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Satellite Monitoring of Hazards: A Focus on Istanbul, Turkey

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Satellite remote sensing data can provide important information on ground displacement, which can help scientists better understand and monitor geohazards such as earthquakes, volcano unrest, or landslides. However, access to such data and their results often has been difficult or has occurred with significant delay. As a result, a remotely sensed assessment of ground displacements is often not available until months or years after the occurrence of a natural disaster.

In an attempt to facilitate access to satellite radar data and associated results in near real time, and to allow integration with other space-based and ground-based observation resources, the geohazards scientific community together with the European Space Agency (ESA) initiated the Geohazard Supersites program. As a contribution to risk reduction, this program seeks to promote data use and advance scientific research before, during, and after natural disasters. This program is contributing to the Group on Earth Observations (GEO) theme "Reducing the loss of life and property from natural and human-induced disasters." GEO is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS, launched by the leading industrialized countries in response to the 2002 World Summit on Sustainable Development.

One focus of the Geohazard Supersites program is to understand and monitor deformation activity in the vicinity of Istanbul, Turkey. Istanbul, with more than 10 million inhabitants, lies along the strike-slip North Anatolian Fault. With satellites, scientists are monitoring in near real time ground deformation and fault displacement for this major metropolitan area.

Monitoring Deformation Using Interferometric Synthetic Aperture Radar

In the twentieth century, progressively westward migrating earthquakes ruptured more than 700 kilometers of the North Anatolian Fault [*Reilinger et al.,* 2000]. The last major earthquake in this sequence, which was anticipated based on the previous sequence of earthquakes [*Stein et al.*, 1997], hit the region in 1999. This magnitude 7.4 earthquake, focused about 50 kilometers east of Istanbul, in Izmit, caused more than 17,000 deaths—approximately 1000 fatalities in Istanbul alone—in addition to severe damage and economic loss across the region. Now stress is building up west of Izmit [*Lorenzo-Martin et al.,* 2006], which implies that the next major event could occur adjacent to Istanbul itself. The vulnerability of Istanbul is increasing sharply, as the population has more than doubled since 1980 and the number of buildings has grown accordingly.

To better prepare for the potential high-risk scenario of an earthquake close to Istanbul, scientists from around the world are using the regularly updated Geohazard Supersites data platform to investigate surface deformation of the greater Istanbul region. This effort includes interferometric synthetic aperture radar (InSAR), a microwave remote sensing technique that has already been shown to provide valuable information about surface deformation in Istanbul [*Reilinger et al.,* 2000; *Wright et al.,* 2001]. Thus far, more than 500 images provided by ESA and acquired by the European Remote Sensing (ERS) 1, ERS 2, and Envisat satellites since 1992 can be downloaded from the Geohazard Supersites virtual platform for time series analysis. By applying an advanced InSAR time series approach [*Berardino et al.*, 2002], the deformation history of the past 2 decades can now be seen in unprecedented spatial and temporal detail.

Results show several ongoing deformation phenomena, including surface displacement caused by movements at the North Anatolian Fault and an extended subsidence pattern in urban areas that are underlain by young sediments (Figure 1). The ongoing subsidence marks substratum material consolidation processes, which

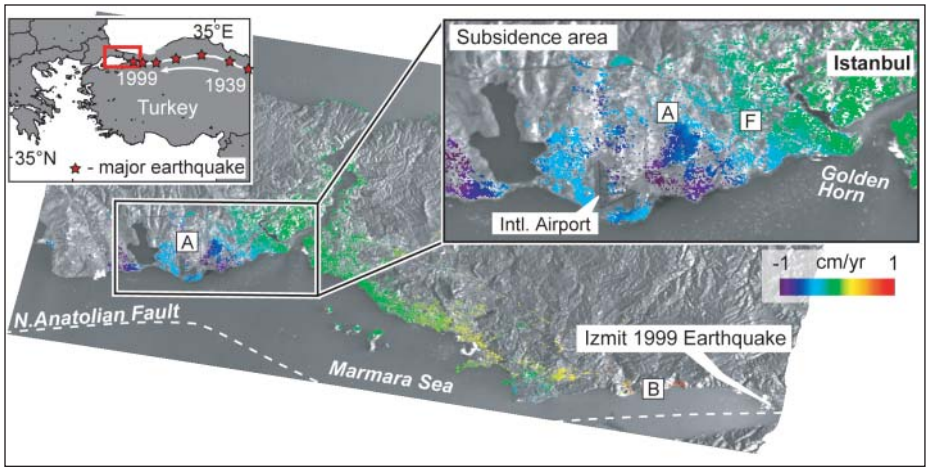

Fig. 1. Mean ground velocity map of the Istanbul supersite (http://supersites.unavco.org/) retrieved by radar data acquired by the European Remote Sensing (ERS) 1, ERS 2, and Envisat satellites from 1992 to 2010. Measured displacements are shown in the line of sight (23° from vertical) of the satellites: Red is ground movement toward the satellite, blue is away from the satellite. In the Avcılar district (letter A), pixels are showing ground subsidence. This rapidly growing urban area (enlarged at top right) hosts important infrastructure (such as the international airport) and was damaged by the Izmit earthquake in 1999 and by floods in 2009. Closer to the Izmit epicenter (B), pixels show ground movement caused by the earthquake. The white dashed line shows approximate location of the North Anatolian Fault. The distance between A and B is about 80 kilometers. In the enlargement, A is the district of Avcılar and F is the district of Fatih. The inset (top left) shows the sequence of earthquakes beginning in 1939 along the North Anatolian Fault propagating westward until the occurrence of the 1999 Izmit earthquake, as well as the location of the study area (red rectangle).

may have direct and indirect consequences for other geohazards—for example, a flood in these subsiding regions caused 30 fatalities in early September 2009. In addition, some of these subsiding regions (e.g., near the districts of Fatih and Avcılar) were heavily damaged during the Izmit earthquake due to localized seismic amplification [*Picozzi et al.*, 2009], causing some to wonder about the spatial correlation between subsidence and earthquake damage [cf. *Akarvardar et al.*, 2009].

Because modern advanced InSAR processing techniques can regularly be complemented by including any newly acquired satellite images, scientists can monitor the future temporal evolution of the deformation dynamics in the Istanbul region. The results shown here are available online through an interactive geographic information system (GIS) interface (http://webgis.irea.cnr.it/) and can be further validated and analyzed by integration of other data via the Geohazard Supersites Web interface (http://supersites.unavco.org/). It is hoped that continued monitoring of the region will provide clues as to when and where the next earthquake will strike.

Implications for Hazard Mitigation and Management

As is seen in the case of Istanbul, temporally and spatially dense InSAR images provide robust geodetic monitoring. Because natural hazards involving earthquakes, landslides, and flooding have to be explored in a dynamically evolving context, such satellite geodesy can provide additional information and offers a new, invaluable monitoring capability for complex multihazard scenarios.

Monitoring Istanbul through InSAR highlights the benefits of the easy data access and sharing supported by the Geohazard Supersites program. Such access and exchange of data will prove vital to hazard mitigation and management efforts worldwide.

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NEWS

Report Calls for Climate Panel Reforms

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The process by which the Intergovernmental Panel on Climate Change (IPCC) operates and produces its periodic assessments requires some fundamental changes so that it is more effective and transparent, according to a 30 August report of the InterAcademy Council (IAC). The report recommends modernizing the IPCC management structure, including imposing a limit of one term for the IPCC chair and other key IPCC leaders, to "ensure a greater infusion of fresh perspectives on the assessments." The report notes that a two-term appointment, for a total of 12 years, "is too long for a field as dynamic and contested as climate change." Current IPCC chair Rajendra Pachauri is in his second term and has held the position since 2002.

The report also recommends creating an executive committee to act on the panel's behalf between plenary sessions; electing an executive director; strengthening the peer-review process; better characterizing and communicating uncertainties; developing an effective communications strategy; and increasing transparency about IPCC processes and procedures, including establishing a conflict of interest policy.

IAC reviewed IPCC's processes and procedures in the wake of some criticism regarding the inclusion in IPCC's Fourth Assessment Report (AR4) of non-peer-reviewed information about the disappearance of Himalaya glaciers. "The committee concludes that the IPCC assessment process has been successful overall and has served society well," the report, prepared by IAC's Committee to Review the IPCC, notes. "However, despite these successes, some fundamental changes to the process and the management structure are essential."

"The errors made [in AR4] did dent the credibility of the process," IAC committee chair Harold Robinson said at a news briefing. "We think what we recommended will restore some of this [trust]."

At a separate 30 August briefing, Pachauri defended IPCC science and noted that the scientific community agrees "by overwhelming consensus" that climate change is real. "Science thrives on honest, well-reasoned debate. And there has been a productive debate this year about how to further strengthen the IPCC's work. But we also have to remember that honest scientific discourse wilts under gross distortions and ideologically driven posturing. Sadly, such tactics have been a prominent feature of climate science for many years, and they show no signs of letting up," he said.

Pachauri, who has been criticized for serving as an advisor for some for-profit organizations, said any decision regarding his continued role as IPCC chair and other IAC recommendations would be discussed at the next plenary session, in October. He added that a formal conflict of interest policy would make the IPCC more transparent and that IAC's recommendations would support management reforms he said he had initiated.

Achim Steiner, executive director of the United Nations Environment Programme (UNEP), said the IAC recommendations could strengthen the administration, management, functioning, and work of the IPCC as it undertakes its fifth assessment. "With the fundamental science underpinning the IPCC's assessment reports not in doubt, and clear recommendations on how to move forward in respect to the administration of the IPCC, the international community must move beyond the current paralysis in developing an effective response" to climate change. UNEP and the World Meteorological Organization established and cohost the IPCC.

For more information, visit http://interacademycouncil.net/.

—Randy Showstack, Staff Writer

Editor's note: See AGU president Michael J. McPhaden's message about the IAC report at http://www.agu.org/about/presidents_msg/.