Open chamber system for measuring evaporation

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1. Introduction

Accurate estimation of evaporation has been important in various disciplines. For instance in meteorology, the water vapor cycle is of vital importance in understanding many physical processes in the atmosphere. In agricultural practice a minimum supply of water to crop can not be set without knowing how much water is evaporated. Chambers have been used in measuring evaporation for several decades. The errors related to evaporation measurements are caused mainly due to the alteration of natural profiles of turbulence, radiation, temperature and humidity. Thus it has become important to design a chamber that minimizes its' influence on natural condition. This paper describes the design of a new open chamber system for measuring evaporation and the accuracy of the measurements were carefully checked under both laboratory and field conditions.

2. Measuring equipment

Figure 1 schematically illustrates the open ventilated chamber system used for measuring evaporation. The evaporation measuring equipment is based on the idea that when an air stream is injected into the ventilated chamber, the flux from surface into the chamber increases the absolute humidity of the extracted air. A suction arrangement is used in passing the air through the system to avoid pump effects.

The system mainly consists of two units; an open chamber and a set of equipment for measuring evaporation, proposed by Mohamed et al.[1)] in 1997. The interior dimensions of the Perspex chamber are; length 120 cm, width and height 50 cm each. For relatively easy handling and transportation, the chamber is made of two 60 cm long sections which can be connected in the field. The uniqueness in this chamber is that it is open at its inlet. To sample the inflow air for its average relative humidity and temperatures, a small amount of air is sucked by a tubel arrangement at the open end as shown in Fig.1. A small pump is used in sucking air through the small tubes provided at the entrance of the chamber. All the tubes are connected to a small "box" type container, which is used to provide good mixing of air before it is measured for inlet relative humidity and temperature. As shown in the figure, the sampling arrangement is spread throughout the cross section of the chamber, facilitating sampling of the entire air profile at the inlet. The inlet has the same cross sectional area as the entire box, which will reduce the resistance to flow, while the system is under operation.

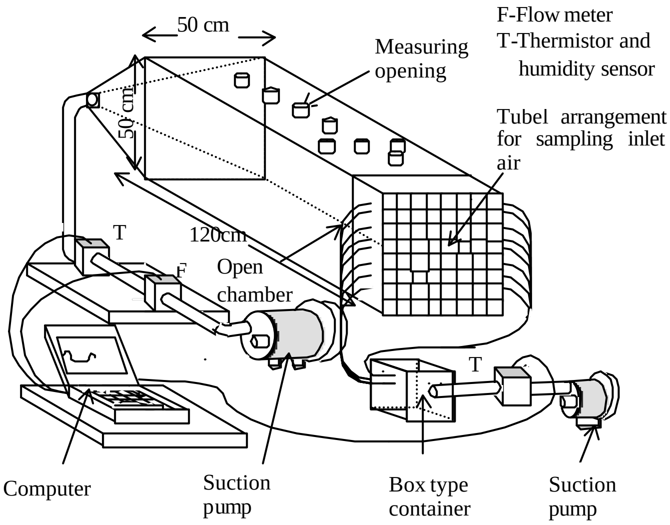

Fig.1. Schematic illustration of the new equipment for measuring evaporation

3. Accuracy control of the chamber

Accuracy of the entire system was checked in the laboratory by comparing the measured evaporation with weight losses recorded by a balance. Accuracy checks were made for different operating wind speeds in the chamber ranging from 0.05 ms^{-1} to 0.1 ms^{-1} in the laboratory. Figure 2 illustrates the results of the experiment carried out under an operating wind speed of 0.1 ms^{-1}. To investigate the accuracy of the new open ventilated chamber system under natural conditions, a field check was carried out in the premises of Saitama University. Under natural conditions, the evaporation was compared with the weight losses recorded by a balance at an operating wind speed of 0.09 ms^{-1} and the results are shown in Fig. 3. During the field check it was found that the evaporation measured by the equipment gives positive values during the daytime, while the nighttime ones being negative as shown in Figure 4. This variation might have caused due to the dew drop phenomena. Figures 5 and 6 give the transient change of temperature and relative humidity of inflow and outflow of the chamber during the field check respectively. It can be seen that the open chamber system can be well used under natural conditions.

4. Field experiment

A stand was established in the premises of Saitama University by cultivating a plant (radish), with a density of 4800 units/m^2 in sandy soil. The chamber was placed on the vegetated area and measurements were taken at an operating wind speed of 0.09 ms^{-1}. The diurnal variation of evapotranspiration and net radiation obtained during the experiment is given in figure 7 and 8 respectively.

Key words: Evaporation, Open chamber, Accuracy check
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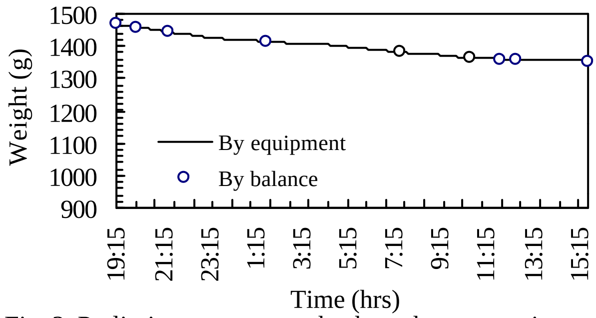

Fig. 2. Preliminary accuracy check on the new equipment in the laboratory

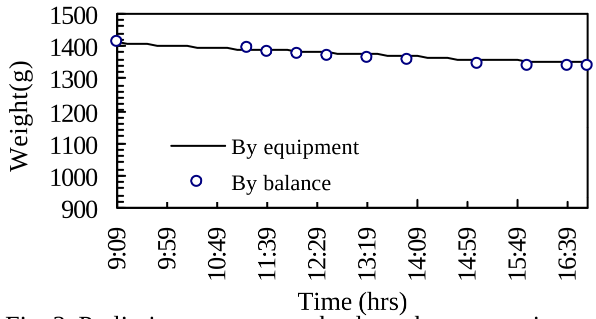

Fig. 3. Preliminary accuracy check on the new equipment in the field

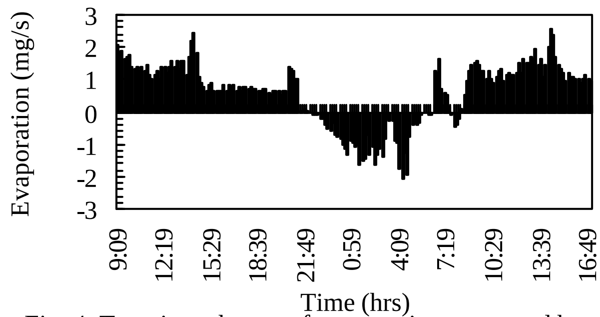

Fig. 4. Transient change of evaporation measured by the equipment during the field check

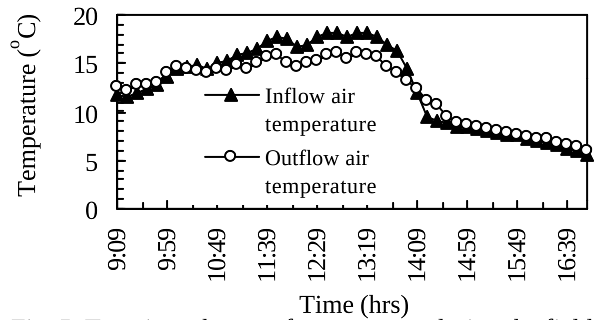

Fig. 5. Transient change of temperature during the field check

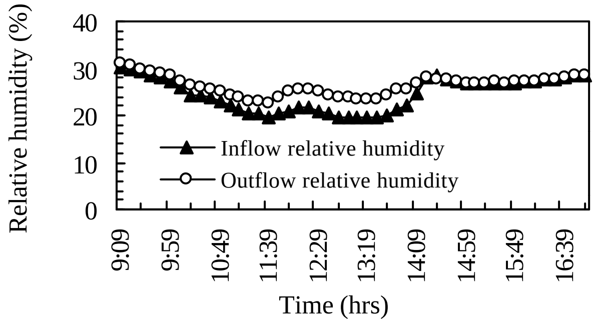

Fig. 6. Transient change of relative humidity during the field check

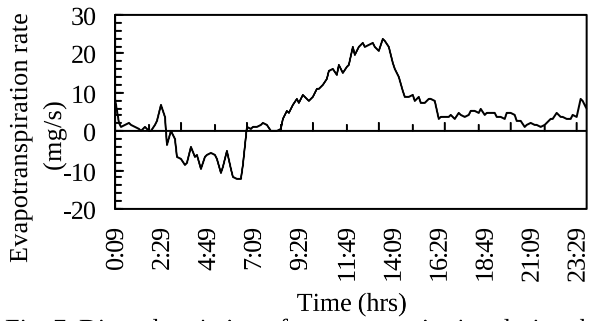

Fig. 7. Diurnal variation of evapotranspiration during the field experiment

5. Conclusions

Both laboratory and field tests on the open chamber system give an idea of the accuracy of the evaporation measuring system using an open chamber. Although an accurate measurement of pressure difference within and outside the chamber was not performed yet, rough measurements indicate that the pressure difference is almost zero. Evaporation measurements during the daytime were found to be positive while the nighttime ones gave negative values. This variation might have occurred due to the dew drop phenomena. The chamber might give better results if it is kept with good agreement with ambient conditions. The design with an open chamber seems to be a good compromise in constructing a system, which has minimal effect on natural conditions, hence on evaporation from the surface.

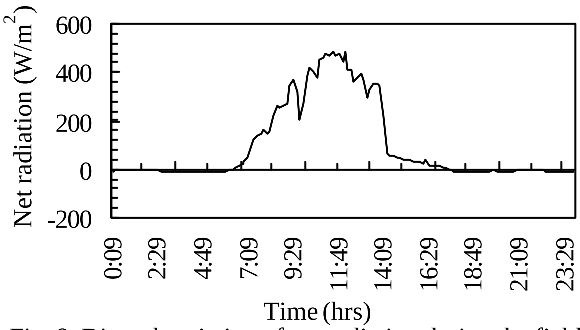

Fig. 8. Diurnal variation of net radiation during the field experiment

6. References

1) Mohamed A.A., Watanabe K., Kurokawa U., (1997): Simple method for determining the bare soil resistance to evaporation. *Journal of ground water Hydrology*, 39(2), 97-113