



CORRELATION BETWEEN TROPICAL-LIKE CYCLONES IN THE MEDITERRANEAN SEA AND THE SPACE WEATHER

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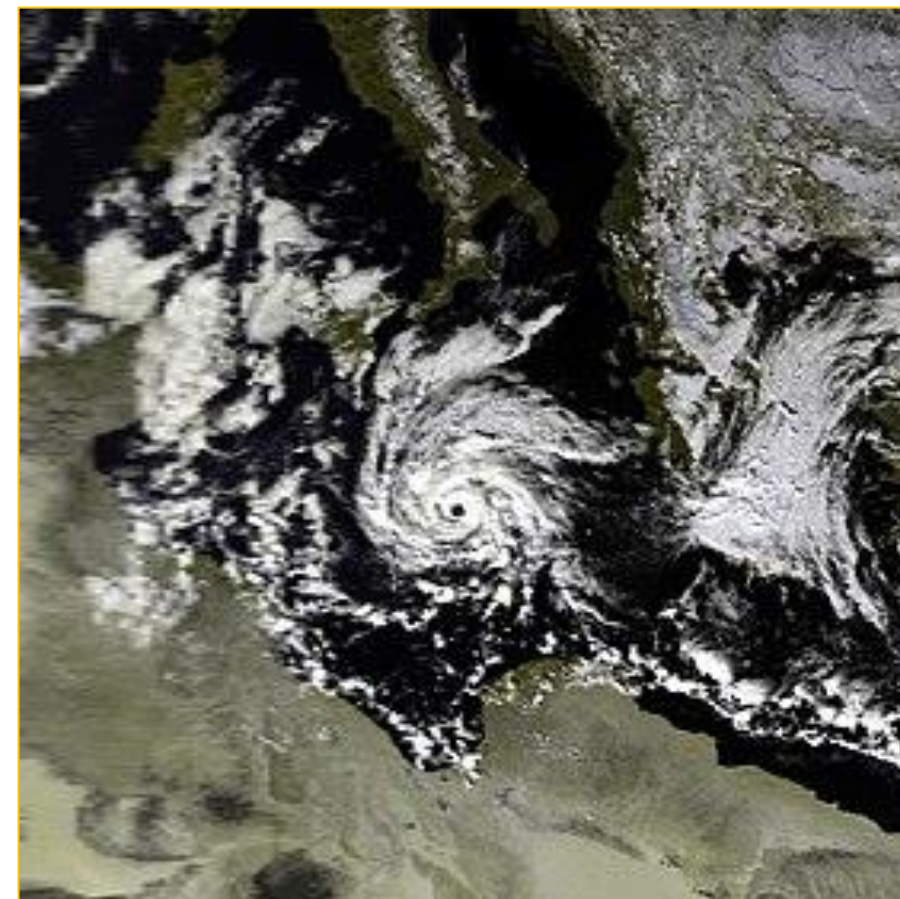
Introduction

Medicanes or Mediterranean cyclones

- This term does not refer to a particular hurricane but to a type of cyclone that, when fully developed, has similar characteristics to a **tropical cyclone** – TC
- **TC** are fast-rotating meteorological systems characterized by:
 - a centre of low pressure,
 - closed atmospheric circulation,
 - strong winds and,
 - a spiral arrangement of thunderstorms that give a lot of rain.

Objective

- exploring the ionospheric response to Medicanes



[NOAA](#) Mediterranean Cyclone 16 Jan 1995

Methods and data

- Medicanes
 - Nov 2014
 - Oct 2016
 - Nov 2017
- GNSS TEC estimated using Vshell – ICTP Trieste
- 8 EPN GNSS
 - LAMP
 - ALME
 - MARS
 - CASB
 - NOA1
 - ZADA
 - SRJV

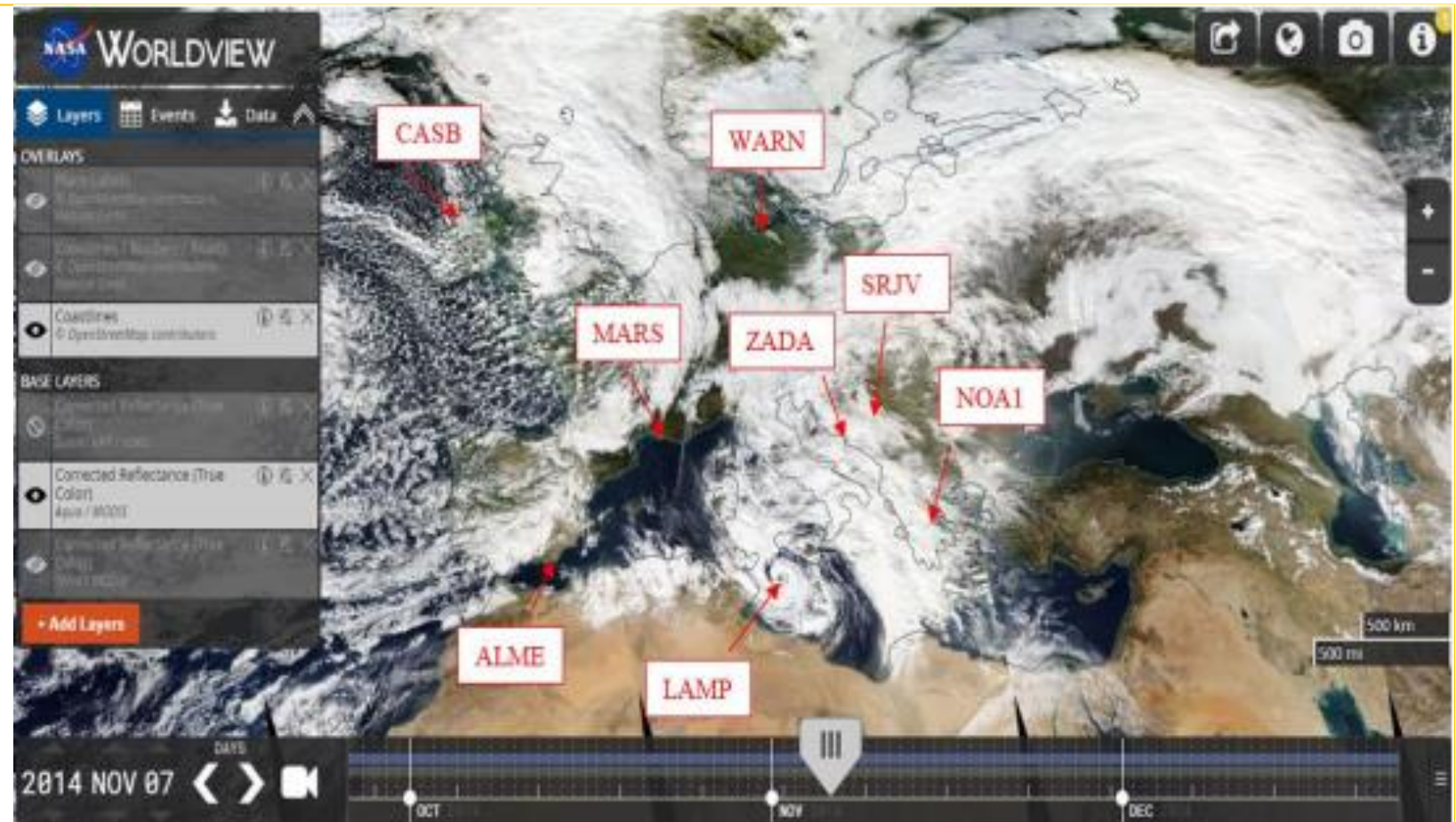


Photo credit: [NASA](https://worldview.nasa.gov/)

Results

Following slides show results:

- Daily VTEC medians for the medicane and IDD* in November 2014
- Daily VTEC variations on the day of TC in November 2014
- Daily VTEC variation in October 2016
- Daily VTEC variation in November 2017
- Variation of $vTEC * sigma$ for all three TC

$$vTEC * sigma = \frac{vTEC - vTEC_{mean}}{\sigma}$$

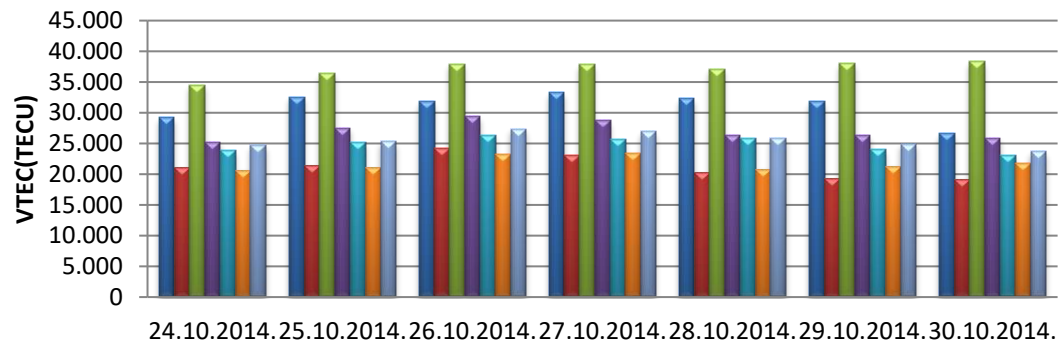
*IDD – International **D**isturbed **D**ays

Results

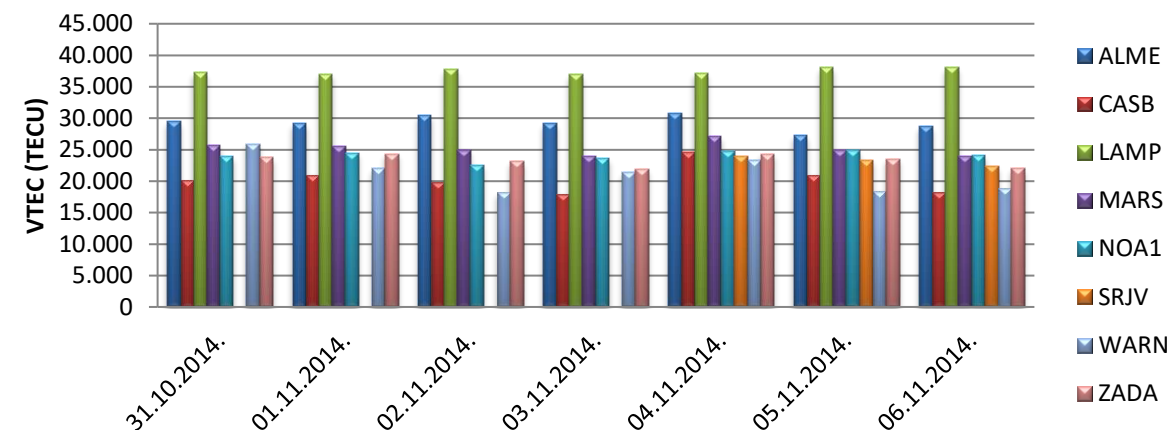


Medicane „Qendresa I“ November 2014

Daily medians of VTEC
24/10/2014 – 30/10/2014/

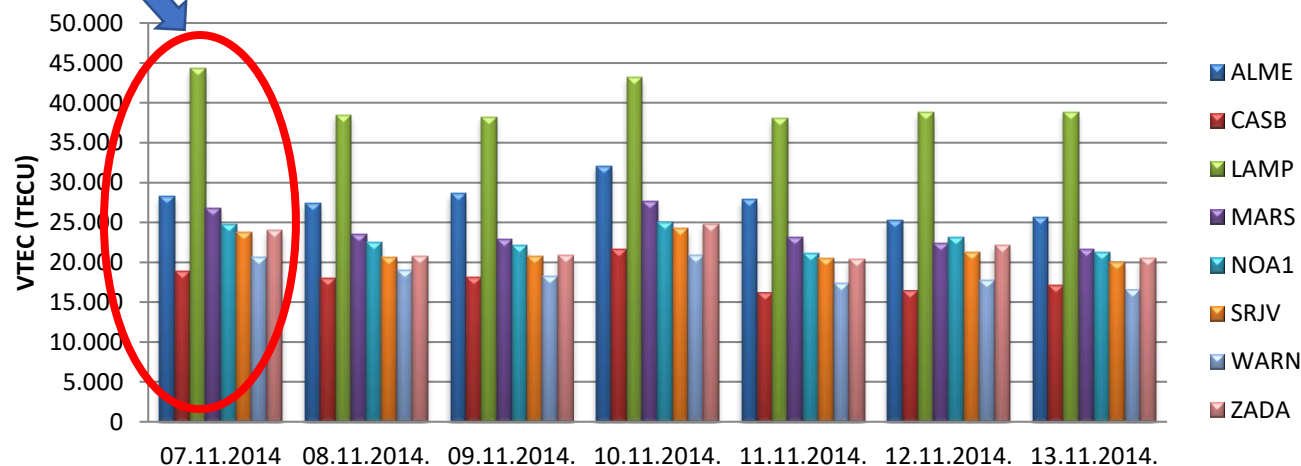


Daily medians of VTEC
31/10/2014 - 06/11/2014

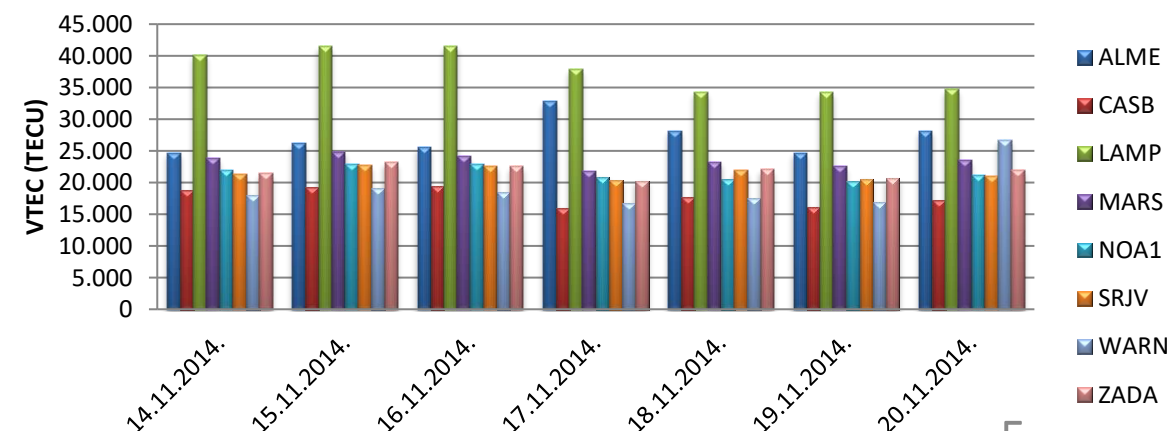


Day of TC
„Qendresa I“

Daily medians of VTEC
07/11/2014/ - 13/11/2014



Daily medians of VTEC
14/11/2014/ - 20/11/2014

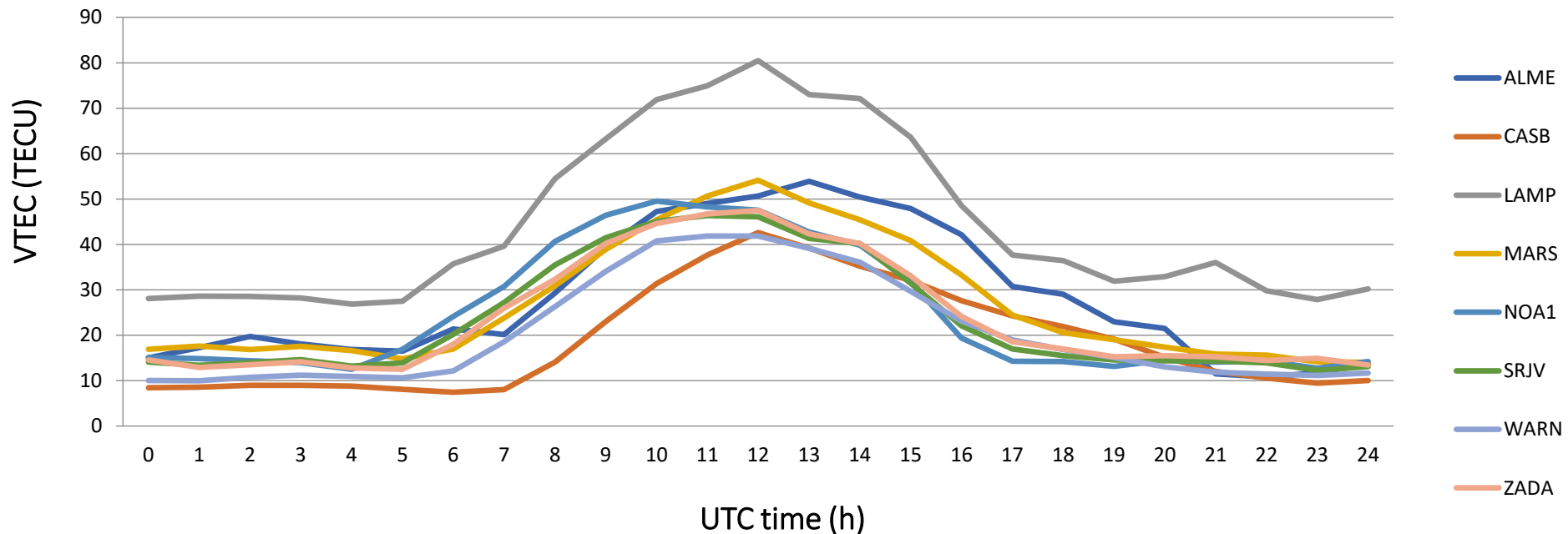


Results



Medicane „Qendresa I“ November 2014

Daily variation of VTEC on day of TC 07/11/2014 (DOY 311 2014)



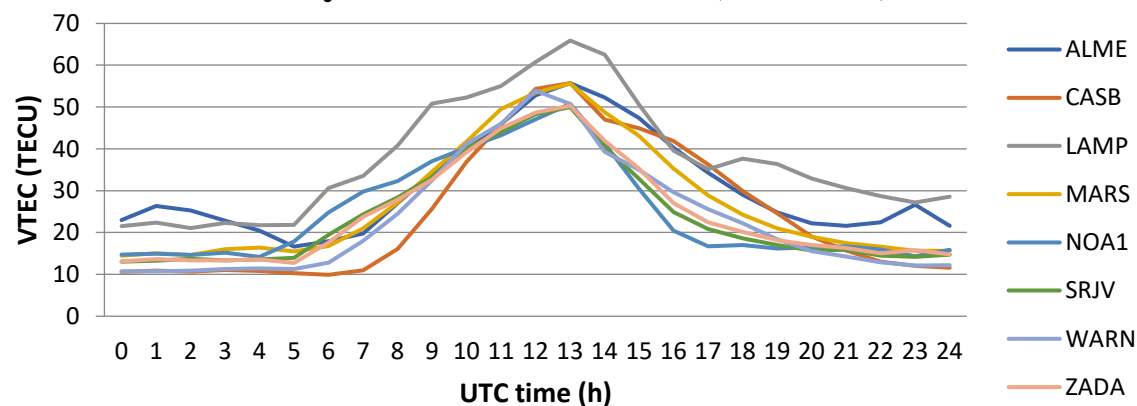
- Station LAMP is the closest to the eye of the storm and its max VTEC was **80.45 TECU** at 12:00 UTC
- The TC reached its maximum intensity at 10:00 UTC, Nov 07, 2014
- CASB and WARN were the farthest stations from the storm and their max VTEC values were 2x smaller compared to LAMP (at the same time of the day).

Results

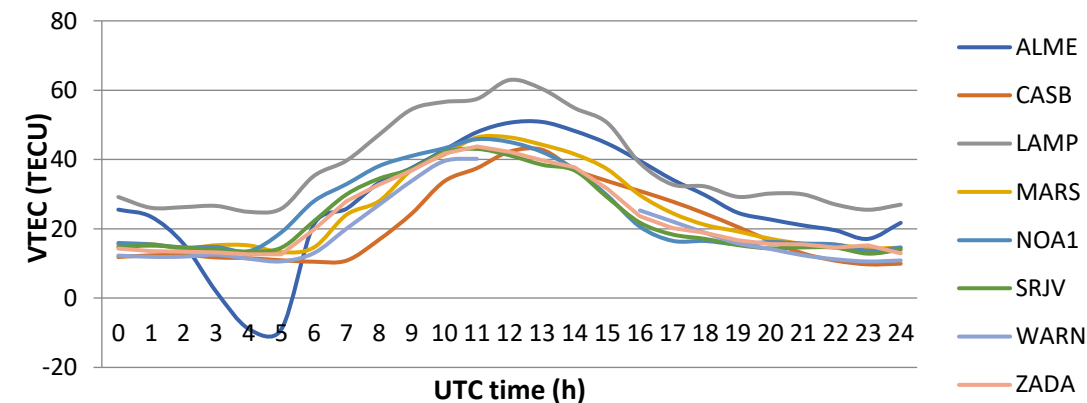


International disturbed days – IDD in the November 2014

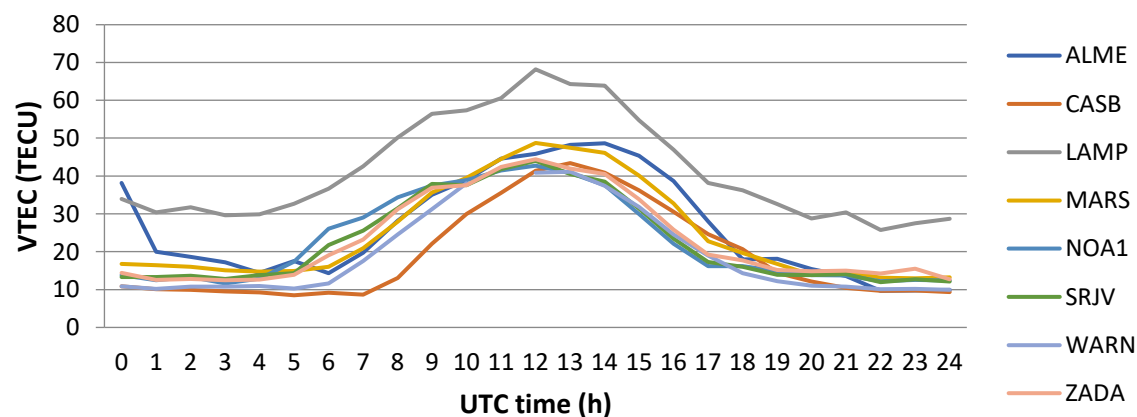
Daily variation 04/11/2014 (DOY 308)



Daily variation VTEC 05/11/2014 (DOY 309)



Daily variations VTEC 15/11/2014 (DOY 319)

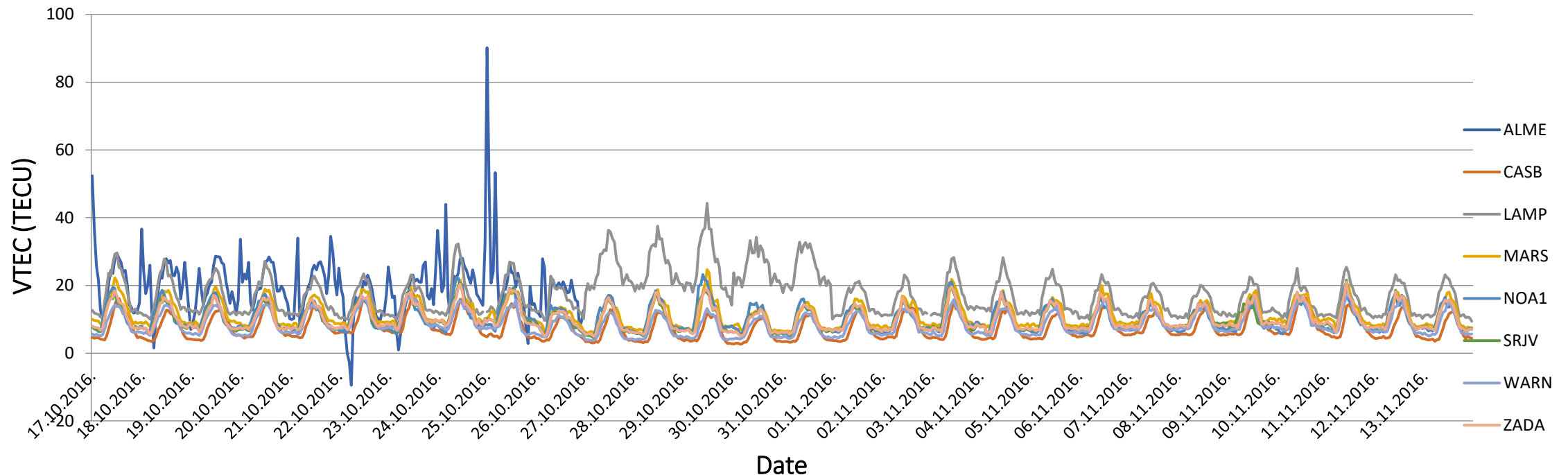


Results



Medicane „90M“ / „Trixi“, October 2016

Daily variation of VTEC 17/10/2016 - 13/11/2016

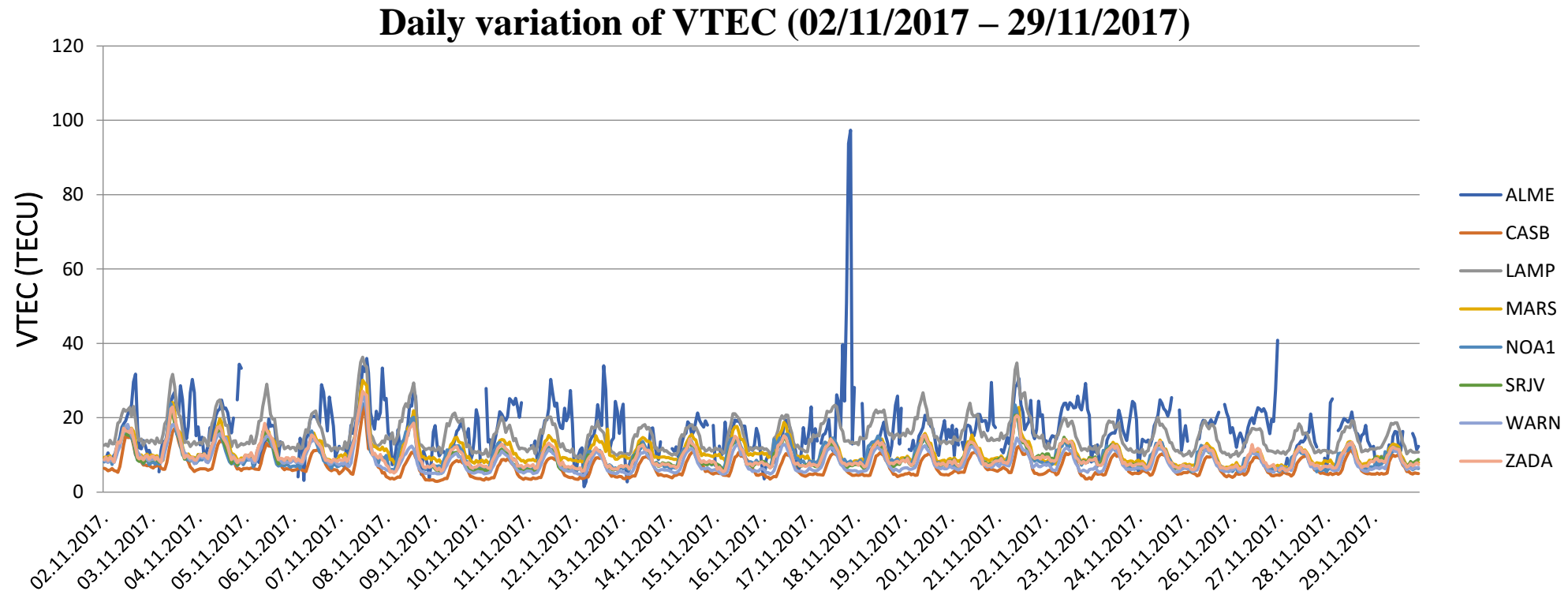


- The tropical cyclone started on Oct 28, hit Malta and slowed down the next day. It re-intensified on Oct 31
- LAMP VTEC data (Italy) reflected the impact of the TC (40 TECU)
- MARS (Italy-Nord) and NOA1 (Greece) showed a smaller VTEC increase (20 TECU)
- SRJV (Bosnia&Herzegovina), WARN (Poland), and CASB (Ireland) showed max VTEC values of approx. 10 TECU

Results



Medicane „Numa“, November 2017



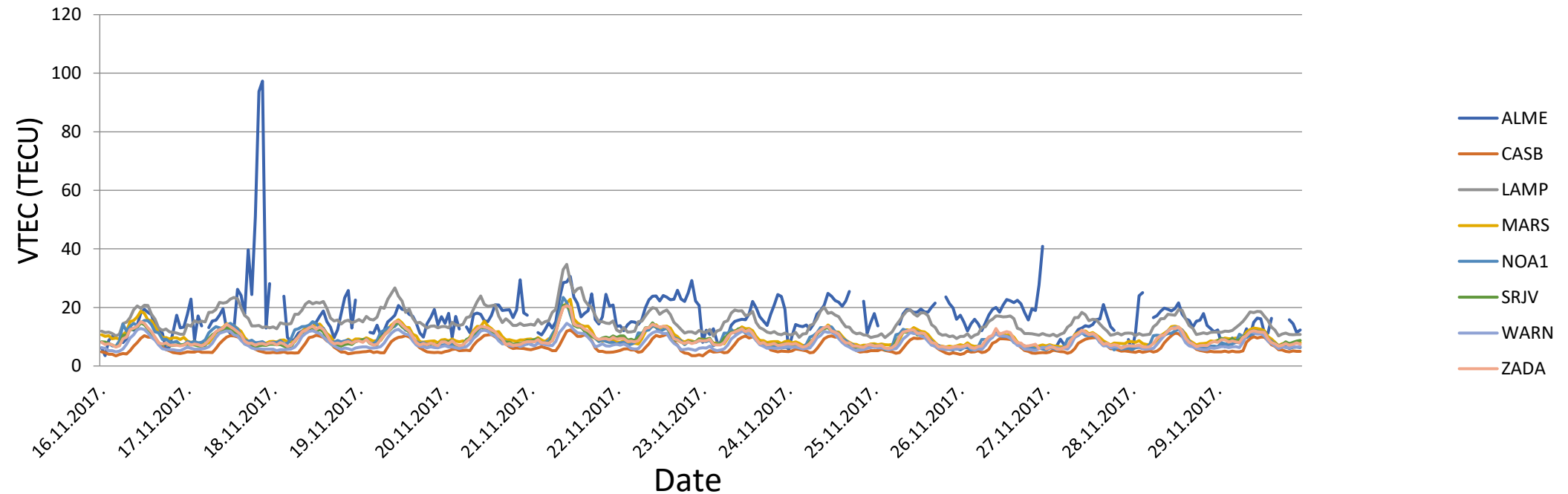
- CIR (Co-rotating interaction regions) hit the Earth on Nov 16, 2017
- This was also the day of a hurricane close to ALME, LAMP, MARS and NOA1 on Nov 21.
- Highest VTEC values at ALME (over 90 TECU) could have been possibly caused by the hurricane, since the other stations (far from the hurricane's eye) did not show extreme VTEC variations. On the other hand, cycle slips were found in the GNSS data of ALME, which could have also been mapped into the VTEC anomalies.

Results



Medicane „Numa“/„Zenon“, November 2017

Solar activity (16/11/2017 - 29/11/2017)

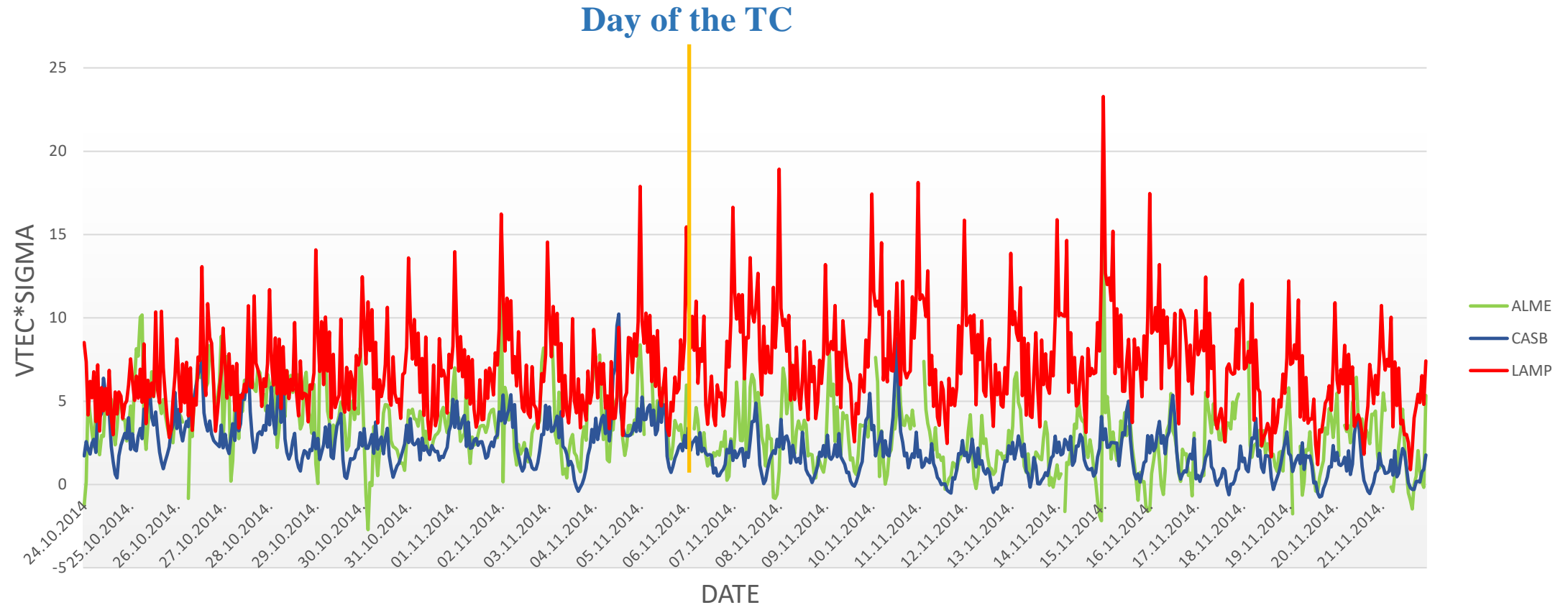


- CIR (Co-rotating interaction regions) hit the Earth on Nov 16, 2017
- The TC „Numa“ reached its highest intensity on Nov 18, becoming one of the few Mediterranean hurricanes.
- VTEC values for ALME were not reliable, due to the occurrence of cycle slips.
- LAMP, MARS and NOA1 showed increased VTEC values on Nov 21.

Results



Medicane in November 2014

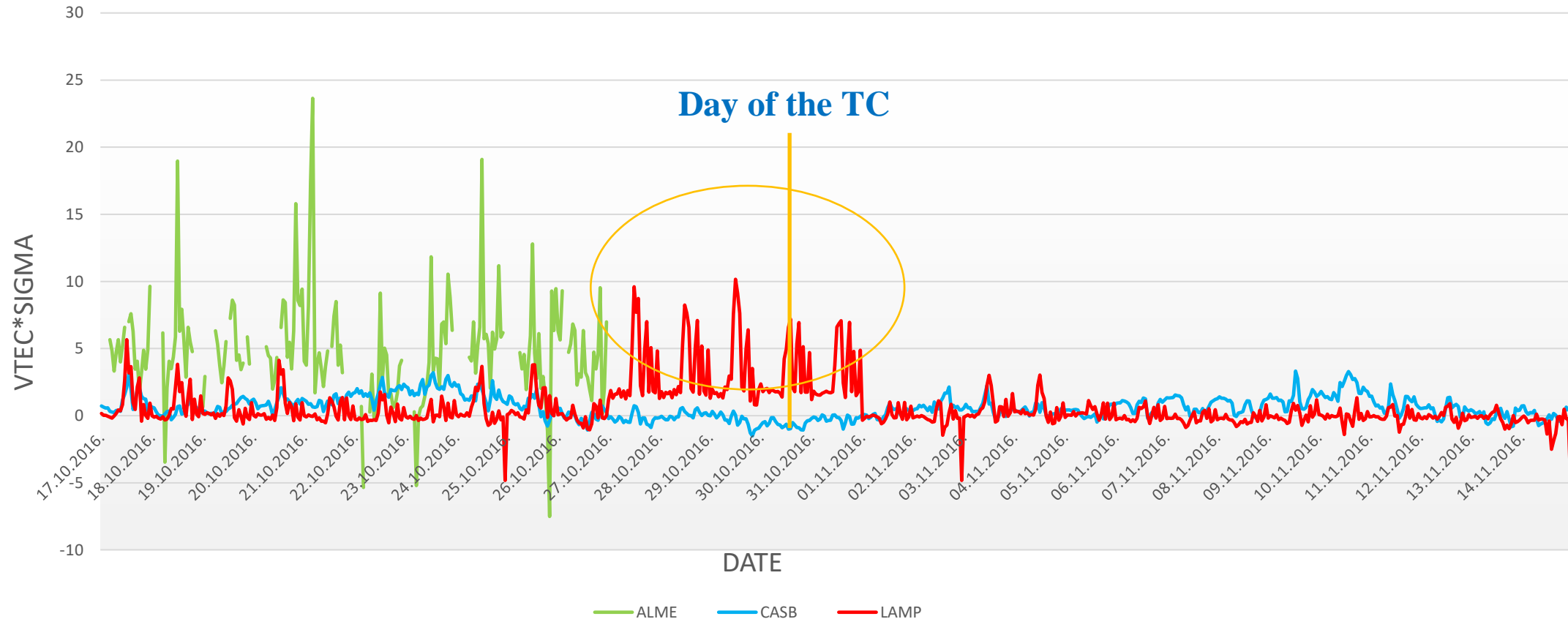


Time series of the $vTEC * \sigma$: Station LAMP - red (Italy) is the closest to the tropical storm. Parameter $vTEC * \sigma$ are quite bigger within days before, during and after the day of the TC than ALME – green (Spain) or CASB - blue (Ireland) which were far away and out of the TC impact.

Results



Medicane in October 2016

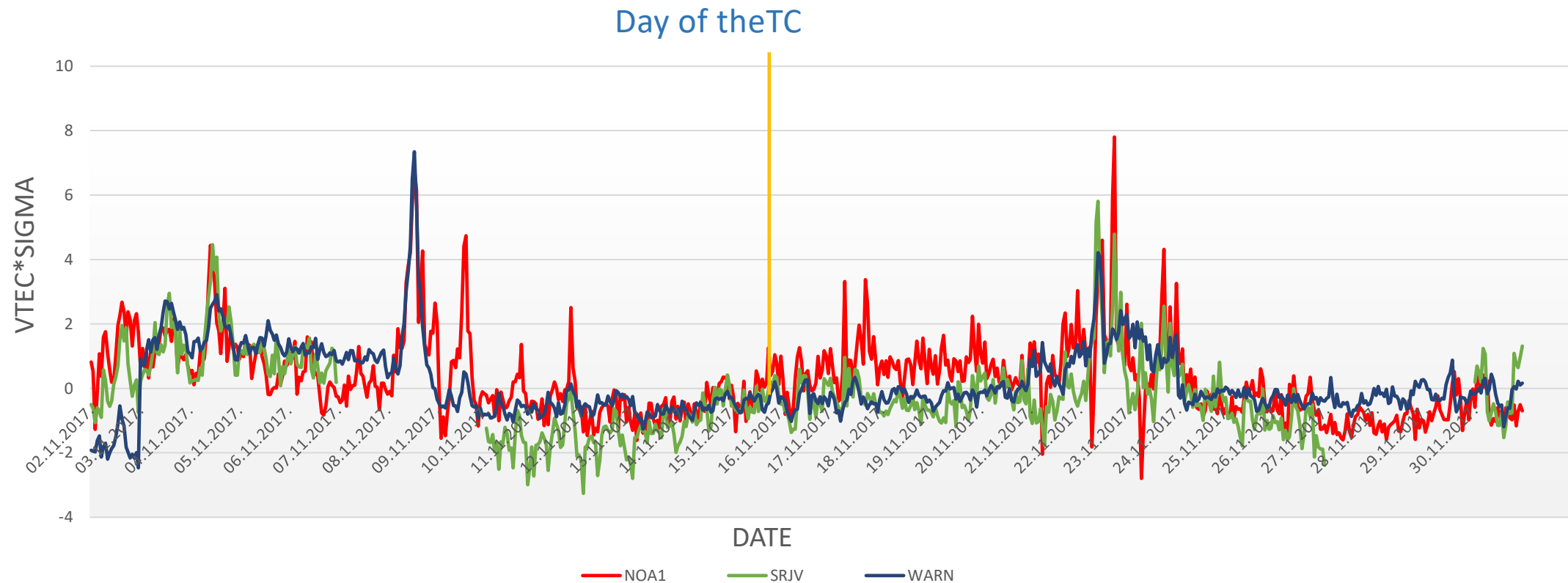


Time series of the $vTEC * \sigma$: Station LAMP – red (Italy) is the closest to the tropical storm. Parameter $vTEC * \sigma$ are bigger within three days before, during and one day after the TC than at station CASB - blue (Ireland) which was far away. Station ALME – green (Spain) did not have all available observation data for this period.

Results



Medicane November 2017



Time series of the $vTEC * \sigma$: Station NOA1 - red (Greece) is the closest to the hurricane. Parameter $vTEC * \sigma$ are bigger within days after the hurricane at NOA1 than at SRJV - green (Sarajevo, B&H) or WARN - blue (Germany) which were far from the hurricane's eye.

Conclusions



- This study was an investigation of the ionospheric response to Medicanes on Nov 2014, Oct 2016, and Nov 2017.
- GNSS TEC variations and anomalies before, during and after tropical cyclones were analyzed at EPN stations in and outside of the area impacted by Medicanes.
- The ionospheric response to tropical storms requires careful observation of geophysical conditions, since detection and identification of the ionospheric response to tropical cyclones are possible under calm geophysical conditions.
- The research showed that the main factors that suppress the effects of the troposphere on the ionosphere are geomagnetic storms.
- Results show that increased VTEC values at GNSS stations near the TC eye could be correlated with the tropical cyclones' impact.
- There is a need for a deeper investigation of these complex systems.

This presentation is based on the reserach carried out within the frame of the master thesis of (Lavić, 2019).

- *Lavić, A. (2019): Correlation between tropical-like cyclones in the Mediterranean and space weather, Master thesis. University of Sarajevo – Faculty of Civil Engineering.*

In this research some of the used references were:

- *Rodriguez-Bouza, M., Herraiz, M., Rodriguez-Caderot, G., Radicella, S.M., (2016) : Ionospheric TEC disturbance during the Mediterranean tropical-like cyclone occured on November 2014.; International Beacon Satellite Symposium BSS-2016, Italy*
- *Cavicchia, L.: A long term climatology of Medicanes, University of Venice, Doctor thesis, 2013*
- *Ciraolo, L.: Ionospheric Total Electron Content (TEC) from the Global Positioning System, Personal communication, 2012*
- *Lionello et al: Objective climatology of cyclones in the Mediterranean region: a consensus view among methods with different system identification and tracking criteria, Tellus A: Dynamic Meteorology and Oceanography, Italy, 2016*
- *Mendoza: The effects of Space weather on Hurricane activity, Recent Hurricane Research-Climate, Dynamics and Societal Impacts, Institute of Geophysics, Mexico, 2011*
- *Mulić, M., Natraš, R.: Ionosphere TEC Variations Over Bosnia and Herzegovina Using GNSS Data, a chapter in: Cefalo, R., Zielinski, J.B., Barbarella, M., (eds): New Advanced GNSS and 3D Spatial Techniques, 2017*
- *Natras R., Mulic M. (2018) Geodetic Remote Sensing of Ionosphere in Relation to Space Weather and Seismic Activity in B&H. In: Freymueller J., Sánchez L. (eds) International Symposium on Advancing Geodesy in a Changing World. International Association of Geodesy Symposia, vol 149. Springer*
- *Natras, R., D. Krdzalic, D. Horozovic, A. Tabakovic, M. Mulic: "GNSS ionospheric TEC and positioning accuracy during intense space and terrestrial weather events in B&H"; Geodetski Vestnik, 63 (2019), 1; 73 - 91.*
- *Pytharoulis, I. et al: Study of the hurricane-like Mediterranean cyclone of January 1995. Phys. Chem. Earth (B) 24, 1999*



Thank you!



HR EXCELLENCE IN RESEARCH

