

Observed and simulated Ammonia concentration 7

IASI data and GEOS-Chem simulation

2020.12

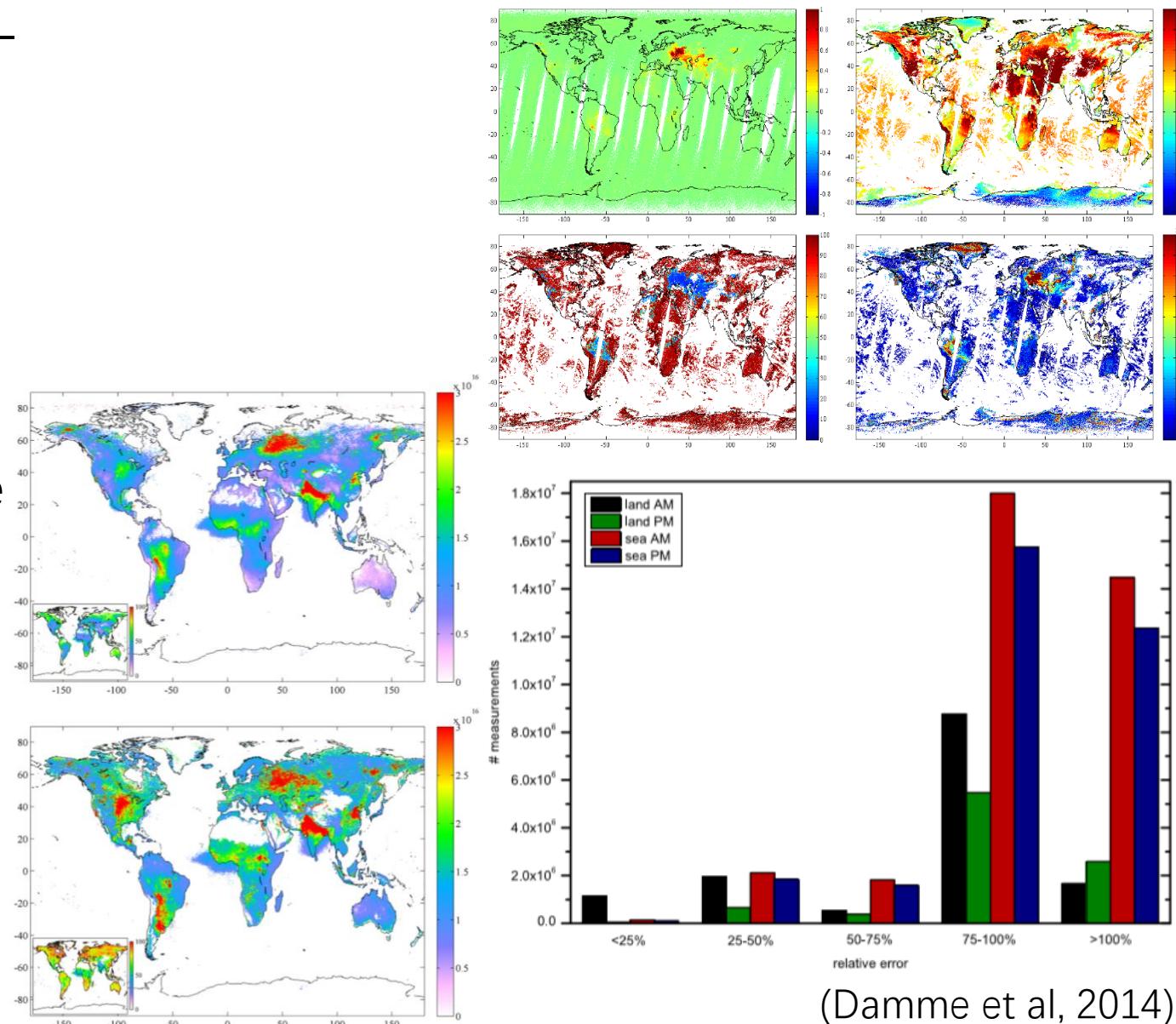
- Accomplished:
 - 1. seasonal mean distribution of GEOS-Chem and IASI (add Ocean)
 - 2. seasonal trend distribution of GEOS-Chem and IASI (add Ocean)
 - 3. seasonal mean distribution of NH₃ emissions
 - 4. seasonal trend distribution of NH₃ emissions
 - 5. filter IASI daily datasets (cloud coverage, uncertainty)
- Ammonia Data:
 - IASI total columns: Reanalyzed IASI/Metop-A (2008-2018)
 - 1°×1°, monthly, L3
 - Daily, L2
 - GEOS-Chem simulation, 4°×5°, daily
 - column concentration (2008-2018)
- Emission Data:
 - HEMCO_diagnostics, NH₃, 4°×5°, monthly, 2008-2018
 - 'Anthro', 'BioBurn', 'Ship', 'Seabirds', 'Total', 'Natural'
- Ongoing:
 - 1. filter the IASI daily datasets with ERA5 ECMWF
 - 2. consider regional trend
 - 3. turn off the biomass burning emission

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

Global distributions, time series and error characterization of atmospheric NH₃ from IASI satellite

- Global processing of IASI data—
data filter
 - Cloud fraction < 25%
 - Surface temperature > 265.15K
 - Error: Greenland or Antarctica
- Product evaluation
 - the **relative error** on the retrieved NH₃ column (2007.11-2012.10): the majority of measurements have **an error above 75%**
- Global and regional distributions
 - $\bar{x} = \frac{\sum w_i x_i}{\sum w_i}$, $w_i = 1/\sigma^2$ and σ is the error $\bar{\sigma} = \frac{\sum \frac{1}{\sigma_i}}{\sum \frac{1}{\sigma_i^2}}$.
- Global and regional distributions
 - NH₃ total column distribution: **fire-related, agriculture**



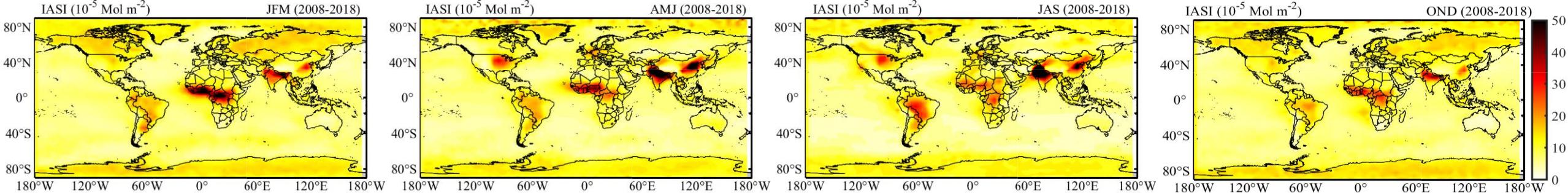
(Damme et al, 2014)

IASI daily data

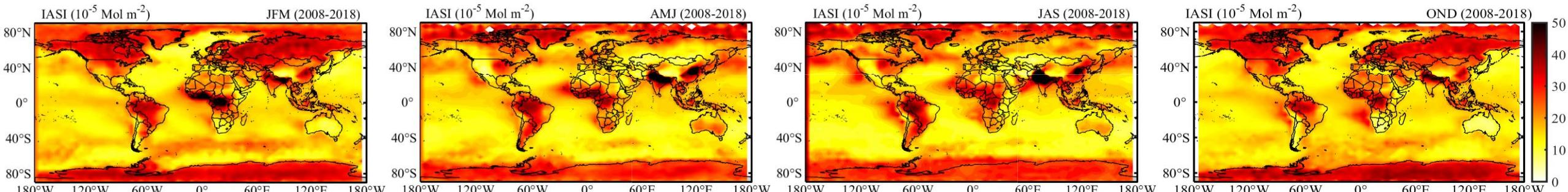
- Missing date (37 days):
 - 2008 (13 days): 1.17-18, 3.20-3.26, 12.10-11, 12.30-31
 - 2009 (3 days): 1.1, 1.23, 10.1
 - 2010 (5 days): 5.18, 8.31, 9.1-9.3
 - 2011 (2 days): 10.23-24
 - 2012 (0)
 - 2013 (2 days): 11.6-7
 - 2014 (7 days): 2.19-2.20, 9.9-9.13
 - 2015 (3 days): 4.10-4.12
 - 2016 (0)
 - 2017 (1 day): 6.7
 - 2018 (1 day): 12.31
- Filter
 - Nh3 total column uncertainty: [-75%, 75%]
 - Cloud coverage: [0, 25%]
- meteorological input data: ERA5 ECMWF

IASI total column concentration of seasonal mean

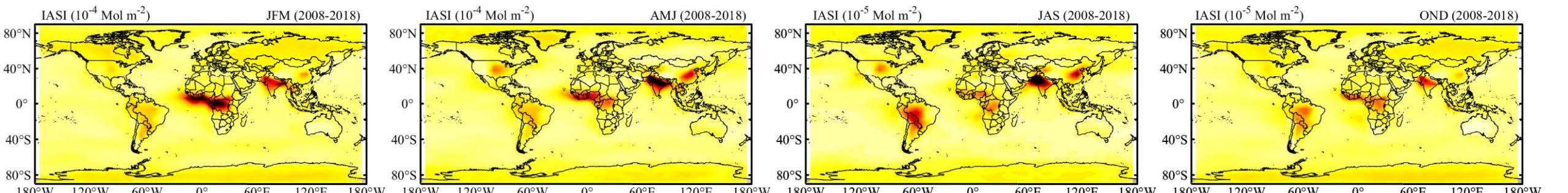
No filter (daily)



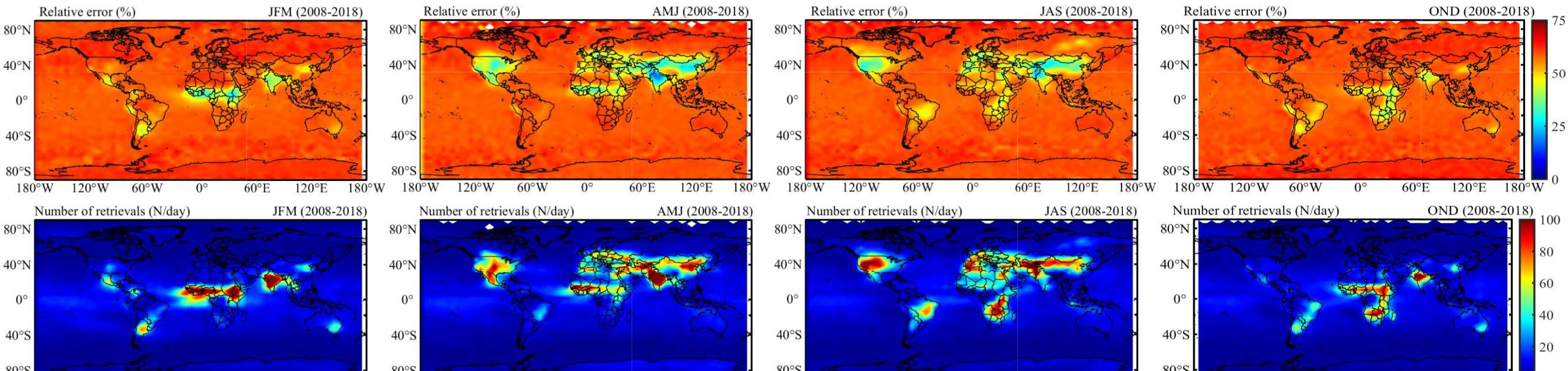
With filter (daily)



Monthly



retrieval parameters and properties

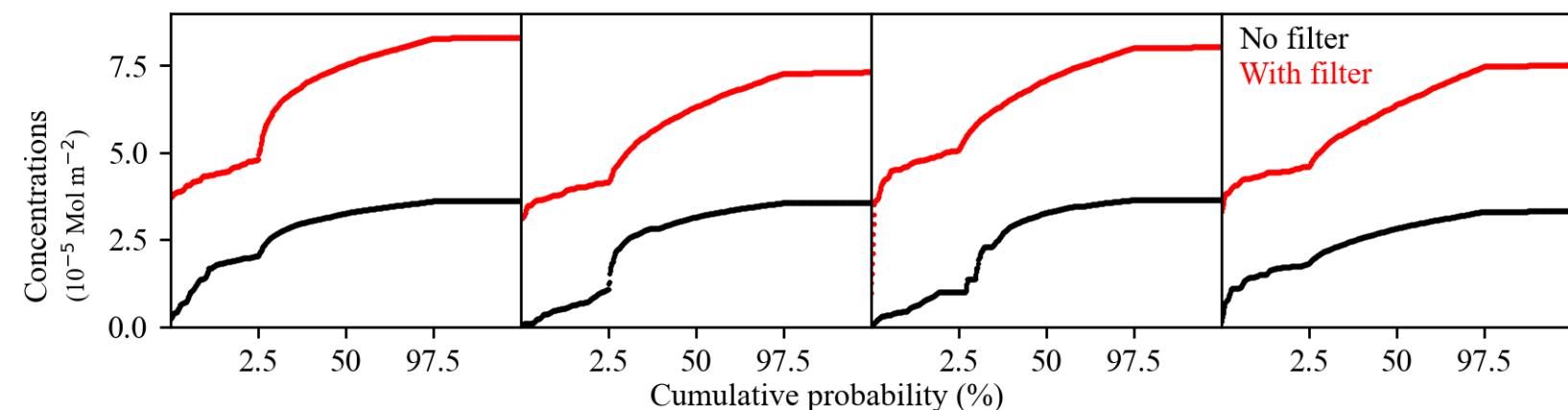


JFM

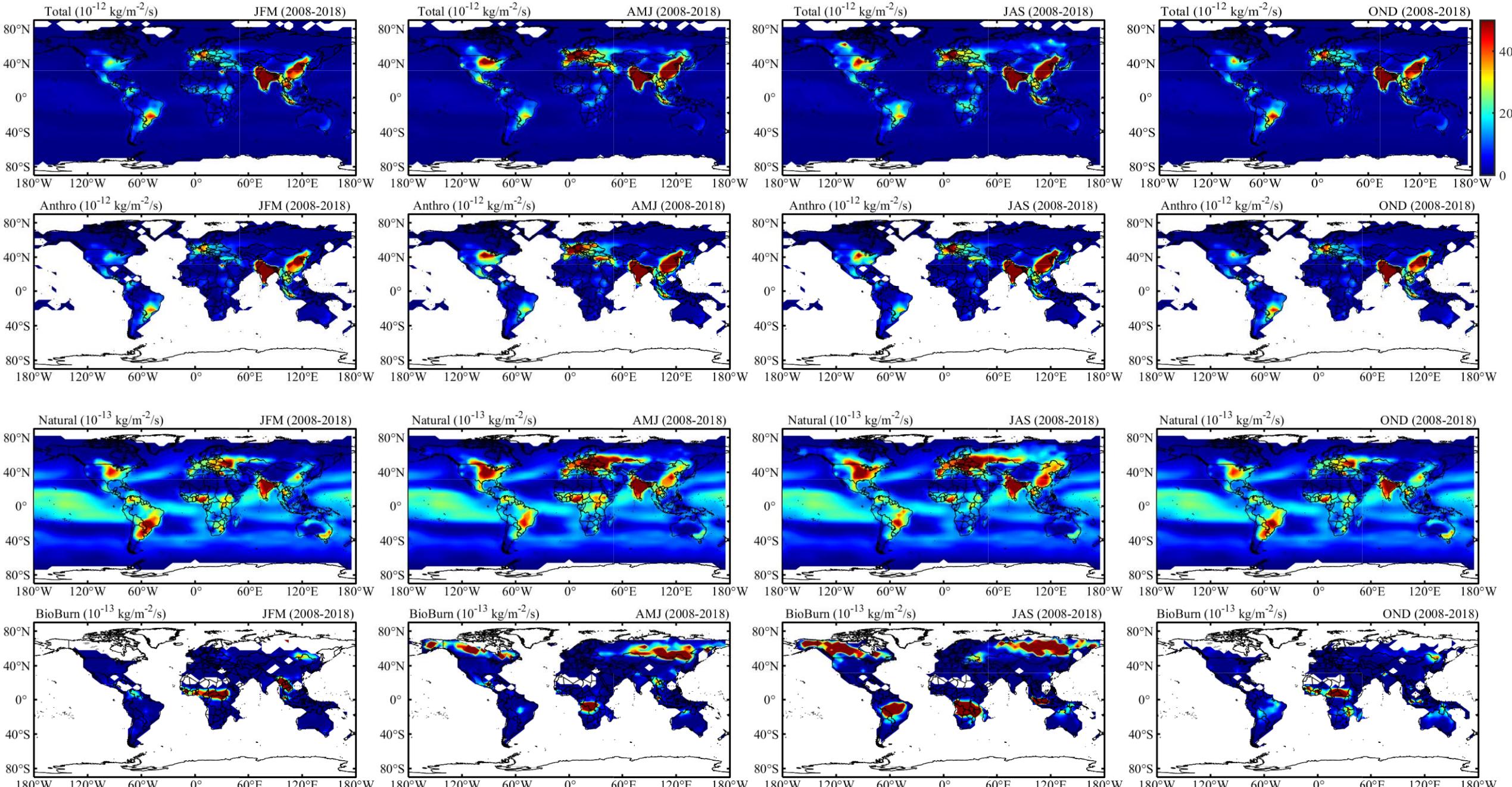
AMJ

JAS

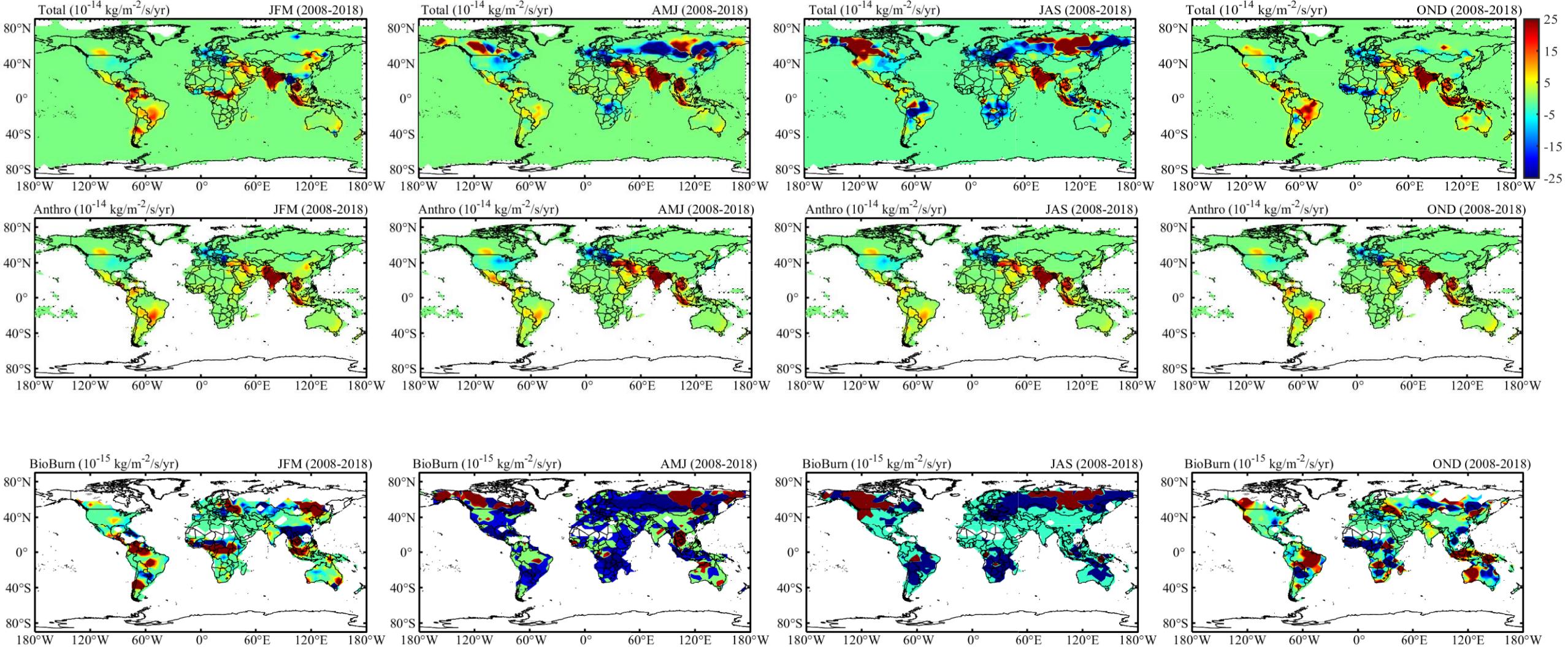
OND



Seasonal emission mean spatial distribution (monthly)

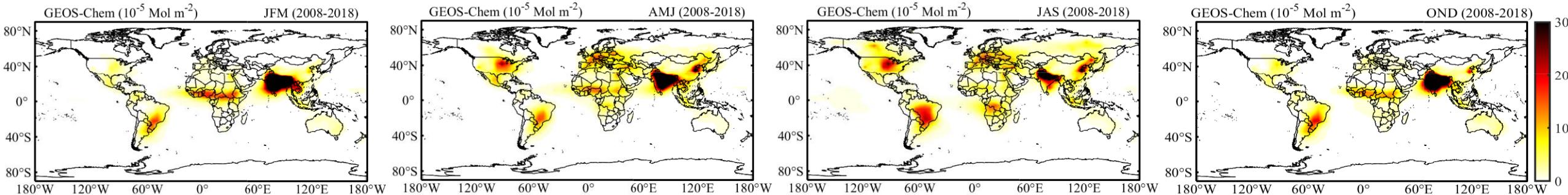


Seasonal emission trend spatial distribution (monthly)

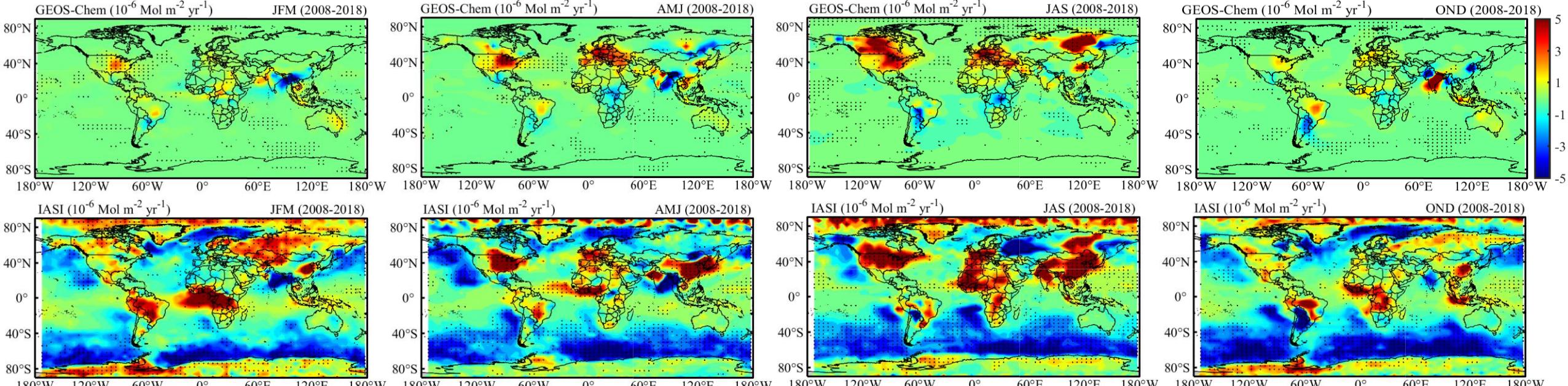


Seasonal concentration mean and trend spatial distribution (monthly)

Mean

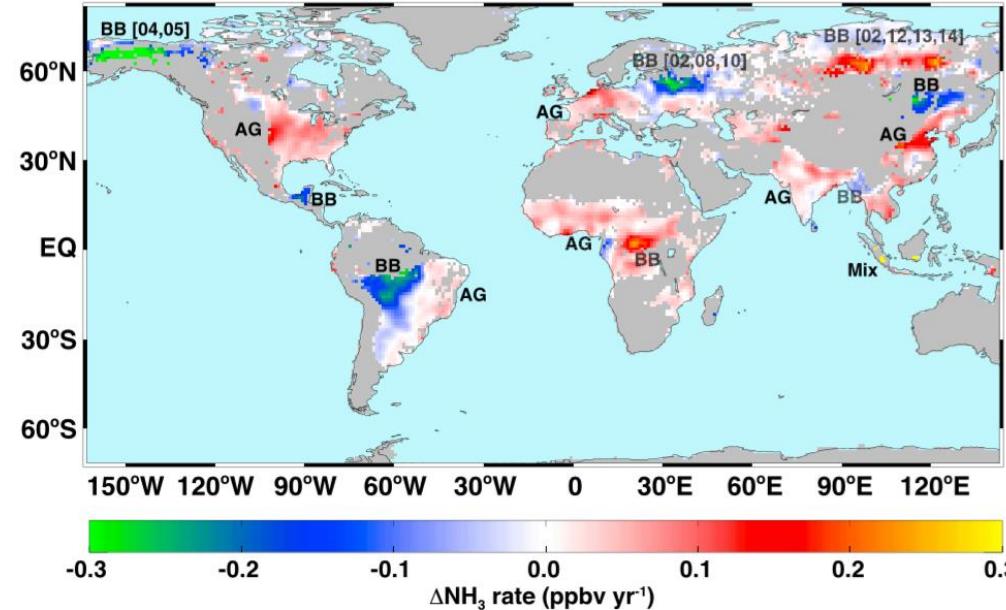


Trend



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)

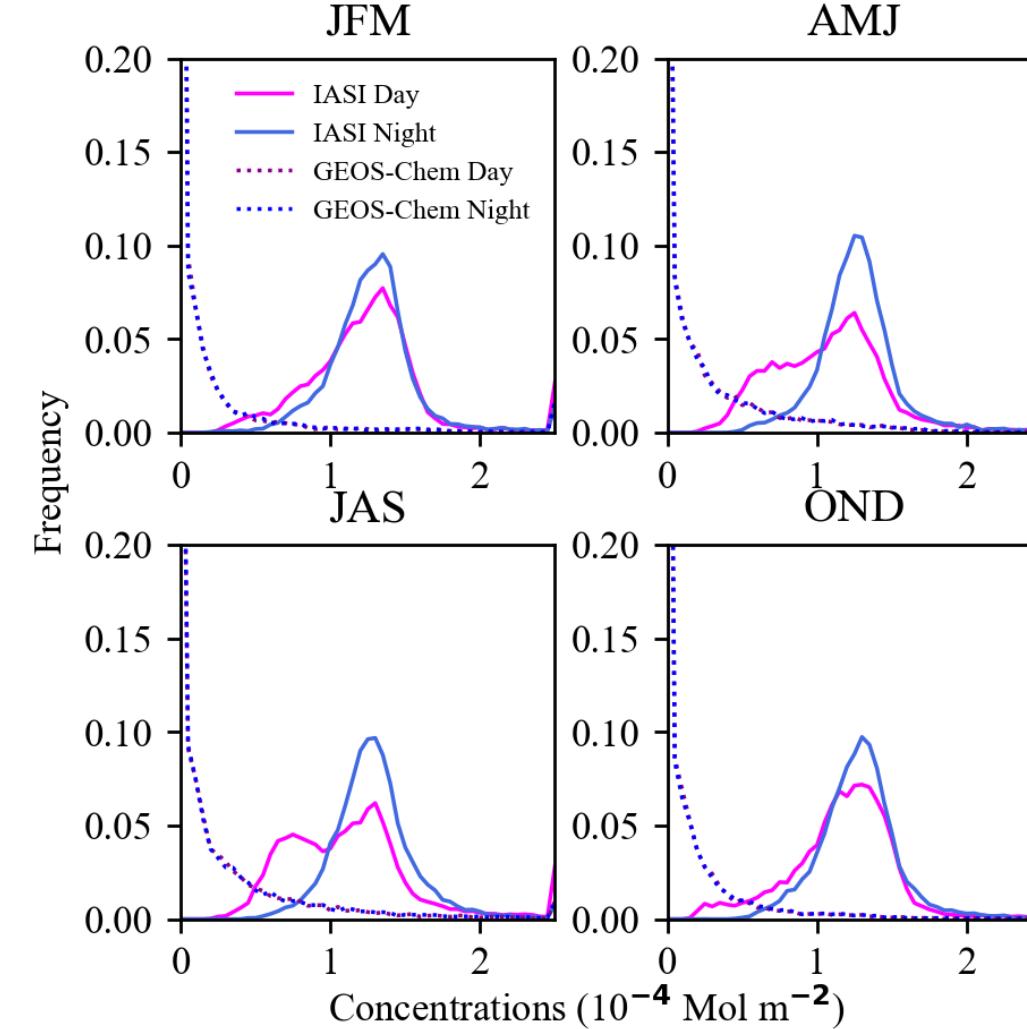
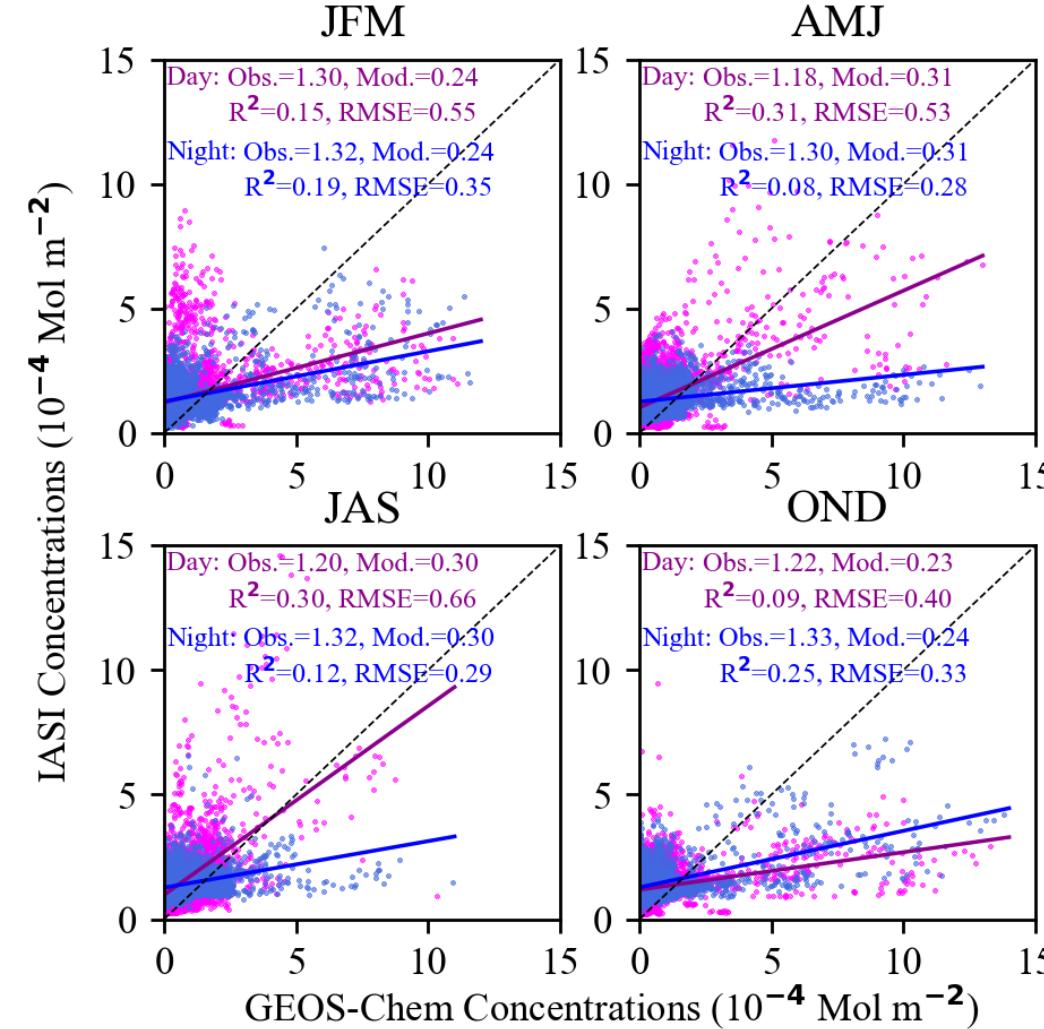
total column concentration

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

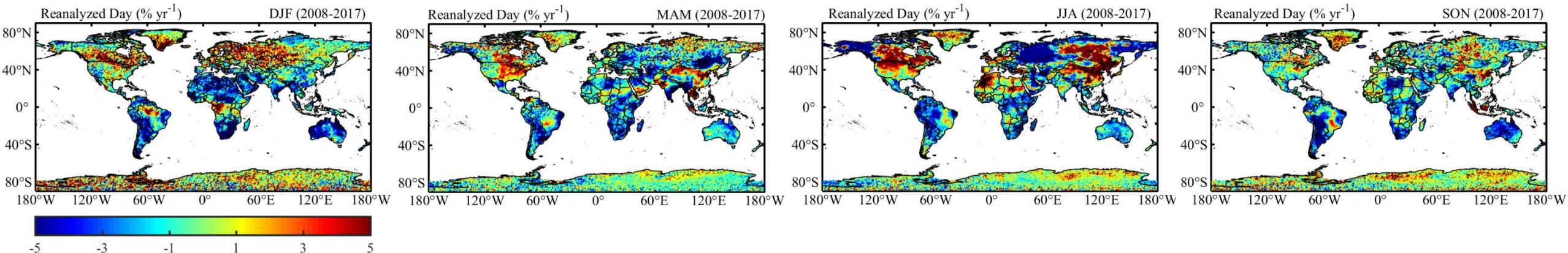
- Latitude: 46 degrees
 - 88°-90°: 2x5 to 1x1, 2 degrees
 - 0-88°: 4x5 to 1x1, 44 degrees
- Method:
 - Step1: mask ocean, set as NaN
 - Step2: calculate mean value in each upscaling grid

Comparison of GEOS-Chem and IASI total column concentrations

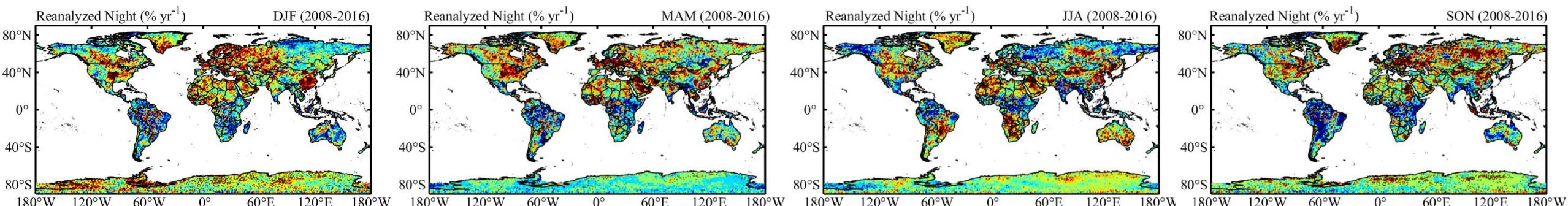


Spatial distribution of ammonia observations trend/mean

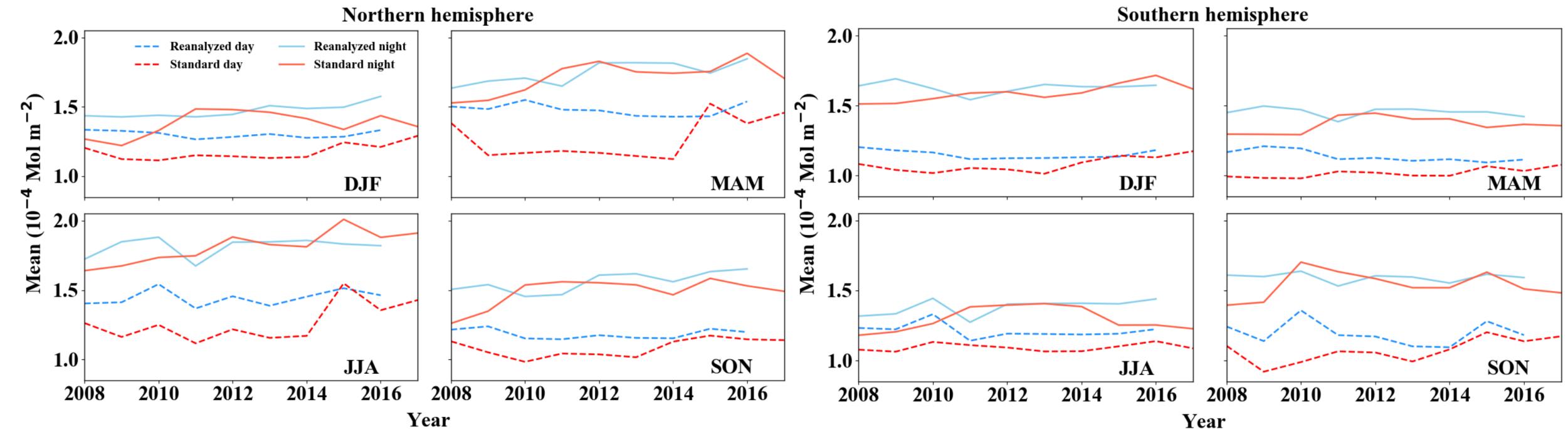
(a) day



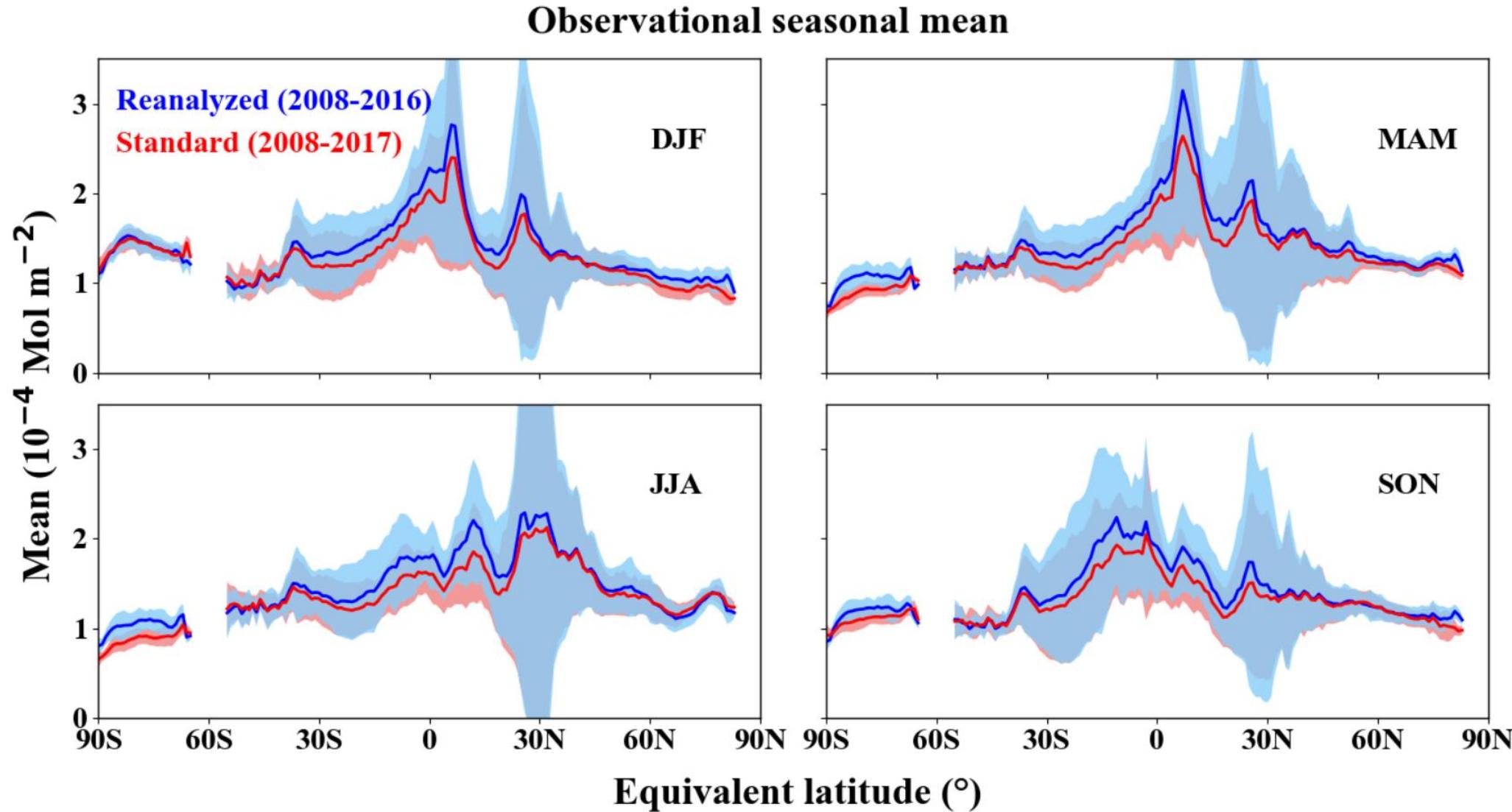
(b) night

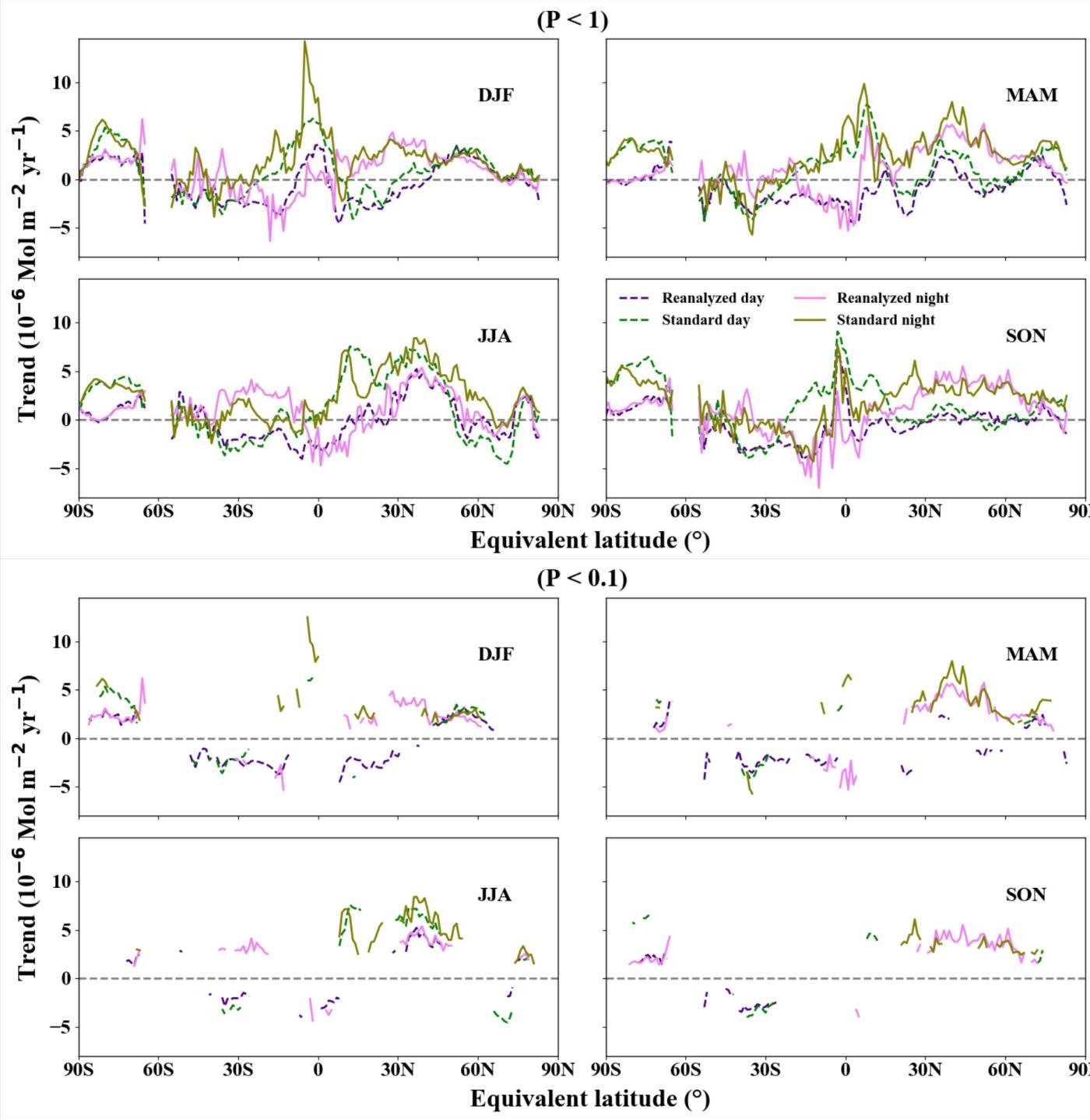


Seasonal change for NH and SH (day and night)

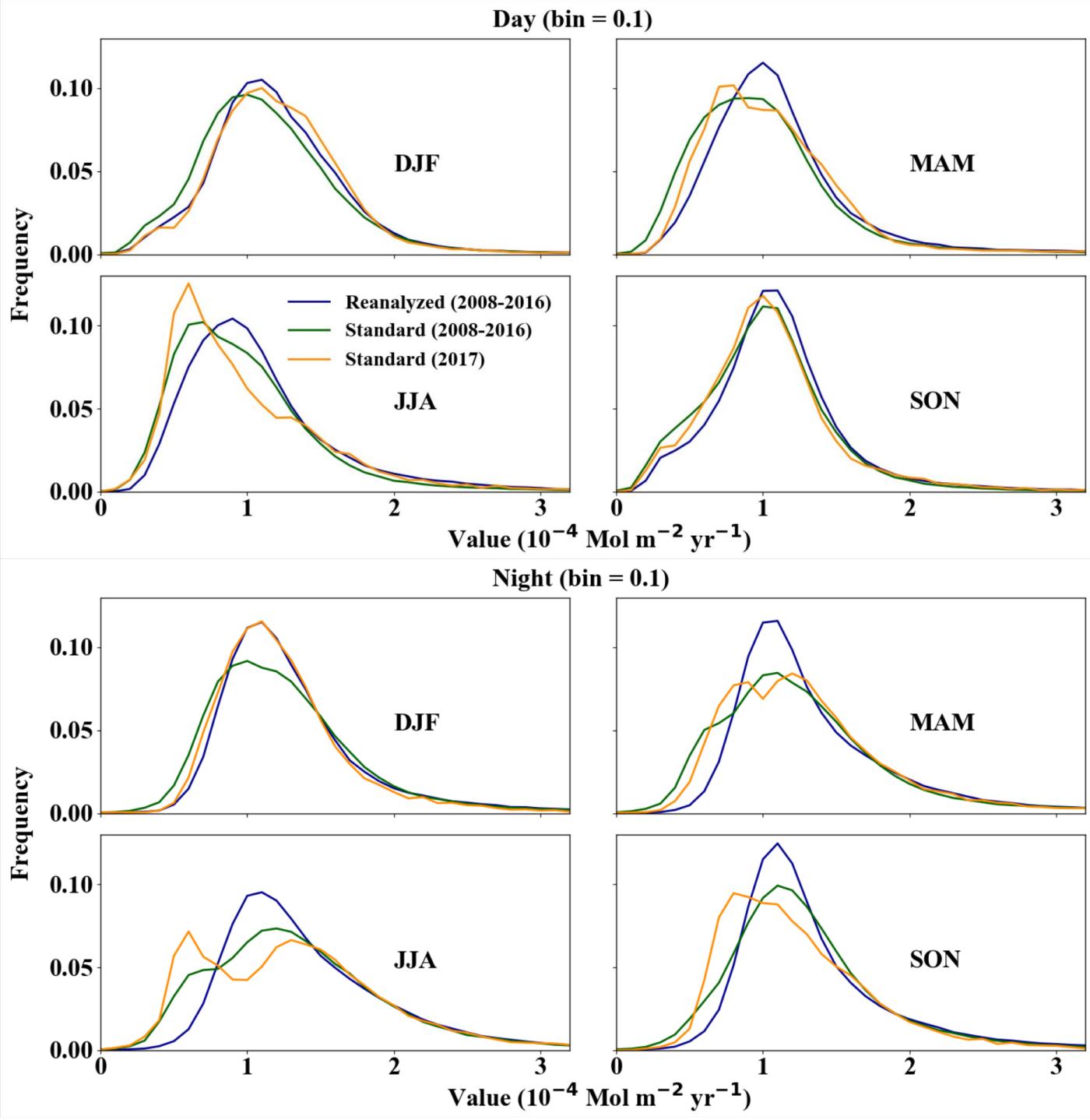


Seasonal mean of Land for equivalent latitude (within 1 sigma standard deviations)



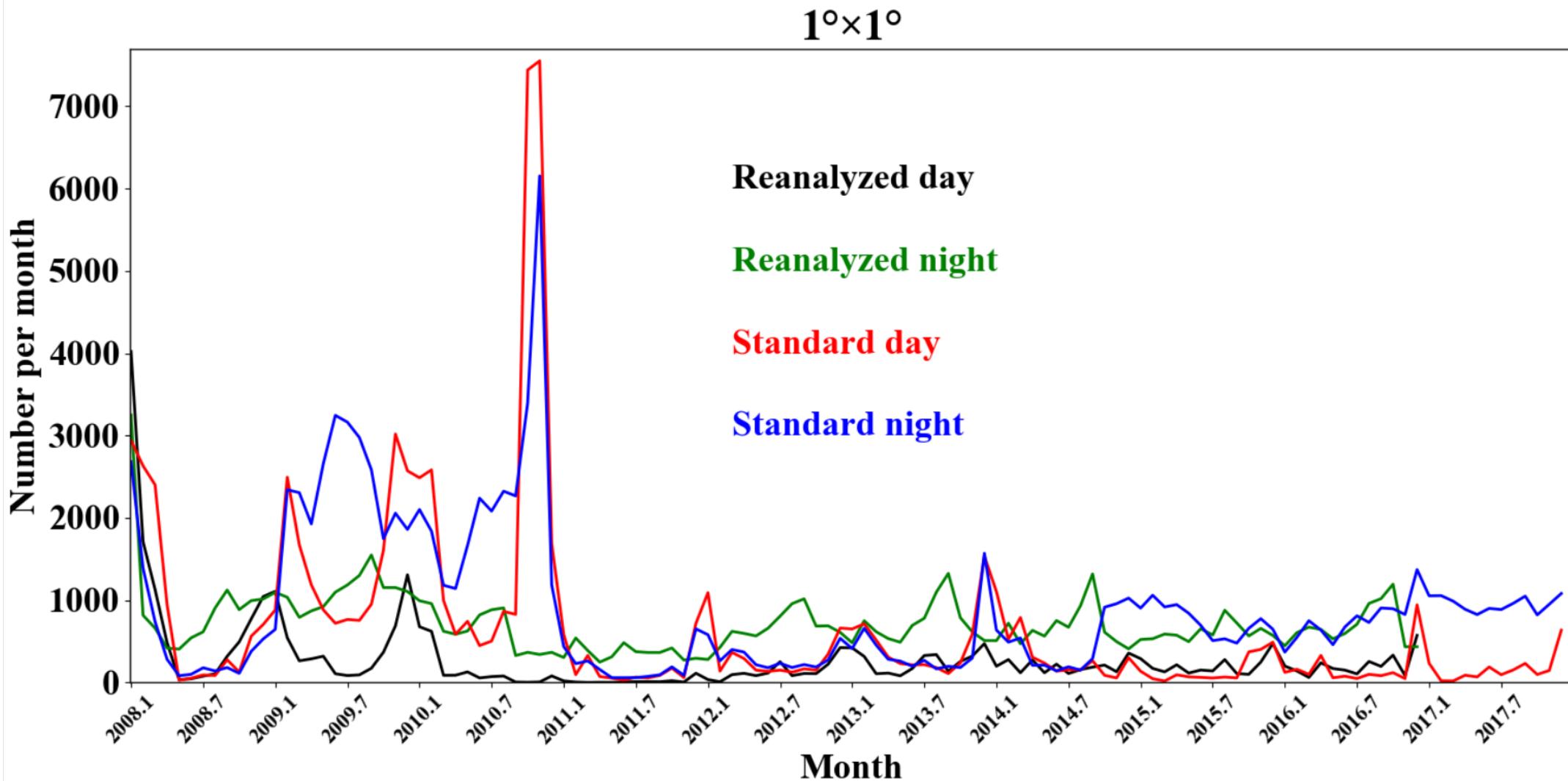


Seasonal trend in the equivalent latitude over 2008-2016 (day and night)



PDF of the 2008-2016 and 2017 (day and night)

Missing value of datasets over 2008-2017 (per month)



End