Chemistry-Climate Working Group

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CAM-chem Development Timeline for CMIP7

See Presentations on different topics on Monday and Tuesday morning

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

CESM summer meeting

Coupled runs with full chemistry, PI control, historical

Produce new forcing files

Winter 2023

Summer 2024

Fall 2024

CESM Chemistry Options

WACCM

TSMLT (SLH)
234 tracers

Middle Atmosphere (MA)
100 tracers

Specified Chemistry (GHG Chemistry)
31 tracers

Troposphere Stratosphere Mesosphere Lower Thermosphere Chemistry (TSMLT) / MAM5 (WACCM-CMIP6)

Includes comprehensive tropospheric chemistry and interactive aerosol (suited for air quality studies), and comprehensive stratospheric chemistry and interactive aerosol , includes ions for upper atmosphere chemistry. Only this mechanism is suited to provide oxidant, ozone, fields for specified chemistry runs.

Middle Atmosphere Chemistry (MA) / MAM5

Includes simplified tropospheric chemistry (unrealistic ozone), and comprehensive stratospheric chemistry, interactive aerosol. Suited for middle atmosphere chemistry, aerosol, and transport studies.

Specified Chemistry /Greenhouse Gas Chemistry (GHG) / MAM4

Includes interactive tropospheric aerosols and greenhouse gases in the atmosphere (prescribed at the boundary) and tropospheric aerosol, uses prescribed ozone, oxidants, and aerosol (for the stratosphere only) from TSMLT chemistry.

WACCM MA chemistry can be run with a sectional aerosol model

CESM Chemistry Options

mid/low top

Air Quality Chemistry

TS1: 231 tracers

TS2/3: 278 tracers

SLH chemistry: 277 tracers

MOZAIC (nitrate)
CARMA (sect.)

MOZART-TS1: includes comprehensive tropospheric chemistry and interactive aerosol (suited for air quality studies), and comprehensive stratospheric chemistry and interactive aerosol

MOZART-TS2/3: Speciated alkane oxidation: The alkane chemical mechanism is expanded from one surrogate species (BIGALK) to 5 surrogate species (NBUTANE, ISOBUTANE, NPENTANE, IPENTANE, and C6ALKANES).

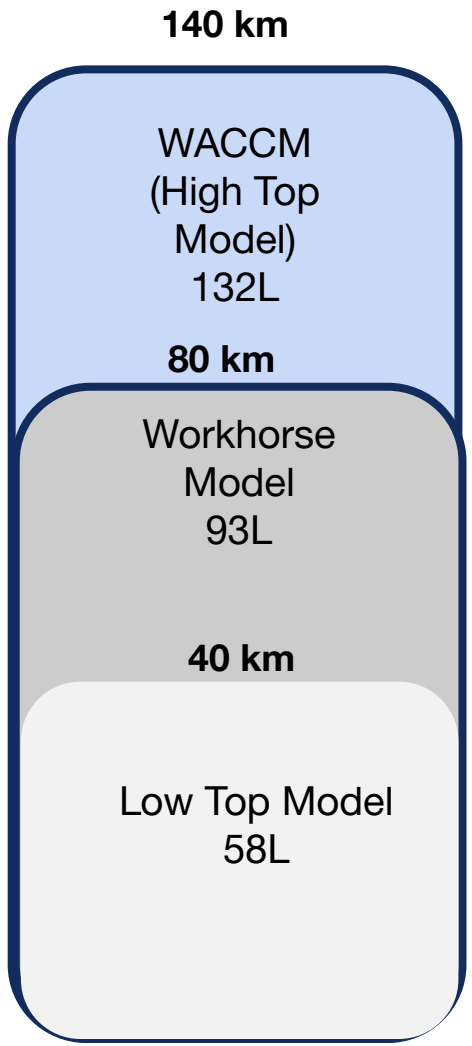
SLH chemistry: include very short-lived halogen emissions (natural and anthropogenic) and chemistry to produce a more realistic halogen burden in the troposphere and stratosphere, altering climate relevant species as ozone, methane and aerosols. It can be mapped to both MOZART-TS1 and TSMLT. **Most realistic Greenhouse gas Chemistry**

MOZAIC: includes nitrates and comprehensive nitrogen chemistry

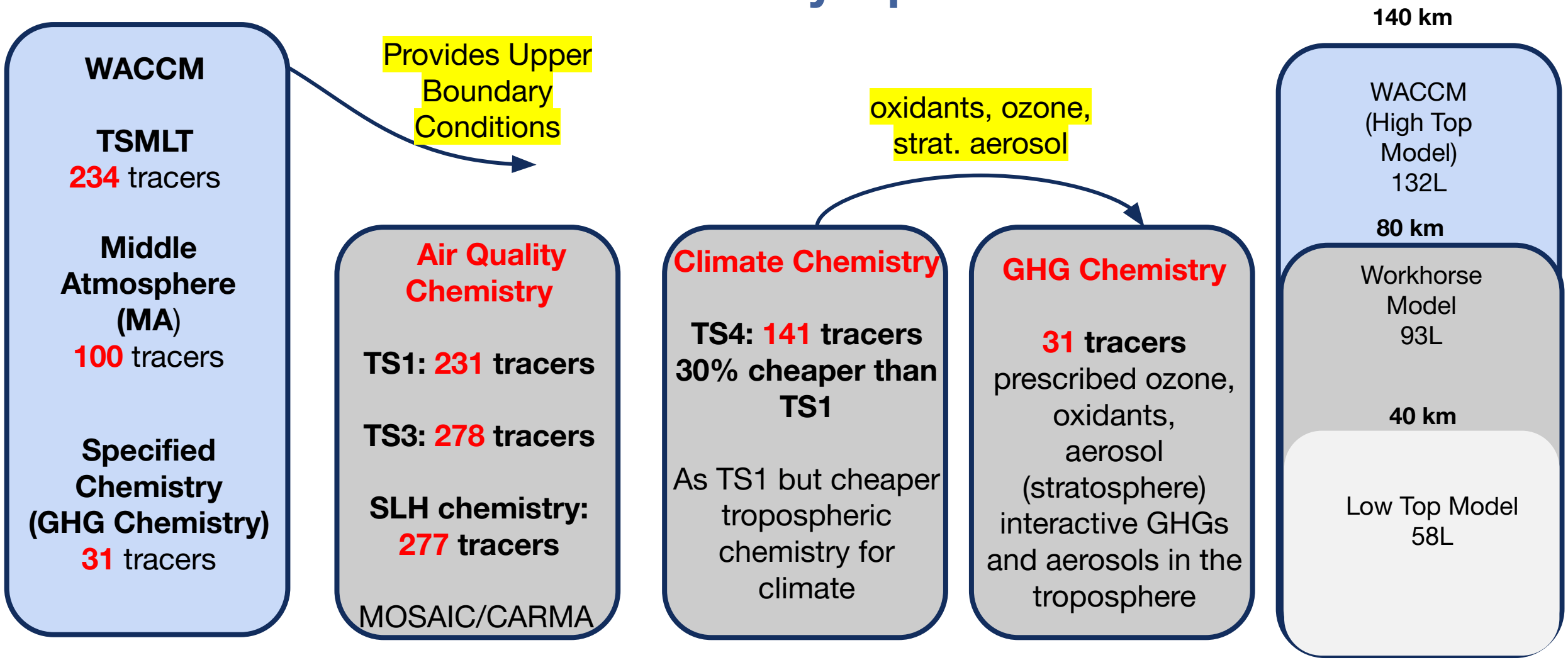
MOZART-TS4: Full stratospheric chemistry, an updated version of MOZART-2 chemistry for the troposphere to be suitable for climate simulations and a cheaper option for use with MOSAIC-MAM (forming nitrate aerosols) -> **Climate Chemistry**

Default Aerosol Model: Modal Aerosol Model (MAM5)

GHG-Chemistry: Requires information from either scheme above



CESM Chemistry Options



Fully coupled simulations with chemistry are required for GHG chemistry runs

Other CAM-chem Development Highlights

CESM CAM-chem 32L vs 58L vs 93L development version fv09 vs ne30pg3 (CSLAM)

- Model performance with cam6 physics, new chemistry updates
- TS3 chemistry work ongoing for improved air-quality simulations

GEOS-Chem with HEMCO emissions

CESM CAM-chem MPAS

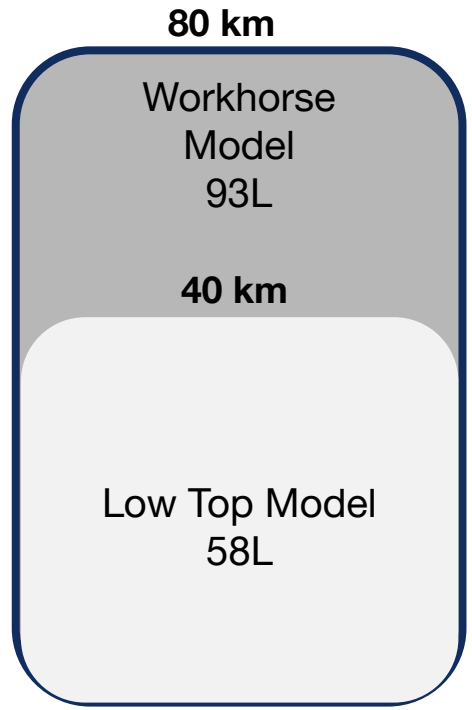
CESM CAM-chem and WACCM-MA CARMA

- Model branch (CESM2.2) is released and available for users

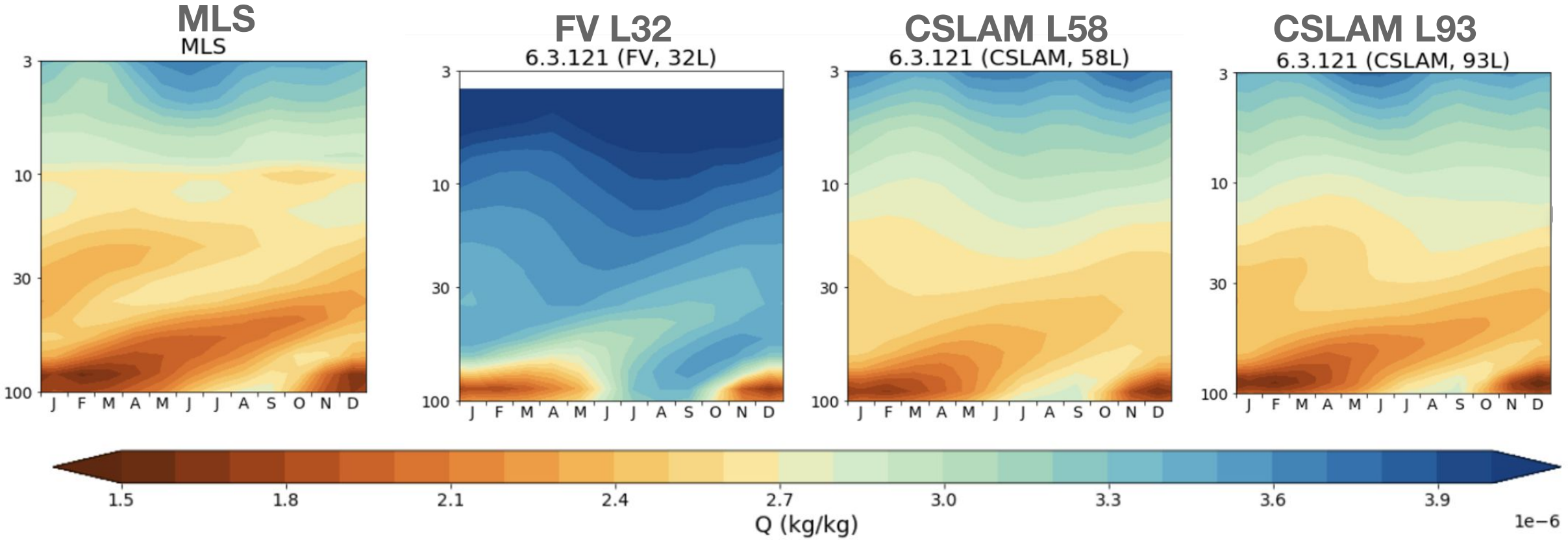
CESM CAM-chem with SLH halogen chemistry (currently in CESM2.2.0)

CESM CAM-chem methane emission-driving simulations (Mirrezaei's talk)

Marine Organic Aerosol Emissions (Issue #531) -> not yet started
MEGAN3.1 code in CTSM (Issue #1323) -> not yet started



CAM-chem cam6 physics 32, 58, and 93L comparisons



Development version with cam6 physics does not scientifically support FV L32 (often used for nudged CAMchem simulations)

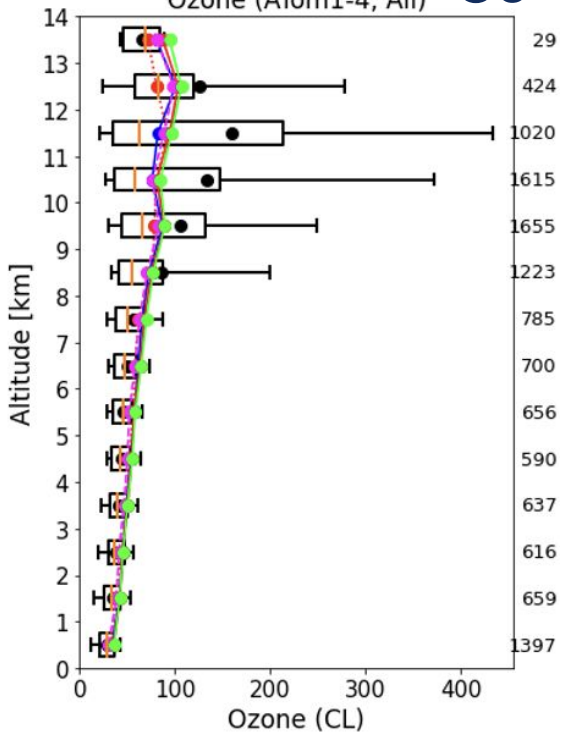
- caution: tape recorder in the stratosphere has a wet bias using FV L32
- L58 and L93 look reasonable

work by Duseong Jo

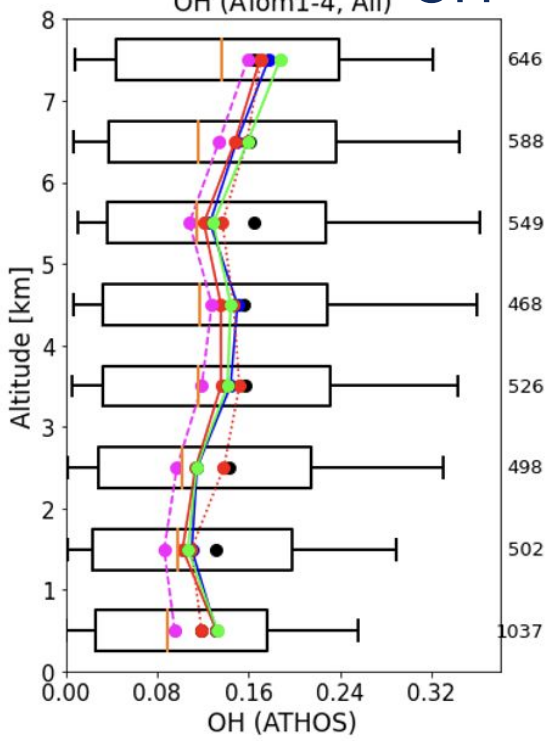
CAM-chem cam6 physics 32, 58, and 93L comparisons

ATOM 1-4 averages

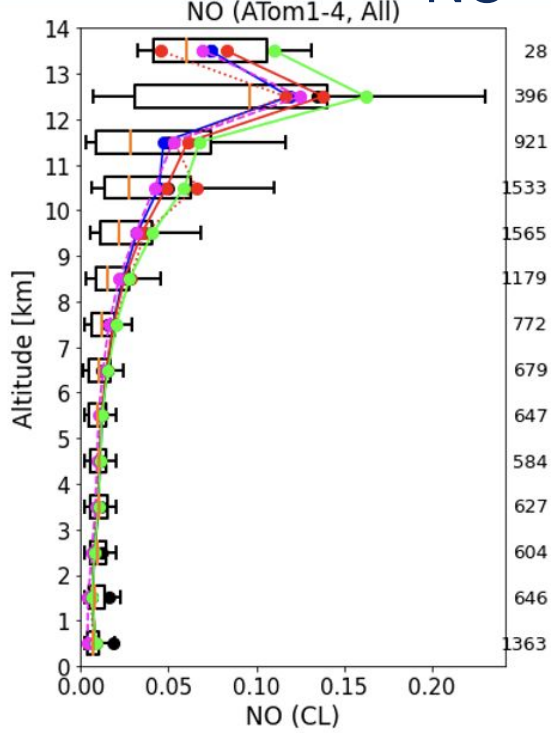
O3



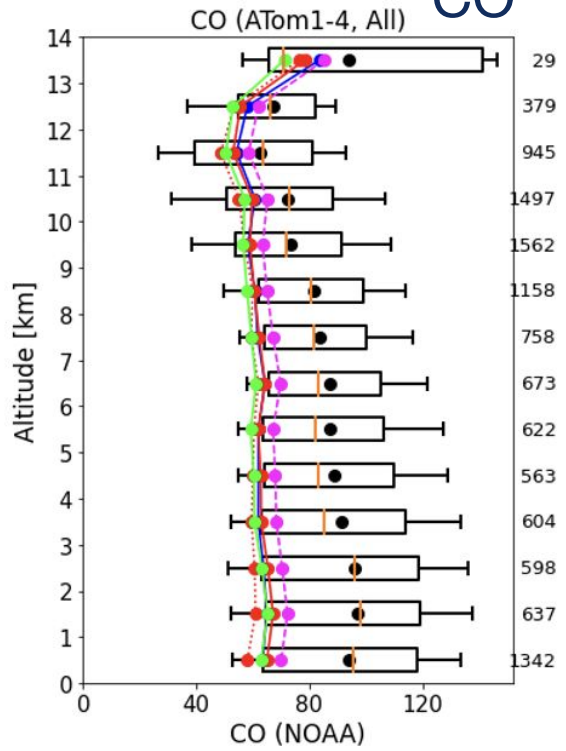
OH

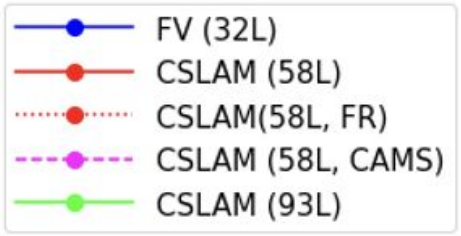


NO



CO



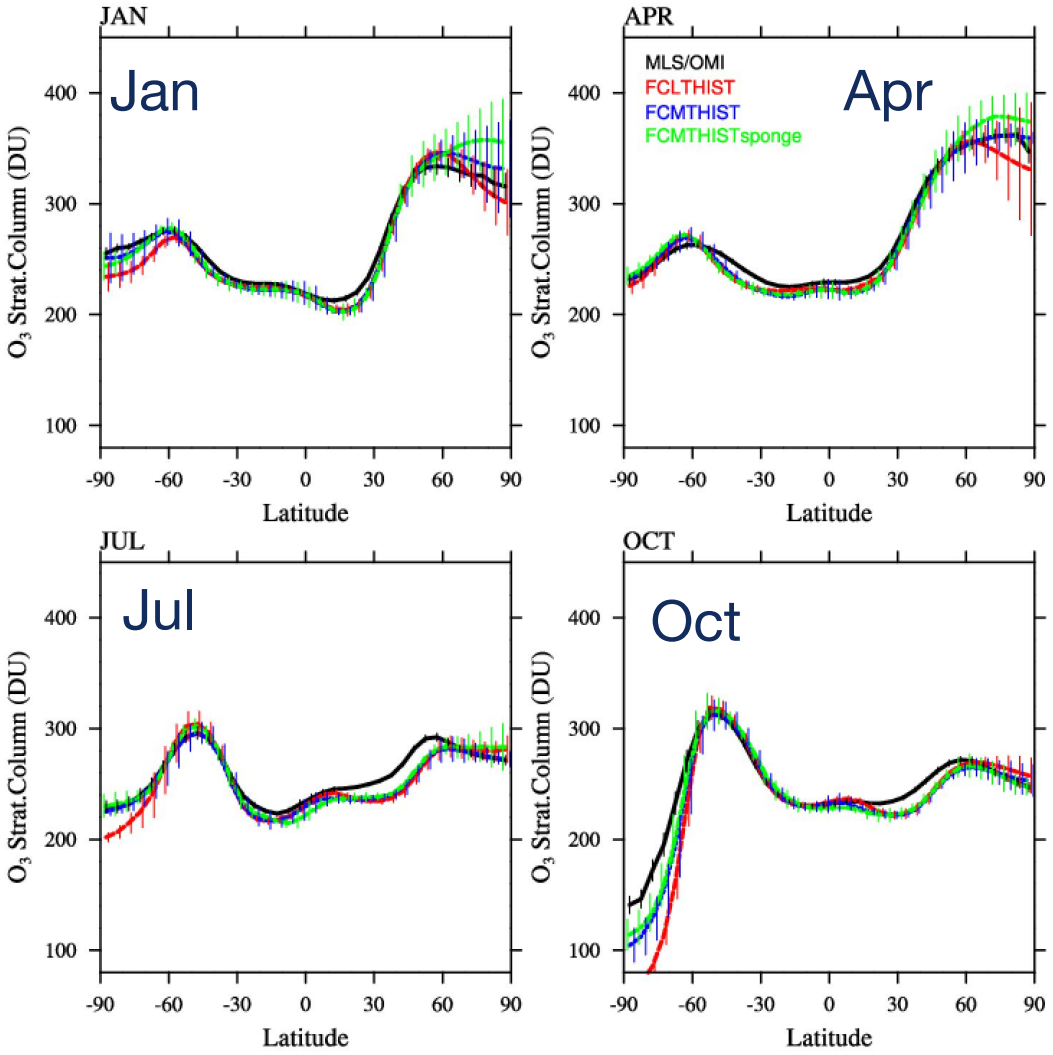


Chemistry performance:

- little differences between different model version
- different emissions (pink) show stronger differences

work by Duseong Jo

CAM-chem cam-dev (cam6.3.132) physics 93L comparisons



Stratospheric Column Ozone comparison (10 years)

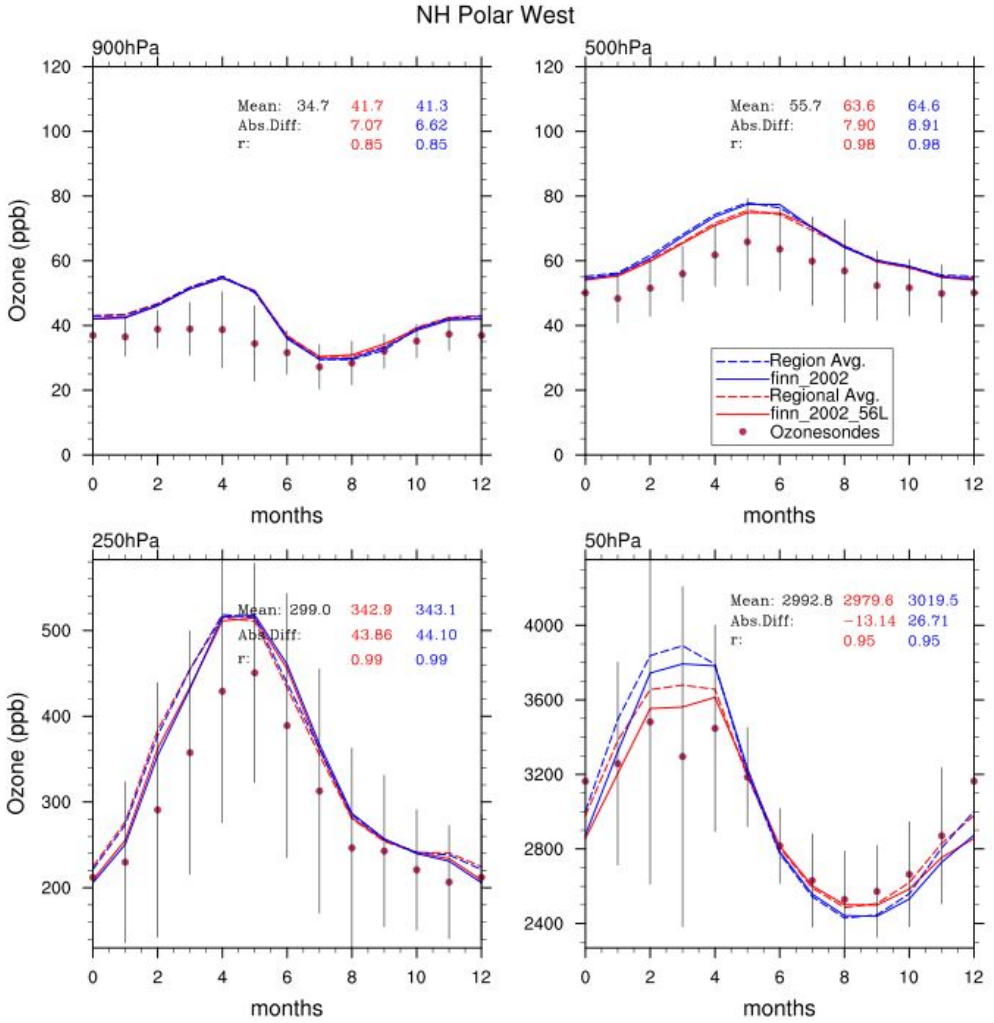
- MLS/OMI
- FCLTHIST (low top with TS1 chemistry)
- FCMTHIST (mid top with TS1 chemistry)
- FCMTHIST (mid top with TS1 chemistry), science optimized (faster)

FCMTHIST was somewhat tuned to improve cold bias (ongoing work, see later presentation)

FCLTHIST was not tuned yet, shows a much stronger bias in the Oct SH polar region

Chemistry Diagnostics for the AMWG Diagnostic Framework (ADF)

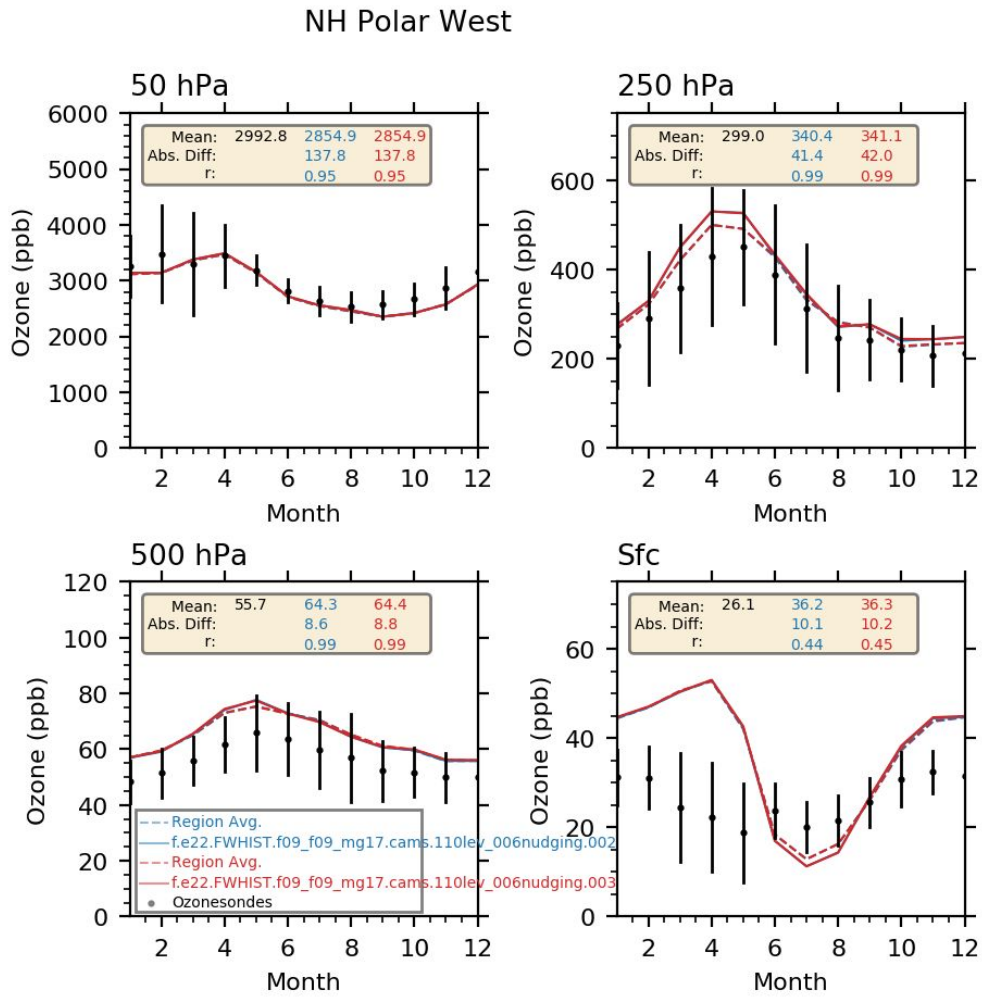
AMWG Diagnostics



adding chemistry, aerosol, tables and other diagnostics

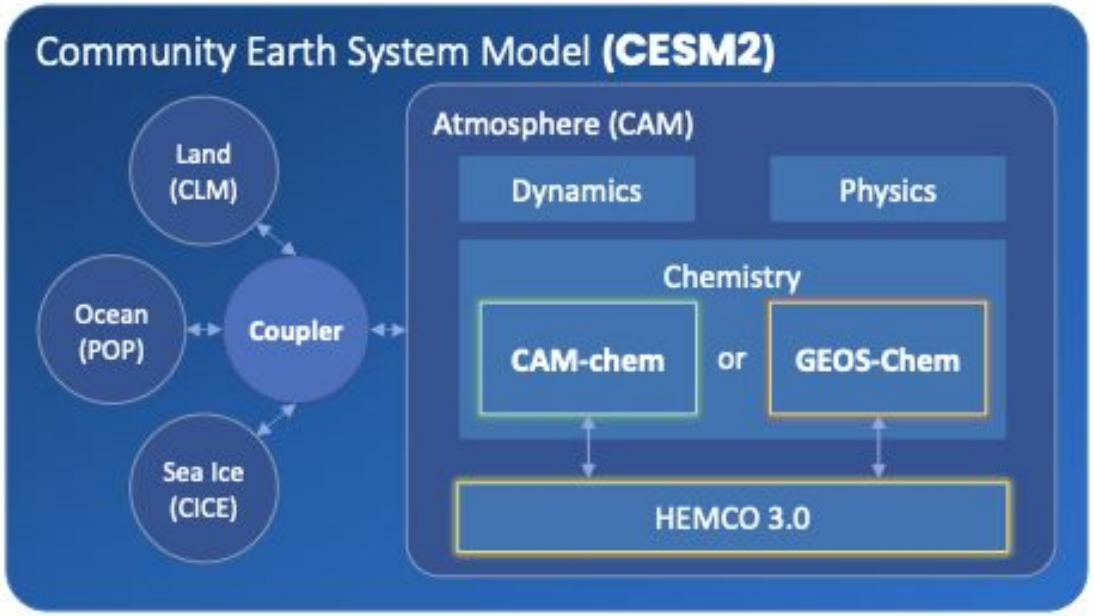
thanks to Justin Richling and Shawn Honomichl

ADF

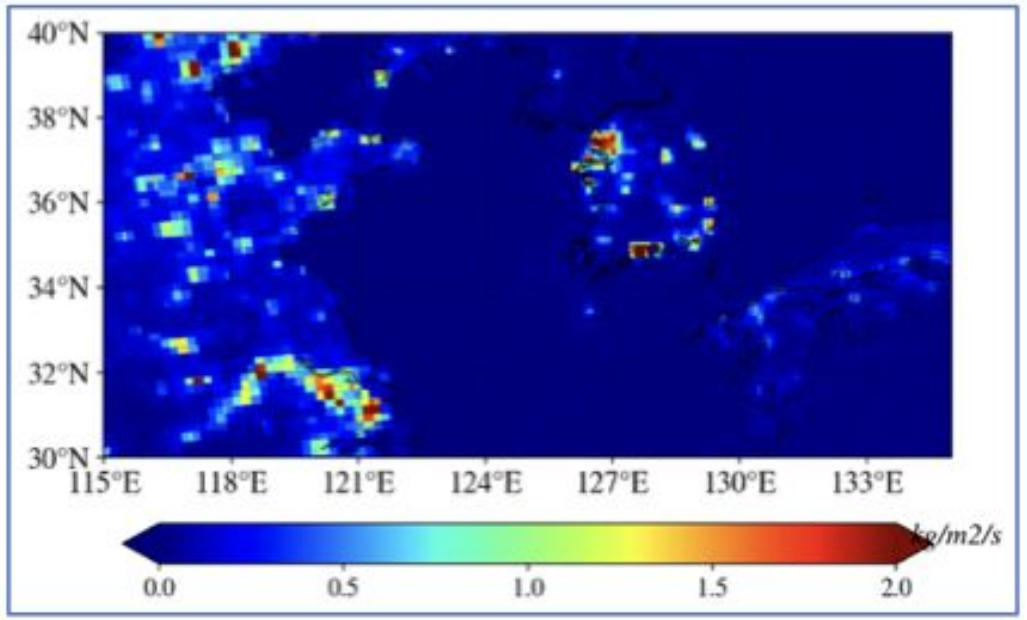


Both GEOS-Chem chemistry and HEMCO emissions (for CAM-chem & GEOS-Chem chemistry) are now available in CAM development (cam6_3_147)

GEOS-Chem available as alternative chemistry option to CAM-chem



HEMCO available as emissions option for CAM-chem NO emissions on MUSICA Korea grid (grid from: Duseong Jo)



Compsets now available for testing with HEMCO and GEOS-Chem!

- HEMCO compsets with CAM-chem: FCnudged_*HCO*, FCSD_*HCO*, … or namelist option (`use_hemco = .true.`)
- GEOS-Chem compsets: FCnudged_*GC*, FCSD_*GC*, …

GEOS-Chem within CESM described by *Fritz et al. 2022 GMD* and detailed intercomparison with CAM-chem will be submitted soon to ACP.

thanks to Haipeng Lin