SURFACE WAVE BREAKING CAUSED BY INTERNAL SOLITARY WAVES

Effects on Radar Backscattering Measured by SAR and Radar Altimeter

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SUPPLEMENT S2

Here, we evaluate whether the characteristic signals in significant wave height (SWH, sometimes abbreviated to H_s in the literature) visible in **Figure 5** are associated with an isolated event, or whether they are also found in other events. To investigate this, we used synthetic aperture radar (SAR) altimeter (SRAL) data in synergy with optical imagery (OLCI) from Sentinel-3 satellites. We first screened OLCI images for surface signatures of large-scale internal solitary waves (ISWs) in the same region (off the Brazilian Shelf) and also in other regions known for large-scale ISWs (the Banda Sea in the Indian Ocean) and then analyzed the corresponding SRAL data.

Note that regions such as the South China Sea, where very large ISWs are known to be associated with breaking surface waves (see, e.g., Figure 8 in Liu et al., 2008), cannot (a priori) be used in this analysis since we need a proper configuration (see **Box 2**) between the ISWs' propagation directions and the satellite ground tracks. In the South China Sea, the ISWs and the altimeter tracks are nearly perpendicular, rendering the enhanced ground resolution provided by SRAL essentially useless. The large-scale ISWs propagating in a nearly meridional direction in the Banda Sea (near Indonesia) fulfill the optimum geometry for SRAL observation of ISWs, and we focused our search there (and in our current study region) for additional cases showing strong evidence of enhanced surface wave breaking in the SRAL altimeter data.

We found 9 more cases with SWH profiles similar to those presented in **Figure 5**. The table below shows a list of these cases along with representative measurements of SWH ahead of and behind the ISWs (i.e., similar to **Figure 5**). According to these results, the SWH estimates retrieved from SRAL show that a decrease is consistently detected between the waves' leading and trailing sections, of about 30% (on average) of the unperturbed SWHs (i.e., ahead of the ISW). We also note that these changes in SWH hold for different wind conditions, ranging from weak to moderate (and even strong) winds, and with different directions, which adds to the robustness of the results obtained in this study.

Finally, recalling that energy in surface waves is proportional to surface wave height squared (H_s^2), the large change in SWH from the leading (front) section to the trailing (rear) section of a large-scale ISW, suggests that ISW-induced surface wave breaking must cause significant energy dissipation. This would be consistent with the turbulent wake (in the form of whitish foam filaments) visible in the high resolution MSI Sentinel-2 image shown on the title page, which is located behind the rough band containing breaking waves that generate white caps.

TABLE S2-1. List of Sentinel-3 cases exhibiting large-scale ISWs in optical imagery (OLCI) in synergy with the corresponding sea surface signatures from the SRAL altimeter. For each case, a representative measure of significant wave height (SWH or H_s) is given for leading (front) and trailing (rear) sections of the leading ISW. Differences between these characteristic values ($\Delta Hs = Hs_{front} - Hs_{rear}$) are also shown, as well as differences for their squared values (which scale with a measure of the energy in the surface waves). Representative propagation directions and coordinates are given along with estimates for local surface winds (from ECMWF) and for the surface wave field (including direction and wave period, from https://earth.nullschool.net/). Permalinks for the OLCI acquisitions are provided by OceanDataLab - https://www.oceandatalab.com.

	Date	Hs_{front} (m)	Hs_{rear} (m)	ΔH_s (m)	ΔH_s (%)	ΔH_s^2 (%)	ISW °TN	Lon, Lat	Local Surface Wind	Peak Wave Direction		Permalink
										°TN	Period	
Tropical West Atlantic	Oct 18, 2020	1.57	1.22	0.35	22%	**40%**	15	315.7°E, 4.0°N	4 m s^{-1} from the E	100	8 s	https://odl.bzh/VNpmMNA8
	Aug 25, 2020*	1.78	1.26	0.52	29%	**50%**	30	315.8°E, 4.7°N	2 m s^{-1} from the SE	110	10 s	https://odl.bzh/hLMM7tDW
	Oct 24, 2018	1.78	1.52	0.26	15%	**27%**	45	317.0°E, 5.7°N	5 m s^{-1} from the E	340	11 s	https://odl.bzh/aTt8t6Qz
	Oct 11, 2017	2.35	1.95	0.40	17%	**31%**	60	316.7°E, 4.3°N	9 m s^{-1} from the SE	110	9 s	https://odl.bzh/yZX-cZz_
	Oct 7, 2017	2.01	1.81	0.20	10%	**19%**	45	316.0°E, 5.5°N	4 m s^{-1} from the E	130	9 s	https://odl.bzh/cOkaodiB
	Sep 1, 2016	1.23	0.99	0.24	20%	**35%**	45	316.9°E, 5.6°N	4 m s^{-1} from the SE	120	8 s	https://sentinelshare.page.link/S2Kh
Indian Ocean (Banda Sea)	Sep 16, 2019	1.18	0.74	0.44	37%	**61%**	345	125.2°E, 7.4°S	7 m s^{-1} from the NE	80	6 s	https://odl.bzh/tr6Ekhii
	Aug 20, 2019	1.12	0.69	0.43	38%	**62%**	0	125.5°E, 6.2°S	10 m s^{-1} from the SE	110	6 s	https://odl.bzh/JrlaUoWi
	Apr 21, 2019	0.67	0.34	0.33	49%	**74%**	15	125.7°E, 7.3°S	8 m s^{-1} from the E	90	5 s	https://odl.bzh/PnVpRPbb
	Oct 27, 2018	0.44	0.16	0.28	64%	**87%**	345	125.3°E, 7.2°S	2 m s^{-1} from the SW	105	3 s	https://odl.bzh/S9XMbJZO

*In Figure 5.