Motivation

The estimation of lake water level variations with satellite altimetry is a challenging task because the majority of altimeter waveforms of smaller lakes are contaminated by land. The main goal of this study is the determination of improved long-term water level time series of lakes due to combination of Envisat, CryoSat-2 and SARAL/AltiKa altimeter measurements in an optimal way. While Envisat or SARAL/AltiKa carry classical pulse-limited radar altimeters on board, CryoSat-2 carries a Delay-Doppler/SAR altimeter on board that allows to exploit the full Doppler bandwidth. Depending on the observation technique and surface conditions the altimeter waveforms vary from specular over land to multi-peak at the land/water transition and brown-like in the center of the lake. In a first step, we have developed a new processing strategy for CryoSat-2 SAR data over lakes based on waveform classification, retracking and outlier rejection. The results are validated with water level time series derived from classical altimeter missions and in-situ gauging data.

Processing strategy for CryoSat-2 SAR data over lakes

1. Waveform classification:

Three classes of CryoSat-2 SAR multi-looked waveforms: water, land/water transition and land can be identified by using the three parameters of the Offset Center of Gravity (OCOG) retracker: amplitude (A) and width (W) of the waveform as well as the gate position of the waveform center of gravity (COG), see Figure 1.

The cluster centers of the three classes are determined by applying the k-means algorithm to the three OCOG parameters of the CryoSat-2 SAR waveforms in the training area of the lake Torne Sapr (see Figure 2). While the cluster for water is well identified, the cluster for the land/water transition contains data points which should be referred to the cluster land. This problem can be solved by adapting the condition that waveforms at the land/water transition should contain one single peak before the main peak. In future we want to consider this feature within the clustering.

2. Waveform retracking algorithms:

Over water, the leading sub-waveform which has to be retracted is located around the maximum peak of the waveform (see Figure 1). Therefore in our implementation of the Maximum Peak Threshold Retracker (MTPR) and Narrow Primary Peak Threshold Retracker (NPPTR) we choose the waveform around the maximum peak is chosen. We call it the Maximum Peak Threshold Retracker (MTPR).

Waveforms near the land/water transition are contaminated by land signals and therefore they exhibit a smaller peak before the main peak (see Figure 1). Here the leading sub-waveform is located around the peak before the maximum peak. Therefore these waveforms are retracted with the Narrow Primary Peak Threshold Retracker (NPPTR, Jain et al., 2015).

To avoid offsets between the two different retrackers MTPR and NPPTR the same threshold level of 50% is used for both retrackers (see Figure 3).

3. Outlier rejection:

Inaccurate water levels must be rejected before the determination of the median of the water heights of each track. Therefore the following outlier criteria are applied:

- latitude and longitude thresholds,
- water height thresholds,
- moving 5-point standard deviation [-2 ... +2] smaller than 10 cm.

Data sources for the validation

- Modeled water level time series derived from CryoSat-2 SAR observations by the Technical University of Denmark (DTU) are provided via the open web service AltWater (Altimeter for inland Water, http://www.altwater.dtu.space/index.html).
- Multi-mission water level time series derived from classical altimeter missions such as Envisat, Jason-2 and SARAL/AltiKa are provided by the open web service DAHITI (Database for Hydrological Time Series over Inland Waters, http://dahiti.dgfi.tum.de/en/), which is run by the Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM).

Results

Comparison of lake water level time series derived from CryoSat-2 SAR data (DGFI-TUM) with external data sets.

Conclusions / Outlook

- The CryoSat-2 SAR mode waveform classification based on the three OCOG parameters is successfully applied over smaller and larger lakes.
- DGFI-TUM water level time series based on CryoSat-2 SAR data show similar quality as the modeled CryoSat-2 water level time series of DTU.
- Water heights especially of smaller lakes can be derived from CryoSat-2 SAR multi-look conditions with the same precision than from classical altimeter waveforms.
- In the next step, the CryoSat-2 SAR data processing shall be integrated in DAHITI in order to determine improved long-term water level time series.
- In future, this classification algorithm and class-dependent processing strategy shall be adopted to the new CryoSat-2 Baseline C and Sentinel-3 products.

References:


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