

Observed and simulated Ammonia concentration 8

IASI data and GEOS-Chem simulation

2020.12

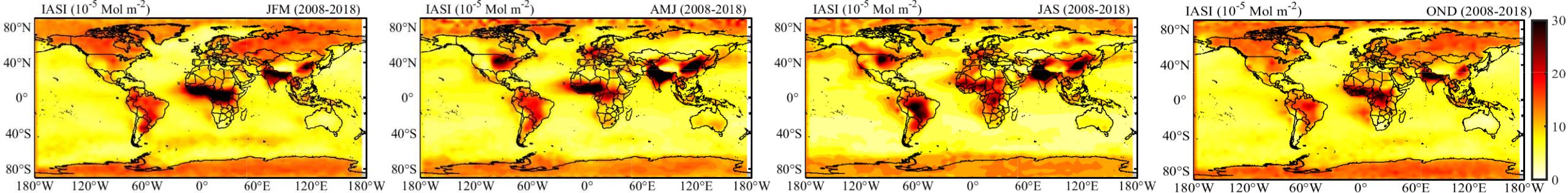
- Accomplished:
 - 1. annual concentration mean distribution of GEOS-Chem and IASI (add Ocean)
 - 2. monthly concentration trend distribution of GEOS-Chem and IASI (add Ocean)
 - 3. annual concentration change over the India-China, Africa and South America (land)
 - 4. filter IASI daily datasets (cloud coverage, skin temperature)
- Ammonia Data:
 - IASI total columns: Reanalyzed IASI/Metop-A
 - Daily, L2, $1^\circ \times 1^\circ$ (2008-2018)
 - GEOS-Chem simulation, $4^\circ \times 5^\circ$, daily
 - column concentration (2008-2018)
- meteorological input data
 - ECMWF ERA5 skin temperature, $0.25^\circ \times 0.25^\circ$
 - hourly data on single levels (2008-2018), 9:00/10:00
- Ongoing:
 - 1. consider regional simulation by high resolution ($1/2 \times 2/3$)

IASI daily data

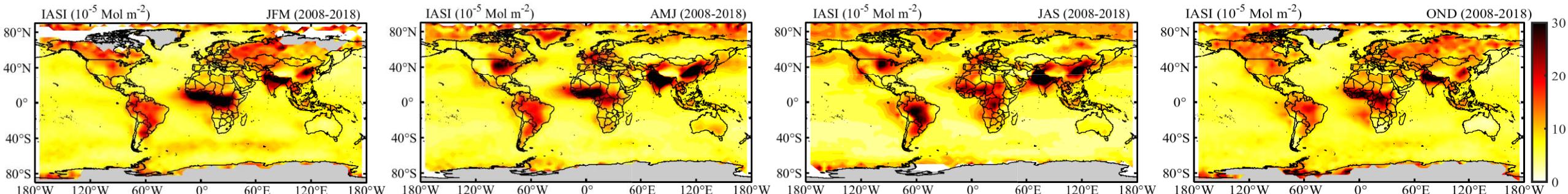
- Missing date (37 days):
 - 2008 (13 days): 1.17-18, 3.20-3.26, 12.10-11, 12.30-31
 - 2009 (3 days): 1.1, 1.23, 10.1
 - 2010 (5 days): 5.18, 8.31, 9.1-9.3
 - 2011 (2 days): 10.23-24
 - 2012 (0)
 - 2013 (2 days): 11.6-7
 - 2014 (7 days): 2.19-2.20, 9.9-9.13
 - 2015 (3 days): 4.10-4.12
 - 2016 (0)
 - 2017 (1 day): 6.7
 - 2018 (1 day): 12.31
- Filter
 - Cloud coverage: [0, 25%]
 - Skin temperature: > 263.15 K

IASI total column concentration of seasonal mean

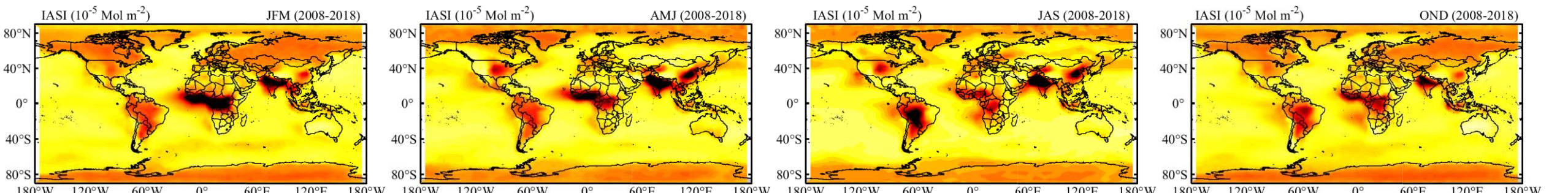
No filter (daily)



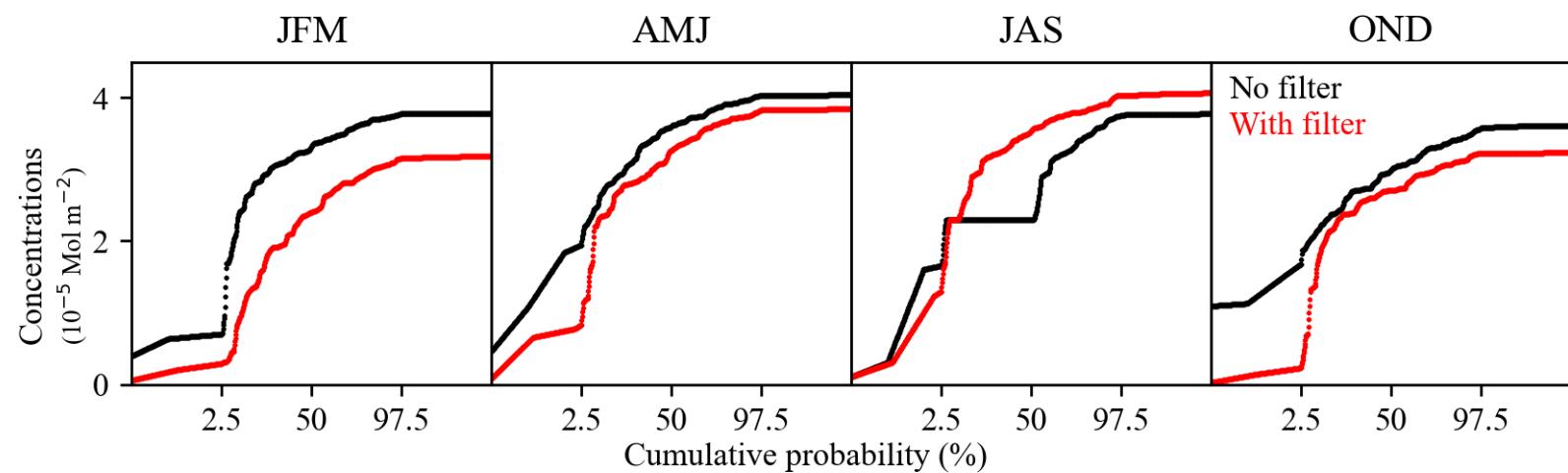
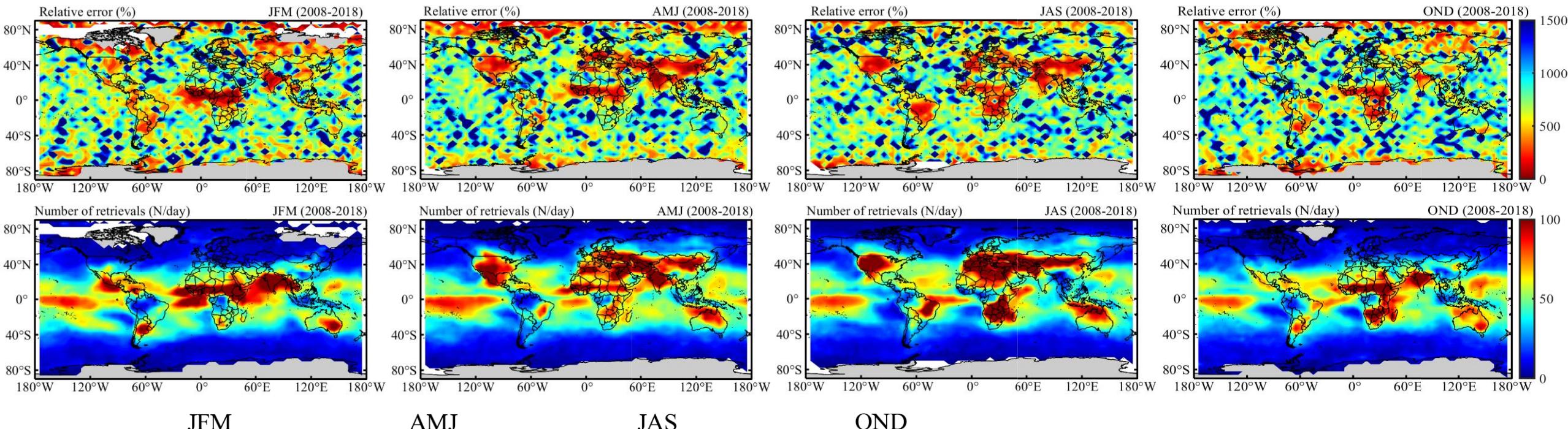
With filter (daily)



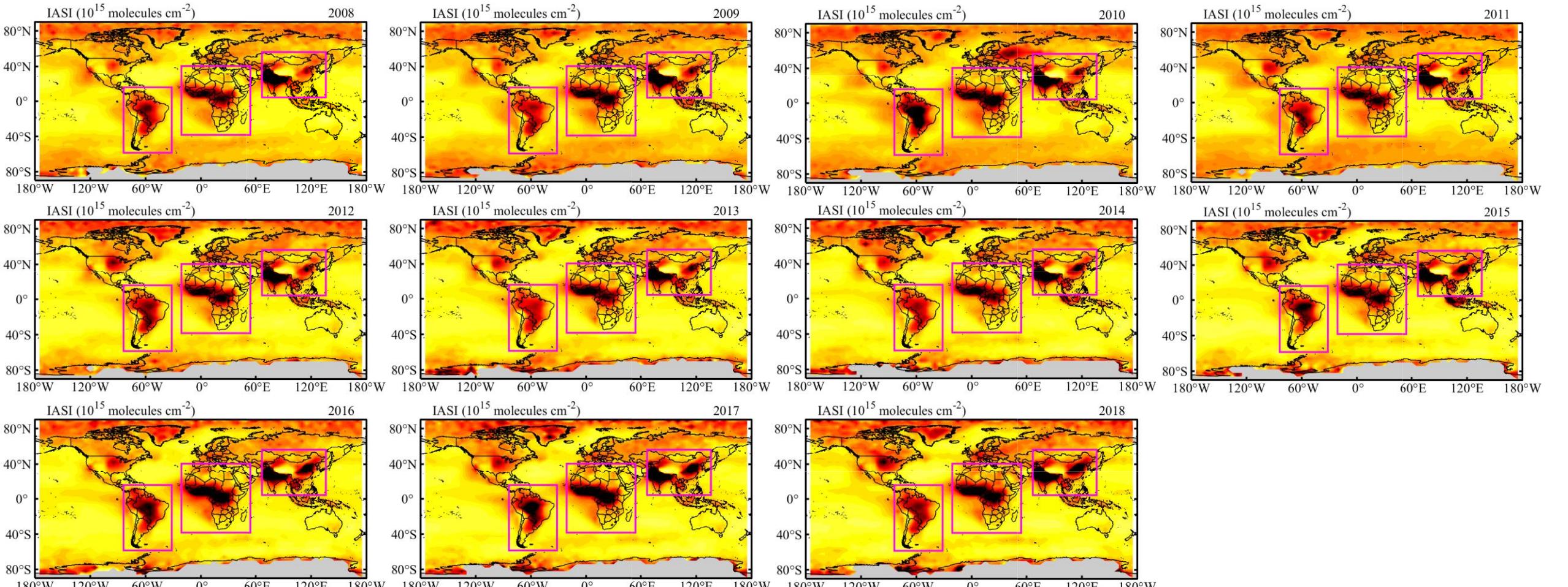
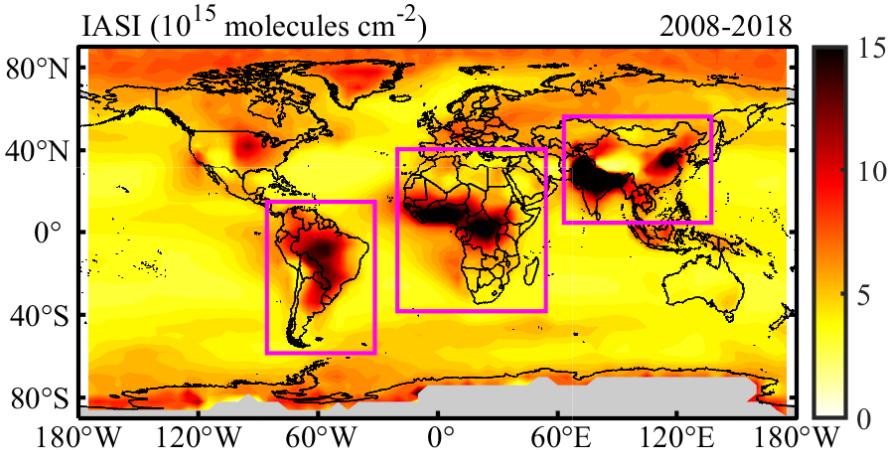
Monthly



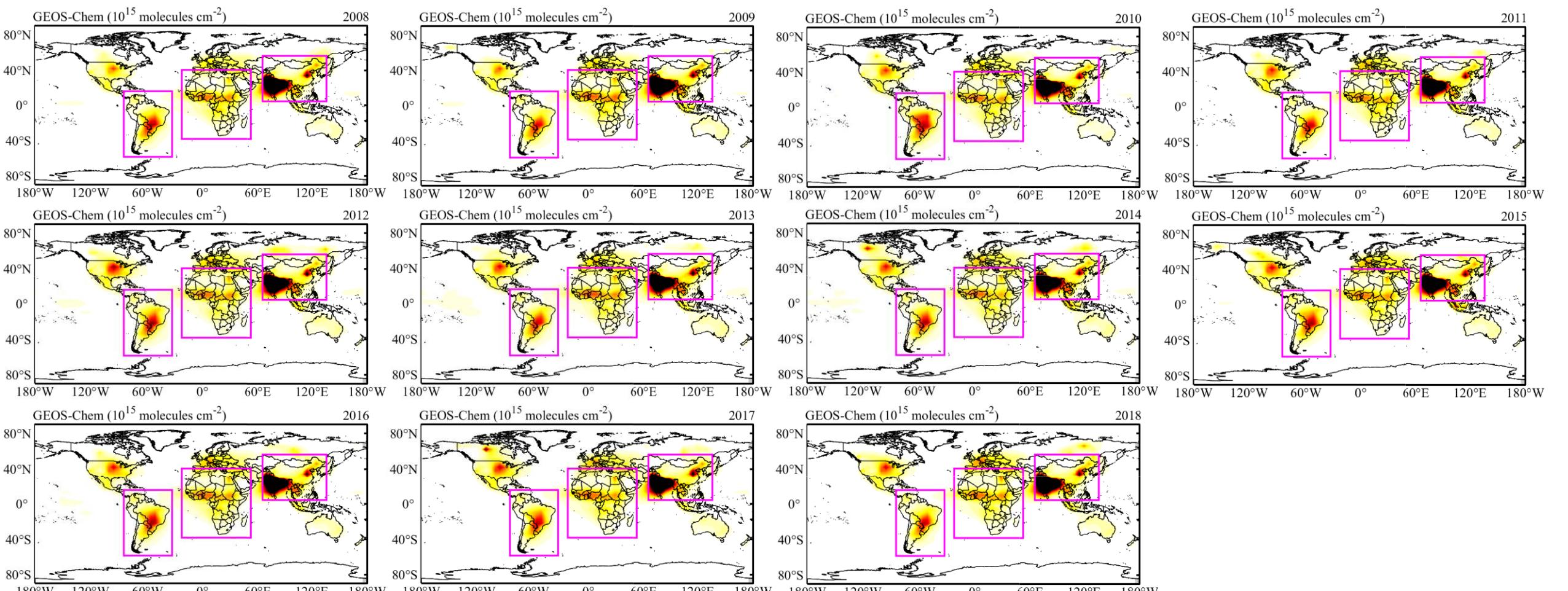
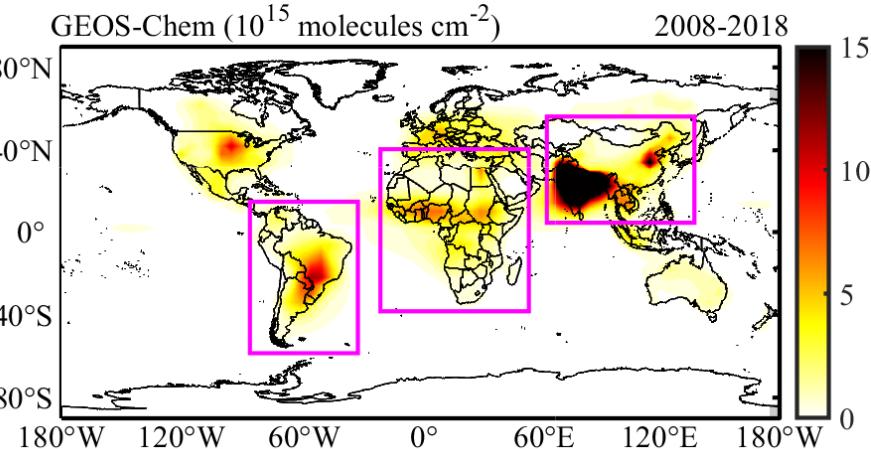
retrieval parameters and properties



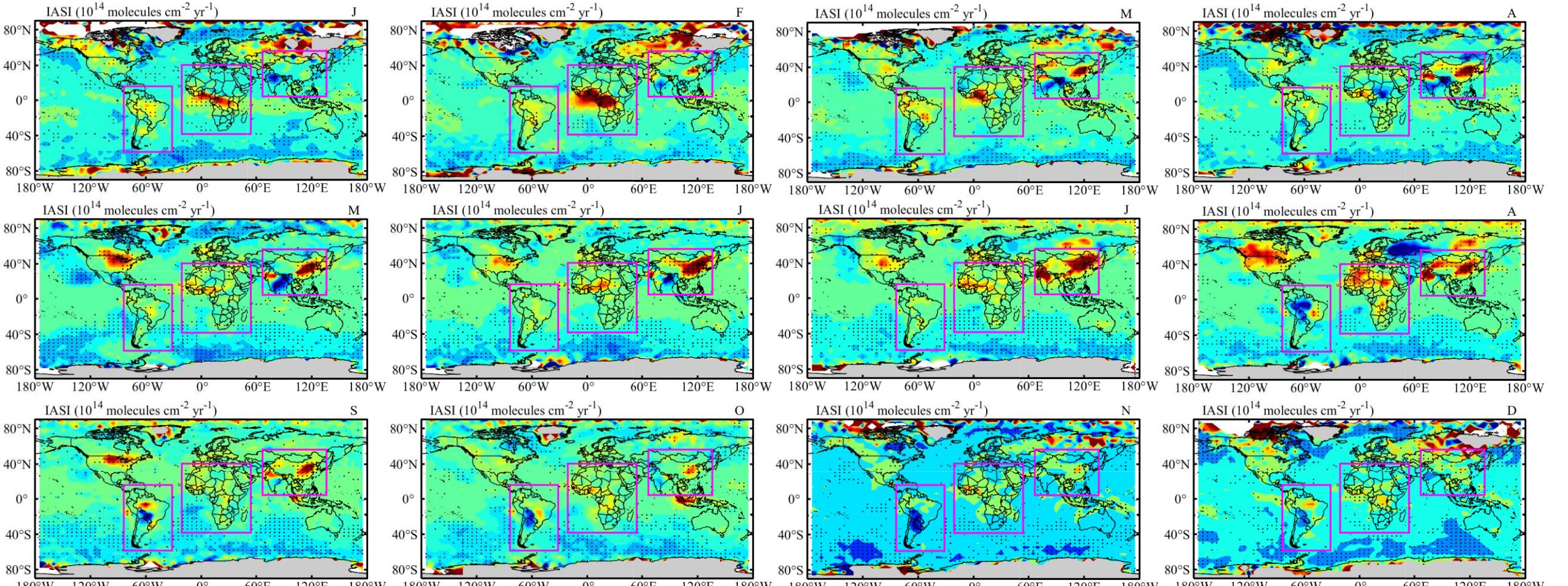
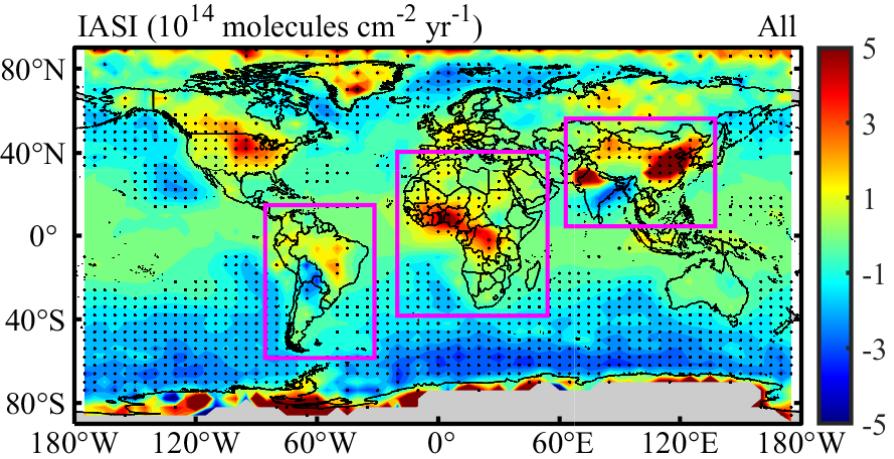
IASI mean in annual concentration distribution



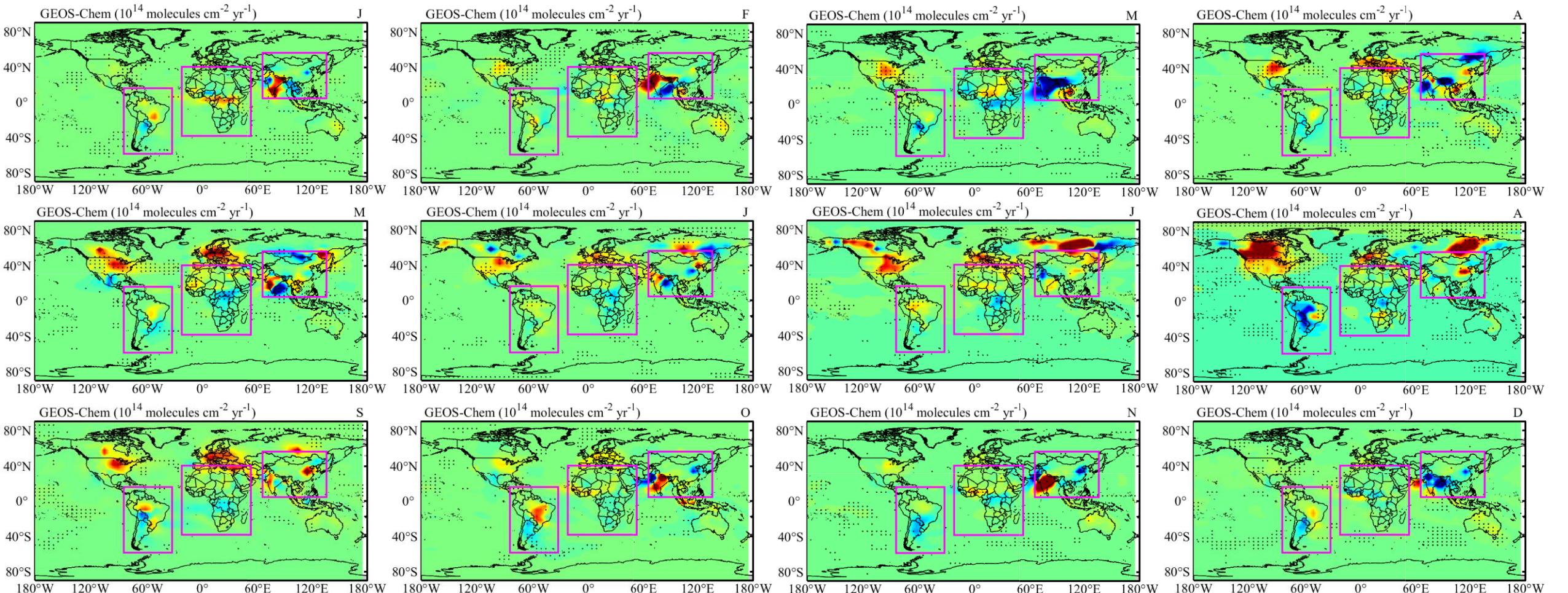
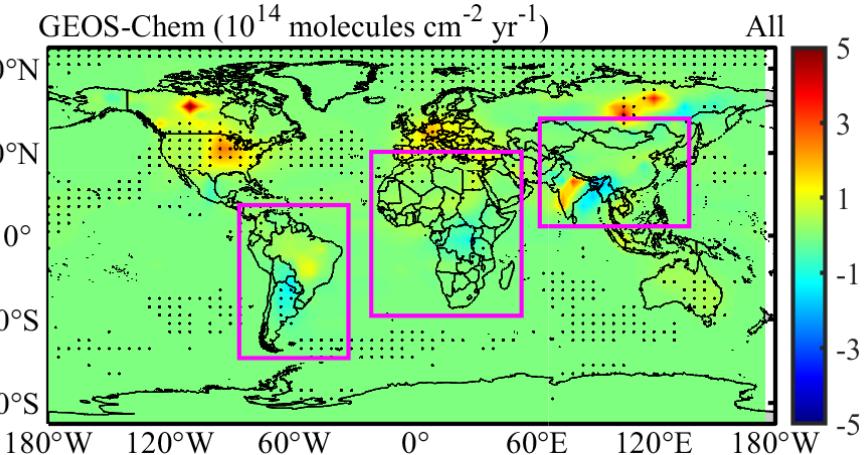
GEOS-Chem mean in annual concentration distribution



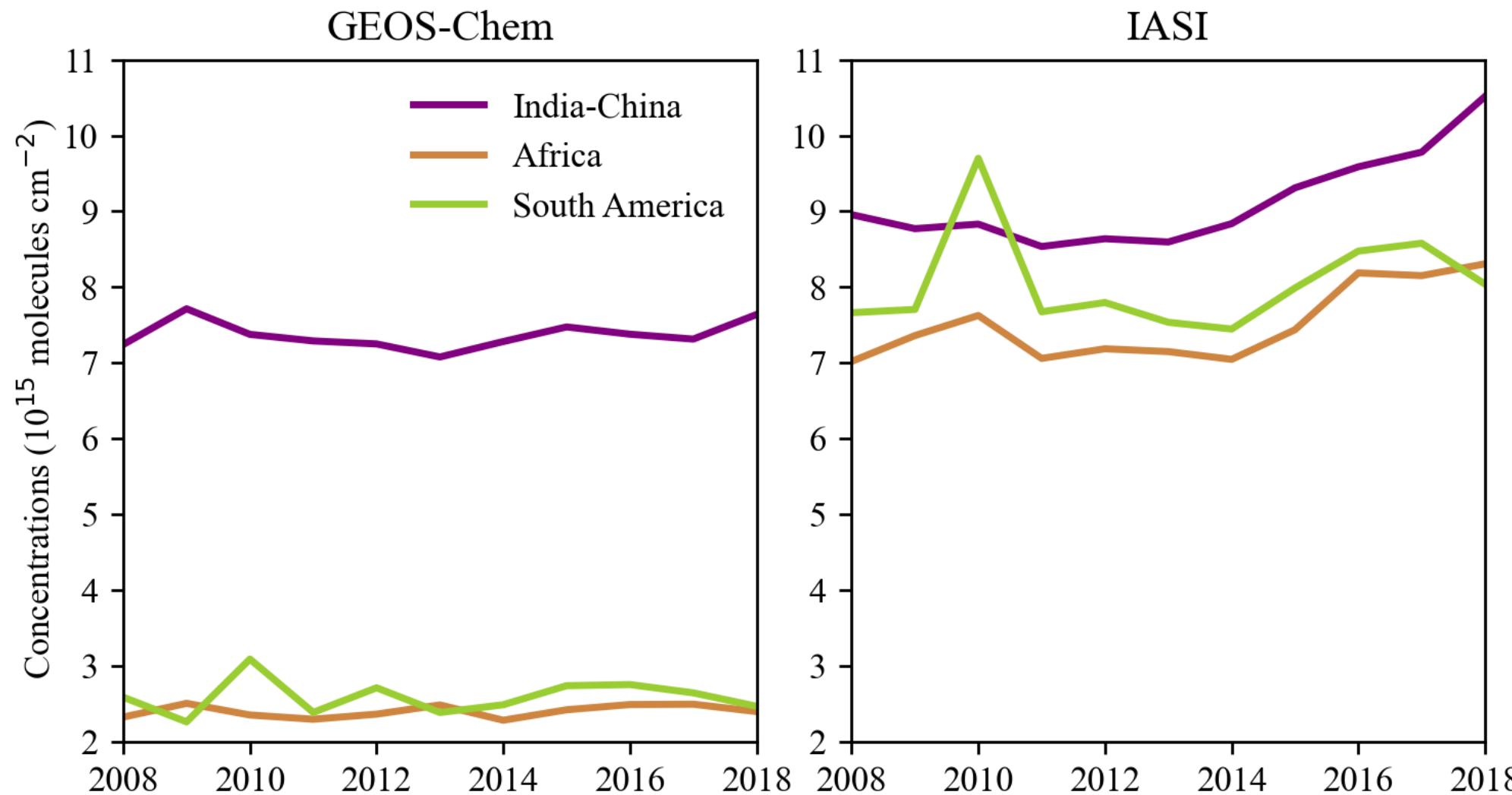
IASI trend in monthly concentration distribution



GEOS-Chem trend in monthly concentration distribution



Annual concentration mean of GEO-Chem and IASI over the India-China, Africa and South America



Aerosols and Clouds

- Radiative Forcing
 - radiative imbalance: greenhouse gases $\sim = +3.26 \text{ W m}^{-2}$
 - Solar Heating
 - Terrestrial InfraRed Cooling
 - no feedbacks
 - Direct forcing
 - Indirect forcing
 - Effective radiative forcing
 - Expand direct forcing to account for adjustments of atmospheric radiative changes
- Reflected solar radiation (107)
 - Clouds: 54
 - the surface: 51
 - Aerosols: 2

$$F = \Delta R = \Delta \tau_a \left[\frac{\partial R}{\partial \tau_a} \right] + \Delta \ln N_d \left[\frac{\partial R}{\partial \ln N_d} \right]_{L,C}$$

L = liquid water path
C = cloud fraction

Direct forcing Indirect forcing

$$\mathcal{E} = \Delta \tau_a \left[\frac{\partial R}{\partial \tau_a} \right] + \Delta \tau_a \left[\frac{dR}{dR_{atm}} \right] \left[\frac{dR_{atm}}{d\tau_a} \right] + \Delta \ln N_d \left[\frac{dR}{d\ln N_d} \right]$$

Aerosols and Clouds

- aerosol effects on clouds:
 - cloud condensation nuclei: control the number concentrations
 - affect the size of hydrometeors
 - affect the precipitation
- Cloud effects on aerosols
 - Heterogeneous reactions: a source of aerosol mass
 - Precipitation: the primary sink of aerosols
- Uncertainty analysis based on global 3-D model study
 - Model-predicted range in quantities
 - Establish the effects of uncertainty in
 - Size distribution
 - Aerosol mass concentrations
 - Treatment of updraft velocity
 - RH and cloud field

Aerosols and Clouds

- Blackbody emission: $E = \epsilon \sigma T^4$
- Planetary energy balance
 - Absorbed solar energy flux:
 - $\alpha_p = 0.29$, $S_0 = 1360 \text{ W m}^{-2}$
 - $Q_{abs} = 241 \text{ W m}^{-2}$
 - $T_e = 255 \text{ K}$
 - Green house effect G:
$$Q_{abs} = \frac{S_0}{4} (1 - \alpha_p)$$
$$\frac{S_0}{4} (1 - \alpha_p) = \sigma T_e^4$$
- Climate sensitivity:
 - General: the magnitude of $G = \sigma T_s^4 - \sigma T_e^4$ relative to a measure of forcing that initiates the change
 - Certain climate modeling communities: the equilibrium change in global in response to a doubling of CO₂
- equilibrium climate: TOA net energy flux is 0
- feedback mechanism: implicate the magnitude of equilibrium climate response to forcing
 - Positive: increase
 - Negative: decrease

total column concentration

- $\Omega = \sum_{i=1}^{47} c_i \times rho_i \times h_i \times k$
 - Ω : total column concentration, [mol/m²]
 - c_i : 'IJ-AVG-\$_NH3', mixing ratio for each level, [ppbv] to [v/v] (*1E-9)
 - rho_i : 'TIME-SER_AIRDEN', air density for each level, [molecules/cm³]
 - h_i : 'BXHGHT-\$_BXHEIGHT', grid box height for each level, [m] to [cm] (*100)
 - k : 1/6.02214179E19, multiplication factor to convert [molecules/cm²] to [mol/m²]

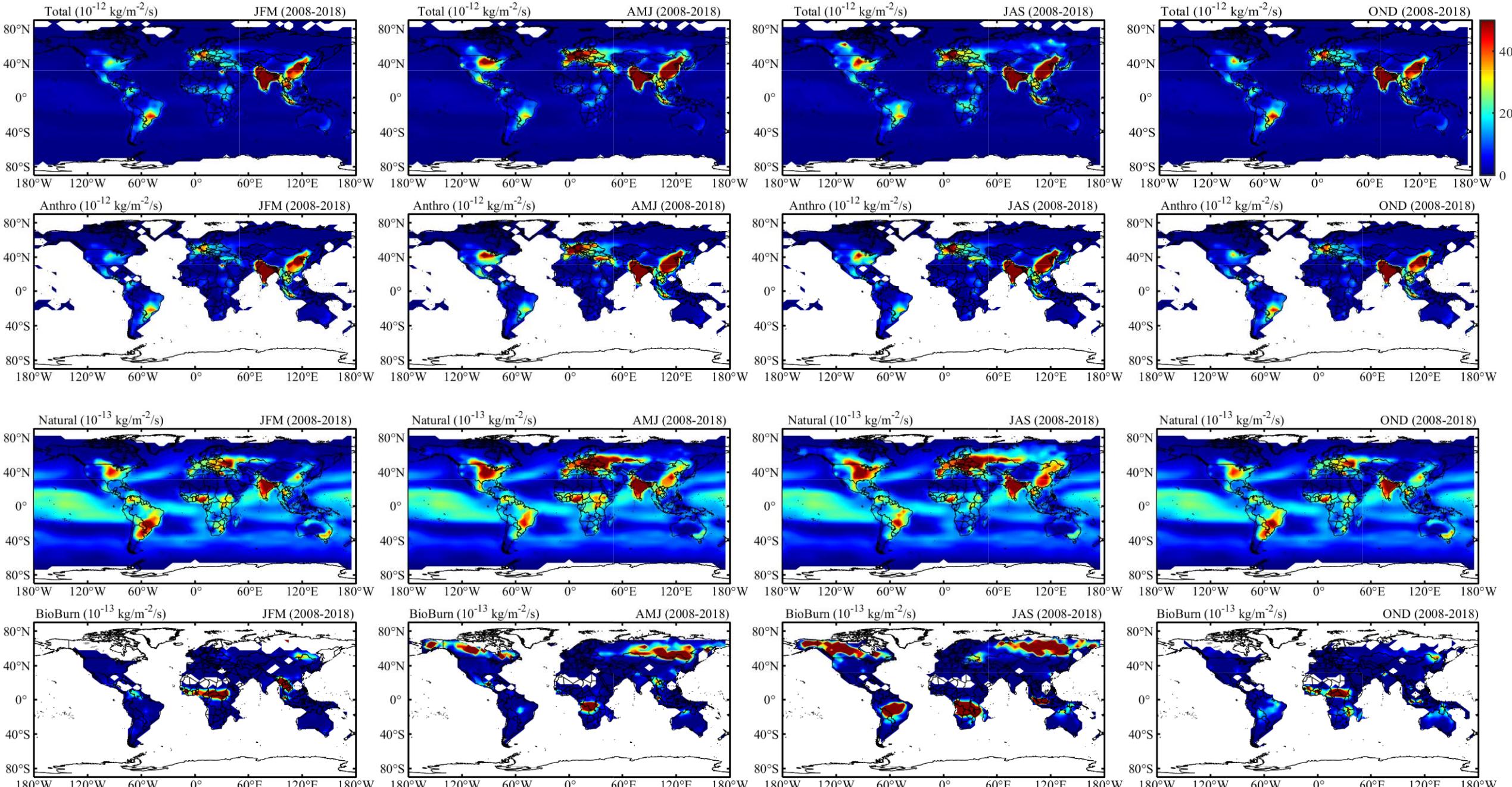
Regrid 180x360 to 46x72

- Latitude: 46 degrees
 - 88°-90°: 2x5 to 1x1, 2 degrees
 - 0-88°: 4x5 to 1x1, 44 degrees
- Method:
 - Step1: mask ocean, set as NaN
 - Step2: calculate mean value in each upscaling grid

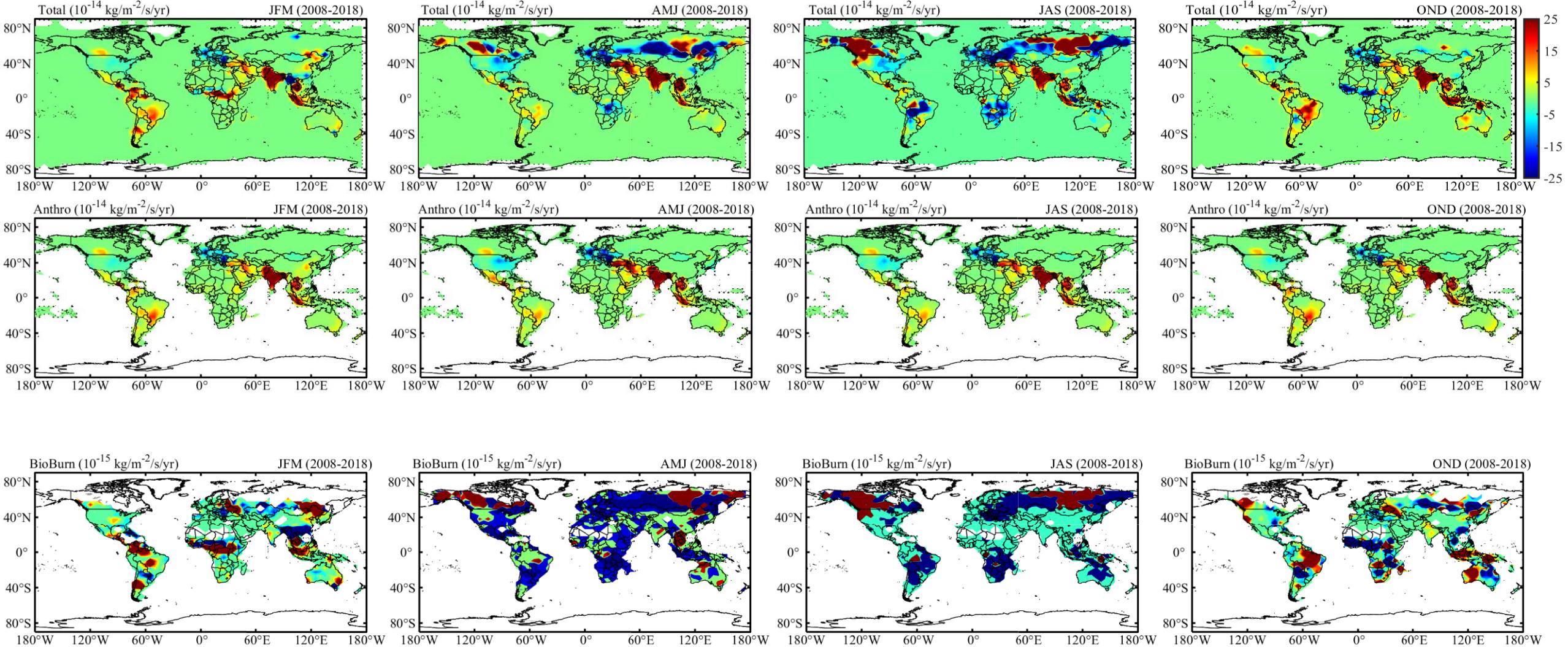
emissions

- Anthropogenic
 - APEI: Historical Canadian emissions (1990-2014)
 - NEI2011_MONMEAN: US emissions
 - MIX: Asian anthropogenic emissions
 - DICE_Africa: emissions from inefficient combustion over Africa
 - CEDS: Global anthropogenic emissions
 - POET_EOH: aldehydes and alcohols
 - TZOMPASOSA: global fossil fuel and biofuel emissions of C2H6 for 2010
 - XIAO_C3H8: C2H6 and C3H8
 - AFCID: PM2.5 dust emission
- Natural
 - GEIA_NH3: 1990 (obsolete now)
 - SEABIRD_DECAYING_PLANTS: the oceanic emissions of acetaldehyde
 - NH3: the Arctic seabird
- Biomass burning
 - GFED4: biomass burning emissions
- Ship
 - CEDS_SHIP
 - SHIP

Seasonal emission mean spatial distribution (monthly)

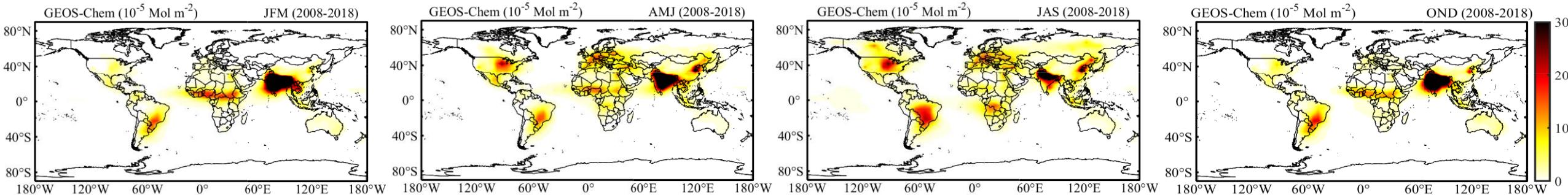


Seasonal emission trend spatial distribution (monthly)

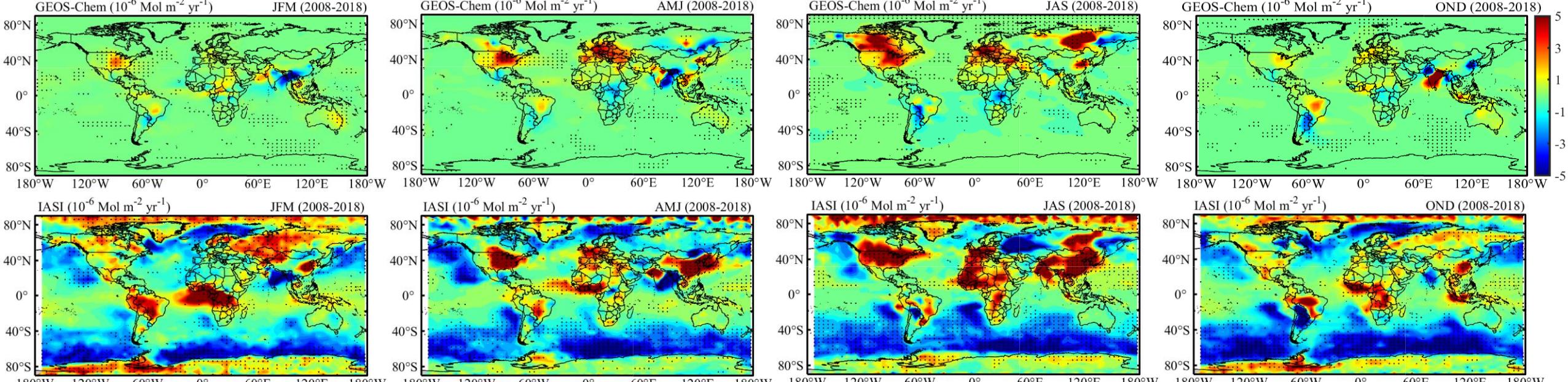


Seasonal concentration mean and trend spatial distribution (monthly)

Mean

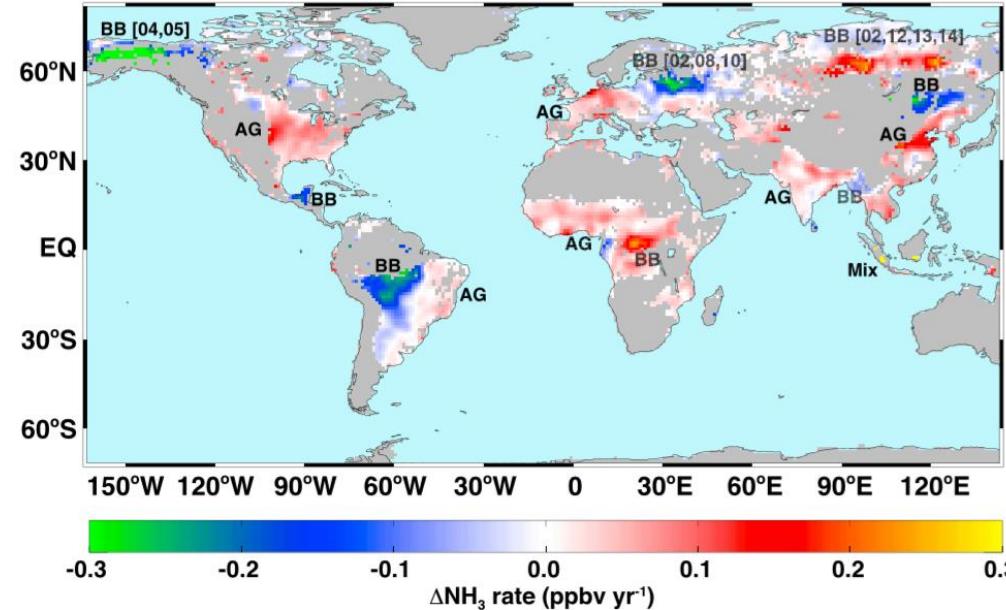


Trend



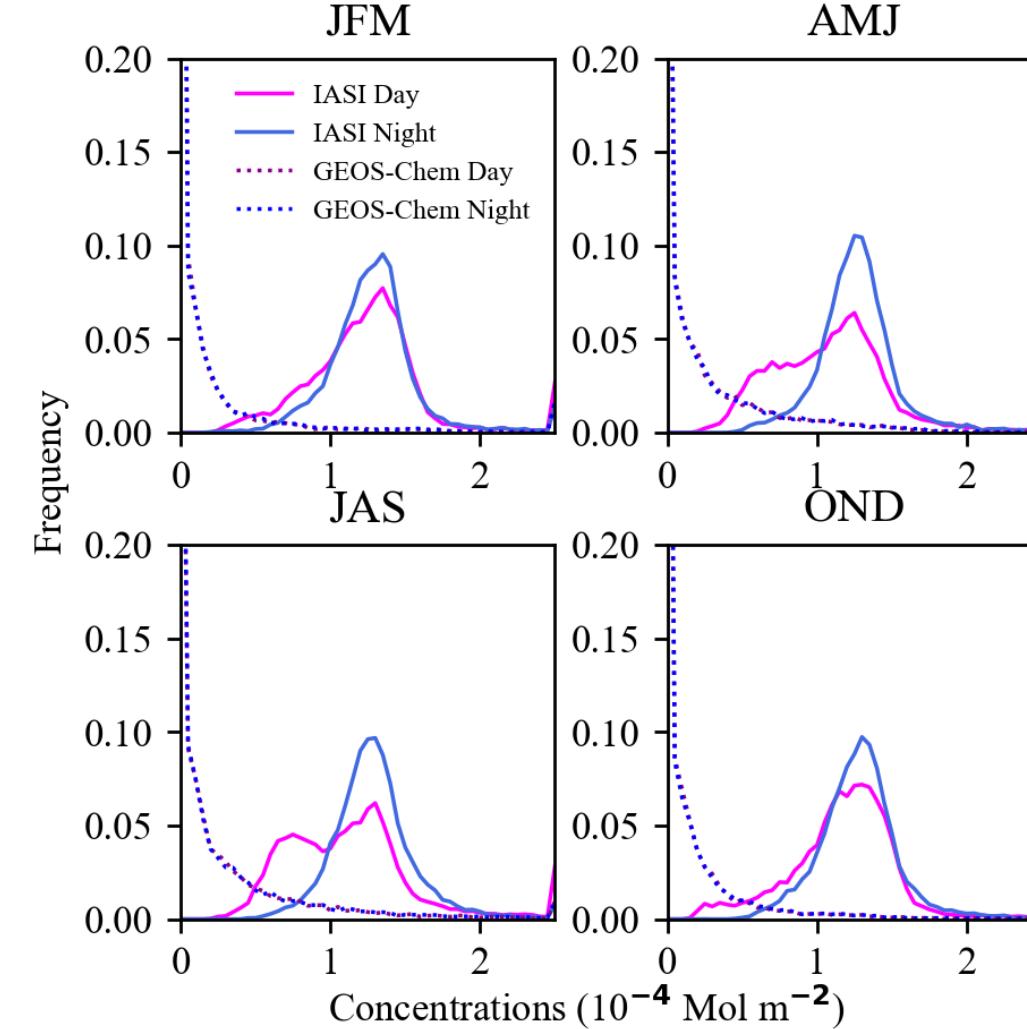
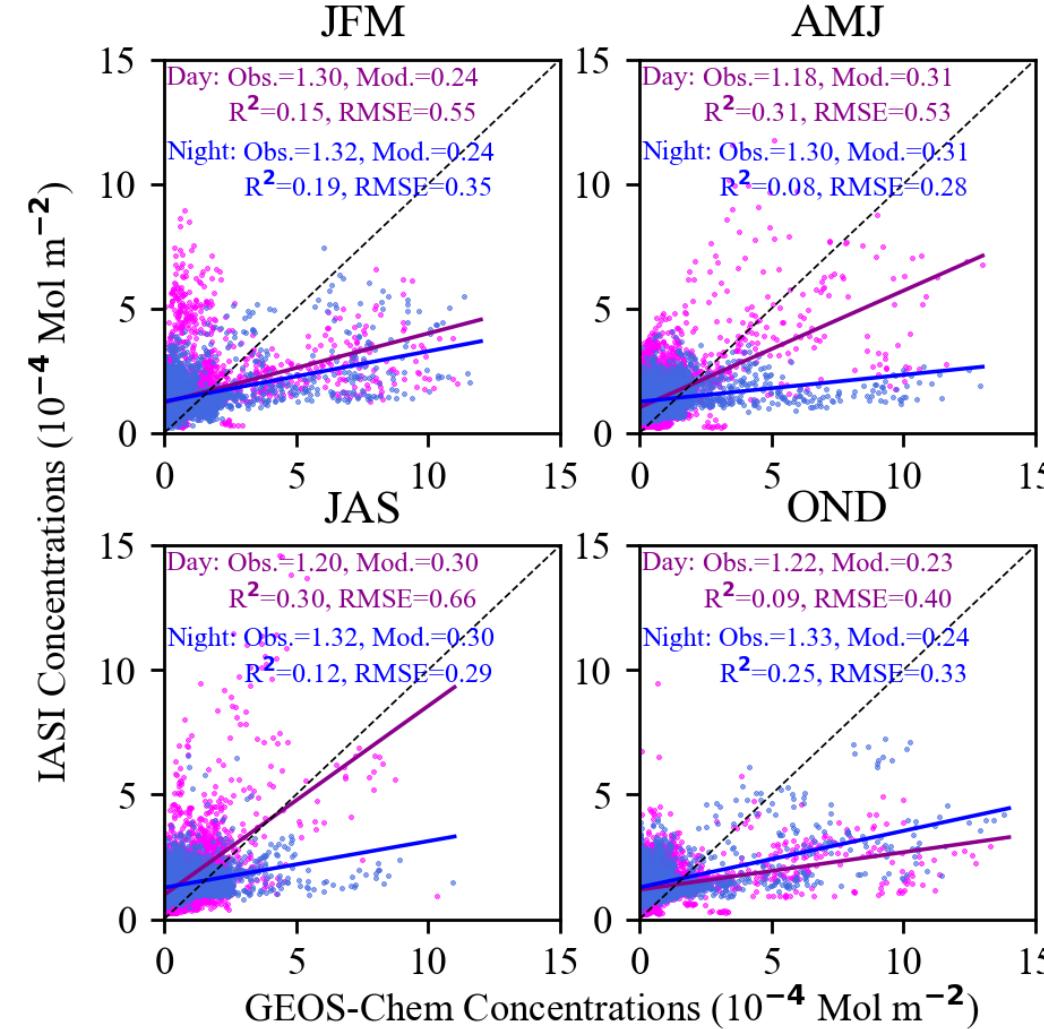
Increased atmospheric ammonia over the world's major agricultural areas detected from space

- provides evidence of substantial increases in atmospheric ammonia (NH_3) concentrations (14 year) over several of the world's major agricultural regions
- The rate of change of NH_3 volume mixing ratio (VMR) in parts-per-billion by volume (ppbv) per year computed
 - BB: biomass burning
 - AG: agricultural

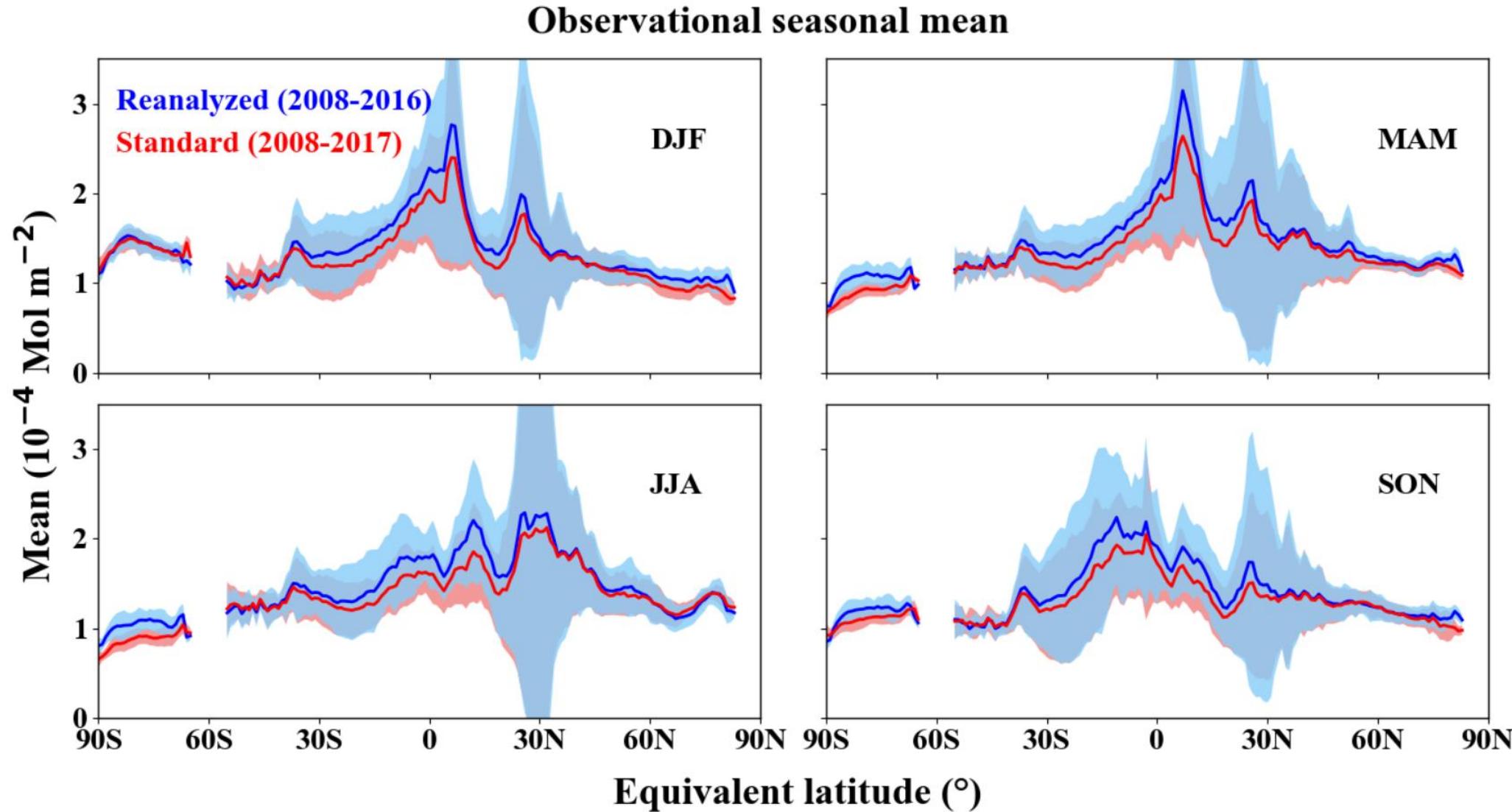


(Warner et al, 2017)

Comparison of GEOS-Chem and IASI total column concentrations



Seasonal mean of Land for equivalent latitude (within 1 sigma standard deviations)



End