WRFDA 2016 Update

Jake Liu

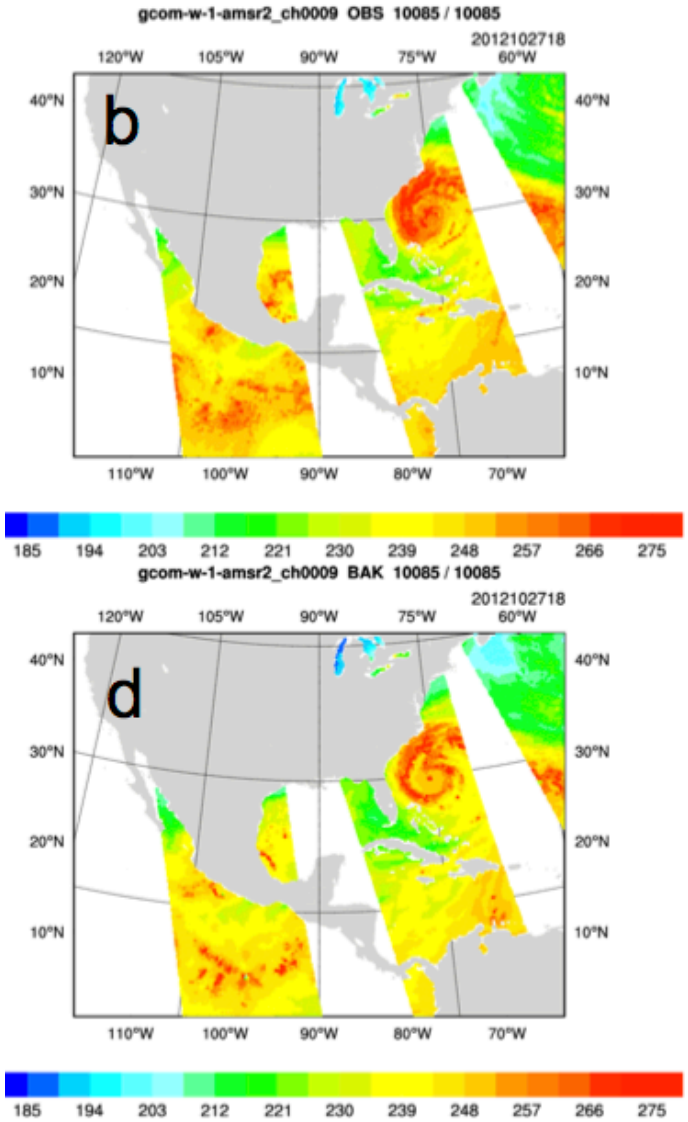
Jenny Sun, Jamie Bresch, Michael Kavulich, Feng Gao, Chun Yang, Syed Rizvi, Junmei Ban, Ying Zhang, Yaodeng Chen

NCAR/MMM

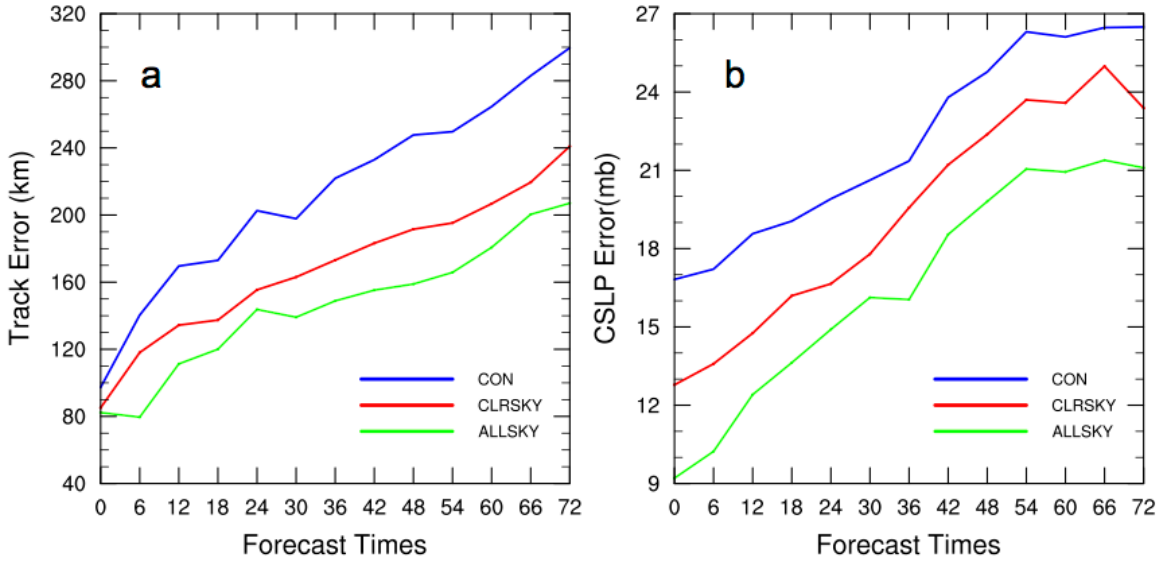
Outline

- New features in WRFDA V3.8
- Ongoing developments

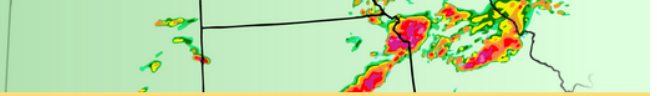
New all-sky radiance DA: AMSR2



Channel	Frequency (GHz)	Polarization	Footprint (along scan* along track)
1,2	6.925	V,H	35*61 km
3,4	7.3	V,H	35*61 km
5,6	10.65	V,H	24*41 km
7,8	18.7	V,H	13*22 km
9,10	23.8	V,H	15*26 km
11,12	36.5	V,H	7*12 km
13,14	89.0	V,H	3*5 km



WRFDA *USERS* PAGE



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WRFDA beta releases

WRFDA: Beta releases

WRFDA is undergoing continuous development as more capabilities are added, both by NCAR scientists and community contributors. On this page you can find pre-release versions of new capabilities. As these capabilities are new and not fully tested, we appreciate any feedback you can offer us: contact us through wrfhelp or the WRFDA webmaster.

Below is a list of the current beta releases we have available.

AMSR2 Cloudy Radiance assimilation

Typically, with radiance assimilation in WRFDA, pixels which are determined to have clouds in them are rejected. However, we have developed the ability to assimilate cloud-affected radiance observations with the JAXA GCOM-W1 AMSR2 instrument. This capability is described in this PDF guide, and in the following publication:

> Chun Yang, Zhiquan Liu, Jamie Bresch, Syed R. H. Rizvi, Xiang-Yu Huang and Jinzhong Min, 2016: AMSR2 all-sky radiance assimilation and its impact on the analysis and forecast of Hurricane Sandy with a limited-area data assimilation system. *Tellus A*, **68**, 30917, doi:10.3402/tellusa.v68.30917.

Download pre-release code

To download beta release code:

Fill out the registration form by clicking **'New Users'** below, or select **'Returning Users'** if you have already registered to download WRF or WRFDA in the past. You will be redirected to a page where you can download a tar file with the code you are interested in.

New Users

Returning Users

See DA session's talk by Chun Yang:
Impact of assimilating all-sky AMSR-2 radiance observations on forecast of Hurricane Sandy

New dynamic constraint capability

- A user-contributed new "weak penalty constraint" (WPEC) option has been added to WRFDA to enhance mass/wind balance (re-invented from MM5-3DVAR implementation).
- It can be used for hybrid-3DVAR, or for pure 3DVAR.
- The constraint is implemented as an additional cost function term,

$$J_d = G(\mathbf{x})^T \Gamma^{-1} G(\mathbf{x})$$

- Where $G(\mathbf{x})$ is the dynamic constraint, and Γ^{-1} is a namelist-controlled weighting factor. The non-linear operator G is steady state momentum equation:

$$G = \vec{V} \cdot \nabla_\sigma \vec{V} + f\vec{k} \times \vec{V} + \nabla_\sigma \phi + \frac{1}{\rho} \nabla_\sigma p$$

Cyclostrophic term **Geostrophic term**

New dynamic constraint capability

- This new option is controlled by a simple set of namelist options:

```
&wrfvar12
 use_wpec    = .true.
 wpec_factor = 0.001
 balance_type= 3
```

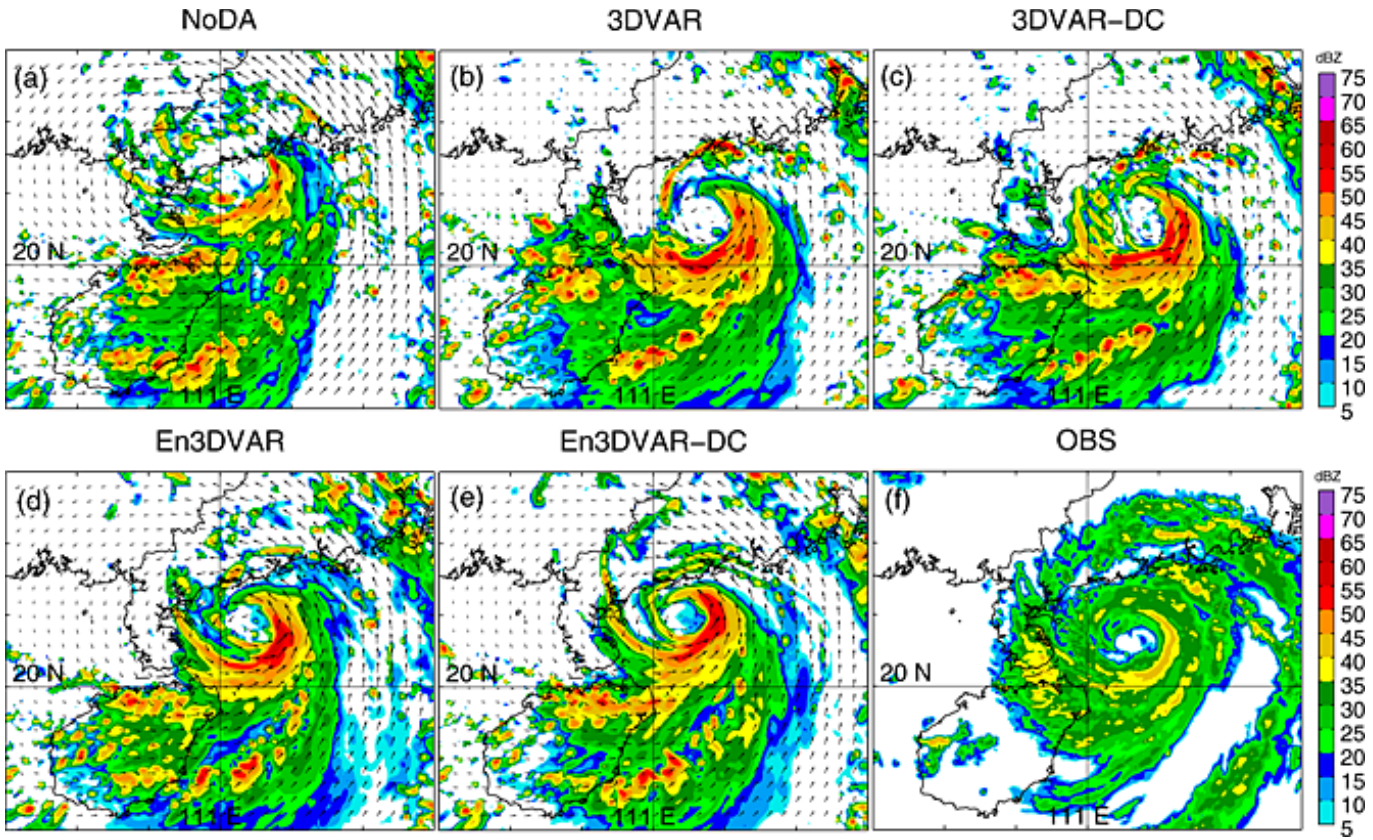
enables constraint term

1/Γ, weighting factor

1 = geostrophic term
2 = cyclostrophic term
3 = both terms (recommended)

New dynamic constraint option

Li, Xin, Jie Ming, Ming Xue, Yuan Wang, and Kun Zhao, 2015: Implementation of a dynamic equation constraint based on the steady state momentum equations within the WRF hybrid ensemble–3DVar data assimilation system and test with radar T-TREC wind assimilation for tropical Cyclone Chanthu (2010). *JGR*, **120**, 4017–4039.



- Analyzed reflectivity with and w/o the dynamic constraint

Other updates and fixes in V3.8

- WRFPlus (TL/AD of WRF) upgraded to be consistent with WRF V3.8
  - Fixed WRFPLUS/4DVAR compilation errors for some IBM/AIX systems (Thanks to Zhou Lilong from National Meterological Center of CMA).
- The CV7 Background error option has undergone a major bug fixes. **Users of this option should upgrade to WRFDA 3.8, since the older release code produces incorrect results.**

- Updated RTTOV interface to supports RTTOV V11.1, 11.2, or 11.3
- WRFDA can now be compiled with HDF5 lib to read HDF5 format files (for AMSR2 assimilation)
- Fixed problems with excessive noise in moisture field for some radar options (use_radar_rhv, use_radar_rqv)
- Improved consistency of surface diagnostics (T2, Q2, U10, and V10) between WRFDA and WRF

Real-Time WRF/WRFDA-hybrid analysis/forecast over CONUS

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WRF Users Page

Have questions? Try our FAQ first!

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) Laboratory of NCAR currently maintains and supports a subset of the overall WRF code (Version 3) that includes:

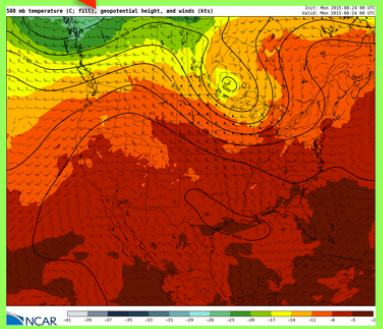
- WRF Software Framework (WSF)
- Advanced Research WRF (ARW) dynamic solver, including one-way, two-way nesting and moving nests, grid and observation nudging
- WRF Pre-Processing System (WPS)
- **WRF Data Assimilation System (WRFDA)** *(found on this site)*
- Numerous physics packages contributed by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

LATEST WRFDA RELEASE

WRFDA Version 3.7.1
(Released August 14, 2015)

WRF / WRFDA REALTIME FORECAST



Click here for latest 48-hr forecast

UPCOMING EVENTS

June, 2016

2016 WRF Workshop, NCAR Center Green Campus, Boulder, CO, USA.

WHAT'S NEW

NCAR WRF/WRFDA

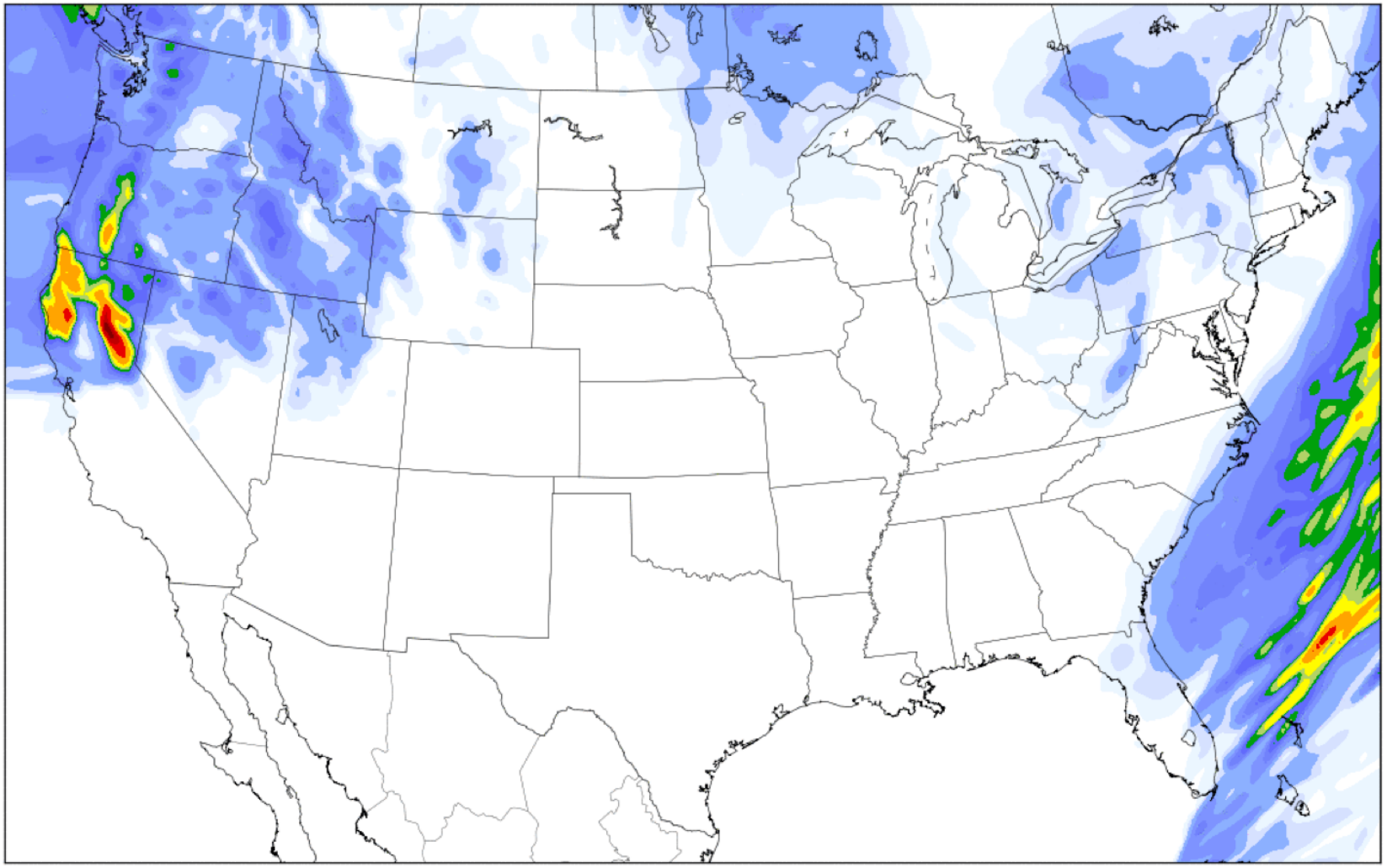
Initialized: 00 UTC Fri 29 Jan 2016

Surface/Precip | Upper-Air | Severe | Obs. Diag. | Anl. State | Increments

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 **24** 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

15-km ARW WRF 24-hr accumulated precipitation (in)

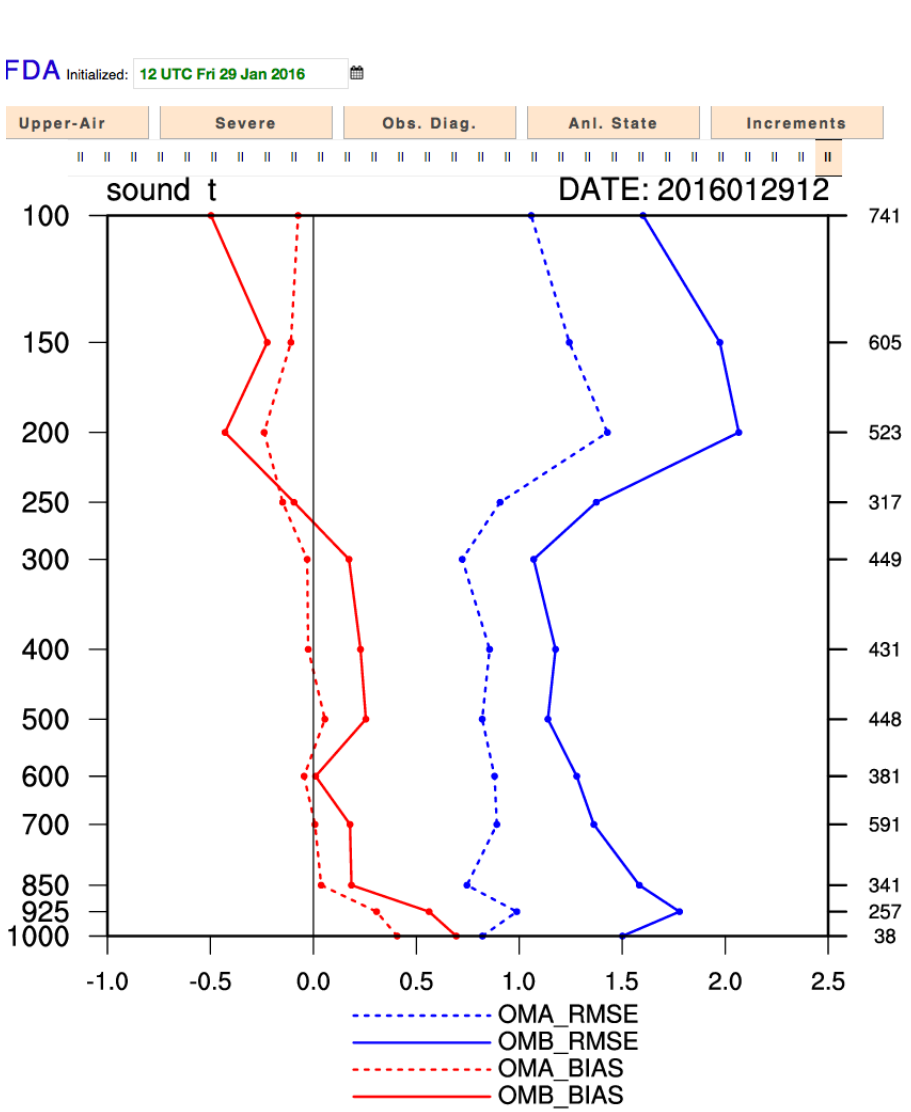
Init: Fri 2016-01-29 00 UTC
Valid: Sat 2016-01-30 00 UTC

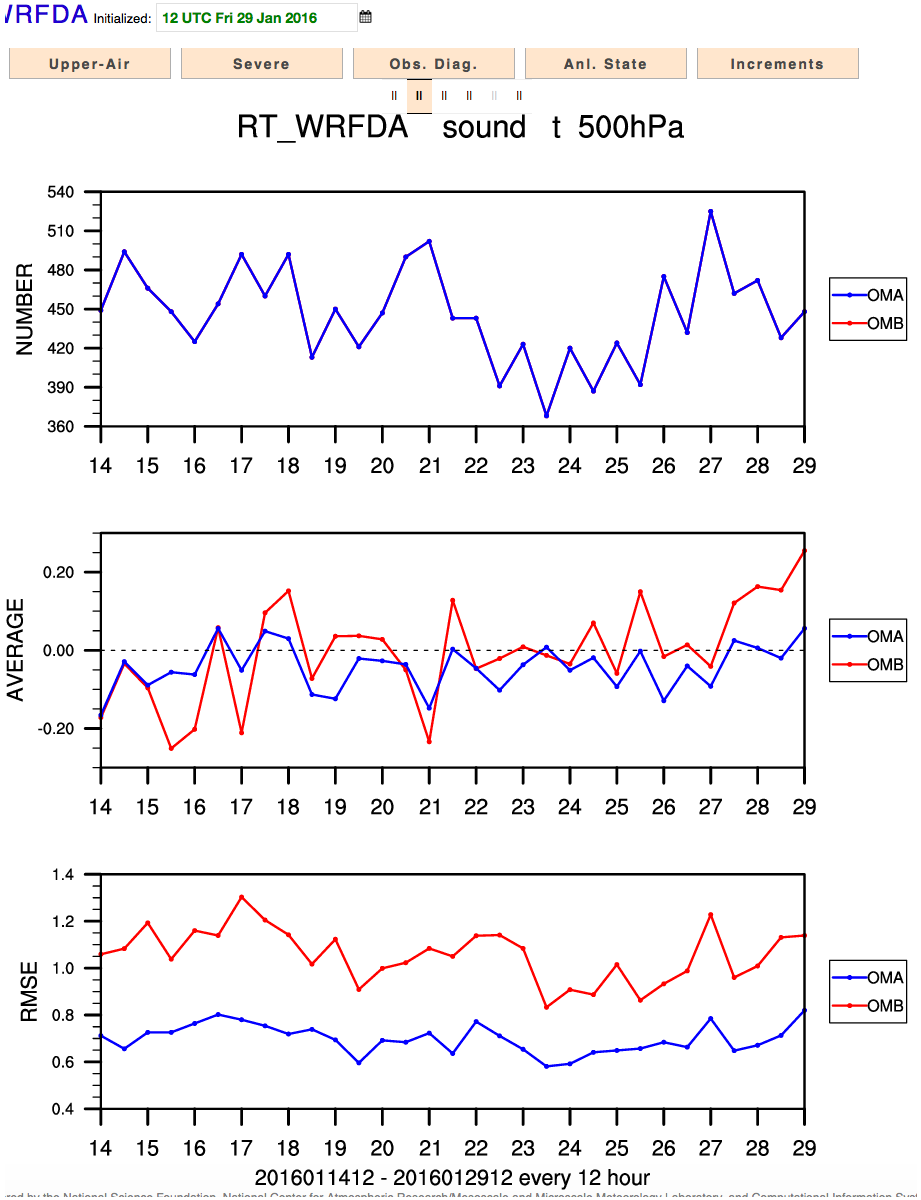


NCAR

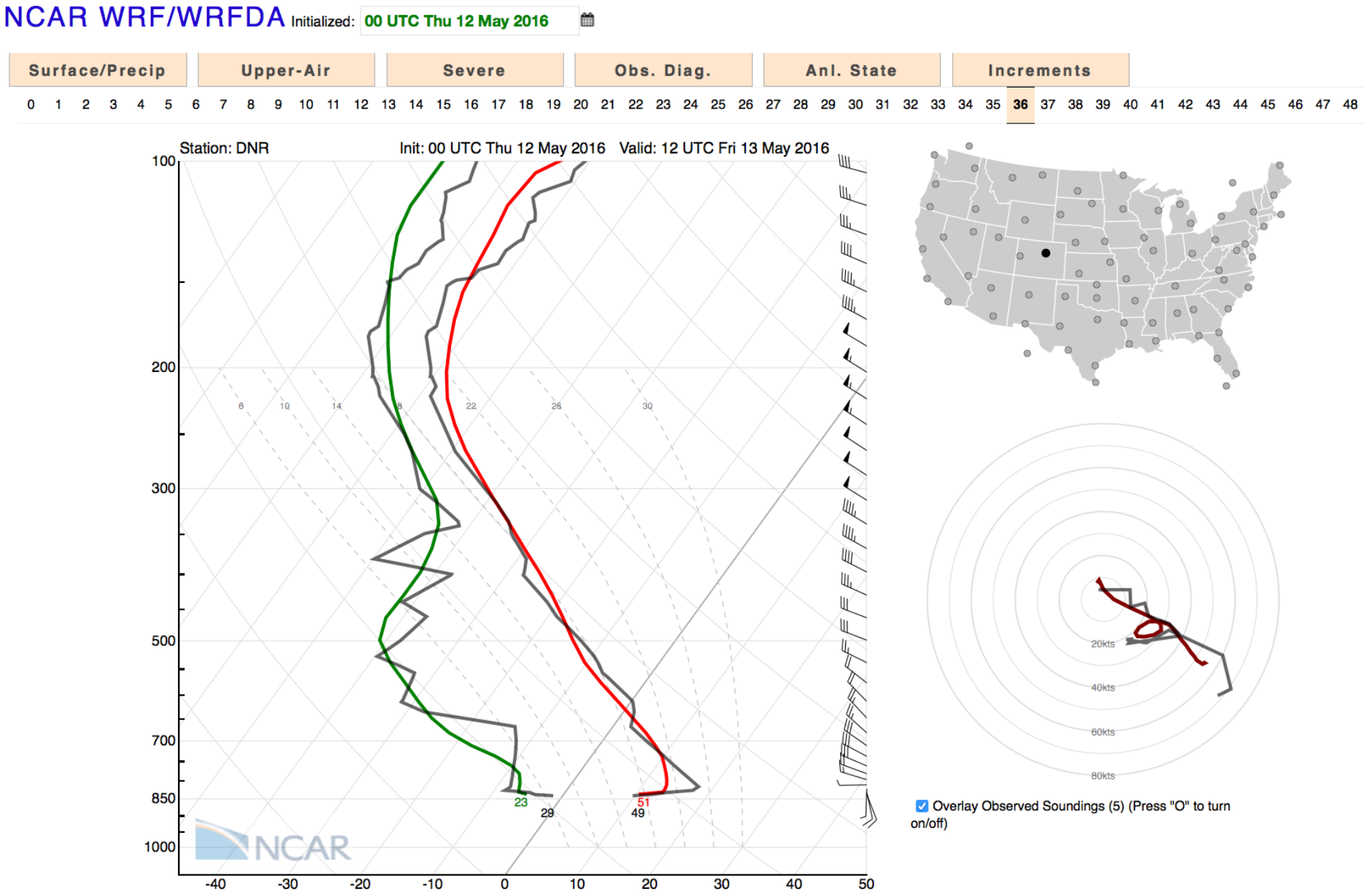
0.00 0.01 0.05 0.10 0.25 0.50 0.75 1.00 1.25 1.50 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00

Forecasts sponsored by the National Science Foundation, National Center for Atmospheric Research/Mesoscale and Microscale Meteorology Laboratory, and Computational Information Systems Laboratory


FDA Initialized: 12 UTC Fri 29 Jan 2016
Upper-Air
Severe
Obs. Diag.
Anl. State
Increments
sound t
DATE: 2016012912
100
150
200
250
300
400
500
600
700
850
925
1000
741
605
523
317
449
431
448
381
591
341
257
38
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
OMA_RMSE
OMB_RMSE
OMA_BIAS
OMB_BIAS


/RFDA Initialized: 12 UTC Fri 29 Jan 2016
Upper-Air
Severe
Obs. Diag.
Anl. State
Increments
RT_WRFDA sound t 500hPa
NUMBER
540
510
480
450
420
390
360
AVERAGE
0.20
0.00
-0.20
RMSE
1.4
1.2
1.0
0.8
0.6
0.4
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
OMA
OMB
2016011412 - 2016012912 every 12 hour

Real-time WRF/WRFDA forecast



Outline

- New features in WRFDA V3.8

- Ongoing developments

Variational Bias Correction of Aircraft T

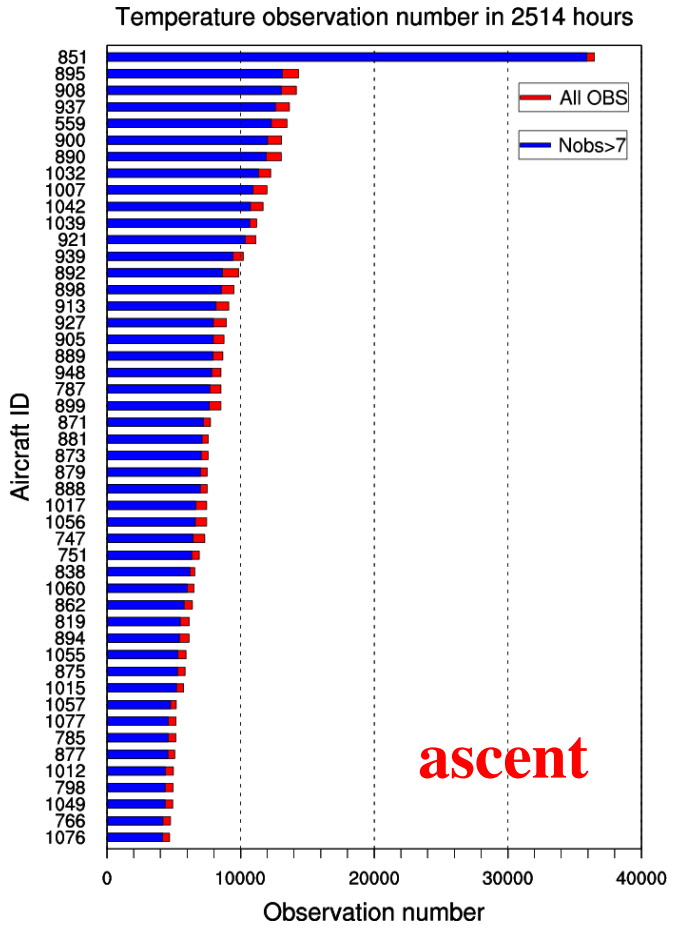
$$J(\mathbf{x},\boldsymbol{\beta}) = (\mathbf{x}-\mathbf{x}_\mathrm{b})^\mathrm{T}\mathbf{B}_\mathrm{x}^{-1}(\mathbf{x}-\mathbf{x}_\mathrm{b}) + (\boldsymbol{\beta}-\boldsymbol{\beta}_\mathrm{b})^\mathrm{T}\mathbf{B}_\beta^{-1}(\boldsymbol{\beta}-\boldsymbol{\beta}_\mathrm{b}) + (\mathbf{y}-H[\mathbf{x},\mathbf{y},\boldsymbol{\beta}])^\mathrm{T}\mathbf{R}^{-1}(\mathbf{y}-H[\mathbf{x},\mathbf{y},\boldsymbol{\beta}])$$

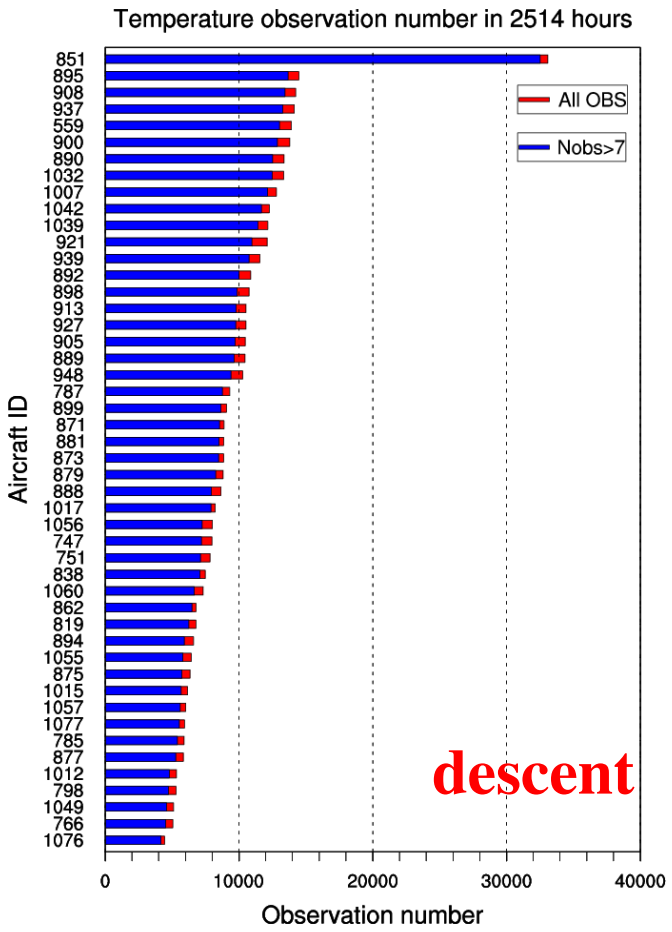
$$H(\mathbf{x},\mathbf{y},\boldsymbol{\beta}) = H(\mathbf{x}) - b(\mathbf{y},\boldsymbol{\beta})$$

$$b(\mathbf{y},\boldsymbol{\beta}) = \sum_{n=0}^{N}\beta_n p_n(\mathbf{y}) = \begin{cases} \beta_{0+} + \beta_{1+}w & \text{if} \quad w > 0 \\ \beta_{0-} + \beta_{1-}w & \text{if} \quad w < 0 \end{cases}$$

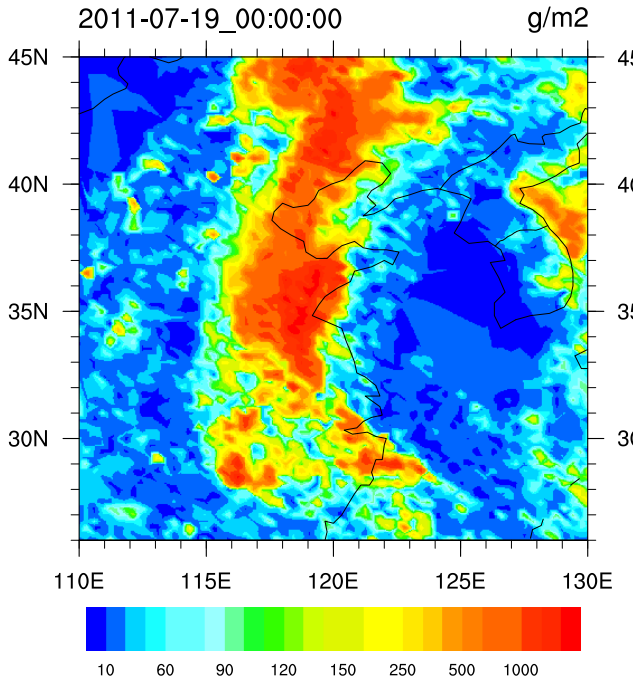
$w = \dfrac{\mathrm{dp}}{\mathrm{dt}}$, β **is updated in cost function each cycle and written in parameter table.**

Aircraft T VarBC is aircraft by aircraft

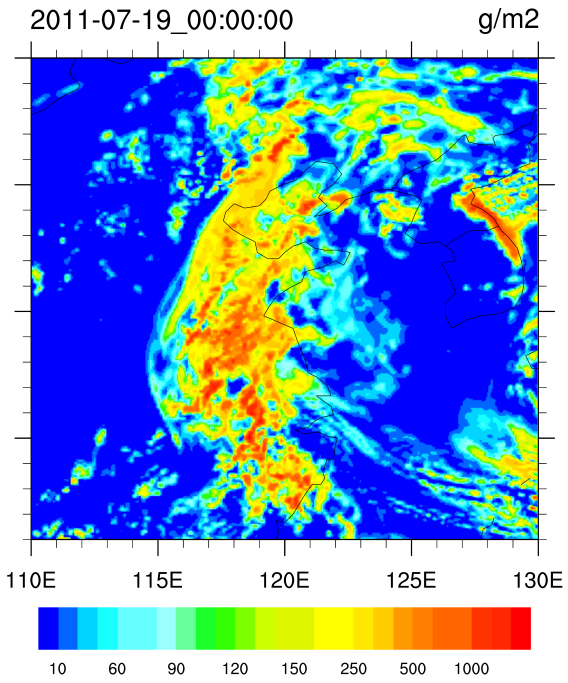




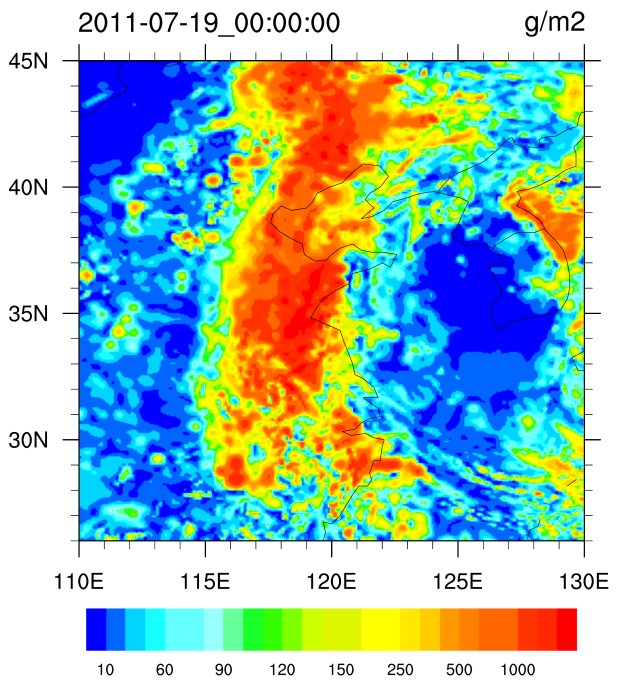
Geostationary retrieved CLWP/CIWP product DA over China



Observed CLWP

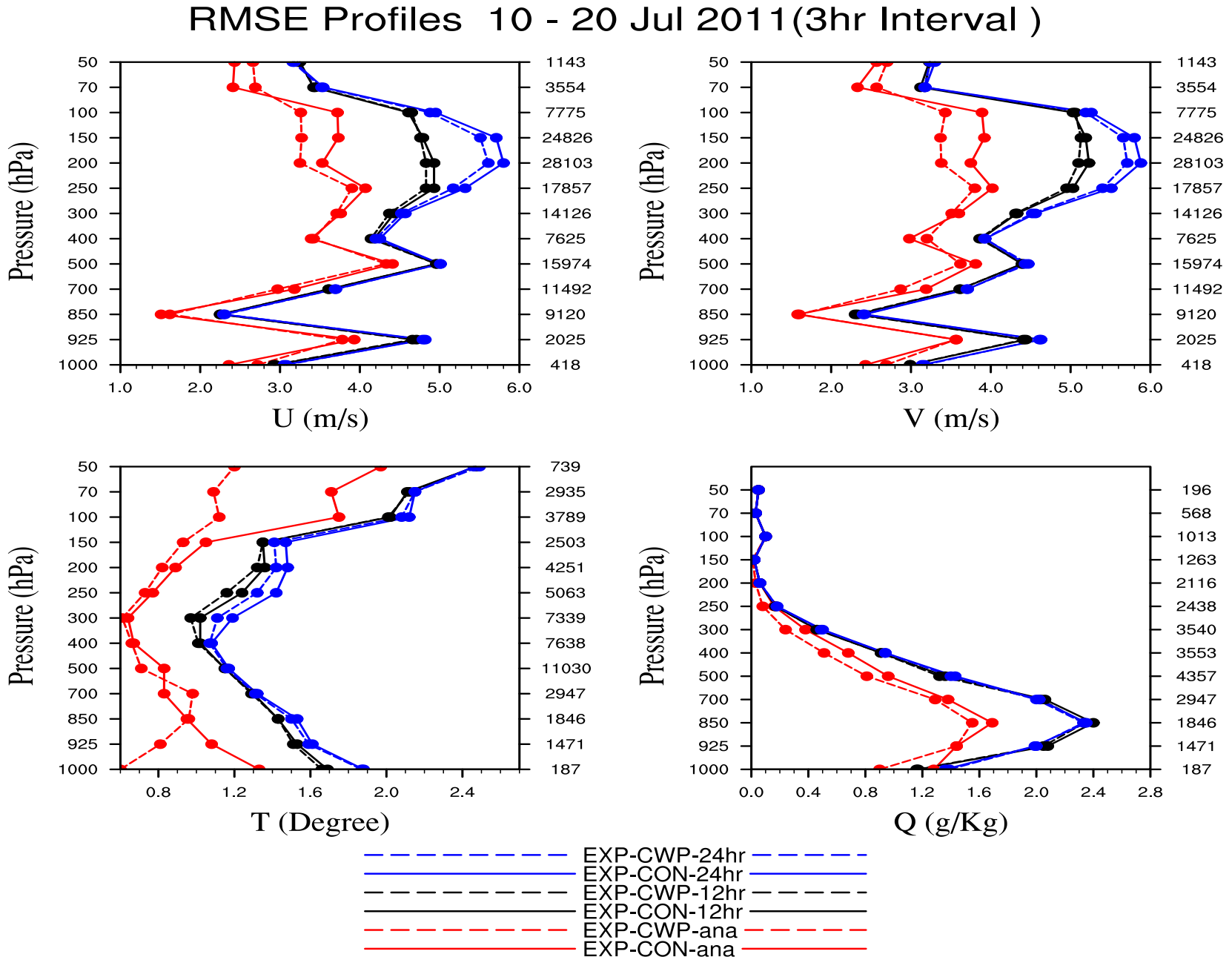


Analyzed CLWP w/o CLWP/CIWP DA



Analyzed CLWP with CLWP/CIWP DA

Geostationary retrieved CLWP/CIWP product DA over China



Other ongoing work

- Implemented Hybrid-4DEnVAR
  - Improving computing efficiency
- Continue developing Multi-Resolution Incremental 4DVAR (MRI-4DVAR)
- Continue developing cloudy radiance/product DA
- Improving surface data assimilation
- Improving radar DA
  - Adding divergence constraint

Summary

- New features in WRFDA V3.8
  - AMSR2 all-sky radiance DA
  - New option for dynamic constraint
- NCAR/MMM real-time WRFDA/WRF
- Ongoing developments
  - VarBC for aircraft T, cloudy radiance/product DA
  - Hybrid-4DEnVar, MRI-4DVAR
  - Surface DA, radar DA