# Chemistry-Ecosystems-Climate Working Group Update

GEOS-Chem

**GEOS-Chem Steering Committee Meeting, Aug 24, 2021**

# Chemistry-Ecosystems-Climate (CEC) Working Group

- **Steers model developments focused on coupling atmospheric chemistry with components of the broader Earth system**

- **Current Co-Chairs**
  - Jeff Geddes (Boston University; jgeddes@bu.edu)
  - Hong Liao (Nanjing University of Information Science & Technology; hongliao@nuist.edu.cn)
  - Lee T. Murray (University of Rochester; lee.murray@rochester.edu)
  - Amos Tai (Chinese University of Hong Kong; amostai@cuhk.edu.hk)

- **E-mail list:** geos-chem-climate@g.harvard.edu

- **Ongoing project list / wiki page**
  - http://wiki.seas.harvard.edu/geos-chem/index.php/Chemistry-Ecosystems-Climate_Working_Group

# Recent Developments

- **Future emission inventories developed for dust and smoke BC+OC in western USA under RCP 4.5 and 8.5 for the 2011-2100 period (Yang Li et al., 2020; 2021)**
  - Li et al. (2020), Trends and spatial shifts in lightning fires and smoke concentrations in response to 21st century climate over the national forests and parks of the western United States, *Atmos Chem Phys*, 20, 8827-8838, doi:10.5194/acp-20-8827-2020
  - Li et al. (2021), Response of dust emissions in southwestern North America to 21st century trends in climate, $CO_2$ fertilization, and land use: Implications for air quality, *Atmos Chem Phys*, 21, 57-68, doi:10.5194/acp-21-57-2021

# Recent Developments

- GC-YIBS (X. Yue, NUIST)
  - GC-YIBs model, GC provides hourly aerodynamic resistance, boundary layer resistance, and surface $O_3$ to YIBs.
  - YIBs provides dynamically predicted daily LAI and hourly stomatal conductance for the dry deposition scheme within GC
  - v1.0 (10.5281/zenodo.3659346); 1.1 (10.5281/zenodo.3993832)

- Ecophysiology module (A. Tai, CUHK)
  - Computation of photosynthesis and photosynthesis-based stomatal resistance for dry deposition; water stress dependence; ozone damage on plants; photosynthesis-based isoprene emission to replace MEGAN isoprene emissions; can output plant-type specific dry deposition velocities, isoprene emissions and other quantities
  - https://github.com/amospktai/geos-chem-ecophysiology; sent to GCST

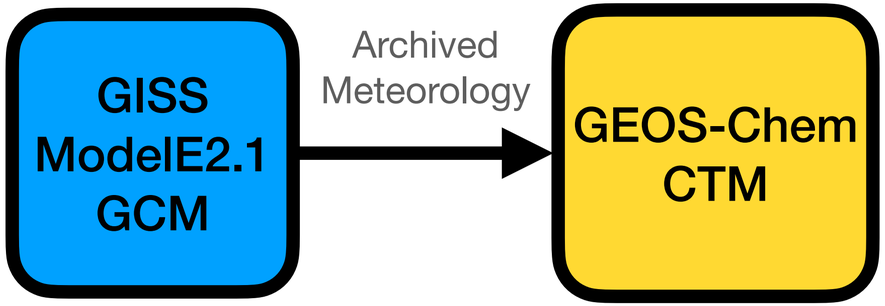
# Recent Developments

- **WRF-GC: v2.0 (Feng et al., 2021)**
  - Feng et al. (2021), WRF-GC (v2.0): online two-way coupling of WRF (v3.9.1.1) and GEOS-Chem (v12.7.2) for modeling regional atmospheric chemistry–meteorology interactions, *Geosci Mod Dev*, 14, 3741-3768, doi:10.5194/gmd-14-3741-2021
- **CESM2-GC and GEOS**
- **GISS-GC: GCAP 2.0 and ICECAP 2.0 (Murray et al., 2021)**
  - Murray et al. (2021), GCAP 2.0: A global 3-D chemical-transport model framework for past, present, and future climate scenarios, *Geosci Model Dev*, *in press*, doi:10.5194/gmd-2021-144

# GISS-GC: One-way offline coupling

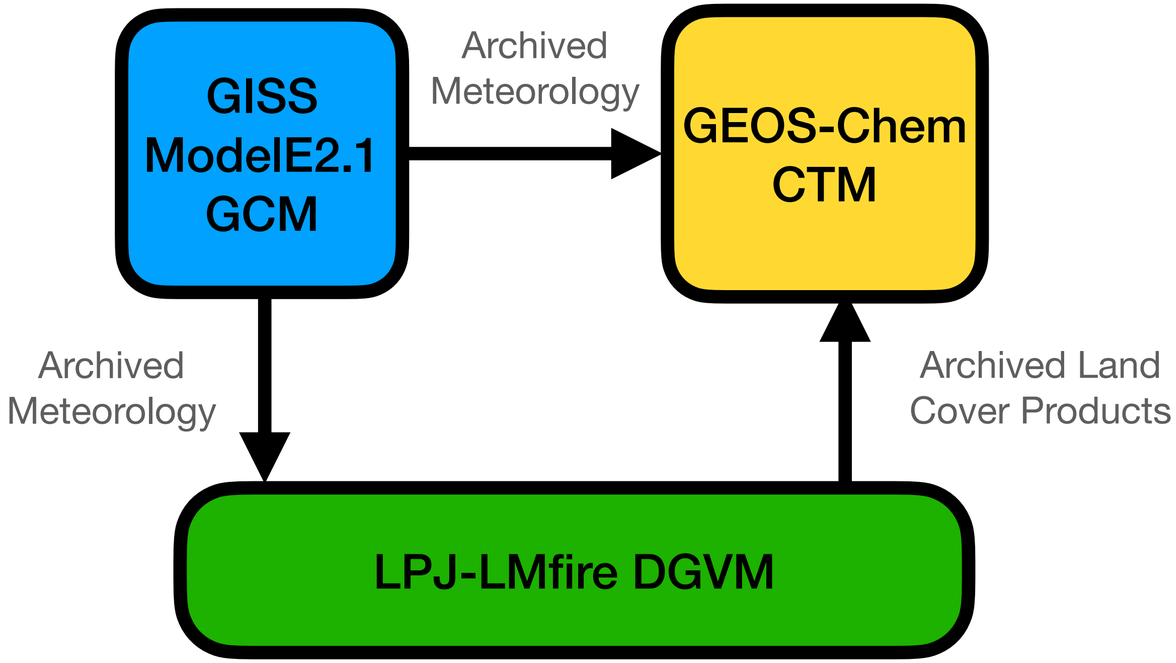
- **Entered GEOS-Chem in 13.1.0**

## GCAP 2.0




[Murray et al., *GMD*, 2021]

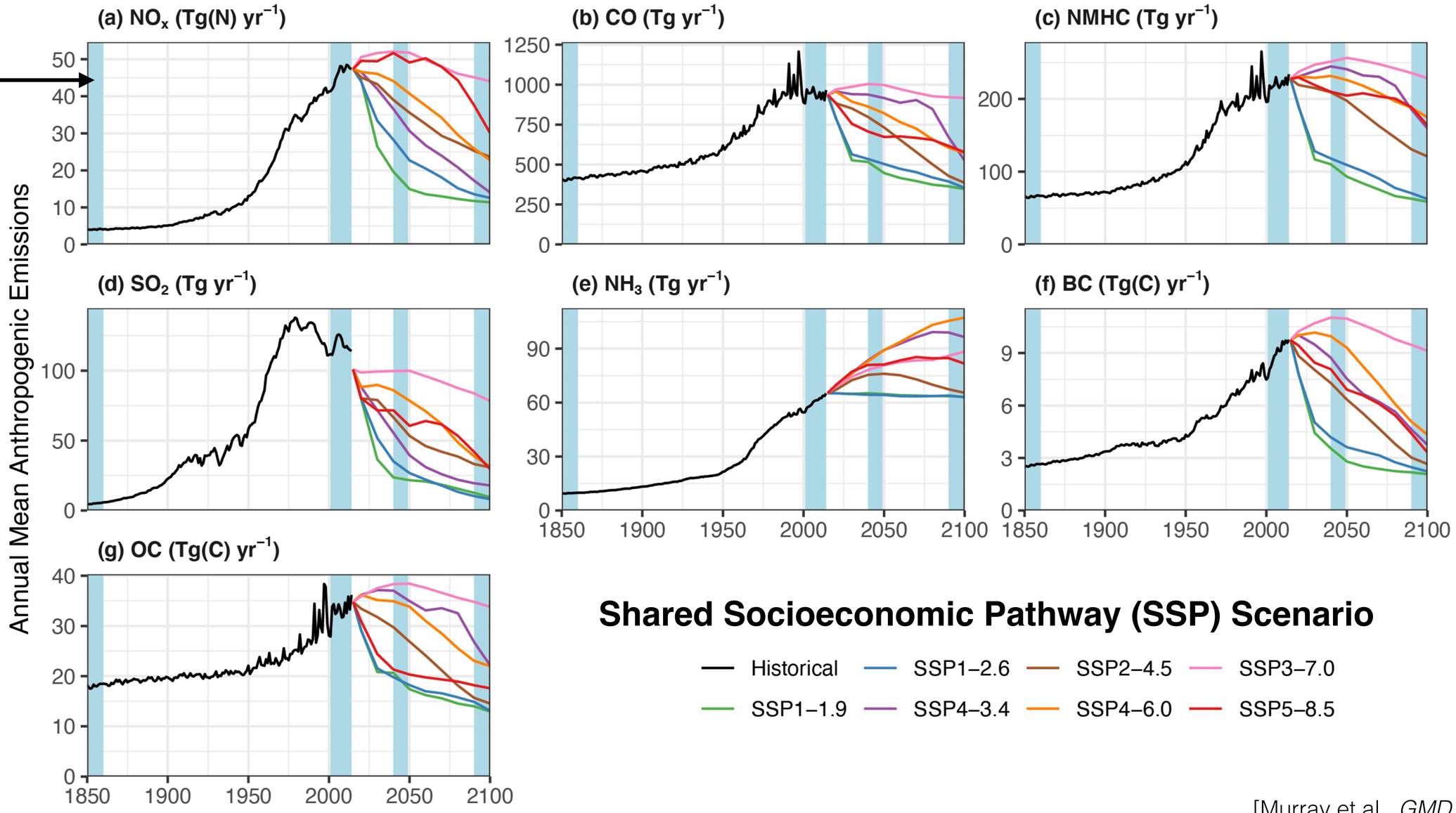
## ICECAP 2.0




[Tie et al., *in preparation*]

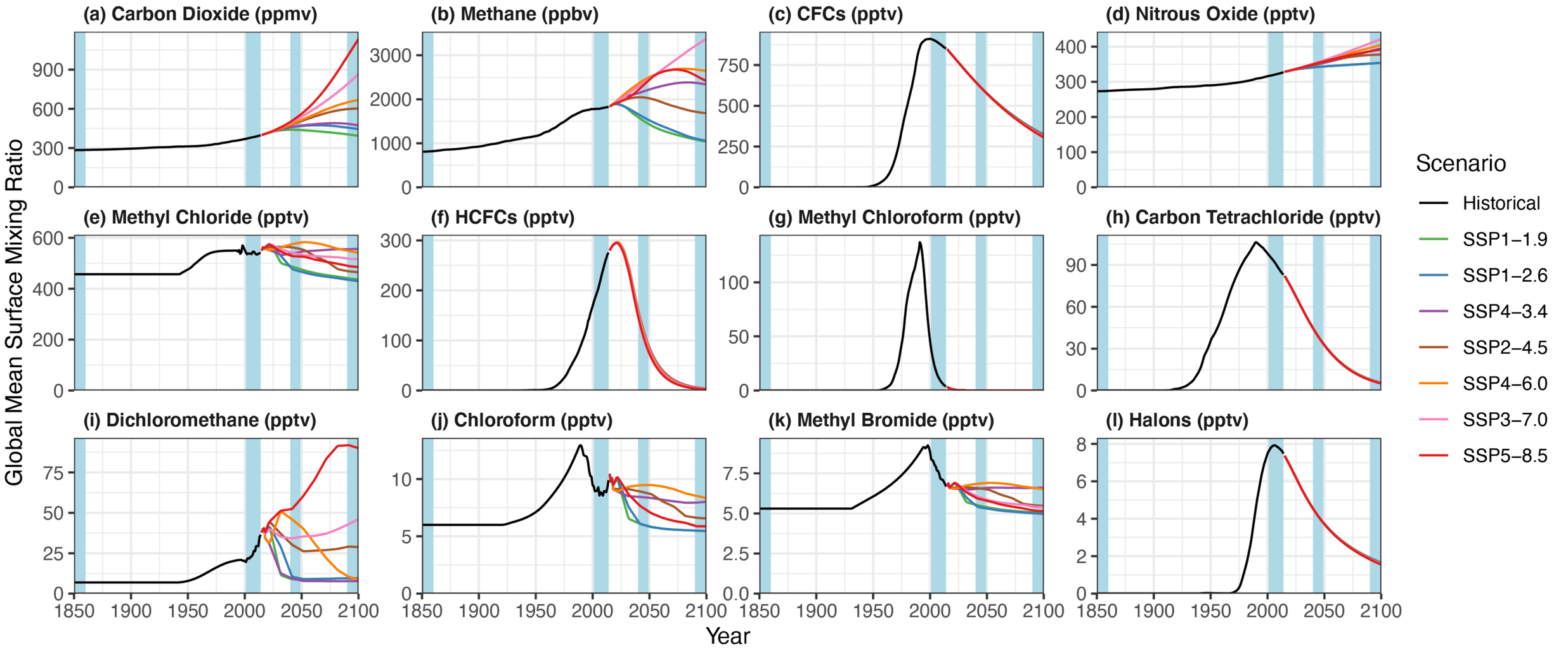
# CMIP6 past and future emissions have been processed for GEOS-Chem

**Years with Presently Available Meteorology**




[Murray et al., *GMD*, 2021]

# CMIP6 surface boundary conditions have been processed for GEOS-Chem




[Murray et al., *GMD*, 2021]

# Available Meteorology

- **GISS-GC repository at [http://atmos.earth.rochester.edu/input/gc/ExtData/](http://atmos.earth.rochester.edu/input/gc/ExtData/)**

## GCAP 2.0

| Scenario | 1851-1860 | 2001-2014 | 2040-2049 | 2090-2099 |
|---|---|---|---|---|
| Historical | 🌍 | 🌍 | | |
| Historical (Nudged to MERRA-2) | | 🌍 | | |
| SSP1-1.9 (Extreme Mitigation) | | | 🌍 | 🌍 |
| SSP1-2.6 | | | 🌍 | 🌍 |
| SSP4-3.4 (Paris Agreement) | | | 🌍 | 🌍 |
| SSP2-4.5 | | | 🌍 | 🌍 |
| SSP4-6.0 | | | 🌍 | 🌍 |
| SSP3-7.0 | | | 🌍 | 🌍 |
| SSP5-8.5 (Extreme Warming) | | | 🌍 | 🌍 |

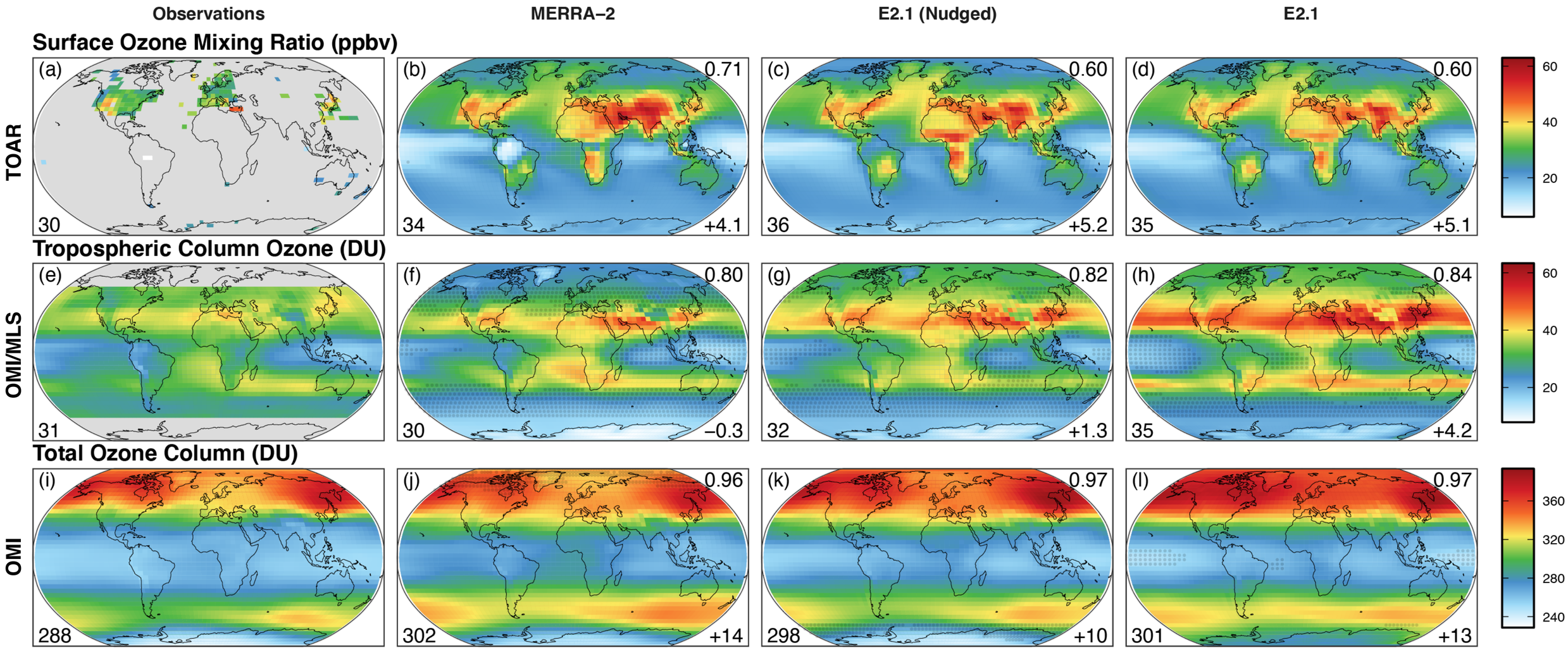
Scenario Number

Target Warming Limit (W m$^{-2}$)

## ICECAP 2.0

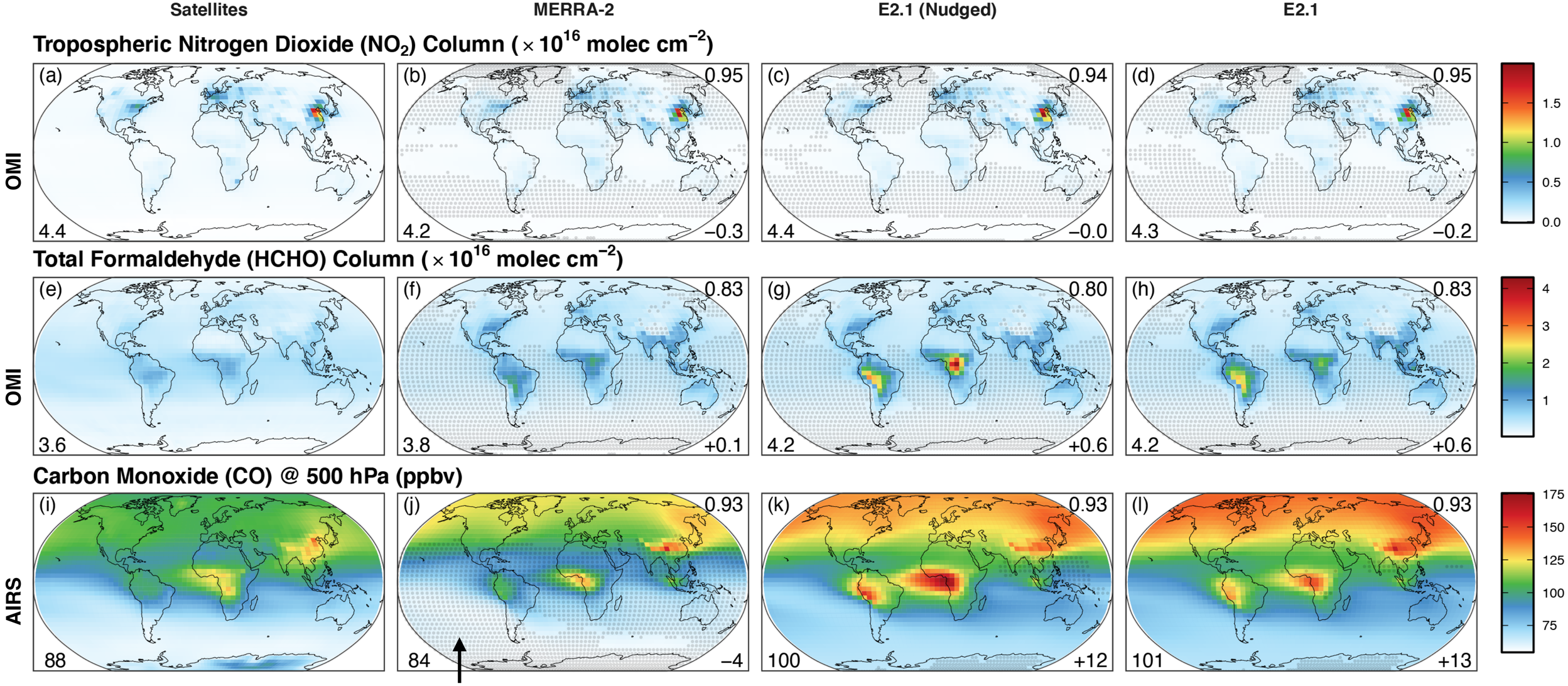
| Scenario | Orbital Forcing (ka) | $\Delta T_s$ | SSTs |
|---|---|---|---|
| Present Day | -0.05 | 0 | CMIP6 |
| Preindustrial | 0.1 | -0.7 | CMIP6 |
| Mid-Holocene | 6 | -0.6 | PMIP4 |
| Last Glacial Maximum | 21 | -4.7 | PMIP4 |
| | | -5.7 | *Tierney et al.* [2020] |
| Last Interglacial | 127 | -0.4 | PMIP4 |

# Present-Day Chem/Transport Broadly Consistent with MERRA-2 GC




[Murray et al., *GMD*, 2021]

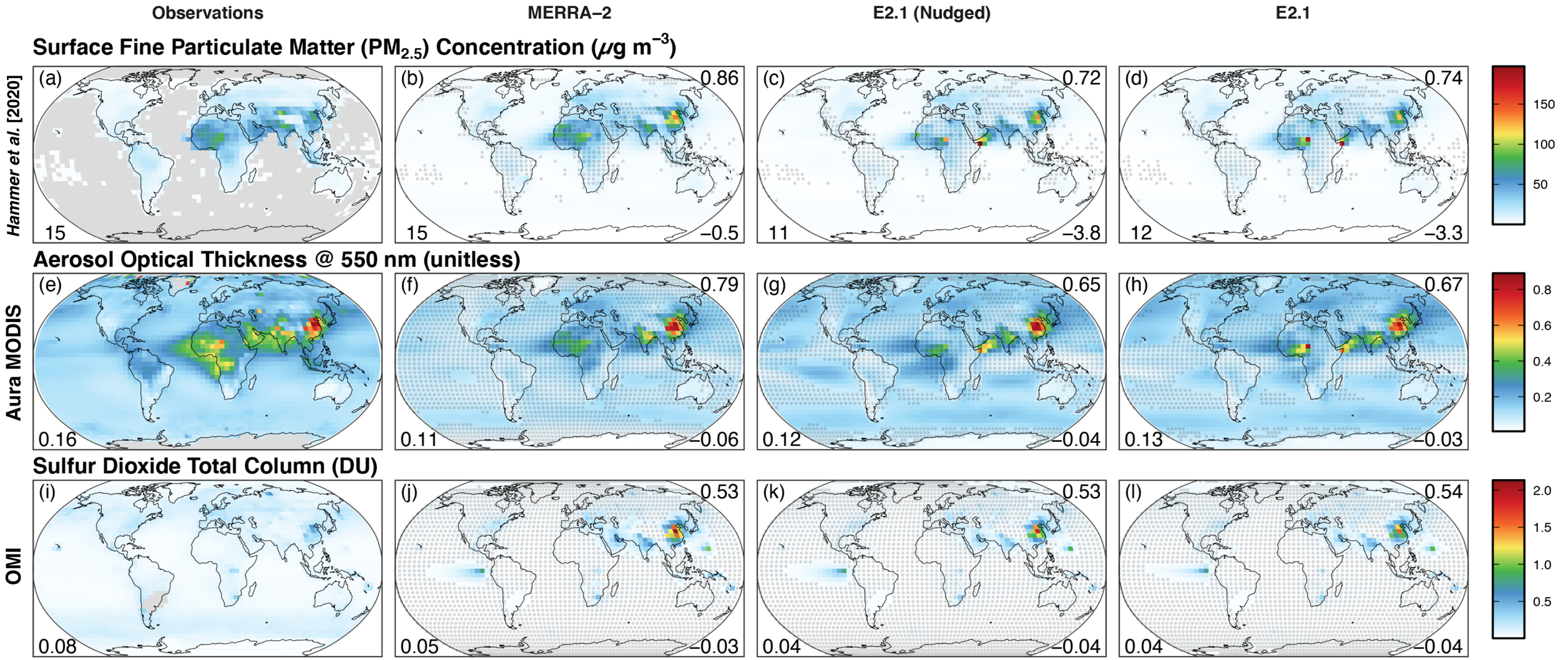
# Present-Day Chem/Transport Broadly Consistent with MERRA-2 GC




Stippling shows areas statistically different from observations

[Murray et al., *GMD*, 2021]

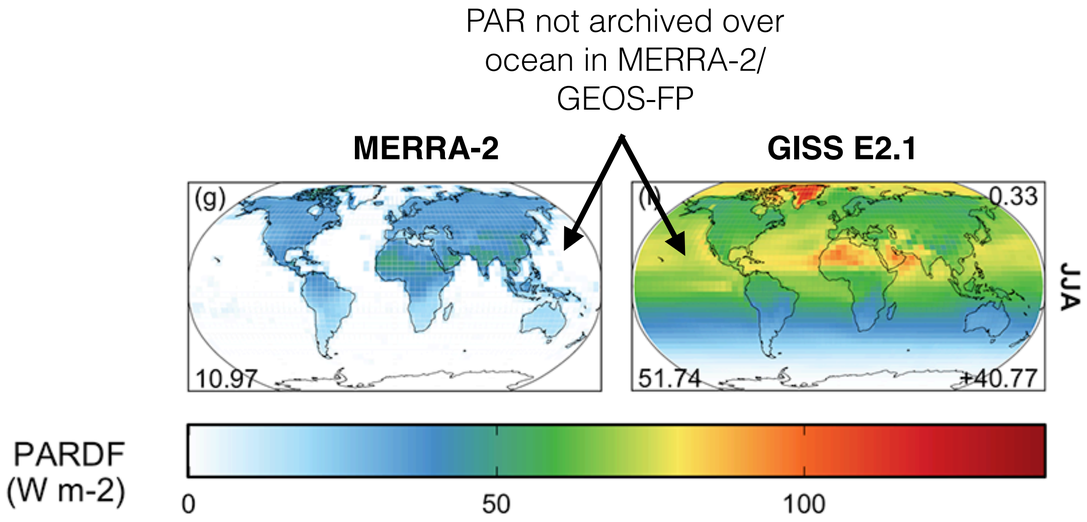
# Present-Day Chem/Transport Broadly Consistent with MERRA-2 GC

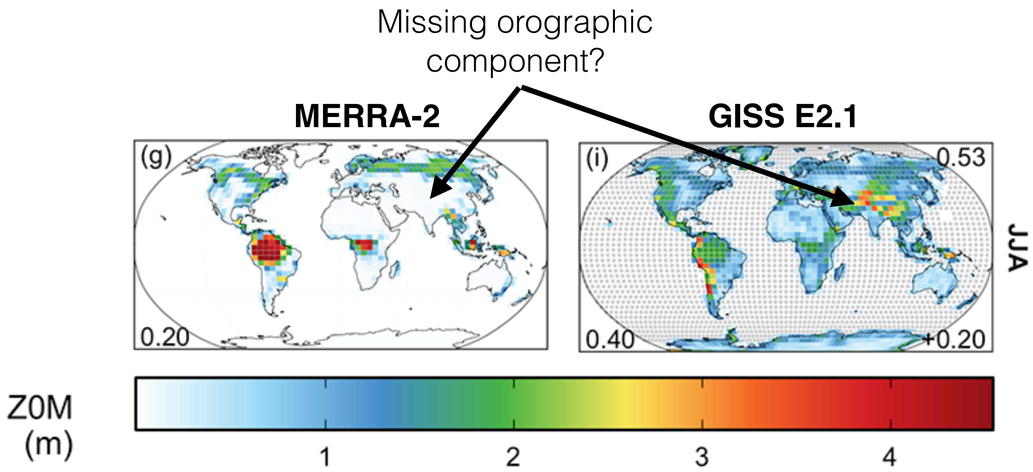
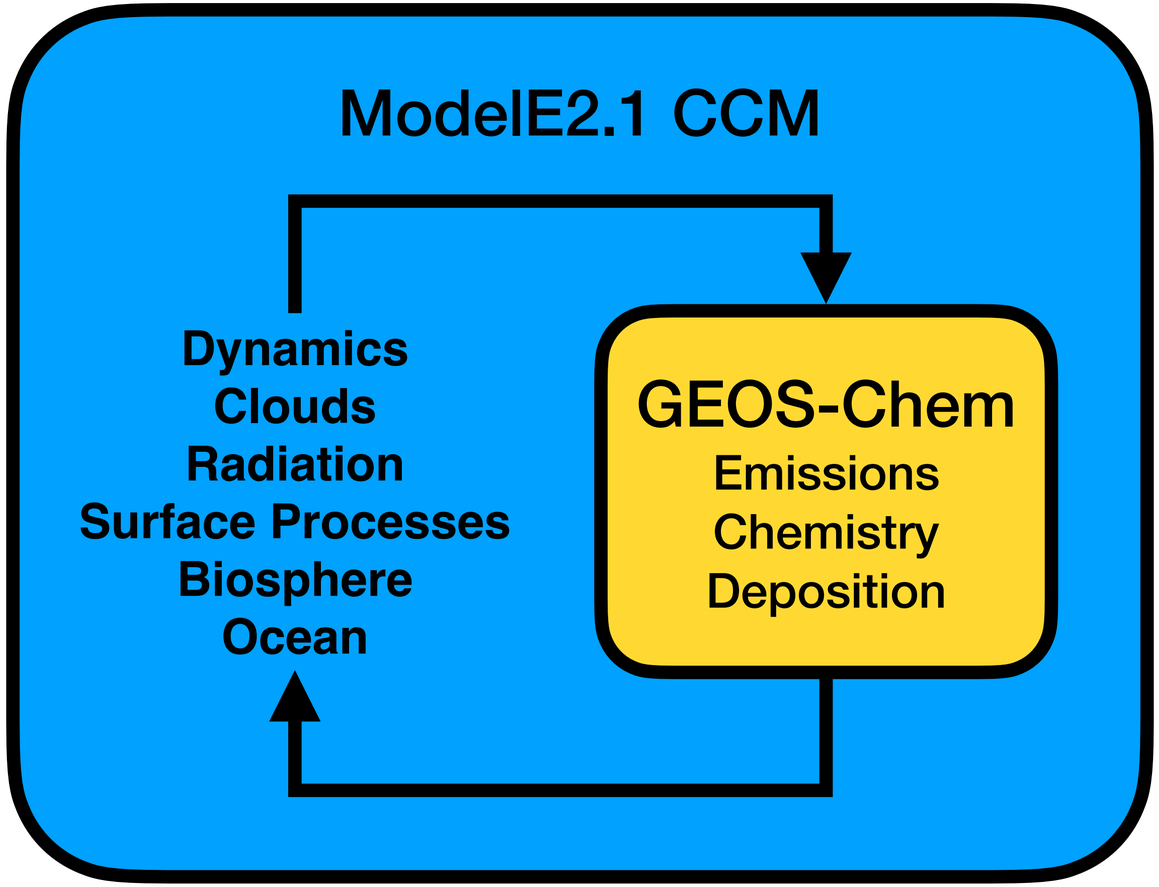



[Murray et al., *GMD*, 2021]

# Lessons Learned for GEOS-Chem

- **MERRA-2/GEOS-FP photosynthetic active radiation and surface roughness**






# GISS-GC: Two-way online coupling (in beta testing)