Assessing Potential Impact of Air Pollutants Observations from Geostationary Satellite on Air Quality Prediction through OSSEs

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1 Introduction

The Ministry of Environment (MOE) of Korea is developing the Geostationary Environmental Monitoring Spectrometer (GEMS) which is planned to be launched aboard a Korean geostationary satellite in 2019.

The missions of GEMS are to monitor and provide measurements of atmospheric composition (e.g., O_3, NO_2, SO_2, HCHO, and aerosol) over Asia in daytime.

To assess potential impact of radiance observations from GEMS, it is essential to conduct the observation system simulation experiments (OSSEs) using synthetic radiances.

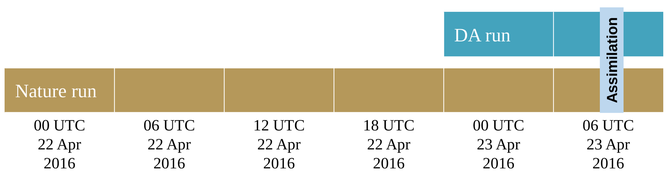

Fig. 3. Model integration configuration

2 Methods

- Maximum Likelihood Ensemble Filter (MLEF; Zupanski, 2005; Zupanski et al., 2008)
  - Hybrid ensemble-variational data assimilation

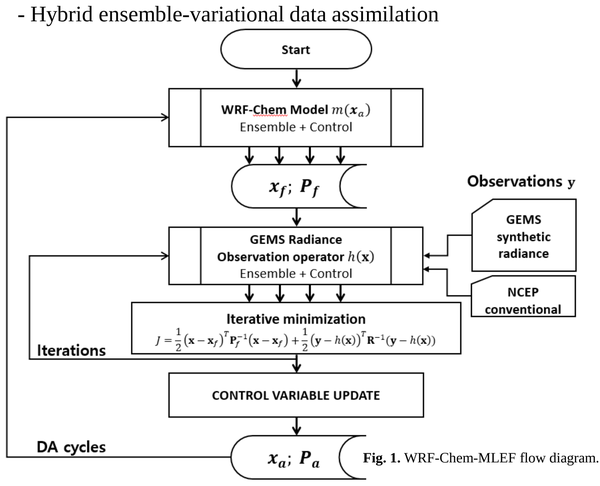

Fig. 1. WRF-Chem-MLEF flow diagram.

Experimental design

	Nature run	DA run
Model domain (Fig.2)	385 × 321 × 51, 7.5 km	129 × 127 × 51, 30 km
Chemistry option	MOZCART option	CBMZ option
Integration time (Fig. 3)	2016.4.21. 00 UTC – 2016.4.22. 06 UTC	2016.4.22. 00 UTC – 2016.4.22. 06 UTC
Initial & Boundary condition	NOAA/NCEP global model –Global Forecasting System	
Observations	-	1. NCEP conventional observation data 2. Synthetic radiances

Control variables

- Meteorological variables : horizontal wind (u,v), perturbation potential temperature (θ), perturbation geopotential, perturbation dry air mass and water vapor mixing ratio (q_v).
- Chemical variables : O_3, NO_2, SO_2, and HCHO.

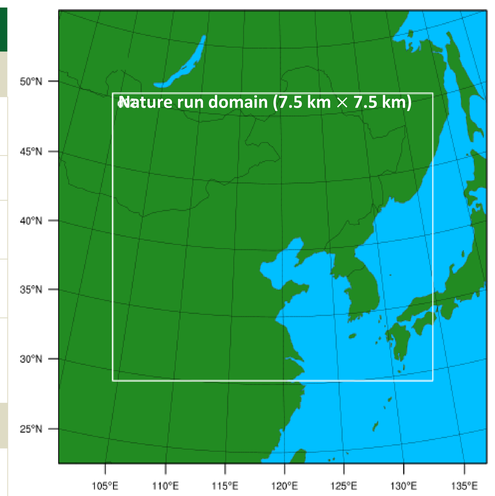

Fig. 2. Model domain for DA forecast with 30 km horizontal resolution and truth forecast with 7.5 km horizontal resolution (white box).

3 Results

Nature run and DA run

- DA run started one day later than Nature run and employed different chemistry option, thus making different forecast on 06 UTC 22 April.
- Compared to Nature run, background of DA run over-predicted O_3 in the Republic of Korea and nearby sea, NO_2 and SO_2 in the east of China, temperature nearby Mt. Paektu. Also transport of pollutants (O_3, NO_2, and SO_2) seemed slower than the Nature run.

Impact of NCEP meteorological conventional observations

- Conventional observations are unrelated to the Nature run. Therefore, analysis increments of conventional DA show different result from Nature run.
- DA of conventional observations modify temperature to be higher in the Bohai sea and lower in the middle of the Mongolia. Wind is modified to be higher (lower) in the northwestern (southeastern) part of the lower pressure located on the Manchuria.
- Due to the roll of cross-covariance terms (Park et al., 2015), conventional observations impact on chemistry variables. It seems that increased temperature increases O_3 in the Bohai sea. Increased wind decreases O_3 concentration in the Kyushu, whereas decreased wind increases O_3 concentration in the Yellow sea. Actually it is related to wind direction and sufficient concentration. SO_2 is also increased in the Yellow sea where wind vectors are centered and SO_2 shows high concentration relatively while NO_2 is not increased in same area.

Impact of NCEP conventional observations and synthetic radiances

- Assimilating synthetic radiances adds information of the Nature run to background of the DA run since synthetic radiances were generated from Nature run. However, impacts of conventional observations and synthetic radiances cancel out each other since they are assimilated simultaneously.
- After assimilation, the temperature analysis increments are weakened in the Bohai sea, negative analysis increment of MT. Paektu is due to low temperature in the Nature run in that area.
- For O_3, strong positive increments in conventional data assimilation is nearly disappeared, and negative increments appeared in the eastern Manchuria. It seems that synthetic radiances modify the over-predicted O_3 background. Appling SO_2 difference of the Nature run and the DA run background, strong positive increment in the Yellow sea is decreased after assimilating synthetic radiances.

4 Conclusions

- The potential impact of GEMS radiance assimilation is assessed with the MLEF data assimilation system coupled with WRF-Chem. Since GEMS radiances are not available yet, we generate synthetic radiances.
- To see the potential impact of GEMS radiation on existing prediction system, we performed two data assimilation experiments; (1) assimilating NCEP conventional data, and (2) assimilating both NCEP conventional data and GEMS synthetic radiances
- The results show assimilating only conventional data can affect chemistry variables due to cross-covariance of MLEF system. Transportation by wind shows strong impact on chemistry variables. O_3 shows strong correlation with temperature.
- The results show assimilating both NCEP conventional data and GEMS synthetic radiances affect DA run background. However, the impact of each observation is offset against each other.

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