Impact of Assimilating GOES-Imager radiance with a rapid refresh assimilation system for convection-permitting forecast over Mexico

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GOES-Imager

Data Source: NESDIS CLASS (Comprehensive large array-data stewardship system)
NetCDF format

GOES-15 (West)

GOES-13 (East)

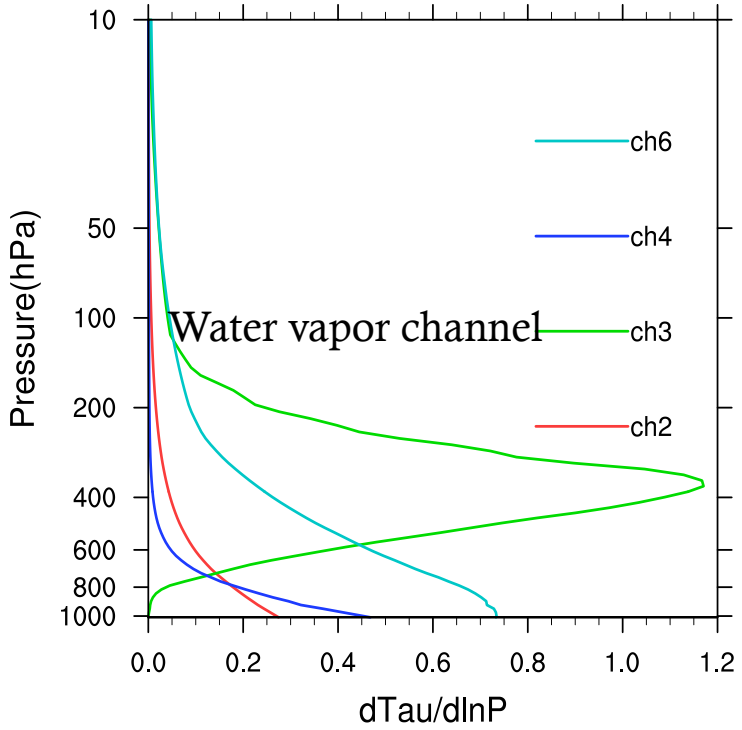
Full disk imagery of every 15 minutes from two satellites

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



Data Calibration

- GVAR count (0-1023) then converted to scene radiance

$$R = (X-b)/m$$

  - R: radiance; X: GVAR count; m & b: calibration coefficients

- Then convert radiance to effective temperature

$$T_{eff} = \frac{c_2 * v}{\ln\left[1+\left(c_1 * v^3\right)/R\right]}$$

$$c_1 = 1.191066\times10^{-5}$$

$$c_2 = 1.43833$$

- Finally convert effective T to brightness T

$$T = \alpha + \beta * T_{eff} + \gamma * T_{eff}^{\ 2}$$

Weinreb and Han (2011)

Data Geolocation

GOES-13 located at 75° W, ~36000km above equator

$$lon_{sat} = -75 * \pi / 180$$

$$\theta = \left| lon - lon_{sat} \right|$$

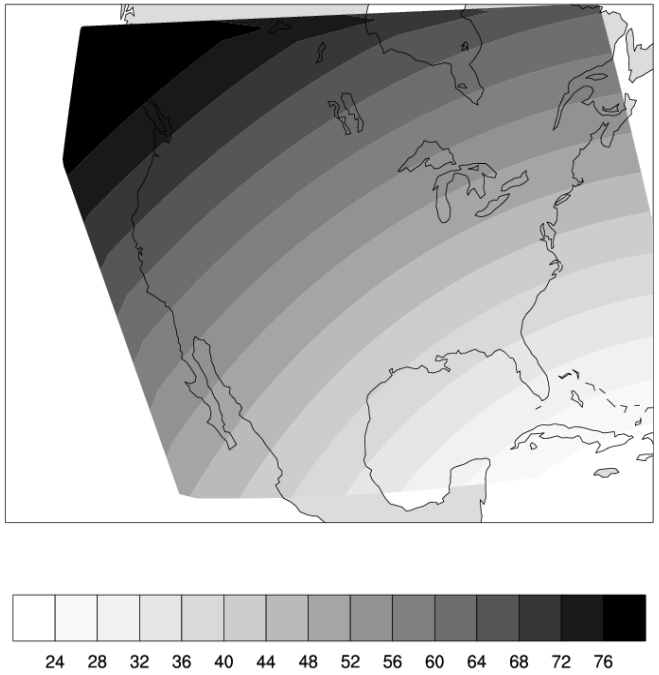
$$r_1 = \left(2 * r_e * \sin\left(\theta/2\right) - r_e * \left(1 - \cos\left(lat\right)\right) * \sin\left(\theta/2\right)\right)^2$$

$$+ \left(2 * r_e * \sin\left(lat/2\right)\right)^2 - \left(r_e * \left(1 - \cos\left(lat\right)\right) * \sin\left(\theta/2\right)\right)^2$$

$$\theta_1 = 2 * \sin^{-1}\left(\left(2 * \sin^{-1}\sqrt{r_1}\right) / r_e / 2\right)$$

$$\theta_2 = \tan^{-1}\left(r_e * \sin\theta_1 / \left(r_h + r_e * \left(1 - \sin\theta_1\right)\right)\right)$$

$$\theta_z = \left(\theta_1 + \theta_2\right) * 180 / \pi$$



θ_z Satellite zenith angle，

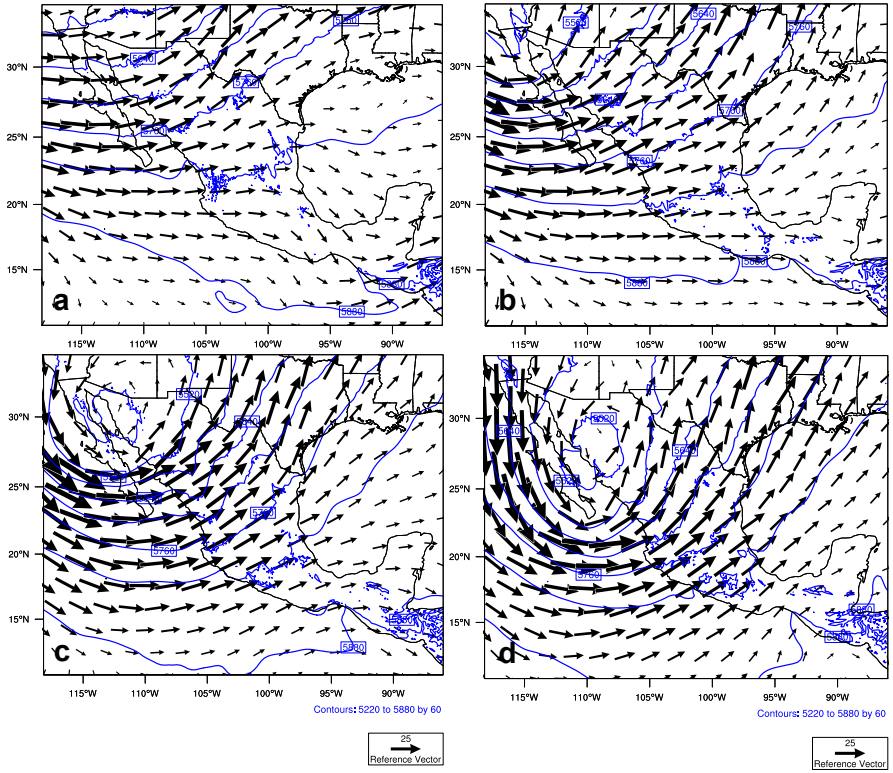
r_e Earth radius，

r_h Satellite altitute

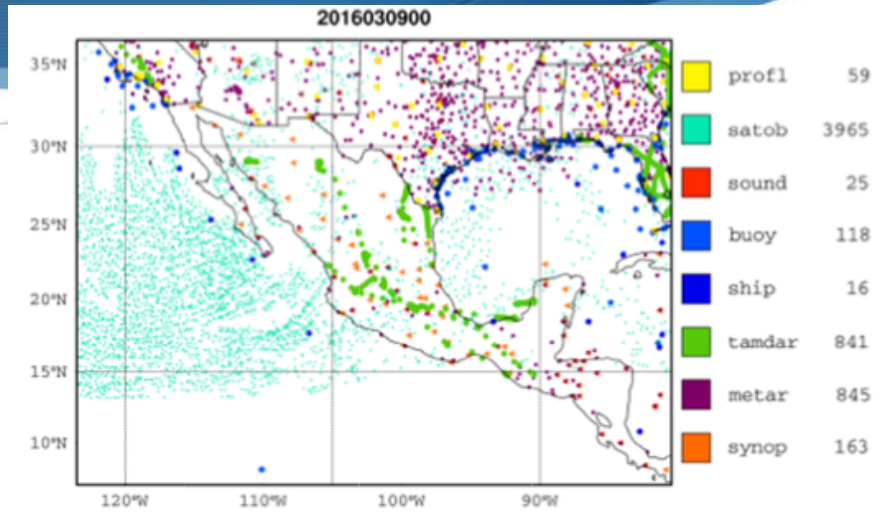
Quality Control

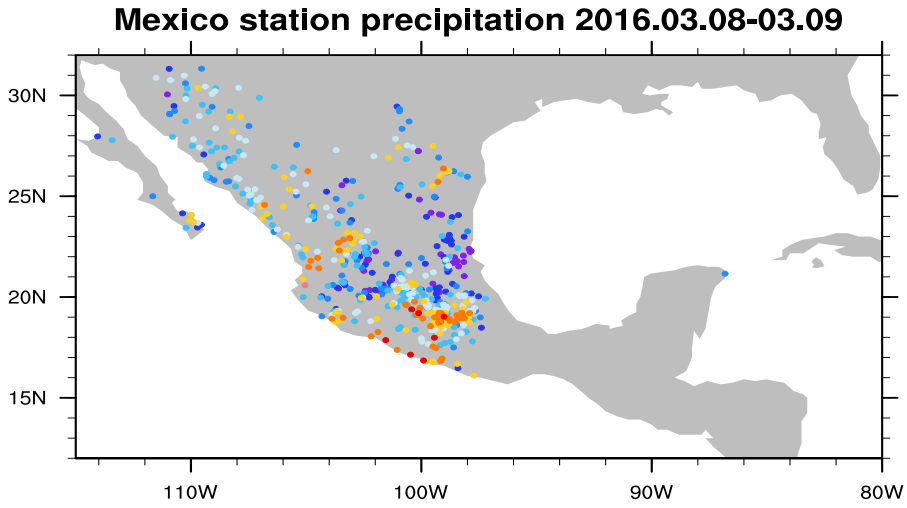
1. Reject pixels over mixed land surface
2. Channels 4 and 6 only used over water, channel 3 used over both land and water
3. Reject pixels with the model background CLWP>0.2mm
4. Cloud-detection: use Tb4 (model) – Tb4 (obs) (Hocking et al, 2010)
5. Background departure (OMB) check

A heavy rainfall event



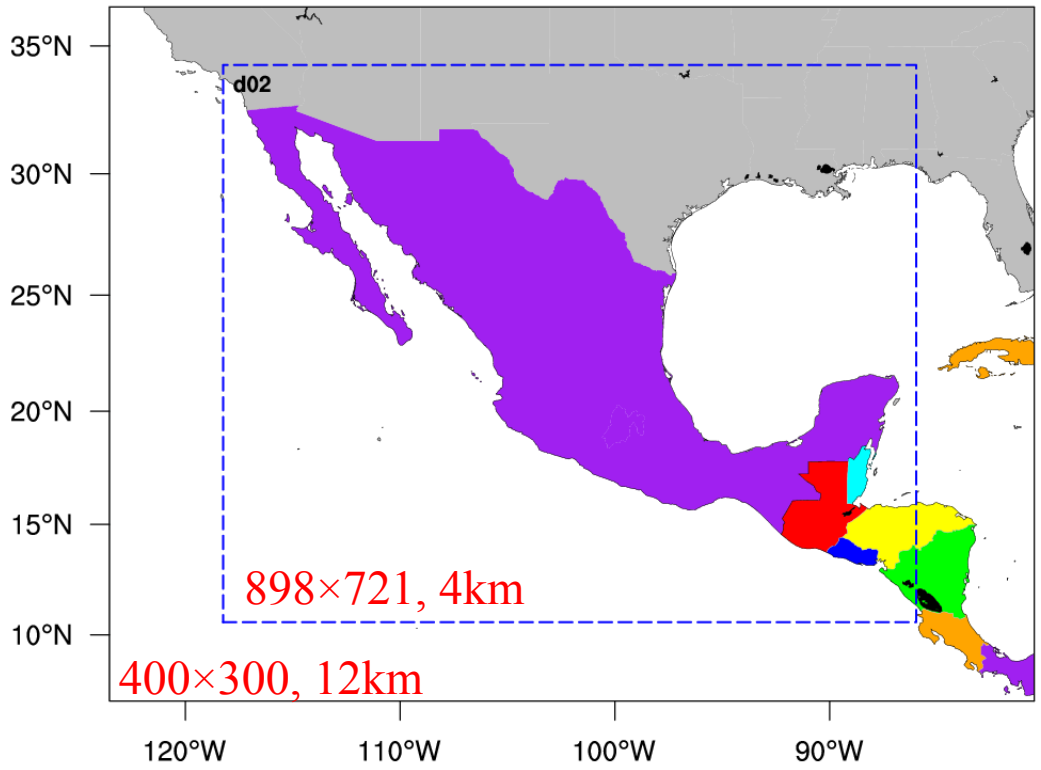
03/07/2016, (a) 12z (b) 03/08 00z, (c) 12z; (d) 03/09 00z.
500 Z (m) and wind (m/s)





24-h accumulated rainfall (mm)

Configuration



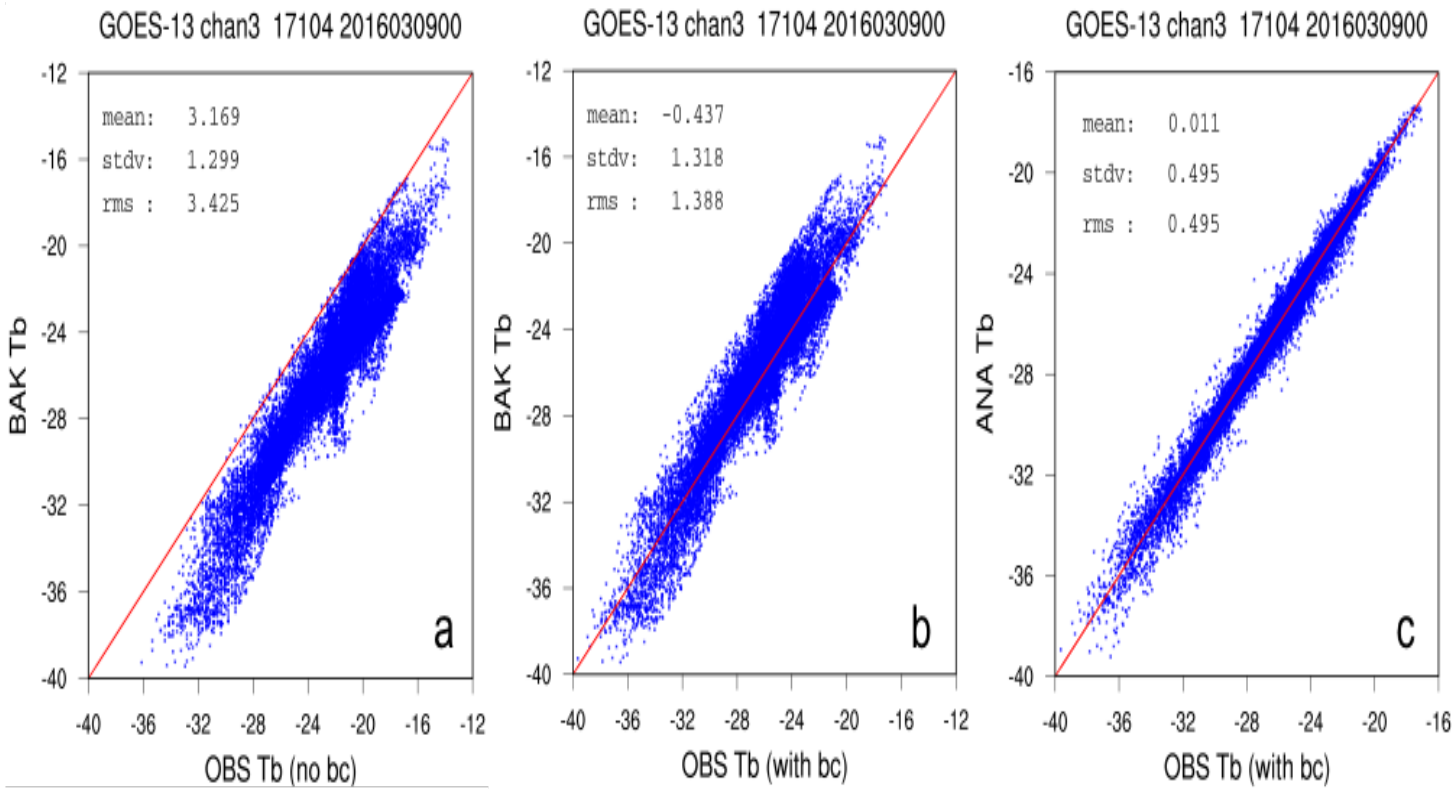
WRF: V3.7.1
Model top: 50 hPa
Vertical levels: 51
Landuse: MODIS-based

mp_physics=10
ra_lw_physics=4
ra_sw_physics=4
sf_sfclay_physics=1
sf_surface_physics= 2
bl_pbl_physics= 1
cu_physics= 1, 0

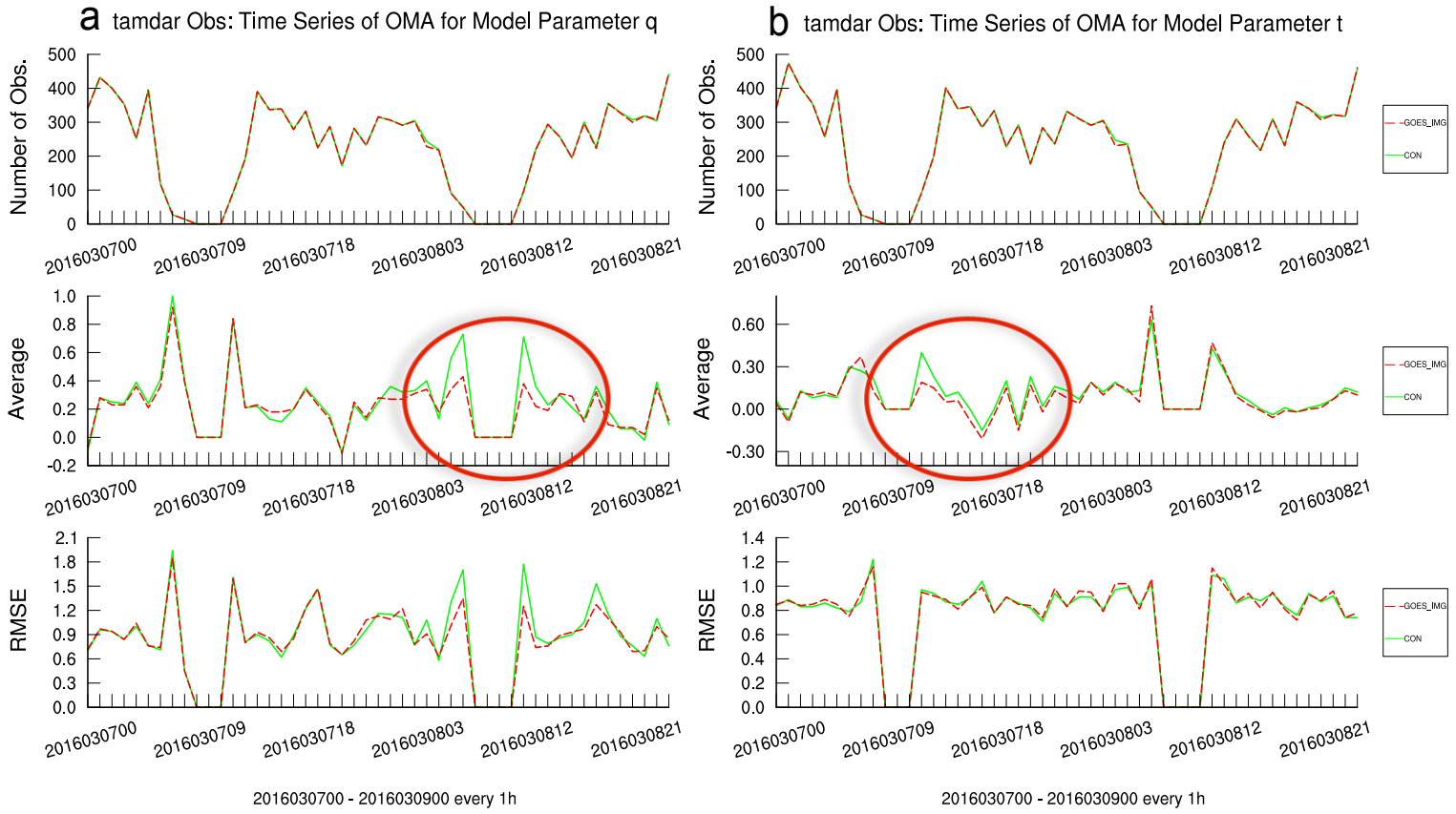
2016030700-0900，hourly cycling, dual-res. Hybrid + blending
0712、0800、0812、0900 24-h forecast

CON: GTS+TAMDAR+AMSUA
GOES_IMG: GTS+TAMDAR+AMSUA+GOES-Imager（channels 3, 4, 6）

Radiance Variational Bias Correction



Time series of Analysis Verify against TAMDAR

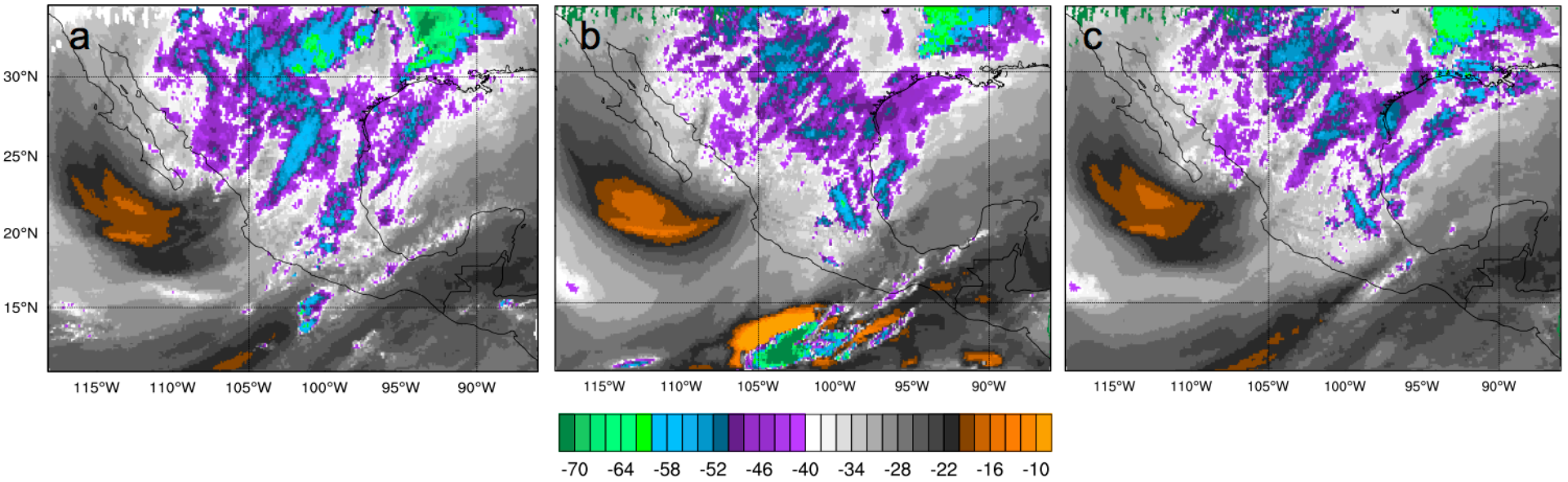


Analysis valid at 00 UTC, 2016/03/09

Observed WV channel

No GEOS-Imager DA

With GOES-Imager DA



Cloudy radiances

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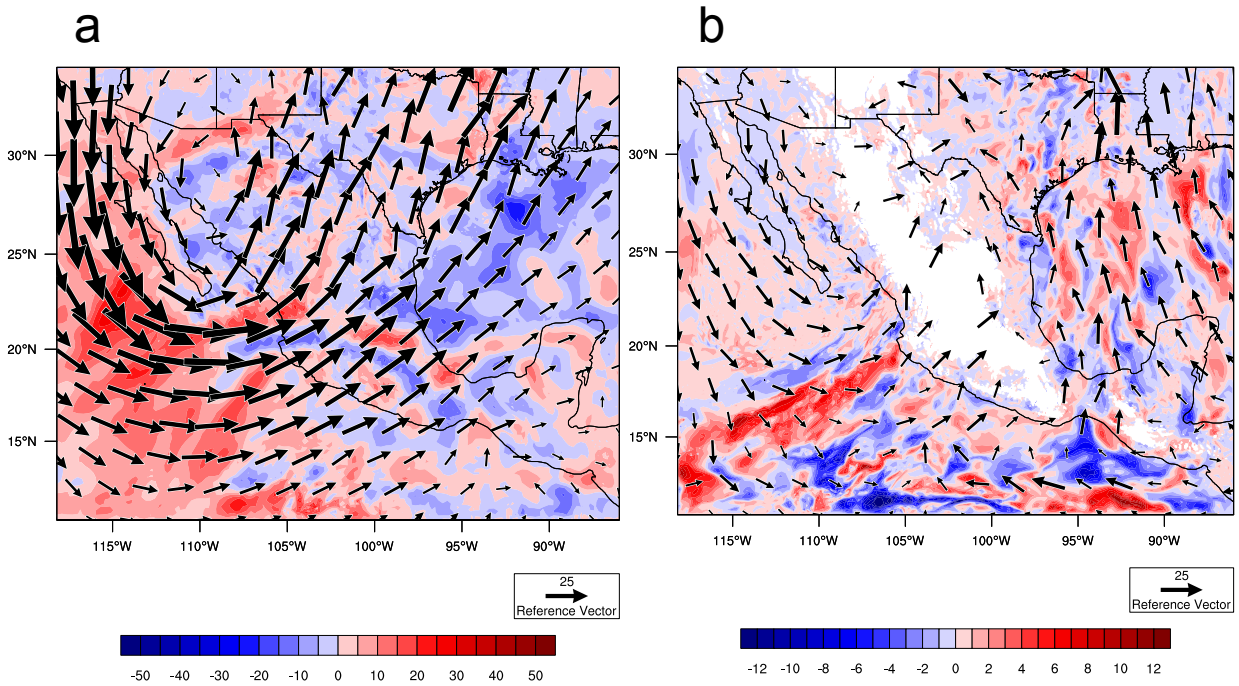
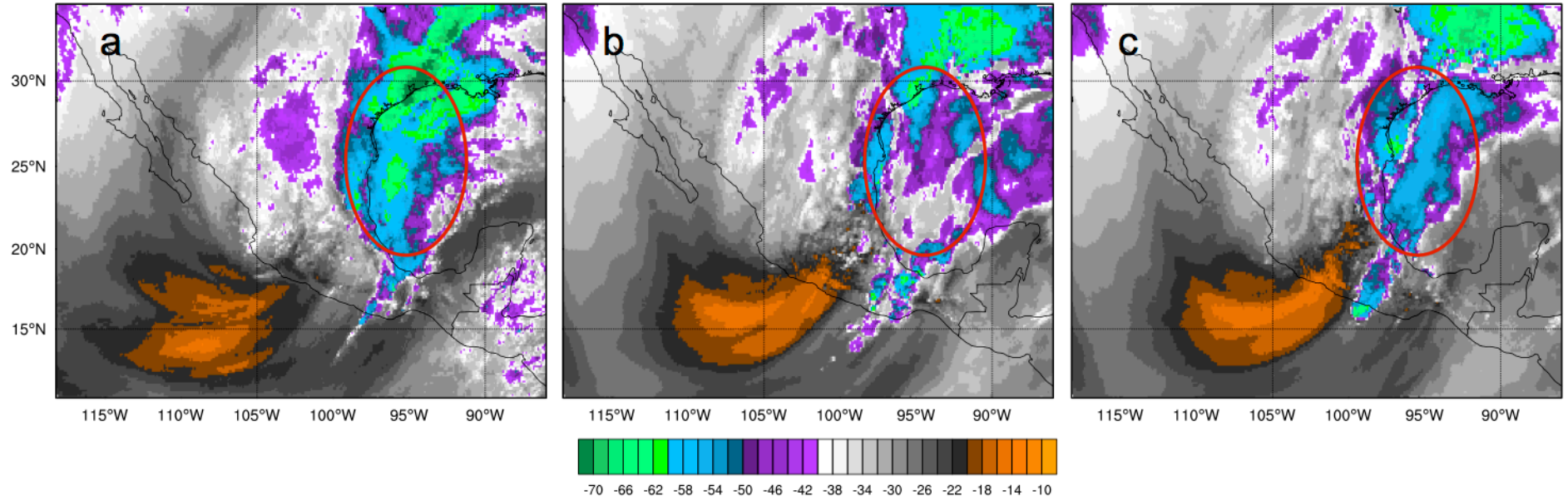
Analysis at 03/09/2016 00z



500 hPa Z and 850 hPa moisture difference

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



Observed WV channel

No GEOS-Imager DA

With GOES-Imager DA

Cloudy radiances

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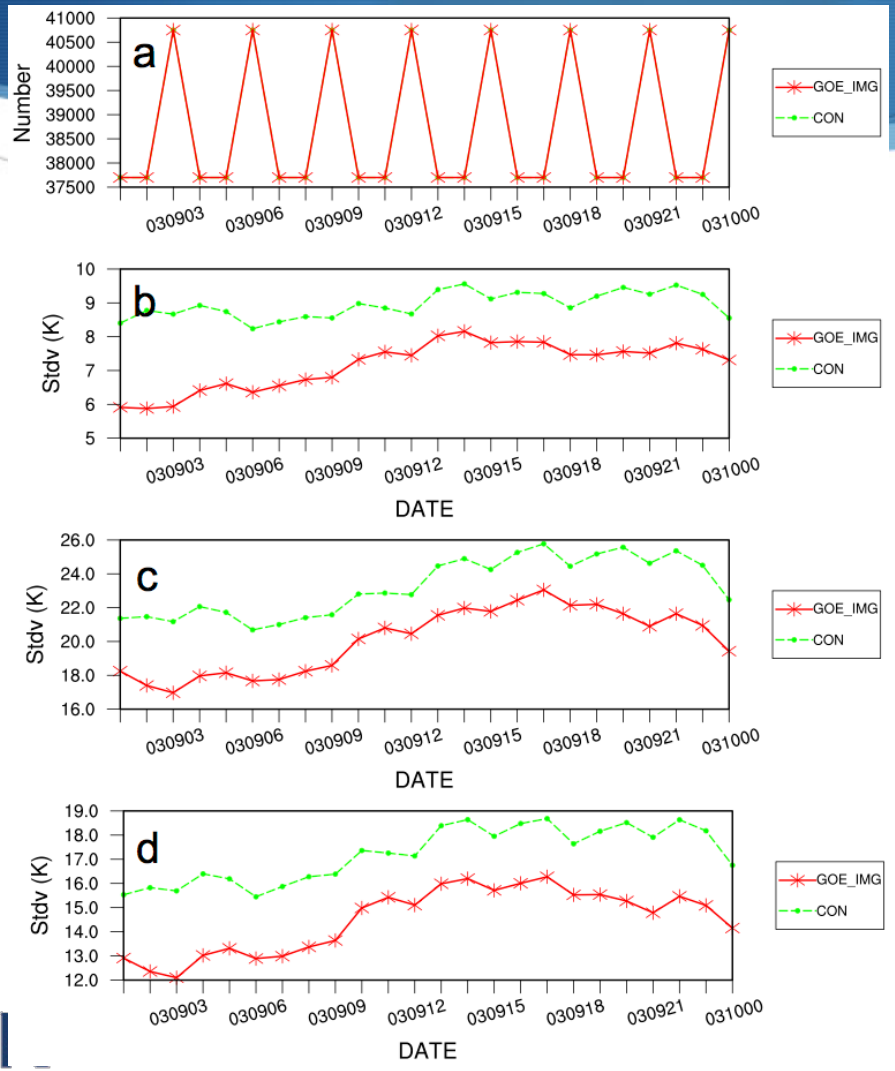
24-h forecast verify against GEOS-Imager cloudy radiances



Channel 3

Channel 4

Channel 6

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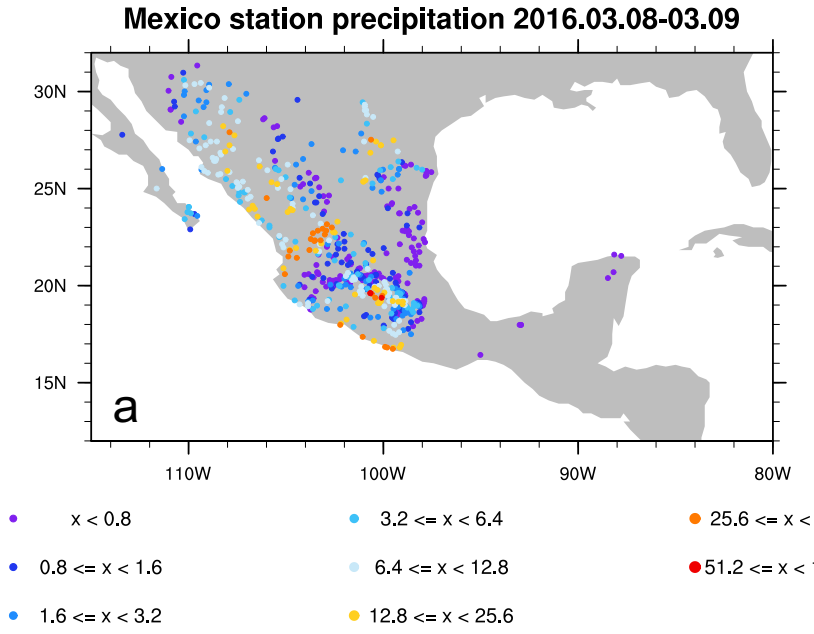
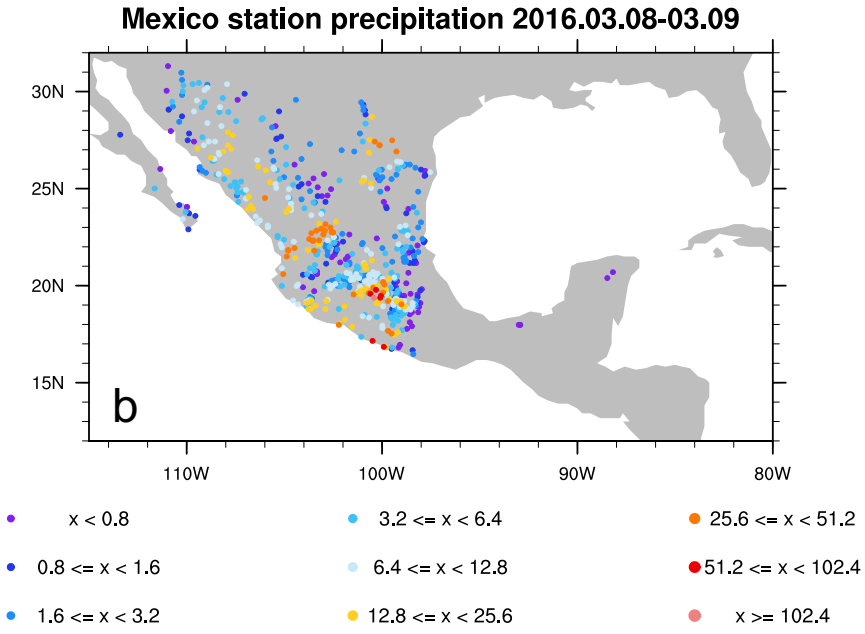
24-h precipitation forecast

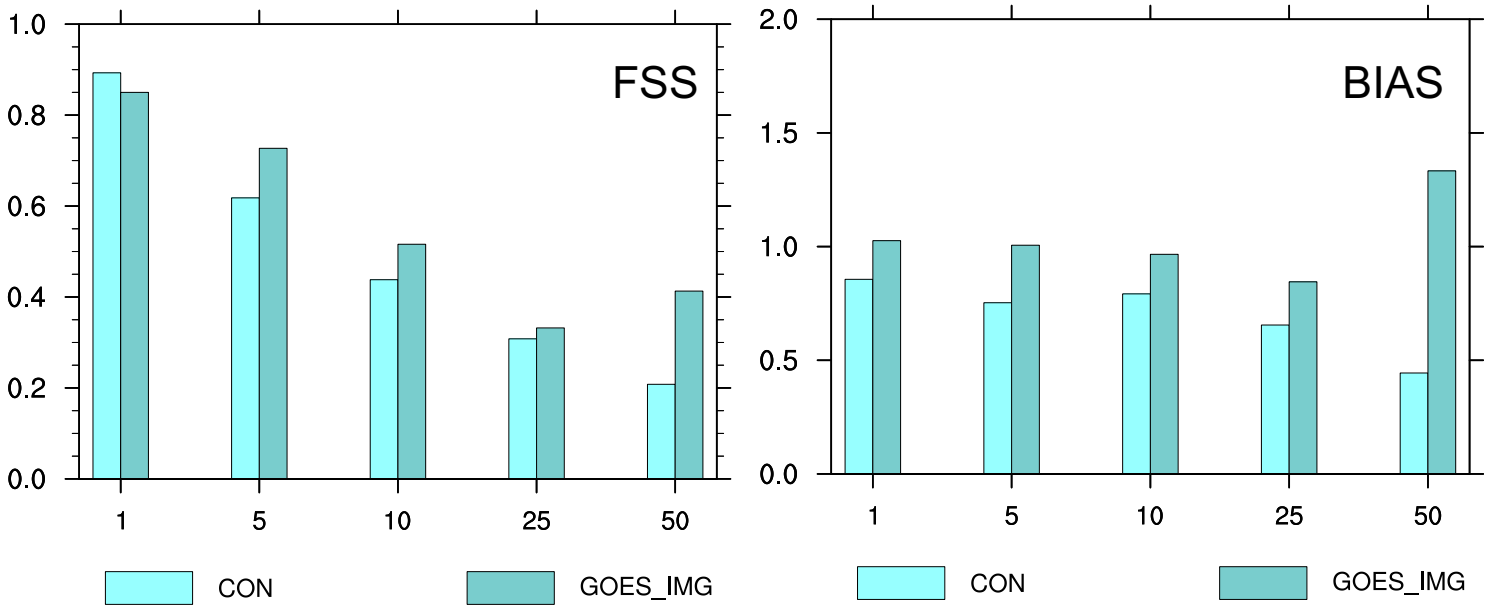


CONTROL



GOES-Imager

Precip. Forecast Ccore



Summary

- GOES-Imager radiance DA capability is implemented in WRFDA.
- GOES-Imager Radiance DA improved T and Q analysis (and cloud field from DA cycling effect)
- Lead to improved precipitation forecast for a heavy rainfall event

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.