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How small is a small cloud?

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Abstract. The interplay between clouds and aerosols and their contribution to the radiation budget is one of the largest uncertainties of climate change. Most work to date has separated cloudy and cloud-free areas in order to evaluate the individual radiative forcing of aerosols, clouds, and aerosol effects on clouds.

Here we examine the size distribution and the optical properties of small, sparse cumulus clouds and the associated optical properties of what is considered a cloud-free atmosphere within the cloud field. We show that any separation between clouds and cloud free atmosphere will incur errors in the calculated radiative forcing.

The nature of small cumulus cloud size distributions suggests that at any resolution, a significant fraction of the clouds are missed, and their optical properties are relegated to the apparent cloud-free optical properties. At the same time, the cloudy portion incorporates significant contribution from non-cloudy pixels.

We show that the largest contribution to the total cloud reflectance comes from the smallest clouds and that the spatial resolution changes the apparent energy flux of a broken cloudy scene. When changing the resolution from 30 m to 1 km (Landsat to MODIS) the average "cloud-free" reflectance at 1.65 μm increases from 0.0095 to 0.0115 (>20%), the cloud reflectance decreases from 0.13 to 0.066 (~50%), and the cloud coverage doubles, resulting in an important impact on climate forcing estimations. The apparent aerosol forcing is on the order of 0.5 to 1 Wm^{-2} per cloud field.

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