Geophysical Research Abstracts
Vol. 15, EGU2013-3494-1, 2013
EGU General Assembly 2013

Spatial distribution of cloud overlap parameter: assessment based on satellite data

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Assumptions on cloud overlap implemented in a climate model may affect markedly modeled radiative fluxes. To increase the ability of climate models to simulate the real climate, it is preferable to know the value of the cloud overlap parameter α which is a measure of the relative weight of maximum (α = 1) and random (α = 0) overlap. This parameter may be used to diagnose relative contribution of convective and stratiform cloudiness to total cloud fraction.

Here we present an estimat of geographical distribution of α derived from up-to-date satellite observations. To assess values of total cloud fraction, we used cloud masks CERES and MODIS, which both are based on multispectral passive observations from Aqua satellite (CERES SSF product and MODIS collection 5.1). Active CALIOP lidar observations were used to evaluate cloud fraction at different levels (CALIPSO-GOCCP dataset). Cloud overlap parameter α was calculated by merging passive and active satellite datasets. Only monthly means for 2006-2010 were used in these calculations.

The most prominent annual cycle of α is noted in the monsoon regions where α is close to 1 in winter and almost 0 in summer. For CERES total cloud fraction, α is equal to 0.36 in July (0.38 in January) for the entire Earth, it is 0.39 (0.44) in Northern Hemisphere and 0.33 (0.33) in Southern Hemisphere. Values of α are lower when MODIS total cloud fraction is used: global annual mean α is 0.37 for CERES and 0.25 for MODIS.

We found that α is linearly dependent on total cloud fraction in most regions, except in the southern tropics. The maximum cloud overlap (α is close to 1) is associated with small values of cloud fraction and occurs in subtropical highs over the ocean and in subtropical and polar deserts over land. On the other hand, the random cloud overlap (α is close to 0) occurs in regions with large values of cloud fraction (e.g. ITCZ and midlatitudinal storm tracks). Moreover, we found that vast regions of the Southern Ocean (around 60S) are characterized by negative values of α, mostly in summer. Presumably, an assumption of the minimum overlap of cloud layers should be used in these regions due to strong baroclinic instability and horizontal shift of cloud layers.

The work has been supported by the grant of the RF President MK-3259.2012.5 and by the Russian Foundation of Basic Research under grant 12-05-00972.