Geophysical Research Abstracts
Vol. 19, EGU2017-15209, 2017
EGU General Assembly 2017

The Link between Ice Crystal Complexity and Light Scattering Properties in Tropical Cirrus

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Cirrus clouds contribute to Earth's energy budget by scattering and absorbing solar radiation. However, the magnitude and even the sign of the cirrus radiative forcing are still under debate. The cirrus radiative forcing is strongly dependent on the ice crystal shape, size and degree of complexity. Decades of in-situ measurements have given information on the size and shape of ice crystals, but direct measurements of ice crystal complexity are largely missing. Yet, modeling studies have shown that adding complexity to ice crystal optical models significantly changes the scattering properties of ice crystals and can lead to enhancement of the cloud albedo effect.

In this contribution we discuss the first direct in-situ measurements of ice crystal complexity together with simultaneous measurements of cloud angular light scattering properties in tropical cirrus. The results have been gathered during the German-Brazilian cooperative aircraft campaign ACRIDICON-CHUVA over the Amazonas in September/October 2014. We found out that in convective outflows formed over polluted regions large-scale crystal complexity is enhanced through formation of aggregated ice particles. Small (sub-50 μm) ice particles were observed in large numbers in all probed cirrus clouds. These small ice particles were shown to have a large degree of small-scale complexity. The high degree of both small- and large-scale crystal complexity resulted in uniform ensemble angular light scattering properties of the measured cirrus clouds independent of their origin (in-situ or outflow) or pollution grade. A smooth and featureless scattering phase function with high fraction of backward scattering (low asymmetry parameter) was identified for the measured tropical cirrus clouds.