TIE-GCM at CCMC

The NCAR Thermosphere-Ionosphere-Electrodynamics General Circulation Model at the Community Coordinated Modeling Center

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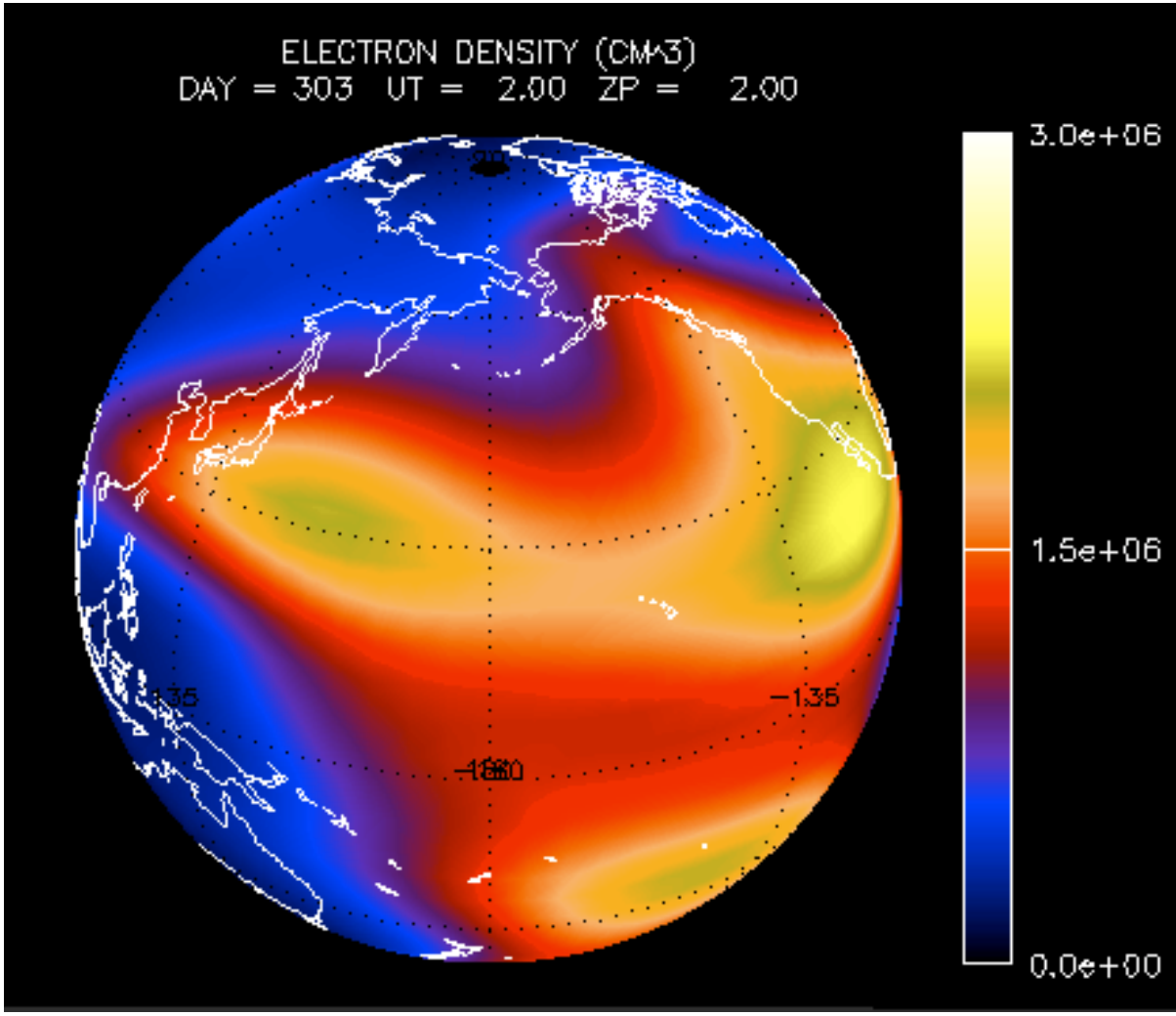
NCAR

Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM)

- Developed by Ray Roble, Bob Dickinson, Art Richmond, et al.
- Small group of in-house developers and visitors
- Cross-platform release (version 1.9), June 2008
- User manual complete
- Documentation mostly complete
- Open-source academic research license
- Now running at CCMC



Development History

Thermosphere General Circulation Model

(TGCM) (97~500 km) [*Roble et al.*, 1982]

Thermosphere-Ionosphere General Circulation Model

(TIGCM) (97~500 km) [*Roble et al.*, 1988]

Thermosphere-Ionosphere-Electrodynamics General Circulation Model

(TIE-GCM) (97~500 km) [*Richmond et al.,* 1992]

Thermosphere-Ionosphere-Mesosphere-Electrodynamics GCM

(TIME-GCM) (30~500 km) [*Roble et al., 1994*]

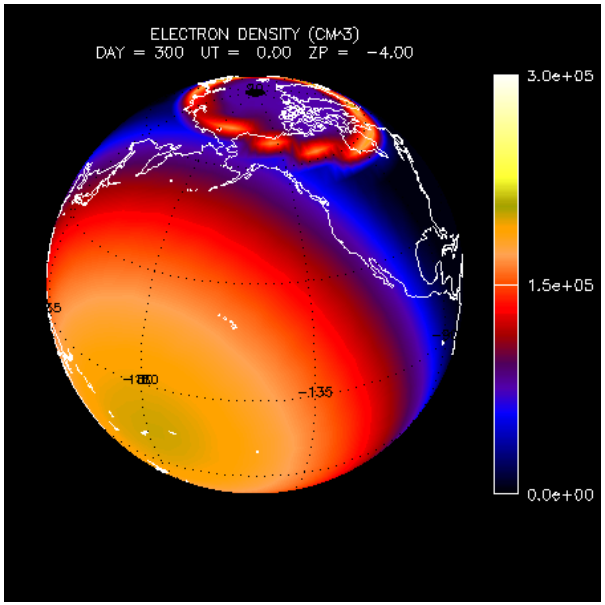
Whole Atmosphere Community Climate Model

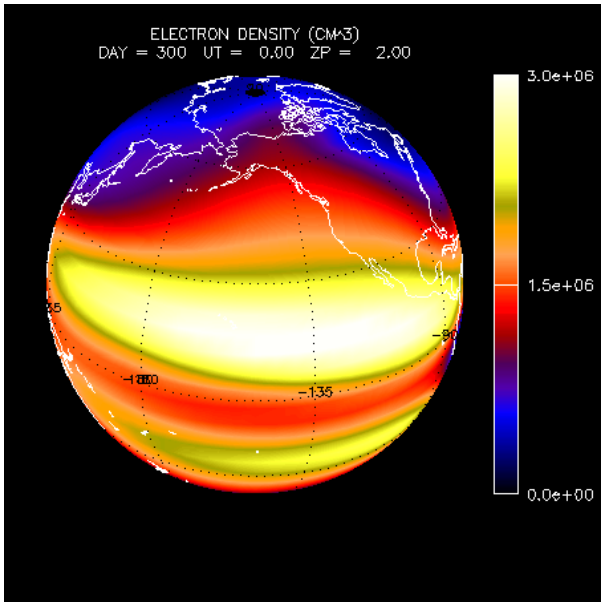
(WACCM) (0~150 km) [*Garcia et al.,* 2007]

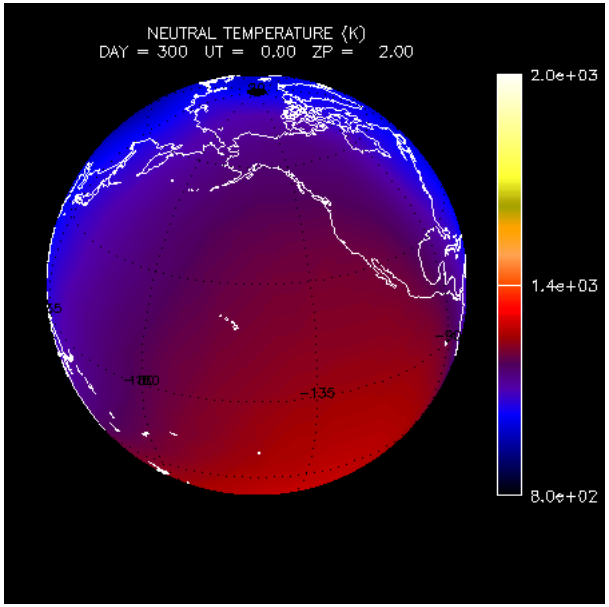
Extended Whole Atmosphere Community Climate Model

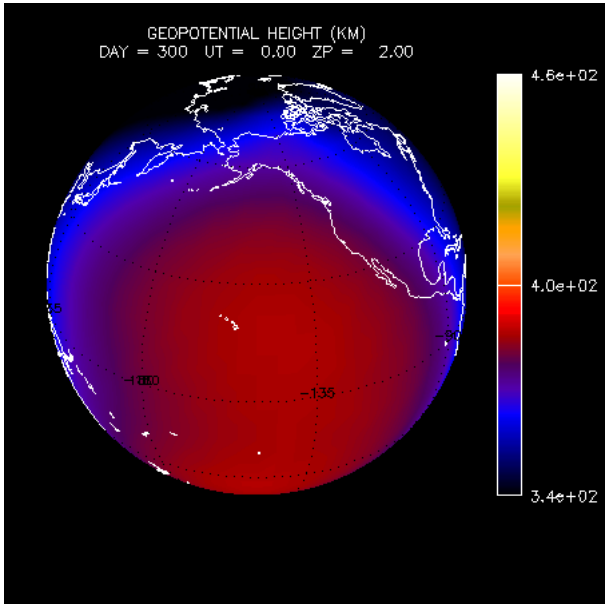
(WACCM-X) (0~500 km) [*Liu et al.*, 2010]

The 2003 “Halloween” Geomagnetic Storm

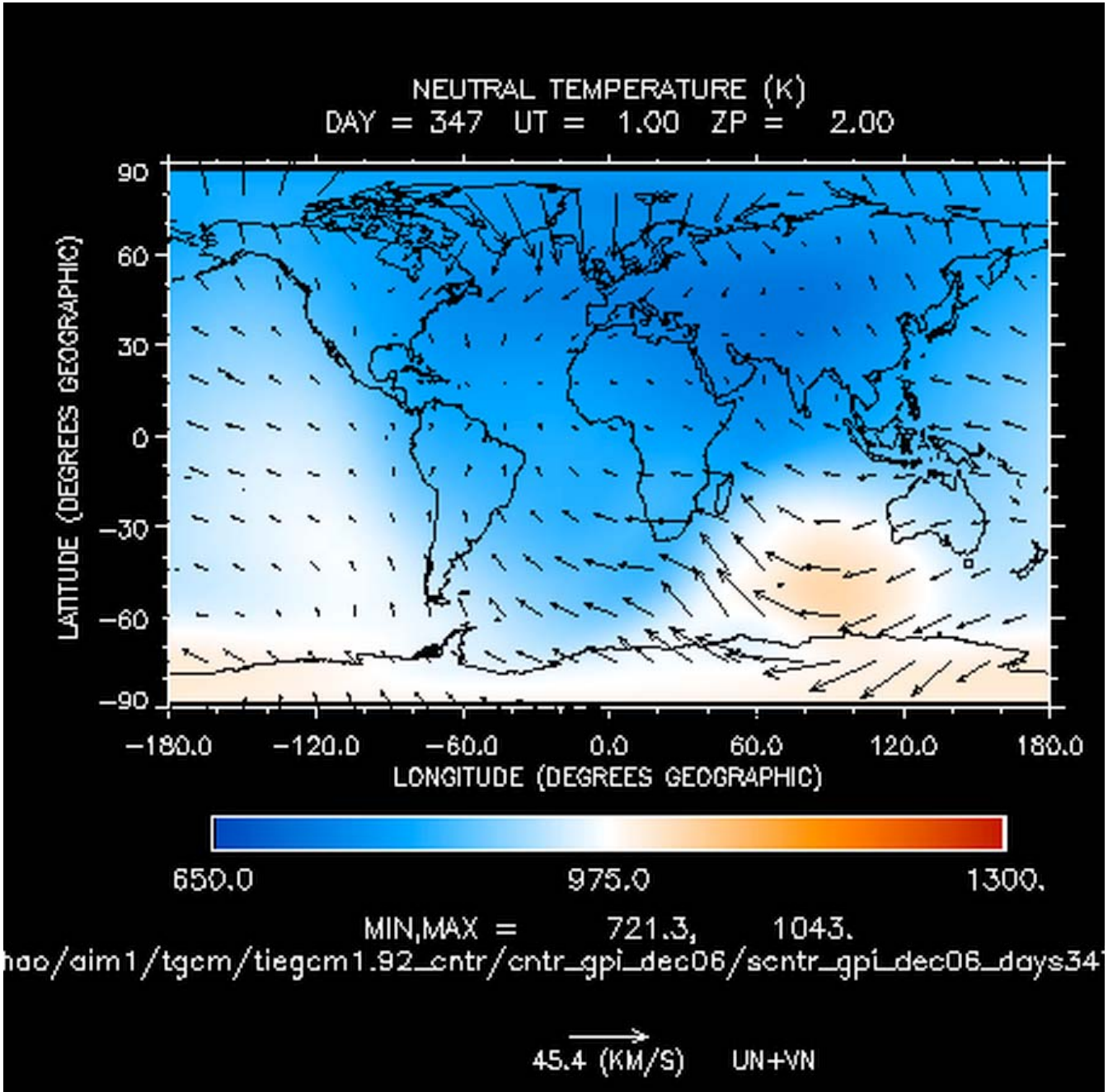




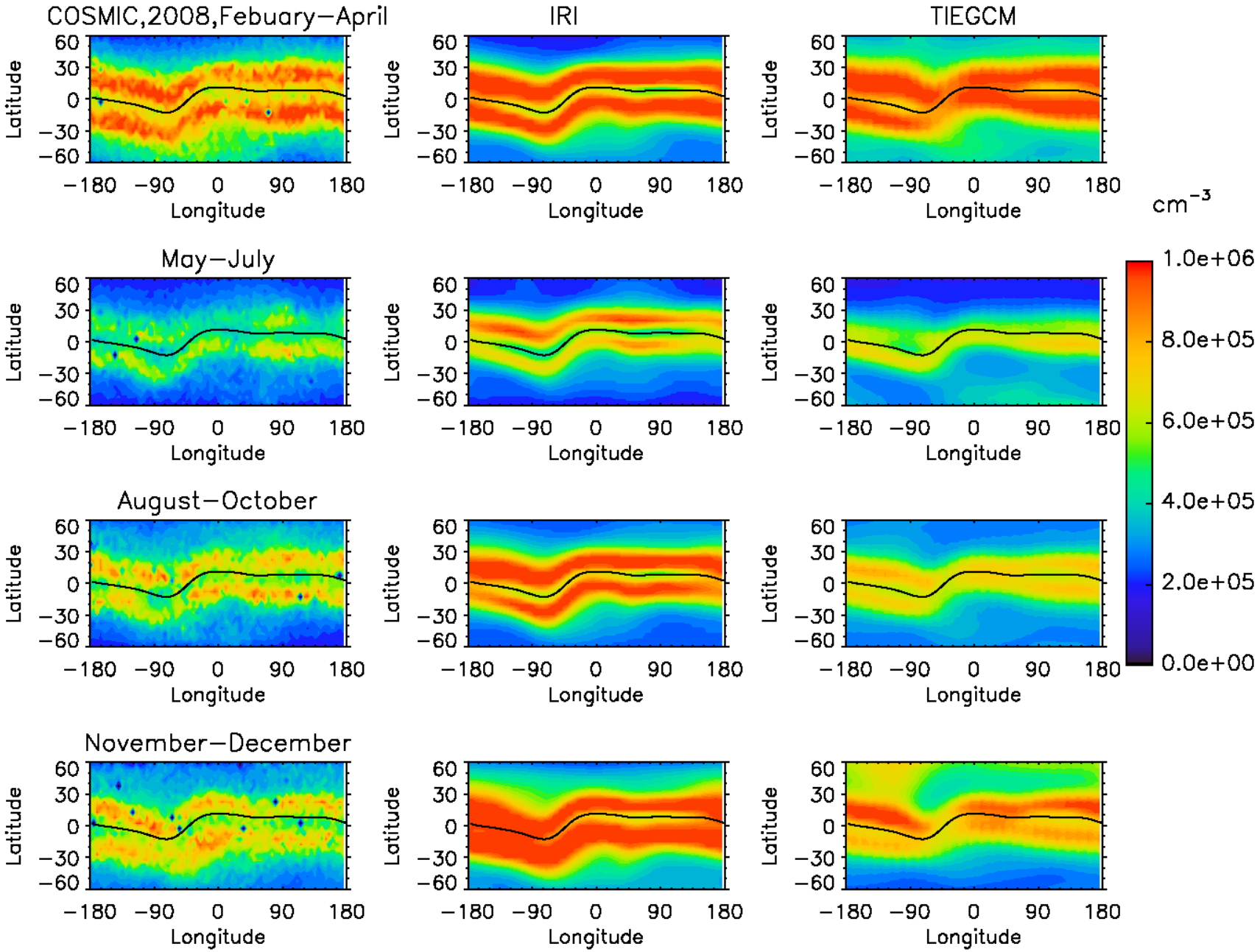




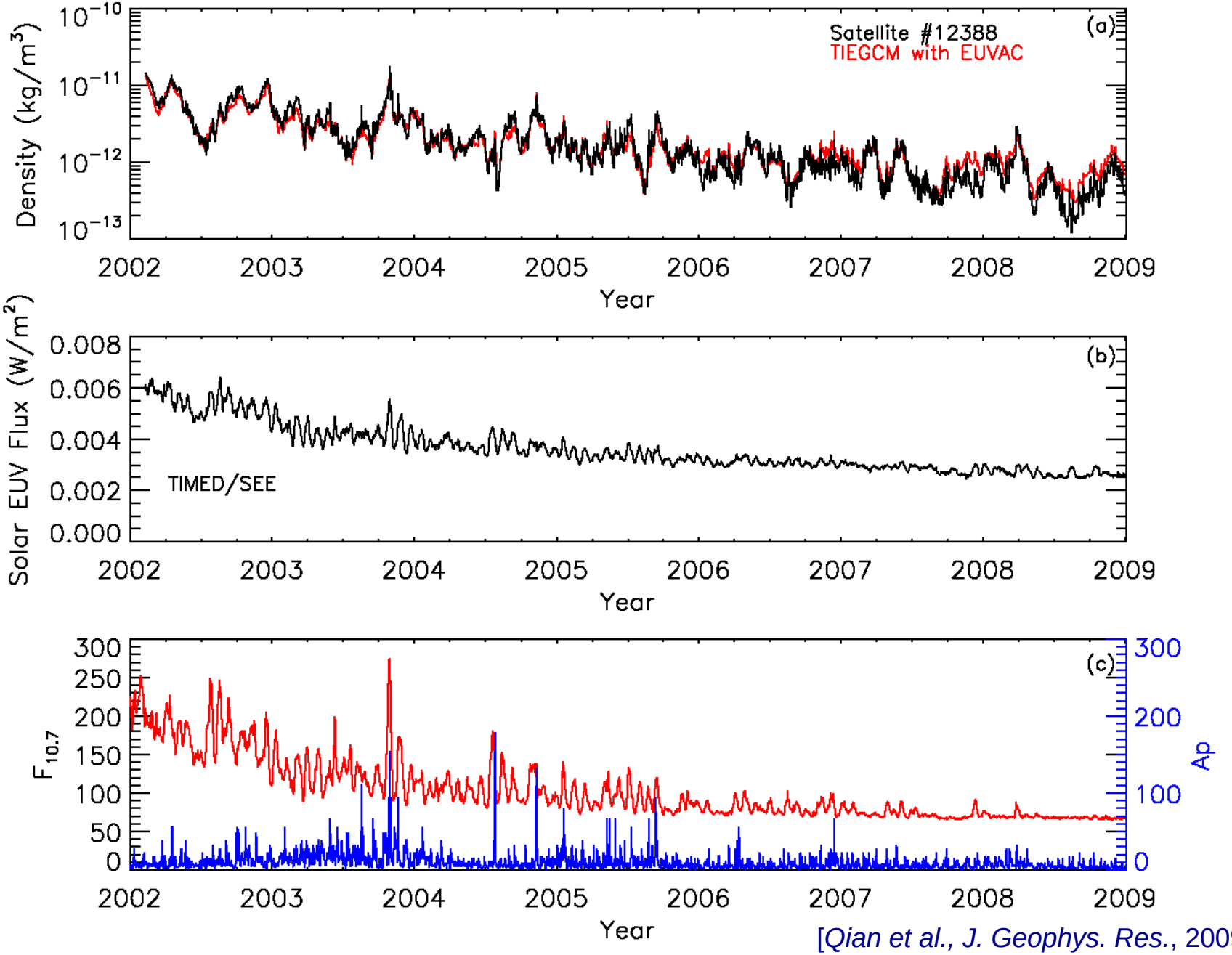
December 2006 “AGU Storm”



Ionospheric Climatology, 2008



Thermospheric Density during the Declining Phase of SC #23



[*Qian et al., J. Geophys. Res.*, 2009]

Numerical Approach

The TIE-GCM is a comprehensive, first-principles, three-dimensional, non-linear representation of the coupled thermosphere and ionosphere system that includes a self-consistent solution of the low-latitude electric field.

The model solves the three-dimensional momentum, energy and continuity equations for neutral and ion species at each time step, using a semi-implicit, fourth-order, centered finite difference scheme, on each pressure surface.

29 constant-pressure levels in the vertical, from ~97 km to ~500 km altitude

5° x 5° latitude / longitude grid.

Time step is 120 s.

Assumes Hydrostatic equilibrium, constant gravity, steady-state ion and electron energy equations, and incompressibility on constant pressure surfaces. Ion velocities are specified by the potential field and ExB drifts

Implemented in F90 and MPI. Runs on 1 to ~32 processors. Uses netCDF for I/O.

~0.5 s / time step on NCAR bluefire computer (~200 x real time)

Boundary Conditions

- **Solar EUV inputs:**
  - F10.7 proxy index used to drive EUVAC solar irradiance model
    - or, measurements of solar EUV irradiance (e.g., TIMED/SEE)

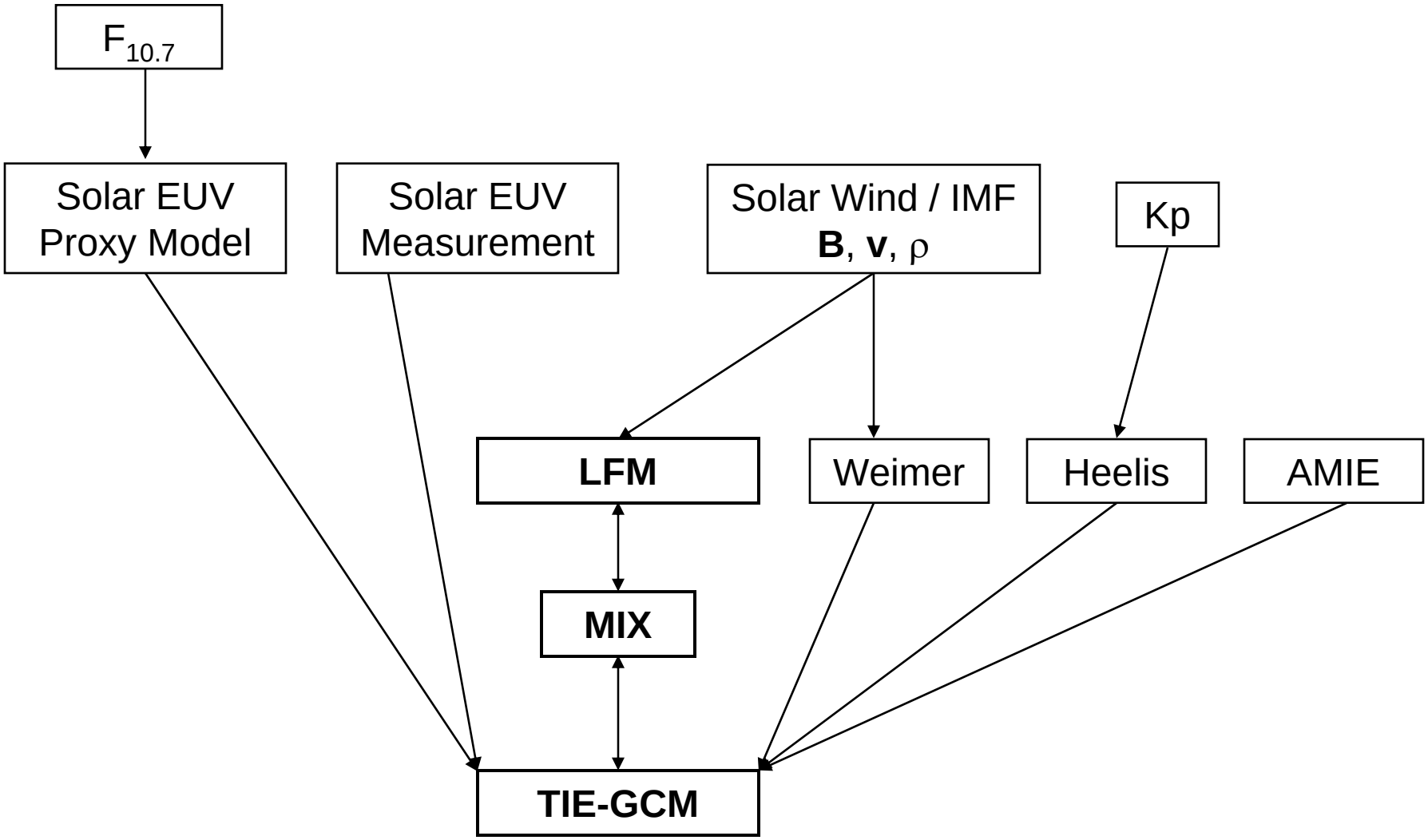
- **Particle precipitation:**
  - Hemispheric Power in GW, obtained from 3-hour Kp index
    - or, Hemispheric Power in GW, obtained from solar wind / IMF parameters

- **Ionospheric electric fields at high latitudes:**
  - Heelis model, based on 3-hour Kp index
    - or, Weimer model, based on solar wind /IMF parameters
      - or, AMIE

- **Other upper boundary conditions:**
  - Electron flux and heat flux applied using empirical formulations

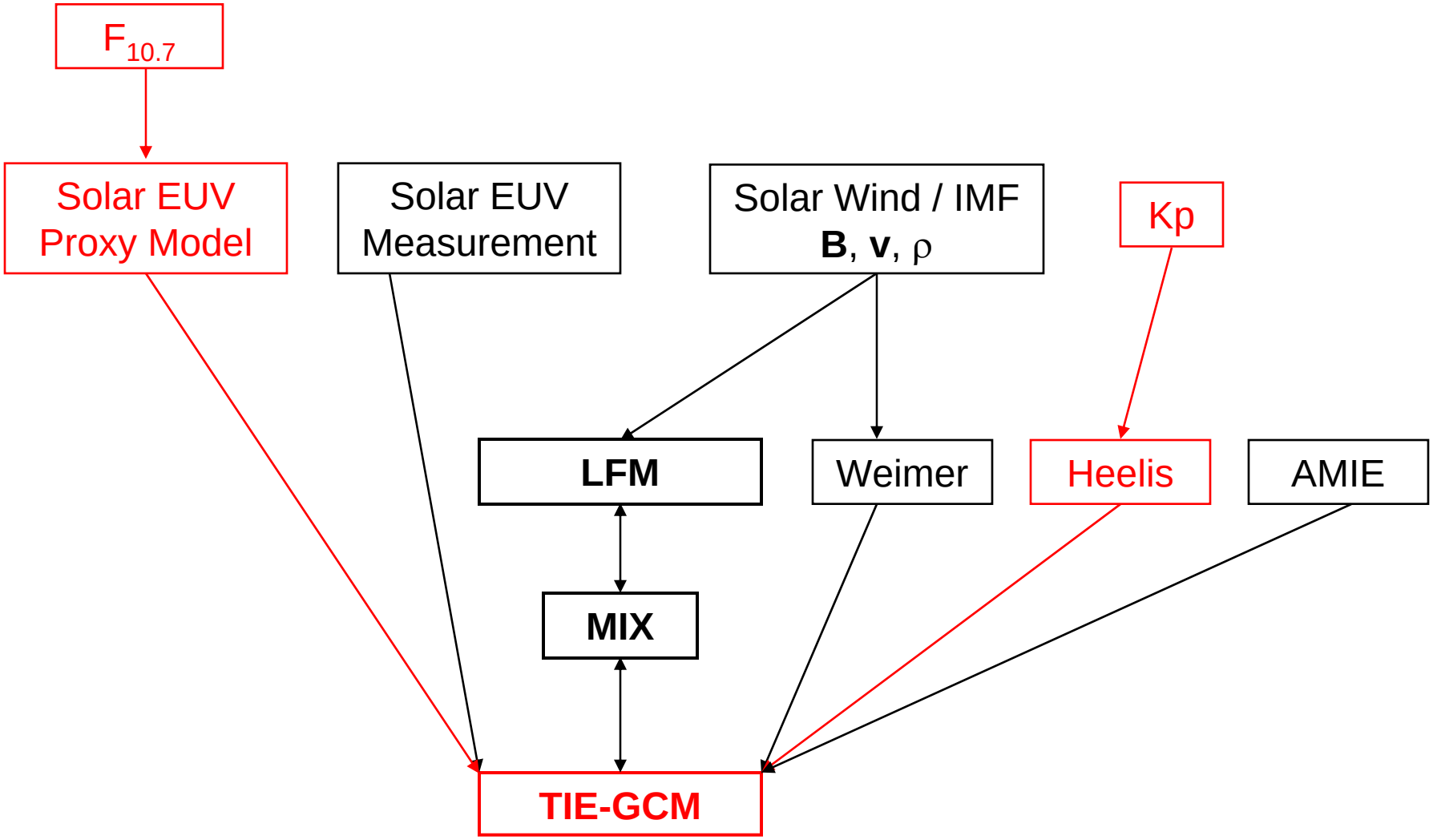
- **Lower boundary:**
  - Atmospheric tides specified using the Global Scale Wave Model (GSWM)
  - Eddy diffusion specified with height roll-off
  - Atomic oxygen calculated assuming peak at 97 km
  - CO_2 mixing ratio specified at lower boundary, diffusive equilibrium assumed

TIE-GCM "Extraterrestrial" Inputs and Options



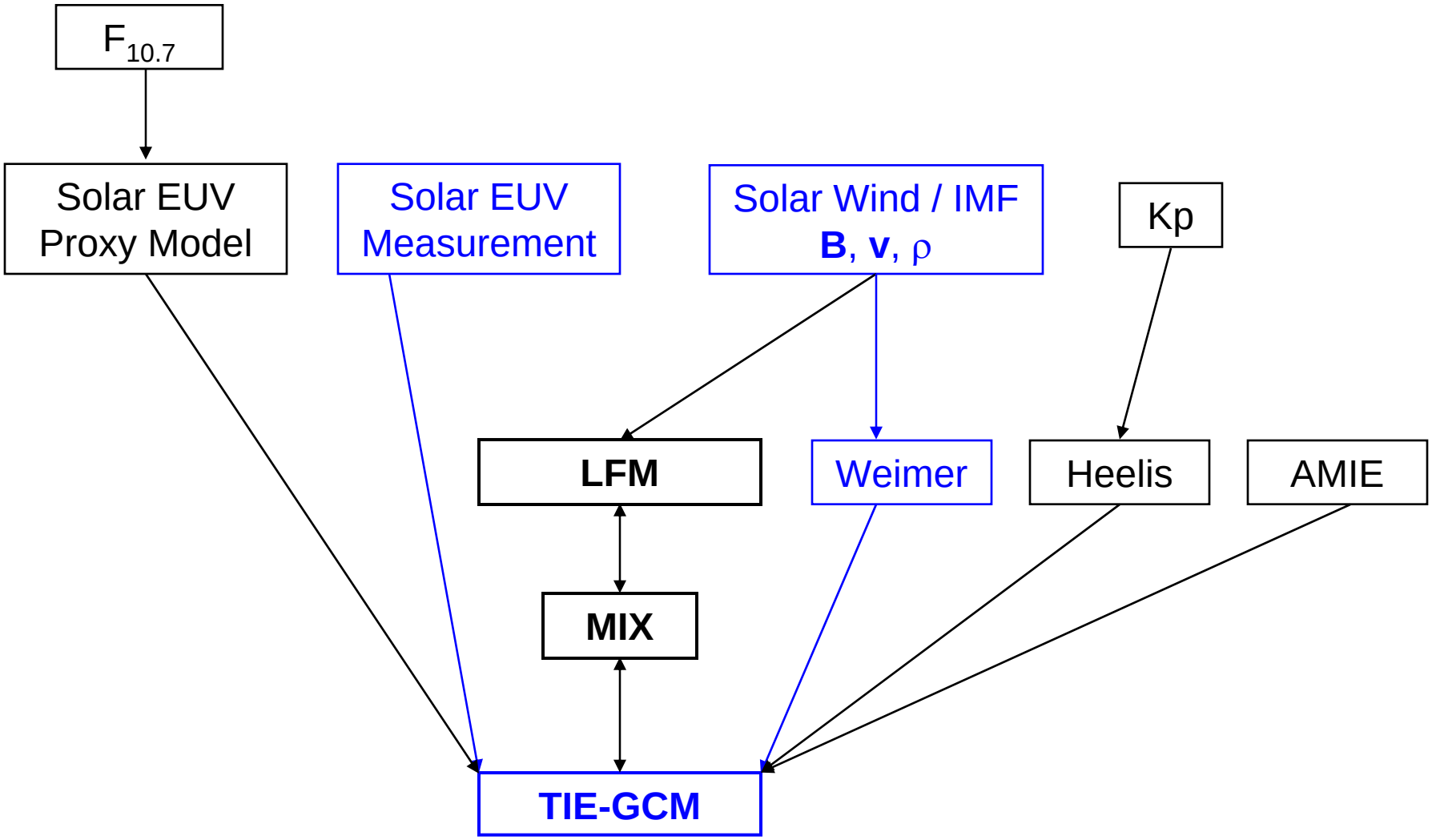
TIE-GCM "Extraterrestrial" Inputs and Options

Initial Installation at CCMC



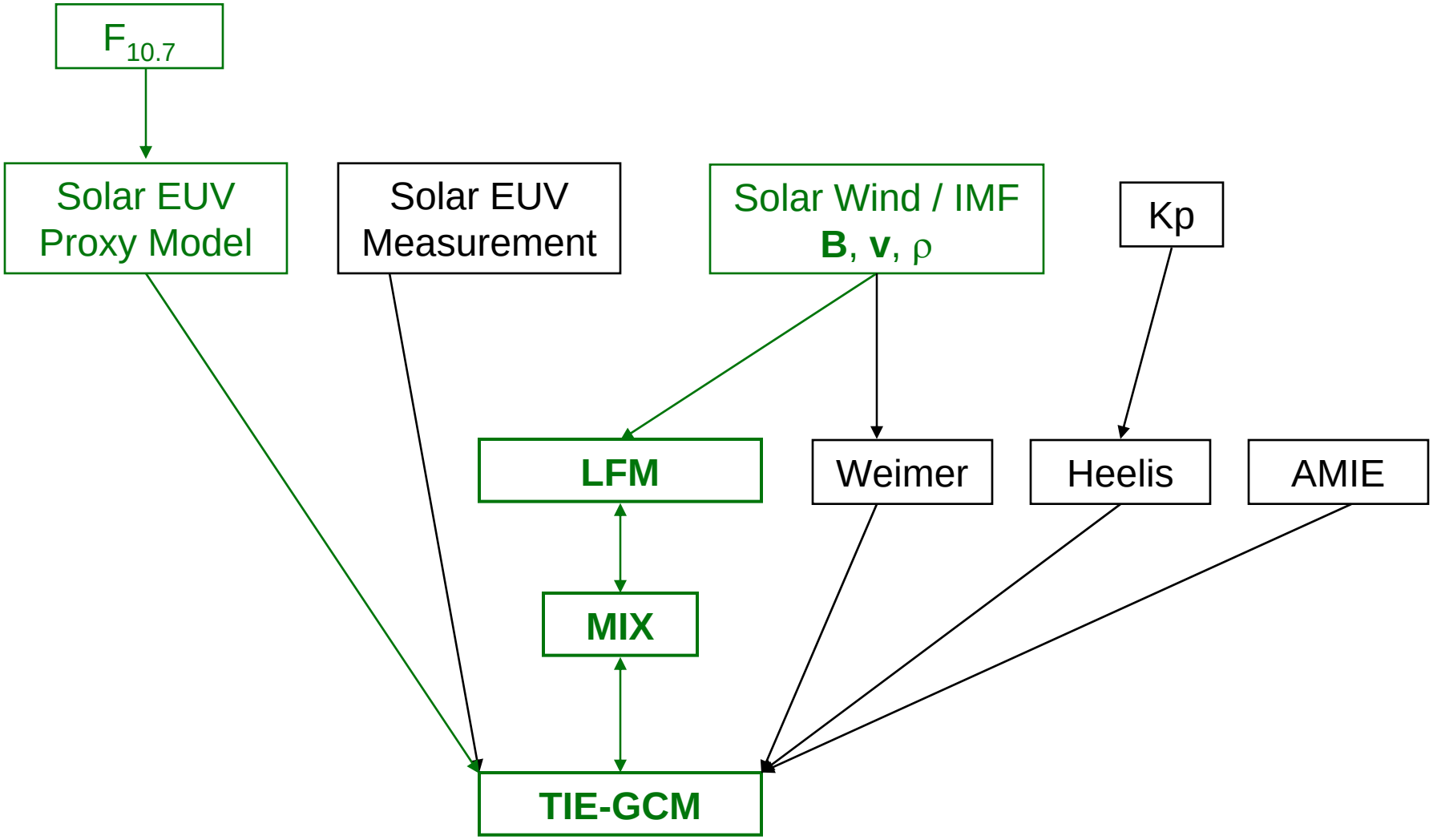
TIE-GCM "Extraterrestrial" Inputs and Options

Goal for "Stand-Alone" Mode (currently in test)

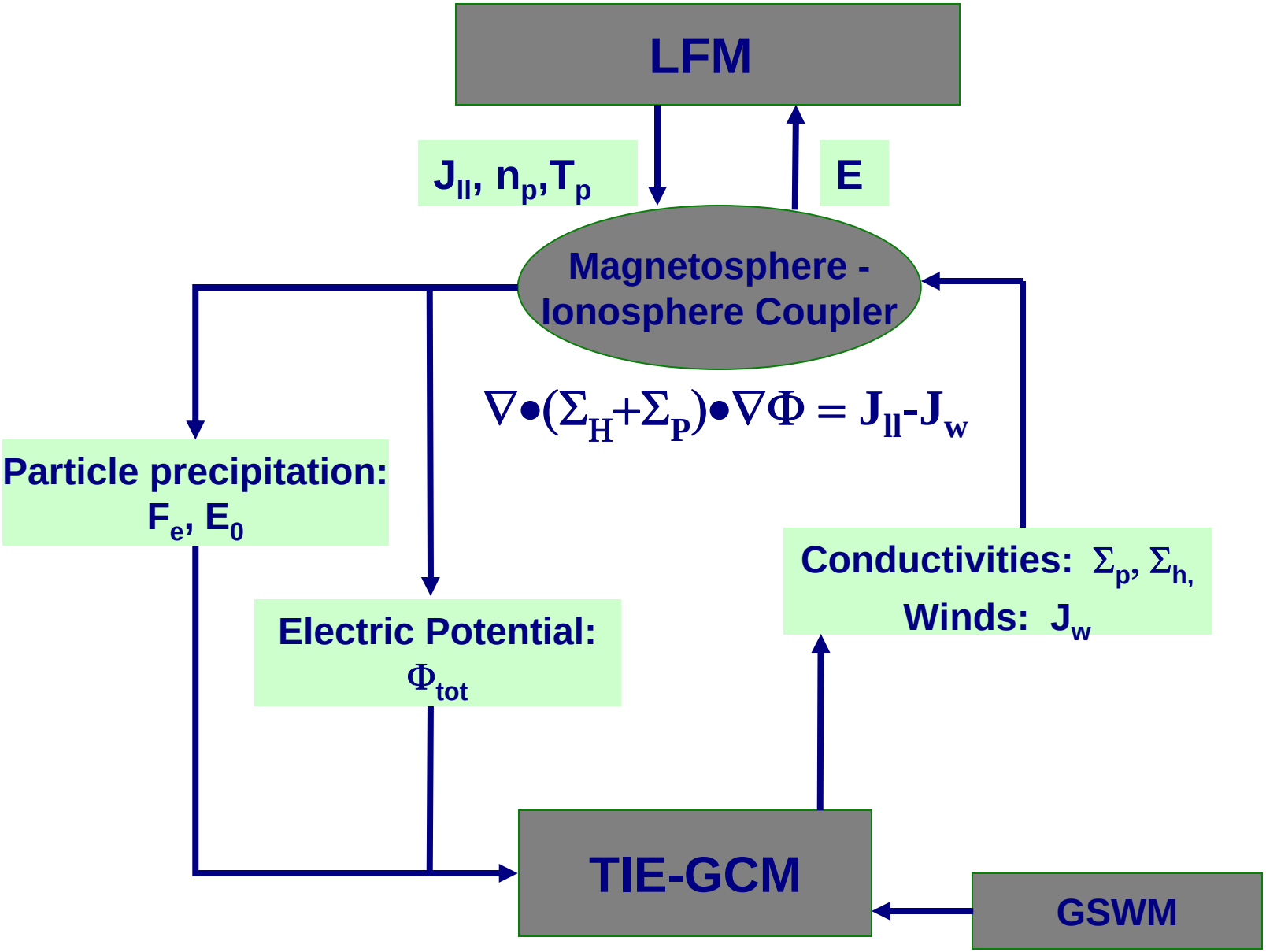


TIE-GCM "Extraterrestrial" Inputs and Options

CMIT Configuration at CCMC



Coupled Magnetosphere-Ionosphere-Thermosphere Model



A Community Model at the Community Center

To us, a community model means that scientific researchers can share the model results, run the model themselves, and/or participate in model development.

The source code is available under the auspices of an open-source academic research license.

Meaning, you can have the code, but you can't sell it, and we request that you adhere to academic norms with regard to collaboration, collegiality, and citation.

If you want to look at archived model results...

Available from the NCAR Data Portal at http://cdp.ucar.edu

If you want to do a particular model run...

Available through "runs on request" at CCMC

If you want to run the model yourself...

Download, install, and run the model on your computer, or,

Obtain an account on HAO/NCAR computers and run it there

If you want to participate in model development...

...give us a call

...come for a visit

...take-out boxes supplied

Information, User Guide, Documentation, Source Code...

Main page:

http://www.hao.ucar.edu/modeling/tgcm

User Guide:

http://www.hao.ucar.edu/modeling/tgcm/doc/userguide

Draft Documentation:

http://www.hao.ucar.edu/modeling/tgcm/doc/tiegcm_modeldes.pdf

Post-Processors:

http://www.hao.ucar.edu/modeling/tgcm//doc/userguide/node8.html

Code Map:

http://www.hao.ucar.edu/modeling/tgcm/download/files/tiegcm_codestruct.pdf

TGCM Home

Models
TIE-GCM
TIME-GCM
Global Mean

Processors
intro to processors
tgcmproc_f90
tgcmproc_idl
ncl

Downloads
download

Getting Help
user guide .html .pdf
model description (coming soon)
mailing list
tiegcm wiki

Research
highlights

Simulations
ncar community data portal

THE THERMOSPHERIC GENERAL CIRCULATION MODELS (TGCM'S)

Introduction

The High Altitude Observatory at the National Center for Atmospheric Research has developed a series of numeric simulation models of the earth's upper atmosphere, including the upper Stratosphere, Mesosphere, and Thermospere. The Thermospheric General Circulation Models (TGCM's) are three-dimensional, time-dependent models of the EARTH's neutral upper atmosphere. The models use a finite differencing technique to obtain a self-consistent solution for the coupled, nonlinear equations of hydrodynamics, thermodynamics, continuity of the neutral gas and for the coupling between the dynamics and the composition.

Recent models in the series include a self-consistent aeronomic scheme for the coupled Thermosphere/Ionosphere system, the Thermosphere Ionosphere Electrodynamic General Circulation Model (TIEGCM), and an extension of the lower boundary from 97 to 30 km, including the physical and chemical processes appropriate for the Mesosphere and upper Stratosphere, the Thermosphere Ionosphere Mesosphere Electrodynamic General Circulation Model (TIME-GCM). A global mean, or column model, has also been developed in parallel with the TGCM's. The global mean model is used as a time-dependent, one-dimensional platform from which new chemical, dynamic and numeric schemes are developed and tested before being introduced into the 3-d GCM's.

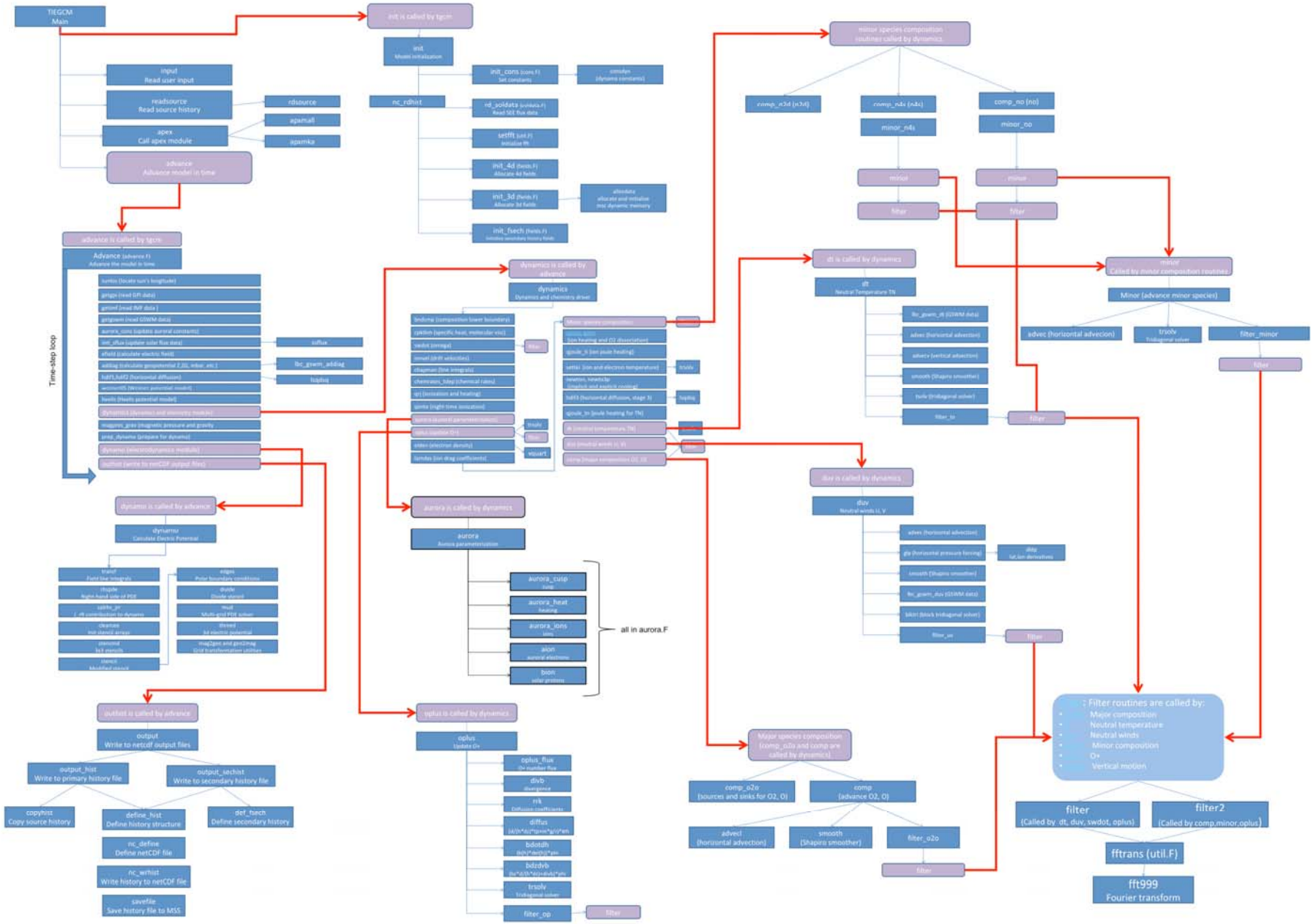
What's New

June 20, 2008: Announcing the release of TIEGCM version 1.9
tiegcm1.9 Release Notes
Model source code download coming soon (will require email registration)

Documentation

User's Guide to the Models and Post-processors (updated June, 2008): [html] [pdf]
Model description coming soon..

Structural Diagram of the NCAR TIE-GCM



A Few Things Learned in the Early Going

We have put a lot of effort into rigorous code branch control, change tracking, and but anomaly reporting, but...

It’s not enough to control the code.

It’s also important to control the input files

A lot of model results are actually produced in the post-processing

(do we need to control the post-processor software as well?)

Current Development and Future Plans

- Weimer model high-latitude potential specification using solar wind / IMF inputs
- Seasonal variation of lower boundary eddy diffusion
- TIMED boundary condition specifications
  - SEE solar EUV
  - TIDI/SABER lower boundary condition tides
  - GUVI-based empirical auroral oval
- High-resolution version (2.5° x 2.5° x H/4)
- Global Ionosphere Plasmasphere (GIP) model on closed field lines
- Continued development of the Coupled Magnetosphere-Ionosphere-Thermosphere (CMIT) model