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MMASTER: Improved ASTER DEMs for Elevation Change Monitoring

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The analysis of the change of the Earth's surface relies on time series of DEMs, which in turn rely on the high quality acquisition and processing of data. The last few years have seen an impressive expansion of the operating satellite systems – both optical, such as Pleiades or Worldview, or microwave, such as TerraSar-X – that are able to produce very high resolution products with minimal errors, but whose spatial and/or temporal cover is limited. The Terra (EOS AM-1) satellite was launched in December 1999 on a Sun-synchronous orbit with the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) system on board. For more than 18 years, pairs of stereo images were collected by ASTER globally at a 15-m resolution in the near infra-red band, making its data the largest consistent multi-temporal dataset of stereo images available worldwide.

The potential of ASTER data lies in its long consistent time series that is unrivaled, though not fully exploited for change analysis due to lack of data accuracy and precision in the standard DEM product distributed by NASA (AST14DEM). ASTER data are strongly affected by attitude jitter, mainly of approximately 4 and 30 km wavelength, and improving the generation of ASTER DEMs requires removal of this effect. We developed MMASTER, an improved method for ASTER DEM generation and implemented it in the open source photogrammetric library and software suite MicMac. The method relies on the computation of a rational polynomial coefficients (RPC) model and the detection and correction of cross-track sensor jitter in order to compute DEMs. Our sensor modeling does not require ground control points and thus allows for automatic processing of large data volumes.

The data produced by the MMASTER system are a significant improvement on the AST14DEM products with the precision increasing from 20m to 5m. This opens up a new realm of potential applications in a wide variety of fields: glacier volume change can be estimated with a higher confidence; the effects of a volcanic eruption on its local environment can be better quantified; the former tree height of a clear-cut forest can be well estimated. The increase in quality can also help estimating radar penetration in vegetation, but also on snow and ice when compared to radar-interferometric DEMs, a still ill-resolved issue. In addition, the quality of the orthoimages that can be computed is improved, opening up the opportunity for better assessment of horizontal shift in terrain.