Dynamical Downscaling GPM data and MERRA2 global reanalyses using NU-WRF Ensemble Data Assimilation system: a case study of 2014 Thanksgiving winter storm

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INTRODUCTION

Precipitation is a very important parameter in numerical weather prediction and reanalyses for both research and societal applications. Atmospheric retrospective analyses integrate a variety of observing systems with numerical models to produce a temporally and spatially consistent synthesis of data for weather and climate variability studies. Even though reanalyses are not purely based on observations, they provide objectively analyzed fields dynamically and physically consistent with observations from a wide range of platforms and in various scales.

GPM and PMM provide almost two decades of global precipitation data record. However, assimilation of precipitation data requires a temporal and spatial scale that matches the underlining micro-physical processes and special radiative transfer modeling if the observations are indirect measurements from satellite remote-sensing instruments. Because of these obstacles the satellite precipitation data is not directly assimilated in the global Modern-Era Retrospective Analysis for Research and Applications (MERRA2).

In this work, we use the NASA Unified WRF Ensemble Data Assimilation System (NU-WRF EDAS) to directly assimilate GPM core and constellation Level 1C radiance into WRF. The analysis at cloud-resolving resolution (9 or 3KM grid spacing) is an optimal combination of information from dynamically downscaled GPM data and MERRA2 via ensemble data assimilation framework. This can be a viable approach to produce high-resolution regional retrospective reanalyses with effective utilization of PMM satellite precipitation data record including all cross-calibrated constellation instruments. A winter storm case is presented to examine the data influence to storm characteristics and assess the uncertainties from radiative transfer modeling for frozen precipitation in microwave observation operators.

Global Reanlyses via GOES-5 Data Assimilation System (MEERA2) at resolution 0.5 degree grid spacing

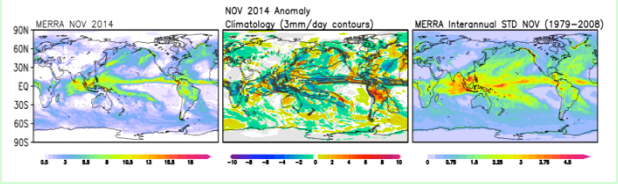

***Figure* 1.1.** surface precipitation in global reanalyses: November 2014 monthly mean, climatology, and inter-annual variability

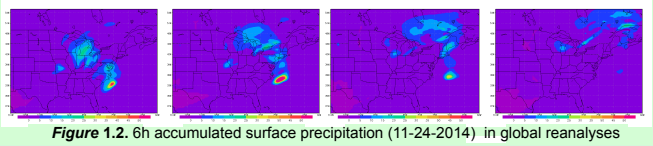

***Figure* 1.2.** 6h accumulated surface precipitation (11-24-2014) in global reanalyses

GPM core & constellation observations (level-1C) overpasses during 2014 Thanksgiving winter storm

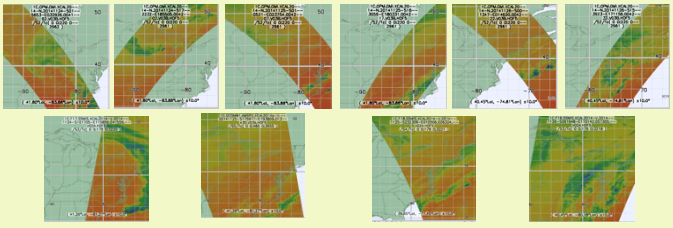

***Figure* 2.** brightness temperatures at high frequency channels (89, 166, 183+/7) : GMI, SSMIS NOAA16, 17, 18, and AMSR2

Uncertainty in radiance observation operator with frozen precipitation

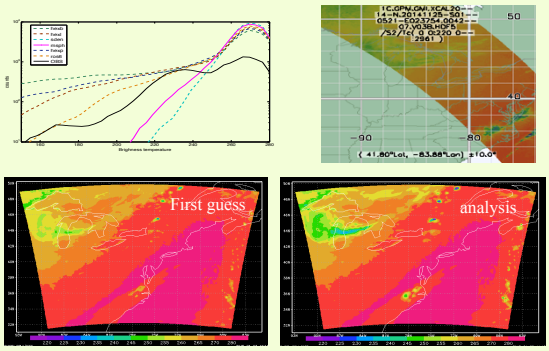

Figure 3. (a) distribution of simulated radiance with different snow particle shape assumptions and mass-diameter relationship, comparing to observations, (b) GMI observations ,(c) first guess simulated using soft-sphere shape assumption and fixed density for snow, and (d) analysis at 166GHz (stronger brightness temperature depression)

Verification of GPM data impact to forecasts of storm track and surface precipitation (6h accumulation, 11-24-2014)

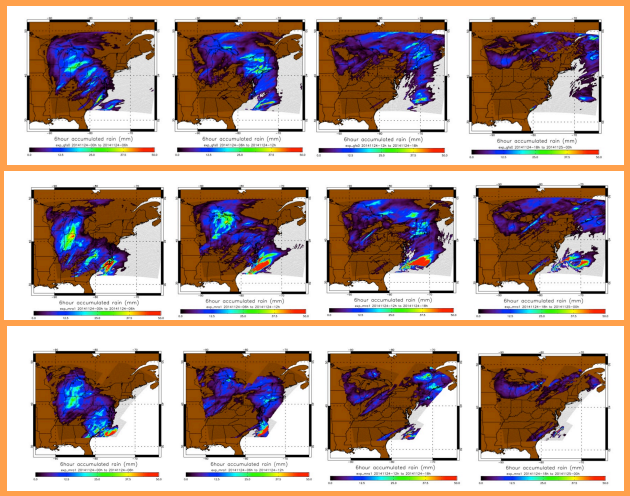

***Figure* 4**. (a) storm forecasts without assimilation of GPM data , (b) storm forecasts with assimilation of GPM data, and (c) ground-based verification data (Stage IV)

SUMMARY

- ❑ The NU-WRF Ensemble Data Assimilation System has been developed with capability of direct assimilating GPM core and constellation level1C radiance data under a wide environmental conditions.
- ❑ NU-WRF EDAS can dynamically downscale GPM observations and global reanalyses such as MERRA2 to produce high-resolution regional reanalyses and numerical predictions
- ❑ Uncertainty in radiance observation operator with frozen particles could cause biased analyses and forecasts. More realistic and state-dependent radiative transfer modeling for snow need to be implemented.

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