Next-Generation Ionosphere Module for WACCM

Stan Solomon and the AIM Section

High Altitude Observatory

National Center for Atmospheric Research

NCAR

HAO

Do we really need a new ionosphere module?

Current approach in TGCM and WACCM:

- Dynamical calculations performed in the geographic coordinate system
  - — Except for electrodynamo, which is calculated in geomagnetic coordinates
- Solar rates calculated in geographic coordinates
- Aurora calculated in geomagnetic coordinates but applied in geographic
- Ion chemistry integrated into neutral chemistry

Problems with this approach:

- Upper boundary condition — approximate ion and heat flux
- Not high enough during big storms
- No light ions (H^+, He^+)
- Difficulty porting ion transport methodology to CAM column physics

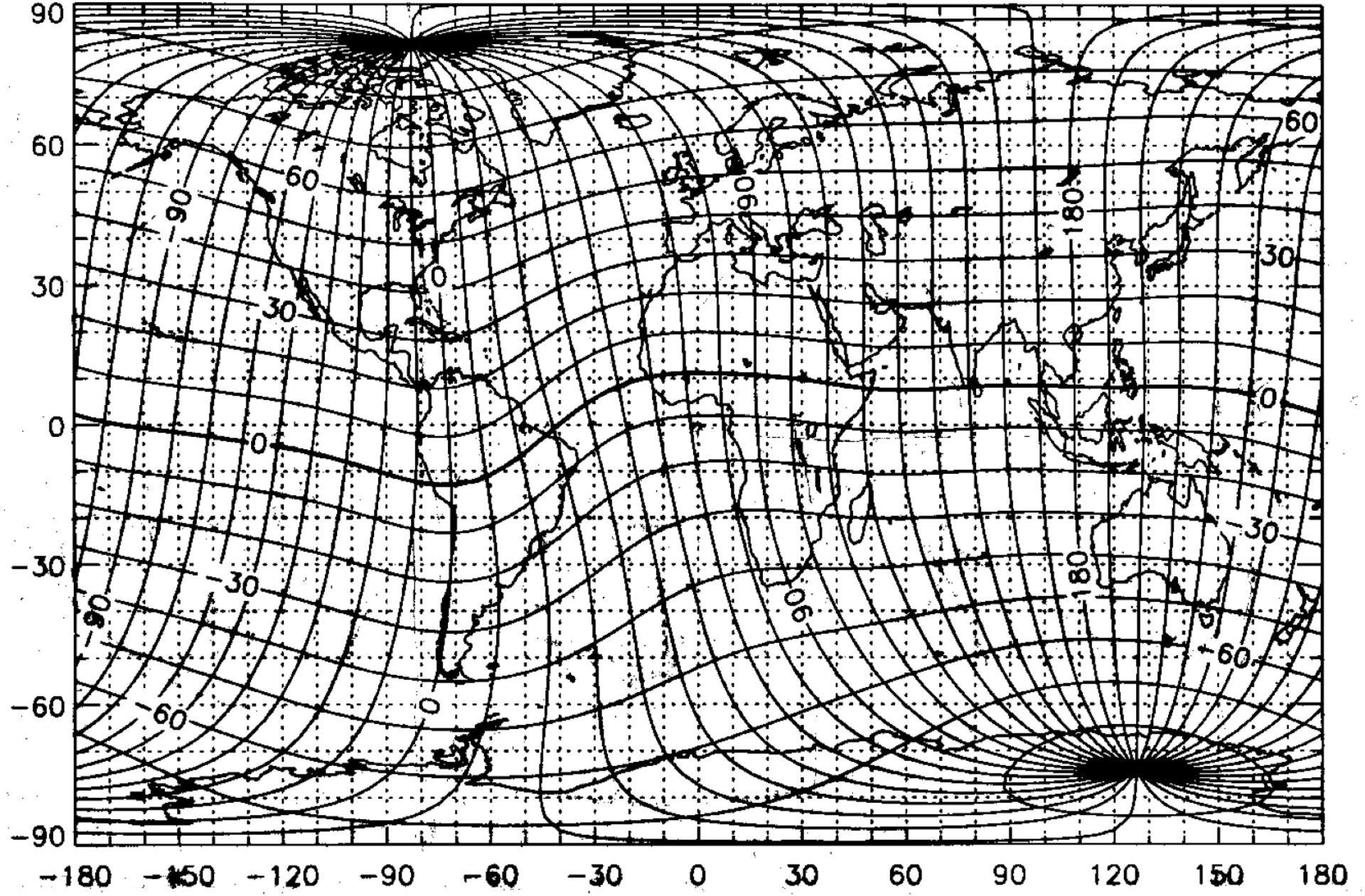
Perhaps these can be addressed with incremental development:

- Calculate better upper boundary using a plasmasphere model
- Extend altitude range
- Add light ion transport
- Work with CAM dynamics to solve ion transport issues

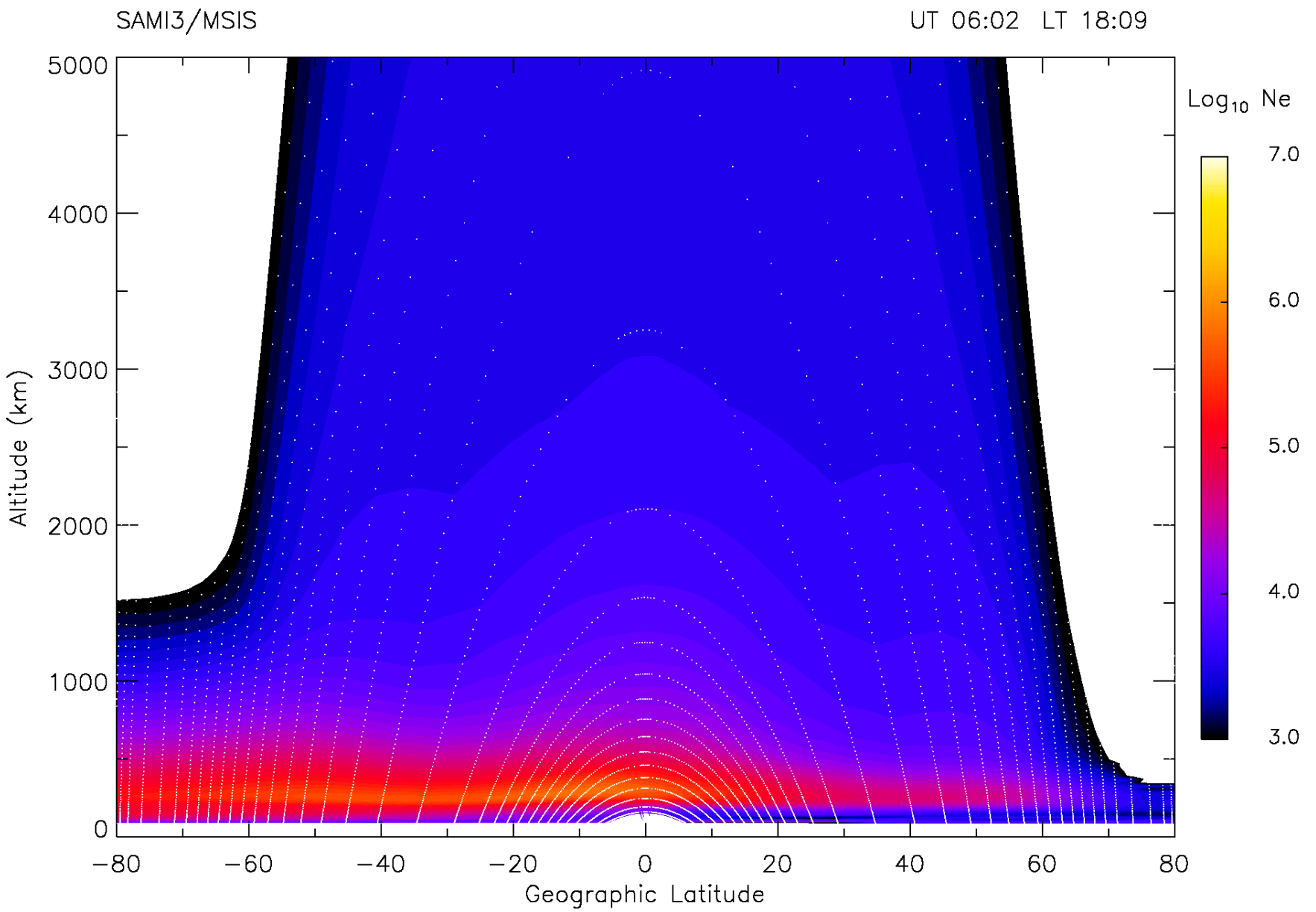
Still left with some basic issues:

- No self-consistent ionosphere-plasmasphere scheme
- Hard to say how we would do light ions in CAM

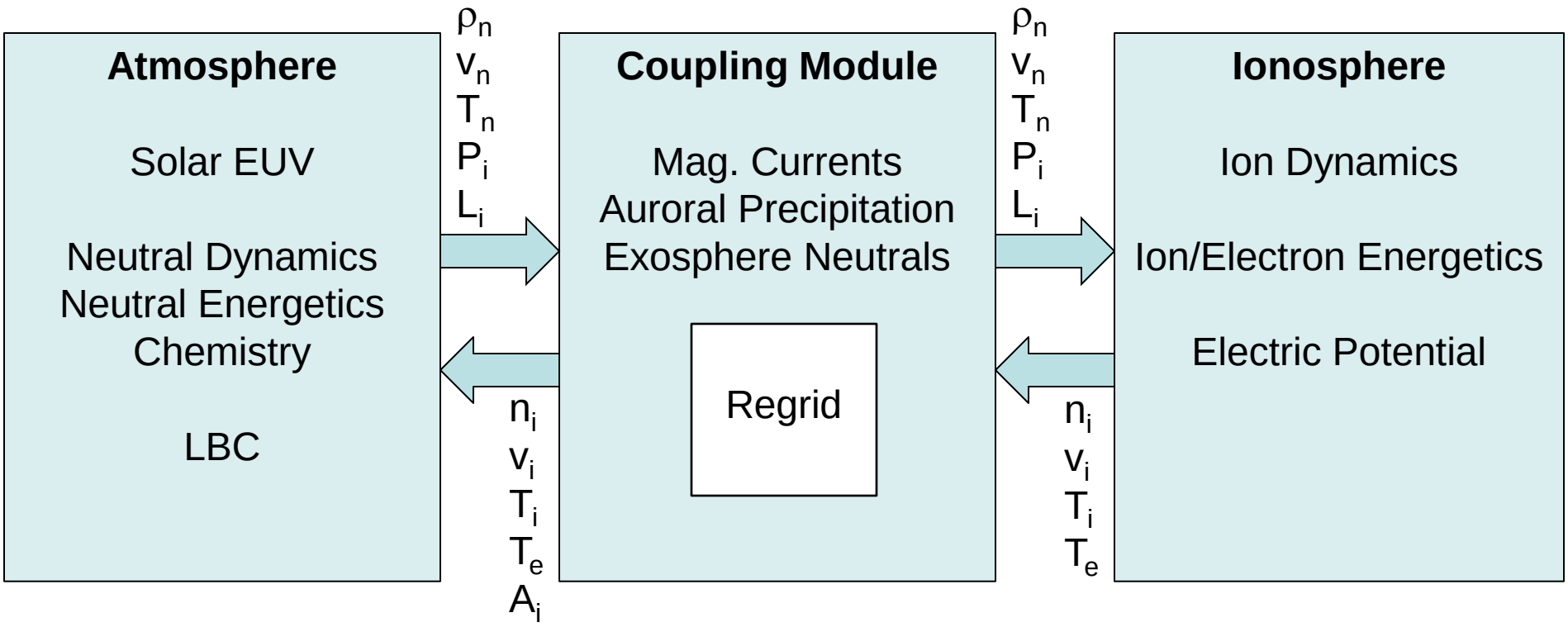
Geomagnetic Coordinates



Geomagnetic Coordinates



Architectural Concept for Atmosphere-Ionosphere Coupling



How would this be implemented in CESM?

Discussion among HAO developers and CGD software engineers, 12/13/12:

Recommendation that ionosphere become a “sub-component” of WACCM

— Only needs to communicate with the atmosphere

What is a “sub-component?”

— Not a fully independent CESM component (e.g., ice sheet model)

— Not just a piece of WACCM, either

— Could use MCT or ESMF tools to perform coupling functions

Candidate Ionospheric Models

FLIP/IPE (Richards / Maruyama / NOAA-CIRES)

SAMI3 (Huba / NRL)

TIME-3D (Ren et al. / CAS)

...all of these have their own photochemistry, photoelectrons, etc.

...for this architectural concept, would need to replace internal with external rates

...also significant performance issues