Climatology of satellite-derived cloud overlap parameter

Chernokulsky A.V., Eliseev A.V.
A.M. Obukhov Institute of Atmospheric Physics RAS
a.chernokulsky@ifaran.ru

Clouds are the main source of the uncertainties in modern global climate models (GCMs) [IPCC, 2007]. Different assumptions on cloud overlap implemented in a climate model may affect markedly modeled radiative fluxes [Barker et al., 1999]. Even small biases in fractional cloud cover can lead to substantial differences in climate feedbacks among global climate models [Clement et al., 2009].

For increasing 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 identified following by [Hogan and Illingworth, 2000]: $\alpha = (C_{true} - C_{rand})/(C_{max} - C_{rand})$, where C_{true} is real cloud cover value, C_{rand} is cloud cover obtained assuming random overlap and C_{max} is cloud cover obtained assuming maximum overlap. Thus, α can treated as a measure of the relative weight of maximum (α = 1) and random (α = 0) overlap.

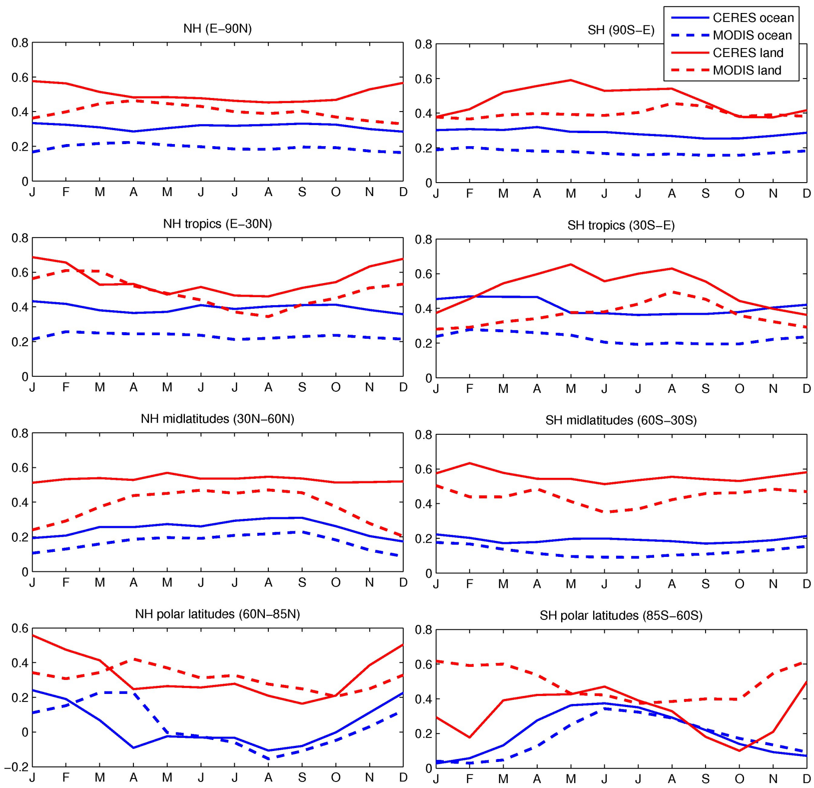
To estimate climatology of α we used quasi-simultaneous satellite observations from A-Train Aqua and CALIPSO satellites [Chernokulsky and Eliseev, 2012]. Values of C_{true} were evaluated based on results of MODIS and CERES algorithms. Joint usage of CERES and MODIS data allow us to estimate the results' sensitivity to the initial data uncertainty. CALIPSO-GOCCP data were used to estimate cloud cover on different level and to compute values of C_{rand} and C_{max}. Monthly means for 2006-2010 were used.

Cloud overlap parameter α derived from global annual means of C_{true}, C_{rand} and C_{max} is varied between 0.36 (for CERES C_{true}) and 0.26 (for MODIS C_{true}) (Table 1). It is smaller over the ocean and higher over land. This comes from prevailing random-overlapped stratiform clouds over the ocean and maximum-overlapped convective clouds over land. Thus, α may be used to diagnose relative contribution of convective and stratiform cloudiness to total cloud fraction. In general, annual cycle of α is larger over land than over the ocean (Fig. 1) because of convective processes activation over land during summer and increasing α. 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.

Table 1. Values of α derived from global and hemispheric means of C_{true}, C_{rand} and C_{max}. First value of α is based on CERES C_{true}, the second one is based on MODIS C_{true}.

		Annual	January	July
Global	Land+Ocean	0.36 / 0.26	0.38 / 0.24	0.36 / 0.25
	Only land	0.49 / 0.40	0.51 / 0.37	0.48 / 0.40
	Only ocean	0.30 / 0.18	0.32 / 0.18	0.30 / 0.17
Northern Hemisphere	Land+Ocean	0.40 / 0.27	0.44 / 0.25	0.39 / 0.29
	Only land	0.50 / 0.40	0.58 / 0.36	0.46 / 0.40
	Only ocean	0.31 / 0.18	0.33 / 0.17	0.32 / 0.18
Southern Hemisphere	Land+Ocean	0.32 / 0.22	0.33 / 0.23	0.33 / 0.21
	Only land	0.47 / 0.40	0.38 / 0.37	0.54 / 0.40
	Only ocean	0.29 / 0.18	0.30 / 0.19	0.28 / 0.16

We found that α is linearly dependent on total cloud fraction in most regions, except in the southern tropics ocean. 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 (Fig. 2). On the other hand, the random cloud overlap (α is close to 0) occurs in regions with high 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.

Figure 1. Annual cycle of α for different regions.

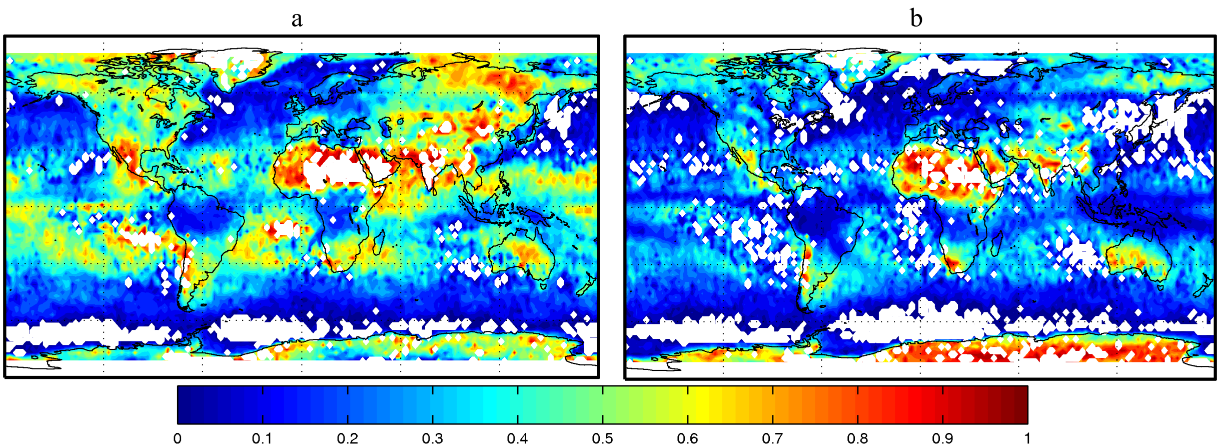


Figure 2. Climatology of α derived from annual means of C_{rand} , C_{max} and C_{true} (CERES (a) and MODIS (b)) (regions with α less than 0 and more than 1are blanked) .

References

1. Barker, H. W., G. L. Stephens, and Q. Fu. (1999). The sensitivity of domain-averaged solar fluxes to assumptions about cloud ge- ometry. *Quart. J. Roy. Meteor. Soc., 125*, 2127–2152.
2. Chernokulsky A.V. and Eliseev A.V. Assessing spatial distribution of cloud overlap parameter from satellite data. Abstracts of 3rd International Conference on Earth System Modelling. Hamburg, Germany. 2012. Abstract No 3ICESM-305.
3. Clement, A., Burgman, R., & Norris, J. R. (2009). Observational and Model Evidence for Positive Low-Level Cloud Feedback. *Science, 325* (5939), 460-464.
4. IPCC: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change *(Solomon S., Qin D., Manning M. et al., Eds.)*. Cambridge: Cambridge University Press, 2007. 996 pp.
5. Hogan, R. J., & Illingworth, A. J. (2000). Deriving cloud overlap statistics from radar. *Quart. J. Roy. Meteor. Soc.*, *126*, 2903–2909.