SEA STATE IMPACTS ON ALTIMETER MEASUREMENTS

D. Vandemark (NASA/Goddard Space Flight Center, USA),
G. S. Brown (Virginia Polytechnic Institute and State University, USA),
B. Chapron (IFREMER, France),
P. Gaspar (CLS Space Oceanography Division, France),
G. S. Hayne, D. W. Hancock III and E. J. Walsh (NASA/Goddard Space Flight Center, USA),
D. R. Thompson (Johns Hopkins University, USA)

This research represents attempts to improve on two remaining areas of uncertainty in the altimeter measurement. Objectives are:

1. **Improvement of the range correction algorithm for sea state bias (SSB) effects**
2. **Characterization of unusually strong ocean backscatter return signals and assessment of their impact on altimeter data products.**

Sea State Bias Algorithm Improvement

Each altimeter sea surface height estimate includes a range correction to account for the ocean return from a non-Gaussian sea surface. This range correction is termed the sea state bias (SSB) correction and is associated with a given altimeter's method of measuring and tracking the ocean return as well as a sea surface dependent component termed the electromagnetic bias. It is the electromagnetic bias that represents the largest source of uncertainty in the SSB correction. The need for an improvement is apparent. With a standard deviation as large as 2 cm, SSB estimate error is the largest uncertainty in the TOPEX SSH error budget.

Our research objective is to address the difficult topic of improving on existing empirically-derived algorithms for the SSB correction. The difficulty arises from two directions: the precise cause of the electromagnetic bias is unknown, and collocated TOPEX correlatives for empirical models are limited to significant wave height and wind speed. We address both issues in this study.

The following approach is used to examine the mechanism causing an electromagnetic bias:

1. Refine the theoretical model to handle long and short waves plus long-short wave interactions. This will represent a merger of past studies that dealt with exclusively one scale or the other [e.g. Jackson, 1979, Glazman et al., 1996, Rodriquez et al., 1992]. Such a change is required to obtain any service from theoretical developments. With this revision in place, the model may be applied and tested against data sets including aircraft electromagnetic bias data (see (ii)). The model will also point out possible new correlative information in global data sets available from satellite scatterometers (e.g. NSCAT, ERS) and ocean wave models (WAM).

2. Revisit past electromagnetic bias field experiment data sets with an objective of determining the reason for the electromagnetic bias rather than the development of an empirical algorithm.
3. A hard limitation in empirical attempts to correct for the electromagnetic bias is the availability of only two altimeter measurements, significant wave height and wind speed. While extremely valuable, these two inputs are probably not sufficient, as evidenced by the uncertainty remaining when using present SSB algorithms. The uncertainty includes a regional signature indicating that additional or better sea surface information is needed. We plan to:
4. Devise new non-parametric formulation for empirical electromagnetic bias algorithms [e.g. Gaspar and Florens, 1997].
5. Examine the effect of using altimeter-derived wind speed as input to the SSB algorithm versus alternative wind field data.
6. Search out non-altimetric data products that may be of service to SSB estimation. This task is specifically targeting the use of global long wave model and scatterometer data sets such as NSCAT and ERS-1 and 2.

Sigma Naught Blooms

Roughly 5% of TOPEX deep ocean data are contaminated by a phenomena we have coined 'sigma naught bloom'. These TOPEX measurements are always characterized by unusually high backscattered signal returns, and usually occur during low sea state conditions. In addition to the high power level, the return signal shape varies significantly from shapes used to develop the altimeter's tracking algorithm. One common result during a bloom is that the tracker loses lock, degrading sea surface height and sea state information. However, there are also bloom cases where TOPEX flags indicate valid geophysical data when this may not be the case. There are significant and repeatable seasonal and regional patterns to the global bloom data set. While we expect sigma naught bloom data are associated with very calm, light wind conditions, no in situ data are yet available for confirmation.

This study will address the characterization, modeling and proper data flagging of sigma naught bloom data. The modeling approach is based on the assumption that these data represent cases of coherent scattering where there is little or no pulse-to-pulse decorrelation [Brown, 1982]. In this case, smooth surface scattering supplants the nominal TOPEX incoherent rough surface scattering model. Initial attempts to classify these waveforms has proven difficult as they are extremely varied, but it is hoped that the modeling effort will lead to the capability to extract accurate range and sea state information from these data.

Additionally, experience with the TOPEX data will be used as a guide to the development of proper sigma naught bloom flagging of Jason-1 GDR.

References :

- Brown, G.S. , 1982: A theory for near-normal incidence microwave scattering from first year sea ice, *Radio Science, 17*(1), 233-243.
- Gaspar, P. and J.P. Florens, 1997: Estimation of the sea state bias in radar altimeter measurements of sea level results from a new non-parametric method, *J. Geophys. Res.* (submitted).
- Glazman R.E., et al. , 1996: Numerical analysis of the sea state bias for satellite altimetry, *J. Geophys. Res. 101*,3789-3799.

- Jackson, F.C., 1979: The reflection of impulses from a nonlinear random sea, *J. Geophys. Res.*,*84*, 4939-4943.
- Rodriquez, E. et al., 1992: The effect of small-wave modulation on the electromagnetic bias, *J. Geophys. Res.*, *97*, 2379-2389.