Accounting for the effect of observation errors on verification

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Thanks to: Beth Ebert

Outline

- Assumptions

- Root-mean-square error
- Rank Histograms
- Categorical verification (ROC)

- Verification against analysis

Assumptions

- We know the distribution of observation errors
- The errors in the observations are independent of the observed value, the forecast value and the errors in other observations (additive, uncorrelated noise)
- In this case, verification is against radio-sonde observations of wind speed at 850 hPa
- Observation errors are assumed gaussian with zero mean and standard deviation 1.6 m/s

How to estimate the observation errors?

- With difficulty!
- Differences between observations at different locations (extrapolate distance between obs to zero) – NB Ingleby, J. Atmos. Ocean. Technology, **18**, 1102,-1107 (2001)
- It may be possible to diagnose them from a series of assimilation cycles – G Desroziers et al, QJ, **131**, 3385-3396 (2005)

Verification details

- Verification performed for 1 November 2006 to 26 January 2007 on MOGREPS global ensemble
- An in-sample bias correction has been applied to the forecast data
- Any event threshold are basic (e.g. wind speed > 10m/s) so Hamill et al's (QJ, in press) "false skill" issue is not addressed

RMS error

- The effect of observation errors is

$$RMS(f,o) = \sqrt{RMS(f,t)^2 + RMS(o,t)^2}$$

What we measure — $RMS(f,o)$

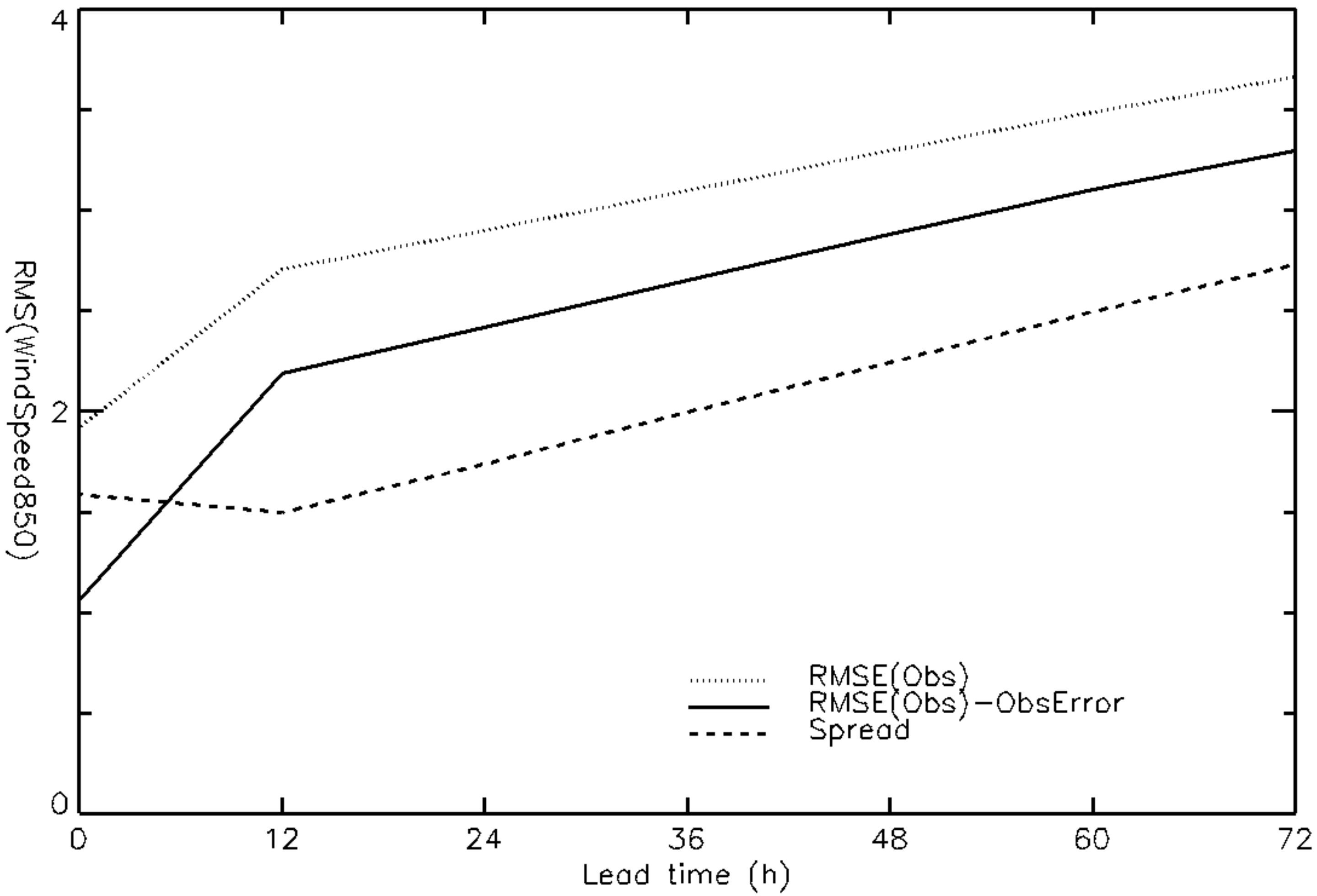
What we want to measure — $RMS(f,t)$

The observation error — $RMS(o,t)$

- So, we estimate the “true” RMS error by

$$RMS_{est}(f,t) = \sqrt{RMS(f,o)^2 - RMS(o,t)^2}$$

RMS error - results

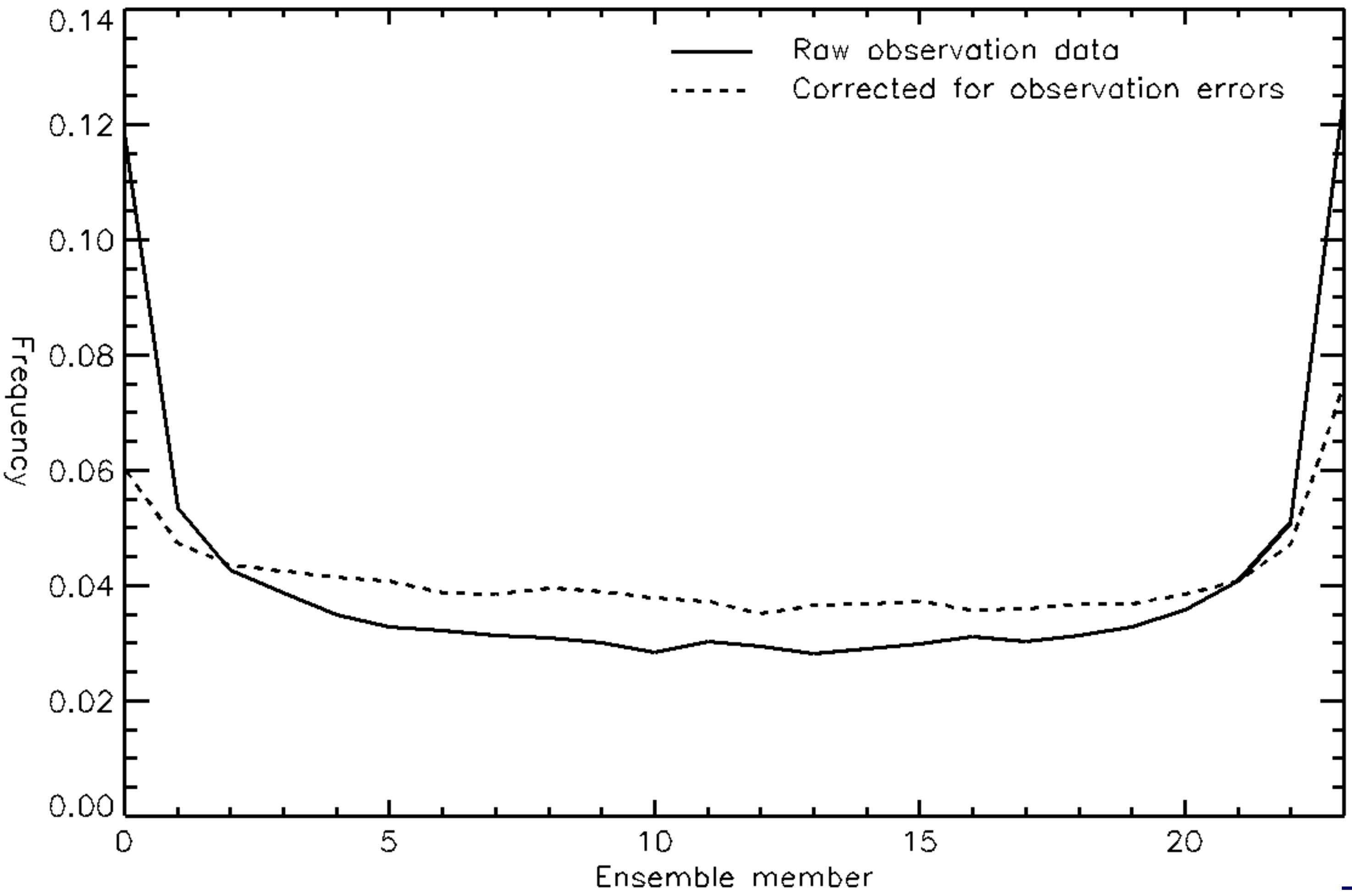


Rank histograms

- To calculate the rank histogram, rank the ensemble forecasts, and find between which members the verification falls
- If the ensemble is sampling from the distribution of forecast errors, then the rank histogram should be flat
- Remove the effect of observation errors by perturbing each ensemble member's forecast by the observational error

Saetra et al, Mon. Weather Rev. **132**, 1487-1501 (2004)

Rank histograms – 850 hPa wind speed



Near-flat when observation errors accounted for

T+72h forecasts

Contingency tables

- If the distribution of observed values (given the model forecast some event to occur) is

$$P_o(x \mid F = 1)$$

- then, under our assumptions about observation errors, this is related to the distribution of true values by

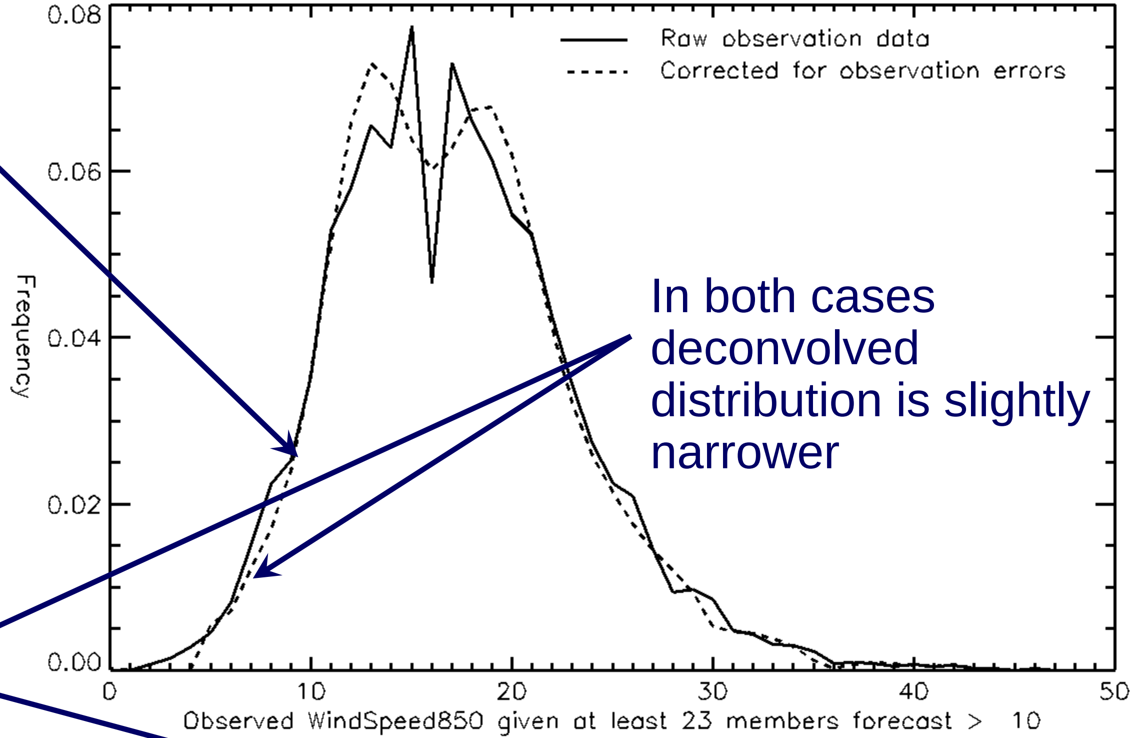
$$P_o(x \mid F = 1) = \int_{-\infty}^{\infty} P_t(y \mid F = 1) P_e(x - y) dy$$

True values   Observation errors

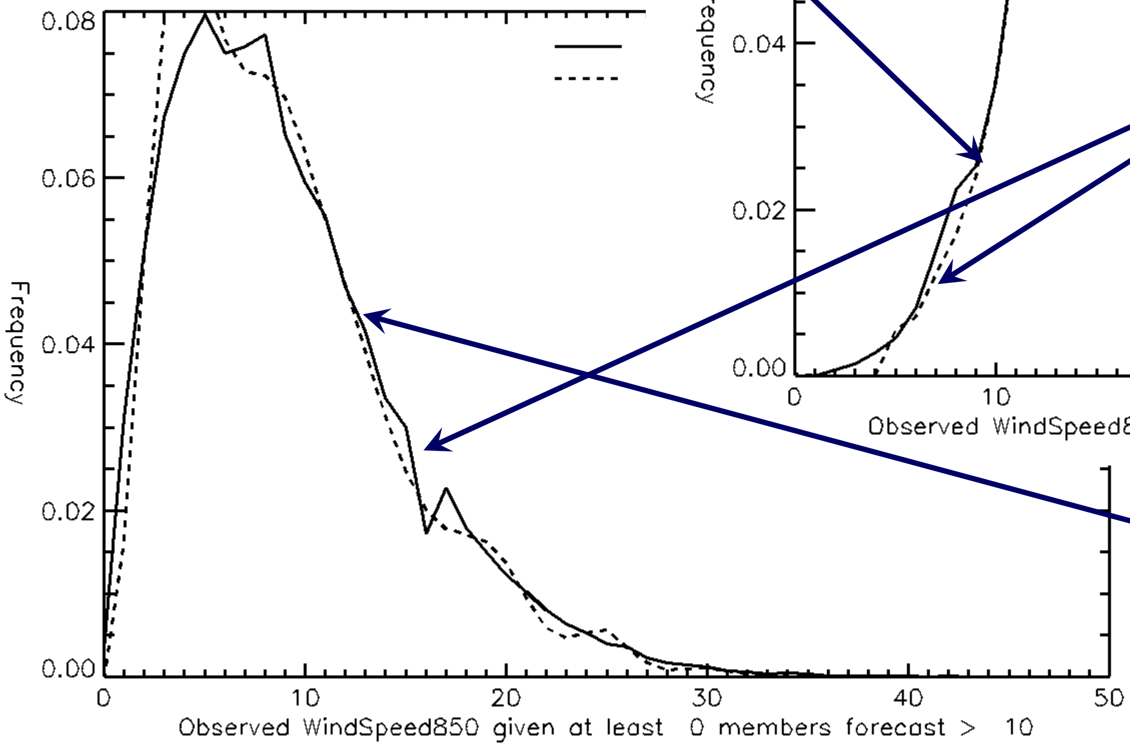
Bowler, Mon. Weather Rev., **134**, 1600-1606 (2006)

Observation distribution

Most observations show wind speed greater than 10m/s when all members forecast this

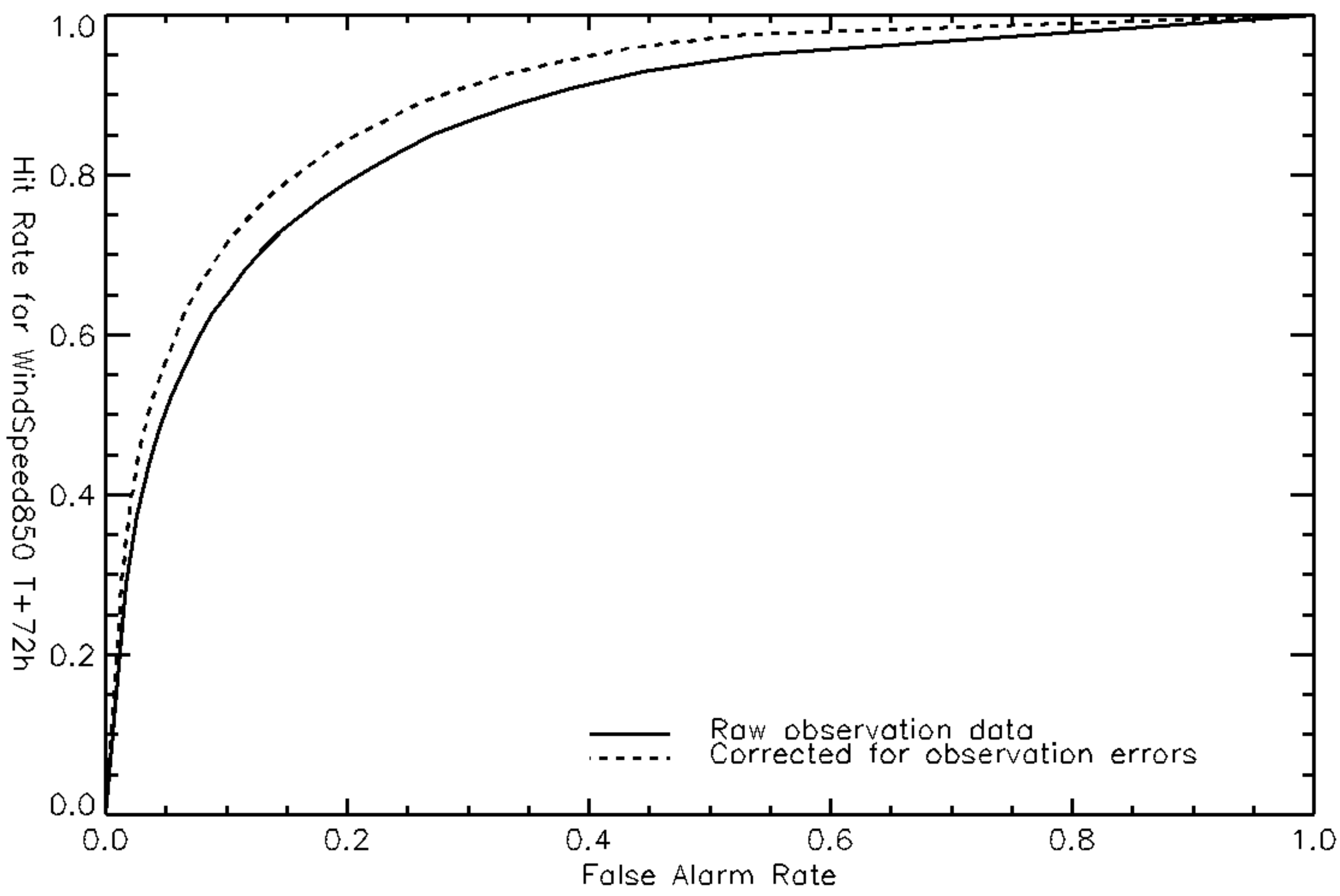


In both cases deconvolved distribution is slightly narrower

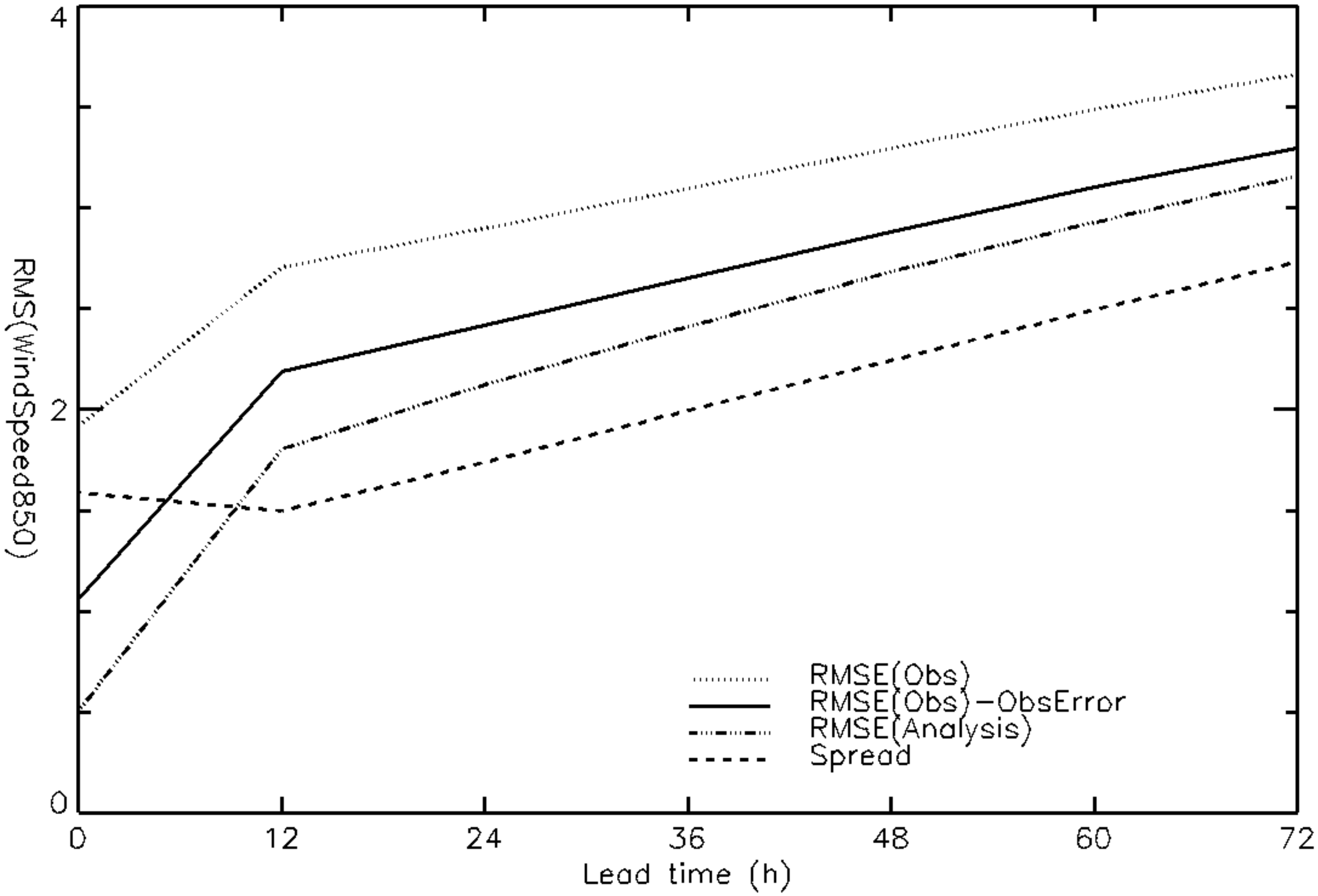


Distribution of all observed wind speeds

ROC for wind speed 850hPa > 10m/s T+72



Verification against analysis - RMSE



- Verification against analysis gives a lower RMSE than verification against observations, corrected for their error, either:
- Our estimate of the observation error is too low
- The analysis has errors, which are correlated with forecast errors

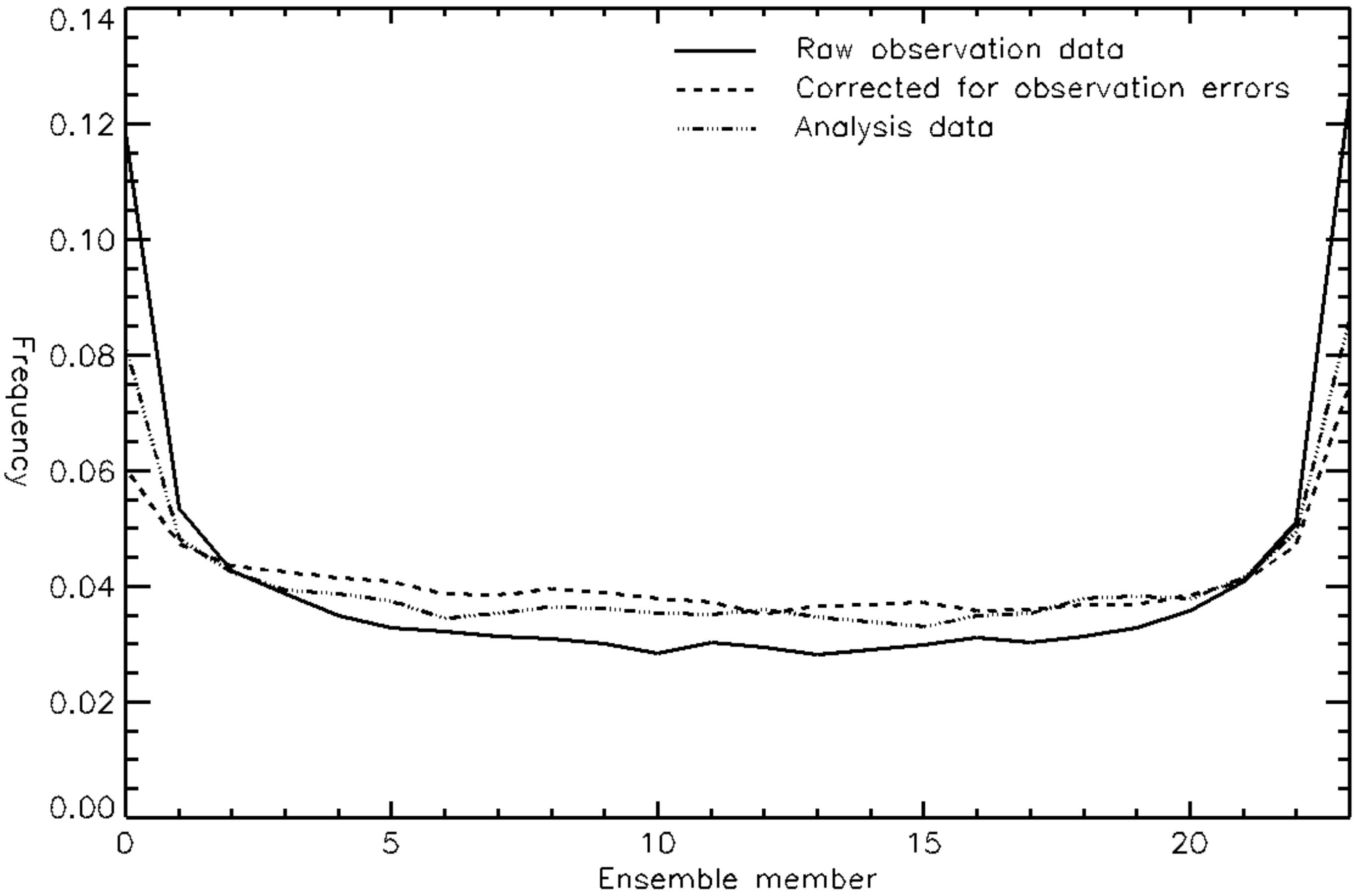
Correlation of analysis and forecast error

- Looked at by Simmons and Hollingsworth (QJ, 2002) for 500 hPa height
- They found correlations of analysis error of around 0.5 (or less) at 1 day

- For wind speed at 850 hPa, when fitting data using an AR-1 correlation model
- Observation error = 1.6 m/s
- Analysis error = 0.6 m/s
- Correlation between analysis and forecast error

T+12	T+24	T+36	T+48	T+60	T+72
0.83	0.69	0.57	0.47	0.39	0.33

Verification against analysis – Rank hist



- Verification against analysis gives more outliers than verification against observations, corrected for errors

Summary

- Assumptions

- Root-mean-square error
- Rank Histograms
- Categorical verification (ROC)

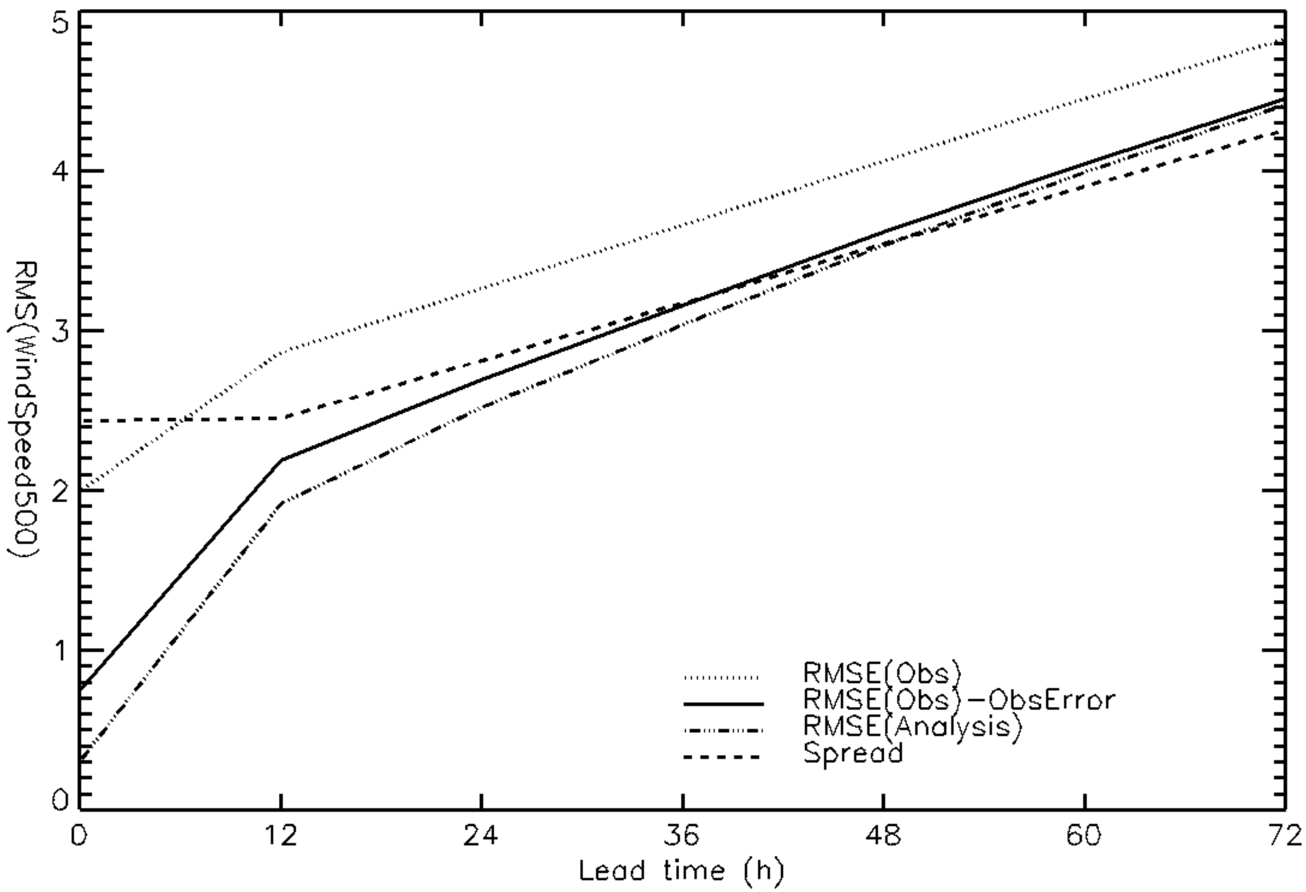
- Verification against analysis

Any questions?

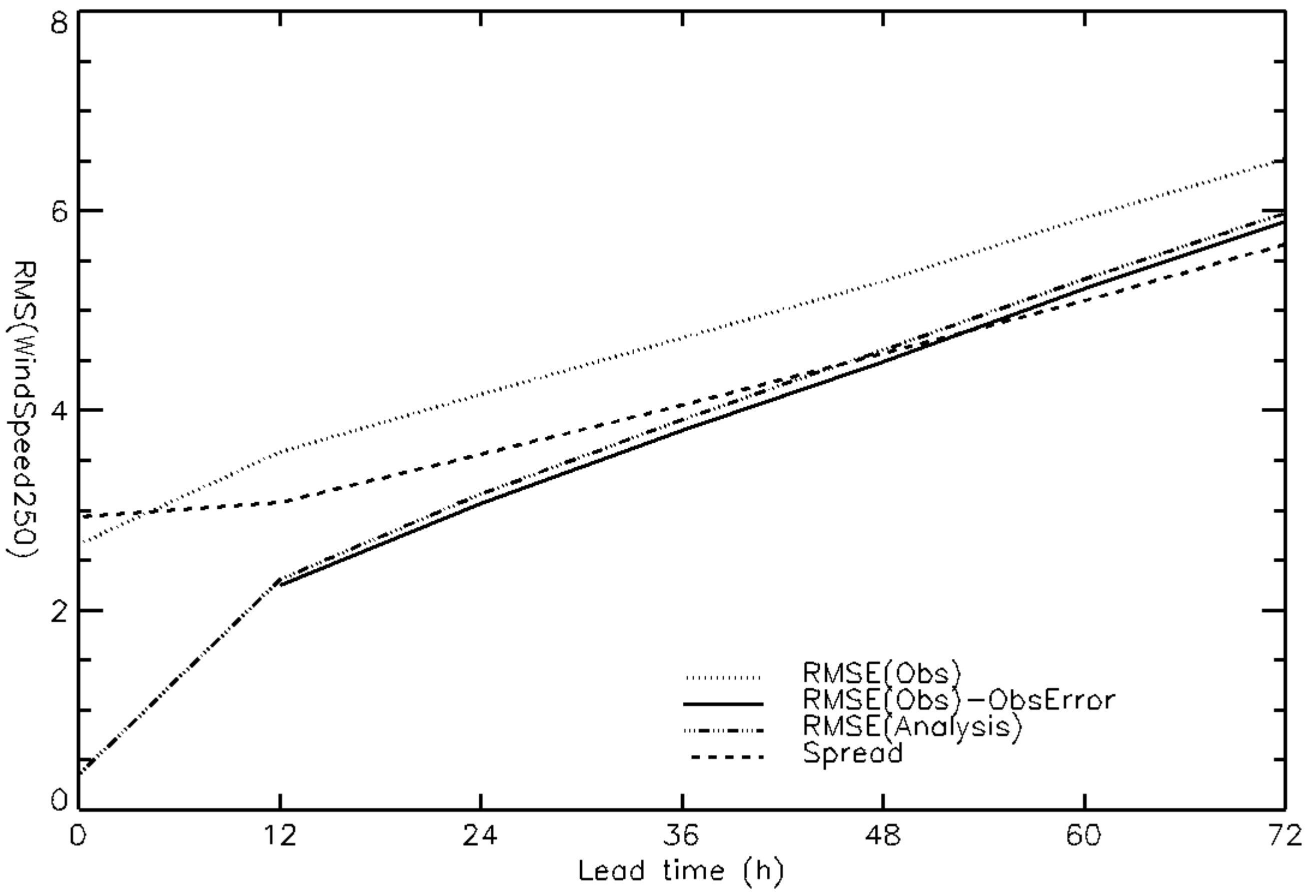
Perturbing Forecasts vs Deconvolution

- Adding the observation error to the forecasts is treating the observation error as an error in the forecast
- For example, one might say that the forecast is unable to represent the small-scale detail, and needs to be downscaled to the observation site – this would reduce the resolution of the ensemble forecast
- The deconvolution approach treats the observation as being in error
- Since rank histograms are not measuring resolution, the difference is unimportant
- The distinction is important for categorical verification

RMSE T500

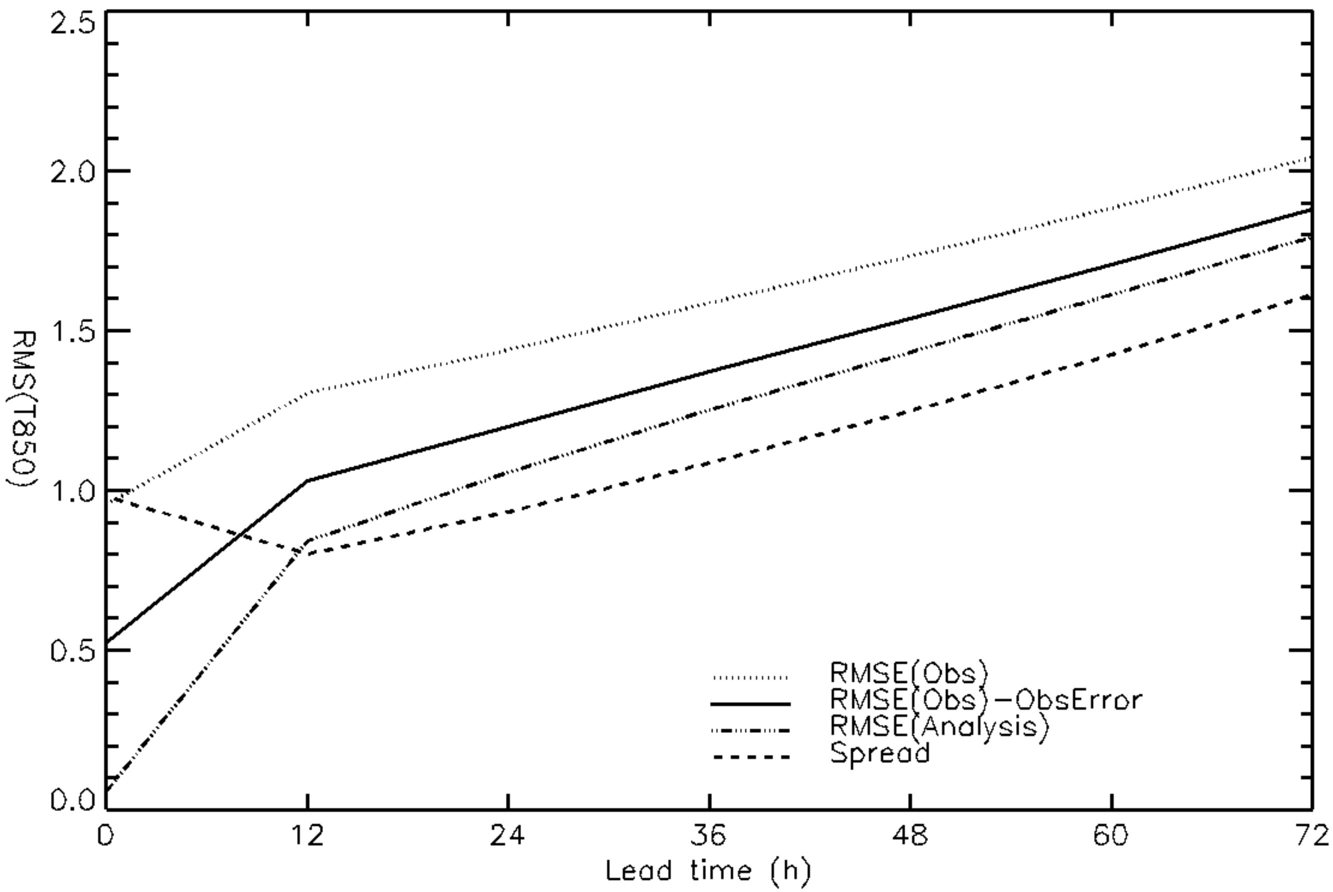

5
4
3
2
1
0
RMS(WindSpeed500)
0
12
24
36
48
60
72
Lead time (h)
RMSE(Obs)
RMSE(Obs)−ObsError
RMSE(Analysis)
Spread

RMSE T250



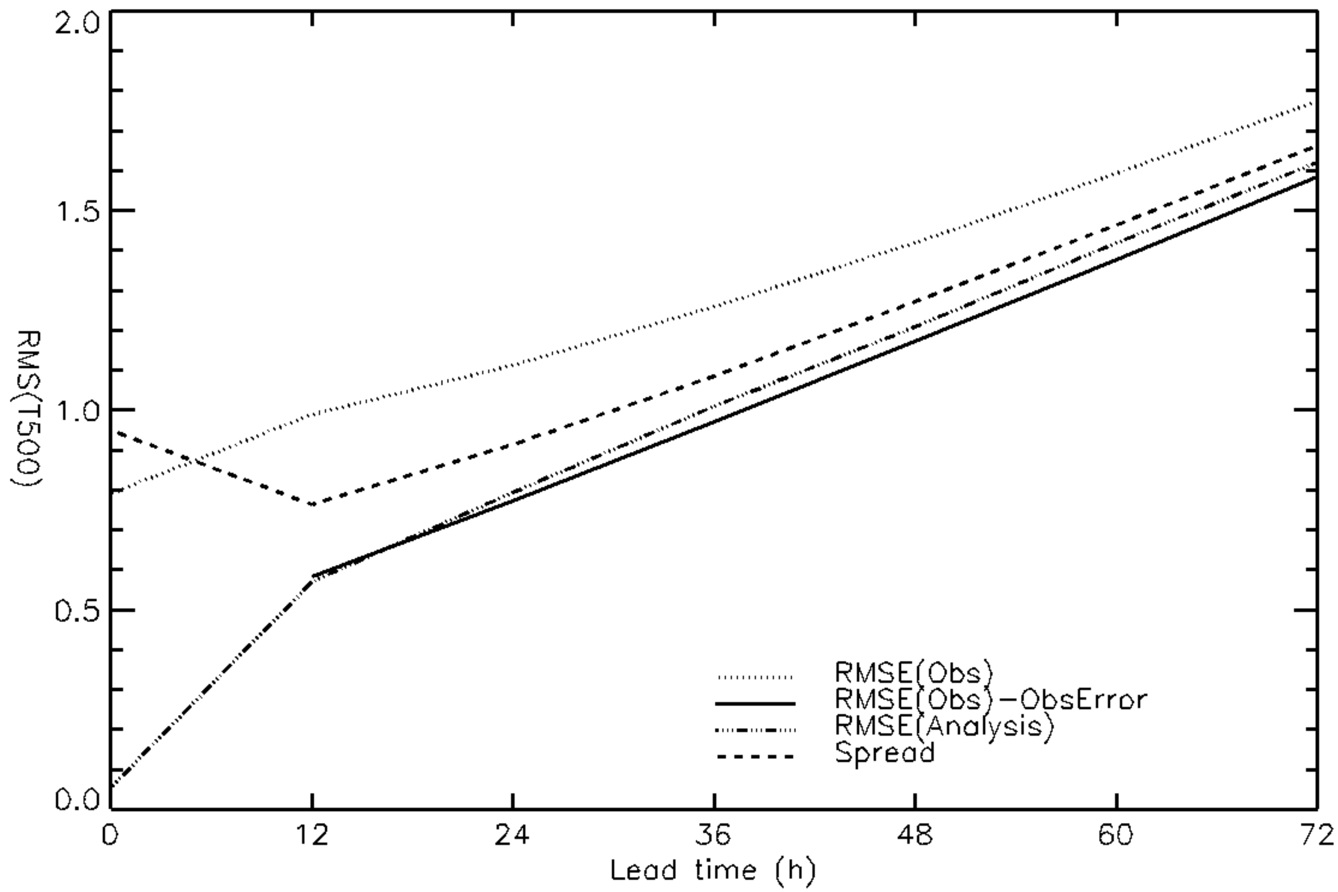
8
6
4
2
0
RMS(WindSpeed250)
0
12
24
36
48
60
72
Lead time (h)
RMSE(Obs)
RMSE(Obs)−ObsError
RMSE(Analysis)
Spread

RMSE T850



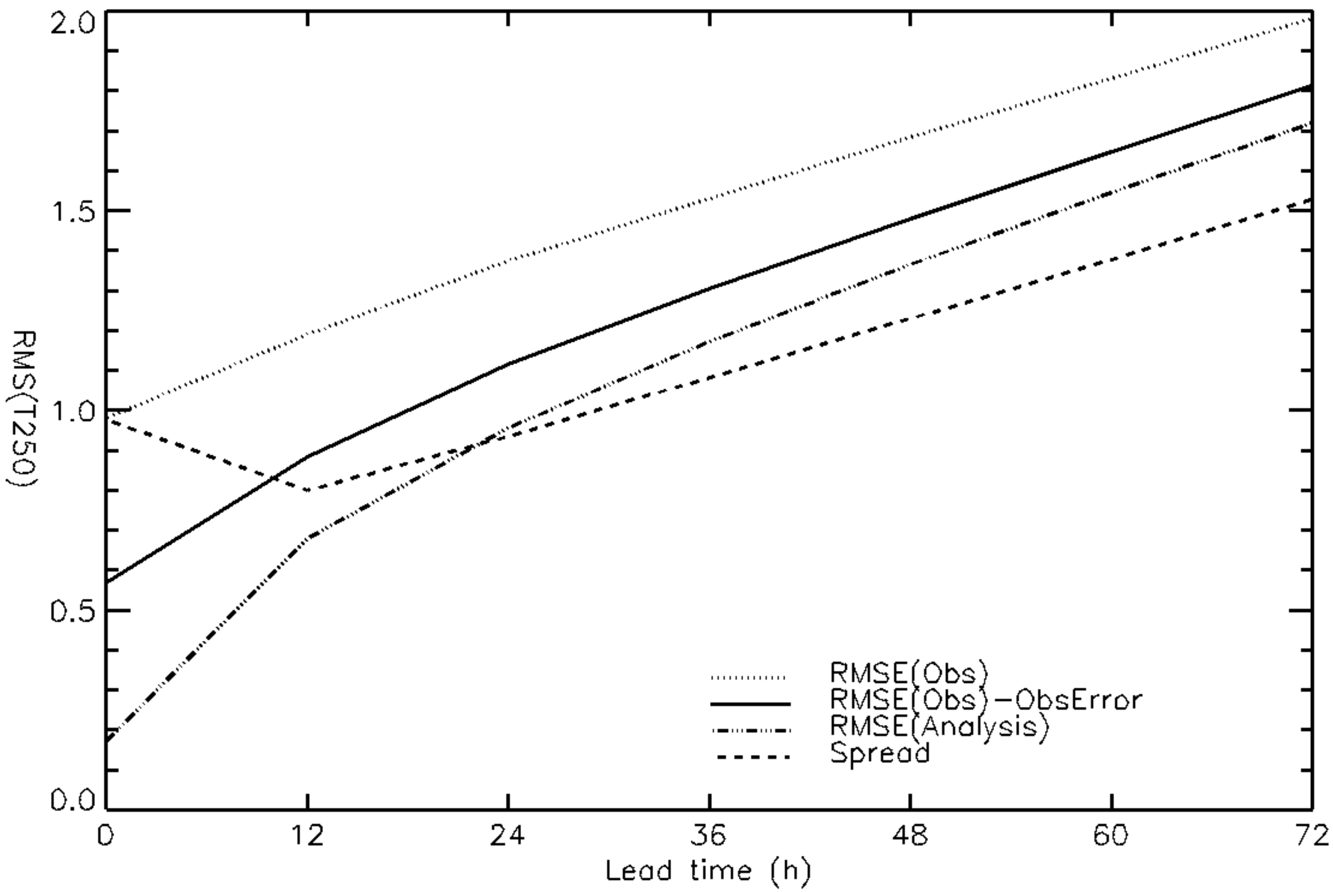
2.5
2.0
1.5
1.0
0.5
0.0
RMS(T850)
0
12
24
36
48
60
72
Lead time (h)
RMSE(Obs)
RMSE(Obs)−ObsError
RMSE(Analysis)
Spread

RMSE T500



2.0
1.5
1.0
0.5
0.0
RMS(T500)
0
12
24
36
48
60
72
Lead time (h)
RMSE(Obs)
RMSE(Obs)–ObsError
RMSE(Analysis)
Spread

RMSE T250



2.0
1.5
1.0
0.5
0.0
RMS(T250)
0
12
24
36
48
60
72
Lead time (h)
RMSE(Obs)
RMSE(Obs)−ObsError
RMSE(Analysis)
Spread