Chemistry-Climate Working Group

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CESM Chemistry Options

WACCM

TSMLT
234 tracers

Middle Atmosphere (MA)
100 tracers

Specified Chemistry (GHG Chemistry)
31 tracers

Provides Upper Boundary Conditions

oxidants, ozone, strat. aerosol

Air Quality Chemistry

TS1: 231 tracers

TS3: 278 tracers

SLH chemistry: 277 tracers

MOSAIC/CARMA

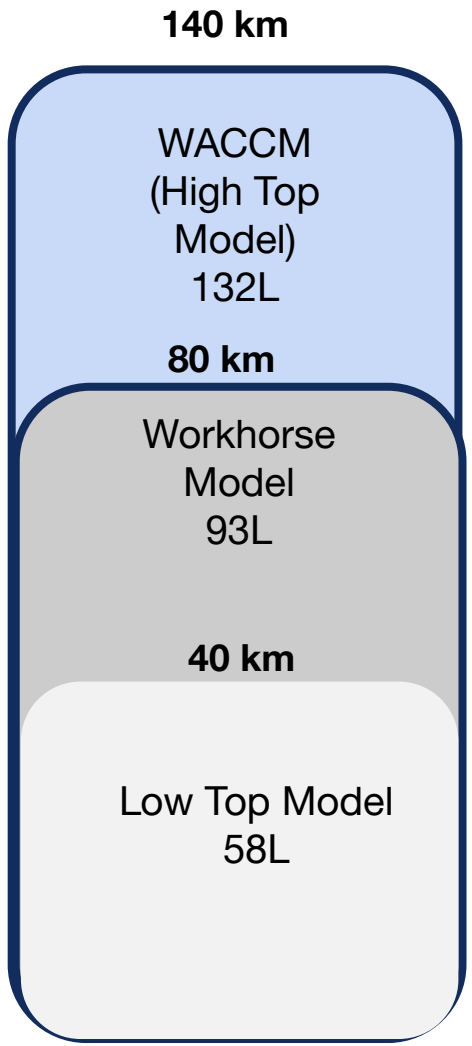
Climate Chemistry

TS4: 141 tracers
30% cheaper than TS1

As TS1 but cheaper tropospheric chemistry for climate

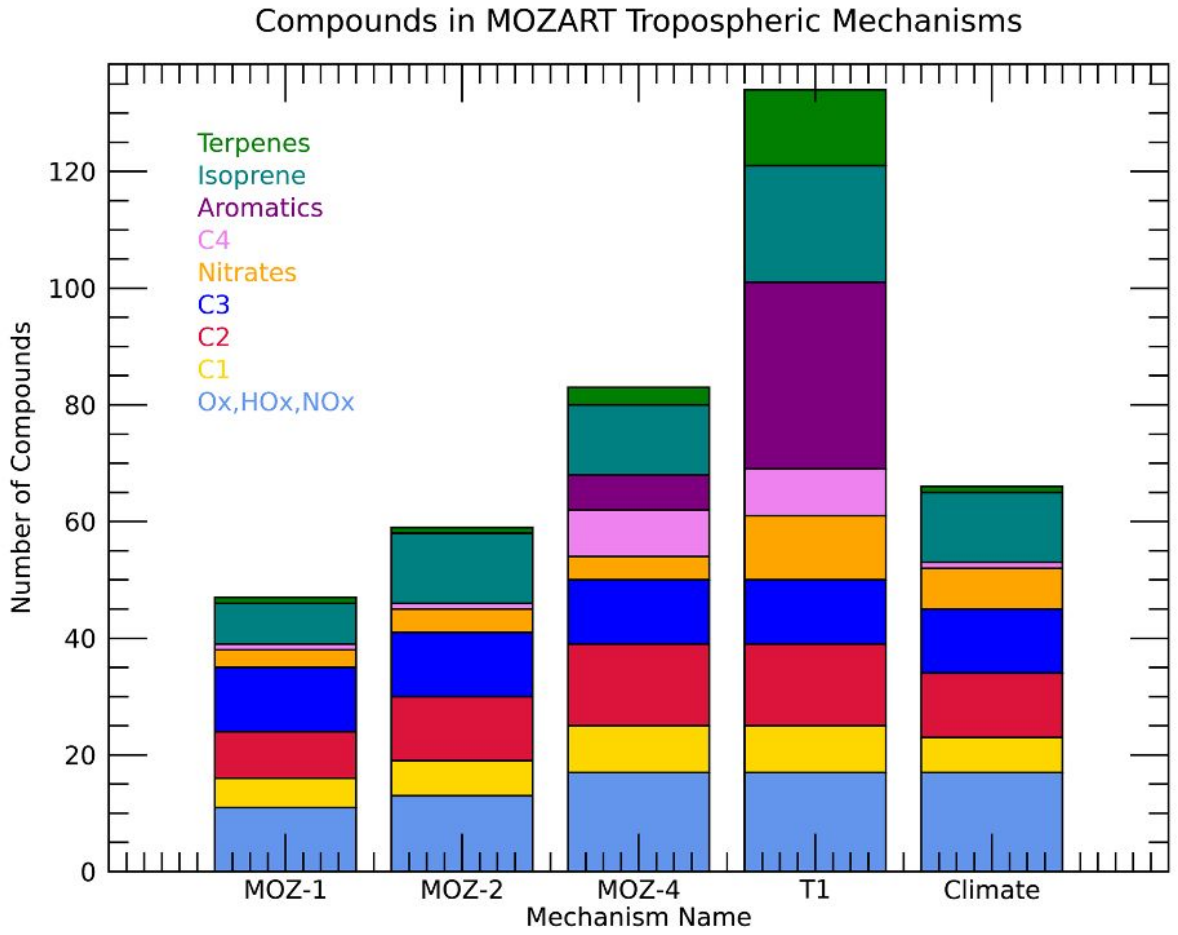
GHG Chemistry

31 tracers
prescribed ozone, oxidants, aerosol (stratosphere) interactive GHGs and aerosols in the troposphere



Fully coupled simulations with chemistry are required for GHG chemistry runs

MOZART Family of Chemical Mechanisms

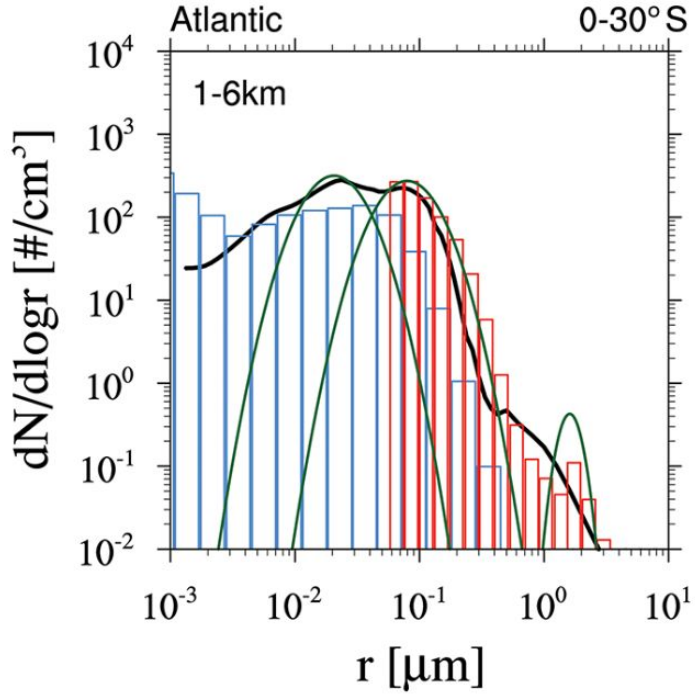


- Increasing complexity as computing power increases
- The MOZART-Climate mechanism is comparable to MOZART-2 (Horowitz et al., 2003)
- Similar mechanism used in GFDL AM4 (Horowitz et al., 2019)
- MOZART-Climate not optimal for air quality studies, but should appropriately simulate oxidants and aerosols for chemistry-climate studies and for creating specified oxidants for CAM

Aerosol Options in CESM2

MAM5 for stratospheric chemistry options

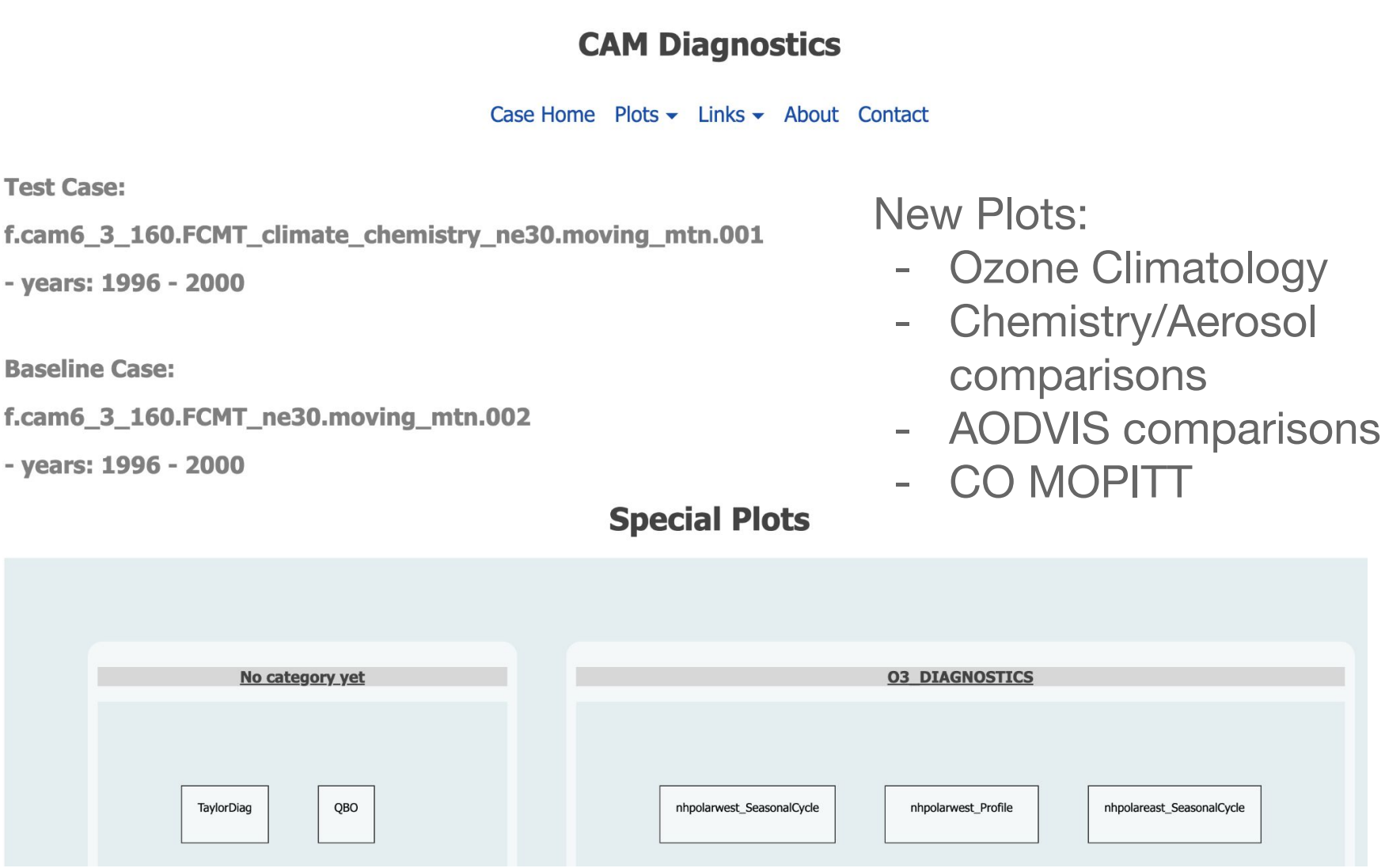
Aerosol Model	CARMA	MAM4
Size description	40 bins (20 per group) Mixed group: 0.05–8.7 μm Pure group: 0.2 nm to 1.3 μm	Primary carbon (0.06–0.30 μm) Aitken (0.015–0.053 μm) Accumulation (0.058–0.48 μm) Coarse modes (0.4–40 μm)
Species types	Sulfate, primary organic, secondary organic, black carbon, sea salt, dust	Sulfate, primary organic, secondary organic, black carbon, sea salt, dust
Groups and species	Mixed group: MX; pure group: PRSULF MX: total (incl. SULF), BC, OC, SALT, DUST SOA (or SOA1, SOA2, SOA3, SOA4, SOA5)	Internally mixed modes of so4, pom, bc, ncl, dst soa (or soa1, soa2, soa3, soa4, soa5)
Morphology (core or shell) for optics	Core: BC, DUST Shell: SULF, OC, SALT, H2O	



Tilmes et al., 2023

Ongoing (SIMA and MUSICA Efforts) Implementation of an updated Aerosol Interface

New ADF Chemistry Options in Development



New Plots:

- Ozone Climatology
- Chemistry/Aerosol comparisons
- AODVIS comparisons
- CO MOPITT

Model Simulations with the Recent Code Base
CAMchem TS1 vs CAMchem Climate Chemistry (1996-2000)

25K/yr 2 yrs a day

Air Quality Chemistry

TS1: 231 tracers

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SLH chemistry: 277 tracers

MOSAIC/CARMA

19K/yr 4 yrs a day

Climate Chemistry

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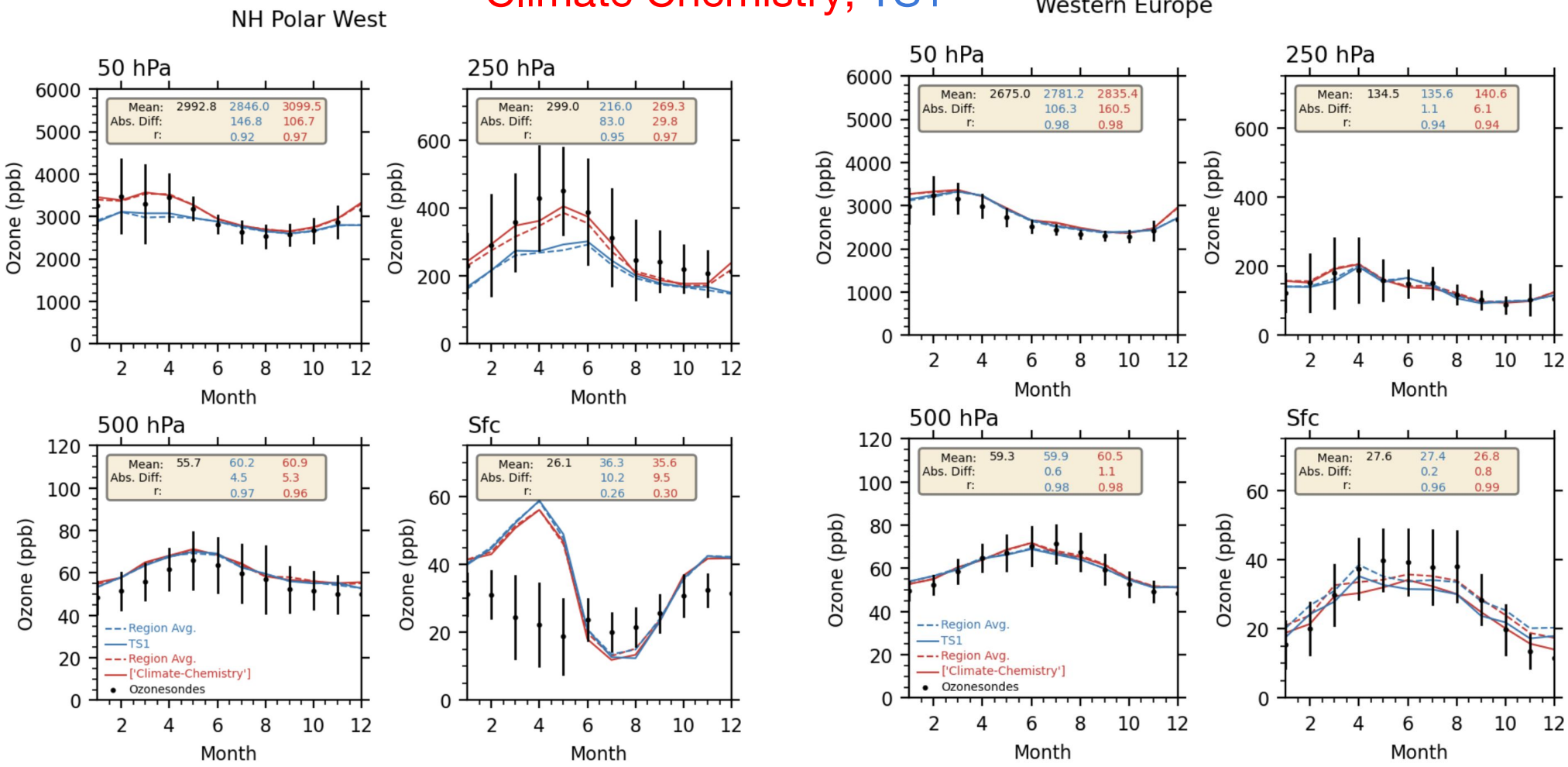
Climate Chemistry, TS1



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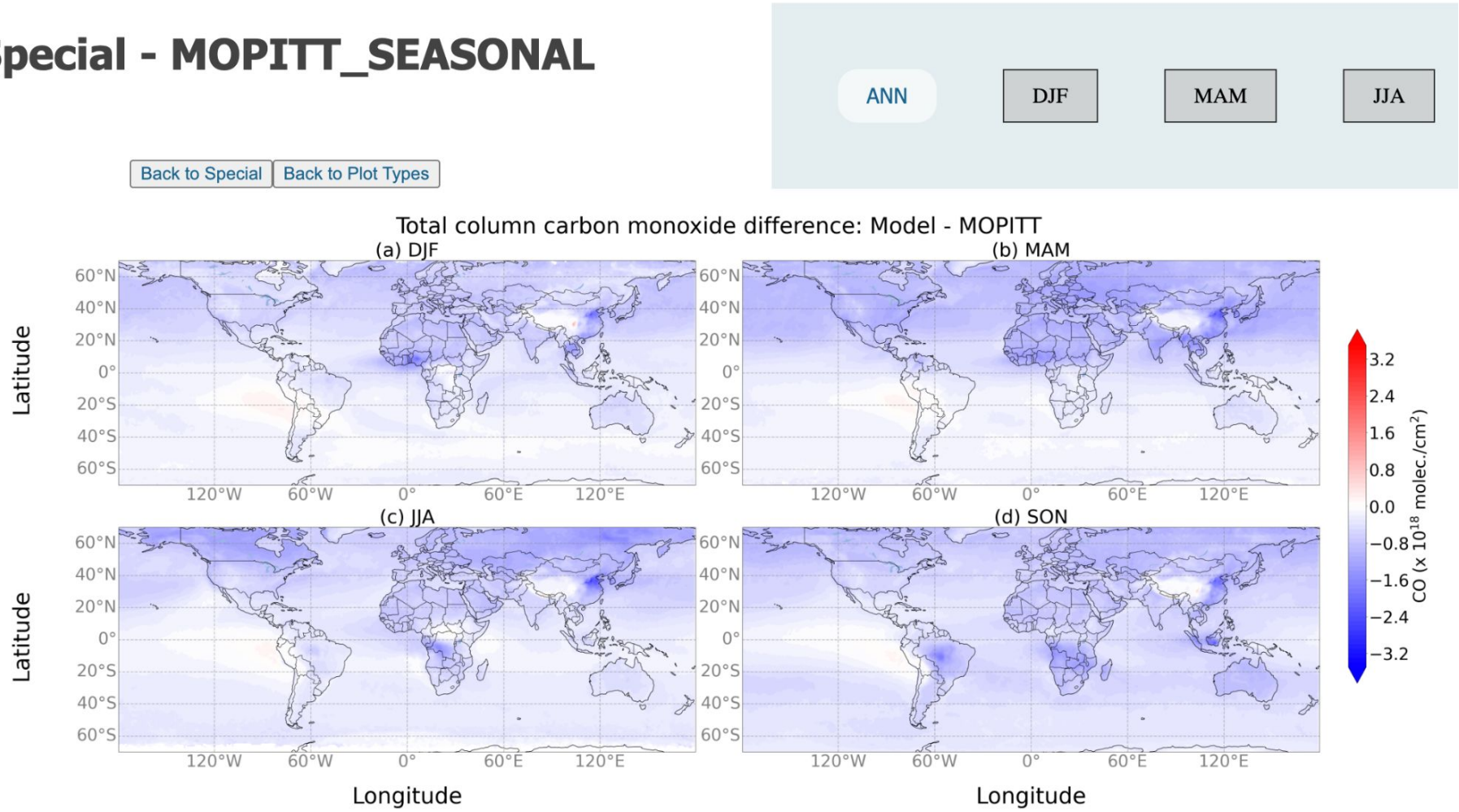
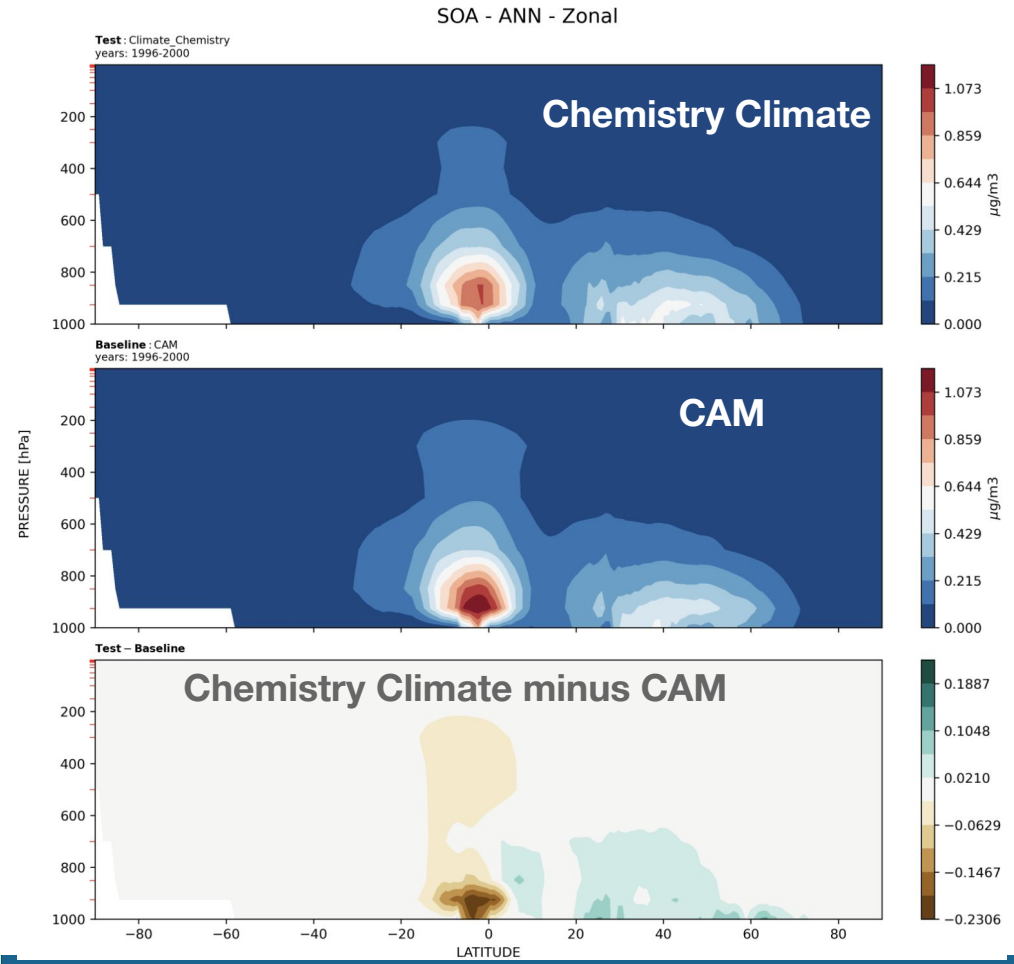


Model Simulations with the Recent Code Base
CAMchem Climate Chemistry vs CAM (1996-2000)

Secondary Organic Aerosol (ANN)

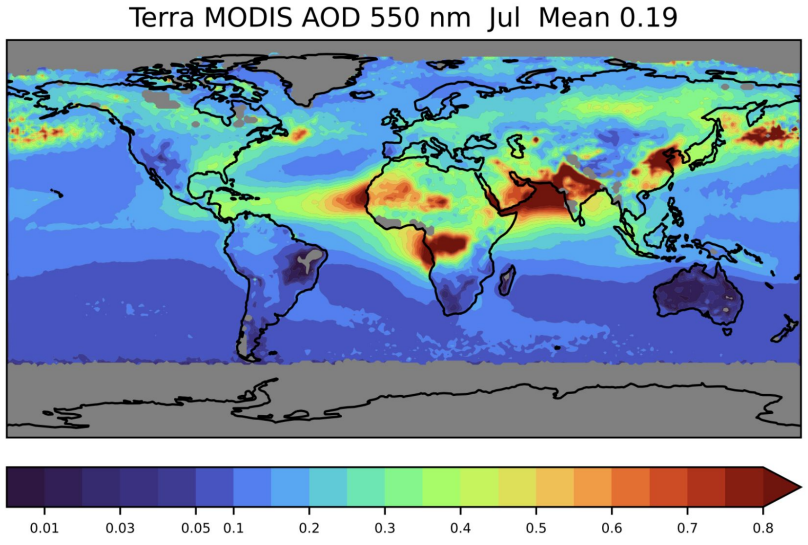


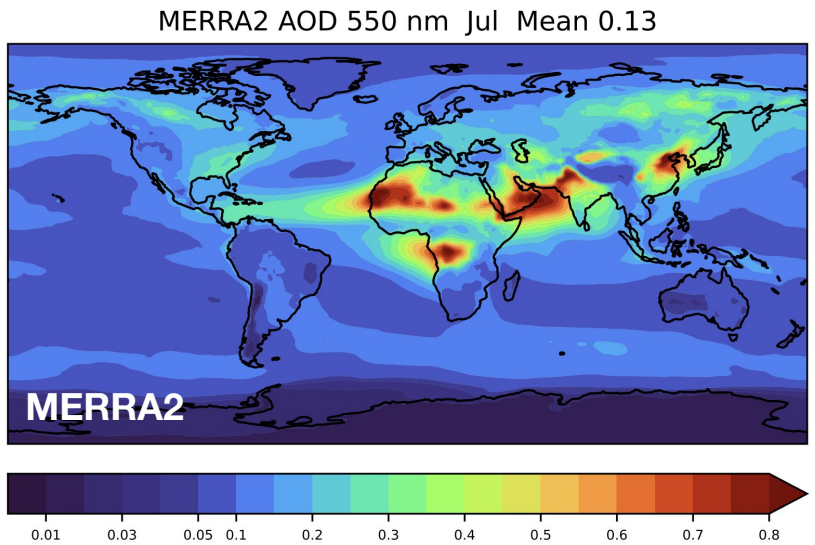
	TS1	Chemistry Climate	CAM
RESTOM	2.48	2.42	2.16
POM-BURDEN (Tg)	0.57	0.56	0.53
SOA-BURDEN (Tg)	0.76	0.72	0.75
BC-BURDEN (Tg)	0.14	0.13	0.13
DUST-BURDEN (Tg)	37.07	37.51	37.25
SALT-BURDEN (Tg)	10.87	10.89	10.79
SO4-BURDEN (TgS)	0.63	0.63	0.55

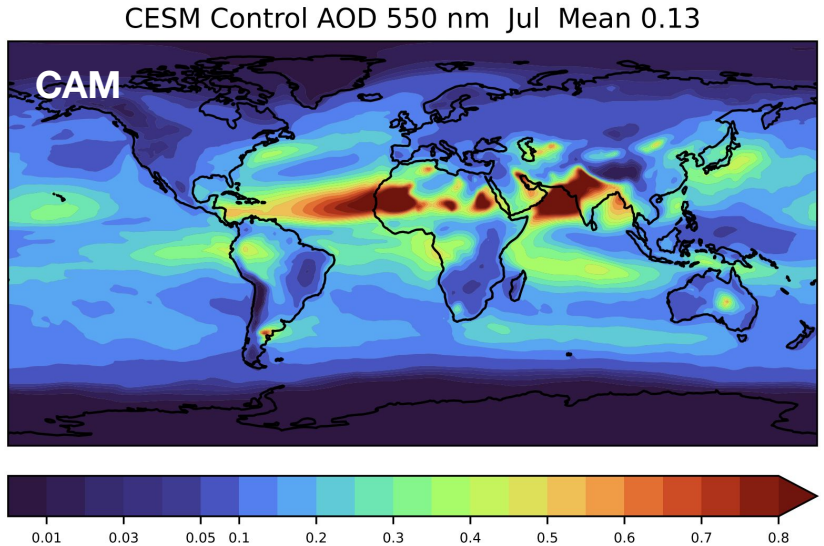
TS1 and Chemistry-Climate show similar aerosol burden compared to CAM. However, sulfate is lower in CAM (chemical production) -> **differences in RESTOM**

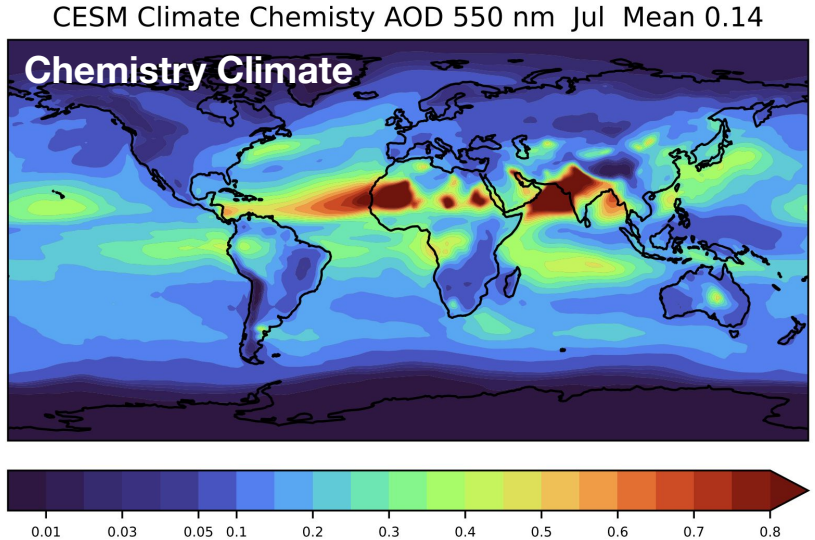
CAMchem Climate-Chemistry vs CAM (1996 - 2000)

2001-2020









CESM configuration show a high bias due to dust and sea-salt and low bias over the Northern Hemisphere

-> Likely impact on the North to South gradient in RESTOM

-> Updates expected with the new dust emission implementation

CAM-chem Development Timeline for CMIP7

Fully coupled chemistry runs (B-CASE) are needed to provide input for CAM

direct effects on aerosol, clouds and radiation

New dust emission scheme

direct effects on chemistry -> aerosol, ozone, oxidants -> radiation

Soil NOx emissions (land)

New Photolysis TUV-X

Gravity Wave Tuning for MT

Climate Chemistry Tests

Mid-top Upper Boundary tests

Mid-top chemistry runs 1960-2020 fixed SST runs

Produce new forcing files

Coupled runs with full chemistry, PI control, historical

Produce new forcing files

Winter 2023 | Summer 2024 | Fall 2024

Announcement: MUSICA input data on glade

- /glade/p/ locations were removed by CISL early 2024
- A need to move and **consolidate input data locations**

Input data file structure

```
/glade/campaign/acom/MUSICA/
                          emis/
                              cams/
                              cmip6/
                              gfed/
                              … etc
                          init/
                          met_data/
                          README
                          restarts/
                          wrfchem_input/
```

***** Finalized locations by the end of Summer 2024 *****