A portable radar interferometer for the measurement of surface deformation

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Satellite radar interferometry has been used extensively for ground-motion monitoring with good success. In the case of landslides, glaciers and rock-glaciers, for example, space-borne radar interferometry has a good potential to get an overview on surface deformation. The role of space-borne radar interferometry as an element in a warning system is however constrained by the specific space-borne radar imaging geometry, the typical multiple-week repeat-interval, and uncertainties in the data availability. Most of these limitations can be overcome with an in-situ radar imaging system [1,2].

Gamma Remote Sensing has developed a portable radar interferometer that utilizes real-aperture antennas, each 2 meters in length, to obtain high azimuth resolution [3,4]. Images are acquired line by line while rotating the transmitting and receiving antennas about a vertical axis (Figure 1). The installation effort is relatively small and the instrument is portable and can be battery operated. Individual measurements can be taken in less than 15 minutes and the acquisition time is limited primarily by the speed of the rotational scanner. Each image line is acquired in approximately 2ms hence there is little or no movement of the scene to introduce temporal decorrelation.

Phase differences between successive images acquired from the same location are used to determine line-of-sight displacements δ from the differential phase ϕ via the relationship $\delta = -\lambda\cdot\phi/4\pi$ where λ is the wavelength. The instrument operates at 17.2 GHz (Ku-Band, λ=17.4 mm) with a displacement measurement sensitivity better than 1 mm. The range resolution of the radar δr = c/2*B is determined by the 200 MHz bandwidth B and is equal to approximately 75 cm. Because this is a real-aperture imaging system, the azimuth resolution is determined by the antenna beamwidth and slant range R, $\delta az = R \sin\theta$. In the case of our terrestrial radar, the azimuth beamwidth is 0.4 degree yielding an azimuth resolution of about 7m at a slant range of 1km.

The instrument uses two receiving antennas with a short baseline to form an interferometer. Phase differences between simultaneous acquisitions by these antennas are used to calculate the precise look angle relative to the baseline, permitting derivation of the surface topography. Expected statistical noise in the height measurements is on the order of 1 meter.

In this contribution the design, measurement principles and characteristics of the portable radar interferometer are presented. Results obtained in a series of experiments started in September 2007 over glaciers (e.g. Rhonegletscher and Gornergletscher) and landslides (e.g. Tessina, Pian San Giacomo) are also discussed.

Figure 1. The portable radar interferometer deployed over the Gornergletscher showing the rotational scanner, antenna support structure, antennas, and microwave assembly.

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