N90-28266

A poster presented at the FIRE/ASTEX Workshop, Monterey, CA, July 10-14, 1989.

Turbulent Statistics in the Vicinity of an SST Front: A North Wind Case, FASINEX February 16, 1986.[1]

Steven A. Stage & Chris Herbster
Department of Meteorology
Florida State University
Tallahassee, Florida

----

1. This is FASINEX contribution number 76.

PRECEDING PAGE BLANK NOT FILMED

A poster presented at the FIRE/ASTEX Workshop, Monterey, CA, July 10-14, 1988.

Turbulent Statistics in the Vicinity of an SST Front: A North Wind Case, FASINEX February 16, 1986.[1]

Steven A. Stage & Chris Herbster
Department of Meteorology
Florida State University
Tallahassee, Florida 32306-3034

1. This is FASINEX contribution number 76.

Summary

The technique of boxcar variances and covariances is used to examine NCAR Electra data from FASINEX. This technique has been developed to examine changes in turbulent fluxes near an SST front. The results demonstrate the influence of the SST front on the MABL. Data shown here are for February 16, 1986, when the winds blew from over cold water to warm. The front directly produced horizontal variability in the turbulence. The front also induced a secondary circulation which further modified the turbulence.

1

References

Gennaro H. Crescenti: Turbulent Variances and Covariance in a Non-Homogeneous Marine Atmospheric Boundary Layer. M. S. Thesis, Florida State University, Tallahassee, FL, April, 1988.

Stage, S.A., and R.A. Weller, 1985: The Frontal Air-Sea Interaction Experiment (FASINEX)); Part I: Background and Scientific Objectives. Bull Amer. Meteor. Soc., 66, 1511-1520.

Stage, S.A., and R.A. Weller, 1986: The Frontal Air-Sea Interaction Experiment (FASINEX)); Part II: Experimental Plan. Bull Amer. Meteor. Soc., 67, 16-20.

2

Boxcar Covariances

The technique follows Crescenti (1988). Let the boxcar average of any measured variable S(t) be defined by

$$\langle S\rangle(t) = (1/T) \int_{-T/2}^{T/2} S(t+t')\,dt' \qquad (1)$$

where T is the length of the boxcar. Then we can define the boxcar covariance of S and R by

$$\mathrm{COV}_{T}(S,R) = (1/T) \int_{-T/2}^{T/2} [S(t+t') - \langle S\rangle(t)]\,[R(t+t') - \langle R\rangle(t)]\,dt'. \qquad (2)$$

3

Note that the arguments of <S> and <R> are functions of t and therefore that the covariance is just the covariance which would be obtained by breaking the data into blocks of length T. This is ***not*** the value obtained by finding S' and R' using a high pass running mean filter and then taking the boxcar average of their product. That covariance would have t+t' as the argument for <S> and <R> above. Further let the correlation between S and R be given by

$$\mathrm{COR}_*(S,R) = \mathrm{COV}_*(S,R)\,[\,\mathrm{COV}_*(S,S)\ \mathrm{COV}_*(R,R)\,]^{-0.5}. \qquad (3)$$

We are then able to define the detrended covariance of S and R as

4

$$\mathrm{COV}(S,R) = \mathrm{COV}_*(S,R)\,[\,1 - \mathrm{COR}_*(S,t)\,\mathrm{COR}_*(R,t) / \mathrm{COR}_*(S,R)\,]. \qquad (4)$$

The above is the same value obtained by taking a block of data centered at time t and computing the covariance between linearly detrended S and R. A detrended correlation can also be defined from COV. All of the figures shown here use detrended covariances and correlations.

Further let R_H denote the Hilbert transform of R and define the boxcar coherence as

$$\mathrm{COH}(S,R) = [\,\mathrm{COV}(S,R)^2 + \mathrm{COV}(S,R_H)^2\,]^{0.5}. \qquad (5)$$

Finally let the boxcar phase angle be

$$\mathrm{Phase}(S,R) = \mathrm{Tan}^{-1}\,[\,\mathrm{COV}(S,R) / \mathrm{COV}(S,R_H)\,]. \qquad (6)$$

5

Results

The Data: All data shown are from the Frontal Air-Sea Interaction Experiment (FASINEX, see Stage and Weller, 1985, 1986). These data were obtained by the NCAR Electra flying at 35 m elevation on February 16, 1986.

On the flight leg shown the mean winds were 7.8 m/s from 31 deg--nearly perpendicular to the SST front from over cold to warm water (right to left in these plots). Other flight legs on this same day show similar features.

Following Crescenti (1988), all boxcars shown here use 60 s (6 km) averages. Horizontal wind components have been rotated so that U is along the mean wind for the leg.

6

Regions in the flow: The SST front was very sharp and was located between 60 and 64 km. The total magnitude of the front was 2.5°C. Based on examination of all the statistics, the flow can be divided into 5 regions as follows:

R1: Over the cold water upwind (north) of the front.

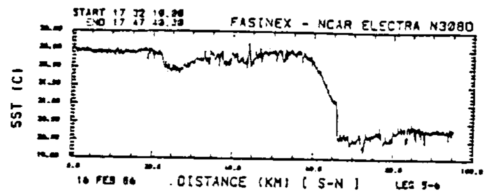
R2: A dry downdraft region ~20 km wide over and just upwind of the front.

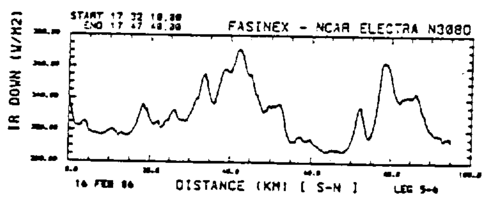
R3: A ~30 km wide region of enhanced convection just downwind (south) of the front believed to represent a secondary circulation cell.

R4: A narrow (~10 km wide) region at the downwind edge of R3 believed to be the boundary of the secondary circulation cell.

R5: Flow over warm water farther downwind.

7





8

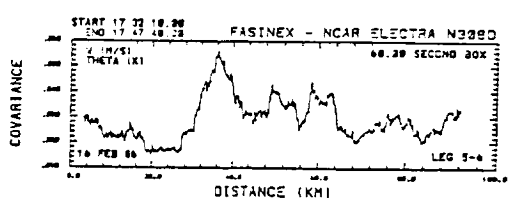
Heat and Vapor

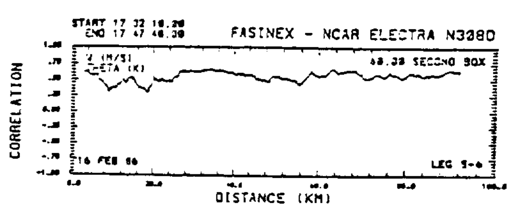
The heat flux, COV(W,Θ), was upward and produced increasing Θ throughout the leg. COV(W,Θ) decreased from R1 to R2 then sharply increased at the front and remained high in R3. It decreased in R4 and R5, but remained higher than in R1. COR, COH and Phase were all relatively flat indicating than changes in the heat flux were caused by changes in the variances of W and Θ.

R2 is seen in Q, W and $P_{35\ m}$ as a dry, high pressure downdraft.

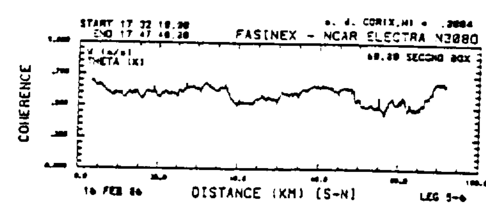
Q was high in R1, was suppressed by the downdrafts in R2, and then gradually increased in R3 before decreasing in R4. Vapor flux (not shown on poster) was upwards and showed little change during the leg.

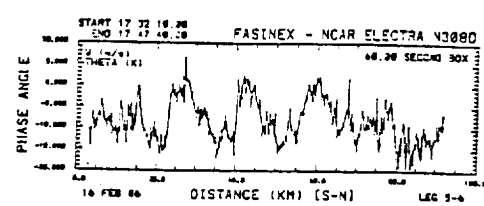
9





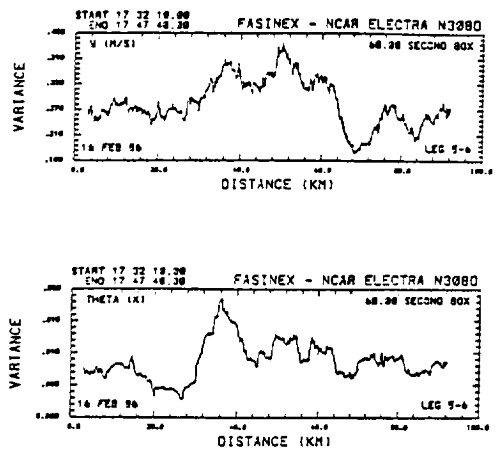
10



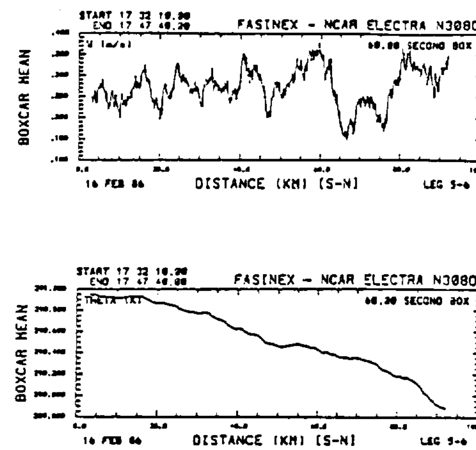


11

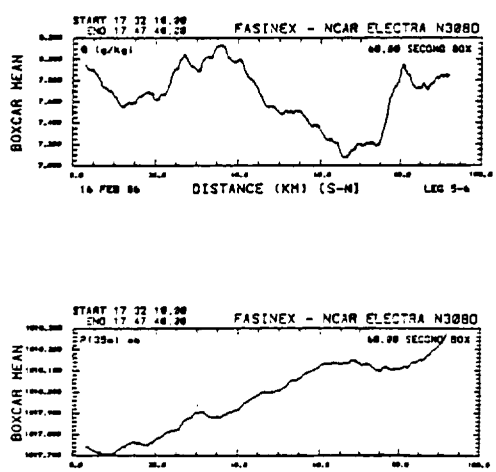
ORIGINAL PAGE IS
OF POOR QUALITY



12



13



14

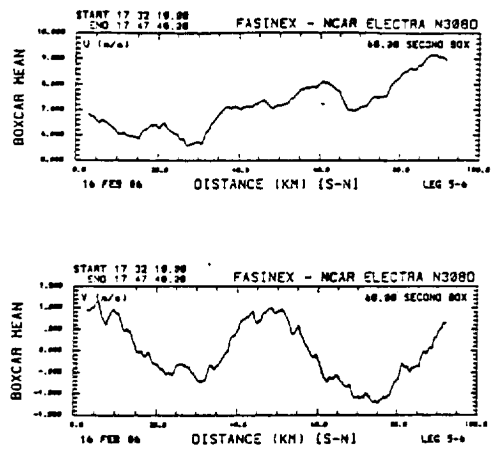
Momentum

U shows locally lower wind in R2 and R4 and higher in R3. V is remarkably sinusoidal suggesting possible wave motion. Winds are more westerly in R2 and R4 and more easterly in R1, R3, and R5. Stress (-COV(U,W)) is largest in R2. This enhanced stress near the front is the result of a change in the phase angle between U and W, not COR or COH. Stress is surprisingly similar in R1 and R3.

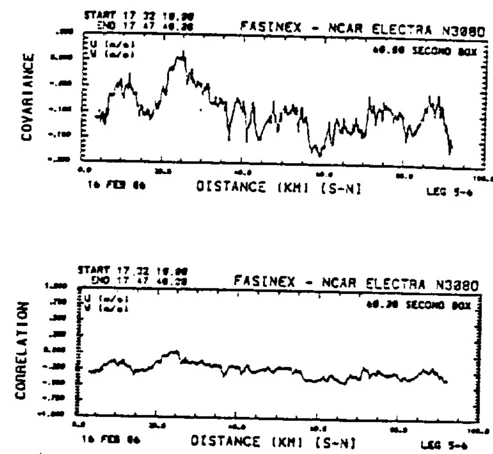
Stress, COR, and COH are near zero in R4. It is this feature which led us to identify R4 as a distinct region rather than simply the boundary between R3 and R5. Both U and W have high variances in R4. We do not yet understand the mechanism producing low stress in R4, but believe that it is associated with the boundary of the secondary cell in R3.

15

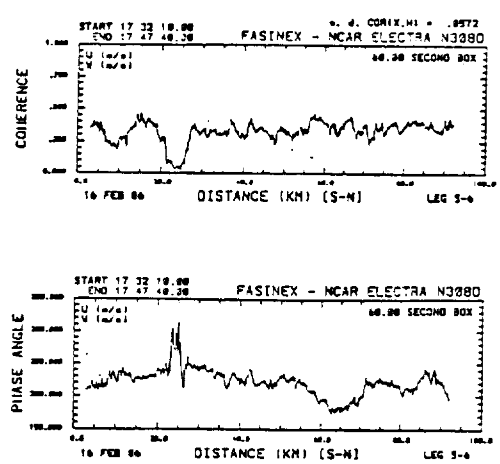
ORIGINAL PAGE IS
OF POOR QUALITY



16



17



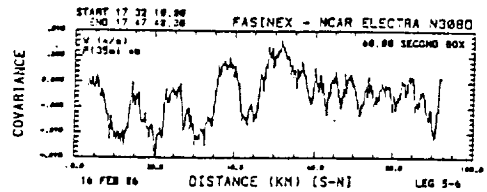
18

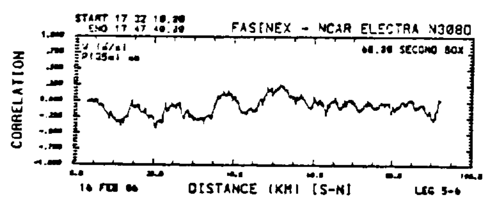
W and $P_{35\,m}$

These plots are shown because of their intriguing, wave-like character. The wavelength of these fluctuations is ~4 km over the cold water and ~8 km over the warm. The amplitude of fluctuations is also much larger over warm water. We *speculate* that these fluctuations may be a modulation of the turbulence by horizontal roll vortices. One puzzling aspect of these plots is that COR changes wavelength and magnitude around 56 km, but that COH changes around 36 km.

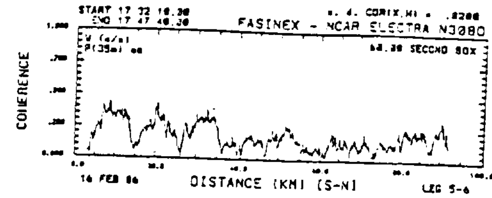
19

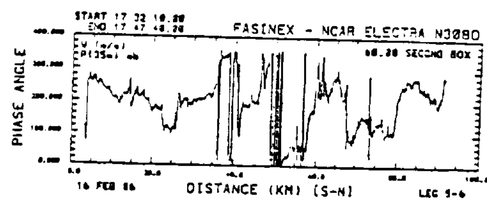
ORIGINAL PAGE IS
OF POOR QUALITY





20





21

ORIGINAL PAGE IS
OF POOR QUALITY