Seeking an eye using several ears: cyclonic storms as heard by seismic arrays.

Julián Pelaez, Dirk Becker, and Céline Hadziioannou
University of Hamburg, Institute of Geophysics, Hamburg, Germany (contact: julian.pelaez-quinones@studium.uni-hamburg.de)

Under certain conditions, ocean surface gravity waves (SGW) interact with the seafloor underneath to trigger relatively faint but measurable seismic waves known as ocean microseisms. Cyclonic storms (e.g. hurricanes, typhoons) wandering over the ocean are major (non-stationary) sources of the former, thus opening the possibility of tracking and studying cyclones by means of their corresponding microseisms.

For this purpose, we identified storm-related microseisms hidden in the ambient seismic wavefield via array processing. Polarization beamforming, a robust and well-known technique is implemented. The analyses hinge on surface waves (Love and Rayleigh) which, in contrast to P-waves, are stronger but only constrain direction of arrival (without source remoteness). We use a few land-based virtual seismic arrays surrounding the North Atlantic to investigate the signatures of major hurricanes in the microseismic band (0.05-0.16 Hz), in a joint attempt to continuously triangulate their tracks.

In general, a better correlation with the tracks was observed for surface waves in comparison to P-waves. At the same frequency band, there is a good agreement between storm-related Love and retrograde Rayleigh wave signatures, suggesting a common amplification mechanism and co-located excitation area. However, the Love wavefield appears to be comparatively more diffuse and weaker than that of Rayleigh waves, which in turn produced the sharpest and most accurate trackings.

Our findings show that storm microseisms are intermittently excited with modulated amplitude at localized oceanic regions, particularly over the shallow continental shelves and slopes, having maximum amplitudes virtually independent of storm category. In most cases no detection was possible over deep oceanic regions, nor at distant arrays. Additionally, the rear quadrants and trailing swells of the cyclone provide the optimum SGW spectrum for the generation of microseisms, often shifted more than 500 km off the "eye". Occasionally, the passage of a cyclone near an island appears to trigger strong stationary signals lasting for a couple of days.

As a result of the aforementioned and added to the strong attenuation of storm microseisms, the inversion of tracks or physical properties of storms using a few far-field arrays is discontinuous in most cases, being reliable only if benchmark atmospheric and/or oceanic data is available for
comparison.

Even if challenging due to the complexity of the coupled phenomena responsible for microseisms, the inversion of site properties, such as bathymetric parameters (e.g., depth, seabed geomorphology), near-bottom geology or SGW spectrum might be possible if storms are treated as natural sources in time-lapse ambient noise investigations. This will likely require near-field (land and underwater) observations using optimal arrays or dense, widespread sensor networks. Improved detection and understanding of ocean microseisms carries a great potential to contribute to mechanically coupled atmosphere-ocean-earth models.