# The Rough Evaporation Duct (RED) Experiment: Microwave Propagation over the Sea

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Prediction of microwave and infrared signal propagation over a wind-roughened sea relies on a thorough knowledge of signal interaction with the sea surface, the mean profiles of pressure (*P*), humidity (*Q*), temperature (*T*), wind (*U*), their turbulent fluctuations (*p, q, t, u*), and the vertical distribution of aerosols. Yet, within the marine surface layer, these mechanisms are not sufficiently understood nor has satisfactory data been taken to validate models. The RED experiment was designed to provide first data for validation of both meteorological and microwave frequency propagation models in the marine surface layer for rough surface conditions including the effects of surface waves.

Over the ocean, "smooth-rough" surface similarity theory is often applied to construct profiles of *P, Q, T,* and *U* in the surface layer. In this context, the "rough" boundary layer is derived from empirical relations where ocean wave characteristics are neglected. For seas where wind speeds are less than 10 $ms^{-1}$ and wave age near unity, there is excellent agreement for both meteorological and microwave propagation theory and measurements. However, recent evidence indicates that even small waves perturb *P, Q*, *T*, and *U* profiles throughout the surface layer. Indirect evidence of surface induced distortion of *P, Q*, and *T* profiles via modeling of the vertical microwave refractivity profile (*i.e.,* the evaporation duct) is indicated by analyses of previous microwave signal propagation experiments.

The RED experiment was conducted offshore of the Hawaiian Island of Oahu in late summer, mid-August to mid-September, of 2001. *R/P FLIP*, moored about 10 km off of the NE coast of Oahu, hosted the primary meteorological sensor suites and served as a terminus for the propagation links. There were eleven scientists and engineers aboard *R/P FLIP* who installed instruments measuring mean and turbulent meteorological quantities, sea wave heights, directions, and kinematics, upward and downward radiance, near surface bubble generation, atmospheric particle size distributions, laser probing of the atmosphere, and sources for both microwave and electro-optic signals. In addition to *R/P FLIP*, two land sites were instrumented with microwave and electro-optic receivers and meteorological sensors, two buoys were deployed, a small boat was instrumented, and two aircraft flew various tracks to sense both sea and atmospheric conditions. In all, more than 25 people from four countries, six universities, and four government agencies were directly involved with the RED experiment.