Observed and simulated Ammonia concentration 10

IASI data and GEOS-Chem simulation

2020.12

- Accomplished:
  - 1. IASI emission fluxes versus GEOS-Chem emission inventory (fixed τ and GEOS-Chem τ)
  - 2. IASI average distribution of oversampling methods and filtered methods over 2008-2016
- Ammonia Data:
  - IASI total columns: Reanalyzed IASI/Metop-A
    - Daily, L2, 1°×1° (2008-2018)
  - GEOS-Chem simulation, 4°×5°, daily
    - column concentration (2008-2018)
  - the reanalysed IASI NH3 dataset (ANNINH3-v2.1R-I)
    - Oversampling methods, 0.01°×0.01°, 70N-70S, (2008-2016)
- meteorological input data
  - ECMWF ERA5 skin temperature, 0.25°x0.25°
    - hourly data on single levels (2008-2018), 9:00/10:00
- Ongoing:
  - 1. ocean background

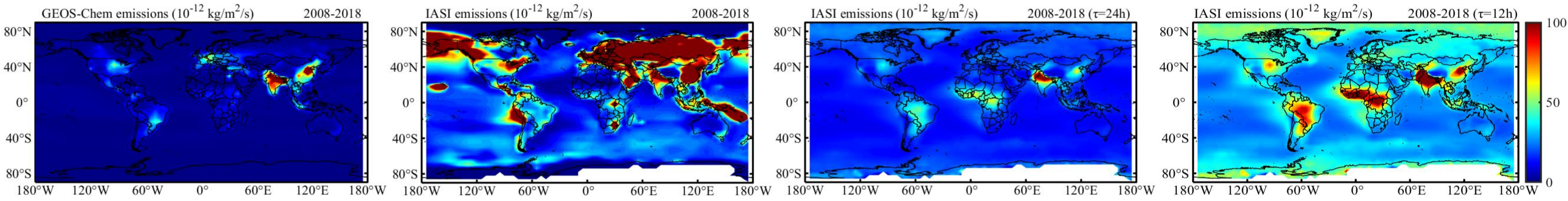
IASI emission flux calculations

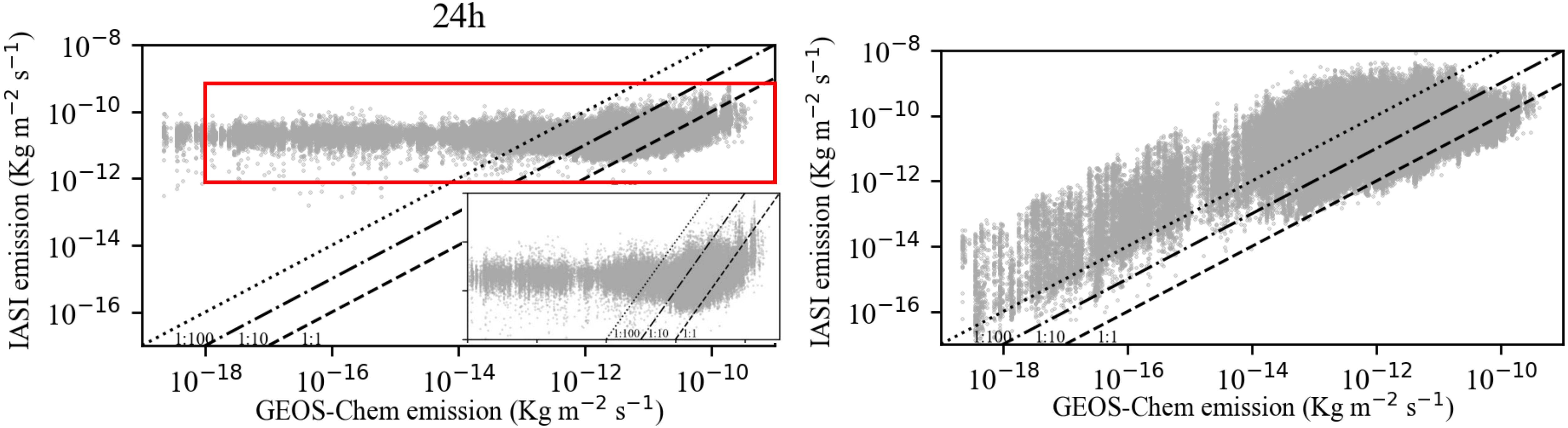
- $E = M/\tau$
  - E: emission fluxes, assumes stationarity and constant first-order loss terms
  - M: the total mass contained within the assumed box
  - τ: The effective lifetime or residence time of NH3 within a given box
- $\tau_{mod} = \frac{M_{mod}}{E_{mod}}$
- $E_{obs} = \frac{M_{obs}}{\tau_{mod}} = M_{obs} * \frac{E_{mod}}{M_{mod}} = E_{mod} * \frac{C_{obs}}{C_{mod}}$

Table SI1: NH_3 lifetime estimates reported in the literature.

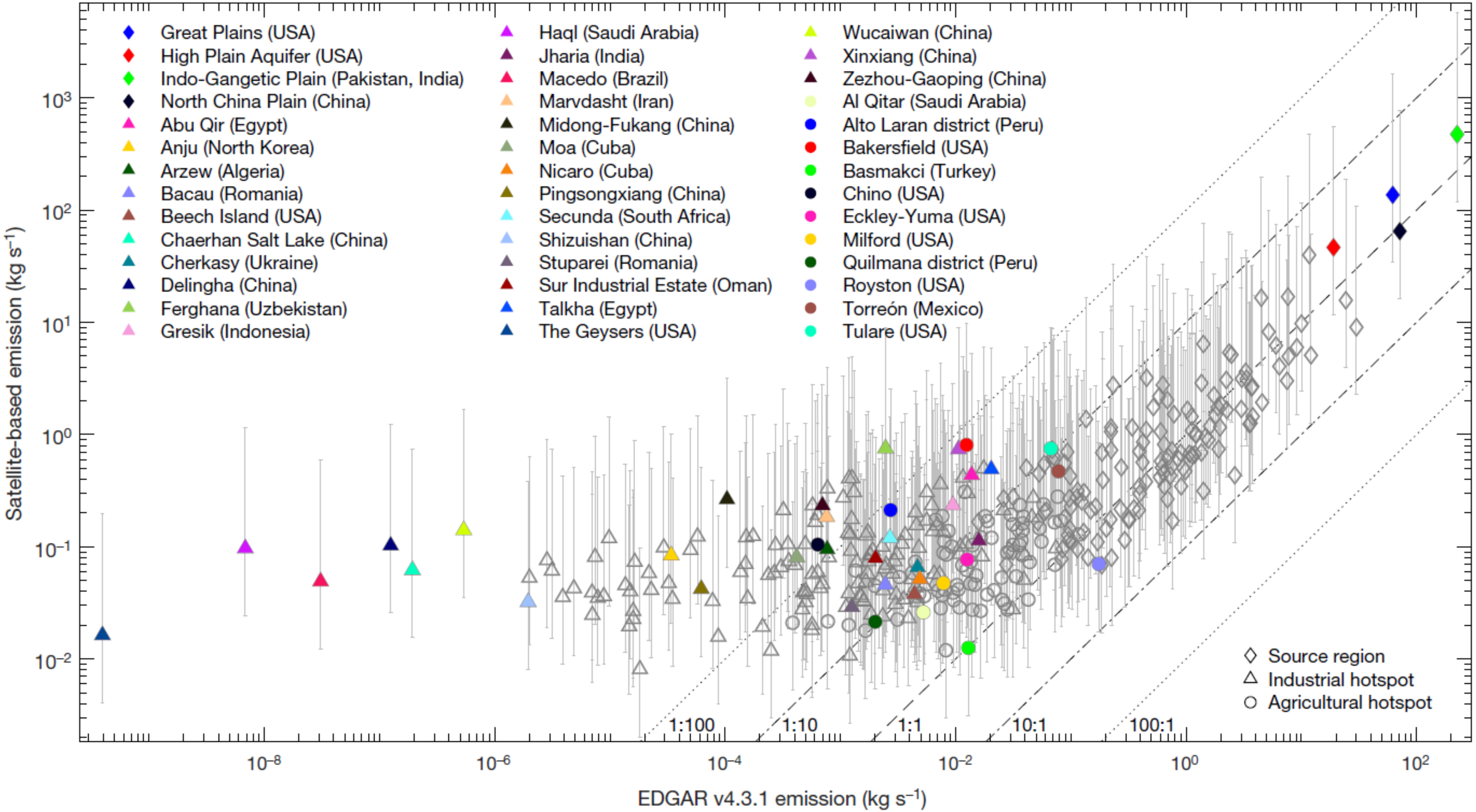
REFERENCE	LIFETIME	COMMENT
Norman and Leck, 2005	Few hours	Clean remote ocean
	Several days	Dust/Biomass plumes over ocean
Quinn et al., 1990	Order of hours	Central Pacific Ocean
Flechard and Fowler, 1998	1-2 hours	Scottish moorland site
Sutton, 1990	10 hours	Using dry deposition velocity by Duyzer et al. (1987)
Möller and Schieferdecker 1985	19 hours	Using dry deposition rates of Mészáros and Horváth (1984)
Hertel et al., 2012	24 hours	Simulations over Europe
Dentener and Crutzen, 1994	Order of hours	
Whitburn et al., 2016	17-23 hours	Fire plume
Hauglustaine et al., 2014	15 hours	Average global model

IASI emission fluxes versus GEOS-Chem emission inventory





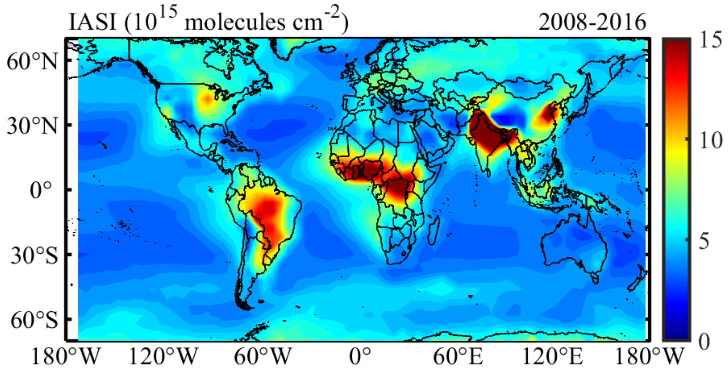
Satellite-derived emission fluxes versus a bottom-up emission inventory



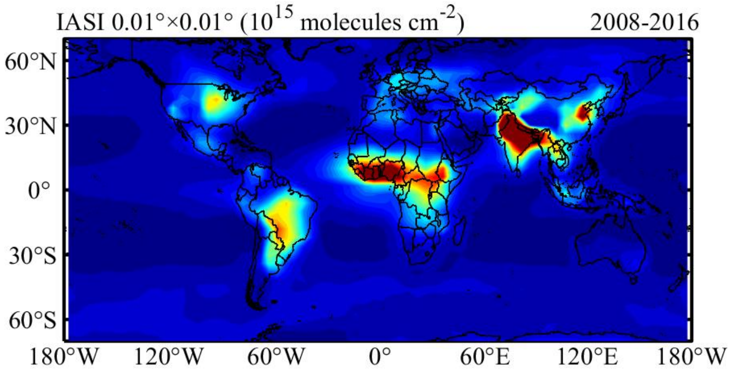
Damme et al., 2018

average distribution of oversampling methods and filtered methods over 2008-2016 in 70N-70S

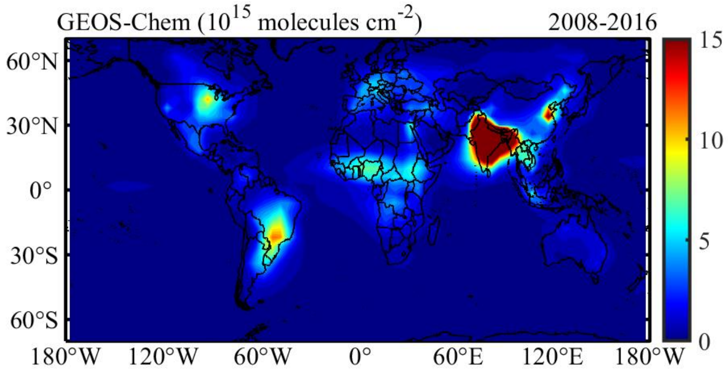
a)



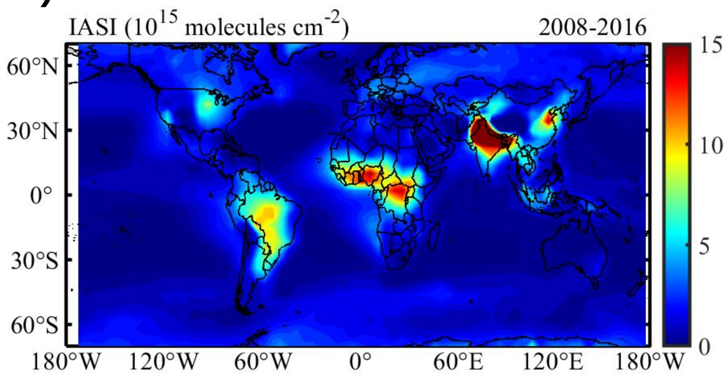
b)



c)



d)



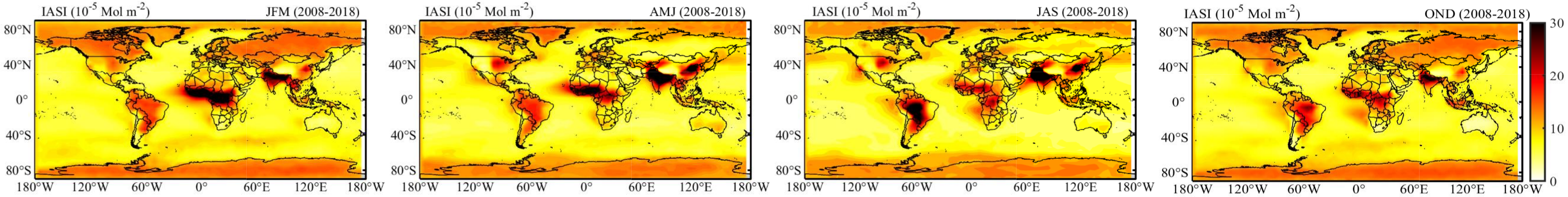
10 value of all the pixels

IASI daily data

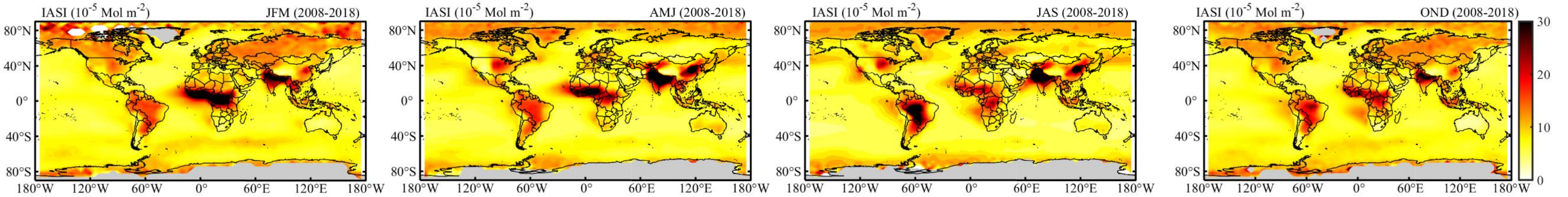
- Missing date (37 days):
  - 2008 (13 days): 1.17-18, 3.20-3.26, 12.10-11, 12.30-31
  - 2009 (3 days): 1.1, 1.23, 10.1
  - 2010 (5 days): 5.18, 8.31, 9.1-9.3
  - 2011 (2 days): 10.23-24
  - 2012 (0)
  - 2013 (2 days): 11.6-7
  - 2014 (7 days): 2.19-2.20, 9.9-9.13
  - 2015 (3 days): 4.10-4.12
  - 2016 (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

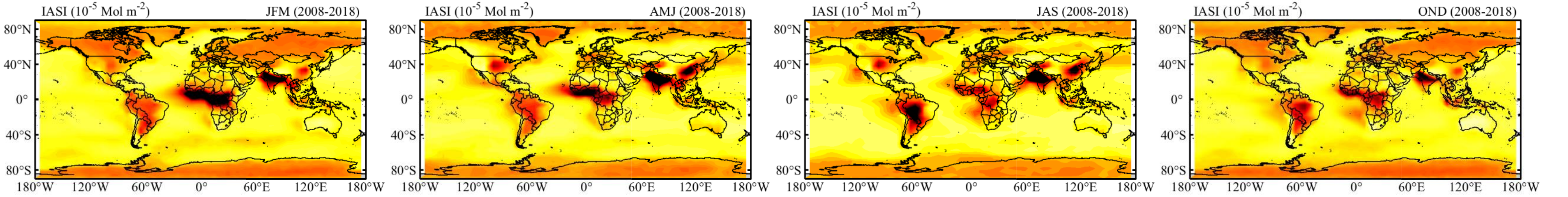
No filter (daily)



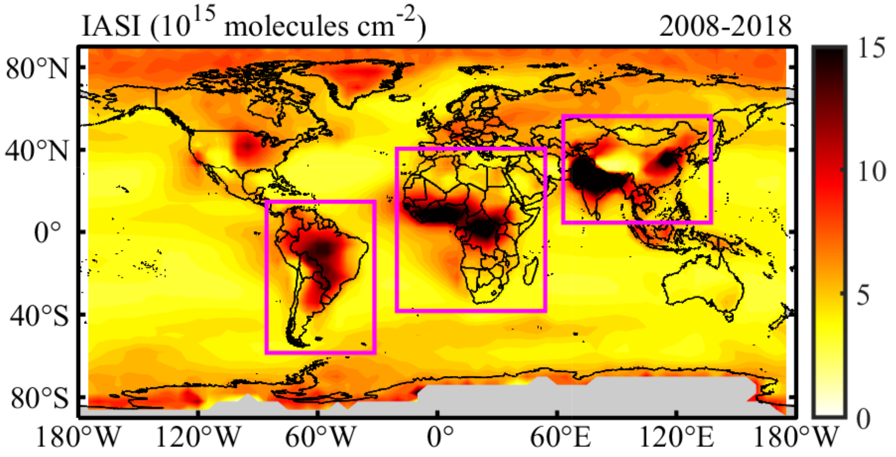
With filter (daily)

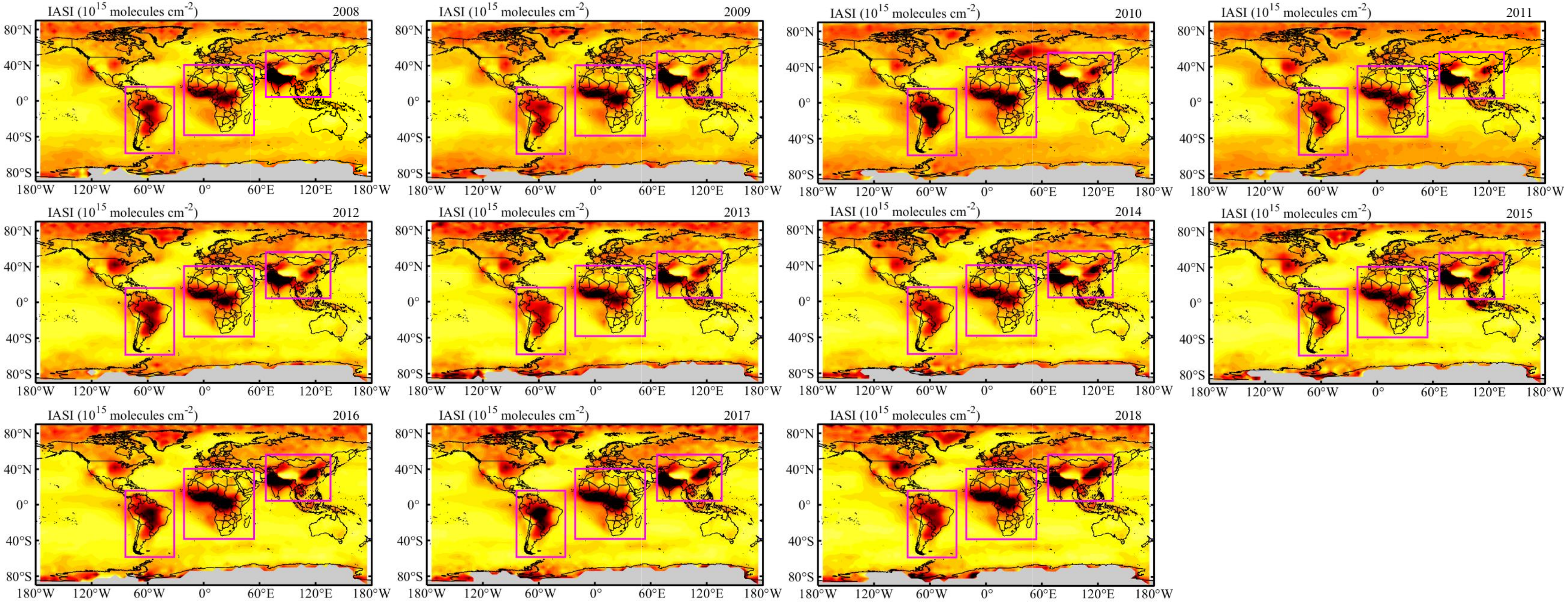


Monthly

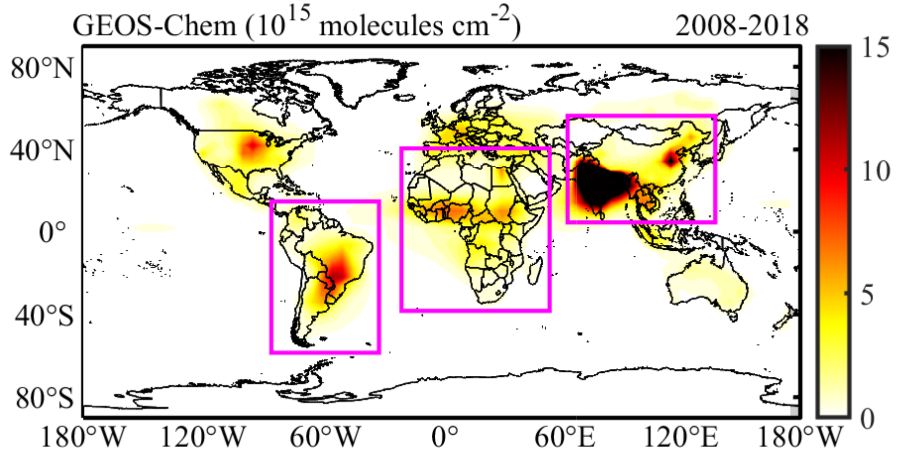


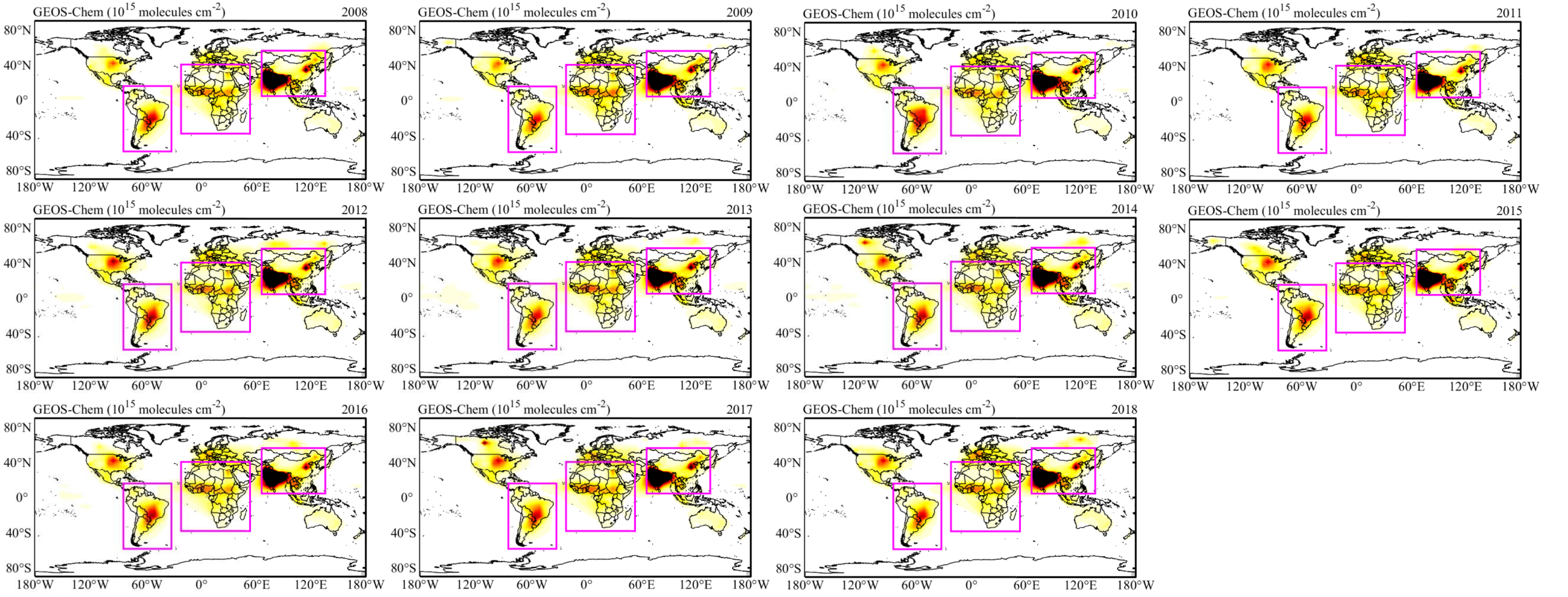
IASI mean in annual concentration distribution



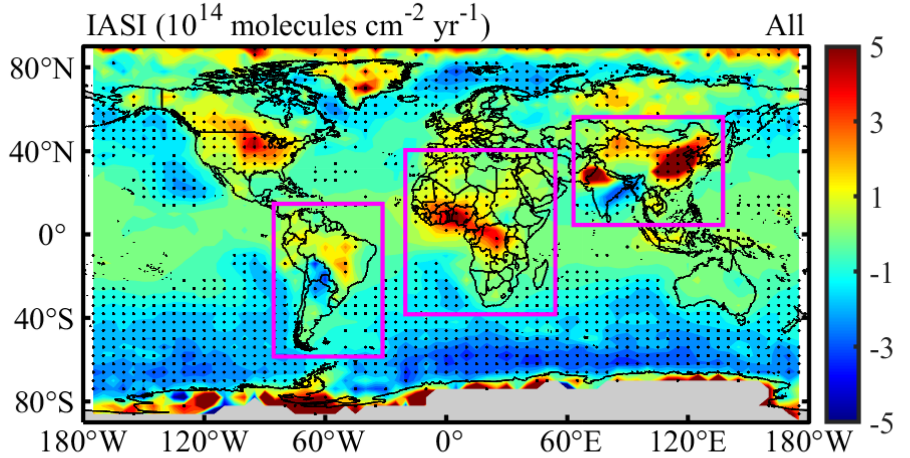


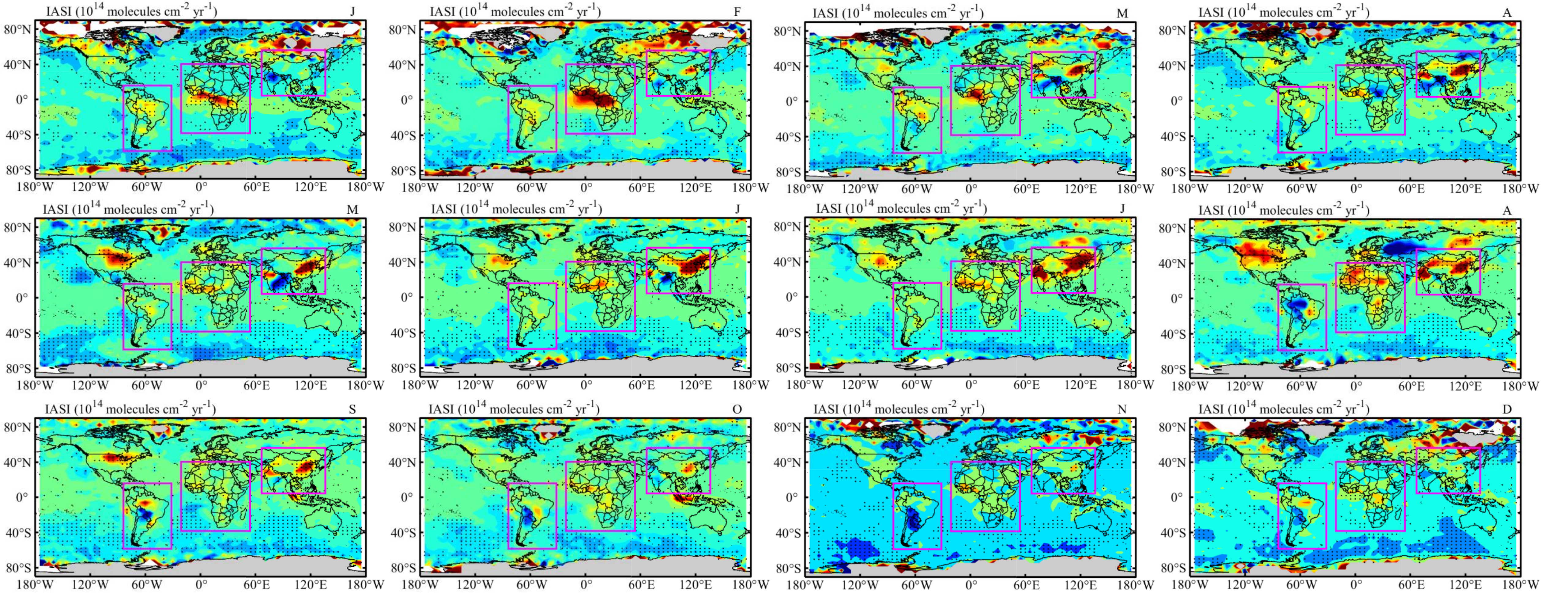
GEOS-Chem mean in annual concentration distribution



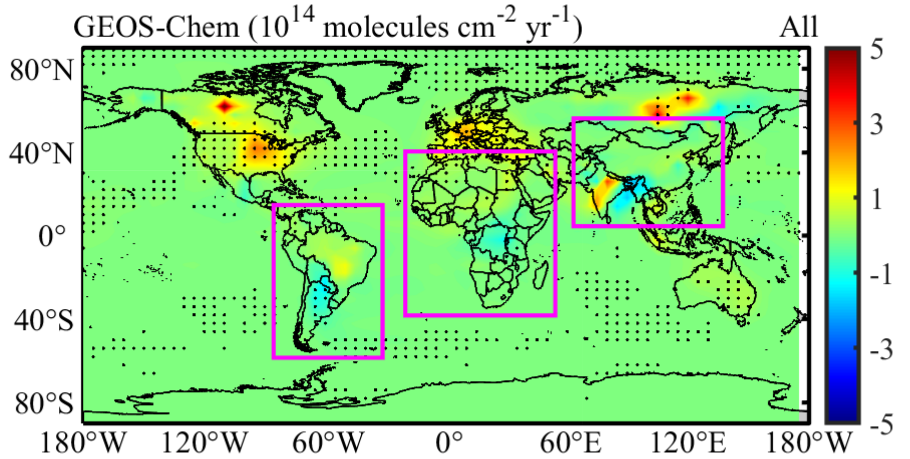


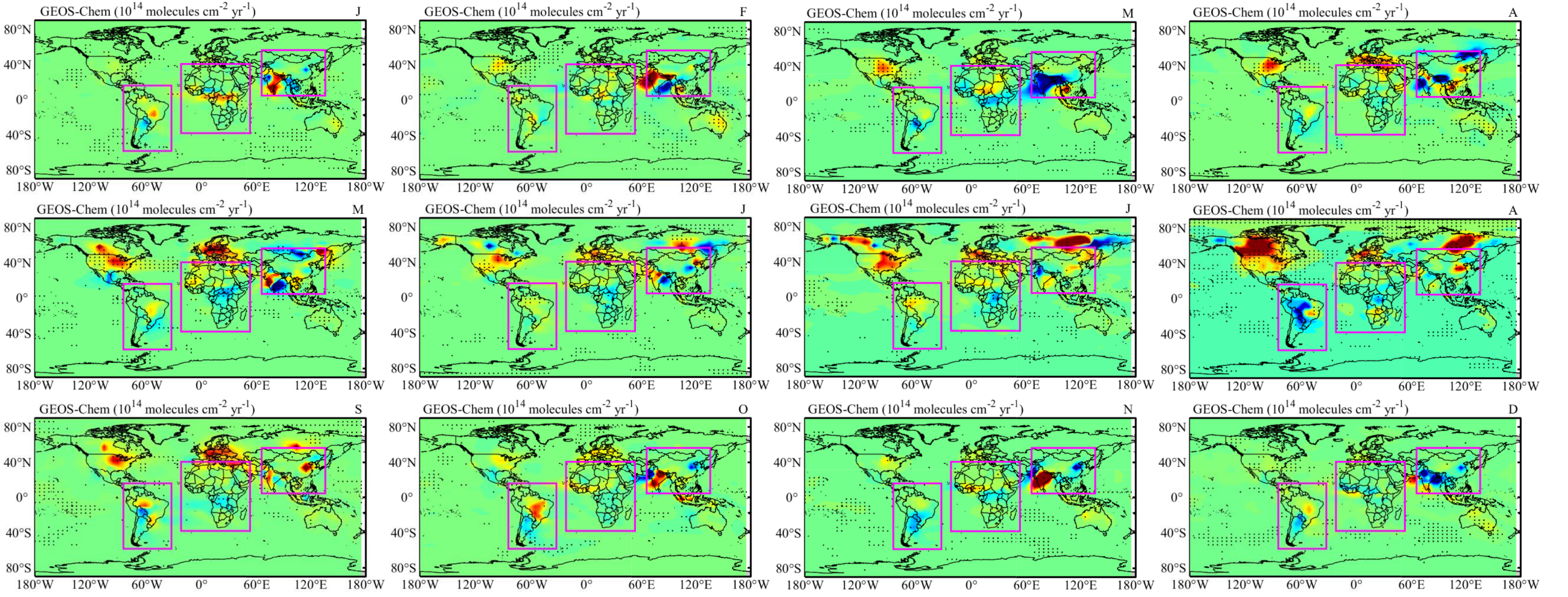
IASI trend in monthly concentration distribution



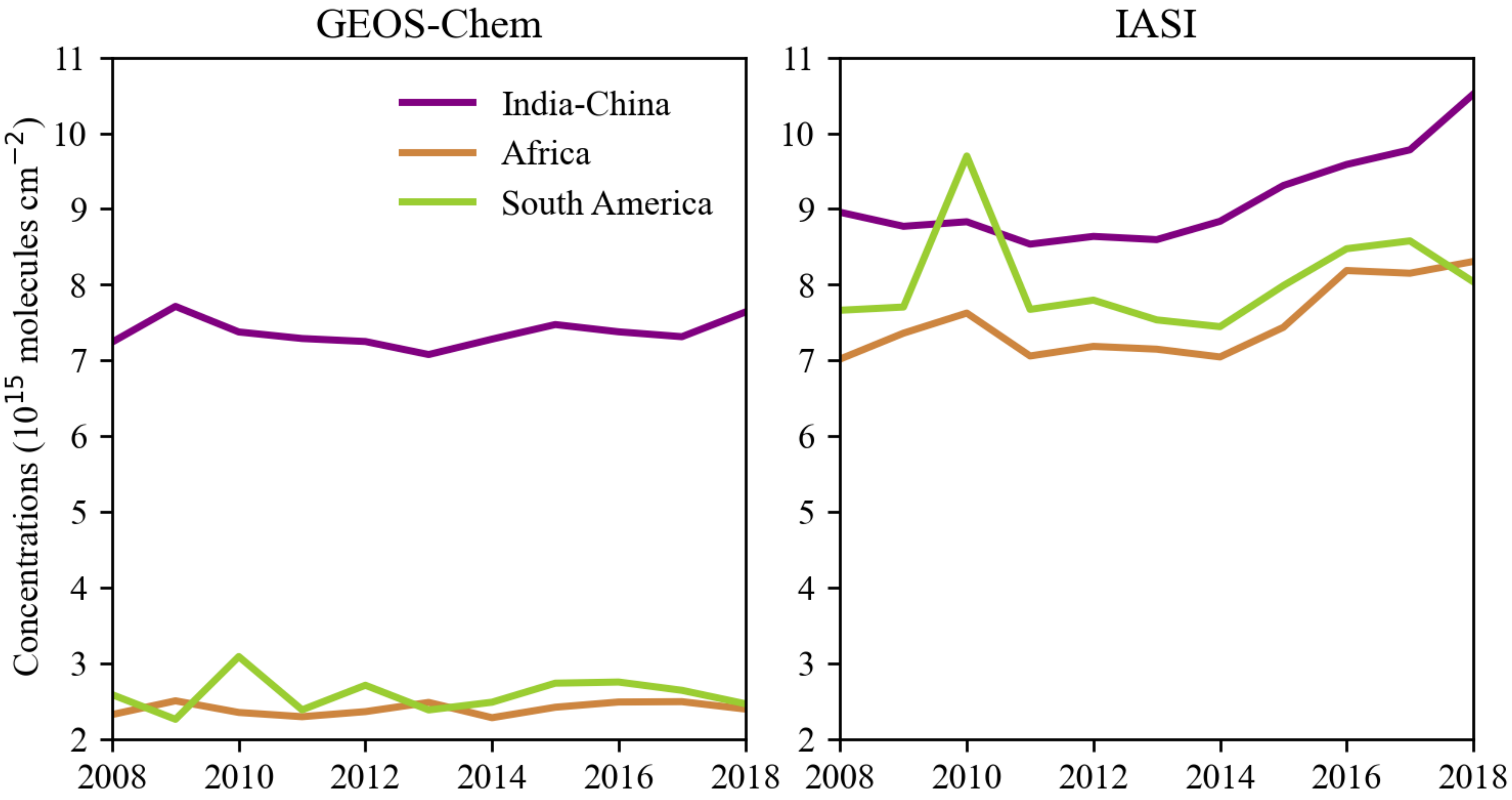


GEOS-Chem trend in monthly concentration distribution





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



total column concentration

- $\Omega = \sum_{i=1}^{47} c_{\mathrm{i}} \times rho_i \times h_i \times k$
  - $\boldsymbol{\Omega}$**: 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]

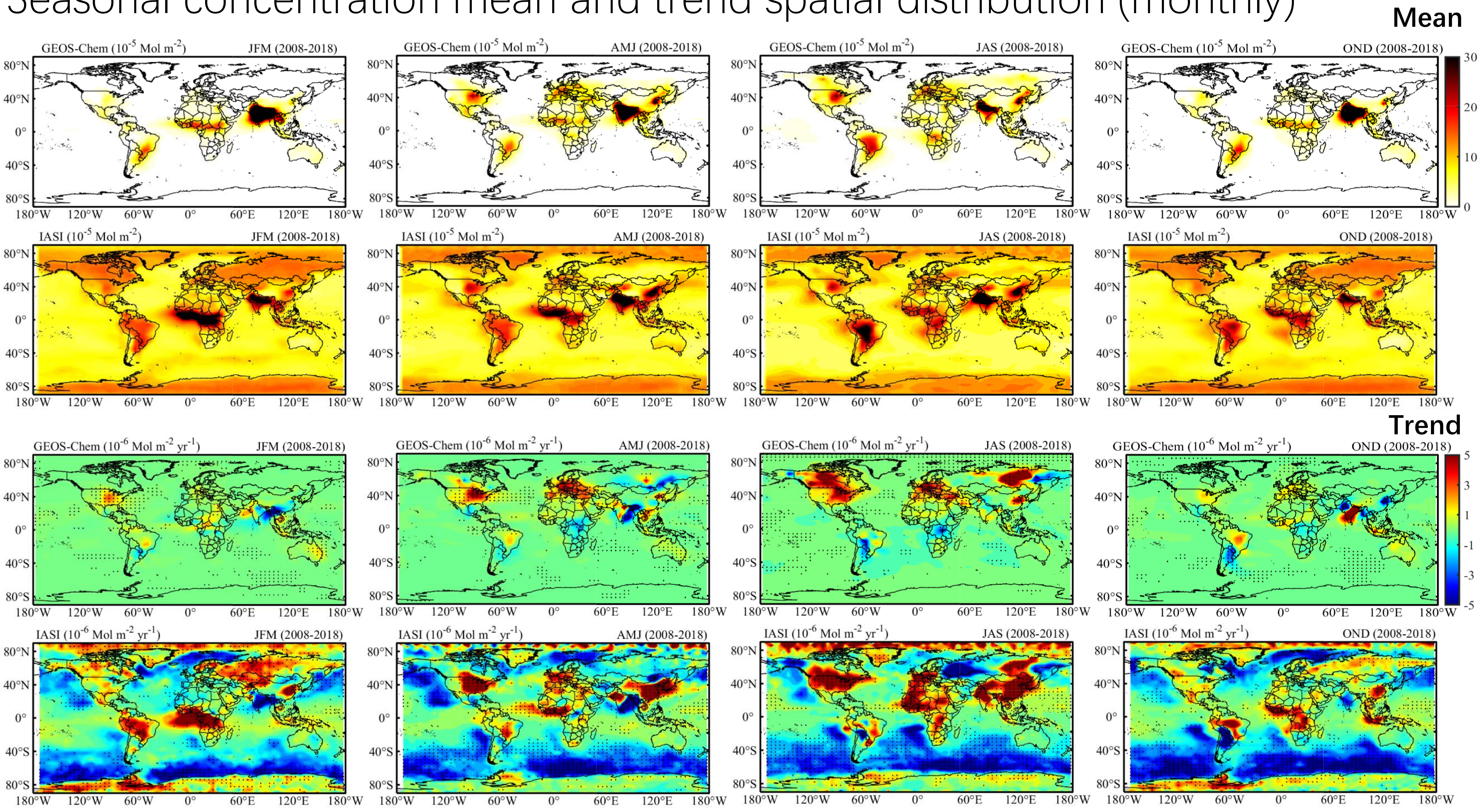
Regrid 180x360 to 46x72

- 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

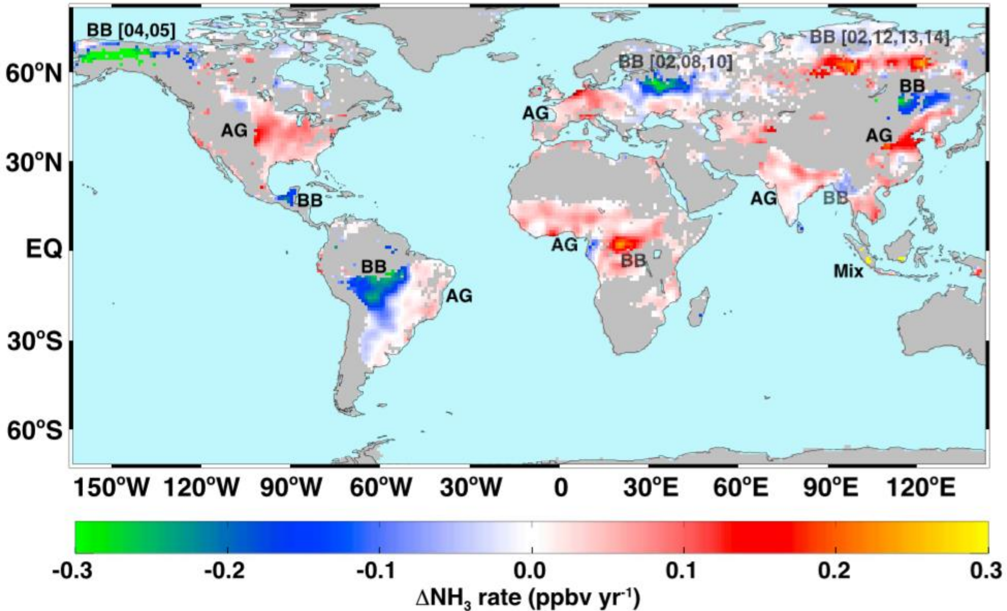
- Anthropogenic
  - APEI: Historical Canadian emissions (1990-2014)
  - NEI2011_MONMEAN: US emissions
  - MIX: Asian anthropogenic emissions
  - DICE_Africa: emissions from inefficient combustion over Africa
  - CEDS: Global anthropogenic emissions
  - POET_EOH: aldehydes and alcohols
  - TZOMPASOSA: 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 concentration mean and trend spatial distribution (monthly)



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

- provides evidence of substantial increases in atmospheric ammonia (NH3) concentrations (14year) over several of the worlds major agricultural regions
- The rate of change of NH3 volume mixing ratio (VMR) in parts-per-billion by volume (ppbv) per year computed
  - BB: biomass burning
  - AG: agricultural



(Warner et al, 2017)

End