Forecaster input to UKV model development

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13th – 15th May 2013 DWD, Offenbach, Germany

Contents

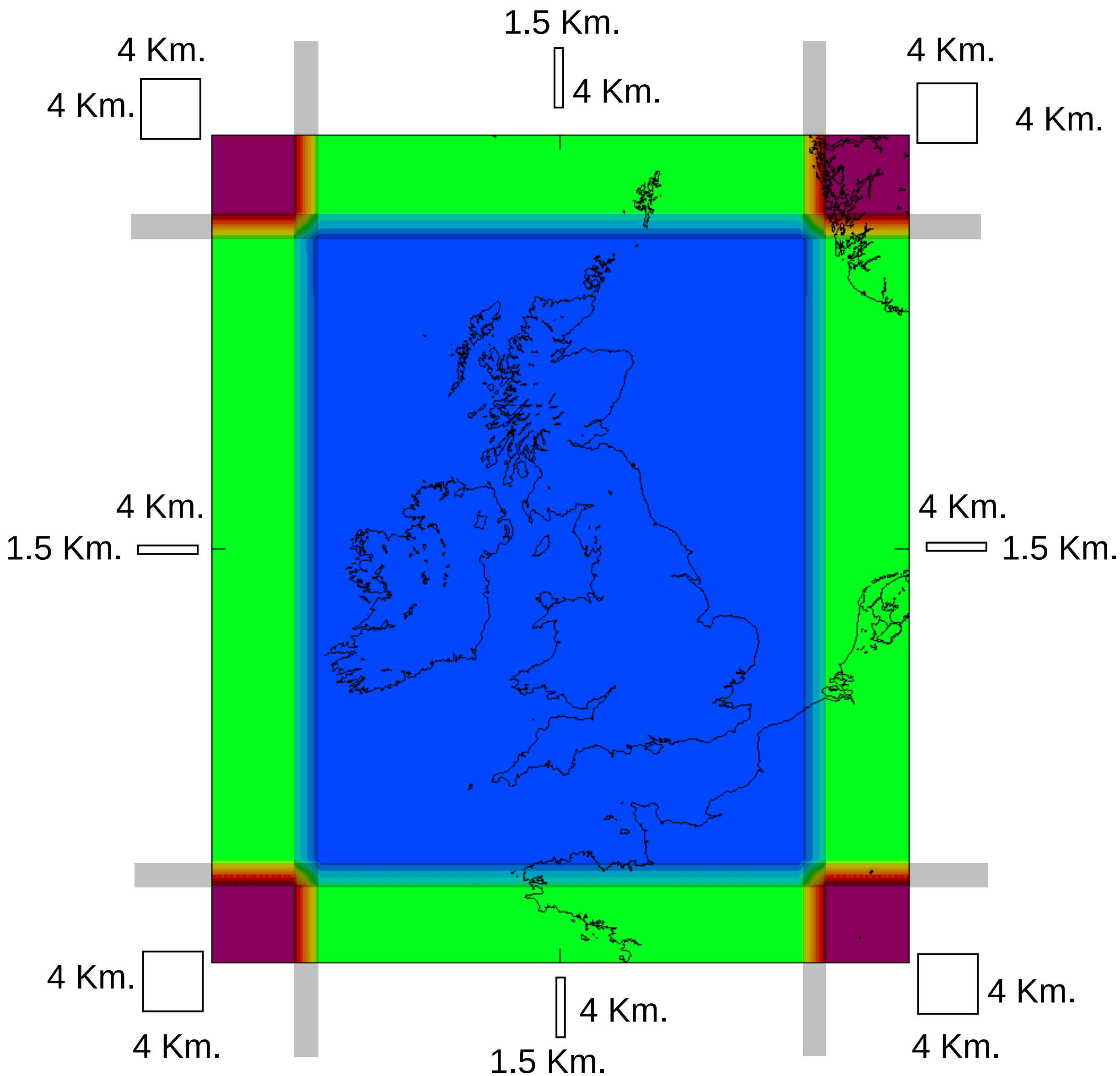
- The UKV Model
- NWP Problem Group
- Examples of problems raised by forecasters
- 1) Snow/temperature
- 2) Wind gust
- Conclusions

Contents

The UKV model

- The Met Office has been running the UKV model Operationally since 2009.
- This model is variable resolution, with the fixed resolution of interior having a gridlength of 1.5km
- The model is driven by the 25km resolution Global model which supplies hourly boundary conditions.
- The UKV runs to T+36, eight times a day and a continuous 3D-VAR data assimilation cycle

UKV Model


1.5 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
1.5 Km.
4 Km.
1.5 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
1.5 Km.

High Resolution specific

- Radiation:
  - Orographic correction
- Microphysics:
  - Prognostic rain (horizontal advection of precipitates).
  - Autoconversion limits dependent on aerosol concentration
- Convection:
  - Parametrization switched off
- Gravity Wave Drag / Orographic Drag:
  - Parametrization switched off
- Horizontal Diffusion:
  - 2D Smagorinsky (no horizontal diffusion)

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NWP Problem Group

- The NWP Problem Group is a forum where forecasters and modellers meet on a regular basis and discuss progress on model problems.
- A database of problems raised by forecasters is maintained.
- These problems are either felt to be systematic in nature or involve model forecasts of events that are unusually high profile and which have a high level of public or political interest.
- The model problems relate to all of the operational model configurations and a number of them relate to the UKV.
- These problems relate to forecasts of temperature, cloud, precipitation, snow, visibility and wind gust.

NWP Problem Group

Met Office

Updated : 30th April 2013 ***Mike Bush***

Problem Themes	Priority	Active Problems						
		Global & General	NAE	UKV	CAM	Ensemble	Wave	UKPP
Fog & Visibility	H		430 475	430 465 475				480
Low Cloud/Stratocumulus moist superadiabatic profs	H	387 473	450 467 481	464 467 481	458 471			
Snow	H	445 484	445	468 483 484				
Warm US Bias and embedded CBs	H	474 482						
Insufficient spread in ensemble	H					405 424		
Precipitation (L.Scale/General)	M	457 472 478	472 478	472 478	451 455 456 461			
Showers	M	453 484	419	419 463 464 483 484				
Pressure/Development	M	446			452			
Diurnal Cycle	M			441 463				
Near surface winds	M			477			436 469	
Surface temperatures (general)	M	387 413		441 468 476	387	440		

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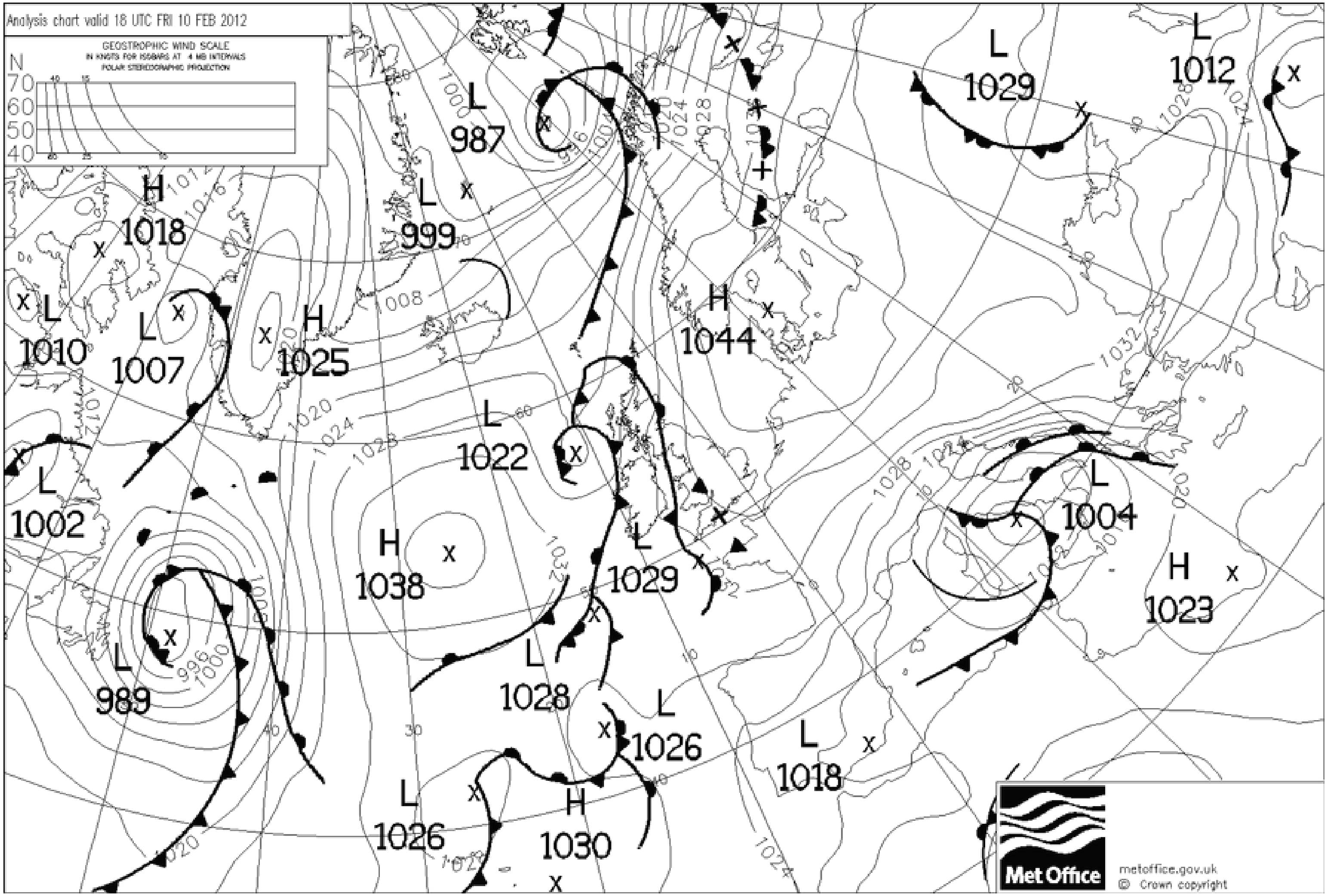
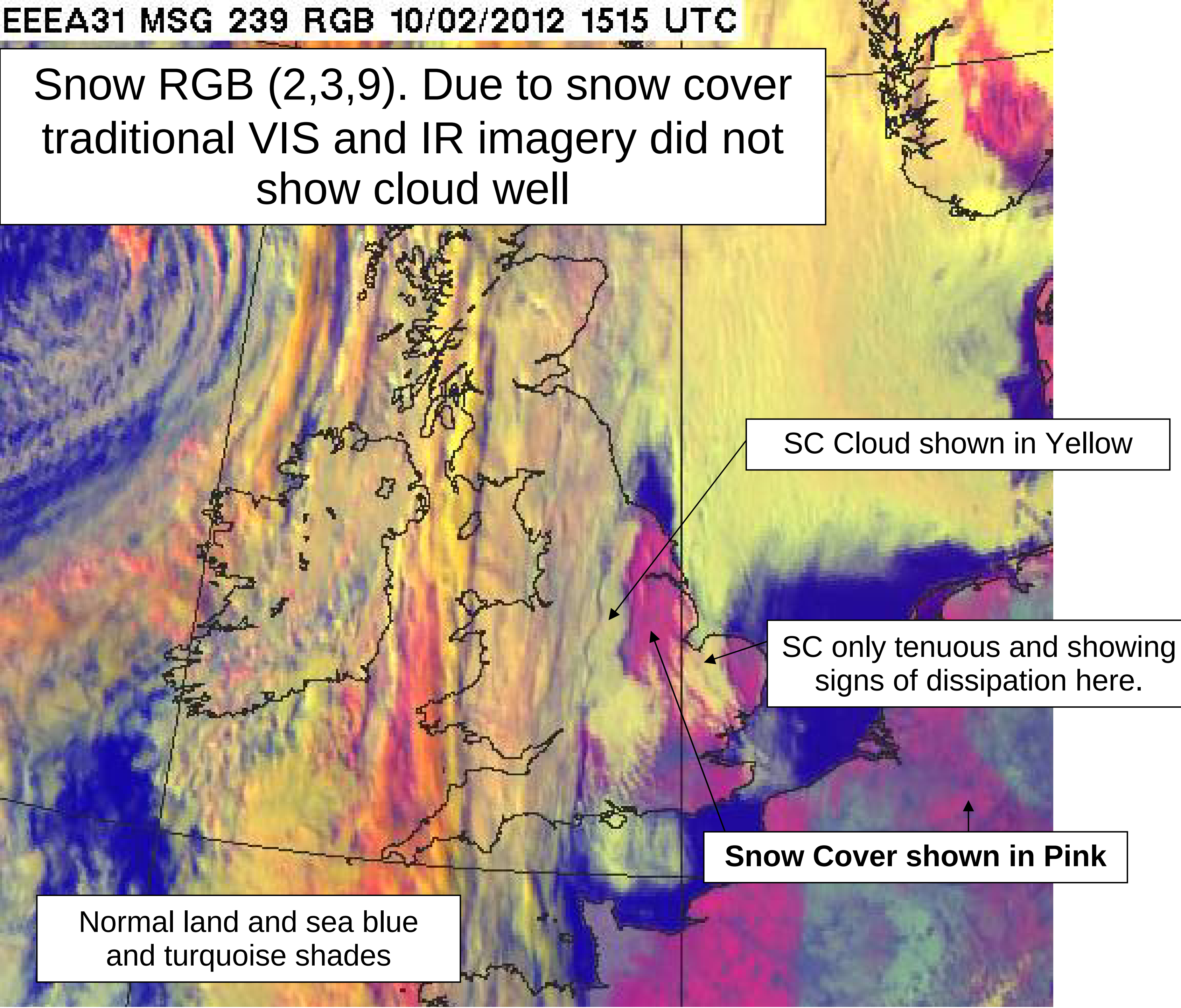
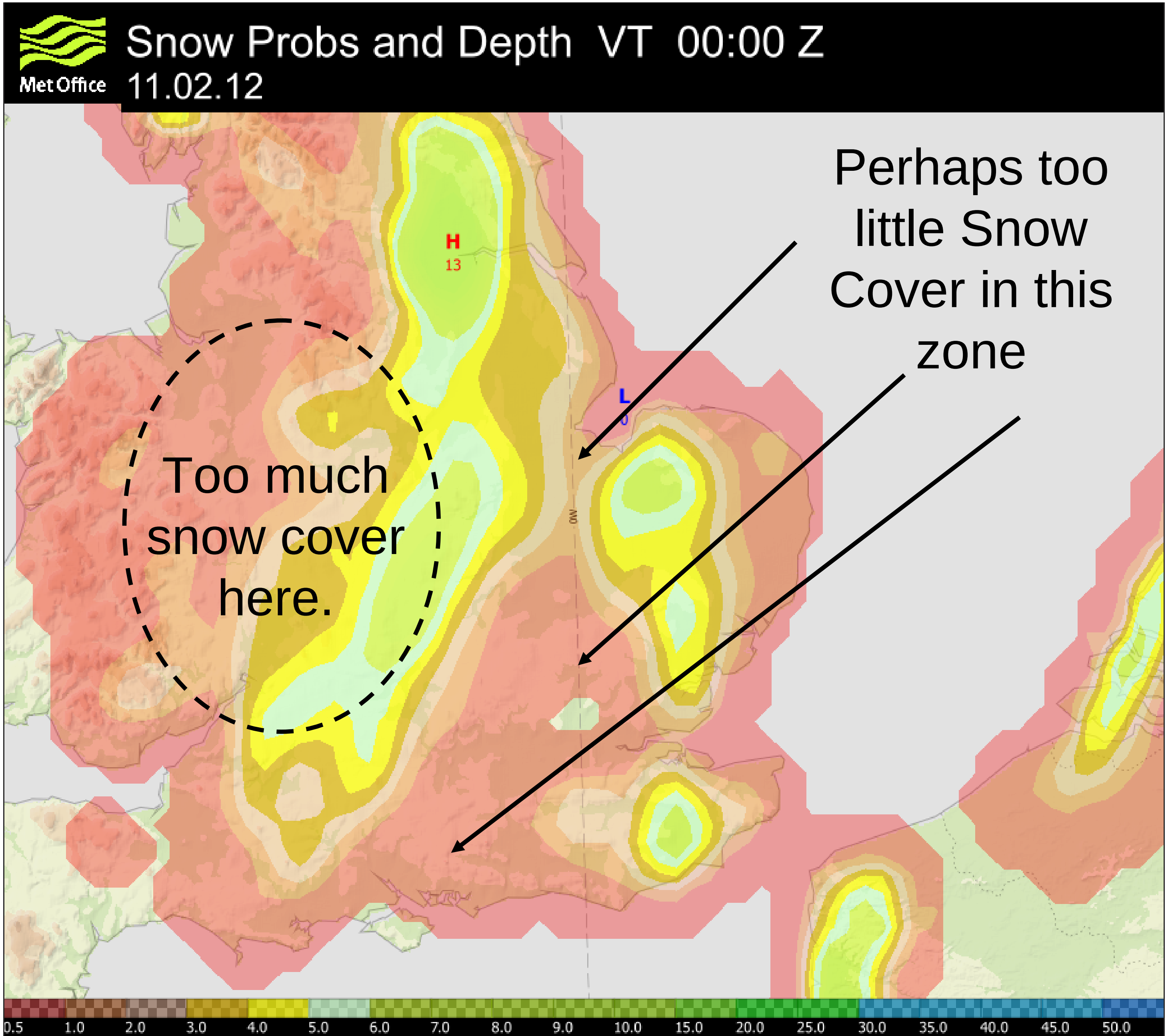
Analysis chart 10/02/12 18Z



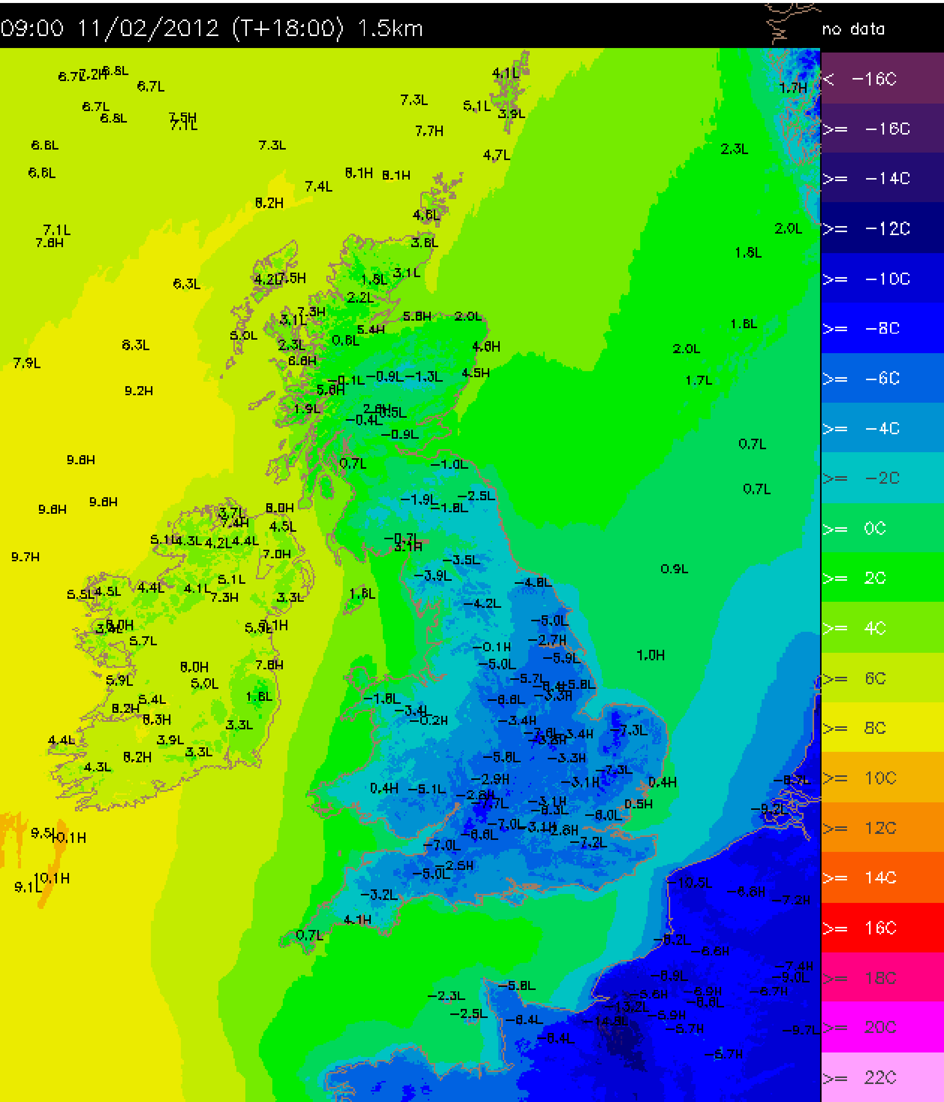

EEEA31 MSG 239 RGB 10/02/2012 1515 UTC
Snow RGB (2,3,9). Due to snow cover traditional VIS and IR imagery did not show cloud well
SC Cloud shown in Yellow
SC only tenuous and showing signs of dissipation here.
Snow Cover shown in Pink
Normal land and sea blue and turquoise shades

Snow cover from the model (18Z NAE) was relatively well handled

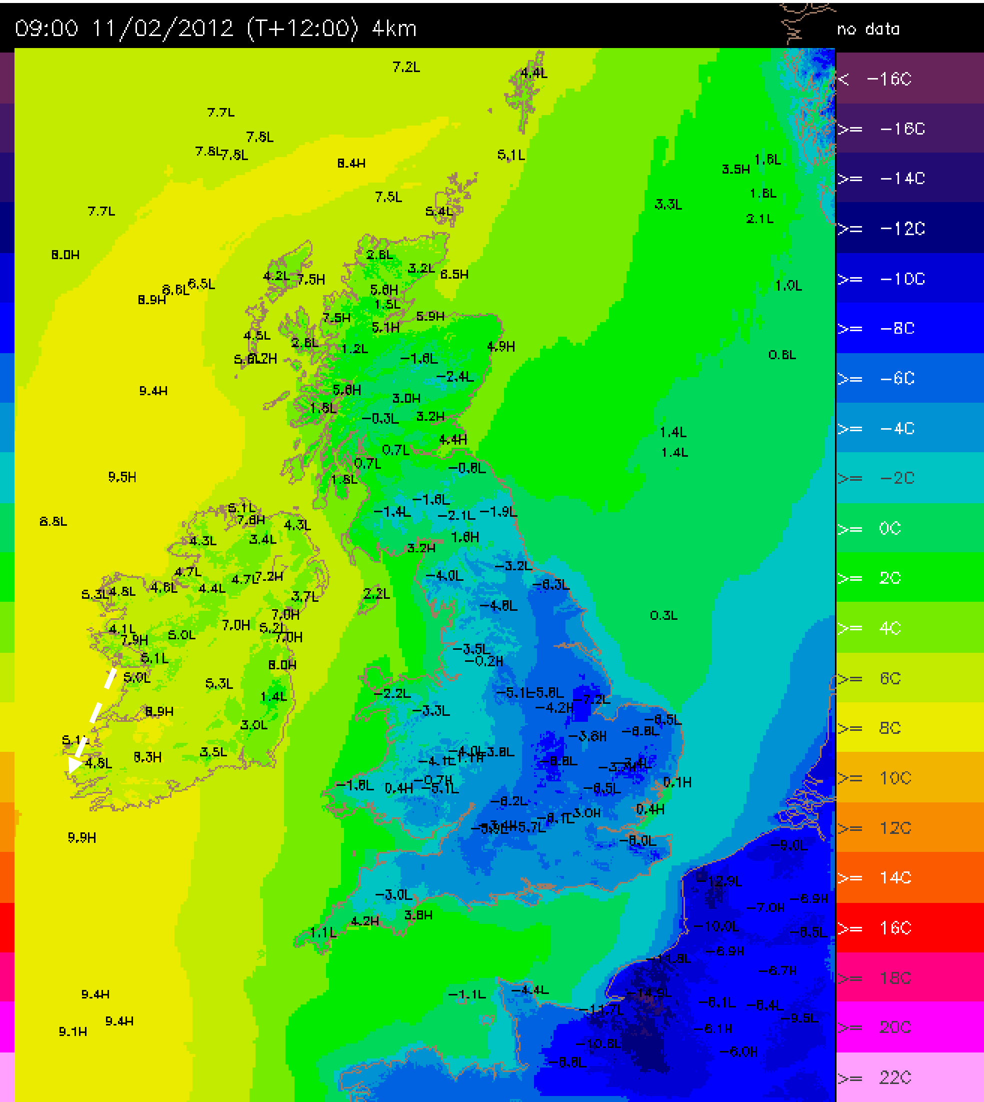


Min to 09Z on 11th from Post-processed UKV and UK4 21Z runs

UKV: -7.7 deg



UK 4: -8.8 deg

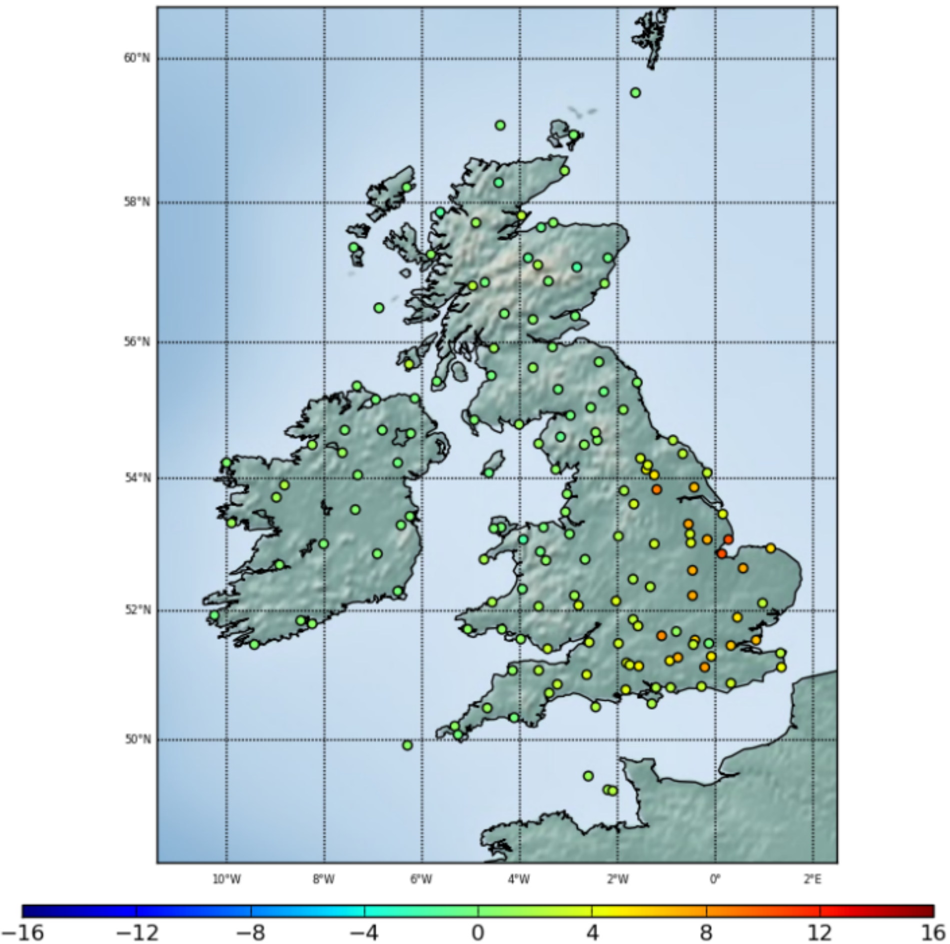


Met Office

Screen temperature verification 11/02/12 06UTC

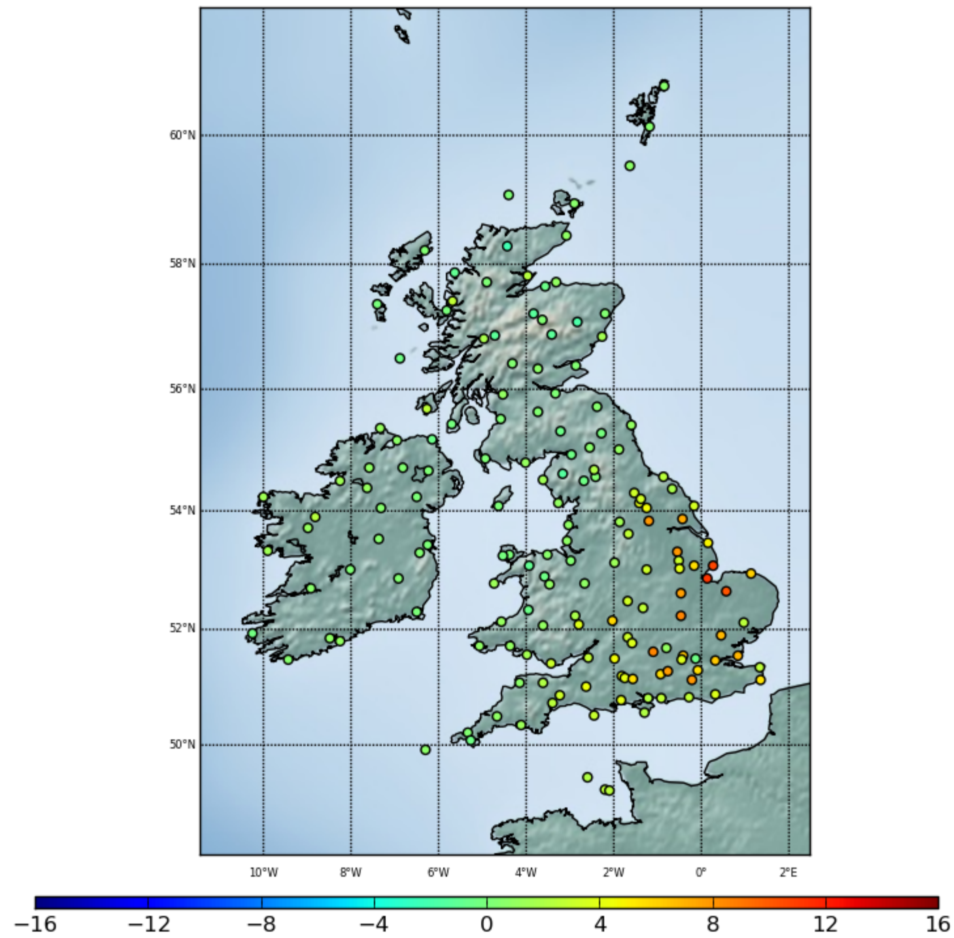
UKV T+9

Surface (1.5m) Temperature (deg K), Mean Error (Forecast - Observations), T+9,
20120211 to 20120211, Surface Obs, UK-UKV



UK4 T+9

Surface (1.5m) Temperature (deg K), Mean Error (Forecast - Observations), T+9,
20120211 to 20120211, Surface Obs, UK-UK4



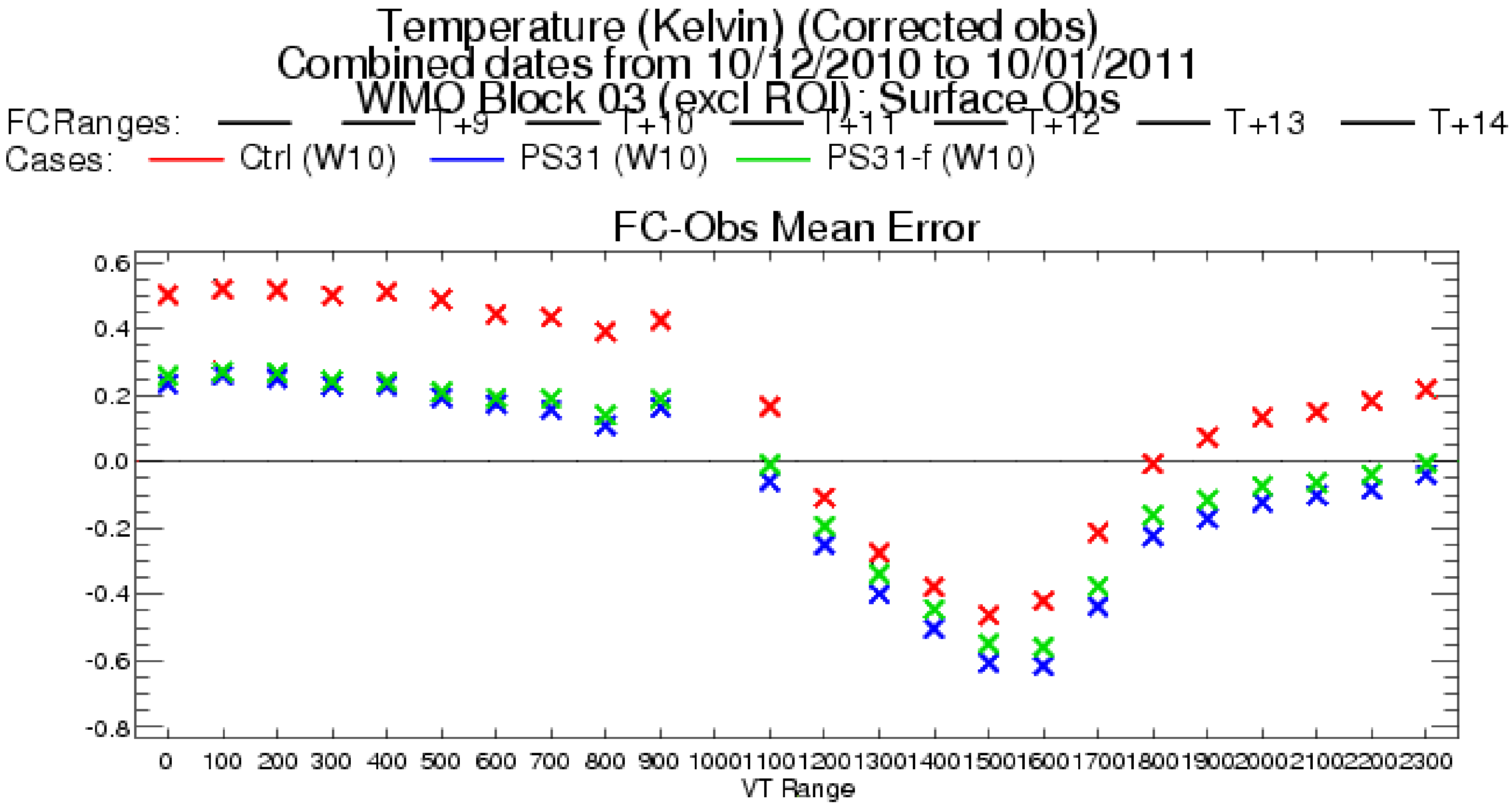
Modelling challenges for this case

- Snow cover
- Current snow scheme is a zero-layer scheme
- The warm bias is associated with excessive ground heat fluxes.
- The greater insulating effect of the new multilayer snow scheme (currently under test) can give significant reductions in temperature in this case
- Stratocumulus
- Stable boundary layer issues

Stable boundary layer package

- A stable boundary layer package was implemented on 04th December 2012
- One of the major components of the package is a change to the stability functions from "Mes tails" to "sharpest".
- This leads to reduced mixing in stable conditions.
- It cools the Screen Temperature at night and significantly improves Screen Temperature and Relative Humidity scores.

PS31 improvement to temperature diurnal cycle



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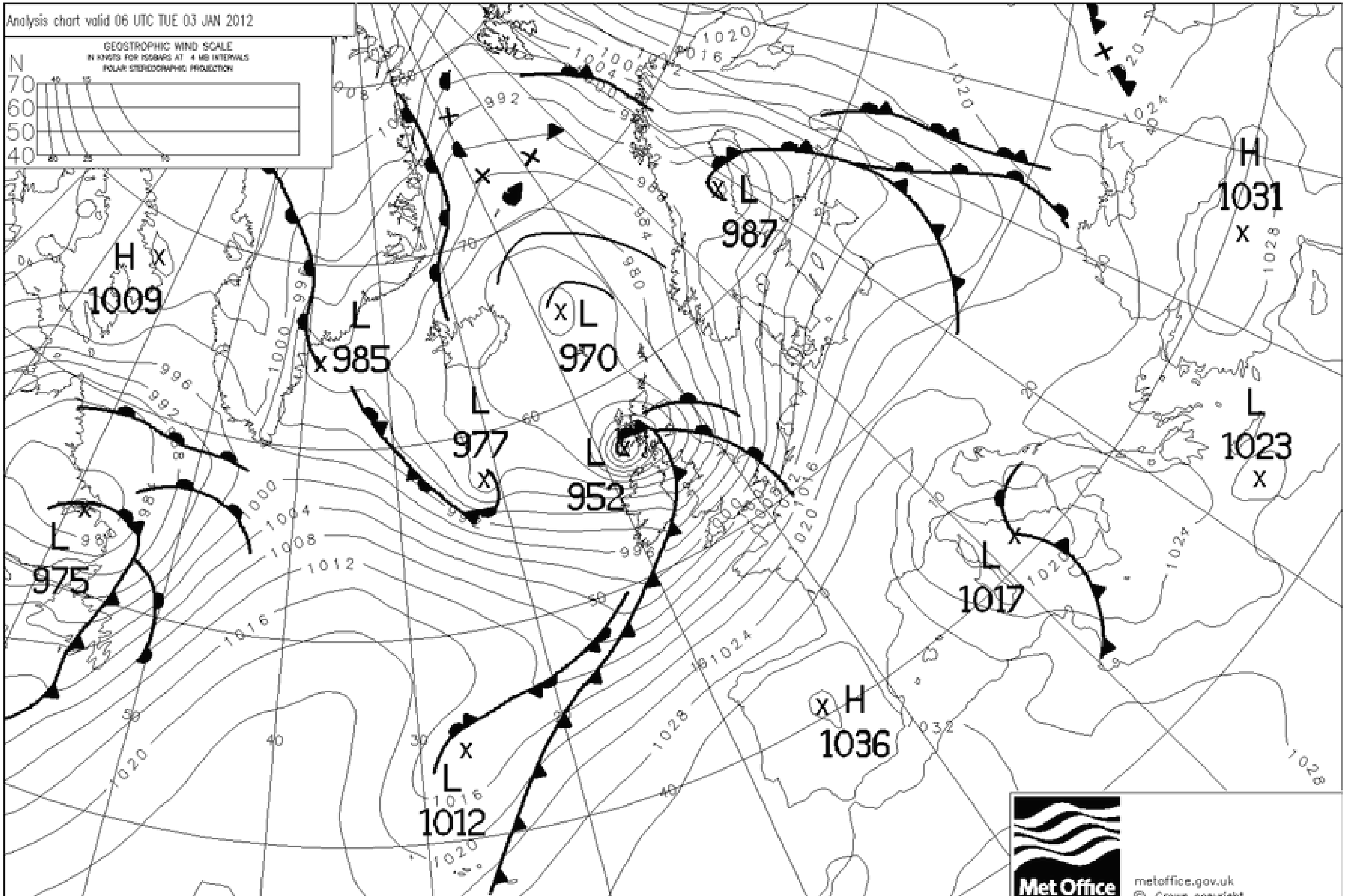
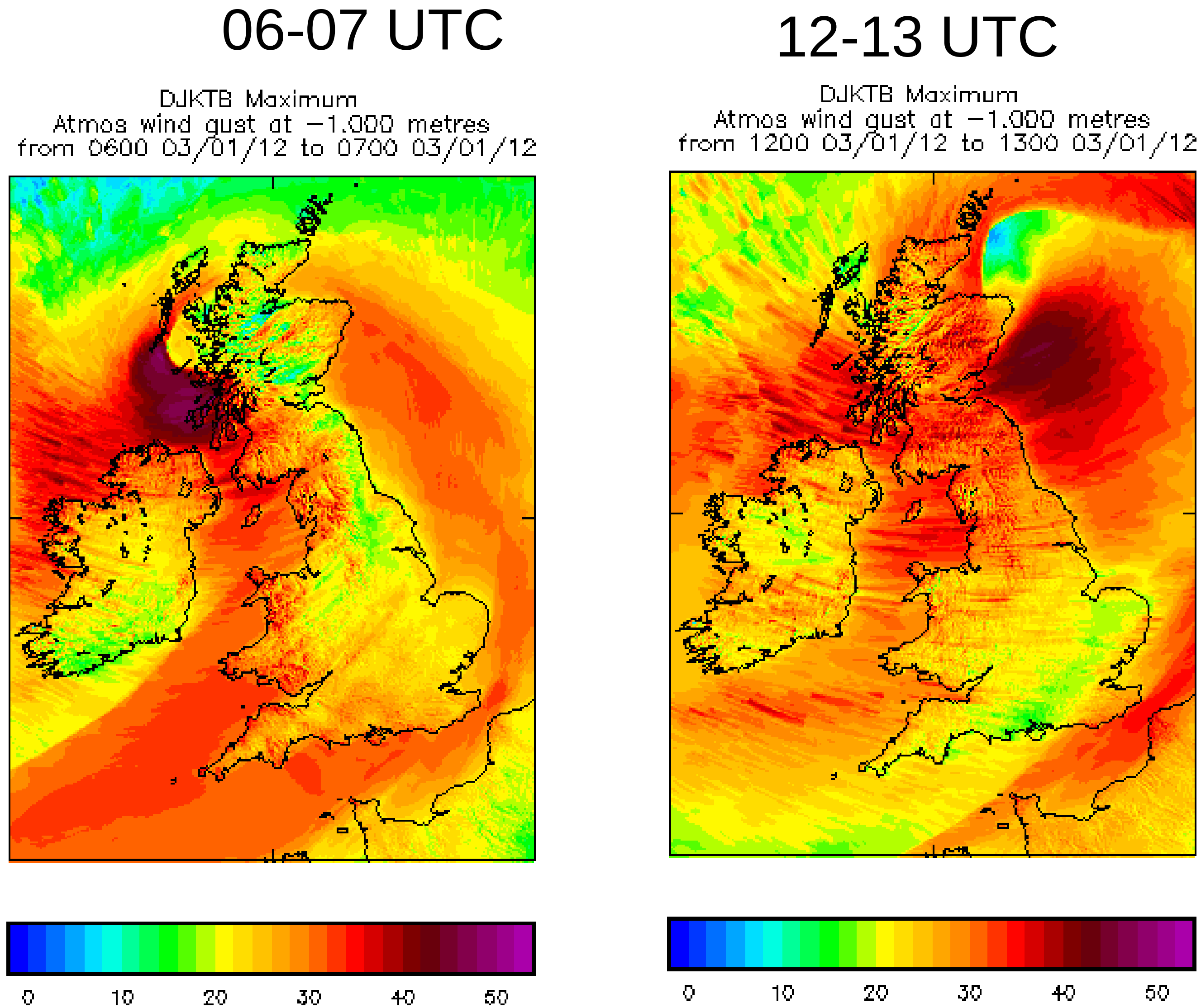
Cyclone Ulli: 03/01/12

- “The UKV has, in general, been over-estimating surface wind gusts, particularly in unstable regimes.
- The error increases with wind speed. Normally the error is around 5 to 10 knots, but at the higher end can be 20 knots or more.
- Model gusts associated with the sting jet event that took place across central Scotland on 3rd Jan peaked in the mid to high 50's of metres per second range.
- In reality measured peak gusts were around 90 knots, i.e. approx 20 knots lower than UKV.
- UK4 also generally over-estimates but to a lesser degree (around 5 knots or so).”

Analysis 03/01/12 06Z



UKV wind gust

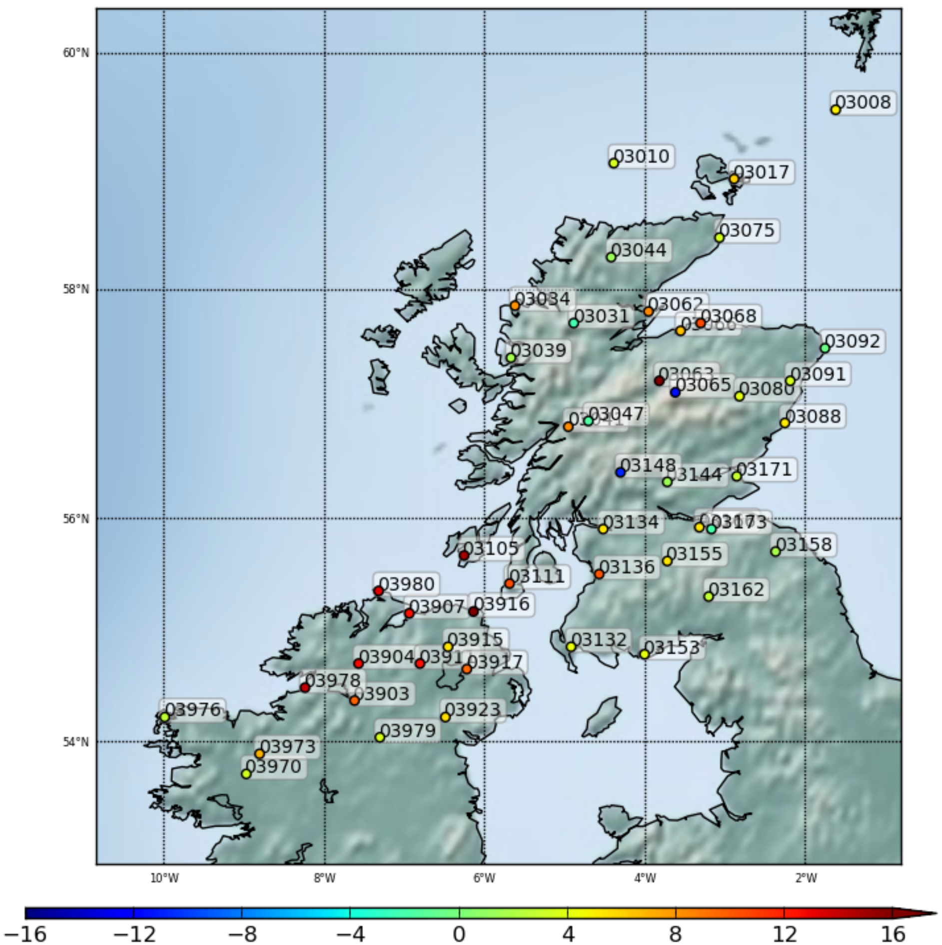


Wind gust verification 03/01/12 12z

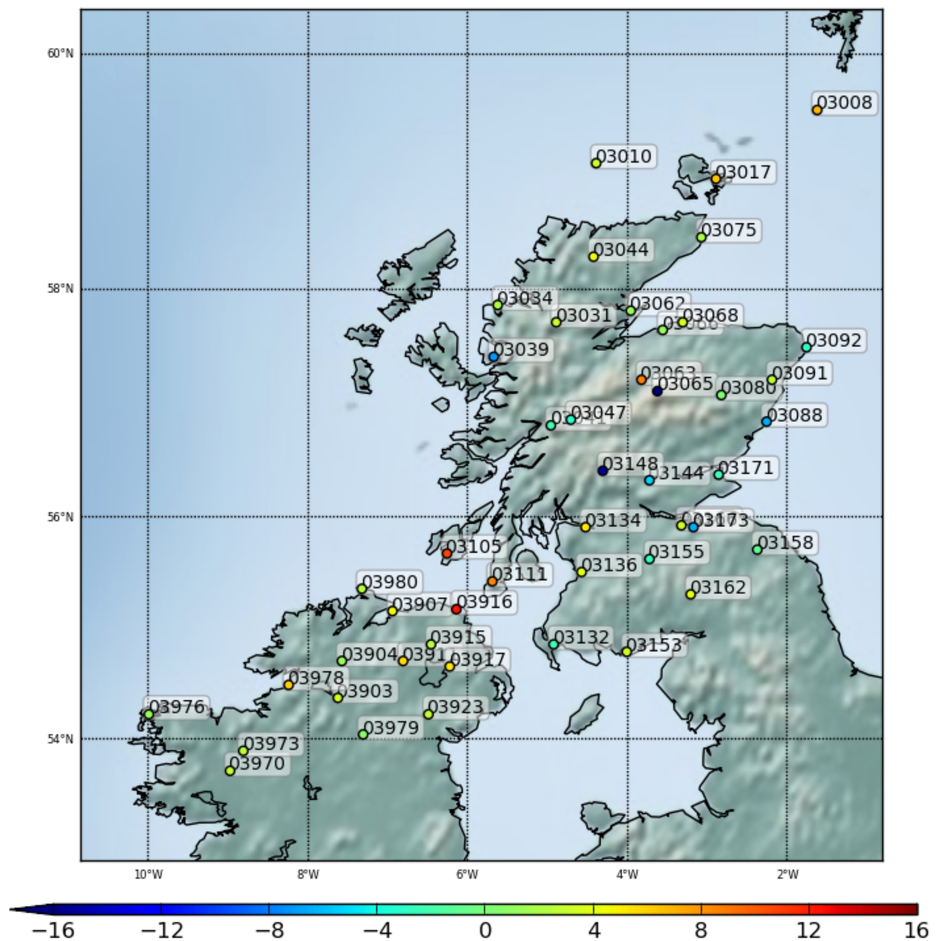
UKV T+9

UK4 T+9

Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UKV

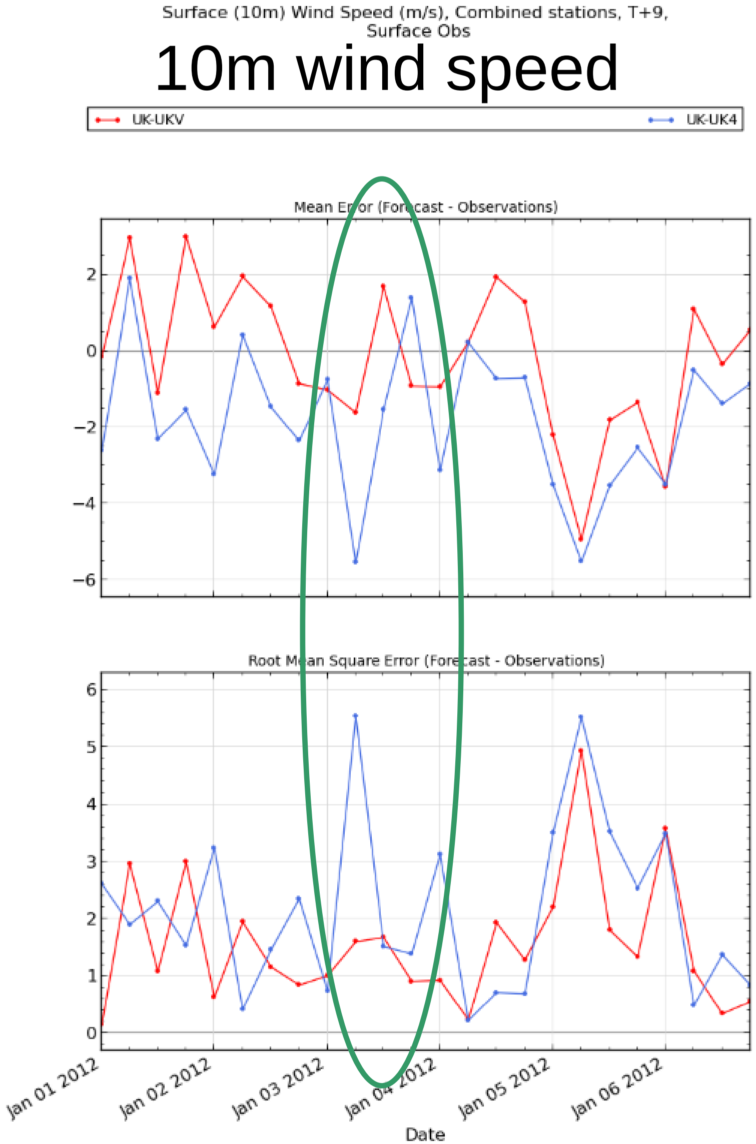


Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UK4



Bias and RMSE timeseries: 03978 Finner

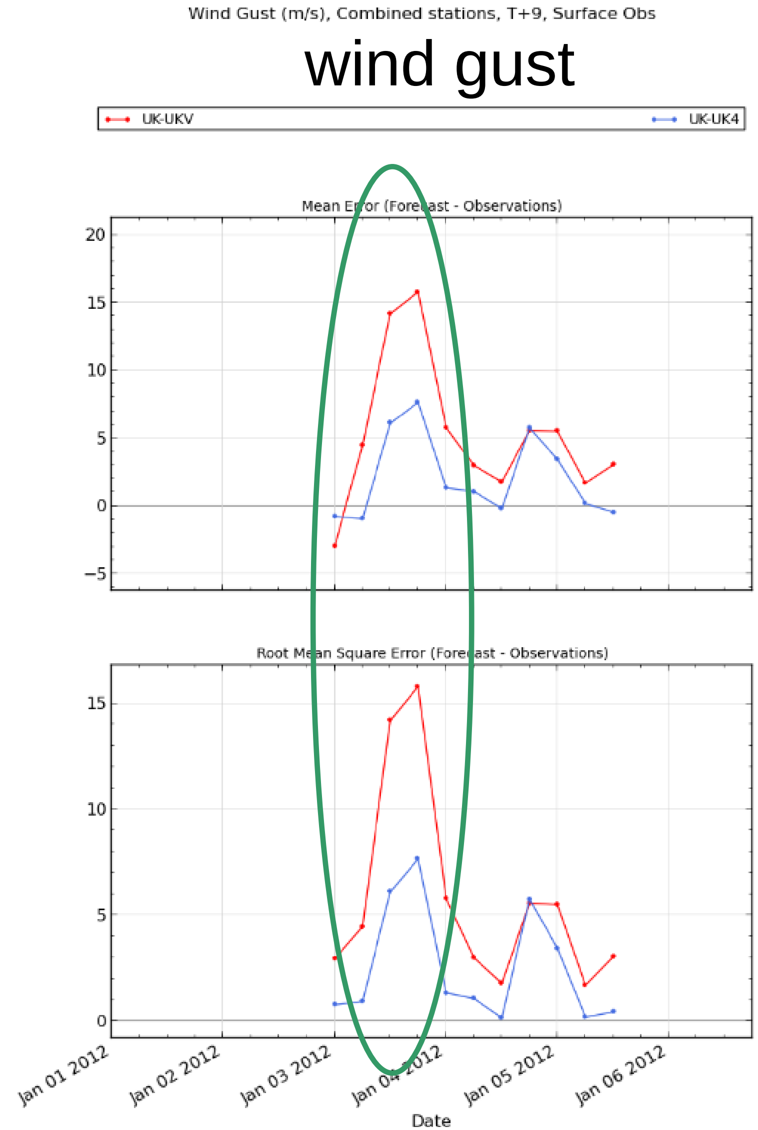
10m wind speed



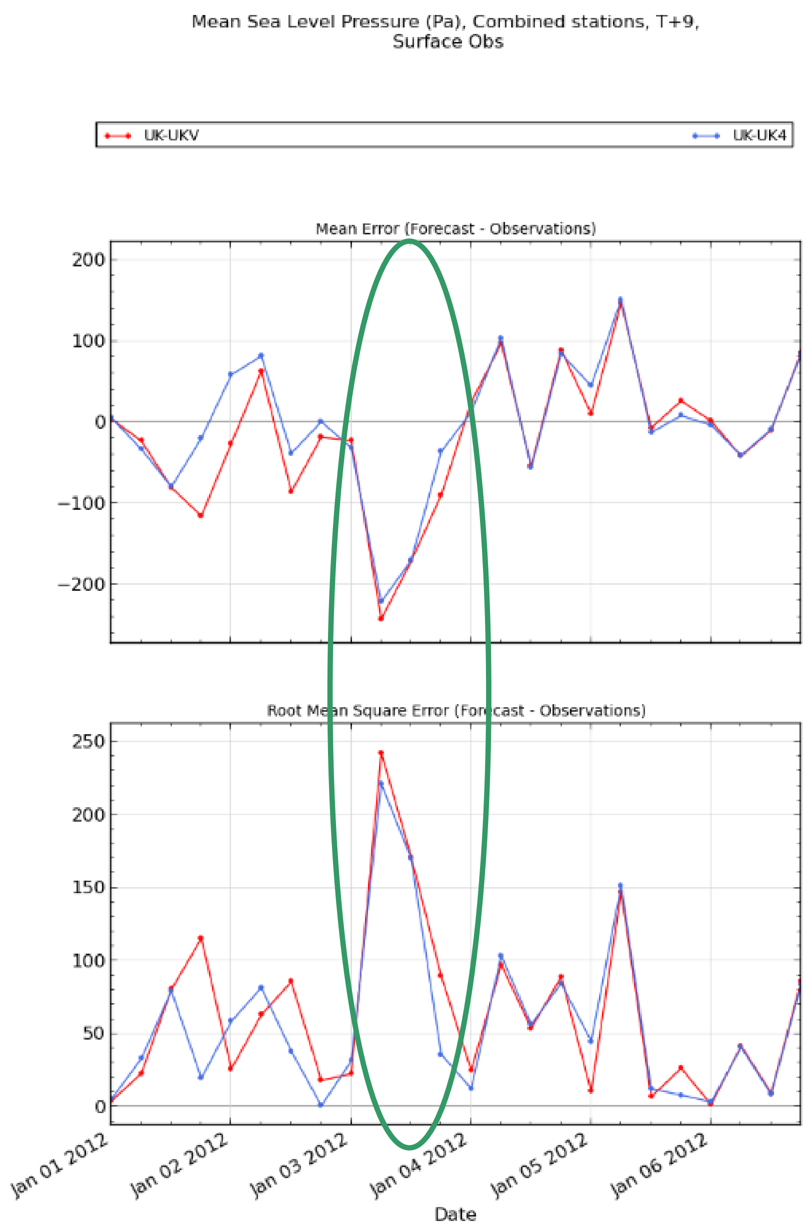
Bias

RMSE

wind gust



Bias and RMSE PMSL timeseries 03978

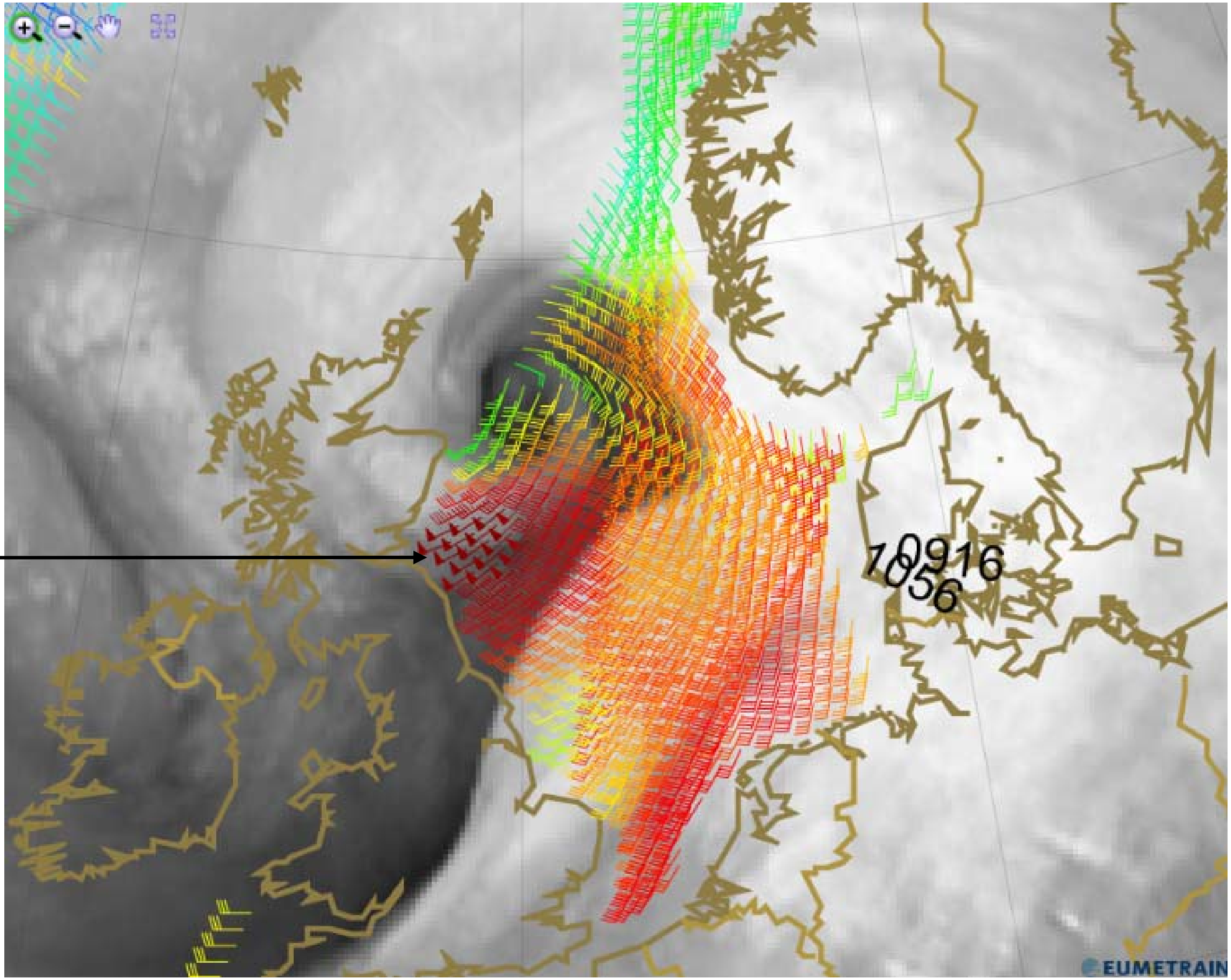


Bias

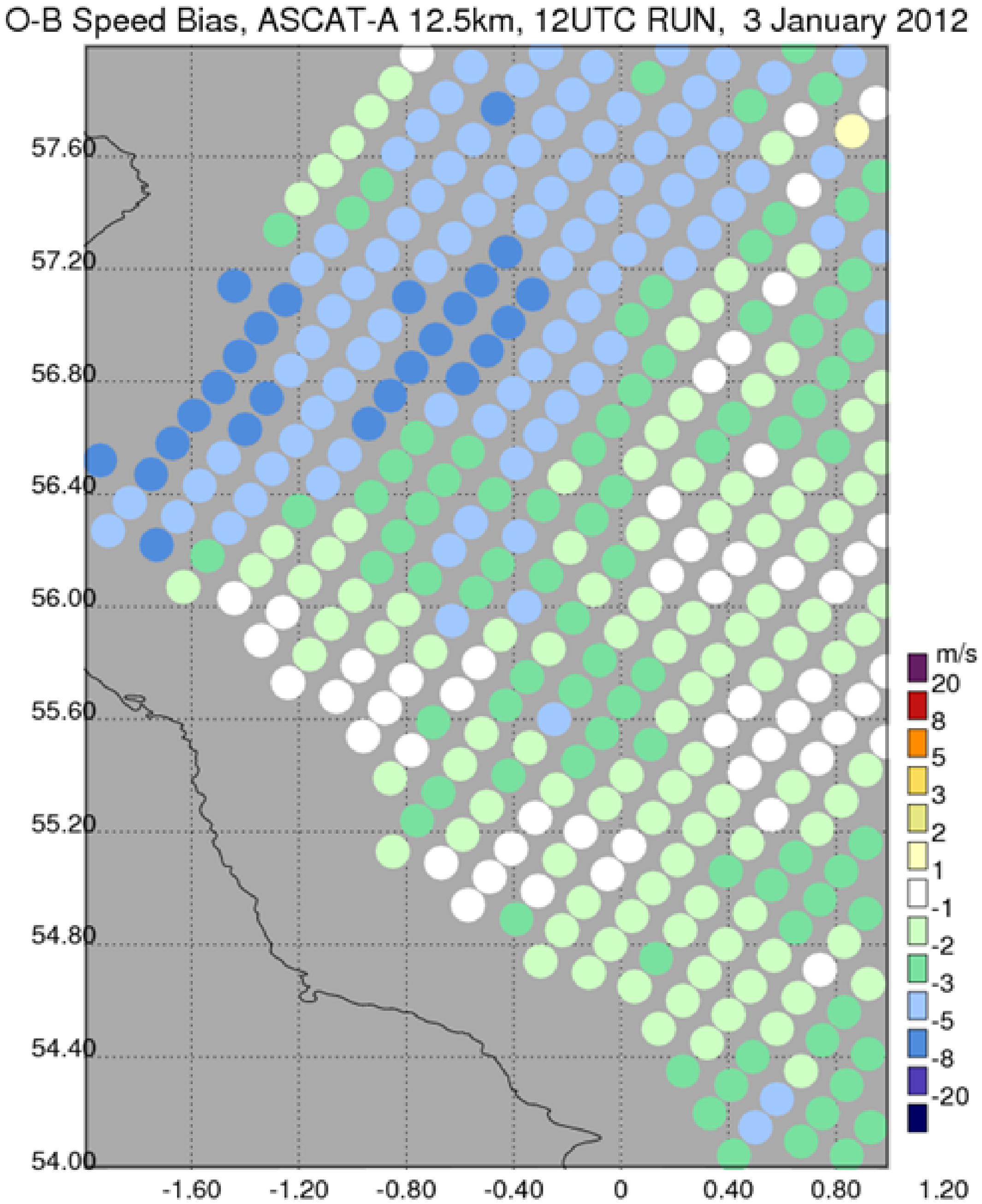
RMSE

Metop-A ASCAT winds 03/01/12 12Z

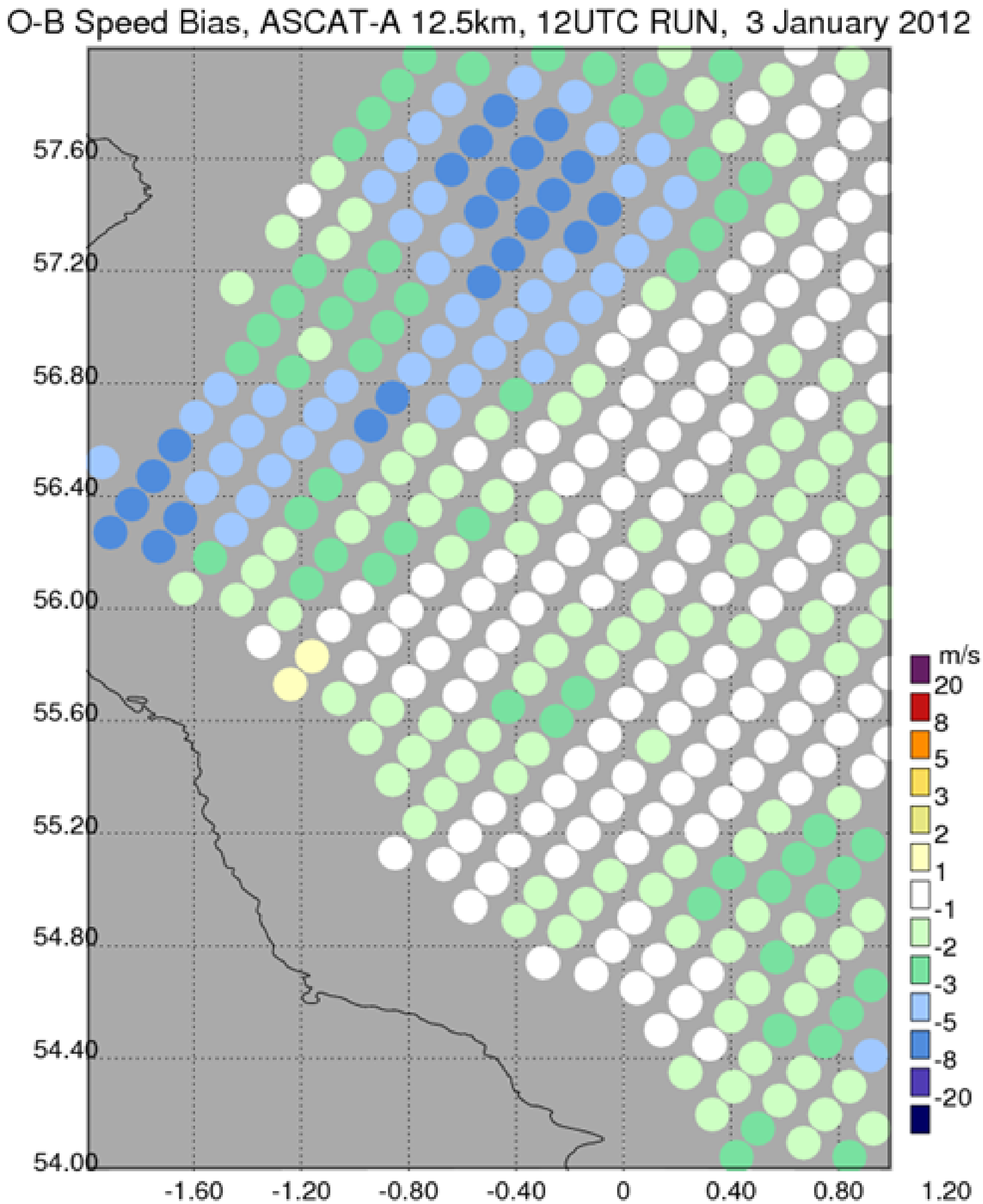
50 knots



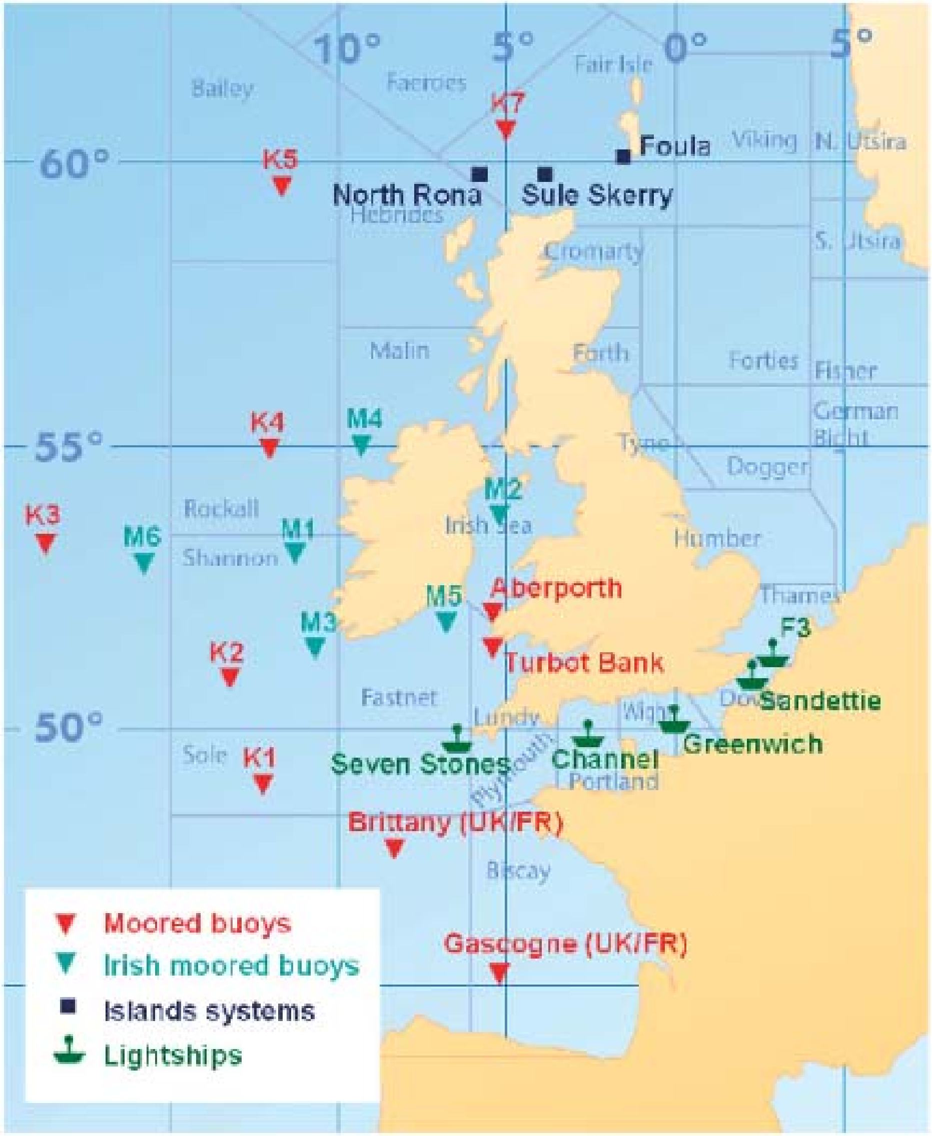
UKV O-B speed bias



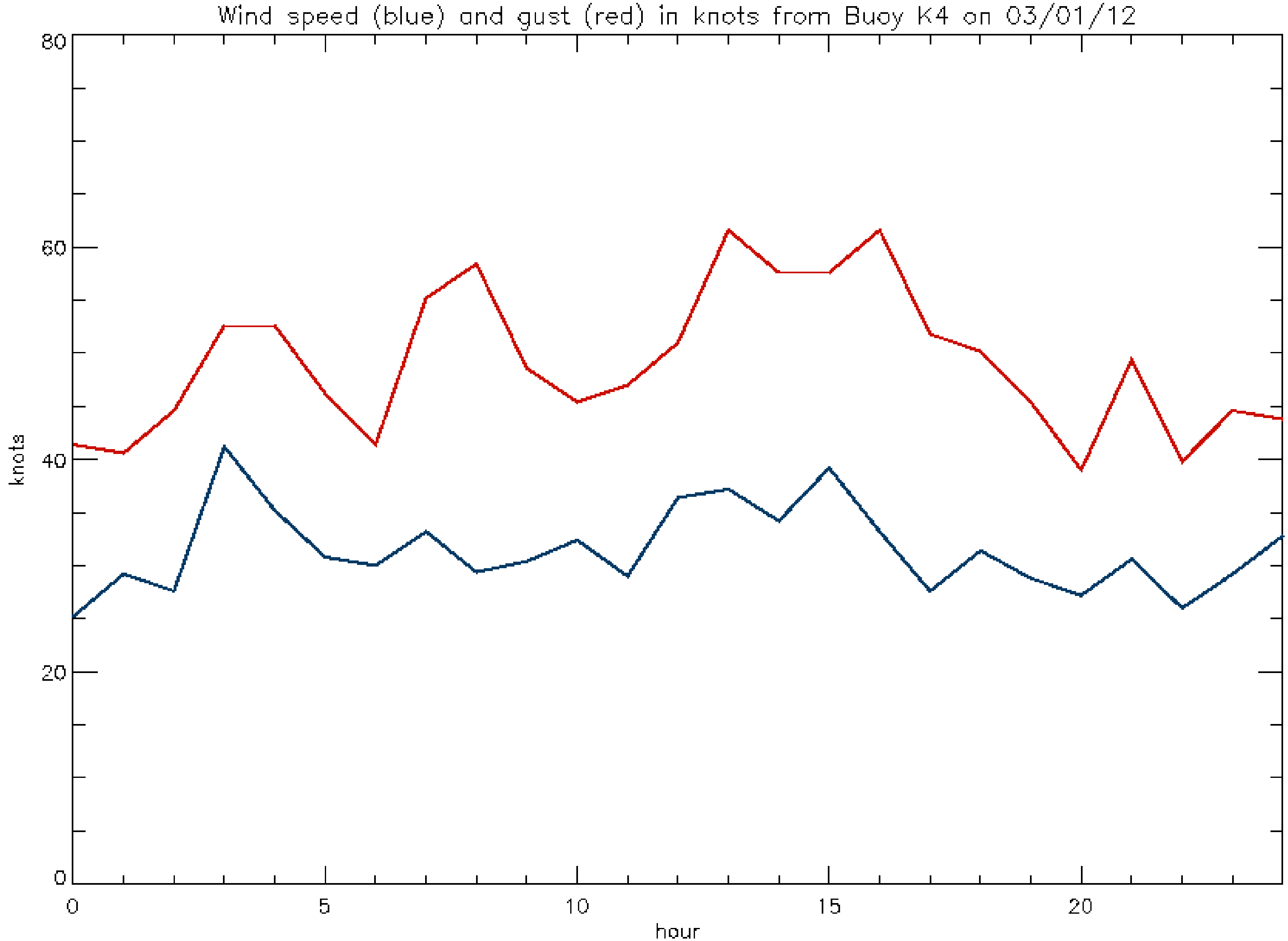
UK4 O-B speed bias



Location of Buoys Turton et al. (2008)



Buoy K4



Wind speed (blue) and gust (red) in knots from Buoy K4 on 03/01/12
80
60
40
20
0
knots
0
5
10
15
20
hour

Wind gust diagnostic

- Based on ECMWF diagnostic. Relies on calculations of boundary layer turbulence and vertical transport of momentum
- **gust_wind = 10m wind + sigma_u * f (c_ugn, z0m_eff)** [c_ugn= 4.0]
- It also takes into account BL stability:

$$\sigma_u = 2.29 u_* \left(1 - \frac{0.5}{12}\frac{z_i}{\mathcal{L}}\right)^{1/3} \quad \text{for } \mathcal{L} < 0 \quad \text{Unstable}$$

$$\sigma_u = 2.29 u_* \quad \text{for } \mathcal{L} > 0 \quad \text{Stable}$$

- z0m_eff for the UK4 >> UKV over land as orographic drag scheme is switched off in the UKV
- Over sea z0m_eff = z0m_sea = f (ustar squared)
- ustar is related to the mean wind speed
- Should be valid for UKV because the boundary layer turbulence should not be explicitly resolvable by a 1.5km model.
- Maybe not valid in the tropics (deep convection) but should be valid in the mid latitudes

Gust parametrizations (non convective)

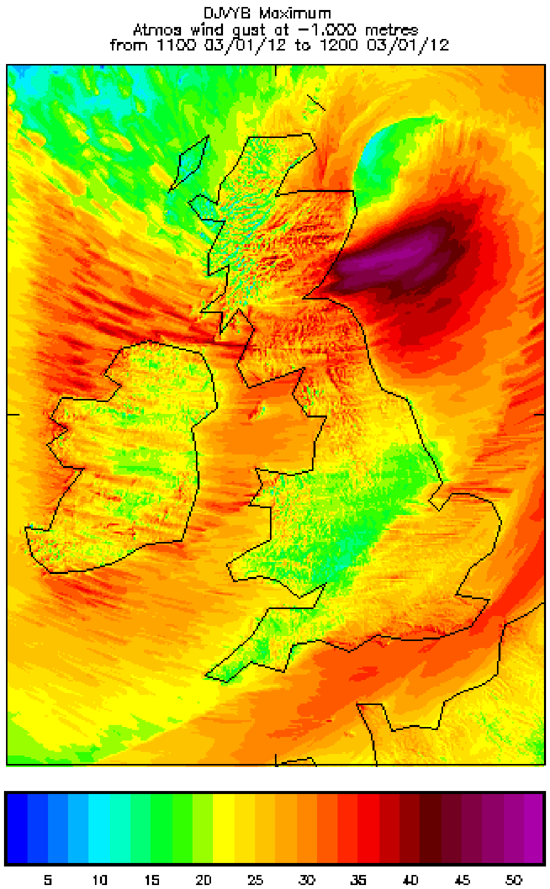
Met Office

Model/system	Met service	formula	references	notes
MetUM	Met Office	$U_g = U + \sigma f(\kappa, c_{ugn}, z_{0m\_eff})$	Panofsky and Dutton (1984)	$\sigma \sim u_*$, depends on mixed layer details
VMM	Met Office	$U_g = U + C\sigma$	Wilson et al. (2010), Wilson and Vosper (2011)	$\sigma \sim u_*$
IFS/HIRLAM	ECMWF/AEMET	$U_g = U + c_{ugn1}\sigma$	IFS documentation CY33R1:IV:3.12.4 Beljaars (1987), Panofsky et al. (1977) Calvo and Morales (2009)*, Calvo et al. (2010)* Della-Marta et al. (2009)*	$\sigma \sim u_*$, depends on mixed layer details $c_{ugn1} = 7.71$ (formerly function of z_{0m_eff})
COSMO-EU	DWD	$U_g = U + \alpha 2.4\sqrt{C_D}U$	Panofsky and Dutton (1984), Schulz (2008)	$u_* \sim \sqrt{C_D}U$
MM5/WRF	-	$U_g = U + c_{ugn1}\sqrt{C_D}U$	Simon et al. (2011)*	LGUST parameterisation
NIMROD/UKPP	Met Office	$U_g = (0.89 - 0.002U_{max})U_{max}$	Ashton (2004)*	U_{max} - max model wind 0-1km
ATWIS	RWIC	$U_g \sim U(z_{BL\_top})$	James and Block (1998)	Re-based turbulence threshold
MM5	AFWA	$U_g = U(z_{stable})$	LaCroix (2002)*	Often defaults to BL top
WRF	-	$U_g = f(U_{BL\_top}, z_{BL\_top})$	http://forum.wrfforum.com /viewtopic.php?f=8&t=948	
HIRLAM	KNMI	$U_g = U + gr_\sigma\sqrt{2E}$	Schreur and Geertsema (2008) Calvo and Morales (2009)*, Calvo et al. (2010)*	g - normalised gust for given probability E - turbulence intensity r_σ - anemometer sampling factor
ARPEGE/ AROME/ ALADIN	Meteo-France	$U_g = U + 3.5\sqrt{E(20m)}$	Seity et al. (2010)*, Calvo and Morales (2009)* Calvo et al. (2010)*	E - turbulence intensity Max U_g over 1 hr used
MM5	AFWA	See discussion	LaCroix (2002)* Agustsson and Olafsson (2009)*	WGE method
WRF	-	See discussion	Agustsson and Olafsson (2009)* Simon et al. (2011)*	WGE method
RAMS	HKO	See discussion	e.g. Chan et al. (2011)*	WGE method
GEM-LAM	CMC	See discussion	Higuchi et al. (2008)*	WGE method
CRCM	EC	See discussion	Goyette et al. (2003)*, Nilsson et al. (2007)*	WGE method
ALAPS	Antarctic CRC	See discussion	Adams (2004)	WGE method
LM	MeteoSwiss	See discussion	Walser et al. (2006)	WGE method

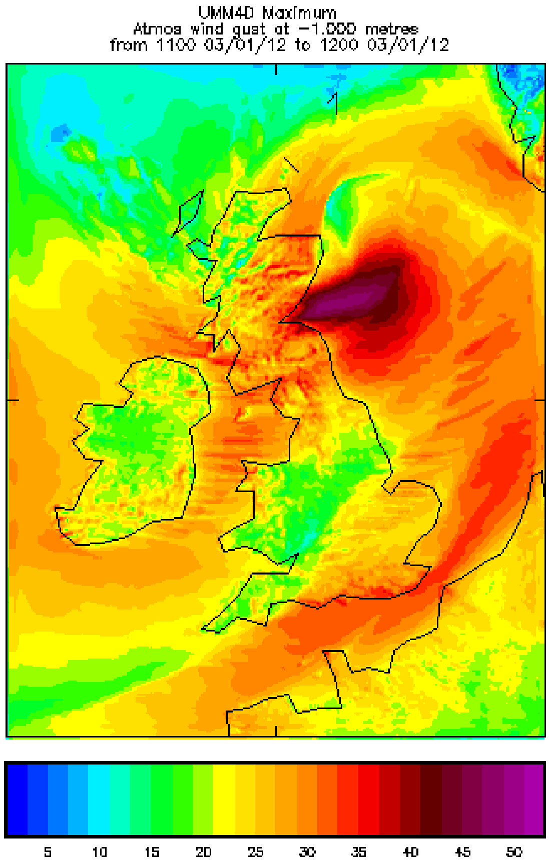
TABLE 1. Gust parameterisations/diagnostics used in different models and/or by different national met services. These may feature in NWP models, nowcasting systems, or simply ad hoc methods. Methods have been grouped in terms of similar bases. Original references or references which provide the basis for a given scheme are included where possible, and other appearances of each scheme in the literature are also given (* - not original reference). U refers to the 10m wind. The Advanced Transportation Weather Information System (ATWIS) is run by the Regional Weather Information Centre (RWIC) operating in Dakota.

Wind gust: UKV, UK4 and difference

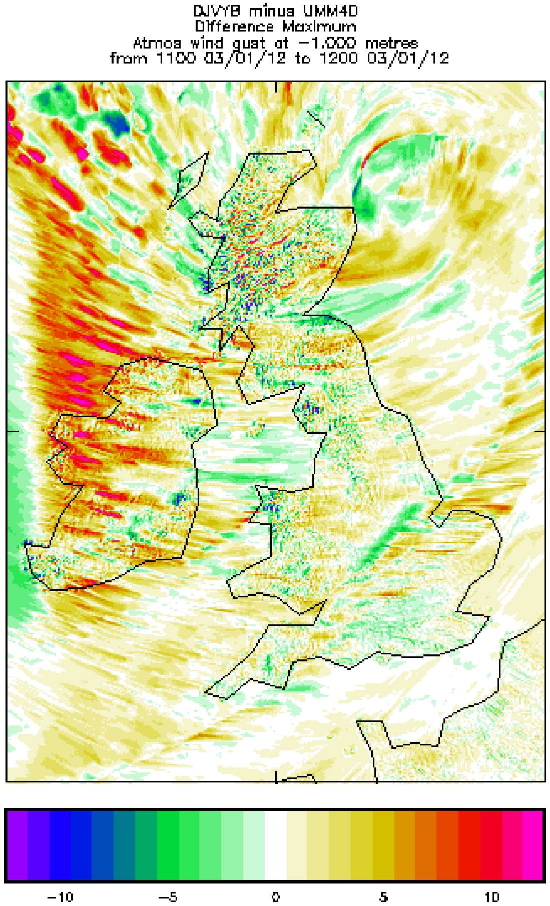
UKV



UK4

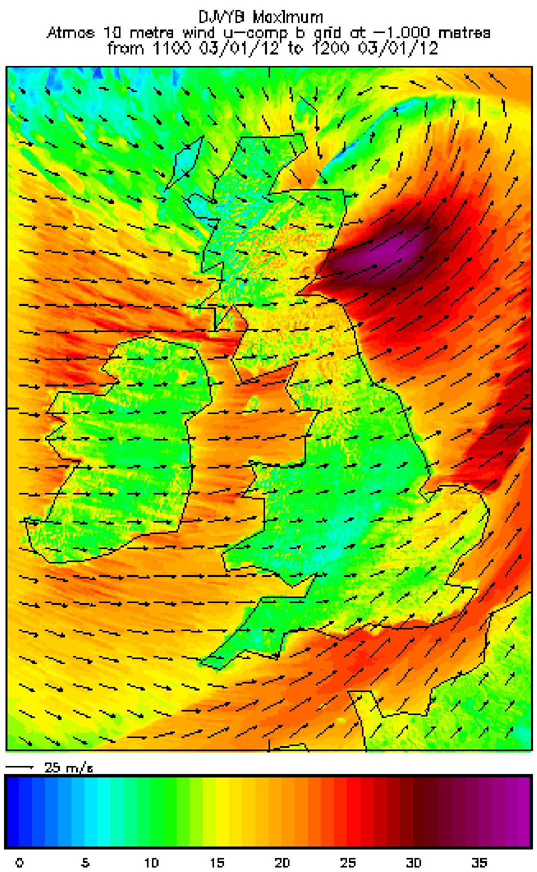


Difference

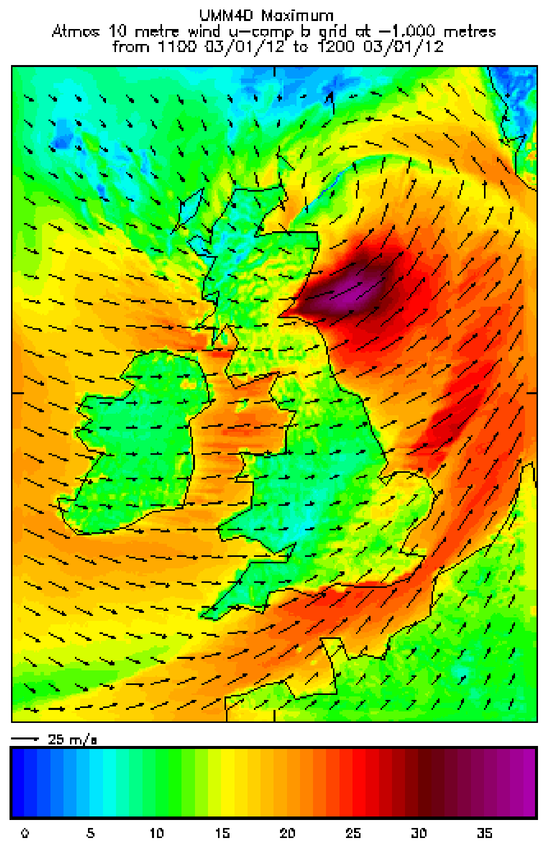


10m wind: UKV, UK4 and difference

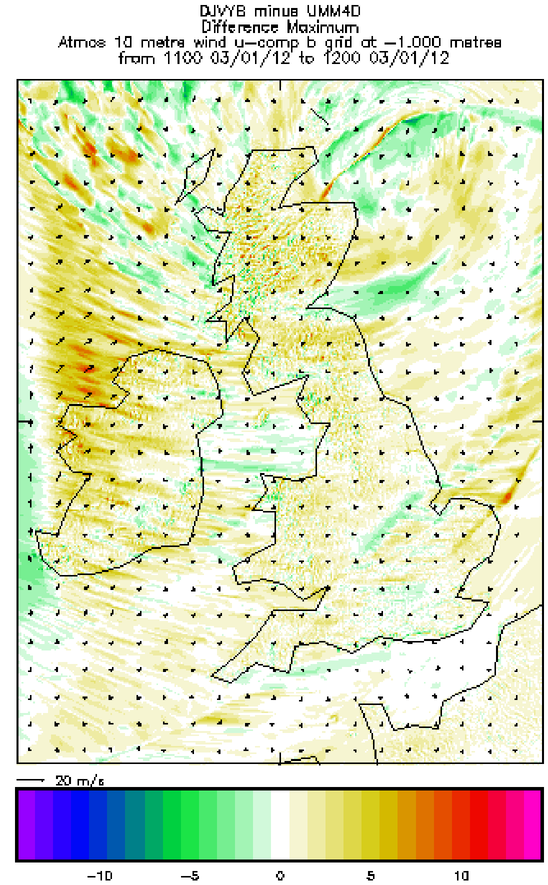
UKV



UK4

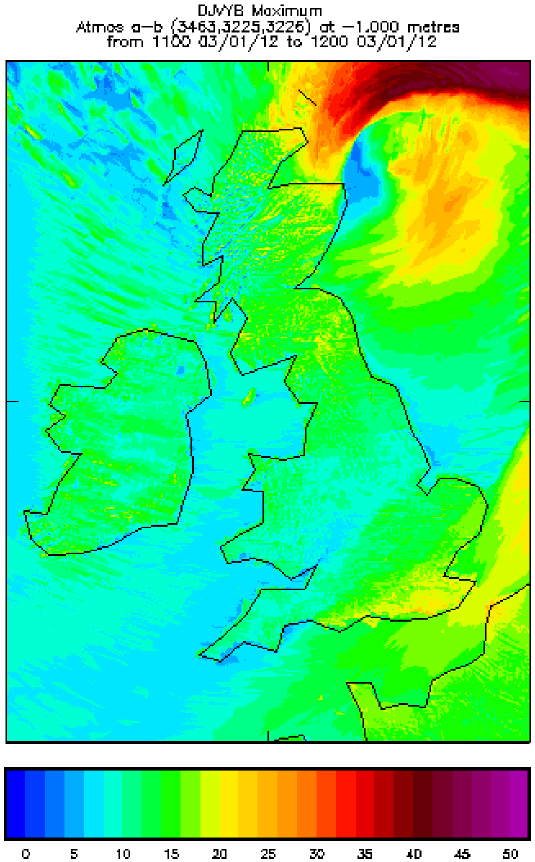
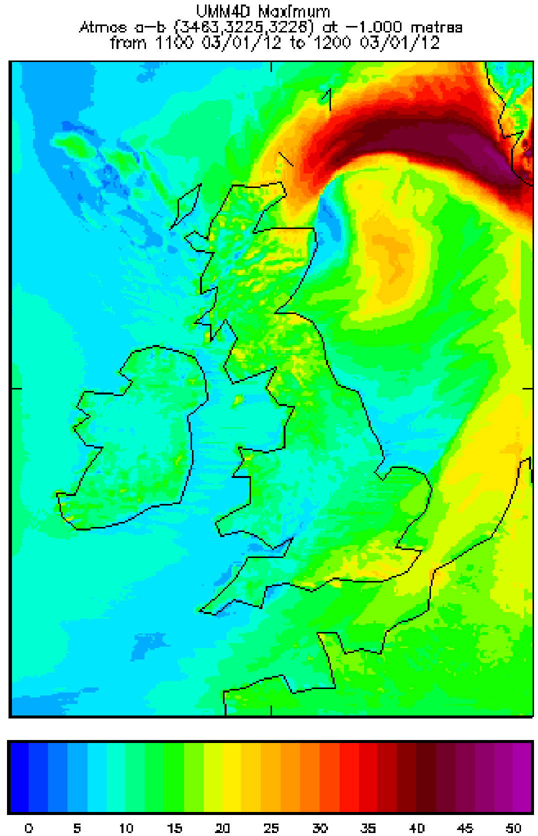
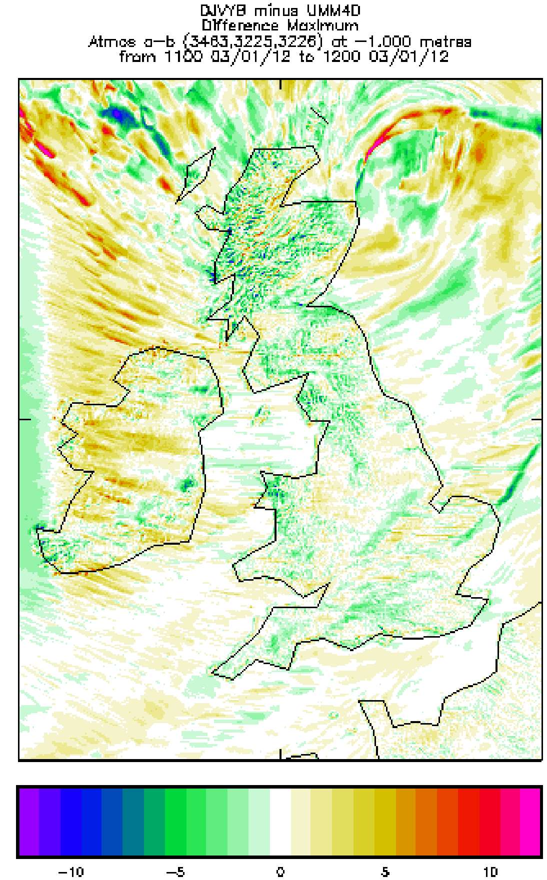


Difference



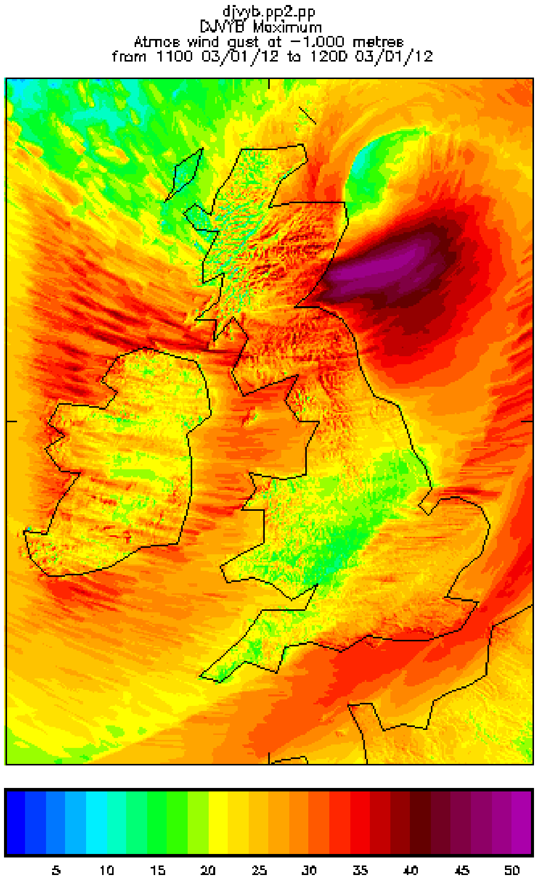
sigma_u * f (c_ugn, z0m_eff)

Met Office

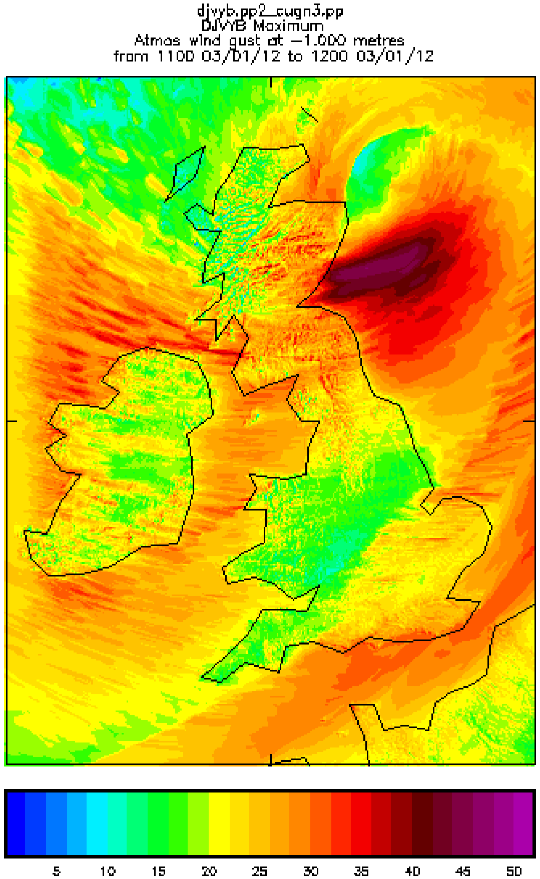
UKV	UK4	Difference
		

Impact of reducing c_ugn from 4.0 to 3.0

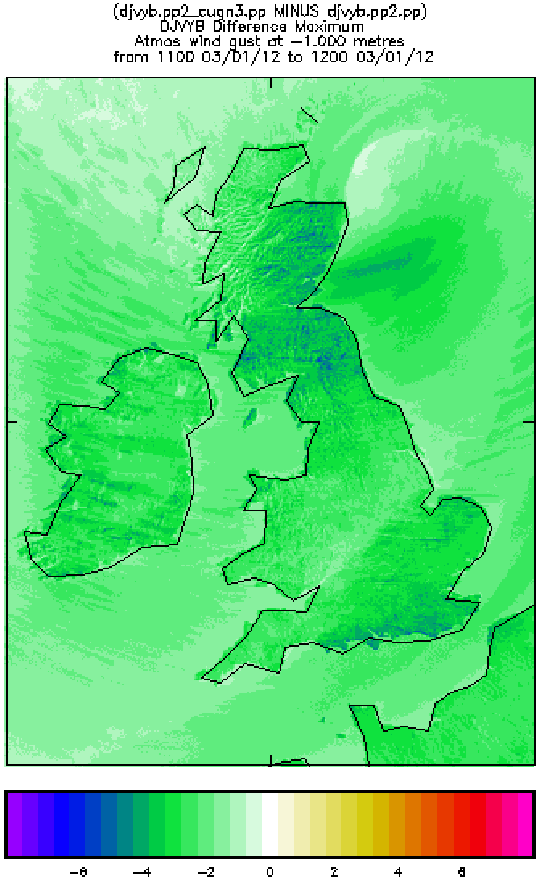
C_ugn=4.0



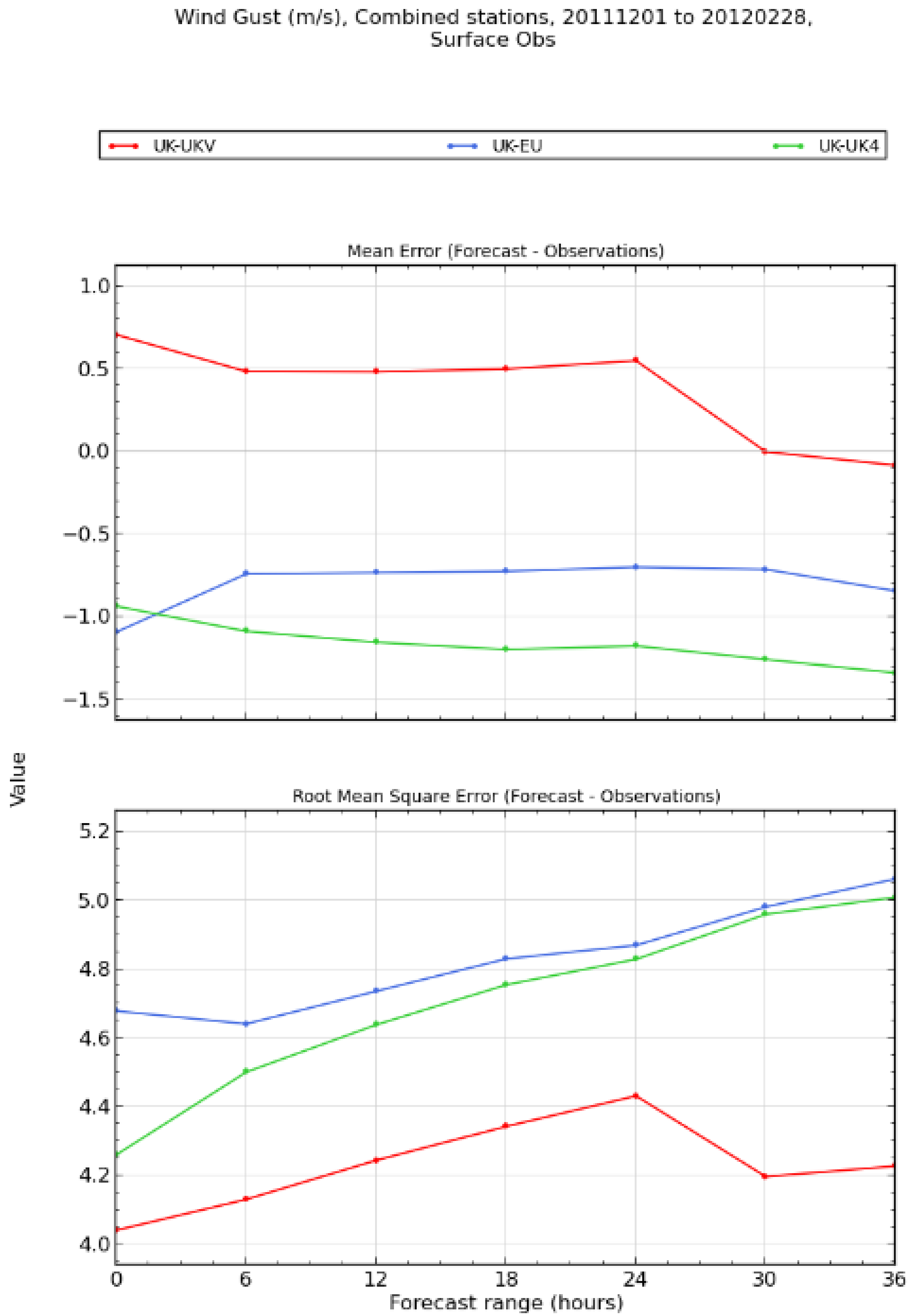
C_ugn=3.0



Difference



Met Office



Bias

Wind gust Verification

Error vs F/C range

Block 03 Land stations DJF11/12

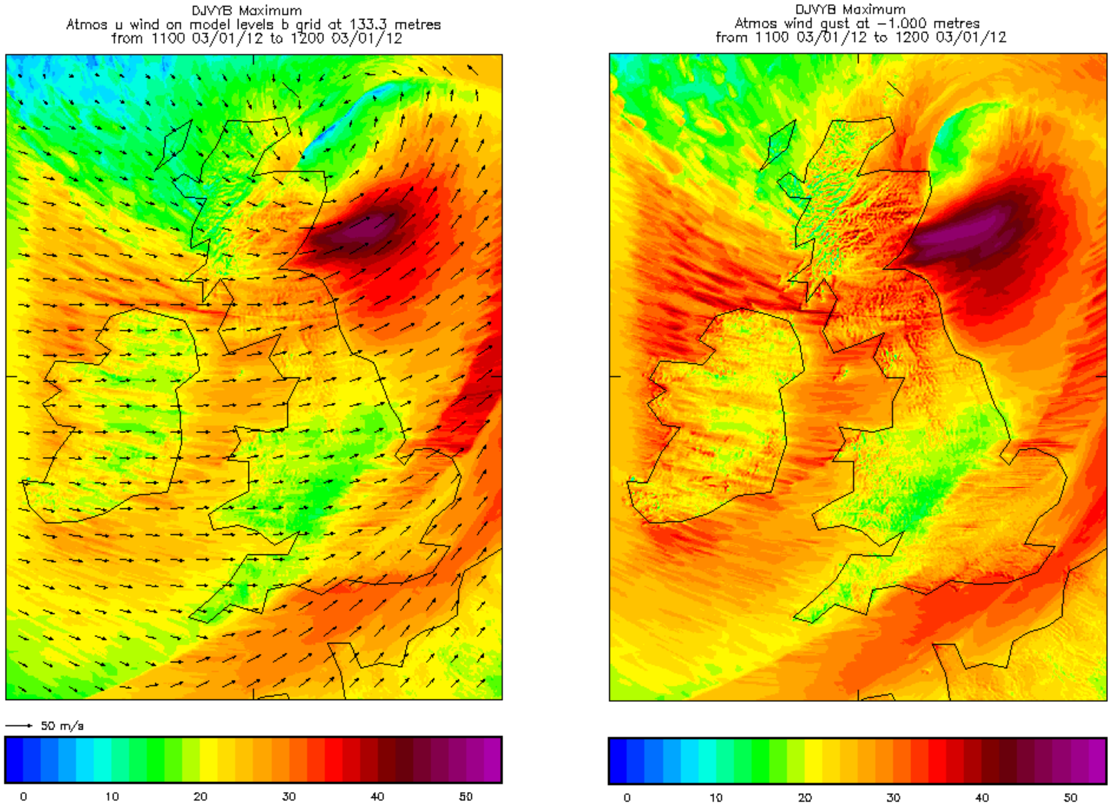
RMSE

Hypothesis and interesting questions

- UKV mean wind (10m) over convective areas is stronger than UK4
- This is may be because it is partly resolving convective motions
- These differences are amplified by the way the wind gust diagnostic is written
- It is difficult to get obs to verify even the mean wind over the sea in these for this event!
- It would be interesting to know whether the diagnostic would produce a correct gust given a perfect mean wind as input.
- Have other modelling consortia seen similar behaviour?
- John Edwards testing a wind speed dependent Charnock parameter (increases with wind speed, increasing z0m_sea)

UKV model level 6 winds and gust

- Operational change to the UKPP (Post Processing) system (fed by the UKV) planned for 18th June 2013
- Model level winds at 150m will be used instead of gust diagnostic



Conclusions

• The NWP Problem Group is a forum where forecasters and modellers meet on a regular basis and discuss progress on model problems.

• Some problems already have a research plan in place to tackle them (for example the stable boundary layer package).

• Other problems such as the wind gust example can lead to more emphasis being placed on certain aspects of the research plan

• Mark weeks will spend 3 months investigating wind gusts with Simon Vosper and Peter Sheridan. Originally the aim was to look at orographic flow related gusts but the remit has now been broadened.

Questions

Standard Reporting form

To submit a problem for review please complete the form below, paste supporting images into this document and send to Steve Willington.

Reported by:	
Nature of model problem (eg visibility, precipitation, temperature etc):	
Detailed description of problem:	
Is this a one-off or a systematic problem:	
Date(s) on which model displays problem:	
Runs of model and validity time (eg QV03 run of the model validating at 12z on the xx^th^)	
Is the model post-processed or raw?	
Platform model data is being viewed on (eg Visual Weather, UKPP website etc):	
Does the problem affect more than one configuration? If so which ones?	
Are there verifying obs to hand? Please include as this speeds up subsequent investigations.	
Are there snapshots of models images (eg NWP fields, forecast profiles) illustrating the problem. Again please include as this speeds up subsequent investigations	

Actual minima (degrees)

Met Office

- Holbeach (Lincolnshire): -15.6
- Wainfleet (Lincolnshire): -14.4
- Marham (Norfolk): -14.3
- Scampton (Lincolnshire): -13.4
- Coningsby (Lincolnshire): -13.2
- Church Fenton (North Yorkshire): -12.9
- Leconfield (East Yorkshire): -12.7
- Benson (Oxfordshire): -12.5
- Wittering (Cambridgeshire): -12.5
- Bedford (Bedfordshire): -12.3
- Northolt (Greater London): -9.6

Surface stress: ustar

- z0m_sea = (alpha * Ustar squared)/g
- Alpha = Charnock parameter = 0.018
- Ustar ~ mean wind speed/20
- Ustar is the vector sum of surface stress components (i.e. Stress evaluated at z=0)
- Ustar = ((u'w'_bar)^2 + (v'w'_bar)^2)^0.25 (units m/s)
- It gives an idea of the strength of eddies generated by surface friction or surface drag.
- du/dz = Ustar/kz

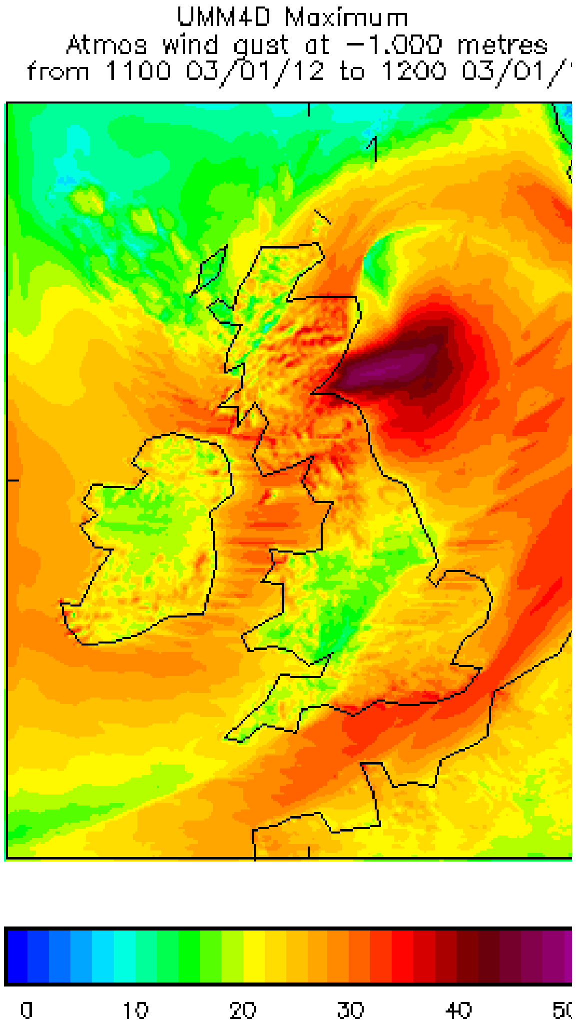
Impact of time processing (UK4)

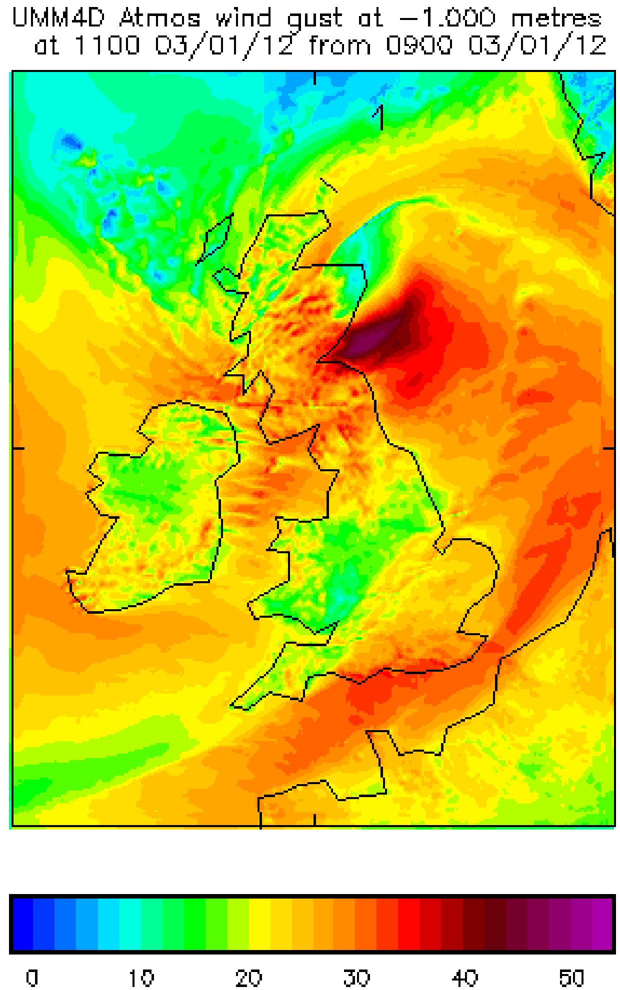
instantaneous

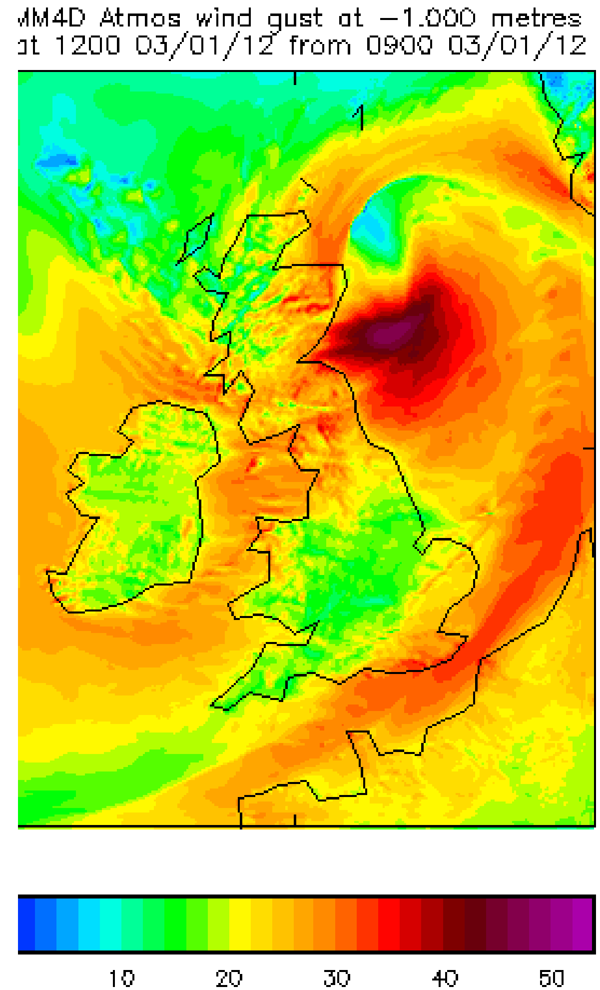
max in preceding hour

11Z

12Z

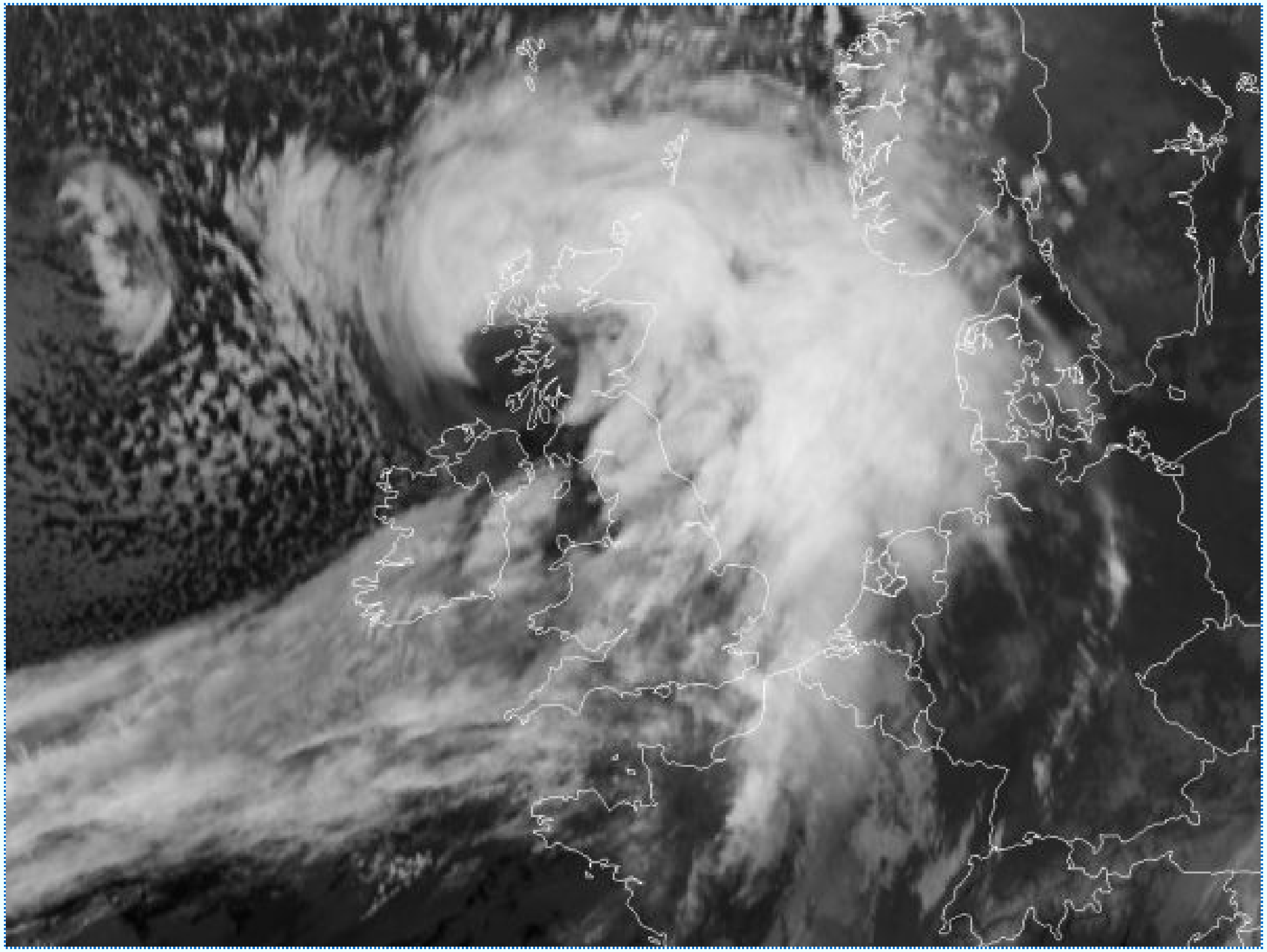






Meteosat-9 IR Image 03/01/12 06 UTC

Meteosat-9 IR10.8 Image



Met-9, 3 January 2012, 06:00 UTC
Channel 09 (IR10.8)

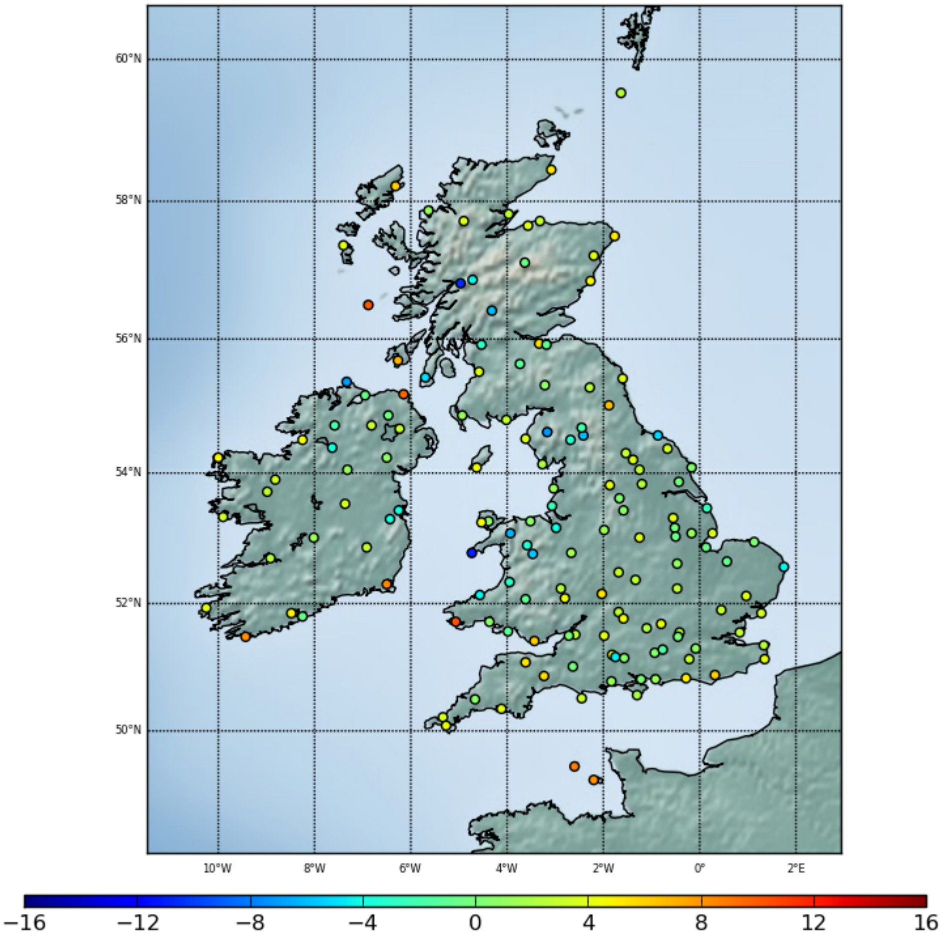
Wind gust 03/01/12 06z

Met Office

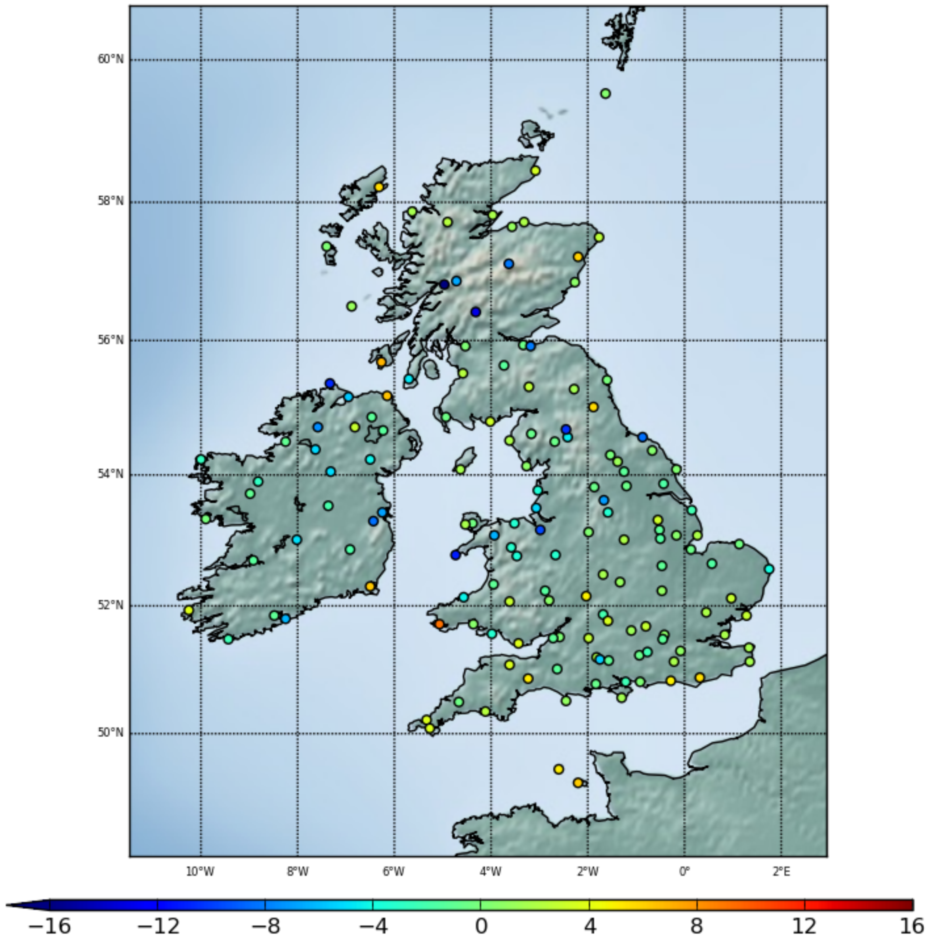
UKV   T+9

UK4   T+9

Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UKV



Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UK4

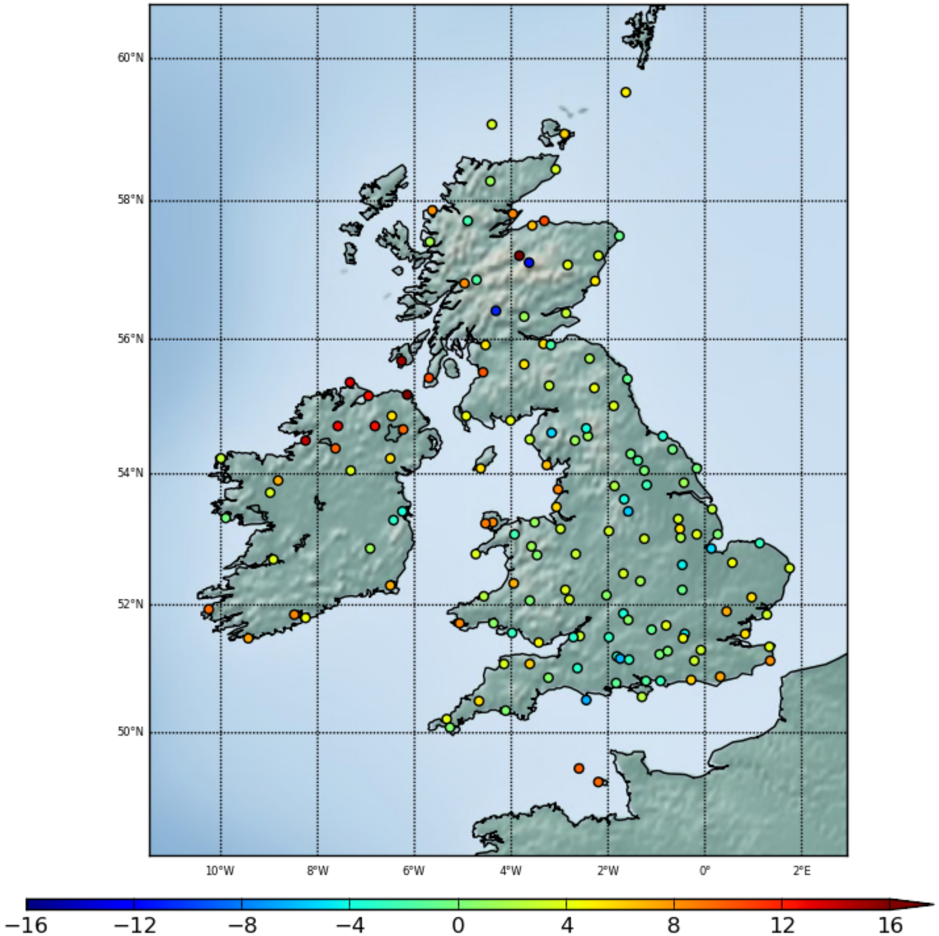


Wind gust 03/01/12 12z

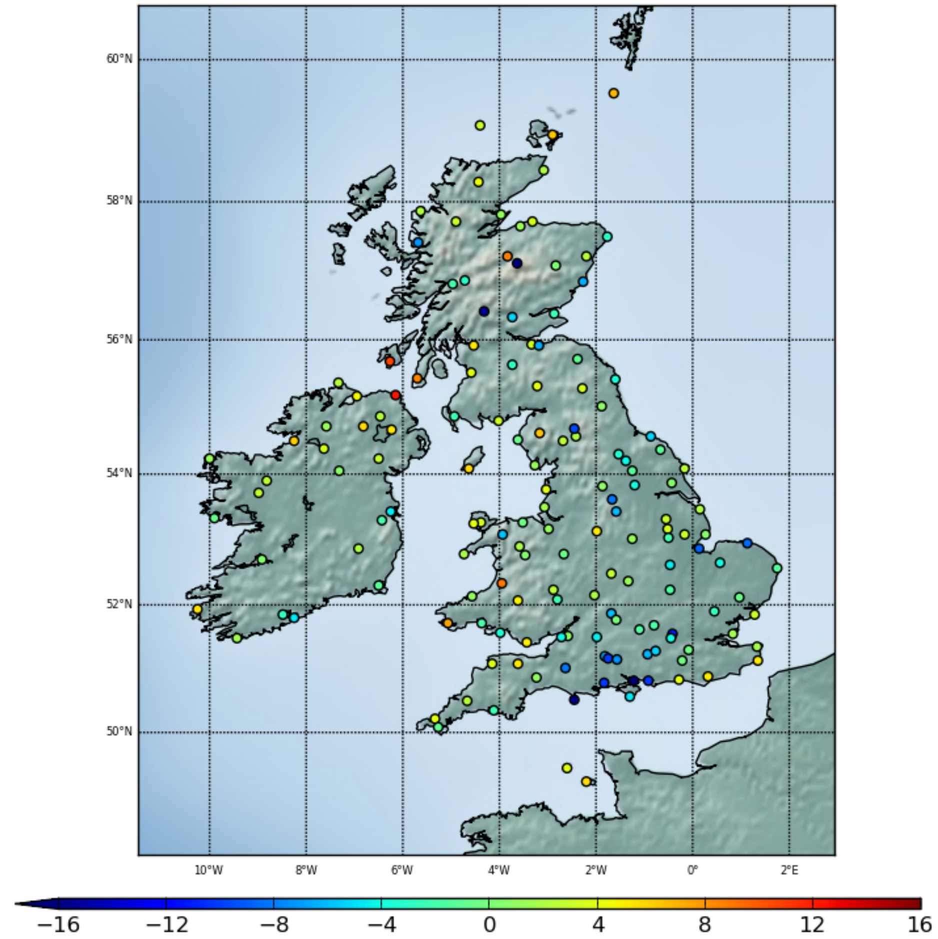
UKV T+9

UK4 T+9

Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UKV



Wind Gust (m/s), Mean Error (Forecast - Observations), T+9, 20120103 to 20120103, Surface Obs, UK-UK4



Bias and RMSE Timeseries 03001-03200 and 03901-03930

Surface (10m) Wind Speed (m/s), Combined stations, T+9, Surface Obs

10m wind speed

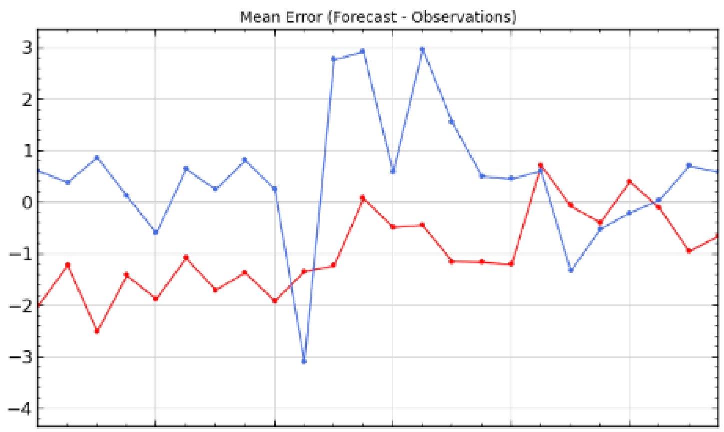
UK-UKV   UK-UK4

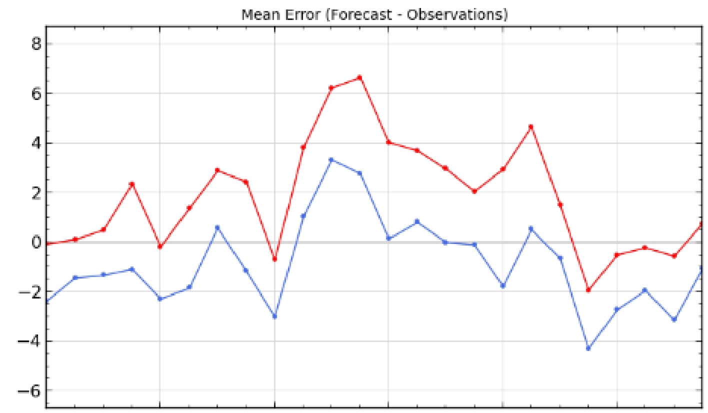
Wind Gust (m/s), Combined stations, T+21, Surface Obs

wind gust

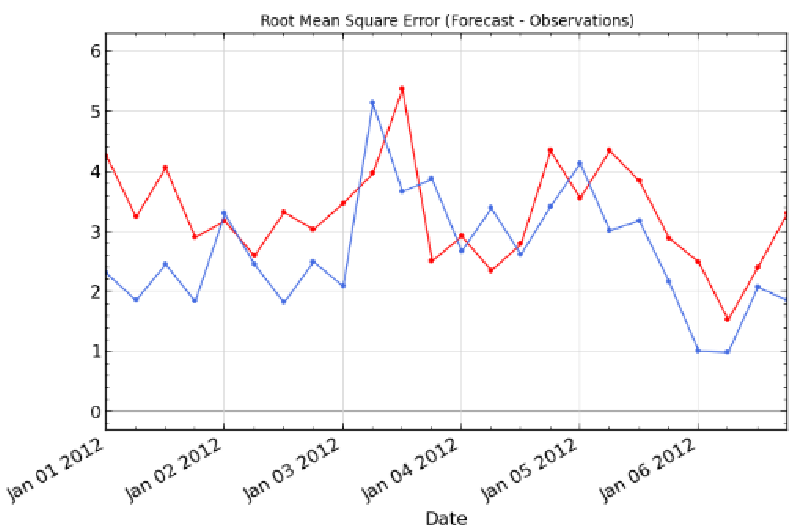
UK-UKV   UK-UK4

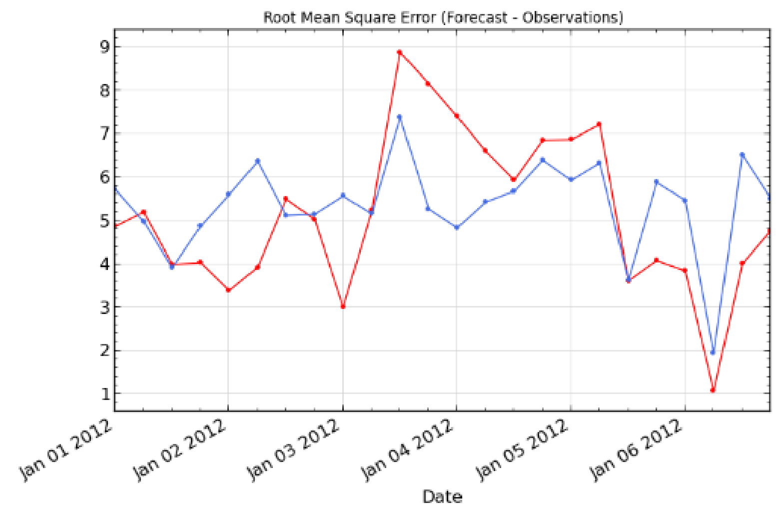
Bias



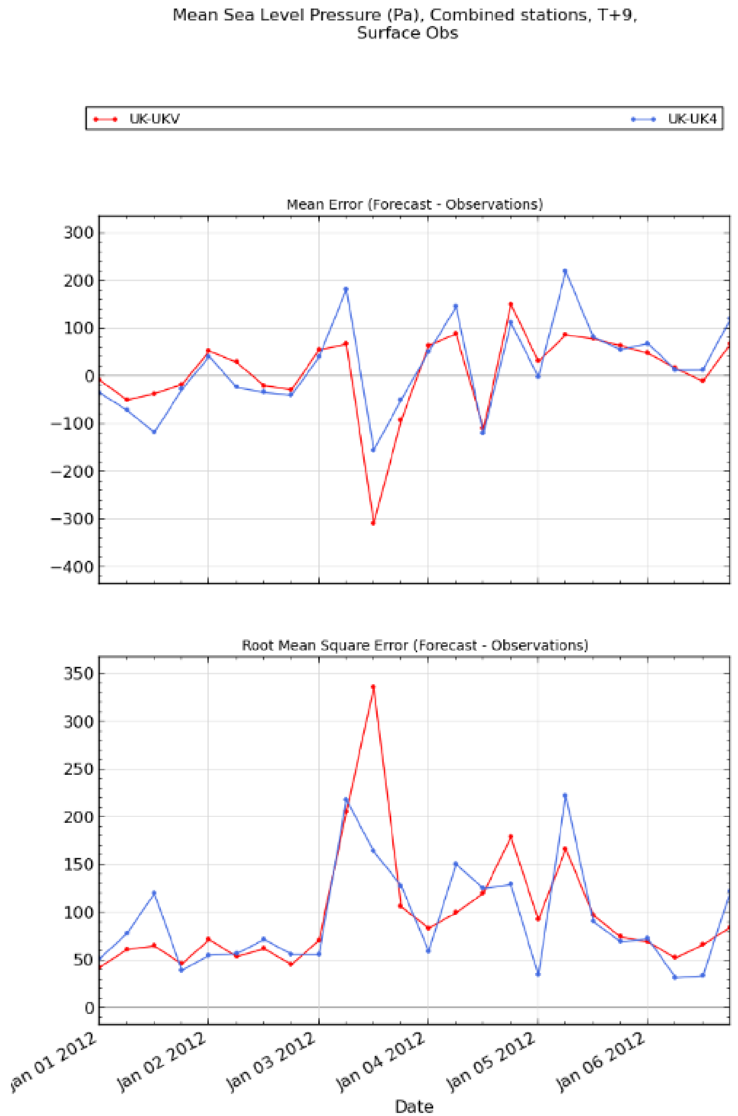


RMSE



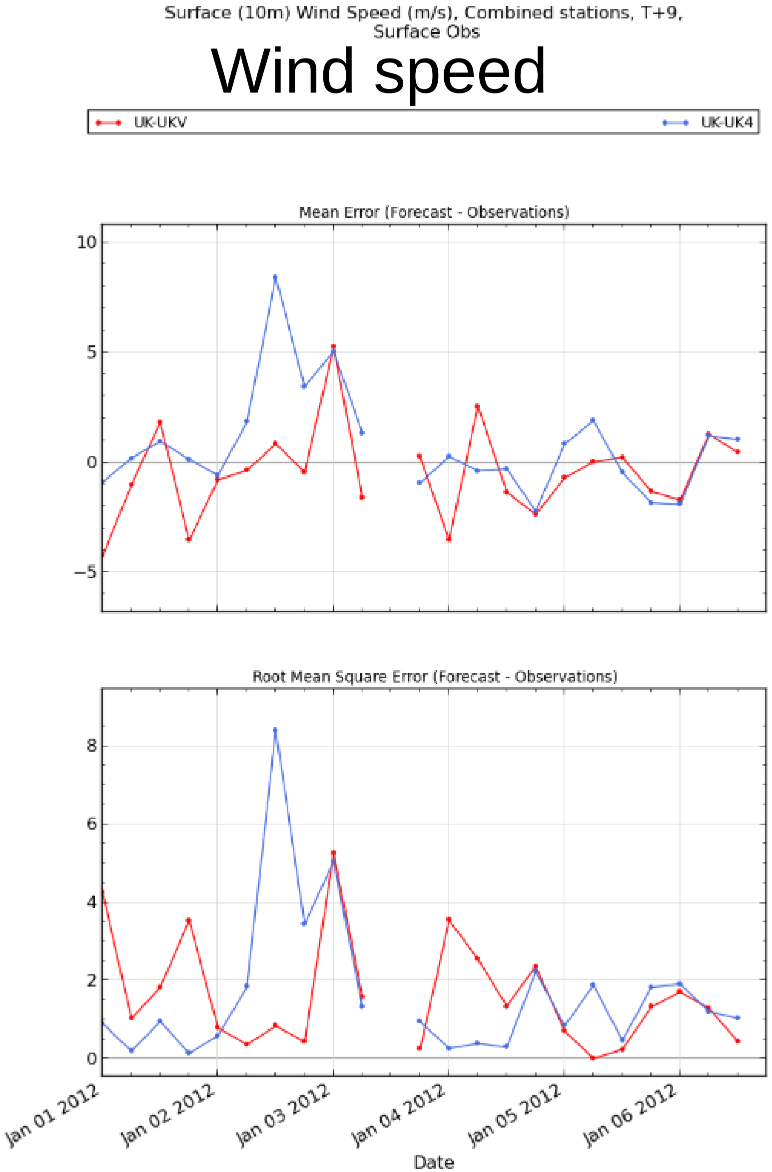


Bias and RMSE PMSL Timeseries 03001-03200 and 03901-03930

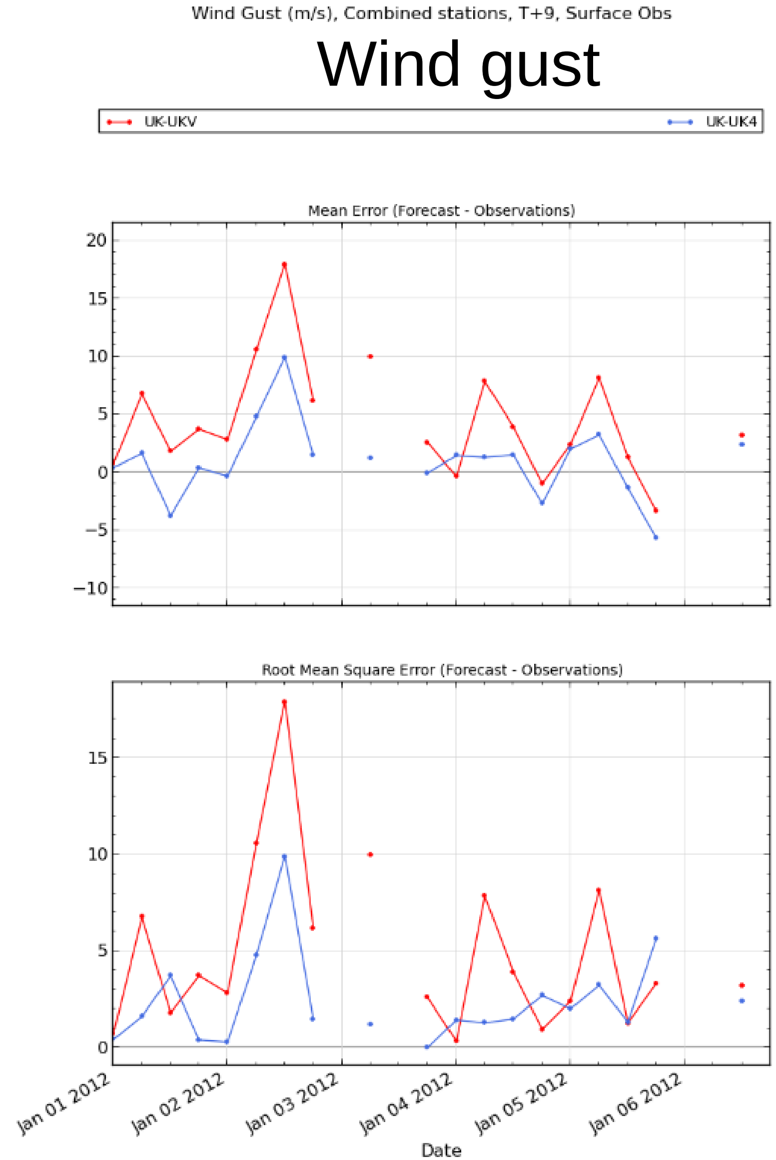


Bias and RMSE timeseries: 03100 Tiree

Wind speed



Wind gust

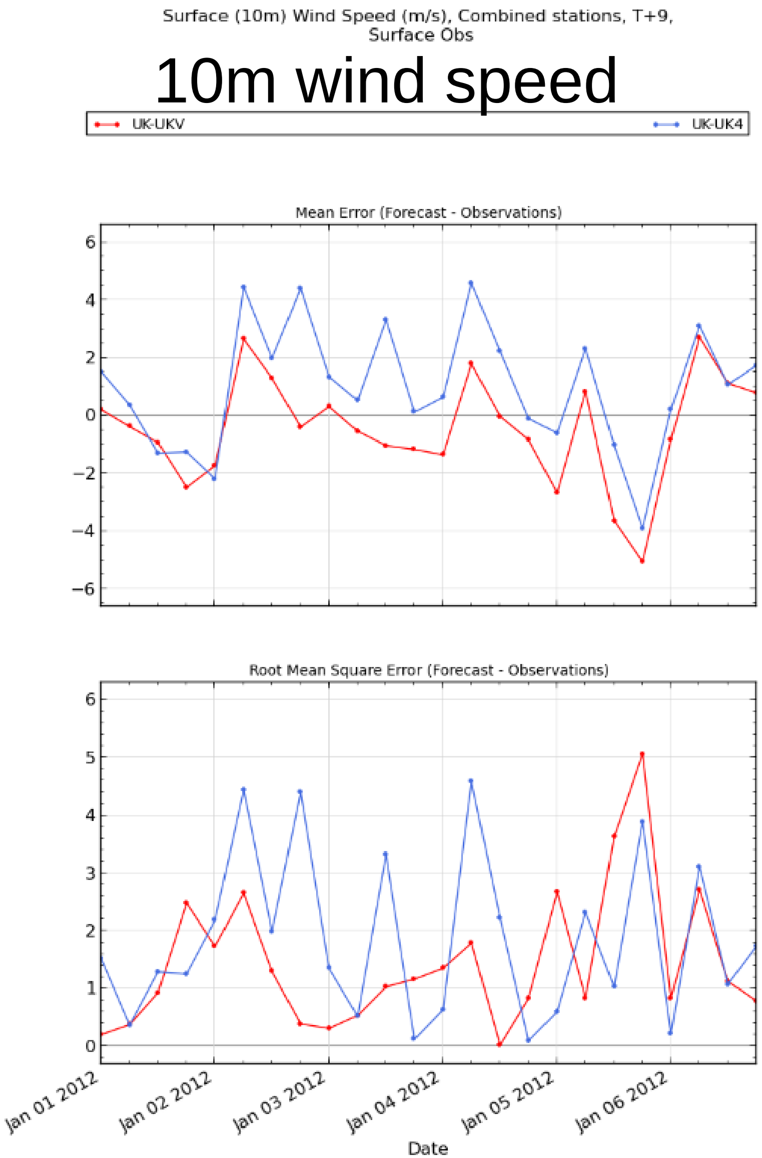


Bias

RMSE

Bias and RMSE timeseries: 03105 Port Ellen

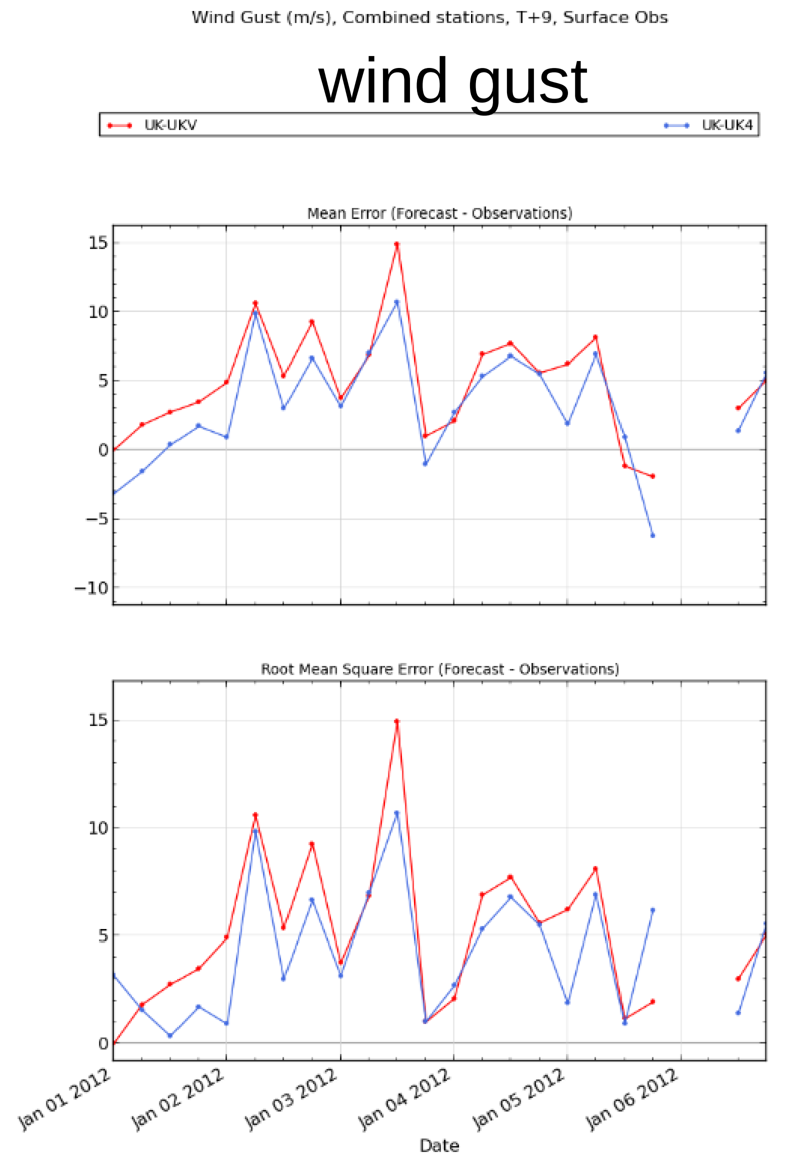
10m wind speed



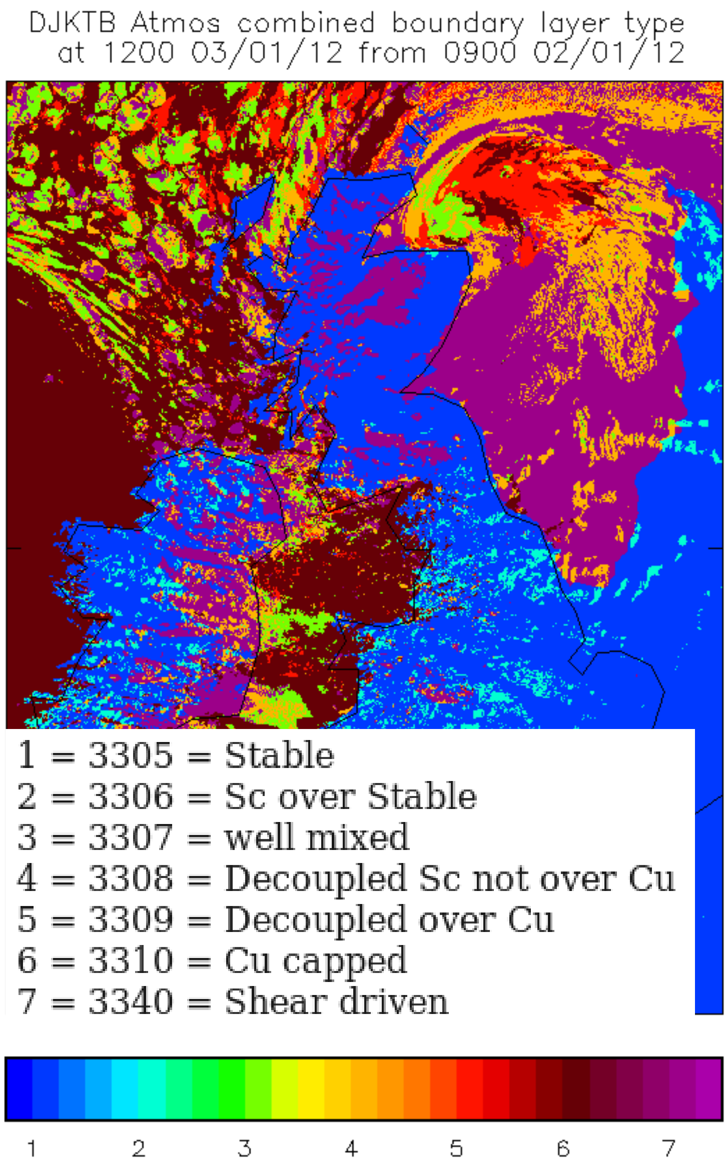
Bias

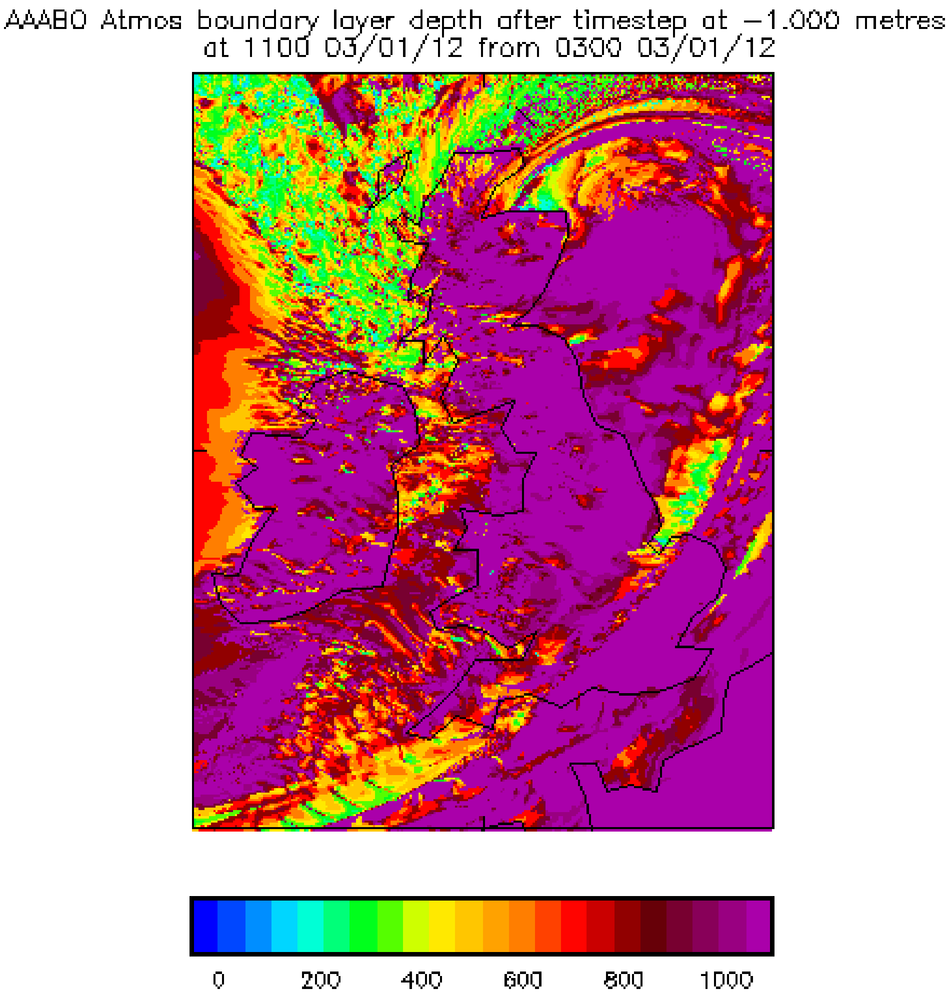
RMSE

wind gust



Model boundary layer type and depth





Cyclone Ulli, 3 Jan 2012

ASCAT observations

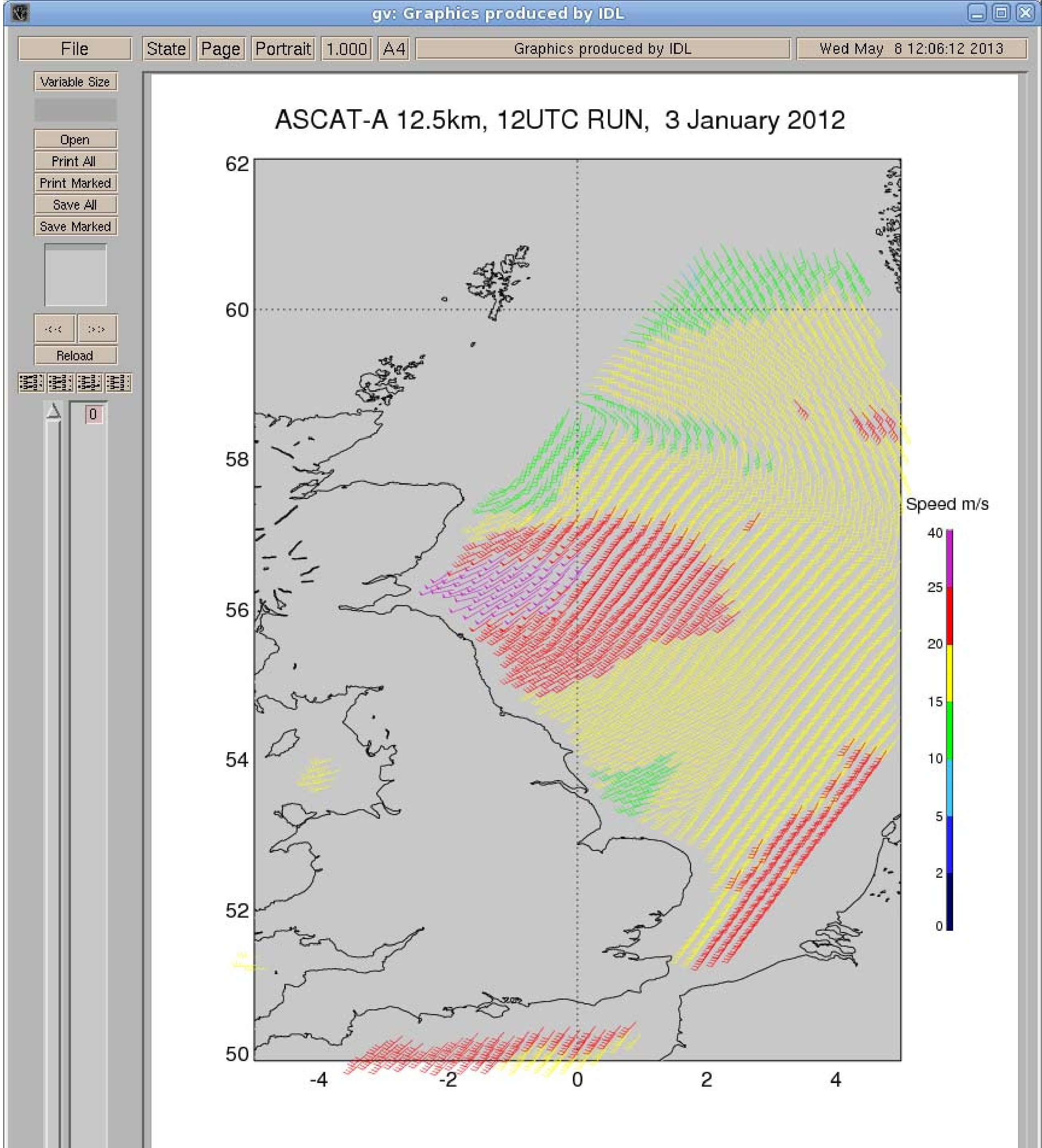
- ASCAT on Metop-A
- 12.5-km sampling (25-km resolution)
- 1056 UTC overpass
- All wind vectors plotted (no QC applied)

Model data

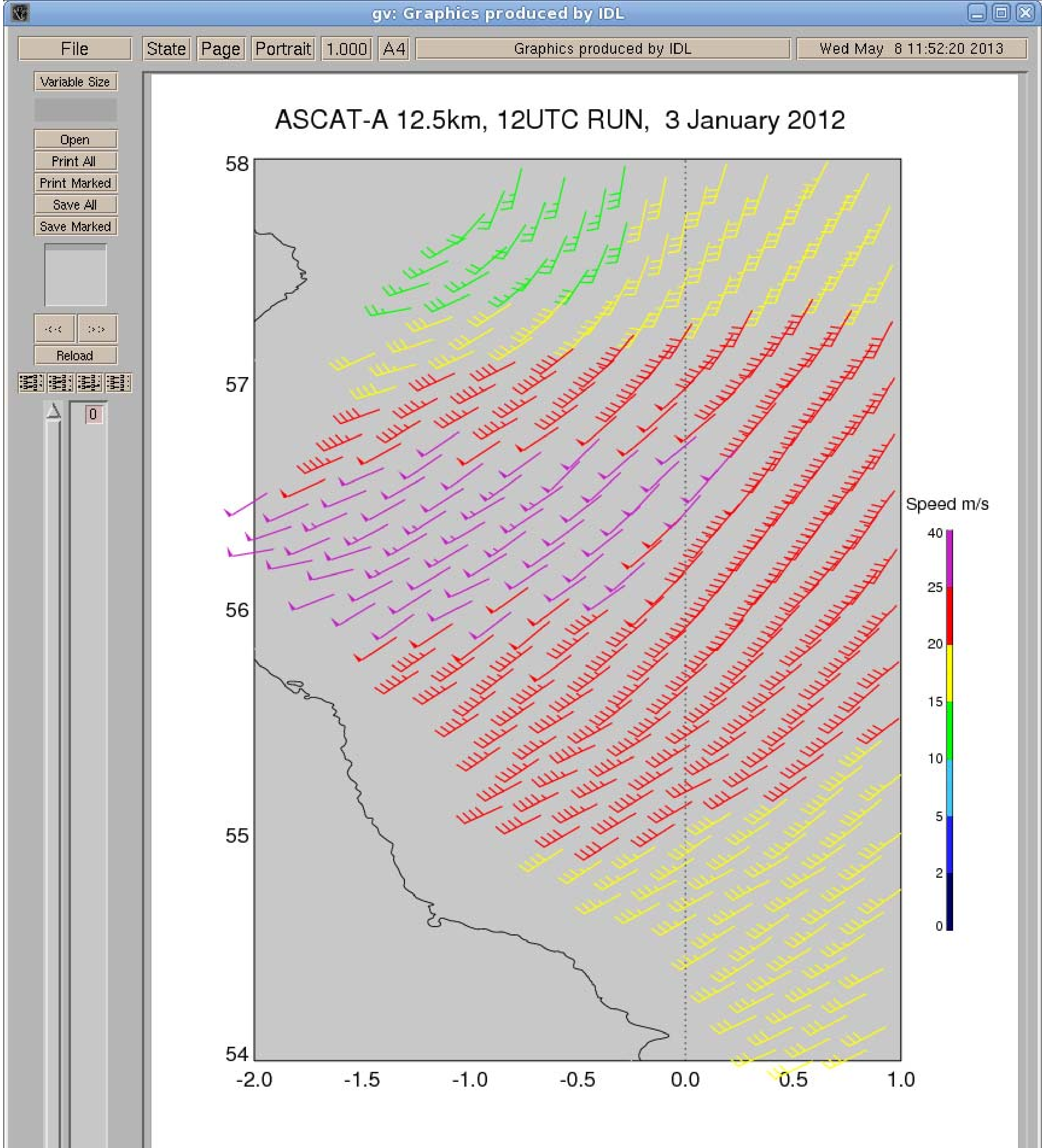
- 10m winds interpolated to observation location/time
  - UKV background (T+3 fc)
  - UK4 background (T+3 fc)

ASCAT-A observations

Wide view

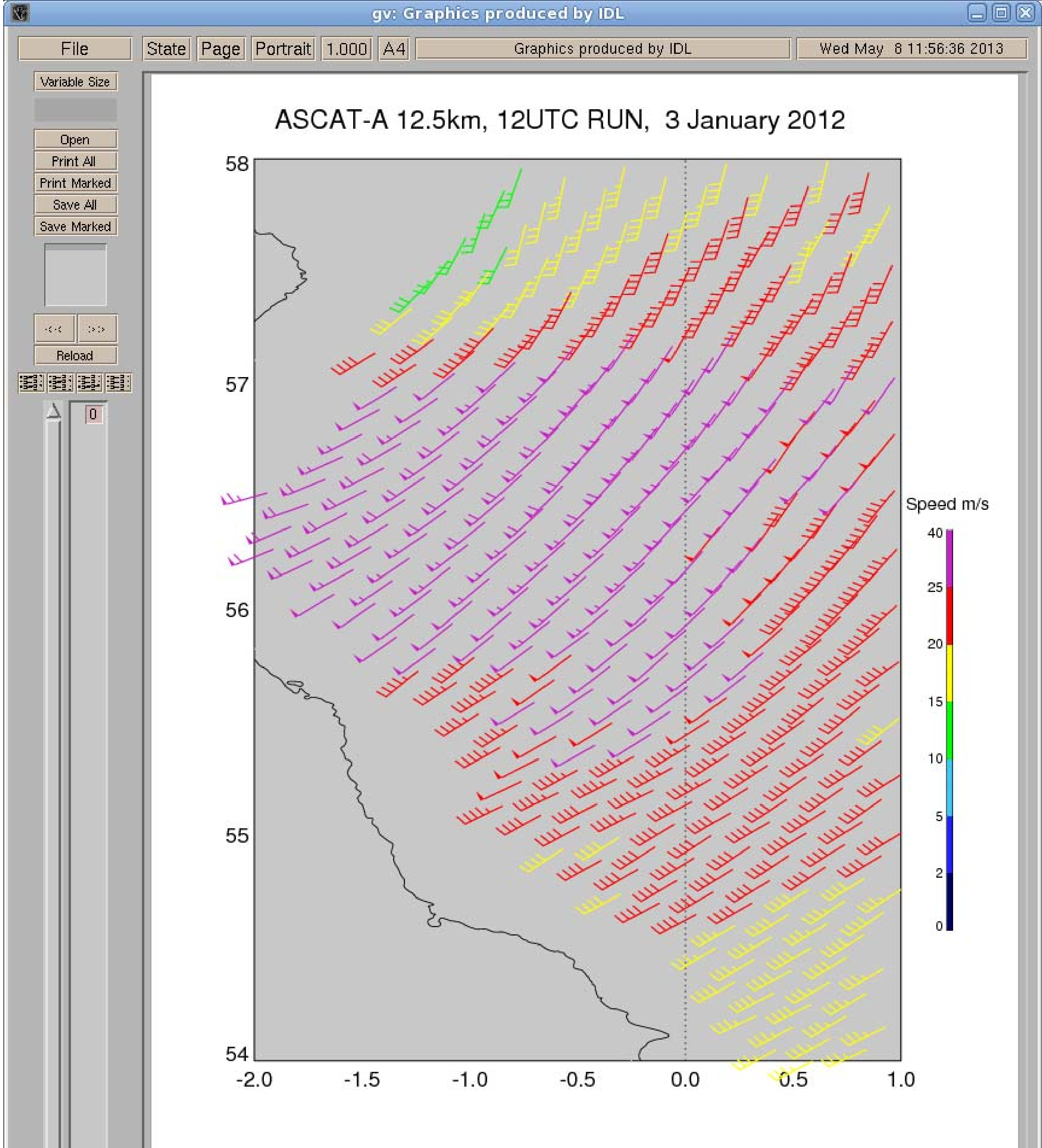


ASCAT-A observations



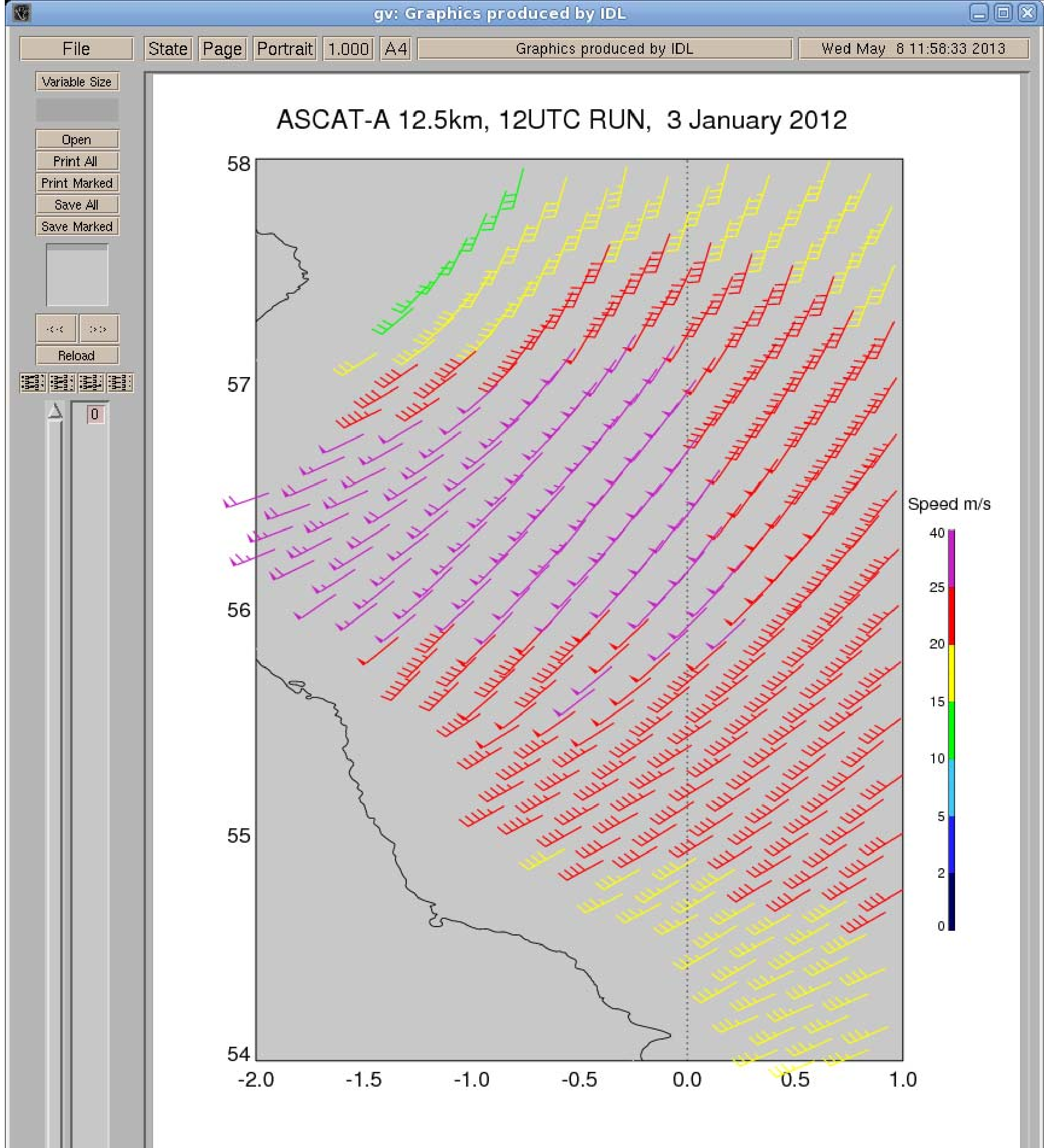
Met Office

UKV background

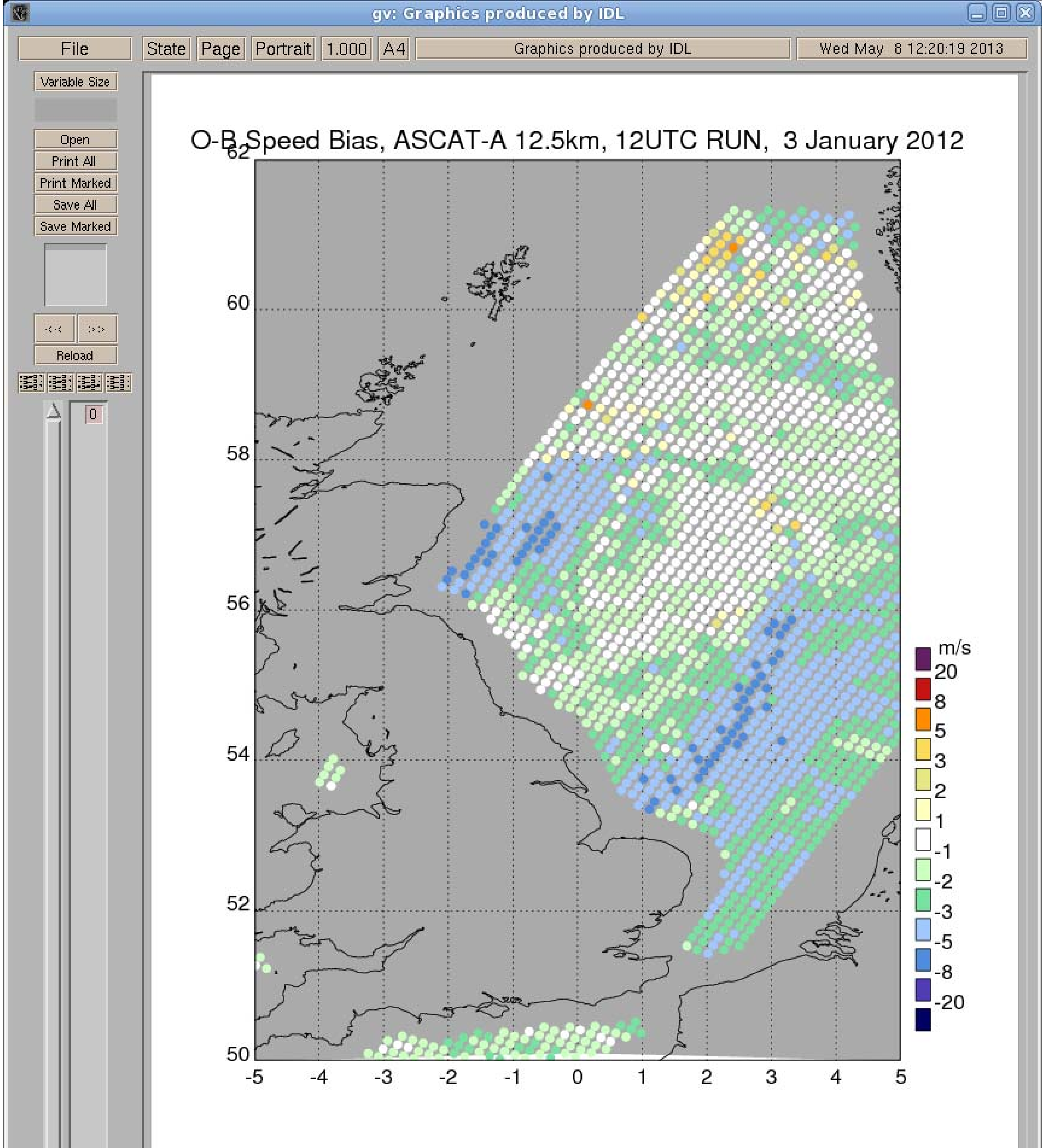


Met Office

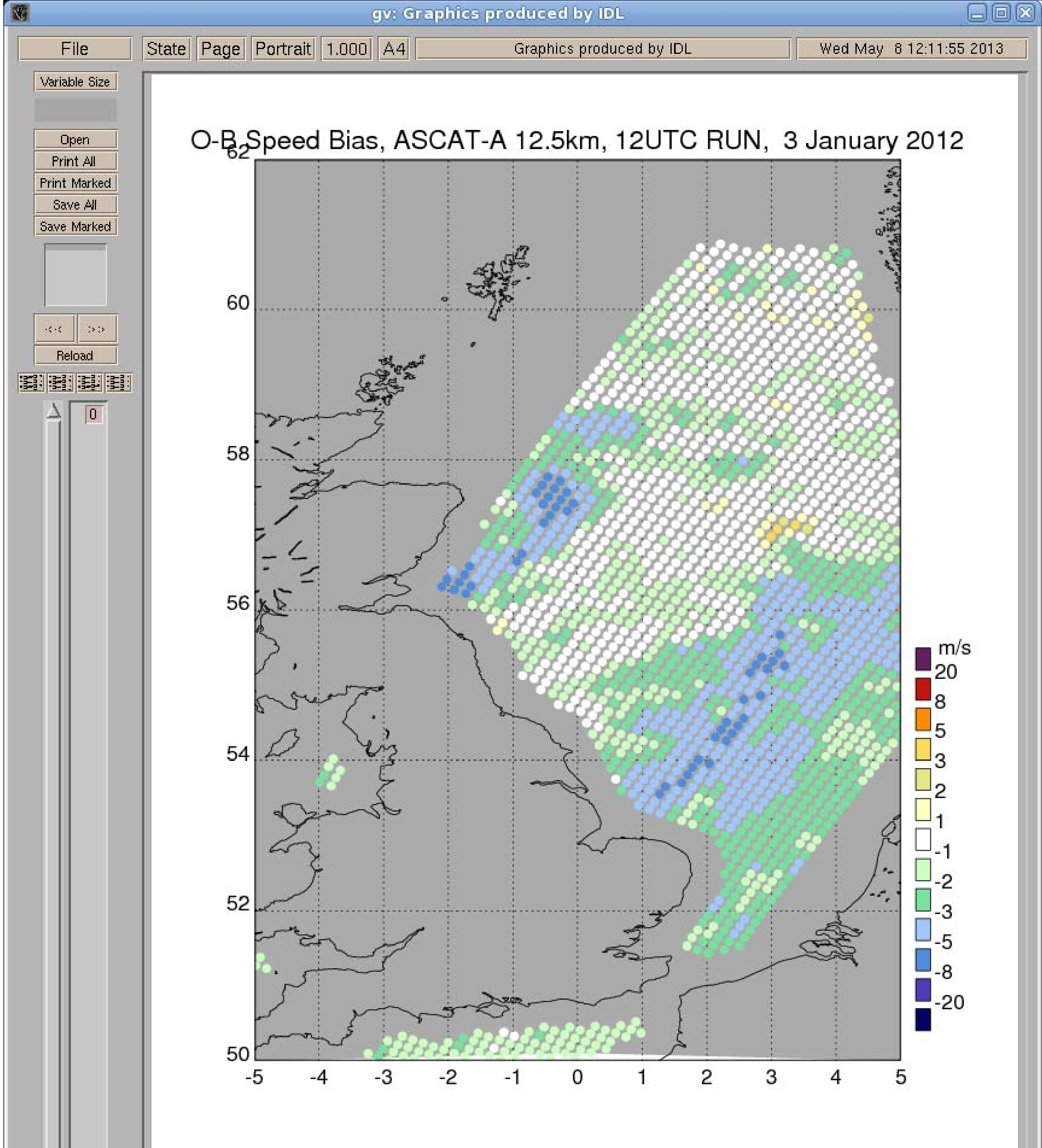
UK4 background



UKV O-B speed bias



UK4 O-B speed bias



Contents

- The UKV Model
- NWP Problem Group
- **Examples of problems raised by forecasters**
- 1) Snow/temperature
- 2) Wind gust
- **3) Precipitation**
- Conclusions

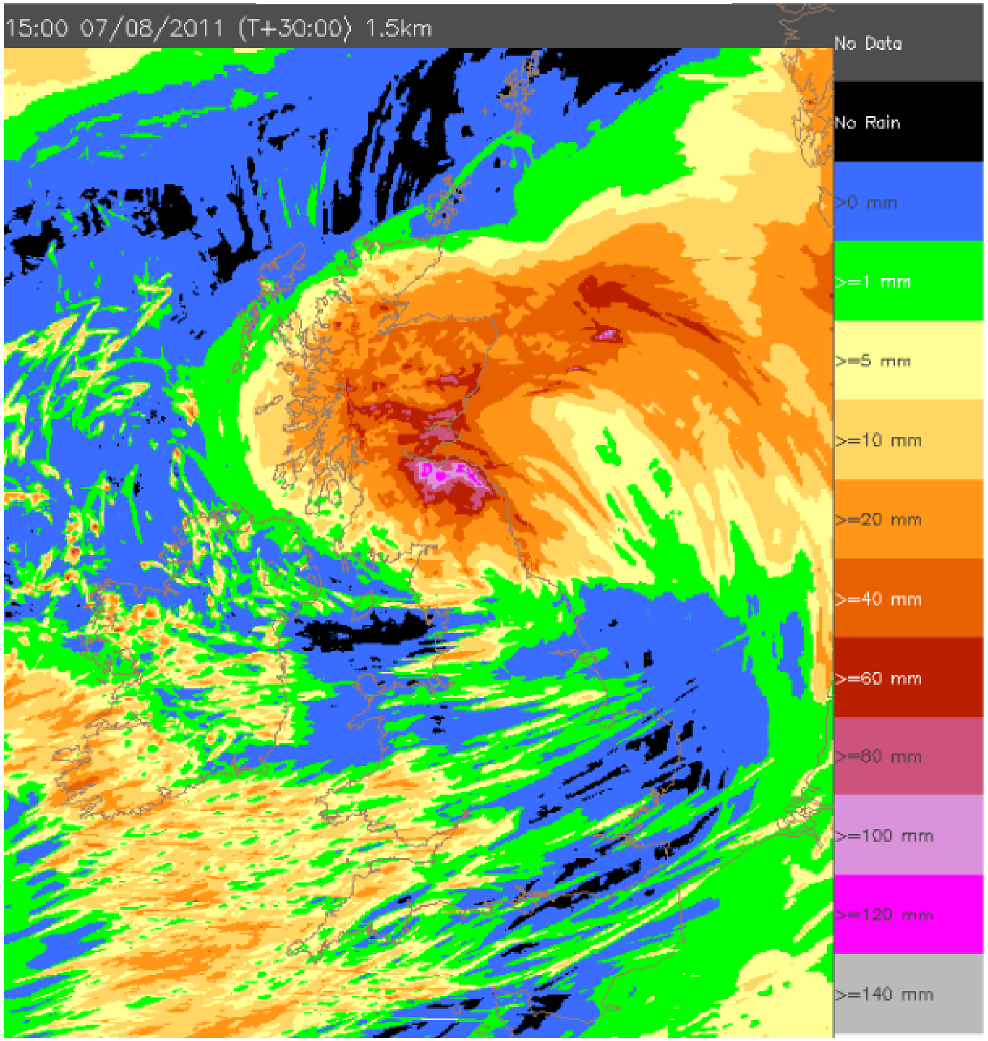
Edinburgh rain 06th/07th August 2011

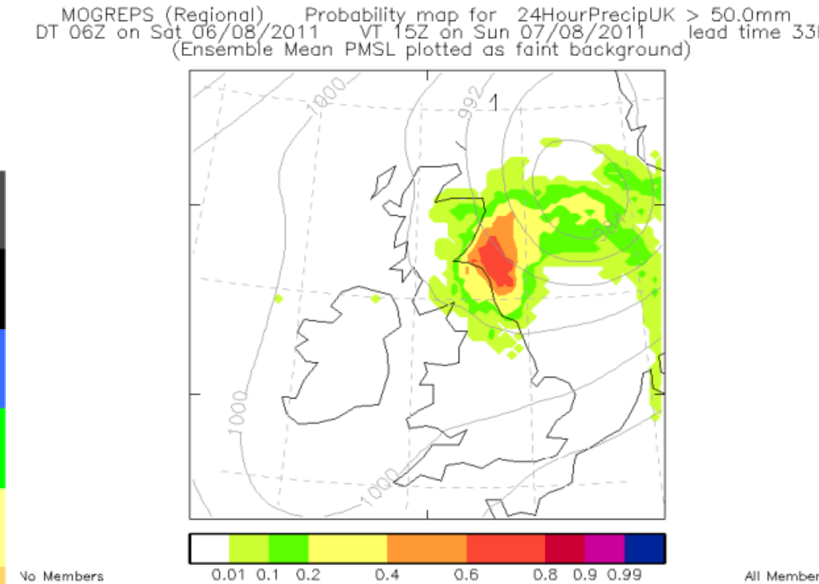
- An area of thundery rain moved into southeast Scotland overnight 6th/7th August.
- Model rainfall totals from 12Z and 18Z NAE and Global Model on 6th gave over 100mm in a 24 hour period in the Edinburgh area. The UKV also showed very large accumulations.
- Given that these large totals were focused on a populated area (also swelled by people visiting the Edinburgh Festival), the Chief Forecaster took a decision to issue a red warning.
- In the event, the large rainfall totals did not materialise, partly due to the heavier cells remaining offshore and also because the rain nudged further north rather than being locked across the Edinburgh area.
- Actual totals for Edinburgh for a 48-hour period (06/0900 to 08/0900) were around 35mm.

Met Office

UKV, MOGREPS-R and ECMWF precipitation accumulations

DT0900 UKV 24hr rain to 15Z





ECMWF deterministic 24 hr precipitation – yellow more than 50 mm