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Large-scale influences on the behavior of subtropical stratocumulus clouds

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In the American and African monsoon systems, the typical upper-level anticyclone/low-level heat low structure is accompanied by ascent to the east, where convective and subtropical convergence zones develop, and subsidence to the west over the cool waters of the eastern Pacific and Atlantic Oceans. In these subsidence regions, stratocumulus decks provide a radiative heat sink to the tropical atmosphere. Thus, marine subtropical stratocumuli play an important role in the global climate.

Despite the link with the monsoon systems mentioned previously, the seasonal cycle of stratocumulus incidence in the southeastern tropical Pacific and Atlantic does not peak during austral summer. The present paper examines the reasons for this behavior, with an emphasis on the role played by orography in adjacent continents.

Our approach uses an uncoupled atmospheric general circulation model that produces a realistic simulation of stratocumulus. In two sets of experiments we isolate the influence of the South American and African mountains by comparing control and no-orography simulations. In both cases the removal of orography results in a decrease of marine stratocumulus incidence to the west, with the largest differences in austral winter. The continental orography, therefore, contributes significantly to determine the seasonal cycle of stratocumulus decks in the southeastern tropical Pacific and Atlantic.

An analysis of the results reveals that the control simulation produces higher static stability in the lower troposphere over both the southeastern tropical Atlantic and Pacific, albeit by fundamentally different mechanisms. In the former case, the relatively low African mountains induce an anticyclonic circulation centered over the continent at low levels. Over the southeastern Atlantic, this anticyclonic circulation is associated with warm horizontal advection and increased stability of the lower troposphere. In the Pacific case, on the other hand, the high and steep Andes Mountains divert impinging midlatitude westerlies along the South American coast. In the stratocumulus region at surface levels, this leads to cold horizontal advection; at higher levels it leads to subsidence warming as the air sinks equatorward and approximately along the sloping isentropes. Both effects increase the stability of the lower troposphere.