Dynamically Consistent Computation of Exchange Processes at the Air-Sea Interface

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A dynamically consistent framework for modelling atmosphere-ocean exchange processes must take account of surface waves and other movements of the air-water interface, either explicitly or implicitly. In order to calculate the effect of waves, it is necessary to employ a consistent formulation of the balance of energy, mass and momentum, within the airflow, wave field, and water column, taking into account the Earth's rotation for periods of time greater than a few hours. It is also advisable to use a coordinate system which can represent vertical variations at scales much smaller than the wave height, for example, a surface-following coordinate system. We may account for the waves explicitly by employing a numerical spectral wave model, and applying a suitable theory of wave--mean flow interaction. A closed system of equations may be obtained to second order in wave slope by applying wave action conservation equations in the propagation of the spectral wave components. A coupled model system may also take account of the effect of turbulence and depth-varying currents on wave propagation and dissipation, the presence of surface films and sea ice, and the generation of Langmuir circulations. An outline is given of how this formulation may be applied to the atmosphere--ocean exchange of gas species and particulate material.