Impacts of COVID-19 on Aerosol and Radiative Forcing in China

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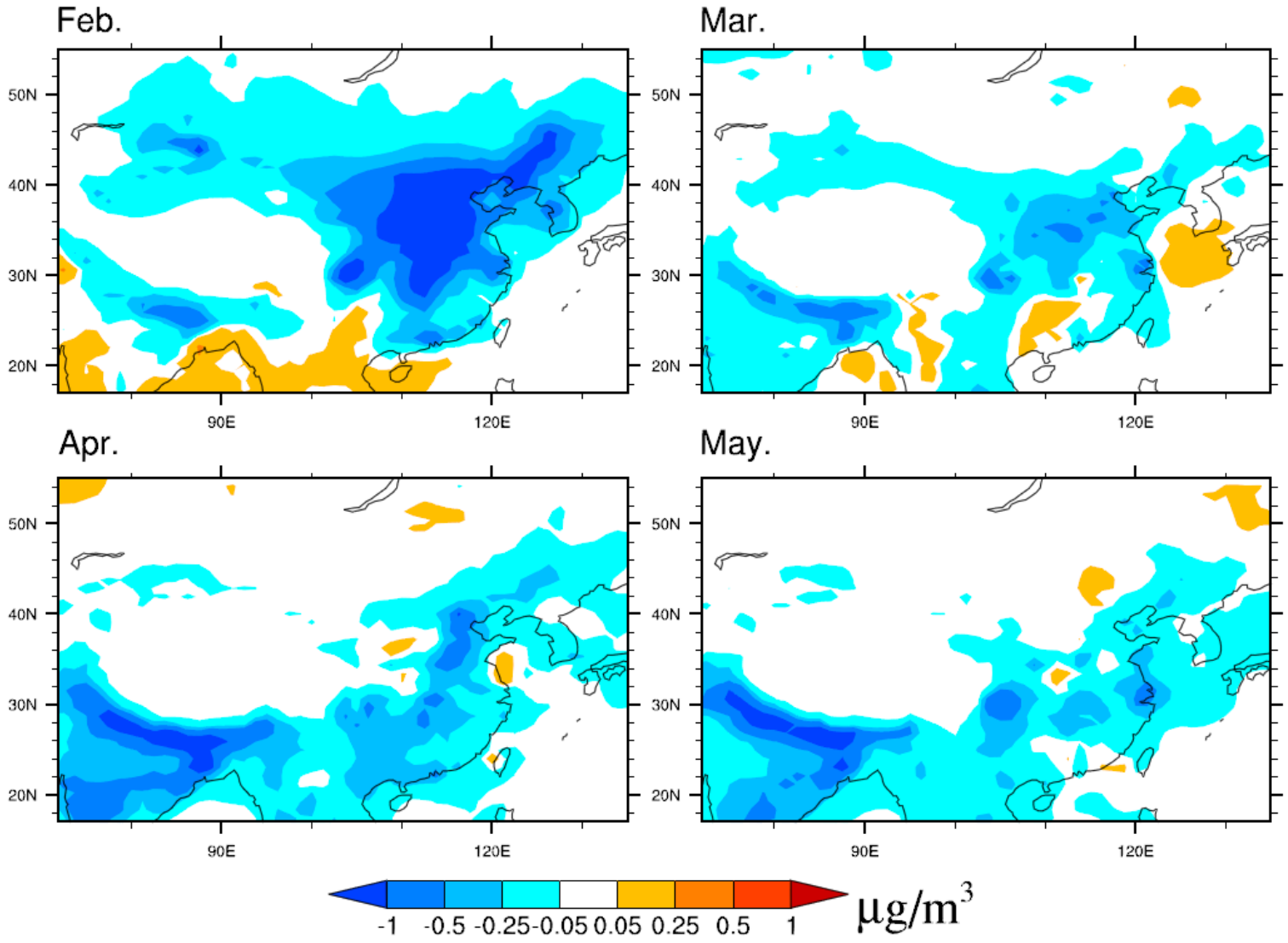
Model Configuration

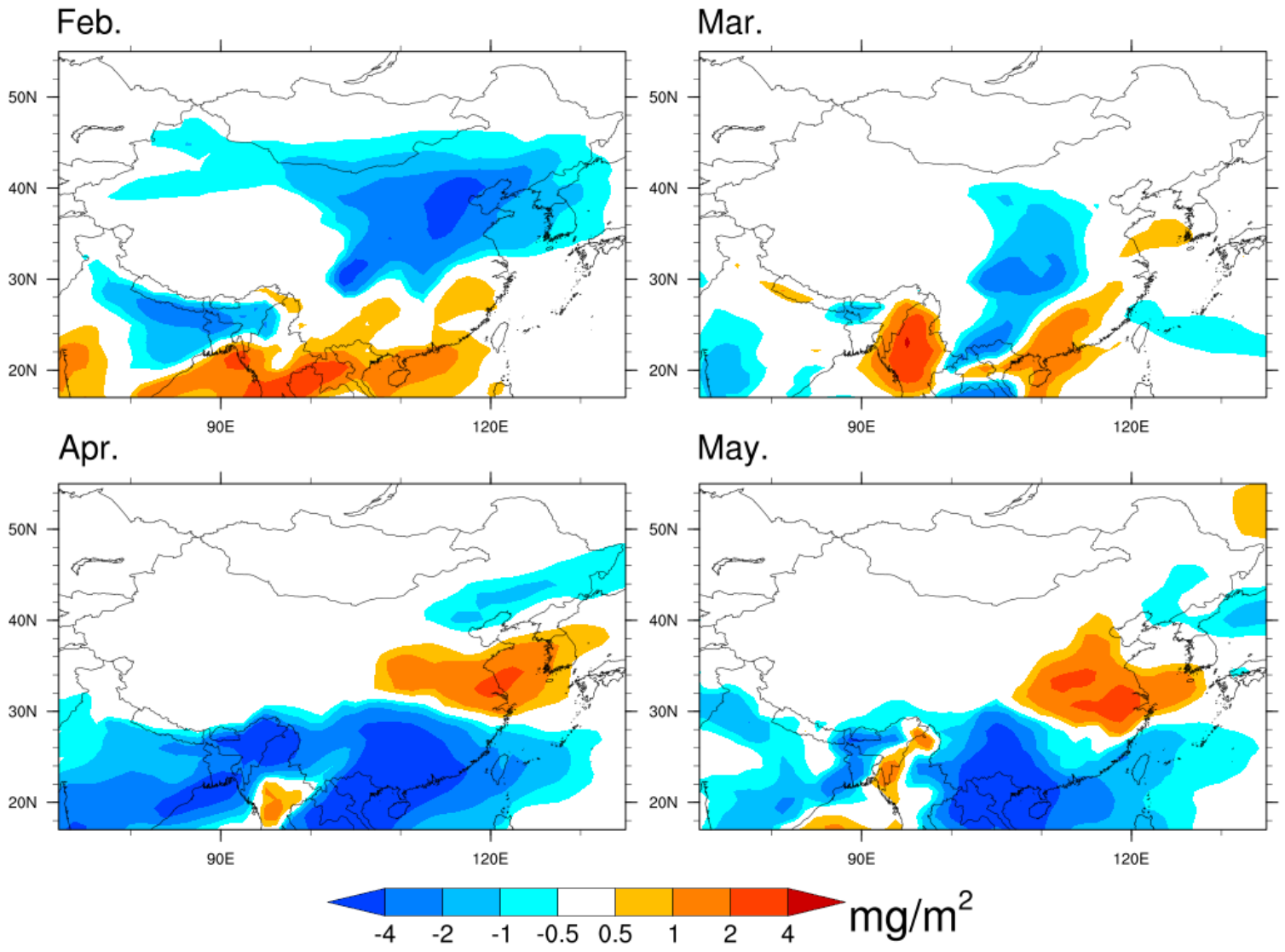
- NCAR CESM2.1.0
  - 4-mode **Modal Aerosol Module** (Liu et al. 2016)
  - **MOZART** full chemistry
  - **Nitrate** aerosol by MOSAIC module to treat gas-particle partitioning
  - **SOA** by volatility-basis set (VBS)
- AMIP runs with observed SSTs
  - 2015.01 ~ 2020.06 (10 ensembles) at 0.9° × 1.25° horizontal resolution
  - **SSP** case: with SSP245 emissions for 2015-2020
  - **COVID** case: SSP245 emissions in 2020 revised according to emission reduction during COVID period [Forster et al. 2020, V4]

COVID – SSP for Feb-May 2020 over China

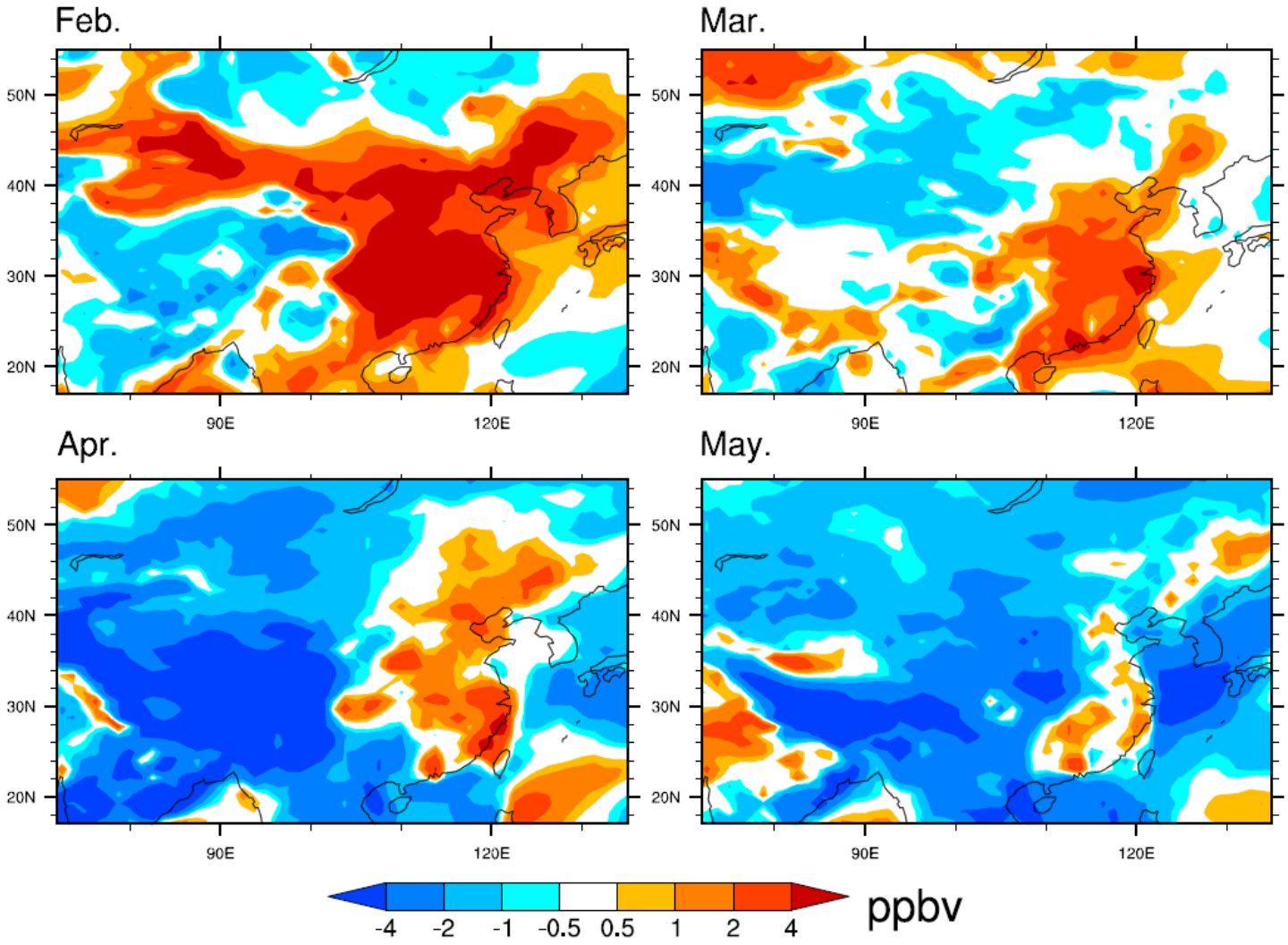
BC concentration change at surface



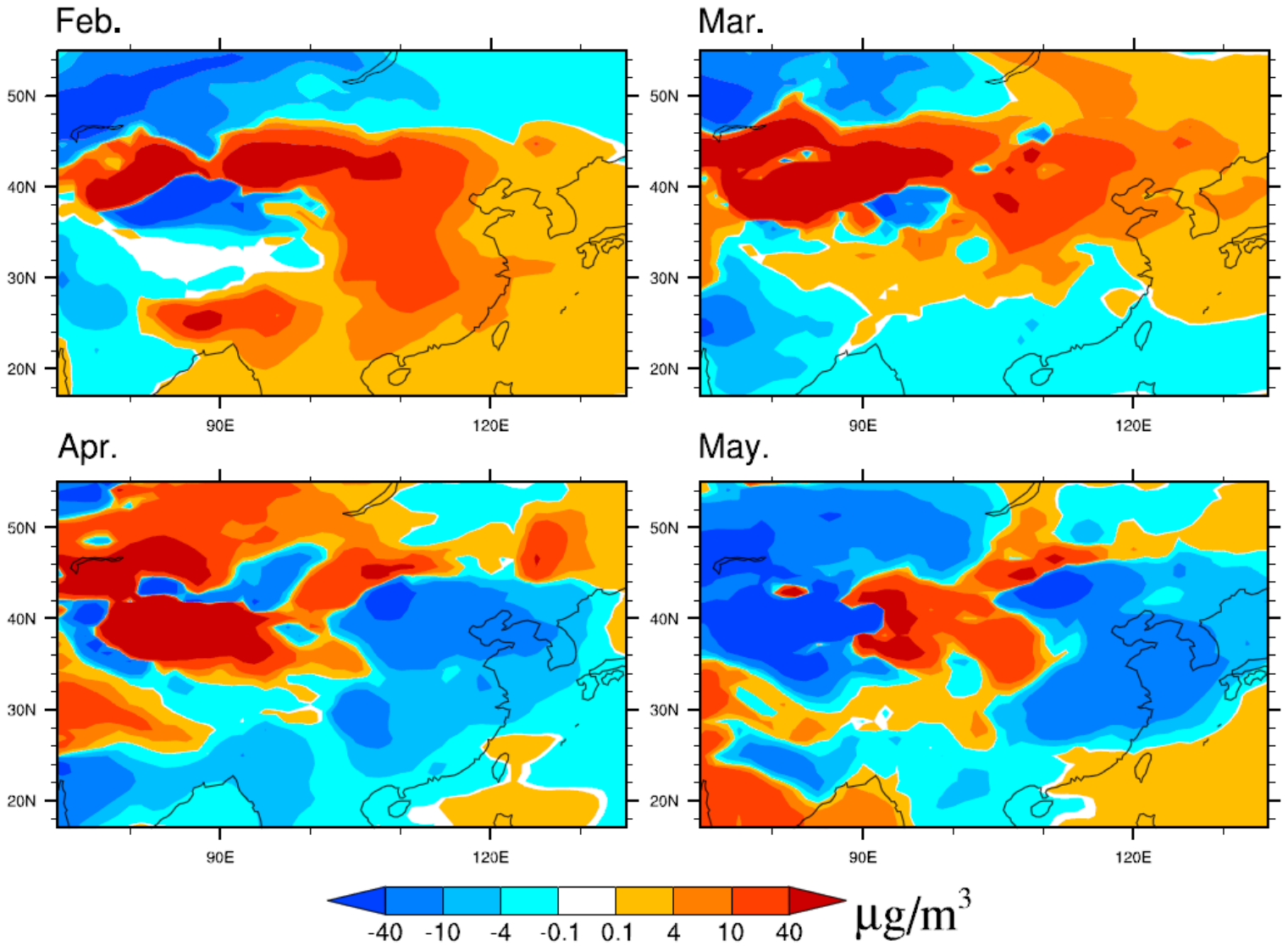
SOA concentration change (column)



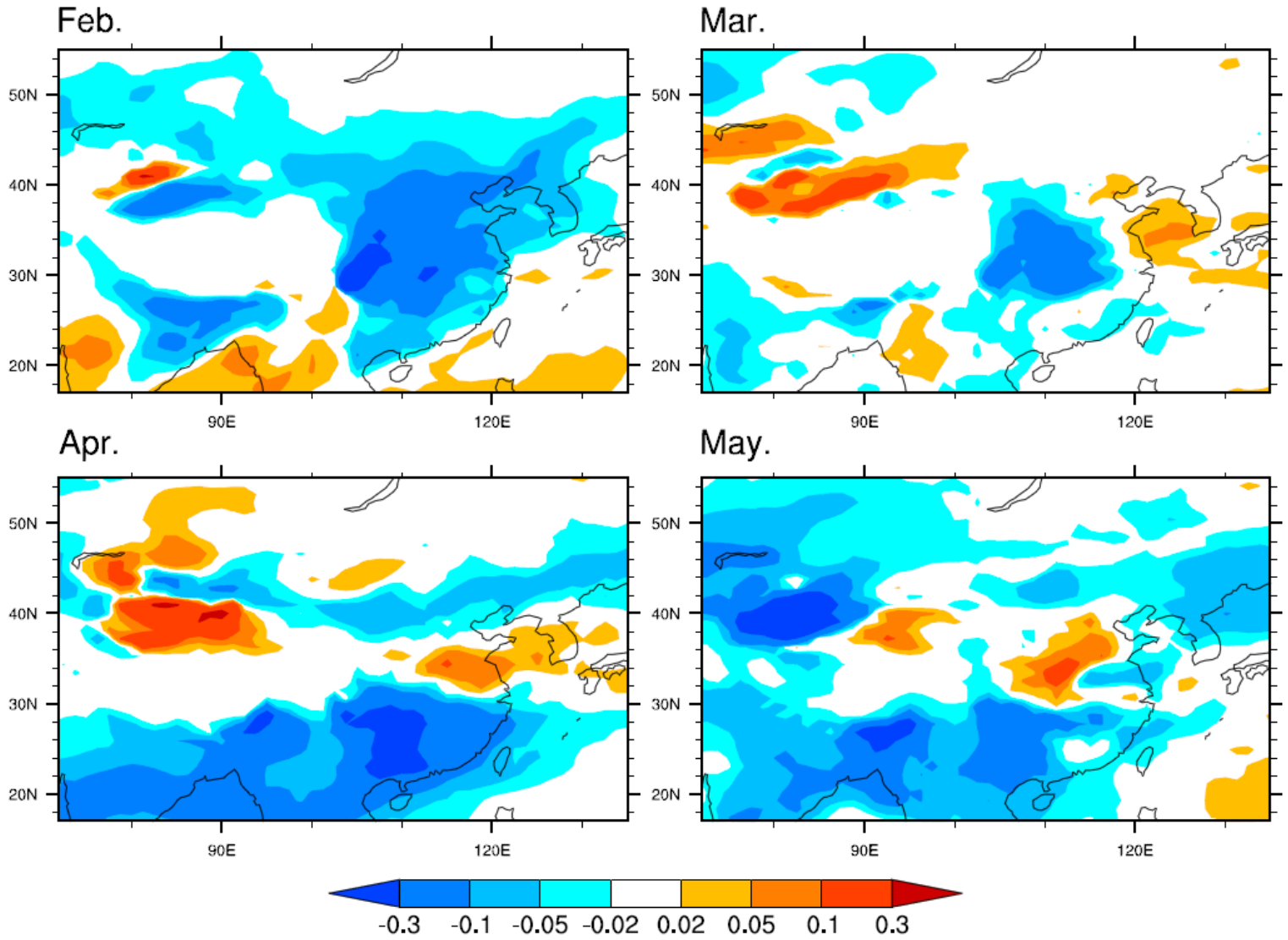
Ozone change (surface)



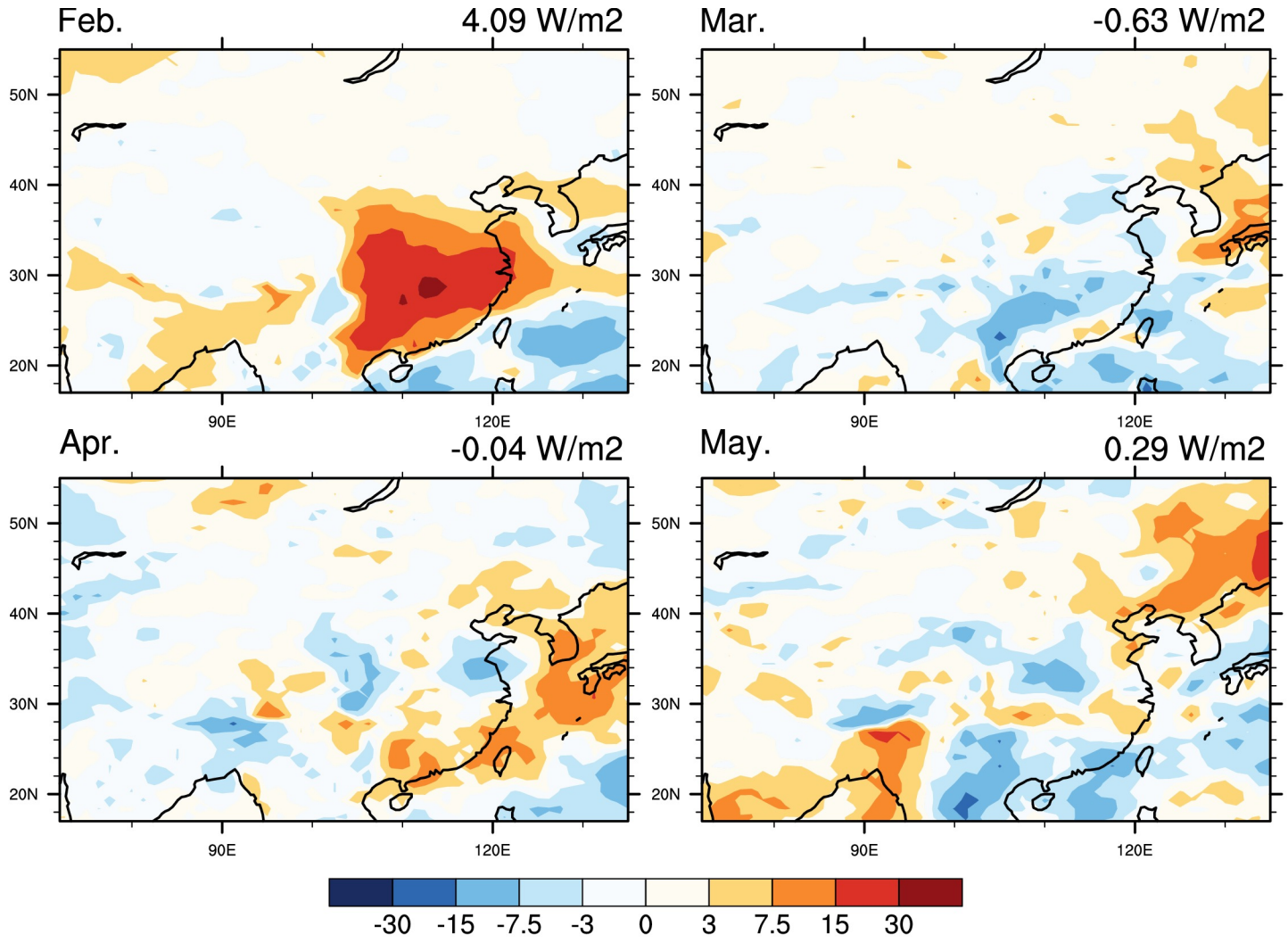
Dust concentration change (surface)



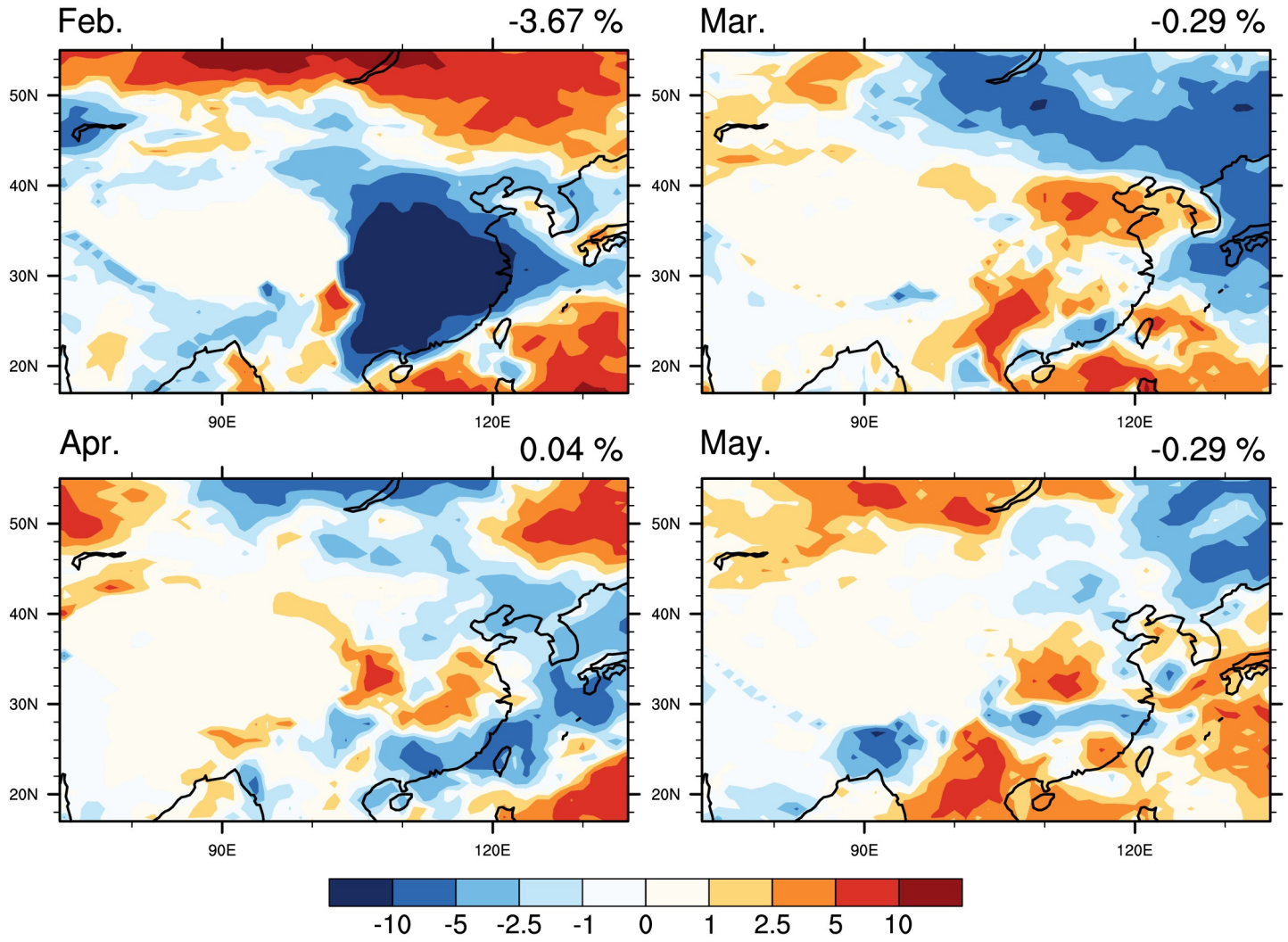
AOD change (550 nm)



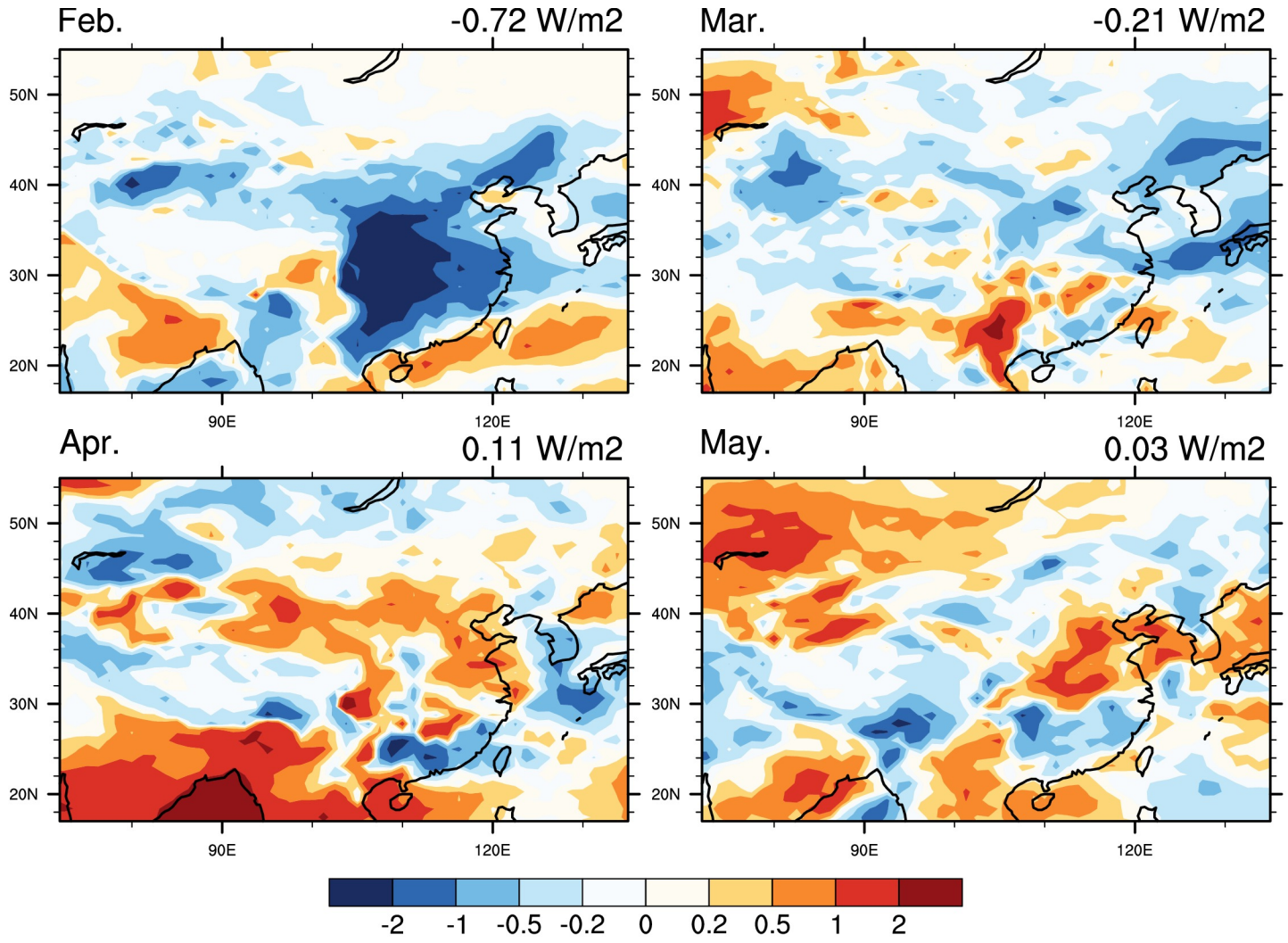
RF_{aci} : Radiative forcing due to ACI



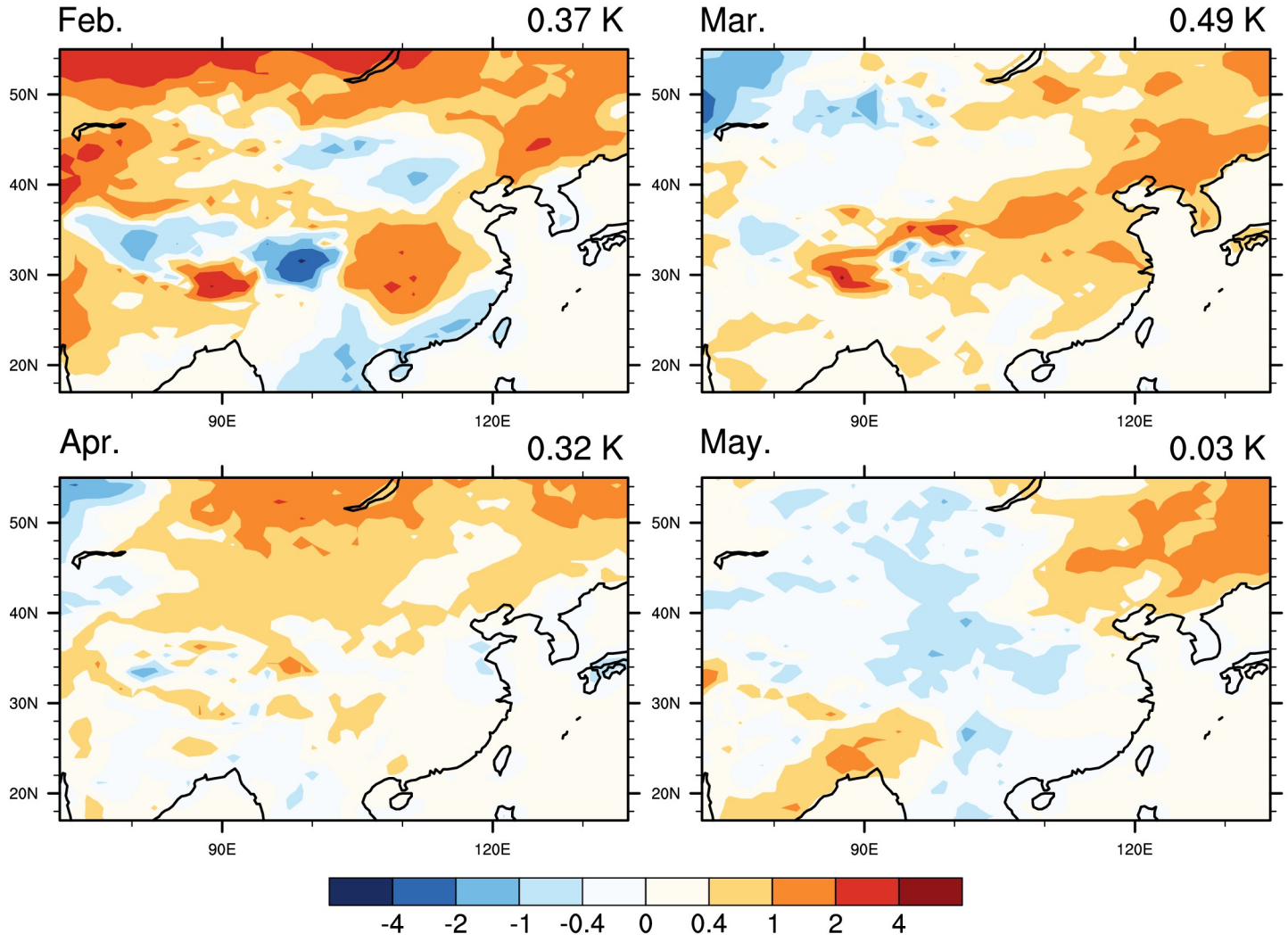
Low CF


Feb.
-3.67 %
Mar.
-0.29 %
Apr.
0.04 %
May.
-0.29 %
50N
40N
30N
20N
90E
120E
-10
-5
-2.5
-1
0
1
2.5
5
10

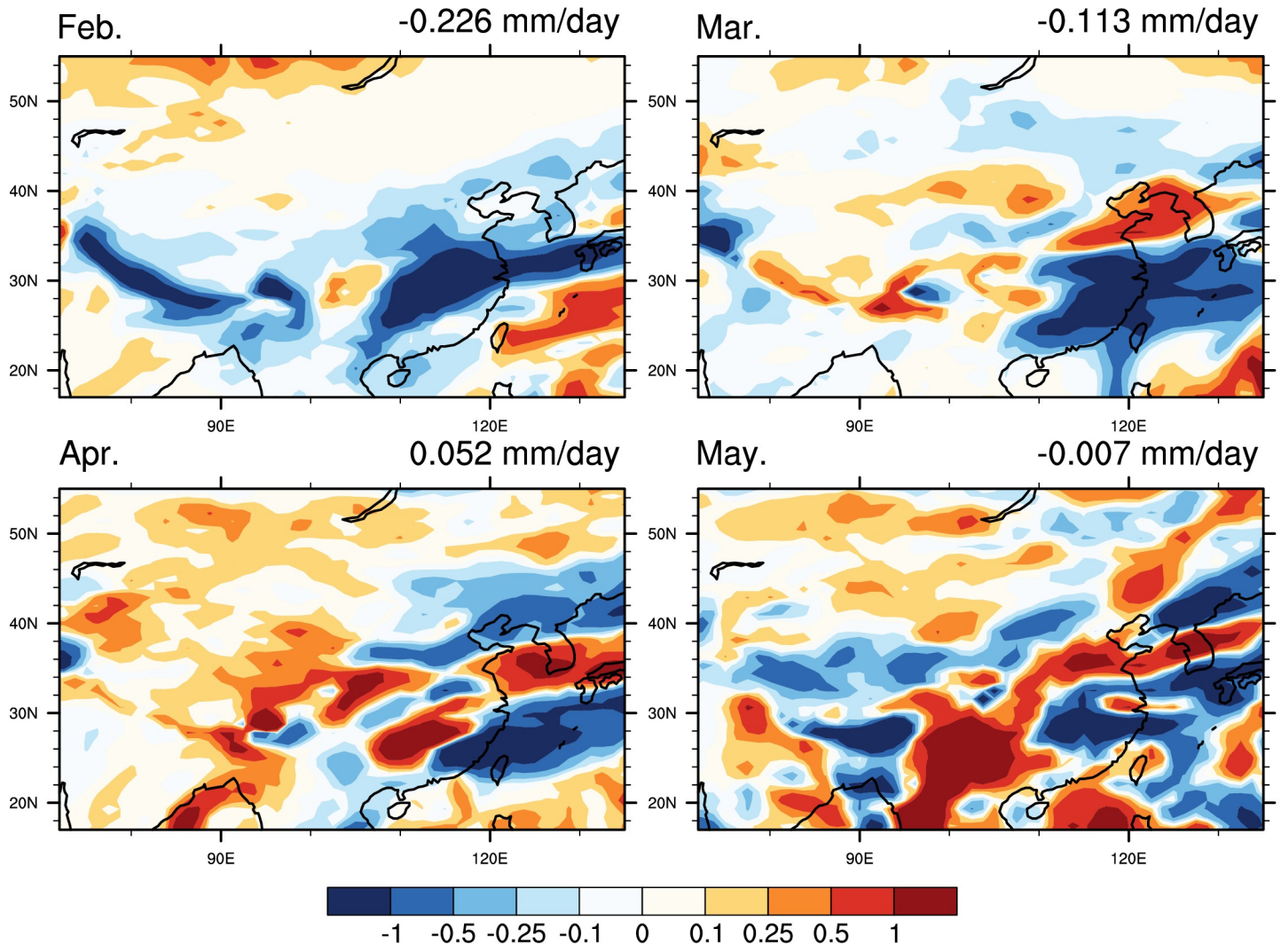
RF_{ari} : Radiative forcing due to ARI



Surface temperature



Precipitation change (large-scale clouds)

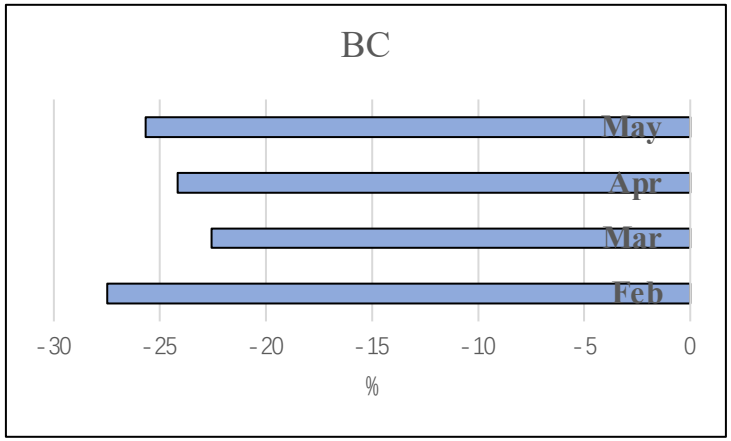


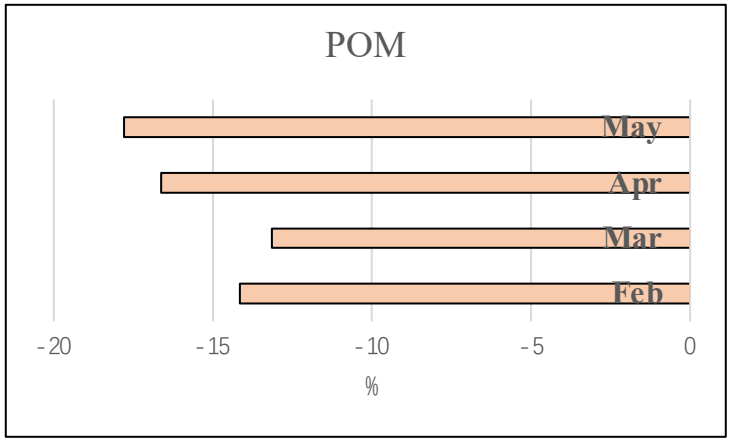
Conclusions

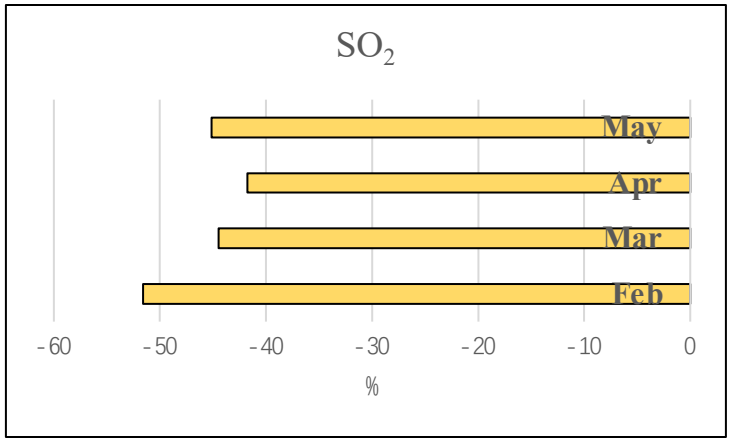
- **A comprehensive chemistry-climate model CESM2 is used to simulate the effects of COVID emission reductions on aerosol, radiative flux, and climate in China in February to May 2020.**
- **Model simulates a reduction of primary aerosols (e.g., BC) as a result of emission reductions. However, simulated secondary aerosols (SOA, nitrate) are increased in central China in spring due to increased oxidation capacity (e.g., O_3).**
- **Strong positive RF_{aci} (warming) across China in February due to reduced low clouds. Negative RF_{aci} (cooling) in central China in spring due to increased secondary aerosols.**
- **Strong negative RF_{ari} (cooling) across China in February due to reduced BC and low clouds.**
- **Surface temperature (1-2º) increased, and precipitation decreased in February and March due to reduced clouds.**

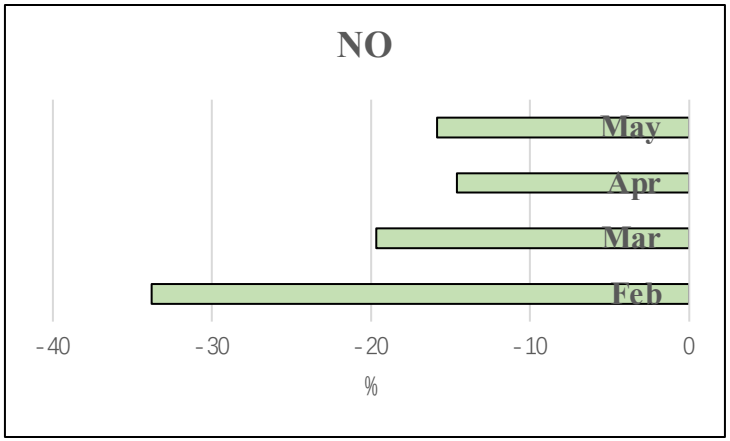
Thanks

Reduction of aerosol & precursor emissions in China

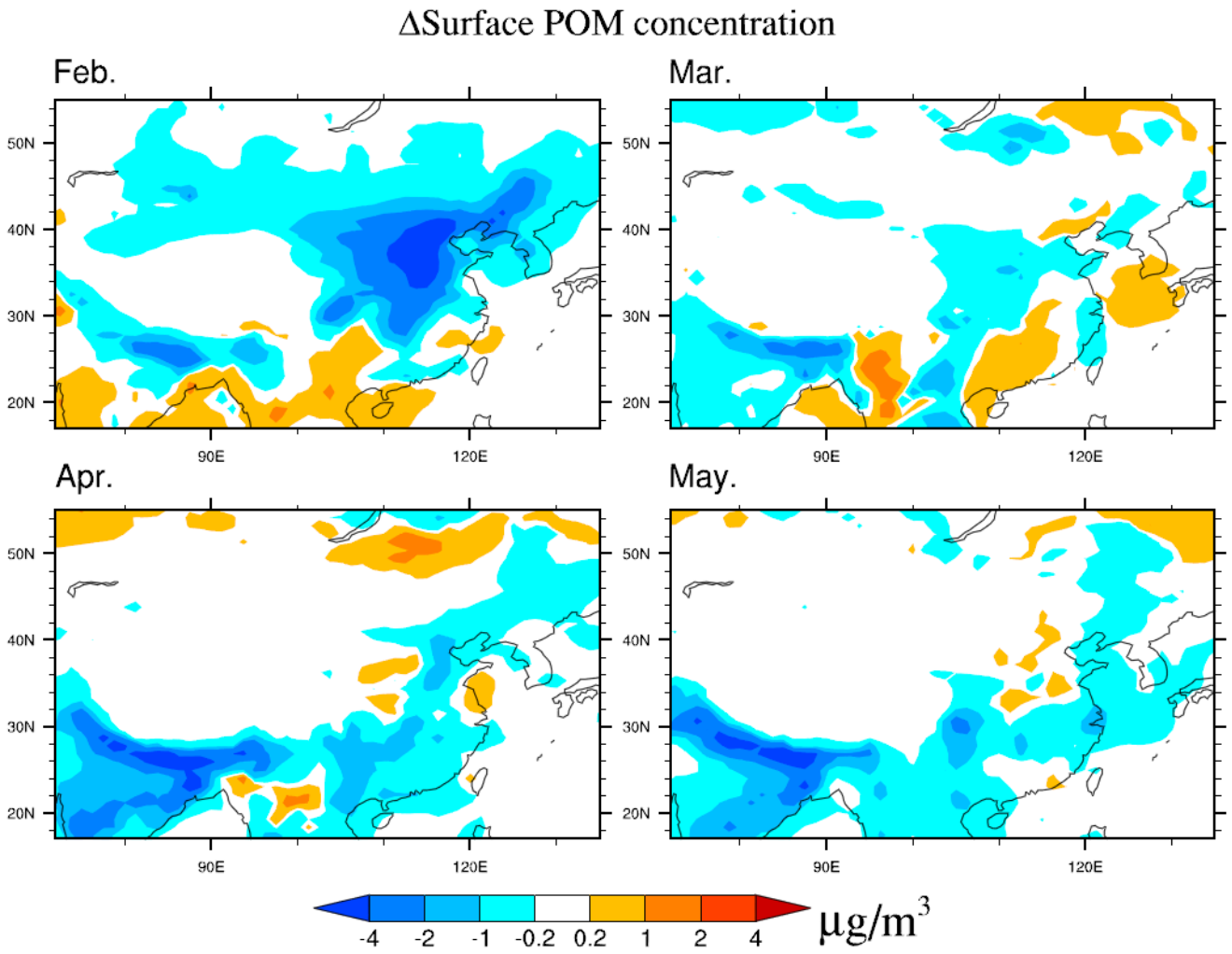




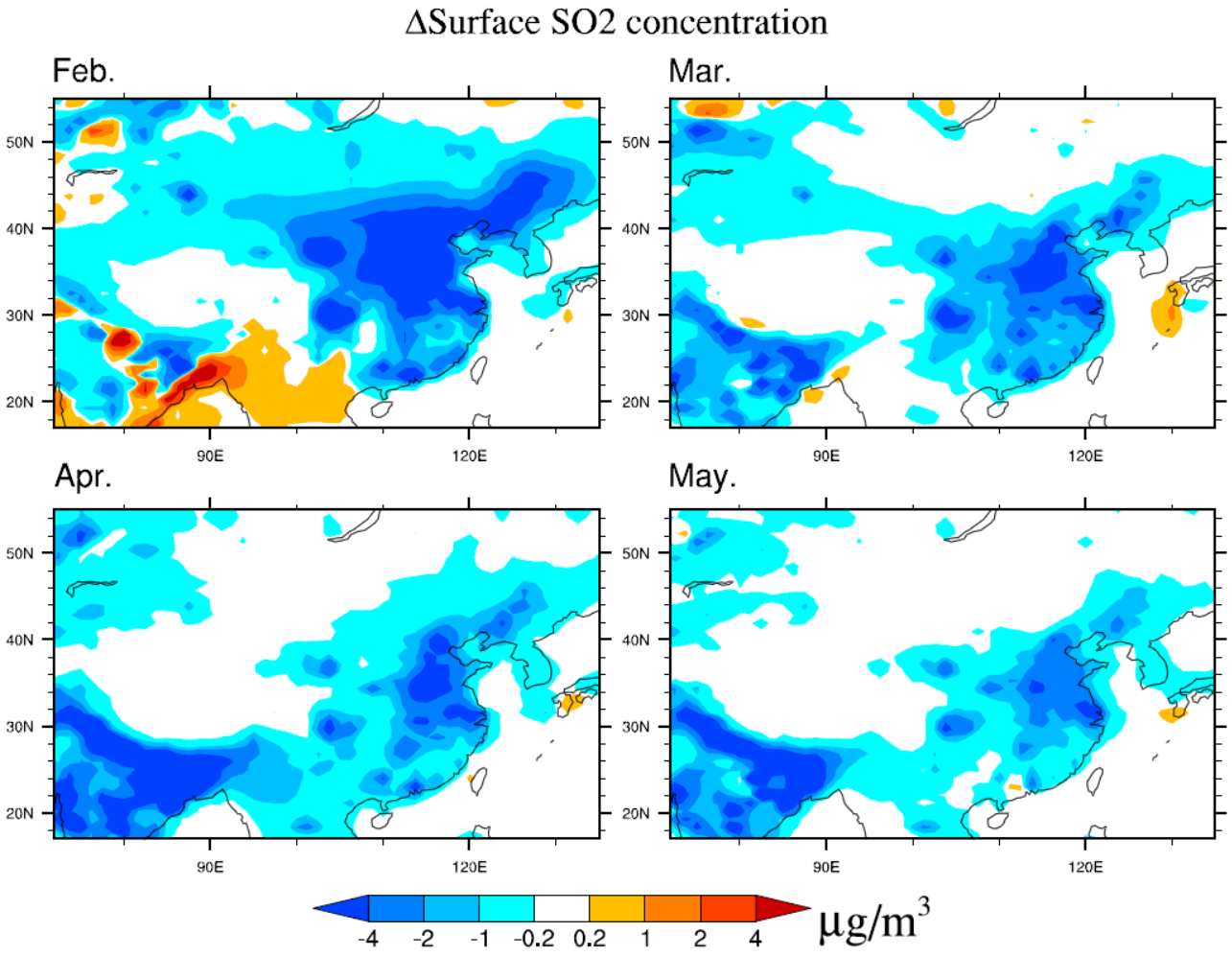




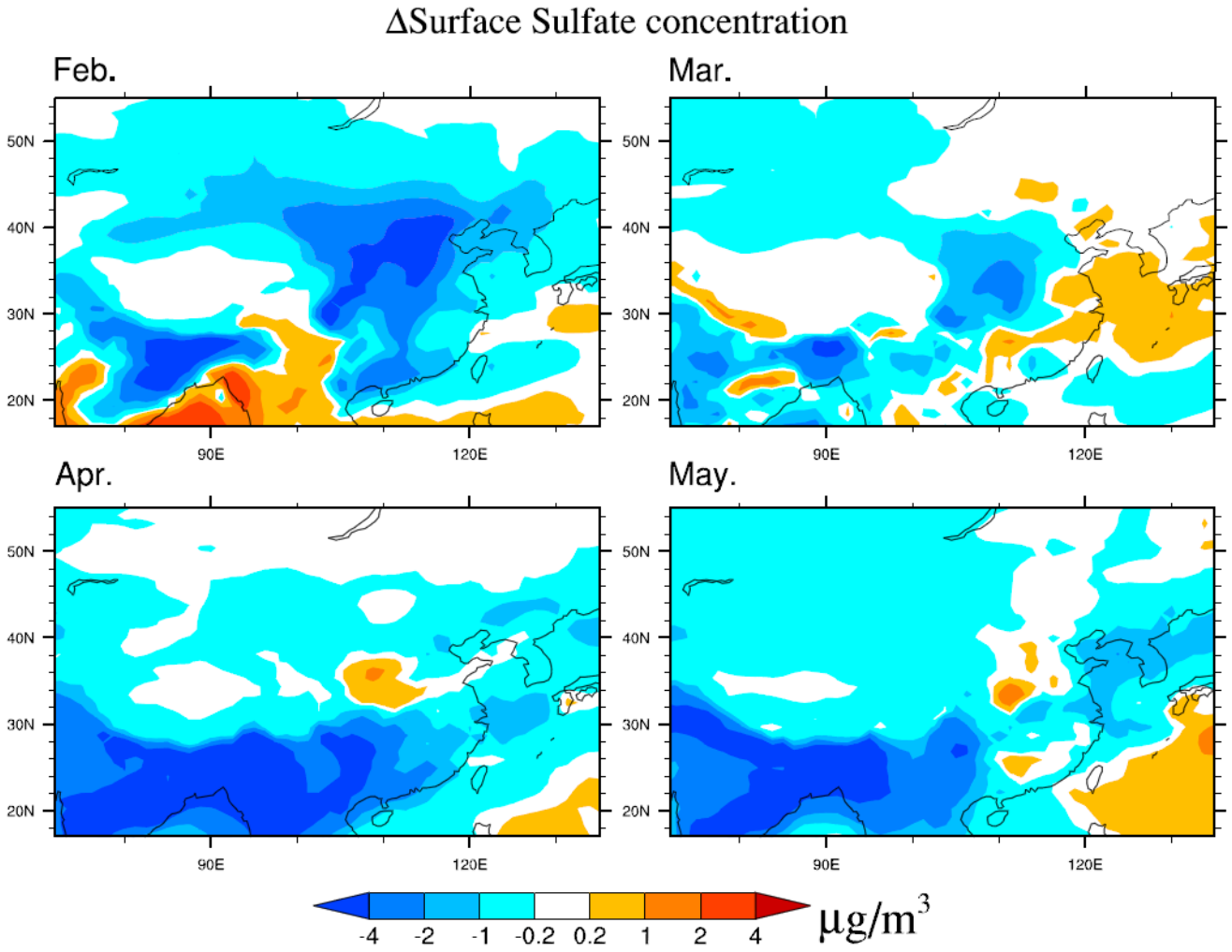
POM (surface)


ΔSurface POM concentration
Feb.
Mar.
Apr.
May.
50N
40N
30N
20N
90E
120E
-4
-2
-1
-0.2
0.2
1
2
4
μg/m3

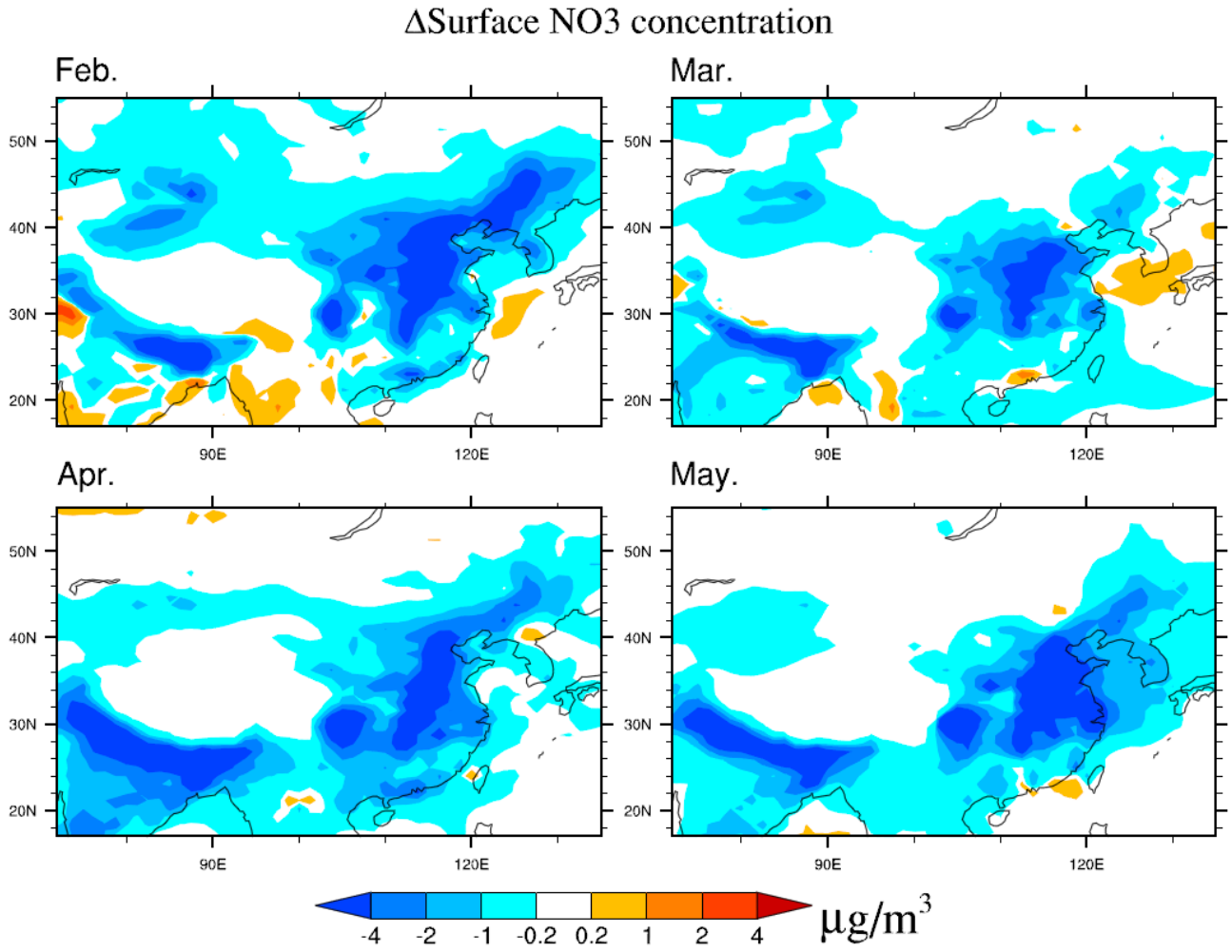
SO_2 (surface)


ΔSurface SO2 concentration
Feb.
Mar.
Apr.
May.
50N
40N
30N
20N
90E
120E
-4
-2
-1
-0.2
0.2
1
2
4
μg/m3

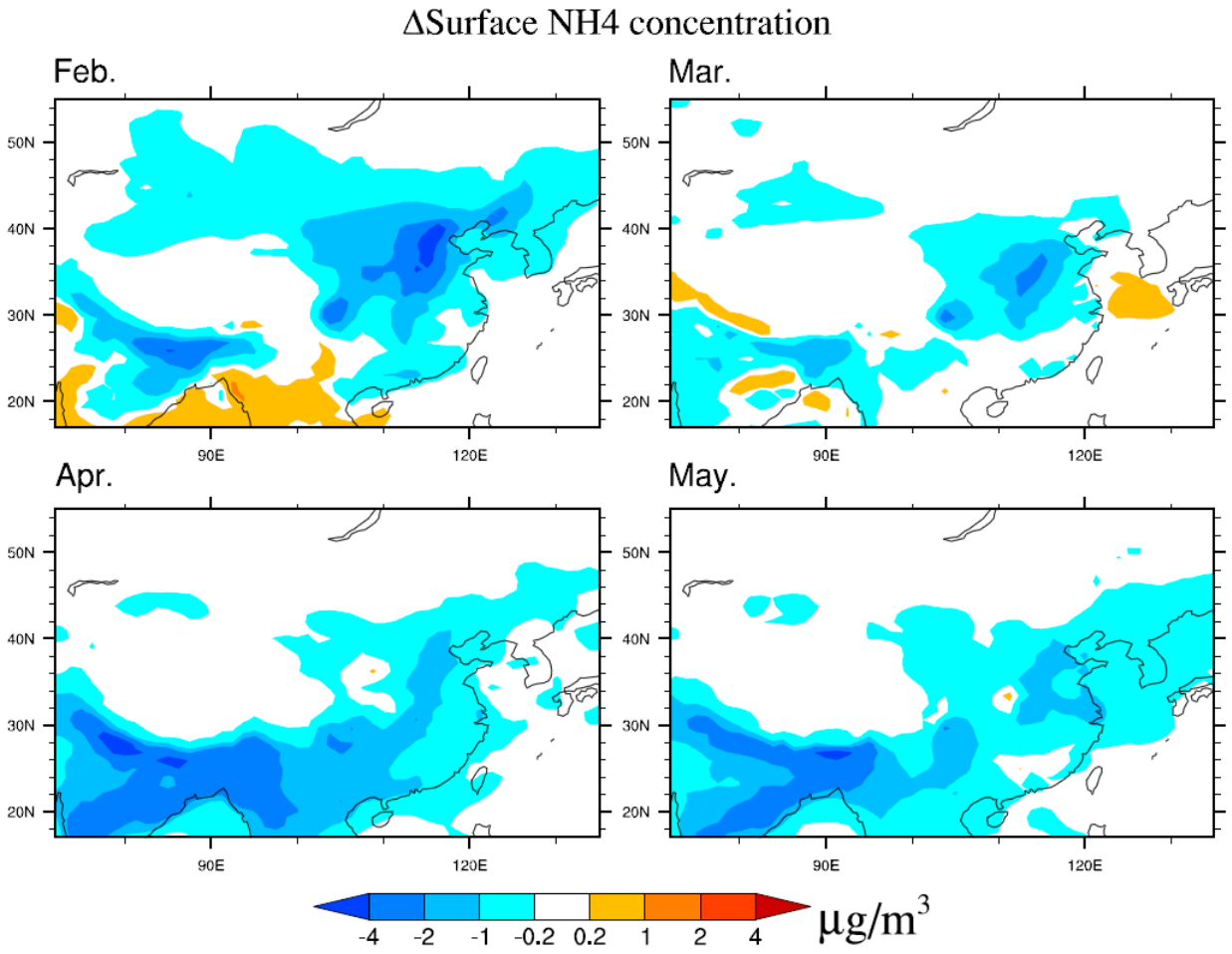
Sulfate aerosol (surface)



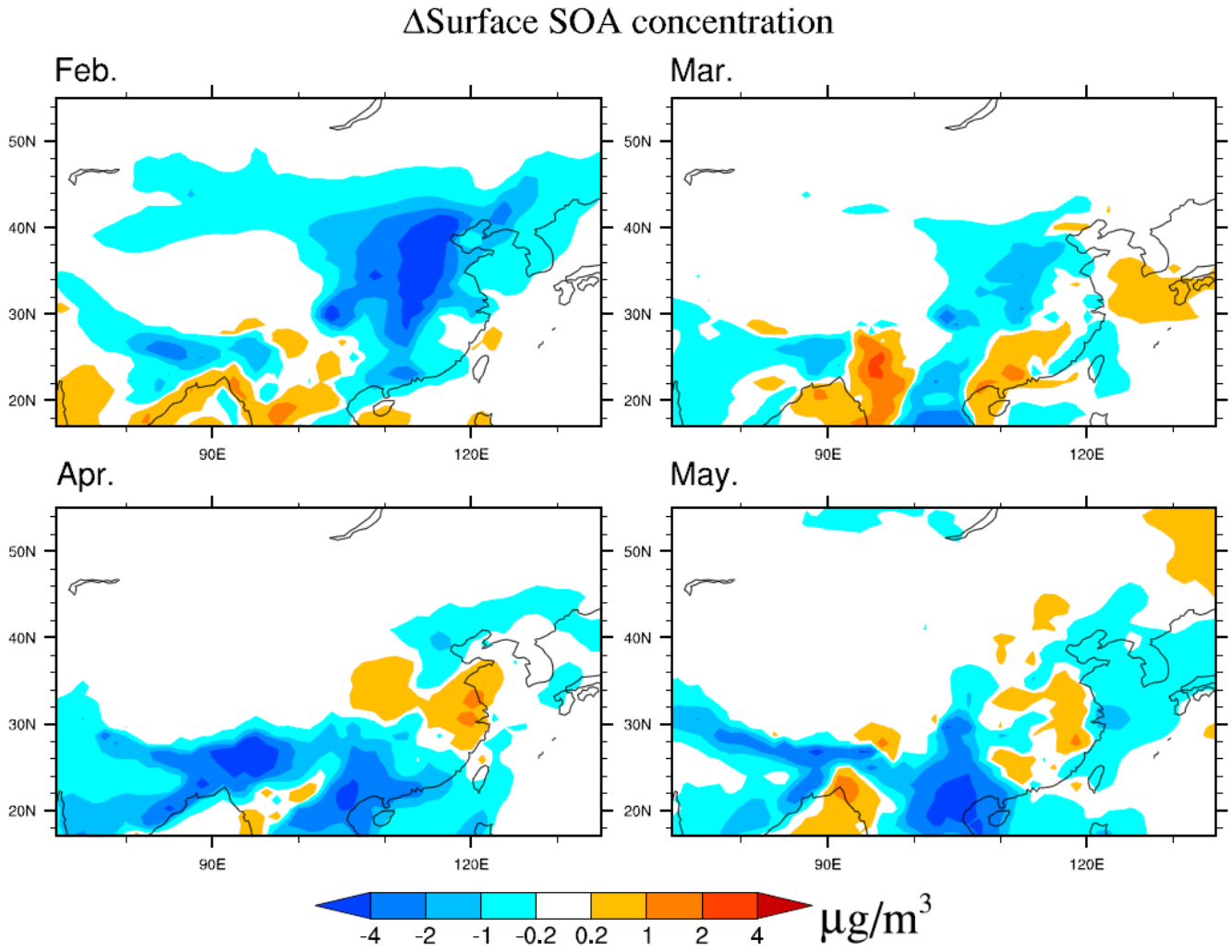
Nitrate aerosol (surface)



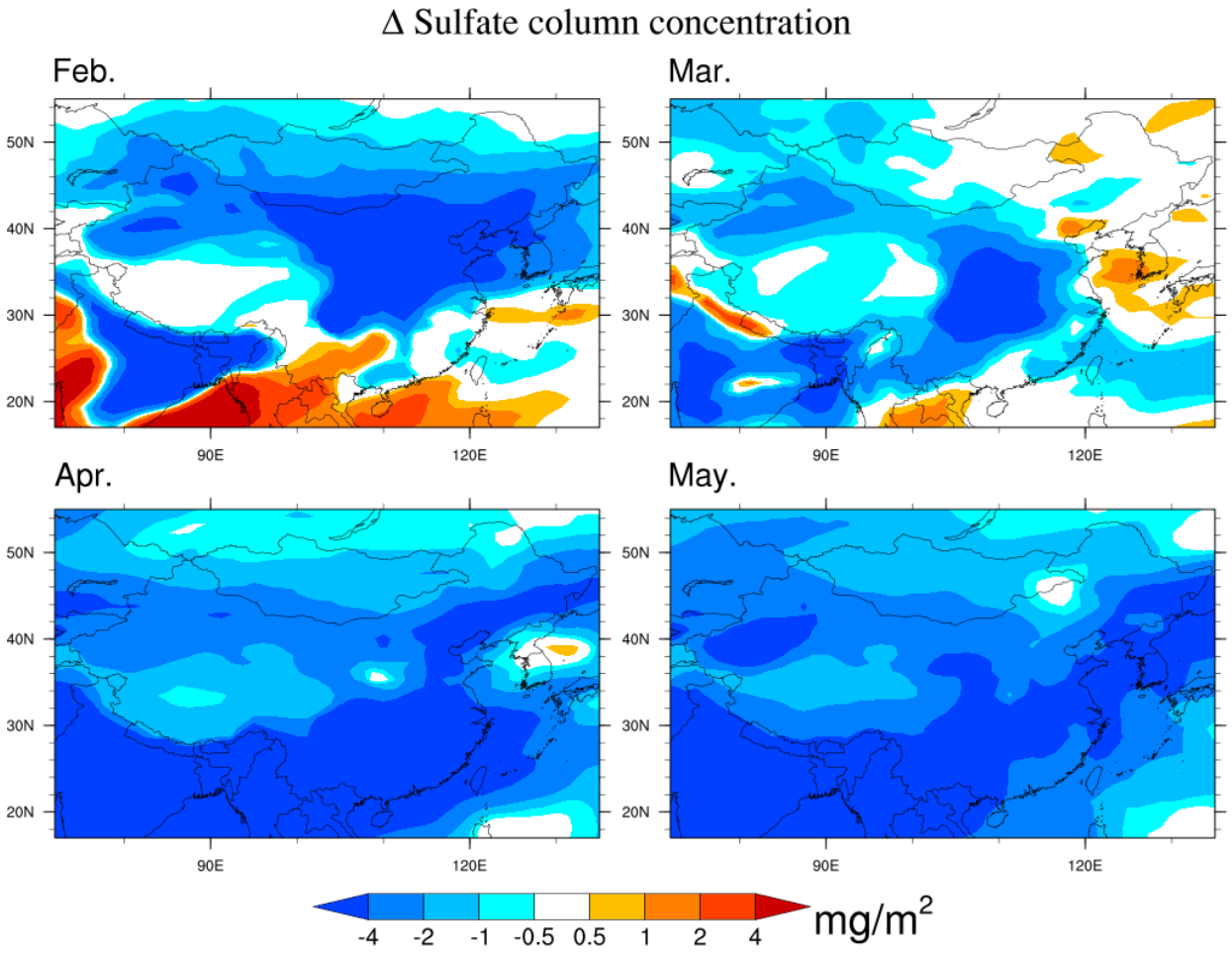
Ammonium (surface)



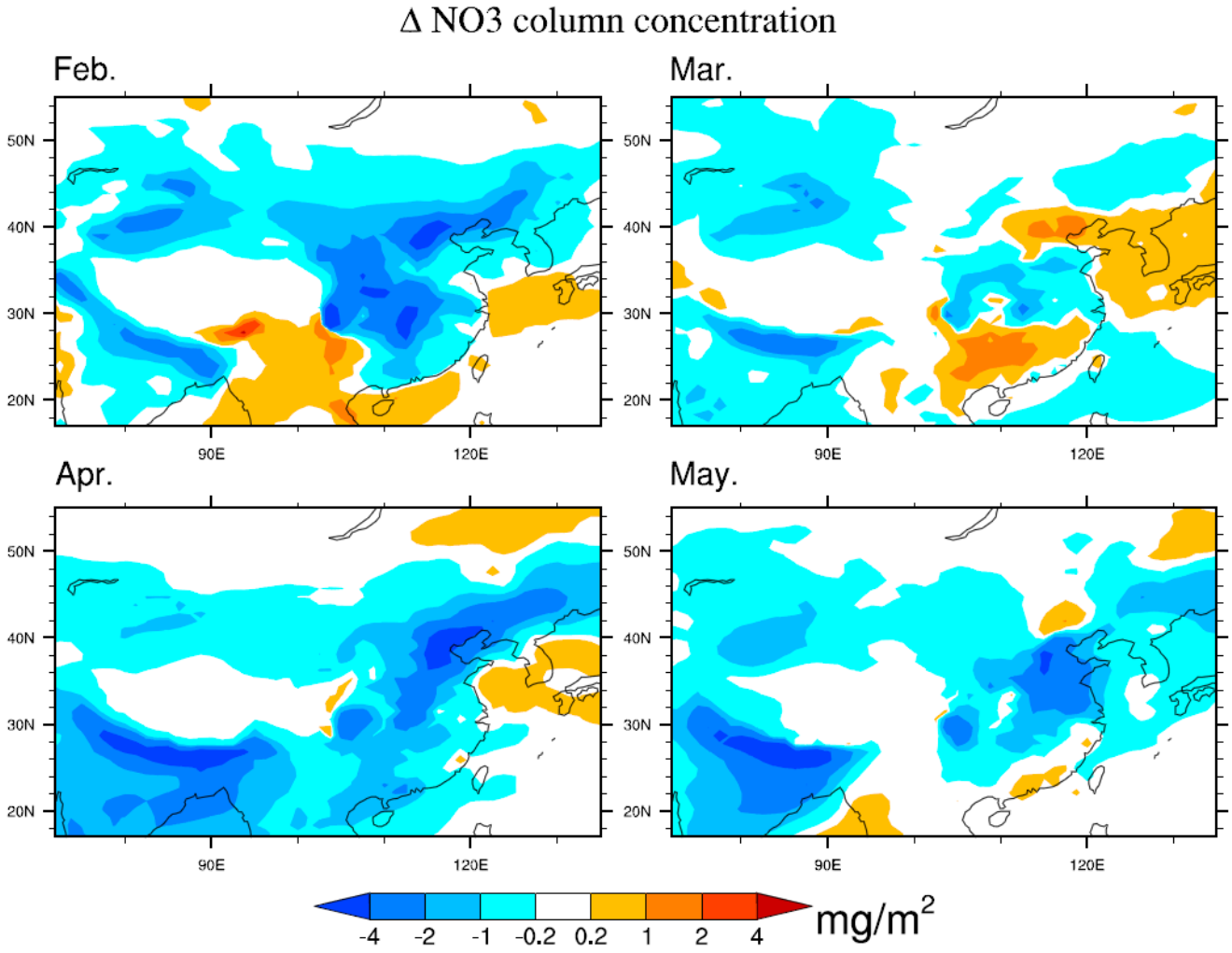
SOA (surface)


ΔSurface SOA concentration
Feb.
Mar.
Apr.
May.
50N
40N
30N
20N
90E
120E
-4
-2
-1
-0.2
0.2
1
2
4
μg/m3

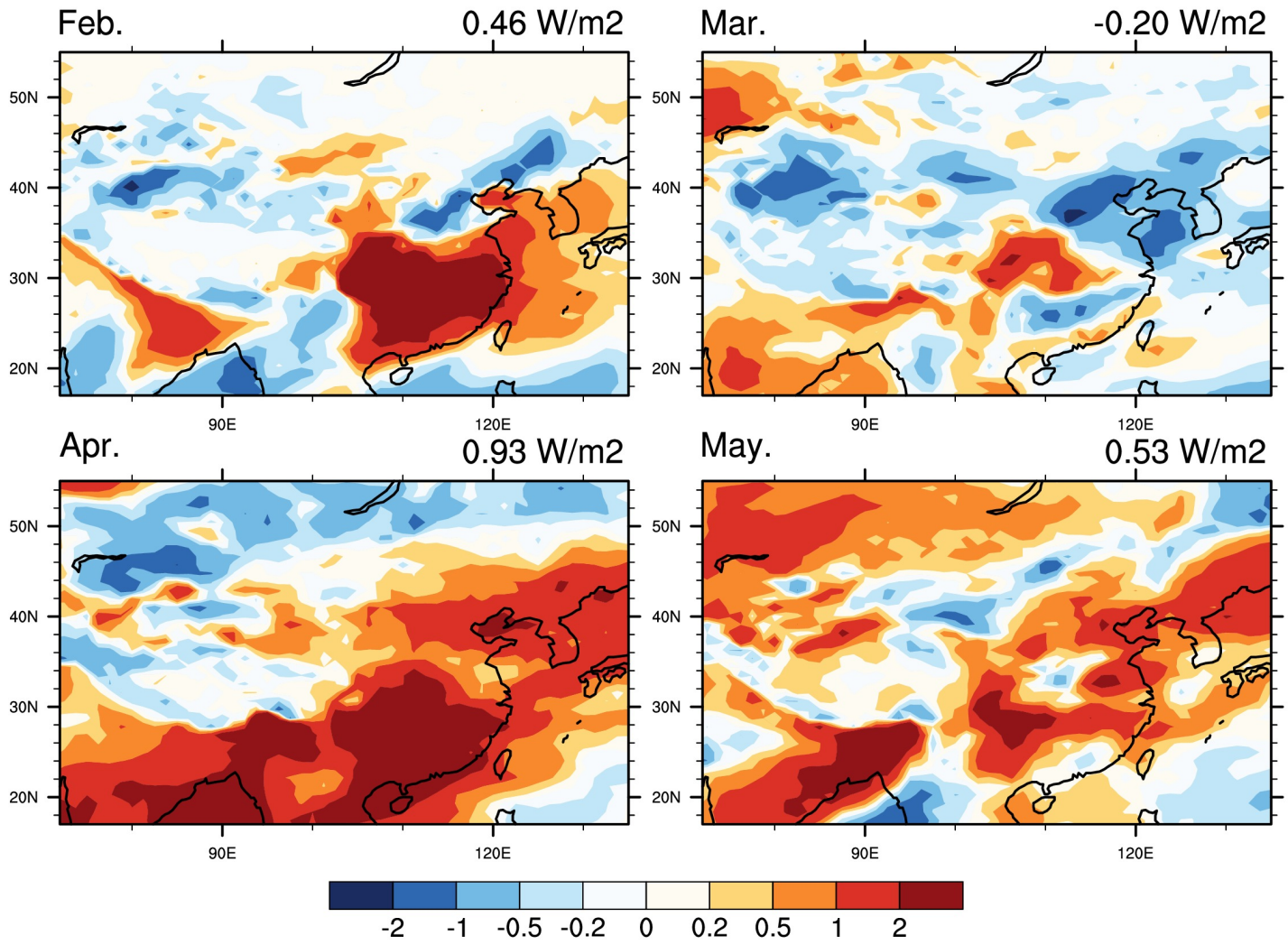
Sulfate aerosol (column)



Nitrate aerosol (column)

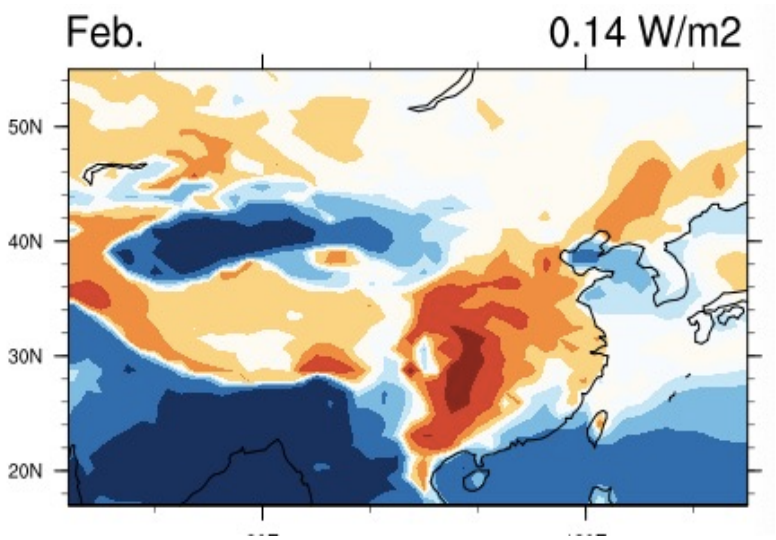


RF_{ari} (clear-sky)

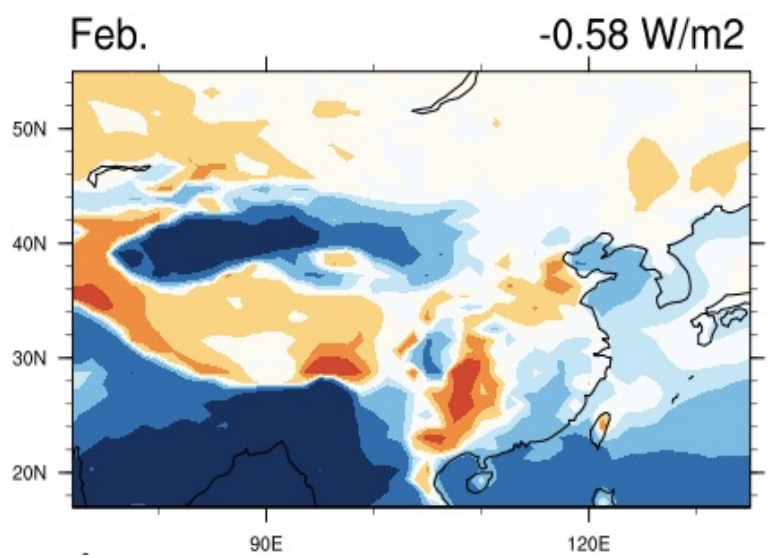


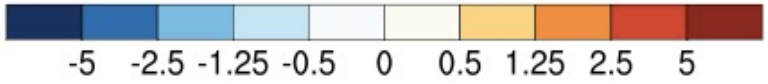
RF_{ari} (all-sky), February

SSP

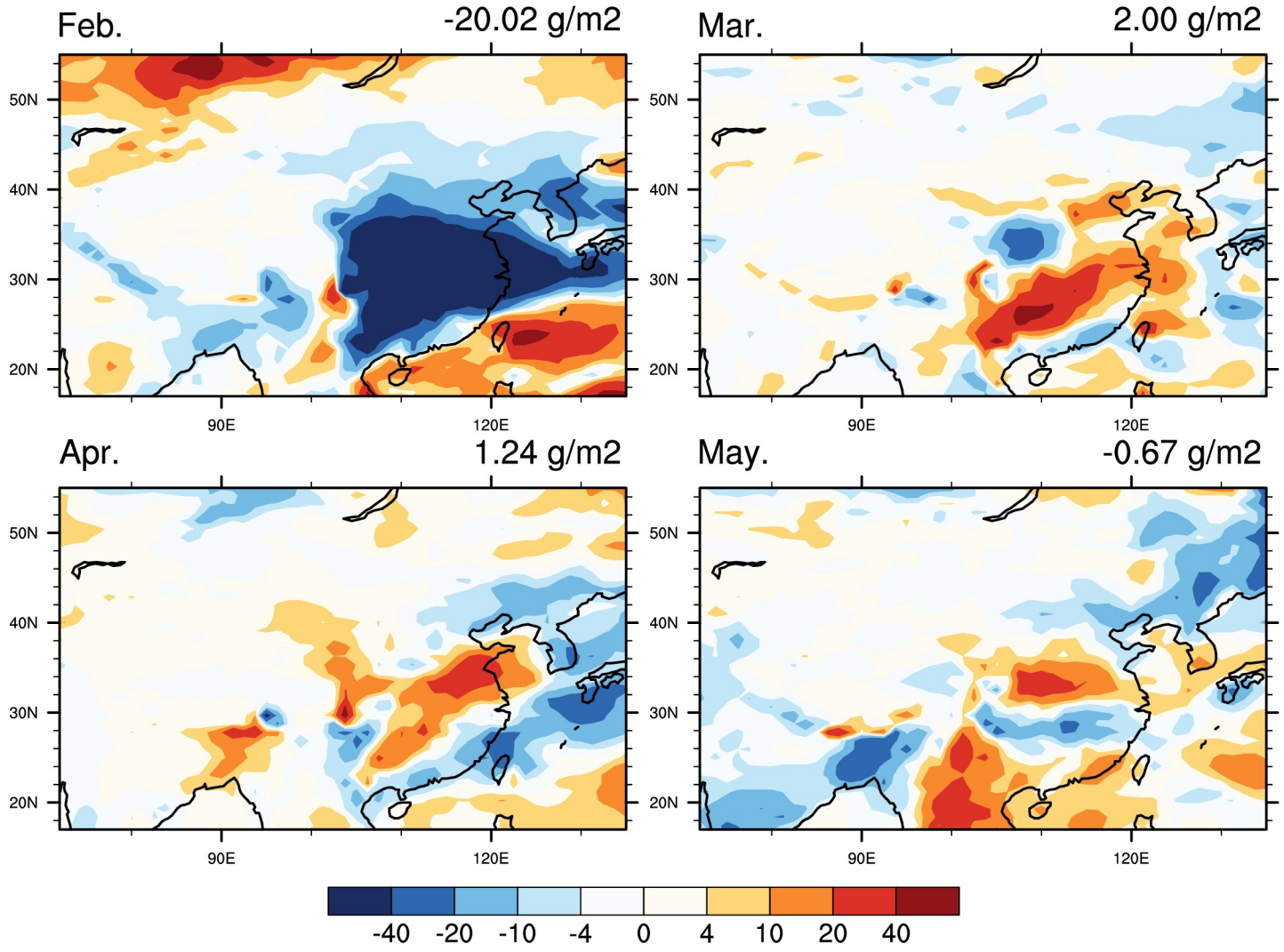


COVID

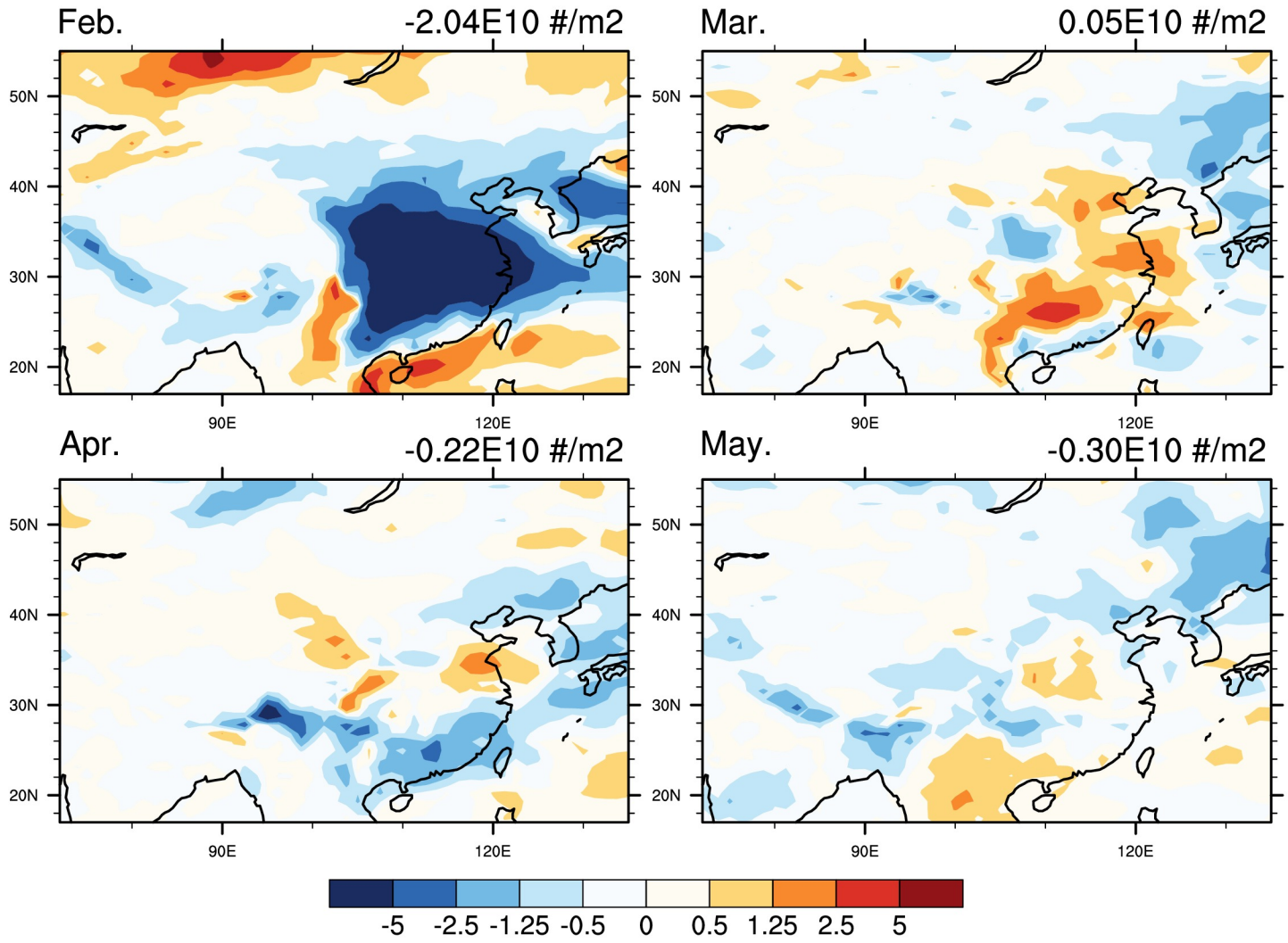




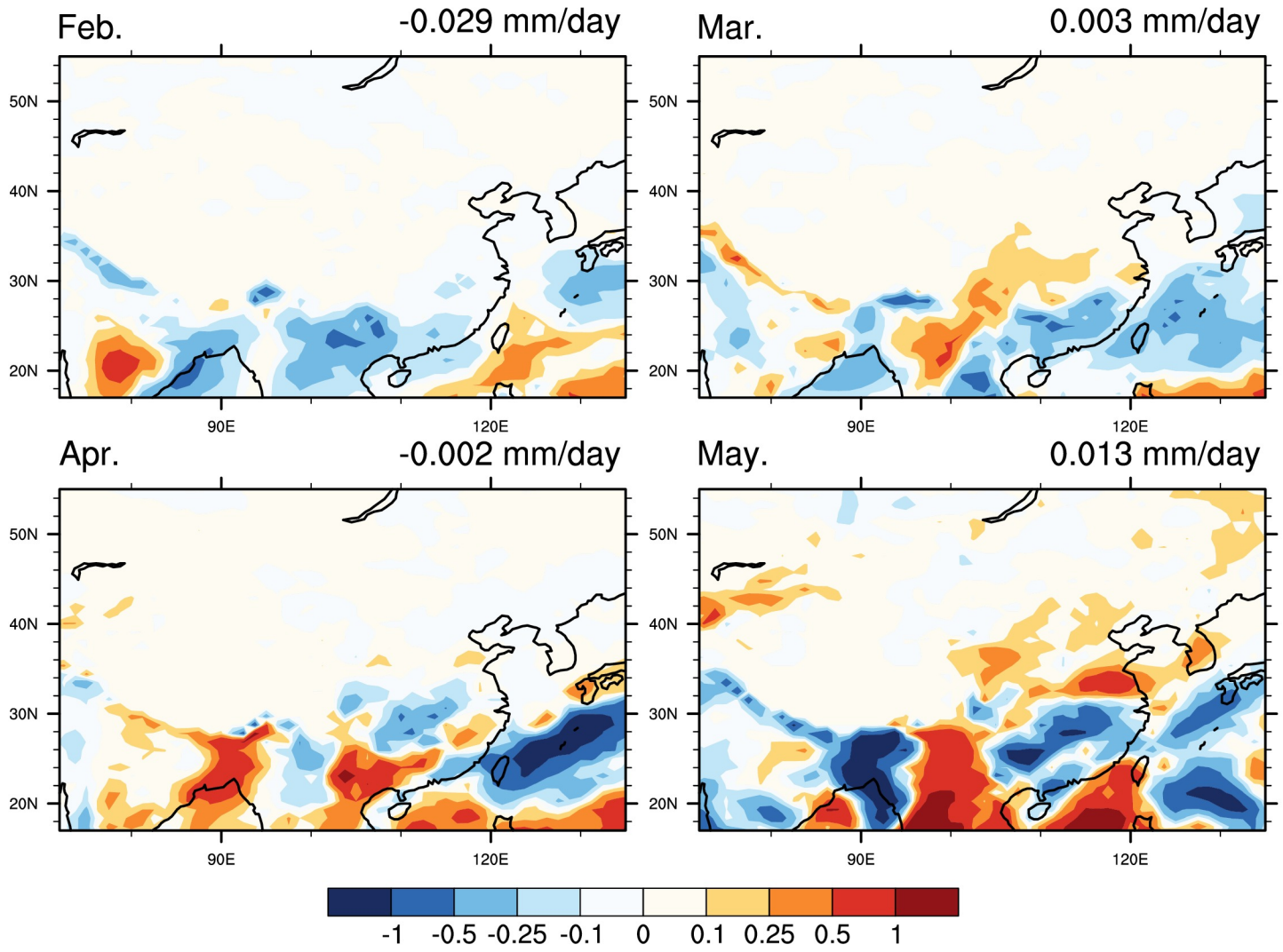
LWP


Feb.
-20.02 g/m2
Mar.
2.00 g/m2
Apr.
1.24 g/m2
May.
-0.67 g/m2
50N
40N
30N
20N
90E
120E
-40
-20
-10
-4
0
4
10
20
40

CDNC

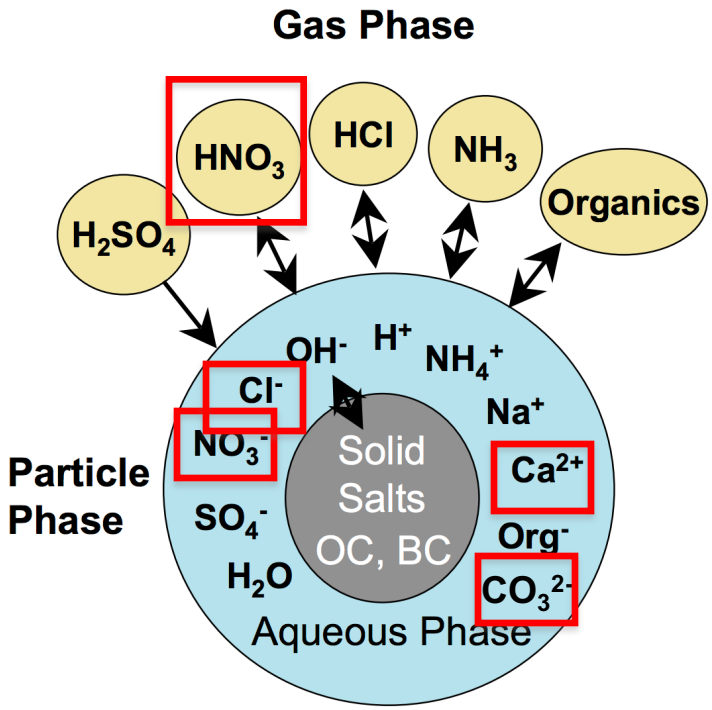

Feb.
-2.04E10 #/m2
Mar.
0.05E10 #/m2
Apr.
-0.22E10 #/m2
May.
-0.30E10 #/m2
50N
40N
30N
20N
90E
120E
-5
-2.5
-1.25
-0.5
0
0.5
1.25
2.5
5

PRECC


Feb.
-0.029 mm/day
Mar.
0.003 mm/day
Apr.
-0.002 mm/day
May.
0.013 mm/day
50N
40N
30N
20N
90E
120E
-1
-0.5
-0.25
-0.1
0
0.1
0.25
0.5
1

Nitrate aerosol in CAM6

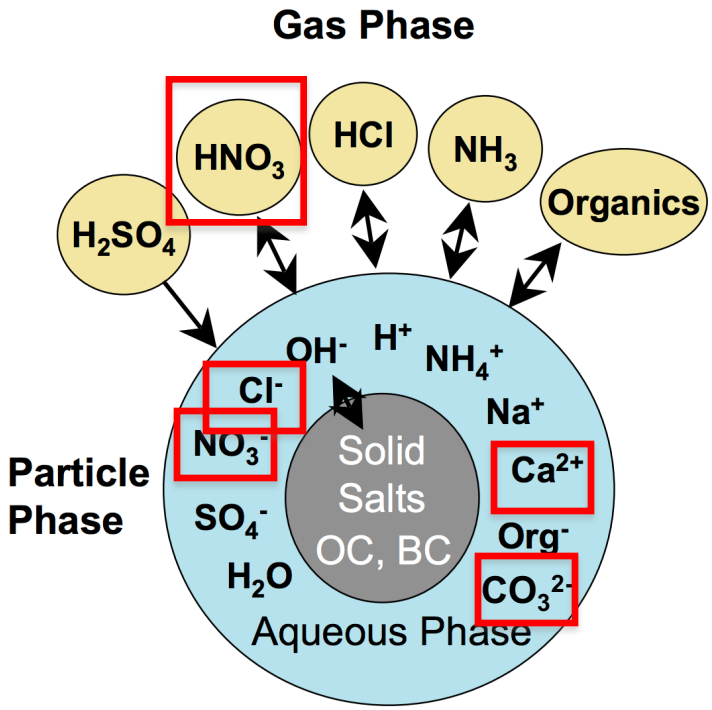
- In order to treat NO3 aerosol, Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) module [Zaveri et al., 2008] is coupled with MAM4 of CESM2[Lu, Liu, et al., under review].
- In the version of MAM coupled with MOSAIC, *gas-aerosol exchange* is treated by MOSAIC. The remaining processes are still treated by MAM



Source: presentation by Zaveri WRF tutorial, 2008

Nitrate aerosol in CAM6

No.	Species	Accum.	Aitken	coarse	Primary Carbon
1.	BC	X			X
2.	POM	X			X
3.	SOA X 5	X	X		
4.	SO4	X	X	X	
5.	NH4	X	X	X	
6.	NO3	X	X	X	
7.	Cl	X	X	X	
8.	Na	X	X	X	
9.	Dust	X		X	
10.	Ca	X		X	
11.	CO3	X		X	
Total		15	10	8	2



Source: presentation by Zaveri WRF tutorial, 2008