NRL SAMI3 IONOSPHERE/PLASMASPHERE MODEL: STATUS

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SAMI2/3 AT CCMC

- magnetic field: IGRF-like
- interhemispheric: low- to mid-latitude ($\pm 60^\circ$)
- Nonorthogonal, nonuniform fixed grid
- seven (7) ion species (all ions are equal):
  H^+, He^+, N^+, O^+, N_2^+, NO^+, and O_2^+
  - solve continuity and momentum for all 7 species
  - solve temperature for H^+, He^+, O^+, and e^-
- Plasma motion
  - $\mathbf{E} \times \mathbf{B}$ drift perpendicular to **B** (uses Fejer/Scherliess model)
  - Ion inertia included parallel to **B**
- neutral species: NRLMSISE00 and HWM93
- chemistry: 21 reactions + recombination
- photoionization: Daytime (EUVAC) and nighttime

CURRENT STATUS

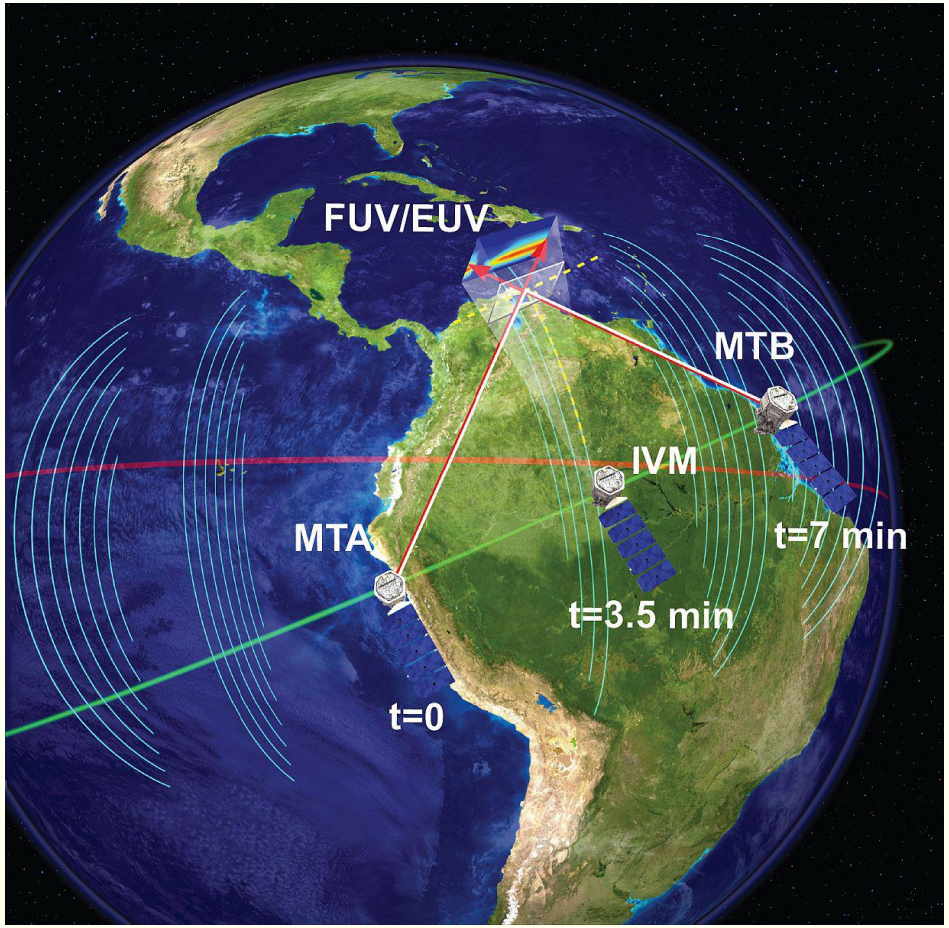
- neutral composition/wind/temperature:
  - TIEGCM
  - TIMEGCM
  - GITM
  - WACCM-X
- neutral wind dynamo electric field (replaces Fejer/Scherliess)
- magnetic field:
  - tilted/non-tilted dipole
  - Richmond Apex Model (IGRF)
- interhemispheric: low- to high-latitude ($\pm 89^{\circ}$)
- high latitude potential:
  - analytical: Volland-Stern-Maynard-Chen
  - empirical: Weimer
  - data-driven: AMIE
- SAMI3/RCM
- include metal ions (Fe^{+}, Mg^{+})

SOME HIGHLIGHTS

- SAMI3 ICON
- SAMI3/RCM/GITM
- metal ion dynamics

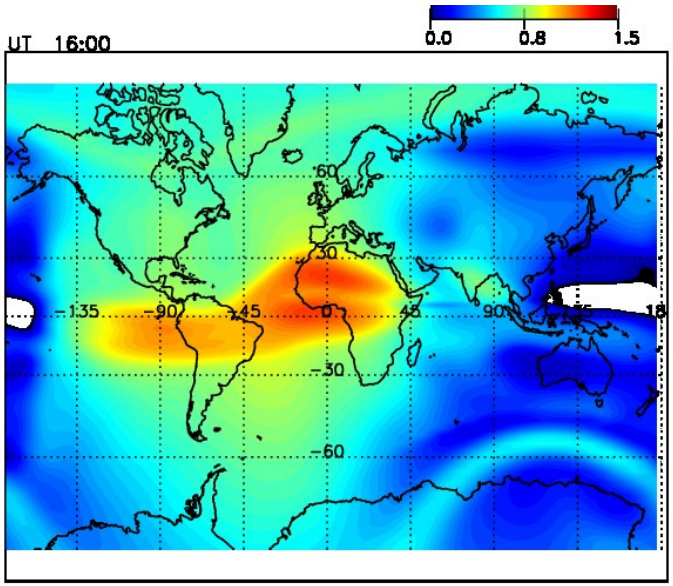
SAMI3 ICON

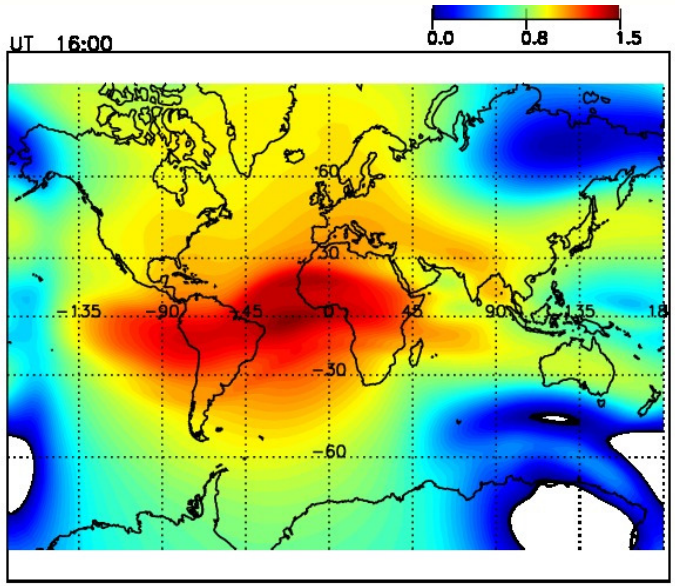
- primary objective of the ICON mission is to measure E and F region winds
- relate to day-to-day variability of the ionosphere
- specify lower boundary of TIEGCM with tidal motions using Hough modes
- TIEGCM data used in SAMI3 (along with high latitude potential from AMIE)

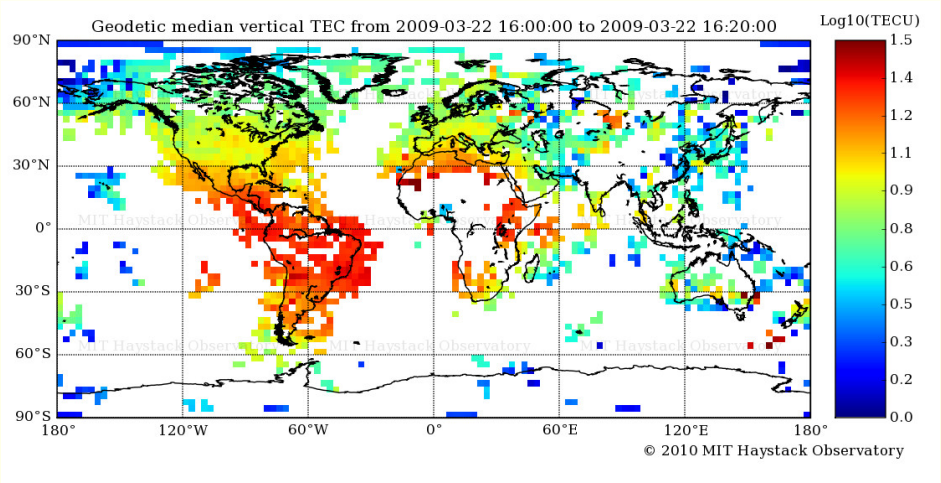


SAMI3, TIEGCM AND GPS TEC

$\log_{10}$ scale

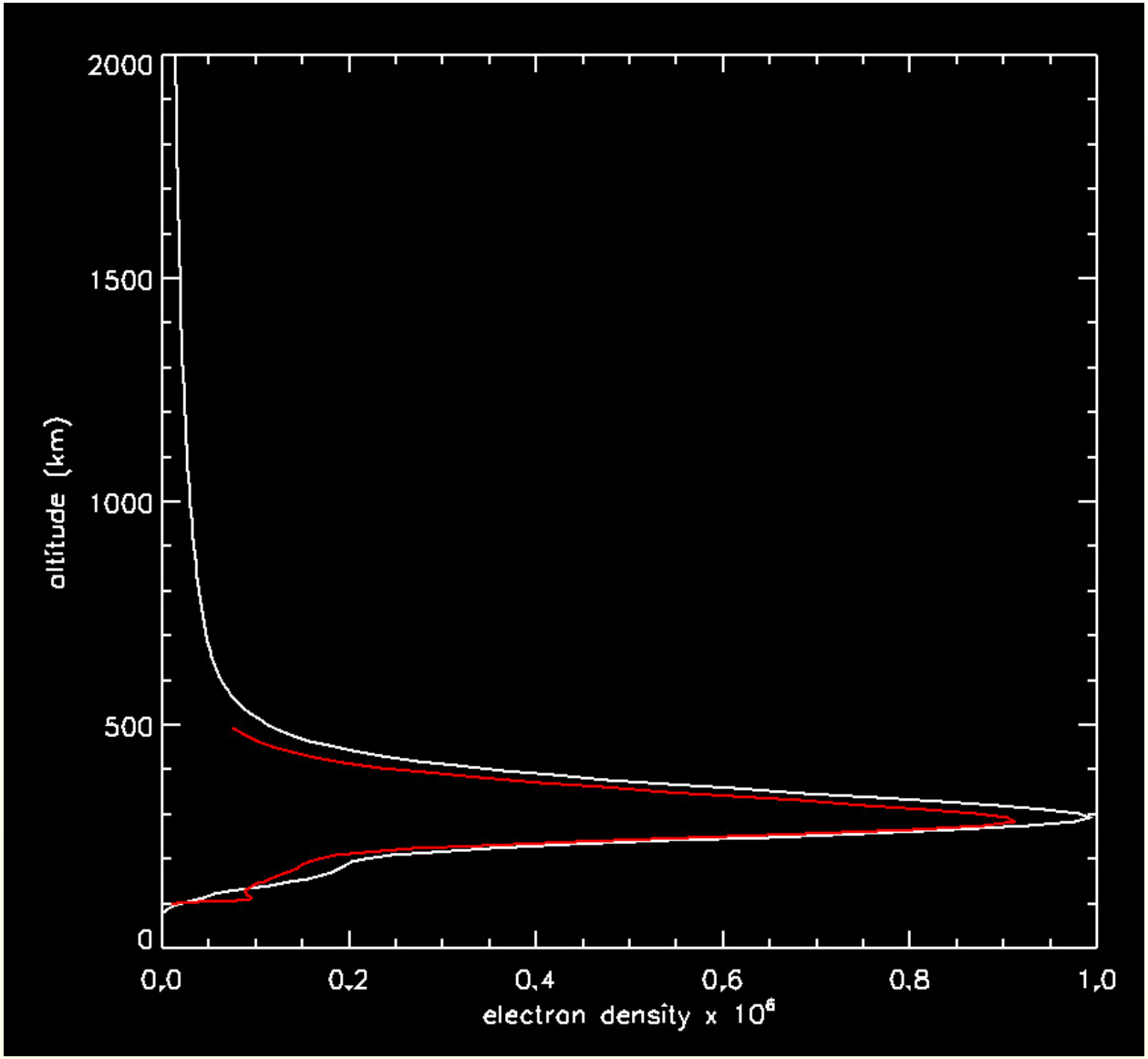






SAMI3/TIEGCM ELECTRON DENSITY VS ALTITUDE

SAMI3 (white) and TIEGCM (red)

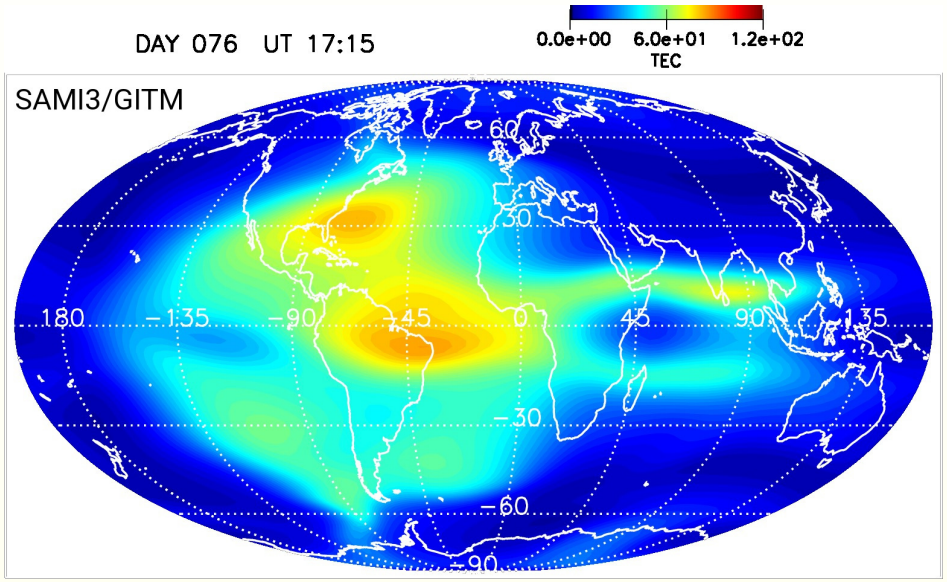


SAMI3/RCM/GITM

- NASA grand challenge project
- goal: self-consistently couple SAMI3/RCM/GITM
- SAMI3/RCM: self-consistently coupled electrodynamically
- SAMI3/GITM: only one-way coupling, e.g., GITM provides neutral density, temperature, and winds to SAMI3 (instead of NRLMSISE00/HWM14)
- results for March 2015 storm

TEC

global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0.0e+00 6.0e+01 1.2e+02
TEC
SAMI3/GITM
60
30
180
-135
-90
-45
0
45
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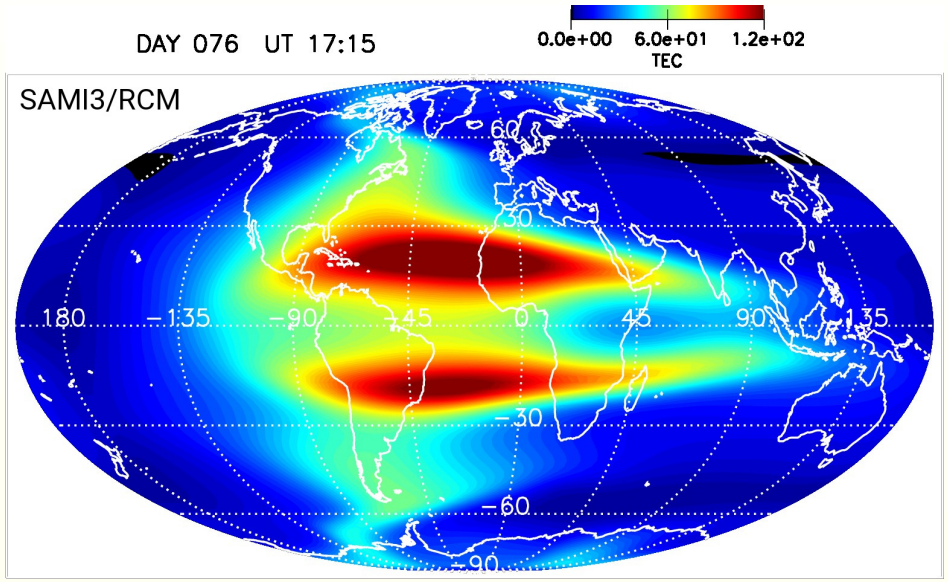
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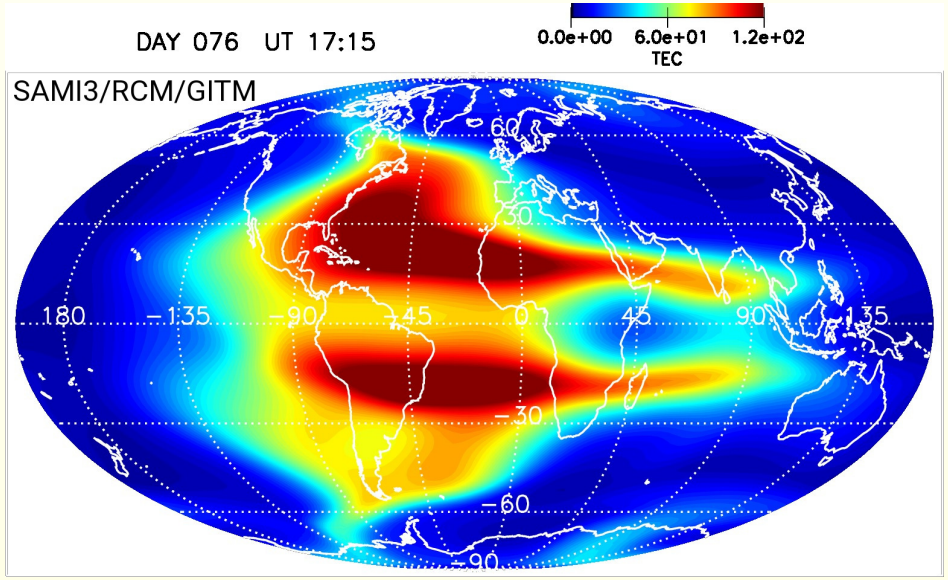
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SAMI3/RCM/GITM
60
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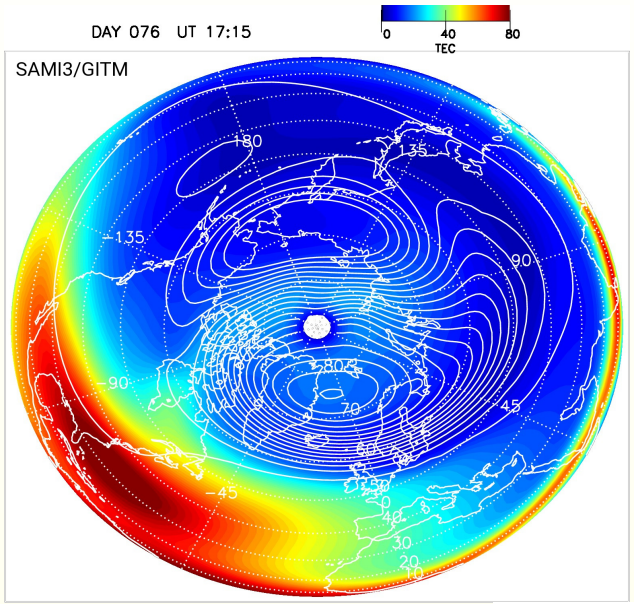
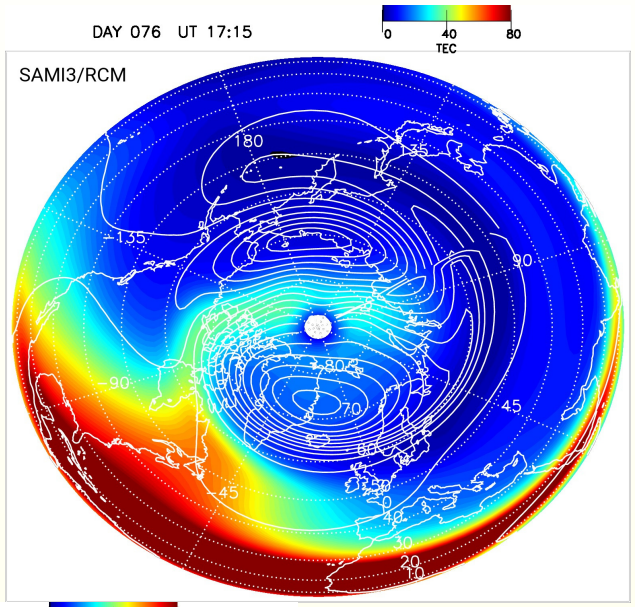
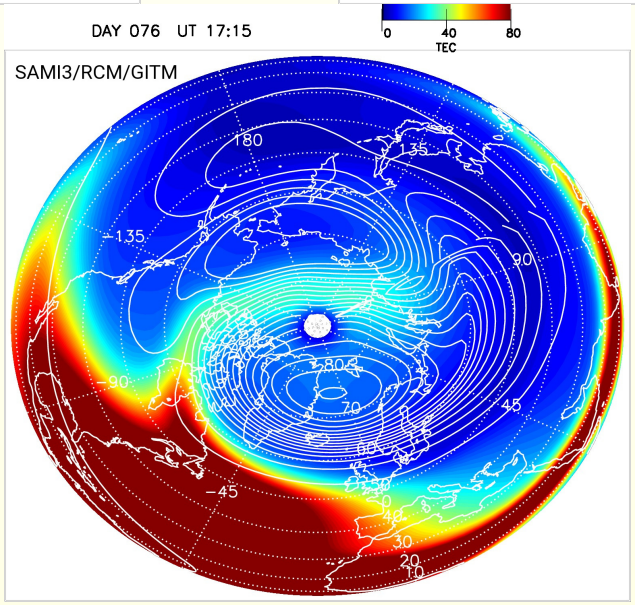
TEC

polar cap region

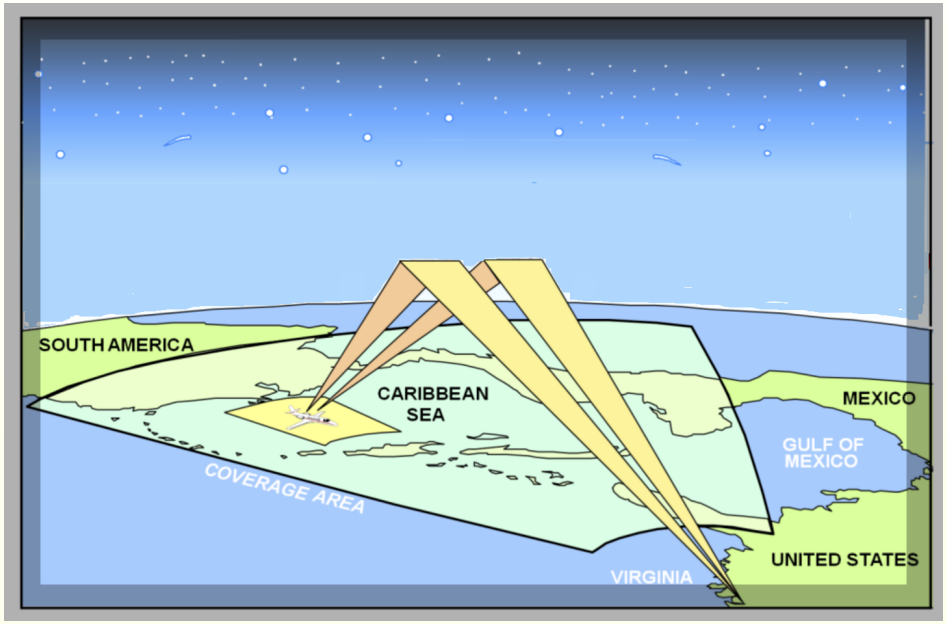




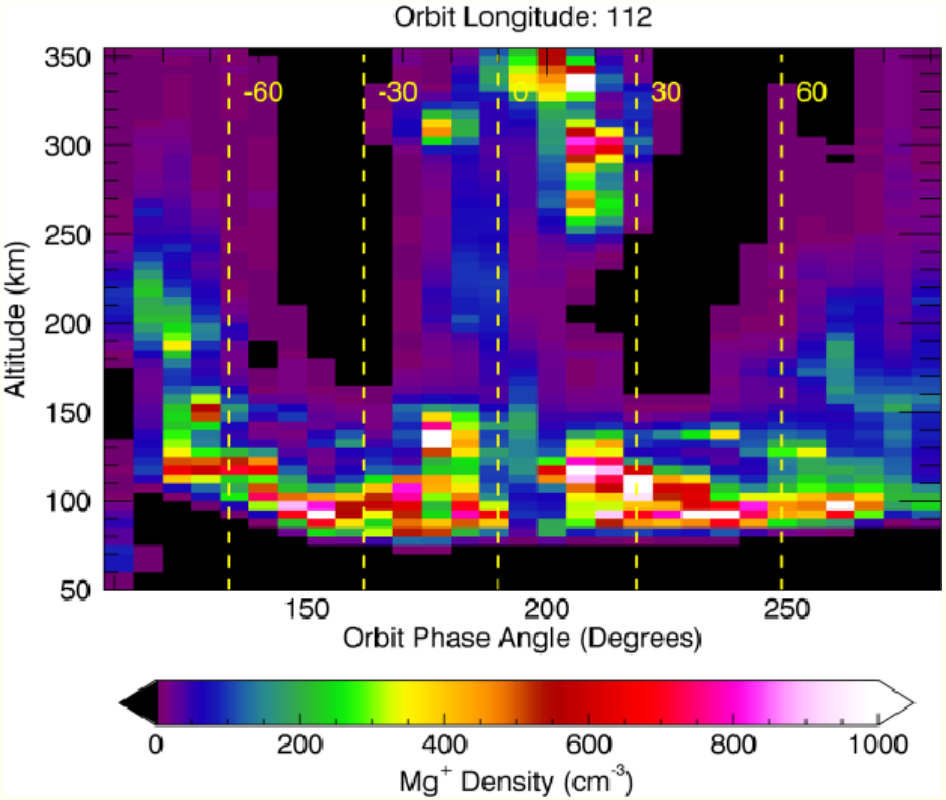


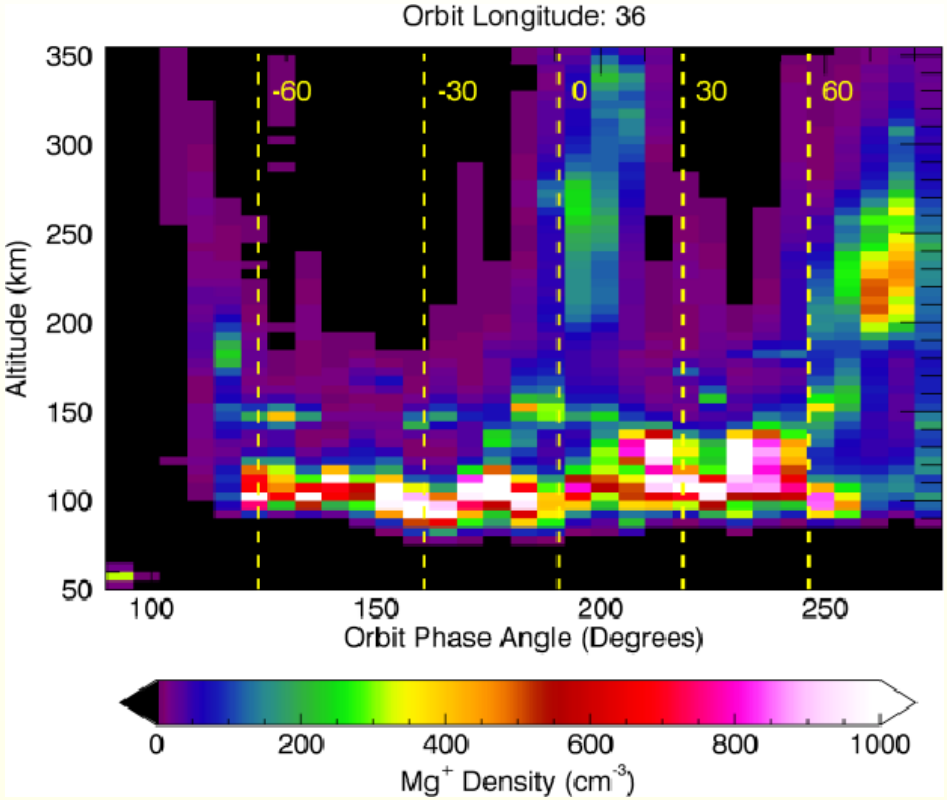
SPACE WEATHER ISSUE: SPORADIC E

- sporadic E: thin ionization layers that form in the altitude range 90 - 150 km
- for $n_e \gtrsim 10^5$ cm^{-3} can adversely impact over-the-horizon radar (OTHR)
- can be caused by metal ions (e.g., Fe^+, Mg^+) from meteoritic deposition



OBSERVATIONS





BIG ISSUE: TRANSPORT

transition from magnetized to unmagnetized - first order

- magnetized regime: $(\nu_{in}/\Omega_i)^2 << 1$

$$\mathbf{V}_{i\perp} = \frac{c\mathbf{E}}{B} \times \hat{\mathbf{e}}_\mathbf{z} + \frac{\nu_{in}}{\Omega_i}\frac{c\mathbf{E}}{B}$$

ion motion in both $\mathbf{E} \times \mathbf{B}$ and $\mathbf{E}$ directions, i.e. Hall and Pedersen drifts

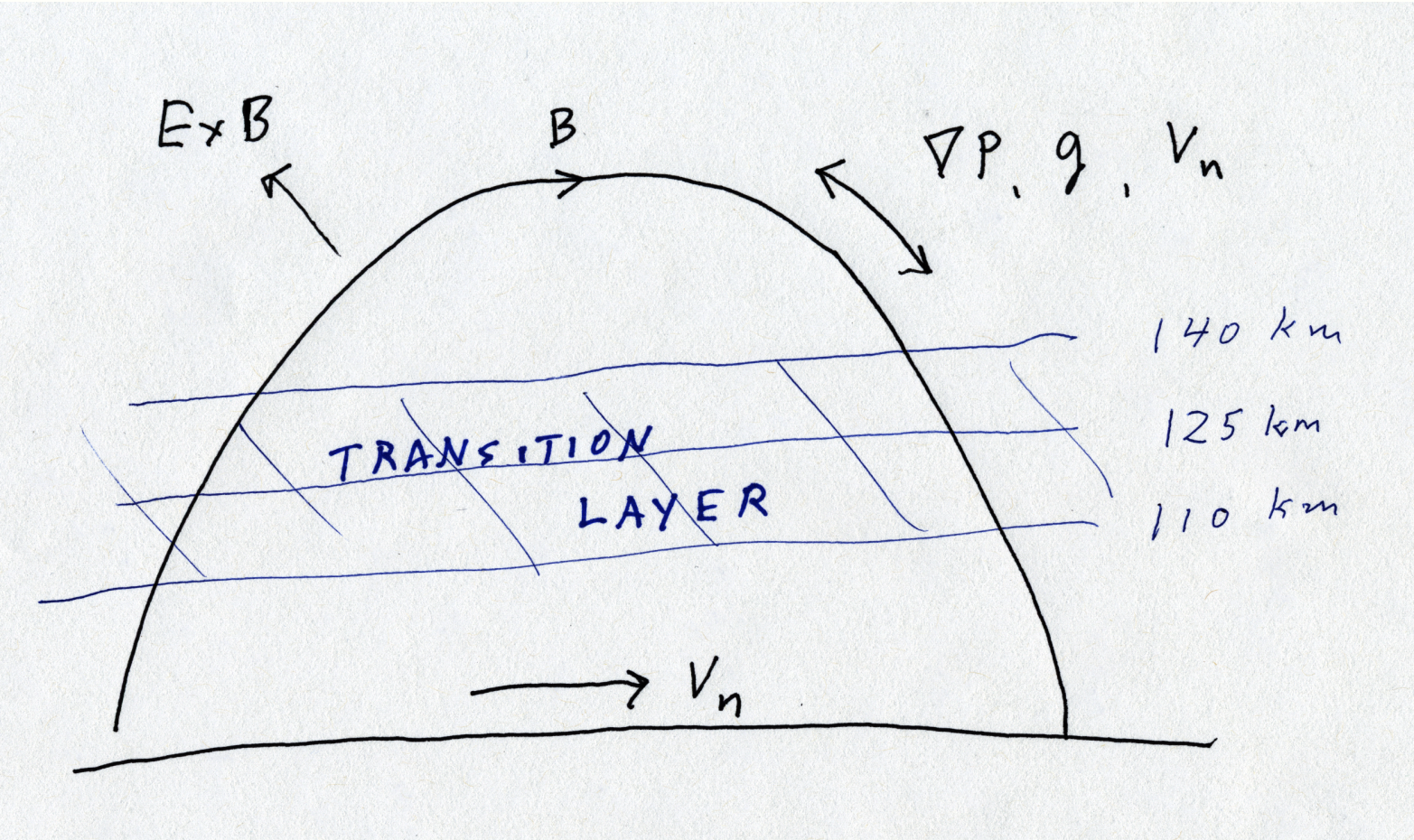
- unmagnetized regime: $(\nu_{in}/\Omega_i)^2 >> 1$

$$\mathbf{V}_i = \mathbf{V}_n + \frac{1}{1+\nu_{in}^2/\Omega_i^2}\left(\frac{\nu_{in}}{\Omega_i}\mathbf{V}_n \times \hat{\mathbf{e}}_\mathbf{z}\right)$$

can cause vertical plasma motion (e.g, layer formation)

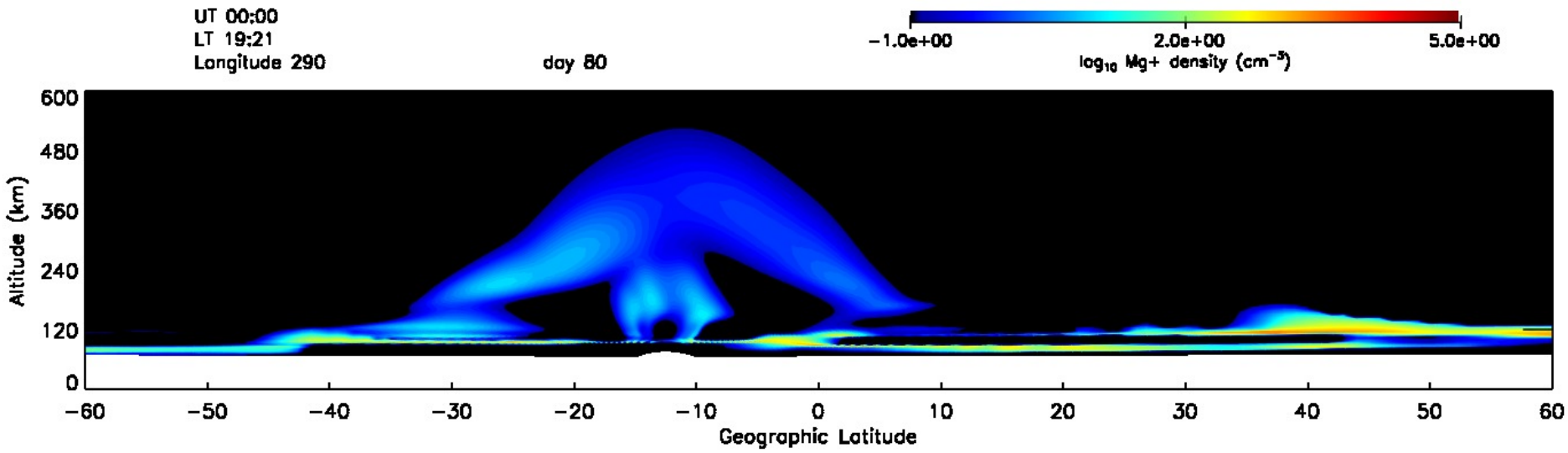
SCHEMATIC

transition from magnetized to unmagnetized



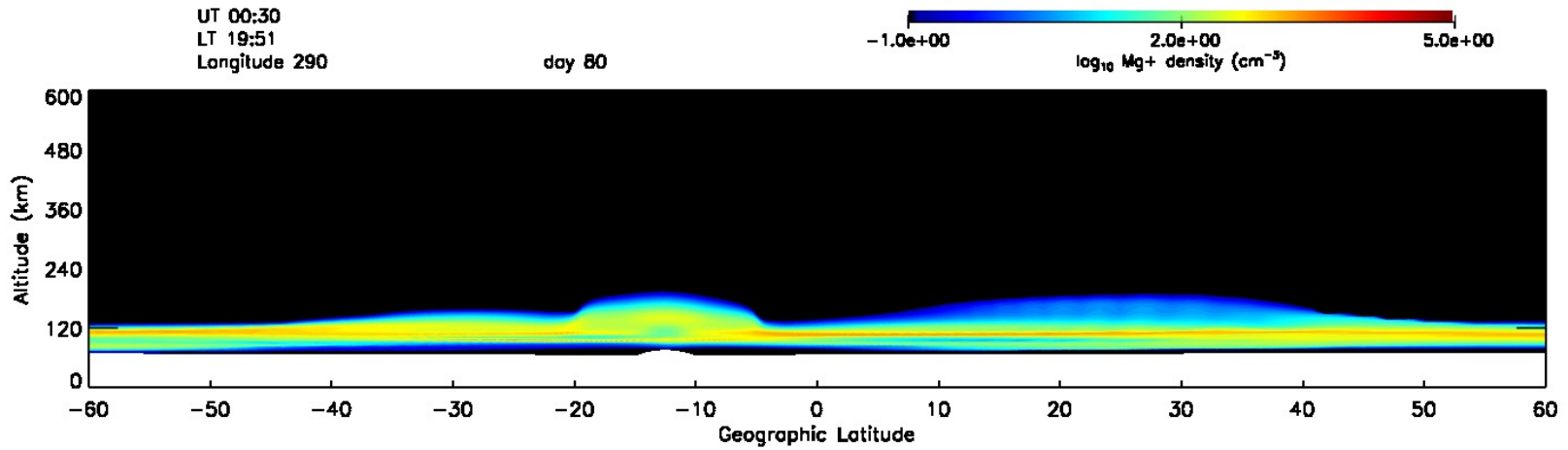
Mg^+ LAYERING/TRANSPORT

latitude vs altitude



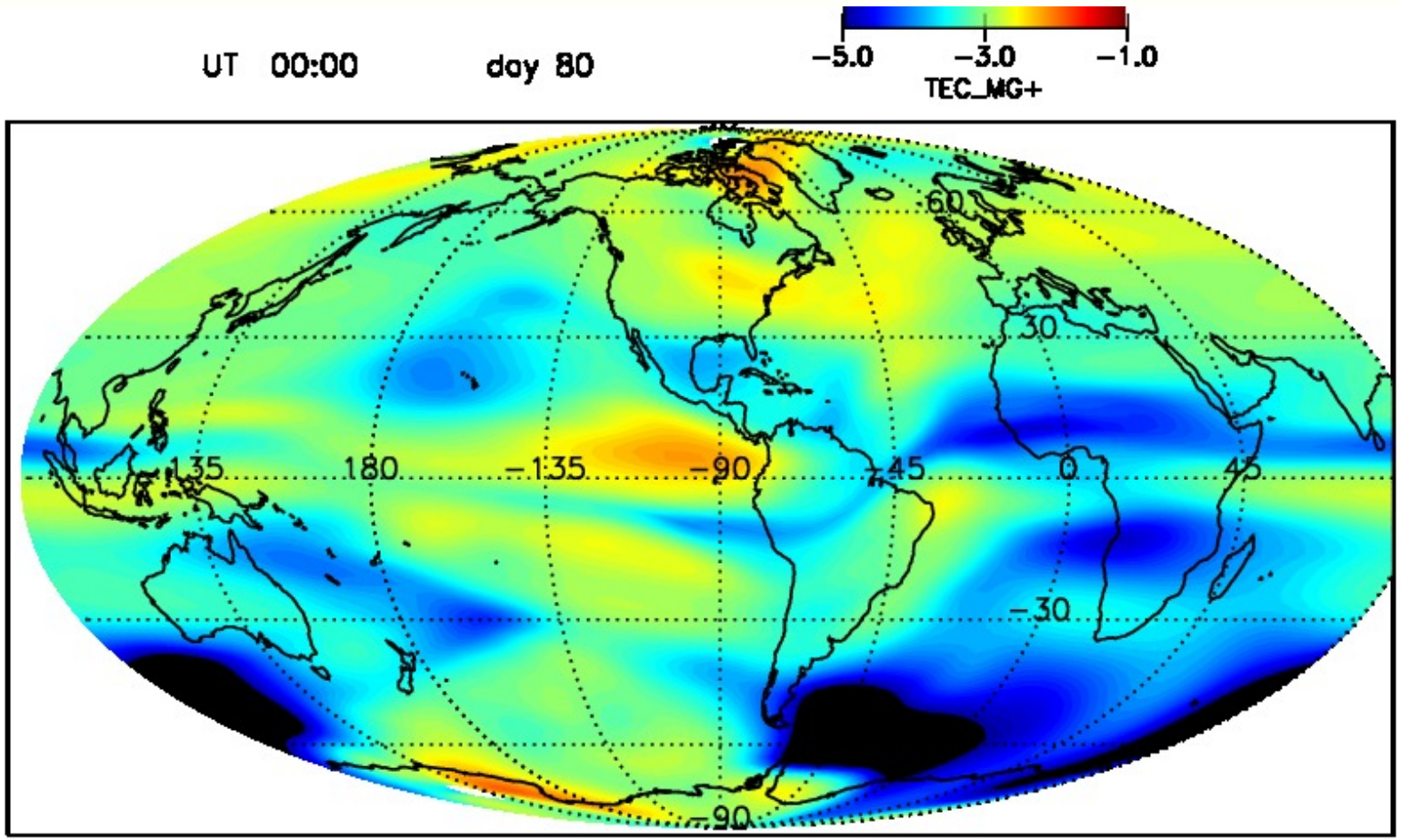
Mg^+ LAYERING/TRANSPORT DYNAMICS

latitude vs altitude



Mg^+ 'TEC' GLOBAL VIEW

column density: longitude vs latitude



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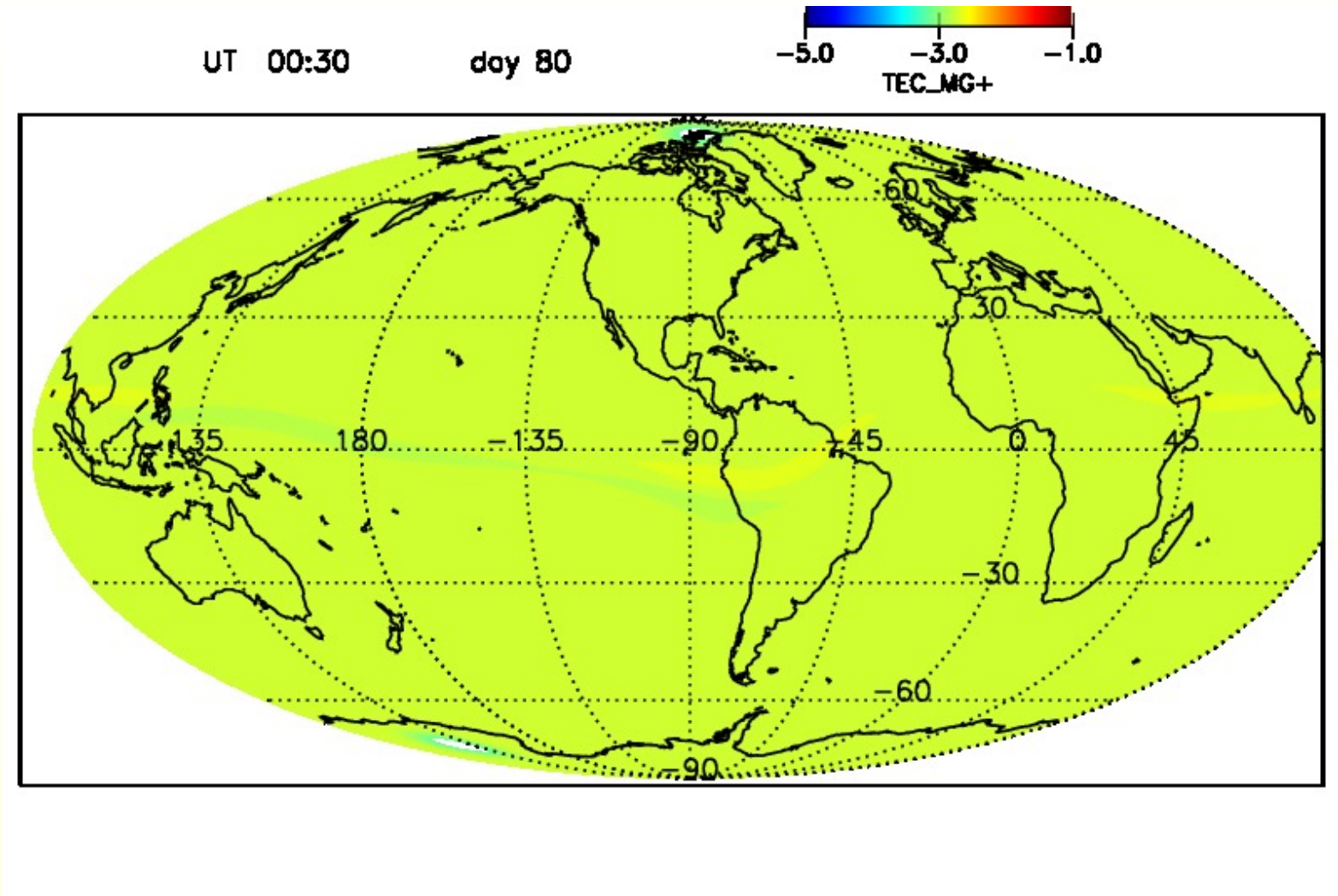

THE FUTURE

- SAMI3/ICON will run daily on the ICON server using TIEGCM/AMIE data
- SAMI3/GITM will be self-consistently coupled, i.e., SAMI3 will provide ion density, temperature, and velocities to GITM
- impact of metal ions on HF propagation
- develop high resolution global model with high-order flux-corrected transport