Abstract

This technical report describes the direct outcome from the project entitled "Studies of energy exchange processes between the ocean-ground surface and atmosphere", which was sponsored by the Science and Technology Agency from 1985 to 1989. The energy exchange processes are not only important for driving the atmospheric and oceanic circulations but also play a crucial role in controlling the interactions between atmospheric and oceanic motions.

The main purpose of the present study is to clarify the energy exchange processes and to establish the basis for parameterization of these processes. The results of the study will contribute to elucidate the mechanism of the climatic change and to improve long-range weather forecast.

The present report consists of four chapters.

In Chapter 1, observational studies were made over a barley field in Hachiro-gata and over a complex terrain in the Musashi Hill Forest Park to investigate the air-land surface energy interaction.

The values of the Dalton and the Stanton numbers over the saturated barley field in Hachiro-gata were determined. A comparison with the direct flux measurements showed that the bulk parameterization by use of the Dalton and the Stanton numbers is suitable for estimating the evaporative flux over the saturated surface with vegetation.

The roughness height and the zero-plane displacement over the complex terrain in the Musashi Hill Forest Park were determined from the wind profiles obtained from captive balloon observations and the roughness parameters were parameterized with the standard deviation of the ground undulations.

The value of canopy flow index was determined from the wind profiles within the canopy. In addition, a simple estimation of evaporative flux by the Penman method was done from the continuous observations of temperature, humidity and wind velocities at the memorial tower in the Forest Park.

In Chapter 2, thirteen thermometers and two depthmeters on the mooring rope of the marine meteorological buoy which has been maintained by the Japan Meteorological Agency at (135E, 29N) were set in order to obtain long-term in-situ measurement of the flux variables (heat and momentum fluxes between ocean and atmosphere) which control seasonal and

interannual variations of oceanic and atmospheric circulations. The measurement data obtained were scarce due to the difficulty of maintaining a stable observation platform on the sea for more than a year.

The time series of water temperature thus obtained (every 90 minutes for 11 levels in the upper 500m layer) together with meteorological data for the two years and five months from April 1988 to September 1990 were analyzed. Temporal variations of energy and momentum fluxes and water temperature were also analyzed. Preliminary results of simulation of the water temperature variations driven by the observed flux data were shown.

In Chapter 3, convectively- and mechanically-driven mixed layers similar to those observed in the atmospheres and oceans were produced in a water tank, and their characteristics and energy transport were studied. A stable density stratification in the basic state was produced by heating (cooling) the top lid (bottom) of the water tank the sidewalls of which were coaxial cylinders. The convective mixed layer was produced by suddenly cooling the top lid, while the mechanical mixed layer by suddenly rotating the lid. Temperature and circumferential velocity were measured at 28 and 36 levels, respectively, at the mean radius of the water tank to obtain the time evolutions of their vertical profiles. The results of four experiments on the convective mixed layer and one experiment on the mechanical mixed layer are described.

In Chapter 4, numerical experiments and model revisions were made on the energy exchange processes between the atmosphere and the surface using the Meteorological Research Institute Atmospheric General Circulation Model (MRI • GCM). A case study of the 1983 early summer El Niño was performed to investigate the atmospheric response to the sea surface temperature anomalies. The accordance with the observation was satisfactory and the submodel of energy exchange between atmosphere and ocean seemed to offer no serious problems.

Sensitivity experiments on the surface albedo, including the albedo of snow, and the soil moisture were performed. The results showed the large sensitivity of the summer climate over the land surface to the albedo and soil moisture specifications. The specified albedo in the model was modified based on the existing observations. A multi-soil-layer model was also tested.