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Volunteering for the future – Geospatial excellence for a better living

Use of altimetry data to determine the height of inland water surface – the case study

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Purpose

- The level of lakes (such as the American and African Great Lakes, etc) varies through the seasons according to inputs (rain rates, snow melting, etc) and outputs (evaporation, withdrawal, etc), and is thus a very sensitive indicator of regional **climate variations**.
- The main purpose of this study is showing that the study of the surface of inland waters is a relatively easy issue and can be carried out even by a non specialist.
- To do this, use the Janson 2 mission data developed by LEGOS and the BRAT software.

Main points of presentation

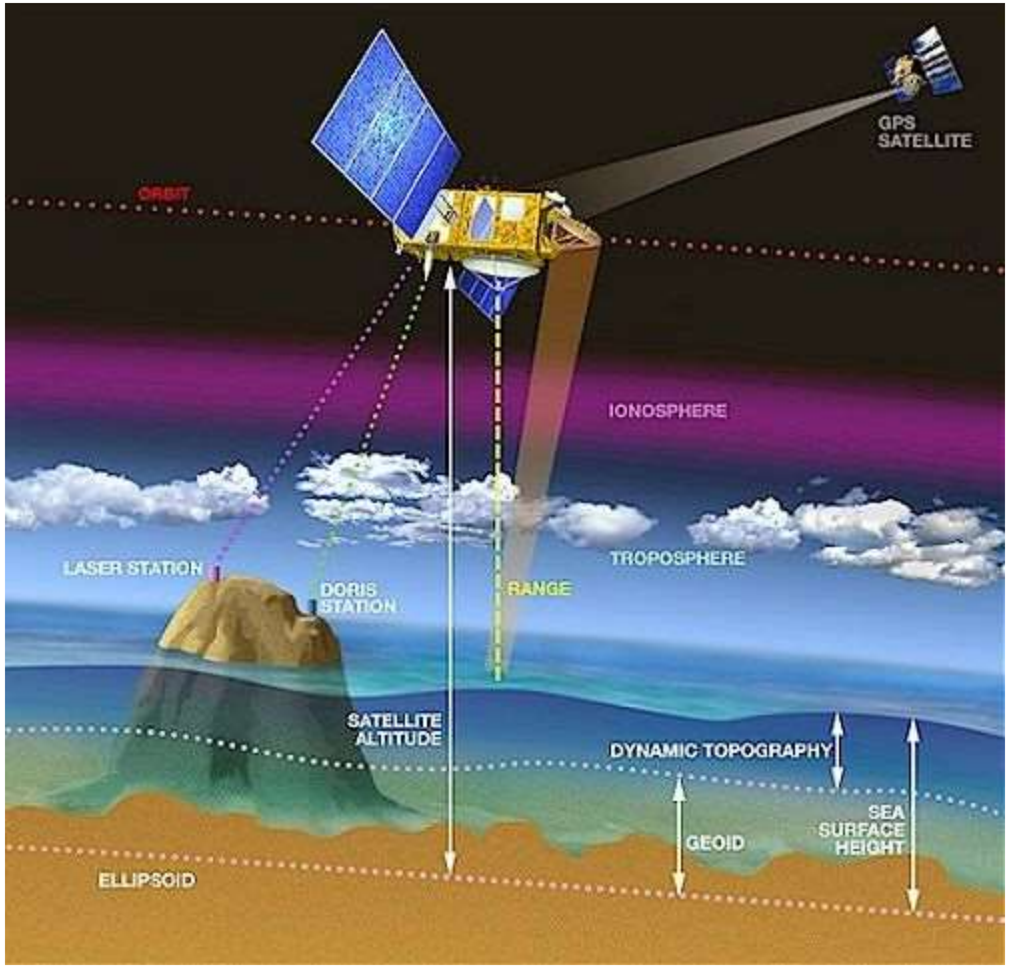
- Introduction
  - some basic information on satellite altimetry
- Description of the study area
- Altimetric data
- Computation
- Final results
- Conclusions

Introduction

- One of the advantages of satellite altimetry is the uniformity of measurement ranging from a dozen to several dozen days.
- Observations are made along the orbital path of the satellite, with the orbit being determined with an accuracy of 1 or 2 cm.
- Altimeter measurement is based on the recording of reflected radar signals from the target surface.
- This technique provides the ability to obtain data anyway of the season or weather.
- The surface roughness, the influence of the troposphere and ionosphere and the occurrence of terrestrial tides are of great importance for the registration process..

Introduction

- Radar altimeters on board the satellites transmit signals at high frequencies to Earth and receive the echoes from the surface (the 'waveform') and yields the range R measurements.
- However, as electromagnetic waves travel through the atmosphere, and are decelerated by water vapour or ionisation.
- Once these phenomena have been corrected for, the final range can be estimated with great accuracy (cm).



Introduction

- The final aim is to measure surface height relative to a terrestrial reference frame, .
- This requires independent measurements of the satellite's orbital trajectory, i.e. exact latitude, longitude and hight

Height = Atitude - Range

Height = Altitude – Range - Geoid

Past, present and future altimeters satellite missions

- The first altimetry missions appeared already in the seventies
  - SEASAT 1978, Geosat 1985,…..Jason-1, 2001,
- Current satellite missions:
  - Jason 2 2008, …….Saral,……Sentinel – 3…. Sentinel-6/Jason-CS, August 23, 2022

Jason-2 orbital path (red line) passing through a fragment of Lake Śniardwy

Descripton of the study area

- The object of research in this work is the largest lake in Poland – Śniardwy.
- The lake is located in the north-eastern part of Poland, within the Masurian Landscape Park.
- Lake Śniardwy is connected through the strait with lakes Mikołajskie and Bełdany and a short channel with Lake Łuknajno.
- Together with the lakes Białawki, Roś, Tuchlin, and Tyrkło, the reservoir is part of the Great Masurian Lakes
- The area of the lake covers an area of 1 148 km^2 and the estimated dimensions of the lake are 22.1 km by 13.4 km.
- The lake is quite shallow, the maximum depth does not exceed 23 m, while the average depth reaches about 6 m.
- The circumference of the lake exceeds 80 km, and the height of the water surface is about 116.1 m above the sea.

Data used

- Near coasts and lands, the use of satellite altimetry is limited due to increased measurement errors.
- To recover this data near the coast, which contains useful information for coastal research, the French Spatial Agency (CNES) funded the development of a PISTACH project dedicated to processing altimeter measurements of the Jason-2 satellite in the coastal ocean zone.
- PISTACH "hydro" products for land areas are available on the Aviso FTP server.
- Therefore, the PISTACH data have been used in this paper.
- To determine the height of the area of Lake Śniardwy, 300 PISTACH files were used in this work, covering the measurement period from July 15, 2008, to September 26, 2016, with a 10-day repetition cycle.

Conclusion: PISTACH is usefull

Calculations

- To calculate the height of Lake Śniardwy, free software BRAT (Broadview Radar Altimetry Toolbox) was used.
- BRAT is a set of tools designed to process radar altimeter data.
- Before calculating the final height of the surface of Lake Śniardwy, an important part of the research considering of propagation corrections, geophysical corrections, and selected retracker algorithms.

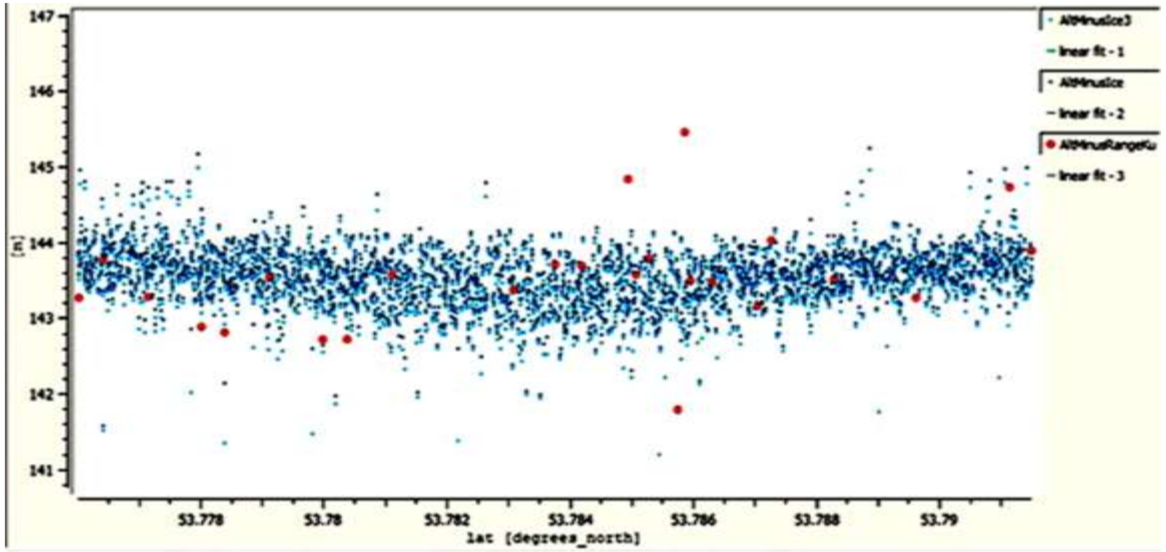
Conclusion: BRAT is very usefull software

Comparison of Ice1 (green), Ice2 (blue), Range (red) retracking algorithms - basic informarion

- Waveform: The magnitude and shape of the radar altimetry return echoes
- Retracking altimetry data is done by computing the departure of the waveform’s leading edge from the altimeter tracking gate and correcting the satellite range measurement (and surface elevation) accordingly

Comparison of Ice1 (green), Ice2 (blue), Range (red) retracking algorithms

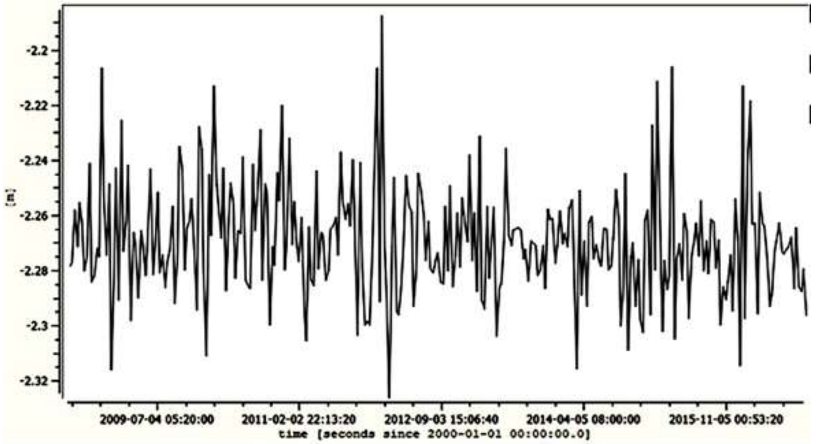
- In the case of Ice1, there is a large discrepancy, as the values range from 34 m to 145.2 m.
- Less discrepancy occurs when using the Ice3 algorithm 134 145
- Range algorithm: only few computed heights

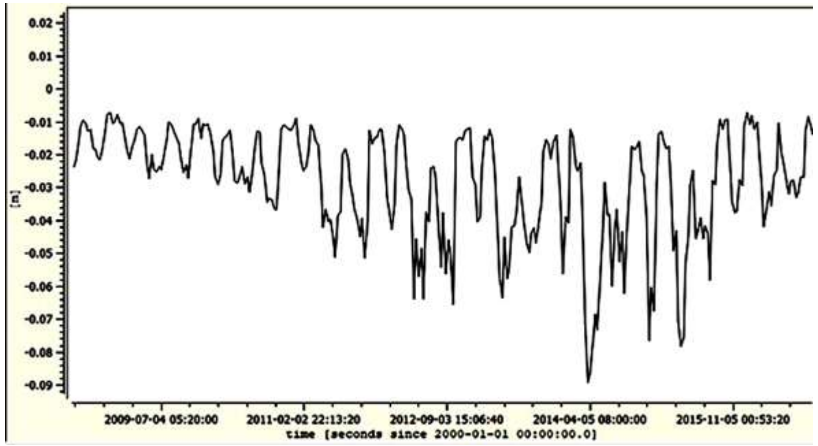


Conlusion: ice1 algorithm

Computation of propagation corrections

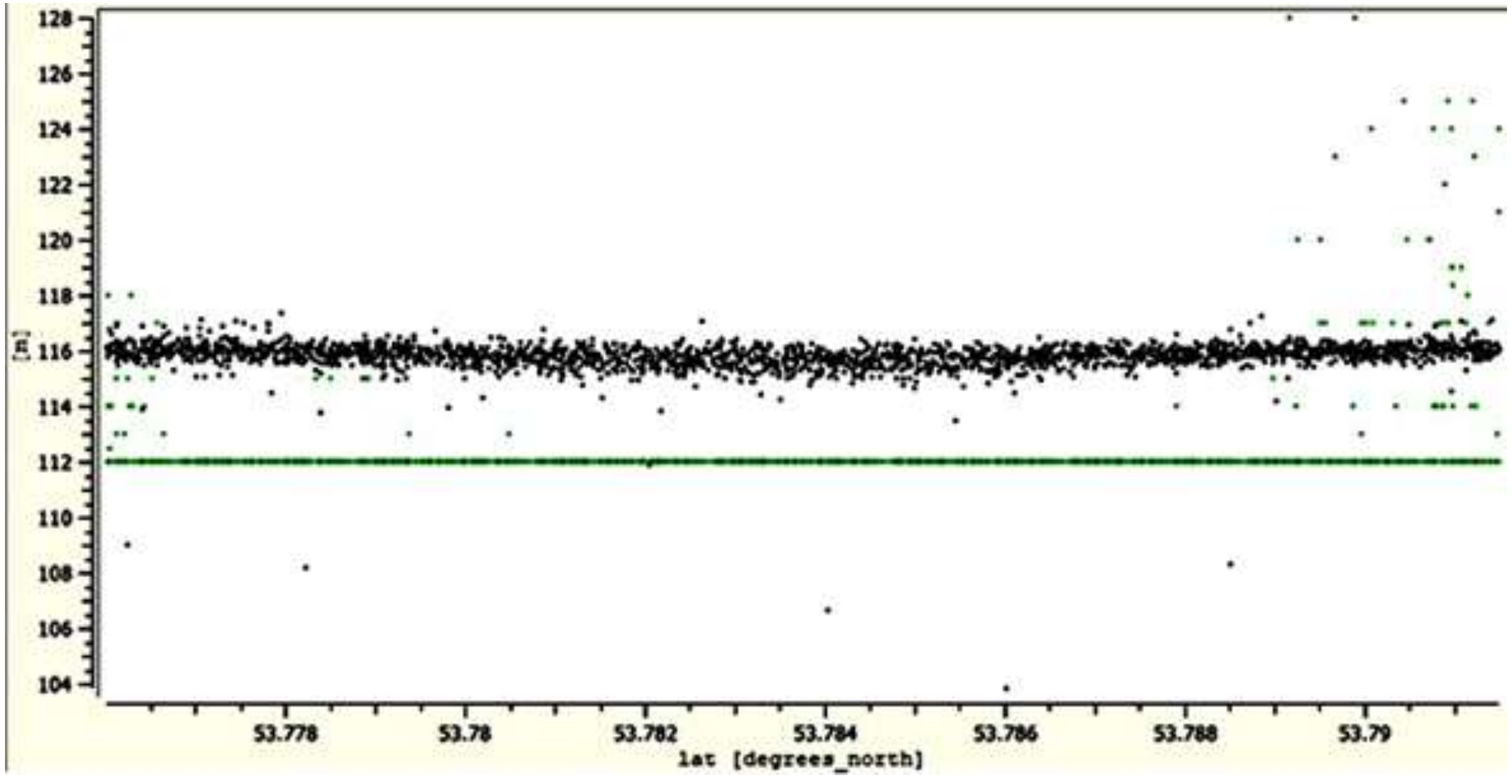
- Tropospheric correction (dry, wet) were calculated based on differential pressure and radiometer (see dry corr.)
- Ionospheric correction was calculated using the GIM (Global Ionosphere Maps) model
- Corrections were computed using BRAT software





The first approach of water surface altitude calculation

Heigth (WSA) = altitude - range_ice3_ku - model_dry_tropo_corr - model_wet_tropo_corr - iono_corr_gim_ku - pole_tide - solid_earth_tide – geoid_EGM2008



The shape of the waveforms of the reflected waves and the sigma0 scattering coefficient

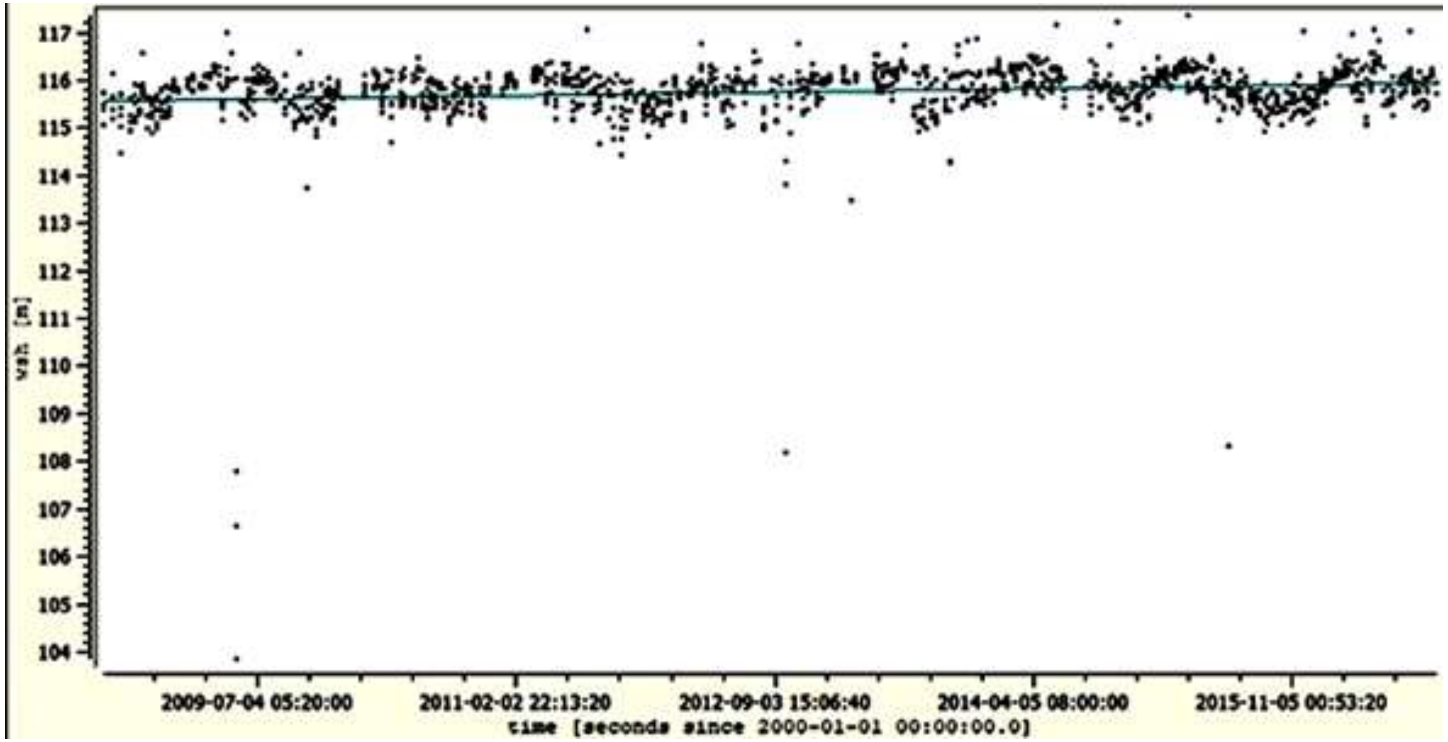
- Waveform: The magnitude and shape of the radar altimetry return echoes. Few classes of waveform.
- Sigma 0: or sigma-naught, or backscatter coefficient, reflexivity coefficient of the radar wave on the surface

The shape of the waveforms of the reflected waves and the sigma0 scattering coefficient

- PISTACH products can provide a more accurate height analysis by using additional data selection criteria.
- In the second attempt of calculating the WSA, the shape of the waveforms of the reflected waves and the sigma0 scattering coefficient was considered and individual classes of waveforms of signals (waveforms) for the area of Lake Śniardwy were examined.
- The study showed the predominance of the presence of waveforms belonging to class 2. The shape of class 2 waves is characteristic of undisturbed surfaces. This analysis confirmed the acceptance of the choice of the Ice3 algorithm, which is dedicated to peak waveforms
- The backscattering coefficient can also bring useful information to the data selection. We observe almost the same sigma0 values over the water body: it is possible to introduce this specificity in the data selection.

Final computation

- Determination of the WSA of the area of Lake Śniardwy
- in the years 2008-2016
- considering sigma0 and waveforms of class 2 as a function of time



Summary and conclusions

- The lake Śniardwy level changes were calculated with 300 altimetric observations repeated every 10 days in the period from 2008 to 2016.
- The mean level of Lake Śniardwy was calculated relative to the global geoid model EGM2008.
- The results of the calculations have shown seasonal changes of 10 cm in the level of the tested object.
- The average heights calculated in the period from 2008 to 2016 are in the range of 115.57 m to 115.90 m.
- The regression line indicates an increase in the surface of the lake of 3.4 cm/year.
- It is estimated that the surface of the lake has been determined with an accuracy of a few centimeters.
- Unfortunately, there is no independent data from the lake tide gauge, which does not allow a more accurate assessment of the accuracy of altimetric method.

Thank you for your attention