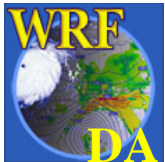# WRFVAR

A Community Facility for Variational Data Assimilation

Hans Huang
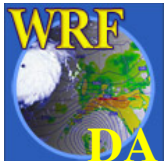**NCAR**

WRFDA
A Community Facility for Data Assimilation

Xiang-Yu Huang
NCAR

WRFDA Overview

- **Goal:** Community WRF DA system for
  - regional/global,
  - research/operations, and
  - deterministic/probabilistic applications.
- **Techniques:**
  - 3D-Var
  - 4D-Var (regional)
  - Ensemble DA
  - Hybrid Variational/Ensemble DA
- **Model:** WRF (ARW, NMM, Global)
- **Observations:** Conv. + Sat. + Radar (+Bogus)

www.mmm.ucar.edu/wrf/users/wrfda

Recent Tutorials at NCAR

1. WRFDA Overview
2. Observation Pre-processing
3. WRFDA System
4. WRFDA Set-up, Run
5. WRFDA Background Error Estimations
6. Radar Data
7. Satellite Data
8. WRF 4D-Var
9. WRF Hybrid Data Assimilation System
10. WRFDA Tools and Verification
11. Observation Sensitivity

Practice

1. obsproc
2. wrfda (3D-Var)
3. Single-ob tests
4. Gen_be
5. Radar
6. Radiance
7. 4D-Var
8. Hybrid
9. Advanced (optional)

The next: July 2013
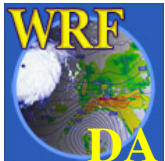
New features, v3.4, April 2012

- WRFPLUS (WRF adjoint and tangent linear model) has been upgraded to V3.4 and it is consistent with the released WRF version 3.4;

- WRFDA was also upgraded to V3.4 and the 4D-Var system now supports compilation to run in parallel with distributed memory;

- Precipitation data assimilation is now supported by the 4D-Var system;

- Forecast Sensitivity to Observations (FSO) has been updated to work with WRFPLUS V3.4;

- Analysis control variables have been expanded to include four types of cloud hydrometeors: cloud liquid water, cloud ice, snow and rain;

- Additional diagnostics have been added to the GEN_BE software package to stratify the model background error statistics by "rain class". The new "bin_type =7" defines four categories through thresholds in the background rainfall.
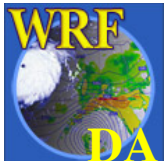
WRFDA v3.4 can assimilate

- In-Situ observations:
  - Surface (SYNOP, METAR, SHIP, BUOY).
  - Upper air (TEMP, PIBAL, AIREP, ACARS, TAMDAR).

- Remotely sensed observations:
  - Atmospheric Motion Vectors (geo/polar).
  - SATEM thickness.
  - Ground-based GPS Total Precipitable Water/Zenith Total Delay.
  - SSM/I oceanic surface wind speed and TPW.
  - Scatterometer oceanic surface winds.
  - Wind Profiler.
  - Radar radial velocities and reflectivities.
  - Satellite temperature/humidity/thickness profiles.
  - GPS refractivity (e.g. COSMIC).
  - Stage IV precipitation/rain rate data (4D-Var)

- Radiances (using RTTOV or CRTM):
  - HIRS   NOAA-16, NOAA-17, NOAA-18, NOAA-19, METOP-2
  - AMSU-A   NOAA-15, NOAA-16, NOAA-18, NOAA-19, EOS-Aqua, METOP-2
  - AMSU-B   NOAA-15, NOAA-16, NOAA-17
  - MHS   NOAA-18, NOAA-19, METOP-2
  - AIRS   EOS-Aqua
  - SSMIS   DMSP-16, DMSP-17, DMSP-18

- Bogus data:
  - TC bogus
  - Global bogus

Multi-incremental 4dvar:
Prepare operational configurations

- Calculate the innovation at high resolution with full nonlinear model.

- Search the minimization at lower resolution with simplified TL/AD model.

- Different outer loop may has different resolution.
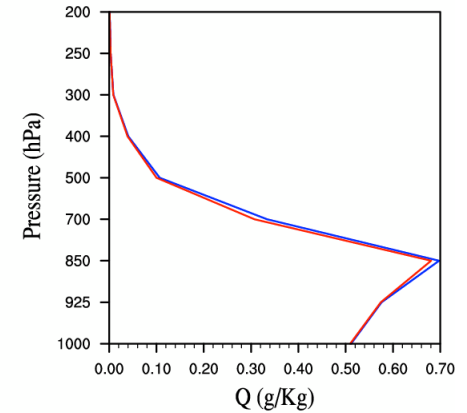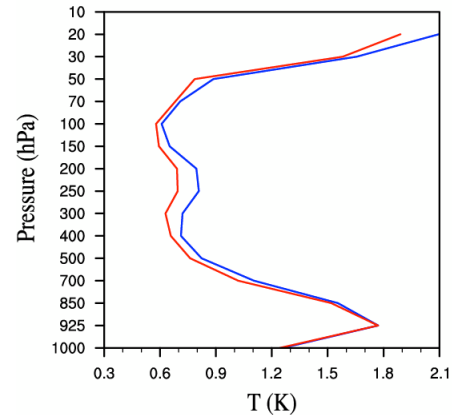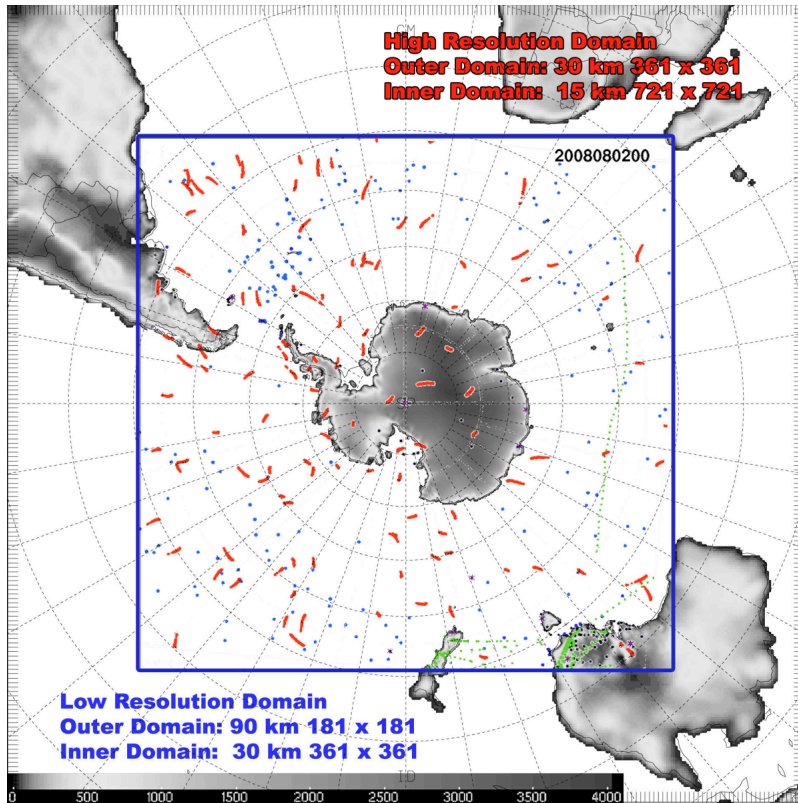
Computational saving

CPU : Intel(R) Xeon(R) CPU X7560 @ 2.27GHz

Denmark case: 121 X 91 @ 30km, 45 levels, top 50hPa, dt=180s,
6Hr window, 32 iterations max.
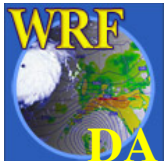
– 4dvar full resolution (32 cores): about 4 hours

– 4dvar multi-increment : about 22 minutes
  • innovation   (16 cores) : 2 minutes
  • minimization (16 cores) : 20 minutes

3DVAR vs. 4DVAR over Antarctic
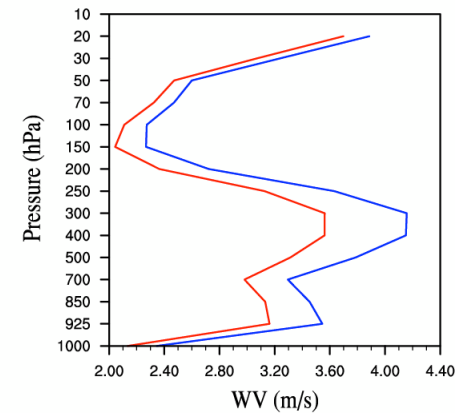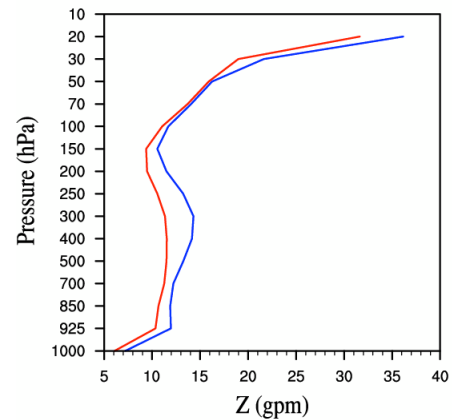
12 FC against ERA-Interim reanalysis (with radiance data assimilated in both 3DVAR and 4DVAR) for 10-d period.

WRFDA v3.5

- Release date: April 2013
- New features:
  - Support for data from additional satellite instruments:
    - METOP: Infrared Atmospheric Sounding Interferometer (IASI)
    - Suomi NPP: Advanced Technology Microwave Sounder (ATMS)
    - FY3: Microwave Temperature Sounder (MWTS) and Microwave Humidity Sounder (MWHS)
  - Direct wind speed/direction assimilation (planned)
  - ETKF will now be officially supported
  - Support for new ECMWF cloud detection scheme
  - Allowing variable number of inner-loop cost function minimizations for each outer-loop
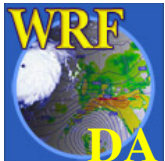
After WRFDA v3.5

- The recoded stand-alone GEN_BE
- More satellite platform/instruments (e.g. CrIS)
- Revision of the energy norm used by FSO
- Displacement analysis
- Multivariate cloud analysis
- Ensemble Variational Integrated Lanczos (EVIL)