The unraveling of the 2007 continental rifting event in Northern Tanzania

Towards a multi-acquisition InSAR approach

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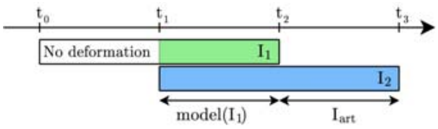
Introduction

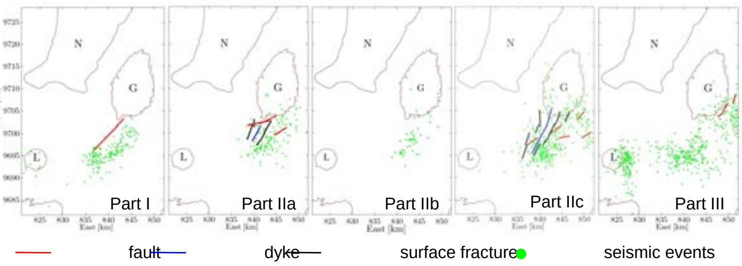
From July to September 2007 a series of moderate earthquakes, culminating in a Mw 5.9 main event on July 17th, struck the southern flank of the Gelai volcano in northern Tanzania. The event was also detected by a nearby GPS station, recording displacements up to 5.7 cm, and two SAR sensors. Thanks to a systematic programming of SAR data we were able to map the total affected area (~50x70 km) by this seismic event by means of InSAR. The crisis lead to effusive eruptions of the nearby Ol Doinyo Lengai volcano as from mid-June, evolving into unusual explosive activity from September 4th on. This suggests a large role of magma in the seismic swarm.
This seismic swarm is recognized to be a consequence of a rifting episode (Calais et al. 2009, Baer et al. 2008, Biggs et al. 2009). Most deformation patterns detected by InSAR in these periods are very complex and the resulting hypotheses by these different studies are not unambiguous.
This work presents a strategy, based on numerical modeling, that combines data from different sensors aiming at the decomposition of the deformation in smaller temporal baselines. The approach is applied to eight interferograms spanning periods from January to October 2007 (Fig.3).

The principle: multi-sensor InSAR cascading

- Creation of artificial interferograms (I_{art}) with decreased temporal baselines
- Part of deformation is modeled instead of full deformation pattern
- Numerical modeling: combination of a 3D mixed boundary element method (3D-MBEM) and a neighbourhood algorithm (NA) (Cayol, 1996; Fukushima, 2006; Sambridge 1999a/b)



Chronology



Discussion

The multi-sensor InSAR aprroach is applied with success on the Tanzanian data set and revealed the chronology of events. Magma displacements involve rock failure or fault slip, explaining the seismic events below the Lengai after September 4 only. In this particular case, the source of magma which is injected on the southern flank of the Gelai, is located below the southern half of central graben, where seismic events are measured up to depths of 15 km. A migration in time towards the northwest and the surface is observed. Also a clockwise rotation of the fault striking is observed. In the third part of the swarm, only significant surface displacements are visible in the interferograms at the southeastern flank of the Gelai. However, a lot of seismic events are still measured below the Lengai and the southern half of the graben, pointing to ongoing magma displacements in the crust. This stresses the importance of cooperation between different teams applying different geodetic techniques, such as radar remote sensing, GPS receivers and seismic stations.

Regional Setting

The Ol Doinyo Lengai and Gelai volcanoes are located to the south and the east of Lake Natron, on the Eastern branch of the East African Rift (EAR). The Lengai is well known for being the world's only active volcano erupting low temperature highly fluid natrocarbonatites lava. Its episodic moderate effusive volcanic activity is usually mainly limited to the crater. After signs of renewed activity since July 2007, it entered in eruption with a more explosive style in early September. Gelai volcano has no known historical activity.

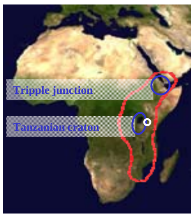


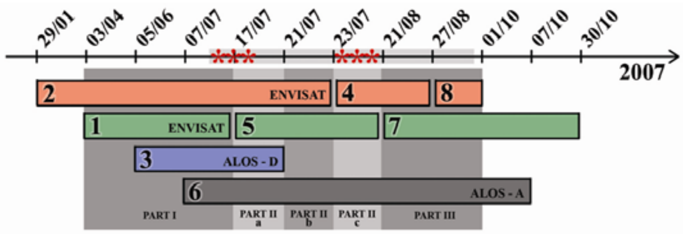
Fig.1: The EAR

Fig.2: The Tanzanian sector of the EAR

Fig.3: Surface ruptures

Fig.4: Lengai eruption (2007)

Data Selection



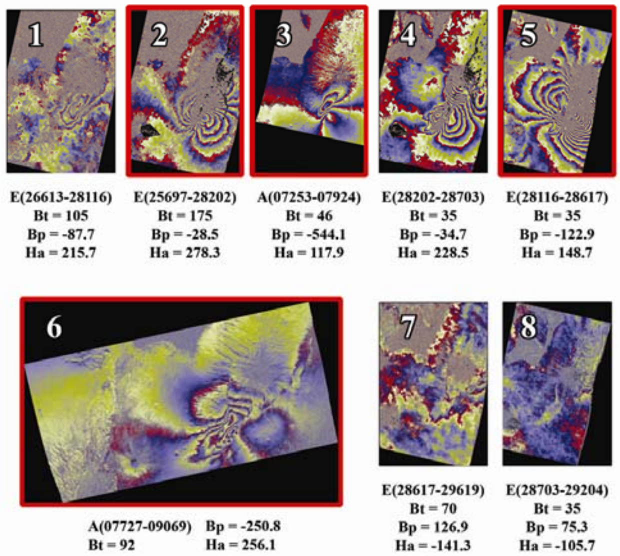


Fig.5: Summary of the differential interferometric results from January 29 to October 30, 2007. The interferograms are named by their respective orbit numbers

: Envisat track 92 (swath is2)	Bt	: temporal baseline
: Envisat track 6 (swath is6)	Bp	: perpendicular baseline
: descending ALOS	Ha	: height ambiguity
: ascending ALOS		
* : larger than 5 Mw earthquakes of the seismic swarm		
: interferograms covering the main shock		
: seismic swarm		

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