Status of a CAM5.5 Reanalysis for CESM Research

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Support from:

CSEG: Bertini, Edwards, Vertenstein

DART: Anderson, Karspeck, Collins, Kershaw

CGD: Tomas, Bryan,Lauritzen, Tribbia

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Outline

Working backwards…

6) Future Work
5) End Uses
4) Summary
3) End Products
2) Preliminary results
1) Implementation

Questions We Hope to Answer Soon, with Input from CAM Experts

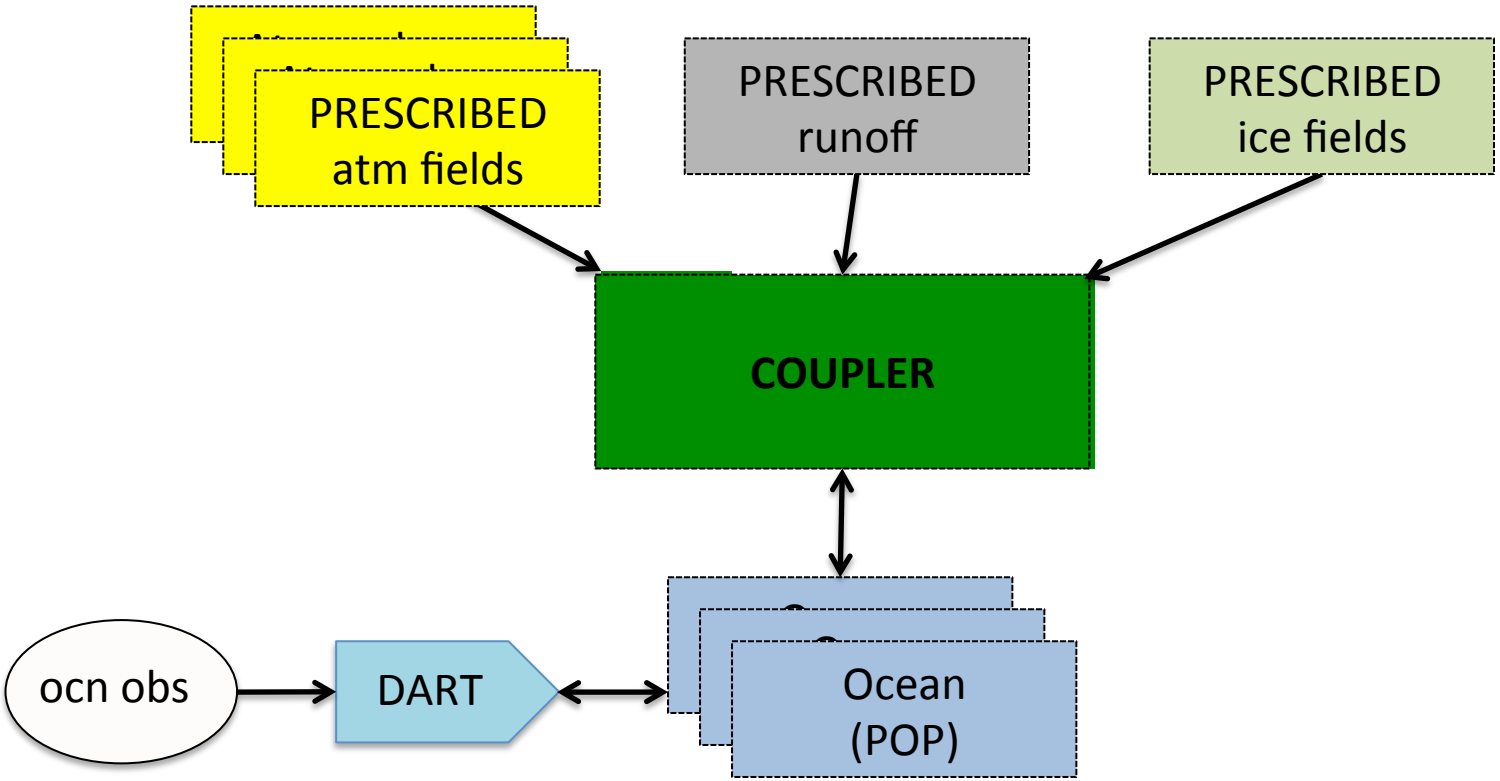
Why is the new 1 degree CAM5.5 assimilation not better than the 2 degree CAM4?

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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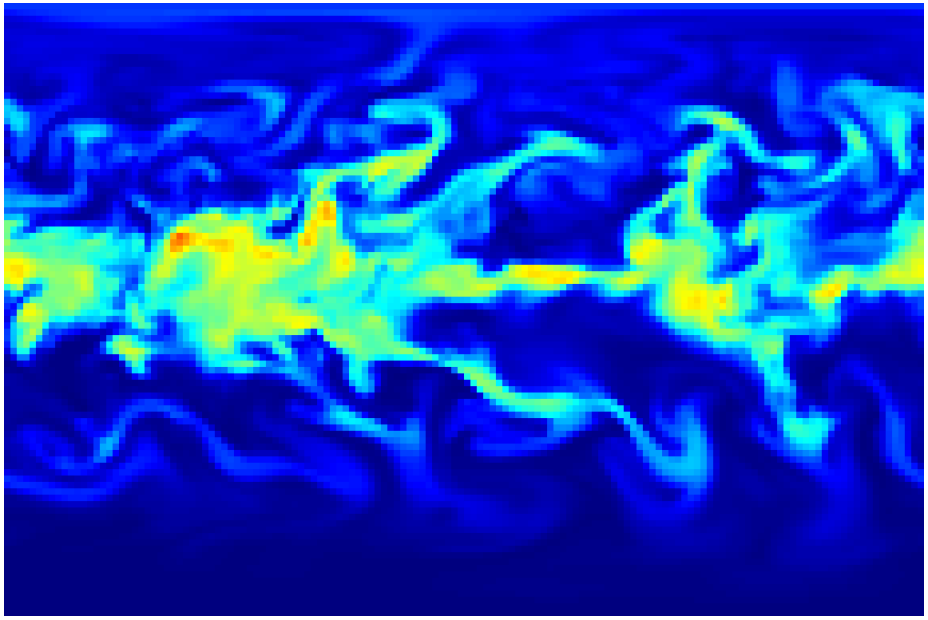
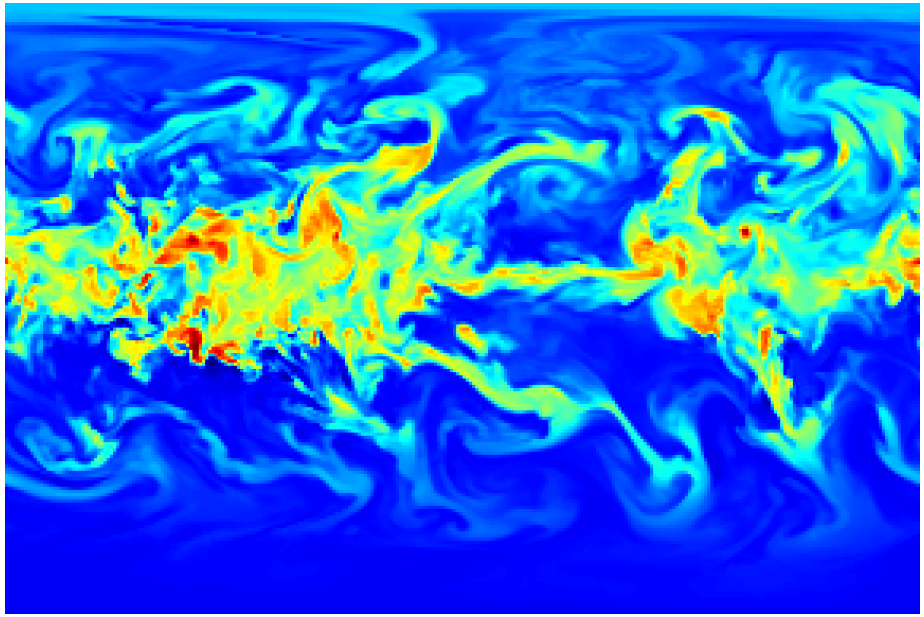
- Ensemble Forecasting
  - Study specific, actual events
  - CAM, CLM, POP, coupled, …

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, 4^{th}-order divergence damping)
- ✓ 0.25 degree, daily SST from AVHRR, instead of 1 degree monthly interpolated in time

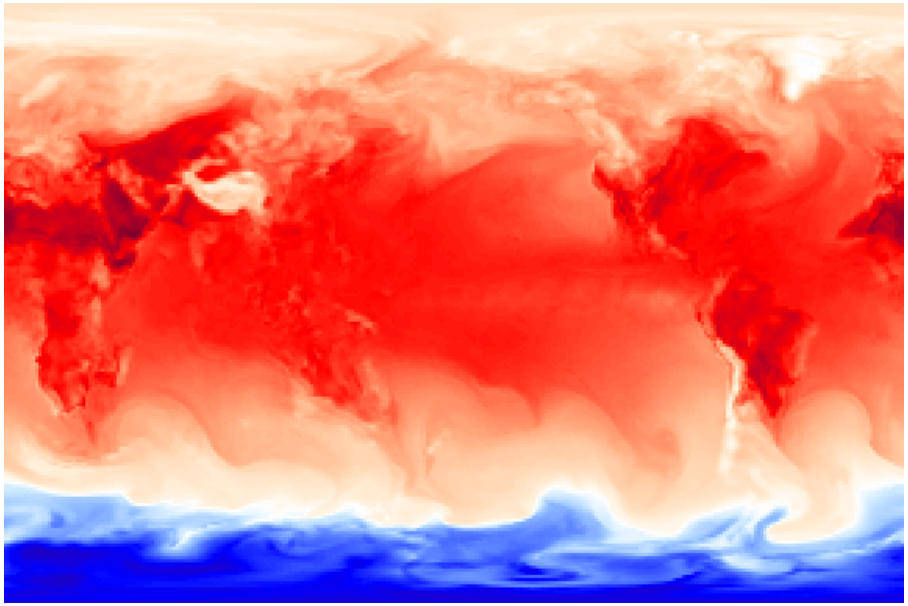
a2xavg_ fields

Meteorology	Radiation	Aerosols (for CICE? BGC later)
_Sa_z	_Faxa_lwdn	_Faxa_bcphidry
_Sa_u	_Faxa_swndr	_Faxa_bcphodry
_Sa_v	_Faxa_swvdr	_Faxa_bcphiwet
_Sa_tbot	_Faxa_swndf	_Faxa_ocphidry
_Sa_ptem	_Faxa_swvdf	_Faxa_ocphodry
_Sa_shum	_Faxa_swnet	_Faxa_ocphiwet
_Sa_pbot		_Faxa_dstwet1
_Sa_dens		_Faxa_dstwet2
_Sa_pslv		_Faxa_dstwet3
_Sa_co2prog		_Faxa_dstwet4
_Sa_co2diag		_Faxa_dstdry1
_Faxa_rainc		_Faxa_dstdry2
_Faxa_rainl		_Faxa_dstdry3
_Faxa_snowc		_Faxa_dstdry4
_Faxa_snowl		

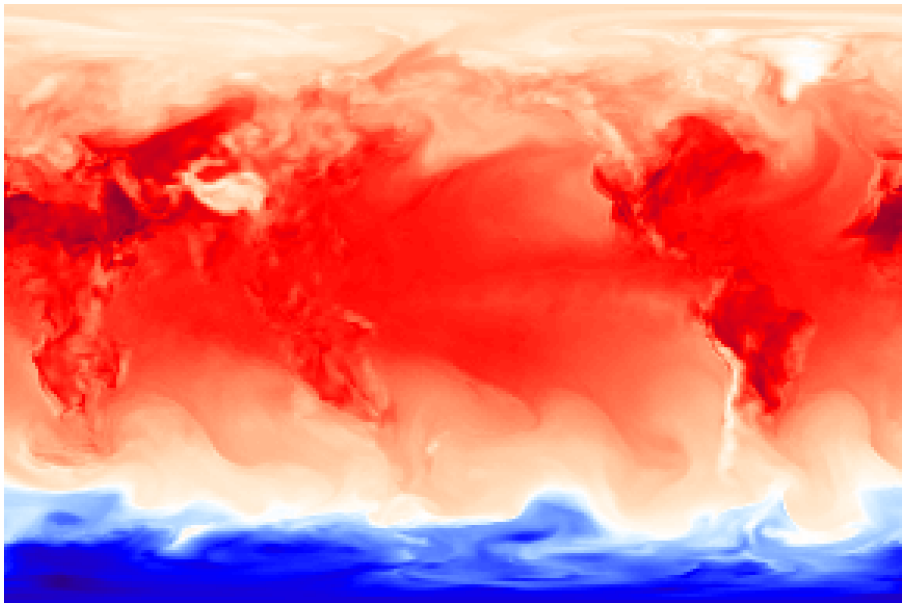
drof forcing needed for POP (Lindsay)

Ensemble Temperature Differences

Member 1, level 30



Member 2, level 30



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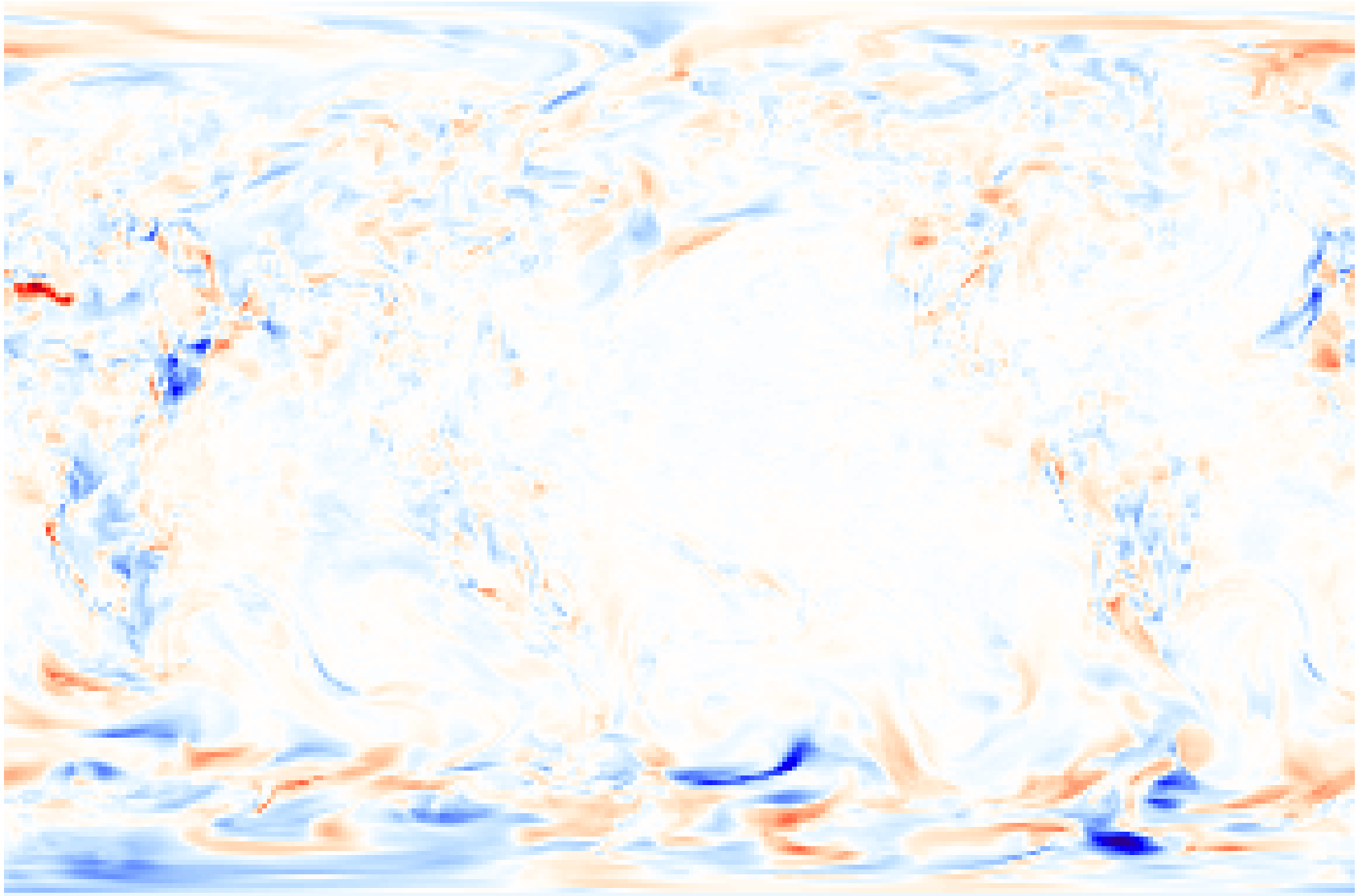
Each member is an equally likely representation of the atmosphere, given the observational network and errors, and the model uncertainty.

Member 2-1, Temperature



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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.

End Products

③ Extended Set of Reanalysis Variables

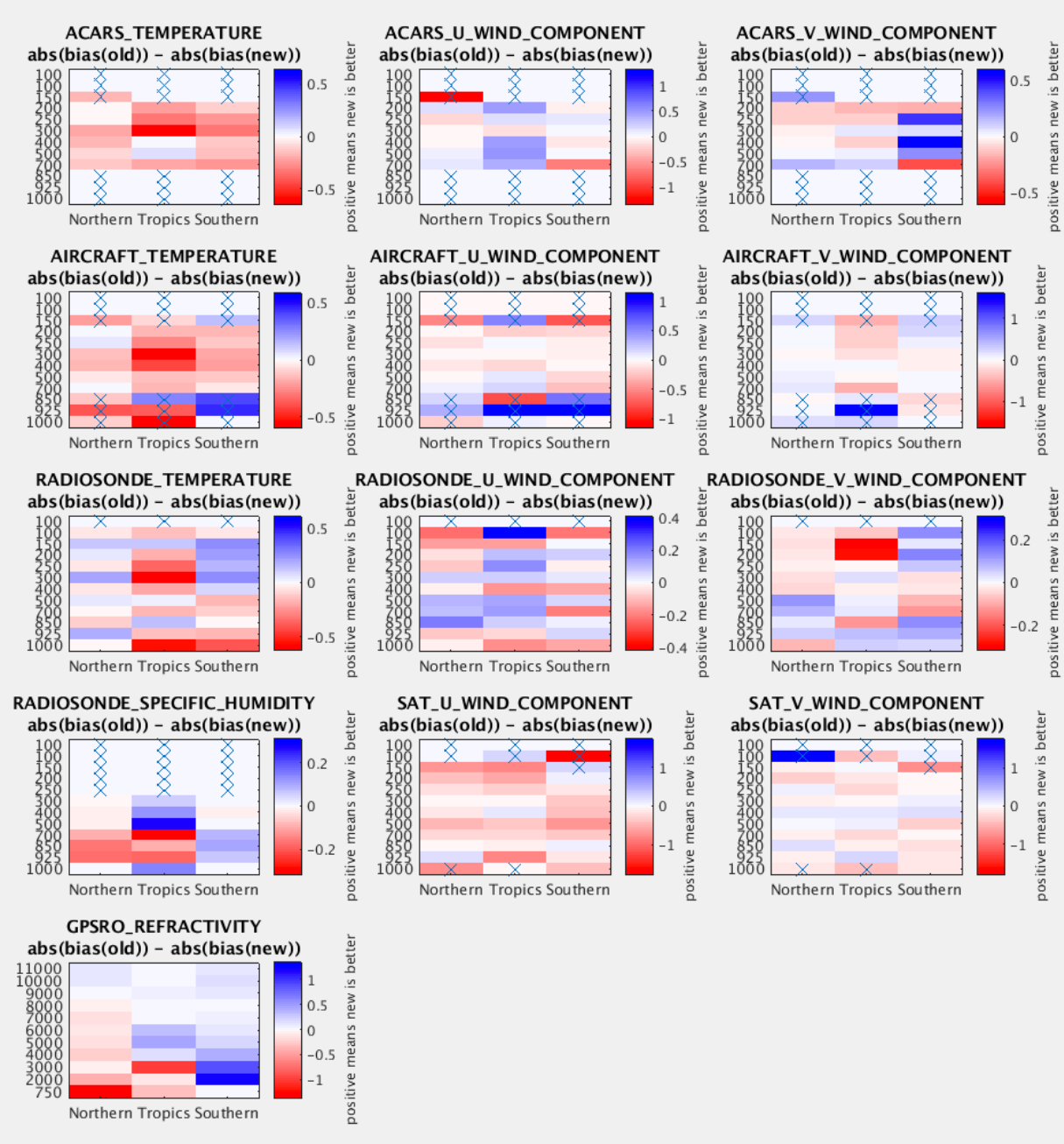
- ✓ CAM restart and initial files
- ✓ CLM, CICE, and RTM restart files
- ✓ CPL restart file (51 Gb due to 80 member ensemble)
- ✓ several times/month (? advice is welcome.)

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.

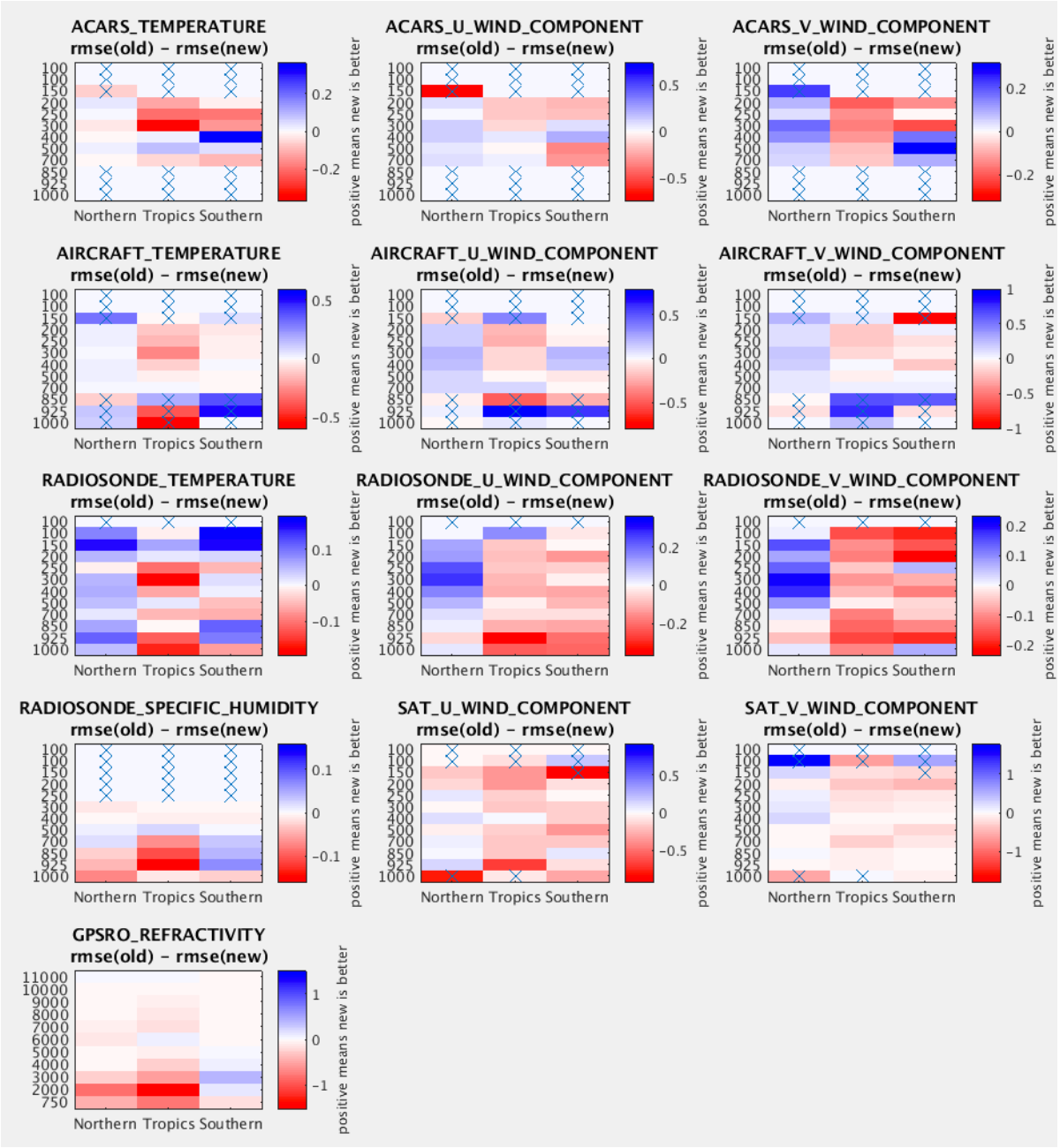
Blue = new is better.

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.

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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 (4^{th} order divergence -> 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.

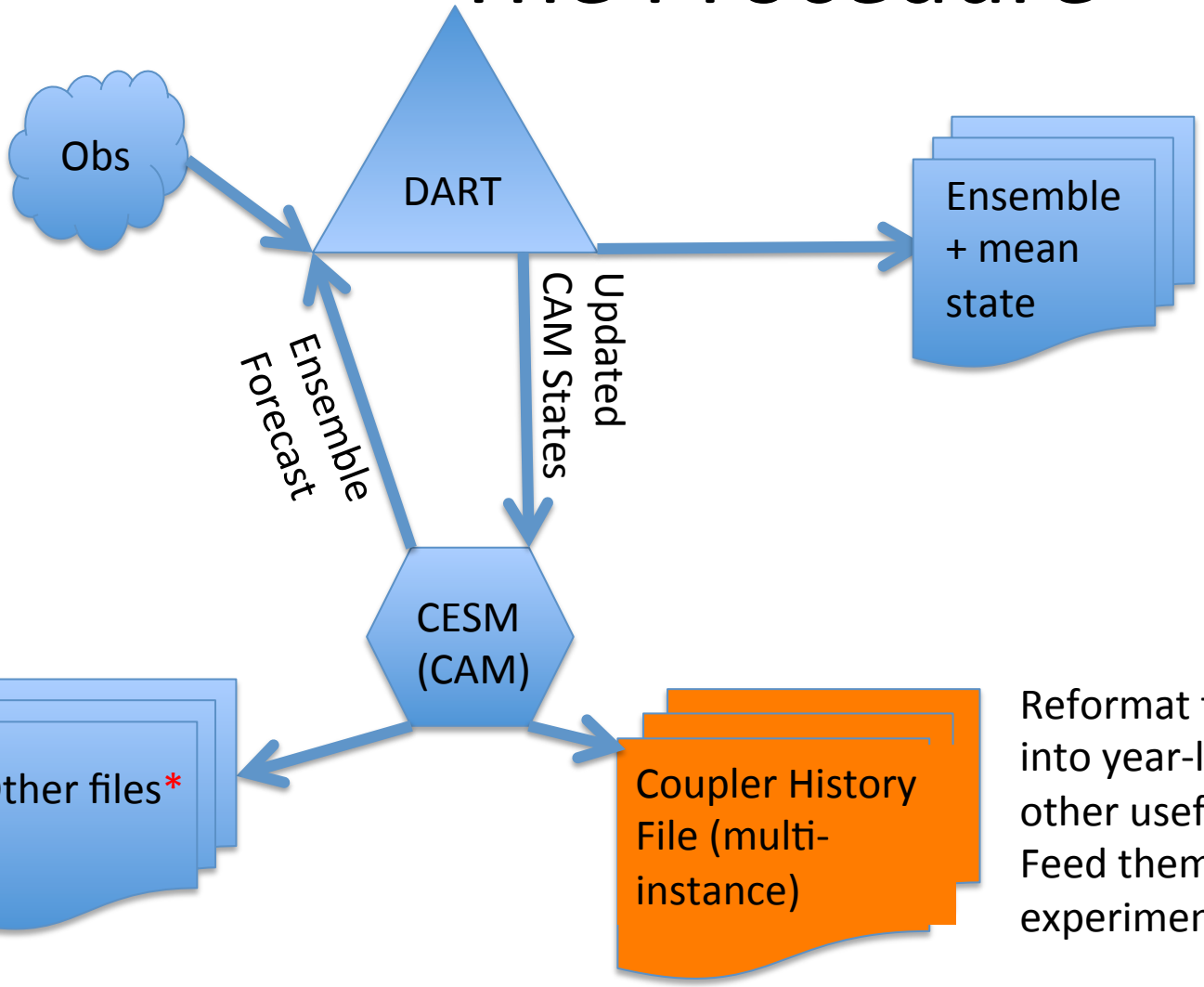
Implementation

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.

The Procedure



Is mean useful for forcing?

Reformat the coupler history files into year-long stream files and other useful forms.
Feed them to C, D, G, I compset experiments.

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

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

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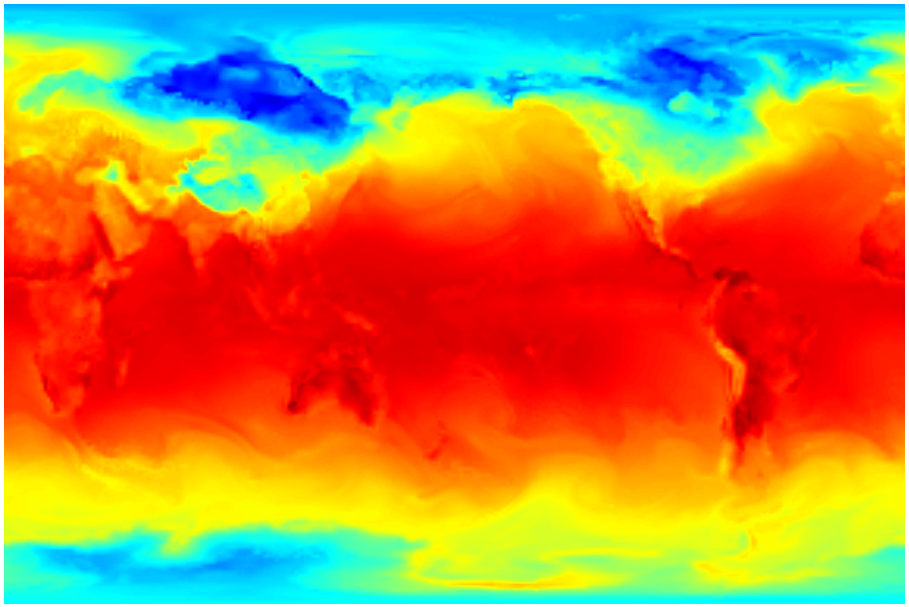

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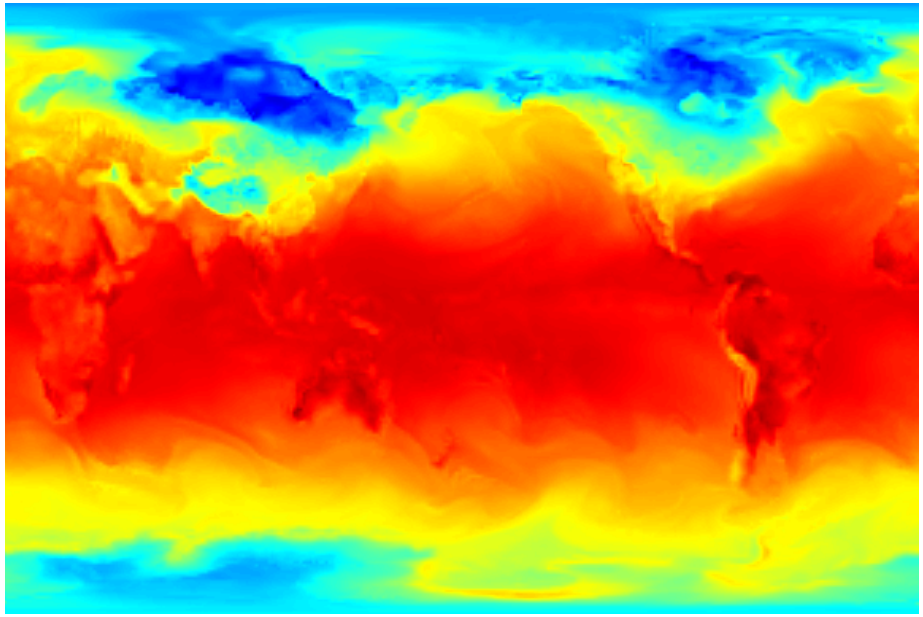

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