WRFDA 2011 Overview

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Acknowledge:

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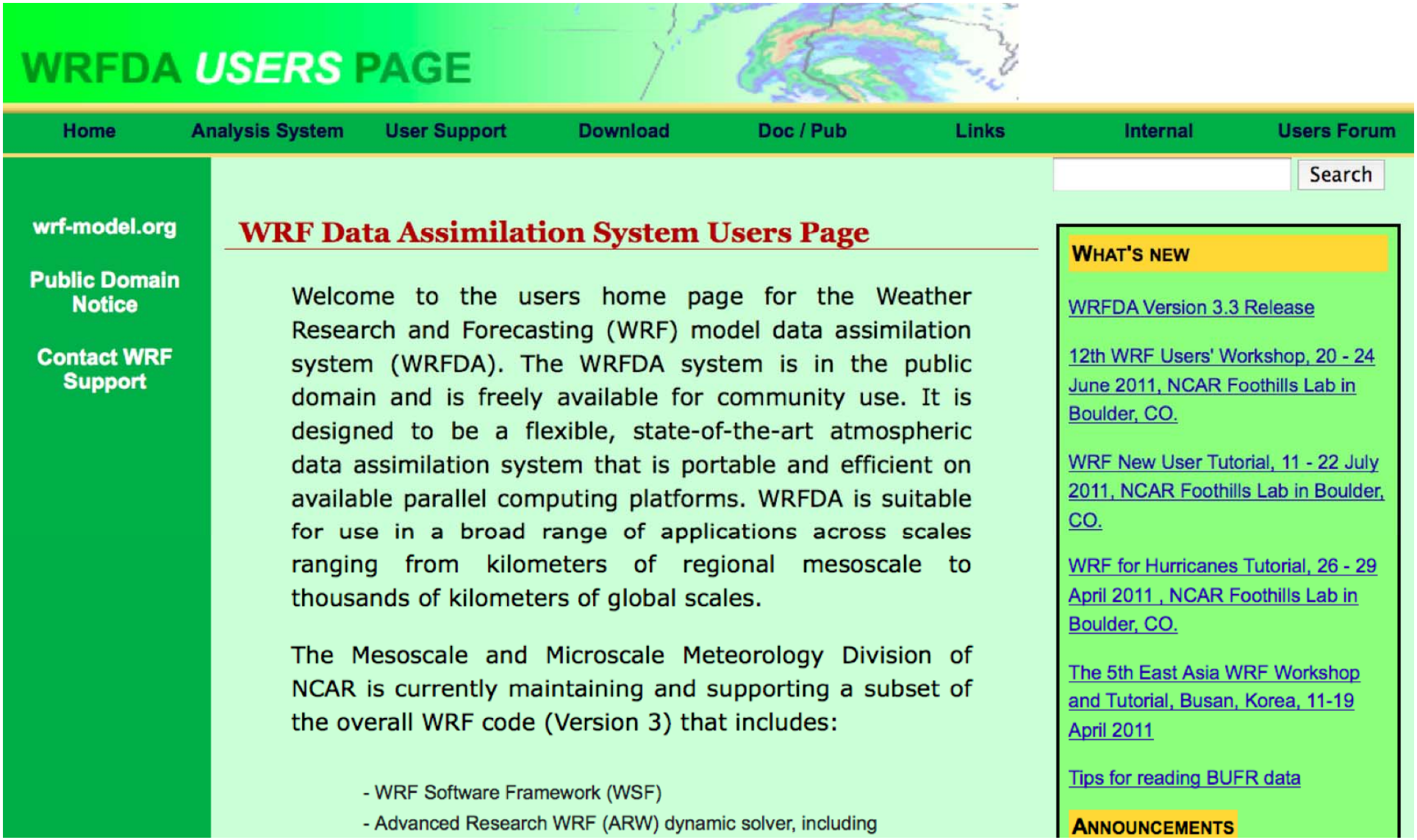
WRFDA Overview

- **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)
- **Support:**
  - NCAR/NESL/MMM/DAS
    (Data Assimilation Section, also supporting WRF/DART)
  - NCAR/RAL/JNT/DAT
    (Data Assimilation Team, also supporting GSI)

(Xin Zhang)

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



Recent Tutorials at NCAR

(Hui-Chuan Lin)

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: 20-22 July 2011

WRFDA.3.3 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).
- 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
- Bogus data:
  - TC bogus
  - Global bogus

New features, v3.3, April 2011

- WRFPLUS3 – WRF TL/AD based on WRF3.3
- 4D-Var redesigned/upgraded
- RTM interface updated:
  - RTTOV (v10.0)
  - CRTM (v2.0.2)
- NOAA-19 AMSUA and MHS added.
- New background error option (cv6).
  - Add additional variables, e.g. unbalanced velocity potential, to balance computations
  - Fully multivariate including relative humidity
- Capability to generate forecast sensitivity to observations (FSO), compatible with WRF3.3

A recent adjoint-based observation impact study (or FSO)

Thomas Auligné, Xin Zhang, Hongli Wang, Anwei Lai, Xiaoyan Zhang, Hui-Chuan Lin, Qingnong Xiao, Yansong Bao, Zhiquan Liu, Xiang-Yu Huang

FSO - Forecast Sensitivity to Observations

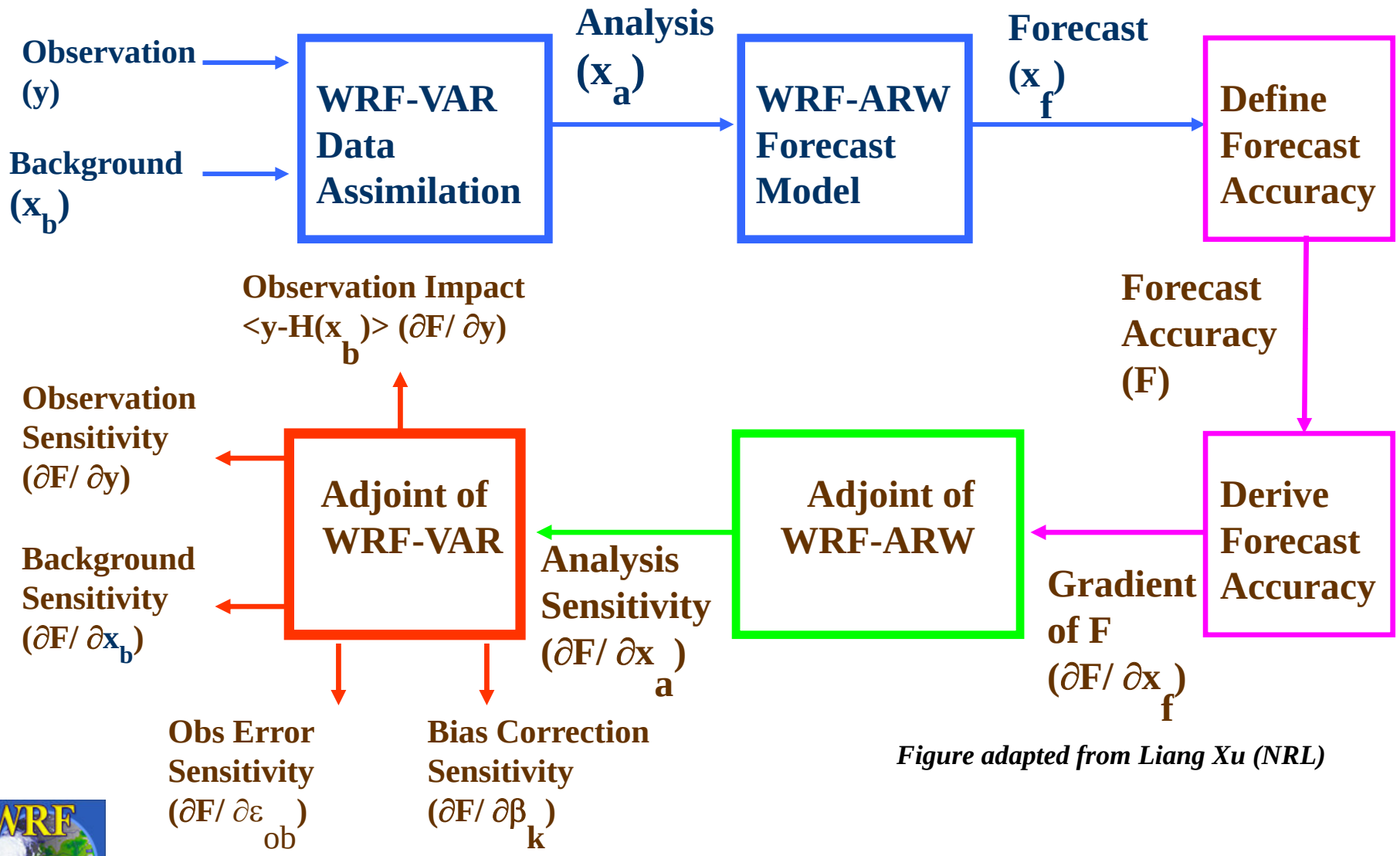


Figure adapted from Liang Xu (NRL)

Limitations

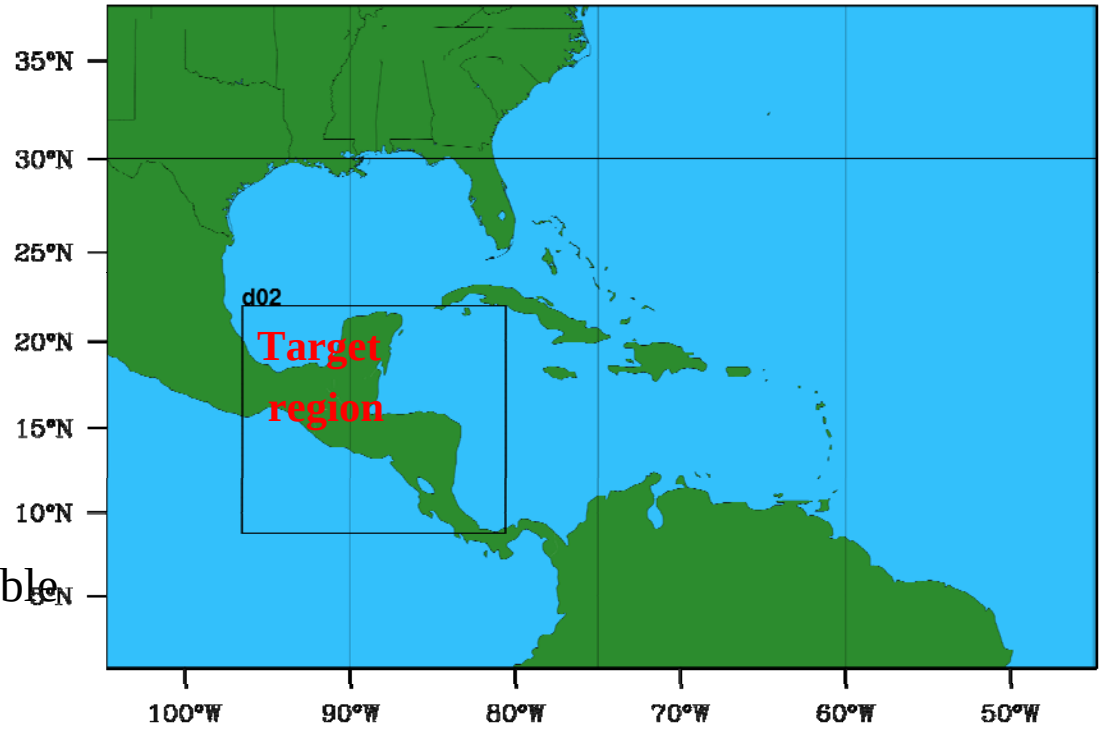
- Approximation of “truth”
- Dependence of norm
- Linear assumptions
  - Adjoint of the forecast model
  - Adjoint of the analysis (assimilation)
- …

T8 (45km) Results

One month:2007081506-2007091512

- WRFV3.2.1
- MAP_PROJ=Mercator
- WE =140
- SN =94
- DX =45km
- DY =45km
- E_VERT =57
- MP_PHYSICS=WSM 5-class scheme
- CU_PHYSICS= Grell 3D ensemble scheme

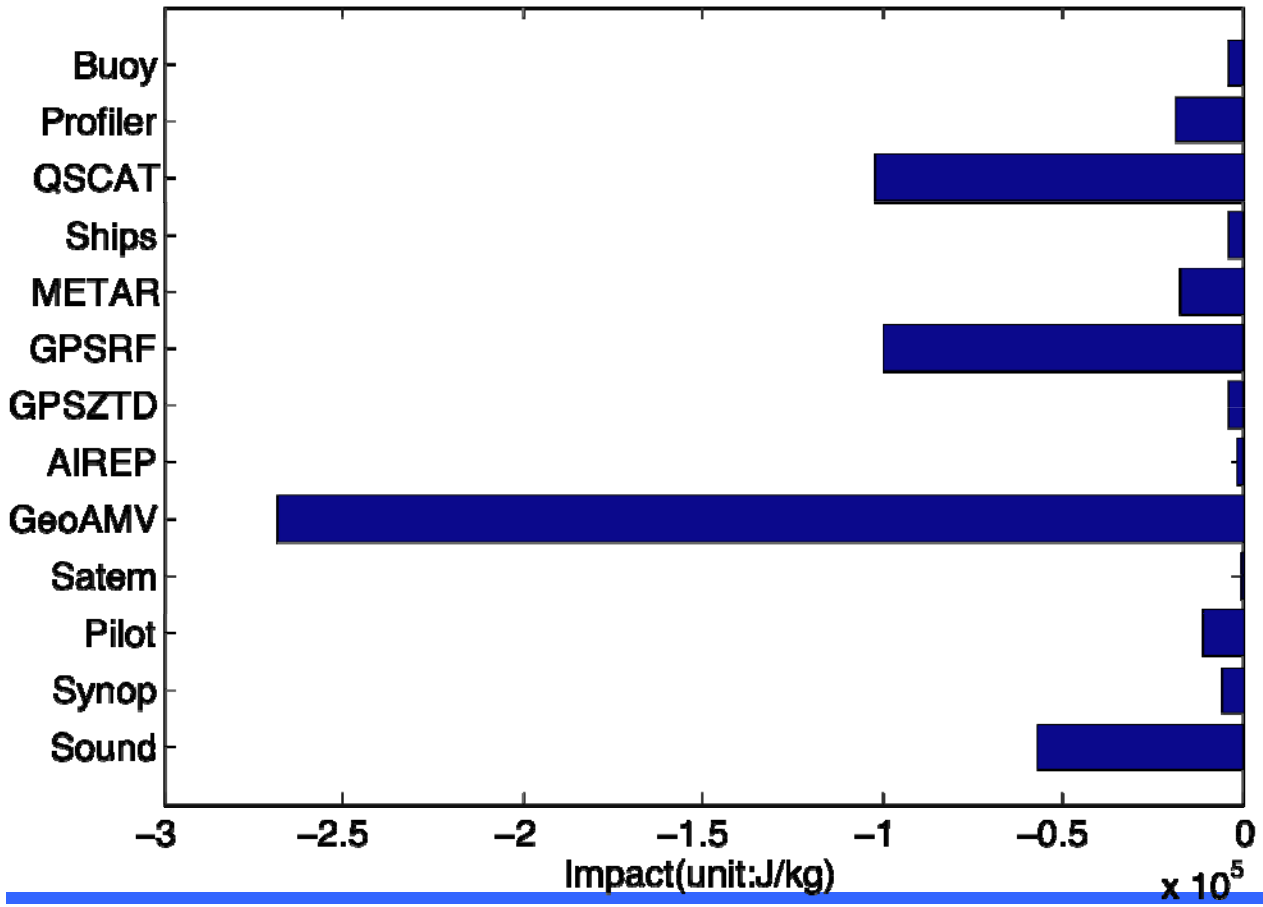
AWFA T8

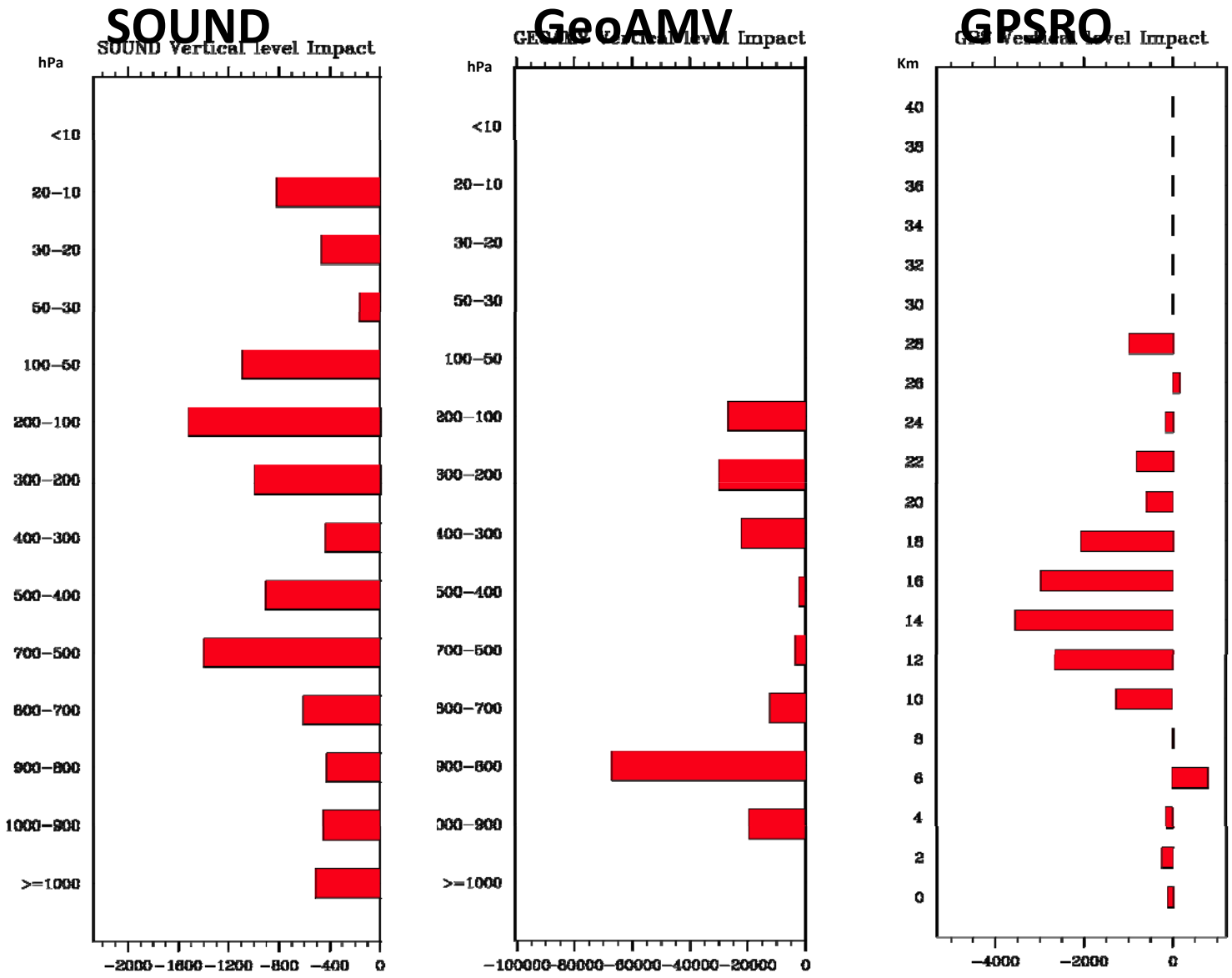


- **ADJ_ISTART=20 ADJ_IEND=60**
- **ADJ_JSTART=20 ADJ_JEND=60**
- **ADJ_KSTART=1 ADJ_KEND=27**

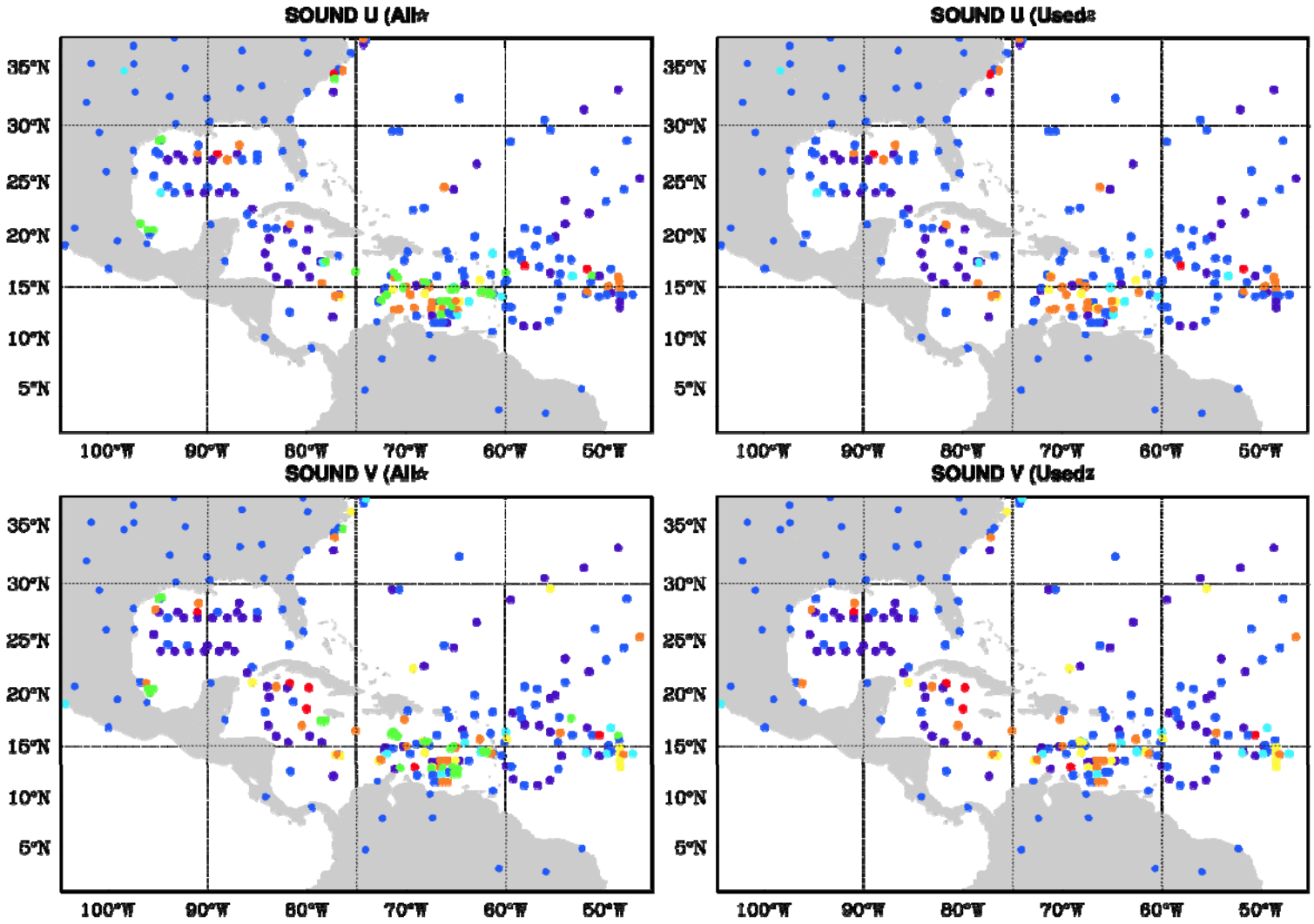
WRFV3 Version 3.2.1
WRFDA Version 3.2.1
WRFPLUS2.0

Impact of observations on 6h forecasts (grouped according to observing systems)



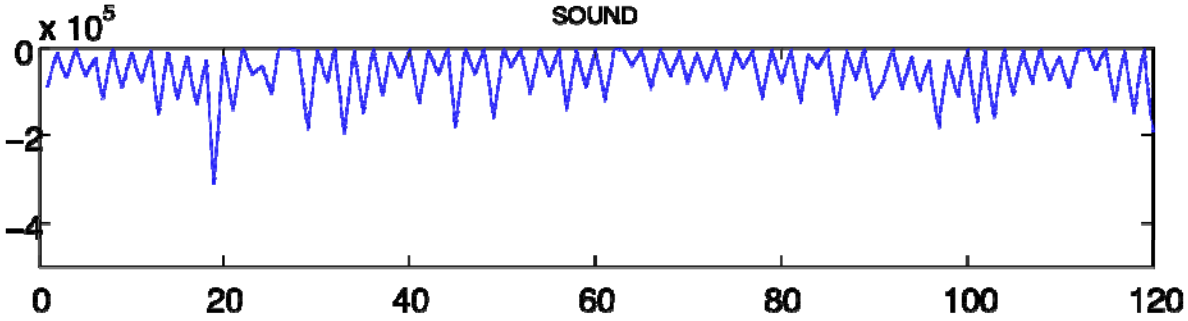


Vertical Impact distribution, unit: J/Kg

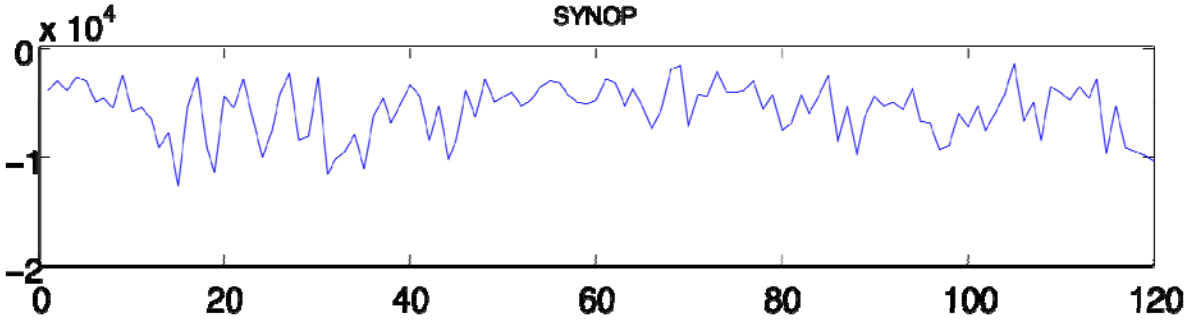

SOUND U (All)
SOUND U (Used)
SOUND V (All)
SOUND V (Used)
35°N
30°N
25°N
20°N
15°N
10°N
5°N
100°W
90°W
80°W
70°W
60°W
50°W
x<-500
-500<=x<-50
-50<=x<0
0<=x<50
50<=x<500
x>=500
x=0

Time series of impact of observations on 6h forecasts

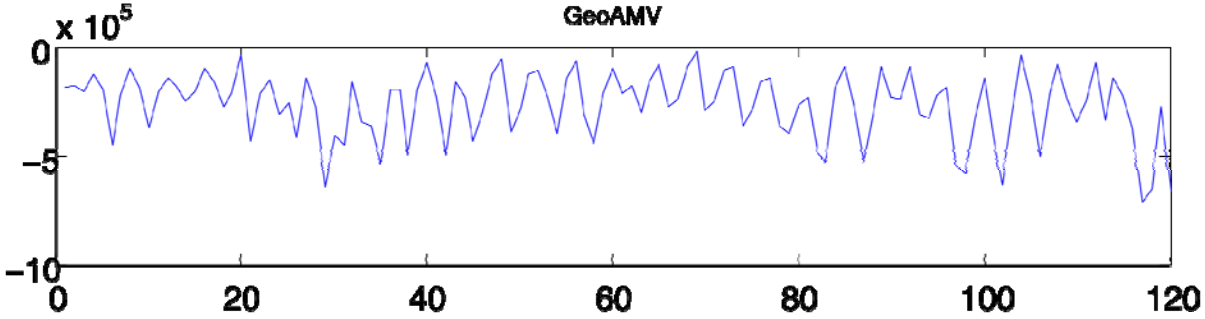
SOUND



SYNOP



GeoAMV



X axis :time. 4 times per day during 30days ;
Y axis : Impact on the forecasting (Unit:J/kg)

Further development of WRFDA 4D-Var
(Xin Zhang)

- Parallelization of WRFPLUS V3.3 adjoint model.
- Multi-incremental WRF 4D-Var: Calculate innovation in high resolution, do minimization on lower resolution.
- Systematic tests of the simplified physics of WRFDA 4D-Var
- Add convectional rainfall and non-convectional rainfall in forcing.
- Add tangent linear and adjoint codes of GSFC short-wave scheme in WRFPLUS.

Development of WRF 4D-Var for Radar
(Hongli Wang and Jenny Sun)

1. Radar reflectivity assimilation
   - Assimilating retrieved rainwater from RF;
   - The error of retrieved rainwater is specified by error of RF.
2. New control variables and background error covariance
   - Cloud water (*qc*), rain water (*qr*) and ice (*qi*);
   - Recursive filter is used to model horizontal correlation ;
   - Vertical correlation is considered by EOFs;
3. Microphysics scheme
   - Linear/adjoint of a Kessler warm-rain scheme;
   - Incorporated into WRF tangent/adjoint model.

Further development of Lanczos minimization
(Thomas Auligne)

- The stopping criterion is based on information content (i.e. the relative analysis increment) rather than the gradient norm. This avoids expensive unnecessary calculation for the gradient.
- The Lanczos eigenpairs produced during the minimization can be stored into files. The WRFDA data assimilation can read these files
  a) to avoid re-running the assimilation for the observation impact and/or
  b) to precondition subsequent minimizations and converge faster.

WRFDA Variational/Ensemble Hybrid System
(Arthur P. Mizzi)

1. Various ETKF inflation factors
2. Vertical localization of the hybrid extended control variable
3. Hybrid with LETKF
4. Hybrid with DART

Summary

1. WRFDA 2011 Overview
   - Community System
   - Techniques: 3D-Var, 4D-Var, EnKF, Hybrid
   - New features in the latest release (v3.3, April 2011)
2. A recent adjoint-based observation impact study
   - The concept and limitations
   - Applications
3. Ongoing activities