B-4.3 Detection of global warming evidence in Siberia
B-4.3.1 Climate Change and Transportation Model in Siberia

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Abstract

The increase of atmospheric greenhouse gases suppresses the radiative cooling and its effect to the climate is efficient in high latitude and continental area. The basic study of energy and water cycle in Siberia is important to evaluate this process. Here, the energy balance a over typical wetland in West Siberia and the transportation process in the temperature inversion layer have been studied. The ratio among the energy flow were 32, 45, 20% of the solar radiation are released by radiation, latent heat and sensible heat, respectively, and 3% may be used to increase the soil temperature in sunny days.

The formation of temperature inversion keeps the emitted trace gases in it, and the release it during the growth of turbulent transportation. By a turbulent boundary layer mode, the vertical profile of trace gases is simulated, and compared with the experimental results. The relative values of surface concentration of CH4, CO2 and O3 are well simulated but there are serious discrepancy between the observed and the model result in magnitudes.

Key Words Hydrology, Water cycle, Greenhouse gases, Siberia

1.Introduction

The increase of atmospheric greenhouse gases suppresses the radiative cooling and its effect to the climate is efficient in high latitude and continental area. Among the important processes which is not included in GCM is the planetary boundary process. The absorption and emission of greenhouse gases occur on terrestrial surface, and the transportation of them in the planetary boundary process should be studied both experimentally and by model calculation comparison.

2.Energy balance at wetland

In order to study the energy balance in wetland, the balloon experiment to measure the vertical profiles of meteorological variables and their diurnal change, the remote sensing of air temperature profile by use of passive microwave sensor, and the energy balance measurement by use of solar radiation, radiation balance, sonic anemometer and water level sensors have been performed in West Siberia wetland.

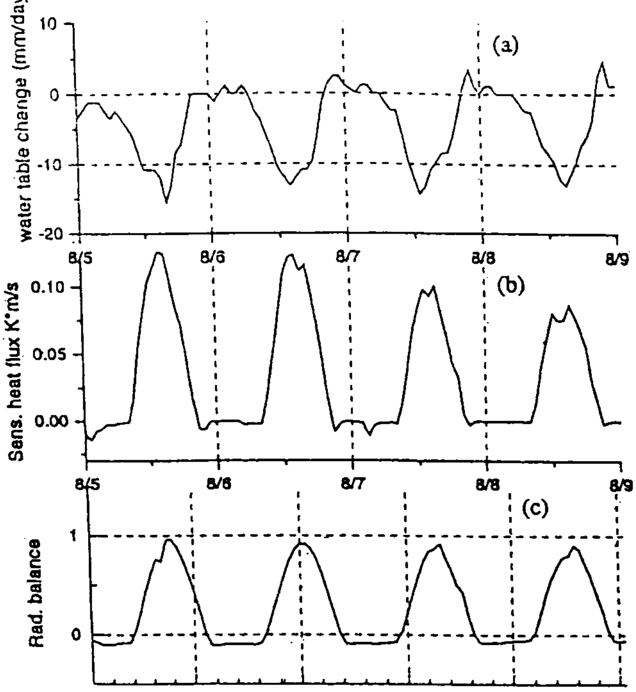

Fig. 1. Water level change, sensible heat flux and radiation balance observed in wetland. August 5 - 9 in 1995.

Fig.1 shows the diurnal variation of water level, sensible heat flux obtained from air temperature and vertical wind velocity co-variance by ultrasonic anemometer, and radiation balance in sunny days in August 5 to 9, 1995. The water level measured by sensitive pressure gauge decreased in day time but constant in night time, and the horizontal water flow is absent. The latent heat flux was calculated from this evaporation rate. The energy balance in a day is shown schematically in Fig.2.

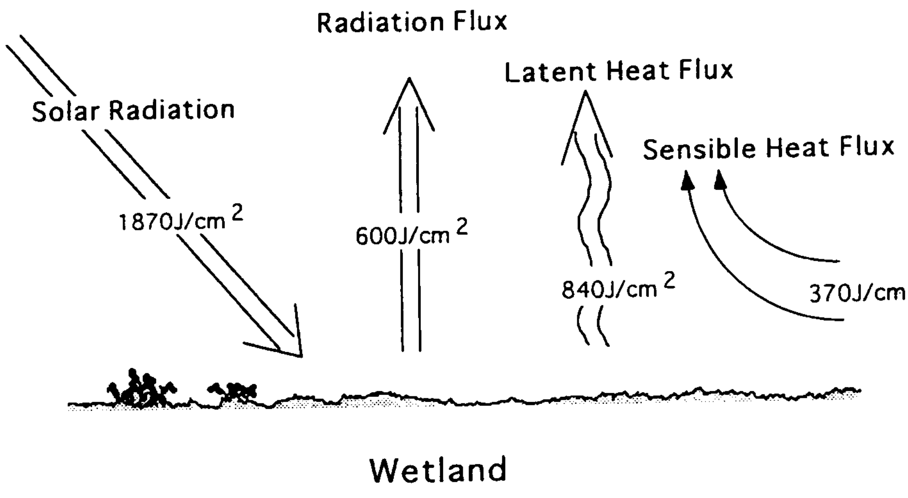

Fig.2. Daily energy flow in wetland on sunny days in summer.

3. Microwave temperature profile measurement

The microwave temperature profiler is developed by Central Aerological Observatory and improved by this group was used for the continuous measurement in July-August in 1995. The principle of operation is to measure the microwave radiation from water vapor which is in equilibrium with air temperature which is partially absorbed by oxygen. The radiation intensities from different zenith angle are obtained scanning the antenna, and the data is deconvoluted to obtain the vertical temperature profile assuming the horizontal homogeneity of atmospheric temperature, which is valid if there is no surface inhomogenity. This instrument works fully automatically and a typical diurnal change of potential temperature is shown in Fig.1. As the result of radiative cooling on surface after the sunset, the surface temperature decreases down to 9 ℃ at 7a.m. in local time; note that the local time is two hours earlier than the astronomical time. After the sunrise, the the surface air temperature comes to increase and the vertical mixing starts. As the result, the cooled air is transported to higher altitude and the temperature above 200m is lowest at around 11:00 a.m. The thermal convex is strong in the period from 11:00 a.m. to 18:00 p.m. but the surface temperature is higher and the atmosphere is unstable. The surface temperature again starts to decrease leaving the upper temperature high. The temperature inversion between 200 and 0 m is 5 degrees or more frequently.

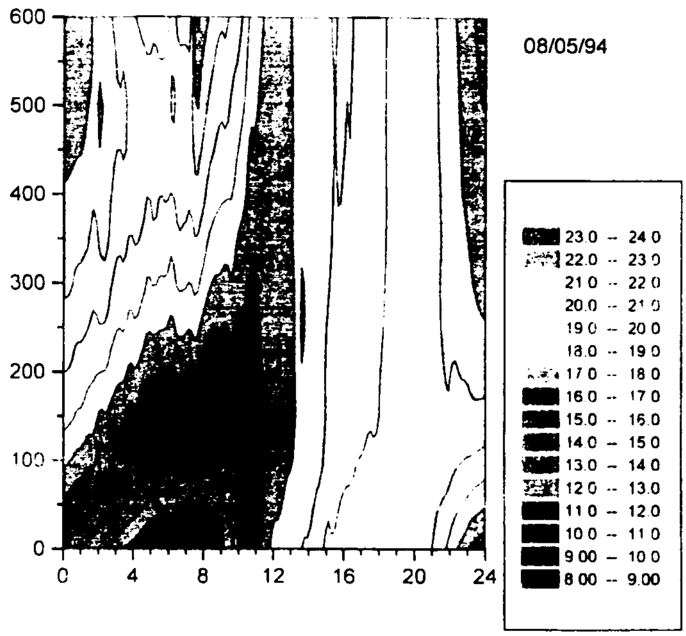

Fig.3. Potential temperature profile observed by microwave radiometer. Vertical axis is altitude in m, and horizontal is hour of a day. Data of sunny day, Aug.5, 1995, at Plotnikovo

4.Turbulent boundary layer model calculation of trace gases

The vertical concentration profile and the diurnal variation of concentration of trace gases emitted or decomposed on surface is a good tracer of vertical turbulent mixing. The problem to be solved is to simulate the inversion layer formation and destruction, and the temperature profile has been the unique parameter to compare with the observation. Here, we compared the model calculation of methane concentration profile and diurnal variation with the observation.

Turbulence parameters hear the ground were studied using the sonic anemometer data; wind components and temperature in the resolution of 10Hz. The eddy diffusivity coefficient for vertical transport of the momentum is calculated by the equation;

and the Monin-Obukhov length scale, L, friction velocity, u*, and wind stress, τ, are calculated by the following equations, where the necessary values are observed by sonic anemometer.

The estimated eddy diffusivity for momentum and the measured methane concentrations are shown in Fig.4. Very slow turbulent transport and high methane concentration perfectly match each other both in period and strength. The suppression of turbulent transport precedes to the increase of methane, and vise versa.

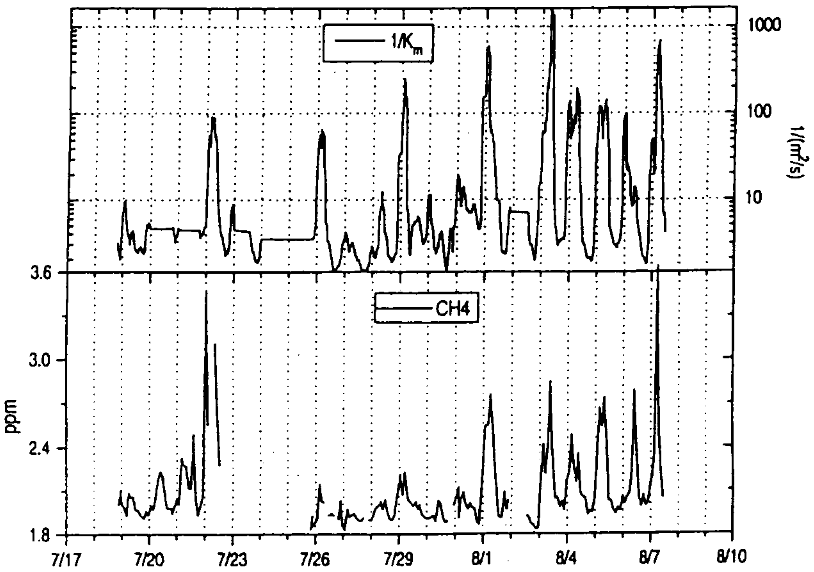

Fig.4. Eddy diffusivity for momentum and methane concentration at 5 m level.

The model simulation of nocturnal accumulation of methane by use of one dimensional model is shown in Fig.5. A surface temperature dynamics which drives model has been derived from a temperature difference between 0 and 400m. Geostrophic wind of 5.5m, surface roughness of 2cm, minimal vertical diffusivity of 0.2m2 s-1, the background methane concentration of 1.8 ppm, surface flux of 150 ppm m day-1, and deposition rate of 0. Instead of deposition rate, the relaxation time of methane, 2 days, was used which is ascribed to the horizontal transportation in practice. The temperature at 200m decreases mainly by radiative cooling and the gradient of temperature is smaller than the methane profile. The variation of methane concentration is simulated well but calculate result in Fig.5 is doubled in magnitude to fit the observation. The source of this discrepancy is not clear, either the flux is different or other model parameter is inadequate, and further study is necessary.

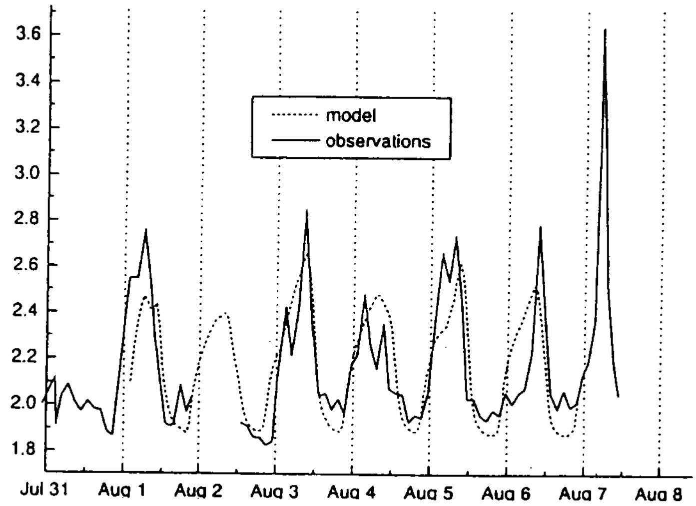

Fig. 5. Methane concentration observed at 5m above the surface (solid line) and the model calculation (the amplitude is doubled, broken line).

6. Conclusion

Energy flow in wetland was obtained on sunny days in summer.

The temperature profile was observed by microwave temperature profiler automatically, and it will be a powerful tool to understand the vertical transport process of emitted/absorbed trace gases.

Model calculation based on the turbulence parameters obtained by sonic anemometer simulated the diurnal and day to day variation of surface methane concentration, but further study is necessary for the quantitative simulation.