



# WRFDA 2017 Update

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# Outline

- New features in WRFDA V3.9
- Ongoing R&D

# New Features in V3.9

- AMSR2 all-sky radiance DA
  - From beta release to official release, see Yang et al., 2016, Tellus.
- Hybrid-4DEnVAR
  - 4D extension of hybrid-3DEnVar (also known as hybrid-3DVAR)
- No rain echo radar DA
  - Contributed by Prof. Ki-Hong Min of Kyungpook National University (kmin@knu.ac.kr)
- 3DVAR & hybrid-3D/4DEnVar work with new hybrid vertical coordinate WRF (not for 4DVAR yet)

# Cost function of Hybrid-4DEnVar

Time index  $k$  within  
DA time window

$$J(\mathbf{x}'_f, \boldsymbol{\alpha}) = \beta_f \frac{1}{2} (\mathbf{x}'_f)^T \mathbf{B}_f^{-1} (\mathbf{x}'_f) + \beta_e \frac{1}{2} \sum_{n=1}^N (\boldsymbol{\alpha}^n)^T \mathbf{L}^{-1} (\boldsymbol{\alpha}^n) + \frac{1}{2} \sum_{k=1}^K (\mathbf{H}_k \mathbf{x}'_k - \mathbf{y}'_k)^T \mathbf{R}_k^{-1} (\mathbf{H}_k \mathbf{x}'_k - \mathbf{y}'_k)$$

Where the 4D increment is prescribed exclusively through linear combinations of the 4D ensemble perturbations plus static contribution

$$\mathbf{x}'_k = \mathbf{x}'_f + \sum_{n=1}^N \left( \boldsymbol{\alpha}^n \circ (\mathbf{x}_e)_k^n \right)$$

Ensemble perturbations  
(4D at multiple times  
within DA time window)

Here, the static contribution is considered time-invariant (i.e. from 3DVAR-FGAT). Weighting parameters exist just as in the other hybrid variants.

**no TL/Adjoint of WRF needed**

# Namelist setting for hybrid-4DEnVar

**&wrfvar3**

**num\_fgat\_time = 7,**

**&wrfvar16**

**use\_4denvar = .true.,**

**ensdim\_alpha = 50,**

**For this particular setting, will need 7 first guess files to calculate OmB at 7 time slots within time window, also need 50\*7 ensemble files!**

# Other updates and fixes

- Update **CRTM** from version 2.1.3 to 2.2.3
- Fixed duplicate calls to adjoint and tangent linear models for 4DVAR with **calculate\_cg\_cost\_fn=true**, unnecessarily doubling runtime.
- Fixed discontinuities when using **dual-resolution hybrid** with 5:1 parent:nest ratio

**See <http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-3.9.html> for a more complete list of fixes.**

# Ongoing R&D

- Stage-IV rainfall 4DVAR DA at convective-scale
- Multi-Resolution Incremental 4DVAR
- Himawari-8 AHI clear-sky radiance DA
- GOES-Imager radiance DA
- WRFDA extension for chemistry DA

# Stage-IV 4DVAR DA: 1h - 3h forecast

1-h

2-h

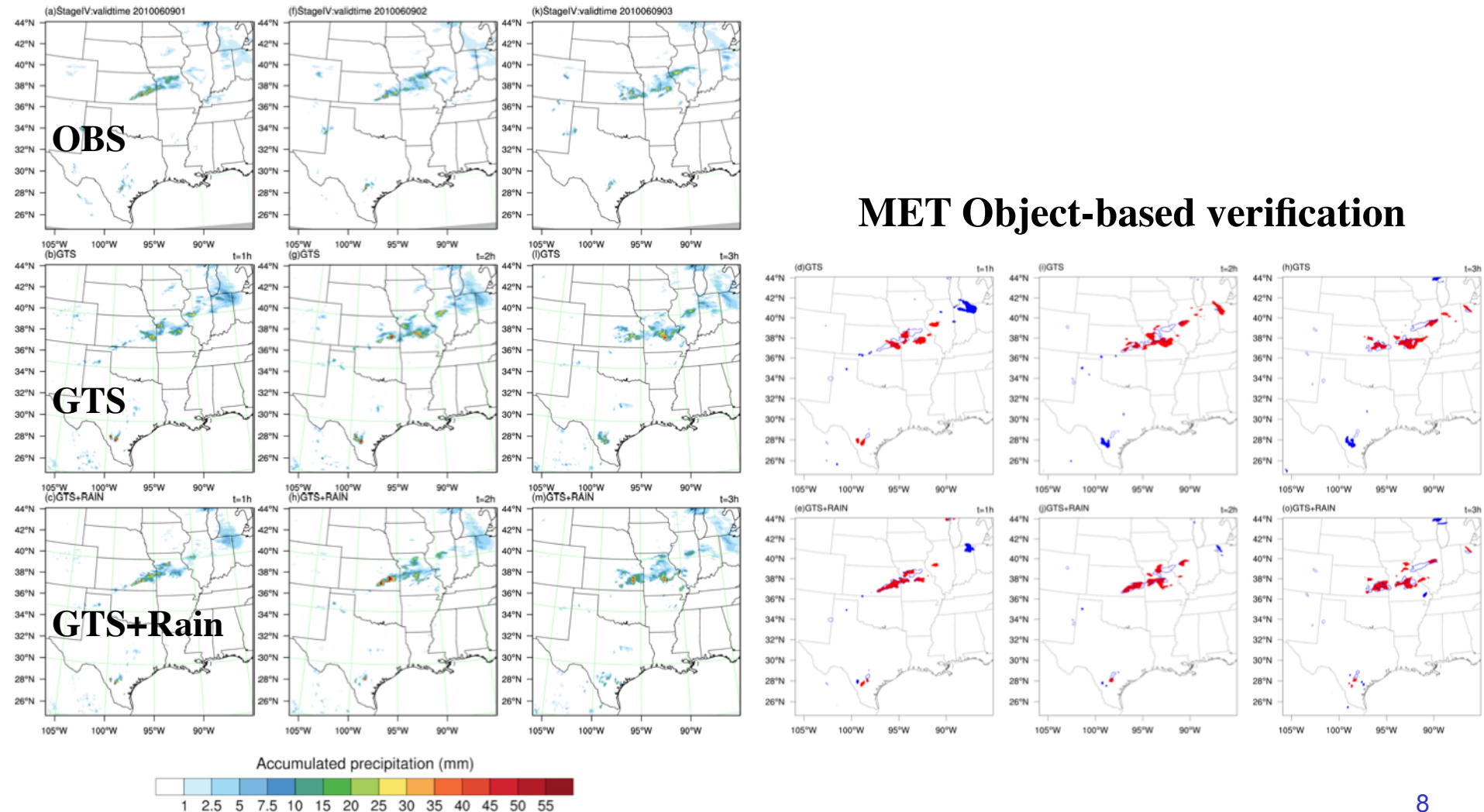
3-h

1-h

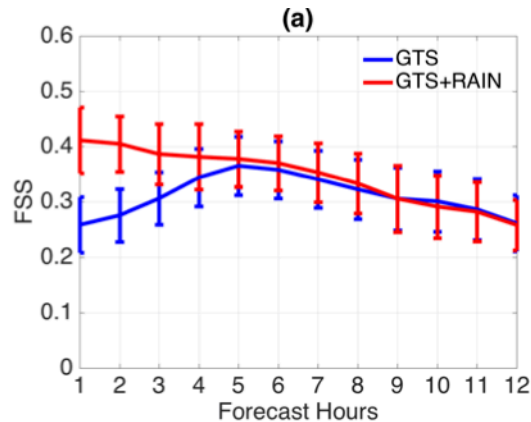
2-h

3-h

**MET Object-based verification**

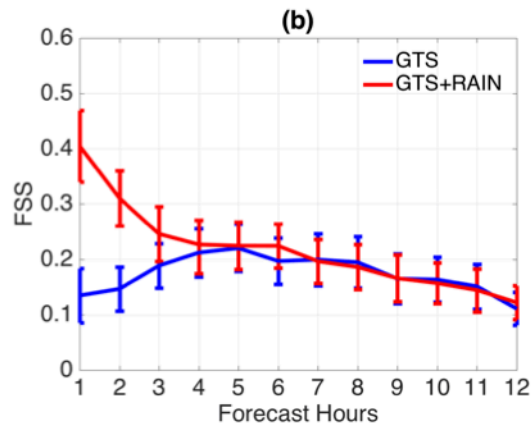


# One week score (9-15 June, 2010)



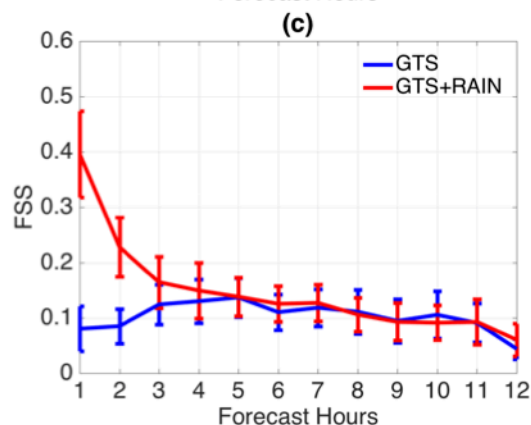
**1 mm**

**Statistics over 28 forecasts**



**5 mm**

**Ban et al., 2017, Tellus, under review**



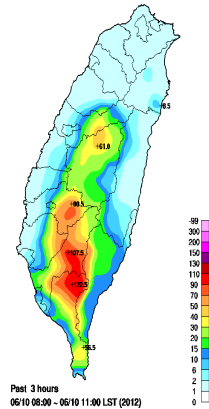
**10 mm**

# MRI-4DVAR: rainfall forecast over Taiwan

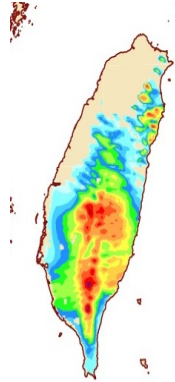
**3-hr acc.  
Rainfall**

**OBS  
rainfall**

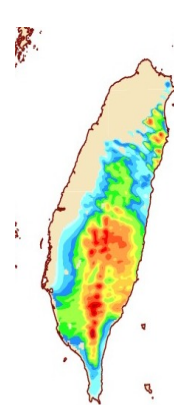
CIR12 122.5 mm



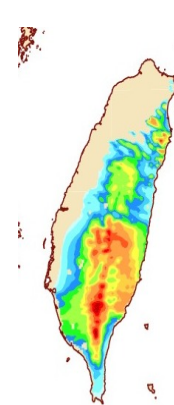
**2km/2km  
4DVAR**



**6km/6km  
MRI-4DVAR**

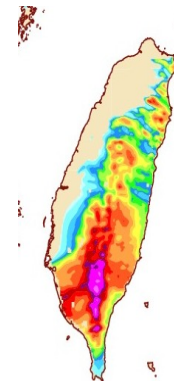
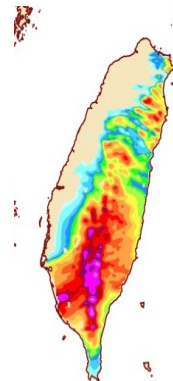
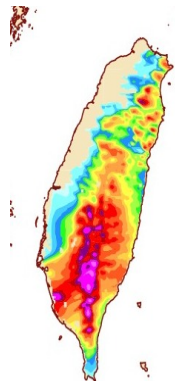
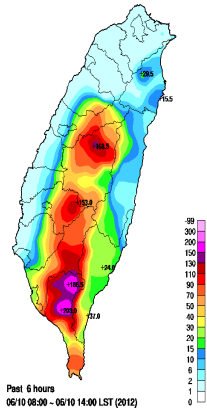


**18km/6km  
MRI-4DVAR**



**6-hr acc.  
rainfall**

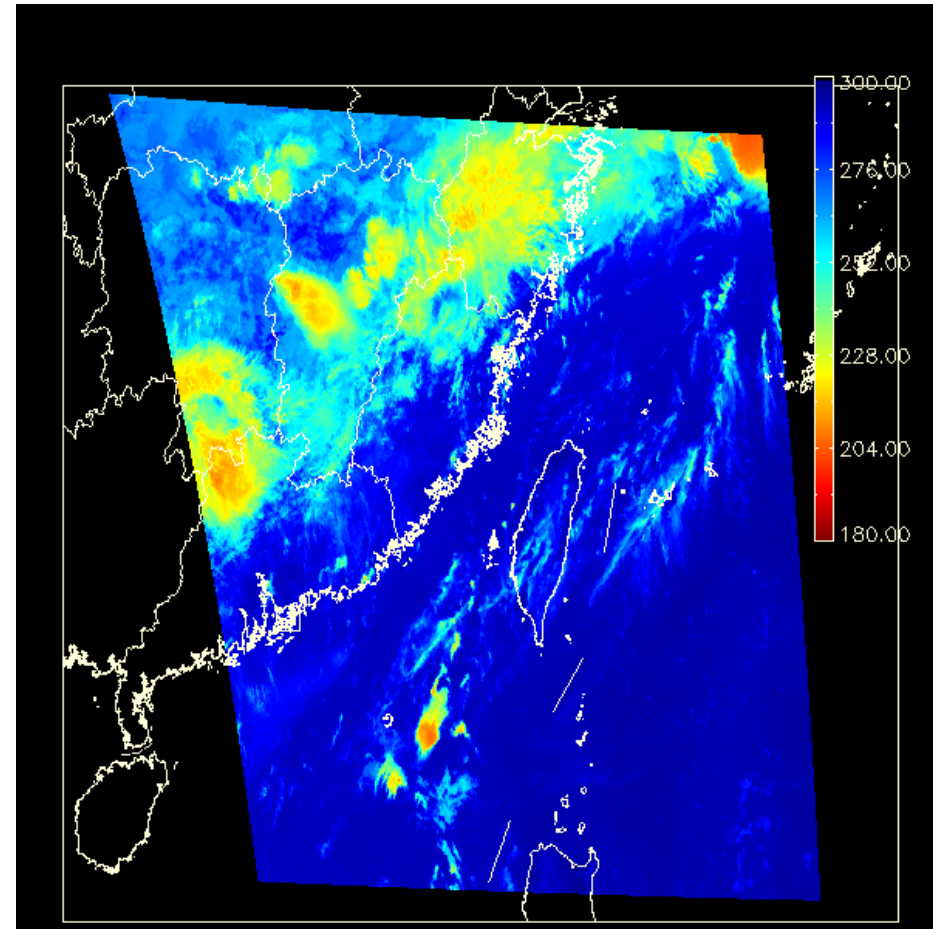
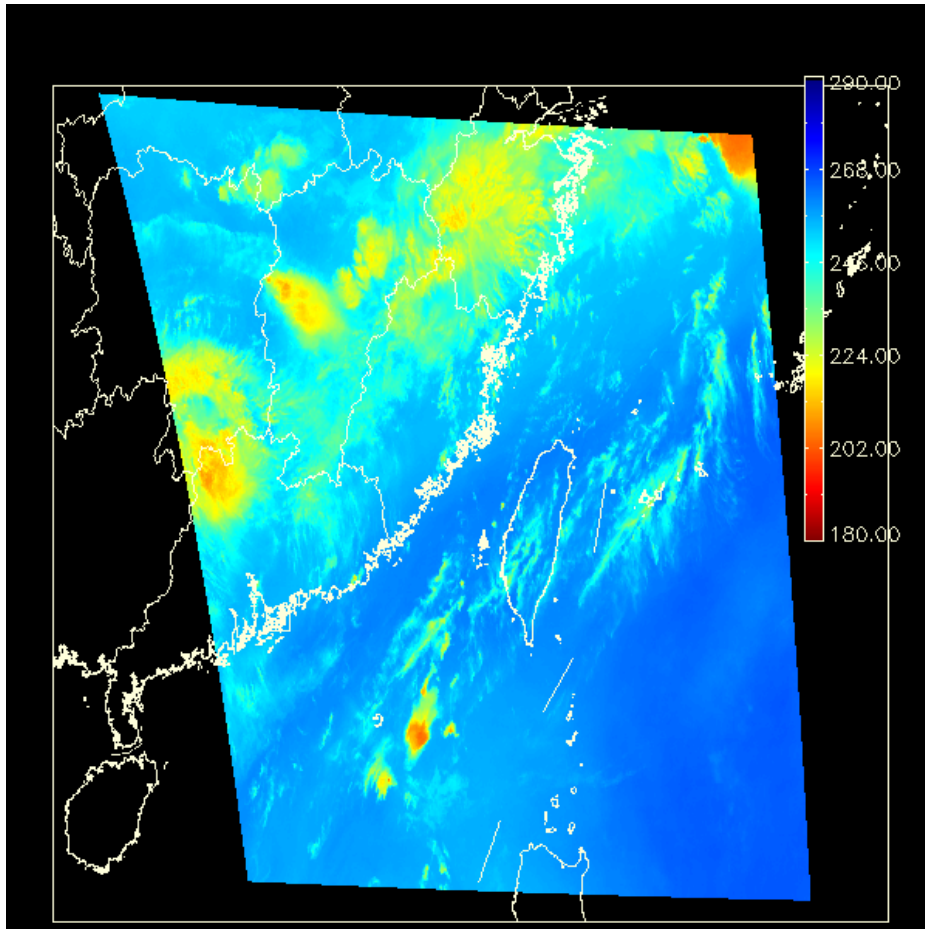
CIR24 203.0 mm



# Himawari-8 AHI Imagery over Taiwan

**7.3 um water vapor channel**

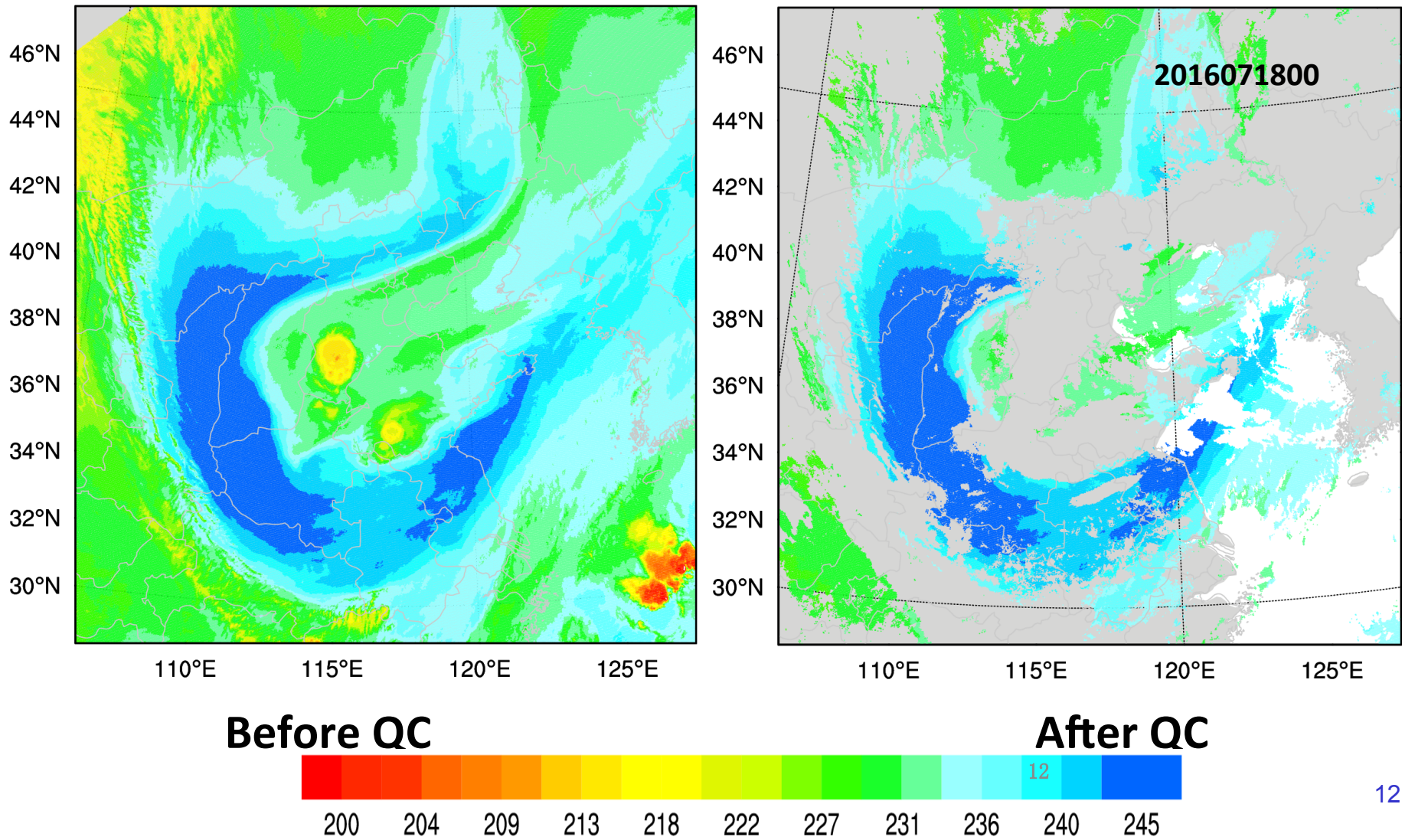
**8.6 um infrared channel**



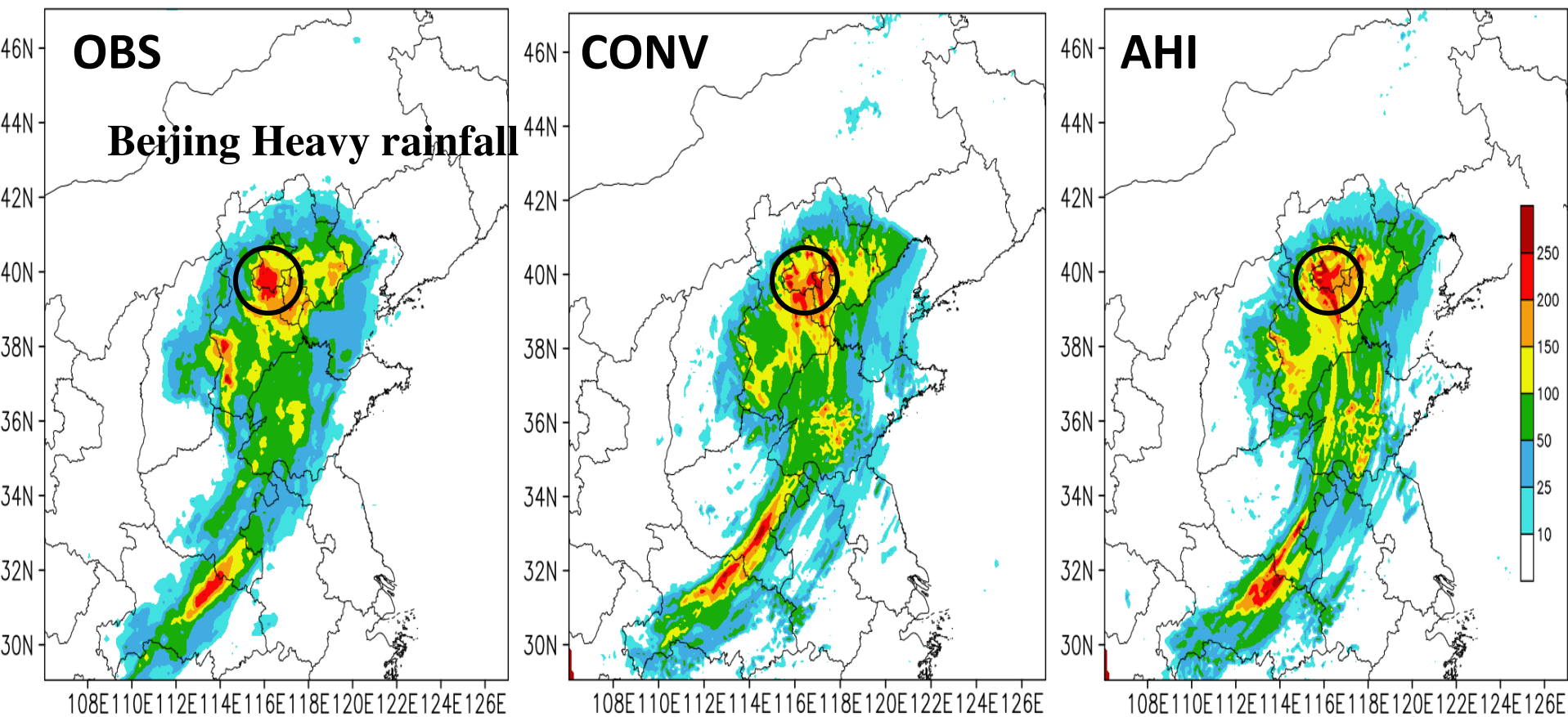
**Every 10-min from 8am to 6:50pm local time, 2015-06-14**

# AHI 3 WV channels hourly clear-sky radiance DA with WRFDA-3DVAR @3km

## AHI Radiance water vapor channel



# 24h accumulated rainfall field initialized at 2016071912



# Thursday Morning DA Session

- GOES-Imager radiance DA (2018 release)

## 7B.5

Impact of Assimilating GOES-Imager Radiance with A Rapid Refresh Assimilation System for Convection-Permitting Forecast over Mexico.

Yang, Chun, *Nanjing University of Information Science & Technology (NUIST)*,  
**Zhiquan Liu**, *National Center for Atmospheric Research*, Feng Gao, Peter Childs,  
*Panasonic Weather Solution*, and Jinzhong Min, *NUIST*

- WRFDA extension for WRF-Chem
  - We will further develop chemistry DA capability and target for public release in 2019

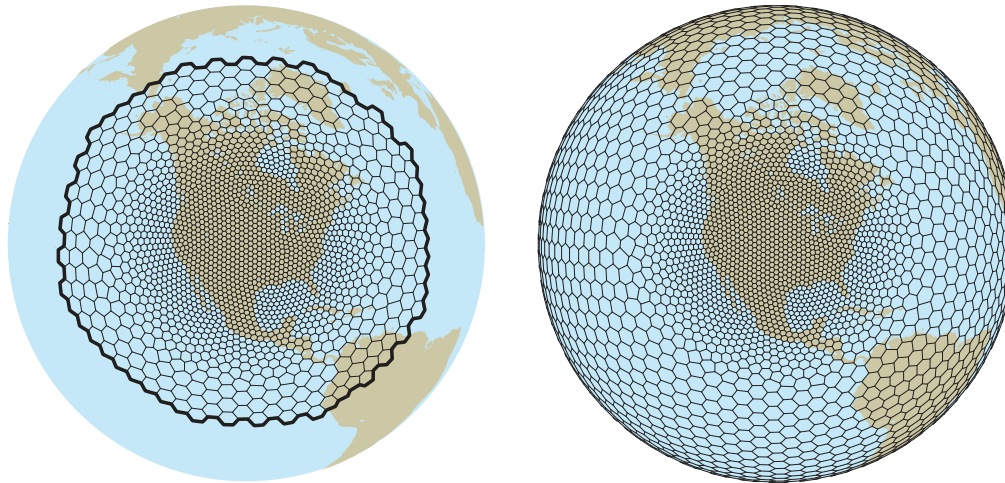
## 7B.2

Application of the randomized incremental optimal technique (RIOT) for parallelization of 4D-Var in WRFDA-Chem.

**Guerrette, Jonathan**, *National Oceanic and Atmospheric Administration*,  
Nicolas Bousserez, and Daven Henze, *University of Colorado at Boulder*

# Began to design Next-Generation DA

- New DA framework shall be generic, e.g., not tied to a specific model
- However, MMM's focus will be for MPAS convective-scale applications (both global and regional)
  - Key is to properly modeling forecast error covariances on unstructured mesh with local refinement



- Partnership with other institutions having similar goal