

Automatic bathymetry retrieval from Sentinel-1 and TerraSAR-X data

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We have developed an algorithm for automatic derivation of the bathymetry in coastal seas using Sentinel-1 and TerraSAR-X satellite data.

Recently, the TanDEM-X mission successfully finished generating a new high-resolution topography worldwide. However, about 70% of the Earth is covered by oceans, where the sea floor topography cannot be measured by a single spaceborne Earth Observation technology today. With growing efforts in global shipping and offshore constructions like wind parks, the knowledge of bathymetry becomes increasingly important. Our algorithm can retrieve the bathymetry in continental shelf areas with water depths from about 100 to 10 meters. In these depths, the shoaling effect leads to swell waves becoming shorter when reaching shallower waters.

The developed algorithm is part of a maritime SAR processing chain designed to derive multiple L2 products like wind, sea state, ship detection or sea ice automatically and in Near Real Time (NRT). For the bathymetry retrieval, the land is masked out and the image is subdivided into a grid of square subscenes. In preparation for the FFT analysis, spectral contaminations like ships, wind parks, current boundaries or wind streaks are filtered out for an accurate sea state and wave length retrieval. Then we can retrieve the peak wave length for each subscene from the FFT spectra.

To calculate the water depth, the dispersion relation in intermediate depth waters must be solved, which requires the peak wave length and peak wave period as parameters. However, the wave period cannot be retrieved from SAR images. Measurement buoys for wave period data are very sparse, but can be used as input when available. We therefore use existing coarse datasets like General Bathymetric Charts of the Oceans (GEBCO) as first guess data on the water depth. The optimal peak wave period is determined with a root mean square deviation (RMSD) analysis comparing the depths at every grid point of the scene for a range of possible wave periods and using the one resulting in the smallest deviation. With this, the water depth can then be calculated at every grid point. Comparisons to existing bathymetry data yield an unbiased RMSD of about 12 meters for the full 10m to 100m range of depths or about 15% of the depth.

The presented method requires the presence of long swell waves and light to medium wind, hence, not every SAR acquisition of coastal waters is suitable for bathymetry derivation. For this application, TerraSAR-X is technically preferable due to its ability to detect wavelengths down to 30m, where Sentinel-1 requires longer wavelengths of 120m for bathymetry retrieval. However, TerraSAR-X data are only available when previously ordered while Sentinel-1 data are acquired constantly and freely accessible from the Copernicus data hub, which facilitates the retrieval of suitable scenes worldwide.