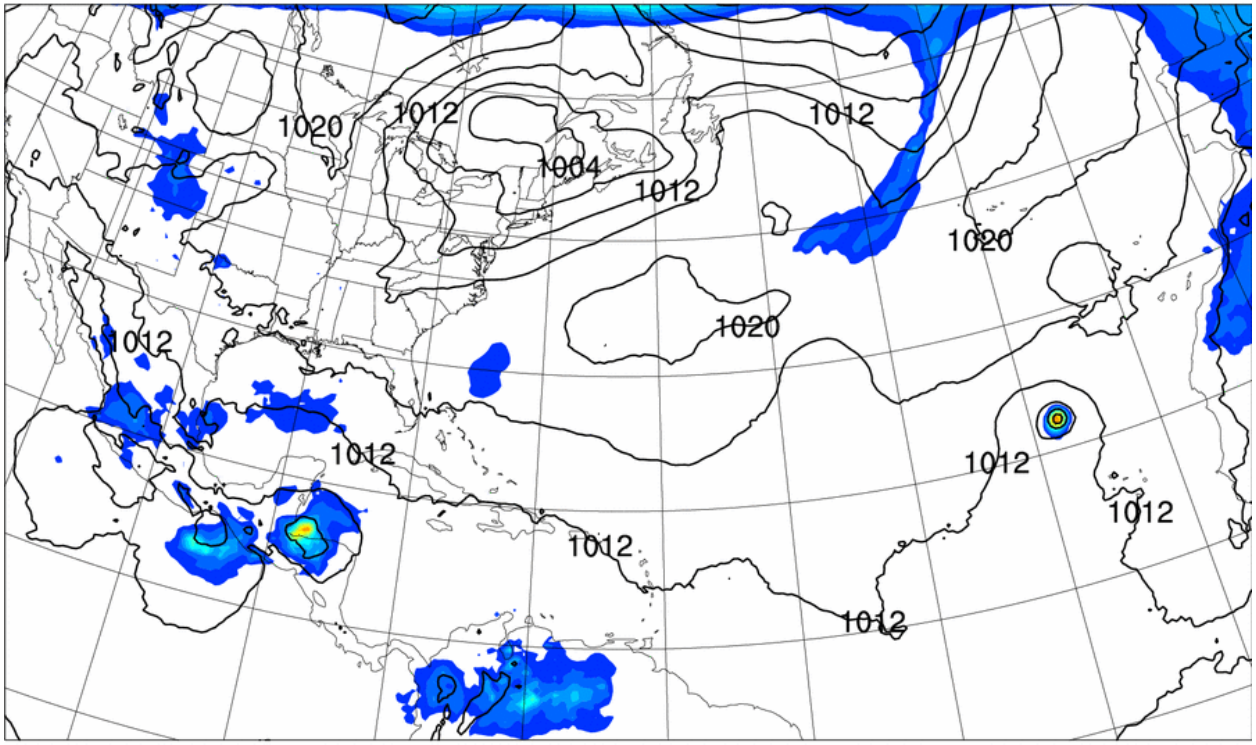
Cycling Data Assimilation with WRF/DART



Chris Snyder, NCAR

NCAR is supported by the National Science Foundation

Overview

1. Cycling WRF/DART (i.e. multiple forecast/analysis cycles) is essential to realize benefits of ensemble DA
2. Running WRF/DART, or any cycling assimilation system, is more complicated than running WRF alone

Why Cycle WRF/DART?

Benefits of ensemble DA come from use of ensemble covariances

- These are estimated from ensemble of forecasts
- Deviations of ensemble members about mean should represent statistics of short-range forecast errors *at that instant*
- Thus, ensemble should reflect effects of recent observations and of recent evolution of forecast errors under model dynamics
- Essential to perform multiple cycles. For TCs, 3-4 days of 6-hourly cycling is usually sufficient

What is WRF/DART?

WRF/ARW is forecast model

Data Assimilation Research Testbed (DART) does assimilation

- Provides EnKF algorithm(s)
- General framework, used for several other models
- See http://www.image.ucar.edu/DAReS/DART/

Set of interfaces between WRF and DART

- Translate between WRF variables and DART state vector
- Compute distance from given lat, lon to any element of state vector
- Advance model (i.e. perform forecast); for WRF, subroutine call to Unix script

Suite of observation operators

- Includes Doppler radar and various GPS; no radiances

Running WRF/DART

Recall that EnKF has a forecast step and an analysis step

Forecast step:

- Ensemble forecast, using full nonlinear model, to next analysis time
- Must account for uncertainty in lateral and surface BCs

Analysis step:

- Inputs are ensemble of WRF forecasts + observations
- Output is ensemble of WRF analyses + observation diagnostics, such as forecast and analyzed values of observed quantities

Forecast Step

DART calls subroutine to make forecast to next analysis time

Subroutine calls shell script to run WRF

- Standard approach is to run one member per processor
- Then wrfout files read and translated to DART state vector

Ensemble of lateral BCs

- Shell script constructs ensemble of LBC files, one per member,
- Uses specified external source (e.g. GFS) as mean LBC
- Each member's LBC is perturbed using spatially correlated noise produced by WRFDA via "RANDOMCV" option.

Analysis Step

DART has observations and WRF forecasts in memory

Forward operators computed for all observations, all members

- Ensemble of forecasts for each observed variable

Analysis ensemble computed via EnKF algorithm

- Particular flavor in DART is the “ensemble adjustment” Kalman filter (Anderson 2001)
- Also provides updated/analyzed values for observed variables

Observation Processing and Diagnostics

DART reads observations from obs_seq files

- Ascii format
- Linked list of **scalar** observations
- Model independent
- Extensible; can add various information and metadata to these files

Translators from several observation sources to DART obs_seq

- PrepBUFR, MADIS, obsproc output
- Exclude some obs based on source QC flags, or not

Observation preprocessing

- Restriction to specified domain
- Merging multiple files
- Superobing or thinning

Diagnostic tools

- WRF/DART diagnostics in observation space almost exclusively
- E.g. fit of prior (background) forecast to observations
- Use MATLAB

Caveats

WRF/DART is not a “push button” system

Need to be able to install and run:

- WRF
- WRFDA
- DART + associated shell scripts

Observation processing crucial and highly dependent on application and source of observations

Diagnostics require MATLAB

Getting Started

Online DART basics

- See http://www.image.ucar.edu/DAReS/DART/DART_Starting.php
- Begin with experiment with low-order model: fast, simple to visualize and understand, straightforward to debug

WRF/DART test case

- CONUS domain, low resolution
- Includes obs_seq files, ensemble of initial conditions and LBCs