Impacts of Biogenic and Anthropogenic Emissions on Summertime Ozone Formation in the Guanzhong Basin, China

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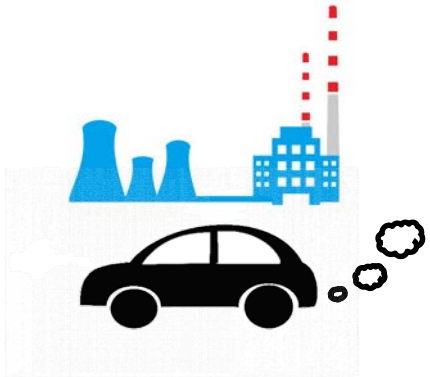
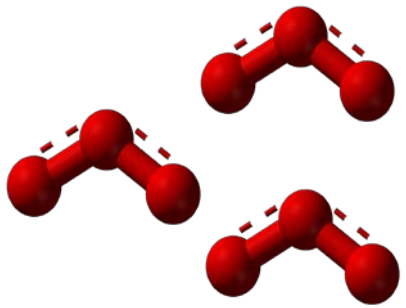


NO_x & VOCs

\+

VOCs

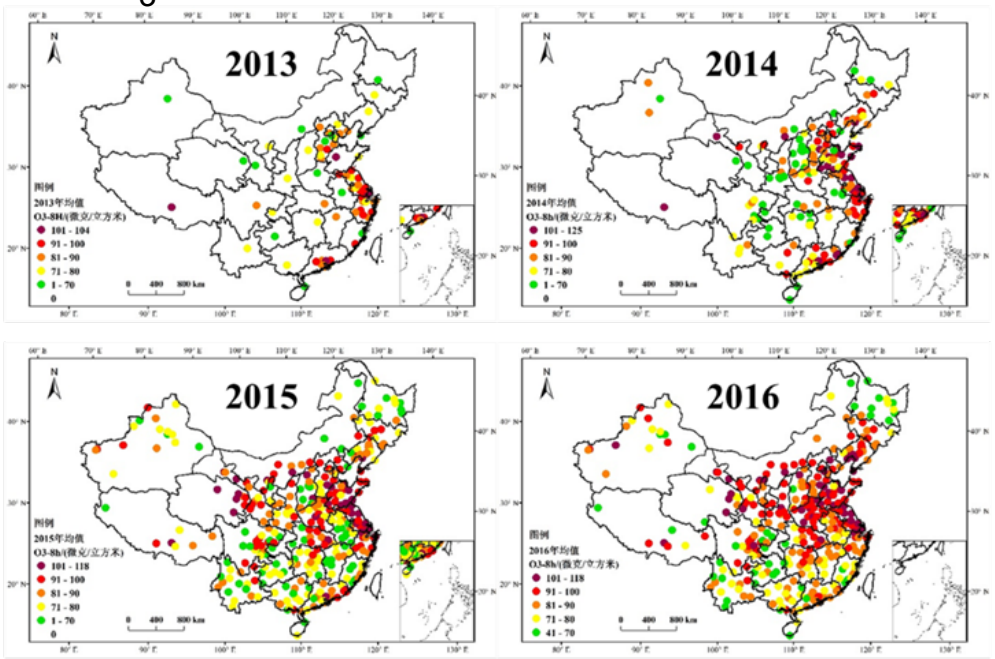


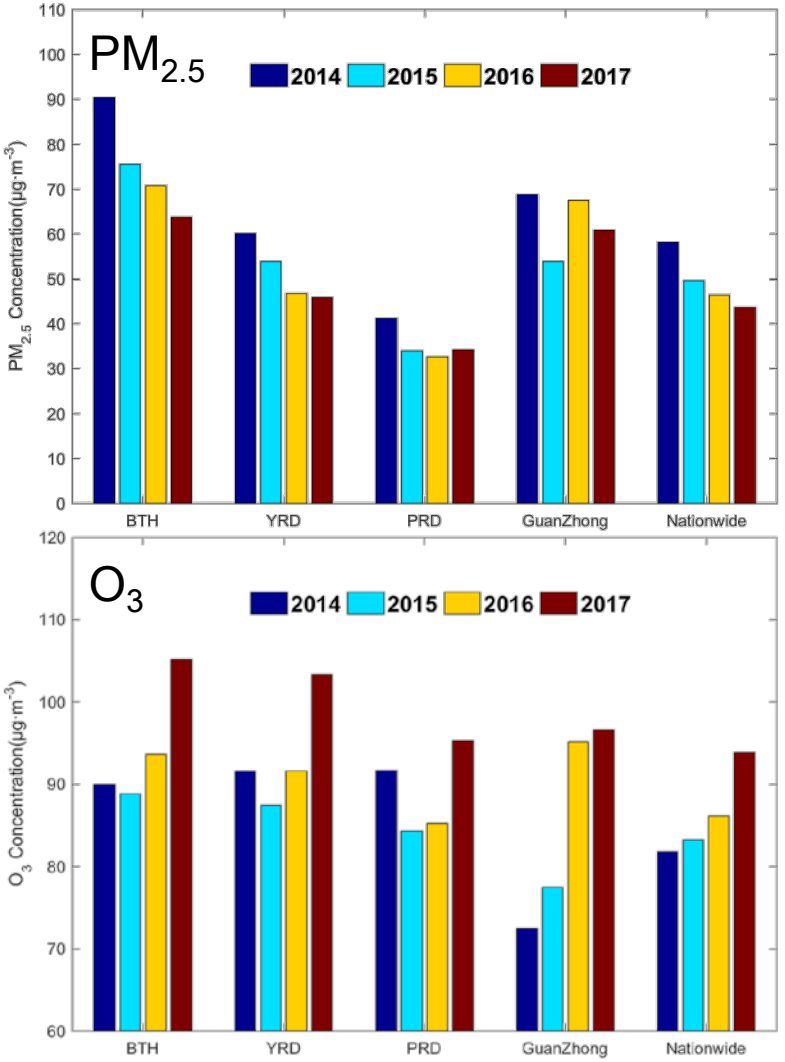
Ozone

1 + 1 = 2 + X ?

Increasing O_3 pollution in China

8h-O_3



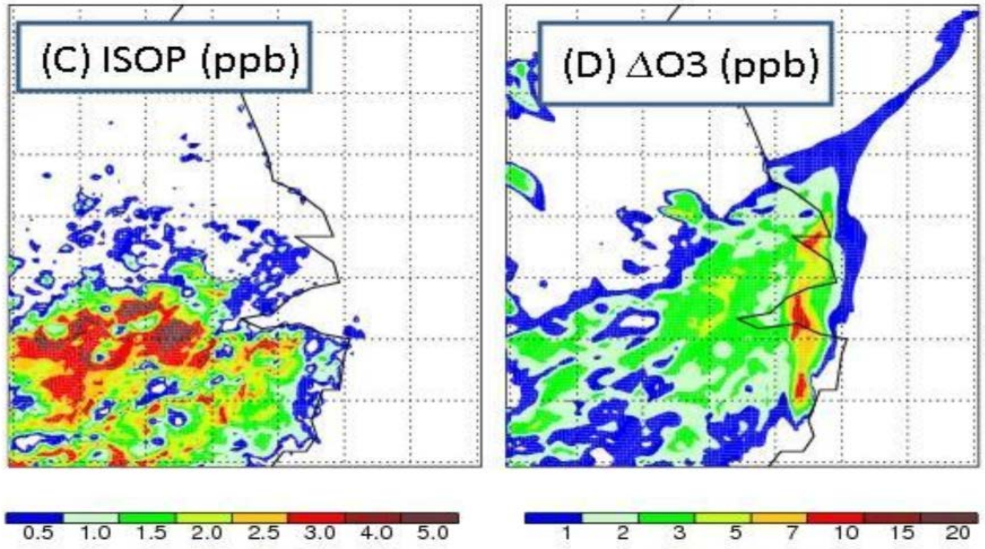


Surface O_3 level has been increasing in most Chinese cities in recent years.

Particularly, in the Guanzhong basin (increased by 33%), BTH (17%), and YRD (13%).

[From China National Environmental Monitoring Centre]

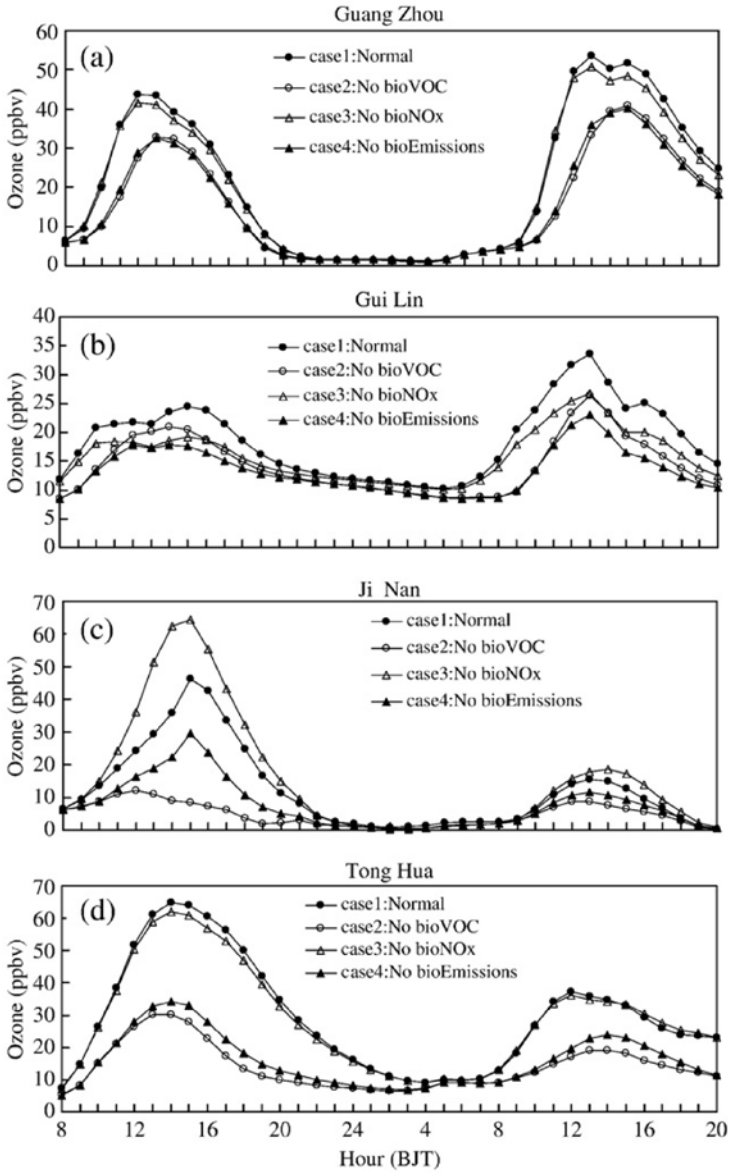
Biogenic sources are important for O_3 formation



[Geng et al., 2011]

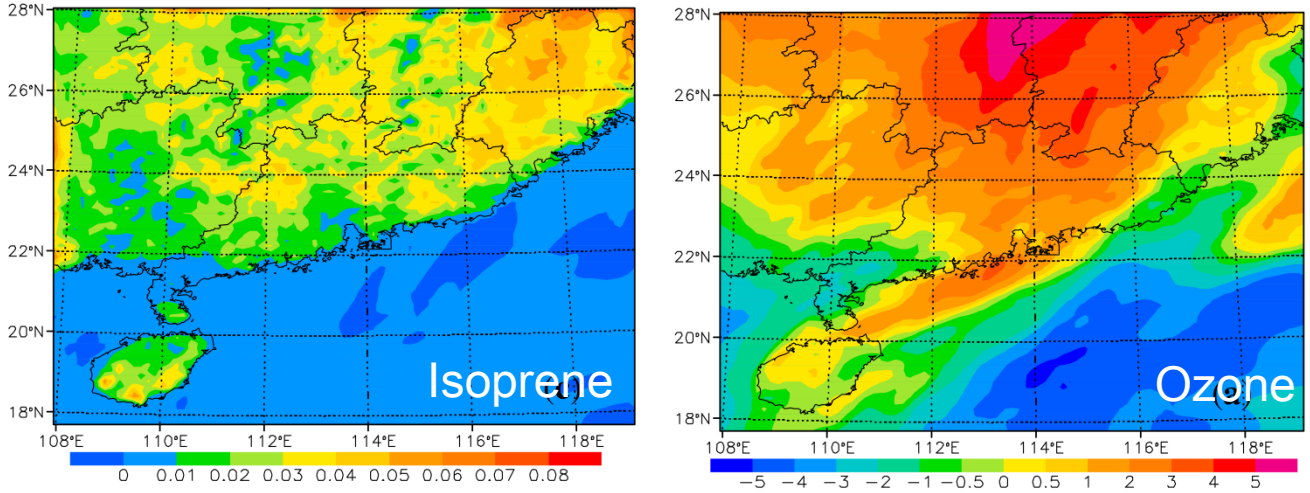
Biogenic emission have remarkable impacts on O_3 in eastern China, increasing urban O_3 concentration by 20-50%.

Biogenic emission from the forest in Zhejiang can even enhance O_3 production (6-8 ppb h^{-1}) in Shanghai, a city ~300 km apart.



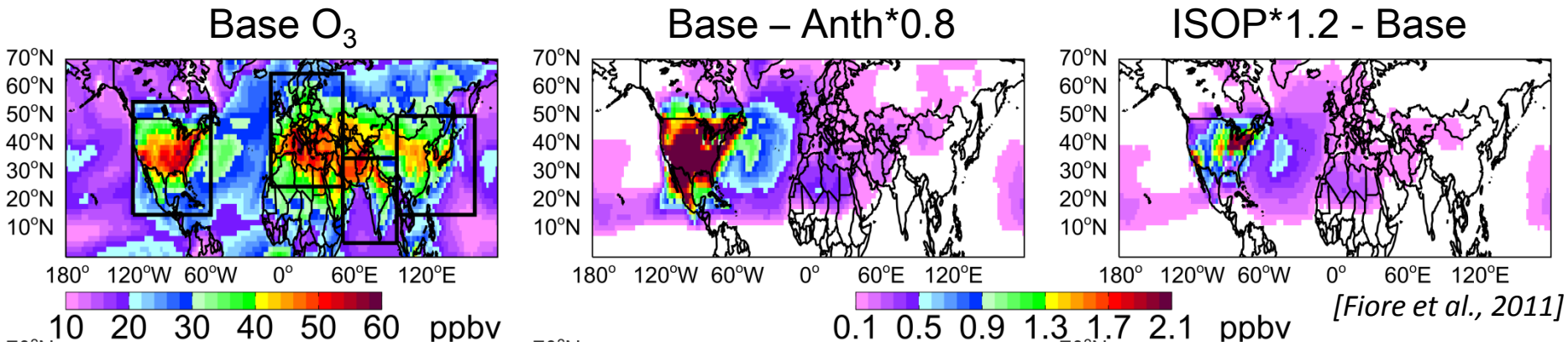
[Wang et al., 2008]

Biogenic effect on O_3 may increase in future due to global warning and land-use change



Surface O_3 would increase by ~5 ppb in Southern China due to climate and biogenic emission changes between 2050 and 2000.

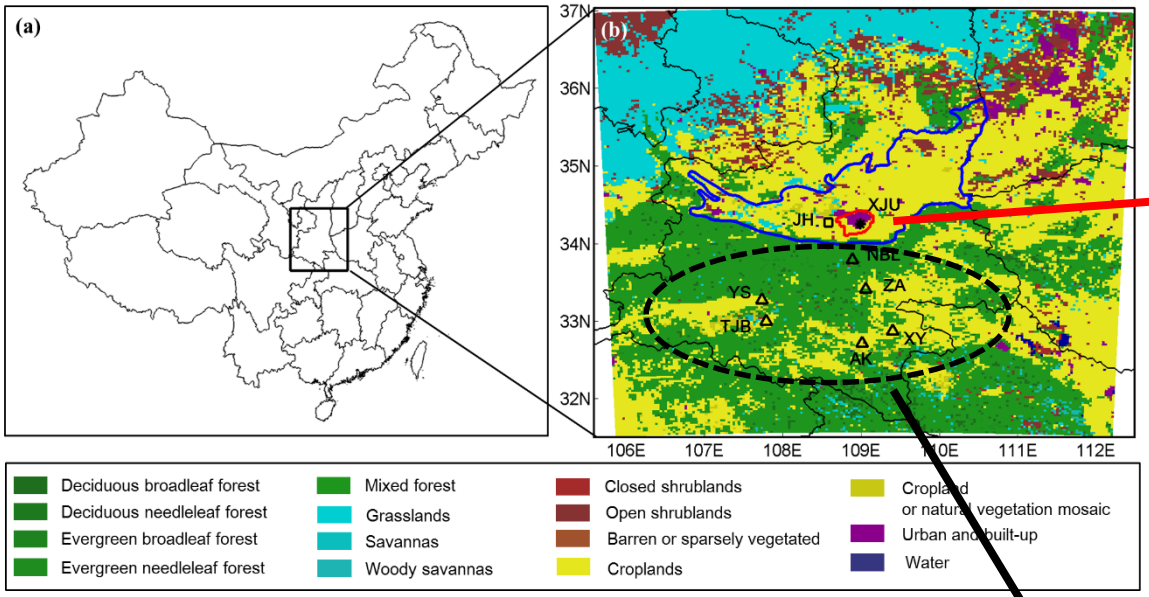
[Liu et al., 2013]



[Fiore et al., 2011]

Future increases in North America isoprene emissions could offset decreases in Europe surface O_3 resulting from controls on North America anthropogenic emissions

Research region and sampling sites



Simulation setting
Model: WRF-Chem
Period: 15th-30th Aug. 2011
Domain: 200*200 grids
Horizontal: 28 layers
Resolution: 3km

Biogenic VOC sampling

How to quantify the pure and synergistic impacts of Anth and Bio sources on O_3

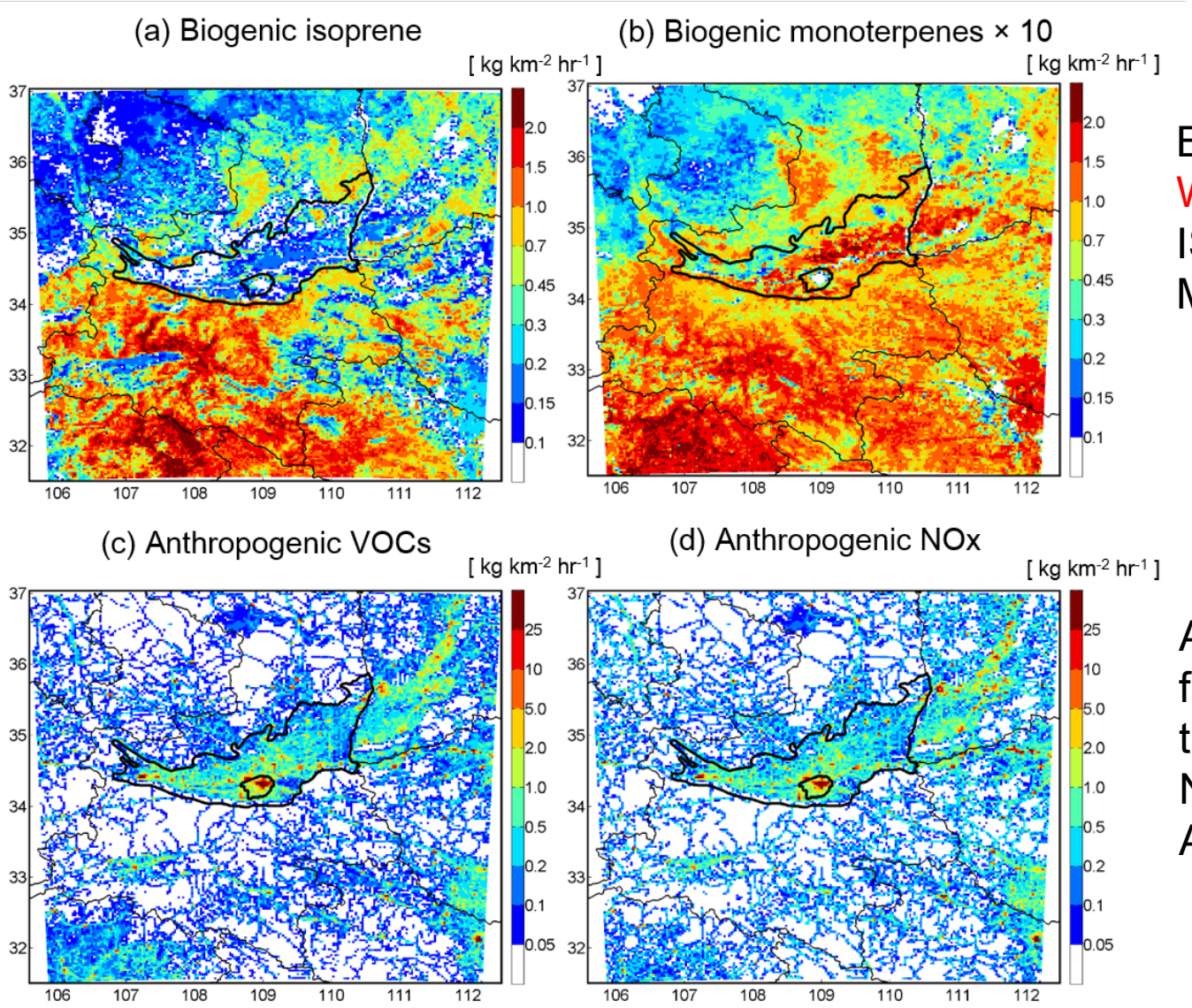
Total O_3 = Pure Anth O_3 + Pure Bio O_3
+ Synergistic Anth-Bio O_3 + Background O_3

Factor Separation Approach (FSA) *[Stein and Alpert, 1993]*

Simulation	Simulation results	Anthropogenic emission	Biogenic emission
BASE	$f_{anth\text{-}bio}$	✓	✓
ANTH	f_{anth}	✓	×
BIO	f_{bio}	×	✓
NEITHER	f_0	×	×

Contribution	
$f_{anth\text{-}bio} - f_{bio}$	Actual contribution of anthropogenic emissions
$f_{anth\text{-}bio} - f_{anth}$	Actual contribution of biogenic emissions
$f'_0 = f_0$	The contribution of background transport
$f'_{anth} = f_{anth} - f_0$	Pure contribution of anthropogenic emissions
$f'_{bio} = f_{bio} - f_0$	Pure contribution of biogenic emissions
$f'_{anth\text{-}bio} = f_{anth\text{-}bio} - (f_{anth} + f_{bio}) + f_0$	Synergistic contribution of anthropogenic and biogenic emissions

Anth and Bio emission estimates in the Guanzhong basin



Biogenic emission from WRF-MEGAN

ISOP = 157 Gg mon^{-1}

MONO = 22.8 Gg mon^{-1}

Anthropogenic emission from MEIC (downscaled to 3km)

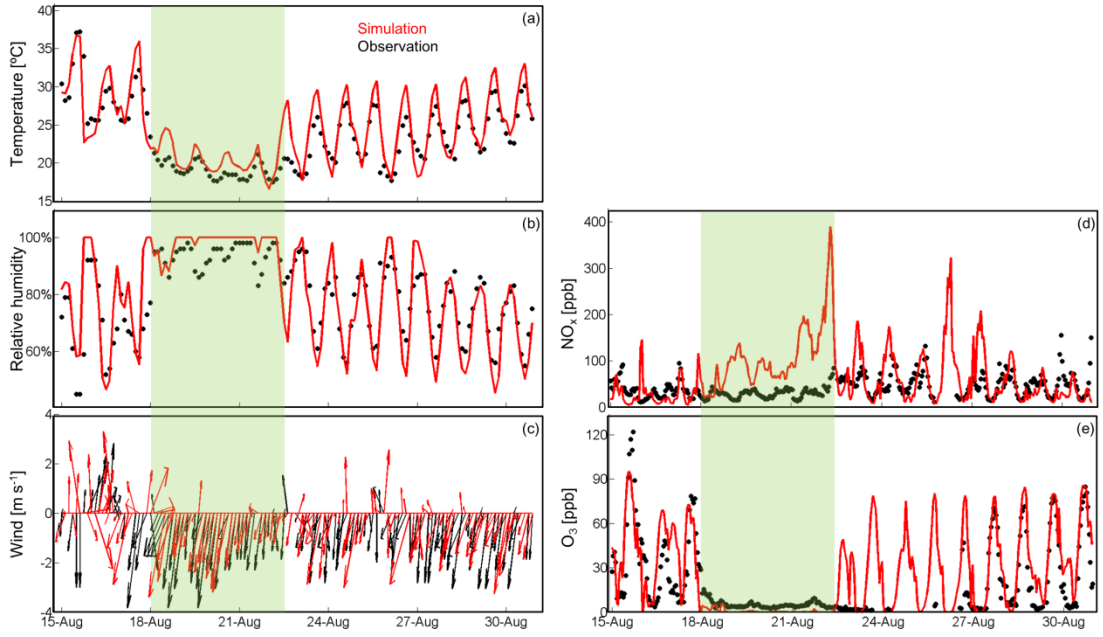
NO_x = 110 Gg mon^{-1}

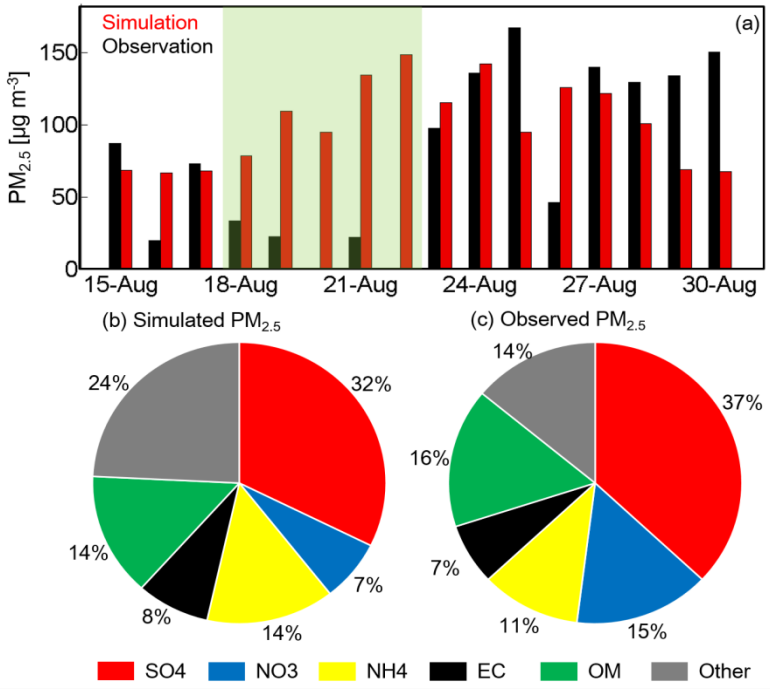
AVOC = 72.2 Gg mon^{-1}

Model evaluation

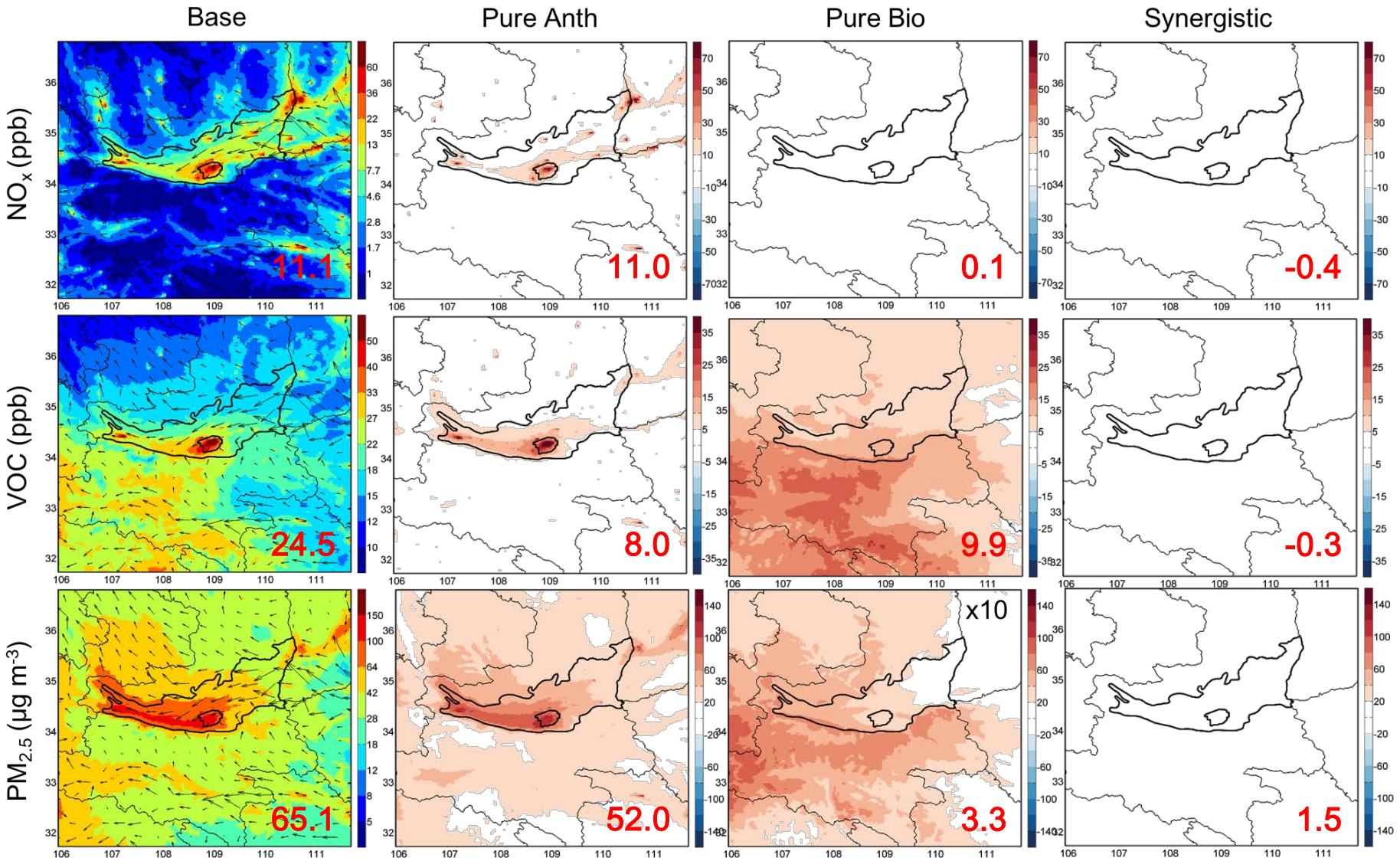
	Mean		r [d]	NMB [d]	RMSE [d]
	Observation	Simulation			
Meteorology [b]					
Wind speed (m s^{-1})	2.6	2.5	-	-6%	1.8
Temperature (°C)	25.1	24.2	0.86	4%	2.5
Relative humidity	73.6%	74.2%	0.72	1%	12%
Air quality [c]					
NO_x (ppb)	47.0	46.6	0.36	-1%	18.1
O_3 (ppb)	31.5	38.7	0.72	21%	8.1
$PM_{2.5}$ (μg m^{-3})	107	94.6	-	-12%	49.3
Isoprene (ppb)	1.3	1.4	-	4%	0.66
Monoterpenes (ppb)	0.21	0.22	-	6%	0.14

Our model well-reproduced observed air quality, BVOC and meteorological parameters, with normalized mean bias less than ±21%

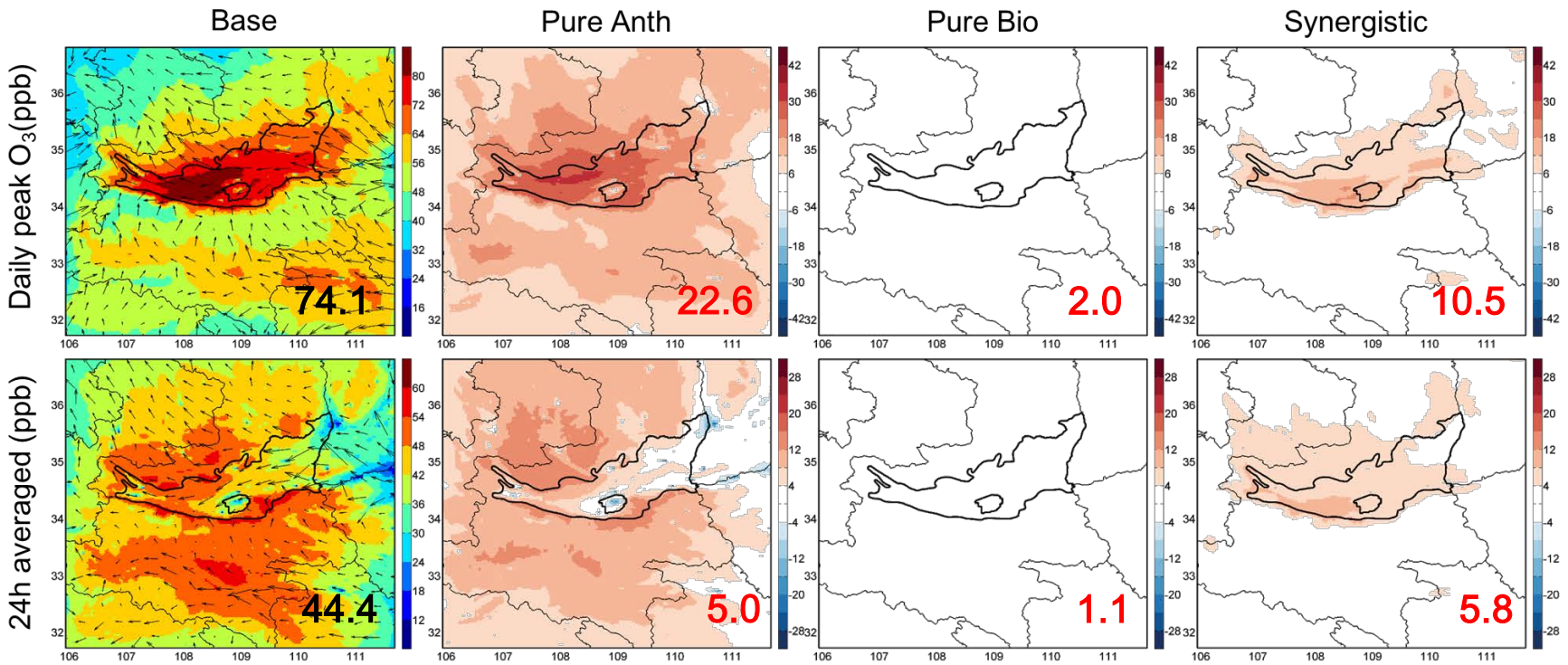


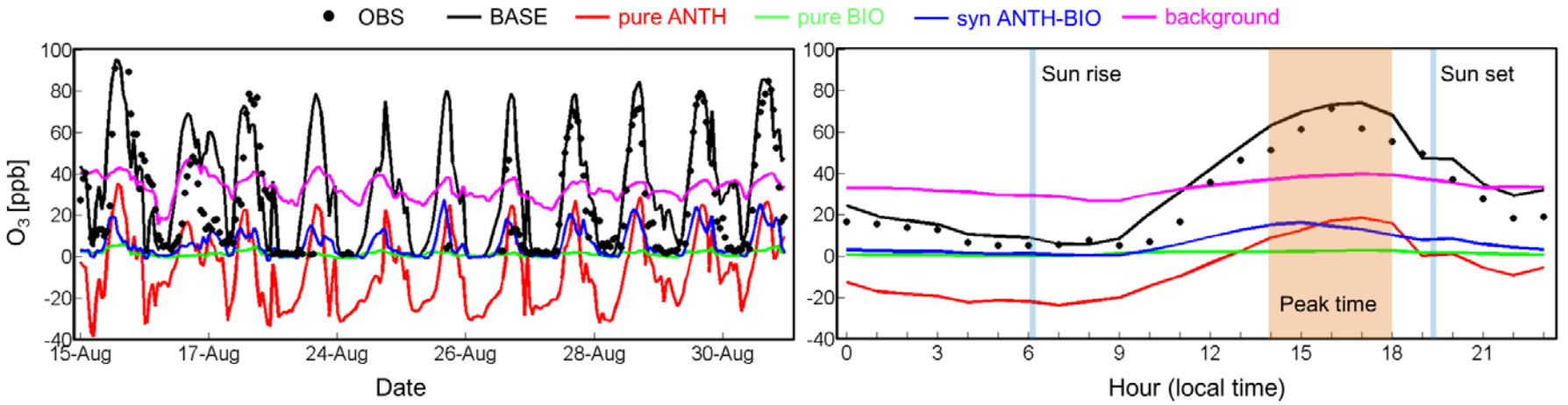


Sources of NO_x, VOC and $PM_{2.5}$ in Guanzhong



O_3 formation is promoted by interaction between Bio VOCs and Anth NO_x





Conclusion

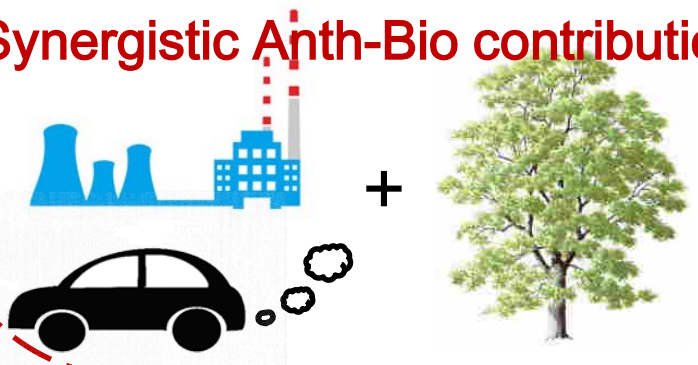
Pure Anth contribution

NO_x	99%
VOCs	33%
$PM_{2.5}$	80%
Daily Peak O_3	30%

Pure Bio contribution

NO_x	1%
VOCs	40%
$PM_{2.5}$	5%
Daily Peak O_3	3%

Synergistic Anth-Bio contribution



NO_x	-1%
VOCs	-1%
$PM_{2.5}$	2%
Daily Peak O_3	14%

Thank you

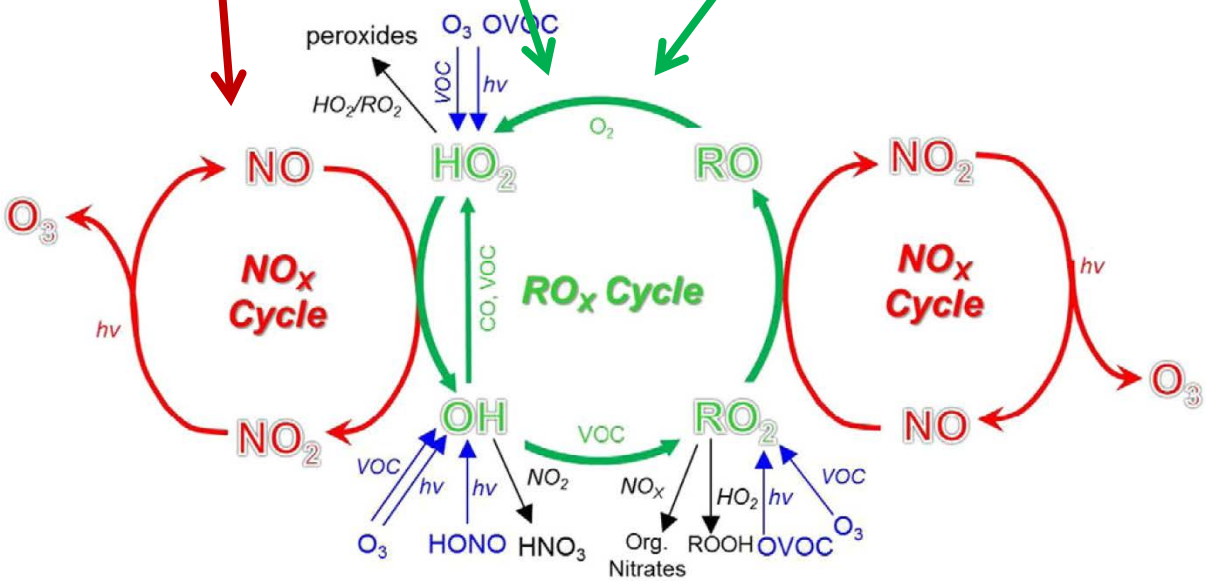
O_3 formation mechanism and the precursors

AVOC (~150 Tg yr^{-1})

NO_x (~130 Tg yr^{-1})

BVOC (~500 Tg yr^{-1}),

Isoprene, monoterpene, …



[Wang et al., 2017; Heald et al., 2016; Zeng et al., 2008]