Validation and improvement of Taiwan Emission inventory for air quality modeling

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Introduction

- The performance of air quality modeling (AQM) depends largely on the uncertainty of emission inventory.

- The Taiwan EPA (TEPA) has released the latest TEDS10.0 (Taiwan Emission Database System, version 10.0) based on 2016.

- The object of this study is :

1. To improve the uncertainty of emission inventory.
2. To provide suggestions of several aspects to be improved to the TEPA.

Method – Emission inventory and Model

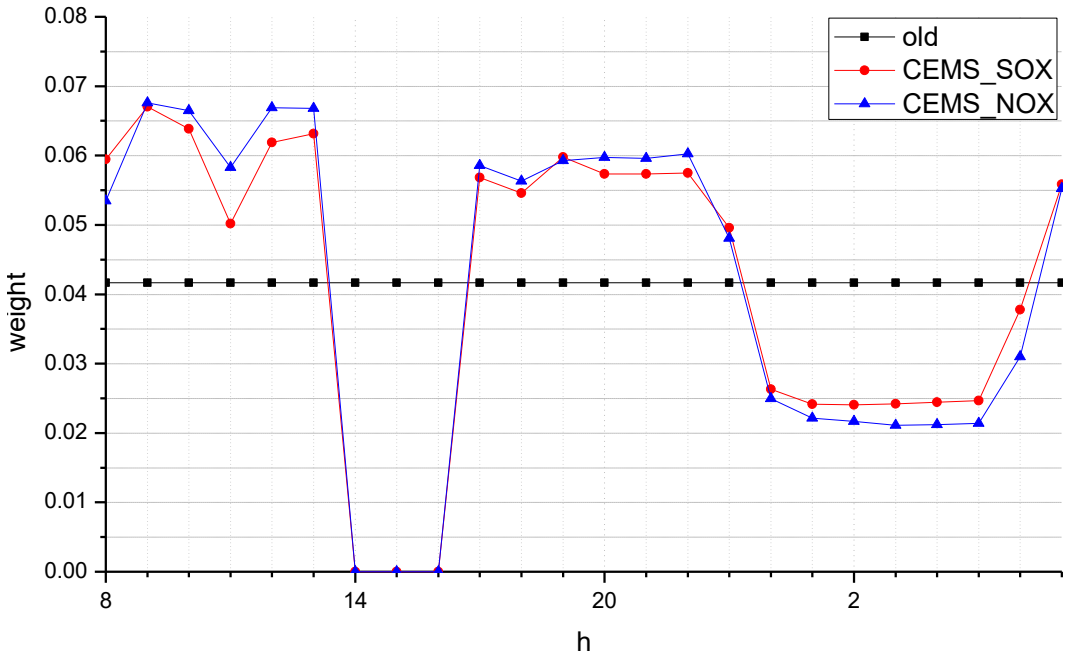
- Based emission Inventory: TEDS 10.0 (based on 2016).
- Emission Model:SMOKE v4.6 (Sparse Matrix Operator Kerner Emissions)
- Large point source emissions:CEMS (Continuous Emission Monitoring System) data

	smokev2.7(Base)	smokev4.6(Improvement)
model	SMOKE v2.7	SMOKE v4.6
Point	TEDS9.1	TEDS10.0 CMES106
Mobile	TEDS9.1	TEDS10.0
Area	TEDS9.1	TEDS10.0
Biogenic	BEIS2	BEIS3.61
chemical mechanism	CB4	CB05

Method-
Continuous Emission Monitoring System

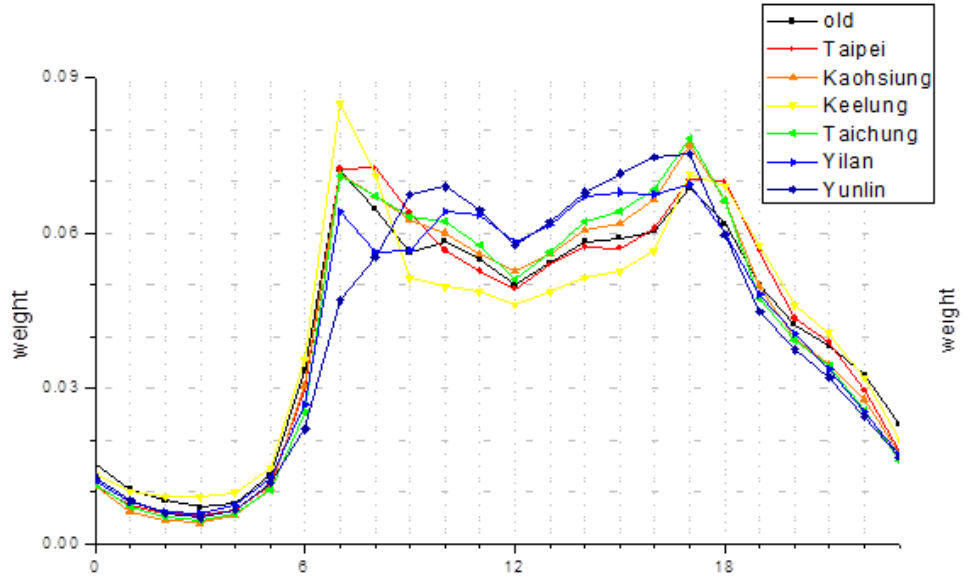
- To improve the point source emissions, we used the CEMS (Continuous Emission Monitoring System) data.
- This monitoring system included 65% of all point source emissions.
- Data frequency : hourly

- Applying CEMS data to point source emission should be closer to the reality.

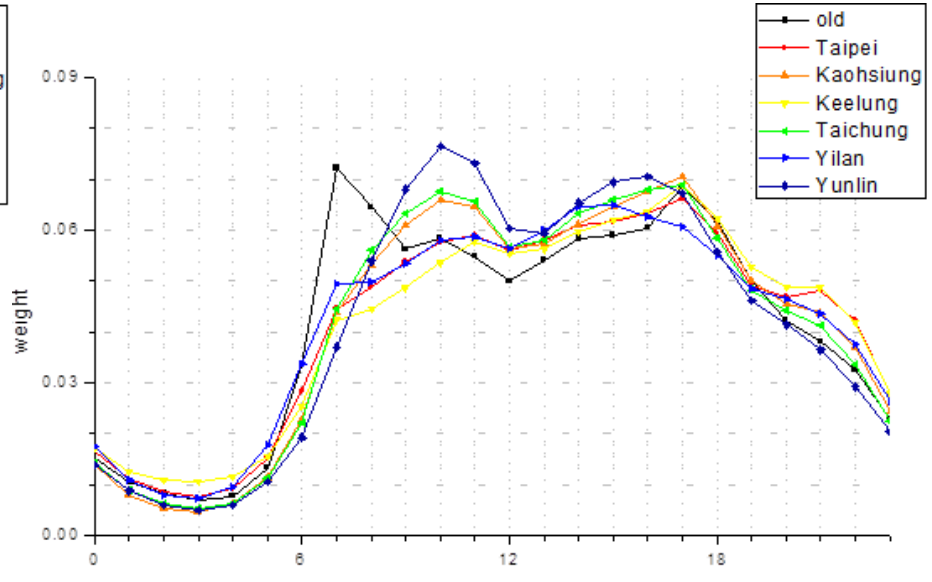


Method- Electronic Toll Collection

- Electronic Toll Collection (ETC) data could be used to improve the mobile source emissions.
- On weekday, there are few different between each city.
- On weekend, the temporal profiles have different pattern, which display the higher weight in the afternoon.



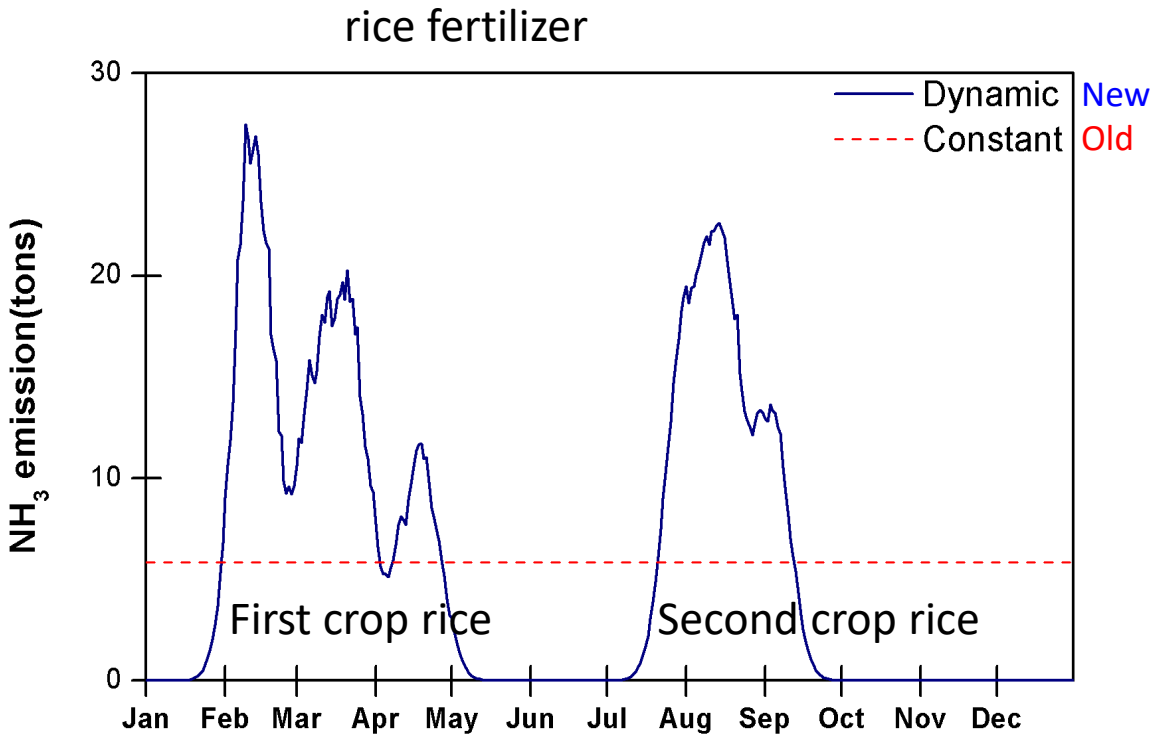
Hourly temporal profile on Tuesday

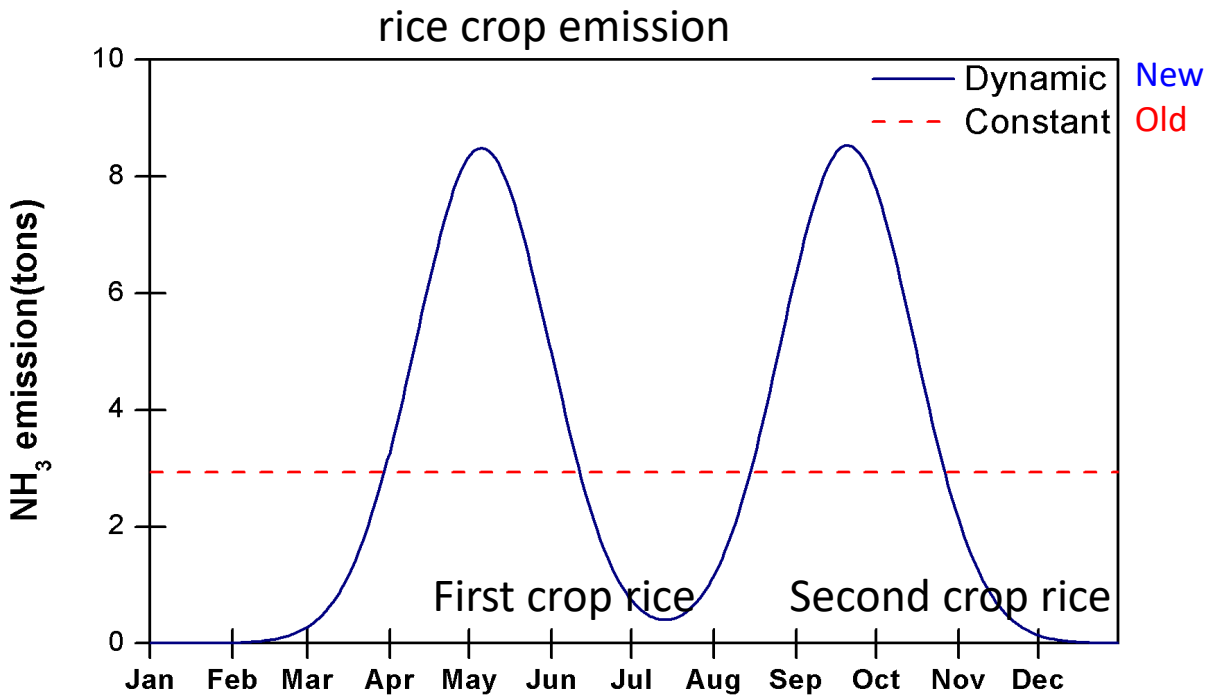


Hourly temporal profile on Saturday

Method- daily NH_3 emission allocation

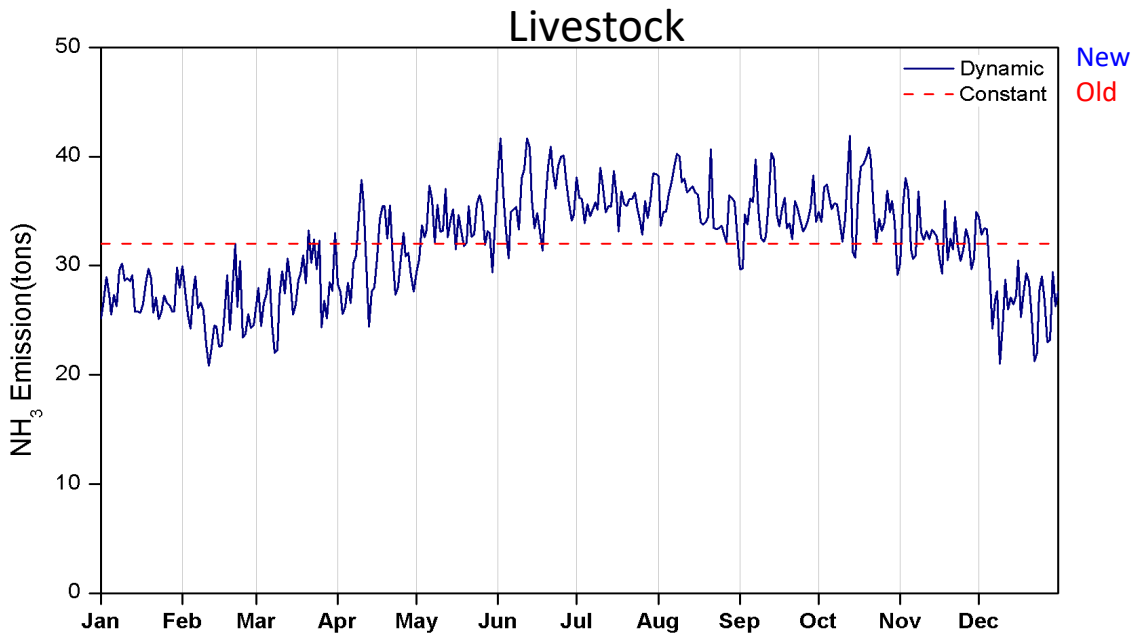
- We calculate NH_3 dynamic emission following Gyldenkærne et al.(2005), and Hsu et al.(2018).
- The dynamic emission have higher value in growing seasons.





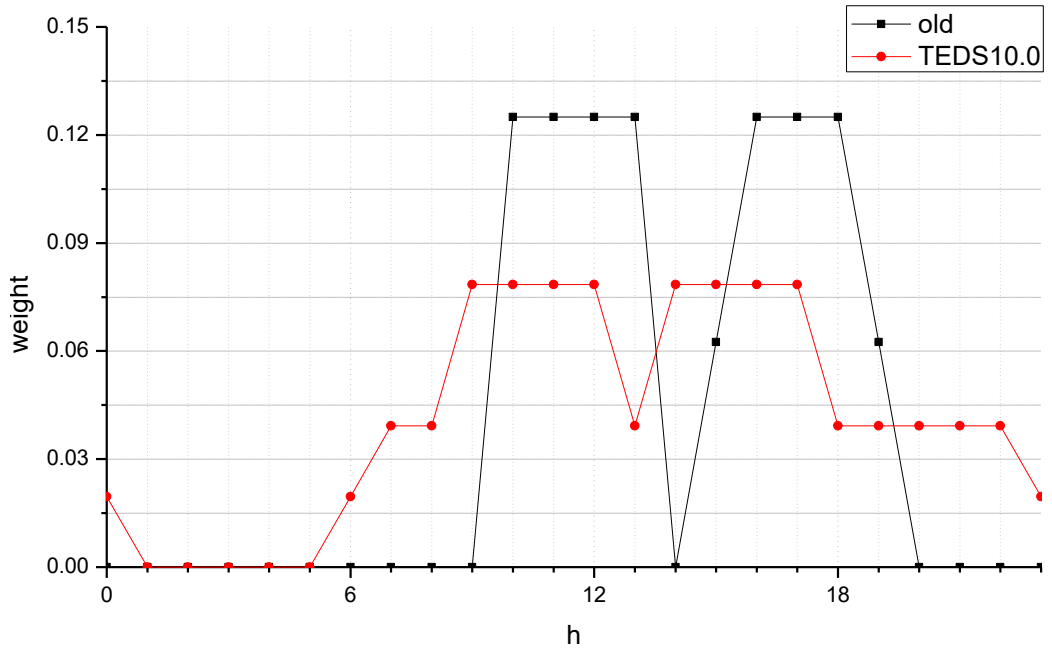
Method- daily NH_3 emission allocation

- We calculate NH_3 dynamic emission following Gyldenkærne et al.(2005), and Hsu et al.(2018).
- The dynamic NH_3 emission of Livestock have higher value in summer months.



Method – Other area source emissions

- We also have used the newest temporal profiles suggested by Taiwan EPA for area sources
- For example, the lower figure denotes the temporal profile for general consumer goods like sprayers.



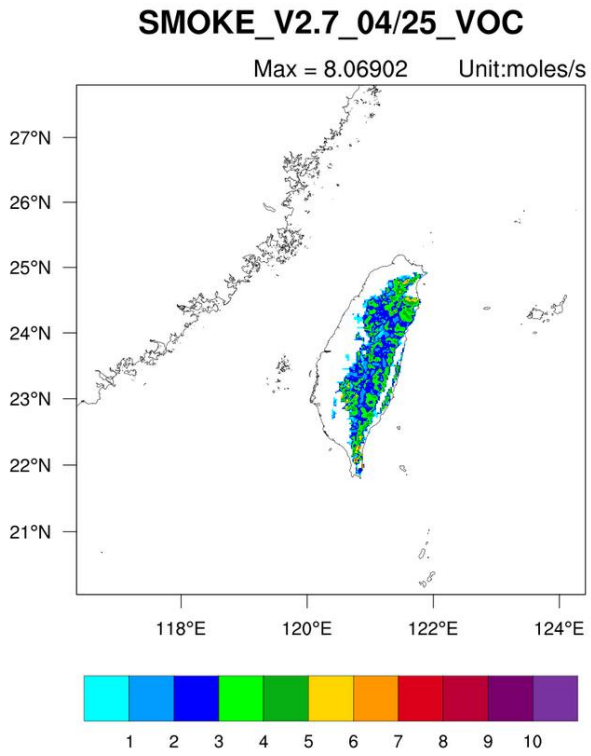
Method –Biogenic Emission

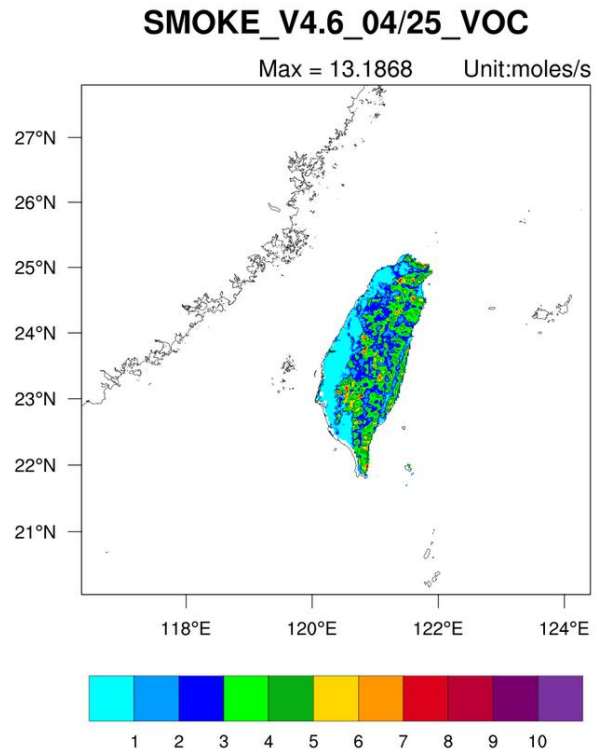
- In the study, we use BEIS3.61 to calculate Biogenic emission.
- The landuse data in TEDS10.0 include forest and urban area(Chang et al., 2005).The landuse data in old version include forest area only.

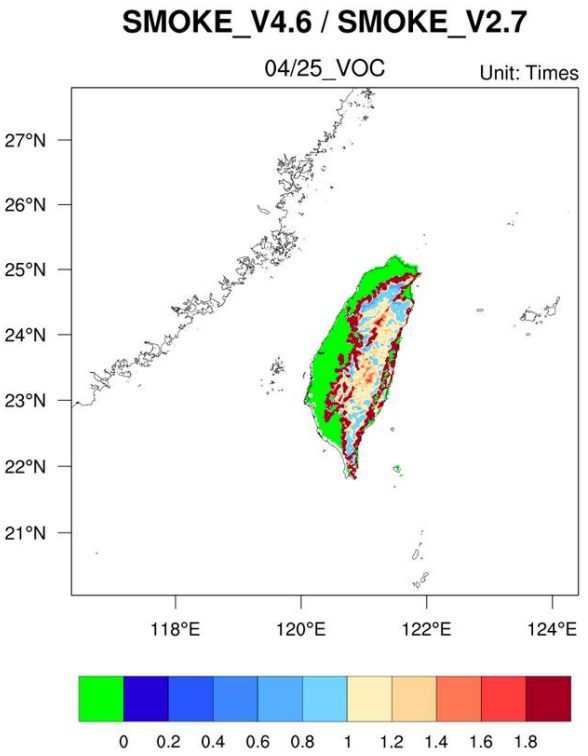
Model	BEIS2	BEIS3.61		
Characteristic	Leaf area index	Leaf area index Dry Leaf Biomass Winter Biomass Specific Leaf Weight		
Emission Factor	ISOP Mono-Terpenes Others VOC NO	ISOP MBO METH APIN BPIN D3CAR DLIM CAMPH MYRC ATERP BPHE SABI PCYM	OCIM ATHU TRPO GTERP ETHE PROPE ETHO ACET HEXA HEXE HEXY	FORM ACTAL BUTE ETHA FORAC ACTAC BUTO CO Other VOCs SESQT NO

Method –Biogenic Emission

- The biogenic emission calculation by SMOKE v4.6 is obviously reasonable in urban area. In addition, the emissions is lower value in some mountain area.

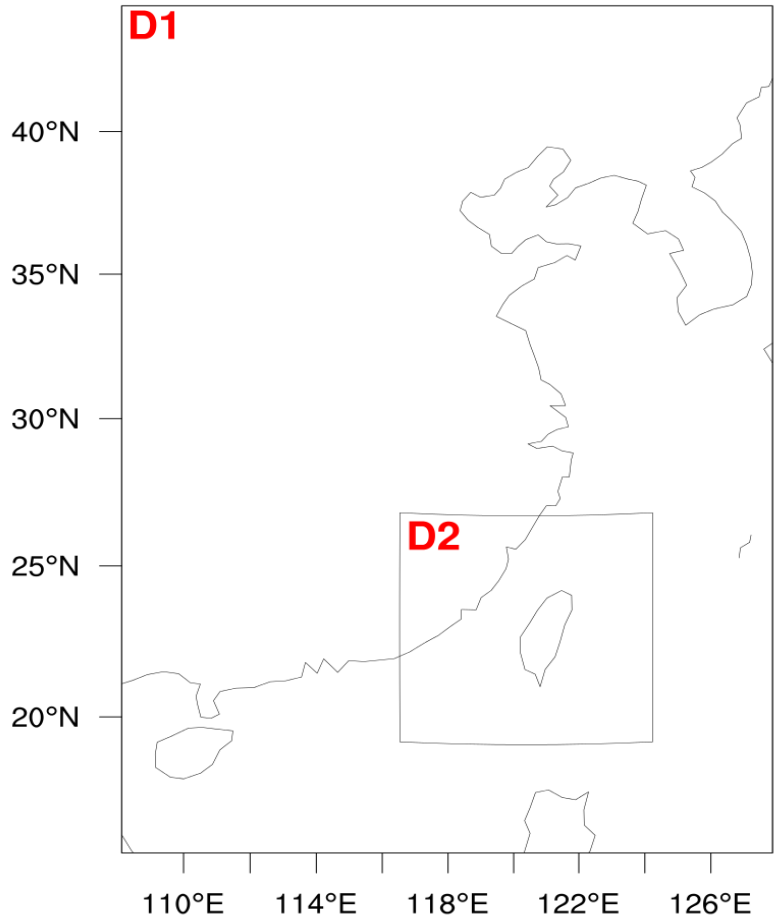






Air quality modeling

- In this study, we propose two experiments(smokev2.7, smokev4.6) to investigate the result of emission treatment.
- WRF:Version 3.9.1
- CMAQ:Version 5.2.1
- Domain1 resolution:9 km * 9 km
- Domain2 resolution:3 km * 3 km
- Vertical resolution: 45 levels
- Simulation Time Period:2017/03/16~2017/04/29



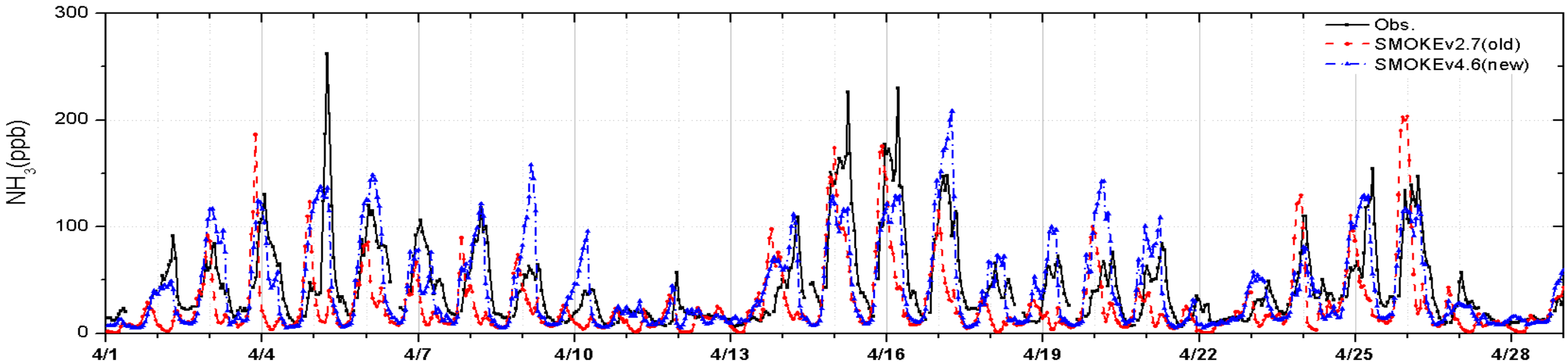
Result-
Model and observation data comparison

The data of SMOKEv2.7 is usually low in the early morning.
This situation has been improved in SMOKEv4.6.

Correlation coefficient (R)

SMOKEv2.7(old): 0.47

SMOKEv4.6(new): 0.72



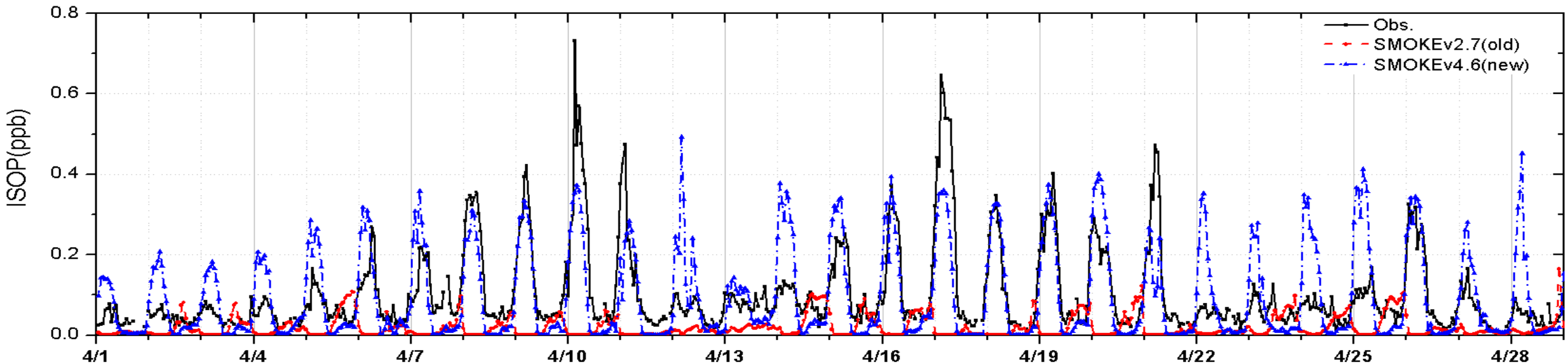
Result-
Model and observation data comparison

The data of SMOKEv4.6 displayed more reasonable daily changes than the data of SMOKEv2.7.

Correlation coefficient (R)

SMOKEv2.7(old): -0.29

SMOKEv4.6(new): 0.65



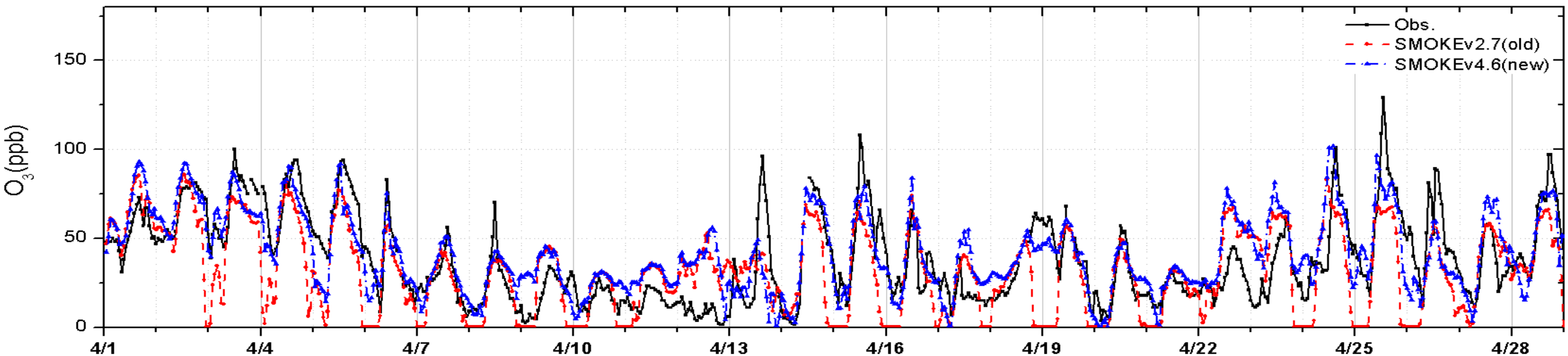
Result-
Model and observation data comparison

Sometimes the data of SMOKEv2.7 was zero in the midnight.
This situation has been improved in SMOKEv4.6.

Correlation coefficient (R)

SMOKEv2.7(old): 0.62

SMOKEv4.6(new): 0.77



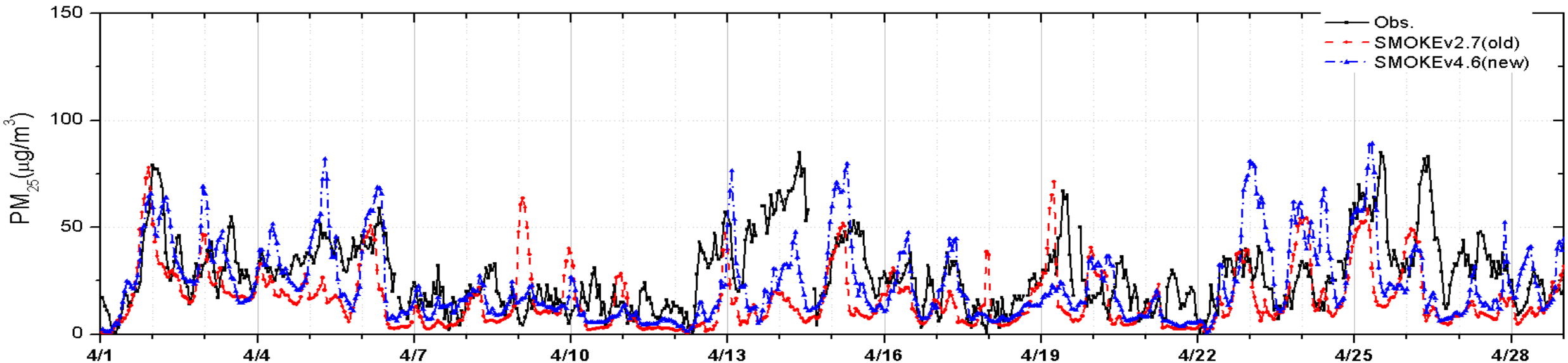
Result-
Model and observation data comparison

The result of SMOKEv4.6 is much better than SMOKEv2.7.

Correlation coefficient (R)

SMOKEv2.7(old): 0.32

SMOKEv4.6(new): 0.45



Summary

- The temporal profile of Taiwan Emission Database System still had largely uncertain.
- We used the hourly monitoring data, and the meteorological data to improve the temporal profile of emission inventory.
- The performance of air quality modeling show that these methods could improve the correlation coefficient of pollutant well.