Data Assimilation in the Whole Atmosphere Community Climate Model

Nick Pedatella

Collaborators: Hanli Liu, Kevin Raeder, and Jeffrey Anderson

1High Altitude Observatory, National Center for Atmospheric Research
2Institute for Mathematics Applied to Geosciences, National Center for Atmospheric Research
Outline

• Motivation
• Data Assimilation and Research Testbed (DART)
• Results:
  - Synthetic Observation Case
  - Real Observation Case
• Summary and Conclusions
Motivation: Why Data Assimilation?

- Current approach to simulate real events in WACCM is by nudging WACCM to external reanalysis (MERRA, NOGAPS-ALPHA, etc.):
  - Some control is lost due to using an external model as the ‘truth’
  - Typically nudge only up to ~60-70 km, potentially resulting in missing information above this altitude
  - Not entirely clear how well tides are reproduced given the potentially coarse temporal resolution of the analysis
- Including a data assimilation scheme directly in the WACCM should provide a better representation of the real atmospheric state
- In addition to dynamics, many other potential uses of DA:
  - Assimilation of chemical species
  - Parameter estimation
  - Ionosphere and upper atmosphere applications
- Ensemble Kalman filter developed and distributed by NCAR/IMAGe
- Used for numerous applications (CAM, TIE-GCM, WRF)
- ‘Easily’ adapted to different models
Implementation of DART with WACCM

- Almost entirely based on the framework developed for CAM/DART
- Uses the CESM multi-instance capability to run N-members of WACCM simultaneously
- Standard lower atmosphere observations and TIMED/SABER observations of the middle/upper atmosphere are assimilated
- Assimilation performed every six hours
- Preliminary experiments run from 1 Nov. 0UT to 10 Nov. 0UT:
  - Synthetic observations obtained by sampling a known model state
  - Real observations
- For a 40 member ensemble, one simulated day requires ~400 core hours on Yellowstone
  - Computational expense likely limits studies that are on the order of weeks
Outline

• Motivation
• Data Assimilation and Research Testbed (DART)
• Results:
  - Synthetic Observation Case
  - Real Observation Case
• Summary and Conclusions
Temperature Root Mean Square Error at 500 hPa

1 November, 0UT

2 November, 0UT

6 November, 0UT

10 November, 0UT
Error remains in poorly observed regions.
Temperature Root Mean Square Error at 0.01 hPa without SABER observations

Error reduction due to lower atmosphere observations.
Temperature Root Mean Square Error at 0.01 hPa with SABER observations

1 November, 0UT

2 November, 0UT

6 November, 0UT

10 November, 0UT

Region with no SABER observations
Outline

• Motivation

• Data Assimilation and Research Testbed (DART)

• Results:
  - Synthetic Observation Case
  - Real Observation Case

• Summary and Conclusions
RMSE and bias relative to radiosonde observations

CAM
80 member ens.
Results from K. Raeder

WACCM
40 member ens.

data file: /glade/scratch/nickp/archive/waccm_40mem_realobs
RMSE relative to radiosonde observations

CAM
80 member ens.
Results from K. Raeder

WACCM
40 member ens.

500hPa, North America

- CAM: 80 member ensemble
- WACCM: 40 member ensemble

RMSE values for different regions:
- Northern Hemisphere
- Southern Hemisphere
- Tropics
- North America

Data file: /glade/scratch/nickp/archive/waccm_40mem_realobs

RMSE values shown for each day from 11/01 to 11/10, 2008.
Error relative to NCEP 500hPa geopotential height

2 November, 0UT

4 November, 0UT

7 November, 0UT

10 November, 0UT

km

0.2

0.1

0.0

-0.1

-0.2
• The DART has been used to add the capability of data assimilation to the WACCM.
• Currently can assimilate a full set of lower atmosphere observations and middle/upper atmosphere temperature from SABER.
• Preliminary results demonstrate the potential of the data assimilation in the WACCM, and future studies are planned.
• WACCM will hopefully become part of the DART standard release, providing anyone interested the option to perform data assimilation.