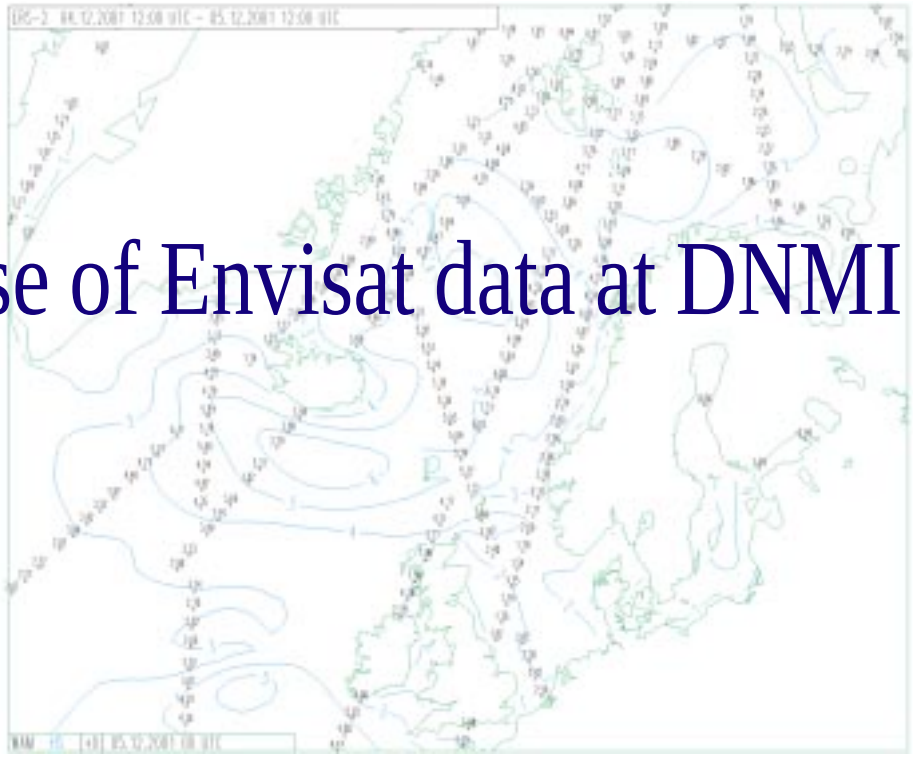
Plans for use of Envisat data at DNMI



The figure is showing analyced significant wave heights (isolines) from DNMIs operational wave model WAM valid 3 December 2001 00 UTC together with one day of altimeter wave height mesurements from ERS-2.

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DNMI, the Norwegian Meteorological Institute, participate in a larger EU-funded project, EnviWave. The overall aim of the project is to improve the usefulness of ocean wave information derived from Envisat ASAR, Advanced Synthetic Aperture Radar, and RA-2, Radar Altimeter, within applied oceanography, ocean climatology, and meteorology. DNMI will focus on the use of the data in operational ocean wave analysis and forecasting.

Use of satellite observations in wave modelling

In operational weather and ocean state forecasting a key tool is the numerical weather, wave and ocean models. To run these forecast models a good description of the weather and sea state at the starting point, the initial time of the forecast, is essential. To create initial fields for the model runs large amount of real time observations are used. The observations are assimilated into the model. In the assimilation a first guess of the model field taken from a short forecast is corrected by means of the observations. However, a general problem is the lack of reliable observations over the oceans. In later years satellite data have dramatically improved this situation, and assimilation in numerical models is one of the most efficient way of utilizing the new satellite observations. The assimilation process is however not straight forward as the relations between the satellite measurements and the geophysical quantities are very complex.

Experience with use of ERS SAR data

At DNMI a system for assimilation of observed wave spectra into DNMI's operational wave model, *WAM*, has been developed and tested [Breivik et al 1998]. For a test period of three months wave spectra derived from ERS SAR data were assimilated into WAM. The resulting forecasts were compared to forecasts obtained without the assimilation of SAR data. The impact of using SAR data was found to be slightly positive in the long wave part, *swell*, of the spectra, but generally rather limited. Several reasons explain the limitation of impact. The SAR wave observations did not have any information in the shorter wave lengths (wind sea), and the information on wave direction was ambiguous (giving two possible solutions). Another reasons for limited impact was the generally low number of available SAR observations.

The Section for Remote Sensing in the R&D Dep at DNMI is working with use of satellite data in operational meteorology and oceanography. This implies assimilation in numerical forecast models as well as development of tools for nowcasting. Lars-Anders Breivik is heading the section and has long experience with work on utilization of satellite data in DNMI's atmosphere and ocean wave models.

Experience with use of ERS altimeter data

From radar altimeter data one can estimate significant wave height and wind speed on the ocean surface. Altimeter wave height data from ERS-2 are currently operationally assimilated into the wave model WAM at DNMI [Breivik and Reistad 1994], and the main positive impact on the analysis and forecast comes in wave situations dominated swell.

Impact of wave data assimilation on swell forecasts

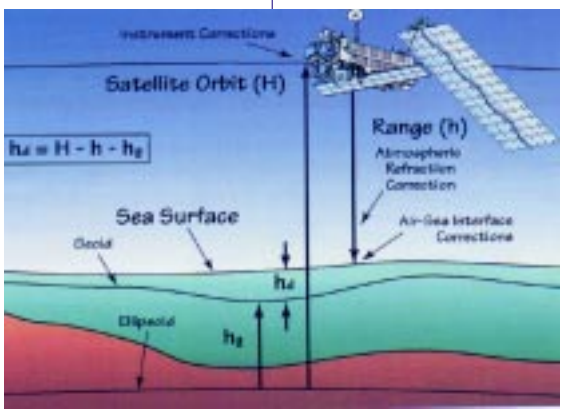
The development of the ocean waves is dominated by the atmospheric winds. In ocean wave modelling a correct description of the ocean surface winds is the key to success in wave forecasting. Operational wave models are forced by wind analysis and forecasts from the numerical weather prediction models. At DNMI the WAM model use wind input data from the operational weather prediction model *HIRLAM*. The effect of correcting the wave model field in the data assimilation will therefore often relatively quickly fade out due to the forcing of the wind input. However for long waves, *swell*, propagating undisturbed by the wind, the effect of assimilation of wave observations in wave models can be kept for a long time.

Example of use of swell forecasts

Good analysis and forecasts of ocean wave swell is crucial for many purposes. An example of operational use of wave forecasts is *heave* forecasting. The oil exploration and production in European waters is moving towards areas with larger water depths, and the use of floating rigs and vessels is increasing. Such installations are sometimes exposed to large vertical movements, heave, often with no apparent wind or waves to cause the movement. Each rig responds differently to waves, but it is common that large rigs have a resonance period of 20 s or more. Such long waves may give vertical movements in the rig twice as large as the wave height. Unexpected vertical movements might lead to expensive interruption of the drilling, and in worst cases to serious oil pollution. Heave forecasts have been issued by DNMI for two different rigs when drilling at 1000-1500 m depth outside Mid-Norway. These are based on a response function for the individual rig and predicted wave energy spectra from the wave model WAM. If the heave forecast is of a certain quality it enables the operator to take precautionary measures before the approach of critical wave conditions. The results are promising, but very sensitive to the swell (long wave) part of the spectra.

ENVISAT data and assimilation in the wave model

DNMI will receive wave information from the new SAR instrument ASAR and the new radar altimeter RA-2 in near real time. In the framework of the EnviWave project the data will be assimilated in the WAM model. The positive impact on wave forecasting is expected to increase compared to the experience with ERS. One reason is that the total number of available ASAR observations will increase significantly compared to ERS SAR. In addition a new technique, developed by scientists at NORUT, Tromsø (one of the partners in the EnviWave project) makes the ASAR wave spectra independent of model first guess. Assimilation of the data is expected to especially improve the swell part of the model spectra, and as described above, for many applications swell forecasts are of particular importance.



RA-2 measurement principle.
Figure: ESA

Use of ENVISAT data in nowcasting

For continuously monitoring of the weather and sea state and the performance of the models the on duty maritime forecaster needs access to reliable observations. This access must be within a short time limit, and the observations must be easy available and easy to monitor. This near real time monitoring of the weather and sea state is called *nowcasting*. Besides being assimilated in the wave models the ASAR wave mode data, and the RA-2 wave observations have high potential applied in marine nowcasting. As a part of the EnviWave project tools for monitoring of ASAR and RA-2 wave data will be developed, implemented and further tested by operational forecasters.

References

Breivik, L.A., M. Reistad, H. Schyberg, J. Sunde, H.E. Krogstad, H. Johnsen, 1998: *Assimilation of ERS SAR wave spectra in an operational wave model*, J. Geophys. Res., Vol.103, No. C4, pp.7887-7900.

Breivik, L.A. and M. Reistad, 1994: *Assimilation of ERS-1 Altimeter Wave Heights in an Operational Numerical Wave Model*. Weather and Forecasting, Vol. 9 No. 3.