



DInSAR ground deformation estimation and Swarm Observations of ULF Pulsation Activity for the 2016 Central Italy Earthquake sequence

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GeoHub Service

BEYOND Centre of Excellence for EO-based monitoring of Natural Disasters

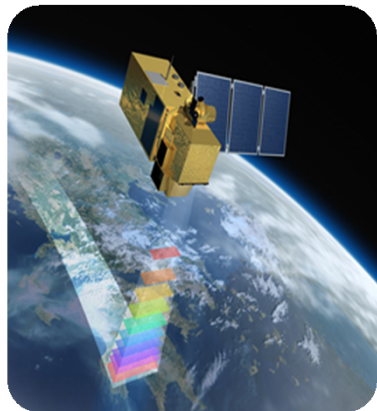
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Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS)

National Observatory of Athens (NOA)



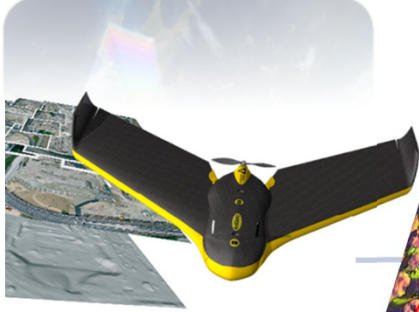
Monitoring Systems



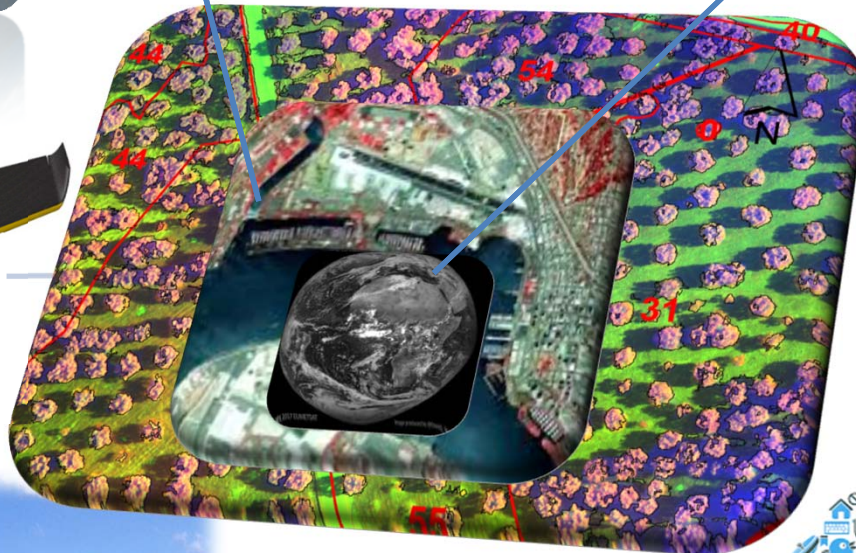
Polar orbit satellites
X-/L-band Station
Sentinel
Mirror Site



Geostationary orbit satellites
MSG Seviri



UAVs



in-situ

In-situ platforms & networks





38th Annual EARSeL Symposium 9-12 July 2018
 Earth Observation Supporting Sustainability Research
 Chania, Crete, Greece



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Hellenic National Sentinel Data Mirror Site / ESA-NOA Agreement



Sentinel Image Processing Toolbox Overview and Description Text
[View the Sentinel Processing Toolbox User Manual](#)

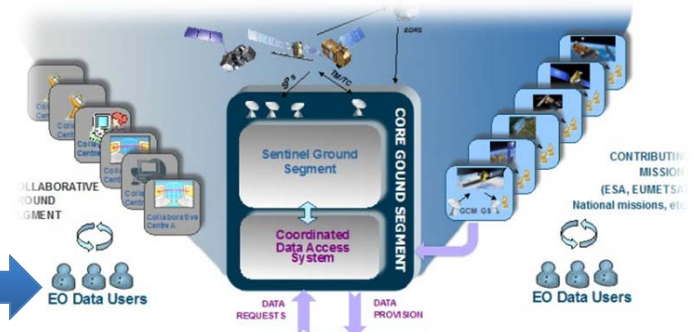
NOA Hellenic National Sentinel Data Mirror Site Team
 NOA Official: Prof. Kanaris C. Tsiganos, President of NOA
 Scientific Coordinator: Dr. Haris Kontos, Research Director
 WebMaster: MSc. Theodoros Herekakis, Research Associate
 Development: MSc. Vassilis Tsironis, Research Associate
 Curator: Mr. Vaggelis Papakirou, Research Associate

BEYOND
 National Observatory of Athens

Web Template created with Artisteer

Sentinel-1
Sentinel-2
Sentinel-3
Sentinel-5p

<http://sentinels.space.noa.gr>



Distributes 150-200 GB/day
Operates non-stop 24/7
Powered by the GRNET/GEANT Network Speed 150-200 Mbps
250 Users in South-East Europe



The role of the BEYOND EO Center of Excellence in the European EO Programme Copernicus for emergency management worldwide: Prevention - Preparedness - Risk Assessment - Response - Mitigation



Regulation (EU) No 377/2014 - Copernicus

Copernicus Work Programme

Sendai Framework (UN)
 for Disaster Risk Reduction 2015-2030

COPERNICUS
 Emergency Management Service

Home | What is Copernicus | EMS - Mapping | EMS - Early Warning System

LATEST NEWS · 2017-03-08 | [EMS038] Post-disaster situation analyses of flood and landslides in Lima, Peru

EMS - MAPPING

- Service Overview
- Who can use the service
- How to use the service
- Products: Rapid Mapping
- Products: Risk and Recovery
- Quality control / Feedback
- User Guide

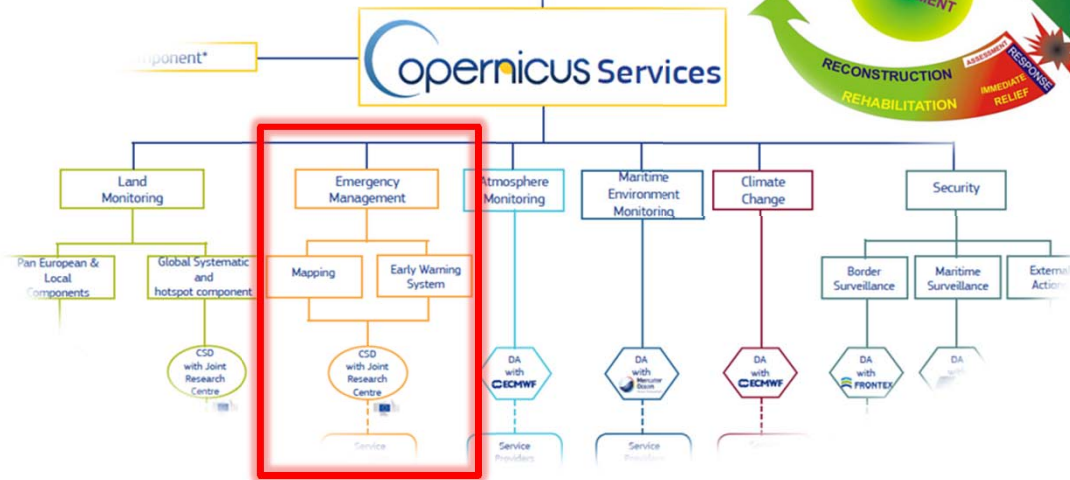
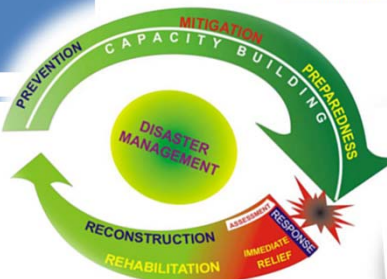
RAPID MAPPING

- List of Activations

List of EMS Risk and Recovery Mapping Activations

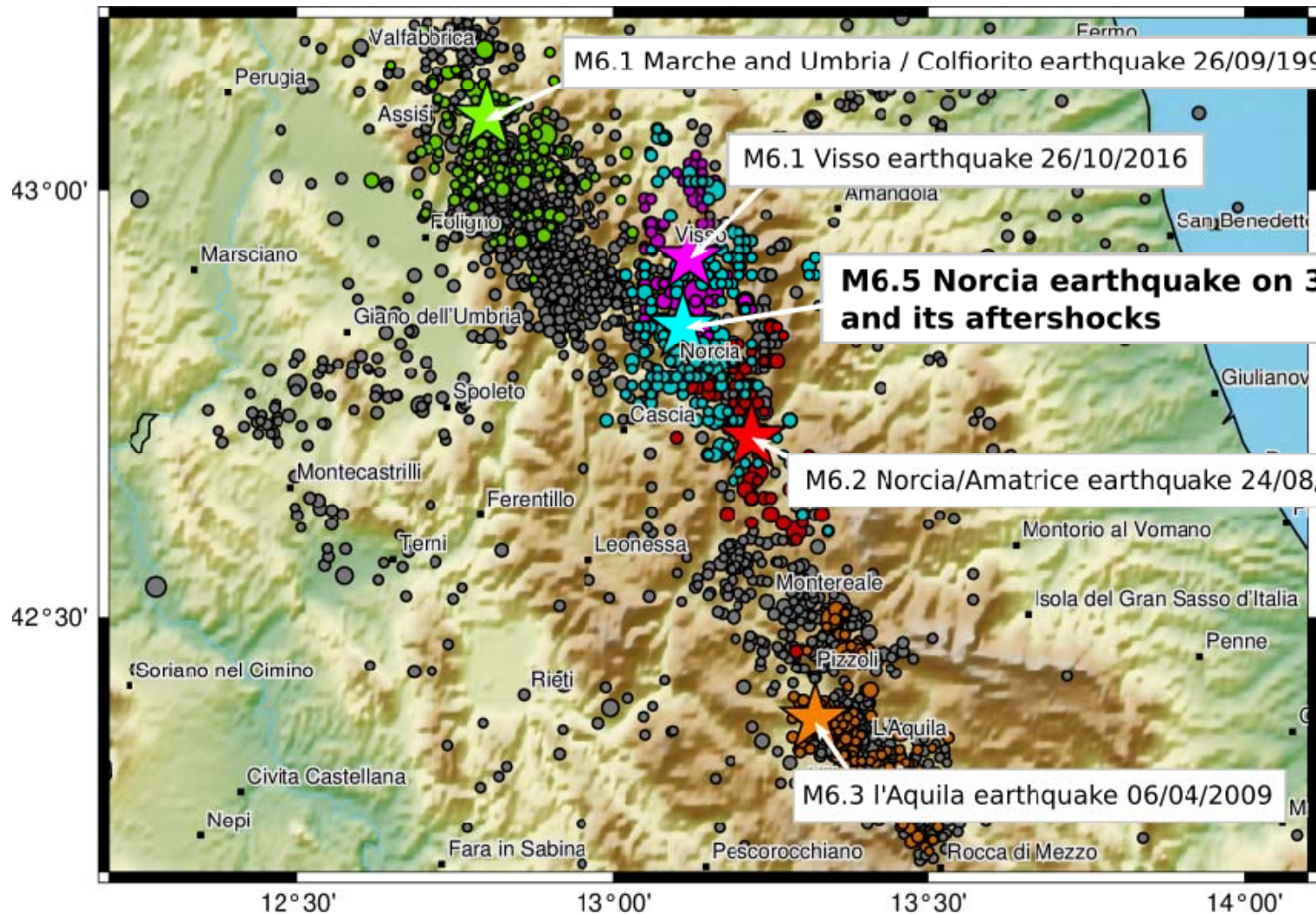
Title	Event Type	Event Date (UTC)	Affected Countries
Contains	Drought Epidemic Extreme temperature Humanitarian Infestation Mass movement	Start date E.g. 2017-10-08 End date E.g. 2017-10-08	Afghanistan Albania Australia Austria Bangladesh Belgium Bermuda

Act. Code	Title	Country/Terr.	Feed
EMS043	Tsunami risks assessment in Southern Italy	Italy	
EMS041	Forest fire risks assessment in Croatia	Croatia	
EMS040	Nation-wide asset mapping Finland	Finland	





Distribution of main seismic sequences in Italy from 1997 to 02/11/2016

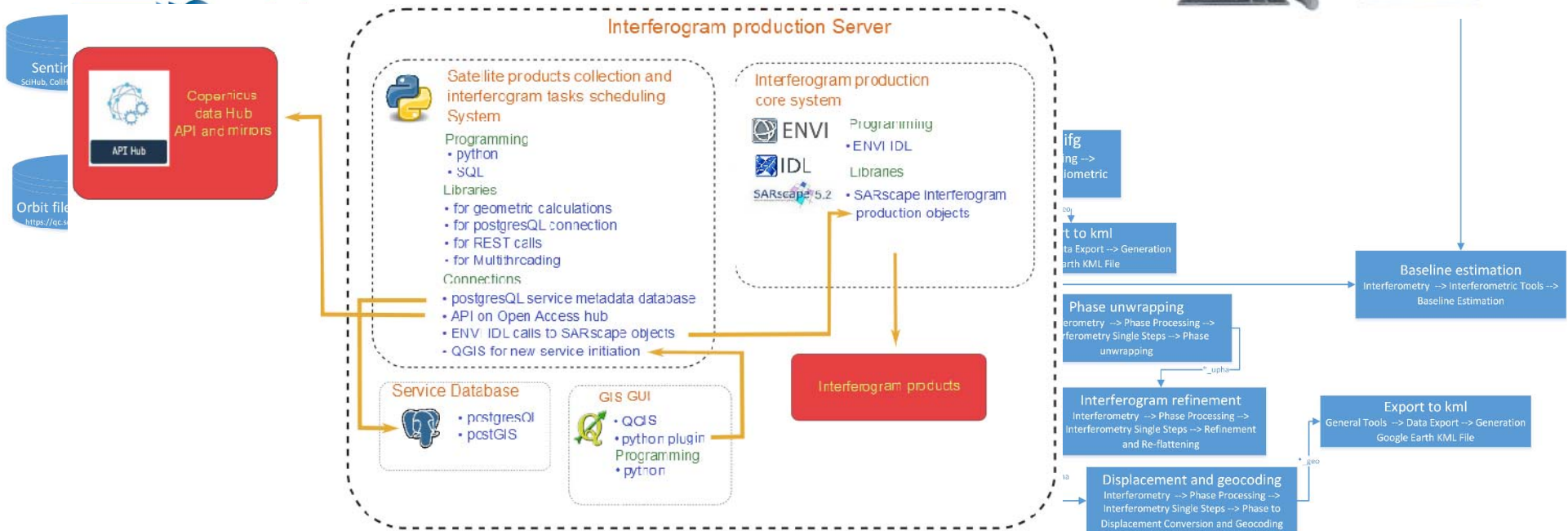
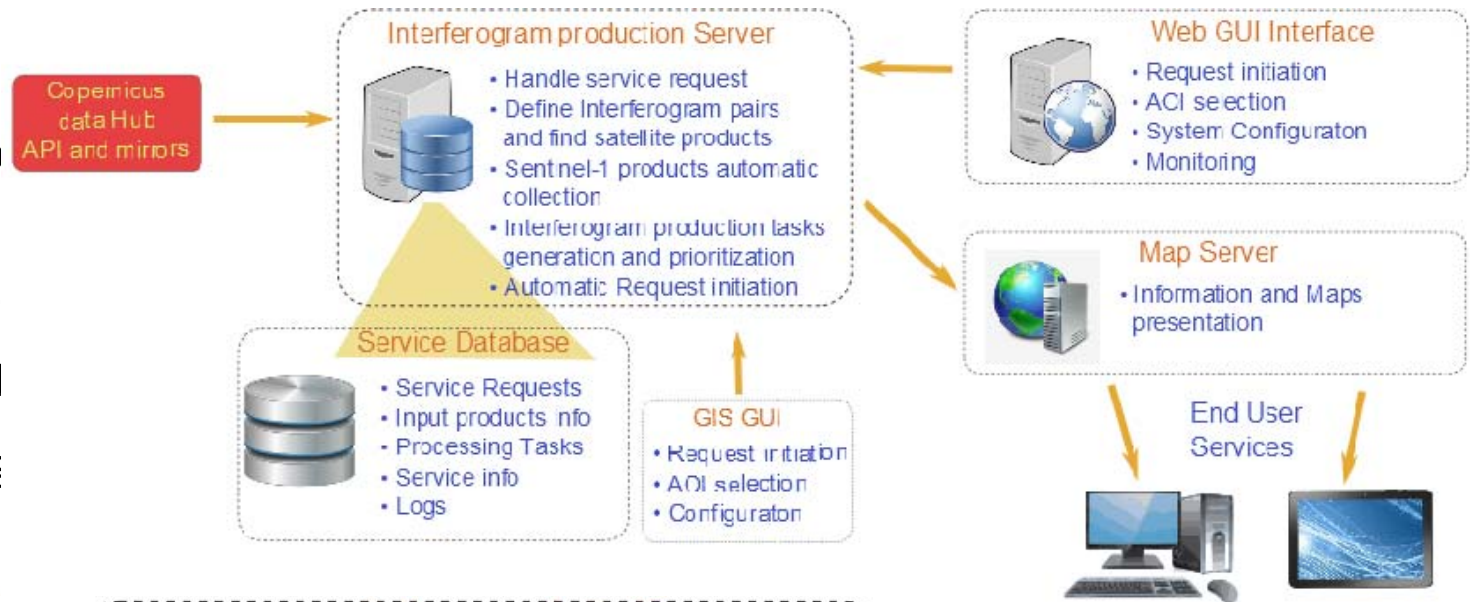


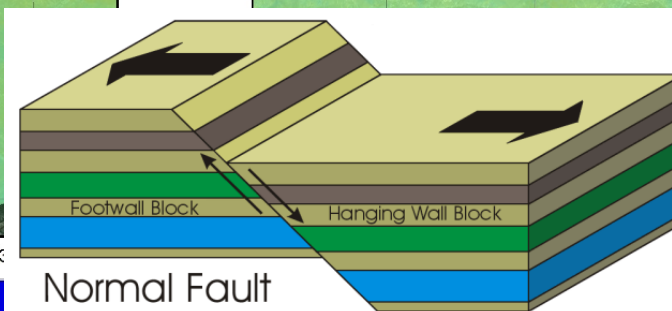
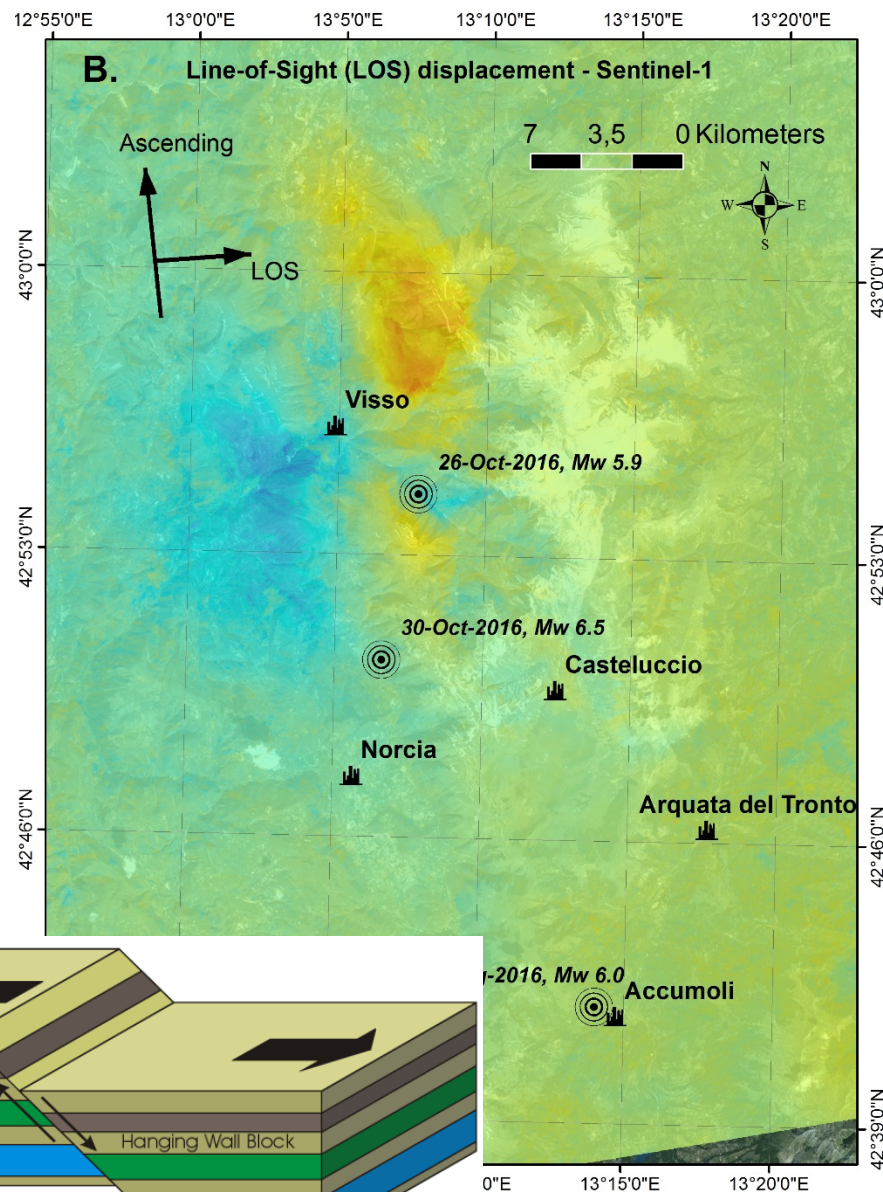
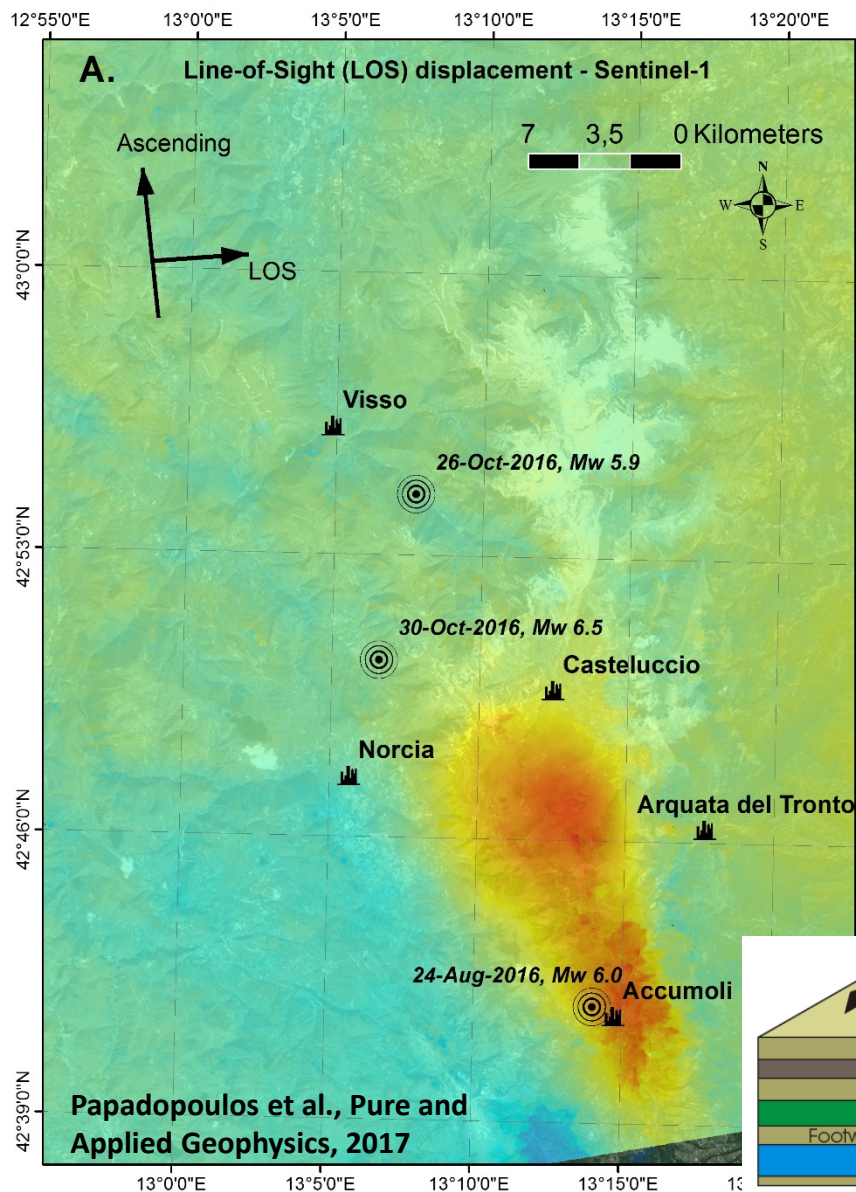
Seismic events of magnitude > 3 from ISC and EMSC database

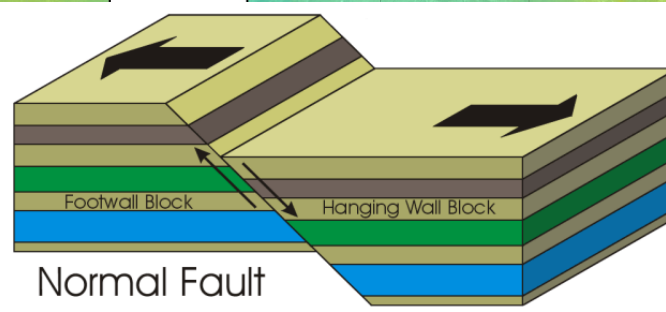
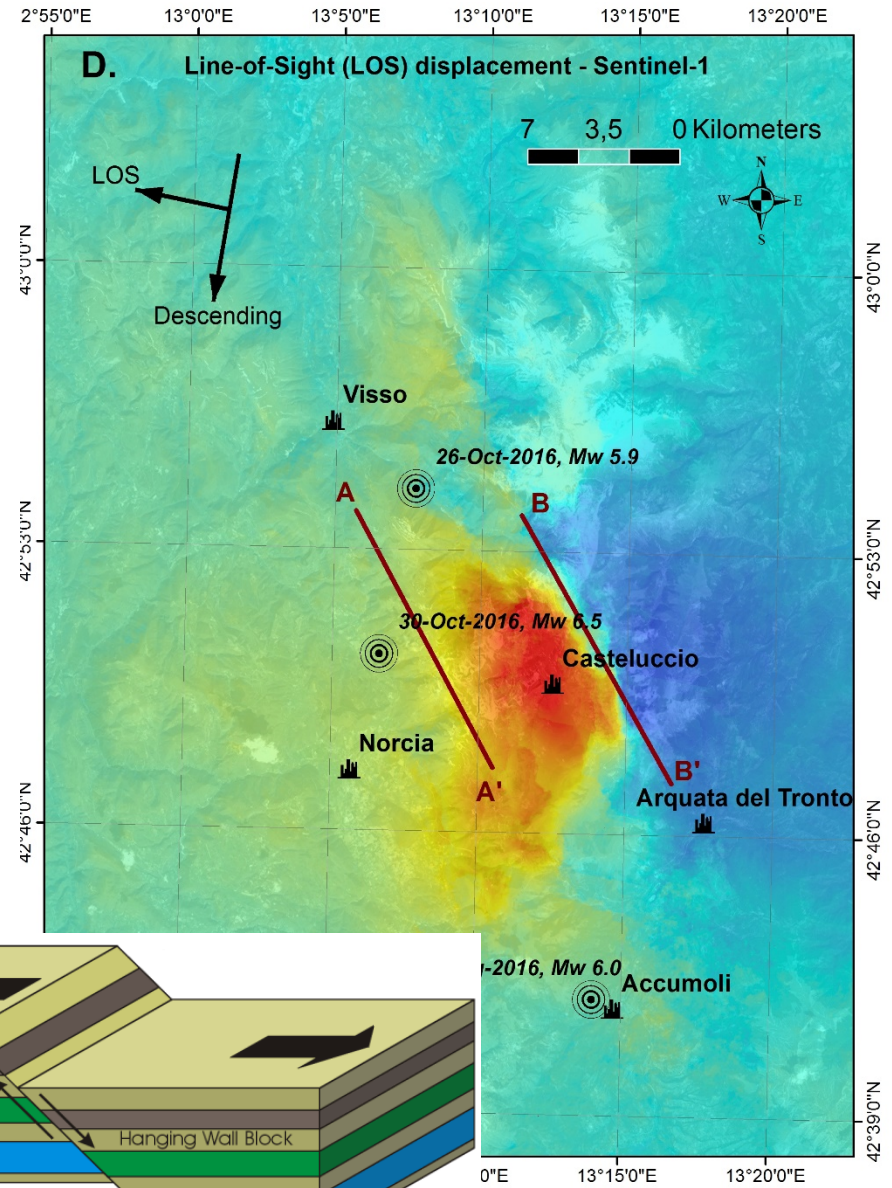
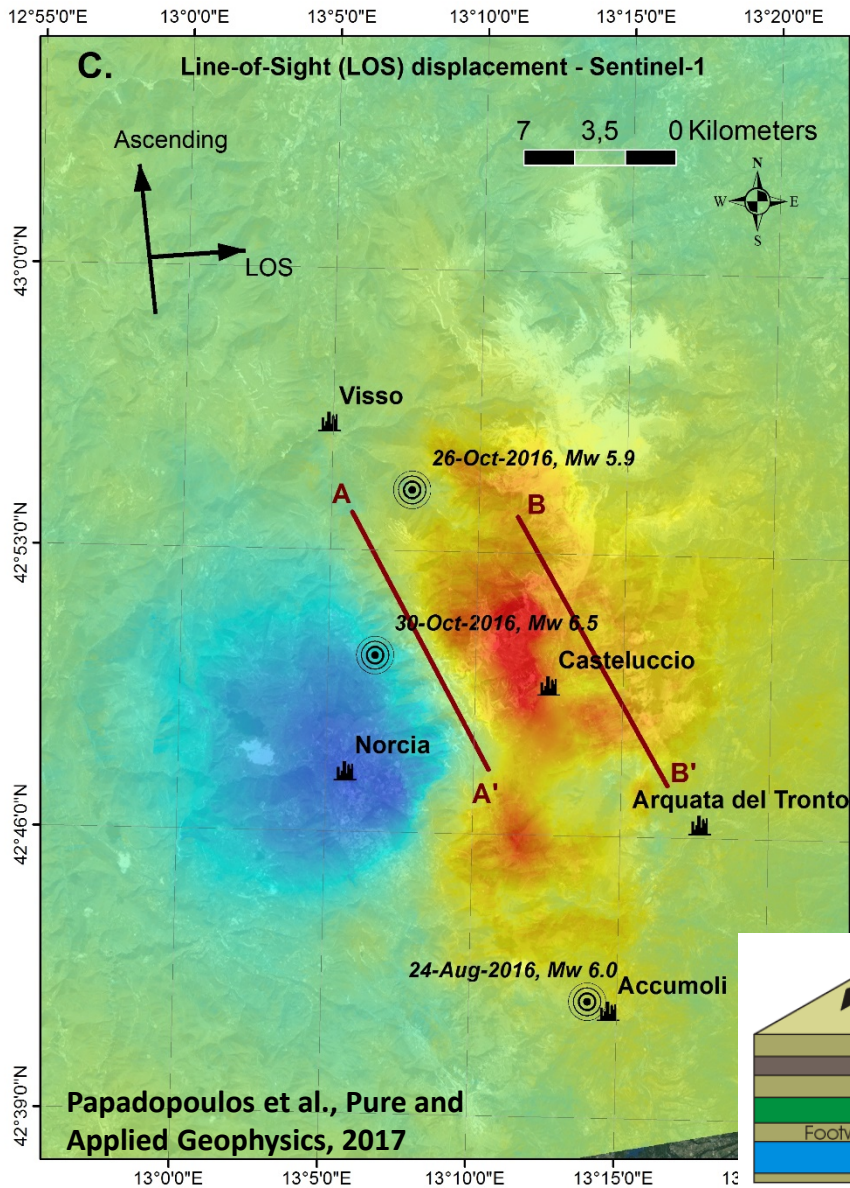
Three shallow, normal faulting very strong earthquakes rupturing in an NW–SE striking zone

A fully automatic system for
 deformation

- GeoHub connection
- Download of satellite products
- Processing of SAR data



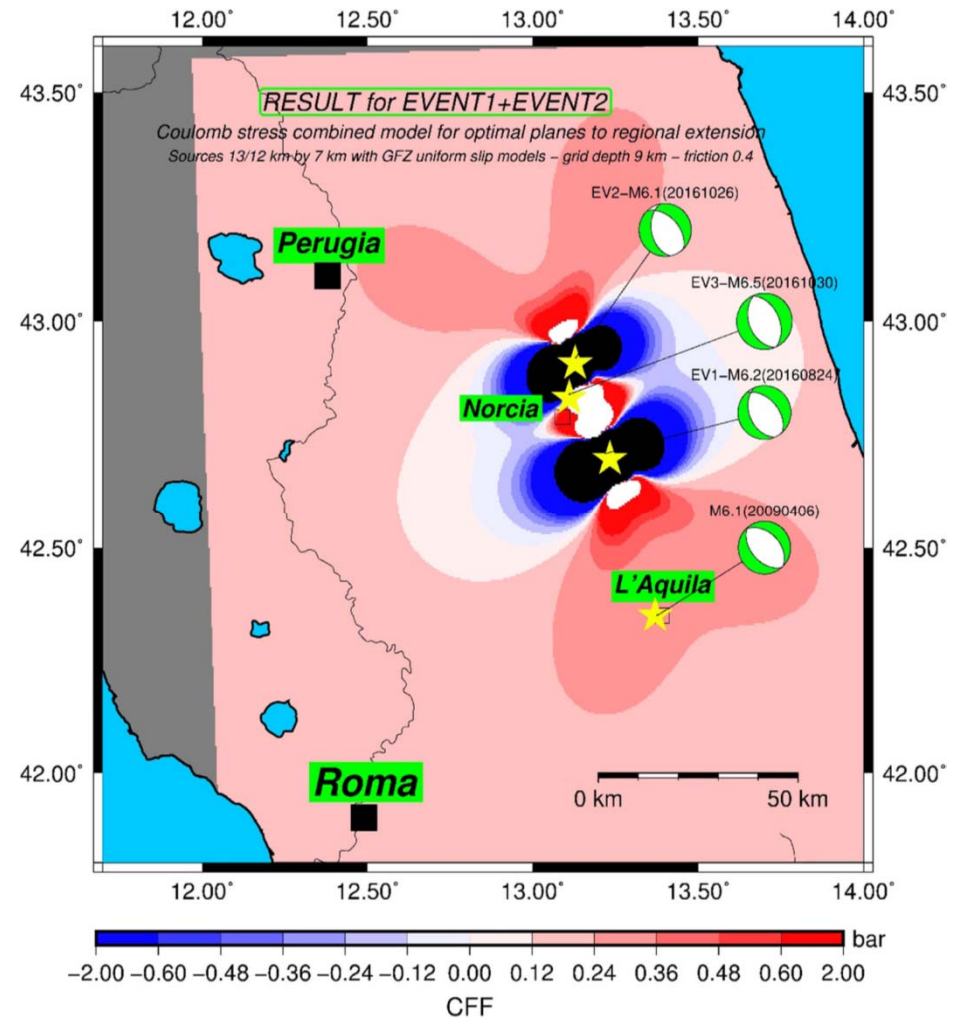




Conclusions

- Showed ground deformation directivity from events 1 and 2 towards event 3, which is consistent with the rupture process directivity
- Based on rupture directivity and ground deformation pattern, we put forward the hypothesis that the area of the second event was stress loaded by the first one and that both the first and second earthquake events caused stress loading in the area, where the third event ruptured.
- Coulomb stress-transfer modelling yields strong evidence in favor of our hypothesis.

Papadopoulos et al., Pure and Applied Geophysics, 2017



Swarm mission

Each satellite is measuring:

- Strength and direction of the magnetic field
- Plasma conditions and characteristics
- Location

The Constellation:

- 3 identical satellites:
 2 side-by-side in low orbit (<460km)
 1 in higher orbit (< 530km)
- three orbital planes for optimal coverage in space and time



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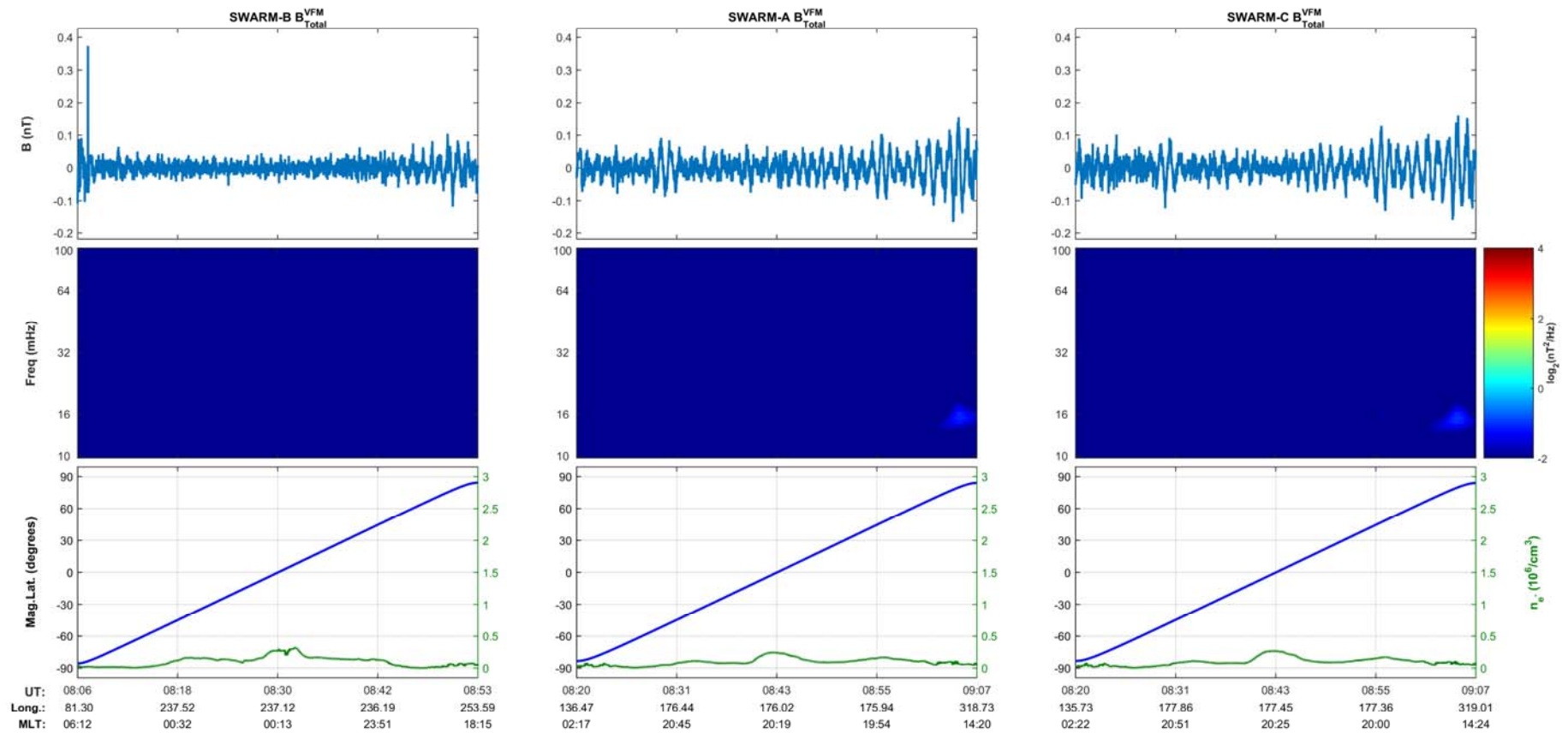


ULF Wave Activity & Earthquakes

- There have been several studies suggesting that ULF pulsations may be associated with earthquakes [Fraser-Smith et al., 1990; Hayakawa et al., 1996].
- The majority of these studies refers to the detection of these signals in ground-based magnetometer measurements (Hayakawa et al., 2015; Contoyiannis et al., 2016; Potirakis et al., 2016 and references therein).
- On the other hand, there is only a handful of studies that have been attempted to correlate ULF pulsations with seismic activity from space-borne measurements [e.g., Balasis and Manda, 2007 for CHAMP satellite and Walker et al., 2013 for DEMETER satellite].

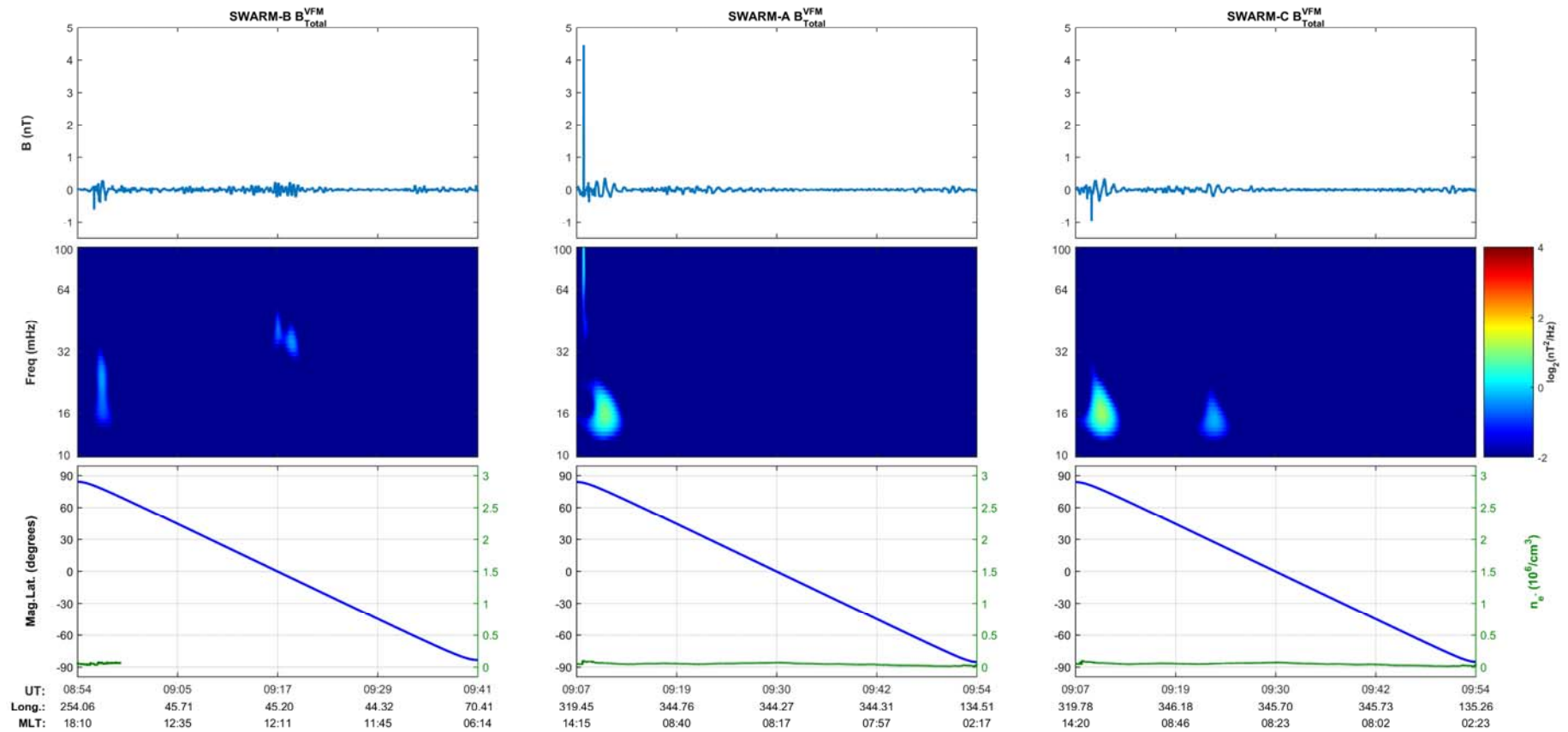
Central Italy Earthquake (24/08/2016, 01:36:33 UT)

Date: 23 Aug 2016



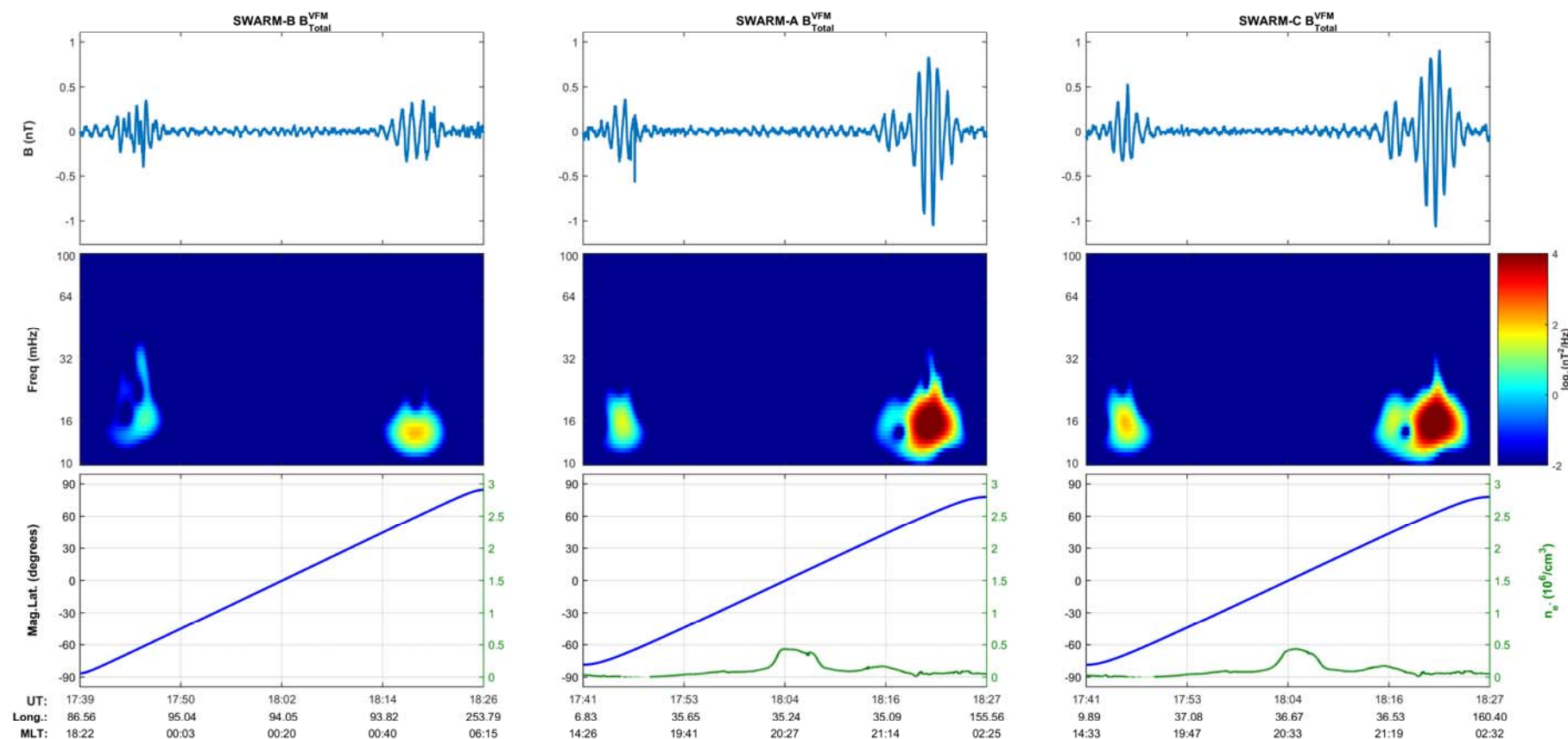
Central Italy Earthquake (24/08/2016, 01:36:33 UT)

Date: 23 Aug 2016



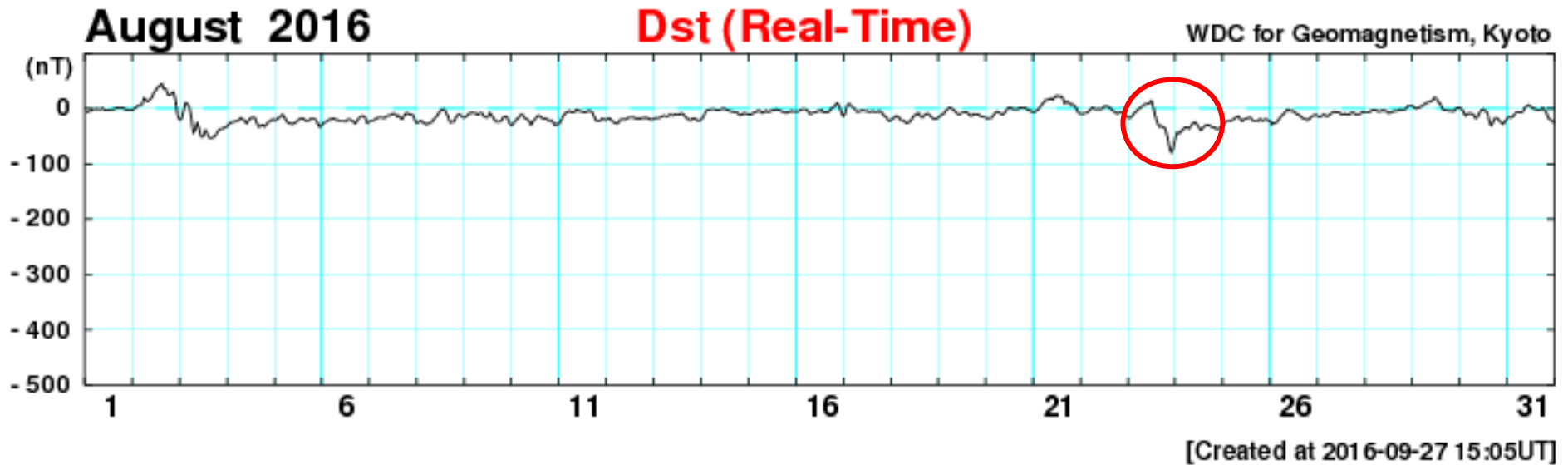
Central Italy Earthquake (24/08/2016, 01:36:33 UT)

Date: 23 Aug 2016



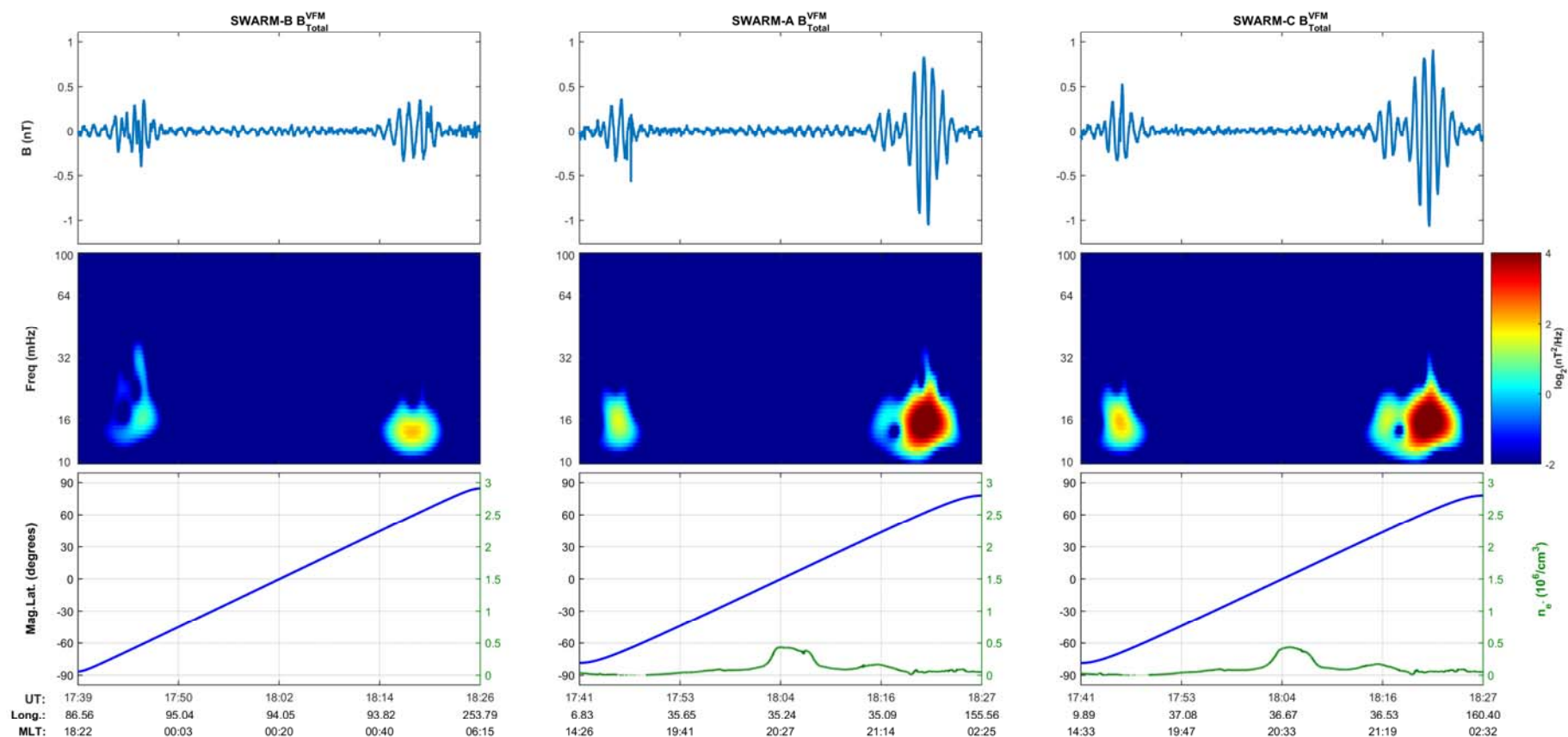


Central Italy Earthquake (23/08/2016, 22:00 UT, Dst = -80 nT)



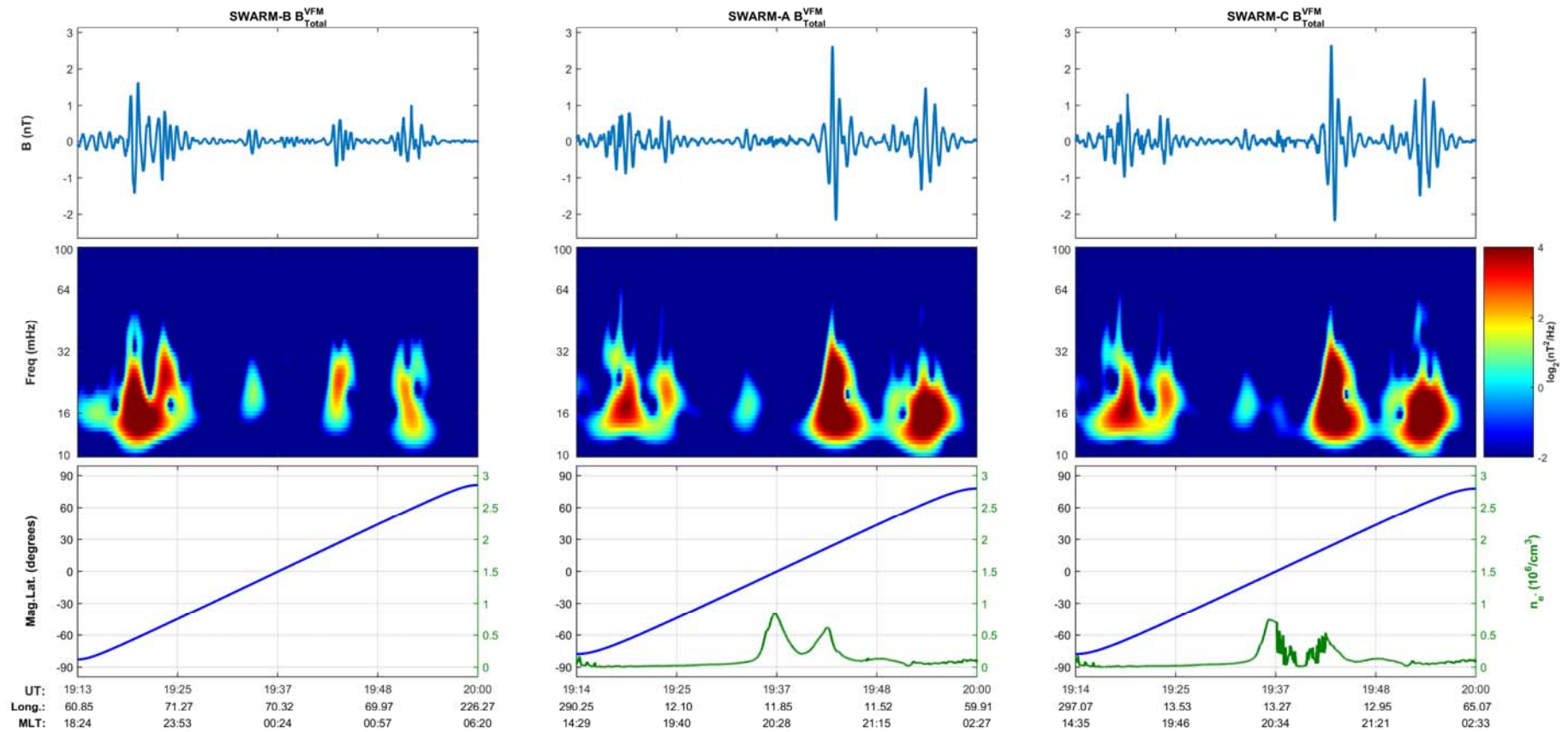
Central Italy Earthquake (24/08/2016, 01:36:33 UT)

Date: 23 Aug 2016



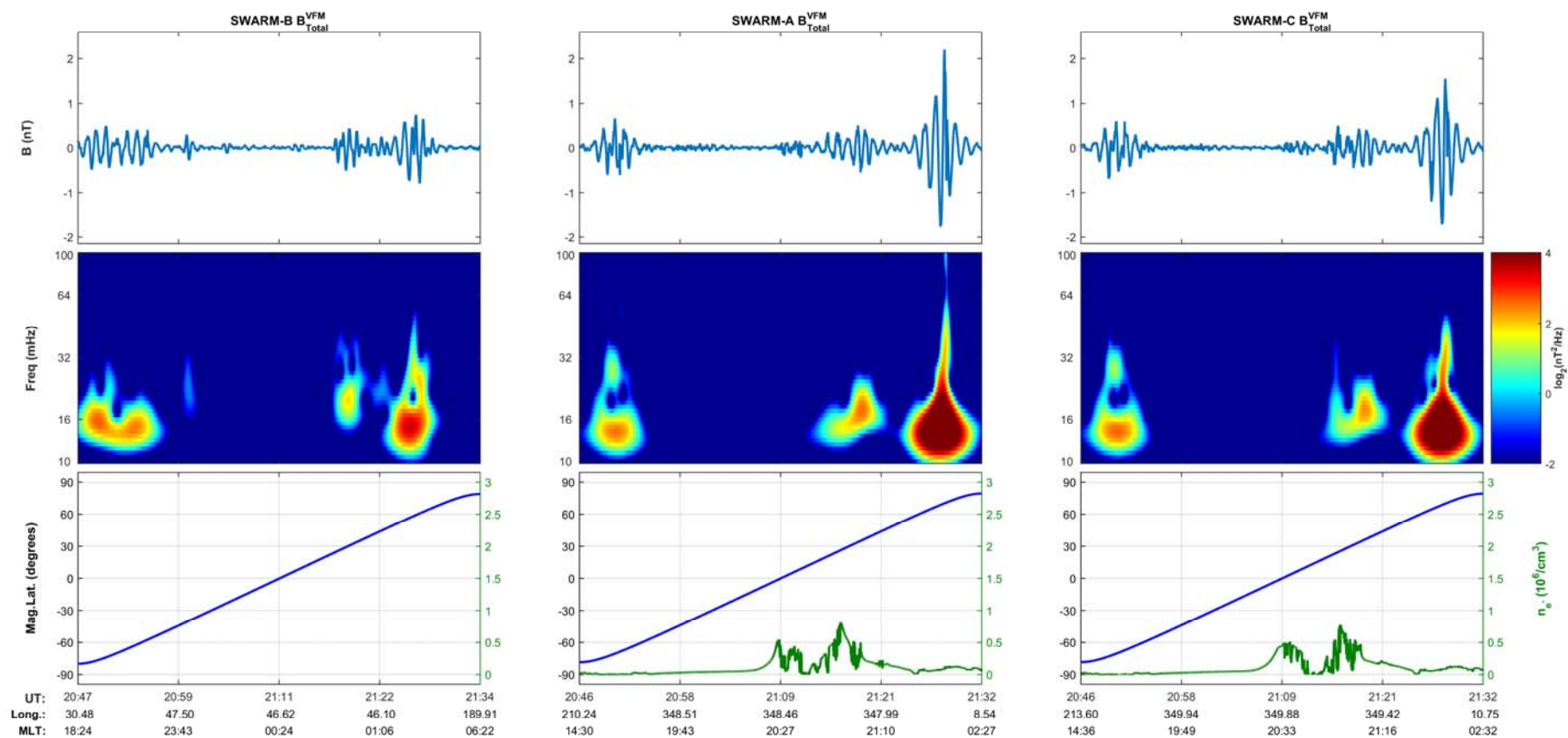
Central Italy Earthquake (42.71°, 13.17°)

Date: 23 Aug 2016



Central Italy Earthquake (42.71°, 13.17°)

Date: 23 Aug 2016





Summary

- Swarm offers a great opportunity to study ULF waves in the topside ionosphere with unprecedented detail leading to new science discoveries.
- Additionally, Swarm may provide new possibilities towards improving the current state-of-the-art in studying satellite data with respect to earthquake-related signals through:
 - The exploitation of lower (1 Hz) but more importantly higher (50 Hz) resolution magnetic field data as well as electric field data from the Swarm mission.
 - The combination with ground magnetic field measurements when conjunctions between Swarm and ground magnetic stations occur.



Thank you for your attention!

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