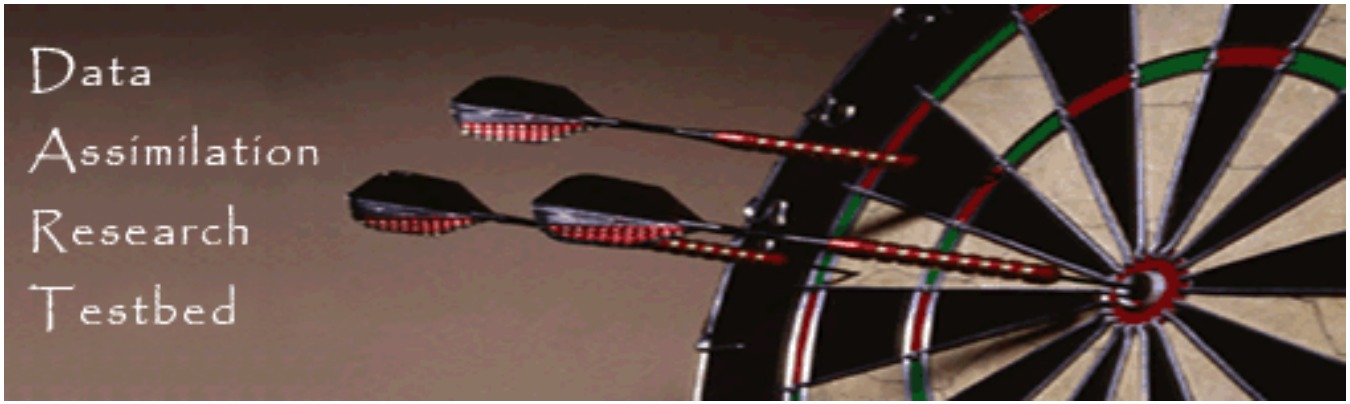
A Wishlist of CESM Capabilities for Support of Ensemble Data Assimilation with DART

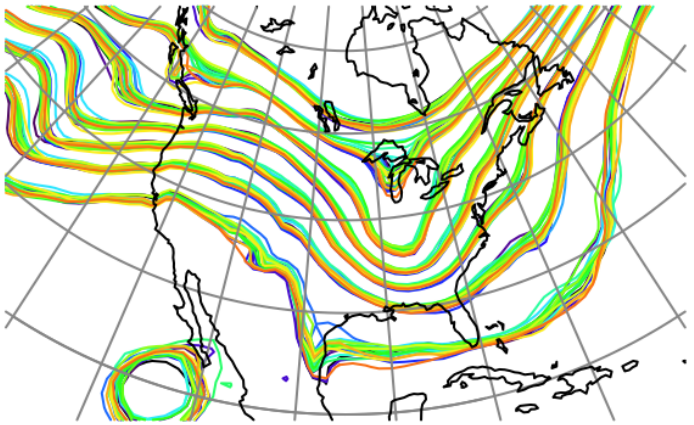


Jeff Anderson, Nancy Collins

NCAR Data Assimilation Research Section

What is Data Assimilation?

Observations combined with a Model forecast…



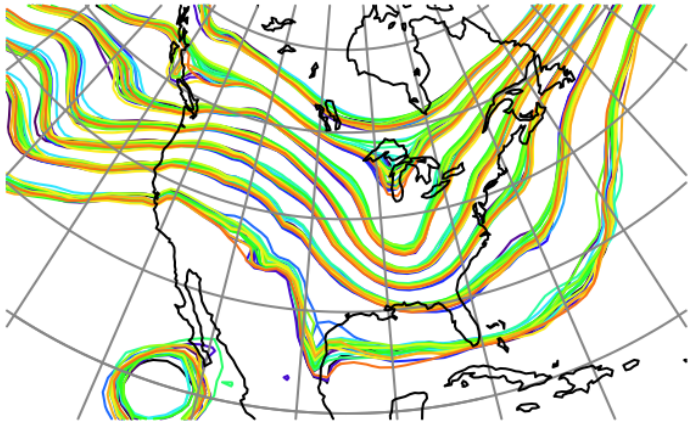
…to produce an analysis
(best possible estimate).

What is Data Assimilation?

Observations combined with a Model forecast…

+

Ensemble DA produces a set of 'equally-likely' analyses.



…to produce an analysis (best possible estimate).

What is a model?

A state machine;

- Given state x_t at time t,
- Some additional input f,
- A target time $t+\delta t$,
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Normally, we want the state (a vector) to be as small as possible
(Gridded u, v, T, ps, cloud liquid, cloud ice for CAM for instance).

Want to make forecasts of arbitrary lengths (6 hours, or even shorter).

Observation operators

To assimilate an observation y,
Must compute an estimate of its value given the model state,
$y_{est} = h(x_t)$.

Examples:

- Radiosonde temperature: just interpolate gridded T;

- AMSU A radiance: insert soil temperature, snow characteristics, atmospheric moisture, ice, temperature, and cloud profiles in radiative transfer model.

The Wishlist: What Assimilation needs from Model

Make forecasts of arbitrary lengths,
Modify the state and start a new forecast,
Compute any forward observation operator for any time
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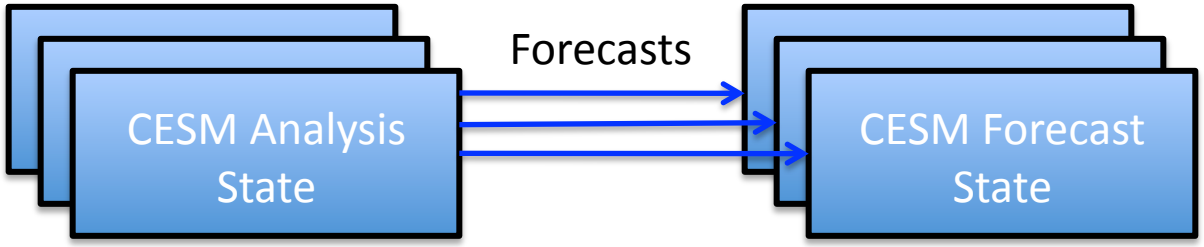
Need to do all of this for an ensemble of model states.

And we'd like it to run efficiently on any platform with any compiler.

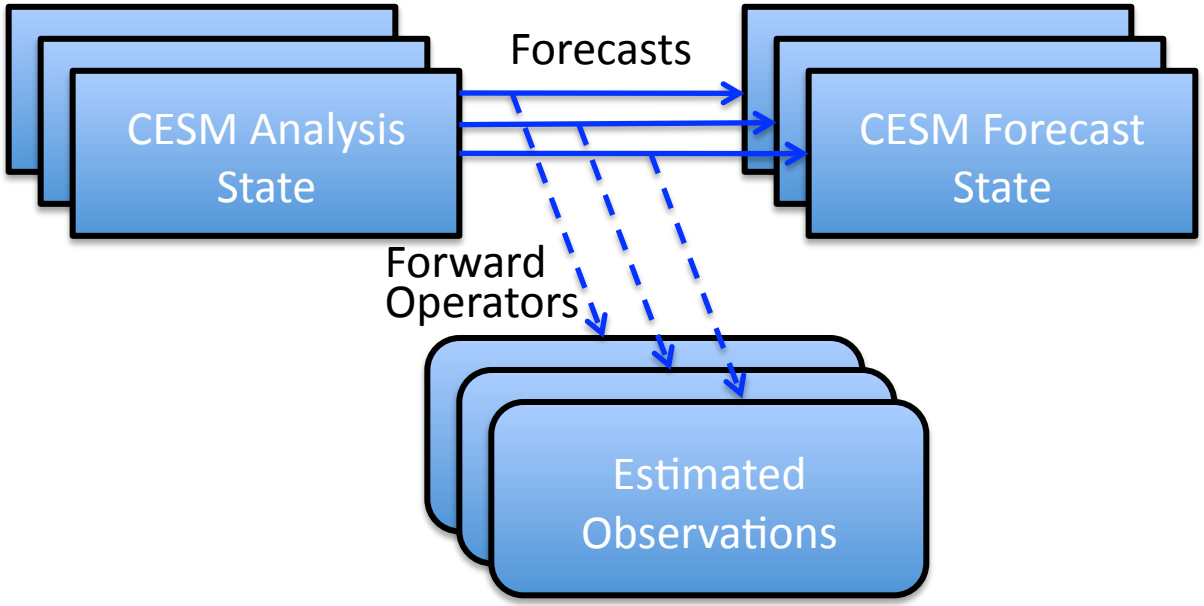
A Possible Assimilation Work Flow

1. CESM Model Makes Forecasts



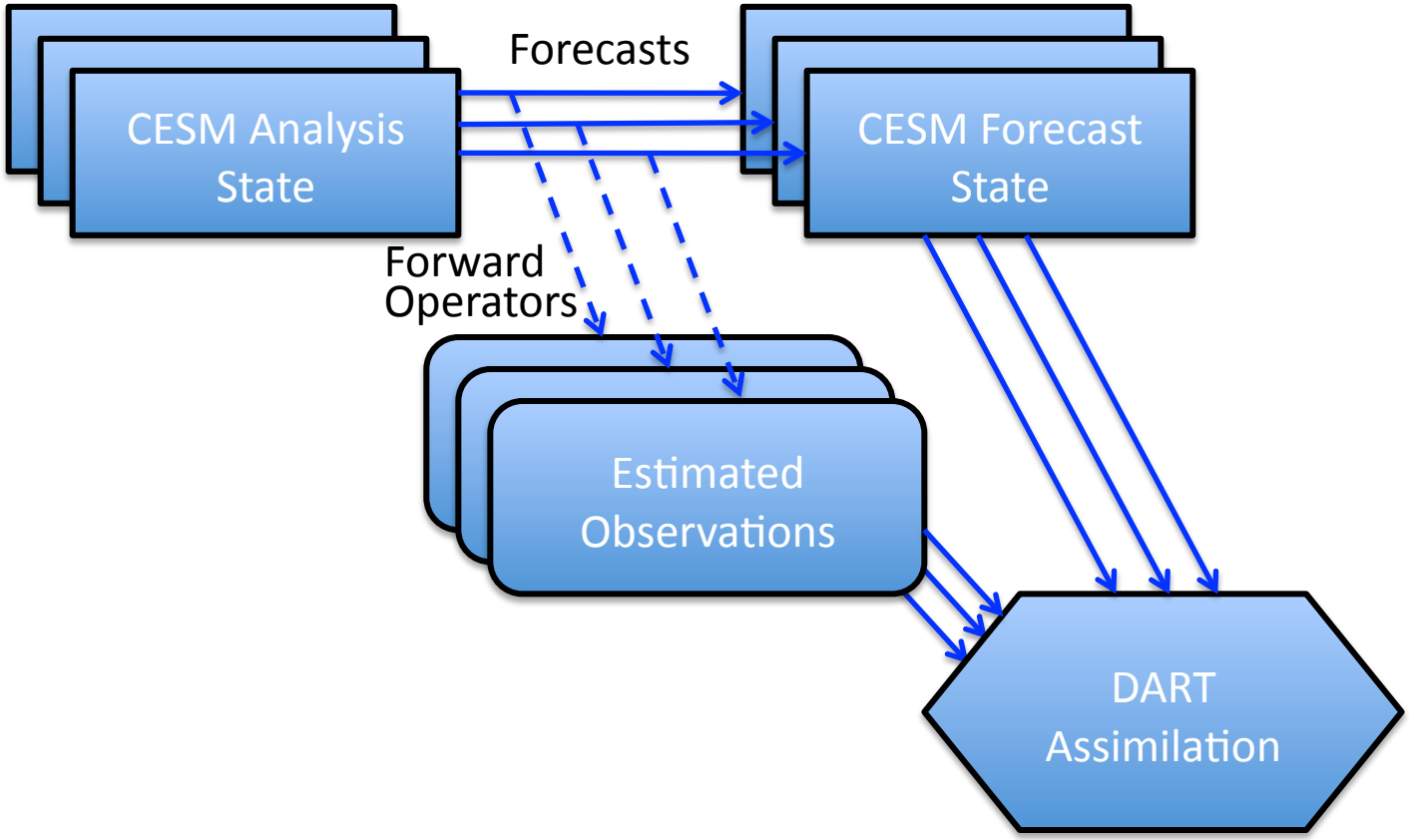
A Possible Assimilation Work Flow

2. CESM Model Also Computes Observations



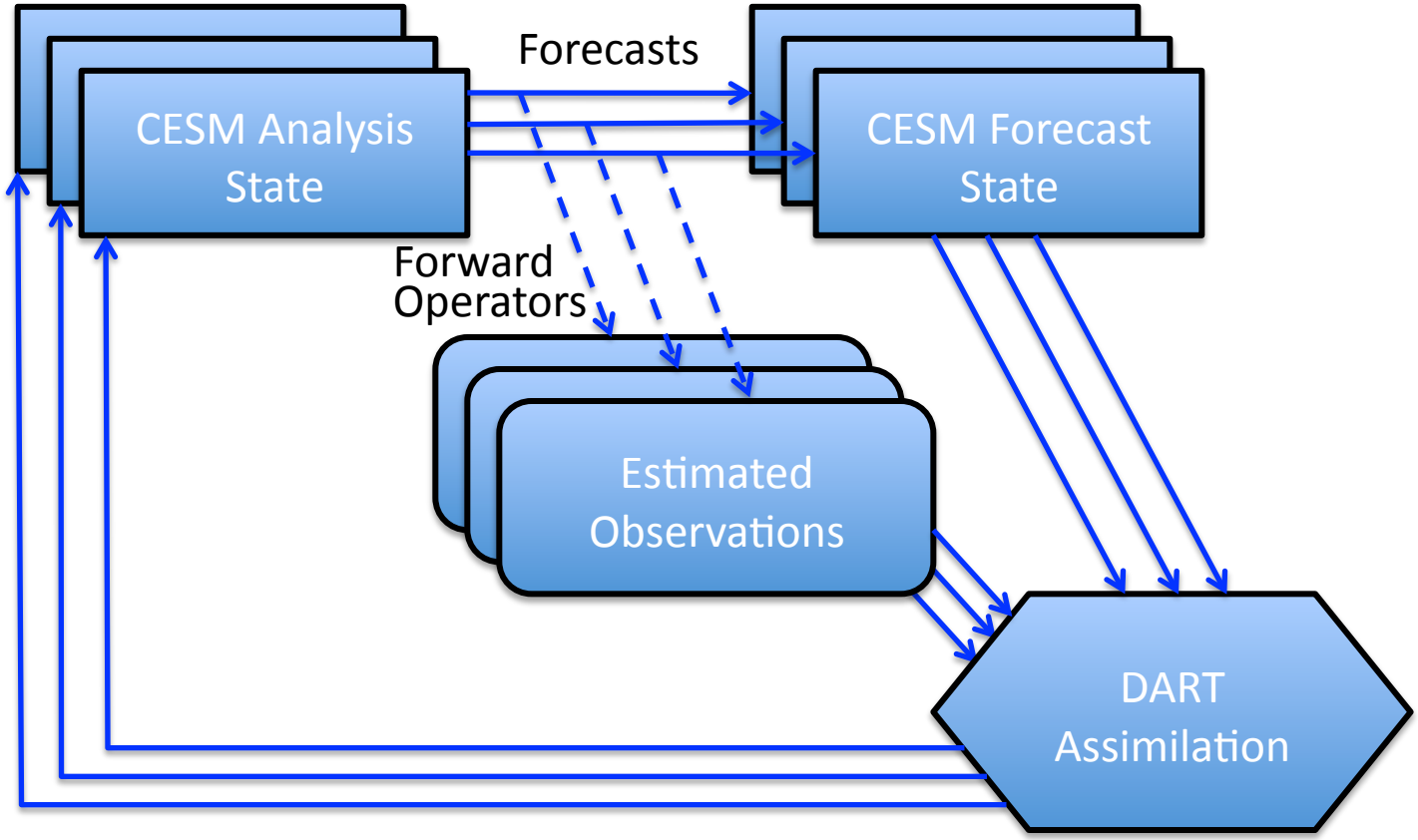
A Possible Assimilation Work Flow

3. DART gets forecasts, observations



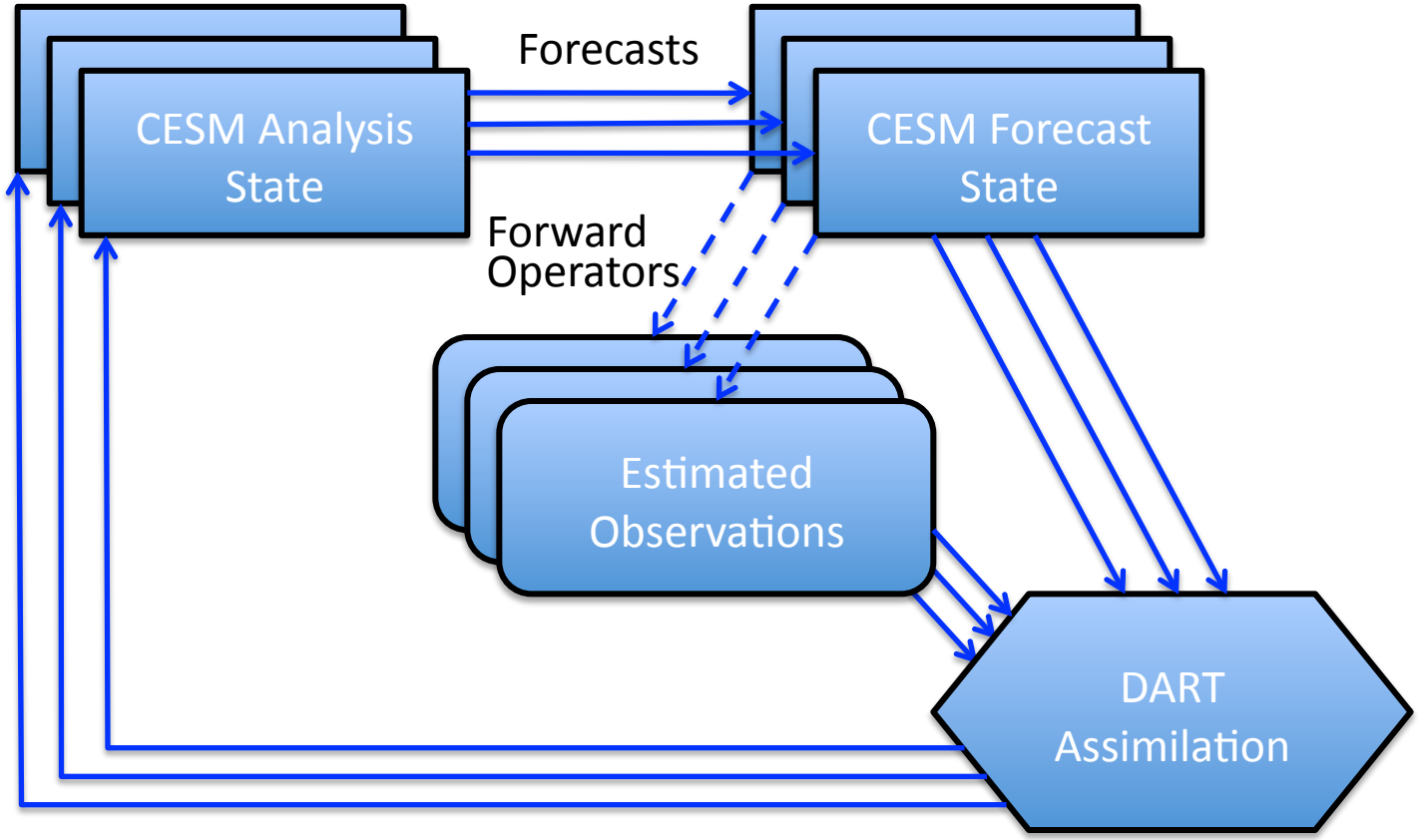
A Possible Assimilation Work Flow

4. DART creates CESM model analyses



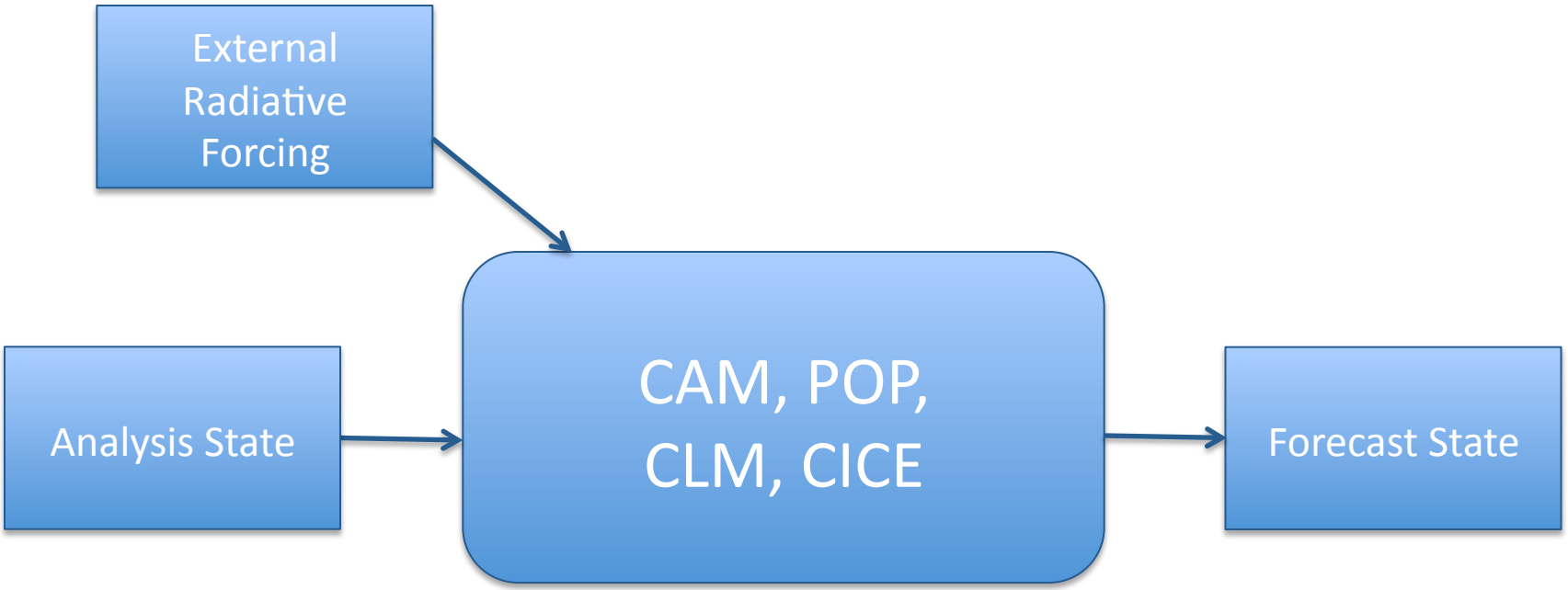
A Possible Assimilation Work Flow

For now, DART can make observations from state.



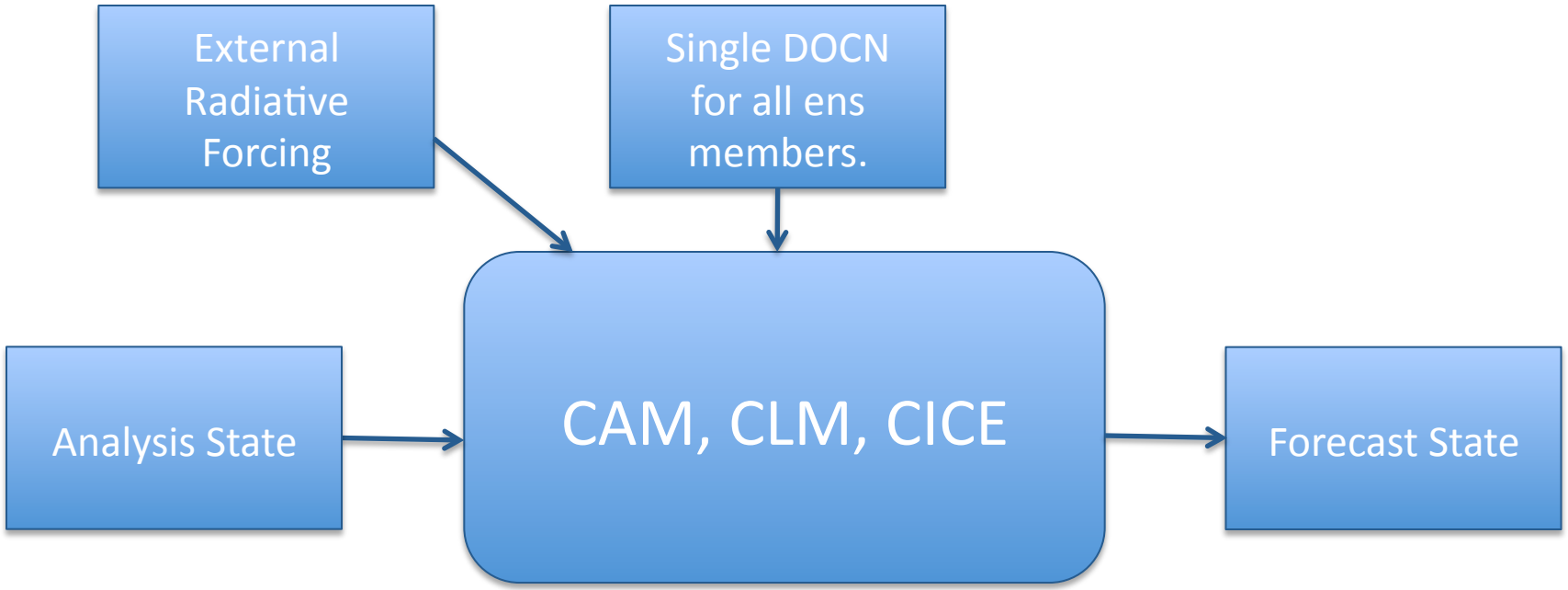
CESM Models For Assimilation

Model could be a full dynamical coupled system.



CESM Models For Assimilation

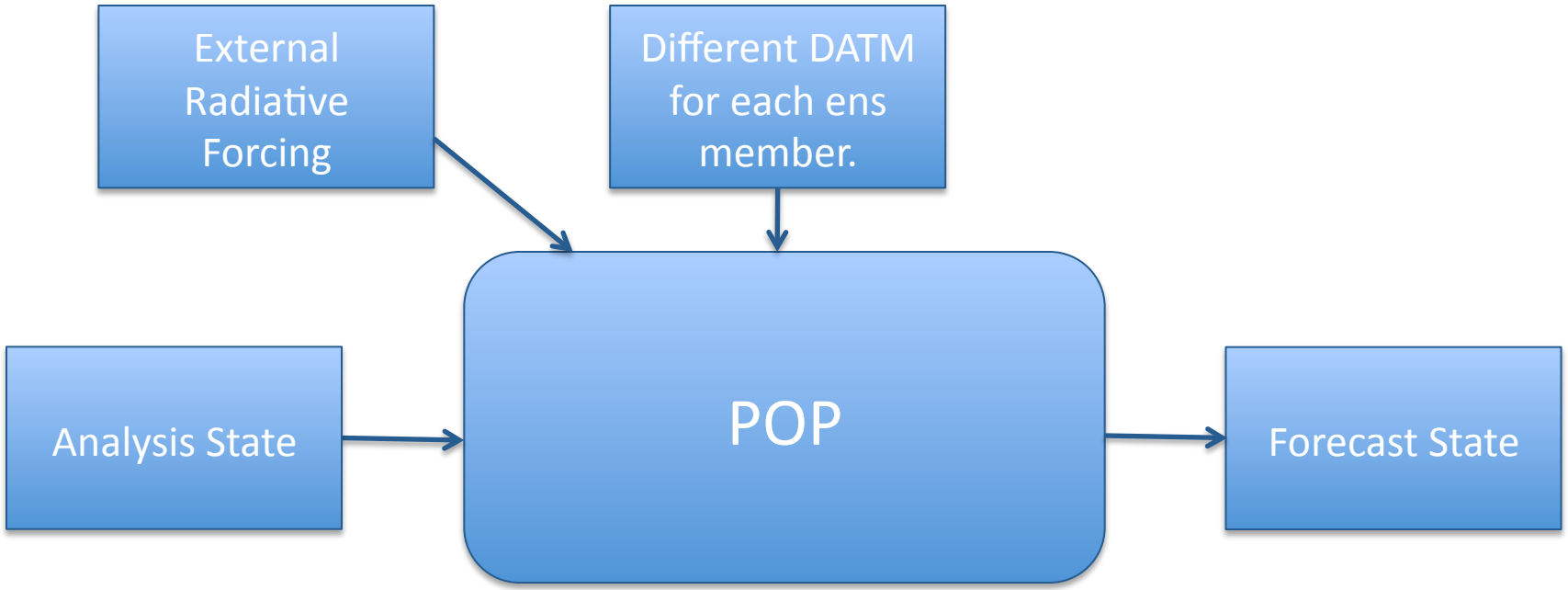
Model could be a subset of the coupled system with data forcing.



This configuration has been implemented for CAM 80-member reanalyses.

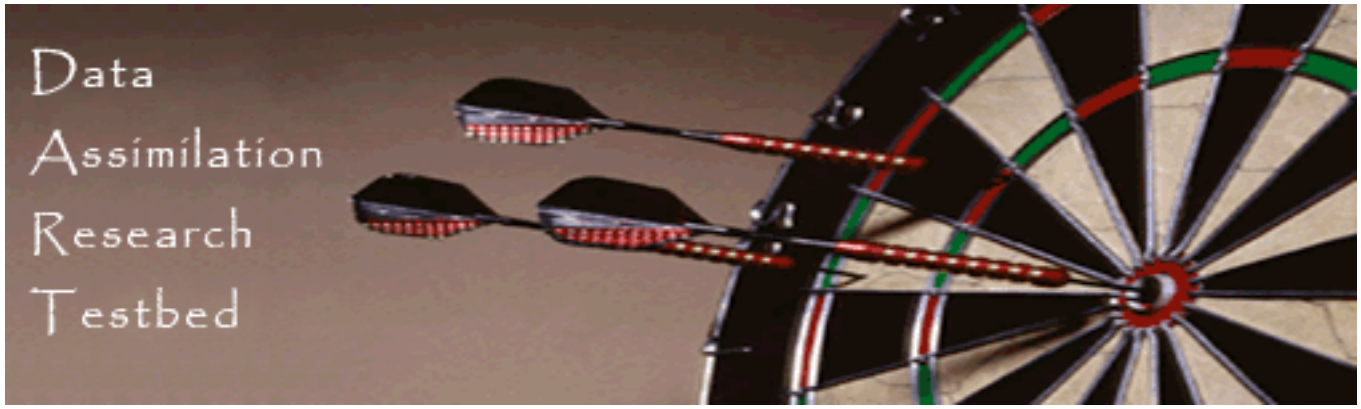
CESM Models For Assimilation

Model could be a subset of the coupled system with data forcing.



This configuration has been implemented for decadal prediction initial conditions.

Current Status



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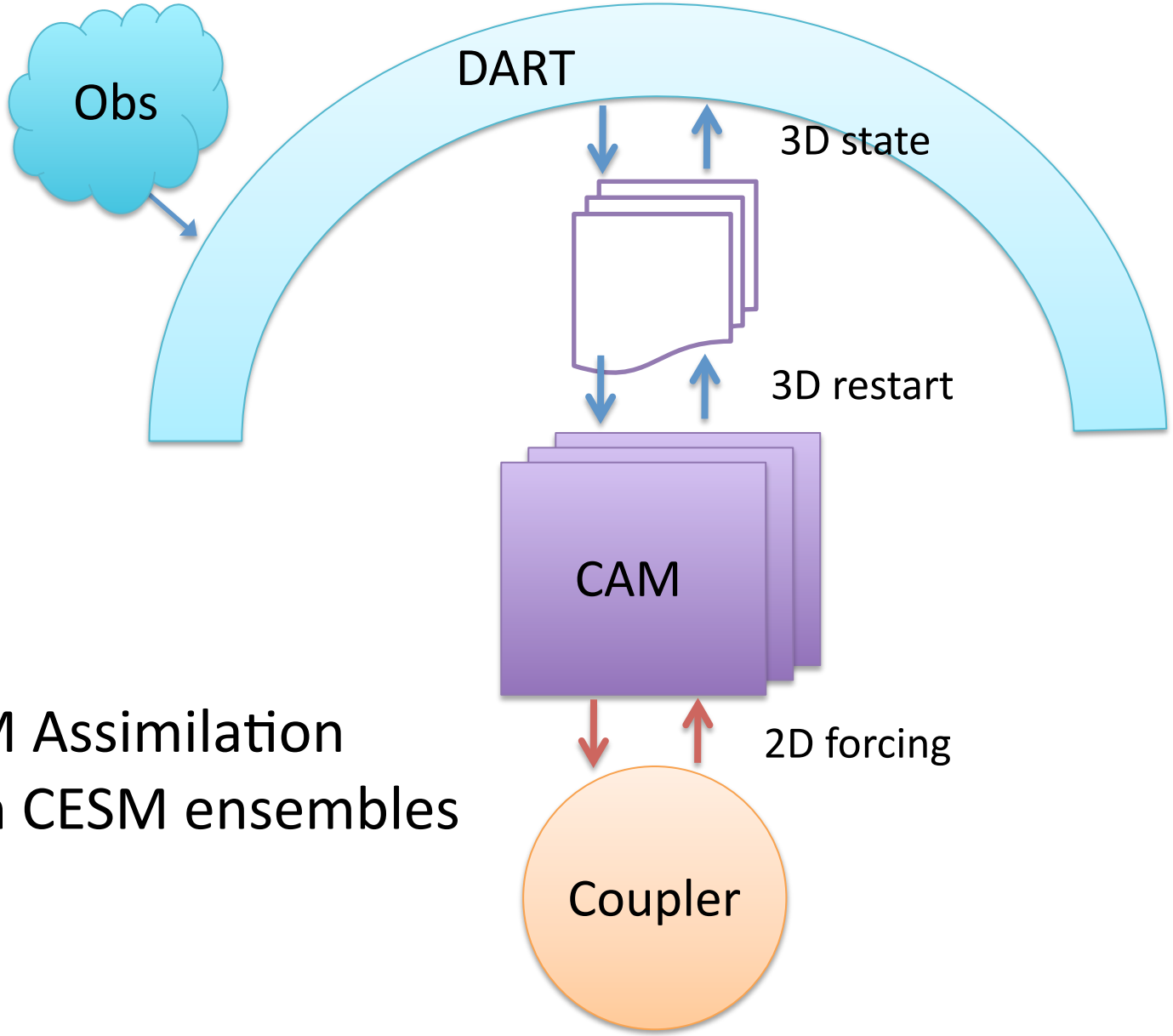
With thanks to the NSF PetaApps group
for the Interactive Ensemble Capability

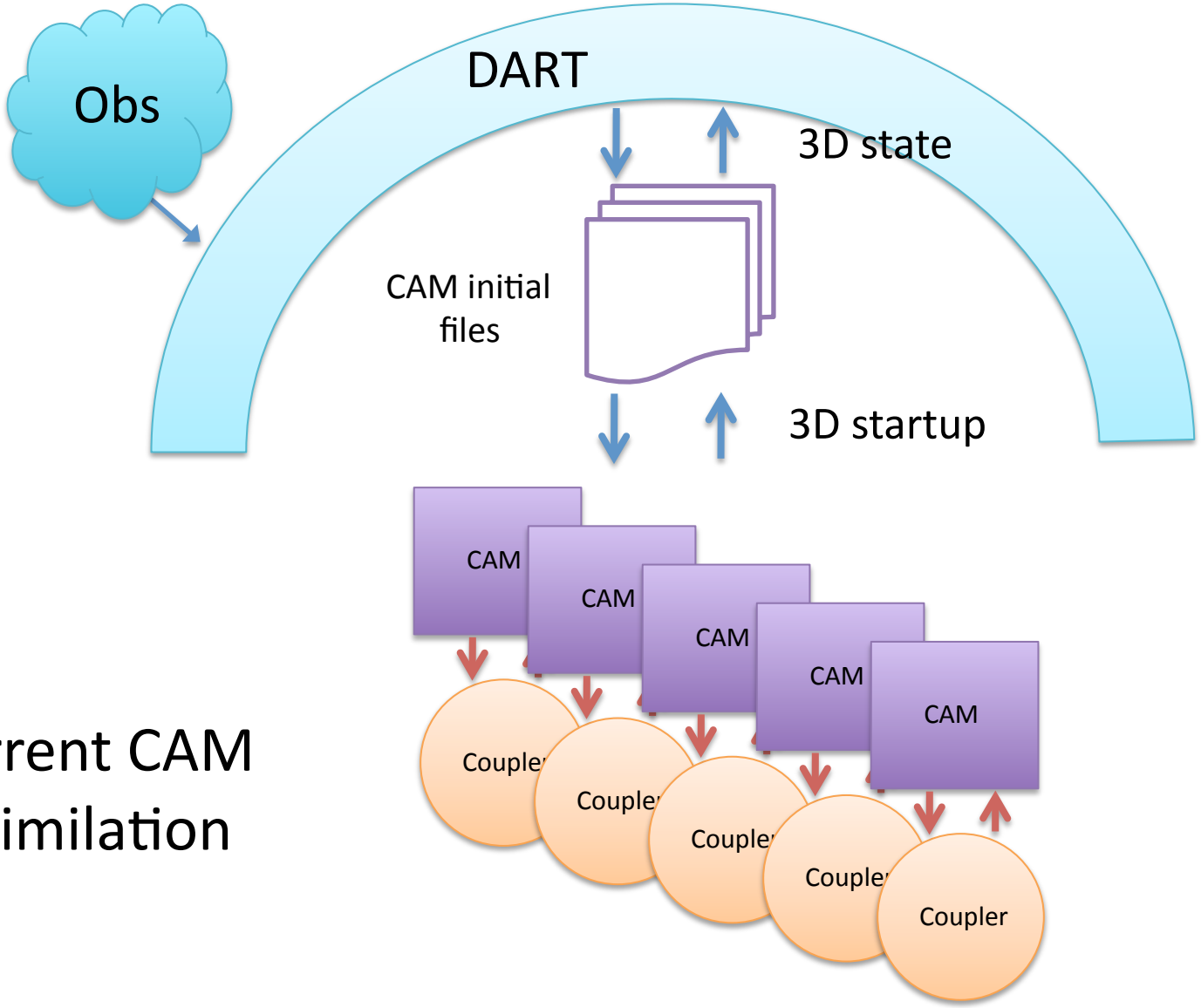
What we are doing now

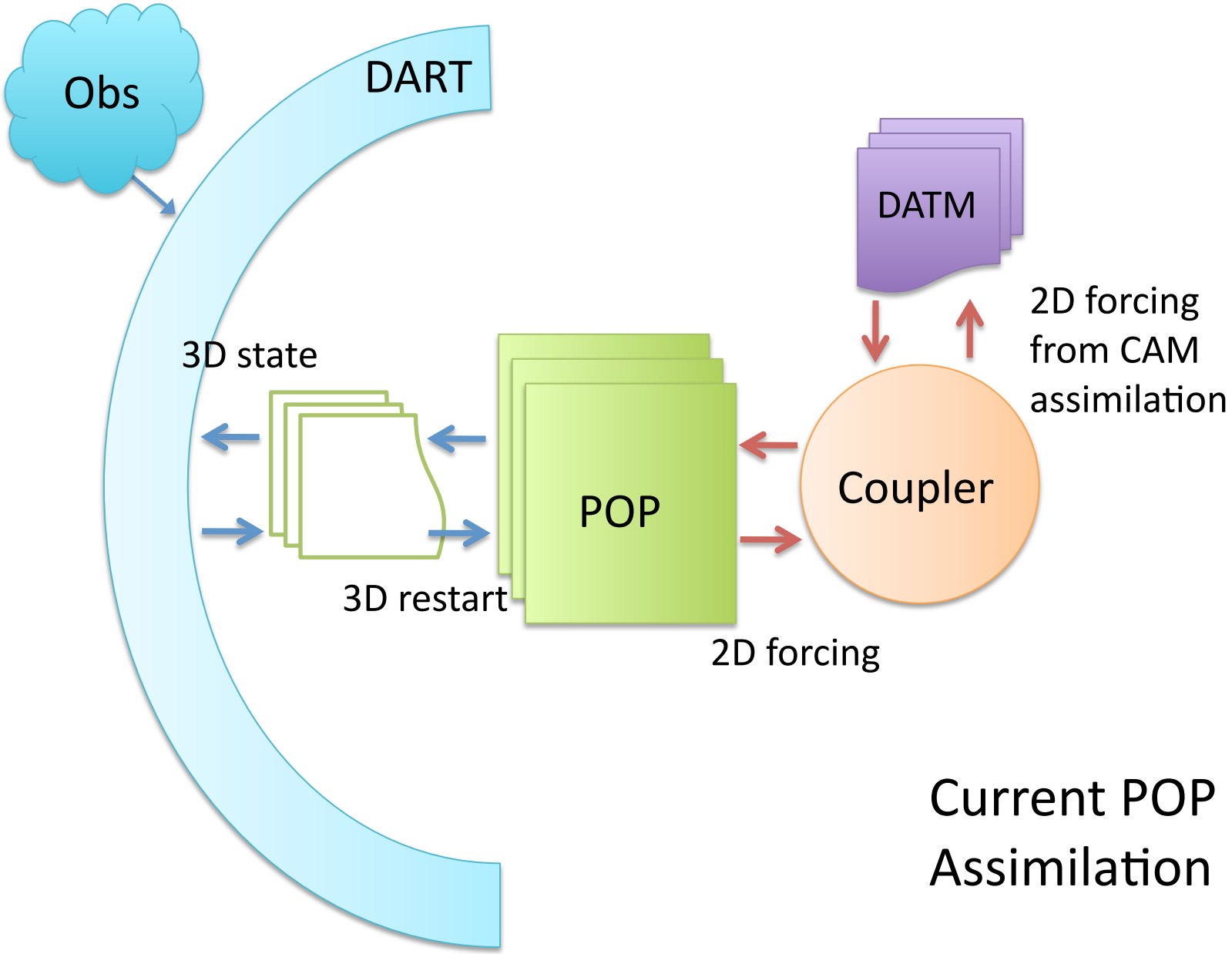
- CAM
  - Assimilating ATM obs with multiple executables of CAM
  - Could now also use CESM w/ ensembles of CAM
- POP
  - Use new CESM ensemble capability
  - Assimilating OCN obs with CESM POP
  - Start and stop CESM each day
  - CESM job script calls DART assimilation script
  - Transfer state by reading/writing restart files
- CLM
  - Just starting implementation with CESM CLM

CAM Assimilation with CESM ensembles



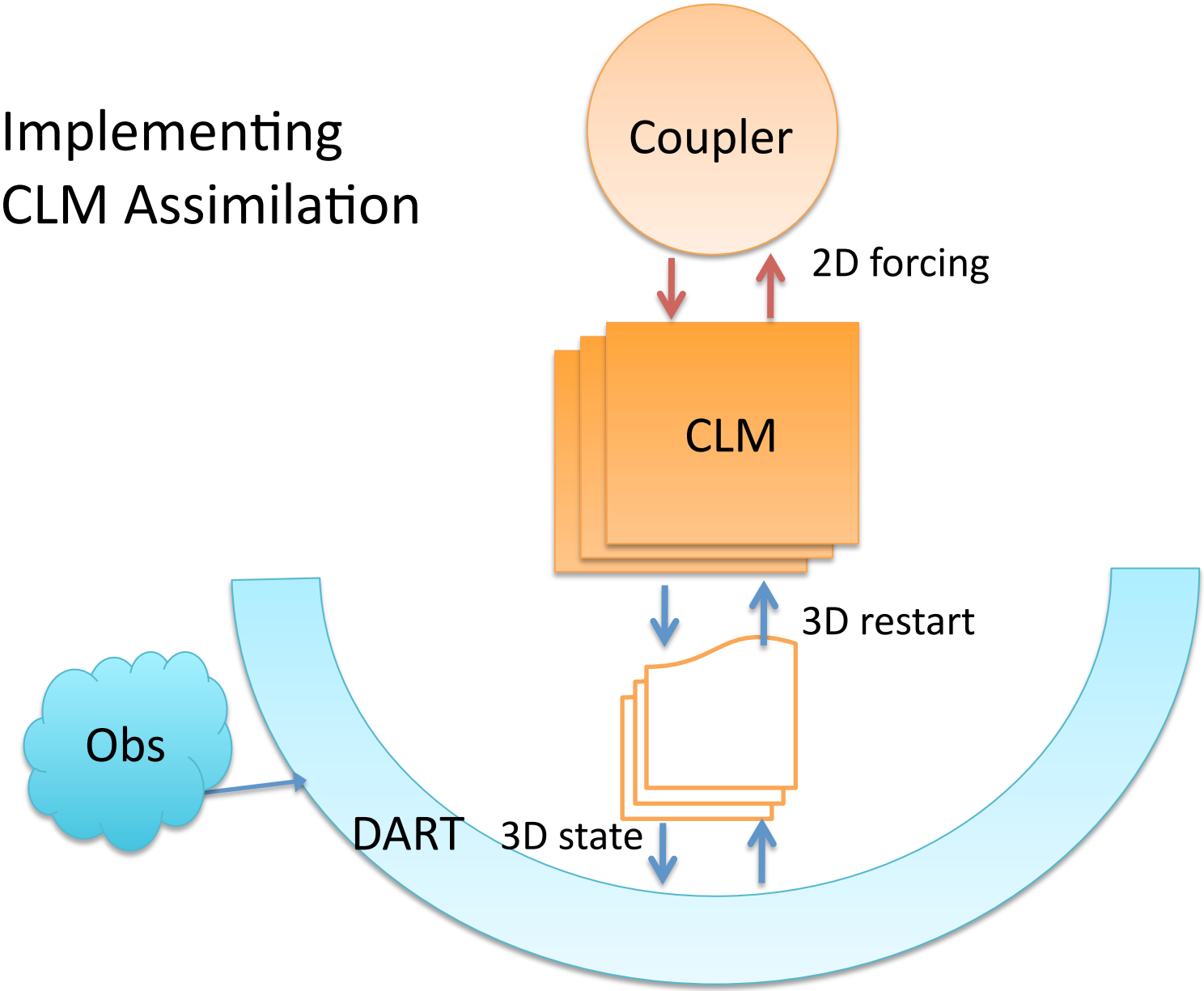
Current CAM Assimilation



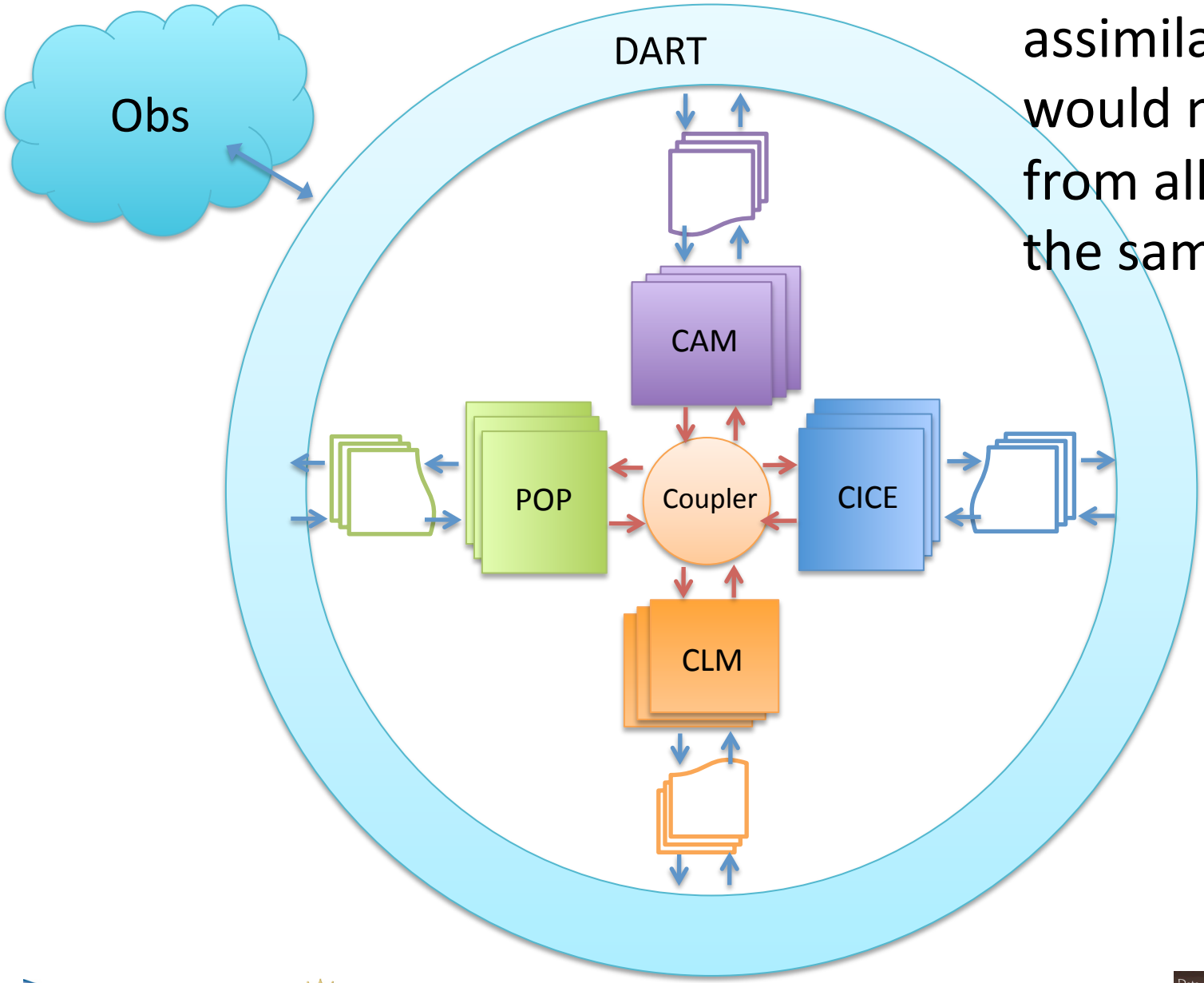


Current POP Assimilation

Implementing CLM Assimilation



Fully coupled assimilation would need data from all models at the same time



We Use Files as Intermediates

- It would be nice to intercept the fields in memory and alter them on the fly, but
- DART needs 2 different data decompositions at various times in the assimilation process
  - Entire state (for computing forward operators)
  - Subset of state but all ensemble members (for statistics, regression, increments)
- Better load balancing if close grid points are not grouped in same task
- The coupler only has 2D boundary data
  - We need full 3D fields to compute estimated observation values (forward operators)

Interrupting CESM

- We currently stop CESM before assimilating to take advantage of
  - Existing restart file write/read capabilities
  - Initialization code that recomputes derived fields
- Could keep CESM running if we could interrupt cleanly
  - Write state data out to files, or send it via MPI
    - Still need different data decomposition
  - CESM must wait to read in updated data
  - Need to recompute derived fields

Why not use model information?

- DART intentionally makes high walls between a model, the observations, and the assimilation code
  - No grid information
  - No field layout information
  - No dependency on model changes
- The same observations can be assimilated into corresponding models from different groups
- Any models can use the same assimilation tools, new techniques
- New models need to write one Fortran90 module with no more than 16 subroutines to interface to DART

Web and Contact Info

- http://www.image.ucar.edu/DAReS/DART
- General questions: dart@ucar.edu
- Or contact the DART team members directly:
  - Jeff Anderson: jla@ucar.edu
  - Kevin Raeder: raeder@ucar.edu
  - Tim Hoar: thoar@ucar.edu
  - Nancy Collins: nancy@ucar.edu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