


Characterization of Air Quality in Bangkok Metropolitan Region, Thailand

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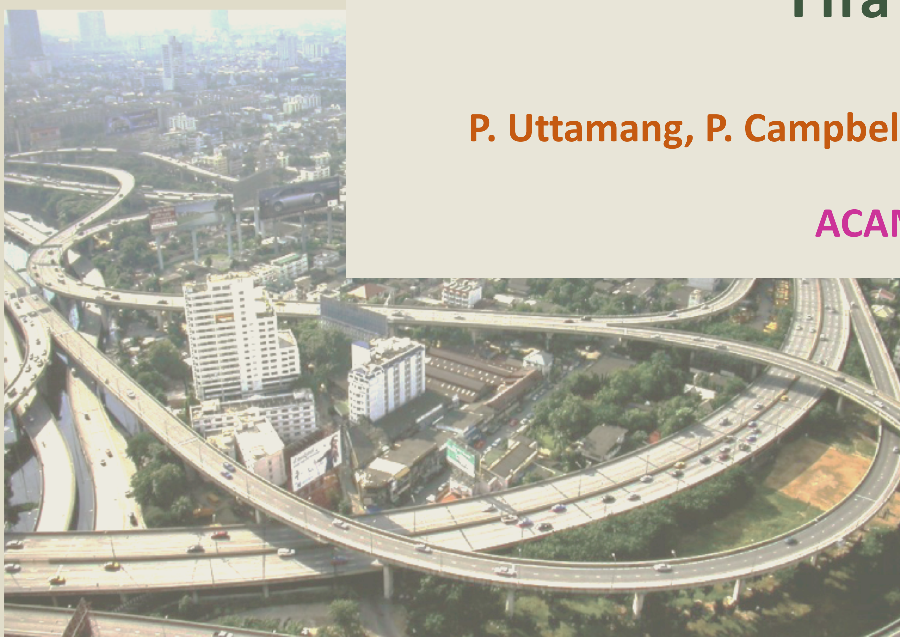
ACAM 2019

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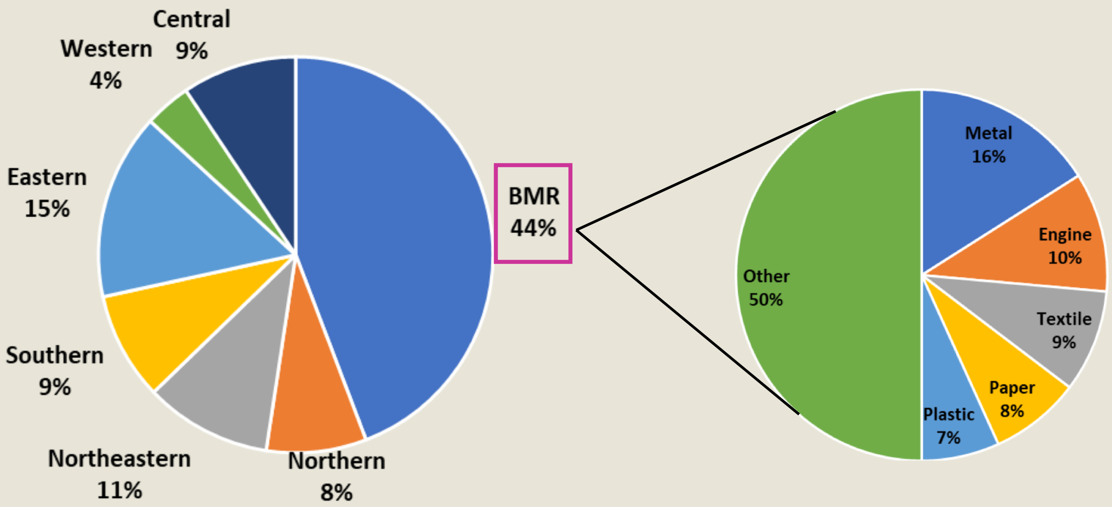
Study Area: Bangkok Metropolitan Region (BMR)

The BMR: In the central region. Consists with 6 provinces. 1.5% of the total area of Thailand.

Economy



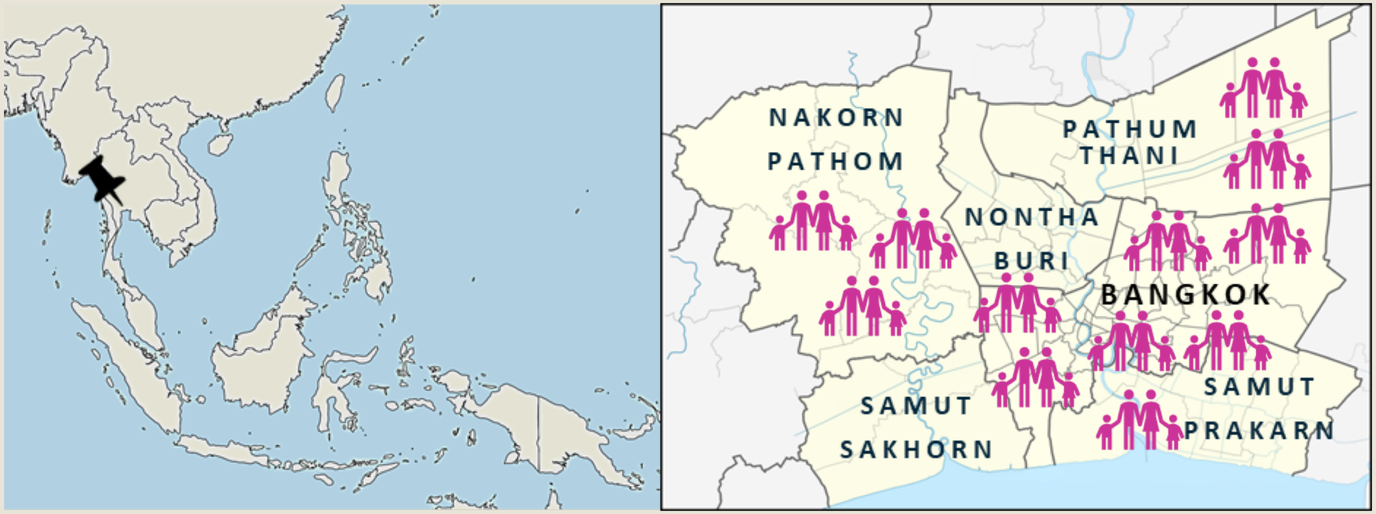
% share of Thailand's GDP

% share of GDP in the BMR

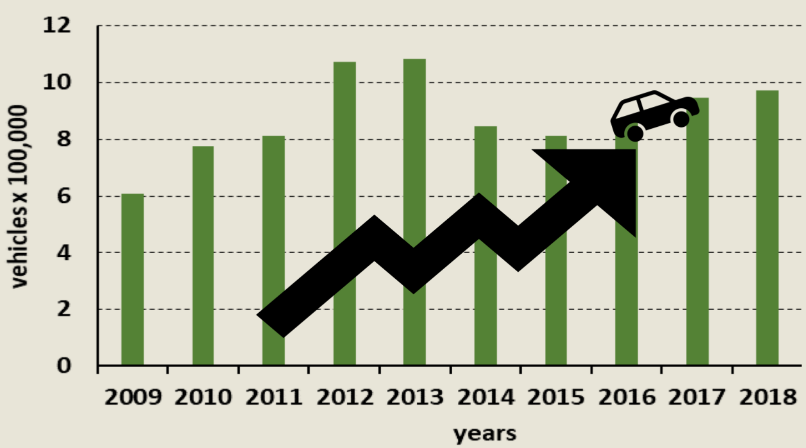
The BMR shares ~ 44% of the total GDP.

Most of the GDP comes from manufacturing.

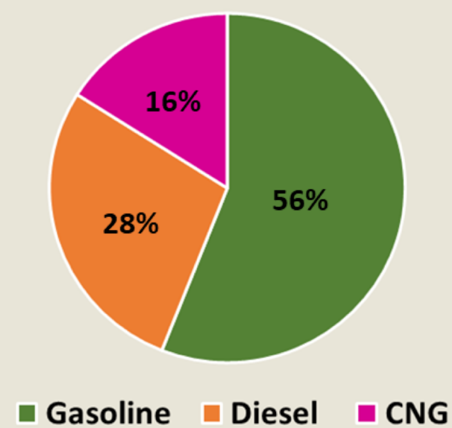
Bangkok Metropolitan Region (BMR)



High population density: ~5,300 people km^{-2} (~16% of the total population in Thailand (~11 Mill))
High vehicle density: ~10 million new registered vehicles in 2014.



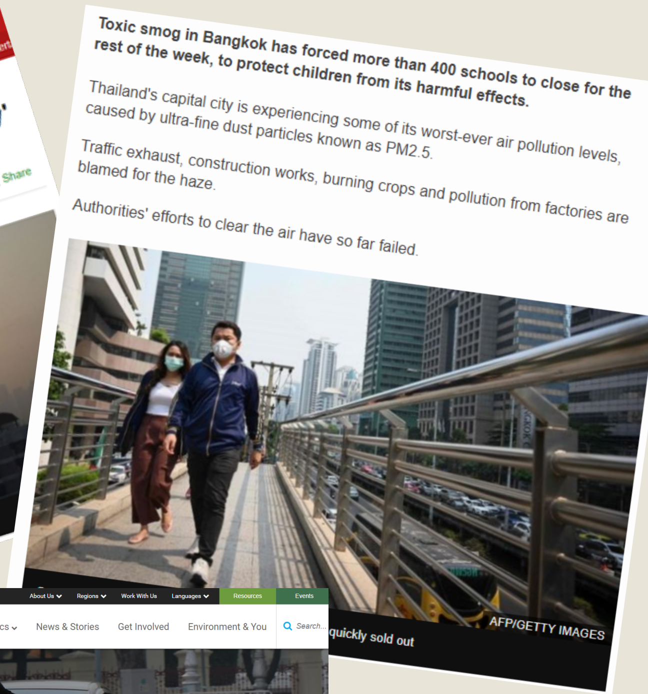
New Vehicles in Bangkok

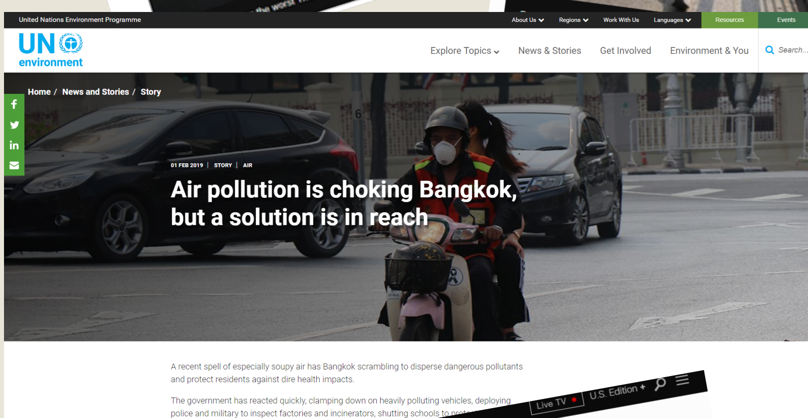


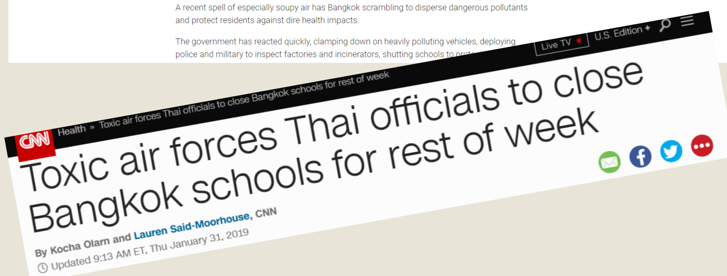
%Share of fuel types

In the past 10 years: number of new vehicles in the BMR has been increasing continuously.

Air Quality Issues in the BMR







The BMR has experienced in air quality degradation since 1995, especially high O_3 and fine PM concentrations

National Ambient Air Quality Standard of Thailand for

- **hourly O_3 = 100 ppb**
- **daily PM2.5 = 0.05 mg m^{-3}**

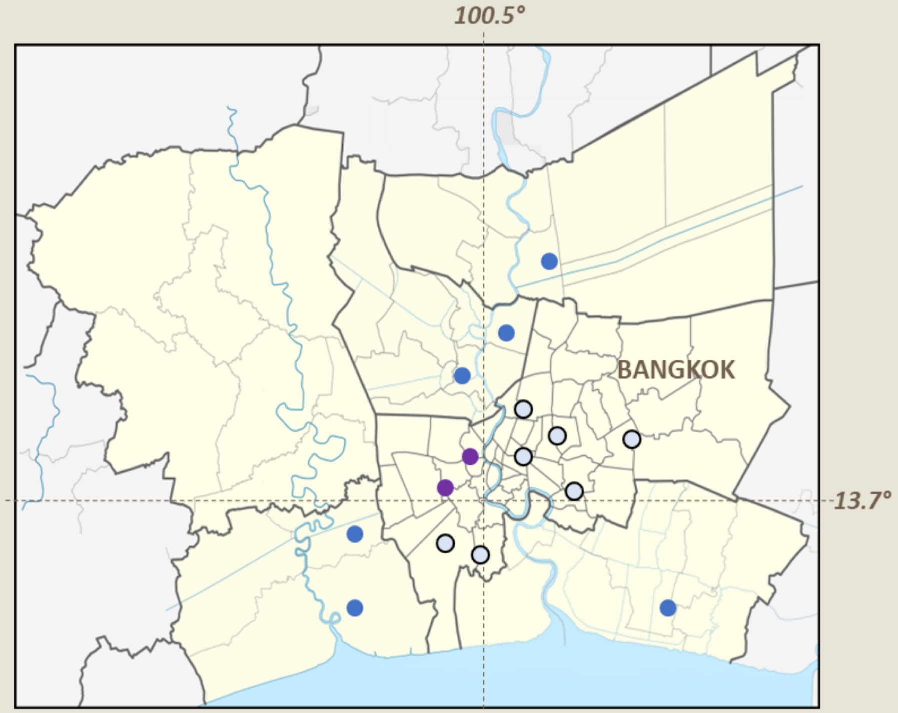
How to study air quality?

Observational-based

Model-based

Combine observational-analysis with model-based analysis.

Investigate processes elevating gaseous criteria pollutants levels in the BMR.



Vicinities

- 7 suburb sites

Bangkok

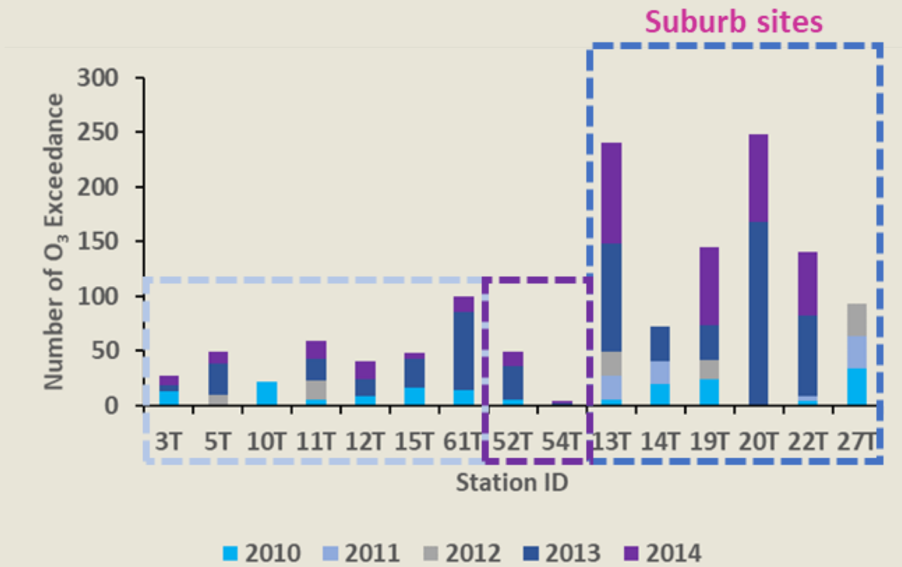
- ○ 6 ambient sites
- ● 2 road sites

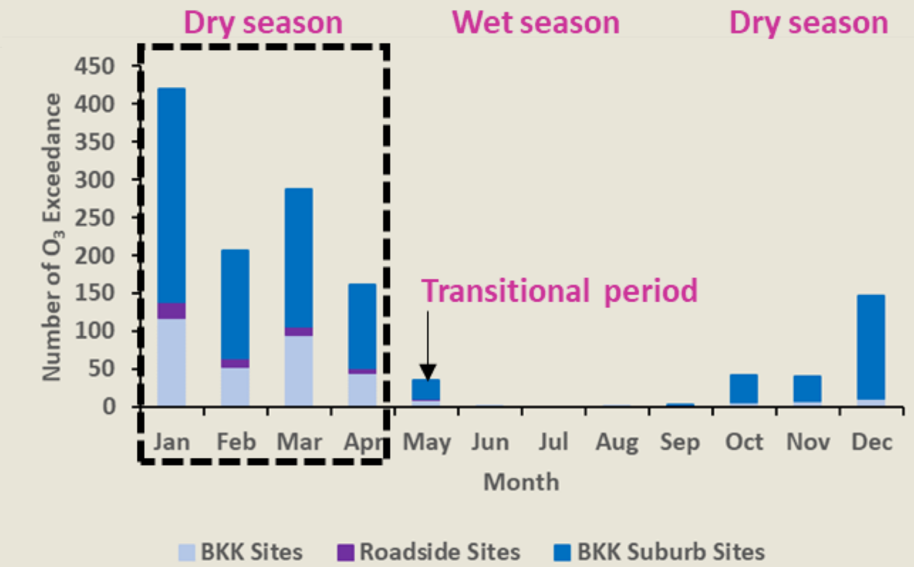
- Hourly meteorological parameters and gaseous concentrations.
- During 2010-2014 (5 years).
- Provided by Pollution Control Department, Thailand.
- 15 monitoring stations.

Result: ambient air quality trends

Species: CO, NO_2, SO_2, O_3.

- **Hourly concentrations of CO, NO_x, SO_2 were below the Thailand NAAQS.**
- **Exceedances in hourly O_3 NAAQS (>100 ppb).**





- **O_3 exceedance events occurred every year.**
- **Suburb sites > ambient sites > road sites**

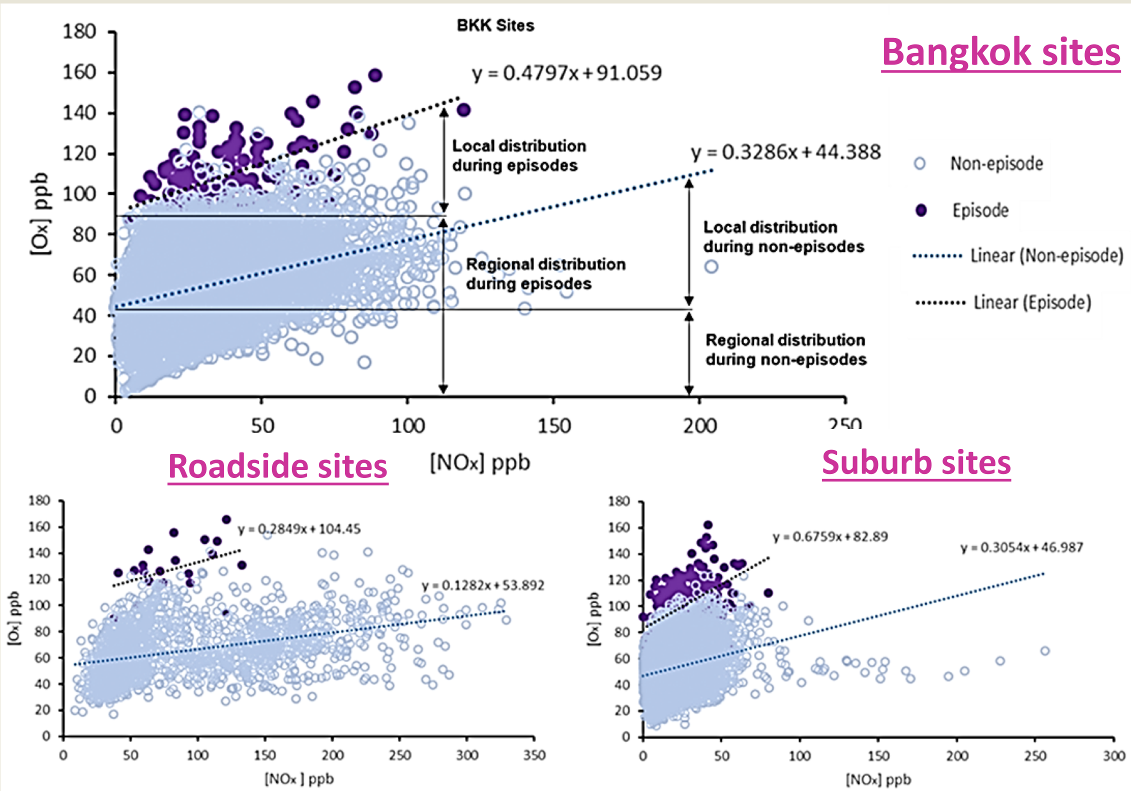
- **O_3 exceedance events mostly occurred in dry season.**

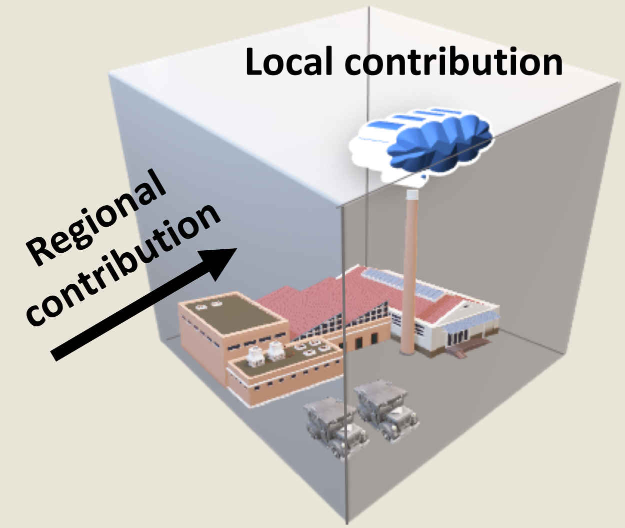
(Uttamang et al., 2018)

Local and regional contribution to O_x

Method: Linear regression.

Impact of local and regional contributions of O_x (O_3+NO_2) on O_3 levels.





Sites	Non O_3 episodes	O_3 episodes
BKK site	Y = 0.33 + 44.4	Y = 0.48x + 91.1
Roadside	Y = 0.13x + 53.9	Y = 0.29x + 104.5
Suburb	Y = 0.31x + 47.0	Y = 0.68x + 82.9

Contributions	Non O_3 episodes	O_3 episodes
Local (slope, m)	~0.26	~0.48
Regional	~48 ppb	~95 ppb

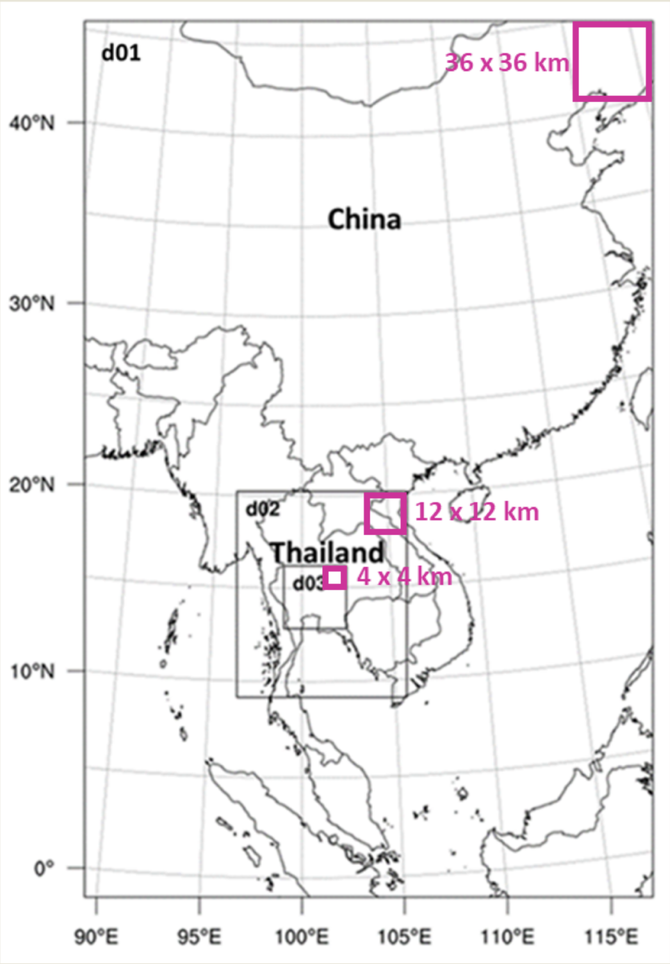
(Uttamang et al., 2018)

Effect of Long-range Transport Elevating O_3 in the BMR

Model: WRF-Chem v 3.9.1

Domain: A triple-nested domain (36-, 24-, 4-km res.).

Model-based



Meteorology: NCEP-FNL 1˚× 1˚ res.

Biogenic emission: Online MEGAN

Initial/Boundary conditions: MOZART

Anthropogenic emission: EDGAR-HTAP 0.1˚× 0.1˚ res.

Spin-up time: Dec 18 to 31, 2009

Study period: Jan 1 to March 31, 2010

Re-initialize met: every 10 days

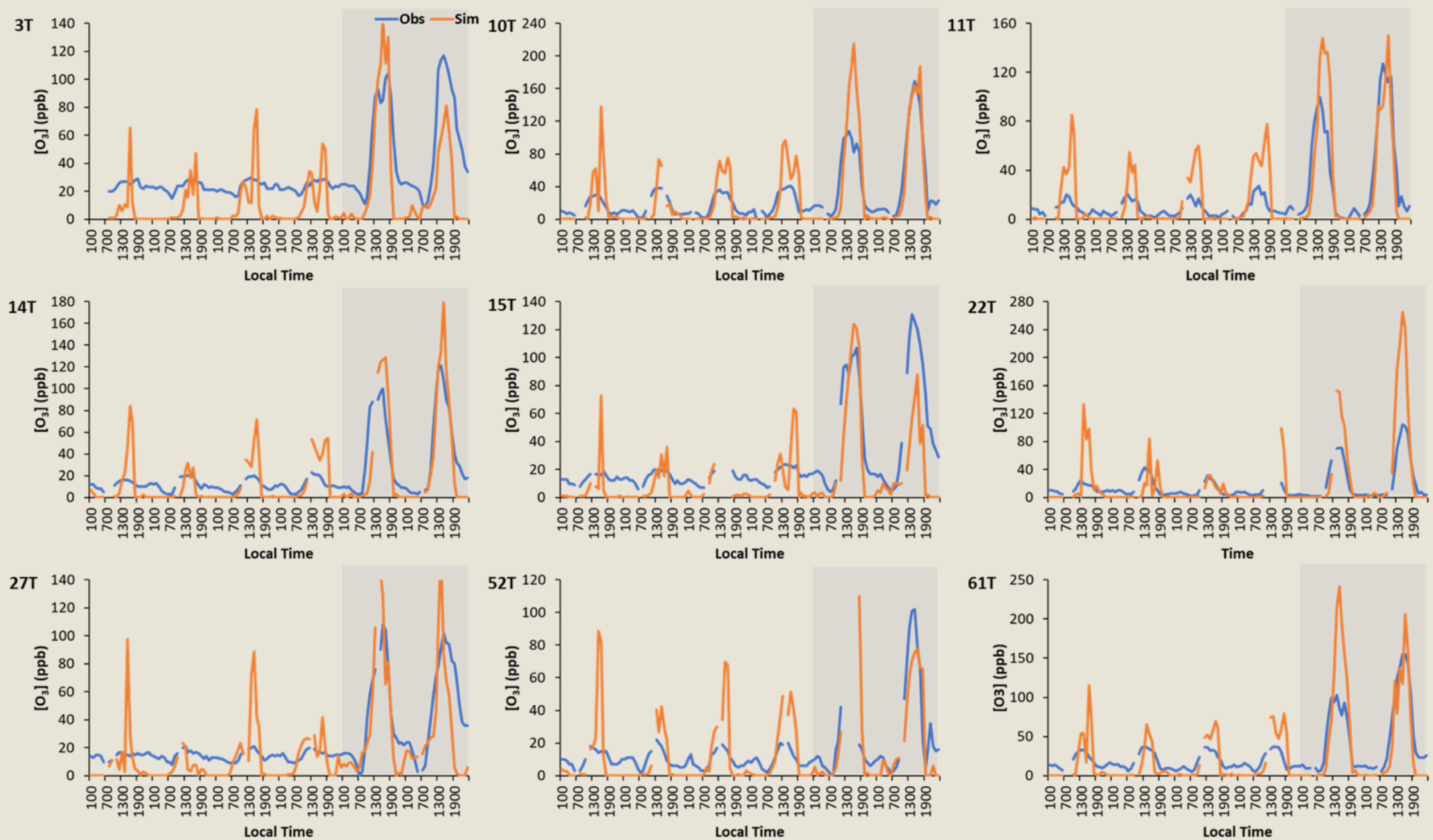
Physics and chemistry options

Physics	
Microphysics	Thompson
LW radiation	RRTMG
SW radiation	RRTMG
PBL	Yonsei University
Cumulus physics	Grell-Freitas (only d01 and d02)
Chemistry	
Chemical mechanism	RADM2-MADE/SORGAM

Model-based analysis: Model Evaluation

- O_3 episode: March 5 to 6, 2010.
- $[O_3]_{hourly}$ > 100 ppb were observed from 9 monitoring stations in the BMR.

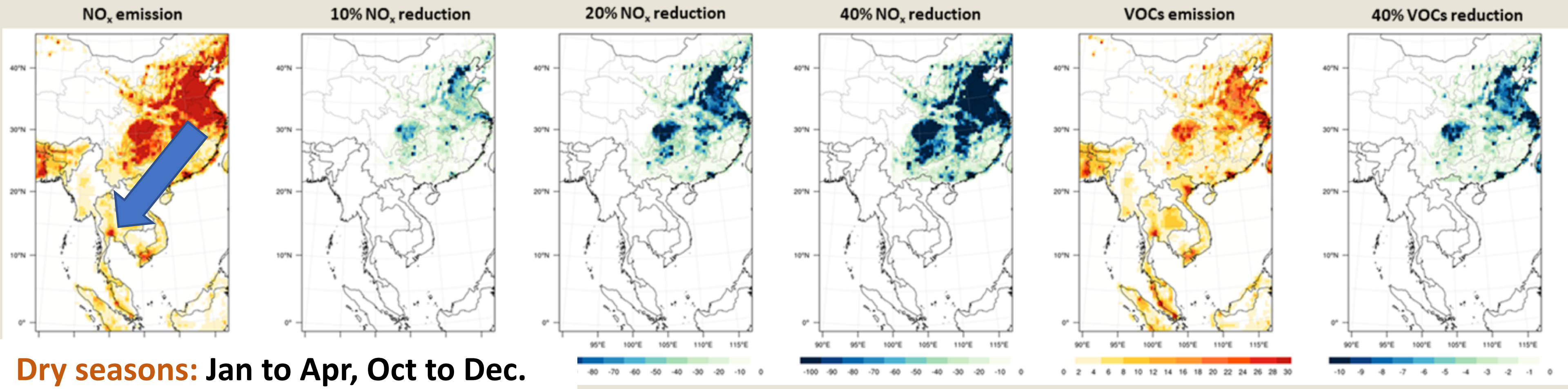
O_3 from Obs vs Sim, March 1 to 6, 2010, at the 9 monitoring stations.



the model predicts O_3 concentrations reasonably and performs well in capturing the O_3 event

(Uttamang et al., in preparation)

Effect of Long-range Transport of Pollutants Originating from China



Dry seasons: Jan to Apr, Oct to Dec.

Predominant wind direction: Northeast monsoon winds.

sensitivity – baseline)

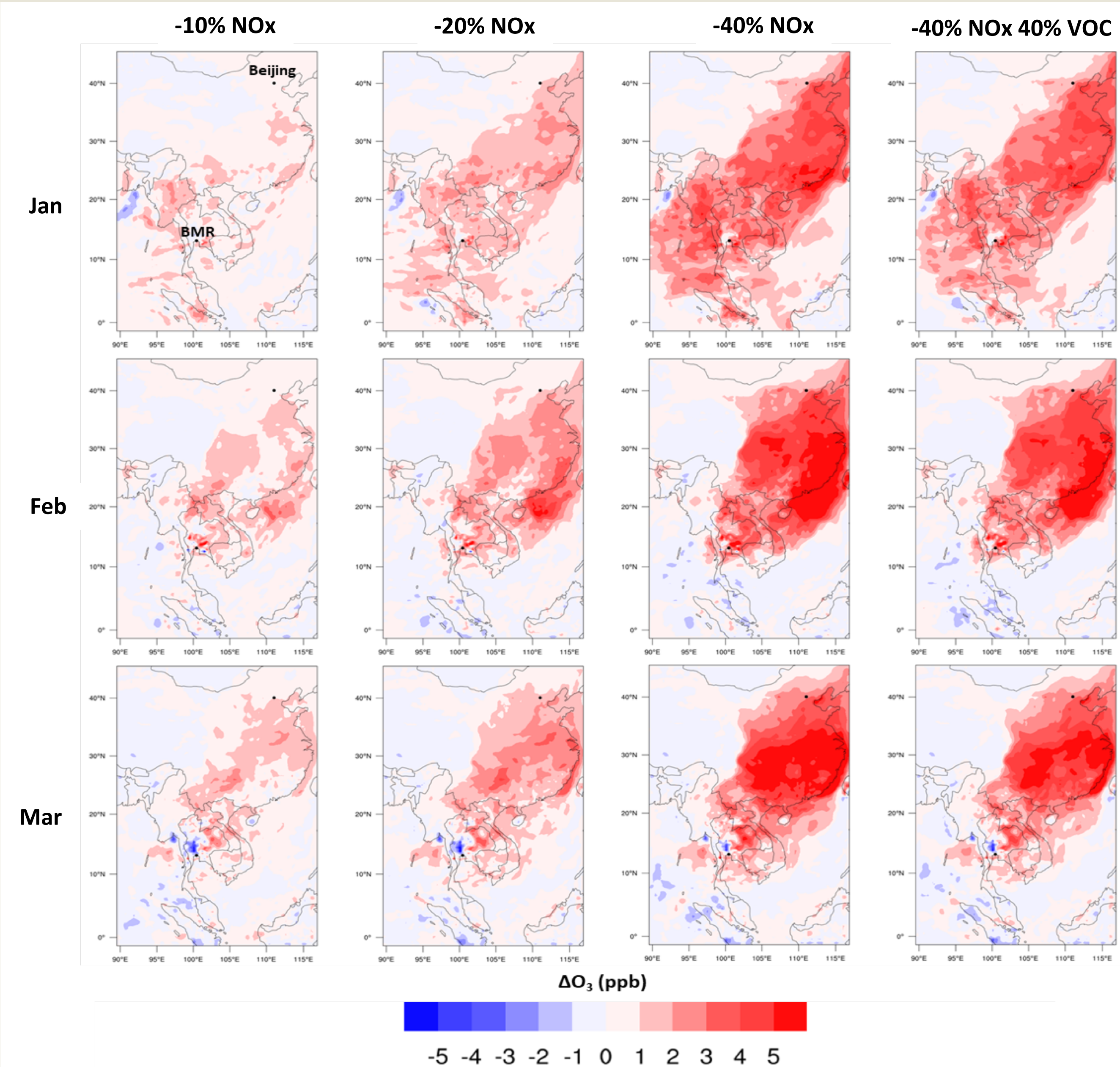
EDGAR-HTAP

Simulations	Adjusted China's emissions		Note
	NO_x	VOC	
Baseline	No	No	
Sensitivity			
- Strategy 1 (S1)	10% reduction	No	The national reduction target during China's 12th FYP (Wang et al., 2014a)
- Strategy 2 (S2)	20% reduction	No	to examine the responses of O_3 and its precursors in the BMR due to different China's NO_x emission reductions.
- Strategy 3 (S3)	40% reduction	No	
- Strategy 4 (S4)	40% reduction	40% reduction	Optional China's NO_x and VOC emissions reductions proposed by Wang and Hao, 2012. to investigate implications for including VOC emission reduction strategies in China.

(Uttamang et al., in preparation)

Spatial distribution of delta O_3 based on emission reduction in China

(delta of O_3 = O_3 sensitivity simulations – O_3 baseline simulation)



outermost domain

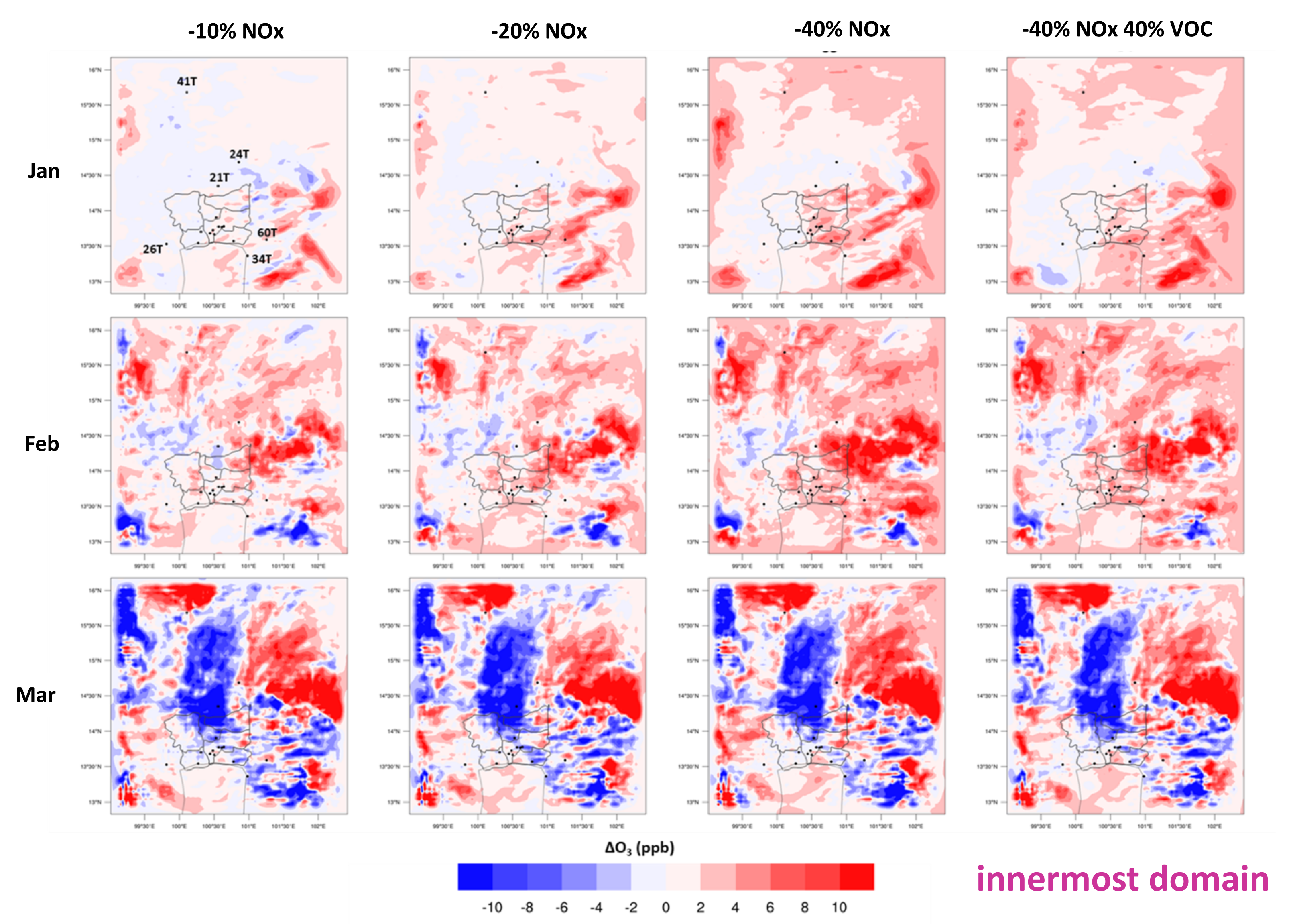
- Slightly increase the monthly-average O_3 (~1% to ~5%) due to NO_x reductions.

- Eastern China to southeast Asia in NE/SW directions.

- Mitigated by incorporating 40% VOC reduction.

(Uttamang et al., in preparation)

Spatial Distribution of Delta O_3



innermost domain

increase in the monthly-average O_3 (~ 1 to 6%) due to NO_x reductions.

(Uttamang et al., in preparation)

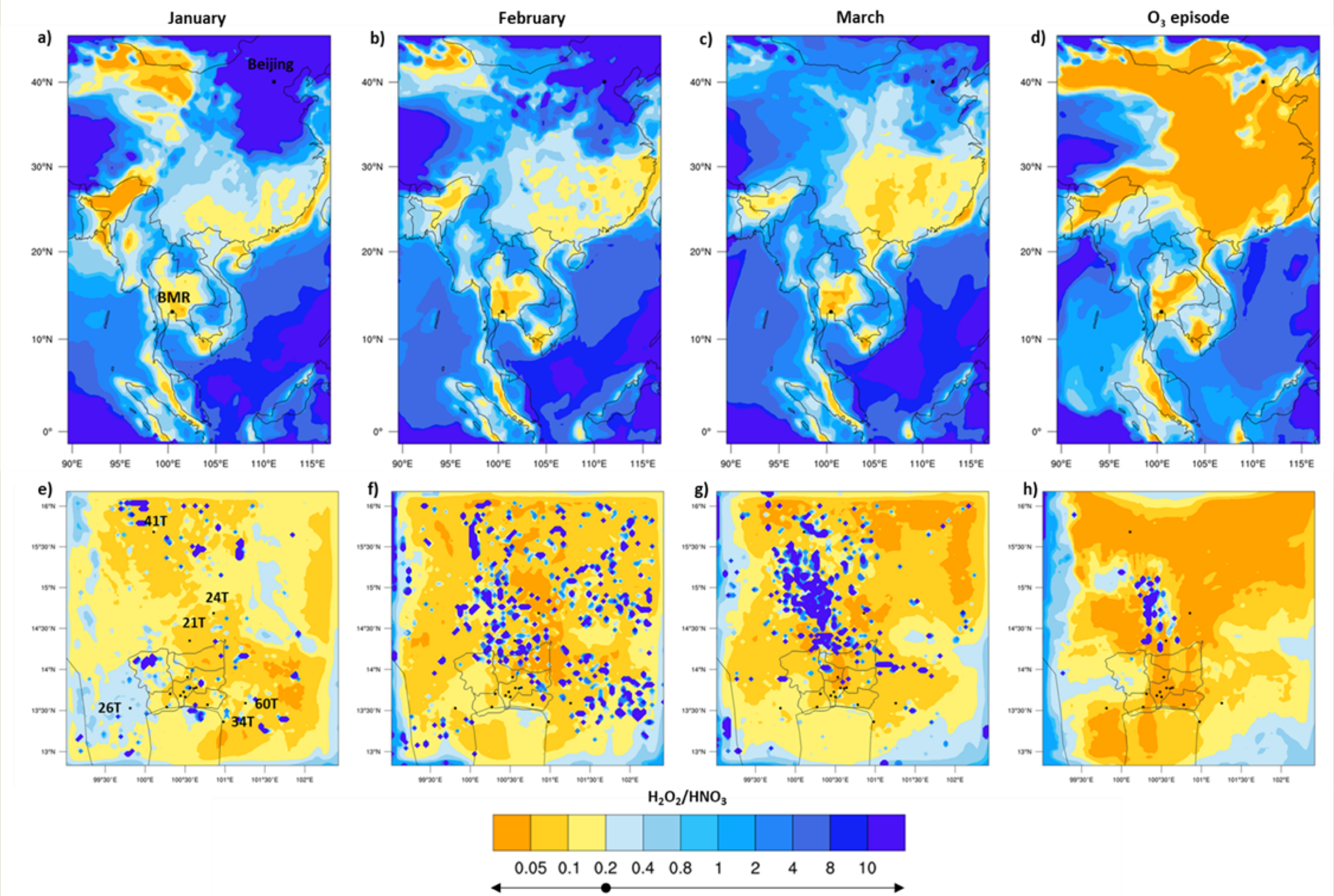
Indicators analysis: indicates VOC-, NO_x-limited regions

H_2O_2/HNO_3, O_3/NO_x, O_3/NO_y, O_3/NO_z, $HCHO/NO_2$ and $HCHO/NO_y$

The spatial distributions of H_2O_2/HNO_3

Outermost domain

Innermost domain



(Uttamang et al., in preparation)

Summary

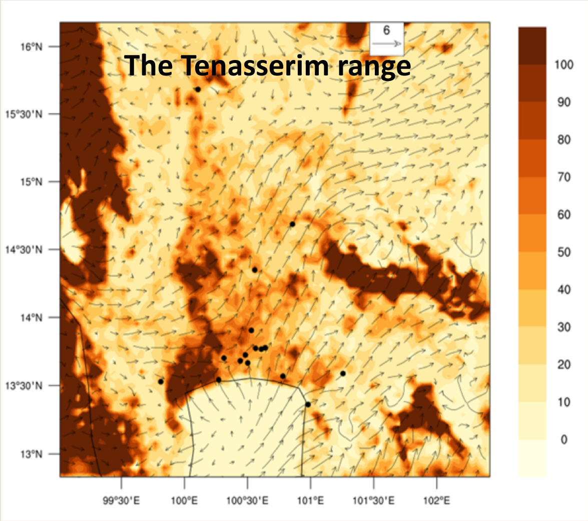
Regional scale

- China's emissions play an important role in controlling the pollutant levels in this region.
- The changes in regional NO_x correspond directly to the changes in China's NO_x emissions.
- East China to Southeast Asia are VOC-limited.
- Controlling only NO_x emissions is not an effective strategy but the decreases in VOC emissions will provide more benefit to control O_3 concentrations.

In the BMR

- Long-range transport as far as originating from China influences the O_3 levels.
- More likely to be VOC-limited, however biogenic VOC (BVOC) emissions will favor O_3 formation.

BVOC emission



Acknowledgements

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