Role of Spaceborne Cloud Radar in Precipitation Physics

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The conversion rate from cloud water/ice to rain/snow water and the precipitation efficiency change largely depending on the horizontal scale and type of cloud systems as shown in Fig.1. Although many researchers have parameterized and estimated these values in their numerical models (e.g., Kessler, 1969; Ogura and Takahashi, 1971; Sasamori, 1975; Roads, 1978; Lin et al., 1983; Fovell and Ogura, 1988; Ikawa, 1988; Ferrier et al., 1996; Szeto et al., 1997), only a limited number of observational studies have reported these values (Braham, 1952; Newton, 1966; Auer and Marwitz, 1968; Dennis et al., 1970; Fankhauser, 1971; Foote and Fankhauser, 1973; Ogura and Cho, 1973; Yanai et al., 1973; Hobbs et al., 1980; Takeda and Natsuki, 1982; Fankhauser, 1988). Especially, there are no reports on global distribution of these values and their temporal change.

Rainfall/snowfall intensity, cloud water/ice amount and water vapor flux are necessary to calculate the conversion rate and the precipitation efficiency. Unfortunately, we cannot simultaneously measure these values by using any artificial satellites at the present moment. Figure 2 illustrates 0th order and qualitative global distribution of the conversion rate and the precipitation efficiency. Figure 2a and 2b show the global distribution of the ratio between SSMI(rain) and SSMI(cloud water) and that of the ratio between SSMI(cloud water) and SSMI(vapor). Here, SSMI(rain), SSMI(cloud water) and SSMI(vapor) mean 10-years (1986-1996) average of monthly mean rainfall rate, that of monthly mean cloud water amount, and that of monthly mean water vapor amount measured by SSMI (all data were provided by Remote Sensing Systems). The conversion rates within midlatitude cloud of northern hemisphere are comparable with those within cloud systems in ITCZ, and show seasonal change (winter maximum). Contrary to the conversion rate, the SSMI(cloud water)/ SSMI(vapor) ratio of midlatitude and highlatitude cloud systems is much larger than that of tropical cloud systems. These figures suggest that water vapor is more efficiently converted into cloud water and rainwater in mid- and high latitudes than in the tropical region.

The conversion rate and the precipitation efficiency depend not only on microphysical properties of clouds but also on multilayer structure of cloud systems, for example, the seeder-feeder process. Also, it is apparent that the exact estimation of the amount of snowfall both over the ocean and land is essential to study water and energy cycles in cold regions and their effect on climate. Therefore, the spaceborne cloud radar will undoubtedly contribute to estimate and deduce these values and properties.

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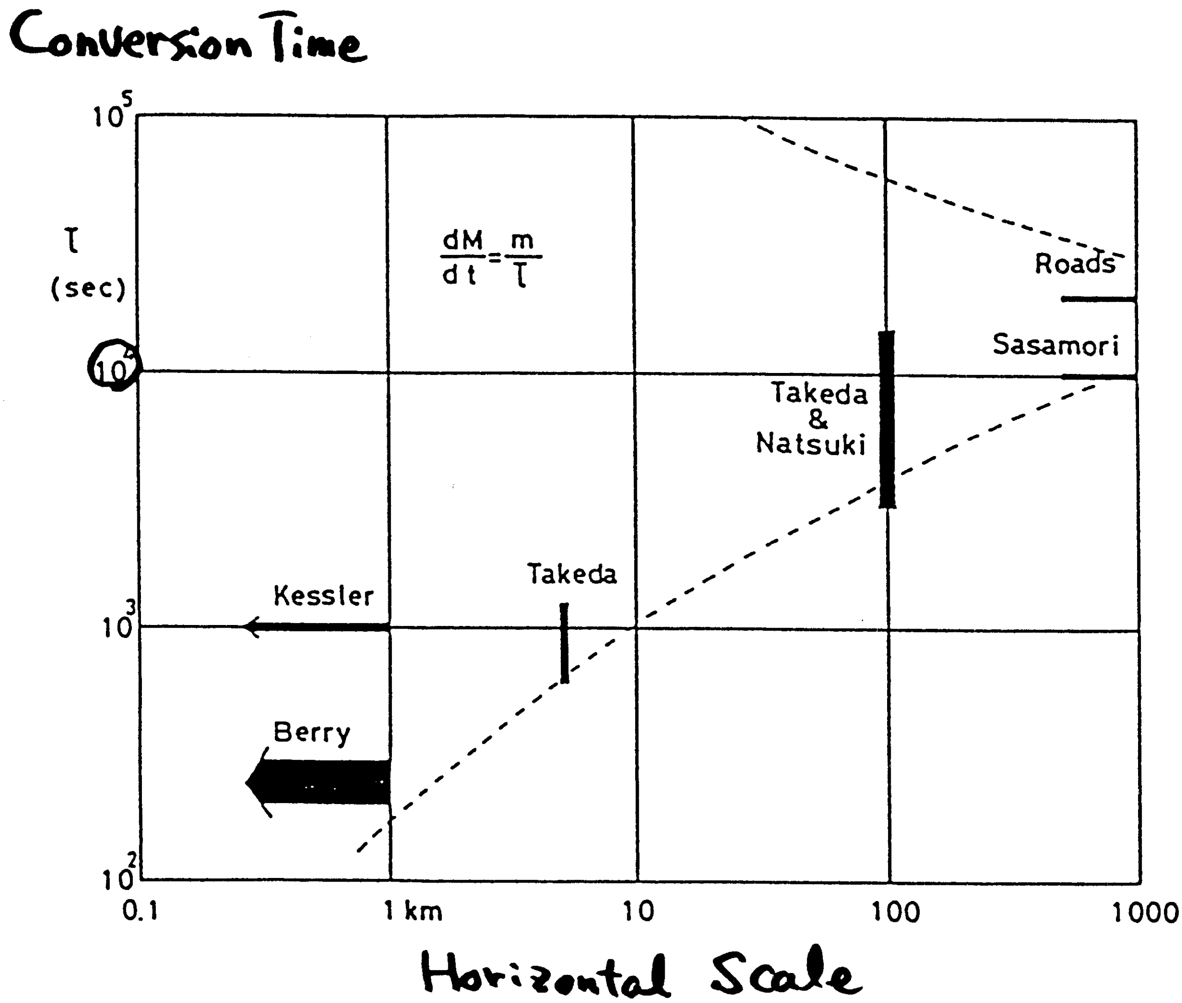

Conversion Time
10^5
τ
(sec)
$\frac{dM}{dt}=\frac{m}{\tau}$
Roads
Sasamori
10^4
Takeda & Natsuki
Takeda
Kessler
10^3
Berry
10^2
0.1
1 km
10
100
1000
Horizontal Scale

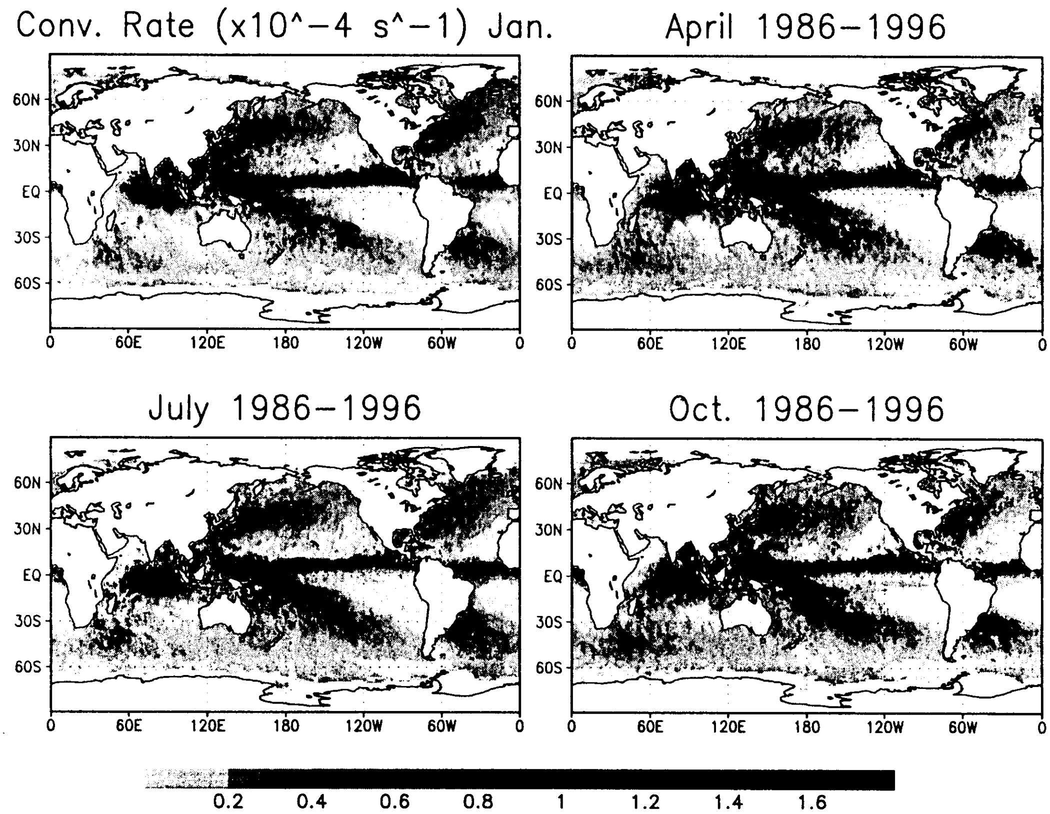

Figure 1: Conversion time (s) corresponding to horizontal scale of phenomena (Takeda et al., 1990)

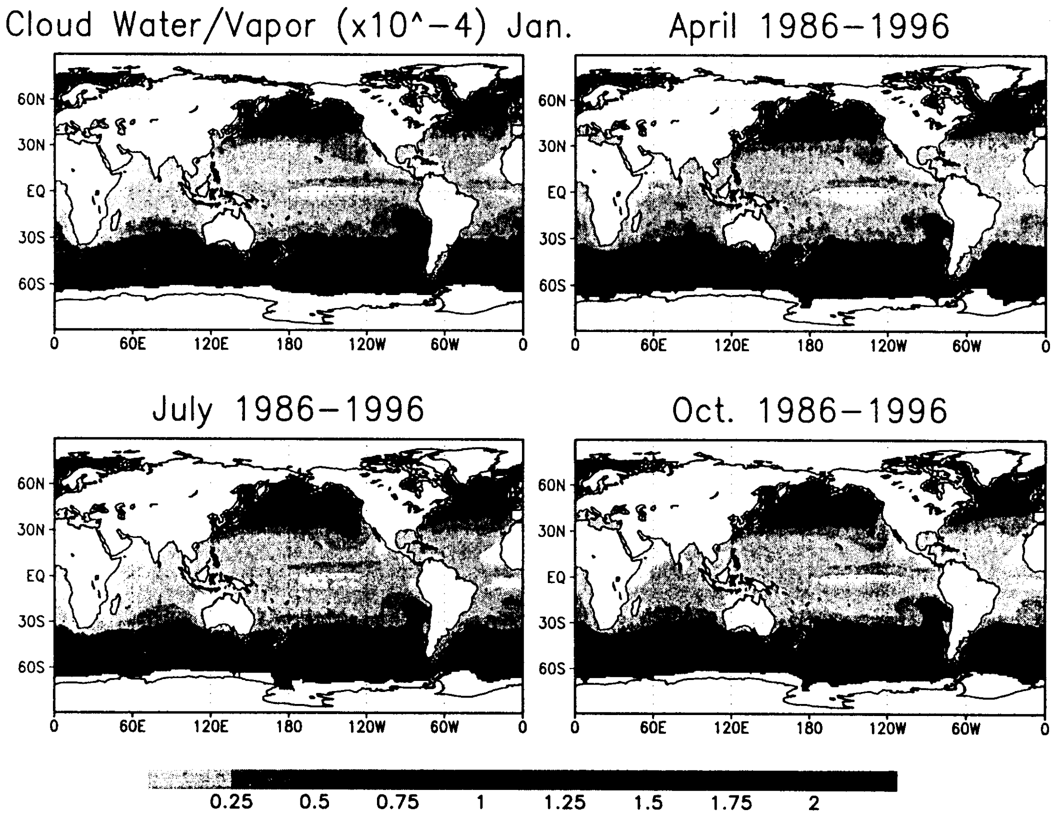

Figure 2: The global distribution of the ratio between SSMI(rain) and SSMI(cloud water) (2a) and that of the ratio between SSMI(cloud water) and SSMI(vapor) (2b). All data were provided by Remote Sensing Systems.