Earthquakes and Tectonics

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Session Overview

- Large session with 5 oral sections during two days
- 30 oral presentations and 42 posters
- Many topics presented, inter- and co-seismic deformation, fault creep
- Several presentations on recent important earthquakes in Japan, New Zealand and Haiti
- Data presented primarily from Envisat, ERS-1/2 and ALOS. Some studies used TerraSAR-X data, but almost no results reported based on Radarsat-2 or Cosmo-Skymed

Interseismic Deformation

- Several studies demonstrated the usefulness of InSAR to measure interseismic deformation and thus for Earthquake Hazard Assessment
- Almost all presentations used ERS/Envisat archives
- Improvements presented in dealing with atmospheric signals
- Techniques presented for combining InSAR and GPS to generate strain-rate maps
- Most presentations focused on Tibet, the Middle East, and the western US.
- Deformation across Himalayas shown!

Earthquake Studies

- Incredible complexity of earthquake faulting was demonstrated
- TerraSAR-X data used to measure absolute ground displacements
- Multi-sensor L-,C-,X-band studies demonstrated redundancy and complementarities
- Improvements in EQ damage mapping shown
- EQ inversion techniques discussed
- Tohoku, Christchurch, and Haiti earthquakes, but also in Mexico, Africa, Tibet, Middle East and many more (in poster session)

Creep and Fault Offset Studies

- Strength of InSAR once again demonstrated in measuring mm-scale fault movements
- Number of studies, California, Taiwan, Africa and other places
- Spatio-temporal variations of creep shown
- Fault motion details and fault interaction shown in Afar in a couple of presentations

Other Studies

- Complex rift zone deformation was presented, Afar and in Iceland
- Only one presentation focused on post-seismic deformation (Haiti), but analysis of post-seismic deformation was a part of several talks

Seed Questions

1) *What recommendations does this thematic community have for Sentinel-1 observation scenarios over InSAR areas of interest, in terms of revisit frequency and pass (ascending/descending).*

- Simple and boring observation scenario recommended
- High revisit frequency (every pass) over active areas
- Regular acquisitions in other areas
- Two look directions important
- Same mode and small baselines
- Concerns about the fine azimuth co-registration and possible ramps, which might look like interseismic deformation. Long data-takes important

2) What are the new InSAR findings in earthquakes and tectonics studies since FRINGE 2009?

- Many examples of time-series analyses, to study spatiotemporal variations of fault creeps and transients, in addition to better estimating interseismic deformation.
- DLR showed absolute displacement measurements using TSX sub-pixel cross-correlation (pixel offset tracking).
- X-, C-, L-band sensor data were used, which provided redundancy and complementary information.
- Constellations such as COSMO-SkyMed provide much more rapid repeat times, although presently they have very limited access, few acquisitions and small archives.
- GEO Event Supersites have provided much more access to data for several recent earthquakes, greatly increasing the number of people who have studied those events.

3) *Operations of ALOS and ERS2 have been terminated and InSAR usage of ENVISAT data is limited. In this period of time, what further actions can we make to facilitate access to other satellite radar data?*

- The E&T community understands that ESA has limited influence on other SAR data providers, but hopes ESA can help to encourage methods to get better access to SAR data from TerraSAR-X, COSMO-SkyMed and Radarsat-2 for scientific research.

4) What can ESA do more to help scientists to further exploit the existing 20-year SAR data archive of ERS1, ERS2, ENVISAT?

- The E&T community would like to thank ESA for acquiring this unique archive of SAR data and making it available for scientific research.
- When possible, providing online access to large parts of the SAR archive data would be a huge help for scientists to further exploit the existing data.
- It would be helpful if the Eoli catalog were cleaned up.
- It would be extremely helpful for earthquake response if ESA could provide rapid preliminary orbit data.
- We also encourage ESA to continue to acquire as much Envisat data over high strain tectonic zones as possible to ensure that data are available for future earthquakes.

5) The Supersite initiative has shown the potential of fast and free satellite data distribution following major earthquakes. Should we try to extend these efforts to moderate earthquakes? If so, what would be the best way of doing so?

- Not discussed in our session, deferred to Supersite session.

6) How can we prepare to analyze the volume of data that will be acquired with the Sentinel mission?

- It would be good to have all the existing data online, easily accessible. This will help to prepare for large data volumes.
- Some virtual data that simulate Sentinel-1 products or actual TOPS SAR acquisitions from TerraSAR-X or Radarsat-2 are necessary for the users to prepare.
- ESA might consider to provide geocoded interferograms, perhaps using a “process on demand” method.
- Not only image data but also auxillary products may be useful. For example releasing raw GPS data from the satellite would motivate new methods of determination of precise orbits, and ESA can get feedback for improvements.

7) Has there been recent developments in methodology that are useful for studying earthquake and tectonic studies? If so, how can we promote using such techniques?

- ESA is developing NEST+DORIS toolbox, more tools need to be included, e.g. offset-tracking and time-series analysis. Making source code fully open (e.g. NEST SAR processor) would help advancing methods.
- It would also be great to have an open source package or packages for doing earthquake source inversions. Some source code for InSAR data resampling is available at http://roipac.org

8) What are the options currently available to correct InSAR data from tropospheric errors? And how could this be improved in the future? Are any future ESA sensors going to help?

- The situation has improved a lot in the last two years, we now have a few options for the correction.
- OSCAR service will start soon at http://oscar.jpl.nasa.gov (temp. available now at http://oscarproject.jpl.nasa.gov). Initial service is MODIS near-infrared water vapor zenith path delay, to be followed soon by ECMWF operational weather forecast model estimates of zenith path delay (dry and wet) and combined products interpolated spatially and vertically to high resolution using a DEM.
- ESA might consider providing atmospheric phase screens as standard products, if information is available to estimate this from other future sensors.

E&T Recommendations 1

1. The observation strategy for Sentinel-1 should consist of one main mode, with as frequent acquisitions over tectonically active areas as possible (along with regular acquisitions in other areas), with a priority on two look directions, with small baselines, single polarization, and long data-takes.
2. ESA should make available some virtual data that simulate Sentinel-1 products or actual TOPS SAR acquisitions from TerraSAR-X or Radarsat-2 for the user community to prepare
3. ESA should provide estimates of fine offset between TOPS SAR scenes to avoid phase ramp from small mis-registration of interferograms
4. Consider using higher resolution modes over active tectonic regions to enable along-track deformation measurements with multiple-aperture interferometry or sub-pixel correlation

E&T Recommendations 2

5. ESA should make RAW auxiliary data for Sentinel-1 available once the mission starts, e.g. raw GPS data for orbit determination
6. More ERS/Envisat data should become freely available online, to facilitate further exploitation of these huge archives and for scientists to get better prepared for Sentinel-1 data volumes
7. ESA should acquire as much Envisat SAR data around 38°N as possible, also in areas that are not tectonically very active
8. ESA should provide rapid preliminary orbit data for Envisat to help rapid response to earthquakes