# Jason-2 radar altimeter signatures of Internal Solitary Waves in the ocean

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Internal Waves of tidal frequency (i.e. Internal Tides) are successfully detected in sea?surface height (SSH) by satellite altimetry (Ray and Mitchum, 1996). Shorter period nonlinear internal waves or Internal Solitary Waves (ISWs), whose periods are an order of magnitude smaller than tidal internal waves, are however generally assumed too small to be detected with standard altimeters (at low sampling rates, i.e. 1 Hz). This is because the Radar Altimeter (RA) footprint is somewhat larger, or of similar size at best, than the ISWs typical wavelengths. Here it will be demonstrated that new generation high sampling rate satellite altimetry data (i.e. ~20 Hz) hold a variety of short-period signatures that are consistent with surface manifestations of ISWs in the ocean. Our observational method is based on satellite synergy with imaging sensors such as Synthetic Aperture Radar (SAR) and other high-resolution optical sensors (e.g. 250m resolution MODIS images) with which ISWs are unambiguously recognized. Straining of decimeter-scale surface waves due to ISW orbital currents is known to cause roughness variations along internal wave propagation fields. This effect was demonstrated by measurements of wind wave slope variances associated with short-period ISWs in the pioneer work of Hughes and Grant (1978). Mean square slope can be estimated from nadir looking RAs using a geometric optics (specular) scattering model (Brown, 1990; Jackson et al., 1992; Frew et al., 2007), and directly obtained from backscatter (sigma0) along-track records. Here, we use differential scattering from the dual-band (Ku- and C-bands) microwave pulses of the Jason-2 high-rate RA to isolate the contribution of small-scale surface waves to mean square slope. The differenced altimeter mean square slope estimate, derived for the nominal wave number range 40–100 rad/m, is then used to detect roughness variations in records of along-track high sampling rate RAs. Subsequently these high-frequency signatures are compared with quasi-simultaneous satellite imagery with imprints of ISWs. The RA signatures consistent with ISWs are also apparent in radargrams of the Sensor Geophysical Data Records (SGDR), in high resolution (20-Hz) data. The waveforms shape, in particular their trailing edge, is modified by the presence of ISWs with respect to waveforms unperturbed by short-period internal waves. Furthermore, an altimeter can be interpreted as a high resolution imaging instrument whose geometry is annular and not rectangular. Hence, a method based on the computation of the imaging matrix and its pseudoinverse to infer the surface backscatter at high resolution (300 m) from the measured waveforms (Tournadre et al., 2011) has been applied to the case of ISW observations. The method confirms the existence of radar backscatter variations consistent with ISW patterns on the ocean surface.

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