Sea Level Analyses using ENVISAT

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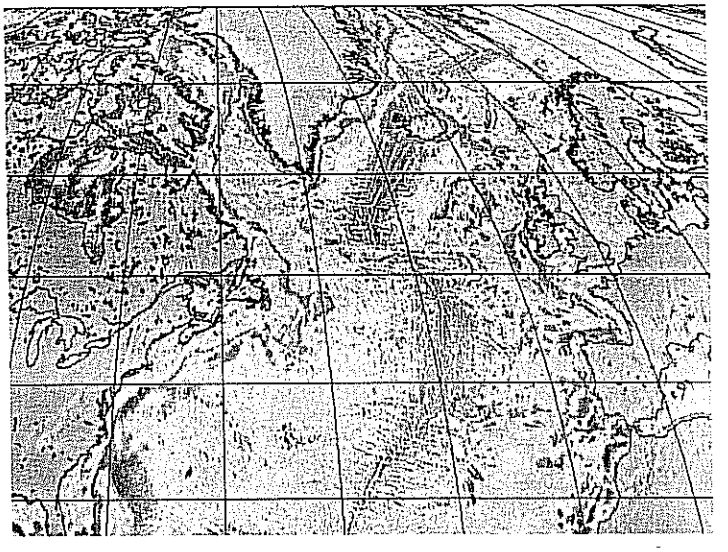
For more than a decade, remote sensing has successfully been used to monitor the ocean surface and has provided valuable information about the dynamics of the worlds oceans and the marine gravity field. Even though two satellite missions carrying radar altimeters are currently in operation, sea level variability is still observed that cannot be fully explained due to insufficient coverage.



The goal of the ENVISAT activities is to develop methods for integrating multi sensor and multi channel satellite data for improved recovery of the sea level height. This will be carried out at regional scales (10-20 km) in the North Atlantic region as well as at local scales (3-5 km) in the Danish seas. Hereby, the understanding of the ocean, its state, and its dynamics will be improved. In turn, this will lead to enhanced ocean tides modeling and determination of the geoid, the sea level, and possible effects of Global Change.

Per Knudsen, Ph.D. in Geodesy, Head of Geodetic Department at the National Survey and Cadastre - Denmark (Kort & Matrikelstyrelsen) has contributed toresearch in Satellite altimetry for a variety of applications such as modelling marine gravity field, ocean tides, seasonal cycle, and long-term sea level changes.

Ole B. Andersen, Ph.D. in Geodesy, Senior Scientist, Geodetic Department at the National Survey and Cadastre - Denmark (Kort & Matrikelstyrelsen) has contributed to research in Satellite altimetry for a variety of applications such as modelling ocean tides, marine gravity field, seasonal cycle, and long-term sea level changes.

Carl Christian Tscherning, Professor in Geodesy, Geophysical Department NBIfAFG at the University of Copenhagen has contributet to research in a variety of fields within physical geodesy, such as gravity field modelling, satellite altimetry, and gravity field recovery from the GOCE satellite mission. He is Principal Investigator of previous ERS activities and these ENVISAT activities.

Synergetic multi sensor improved recovery of the sea level

The satellite altimeter data are available along the satellites ground tracks. During ERM mode of ENVISAT the measurements are repeated at regular intervals of 35 days. Due to different orbit configurations of other satellite missions their spatial and temporal distribution of the observations varies from the ENVISAT sampling characteristics. Hence, an optimum interpolation technique that takes both spatial and temporal correlations into account must be developed to combine sea level heights measured by ENIVISAT and other satellite missions.

The ocean temperature is known to be correlated with the sea level. The AATSR instrument onboard the ENVISAT satellites scans the sea surface temperature in a 500 km swath and provides almost global coverage every three days. Since a global coverage of ENVISAT altimetry is provided every 35 days only, the density of the AATSR data is much higher. The two data sources are sought integrated in an improved recovery of the sea level utilising the empirical correlations. Similarly by merging the ENVISAT data sets with observations from the ERS-1 and ERS-2 long term changes in sea surface temperature and sea level height are analysed to investigate the dynamic of the seasonal changes.

From space the ocean surface may "look" different in different regions. Hence, observations from the MERIS instrument can be used to distinguish between light fresh surface run-off water and heavier saline ocean water. The characteristics of the different ocean water masses will be identified using the full multi channel data sets, i.e. both visible, near visible, and infra red. Preparations in form of study of CZCS and SeaWifs data have already been undertaken. As opposed to analyses of the individual groups of data, statistical analyses of the joint multi-source data can reveal otherwise uncovered cross dependencies. The discrimination will be based on optimal subsets of directly measured variables and derived variables (such as principal components and spatial extensions, texture variables etc.).

Globally, images of all channels will be available daily. Hence, such satellites provide an enormous amount of information about the ocean. As with the AATSR data, a possible integration into the sea level determination may result in a dramatic improvement of the accuracy of the sea level in both the temporal and spatial domains. The multi channel data will be analysed together with the sea level data in order to extract empirical correlations.

Geodetic and oceanographic use of improved sea level data

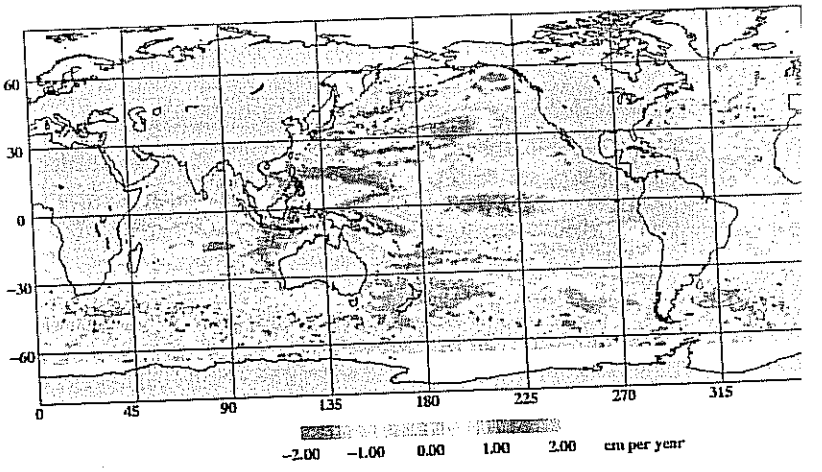
Having established a set of improved sea level data these data can be used for various geophysical studies:

Enhanced mapping of the mean sea surface and the gravity field.

Data from the ERS-1 geodetic mission has improved the mapping of the marine gravity field dramatically. However, at intermediate wavelength (200-1000) km uncertainties still exists which require the use of a long consistent repeated data set. The radar altimeter data from the ERS-1, ERS-2 and ENVISAT-1 in synergy with the altimeter data from the TOPEX/POSEIDON altimeter will provide an important contribution for this task. A full coverage of the gravity field cannot be carried out before data from the gravity satellite mission become available, but interesting details about geological structures may be recovered.

Enhanced marine geoid modelling

The present marine geoid models only represents the global signatures of the geoid adequately, and they cannot be used for detailed studies of the ocean dynamics and heat transport. In order to make further progress in the analysis of the ocean dynamics a more accurate geoid information is required. Methods for enhanced geoid modelling using altimetry from several satellites will be studied and models will be derived and available models will be tested in the North Sea and the Adriatic Sea.



Modelling of ocean tides and ocean dynamics

During recent years the ocean tides has been improved vastly in the deep ocean. However, in shallow seas there is still a need for improving the ocean tide models. In these regions shallow water tides and seasonal variations in the harmonic constituents become important. Having the permanent and major part of the time varying signal in the sea level mapped studies of the ocean circulation can be performed from the enhanced sea level observations.

Modelling of sea level changes

The improved sea level data from both satellite and tide gauge stations will also be used in an analysis of the seasonal sea level changes as well as inter and intra-seasonal variations. Especially, the spatial and temporal characteristics of the sea level changes will be described and compared with changes in sea surface temperature and other parameters.