# Data Assimilation in WACCMX

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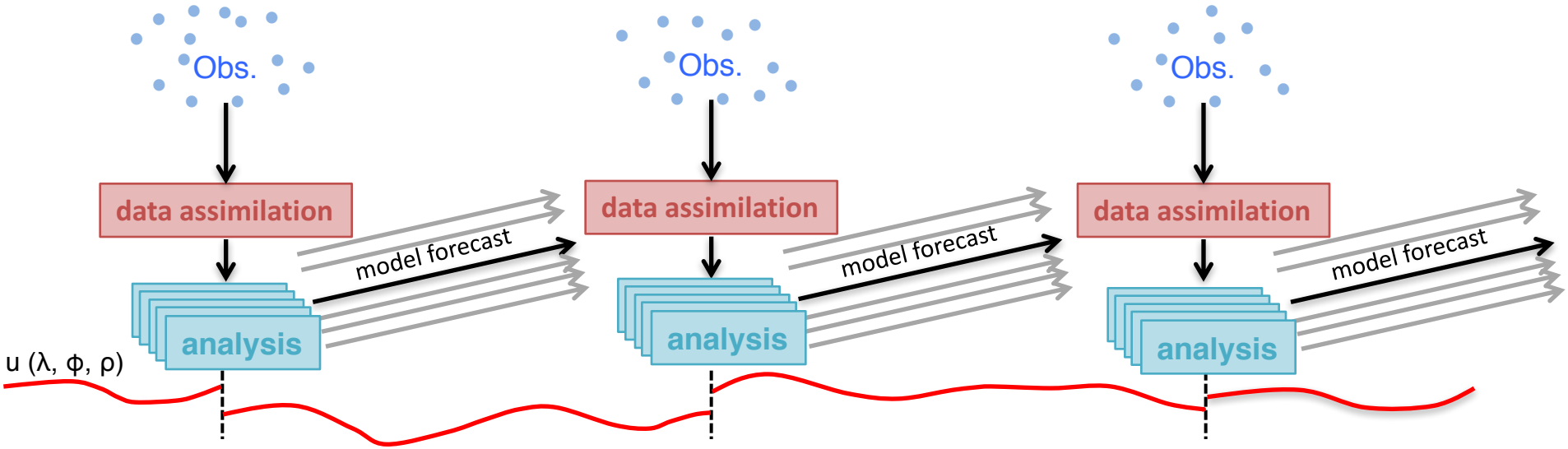
CEDAR Workshop
June 19-23, 2017

# 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

***DART*** – Data Assimilation Research Testbed
***WACCM*** – Whole Atmosphere Community Climate Model

# WACCM+DART

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

Lower Atmosphere Observations:

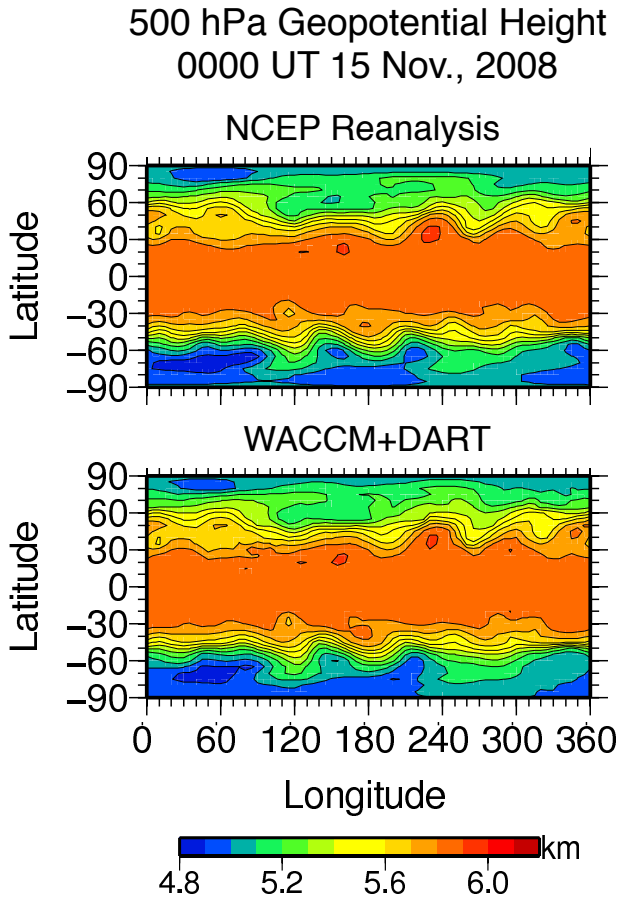
- Aircraft temperature and wind
- Radiosonde temperature and wind
- Satellite drift winds
- COSMIC GPS refractivity

Middle 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




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.

# WACCMX+DART

Framework for WACCMX+DART is identical to WACCM+DART.

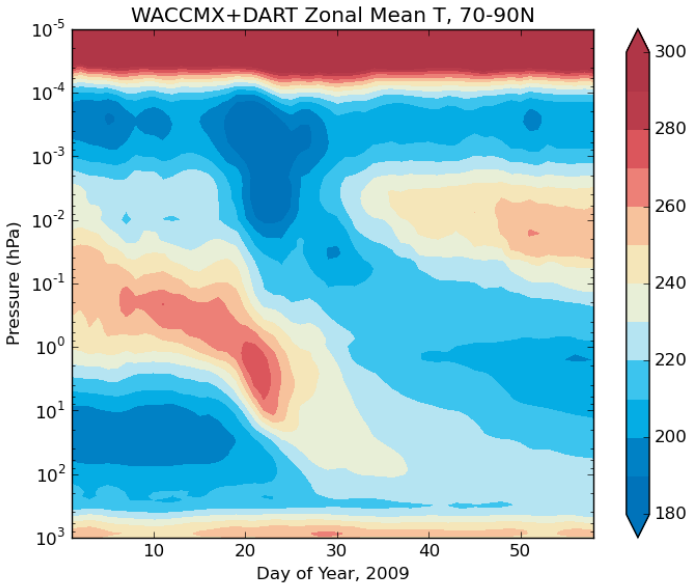
Same observations are assimilated in the troposphere, stratosphere, and mesosphere.

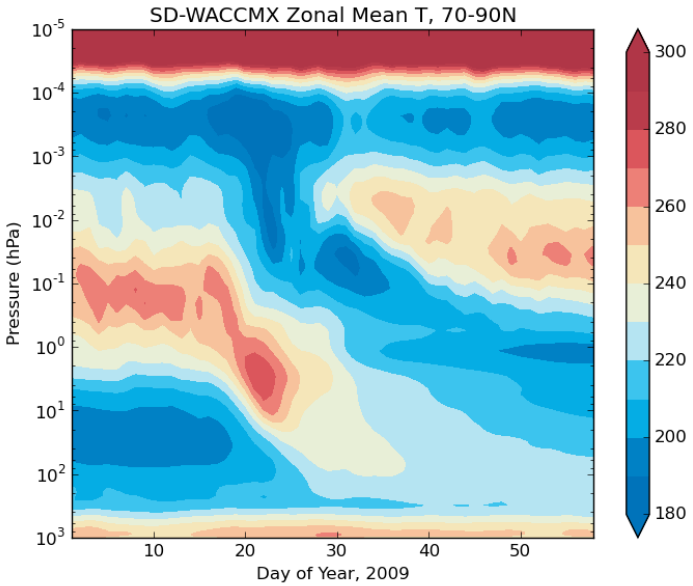
Main change between WACCMX+DART and WACCM+DART is increased damping in WACCMX which is necessary for model stability.

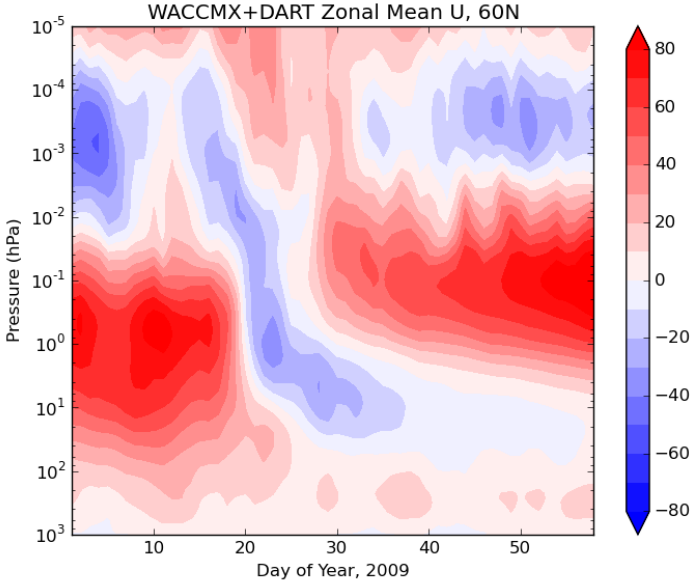
Changes made for model stability do have a slight negative impact on performance of the data assimilation in the troposphere-stratosphere.

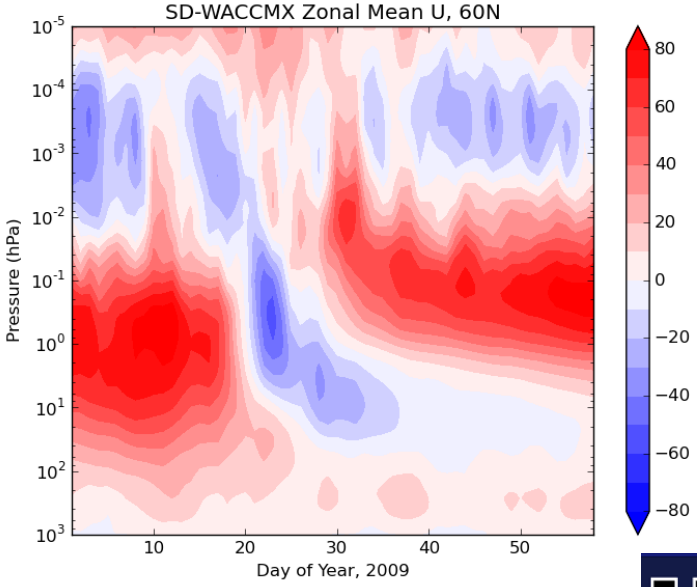
We have performed initial WACCMX+DART simulations for the 2009 SSW time period.

# Middle Atmosphere Variability in WACCMX+DART and SD-WACCMX

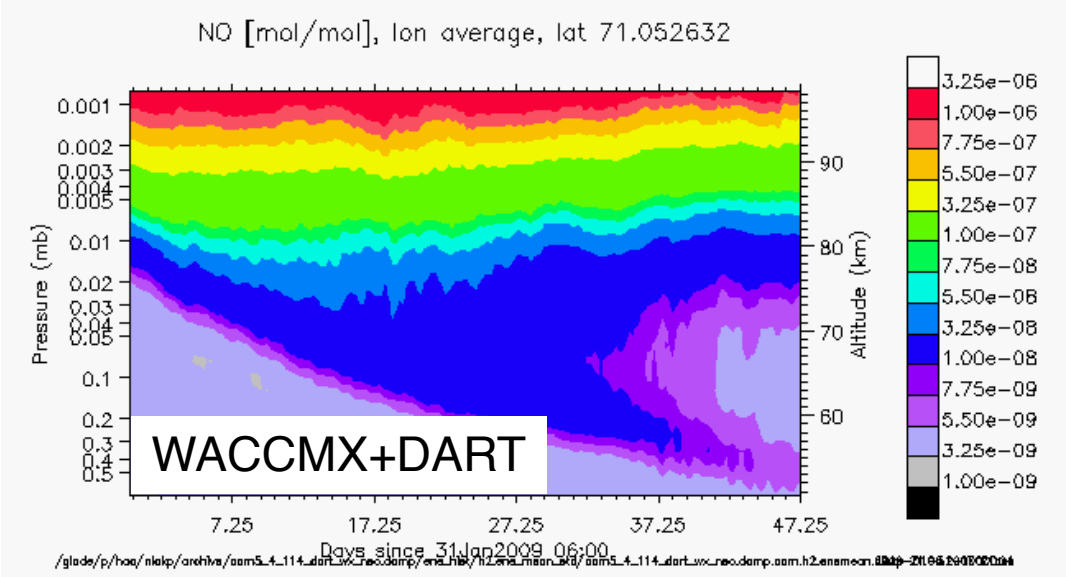


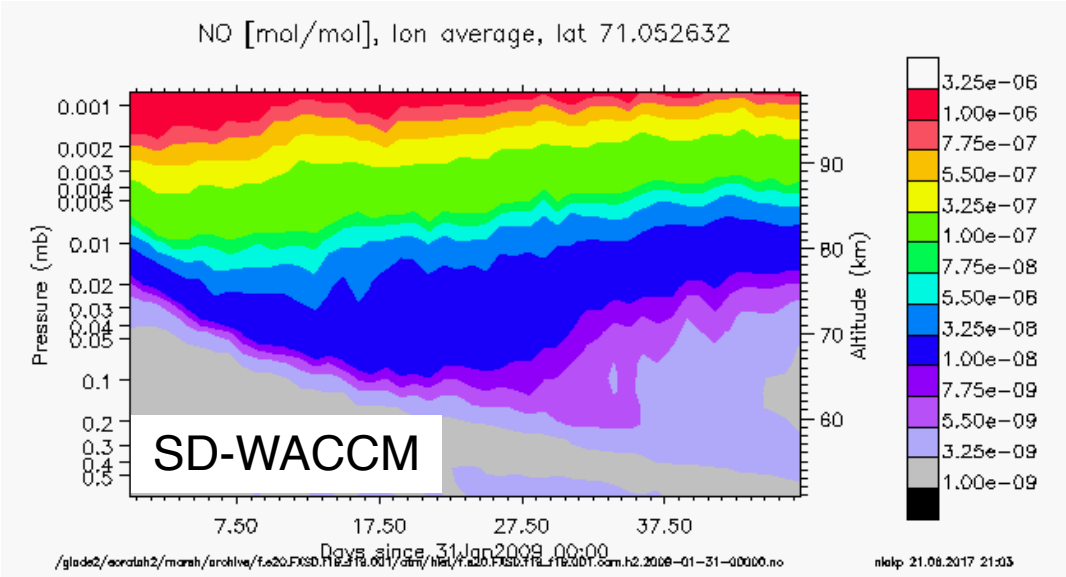



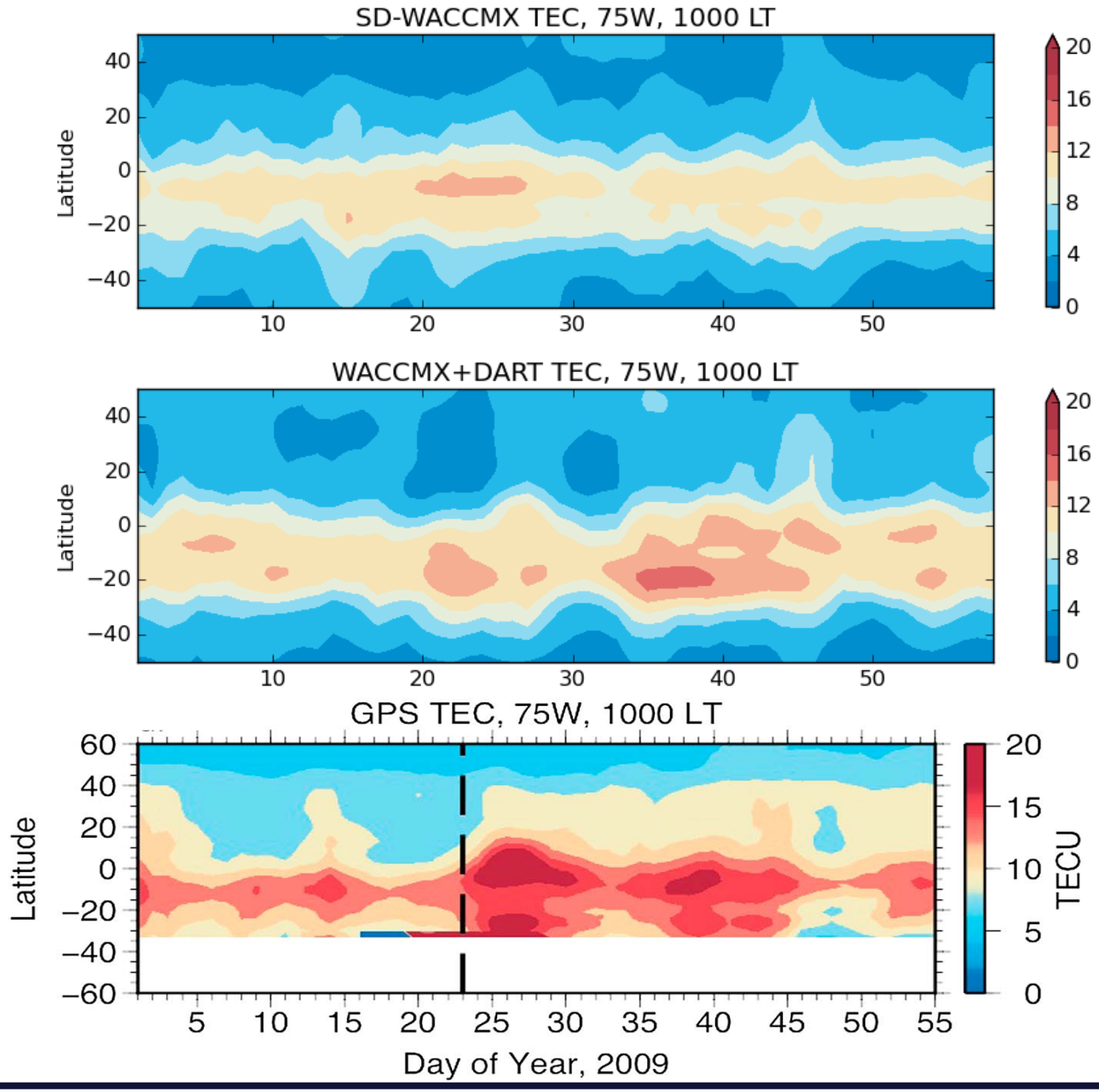



# Middle Atmosphere Variability in WACCMX+DART and SD-WACCMX

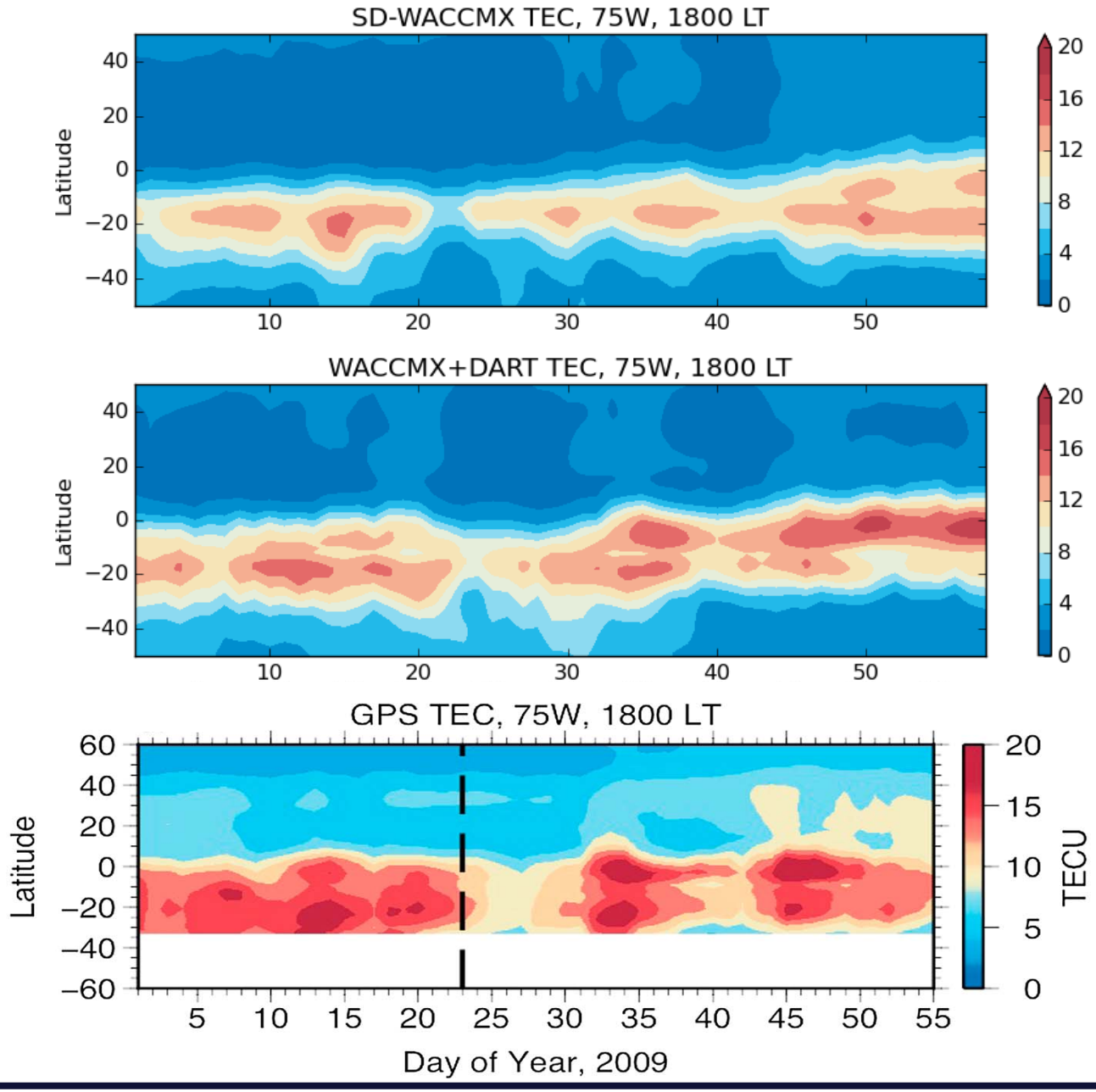


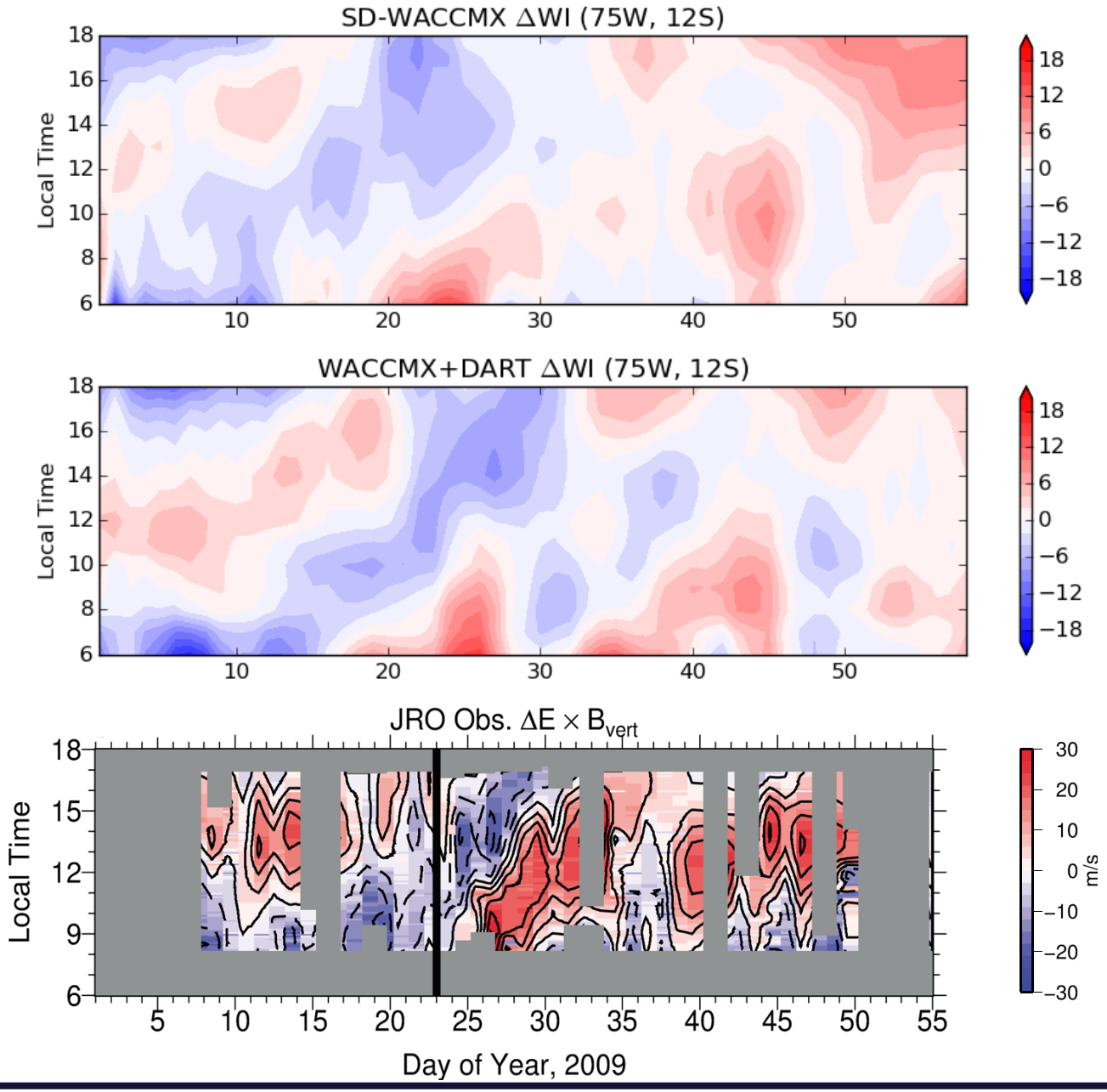
# GPS TEC Variability in WACCMX+DART and SD-WACCMX



# GPS TEC Variability in WACCMX+DART and SD-WACCMX



# **E** x **B** Drift Variability in WACCMX+DART and SD-WACCMX



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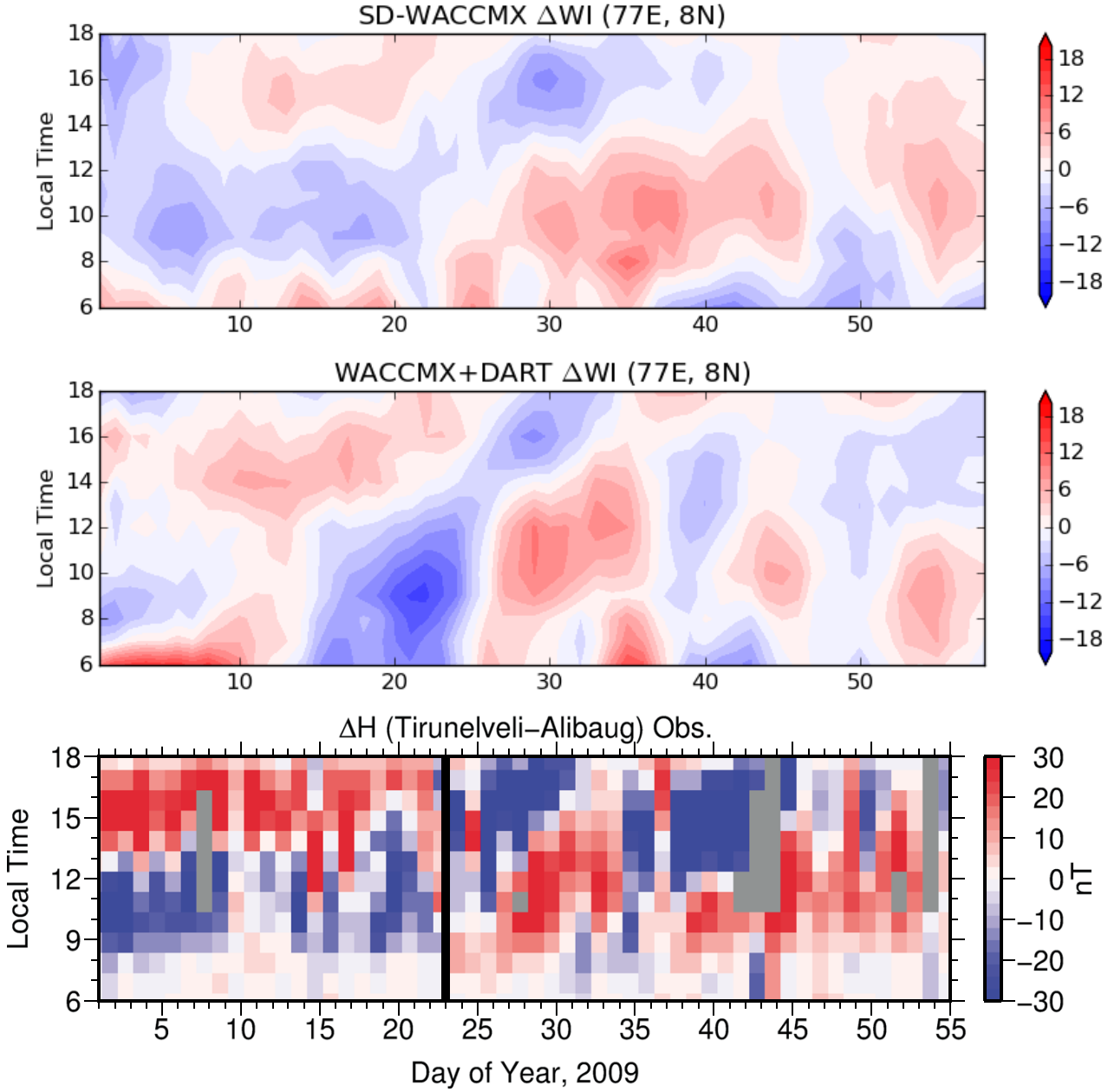

# Summary

Recent developments in WACCMX support whole atmosphere data assimilation, providing a global view of the troposphere, stratosphere, mesosphere, thermosphere, and ionosphere state

Currently WACCMX+DART can assimilate lower and middle atmosphere observations.

We are planning to implement assimilation of ionosphere-thermosphere observations (COSMIC electron density, ground-based GPS TEC, ICON, GOLD, …) in the near future.

Assimilation of upper atmosphere observations into WACCMX+DART has the potential to provide new insights into the ionosphere-thermosphere system

- Self consistently combines different observations that are spatially and temporally distributed.
- Can provide information about fields that are not directly observed
- Provides global view of the ionosphere-thermosphere driven by both lower atmosphere forcing and solar/geomagnetic variability.

WACCMX+DART requires code modifications to the standard CESM2.0 release. These are available from nickp@ucar.edu