

The Data Assimilation Research Testbed: A community data assimilation facility

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The Data Assimilation Problem:

Given: **1. A physical system (atmosphere, ocean...)**

2. Observations of the physical system

Usually sparse and irregular in time and space.

Instruments have error of which we have a (poor) estimate.

Observations may be of 'non-state' quantities.

Many observations may have very low information content.

3. A model of the physical system

Usually thought of as approximating time evolution.

Could also be just a model of balance (attractor) relations.

Truncated representation of 'continuous' physical system.

Often quasi-regular discretization in space and/or time.

Generally characterized by 'large' systematic errors.

May be ergodic with some sort of 'attractor'.

We want to increase our information about all three pieces:

1. Get an improved estimate of state of physical system

Includes time evolution and ‘balances’.

Initial conditions for forecasts.

High quality analyses (re-analyses).

2. Get better estimates of observing system error characteristics

Estimate value of existing observations.

Design observing systems that provide increased information.

3. Improve model of physical system

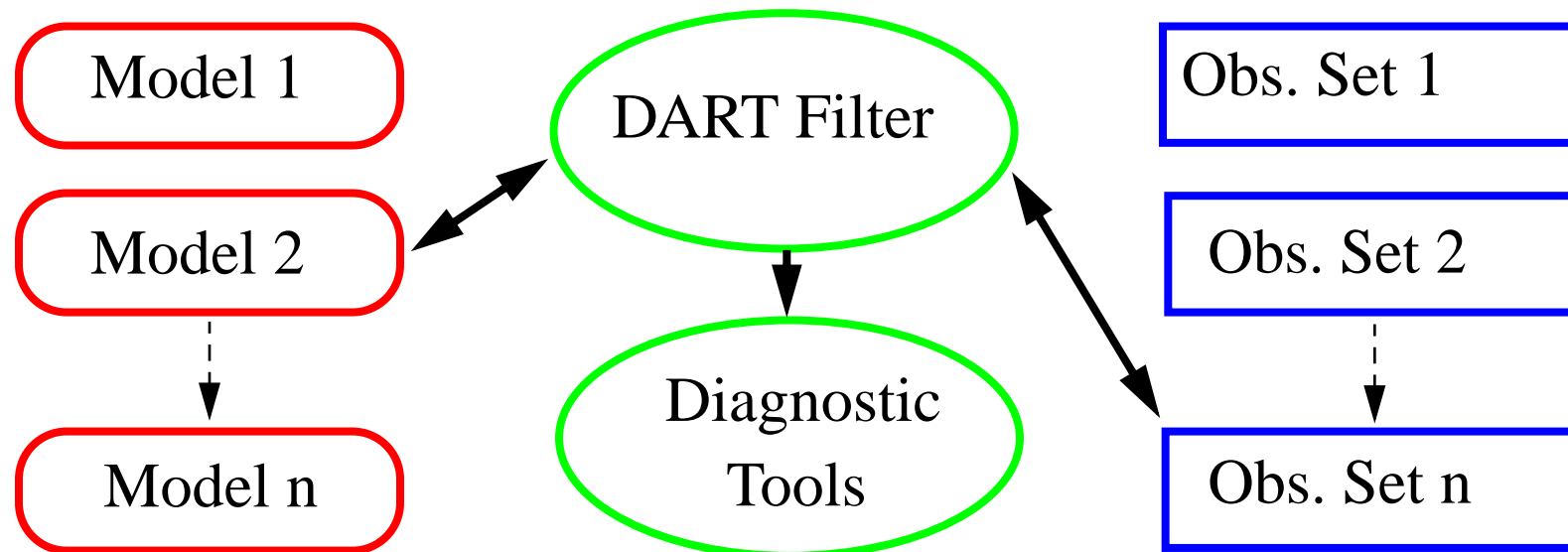
Evaluate model systematic errors.

Select appropriate values for model parameters.

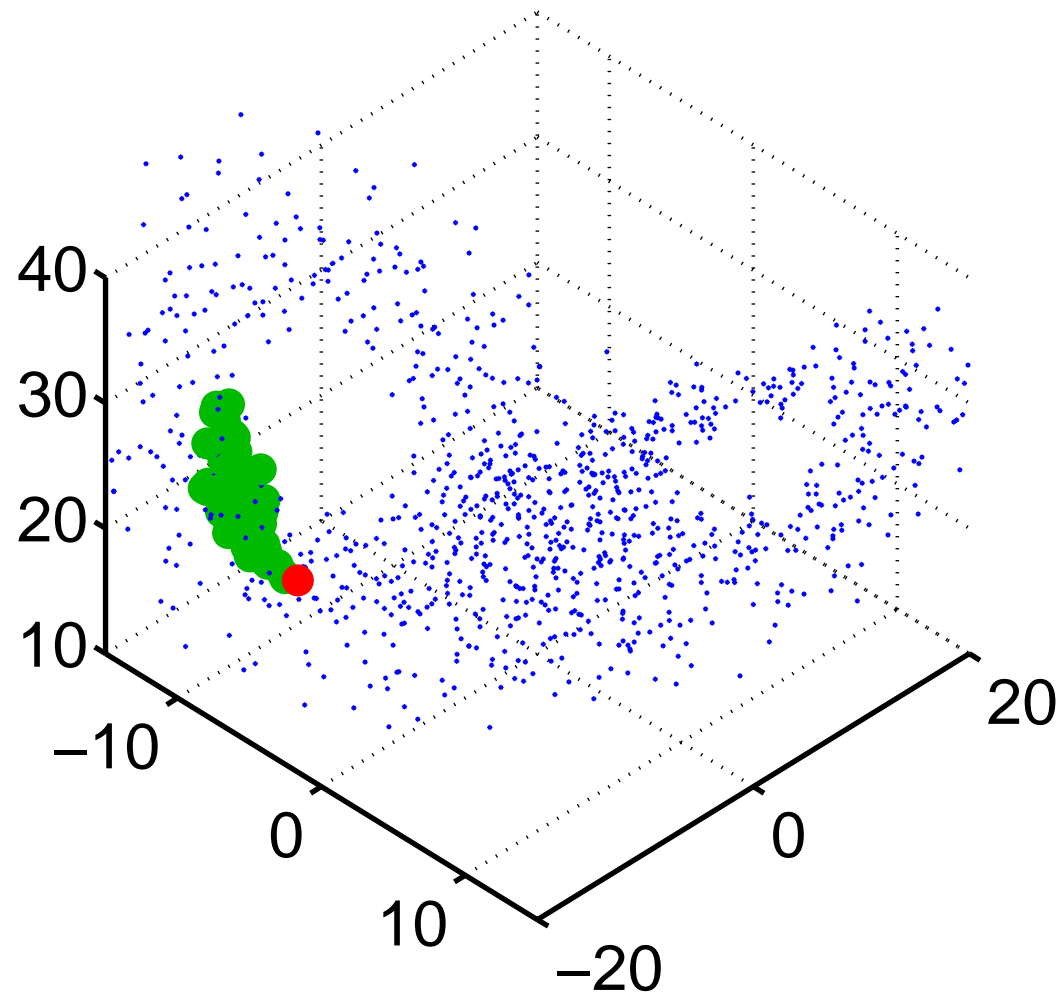
Evaluate relative characteristics of different models.

The Data Assimilation Research Testbed (DART)

- A. Combine assimilation algorithms, models, and observation sets.
- B. Diagnostic tools for assimilation experimentation.
- C. Compliant models and observation sets (real and synthetic).
- D. A high-quality, generic ensemble filtering algorithm.



Ensemble filter in the Lorenz-63 3-variable chaotic model.



Observation in red.

Prior ensemble in green.

Observing all three state variables.

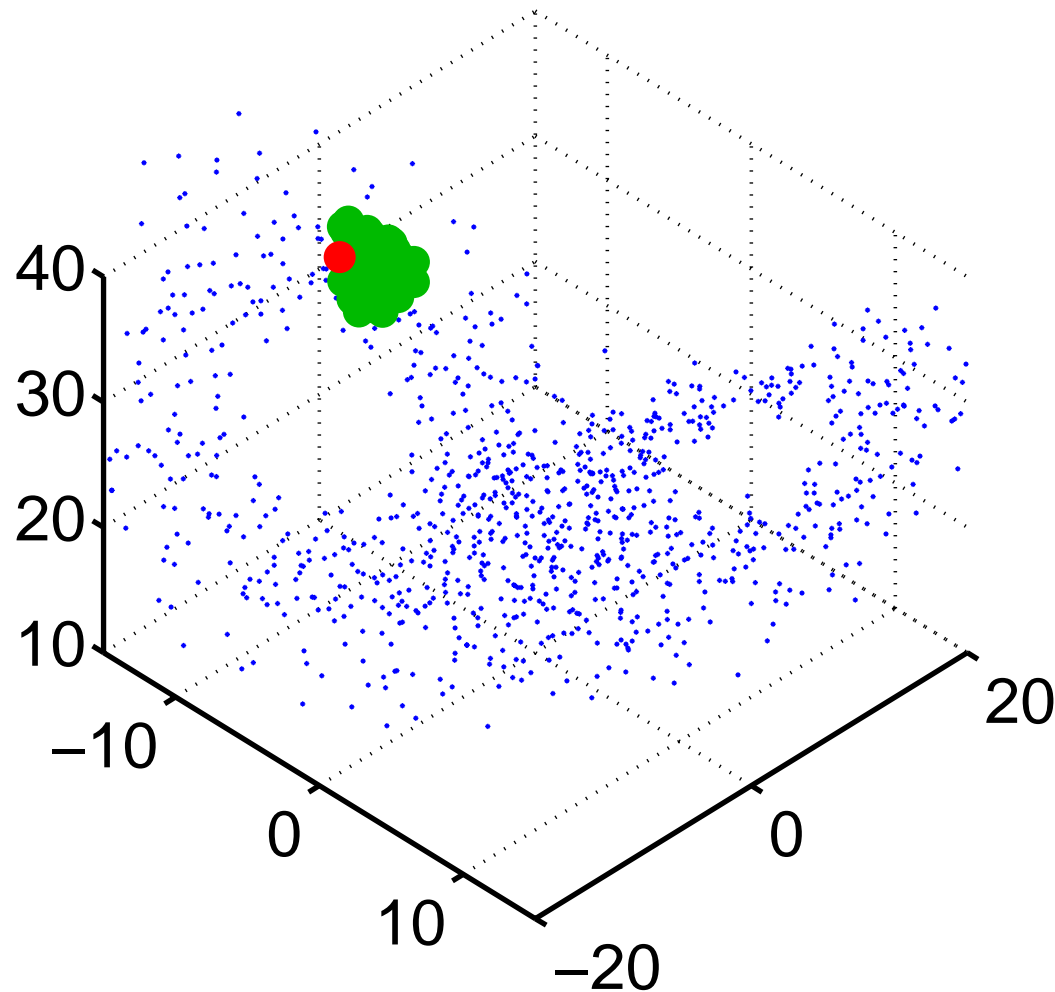
Obs. error variance = 4.0.

4, 20-member ensembles.

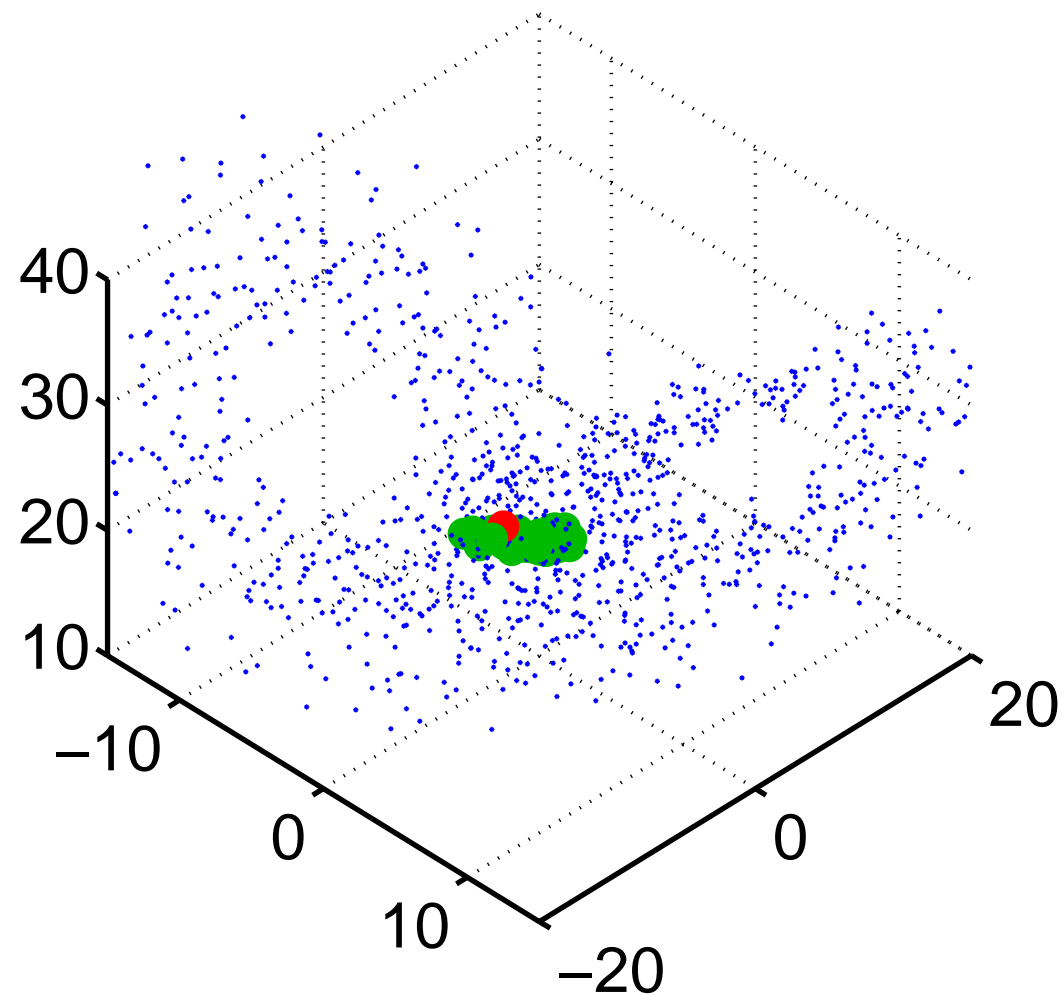
Ensemble filter in the Lorenz-63 3-variable chaotic model.

Observation in red.

Prior ensemble in green.



Ensemble filter in the Lorenz-63 3-variable chaotic model.

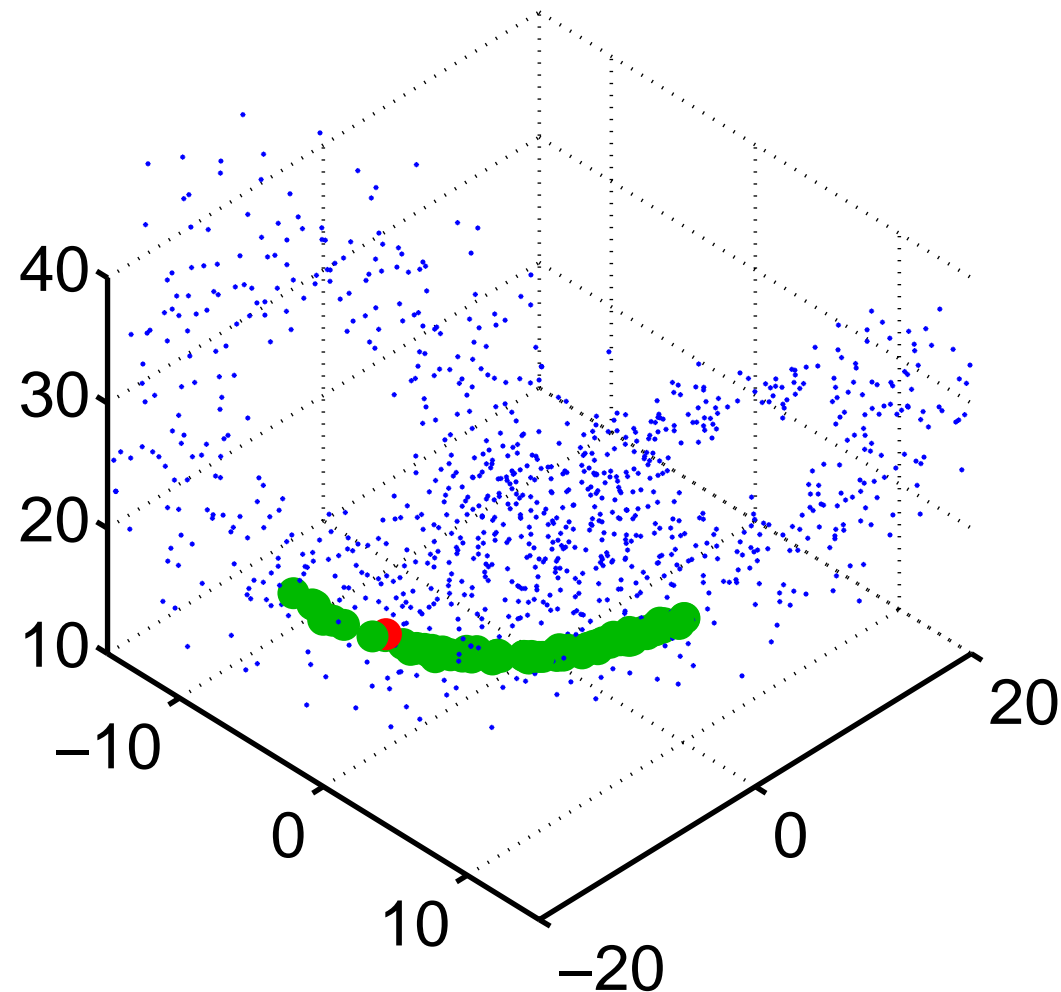


Observation in red.

Prior ensemble in green.

Passing through
unpredictable region.

Ensemble filter in the Lorenz-63 3-variable chaotic model.



Observation in red.

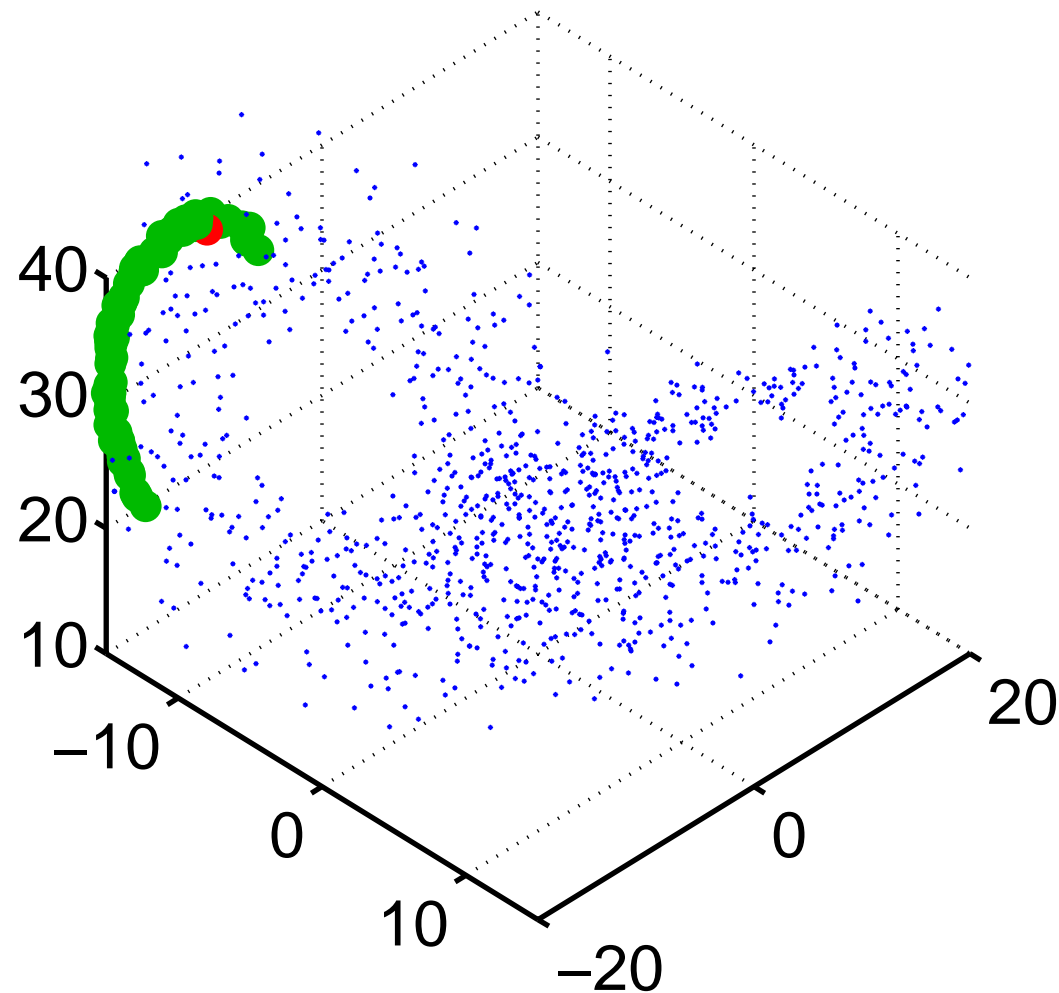
Prior ensemble in green.

Part of ensemble heads for one lobe, the rest for the other.

Ensemble filter in the Lorenz-63 3-variable chaotic model.

Observation in red.

Prior ensemble in green.



DART compliant models (largest set ever with assim system)

1. Many low-order models (Lorenz63, L84, L96, L2004,...)
2. Global 2-level PE model (from NOAA/CDC)
3. CGD's CAM 2.0 & 3.0 (global spectral model)
4. GFDL FMS B-grid GCM (global grid point model)
5. MIT GCM (from Jim Hansen; configured for annulus)
6. WRF model
7. NCEP GFS (assisted by NOAA/CDC)
8. GFDL MOM3/4 ocean model
9. ACD's ROSE model (upper atmosphere with chemistry)
10. Cane-Zebiak intermediate coupled ocean-atmosphere (LDEO5)

This allows for a hierarchical approach to filter development.

Also supports data assimilation instruction.

Results from CAM Assimilation: January, 2003

Model:

CAM 3.0 T42L26

U, V, T, Q and PS state variables impacted by observations.

Land model (CLM 2.0) not impacted by observations.

Climatological SSTs.

Assimilation / Prediction Experiments:

80 member ensemble divided into 4 equal groups.

Initialized from a climatological distribution (huge spread).

Initial tests for January, 2003.

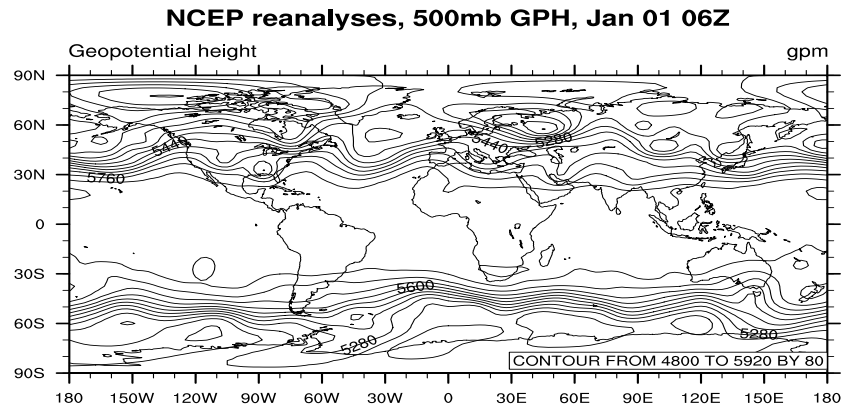
Uses most observations used in reanalysis

(Radiosondes, ACARS, Satellite Winds..., no surface obs.).

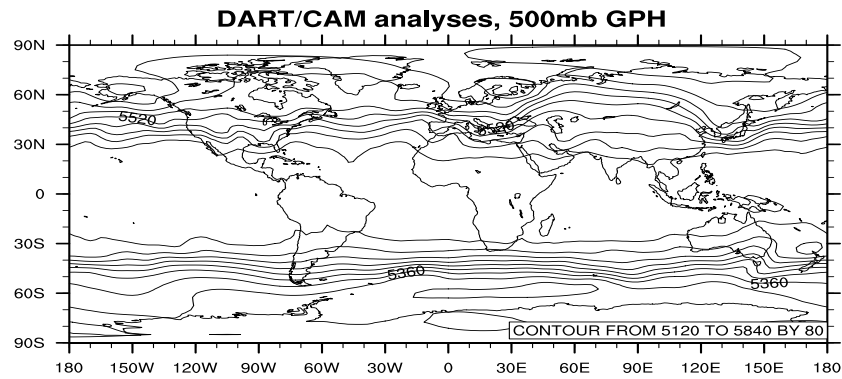
Assimilated every 6 hours; +/- 1.5 hour window for obs.

Adaptive error correction algorithm with fixed variance.

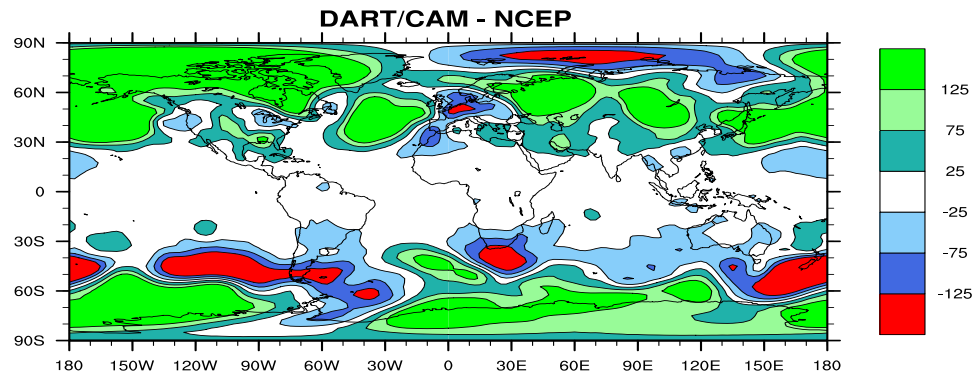
After 6 hours



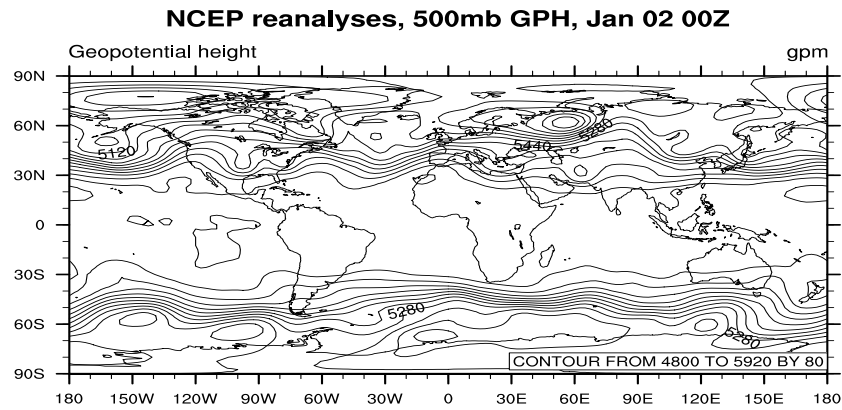
NCEP



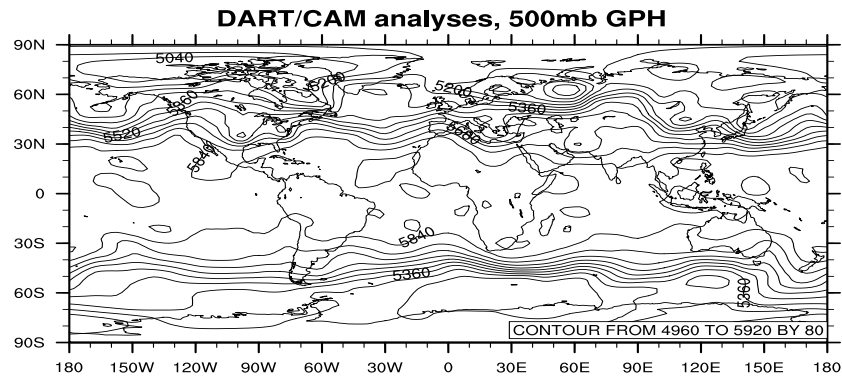
DART



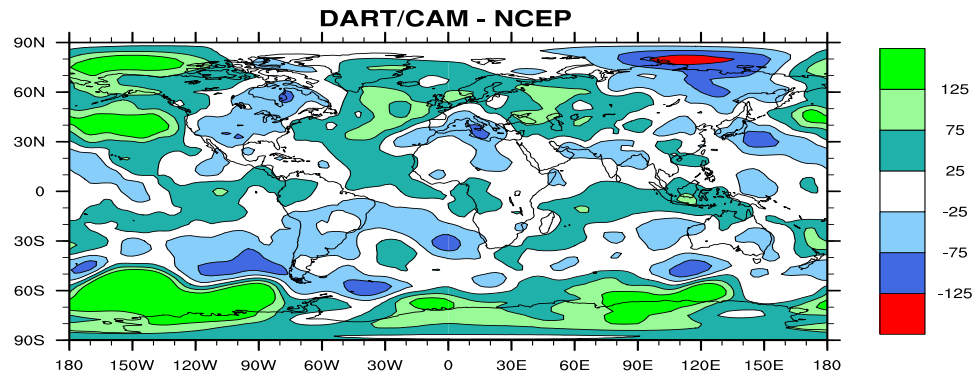
After 1 Day



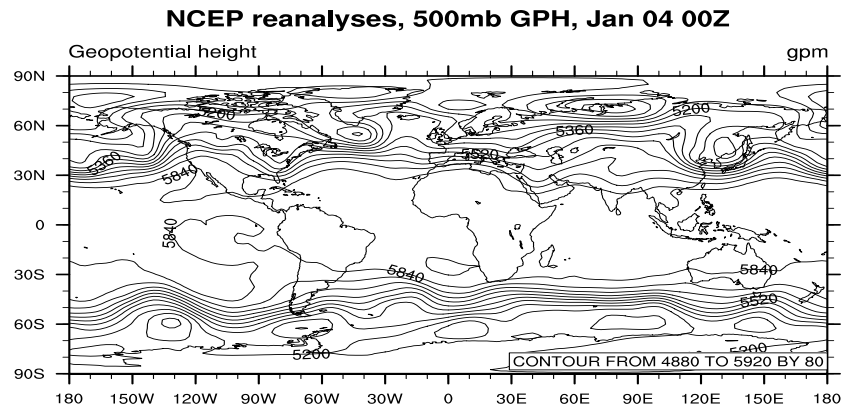
NCEP



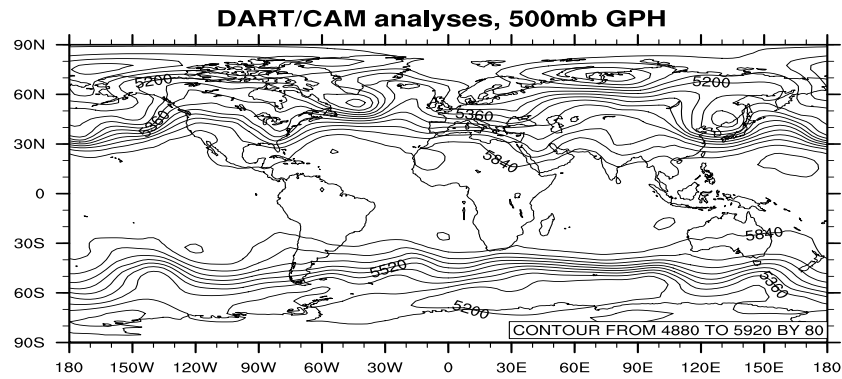
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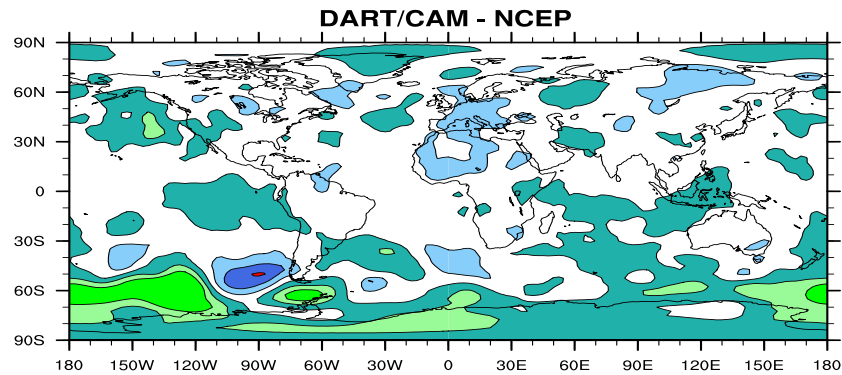
After 3 Days



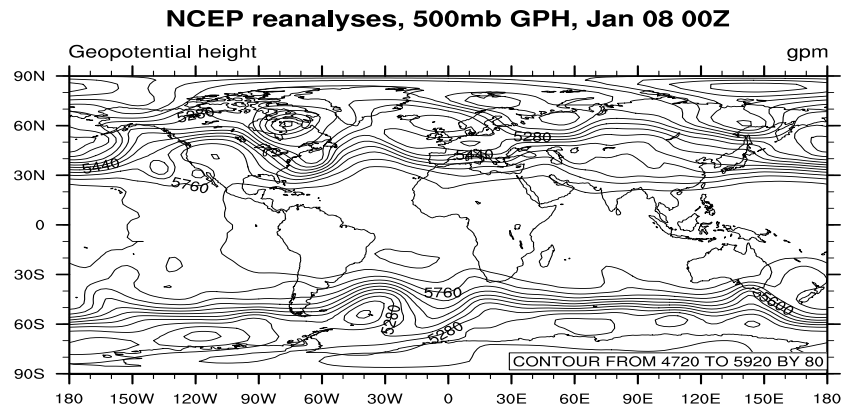
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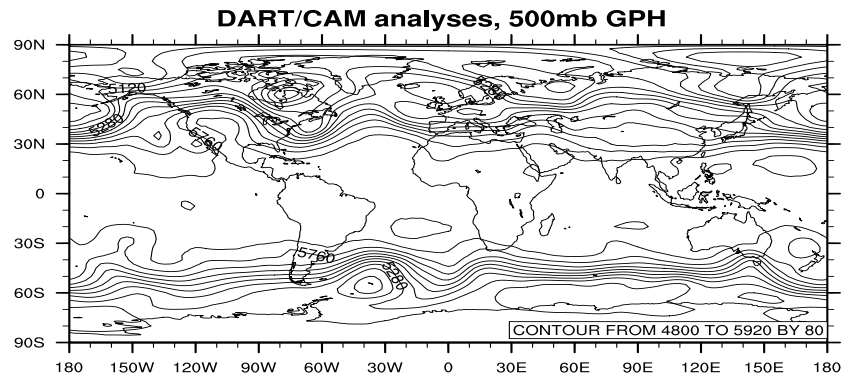
DART



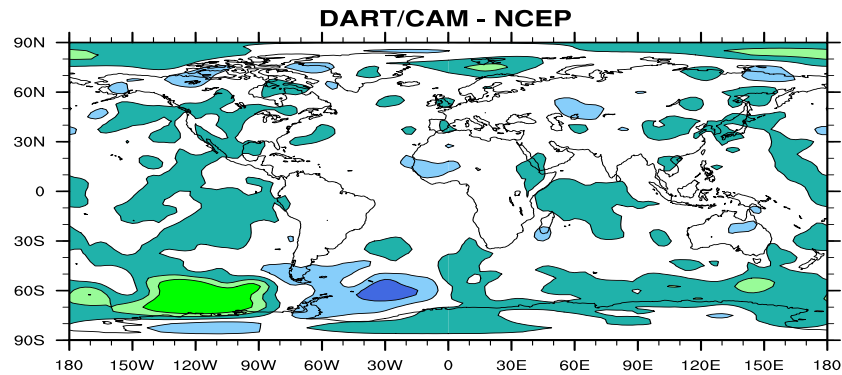
After 7 Days



NCEP

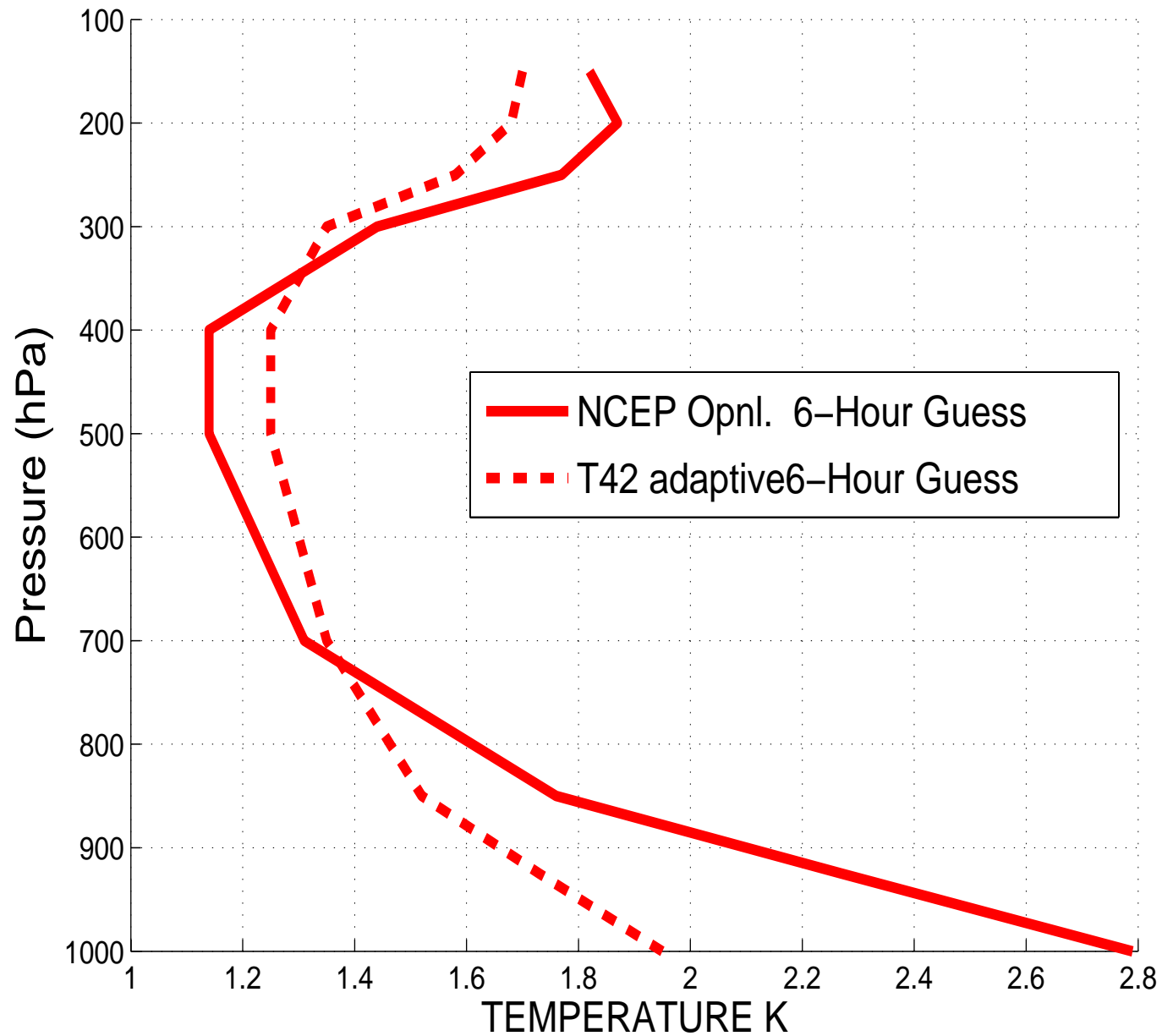


DART



Difference

Jan. 2003 Northern Hemisphere Temperature: Root Mean Square Error



DART compliant Forward Operators and Datasets

Many linear and non-linear forward operators for low-order models.

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

Radar reflectivity, GPS refractivity for realistic models.

Can ingest observations from reanalysis or operational BUFR files.

Can create synthetic (perfect model) observations for any of these.

Initial Releases of the DART Facility are Available On-line at:

<http://www.image.ucar.edu/DAI/DART/>

Limited support for now, but a number of external users.

Additional features, models, observations in future releases.