How to quantify storm impact on the ionosphere and thermosphere

Tim Fuller-Rowell

NOAA Space Weather Prediction Center and
CIRES University of Colorado

Storm response: talking points
Identify and validate the physical processes?

Process 1

Quantifying the storm energy input

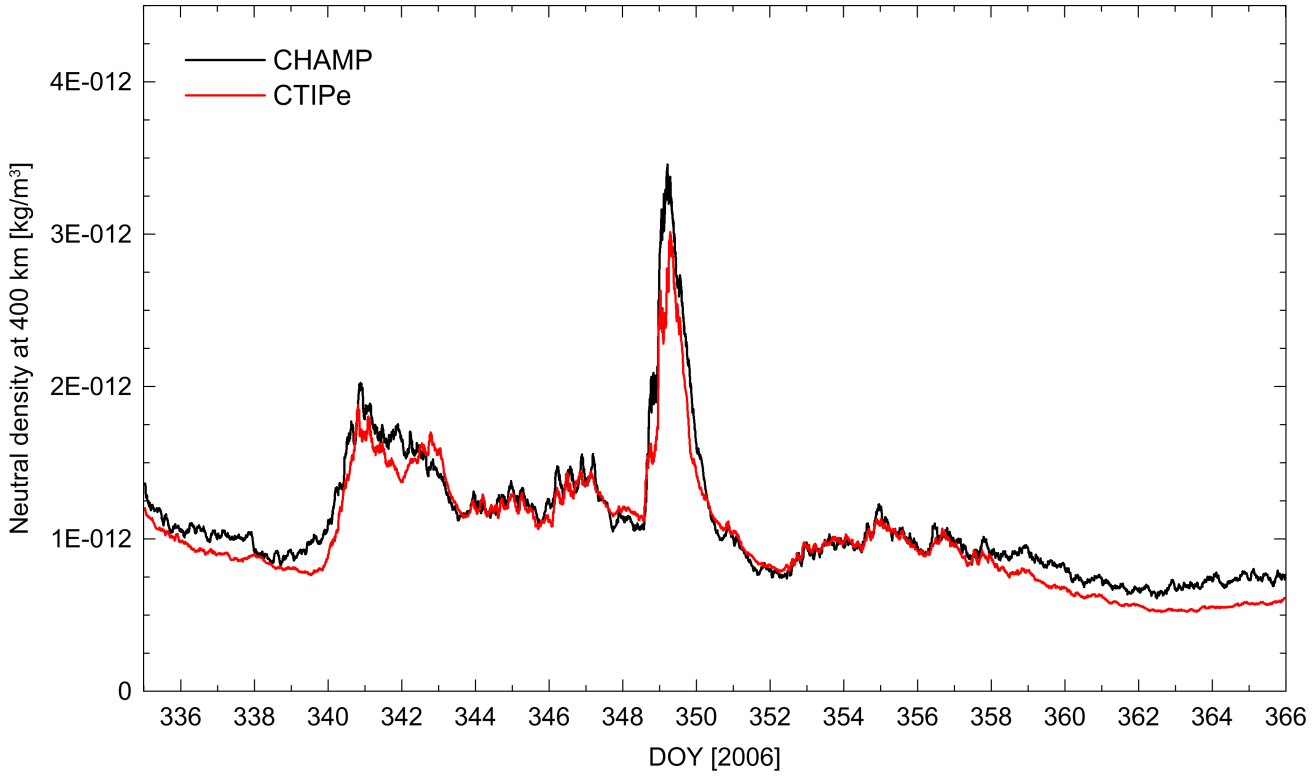
- Increase in magnetospheric/ionospheric high latitude convection and auroral precipitation
- Enhances conductivity at high latitudes and NO production
- [High latitude winds accelerate by ion drag]
- Joule heating increase, radiative cooling, thermal expansion, and increase in neutral density

Magnitude of Joule heating hard to validate.

NO cooling IR radiation measured by SABER ($\propto$ NO and T)

Rate of temperature/density response and recovery

CTIPe vs CHAMP Dec 2006
Mariangel Fedrizzi



Process 2

Expansion of convection to low latitudes

- Penetration electric fields imposed at low latitude
- Recovery/shielding time-constants
- EIA response

Time series of penetration electric field difficult to validate (e.g., Jicamarca, magnetometers).

Confused by dynamo.

Confused by variations in shielding time constants.

Later: validation of total E at low latitudes, penetration + dynamo + time constants

Later: Validate integrated response of equatorial ionospheric anomaly (EIA)

Process 3

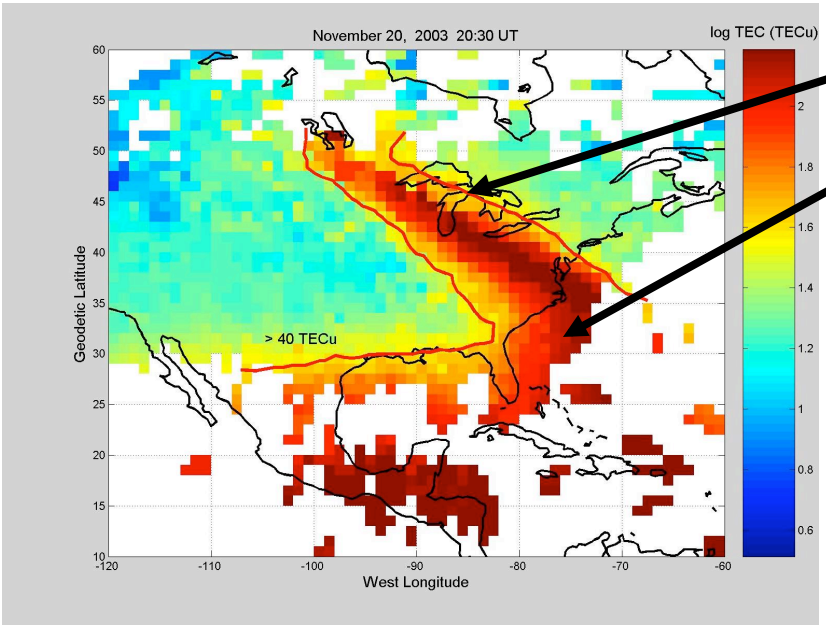
Build-up of plasma and structure at mid-latitudes

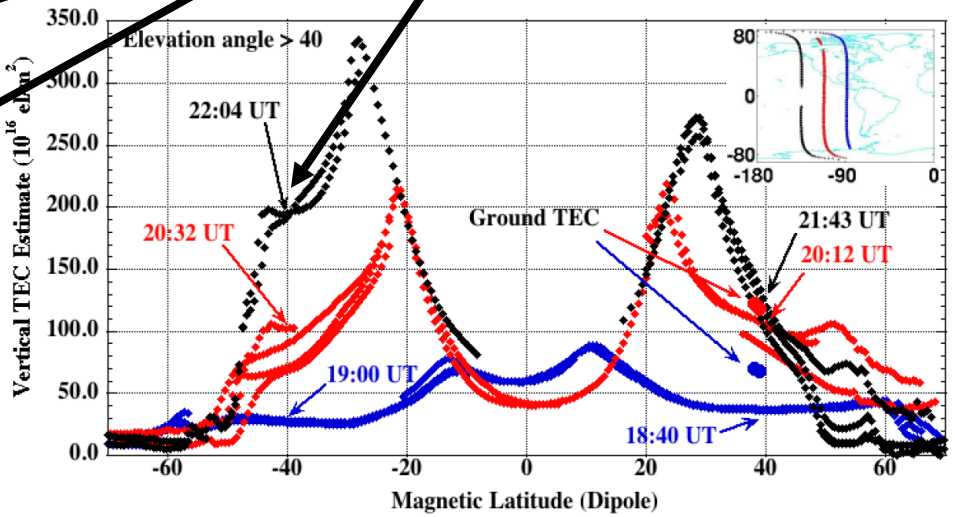
Validate TEC from GPS maps

Validate in-situ from satellite

Validate point with ionosondes

Large increases in TEC (bulge) and structure (SED)

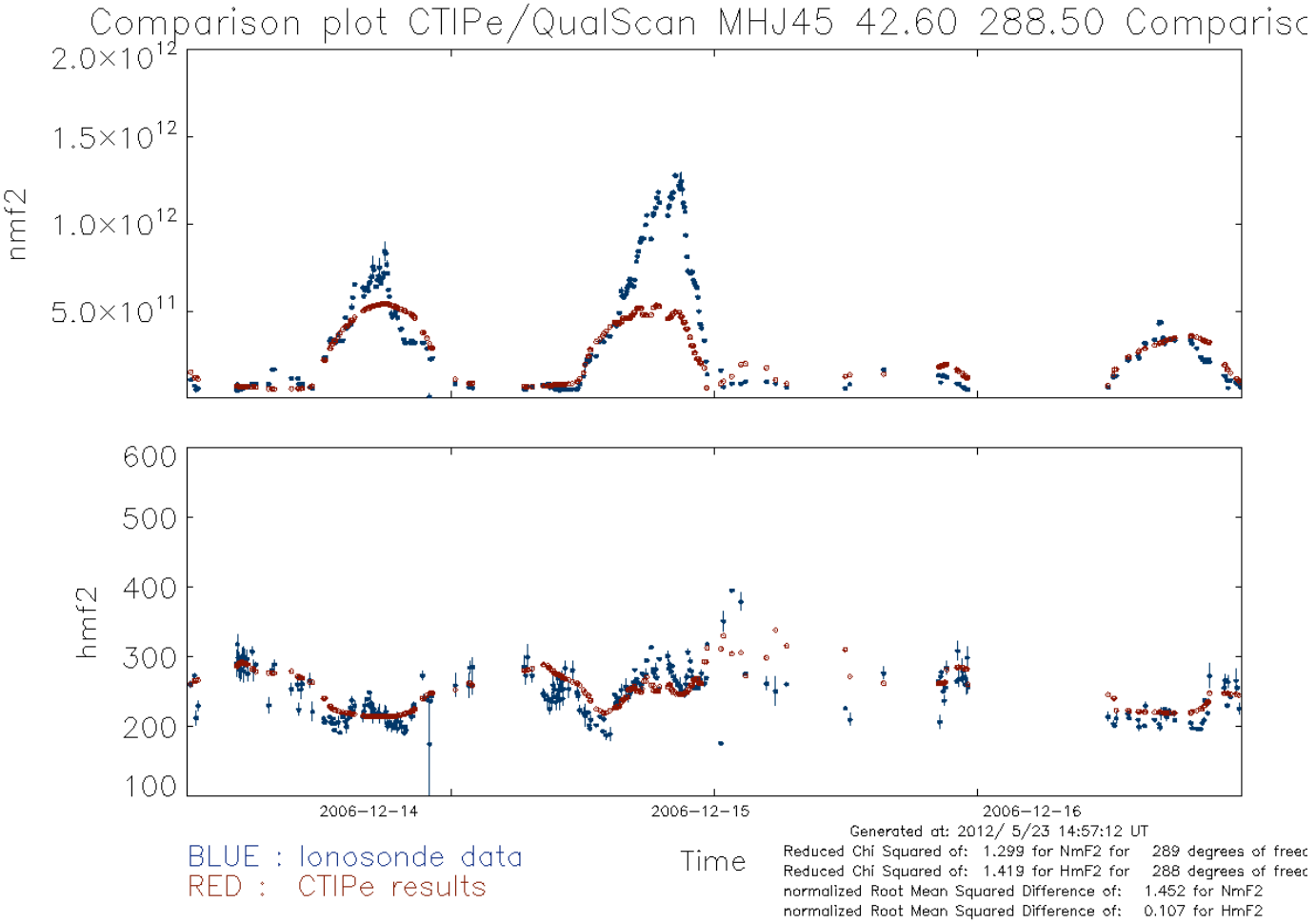




Foster and Coster

Mannucci et al 2005

Ionosonde NmF2, hmF2 at Millstone Hill



Process 4

Gravity wave propagation from high to low latitude

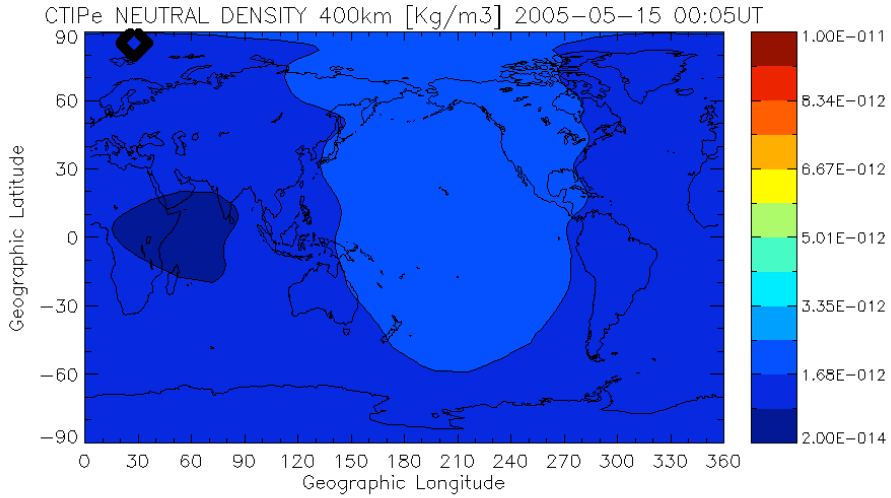
Validate arrival and magnitude of waves.

C/NOFS observations.

Ground-based FPI.

CHAMP density waves.

Can be a complicated superposition.



Process 5

Onset/timing/evolution of global circulation

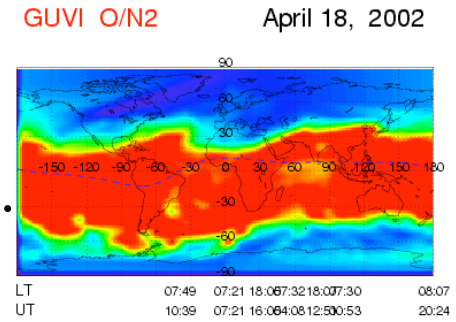
Difficult to validate.

Process 6

Onset/timing/evolution of neutral composition change

Response and recovery of O/N_2, e.g., TIMED/GUVI.

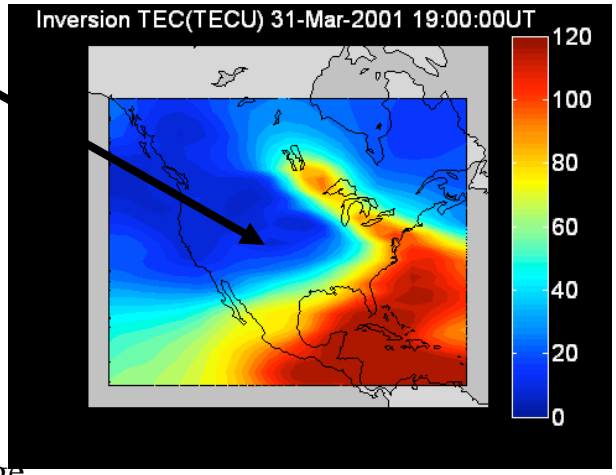
Movement of boundaries in O/N_2, e.g., TIMED/GUVI.



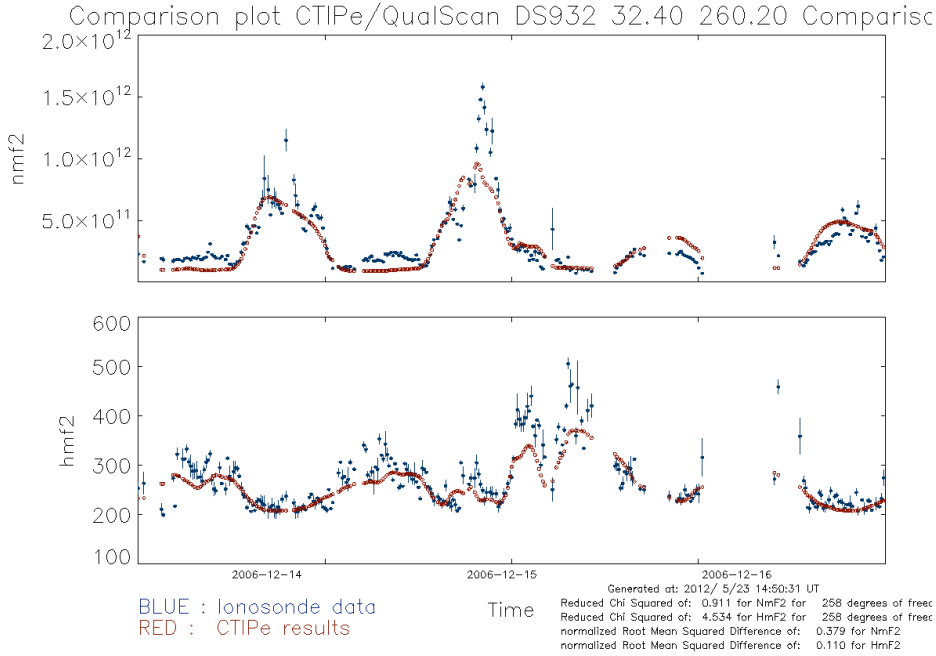
Process 7

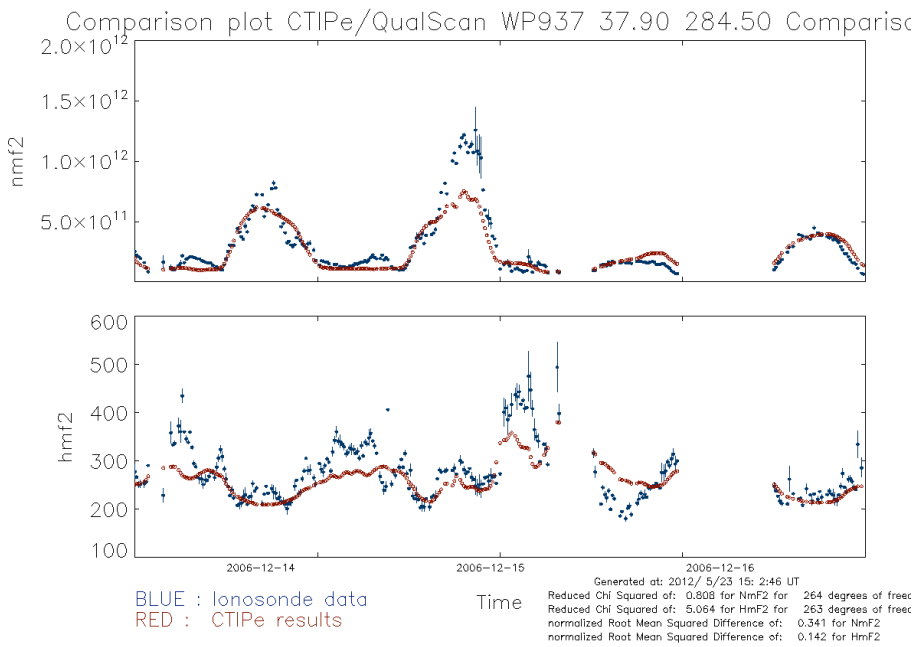
Ionospheric negative storm phase at mid latitude

- Validate TEC from GPS maps
- Validate in-situ from satellite
- Validation point with ionosondes



Ionosondes at mid-latitude





Process 8

Disturbance dynamo

Difficult to validate.

Confused by penetration electric field and its time constants.

Process 2 and 8

- Penetration and disturbance dynamo at low latitudes combined

Time series of electric field (e.g., Jicamarca, magnetometers).

Validation of total E at low latitudes, penetration + dynamo + time constants

Validate total EIA response

Validate processes

Process 1: Quantifying the storm energy input.

Process 3: Build-up of plasma and structure at mid-latitudes

Process 4: Gravity wave propagation from high to low latitude

Process 6: Onset/timing/evolution of neutral composition change

Process 7: Ionospheric negative storm phase at mid latitude

Process 2 and 8: Combined penetration and dynamo electric fields and EIA response