Automated extraction and fusion of the intertidal and subtidal bathymetry from the Landsat and Sentinel satellite data

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Monitoring of the intertidal and subtidal bathymetry at large spatiotemporal scales using traditional surveying methods is a challenging and costly task. With the abundance of freely available satellite data in the last years and the availability of parallel processing platforms like Google Earth Engine, an automated derivation of bathymetry from satellite data sounds very attractive. A number of methods exist to extract bathymetry from satellite data, including methods to derive bathymetry for the **intertidal** zone [1], by combining water/land boundary dynamics with the water level measurements. At the same time, the light attenuation in a water column, observed by optical satellite sensors, can be used to infer water depth from spectral reflectance, providing a way to estimate **subtidal** bathymetry [2].

In this research, we will discuss both of these methods and will explore how they can be combined to generate consistent intertidal and subtidal bathymetry data. Our algorithm is based on the use of multitemporal optical satellite data to estimate water occurrence for the intertidal zone and the use of inverse-depth methods to derive bathymetry for the subtidal zone. Furthermore, we combine both bathymetric products to derive a single consistent bathymetry dataset (Figure 1).

The algorithm has been applied to derive bathymetry for the Dutch coast but it is transferable to other coastal areas. A great advantage in the estimation of satellite-derived bathymetries is the high temporal frequency (3-5 days) of sampling provided by the satellite sensors, addressing the need for data on short-duration morphological changes.

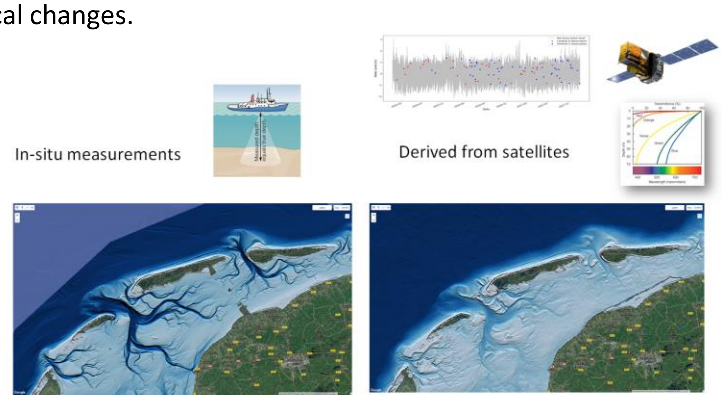

Figure 1: Vaklodingen Bathymetry (in-situ data source for Dutch waters) on the left and Satellite-Derived Bathymetry on the right. Source: https://earthengine.google.com.

Our method is implemented within the Google Earth Engine parallel processing platform and makes use of NASA/USGS Landsat 8 and ESA/Copernicus Sentinel-2 satellite imagery. The outline of the method is shown in Figure 2. We apply a two-step approach to remove cloudy pixels from the input data. The first step includes filtering of cloudy images by means of computing cloudiness of observed TOA reflectance over small image patches. This metric is combined with the cloud frequency estimated from MODIS data [3]. The second step includes per-pixel cloud masking followed by intertidal and subtidal bathymetry estimation algorithms. After calibration of the subtidal bathymetry using in-situ measurements, the end product is a fusion of high-resolution, high temporal intertidal and subtidal bathymetry.

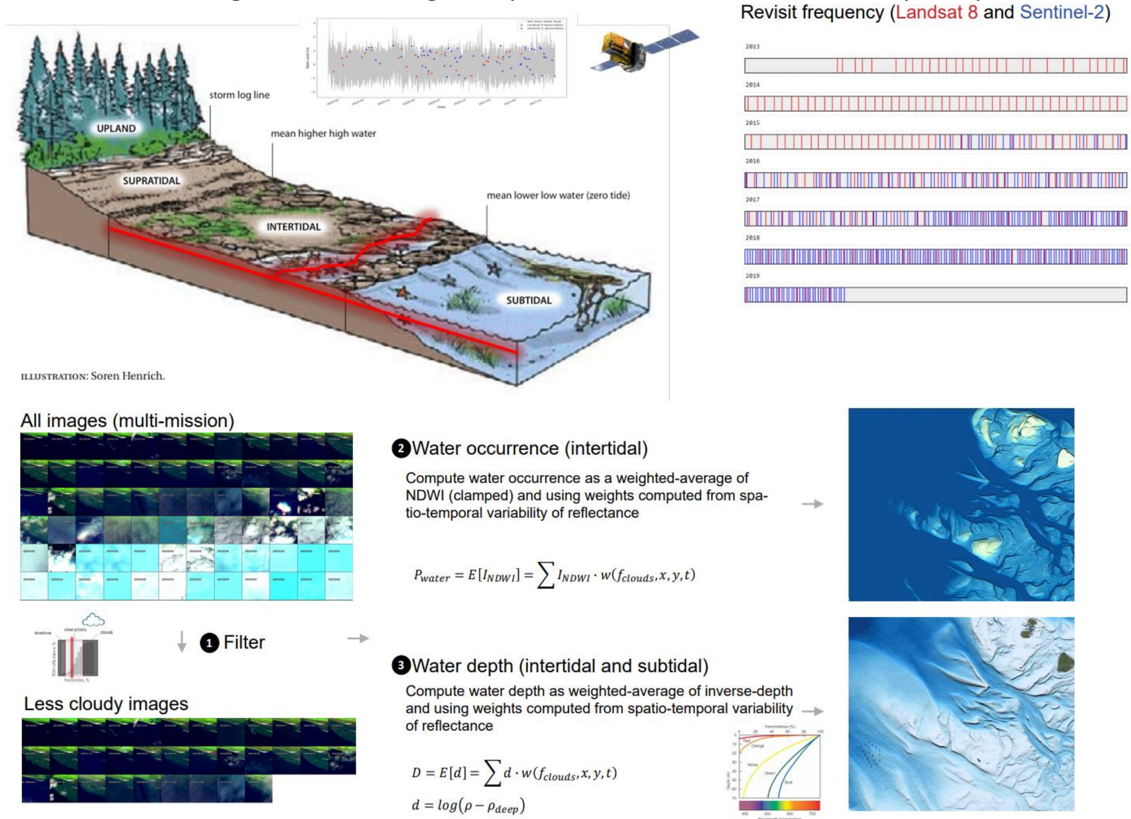

Figure 2: Overview of the method used for the processing of Landsat 8 and Sentinel-2 satellite imagery, combining intertidal (2) and subtidal (3) bathymetry generation.

The results of this research were used to improve coastline detection in the European Marine Observation and Data Network (EMODnet) bathymetry. Future developments of the algorithm will include fusion of intertidal and subtidal bathymetry for large extents, or even globally, as well as more extensive calibration and validation with in-situ data.

Potential applications include automated monitoring and mapping of bathymetry, operating as a service allowing to turn Earth Observation (EO) data into bathymetric products, assuming the presence of inter-tidal zone for intertidal and sufficient water clarity for sub-tidal bathymetries.

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References

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