

Ammonia concentration observation and modeling simulation 4

IASI data and GEOS-Chem model

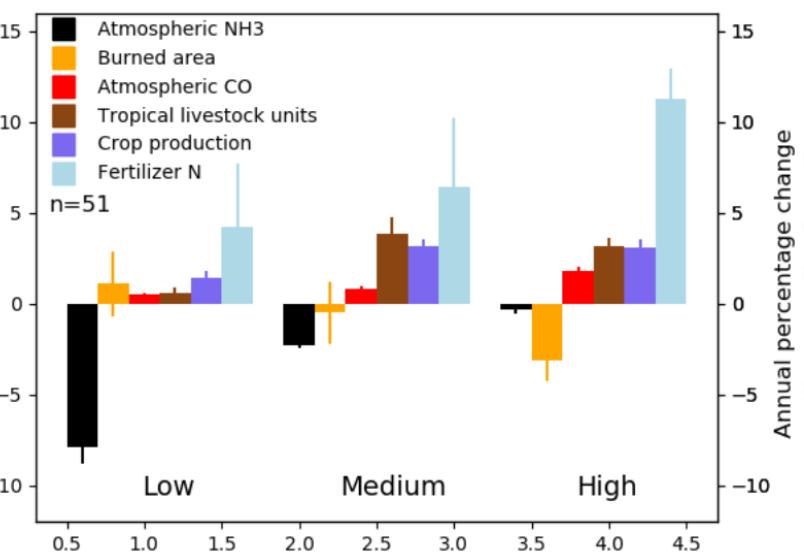
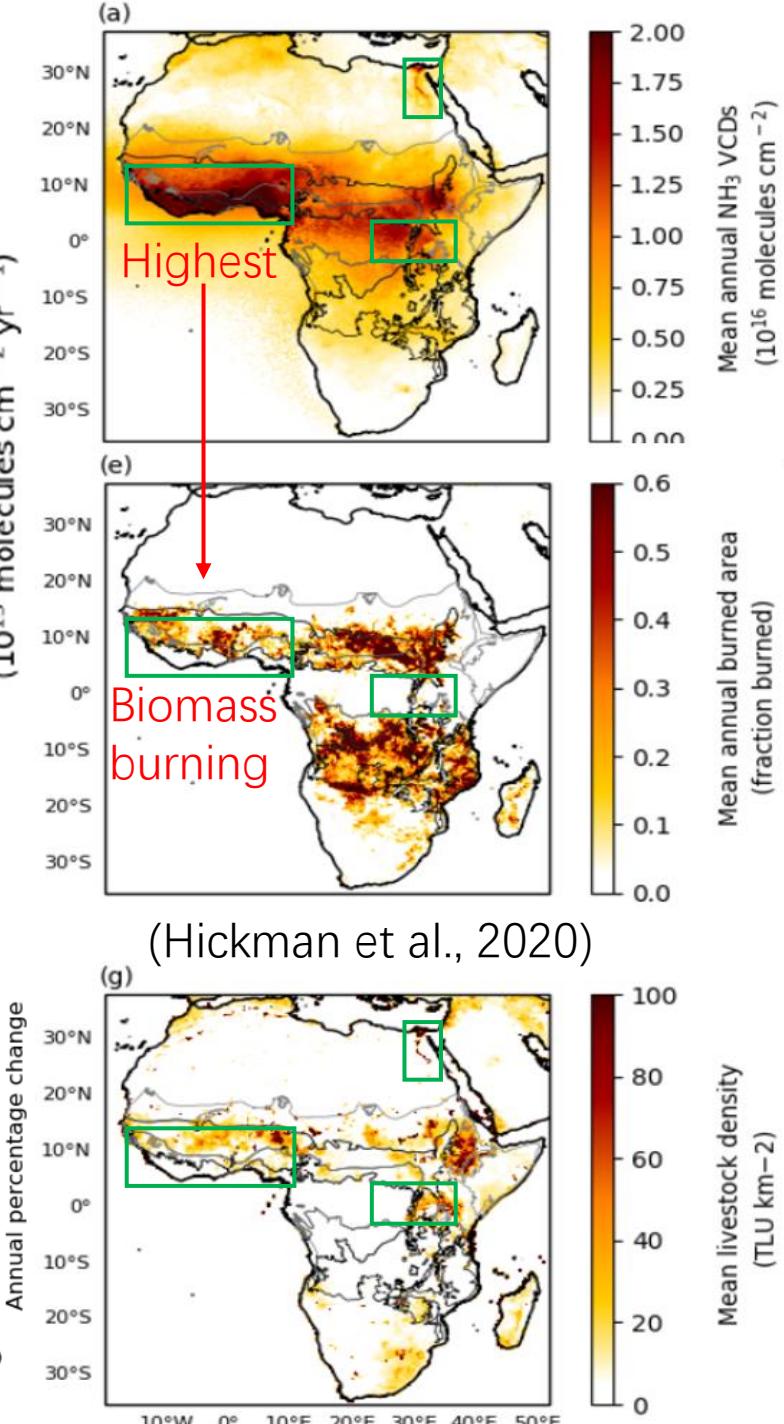
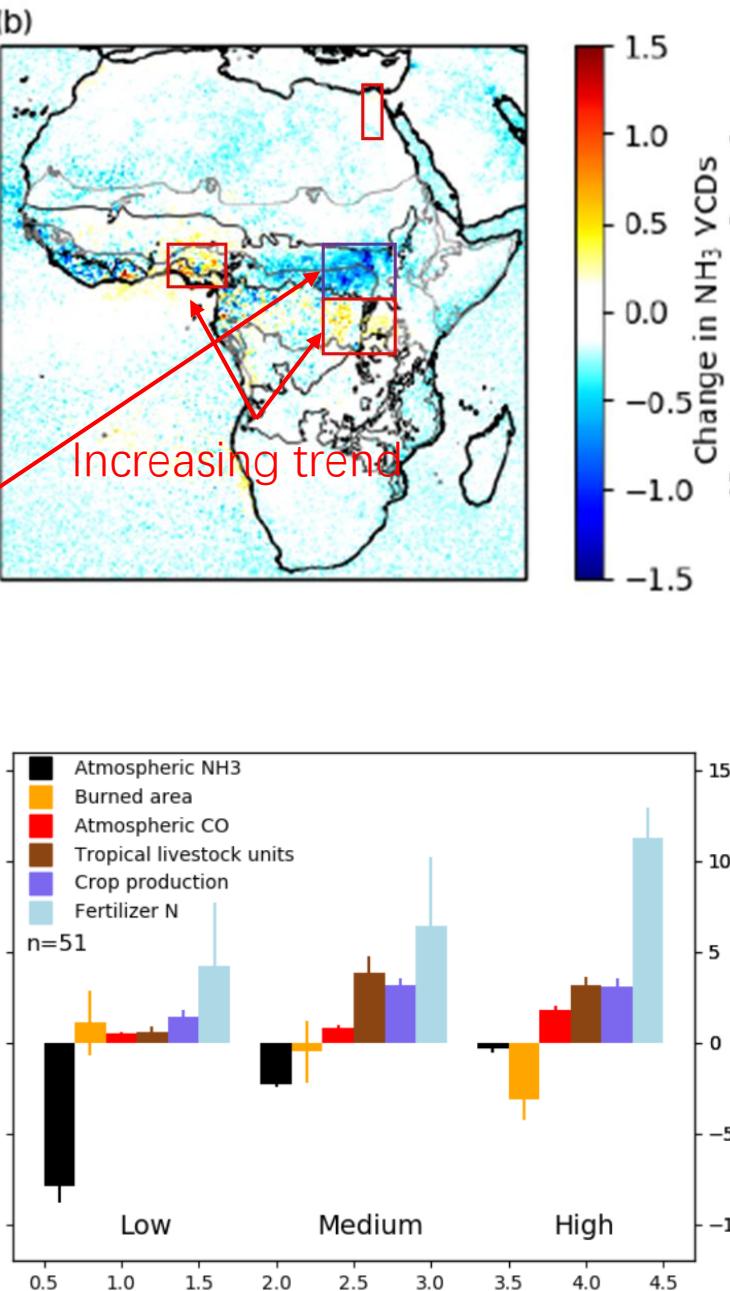
2020.12

- Accomplished:
 - 1. literature: NH₃ trend in Africa drove by biomass burning, wetland extend or agriculture
 - 2. literature: Interannual variability of ammonia concentrations over the United States: sources and implications
 - 3. filter IASI daily datasets by cloud coverage and skin temperature
 - 4. annual NH₃ concentration mean distribution of GEOS-Chem and IASI
 - 5. monthly NH₃ concentration trend distribution of GEOS-Chem and IASI
 - 6. annual concentration change over the India-China, Africa and South America
 - 7. seasonal GEOS-Chem emission distribution
- 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

literature

NH₃ trend in Africa (2008-2017)

- NH₃ source
 - Agriculture: the global largest source
 - urea fertilizer: extremely low in sub-Saharan Africa
 - livestock excreta: very low in sub-Saharan Africa
 - soil: ammonium dissociation ($NH_4^+ + OH^- \leftrightarrow H_2O + NH_3$)
 - Biomass burning: 60-70% from Africa
- Global data:
 - IASI-A: NH₃, CO
 - TRMM: daily precipitation
 - NOAA Global Surface Temperature Dataset: 0.5° gridded 2m monthly
 - MODIS MCD64A1: 0.25° gridded monthly burned area
 - MODIS MCD12C1: 0.25° gridded land cover product
 - ACLED: violent and non-violent conflict events
- Wetland extent: Sudden decreasing trend
 - MODIS MOD09A1: monthly flood maps (8-days)
 - First stage: distinguish seasonally flooded
 - Second stage: identify the timing and duration of flooding
- Spatial relationships: (0.25° × 0.25°)
 - mean annual tropospheric NH₃ concentration
 - independent variables
 - population density
 - cropped area
- National analyses: UN FAOSTAT (51 African countries: low/medium/high)
 - livestock numbers
 - crop production
 - fertilizer N use



Interannual variability of ammonia concentrations over the United States [2008–2012 (JJA)]

- use observations to investigate **the variability of ammonia**

- GEOS-Chem simulation

- v9-02, US: 0.5×0.667 , Global: 2×2.5
- Emission:

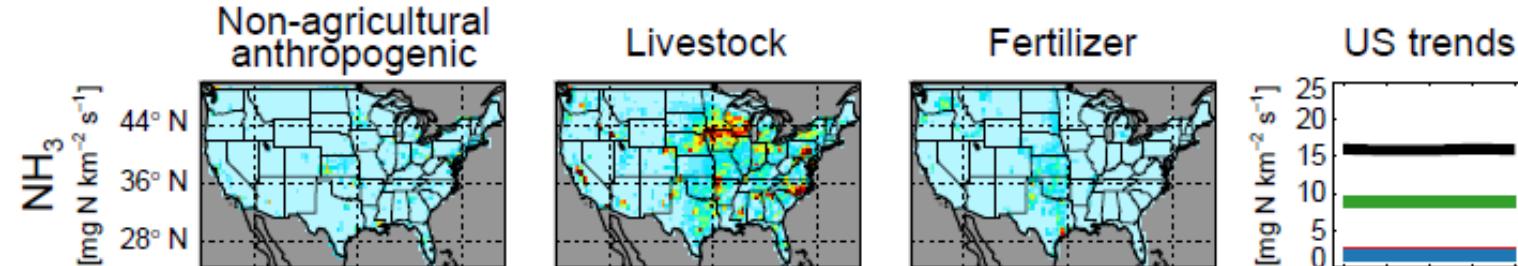
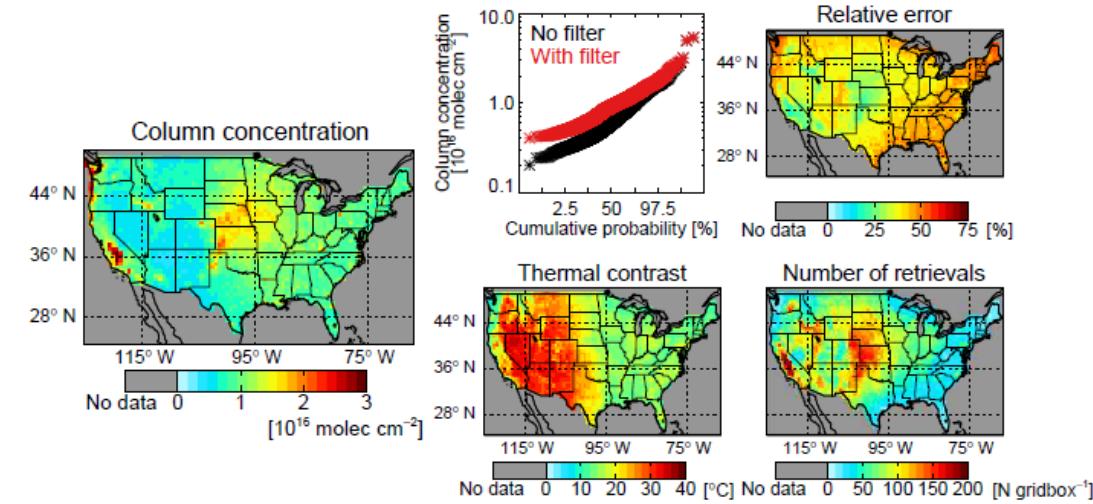
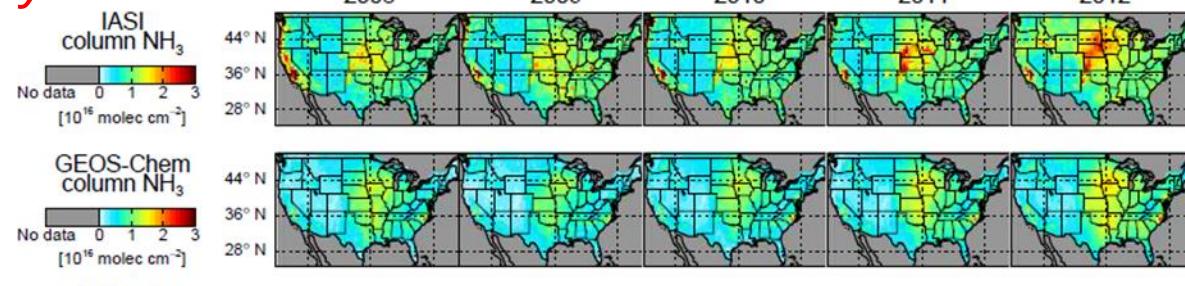
- Anthropogenic ammonia: EPA NEI-2005 inventory (**78%**)
 - livestock
 - Fertilizer
 - non-agricultural
- biomass burning: FINN (**2%**)

- IASI satellite column measurements

- gridding and averaging scheme**: compute the mean column concentration weighted by relative error of the native retrievals

- cloud cover $< 25\%$
- skin temperature $> -10^\circ \text{C}$
- relative error $< 75\%$

(Schiferl et al, 2016)



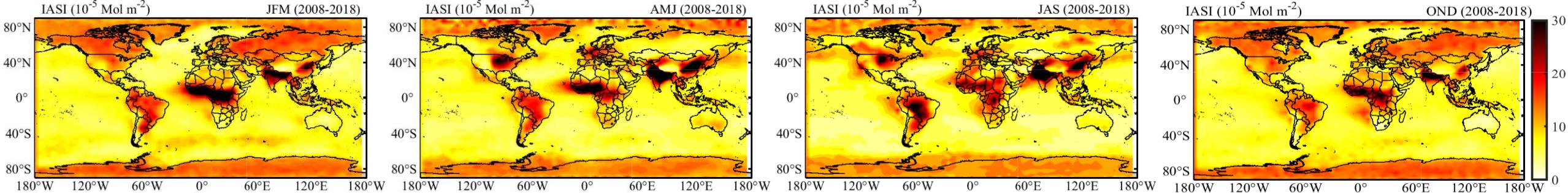
results

IASI daily data filtering scheme

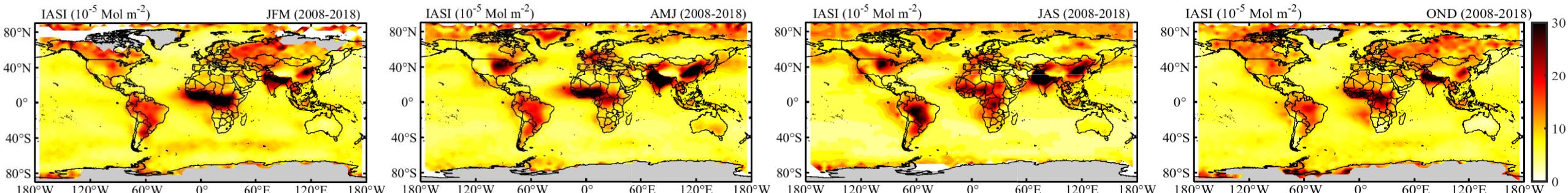
- Missing date (37 days):
- Filter
 - Cloud coverage: [0, 25%]
 - Skin temperature: $> 263.15 \text{ K}$
- Regrid: calculate mean value in each 4x5 grid as GEOS-Chem
- Relative error: Uncertainty on the NH₃ total column
- Number of retrievals: the count of value in each grid

IASI total column concentration of seasonal mean

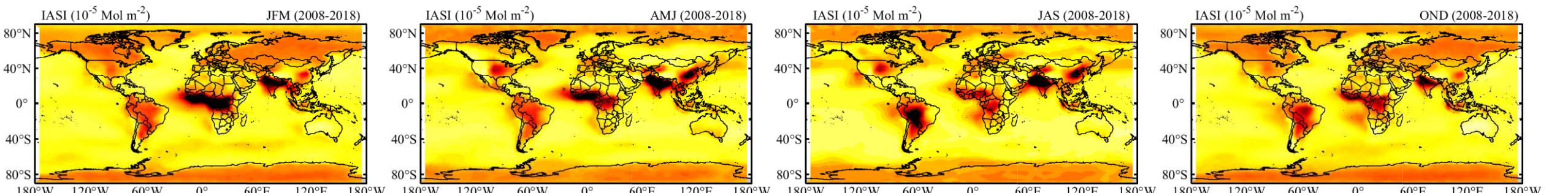
No filter (daily)



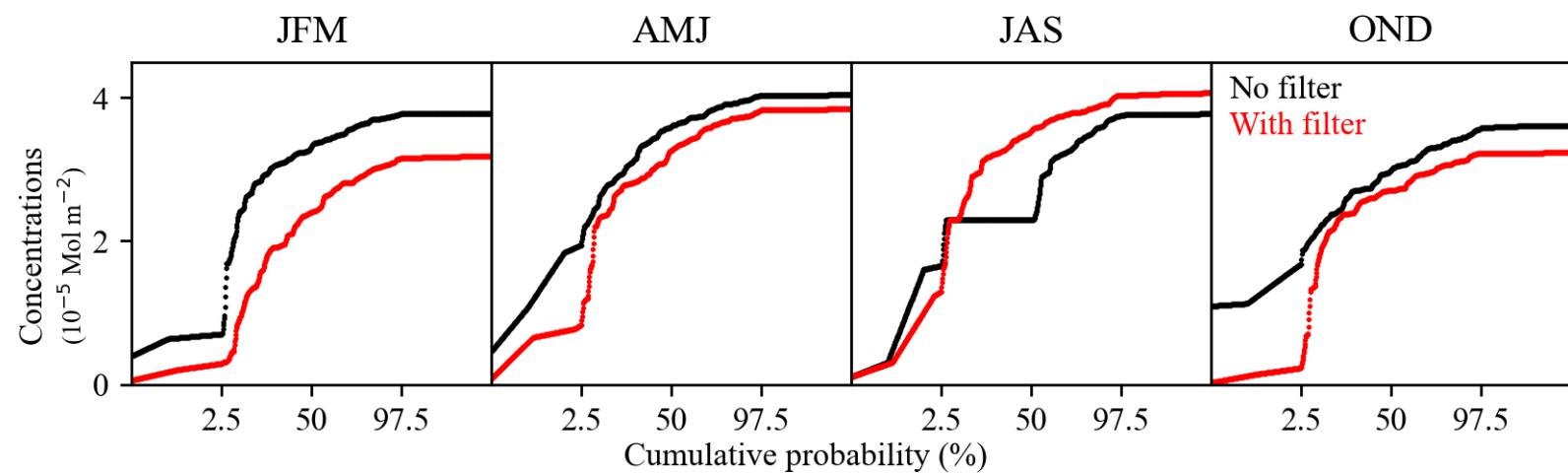
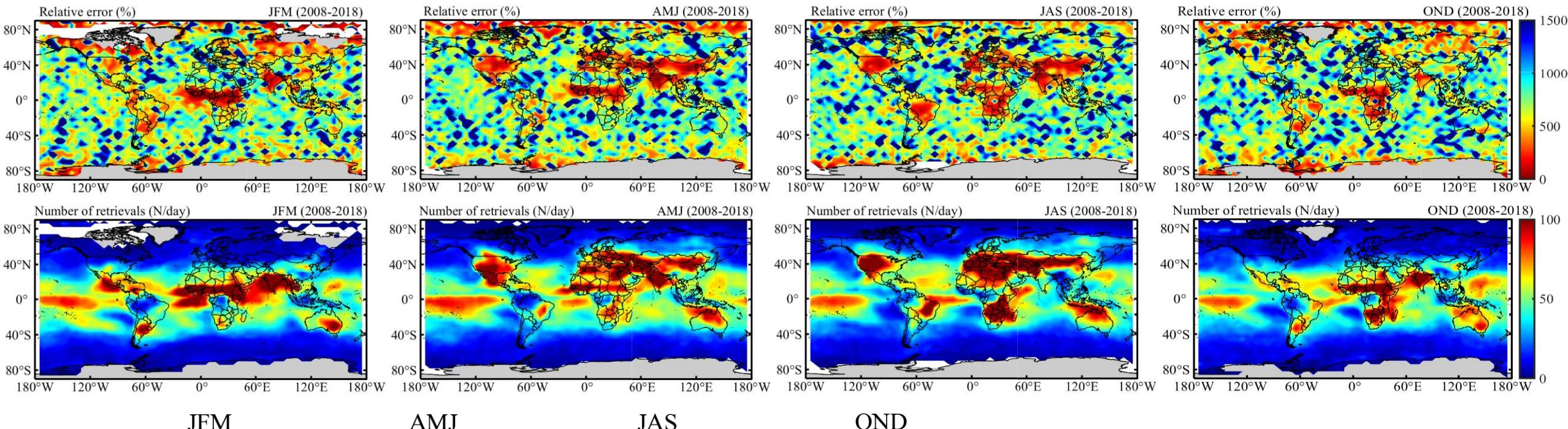
With filter (daily)



Monthly



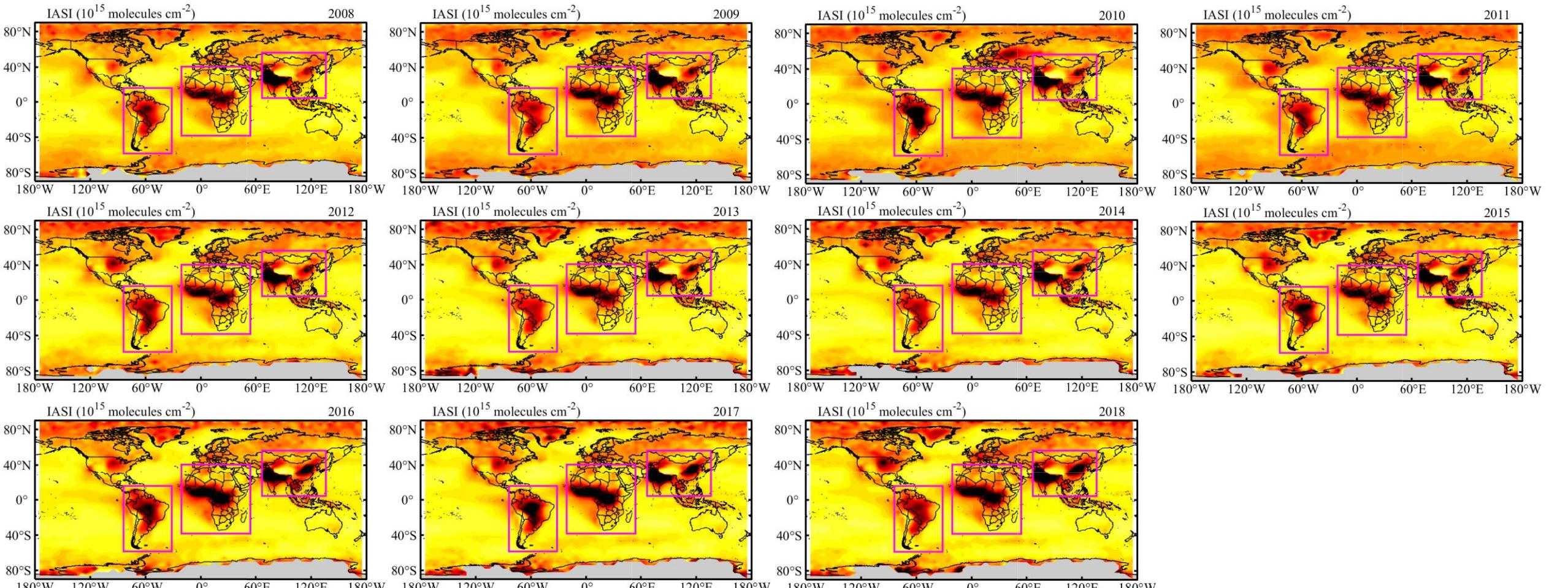
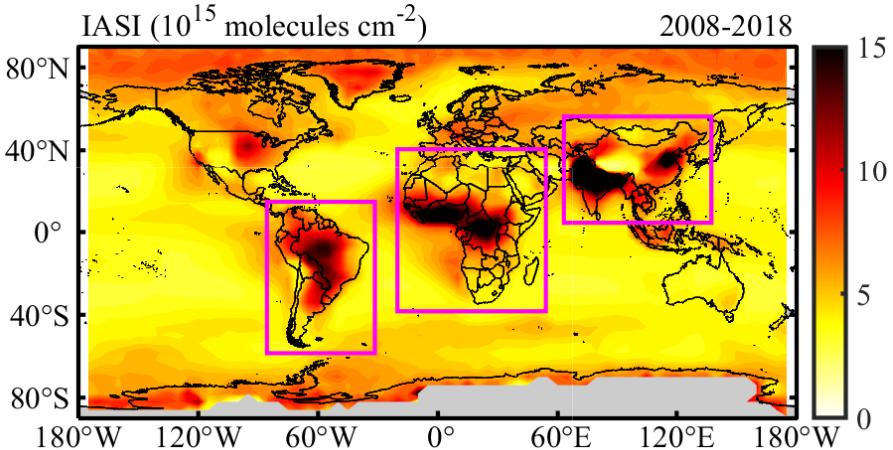
retrieval parameters and properties



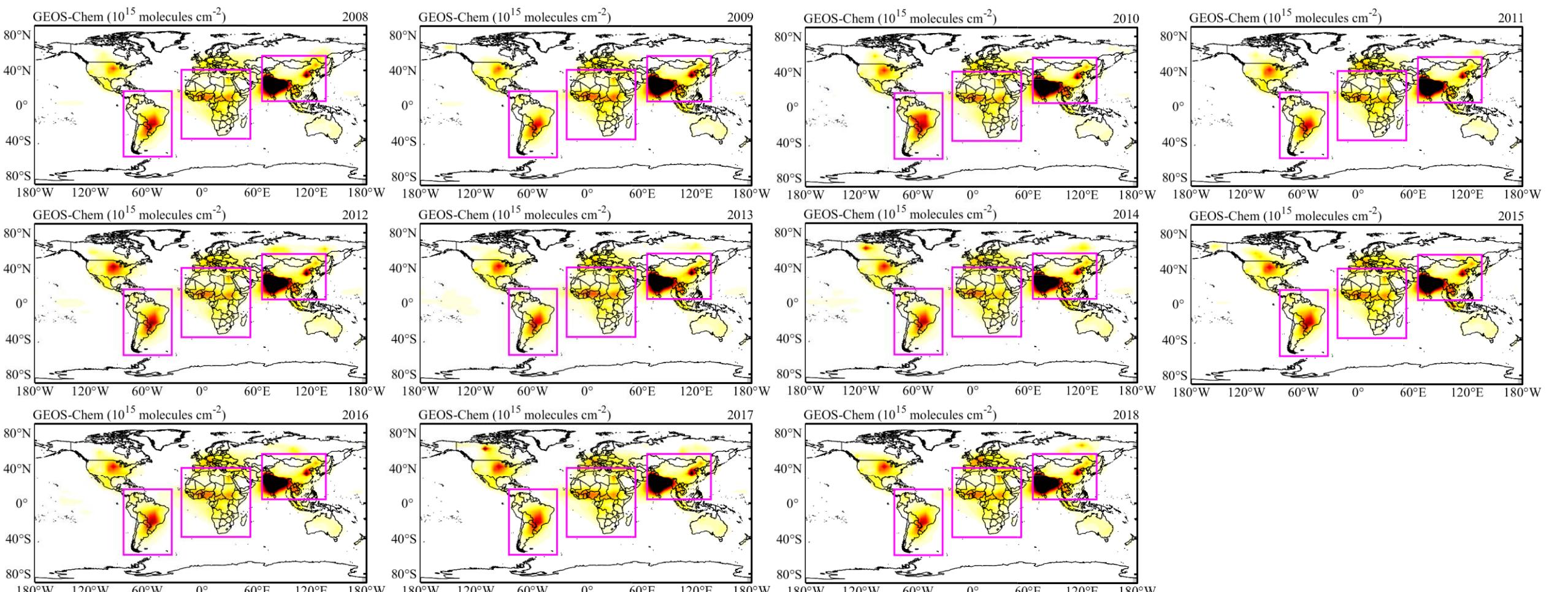
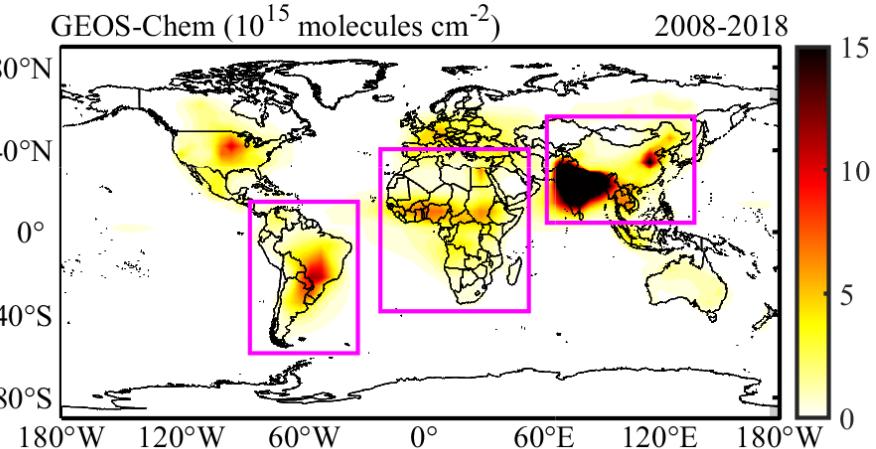
GEOS-Chem total column concentration

- $\Omega = \sum_{i=1}^{47} c_i \times rho_i \times h_i$
 - 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)

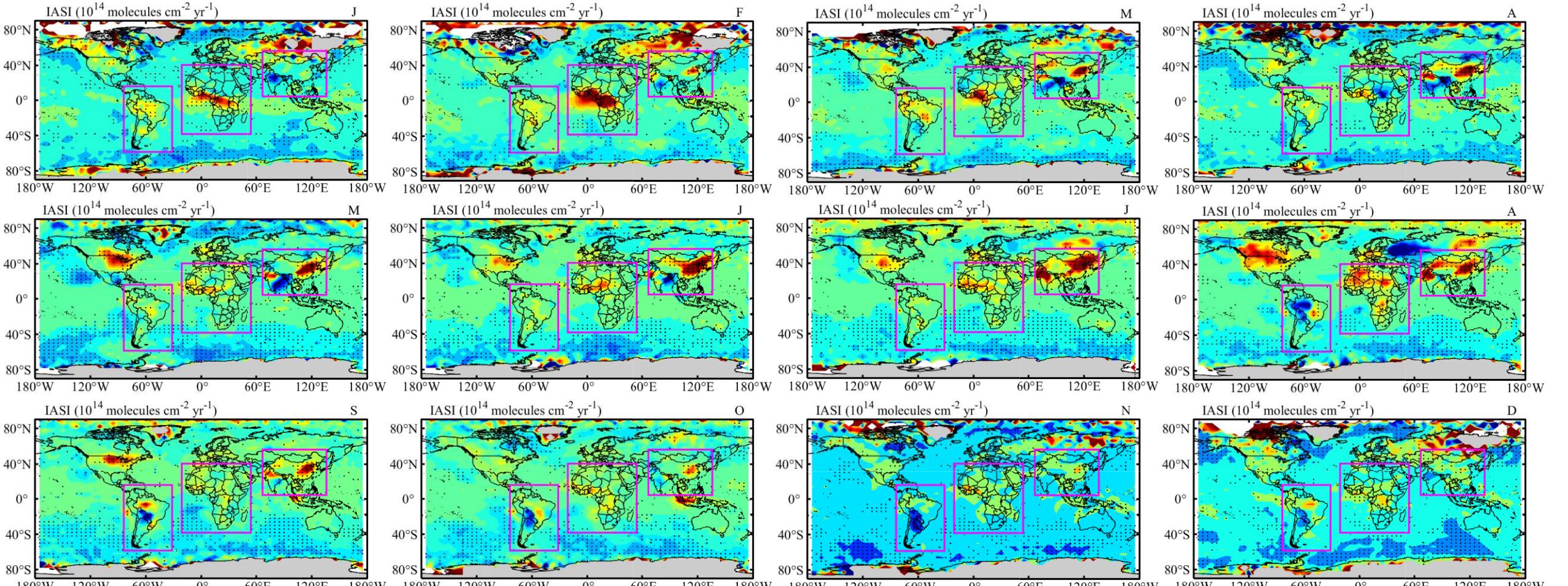
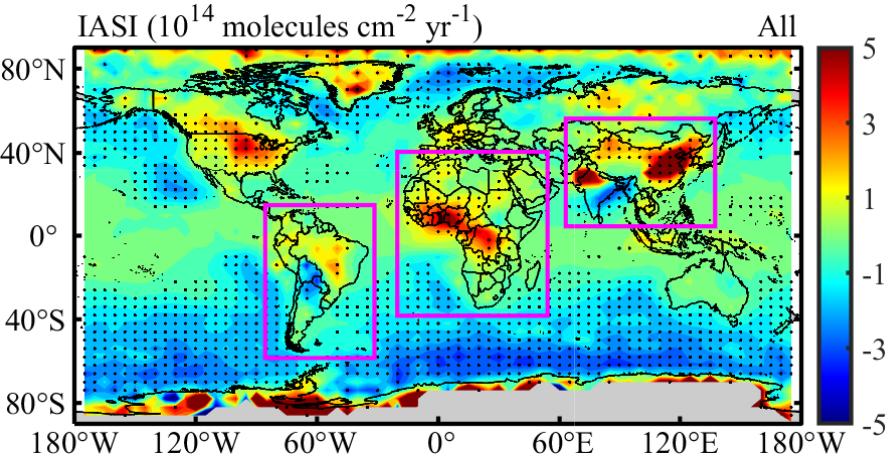
IASI mean in annual concentration distribution



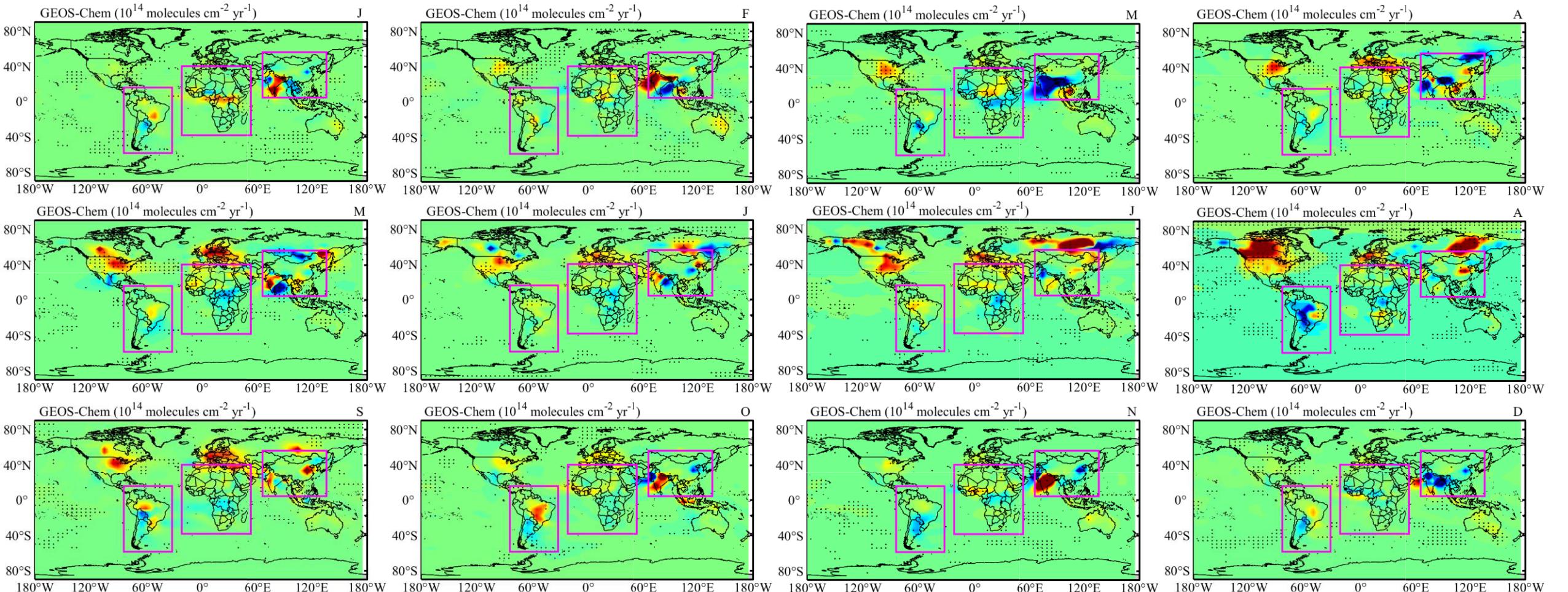
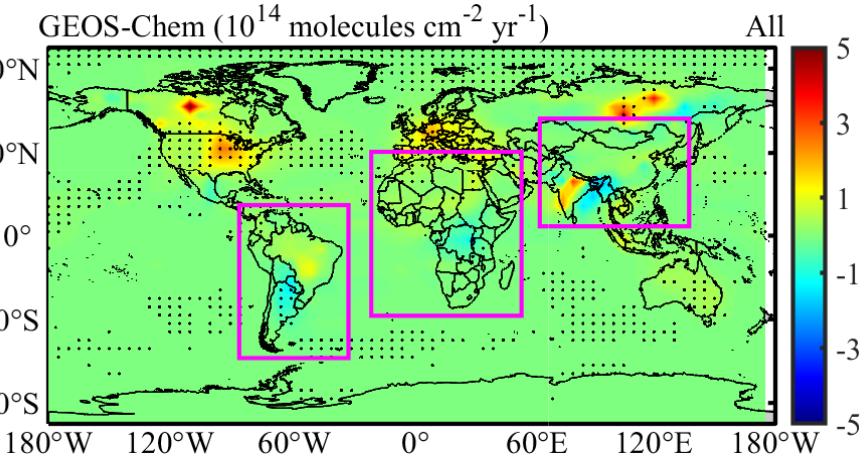
GEOS-Chem mean in annual concentration distribution



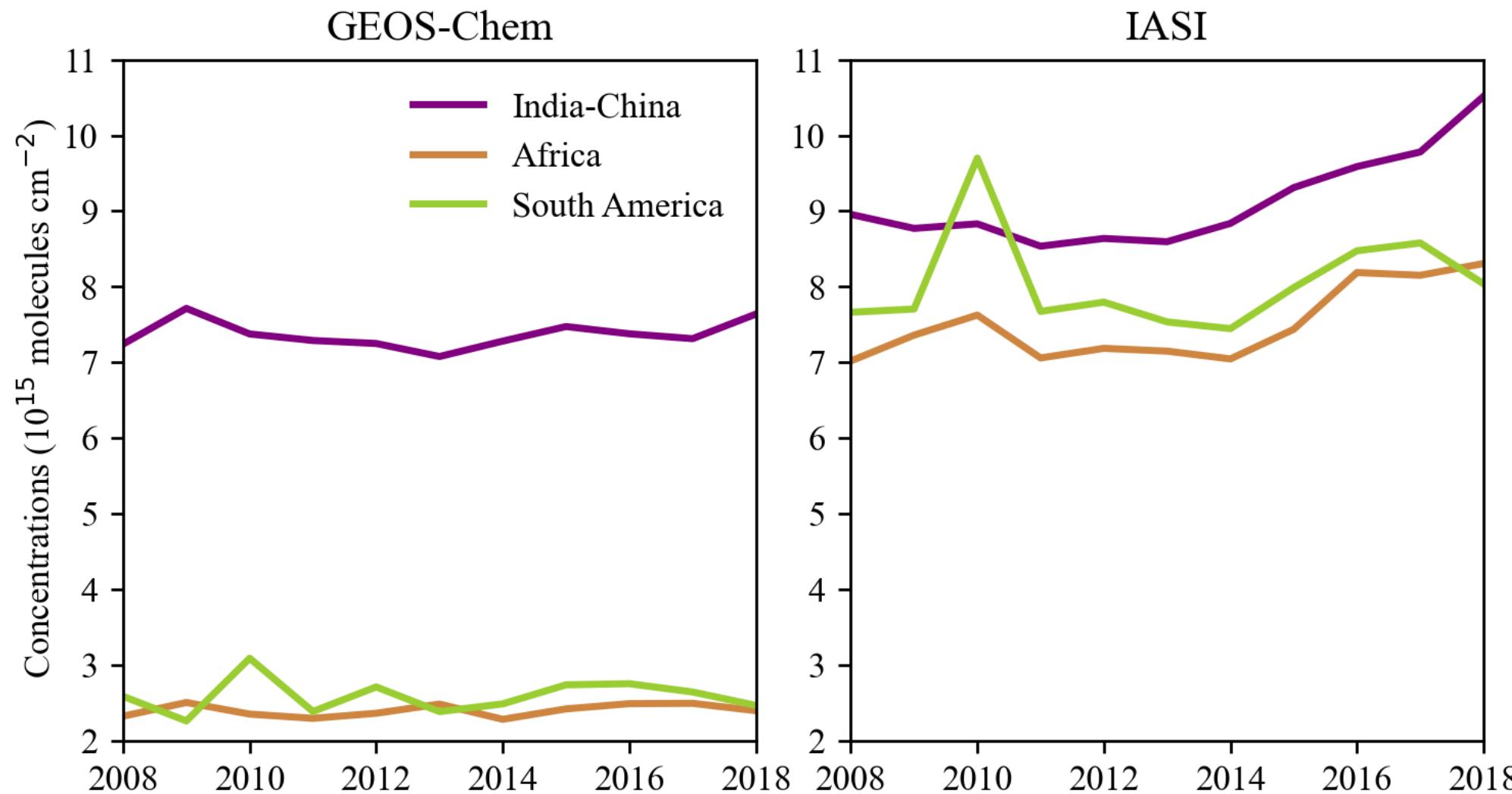
IASI trend in monthly concentration distribution



GEOS-Chem trend in monthly concentration distribution

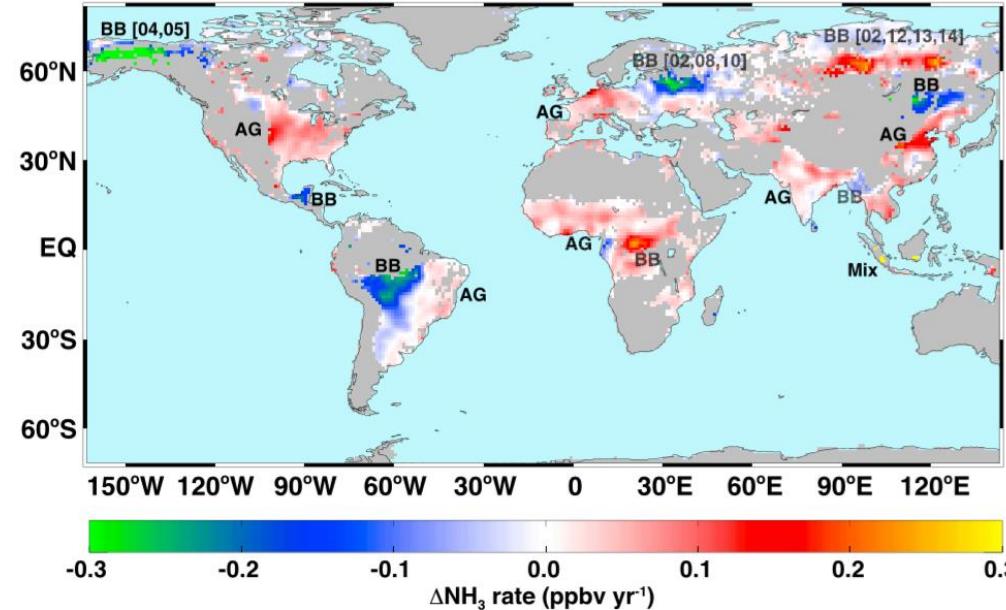


Annual concentration mean of GEO-Chem and IASI over the India-China, Africa and South America



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

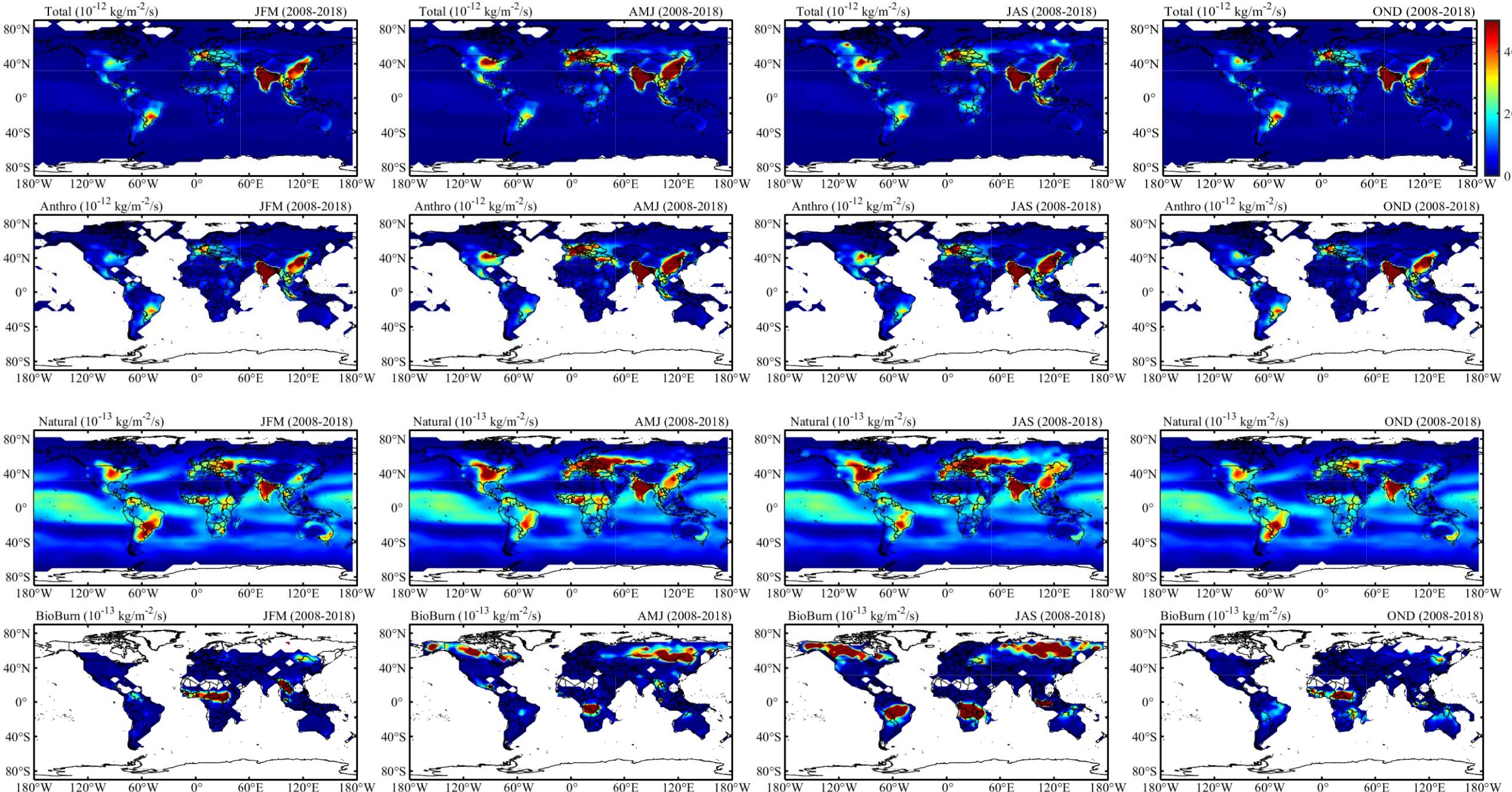


(Warner et al, 2016)

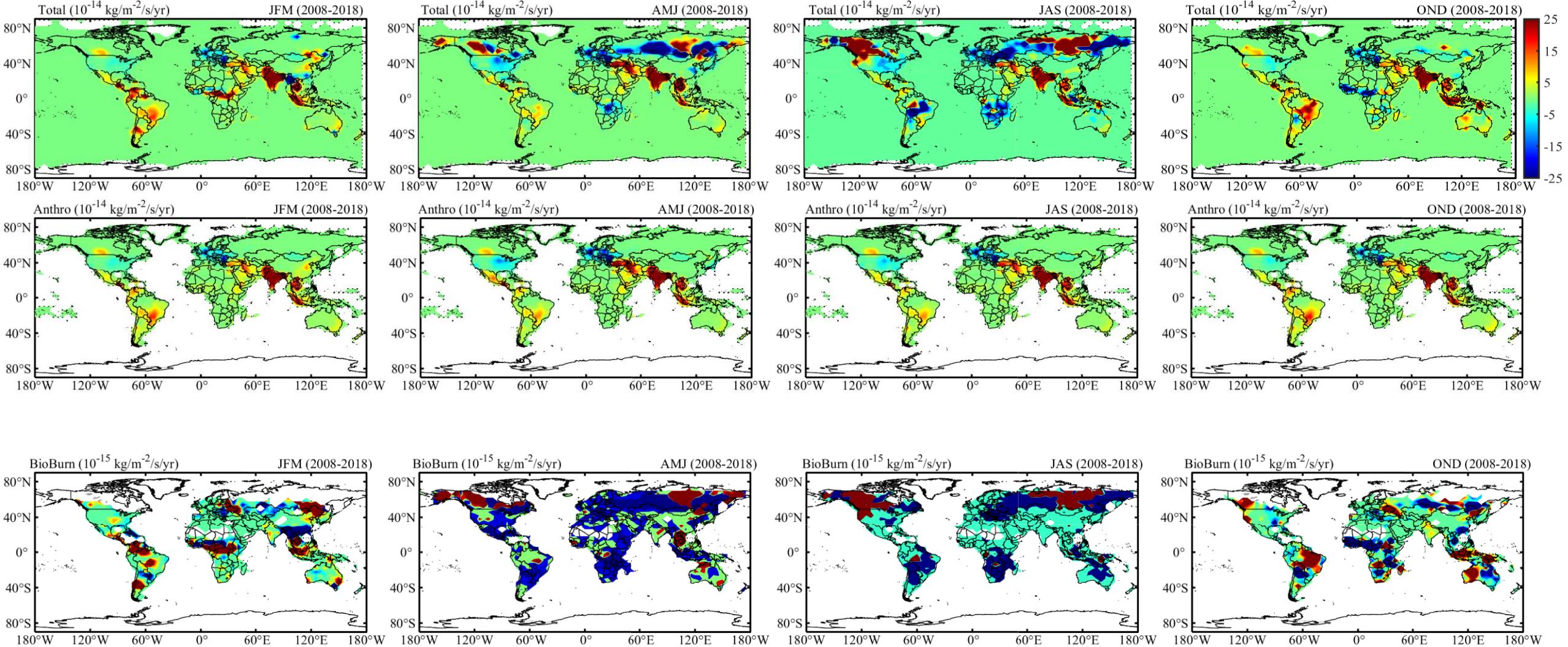
GEOS-Chem emissions

- 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)



End