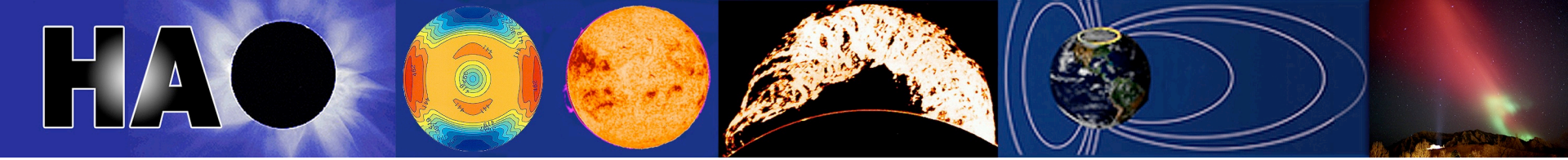


Modeling Ionospheric Super-Fountain Effect Based on the Coupled TIMEGCM-SAMI3

Gang Lu and Joe Huba

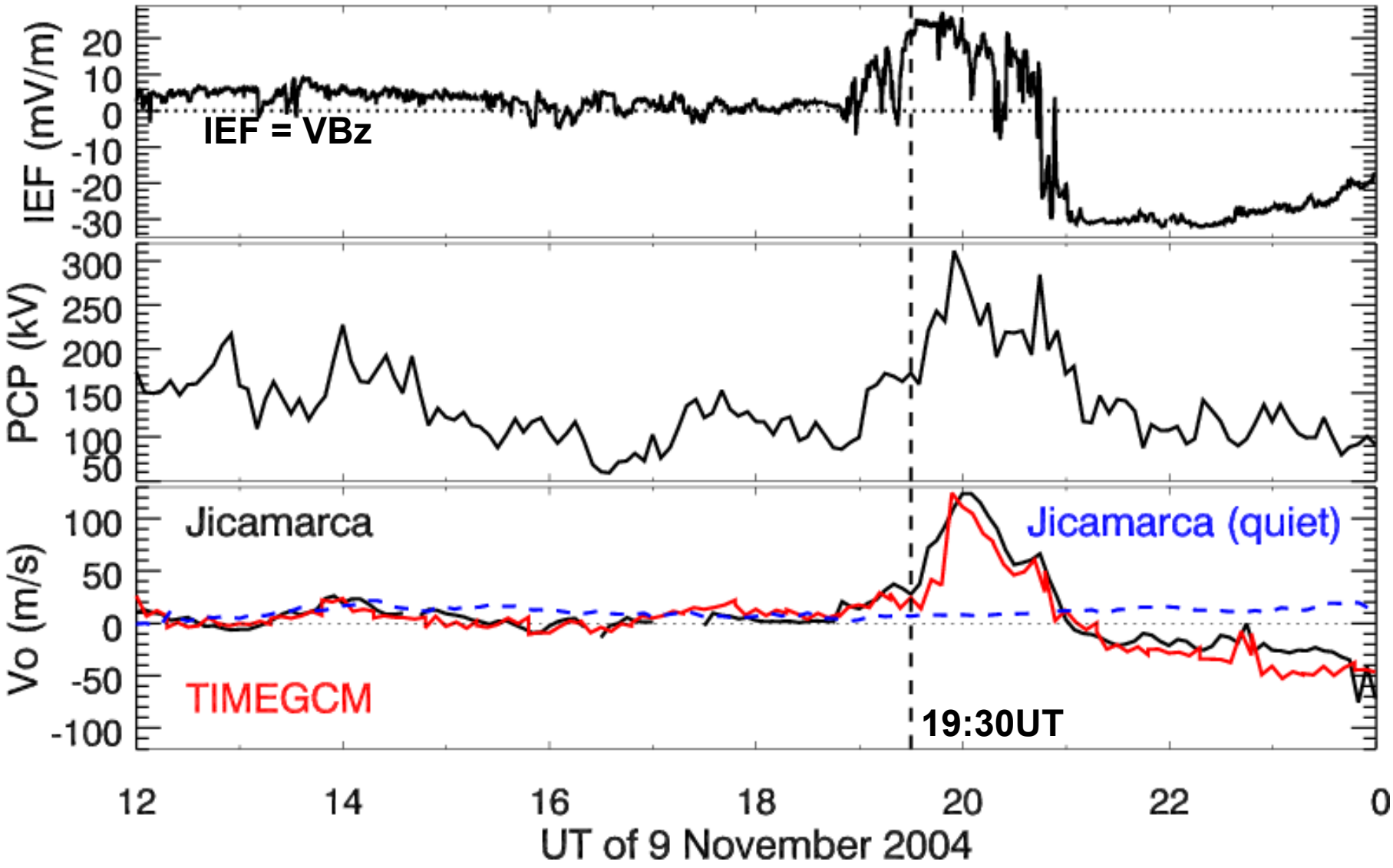
SAMI3

- A 3d global model of the ionosphere and plasmasphere, extending from 85km to a few R_E;
- Non-orthogonal, non-uniform, fixed grids, and the spatial resolution decreases with increasing altitude;
- Solving time-dependent equations of continuity and momentum for electrons and 7 ion species (i.e., H^+, He^+, O^+, O_2^+, N^+, N_2^+, and NO^+);
- Solving temperature/energy equations for 3 ion species (H^+, He^+, and O^+) as well as electrons;
- Including the ion inertia term in the ion momentum equation.

The Coupled TIMEGCM-SAMI3

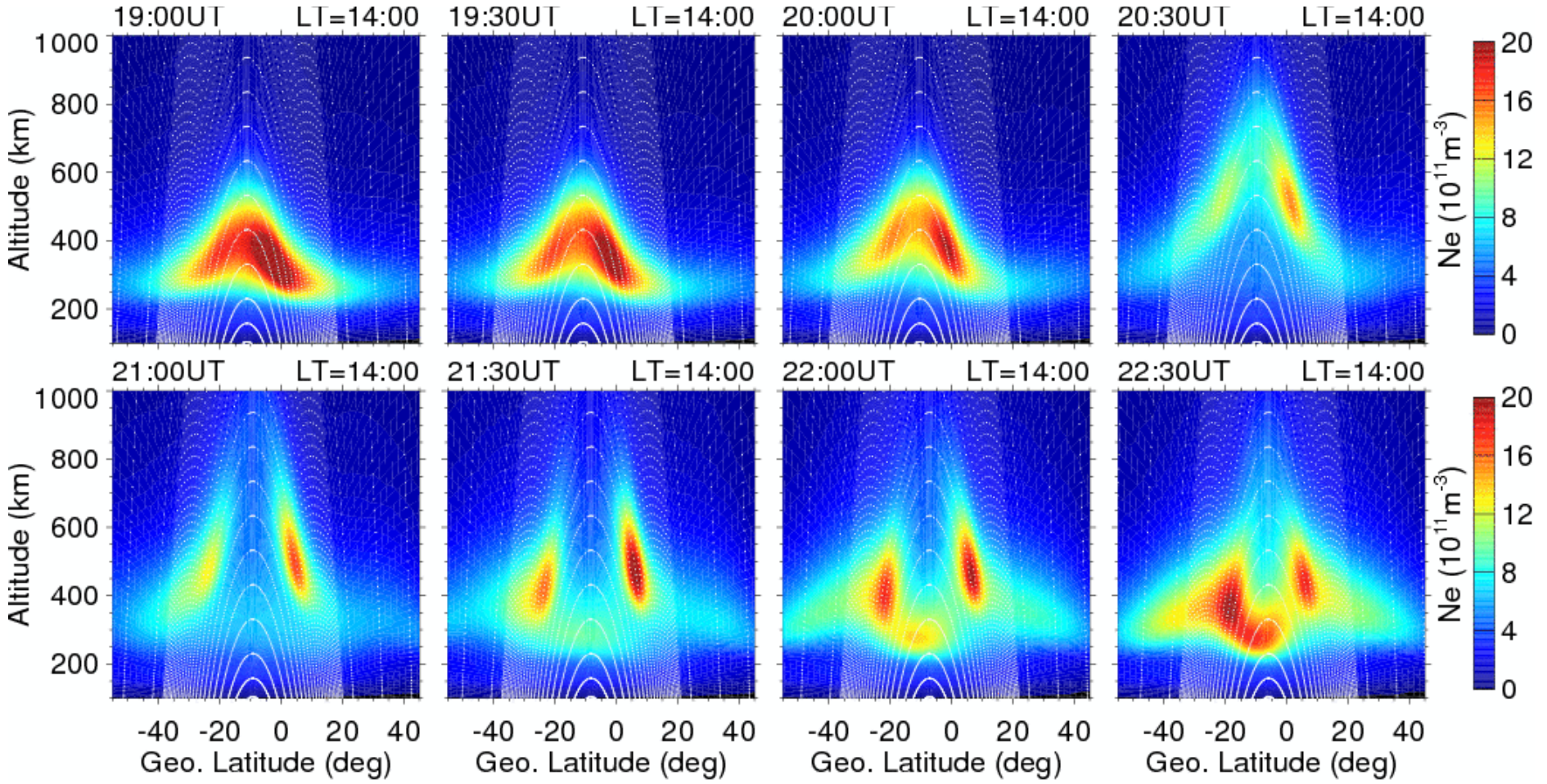
- Neutral species (i.e., H, O, O_2, N, N_2, and NO), but He from NRLMSIS00;
- Neutral temperature, neutral wind, (and electric field);
- Auroral energy flux and mean energy from AMIE-TIMEGCM;
- Implemented the auroral ionization code in SAMI3;
- The 5-min TIMEGCM outputs are interpolated spatially and temporally to drive SAMI3;
- Currently, it is one-way coupling!

Distributions of IEF, PCP, and Vertical Ion Drift



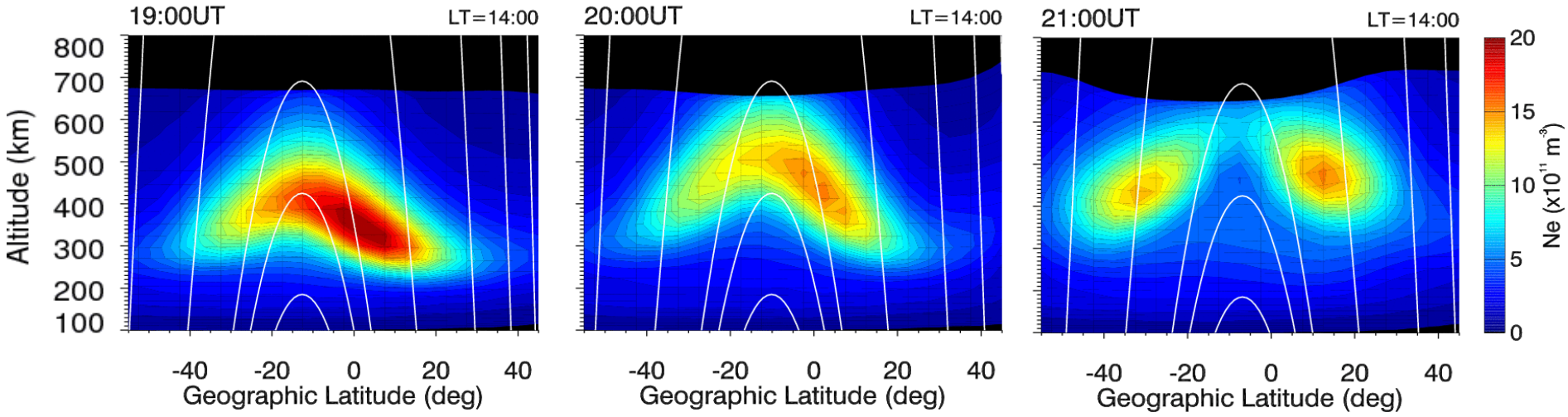
[Lu et al., JGR 2012]

Ne Variations during the course of PPEF

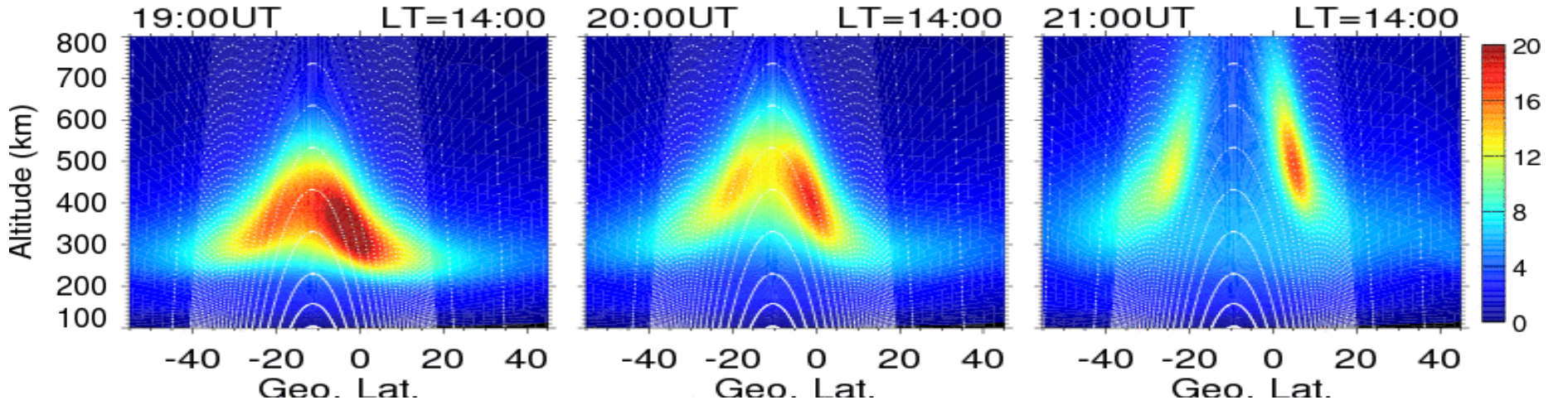


Comparison of TIMEGCM and SAMI Ne

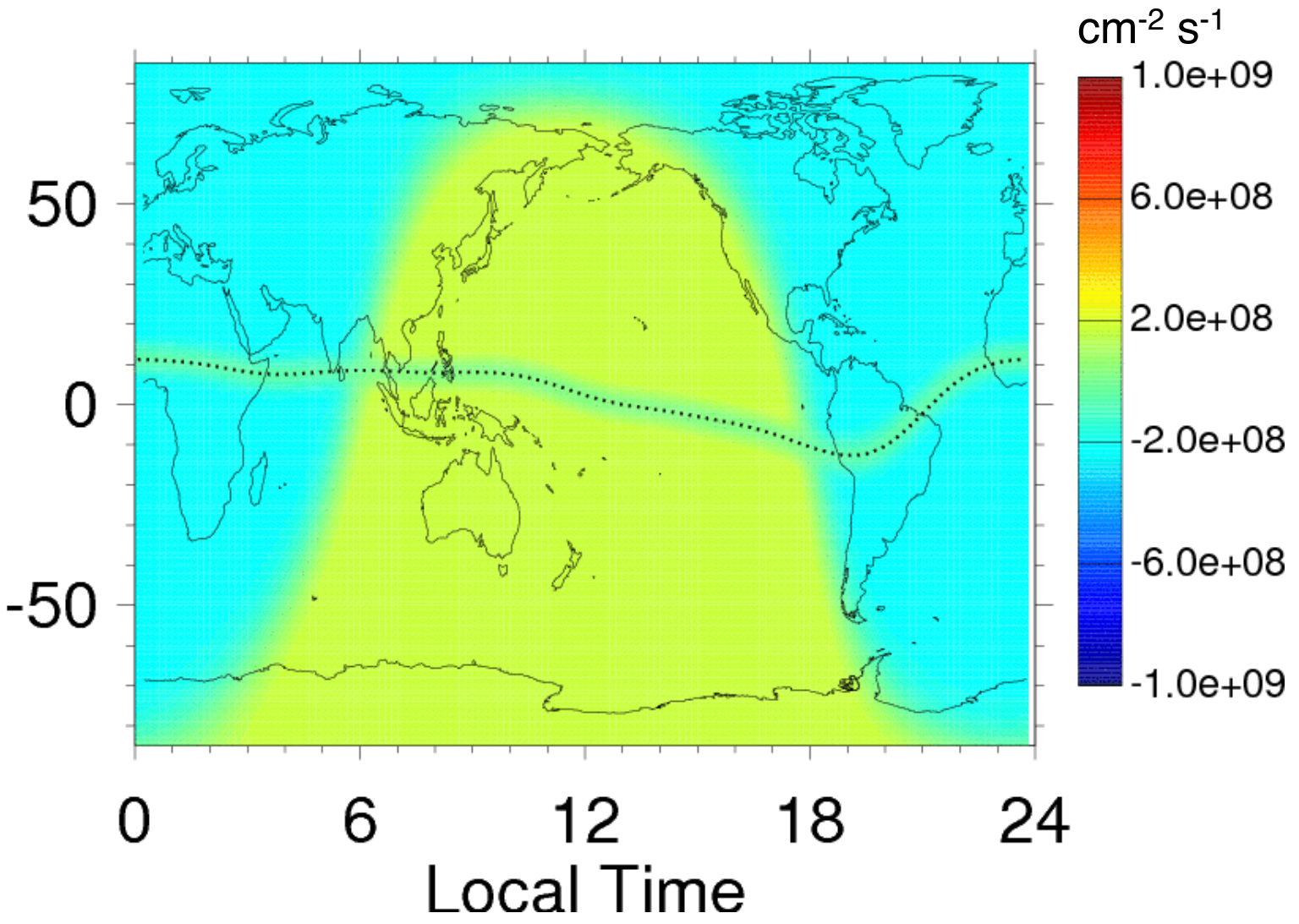
TIMEGCM



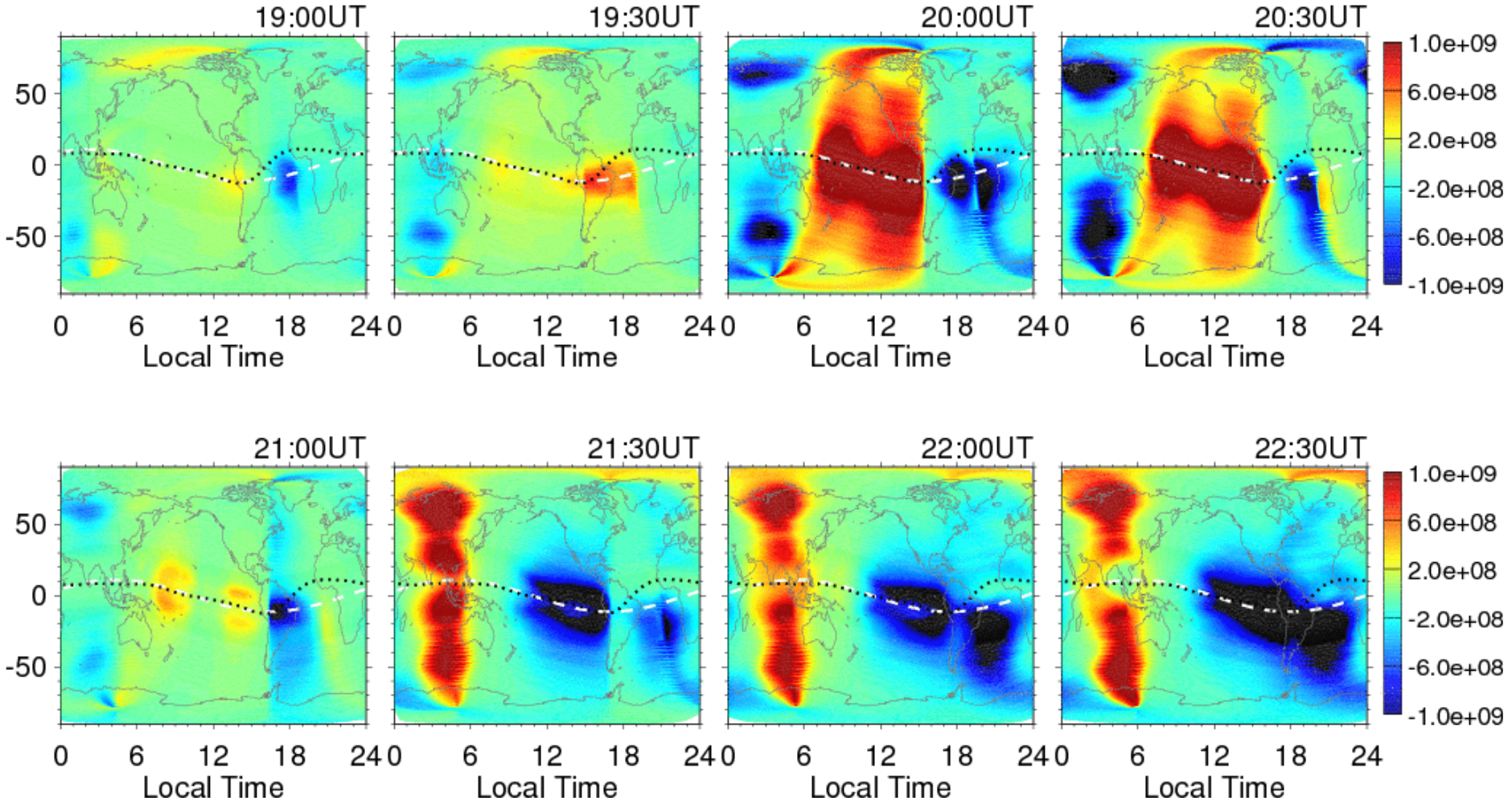
Coupled TIMEGCM-SAMI3



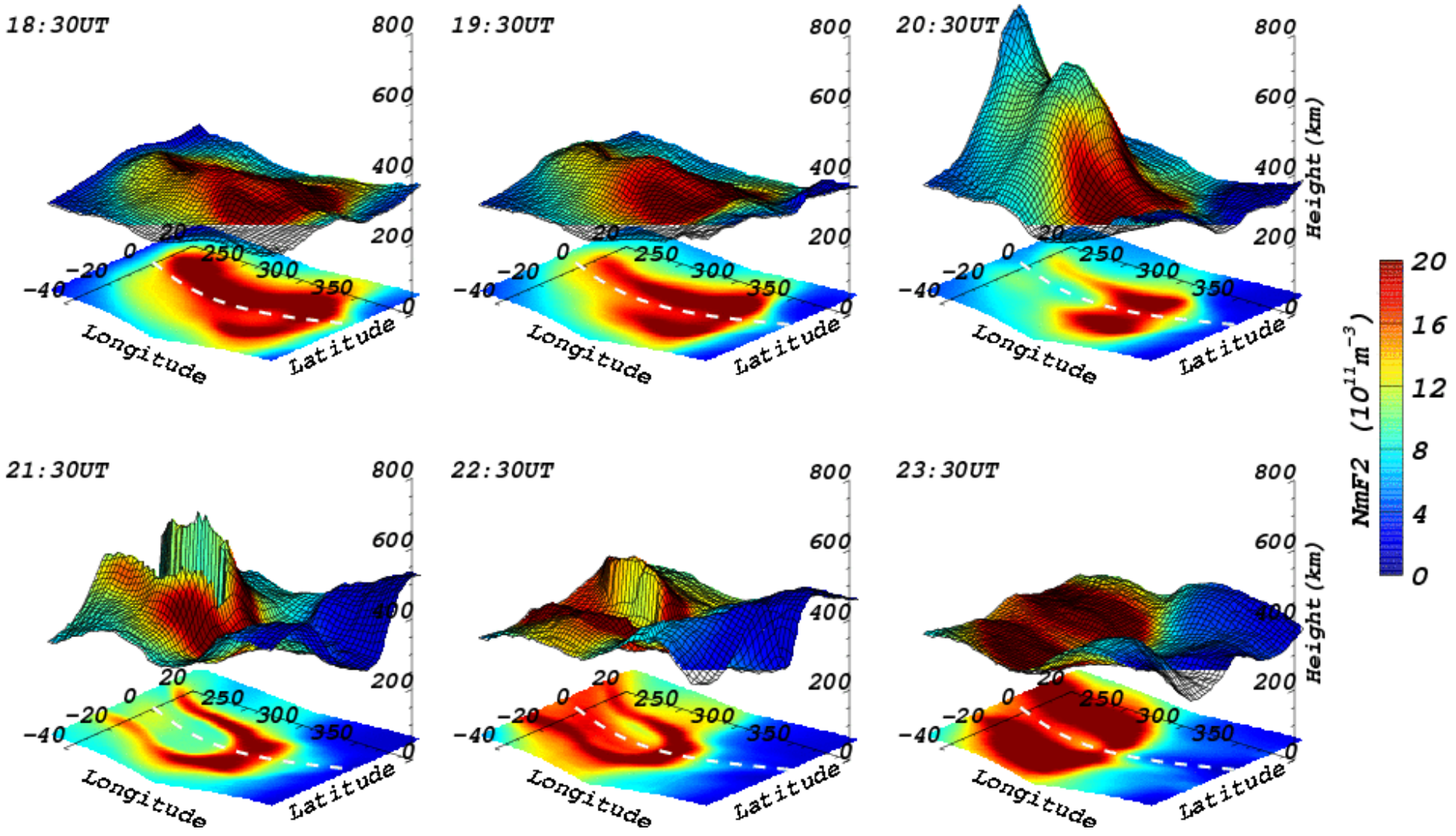
TIMEGCM O^+ Flux at 680 km

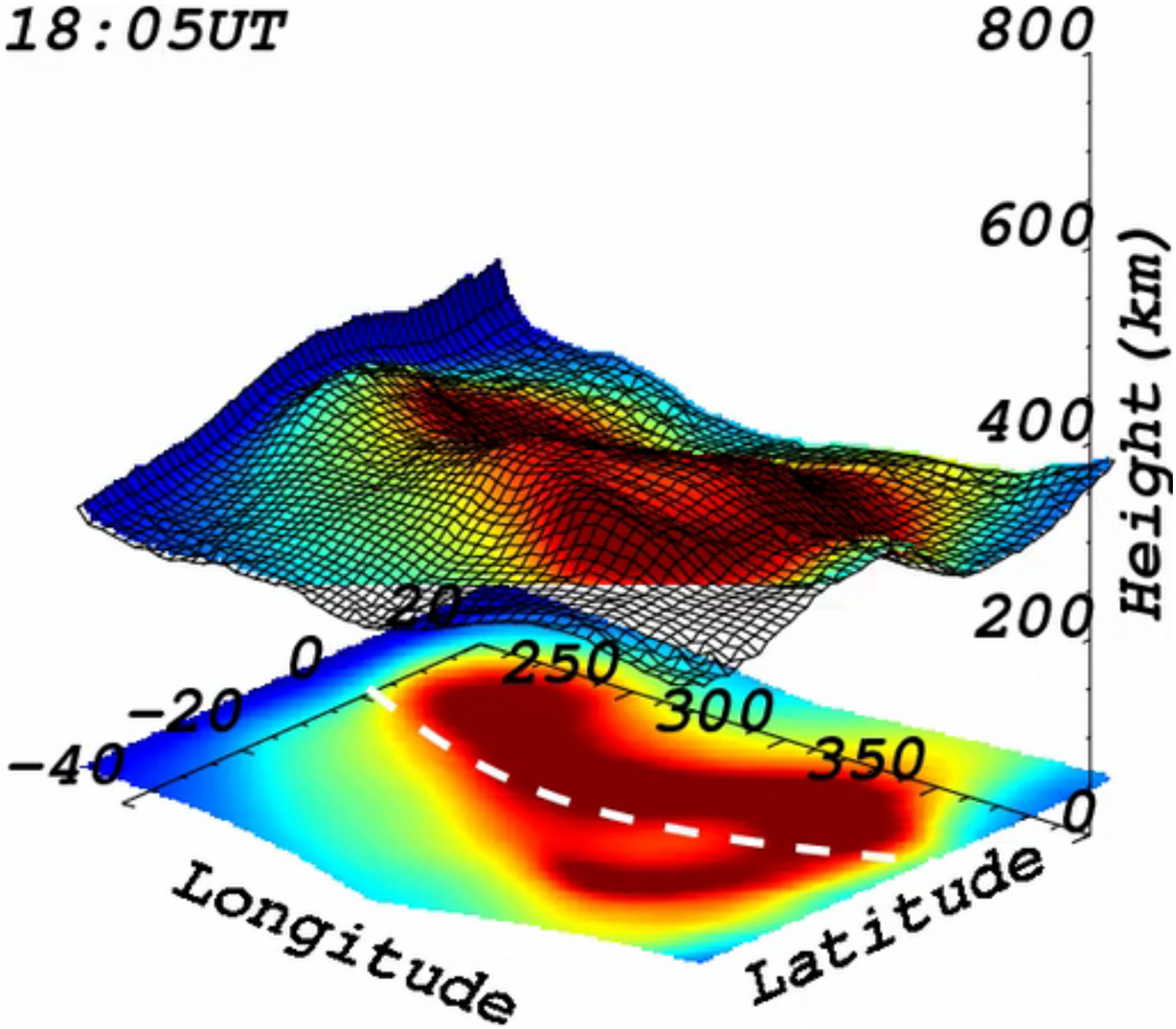


SAMI O^+ Flux at 680 km

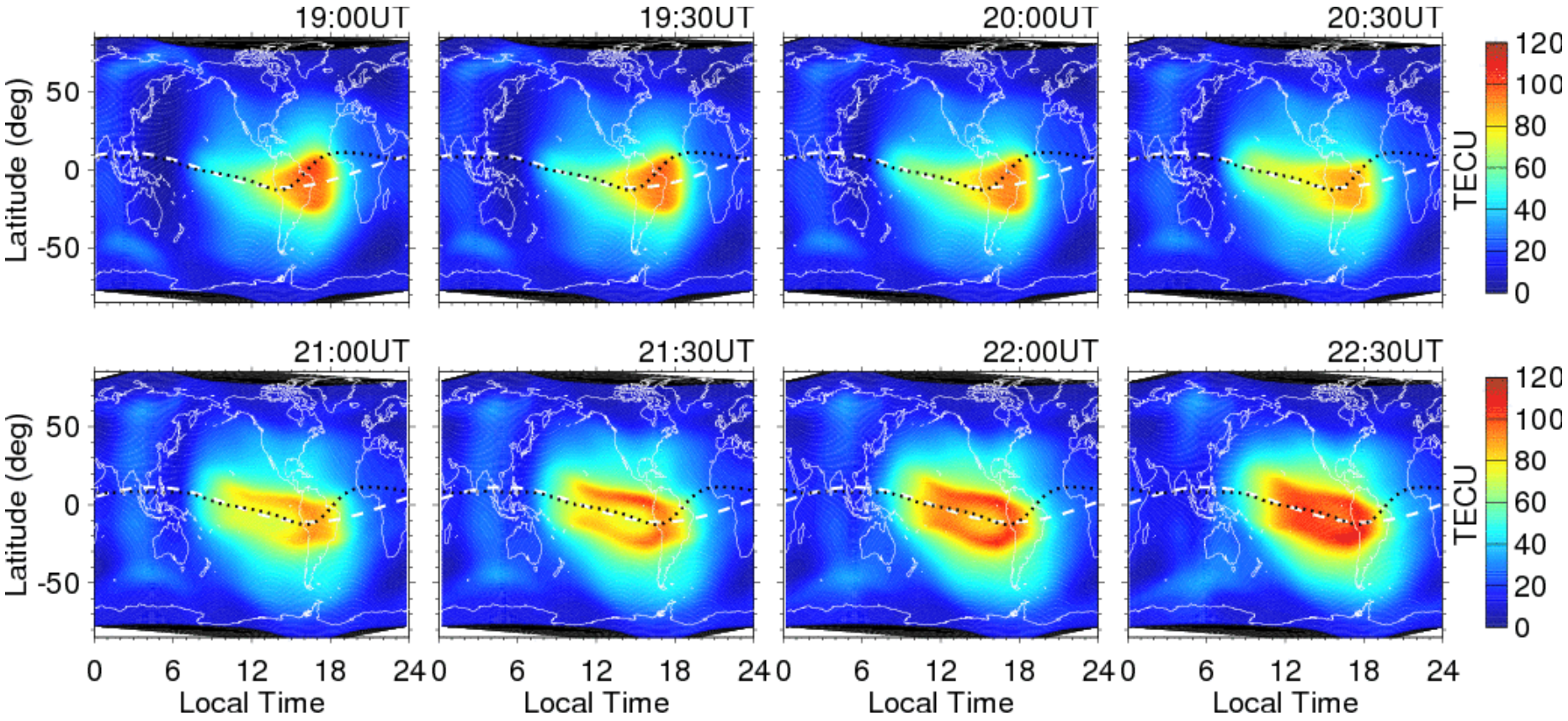


Evolution of HmF_2 During PPEF

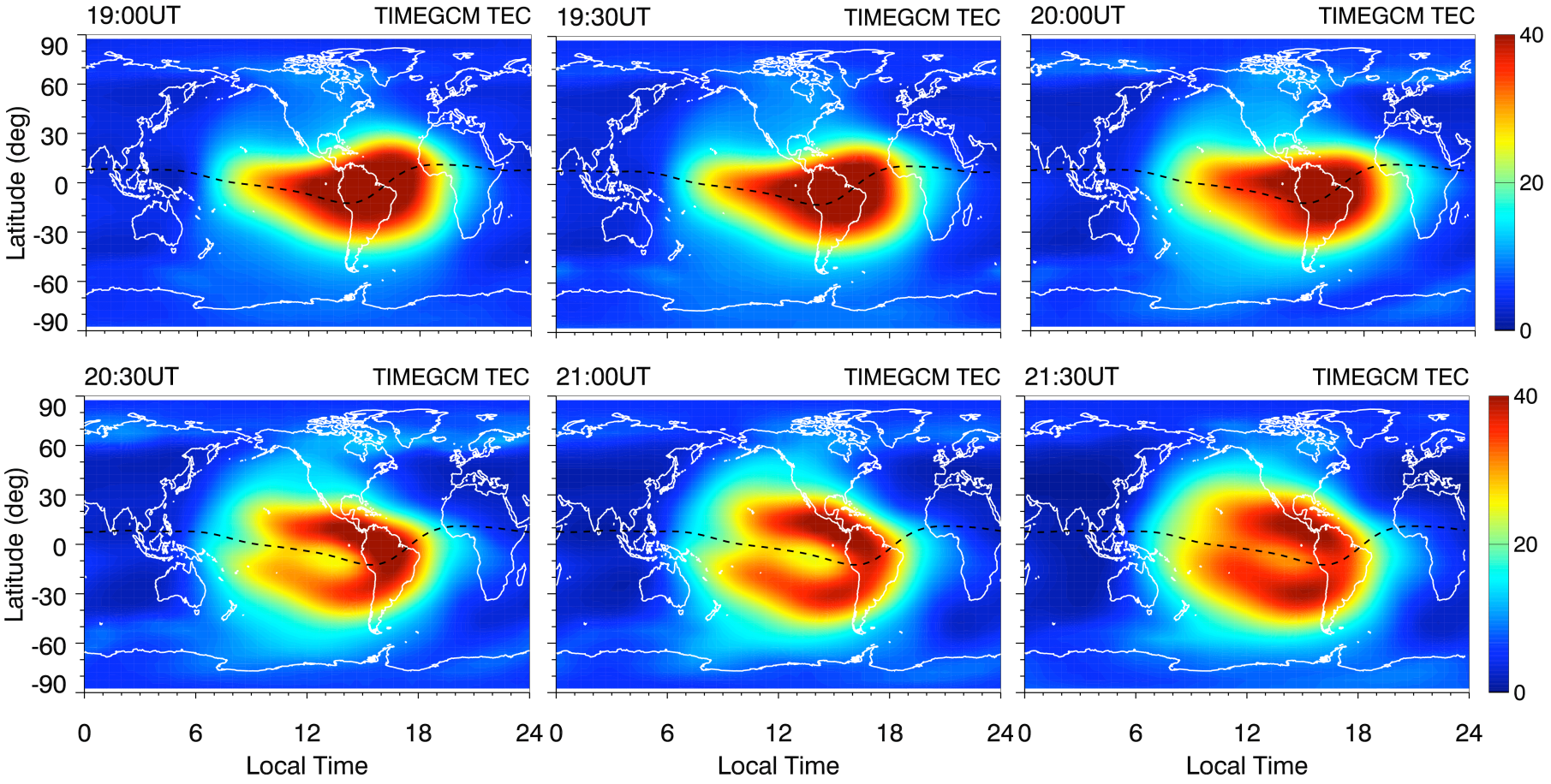



18:05UT
800
600
400
200
Height (km)
20
0
−20
−40
250
300
350
0
Longitude
Latitude

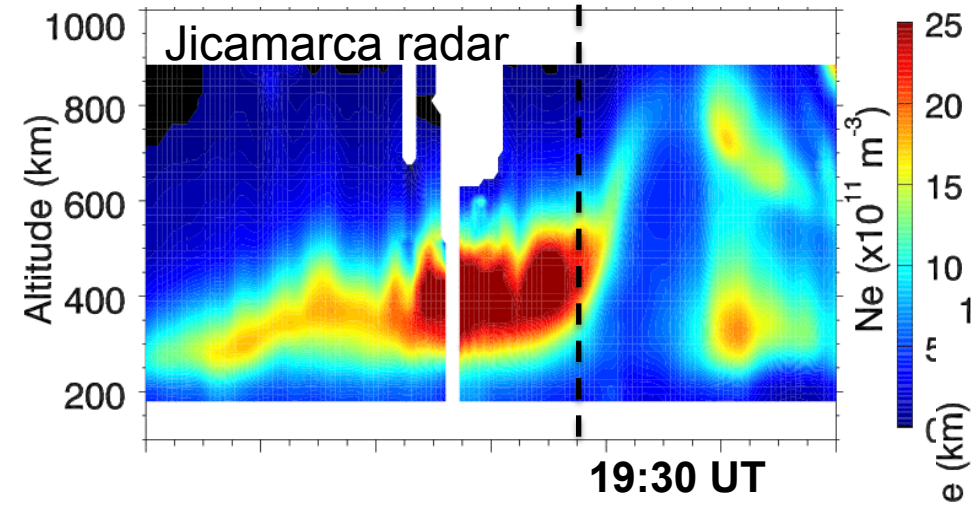
TEC Maps at Selected UT During PPEF

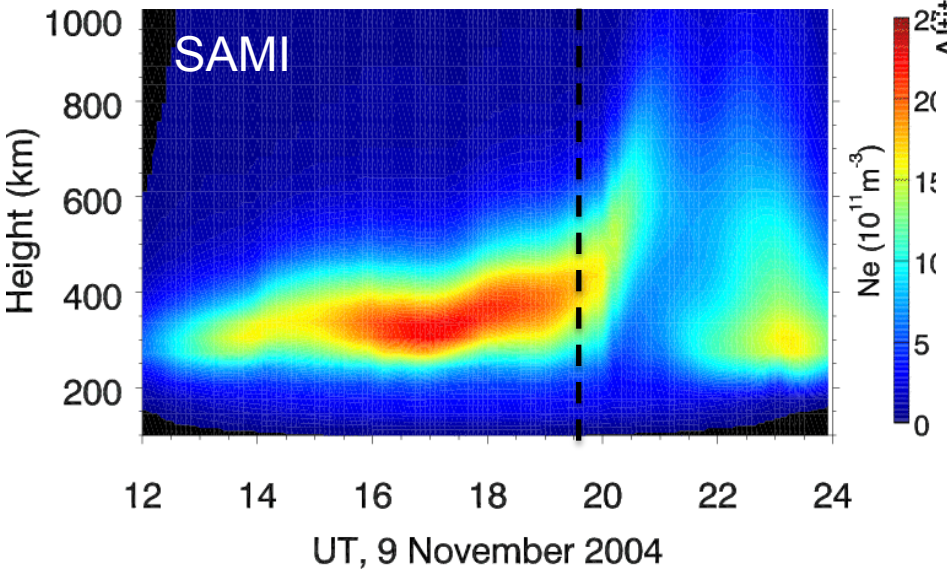


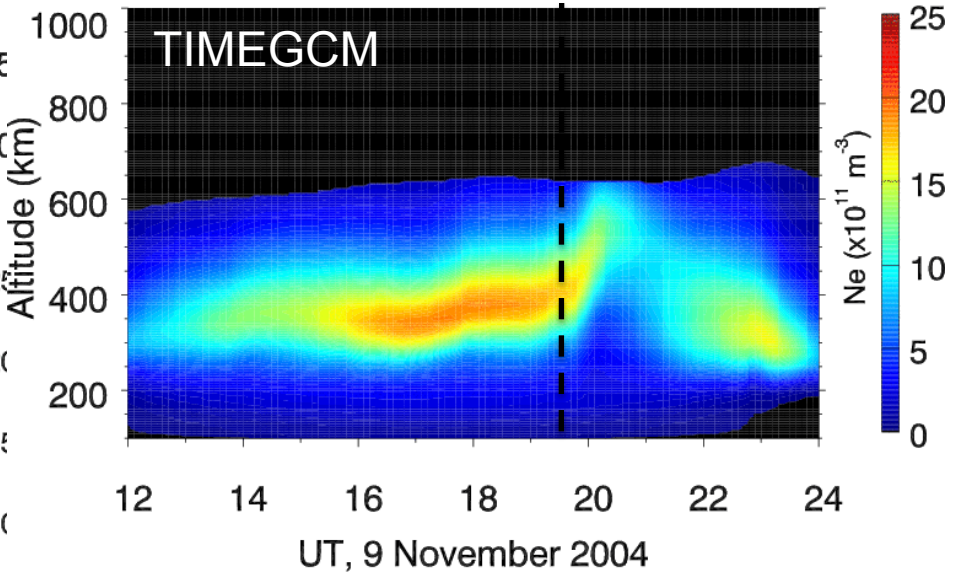
TIMEGCM TEC (below ~680km)



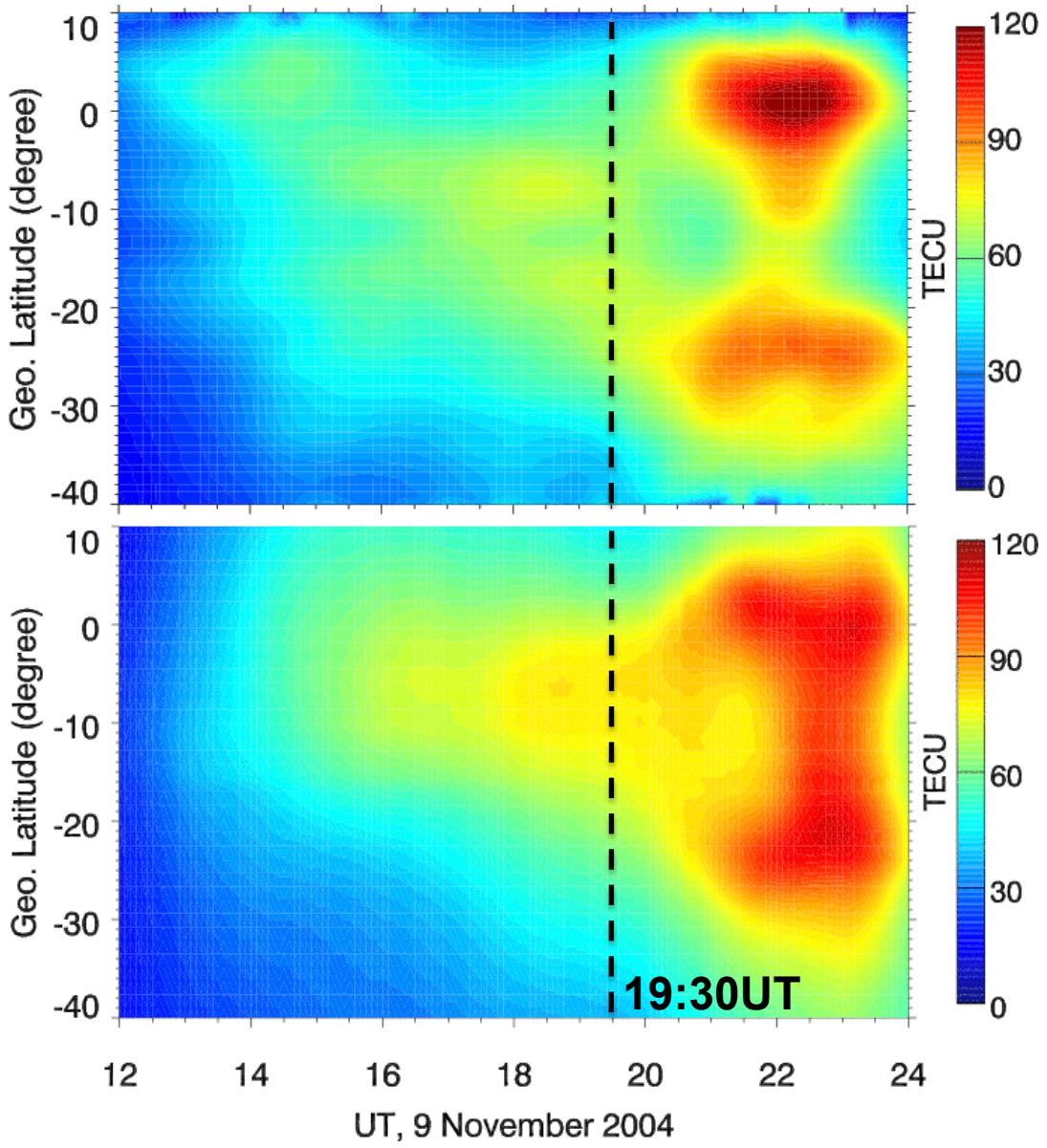
Comparison of Observed and Modeled Ne







Comparison of Observed and Modeled TEC at 75°W



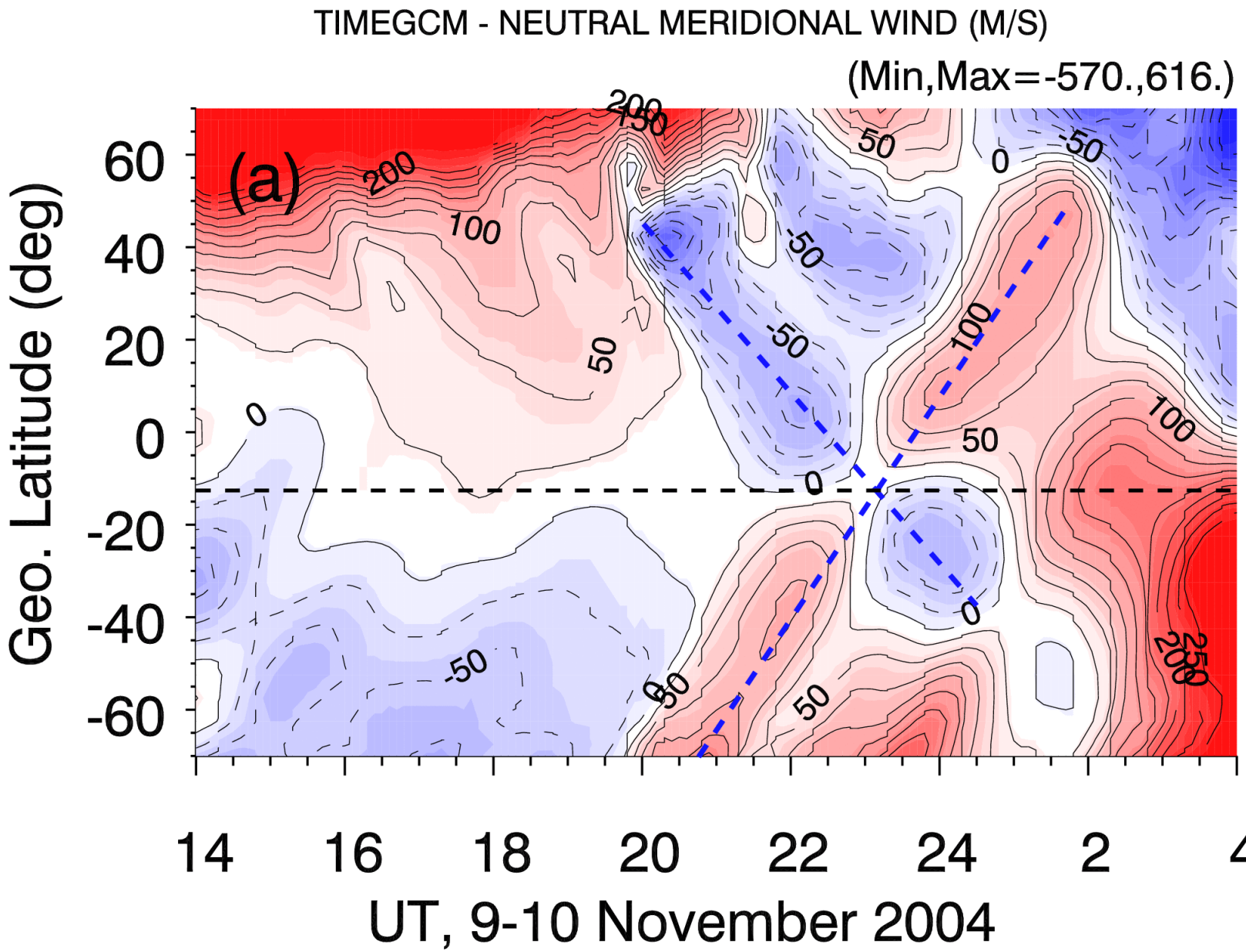
Boston College South American GPS Chain

TIMEGCM-SAMI3

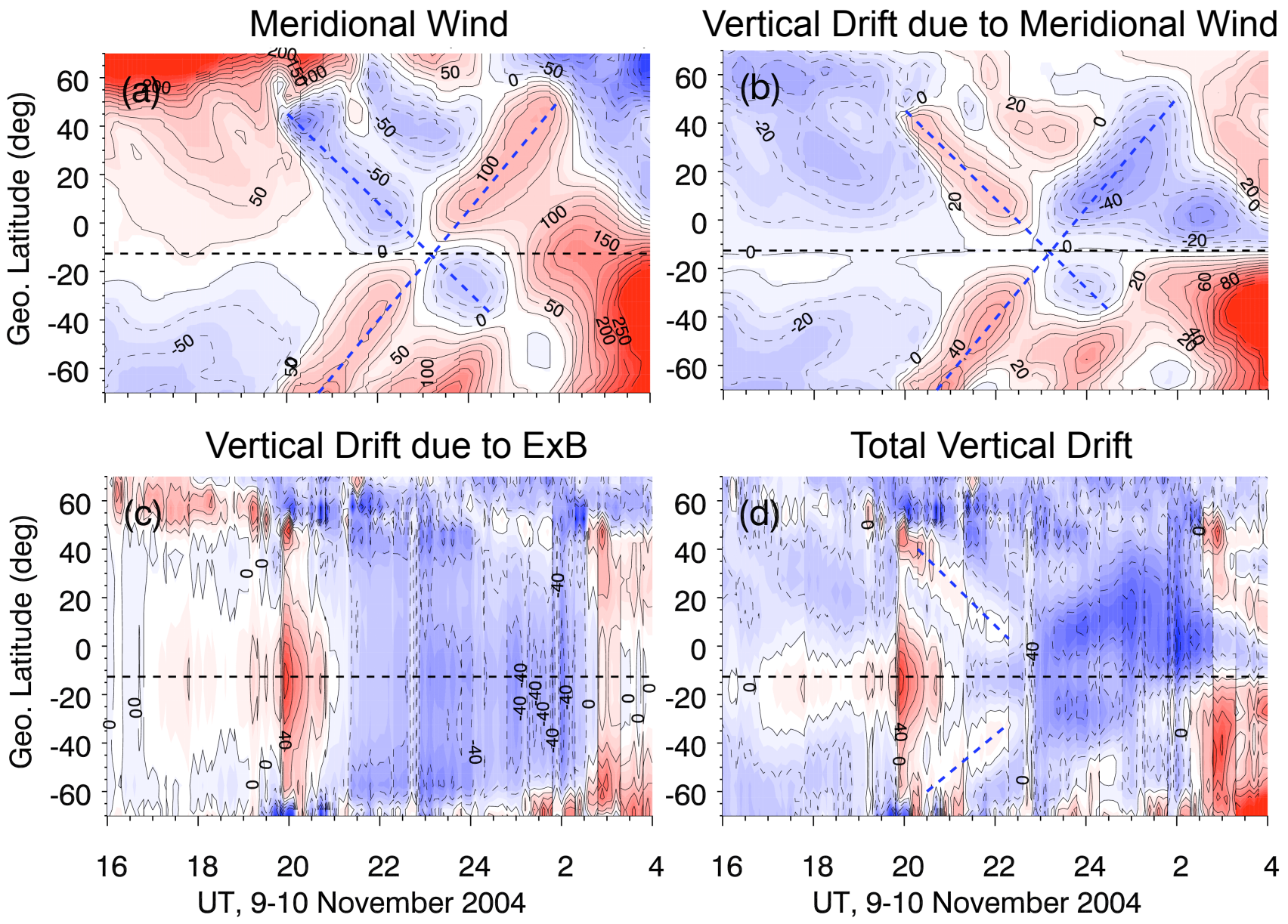
Summary

- The coupled model eliminates the upper boundary limitations of the TIMEGCM, showing a much improved agreement with observations;
- During PPEF, the super-fountain effect can lift the *F*-layer above 800 km;
- The O^+ fluxes exhibits complex latitudinal and longitudinal variations during PPEF, with strong upward and downward flows in localized regions, making it very difficult to parameterize the O^+ flux in the top ionosphere.
- Future improvements are needed:

  - realistic magnetic fields (i.e., IGRF)
  - two-way coupling

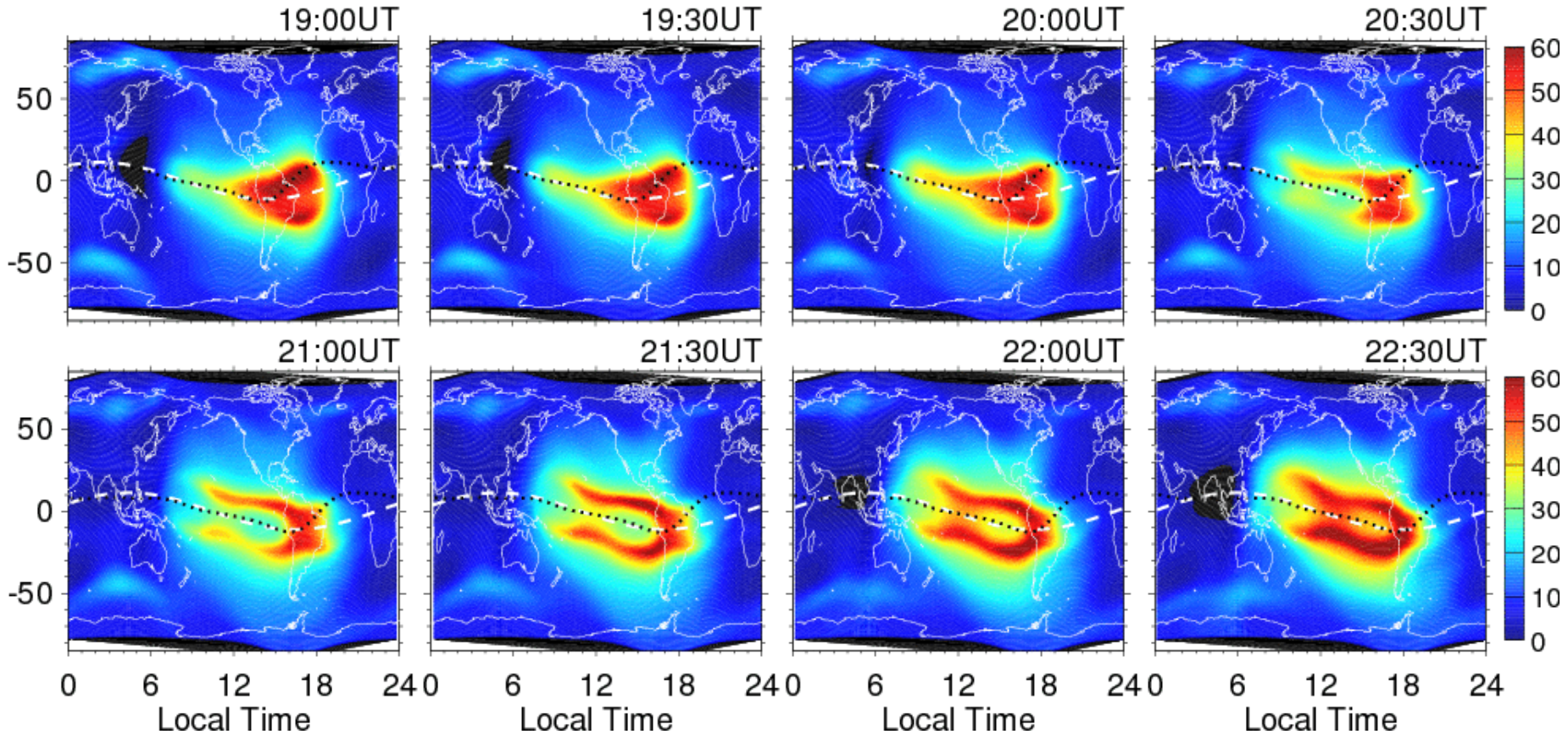


[Lu et al., JGR 2012]

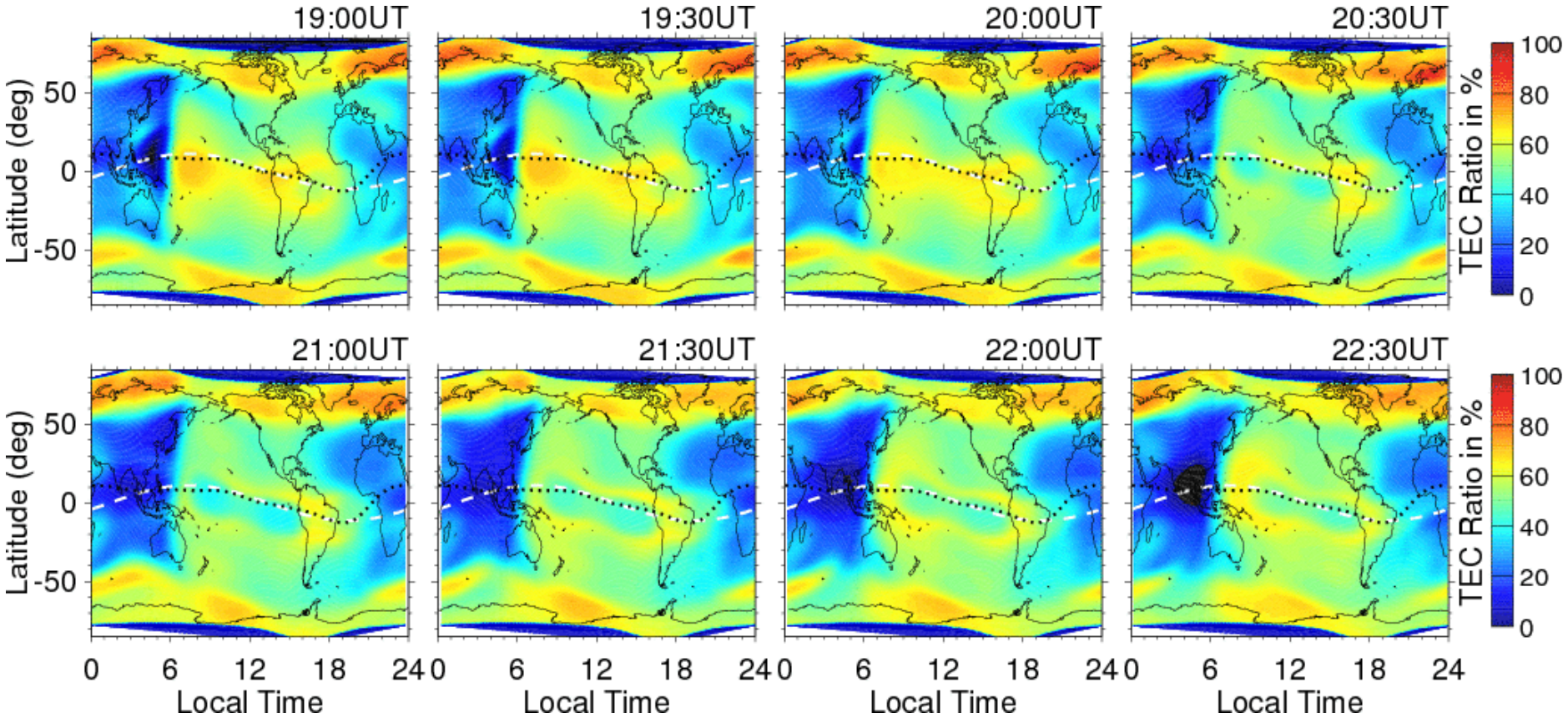


[Lu et al., JGR 2012]

SAMI TEC (below 680km) Maps

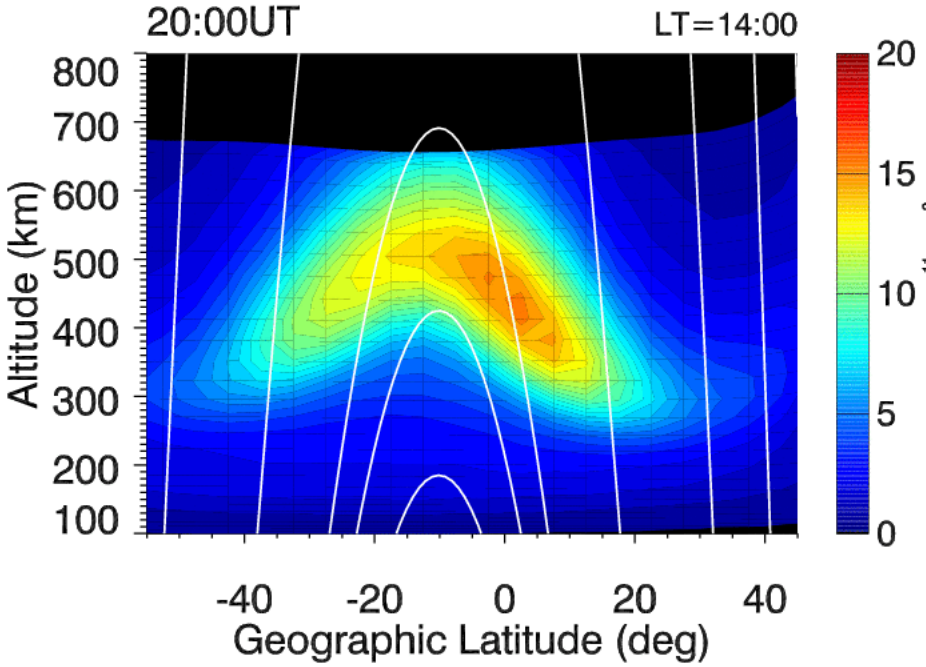


Ratio of TEC (below 680km)/TEC

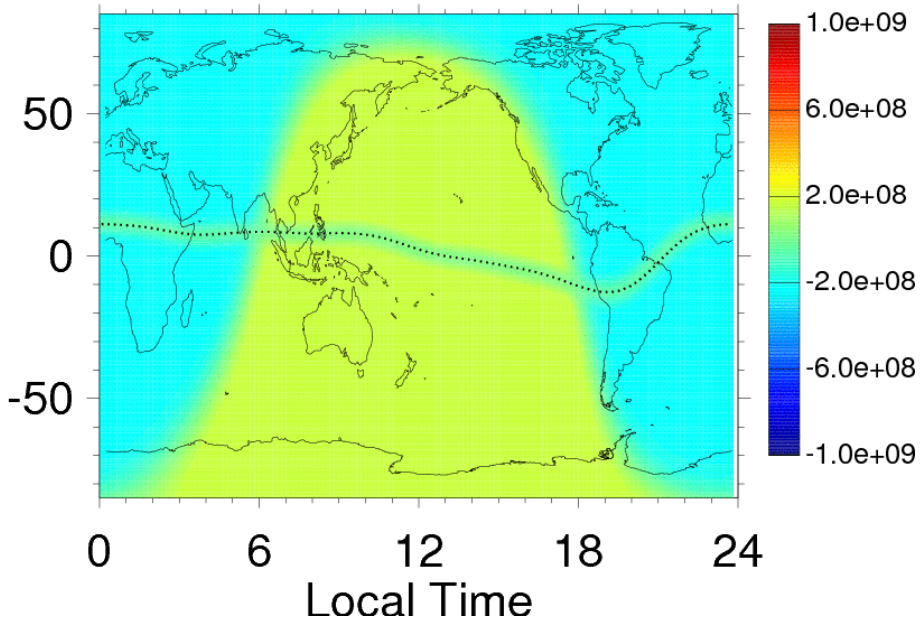


Two Major Limitations of the TIMEGCM

Fixed Upper Boundary at ~680 km



Prescribed O^+ Flux at the Upper Boundary



neutrals: H, O, O_2, N, NO, N_2
neutral wind and T_N
(electric fields)

TIMEGCM → **SAMI3**