

# Ionospheric TEC disturbance during the Mediterranean tropical-like cyclone occurred on November 2014

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# OUTLINE

- IONOSPHERE-ATMOSPHERE COUPLING
- MEDICANE
- EXTERNAL INFLUENCES
- IONOSPHERE DISTURBANCES
- CONCLUSIONS

# IONOSPHERE-ATMOSPHERE COUPLING

## Ionosphere variability:

- Solar ionizing flux



“Normal” variability

- Space weather events



Geomagnetic storms

# IONOSPHERE-ATMOSPHERE COUPLING

## Ionosphere variability:

- From below:

- Lithosphere:



Earthquakes, volcanoes

- Atmosphere:



Phenomena in  
Troposphere and  
Stratosphere



# IONOSPHERE-ATMOSPHERE COUPLING

- Coupling between the neutral atmosphere and the ionosphere.
- Upward propagation of internal atmospheric waves.
- These waves are a source of energy and momentum to the ionosphere.

# IONOSPHERE-ATMOSPHERE COUPLING

Gravity waves generate in the lower layers by:

- Sudden stratospheric warmings
- Meteorological fronts
- Convection systems
  - Thunderstorm
- Cyclones:
  - Tropical storm
  - Hurricane
  - Typhoon

# MEDICANE

MEDiterranean hurriCANE

03:00 7th – 12:00 8th

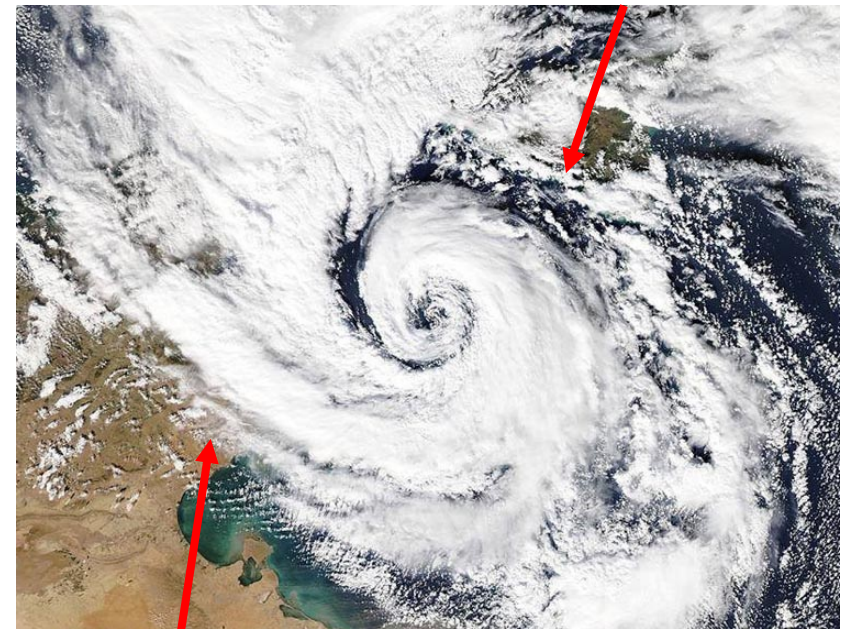
November 2014

Eye-Wall:

154 km/h

979 hPa

Category 2

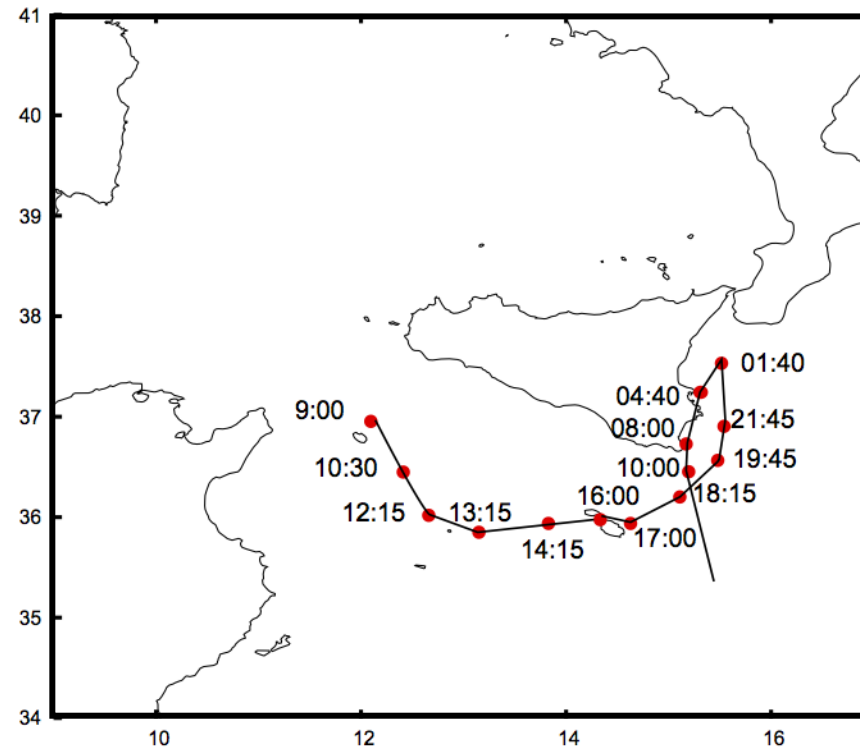


Sicily

Tunisian coast

# MEDICANE

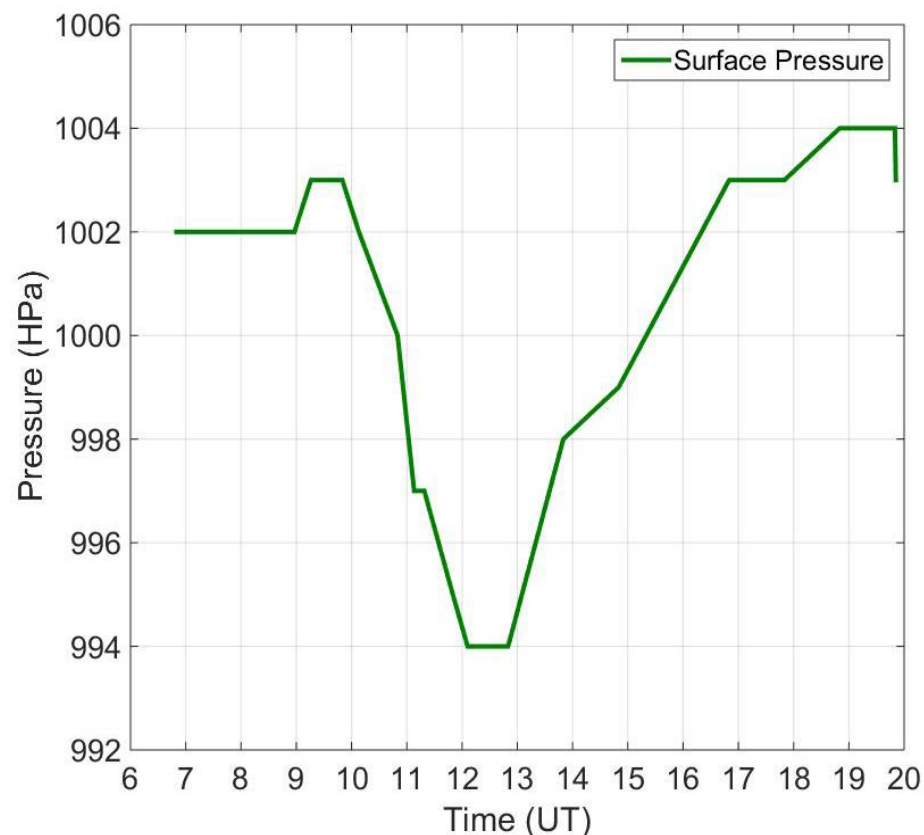
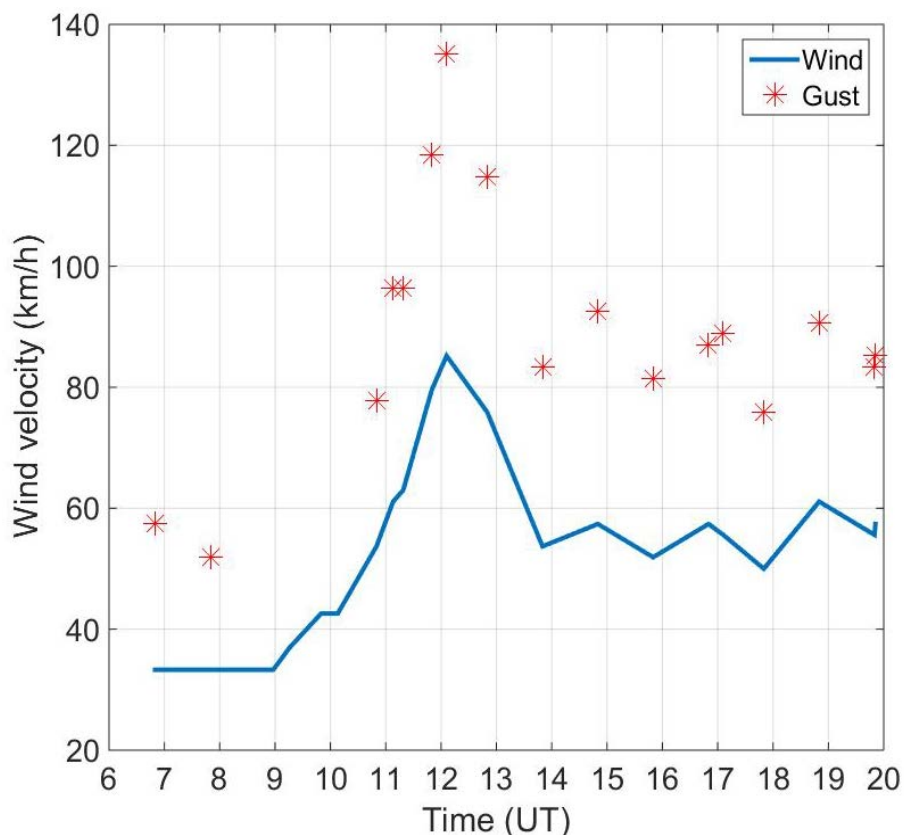
## Medicane trajectory



“Thermal structure and dynamical modeling of a Mediterranean Tropical-like cyclone” PhD Thesis G.Cioni

# MEDICANE

## Wind velocity and Surface Pressure in Lampedusa Island on 7<sup>th</sup> November 2014

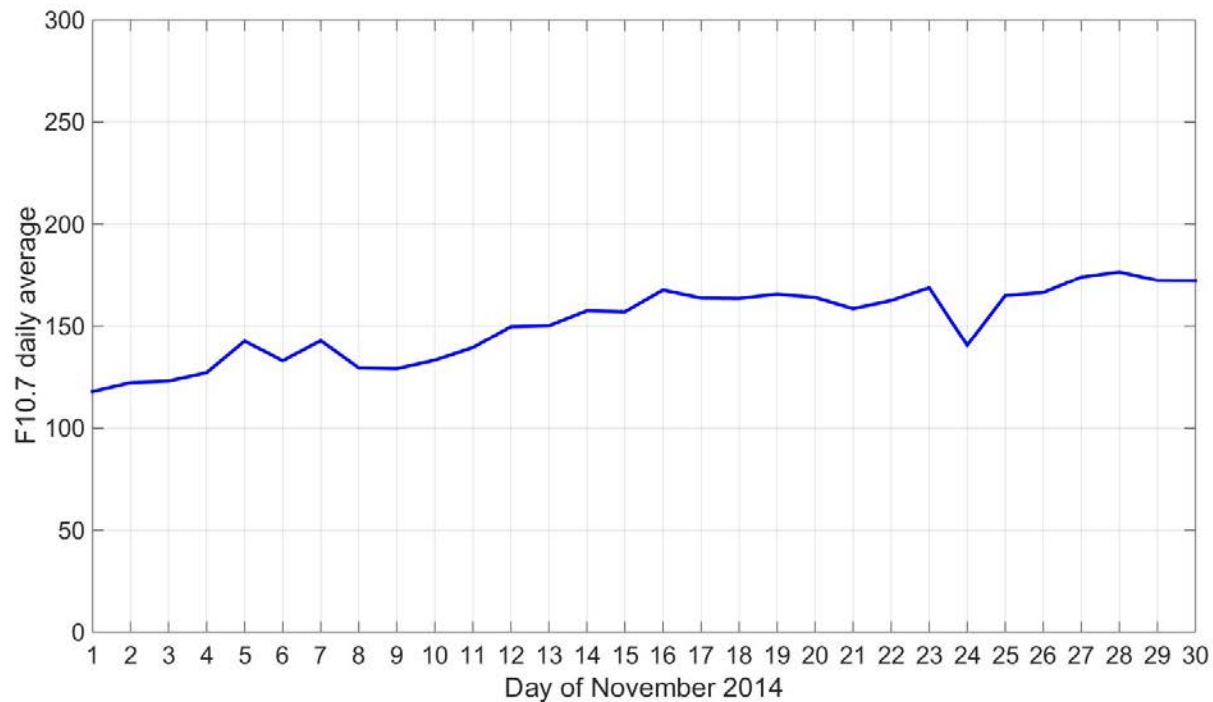


# EXTERNAL INFLUENCES

- From the Sun:
  - Solar ionization flux
  - Geomagnetic storms
- From below:
  - Earthquakes

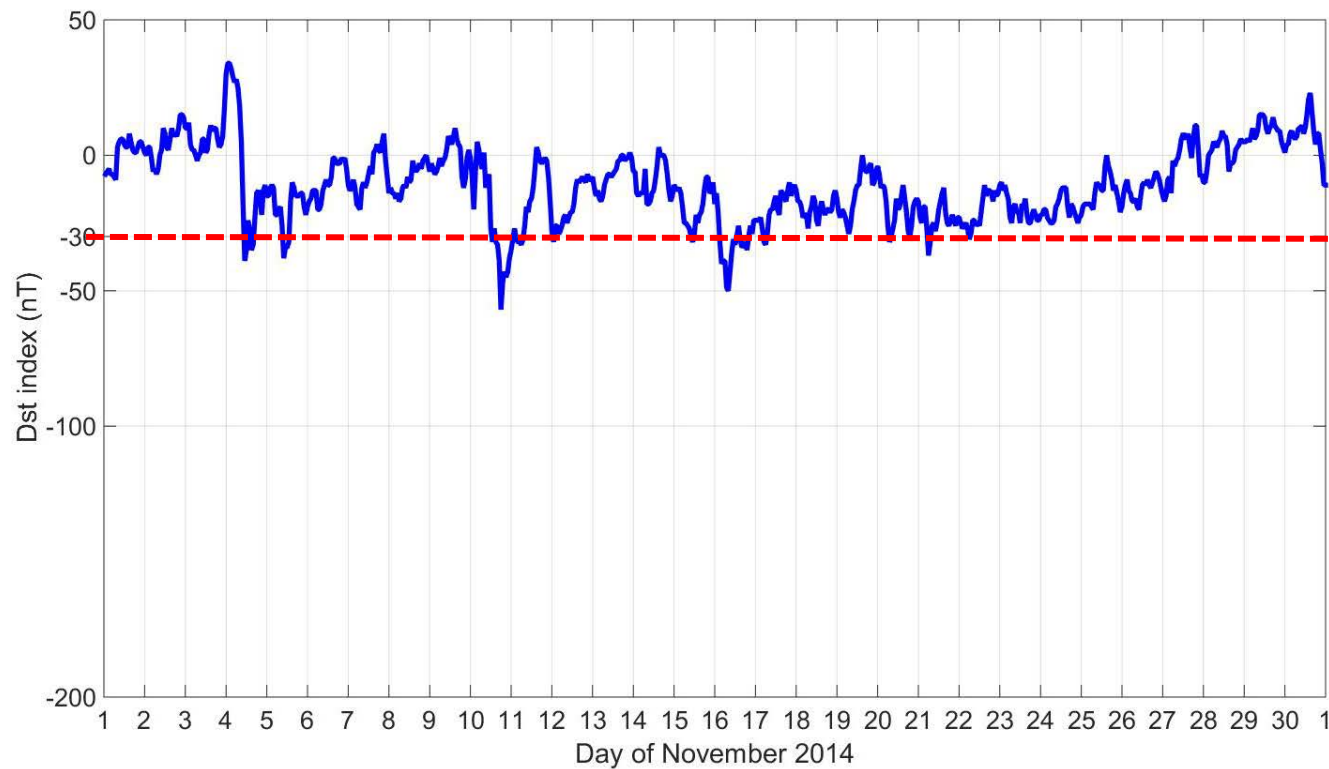
# EXTERNAL INFLUENCES

- Solar ionizing flux



# EXTERNAL INFLUENCES

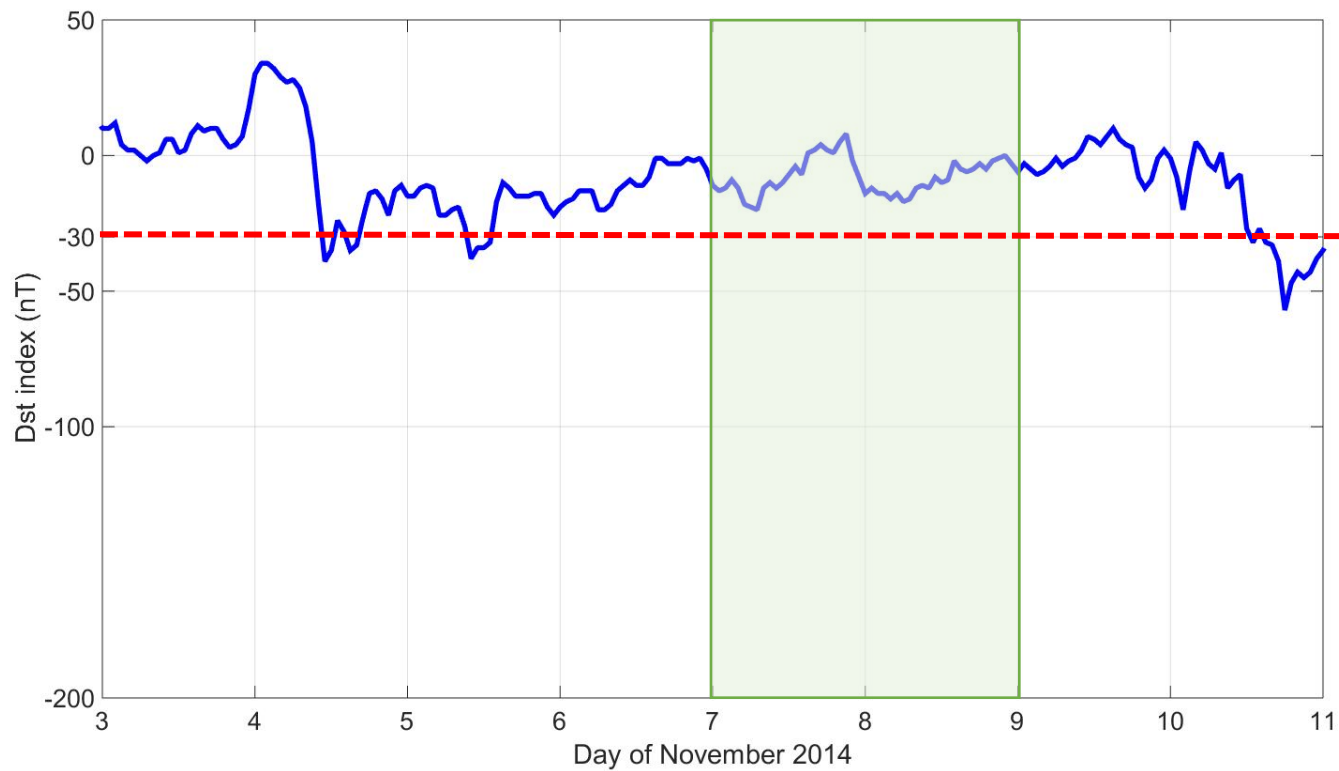
- Geomagnetic activity: Dst index





# EXTERNAL INFLUENCES

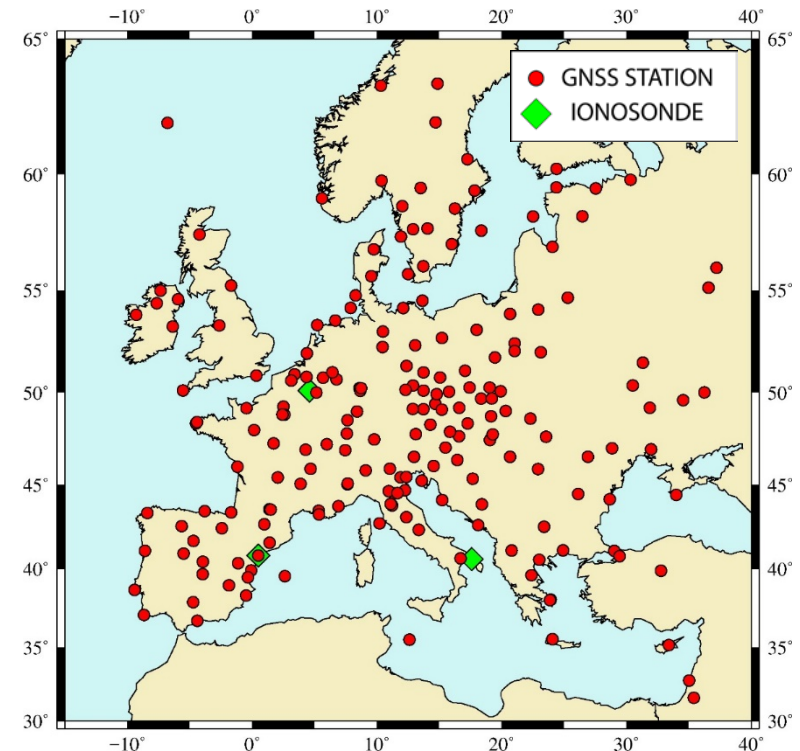
- Geomagnetic activity: Dst index



# IONOSPHERIC DISTURBANCES

TEC data from 201 GNSS stations.

- Calibration technique developed by Profesor Ciruolo:
  - vTEC over each station
  - 1 minute rate



# IONOSPHERIC DISTURBANCES

- Ionospheric behavior analyze trough:

$$vTECsigma = \frac{vTEC - vTECmean}{\sigma}$$

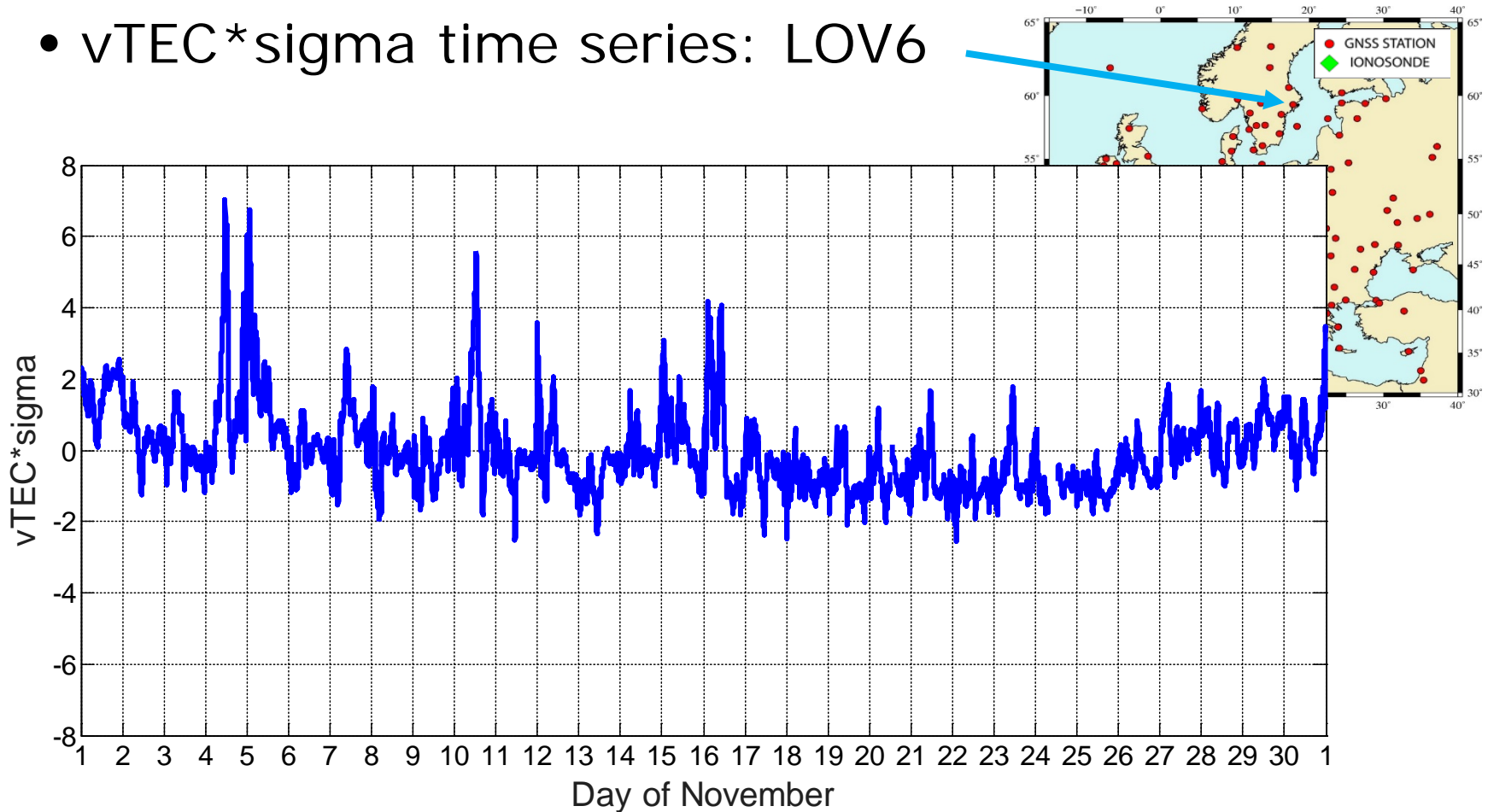
Davidenko and Pulinets, 2012

The mean value and standard deviation have been calculated with the 10 International Quiet Days of November 2014.

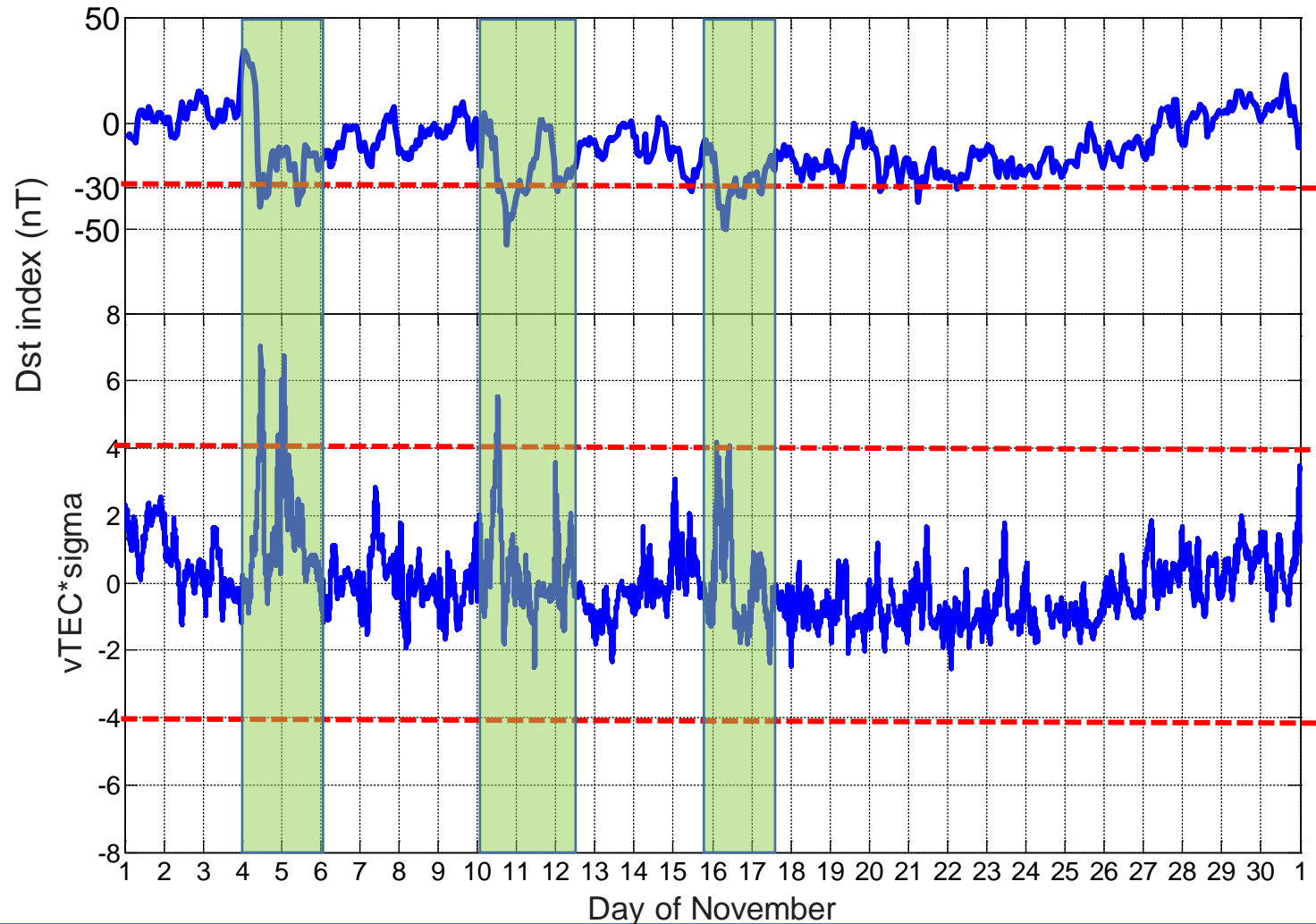
Threshold value : 4 (99% percentile)

# IONOSPHERIC DISTURBANCES

- vTEC\*sigma time series: LOV6



# IONOSPHERIC DISTURBANCES

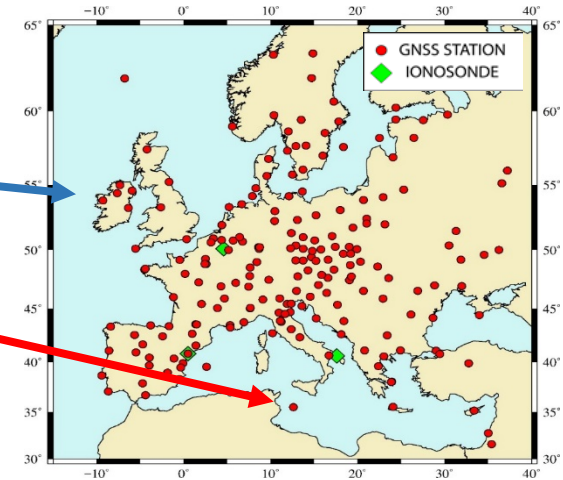
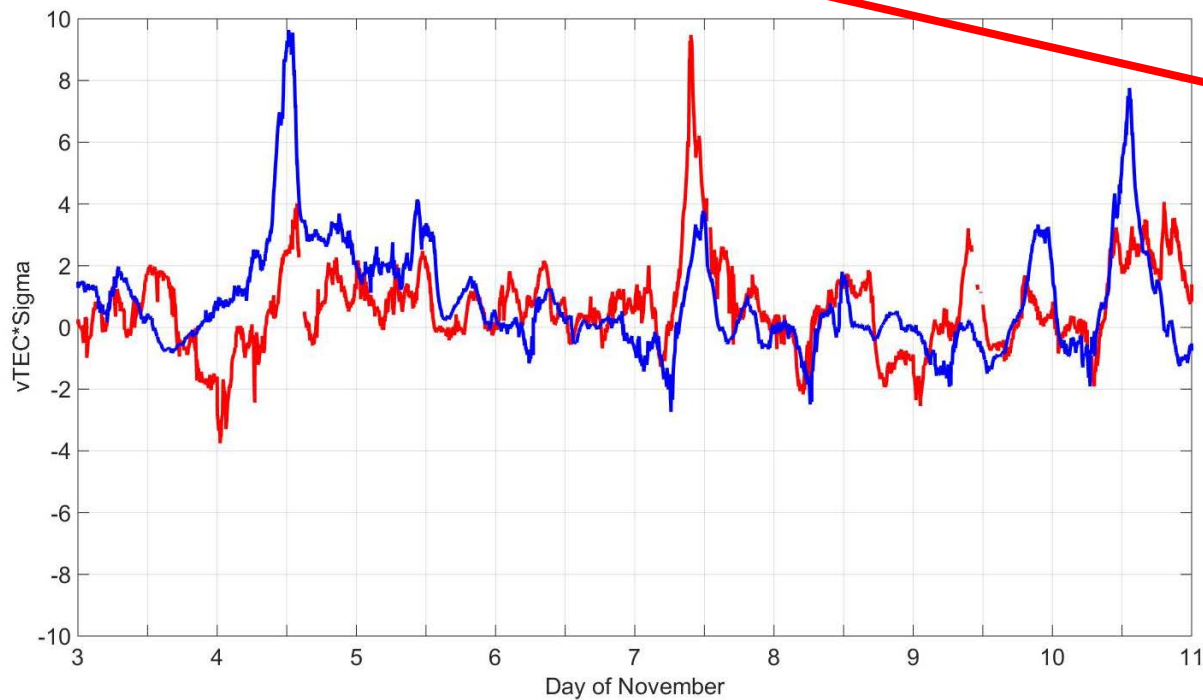


# IONOSPHERIC DISTURBANCES

- vTEC\*sigma time series:

CASB

LAMP

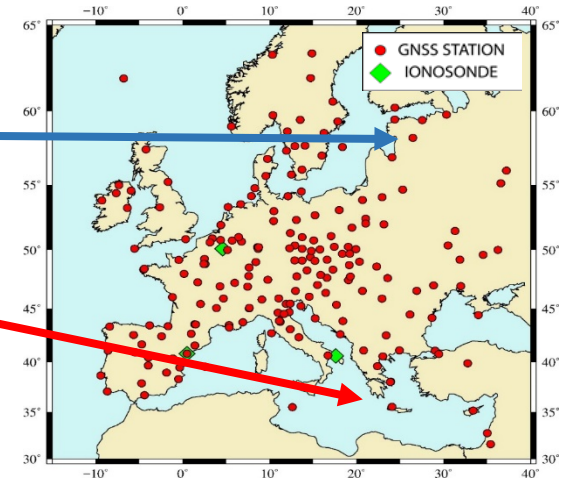
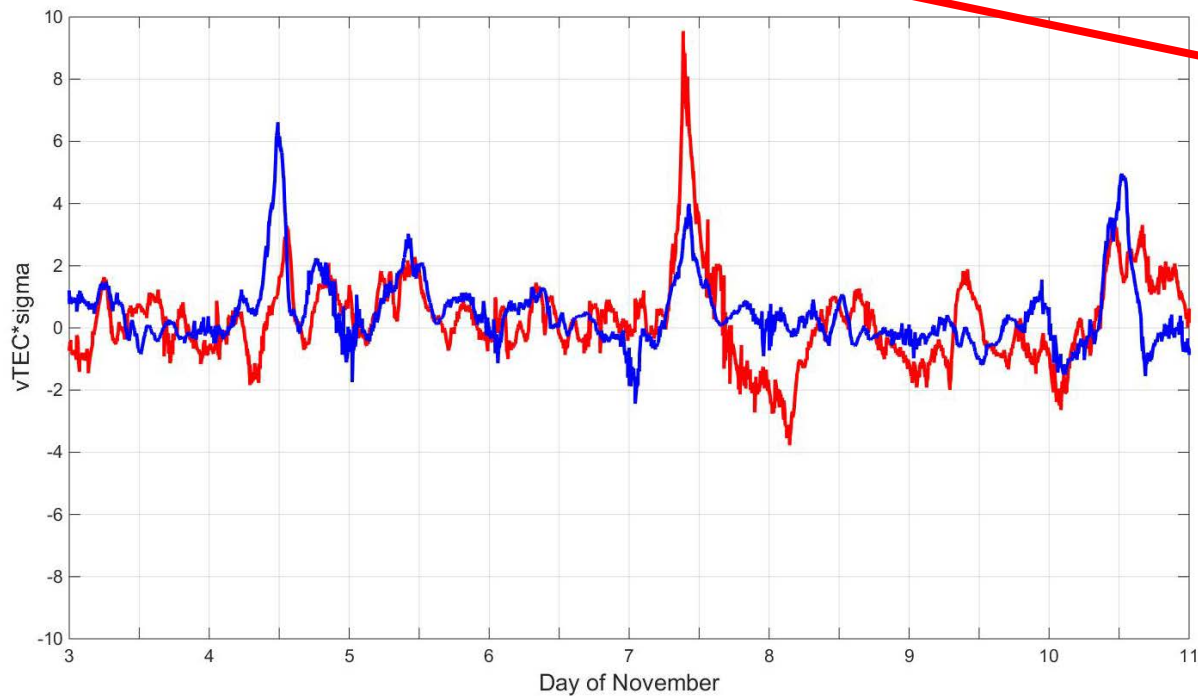


# IONOSPHERIC DISTURBANCES

- vTEC\*sigma time series:

RIGA

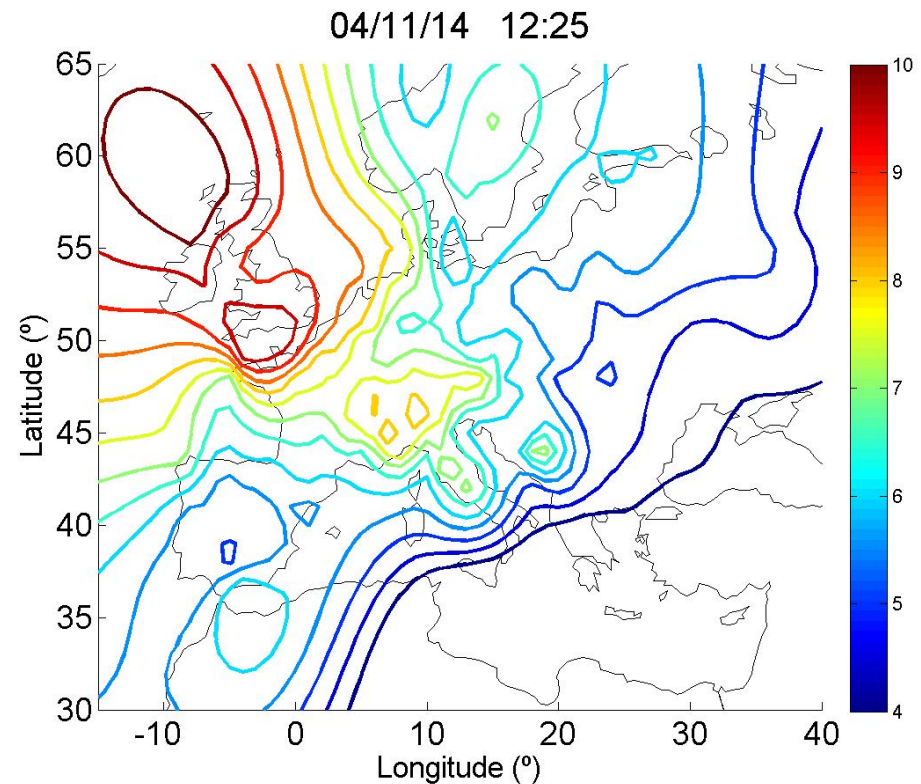
TUC2





# IONOSPHERIC DISTURBANCES

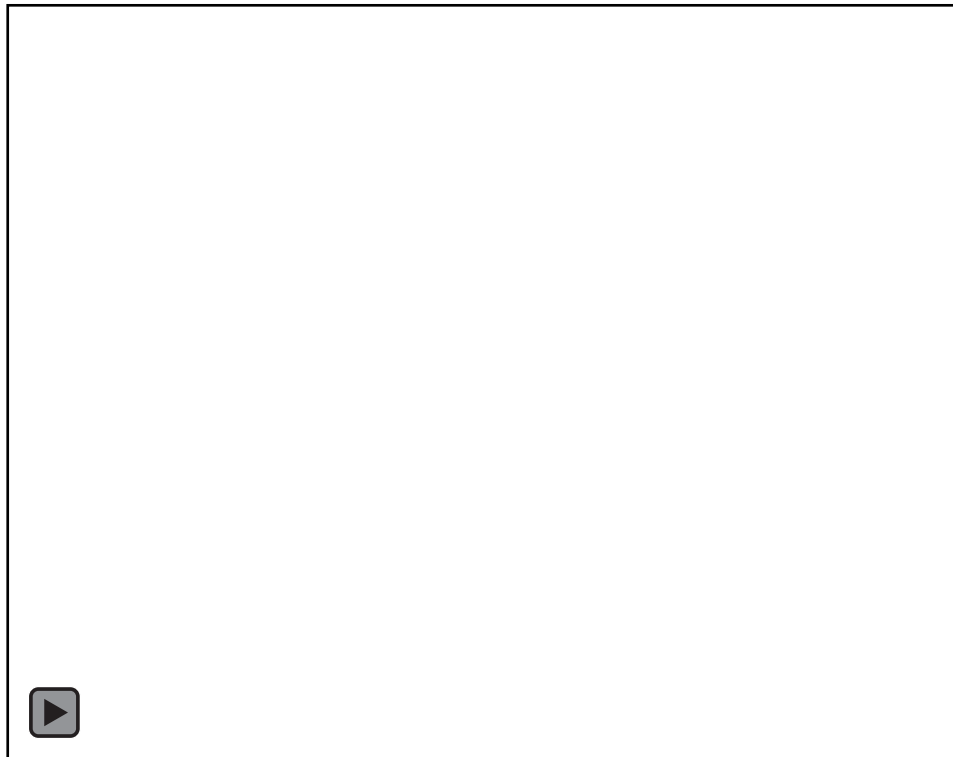
- vTEC\*sigma values over each station
- Kriging interpolation
- Isolines:
  - Since 4
  - Every 0.5
  - Every 5 minutes





# IONOSPHERIC DISTURBANCES

- Disturbance originated by the Geomagnetic Storm on 4th November.



# IONOSPHERIC DISTURBANCES

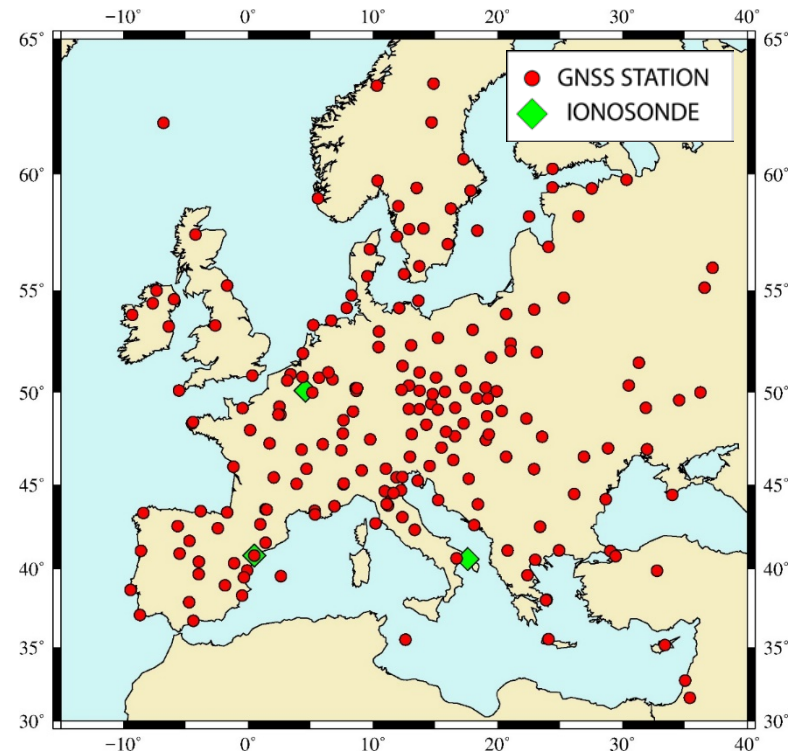
- Disturbance originated by the Medicane on 7th November.



# IONOSPHERIC DISTURBANCES

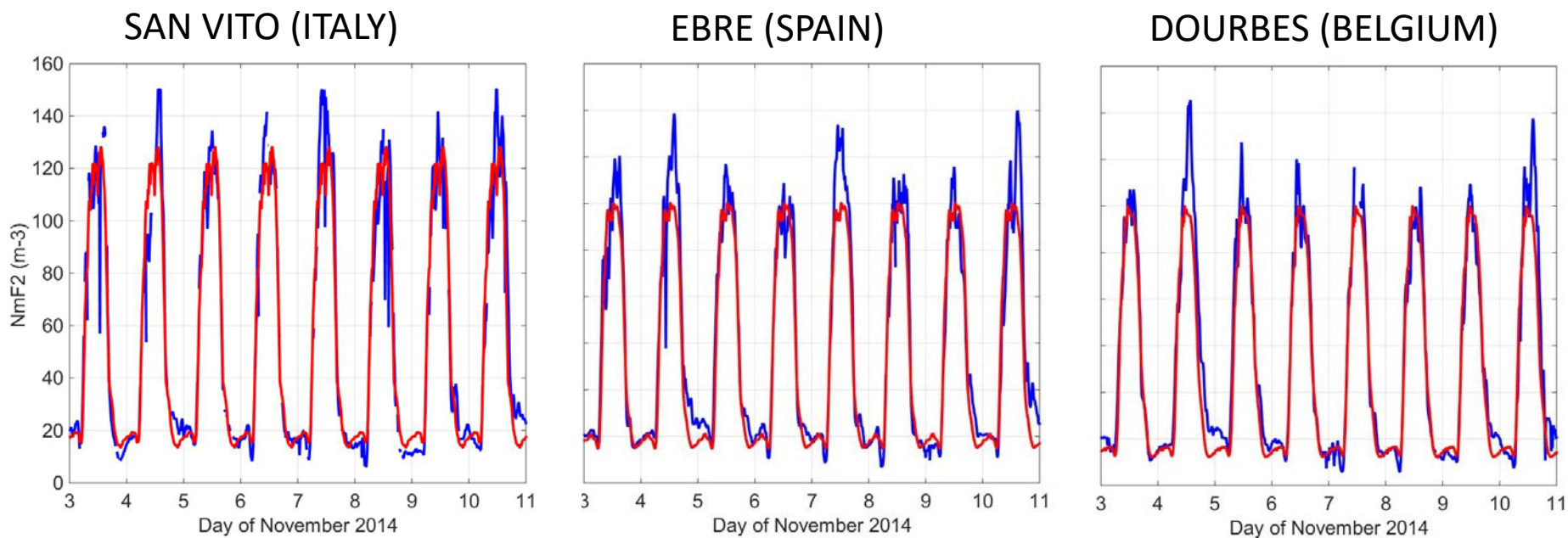
Data from 3 Ionosondes:

- San Vito (Italy)
  - Ebre (Spain)
  - Dourbes (Belgium)
- 
- foF2  $\longrightarrow$  NmF2
  - hmF2
  - 15 minute rate



# IONOSPHERIC DISTURBANCES

- Time series NmF2

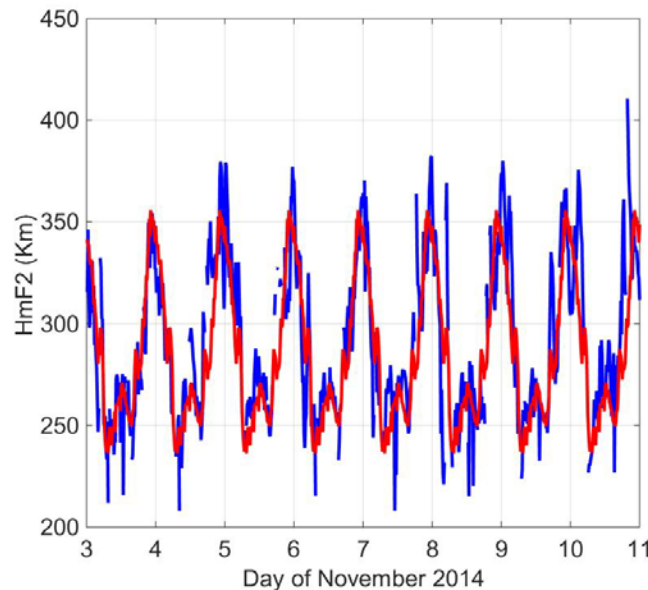


— Observable value  
— Mean value

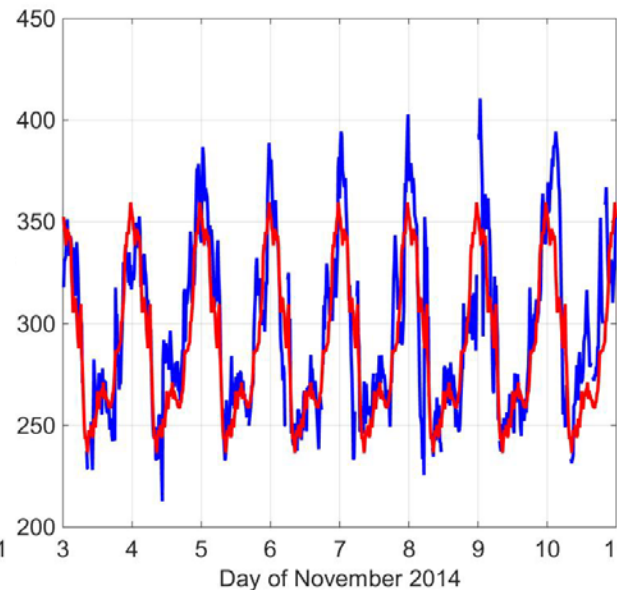
# IONOSPHERIC DISTURBANCES

- Time series HmF2

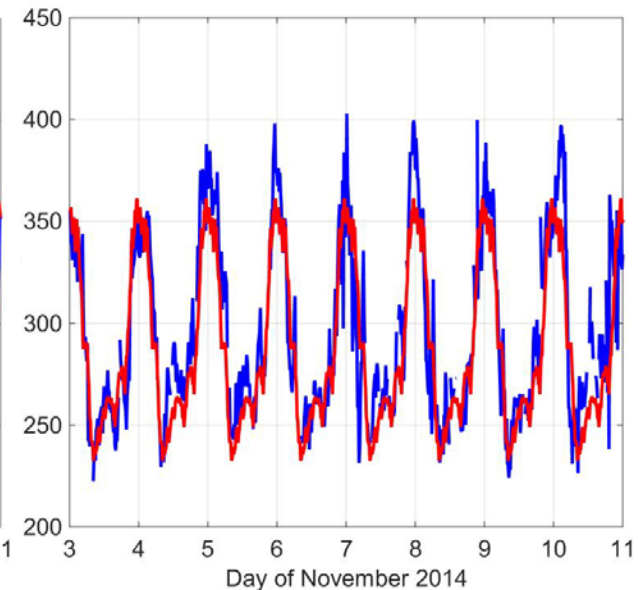
### SAN VITO (ITALY)



### EBRE (SPAIN)



### DOURBES (BELGIUM)



— Observable value  
— Mean value

# CONCLUSIONS

- Solar and geomagnetic conditions were quiet during the Medicane occurred between 7th and 8th November 2014
- A TEC disturbance is observed during the formation of the Medicane, from 8:15 to 12:00.

# CONCLUSIONS

- The behavior of the anomalous  $vTEC^*$  sigma values is very different from the anomalies caused by a geomagnetic storm.
- A NmF2 disturbance appears in the ionosondes closer to the Medicane.
- No hmF2 disturbances related to the Medicane are observed.

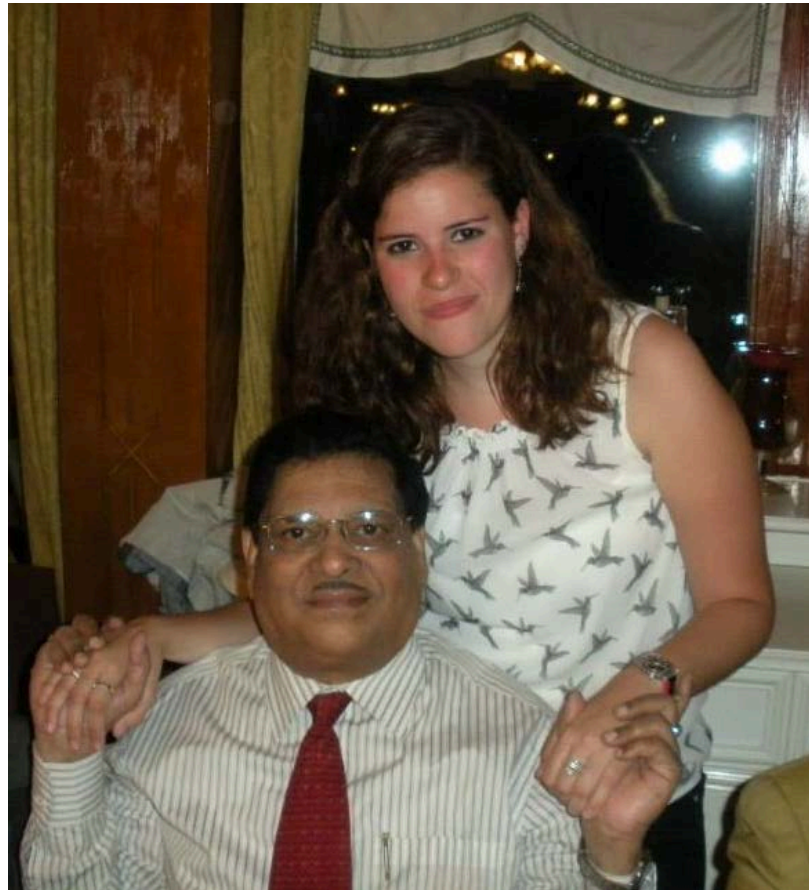
# ACKNOWLEDGEMENTS

To the following Data Center:

- OMNIWeb Plus Interface
- WDC for Geomagnetism, Kyoto University
- GNSS networks: IGS and EUREF
- USAF NEXION Digisonde network



IN MEMORIAM  
Dr. P.V.S. Rama Rao



THANK YOU FOR YOUR ATTENTION

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