GROUP ON EARTH OBSERVATIONS

GEO-VIII

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Geohazard Supersites and Natural Laboratories Progress Report

Document 9

For information

Geohazard Supersites and Natural Laboratories Progress Report

1 RECOMMENDATIONS

The task leadership recommends to the Plenary to:

- Take note of the significant progress made in international coordination of space-based geohazard monitoring and data sharing since 2010;
- Recognize that a global approach can lead to a better understanding of geohazards and to the mitigation of geological disasters;
- Appreciate that the Geohazard Supersites cross-cut between existing and emerging space- and in-situ observation systems.

And to:

- Encourage national geohazard monitoring agencies to contribute in-situ data for a global network of natural laboratories;
- Develop a USA-EU-Japan demonstrator project to virtually interconnect GPS in-situ data;
- Fully exploit data policies of past and current satellite missions to complete the SAR data holdings of the Geohazard Supersites.

2 EXECUTIVE SUMMARY

The overarching objective of the Geohazard Supersites is:

“To enrich our knowledge about geohazards by empowering the global scientific community through collaboration of space and in-situ data providers and cross-domain sharing of data and knowledge. Policy makers and national agencies will benefit from the new scientific knowledge for the assessment and mitigation of geological risks."

The Geohazard Supersites is a partnership of organizations and scientists involved in the monitoring and assessment of geohazards. The stakeholders are:

- agencies responsible for the in-situ monitoring of earthquake and volcanic areas providing the in-situ data;
- space agencies and satellite operators providing the satellite data;
- the global geohazard scientific community.

The strategy to achieve the objective is (1) by improved monitoring through coordination of space and in-situ data providers for selected sites (Geohazard Supersites) and regions (natural laboratories for geohazards), (2) by an e-infrastructure virtually connecting the data providers and users and (3) by open access to all relevant data sets according to the GEO data sharing principles (seismic, GPS and interferometric synthetic aperture radar (InSAR)).

The rationale behind the Geohazard Supersites is that improved monitoring and scientific understanding of geohazards can lead to the mitigation of geological disasters. The 2010-2011 earthquake and tsunami disasters in Haiti and Japan painfully demonstrated that better preparedness could have reduced the human and economic toll.

3 BENEFITS FOR POLICY MAKERS AND GOVERNMENTS

The Geohazard Supersites charter new waters of international collaboration. The benefits include:

- Scientists around the world work on the Geohazard Supersites in a collaborative, inter-disciplinary and cross-cutting manner and deliver new scientific discoveries at “no cost” to the governments;
- National monitoring agencies can use the Geohazard Supersites as a resource for advising decision makers;
- Synenergy between multi-sensor satellite observations and in-situ observation systems leads to improved geohazard monitoring and better assessment of earthquake and volcanic risk.

4 ACHIEVEMENTS

4.1 Collaboration of space and in-situ data providers

The principal achievement of the last years was successful collaboration between space- and in-situ data provider for the common goal of improving geohazard monitoring. Under coordination of CEOS, nearly all satellite data providers have established procedures and means for data provision. The European in-situ data provider under the coordination of the European Plate Observatory System (EPOS) and the U.S. institutions (U.S. Geological Survey and Unavco/Earthscope) are now teaming up to support the initiative.

4.2 Establishment of initial Supersites

Geohazard Supersites are areas exposed to particular geological hazards for which space and in-situ data provider systematically acquire geophysical data which are available trough a common e-infrastructure. The initial earthquake Supersites are Istanbul, Los Angeles, and Vancouver/Seattle and the initial volcano Supersites are Hawaii, Mt. Etna and Vesuvius/Campi Flegreii. Tokyo-Mt. Fuji is both, earthquake and volcano Supersite. A typical example of a Supersites data product is shown for the Istanbul Supersite in Fig. 1. The combination of satellite-based measurements (InSAR velocity field, color-shaded) with in-situ measurements (GPS, white vectors) leads to better estimates about the relative motion between the Eurasian plate in the north (containing Istanbul) and the Anatolian plate in the south and the earthquake hazard of Istanbul. The Istanbul Supersite activities are led by the TÜBITAK Marmara Research Center.

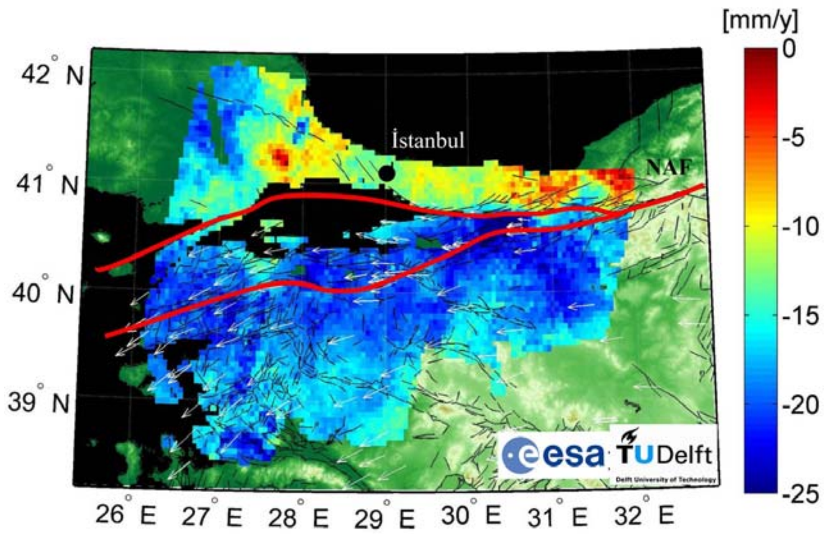

Figure 1. *Istanbul Supersite. Preliminary ground velocity in the East direction derived from data of ESA's Envisat satellite between 2003-2010. Blue colors south of the Marmara Sea indicate ground velocity of 2 cm/year (towards Greece) with respect to stable Eurasia. White vectors: in-situ GPS measurements (Aktug et al. 09). These data provide information about how the strain is accumulated during the relative motion of the tectonic plates and eventually released in earthquakes.*

4.3 Haiti earthquake event Supersite

In the days following the disastrous earthquake of January 12, 2010 that killed ~200,000 people the question on everybody's mind was the risk for another earthquake. Could the earthquake be the foreshock for another, even more destructive event? The information needed to assess this possibility was the precise location and rupture length of the earthquake. Satellite-based interferometric synthetic aperture radar (InSAR)can provide this information. The InSAR technique combines two radar images from before and after the earthquake to measure ground deformation from which the rupture area can be inferred.

On January 25th the Japanese space agency (JAXA) acquired a critical SAR image and provided this immediately to the Geohazard Supersites. Several research groups around the world analyzed the data and found that the rupture stopped about 25 km west of Port-Au-Prince (Fig. 2). A well-known fault passing south of the city was not ruptured. This fault will break in the future, implying a very high earthquake risk. This information was used by scientists to advice rescue organizations and decision makers. Subsequent studies refined the picture, suggesting that a hidden fault a few km further north caused the earthquake.

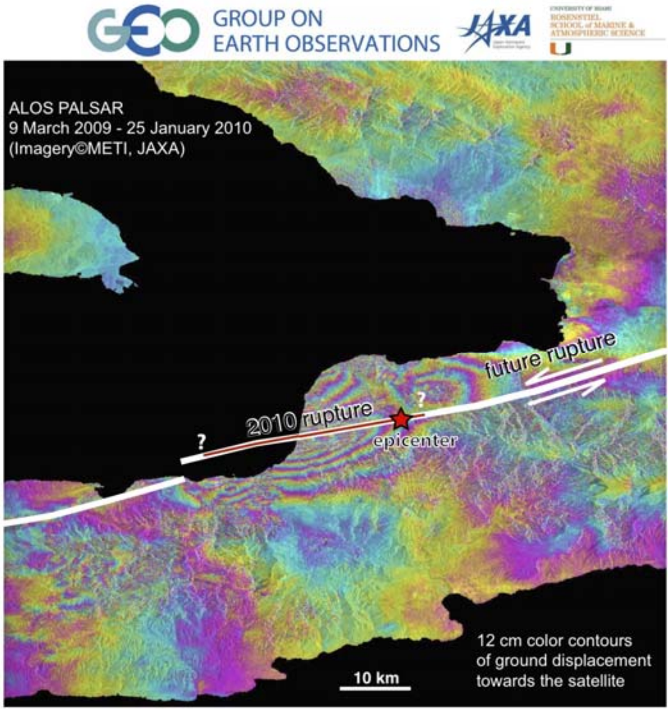

Figure 2. *Satellite radar interferogram based on JAXA's ALOS data showing ground deformation associated with the January 2010 Haiti earthquake. One color cycle corresponds to 12 cm ground displacement. The interferogram shows that the earthquake did not rupture the fault near Port-au-Prince which remains to be ruptured in the future. The new information about the earthquake rupture was very important to assess the earthquake risk of Port-au-Prince. The interpretation has since then been refined in three publications in the journal Nature Geosciences.*

4.4 Japan earthquake event Supersite

On March 11, 2011 a magnitude 9 earthquake occurred offshore Tohoku in northern Honshu. The Pacific plate moved by more than 20 meters under the Eurasian plate – the largest earthquake in Japan since at least 1000 years. The associated tsunami resulted in ~20,000 people dead or missing.

Unlike Haiti, Japan is very well equipped with in-situ observation systems. The GPS network of the Geospatial Information Authority of Japan (GSI) provided information about the ground deformation within minutes after the event. The Geohazard Supersites supplemented this information by InSAR measurements using multiple satellites (Fig. 3). The combination of in-situ with satellite-based measurements leads to very precise measurements, which helps to estimate the current earthquake hazard in Japan.

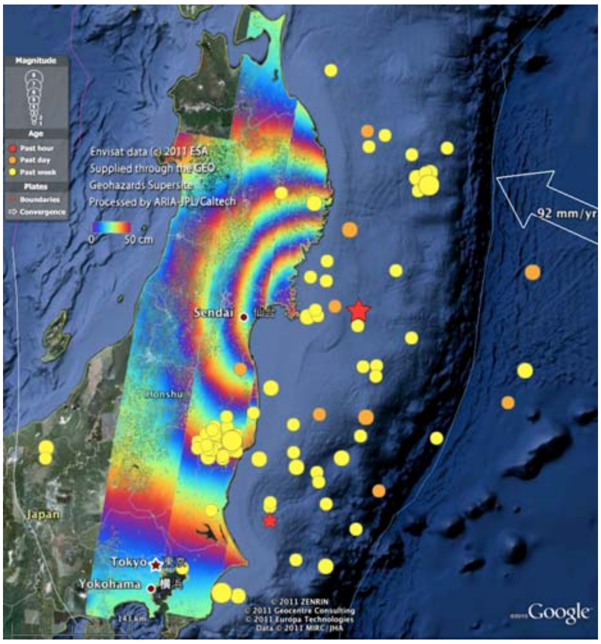

Figure 3. *Satellite radar interferogram of the March 2011 Japan earthquake obtained using ESA's Envisat satellite. One color cycle corresponds to 0.5 m ground movement in direction towards the satellite(interferogram contributed to theGEO Supersite within hours after image acquisition). JAXA and DLR also provided imagery for this event. After the demise of JAXA's ALOS satellite in April 2011, Envisat continues area-wide ground deformation monitoring of Japan. All data are openly available to the international geohazard community.*

4.5 European Union advances sharing of in-situ data

To make a contribution to the GEO 2012-2015 Work Plan the European Commission issued a call for proposals for long-term monitoring of geologically active regions following the Supersites concept. Each selected project will receive up to 6 million Euro for in-situ instrumentation. The European Plate Boundary Observatory (EPOS), which also serves as the task co-lead of the Geohazard Supersites, will assist the in the implementation of the data sharing and CEOS will provide the space-based data.

4.6 Designing the Turkey natural laboratory for geohazards

Earthquake hazard is of regional nature. Istanbul is threatened by earthquakes along the North Anatolian Fault, the ~1000 km long plate boundary fault between the Eurasi an and Anatolian plates. The fault passes ~15 km south of Istanbul through the Marmara Sea. Estimating Istanbul's earthquake hazard requires observation programs at multiple locations along the plate boundary. Recognizing the regional nature of the earthquake hazard, the Geohazard Supersites implemented the Turkey natural laboratory (Fig. 4). ESA has provided their entire data archive for Turkey. The TerraSAR-X satellite of the DLR is systematically observing selected sites along the North Anatolian Fault. The Turkish partners (TÜBITAK Marmara Research Center, Kandilli Observatory and Kultur University of Istanbul) are acquiring ground-based data to complement the space-based observations.

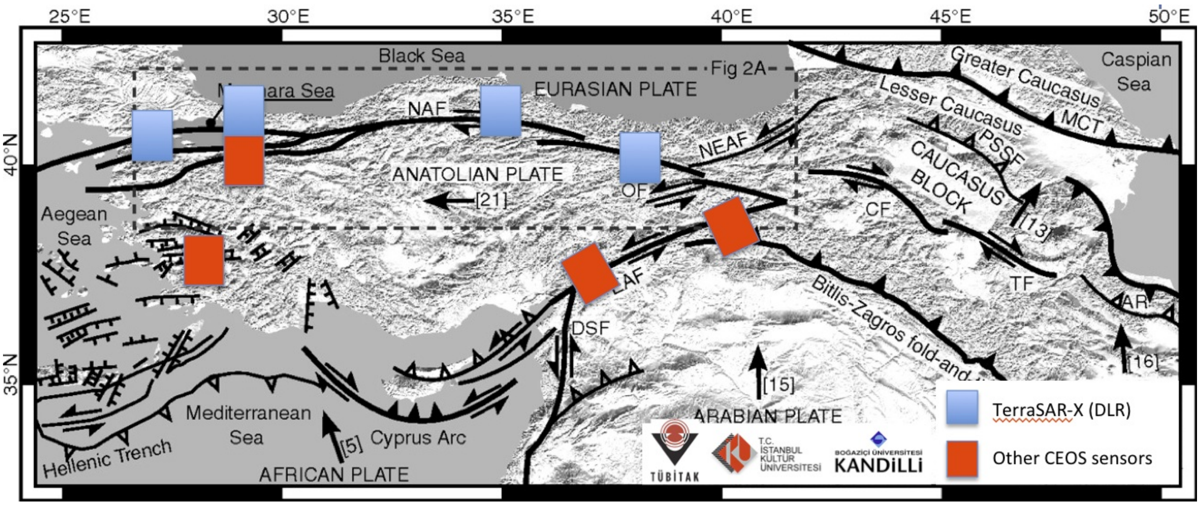

Figure 4. *Turkey Natural Laboratory for geohazards. TerraSAR-X is imaging several sites along the North Anatolian fault (NAF). The other sites will be imaged using other CEOS sensors. The Turkish monitoring agencies undertake in-situ measurements to complement the space-based observations.*

5 OPPORTUNITIES FOR NATIONAL AND LOCAL GOVERNMENTS

Governments can capitalize on the Geohazard Supersites in multiple ways. First, they can directly use newly generated information for risk reduction. Second, they can facilitate the study of particular geohazards by supporting in-situ monitoring programs following the above-mentioned example of the European Union. Third, governments, through Space Agencies, can stimulate research of particular regions by the provision of relevant data. For example, ESA is stimulating geohazard research in Turkey by providing online access to their entire data assets via the Turkey Natural Laboratory. In the same way, Japan could encourage geohazard research in Japan by providing in-situ and satellite data of Japan.

6 MOBILIZING AND INTERCONNECTING IN-SITU DATA PROVIDER

In the absence of a strong coordinating body such as the Committee of Earth Observations Satellites (CEOS) for Space Agencies, the participation of in-situ data provider can't progress as rapidly as for the satellite data provider. There are West-East differences in the sharing of in-situ data to be overcome. Data sharing is well established in the U.S. and Canada but limited to non-existent in parts of Asia. ***Governments should encourage national monitoring agencies to contribute data to, and take advantage of, the Geohazard Supersites.***

6.1 Proposed pilot project for in-situ data sharing

Key measurements for understanding geohazards are the in-situ GPS networks in Japan (~1200 stations), North America (~1500 stations) and Europe (~2200 stations). Some of these data are not yet openly available. ***Japan, USA and the European Commission are encouraged to implement a pilot project on sharing of GPS data.***