**WACCM-X**

- The Whole Atmosphere Community Climate Model – eXtended (WACCM-X) is a comprehensive numerical global model of the Earth’s atmosphere spanning a vertical range from the surface to the upper thermosphere. See Liu et al., 2010 for full description.
- Currently under development in the High Altitude Observatory (HAO), along with the Atmosphere Chemistry Observations and Modeling (ACOM) Laboratory and the Climate and Global Dynamics (CGD) Laboratory, at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado.
- Atmospheric component option of the Community Earth System Model (CESM) and based on the Community Atmosphere Model (CAM) and the Whole Atmosphere Community Climate Model (WACCM).
- Standard resolution: Horizontal: 1.9° x 2.5° latitude x longitude, Vertical: ½ scale height, Temporal: 5 minute time step with ion transport and neutral dynamics sub-stepping at ~1 minute.

**Current Development – Energetics**

- Implement solver for electron and ion temperature
- Thermal electron heating increases thermosphere neutral temperature
- O(P) cooling gives ~30-50K decrease in thermosphere neutral temperature

**Current Development – Low Latitude Electrodynamics**

- Ion Drifts - Global
- Ion Drifts - Equator
- Scherliess & Fejer, 1999

**Current Development – Ion-Electron Transport**

- Transition to new improved dynamical core
- Increase WACCM-X SE horizontal/vertical resolution
- Started with running a higher resolution version of WACCM (GRL article, Liu et al., 2014)
- 0.25° (~25km) horizontal resolution, 1/10 scale height vertical resolution – realistic gravity wave signatures in lower thermosphere and improved tides

**Future Plans**

- Verification/validation of current developments
- Higher model top and increase vertical resolution
- Aurora and high latitude electrodynamics and coupling to lower latitudes
- Geomagnetic grid for ion transport and electrodynamo
- Plasmasphere model coupling

**Next-Generation Coupling Structure**

- Upper boundary hydrogen flux and add helium
- Increase horizontal resolution using current Finite Volume (FV) dynamical core
  - From ~2° (~200km) to ~1° (~100km)

**Summary**

- Current ongoing improvements to WACCM-X:
  - Energetics to produce electron and ion temperature and thermal electron heating
  - Low latitude electrodynamics solver producing realistic vertical and horizontal ion drifts
  - Ion transport producing realistic O+ density
  - Higher resolution model and transition to new improved dynamical core
  - Higher horizontal and vertical resolution simulations

**References**

