Whole Atmosphere Working Group Updates

CESM Atmosphere, Chemistry-Climate, and Whole Atmosphere Winter WG Meeting

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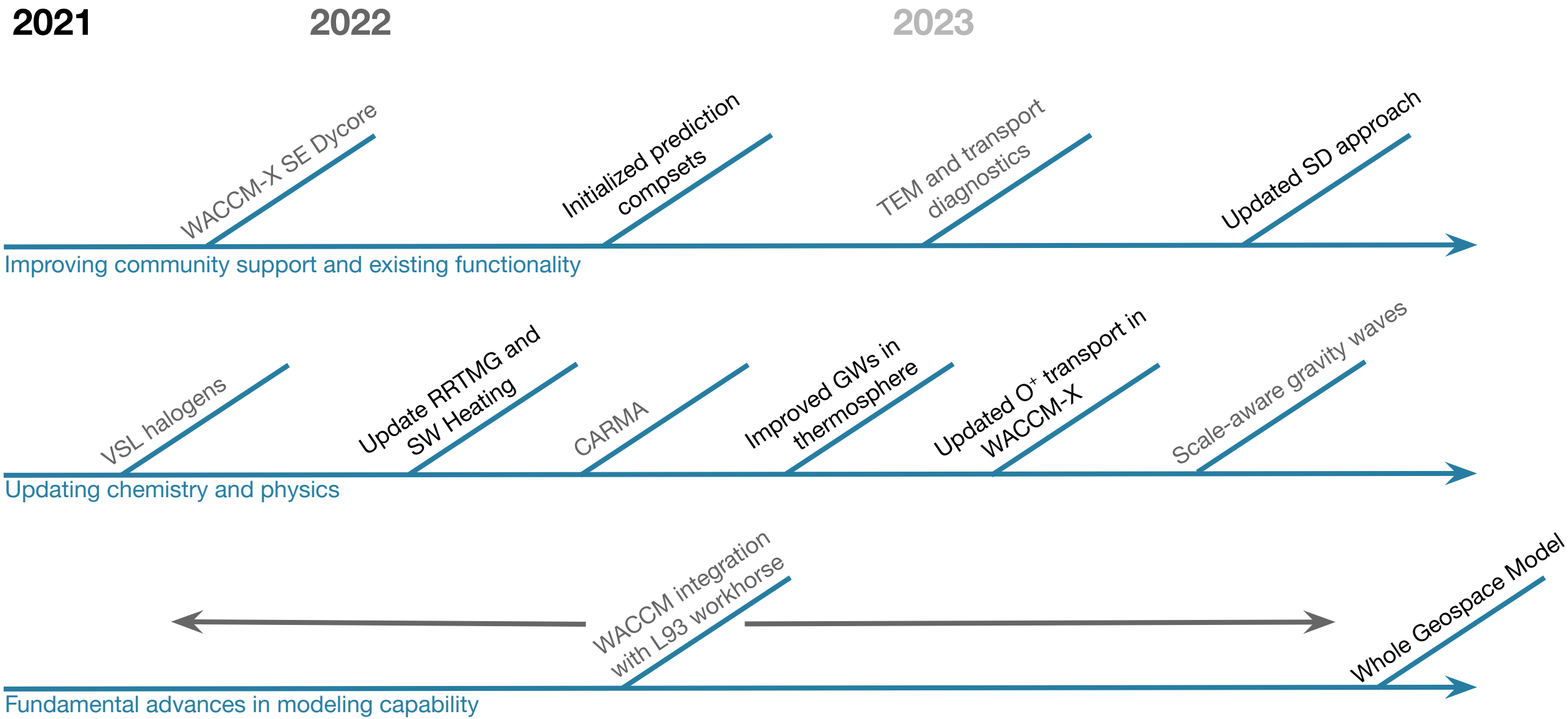
WAWG Development Timeline

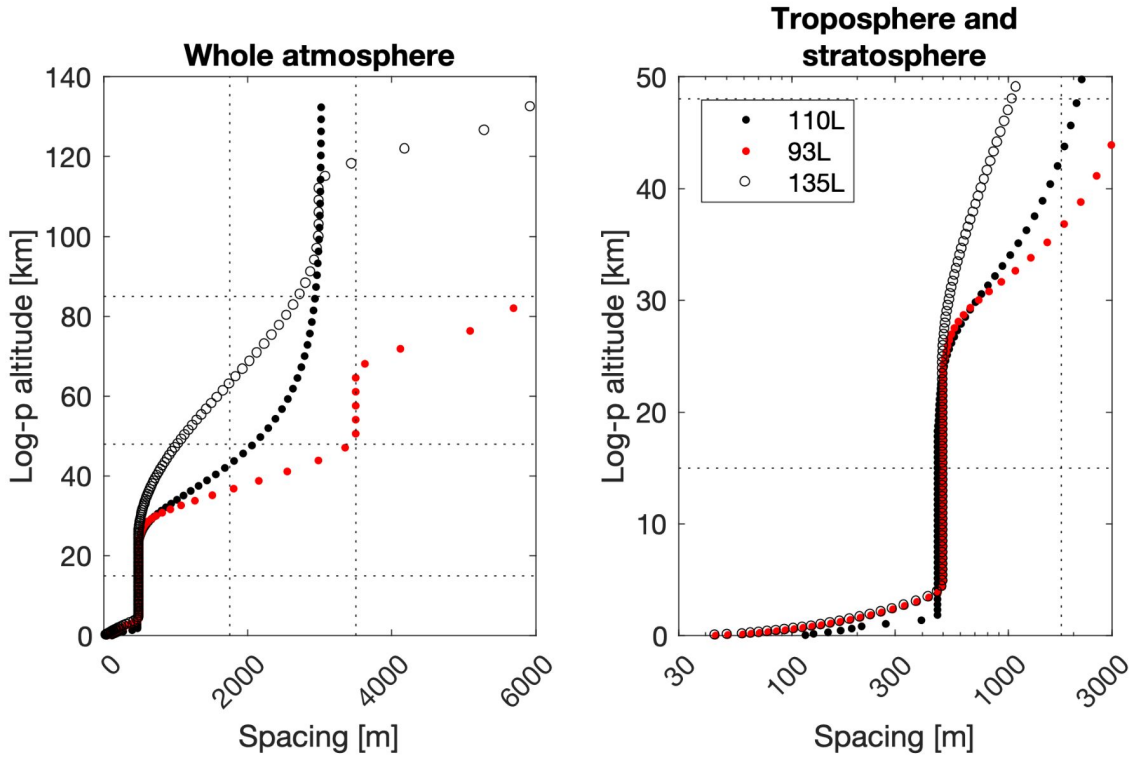


Physics Developments and WAWG Priorities

- Physics developments relevant to the whole atmosphere
  - TUV-x (Talk by Doug on Wednesday)
  - CARMA (Talks on Tuesday afternoon)
  - Dry stratosphere fix - CLUBB limiter was heating/drying unphysically in stratosphere
- Key development priorities
  - Evaluation and tuning of L135 WACCM and L183 WACCM-X using the SE dycore
  - MPAS vertical extension
  - WACCM-X + GAMERA
- Key production tasks
  - Sudden stratospheric warming dynamics in L135 WACCM
  - Climate/geoengineering simulations at L93 and L135 (joint w/CCWG)
  - Climate and geoengineering impact on space environment

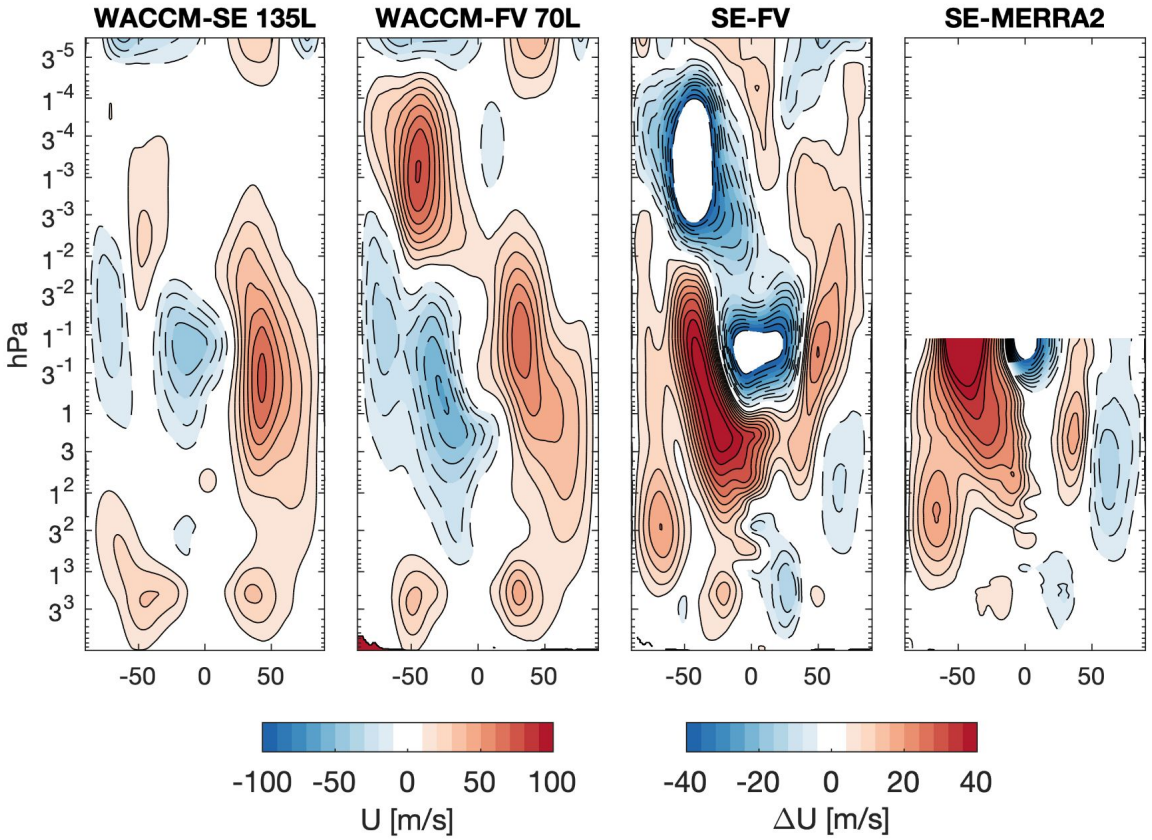
Toward WACCM7, integrating with the CAM workhorse model

- 135L vertical grid in two configurations
  - 2 deg. nominal spectral element (SE), with middle atmosphere chemistry (8k core hours/sim year)
  - 1 deg. nominal SE, with comprehensive whole atmosphere chemistry (~48k core hours/sim year)
- Both will inherit CAM workhorse tuning in the boundary layer, troposphere, and lower stratosphere



(Above) existing and prototype vertical grids and their vertical grid spacing. Vertical dotted lines indicate ¼ and ½ of a 7km scale height, while horizontal dotted lines indicated approximately the tropopause, stratopause, and mesopause.

Toward WACCM7, integrating with the CAM workhorse model



DJF zonal wind in SE and FV WACCM simulations, their difference, and the difference between SE and MERRA2. Taken from an initial WACCM-SE 135L simulation using the same gravity wave parameters as a comparable horizontal/vertical resolution FV configuration.

- Initial testing of 2 deg. nominal SE with middle atmosphere chemistry
- Carrying over gravity wave settings from 2 deg. SE 110L results in ⅓ of the frontal gravity wave forcing in the mesosphere
- QBO testing will start once we have a good base state
  - See Wednesday talks by Rolando and Mijeong on the QBO in 2 deg. WACCM-FV

CMORizing process for CCMI2022 (and beyond)

- CMOR = Climate Model Output Rewriter
- Current CESM CMIP6 CMOR workflow cannot* be applied to new MIPs requiring CMORized output
  - dreqPy + many-MB hashcode dictionary file
- Stop-gap CMOR package has been created to get CCMI 2022 output processed and released on time
  - Transforms/interpolates, appends attributes, performs operations (TEM, unit conversions, age of air, integrals)
  - Entire package <1200 lines in MATLAB
- Working groups need to discuss future of CMORization
  - Can CMOR be done online?

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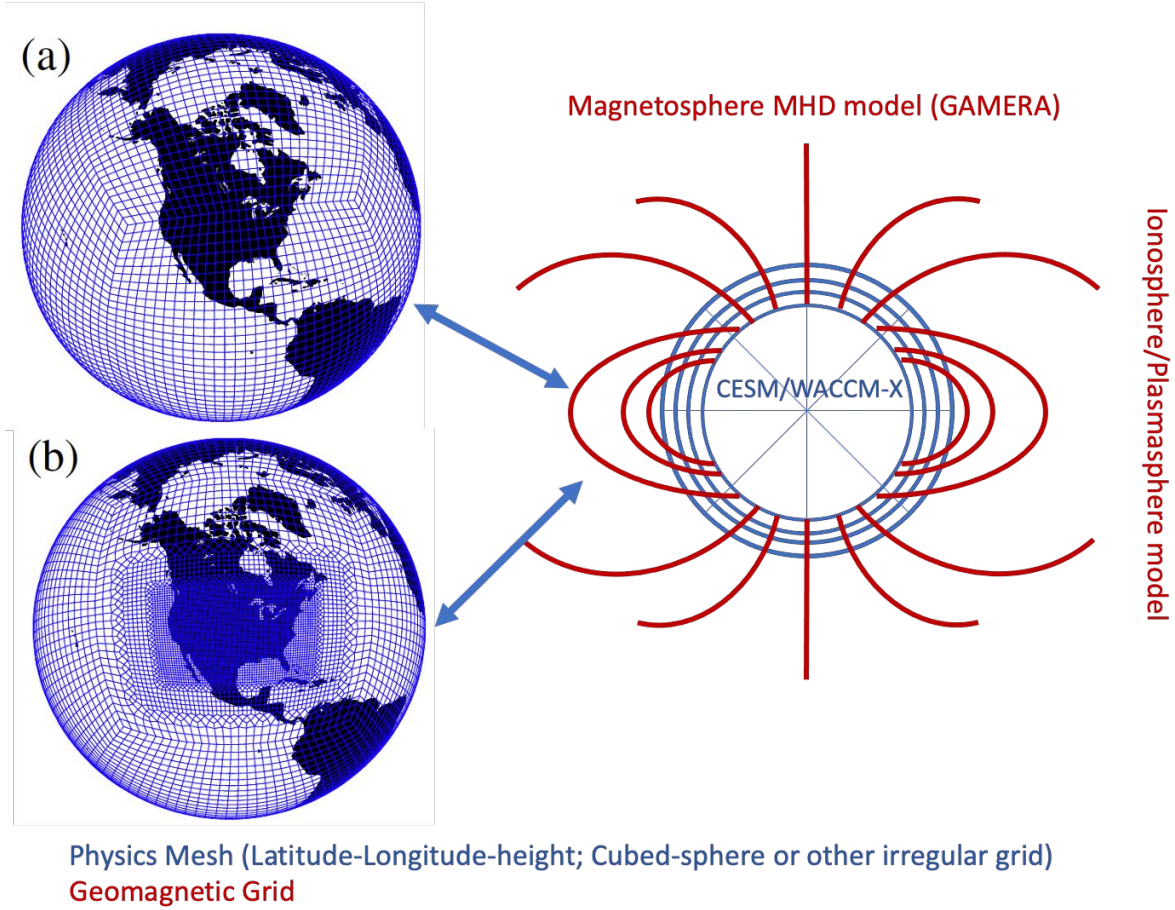
Dictionary mapping CESM to MIP variables

https://github.com/nadavis-ncar/CESM-CMORize

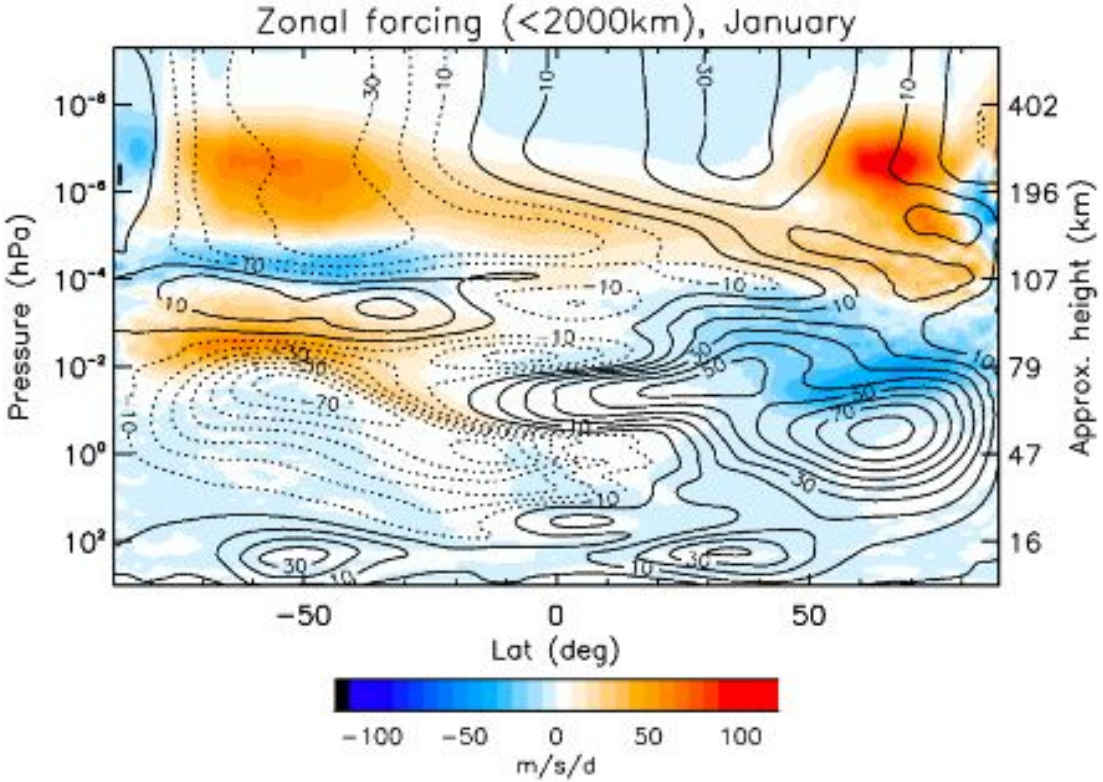
WACCM-X SE Development

- Neutral dynamics and physics
  - WACCM-X species dependent SE dynamical core with CSLAM transport
  - Cubed sphere grid (no polar singularity)
  - Molecular viscosity/diffusion in horizontal direction
- Regridding between physics mesh and geomagnetic grid
  - Interactive ionospheric dynamo, transport, and energetics.
- High resolution configuration:
  - ~25km horizontal, 0.1 scale height vertical
- Developed as part of SIMA initiative

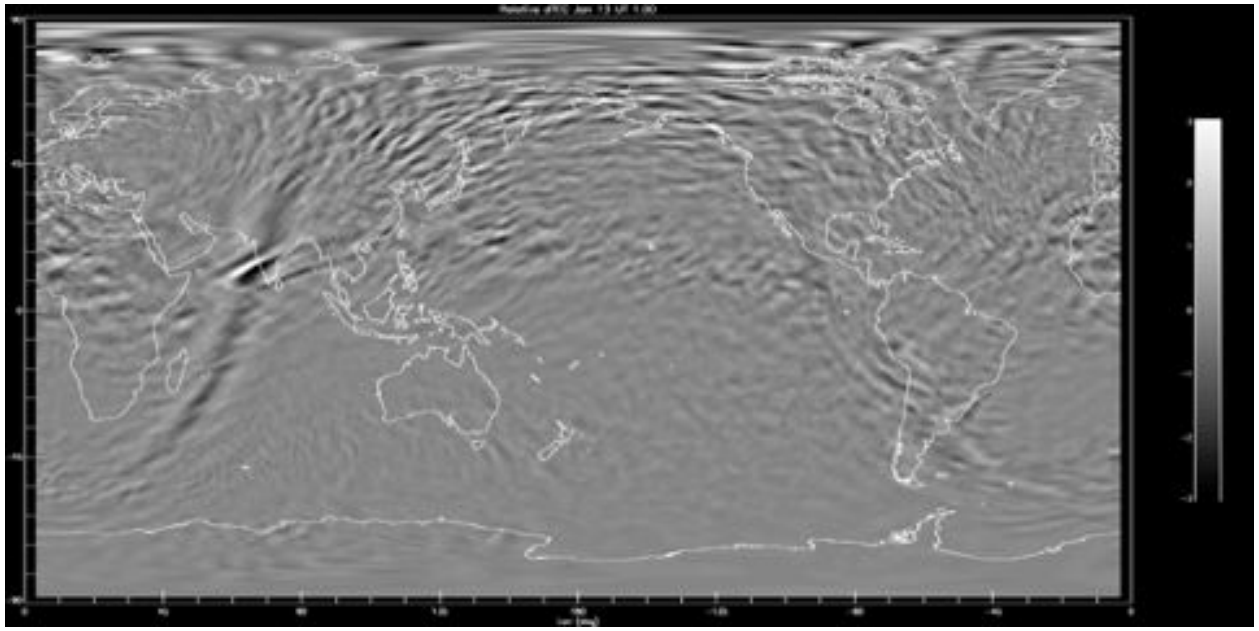


High Resolution WACCM-X SE

- Better representation of gravity wave forcing in high-resolution WACCM-X improves dynamics and thermosphere composition
- Resolves small-scale perturbations in thermosphere and ionosphere, such as those that occur during the Hunga-Tonga eruption

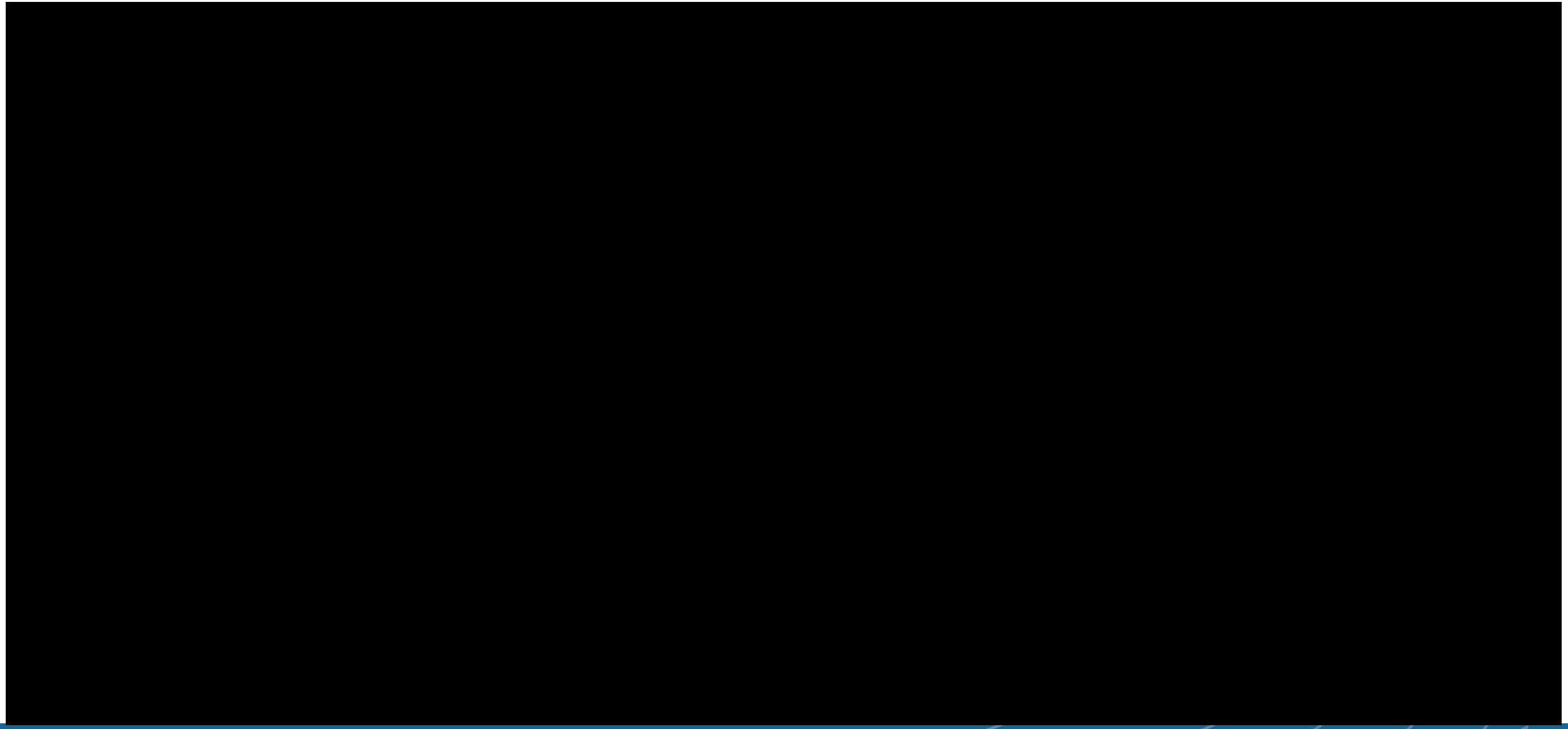


Perturbations in Total Electron Content (periods < 2 h)

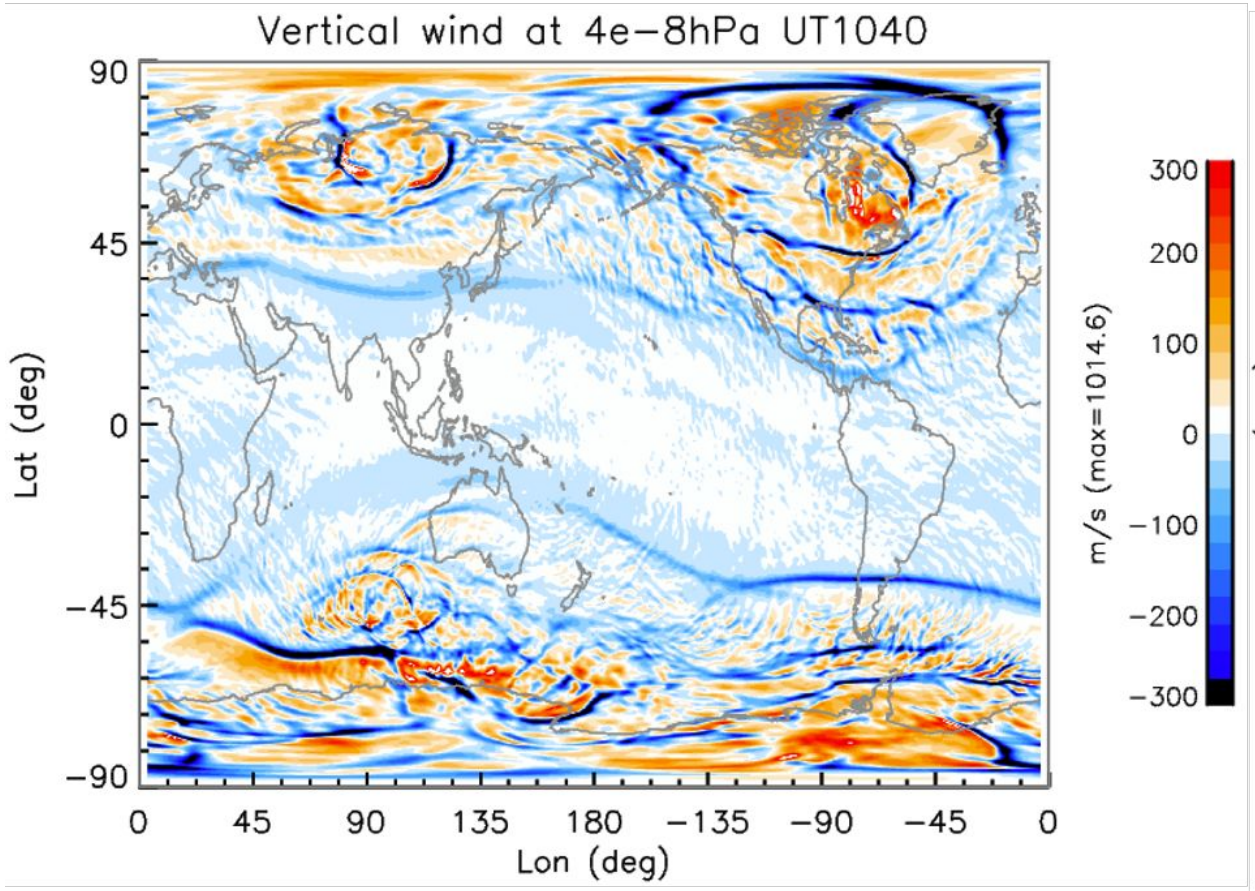


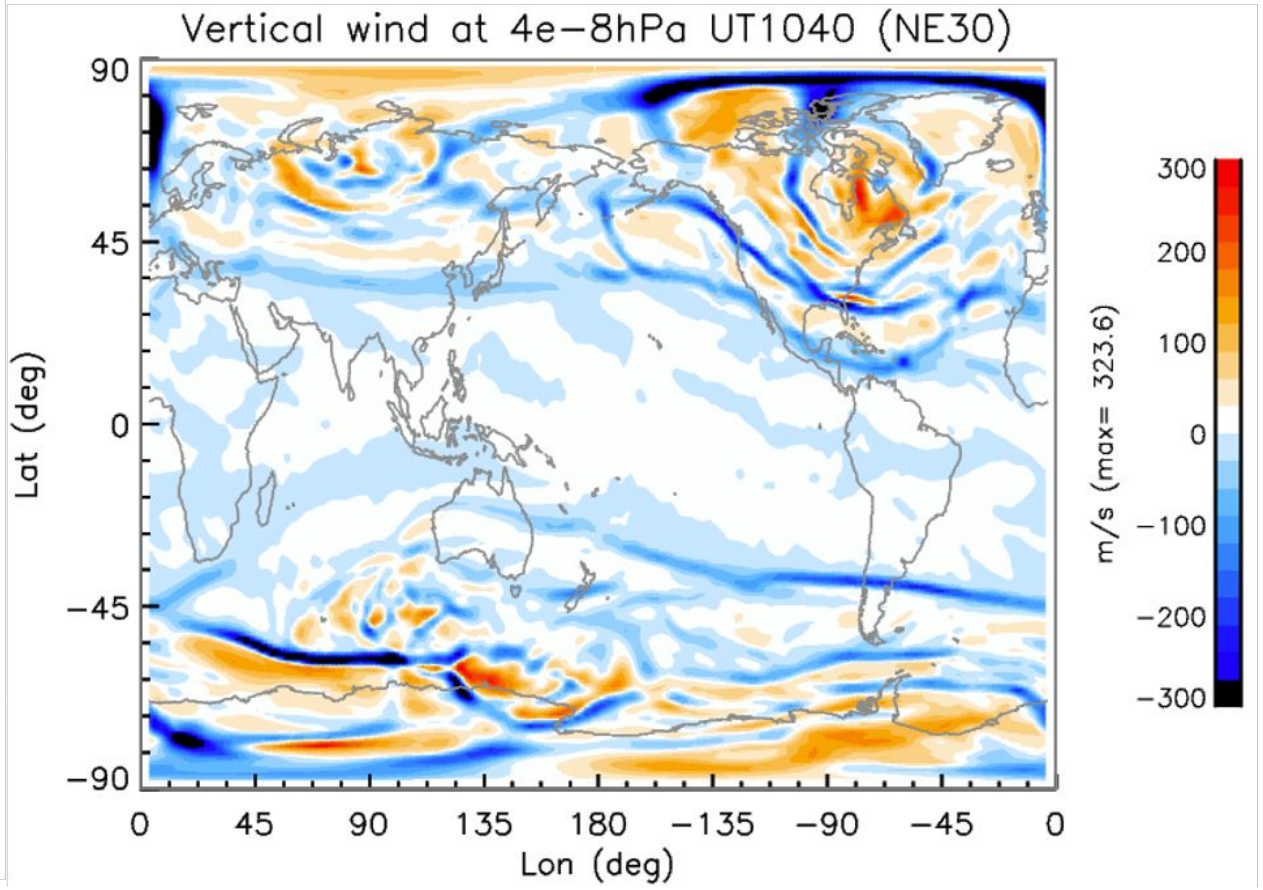
Credit: Hanli Liu

WACCM-X simulations of surface pressure (bottom) and total electron content (top) following Hunga-Tonga eruption



Towards a Whole Geospace Model: WACCM-X/GAMERA





Thermosphere vertical winds in WACCM-X driven by GAMERA (Grid-Agnostic MHD for Extended Research Applications) high-latitude forcing at high and low resolutions

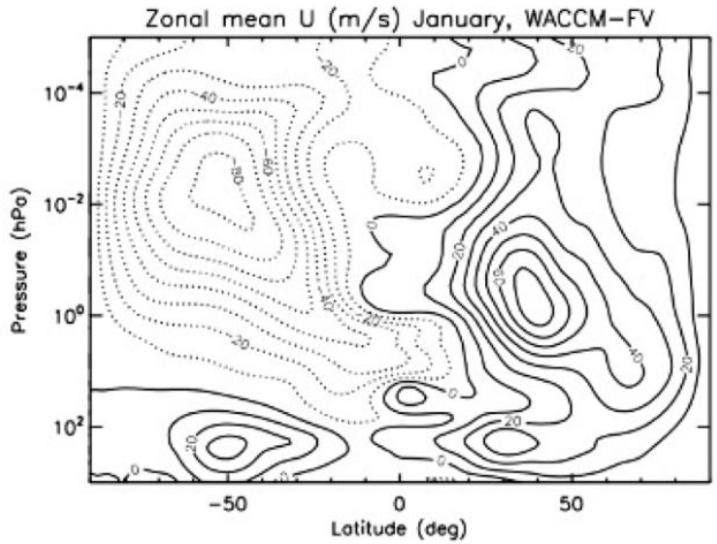
WAWG summary and future plans

- 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
- Additional ongoing developments:
  - Specified dynamics high-resolution WACCM/WACCM-X
  - Extension of MPAS into the thermosphere (Soudeh Kamali presentation)
  - Improved gravity wave parameterizations to address model biases and wave effects in the thermosphere

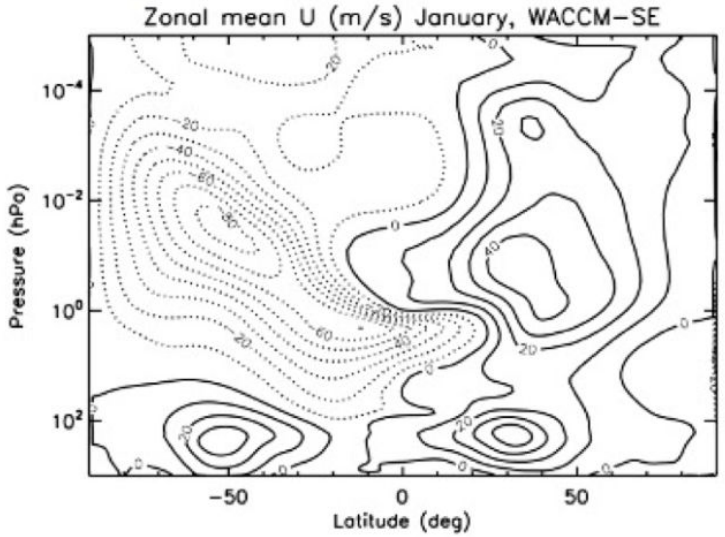
Upper Atmosphere Extension of MPAS

- 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

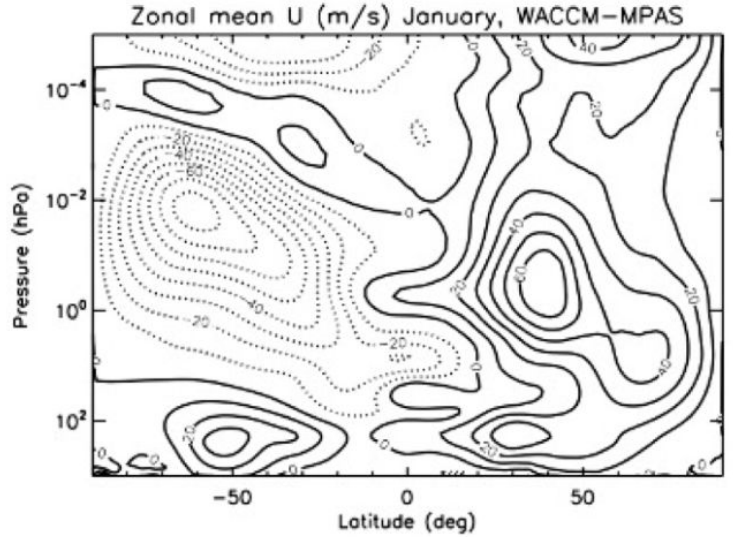
Finite Volume (FV)



Spectral Element (SE)



MPAS-A



Credit: Soudeh Kamali