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Cirrus Cloud Radiative Forcing at the top of Atmosphere using the Nighttime Global Distribution with the Microphysical Parameters derived from AVHRR

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The radiative effect of cirrus clouds is particularly ambiguous in the climate research. Cirrus clouds exist in a very high altitude with ice cloud particles that are almost transparent to solar radiation despite the fact that some extent of infrared radiation from the Earth is absorbed according to their microphysical properties. Therefore, they are thought to have a warming effect on the climate of the Earth (IPCC 2007). However, it is not actually settled yet how much warming or cooling is caused by their radiative effect because their microphysical properties (i.e. cloud optical thickness, ice particle size, shape, etc.) and physical conditions (i.e. cloud temperature, geometrical structure, etc.,) still remain uncertain. For these reasons, cirrus clouds have become one of the most important research targets in understanding the Earth's radiative budget and the Earth's climate system (Charlock and Ramanathan 1985; Baker 1997; Ramanathan 1987; Hansen et al. 1998; Ramanathan et al. 1989).

We simulated global cirrus cloud radiative forcing (CRFci) distributions at the top of the atmosphere (TOA) using cirrus cloud microphysical parameters: cirrus cloud effective radius (Reci), cirrus cloud optical thickness (COTci), and cirrus cloud top temperature (CTTci), retrieved from AVHRR nighttime data (Katagiri and Nakajima 2004). This study shows that cirrus clouds warm the atmosphere. Cirrus clouds over the tropics, especially, produce a large warming effect. TOA cloud radiative forcing (CRF) of the entire cloud system, on the other hand, has a negative value caused by the significant cooling effect of optically thick clouds.

Reci, COTci and CTTci were obtained by the nighttime AVHRR data analysis (Katagiri and Nakajima, 2004). They were used for CRFci calculations.

In this study, we used the radiative transfer model, "mstran", for the radiative flux calculations. This code is used in the AORI/NIES MIROC GCM for calculation of the radiative transfer. The mstran model adopts a k-distribution method with a two-stream method (Nakajima et al. 2000) in which an 18-band channel is subdivided into 6 sub-channels with a wavelength range from 0.2 μm to 200 μm. We calculated CRFci with the horizontal spatial resolution of 2.5° x 2.5° longitude-latitude grids using the global distribution of Reci, in which cirrus cloud particles were treated as spherical with side scattering increased to emulate random oriented non-spherical ice particles with halo-like phenomena. The cirrus clouds amounts of 2.5° x 2.5° grid were assumed to be 100%, because cirrus clouds broaden enough, although cirrus clouds have heterogeneous COTci.

We computed CRFci dependency on Reci, COTci, and CTTci to examine its behavior, and found that cooling effects occur with clouds when their COTci is larger than 5 with a CTTci of 220 K, and 2.5 with a CTTci of 235 K, and their effects almost independent of Reci in the nighttime. Furthermore, we studied CRFci in April 1987, an El Niño year, and 1990, a neutral year, and found that a larger amount of cirrus clouds appeared in the tropics off Peru in 1987 than in 1990. But the globally averaged net cloud radiative forcing was smaller by 0.55 W/m2 in 1987 than in 1990.