Title : Deterministic dynamic wind-wave couplings for the marine atmospheric boundary layer

Keywords: ocean-atmosphere interaction, field data analysis, numerical modeling, sea states, atmospheric turbulence

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Subject :

The marine atmospheric boundary layer (MABL), along with the upper layers of the ocean, play a central role in air-sea fluxes of mass, momentum, heat and humidity providing crucial boundary conditions for the atmosphere and the ocean which drive the evolution of weather conditions and the climate. The standard model used to parameterize the characteristics of the near-surface atmosphere, including in marine conditions, is based on the logarithmic law and the Monin-Obukhov similarity theory (MOST) taking into account the thermal stability of the atmosphere. This approach describes turbulence in the surface layer using the assumptions of stationarity and horizontal homogeneity and involves turbulent fluxes of constant sensible heat, momentum, and moisture in the surface layer (SL). It is from these hypotheses that the vertical average atmospheric profiles are parameterized.

We know that this approach, built for the onshore boundary layer, is called into question in the MABL, close to the surface by the dynamic air-sea interactions (waves, currents, breaking, etc.) which are likely to move the velocity, temperature and humidity profiles appart from of those predicted by MOST. This is particularly the case for large swells associated with weak wind, a case observed in the laboratory, in simulation and in-situ (Buckley et al, 2016, Veron et al, 2009, Paskin et al, 2022a). But observations of profiles close to the surface remain relatively rare, which limits the understanding of the physics and the parameterization of such interactions, particularly for cases of wave feedback towards the atmosphere or misaligned wave-wind conditions...

The LHEEA has been working on these questions for several years from a numerical point of view through CFD RANS simulation tools (Perignon et al., 2014) then through a model developed by (Cathelain, 2017) and (Paskin et al. , 2022b), based on an atmospheric LES approach (Sullivan et al. 2014) and HOS approach (Ducrozet et al. 2016) making it possible to locally represent in a deterministic manner the dynamic ocean-atmosphere coupling, and by field measurement campaigns using a scanning LiDAR (Paskin et al 2022a, Conan and Visich 2023) allowing the measurement of wind and turbulence profiles in real conditions.

The proposed thesis focuses on the description of all environmental conditions and aims to finely characterize the dynamics of three-dimensional atmospheric flows, at the scales of interactions with marine structures thanks to the exploitation of the coupled numerical model and in-situ measurements by scanning LiDAR with particular interest on **the cases of feedback of the swell on the atmosphere.**

In addition to a bibliographic review and the handling of the laboratory's numerical and experimental resources, the work will be structured around:

- post-processing of wind fields from existing cases archived, simulated during the thesis of M. Cathelain and L. Paskin, and from complementary cases to simulate.
- post-processing of field data of wind profile, turbulence and surface flows from the different field campaigns available and possibly new field campaigns.
- analysis of the impact of different sea states on the aerodynamic characteristics of the MABL (roughness aerodynamics, turbulent organization, wind profile in the low layers…), particularly in cases of misalignment wind/swell.

This thesis work is part of a strong dynamic of the LHEEA in recent years on the study of oceanic environmental conditions. The work undertaken will be able to rely on the numerical and experimental developments of the LHEEA, and it will benefit from the resources of the OPEN-C Foundation (SEM-REV, etc.) and various partners on these themes (Ifremer, MIO- IRPHE, etc.). This work will lead to communications at international conferences as well as publications in journals.

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