Whole Atmosphere Working Group Updates

27th CESM Annual Workshop

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WACCM-X SE Development

- SE dycore modified to account for species dependent Cp, R, and m in the thermosphere, as well as molecular viscosity and thermal conduction in the horizontal direction

- Efficient regridding scheme implemented to transform between SE coordinates and the geomagnetic grid for ionosphere electrodynamics

- Addressed the large memory footprint of the model

- Ongoing developments:
  - High-resolution capabilities
  - Coupling with GAMERA magnetospheric model
 - Meteorological constraint through nudging and data assimilation

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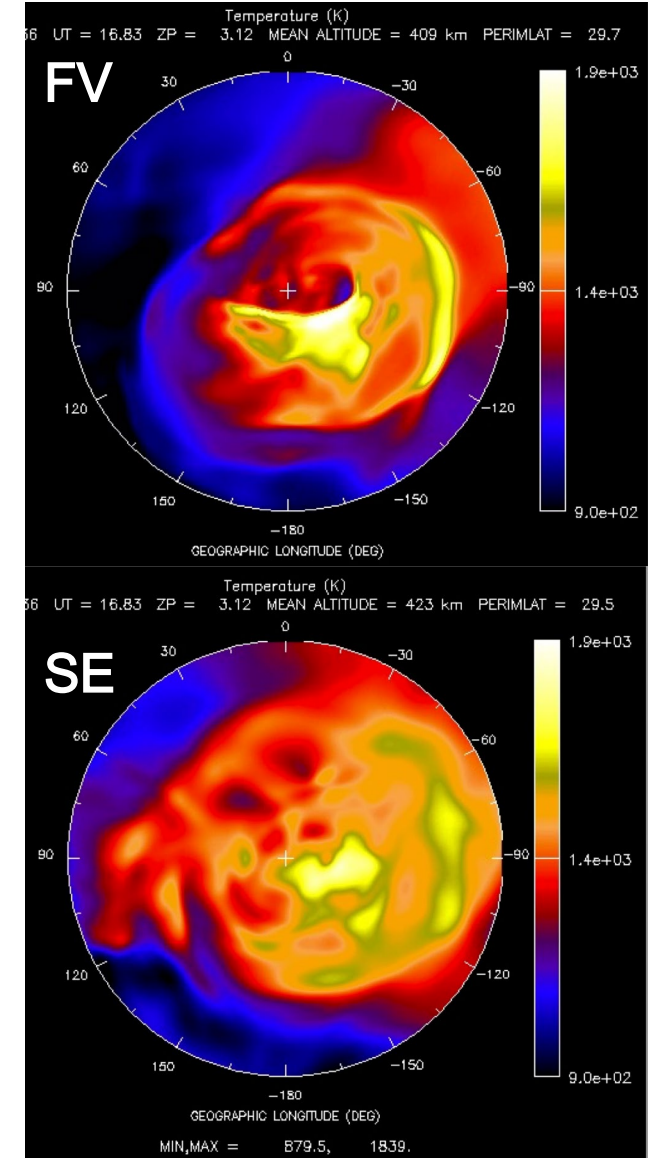
High Resolution WACCM -X SE

- NE120 (with output interpolated on 0.25 ° x 0.25° lat/lon grid)
- 0.1 scale height vertical resolution in the middle/upper atmosphere (L273)
- Constant solar condition (F10.7=120 sfu) and geomagnetically quiet (kp=0.33)
- No parameterized gravity waves
- Simulations finished for January-August of a generic year (and running)
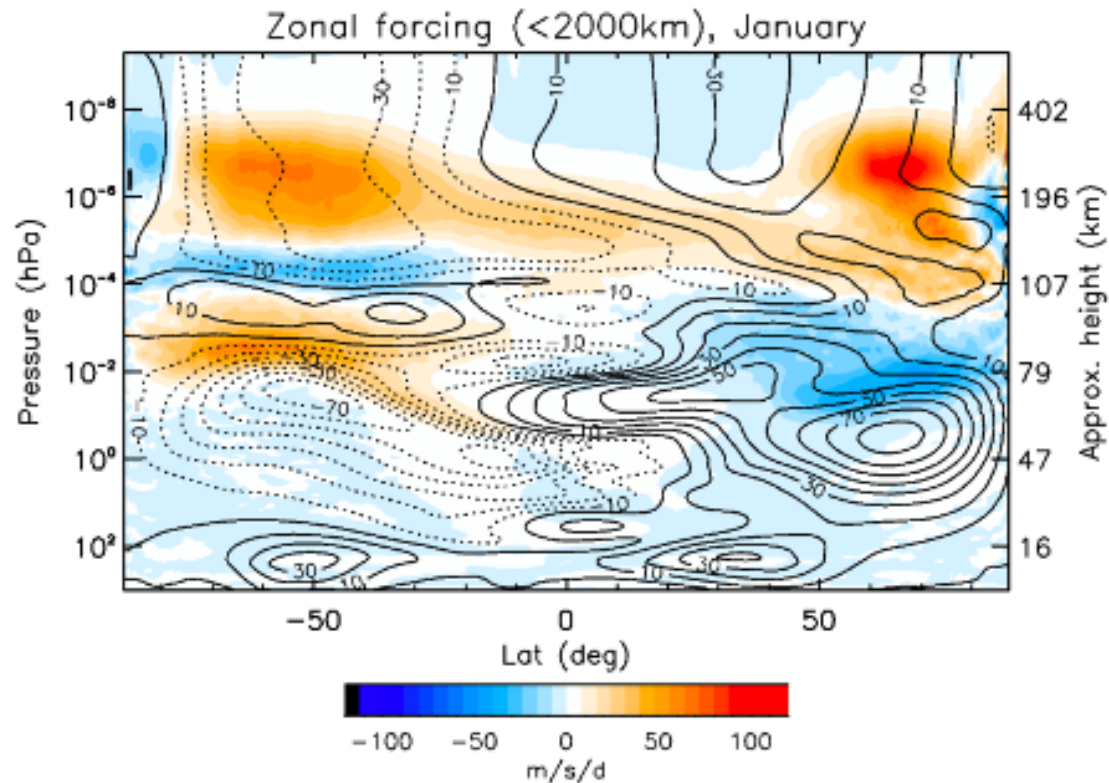
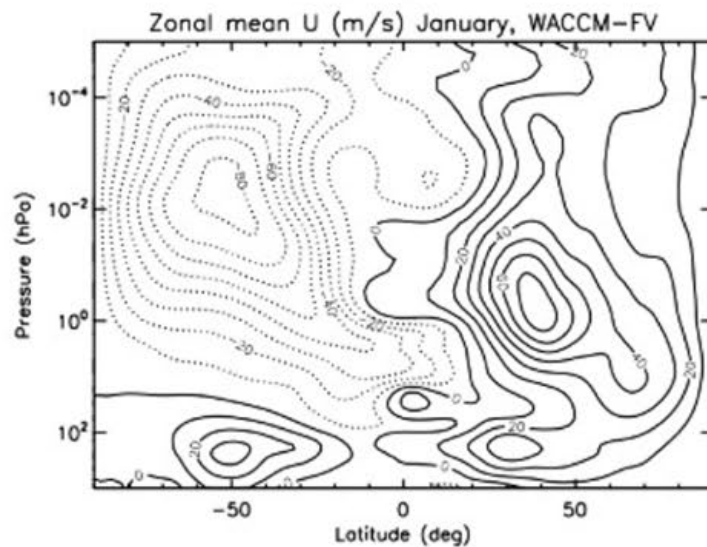Perturbations in Total Electron Content (periods < 2 h)
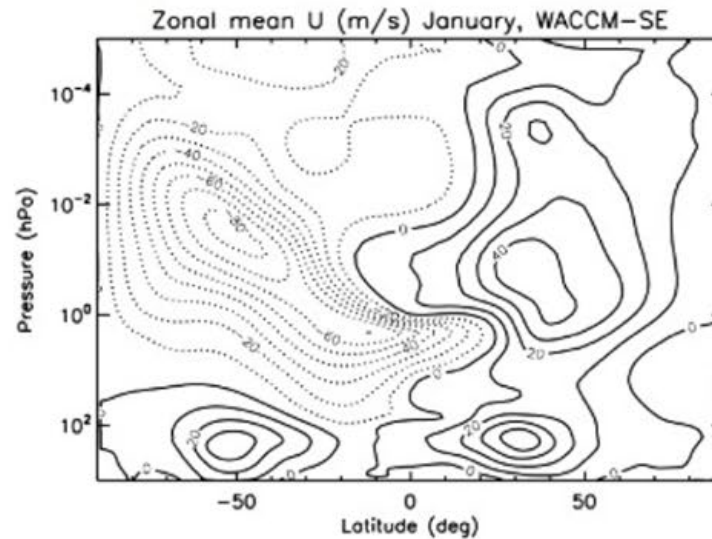

Credit: Hanli Liu

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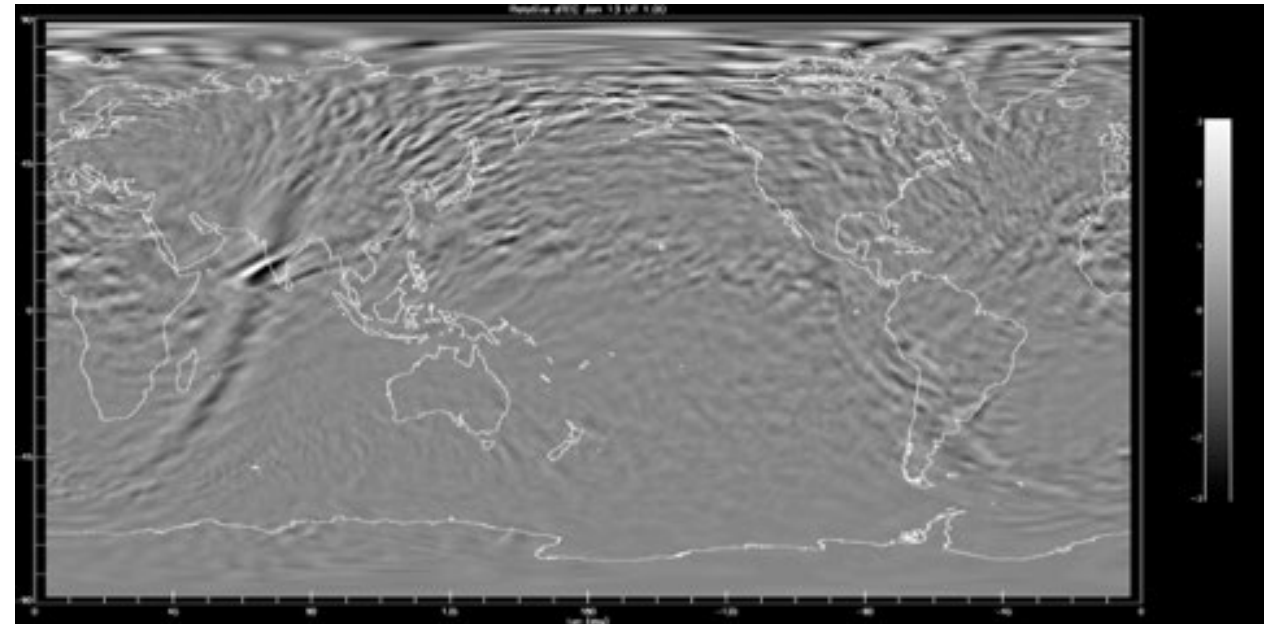
Upper Atmosphere Extension of MPAS

- MPAS-A was extended to higher altitudes (supported by SIMA)
- Provides non-hydrostatic capabilities to WACCM
- The mean zonal wind and temperature climatology from SC -WACCM/MPAS-A was validated against results from SC -WACCM using FV and SE dynamical cores.
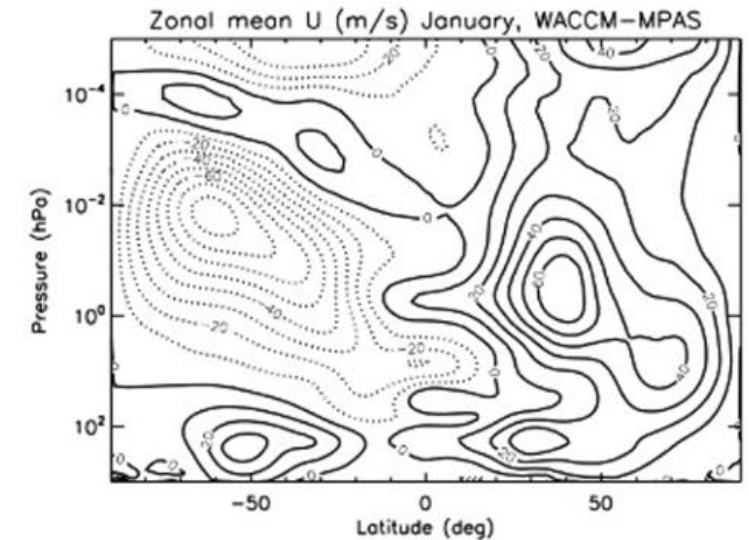- More details presented in Chemistry/Whole Atm. WG session on Wednesday

Credit: Soudeh Kamali

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New Methods for Prescribing Solar and Geomagnetic Forcing

https://github.com/NCAR/solar-forcing

Ion-pair production rates from energetic electron precipitation
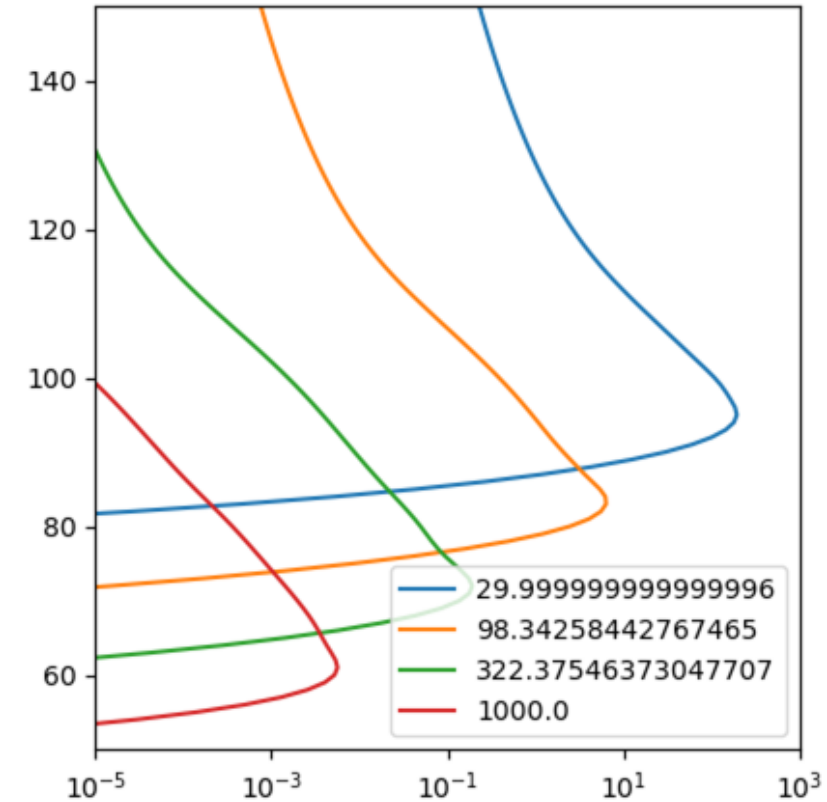
Middle atmosphere (MA) configurations of CESM2(WACCM6)

a) TSMLT $ECS_{2xCO2}=4.8$ K

b) MA $ECS_{2xCO2}=5.1$ K

c) MA 2° $ECS_{2xCO2}=4.8$ K

TOA net downward radiative flux [W/m²]

GMST anomaly [K]
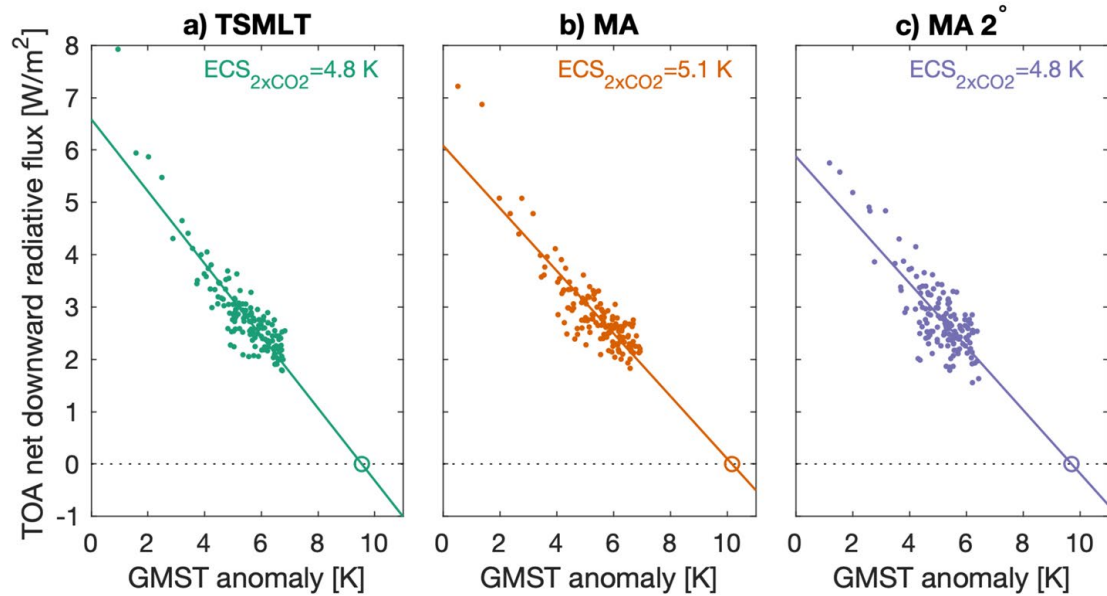
- WACCM6 MA at both 1 and 2 deg horizontal resolution are economical configurations of WACCM6 (see table)

- Equivalent climate sensitivities, mean climates, and variability

- Some differences in background stratospheric AOD due to weaker upper tropospheric SO_2 oxidation

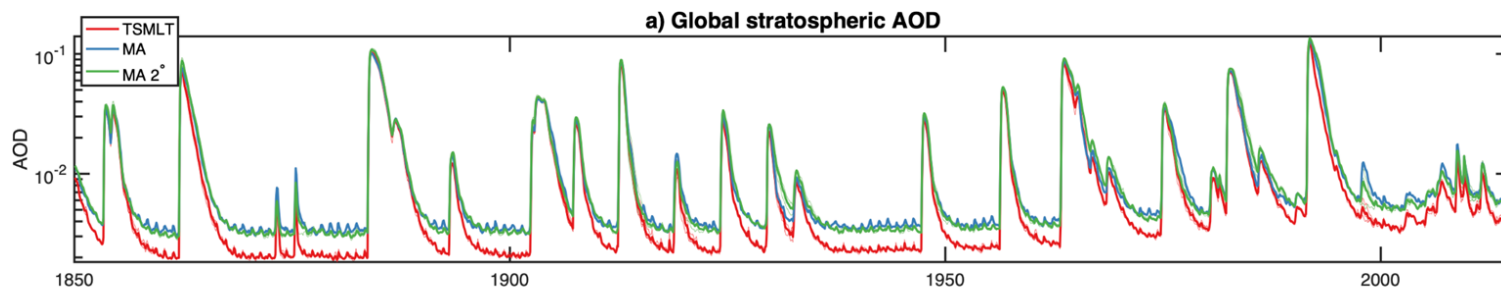*(Upper left) equilibrium climate sensitivity to doubling of CO2 evaluated with the 4xCO2 experiment*

(Lower left) global stratospheric AOD in the HIST experiment

(Lower right) core hours to produce 1 simulated year, b compset

a) Global stratospheric AOD

1 deg. TSMLT	30,000 core hours
1 deg. MA	10,000 core hours
2 deg. MA	3,000 core hours

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WAWG Development Timeline

2021 2022 2023

Improving community support and existing functionality

- WACCM-X SE Dycore
- RR WACCM Compset
- Initialized prediction compsets
- TEM and transport diagnostics
- Updated SD approach

Updating chemistry and physics

- VSL halogens
- Update RRTMG and SW Heating
- CARMA
- Improved GWs in thermosphere
- Updated O$^+$ transport in WACCM-X
- Scale-aware gravity waves

Fundamental advances in modeling capability

- WACCM integration with L93 workhorse
- Whole Geospace Model

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Integrating WACCM with the upcoming CESM workhorse model

- Upcoming CAM workhorse model has 80km lid, increased vertical resolution
- Plan to evaluate two new vertical grids to become the next default for WACCM
  - 109L, "stack-on-top" WACCM
  - 128L
- Taper in sponge layer for stability in SE dycore
- Both will inherit CAM workhorse tuning in the boundary layer and troposphere
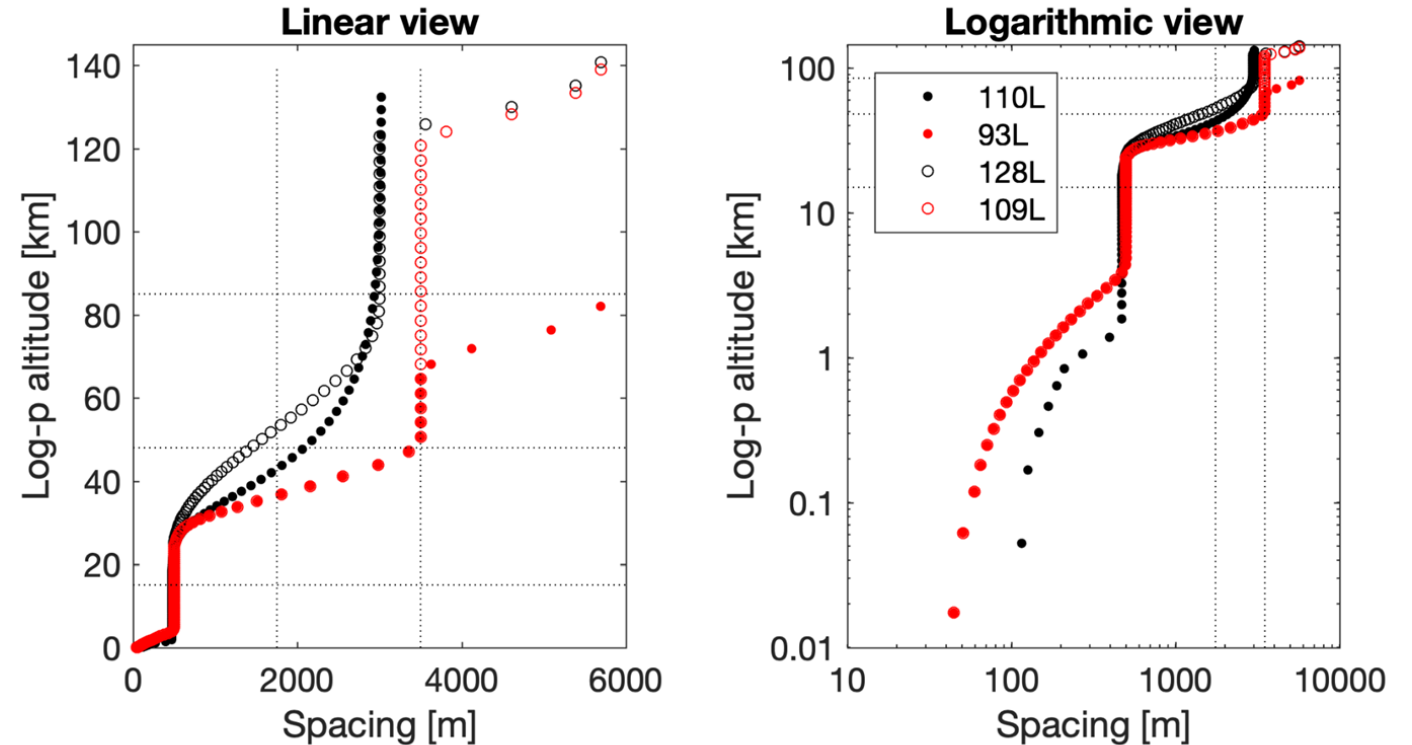
(Above) existing and proposed vertical grids and their vertical grid spacing. Vertical dotted lines indicate ¼ and ½ of the 7km scale height, while horizontal dotted lines indicated the tropopause, stratopause, and mesopause.

WAWG summary and future plans

- WACCM and WACCM-X continue to be highly valuable for middle-upper atmosphere research, and are being adapted for Earth system predictability research and applications

- Parallel development of simplified/low-cost and cutting edge/high-cost model configurations

- New developments aimed at addressing existing model biases and advancing current capabilities