



Results from the MOGREPS Regional Ensemble — A comparison of downscaled global perturbations versus perturbations from the ETKF for the regional ensemble.

Neill Bowler and [Sarah Beare](#) - EWGLAM Madrid October 2008.



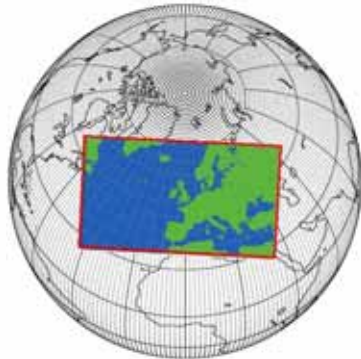
Contents

This presentation covers the following areas

- Introduction to MOGREPS
- Experiment design
- Results
- Summary and conclusions



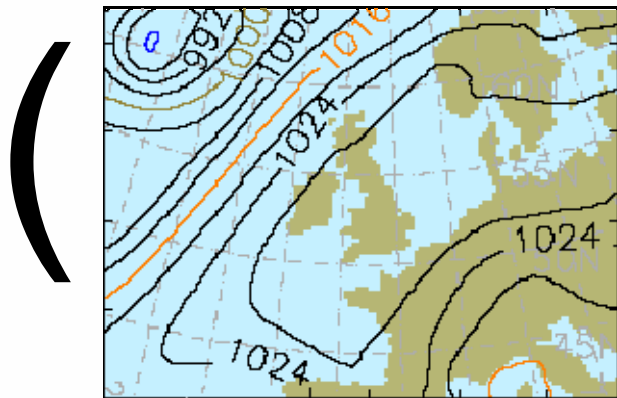
MOGREPS Overview



- Global Ensemble (N144L38 – T+72) run at 00Z and 12Z
- Regional Ensemble (24km,L38 – T+54) run at 06Z and 18Z
- 23 perturbed members + control
- ETKF Initial Conditions
- Representation of model error
- Routinely run since September 2005
- Now fully operational

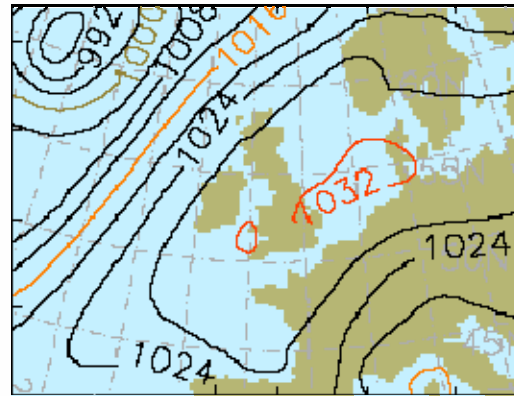


Global Perturbations



T+7 perturbed forecast

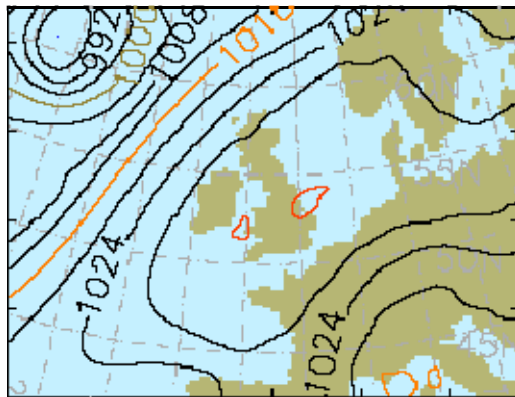
Reconfigured to 24km



T+7 control forecast

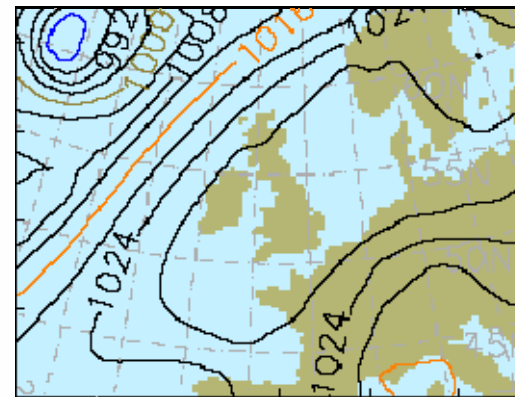
Reconfigured to 24km

+



Control analysis

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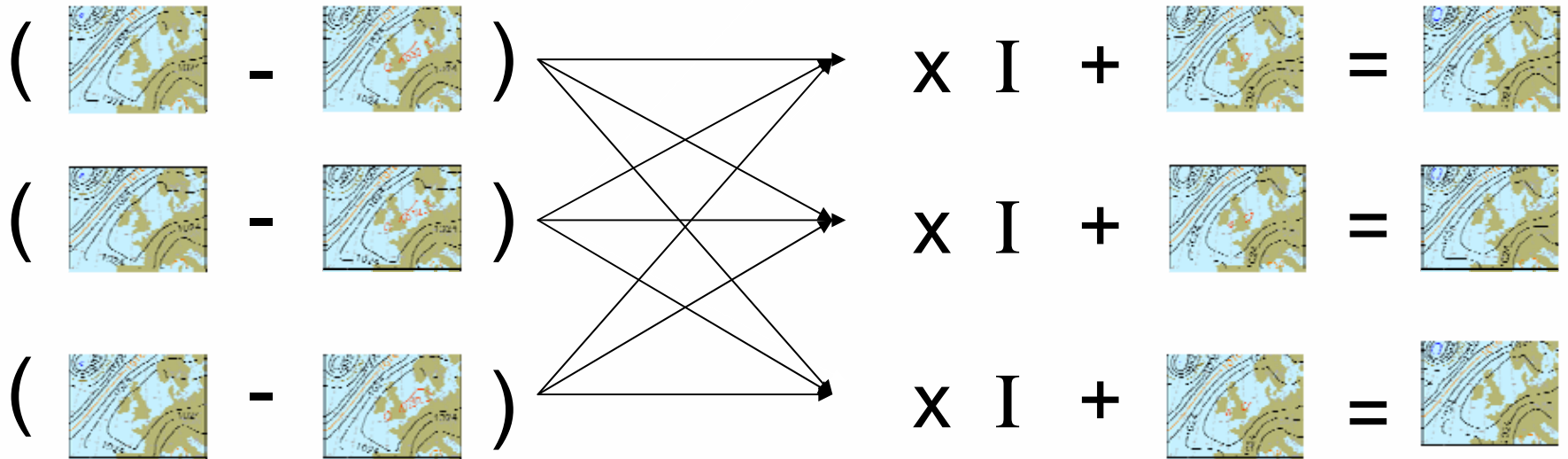


Perturbed analysis



Ensemble Transform Kalman Filter (ETKF)

$$X^a = X^f T \Pi_n$$



T+12 perturbed forecast

T+12 ensemble mean forecast

Transform matrix

Inflation factor

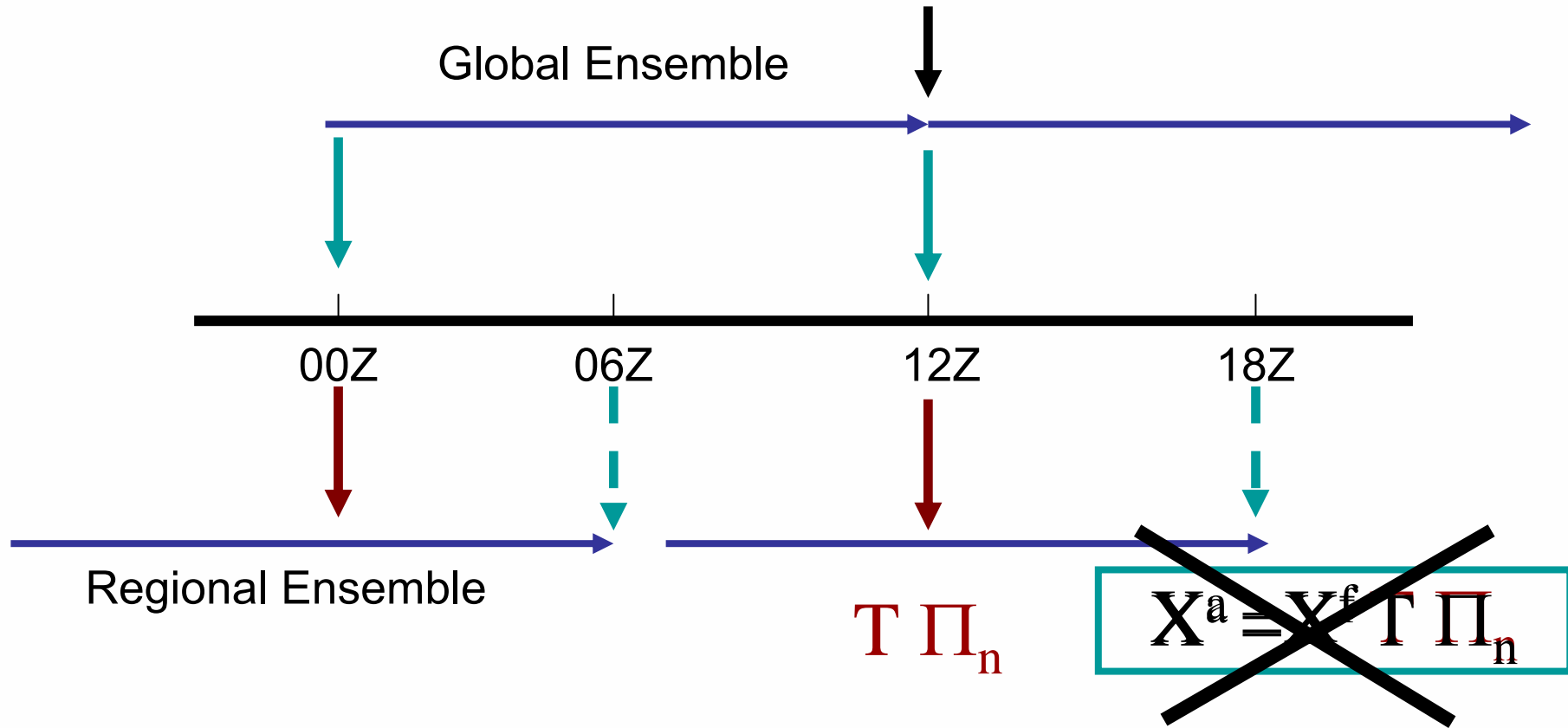
Control analysis

Perturbed analysis



ETKF Continued..

$$X^a = X^f T \Pi_n$$





Experiment Design

- 10 December 2006 – 13 January 2007
- One full forecast run per day at 18 UTC
- Both Global and Regional ensembles use UM vn6.1
- Identical 24km model versions and global LBCs used in each case.
- The ensemble using the regional ETKF was spun up for 1 week

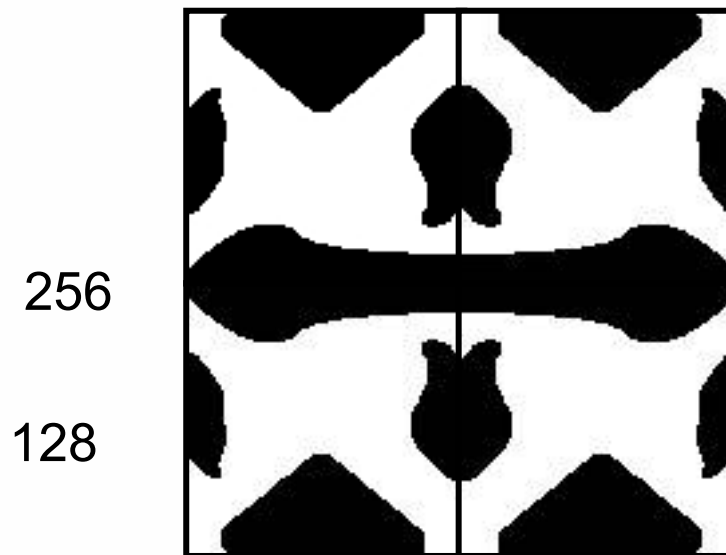


Power Spectra

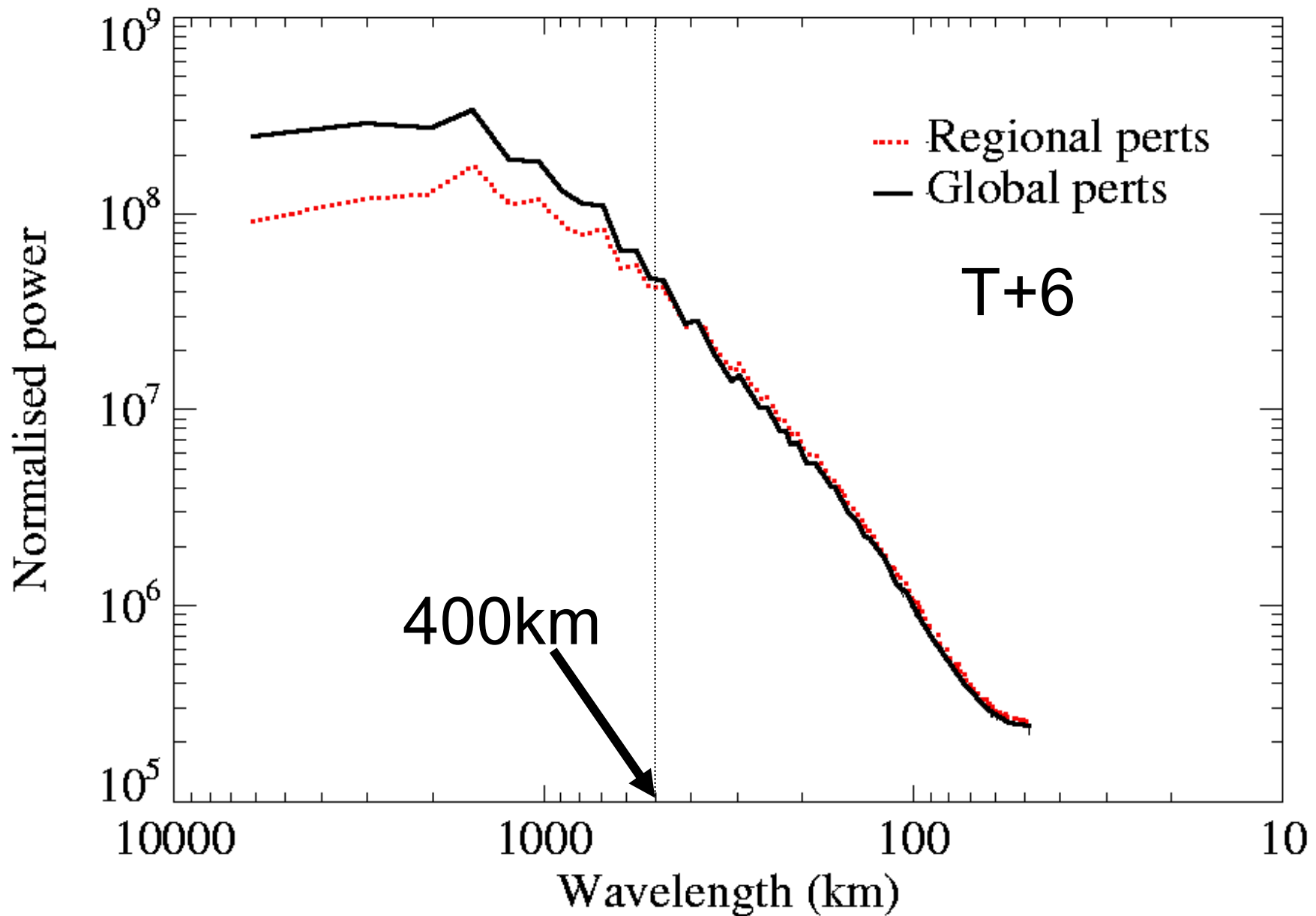
$$\text{Mean Spectrum} = \sum_j^{N_{\text{days}}} \sum_i^{N_{\text{mem}}} \text{Spectrum}(X_{i,j} - \bar{X}_j)$$

X = perturbed member forecast

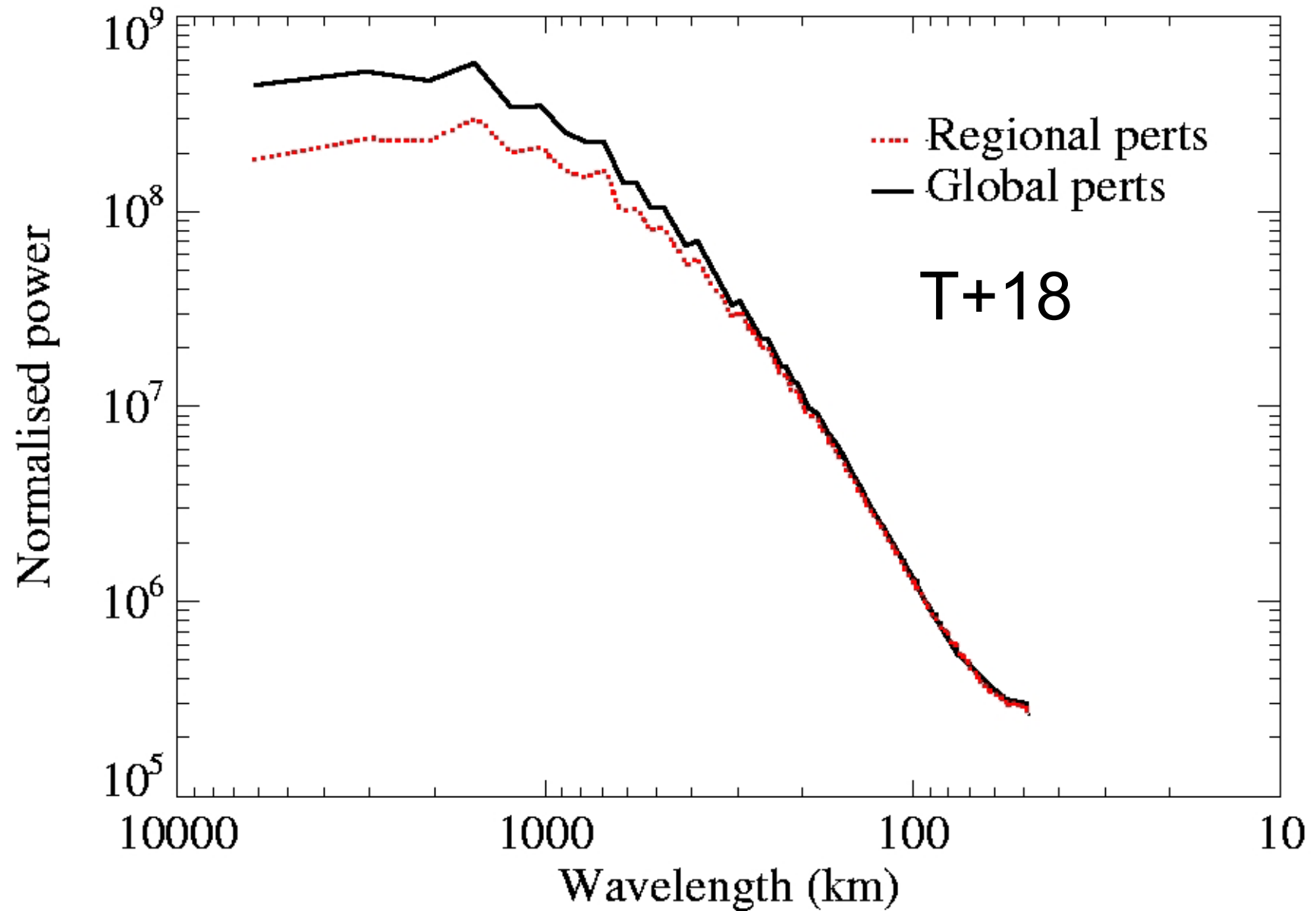
\bar{X} = Ens mean forecast



Power Spectrum of 850hPa Temperature



Power Spectrum of 850hPa Temperature





Verification Results

- RMS Spread and Error
- Spread Error Correlation
- Continuous ranked probability score



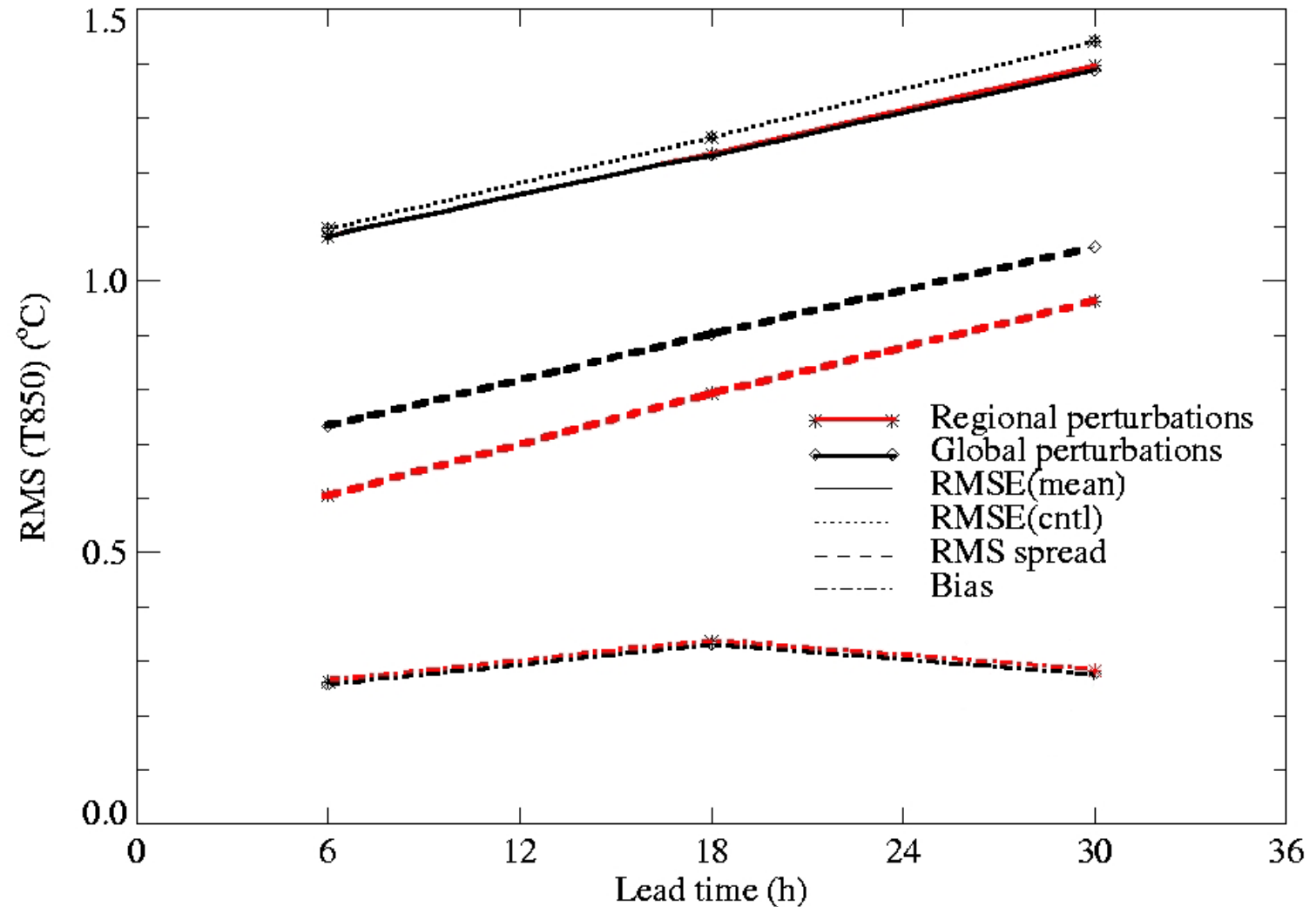
Accounting for Observation Errors

- $RMSE_c = \sqrt{RMSE^2 - ObsErr^2}$
- Perturb each ensemble member by a random number drawn from Gaussian distribution.

$$X \sim N (\text{mean} = 0, \text{variance} = ObsErr^2)$$

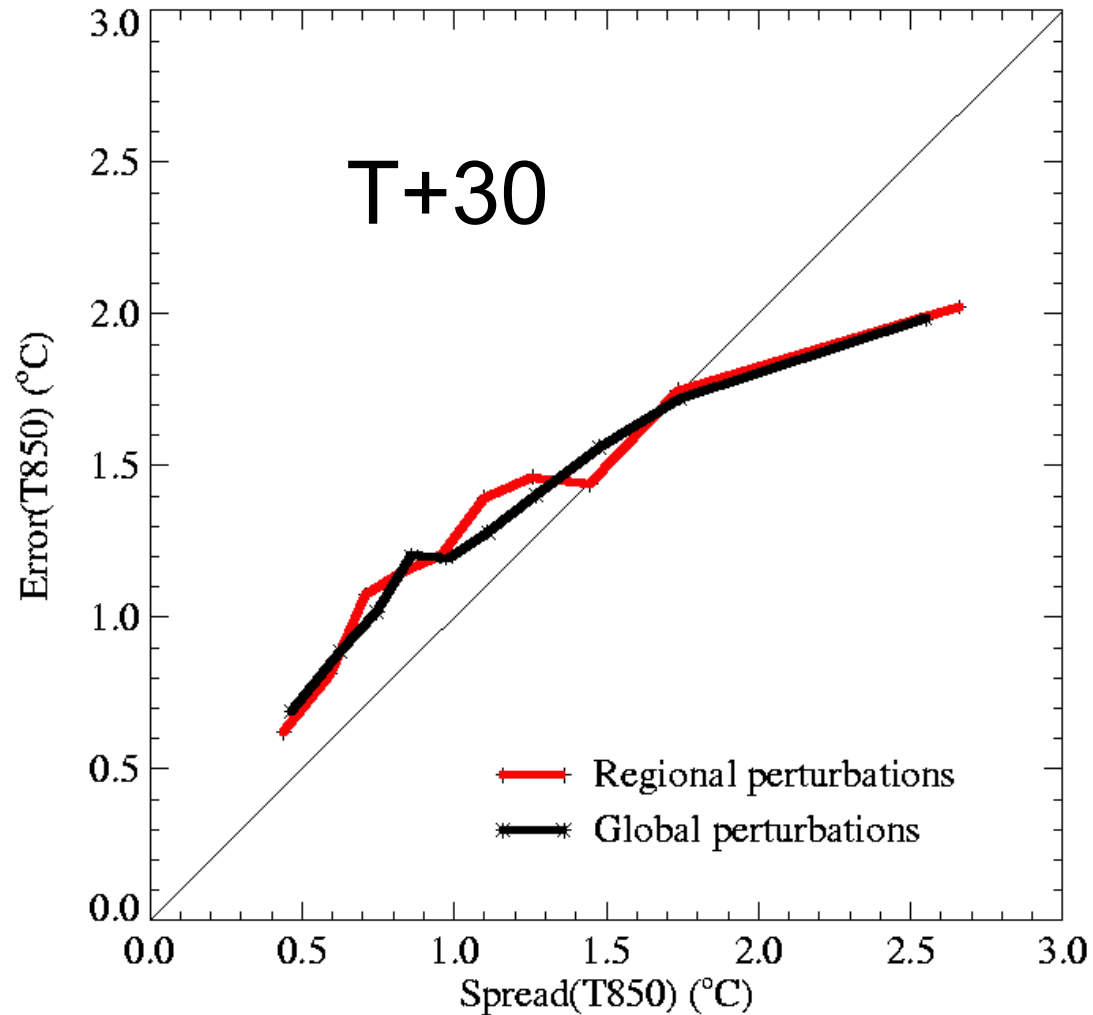


RMS Spread and Error T850





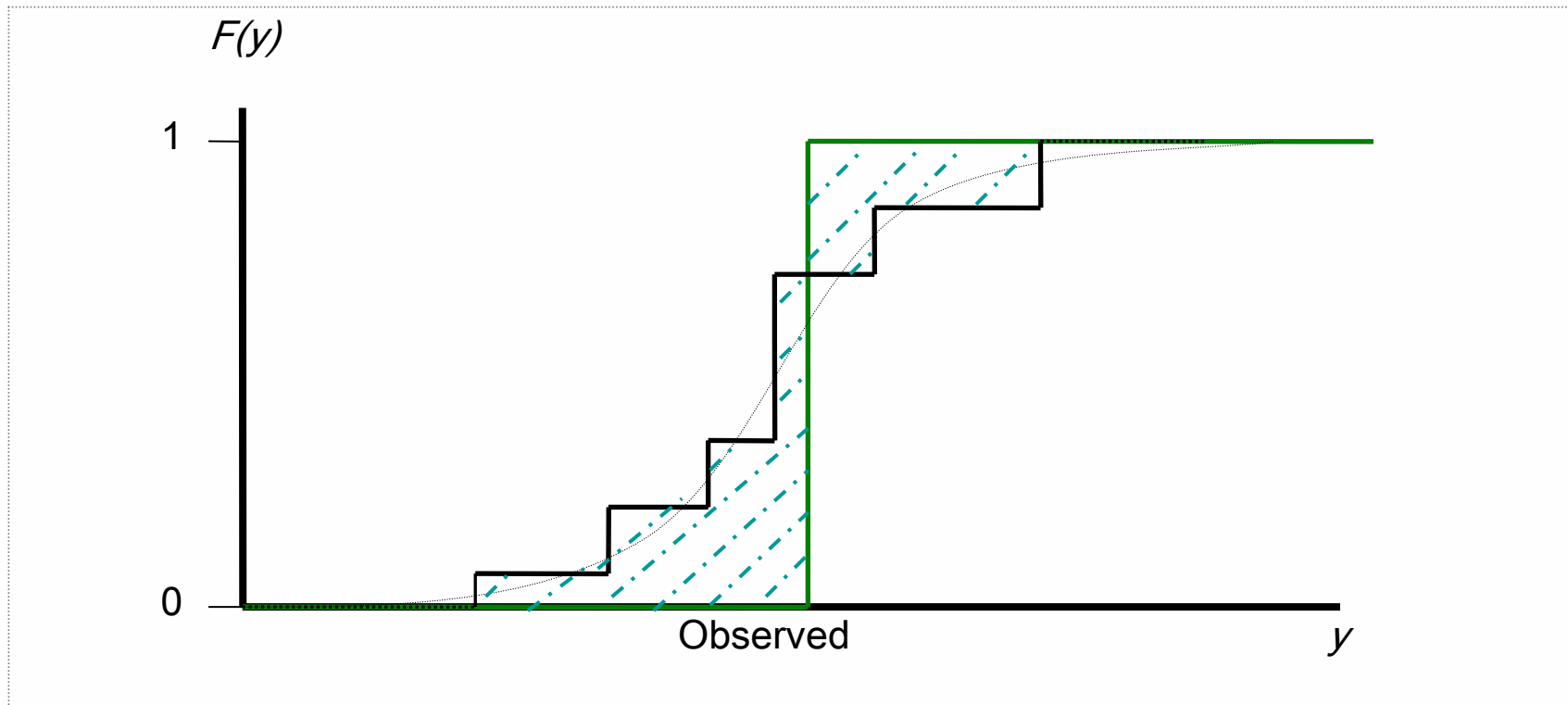
Spread Error Correlation T850





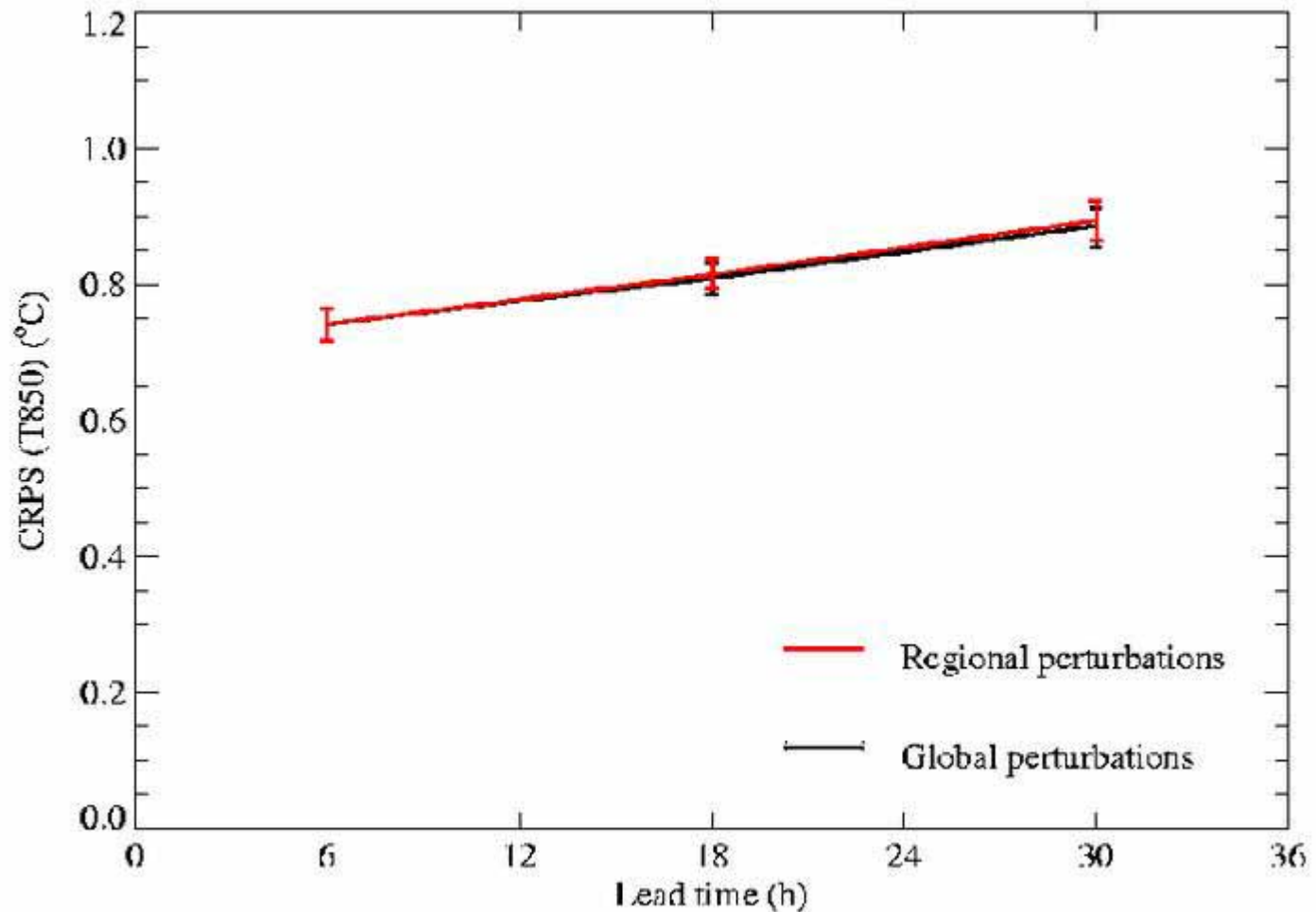
Continuous Ranked Probability Score

$$CRPS = \int_{-\infty}^{\infty} [F(y) - H_o(y)]^2 dy$$





850hPa Temperature Continuous Ranked Probability Score





CRPS Differences (raw data)

Variable	T+6h	T+18h	T+30h
T 1.5m	0.09%	-0.11%	-0.35%
10m WS	-0.06%	-0.19%	-0.53%
PMSL	2.21%	1.70%	0.89%
6h Precip	-3.03%	-3.43%	-3.27%
T850	-0.51%	-0.58%	-1.49%
T500	0.95%	0.54%	-0.15%
T250	0.42%	0.72%	-0.28%
WS850	-0.75%	-0.11%	-0.83%
WS500	0.72%	0.01%	0.41%
WS250	1.00%	1.46%	0.13%
Z500	0.89%	0.35%	-0.42%

Positive = regional perturbations better

Negative = global perturbations better

Red/blue = statistically significant results at 5% level



CRPS Differences (calibrated data)

Variable	T+6h	T+18h	T+30h
T 1.5m	0.10%	0.05%	-0.23%
10m WS	-0.17%	-0.40%	-0.36%
PMSL	0.55%	-0.49%	-0.76%
6h Precip	-0.68%	-0.77%	-1.13%
T850	-0.20%	-0.13%	-1.10%
T500	0.06%	-0.27%	-1.00%
T250	0.49%	0.52%	-0.31%
WS850	-0.70%	-0.07%	-1.04%
WS500	0.51%	-0.46%	0.10%
WS250	0.44 %	1.06%	-0.20%
Z500	0.59%	-0.41%	-1.09%

Positive = regional perturbations better

Negative = global perturbations better

Red/blue = statistically significant results at 5% level



In Summary

- ETKF perturbations for the regional ensemble contain more power on scales < 400 km, for up to 12hr into the forecast.
- Differences in spread observed in the two ensembles.
- RMSE of ensemble mean forecast for global perturbations lower than RMSE of regional ETKF perturbations.
- The performance of the two ensembles are very similar with higher skill observed when the perturbations are derived from the global ensemble.
- Improving on “dynamical downscaling” with explicit regional ensemble IC perturbations could be difficult.
- Implications for the MOGREPS-R ensemble.



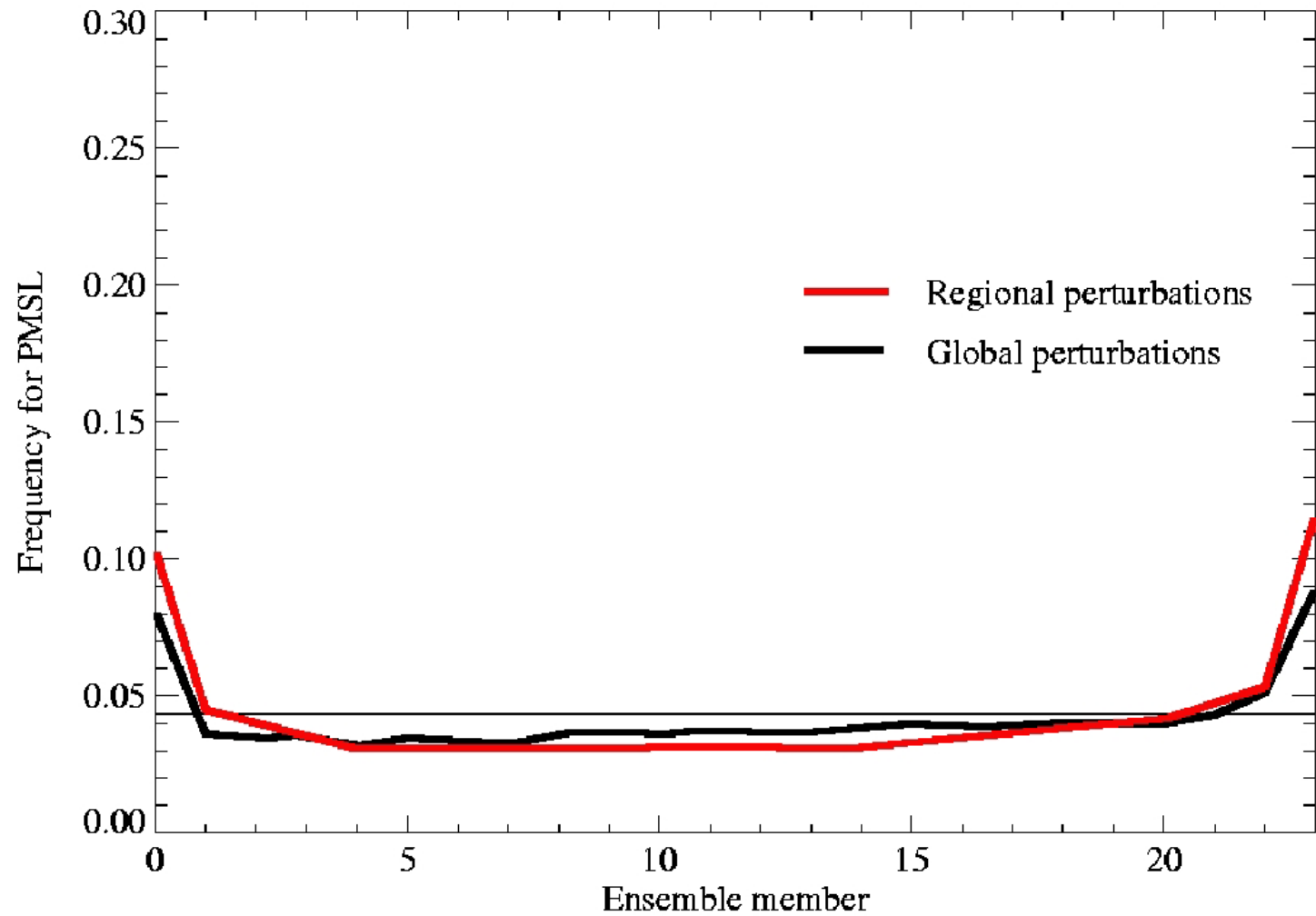
Met Office



Questions and Answers

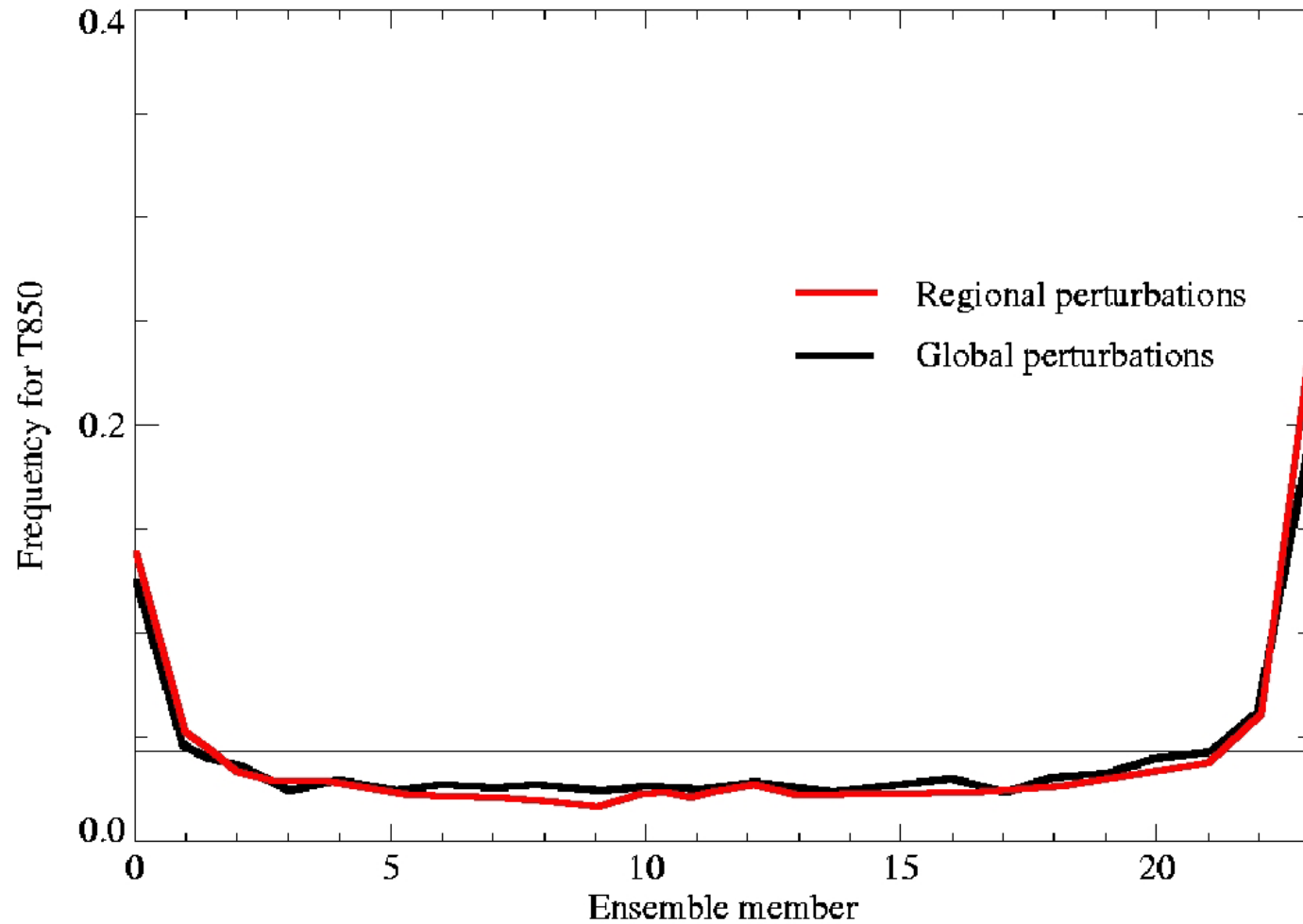


Rank Histogram PMSL





Rank Histogram T850





Bias Correction and calibration

- Step one

Perturbed Fc – Mean error (Bias) of Ens Mean Fc

- Step two

Recalculate RMS spread about the ensemble mean

- Step three

Adjust the spread to match the RMSE of the ensemble mean forecast.



Regional ETKF v Global ETKF

- Global ETKF uses localisation, transform matrix calculated using T+12 forecasts and applied to perturbations valid at T+12.
- No localisation applied to regional ETKF
- Transform matrix and inflation factor calculated using observations centred around 00Z (12Z) for a 06Z (18Z) run of the regional ensemble, i.e., T+6 forecast.
- Transform matrix applied to the T+12 perturbations valid at 06 or 18Z.
- Offset assumes the non linearities of small perturbations are negligible
- Inflation factor calculated using radiosonde observations only.



Continuous Ranked Probability Score

- Overall measure – compares the ensemble and observation distributions.
- CRPS \equiv the Brier Score integrated over all possible thresholds.

or

- CRPS \equiv the Ranked Probability Score with infinitely small bin sizes.

or

- CRPS \equiv Mean Absolute Error (in the deterministic case)
- Takes the unit of the variable calculated, smaller the better.

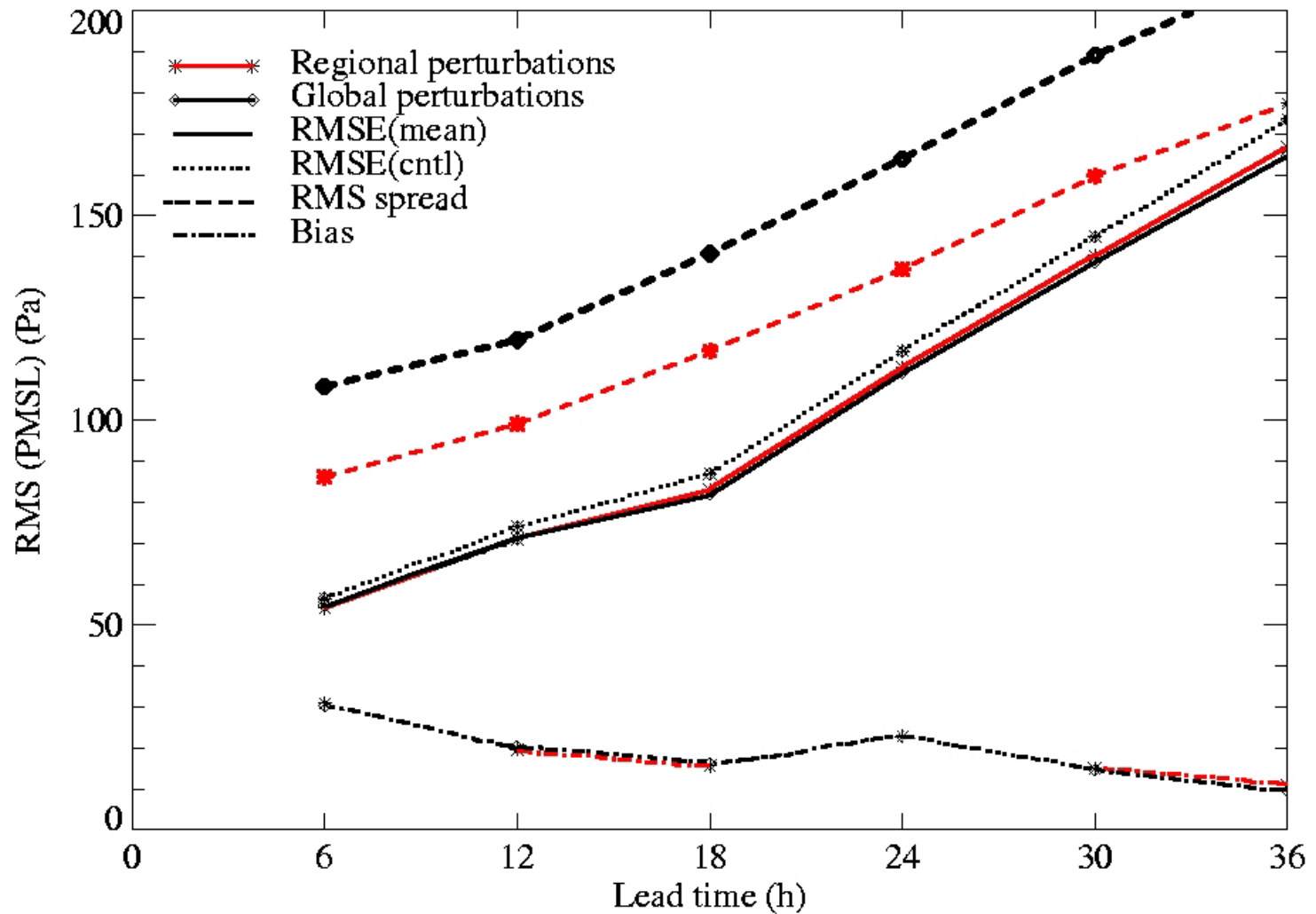


Bootstrap re-sampling

- Each day in record is treated separately
- Assumes no correlation in errors between days but that errors between stations are perfectly correlated.
- Because both ensembles are subject to the same weather, the difference in the CRPS may be more robust than the score itself.

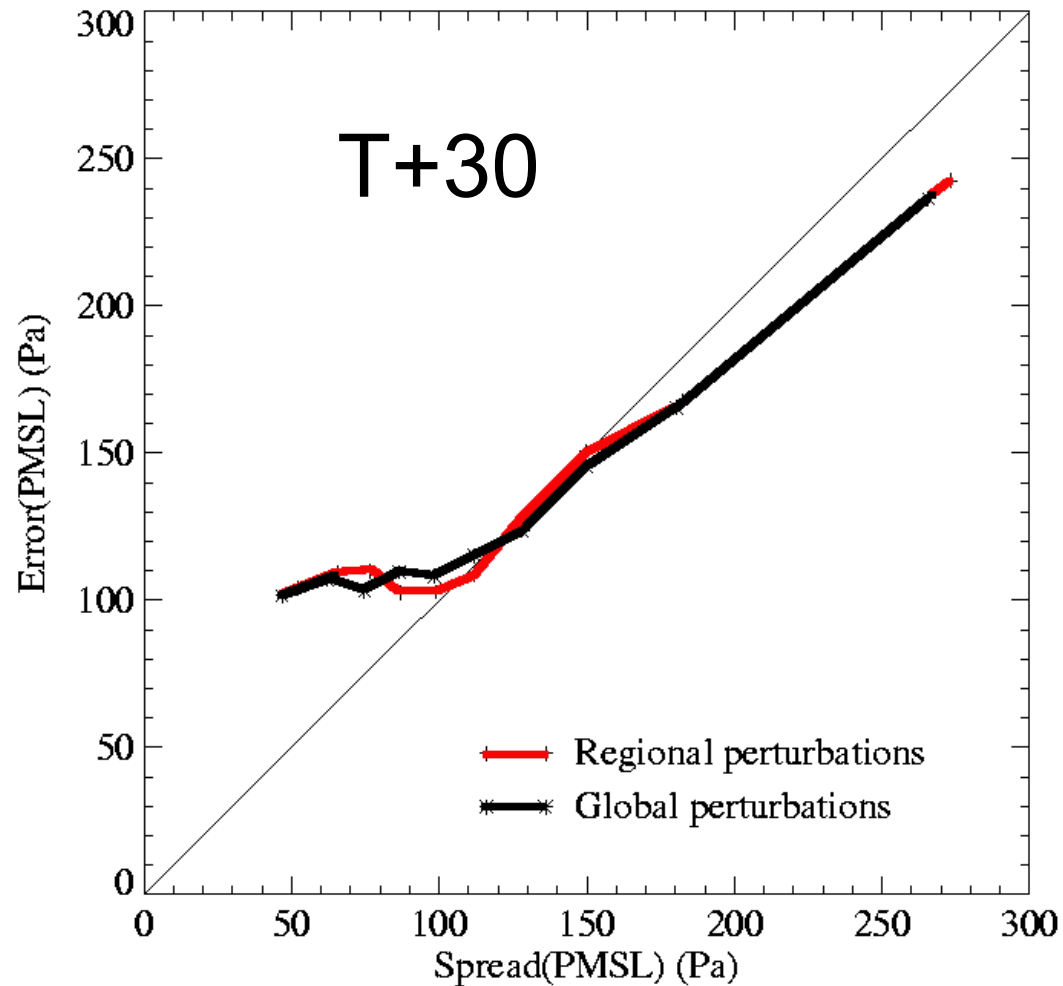


RMS Spread and Error - PMSL





Spread Error Correlation PMSL





References

Bowler and Mylne (2008)

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Continuous Ranked Probability Score PMSL

