

Chemistry-Climate Working Group

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CAM-chem Development Highlights

CAM7-chem Workhorse Model: 93L (80km) and 58L (40km) (ne30pg3)

- Development is in progress, working with AMWG to tune the model. Recent developments: MAM5, new chemistry updates, changes in physics etc.

CESM CAM-chem 32L development version fv09 vs ne30pg3 (CSLAM)

- Model performance with cam6 physics is being evaluated

CESM CAM-chem simpler Chemistry

- TS4 new reduced mechanism by Louisa

CESM CAM-chem MPAS

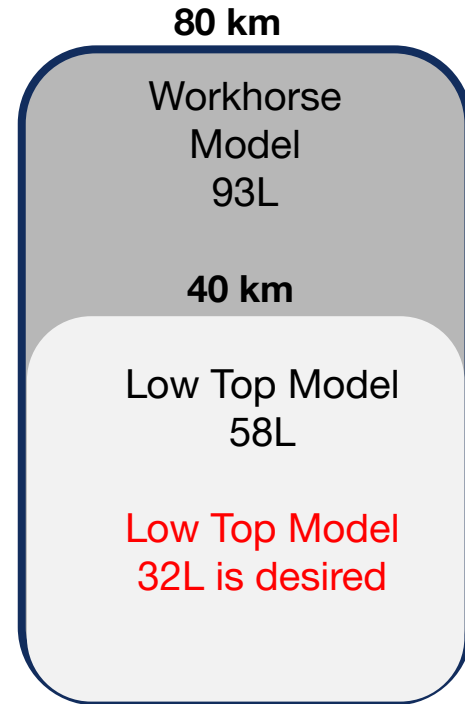
- Initial runs were performed and show good results by Mary, Francis and Ren

CESM CAM-chem and WACCM-MA CARMA

- Model branch is released and available for users

CESM CAM-chem with VSL halogen chemistry

- Presentation by Rafa and Alfonso



Additional Updates in the Pipeline for CAM/ CAM-chem development

- HEMCO Emission Component (Issue #560) -> in progress
- New photolysis scheme (TUV-x) -> in progress
- New dust emission scheme in CTSM -> in progress
- Marine Organic Aerosol Emissions (Issue #531) -> not yet started
- MEGAN3.1 code in CTSM (Issue #1323) -> not yet started
- Online soil NO emissions (CTSM issue #1952) -> not yet started
- Planned work with AMWG on a 32L vertical grid
- Very-Short-Lived Halogens implementation into CESM

CAM-chem TS4 simplified chemical mechanism

MOZART-TS4 - simplified, similar to MOZART-2 (Louisa Emmons)

- GFDL - AM4 uses something similar (Horowitz et al., 2019; doi:10.1029/2019MS002032)

Differences from TS1:

- Remove BIGENE, aromatics
- BIGALK only makes C₃H₇O₂
- Isoprene & Terpene chemistry similar to MOZART-4
- Full stratospheric chemistry, except for F, COF₂, COFCl
- Full sulfur chemistry (S, SO, SO₃, etc.)
- Simplified SOA (could expand back to VBS-SOA)

| | TS4 | TS1 |
|---------------------------|------------|------------|
| # species (total) | 141 | 231 |
| # not-transported species | 15 | 42 |
| PE-hrs / sim-year | 5400 | 7360 |

CAM-chem TS4 simplified chemical mechanism

One year specified dynamics simulation 2010: very small TOA difference (0.05 W/m²)

| | TS4 | TS1 |
|--------------|------------|------------|
| Ozone (Tg) | 335 | 341 |
| CO (Tg) | 269 | 266 |
| Methane (Tg) | 4198 | 4195 |
| POM (TgC) | 0.61 | 0.65 |
| SOA (TgC) | 0.76 | 0.71 |
| BC (TgC) | 0.11 | 0.12 |
| SO4 (TgS) | 0.50 | 0.73 |

CESM CAM-chem MPAS: 60 - 3 km grid mesh

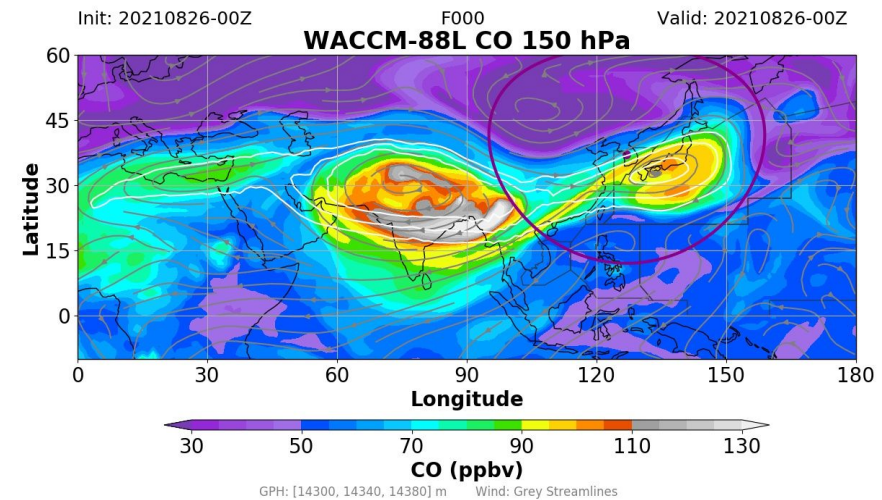
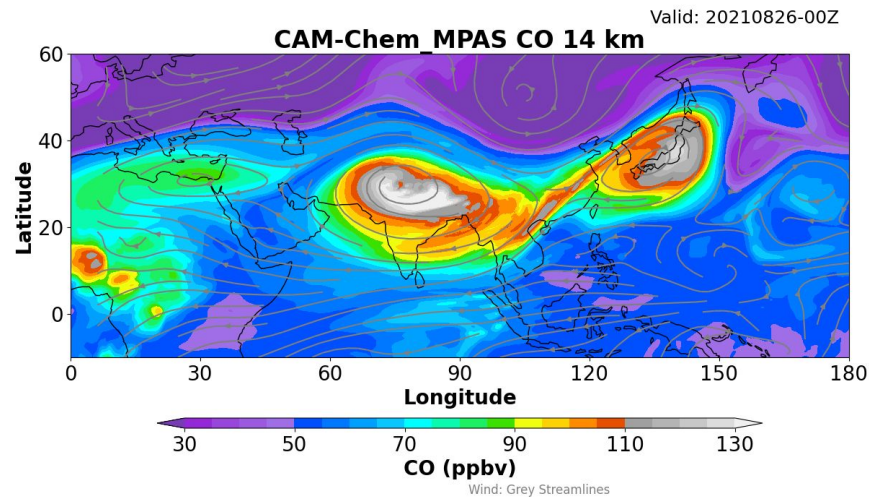
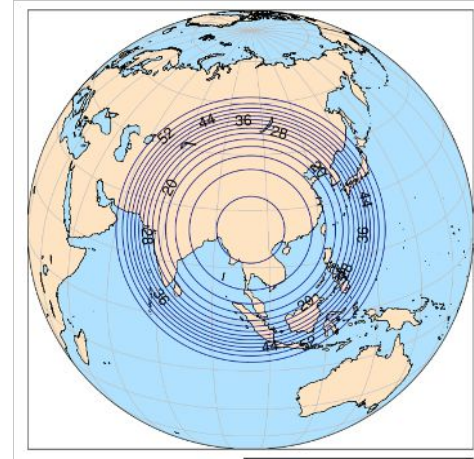
Asian Summer Monsoon dry run forecast =case study: 23.-28. August 2019

Troposphere-Stratosphere (TS1) chemistry
(168 trace gases & aerosols)

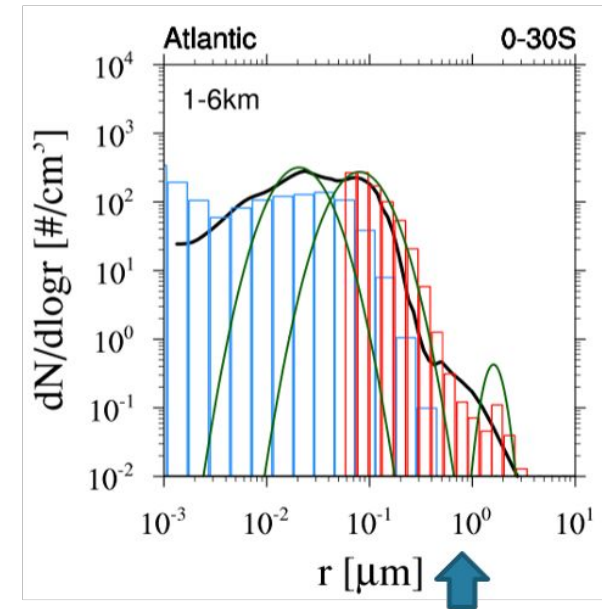
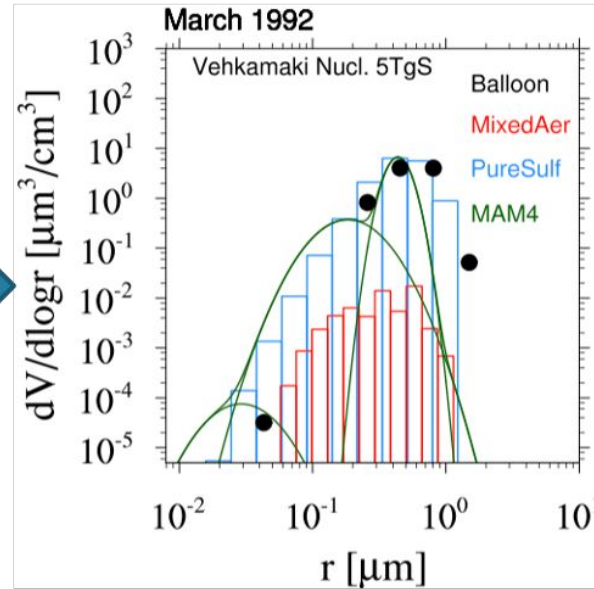
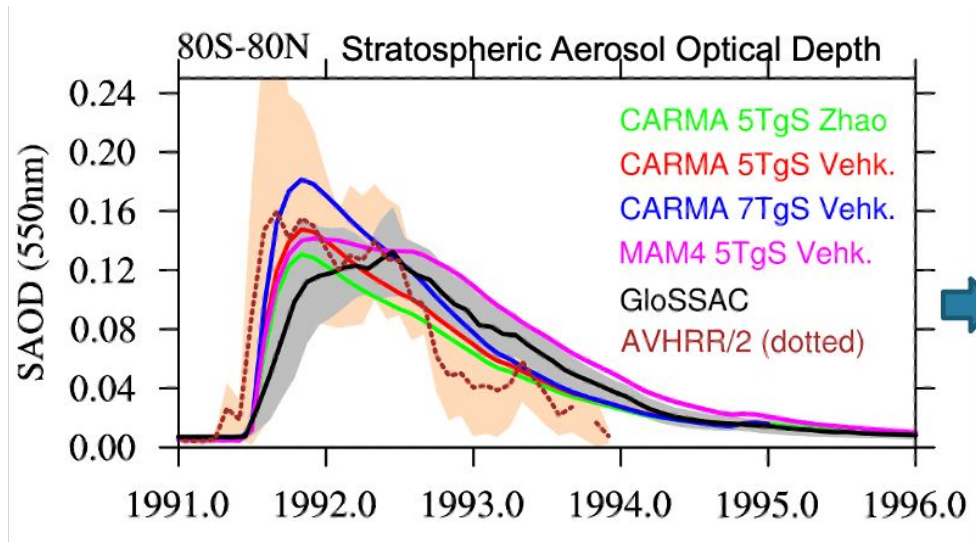
5-day test run:

- Model Cost: 2021401.65 pe-hrs/simulated_year
- Model Throughput: 0.09 simulated_years/day
- total pes active : 7200
- mpi tasks per node : 36

(200 cheyenne large memory nodes)

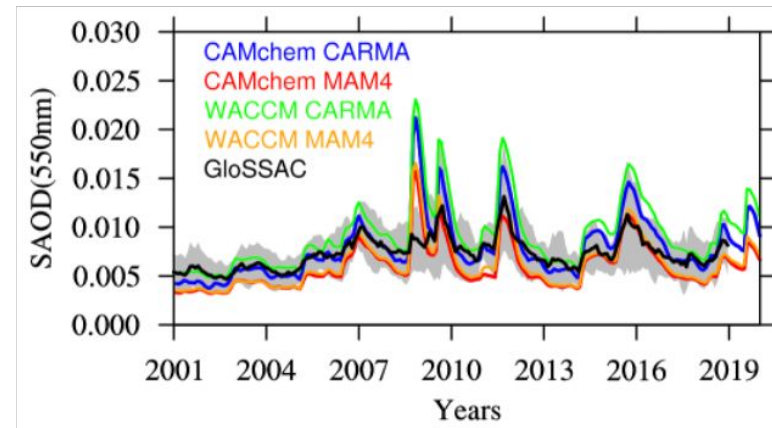


CESM2 CARMA Sectional Aerosol Model Implementation



WACCM-MA and CAMchem CARMA vs MAM4

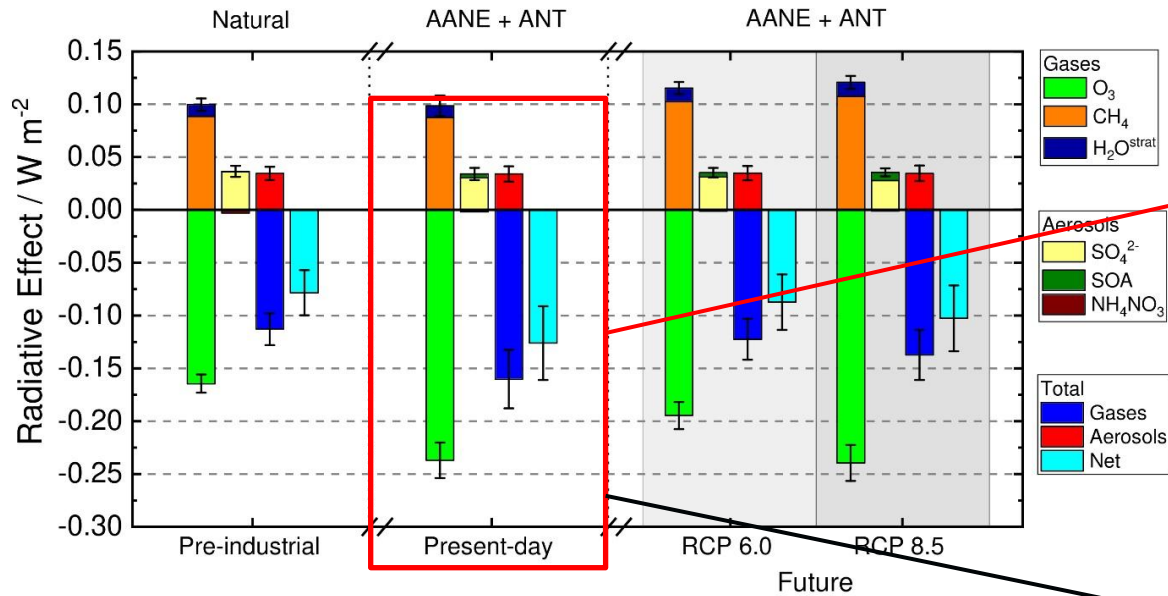
- Both CARMA and MAM4 reproduce stratospheric aerosol properties quite well over the Mt Pinatubo period and for smaller volcanoes and background conditions
- CARMA shows an improved representation of the aerosol volume size distribution compared to observations over the Mt Pinatubo period (March 1992, in 20km)
- > can make an important difference for Geoengineering studies
- CARMA better captures size distribution in the troposphere, e.g., Atlantic 1-6km 2016-2018 in comparison to ATom aircraft observations



(Tilmes et al. 2023, GMD in review)

Natural short-lived halogens (SLH) exert an indirect cooling effect on climate

CESM1 (CAM4-Chem) SLH with RRTMG
(updates on CESM2-SLH in ChemCWG on Wed 14th)



RE (Net)
-0.13±0.03

TOA Radiative Effect
at present ($W m^{-2}$)

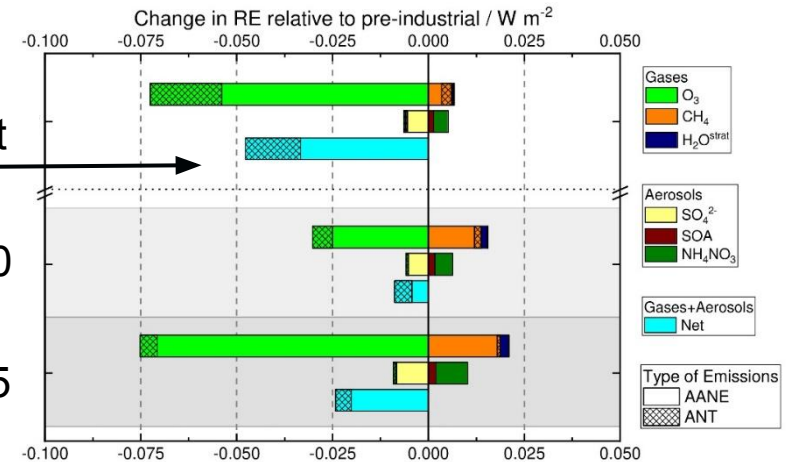
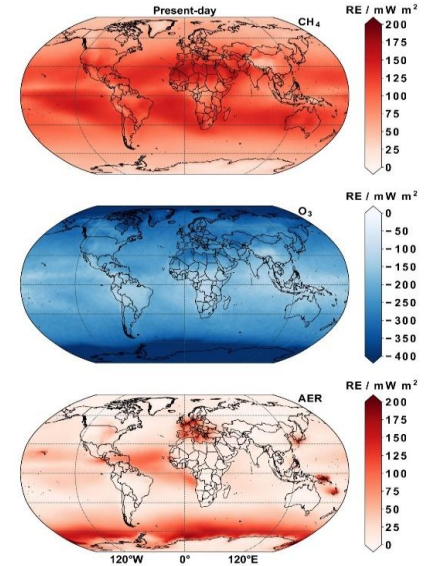
Change in RE
over time ($W m^{-2}$)

ΔRE (Net)
-0.05±0.03

RE (CH₄)
+0.09±0.01

RE (O₃)
-0.24±0.02

RE (Aer)
+0.03±0.01



(Saiz-Lopez et al., Nature, 2023)

- Halogen influence on Short Lived Climate Forcers induce non-linear changes in the radiative effect of O₃, CH₄, aerosols and H₂O^{strat}, resulting in a net indirect cooling effect that has buffered global warming since pre-industrial times.
- Coupling between SLH and atmospheric pollutants result in the Anthropogenic Amplification of Natural Emissions (AANE).

Discussion: Question and Needs from the Community

What are your needs regarding CAM-chem capabilities /developments with regard to:

- Chemistry complexity
- Aerosol developments
- Model resolutions and vertical extent