Surface deformation in the Roer Valley Rift System, The Netherlands, as observed by spaceborne radar.

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Abstract

In principle, Persistent Scatterer Interferometry (PSI) methodologies measure ground motion with 1 mm/yr precision by using the scatterers that remain coherent over a series of radar acquisitions (Ferretti, 2001). In this study, we present the results of applying this technique to measure land deformation in the Roer Valley Rift System (RVRS) area, where recent earthquake and geological evidence have probed an uninterrupted seismic activity.

1 Introduction

Figure 1. Main blocks of the RVRS and the tensional forces (arrows). The processed area is shown as a red rectangle.

The RVRS consists primarily of three distinct parts. The Peel and the Campine blocks located respectively North and South of the Rover Valley Graben, which is the main subsiding structure. Then, the principal faults systems are the Peel Boundary Fault Zone (PBFZ) and the Feldbiss fault zone (FFZ) which separate respectively the Peel block and the Campine block from the Rover Valley Graben, see fig. 1.

The current rifting episode is due to the influence Alpine collision and the North Atlantic rift system.

During the last decades some moderate seismic activities, such as the earthquakes of magnitude 4.7 in Uden (1932), 5.9 in Roermond (1992) and 4.9 in Aachen in 2002 (Michon et al. (2003),van Balen et al. (2005)), prove an uninterrupted activity of the rift, in particular in the PBFZ and the FFZ.

Geomorphologic studies show in the south of FFZ rates of 55–65 mm/ky, and in the north-west of the PBFZ rates of 200 mm/ky (Michon and van Balen, 2005).

In addition to that, recent vertical motion across the FFZ was measured with leveling (Demoulin, 2006) . These results revealed the great influence of the water level changes on surface deformation. Nevertheless after removing such effects (Demoulin, 2006) measured −0.6 mm/yr subsidence of the graben with respect to the Campine block.

2 Observations

We combined two type of observations radar interferometry and ground water levels to study the deformation in the RVRS.

2.1 Radar Interferometry

We analyzed more than 70 images acquired between 1992 and 2001 to obtain deformation time series. From these, we estimated rates and the amplitude of 1-year-periodic signal.

2.1.1 Rates

The estimations show that unexpectedly the Roer Valley Graben (RVG) is uplifting with respect to the Peel block at a rate of +1mm/yr, fig. 2. The tectonic faults are shown in black. The circle shows the location of the reference of the estimations.

Therefore, the linear deformation seems not to be of tectonic nature. The origin of this motion has probably its origin in water level changes.

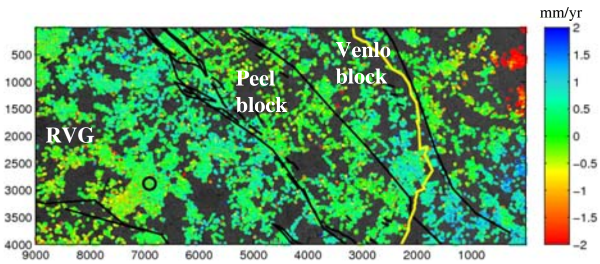

Figure 2. Linear deformation rates estimated from radar observations. The model included also a 1-year periodic signal (see fig. 3). Faults are shown in black and the country borders in yellow.

2.1.2 Amplitude periodic signal

The amplitude of the periodic signal reveals also spatial correlation with fault location. Smaller amplitudes are found in the Peel block and larger amplitude in the RVG and the Venlo block, fig.3.

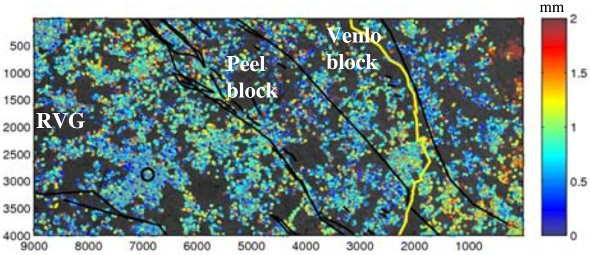

Figure 3. Amplitude of the seasonal signal. (legend as before)..

2.2 Water levels and radar time series

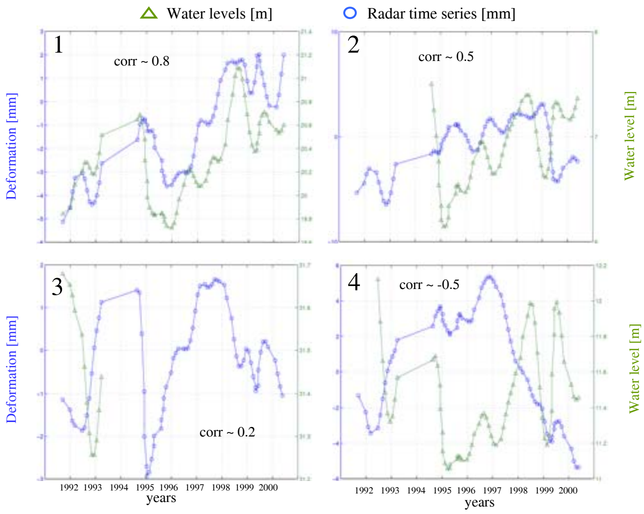

Figure 4. Radar time series and water levels both with respect to ref., see fig. 5.

The water levels were interpolated to the radar acquisitions times. Then the radar data was interpolated at the water gauges location. Then the same are was taken as reference for both data type, shown as ref. In fig.5. They are compared in 4 plots shown in fig. 4. The variations due to seasonal changes seem to match. However, correlation between the two depends on the location, see fig. 5.

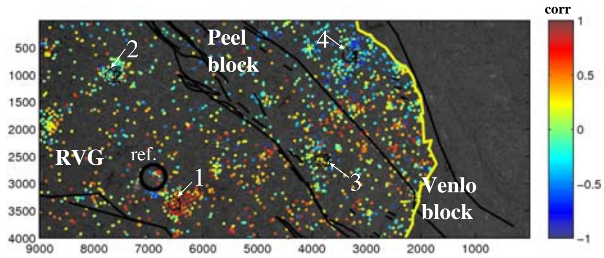

Figure 5. Correlation between water levels and radar time series at the water gauges location. The time series 1-4 are plot in fig.4. Water level and radar data are with respect the area given by ref.

Conclusions

The radar time series have shown an unexpected deformation with uplifting rates of +1mm/yr in the RVG.

At this stage we cannot draw any definitive conclusion on the nature of the detected deformation, but it seems to depend on ground water levels or other related seasonal effects. For example, the surface deformation contains a periodic signal whose amplitude correlates with fault position.

We compare these results with water levels recorded in the area. The correlation between the two seems depend on the location,being high for the southern part of RVG. We also found that they anti correlated in the north of the Venlo block

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