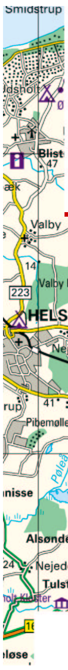

Review of T/P altimetry derived scientific results at the KMS- Denmark

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The National Survey and Cadastre (KMS) in Denmark contributes to the work of the extended science working team in place since 1998 within several fields like the modeling of sea level changes and variability as well as modeling of ocean tides. ***This poster presents several results obtained during this period.***

Improved sea level from water level recorders and satellite altimetry

Aims: -Investigate relationship between satellite SSH data and water level recorders in the North Sea.

Combine the high temporal resolution of water level recorders with high spatial resolution from satellites.

Focus on:
Non tidal processes, I.e. meteorological effects: Internal and external surges, inverse barometer effects etc.

Test case:
How well can SSH from ERS 1+2 crossovers be described using T/P + Water level recorders ?

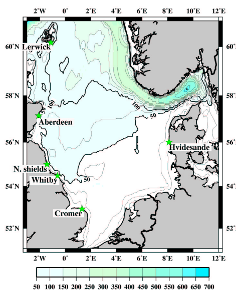
Satellite data:

9 years of TOPEX/POSEIDON Pathfinder Altimetry observations every 9.9 days ~ 300 repeat cycles

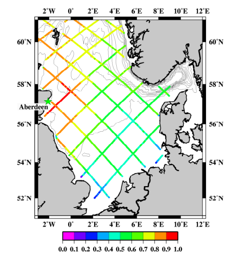
Test data: 6 years of ERS 1 and 2 observations every 35 days ~ 81 repeat cycles

Satellite observations include inverse barometer effects (std dev ~2-3 cm).

Tides removed by response method and harmonic analysis (consistent with sea level recorders)



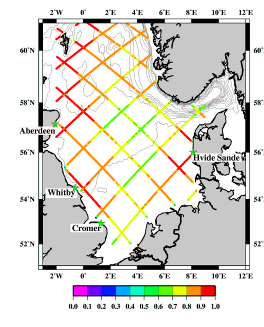
The North Sea, its bathymetry and the location of Tide gauge used.



Temporal Correlation between the T/P observations and the Aberdeen Tide Gauge Recorder over the period 1993-2000. Maximum correlation is obtained roughly 30 km off shore of 0.95

Small time scale, Large spatial scales, high correlation T/P + water level recorders => regression model:

$$\eta_{TP}(t) = \beta_1 ssh_1(t) + \beta_2 ssh_2(t) + \beta_3 ssh_3(t) \cdots + \varepsilon$$



The performance of the Regression model.

Regression model can describe real time sea level from only 4 recorders:

- Correlation > 0.81
- RMS residuals ~10 cm

Regression model superior to other methods and storm surge models.

Shallow water tides from Altimetry.

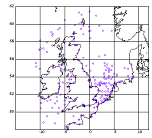
Shallow water tides have large amplitudes on many shelves.

Examples:

- *M4> 50 cm in the English Channel*
- *M4> 20 cm on the Patagonian shelf*
- *MS4> 30 cm in the English Channel*
- *MKS2> 10 cm around the Aleutian island.*

Shallow water tidal currents are important for Biology/sedimentation/tracer distributions as the interaction with astronomical tides (I.e.) M2 + M4 create the strongest tidal currrents.

Removal of tides improves altimetry for oceanography.

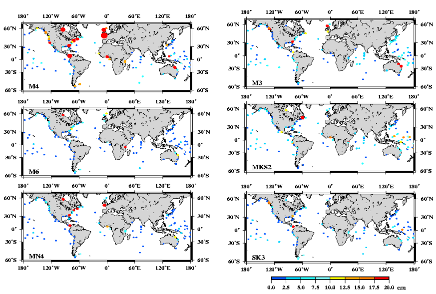


An analysis and comparison with 152 tide gauges on the NW European shelf showed, that the T/P derived M4 model compared with 3.0 cm RMS versus 4.7 cm RMS for the local 12 km resolution Flather hydrodynamic shelf model covers the NW European shelf, and is used operationally for coastal flood forecasting in the United Kingdom

An investigation of alias periods shows that several shallow water constituents can Actually be derived from satellite altimetry.

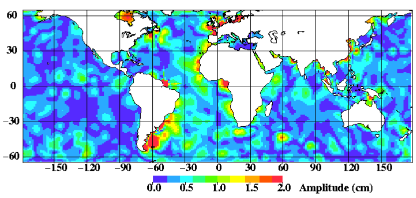
Constituents	Angular speed (origin)	Angular speed (°

110 WOCE tide gauges investigated for the presence of shallow water constituents using POLTIPS.



M4 is shown in the upper left corner. The regions of large amplitudes coincide to a very Nice degree with the computations from T/P altimetry given below.

TOPEX M4 tide model



Subsurface processes detected with satellite altimetry

Subsurface processes such as overflows of dense and cold bottom water through the Denmark Strait and the Faroe Bank Channel are detected as enhanced sea surface height variability in the TOPEX/POSEIDON and the ERS 1+2 satellite altimeter data. The spatial scales of increased variability are 50x50 km centered about 50 km downstream of the Faroe Bank Channel. In the Denmark Strait there is good agreement between gridded variability from the two satellites and the region with enhanced variability extends 150 km downstream from the sill with a width of 50-100 km. The overflows are detected with the TOPEX/POSEIDON satellite during all seasons with a variation in the background level that is correlated with the annual wind forcing. It is shown that caution has to be taken when the method is applied to overflows with large variations in the mean sea surface.

Data

In this study we use TOPEX/POSEIDON (T/P) and ERS 1+2 satellite altimetry observations of SSH that are processed by the Pathfinder team (see http://neptune.gsfc.nasa.gov/ocean.html). The T/P data set is version 8.2 consisting of 294 repeat cycles with a period of 9.92 days (Sep 1992 to May, 2000). All the standard geophysical, media and instrumental corrections have been applied The ERS data set is version 5.0 with a total of 81 repeat cycles from the ERS 1 phase C (18 repeat cycles), ERS 1 phase G (13 repeat cycles) and ERS 2 (50 repeat cycles).

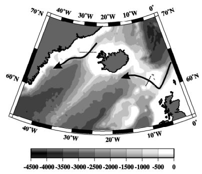


Figure 1. Bathymetry of the North Atlantic in gray shading. The arrows represent the mean path of the overflow water through the Denmark Strait and the Faroe Bank Channel. Dashed lines indicate the sills

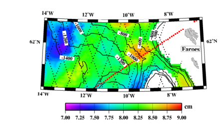


Figure 2. Gridded standard deviation of ERS 1+2 SSH observations (colors) and bathymetry (contours) in the Faroe Bank Channel region. The positions of the ERS ground tracks are overlaid in black and only observations obtained at depths >300 m have been used. The red dots indicate the T/P ground track used in figure 6a.

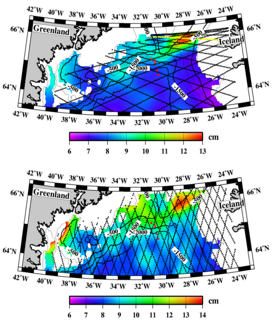


Figure 3. Denmark Strait standard deviation of SSH from the T/P (top) and the ERS 1+2 (bottom) satellites. The bathymetry is contoured and ground tracks are overlaid in black. Only observations from water depths >300 m have been used. The red triangles mark the positions of the moorings in the Dohrn Bank array.

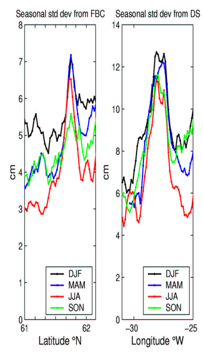


Figure 4. SSH variability calculated from the T/P for the different seasons: December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON). a) Along a ground track ~30 km from the Faroe Bank Channel sill (see positions in figure 2). b) Results from a ground track in the Denmark Strait (see positions in figure 3).

Other Overflow zones

Overflow of dense bottom water from one basin to another is an important mechanism in the distribution of water masses throughout the world oceans. Several important overflows such as the Charlie-Gibbs Fracture Zone, the Mediterranean outflow and the Romanche Fracture Zone overflow exhibit fluctuations and mixing similar to the FBC and the DS With the above findings it is therefore interesting to extend the analysis to some of these regions where dense water flows over a sill and descends. However, several of the overflows with significant transport occur in fracture zones and other areas with large variations in the mean sea surface. In these regions where the sea surface slopes can exceed 10 cm/km the cross-track interpolation using the mean sea surface becomes crucial because errors in the correction can give a signal comparable to the signals from the overflows

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