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Airborne Remote Sensing of Surface and Internal Wave Processes on the Inner Shelf

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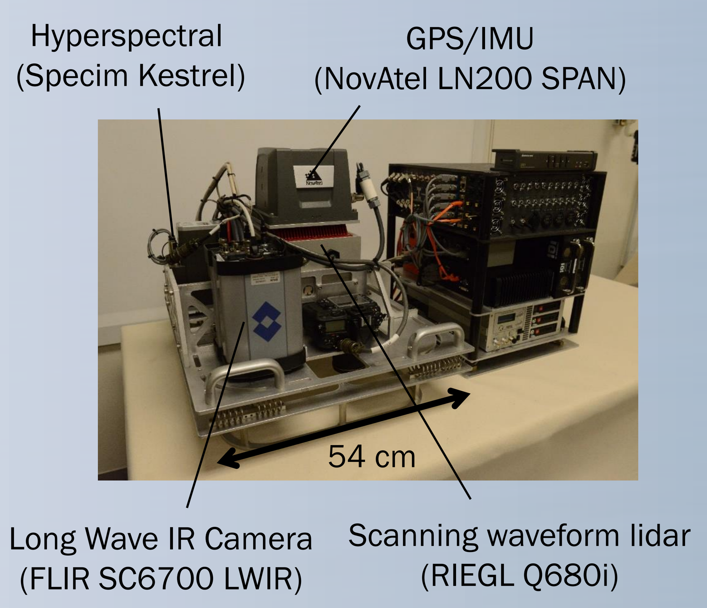
The inner shelf, bounded on the shoreward side by the surf zone and offshore by a depth of approximately 50-100 m is a region in which a variety of physical processes can occur over a wide range of time scales (from fractions of a second for wave breaking, to the two-week spring-neap tidal cycle and seasonal cycles), and length scales (millimeters for the wind-stress supporting gravity-capillary waves and other microstructure, to O(10-100 km) of along and across-shelf processes) associated with a wide range of different forcings. In this work, we report on a large field campaign conducted off the coast of Point Sal, CA in September 2017, as part of the Office of Naval Research funded Departmental Research Initiative (DRI) Inner Shelf program. We used a combination of airborne remote sensing techniques along with in-situ surface and subsurface measurements to investigate the role of surface and internal wave processes on the dynamics, transport and mixing in the water column of the inner shelf.

Tool? The Modular Aerial Sensing System (MASS)

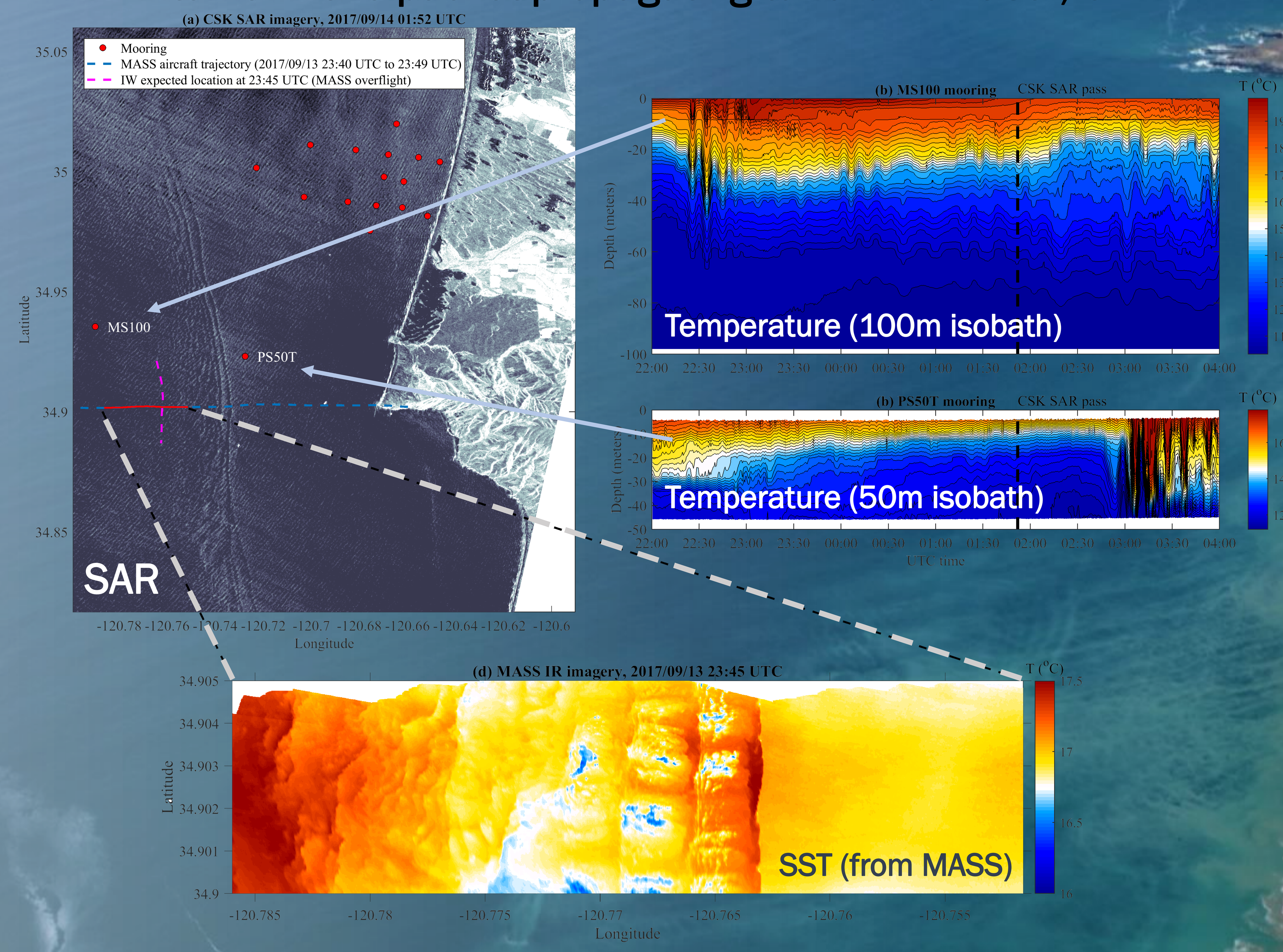


Sensor	Measurement
Scanning Waveform Lidar Riegl Q680i	Sea Surface Height, surface slope, directional wave spectra (vertical accuracy ~2-3cm per point)
Long-wave IR Camera FLIR SC6000 & SC6700	Ocean surface processes, wave kinematics and breaking, frontal processes
High-Resolution Video JaiPulnix AB-800CL	Ocean surface processes, wave kinematics and breaking, frontal processes
Hyperspectral Camera Specim EagleAISA and Kestrel VNIR	Ocean surface and biogeochemical processes
GPS/IMU Novatel SPAN-LN200	Georeferencing, trajectory

Weight	120 kg total (including acquisition rack) / 79 kg without hyperspectral imager
Power requirements	600 W total, 400 W without hyperspectral imagers

Melville, W.K., Lenain, L., Cayan, D.R., Kahru, M., Kleissl, J.P., Linden, P.F. and Statom, N.M., 2016. *The Modular Aerial Sensing System.* Journal of Atmospheric and Oceanic Technology, 33(6), pp.1169-1184.

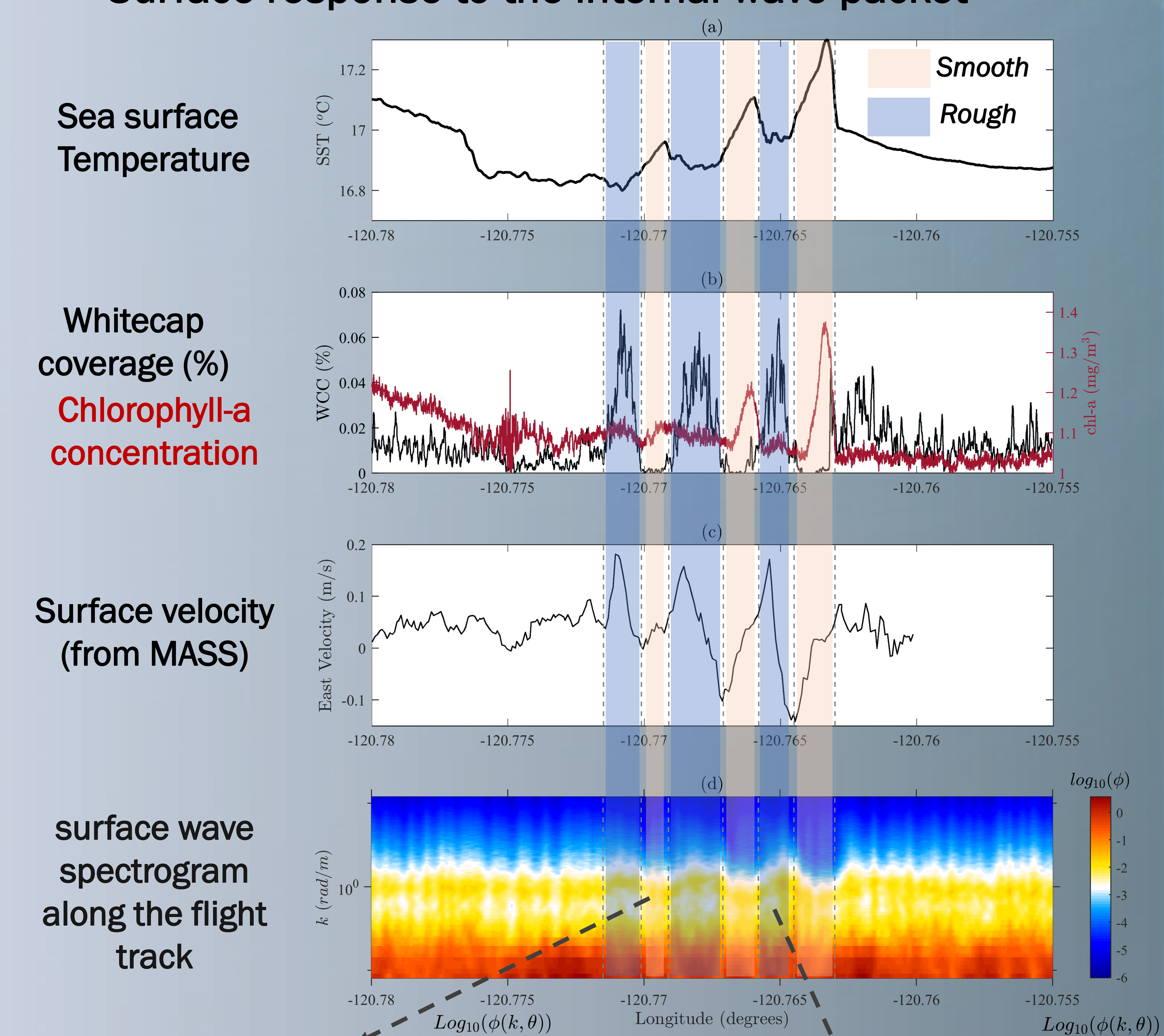
Internal Wave packet propagating toward Point Sal, CA

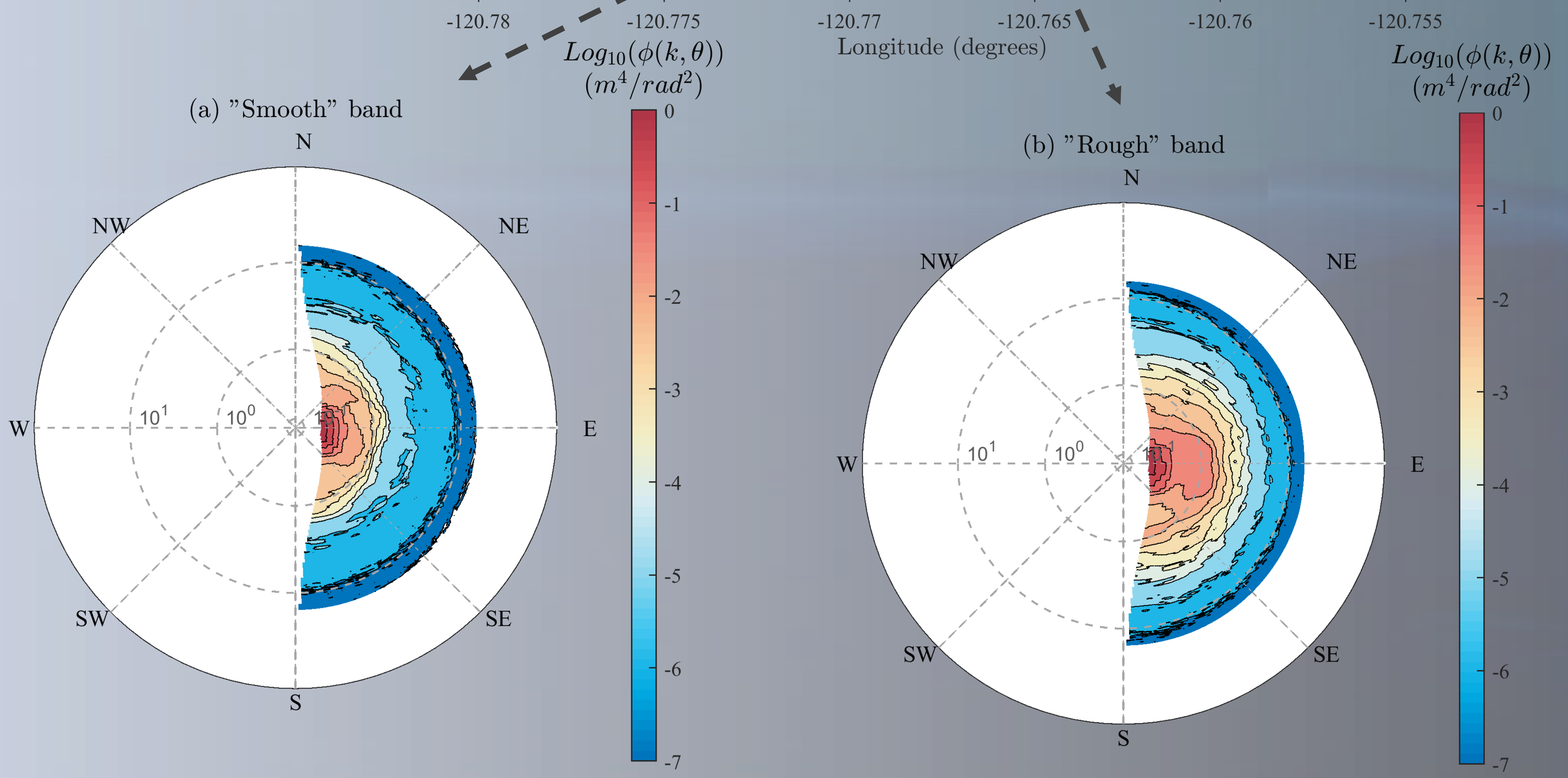


CSK SAR image recorded on September 14 2017 at 01:52 UTC showing a packet of hifg frequency internal waves propagating toward Point Sal during the Innershelf DRI experiment. Also shown are the location of some of the moorings deployed during the field programs (red dots). The temperature profiles collected at two of those sites, MS100 and PS50T, respectively at 100m and 50m water depth is shown in (b), capturing the evolution of the internal waves as they propagate toward shore. (c) shows infrared imagery of the same packet of internal waves on September 13 2017 at 23:45 UTC, approximately two hours before the SAR image depicted in (a). The location of the flight track and the expected location of the front of the IW based on the propagation speed computed from the mooring is also shown.

"Note the modulation of the surface wave field from the internal wave packet (smooth/rough bands sequence), the modulation of the whitecap coverage and the focusing of surface chlorophyll in the forward part of the wave."

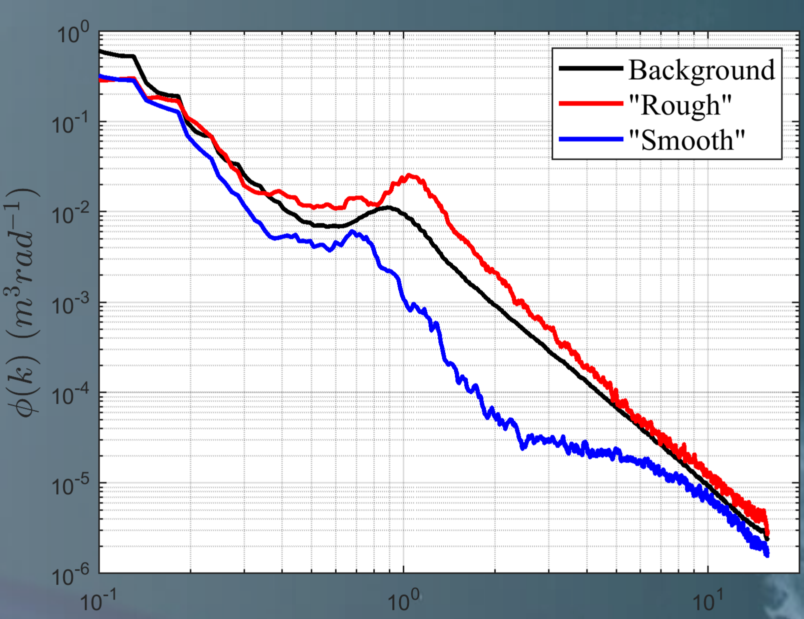
Surface response to the internal wave packet





Directional wavenumber spectrum collected on September 13 2017, of the surface wave field in a (a) a "smooth band" and (b) a "rough" band of the internal wave. Note that the internal waves was propagating toward the West.

Omnidirectional wave spectra of surface waves



Redistribution of energy in the wave spectra computed in "rough" (red color) and "smooth" (blue color) bands of the internal wave packet caused by the surface gravity waves interacting with the internal waves. Background wave spectrum is shown in black.

Lenain L., Grare, L., Pizzo, N. (2020). Modulation of surface waves by non-linear internal waves, Journal of Physical Oceanography, in preparation.

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