SEVENTH FRAMEWORK PROGRAMME

SafeWind

Wind Power Forecasting with Focus on Extremes

Workshop, Palais Brongniart, 31 August 2012, Paris

New ECMWF forecasting products for wind industry

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Some facts behind photos


THE Sun 30p

STILL TIME TO JOIN IN

MISSING BLADE RIDDLE

UFO HITS WIND TURBINE

4am prang at 300ft

A WIND turbine stood wrecked yesterday with one of its giant 65ft blades torn off — after it was hit by a UFO.

Clobbered .. turbine yesterday

Funny…

Japan earthquake: Meltdown alert at Fukushima reactor

Not Funny…

SafeWind concept behind photos…

- Improved wind power forecasting based on high-quality NWP wind fields…

• new interactive operational platform: ecCharts

• new increase of vertical resolution by the end of 2012

• higher temporal (1-hour) resolution through the Boundary Condition Project

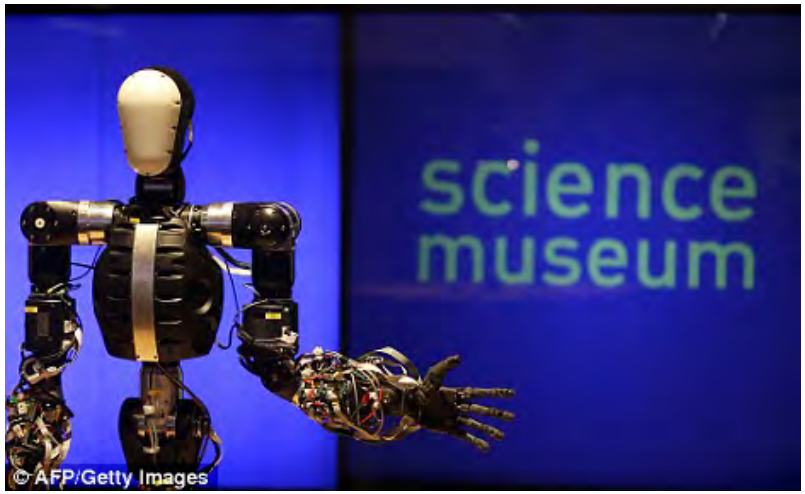
SafeWind concept behind photos (cont.)

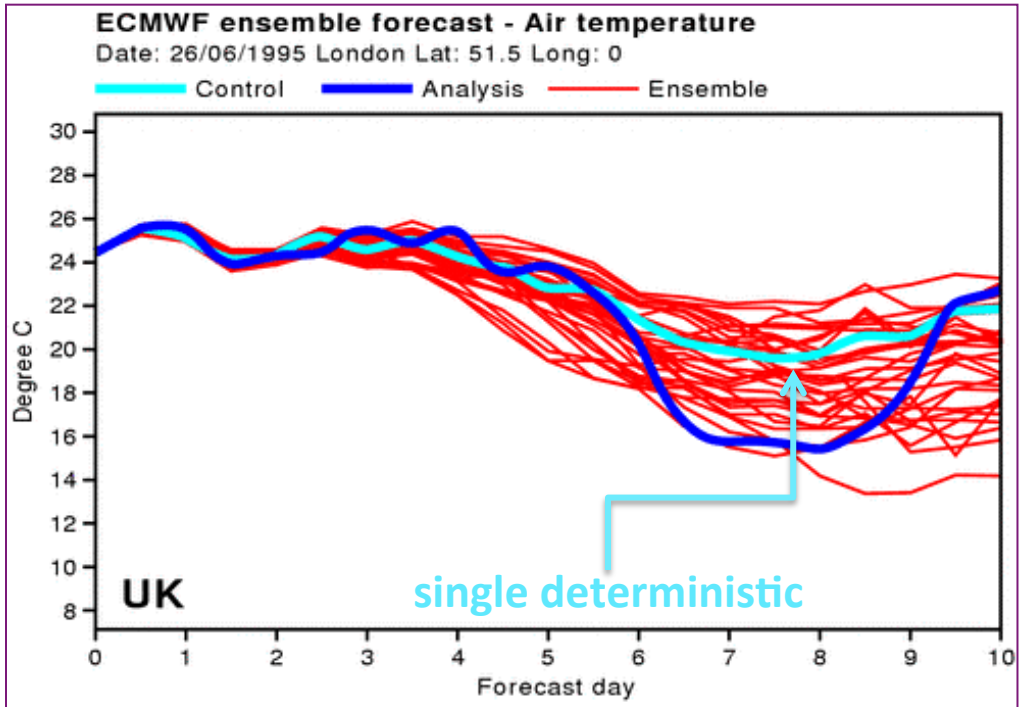
- Focusing on high-impact events (extremes)

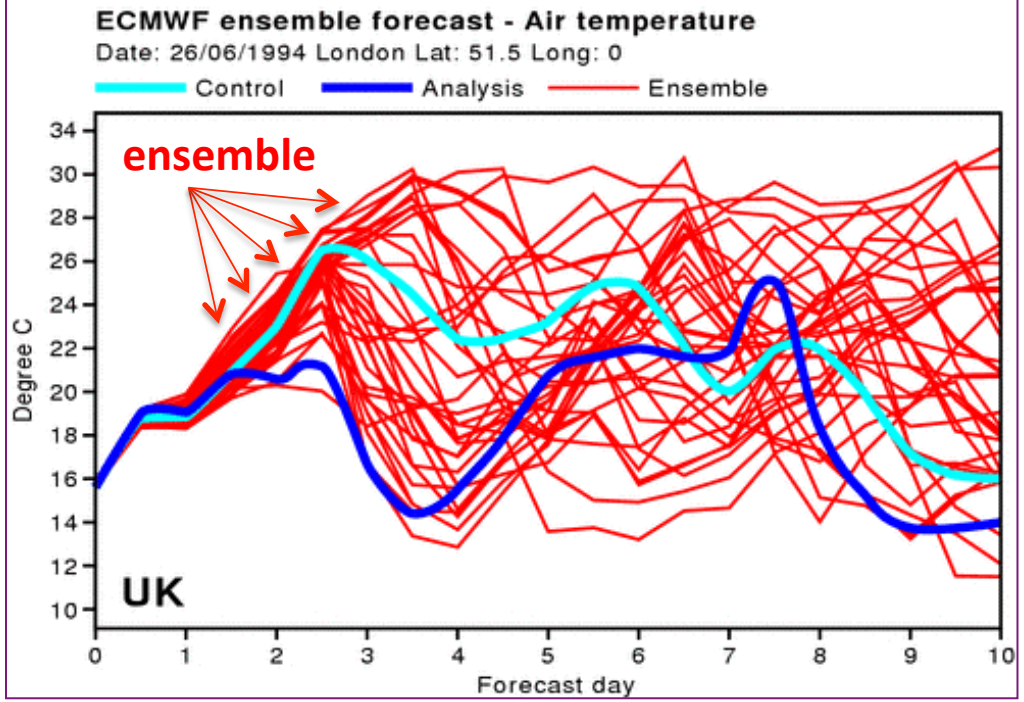
Clear demonstration of setting optimal thresholds for the Extreme Forecast Index

One slide introduction to chaos…

It was a few years back when this man (Tim) asked me to prepare a poster for an exhibition of CHAOS at the…







Introduction to ECMWF main forecasting platforms

	assimilation 4DVar	resolution	no. of members	area	forecast range	forecast frequency	ocean coupling
Deterministic model - HIRES	**12h**	**≈16 Km L91**	**1**	**Global**	**10 days**	**Twice a day**	**No**
EPS **Ensemble Prediction System** **Monthly Forecast System**	**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 system 4	**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(s)	**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**		

Footprints of Tropical & extra-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)*

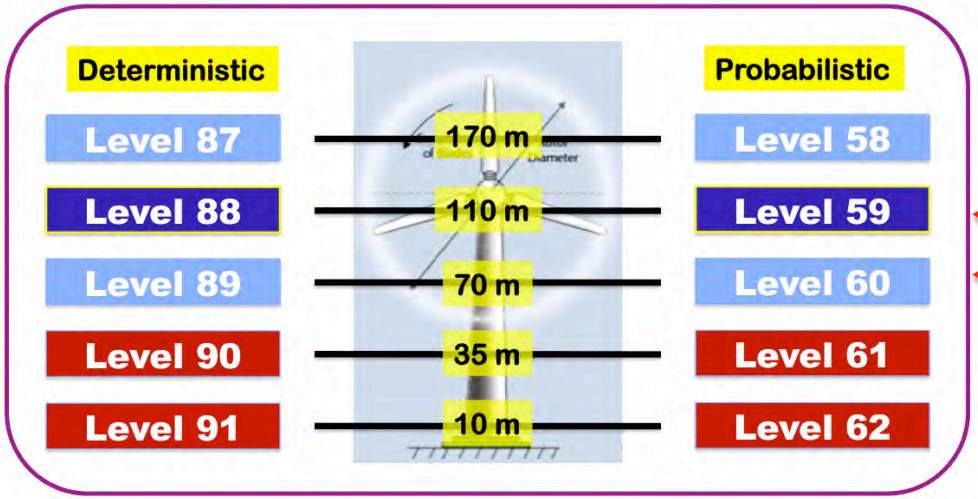
Event	Date
Xynthia	27-28 February 2010

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

Outline

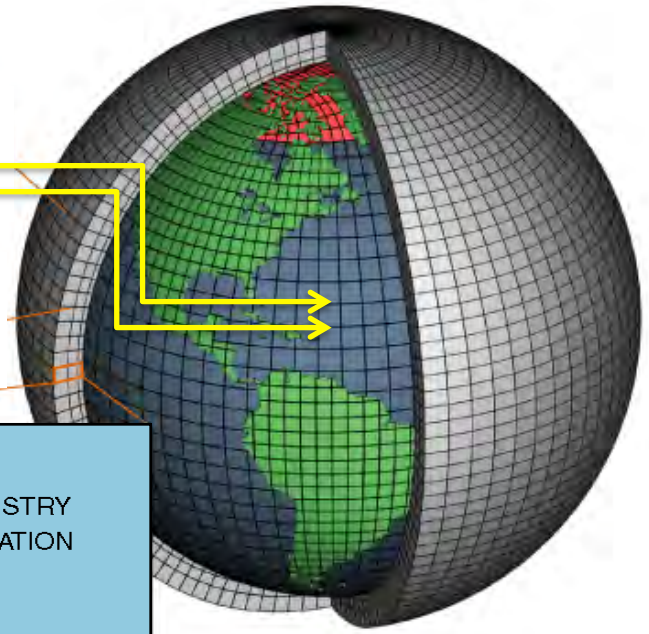
- Utilising model levels: the birth of 100-meter HIRES & EPS winds
- Complementing instantaneous winds: the concept of Gust Factor(s)
- Higher vertical and temporal resolution products
- Going after high-impact events: Extreme Forecast Index
- New ECMWF interactive operational platform for forecasters: ecCharts

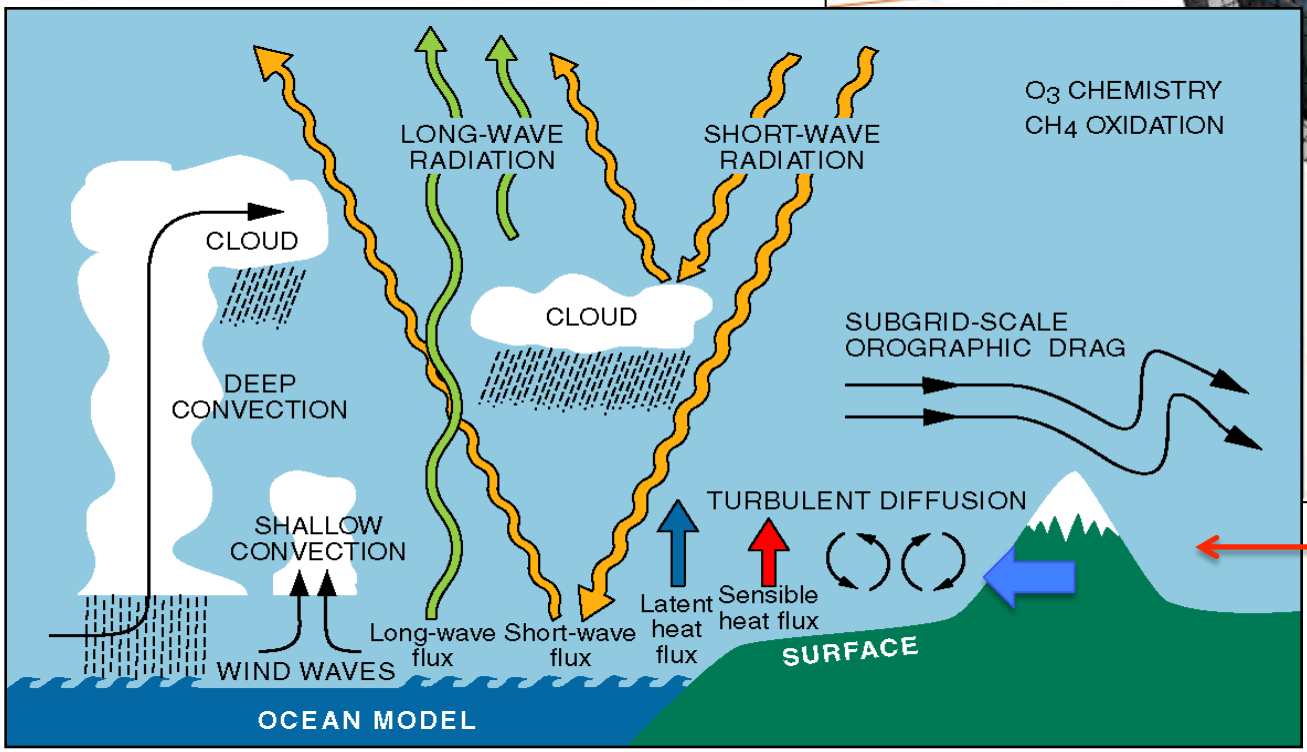
A closer look inside ECMWF model



horizontal resolution

vertical resolution

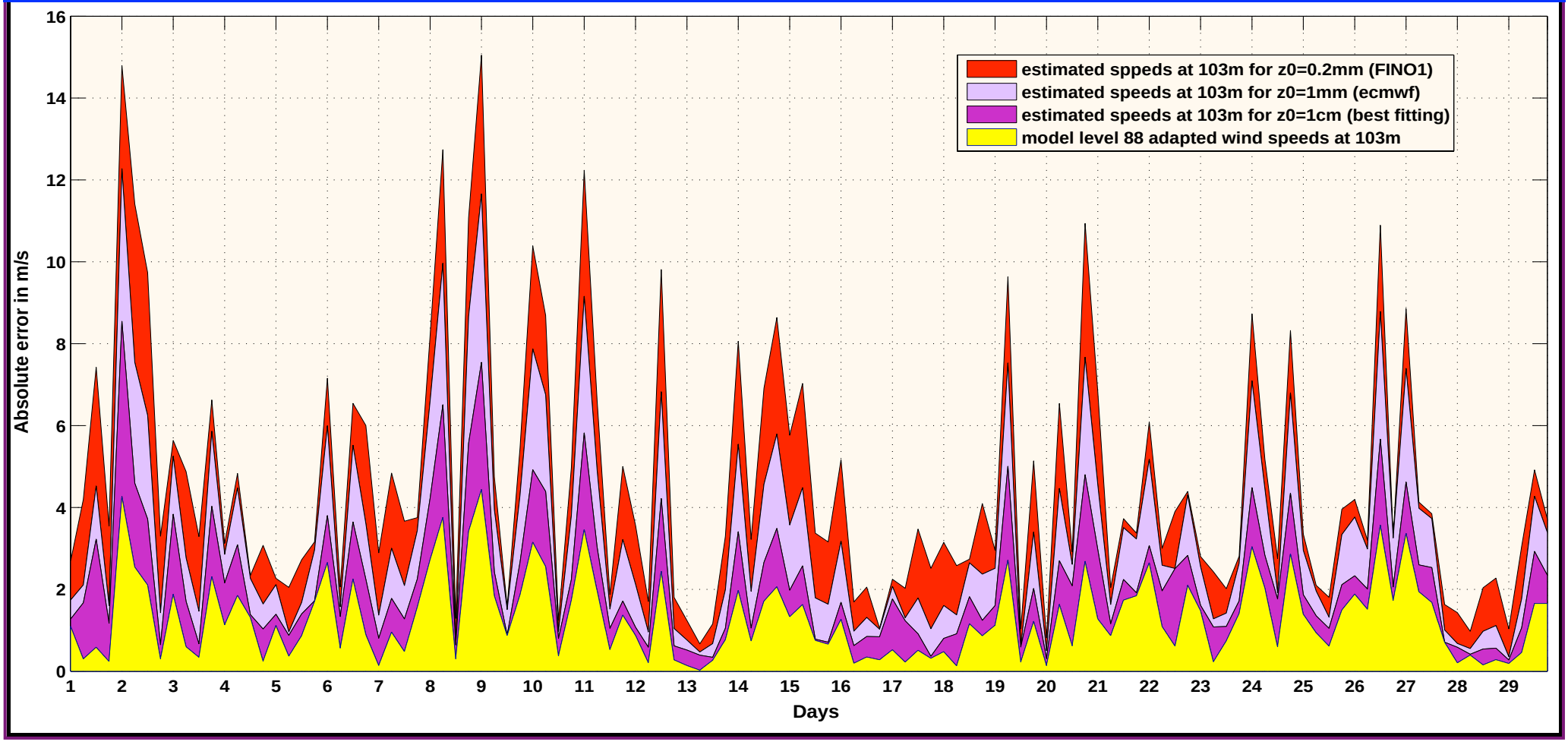




physical parametrization

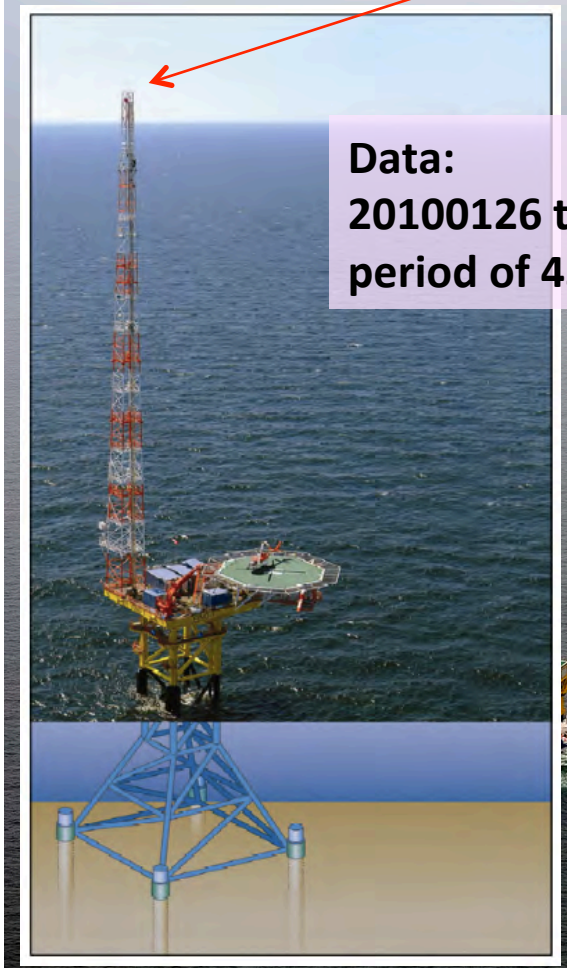
• Utilising model levels: the birth of 100-meter winds

Smallest RMS Error by utilising model levels…



Verification of 100-meter winds against FINO1 & FINO2 platforms

103 meters



Data:
20100126 to 20110331
period of 430 days

FINO1 platform at North Sea

Location:
Borkum Riff
N 54° 01'
E 06° 35'
45 km North of Island Borkum
Water Depth: approx. 28 m

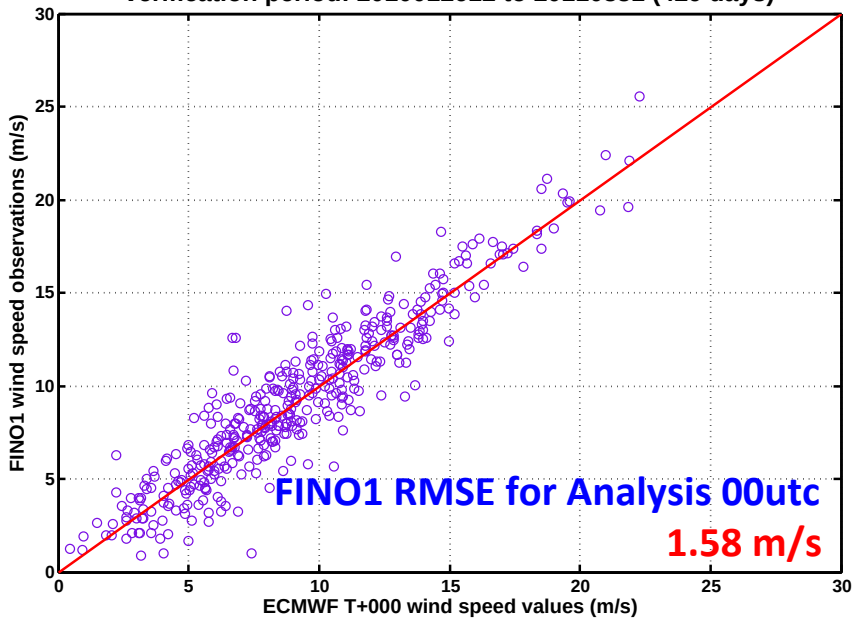
102 meters

Data:
20100126 to 20100930
period of 248 days

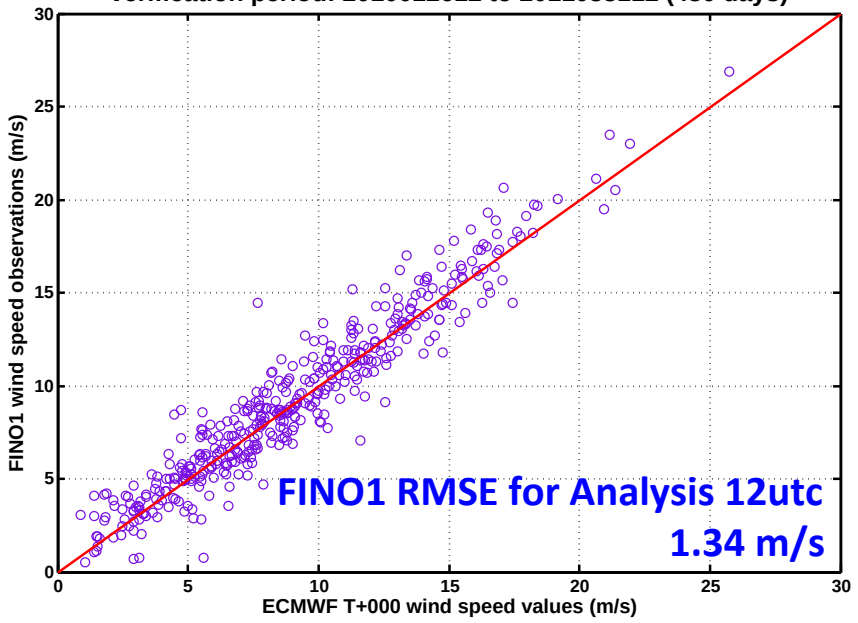
FINO2 platform at Baltic Sea

Location: "Kriegers Flak", 39 km north of the island Rügen, water depth: ~20 m
N 55° 00.42', E 13° 09.25'

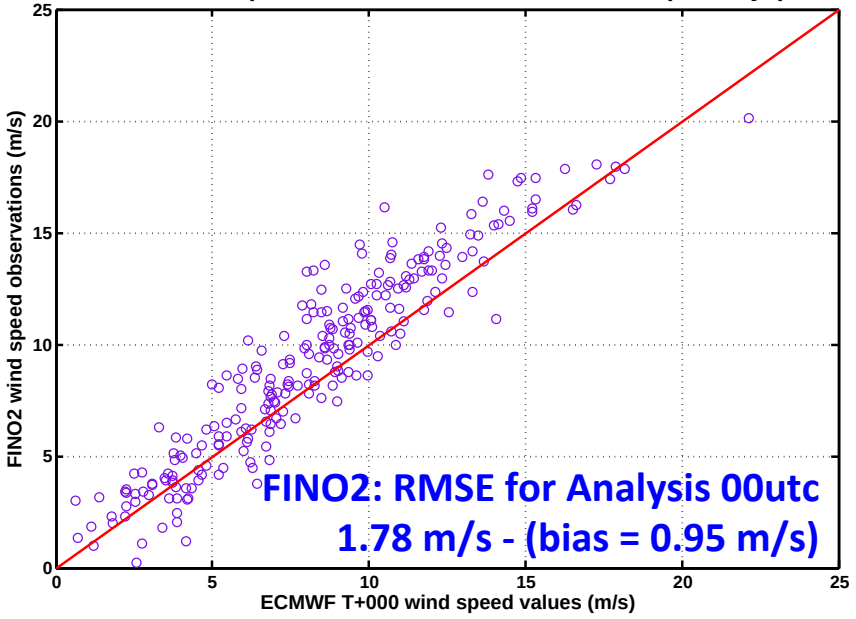
ECMWF 100–meter speed analysis 00 UTC vs FINO1 observations at 100 meters
verification period: 2010012612 to 20110331 (429 days)



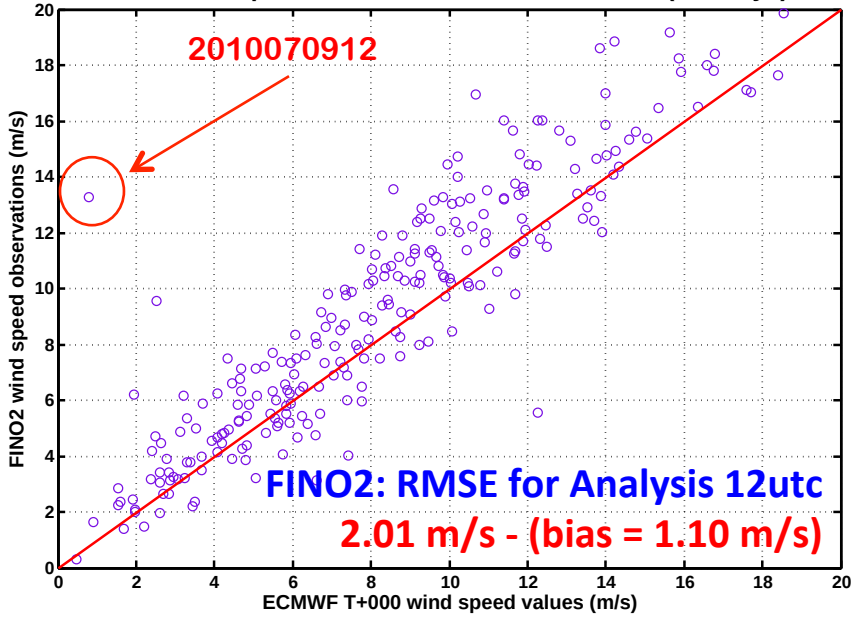
ECMWF 100–meter speed analysis 12 UTC vs FINO1 observations at 100 meters
verification period: 2010012612 to 2011033112 (430 days)



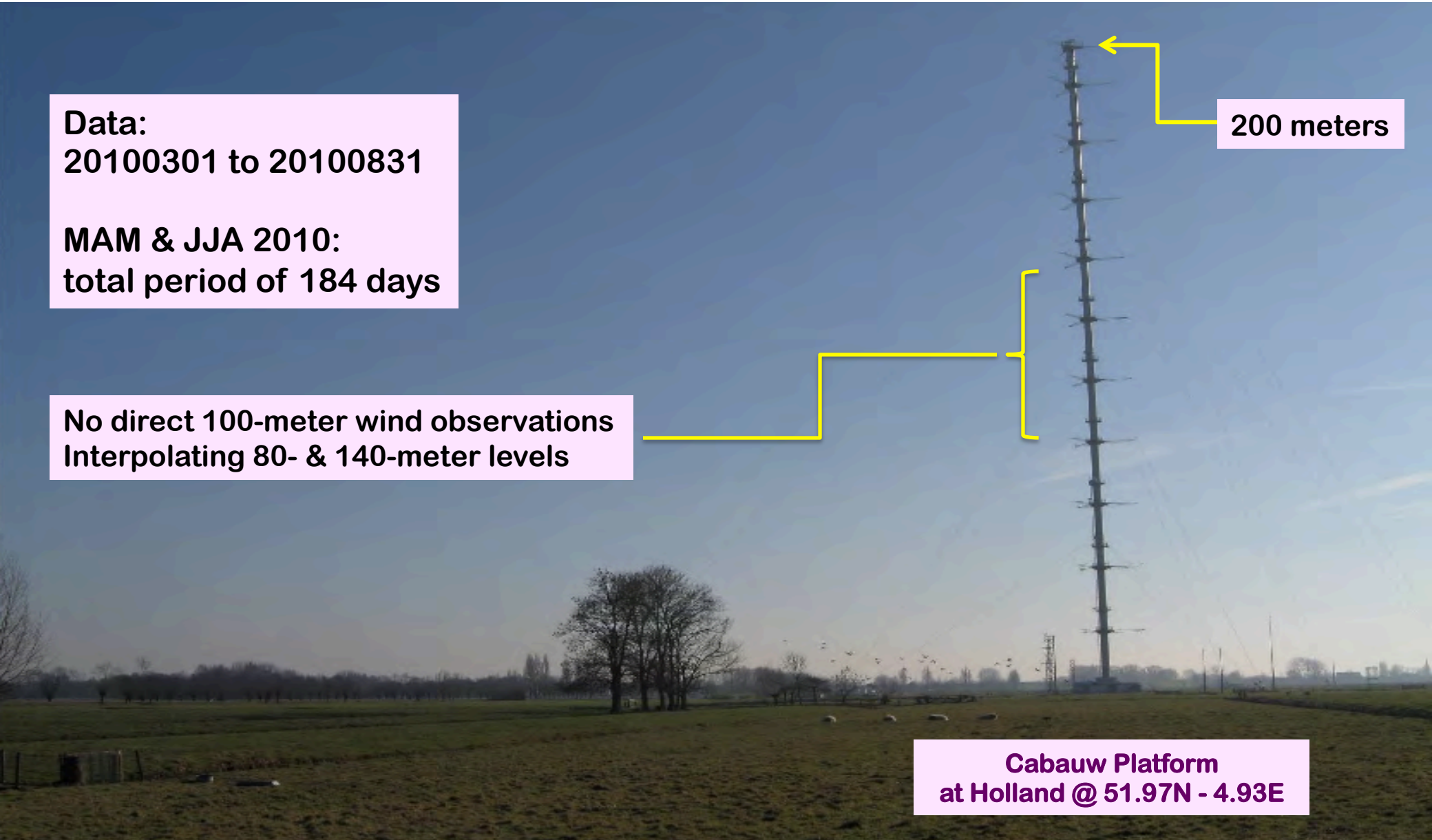
ECMWF 100–meter speed analysis 00 UTC vs FINO2 observations at 102 meters
verification period: 2010012700 to 2010100100 (248 days)



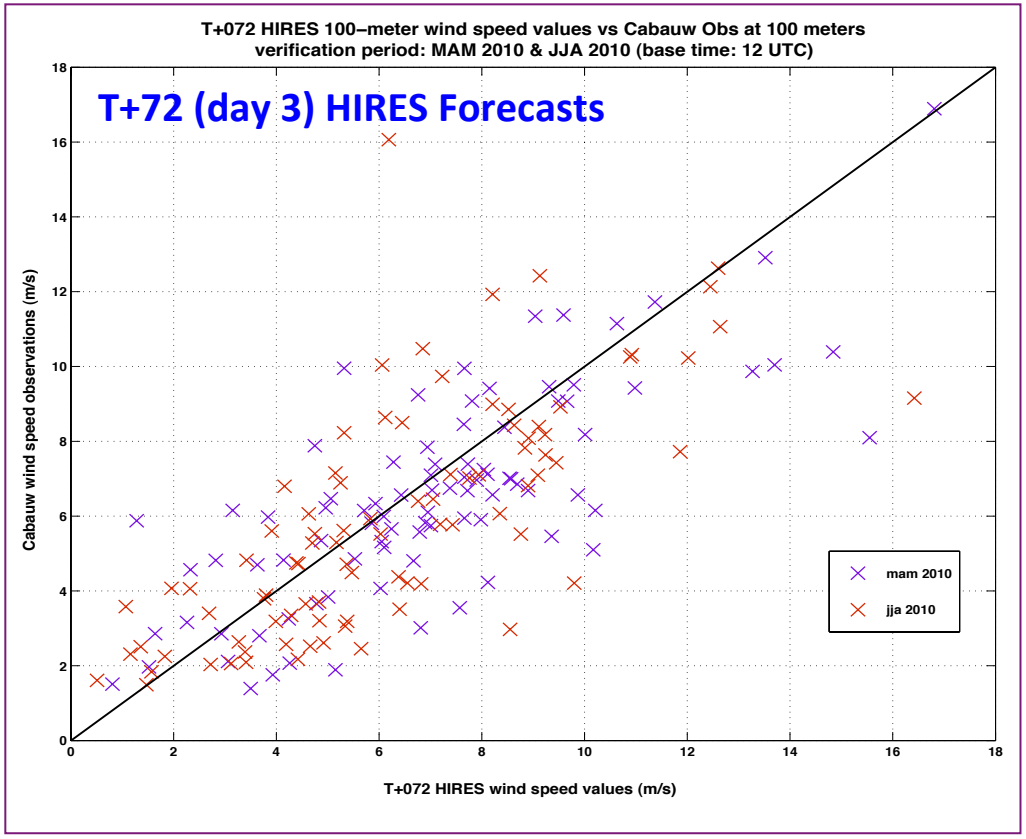
ECMWF 100–meter speed analysis 12 UTC vs FINO2 observations at 102 meters
verification period: 2010012612 to 2010093012 (248 days)

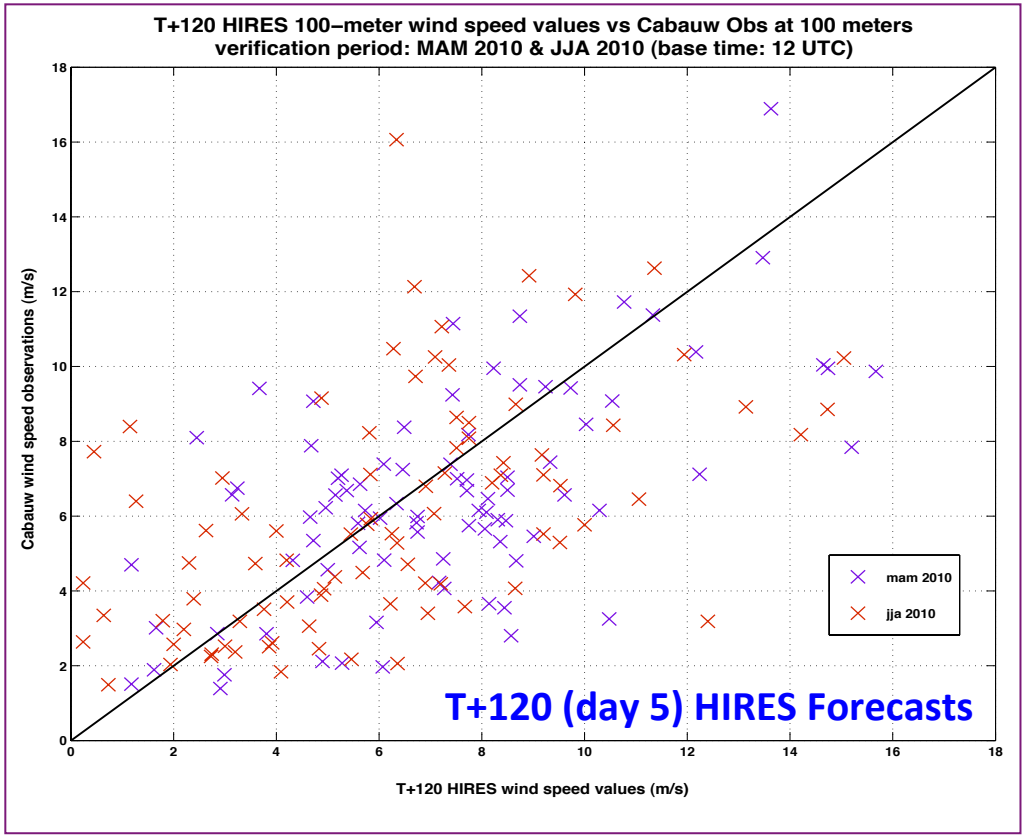


Verification of 100-meter winds against Cabauw platform



Verification of 100-meter winds against Cabauw platform (cont.)





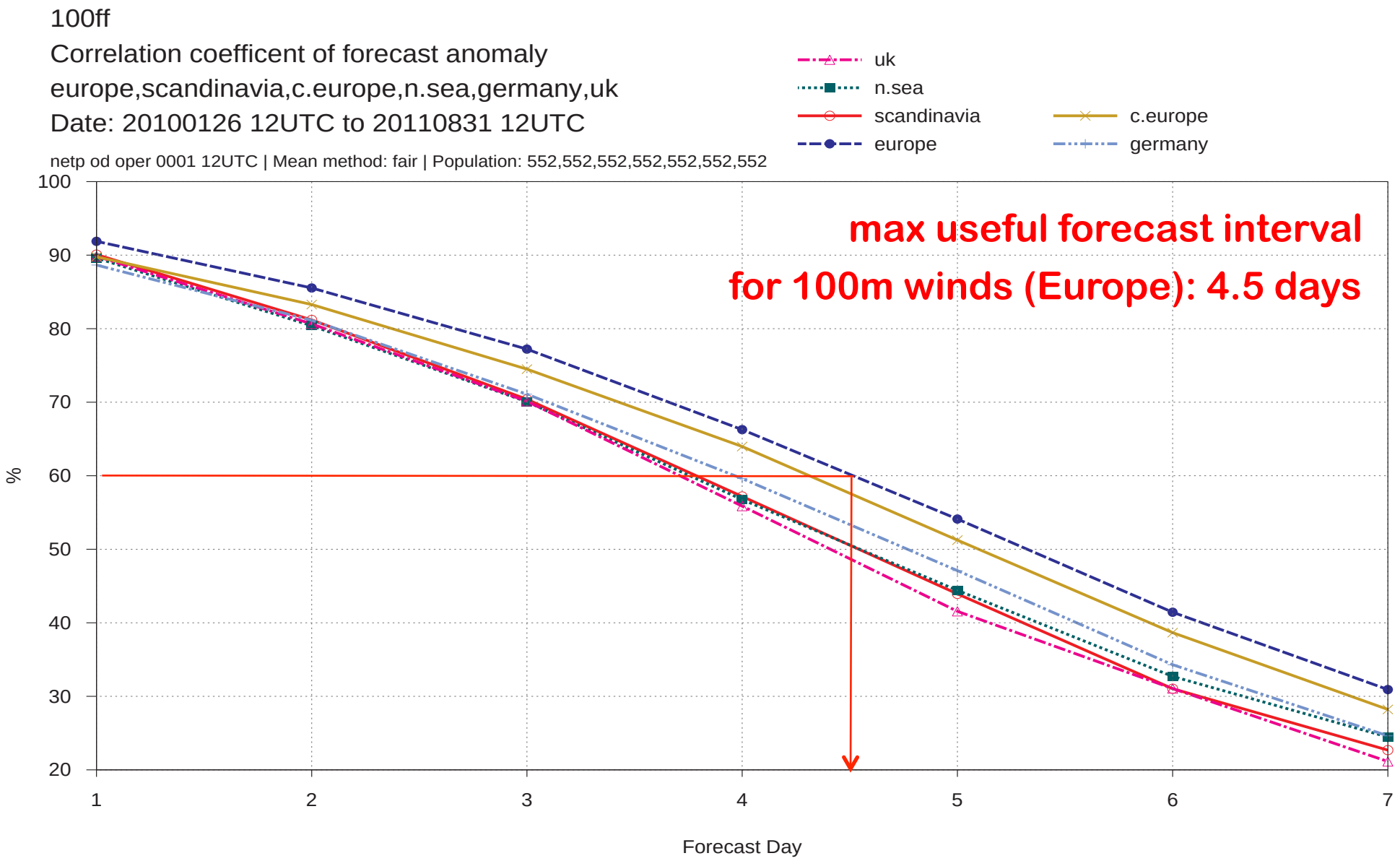
RMSE for HIRES during MAM 2010
T+072 (12 UTC) = 2.96 m/s

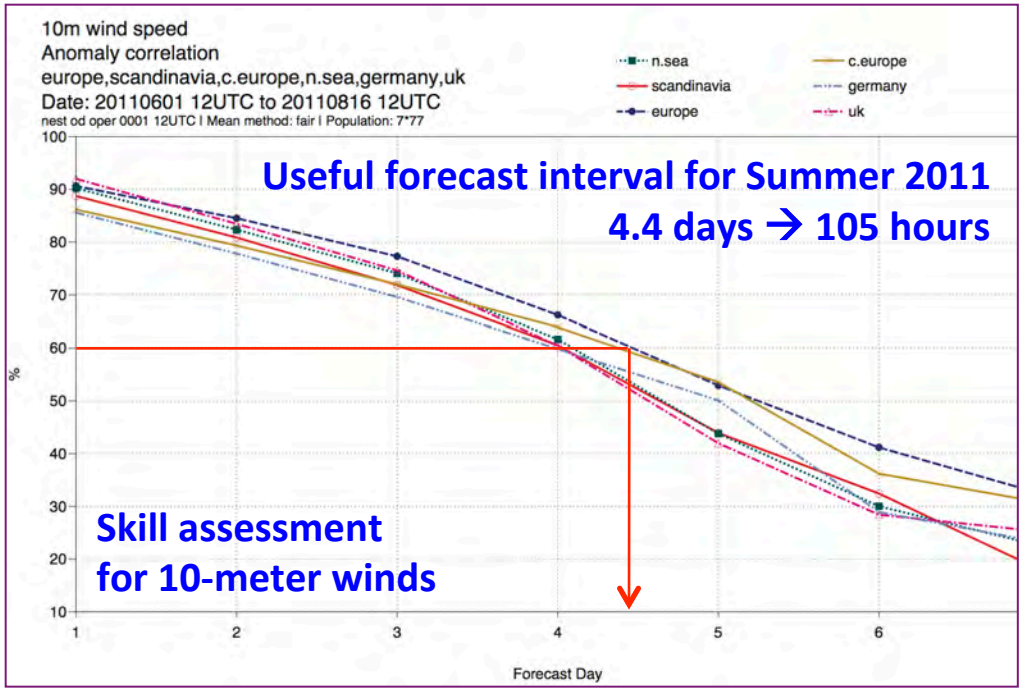
RMSE for HIRES during JJA 2010
T+072 (12 UTC) = 3.14 m/s

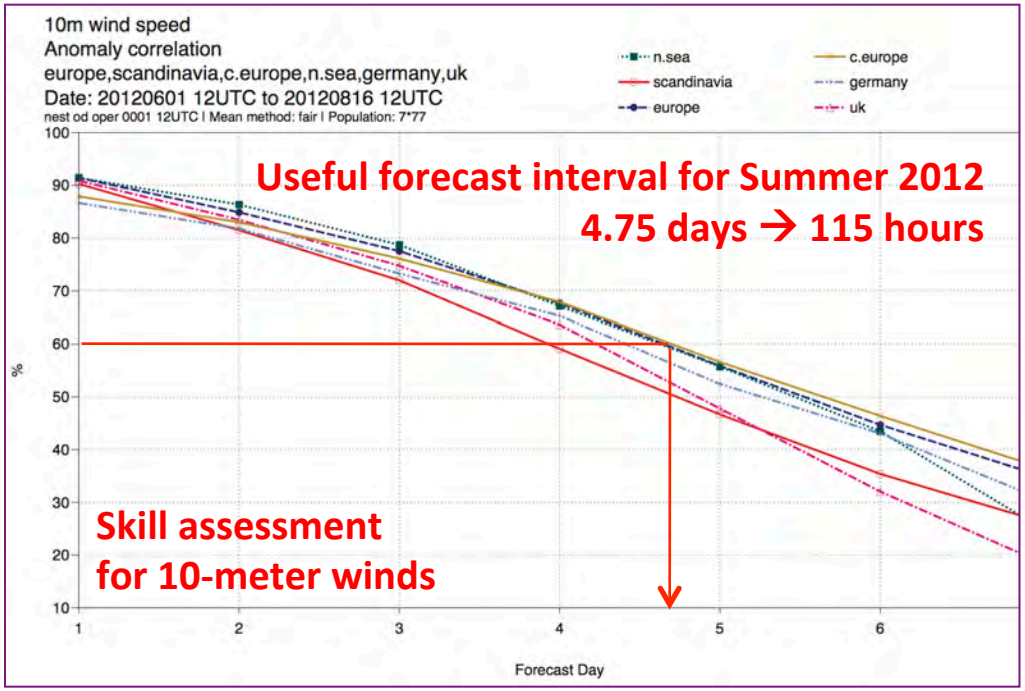
RMSE for HIRES during MAM 2010
T+120 (12 UTC) = 3.10 m/s

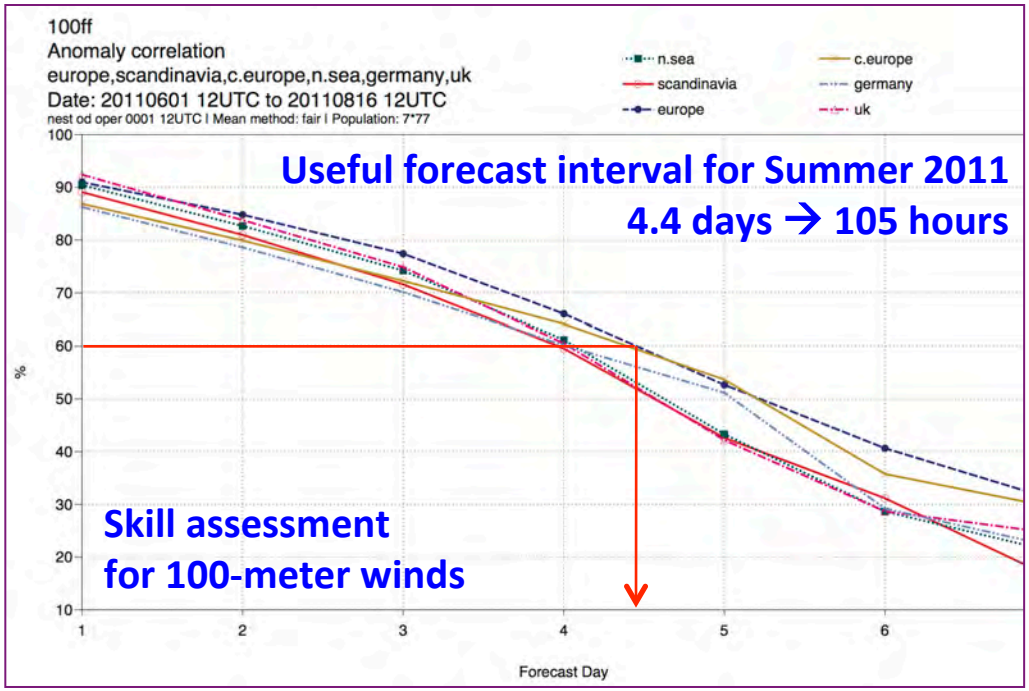
RMSE for HIRES during JJA 2010
T+120 (12 UTC) = 3.32 m/s

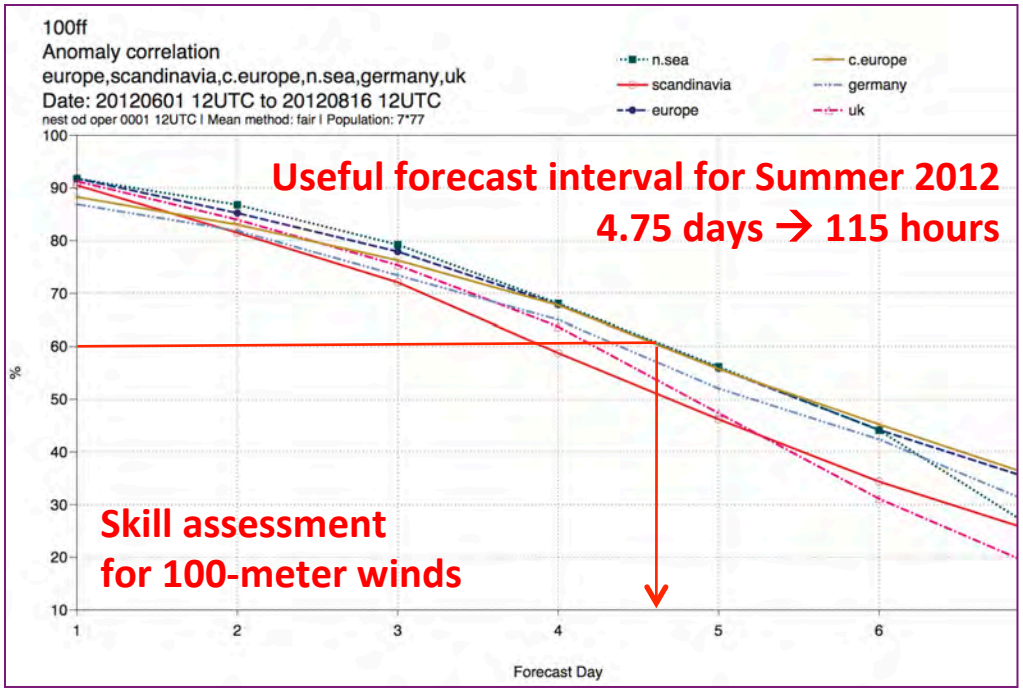
Assessing the skill of 100-meter winds over various European subareas for 552 days



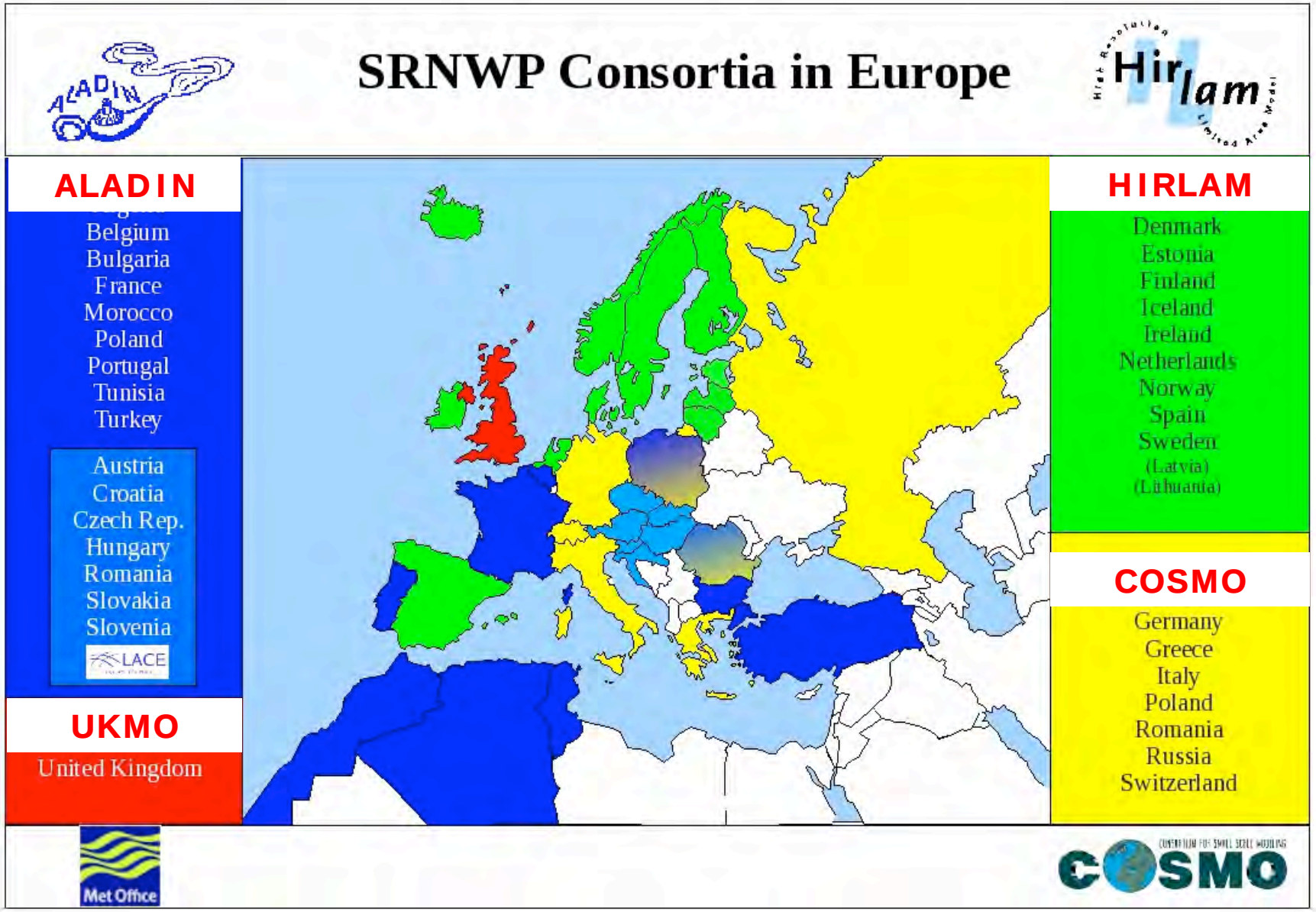

10m wind speed
Anomaly correlation
europe,scandinavia,c.europe,n.sea,germany,uk
Date: 20110601 12UTC to 20110816 12UTC
nest od oper 0001 12UTC I Mean method: fair I Population: 7*77
n.sea
c.europe
scandinavia
germany
europe
uk
Useful forecast interval for Summer 2011
4.4 days → 105 hours
Skill assessment
for 10-meter winds
%
Forecast Day


10m wind speed
Anomaly correlation
europe,scandinavia,c.europe,n.sea,germany,uk
Date: 20120601 12UTC to 20120816 12UTC
nest od oper 0001 12UTC I Mean method: fair I Population: 7*77
n.sea
c.europe
scandinavia
germany
europe
uk
Useful forecast interval for Summer 2012
4.75 days → 115 hours
Skill assessment
for 10-meter winds
%
Forecast Day


100ff
Anomaly correlation
europe,scandinavia,c.europe,n.sea,germany,uk
Date: 20110601 12UTC to 20110816 12UTC
nest od oper 0001 12UTC I Mean method: fair I Population: 7*77
n.sea
c.europe
scandinavia
germany
europe
uk
Useful forecast interval for Summer 2011
4.4 days → 105 hours
Skill assessment
for 100-meter winds
%
Forecast Day


100ff
Anomaly correlation
europe,scandinavia,c.europe,n.sea,germany,uk
Date: 20120601 12UTC to 20120816 12UTC
nest od oper 0001 12UTC I Mean method: fair I Population: 7*77
n.sea
c.europe
scandinavia
germany
europe
uk
Useful forecast interval for Summer 2012
4.75 days → 115 hours
Skill assessment
for 100-meter winds
%
Forecast Day

Main numerical Limited Area Model systems in Europe



• Complementing instantaneous wind fields: Gust Factor(s)

IFS Gust Factor (GF) valid for surface (10 meters)

$$U_{10\ gust} = \underbrace{U_{10}} + \underbrace{7.71\ u_* [\ 1 + f(z/L)\ ]} + \underbrace{amax(0,\ U_{850} - U_{950})}$$

10 meter wind + **stability term** + **convective term**

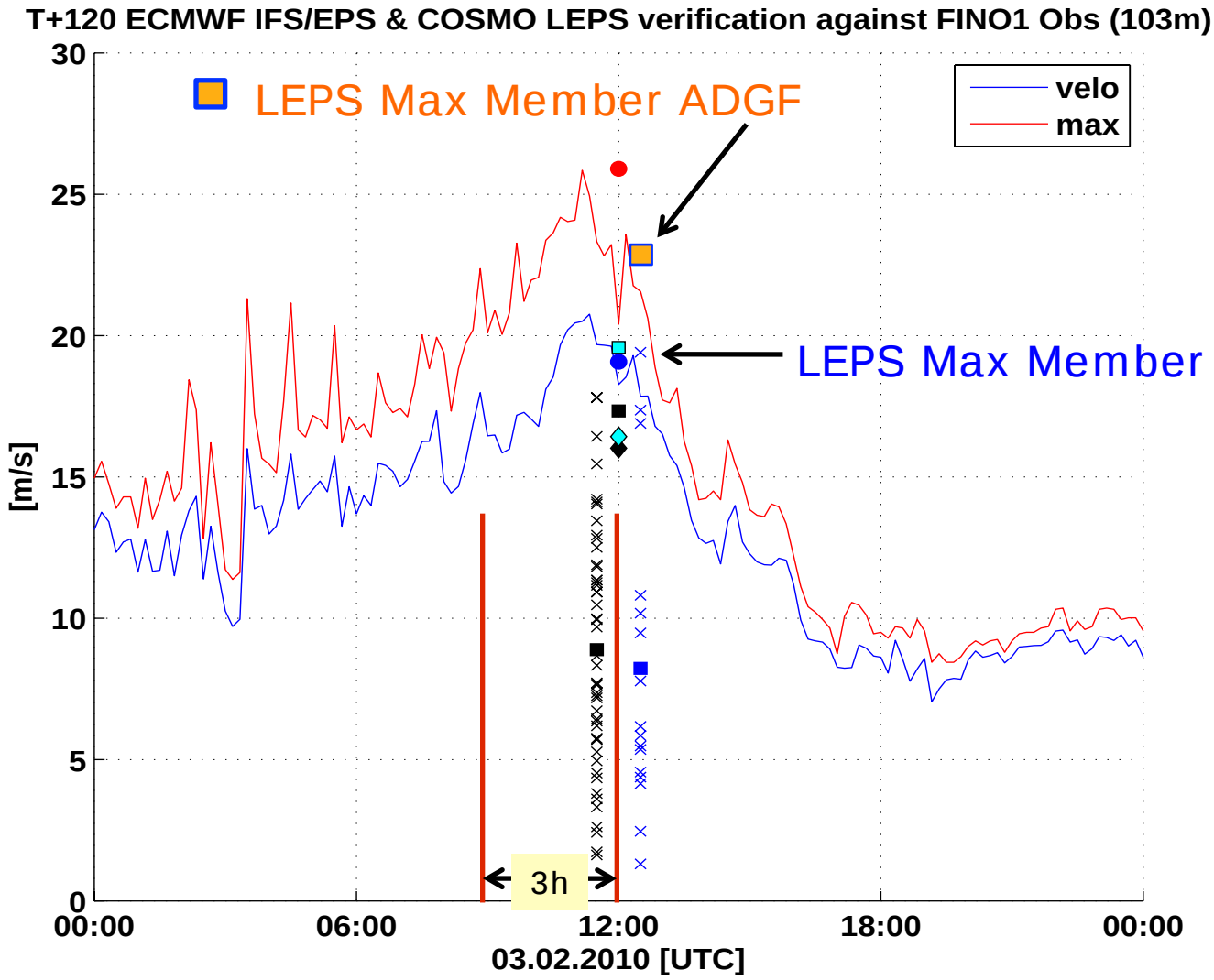
ADapted Gust Factor (ADGF) valid for 110 meters

$$ADGF = \underbrace{U_{10\ gust}} + \underbrace{(U_{model\ level\ 88} - U_{10})}$$

IFS Gust Factor (GF) + **difference of ml88 – ml91 winds**

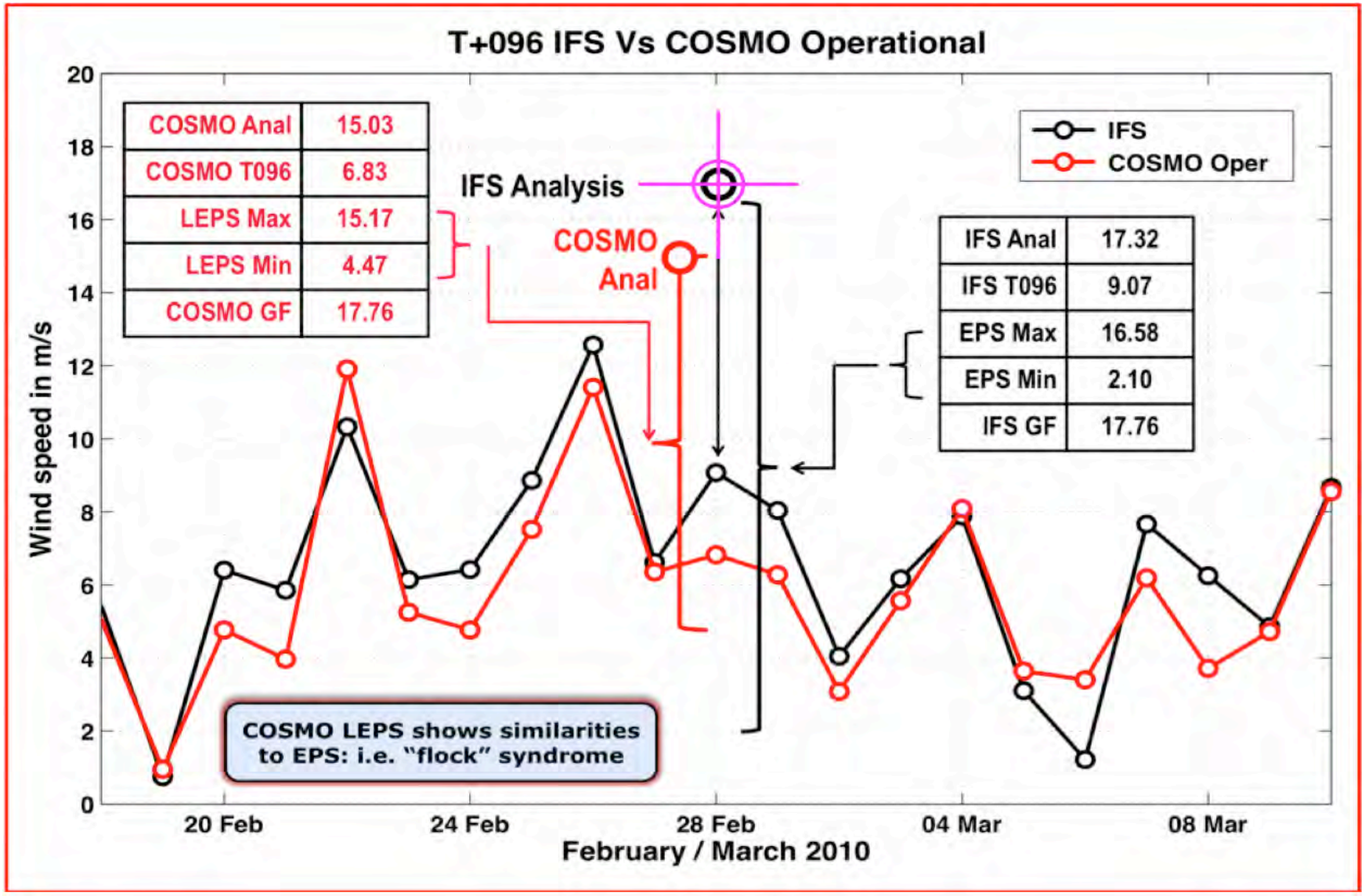
FINO1 Observations Platform

An example of an extreme event (>25 m/s)



- 3-hour Obs max
- 10-min Obs velo
- IFS 100m velo
- IFS 100m 3h-ADGF
- COSMO 110m velo
- COSMO 110m 3h-ADGF
- EPS 50m
- COSMO 16m

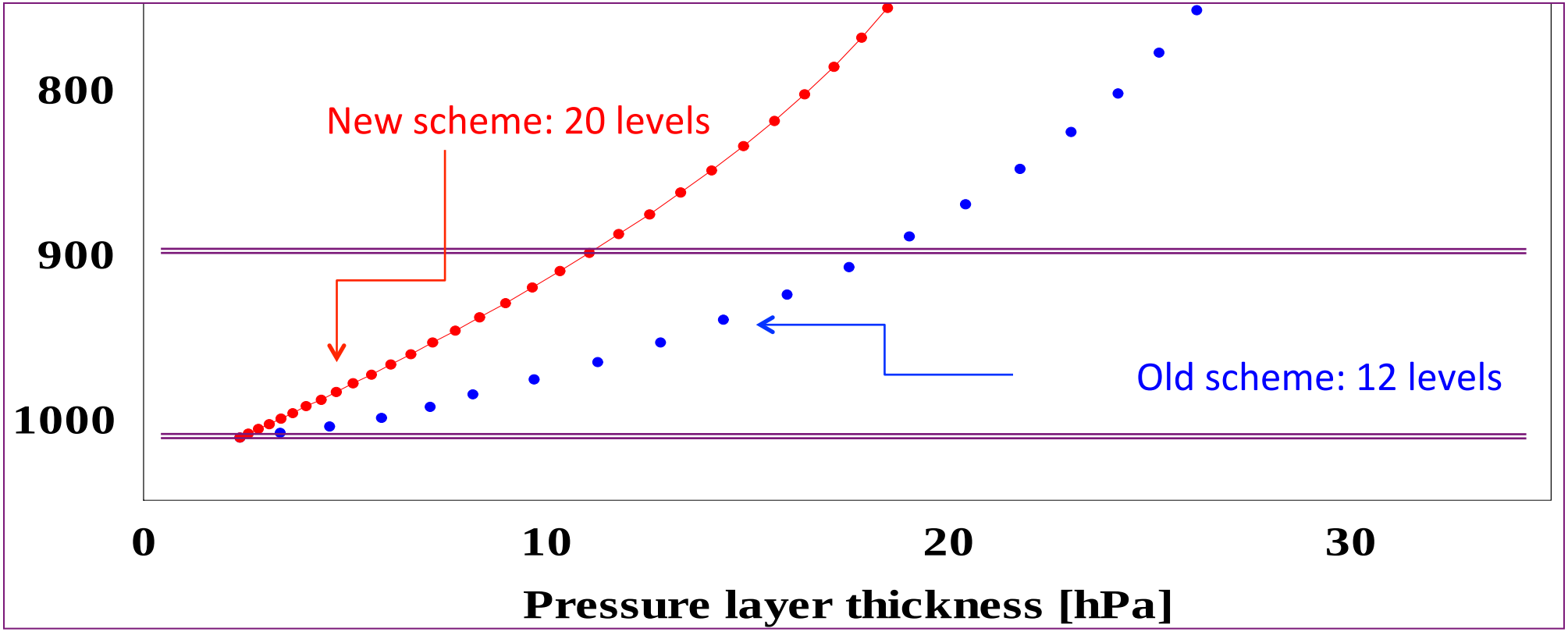
- **Complementing instantaneous model winds (cont.)**



- **Higher temporal & vertical resolution products**

Vertical resolution increase from 91 to 137 levels (by the end of 2012)

Almost doubling number of model levels at lower atmosphere



• Higher temporal & vertical resolution products (cont.)

At its 50th session (June 1999), the ECMWF Council approved the implementation of the Boundary Condition Optional Project (BC).

The Boundary Conditions Suite was set up in June 2000. It was set up as a separate operational suite to limit the impact on the core ECMWF activities.

A data cut-off time of 4 hours was used and 3D-Var analysis and forecasts ran to **90 hours at 00, 06, 12 and 18 UTC** with 3-hourly post-processing

*Currently: **1-hour** post-processing*

Analysis Cycle	Analysis/Forecast time	Time Available
00:00	Analysis	05:40
	Forecast Time Step 90	06:12
06:00	Analysis	11:40
	Forecast Time Step 90	12:12
12:00	Analysis	17:40
	Forecast Time Step 90	18:12
18:00	Analysis	23:40
	Forecast Time Step 90	00:12

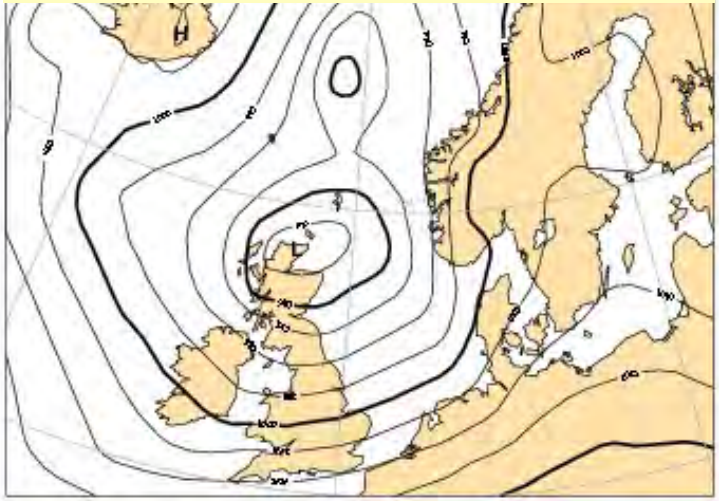
• Going after high-impact events: Extreme Forecast Index

Scotland storm blackout hitting thousands

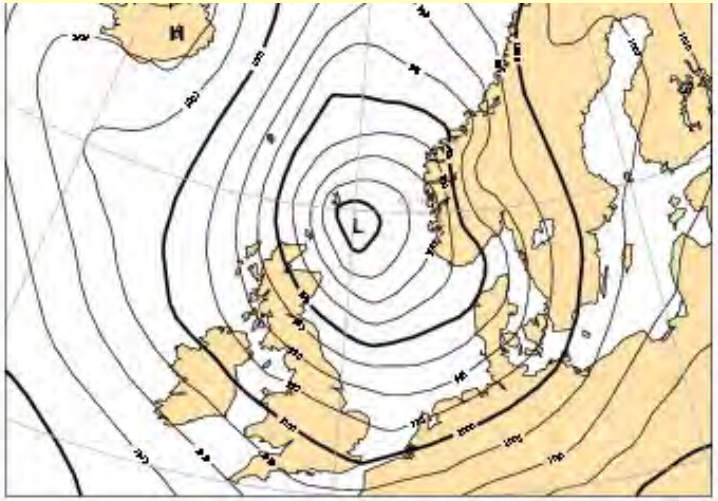
Scotland hammered by severe wind storm

• Going after high-impact events: Extreme Forecast Index (cont.)

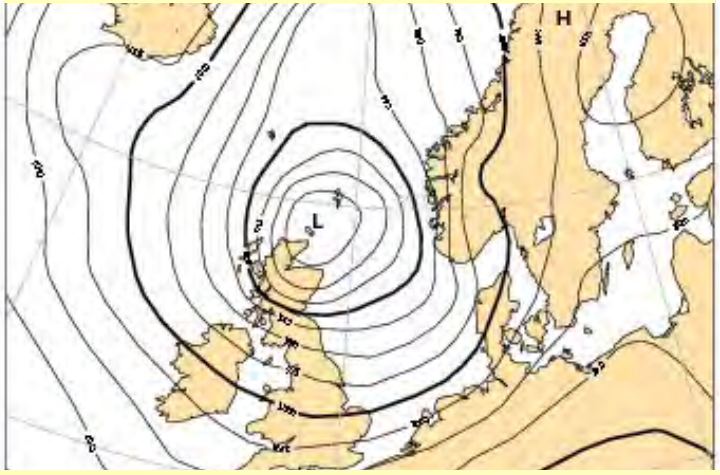
High-resolution single IFS MSLP T+90 hours



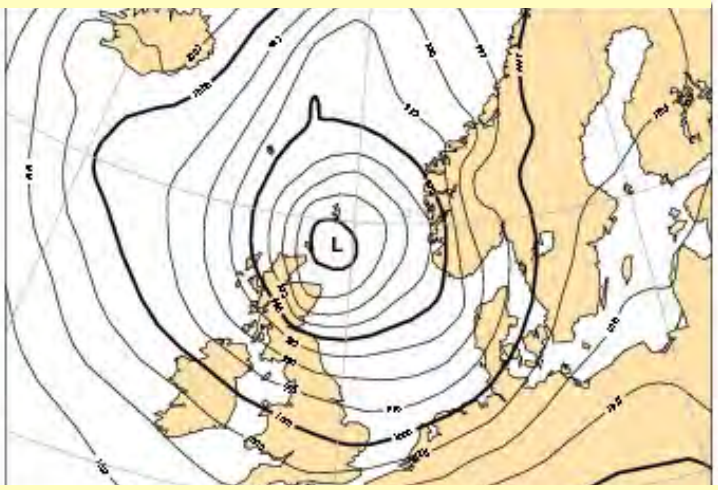
High-resolution single IFS MSLP T+84 hours



High-resolution single IFS MSLP T+66 hours

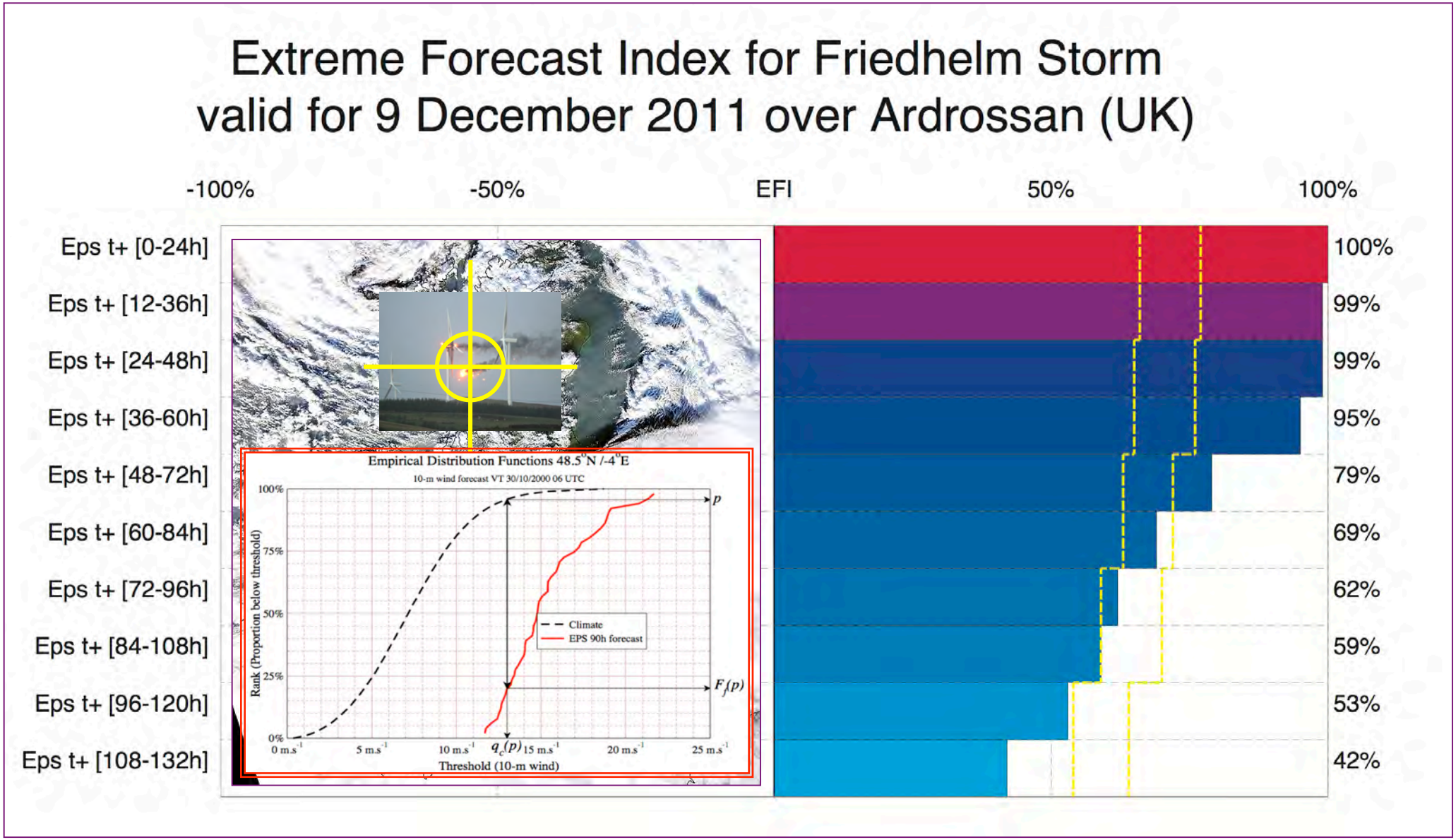


High-resolution single IFS MSLP T+54 hours



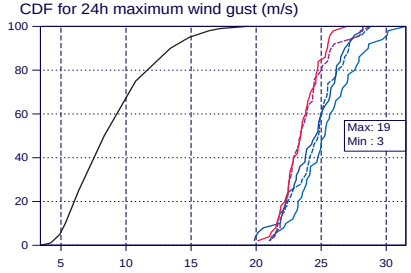
Throughout from 5 December: HIRES is strongly (>95%) supported by the EPS

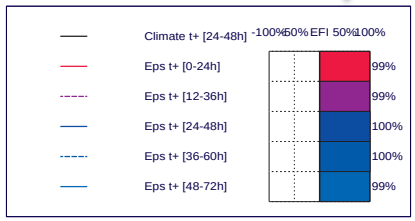
• Going after high-impact events: Extreme Forecast Index (cont.)



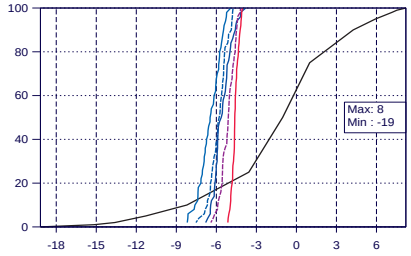
Clear saturation of EFI values …

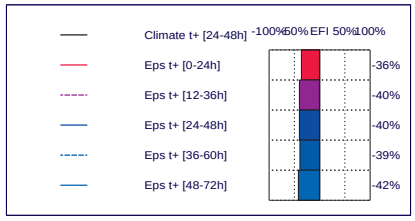
CDF for 24h maximum wind gust (m/s)





CDF for 24h mean 2m temperature (°C)





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

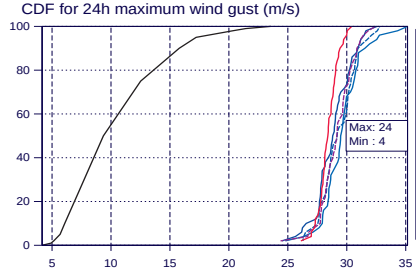
Carbon County Airport, Utah

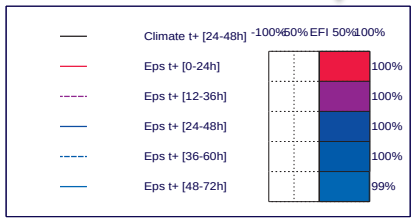
Violent
wind storm
leaves path
of destruction

California
Nevada
Utah (mainly)

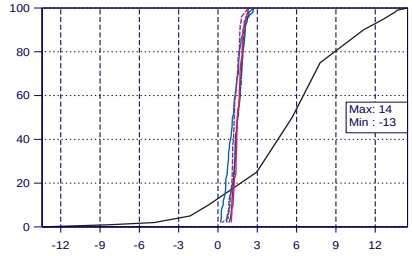
Dec 01, 2011

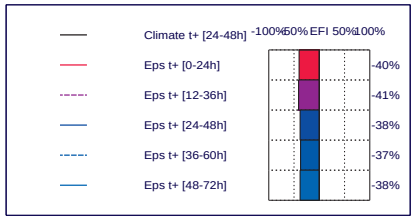
CDF for 24h maximum wind gust (m/s)





CDF for 24h mean 2m temperature (°C)





Max:
Min:

24-48h M-Climate extrema

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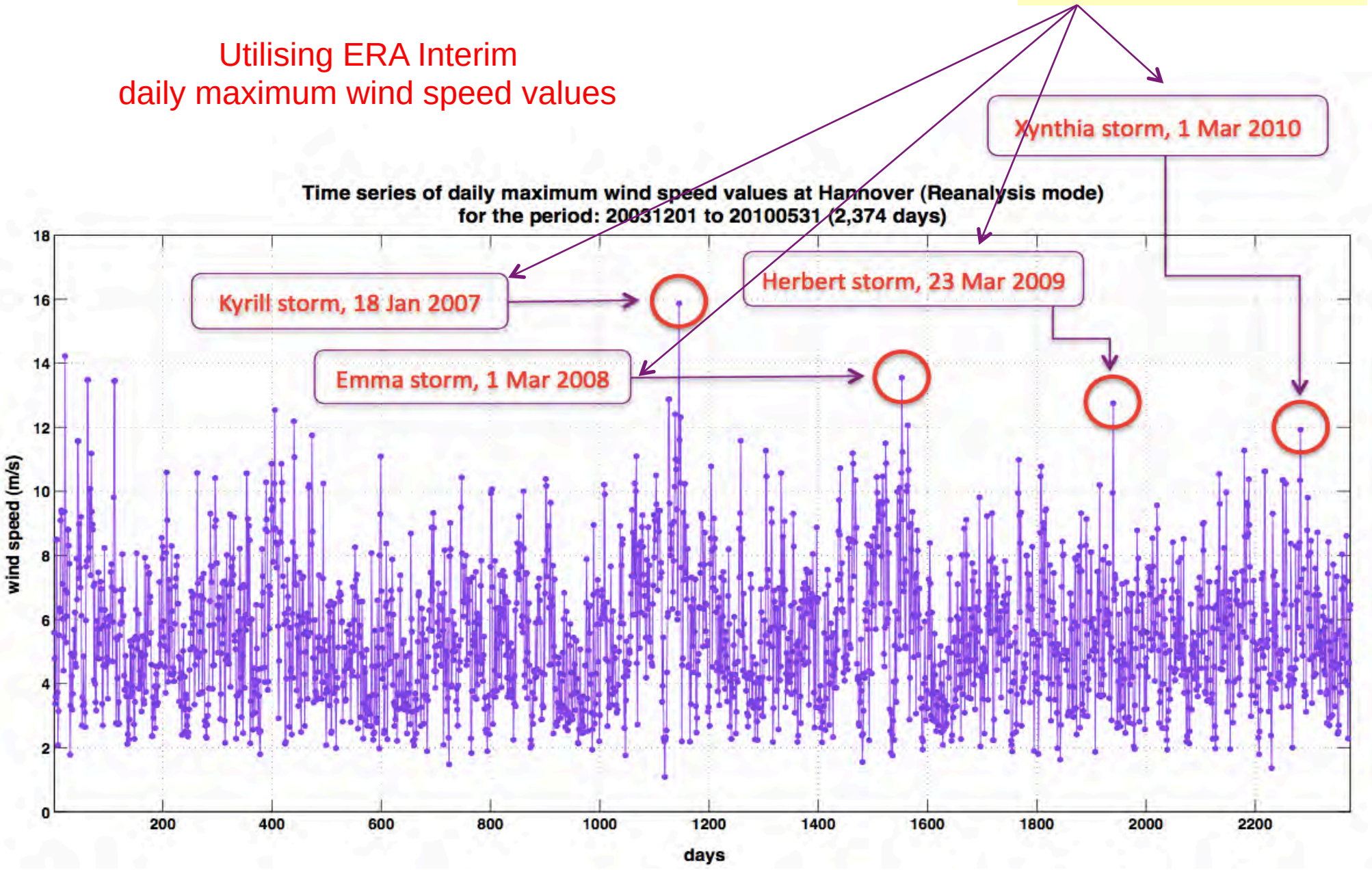
ECMWF

Badger Spring, Utah

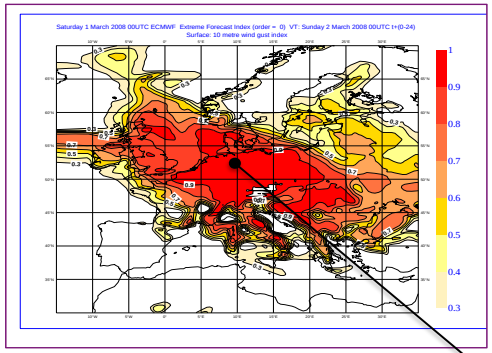
Spikes – footprints of extremes

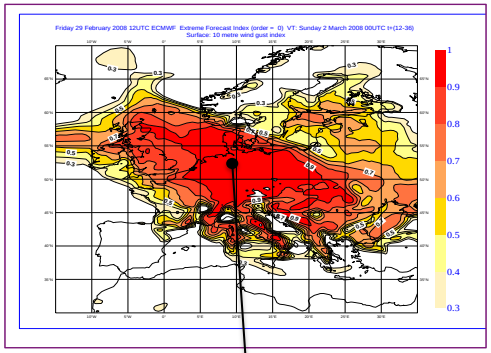
Utilising ERA Interim
daily maximum wind speed values

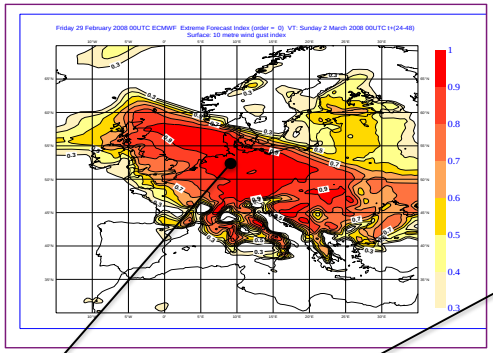
Focusing on

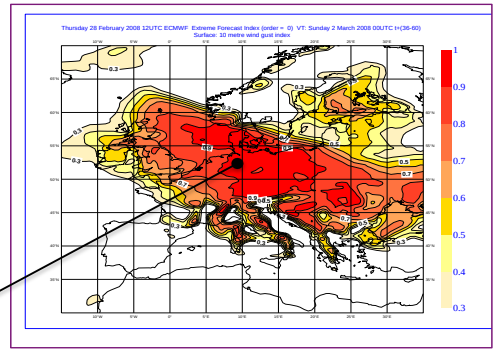


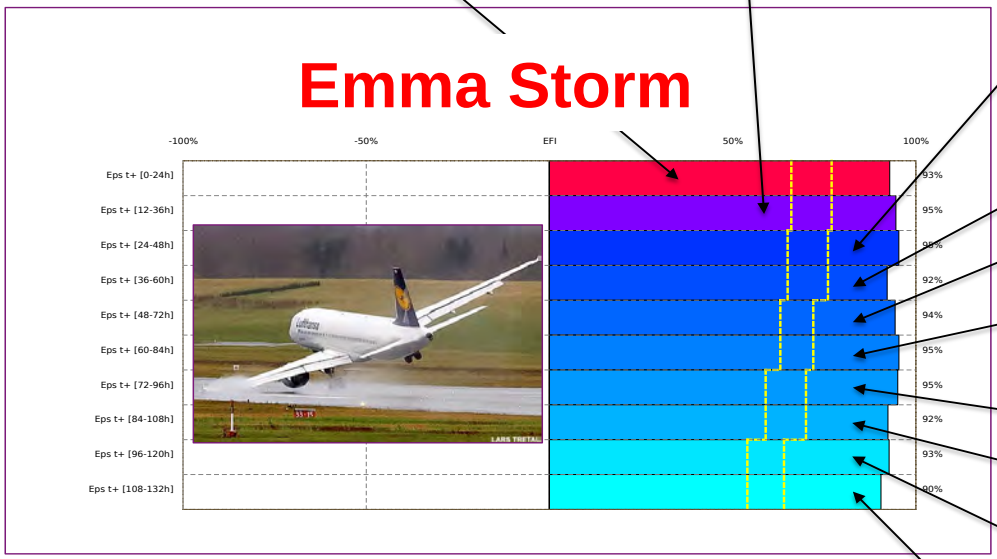
Emma Storm

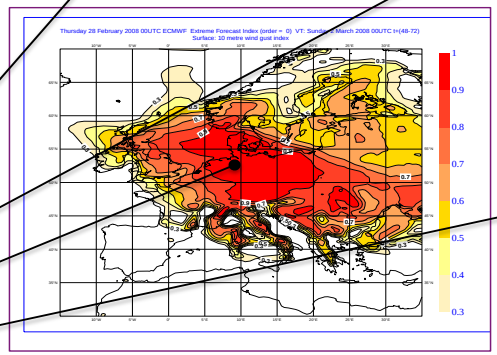

Saturday 1 March 2008 00UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(0-24)
Surface: 10 metre wind gust index

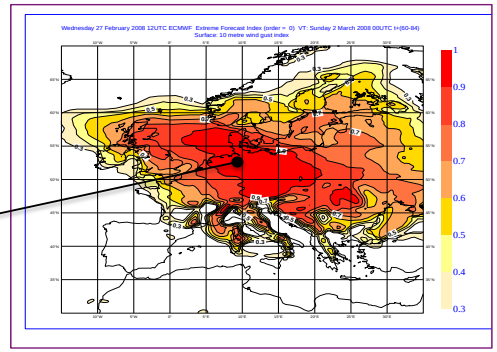

Friday 29 February 2008 12UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(12-36)
Surface: 10 metre wind gust index

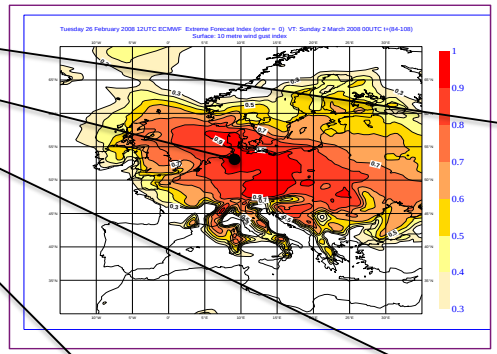

Friday 29 February 2008 00UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(24-48)
Surface: 10 metre wind gust index

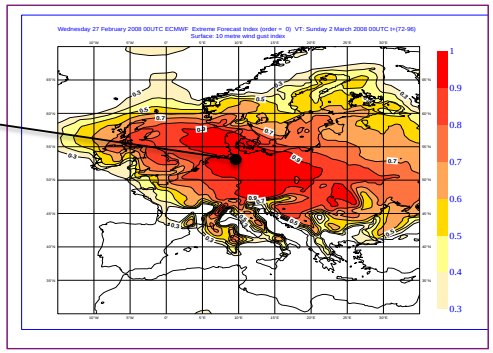

Thursday 28 February 2008 12UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(36-60)
Surface: 10 metre wind gust index

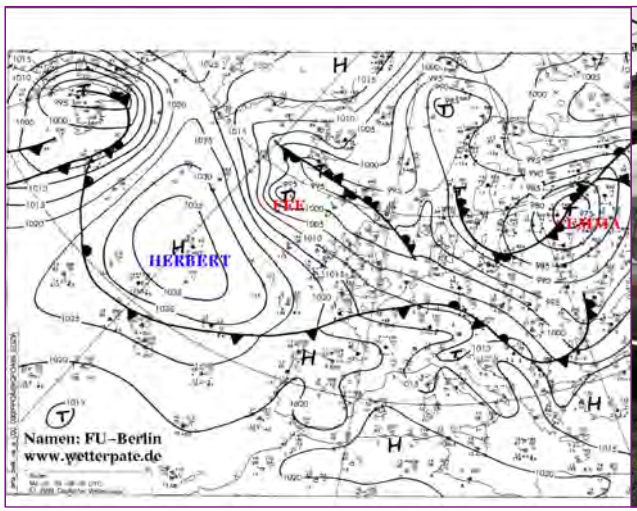

-100%
-50%
EFI
50%
100%
Eps t+ [0-24h]
Eps t+ [12-36h]
Eps t+ [24-48h]
Eps t+ [36-60h]
Eps t+ [48-72h]
Eps t+ [60-84h]
Eps t+ [72-96h]
Eps t+ [84-108h]
Eps t+ [96-120h]
Eps t+ [108-132h]
93%
95%
96%
92%
94%
95%
95%
92%
93%
90%

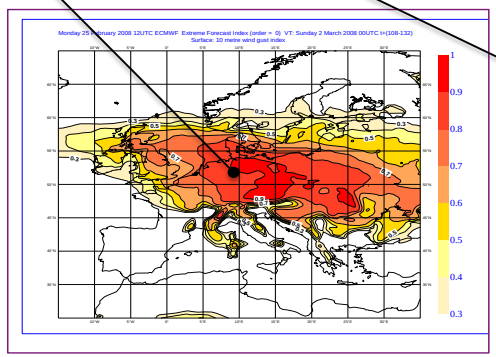

Thursday 28 February 2008 00UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(48-72)
Surface: 10 metre wind gust index

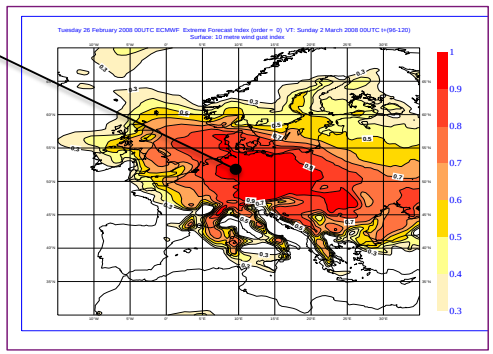

Wednesday 27 February 2008 12UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(60-84)
Surface: 10 metre wind gust index

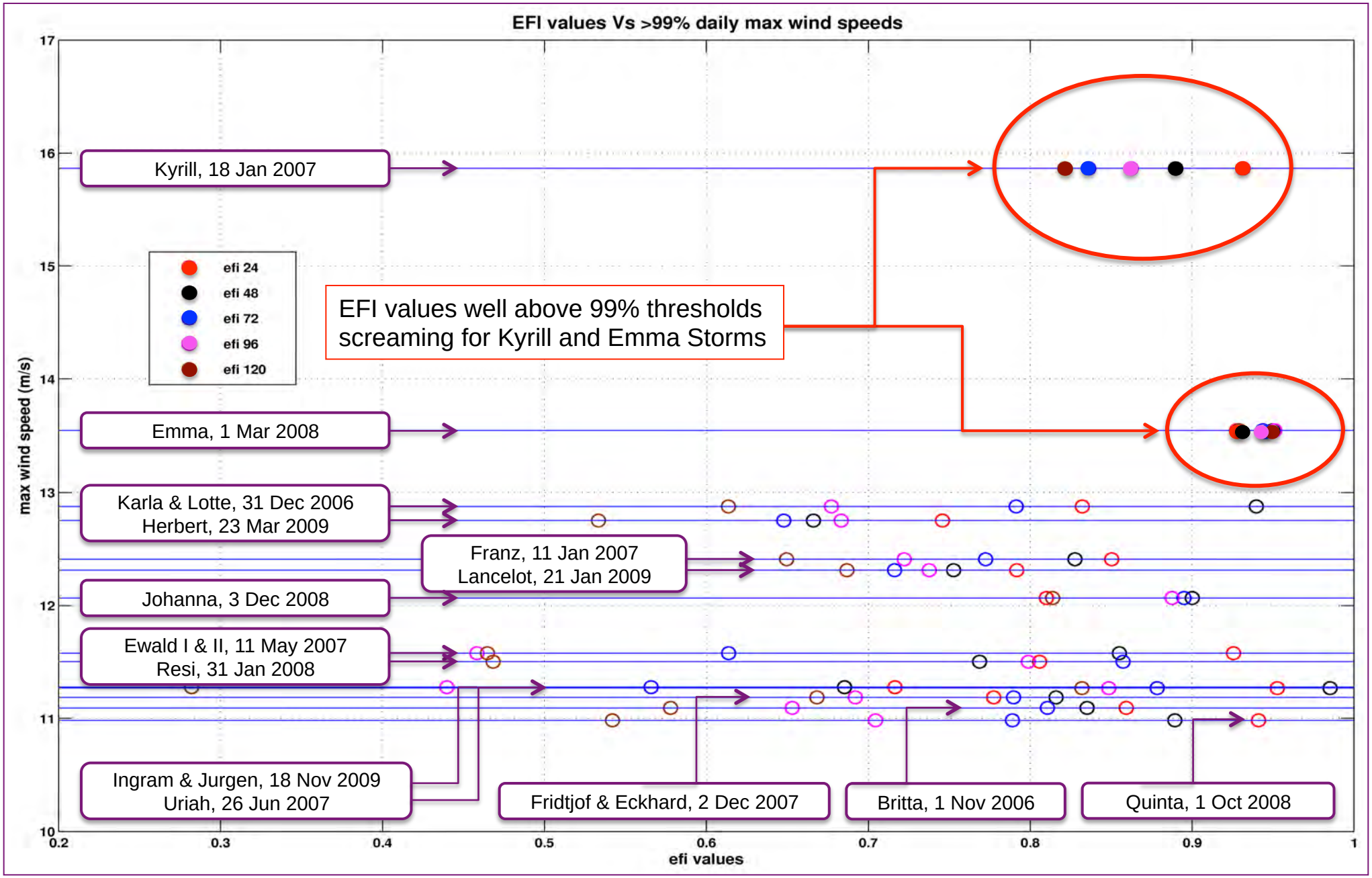

Tuesday 26 February 2008 12UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(84-108)
Surface: 10 metre wind gust index

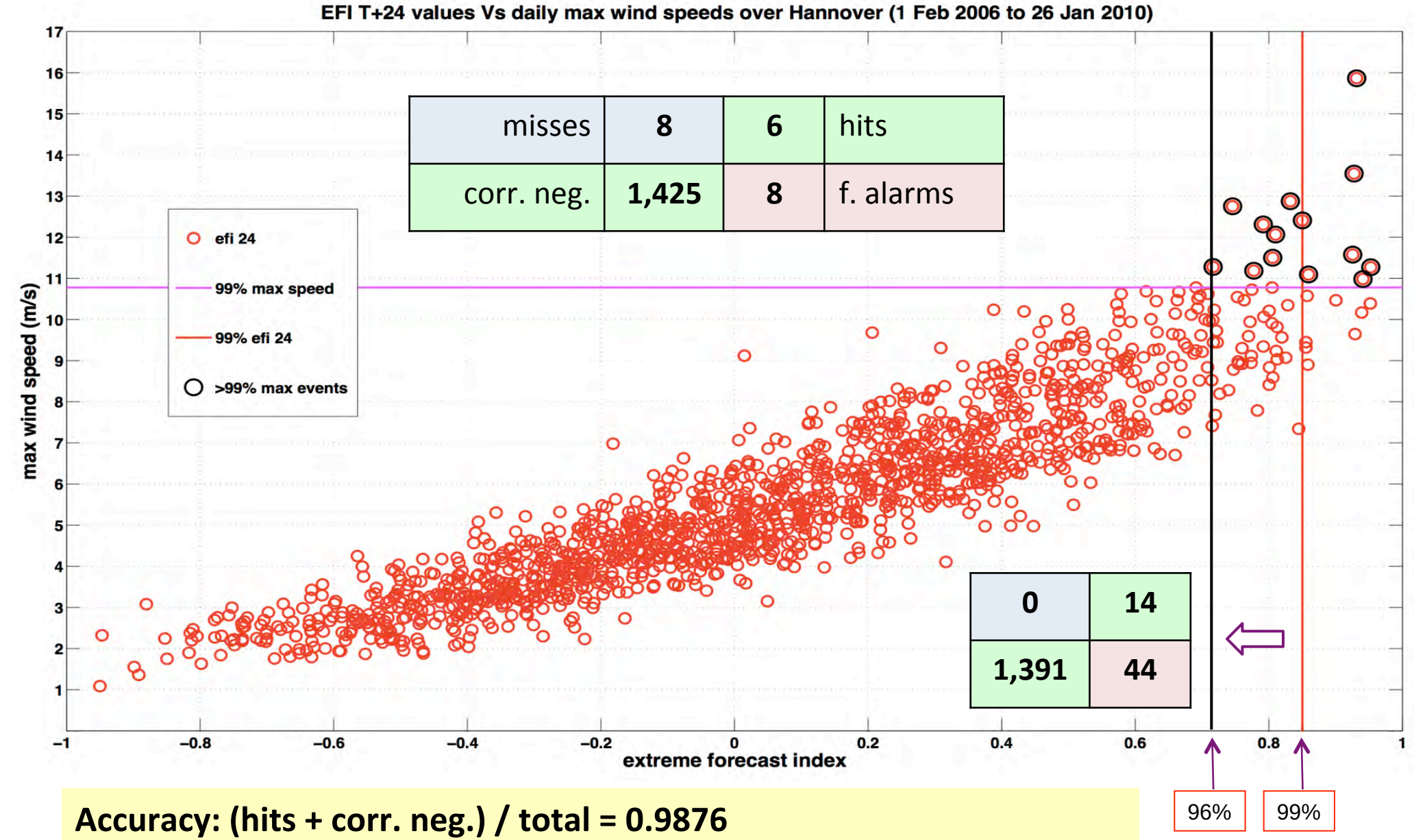

Wednesday 27 February 2008 00UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(72-96)
Surface: 10 metre wind gust index


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


Monday 25 February 2008 12UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(108-132)
Surface: 10 metre wind gust index


Tuesday 26 February 2008 00UTC ECMWF Extreme Forecast Index (order = 0) VT: Sunday 2 March 2008 00UTC t+(96-120)
Surface: 10 metre wind gust index


EFI values Vs >99% daily max wind speeds
max wind speed (m/s)
efi values
efi 24
efi 48
efi 72
efi 96
efi 120
Kyrill, 18 Jan 2007
Emma, 1 Mar 2008
Karla & Lotte, 31 Dec 2006
Herbert, 23 Mar 2009
Franz, 11 Jan 2007
Lancelot, 21 Jan 2009
Johanna, 3 Dec 2008
Ewald I & II, 11 May 2007
Resi, 31 Jan 2008
Ingram & Jurgen, 18 Nov 2009
Uriah, 26 Jun 2007
Fridtjof & Eckhard, 2 Dec 2007
Britta, 1 Nov 2006
Quinta, 1 Oct 2008
EFI values well above 99% thresholds
screaming for Kyrill and Emma Storms

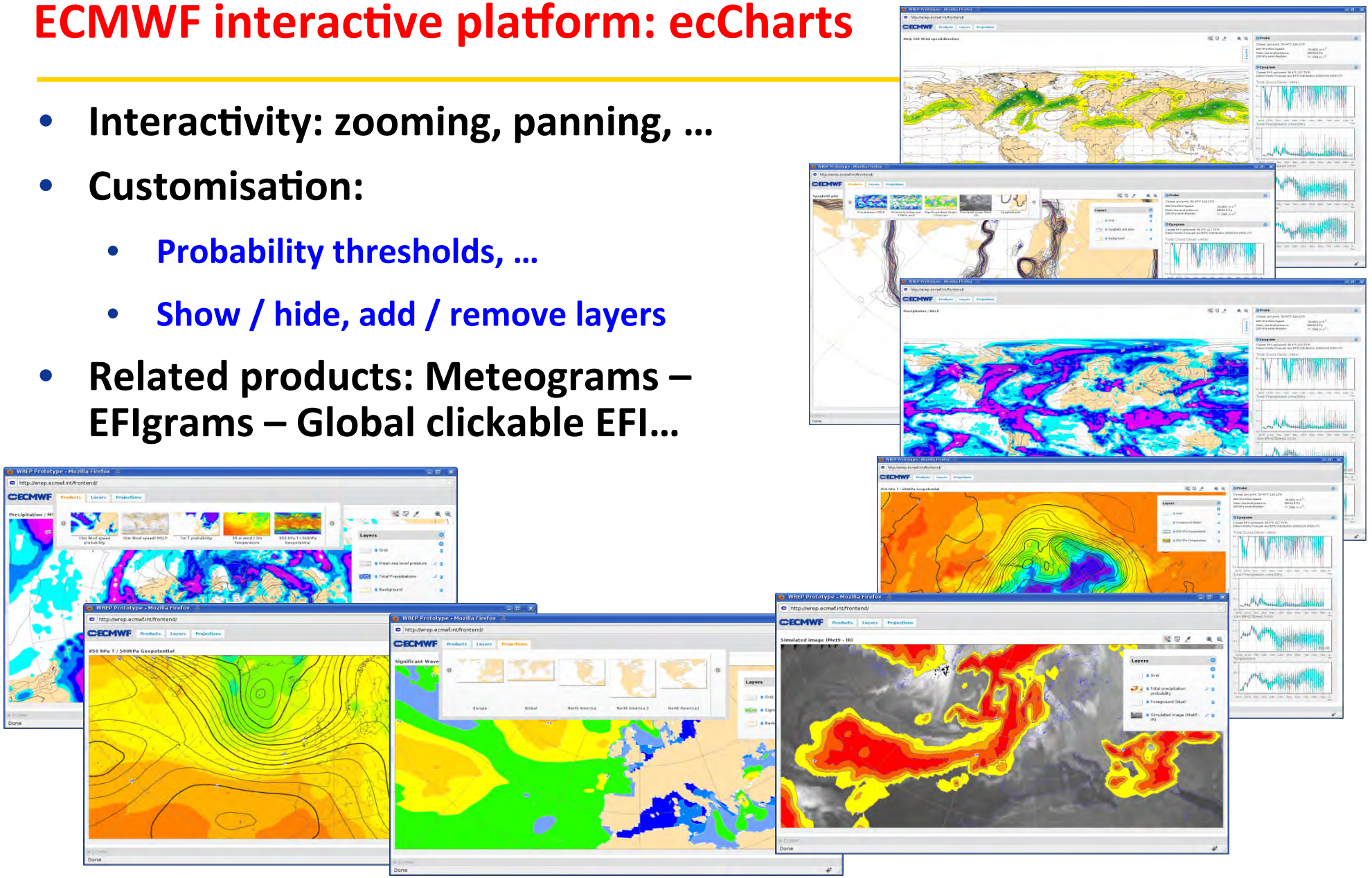


Accuracy: (hits + corr. neg.) / total = 0.9876

Probability of Detection: hits / (hits + misses) = 0.4286

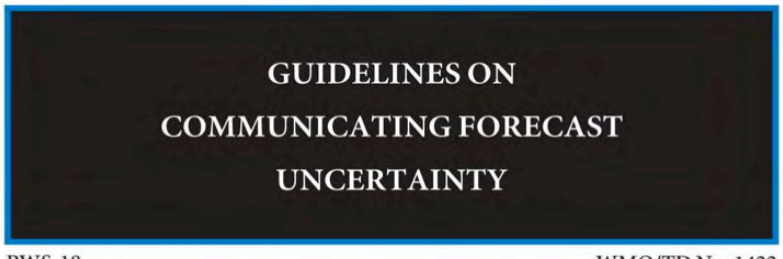
ECMWF interactive platform: ecCharts

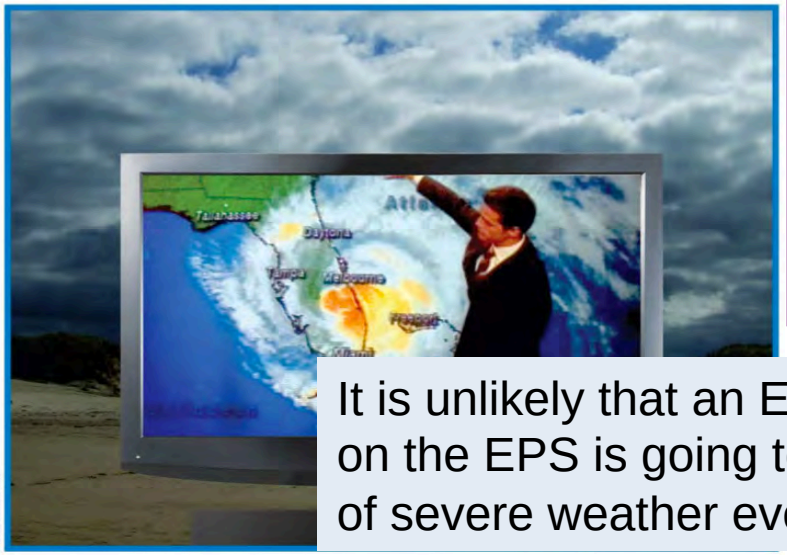
- Interactivity: zooming, panning, …
- Customisation:
  - Probability thresholds, …
  - Show / hide, add / remove layers
- Related products: Meteograms – EFIgrams – Global clickable EFI…

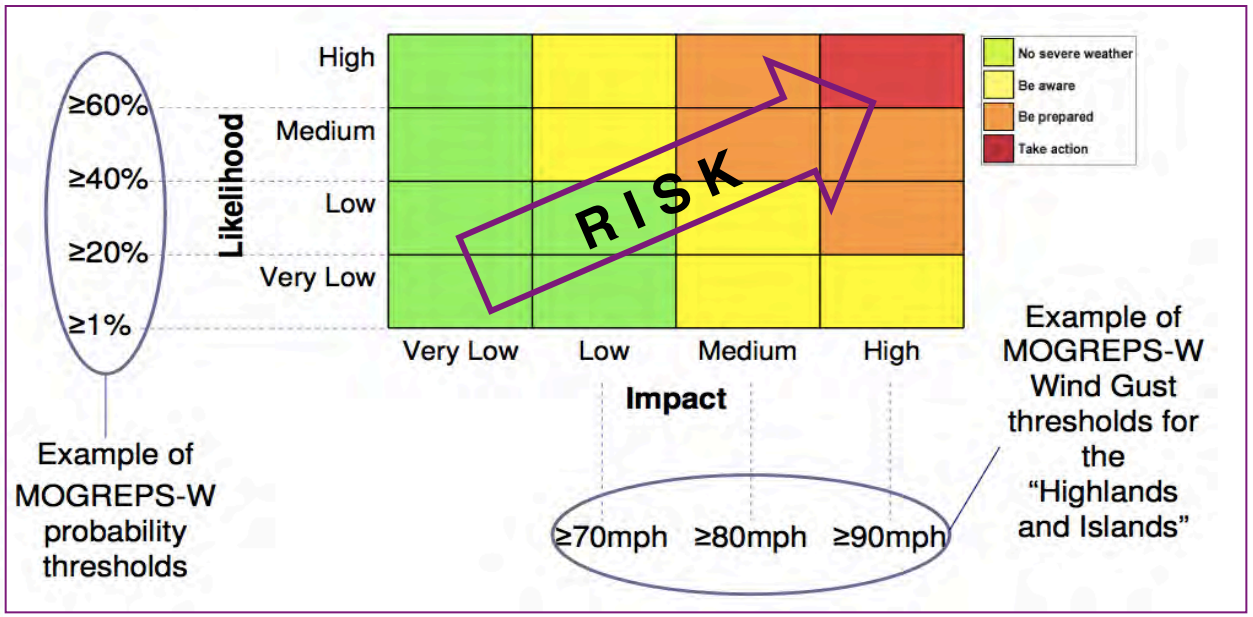


Some extreme… messages

Example of MOGREPS thresholds (Neal et al, 2011)







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

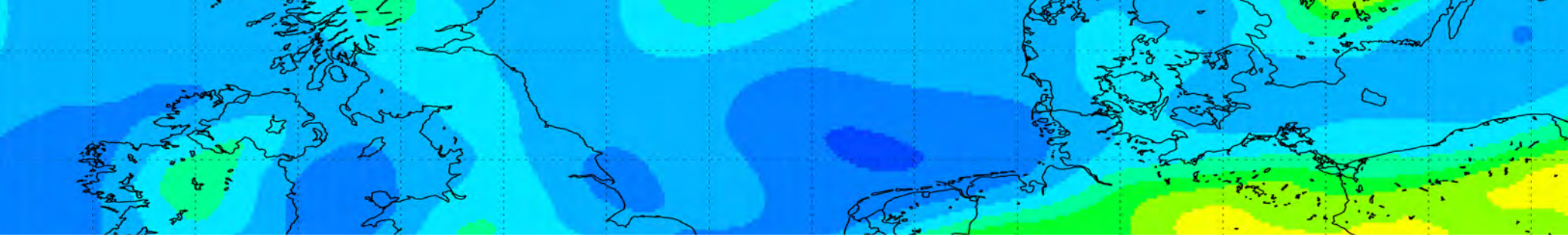
For such "low" probabilities of extremes (in medium-range) utilise **ecCharts** using "extreme" climatological percentiles or extreme (critical) thresholds

In addition, use extreme probabilities combined with **probabilities of return (extra new !!!)**

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

Some final messages

- Utilising model levels: the birth of 100-meter winds
  A real useful set of products (both in HIRES & EPS mode)
- Complementing instantaneous winds: the concept of Gust Factor(s)
  Instantaneous winds seem to be adequate in cases of extremes
- Higher vertical and temporal resolution products
- Going after high-impact events: Extreme Forecast Index
  Setting optimal EFI thresholds is considered both useful & important…
- Enhanced capabilities of ecCharts platform: a forecaster's dream ?

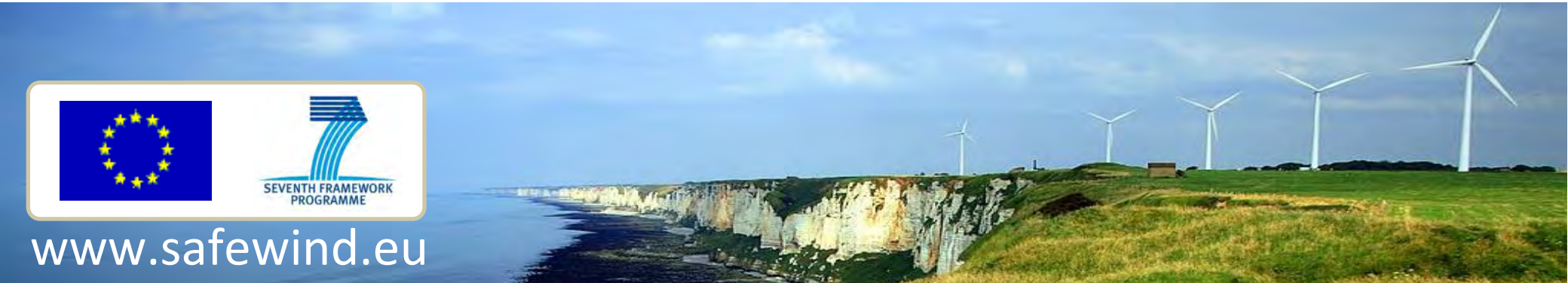


SafeWind

Wind Power Forecasting with Focus on Extremes

Workshop - 31.08.2012

L'Auditorium, Palais Brongniart, Paris



SEVENTH FRAMEWORK PROGRAMME

www.safewind.eu