Aircraft Measurements of Air-Sea Fluxes and the Marine Atmospheric Boundary Layer over the Sea of Japan/East Sea

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LONG-TERM GOALS

The long-terms goals of the research are to understand and parameterize the physics of air–sea interaction and the marine boundary layer over a wide spectrum of weather and ocean conditions. For the Sea of Japan/East Sea experiment will use the Navy CIRPAS Twin Otter research aircraft for turbulence and meteorological measurements.

OBJECTIVES

The objectives are to measure and parameterize the air-sea fluxes of momentum, heat and water vapor (latent heat) under the extreme conditions of cold-air outbreaks over the Sea of Japan/East Sea during winter. Also, the marine boundary-layer vertical structure and its spatial variation will be measured for input to models. The northern section of the Sea of Japan/East Sea is the site of extreme air-sea fluxes during winter. The flow from the Siberian High, channeled through the "Vladivostok Gap," reaches gale force with large air-sea temperature differences. Momentum, sensible and latent heat fluxes reach very large values in the "flux center" near 41N, 132E. The intense and sustained air-sea interaction forces circulation in the ocean. Since the conditions are extreme and the region remote, there are very few data for input and validation for modeling.

APPROACH

The approach is to use an instrumented research aircraft to make the measurements. This will provide the spatial coverage and flexibility of location for the specific synoptic events that cannot be readily achieved with a ship or buoy. The Navy CIRPAS Twin Otter aircraft was provided for the forthcoming research in the period January – March 2000. We developed instrumentation for obtaining high quality turbulence and meteorological measurements from the aircraft. A research flight pattern has been developed to sample the low-level (down to 30m altitude) fluxes and the boundary-layer profiles.

WORK COMPLETED

To date, we have developed and installed instrumentation on the CIRPAS Twin Otter. The main instrumentation is in two groups: turbulence and meteorological.

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Turbulence:

The measurement of the turbulent fluxes of momentum, heat and water vapor (latent heat) require high-fidelity measurements of the vertical and horizontal components of the wind vector, referred to earth coordinates, temperature and humidity.

The relative wind components are obtained from the 5–hole radome pressure-port method. Basically, 5 pressure holes in a cruciform pattern are placed in the radome and the entire nose section of the aircraft becomes a large multi-hole Pitot tube from which the airspeed vector can be obtained from appropriate differential and impact pressure measurements. Sensitivity to turbulent fluctuations is high and bandwidth is sufficient for direct measurement of the fluxes by eddy correlation and estimation from the inertial dissipation technique. Ground speed of the aircraft, vertical velocity and orientation angles are measured from a GPS-inertial unit at 10 Hz.

Air temperature (mean and fluctuations) are measured from commercial aircraft flight test temperature resistance wire probes and UCI-developed fast-response thermistor probes.

Humidity fluctuations are measured by Lyman-alpha and Krypton absorption hygrometers.

Meteorological Measurements:

Horizontal winds are obtained from the radome winds as well as a specially installed Pitot tube and multi-port flight test probe. Several GPS systems are on the aircraft.

Static pressure is obtained from the aircraft's static pressure ports corrected for flow defect by trailing cone flight tests planned for December 1999.

Mean air temperature is obtained from a precision aircraft thermometer.

A chilled mirror dew point/frost point sensor and a capacitive instrument measure mean humidity.

Sea surface temperature is obtained from two infrared radiometers with an upward-looking infrared radiometer installed to correct for radiation from overhead clouds. Standard hemispherical radiometers are also installed.

Data recording and display is done via a computer-controlled 16-bit data acquisition system. Data storage is on CD. Approximately 40 analog channels and two GPS-inertial serial data streams will be recorded continuously at 40 Hz sample rate. The acquisition software is flexible so that changes can be made and future expansion accommodated.

A picture of the aircraft with the radome and associated instrumentation is shown in Figure 1.

Figure 1: CIRPAS Twin Otter Research Aircraft. Turbulence and auxiliary sensors are located in and around the radome.

RESULTS

Part of the aircraft system flew on the 1999 summer stratus/drizzle experiment in Monterey, CA. This included the 5-hole radome system and Lyman-alpha humidiometer.

Planning has proceeded for the field phase of January-March 2000. The aircraft will be based in Misawa, Japan, US-Japanese forces airfield. A field trip in September was conducted and confirmed that the base will support the Twin Otter operations. In addition, there is a USN METOC facility at NAF Misawa, which will be very useful for forecasts for the research flights as well as providing them data.

IMPACT/APPLICATIONS

The impact of this research will be improved understanding and parameterizations of air-sea fluxes and boundary-layer structure in extreme weather conditions typical of the Sea of Japan and other locations.

TRANSITIONS

The USN METOC facility at NAF Misawa was contacted. They are interested in our research project and will provide forecasting support during the field phase. We also coordinated with ONR Asia and briefed the director in September 1999.

RELATED PROJECTS

The aircraft project is a part of the ONR Sea of Japan/East Sea experiment (JES). A DURIP instrumentation grant was also obtained during this grant period to purchase the major equipment for the CIRPAS Twin Otter aircraft.

PUBLICATIONS

Journal Papers:

Khelif, D., S. P. Burns and C. A. Friehe, ``Improved Wind Measurements on Research Aircraft," J. Atmos. and Ocean. Tech., **16**, 860-875 (1999).