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Waveform retracking for improving inland water heights from altimetry

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For more than two decades, satellite radar altimeters have been providing valuable information on level changes of seas and oceans. In recent years, the usage of satellite altimetry to monitor the water level changes of lakes and rivers, as well as in hydrology applications, has become a topic of rising interest.

The altimeter emits a radar pulse, which is reflected at the nadir-surface and measures the two-way travel time, as well as the returned energy as a function of time, resulting in a return waveform. Over the open ocean the waveform shape corresponds to a theoretical model which can be used to infer information on range corrections, significant wave height or wind speed. However, the waveforms over lakes and rivers show patterns which are significantly influenced by signals reflected from land present in the altimeter footprint. This results in a variety of different waveforms shapes ranging from waveforms similar to the theoretical ocean case to completely different ones such as those including only small leading edges and large peaks on the trailing edge. These peaks considerably influence the estimation of the parameters of interest, such as the time origin, connected to the range information, particularly if they are located very close to the leading edge. To mitigate this problem, we present a retracking approach, which combines the advantages of sub-waveform retracking with a flexible waveform model, that allows to model symmetric and asymmetric Gaussian peaks. Based on a preliminary waveform analysis step, a defined window is applied to the total waveform and the parameters are estimated by a flexible fitting procedure.

We retracked Topex/Poseidon, Jason-1 and Jason-2 data over several lakes, including the African lakes Volta and Victoria. The inferred lake level heights are evaluated by comparisons to water heights from in situ gauge observations, the Global Reservoir and Lake Monitoring database, as well as those derived from applying conventional retrackers, such as the β-5 model, threshold retrackers and the sub-waveform retrackers, including our new approach. Results show that sub-waveform retrackers are able to handle a broad spectrum of waveform shapes ranging from the theoretical ocean case to shapes which are significantly contaminated by peaks. The quality of water heights derived from these retrackers, e.g., over Lake Volta is usually better compared to conventional retracking methods, providing standard deviations with respect to gauge data of 32cm, 10cm and 8cm for Topex/Poseidon, Jason-1 and Jason-2, respectively. Results over Lake Victoria in an area with significant land contamination in the altimeter footprint confirmed the favorable performance of the sub-waveform approaches compared to conventional retrackers. Over smaller lakes, such as Lake Naivasha, the water heights still improved compared to the unretracked case, but conventional threshold retrackers showed better results for most of the observed waveforms, which were mostly categorized as singular, specular peaks.