Shortwave Absorption in Tropical Clouds

Contributors
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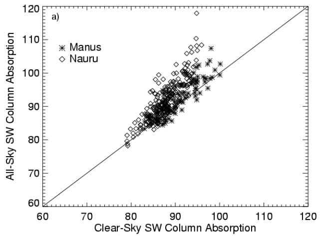
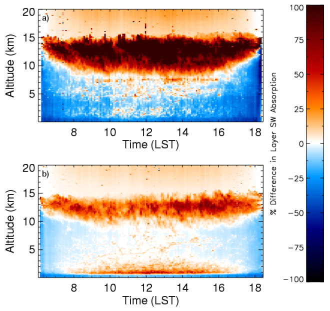
Research Highlight
Radiative heating by clouds is an important component of the total diabatic heating of the atmosphere. Although the radiative effects of clouds on the Earth's energy budget are most readily observable by examining top-of-atmosphere (TOA) and surface fluxes, their direct effect on the atmospheric circulation is through the redistribution of energy vertically in the atmosphere, which has important impacts on local and large-scale atmospheric dynamics. Although measurements of TOA and surface fluxes enable calculation of the total amount of absorption in the column, understanding how clouds act to redistribute energy within the atmospheric column requires measurements of clouds at high vertical and temporal resolution. Using radar observations of cloud properties at the ACRF TWP sites of Manus and Nauru, we calculate estimates of the vertical distribution of solar absorption in the tropical atmosphere.

In this study, we focus on examining changes in the shortwave absorption in the tropical atmosphere associated with the vertical structure and diurnal variability of observed clouds. Clouds can affect the shortwave (SW) column absorption in 3 ways: 1) cloud particles can absorb SW radiation, with the amount of absorption depending strongly on particle composition and particle size; 2) multiple scattering within a cloud can increase the effective water vapor path length and water vapor absorption within the cloud; and 3) SW radiation reflected from the top of a cloud can increase (decrease) the effective water vapor absorption path length if the cloud top is lower (higher) than the majority of the column water vapor.

Although the observed clouds can significantly affect the calculated SW absorption at an instantaneous point in time, clouds produce little change in the daily-average column-integrated absorption at Nauru and Manus. The reason for the small effect on the average absorption is due to the fact that low-level clouds exist $<$ 50% of the time at both sites. The existing low-level clouds may be optically thin (average LWP = 129 g/m2 at Manus and 40 g/m2 at Nauru) and the frequent presence of overlying ice clouds, which reduce the column water vapor absorption by reflecting incoming SW radiation. However, clouds do have a significant effect on the vertical and diurnal variability of SW absorption at Nauru and Manus.



Daily average all-sky and clear-sky calculated SW column absorption at Manus and Nauru. On average, there is little difference in absorption between the all-sky and clear-sky conditions because of the compensating effects of low clouds (which increase column absorption by particle absorption) and high clouds (which decrease absorption by tropospheric water vapor because of reflection of SW at cloud top).



Clouds do strongly influence the average vertical distribution of SW absorption in the column. The figure shows the average percentage change in (45 m thick) layer shortwave absorption due to clouds at a) Manus and b) Nauru. Although they have similar frequency of low clouds, Nauru shows more absorption in the lower troposphere than Manus due to a lower frequency of cirrus clouds, permitting more SW to be absorbed by the column water vapor and low-level clouds.

Reference(s)

McFarlane, S.A., J.H. Mather, T.P. Ackerman, and Z. Liu, 2008, Effect of clouds on the vertical distribution of SW absorption in the Tropics. J. Geophys. Res., in press.

Working Group(s)
Radiative Processes

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