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Using ship-borne GNSS data for geoid model validation at the Baltic Sea

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We present a study of geoid model validation using ship-borne GNSS data on the Bothnian Bay of the Baltic Sea. In autumn 2015 a dedicated gravity survey took place in the Bothnian Bay on board of the surveying vessel Airisto as a part of the FAMOS (Finalising surveys for the Baltic motorways of the sea) Freja project, which is supported by the European Commission with the Connecting Europe Facility. The gravity data was collected to test older existing gravity data in the area and to contribute to a new improved geoid model for the Baltic Sea. The raw GNSS and IMU data of the vessel were recorded in order to study the possibilities for validating geoid models at sea.

In order to derive geoid heights from GNSS-measurements at sea, the GNSS measurements must first be reduced to sea level. The instant sea level, also called sea surface height, must then be modelled and removed in order to get the GNSS positions at the zero height. In theory, the resulting GNSS heights are the geoid heights, giving the distance between the ellipsoid and the geoid surface.

There were altogether 46 lines measured during the campaign on the area. The 1 Hz GNSS-IMU observations were post-processed using the Applanix POSPac MMS 7.1 software. Different processing options were tested and the Single Base –solution was found to be the best strategy. There were some issues with the quality of the data and cycle slips and thus, 37 of the lines were of adequate quality for the geoid validation. The final coordinates were transferred to the coordinate systems related to the geoid models used. Translation of the processed heights to sea level was performed taking the pitch and roll effects of the vessel into account. Also the effects of static and dynamic draft (squat) were applied. For the reduction from sea surface to geoid surface, the sea surface heights were derived from tide gauge data and also from a physical model for the Baltic Sea.

The residual errors between the GNSS-derived geoid heights and geoid heights from geoid models were as low as 2 mm on some lines. When the overall mean is taken from the mean of all lines, the lowest value of 2.1 cm, was achieved using a physical model for the sea surface and comparing with the NKG2015 geoid model. The NKG2015 model together with the tide gauge sea surface yield 3.1 cm. Comparing with Finnish geoid model gave 3.7 and 4.7 cm for the physical model and tide gauge surfaces, respectively. The mean standard deviations were below 5 cm, when the data was filtered with a 10 min. moving average. Thus, it can be said that with high quality GNSS solution and enough information on the coordinate systems, vessel movements and the sea surface heights, geoid heights can be recovered from GNSS observations at sea.