# Top-down $NH_3$ emissions based on IASI observations and GEOS-Chem simulations, 2008-2018

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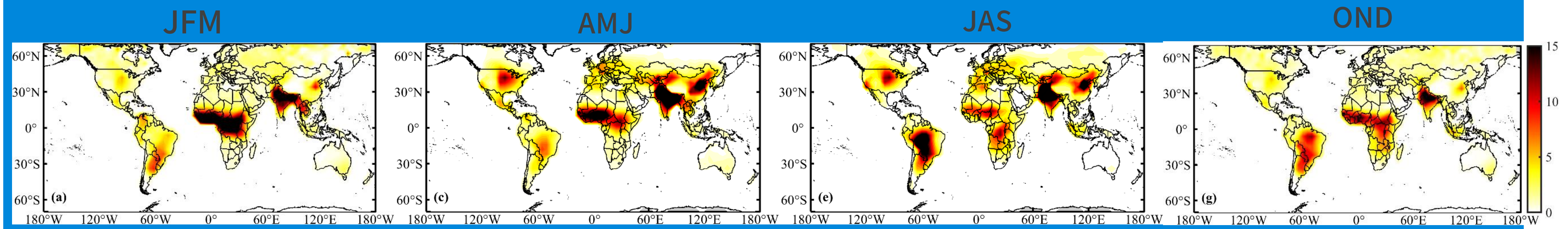
# Research Overview

- Observed and Simulated $NH_3$ Concentrations
- Optimized Emission Fluxes
- Regional Comparison to GEOS-Chem Emissions

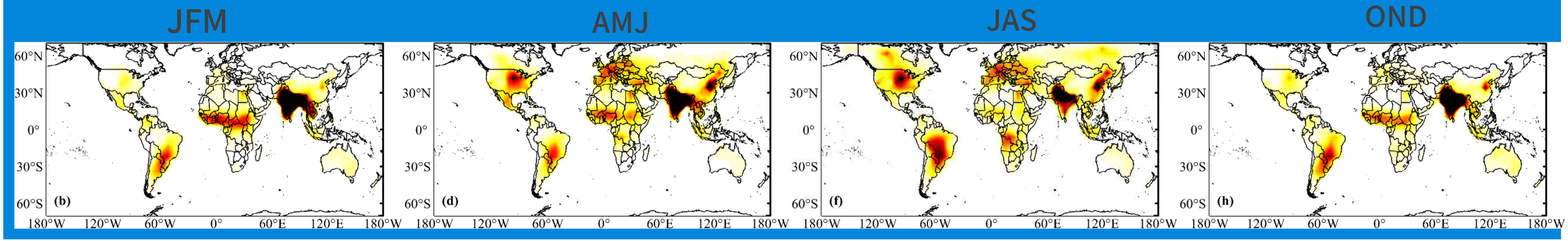
# $NH_3$ Seasonal Concentrations

## Mean ($10^{15}$ molecules $cm^{-2}$)

## IASI observations




## GEOS-Chem simulations

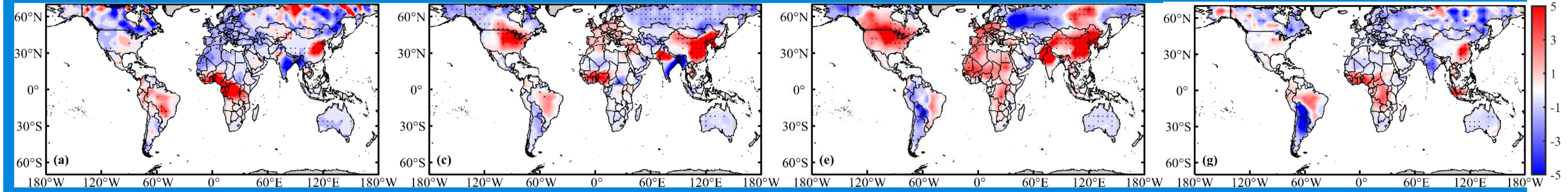


# $NH_3$ Seasonal Concentrations

## Trend ($10^{-6}$ Mol $m^{-2}$ $yr^{-1}$)

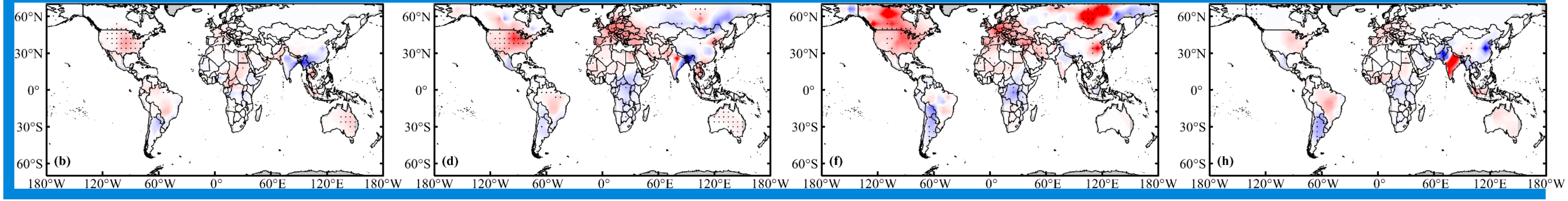
## IASI Observations

JFM AMJ JAS OND




## GEOS-Chem simulations

JFM AMJ JAS OND



# Emission Fluxes

## Lifetime ($\tau$)

### Quasi-equilibrium

Emission fluxes of ammonia

are continuous

$$\tau = \frac{M}{F_{out} + L + D}$$

- $M$: $NH_3$ mass
- $F_{out}$: $NH_3$ mass rate of export
- $L$: $NH_3$ mass rate of chemical reaction
- $D$: $NH_3$ mass rate of deposition, including the wet deposition and the dry deposition

### Ammonia-water equilibrium

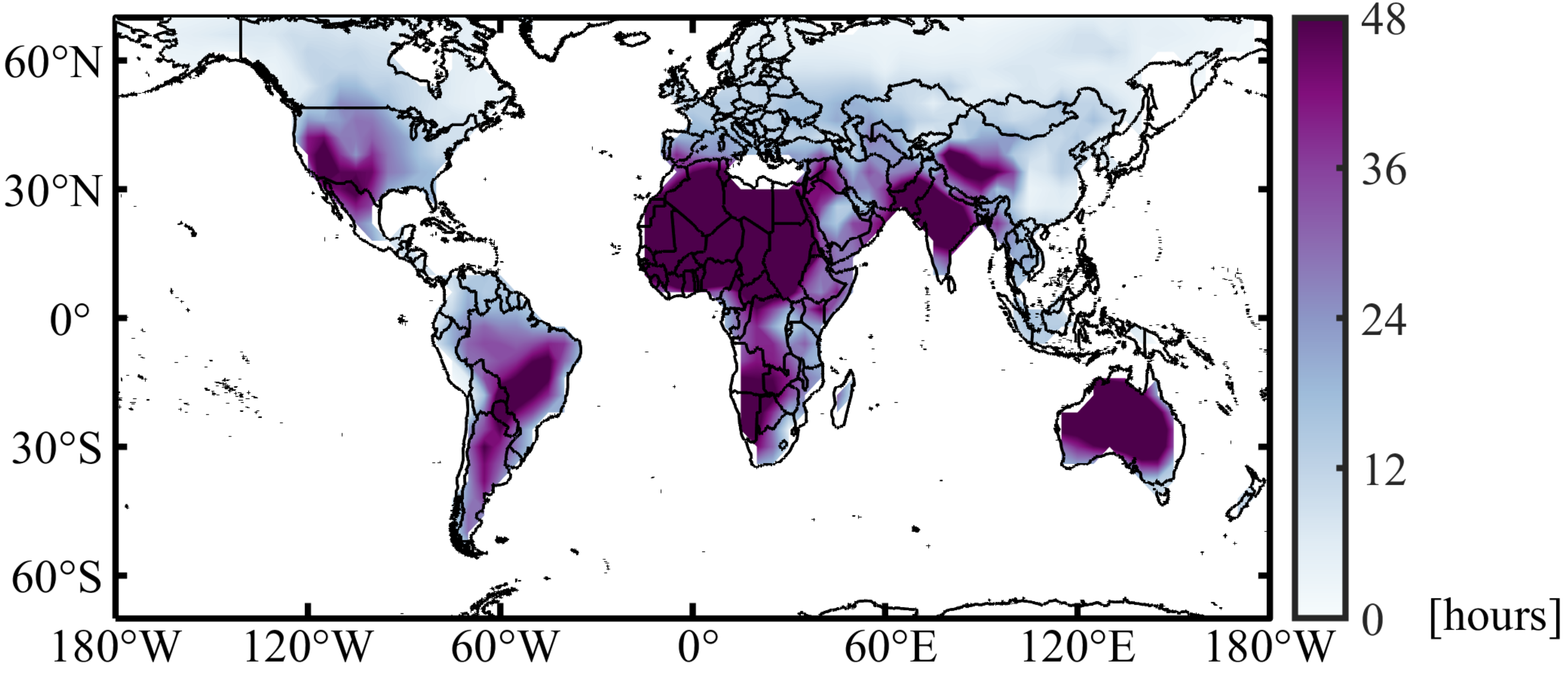
$$NH_3 + H_2O \rightleftharpoons NH_3 \cdot H_2O \rightleftharpoons NH_4^+ + OH^-$$

$$D = D_{NH_3} + D_{NH_4^+}$$

### Modeled lifetime

Neglect the $NH_3$ export ($F_{out}$)

$$\tau_{mod} = \frac{M_{NH_3}}{D_{NH_3} + D_{NH_4^+}}$$




# Emission Fluxes

## Average Lifetime

Apply one-box model that neglect the $NH_3$ export and consider the ammonia-water equilibrium.

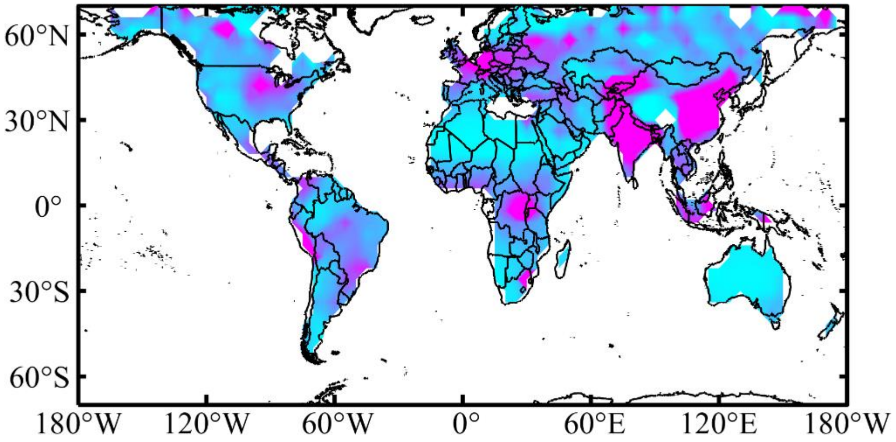
# Emission Fluxes ($\hat{E}$)

$$\hat{E} = \frac{\Delta M_{NH_3}}{\tau_{mod}} + E_{mod}$$

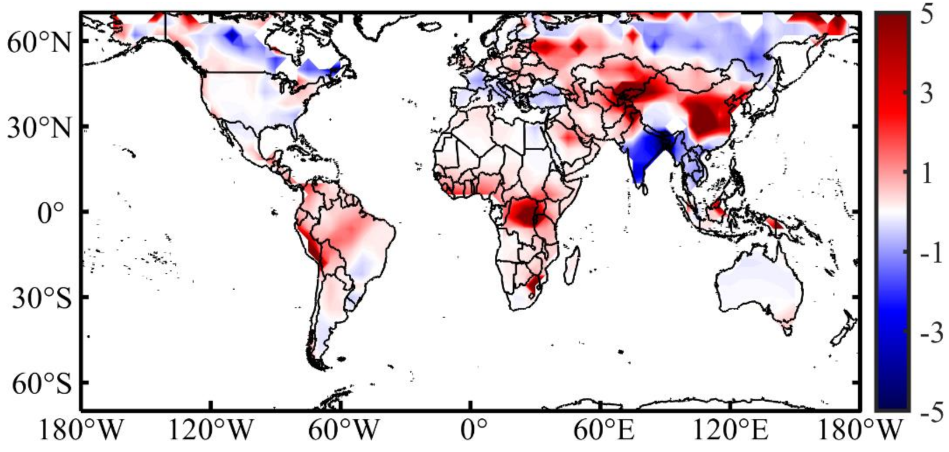
- $\Delta M_{NH_3}$: the $NH_3$ mass difference between observation and simulation in each atmospheric box
- $E_{mod}$: GEOS-Chem emission

Mean ($10^{-11}$ kg $m^{-2}$ $s^{-1}$)

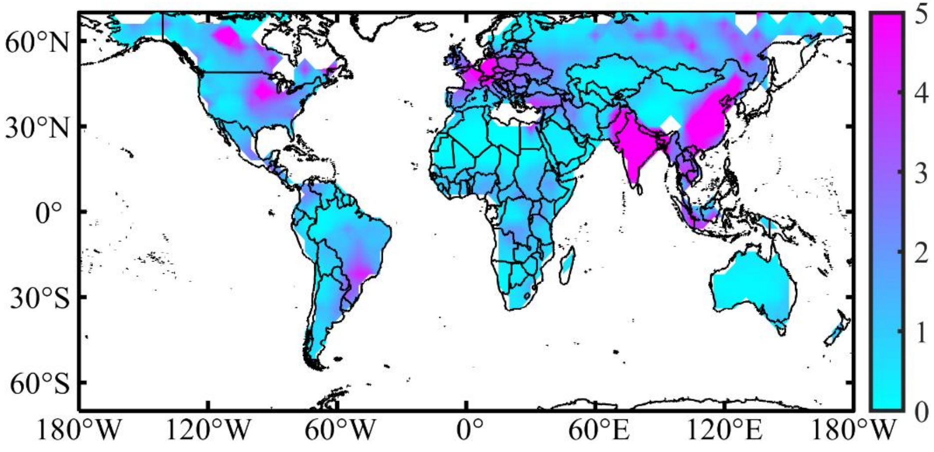
## Optimized (N > 30 $grid^{-1}$ $day^{-1}$)




## Optimized – GEOS-Chem




## GEOS-chem



# Emission Fluxes ($\hat{E}$)

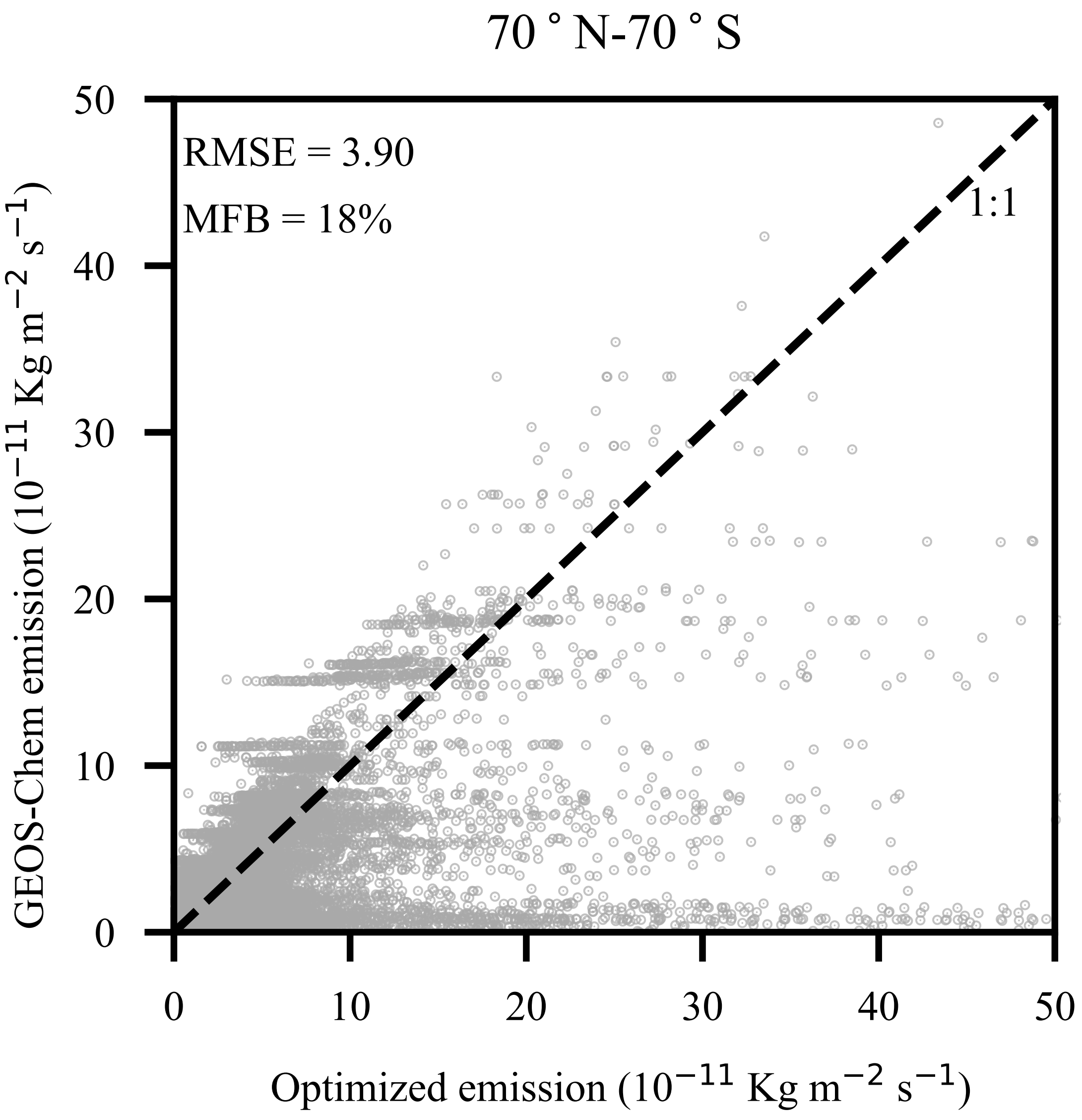
## ■ Optimized versus GEOS-Chem

- Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(E_{Opt,i} - E_{Mod,\,i})^2}$$

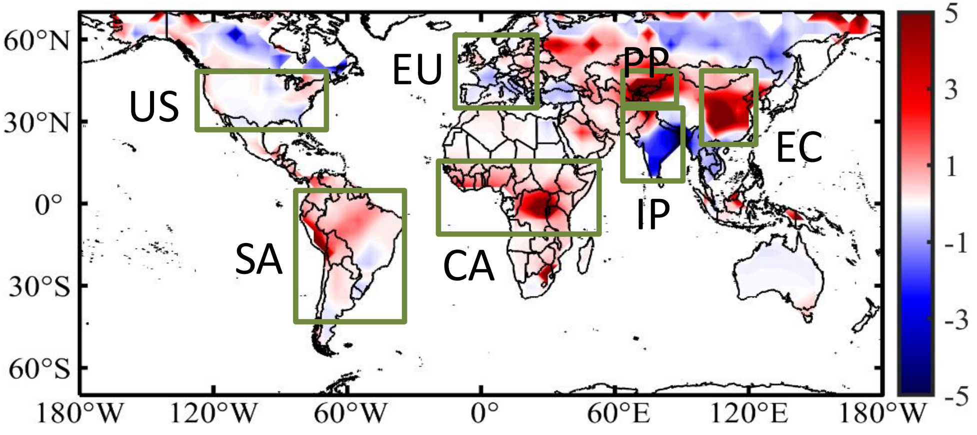
- Mean Fractional Bias (MFB)

$$MFB = \frac{2}{N}\sum_{i=1}^{N}\frac{E_{Opt,i} - E_{Mod,\,i}}{E_{Opt,i} + E_{Mod,\,i}} \times 100\%$$

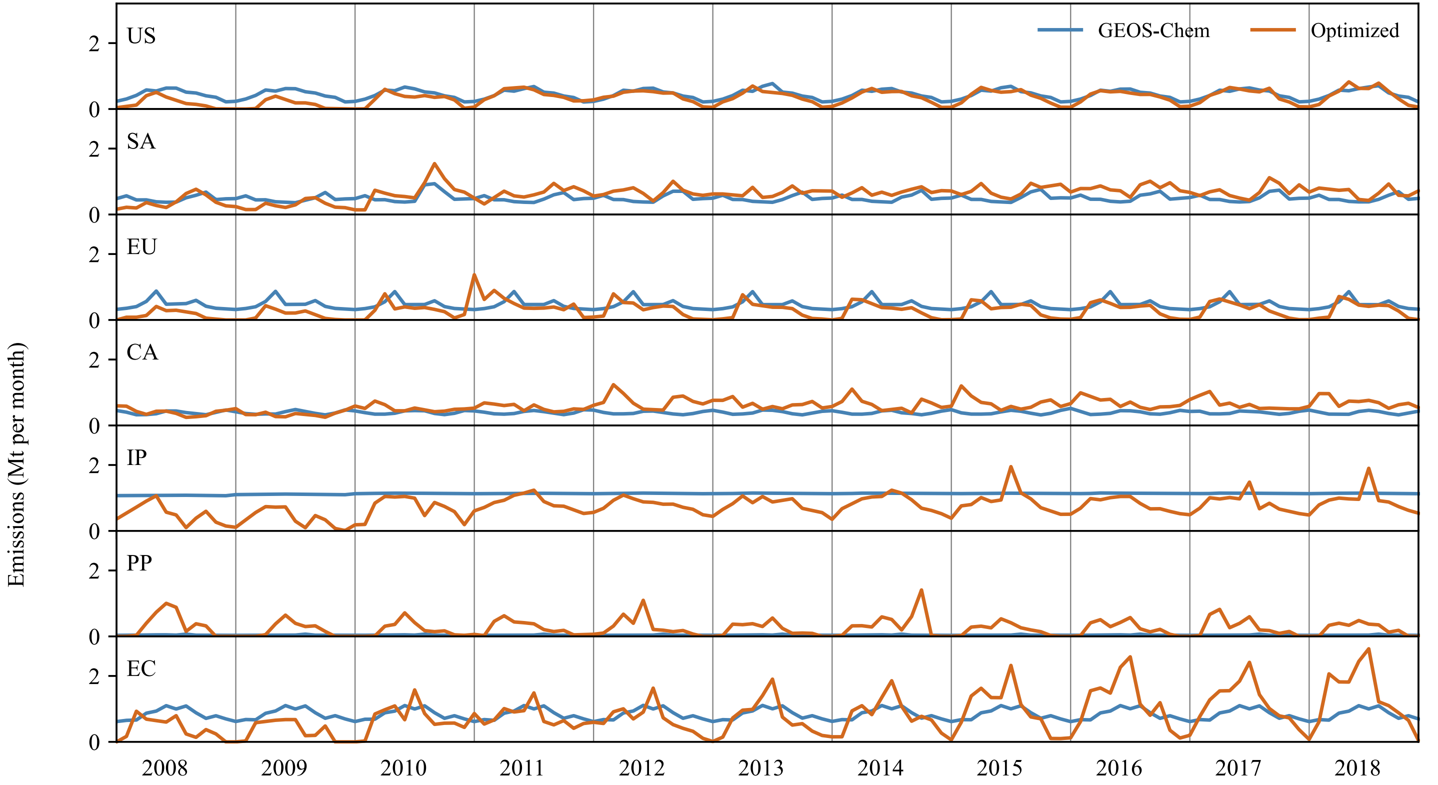


# Regional Comparison

- Optimized – GEOS-Chem (${10^{-11}}$ kg m$^{-2}$ s$^{-1}$)




- Monthly timeseries (replace the missing value by GEOS-Chem emissions)

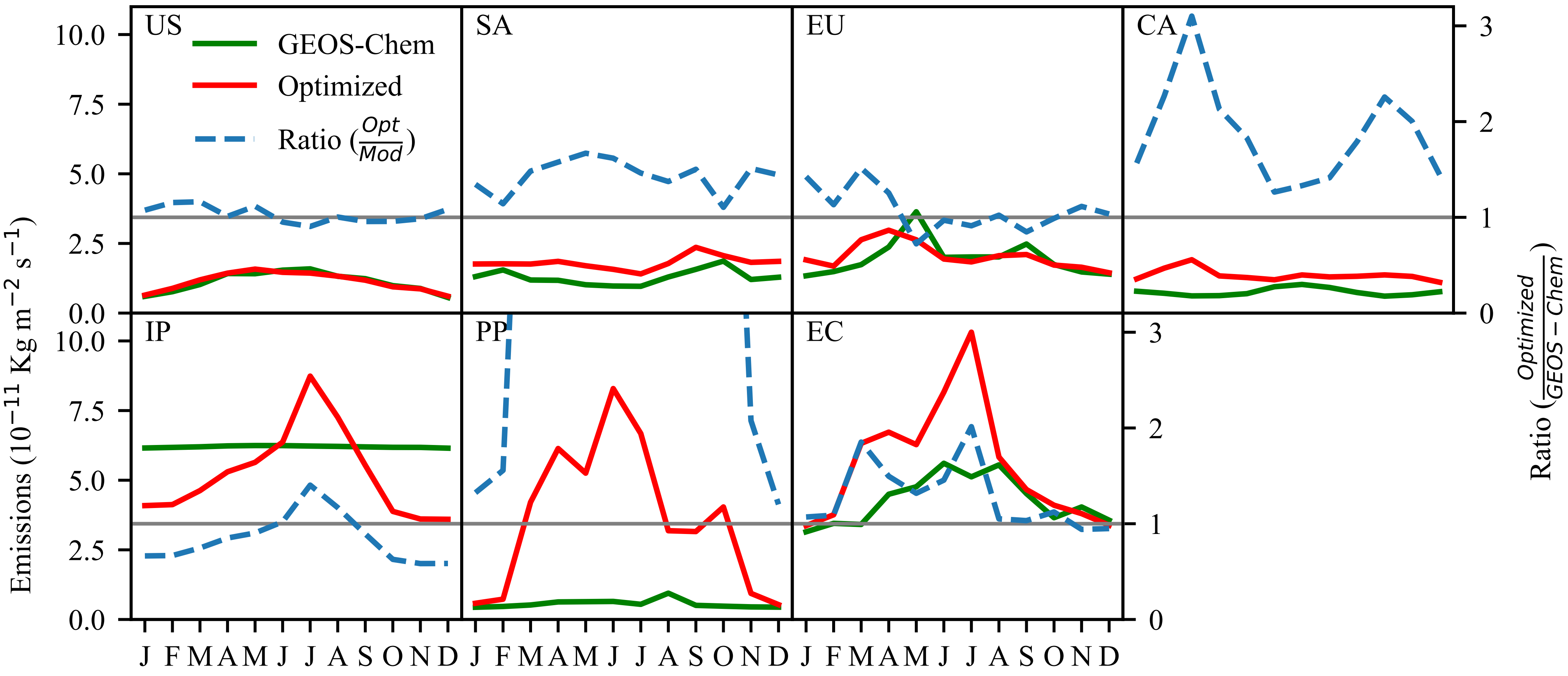



## 7 Regions：

- US: Contiguous United States
- SA: south America
- EU: Europe
- CA: central Africa
- PP: Pamirs Plateau
- IP: India Peninsula
- EC: eastern China

# Regional Comparison

## ■ Monthly variation

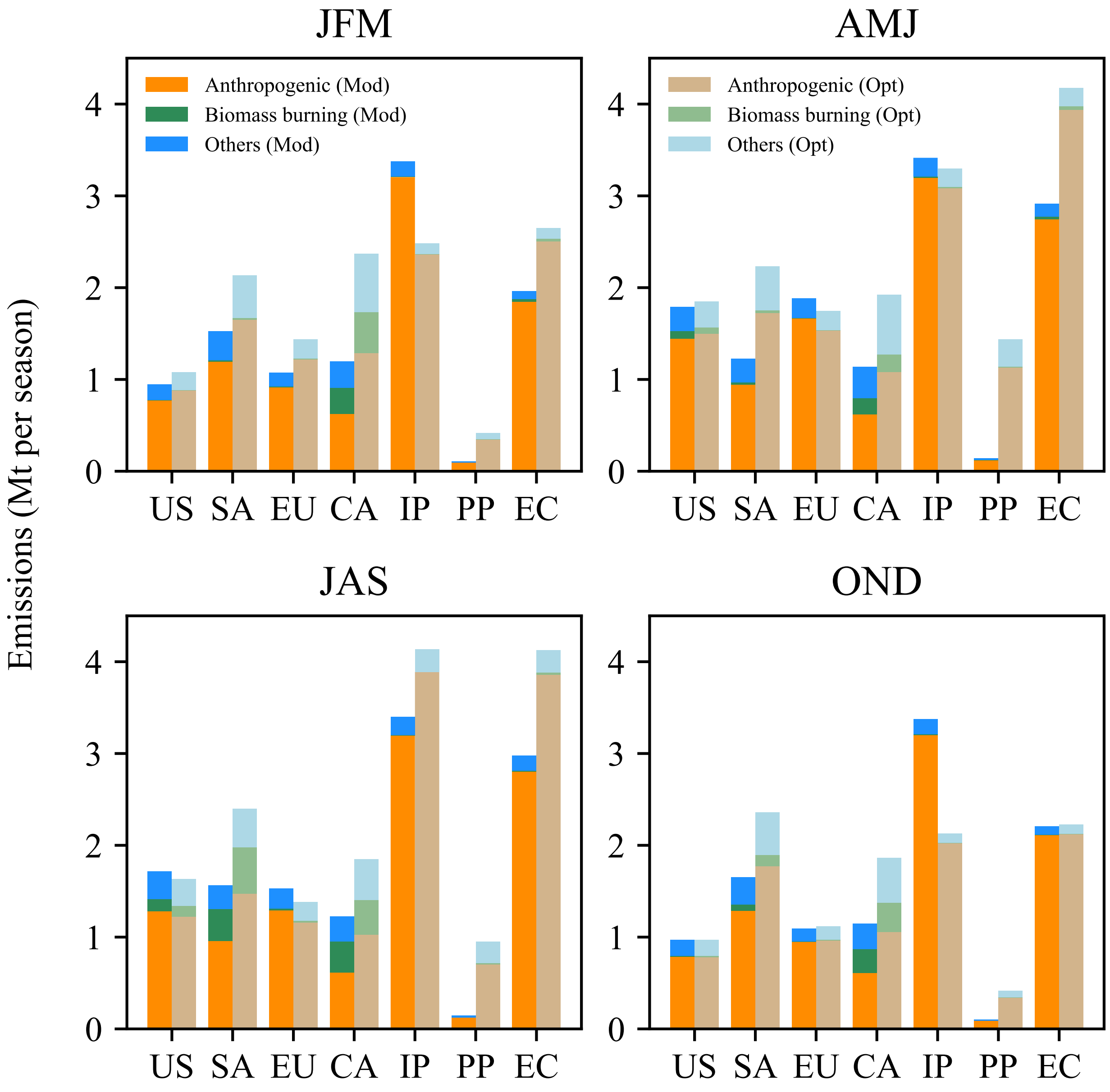


# Regional Comparison

## ■ Proportions of emission sectors

### From GEOS-Chem (monthly)：

- Total
  - Biomass burning
  - Anthropogenic
  - Others



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# THANK YOU!

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