

Refractive Index Effects in the Marine Boundary Layer

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LONG-TERM GOALS

The long-terms goals of the research are to measure the atmospheric mean and turbulence structures and statistics that are related to the propagation of laser and radar signals over the ocean. It has been hypothesized that ocean surface waves have a large effect on propagation in certain wind speed ranges. Previous experiments from R/P FLIP have shown the resonant effects of waves on the momentum flux and turbulence at wind-wave and swell scales. The problem now is to investigate the effects for the scalars that affect propagation -- temperature and water vapor.

OBJECTIVES

The objective was to obtain accurate measurements of the mean temperature and humidity profiles over the ocean together with the surface fluxes of momentum, sensible heat and water vapor (latent heat). Fine-scale, fast response measurements of temperature, humidity and pressure fluctuations were also obtained. These data were taken in conjunction with propagation measurements and surface wave measurements.

APPROACH

The approach was to perform a surface-layer experiment from the R/P FLIP in conjunction with the SPAWAR in situ range propagation measurements to provide the necessary temperature and humidity data that determine the refractive index properties. The CIRPAS Twin Otter aircraft also participated in RED as instrumented for turbulence and mean meteorological quantities in the recent ONR-sponsored Sea of Japan/East Sea experiment.

WORK COMPLETED

The RED experiment was fielded in August-September 2001 off the coast of Oahu, Hawaii. R/P FLIP was moored approximately 10km off shore, the source of radar and optical transmissions. R/P FLIP was moored with an orientation of the keel into the trade winds for low flow distortion. The CIRPAS Twin Otter was based at the nearby MCAS at Kaneohe. The Twin Otter flew aerosol sampling and boundary-layer stack patterns centered on R/P FLIP. 22GB of data were recorded on R/P FLIP and 3GB from the Twin Otter.

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RESULTS

The UCI measurements on R/P FLIP focused on the mean profiles of temperature and humidity over the lower 3-20m above the sea surface. Five levels of solar radiation shielded aspirated accurate temperature probes and chilled-mirror dew point sensors were deployed on a vertical mast away from the flow distortion from R/P FLIP's hull. Five levels of sonic anemometer/thermometers were also on the mast to obtain the wind stress and buoyancy flux. Three Lyman-alpha hygrometers were used to obtain the humidity fluxes. Mean air temperature, sea temperature, wind speed and dew point are displayed over the 12-day experimental period in Figure 1. There was little variation in the trade-wind conditions, with winds from 5-10 m/sec, air temperature 25-26C, dew point 19-24C and sea surface temperature 27C.

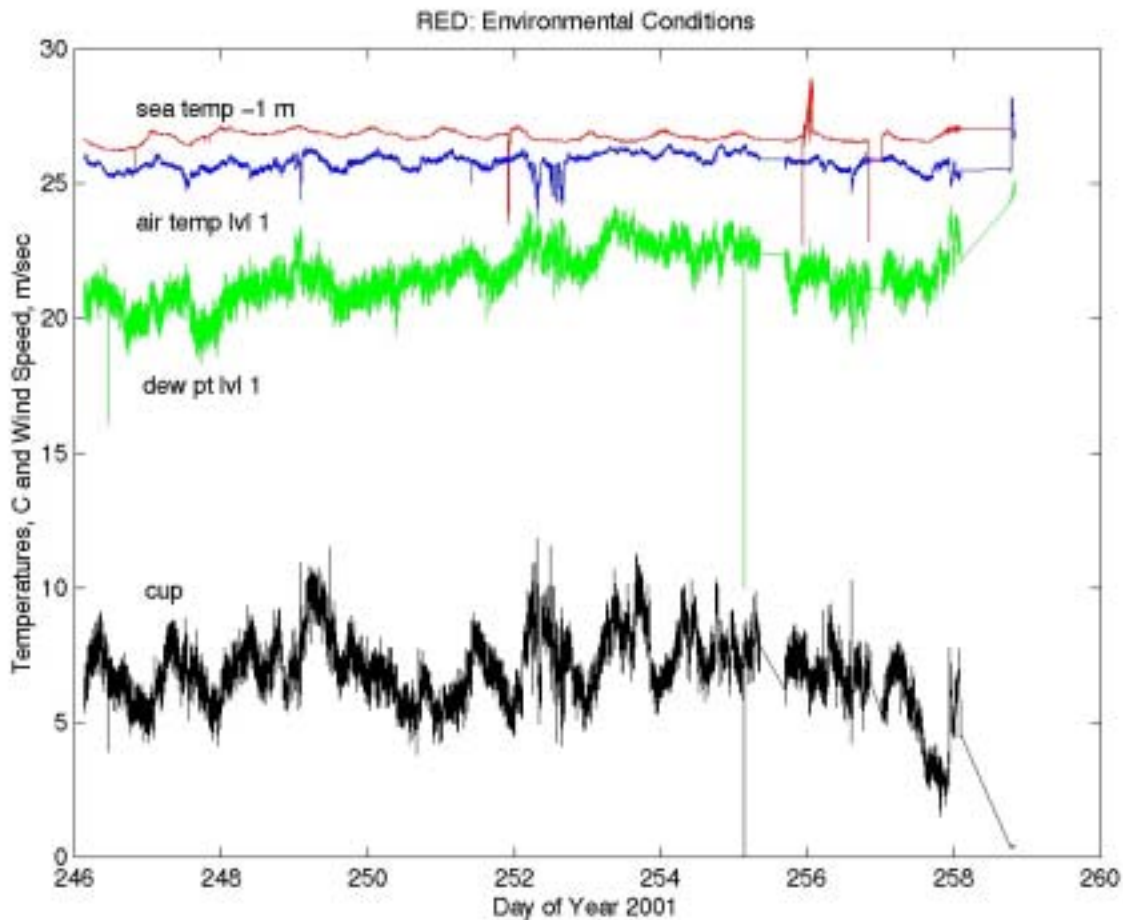


Figure 1: Variation of Mean Meteorological Conditions in RED from R/P FLIP

Analysis to date of the R/P FLIP data has focused on the temperature and humidity profiles and their Monin-Obukhov similarity forms. The hypothesis is that the vertical gradients of the temperature and humidity profiles, when normalized with surface-layer variables, are unique functions of the buoyant stability conditions, expressed as the height above the sea, z , divided by the Obukhov length, L . The Obukhov length is a function of the surface wind stress and heat and water vapor fluxes. The

hypothesis has been tested over land in several experiments for temperature profiles. The only over ocean experiment was done from R/P FLIP in 1968 prior to RED. The RED similarity profile forms are shown in Figure 2, where the normalized slopes for the potential temperature and absolute humidity are plotted versus z/L , together with the result for temperature from Oncley, et al. (1996) over land. It is clear that the RED results over the ocean do not agree with the over-land result, and also the temperature and humidity profiles themselves are different from each other. The slope for humidity (Φ_q) is larger than the over-land result, while that for temperature (Φ_h) is lower. However, the RED results do show the same trends of slope decreasing with increasing buoyant instability as over land.

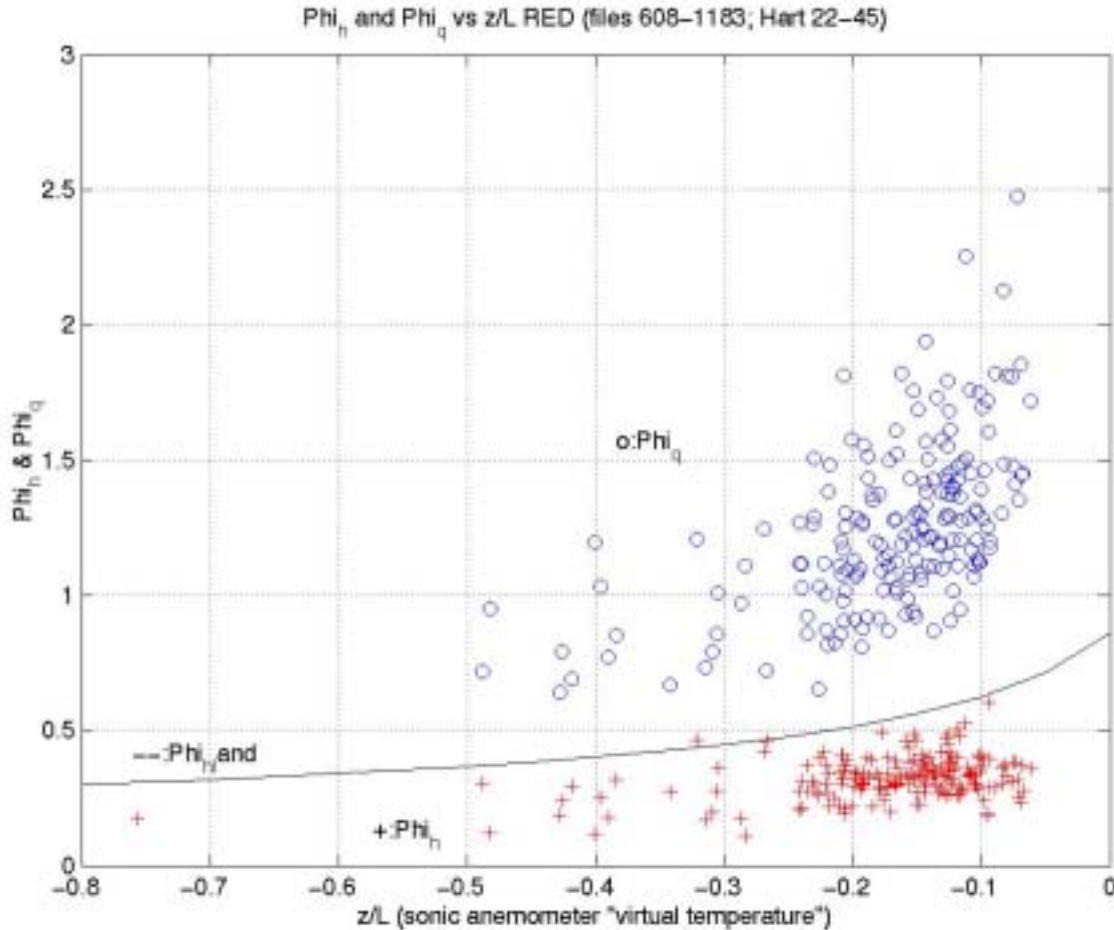


Figure 2: Normalized Potential Temperature (Φ_h) and Humidity (Φ_q) Profiles versus Stability, z/L .

The effects of the widely differing profile results on radar propagation are being studied with SPAWAR San Diego (Kenn Anderson).

IMPACT/APPLICATIONS

The impacts of the research will be in the improvement of the basic understanding of temperature and humidity fluctuations and mean profiles in the atmospheric surface layer over the ocean. These directly affect the refractive index at optical and radar wavelengths. The basic results can then be incorporated into models. The data obtained will also further elucidate the basic physics of wind-wave interaction.

TRANSITIONS

We are working with the Navy Space and Warfare Systems Command, SPAWAR, on the analysis of the RED data. The results have indicated that further experiments, perhaps conducted at Scripps' Pier for convenience, are justified.

RELATED PROJECTS

This project is related to our overall work on air-sea interaction.

PUBLICATIONS

Journal Papers:

None

Abstracts:

Friehe, C. A. and T. Hristov 2002: Temperature and Humidity Profiles from R/P FLIP in RED. American Meteorological Society Annual Meeting, Air-Sea Interaction, submitted.