MESOSCALE VARIABILITY OF LOW-LEVEL WINDS AND TURBULENT FLUXES DURING COLD AIR OUTBREAKS OVER THE LABRADOR SEA

Dr. Bernard Walter
NorthWest Research Associates
P. O. Box 3027
Bellevue, WA 98009
walter@nwra.com
Voice: 425-644-9660, x320 FAX: 425-644-8422
Award No. N0001497C0152

LONG TERM GOALS

Improve the predictive capability of Navy numerical models over the ocean in high heat flux/high wind conditions as are present during cold air outbreak s over the Labrador Sea.

OBJECTIVES

The objective of the proposed project was to obtain measurements of low-level mean winds, temperatures and turbulent fluxes using an instrumented research aircraft in high wind cold air outbreak conditions over the Labrador Sea. Unfortunately it was not possible to obtain the high frequency turbuence measurements during the 1997 Labrador Sea experiment but 1 second flight level data was obtained . These data will be used for:

(1) numerical prediction model validation and data assimilation; and

(2) comparison to coincident oceanographic measurements of convective processes in Labrador Sea waters.

APPROACH

Use an instrumented aircraft to obtain measurements of the spatial variability of wind, temperature and moisture over the Labrador Sea in cold air outbreak conditions during the time period that oceanographic measurements were being made (Jan. - Mar, 1997). It is important to know the downwind and crosswind variations of fluxes in order to know the spatial scales important for transporting heat and momentum between the ocean surface and the atmospheric boundary layer.

ACCOMPLISHMENTS

Several flights were made by an Air Force C-130 over the Labrador Sea to collect data on air temperature, moisture and winds. On one of the flights (Feb, 8) low level stack patterns were flown at three different fetches during a cold air outbreak over the Labrador Sea. In each of the stack patterns measurements were made at 150, 300 and 500 m heights and over crosswind distances of 100 km.

Report Documentation Page					Form Approved OMB No. 0704-0188
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE **30 SEP 1997**		2. REPORT TYPE			3. DATES COVERED **00-00-1997 to 00-00-1997**
4. TITLE AND SUBTITLE **Mesoscale Variability of Low-level Winds and Turbulent Fluxes During Cold Air Outbreaks over the Labrador Sea**					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) **NorthWest Research Associates, Inc,P.O. Box 3027,Bellevue,WA,98009**					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)**	**3**	

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

SCIENTIFIC/TECHNICAL RESULTS

The aircraft measurements have been analyzed with in mind determining the spatial variability of the winds, temperature and moisture fields. Knowledge of the spatial variability of these quantities is important in the accurate estimation of the heat, moisture and momentum fluxes from the ocean to the atmosphere. Stack 1 was flown over the sea ice present along the Labrador coast. Stack 2 was flown about 100 km downwind of stack 1 and stack 3 yet another 100 km further downwind.

At the time of the C-130 flight, AVHRR satellite imagery showed cloud streets present over the Labrador Sea starting just offshore and continuing for hundreds of kilometers downwind. The AVHRR satellite imagery showed cloud streets with spacings of 5-6 km just off the ice edge (at about the position of stack 2) while further downstream (at the position of stack 3) the rolls had merged and spacings had increased to 10-12 km.

Analysis of the aircraft time series of wind, temperature and dewpoint temperature measured on the crosswind runs showed some evidence of roll vortices at stack 1even though cloud streets are not yet visible in the satellite image. There is a strong peak in the spectra of both the velocity and the dewpoint temperature at 5-6 km. In the aircraft data at stack 2, in addition to the 5-6 km scale, there is also evidence of the 10-12 km scale seen in the cloud street spacings further offshore in the AVHRR image. This indicates that in fact both scales are present at the same time but closer to shore the smaller 5-6 km scale is dominant whereas further offshore the 10-12 km scale is dominant in organizing the cloud structures. This may be further evidence of the existence of a hierarchy of scales of roll vortices in the boundary layer as previously proposed by Walter and Overland (1984).

Using the bulk flux formulation for sensible heat flux together with the flight level aircraft data at the stack 3 estimates of sensible heat fluxes were on the order of 1000W/m^2.

IMPACT FOR SCIENCE/SYSTEM APPLICATIONS

NRL Monterey is very interested in knowing more accurately the magnitudes of the strong sensible and latent heat fluxes (greater than 300 W/m^2) in cold air outbreak situations. Estimates of high fluxes in cold outbreaks vary considerably. NRL modelers want to study:

(a) how strong fluxes modify the marine boundary layer;

(b) how they modify the stratification in the ocean mixed layer;

(c) how the fluxes organize the cloud streets and eventual convection downstream; and

(d) if the model(s) (e.g. COAMPS and others), especially the PBL parameterization, realistically reproduce the lower tropospheric structure and handle the rapid temporal and spatial transitions in such situations.

The data set collected by the aircraft during the Labrador Sea experiment is a start toward answering these needs.

The proposed study and data analysis can also be helpful in validating the COAMPS forecasts/simulations. These low level data can also be used in data assimilation experiments to evaluate if such observations are useful in real time situations.

REFERENCE:

Walter, B. and J. Overland, 1984: Observations of logitudinal rolls in a near neutral atmosphere, *Mon. Wea. Rev., 112*, 200-208.