Status of a CAM5.5 Reanalysis for CESM Research

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AMWG Feb 2016
Outline

Working backwards...

6) Future Work
5) End Uses
4) Summary
3) End Products
2) Preliminary results
1) Implementation
Why is the new 1 degree CAM5.5 assimilation not better than the 2 degree CAM4?

Is this the CAM we should use in a reanalysis?
End Uses of the Reanalyses

- Ensemble Data Assimilation with CLM, POP, (CICE, ...)
  - are forced by the atmosphere at the surface,
  - need forcing by an ensemble of atmospheric analyses to maintain ensemble spread
    - prevents rejection of legitimate observations
    - represents model (and atmospheric) uncertainty
- The 2 degree CAM4 forcing data set has been used extensively
- Many researchers would like an updated forcing data set.
Interfacing with DART in a “Single-component” DA, Uncoupled Framework
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- Ensemble Forecasting
  - Study specific, actual events
  - CAM, CLM, POP, coupled, ...
Reanalysis Q 600 hPa 2010/9/1 00Z

2 degree CAM4

1 degree CAM5.5

kg/kg
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- Ensemble Forecasting
  - Study specific, actual events
  - CAM, CLM, POP, coupled, ...
  - Sensitivity analyses;

- Model evaluation
  - Biases relative to a variety of observation types
  - Variability; a measure of expected short term model error
Summary

+ Can do CAM5.5 ensemble data assimilation in a CESM1_5 environment.
+ There will be an up-to-date ensemble of forcing and analyses for CESM and DART research and evaluation.
+ New forcing should be easier to generate and use than the 2 degree CAM4.
+ DART/multi-instance capability is increasingly being incorporated into CESM testing.
+ 1 degree CAM5.5 is not worse, overall, than the 2 degree CAM4 reanalysis.

- 1 degree CAM5.5 is not better, overall, than the 2 degree CAM4 reanalysis.
- Results are not available now, and may need to wait for a released CESM.
- Or we may need to use an older CAM to get results sooner.
End Products

① Ensemble of 'data atmosphere’ forcing for other components to use.
  ✓ 8 times/day
  ✓ Stored in coupler history (.ha.) files, ready for use in CESM
  ✓ Consistent with both observations and CAM
  ✓ Uniform coverage in space and time
  ✓ Realistic range of forcing for POP, CLM, ... data assimilation experiments
  ✓ 80 members (“instances”)
  ✓ CAM5.5-FV (CLUBB, CLM4.5, 4th-order divergence damping)
  ✓ 0.25 degree, daily SST from AVHRR, instead of 1 degree monthly interpolated in time
### a2xavg_ fields

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drof forcing needed for POP (Lindsay)
Each member is an equally likely representation of the atmosphere, given the observational network and errors, and the model uncertainty.
Member 2-1, Temperature

Prior ensemble state

Range of Temperature: -25 to 25 K
Range of longitude: 0 to 358.75 degrees_east
Range of latitude: -90 to 90 degrees_north

Current time: 149627 days since 1601-01-01 00:00:00

Frame 1 in File cam_Prior_Diag.2010-09-01-00000.mem2-1.T30.nc

raeder Mon Feb  8 20:44:54 2016

K
End Products

② Ensemble Reanalyses of Fundamental Model Variables

✓ PS, T, US, VS, Q, CLDLIQ, CLDICE, (...?)
✓ 4 times/day
✓ 2010-2015 planned, but not paid for.
③ Extended Set of Reanalysis Variables

- CAM restart and initial files
- CLM, CICE, and RTM restart files
- CPL restart file (51 Gb due to 80 member ensemble)
- several times/month (? advice is welcome.)
End Products

④ History files?

- Users have requested Z3, RELHUM, OMEGA, CLW, CLI, CONCLD, CLOUD.
- Daily frequency or 6 hourly.
- As many years as possible. 2010-2015 is the current plan.
- It may be more practical to re-run a period of interest and write out the specific variables needed for a study.
- Other ideas?
Preliminary Results: Biases

Differences between 6 hour forecast bias magnitudes, relative to observations, from the new assimilation and the 2 degree, CAM4 assimilation from 2010.

Blue = new is better. Red = new is worse. × = insufficient observations

August 15-31, 2010, of both cases.
Preliminary Results: RMSE

Differences between the RMSE, relative to observations, of the new assimilation and the 2 degree, CAM4 assimilation from 2010. Blue = new is better. Red = new is worse. × = insufficient observations
Preliminary Results: Comments

Assimilation appears to be working correctly.
No overall improvement compared to the 2 degree CAM4 assimilation from 2010.
This is contrary to the operational centers’ experience.
We're looking for ideas about why this is the case.

Some ideas

Go backward:
- Change resolution to 2 degree and keep the rest the same
- Then successively replace pieces of CAM5.5 with CAM4 equivalents
  a) CLUBB
  b) UW PBL
  c) diffusion (4th order divergence $\rightarrow 2^{nd}$)
  d) We don’t have the CAM expertise (or computing time) to take this very far.
- Consider using an older CAM for this reanalysis, if we want to do it this year.

Go forward: with a CESM that has been tested and tuned enough to generate confidence that it is likely to be accepted as the next release.
Implementation

I was able to get an assimilation running by
• settling on cesm1_5_alpha02d, with small pieces imported from subsequent tags,
• creating a new 'resolution'; combining the 0.25 degree SST set with 1 degree CAM-FV
• adding scripting to handle the massive amount of output, deleting much of it when it's no longer needed
• helping CSEG add scripting to CESM enabling successive short forecasts in a single job
• helping CSEG refine archiving strategy and scripts

CSEG and we are working towards making DART/multi-instance compatibility a standard part of CESM testing, so that DART can be used with very recent tags, with very little code work.
Reformat the coupler history files into year-long stream files and other useful forms. Feed them to C, D, G, I compset experiments.

Has all of the a2x fields for each instance of CAM averaged every 3(?) hours.

*Budget variables? ...?
Multi-instance CLM and CICE restarts, CAM initial files. drof needed by POP?

The Procedure

Obs

DART

Updated CAM States

Ensemble + mean state

Ensemble Forecast

Forecast

CESM (CAM)

Coupler History File (multi-instance)

Other files*

Is mean useful for forcing?

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Each member is an equally likely representation of the atmosphere, given the observational network and errors, and the model uncertainty.
Member 2-1,