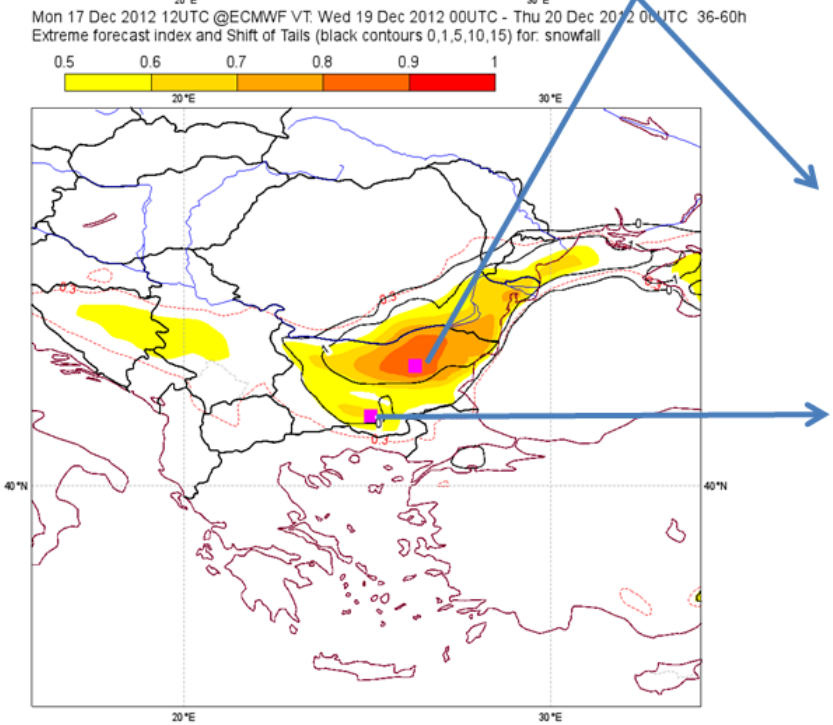


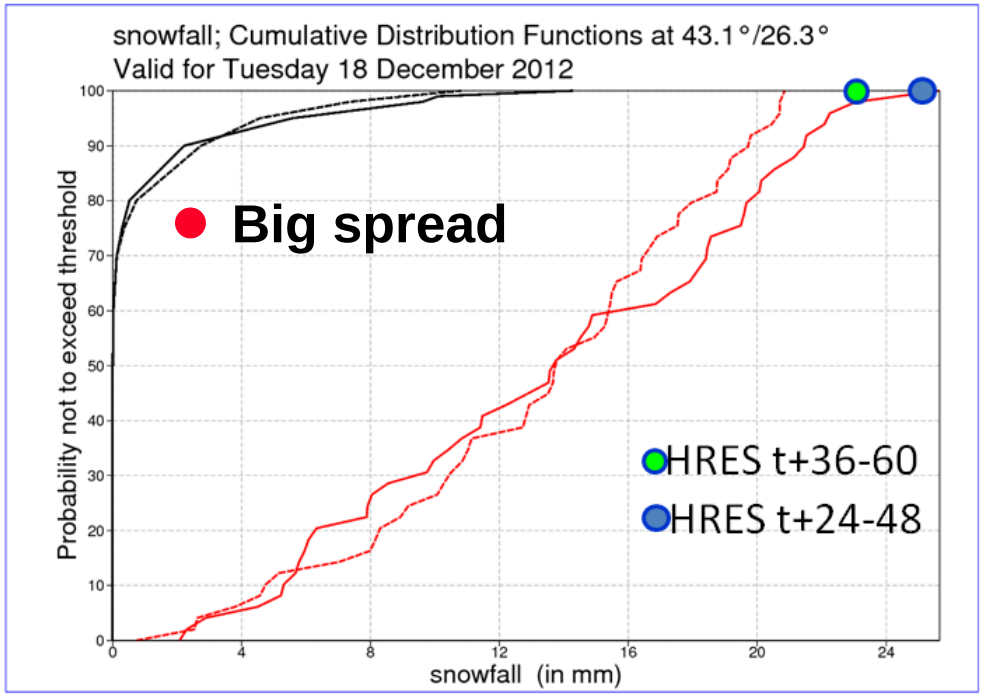


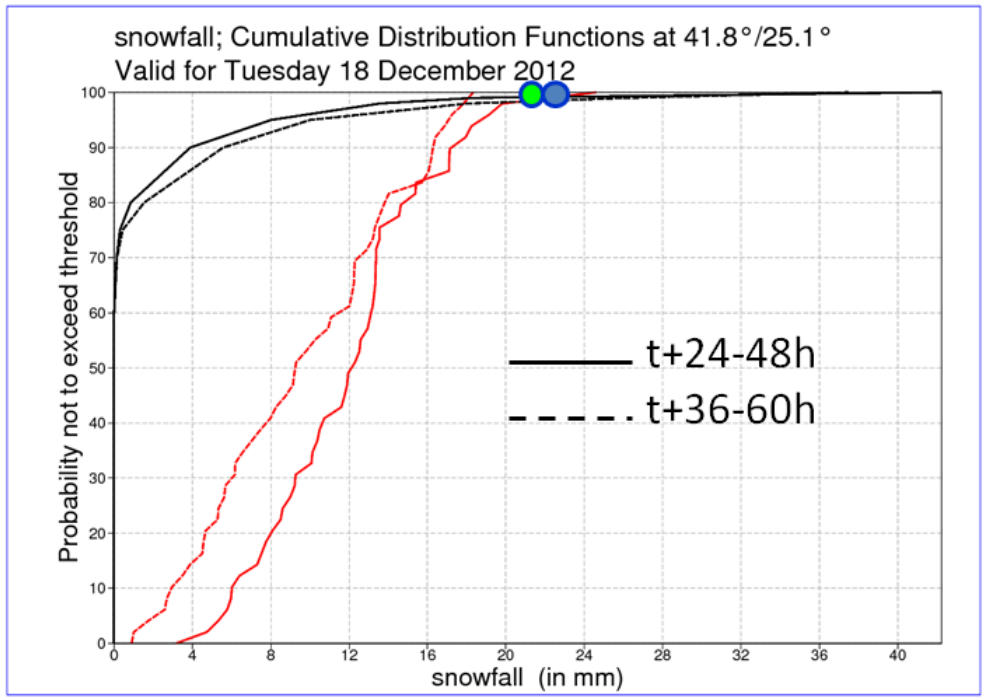
- HRES forecast

- **Big spread in snowfall amounts**
- **HRES is an outlier**


Tue 18 Dec 2012 00UTC @ECMWF VT: Wed 19 Dec 2012 00UTC - Thu 20 Dec 2012 00UTC 24-48h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: snowfall
0.5 0.6 0.7 0.8 0.9 1
20°E
30°E
40°N

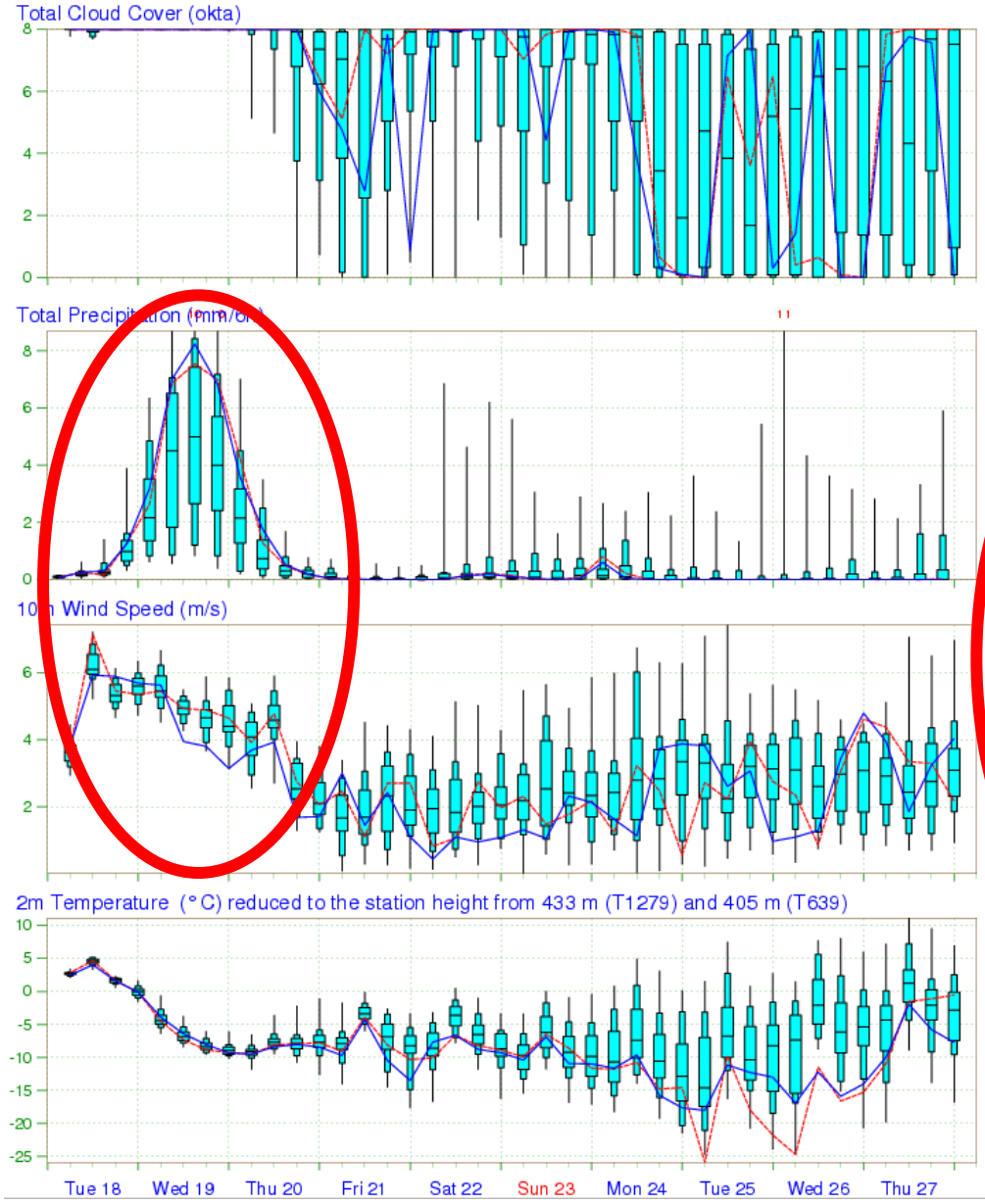

Mon 17 Dec 2012 12UTC @ECMWF VT: Wed 19 Dec 2012 00UTC - Thu 20 Dec 2012 00UTC 36-60h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: snowfall
0.5 0.6 0.7 0.8 0.9 1
20°E
30°E
40°N


snowfall; Cumulative Distribution Functions at 43.1°/26.3°
Valid for Tuesday 18 December 2012
Big spread
HRES t+36-60
HRES t+24-48
Probability not to exceed threshold
snowfall (in mm)

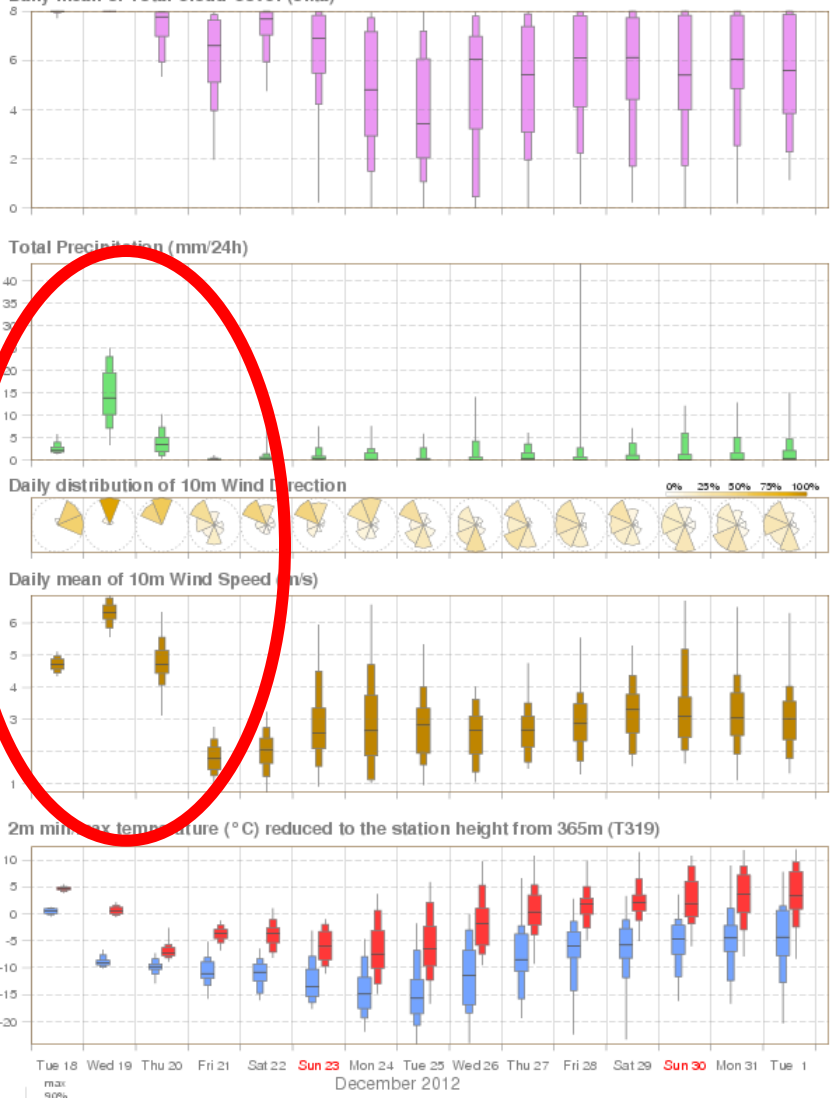

snowfall; Cumulative Distribution Functions at 41.8°/25.1°
Valid for Tuesday 18 December 2012
t+24-48h
t+36-60h
Probability not to exceed threshold
snowfall (in mm)

Lat = 43.1; Lon = 26.3

EPS Meteogram
43.14° N 26.25° E (EPS land point) 431 m
Deterministic Forecast and EPS Distribution Tuesday 18 December 2012 00 UTC

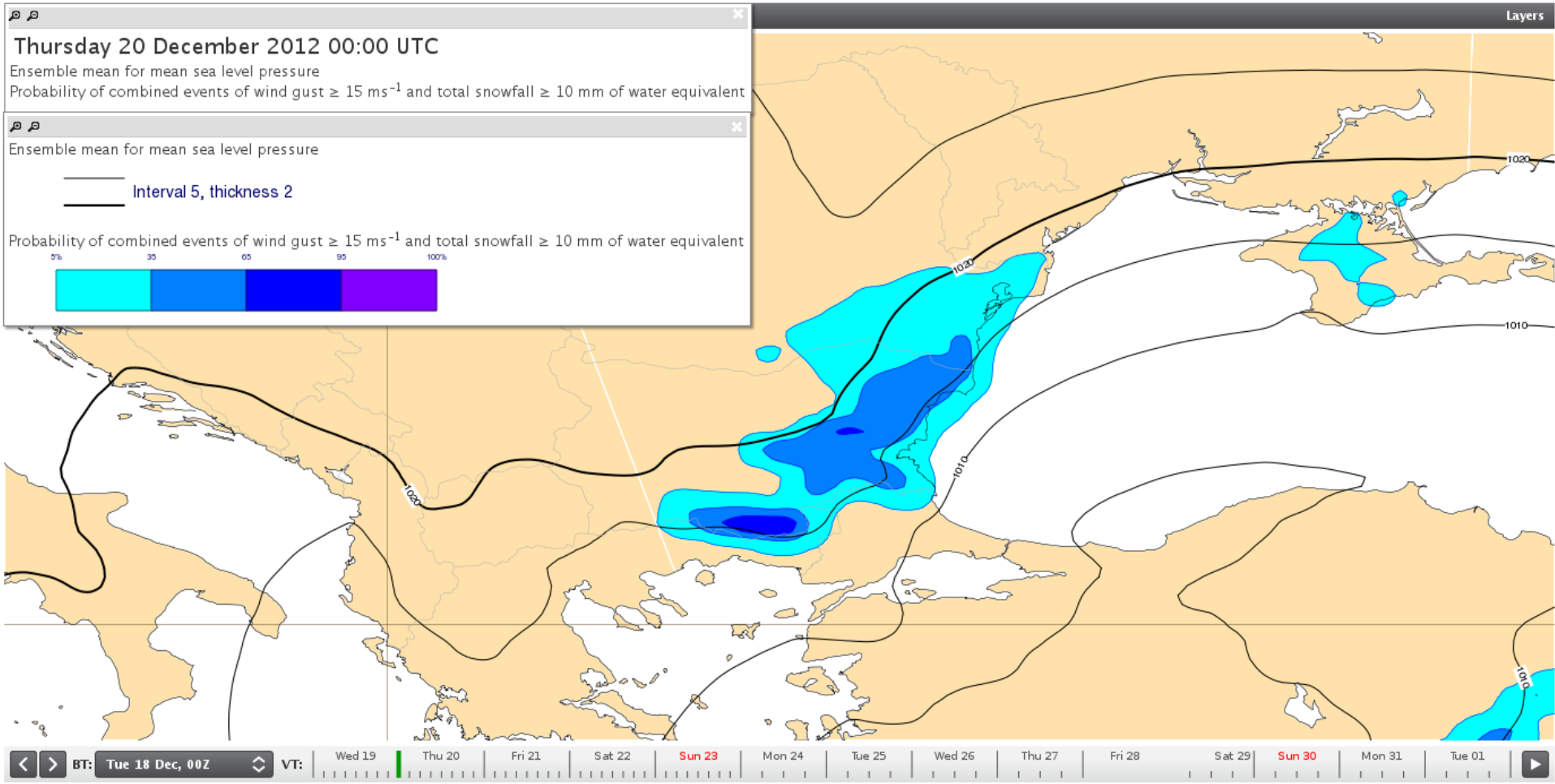


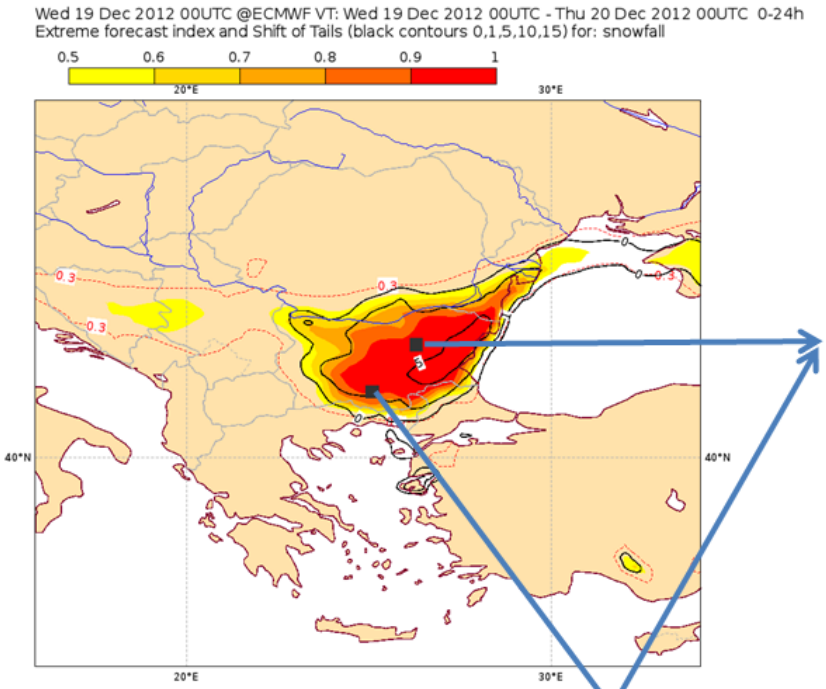
EPS Meteogram
42.96° N 26.64 °E (EPS land point) 431 m
Extended Range Forecast based on EPS Distribution Tuesday 18 December 2012 00 UTC

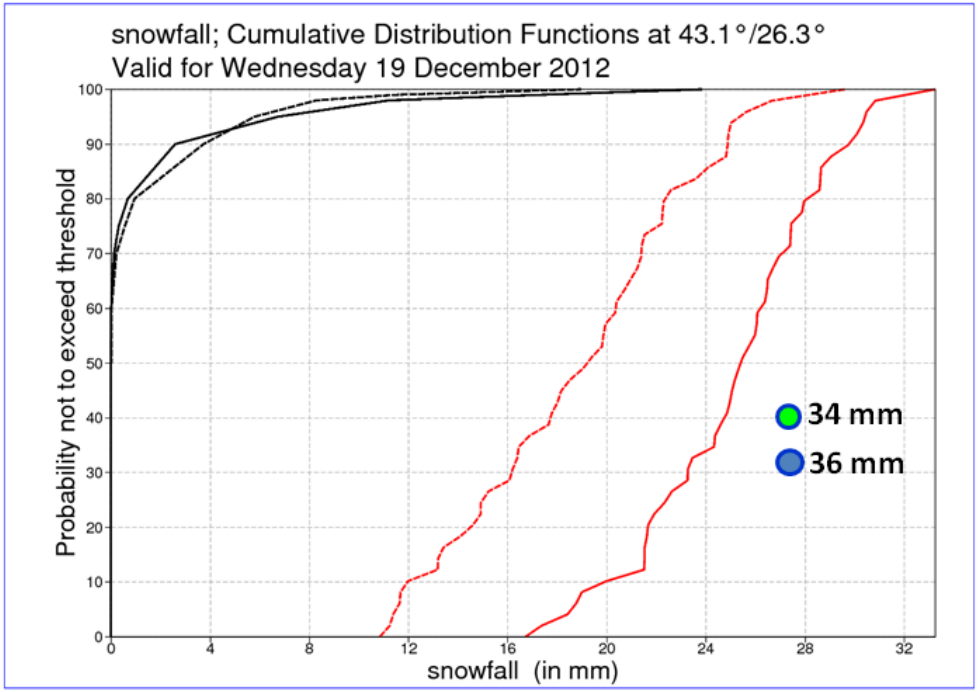


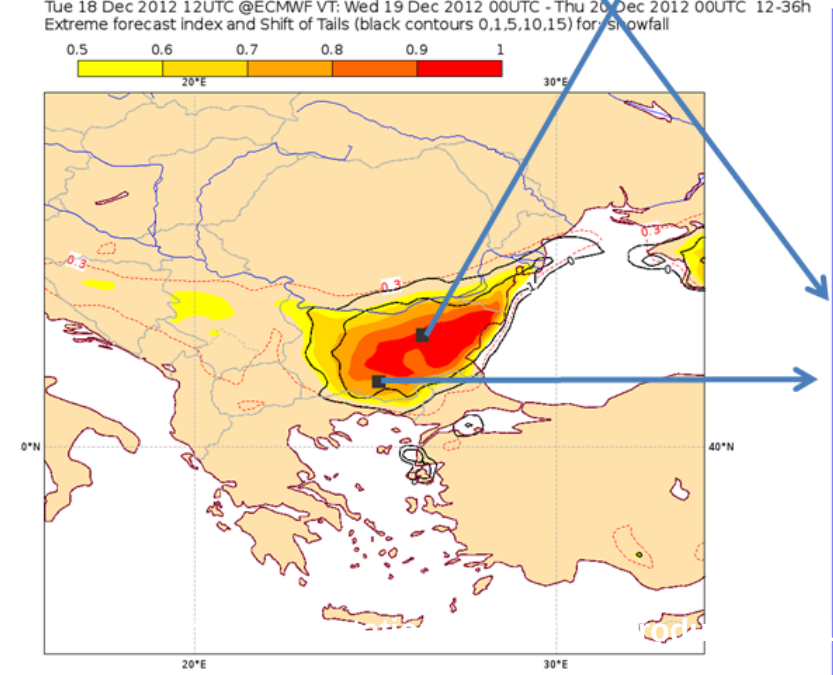
Combined probabilities (blizzards)

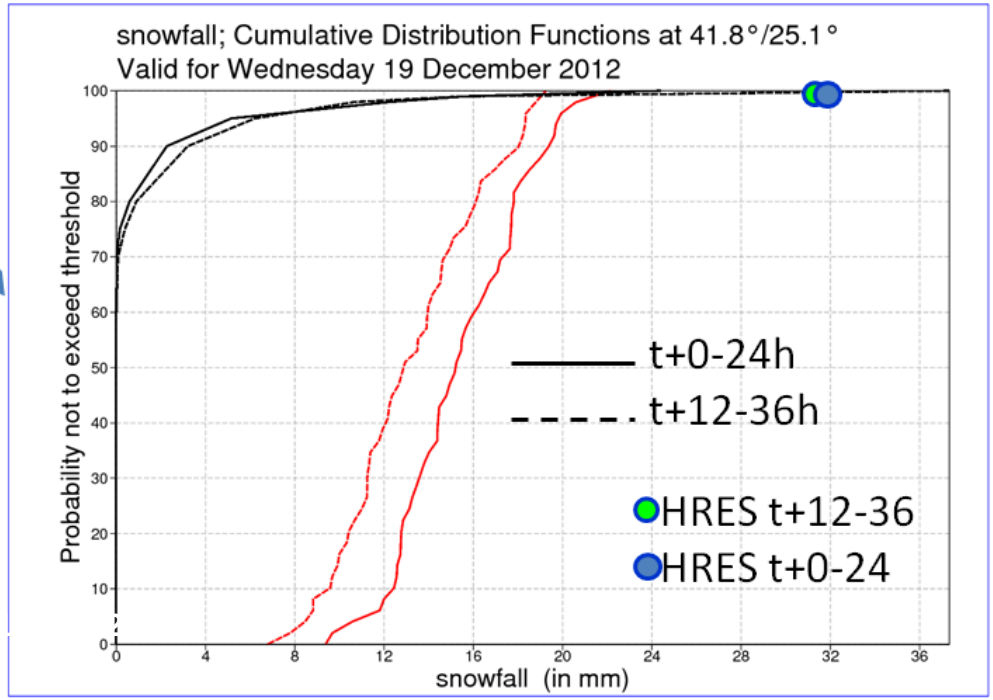
Snowfall > 10 mm/24h; Wind gusts > 15 m/s

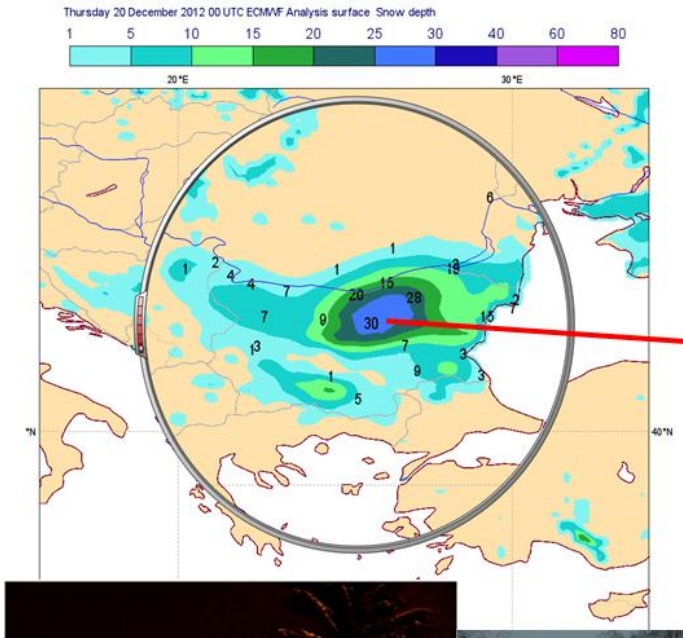


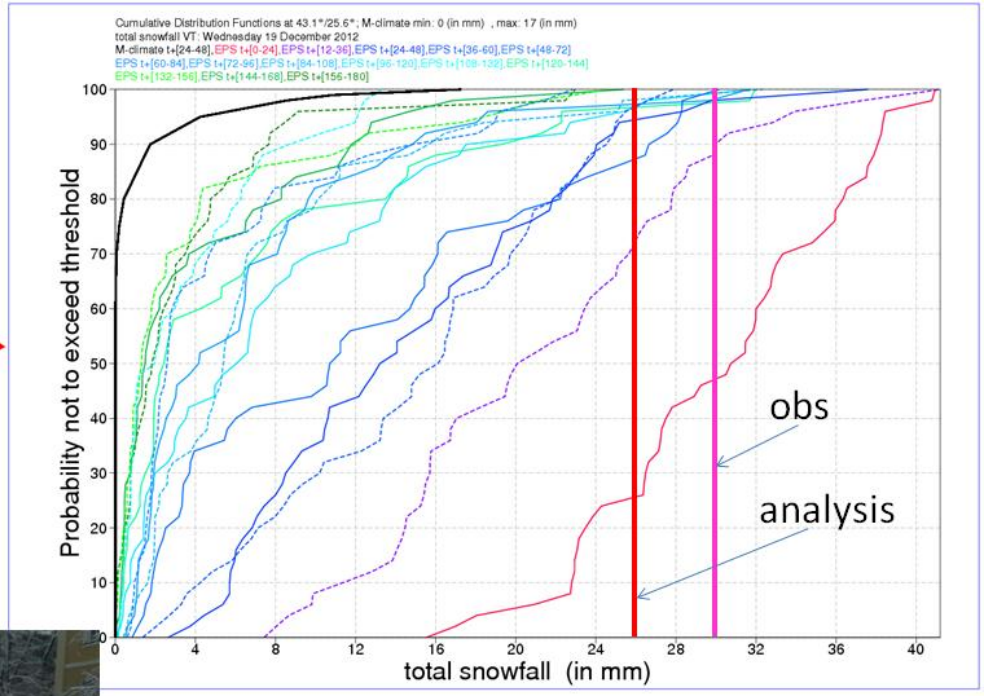

Wed 19 Dec 2012 00UTC @ECMWF VT: Wed 19 Dec 2012 00UTC - Thu 20 Dec 2012 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: snowfall
0.5 0.6 0.7 0.8 0.9 1
20°E
30°E
40°N
0.3
3


snowfall; Cumulative Distribution Functions at 43.1°/26.3°
Valid for Wednesday 19 December 2012
Probability not to exceed threshold
snowfall (in mm)
34 mm
36 mm

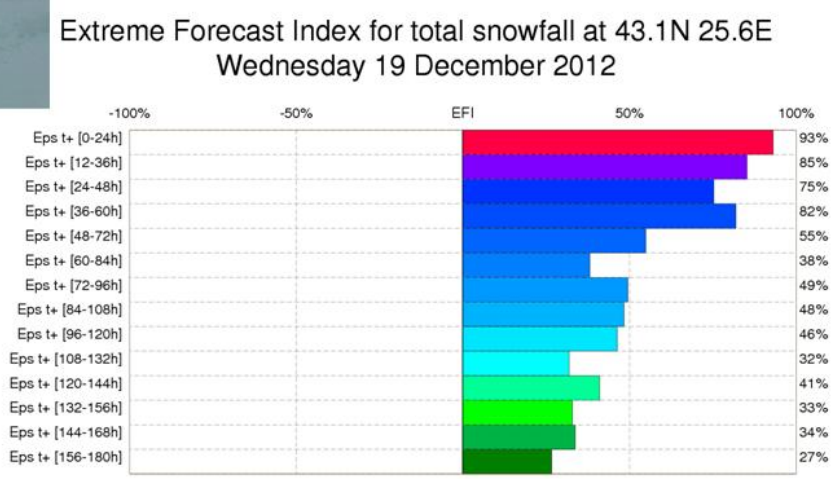

Tue 18 Dec 2012 12UTC @ECMWF VT: Wed 19 Dec 2012 00UTC - Thu 20 Dec 2012 00UTC 12-36h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: snowfall
0.5 0.6 0.7 0.8 0.9 1
20°E
30°E
0°N
40°N
0.3

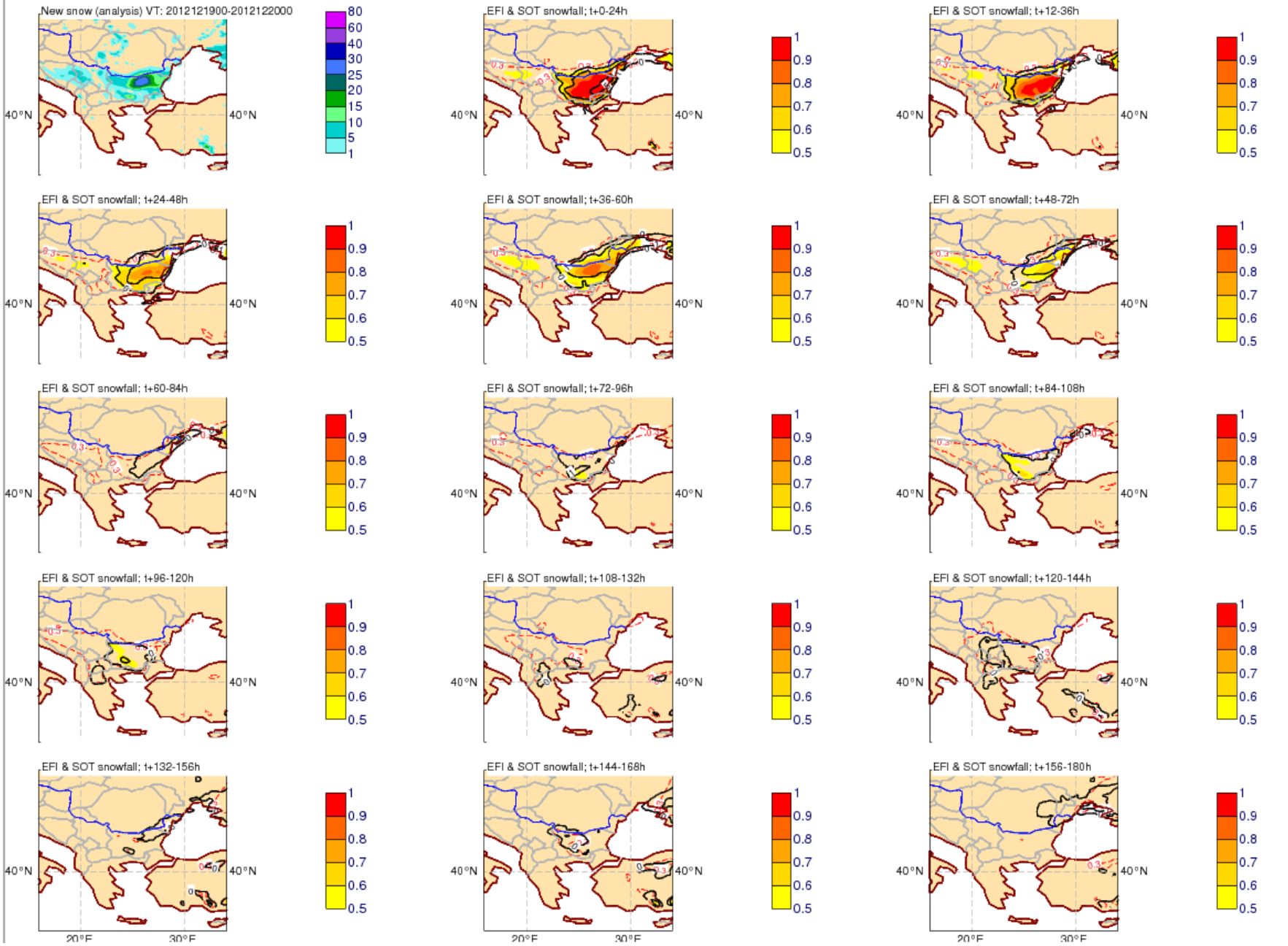

snowfall; Cumulative Distribution Functions at 41.8°/25.1°
Valid for Wednesday 19 December 2012
Probability not to exceed threshold
snowfall (in mm)
t+0-24h
t+12-36h
HRES t+12-36
HRES t+0-24


Thursday 20 December 2012 00 UTC ECMWF Analysis surface Snow depth
1 5 10 15 20 25 30 40 60 80
20°E
30°E
40°N


Cumulative Distribution Functions at 43.1°/25.6°; M-climate min: 0 (in mm) , max: 17 (in mm)
total snowfall VT: Wednesday 19 December 2012
M-climate t+[24-48],EPS t+[0-24],EPS t+[12-36],EPS t+[24-48],EPS t+[36-60],EPS t+[48-72]
EPS t+[60-84],EPS t+[72-96],EPS t+[84-108],EPS t+[96-120],EPS t+[108-132],EPS t+[120-144]
EPS t+[132-156],EPS t+[144-168],EPS t+[156-180]
Probability not to exceed threshold
total snowfall (in mm)
obs
analysis

52 cm


Extreme Forecast Index for total snowfall at 43.1N 25.6E
Wednesday 19 December 2012
-100% -50% EFI 50% 100%
Eps t+ [0-24h] 93%
Eps t+ [12-36h] 85%
Eps t+ [24-48h] 75%
Eps t+ [36-60h] 82%
Eps t+ [48-72h] 55%
Eps t+ [60-84h] 38%
Eps t+ [72-96h] 49%
Eps t+ [84-108h] 48%
Eps t+ [96-120h] 46%
Eps t+ [108-132h] 32%
Eps t+ [120-144h] 41%
Eps t+ [132-156h] 33%
Eps t+ [144-168h] 34%
Eps t+ [156-180h] 27%


New snow (analysis) VT: 2012121900-2012122000
80
60
40
30
25
20
15
10
5
1
EFI & SOT snowfall; t+0-24h
EFI & SOT snowfall; t+12-36h
EFI & SOT snowfall; t+24-48h
EFI & SOT snowfall; t+36-60h
EFI & SOT snowfall; t+48-72h
EFI & SOT snowfall; t+60-84h
EFI & SOT snowfall; t+72-96h
EFI & SOT snowfall; t+84-108h
EFI & SOT snowfall; t+96-120h
EFI & SOT snowfall; t+108-132h
EFI & SOT snowfall; t+120-144h
EFI & SOT snowfall; t+132-156h
EFI & SOT snowfall; t+144-168h
EFI & SOT snowfall; t+156-180h
1
0.9
0.8
0.7
0.6
0.5
40°N
20°E
30°E

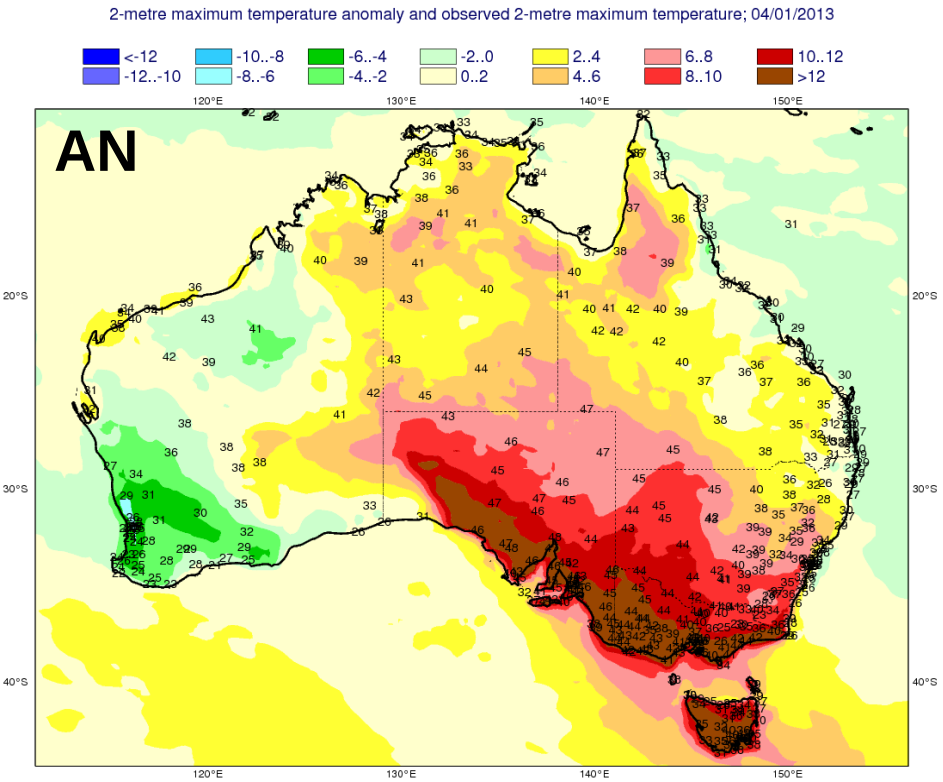
ECMWF

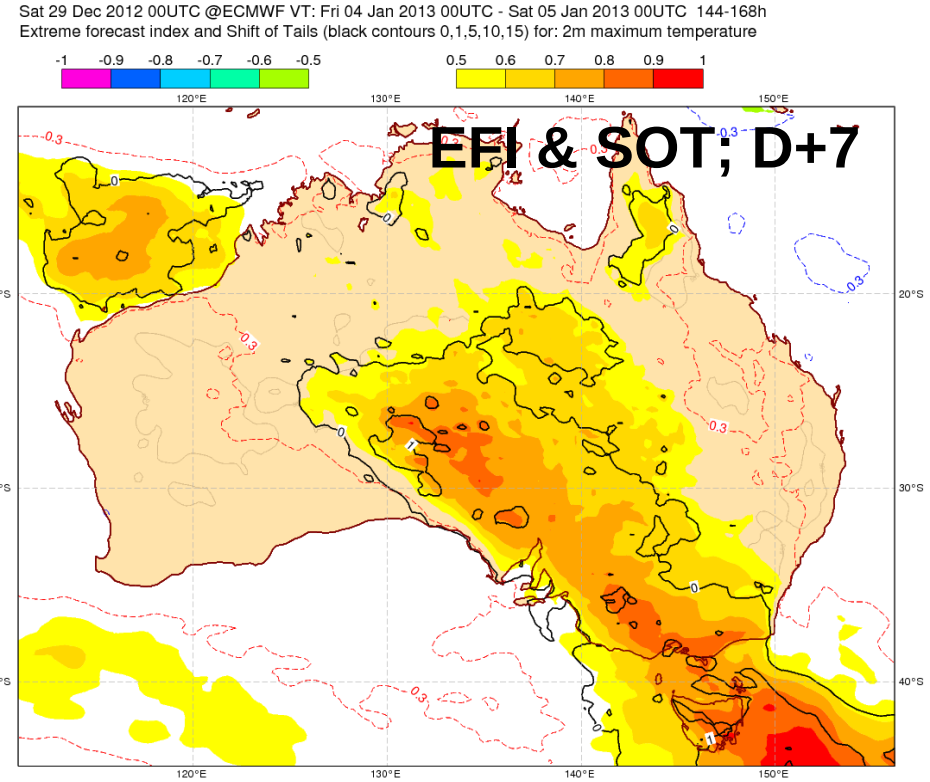
Summary

- SOT was positive 7-days in advance (t+144-168) indicating some chance of significant snowfall across Bulgaria whilst EFI was positive but not very high implying that the forecast is quite uncertain.
- EFI was positive even 7 days in advance, gradually increasing throughout the forecast implying more confidence in the forecast.
- The forecast was actually quite uncertain and only the very last forecast gave clear quantitative picture of the extreme snowfall.
- EFI and SOT together gave a strong enough signal of high risk of extreme snowfall from t+48-72 forecast onwards (3-days in advance).

A CASE OF HEAT WAVE

Australian Heat Wave, winter 2013

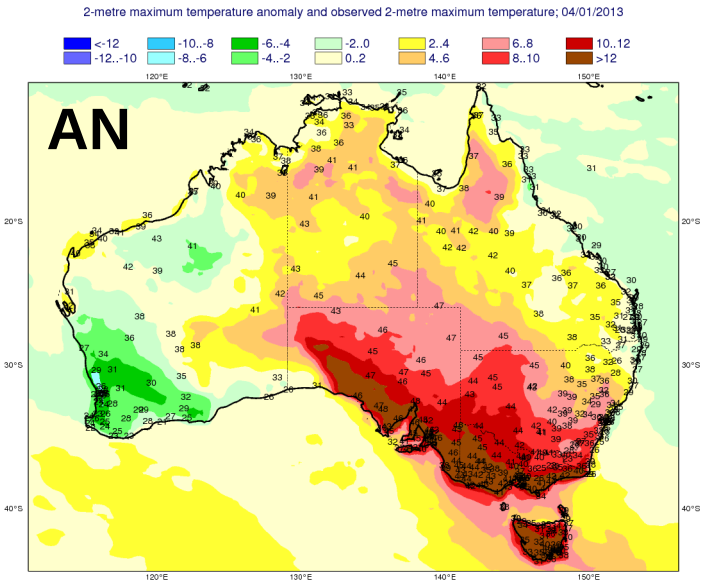




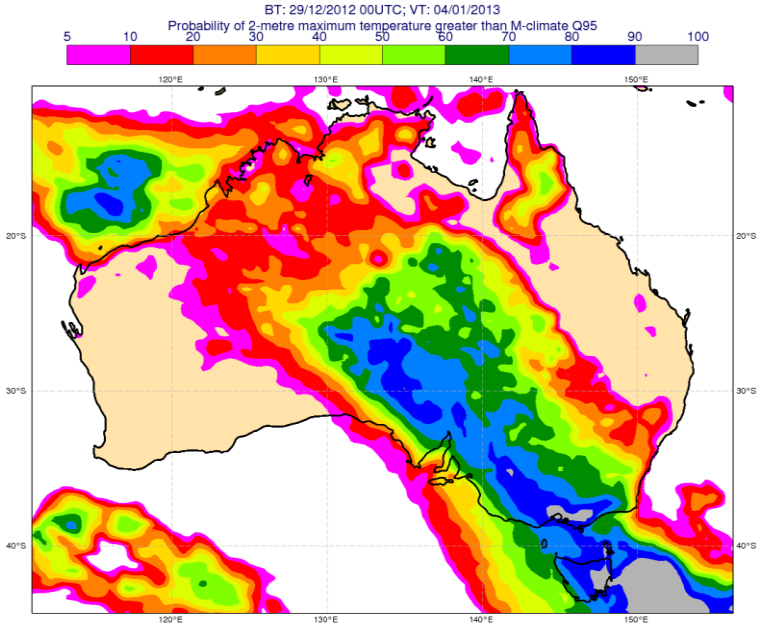
- A widespread heat wave broke many temperature records in central and southern parts of Australia in early January 2013. Temperatures soared to almost 50 ° C.
- EFI and SOT 7 days in advance give a strong signal of abnormally hot weather.

ECMWF

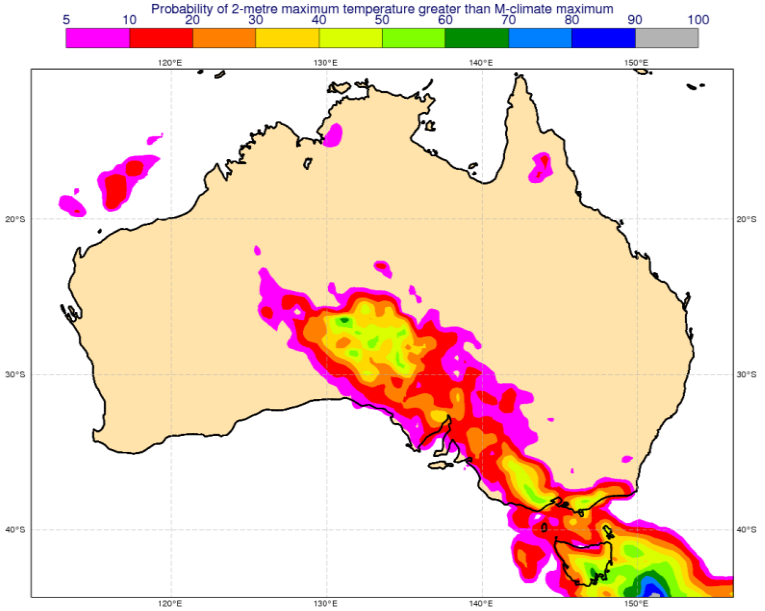
Probabilities



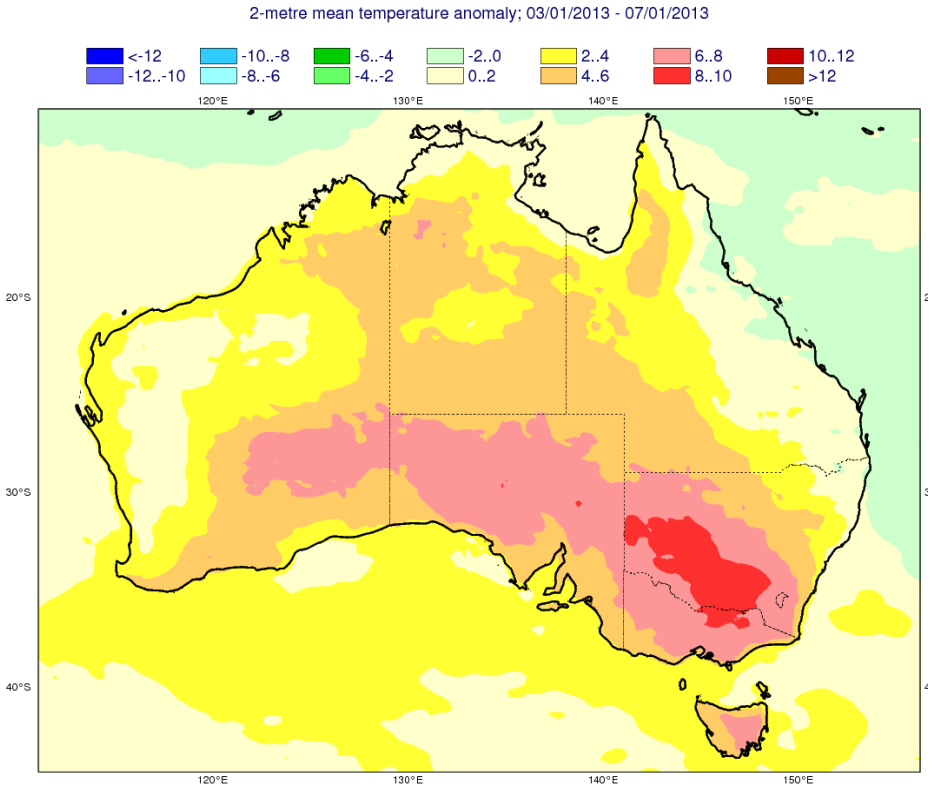
Prob. 2tmax > Q95

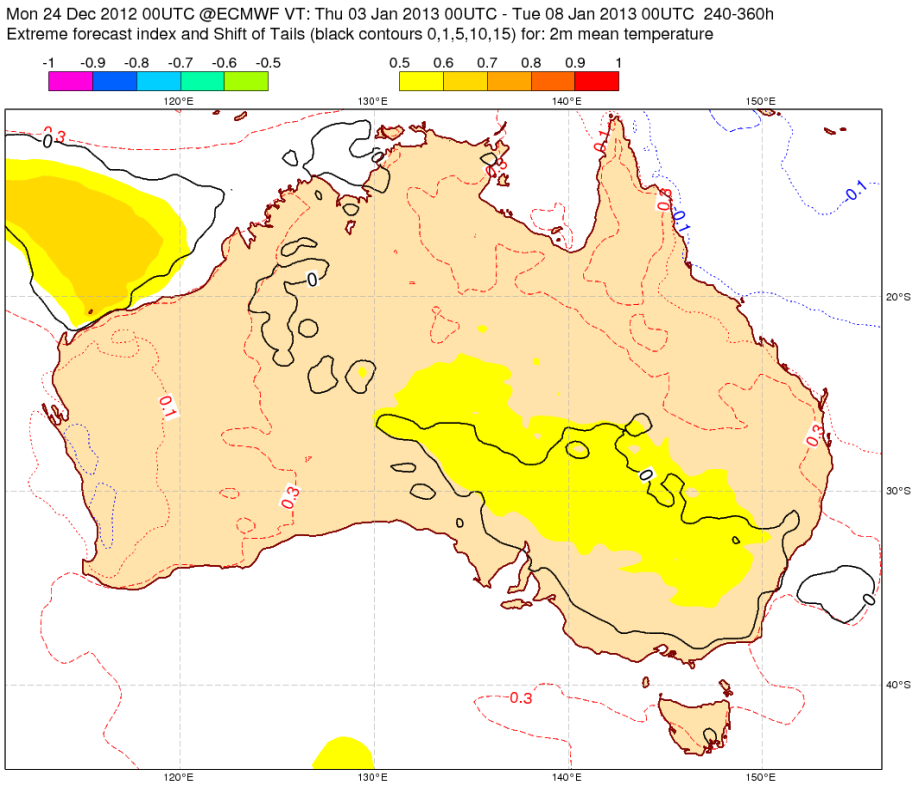


Prob. 2tmax > 16-year return period



EFI & SOT, extended range D+10-15





- **Extended range EFI products for 2t, 10ff and tp from day 10 to 15 have been tested.**

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/