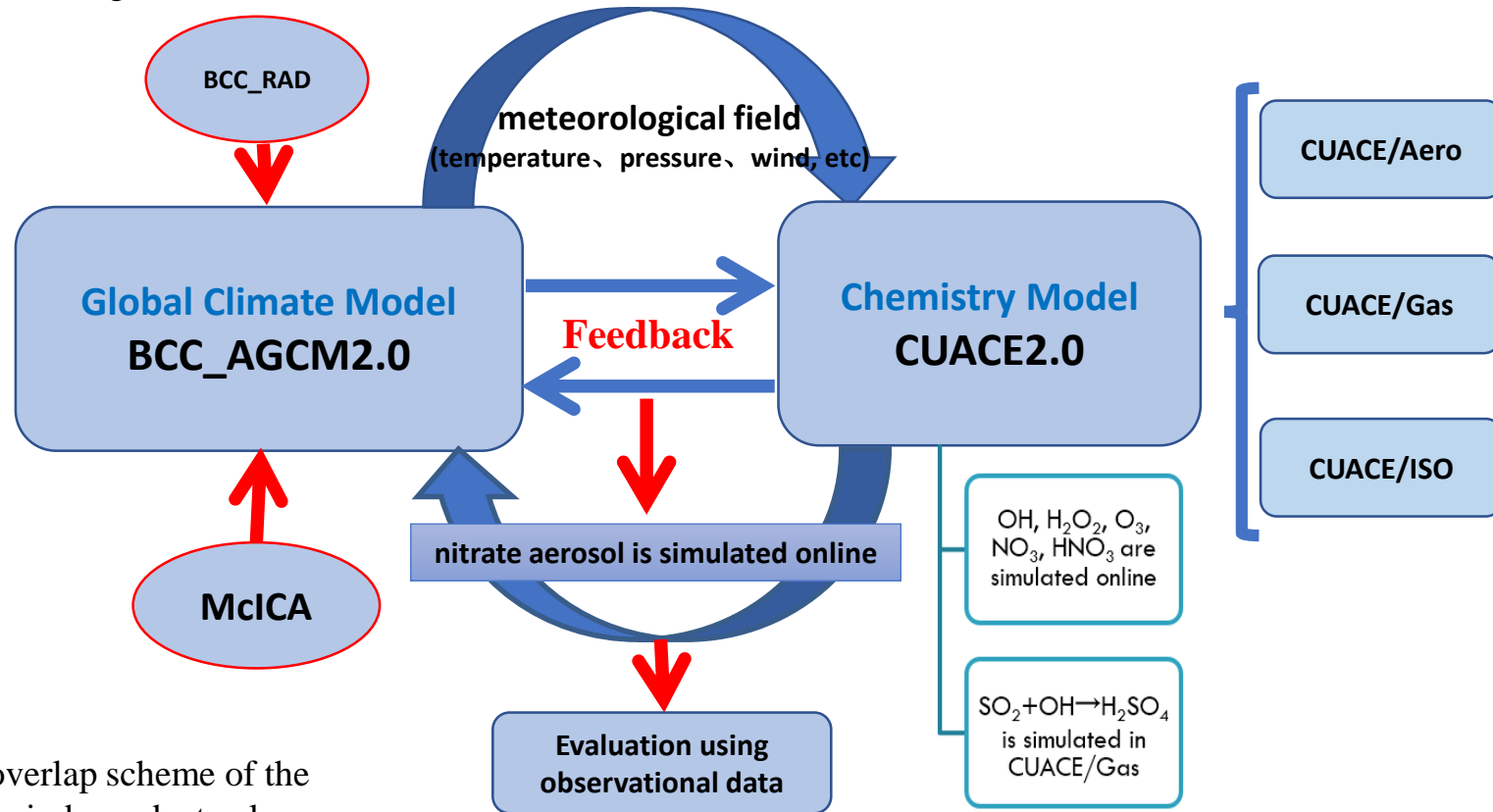


Model Description

new Beijing Climate Center radiation transfer model BCC_RAD (Zhang, 2016; Zhang et al., 2014)



CUACE/Aero was developed by Gong et al. (2002, 2003)

CUACE/Gas based on the RADM2 (Stockwell et al., 1990).

CUACE/ISO CUACE adopts ISORROPIA (West et al., 1998; Nenes et al., 1998, Yu et al., 2005)

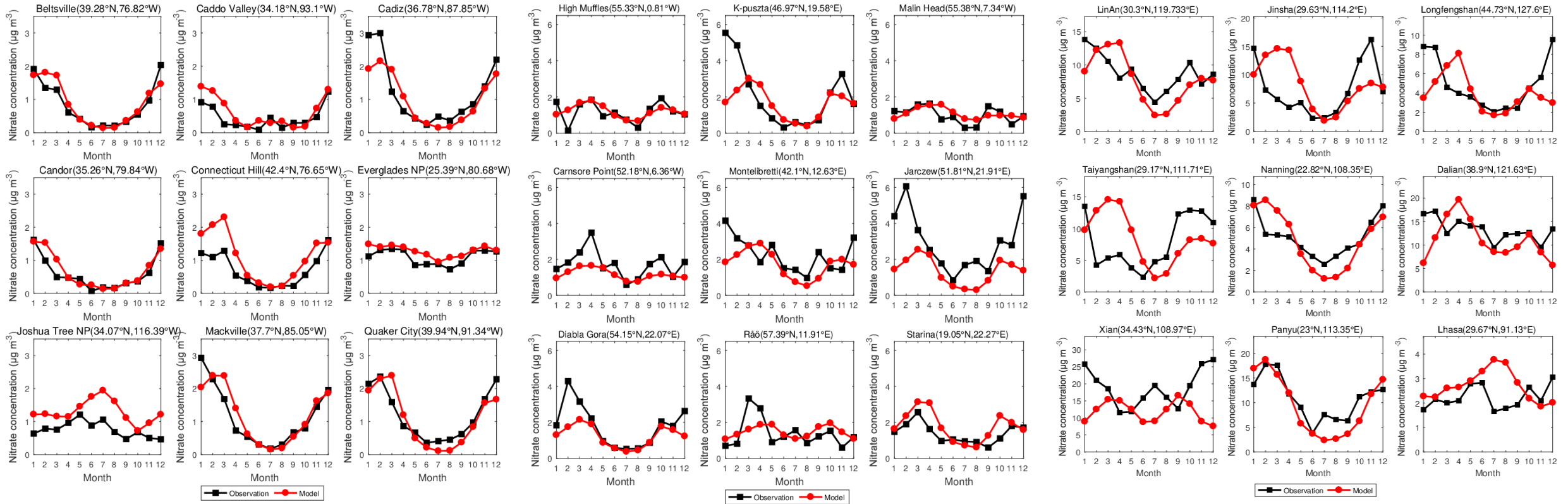
The cloud overlap scheme of the Monte Carlo independent column approximation (McICA) (Jing & Zhang, 2012, 2013; Pincus et al., 2003)

- a horizontal resolution of T42 (approximately $2.8^\circ \times 2.8^\circ$)
- 26 vertical levels, with a rigid lid at about 2.9 hPa. (Wu et al., 2010)

Validation of Simulations ($\mu\text{g m}^{-3}$)

Seasonal cycle of surface nitrate concentrations

—●— model —■— observation



CASTNET **America**

EMEP **Europe**

CAWNET **China**

<https://java.epa.gov/castnet/clearsession.do>

<http://www.emep.int/>

Zhang XY等., 2012

Validation of Simulations ($\mu\text{g m}^{-3}$)

Total Aerosol Optical Depth

(a) Total AOD of model simulation

0.1564

(b) Total AOD from MODIS

0.1772

(c) Model with (nitrate) -without

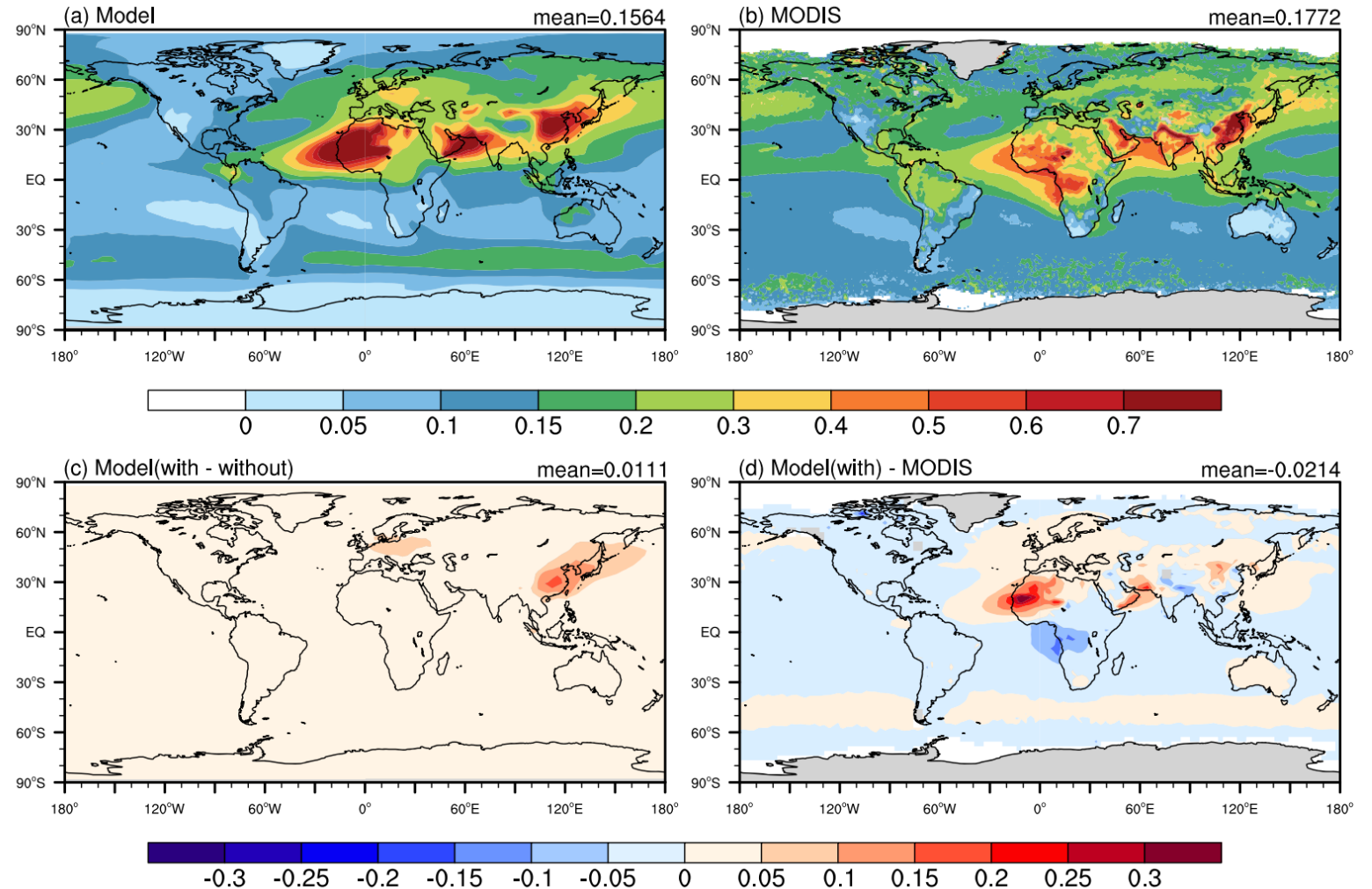
0.0111

(d) Model with (nitrate) -MODIS

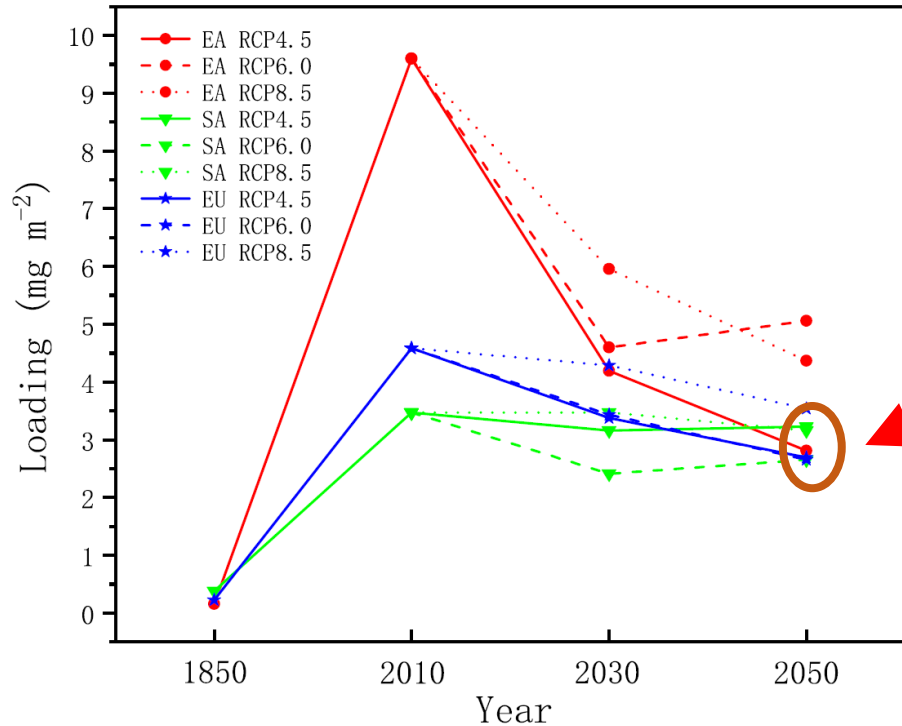
-0.0214

- The **high AOD** in the Sahara region of Africa was mainly due to **high dust emissions**.

- Calculation of AOD in the model does not consider **ammonium salts** and **secondary organic aerosols**, which lead to lower AOD values.



Time Evolution of Nitrate Loading (mg m^{-2})



The PD nitrate loading in EA (9.60 mg m^{-2}) is much higher than those in EU (4.58 mg m^{-2}) and SA (3.47 mg m^{-2}), but it shows a rapid decline in the future until 2050 (except RCP6.0).

The nitrate loading in **South Asia** is predicted to be 3.23 mg m^{-2} by 2050 under **RCP4.5**, exceeding the nitrate loading in East Asia (2.81 mg m^{-2}) and Europe (2.69 mg m^{-2}), making this region **the largest contributor to nitrate emissions** in this scenario.

Nitrate loading in **Europe** is predicted to **decline** under three RCP scenarios

EA: **East Asia** ($20\text{--}45^\circ\text{N}$, $100\text{--}145^\circ\text{E}$)

SA: **South Asia** (SA, $0\text{--}30^\circ\text{N}$, $10\text{--}100^\circ\text{E}$)

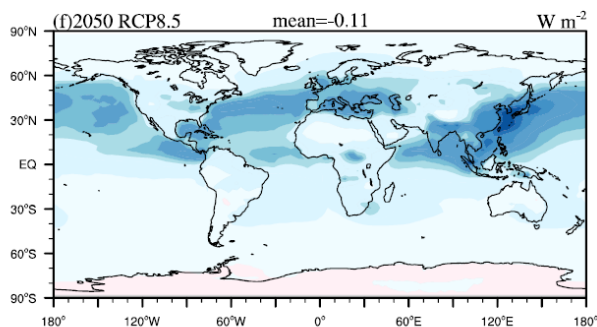
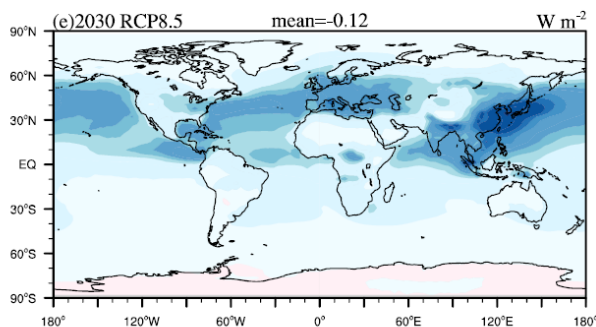
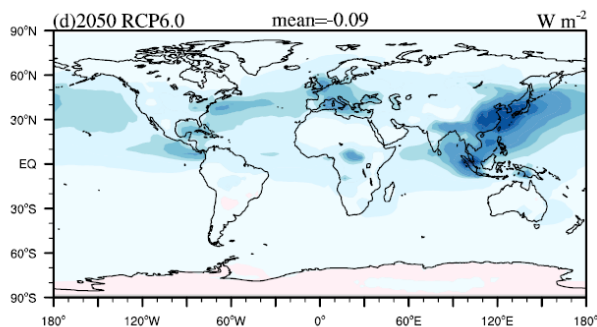
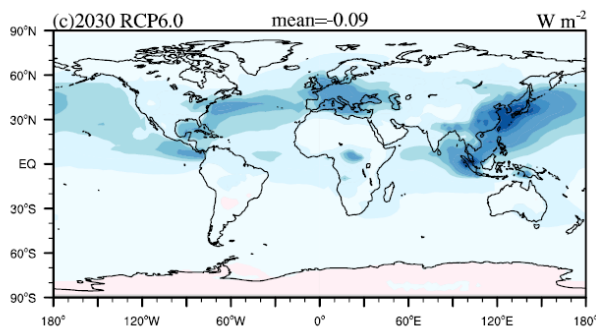
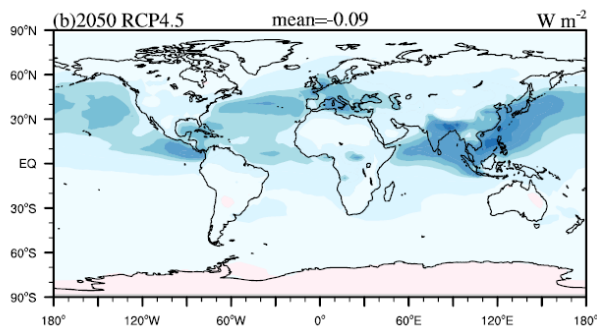
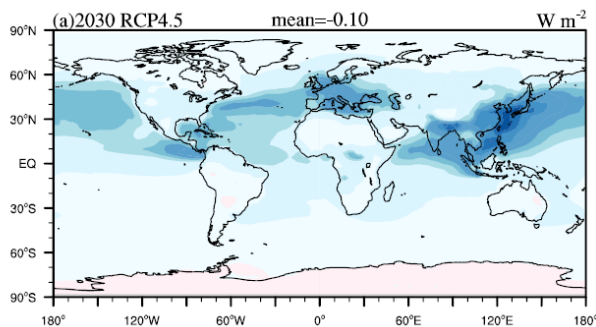
EU: **Europe** ($35\text{--}60^\circ\text{N}$, $0\text{--}45^\circ\text{E}$),

Nitrate DRF & ERF

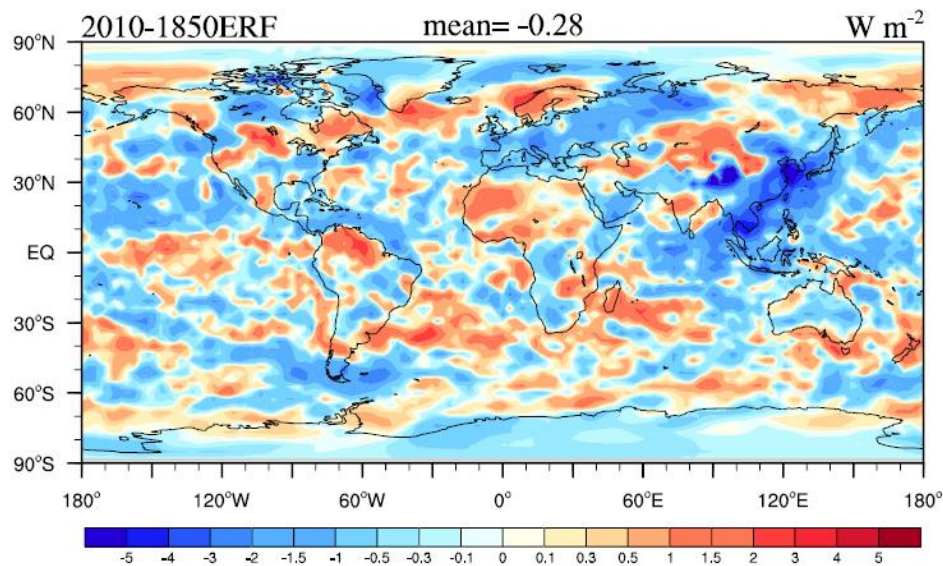
nitrate DRF in the

2030 future

2050



nitrate ERF in 2010 relative to 1850



nitrate ERF in the future

	2030	2050
RCP4.5	-0.17	-0.07
RCP6.0	-0.20	-0.18
RCP8.5	-0.24	-0.19