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Ocean Surface Waves and Turbulence: Air-Sea Fluxes and Climate Variability

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Apart from heating of the atmosphere, two of the most important consequences of current climate variability are changes in sea level, and acidification of the oceans. Over decadal time scales, changes in sea level are caused by changes in heat content and salinity of the ocean, and by changes in mass resulting from exchanges between the ocean, glaciers and other land-based reservoirs. The oceans have absorbed about one third of the anthropogenic CO_2 due to fossil fuel burning. This reduces the green house effect in the atmosphere, but the CO_2 reacts in the surface waters of the ocean to lower pH. Conservative projections of sea level rise over the next century are O(0.1 - 1) m, while ocean acidification is already having an impact on marine ecosystems. Both these processes depend on air-sea fluxes: heat flux for sea level rise, and gas flux for ocean acidification. These fluxes are among the most poorly constrained in current climate models, but both ultimately depend on fluid dynamics at the ocean surface and in the adjacent boundary layers. Traditional boundary layer models of the marine boundary layer and the marine atmospheric boundary layer were based on classical theories of boundary layers over rigid surfaces, but there is increasing evidence that these models must now include surface wave effects. In this talk the motivating climate data and modeling will be briefly reviewed, and then recent work on surface wave dynamics, air-sea fluxes and the adjacent boundary layers will be presented. The roles of surface wave breaking, Langmuir circulations, wave-turbulence interactions and gravity-capillary waves will be discussed.