Development of the China National Climate Center Climate Chemistry Model (BCC-AGCM-GCHP): Model description and evaluation

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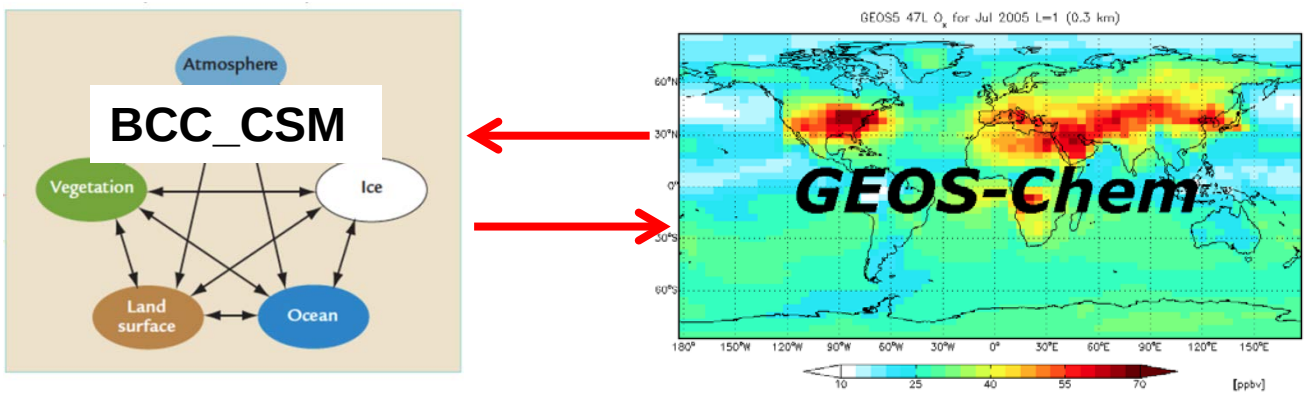
May, 2018



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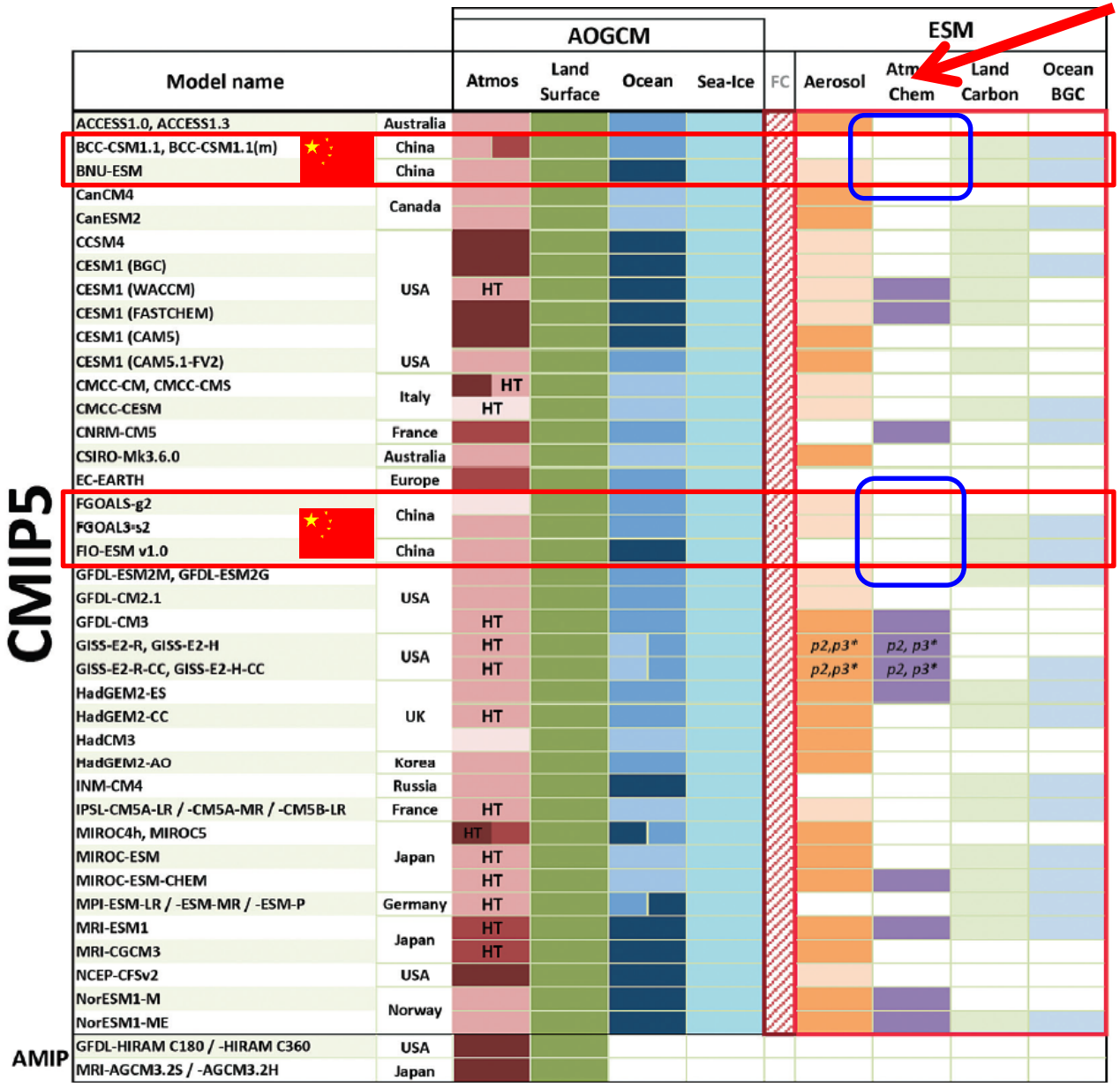
Xiao Lu
Lin Zhang

Harvard University
Long Michael
Daniel Jacob (Group)
GEOS-Chem Support Team

China NCC
Tongwen Wu
NCC scientists

U. Iowa
Jun Wang

Coupling atmospheric chemistry has become a priority for Chinese CSMs developments



Atmospheric chemistry

- **Atmospheric chemistry plays indispensable role in climate systems.**
- **0 of the CMIP5 Chinese CSMs include interactive atmospheric chemistry (2013)**
- **0 of the Chinese models join the recent climate-chemistry model initiative (CCMI) (2017)**

IPCC AR5,2013; Morgenstern, 2017@GMD

Beijing Climate Center Climate System Model (BCC-CSM)

History

CMIP6

2015- …

BCC_ESM1

- BCC_AGCM3(T266, T106)
- BCC_AVIM1.0(T266, T106)
- MOM4-L40v2(1/3°~30km)
- CICE (1/3°~30km)

2012-2017

BCC_CSM2

CMIP5

-2011

BCC_CSM1.1(m)

- BCC_AGCM2.2(T106)
- BCC_AVIM1.0(T106)
- MOM4-L40v2(1/3°~30km)
- SIS(1/3°~30km)

-2009

BCC_CSM1.1

- BCC_AGCM2.1(T42)
- BCC_AVIM1.0(T42)
- MOM4-L40v1(1/3°~30km)
- SIS(1/3°~30km)

2005-2008

BCC_CSM1.0

- BCC_AGCM2.0(T42)
- CLM3(T42)
- POP(1/3°~30km)
- CSIM(1/3~30km)

CMIP3

1995-2004

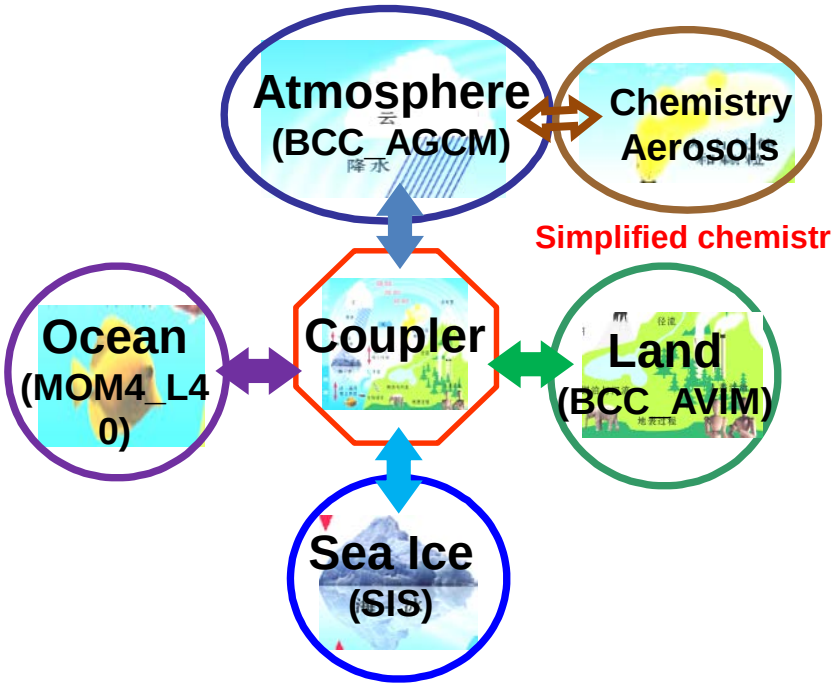
BCC_CM1.0

- BCC_AGCM1.0(T63)
- NCC/LASG OGCM(T63)

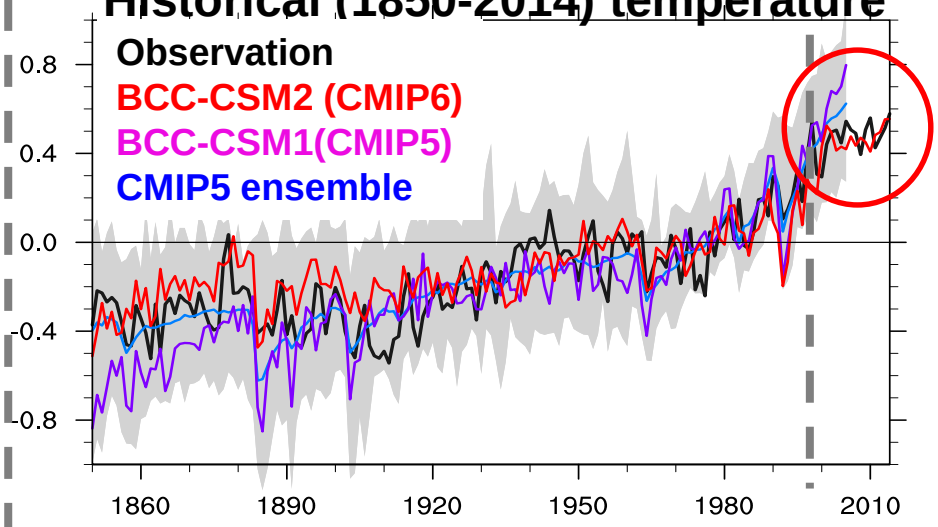
Operated by China National (Beijing) Climate Center

PI: Prof. Tongwen Wu

Present (for CMIP6)



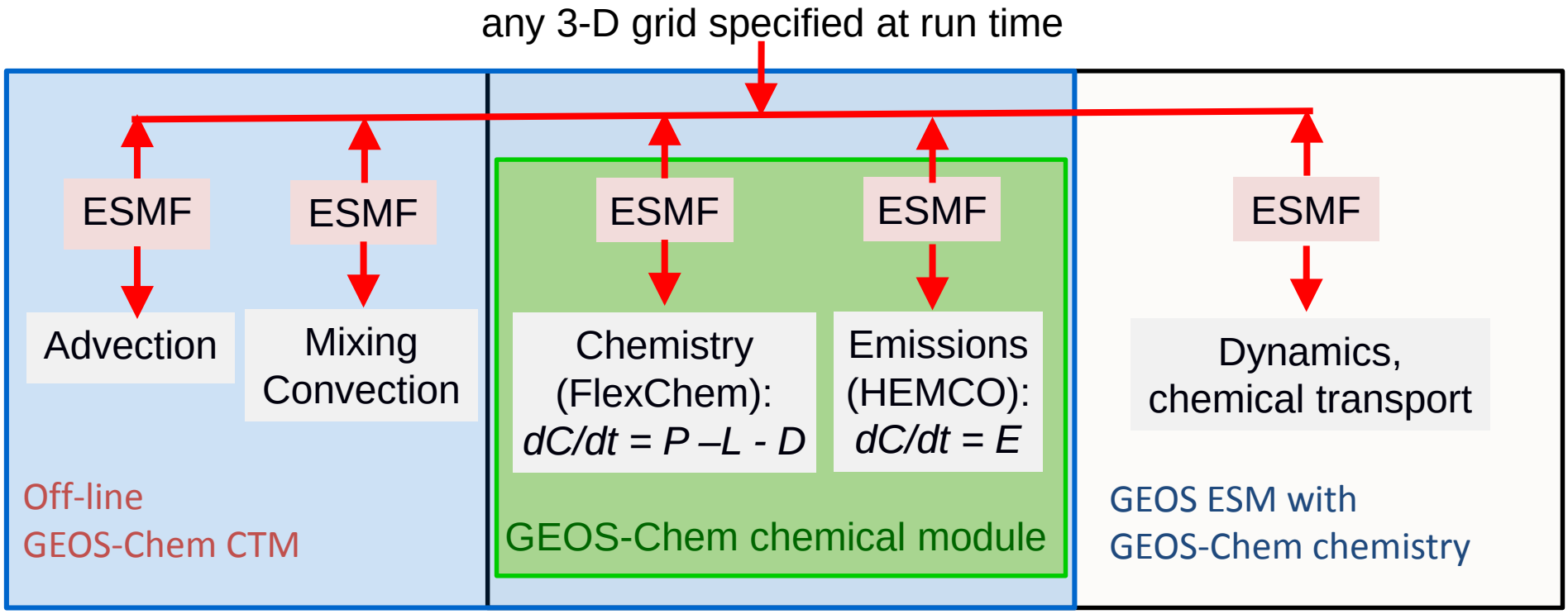
Historical (1850-2014) temperature



GEOS-Chem as chemistry component in BCC-CSM

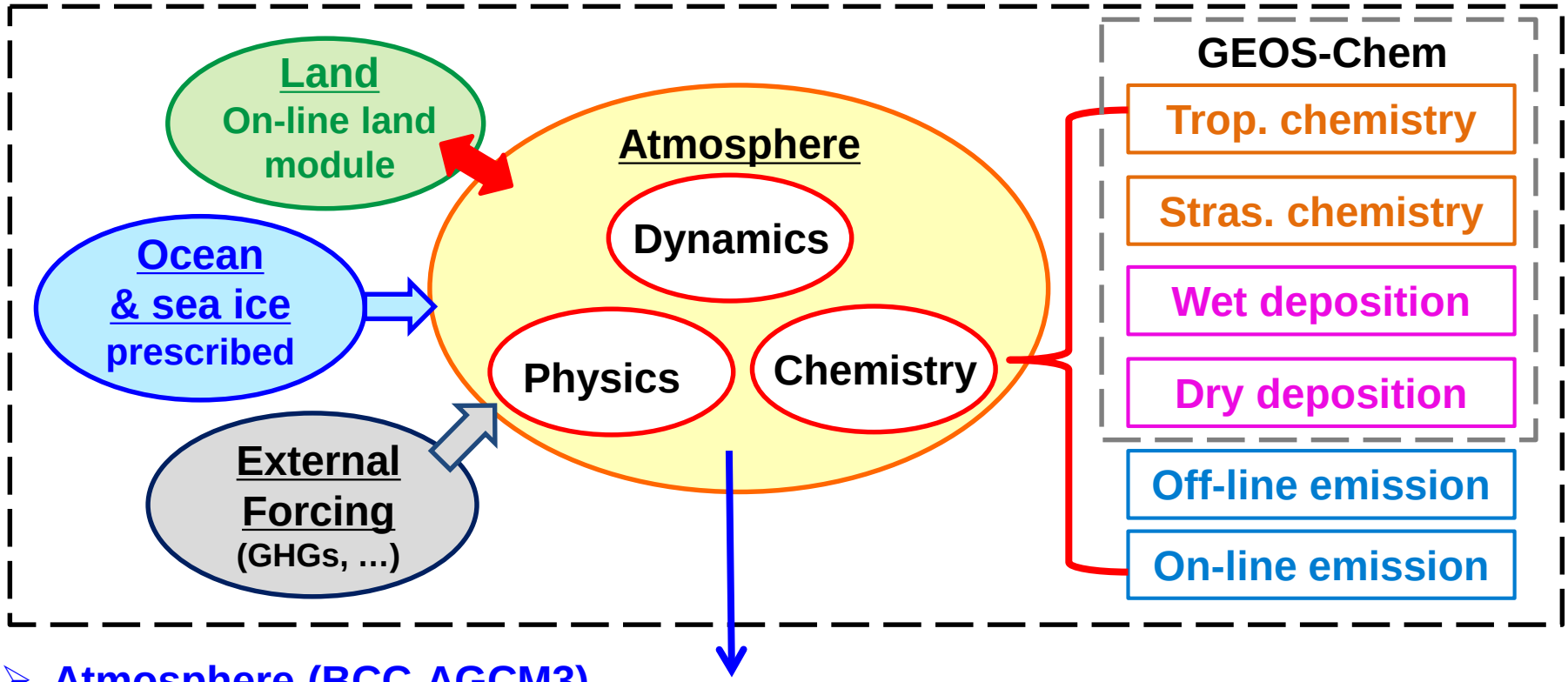
- **GEOS-Chem stays in one of the most advanced state-of-art global chemical transport model.**

- **Development of the grid-independent GEOS-Chem and GCHP (computation is distributed across multiple coordinated nodes using MPI) largely improve the convenience for model coupling.**



Long et al., 2015@GMD; Eastham et al., 2018@GMD

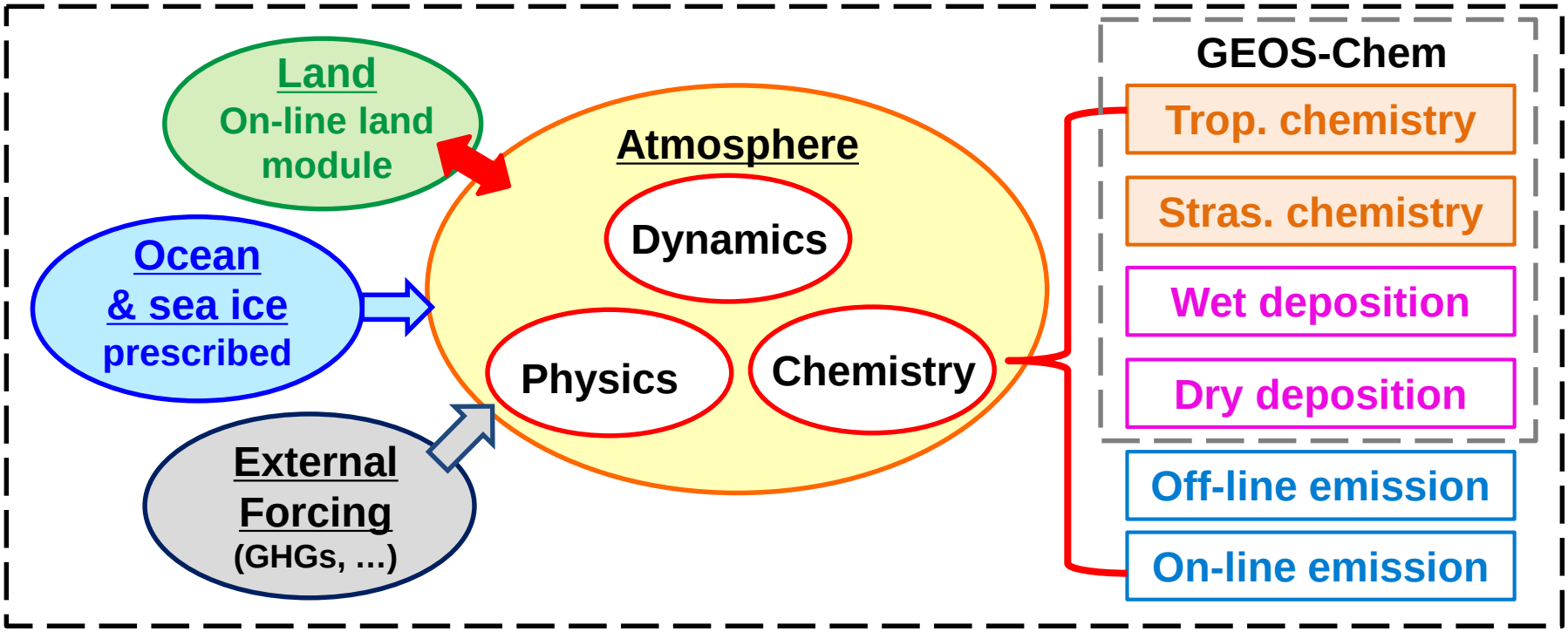
BCC-AGCM-GCHP Coupling framework



- **Atmosphere (BCC-AGCM3)**
- **DyCore:**
- **governing equations performed on global spectral model,T42(~2.8°, L26, Top 2.19 hPa)**
- **Transport: Flux-Form Semi-Lagrangian (FFSL) transport scheme**
- **Physics: micro-physics, convection, clouds, radiation…**

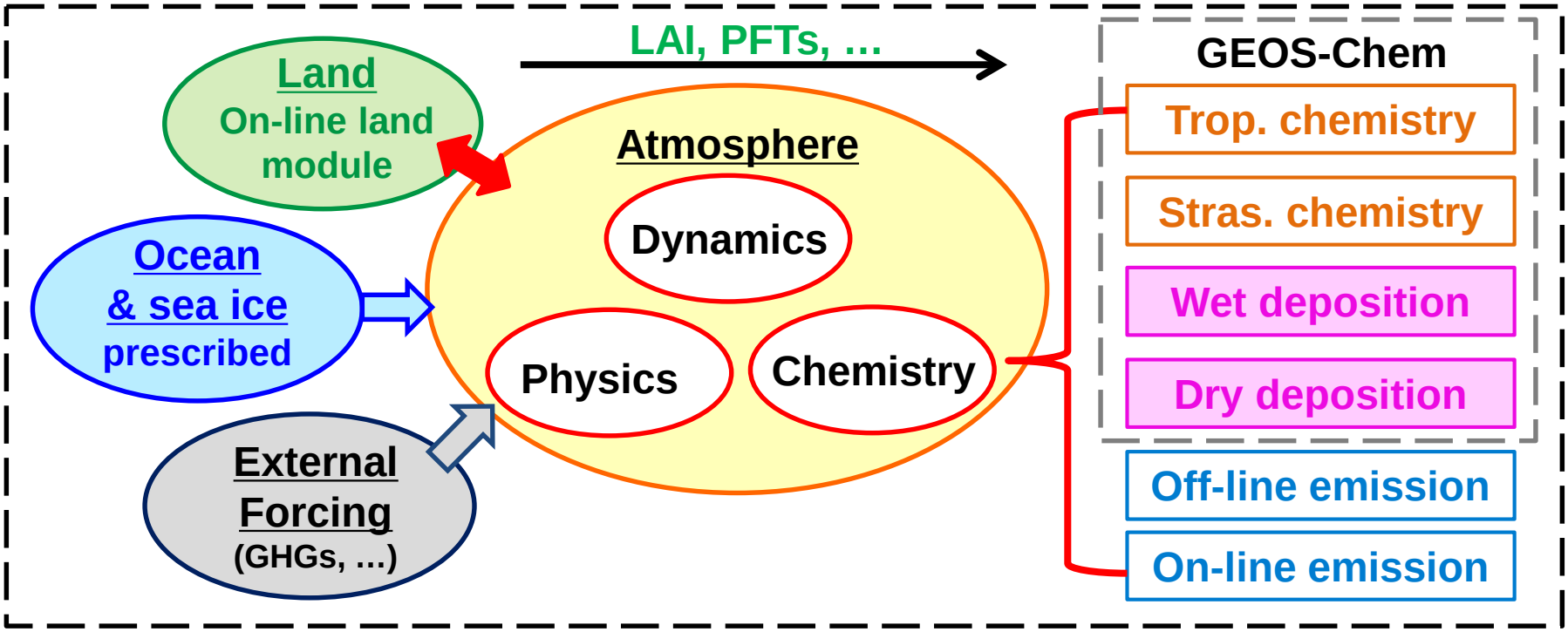
- **Land (BCC-AVIM2)**
- **on-line land surface biogeophysical and plant ecophysiological process, soil carbon cycle. Exchange with atmosphere.**

BCC-AGCM-GCHP: Chemistry



- **Tropospheric chemistry (GCHP-v11-02 "tropchem")**
  - ✓ **NOx-hydrocarbon-Ox-aerosol chemistry**
  - ✓ **58 advected gases and aerosols (excluding bromine species), a total of 155 species**
  - ✓ **Photolysis: Fast-JX scheme; chemical kinetics: JPL and IUPAC**
- **Stratospheric chemistry**
  - ✓ **Linearized Ozone mechanism (LINOZ):a first-order Taylor expansion of ozone tendency as a function of local ozone mixing ratio, temperature, and ozone column overhead.**

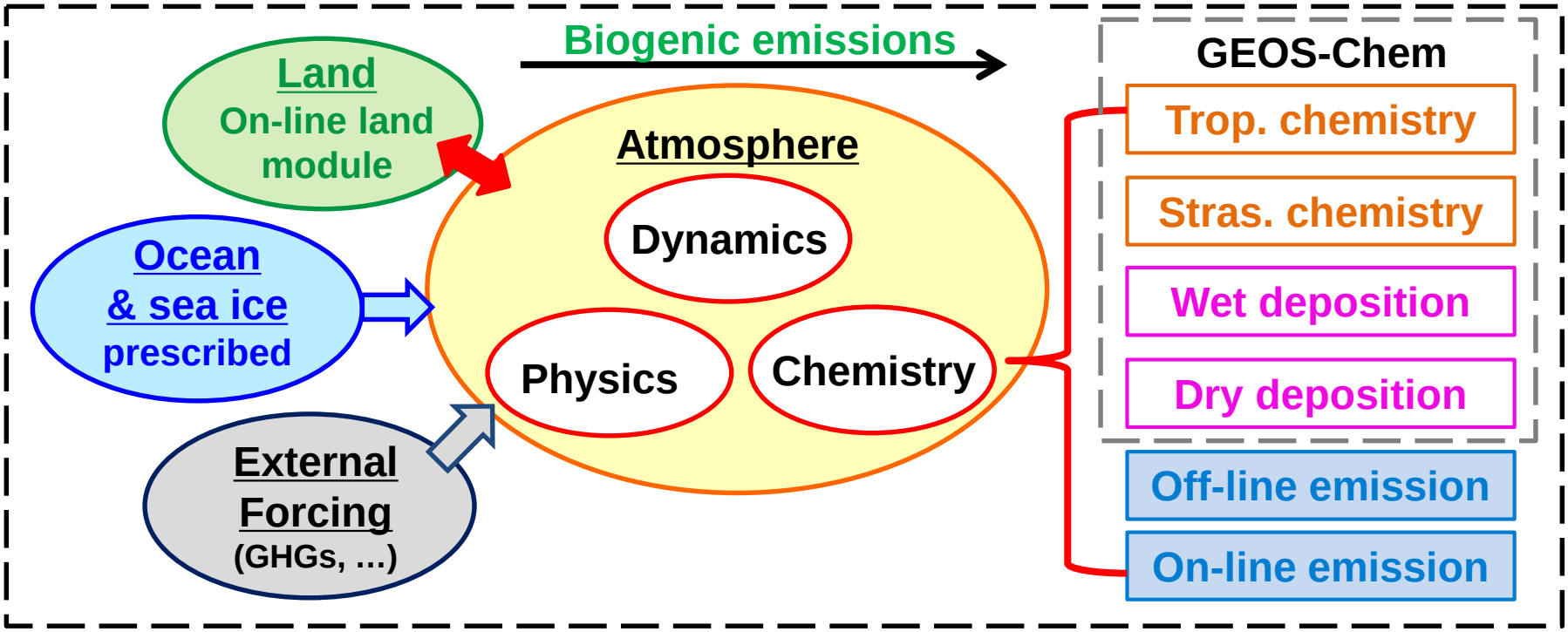
BCC-AGCM-GCHP: Deposition



- **Wet deposition**
  - ✓ in-cloud rainout by precipitation of cloud droplets or ice crystals
  - ✓ below-cloud washout by precipitation

- **Dry deposition**
  - ✓ calculated on-line based on the resistance-in-series scheme
  - ✓ GEOS-Chem plant functional types (PFTs) for dry deposition has been reconciled with the BCC-AVIM
  - ✓ LAI, friction velocity (…) are calculated on-line from the BCC land module

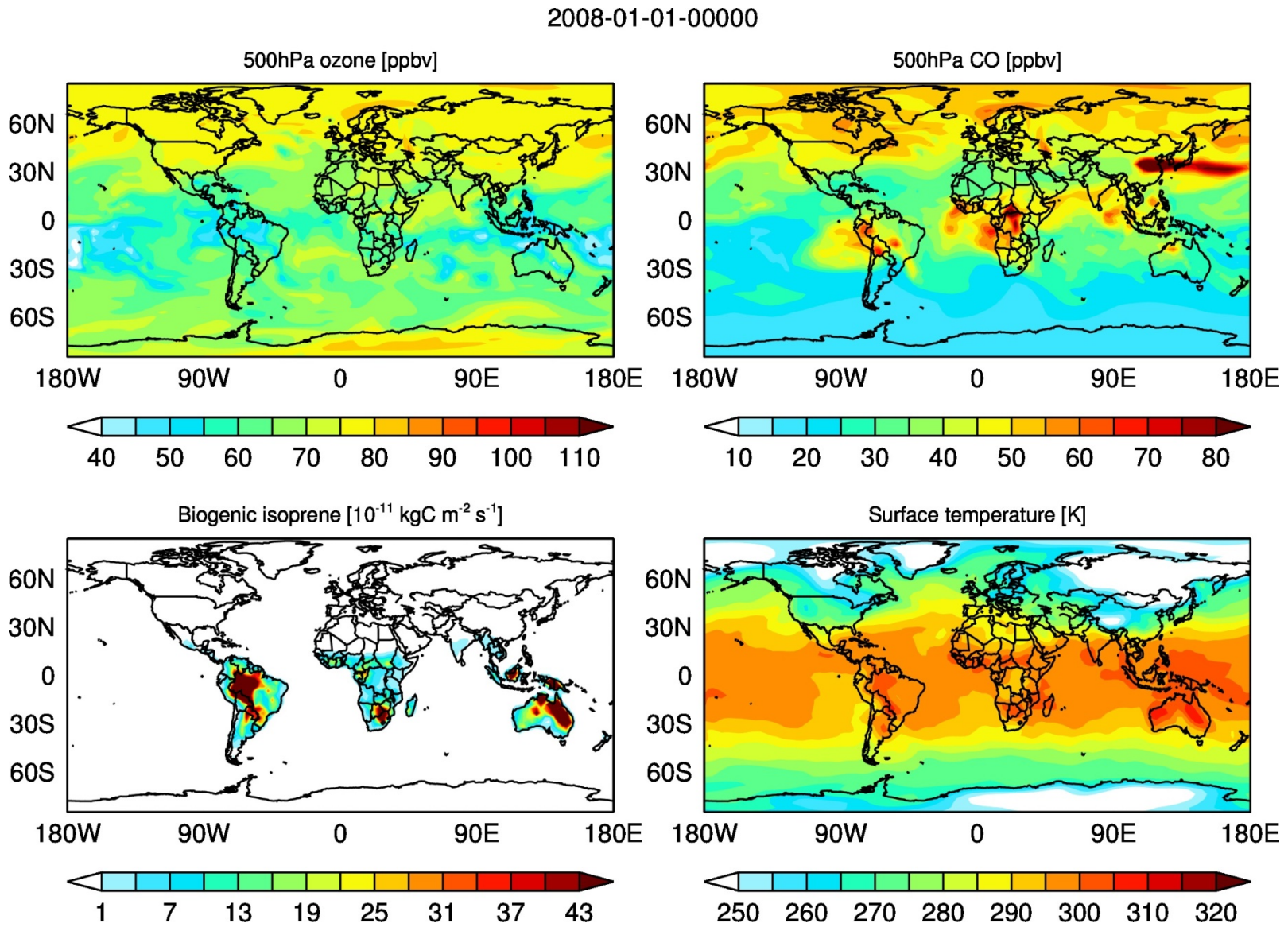
BCC-AGCM-GCHP: Emission



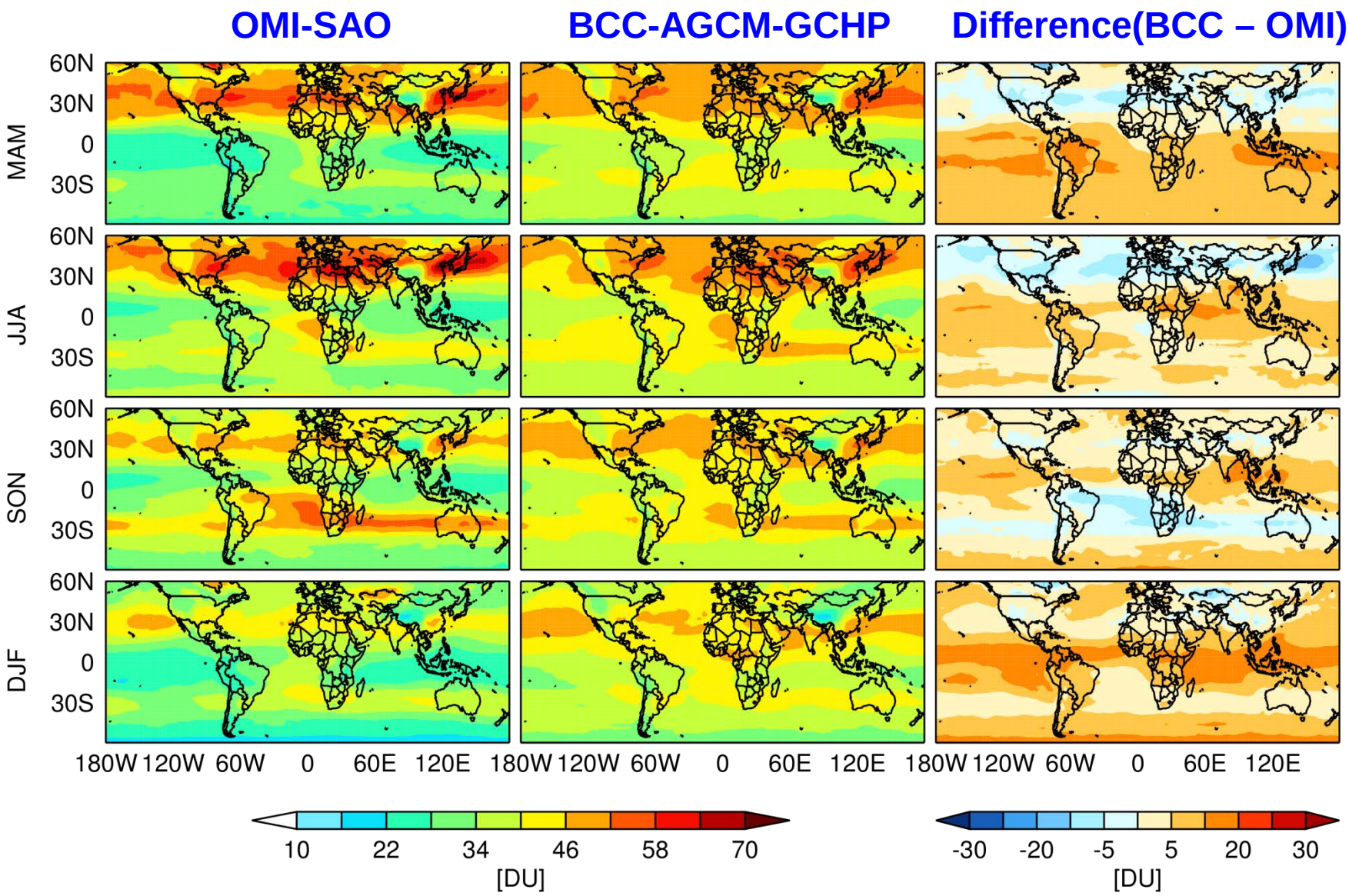
- **Off-line emission (from IPCC6, from 1850-2100)**
  - ✓ Anthropogenic emissions (including 3-D aircraft emissions)
  - ✓ Biomass burning emissions
  - ✓ ....
- **On-line emission (climate-sensitive)**
  - ✓ a) Lightning NOx emission (based on cloud top height)
  - ✓ b) Biogenic emissions (MEGAN, calculated in the land module)
  - ✓ c) Sea salt emissions, d) dust emissions, e) ocean DMS emissions

One-year (2008) daily output from BCC-AGCM-GCHP

Model simulation: 2006-2008 with one-year spin-up, T42(~2.8), 26 layers

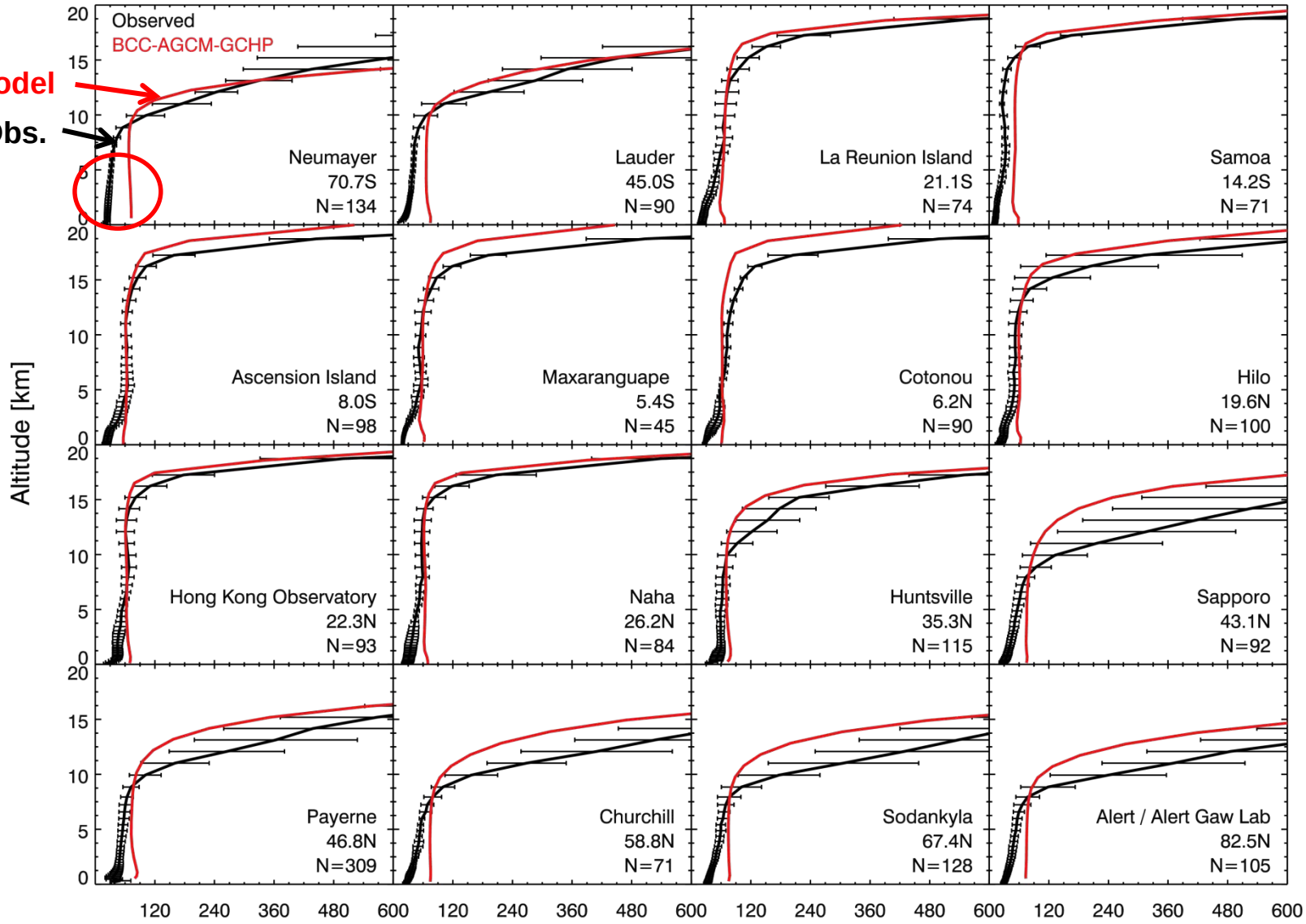


Tropospheric ozone column (satellite vs model)



Tropospheric ozone (ozonesonde vs model)

South

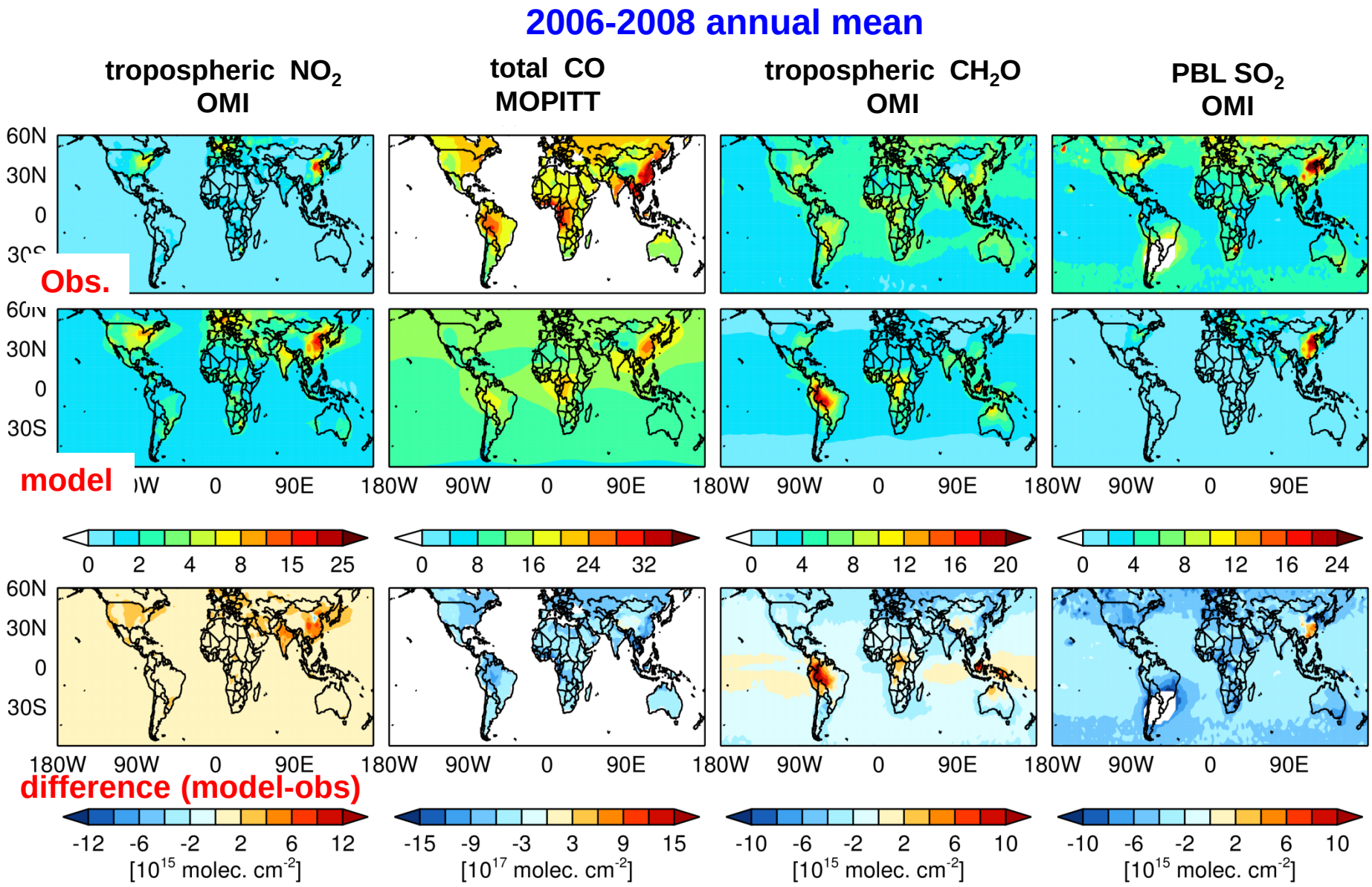


Tropics

North

2006-2008

Evaluation for air pollutants (satellite vs model)



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Future & MANY thanks to the contributors

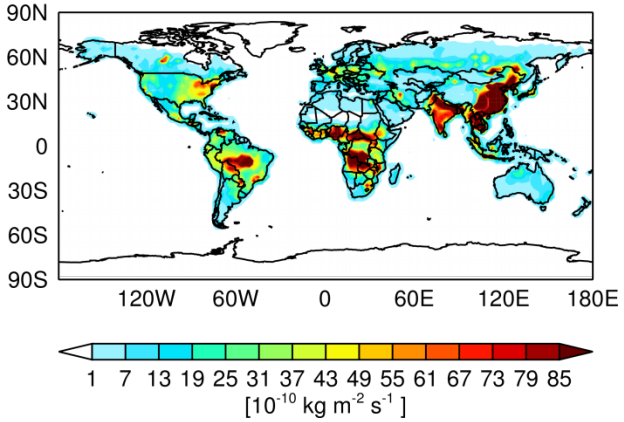
- Comprehensive evaluation of BCC-AGCM-GCHP.
- Implementation of radiation feedback and full stratosphere chemistry for long-term historical simulation.
- Application for future air quality prediction.

- PKU: Xiao Lu (luxiao_atchem@pku.edu.cn), Lin Zhang
- Harvard: Michael Long, Daniel Jacob, Sebastian Eastham, Jiawei Zhuang, Lei Zhu, GEOS-Chem support team (GCST), Harvard China Project
- China NCC: Tongwen Wu, Fang Zhang, Jie Zhang, BCC-CSM science team
- U. IOWA: Jun Wang

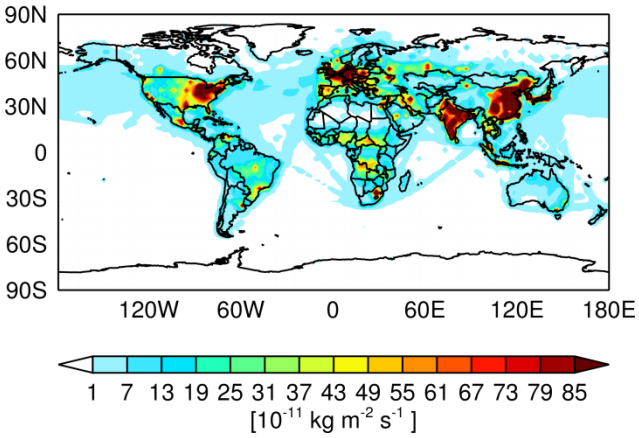
Emissions used in the model

2006-2008 annual mean

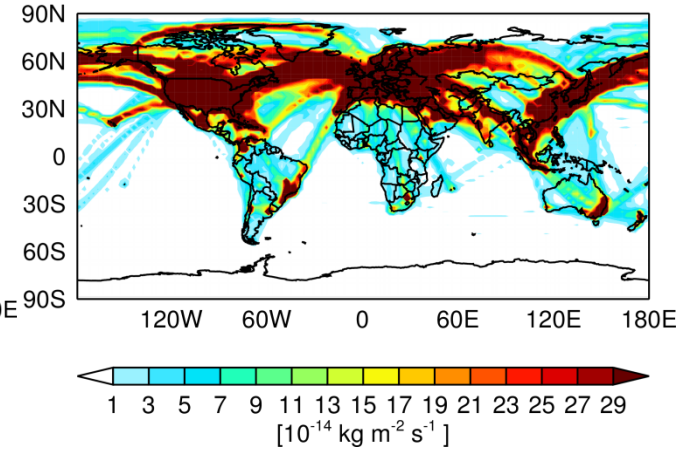
Anthropogenic CO: 1134 Tg CO



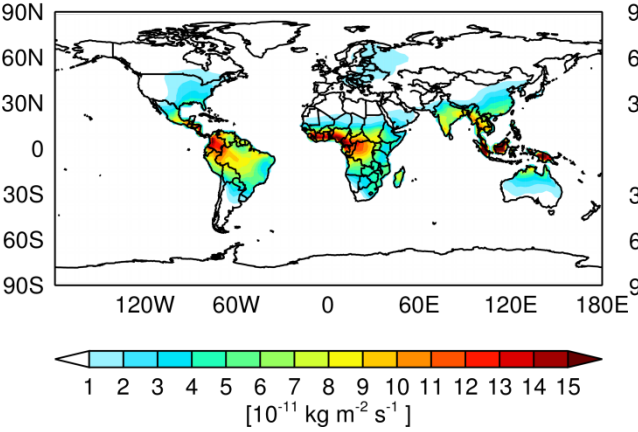
Anthropogenic NO: 53.2 Tg N



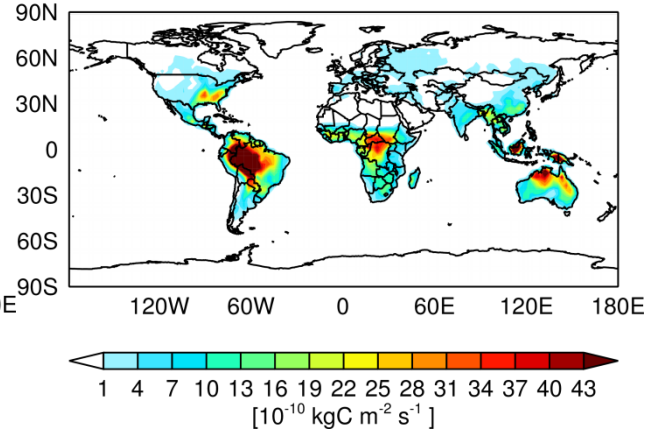
Aircraft SO2: 0.26 Tg SO2



Lighting NO: 5.5 Tg N



Biogenic isoprene: 303 Tg C



Sea DMS: 9.5 Tg S