Abstract

The Carmel Fault is considered as "potentially active". The proximity of the fault to the city of Haifa and petrochemical industrial area raise the need for detailed information whether the fault is active or not, and precise mapping of the active segments. Geological studies of this area failed to observe recent surface deformation. Using tools of ground deformation measurements such as satellite geodesy provides unprecedented information in terms of spatial coverage and precision. This study uses advanced techniques of Interferometric Synthetic Aperture Radar (InSAR), using ERS-1 and ERS-2 satellite images measured between the years 1992-2001 from the northern part of the Carmel Fault.

Conventional InSAR studies have demonstrated the potential of this technique to detect sub-centimeter ground displacements along the satellite to ground line of sight (LOS), with limitations resulting mainly from temporal and geometrical decorrelation, atmospheric artifacts and cycle ambiguity. InSAR is most effective for measurement of large deformation features such as those associated with earthquakes. When trying to apply this technique to measure areas with little or no deformation, such as interseismic deformation, it is difficult, in many cases, to distinguish between the real deformation and the effect of atmospheric signal. To overcome this difficulty for the analysis of the Carmel Fault and minimize the atmospheric noise we use three different approaches of InSAR:

(1) InSAR method based on stacking and permanent scatterers using SIOSAR (Scripps Institute of Oceanography SAR) software. Fifty one interferograms where processed, but due to vast decorelation and unwrapping problems and the time consuming un-automated nature of the process the results were analyzed by the following two other approaches.

(2) InSAR method based on stacking of interferogram "chains" using the ROI-PAC (Repeat Orbit Interferometry Package) software. Thirty six interferograms from three different satellite frames were processed and analyzed, showing outstanding improvement compared to the SIOSAR method and conventional methods. Nevertheless, the results show low signal to noise ratio, and no significant velocity differences between different areas, resulting in no final conclusion whether the Carmel Fault is active or not.

(3) InSAR method based on Permanent Scatterers (PSInSAR), which calculates and removes atmospheric artifacts thus providing time-series and averaged annual velocity with greater precision than the two previous methods. We analyzed forty seven interferograms as time series of LOS ground deformation and averaged annual velocity. This method shows high sensitivity to local deformation such as ground response to compaction, weight of buildings or transit of heavy vehicles. No direct correlation has been found between the PSInSAR results and seismic activity, water level changes or landslide sensitivity. The relatively poor spatial distribution and low number of permanent scatterers in the fault area limits our ability to construct an elastic model which could link the observed deformation to a tectonic mechanism. Cross-sections of the results show that the noise levels are in the same order of the potential deformation signal.

Although no evidence for surface movements along the Carmel Fault was found in this research, elastic models and the present PSInSAR detecting limit show that the possibility of vertical movements lower than 1 mm/year or horizontal movement lower than 4 mm/year cannot be totally ruled out on the NW-SE segments of the Carmel Fault. However, according to earthquake recurrence time estimations on the northern part of the Carmel Fault, it appears that most of the movement along the fault is released by a very slow-rate creep or by small magnitude earthquakes and the probability for a large magnitude earthquake is low and is constrained by a long recurrence time of over 50,000 years.