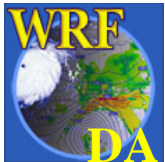


WRFVAR

A Community Facility for Variational Data Assimilation

**Hans Huang
NCAR**



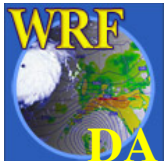
WRFDA

A Community Facility for Data Assimilation

Xiang-Yu Huang
NCAR

Acknowledge:

WRFDA team and many visitors,
AFWA, NCAR, AirDat, NSF-AGS, USWRP, NSF-OPP, NASA, PSU,
CWB, BMB, CAA, KMA, EUMETSAT



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)



WRFDA USERS PAGE
Home Analysis System User Support Download Doc / Pub Links Internal Users Forum

WRFDA Home

Public Domain Notice

Contact WRF Support

WRF Data Assimilation System Users Page

Welcome to the page for users of the Weather Research and Forecasting (WRF) model data assimilation system (WRFDA). The WRFDA system is in the public domain and is freely available for community use. It is designed to be a flexible, state-of-the-art atmospheric data assimilation system that is portable and efficient on available parallel computing platforms. WRFDA is suitable for use in a broad range of applications, across scales ranging from kilometers for regional and mesoscale modeling to thousands of kilometers for global scale modeling.

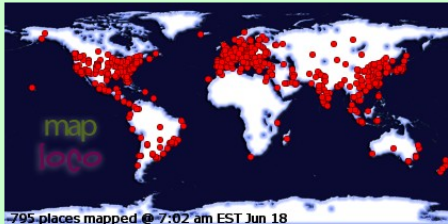
The Mesoscale and Microscale Meteorology (MMM) Division of NCAR currently maintains and supports a subset of the overall WRF code (Version 3) that includes:

- WRF Software Framework (WSF)
- Advanced Research WRF (ARW) dynamic solver, including one-way, two-way nesting and moving nests, grid and observation nudging
- WRF Pre-Processing System (WPS)
- **WRF Data Assimilation System (WRFDA)** *(found on this site)*
- Numerous physics packages contributed by WRF partners and the research community

Other components of the WRF system will be supported for community use in the future, depending on interest and available resources.

Helpful links

- [Download WRFDA](#) Latest version: 3.4 *(Released April 6, 2012)*
- [WRF Model Users Page](#) WRF Model source code, User Guide, and Online Tutorial
- [WRF Model Development Page](#) Information on WRF Development, events, and real-time forecasts



updated 04/09/2012 20:24:45

LATEST WRFDA RELEASE

[WRFDA Version 3.4](#)
(Released April 6, 2012)

WHAT'S NEW

[WRFDA Version 3.3.1](#)
(Released September 27, 2011)

[Presentation of WRF 4D-Var V3.3 Tutorial](#)
24 June 2011, Boulder, CO

[Known Problems for V3.3](#)
(Updated August 5, 2011)

[WRFDA Version 3.3](#)
(Released April 6, 2011)

[12th WRF Users' Workshop, 20 - 24 June 2011, NCAR Foothills Lab in Boulder, CO](#)

[WRF New User Tutorial, 11 - 22 July 2011, NCAR Foothills Lab in Boulder, CO](#)

[WRF for Hurricanes Tutorial, 26 - 29 April 2011, NCAR Foothills Lab in Boulder, CO](#)

[The 5th East Asia WRF Workshop and Tutorial, Busan, Korea, 11-19 April 2011](#)

[Tips for reading BUFR data](#)

ANNOUNCEMENTS

[WRF Workshop, June 26 - 29, 2012](#)

[WRFDA Tutorials](#) *(updated October 2011)*

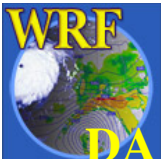
Since July 2011

Visitors

1,444	32	13
1,302	29	13
293	25	11
232	25	9
165	23	9
124	19	9
114	17	9
96	17	9
70	17	8
64	16	8
56	15	7
50	15	7
47	15	7
42	15	7
36	14	6
36	14	6
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Free counters!>

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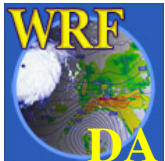
Recent Tutorials at NCAR

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

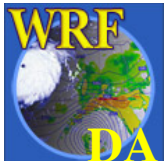
1. obsproc
2. wrfda (3D-Var)
3. Single-ob tests
4. Gen_be
5. Radar
6. Radiance
7. 4D-Var
8. Hybrid
9. Advanced (optional)

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

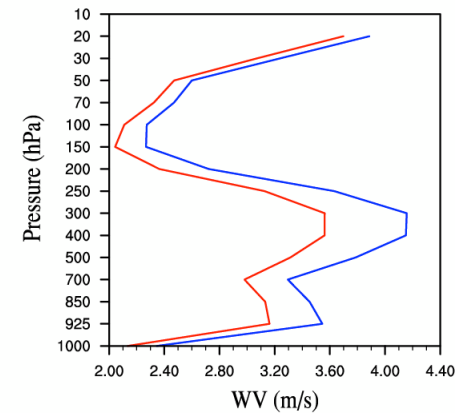
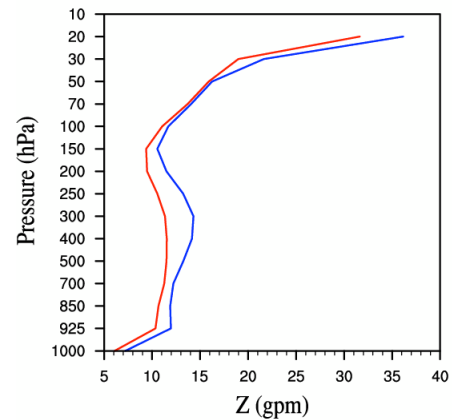
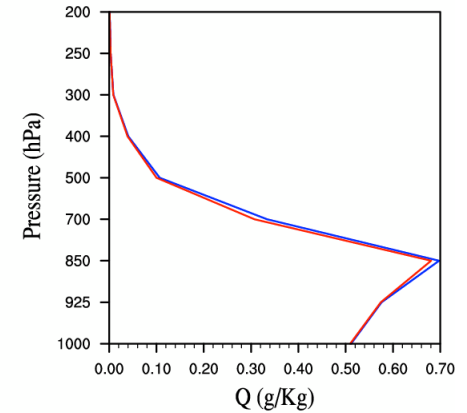
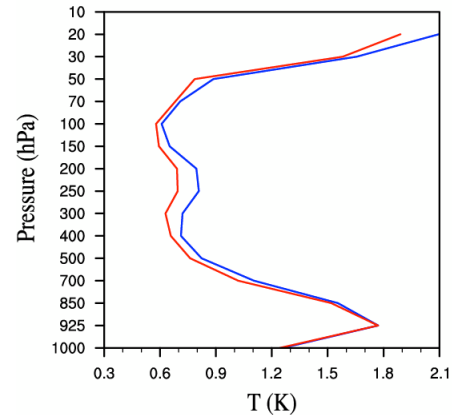
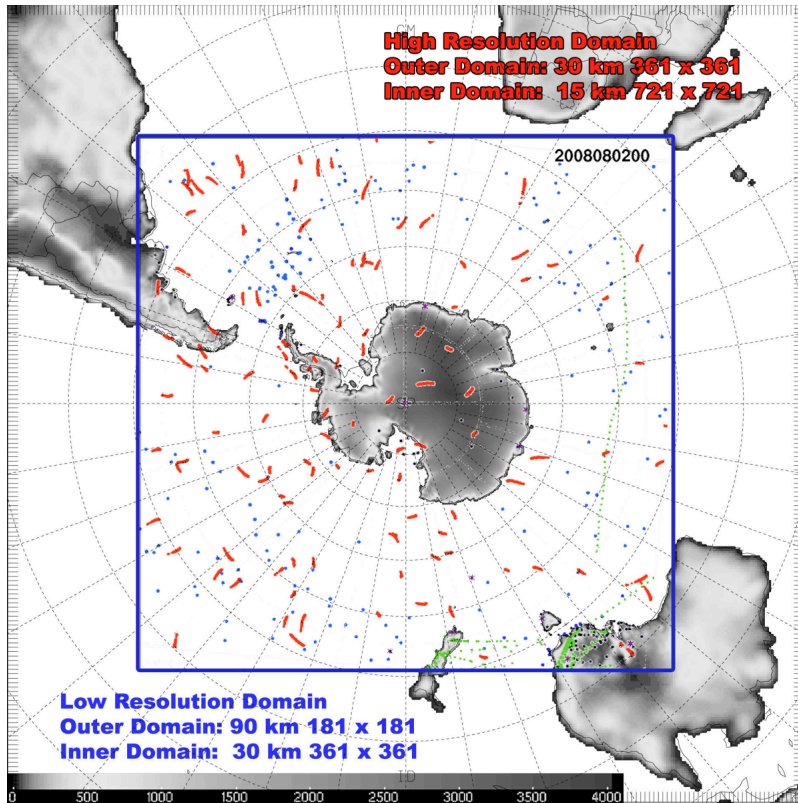
CPU : Intel(R) Xeon(R) CPU X7560 @ 2.27GHz

Denmark case: 121 X 91 @ 30km, 45 levels, top 50hPa, dt=180s,
6Hr window, 32 iterations max.

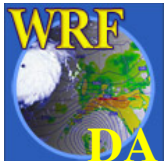
- 4dvar full resolution (32 cores): about **4 hours**
- 4dvar multi-increment : about **22 minutes**
 - innovation (16 cores) : 2 minutes
 - minimization (16 cores) : 20 minutes



3DVAR vs. 4DVAR over Antarctic

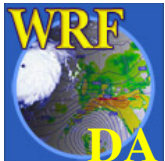


**12 FC against ERA-Interim reanalysis
(with radiance data assimilated in both
3DVAR and 4DVAR) for 10-d period.**



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)

