WRFDA 2018 Update

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NCAR/MMM

Outline

- New and updated features in WRFDA V4.0
- Future plan

New Features in V4.0

- **GOES-Imager radiance DA**
  - Yang et al., 2017
- **GPSRO Excess Phase non-local operator**
  - Chen et al. 2009; Zhang et al., 2014
- **Large Scale Analysis Constraint consistent (LSAC)**
  - Vendrasco et al., 2016
- **Divergence Constraint (DIVC)**
  - Tong et al., 2016

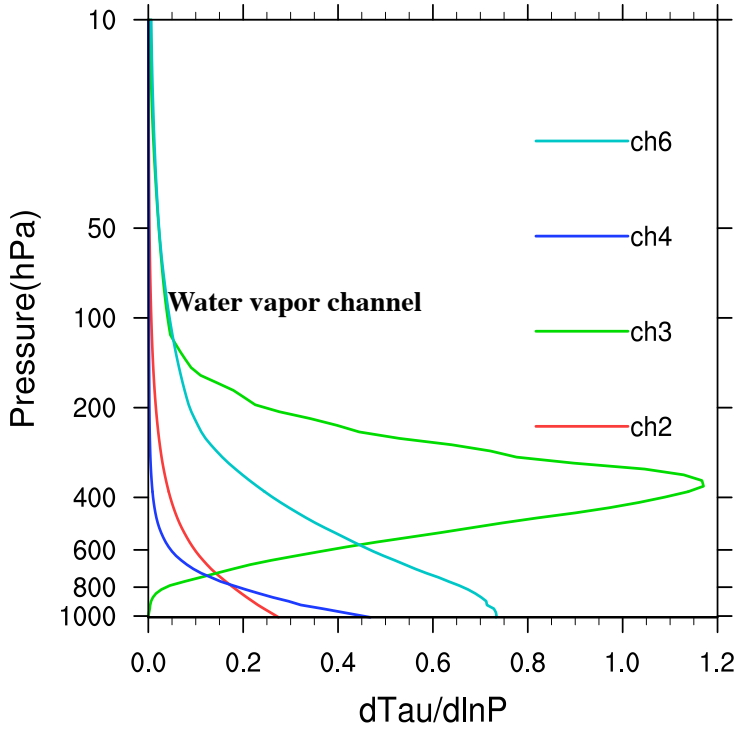
http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.0.html

GOES-Imager

GOES-Imager: 5 channels

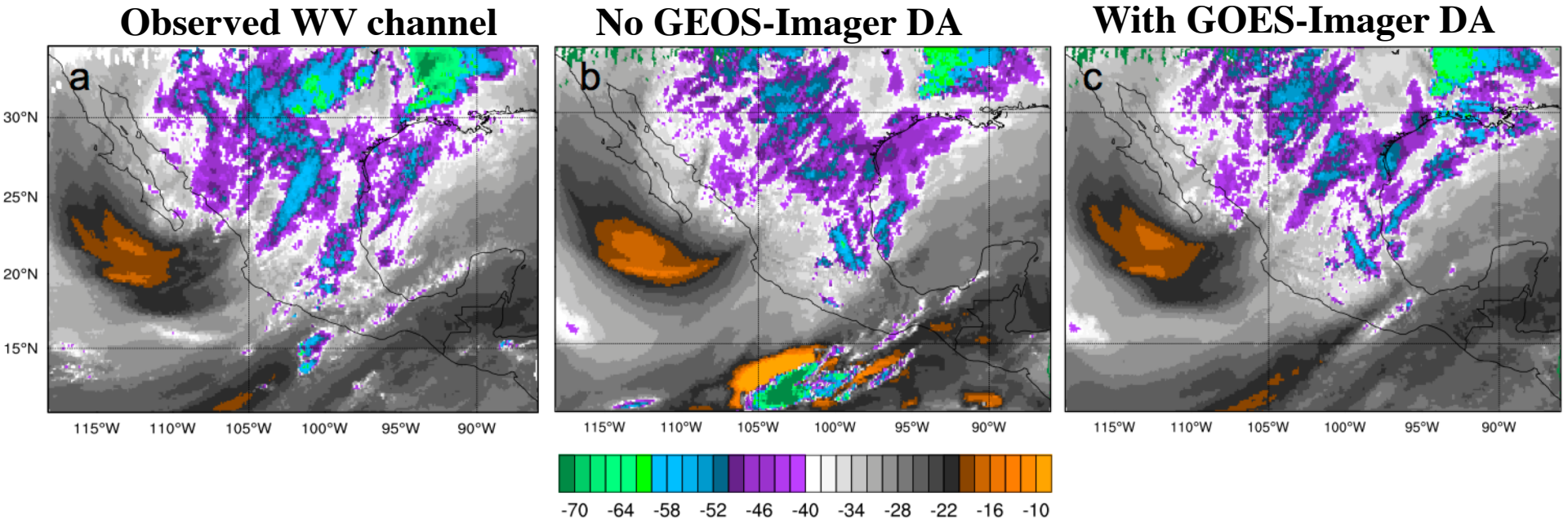
Channel Number	Center Frequency ()	Data Resolution (km)
1	0.65	1.0
2	3.9	4.0
3	6.5	4.0
4	10.7	4.0
6	13.3	8.0

Channels weighting function

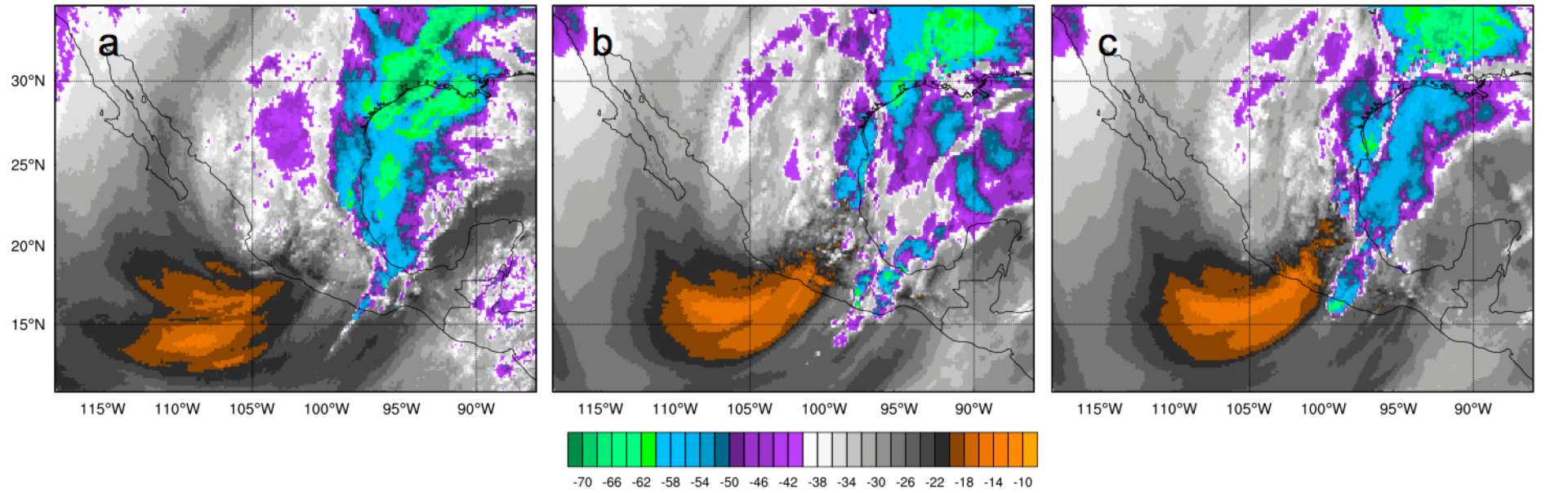


Yang. C., Z. Liu, F. Gao, P. Child, J. Min, 2017: Impact of Assimilating GOES-Imager Clear-sky Radiance with a Rapid Refresh Assimilation System for Convection-Permitting forecast over Mexico, J. G. R. Atmosphere, 122, 5472 – 5490.

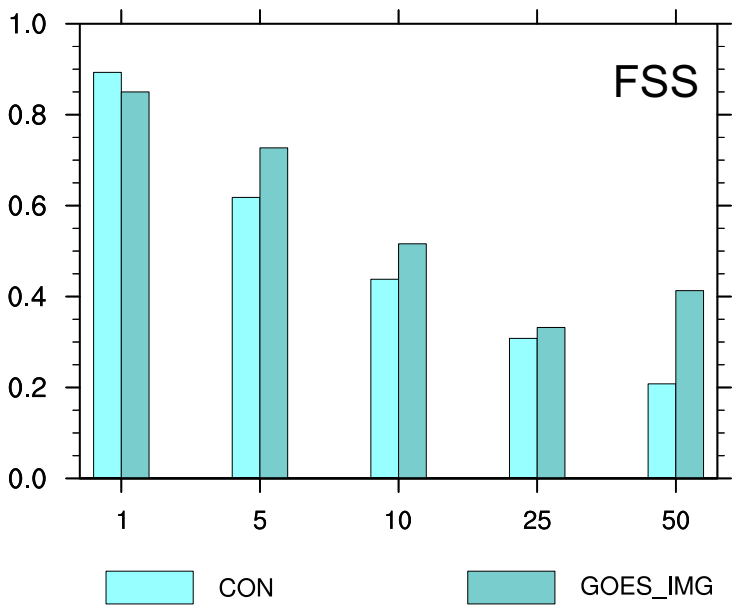
Analysis valid at 00 UTC, 03/09/2016

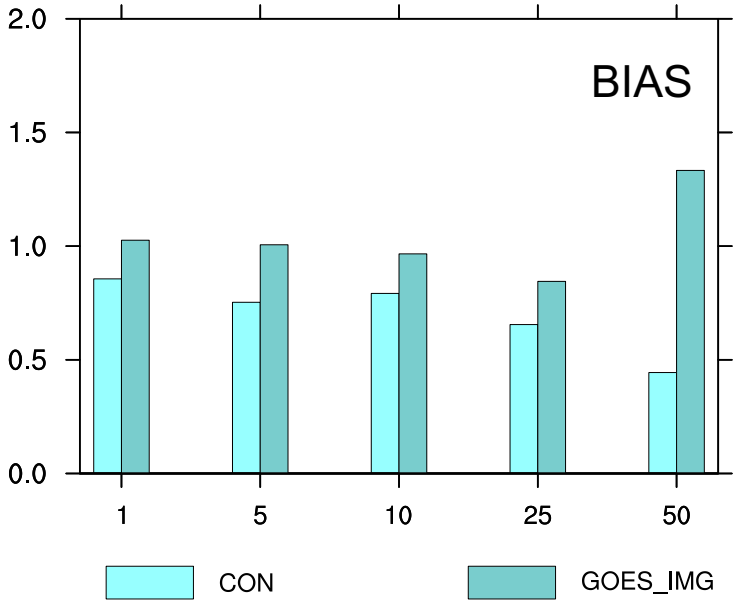


24-h forecast valid at 00 UTC, 03/10/2016

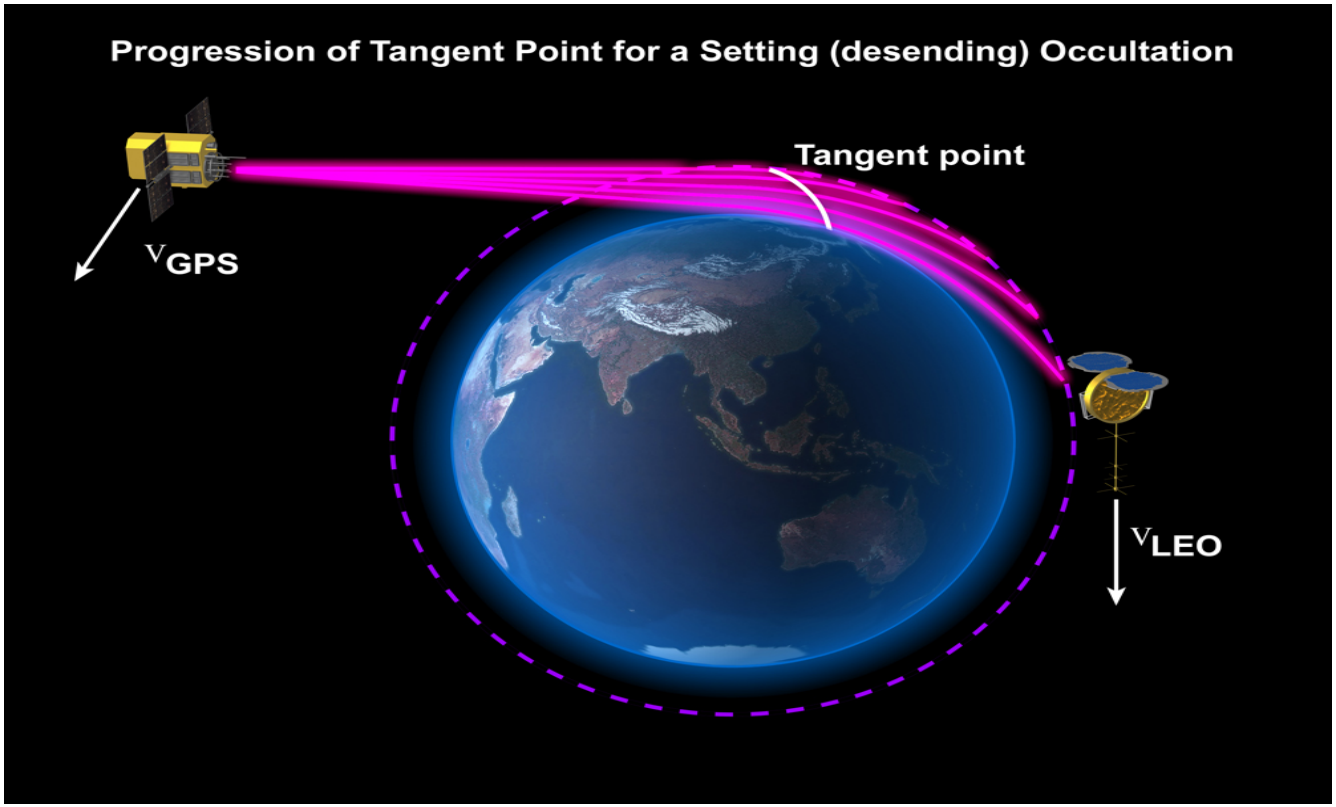


Precip. Forecast Score





GPS Radio Occultation



Local refractivity observation operator at tangent point

$$N = 77.6\frac{p}{T} + 3.73\times 10^5 \frac{pq}{T^2(0.622+0.378q)},$$

Non-local excess phase (S) operator. Both model and observed refractivity integrated along ray line

$$S = \int_{\text{ray}} N\, dl,$$

Non-local operator parallelization

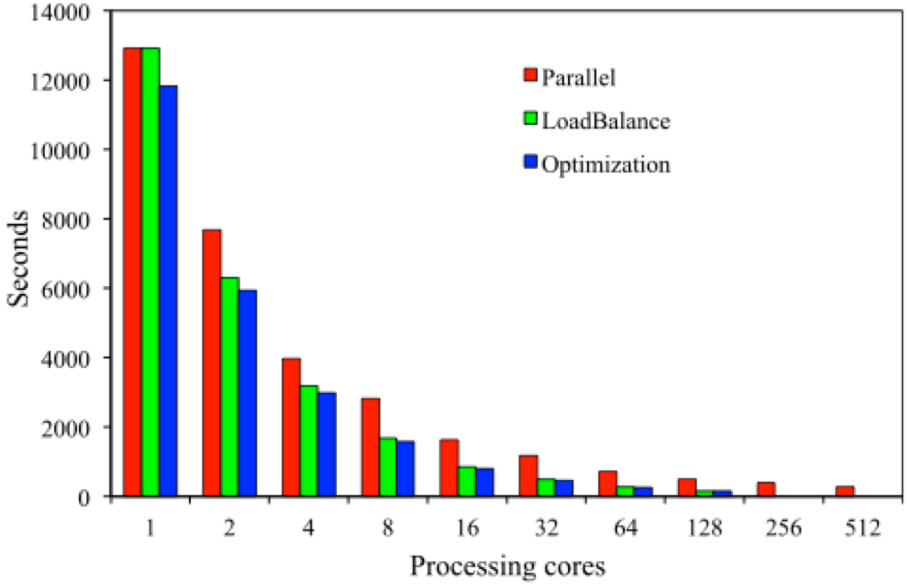


FIG. 2. The wall clock times for a five-iteration minimization of 3DVAR on NCAR Yellowstone.

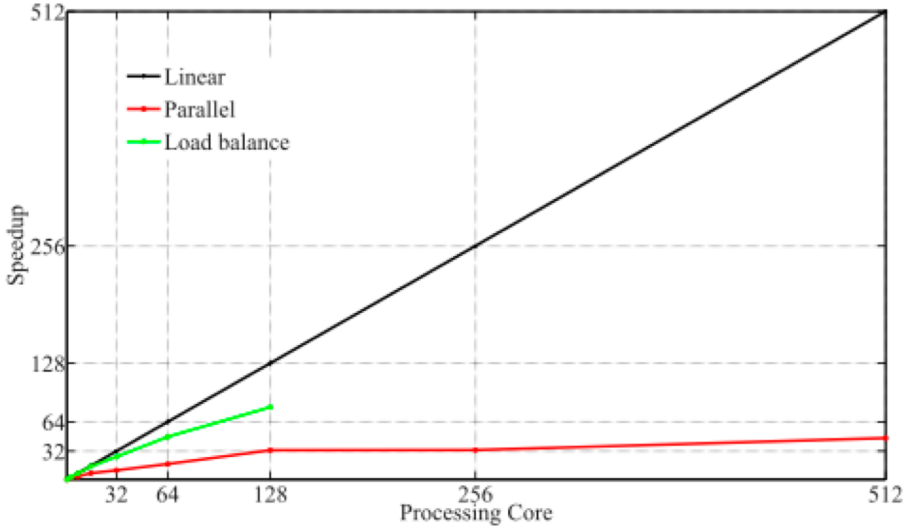


FIG. 3. As in Fig. 2, but for the parallel speedup.

and represents the ideal speedup or acceleration when

Zhang, X.,Y.-H. Kuo, S.-Y. Chen, X.-Y. Huang, and L.F. Hsiao, 2014: Parallelization Strategies for the GPS Radio Occultation Data Assimilation with a Nonlocal Operato r in the Weather Research and Forecasting Model. JTECH, https://doi.org/10.1175/JT ECH-D-13-00195.1

Two new constraints

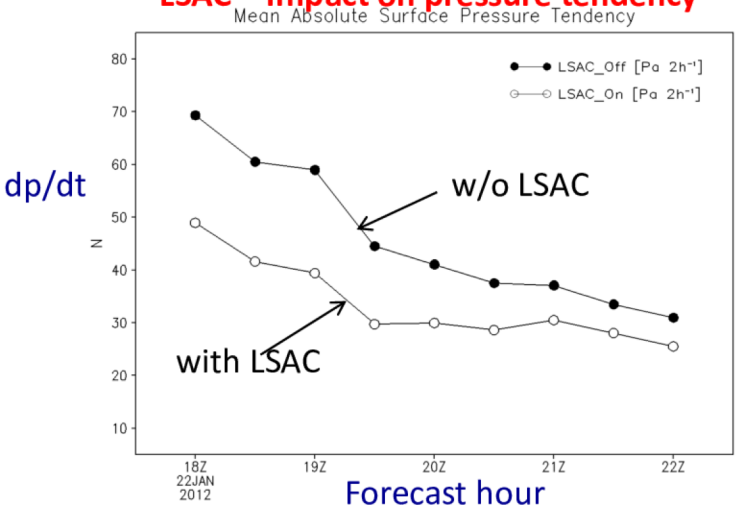
- Large-scale analysis constraint (LSAC0 (Vendrasco et al 2016)
- Divergence Constraint (DIVC) (Tong et al. 2016)

$$J = Jb + Jo + \frac{1}{2}\left(x_b - x_o^{la}\right)^T A^{-1}\left(x_b - x_o^{la}\right) + \frac{1}{2} w_d \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)^2$$

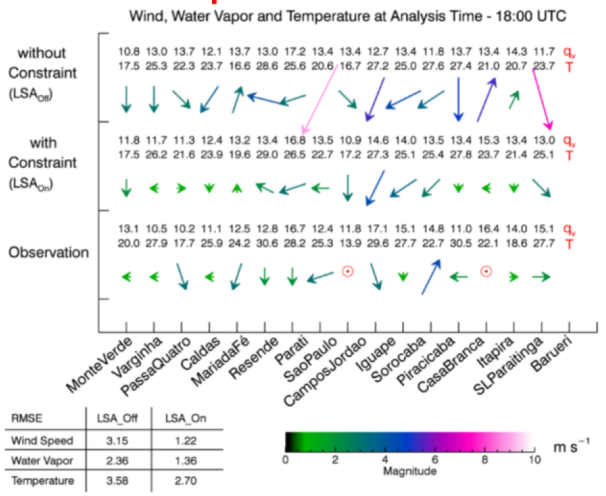
LSAC DIVC

x_o^{la} : large-scale analysis A: Error variance of large-scale analysis W_d: Weighting coefficient

LSAC – Impact on pressure tendency



LSAC - Impact on surface variables

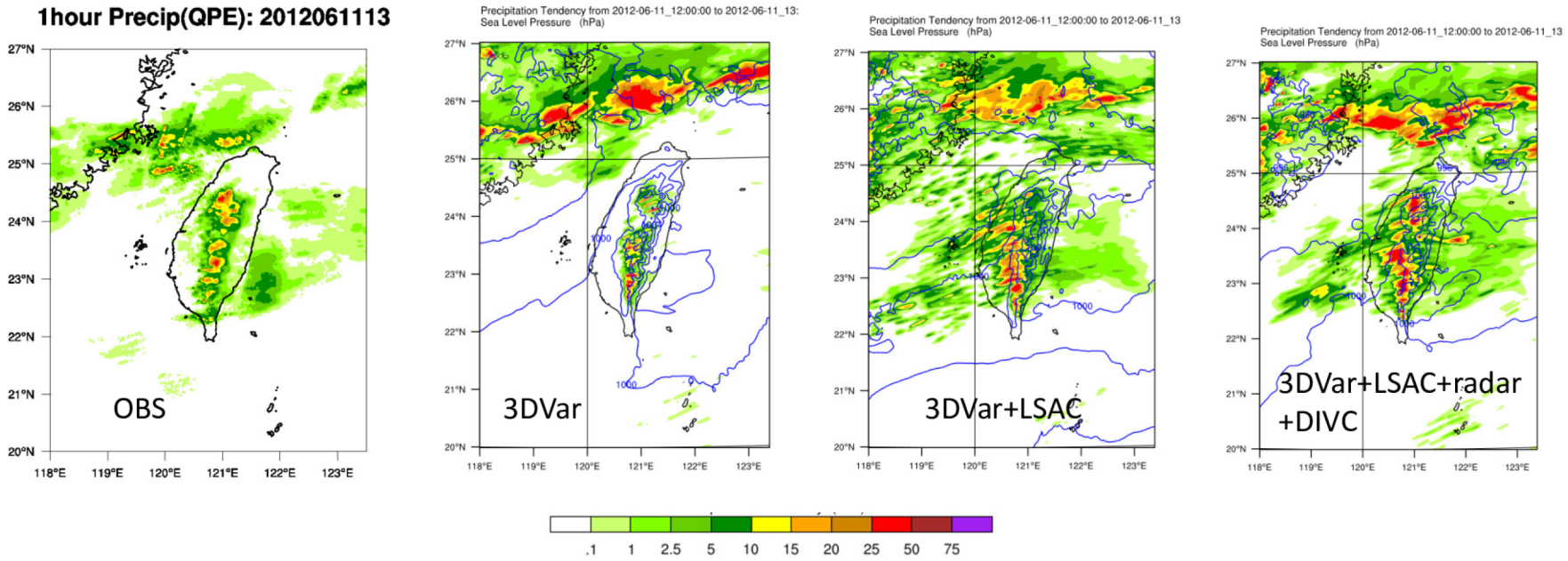


RMSE	LSA_Off	LSA_On
Wind Speed	3.15	1.22
Water Vapor	2.36	1.36
Temperature	3.58	2.70

Impacts on precipitation forecast

Impact of LSAC and DIVC on precipitation forecast

(1h forecasts initialized at 2012061112)



Updated Features

- Prior to V4.0, WRFPlus code has been developed and maintained in a separated branch from WRF.

- WRFPlus is now fully integrated into WRF and TLM/ADJ, located under ~**wrftladj**
  - **No separate WRFPlus tar file needed.**
  - ./configure wrfplus; ./compile wrfplus → wrfplus.exe
  - Hope this will reduce maintenance cost

- Recall: "WRF-Var" (old name of WRFDA) code is merged/integrated into WRF code in V3.0 in April 2008!

Updated Features

- Starting with V4.0, binary CRTM coefficient files are NOT included in any of the WRF or WRFDA tar files. Please

- Download the subset of CRTM coeffs from
  - http://www2.mmm.ucar.edu/wrf/users/wrfda/download/crtm_coeffs.html
- Or the full set of coeffs from JCSDA website
  - ftp://ftp.emc.ncep.noaa.gov/jcsda/CRTM/REL-2.2.3/crtm_v2.2.3.tar.gz

WRFDA with hybrid vertical coordinate (HVC) and moist potential temperature (THM)

- 3DVAR (and hybrid-EnVar) works with HVC since V3.9 (although not extensively tested), but does not work with THM
- Neither WRFPlus nor 4DVAR work with HVC or THM
- To turn off HVC, set hybrid_opt=0 (and etac=0.0)
- To turn off THM, set use_theta_m=0 (this will lead to THM=T in WRF/WRFDA file)

Future Plan

- Make 3dvar (and hybrid-EnVar) works for THM
- Make wrfplus and 4dvar work for HVC and THM

- Multi-Resolution Incremental 4DVAR

- Extend all-sky radiance capability from microwave to infrared such as Himawari-AHI and GOES-16/17 ABI

- Assimilate frequent observations (AHI/ABI, radar) with advanced DA techniques (e.g., 4DVAR, hybrid-EnVar)