How does cloud overlap affect the radiative heating in the tropical upper troposphere / lower stratosphere?

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The Tropical Troposphere Layer (TTL) is the transition zone between the troposphere and the stratosphere in the tropical region. The TTL can extend for several kilometres and it is through the TTL most of the upward transport from the troposphere into the stratosphere takes place. Several mechanisms are believed to play an active role in the transport from the troposphere to the stratosphere whereof cirrus clouds in and around the TTL is one of them. By radiatively heating the air in the TTL the cirrus clouds can support the upwelling motion of the air masses.

Depending on season and location, about 10-20% of all cirrus clouds in the tropics has its cloud top in the TTL and can, therefore, induce radiative heating in the transition zone. However, most of the cirrus clouds are not present as single layer cloud but has one or several cloud-layers beneath. If the underlying cloud-layer is optically thick and has a sufficient cold cloud top it can alter the radiative effect of the cirrus cloud. The radiative heating usually produced by cirrus clouds can instead turn into radiative cooling. Cloud types with sufficiently high optical thickness and low cloud-top temperature to cause such cooling could be altostratus, nimbostratus, or deep convective clouds.

Global observations of the cloud overlap have previously been difficult, but have lately made possible by deployment of satellites with active sensors, such as cloud radar (CPR-CloudSat) and lidar (CALIOP-CALIPSO). In light of this, our study aims to provide observationally based insights of the radiative impact of cloud overlap in the tropical TTL. We quantify the net radiative heating resulting from cirrus clouds in the TTL for both single layer cirrus and cirrus clouds under overlap condition. Furthermore, we investigate the role of optical depth and physical properties of both the cirrus cloud and the underlying cloud plays.

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