# Use and Interpretation of ECMWF Products


## Forecasting Wind Extremes

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# Hypothetical early warning system on a purely deterministic mode ?

## Limitations & capabilities

**ECMWF Integrated Weather Effects Decision Aid System**

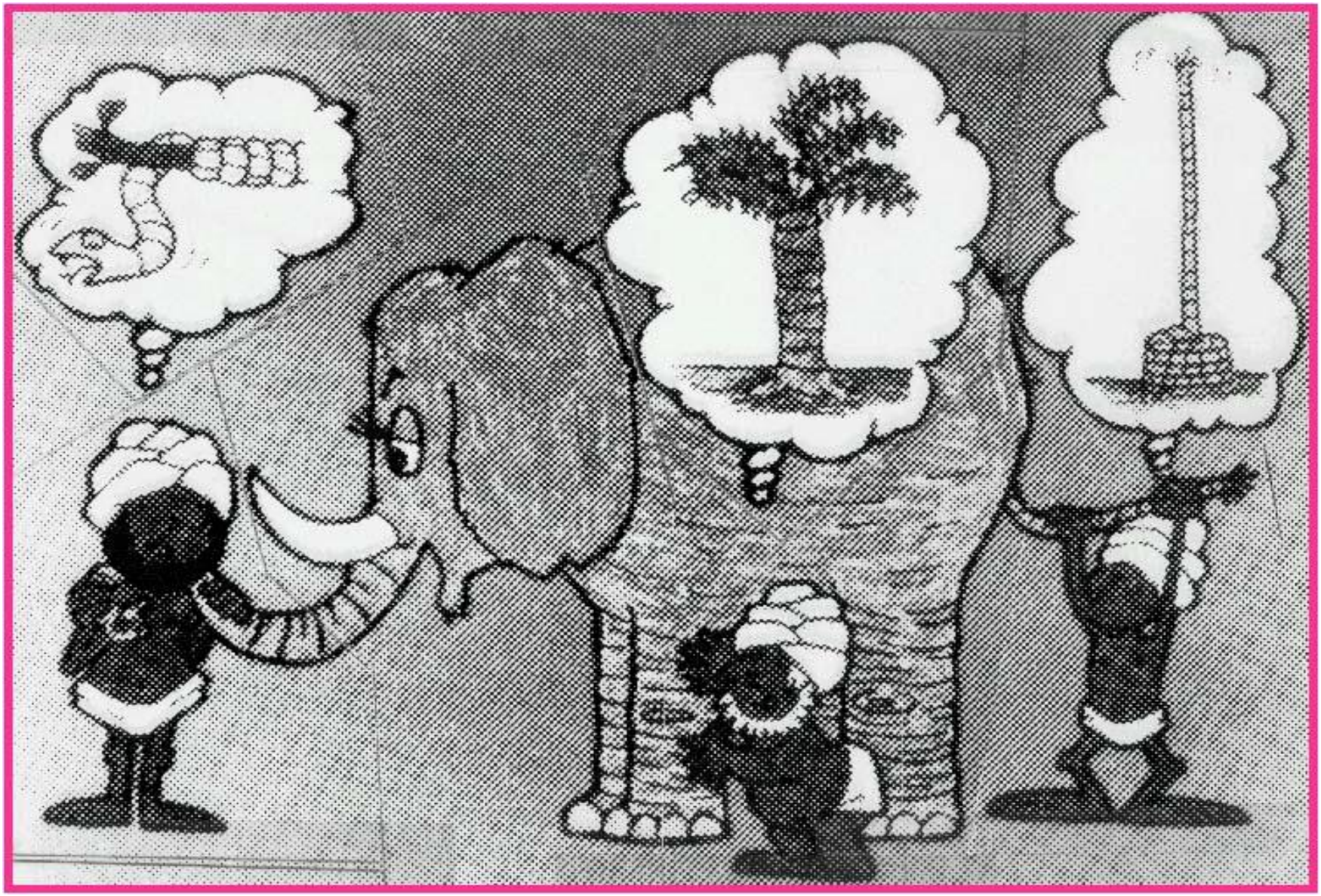
**valid for a specific point (i.e. a capital or an airport)**

**based on the ECMWF high-resolution IFS**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Major Storm | G | G | G | A | G | A | R | R | A | G |
| Severe Convection | G | G | A | G | G | A | A | R | R | A |
| Heat Wave | A | A | R | A | A | G | G | G | G | G |
| Blizzard / Frost | G | G | G | A | G | G | A | A | R | R |
| Hazard to Aviation | G | G | A | G | A | A | R | R | R | A |
| Discomfort: f (T, RH) | A | R | R | R | A | G | G | G | G | A |
| Date / Time | D 1 | D 2 | D 3 | D 4 | D 5 | D 6 | D 7 | D 8 | D 9 | D 10 |

*Unfavorable: NO Danger* G *Marginal* A *Favorable: Danger* R

# The story of the big elephant



# Operational activities at ECMWF

- Observations
  - → Acquisition/Pre-processing/Quality control/Bias correction
- Data assimilation
  - → Dynamical fit to observations
- Data Monitoring

Forecasts

- Archiving
- Products dissemination
- Web Products

Verification

Customer support

| | Assimilation 4DVar | resolution | No of members | Area | Forecast range | Forecast frequency | Ocean coupling |
|---|---|---|---|---|---|---|---|
| Deterministic model | 12h | ≈16 Km L91 | 1 | Global | 10 days | Twice a day | No |
| EPS | 12h | ≈30/60 Km L62 | 51 | Global | 15 days | Twice a day | Coupled after D+10 |
| | | | | | 1 month | Twice a week | Yes NEMO/NEMOVAR |
| Seasonal | 12h | ≈80Km L91 | 51 | Global | 7 months Subset of 15 members run for 13 months every quarter | Once a month | Yes NEMO/NEMOVAR |
| Boundary condition | 6h | ≈16 Km L91 | 1 | Global | 3 days | 4 times a day | |
| Ocean waves | OI 6h | 28 Km | 1 | Global | 10 days | Twice a day | No |
| | | 10 Km | 1 | European waters | 5 days | | |
| | | | | | | | |

# ECMWF Product List

**Forecasts**

**Medium range forecast**

- Analysis
- Deterministic forecast
- Ensemble Prediction System
- Verification
- Epsgrams (ECMWF Member States)
- Epsgrams (WMO Members)
- Special
- Tropical cyclones
- Extra-tropical cyclones
- User Guide: online or acrobat file

**Ocean wave forecast**

- Forecasts
- Verification
- Observation monitoring

**Monthly forecast**

- Introduction
- Forecast
- Verification
- Documentation

**Seasonal forecast**

- Forecast
- Verification
- Documentation

**Ocean Analysis**

- Real time
- Reanalysis
- Documentation

**Monitoring of the observing system**

- Availability
- Monitoring of GUAN stations
- Satellite Data Monitoring
- Monthly monitoring report (PDF archive)

**Medium – Range Forecasts**

**Ocean Wave Forecasts**

**Monthly Forecasts**

**Seasonal Forecasts**

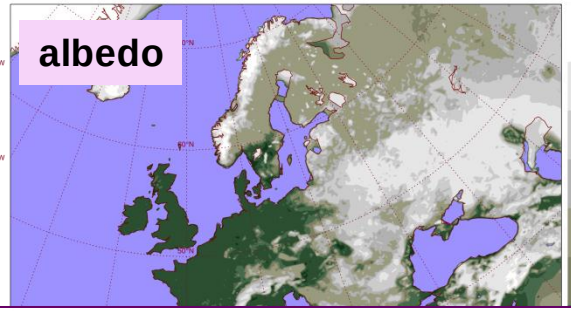
**Ocean Analysis**

**Monitoring of the observing system**

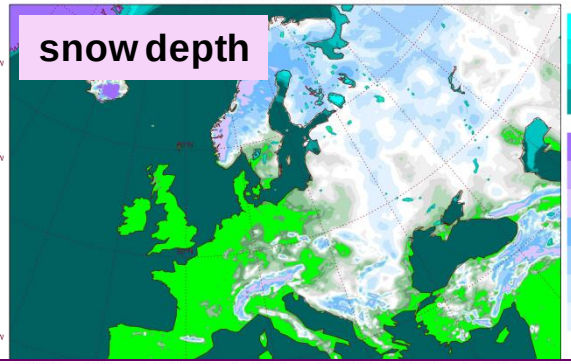
# Analysis

## Snow cover, ice cover, albedo, leaf area index, orography and sea depth

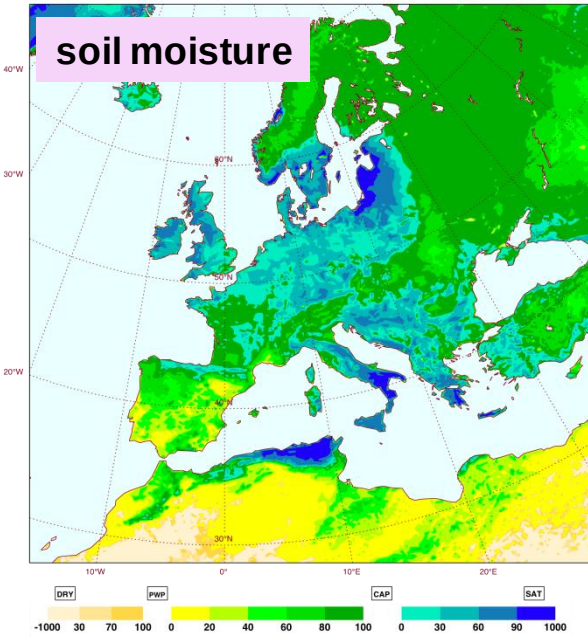
Thursday 23 February 2012 00UTC ECMWF T+0 VT:Thursday 23 February 2012 00 UTC
Albedo (%)



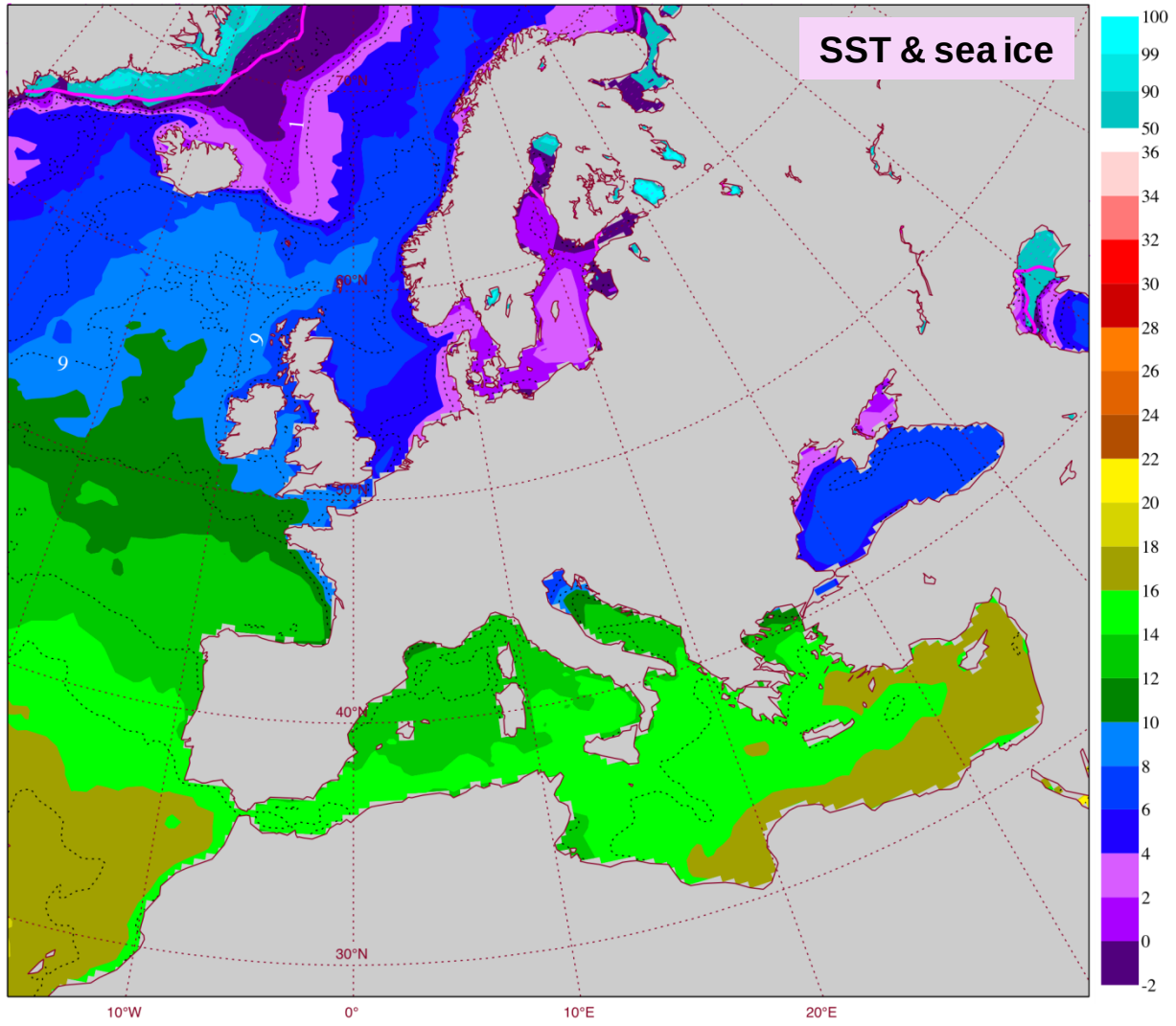

Thursday 23 February 2012 00UTC ECMWF T+0 VT:Thursday 23 February 2012 00 UTC
Snow depth in cm (using varying snow density). Sea ice fraction in %.




Soil Moisture (SM) Layer 1: ECMWF: Thursday 23 February 2012 00UTC T+0 VT:Thursday 23 February 2012 00 UTC
Yellow-Green=Evapotranspiration Efficiency (EE,%)
Browns=SM Residue (%) when EE=0%, Blues=Field Capacity Excess (%) when EE=100%

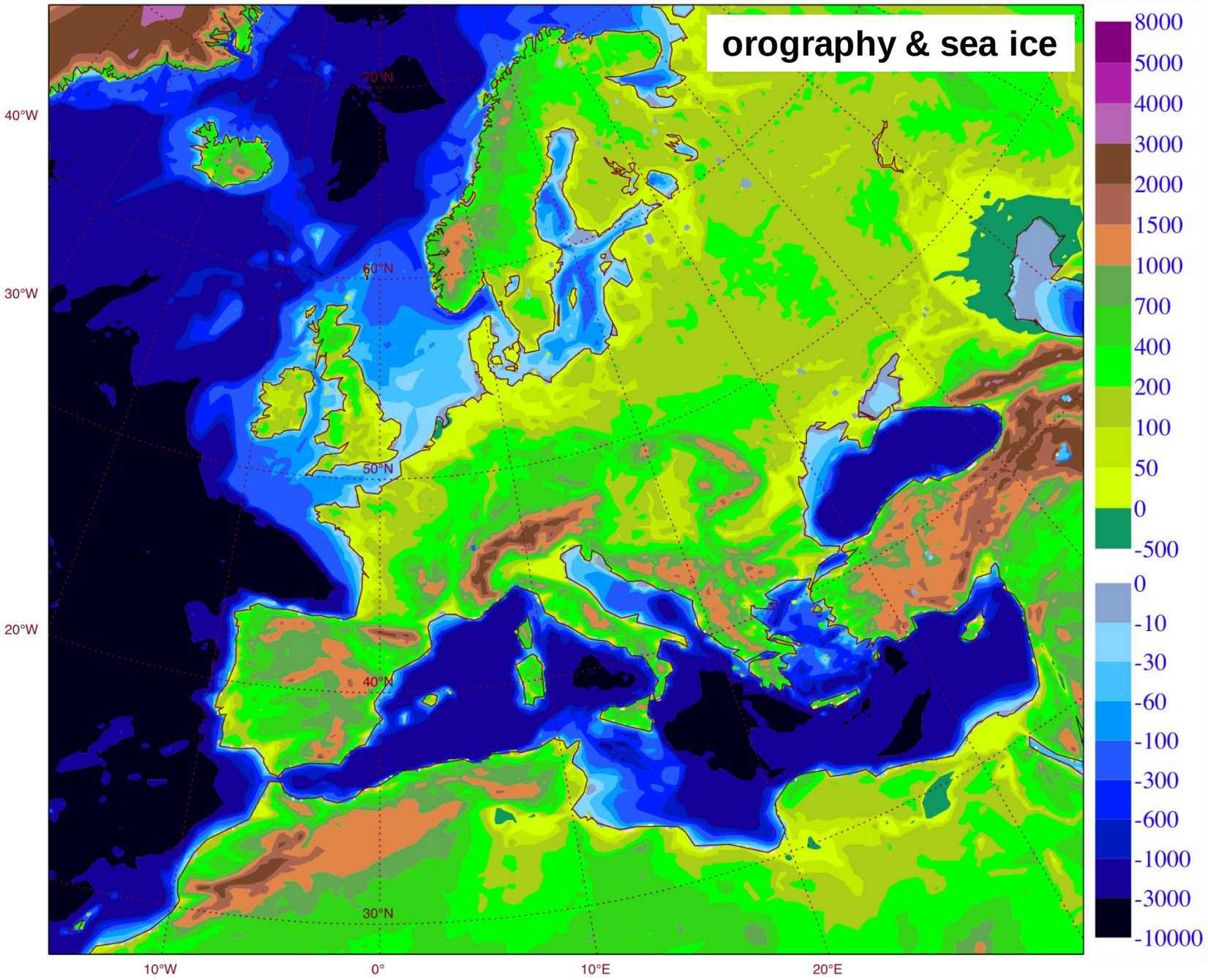



SST and Sea Ice. ECMWF Control run: Thursday 23 February 2012 00UTC T+0 VT:Thursday 23 February 2012 00 UTC
Sea Surface Temperature (C) in control run (bottom legend).
Control Run Sea Ice cover (top legend >= 50% only). climatological sea ice cover in magenta (>= 50%).

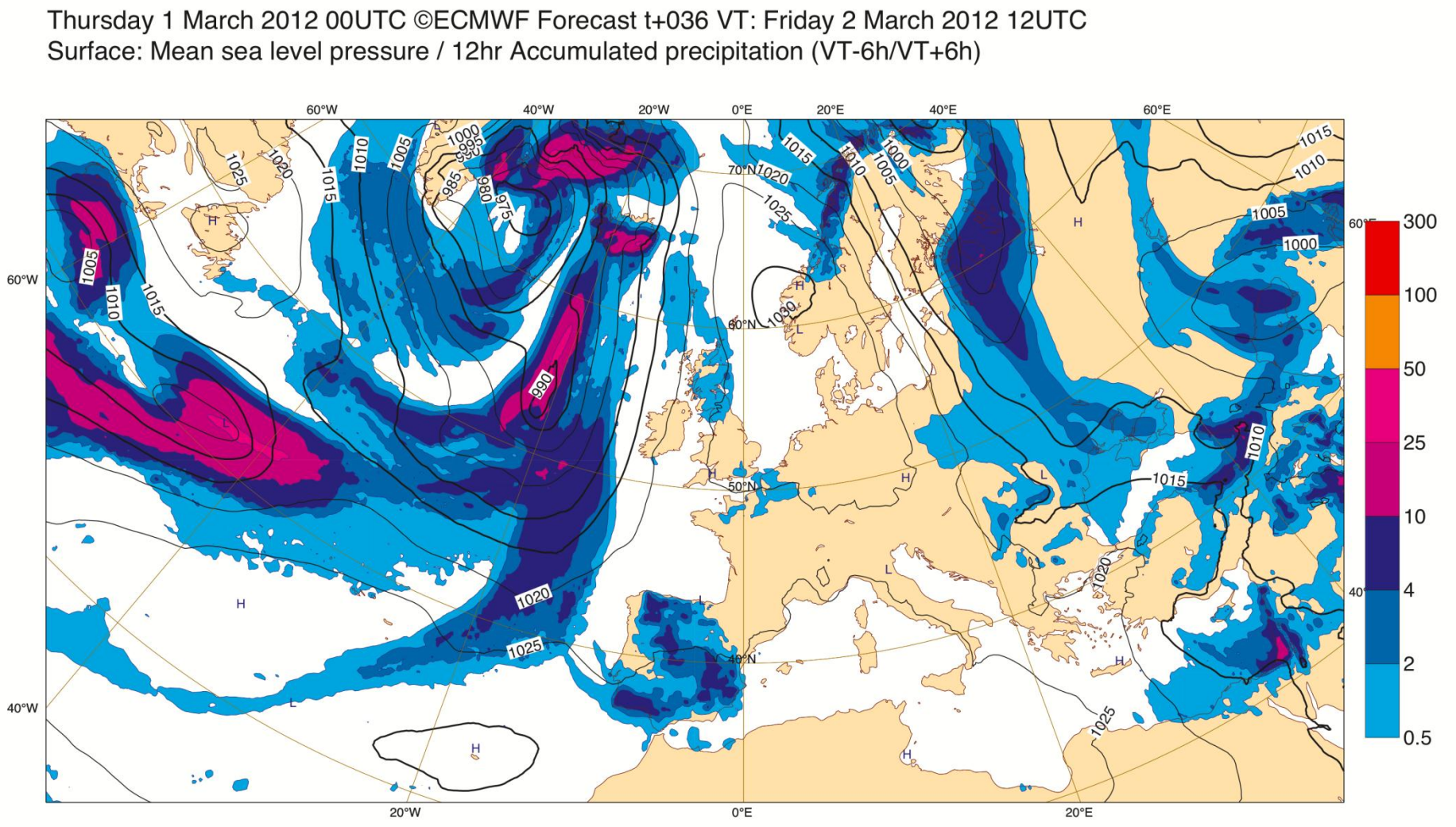


Thursday 23 February 2012 00 UTC

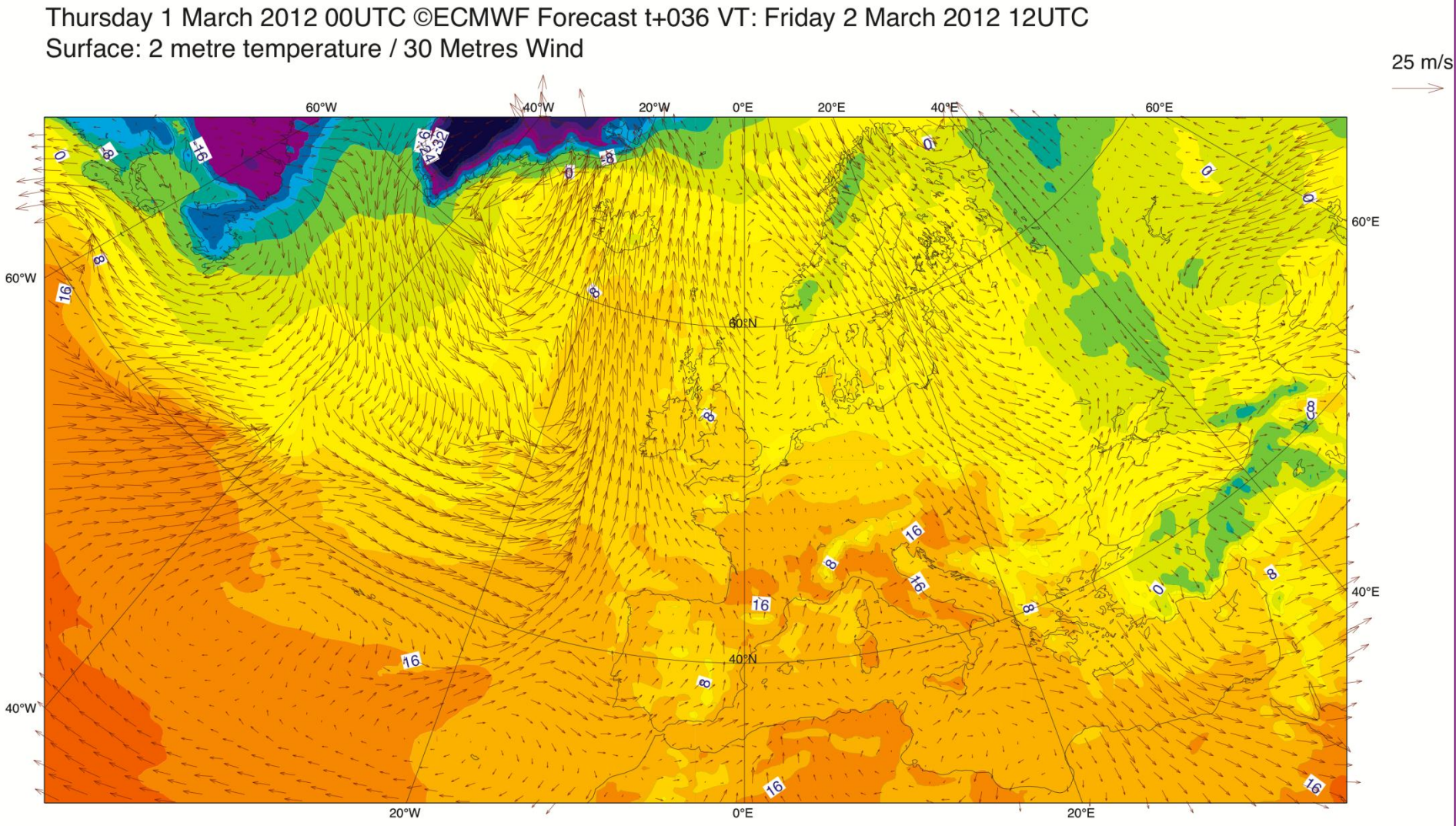
Orography in m (T+0=det, t+120=>eps_d0-d10, t+252=>eps_d11+). sea depth in m (external source).



# T+36 hour forecast example (precipitation)

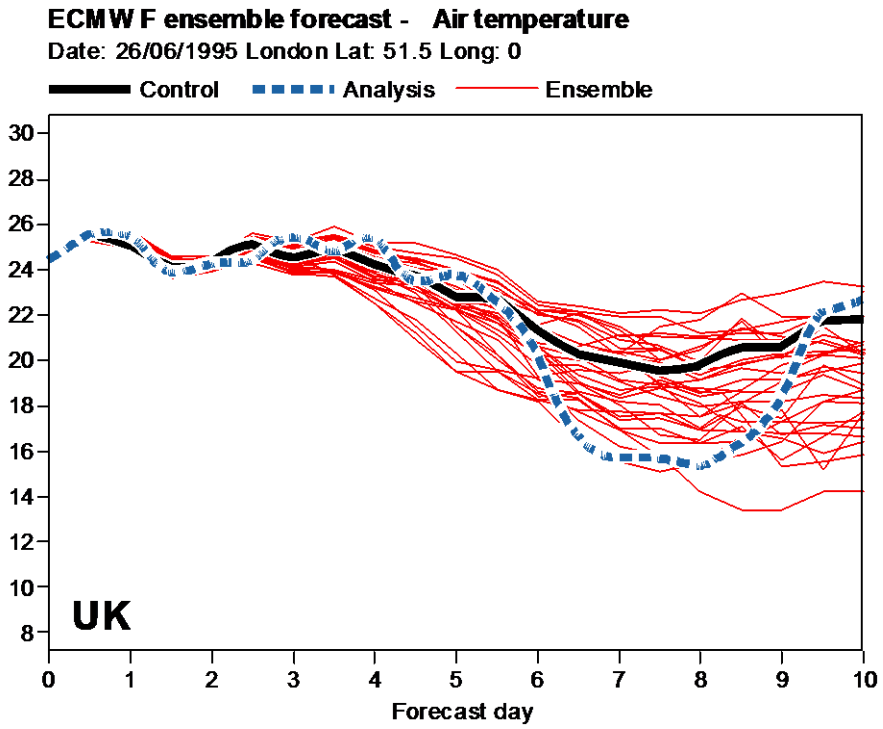


# T+36 hour forecast example
# 2-meter temperature & 30-meter winds

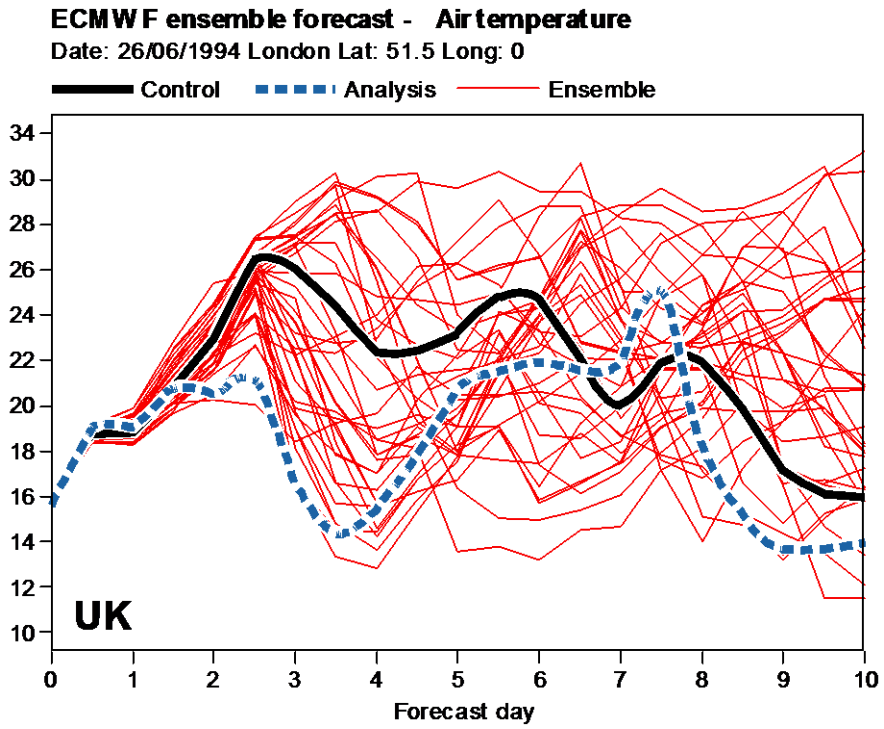


# Flow dependence of forecast errors

26th June 1995




26th June 1994



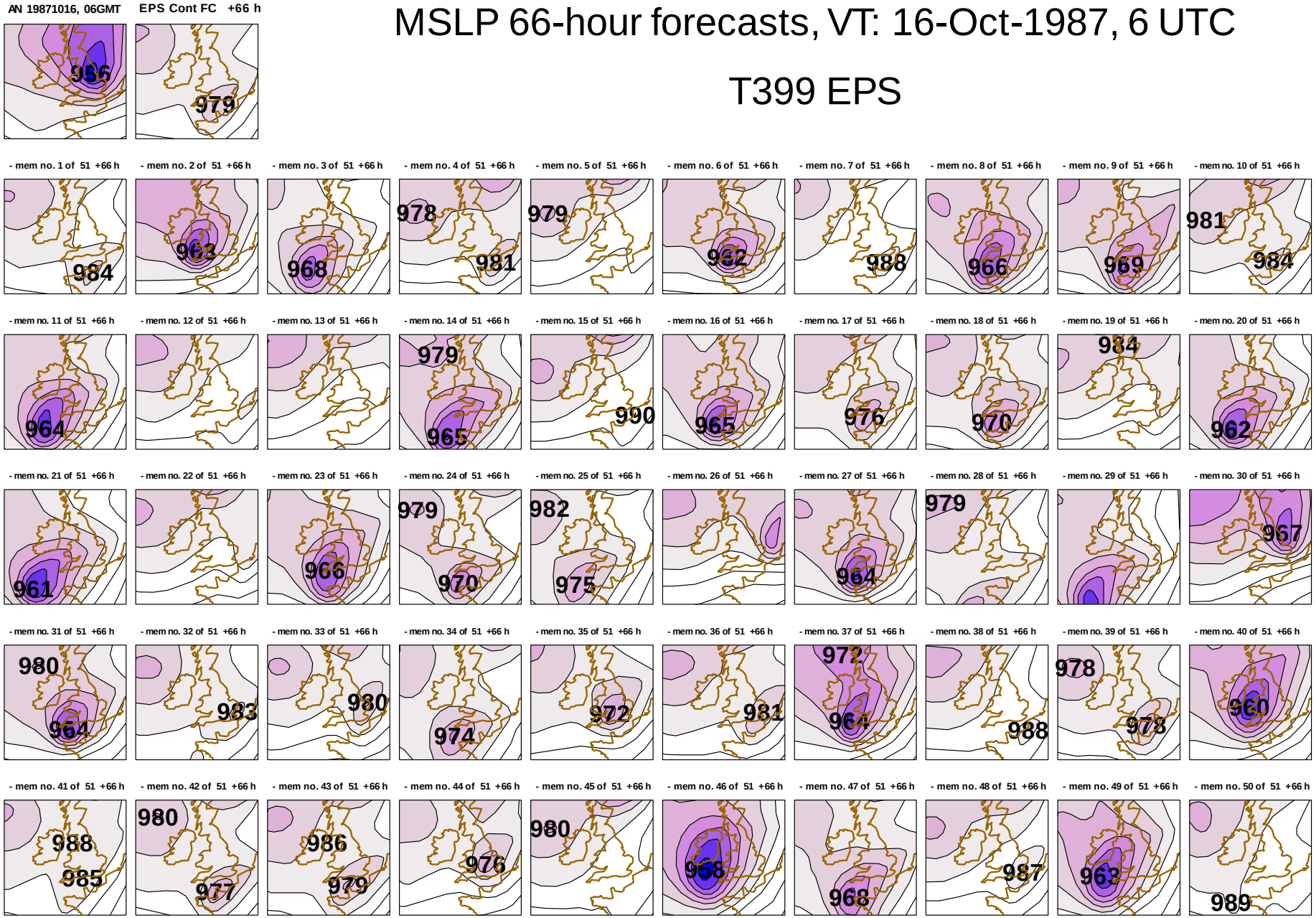

If the forecasts are coherent (small spread) the atmosphere is in a more predictable state than if the forecasts diverge (large spread)

# The 1987 Great Storm in southern England

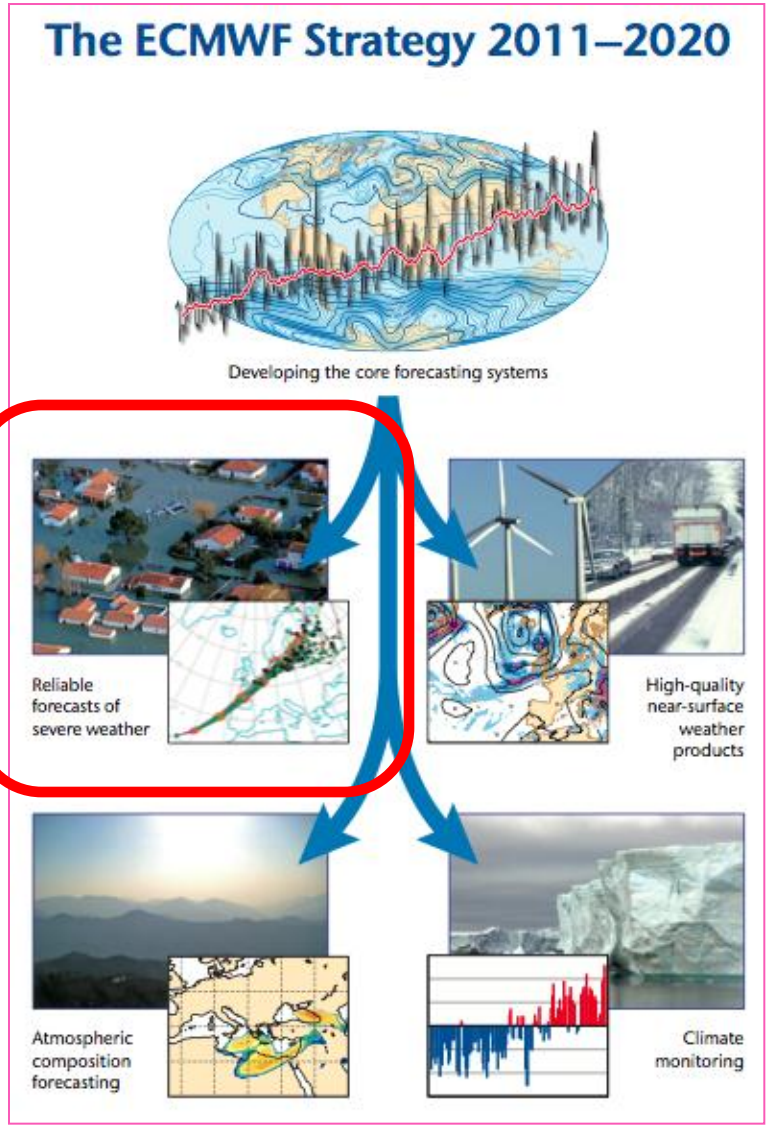
- Night 15/16 October, mean winds 50 mph, gusts 90 mph
- 18 people died
- 15 million trees destroyed
- £2 billion insurance costs
- Widespread damage to transport and buildings
- Several 100 000 people without electricity

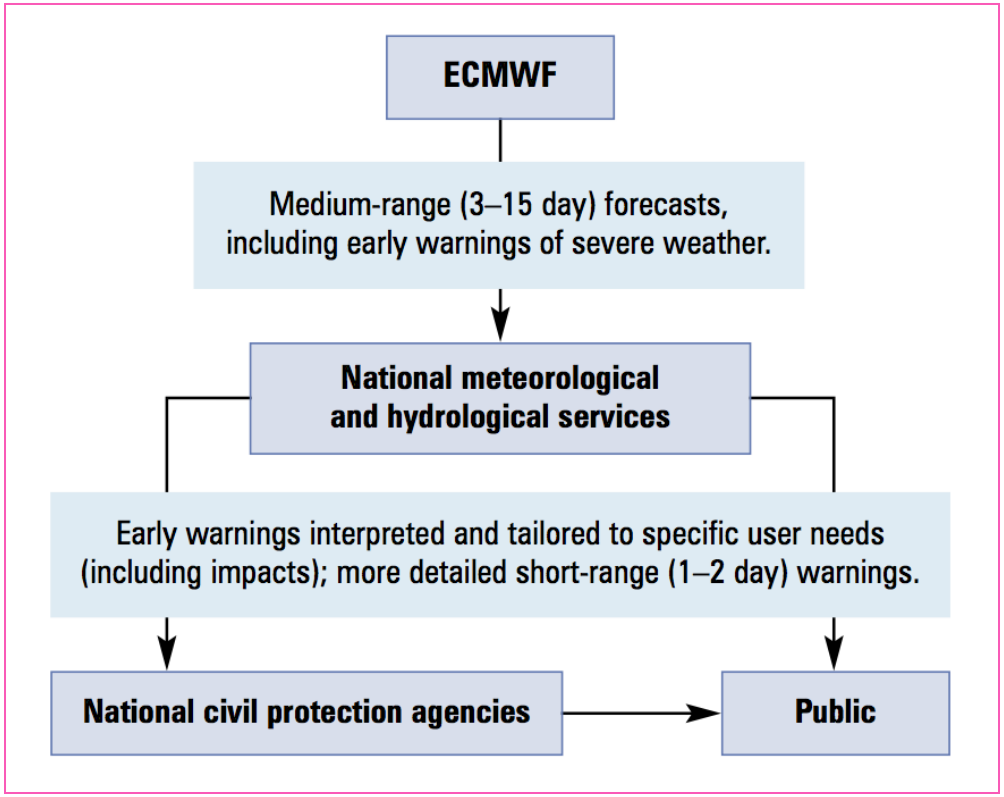
# MSLP 66-hour forecasts, VT: 16-Oct-1987, 6 UTC

## T399 EPS



# Extreme Events – RES – Role of ECMWF & M-R Forecaster (cont.)




**The ECMWF medium-range forecasts are the best in the world, skilful up to a week or more. Can't the forecasts just be used straight away?**

# Types of Tropical Cyclones

| Cyclone Type | Winds |
|---|---|
| Tropical Depression | 25-39 mph |
| Tropical Storm | 40-74 mph |
| Hurricane/Typhoon/Cyclone | ≥ 75 mph |

Most Depressions do not develop into Storms

Majority of Storms reach Hurricane status

The National Hurricane Centre says that a hurricane releases heat energy

at a rate of 50 trillion to 200 trillion watts.

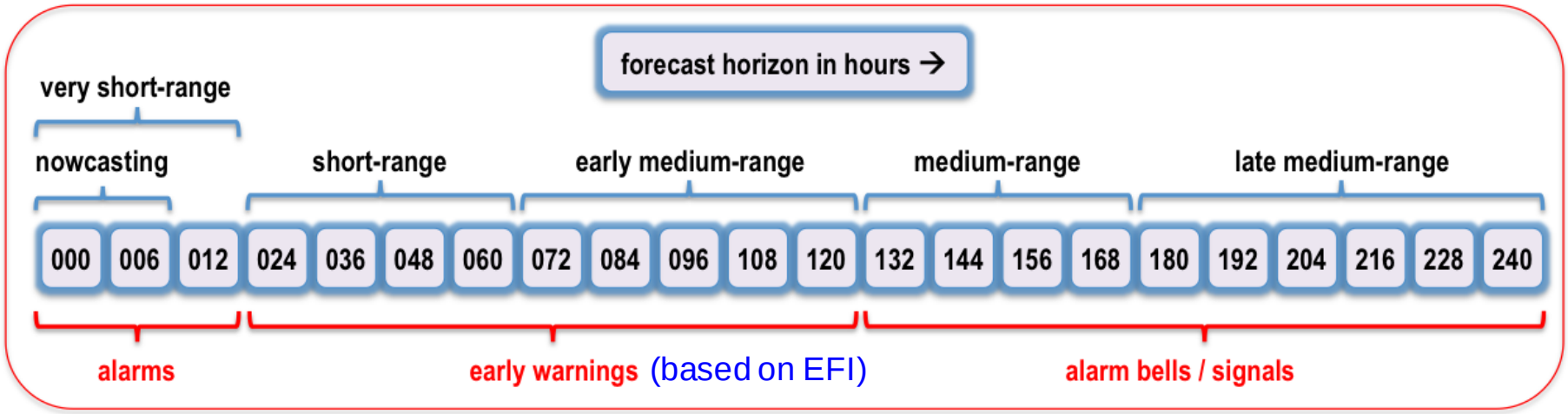
This is the equivalent of a 10-megaton nuclear bomb exploding about every 20 minutes.

Just for comparison: Hiroshima bomb: 0.02-megaton (just a… fire cracker)

| Event | Date |
|---|---|
| Xynthia | 27-28 February 2010 |

A severe windstorm which was generated close to Madeira and from there moved across to the Canary Islands, then Portugal and much of western and northern Spain, before moving on to hit western and southwestern France. The highest gust speeds recorded as of midnight were at approximately 2130 UTC at Alto de Orduña (228 km/h (142 mph)). 50 people have been reported to have died

# Alarm Bells / Signals – Early Warnings




'***Alarms***' information concerning severe weather in the very short-range
Near-real time online observations are utilised in conjunction with immediate very short-term forecast updates on regional and local scales

'***Early warnings***' information about the occurrence of severe weather in the short- and early medium-term based mainly on the EFI

'***Alarm bells / signals***' very low probability extreme events captured by the IFS or some members (sometimes only one) of the EPS in the medium- or even in the late medium-range

## Can products be used directly (say, in the case of strong signals)

This might be true for ordinary weather a few days ahead, but not for unusual,

dangerous or extreme weather events.

Decisions about postponing operations or evacuations cannot be made just by blindly following computer output.

Consider what happens with a modern aircraft. The more they become equipped with advanced instruments and sophisticated techniques the thicker the manuals and the more demanding is the training on how to operate them. Although there are autopilots we all prefer to have trained Pilots in the cockpit

Or

highly trained Captains in command…

# Extreme forecast index (EFI)

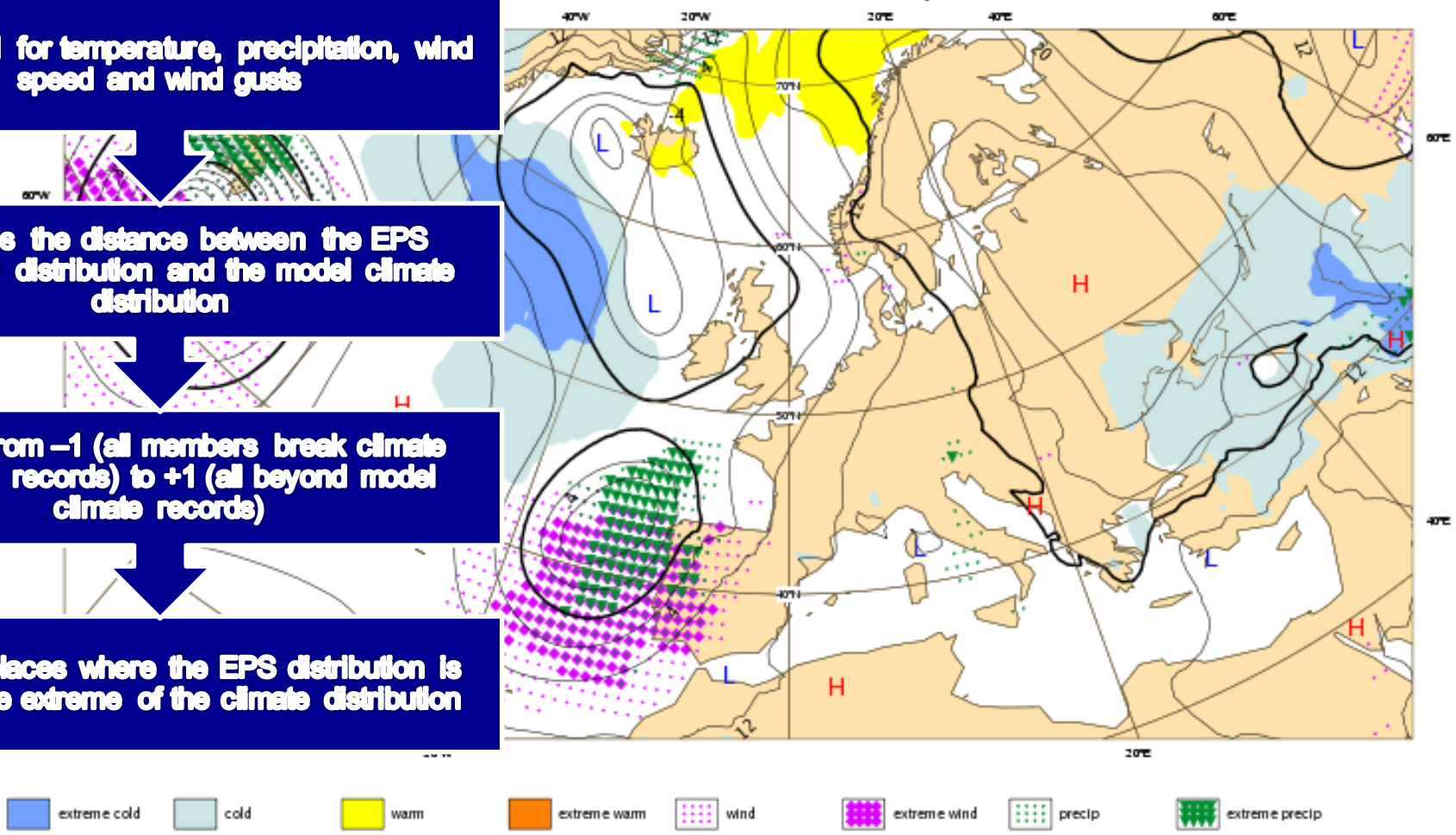
Anomalous weather predicted by EPS: Tuesday 25 October 2011 at 00 UTC
1000 hPa Z ensemble mean ( Wednesday 26 October 2011 at 12 UTC)
and EFI values for Total precipitation,maximum 10m wind gust and mean 2m temperature (all 24h)
valid for 24hours from Wednesday 26 October 2011 at 00 UTC to Thursday 27 October 2011 at 00 UTC

Is computed for temperature, precipitation, wind speed and wind gusts

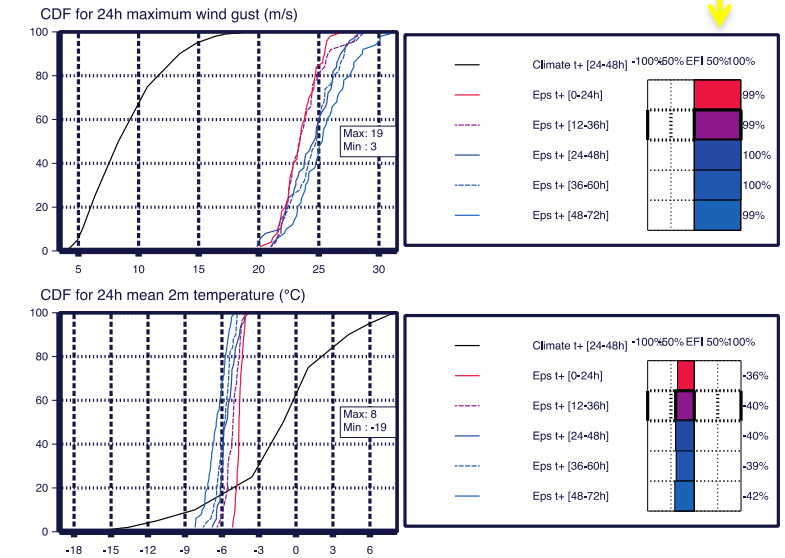
Measures the distance between the EPS cumulative distribution and the model climate distribution

Ranges from –1 (all members break climate minimum records) to +1 (all beyond model climate records)

Indicates places where the EPS distribution is towards the extreme of the climate distribution



## Clear saturation of EFI values …







Max:
Min:

24-48h M-Climate extrema

**M-Climate**: this stands for "Model Climate". It is a function of lead time, date (+/- ~15 days), and model version. It is derived by rerunning a 5 member ensemble, over the last 18 years, once a week (450 realisations). M-Climate is always from the same model version as the displayed EPS data. On this page only the 24-48h lead M-Climate is displayed.

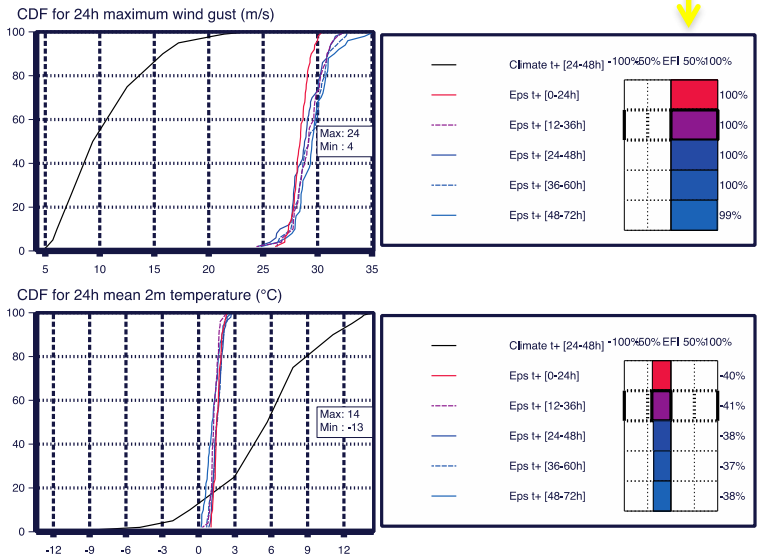
ECMWF

Carbon County Airport, Utah

Violent wind storm leaves path of destruction

California
Nevada
Utah (mainly)

Dec 01, 2011







Max:
Min:

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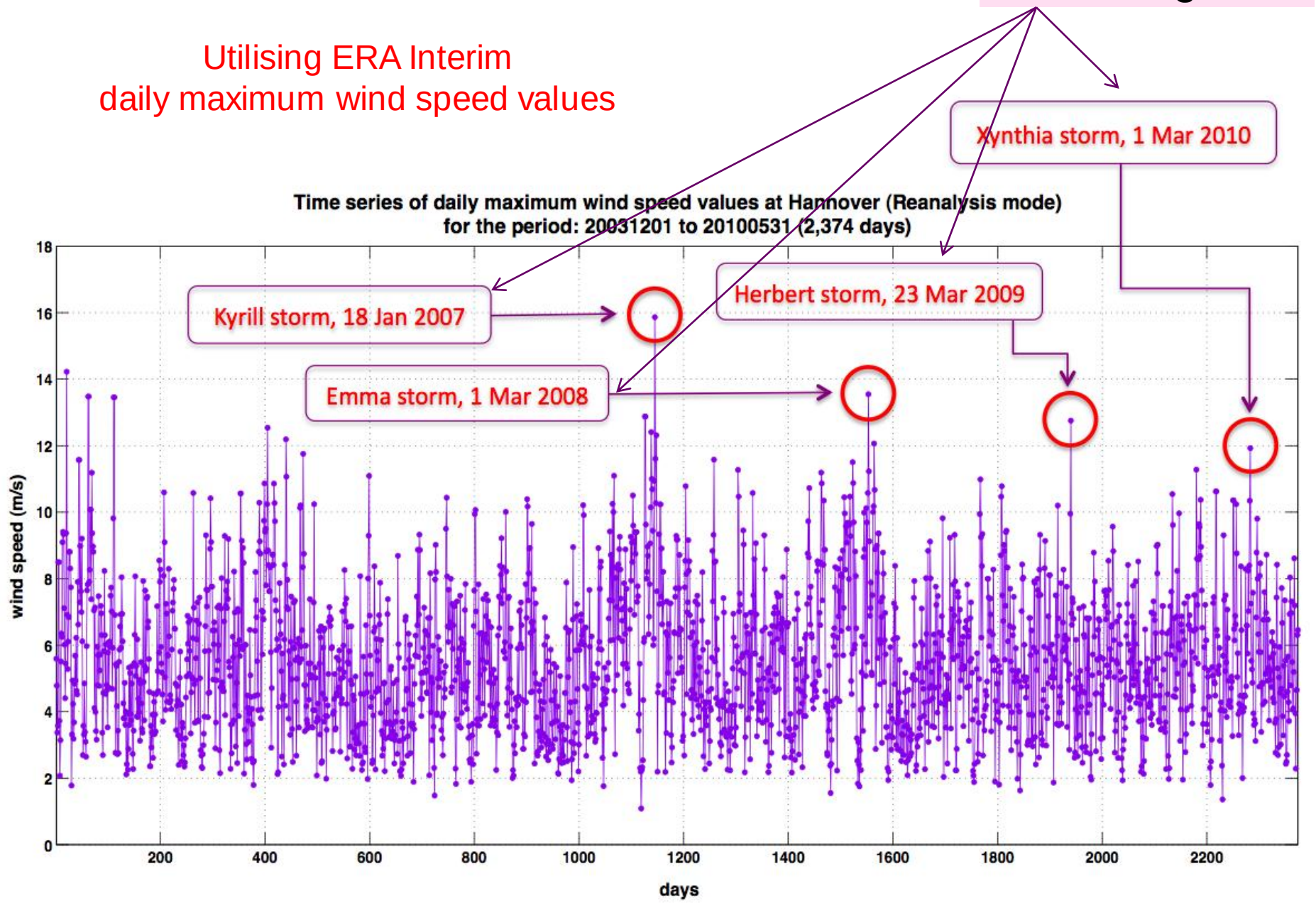
ECMWF

Badger Spring, Utah

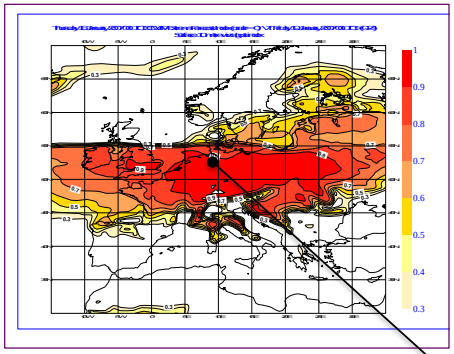
# Spikes – footprints of extremes

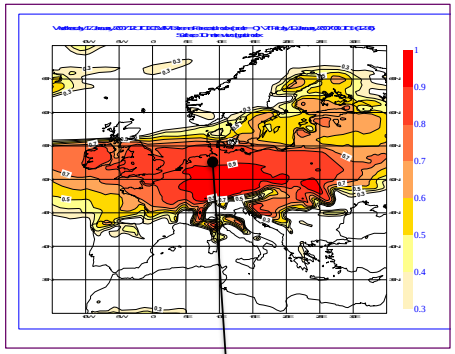
Focusing on

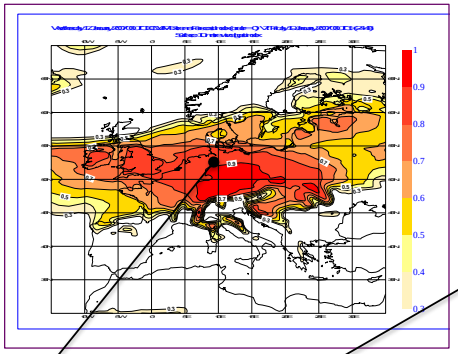
Utilising ERA Interim
daily maximum wind speed values

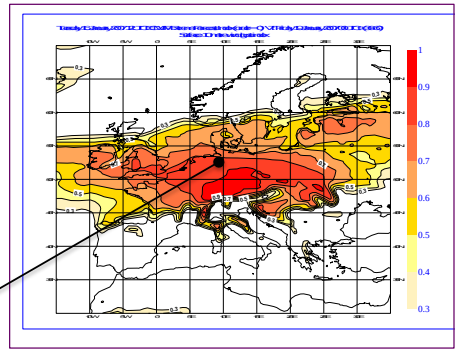


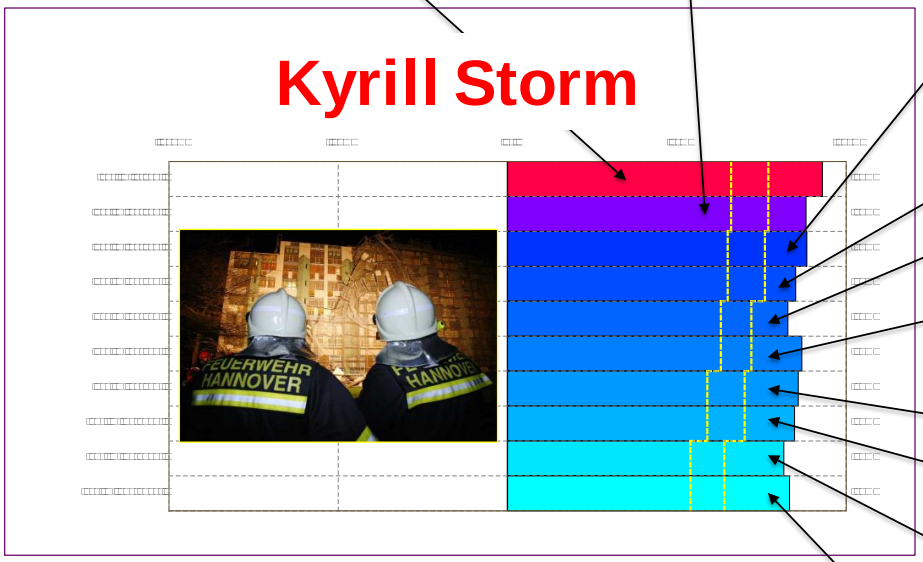
# Kyrill Storm

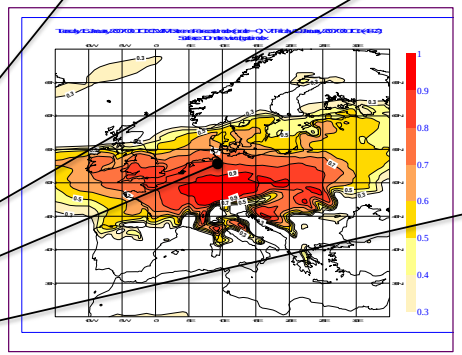


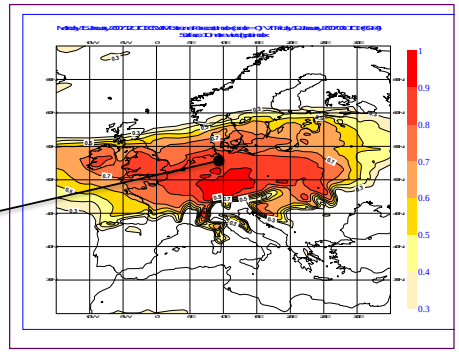


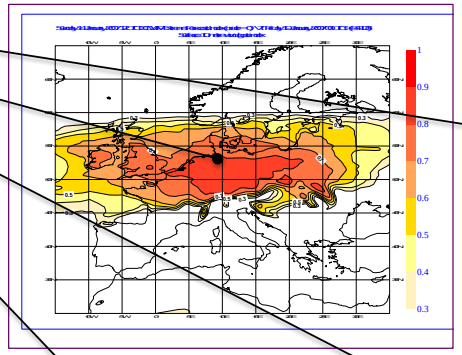


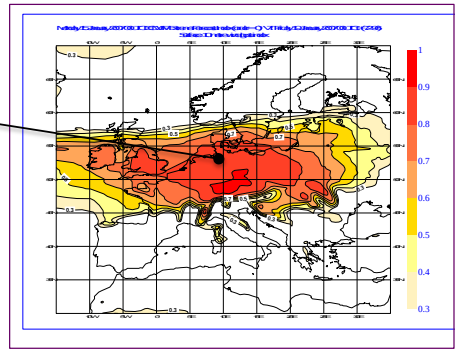


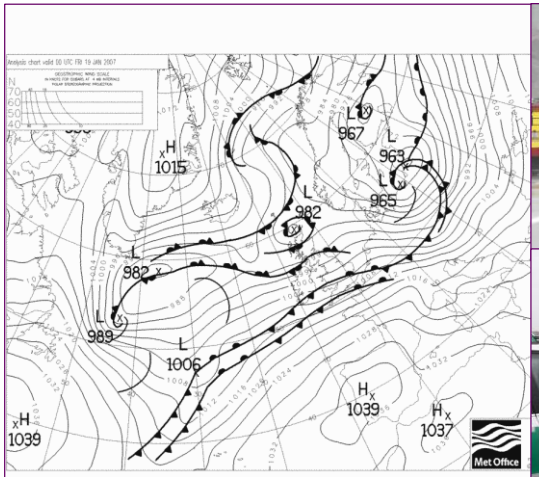


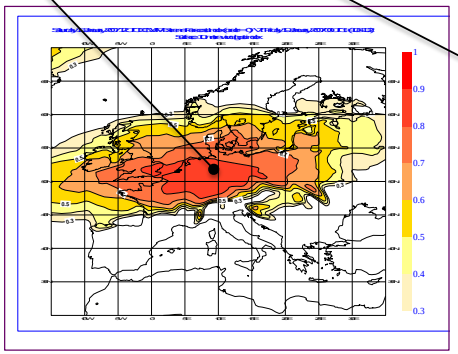


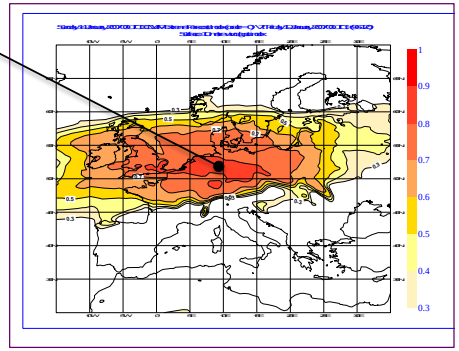




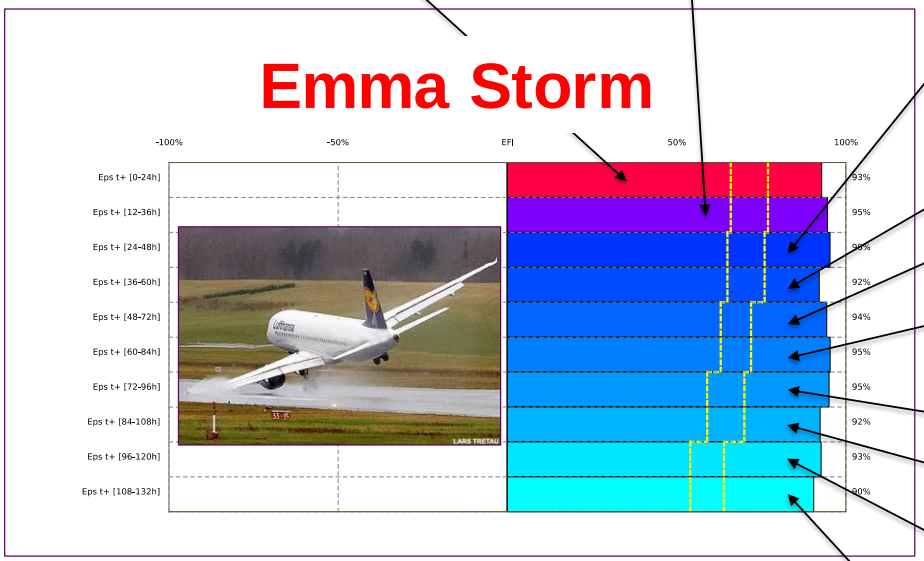








# Emma Storm


-100%
-50%
EFI
50%
100%
Eps t+ [0-24h]
Eps t+ [12-36h]
Eps t+ [24-48h]
Eps t+ [36-60h]
Eps t+ [48-72h]
Eps t+ [60-84h]
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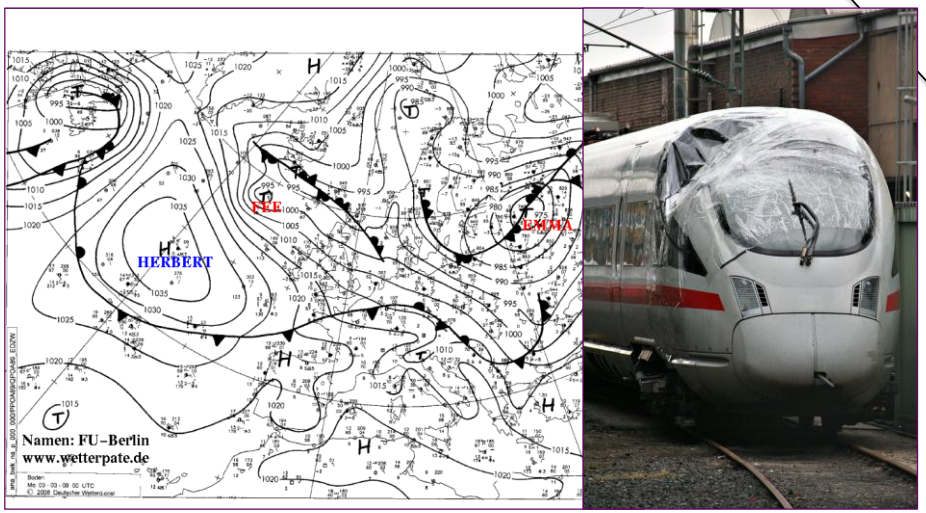
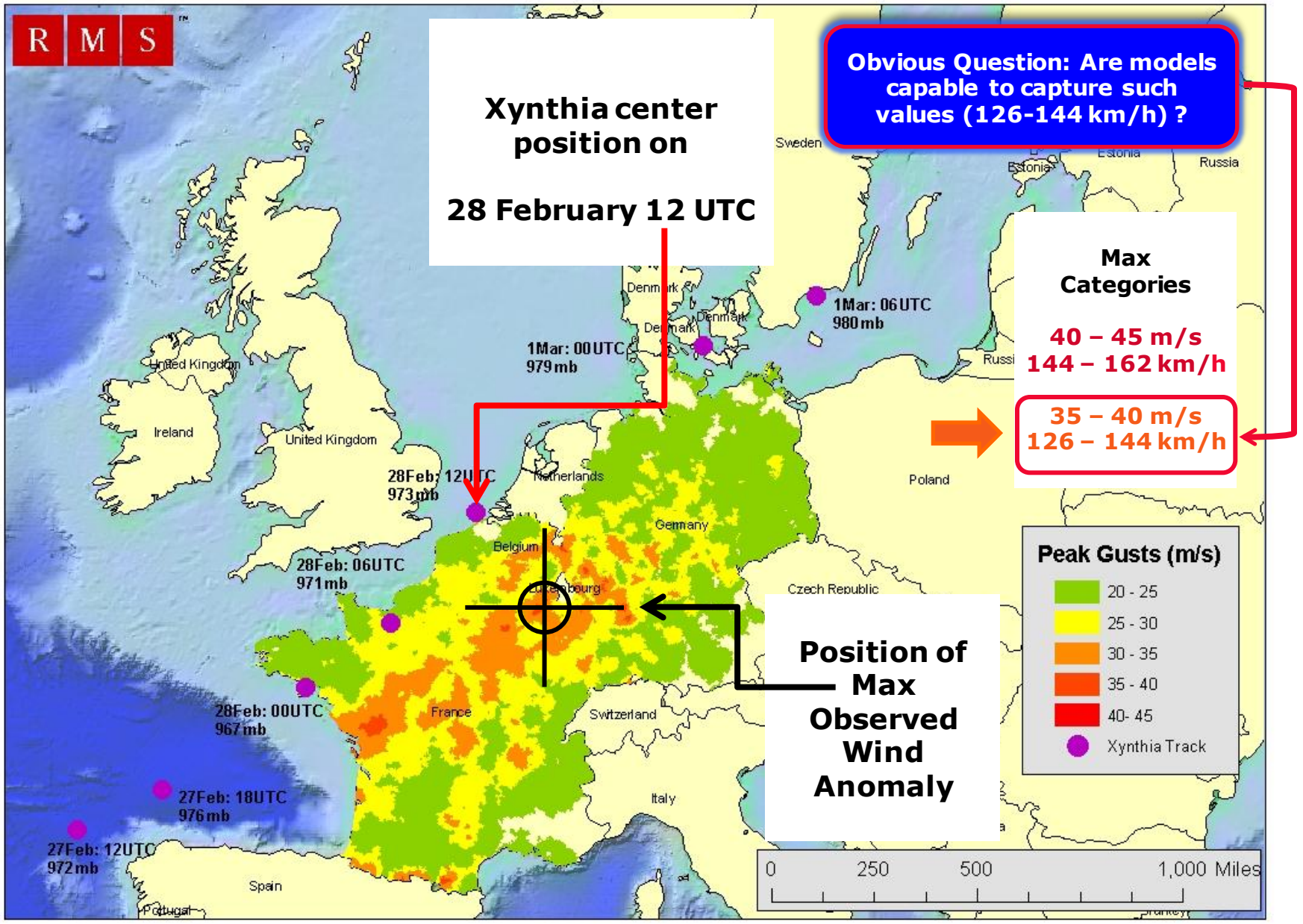
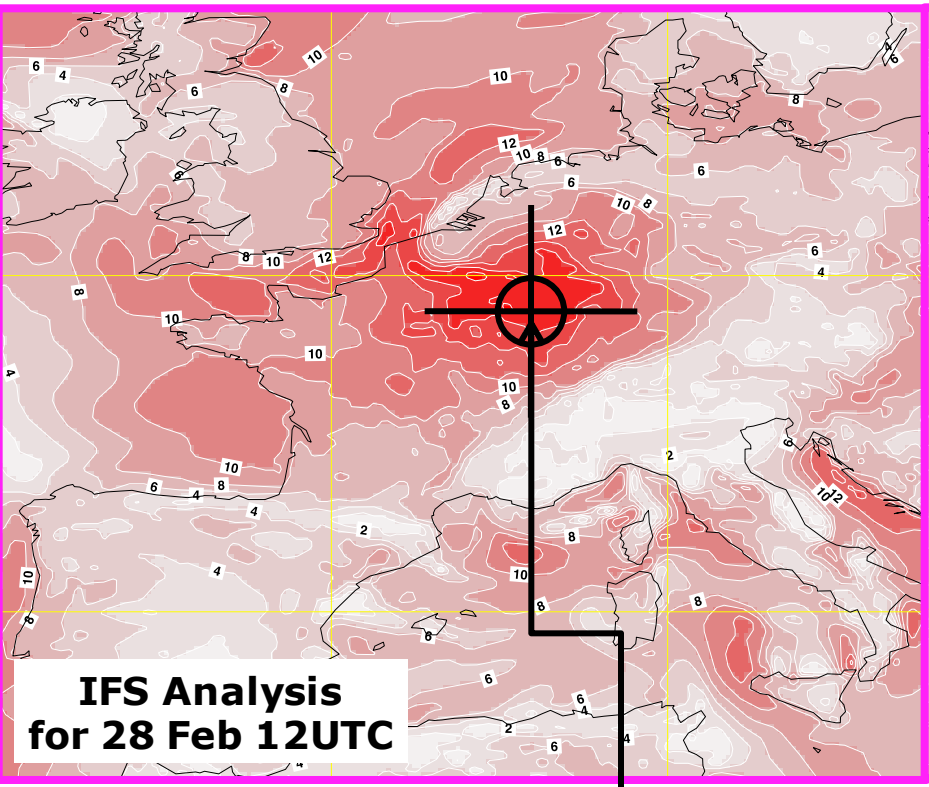
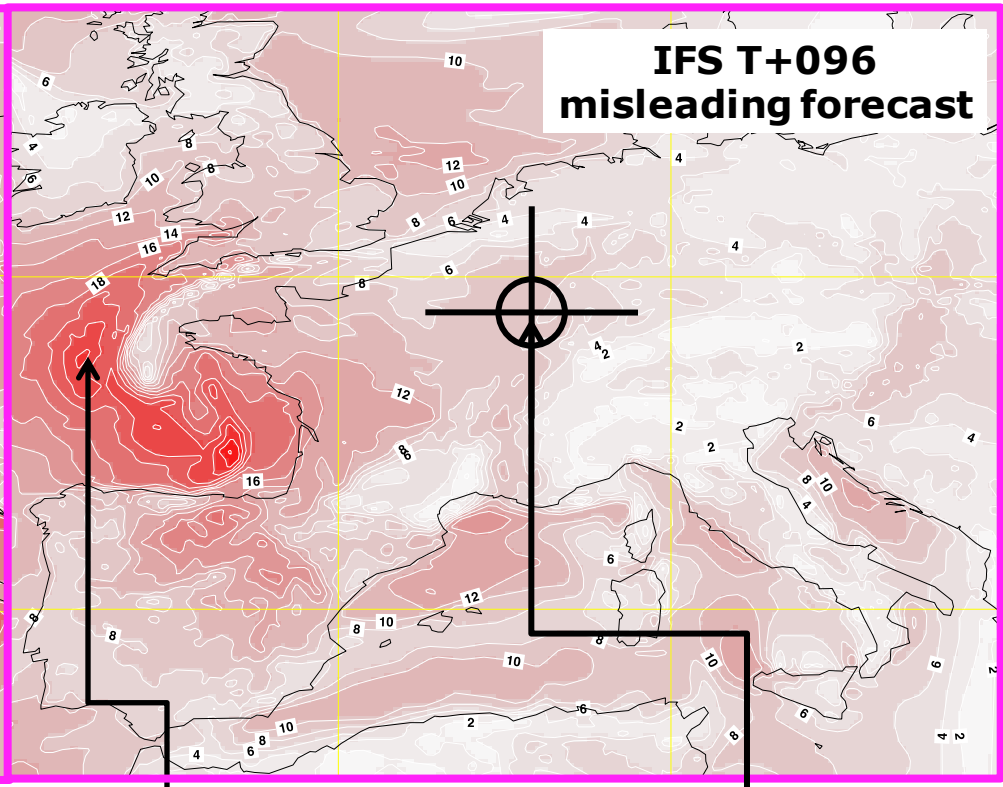

HERBERT
EMMA
Namen: FU-Berlin
www.wetterpate.de

# Utilizing Model's Gusty Components for Xynthia



# XYNTHIA: SIGNIFICANT ERROR OF T+096 IFS




**Area of Maximum Impact**
**Borders of France & Luxemburg**

**Max IFS values: 17 to 18m/s**

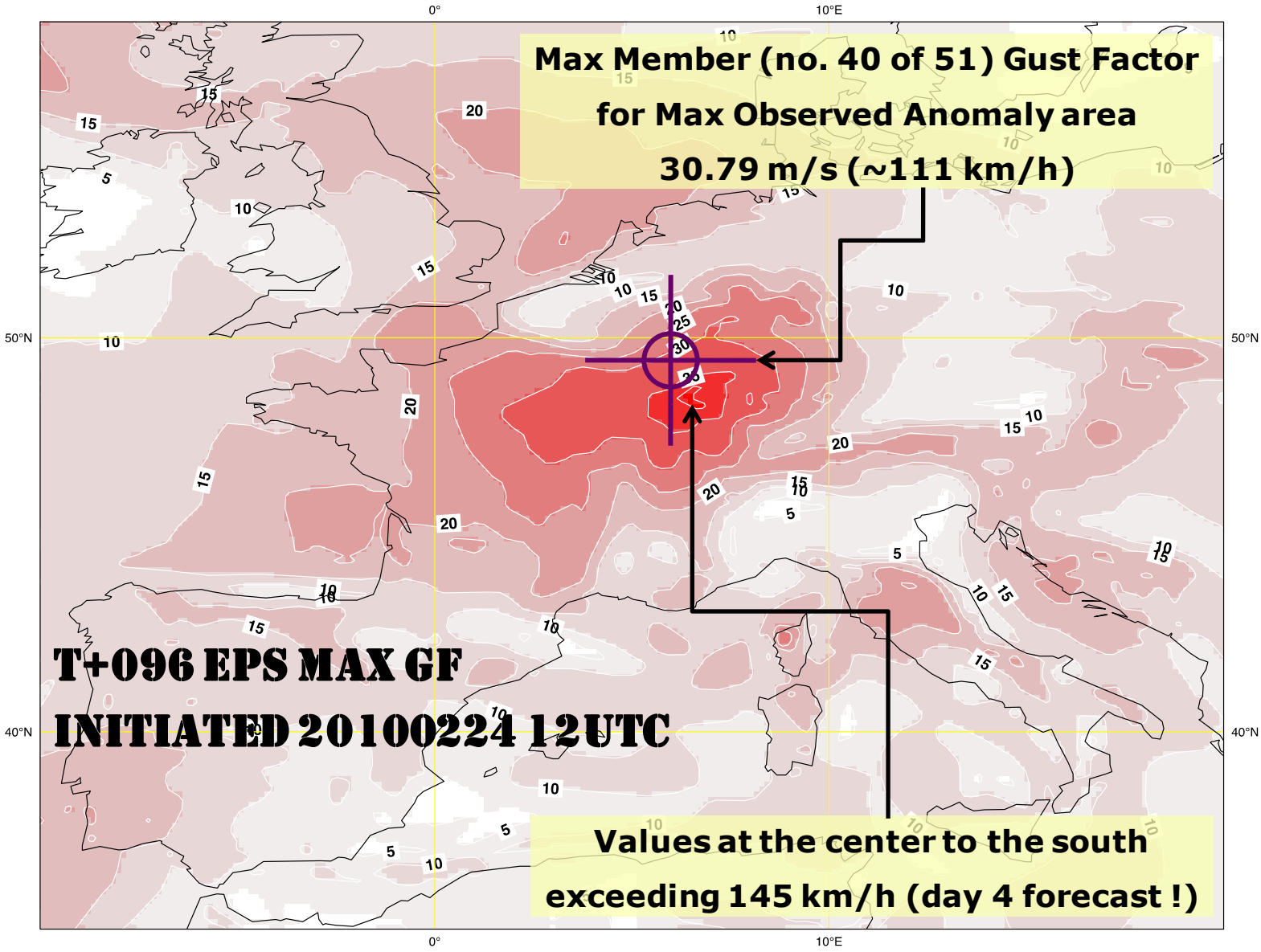
**IFS T+096 values: about 9m/s**

*** Maximum IFS values of 25m/s very far to the west**

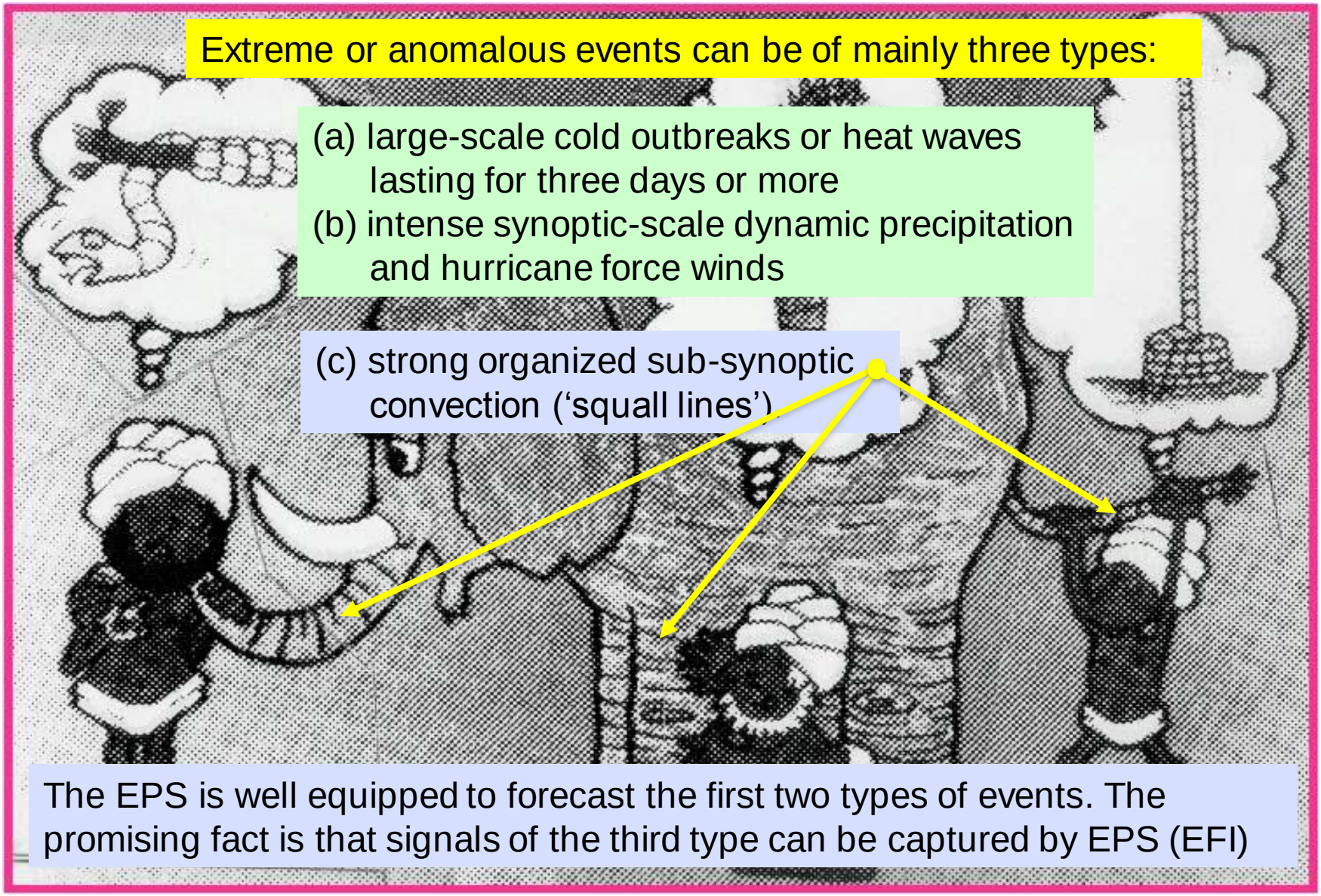


ECMWF

Wednesday 24 February 2010 12UTC ECMWF EPS Perturbed Forecast t+(93-96) VT: Sunday 28 February 2010 12UTC
Surface: 10 metre wind gust - Ensemble member number 40 of 51



# The story of the big elephant (cont.)



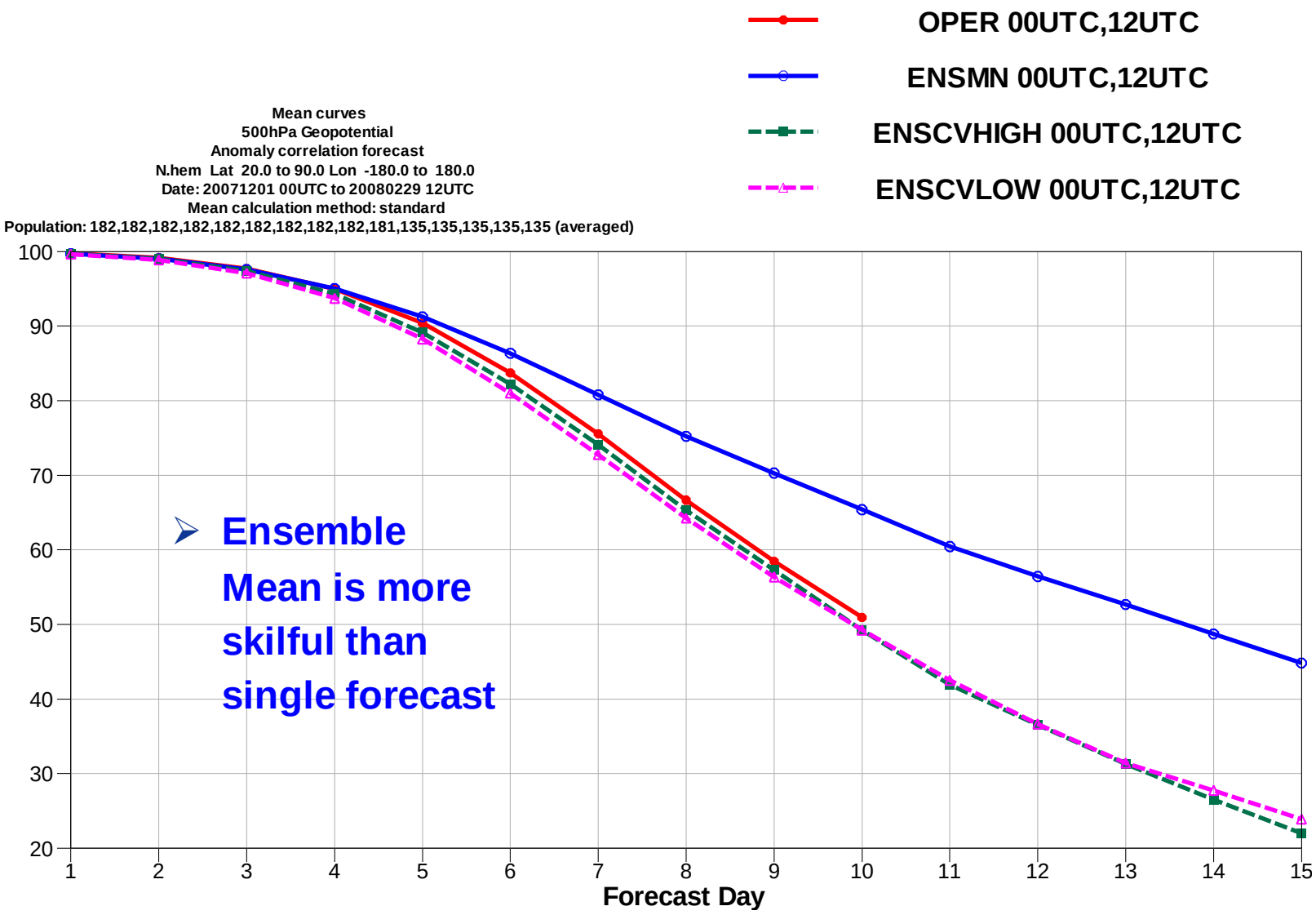
Extreme or anomalous events can be of mainly three types:

(a) large-scale cold outbreaks or heat waves lasting for three days or more
(b) intense synoptic-scale dynamic precipitation and hurricane force winds

(c) strong organized sub-synoptic convection ('squall lines')

The EPS is well equipped to forecast the first two types of events. The promising fact is that signals of the third type can be captured by EPS (EFI)

# Skill of the ensemble mean





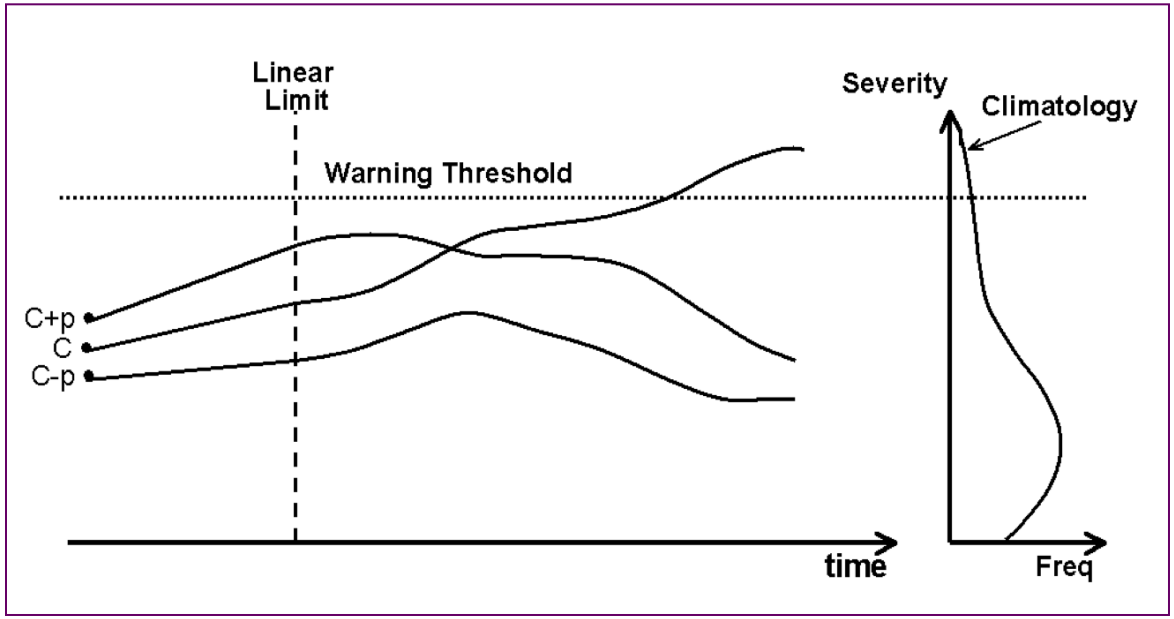

ECMWF

# Some more messages from Mylne & Legg, 2004

in a synoptic situation when severe weather is possible,

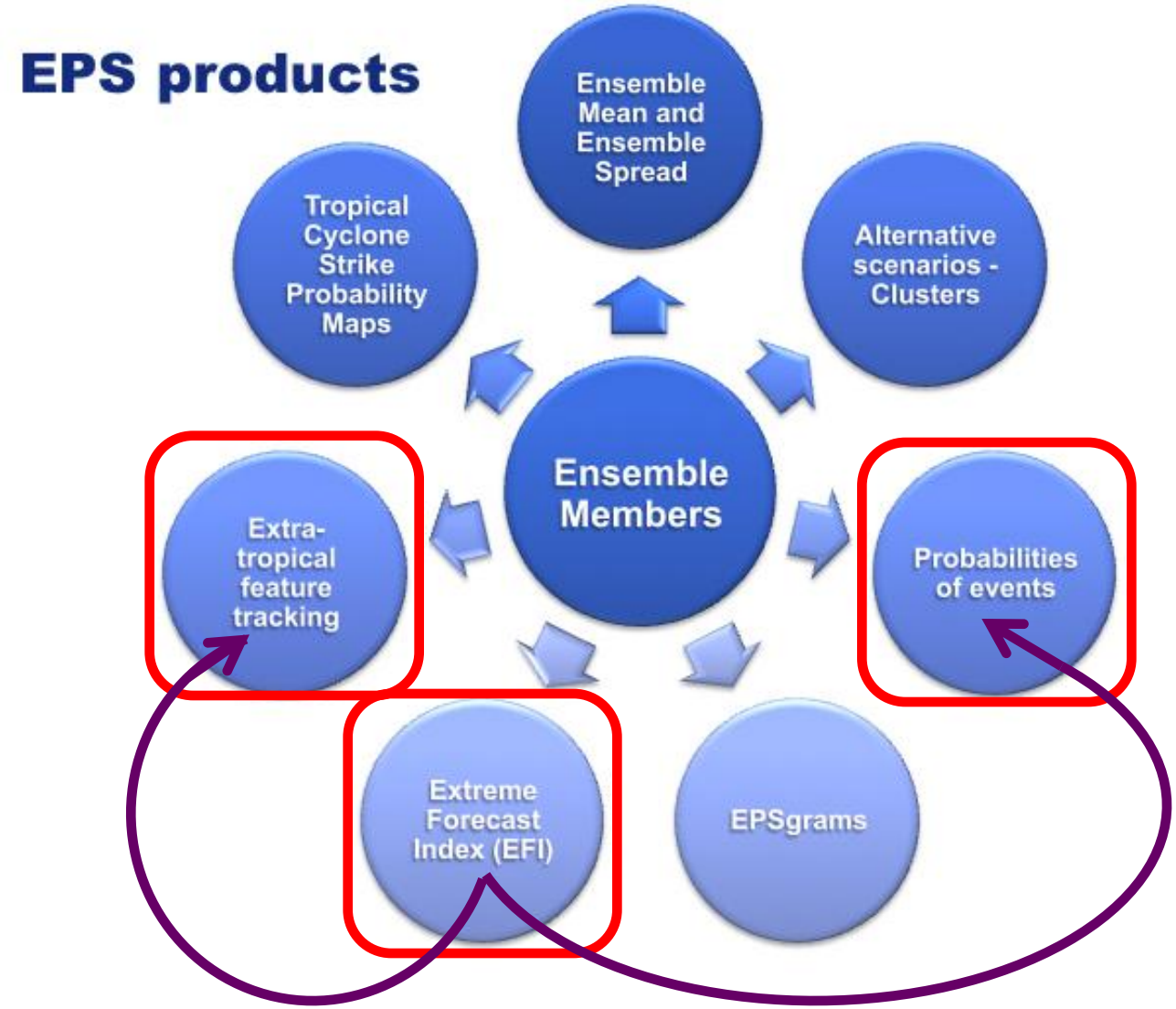
once a forecast moves into the chaotic non-linear regime,

most ensemble members are likely to be drawn towards the model's climatology



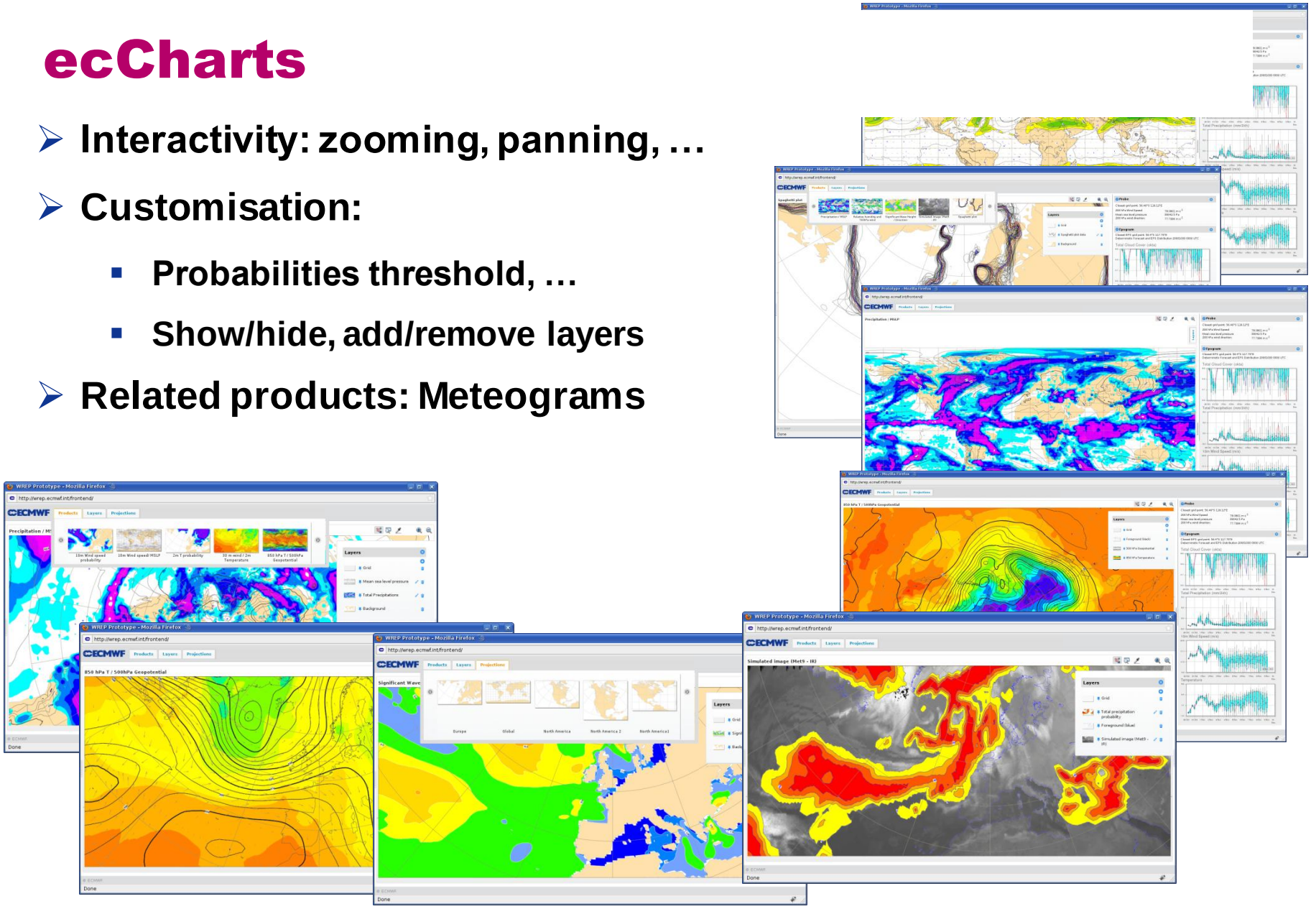

*Thus, although the ensemble can be expected to include members with severe events, it would be unusual for it to predict high probabilities of severe weather.*

# When EFI starts screaming…



# ecCharts

- Interactivity: zooming, panning, …
- Customisation:
  - Probabilities threshold, …
  - Show/hide, add/remove layers
- Related products: Meteograms



# Some more messages

## Example of MOGREPS thresholds (Neal et al, 2011)

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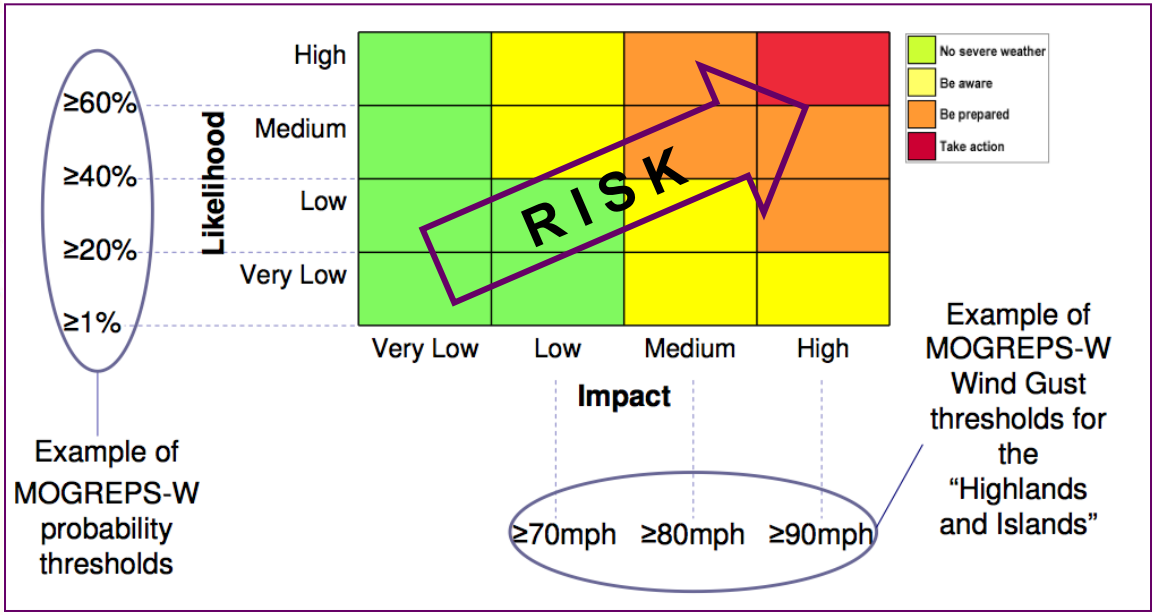


It is unlikely that an Early Warnings system based on the EPS is going to be able to capture the majority of severe weather events several days in advance with a high probability

For such "low" probabilities of extremes (in medium-range) utilise **ecCharts** using "extreme" climatological percentiles or extreme (critical) thresholds

In addition, use extreme probabilities combined with **probabilities of return**

Details of risk can be added nearer the time by utilising Likelihood & Impact diagram