Japan/East Sea Air-Sea Interaction and Meteorology: Boundary-Layer Structure and Model Validation

Carl A. Friehe
Departments of Mechanical Engineering and Earth System Science
University of California, Irvine
Irvine, CA 92697-3975
phone: (949) 824-6259 fax: (949) 824-2249 email:cfriehe@uci.edu

Award #: N000149910205
http://wave.eng.uci.edu

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.

OBJECTIVES

The main objectives are to study the air-sea interaction under the extreme conditions of cold-air outbreaks over the JES during winter. The focus is on *(i)* the determination of boundary-layer structure *(ii)* the measurement of momentum, heat and water vapor (latent heat) air-sea fluxes and their spatial variability and *(iii)* parameterization of these fluxes. Meteorological and turbulence data obtained aboard the Navy CIRPAS Twin Otter research aircraft over the Japan/East Sea (JES) during the winter 2000 will be used.

APPROACH

We instrumented the Navy CIRPAS Twin Otter research aircraft and obtained high quality turbulence and meteorological measurements over the JES in February 2000. The bulk of the measurements were made inside the "Flux Center" (41-42.5N, 131.5-133.5E, Kawamura and Wu, 1998) an area off of Vladivostok characterized by enhanced winds and surface fluxes due to the flow of cold and dry Siberian air channeled through the orographic gap near Vladivostok. Thirteen aircraft flights of up to 9.8 hours duration were flown in cold-air outbreak conditions. Three basic research goals were addressed with different flight patterns: *(i)* Flux Mapping: after transit to the ``Flux Center" south of Vladivostok, the surface-layer fluxes were mapped in a grid pattern at 100 feet with soundings to 5000 feet; *(ii)* Internal Boundary-Layer Growth: after transit to the "Flux Center" south of Vladivostok, a line of soundings from 100 to 3000-5000 feet was flown following an approximate streamline across the JES (five-minutes flux legs were flown at 100 feet between soundings); and *(iii)* Flux Divergence: after transit to the ``Flux Center" south of Vladivostok, a vertical stack pattern was flown to determine the flux divergence profile in the boundary layer.

WORK COMPLETED

The aircraft data were recorded simultaneously on two computers on the aircraft, CIRPAS and UCI, with about 90% overlap. This was fortunate since the UCI computer had a hard disk problem for

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Japan/East Sea Air-Sea Interaction and Meteorology: Boundary-Layer Structure and Model Validation**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Departments of Mechanical Engineering and Earth System Science,,University of California, Irvine,,Irvine,,CA,92697**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

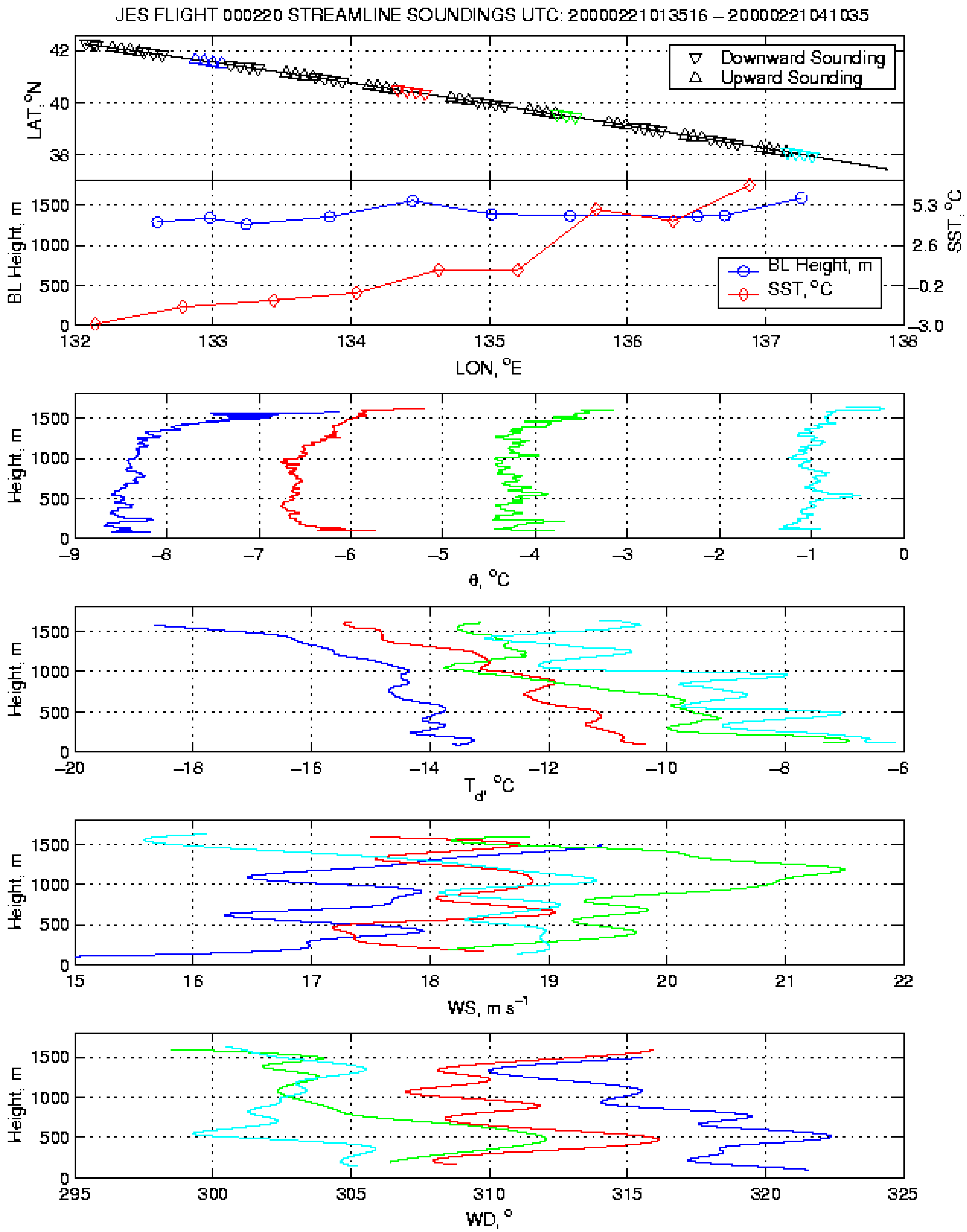
14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

altitudes above about 3000 feet. Between the two computers, we have good data capture, especially in the low-level flux runs. About 5.5 GB of data were obtained.



We are currently in the processing phase for the aircraft data. Dr. Haf Jonsson of CIRPAS has kindly furnished us a time-stamped data file for each flight. We are merging the CIRPAS data with the UCI data. Before the JES deployment, we flew two special test flights out of Marina, CA, to assess the wind and turbulence measurements. In particular, we flew a ``trailing cone" pressure tube to get the static pressure correction for the CIRPAS Twin Otter. We are using these data to work-up the static pressure defect which will result in improved winds.

The quality of recorded signals appears good. There were occasional failures, e.g., sea surface temperature from the KT19.85 IR radiometer on the last flight. Fortunately, we have redundant sensors for the major variables.

RESULTS

An example of the boundary-layer growth across the JES is shown in Fig. 1 for Feb 3 2000. The flight track was to the SW, and the boundary-layer height as given by the jump in potential temperature varies from about 300 to 1200 meters. Many of the interesting features of the JES MABL are revealed by these preliminary results. Down the streamline we observe internal boundary-layer growth which is accompanied by warming and moistening of the MABL and decay and backing of the wind. Honshu's orography may play a role in the thickening of the IBL as well as on the wind direction backing.

Also, the sharp increase in the IBL around 134E seems to be a response to the crossing of the SST front similar to that observed by Friehe, et al. (1991) in FASINEX. Thus there may be *two* internal boundary layers across the JES in cold-air outbreak conditions: the initial IBL and the second IBL caused by the SST front.

As shown in Fig. 2, Prof. Wang of USNPGS has run the COAMPS model for Feb 02 200 and found it predicted boundary-layer growth but at a different rate than the observed and did not show the jump at the SST front. This may be due, at least partially, to the fact that the COAMPS SST used was different from the observed and where, in particular, the SST front was not represented. We will be working with Prof. Wang on data-model comparisons, including turbulence.

IMPACT/APPLICATIONS

The high-quality turbulence and meteorological aircraft data are the first measurements to provide good spatial (both horizontal and vertical) coverage of the boundary layer over the JES in cold-air outbreaks conditions. Their impact is to improve our understanding and parameterizations of air-sea fluxes and boundary-layer structure in extreme weather conditions. Their use as input and validation of JES mesoscale models such as COAMPS and MM5 will enhance the accuracy of these models.

TRANSITIONS

We will be analyzing the aircraft data in cooperation with the modeling efforts of working with Profs. Wang (USNPGS) and Chen (RSMAS, Miami).

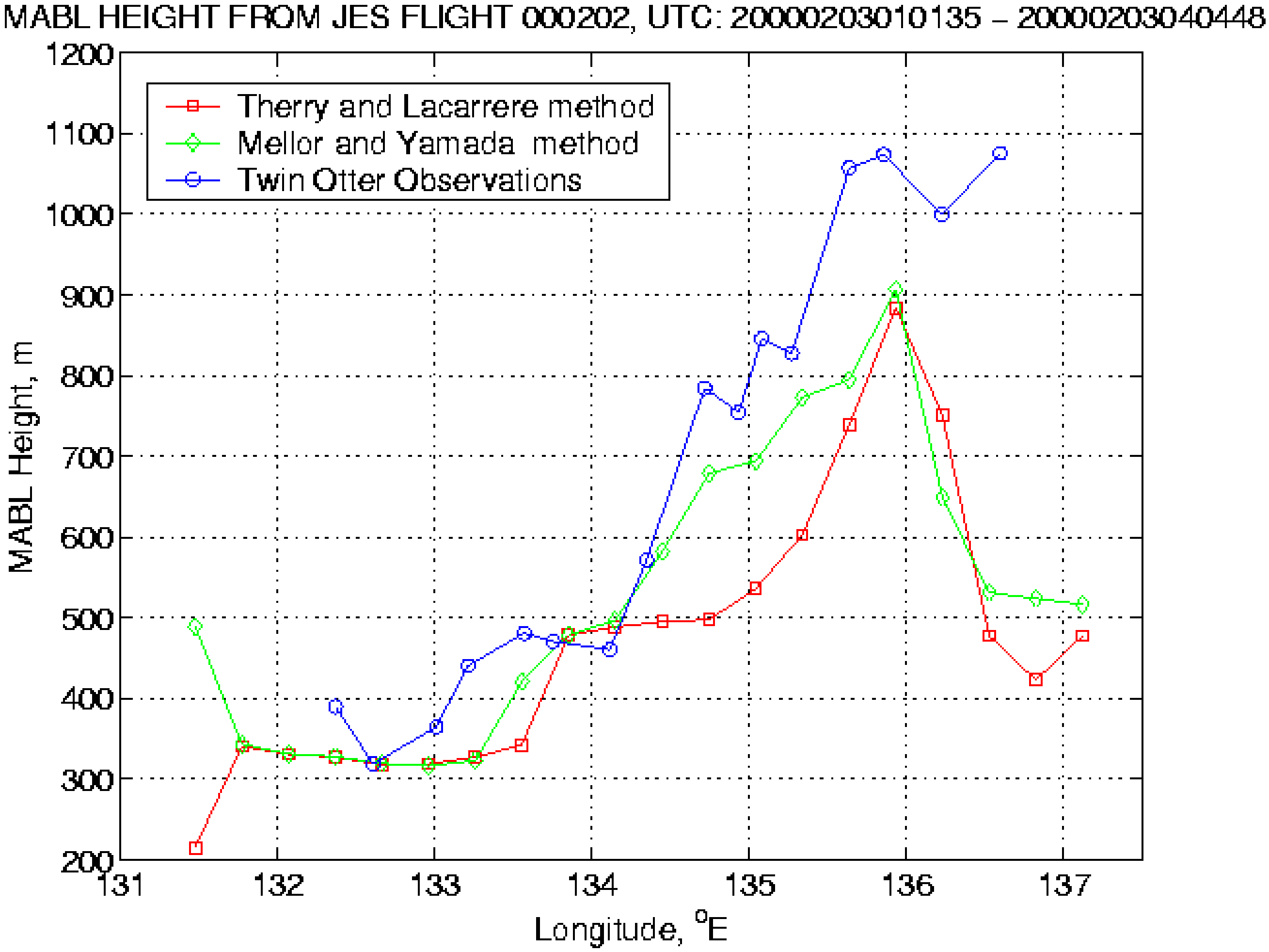


Figure 2: Comparison of observed (Twin Otter) MABL heights to COAMPS results of Prof. Wang (USNPGS).

The instrumentation we developed for the JES experiment has been used on CIRPAS Twin Otter aircraft in recent projects (DEC 1999, DUCK 1999) and will be used in future ones (ACE-Asia 2001, RED 2001).

RELATED PROJECTS

A DURIP instrumentation grant was also obtained during this grant period to purchase the major equipment for the CIRPAS Twin Otter aircraft.

REFERENCES

Friehe, C. A., Shaw, W. J., Rogers, D. P., Davidson, K. L., Large, W. G., Stage, S. A., Crescenti, G. H., Khalsa, S. J. S., Greenhut, G. K., and Li, F., 1991: Air-Sea Fluxes and Surface-Layer Turbulence Around a Sea Surface Temperature Front. J. Geophys. Res., 96, 8,593-8,609.

Kawamura, H. and P. Wu, 1998: Formation Mechanism of Japan Sea Proper Water in the Flux Center off Vladivostok. J. Geophys. Res., 103, 21,611-21,622.

PUBLICATIONS

Journal Articles:

Burns, S.P., D. Khelif, C.A. Friehe, A.G. Williams, P. Hignett, A.L.M. Grant, J.M. Hacker, D.P. Rogers, E.F. Bradley, R.A. Weller, M.F. Cronin, S.P. Anderson, C.W. Fairall, and C.A. Paulson, 1999: Comparisons of aircraft, ship, and buoy meteorological measurements from TOGA COARE. J. Geophys. Res., 104, 30,853-30,883.

Burns, S.P., D. Khelif, C.A. Friehe, P. Hignett, A.G. Williams, A.L.M. Grant, J.M. Hacker, D.E. Hagan, Y.L. Serra, D.P. Rogers, E.F. Bradley, R.A. Weller, C.W. Fairall, S.P. Anderson, and C.A. Paulson, 2000: Comparisons of aircraft, ship, and buoy radiation and SST measurements from TOGA COARE. J. Geophys. Res., 105, 15,627-15,652.

Abstracts:

Khelif, D. and C. A. Friehe: 2000: Surface Forcing and Boundary-Layer Structure Over the Japan/East Sea During Winter Cold-Air Outbreaks. Fall Meeting of American Geophysical Union, San Francisco, CA. (Submitted.)