Application of operational satellite altimetry observations for shelf and coastal seas

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Planned DMI work in OSTST

The research and development that will be carried out at DMI are focused upon the application of satellite altimetry in operational shelf sea/coastal sea and the validation of the satellite observations in these regions. Three different topics are proposed to assess the regional errors and extend the use of satellite altimetry observations for operational purposes.

- **A feasibility study** of the use of satellite altimetry observations in the operational models. The spatial and temporal scales of the weather induced sea surface height (SSH) variations in the North Sea will be compared with the spatial and temporal sampling of the satellite. Tests will be carried out to specify the sea level on the open model boundaries in the North Sea. Data assimilation methods will be applied to assimilate near real time altimetry observations.

- **A validation study:** DMI has access to a large number of real time tide gauge observations in the North Sea/Baltic Sea. The observations will be used to validate the altimetry observations in the shallow waters and near-coastal areas of the North Sea/Baltic Sea. Error statistics will be derived for the TP tandem and Jason-1 missions. A multivariate regression model will be constructed, based upon the available tide gauges and the interleaved mission results. An accuracy of real time sea level of 5-10 cm is expected.

- **Overflow processes:** Satellite observations of SSH can be used to study subsurface and bottom processes such as the dense overflows through the Denmark Strait and the Faroe Bank Channel. The vigorous mixing downstream of the sill shows up as enhanced SSH variability. The overflows play an important role in the global thermohaline circulation and variations may be associated with climate changes.

Preliminary results

Summary
Near-real time altimetry products from Jason-1, T/P tandem mission and ENVISAT have been validated for the North Sea and Baltic Sea to assess the feasibility of using the data for operational purposes. All NRT Jason 1 and Topex/Poseidon observations in the Baltic Sea are currently discarded in the processing of the data. The spatial scales of the sea level variability are determined from satellite and tide gauge data. The characteristic time scales are derived from 45 tide gauges.

The near-real time data are compared against delayed satellite data and output from a 2-dimensional storm surge model to derive error estimates of 8 cm for Jason-1, 8.2 for the T/P tandem mission and 13 cm for ENVISAT. The feasibility of using the data for operational purposes is discussed for different sub regions.

1. Satellite data

The data used in the investigations consist of satellite altimetry data and tidegauge measurements. Both NRT and delayed, post-processsed observations are used.

Near-real time (NRT) sea surface anomalies from the Jason-1 and T/P tandem mission were acquired from JPL. NRT ENVISAT observations were obtained from AVISO. The delayed data were obtained from the Pathfinder team. The figure below indicates the temporal coverage of the data.

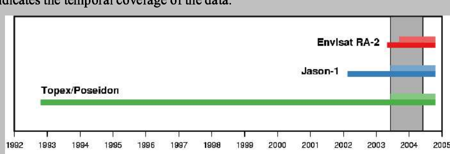


***Figure: Available satellite data**. Horizontal, colored bars indicate available NRT (upper, light color) and delayed (lower, dark color) altimetry data.The vertical grey bar indicates the NRT study period.*

2. Tide gauge data

Hourly tide gauge data were obtained from about 45 tide gauge stations. Data were extracted from January 1, 1992 to June 1, 2004, if available.

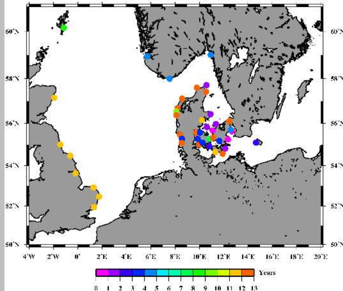


***Figure:** Tide gauge records used in this study. The colors of the circles correspond to the length of the data record in years.*

3. Data return

The real coverage of the datasets was assessed by computing the number of independent observations for 1 x 1 degree boxes. Independent observations are computed by counting observations from the same cycle as one observation.

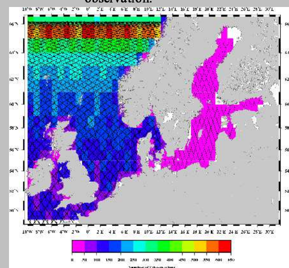


***Figure:**Number of independent NRT observations over a time period of 284 days for all three sensors combined.*

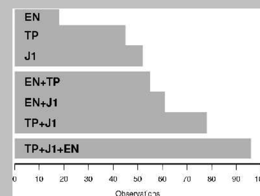
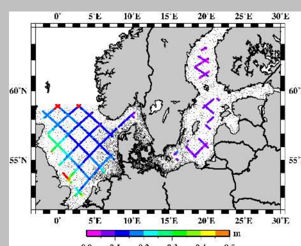


***Figure:** The average number of independent satellite observations in the North Sea for different combinations of satellites.*

4. Validation of NRT data



The delayed Jason-1 data were used for the validation of a 2D finite element storm surge model. The spatial distribution of the errors is shown in the figure to the left.

By assuming that T/P delayed data have an error of 4 cm, we perform pointwise validation against storm surge model and derive the error estimates for North Sea observations:

- **T/P NRT tandem error = 8 cm**
- **Jason-1 NRT error = 8.2 cm**
- **Envisat NRT error = 13 cm**

***Figure:** Pointwise standard deviation of the residuals between delayed Jason-1 observations and model data. The model grid nodes are indicated with black dots.*

5. Characteristic spatial and temporal scales

The spatial scales of the sea level variability were calculated from pointwise correlations between delayed T/P data and tide gauge observations. The correlation results were averaged in bins with a width of 25 km. This procedure was applied for the original observations and for the detided observations. The spatial scales of the total sea level variability signal and for the detided sea level signal are shown below for three areas. In addition, the temporal scales are calculated from tide gauge observations.

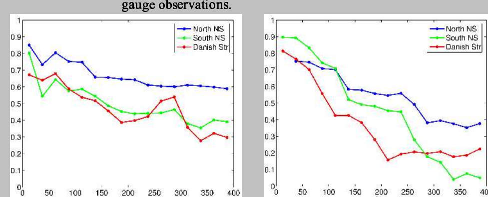


***Figure:** Correlation as a function of distance away from the tide gauges. The left figure shows the results from the total sea level signal whereas the right figure shows results from detided time series*

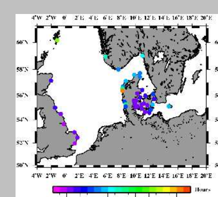


***Figure:** The colors indicate the temporal scales of the non-tidal variability, derived from tidegauges*

6. Discussion

For operational use in the North Sea-Baltic Sea, it is essential that the NRT Jason-1 and T/P satellite data are not discarded due to lack of tide model solutions. According to JPL/NASA, the T/P and J-1 NRT data processing will include Baltic Sea observations in the future (S. Desai, personal communication).

4 areas with distinctly different characteristics have been selected:

Open boundaries in the North Sea
Large model error, large spatial and temporal scales and good data return. The regions are therefore well suited for application of the NRT satellite altimetry data.

North Sea in general
Due to the large sea level variability and the good data return, satellite data are in general well suited for use of satellite data.

Danish Straits
Due to the low data return, the small spatial and temporal scales of the signals and the low sea level variability, the impact of satellite observations is likely to be small for this region.

Baltic Sea
As no NRT J-1 and T/P satellite data exist for this region, and only detided NRT EN data are available, no conclusive statements can be made for this area. The variability as well as the model error is in general low. It is therefore likely that the impact of NRT satellite data will be small but further investigations and NRT J-1 and T/P data are needed in this area.