CNRM, UMR 3589

SEMINAIRE CNRM

N° 2019_13

lundi 25 novembre 2019 à 15h

A SPECTRAL PERSPECTIVE ON THE LOCAL INTERACTION BETWEEN WIND AND WAVES

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Abstract :

Atmospheric air-sea fluxes of momentum and heat originate from complex interactions between low-level atmospheric turbulence and waves, occurring over a wide range of scales near the air-sea interface. State-of-the-science conceptual models explain the mean value of those fluxes for a given mean wind. They describe a local equilibrium between short wind waves and atmospheric turbulence, involving form drag and air-flow separation events on top of localized breakers. However, the observed variability around predicted mean values lacks explanation, suggesting that some coupling mechanisms are still not elucidated.

More generally, the understanding of the local wind-and-waves equilibrium is related to the long-standing question of the influence of a structured boundary (both in terms of geometry and of velocity) on the properties of turbulence at a certain distance from the time-evolving boundary. In this work, this problem is approached by performing a scale-by-scale (or spectral) analysis of turbulence. Based on recent work for wall-bounded turbulence, a conceptual model describing the interactions of atmospheric eddies with a multi-scale structured boundary is proposed. Within this model, atmospheric dominant eddies are assumed to be distorted by the presence of surface waves. When included in a wind-over-waves model, these processes can explain the observed variability of momentum fluxes.

This work supports experimental and numerical efforts to obtain statistical descriptions of atmospheric structures over waves, highlighting key atmospheric state variables related to the coupling between wind and waves. It emphasizes that their accurate determination is essential to advance our understanding of the wind-and-waves coupled system and to improve air-sea fluxes parameterizations.

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