SOME ASPECTS OF SECOND ORDER CLOSURE

FOR TWO DIMENSIONAL TURBULENCE

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN OCEANOGRAPHY

AUGUST 1981

By

Edward Gutteling

Thesis Committee:

Lorenz Magaard, Chairman
Brent Gallagher
Edward Stroup

I. INTRODUCTION

Oceanographers have long been concerned with the problem of determining the effects of turbulence on various types of flows. For example, the Navier-Stokes equation for the mean flow contains a term that is the divergence of the Reynolds stress tensor, a contribution due to turbulence. One of the oldest attempts to estimate the Reynolds stresses has been to model them as the product of the mean shear and a coefficient (the Austausch coefficient). Although this modeling, still widely used, does close the first order (mean flow) equations, it does not accurately reflect the effect of the turbulence for general cases. The Austausch coefficients are found to vary over a wide range for different types and geometries of flow, which makes estimates of the Reynolds stresses unreliable without measurements being made for each case considered. Consequently, second order closures have been sought by attempting to solve the Reynolds stress equations directly and so to eliminate the need for Austausch coefficients.

This approach, however, involves further closure problems by introducing new unknowns into the equations of the flow. In particular, one of the objectives of second and higher order turbulence closures have been to find closure representations for the unknown correlations between turbulent pressure fluctuations and other fluctuating quantities in the flow. This is the problem that will be addressed here.

Except for small scales, much of the ocean's turbulence is greatly suppressed vertically and so can be considered as essentially two-dimensional (2D) turbulence. Consequently the closures described here are for 2D flow. This approach retains oceanic applicability and reduces the mathematical complexity associated with full three-dimensional (3D) flow.