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Simulating the Impact of East Asian Dust Event during the Spring Season on Taiwan: A Testing of the New Windblown Dust Module in CMAQ.

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INTRODUCTION

Mineral dust has been a great concern towards human beings as it carried huge impact on the earth's system. It brings important implication for air quality, reduced the visibility, change the earth's radiation budget, hydrological process and atmospheric chemistry. Asian dust storm events were mostly significant or common during the late winter and spring including March, April and May. It has been a great and popular issue over the northern China, Mongolia and Central Asia during the high wind conditions. Overall, the sources of East Asian Dust can be originated from the deserts from China and Mongolia such as Taklamakan and Gobi deserts. The present study intends to evaluate the performance of CMAQ model in projecting the particulate matter, with the implementation of new dust model modulated by Foroutan et al. (2017).

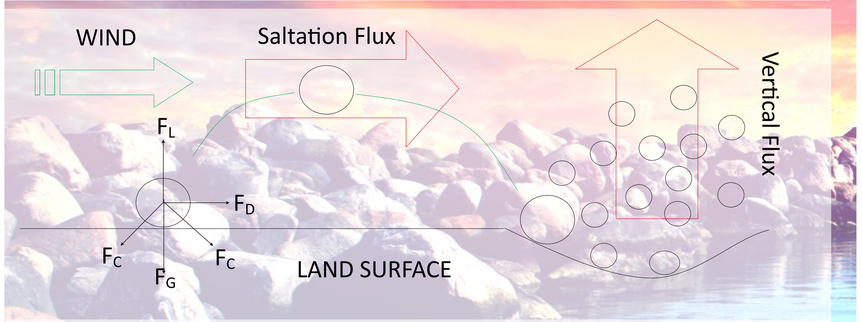
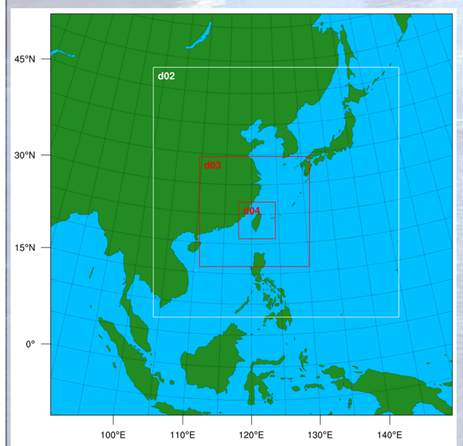


Figure 1: Dust emission mechanism by saltation. The forces exert towards the dust particle: lift (F_L), drag (F_D), gravitational (F_G) and cohesive (F_C) forces.

METHODOLOGY



- Time Frame: April 2018.
- Horizontal Resolution: 81km, 27km, 9km, 3km.
- NCEP GFS Global Forecast System.
- MICS-Asia III Emission Inventory.
- Taiwan Emission Database (TESD9.0).
- Carbon Bond Mechanism (CB05e51) for gas-phase chemistry.
- AERO6 aerosol module.
- Inline photolysis calculation.
- Inline windblown dust scheme.

Figure 2: CMAQ model configuration and set up.

Table 1: Brief descriptions of the simulation scenarios.

Simulation Scenarios	Descriptions
CMAQ_Nodust	Without in-line calculation of dust
CMAQ_Default	With default wind-blown dust emission scheme
CMAQ_Revised	Revised the soil moisture fraction in the dust scheme

RESULTS

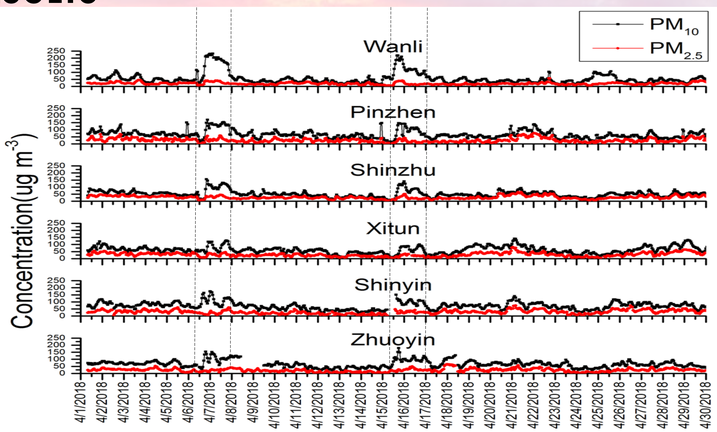


Figure 3: Timeseries of the observed PM_{10} and $PM_{2.5}$ in Wanli, Pinzhen, Shinzhu, Xitun, Shinyin and Zhuoyin stations during April 2018.

Table 2: Evaluation of PM_{10} and $PM_{2.5}$ concentration between the simulation and observation under CMAQ_Nodust, CMAQ_Default and CMAQ_Revised scenarios.

	PM_{10}			PM_{25}		
	Nodust	***Default***	***Revised***	***Nodust***	***Default***	***Revised***
MeanObs	61.25	61.25	61.25	25.48	25.48	25.48
MeanMod	40.01	43.79	46.76	20.45	20.55	21.70
MB	-21.24	-17.45	-14.48	-5.03	-4.93	-3.78
FB	-0.455	-0.348	-0.281	-0.233	-0.228	-0.172
NMB	-34.79	-27.99	-23.15	-20.43	-20.03	-15.43
NME	55.09	54.79	52.55	49.56	49.17	48.75
FAC2	0.761	0.863	0.918	0.932	0.936	1.00
NMSE	0.604	0.501	0.418	0.330	0.322	0.294
RMSE	43.05	42.69	40.74	16.42	16.31	16.65
MNB	-23.88	-13.64	-8.159	-6.77	-6.31	0.643

7th April 2018

16th April 2018

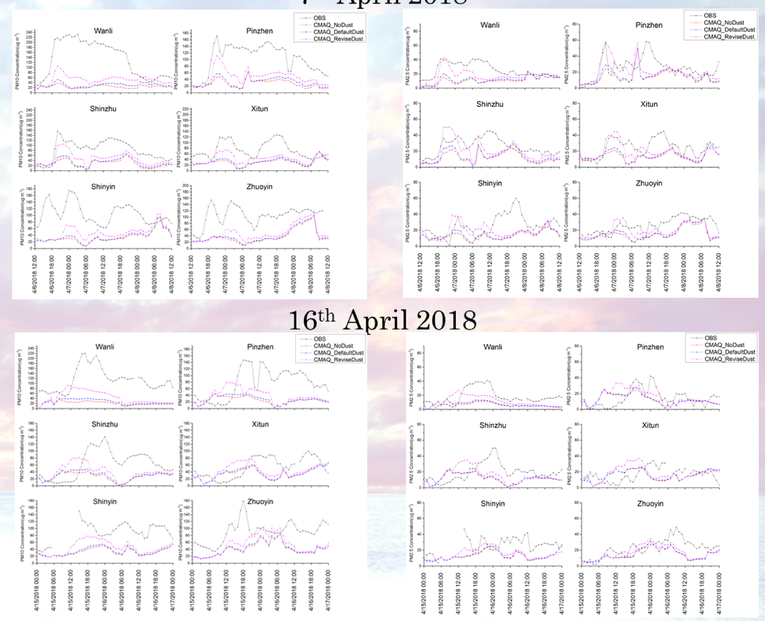


Figure 4: Timeseries of the observed and simulated PM_{10} (left) and $PM_{2.5}$ (right).

CONCLUSION

- East Asian Dust (EAD) is responsible in deteriorated air quality and poor visibility over East Asia (EA) over the past decade. CMAQ (v5.2) model is applied to simulate the particulate matter with the implementation of the new windblown dust emission scheme.
- Overall, the simulation underestimated the particulate matter (PM), probably due to the underestimation of modeled wind speed and overestimation of dry deposition. With the new dust module, the CMAQ simulation shows better performance than without the module incorporation in simulating both PM_{10} and $PM_{2.5}$, with normalized mean bias (NMB) of -23.15% and -15.43% improved from -34.79% and -20.43% respectively. The analysis of a dust storm episode during 7th and 16th April 2018 suggested that the CMAQ model is capable of capturing the dust aerosol concentration.
- The occurrence of the dust storm can be due to the Mongolian cyclonic which initiated the strong northwesterly wind over deserts regions. As for implication, the accuracy of CMAQ simulation can be enhanced by incorporating the new dust module in projecting the long-range transport of dust particle.

Acknowledgment

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