Recent Developments within MOGREPS at the Met Office

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

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NAEFS Workshop, FNMOC
1st - 3rd May 2012, Monterey, CA

Contents

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

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Operational setup and 2012 upgrades

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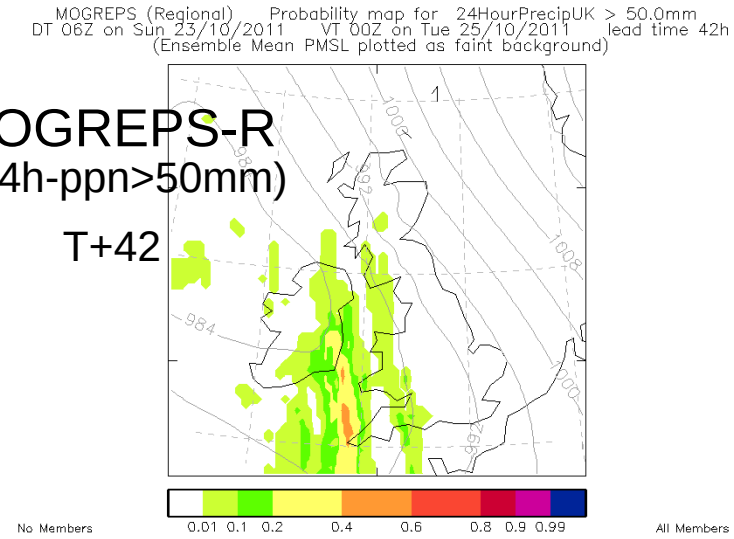
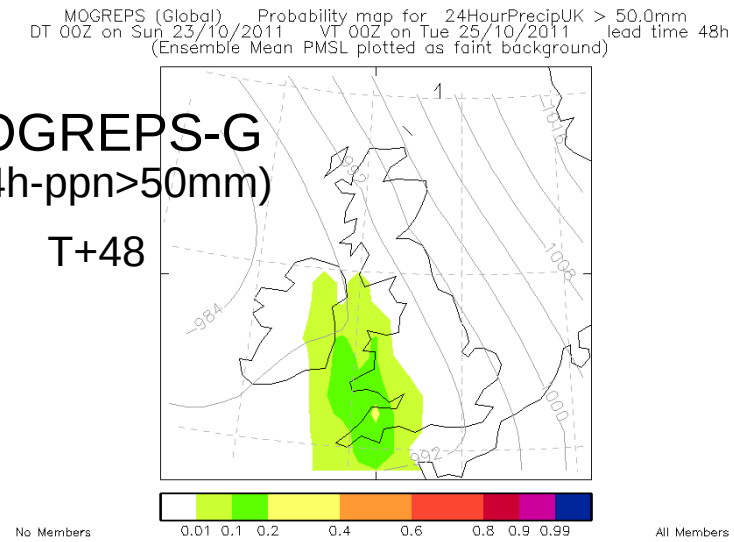
Key Aim of MOGREPS



MOGREPS-R
p(24h-ppn>50mm)
T+42



MOGREPS-G
p(24h-ppn>50mm)
T+48

- Forecasting <u>High-Impact</u> 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

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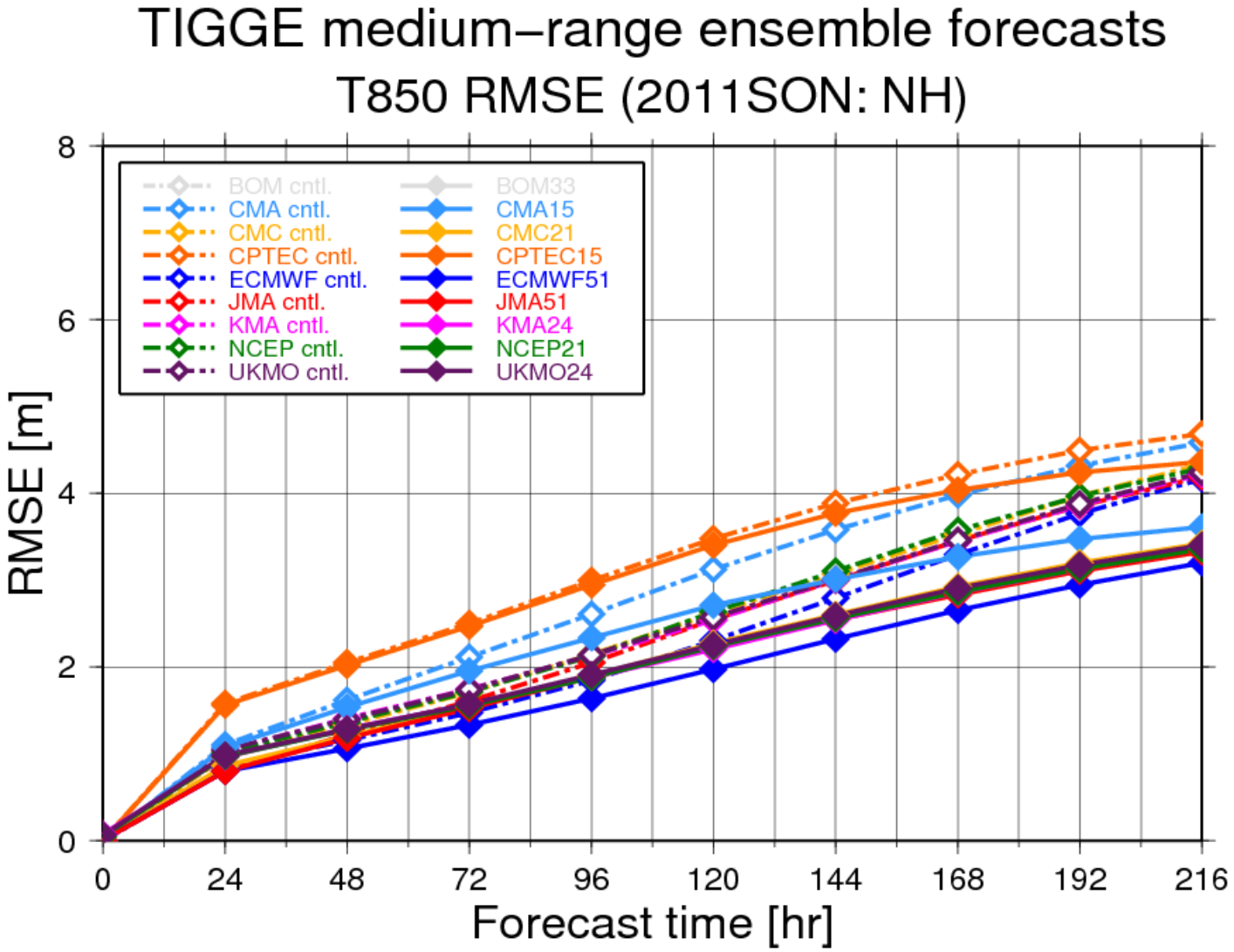
TIGGE “beauty contest”



Courtesy Mio Matsueda

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

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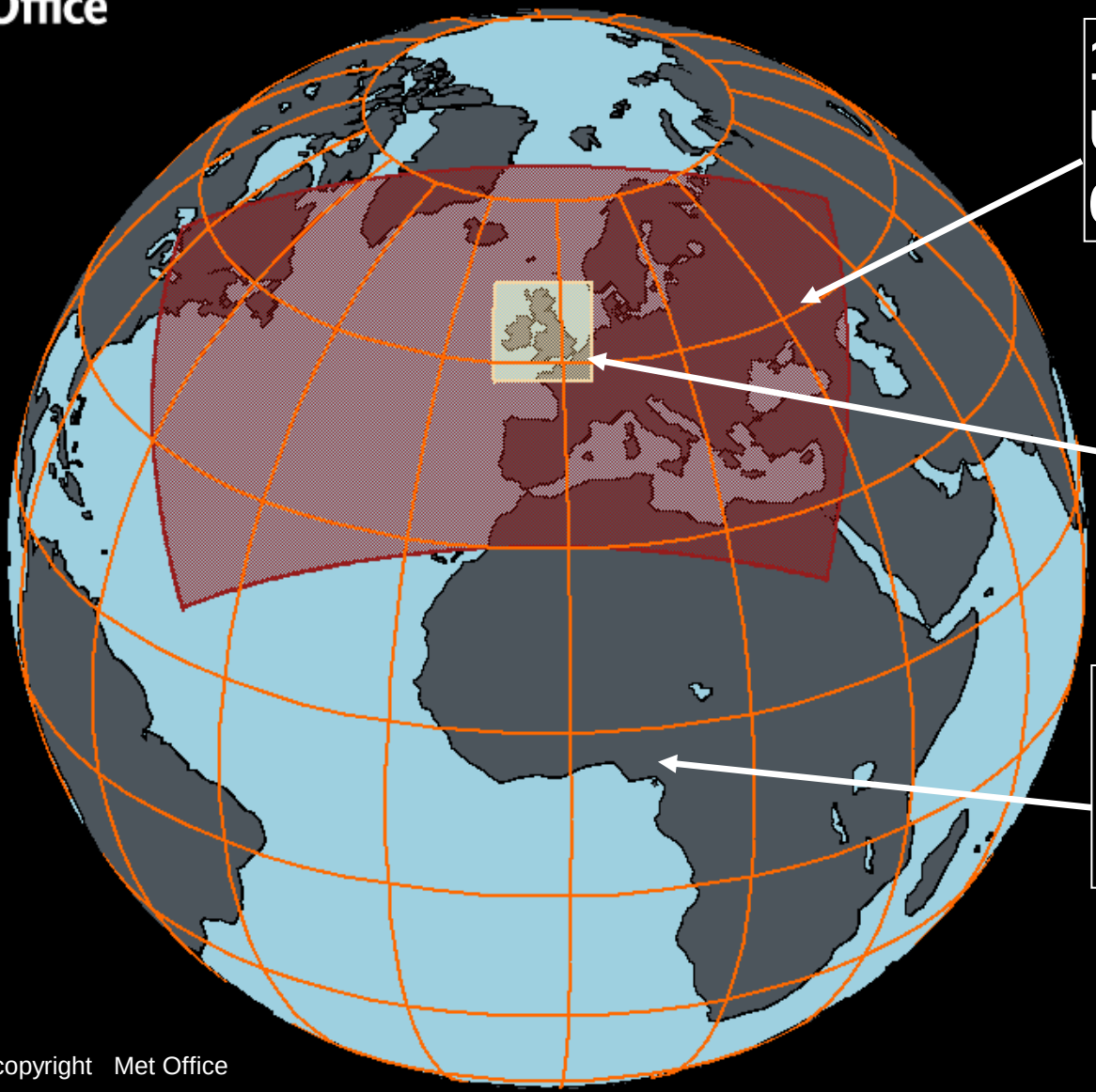
MOGREPS Model domains



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

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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

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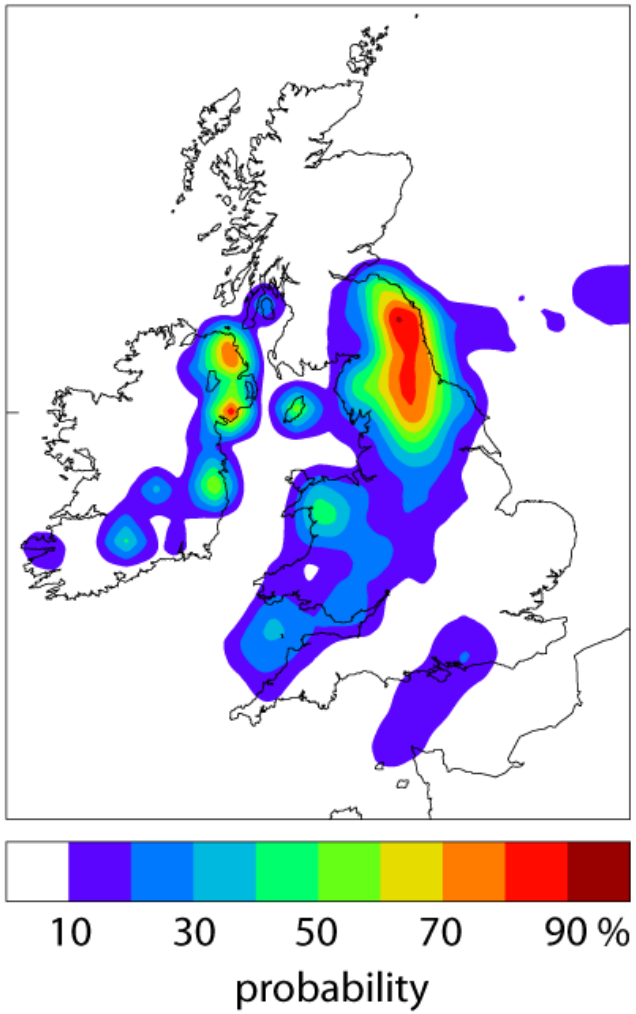
MOGREPS-UK
2.2km UKV model



- 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

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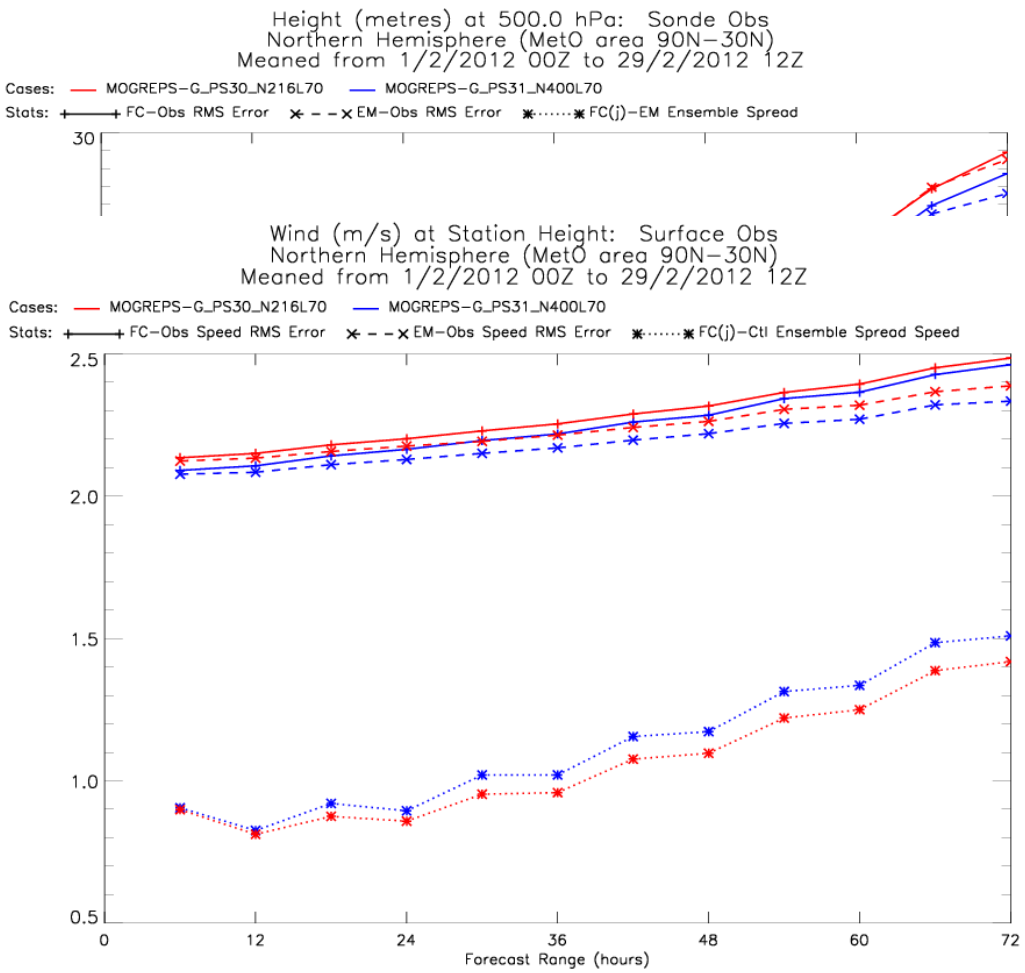
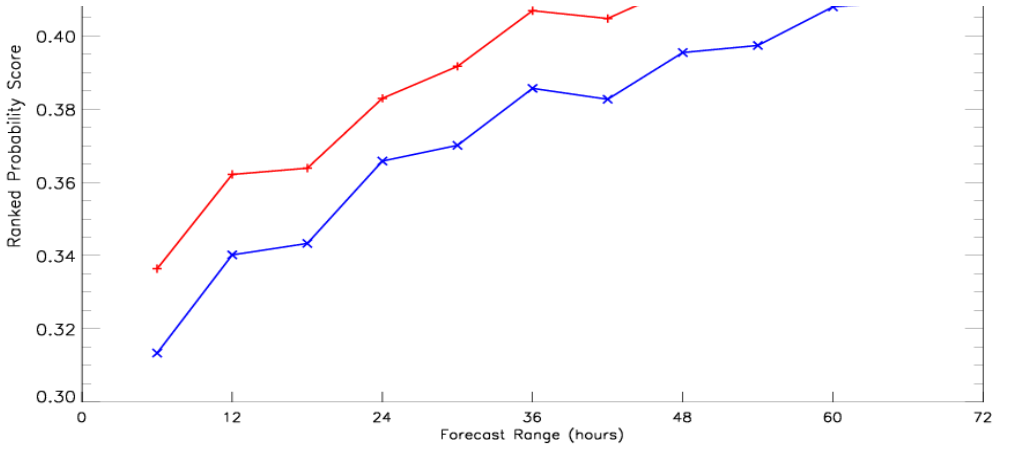
Increased resolution

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





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SST and Soil Moisture Perturbations

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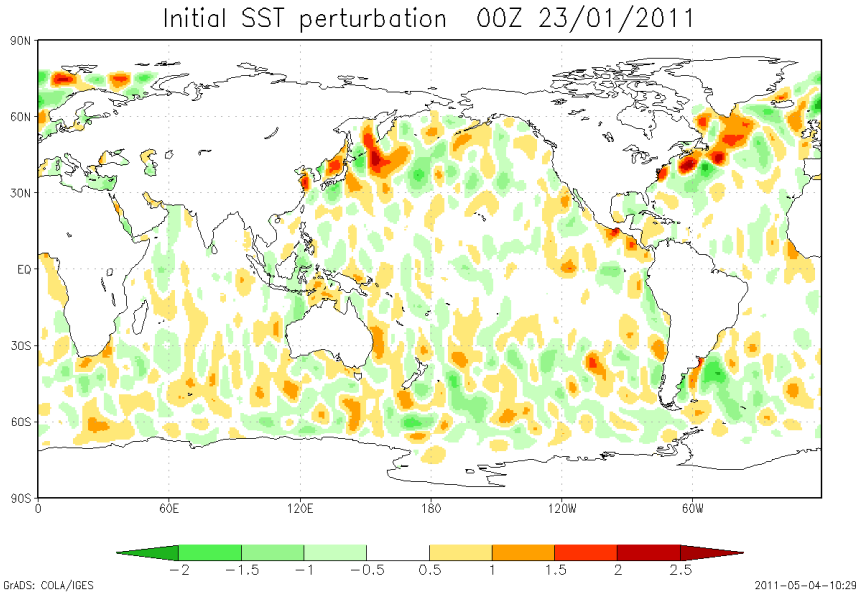
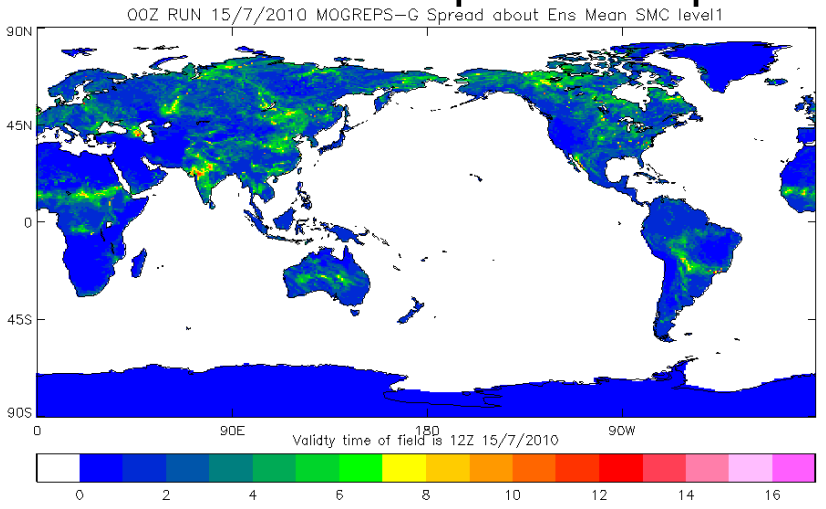
SST & Soil Moisture Perturbations

- SST:
  - Derive statistics of SST fields, e.g. day-to-day δt
  - 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



Soil moisture pert example



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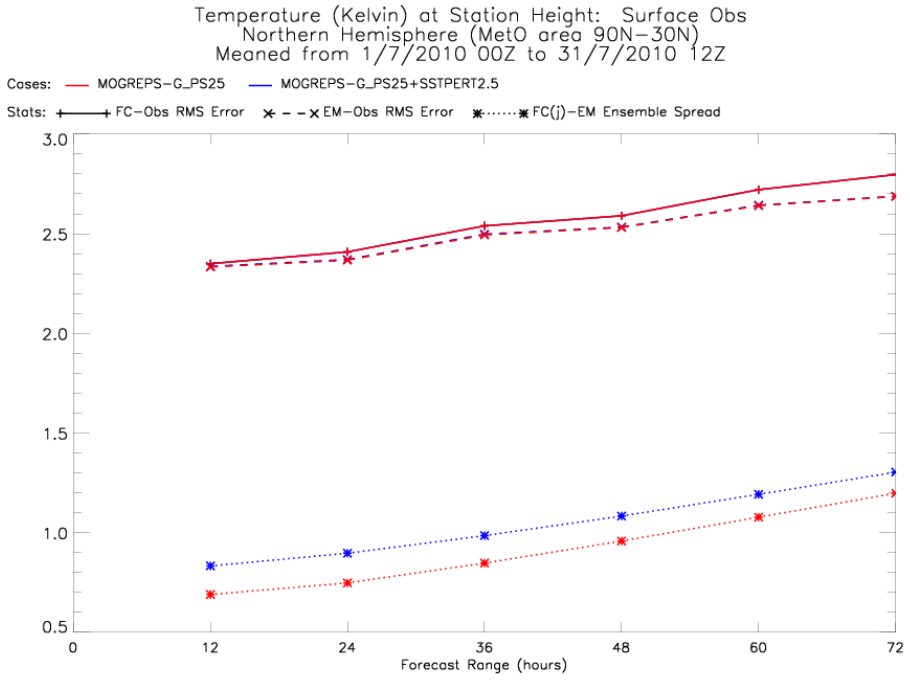
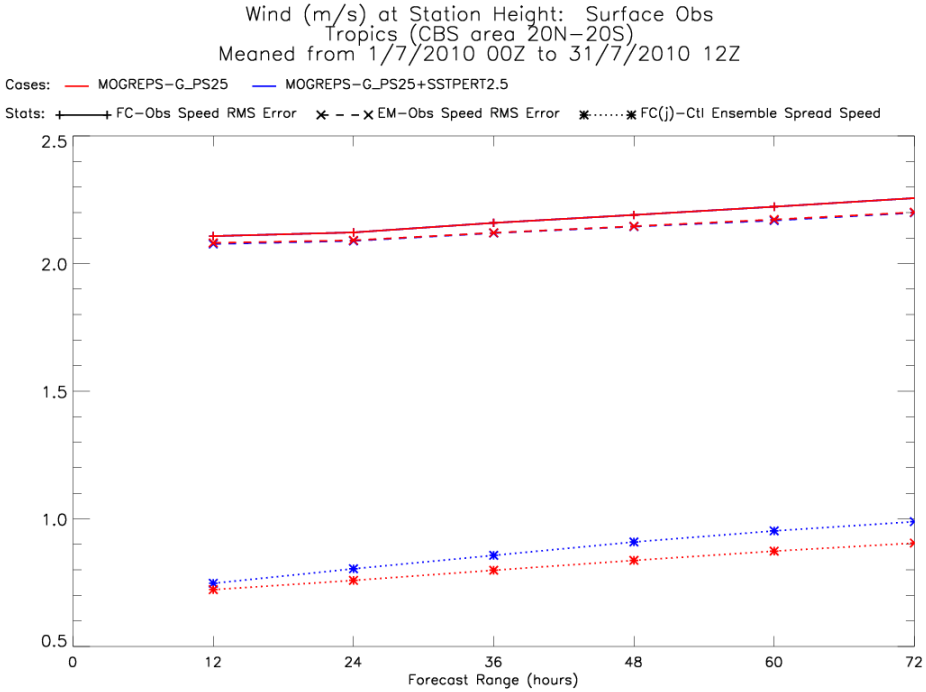
SST Perturbations: Verification scores





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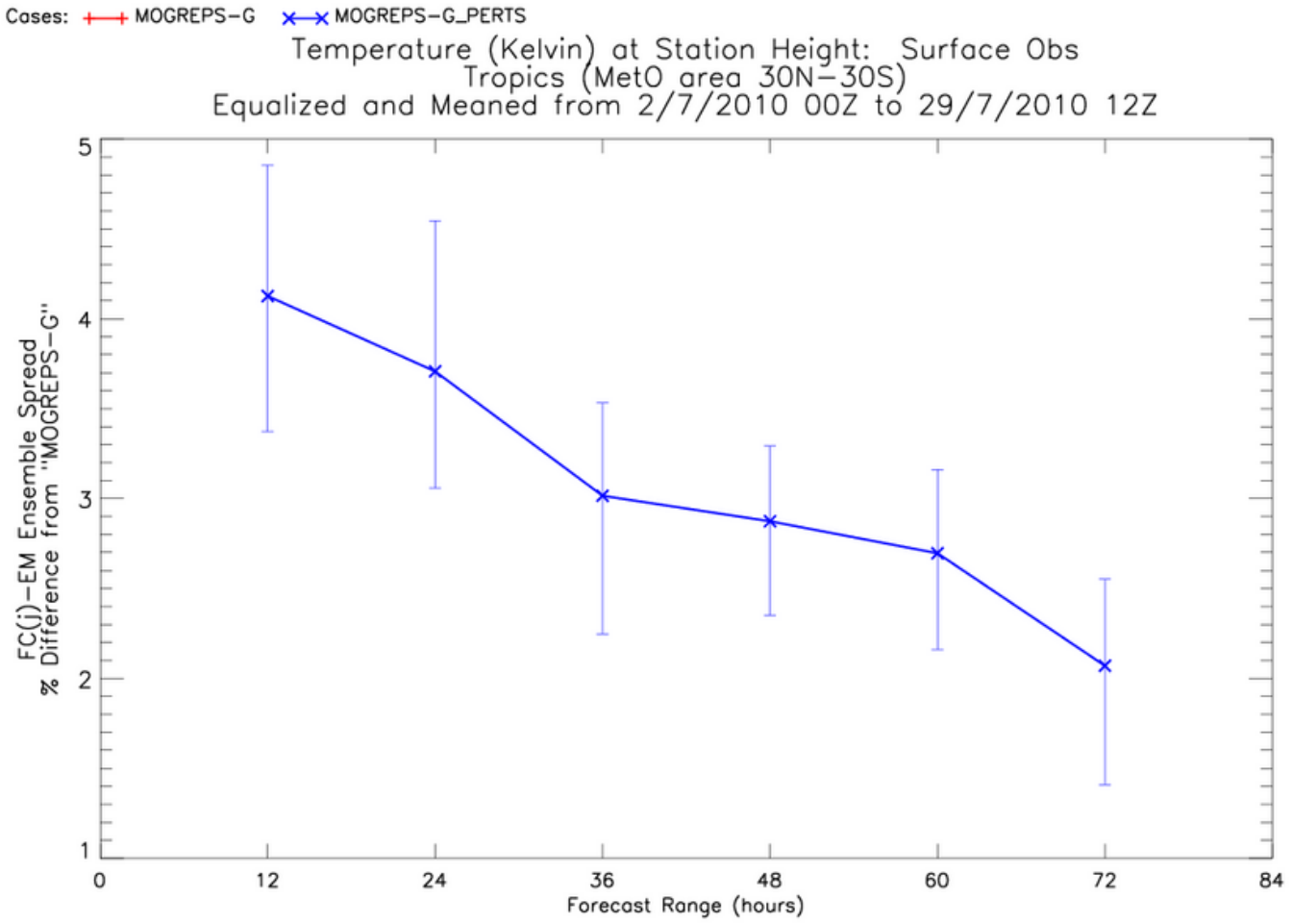
Impact of Soil Moisture Perturbations
T2m Tropics



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Stochastic Physics

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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

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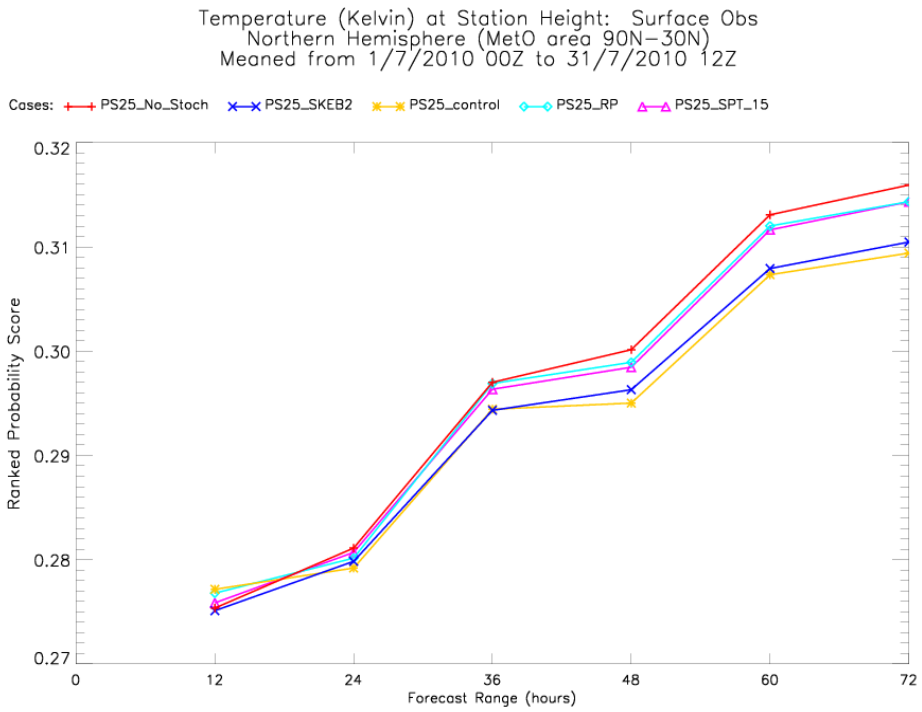
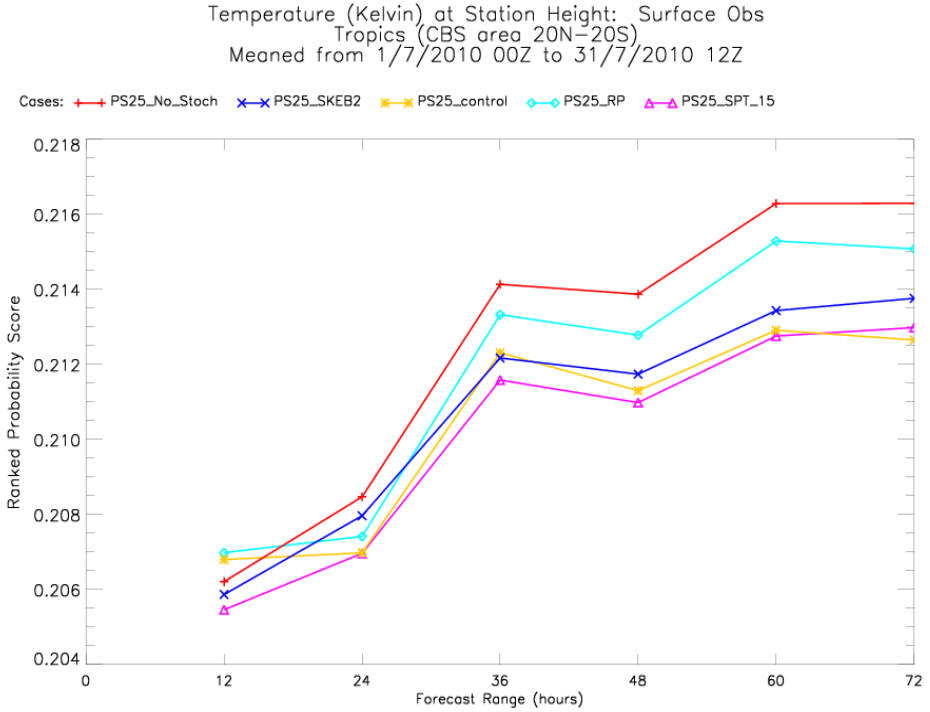
Comparing Stochastic Physics schemes in MOGREPS-G:

Ranked Probability Score: Sfc-Temp





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MOGREPS-W

First-guess Severe Weather Warnings for NSWWS

Estimating Impact – a Risk tool

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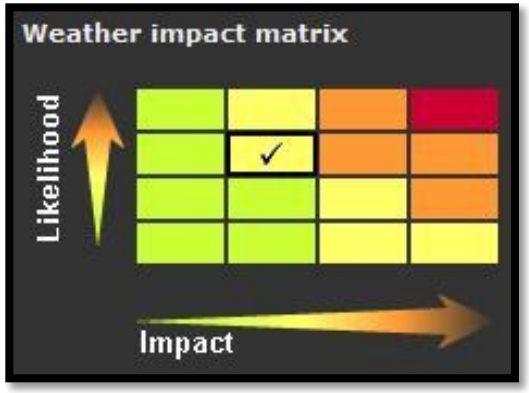
The National Severe Weather Warning Service (NSWWS)

- 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 that just by county area



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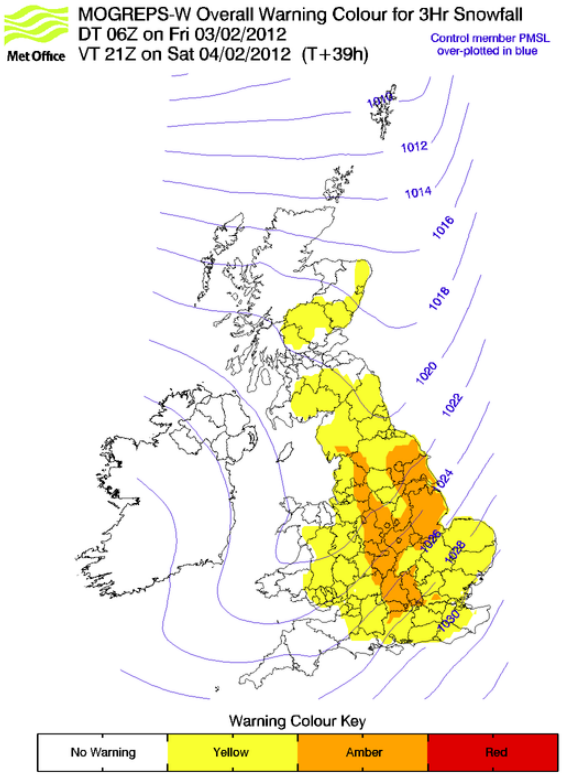
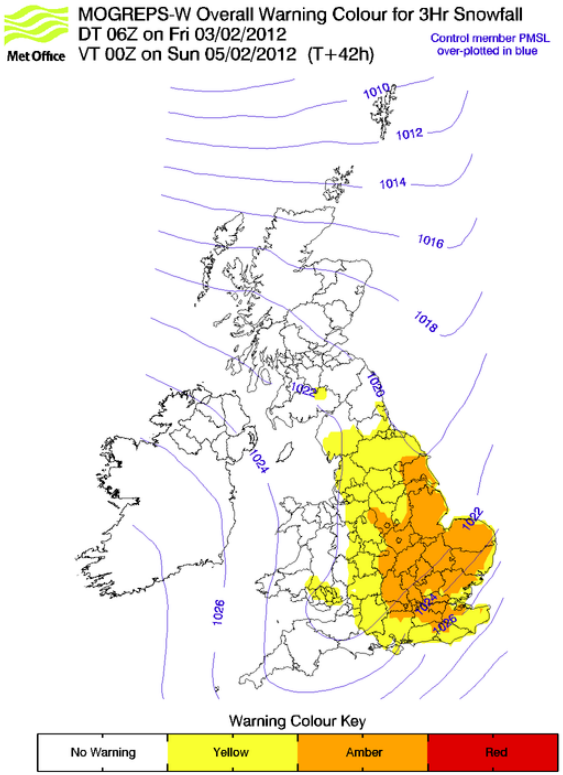
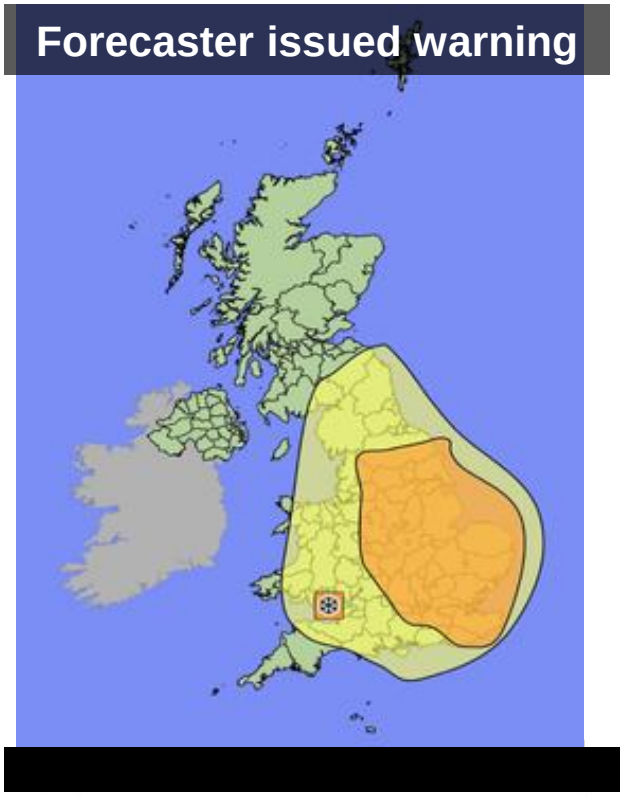
MOGREPS-W

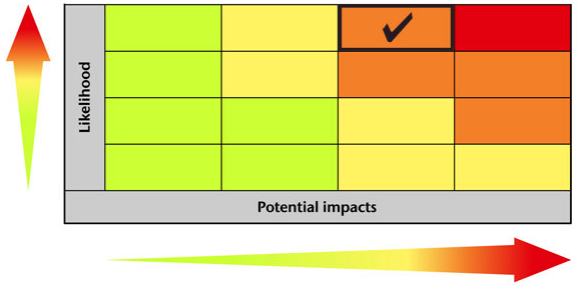
MOGREPS-W presents ensemble information to forecasters in a user-friendly format which mimics the NSWWS colour states, taking account of the expected impact of weather as well as likelihood.







•MOGREPS-W 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.



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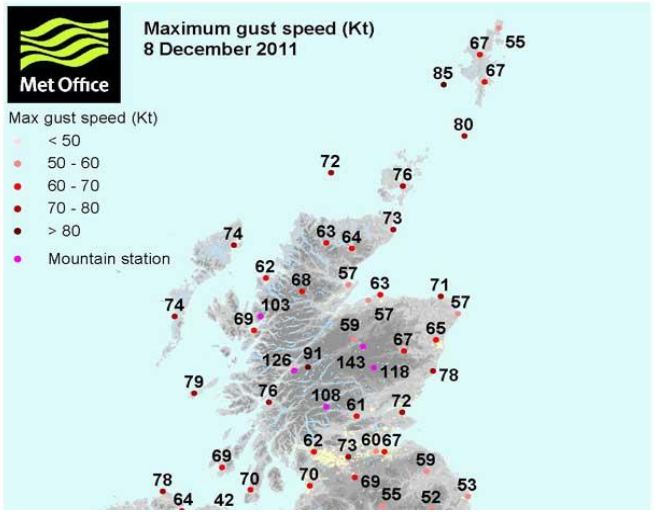
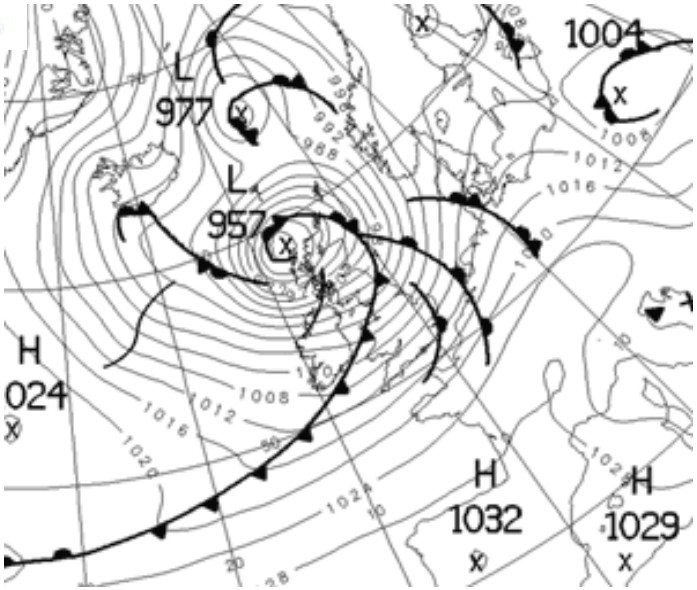
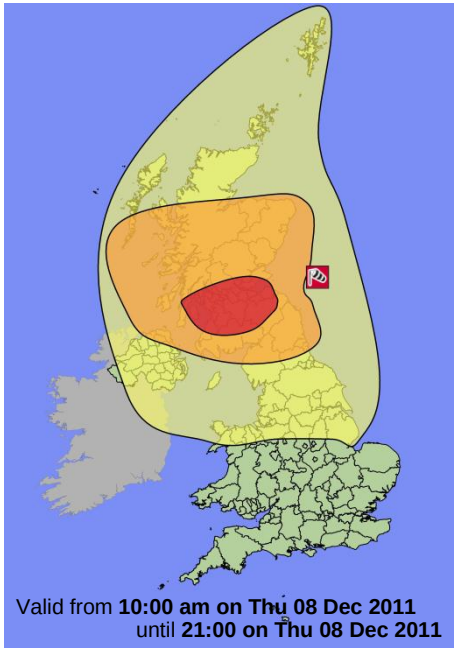
Scotland 8 December 2011

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

- 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







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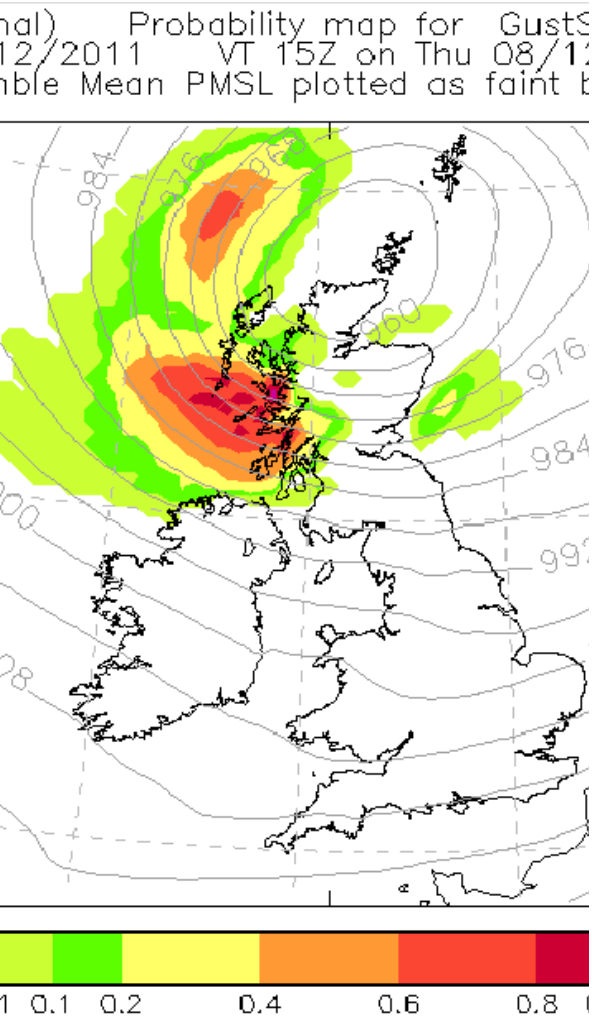
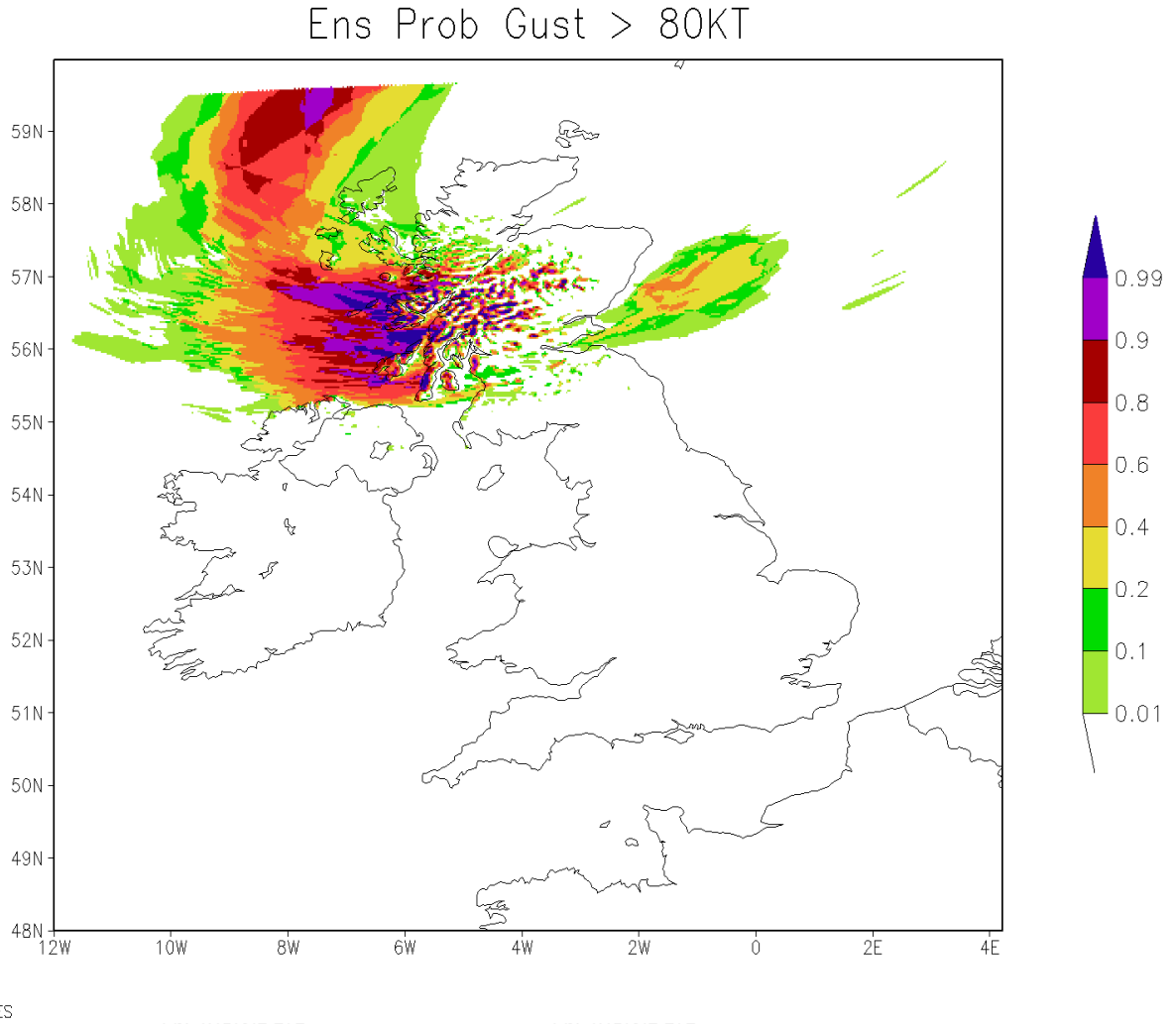
MOGREPS-UK Case Study: Gales in Scotland on 08 Dec 2011





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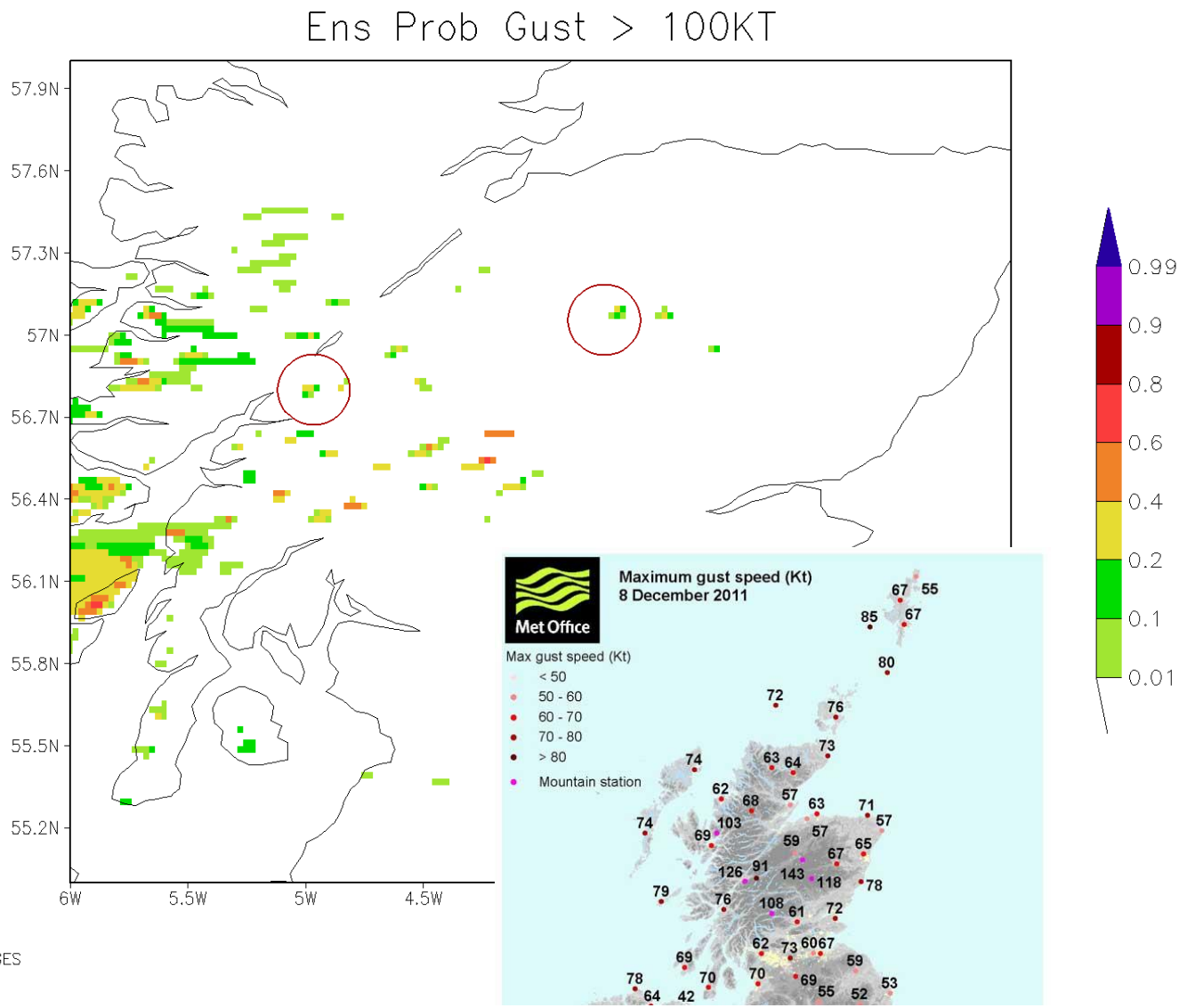
MOGREPS-UK Case Study: Gales in Scotland on 08 Dec 2011



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Forecaster displays

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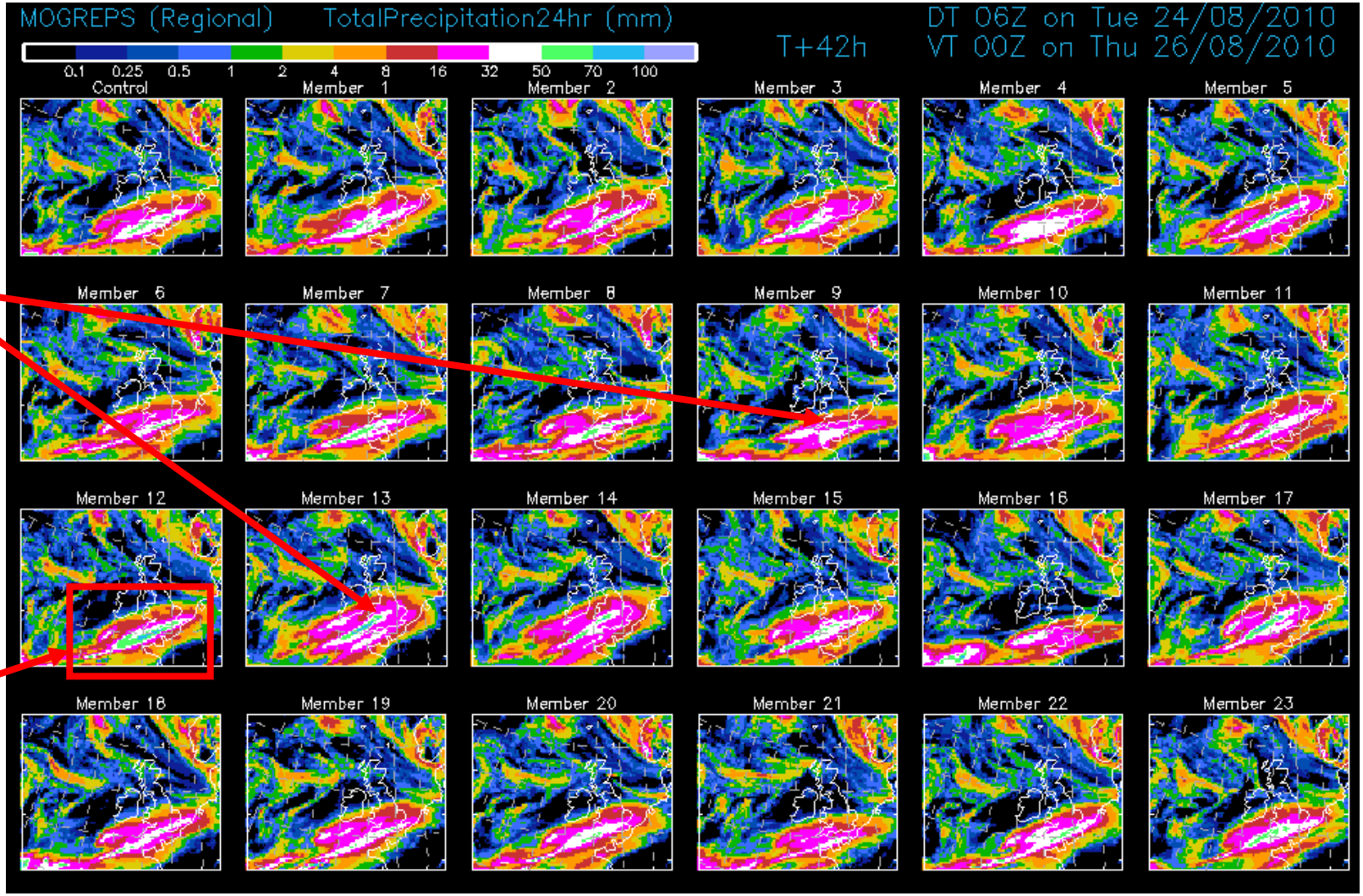
Postage stamp charts
24h precipitation example



Location

Intensity

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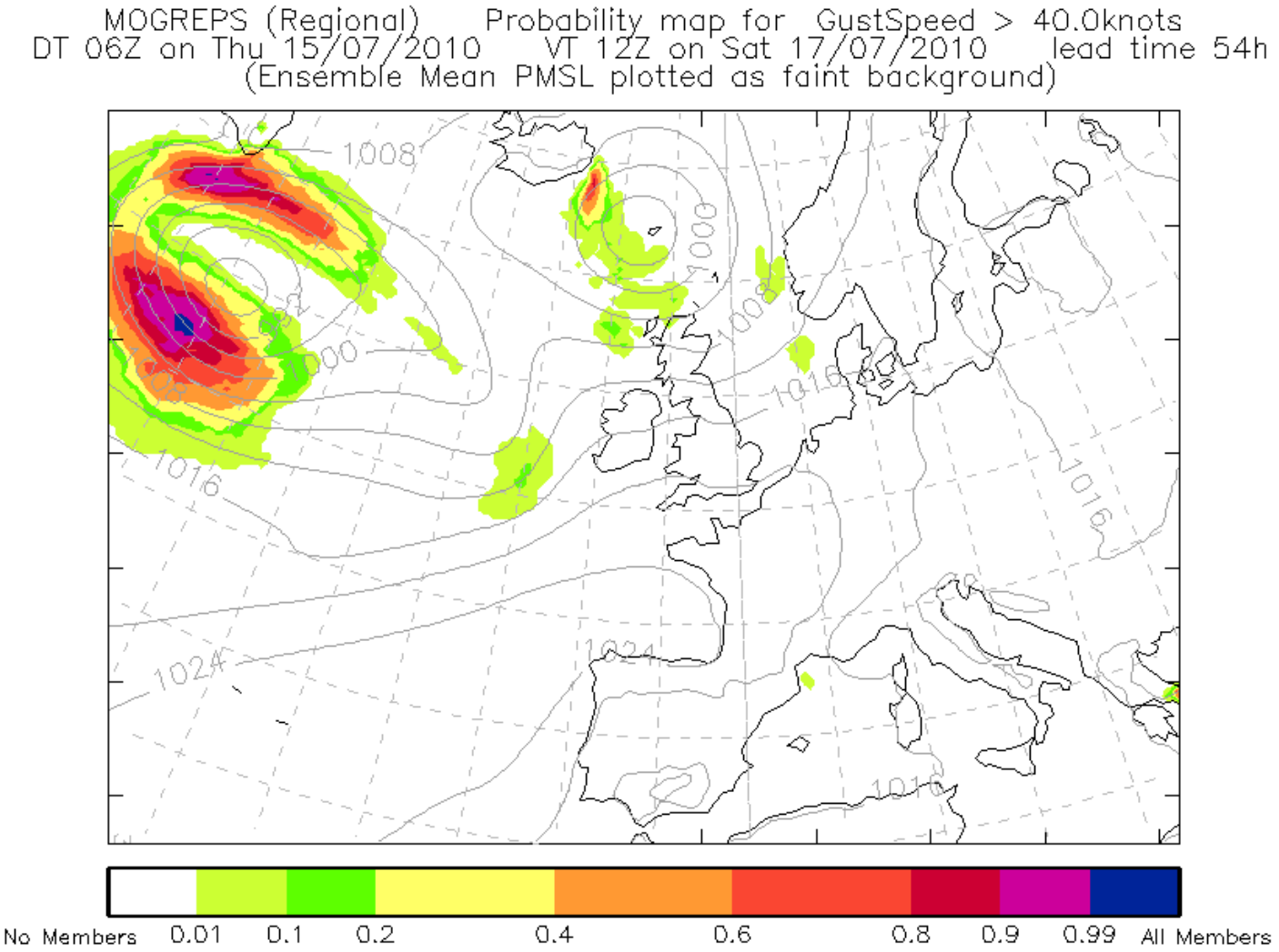
Prob of Gusts>40kt

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



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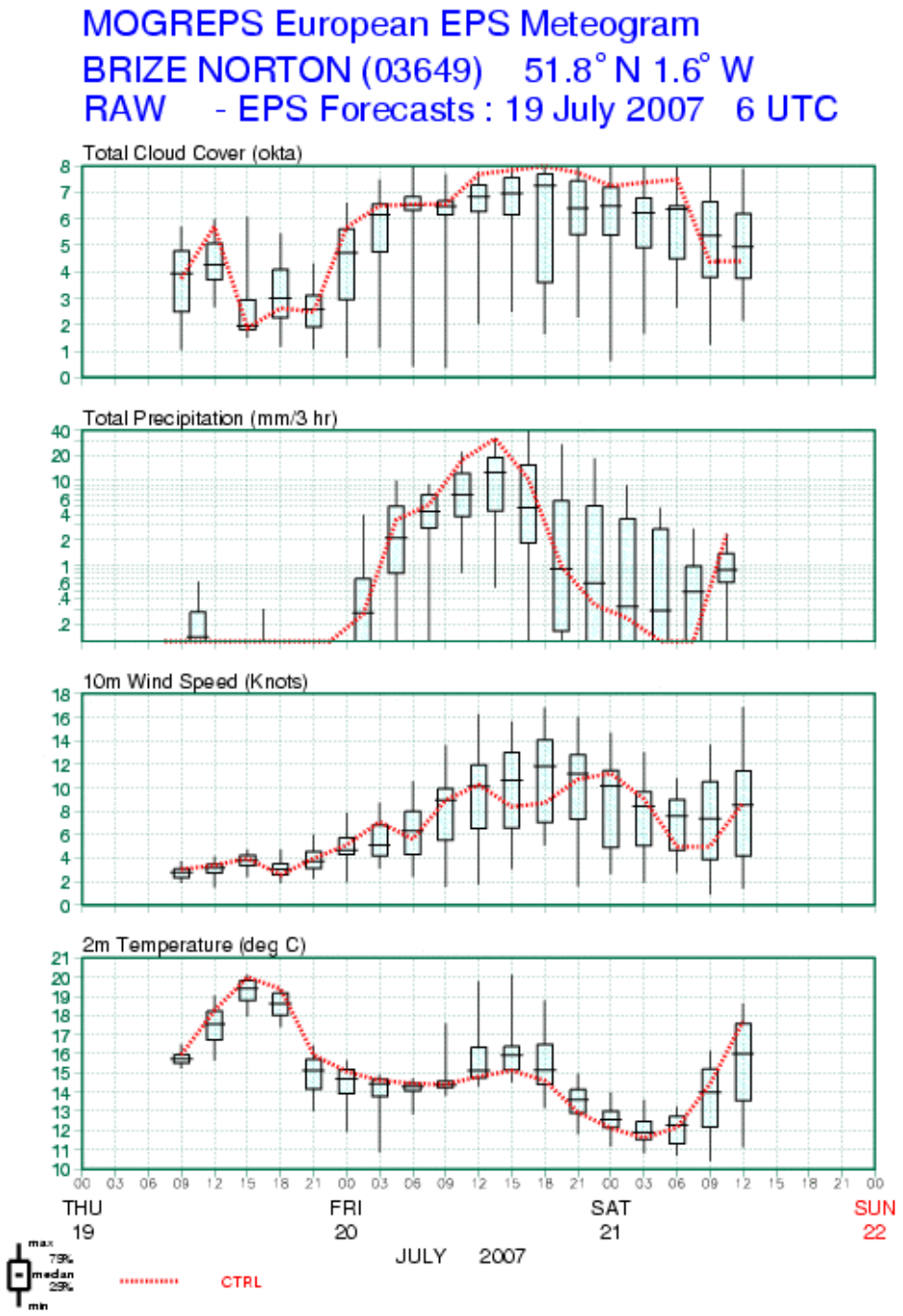

Meteograms

- 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*

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“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

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Best Data updating by Blending

To start – 15 days out

- BestData(T+360) = MOGREPS-15(T+360)

12 hours later

- BestData(T+348) = 0.5*MOGREPS-15(T+348) + 0.5*BestData(T+360)

Current BestData = a * latest forecast + (1-a)* previous BestData

- ‘a’ varies with lead time and model combination

- At shorter range blend in:
  - MOGREPS-R
  - Higher resolution deterministic models including UKV
  - Nowcasts

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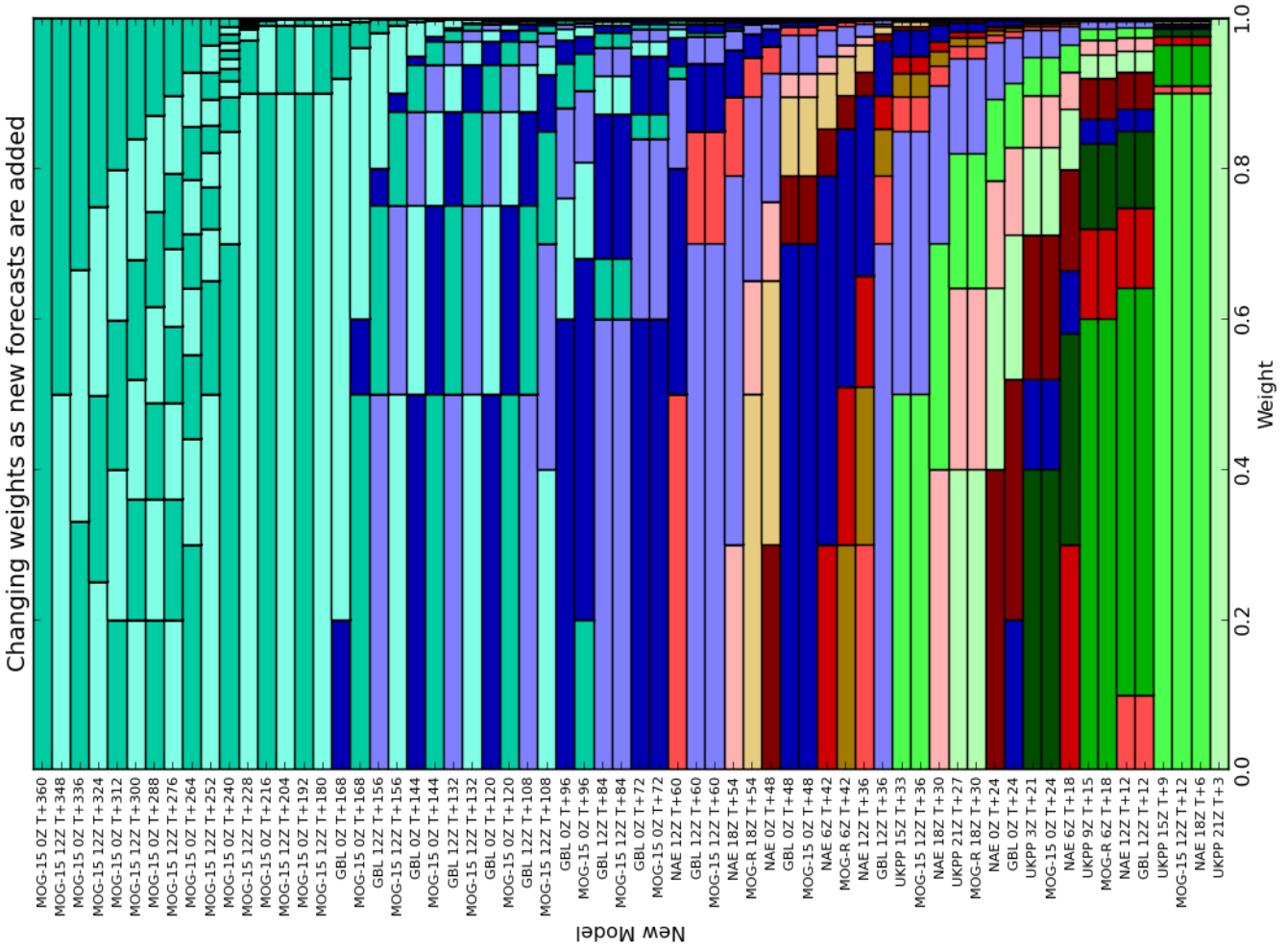
Complex sets of weights by lead-time



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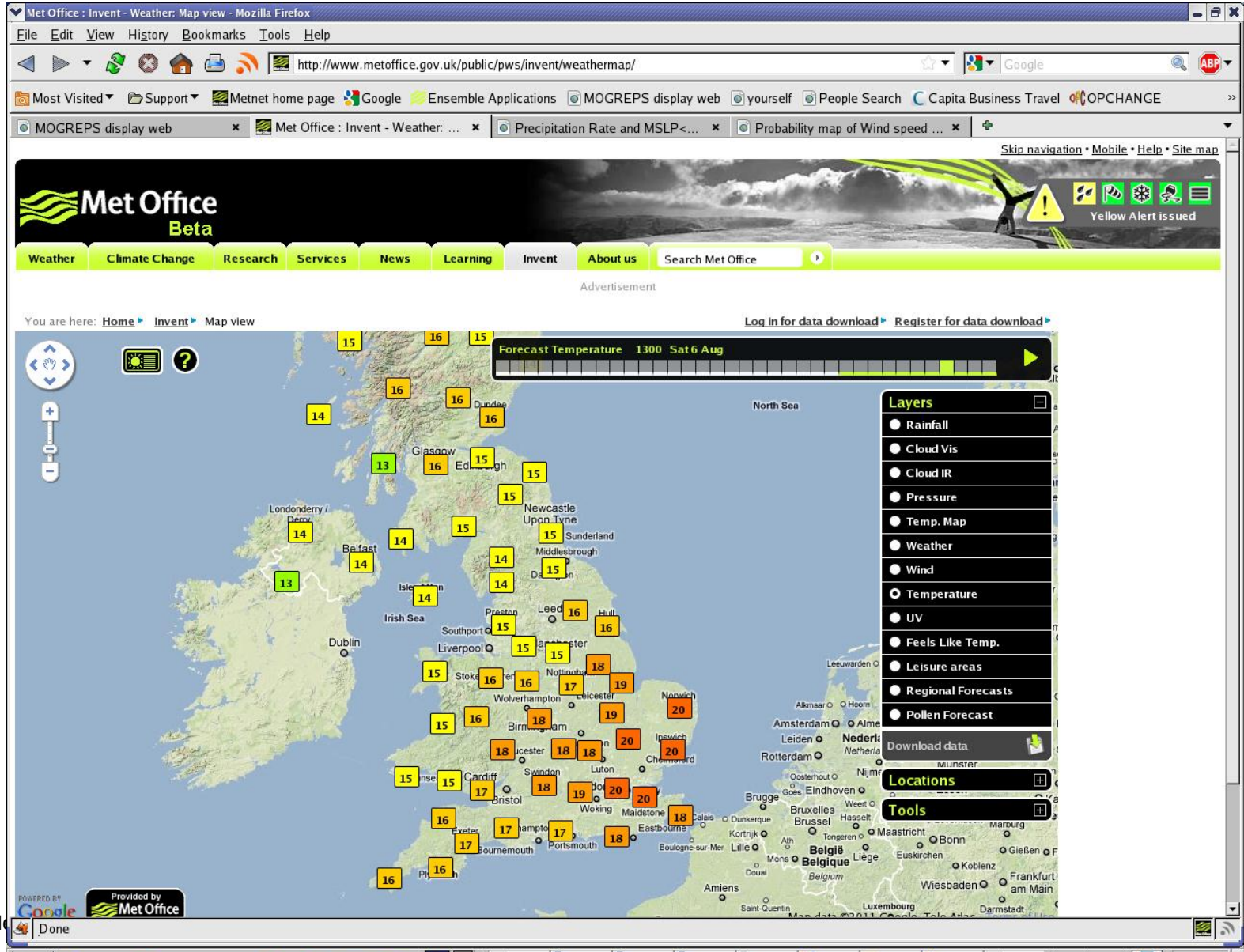
Best Data Temperatures



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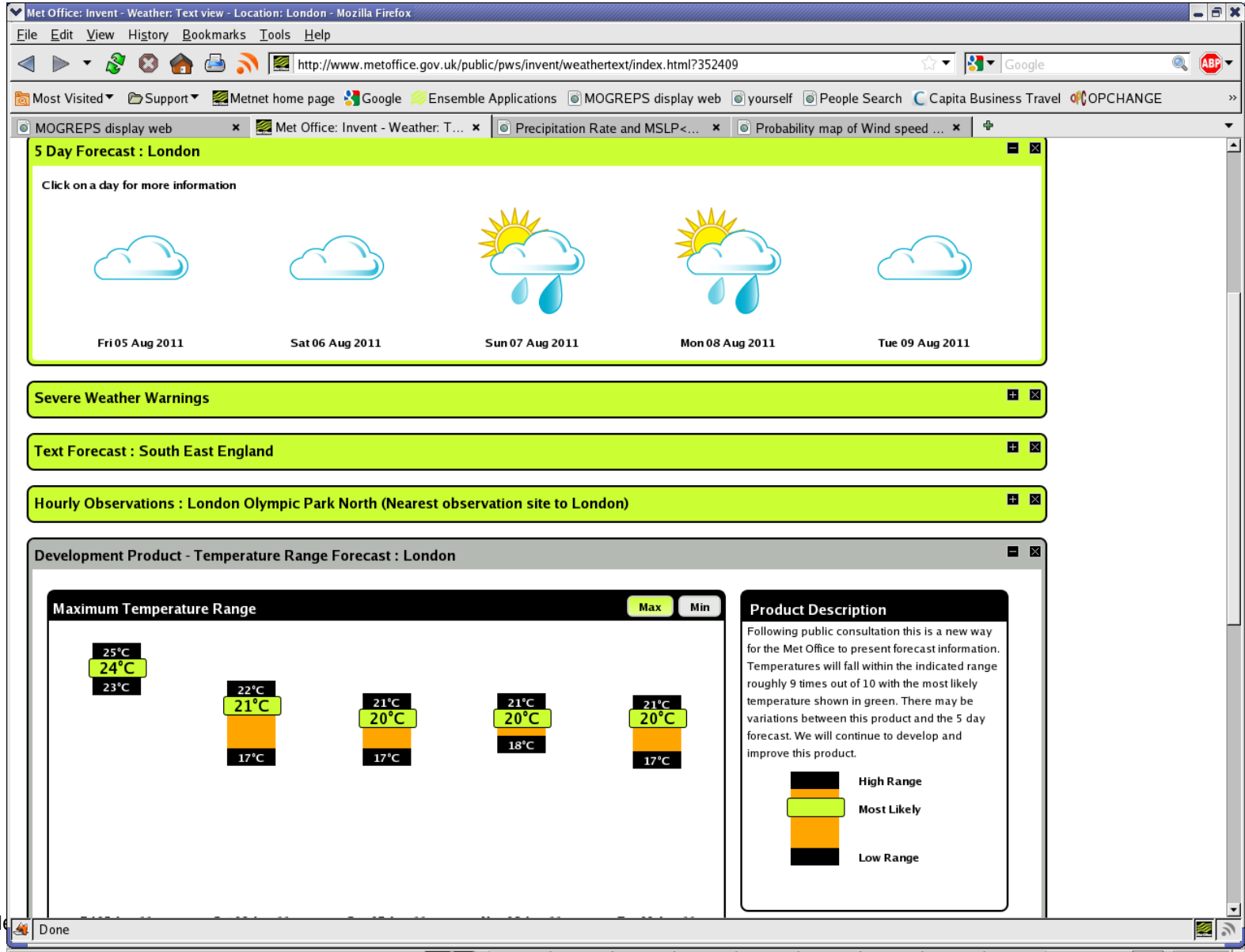
Detail for London



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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

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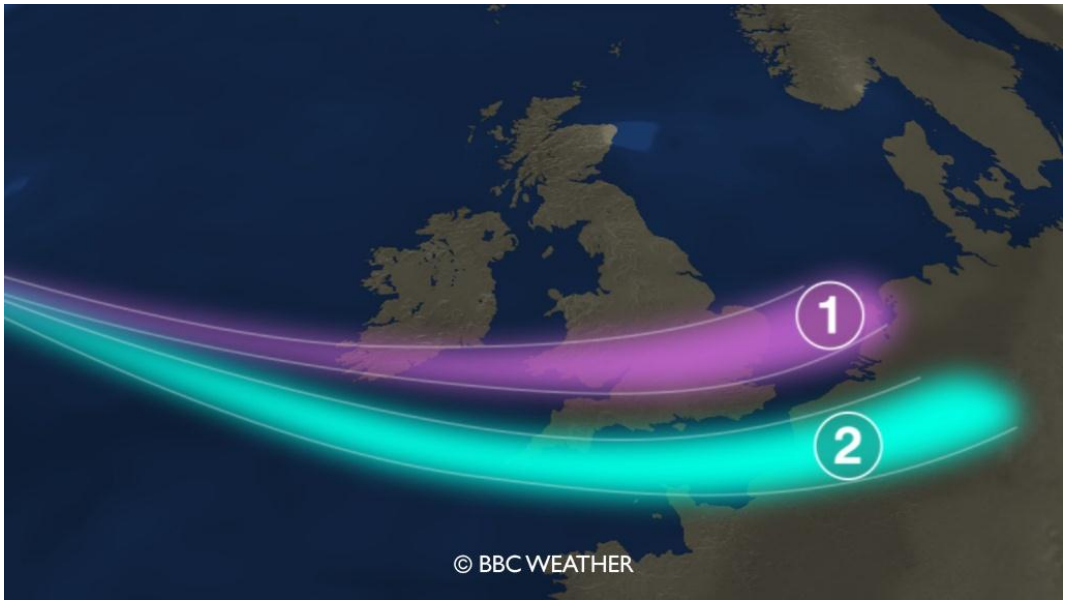
Forecasters communicate low risk of very high impact

- 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).



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Hazard Impact Model

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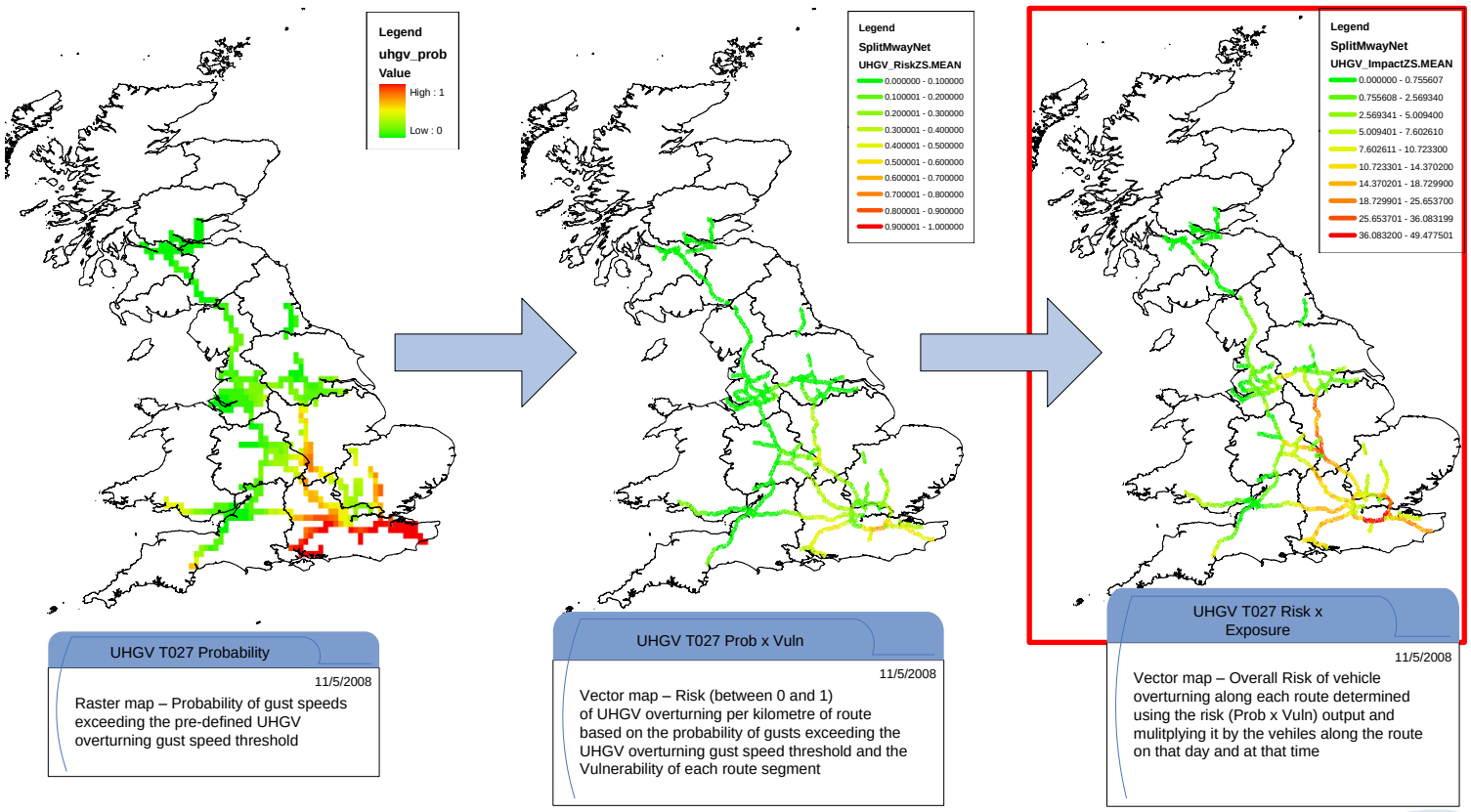
Converting Hazard to Risk

Example for road vehicle overturning due to strong winds

Probability, Vulnerability & Exposure = Risk of Vehicles Overturning

Wednesday, November 05, 2008

OVERALL RISK MAP



UHGV T027 Probability

11/5/2008

Raster map – Probability of gust speeds exceeding the pre-defined UHGV overturning gust speed threshold

UHGV T027 Prob x Vuln

11/5/2008

Vector map – Risk (between 0 and 1) of UHGV overturning per kilometre of route based on the probability of gusts exceeding the UHGV overturning gust speed threshold and the Vulnerability of each route segment

UHGV T027 Risk x Exposure

11/5/2008

Vector map – Overall Risk of vehicle overturning along each route determined using the risk (Prob x Vuln) output and mulitplying it by the vehiles along the route on that day and at that time

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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

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Thank-you !!!

Questions…?

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