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On the origin of the recent surface deformation observed in the Roer Valley Rift System, the southern Netherlands, after spaceborne radar time series analysis

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Abstract

The Roer Valley Rift System is located in the southern Netherlands and the adjacent areas of Germany and Belgium. The total extension of the rift system is approximately 200×100 km^2 and it is oriented in NW-SE direction. The rift is elongated in NW-SW direction suggesting the main tension stress in NE-SW direction.

Neotectonics—the current tectonic period—of the Roer Valley Rift System started in the late Early Miocene ($\sim$20 Myr ago) and is expressed as extension of the rift in NE-SW direction. The neotectonic faulting mode of the rift system is normal, which is in agreement with the present-day orientation of the maximum stress (van Balen et al., 2005). The Roer Valley Rift System consists primarily of three distinct parts. The Peel and the Campine blocks located respectively north and south of the Roer Valley Graben, which is the main subsiding structure. Then, the principal faults systems are the Peel Boundary Fault Zone and the Feldbiss Fault Zone, which separate respectively the Peel block and the Campine block from the Roer Valley Graben.

Although the Roer Valley Rift System is known to be active as demonstrated by continuous seismicity, current slip rates are uncertain. Several studies have revealed a large discrepancy between short and long-term slip rates estimates. Techniques covering short time scales, such as leveling, measure deformation rates in the order of 1 mm/yr, (Groenewoud et al., 1991; van Balen et al., 1998; Houtgast and van Balen, 2000; Demoulin, 2006).

On the other hand, other methods that measure at geological time scales, such as trenching, estimate deformation rates one or two orders of magnitude lower (Vanneste and Verbeeck, 2001; Vanneste et al., 2001; Houtgast et al., 2003, 2005).

Houtgast and van Balen (2000) suggested that these differences were due to a possible 3D fault stress interaction inducing fault motions, which could vary over few decades. If studied on geological scales, these motions are then largely averaged and the variability reduced. However, Camelbeeck et al. (2007) disagreed and proposed that this large variations are not due to plate tectonics but to other external causes, such as errors in the estimations or man induced motion.

The measurements that have been carried out so far, e.g. levelling and trenching, have the common disadvantage of being limited in extend and spatially sparse, which can make the interpretation of the signal difficult.

On the other hand, spaceborne radar interferometry can provide with a large density of observations covering a vast extension, which usually is 100×100 km^2 for the European sensors. We apply radar interferometry time series analysis, in particular persistent scatterers interferometry (PSI) methods, to the Roer Valley Rift system to learn more about surface deformation phenomena that have occurred during the last two decades. PSI detect scattering object that are slightly affected by noise to extract surface deformation information (Ferretti et al., 2001; Hooper et al., 2004; Kampes, 2006).

The results show a deformation signal that correlates with fault location. However, the signal cannot be ascribed to tectonic motion because the direction is opposite to expected. The first nine years of the time series the graben appears to uplift with respect to the adjacent horsts. Furthermore, the mining industry, which is located to the southeast of the graben seems to play a major role on the deformation signal during the whole time series. In this contribution, we analyze PSI estimates and draw conclusions on the origin of the observed deformation signal.

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