A study of the CMAM-DAS using simulated observations

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  - A separation of the impacts of different sources of errors
    - model
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    - An assessment of the extent of the predictability of the mesosphere

CMAM-DAS

- CMAM model
  - 71 vertical levels with the lid at 95km.
  - T47 spectral resolution
- Observations
  - surface obs.
  - 1000-10 mb: radiosondes, aircrafts,
  - 1000- 1mb : AMSU-A, satellite winds
  - No observations higher 1mb
- Assimilation
  - 3dVAR

Simulation of observations

- Use a free model run as a truth
- Create “perfect obs” at locations of REAL measurements
- Add random error with $std = \sigma_{obs}$
- Assimilate simulated obs

By definition:

Error(t) = Forecast(t) –truth(t)

To estimate a stationary part of error covariances take samples from a monthly cycle with assimilation every 6 hours (~120 error samples):

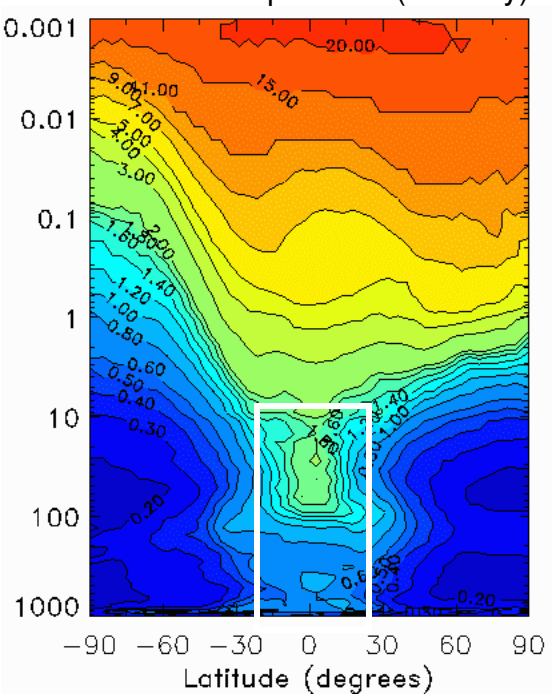
$$VAR = < (Forecast(t_i) - truth(t_i))(Forecast(t_i) - truth(t_i))^T >$$

A study case:

Assimilation of **rounded** 'perfect' Obs:

After a month of assimilation
STD (forecast –truth):

STD for Temperature (January)

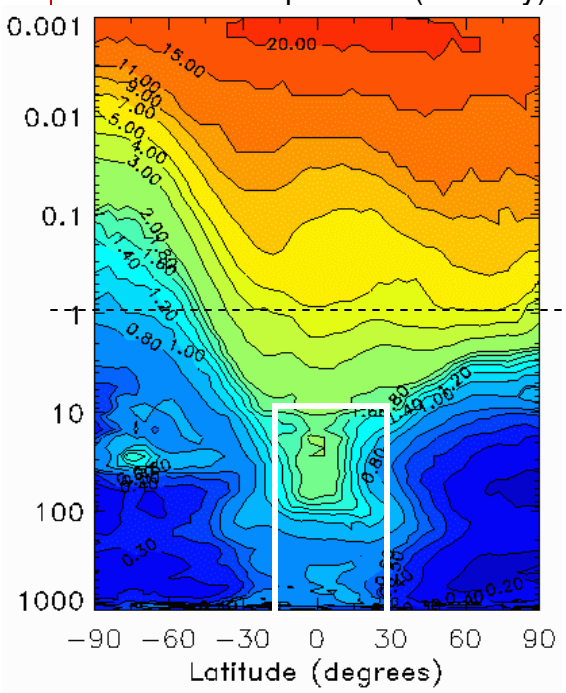


a perfect model and perfect obs → The errors of the method of assimilation

It includes the impact of all the components of the 3dVAR (the minimization, error covariances modeling, balance control,…) and also, the observational network

Assimilation of 'perfect' Obs with perturbed initial state:

STD for Temperature (January)



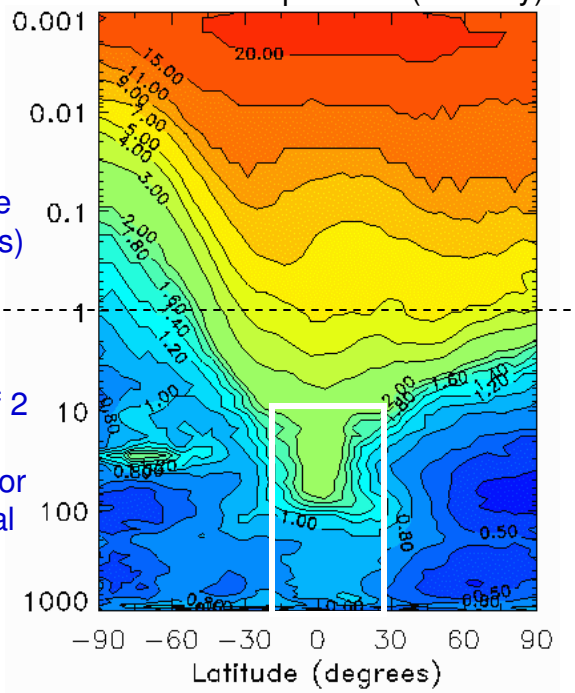
$$J_{obs} = \sum_{i=1}^{N} \frac{(o_i - p_i)^2}{\sigma_{obs}^2} \neq 0$$

$$o_i = round(p_i)$$

$$\Delta J = \sum_{i=1}^{N} \frac{(round(p_i) - p_i)^2}{\sigma_{obs}^2}$$

Assimilation of perturbed 'perfect' Obs, perturbed initial state:

STD for Temperature (January)



Small change (no obs)

Factor of 2 change (except for equatorial regions)

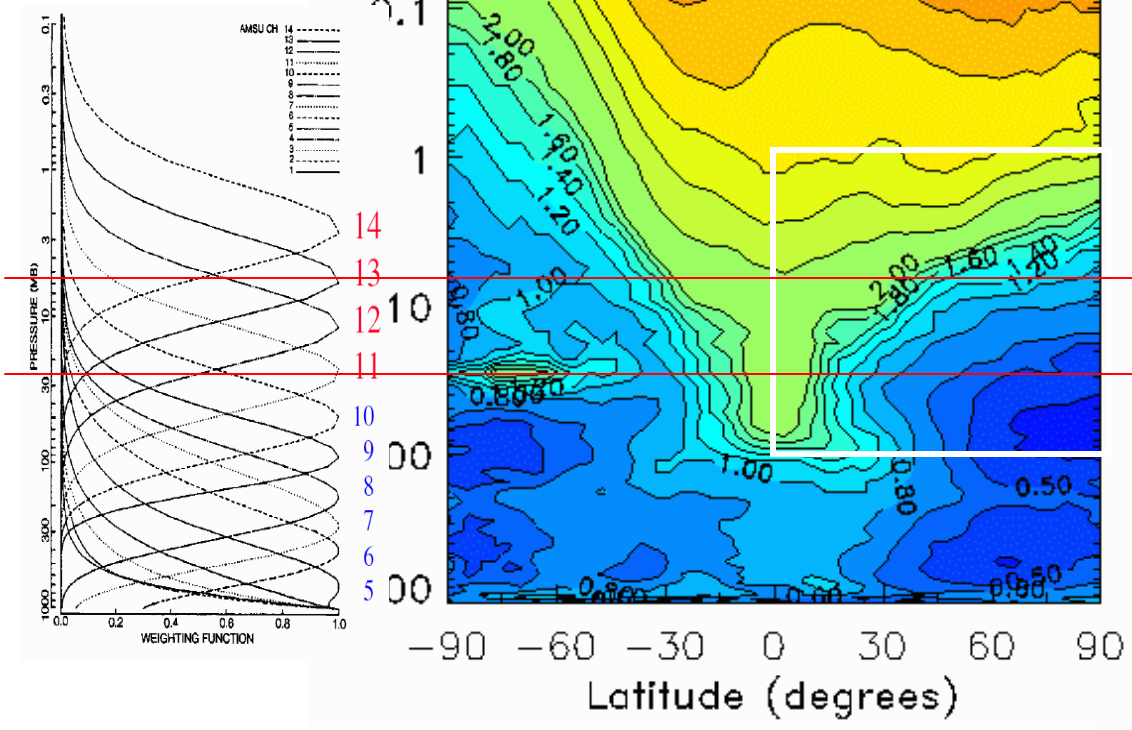
An efficiency of equatorial observations ?

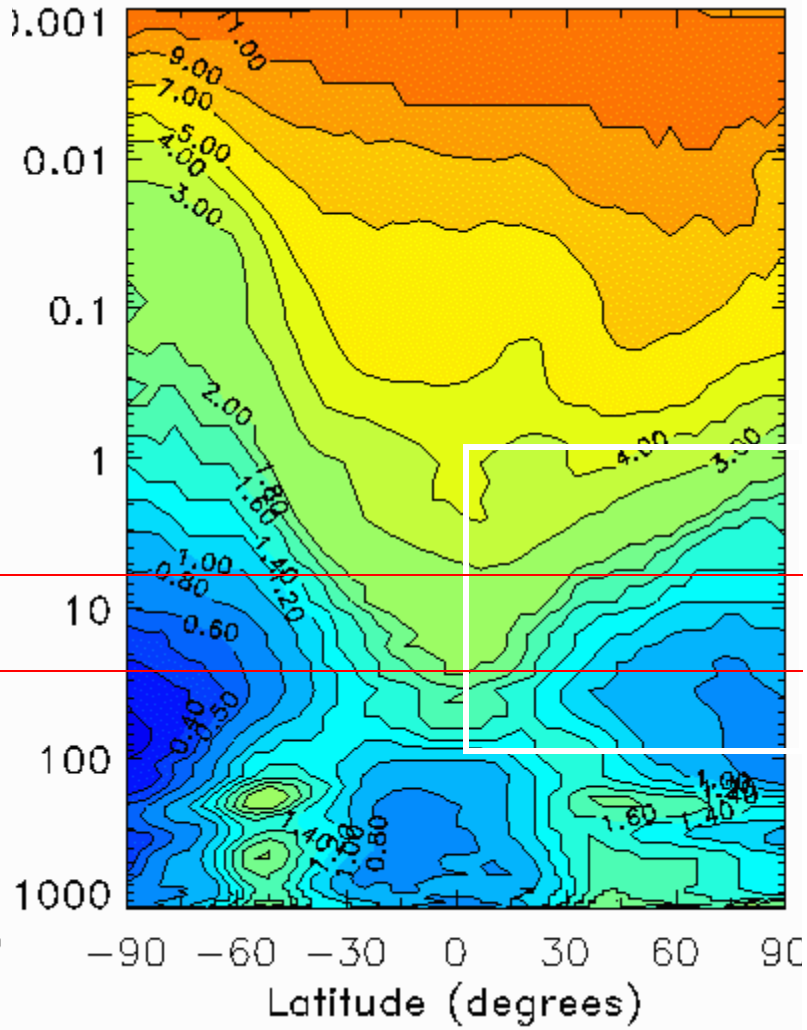
Do new Bg. error variances improve the forecast?

Background error STD for Temperatures (January)

From simulations:

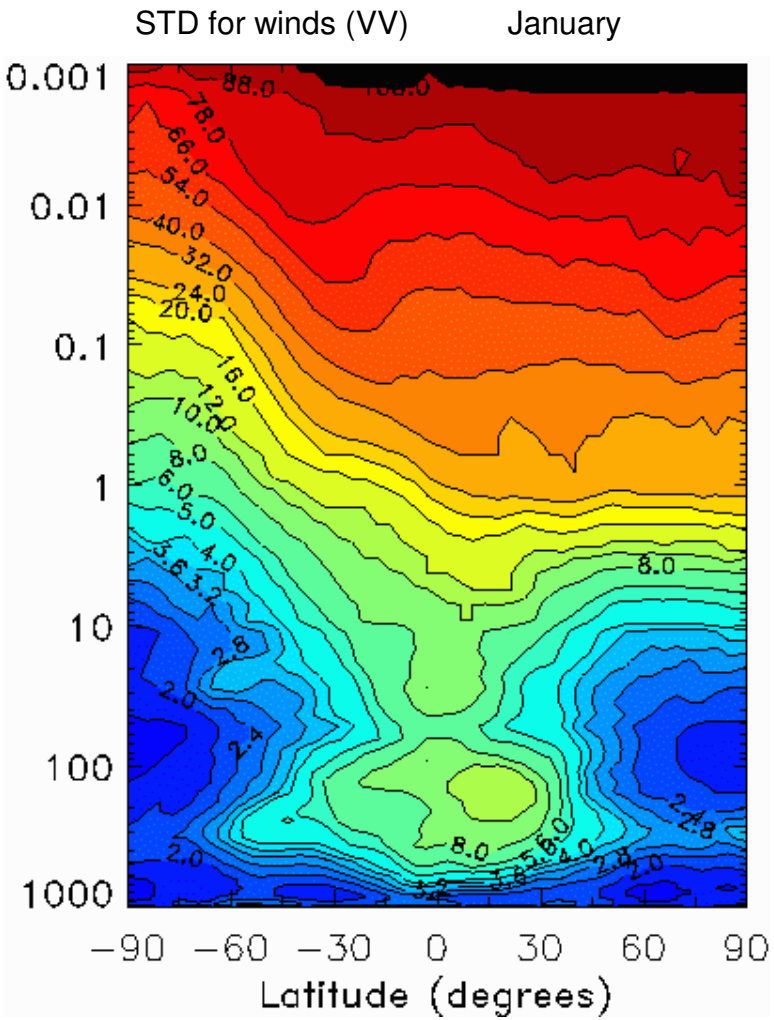
Specified in the CMAM-DAS:



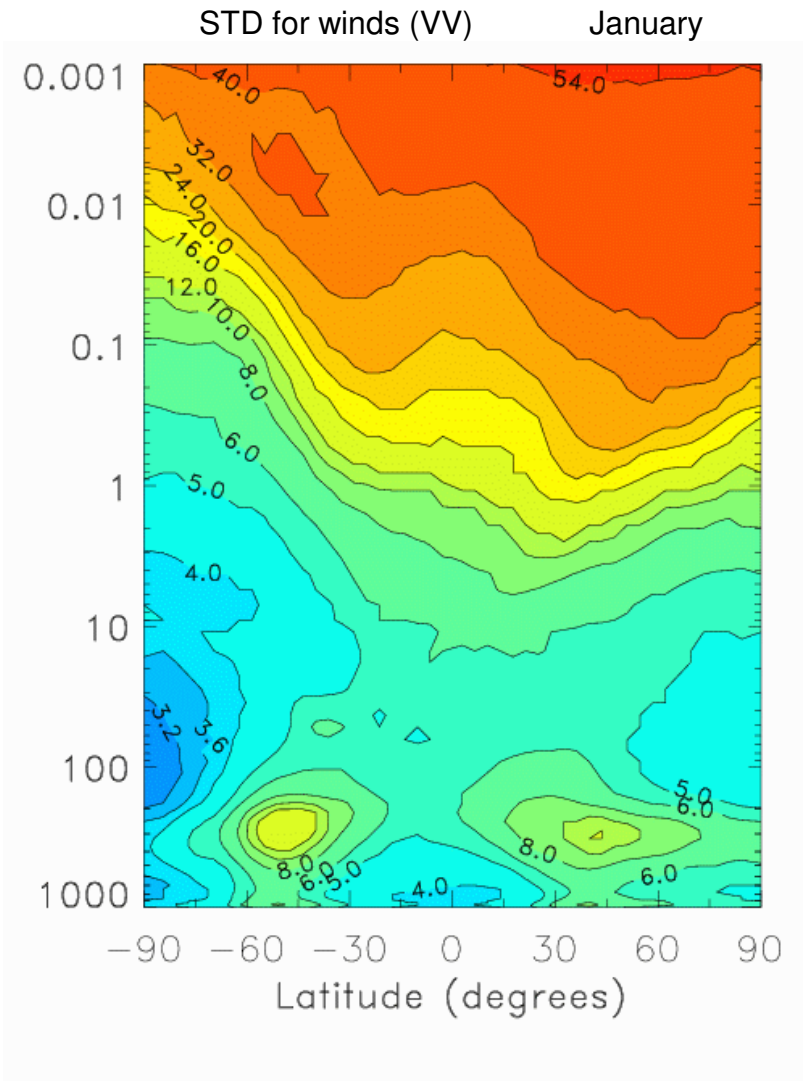


Background error STD for winds (January)

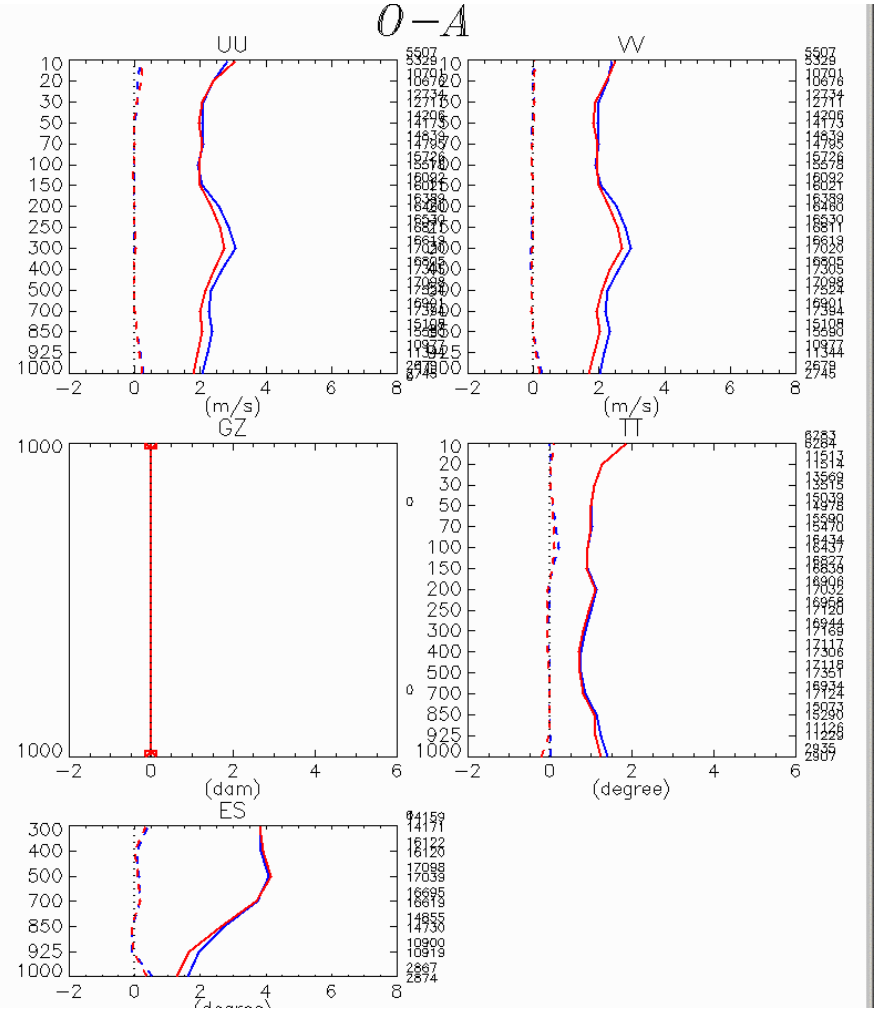
From simulations:

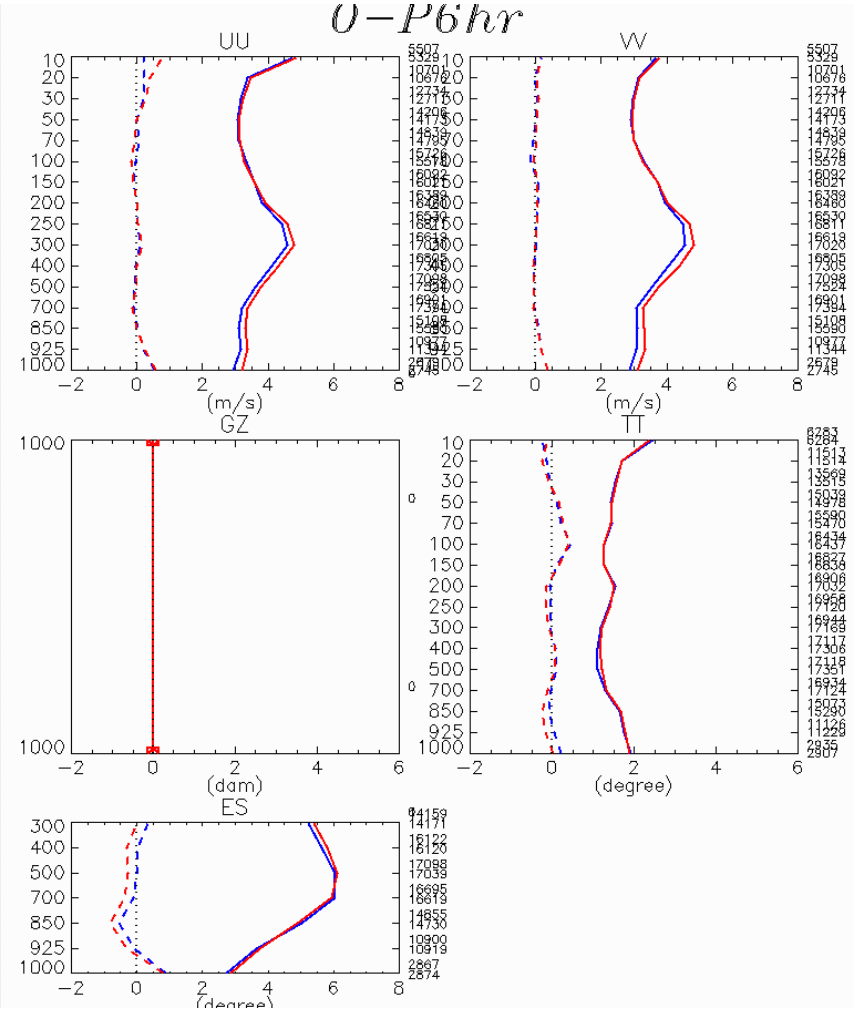


Specified in the CMAM-DAS:



Global Scores (vertical profiles) against radiosondes





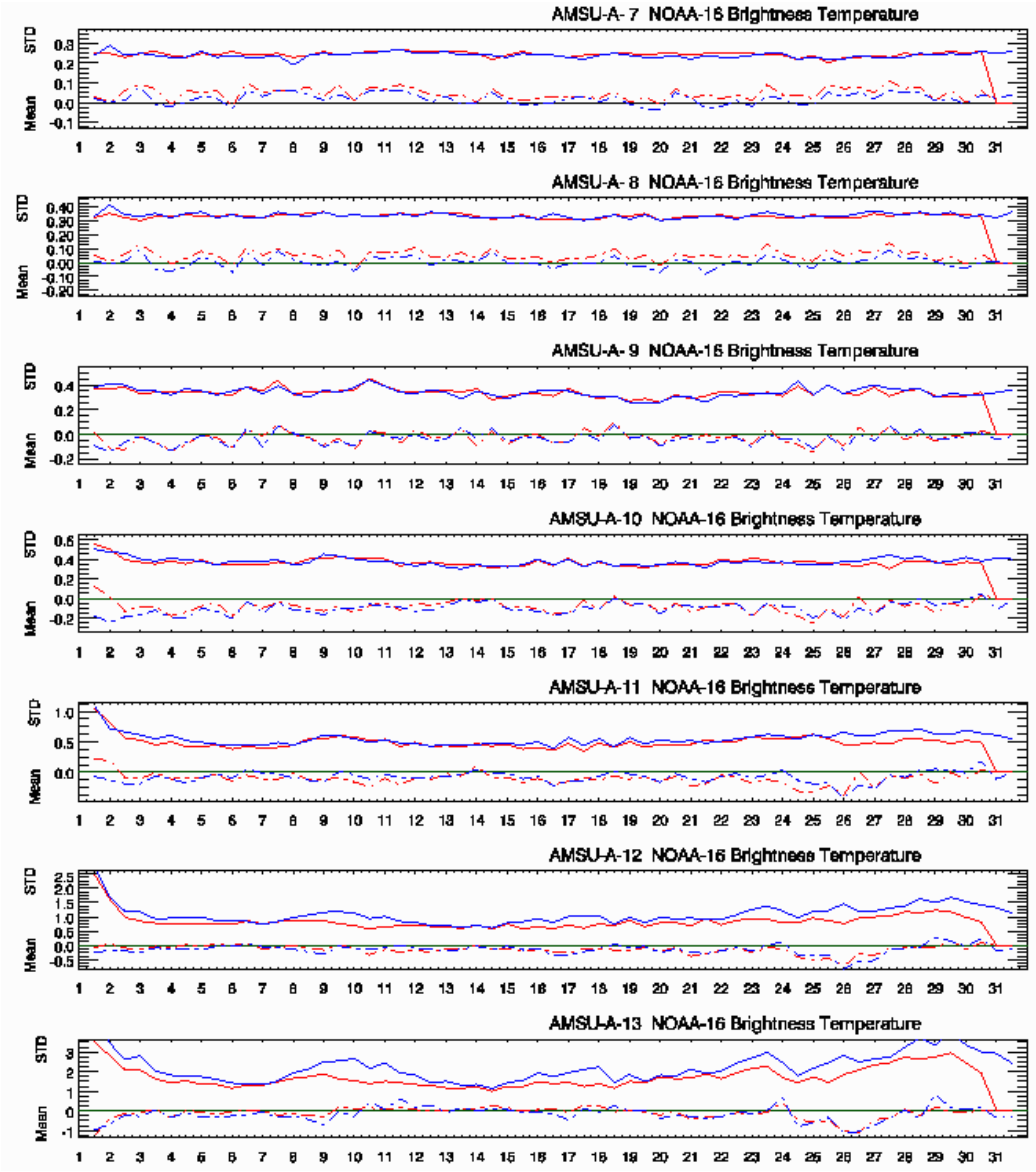
Bg. variances from simulations

Bg. variances Specified in the CMAM_DAS

O-P scores are improved with the new statistics!

O-P Scores (time series) against AMSU

(January 2002, North hemisphere)



Bg. variances from simulations

Specified in the CMAM_DAS

Improvement for upper channels (11-13)

The new error statistics improved the assimilation

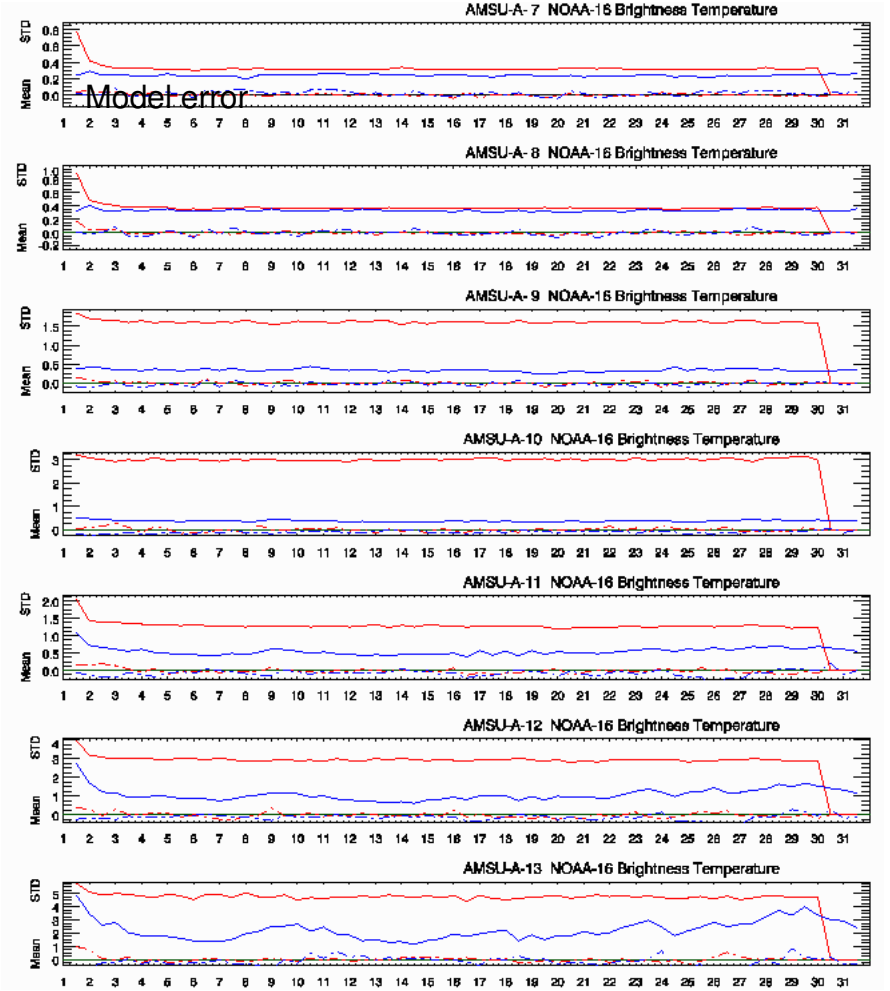
- O-P scores against radiosondes are improved
- O-P scores against AMSU-A are improved for upper channels
- A minimization procedure is now optimized (65 iterations against 130)

A nice property of the derived error variances: a fast convergence

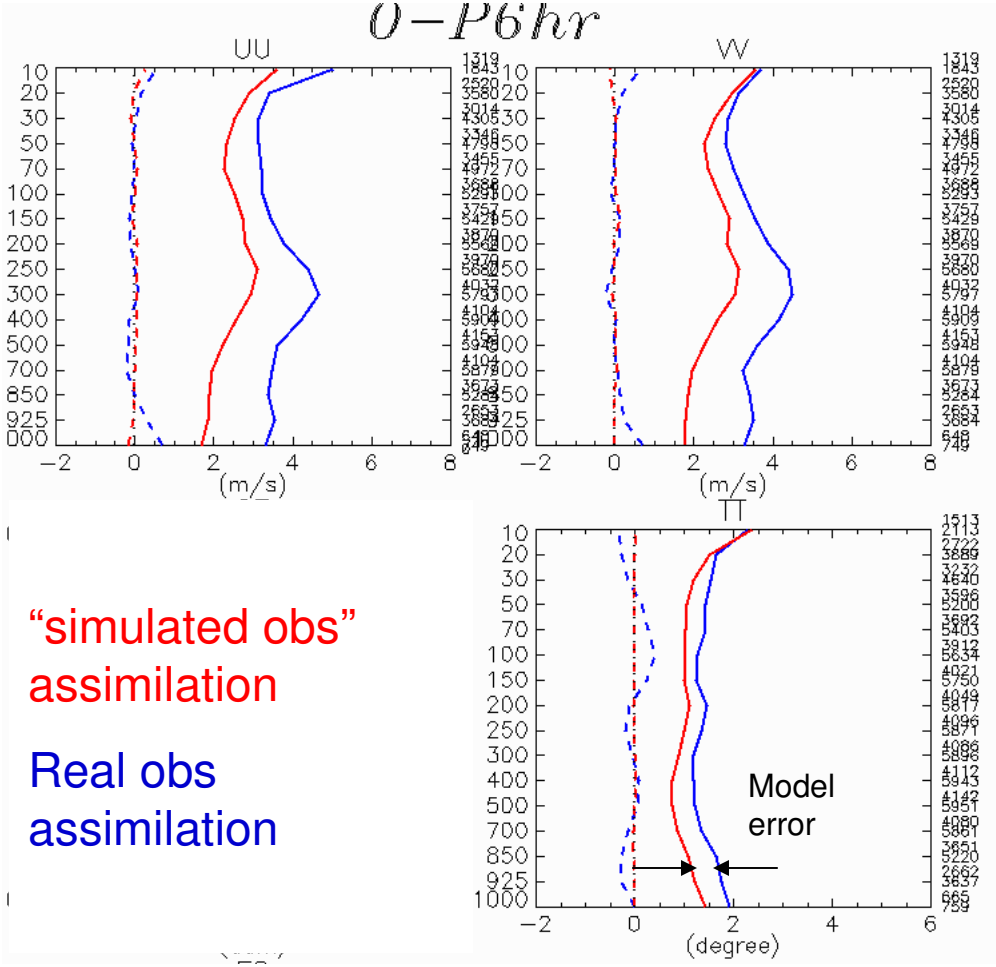
How to verify the variances of Observational errors?

the scores with Simulated/real obs (January)

AMSU-A



radiosondes



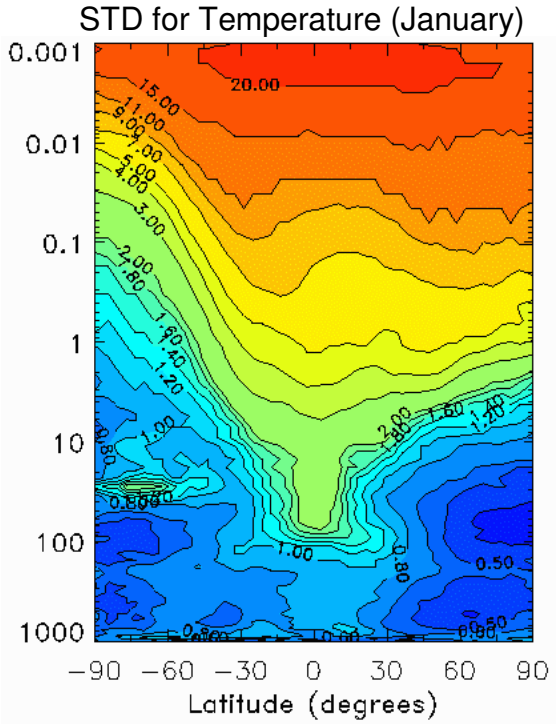
"simulated obs" assimilation

Real obs assimilation

Are the AMSU errors overestimated?

Forecast errors
(from simulations)

After a month of assimilation
STD (forecast –truth):



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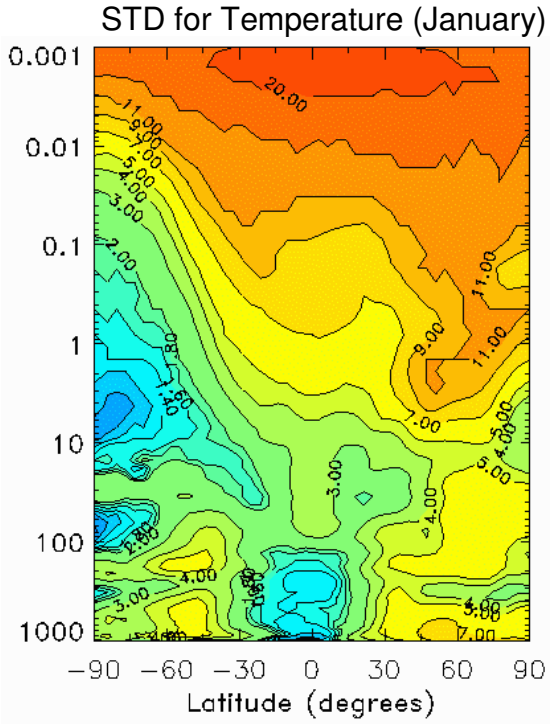
Predictability of the mesosphere ???

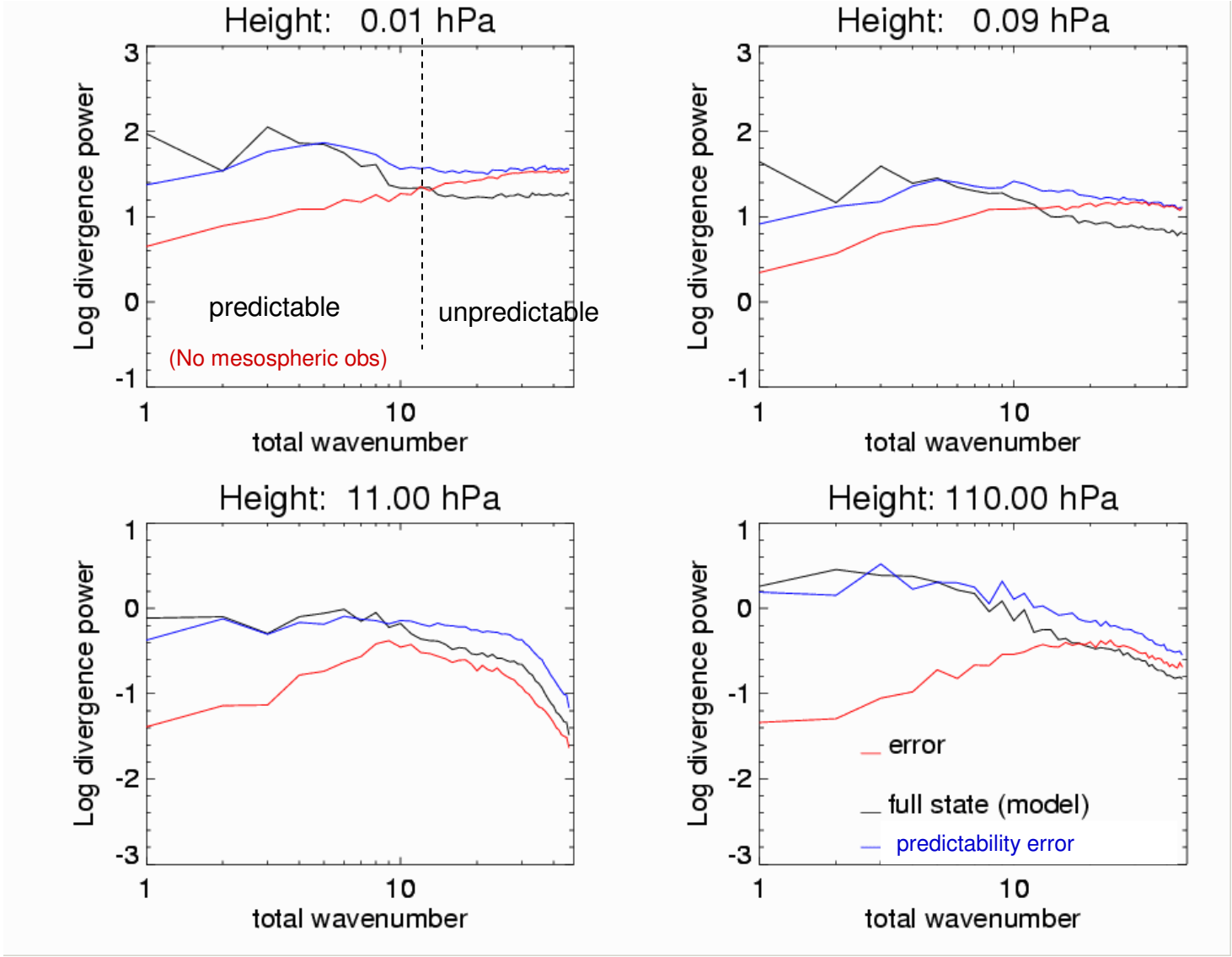
Predictability errors

After a month of a model run

STD (truth2 –truth):



Error's spectra

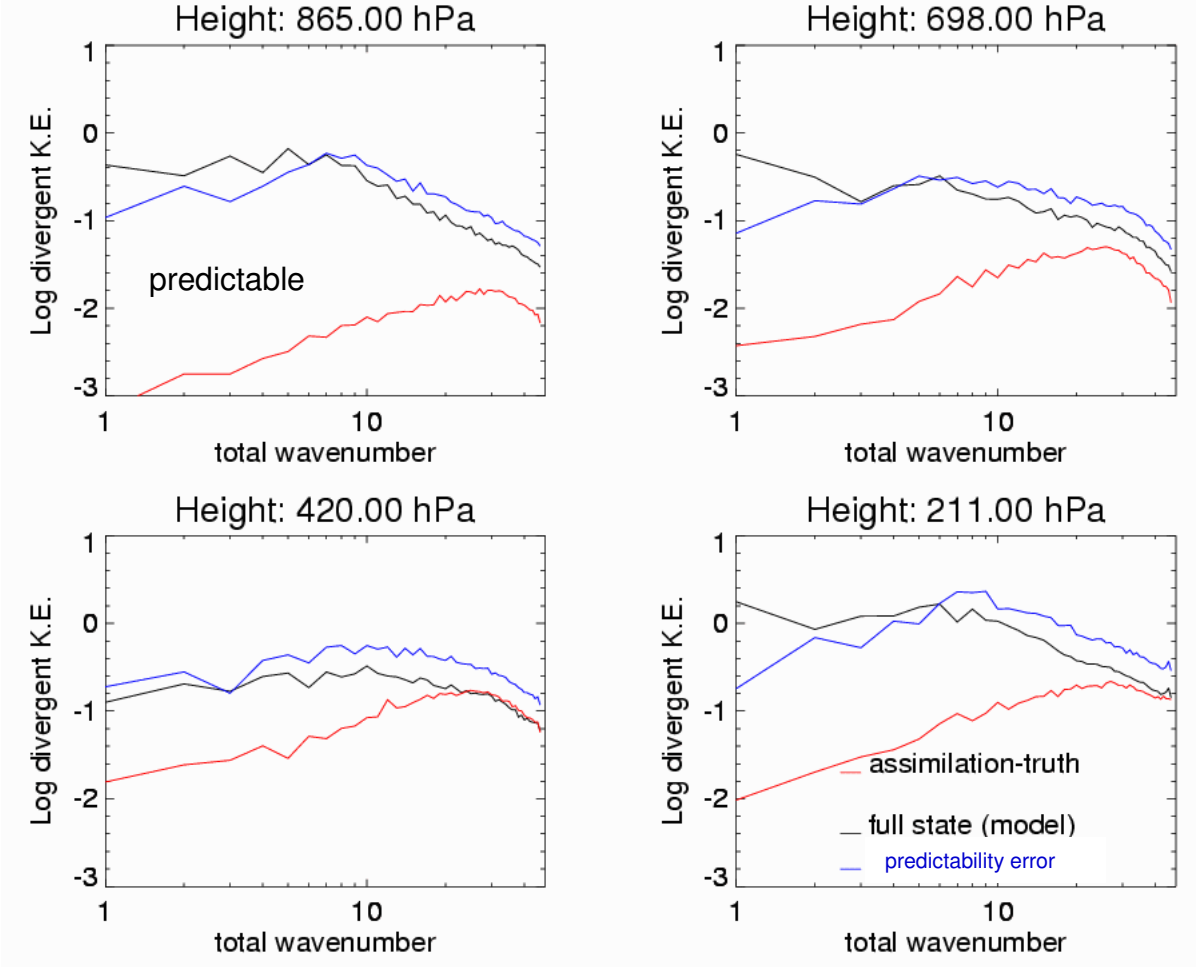


6-h forecast errors

Full state (model)

Predictability errors

In the troposphere



6-h forecast errors

Full state (model)

Predictability errors

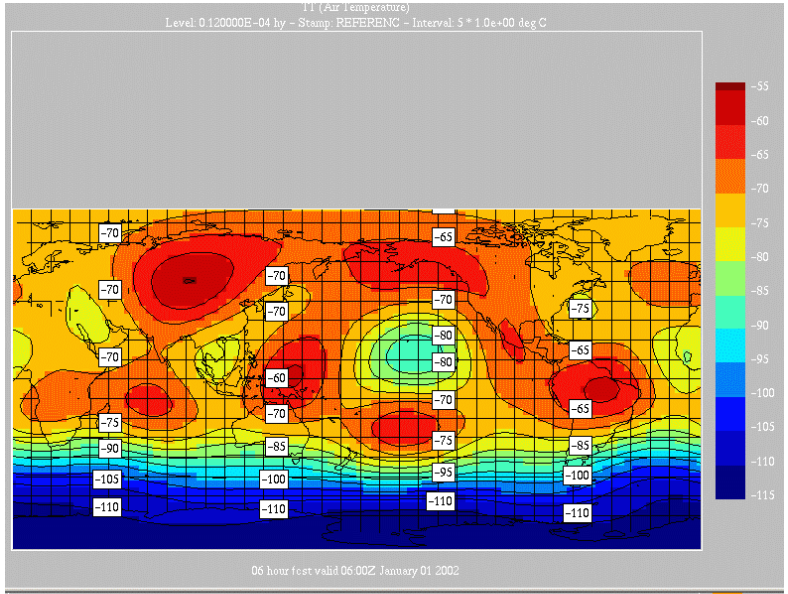
temperatures (T6 truncated) at 0.012mb

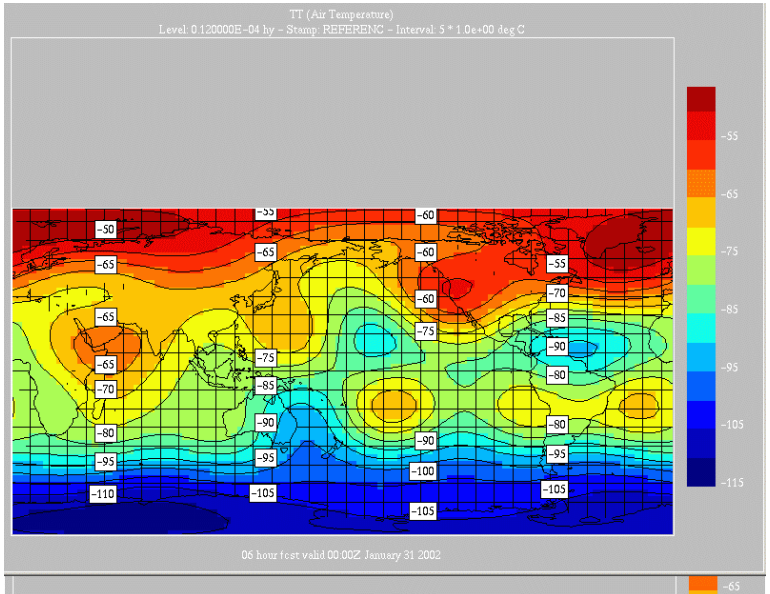
Initial states

After 30 days

truth

assimilation





lat

lon

conclusion

•We have found that the method of simulations may be very useful in controlling a DAS

•applied to the CMAM-DAS it brought quite a few interesting results:

- We learned about forecast errors in the system,
- The impact of observational errors is relatively small in the current system, and the dominating error component arises from the assimilation method itself
- we also respecified the background error covariances in the system
- We saw the way to verify the observational errors and will, probably use it to tune the AMSU variances
- we assessed the predictability of the mesosphere and found the scale dependent limits of the current system to predict the mesosphere
- And we are going to use this method to simulate mesospheric observations in order to see a possible impact.