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Orienting Ocean Bottom Seismic Sensors from Ship Noise Polarization Analysis

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For the RHUM-RUM project (Réunion Hotspot and Upper Mantle – Réunions Unterer Mantel, www.rhum-rum.net), a network of 57 ocean-bottom seismometers (OBS) was installed on the ocean floor around La Réunion Island in the SW Indian Ocean. Part of the network happened to be located beneath a route of heavy ship traffic connecting SE-Asia and the South-Atlantic region. We analysed the ship noise recorded on the OBS and show that it can be used for determining the horizontal orientations of the seismic instruments as they were recording on the ocean floor.

The OBS, provided by the German DEPAS and the French INSU OBS national pools, were equipped with wide-band or broad-band three-components seismic and hydro-acoustic sensors. They were deployed in Nov. 2012 by R/V Marion Dufresne and recovered by R/V Meteor one year later. Depending on the configuration, the OBS recorded for 8 to 13 months.

By combining the trajectories of passing ships - provided by AIS (Automatic Identification system) GPS data - with our geophysical data recorded on the ocean floor, we show that both hydro-acoustic and seismic spectral analyses exhibit clear signals associated with vessels between 1 and 50 Hz, in the high-frequency range of our instruments. Large cargo vessels are detected several hours before and after their closest point of approach (CPA) and show clear Doppler effects which put quantitative constraints on their distances and speeds. By analysing the continuous noise polarization on the three seismic components, we show that the polarization of the noise emitted by ships passing in the neighbourhood of an ocean-bottom seismometer can be used for retrieving the orientation of the OBS horizontal components on the ocean floor with respect to the geographic reference frame. We find good agreement between OBS orientations thus calculated from ship noise and the OBS orientations determined independently from teleseismic body and surface wave polarization methods (Scholz et al., GJI, 2017).