Assimilating Surface and Rawinsonde Data in WRF Microphysics Simulations of Warm-Season Convection for SGP Central Facility

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1. Introduction

Accurate depiction of cloud and precipitation physics in grid-resolvable precipitation algorithms is critical for improving the representation of key climate processes in regional and global climate models. Because grid-resolvable cloud and precipitation processes are governed by the treatment of microphysical processes, we are evaluating the representation of cloud and convection characteristics in eight microphysics schemes of the Weather Research and Forecasting (WRF) model that diagnose/predict at least five water species. Emphasis is given to the impacts of data assimilation.

2. Simulation & Validation Data

- Simulation:- Two-way nested 9- and 3-km grid runs for 8 WRF microphysical schemes with and without data assimilation;
- PWV and precipitation from CMBE and Mace et al.'s (*JGR*, 2006) LWC/IWC and MMCR reflectivity for validation;
- QuickBeam radar simulation package (Haynes et al., *BAMS* 2007) for MMCR reflectivity conversion, with particle size distribution according to Hogan et al. (2006, *JAM*) Thompson et al. (2004, *MWR*), and others.

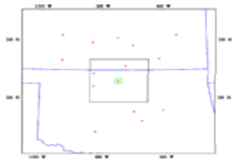

Fig. 1. WRF model domain and locations of SGP surface (red) and rawinsonde (green) stations used for data assimilation.

3. Convection Characteristics

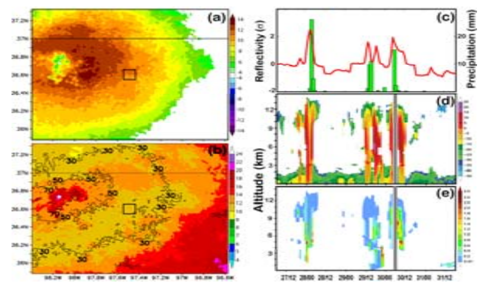

Fig. 2. Spatial and temporal convection signatures at the SGP for May 27-31, 2001. (a) EOF1 and (b) mean (shading, dBZ) and frequency (contour, %, above 10 dBZ) of WSR-88D reflectivity. (c) Time coefficients of EOF1 in (a) and SGP CF precipitation rate (CMBE, green bars). (d) MMCR reflectivity (dBZ) and (e) liquid (below 4 km) and ice (above 4 km) water concentration (g m^{-3}) at the SGP CF.

Conclusions

- Simulated cloud radar reflectivity strongly depends on various aspects of particle size distribution.
- The correlations between observed and simulated IWC/MMCR maximize between 6-7 km AGL for all microphysics schemes.
- The 3DVAR/4DVAR experiments showed improved reproduction of the observed PWV for the Lin et al., WSM6, Goddard, WDM5/WDM6 schemes.
- The 4DVAR WDM6 simulation achieved the highest modal PWV correlation, exceeding +0.9.

4. Cloud Radar Reflectivity

ACRONYMS

CNTRL
No data assimilation

OBNUD
observational nudging analysis

3DVAR
3-dimensional data assimilation

4DVAR
4-dimensional data assimilation

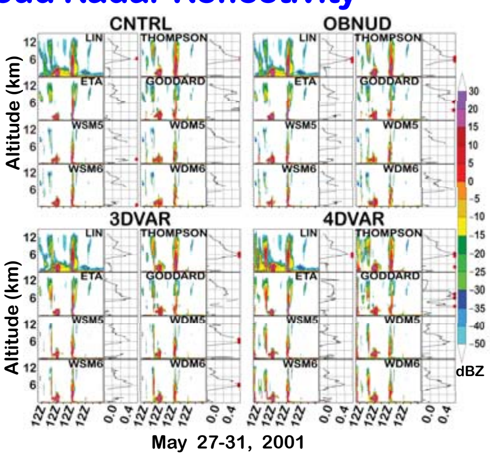

Fig. 3. Simulated reflectivity profiles and their corresponding correlations with observed reflectivity. Cloud radar reflectivity values are averaged over 9 x 9 grid-cell box centered over SGP CF. WSM5(6) and WDM5(6) are WRF Single-Moment 5(6)-class microphysics and WRF Double-Moment 5(6)-class microphysics, respectively.

5. Liquid/Ice Water Content

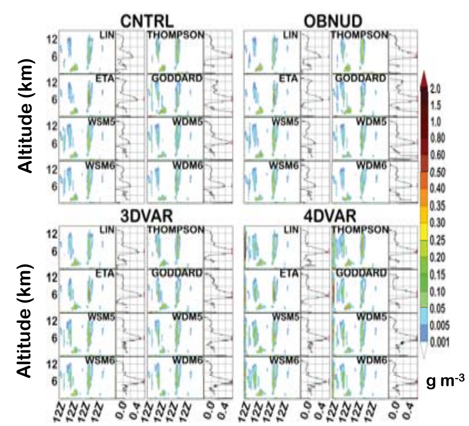

Fig. 4. Same as Fig. 3 except for simulated liquid (below 4 km) and ice (above 4 km) water concentration profiles. Acronyms are as in Fig.3.

6. PWV Correlations

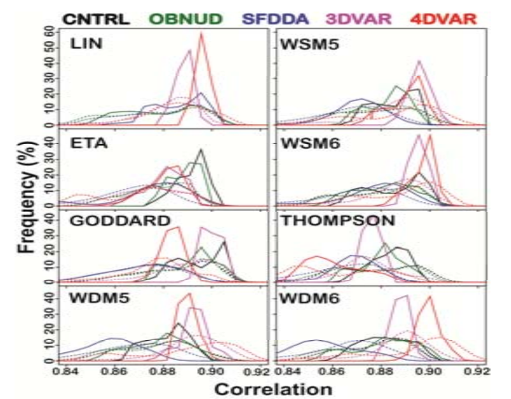

Fig. 5. Probability distributions of correlations between observed (CMBE) and simulated PWV for 8 WRF microphysics simulations with (colors) and without (black) data assimilation for May 27-31, 2001. Correlations were computed for the inner nested domain within 9 x 9 (solid lines) and 35 x 35 (dashed lines) grid-cell boxes surrounding the SGP CF. SFDDA indicates surface analysis nudging. Other acronyms are as in Fig. 3.

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