The impact of nonorographic gravity wave drag on mesospheric analyses from the CMAM-DAS

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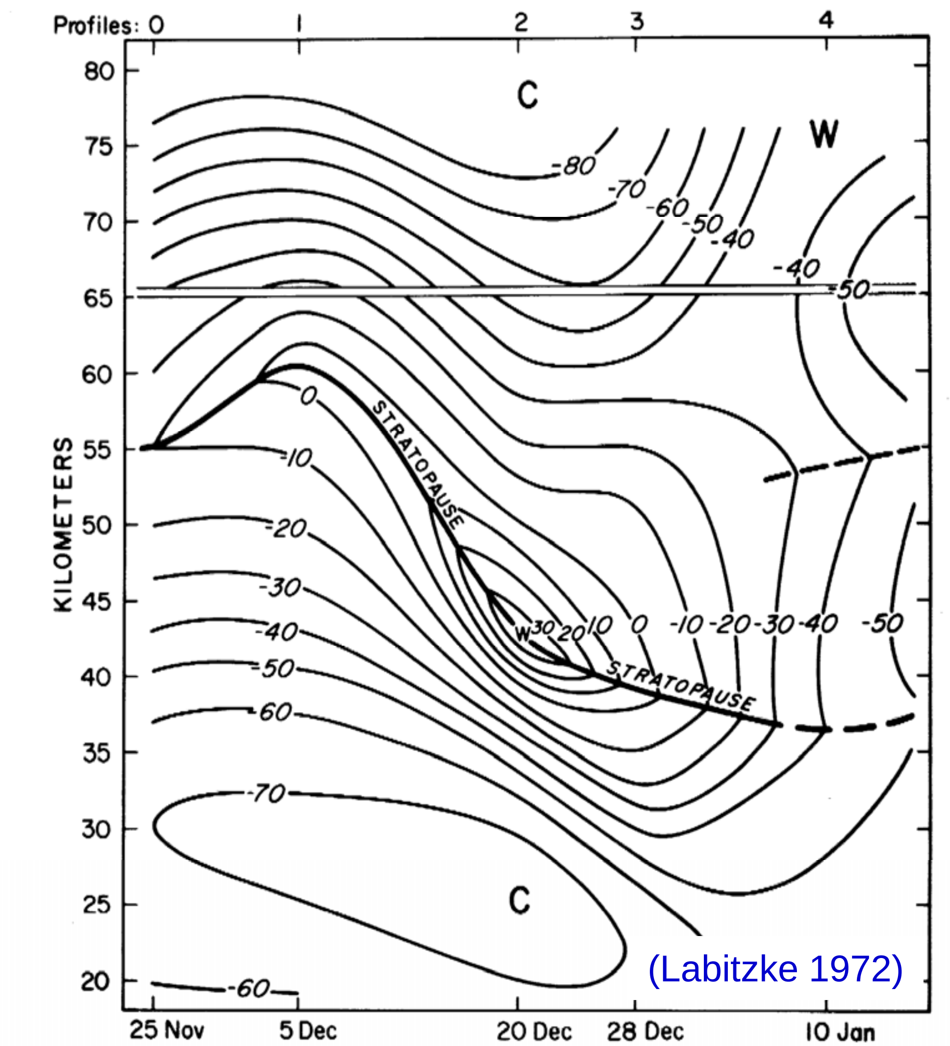
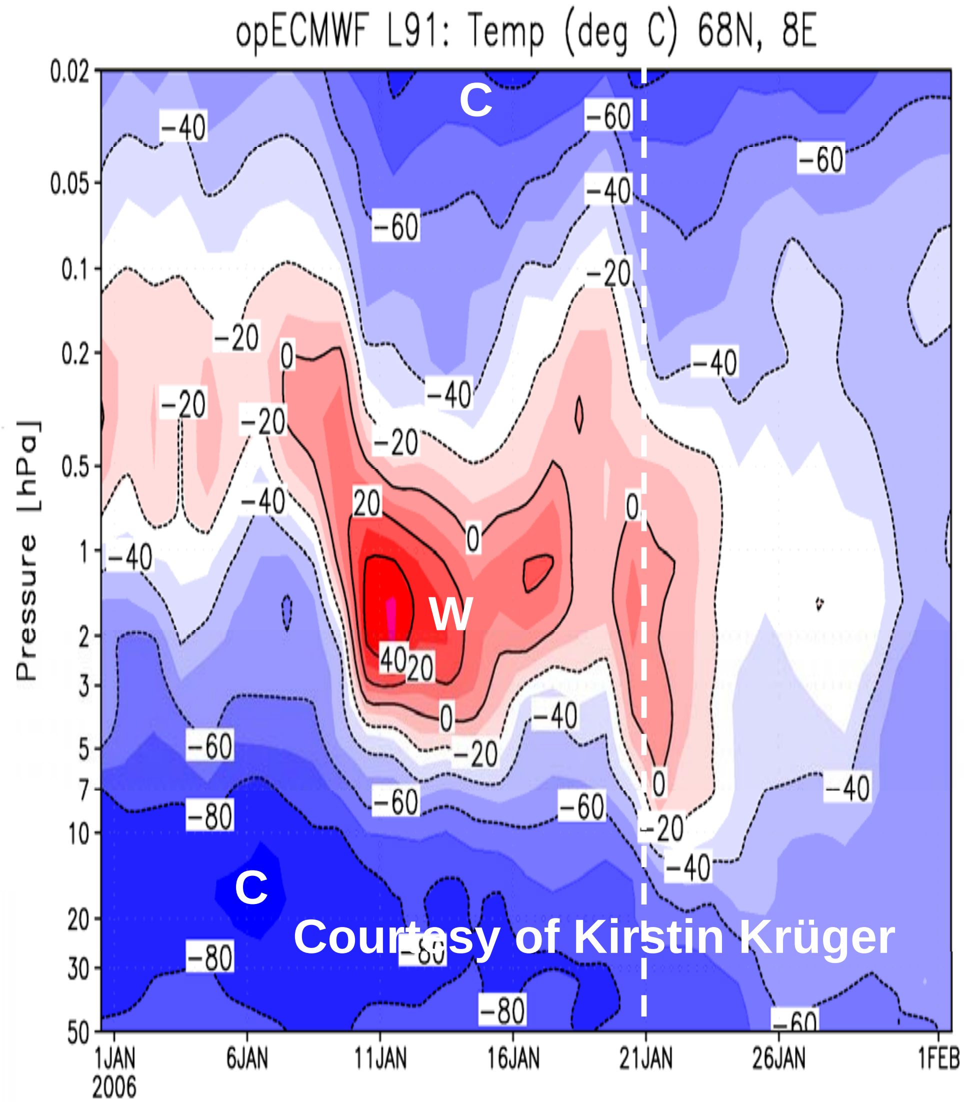
Stratopause evolution during a sudden warming

schematic diagram



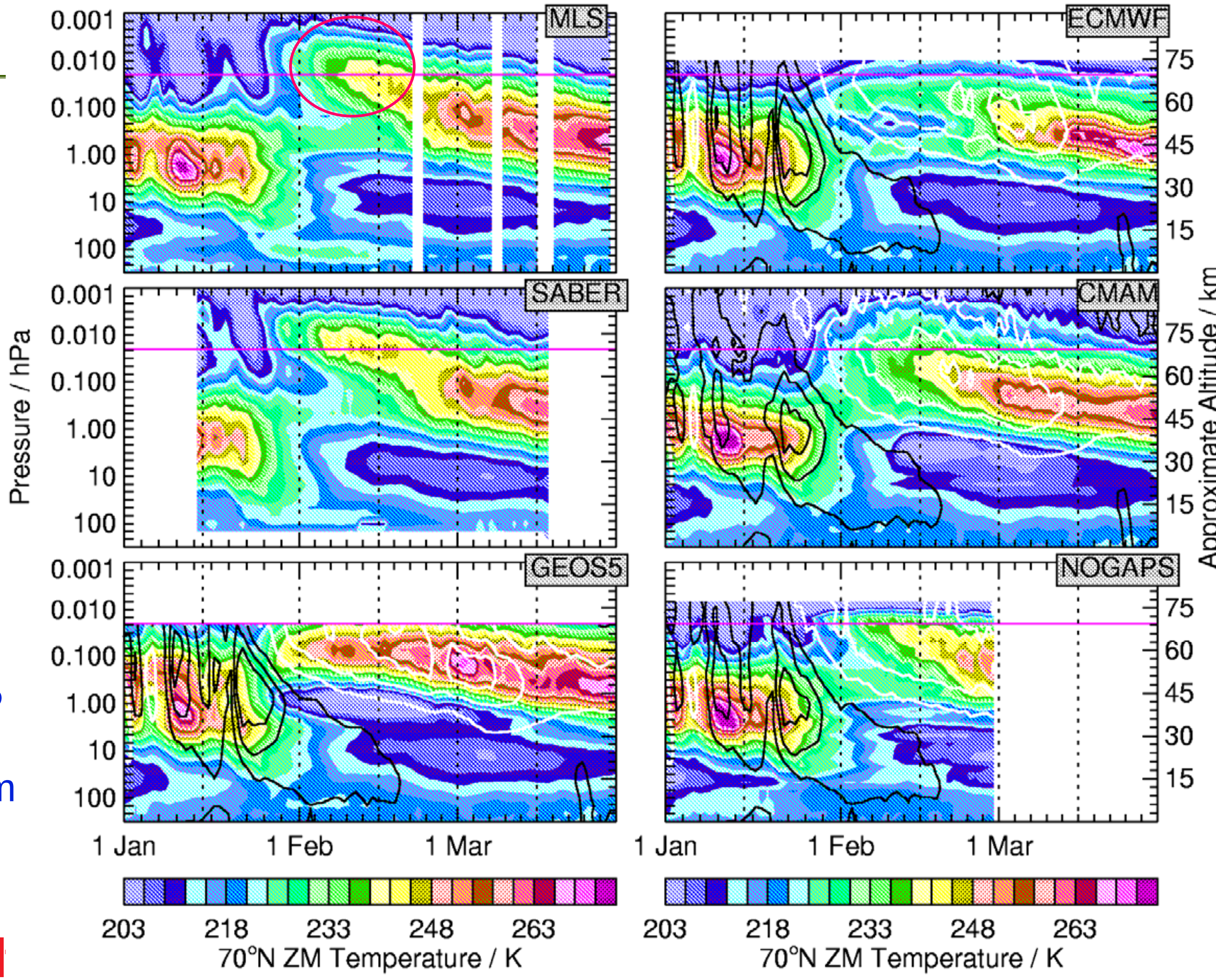
NH winter 2005/06



70ºN zonal mean temperatures during 2006 SSW

Gloria Manney

Stratopause is above 0.01 hPa!



ECMWF
too low
too cold

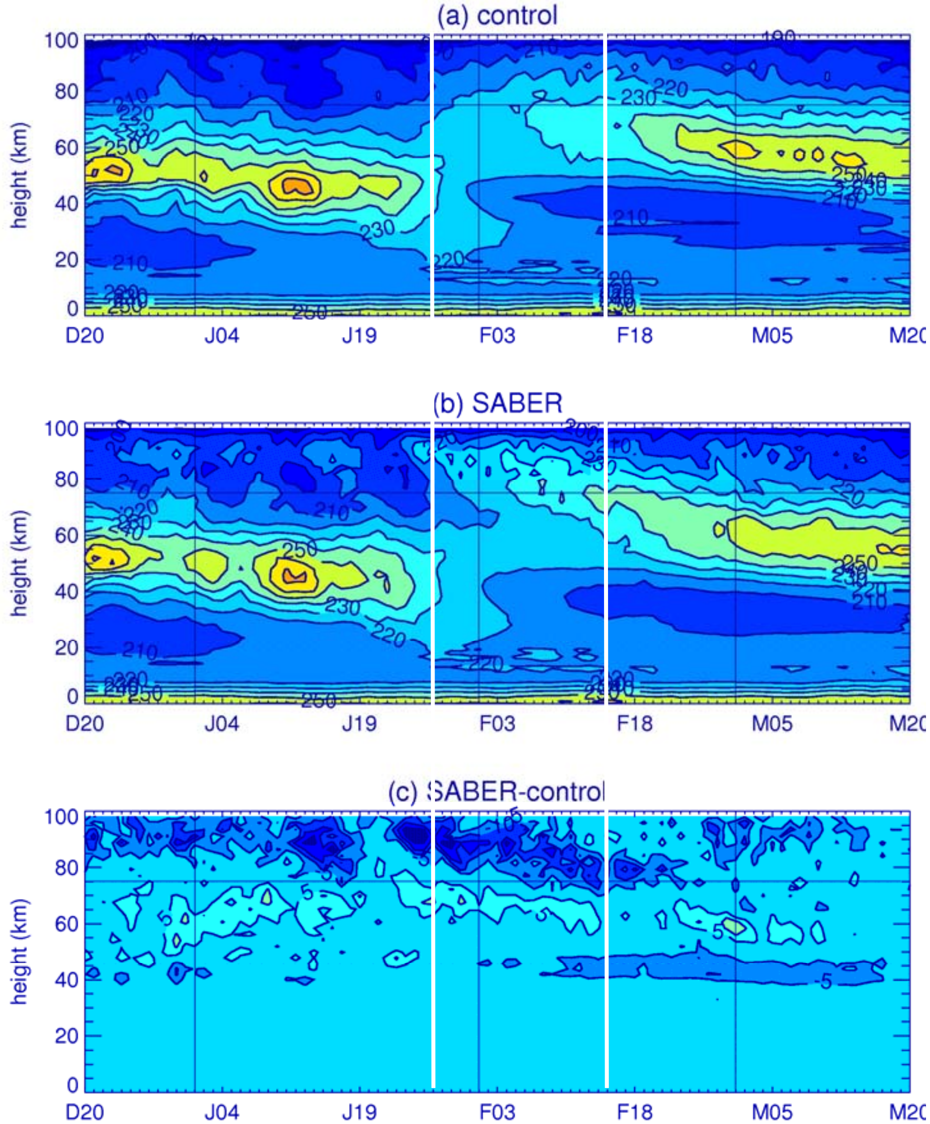
GEOS-5
too low
too warm

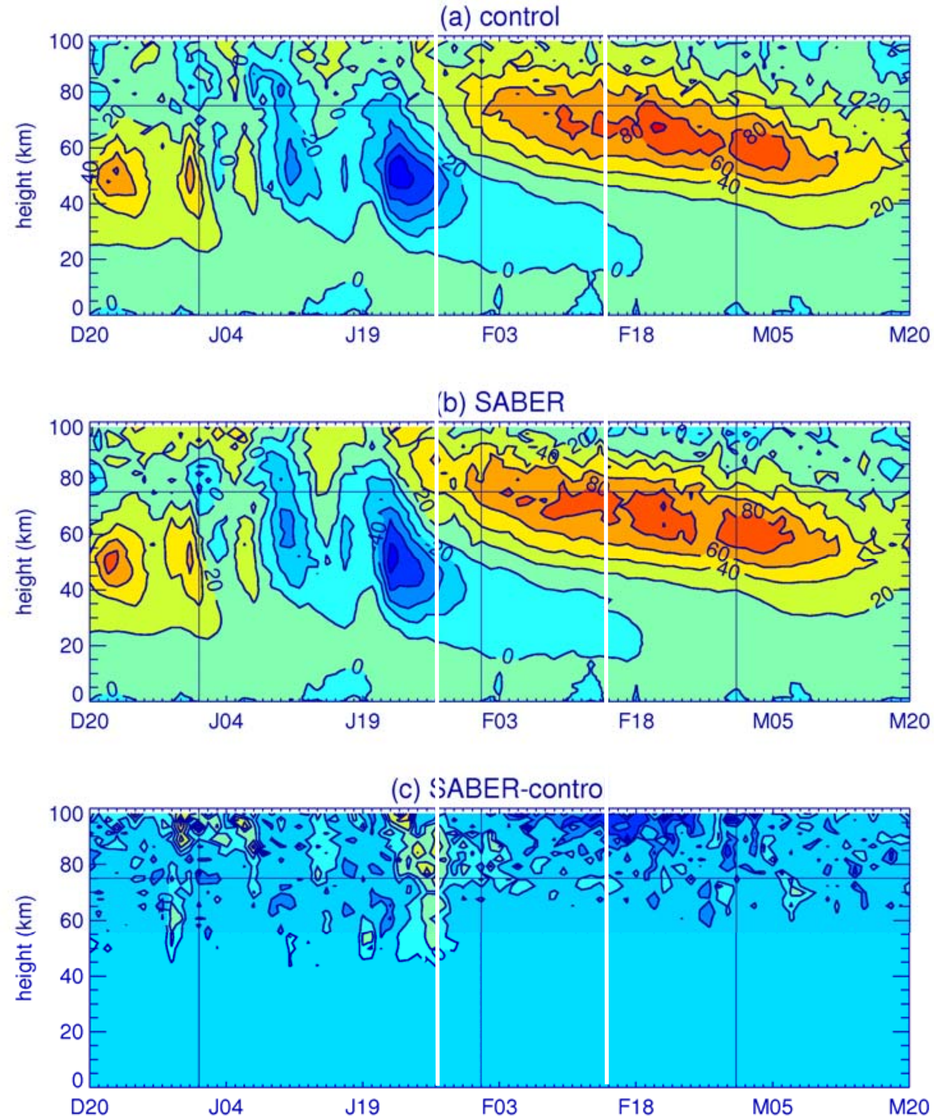
Motivation

- NOGAPS-ALPHA can capture stratopause evolution by assimilating SABER and MLS temperatures
- Why does CMAM-DAS capture stratopause evolution even though neither SABER nor MLS is assimilated?
- Compare cycles with and without mesospheric observations:
  – Control cycle: no obs above ~45 km
  – SABER cycle: assimilate T to 80 km
- Demonstrate that
  - ➢ CMAM-DAS captures stratopause evolution without assimilating observations above ~45 km
  - ➢ Explain why it is able to do this

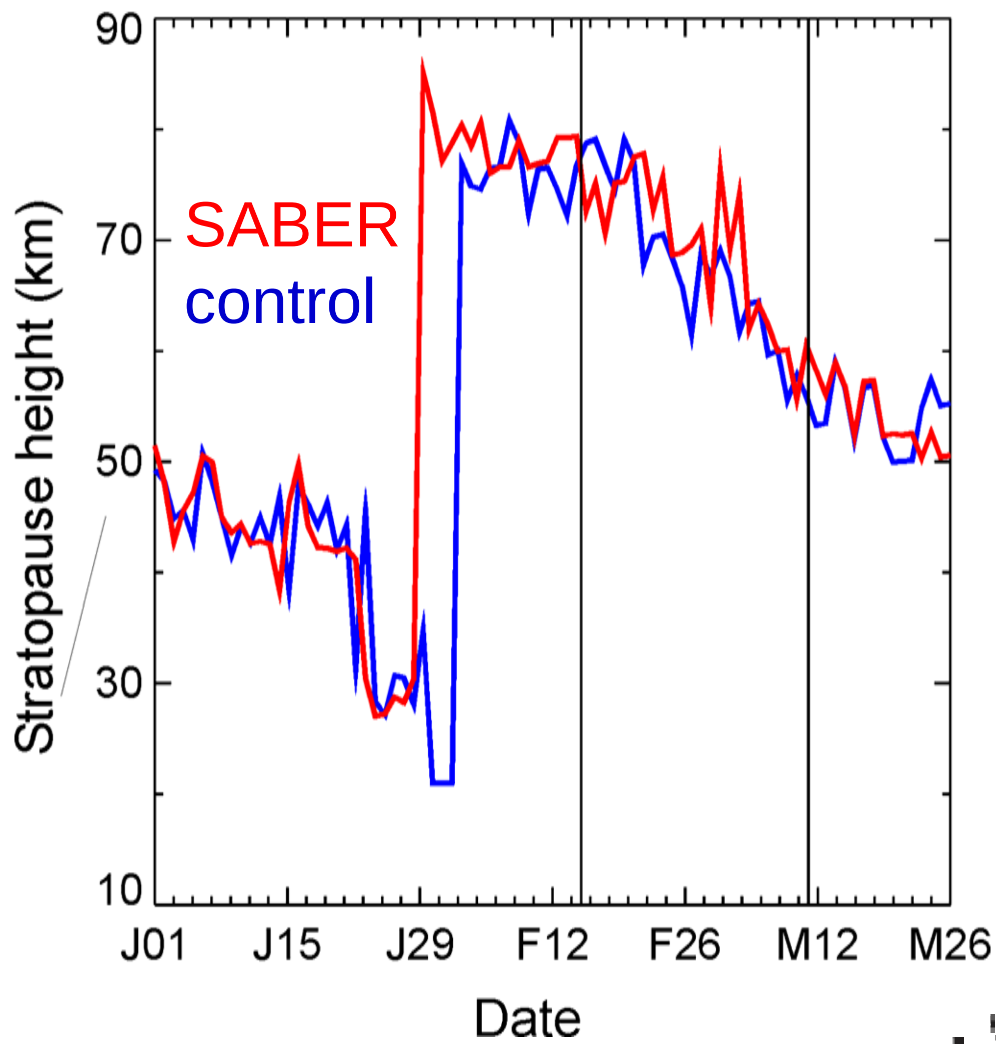
Timing of SSW is captured without assimilating mesospheric observations

Zonal mean T, U at 70°N



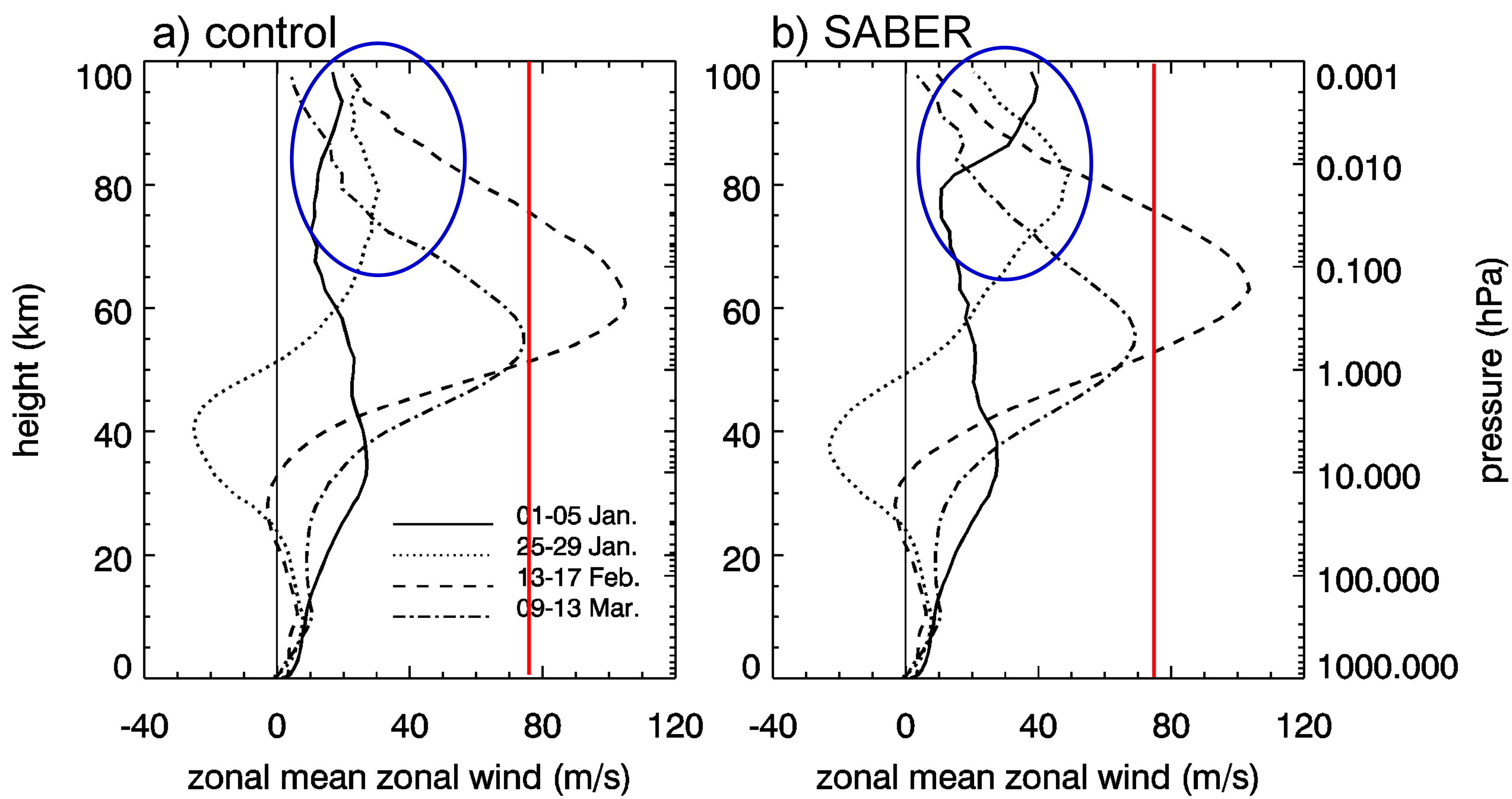


Stratopause height is captured without assimilating mesospheric observations



Zonal mean wind profiles at 60°N are similar below 45 km

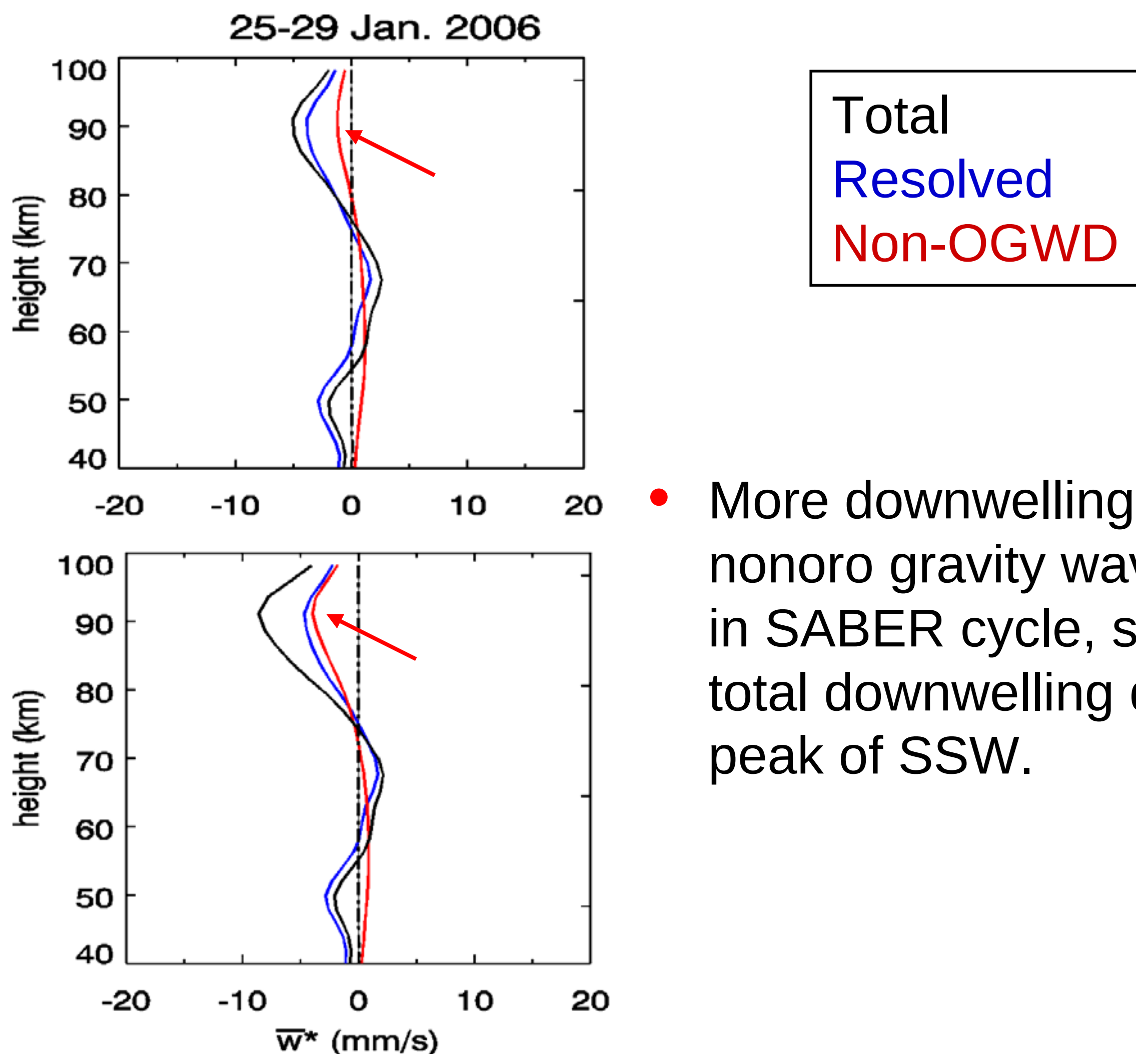
Main differences occur above 75 km



Difference in residual vertical velocity

Control

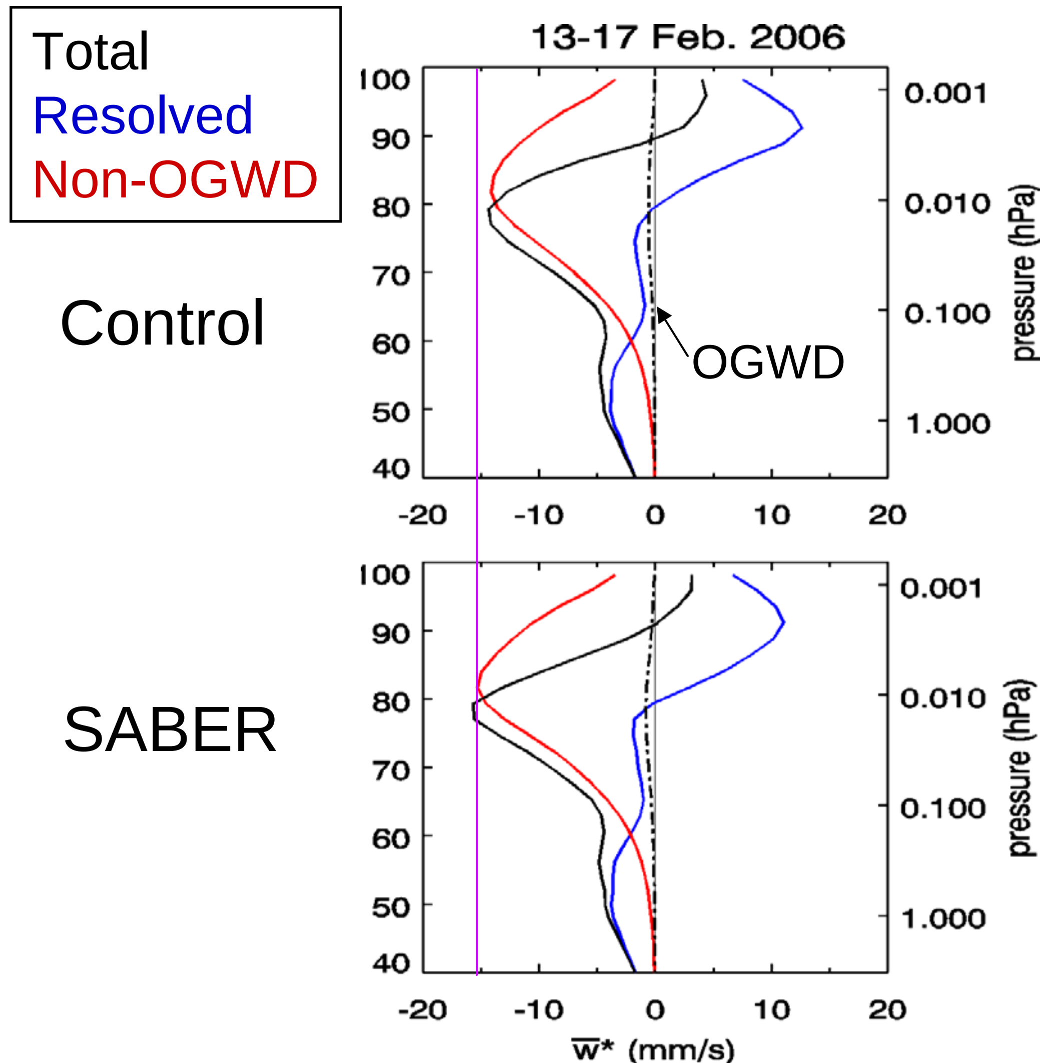
SABER



- More downwelling due to nonoro gravity wave drag in SABER cycle, so more total downwelling during peak of SSW.

Difference in residual vertical velocity

- Wave driving in control and SABER cycles is pretty similar at all other times
- Large forcing due to non-OGWD when stratopause is elevated



Environment Canada Environnement Canada

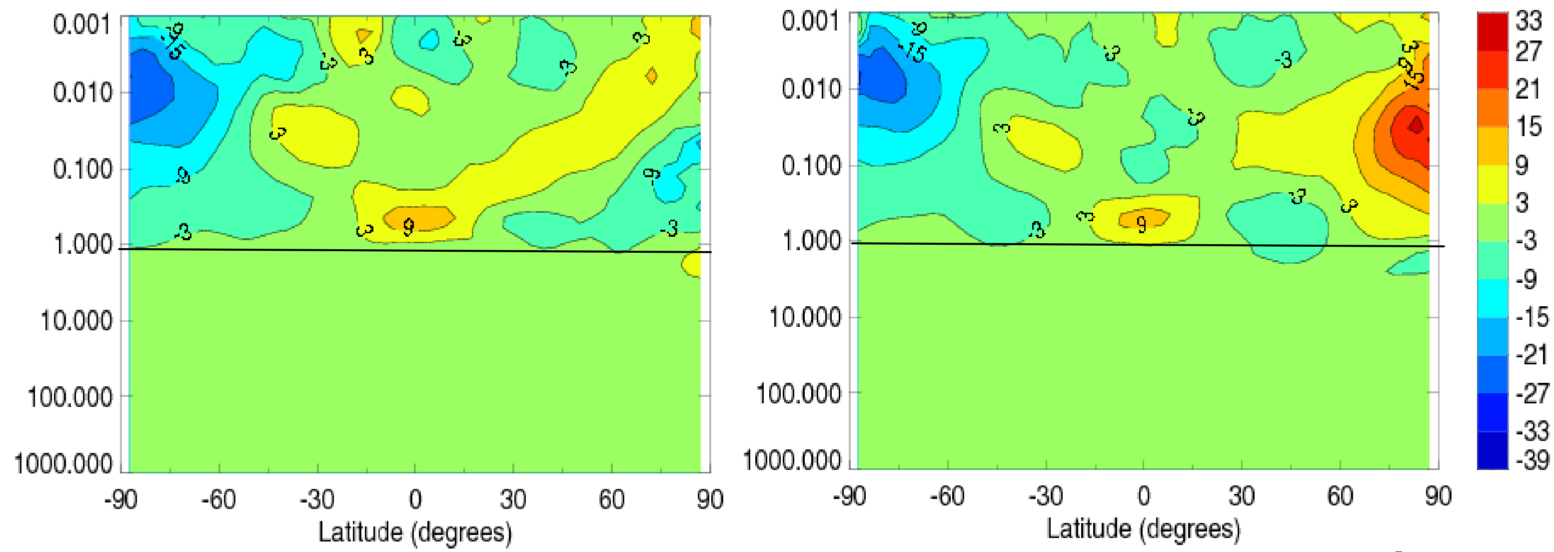
Canada

Zonal mean temperature difference in cycles with and without nonorographic GWD

January 27 0Z

February 15 0Z

control



- Sensitivity to GWD above 45 km
- Greater sensitivity during elevated stratopause
- Sensitivity to GWD depends on flow

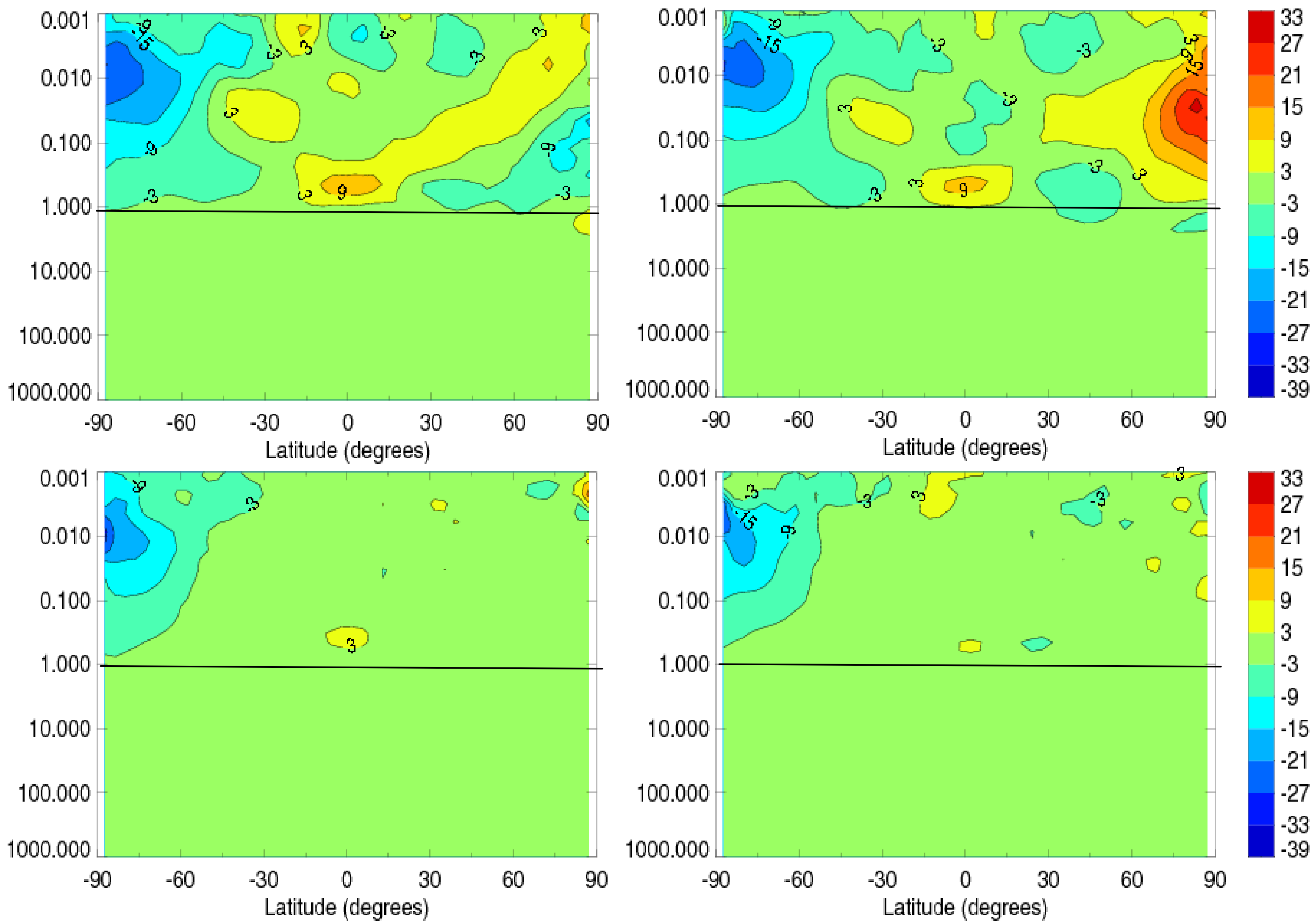
Zonal mean temperature difference in cycles with and without nonorographic GWD

January 27 0Z

February 15 0Z

control

SABER

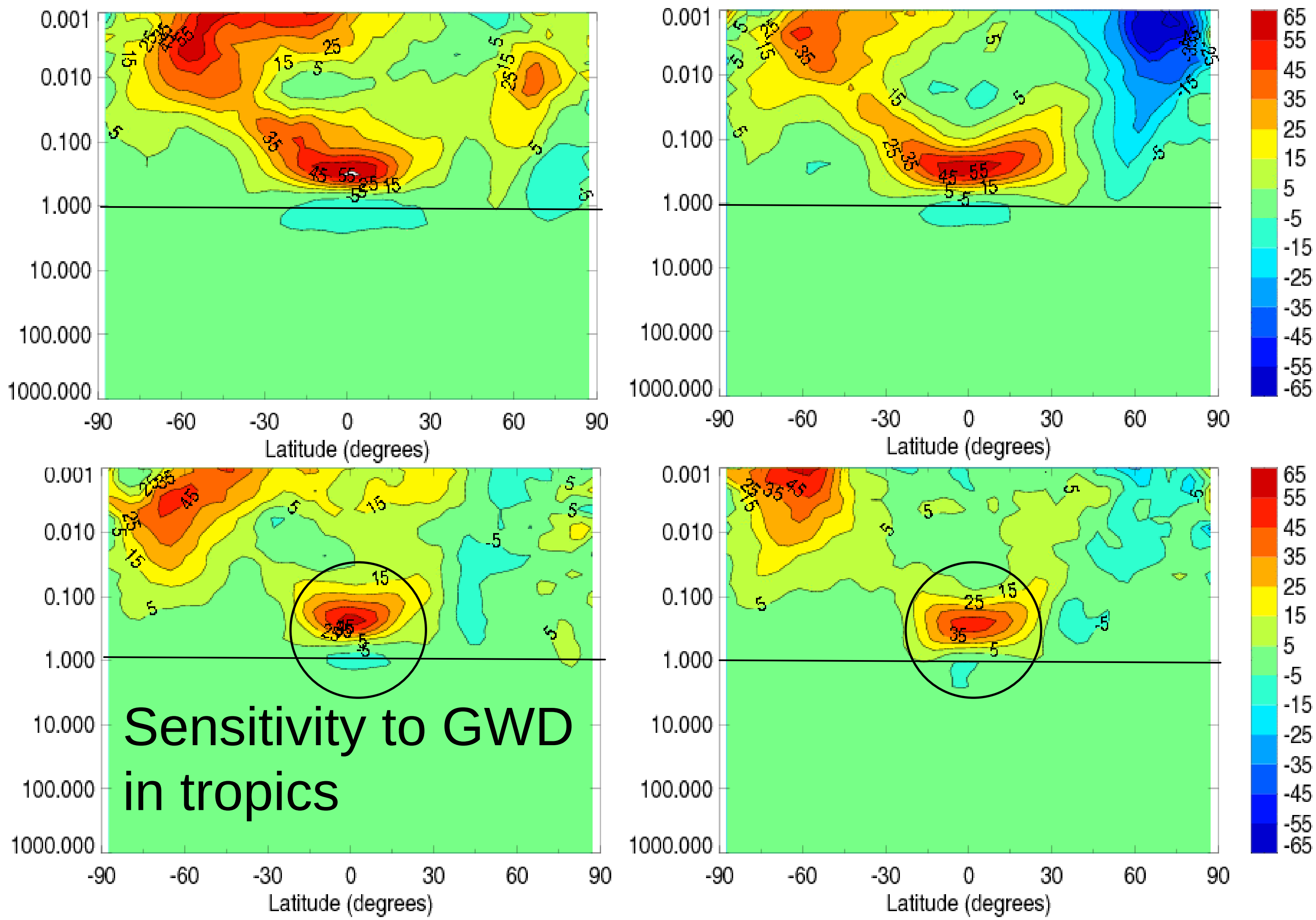


Zonal mean zonal wind difference in cycles with and without nonorographic GWD

January 27 0Z February 15 0Z

control

SABER



- Extratropical mesospheric analyses are *less sensitive* to presence of nonorographic gravity wave drag scheme when SABER temperatures are assimilated

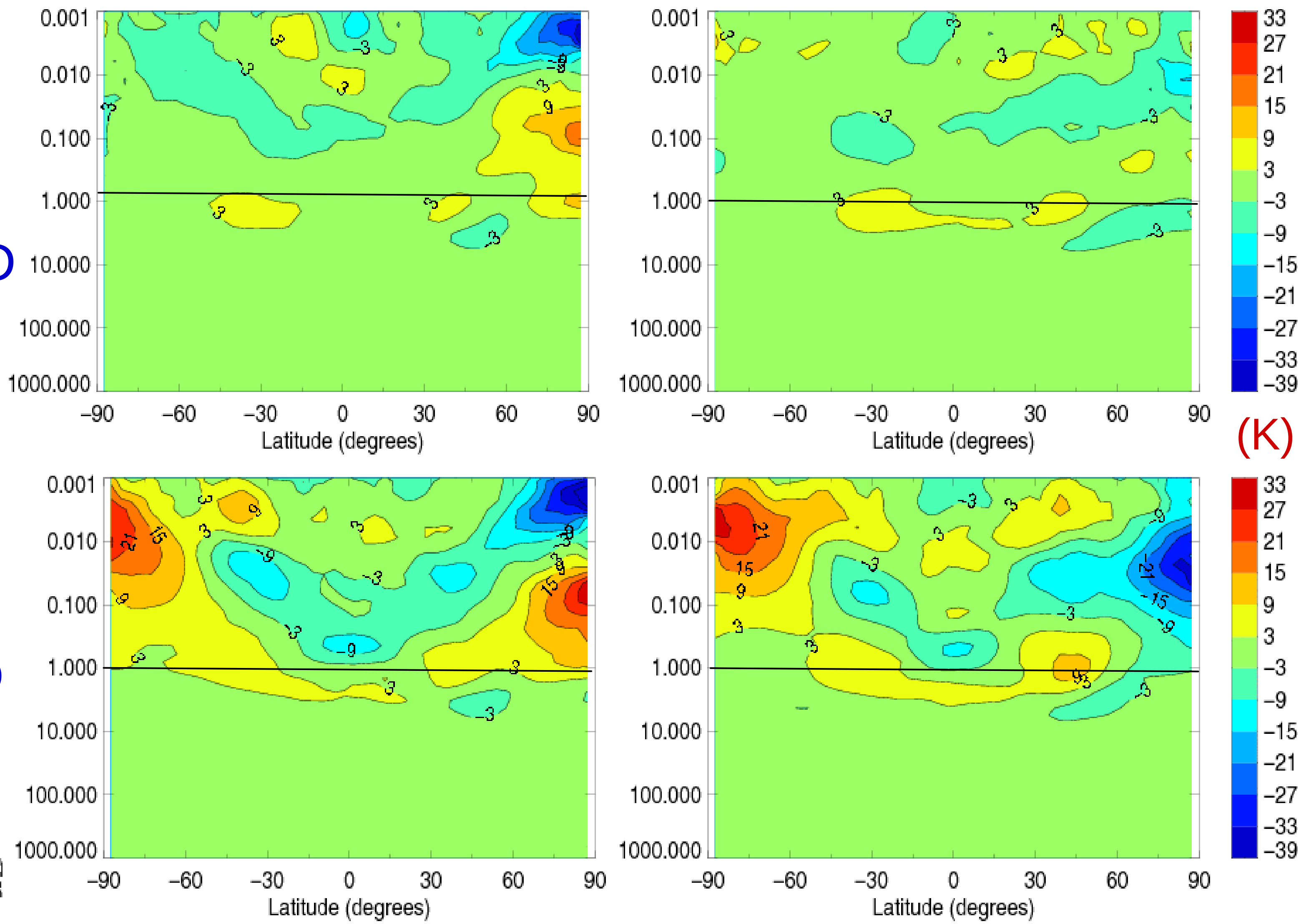
- But are mesospheric analyses *better* with nonoro GWD?
  - Use SABER cycle as "truth" and compute error of
    1) control (with GWD) – SABER
    2) control (without GWD) - SABER

Zonal mean temperature error due to assimilation of mesospheric temperature

January 27 0Z | February 15 0Z

Control with GWD

Control w/o GWD



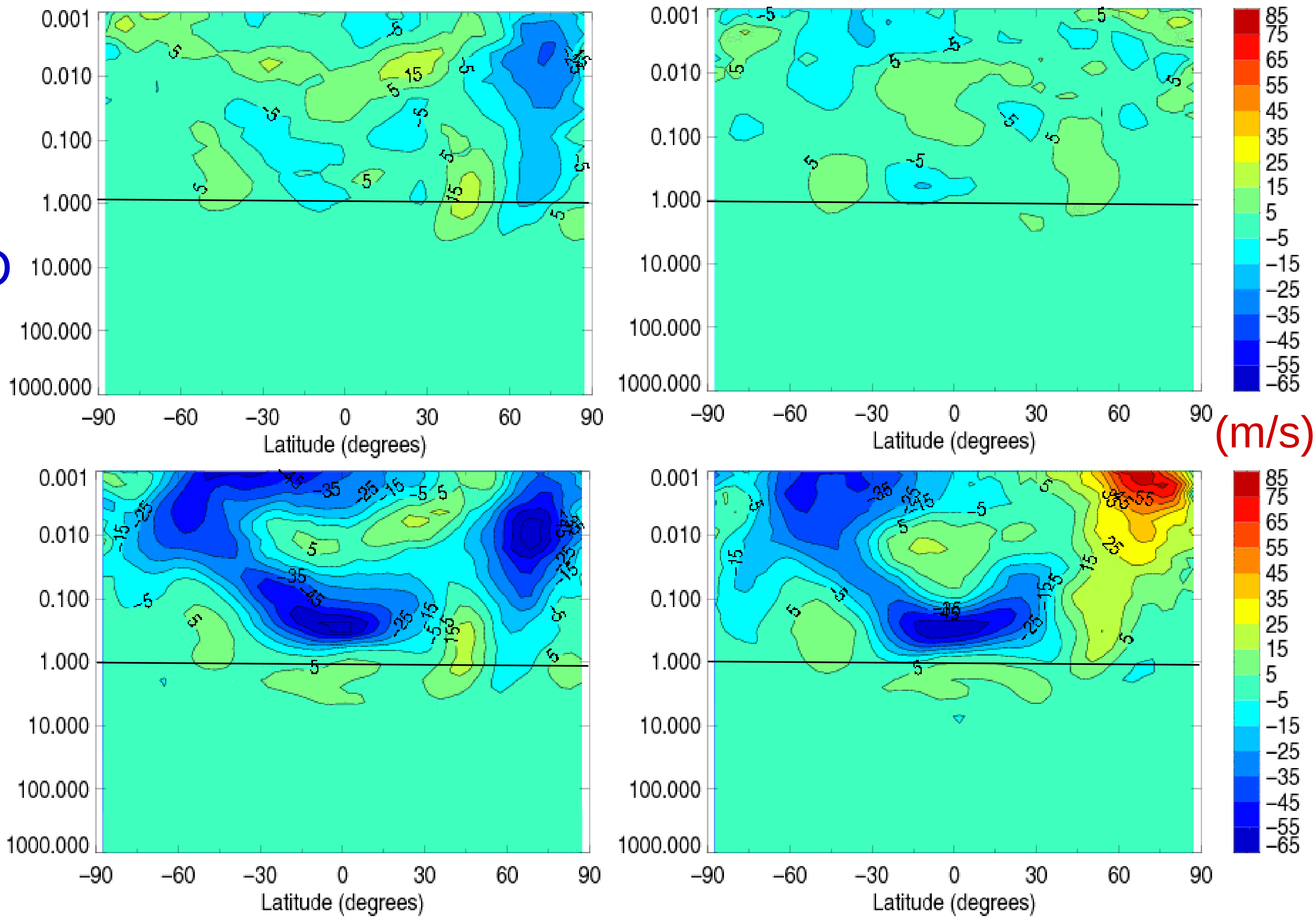
Zonal mean zonal wind error due to assimilation of mesospheric temperature

January 27 0Z

February 15 0Z

Control with GWD

Control w/o GWD

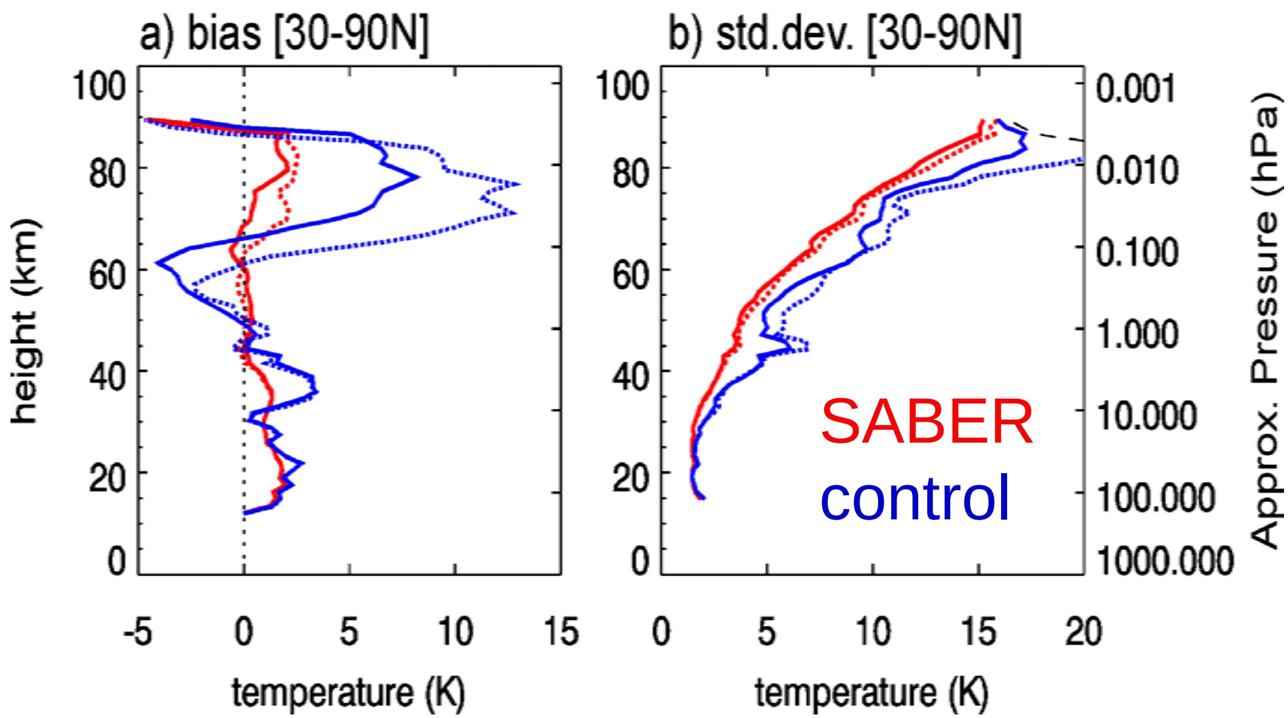


GWD improves fit to observations

SABER T minus 6h forecasts

____ with GWD

- - - - w/o GWD

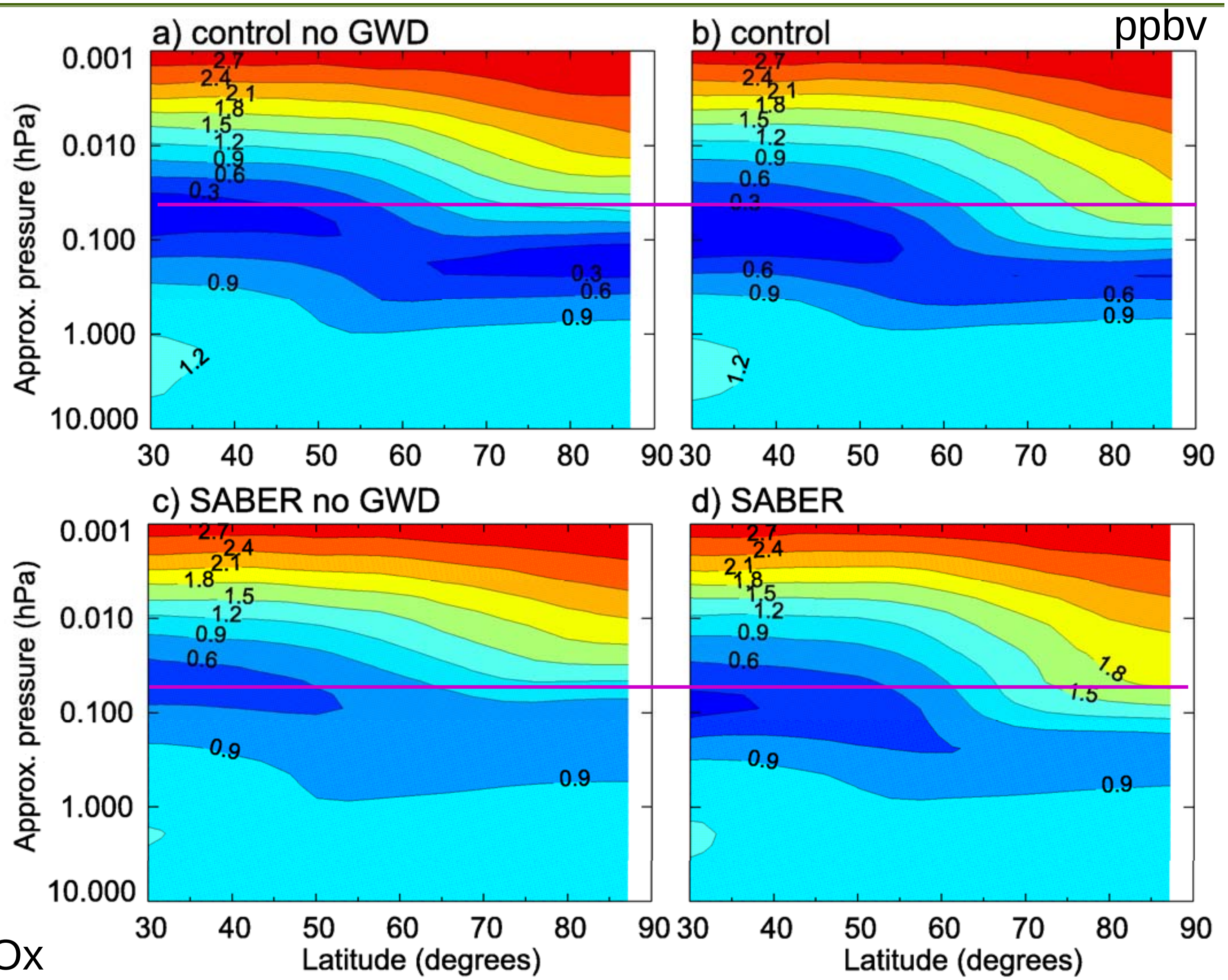


Nonorographic GWD affects descent of polar mesospheric NOx=NO+NO2

February 15 0Z

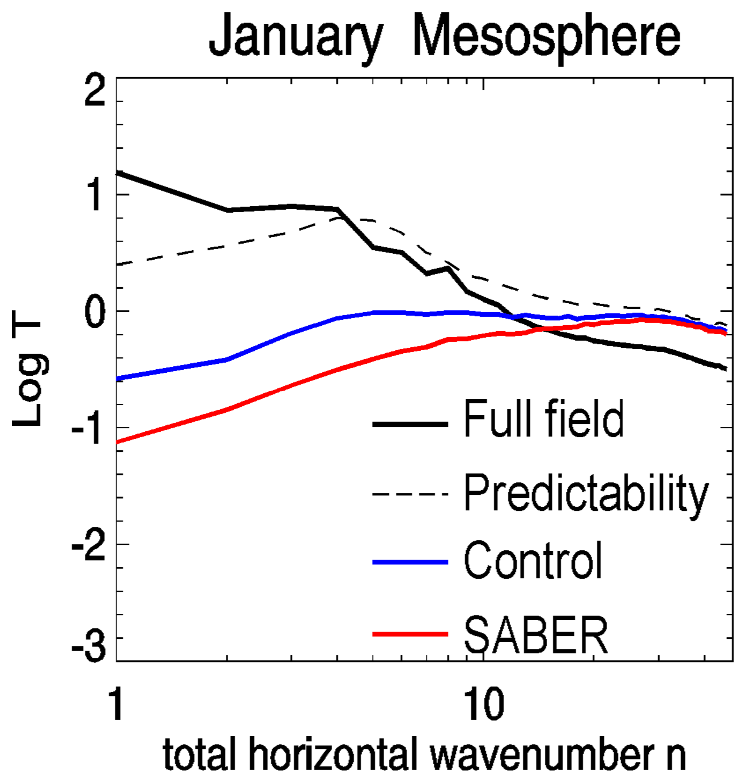
No assimilation of mesospheric observations

Assimilation of SABER mesospheric temperatures



Contours are $\log_{10}$ NOx

CMAM-DAS with simulated obs



- Nezlin et al. (2009) demonstrated that large scales in mesosphere are improved by assimilating obs below 45 km
- Simulated SABER obs help improve large scales below wavenumber 10, with a perfect model
- Results are system dependent

Conclusions

- Even without assimilating any mesospheric observations, CMAM-DAS mesospheric analyses compare to independent measurements due to nonorographic GWD scheme
- Realistic GWD is needed for good mesospheric analyses if mesospheric obs are not assimilated
- Assimilating mesospheric temperatures renders mesospheric analyses less sensitive to GWD scheme
- However mesospheric constituents are still sensitive to presence of GWD. Can we use constituent obs to constrain GWD sources or parameters?
- This work is being reviewed by *J.Geophys.Res*. Look for Ren et al. (2011).