SENTINEL-1: LINK BETWEEN ORBIT CONTROL AND INTERFEROMETRIC SAR BASELINES PERFORMANCE

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1. Abstract

Sentinel-1A was launched in April 2014 in order to provide radar vision for Europe's Copernicus programme. Sentinel-1A carries a 12 m-long advanced synthetic aperture radar (SAR), working at C-band. The advantage of radar as a remote sensing tool is that it can image Earth’s surface through rain and cloud, and regardless of whether it is day or night. Radar data can also be used for monitoring land deformation. The 'radar interferometry' (InSAR) remote sensing technique combines two or more radar images over the same area to detect changes occurring between acquisitions.

Interferometry allows for the monitoring of even slight ground movement – down to a few millimetres – across wide areas. As well as being a valuable resource for urban planners, this kind of information is essential for monitoring shifts from earthquakes, landslides and volcanic uplift.

The performance of the radar interferometry depends strongly on the geometry between the positions of the satellite when the combined acquisitions were taken, namely baselines. The baselines are decomposed in the line of sight of the radar, i.e., parallel baseline, perpendicular to the line of sight, i.e., perpendicular baseline, and in the direction of the satellite velocity, i.e., along-track baseline. Each component is important for different applications.

For the Sentinel-1A mission small baselines are preferred, therefore the following orbit requirement was defined.
“The reference orbit shall be maintained within an Earth-fixed orbital tube of a diameter of 100 meter-rms, at every orbital point, over any repeat cycle, during the nominal mode operation time.”

However, this requirement was very difficult to be implemented operationally, therefore a new formulation of the operational control was derived: a regular absolute ground track control of ±62 meters at the equator and high latitudes fulfil the original orbital tube requirement.
Nevertheless, after Sentinel-1A launch and commissioning it was decided to initially relax the dead-band control to 120 meters. The effect of this change has been translated into orbital tube statistics in order to reassess the original requirement.

But the orbital tube is just an artefact, i.e., a comparison with an ideal reference orbit, whereas the real performance is given by the resulting interferometric baselines. That is to say, the relative geometry between the positions of the satellite over the same area.

An exhaustive analysis of the resulting baselines has been performed by considering the parallel, perpendicular and along-track baselines. The results are linked then to the orbital tube and the dead-band control and the effect of the across-track, radial and along track distance between the two satellite positions and the differences in the semi-major axis, inclination and eccentricity control are addressed.

The immediate result found was that the orbital tube shall not be treated as a circle but as an ellipse, having each axis different impact on the baselines. A major finding was how the eccentricity control affects the synchronization between two acquisitions. Synchronization means that two data takes separated by an integer number of repeat-pass cycles should start at the same orbital position to allow for interferometry, and it is required in SAR acquisition modes like the interferometric wide (IW) swath operational mode of Sentinel-1A. If the data takes are not synchronized, the common available information required for interferometry could be critically reduced. For Sentinel-1A the data takes can be as long as 25 minutes and the synchronization is done once at the beginning of each data take. This synchronization needs to be maintained within 5msec for the whole acquisition duration. By just adjusting the eccentricity control, the radial component of the orbital tube was drastically reduced to 12 m-rms radius and long data takes were possible without losing the common information between both acquisitions.

This paper suggest a new formulation of the orbital requirements, addresses the impact of the dead-band control relaxation in the case of Sentinel-1A , and overall it gives a deep understanding of the link between the orbit control and the performance of InSAR missions.