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PRELIMINARY DETERMINATION OF THE GEOSAT RADAR ALTIMETER NOISE SPECTRUM

The in-flight performance of the GEOSAT radar altimeter is shown to be superior to that of Seasat by comparing noise power spectra derived from collinear tracks. Interpretation of the spectra shows that the portion of the noise contributed by the GEOSAT altimeter itself is about 3 centimeters rms. Additional noise contributed by oceanographic effects raises the total rms noise level to between 5 and 11 centimeters rms.

INTRODUCTION

Satellite altimeter observations of sea-surface topography are composed of geoid height (generally the quantity of greatest interest) plus "noise." As used here, noise includes contributions from orbit errors, radar propagation effects, tides, oceanography, and any electronic noise in the altimeter itself. An analysis of the total noise allows us to quantify the precision with which GEOSAT is able to measure geoid height.

A direct way to study the in-orbit performance of satellite altimeters is to compare the repeatability of the data observed along collinear or repeat tracks by constructing difference time series, i.e., point-by-point differences of corresponding sea-surface height observations collected along different satellite passes. The difference time series consist mostly of noise, since the time-invariant signal of interest—the geoid height—nearly cancels out when the difference profile is computed from a pair of satellite passes separated by less than 2 kilometers.

The total amount of noise in the altimeter observations can be estimated directly from a collinear track difference series by taking one-half of its variance. However, to quantify how the noise varies as a function of spatial wavenumber, along-track-noise power spectral density (PSD) functions must be computed. Noise PSDs have previously been computed using collinear tracks from GEOS-3 and Seasat altimeters.[1]

The methodology we used to derive average noise PSDs for satellite altimeter data is described fully in other publications.[1,2] The results presented below for GEOSAT are preliminary and are based on a relatively small data set. More collinear tracks for this type of analysis are becoming available now from the GEOSAT Exact Repeat Mission, which began in November 1986.

GEOSAT NOISE SPECTRA

The noise PSD derived by analyzing a representative set of eight GEOSAT collinear track pairs is shown in Fig. 1, which also illustrates directly comparable noise PSDs for GEOS-3 and Seasat. For each of the three altimeters, the average noise PSD is shown along with confidence regions for the one-sigma standard deviation bounds.

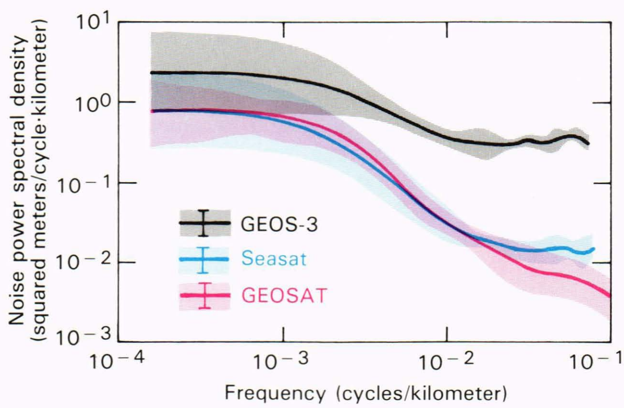

Figure 1—A comparison of satellite altimeter noise spectra.

Two important observations can be made from Fig. 1: (a) at high frequencies (corresponding to spatial wavelengths of less than about 50 kilometers), the GEOSAT noise PSD is the lowest; and (b) at lower frequencies, the level of noise increases and GEOSAT and Seasat noise PSDs are essentially the same.

The electronic noise of the altimeter instrument is essentially white (constant power at all frequencies) as measured in laboratory experiments before launch. Improvements in altimeter design have lowered the threshold of the white-noise floor so that other noise sources (mainly mesoscale oceanography) become visible in the in-orbit noise spectra. Thus, the GEOS-3 altimeter had enough white noise to obscure almost all of the oceanographic noise—about 23 centimeters rms for the best GEOS-3 data after averaging to one sample per second and removing spikes.[1]

The Seasat altimeter had a white-noise level of about 5 centimeters rms, allowing the oceanographic noise to be observable in the noise PSD at wavelengths longer than about 50 kilometers. For GEOSAT, our analysis

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of noise PSDs (and of individual data track PSDs) shows that the average white-noise level is about 3 centimeters rms.

For both GEOSAT and Seasat, the total average noise power integrated over all frequencies is about 8 centimeters rms. (This does not include contributions from orbit errors, which are much longer wavelength effects that are removed by our procedure of subtracting the mean from the along-track difference series before estimating PSDs.) The variability of the total noise power in GEOSAT data depends on geographic location. In areas of major ocean currents (e.g., in the Southern Ocean), the total GEOSAT noise level for a particular pair of tracks is as high as 11 centimeters rms. In quiet areas (e.g., the equatorial Atlantic), the total noise is as low as 5 centimeters.

Thus, we conclude that the GEOSAT altimeter design was successful in reducing the instrument white-noise component below the level achieved with Seasat. GEOSAT data should be able to resolve short-wavelength geoid features slightly better than Seasat. While the oceanographic noise contribution cannot be controlled in the data from any given track, its effects ultimately can be reduced by averaging data over a long period of time. In this way, the GEOSAT Exact Repeat Mission data, consisting of many sets of collinear tracks with relatively low levels of instrument-generated noise, will help to improve our knowledge of both the geoid and the oceanographic effects.

REFERENCES

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