Data Assimilation in WACCM

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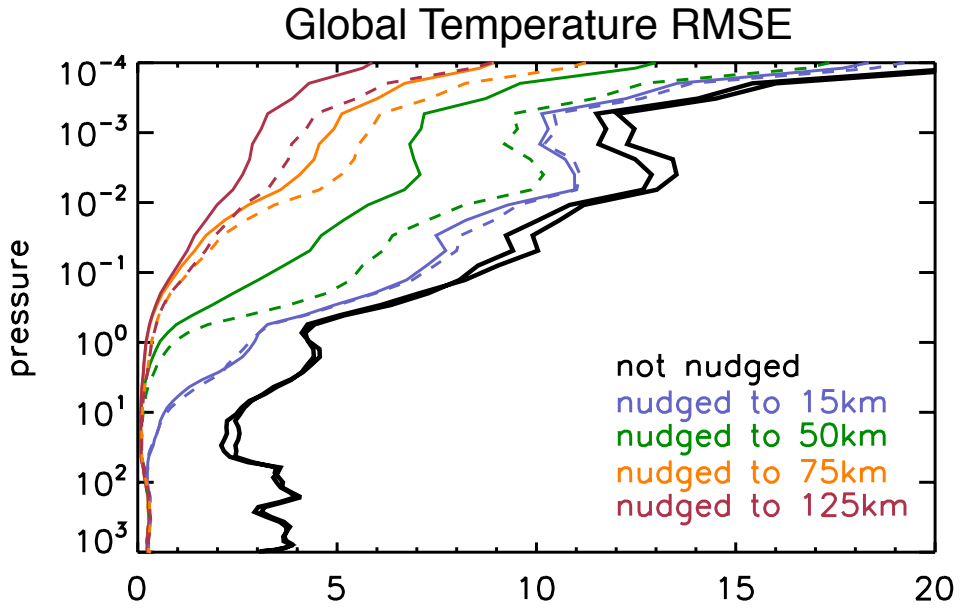
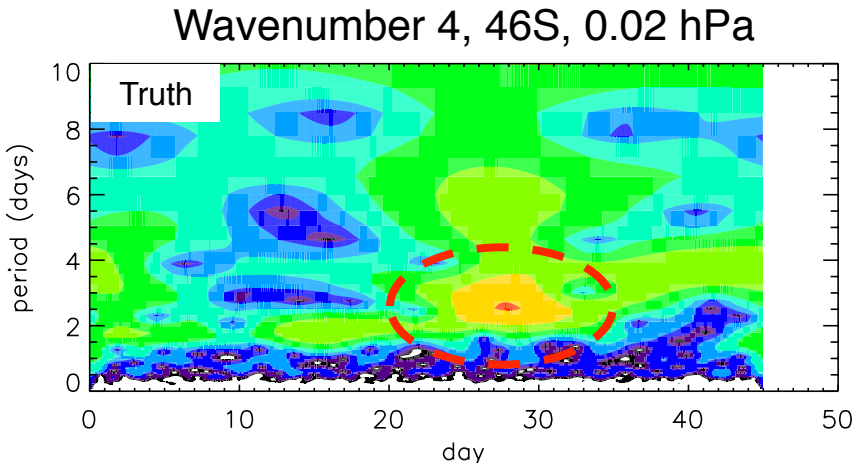
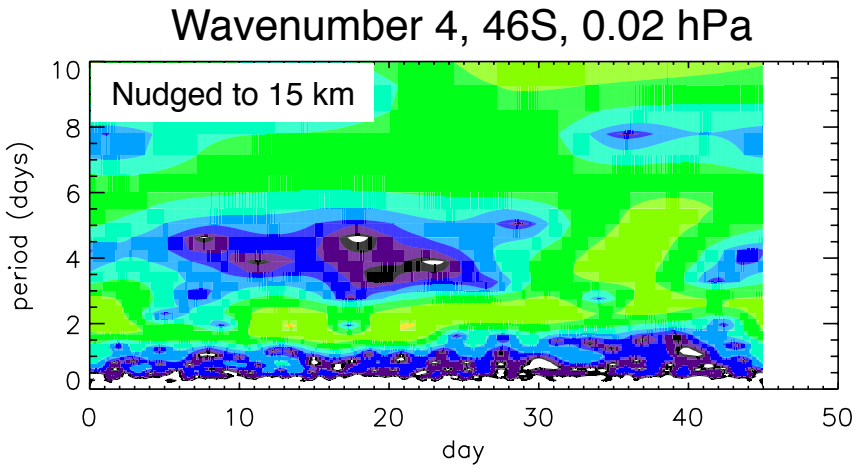
Motivation: Even in perfect model experiments, nudging dynamical fields leads to error growth in the MLT, and does not capture wave dynamics

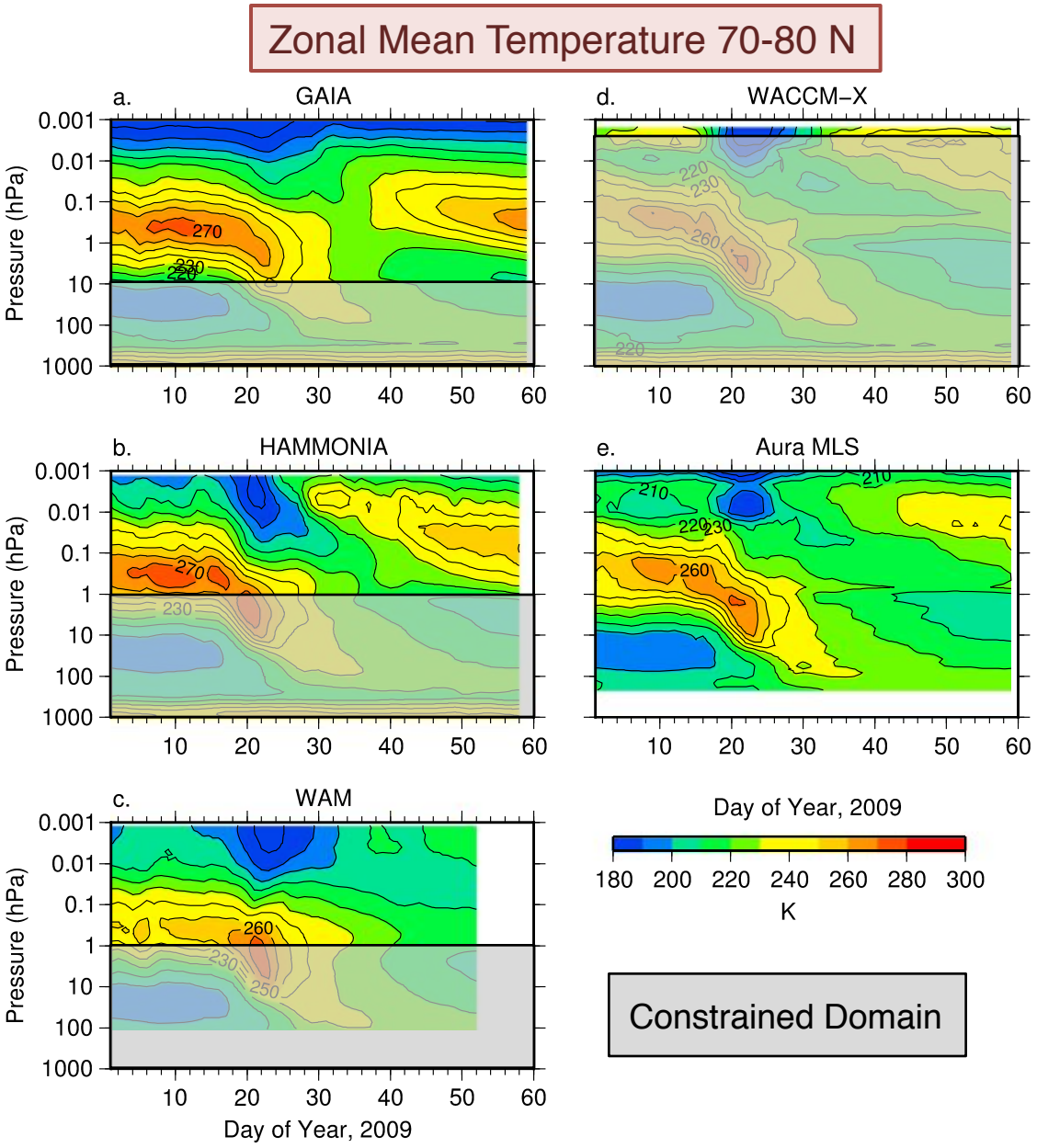






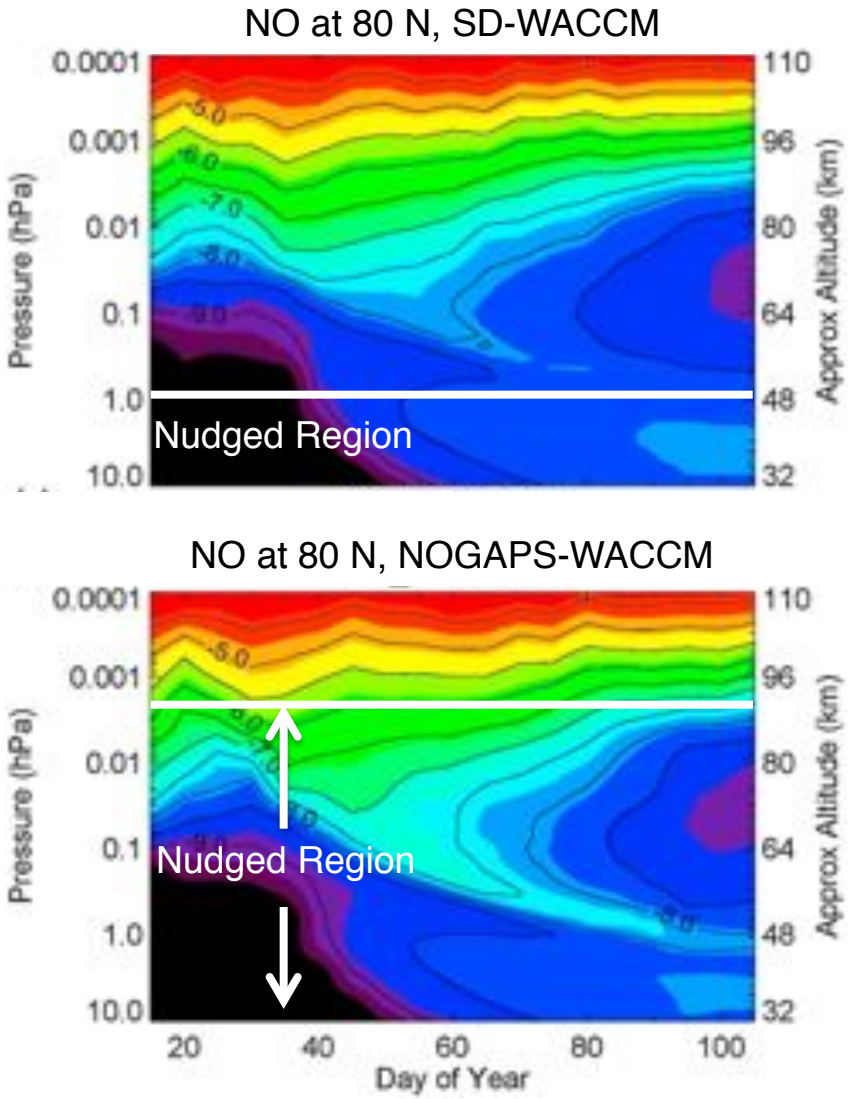
Results courtesy of Anne Smith

Motivation: Large differences occur in the MLT despite constraint at lower altitudes



(Pedatella et al., 2014)

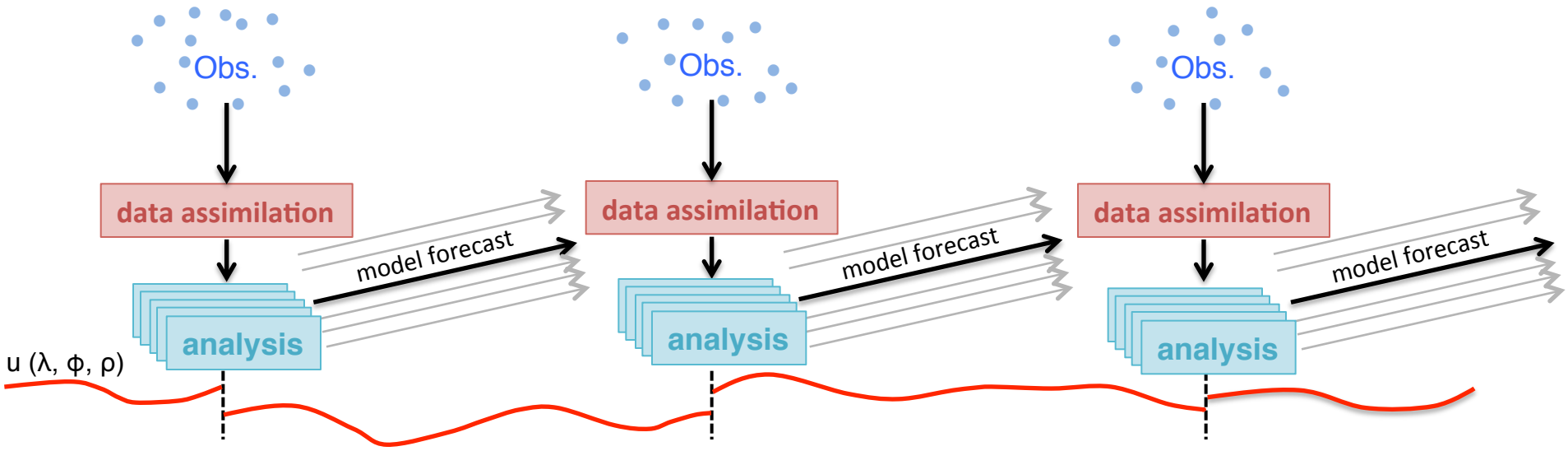
Motivation: Differences in modeled MLT dynamics influence nitric oxide descent



Direct assimilation of lower, middle, and upper atmosphere observations in WACCM is one approach to improving simulations of MLT dynamics

(Siskind et al., 2015)

Data assimilation using DART ensemble Kalman filter



Data assimilation constrains the model directly based on observations providing a more realistic representation of the true state of the atmosphere at a specific time

We use the DART ensemble Kalman filter to implement data assimilation in WACCM

The ensemble approach eliminates the need to specify background covariance, since it is obtained directly from the ensemble of model simulations

WACCM+DART

WACCM+DART provides an atmospheric reanalysis from the surface to the lower thermosphere (~145 km).

Lower Atmosphere Observations:

- Aircraft temperature and wind
- Radiosonde temperature and wind
- Satellite drift winds
- COSMIC GPS refractivity

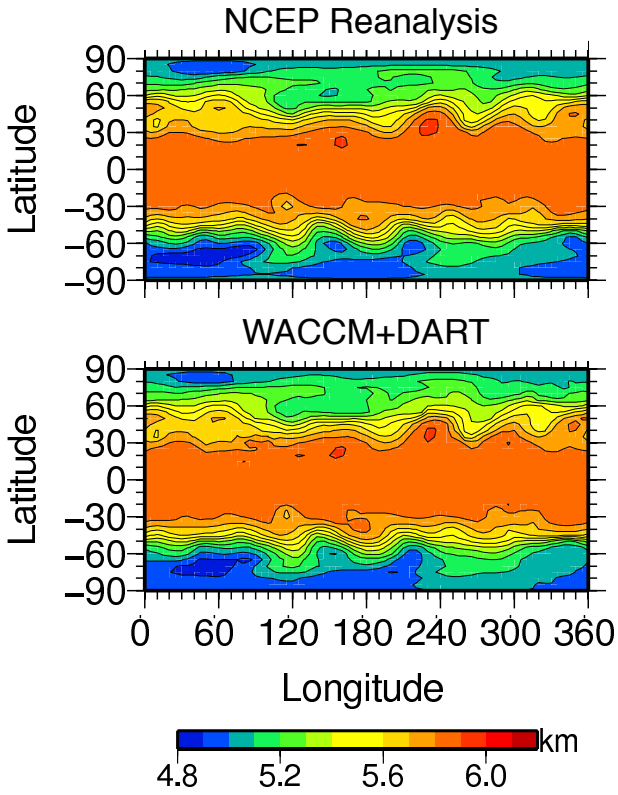
Middle/Upper Atmosphere Observations:

- TIMED/SABER Temperature
- Aura MLS Temperature

Typically use a 40-member ensemble, which is a tradeoff between computational expense and having a sufficiently large ensemble to capture a variety of atmospheric states.

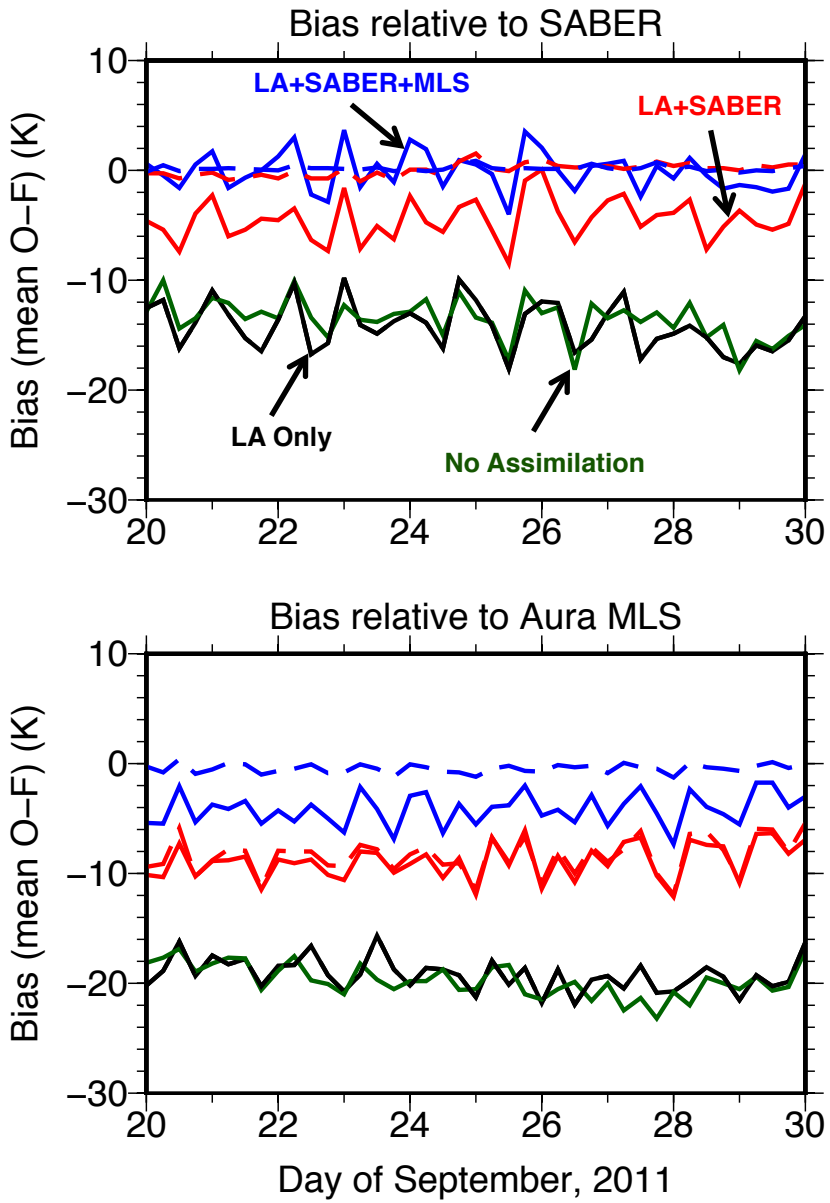
WACCM+DART is useful for correcting model biases, studying dynamical variability due to sudden stratosphere warmings, and short-term tidal variability

500 hPa Geopotential Height
0000 UT 15 Nov., 2008



Pedatella, N. M., K. Raeder, J. L. Anderson, and H.-L. Liu (2014), Ensemble data assimilation in the Whole Atmosphere Community Climate Model, *J. Geophys. Res., 119*, doi: 10.1002/2014JD021776.

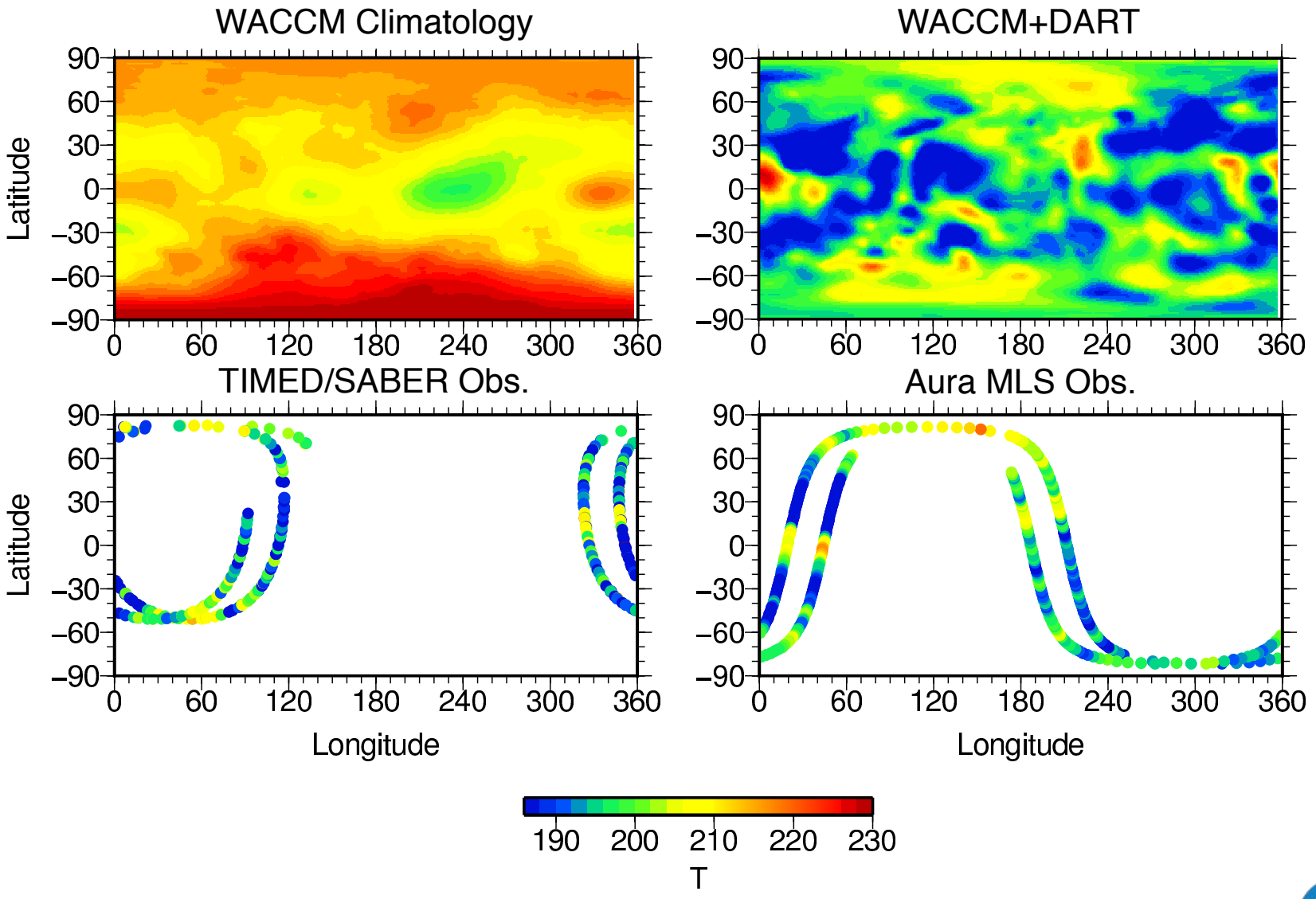
Bias Removal in the MLT



Results for 5 x 10^{-3} hPa

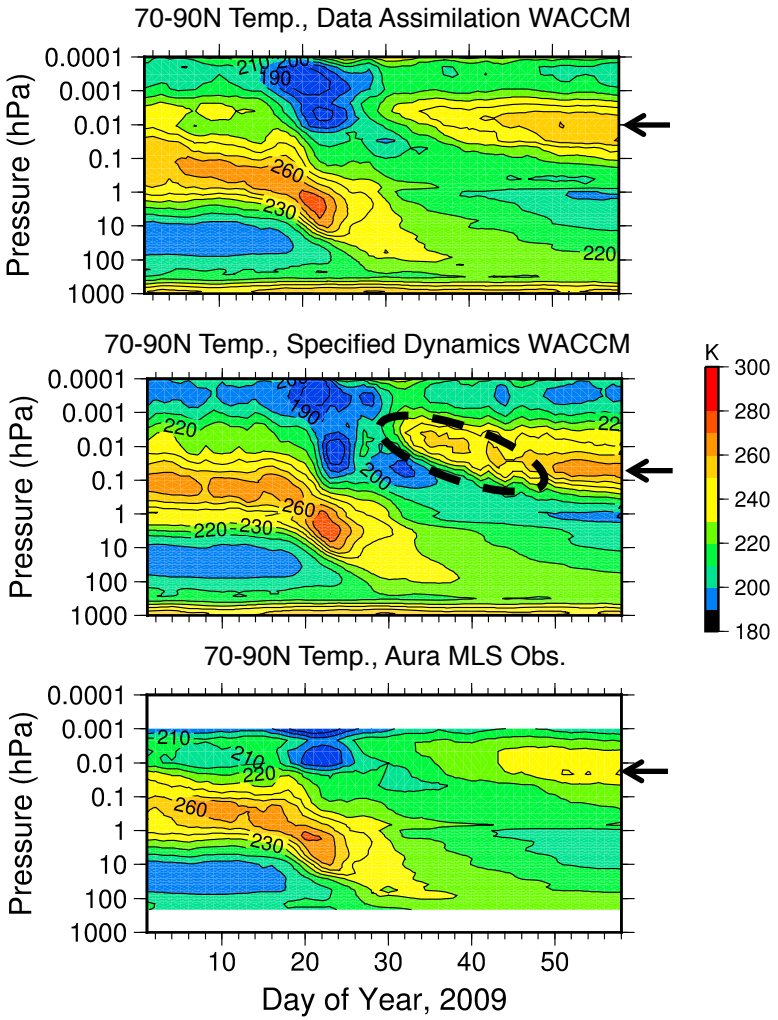
Bias Removal in the MLT

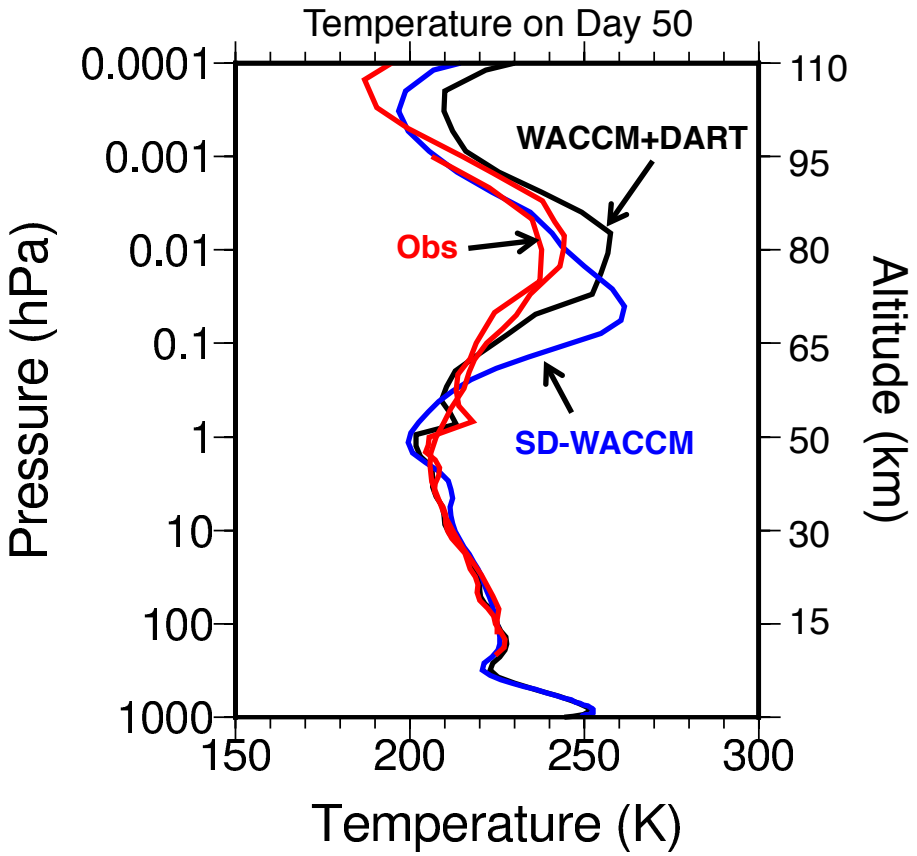
5 x 10^{-3} hPa, Sept. 29 2011, 0000 UT



MLT dynamics during sudden stratosphere warmings

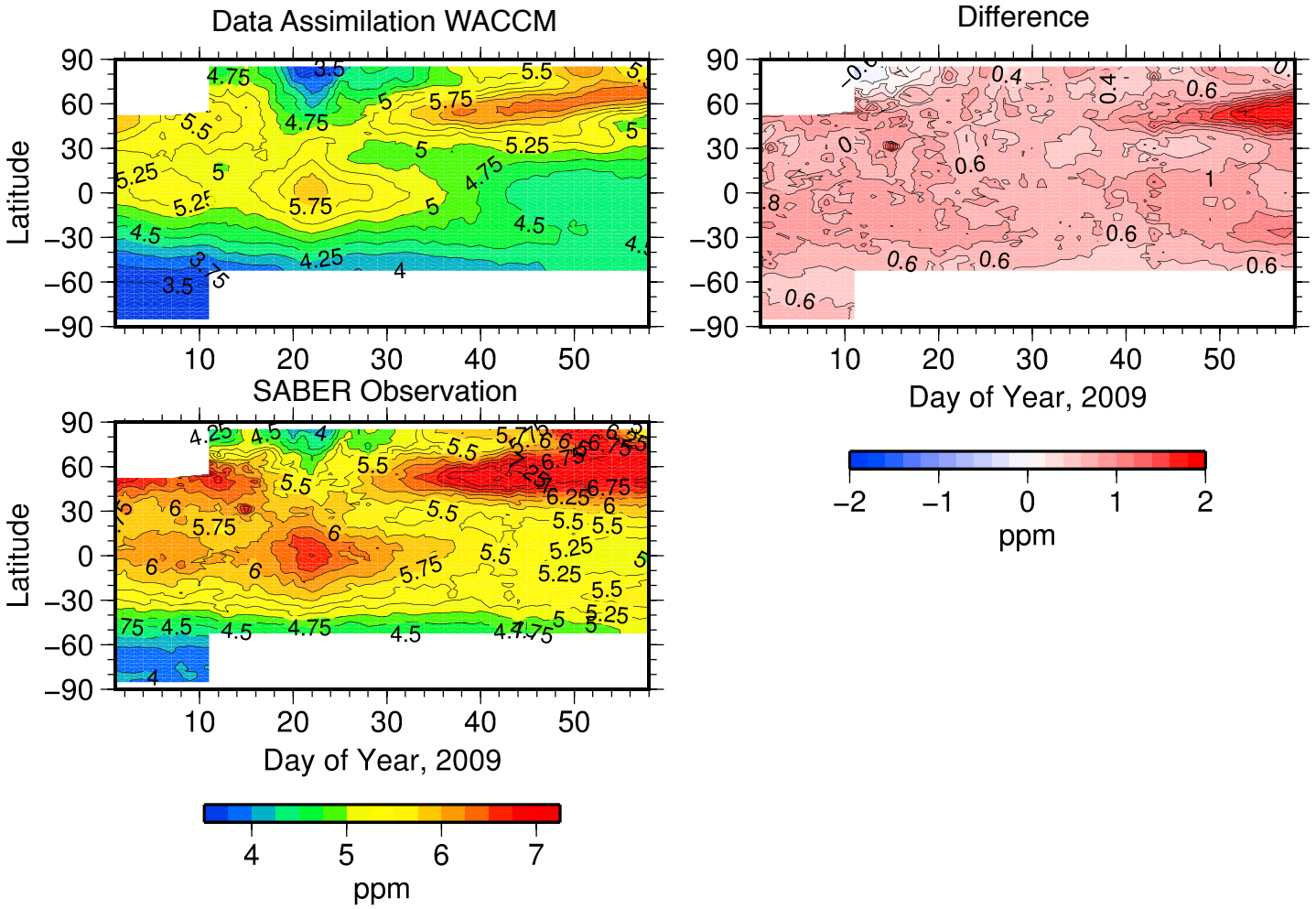
Implementation of data assimilation in the Whole Atmosphere Community Climate Model better captures the dynamic variability in the high latitude wintertime stratosphere and mesosphere.



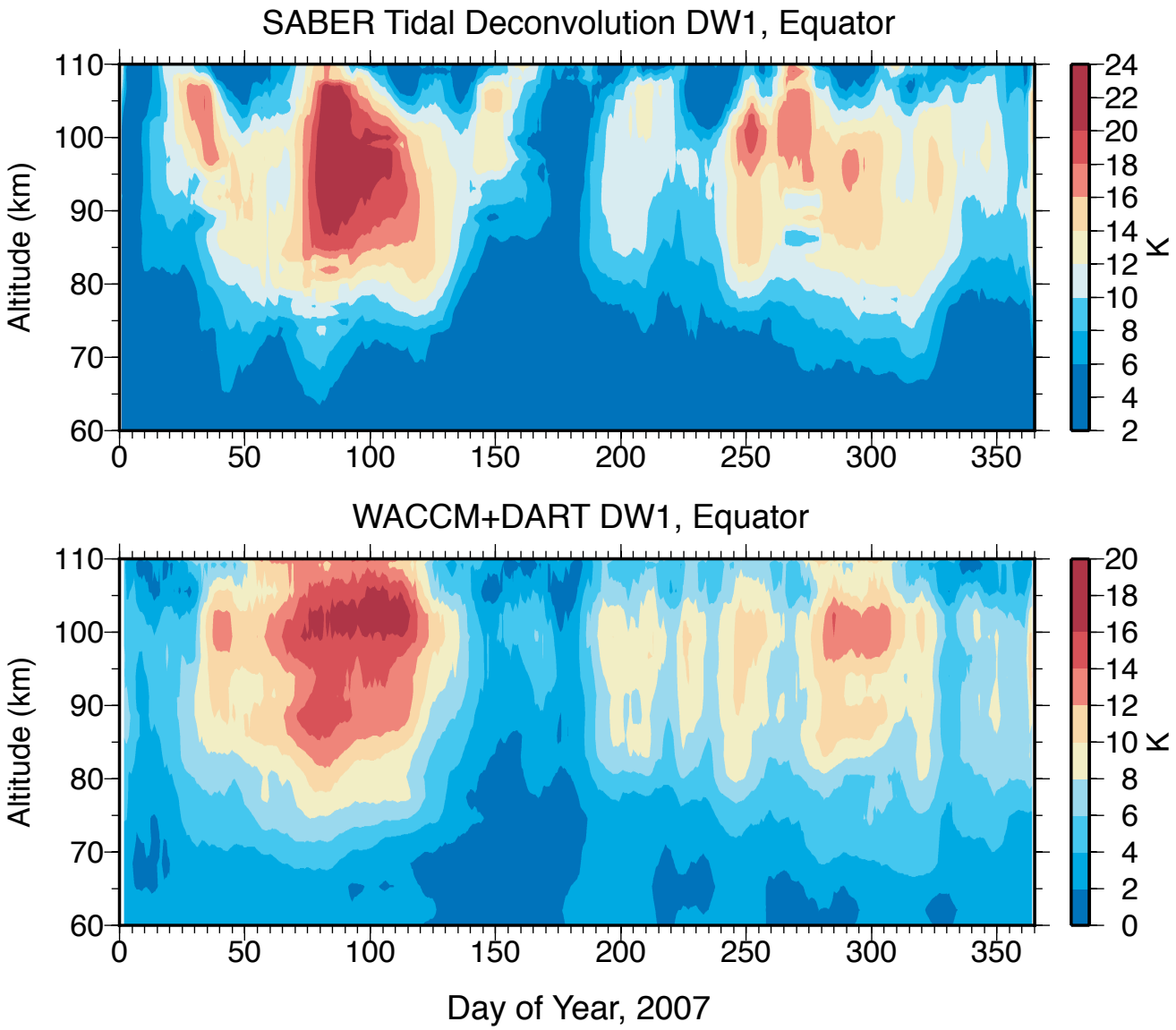


WACCM+DART captures the variability in chemical species during SSWs

Ozone at 2 hPa

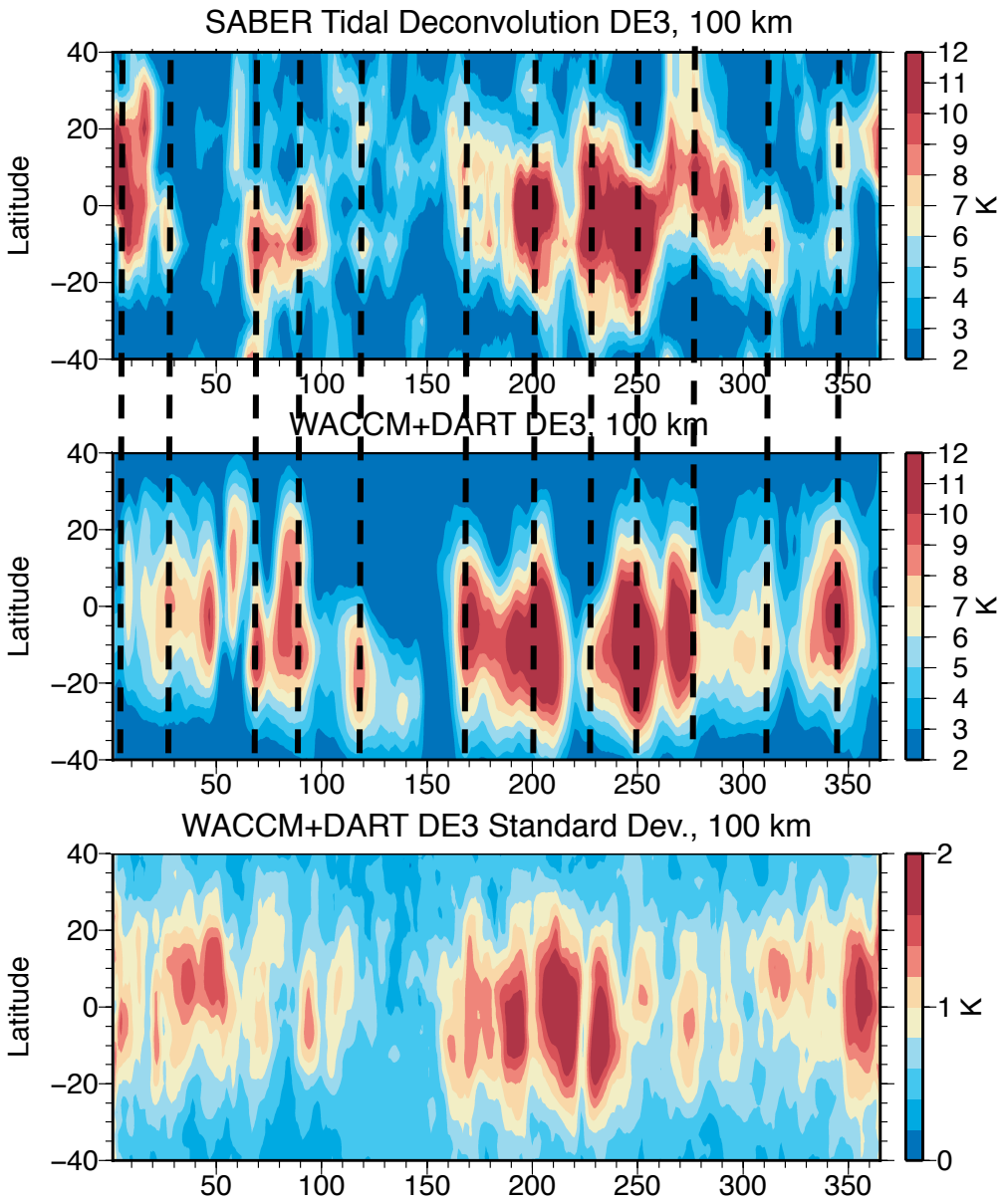


Short-term tidal variability is captured by WACCM+DART



Results based on 10-day average

Short-term tidal variability is captured by WACCM+DART



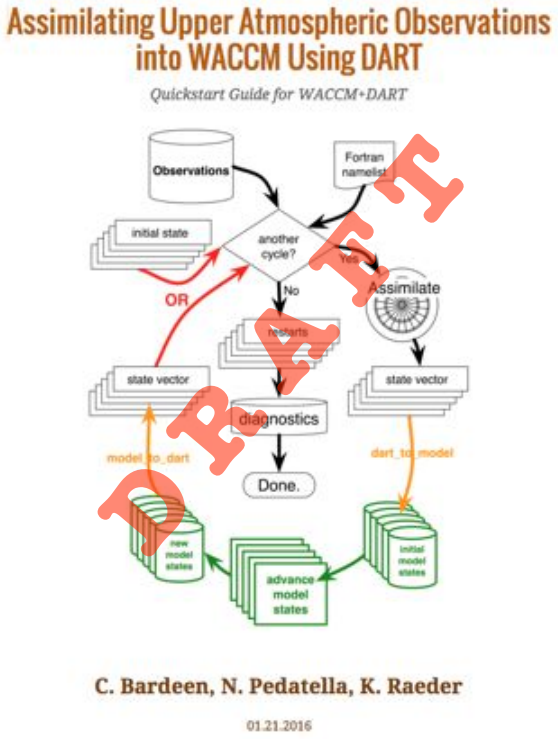
Results based on 10-day average

Summary

The capability to perform data assimilation in WACCM has been implemented using the DART ensemble Kalman filter

By assimilating lower, middle, and upper atmosphere observations WACCM+DART reduces the model bias in the MLT, and can be used to study chemical and dynamical variability associated with sudden stratosphere warmings as well as short-term tidal variability.

A draft document is in preparation that will guide any interested users through setting up and running WACCM+DART



Potential future directions:

- Scientific investigations using WACCM+DART reanalysis
- SD-WACCMX using WACCM+DART to constrain WACCMX up to the lower thermosphere
- Whole atmosphere data assimilation with WACCMX+DART

Data assimilation using DART ensemble Kalman filter