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Solar-Terrestrial Coupling Processes
Tutorial Lecture III

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Ionosphere/Thermosphere:
Response to Disturbances
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Response to Disturbances

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Electrons and Ions

E region

F region

D region

Neutrals

Noon

Midnight

Altitude (km)

Number Densities (m$^{-3}$)

$10^8$ $10^{10}$ $10^{12}$ $10^{14}$ $10^{16}$ $10^{18}$
Ions and electrons spiral up and down based on atmospheric density. High atmospheric density results in increased electron-ion chemical recombination, while low atmospheric density results in decreased electron-ion chemical recombination.
Field-aligned currents between the ionosphere and outer magnetosphere

Currents between southern and northern hemispheres along magnetic field lines
Energy Flux (NH)
with contours of Electric Potential

97:01:10 10:55 UTC
data averaged over \pm 3 mins

contour increment is 10.0 kV
min pot. = -19.38 kV
max pot. = 60.29 kV
UAF Eulerian Ionosphere Model, $\log_{10}[N_e (\text{cm}^{-3})]$ at 350 km

3.00UT, $Kp=5$ - 12.00 LT

12.00UT, $Kp=5$ - 12.00 LT

18.00UT, $Kp=7$ - 21.00UT, $Kp=6$

$F_{10.7} = 225$

1990 March 20

1990 March 21
Energy Flux (NH)

- **97:01:10 02:55 UTC**:
  - Energy Flux: 21 GW
  - Min flux: 0.01 mW/m²
  - Max flux: 2.91 mW/m²

- **97:01:10 11:05 UTC**:
  - Energy Flux: 341 GW
  - Min flux: 0.01 mW/m²
  - Max flux: 71.36 mW/m²

Simple Joule Heating (NH)

- **97:01:10 02:55 UTC**:
  - Simple Joule Heating: 24 GW
  - Min heating: 0.00 mW/m²
  - Max heating: 7.57 mW/m²

- **97:01:10 11:05 UTC**:
  - Simple Joule Heating: 390 GW
  - Min heating: 0.00 mW/m²
  - Max heating: 95.81 kV
RESIDUALS OF NIGHTTIME PERTURBATION CAUSED BY WIND SURGE(S)

REGION 2 FIELD-ALIGNED CURRENTS

COMPOSITION DISTURBANCE ZONE

G. Prölls

EXPANSION CAUSED BY WIND SURGE(S)
January, 1997
Figure 13. Vertical ion velocity observed by the ISR compared with the meridional wind from the TIEGCM and the servo model (positive southward) at Arecibo on the night of January 9–10, 1997. The vertical lines indicate times of possible electric field penetration events (see text).
1997 January 9
ELECTRON DENSITY (CM3)
UT=21.00 LON= -70.00 (DEG) SLT=16.33 (HRS)

MIN, MAX = 0.0000E+00 1.0000E+06 INTERVAL = 1.0000E+05
TGCM13 /GANGLU/TGCM13/J97B10 (DAY,HR.MIN= 9,21, 0)

1997 January 10
ELECTRON DENSITY (CM3)
UT=21.00 LON= -70.00 (DEG) SLT=16.33 (HRS)

MIN, MAX = 0.0000E+00 1.0000E+06 INTERVAL = 1.0000E+05
TGCM13 /GANGLU/TGCM13/J97B22 (DAY,HR.MIN= 10,21, 0)
Figure 1. Idealized time variations of the AE index and polar cap potential drop used in this work.

Figure 2. Equatorial vertical drift perturbations for the conditions and at the five storm times shown in Figure 1. The dots indicate the average perturbation velocities obtained by binning the data; the X denotes an average from less than 5 samples, and the vertical bars are the standard deviations. The solid curves indicate the velocity patterns determined from an analytical model.
Sensitivities of Ionosphere/Thermosphere Response

- Polar ionospheric plasma distribution depends sensitively on space-time distributions of auroral precipitation and electric fields
- Midlatitude boundary between increases and decreases of \( \text{N}_2/\text{O} \) ratio depends sensitively on space-time distribution of high-latitude electric fields and currents
- Amplitude and timing of traveling atmospheric disturbances depends sensitively on temporal variations of high-latitude Joule heating
- Sign and amplitude of low-latitude disturbance electric fields depends sensitively on space-time distribution of high-latitude electric fields and Joule heating

Critical Need for Progress in Predicting Storm Effects in the Ionosphere/Thermosphere:

- Accurate determination of space-time distributions of high-latitude electric fields, currents, and particle precipitation
Some References


1997 January 10 AMIE results
http://www.hao.ucar.edu/public/research/tiso/cedar/jan97.html

1997 January 10 TIE-GCM results
http://www.hao.ucar.edu/public/research/tiso/tgcm/tgcm.html