

Comparison of Air Quality Forecasts over Korea with CMAQ and CAMx during 2014

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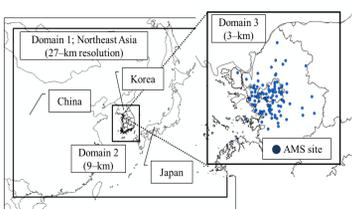
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Introduction

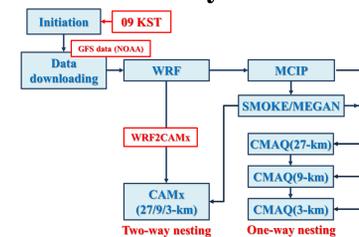
- Ensemble method combines the results of several simulations to increase prediction accuracy.
- As a part of an ensemble air quality forecast system, Community Multi-scale Air Quality (CMAQ) model and Comprehensive Air quality Model with eXtensions (CAMx) were implemented to predict PM concentrations over Northeast Asia.
- In this study, we compare CMAQ and CAMx performances in terms of PM₁₀ predictability over Seoul Metropolitan Area (SMA)

Methodology

Modeling domains



Operation of the forecast system



- The forecast system has been operating since January 2014 over Northeast Asia (27-km), Korea (9-km) and over the Seoul Metropolitan area (3-km; SMA).

CMAQ & CAMx configuration

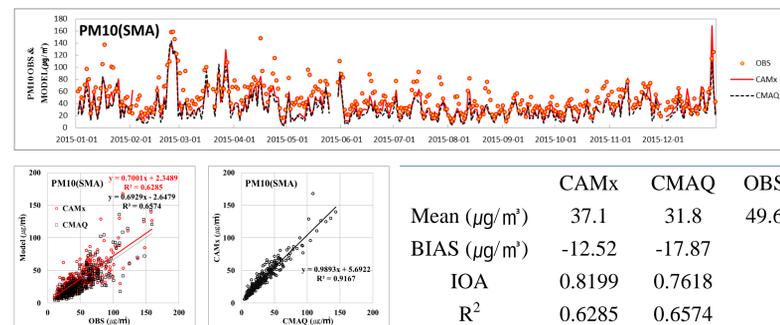
	CCTM	CMAQ (v4.7.1)	CAMx (v6.1)
WRF		Version 3.5.1	
Foreign Emissions		INTEX-B 2006	
Domestic Emissions		CAPSS 2007	
Chemical Mechanism		SAPRC 99	
Aero module		AERO5	CF

PM species mapping table

PM ₁₀	CMAQ	CAMx
Sulfate	ASO4J	PSO4
	ASO4I	
Nitrate	ANO3J	PNO3
	ANO3I	
Ammonium	ANH4J	PNH4
	ANH4I	
EC	AECJ	PEC
PM _{2.5}	AECI	
OC	AALKJ + AXYLJ + AXYL2J + AXYL3J + ATOLJ + ATOL2J + ATOL3J + ABNZJ + ABNZ2J + ABNZ3J + ATRPJ + ATRP2J + AISOJ + AISO2J + AISO3J + ASQTJ + AORGCJ + AORGPJ + AORGPAI + AOLGAJ + AOLGBJ	SOA1 + SOA2 + SOA3 + SOA4 + SOA5 + SOA6 + SOA7 + SOPA + SOPB + POA
PMFINE	A25J	PMFINE
Sea salt	ANAJ + ACLJ + ACLI	NA + PCL
PMC	ACORS + ASOIL + ANAK + ACLK + ASO4K + NH4K + ANO3K	CPRM + CCRS

- CMAQ-ready emissions are converted to prepare CAMx-ready emissions. Low-level and elevated emissions are separated for CAMx operations.
- Major differences are listed as follows:
 - Meteorological data processing: MCIP (CMAQ), WRF2CAMx (CAMx)
 - Aerosol module: AERO5 (CMAQ), CF (CAMx)
 - Elevated emission placement: Offline (CMAQ), Inline (CAMx)
 - Grid nesting: One way (CMAQ), Two-way (CAMx)

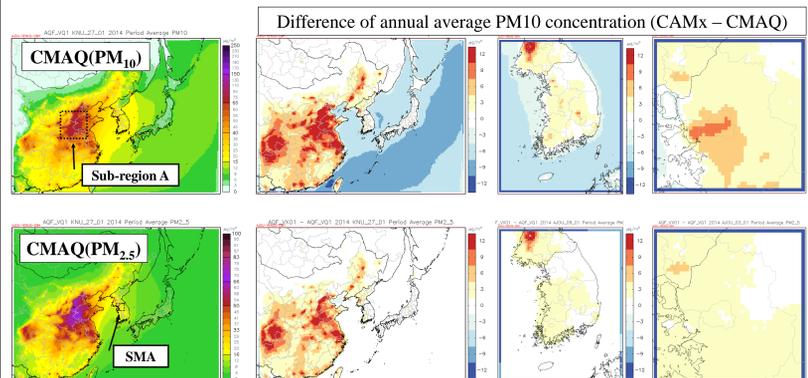
Results 1: Model performance evaluation



- For the entire year of 2014, simulated daily PM₁₀ concentrations were evaluated with the measured concentrations available from the AirKorea surface observation network in the Seoul Metropolitan Area (SMA).
- Overall, the simulated PM₁₀ shows similar daily variation compared to the observations. However, both models under-predicted the observed PM₁₀ by 30~40% (~15 $\mu\text{g}/\text{m}^3$) for the annual mean.

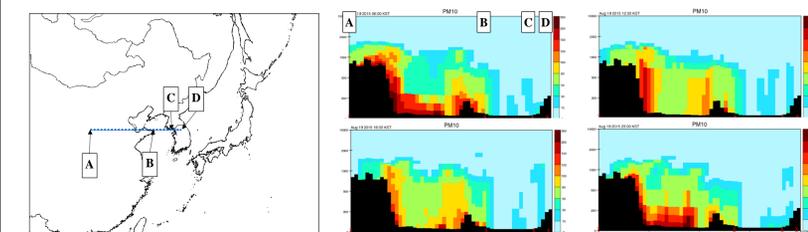
Results 2: Overall comparison

Annual average PM₁₀ spatial plots

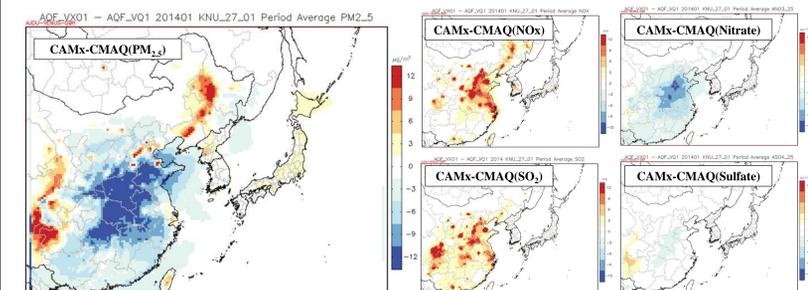


- CAMx predicts ~15 $\mu\text{g}/\text{m}^3$ higher PM₁₀ concentrations than CMAQ when compared for over sub-region A while ~5 $\mu\text{g}/\text{m}^3$ higher over the SMA.

Vertical distribution (CAMx)



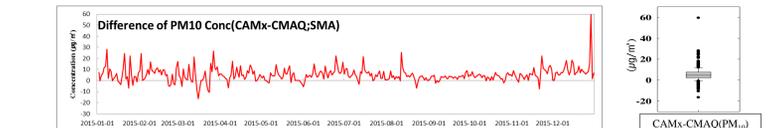
PM_{2.5} and species concentration on January



- The curtain plots show that CAMx may confine PM₁₀ and its precursor emissions near the surface. Vertical diffusivity(Kz) will be further investigated in near future.
- CAMx exhibits higher concentrations for primary pollutants and lower concentrations for secondary pollutants over high emission areas in China. Conversion rates would be different in two models under the emission conditions.

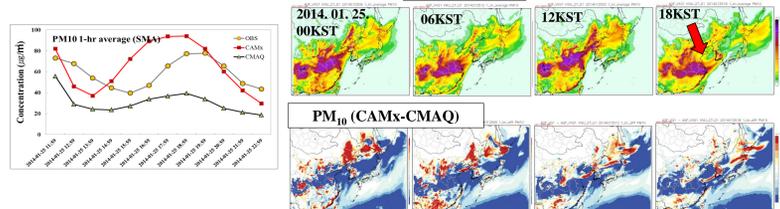
Results 3: Case study

Difference in daily average PM₁₀ predicted by CAMx and CMAQ

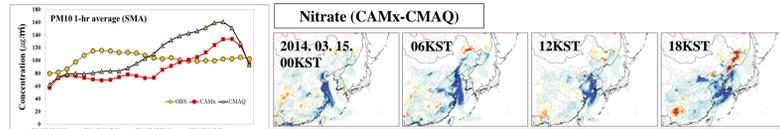


- CAMx generally predicts higher daily average PM₁₀ than CMAQ. The difference ranges from -20 $\mu\text{g}/\text{m}^3$ to 60 $\mu\text{g}/\text{m}^3$.

Case1. January, 25, 2014



Case2. March, 15, 2015



- In Case1, CAMx predicts higher PM₁₀ than CMAQ upwind (Northern China) in previous days. A high-low pressure system brings down CAMx predicted high PM₁₀ air plume to the SMA though North Korea.
- In Case2, CMAQ predicts higher PM₁₀, especially for nitrate than CAMx around offshore China. While transported, CMAQ-simulated high PM₁₀ plume is maintained over Yellow Sea and arrives South Korea.

Results 4: forecasts skill score

The contingency table

		Observed violation			CMAQ	OTV	OFV	No. of Forecast
		True	False					
Forecasted violation	True	a	b	Forecasted true violation (FTV)	FTV	13	0	13
	False	c	d	Forecasted false violation (FFV)	FFV	24	315	339
		Observed true violation (OTV)		Total	No. of Observation	37	315	
		Observed false violation (OFV)			CAMx	OTV	OFV	No. of Forecast
					FTV	14	3	17
					FFV	23	312	335
					No. of Observation	37	315	

- Average forecast accuracy (a.k.a. hit rate) of two models defined as "a/(a+c)" is 45% during high daily PM₁₀ concentration days when observed daily PM₁₀ concentrations were over 80 $\mu\text{g}/\text{m}^3$.

Conclusions

- In this study, we compare CMAQ and CAMx performances in terms of PM predictability over SMA
- the simulated PM₁₀ show similar daily variation compared to the observations. However, both models under-predicted the observed PM₁₀ by 30~40% (~15 $\mu\text{g}/\text{m}^3$) for the annual mean.
- CAMx generally predicts higher daily average PM₁₀ than CMAQ. The difference ranges from -20 $\mu\text{g}/\text{m}^3$ to 60 $\mu\text{g}/\text{m}^3$.
- CAMx may confine PM₁₀ and its precursor emissions near the surface. Vertical diffusivity(Kz) will be further investigated in near future.
- Conversion rates would be different in two models.

Acknowledgement

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