JADE UNIVERSITY OF APPLIED SCIENCES
Wilhelmshaven Oldenburg Elsfleth

Combination of satellite altimetry, tide gauges and shipborne GNSS measurements in the German Bight

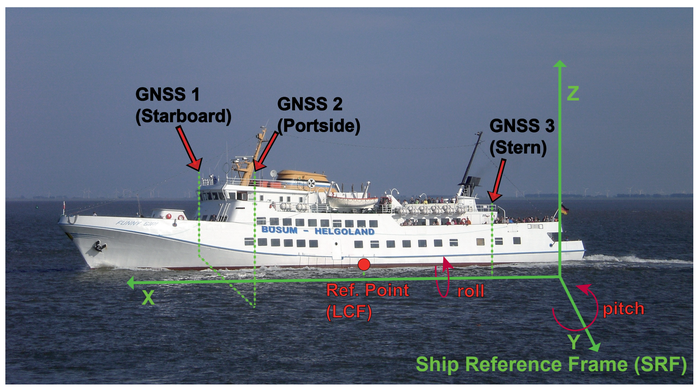
Motivation

High precision and reliable information about the sea surface height (SSH) are of vital interest for the global scientific community. Such data can be collected with remote sensing techniques like satellite altimetry and GNSS reflectometry. These techniques deliver spatially distributed data over the oceans but suffer from interfering signals near coastlines. In this areas tide gauges collect information about the SSH at specific stations. Ship-based GNSS measurements of the SSH can be used to beneficially expand these set of techniques. All three techniques have their own characteristics and show different spatial coverage and temporal resolution of the deduced SSH. A combination seems therefor very promising.

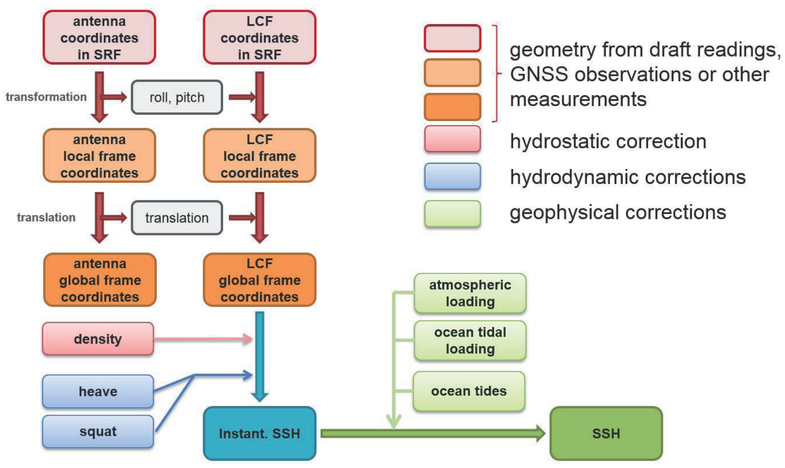
Ship based SSH measurements

At the Jade University a ship based SSH measuring method was developed. Ships are acting as GNSS sensor platforms for a minimum of three GNSS receivers. At least one should be a dual-frequency-receiver to allow for a PPP solution for global applications. Attitude can be derived by transforming antenna coordinates from the ships reference frame (SRF) into the system of relative coordinates stemming from a "moving baseline" kinematic solution. The position of a reference point can then be calculated by using the attitude and the global positions from e.g. a PPP solution.

Hydrostatic and hydrodynamic corrections must be applied to obtain the instantaneous SSH. Fuel consumption, ballast water changes and seawater density are the parameters for the hydrostatic correction calculation. The water surface around a moving ship is influenced by the ship's wave system. A consequence of this hydrodynamic effect is the squat, which is the change of sinkage and trim of a moving ship. A precise consideration of this effect is mandatory for reliable results. Wave induced height changes (heave) can be calculated by epoch-to-epoch double differences. If the instantaneous SSH is further corrected for oceanic tides, ocean tidal loading and atmospheric loading SSH is obtained.



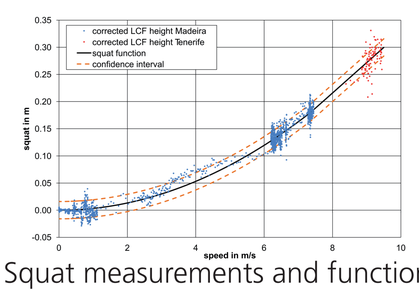
Helgoland ferry with sketch of the measuring setup



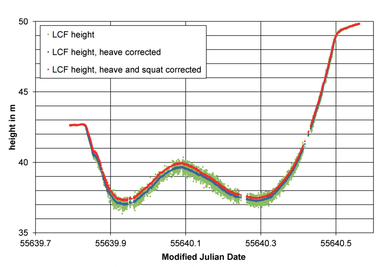
Flowchart of the ship based approach

Previous experiments

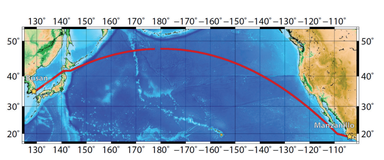
Two experiments where performed to study the ship based approach. A first test was done during a journey of a cruiser vessel between Tenerife and Madeira. Squat was calibrated using an escort craft and CFD calculations where done in addition (Reinking et al. 2012). Second an ocean wide measurement was realized using a container vessel travelling from Busan, South Korea to Manzanillo, Mexico. Fuel consumption, changes in ballast water and the sea water density where taken into account to correct the hydrostatic draft. Squat corrections where calculated using CFD computations. Resulting SSH values where corrected for EGM2008 geoid heights and afterward compared to JASON-2 measurements. An interpolation method and an analysis of crossover points was done (Roggenbuck et al. 2014). The high temporal- and therefor spatial resolution was obvious in both experiments. The analysis of the crossover points indicates an offset of 75.1mm between both techniques which is in a good agreement with other studies.



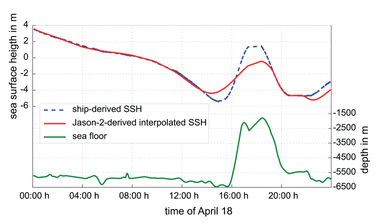
Squat measurements and function



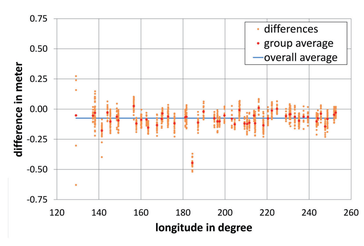
Estimated SSH between Tenerife and Madeira



Vessel track of the ocean wide experiment



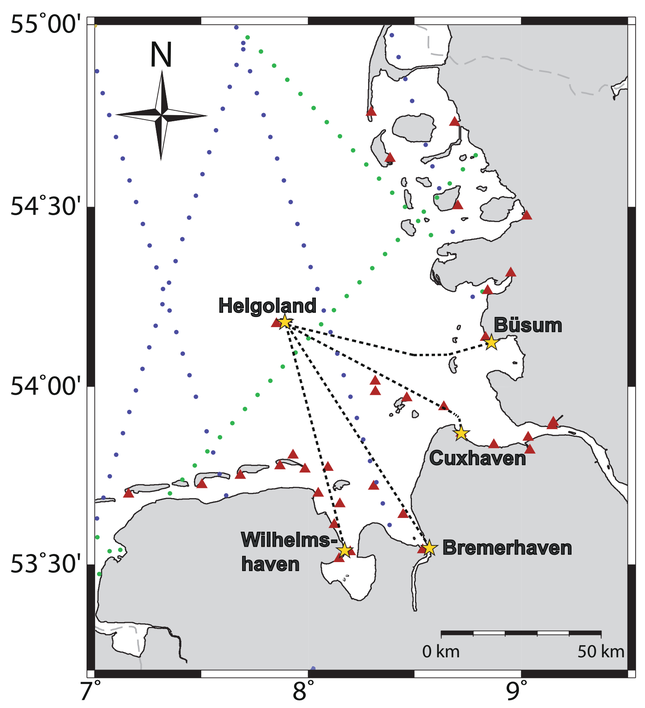
Interpolated altimetry data and ships SSH over the Hawaii-Emperor seamount



Crossover point differences. Ships method and JASON-2

Project idea

In a newly founded, 3 year lasting project a combination approach for tide gauges, satellite altimetry and ship based SSH measurements will be developed. The different characteristics will be taken into account to obtain a precise model of the sea surface. Data from all available altimetry satellites will be merged with tide gauge readings and ship-derived SSH data. The region of interest is the German Bight where strong tidal signals are present. Selected ships will be equipped with low-cost GNSS dual-frequency antennas and receivers. For this purpose we will use research vessels owned by the Federal Maritime and Hydrographic Agency of Germany and ferries which are heading for Helgoland. An automatic processing procedure will be designed and different combination approaches will be studied.



German Bight with available tide gauges (▲), footprints from JASON-2 (●) and SARAL (●) and ferry routes between German ports and Helgoland (⋱)

JADE-HS.D

Literature

Reinking, J., Härting, A., Bastos, L. (2012), *Determination of sea surface height from moving ships with dynamic corrections*, Journal of Geodetic Science, Number 3 / 2012, DOI: 10.2478/v10156-011-0038-3

Roggenbuck, O. , Reinking, J., Härting, A. (2014), *Oceanwide Precise Determination of Sea Surface Height from In-Situ Measurements on Cargo Ships*, Marine Geodesy, 37:1, 77-96, DOI: 10.1080/01490419.2013.868385, 2014

Reinking, J., Härting, A. (2014), *Ship-based Oceanwide Observation of Sea Surface Heights in Consideration of Hydrodynamic Corrections*, Proceedings XXV FIG Congress 2014, Kuala Lumpur, Malaysia, paper no. 6837, 2014

Ole Roggenbuck
Jörg Reinking

Institute of Metrology and Analysis Technique (IMA)
Department of Civil Engineering and Geoinformation
Jade University

Ofener Straße 16/19
26121 Oldenburg
Germany
Tel. +49 441 7708-3754

IMA
Institute of Metrology and Analysis Technique