The 1st Regional GEOS-Chem Asia Meeting (GCA1)

Implications of RCP emissions on future concentration and direct radiative forcing of secondary organic aerosol over China

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High SOA level in China

During a haze event over China in January 2013, SOA contributed 44–71 % to organic aerosol (Huang et al., 2014)

In this study, we want to…

- Examine the future (2000–2050) changes in SOA concentration and its direct radiative forcing (DRF) over China under the Representative Concentration Pathways (RCPs) scenarios.
- Assess the contribution of SOA to $PM_{2.5}$ in the future atmosphere.
- Explore the impacts of individual anthropogenic precursors on SOA formation.

Model description and numerical experiments

➢ Model

GEOS-CHEM, V. 09-01-03

Meteorology: GEOS-5, 2010

Emission: RCP2.6, RCP4.5, RCP6.0, RCP8.5 each decades during 2000–2050

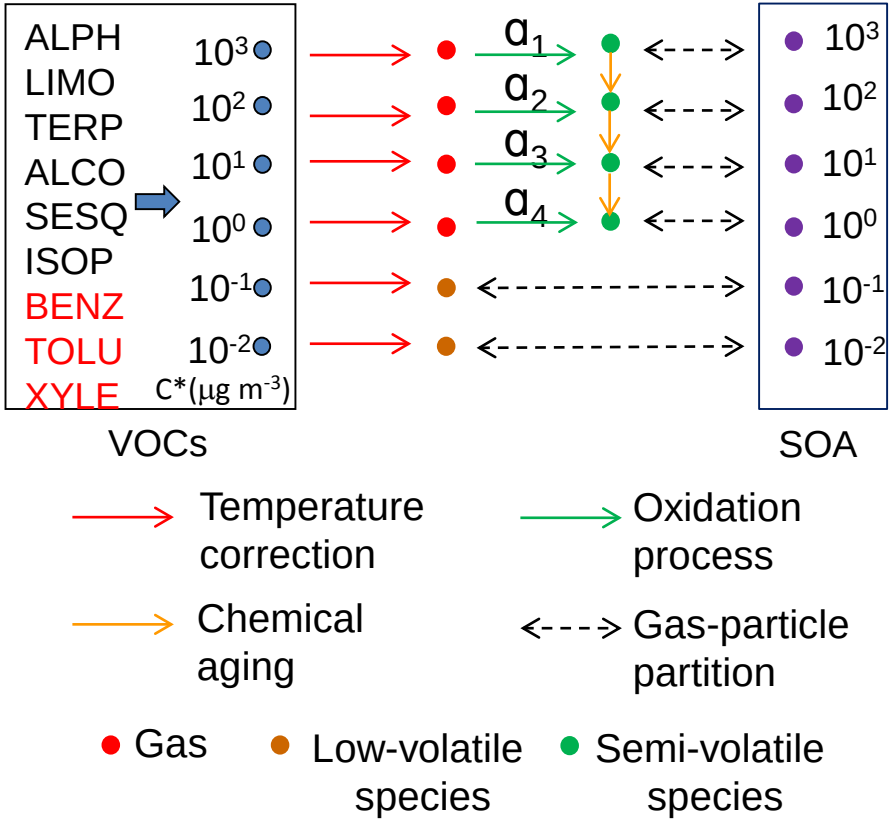
Resolution: 4°x 5° (global)
0.5°x 0.667° (Asia)

➢ Observational data

monthly mean SOA concentrations at 10 sites over China during 2012.10–2013.09.

(xiangd@gig.ac.cn)

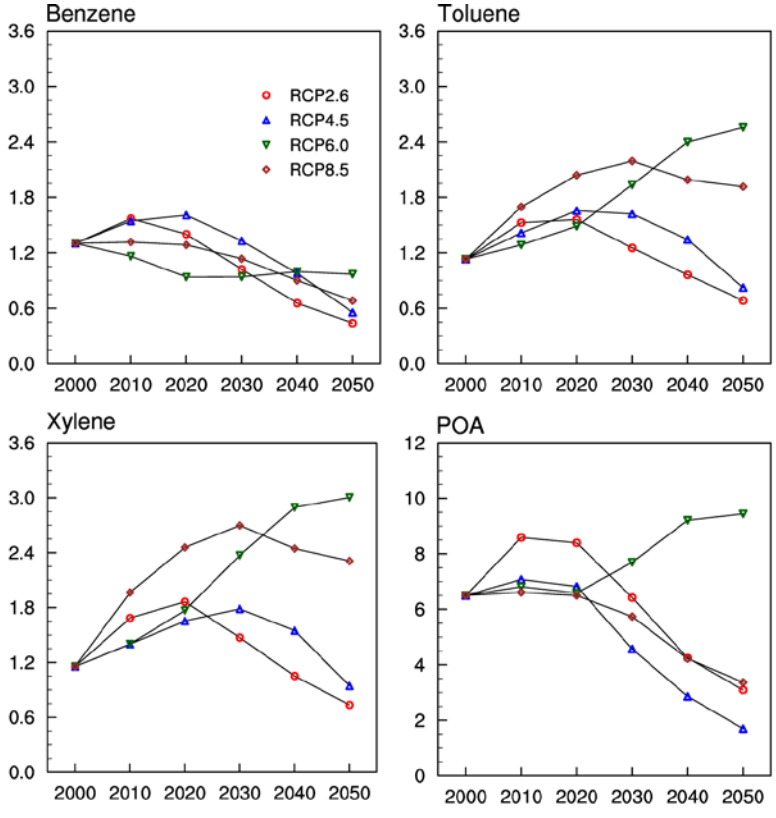
➢ SOA module (Volatility Basis Set)



Aging constants: 4 x10^{-11} cm^3 molecule^{-1} s^{-1} (Jo et al., 2013)

Model description and numerical experiments

Precursor emissions



Annual emissions (units: Tg species yr^{-1})

Experiments

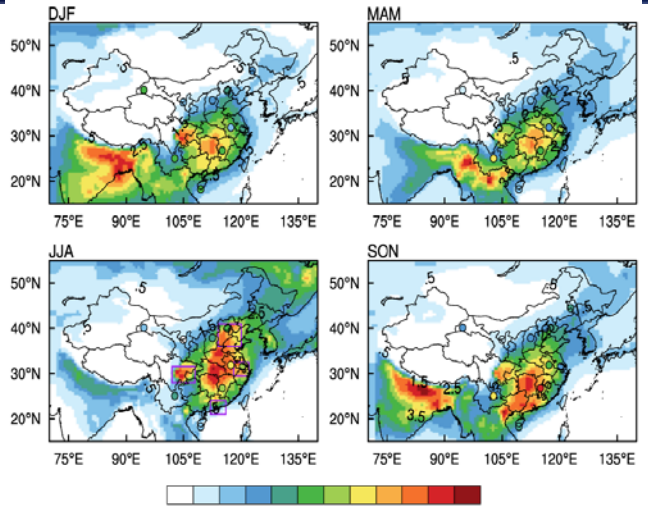
Case	Global		China	
	Aromatic	POA	Aromatic	POA
CTRL_2010	2010	2010	2010	2010
POA_C2050	2010	2010	2010	2050
Arom_C2050	2010	2010	2050	2010
POA_Arom_C2050	2010	2010	2050	2050

Effects of aromatic reduction：(CTRL_2010 – Arom_C2050)

Effects of POA reduction ： (CTRL_2010 – POA_C2050)

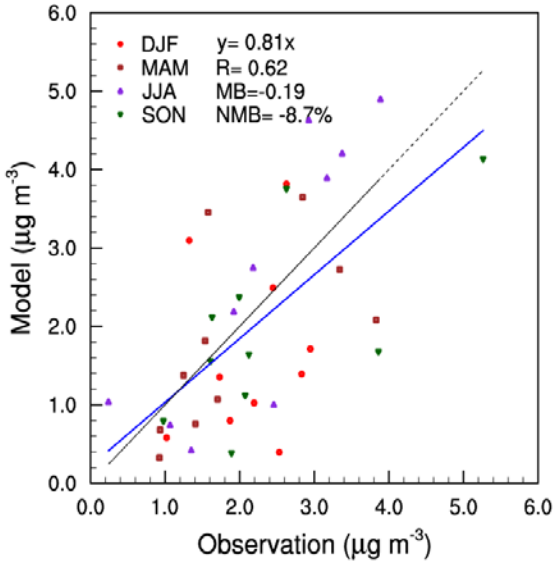
Effects of both reductions：(CTRL_2010 – POA_Arom_C2050)

Model evaluation: simulated vs. observed SOA

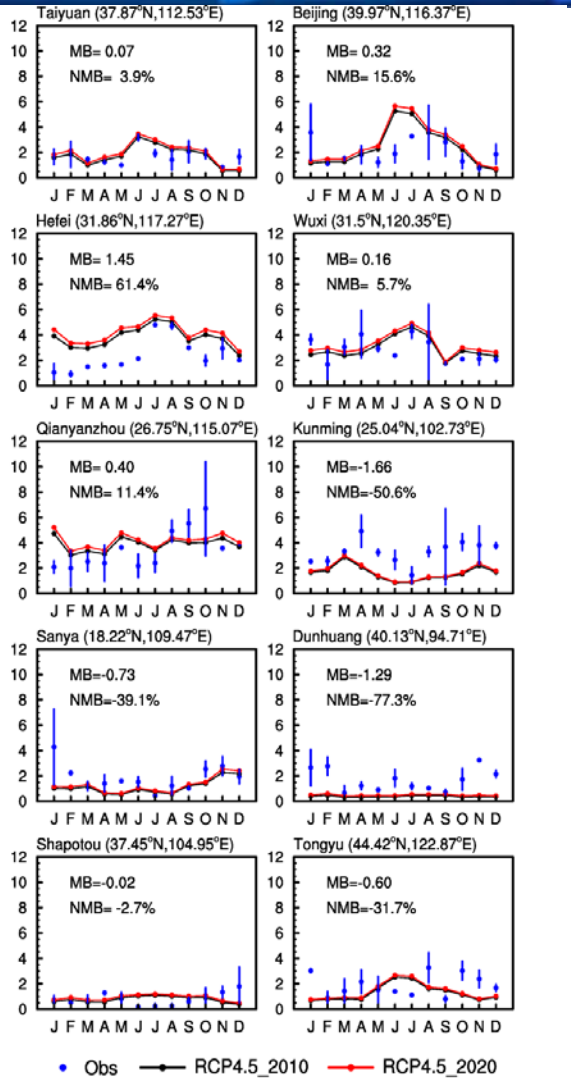


simulation:
RCP4.5, 2010

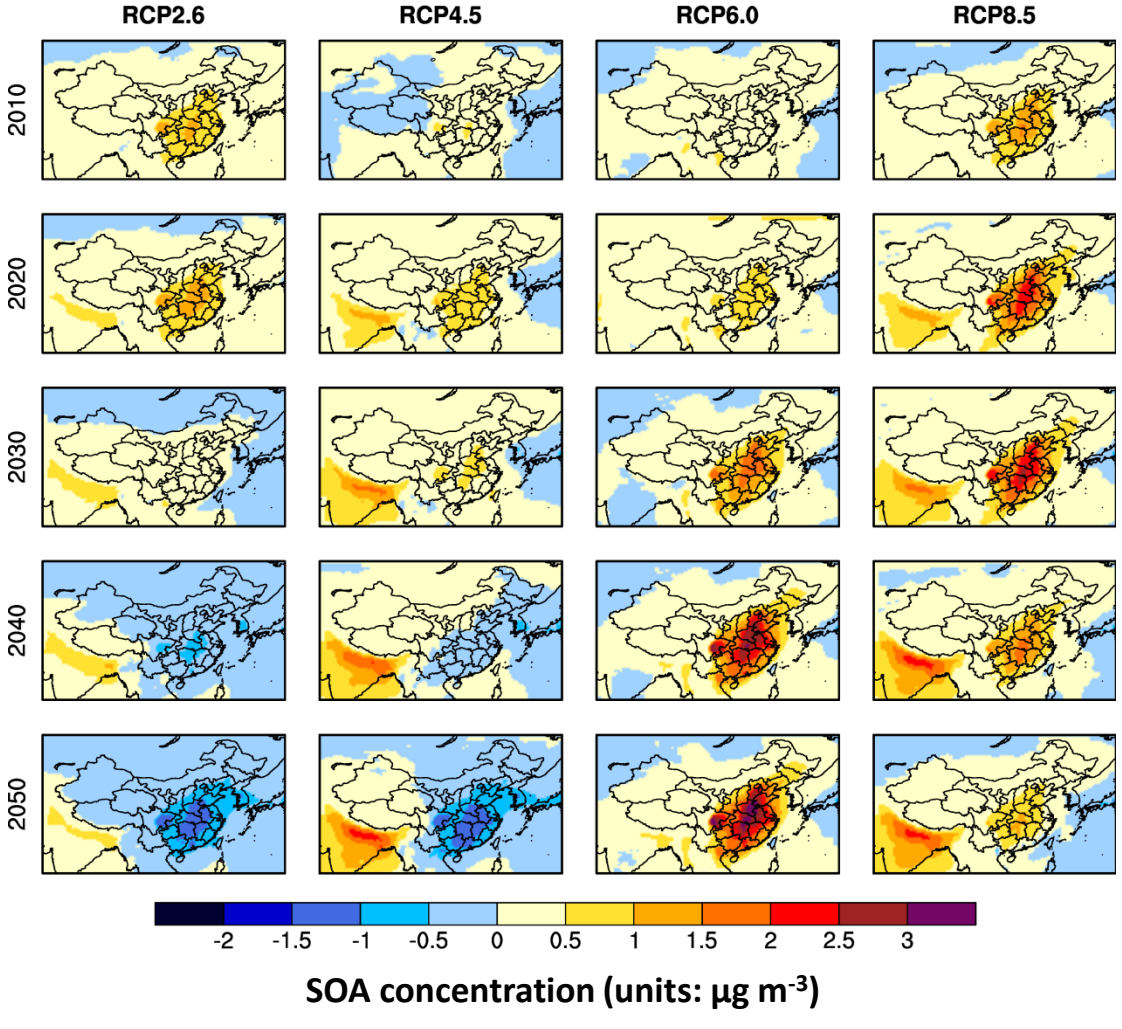
Observation:
2012.10–2013.09



Well captured **spatial distribution** of seasonal mean SOA with R of **0.62** and NMB of **–8.7%** at 10 sites over China.



Results: Future changes in SOA concentration

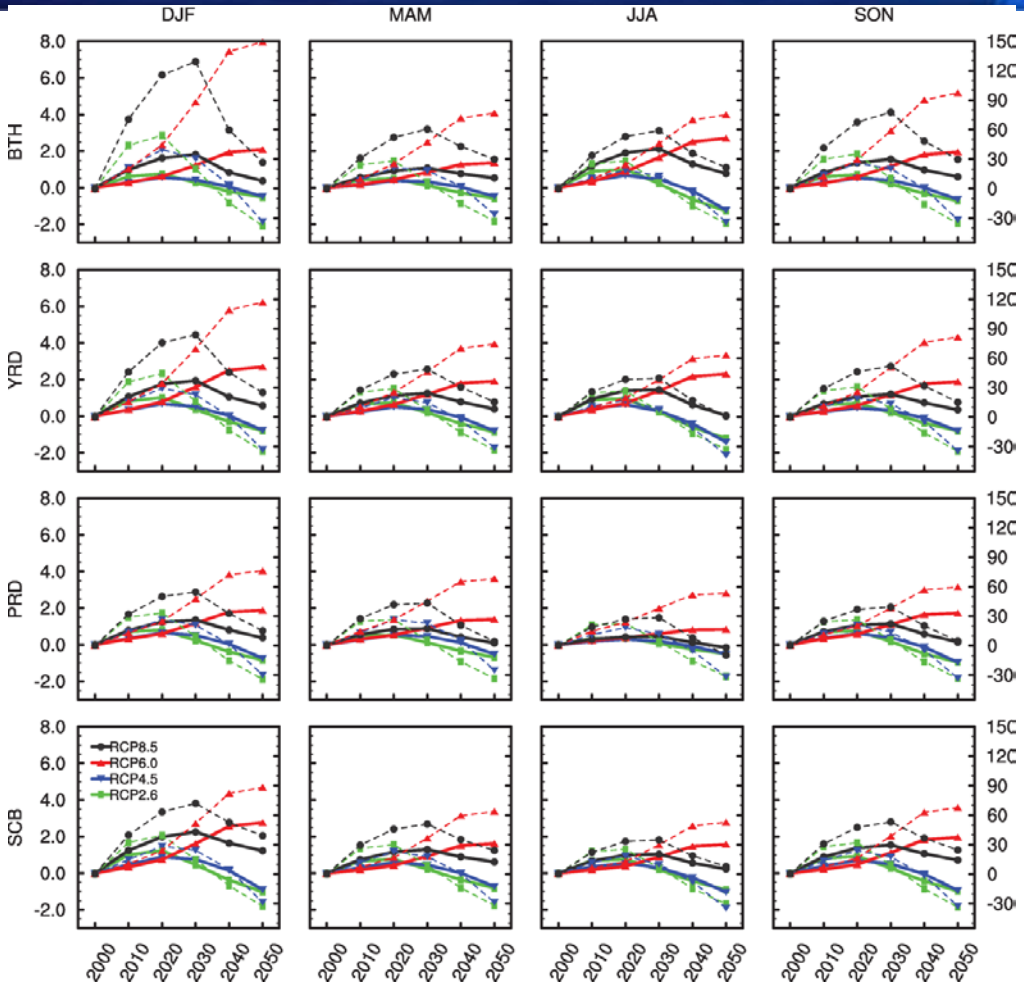


Future trend of SOA:
Highly consistent with the changes of emissions in **toluene** and **xylene**

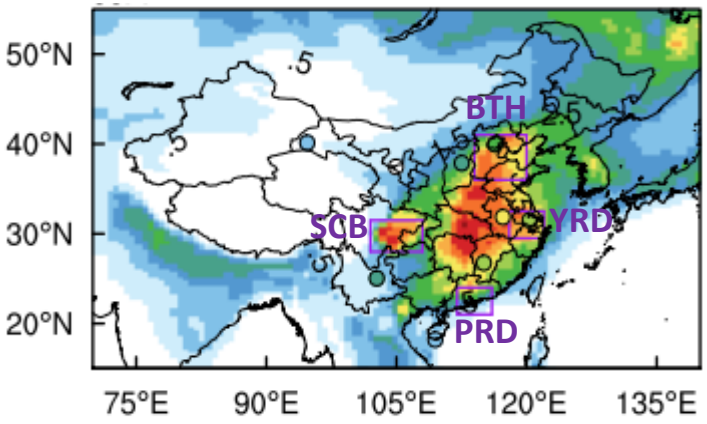
The largest increases in SOA :
Over eastern China

- 25.1% in 2020 under RCP2.6
- 20.4% in 2020 under RCP4.5
- 56.3% in 2050 under RCP6.0
- 44.6% in 2030 under RCP8.5

Results: Future changes in SOA concentration



Absolute changes (left Y axis, solid lines, units: μg m^{-3}) and percentage changes (right Y axis, dashed lines, units: %)

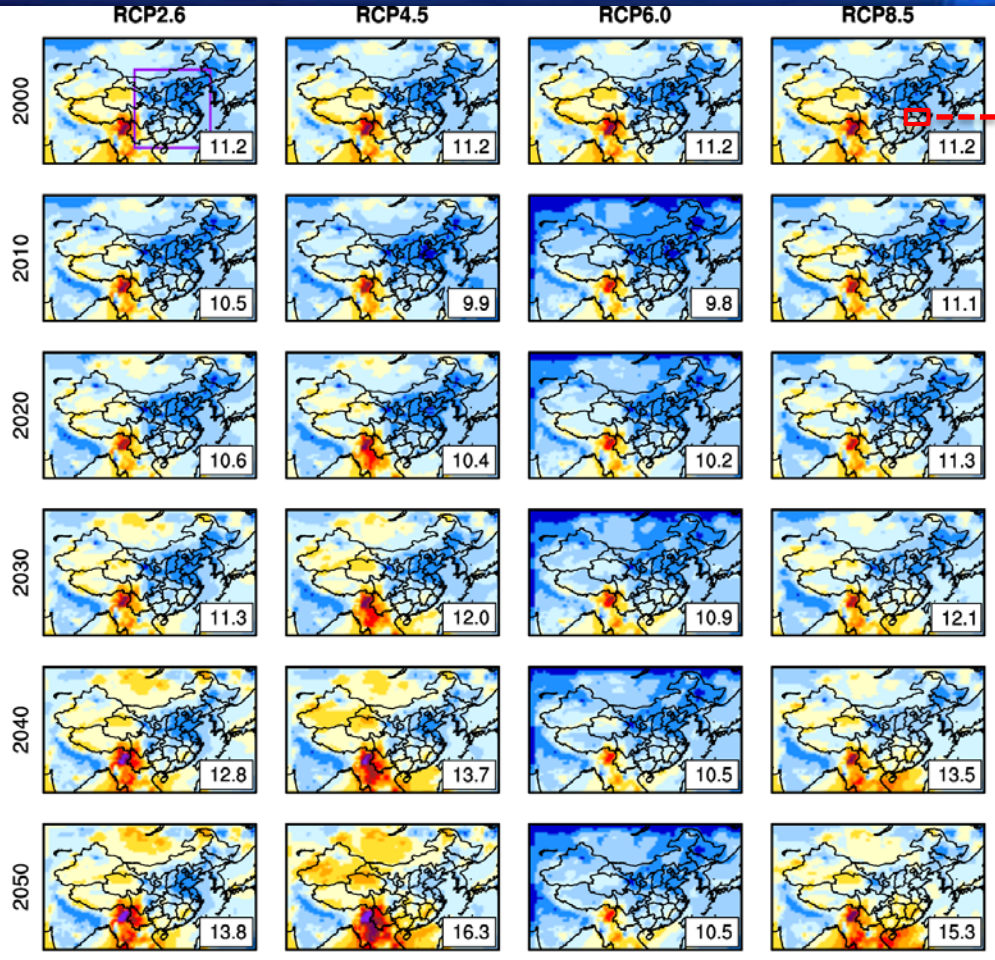


- Beijing-Tianjin-Hebei (BTH)
- Yangtze-River-Delta (YRD)
- Pearl-River-Delta (PRD)
- Sichuan Basin (SCB)

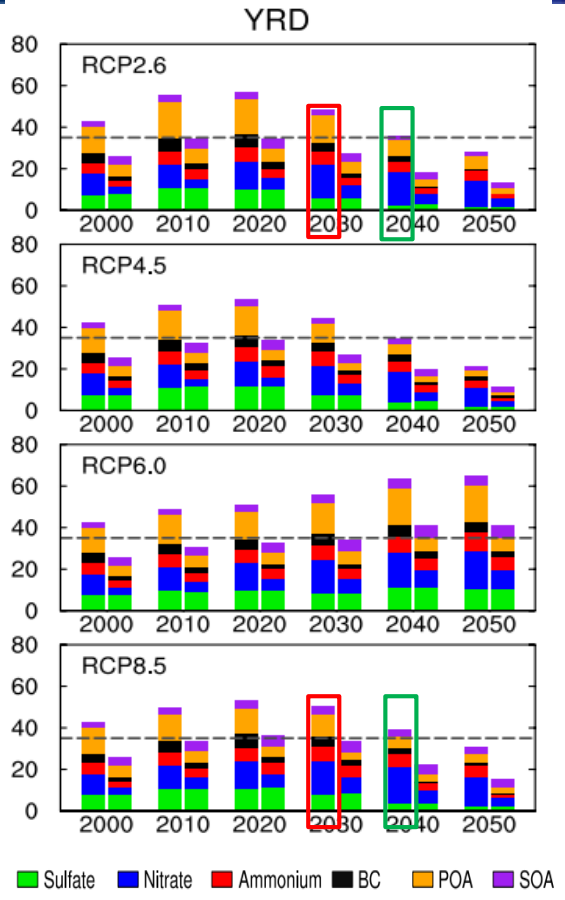
The largest magnitudes in changes:

- BTH: JJA (strong photochemistry)
- YRD: DJF (large changes in emissions)
- PRD: DJF (large changes in emissions)
- SCB: DJF (large changes in emissions)

Results: Future contribution of SOA to $PM_{2.5}$



Contribution of SOA to $PM_{2.5}$ (units: %)



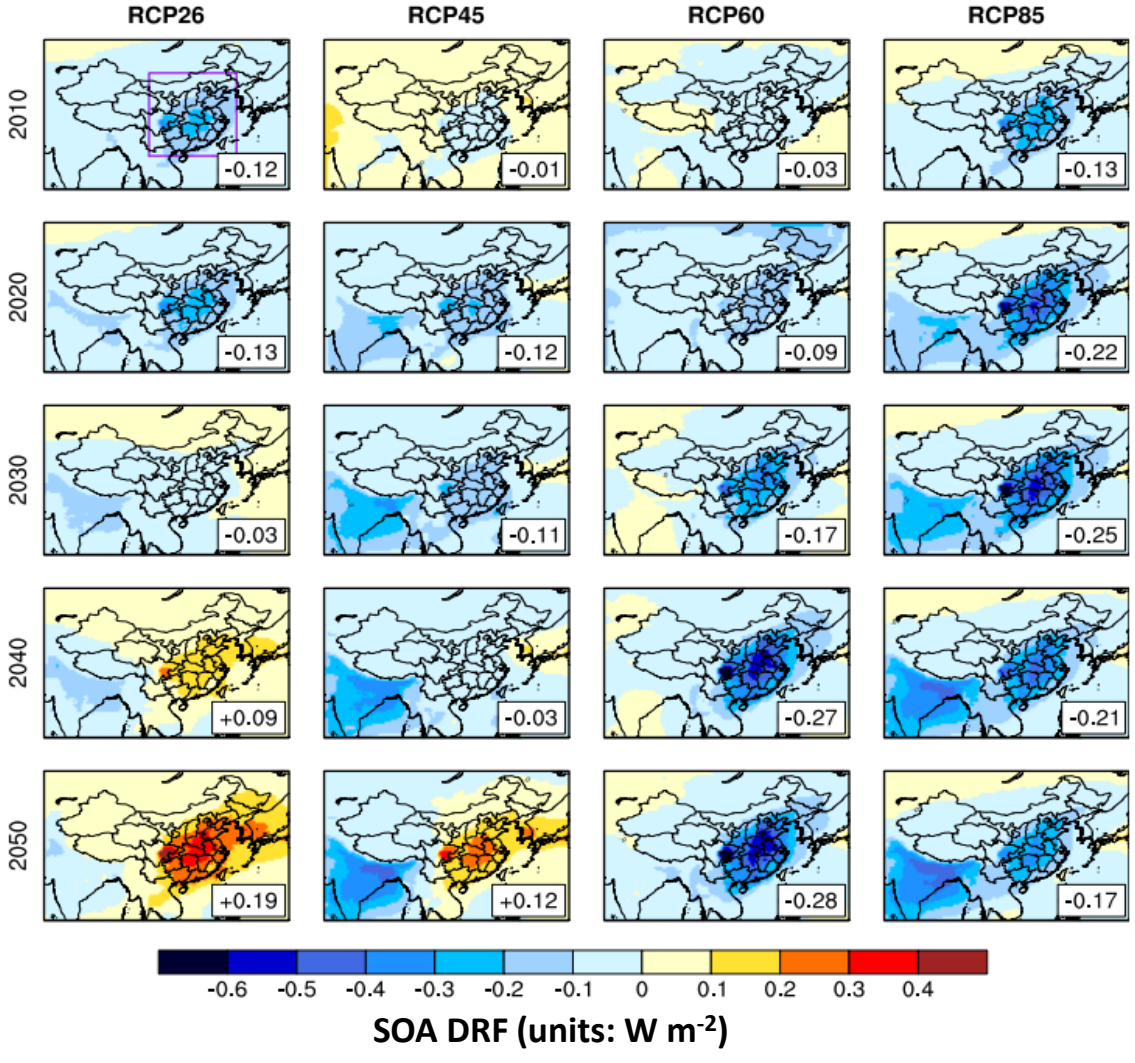
$PM_{2.5}$ concentrations (units: μg m^{-3}) in DJF (left column) and JJA (right column)

Results: Impacts of POA and aromatics on SOA formation

		CTRL_2010	POA_C2050	Arom_C2050	POA_Arom_C2050	POA contribution	Arom contribution	POA+Arom contribution
RCP2.6	SOA Production (Tg yr^{-1})	2.50	2.36	1.81	1.69	0.14	0.69	0.82
	SOA Burden (Tg)	0.0470	0.0457	0.0391	0.0380	0.0012	0.0079	0.0090
	SOA concentration (μg m^{-3})	1.57	1.43	1.121	1.01	0.14	0.45	0.57
	$PM_{2.5}$ Concentration (μg m^{-3})	14.50	12.49	14.061	12.19	2.01	0.44	2.32
	SOA contribution to $PM_{2.5}$ (%)	13.4	13.8	11.4	11.6	-0.4	2.0	1.8
RCP4.5	SOA Production (Tg yr^{-1})	2.27	2.10	1.81	1.66	0.17	0.46	0.61
	SOA Burden (Tg)	0.0405	0.0391	0.0353	0.0341	0.0014	0.0052	0.0064
	SOA concentration (μg m^{-3})	1.40	1.24	1.12	0.98	0.16	0.28	0.42
	$PM_{2.5}$ Concentration (μg m^{-3})	13.39	11.67	13.36	11.50	1.72	0.03	1.89
	SOA contribution to $PM_{2.5}$ (%)	12.6	12.5	10.9	11.0	0.1	1.7	1.6
RCP6.0	SOA Production (Tg yr^{-1})	2.22	2.28	3.02	3.05	-0.05	-0.80	-0.83
	SOA Burden (Tg)	0.0433	0.0437	0.0525	0.0526	-0.0004	-0.0092	-0.0092
	SOA concentration (μg m^{-3})	1.39	1.43	1.94	1.97	-0.04	-0.56	-0.58
	$PM_{2.5}$ Concentration (μg m^{-3})	12.79	13.59	13.10	13.97	-0.80	-0.31	-1.18
	SOA contribution to $PM_{2.5}$ (%)	13.4	13.1	16.2	15.5	0.3	-2.8	-2.1
RCP8.5	SOA Production (Tg yr^{-1})	2.58	2.49	2.63	2.55	0.09	-0.05	0.03
	SOA Burden (Tg)	0.0473	0.0464	0.0479	0.0472	0.0008	-0.0006	0.0001
	SOA concentration (μg m^{-3})	1.63	1.53	1.67	1.59	0.10	-0.05	0.04
	$PM_{2.5}$ Concentration (μg m^{-3})	14.07	12.83	14.02	12.88	1.24	0.05	1.19

Need to control aromatics emissions!!

Results: Future changes in SOA DRF



2000-2050 changes in SOA direct radiative forcing (DRF) :

Over eastern China

- RCP2.6: +0.19 W m^{-2}
- RCP4.5: +0.12 W m^{-2}
- RCP6.0: –0.28 W m^{-2}
- RCP8.5: –0.17 W m^{-2}

Summary:

- The largest increase in SOA over eastern China is simulated to be 25.1% in 2020 under RCP2.6, 20.4% in 2020 under RCP4.5, 56.3% in 2050 under RCP6.0, and 44.6% in 2030 under RCP8.5.

- The role of SOA in $PM_{2.5}$ increases with each decade in 2010–2050 under RCP2.6, RCP4.5, and RCP8.5, with a maximum ratio of concentration of SOA to that of $PM_{2.5}$ of 16.3% in 2050 under RCP4.5 as averaged over eastern China (20°–45°N, 100°–125°E).

- Concentrations of SOA are projected to be able to exceed those of sulfate, ammonium, and BC in the future.

- The future changes in SOA levels over eastern China are simulated to lead to domain-averaged (20°–45°N, 100°–125°E) DRFs of +0.19 W m^{-2}, +0.12 W m^{-2}, –0.28 W m^{-2}, and –0.17 W m^{-2} in 2050 relative to 2000 under RCP2.6, RCP4.5, RCP6.0, and RCP8.5, respectively.

THANKS FOR YOUR ATTENTION!