Ocean Waves and Winds from ENVISAT ASAR Wave Mode

Ocean wind and wave measurements from satellites combined with numerical global wave and atmospheric models are dramatically changing our way of obtaining ocean wave information both for operational and climatological purposes.

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Whereas wave climatology used to be produced from rather crude ocean atlases based on visual ship observations or time and site limited *in-situ* observations, satellite observations are now at the point of providing reliable global long-term wave statistics. At the same time, through data assimilation in operational numerical models, satellite observations are contributing to improved short-term wave forecasts. Satellite wind observations assimilated into atmospheric models contribute indirectly by improving the atmospheric forecast and hence the wind forcing in the wave models.

Synthetic Aperture Radar (SAR) is the only space borne instrument capable of measuring directional properties of ocean waves globally. The SAR Wave Mode concept was initiated with the ERS-1/2 missions and has successfully demonstrated the potential of using the SAR instrument as a means for global mapping of ocean wave fields. The ASAR Wave Mode of the ENVISAT mission will continue and extend these measurements featuring new and better products. When the ASAR is operated in Wave Mode, small areas of the ocean are imaged every 100 Km. This represents an improvement with respect to the ERS wave mode where these imagettes are acquired at 200 Km intervals. The Wave Mode generates a low data rate recorded on-board and can be operated up to 100% of the orbit.

Based on the scientific achievements at NORUT IT in the beginning of 1990's, ESA decided to develop and implement new and improved processing schemes and products for the ENVISAT Wave Mode instrument. NORUT IT was accredited as an Expert Support Laboratory for the ENVISAT ASAR instrument, and was selected as the prime contractor for developing and implementing algorithms for Level 1 (engineering product; cross-spectra) and Level 2 (geophysical product; SAR ocean wave spectra) products of the ASAR Wave Mode. The philosophy of the processing algorithms is to fully utilize the information content in the single-look complex images. The cross-spectral processing was introduced, providing a Level 1 product with significant improved signal-to-noise ratio, and with capability to resolve the 180-degree propagation ambiguity of the detected ocean wave system. These were the two major problems of the previous ERS-1/2 Wave Mode product. The successful implementation and pre-validation results of the Leve1 product led to the development and implementation of a stand-alone Level 2 product as well. The ASAR Wave Mode Level 2 product is solely based on the SAR observations and provides an estimate of the 2 dimensional ocean wave spectra within the SAR imaging spectral domain, and the local near sea surface wind speed. The Level 1 and Level 2 algorithms are now implemented as part of the ENVISAT ground segment, will generate operational and global ocean wave products for the user community.

NORUT IT is part of the ASAR Wave Mode calibration and validation team, and is currently validating ASAR Wave Mode Level 1 and Level 2 products (see figure 1) simulated from ERS Wave Mode data. After the launch, the validation will be conducted on real ENVISAT data collocated with in-situ (buoy, platform, ship) measurements and wave models. A database of collocated ENVISAT and in-situ/ model data will be established for the next 3 years covering different wave climate regions around the World. The database will constitute the basis for assessing the performance of the ASAR Wave Mode Level 1 and Level 2 products in terms of RMS errors, bias, and range of validity.

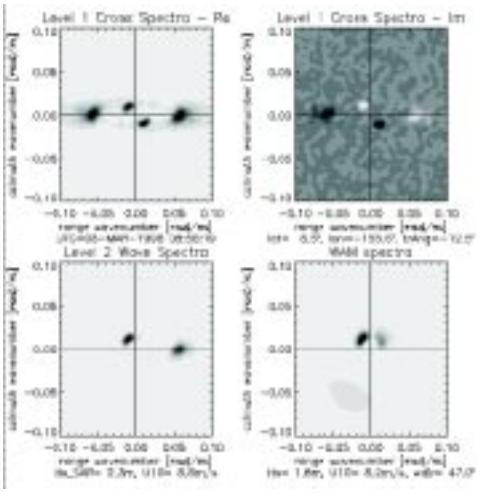

Figure 1: Example of ASAR Level 1 and Level 2 spectra processed from ERS Wave Mode data. The upper plots show the Level 1 cross spectra (real and imaginary part), and the lower left plot shows the corresponding Level 2 ocean wave spectra within the SAR imaging domain. The SAR derived wind speed and significant wave height are annotated in the sub-title. The lower right plot shows the corresponding numerical wave model spectra (WAM). Two wave systems are observed by the SAR, a swell spectrum and a wind sea spectrum. Due to the limit along track resolution of the SAR, the wind sea spectrum is aligned along the range axis.

Harald Johnsen (M'87) received the M.S. and Ph.D. degrees from the University of Tromsø in 1981 and 1984, respectively, all in plasma physics. He worked at the Auroral Observatory/University of Tromsø from 1984 to 1986 as a Graduate Research Assistant. From 1986 he joined NORUT Information Technology Ltd. as a Research Scientist with special interest in synthetic aperture radar (SAR) applications. Since 1995 he has been the Research Manager at the Earth Observation Group at NORUT Information Technology. His main interests are within oceanographic and interferometric applications of SAR data. Dr. Johnsen is a member of the IEEE – Geoscience and Remote Sensing Society. Dr. Johnsen is the project manager for the ASAR Wave Mode Level 1 and Level 2 developments, and a member of the ESA ASAR Wave Mode Cal/Val team.