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Climatology of Global Swell-Atmosphere Interaction

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Abstract

At the ocean surface wind sea and swell waves coexist. Wind sea waves are locally generated growing waves strongly linked to the overlaying wind field. Waves that propagate away from their generation area, throughout entire ocean basins, are called swell. Swell waves do not receive energy from local wind. Ocean wind waves can be seen as the "gearbox" between the atmosphere and the ocean, and are of critical importance to the coupled atmosphere-ocean system, since they modulate most of the air-sea interaction processes and exchanges, particularly the exchange of momentum. This modulation is most of the times sea-state dependent, i.e. it is a function of the prevalence of one type of waves over the other.

The wave age parameter, defined as the relative speed between the peak wave and the wind (c_p[U+2044]U_10), has been largely used in different aspects of the air-sea interaction theory and in practical modeling solutions of wave-atmosphere coupled model systems. The wave age can be used to assess the development of the sea state but also the prevalence (domination) of wind sea or swell waves at the ocean surface. The presence of fast-running waves (swell) during light winds (at high wave age regimes) induces an upward momentum flux, directed from the water surface to the atmosphere. This upward directed momentum has an impact in the lower marine atmospheric boundary layer (MABL): on the one hand it changes the vertical wind speed profile by accelerating the flow at the first few meters (inducing the so called "wave-driven wind"), and on the other hand it changes the overall MABL turbulence structure by limiting the wind shear – in some observed and modeled situations the turbulence is said to have "collapse". The swell interaction with the lower MABL is a function of the wave age but also of the swell steepness, since steeper waves loose more energy into the atmosphere as their energy attenuates. This interaction can be seen as highest in areas where swells are steepest, but also where the wind speed is lowest and consequently the wave age is high. A detailed global climatology of the wave age and swell steepness parameters, based on the ECMWF (European Centre for Medium-Range Weather Forecasts) ERA-Interim reanalysis is presented. It will be shown, in line with previous studies, that the global climatological patterns of the wave age confirm the global dominance of the World Ocean by swell waves. The areas of the ocean where the highest interaction of swell waves and the lower atmosphere can be expected are also presented.