Impact of SABER Temperature Observations on Mesospheric Prediction

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- Recently, it was shown ([Nezlin, Rochon, Polavarapu , Tellus,2009]) that :
  - assimilation of only tropospheric and stratospheric observations can improve the mesosphere in large scales (with horizontal wave numbers less than 10).
  - Prediction of mesospheric small scales with n>10 with no mesospheric observations is principally impossible.

- Goal: to identify the impact of mesospheric measurements (SABER) on mesospheric analyses over different spatial and time scales using a perfect model scenario.

- This is done using Observing System Simulation Experiments with CMAM-DAS (Canadian Middle Atmosphere Model – Data Assimilation System)
  - Nature run: CMAM free model run.
  - addresses only objective impact of the change of observational network
    - Possible underestimating of the impact

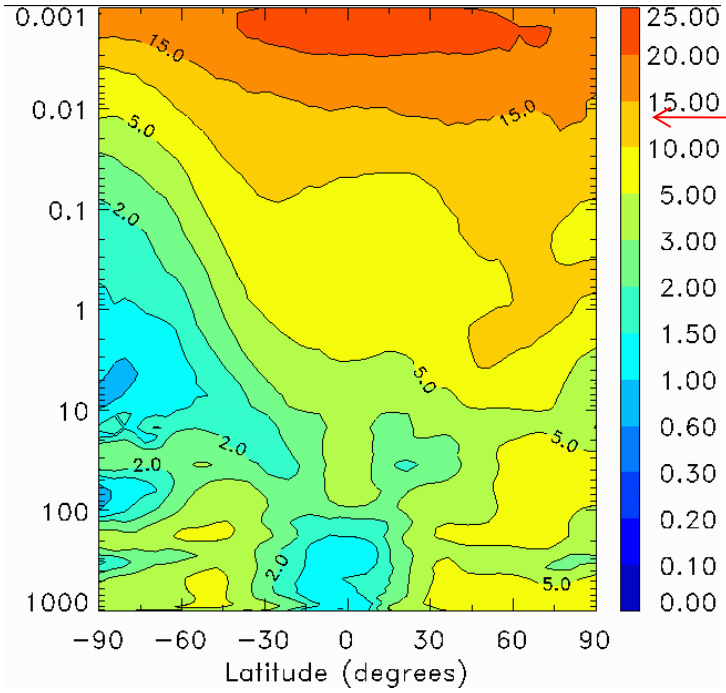
Perfect model assumption

CMAM model
- 71 vertical levels
- lid at 95km.
- T47 spectral resolution

Observations
- surface observations.
- 1000-10 hPa: radiosondes, aircrafts,
- 1000- 1 hPa : AMSU, satellite winds
- No observations higher 1 hPa or SABER temperature observations

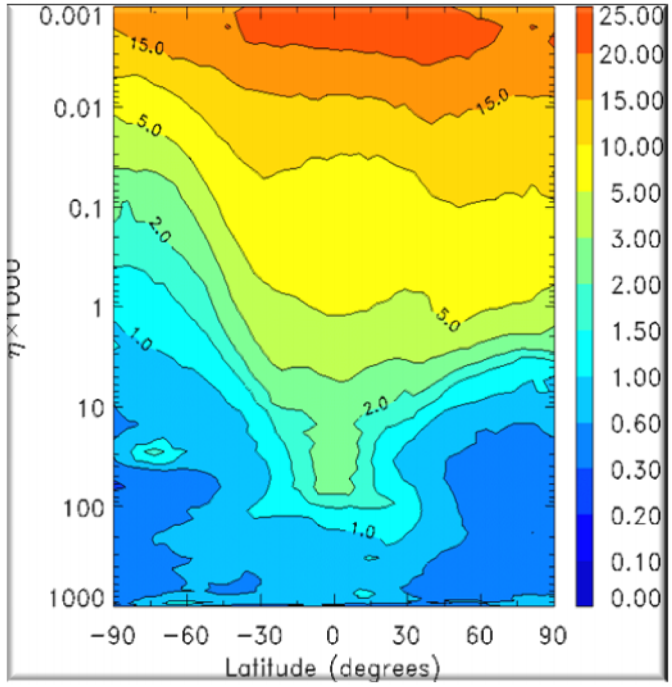
Assimilation
- 3D-VAR with
- 6 hours time step

Predictability error std. dev.
CMAM January



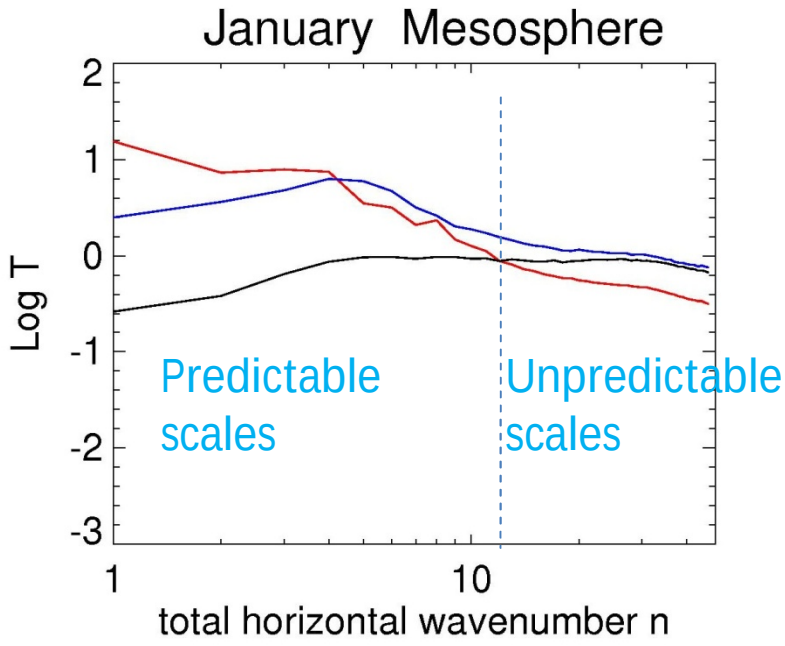
Can assimilation decrease these errors?

Analysis error std. dev.
CMAM-DAS January



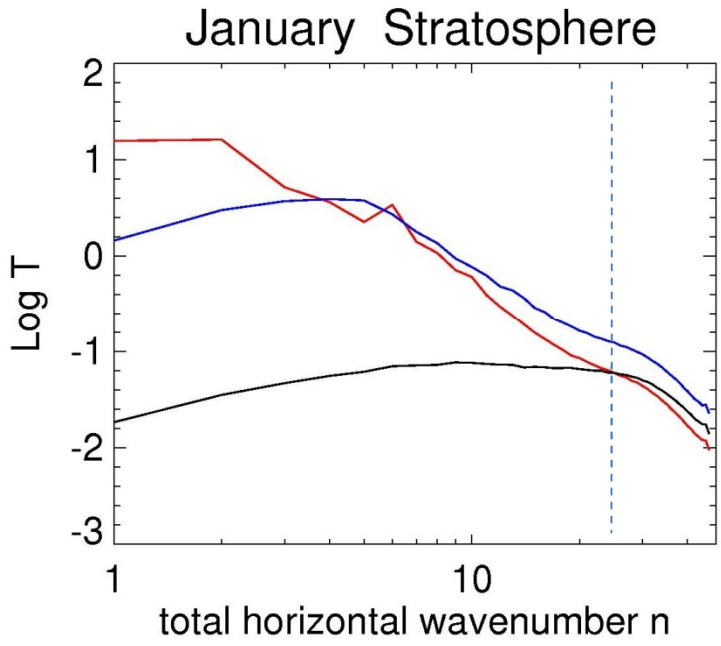
Analysis error spectra

Analysis error Predictability error Model state



Averaged over the levels 1-0.01 mb

Largest scales in the mesosphere are potentially predictable even without mesospheric observations

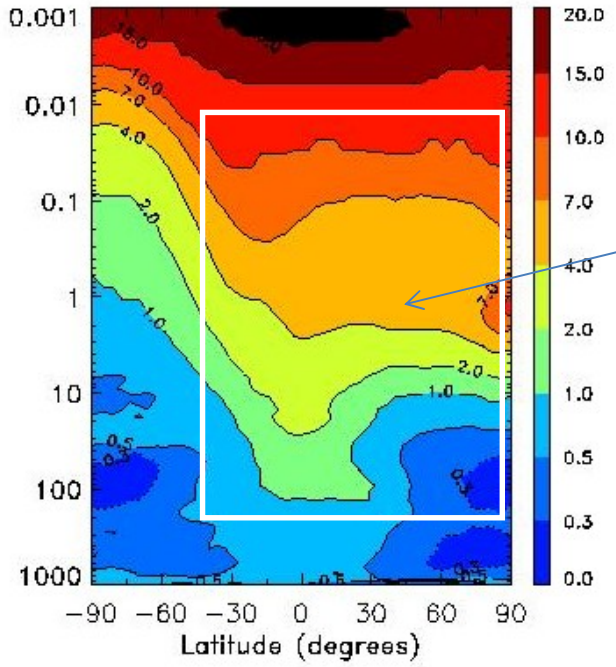


Averaged over the levels 100-1 mb

Smallest scales are not predictable without mesospheric observations even with perfect model and unbiased observations

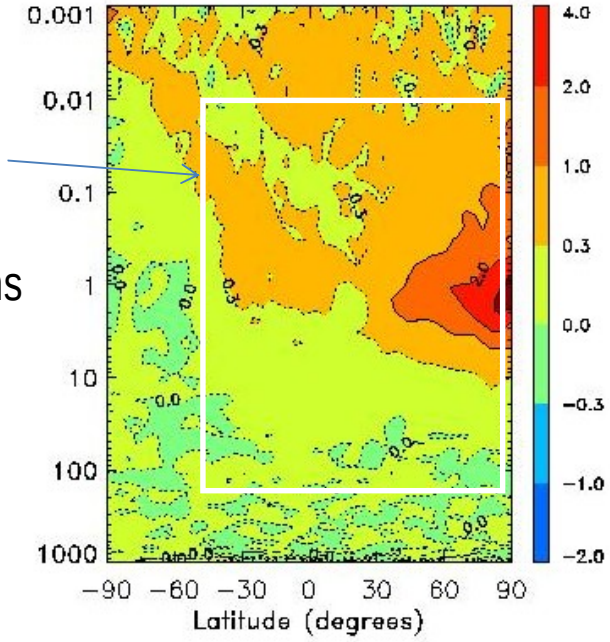
Effect of SABER measurements on temperature errors

Analysis error std. dev. - no SABER
CMAM-DAS January



simulated SABER observations

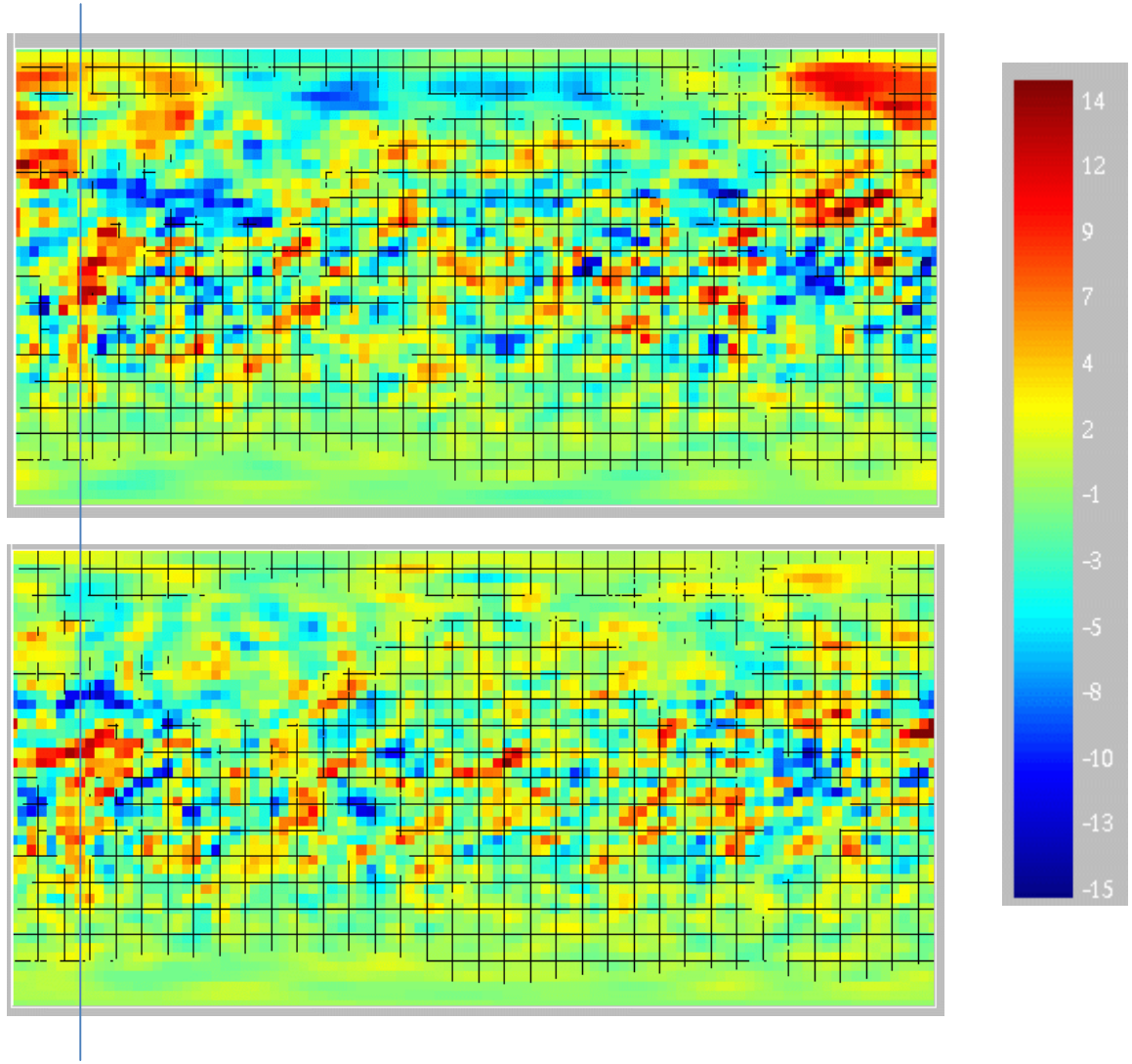
Difference in analysis error std. dev.
(without SABER vs with SABER)



Temperature errors at 1 hPa 2006013100

No SABER:

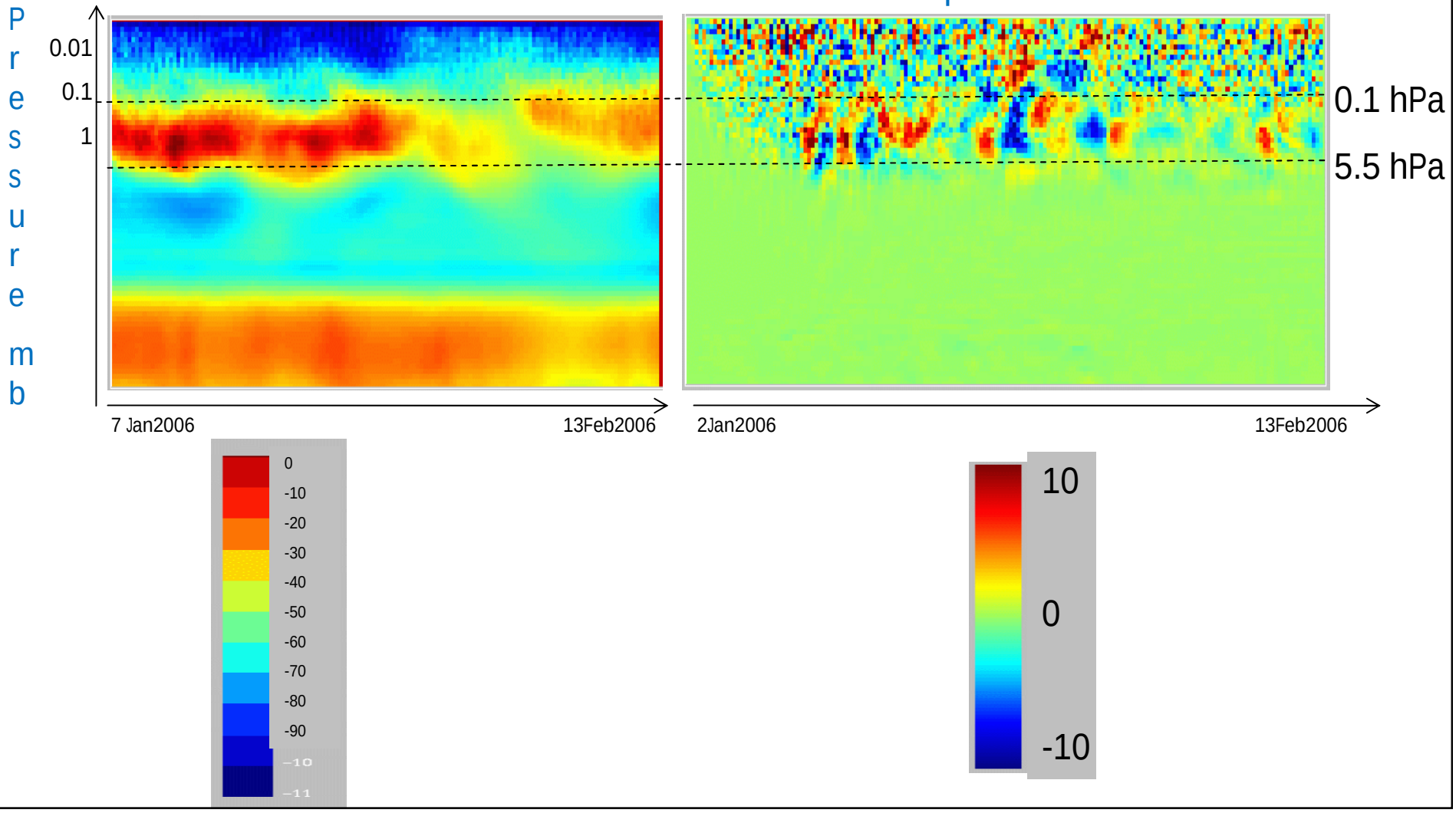
Polar large scaled errors disappear with SABER:



Time series of zonal mean temperature at 80N

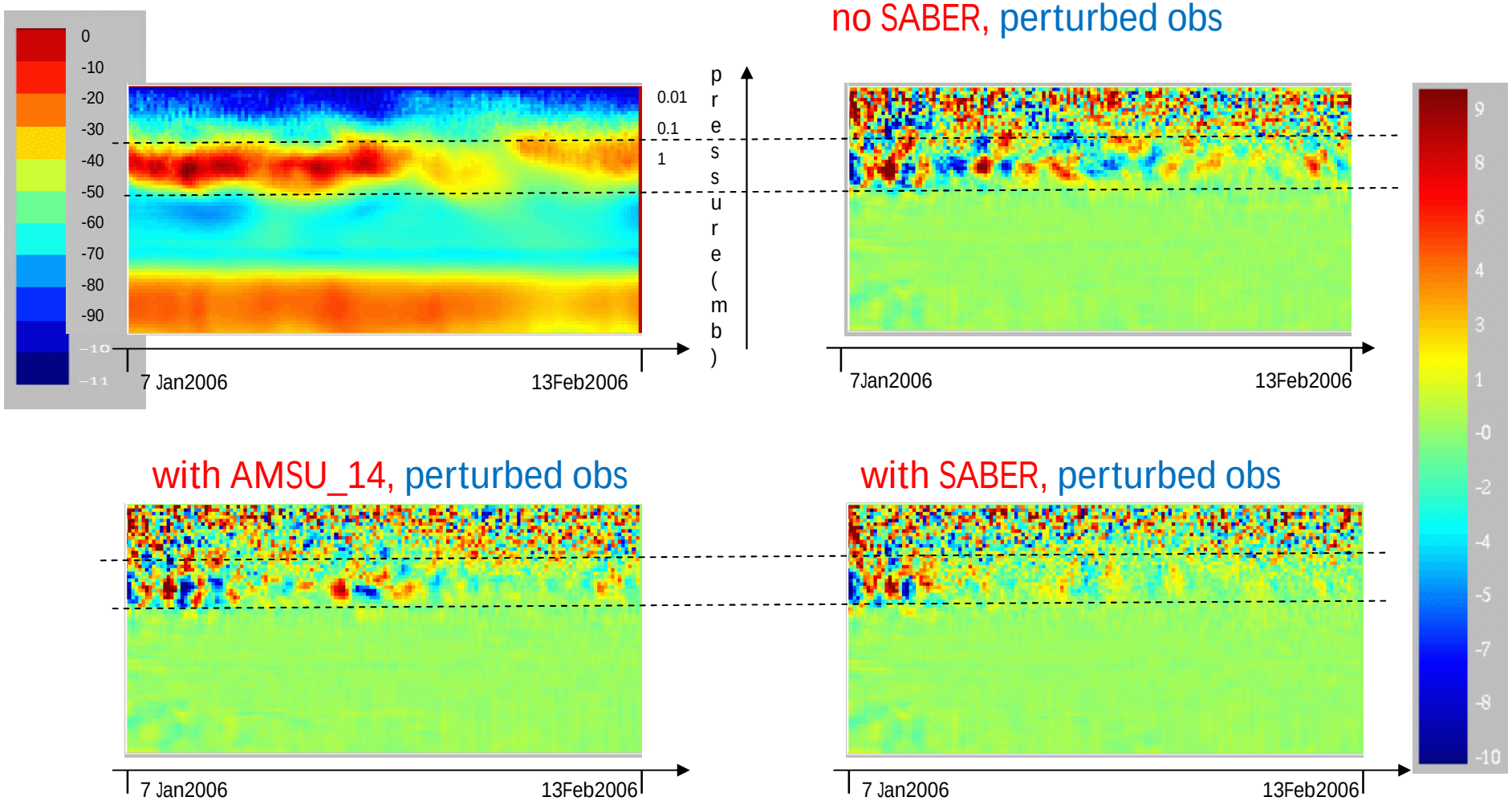
Time series of zonal mean errors temperature at 80N

no SABER, nearly perfect obs
perfect initial condition



Time series of zonal mean temperature at 80N

Time series of errors in zonal mean temperature at 80N

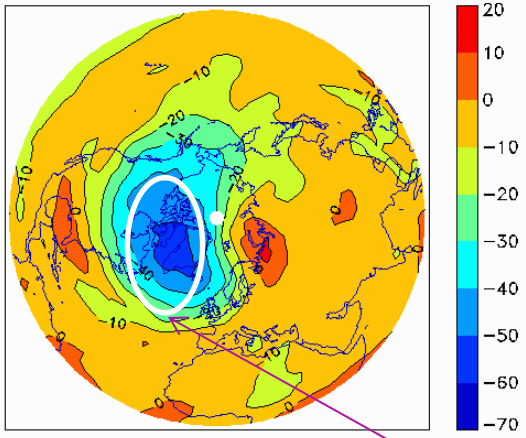


SABER improves zonal mean temperatures at the stratopause

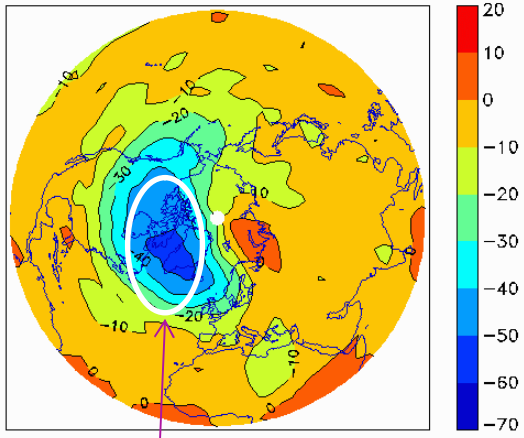
Polar temperature at 1 mb after a month of assimilation

2006020918

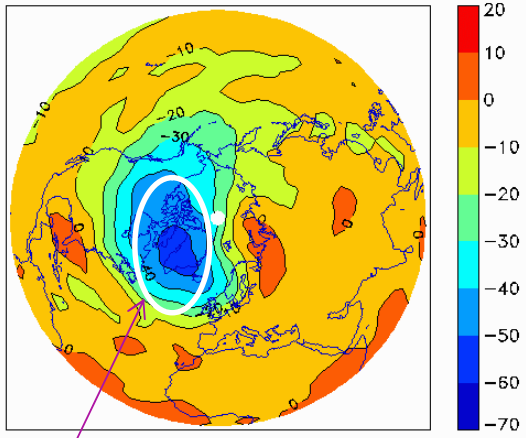
truth



no SABER

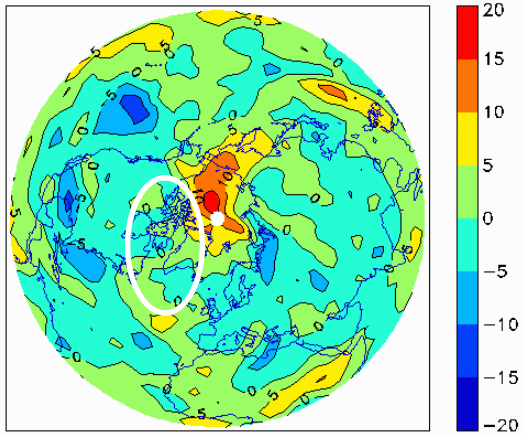


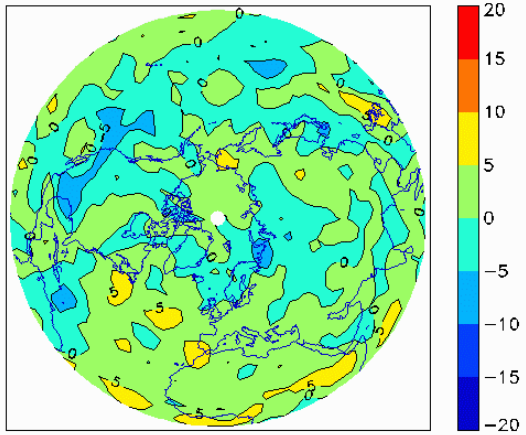
SABER



The center of the vortex is captured

Analysis errors:

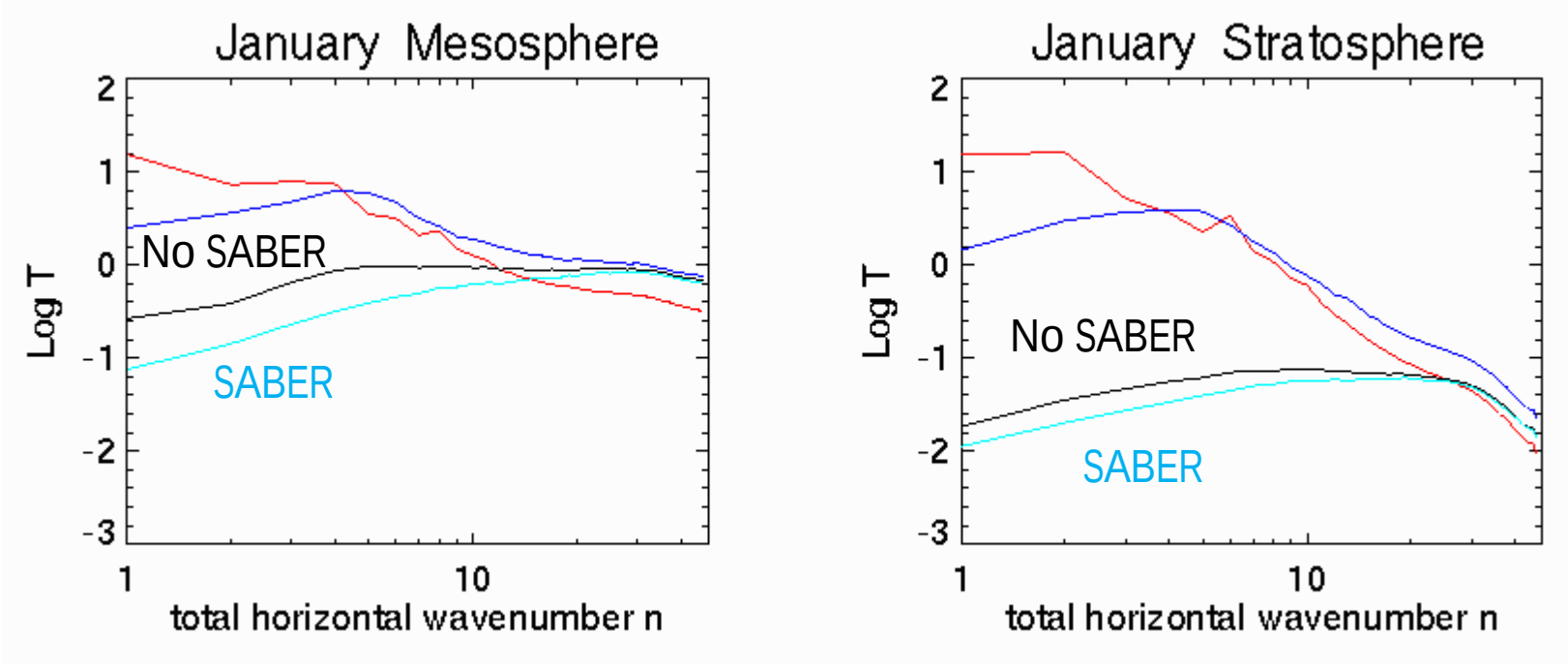




the border of the vortex is not as well captured without SABER

Analysis error spectra

Analysis error with SABER — Analysis error — Predictability error — Model state



SABER improves large scales

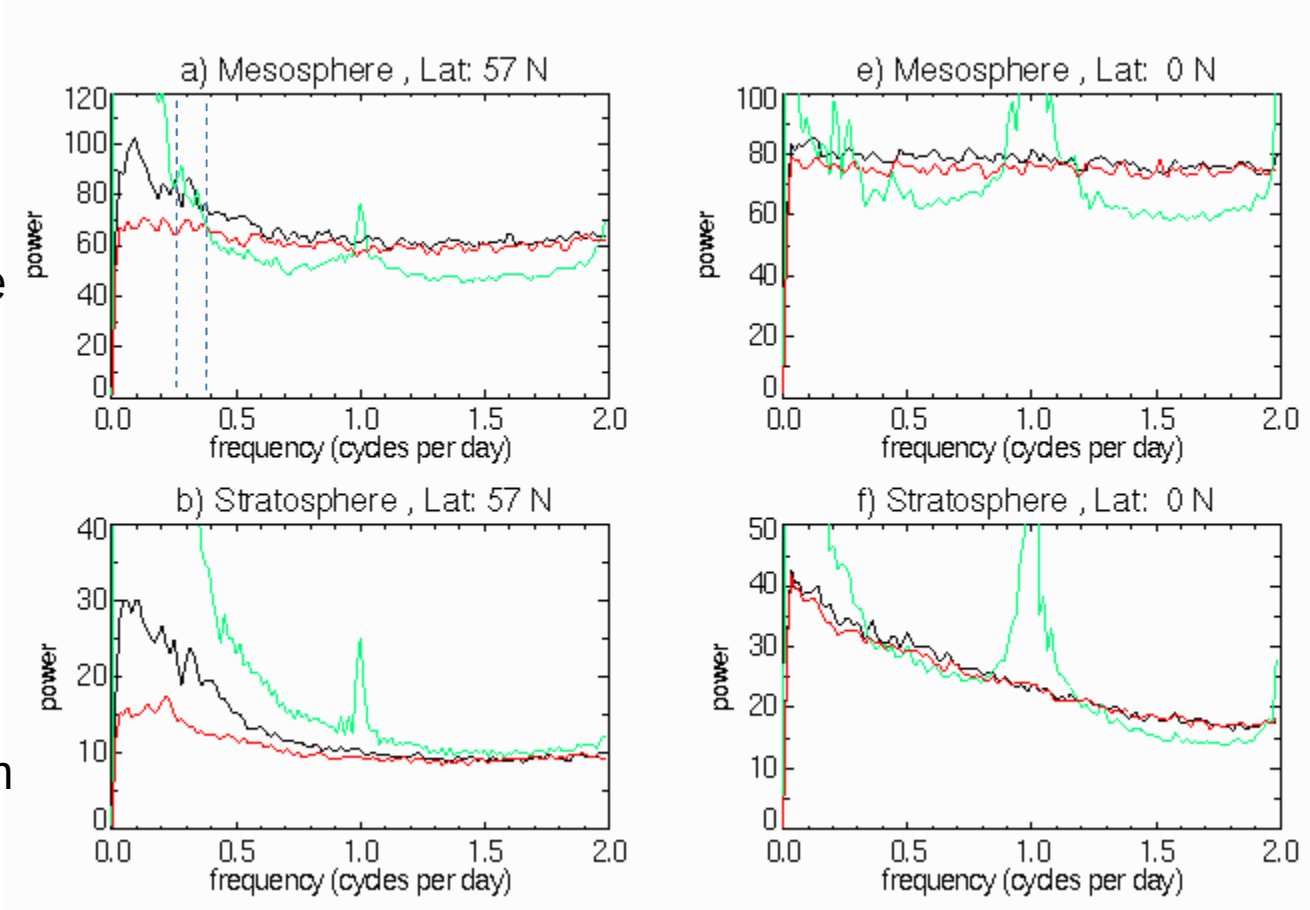
Time frequency spectra of the temperature errors

Analysis error with Saber — Error without Saber — Full state

At high latitudes the effect of SABER is strong:

a. Extension of predictable mesospheric periods from 5 days (without Saber) to 3 days (with Saber)

b. factor of 1.5 in error reduction of the stratospheric low frequencies (longer than 4 days)



In the tropics the effect of SABER is minor:

a. Medium range periods (~2 days) are not predictable even with SABER

conclusions

- SABER allows to capture more stratopause details.
  - The strongest effect of SABER observations is in winter stratopause where the largest time and spatial scales of analysis errors are decreased
  - In reality (assuming biases in observations and in the model) the impact can be bigger
- Since the effect of SABER on small scales is minor, its assimilation does not extend predictability limits (n<10 in the mesosphere)