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.

* 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.

Carry on till we have more observations.

Model k

Model j

Trajectory of model i
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
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

IR (truth)

WRF/3DVAR

DART/32 members

no eye
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