Use and discussions of the Ensemble forecasts at the Swedish Meteorological and Hydrological Institute

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1. Meteorological use of the EPS at SMHI
2. Discussion of some problems
3. Future ensemble plans at SMHI

EPS-mean

Total cloudiness:

- **white** **0-3/8**
- **light grey** **4-6/8**
- **dark grey** **7-8/8**

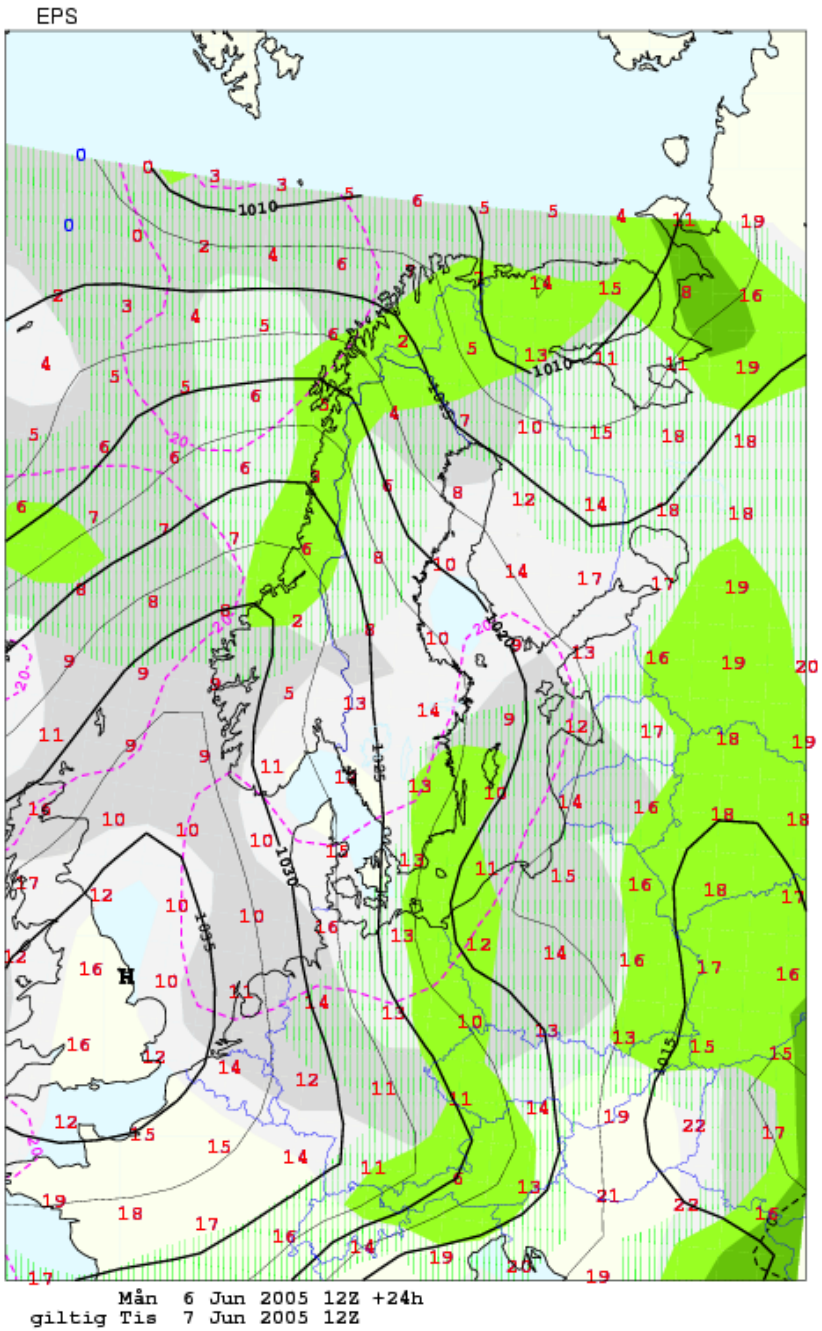
Precipitation:

Mean value over 12 hours.

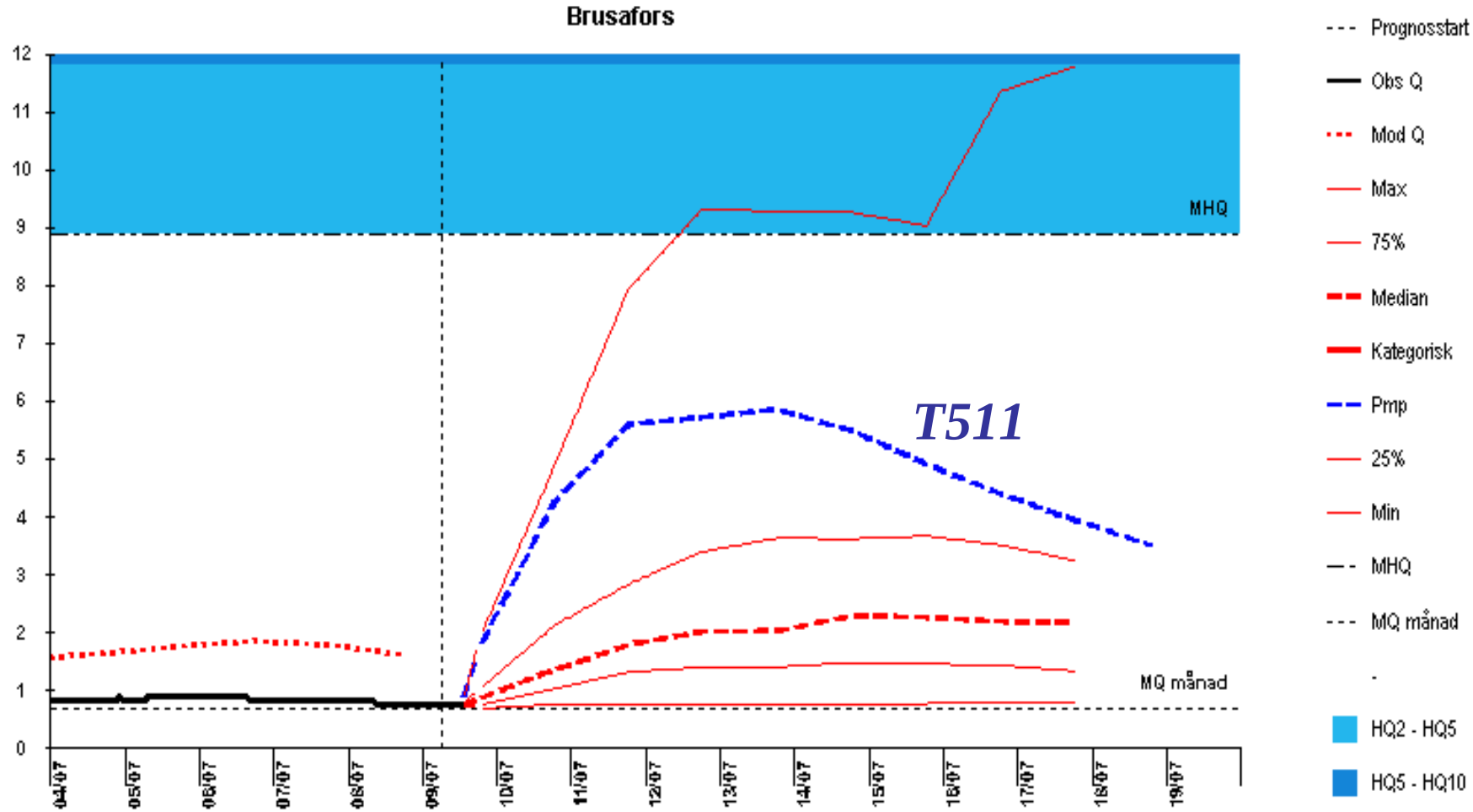
Prec in 67 % of all EPS members

- **dashed green** **> 0,1 mm**
- **Light green** **> 1 mm**
- **Dark green** **> 5 mm**
- **Orange** **> 10 mm**

2005-11-17

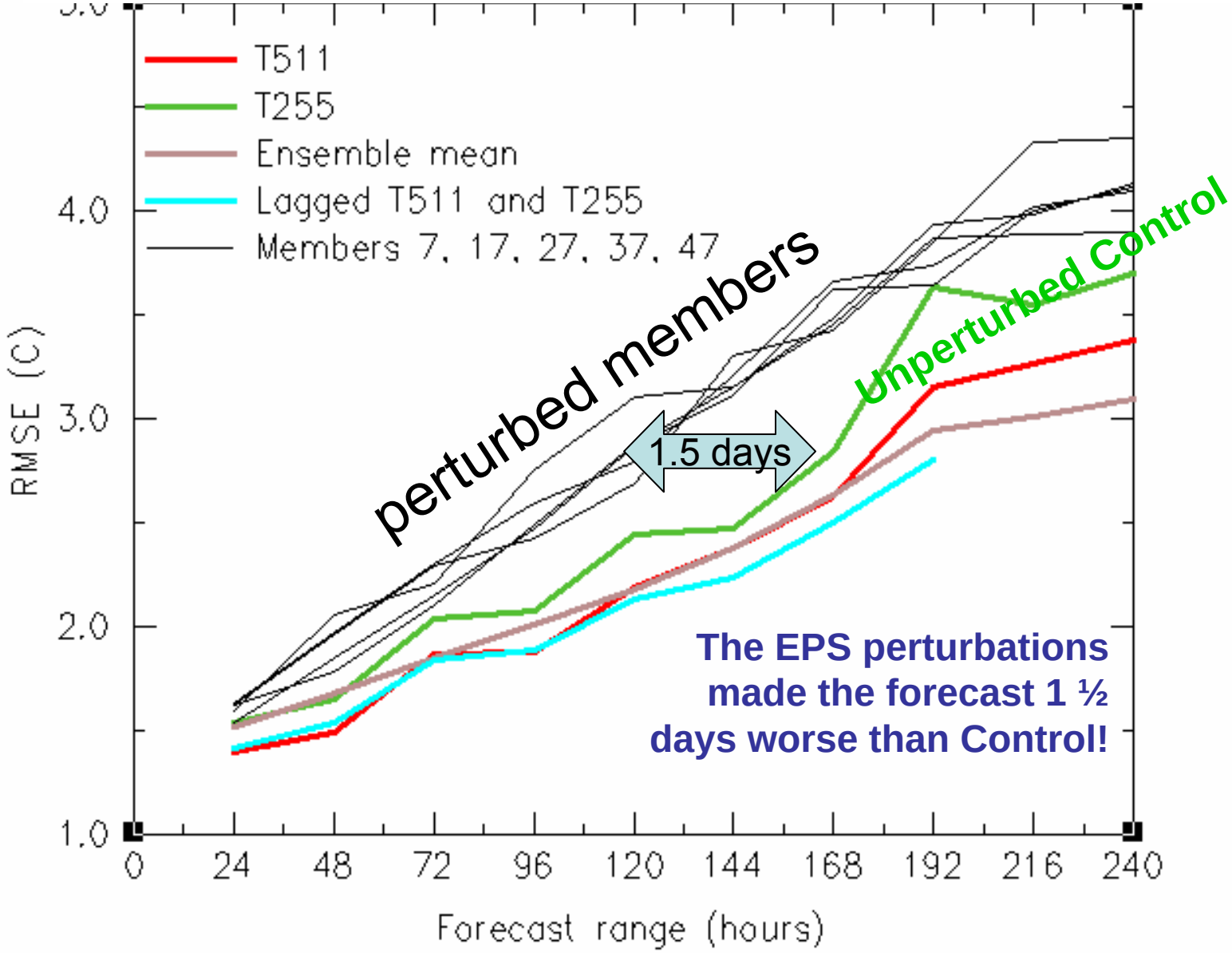


An example of an EPS based hydrological forecast

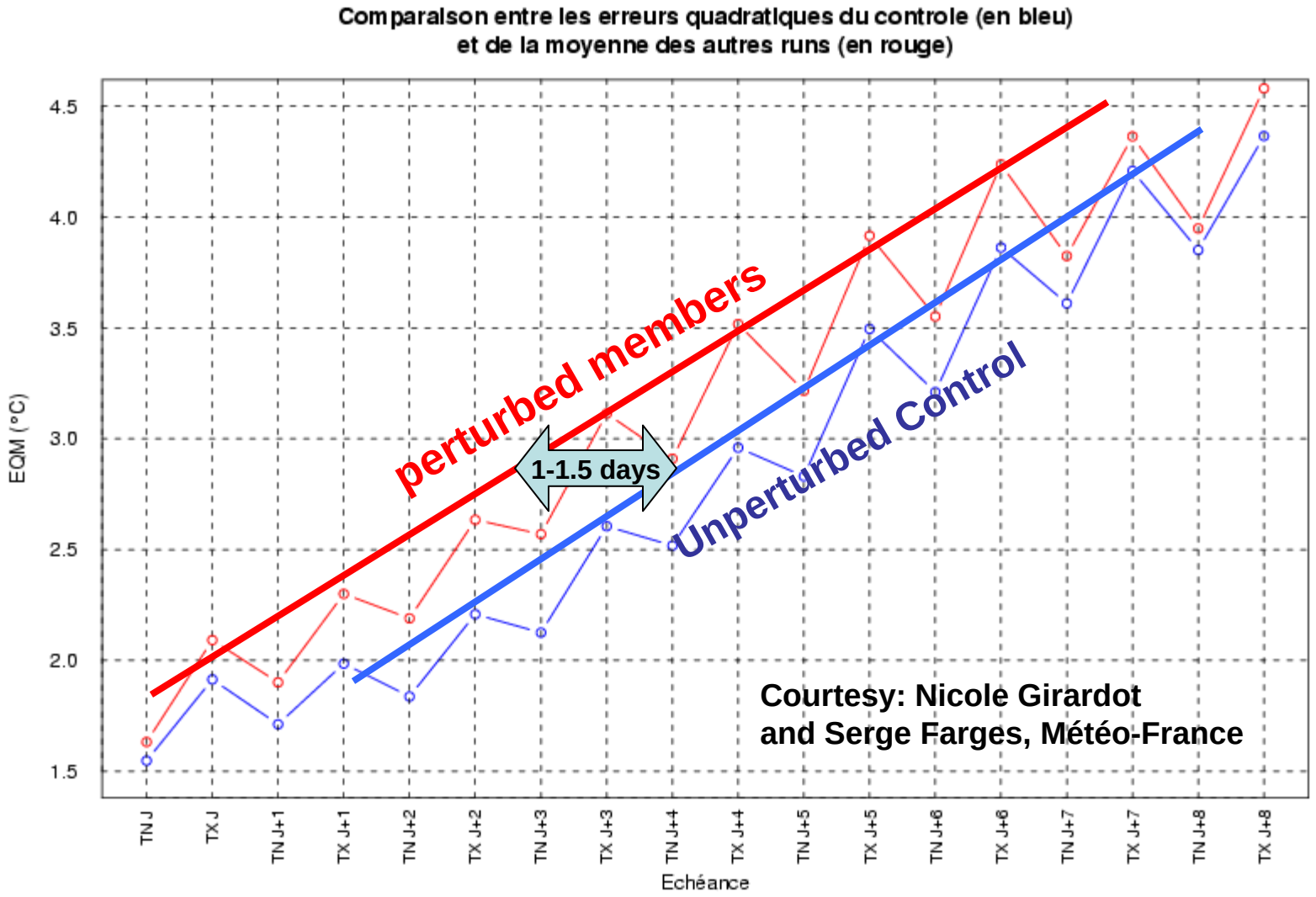


The RMSE of individual EPS members

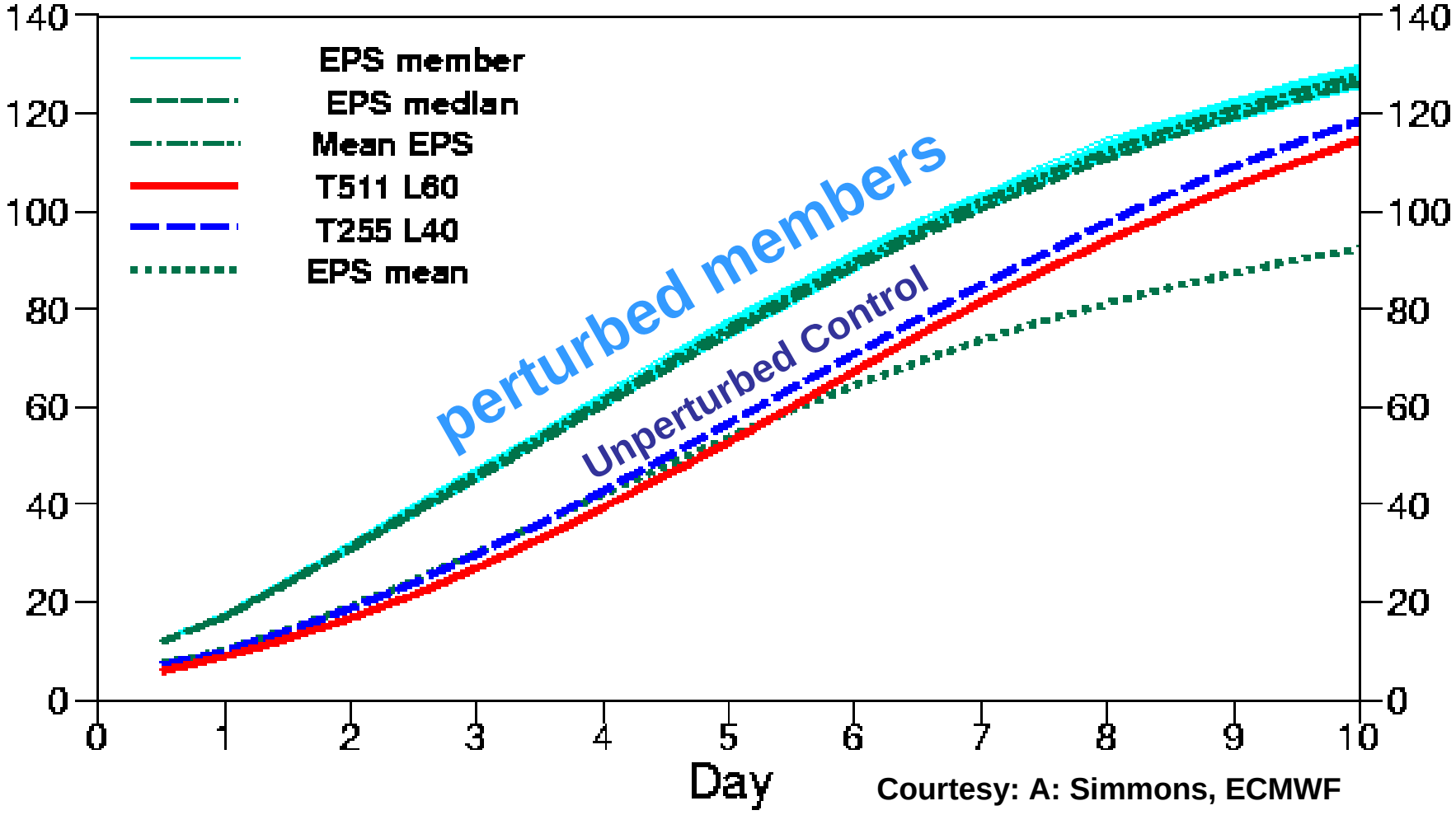
The 2 m temperature forecasts for London 2004-05



2 m temperature forecast for Toulouse 2001-2005



RMSE of 500 hPa Northern Hemisphere winter 2004-05



Courtesy: A: Simmons, ECMWF

Responses from the ECMWF

1. The perturbed analyses have to be 41% worse than the Control analyses

2. Consequently the individually perturbed forecasts have to be up to 41% worse than the Control forecasts

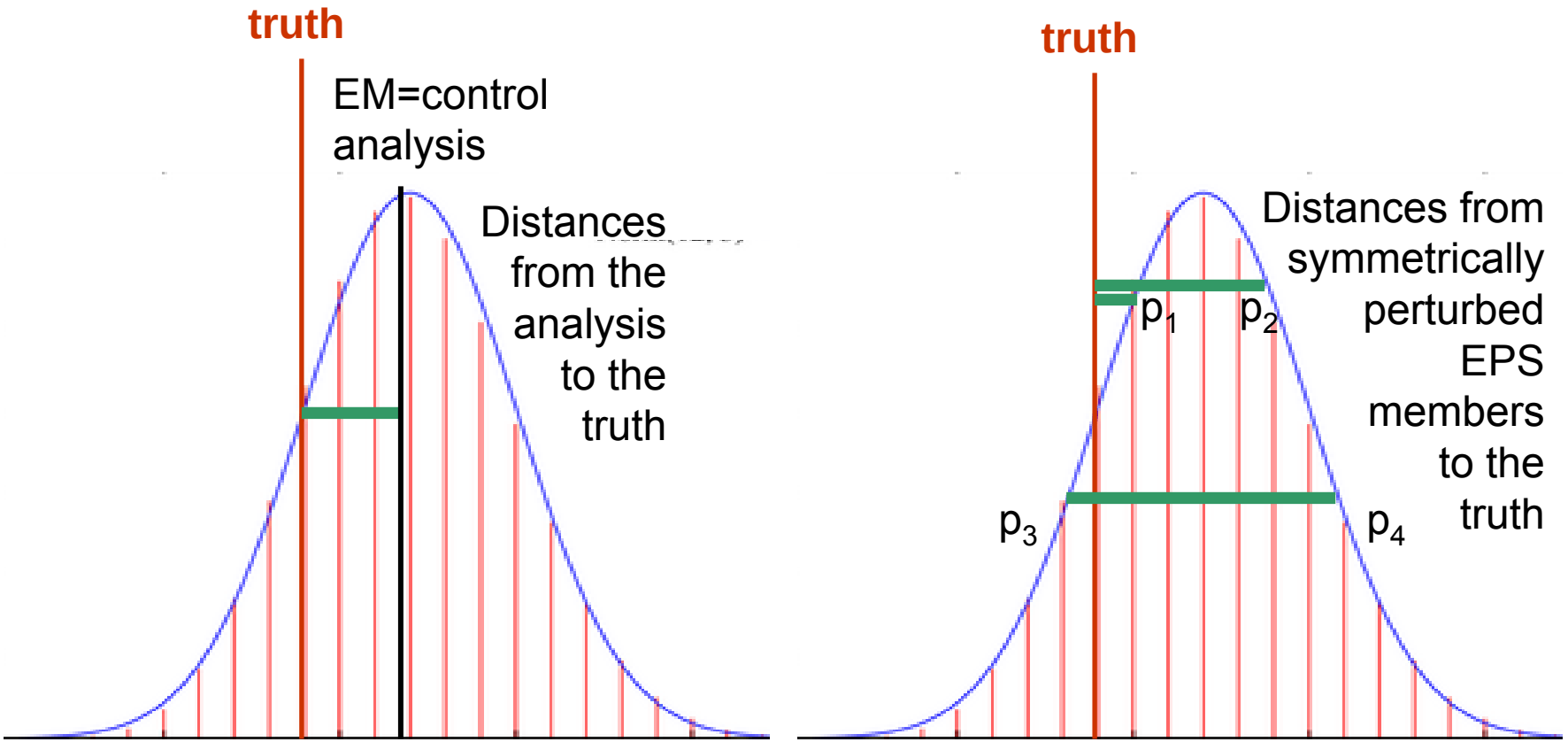
3. The EPS members should not be seen to represent possible future states of equal quality

First statement:

The perturbed analyses have to be up to 41% worse than the Control analysis

-True

Discussions from Gaussian distributions



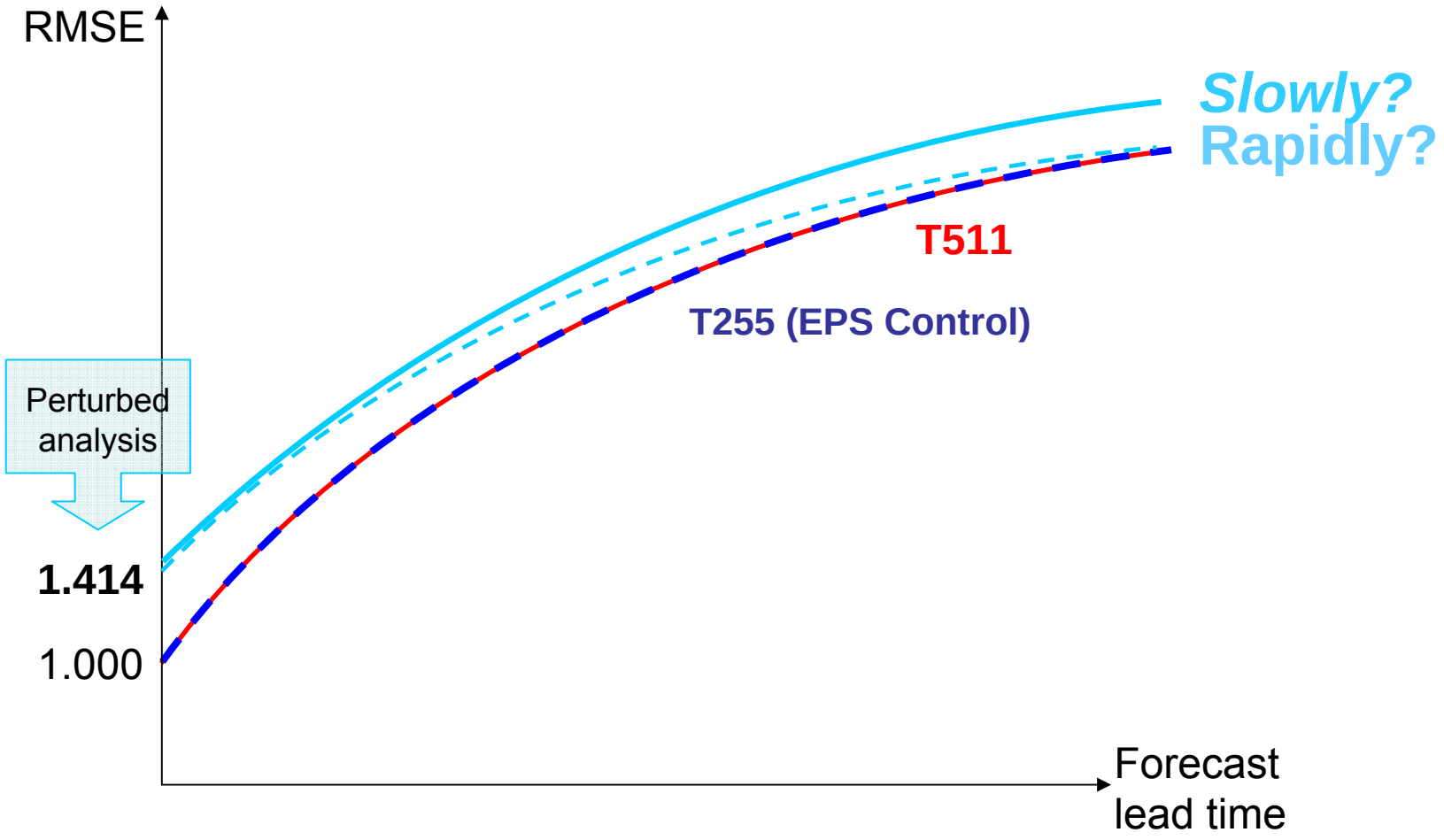
Initially members have up to 41% ($\sqrt{2}$ - 1) larger errors than the analysis

Second statement:

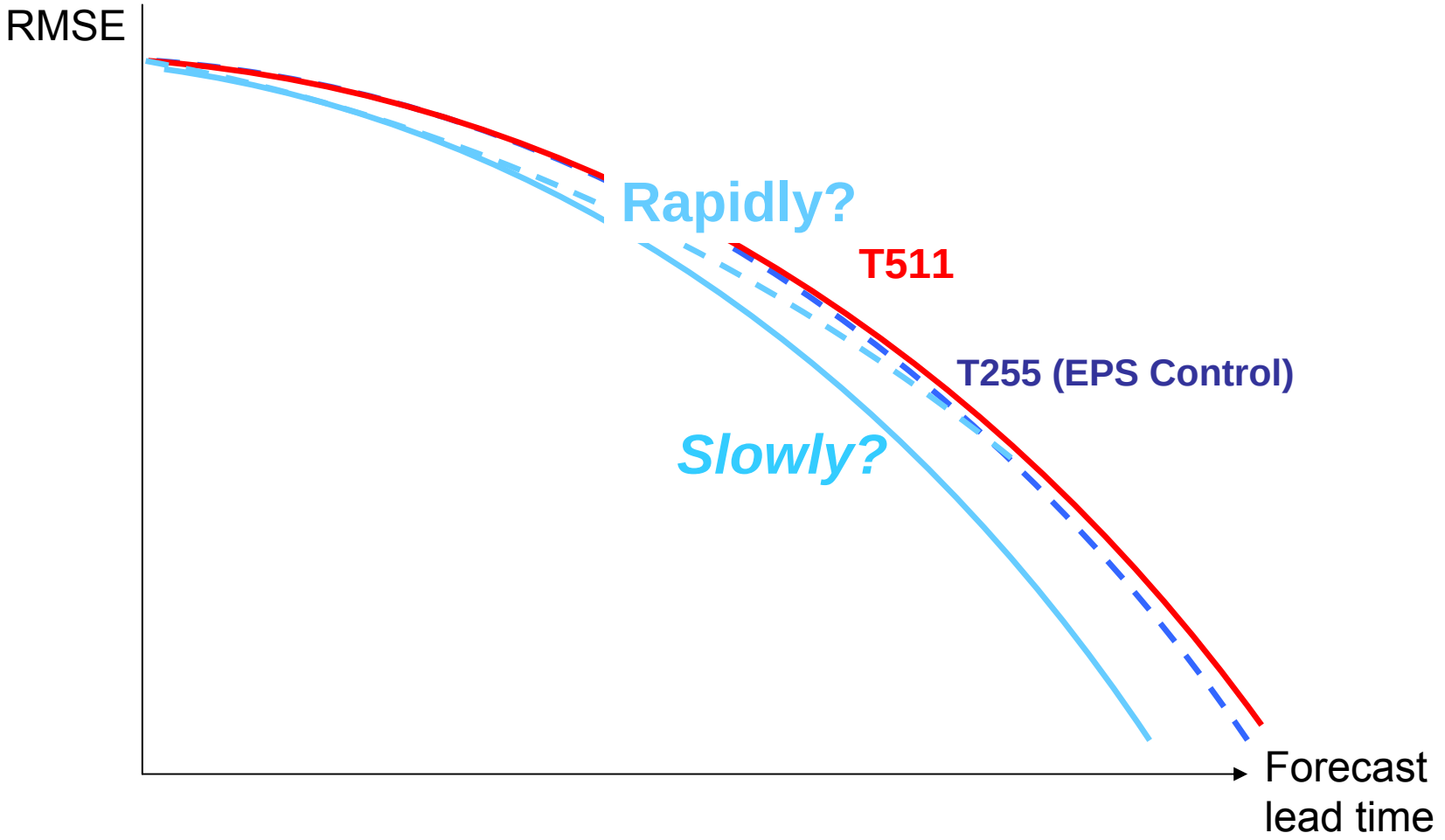
The individually perturbed forecasts have to be up to 41% worse than the Control forecasts

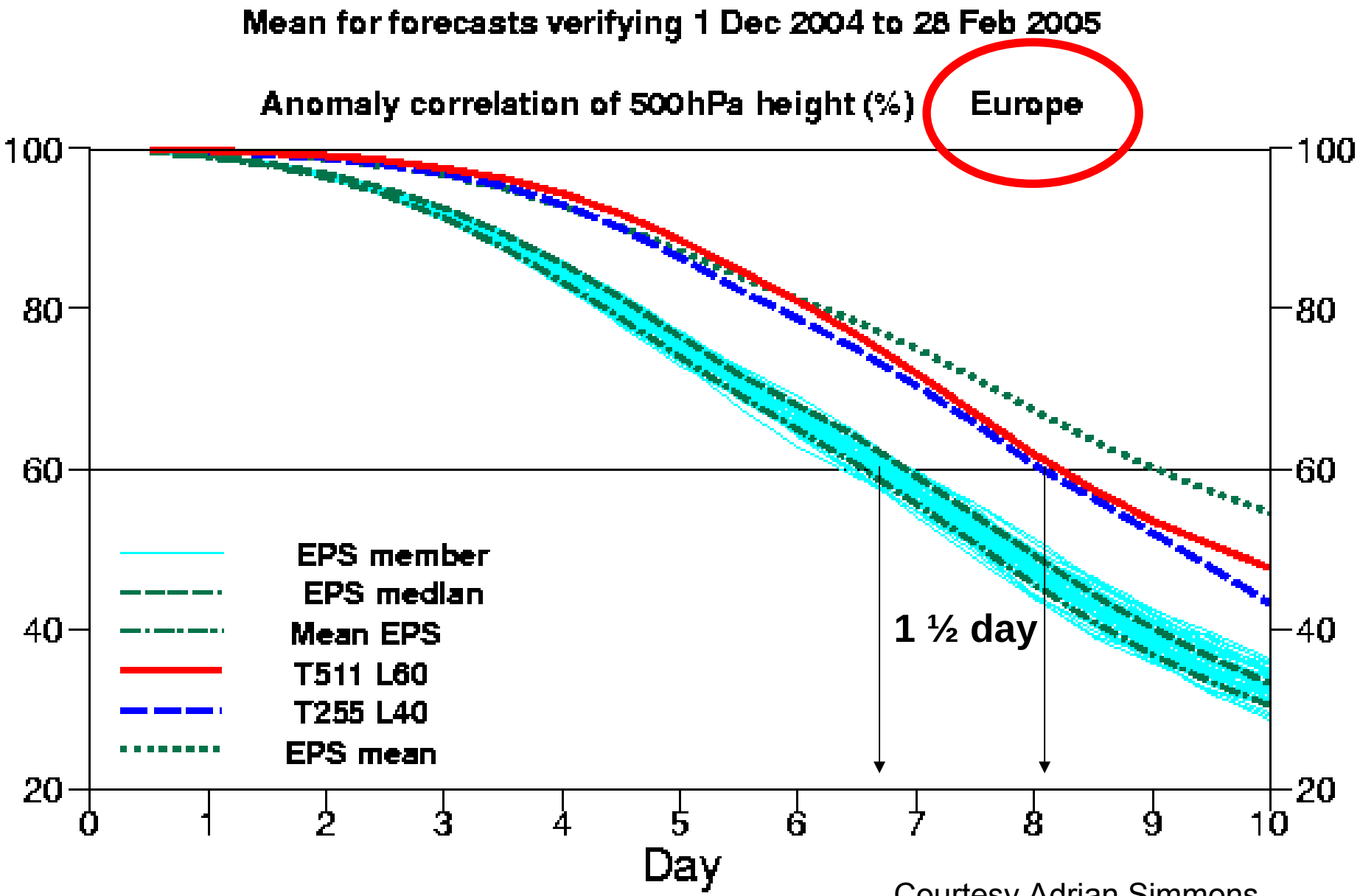
-How quickly should they improve?

The issue is **how fast** the errors of perturbed EPS members should approach the Control forecast error?



The same for the ACC (Anomaly Correlation Coefficient)





Courtesy Adrian Simmons

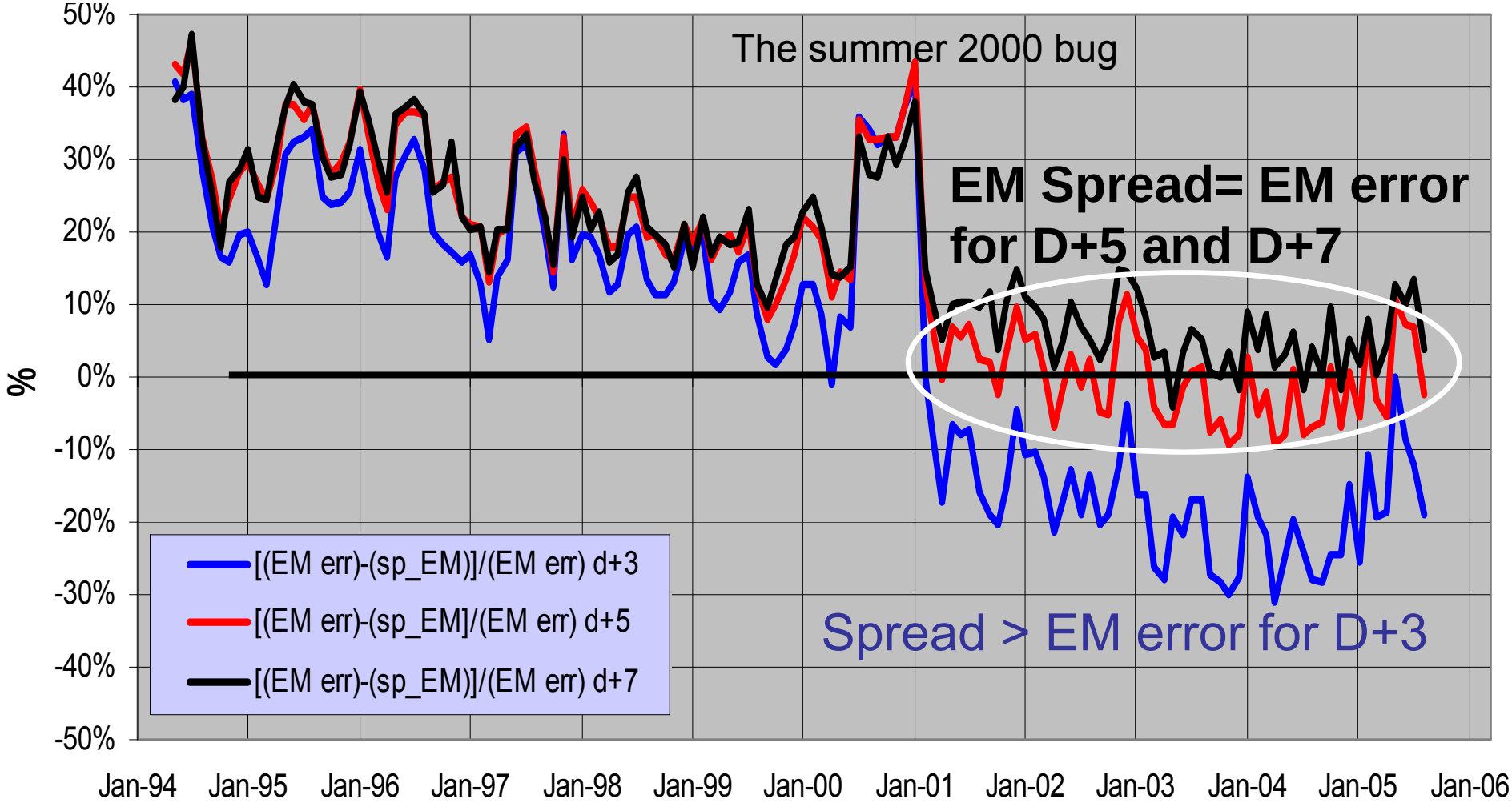
Third statement:

The individual EPS members do not represent possible future states of equal quality.

?

The spread-skill relation

NH: STD and EM error relative diff (RMS) - d+3, D+5 and D+7 (Err_{EM} - $Spread_{EM}/Err_{EM}$)



Should the spread on average match the skill?

It sounds intuitively correct

..but nobody really seems to know

There is no well-known derivation

There are three references: Control, Ensemble Mean and an arbitrary member e.g. 17

The relation between the spread around the Reference and the Reference error

p = perturbed member ref=T255 reference a= analysis

Spread around Reference | **Error of Perturbed forecast** | **Error of Reference forecast** | **Error covariance of perturbed and Reference forecasts**

$$\overline{(p-ref)^2} = \overline{(p-a)^2} + \overline{(ref-a)^2} - \overline{2(p-a)(ref-a)}$$

S_{pr}^2 E_p^2 E_{ref}^2

With $E_p = XE_r$

$$corr = \frac{\overline{E_r E_p}}{|E_r||E_p|}$$

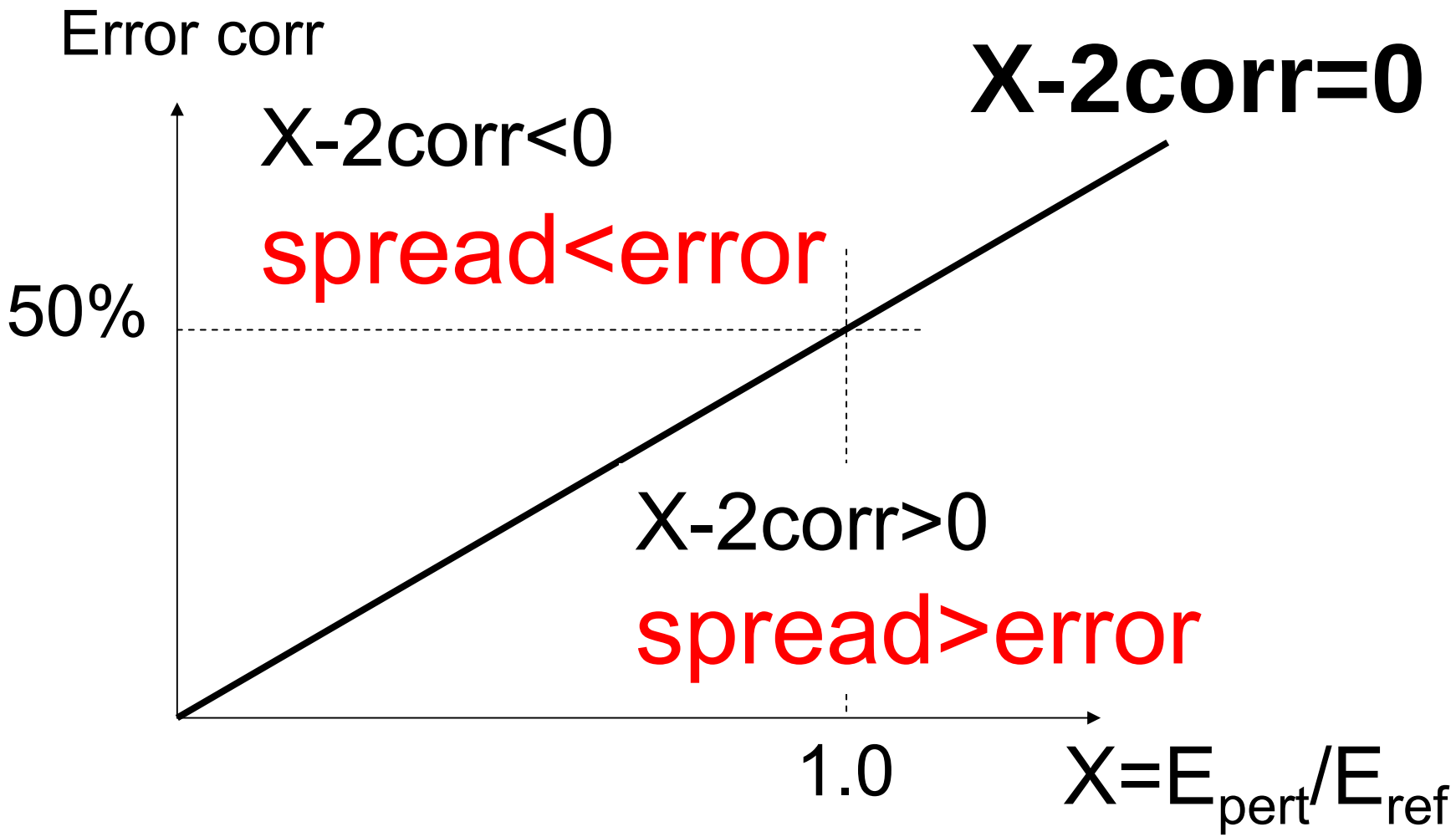
$$\overline{(p-ref)^2} = \overline{(p-a)^2} + \overline{(ref-a)^2} - \overline{2(\mathrm{p}-\mathrm{a})(\mathrm{ref}-\mathrm{a})}$$

With $E_p = XE_r$ $\qquad corr = \dfrac{\overline{\mathrm{E_r E_p}}}{|E_r||E_p|}$

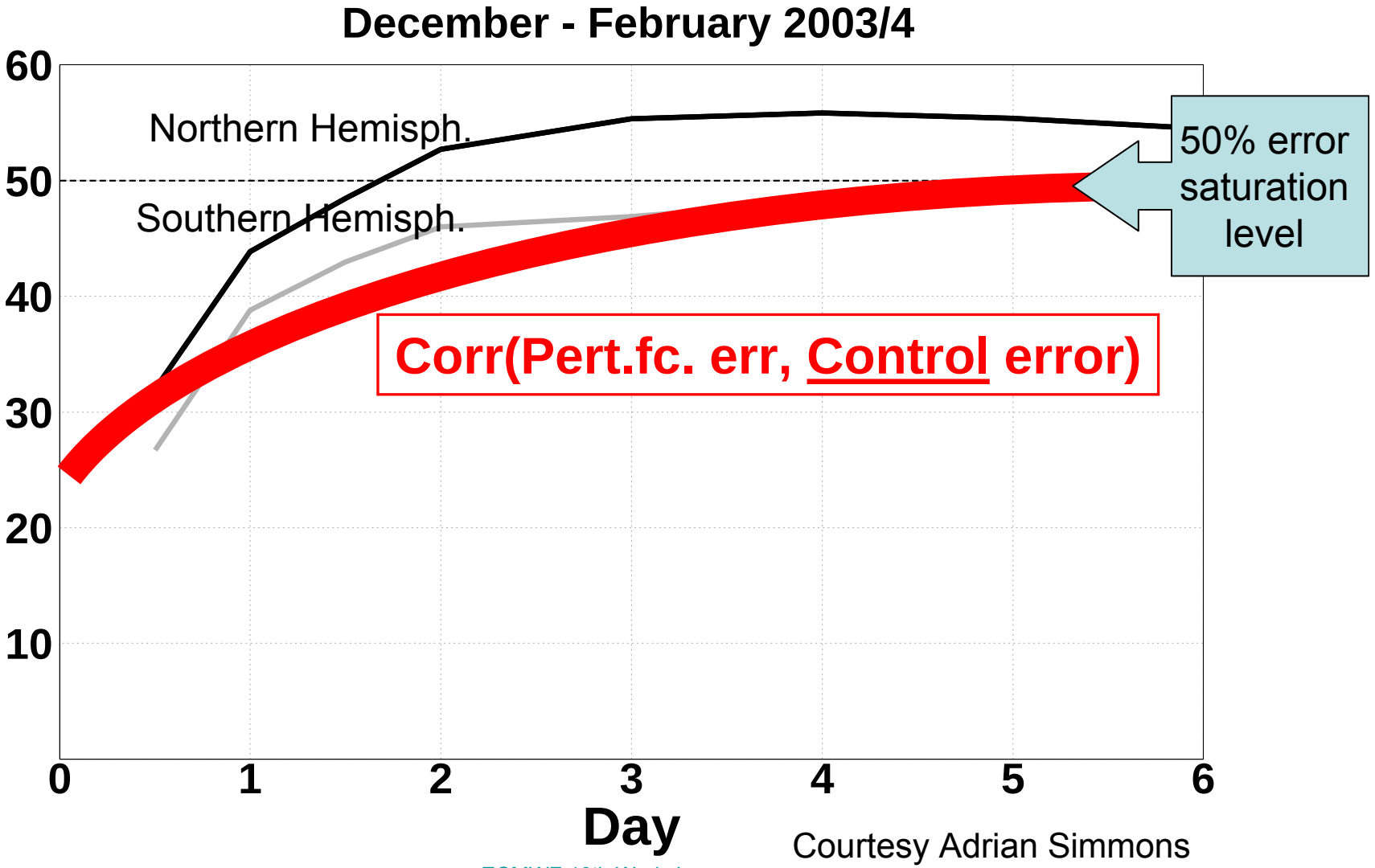
$$S_{pr}^{\ 2} = X^2 E_r^{\ 2} + E_r^{\ 2} - 2corrXE_r^{\ 2}$$

$$\boxed{S_{pr}^{\ 2} = E_r^{\ 2}(X^2 + 1 - 2corrX)}$$

$$S_{pr}^{\ 2} = E_{ref}^{\ 2}(X^2 + 1 - 2corrX)$$

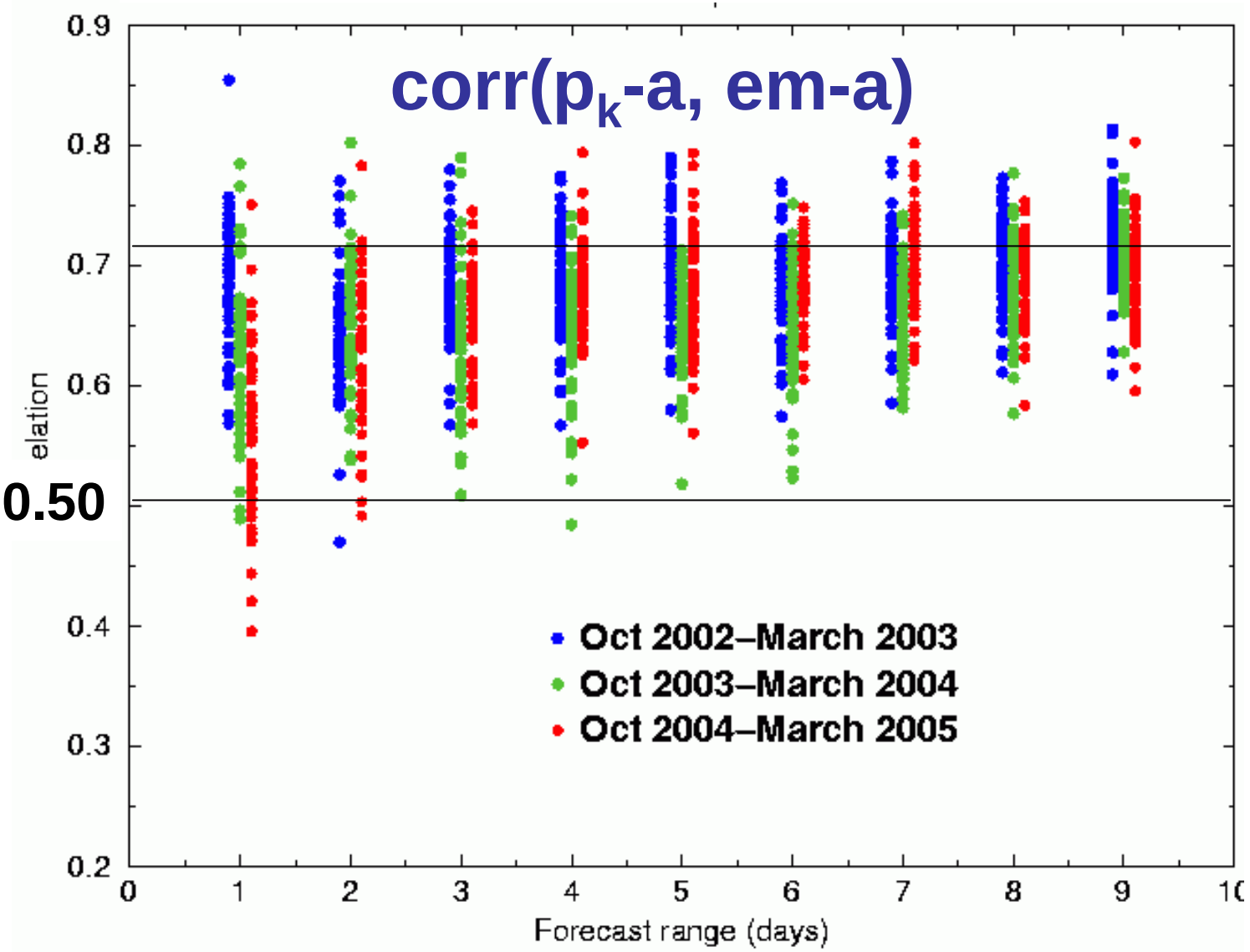


Correlation of 500 hPa forecast errors between the ECMWF and the UKMO global models winter 04-05

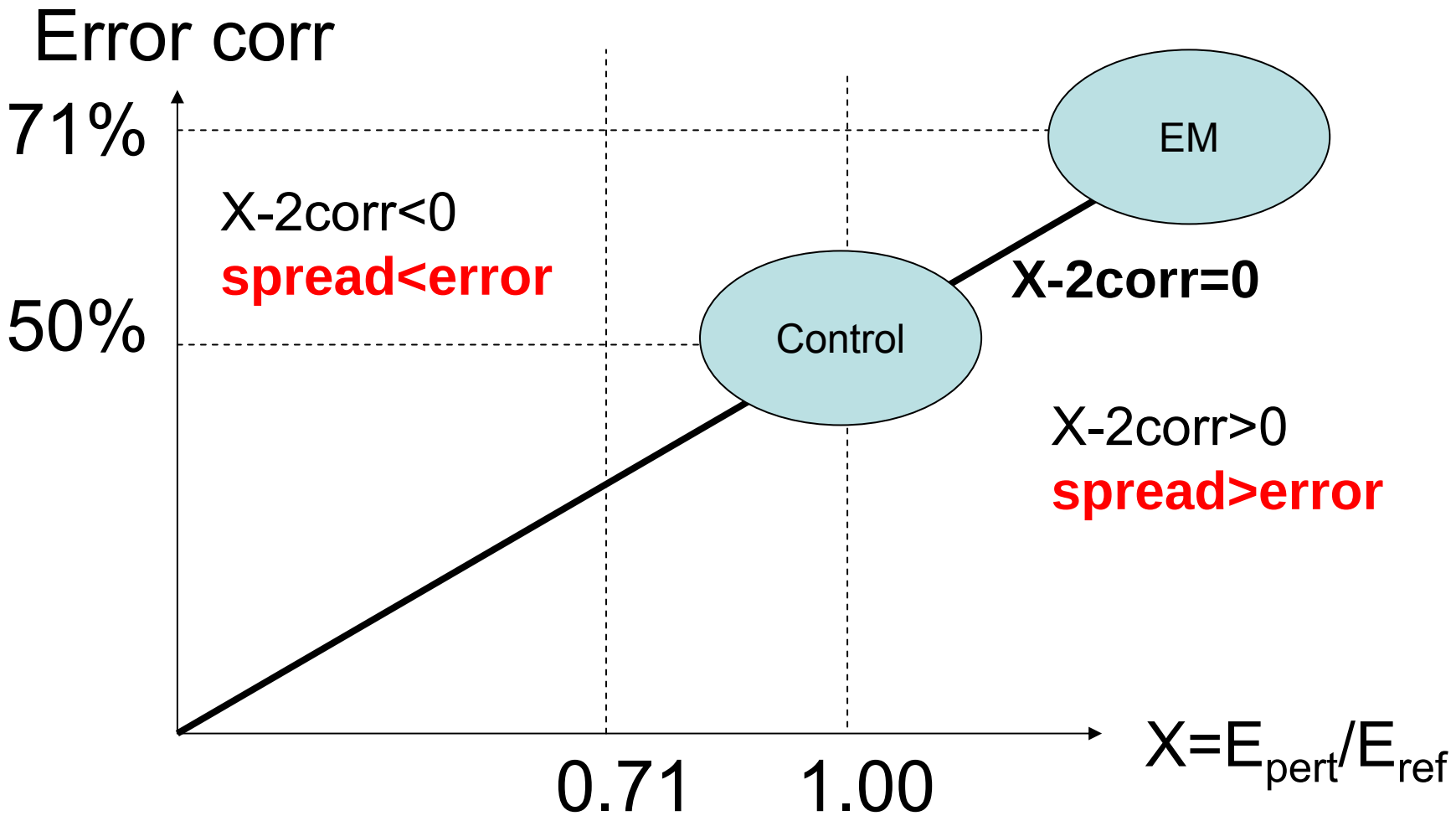


Courtesy Adrian Simmons

Correlation of perturbed member errors and the *ensemble mean* errors



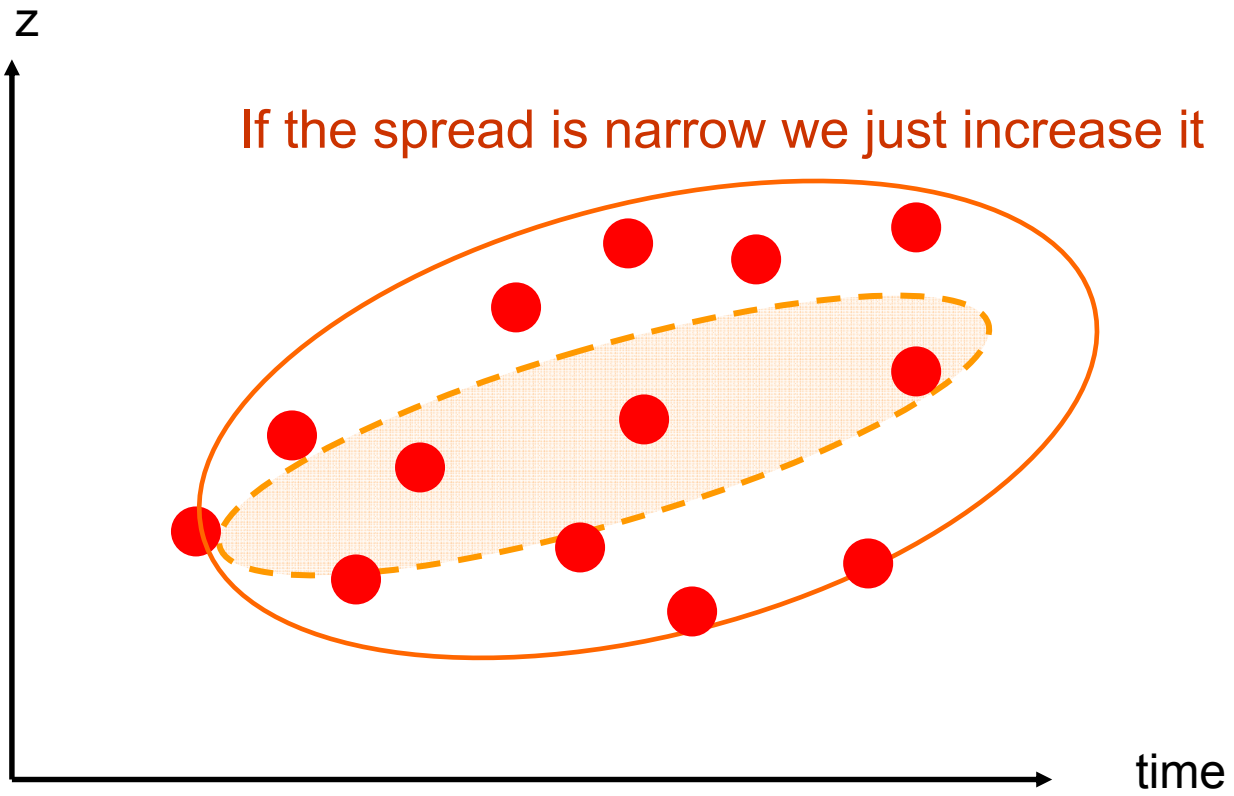
Ideal positions for Control and Ensemble Mean references



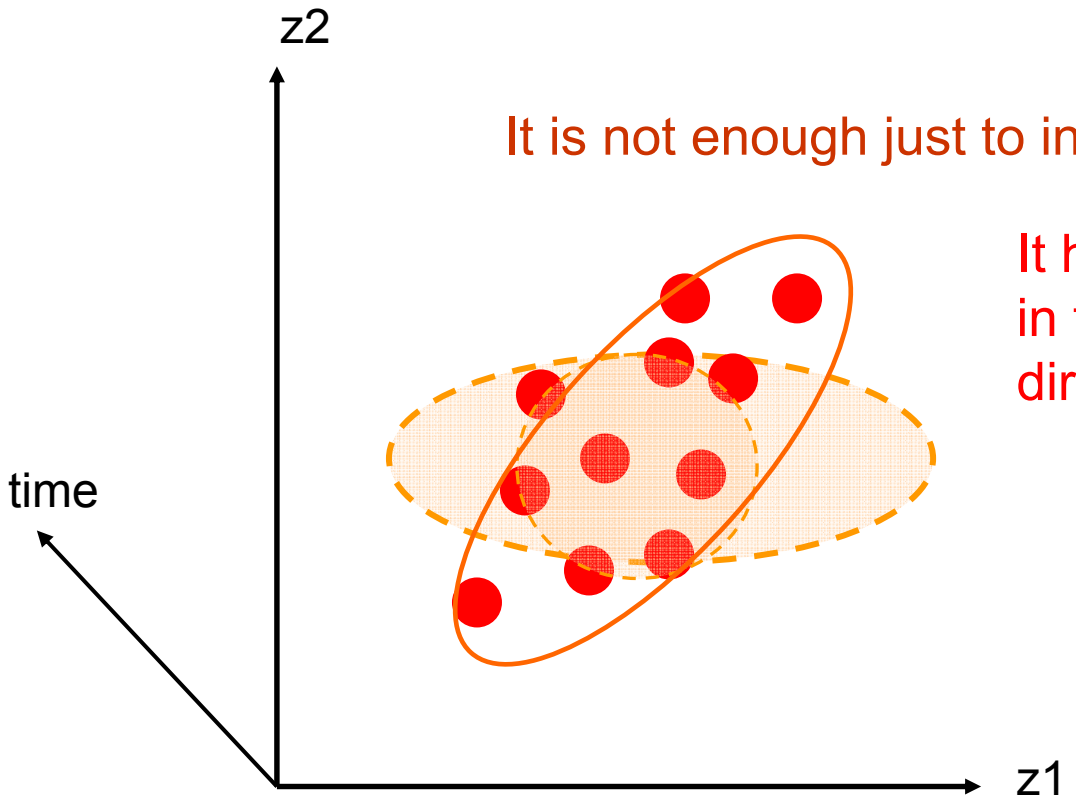
The perturbation technique

The spread is not only about *size*

We tend to think about spread in two dimensions



But the spread is multi-dimensional….



It is not enough just to increase it

It has to be in the right direction

SMHI plans:

Follow the developments in the ensemble research

Develop a ensemble system for HIRLAM

Explore the lagged forecast approach

Pro and cons for a lagged T511 approach

+ During 36-48 h 4-5 deterministic forecasts are produced which are better or as good as the EPS members

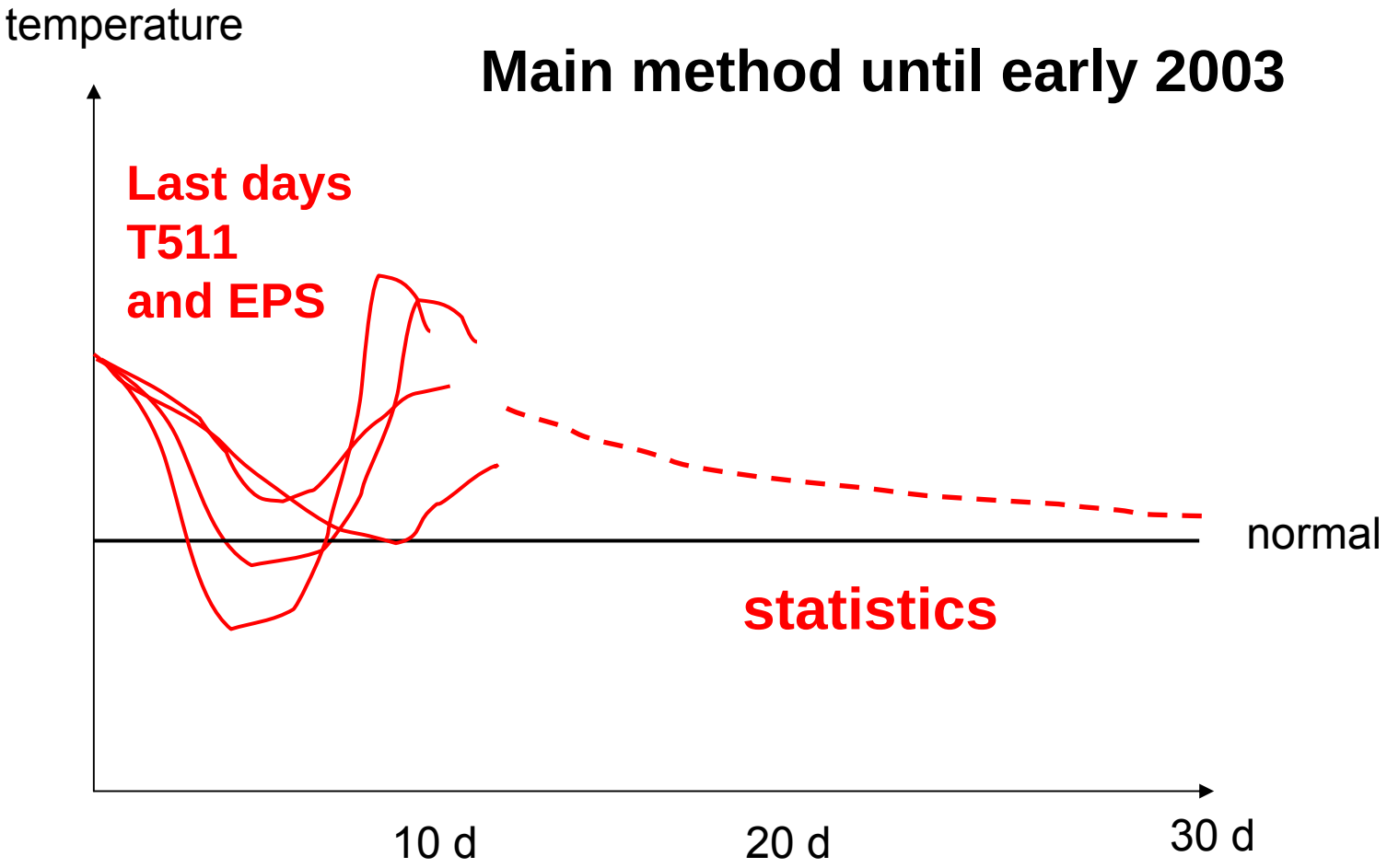
+ These forecasts can be used also in the short range

+ They have a higher geographical resolution

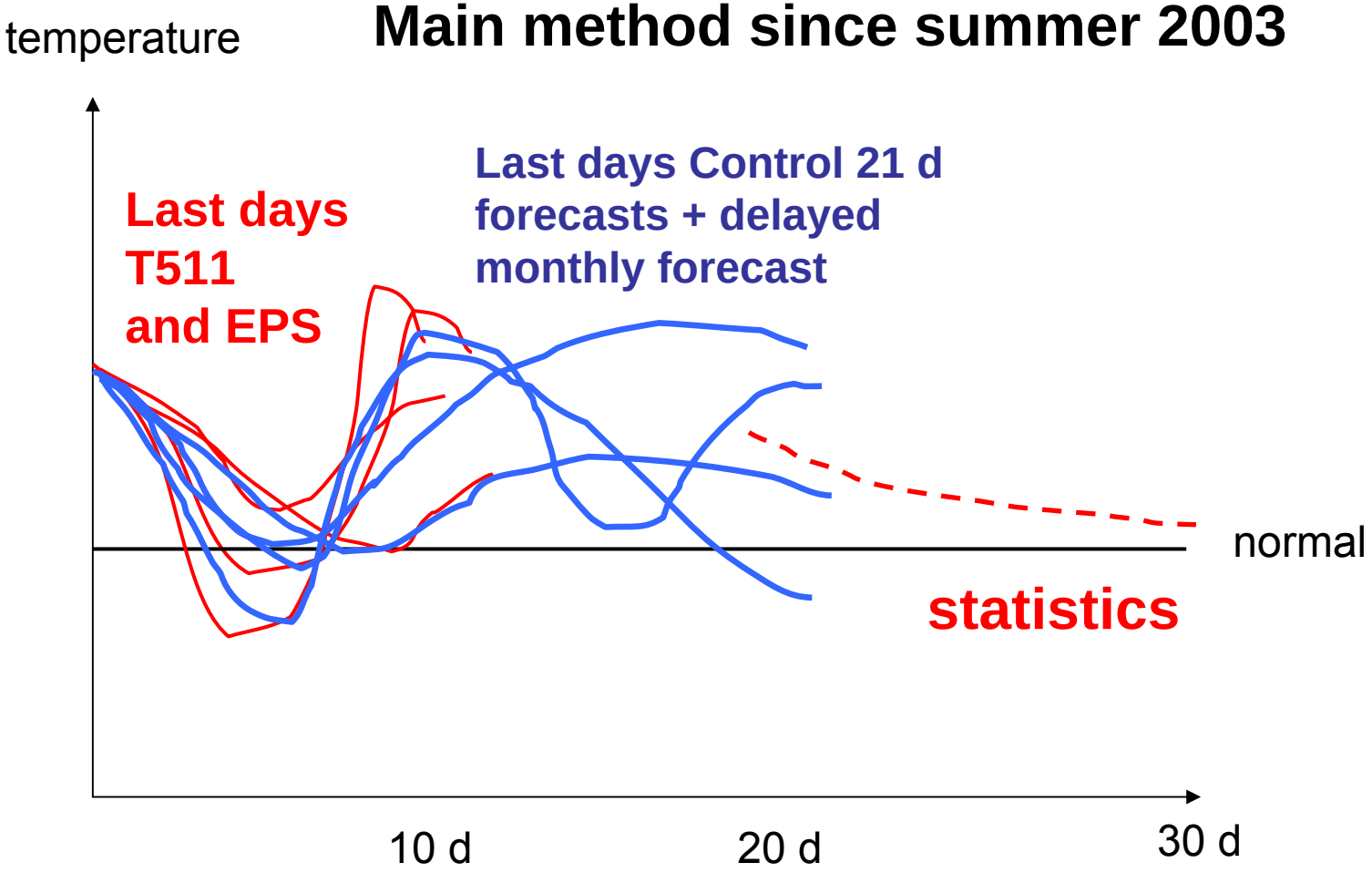
+ It is computationally more easy to administrate

- Slightly smaller spread
- Slightly more jumpiness
- Cruder probability intervals (15-25%)

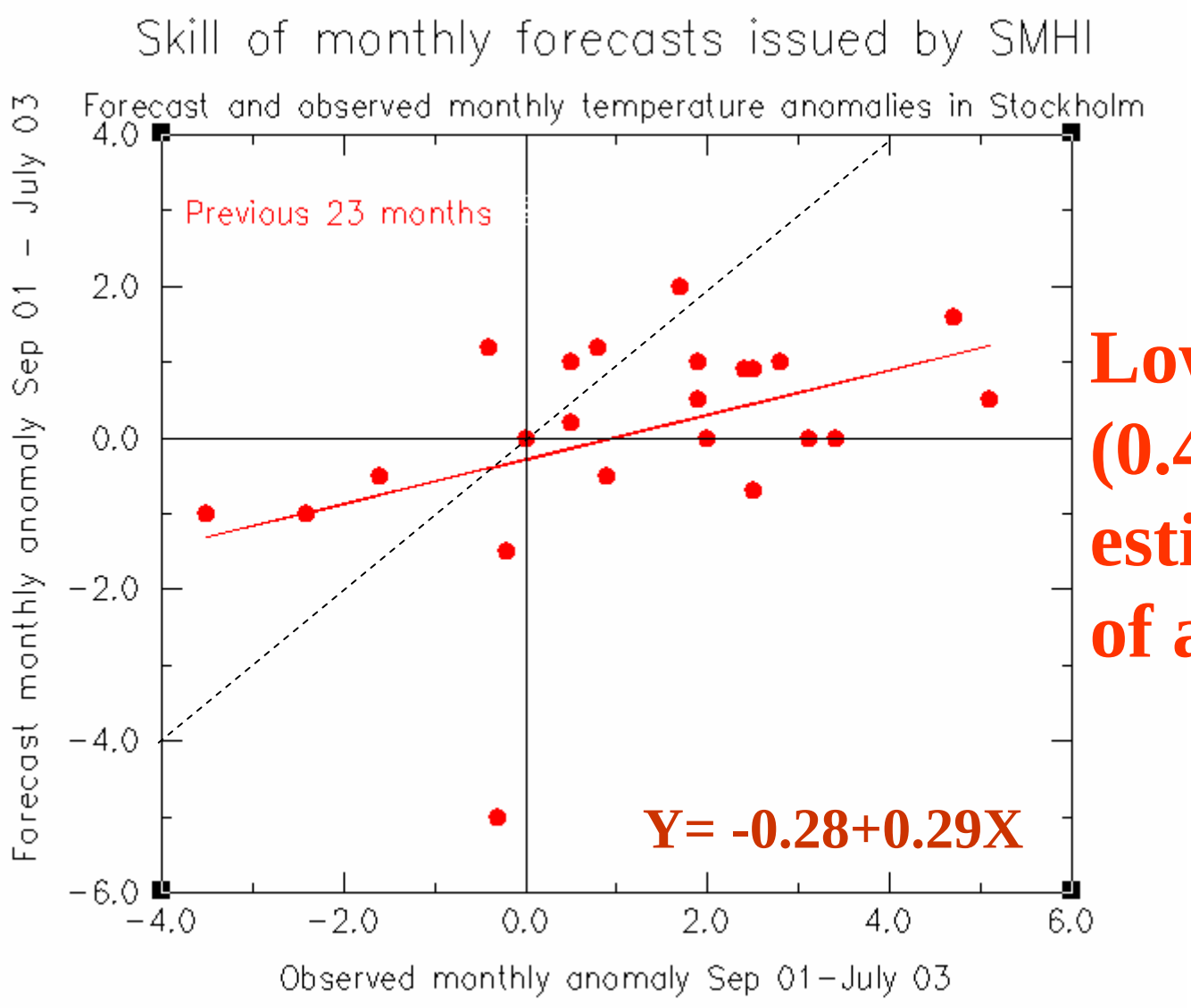
Experience of improved skill in the SMHI monthly forecasts thanks to the lagged approach


temperature
Main method until early 2003
Last days
T511
and EPS
normal
statistics
10 d
20 d
30 d

Main method since summer 2003

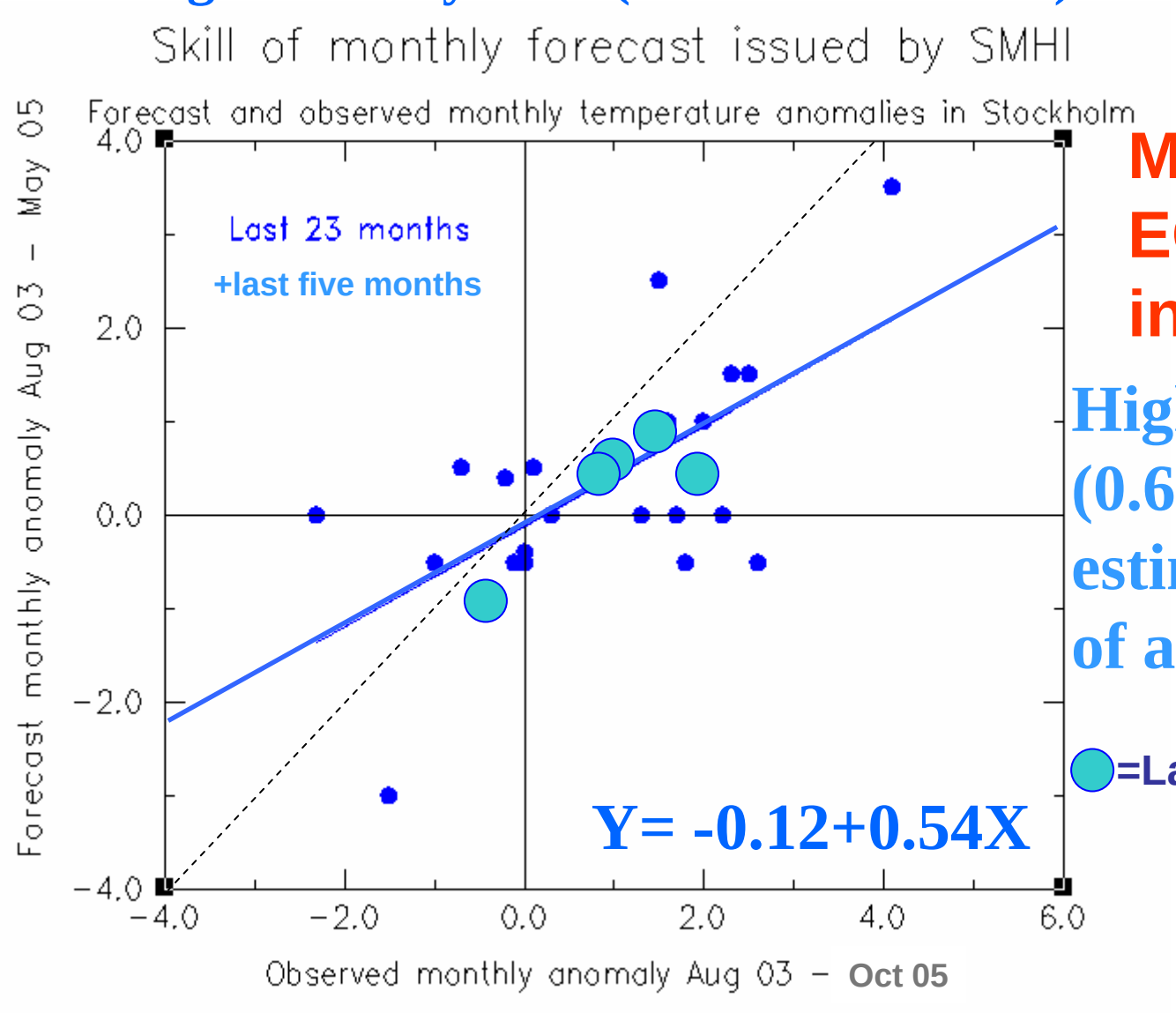


Sep 2001 - Jul 2003



Low correlation (0.43) + under estimation of anomalies

Aug 2003-May 2005 (+last five forecast)



More ECMWF input

Higher correlation (0.66) and better estimation of anomalies

=Last five forecasts

Recommendations:

1. The perturbation technique has to be re-considered

2. More elaborate statistical analyses of the EPS

3. Better daily monitoring of the EPS

4. Also lagged forecasts as reference

5. Specification of what constitutes a good EPS

END