Institute for Mathematics Applied to Geoscience

Data Assimilation Research Section - DAReS

Geophysical Statistics Project - GSP

Turbulence Numerics Team - TNT

Computational Mathematics Group - CMG

Data Assimilation Research Section - DAReS

Data assimilation exploits the information in observations to 'steer' a numerical model.

Put another way, it 'confronts' a numerical model with observations.

Simply running one numerical weather prediction model has been driving supercomputer research.

Our computational challenge is to run MANY (~100) instances of the numerical models (CAM, WRF, ...) simultaneously.

Our blood, sweat and tears is DART - the Data Assimilation Research Testbed

The 'R' in DART is for RESEARCH

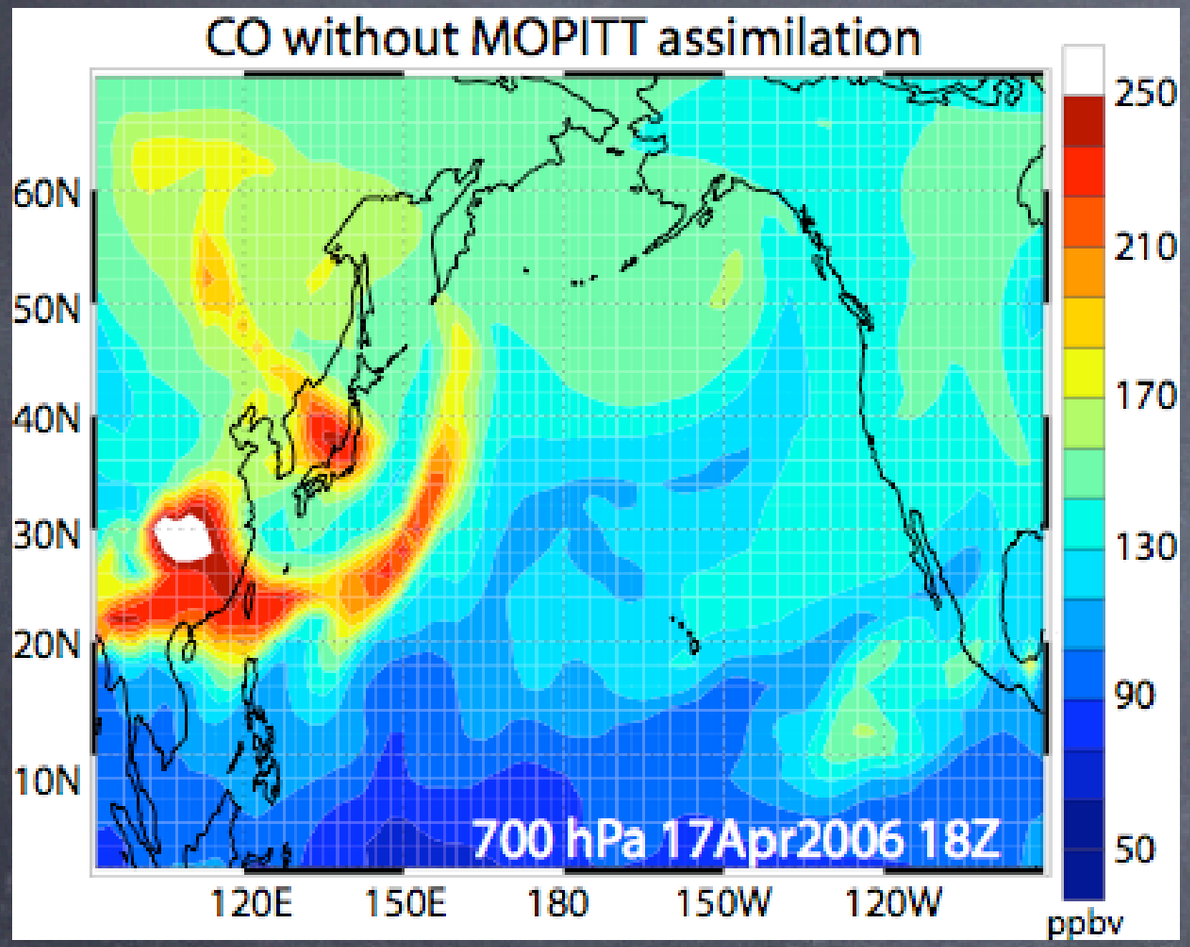
We are all about exploring observations and models.

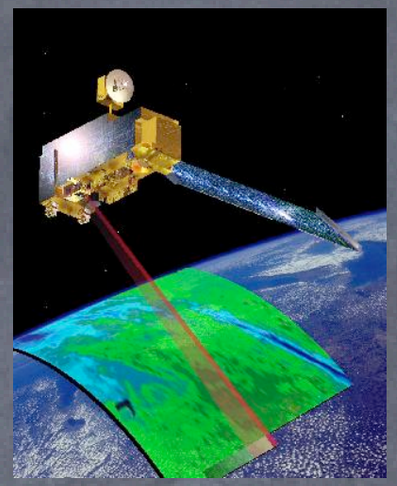
We want to make it easy to incorporate new models and new observations.

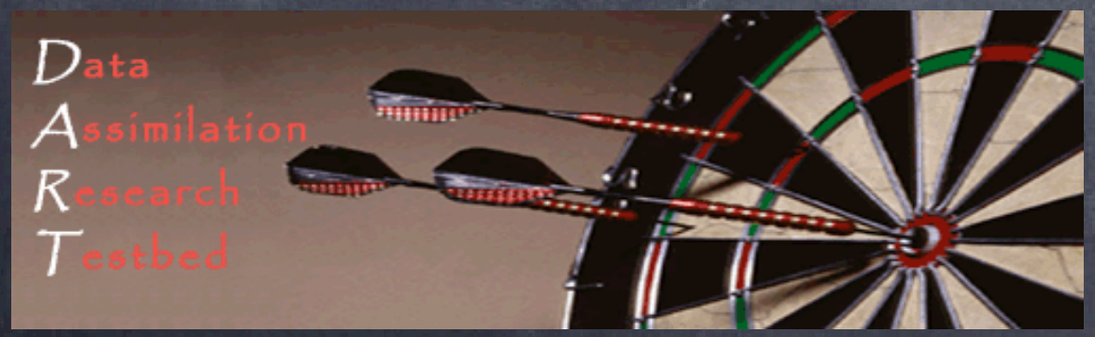
DART has tutorials and a rich set of observations and models to start with!

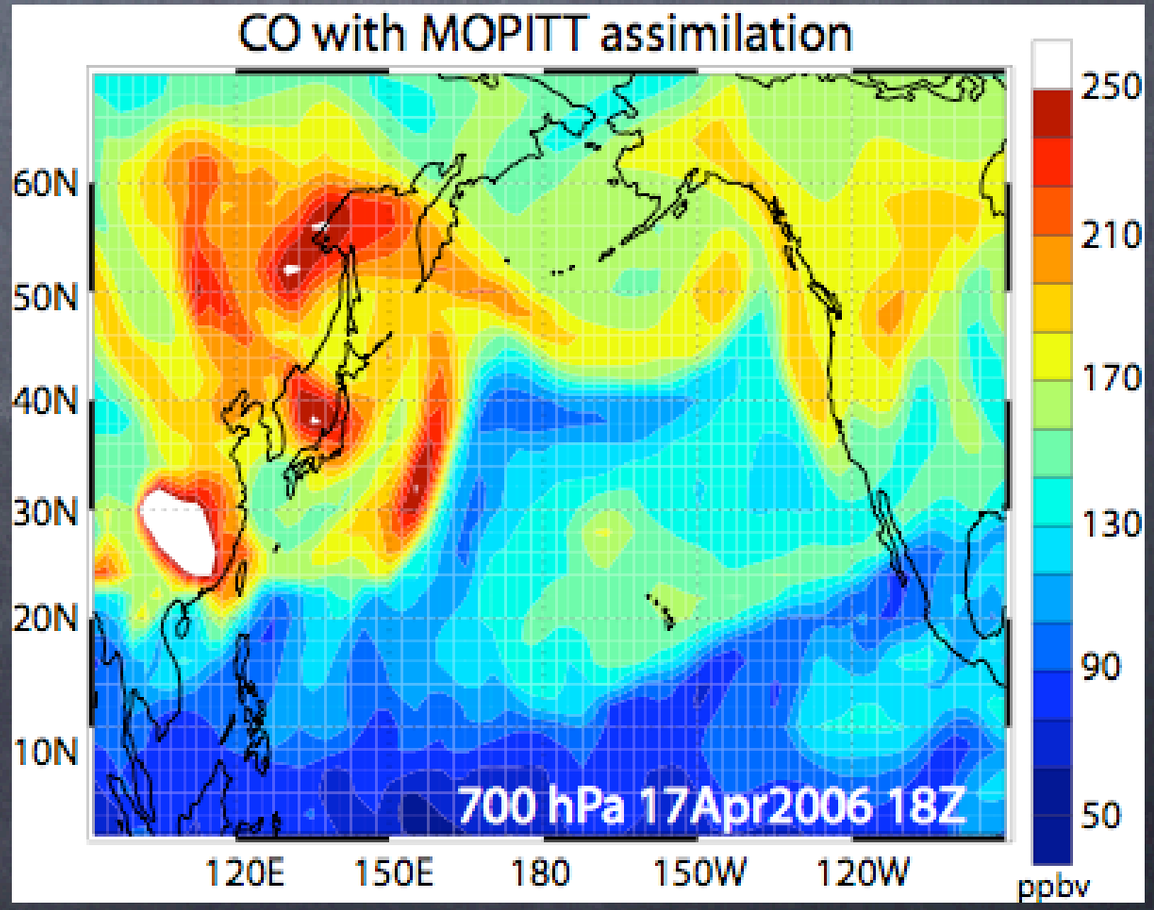
DART allows a lone researcher to explore the effect of novel observations in existing models* without spending their entire career on it.

Still Young!









* CAM in this case

Our Data Assimilation 'MACHINE'

Forward operator 'H' maps state vector to observation space

An observation and its uncertainty

'increments' are applied to reflect the information in the observations

linear regression takes us back to model space

model k

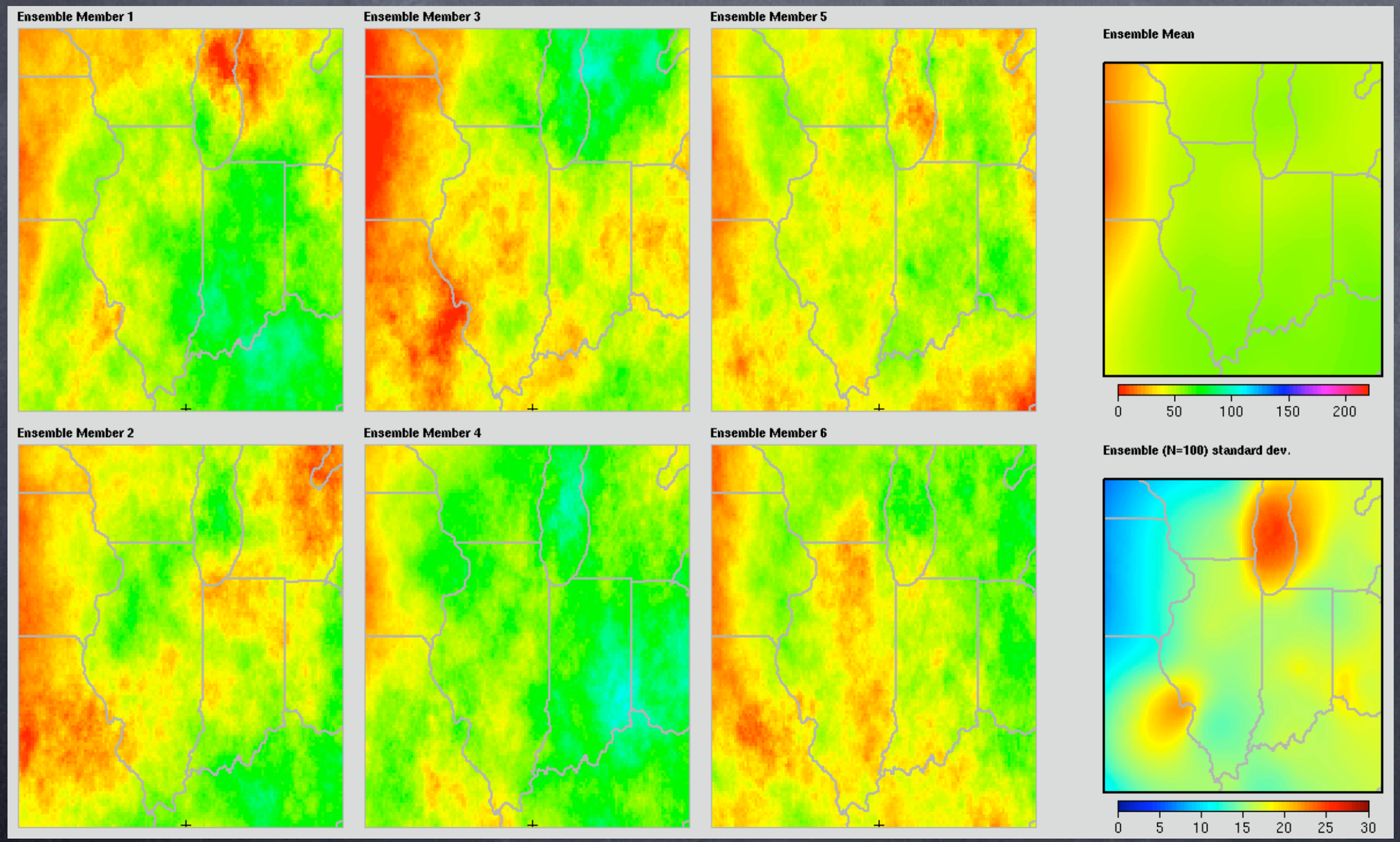
model j

trajectory of model i

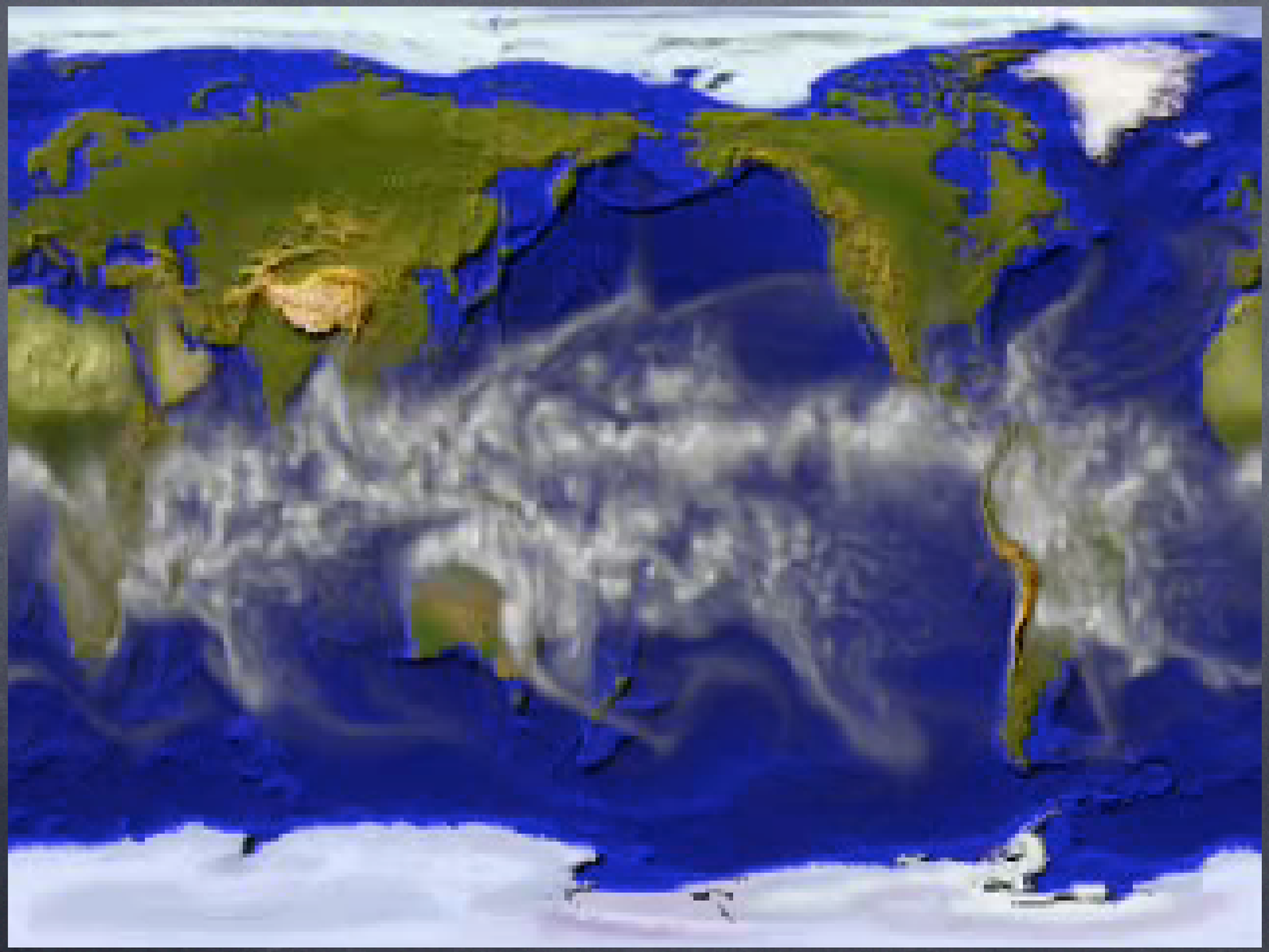
carry on till we have more observations

The MACHINE in action

Each panel is an ensemble member being updated as more station data is being assimilated.



Our challenge is to run MANY of these.



Parallel Implementation

* Must be generic across hardware, architectures, and compilers (MPI)

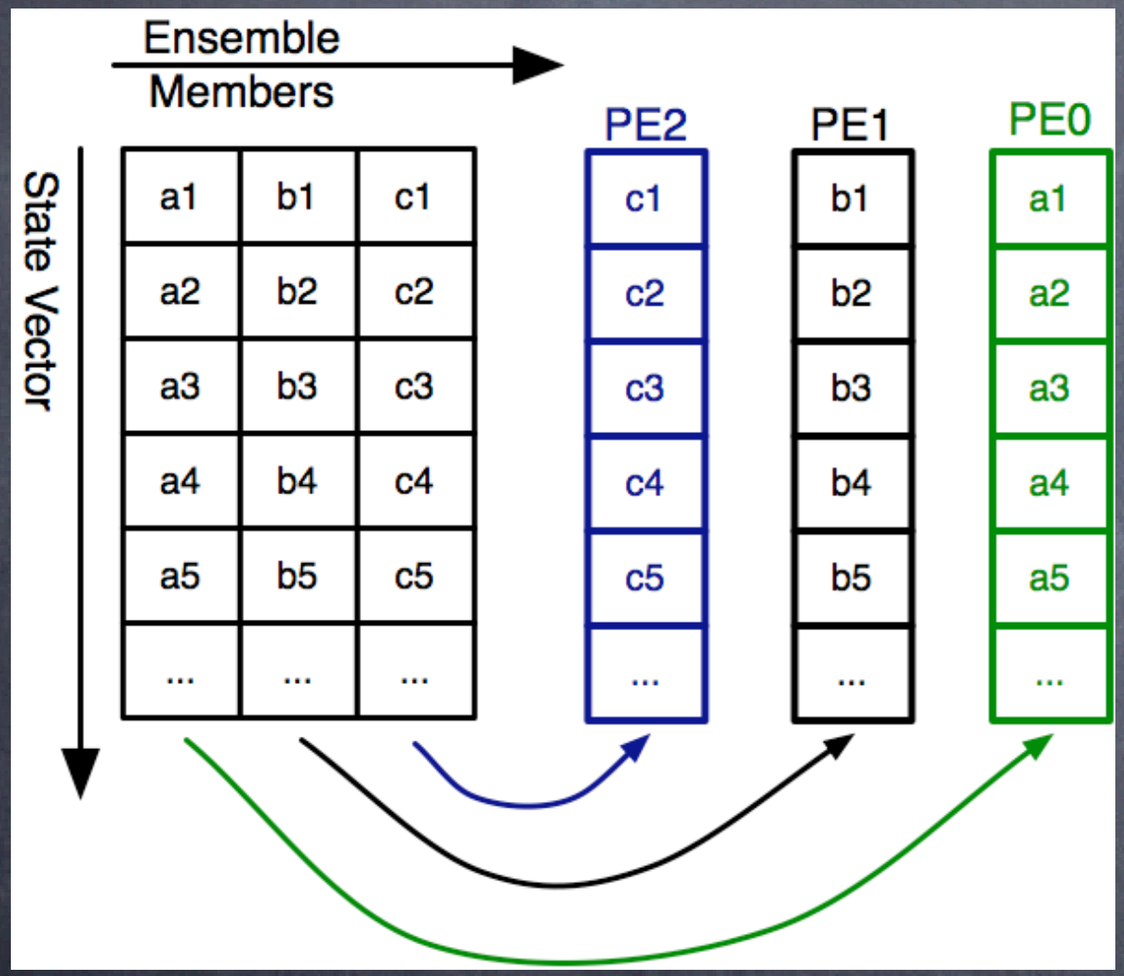
* Must be bitwise reproducible

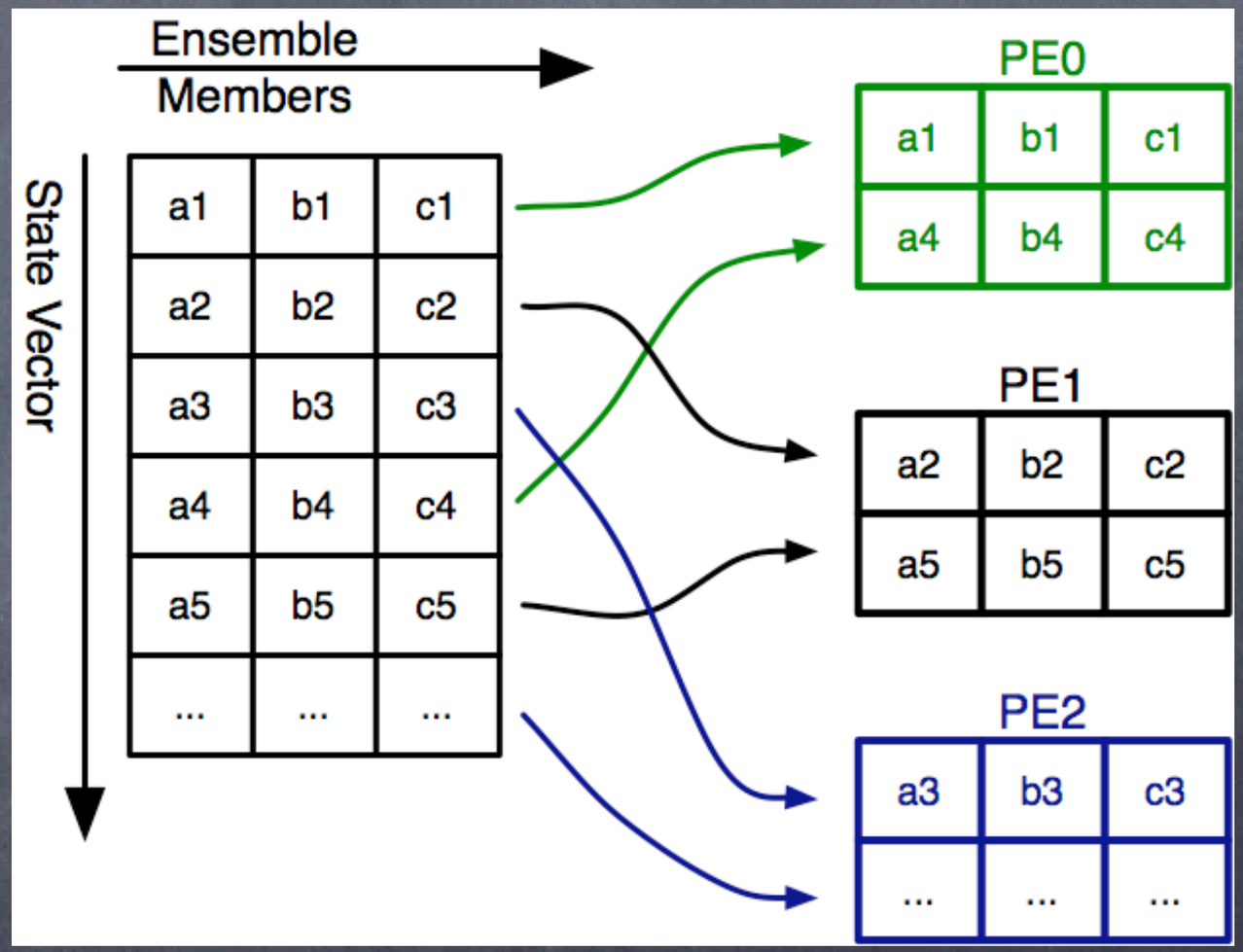
* Must scale reasonably well

- for large number of models running at once, and
- for large models/dataset sizes

Parallel Implementation

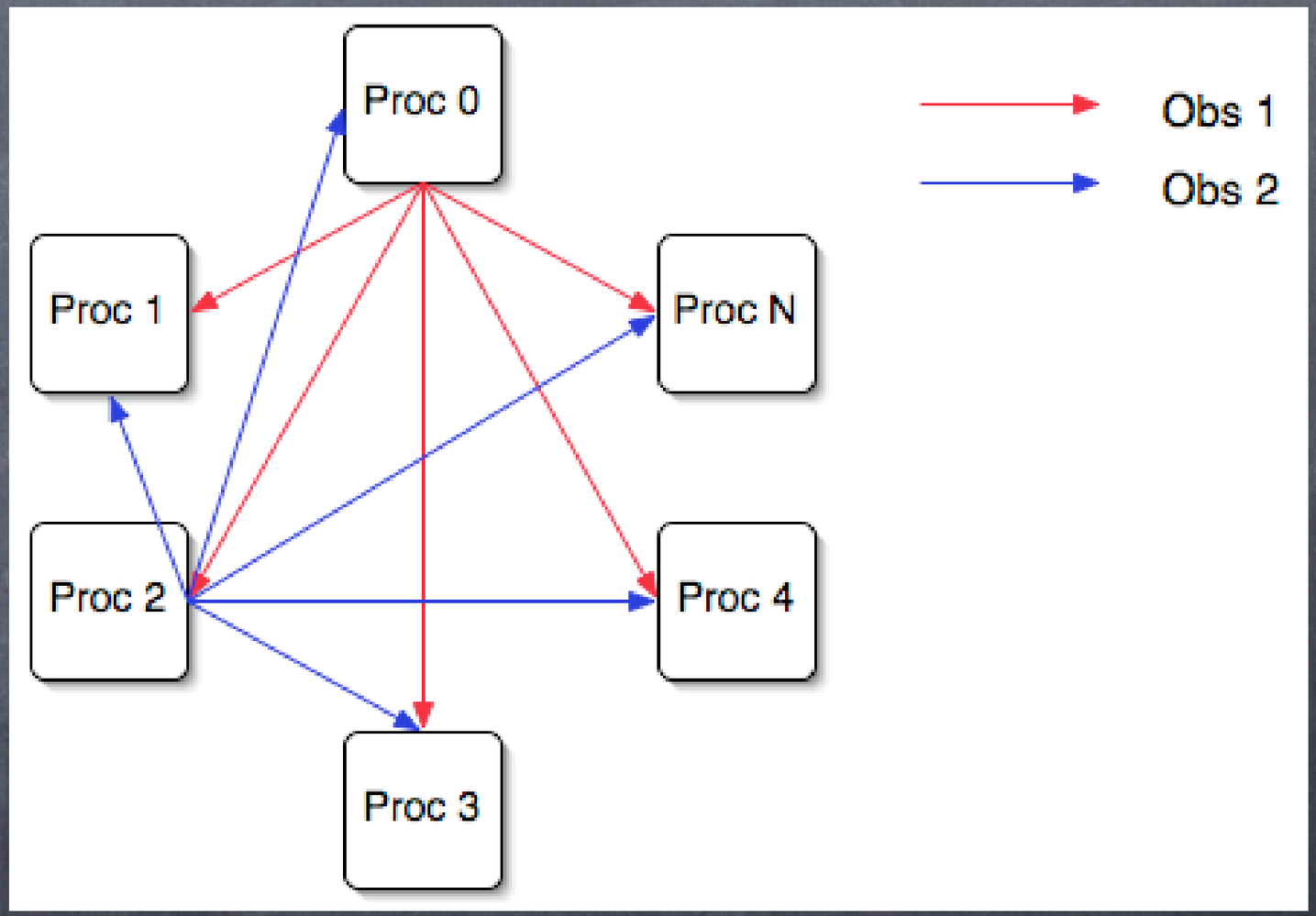
must efficiently implement an all-to-all transpose:



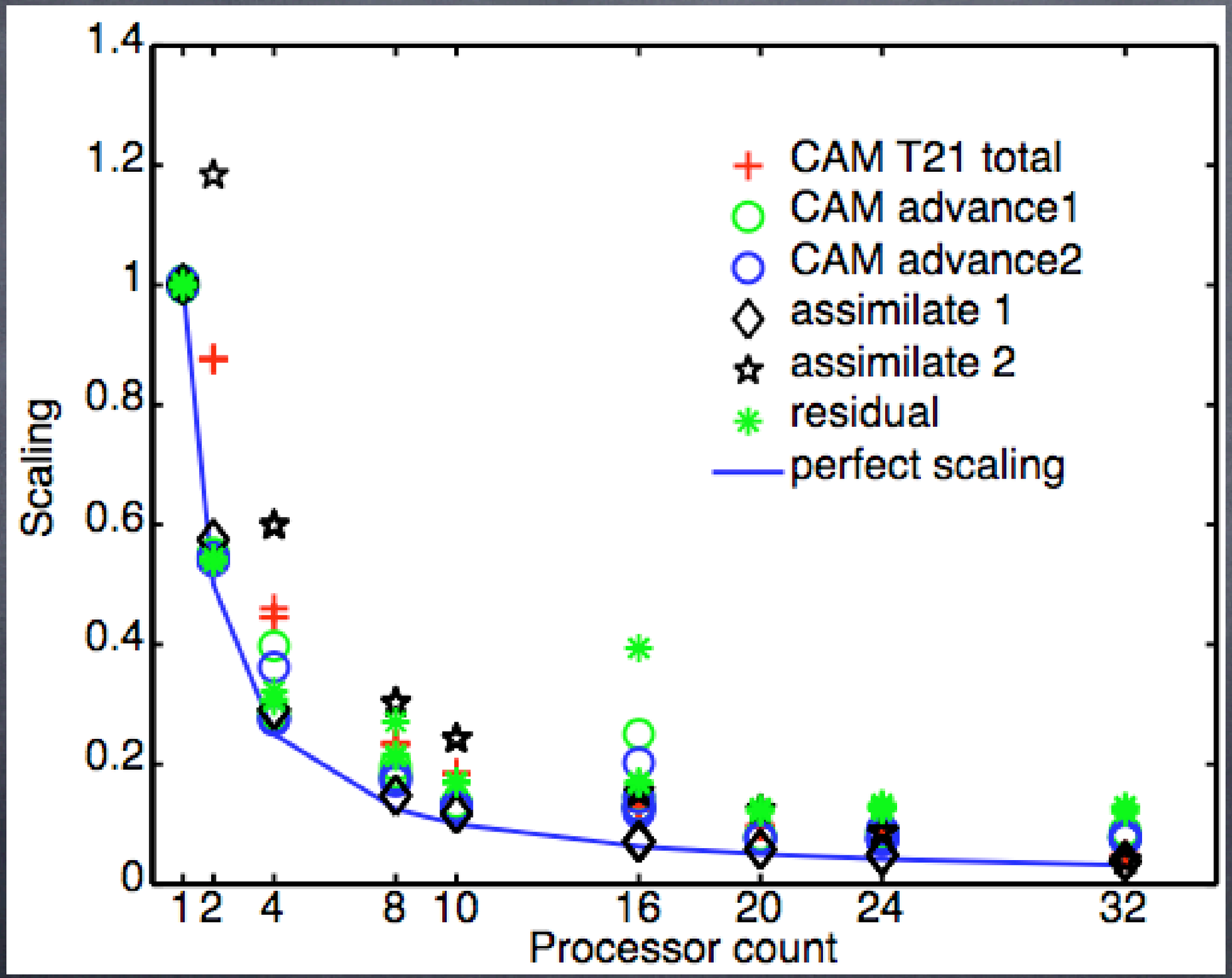


Parallel Implementation - bitwise reproducibility

sequentially process each observation and broadcast increments to state vector



Parallel performance



Data Assimilation Research Testbed : DART

* Many low-order models: Lorenz 63, L84, L96, etc.
* Global 2-level PE model (from NOAA/CDC)
* NCAR's CAM 2.0 & 3.0
* NCAR's WRF (regional) - global/nested/Mars in progress
* GFDL FMS B-Grid GCM (global grid point model)

Forward Operators and Datasets

Many linear, non-linear forward operators for low-models

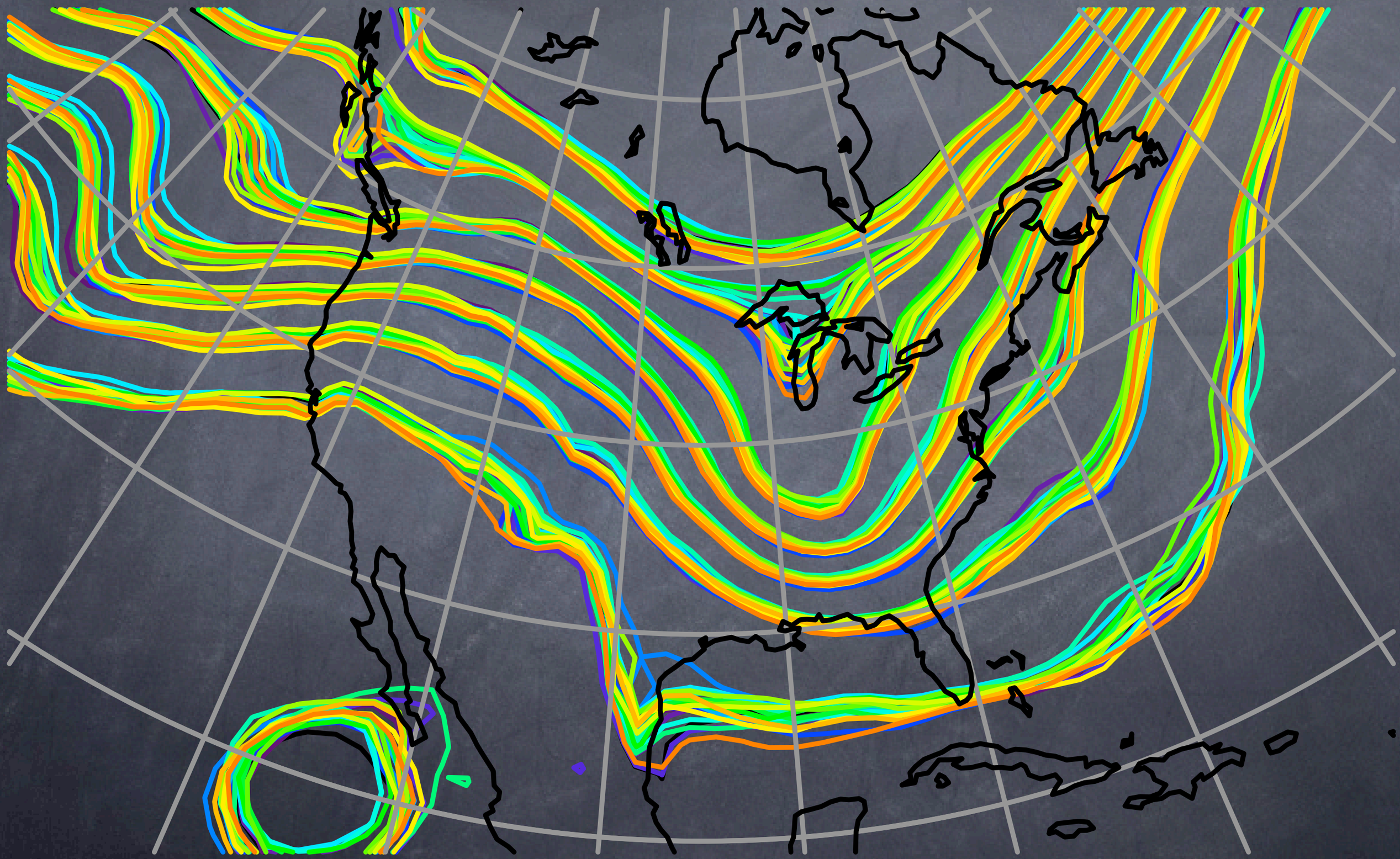
U, V, T, Ps, Q, for realistic models

Radar reflectivity, GPS refractivity for realistic models

Observations from BUFR files (NCEP reanalysis flavor)

Can create synthetic (i.e perfect model) observations for all

DART/CAM T85 GPH @ 500 hPa



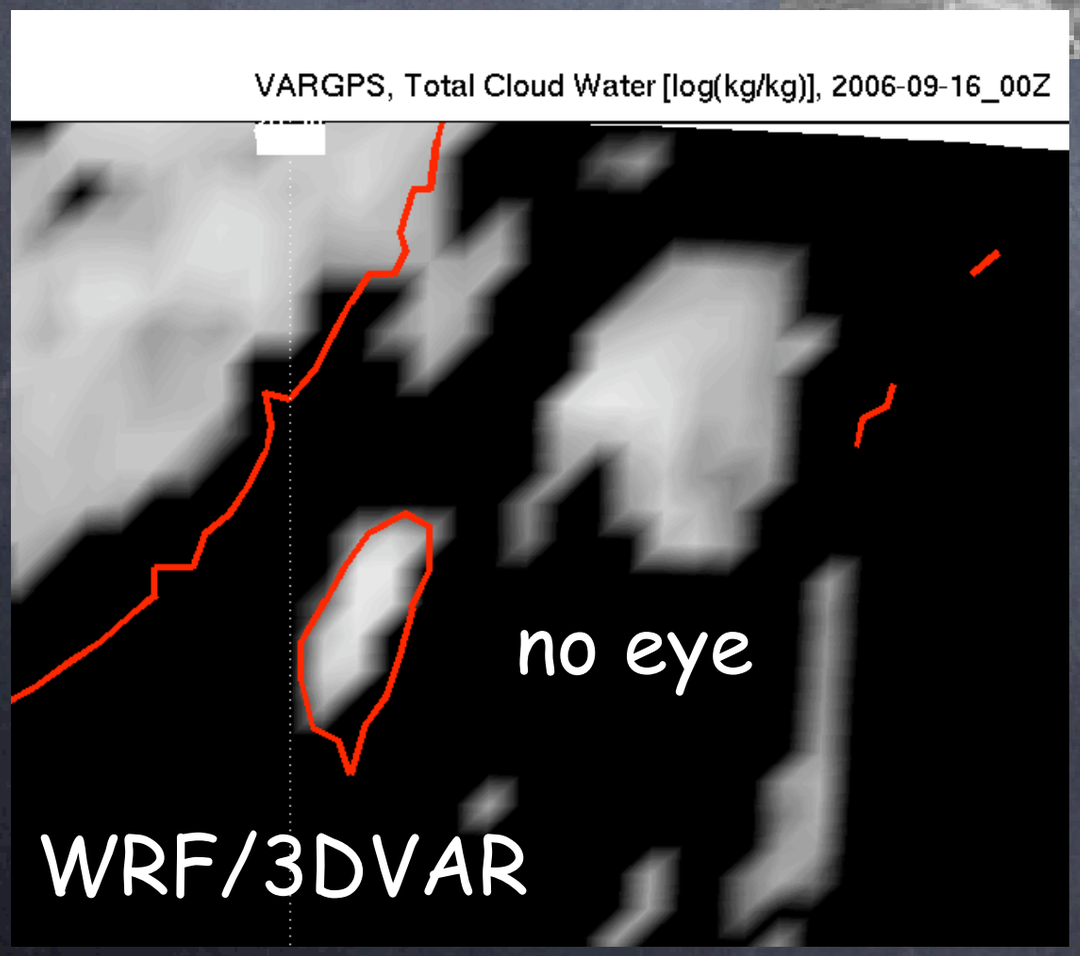
00Z 1 Feb 2003

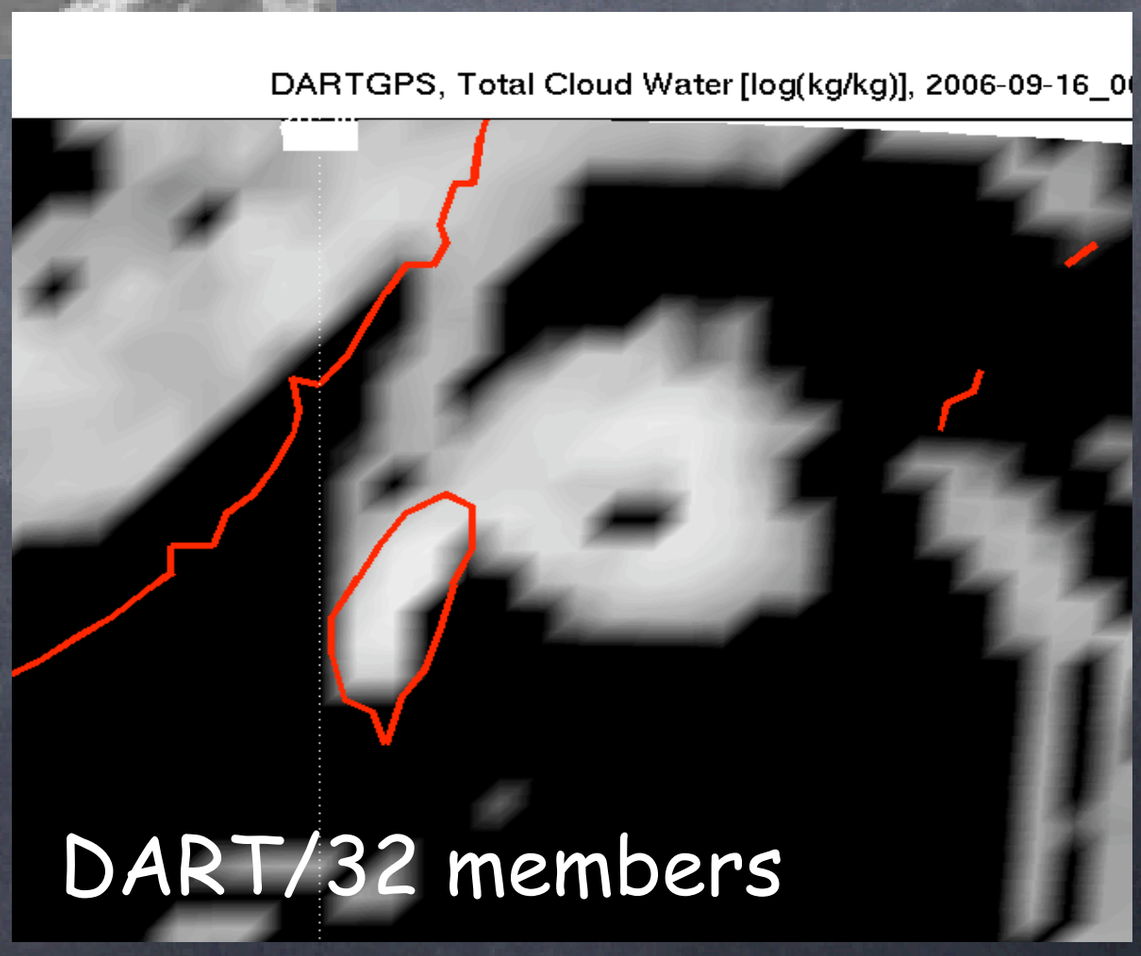
contours 5320 to 5800 by 80

Typhoon Shanshan - GPS obs
3Dvar vs. DART

2Day forecasts:
radiosondes, QuikScat
surface winds, GPS w/
local operator

Spinup: 1hr assim
window for
Sep 13-14 00Z





DART summary

* extensible research facility

* Very Good performance

* Easy to learn ensemble DA - tutorial

www.image.ucar.edu/DAReS/DART

The DART team is Jeff Anderson, Nancy Collins,
Kevin Raeder, Hui Liu, and me - Tim Hoar