Towards the assimilation of space-borne precipitation radar in the ensemble-based variational scheme

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1. Background and Purpose

- Assimilating space-borne precipitation radars will be beneficial in NWP because they provide information on vertical precipitation profile over the both land and sea that are not covered by ground radars.
- They, however, had been underused due to the high nonlinearity of precipitation-related variables and difficult precipitation reproductivity of NWP models.
- An ensemble-based variational assimilation (EnVA) scheme employing a cloud-resolving model (CRM) has been developed to address the nonlinearity issue and effectively utilize precipitation-affected satellite data (Aonashi and Eito 2011).
- We are working on extending EnVA to assimilate TRMM/PR and GPM-core/DPR. We compared reflectivity from observation and CRM to to understand their characteristics and develop QC procedures.

2. Assimilation system basis

- EnVA: A variational scheme that minimize cost function in ensemble forecast error subspace (Lorenc 2003)

$$J(x) = J(\Omega) = \left(x - \overline{x^f}\right)^T \mathbf{P^{-f}} \left(x - \overline{x^f}\right) + (y - H(x))^T \mathbf{R^{-1}} (y - H(x))$$

$$x - \overline{x^f} = P_e^{f/2} \circ \Omega \qquad P_e^{f/2} = \left(x_1^f - \overline{x^f}, x_2^f - \overline{x^f}, , , , x_N^f - \overline{x^f}\right)$$

- EnVA has been recently improved to reduce sampling erros by introducing
  - Neighboring Ensemble (NE) based on spectral localization (Buehner and Charron, 2007) in addition to an adaptive spatial localization
  - Separating analysis variables dependent on horizontal scale
- Details will be given in Aonahi's talk (19.5, 20 Nov)
- CRM: JMA-NonHydrostatic Model (JMA-NHM; Saito et al., 2006)
  - Operationally used in the meso-scale NWP system in JMA
  - Cloud microphysics based on 2-moment 3-ice bulk scheme

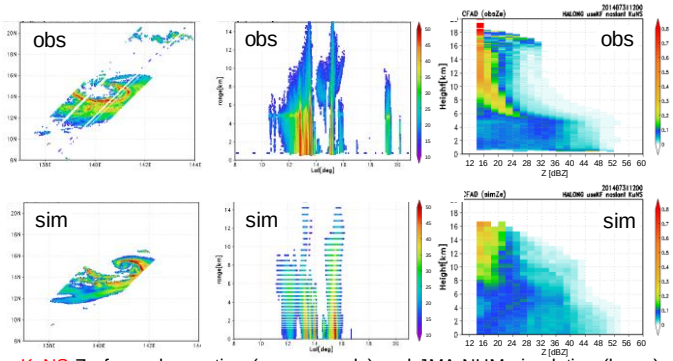
3. Comparison of GPM-core/DPR reflectivity from observation and model

3-1. Method

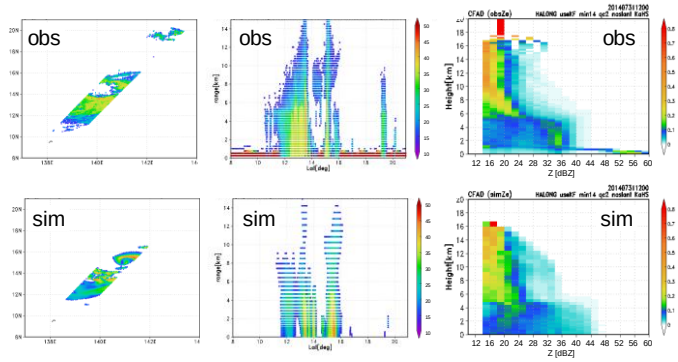
- Target : Typhoon T1411 (Halong)
- JMA-NHM : 12-h forecast from 00 UTC 31 July, 2014.
  5 km resolution, 50 layers and 401x401 grids
- GPM-core/DPR: 2ADPR (KuNS and KaHS), attenuation corrected reflectivity factor (Ze)
  - Remove data with Ze<14 dBZ and clutter-flagged
- Radar simulator : Joint-simulator (Hashino et al., 2013)
  - Multisensor simulator for VIS/IR/MW radiometers and radar/lidar
  - Employ hydrometeor parameters consistent with model and optical parameters based on Mie theory
  - Remove simulation with Ze<14 dBZ

3-2. Results

- Excessive scattering from ice particles for KuPR due to large snow size biase in JMA-NHM
  - This is alleviated for Ka, probably because of relatively small dependency on particle size
- Weaker scattering from liquid particles in JMA-NHM
  - Scarce large particles due to evaporations and rapid falling



KuNS Ze from observation (upper panels) and JMA-NHM simulation (lower) at 3 km height (left), at the middle of of angle bins (middle) and for CFAD (Contoured Frequency by Altitude Diagram)



The same as above but for KaHS Ze.

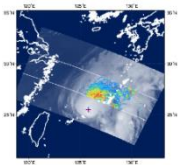
4. Preparation for assimilating PR and DPR in EnVA

4-1. EnVA setting

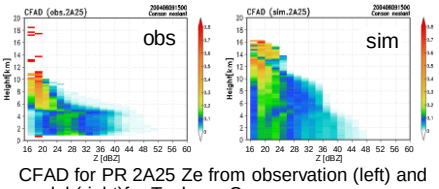
- Target : Typhoon T0404 (Conson)
- JMA-NHM : 7-h forecast from 00 UTC 9 June, 2004
  5 km resolution, 38 layers, and 400x400 grids
- Observation : TRMM/PR 2A25 attenuation corrected Ze

4-2. What is going on?

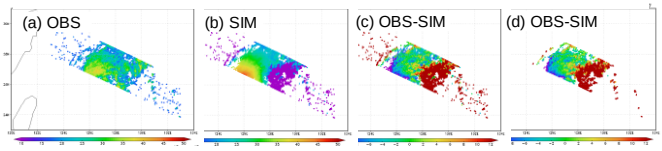
- Incorporating a space-radar processing in EnVA is under dvelopment
- Very conservative QC procedures has been tested in the 1st implementation
  - Reject Ze from ice-particles, melting layer, affected by clutter and smaller than minimum Ze criteria



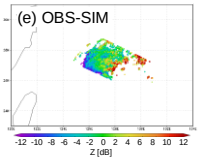
T0404 (Conson) from JAXA/EORC TC database

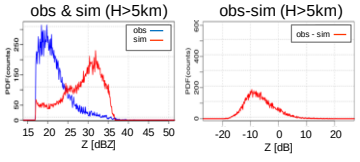


CFAD for PR 2A25 Ze from observation (left) and model (right)for Typhoon Conson.

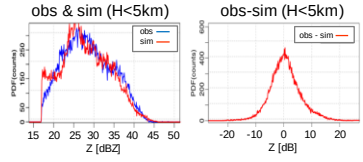


Ze at 2 km height for (a) observation with observed Ze>17 dBZ (OBS), (b) JMA-NHM simulation where OBS is (SIM), and (c) OBS-SIM. (d) same as (c) but exclude pixels flagged as rain. (e) same as (d) but removes pixels with simulated Ze<17dBZ.





PDF of (left) observed Ze and simulated Ze above 5 km height when both are over 17dBZ, and (right) their difference



The same as above but below 5 km height

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