



Medium-range Ensemble Forecasts at the Met Office

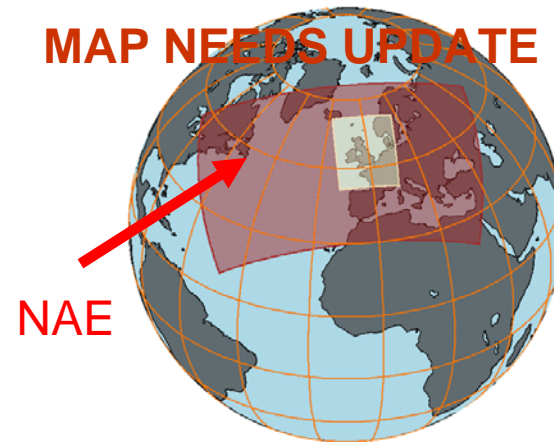
Christine Johnson, Richard Swinbank, Helen Titley
(nee Watkin) and Simon Thompson

With thanks to

- The MOGREPS system
- Medium-range ensemble forecasts
- Multi-model ensembles
- Forecasting high-impact weather

Ensemble forecasting at the Met Office

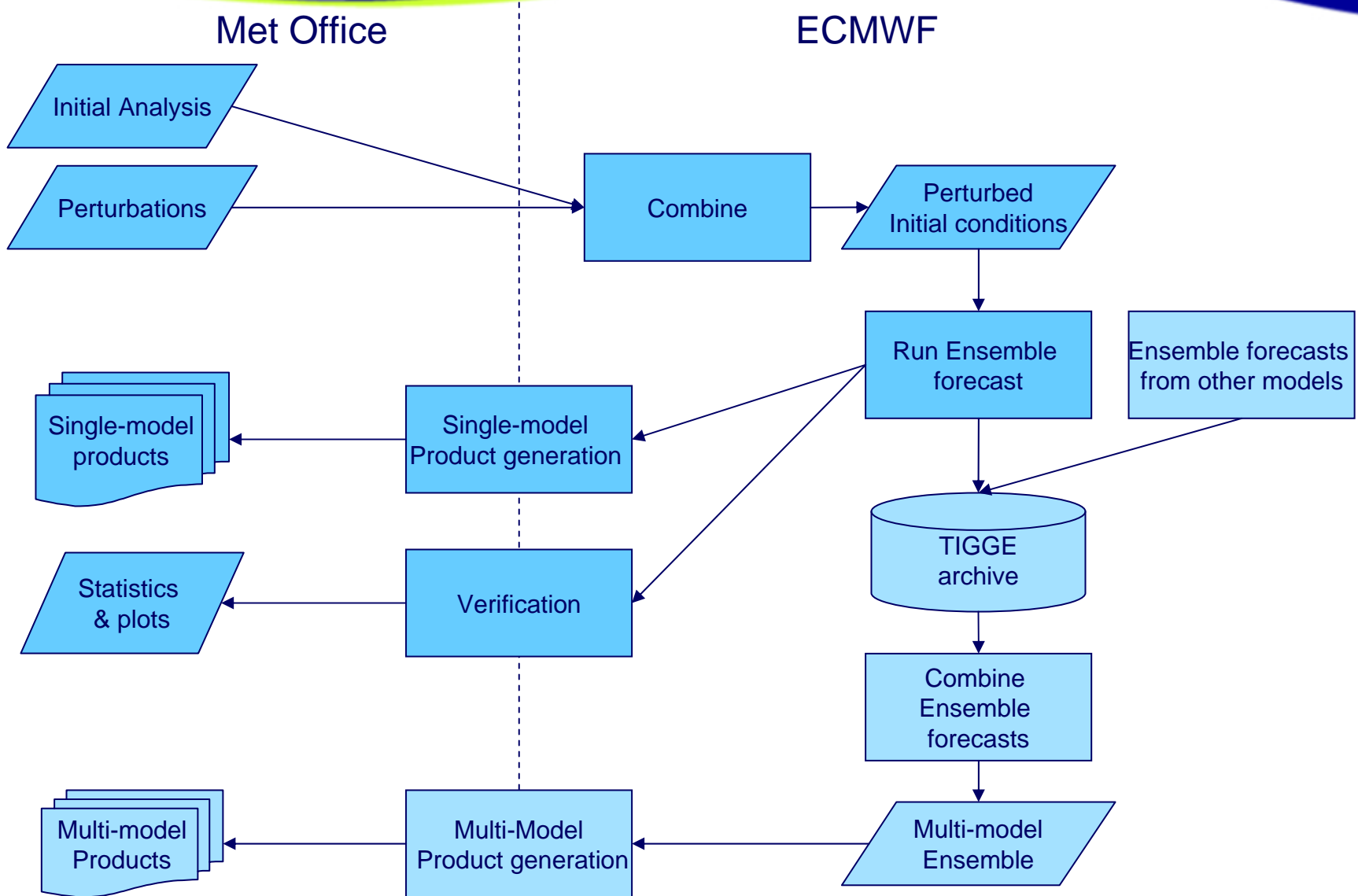
- Ensemble designed for short-range forecasting
 - Regional ensemble over N. Atlantic and Europe (NAE)
 - Nested within global ensemble
 - ETKF perturbations
 - Stochastic physics
 - T+72 global, T+54 NAE
 - Aim to assess uncertainty in short-range, eg.:
 - Rapid cyclogenesis
 - Local details (wind etc)
 - Precipitation
 - Fog and cloud



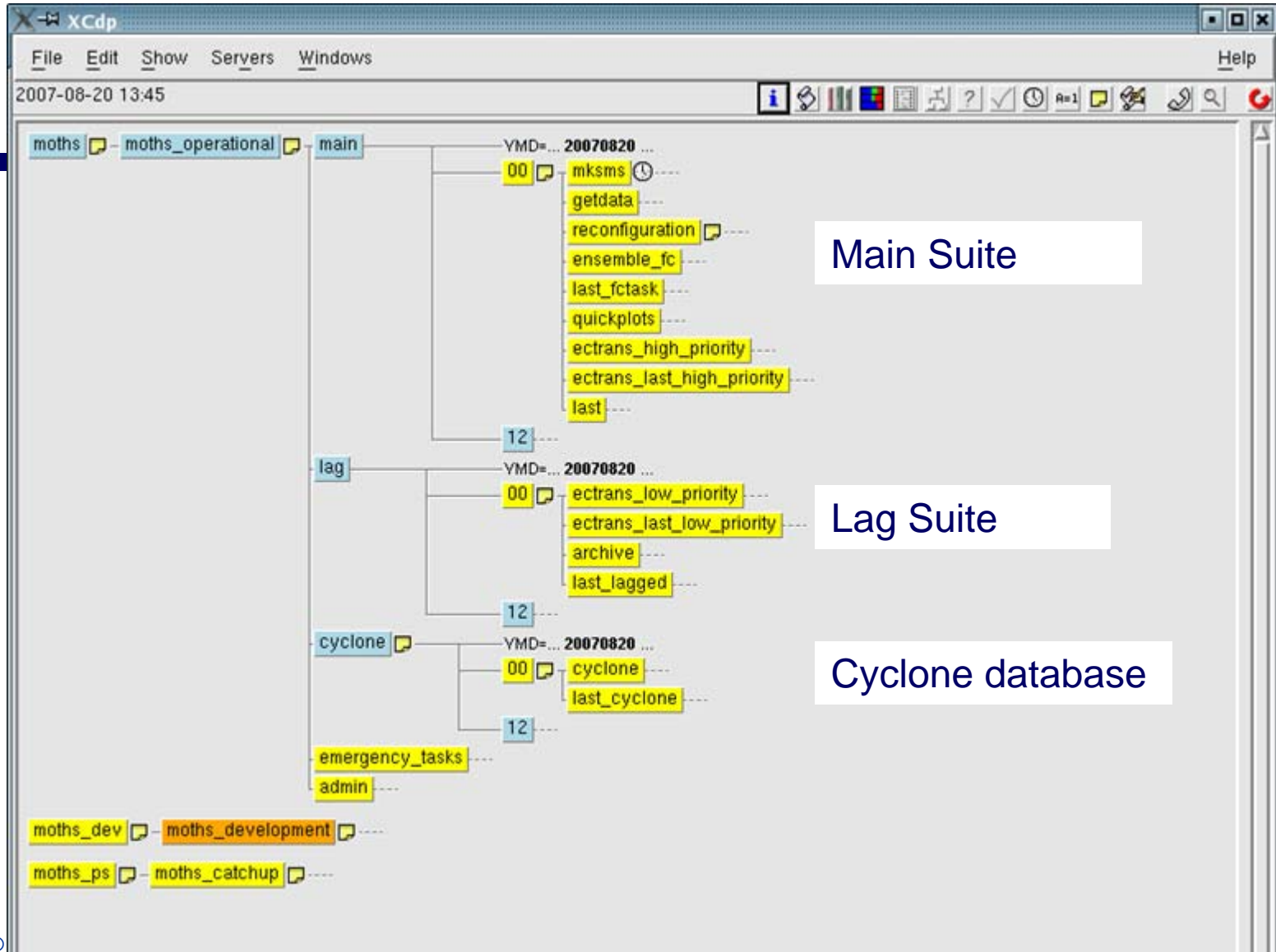
MOGREPS-15; 15-day ensemble forecasts

- Developed from MOGREPS short range ensemble system.
- Ensemble system is run at ECMWF, as a “time critical” suite.
- Met Office ensemble forecasts are now being added to the TIGGE database.
- Results are being combined with forecasts from TIGGE partners, currently ECMWF and NCEP, to form multi-model ensemble.
- Used to supplement operational information supplied to forecasters

Medium Range Ensemble Forecast system



Xcdp Screenshot of suite



Main Suite

Lag Suite

Cyclone database

- More technical details
- 24 members (control + 23 ETKF-based perturbations), run twice a day (0 and 12 UTC).
- Resolution: N144 ($0.833^\circ \times 1.25^\circ$), 38 levels
- Model physics?

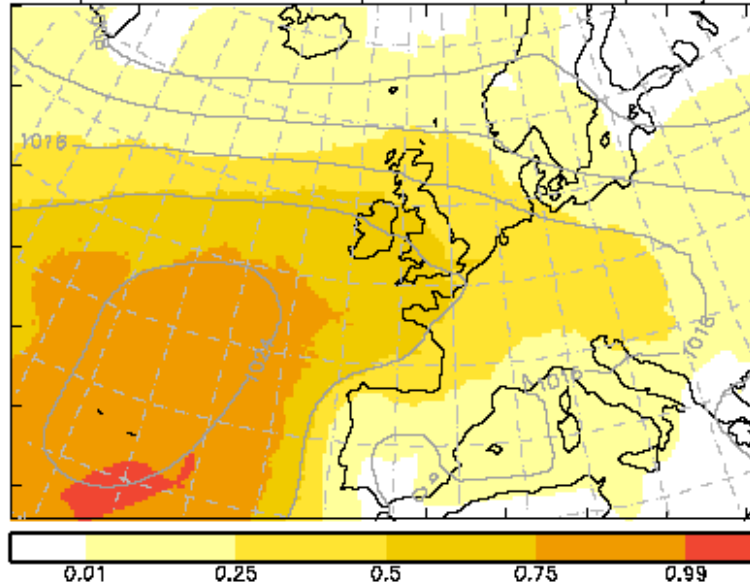
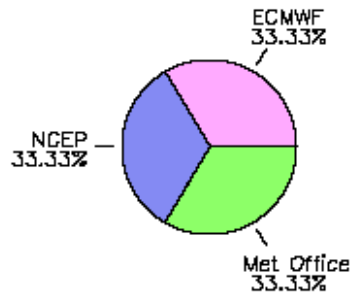
Multi-model ensemble

- Met Office ensemble forecasts are now being added to the TIGGE database
- Results are being combined with forecasts from TIGGE partners, currently ECMWF and NCEP, to form a multi-model ensemble
- Multi-model ensembles combine ensembles created from different models, with the aim of representing the errors in both the initial conditions and the forecast model
- Post-processing steps in order to produce the multi-model ensemble:
 - Bias correction of the single models
 - Combination of the models using model-dependent weights
 - Variance adjustment
- Series of high-impact weather products are output. The benefit of the multimodel is being evaluated through objective verification and by a number of case studies

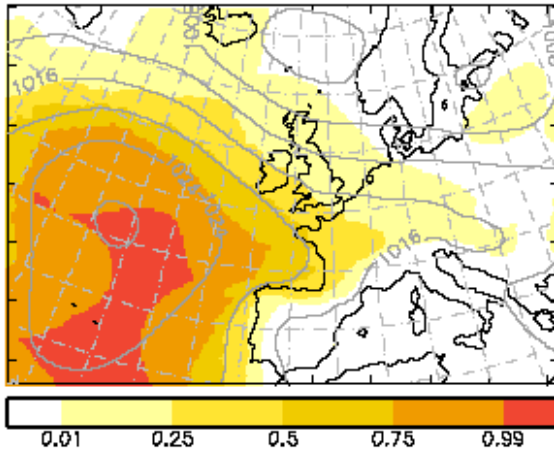
Multimodel products: Probability plot

THORPEX Multimodel Probability map for PMSL > 1020hPa
DT: 00Z Thu 23/08/2007 VT: 12Z Fri 31/08/2007 lead time 204h
(Ensemble Mean PMSL plotted as faint background)

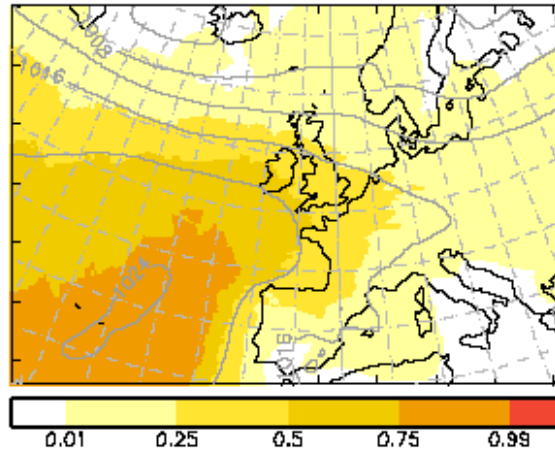
Model weights in the multimodel
(averaged over plot area)



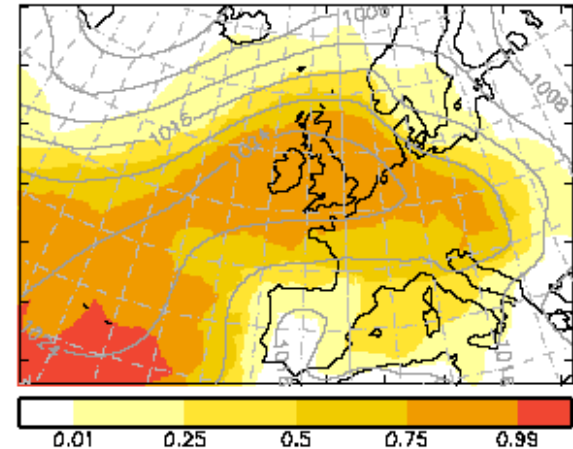
Met Office Ensemble (bias corrected)



ECWFW Ensemble (bias corrected)



NCEP Ensemble (bias corrected)

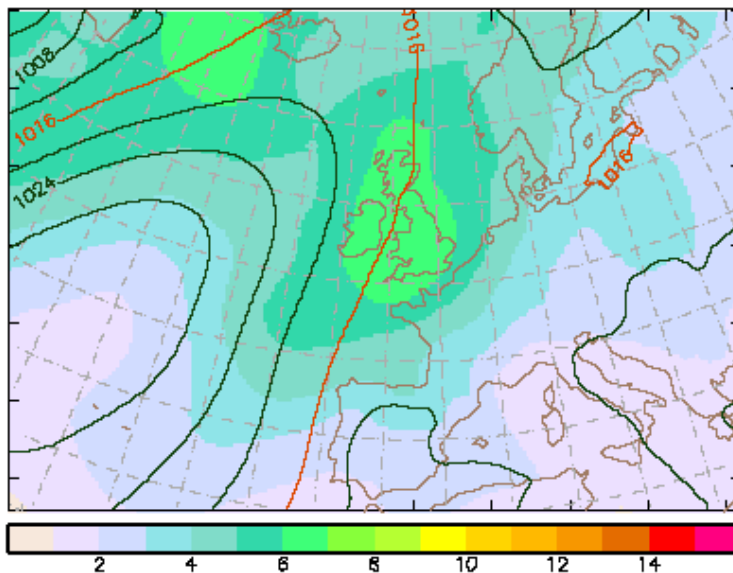
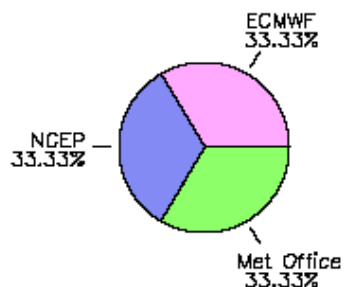


Multimodel products: Mean and spread

THORPEX Multimodel Mean and Spread for PMSL (hPa)

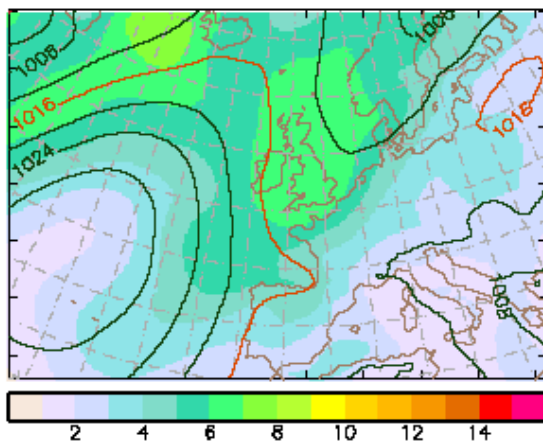
DT: 00Z Tue 14/08/2007 VT: 12Z Sun 19/08/2007 T+132h

Model weights in the multimodel
(averaged over plot area)

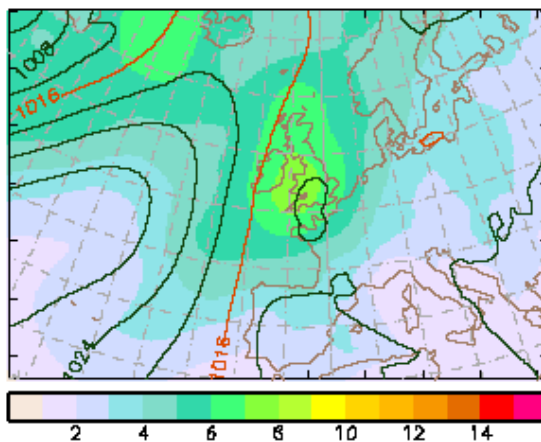


The spreads for the single-models (below) show the spread of all the members from the multimodel ensemble around the single-model mean. The spread gives an indication of the size of the uncertainty in the single model mean, and has a relatively large value if that model is not consistent with the multimodel mean.

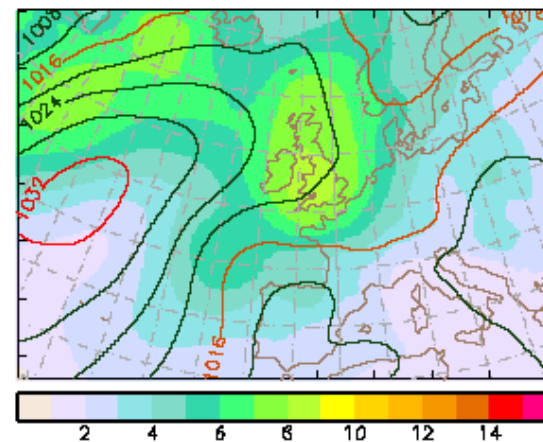
Met Office Ensemble Mean (bias corrected)



ECMWF Ensemble Mean (bias corrected)

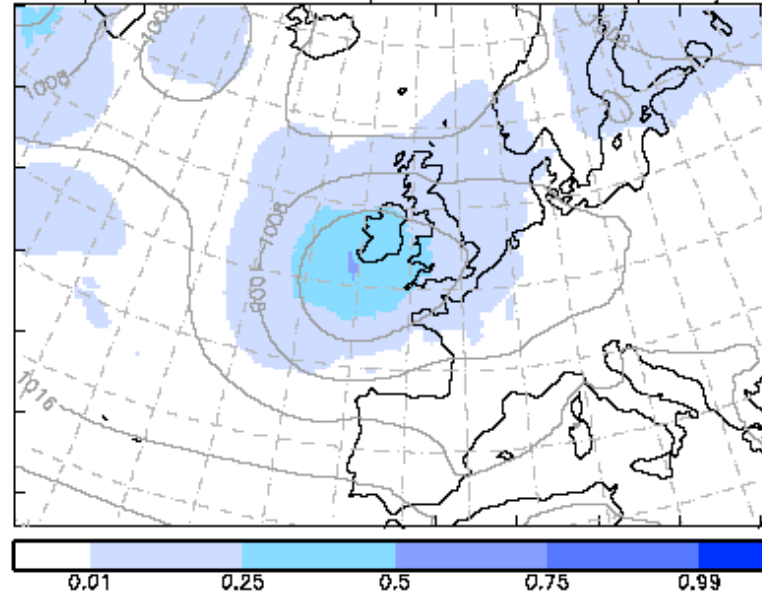


NCEP Ensemble Mean (bias corrected)

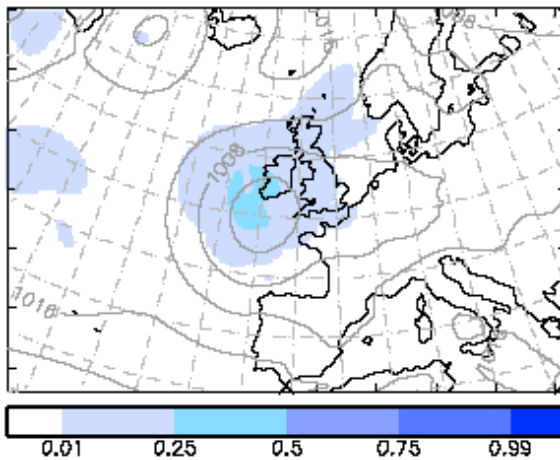


Example Multimodel product: Probability plot

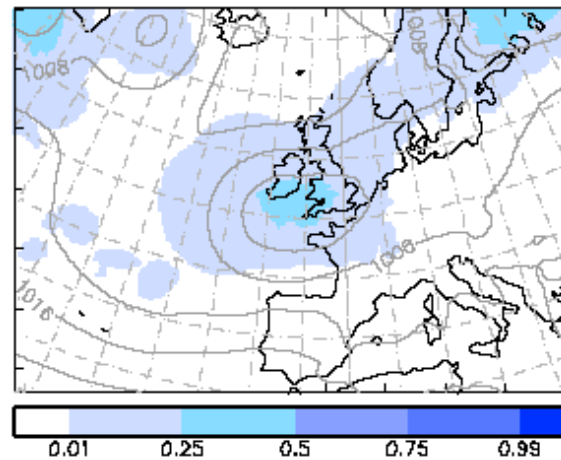
THORPEX Multimodel Probability map for PMSL < 1000hPa
DT: 00Z Mon 11/06/2007 VT: 12Z Fri 15/06/2007 lead time 108h
(Ensemble Mean PMSL plotted as faint background)



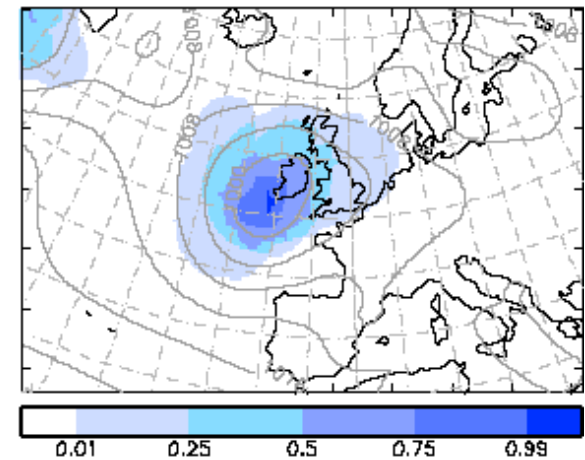
Met Office Ensemble (bias corrected)



ECMWF Ensemble (bias corrected)



NCEP Ensemble (bias corrected)

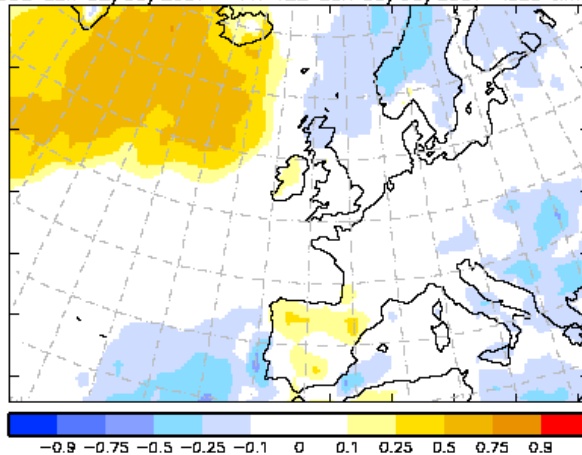
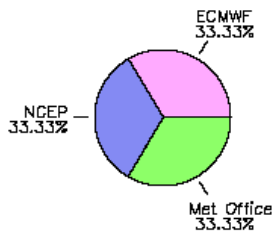


Multimodel products: Anomalies plot

- Met Office ensemble forecasts are now being added to the TIGGE database
- Results are being combined with forecasts from TIGGE partners, currently ECMWF and NCEP, to form a multi-model ensemble

THORPEX Multimodel Probability map for 2mTemperature12Z <5/>95th percentile
DT: 00Z Sun 02/09/2007 VI: 12Z Sun 09/09/2007 lead time 180h

Model weights in the multimodel
(averaged over plot area)



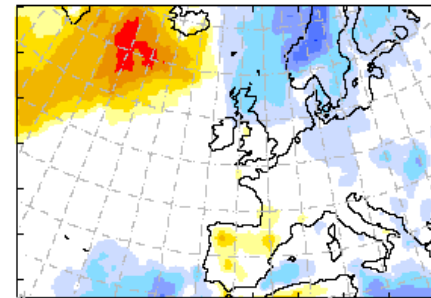
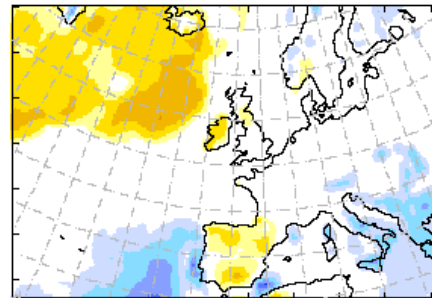
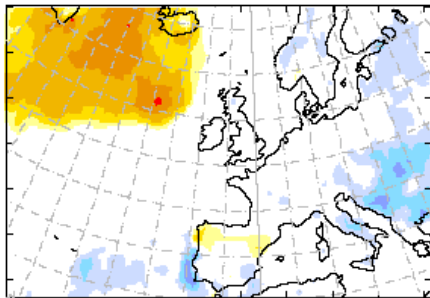
Example temperature anomaly plot showing multimodel probabilities for 2m temp <5th/>95th percentiles

Using ERA-40 based climatology recently compiled by Martin Leutbecher (ECMWF)

Met Office Ensemble (bias corrected)

ECMWF Ensemble (bias corrected)

NCEP Ensemble (bias corrected)



- Verification plot(s)

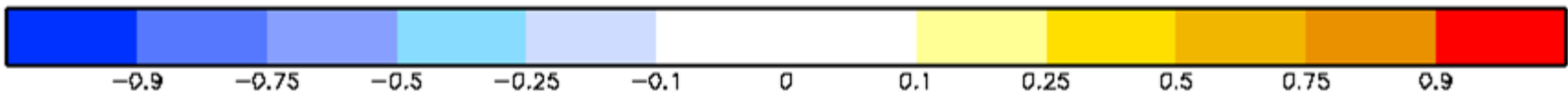
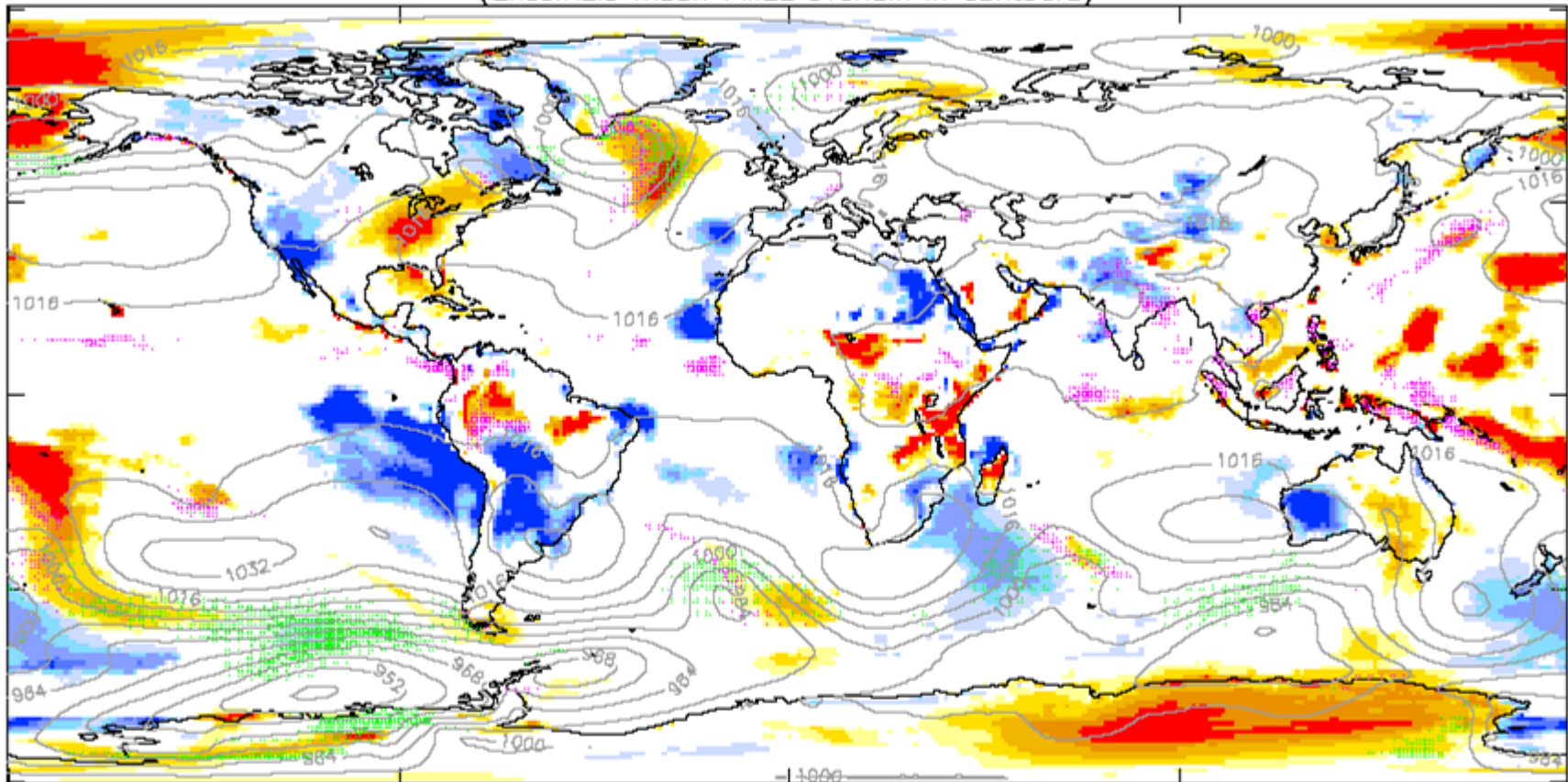


Forecasting High-impact weather

MOGREPS-15 products: Temp/precip/wind risk



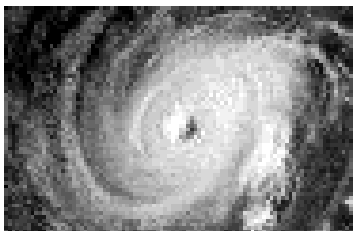
MOGREPS-15 Probability map for 2m temp $<5/>$ 95th percentile,
12hr precip $> 10\text{mm}$, and 10m wind speed $> 28\text{kn}$
DT: 00Z Fri 21/09/2007 VT: 12Z Tue 25/09/2007 lead time 108h
(Ensemble mean PMSL overlain in contours)



Prob of precip $> 10\text{mm}$ 25-50%
 50-75%
 >75%

Prob of wind $> 28\text{kn}$ 25-50%
 50-75%
 >75%

- Almost all high-impact weather is feature-related e.g. extra-tropical cyclones leading to strong winds/heavy rain in the UK
- Numerical models often do not explicitly represent the severe weather parameters, especially in lower resolution ensembles
- They can however represent the features causing the high-impact weather
- For high-impact weather prediction, focus on post-processing ensemble data through automated identification and tracking of synoptic features
- Analysis of feature tracks and attributes allows evaluation of the potential for high-impact weather



Tropical cyclones



Extra-tropical
cyclones

Tropical cyclone ensemble charts

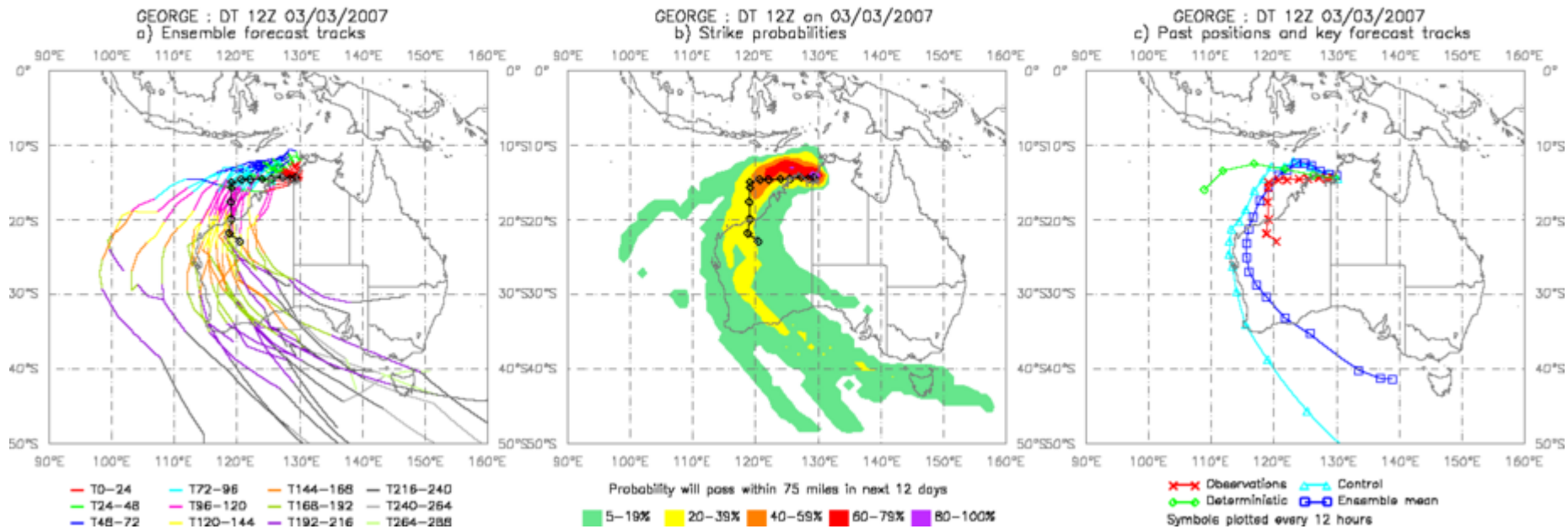


- Tropical cyclones are identified and tracked using 850hPa relative vorticity maxima
- Tracks cyclones out to T+288 and identifies new storms out to T+144
- **Cyclone George**: Landfall 12/03/07 near Port Headland, winds 195km/hr, 3 deaths



Tropical cyclone products from the experimental MOGREPS 15-day ensemble

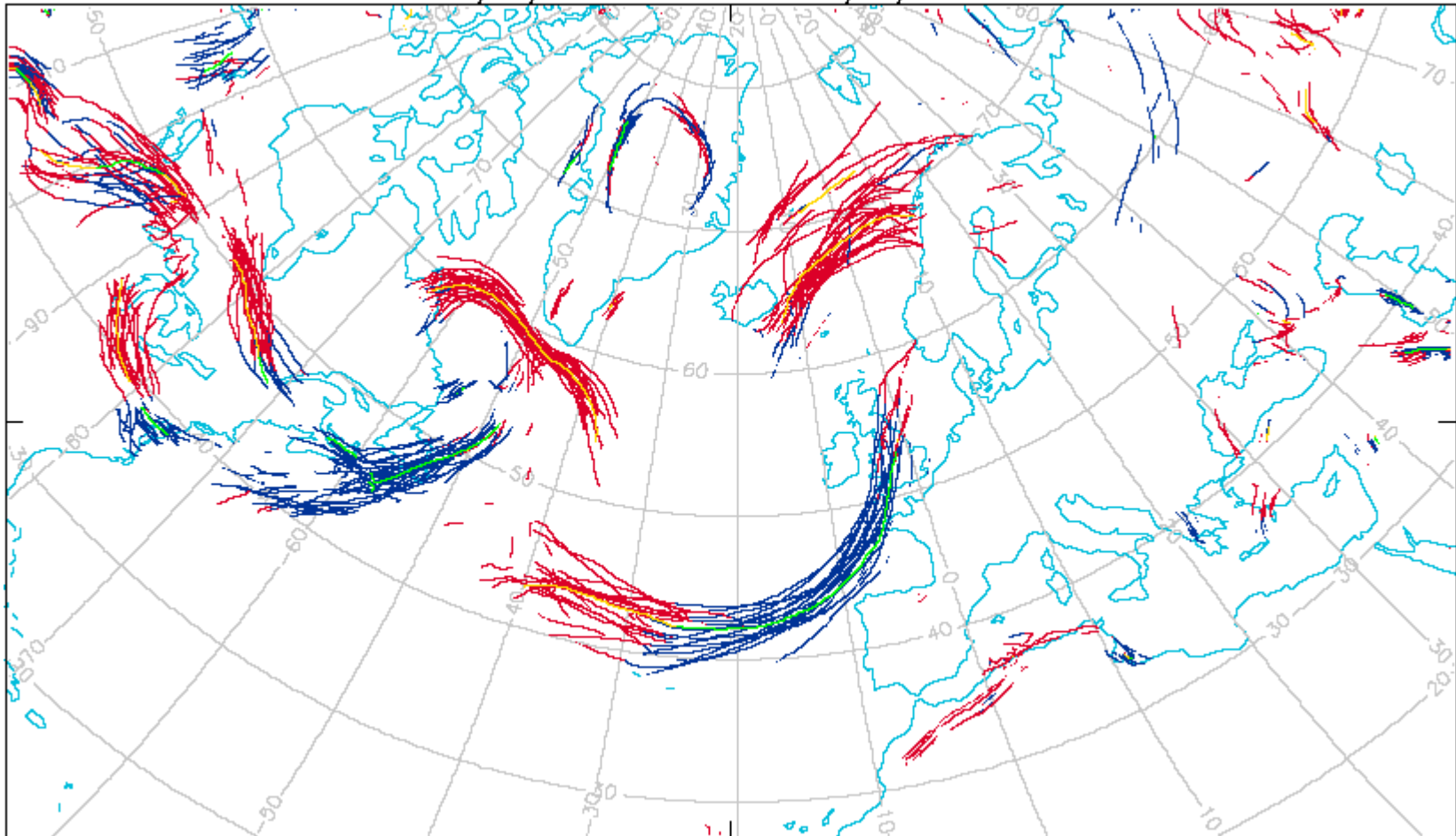
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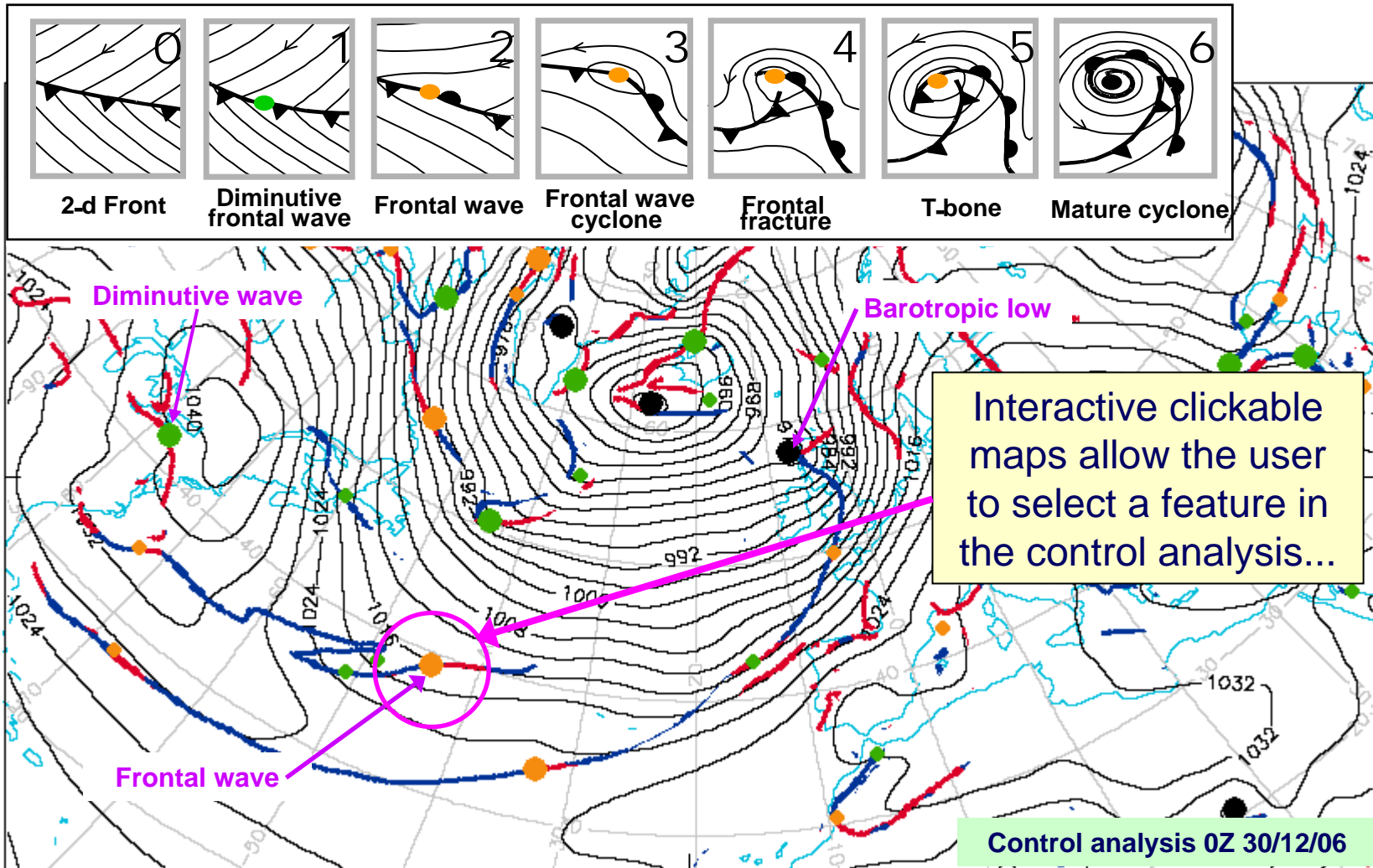
- Mean reduction in forecast errors for ensemble mean compared to deterministic:
 - Similar up to T+72
 - 12% at T+96
 - 23% at T+120

- The cyclone database objectively identifies fronts and cyclonic features in the extra-tropics

DT: 00Z Fri 21/09/2007 VT: 00Z Mon 24/09/2007 lead time 72h



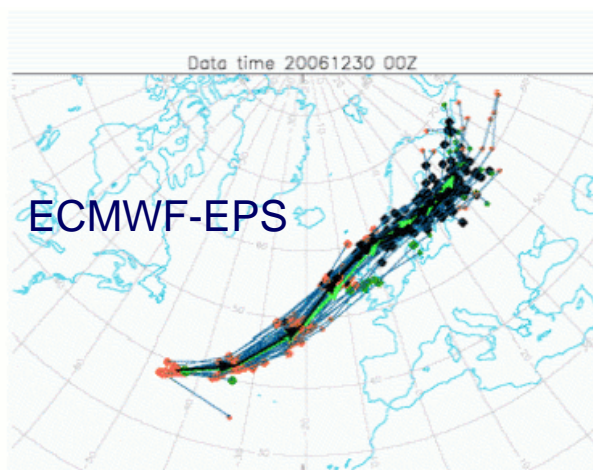
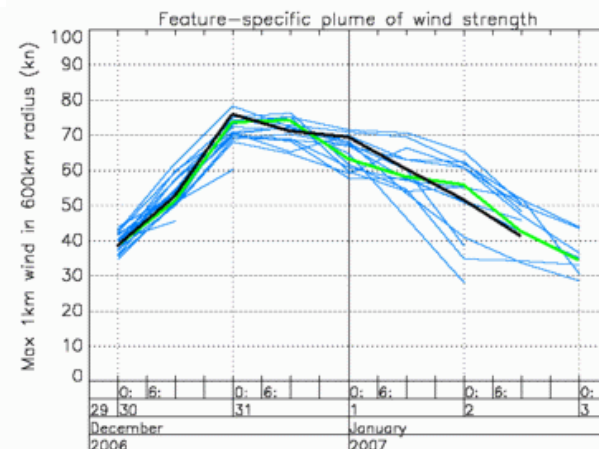
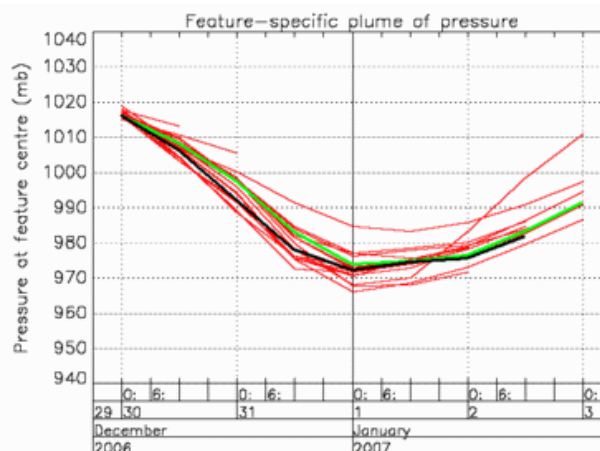
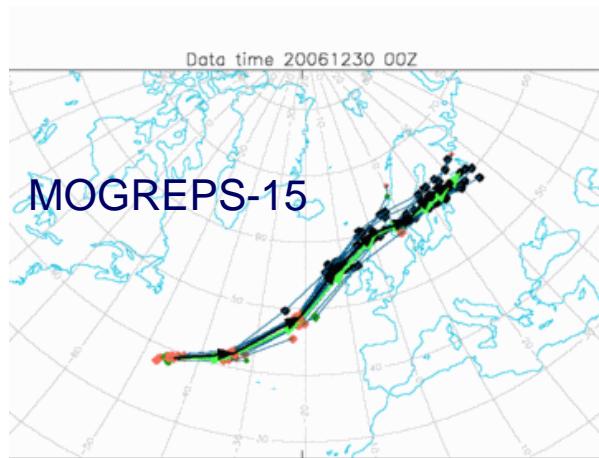
Cyclone database & New Year's Eve storm



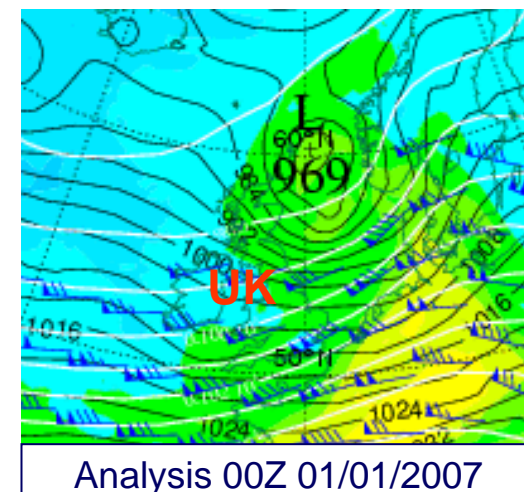
- Tracking scheme uses a combination of forward and backward tracking. It uses extrapolation and 500hPa steering wind to estimate positions, and matches features based on separation distance, type and thickness

Cyclone database: 31/12/2006 example

- Clicking on a feature brings up feature-specific tracks from each ensemble member and matching plumes of intensity measures to identify the potential for high-impact weather

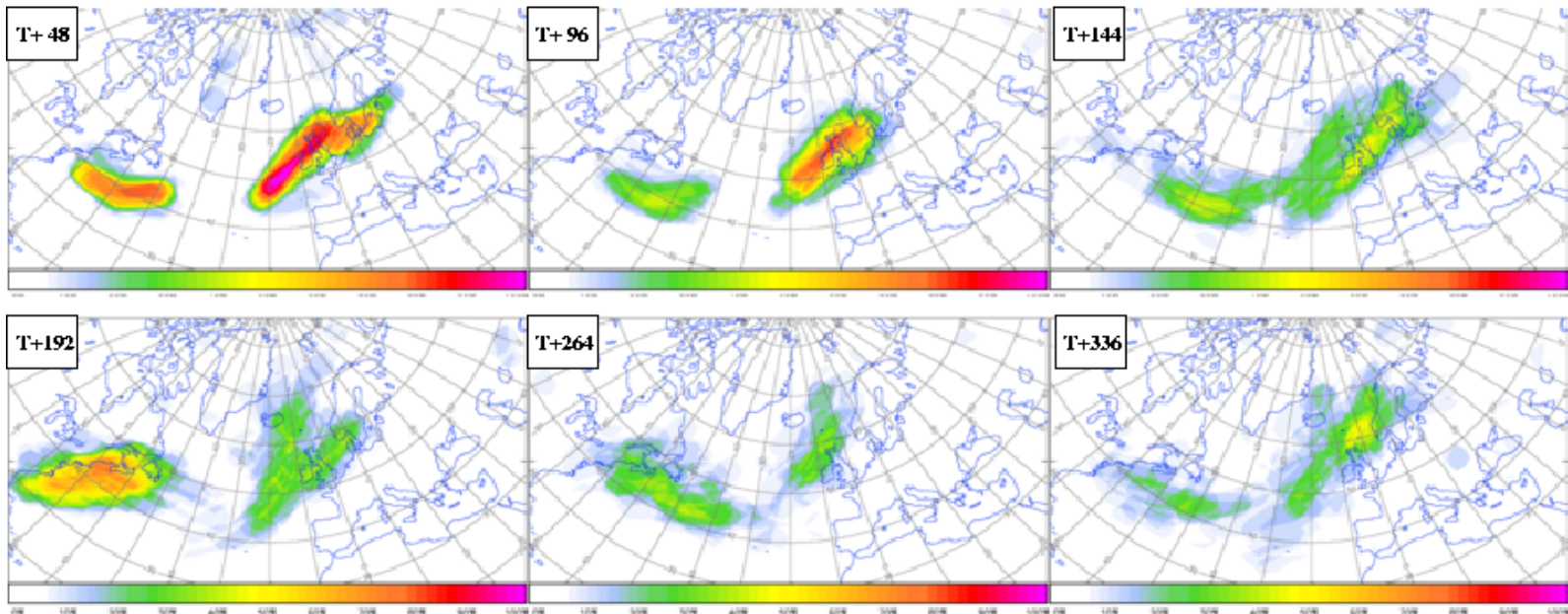


This storm tracked across Scotland, with gusts up to 100mph, leading to the high-profile cancellation of New Year's Eve celebrations and loss of power to 1000s of homes



Strike probability plots

- At longer lead times, the uncertainty in tracking individual features increases (they may well not exist in the initial analysis).
- The strike probability plots give a broader indication of risk of storms, based on cyclone database data.
- Plots show number of MOGREPS-15 ensemble members with potential for surface gusts > 60 kt in each 24-hour period.



- Continue contributing forecasts to TIGGE
- Refine multi-model ensemble
- Expand high-impact products
 - In response to forecasters & other customers
 - Cyclone DB in N Pac for T-PARC(?)
- Work towards development of GIFS
 - Exchange TC info for T-PARC

- Ensemble forecasting is a key technique for improving the prediction of high-impact weather.
- The Met Office is contributing medium-range ensemble forecasts to the TIGGE database, and developing multi-model ensemble methods.
- We are developing a range of tools to highlight the risk of high-impact weather forecast by ensemble prediction systems.
 - Probabilities of exceeding high-impact thresholds
 - Feature-based cyclone diagnostics
 - Tropical cyclone tracks

The background of the slide features a light blue color with several overlapping, wavy, ribbon-like shapes in a slightly darker shade of blue, creating a soft, flowing pattern.

Any Questions?