How to quantify storm impact on the ionosphere and thermosphere

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Magnetospheric forcing initiates a range of physical processes
Goal: Identify the physical processes and develop
process-orientated model validation

Process 1

The geomagnetic storm energy input to the thermosphere-ionosphere system. Quantifying the energy dissipation.

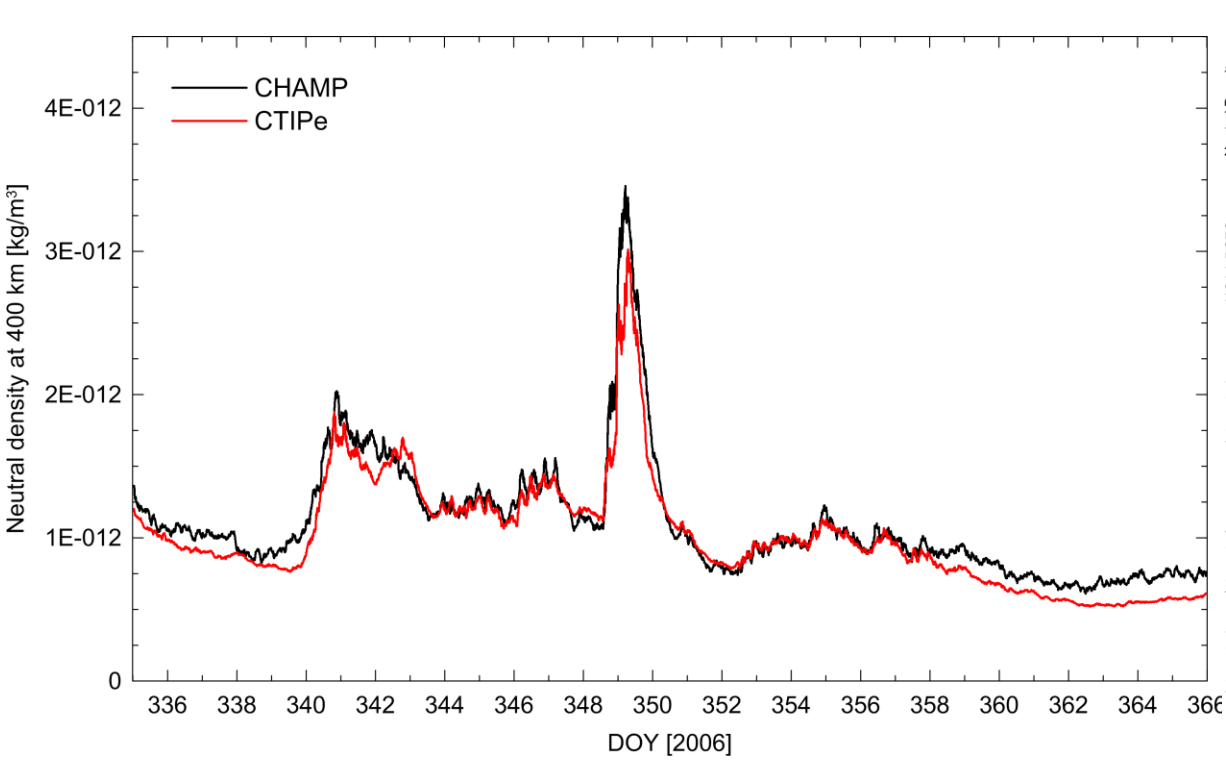
- Increase in magnetospheric/ionospheric high latitude convection and auroral precipitation
- Enhances conductivity at high latitudes and NO production
- [High latitude winds accelerate by ion drag]
- Joule heating/Poynting flux increase, radiative cooling, thermal expansion, and increase in neutral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

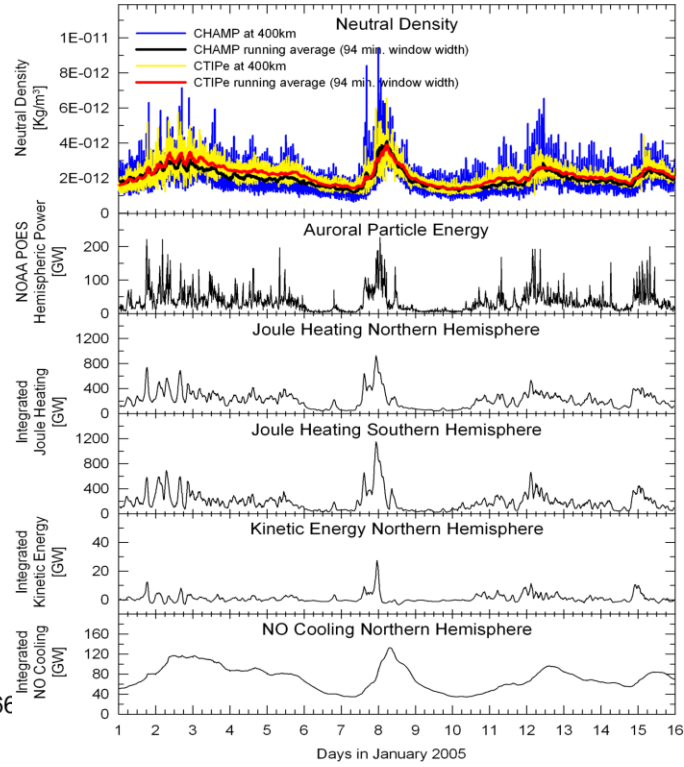
Magnitude of Joule heating hard to validate.

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

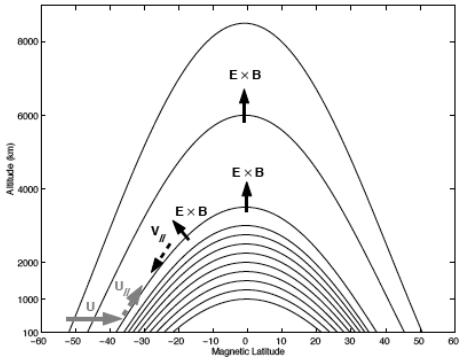




Process 2

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* from Jicamarca ISR and magnetometers difficult to validate .

Confused by dynamo.

Confused by variations in shielding time constants.

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

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

Process 3

Build-up of plasma and structure at mid-latitudes

In-situ production in expanded convection and transport

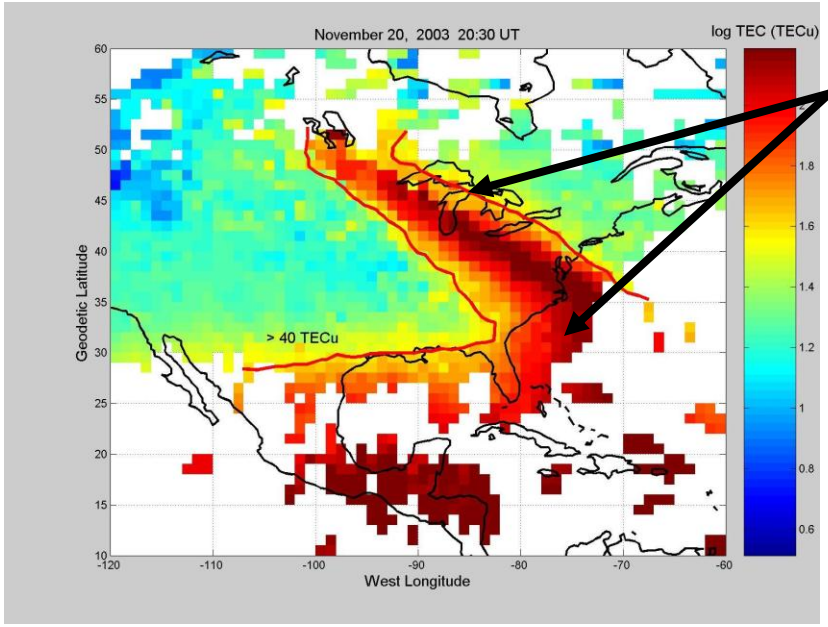
Problem is it may be in combination with other physical processes

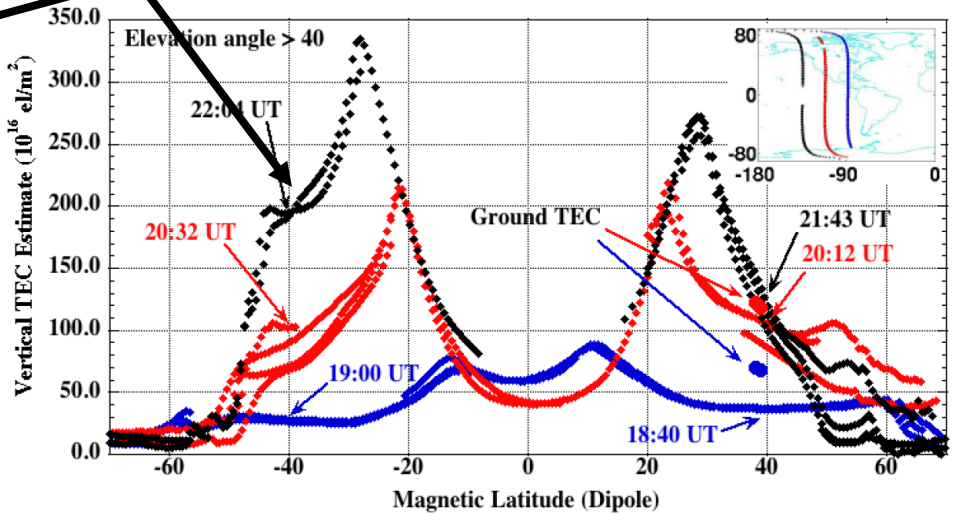
e.g., transport from low latitudes, meridional winds

Validate TEC from GPS maps in some longitude sectors

Validate in-situ from satellite, or point locations with ionosondes

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

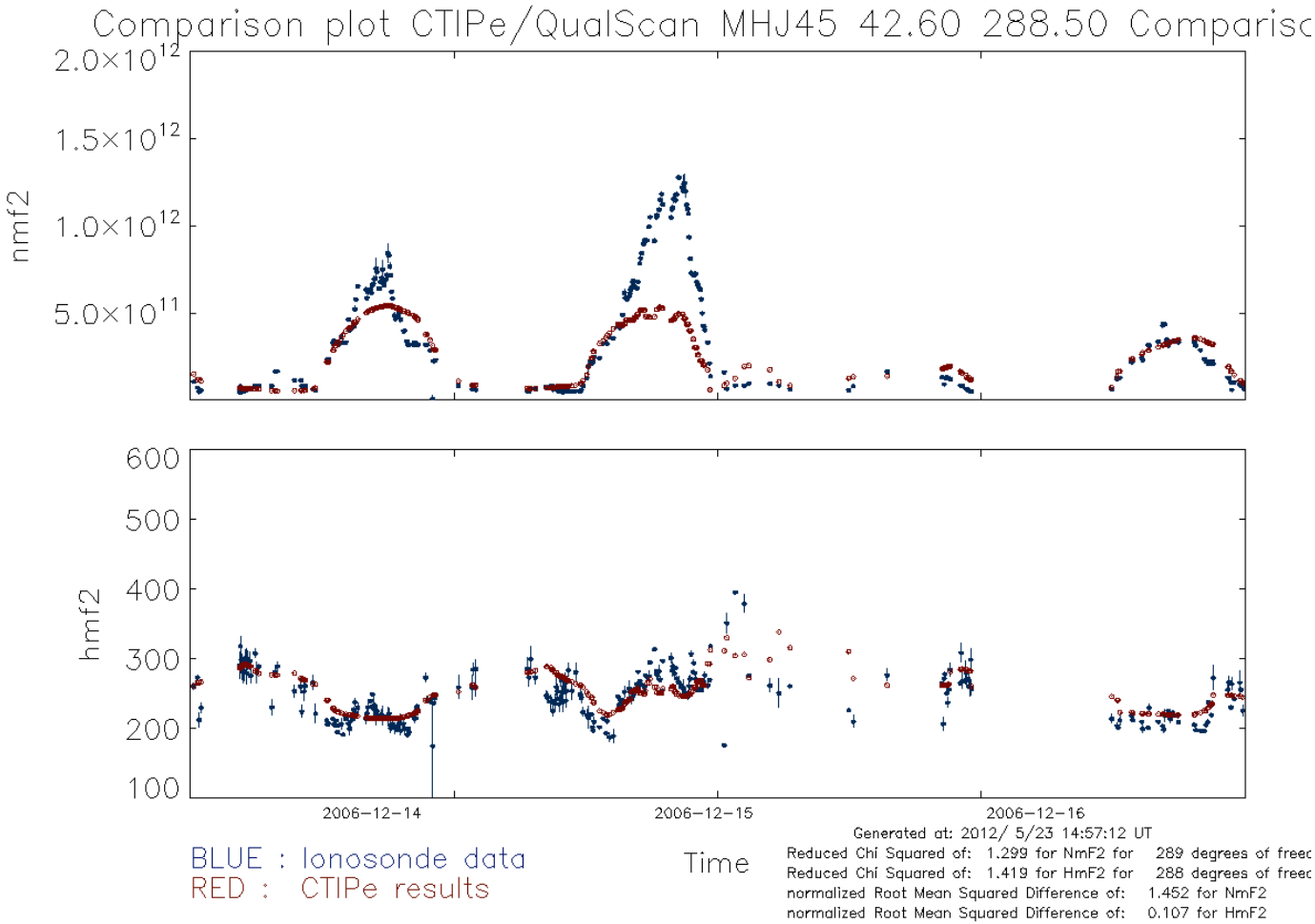




Foster and Coster

Mannucci et al 2005

Ionosonde NmF2, hmF2 at Millstone Hill



Process 4

Gravity wave propagation from high to low latitude

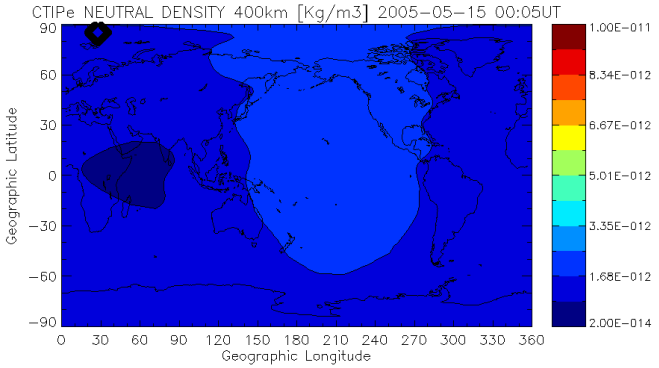
Validate arrival and magnitude of waves.

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.

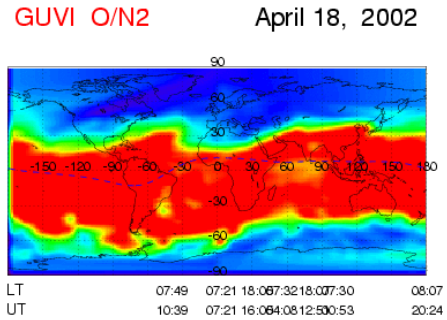
Process 6

Evolution of neutral composition change

Response and recovery of O/N_2

Movement of boundaries in O/N_2

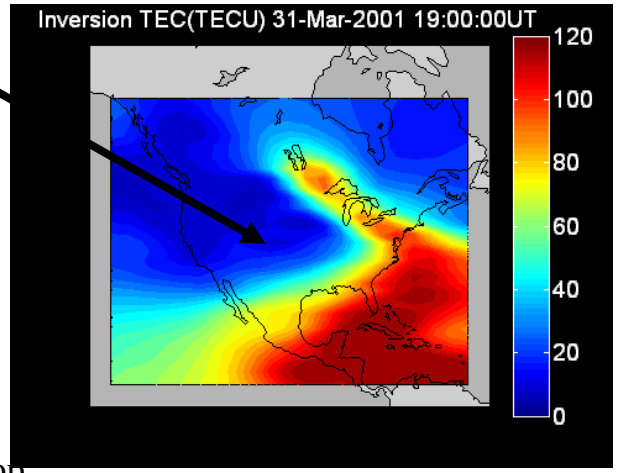
Observations: TIMED/GUVI, SSUSI, GOLD,….



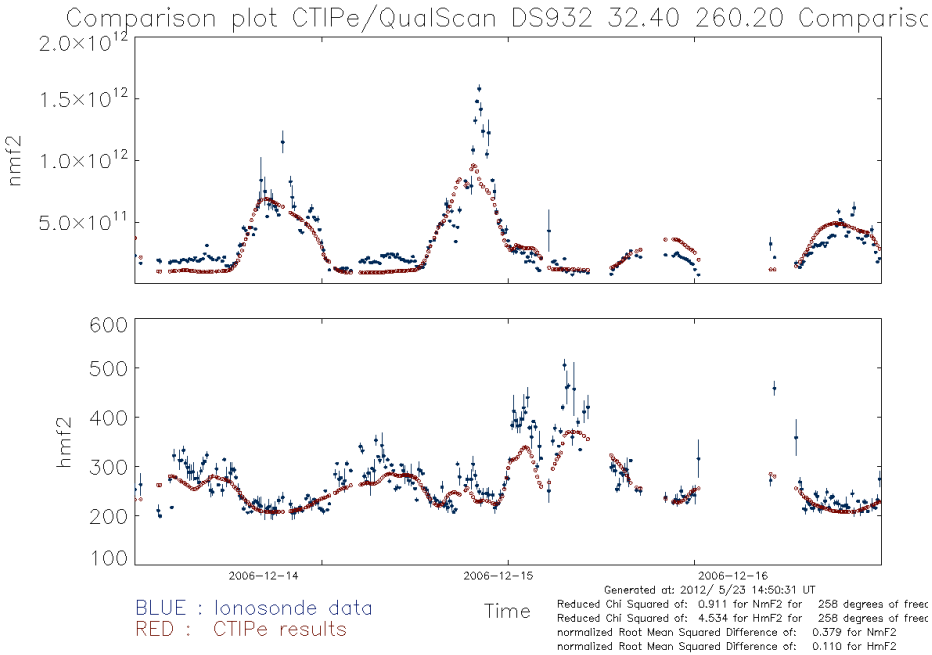
Process 7

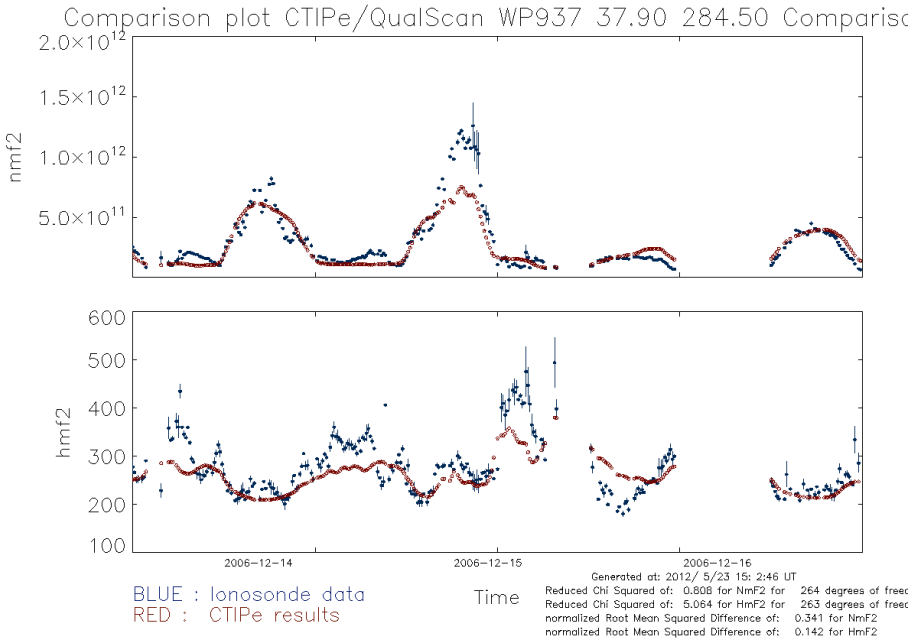
Ionospheric negative storm phase at mid latitude

- 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

- Possibility: Combine penetration and disturbance dynamo at low latitudes

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

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

Validate total EIA response

Suggested **process-orientated** storm metrics for model validation

Process 1: Quantifying the geomagnetic storm energy dissipation

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

Process 4: Gravity wave propagation from high to low latitude

Process 6: Evolution of neutral composition change

Process 7: Ionospheric negative storm phase at mid latitude

Process 2 and 8: Combined penetration and dynamo electric fields