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Turbulent transport process in atmospheric surface layer

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The organized motion or the coherent motion can be detected in wind tunnel and water channel experiments and those motions play an important role for the production of turbulent energy and transport of turbulent fluxes. Similar phenomena can be found in the atmospheric surface layer (Gao et al., 1989). The purpose of this study is to clarify the transport structure and process of turbulent fluxes, especially heat, water vapor and carbon dioxide. The organized motions are detected by using the wavelet transform analysis as well as the conventional statistical method such as Fourier spectral analysis. We consider the dependency of transport process by the organized motion to the atmospheric stability in the surface layer.

The observation was carried out at the test field of Shionomisaki Wind Effect Laboratory, where two sets of the combination of sonic anemometer thermometer and open path H_2O/CO_2 analyzer were mounted at 2m and 20m height.

The evident ramp and inverse ramp structures can be found in the time series of temperature, water vapor and CO_2 in the unstable stability, using the Mexican hut wavelet transform analysis. The co-spectral density in wavelet analysis is considered as the flux at each time scale. The large amount of fluxes is transported at the sudden decrease in scalar ramp structure and the sudden increase in inverse ramp structure in several tens of seconds. The scalar and vertical wind velocity are completely either in phase or out of phase, which means that the turbulent transport by the organized motion occurs at time scales of several tens of seconds.

The quadrant analysis of turbulent flux shows that the rate of the transport amount of scalar by ejection and sweep to the total transport flux increases according to the increase of the atmospheric stability. At 2m height, the transport by ejection is dominant in unstable condition, and that by sweep is larger in the stable condition. At 20m height, transport by ejection is larger than that by sweep in all stability condition.

The flux transport by the organized motions is evaluated quantitatively by using the several conditional analysis methods.

References:

Gao, W., R.H. Shaw and K.T. Paw u, 1989:Observation of organized structure in turbulent flow within and above a forest canopy., Boundary-Layer Meteorol., 47, 340-377.