SEISMIC AND VOLCANIC ACTIVITY IN AFRICA MONITORED BY INSAR

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1. INTRODUCTION

Many African places threatened by geophysical hazards suffer from the lack of (efficient) monitoring systems either because of political, practical or economical reasons. Not to mention the least, a tectonic structure like the 5000 km long East African Rift is so extended that a global ground-based monitoring system is practically unfeasible. In addition, the capture of the full sequence of major tectonic episodes such as dyking or seismo-volcanic crisis requires that the monitoring systems were already in place and recording days or months prior to the main event.

Satellite Radar Interferometry is known to be a possible tool to overcome some of these problems providing that favorable conditions are met and sufficient references archives are available.
It permits the low cost monitoring of remote areas and provides dense sub-centimeter precision displacement measurements over broad regions. Although the SAR operates in all weather conditions and night and days, radar interferometry (InSAR) suffers from possible vegetation-induced decorrelation, which is very often the case in equatorial regions and especially on high lands and fertile volcanoes.

We show here however the benefits of a systematic SAR acquisition procedure over regions prone to seismic and volcanic activity. Thanks to the programming of dense SAR databases initiated in 2005/2006 over some African targets, we could capture the full story of a dyking event, the deformation field of eruptions in vegetated environments and unexpected co-seismic deformation associated to earthquakes located in areas where no local seismic networks were available.
Dense databases resulting from systematic monitoring maximize the chances of a favorable interferometric pair (particularly important in vegetated areas) and offer the possibility of using Time Series methods (like SBAS or Persistent Scatterer Techniques). The systematic InSAR processing provides a good knowledge of the most favorable parameters to be used to compute the interferograms for a given area (allowing a faster computation in case of emergency). It can also inform us about plausible transient atmospheric artifacts that can affect a given area or detect possible systematic (seasonal) artifacts that could be misinterpreted as (part of a) deformation if not recognized.

More detailed description of some of the events briefly described in the present overview can be found in related contributions to the present IGARSS 2009 symposium (see the program).

2. DATA AND SOFTWARES

More than 2000 different interferograms were computed out of the 400 SAR scenes (ERS and ENVISAT) of Fogo (Cape Verde), Ol Doinyo Lengai (Tanzania), Nyiragongo-Nyamulagira (DR of Congo) and Mount Cameroon volcanic areas, as well as a dozen of ALOS L-band PALSAR scenes. The data are provided in the frame of ESA Cat-1 project nr 3224 [1] and ESA-JAXA Cat-1 project nr 3690.

A full automated bulk processing procedure was setup based on the use of open source softwares (DORIS [2], SNAPHU [3], GMT [4]) and leading to the production of geo-referenced wrapped phase interferograms, coherence map and unwrapped phase interferograms in common GIS formats (ENVI®) and GMT. The most interesting interferograms were re-processed with manual refined procedures leading to optimum deformation maps. Precise orbits are provided by the Delft Institute of Earth Observation and Space Systems (DEOS) and ESA. SRTM digital elevation models are provided by USGS [5].

3. RESULTS

The systematic INSAR monitoring of African active volcanic zones proved to be efficient and allowed us to detect significant and major geophysical processes that we will review: the first dyking event ever captured geodetically in a continental rift (Lake Natron; Northern Tanzania) [6], the co-eruptive deformations of the Lengai, Nyiragongo and Nyamulagira volcanoes [7], the co-seismic displacements associated to the mb 6.1 February 3rd 2008 Bukavu earthquake [8] as well as the identification of atmospheric induced phase delays over Fogo and Mount Cameroon volcanoes that can be attributed to the seasonal oscillations of the Inter-tropical Convergence Zone (ITCZ) [9].
These results have been reached thank to the abundance of data. They provided valuable information both for our understanding of geophysical phenomena and for hazard assessment.

That kind of databases would also have most probably facilitated the study of similar events that occurred before our systematic SAR monitoring such as the Nyiragongo 2002 [10] and the Nyamulagira 2002 eruptions, or for events that took place along the EAR like the seismic swarms at Lake Magadi in 1998 [11] and Lake Manyara in 1994 [12]; or for many unknown events.
We therefore encourage the use of systematic SAR acquisition (e.g. through ESA satellite's background mission) over active zones that encompass main tectonic structures in Africa where practical, financial or political problems may limit the use of ground-base monitoring techniques.

11. REFERENCES

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