Observed and simulated Ammonia concentration 6

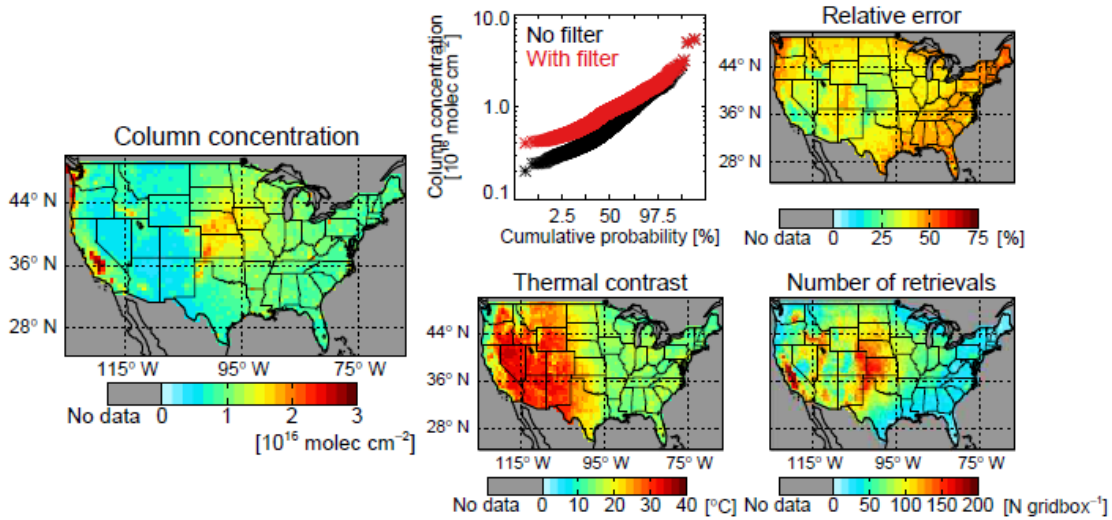
IASI data and GEOS-Chem simulation

2020.11

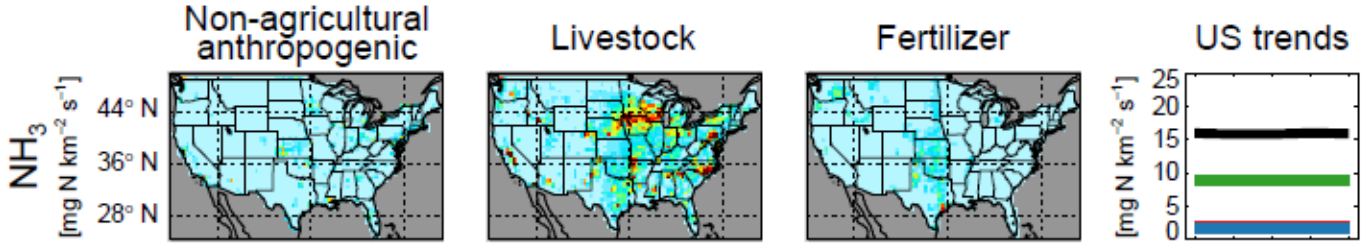
- Accomplished:
  - 1. seasonal mean distribution of GEOS-Chem over 2008-2018
  - 2. seasonal trend distribution of GEOS-Chem over 2008-2018
  - 3. comparison of GEOS-Chem and IASI (R2, PDF)
  - 4. literature: NH3 concentration variability in GEOS-Chem and IASI
- Ammonia Data:
  - IASI total columns, 1°×1°, monthly
    - Reanalyzed IASI/Metop-A (2008-2018) L3
  - GEOS-Chem simulation, 4°×5°, daily
    - column concentration (2008-2018)
- Ongoing:
  - 1. consider the cause of trend

Interannual variability of ammonia concentrations over the United States: sources and implications

- use observations to investigate the variability of ammonia in the US during 2008–2012 (JJA)
  - identify observed ammonia variability
  - Investigate the ability of GEOS-Chem to reproduce observations
  - attribute sources of the model ammonia concentration variability
  - represent the variability of agricultural ammonia emissions
- GEOS-Chem simulation
  - v9-02, US: 0.5 x 0.667, Global: 2 x 2.5
  - Emission:
    - Anthropogenic ammonia (standard version): EPA NEI-2005 inventory (78%)
      - livestock (71%)
      - Fertilizer (15%)
      - non-agricultural
    - biomass burning: FINN (2%)
- IASI satellite column measurements
  - morning overpass
  - gridding and averaging scheme: compute the mean column concentration weighted by relative error of the native retrievals
    - cloud cover < 25%
    - skin temperature >10 ℃
    - relative error < 75%

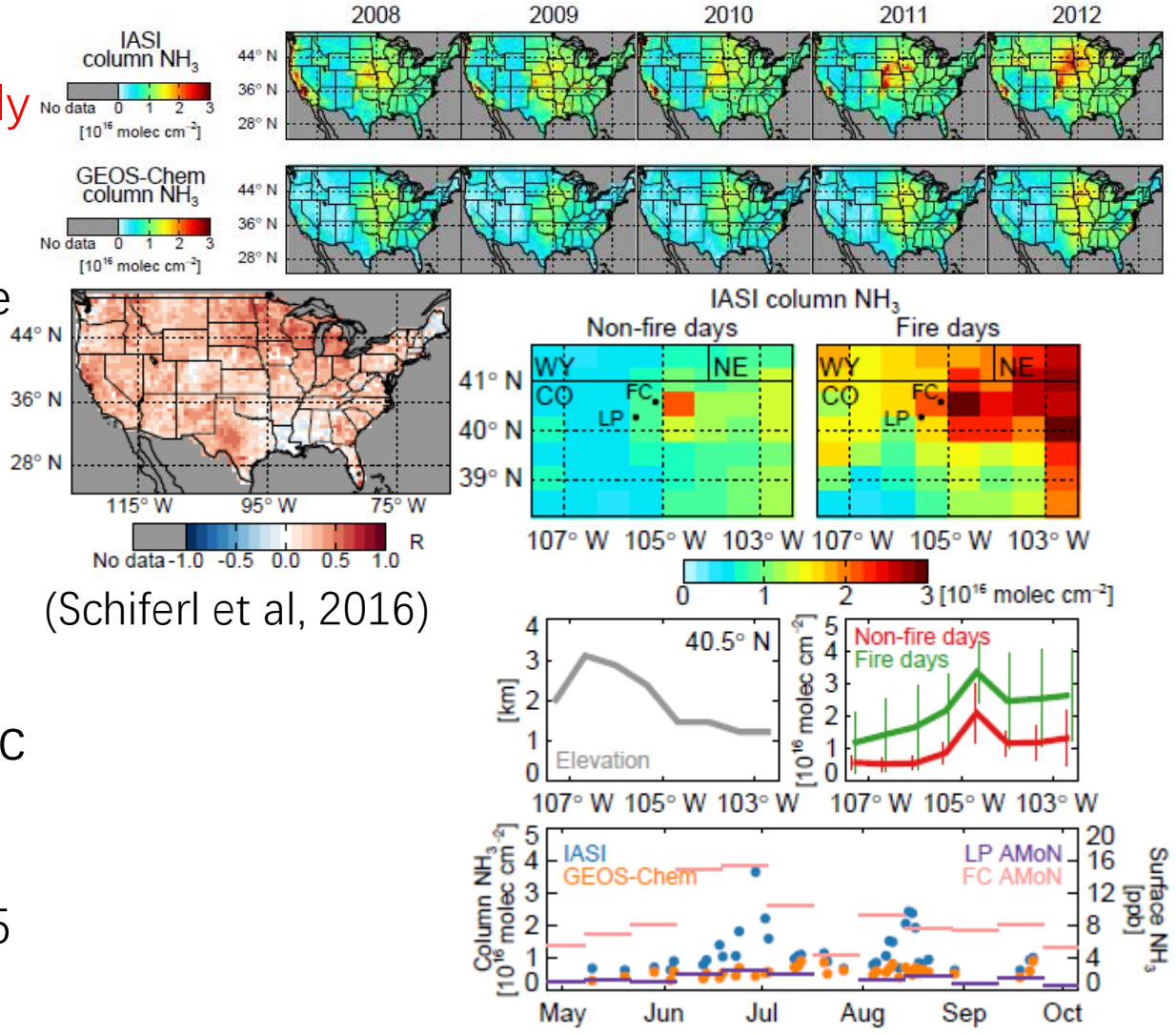


(Schiferl et al, 2016)



Interannual variability of ammonia concentrations over the United States: sources and implications

- Observed year-to-year ammonia variability
  - Observed ammonia concentrations vary significantly from year to year
- Column comparison
  - The simulated ammonia column concentrations are generally well correlated with the IASI observations
- Integrated comparison: Colorado, summer 2012
  - higher on days with wildfire activity
  - the average ammonia concentrations observed are elevated due to fire emissions.
- Updated inventory comparison: anthropogenic emission inventory, NEI-2011
  - a year-specific inventory
  - does not provide a better constraint than NEI-2005



(Schiferl et al, 2016)

Global evaluation of ammonia bidirectional exchange and livestock diurnal variation schemes

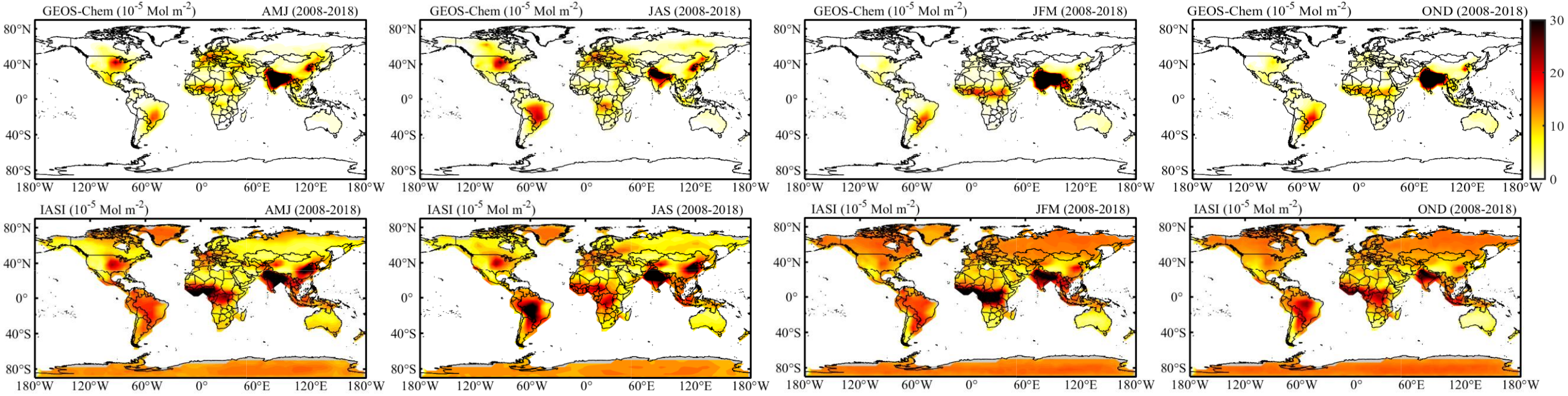
- investigate the diurnal patterns of NH3 emissions and bidirectional air–surface exchange
  - apply a new diurnal distribution pattern to NH3 livestock emissions in GEOS-Chem
  - Implement bidirectional exchange of NH3 in GEOS-Chem
- GEOS-Chem
  - US: 0.5 x 0.667, Global: 2 x 2.5
- GEOS-Chem adjoint model
  - Investigate the sensitivity of modeled NH3
    - soil pH
    - fertilizer application rate
- Observations
  - NH3
    - SEARCH network: NH3
    - AMoN: NH3
  - wet NH4+ deposition
    - NTN
    - CAPMoN
    - EANET

(Zhu et al, 2015)

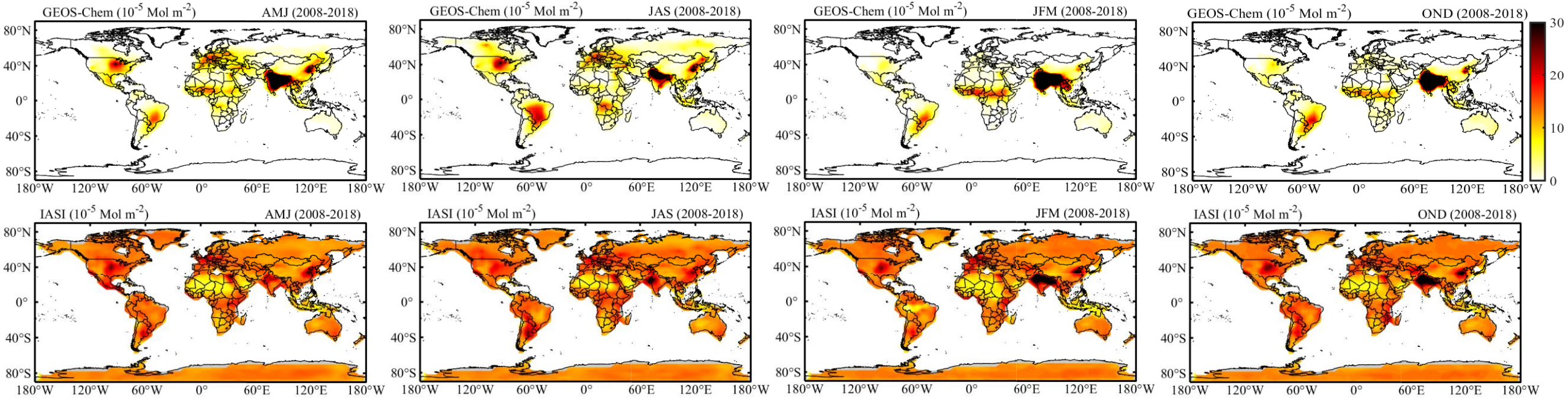
Section	Region	Horizontal resolution	Model version	Anthropogenic emissions inventory	Gross emissions in region (Tg)		
					April	July	October
4.2	USA[a]	1/2° × 2/3°	Static and dynamic	NEI 2005[b]	0.200	0.407	0.223
4.3	Global	2° × 2.5°	Static and dynamic	MASAGE_NH3[c]	6.79	6.59	5.01
6.1.1, 6.1.2	USA	1/2° × 2/3°	BASE[d]	NEI 2005	0.200	0.407	0.223
			BIDI[d]	NEI 2005 livestock + upward BIDI flux[e]	0.153	0.428	0.192
6.1.3	USA	2° × 2.5°	BASE	Optimized emissions inventories[f]	1.04	1.11	1.27
			BIDI		1.12	1.21	1.40
6.2, 6.3, 6.4	Global	2° × 2.5°	BASE	MASAGE_NH3	6.79	6.59	5.01
			BIDI		5.62	6.30	4.73

seasonal mean spatial distribution

Day time

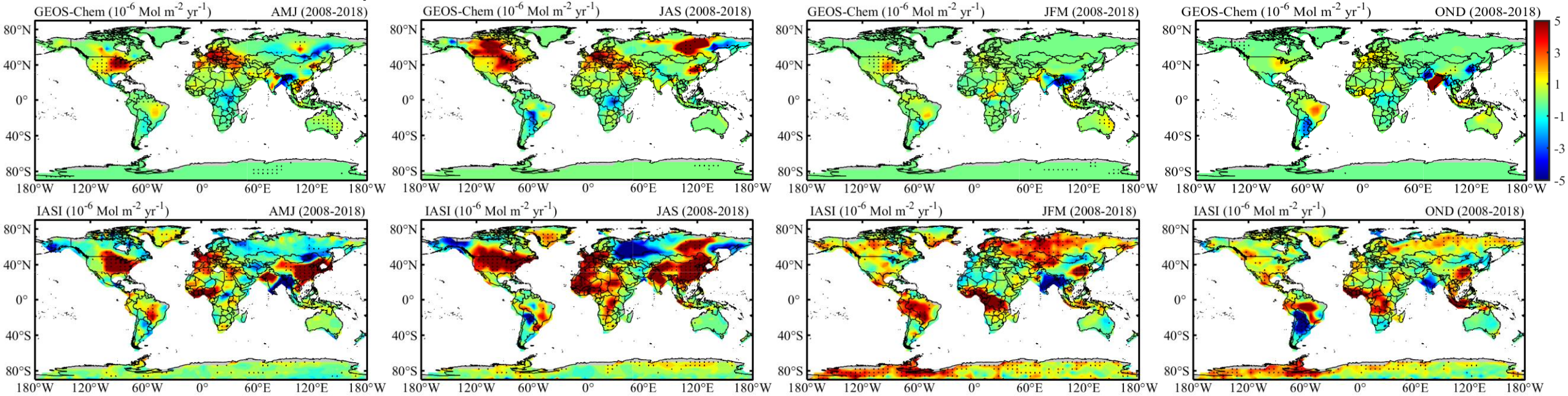


Night time

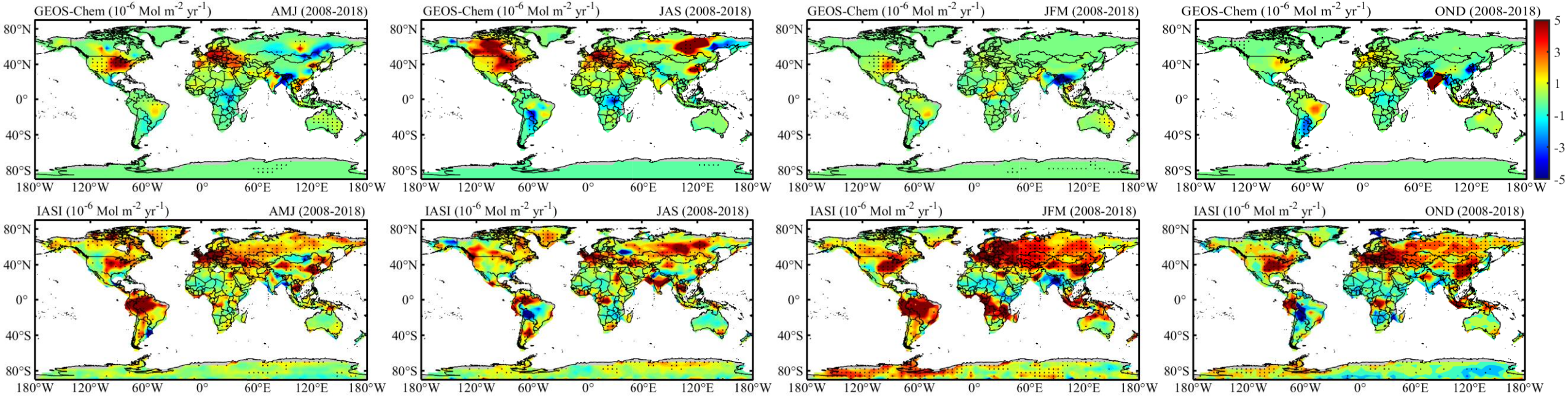


seasonal trend spatial distribution

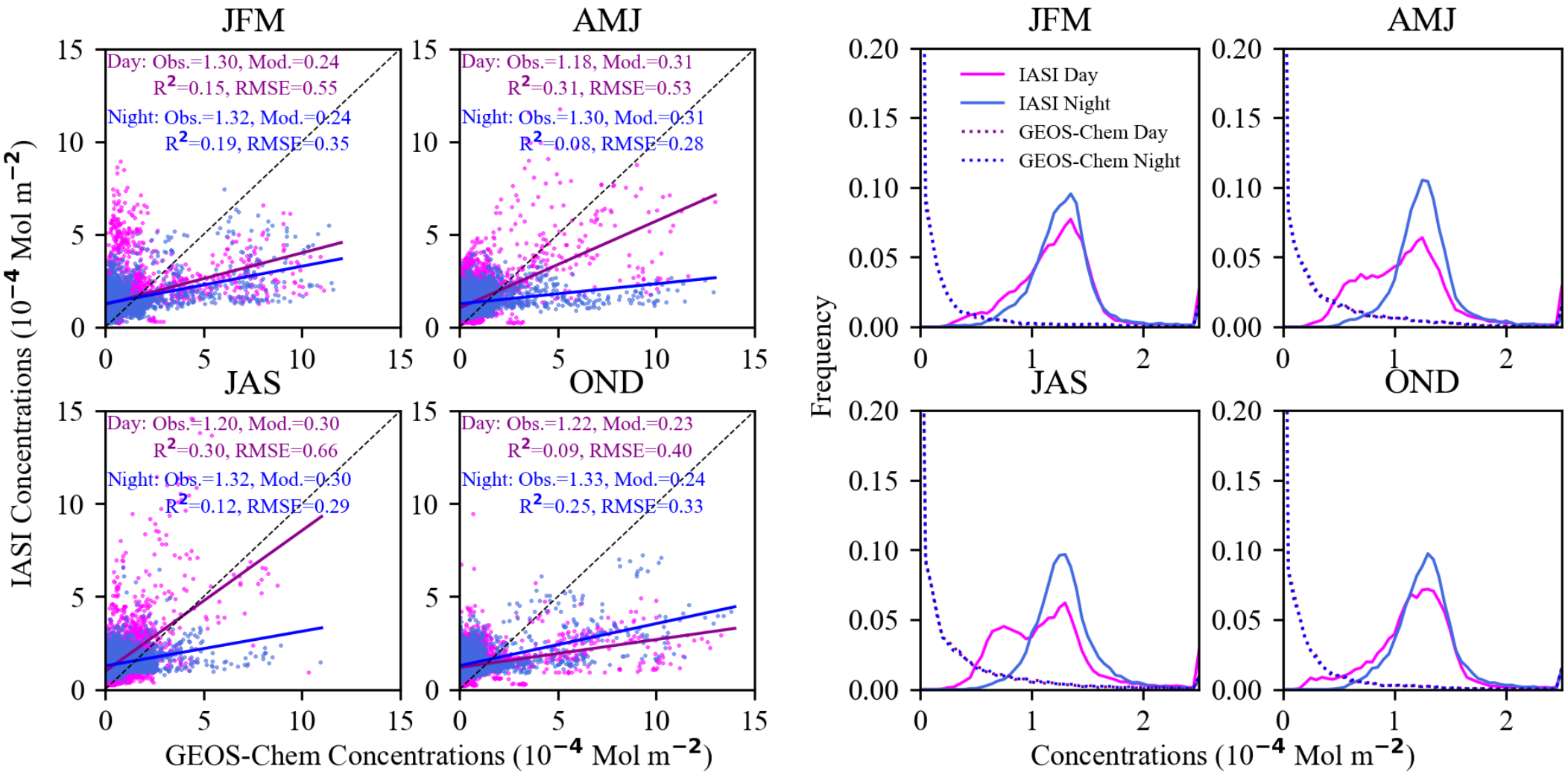
Day time



Night time

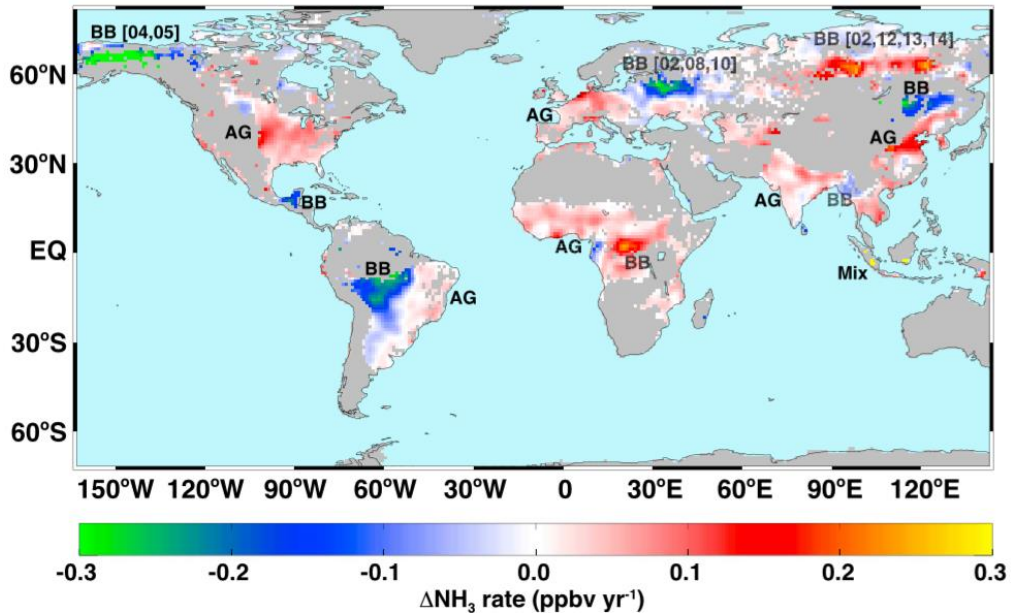


Comparison of GEOS-Chem and IASI total column concentrations



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, 2016)

total column concentration

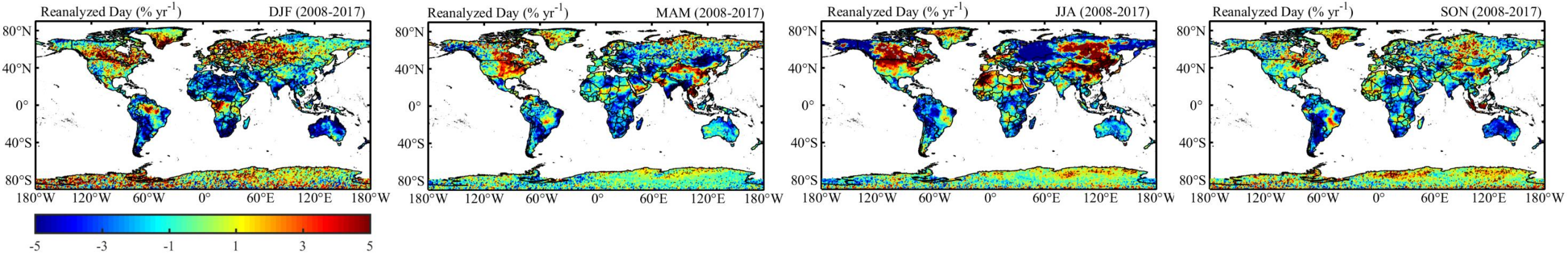
- $\Omega = \sum_{i=1}^{47} c_{\mathrm{i}} \times rho_i \times h_i \times k$
  - Ω: **total column concentration,** [mol/m2]
  - c_{i}: 'IJ-AVG-$_NH3', mixing ratio for each level, [ppbv] to [v/v] (*1E-9)
  - rho_i: 'TIME-SER_AIRDEN', air density for each level, [molecules/cm3]
  - h_i: 'BXHGHT-$_BXHEIGHT', 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

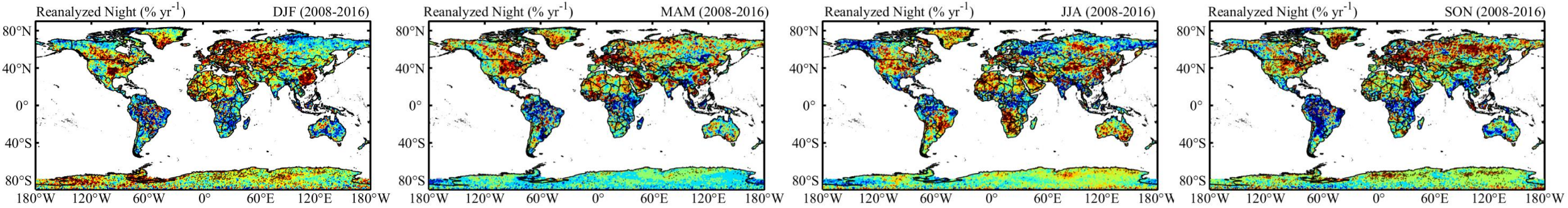
- Latitude: 46 degrees
  - 88°-90°: 2x5 to 1x1, 2 degrees
  - 0-88°: 4x5 to 1x1, 44 degrees
- Method:
  - Step1: mask ocean, set as NaN
  - Step2: calculate mean value in each upscaling grid

Spatial distribution of ammonia observations trend/mean

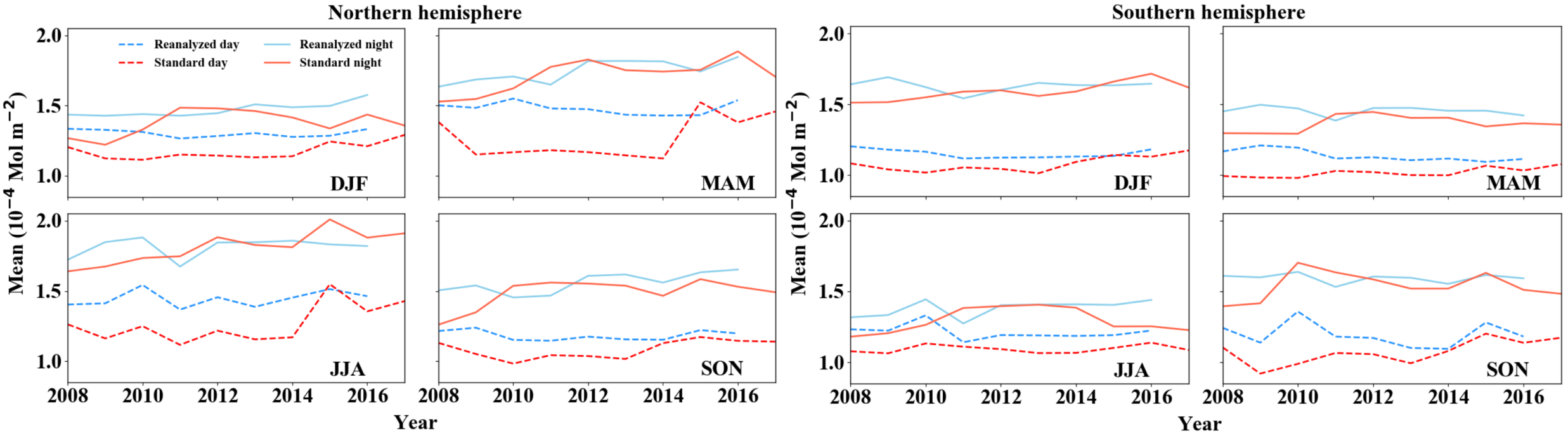
(a) day



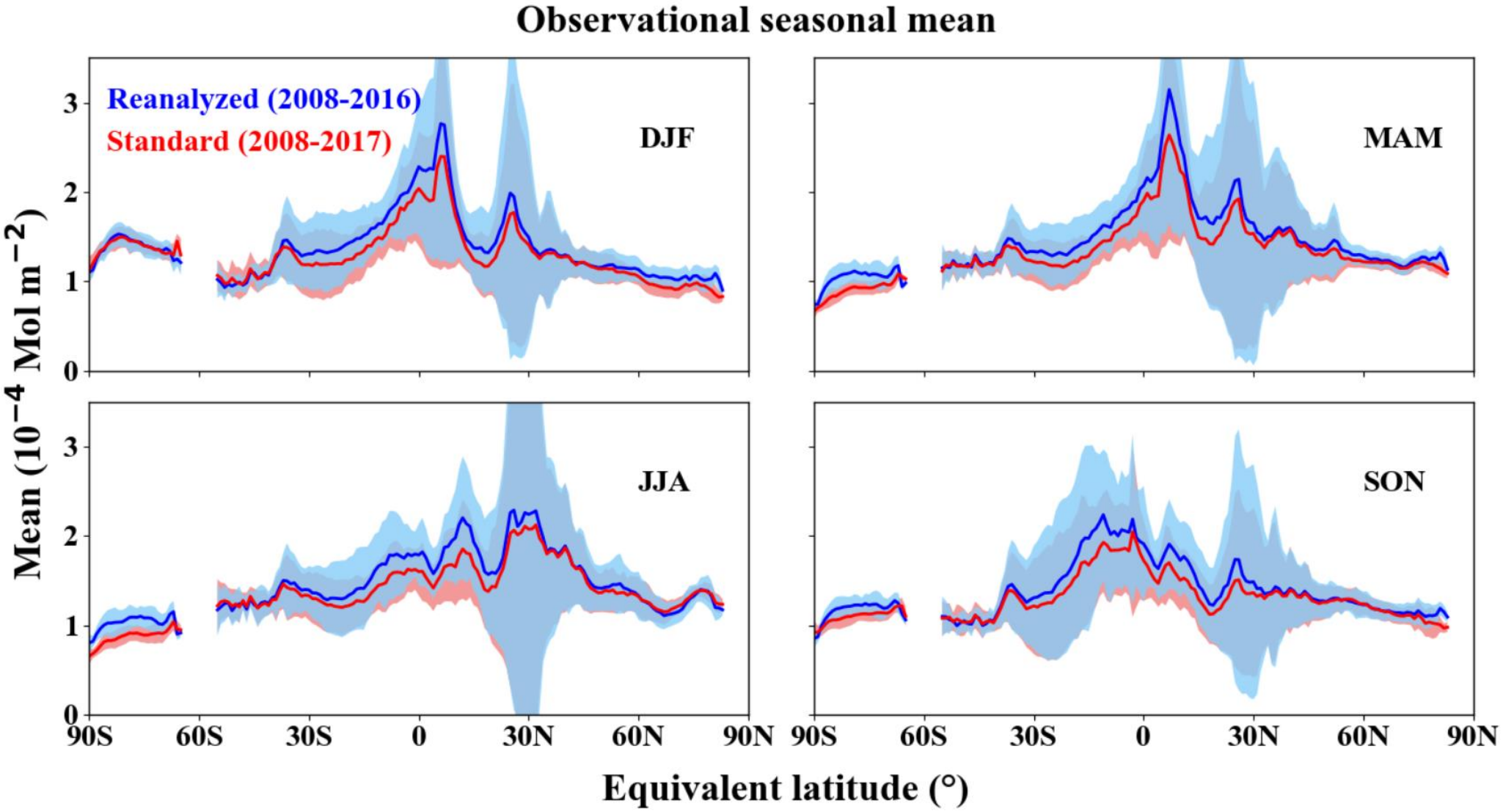
(b) night

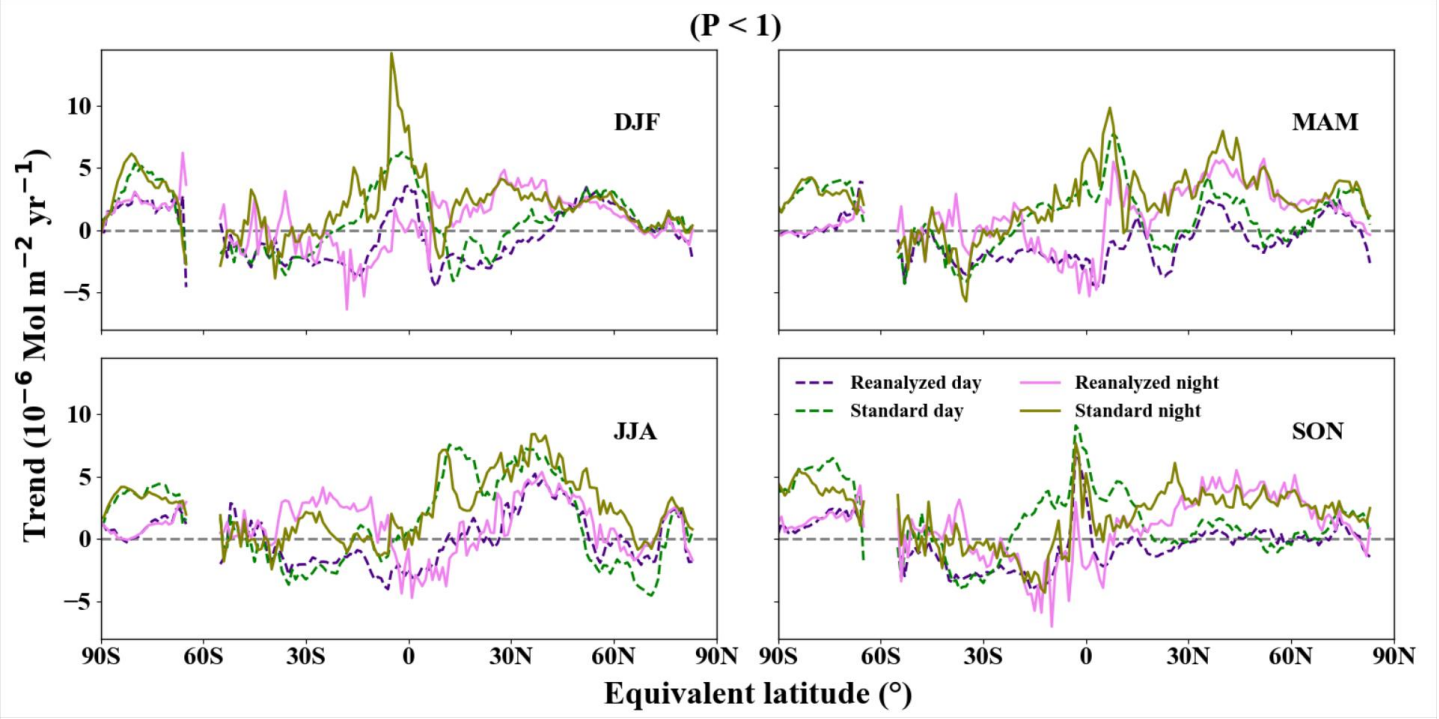


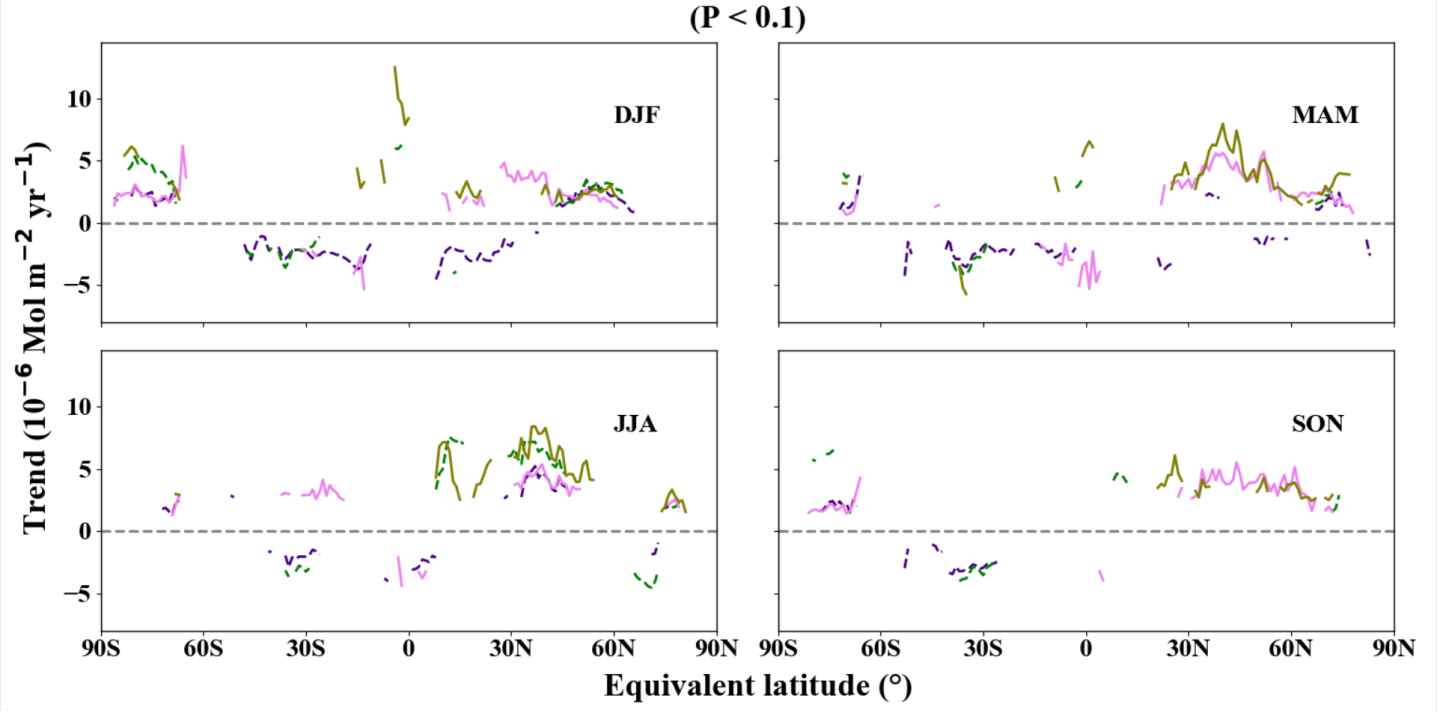
Seasonal change for NH and SH (day and night)



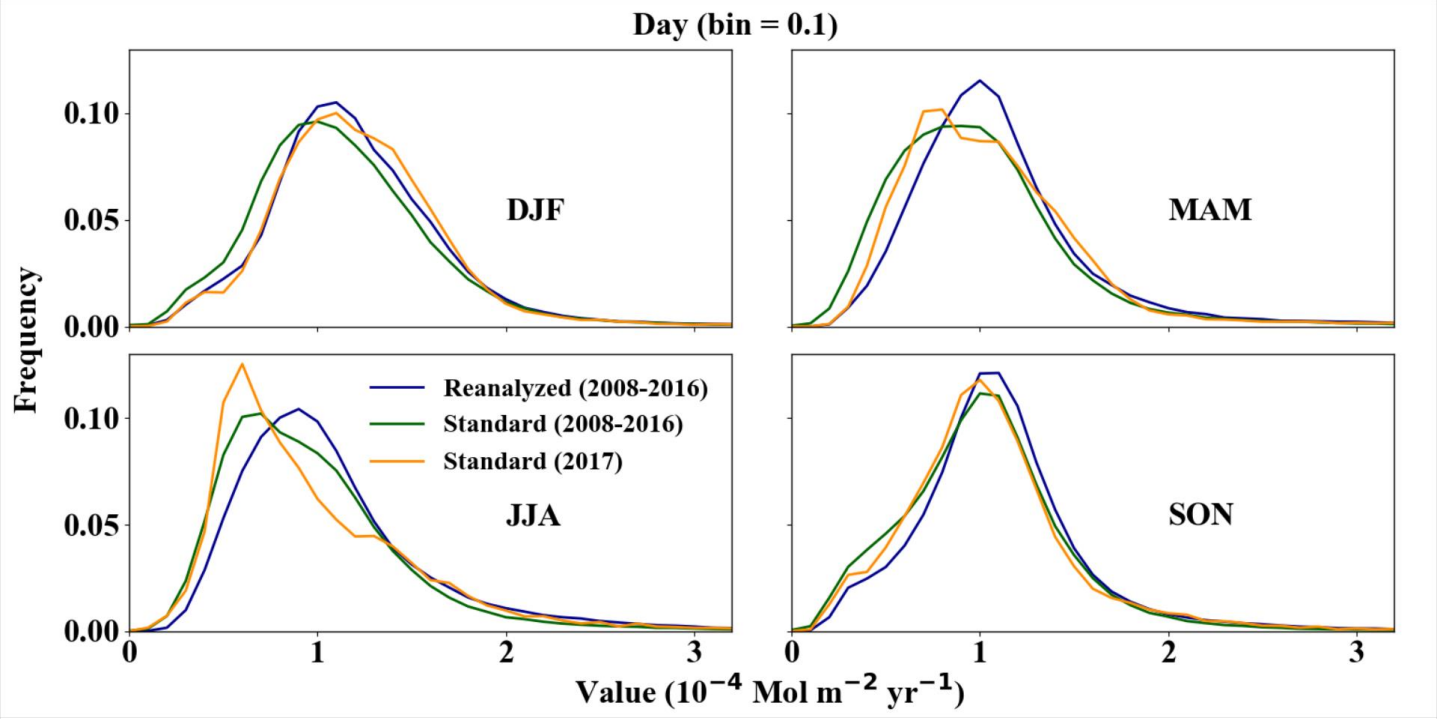
Seasonal mean of Land for equivalent latitude (within 1 sigma standard deviations)

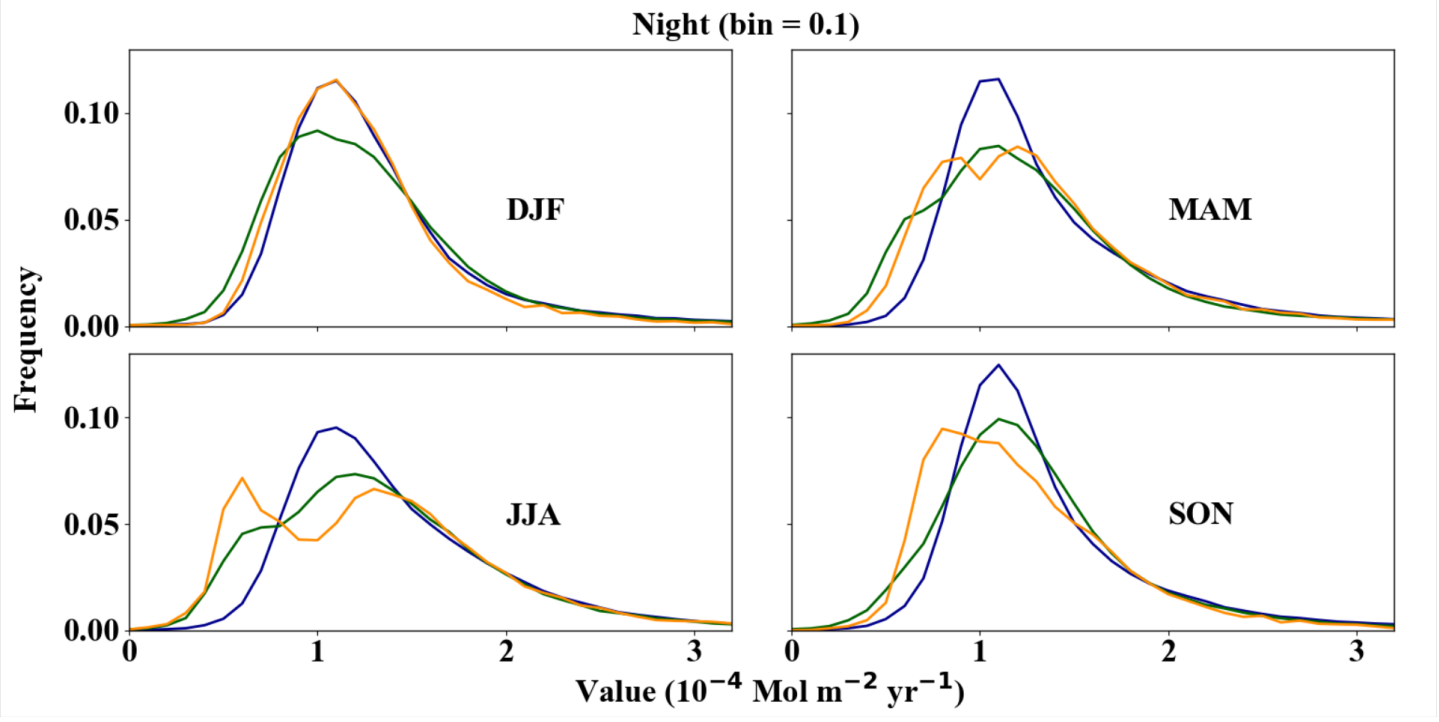






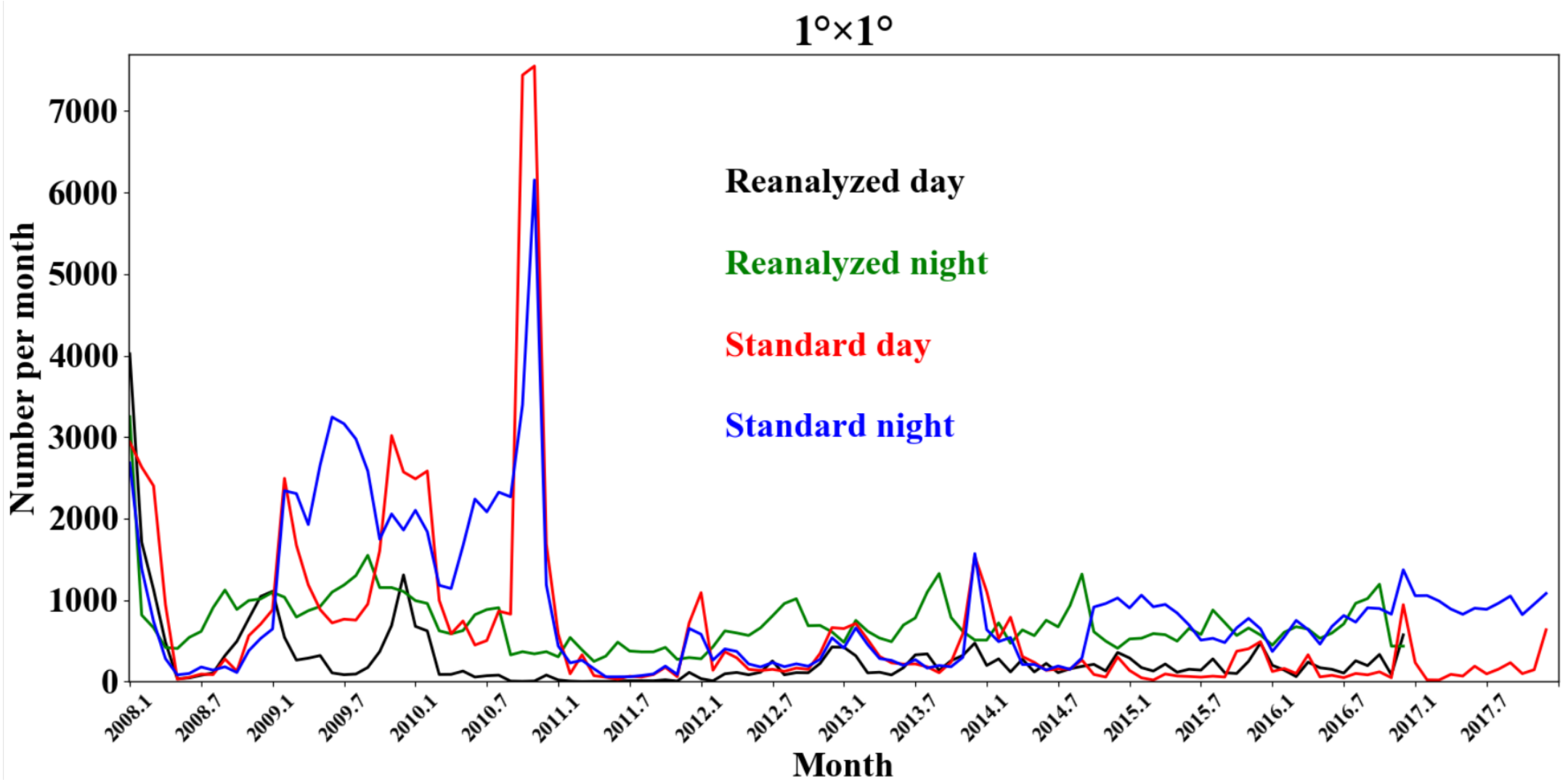
Seasonal trend in the equivalent latitude over 2008-2016 (day and night)





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

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



End