The benefits and developments in ensemble wind forecasting

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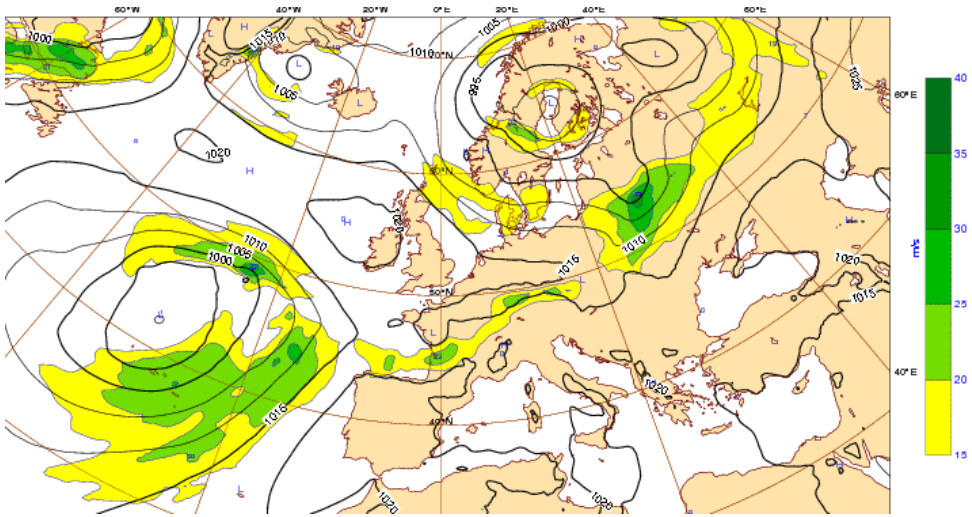
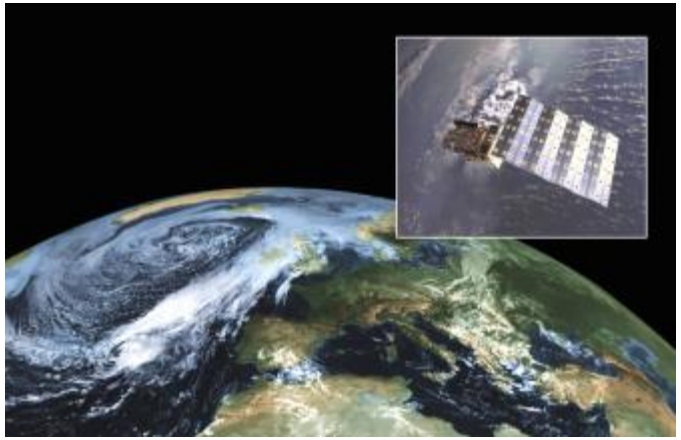
ECMWF – European Centre for Medium-Range Weather Forecasts

ECMWF's global forecasting system

- **High resolution forecast (HRES):** twice per day
  16 km 137-level, to 10 days ahead
- **Ensemble forecast (ENS):** twice daily
  51 members, 30/60 km 91-level, to 15 days ahead
- **Monthly forecast (ENS extension):** twice a week (Mon/Thursday)
  51 members, 30/60 km 91 levels, to 1 month ahead
- **Seasonal forecast (SEAS):** once a month, 41 members, 125 km
  62 levels, to 7 months ahead



Global observations



Global weather forecasts

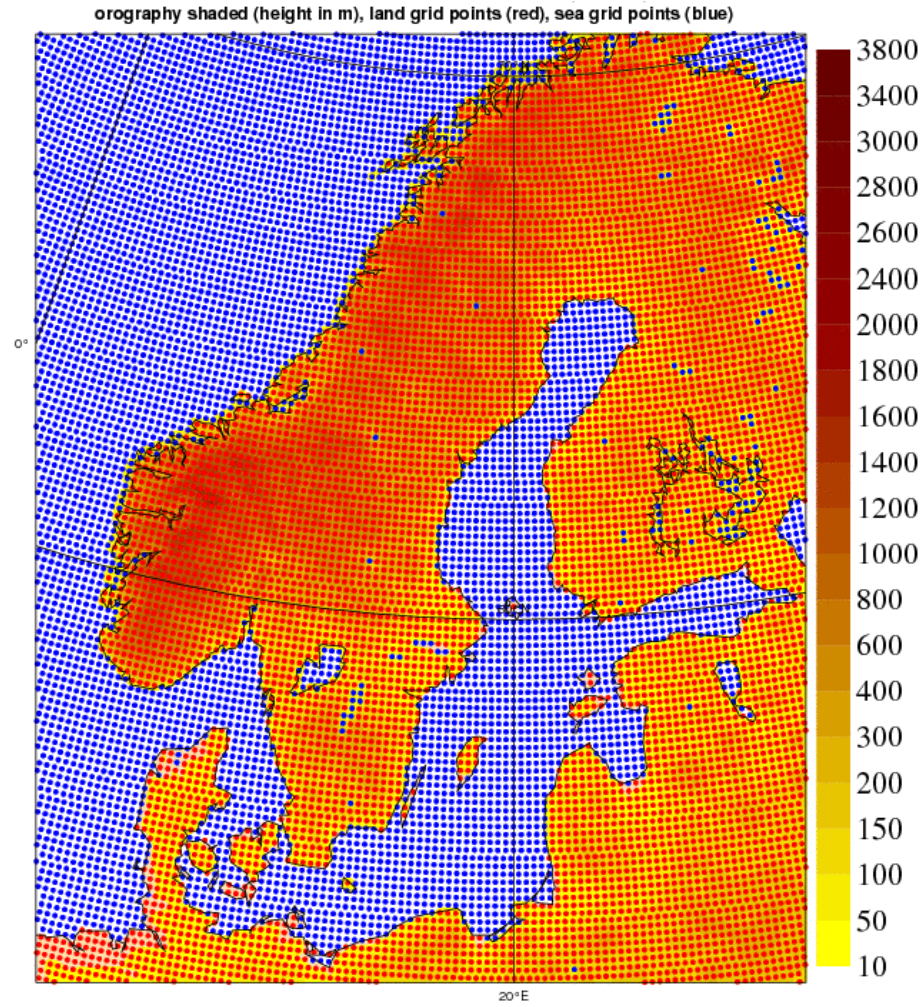
Users

National weather services

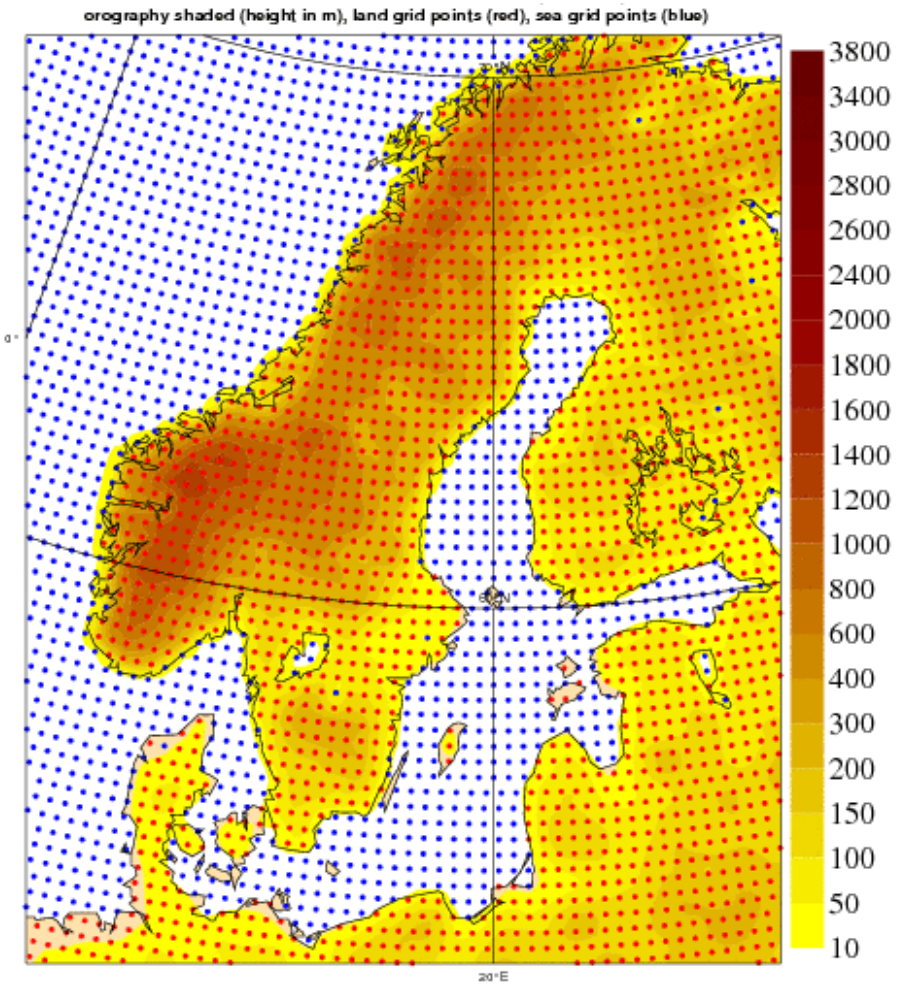
ECMWF

Model grids: HRES (16 km) and ENS (32 km)

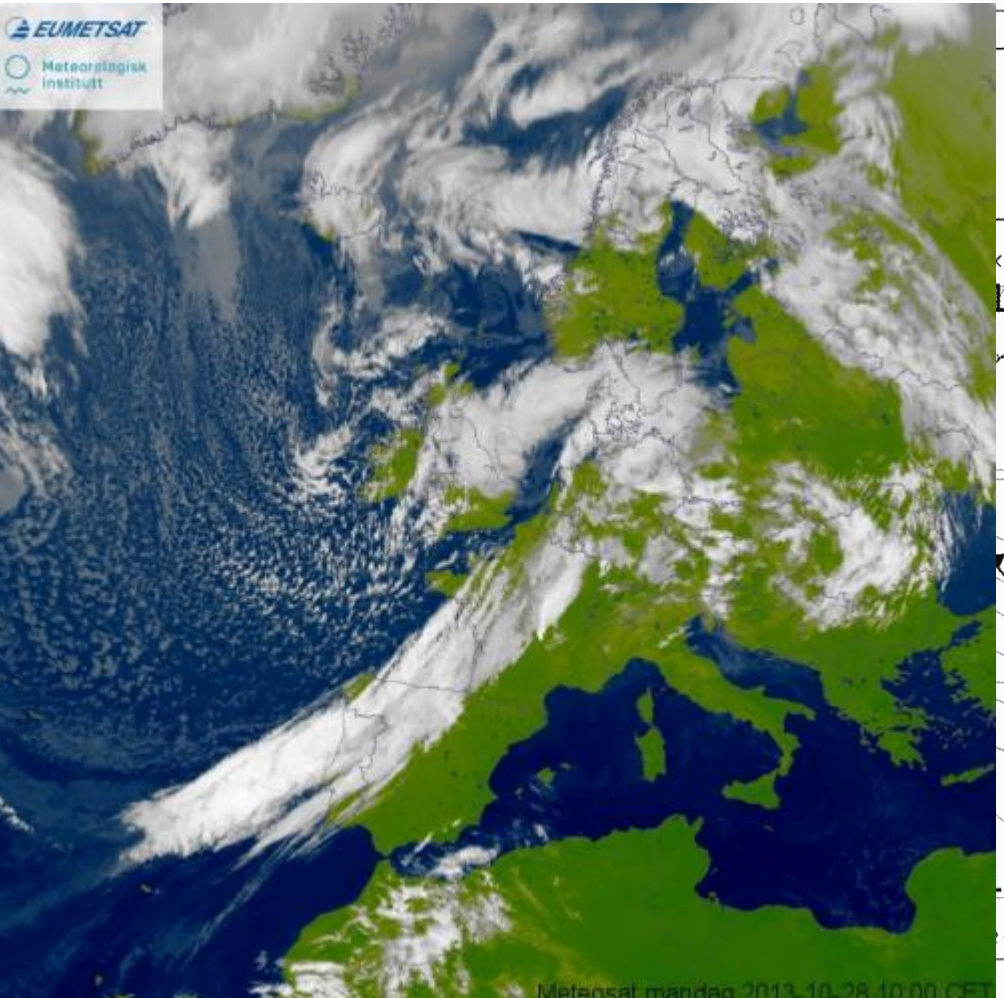
HRES: T1279 (16 km)

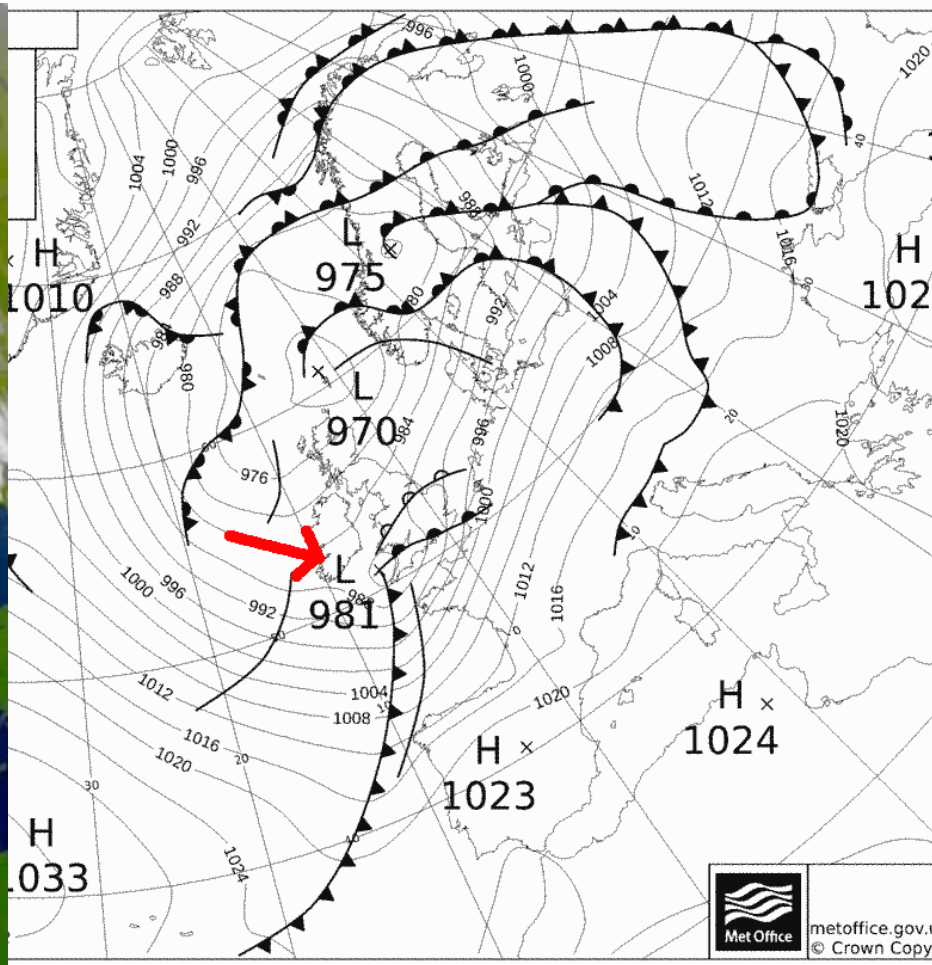


ENS: T639 (32 km)

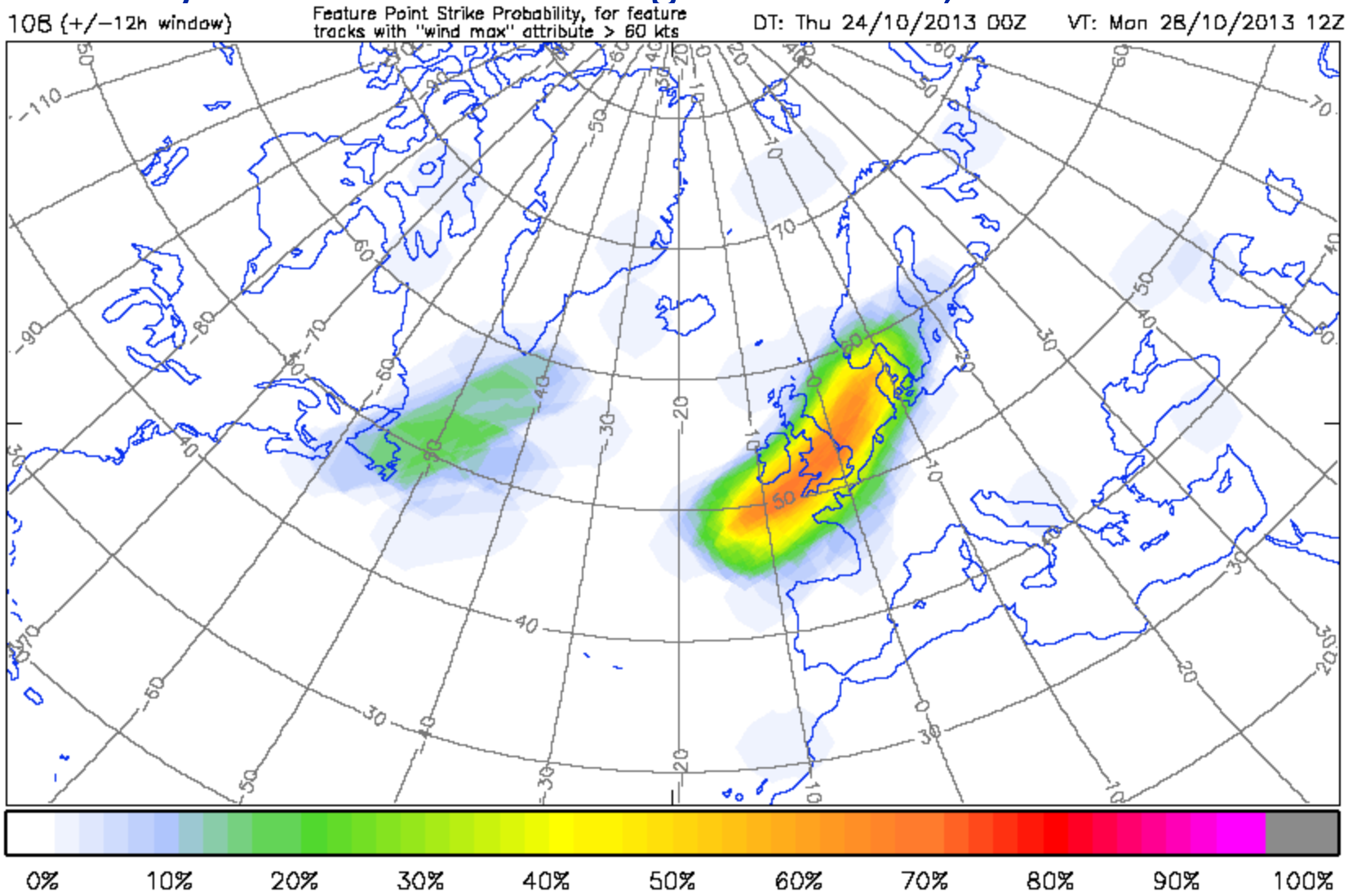


Windstorm 28 October 2013 - St Jude/Simone/Christian



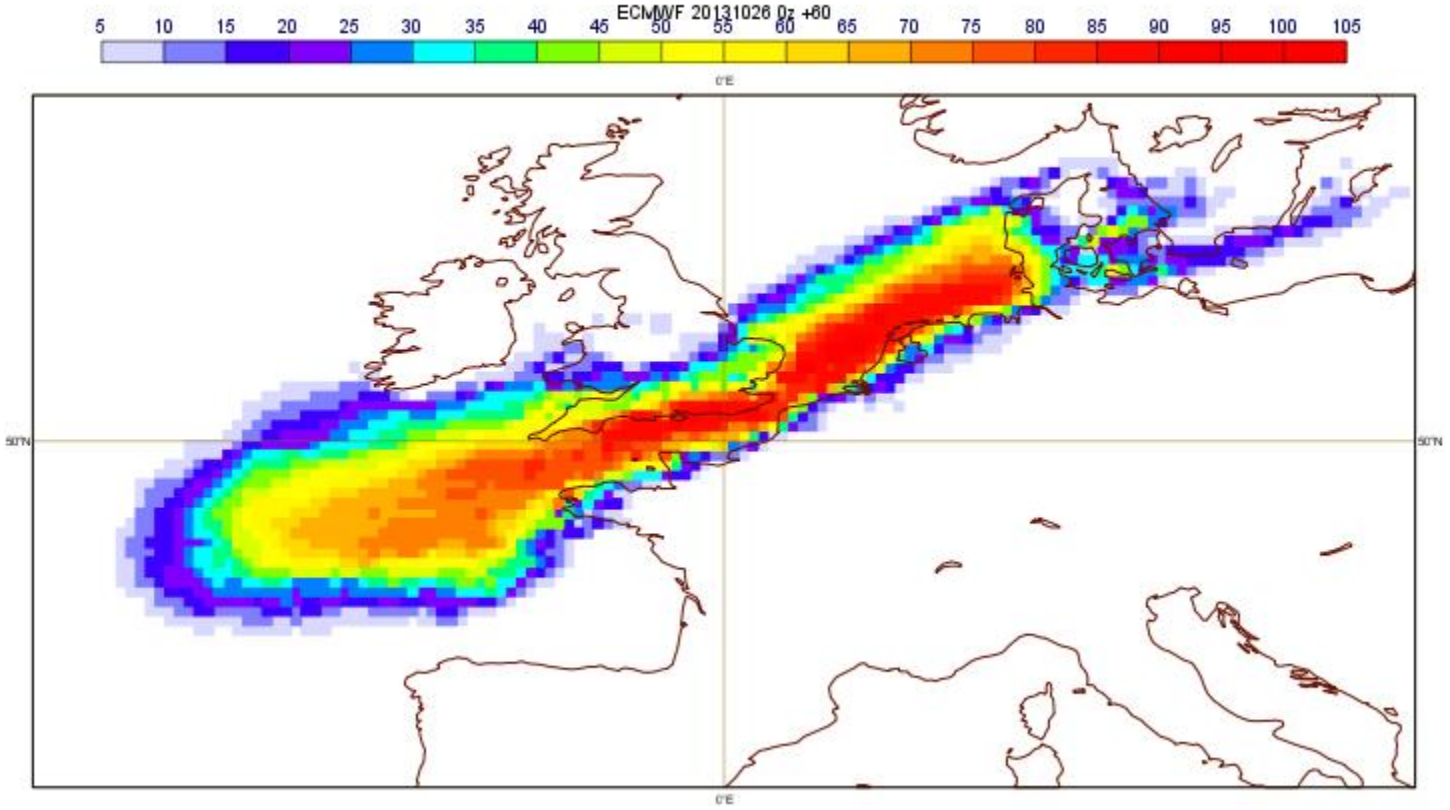


Windstorm 28 October 2013 - St Jude/Simone/Christian
Probability of a storm occurring on the 28th, issued on the 24th

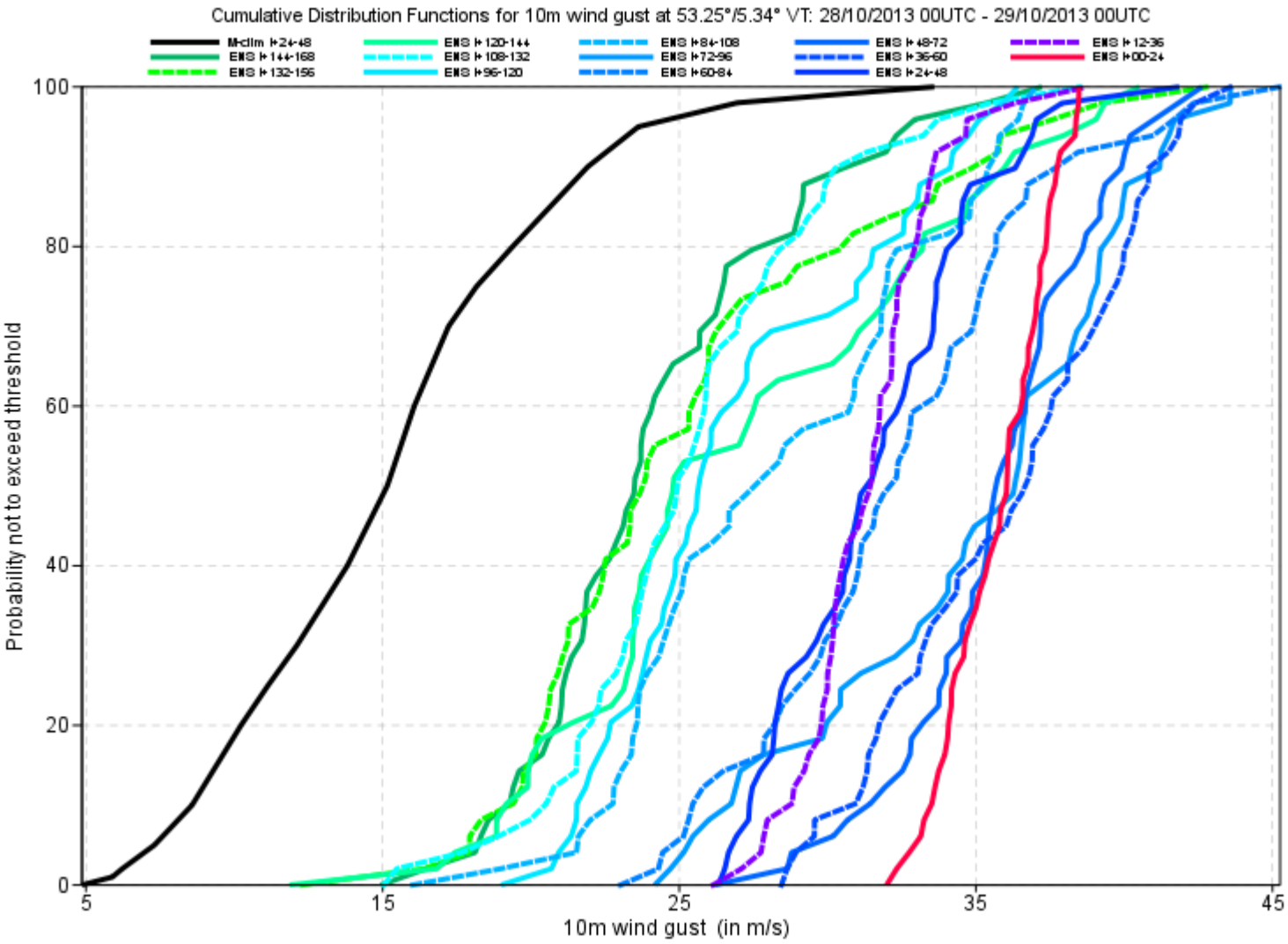


Windstorm 28 October 2013 - St Jude/Simone/Christian

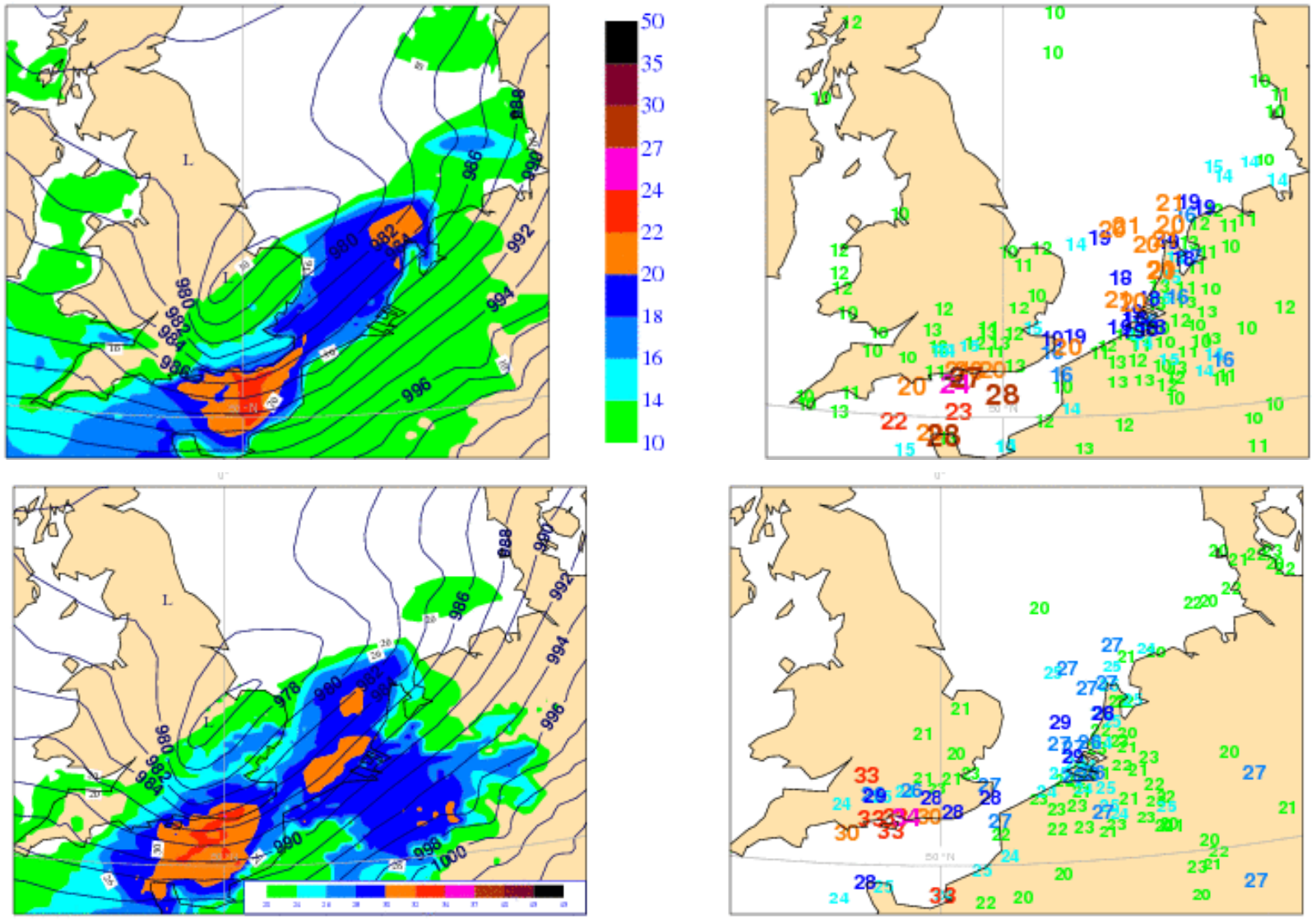
Probability of wind speeds > 33 m/s on the 850 hPa level, on the 28th issued on the 26th



Windstorm 28 October 2013 - St Jude/Simone/Christian
The Netherlands (observed wind gust was > 35 m/s)



Windstorm 28 October 2013 - St Jude/Simone/Christian
Mean wind (top) gust (bottom) at 06 UTC, forecast vs observed



Why do we run a forecast ensemble?

Basic idea:

- Taking account of uncertainty
- Forecasting forecast skill

Forecasting benefits

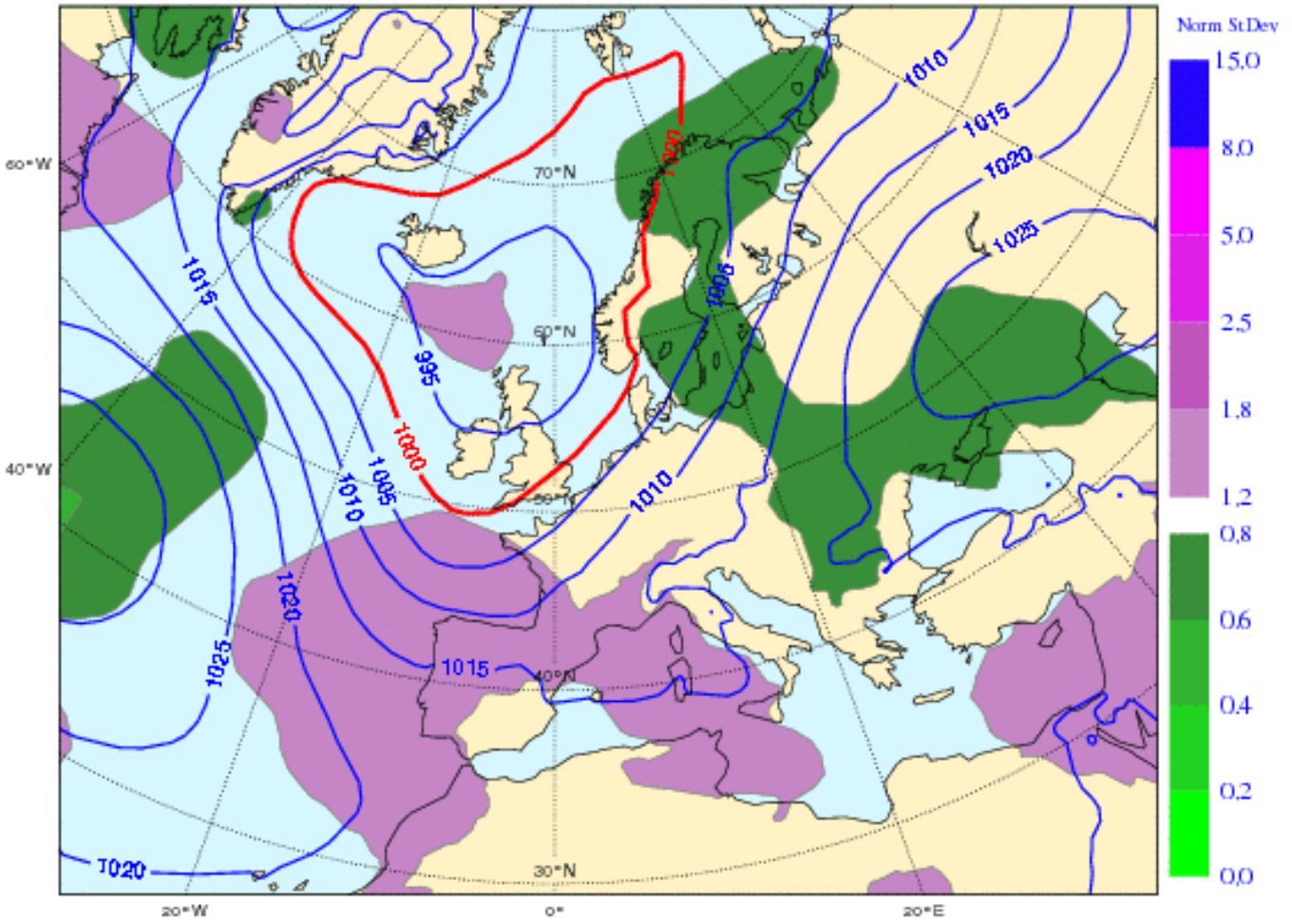
- Assess uncertainty of today's forecast
- Provide alternative forecast scenarios
- Distil the predictable (large-scale) component
- Highlight the risk for rare or extreme (small-scale) events

Continuing challenges

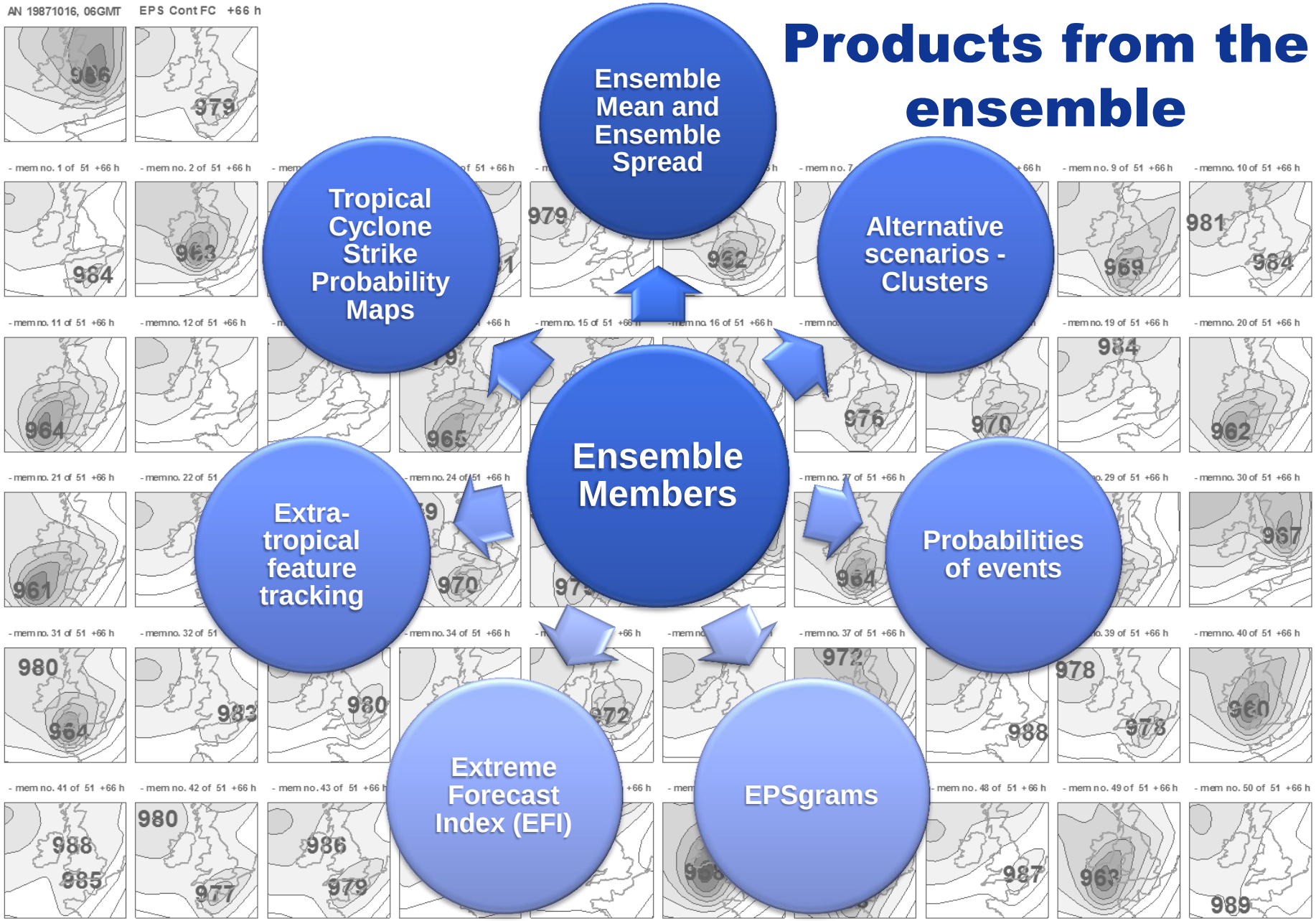
- Forecasting extreme events
- Extending the forecast range

ECMWF

Ensemble mean and ensemble spread



Products from the ensemble



ECMWF

EPSgrams

Highest value of all members

90th centile

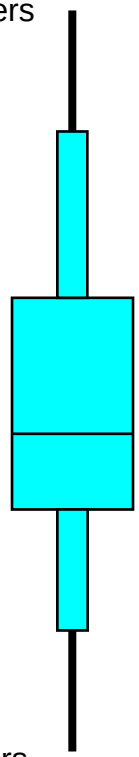
75th centile

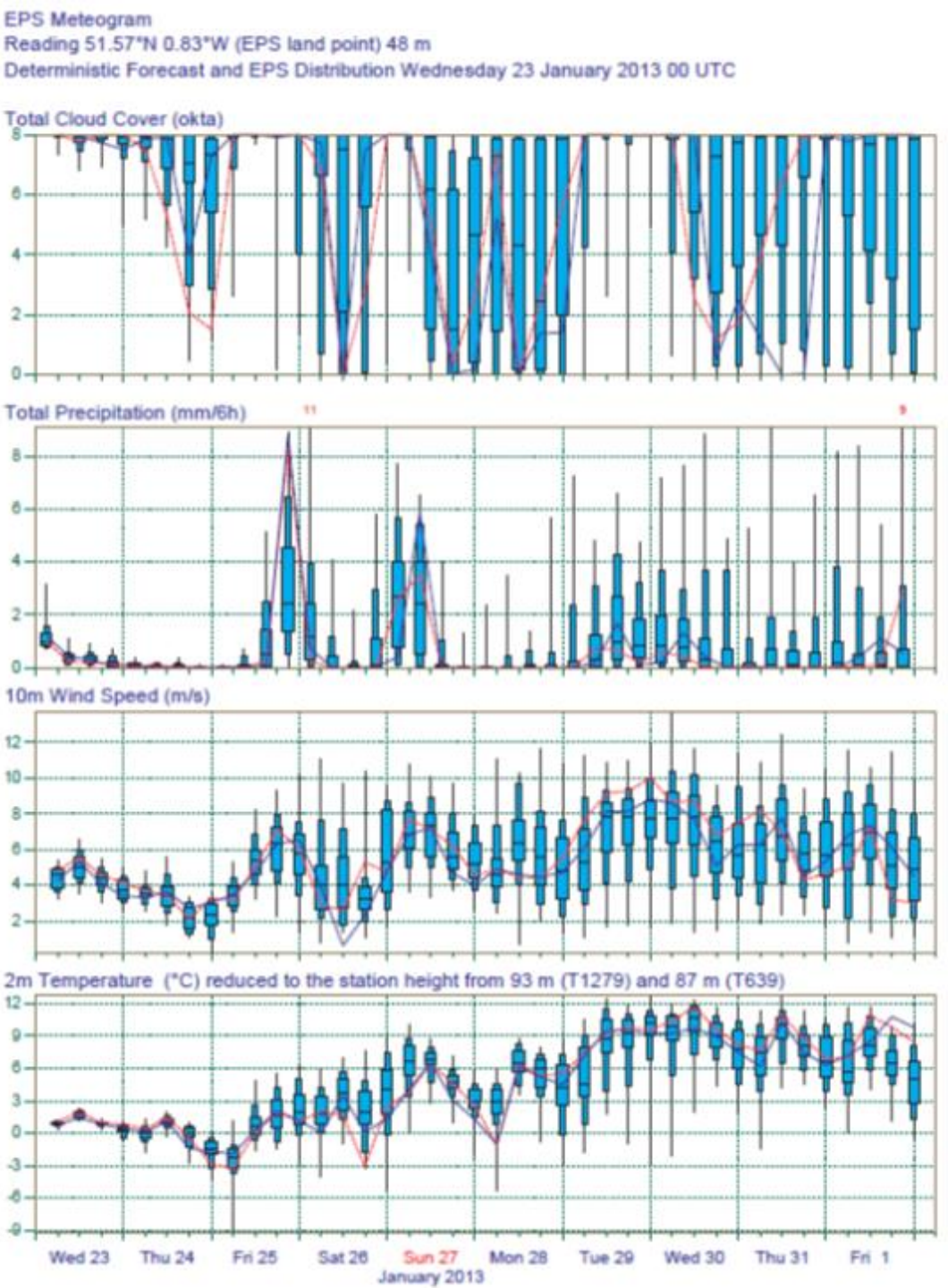
Median

25th centile

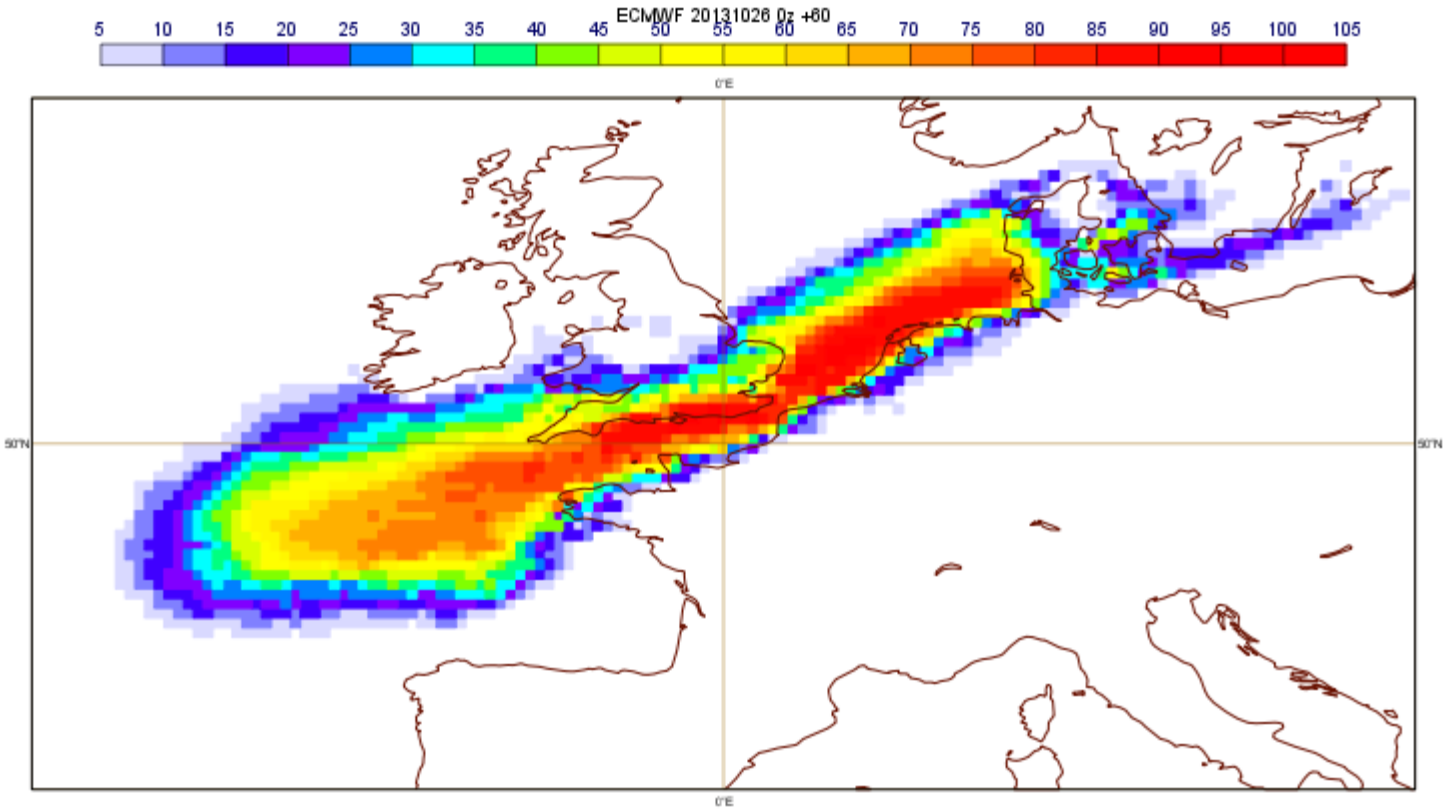
10th centile

Lowest value of all members





Probabilities of events
wind speed at 850 hPa > 33 m/s



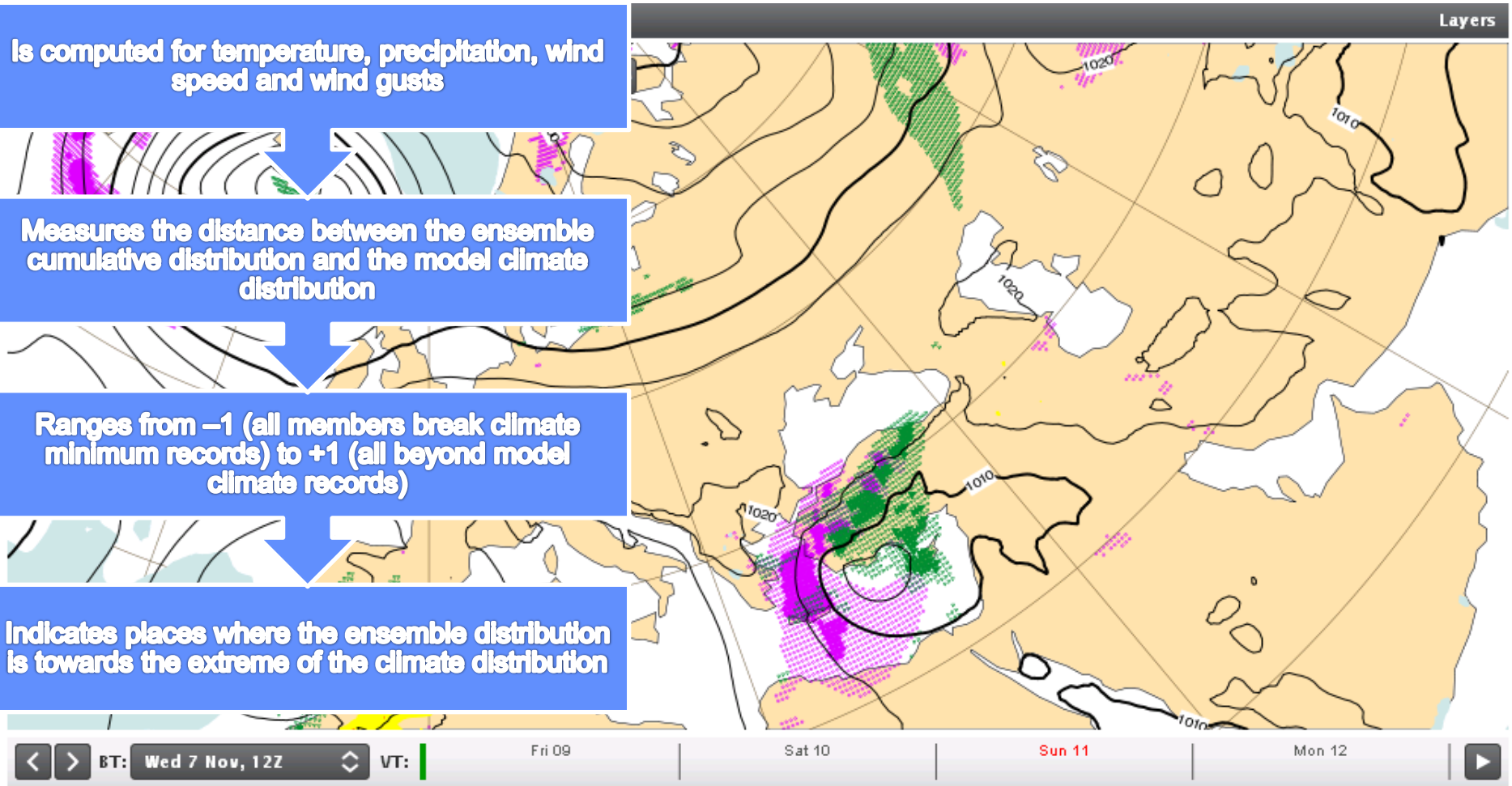
Extreme forecast index (EFI)

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

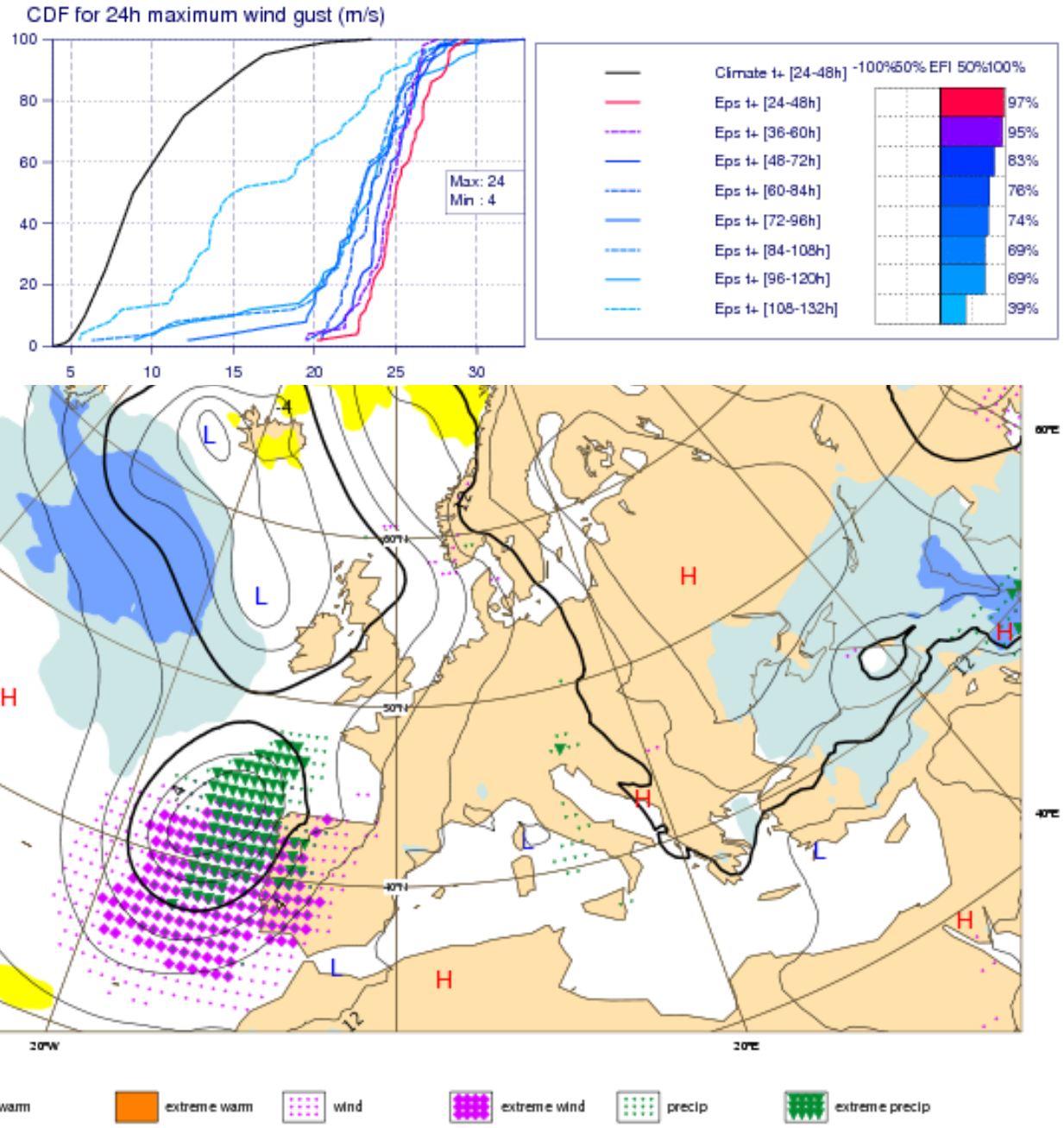
Measures the distance between the ensemble cumulative distribution and the model climate distribution

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

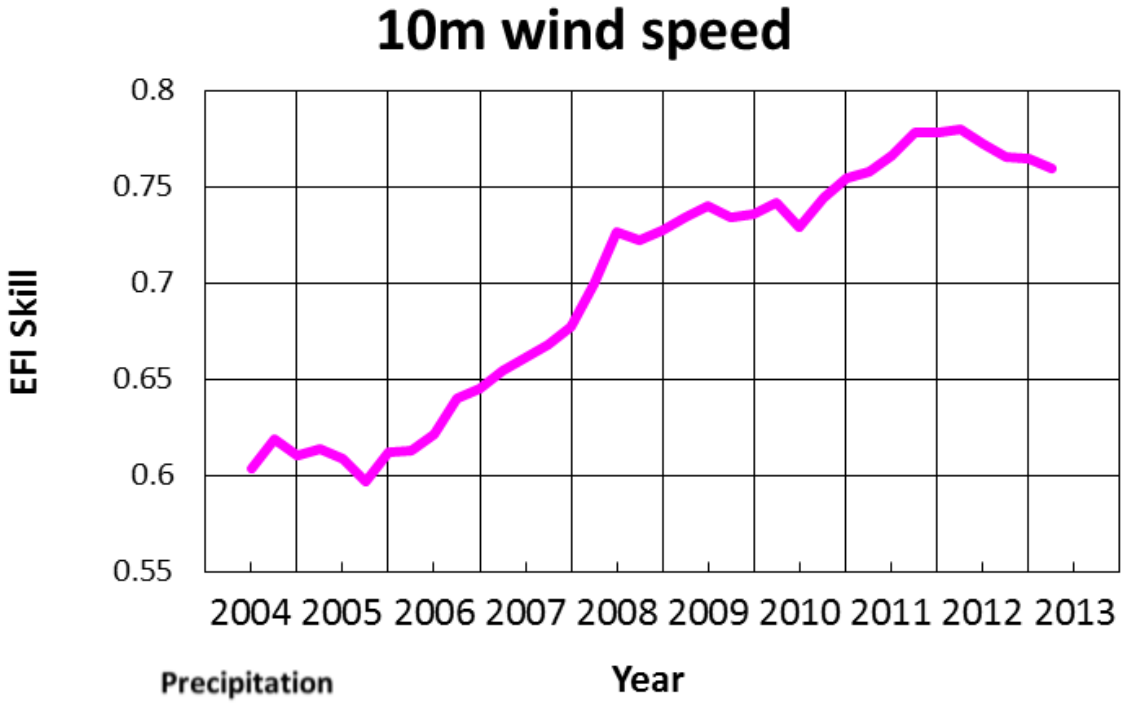
Indicates places where the ensemble distribution is towards the extreme of the climate distribution

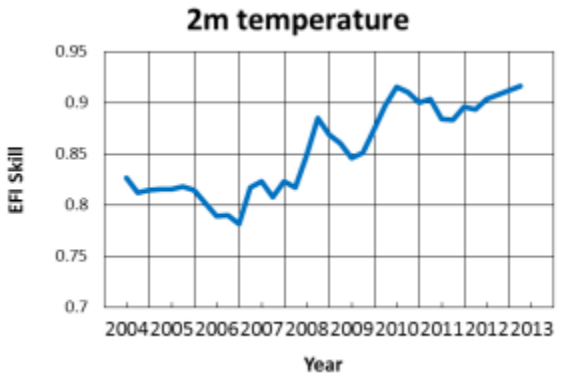


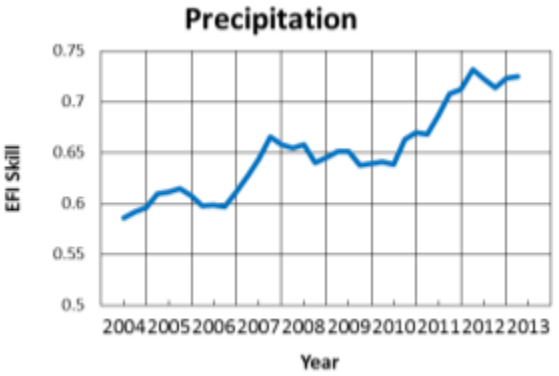
Extreme forecast index (EFI)



Skill of the extreme forecast index (EFI)







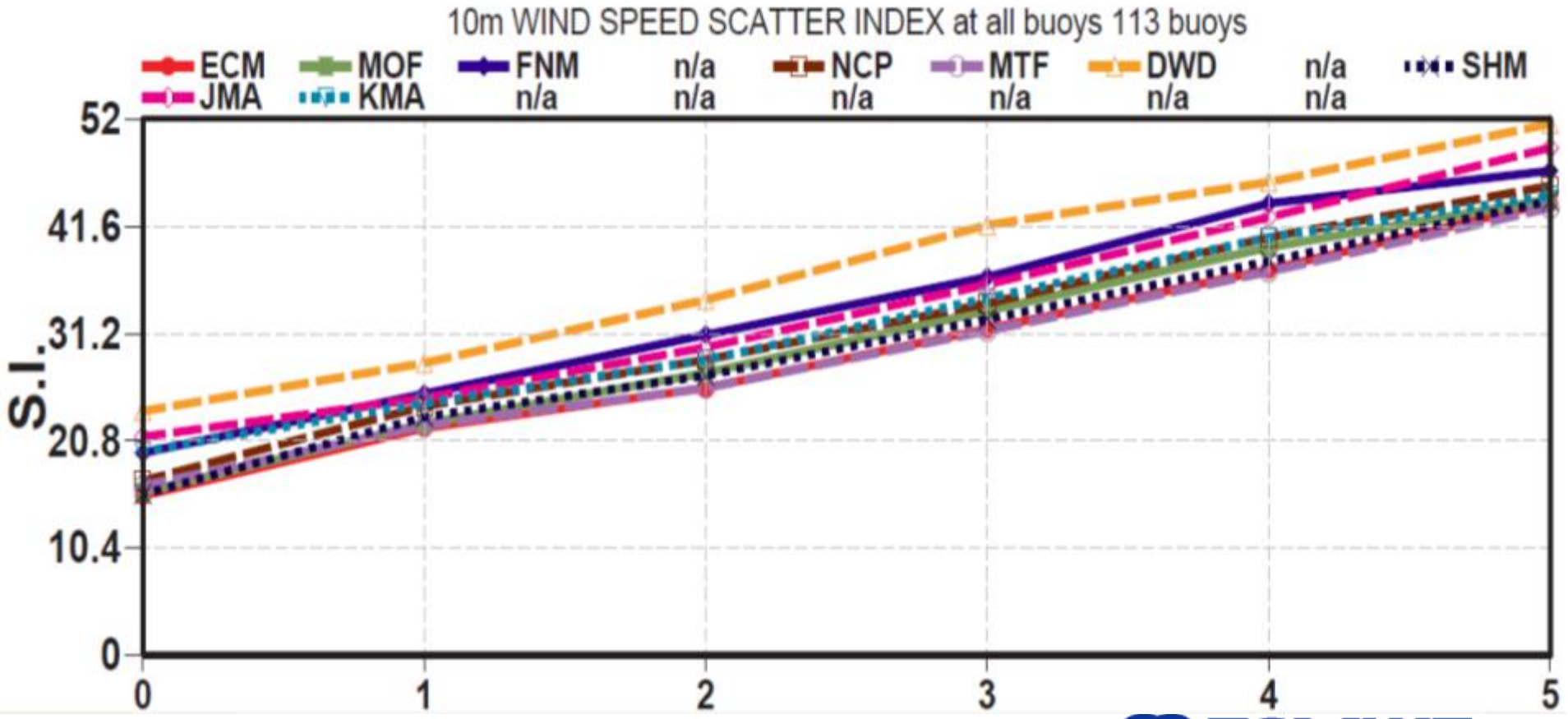
Verification of Extreme Forecast Index (EFI) for precipitation, 10m wind and T2m over Europe showing ROC area from 2004 to 2012 at day 4 (72 - 96 hours ahead)

Extreme event is taken as an observation exceeding 95th percentile of station climate.

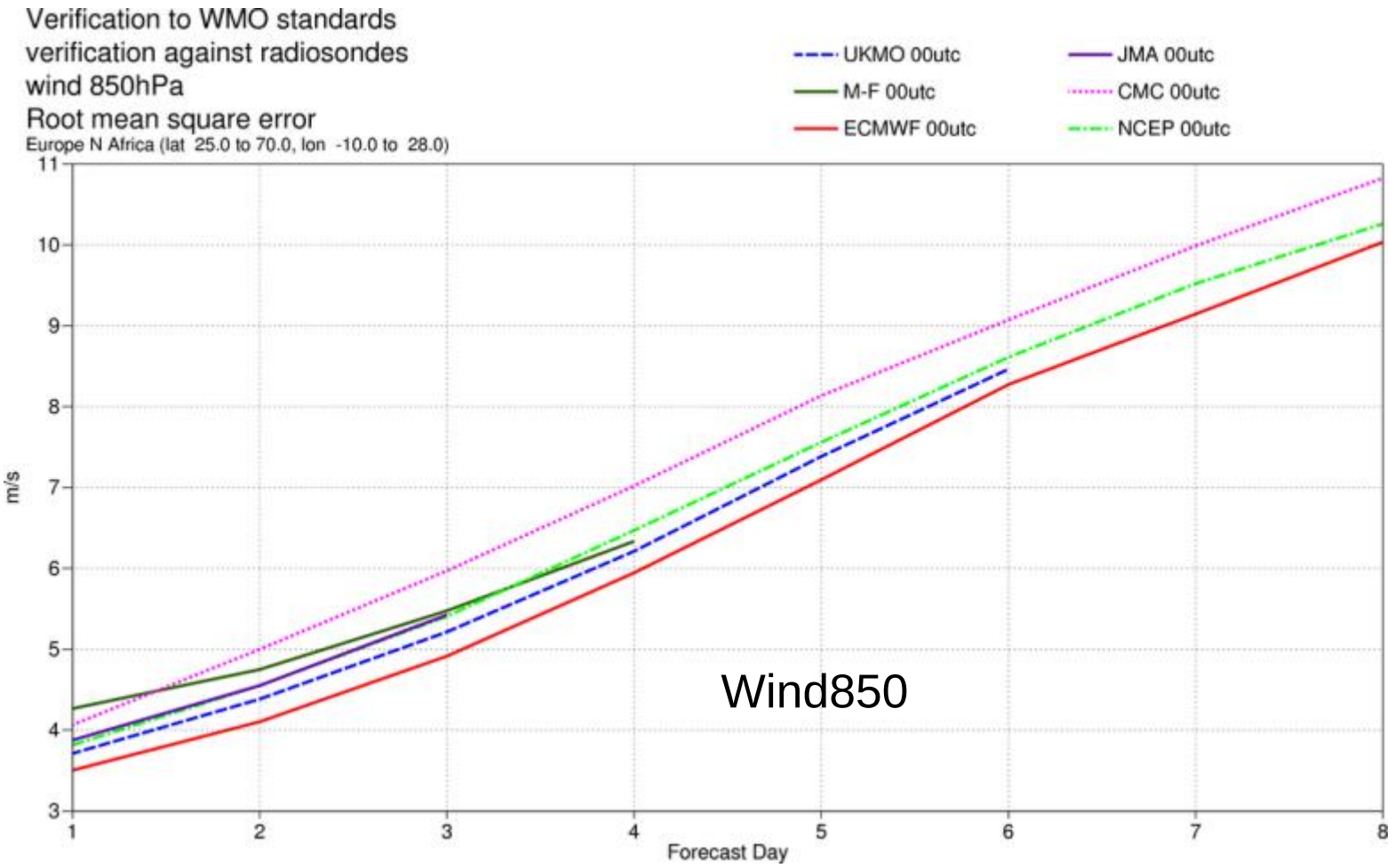
ECMWF

10m wind verification

Comparison of forecast winds against buoy data for ECMWF and other main NWP centres.

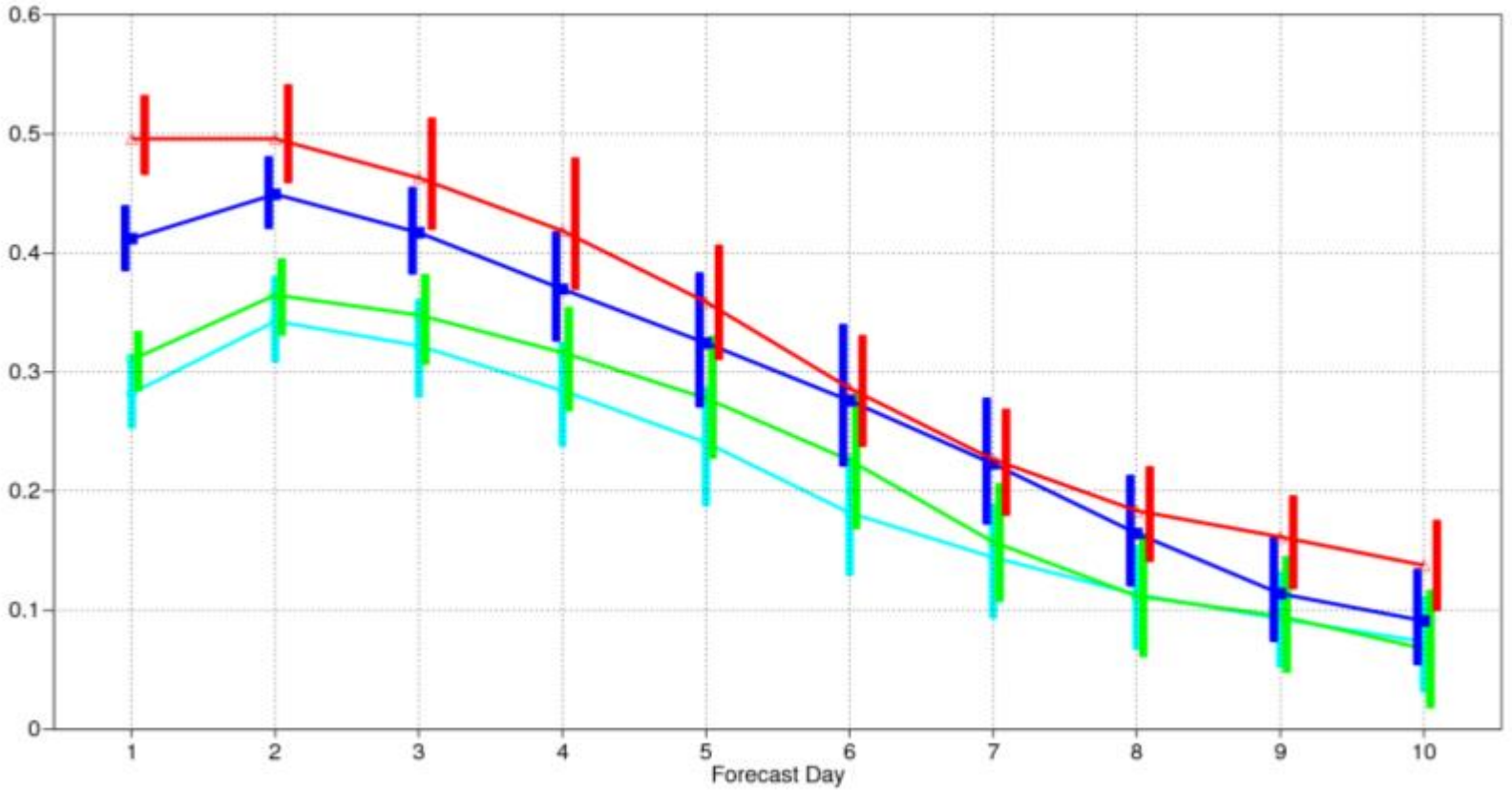


WMO scores using radiosondes, Europe



12-months
August 2012 – July 2013

Improving ECMWF scores for recent model versions



The relative increase in skill of current operational forecasts compared with those made using the forecasting system of 2006. This shows the steady increase in skill from forecasting system improvements in the six-month period November–March during 2009–10 (turquoise), 2010–11 (green), 2011–12 (blue) and 2012–13 (red). Curves show the fractional improvement in anomaly correlation coefficient at 500 hPa for the northern hemisphere extratropics.

Recent model upgrades

26 June 2013 – cycle 38r2:

- **137 levels in high-resolution forecast**
- **Modification of surface drag. Slight reduction of wind speed, most notable in Europe at 12 UTC.**

19 November 2013 – cycle 40r1:

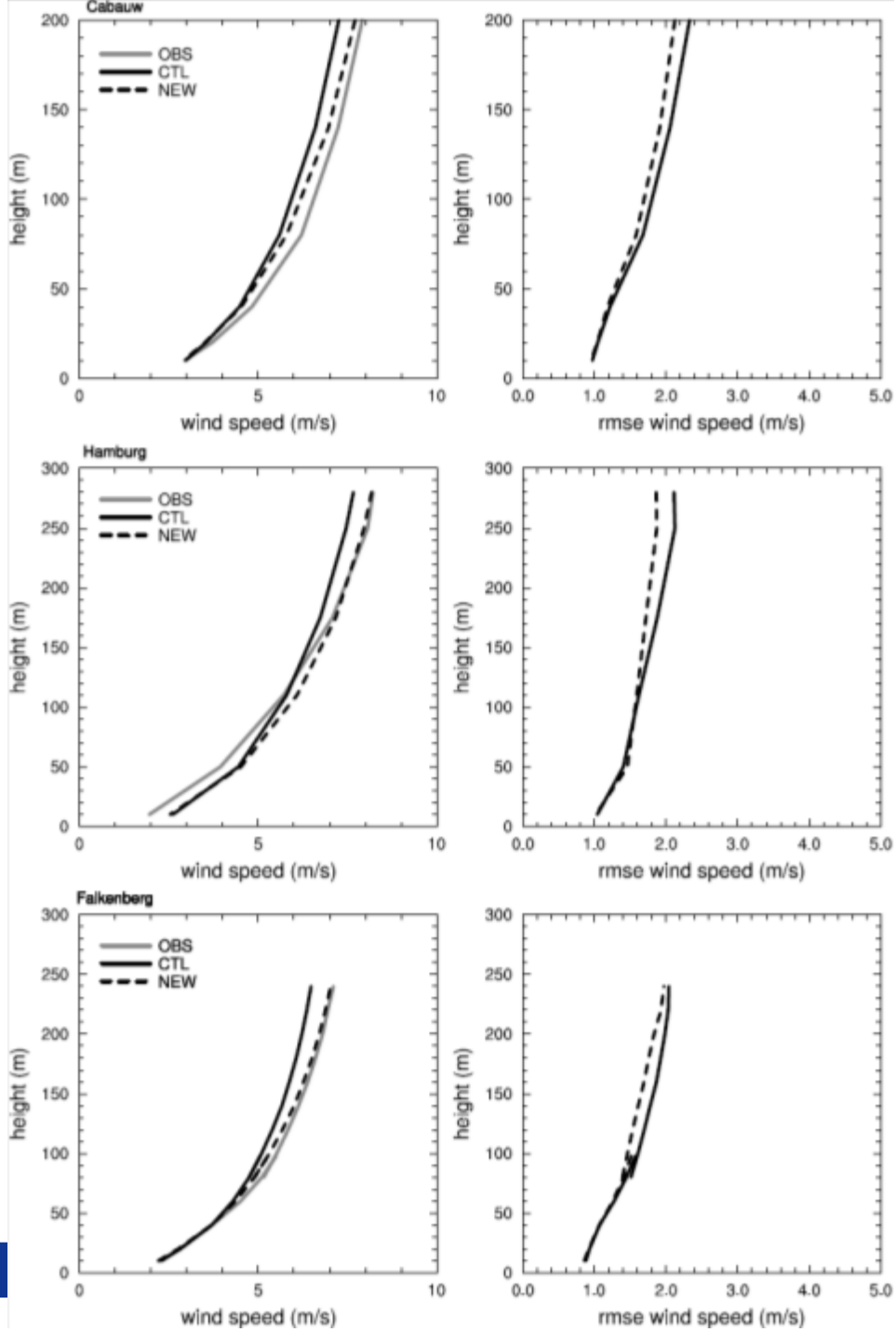
- **91 levels in the forecast ensemble**
- **Changes to stable boundary layer diffusion, turbulent orographic drag, orographic gravity wave drag and surface-atmosphere coupling over forests, which improves boundary layer winds (e.g. at wind turbine hub height) and improves N. hemisphere winter scores.**

Verification of wind speed at a few tall towers in Europe has shown that the night time winds have improved from 50 to 200 m, which is relevant for wind energy applications.

Recent model upgrades

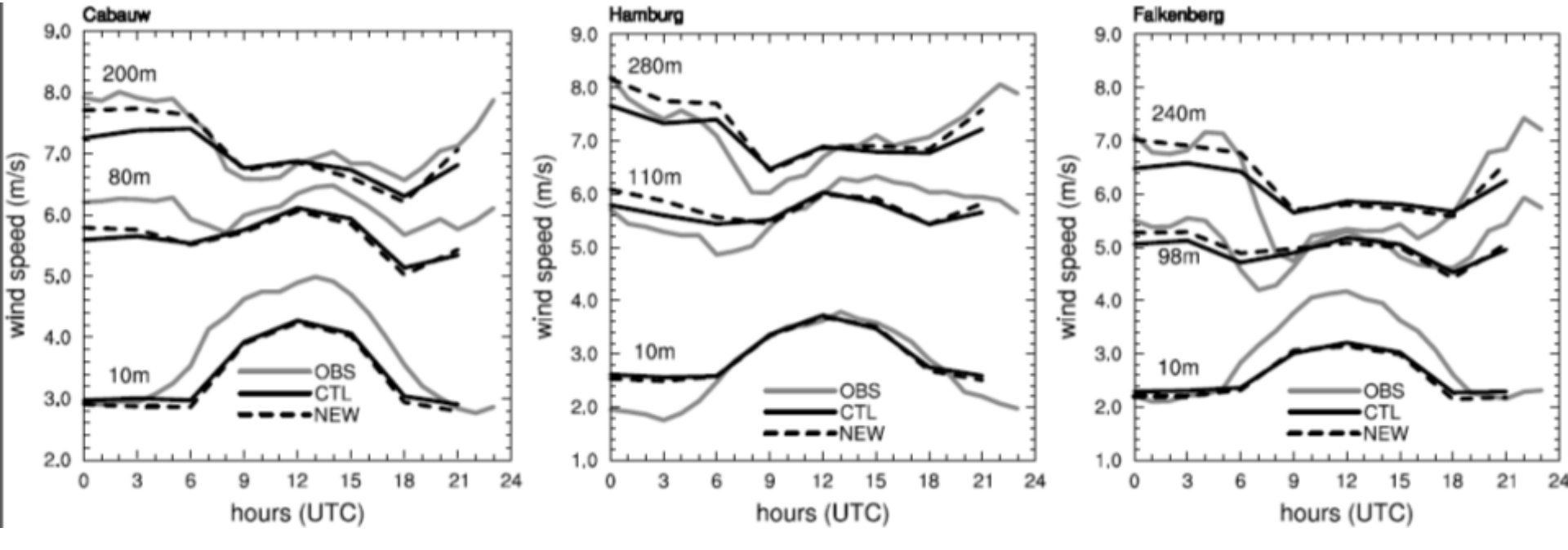
Stable boundary layer, night time, three European towers

19 November 2013 upgrade of the ECMWF model (cycle 40r1).

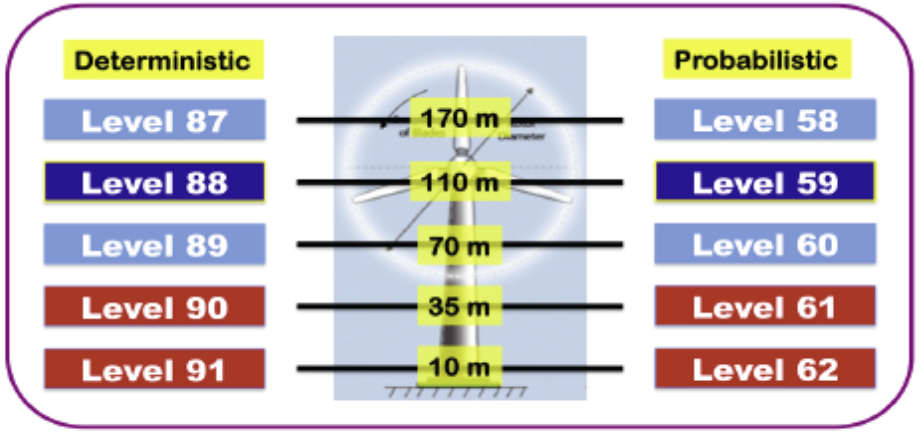


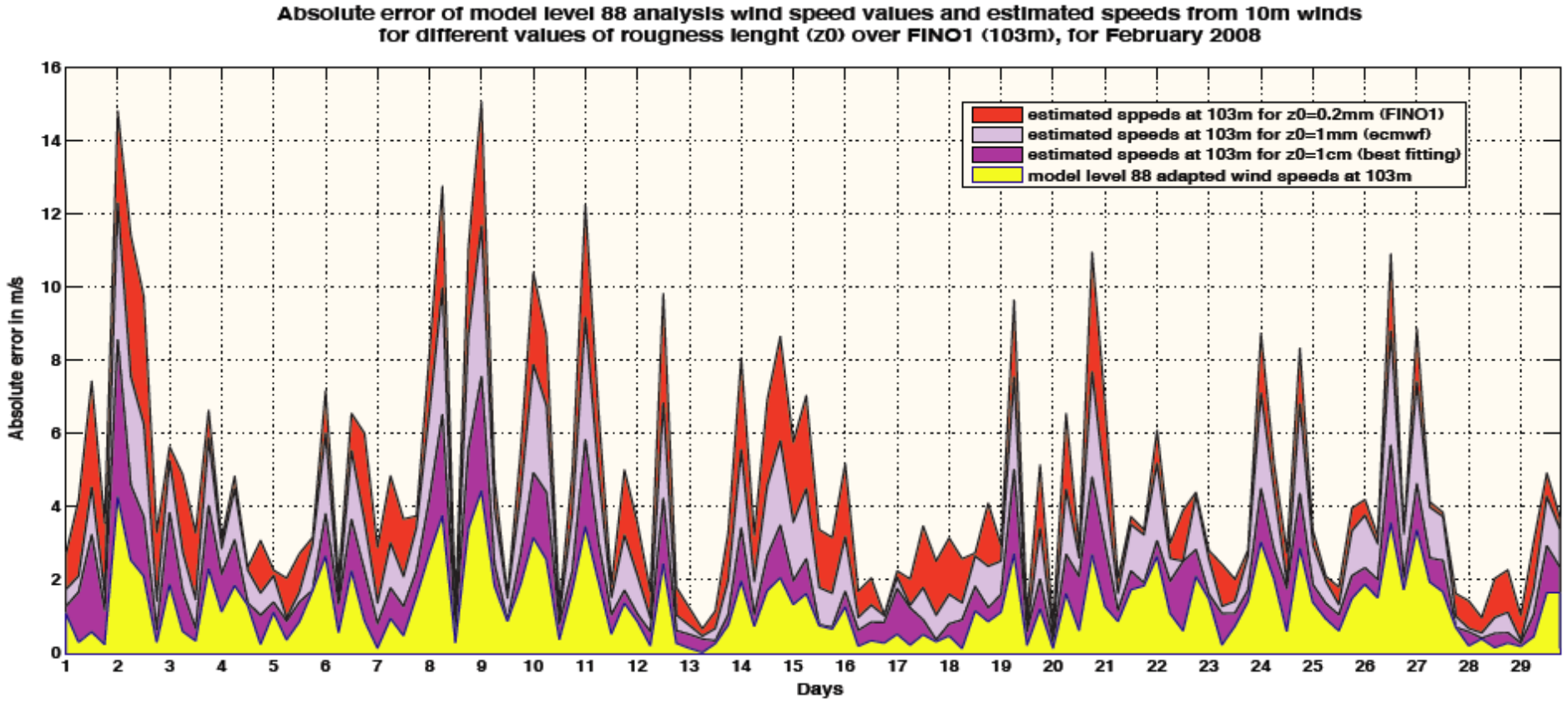
Recent model upgrades

Daily variation in wind speed in three European towers, at three heights

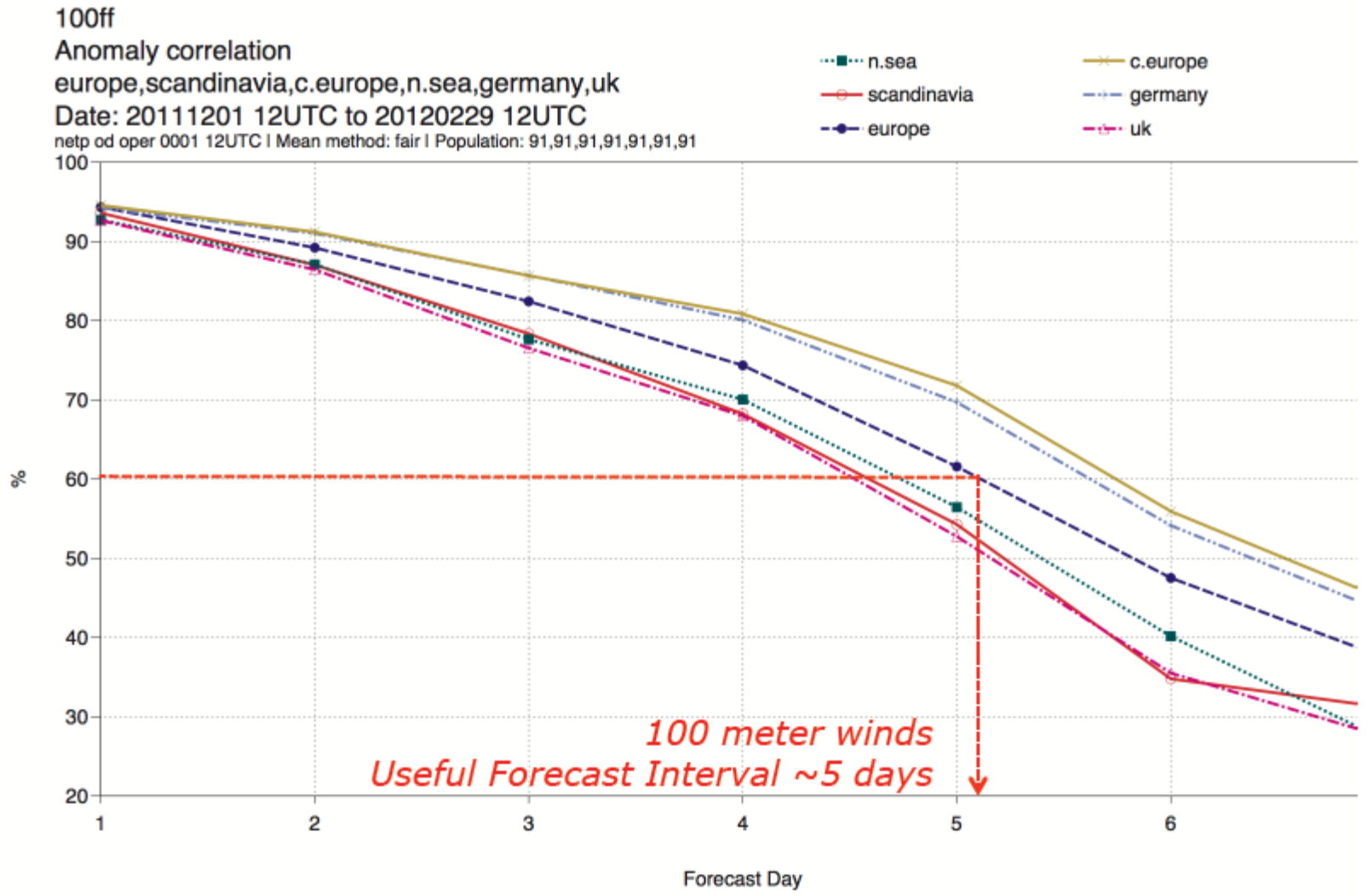


- New ECMWF 100m wind forecasts and analysis publicly available from August 2010...





Verification for 100-meter winds for DJF 2012 (ml 88-89)



Conclusions

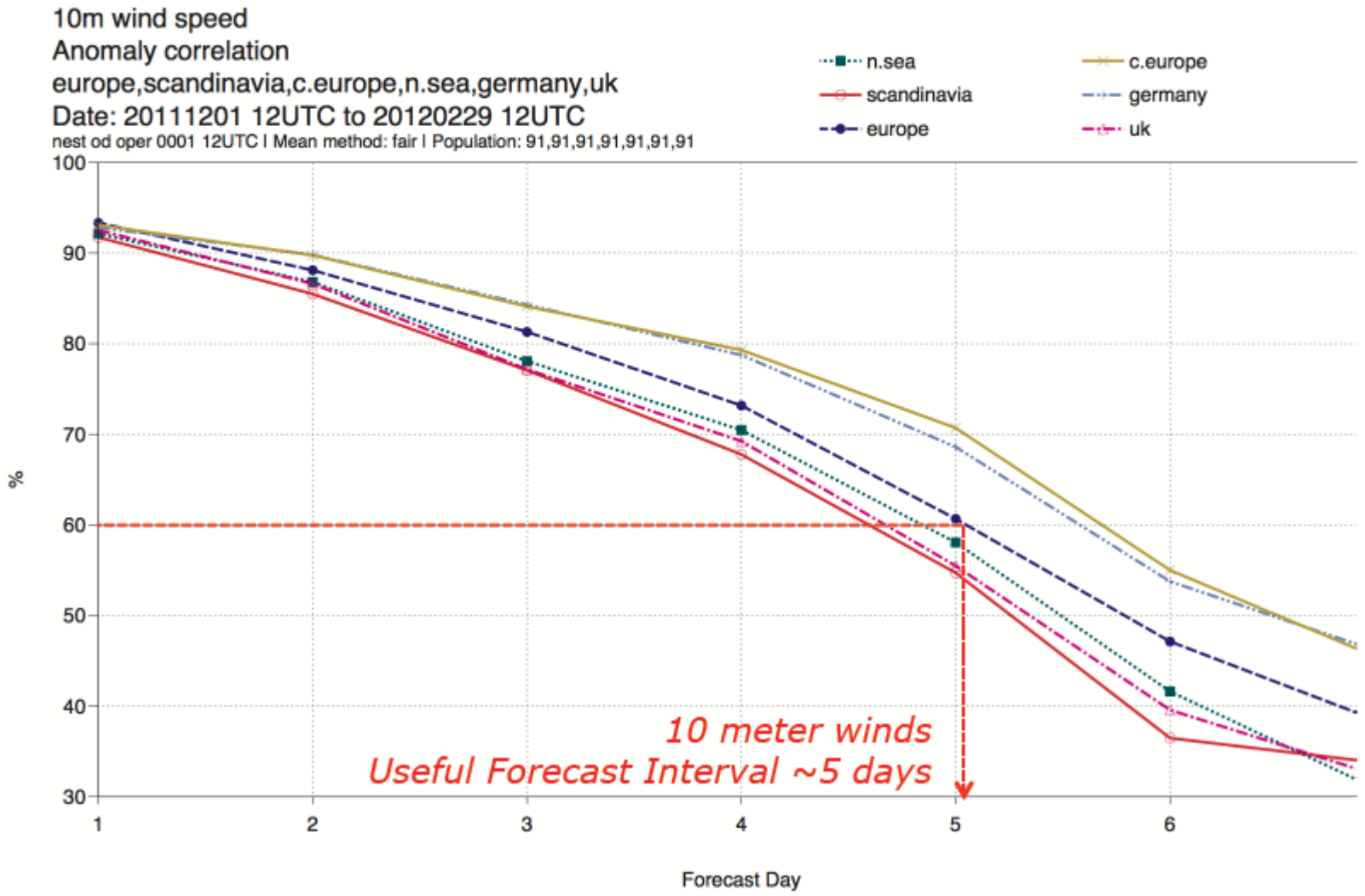
ECMWF has a strong focus on providing early warnings for severe weather events several days ahead, for wind, temperature and precipitation.

Forecasts are often expressed in terms of probabilities (risks) that a certain weather event will occur.

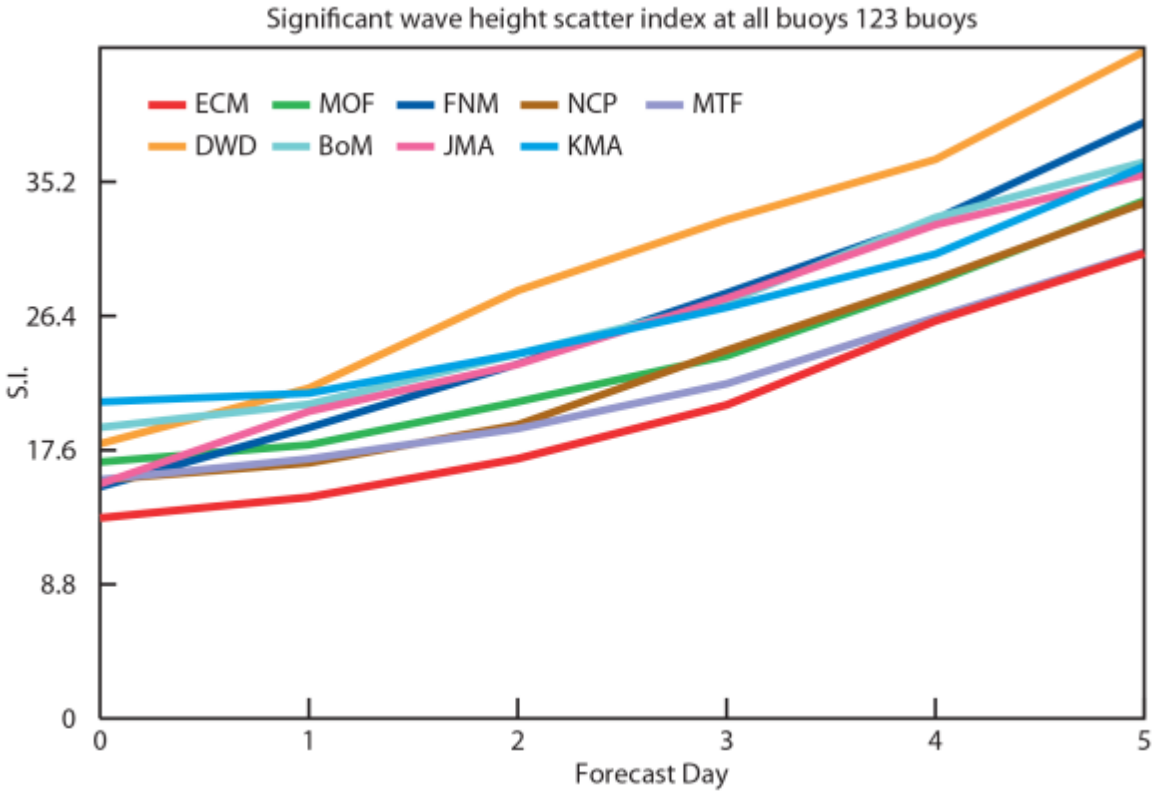
For wind-energy:

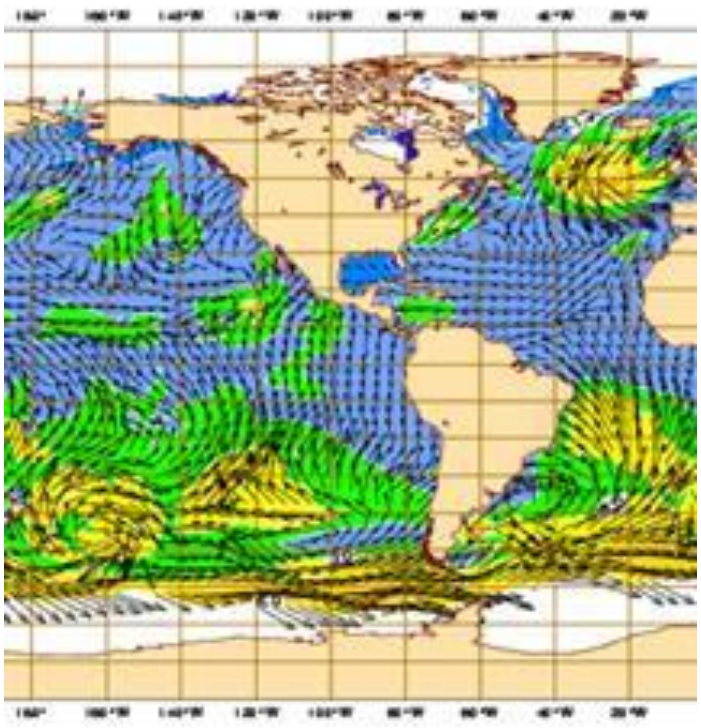
- **Early warnings of wind storms**
- **Specific 100m wind product (since 2010)**
- **Progress to improve the vertical profile of wind in the forecast, and the daily variations in wind speed**
- **Climate reanalysis available for download from data server at www.ecmwf.int/research/era**

Verification for IFS Hi-Res 10-meter winds for DJF 2012



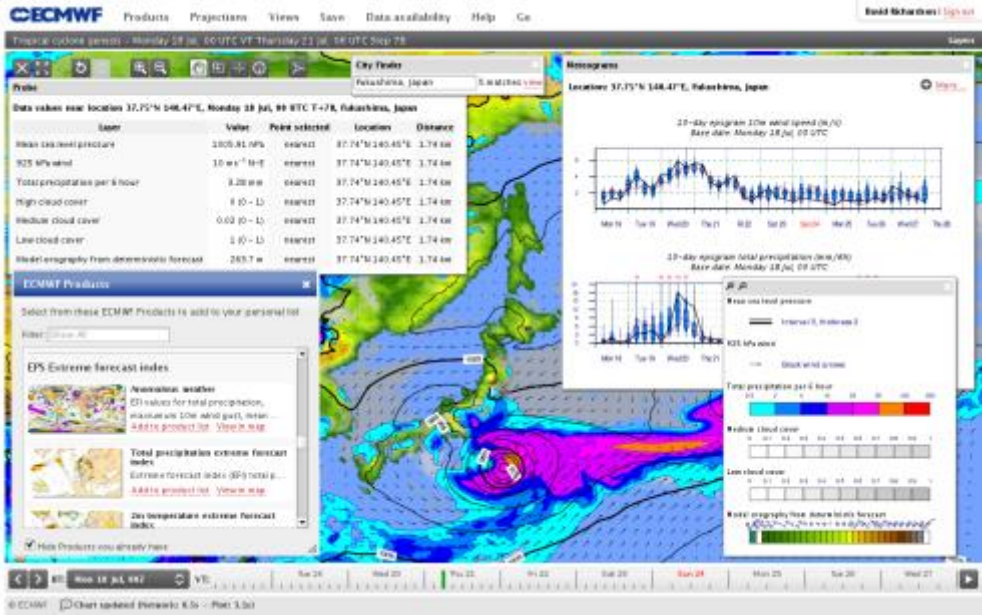
The errors of the ECMWF wave height forecasts (red) compared to other major global centres





The scores for all centres are computed for a fixed set of ocean buoys in a verification project for the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology. The error score is the scatter index (SI – the standard deviation of error normalised by the mean observed value) for forecasts of significant wave height out to five days ahead for the period January - March 2013.

Who uses our data and products?



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