

Upper Atmosphere Models at the National Center for Atmospheric Research

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Models Mentioned Here

Big Models:

Thermosphere-Ionosphere-Electrodynamics General Circulation Model
(TIE-GCM) (95~500 km) [*Art Richmond*]

Thermosphere-Ionosphere-Mesosphere-Electrodynamics GCM
(TIME-GCM) (30~500 km) [*Ray Roble*]

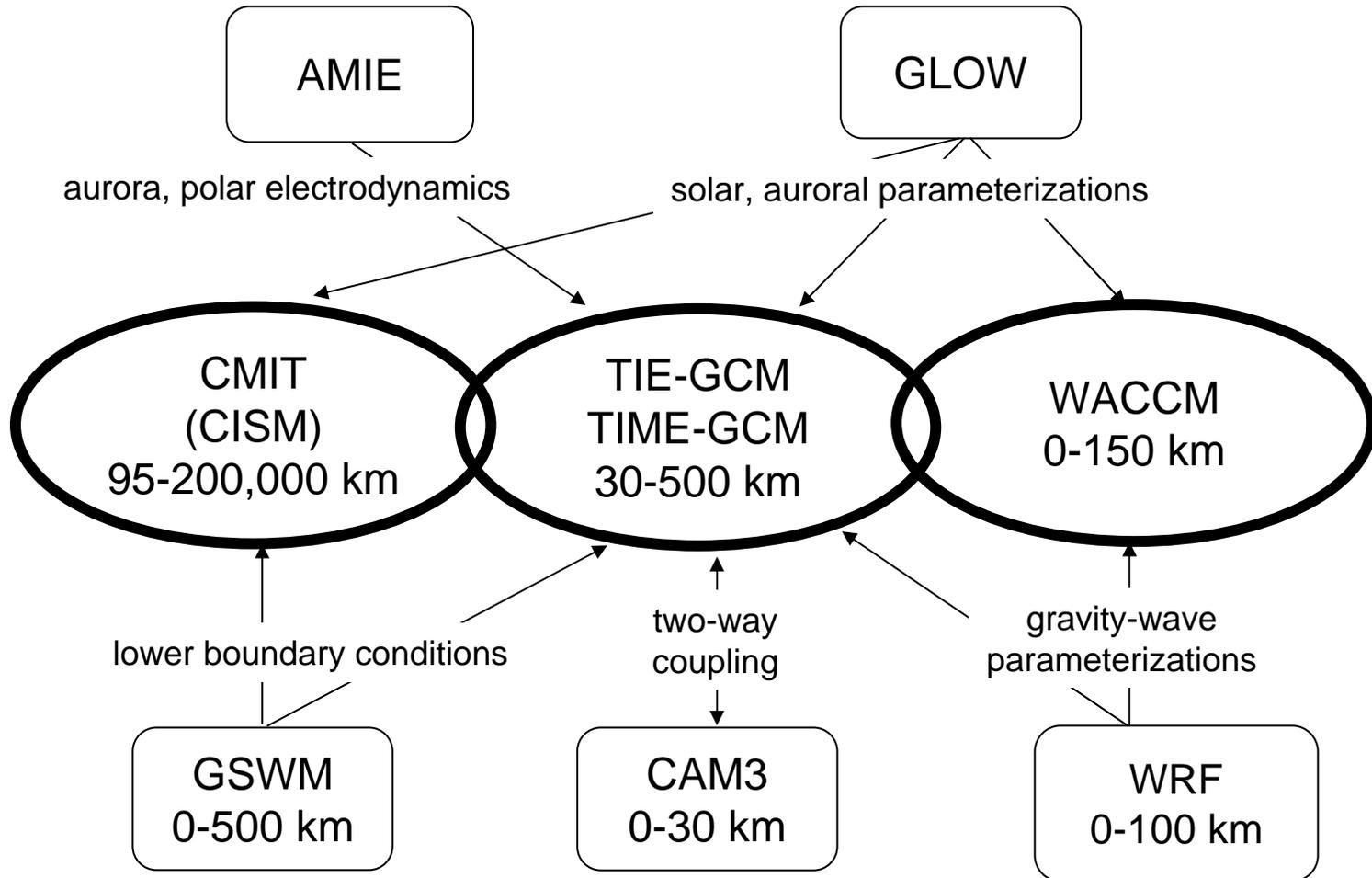
Whole Atmosphere Community Climate Model
(WACCM) (0~150 km) [*Rolando Garcia*]
Extension to ~500 km in progress

Not-So-Big Models:

Global-Scale Wave Model
(GSWM) (0~500 km) [*Maura Hagan*]

Global Airglow Model
(GLOW) (90~1000 km) [*Stan Solomon*]

A Schematic Representation



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

Model Heritage:

Comprehensive coupled model of the thermosphere-ionosphere system with self-consistent electrodynamics [*Richmond et al., JGR, 1991*] based on the TIGCM [*Roble et al., JGR, 1989*].

Recent Developments:

Solar flux specified by EUVAC model *or* by TIMED daily average measurements

New solar energy deposition scheme has been developed

[*Solomon & Qian, JGR, 2005*]

Auroral forcing parameterized using standard algorithm based on Kp

Or, based on AMIE analysis

Or, based on LFM magnetospheric model

Tidal oscillations at lower boundary specified by Global Scale Wave Model

[*Hagan et al., JGR, 1999*]

Advances in MPI code engineering and documentation

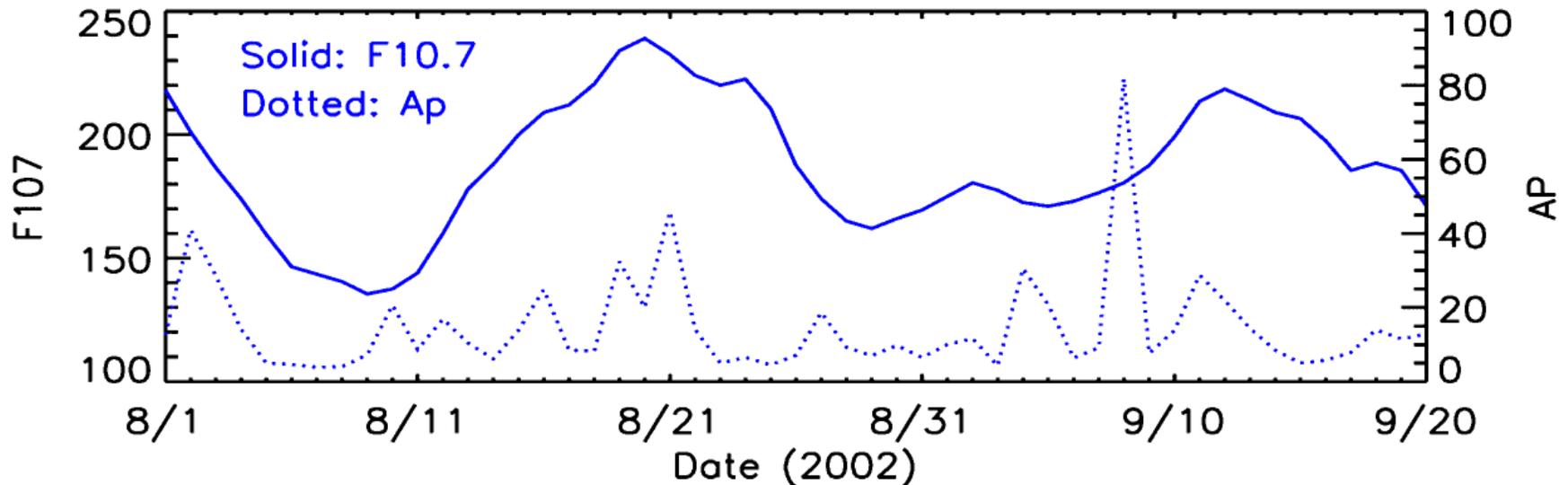
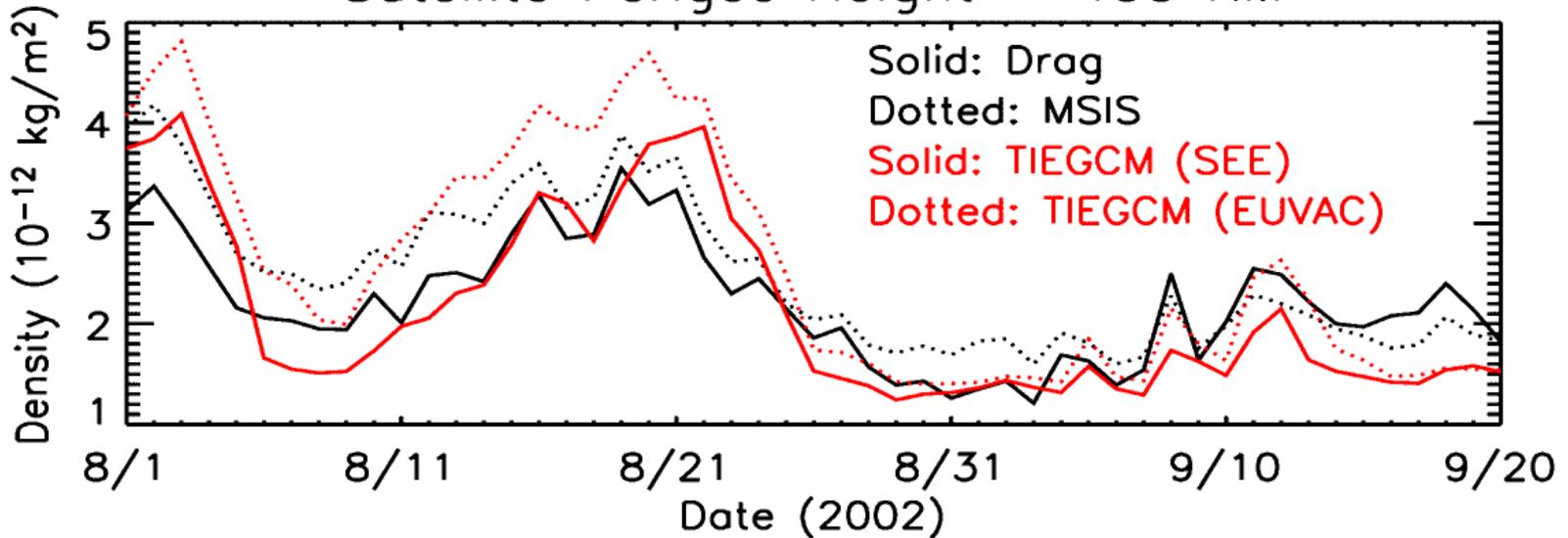
...runs on 1 to ~16 processors; ~1/2 CPU-hour per 1-day run

Current Status:

Impending release of TIE-GCM 1.8

Comparison with Satellite Drag Density Measurements

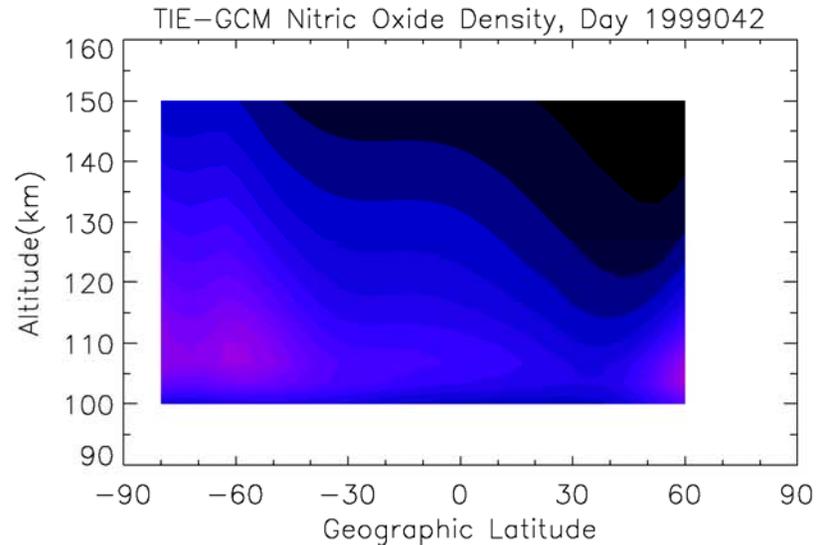
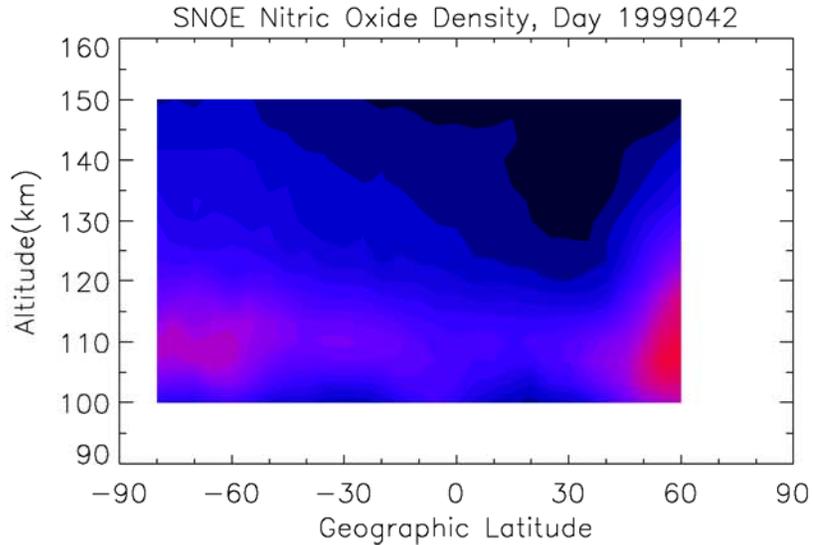
Satellite Perigee Height = 400 KM



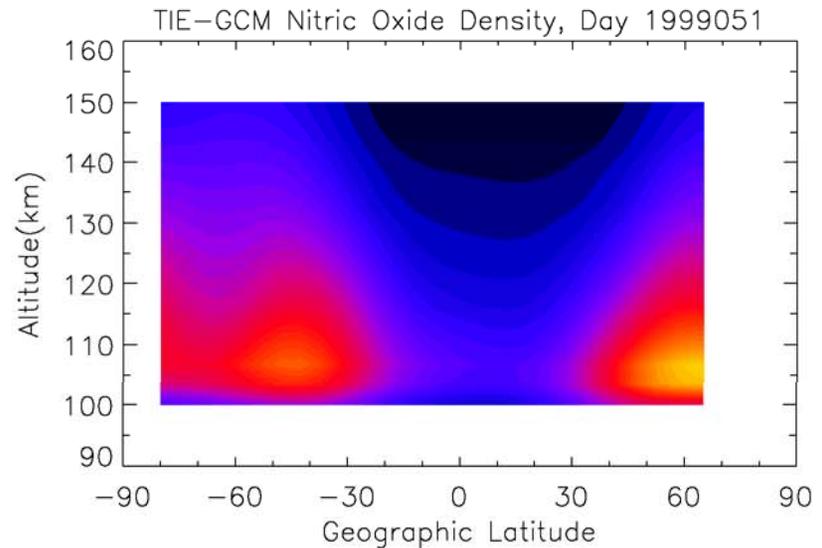
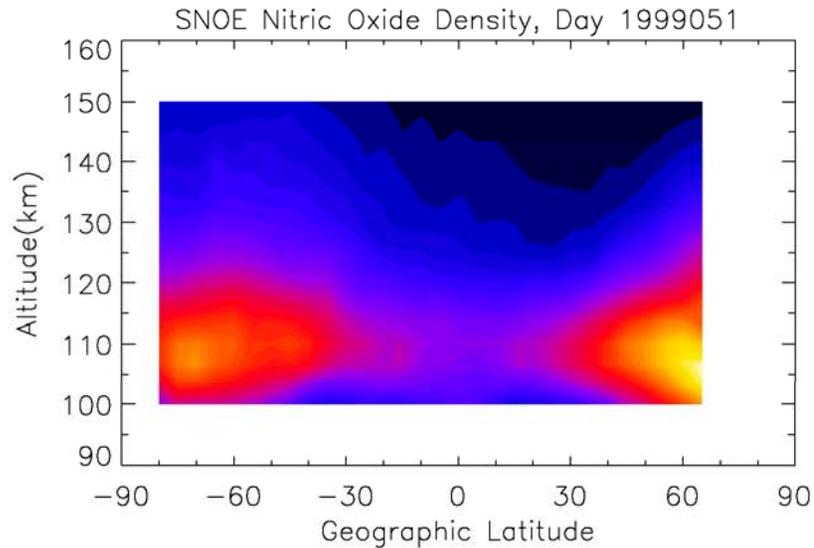
Comparison of SNOE Nitric Oxide Data to TIE-GCM 1.8

SNOE

TIE-GCM



**Low
Aurora**



**High
Aurora**



Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM)

Model Heritage:

Comprehensive coupled model of the thermosphere-ionosphere-mesosphere system with self-consistent electrodynamics and full middle-atmosphere chemistry based on TIE-GCM [*Roble and Ridley, GRL, 1993*]

Recent Developments:

Flux-coupled to CAM3 lower atmosphere model

Can use NCEP analysis fields to specify dynamical forcing at lower boundary

MPI code runs on 8 to ~32 processors

~1 CPU-hour per 1-day run on IBM Power-4's

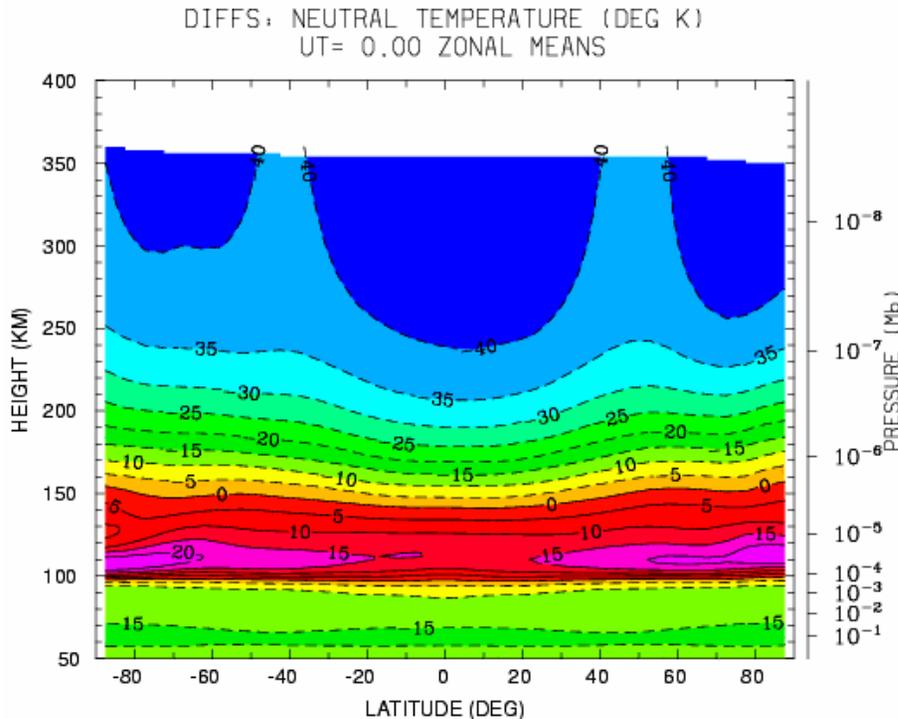
Current Status:

Still a developmental research model

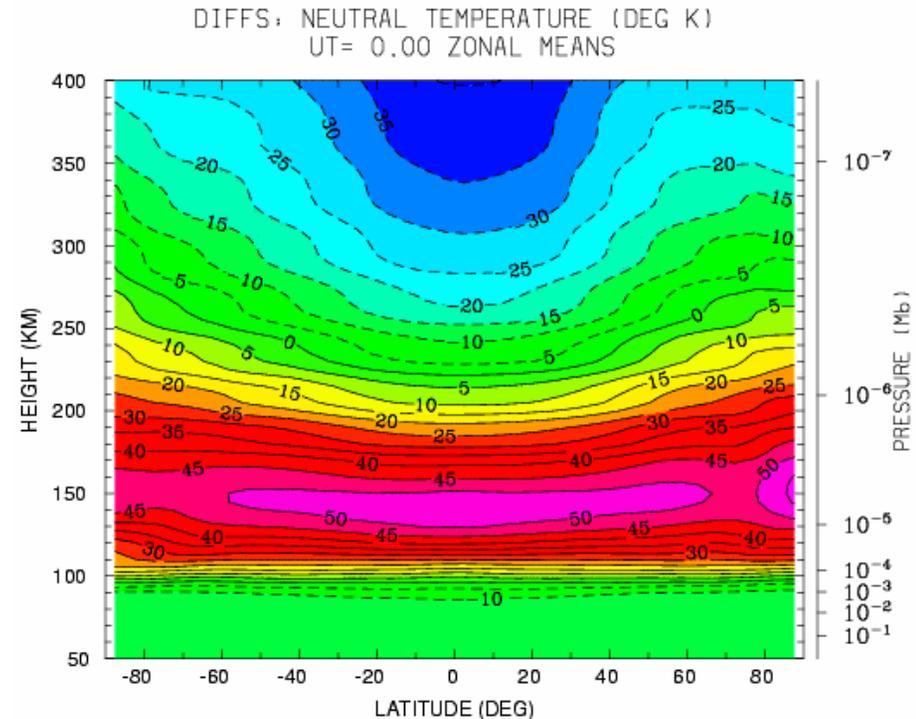
Code is available to interested collaborators

Recent Results — Secular Change in the Thermosphere

Differences in Zonal Mean Temperature (Year-2100 scenario) - (Year-2000 scenario)

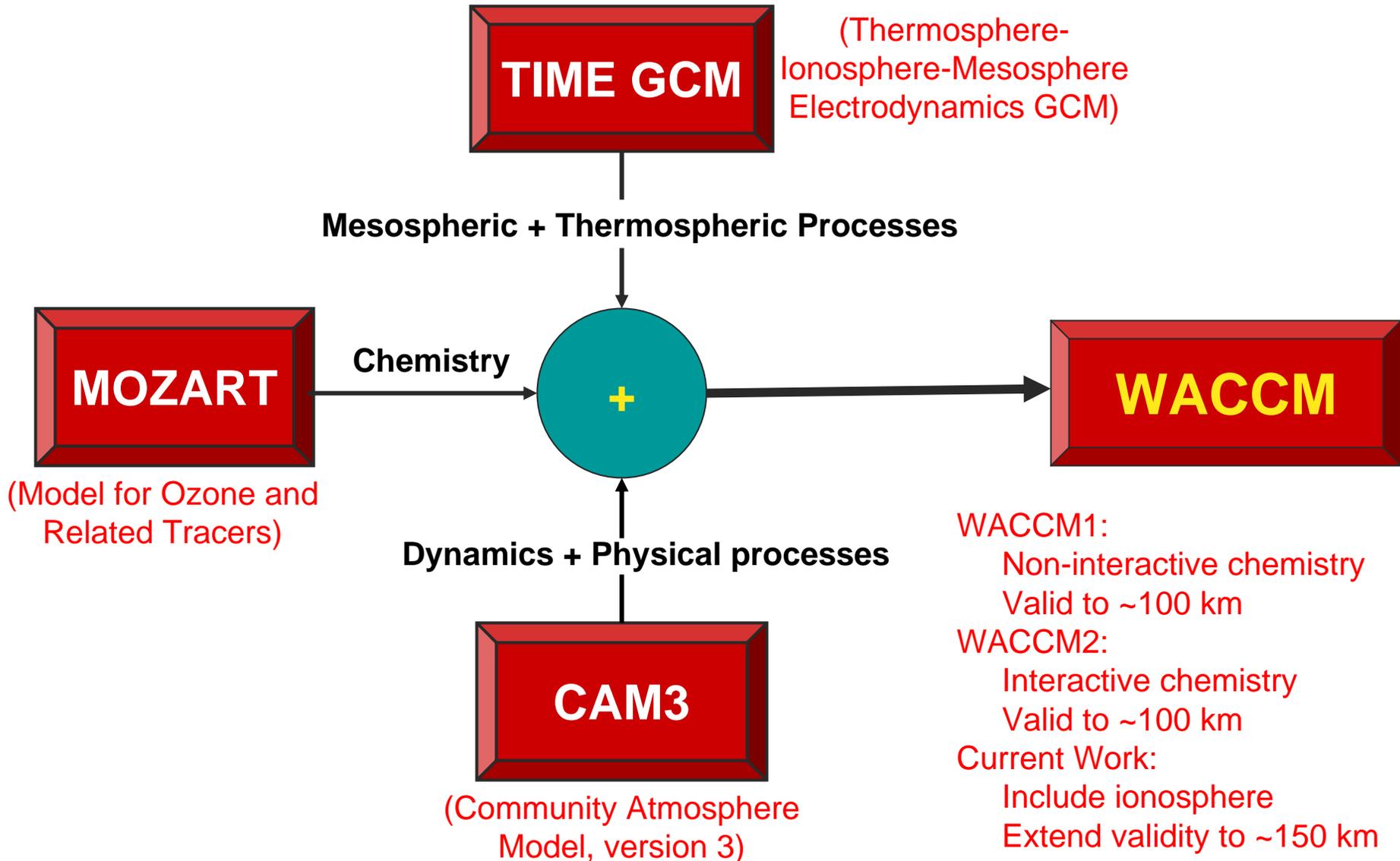


Solar Minimum Conditions



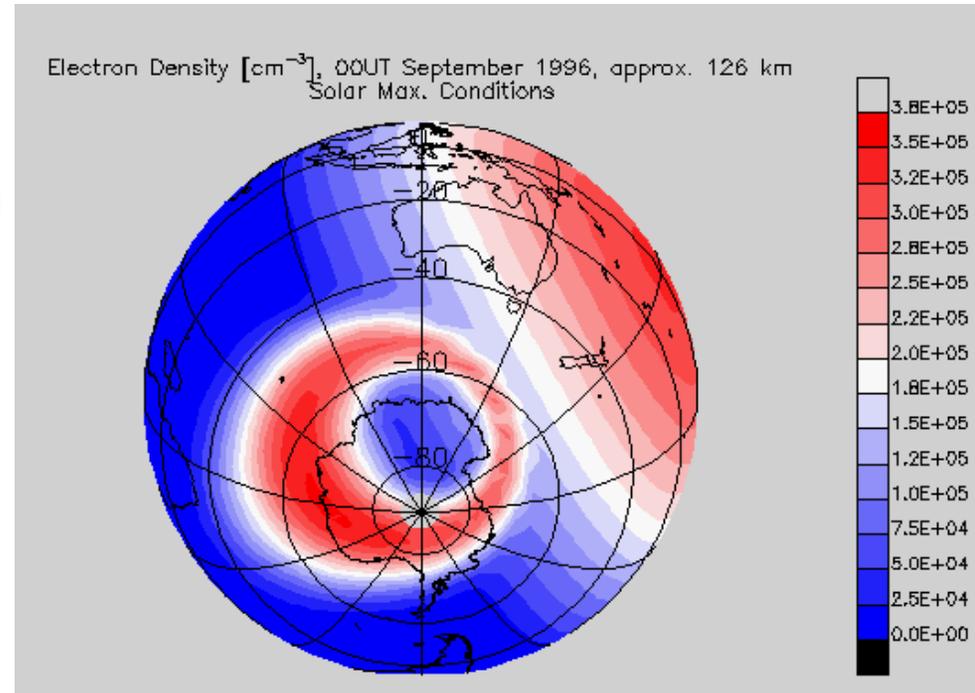
Solar Maximum Conditions

Heritage and Structure of the Whole Atmosphere Community Climate Model



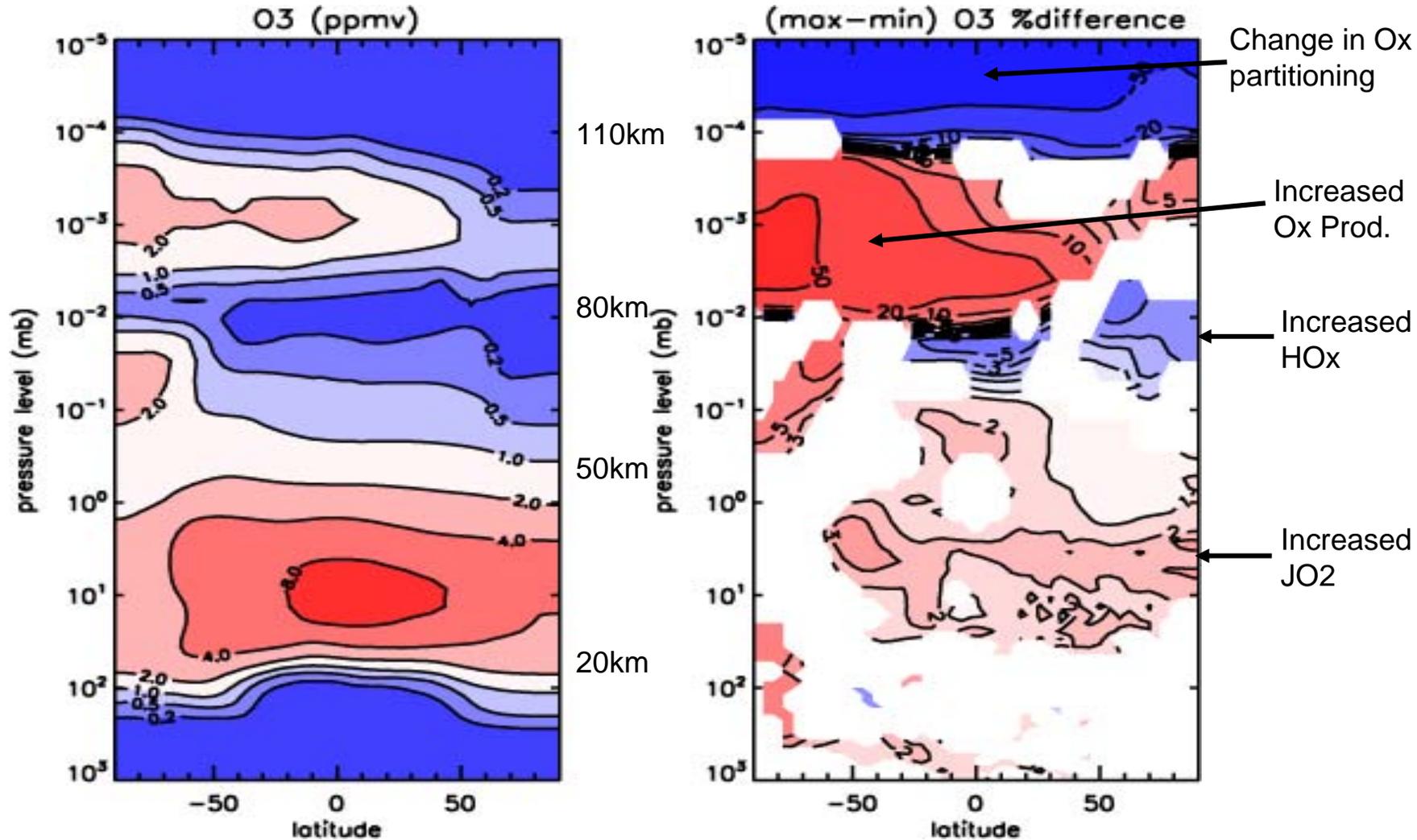
New Developments in WACCM

- WACCM-3 merged with latest version of Community Atmosphere Model (CAM 3.1)
- The following processes are now dealt with in a self-consistent manner:
 - Solar variability
 - Chemical heating
 - Airglow
 - Ion chemistry (5 ions & electrons)
 - EUV and x-ray ionization
 - Auroral processes
 - Particle precipitation
 - Ion drag
 - Joule heating



- ~430 CPU-hours for a 1-year run on IBM Power-4's (typically 64 processors)

Preliminary Results — Solar Cycle Ozone Response



July zonal mean, 15-year average

Current Status of the WACCM

- WACCM 1b is available through Community Data Portal web site at NCAR
 - valid to ~100 km
 - non-interactive chemistry
- WACCM 2 release is TBD
 - interactive chemistry
 - probably superceded by new work
- WACCM 3 is being tested
 - valid to ~150 km
 - includes ionosphere and thermosphere processes
- Next steps will be to include ambipolar diffusion and electrodynamical processes
 - goal is to extend validity to ~500 km
 - full treatment of auroral and dynamo potential