Meteorological and Wave Measurements from a Stable Research Platform at Sea

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LONG-TERM GOALS

The development of short-term wave forecasting capability, a stated goal of the High-Resolution Wave-Air-Sea Interaction project, requires observational information that will both serve to improve the understanding of the underlying physics and will be used to test the predictive potential of wave propagation models. For a stochastic and nonlinear environment such as the air-sea interface, a considerable uncertainty still exists regarding the mechanisms of energy and momentum exchange as well as the rates of that exchange. While wave dynamics on the water side has already been reduced to a computationally-intensive numerical problem (Friehe et al., 2007, section III.B), the complexity of which is determined by the number of nonlinearly interacting wave modes, the wind driving of the waves on the other hand, is less understood. In the past the wind input to the waves traditionally has been described in phenomenological terms, i.e. through exchange coefficients. Although such approach is computationally efficient for large-scale modeling, it is inadequate for phase-resolving forecasts, hence the need for a mechanistic description of the wind input. Such description is now hindered by gaps in theoretical knowledge and in techniques for numerical modeling. Specifically, the observational validation for most of the wind-wave interaction mechanisms proposed so far in theoretical works is lacking. Little is yet known on how to incorporate realistic multi-mode wave fields in models of air flow over waves or what is the proper SGS parameterization for the air flow LES. The goal in this effort is to deliver progress on these open issues.

OBJECTIVES

The end objective of the project is to arrive to a phase-resolved description of the structure and dynamics of the marine atmospheric boundary layer that will be suitable to incorporate in models for short-term wave prediction. Such description should account for the dominant mechanisms responsible for wind-wave energy transfer. Several mechanisms have been proposed so far in theoretical works: (i) random force mechanism considered by Phillips (1957); (ii) critical layer interaction mechanism proposed by Miles (1957); (iii) wave-turbulence interaction mechanism; (iv) nonlinear mechanisms, including sheltering and flow separation. Until now, an observational support exists only for the critical layer mechanism (Hristov *et al.*, 2003). Achieving the formulated goal requires that we identify all the active mechanisms in observational data and quantify their contributions to the wind-wave growth.

Ensuring the practicality of wave forecasts requires that we explore both the dynamical and numerical causes of uncertainty and the propagation of that uncertainty from the radar observations of the surface, through the models and mechanisms employed, to the wave prediction results. The horizon is the natural spatial limitation for the radar, establishing a limitation for the time to produce a forecast. Understanding the uncertainty causes and propagation will let establishing the limits (horizon) of predictability and will allow formulating a criterion for an optimal compromise between dynamic

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14. ABSTRACT
The development of short-term wave forecasting capability, a stated goal of the High-Resolution Wave-Air-Sea Interaction project, requires observational information that will both serve to improve the understanding of the underlying physics and will be used to test the predictive potential of wave propagation models. For a stochastic and nonlinear environment such as the air-sea interface, a considerable uncertainty still exists regarding the mechanisms of energy and momentum exchange as well as the rates of that exchange. While wave dynamics on the water side has already been reduced to a computationally-intensive numerical problem (Friehe et al., 2007, section III.B), the complexity of which is determined by the number of nonlinearly interacting wave modes, the wind driving of the waves on the other hand, is less understood.

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completeness and computational efficiency of the forecasting models, so that the forecasts are produced within the imposed time limits.

APPROACH

The planned approach consists of interpreting and assimilating the field data that are going to be collected in the field experiment within this project. The data on atmospheric pressure fluctuations will serve for estimating the direct wind input to the waves occurring through wave—mean-flow interaction mechanism. The wind velocity measurements are key to identifying traces of wave-turbulence interaction and its contribution to the wave growth. Analysis of data from the wave-follower will be used to detect instances of flow separation (a nonlinear mechanism), to determine its statistics and hopefully, its energetics.

The PI closely collaborates with other members of the project's team. The experimental component is carried out with Carl Friehe (UCI) and Ken Melville (UCSD). Interpretation of radar observations of the sea surface and the work on incorporating realistic sea surfaces into atmospheric boundary layer models will be done with Eric Terril (UCSD) and Peter Sullivan (NCAR).

WORK COMPLETED

At this stage, the completed work included acquiring and building instruments, preparation of mounting gear and cabling. A major part of the effort is developing software for data collection and data access that is to integrate all the instruments scheduled for deployment. An essential feature of the software is the timing and synchronization capability, making it possible to process together data from multiple asynchronous sources.

RESULTS

We currently conduct laboratory testing of instruments and of the data acquisition system hardware components. Figure 1 illustrates the results from one such test. An inertial navigation device communicating with a data acquisition computer over an ethernet link was stationed on a moving vehicle and registered its velocity, heading, three rotation rates, its geographic position, along with other motion parameters. The trajectory defined by the geographic position and the altitude is presented in the Figure. This inertial navigation instument will be used to record the motion of the instrument platform. At the interpretation stage that motion is to be removed from wind velocity, atmospheric pressure and surface elevation data.

IMPACT/APPLICATIONS

The results of this research will be incorporated in operational models for short-term wave modeling and forecasting. The newly acquired knowledge regarding the structure and dynamics of the marine atmospheric boundary layer (MABL) and the statistics of the ocean surface will advance the description and modeling of signal propagation over the ocean. The profound physical similarities between propagation of radar signals over the ocean and acoustic signals in the water will extend possible applications to the acoustic domain. Since the MABL structure and dynamics is also essential in designing and modeling the performance of flying objects operating close to the ocean surface, such engineering applications of this project results are foreseeable as well.

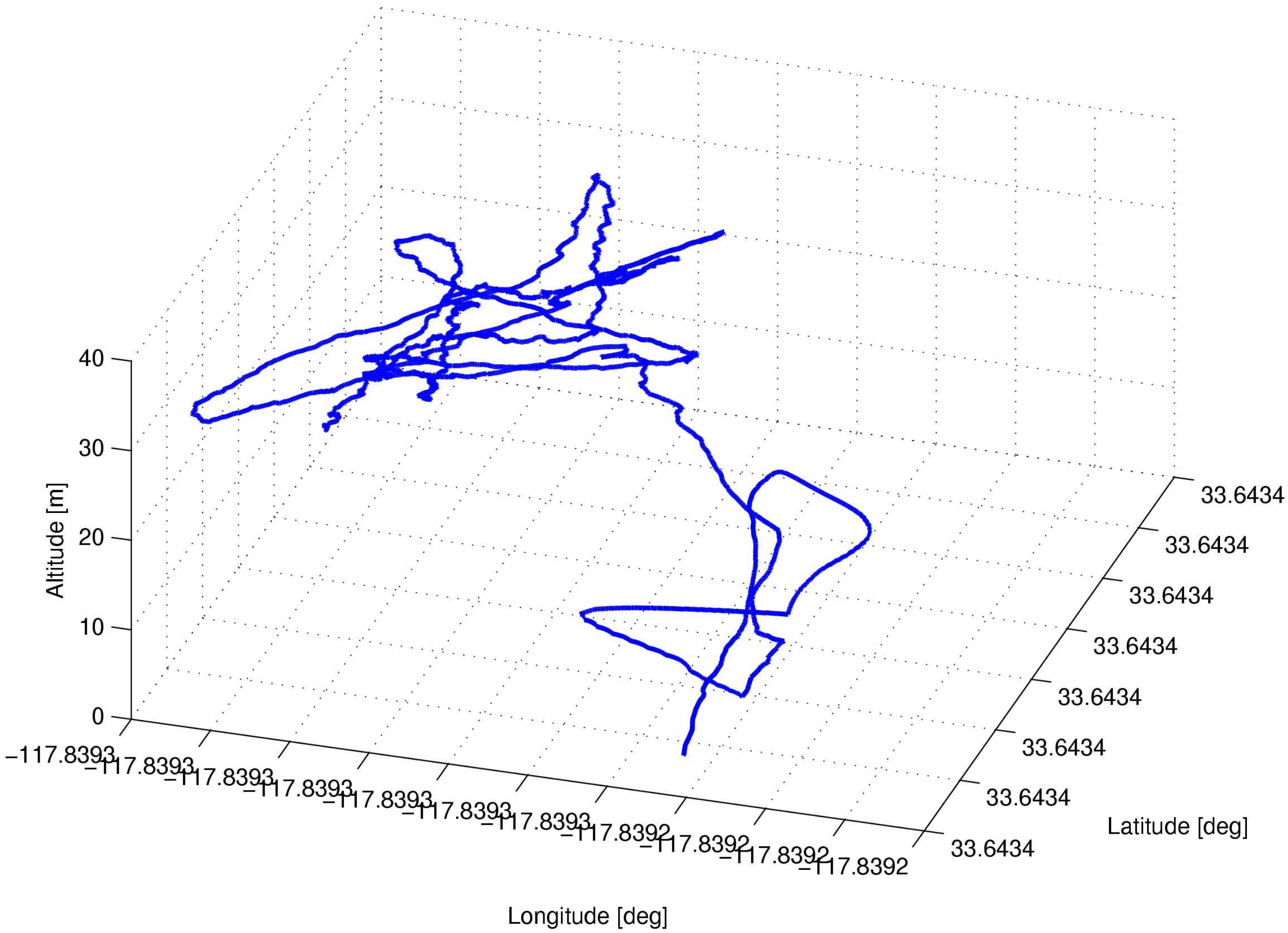

Figure 1. A trajectory obtained during a test of the inertial navigation instrument that will be used in the High-Resolution Wave-Air-Sea Interaction Experiment. Data produced in collaboration with Carl Friehe and Jesus Ruiz-Plancarte of the University of California, Irvine.

RELATED PROJECTS

The PI is unaware of any related projects.

REFERENCES

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