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Non-linear interactions of wind-sea and opposing swell determined through bispectral analysis

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Detailed records of surface waves were acquired from a spar buoy under mixed sea state conditions where the presence of wind-sea and swell was a typical characteristic. In this particular experimental site, offshore winds (so called Tehuano winds) generally occurring during winter season generate waves locally opposing the swell arriving from distant storms in the Southern Pacific and Antartic Oceans. The experimental field campaign was carried out in early 2005 in the Gulf of Tehuantepec (INTOA Experiment), Mexico. Interactions between wind-sea and swell are studied through bispectral analysis of the records obtained at a location where water depth was 60 m. During the absence of winds blowing offshore, swell can certainly be considered as linear and random process with practically zero bispectrum. However, when wind-sea is also present, bispectral values indicate a phase coupling and interactions between both components of the sea state. Under these conditions (Tehuano winds on), interaction between wind-sea and opposing swell is clearly detected, and seems relatively stronger than self interactions such as swell-swell and wind-sea with itself. Bispectral analysis of the sea surface elevation suggests that non-linear interactions between the main components of wind-sea and swell are exciting components at slightly higher (lower) frequencies than those associated with the wind-sea spectral peak, corresponding to the sum (difference) of the frequencies of the two fundamental components. Interactions between wind-sea and swell might induce a decrease in the sea surface roughness at the relevant wave scales as to reduce the momentum flux between the ocean and the atmosphere. A description of this momentum flux as a function of the significant wave height of the locally generated wind-sea ($H_{S_{sea}}$) is addressed, within the context of the influence of the swell significant slope ($H_{S_{swell}}/L_{p_{swell}}$). Higher swell sinificant slopes tend to reduce the wind stress for any given wind-sea condition characterized by its significant wave height.