THE SENTINEL-1 MISSION: CONTRIBUTION TO THE SOLID EARTH SCIENCES

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Solid earth processes are notoriously difficult to fully comprehend, due to the lack of direct observations at depth. Indirect measurements via seismic or electromagnetic waves, or from potential fields (gravity and magnetics) provide information about the earth's interior and its dynamics. For some of these dynamic processes, such as tectonic motion, earth tides or tidal loading, or subsurface pressure changes, the surface geometry of the earth is influences, albeit often with very small amounts and spatial spread out over large areas. For example, changes in geometry of less than 1 cm over 100 km spatial distance can be very important indications of wide-scale geophysical phenomena.

Although the GMES space segment, the Sentinels, has not been designed for scientific objectives, it is evident that the technological improvements of the missions will enable efficient measurements with higher precision levels, or improved resolution or swath extend. Both operational GMES requirements as well as scientific applications will benefit from this development. In this paper, we will specifically discuss the scientific benefits of the Sentinel-1 mission for solid earth applications as mentioned above, and recommend on optimal data acquisition schemes for scientific applications.

Sentinel-1 is a C-band (5,405 GHz) Synthetic Aperture Radar mission, consisting of two satellites (Sentinel-1a and -1b) in a 12-day repeat mode. The main SAR acquisition strategy is the Interferometric Wide Swath (IWS) mode with a swath width of 250 km. Using the TOPS SAR processing approach in combination with a wide bandwidth, a resolution of 5x20 meter in slant range and azimuth, respectively, is possible. This implies a comparable resolution to the successful ERS and Envisat missions, even though range and azimuth are interchanged. See table 1 for characteristics of the Sentinel-1 mission.

Modes	Access Angle	Resolution (Range x Azimuth)	Swath Width	Polarisation
Strip Map	20-45 deg.	5 x 5 m, 1 look	> 80 km	HH+HV, VV+VH
Interferometric Wide Swath TOPS	> 25 deg.	5 x 20 m, 1 look	> 250 km	HH+HV, VV+VH
Extra Wide Swath TOPS	> 20 deg.	20 x 40 m, 1 look	> 400 km	HH+HV, VV+VH
Wave mode (Leap frog method)	23 deg. and 36.5 deg.	5 x 20 m, 1 look	> 20 x 20 km Vignettes at 100 km intervals	HH, VV

Table 1. SAR acquisition modes. The Interferometric wide swath mode will be the default mode of operation. For All Modes: Radiometric accuracy (3 σ): 1 dB; NESZ: -22 dB; PTAR: -25 dB; DTAR: -22 dB

For measuring solid earth processes, the important factors are (i) coherent scattering, (ii) high orbital accuracy, (iii) low phase noise, and (iv) low noise due to other disturbance signals, such as atmospheric delay, and (v) redundancy in the measurements. Coherent scattering is obtained using the two satellites and effectively achieving a repeat interval of 6 days. Such a short repeat interval increases the amount of useful scatterers when compared with the 35 day Envisat mission. As a consequence, many more useful measurements can be extracted from the data. The high revisit rate also quickly decreases atmospheric influence by stacking data sets and estimating the (temporally uncorrelated) atmospheric signal. Especially for areas at higher latitudes, redundancy will be introduced by overlapping swaths, which also aids the decomposition of the deformation vector.

It is expected that the Sentinel-1 mission will play an important role in unveiling solid earth processes that have been obscured from direct observation until now.