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Role of Ocean Waves in the Earth system (Fridtjof Nansen Medal Lecture)

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In this presentation I will start with a brief description of the field of ocean wave forecasting. This will include an introduction to the key quantity of wave forecasting, namely the wave spectrum, and to the role the evolution equation for the wave spectrum, known as the energy balance equation, plays in understanding the role of ocean waves in the earth system. The energy balance equation describes the rate of change of the wave spectrum due to advection and refraction on the one hand and, on the other hand, the rate of change due to physical processes such as wind input, the energy conserving nonlinear four-wave interactions and dissipation by white capping.
If the wave spectrum is known at a certain location then all the wave
quantities such as wave height, period, energy flux and mean wave direction can be obtained. But knowledge of the wave spectrum also allows to obtain information on the statistics of waves. Just recently it has been shown that the occurrence of extreme events is closely linked to the shape of the wave spectrum. Narrow spectra are, compared to broad spectra, much more prone to extreme events, known as freak waves.
Furthermore, for known wave spectrum one may determine, using the
wind input source function, how much momentum the atmosphere is transfering to the ocean waves, which, of course slows down the atmospheric flow. On the other hand, using the white capping source function one may determine the energy flux from breaking waves into the upper ocean which enhances the upper ocean mixing of temperature and currents. This suggests that at the sea surface there is a two-interaction between atmosphere and ocean waves, between ocean waves and ocean circulation and between atmosphere and ocean. At ECMWF we are in the process of developing such a coupled system and some interesting results from numerical experiments will be presented.