NOTES AND CORRESPONDENCE

**Comments on “Peculiar Downward Water Vapor Flux
over Gobi Desert in the Daytime,” By J. Wang and Y. Mitsuta
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Abstract

Wang and Mitsuta (1990) reported that a downward water vapor flux was observed in the daytime over the Gobi desert. The present author pointed out the importance of mean flow contribution to total water vapor flux due to air density fluctuation. The correction factor was estimated to be about –22 % to reduce the downward flux.

1. Introduction

Wang and Mitsuta (1990, hereafter WM) reported that a peculiar downward water vapor flux was observed over the Gobi desert during the daytime. This is based on eddy correlation flux measurement with a sonic anemometer and a thermocouple psychrometer as a pilot observation of HEIFE (Mitsuta, 1988). Furthermore, Wang and Mitsuta (1991) confirmed that the turbulence characteristics during POP (Pilot Observation Period) and PIOP (Pilot Intensive Observation Period) including downward water vapor flux in the daytime are consistent with Monin-Obukhov similarity.

Kobayashi and Shibata (1991) commented that evaporation from the Gobi should be “upward” based on the soil water content measurements. The present author tried to find a way to solve the problem.

2. Water vapor transports due to turbulence and mean flow

It is well known that vertical water vapor flux is expressed as follows

$$E = \overline{\rho'_v w'} + \overline{\rho_v} \bar{w} \quad (1)$$

where ρ_v and w are water vapor density and vertical wind velocity component, respectively. It is assumed that the second term is very small compared

to the first term, and usually neglected. WM had obtained the water vapor flux based on the first term only. However, Webb (1980) has pointed out that transport due to mean flow should be taken into account for the flux of minor constituents, such as CO₂ (or of water vapor as a special case). Ohtaki *et al.* (1989) had accounted for this contribution to CO₂ flux over ocean and they found that the mean flow contribution is large enough to change the direction of the transport.

Koprov (1986) also pointed out that the mean flow contribution to water vapor flux is important in the case of $|\lambda| \gg 1$, where $\lambda = (\overline{w'T'}/T)/(\overline{w'\rho'_v}/\rho)$.

The value of $\bar{w}$ (in mm/sec) can be obtained with Eq. (48b) of Webb *et al.* (1980).

$$\bar{w} = 0.541 \times 10^{-3} LE + 2.798 \times 10^{-3} H \quad (2)$$

where H and LE are sensible and latent heat fluxes in W/m². Typical values during the downward water vapor flux are given by WM as

$$H = 165.13 \text{ W/m}^2, \quad LE = -25.5 \text{ W/m}^2$$

at 11 hr Sept. 14. Then it is evaluated as $\bar{w} = 0.449$ mm/s (upward). The value of $\bar{\rho}_v$ does not appear in WM. However, it is estimated as 5 g/m³ from Wang and Mitsuta (1992). The latent heat flux contribution from the second term of Eq. (1) is evaluated as 5.5 W/m² ($L = 2440$ Joule/g at 25°C). This is about 22 % of the turbulent latent heat flux (–25.5

W/m^2). The total latent heat flux is evaluated as -20 W/m^2 , which is 78 % of the raw turbulent flux.

3. Conclusion

Downward water vapor fluxes were observed by WM over Gobi Desert in the daytime. This is a turbulent flux with eddy correlation method. However, mean flow contribution to total flux should be considered according to Webb *et al.* (1980). During the daytime, the mean flow flux is normally upward, which is the inverse of the present turbulent water vapor flux.

When it is applied to HEIFE typical data, the mean flow contribution was calculated as -22% of the raw turbulent flux. This is not so large as to invert the water vapor flux but it cannot be neglected when the flux is small, as in the present case.

WM also pointed out that 'humidity inversion' was observed during the period of downward water vapor flux. In the humidity inversion condition, water vapor flux can be estimated to be downward, but Webb *et al.* (1980) also commented that this kind of correction should be applied to the mean gradient method for flux estimation.

Even if the mean flow contribution is included, the water vapor flux is still downward (about -20 W/m^2), which is inconsistent with Kobayashi and Shibata (1991). However, this downward flux is mostly observed in a north-westerly wind. It is considered to be a advection effect from the oasis (moist surface) to the Gobi (dry surface), which is unique near the oasis-Gobi boundary. In this situation, downward water vapor flux and humidity

inversion can be observed. However, the application of this idea to a desert far from the boundary is doubtful. More detailed study, including simultaneous measurements near the surface, should be carried out.

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王 介民・光田 寧「ゴビ砂漠において昼間に観測された下向きの水蒸気輸送」
(気象集誌 68 卷 3 号, pp 399–402) に関するコメント

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