A STUDY ON THE TURBULENT PROPERTIES AND VERTICAL SALANITY FLUX IN A STRATIFIED ESTUARY

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Abstract: The purpose of this study is to estimate the correlation of several turbulent properties and vertical salinity flux in a vertically stratified estuary based on the field data. Detailed and continuous measurements of velocity and salinity were carried out in summer in Inohana Lake, Japan, an estuary subjected to the tide in the Pacific Ocean. Variations in the velocity and salinity caused by tidal current, freshwater discharge and wind stress were observed by an ADV, and ADCP and some salinity meters set up in the center of the estuary.

Keywords: turbulent properties, salinity flux, stratified estuary

1. Introduction

In order to analyze and predict environmental problems in an estuary, mixing process due to turbulent motion must be understood. Among the processes, vertical mixing affects transportation of particulates such as the plankton and of dissolved materials. However it is difficult to measure the temporal and spatial distribution of turbulent quantity directly and the process is not yet clear. In this study, in order to understand and explain the process, the vertical mixing parameters such as turbulent properties, the vertical eddy diffusivity and vertical salinity flux were estimated, and then the correlations between the values were discussed. Additionally, the values were compared with the meteorological conditions and density stratification of water.

2. Study Area and Measurements

The field survey was conducted in Inohana Lake. Although Inohana Lake is deeply closed from the ocean, it is strongly influenced by the ocean tide. The maximum tidal range at spring tides is about 60-70 cm and the salinity of water in winter season exceeds 30 psu. The high salinity in the lake is one cause of density stratification and associated hypoxic water formation. Continuous measurements of velocity and salinity for 3-4 days were performed four times in August and September 2005 at a fixed station near the center of Iohana Lake (Yuk et al., 2005). The 3-D velocity was continuously measured for 10 minutes (sampling frequency of 8 Hz) every half an hour by ADV (3-D Acoustic Doppler Velocimeter, Nortek). Simultaneously, the continuous and vertical distributions of salinity were obtained using some salinity meters. The continuous salinity data was recorded every 1 second during the nearly the same period as the velocity measurement, while the salinity was observed every 1 minute vertically at three layers; water depth of approximately 3 m, 4 m and 5 m.

3. Data Processing and Results

Analyses of turbulent velocity and salinity were carried out for all the field data (Chanson et al., 2005 and Yuk et al., 2005). For each velocity and salinity component, the signal was filtered with a high-pass filter

with a threshold; 0.2 Hz≦F for Fourier component frequency F. The vertical gradient of mean salinity $\partial\bar{s}/\partial z$, vertical salinity flux and K_z (the vertical eddy diffusivity) were also estimated (Yuk et al., 2005). Figure 1 illustrates the time series of wind speed, $\overline{u'w'}$, $\overline{v'w'}$, $\overline{w's'}$, $\partial\bar{s}/\partial z$, vertical salinity flux ($\overline{ws}$) and K_z during 2-4 of September 2005, where $\overline{u'w'}$, $\overline{v'w'}$, $\overline{w's'}$ and $\partial\bar{s}/\partial z$ are the average values of turbulent properties and the vertical salinity gradient respectively. When wind is strong, the salinity stratification is low, however turbulent properties, vertical salinity flux and K_z are large generally. Moreover in low salinity stratification, salinity flux seems to be downward. Figure 1 shows a roughly positive correlation between K_z and turbulent properties such as $\overline{u'w'}$, $\overline{v'w'}$ and $\overline{w's'}$. Vertical salinity flux is almost proportional to turbulent properties and K_z.

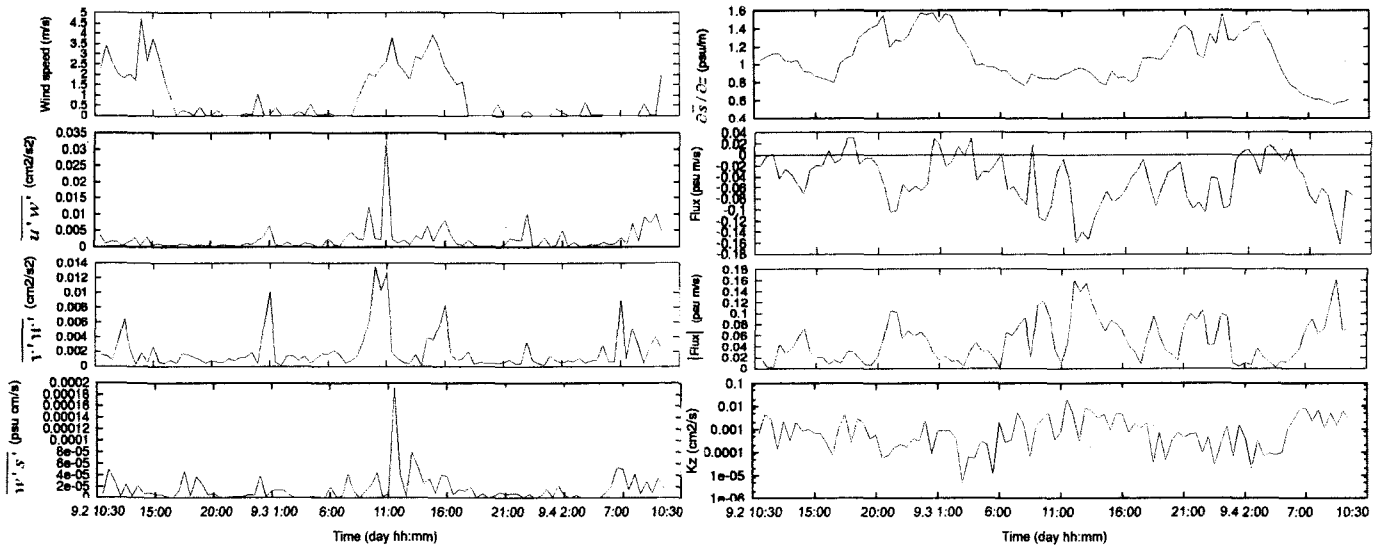

Figure 1. Temporal variation of wind speed, turbulent properties, $\partial\bar{s}/\partial z$, vertical salinity flux and K_z

4. Conclusions

Turbulent properties, vertical salinity flux and vertical eddy diffusivity are in inverse correlation to the degree of salinity stratification ($\partial\bar{s}/\partial z$). More systematic and continuous observation has to be conducted to discuss detailed properties of vertical mixing such as the eddy coefficients, flux and turbulent parameters which are influenced by strength of stratification and external disturbances.

Acknowledgements

This research was financially supported by the 21st Century COE program: Ecological Engineering for Homeostatic Human Activities.

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