WRFDA 2012 Overview

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WRFDA Overview

- **Goal:** Community DA system for
  - regional/global,
  - research/operations, and
  - deterministic/probabilistic applications.

- **Techniques:**
  - 3D-Var
  - 4D-Var (regional)
  - Ensemble DA,
  - Hybrid Var/Ens DA.
FSO - Forecast Sensitivity to Observations

Observation (y)

WRF-VAR Data Assimilation

Analysis (x_a)

WRF-ARW Forecast Model

Forecast (x_f)

Define Forecast Accuracy

Observation Impact <y-H(x_b)> (∂F/∂y)

Observation Sensitivity (∂F/∂y)

Background Sensitivity (∂F/∂x_b)

Adjoint of WRF-VAR

Analysis Sensitivity (∂F/∂x_a)

Bias Correction Sensitivity (∂F/∂β_k)

Obs Error Sensitivity (∂F/∂ε_0b)

Adjoint of WRF-ARW

Gradient of F (∂F/∂x_f)

Derive Forecast Accuracy

Figure adapted from Liang Xu (NRL)

Thomas Auligne
From Langland and Baker (2004)

$x_t$ is the true state, estimated by the analysis at the time of the forecast

$x_f$ is the forecast from analysis $x_a$

$x_g$ is the forecast from first-guess at the time of the analysis $x_a$
More details (for WRFDA implementation)  
Thomas Auligne

$$K^T = R^{-1}H P^a$$

Reference state: Namelist ADJ_REF is defined as
1: $$x_t =$$ Own (WRFDA) analysis
2: $$x_t =$$ Other (NCEP or ECMWF) analysis
3: $$x_t =$$ Observations

Forecast Aspect: depends on reference state
1 and 2: Total Dry Energy
3: WRFDA Observation Cost Function: Jo

Geo. projection: Script option for box (default = whole domain)

Forecast Accuracy Norm: $$e = (x_f-x_t)^T C (x_f-x_t)$$
FSO - Forecast Sensitivity to Observations for Regional Systems

- **Obs(y)**
- **BG(x_b)**
- **WRFDA or GSI**
- **Analysis (x_a)**
- **UpdateB**
- **New BC**
- **Forecast (x_f)**
- **Define Forecast Accuracy**

**Observation Impact**

\[ <y-H(x_b)>(\partial F/\partial y) \]

**FSO**

- **Adjoint of WRFDA or GSI**
- **Adjjoint of UpdateB**
- **BC Sens.**
- **Analysis Sensitivity**

**Obs Error Sensitivity**

\[ (\partial F/\partial \varepsilon_{ob}) \]

**Bias Correction Sensitivity**

\[ (\partial F/\partial \beta_k) \]
12h forecast error estimations (00,12UTC) verified with EC reanalysis
Limitations

• Approximation of “truth”
• Dependence of norm
• Linear assumptions
  – Adjoint of the forecast model
  – Adjoint of the analysis (assimilation)
• …
WRFDA tutorials

21-22 July, 2008. NCAR.
2-4 Feb, 2009. NCAR.
18 April, 2009. South Korea.
20-22 July, 2009. NCAR.
1-3 Feb, 2010. NCAR.
10 April, 2010. Seoul, South Korea.
3-5 August 2010. NCAR.
16 April. Busan, South Korea
20-22 July 2011. NCAR
10-20 October. Bangkok, Thailand.
21 April 2012. Seoul, South Korea.

At recent NCAR tutorials, we have a lecture and a practice session on FSO

The next: 23-25 July 2012. NCAR.
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)
New features, v3.4, 6 April 2012

- WRFPLUS3 (WRF TL/AD) updated/parallelized/optimized.
- 4D-VAR redesigned/upgraded/parallelized/multit-incremental.
- Precipitation assimilation capability added.
- The fully multivariate background error option, cv6, updated.
- Hybrid Var/Ens updated документирован.
- Capability to generate forecast sensitivity to observations (FSO) updated/parallelized.
- NOAA-19 AMSUA and MHS added/tested.
WRF FSO applications

- AFWA data assimilation testbed (at NCAR, both WRFDA and GSI)
- Arctic System Reanalysis project (conv and rad)
- Nanjing Univ of Info Sci Tech, Hubei Met Bureau, Yonsei Univ, Seoul Natl Univ, …
- AFWA operational system (at AFWA)
- AIRDAT pre-operational system (TAMDAR)
- Taiwan Central Weather Bureau operational system.
Monitoring observation impact with Taiwan Central Weather Bureau opearational analysis/forecast system

Xin Zhang annd Hans Huang
National Center for Atmospheric Research
(NCAR is sponsored by the National Science Foundation)
Monitoring observation impact with Taiwan Central Weather Bureau operational analysis/forecast system

Xin Zhang and Xiang-Yu Huang
Average between 2010/03/06 - 2010/12/06 for 03 Z

TAM558
MIDEVA
Banda_Alab
AMH
National
Radar
PMMA
BIPRA
BPR
PDL
AER
GRM
GPR
APAC
ARRAS
CAGN
BIM
Pwin
Sonic
Snow

Forecast error contribution (x10000 J/kg)

Average between 2010/03/06 - 2010/12/06 for 09 Z

TAM558
MIDEVA
Banda_Alab
AMH
National
Radar
PMMA
BIPRA
BPR
AER
GRM
GPR
APAC
ARRAS
CAGN
BIM
Pwin
Sonic
Snow

Forecast error contribution (x10000 J/kg)

Average between 2010/03/12 - 2010/12/12 for 12 Z

TAM558
MIDEVA
Banda_Alab
AMH
National
Radar
PMMA
BIPRA
BPR
AER
GRM
GPR
APAC
ARRAS
CAGN
BIM
Pwin
Sonic
Snow

Forecast error contribution (x10000 J/kg)

Average between 2010/03/18 - 2010/12/18 for 18 Z

TAM558
MIDEVA
Banda_Alab
AMH
National
Radar
PMMA
BIPRA
BPR
AER
GRM
GPR
APAC
ARRAS
CAGN
BIM
Pwin
Sonic
Snow

Forecast error contribution (x10000 J/kg)
• In terms of the observational type

  – The largest error decrease is due to GeoAMV followed by SOUND, SYNOP and GPSREF

  – The impact from SATEM is marginal and neutral.

  – On 0000UTC and 1200UTC, the SOUND is the most important observation to decrease the forecast error, followed by GeoAMV, SYNOP, GPSREF/AIREP

  – on 0600UTC and 1800UTC, the GeoAMV is the most important observation to decrease the forecast error, followed by SYNOP/GPSREF, AIREP
• In terms of the time series of impact of observational type

  – On 0000 and 1200UTC, the SOUND improve the forecasts in general.

  – On 0600UTC and 1800UTC, the SOUND almost degrades the 1/3 of the forecasts. Still trying to understand these results.

  – For other observation types, at 0600UTC and 1800UTC, there are many degraded cases due to observations. Need further investigation.
• In terms of impact per observation for each type

– The GPSREF is the most efficient observation to reduce the 24h forecast error per observation, followed by SYNOP, SHIPS and SOUND. It is consistent with the result from AFWA domains (personal communication with Jason T. Martinelli of AFWA)
Ongoing research activities

- Identify observations with continuous negative impact.
- Tune WRFDA based on observation impact results.
- Improve the assimilation strategy of surface observation assimilation.
- Investigate the differences of verifying forecasts to EC analysis, NCEP GFS analysis, WRFDA analysis and Observations.