



# Recent Developments within MOGREPS at the Met Office

Warren Tennant (with contributions from Ken Mylne, Neill Bowler, Sarah Beare and others)



# Contents

- Operational MOGREPS setup
- SST & soil moisture perturbations
- Stochastic physics
- MOGREPS-W
- Forecaster Displays
- Integrated Post-Processing and Best Data



# Operational setup and 2012 upgrades



# Key Aim of MOGREPS

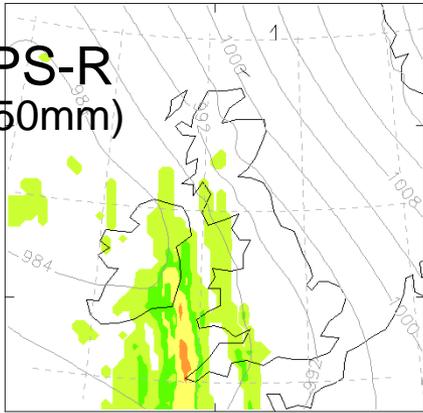
- Forecasting High-Impact Weather
  - Often (but not always) *Severe* weather

## What can we expect?

- Ensemble only as good as model(s) used
  - Probabilities of *resolved* weather
    - e.g. topographic forcing
  - Unresolved features not captured, e.g.
    - Thunderstorms
    - Snow showers advected over land from warm sea
    - Strong winds in tropical cyclones
- Suitable Perturbations for elements of interest e.g.
  - Soil moisture

## MOGREPS-R p(24h-ppn>50mm)

T+42



No Members

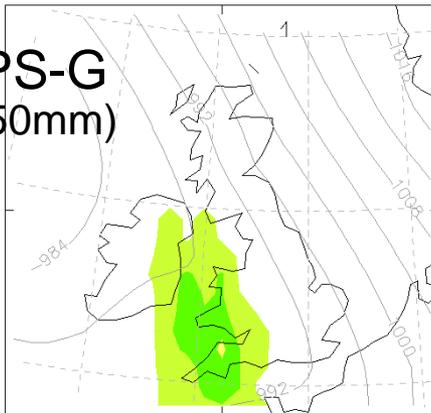


All Members

MOGREPS (Global) Probability map for 24HourPrecipUK > 50.0mm  
DT 00Z on Sun 23/10/2011 VT 00Z on Tue 25/10/2011 lead time 48h  
(Ensemble Mean PMSL plotted as faint background)

## MOGREPS-G p(24h-ppn>50mm)

T+48



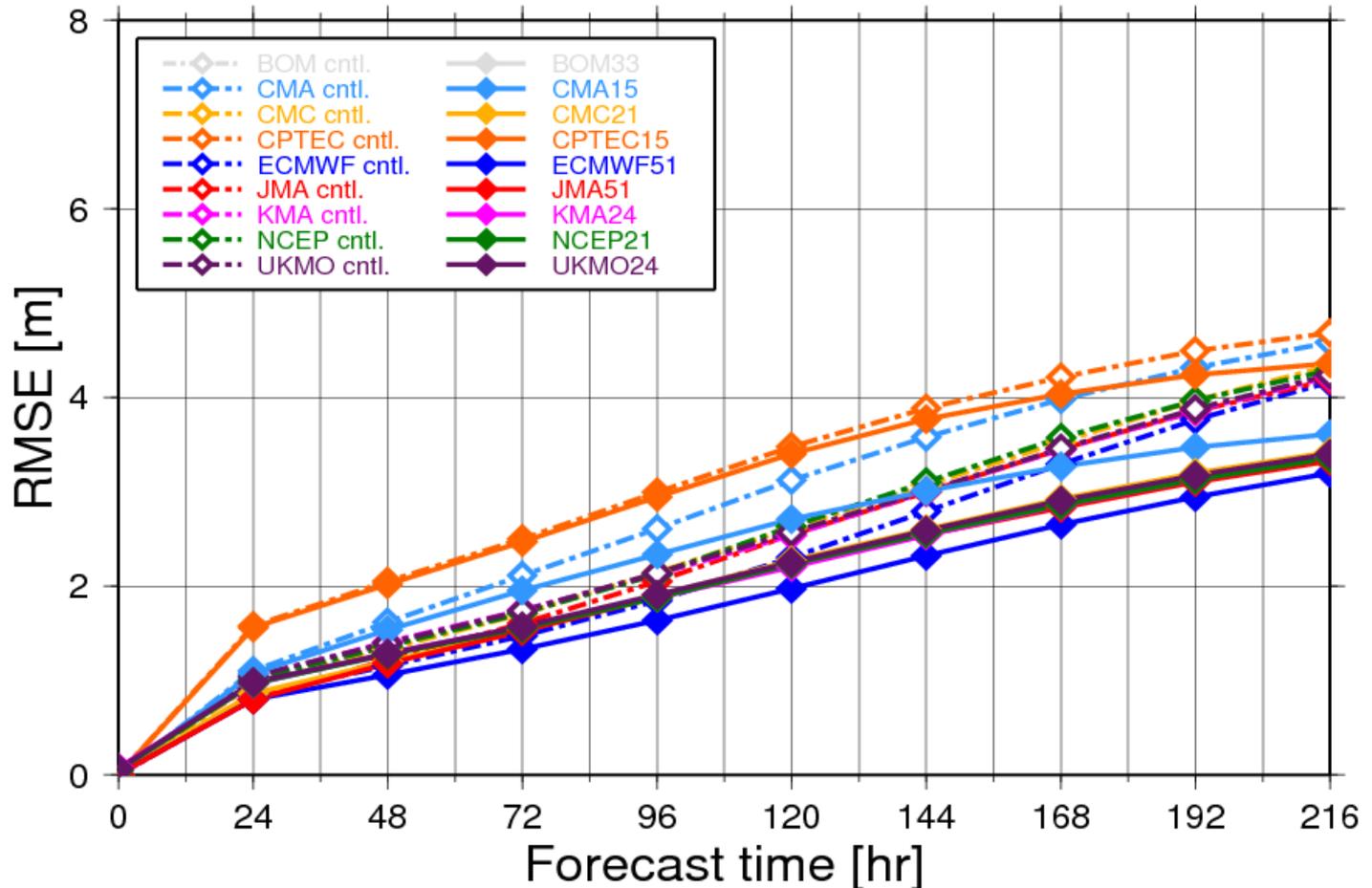
No Members



All Members

# TIGGE “beauty contest”

TIGGE medium-range ensemble forecasts  
T850 RMSE (2011 SON: NH)

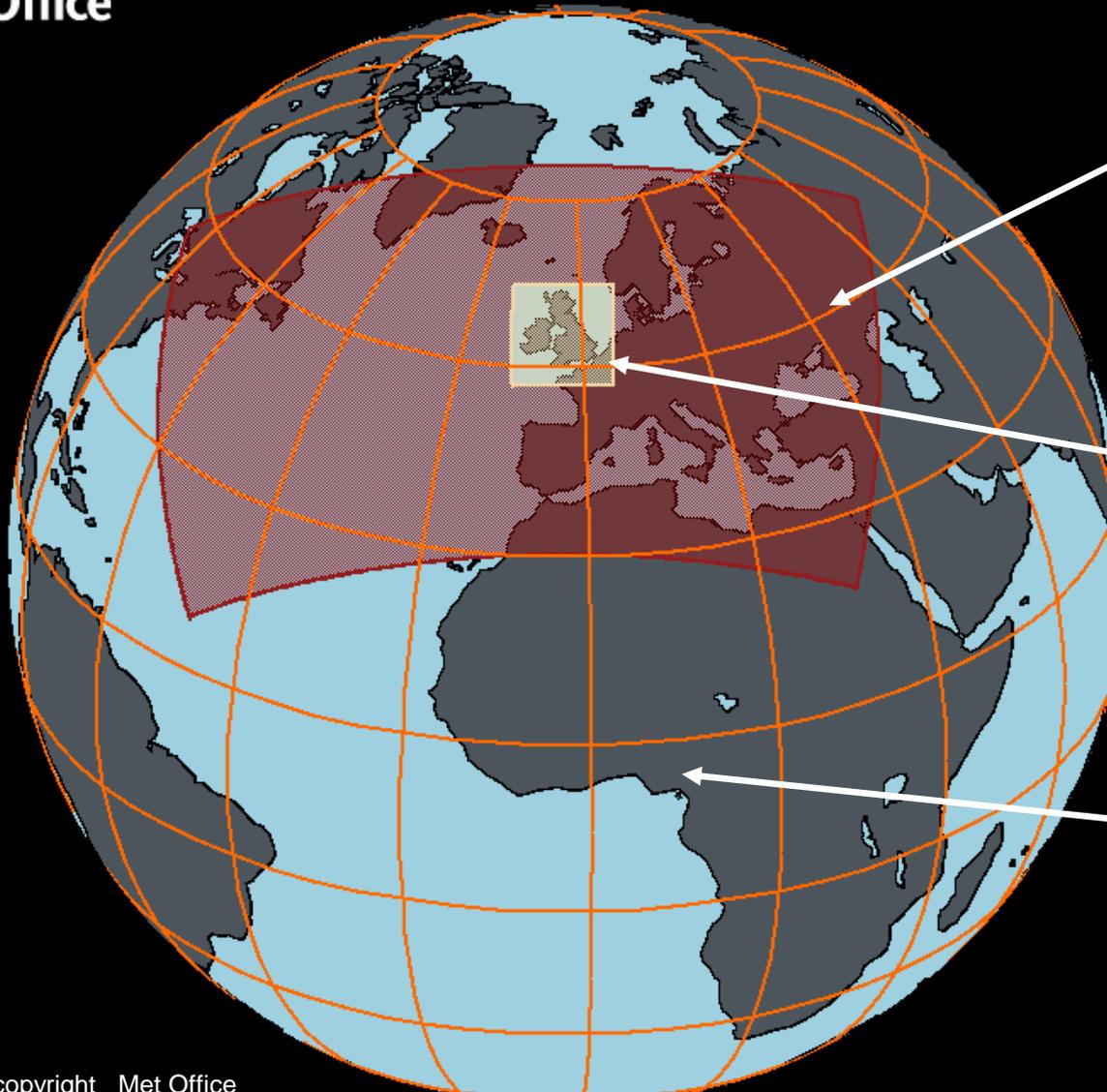


Courtesy Mio Matsueda

see <http://tparc.mri-jma.go.jp/TIGGE/index.html>



# MOGREPS Model domains



**18km grid**  
**Up to 54hr**  
**6-hourly update**

**2.2km grid (new)**  
**Up to 36hr**  
**6-hourly update**

**60km grid**  
**Up to 72hr**  
**6-hourly update**

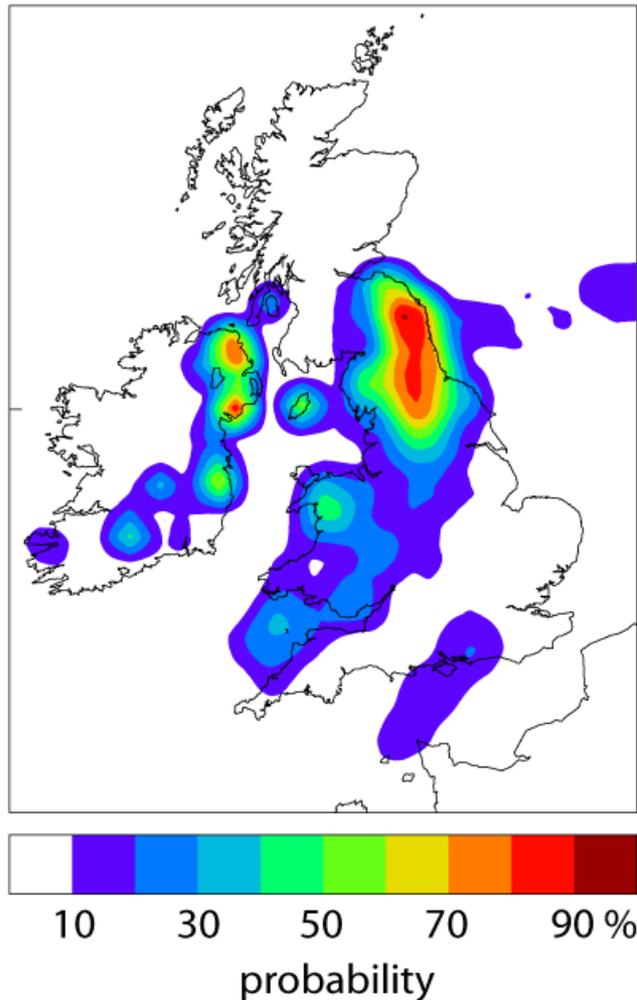


# Overview of 2012 Upgrades

- 4 cycles per day, 12 members per cycle
  - ETKF consists of a full set of 22 members every 6 hours
  - 24-member products by lagging last 2 cycles
- Global ensemble MOGREPS-G ~32 km
- UK convective-scale ensemble MOGREPS-UK 2.2 km
  - Direct nesting in Global
- Retire MOGREPS-R (in 2013 once MOGREPS-UK operational)
- Increase ETKF members from 22 to 44



# MOGREPS-UK 2.2km UKV model



- First operational UK ensemble 2012
  - 12 members, 2.2km
- Now running technical trial with 6h forecasts

Products will use Neighbourhood Processing to account for spatial uncertainty not covered by ensemble spread

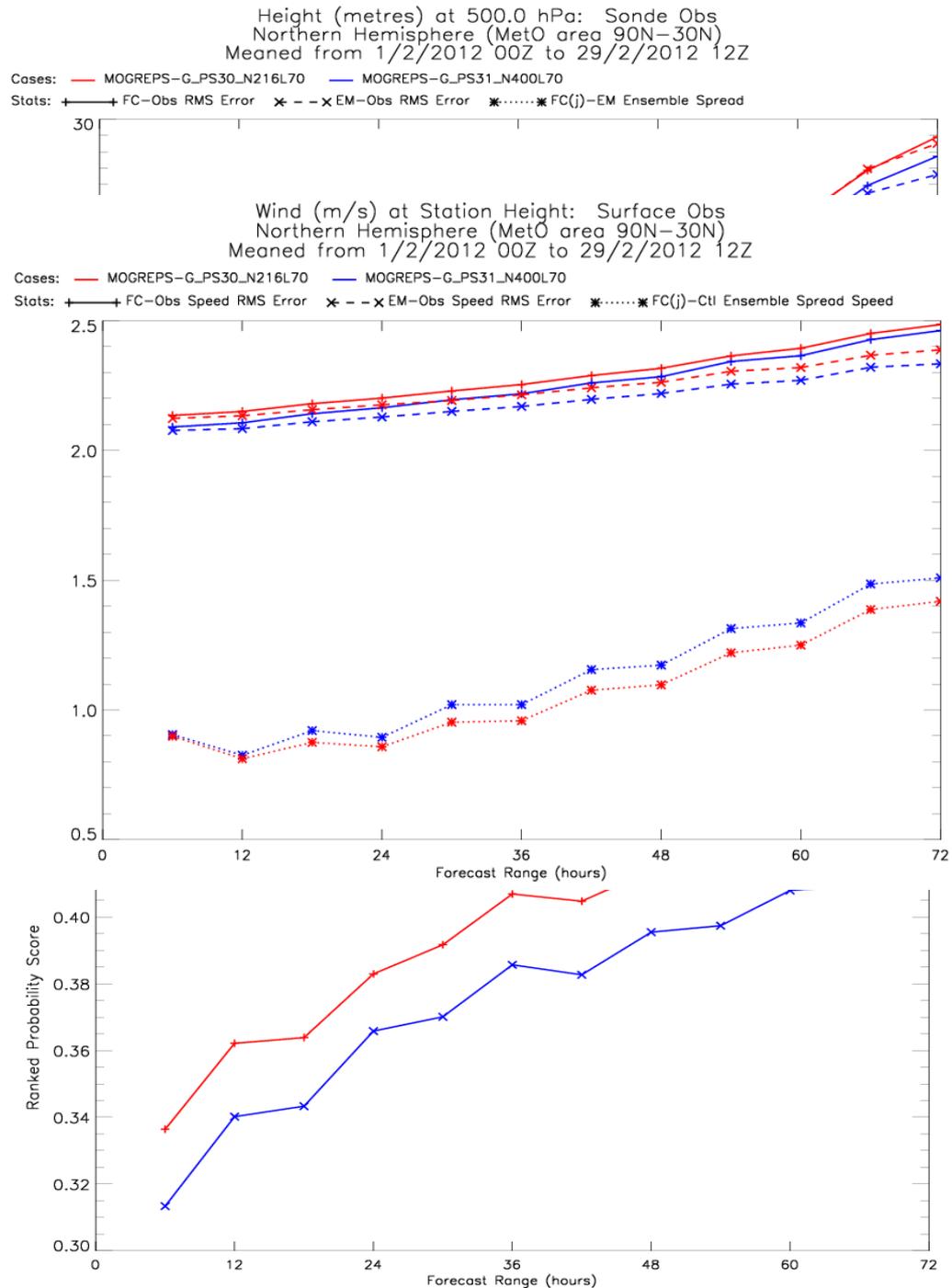
Probability of more than 100 mm of rain in 18 hours within 10 miles of any location



# Increased resolution

**Global: 60km70L → 32km70L  
(planned for Aug 2012)**

- ✓ Decreased RMSE in control member and ensemble mean
- ✓ Compensating change in spread:
  - ✓ increase in 10m wind spread (more eddies resolved)
  - ✓ Decrease in 500Z spread
- ✓ Improved RPS scores
- ✗ Increased cost and runtime





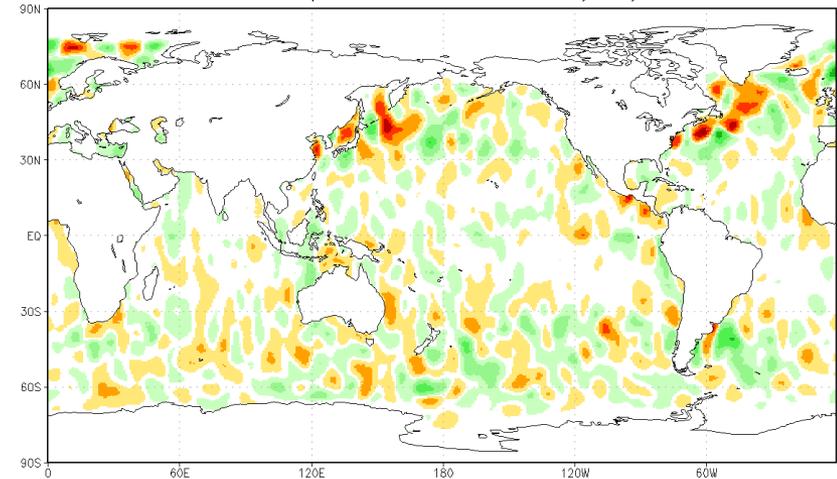
# SST and Soil Moisture Perturbations

# SST & Soil Moisture Perturbations

- SST:
  - Derive statistics of SST fields, e.g. day-to-day  $\delta t$
  - Calculate a power-law for random forcing pattern
  - Perturbation added to SST field (which remains constant during the forecast)
- Soil Moisture:
  - Pass soil moisture of each member through forecast cycles
  - Re-centre perts and check values

## SST pert example

Initial SST perturbation 00Z 23/01/2011

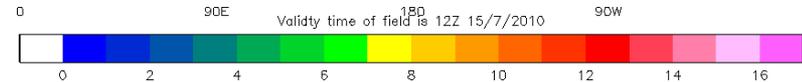
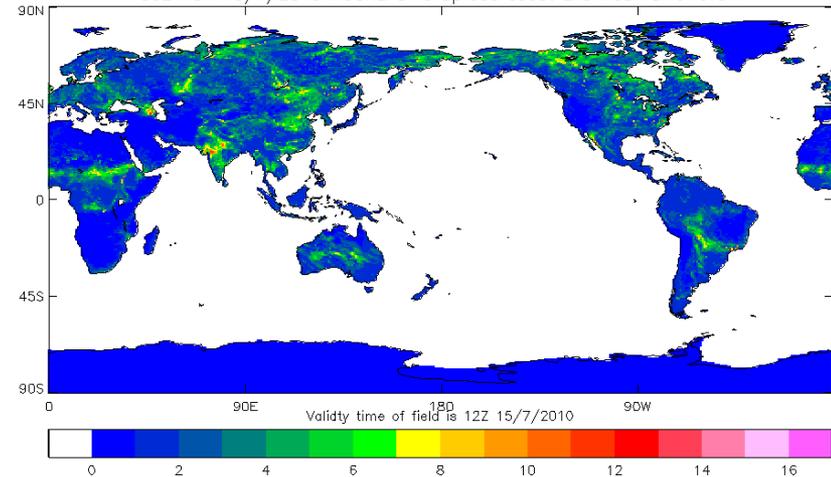


GRADS: COLA/IGES

2011-05-04-10:29

## Soil moisture pert example

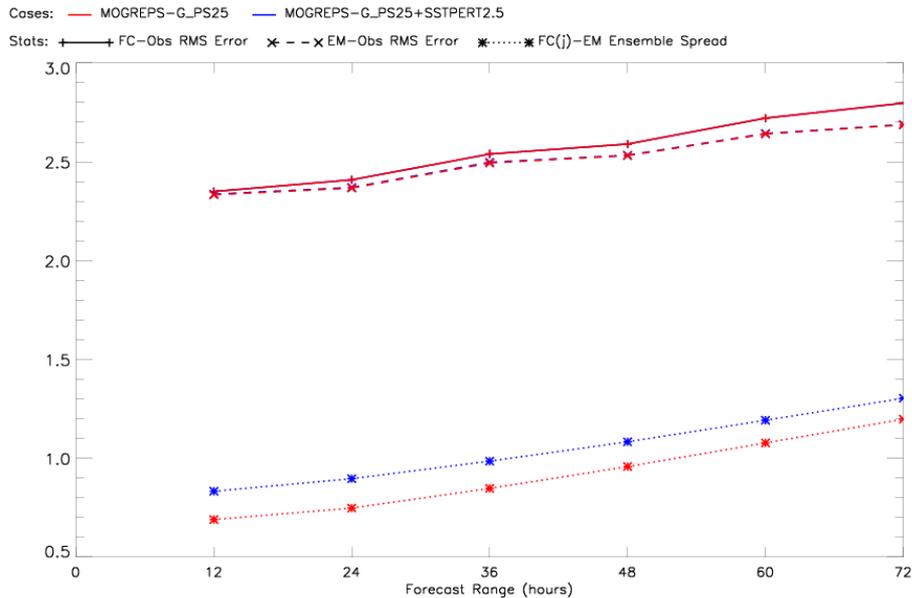
00Z RUN 15/7/2010 MOGREPS-G Spread about Ens Mean SMC level1



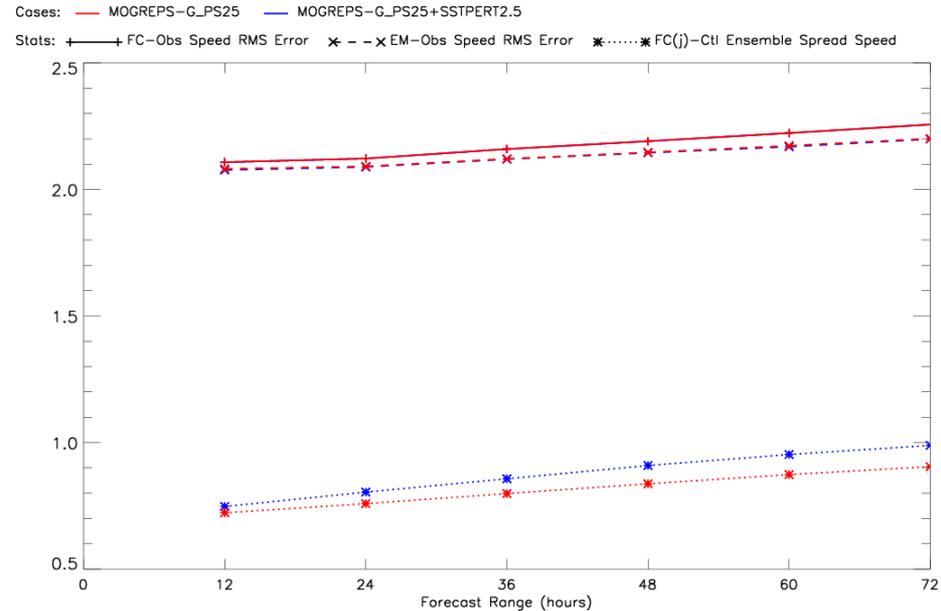


# SST Perturbations: Verification scores

Temperature (Kelvin) at Station Height: Surface Obs  
Northern Hemisphere (MetO area 90N-30N)  
Meaned from 1/7/2010 00Z to 31/7/2010 12Z

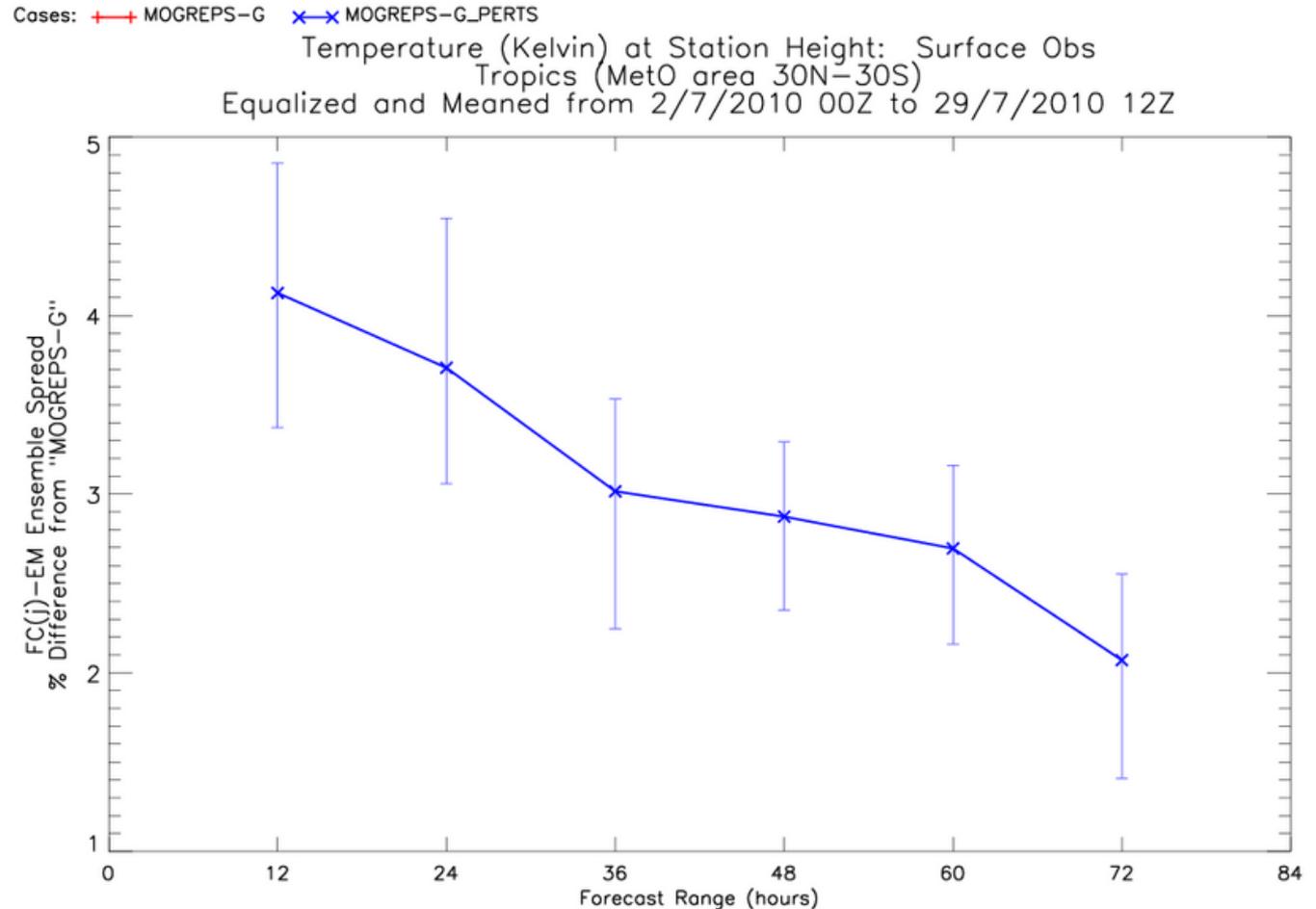


Wind (m/s) at Station Height: Surface Obs  
Tropics (CBS area 20N-20S)  
Meaned from 1/7/2010 00Z to 31/7/2010 12Z





# Impact of Soil Moisture Perturbations *T2m Tropics*





# Stochastic Physics



Met Office

# Stochastic Physics

- SKEB:

- Modulate a stochastic pattern that is generated with specified spatial and temporal characteristics
- Includes effects from numerical scheme smoothing, KE from convection, diffusion of large-scale flow
- Produces rotational and divergent wind components at each time-step

- Random Parameters:

- ~15 parameter values varied by AR1 process in set range
- Each ensemble member equally likely

- Perturbed Physics Tendencies:

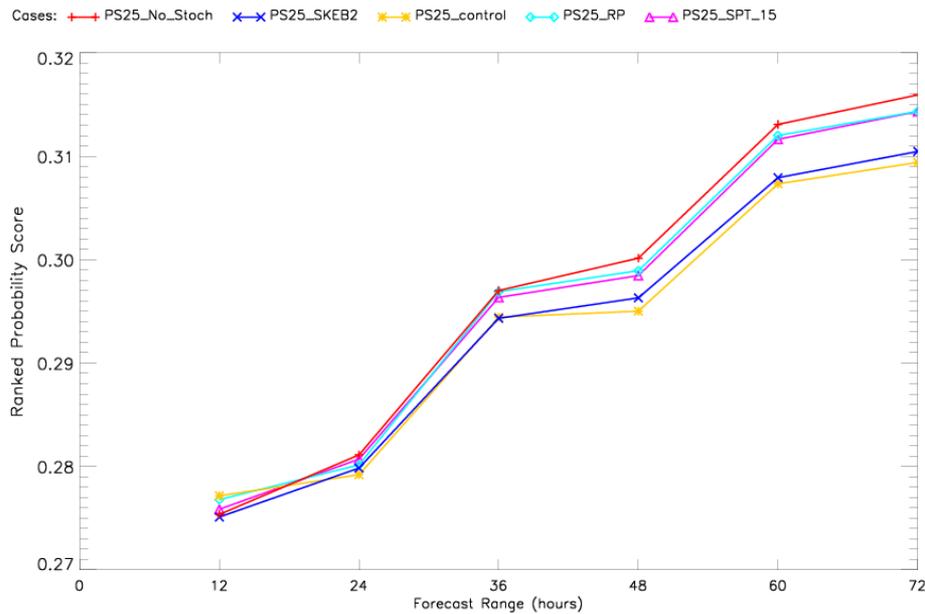
- Testing phase, difficulty with model stability



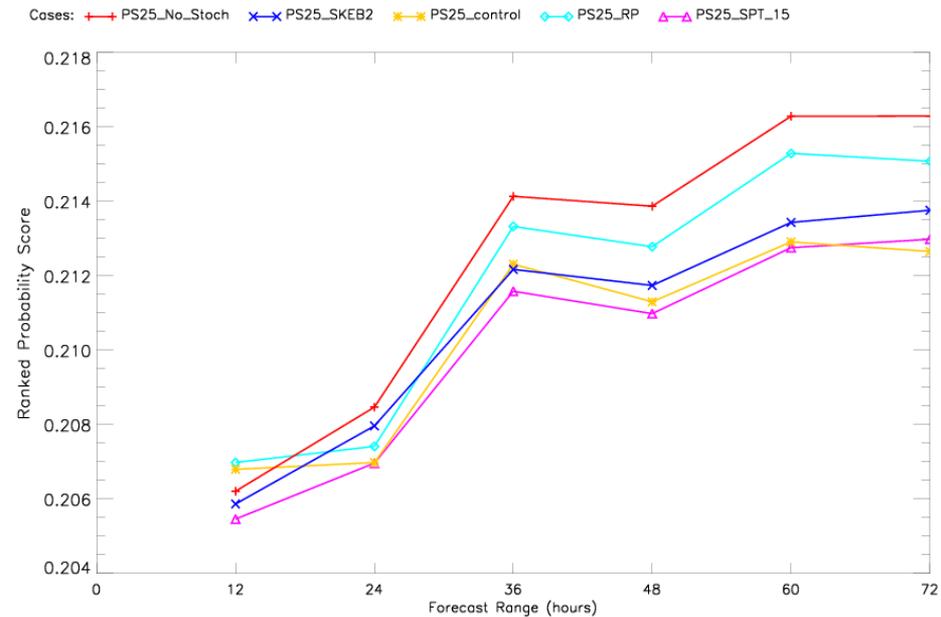
# Comparing Stochastic Physics schemes in MOGREPS-G:

## Ranked Probability Score: Sfc-Temp

Temperature (Kelvin) at Station Height: Surface Obs  
Northern Hemisphere (MetO area 90N-30N)  
Meaned from 1/7/2010 00Z to 31/7/2010 12Z



Temperature (Kelvin) at Station Height: Surface Obs  
Tropics (CBS area 20N-20S)  
Meaned from 1/7/2010 00Z to 31/7/2010 12Z





# MOGREPS-W

First-guess Severe Weather Warnings for NSWWS

Estimating Impact – a Risk tool

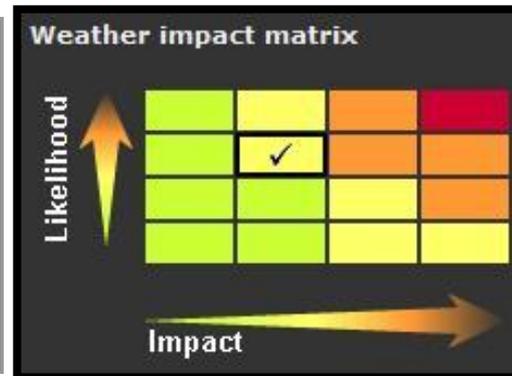


# The National Severe Weather Warning Service (NSWWS)

- Alerts/warnings based on **likelihood** and **impact**
  - **Alerts** - issued more than 24 hours ahead
  - **Warnings** - issued up to 24 hours ahead
- Regionally varying impact thresholds
- Alerts/warnings presented by shape areas on a map rather than just by county area



	No severe weather
	Be aware
	Be prepared
	Take action

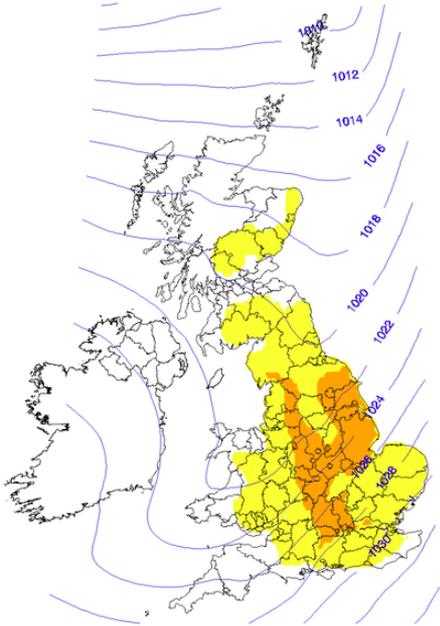




# MOGREPS-W

MOGREPS-W presents ensemble information to forecasters in a user-friendly format which mimics the NSWWS colour states, taking account of the expected impact of weather as well as likelihood.

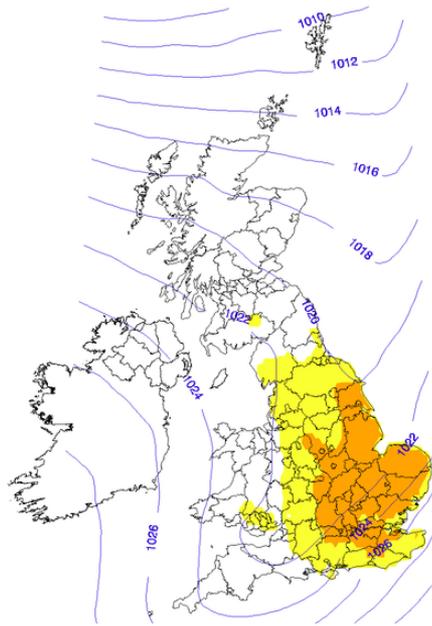
MOGREPS-W Overall Warning Colour for 3Hr Snowfall  
DT 06Z on Fri 03/02/2012  
VT 21Z on Sat 04/02/2012 (T+39h)  
Control member PMSL over-plotted in blue



Warning Colour Key



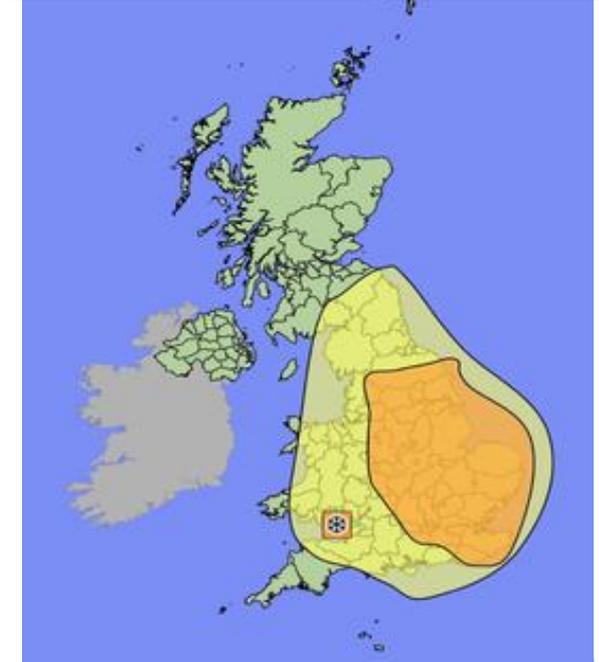
MOGREPS-W Overall Warning Colour for 3Hr Snowfall  
DT 06Z on Fri 03/02/2012  
VT 00Z on Sun 05/02/2012 (T+42h)  
Control member PMSL over-plotted in blue



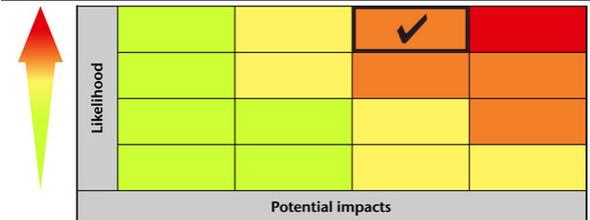
Warning Colour Key



## Forecaster issued warning



•MOGREPS-W shaded much of central and eastern England in amber, showing the highest risk of snow in these areas. Yellow shading extended westwards reflecting uncertainty in how far inland relatively mild Atlantic air would progress. This guidance was used by forecasters when issuing the final warnings.





# Scotland 8 December 2011

“The conditions are exactly as predicted when the Met Office issued its red warning” Nicola Sturgeon, Deputy First Minister

**NEWS** 8 December 2011 Last updated at 16:44

Home World UK England N. Ireland Scotland Wales Business Politics Health Education Sci

Video & Audio Magazine Editors' Blog In Pictures Also in the News Have Your Say Special Rep

LATEST: Judge rules general election pamphlet by Lib Dem candidate was defamatory of former Tory MP

## Storm blackout hitting thousands



Police tell people in Scotland not to travel, as severe winds of up to 165mph batter the country, leaving thousands without power.

**LIVE** Scotland's winter winds

In pictures: Scotland's storm

Satellite image captures storm

Hibs players soaked in training

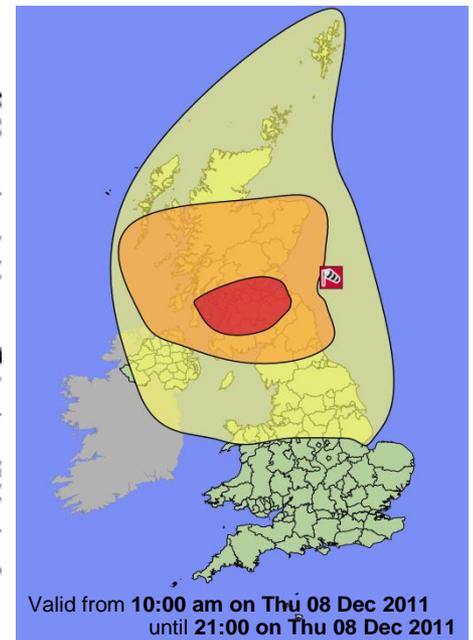
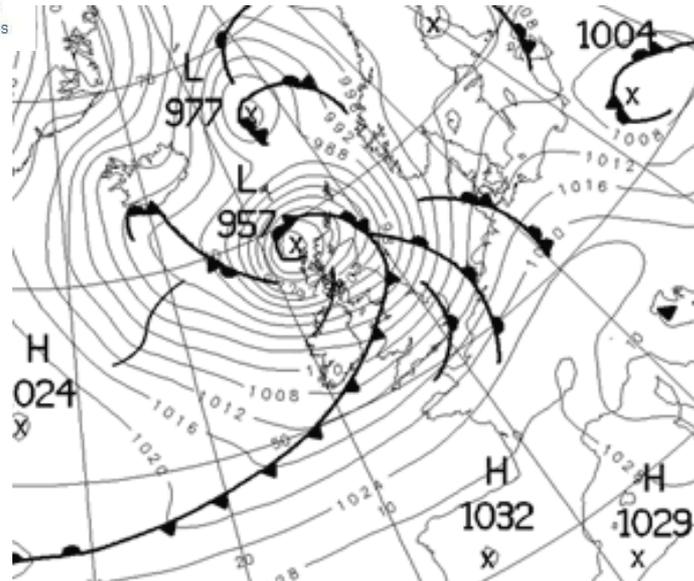
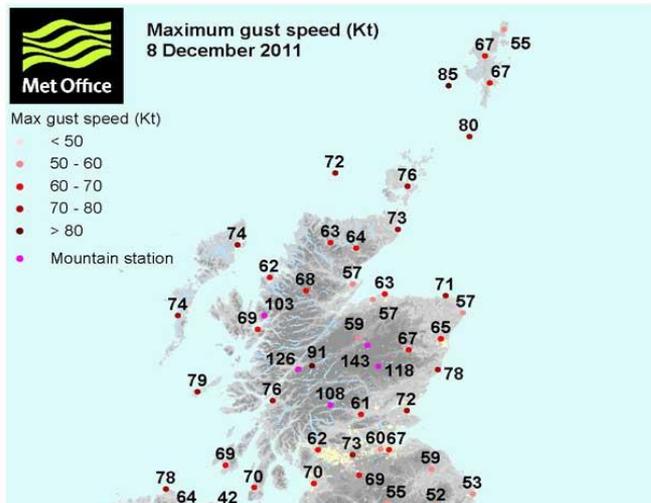
School closures in Scotland

Heavy rain floods roads and hotel

High winds lead to NI disruption

Welsh flood warning amid storms

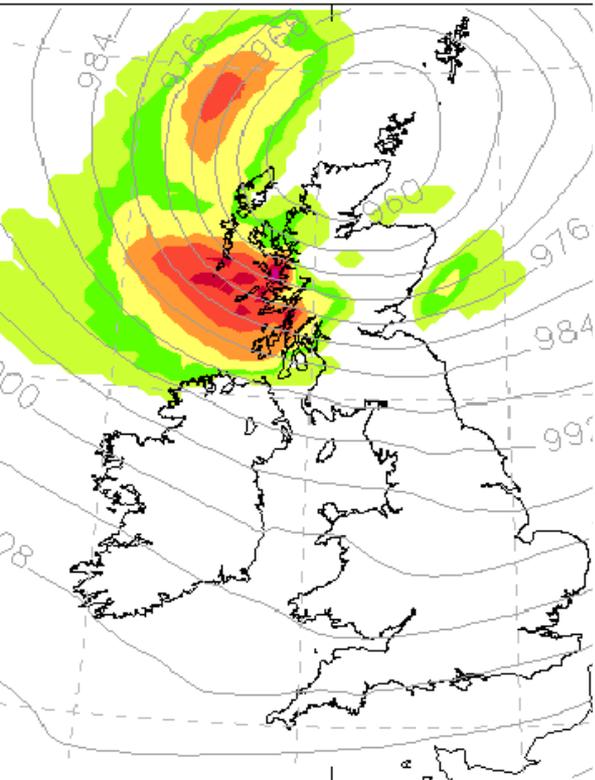
- Mon 5 Dec – Yellow warning issued – meetings with Scottish Govt, Transport Scotland and Resilience community begin
- Wed 7 Dec – Red warning issued
- Thu 8 Dec – Gusts in excess of 100kts



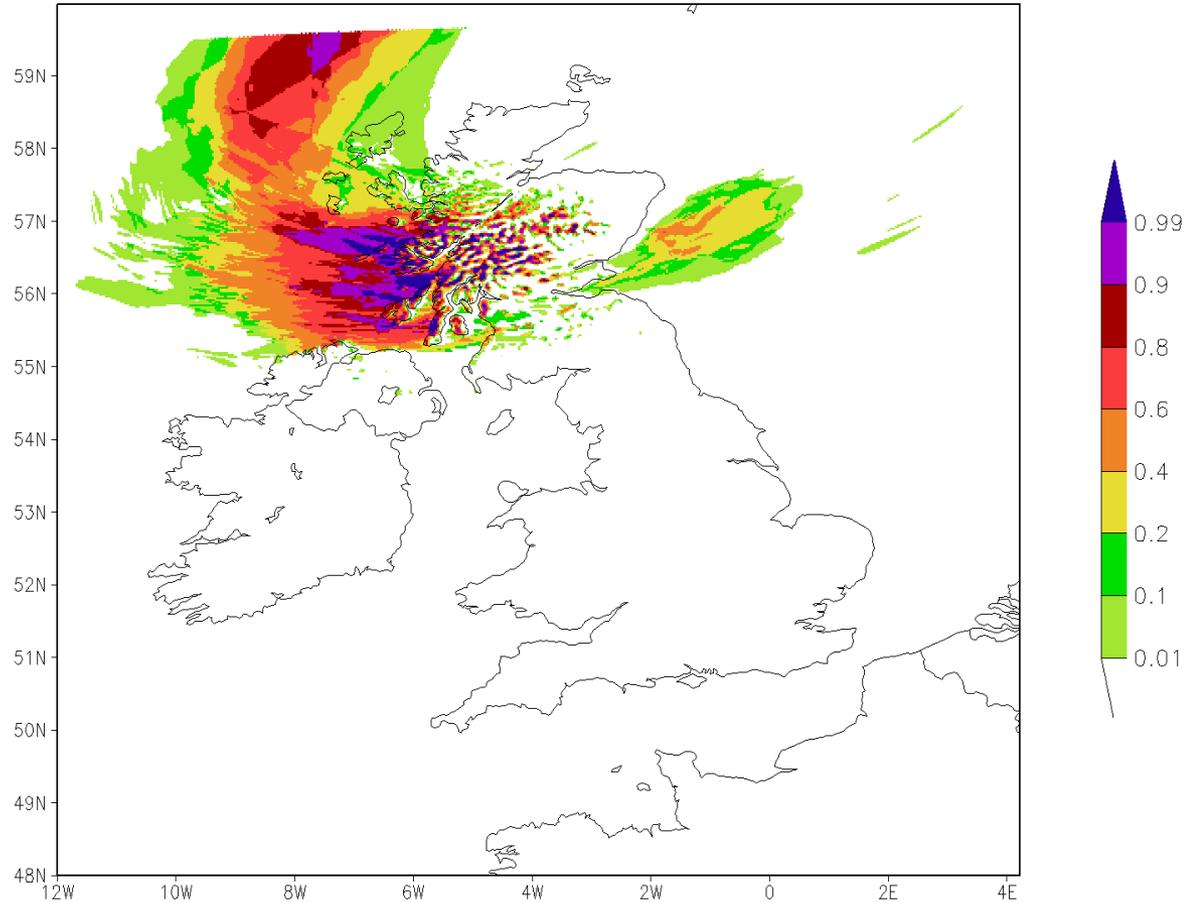


# MOGREPS-UK Case Study: Gales in Scotland on 08 Dec 2011

nal) Probability map for Gusts  
12/2011 VT 15Z on Thu 08/12  
ble Mean PMSL plotted as faint b



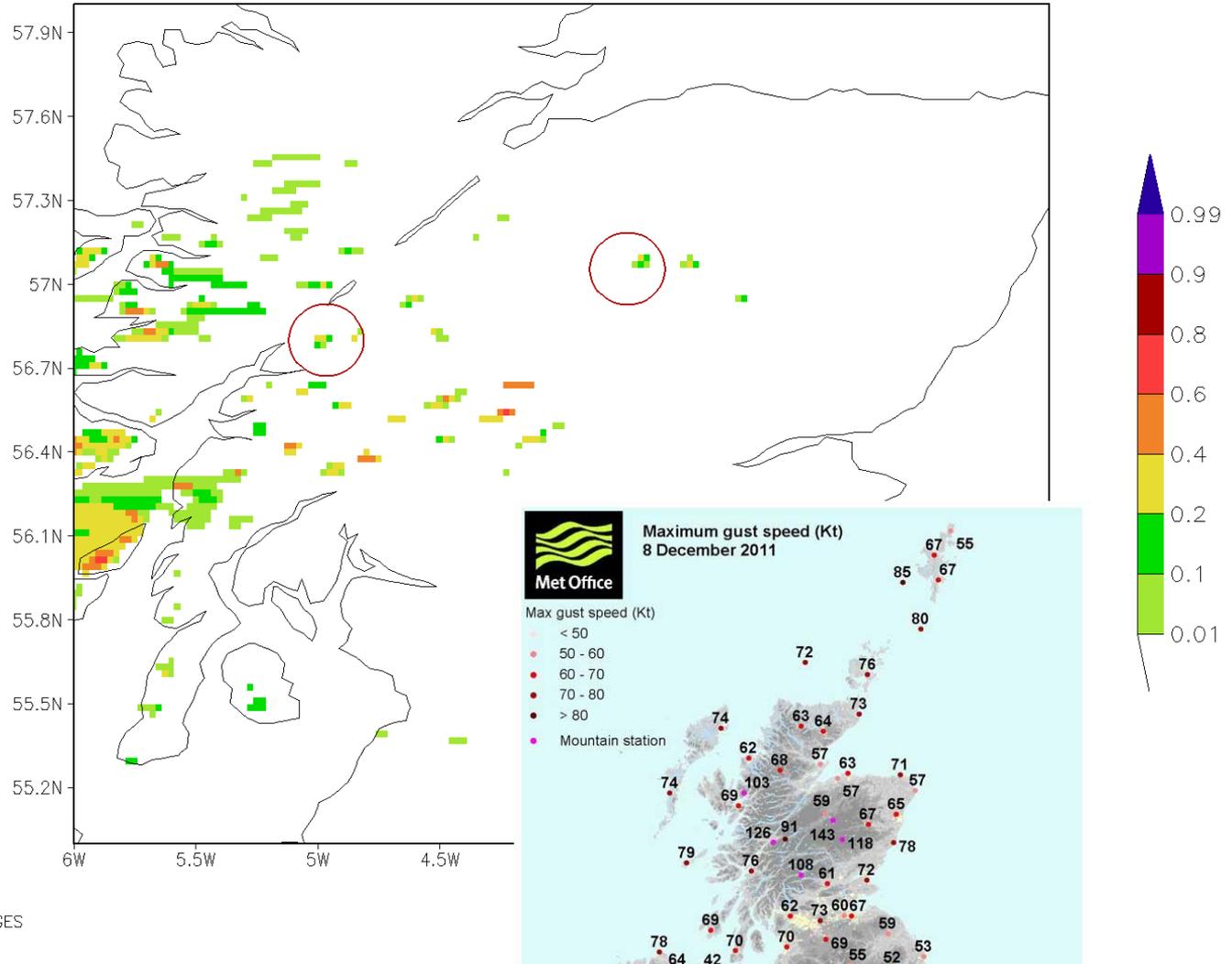
Ens Prob Gust > 80KT





# MOGREPS-UK Case Study: Gales in Scotland on 08 Dec 2011

Ens Prob Gust > 100KT



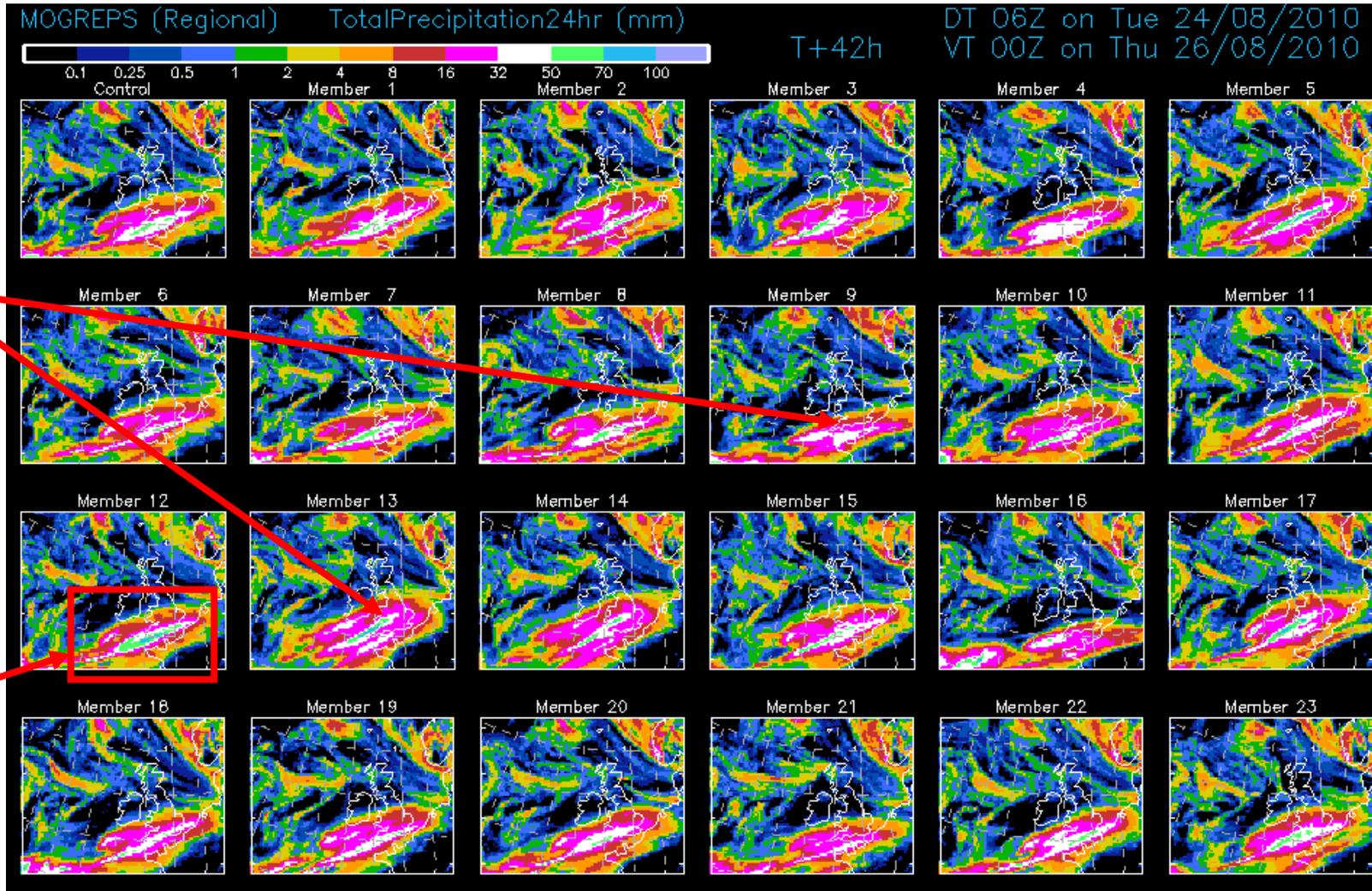
GrADS: COLA/IGES



# Forecaster displays

# Postage stamp charts

## 24h precipitation example



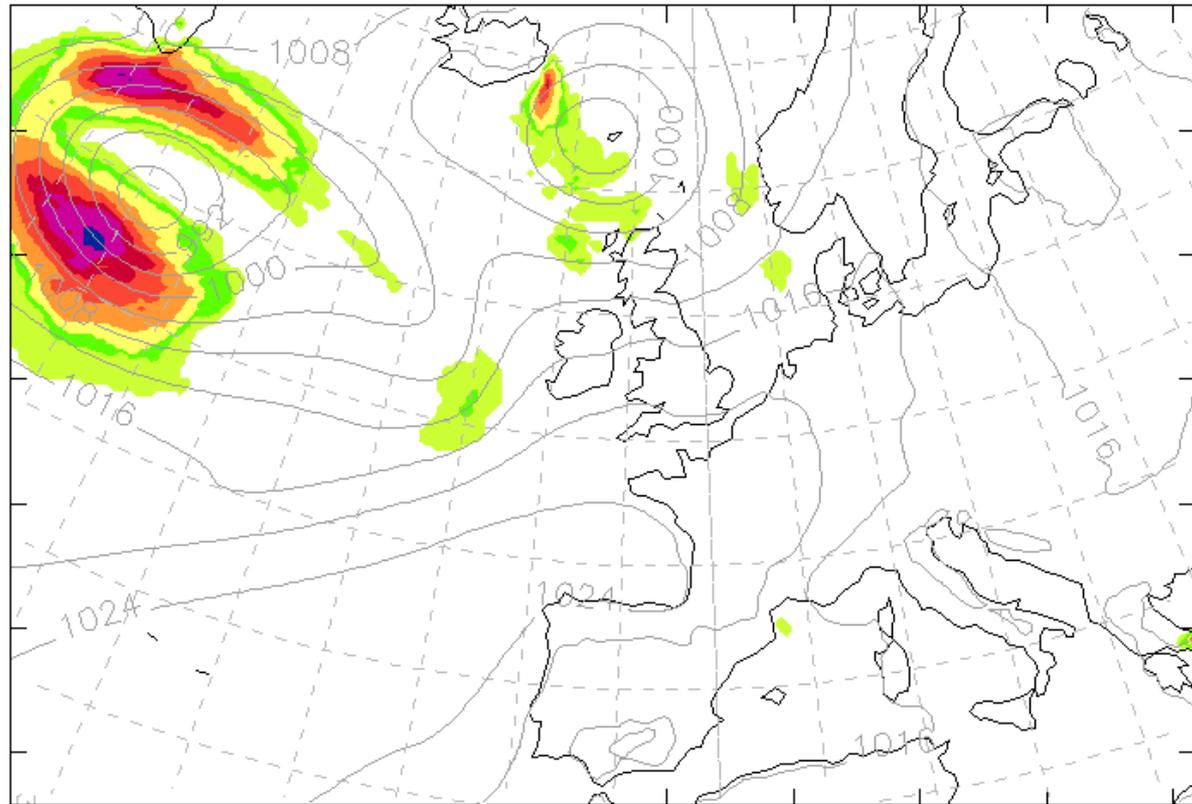
Location

Intensity



# Prob of Gusts > 40kt

MOGREPS (Regional) Probability map for GustSpeed > 40.0knots  
DT 06Z on Thu 15/07/2010 VT 12Z on Sat 17/07/2010 lead time 54h  
(Ensemble Mean PMSL plotted as faint background)

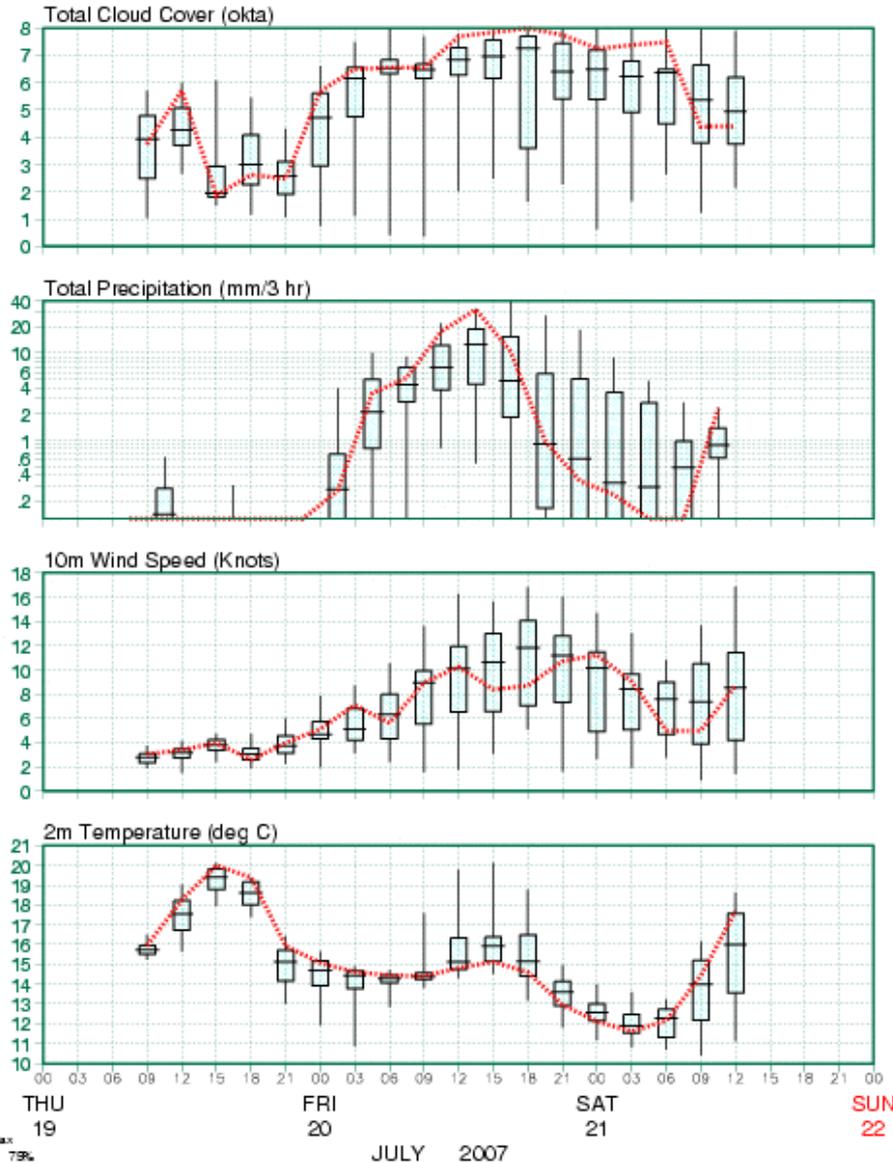


No Members 0.01 0.1 0.2 0.4 0.6 0.8 0.9 0.99 All Members

- Animation helps understanding
- Ensemble mean PMSL sets probs in synoptic context

MOGREPS European EPS Meteogram  
 BRIZE NORTON (03649) 51.8° N 1.6° W  
 RAW - EPS Forecasts : 19 July 2007 6 UTC

# Meteograms



- Plot of ensemble spread
  - Box shows 25-75% range
  - Whiskers show 95% confidence range
  - Central bar shows median – can indicate most probable
- Summarises forecast at one location for
  - 10 days ahead
  - Several variables
- Ensemble forecasts are stored in a site-specific database for many sites around Europe and the World





# Integrated Post-Processing and *Best Data*



# “Best Data” provides a single source of forecast data for all products

- Site-specific forecasts
  - 5000 UK sites
  - 10000 sites worldwide
  - Kalman filter bias corrections (where obs available)
    - Reduces effect of resolution differences
  - Cascade of models by lead-time
    - **Single Value**
      - UKV/UK4
      - NAE
      - MOGREPS Mean
    - **Multi Value (Percentiles)**
      - MOGREPS-UK
      - MOGREPS-R
      - MOGREPS-15

Ensemble starting to be used for “deterministic” Best Data

Ensemble spread adjusted to assure consistency



# Best Data updating by Blending

To start – 15 days out

- $\text{BestData}(T+360) = \text{MOGREPS-15}(T+360)$

12 hours later

- $\text{BestData}(T+348) = 0.5 * \text{MOGREPS-15}(T+348) + 0.5 * \text{BestData}(T+360)$

Current BestData =  $a * \text{latest forecast} + (1-a) * \text{previous BestData}$

- 'a' varies with lead time and model combination
- At shorter range blend in:
  - MOGREPS-R
  - Higher resolution deterministic models including UKV
  - Nowcasts





# Best Data Temperatures

Met Office : Invent - Weather: Map view - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.metoffice.gov.uk/public/pws/invent/weathermap/

Most Visited Support Metnet home page Google Ensemble Applications MOGREPS display web yourself People Search Capita Business Travel OPCHANGE

MOGREPS display web Met Office : Invent - Weather: ... Precipitation Rate and MSLP<... Probability map of Wind speed ...

Skip navigation • Mobile • Help • Site map

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Beta

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Forecast Temperature 1300 Sat 6 Aug

Layers

- Rainfall
- Cloud Vis
- Cloud IR
- Pressure
- Temp. Map
- Weather
- Wind
- Temperature
- UV
- Feels Like Temp.
- Leisure areas
- Regional Forecasts
- Pollen Forecast

Download data

Locations

Tools

POWERED BY Google Met Office

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# Detail for London

Met Office: Invent - Weather: Text view - Location: London - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.metoffice.gov.uk/public/pws/invent/weathertext/index.html?352409

Most Visited Support Metnet home page Google Ensemble Applications MOGREPS display web yourself People Search Capita Business Travel OPCHANGE

MOGREPS display web Met Office: Invent - Weather: T... Precipitation Rate and MSLP<... Probability map of Wind speed ...

### 5 Day Forecast : London

Click on a day for more information

Day	Weather Icon	Date
Fri 05 Aug 2011	Cloud	Fri 05 Aug 2011
Sat 06 Aug 2011	Cloud	Sat 06 Aug 2011
Sun 07 Aug 2011	Sun with rain	Sun 07 Aug 2011
Mon 08 Aug 2011	Sun with rain	Mon 08 Aug 2011
Tue 09 Aug 2011	Cloud	Tue 09 Aug 2011

### Severe Weather Warnings

### Text Forecast : South East England

### Hourly Observations : London Olympic Park North (Nearest observation site to London)

### Development Product - Temperature Range Forecast : London

Maximum Temperature Range

Day	Max	Min
Fri 05 Aug 2011	24°C	17°C
Sat 06 Aug 2011	21°C	17°C
Sun 07 Aug 2011	20°C	17°C
Mon 08 Aug 2011	20°C	18°C
Tue 09 Aug 2011	20°C	17°C

Product Description

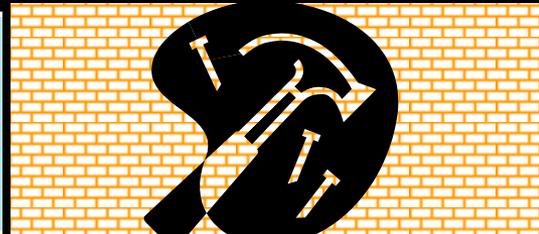
Following public consultation this is a new way for the Met Office to present forecast information. Temperatures will fall within the indicated range roughly 9 times out of 10 with the most likely temperature shown in green. There may be variations between this product and the 5 day forecast. We will continue to develop and improve this product.

High Range  
Most Likely  
Low Range

# Summary of Integration

- Historically we have had:

“Operational”  
Deterministic  
Models



“Supplementary”  
EPS

- Finally we are getting integration:

- Common post-processing
- Compatible formats
- Blended Best Data

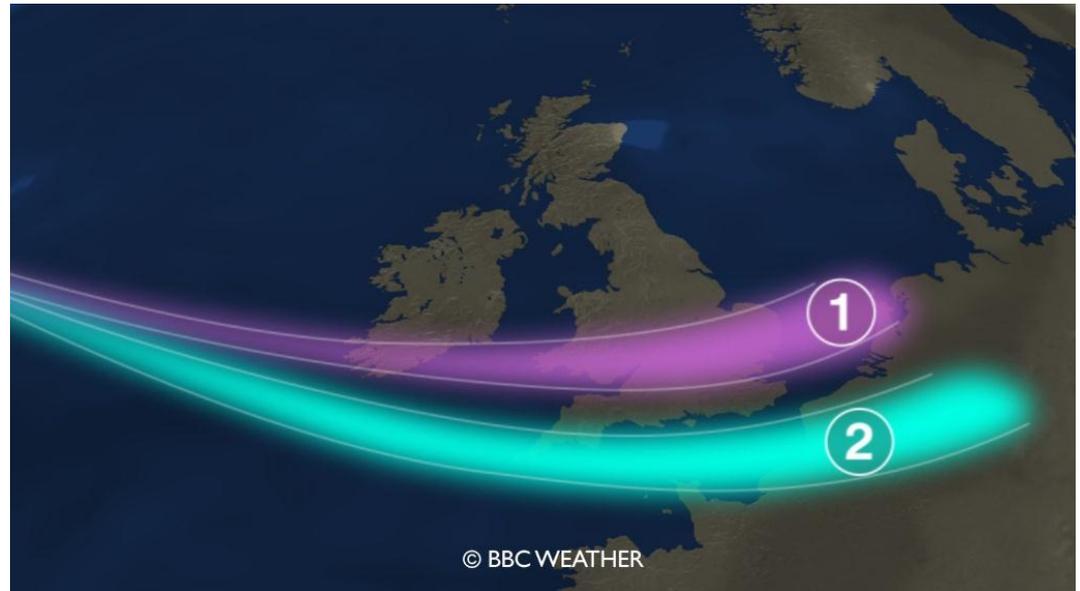
Blended  
Probabilistic  
NWP

- MOGREPS-UK will be integrated from Day 1



# Forecasters communicate low risk of very high impact

- BBC shows two alternative tracks:
  - Track 1 is low probability but highest impact (severe gales and heavy snow).
  - Track 2 has a higher probability but lower impact (some snow, but lighter winds).





# Hazard Impact Model

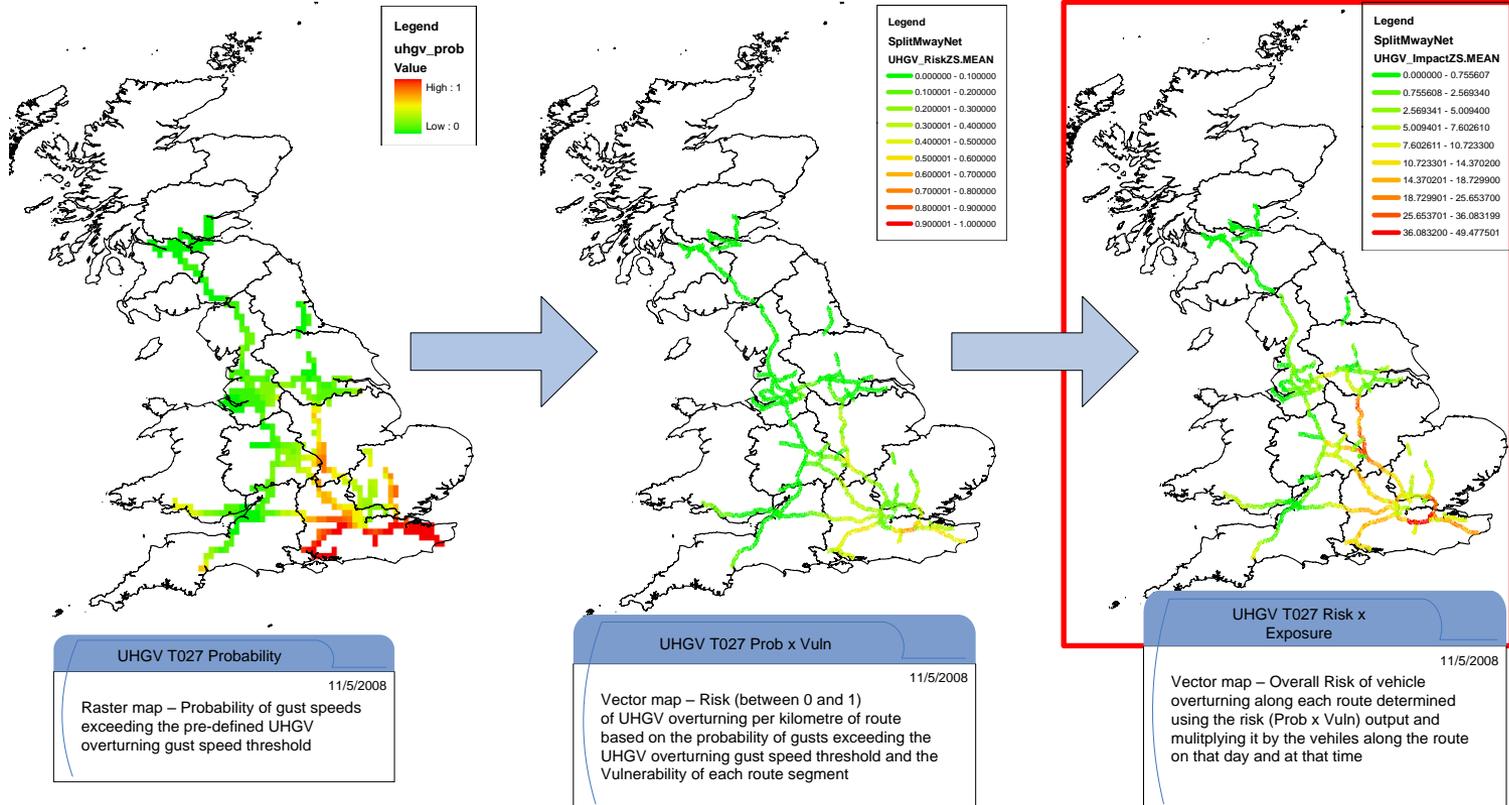
# Converting Hazard to Risk

## Example for road vehicle overturning due to strong winds

Probability, Vulnerability & Exposure = Risk of Vehicles Overturning

Wednesday, November 05, 2008

### OVERALL RISK MAP





# Conclusions

- Main MOGREPS changes in 2012 are:
  - 6-hr ETKF cycling with lagging
  - resolution upgrade of global system to 32km, and
  - introduction of a convective-permitting suite
- SST and SMC perturbations provide useful increase in spread of near-surface variables
- Ensembles are no longer just a nice-to-have extra – they are an integral part of the operational NWP
- Ensembles help us turn weather forecasts into risk management tools



Thank-you !!!

Questions...?