Seasonal Variation of the Physical Properties of Marine Boundary Clouds

Research Highlight

Marine boundary layer (MBL) clouds can regulate significantly the sensitivity of climate models, yet currently they are simulated poorly. This study aims to characterize the seasonal variations of physical properties of these clouds and their associated processes by using measurements from the Atmospheric Radiation Measurement (ARM) mobile facility (AMF) at Point Reyes, reanalysis products, and several independent satellite data sets (International Satellite Cloud Climatology Project [ISCCP], Clouds and the Earth's Radiant Energy System–Moderate Resolution Imaging Spectroradiometer [CERES–MODIS], Geoscience Laser Altimeter System [GLAS], and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation [CALIPSO]). These properties include the MBL cloud-top and cloud-base heights, cloud thickness, the degree of decoupling between clouds and MBL, and inversion strength off the California coast.

ARM data from the AMF Point Reyes deployment are used to validate an algorithm of deriving cloud-top and inversion height from satellite measurements off the California coast. This enabled the construction and synthesis of the cloud macrophyical properties and their seasonal variations.

The main results from this study are as follows: (1) MBL clouds over the northeast subtropical Pacific are more prevalent and associated with a larger in-cloud water path in the summer than in winter. (2) The cloud-top and cloud-base heights are lower in the summer than in the winter. (3) Although the lower-tropospheric stability of the atmosphere is higher in the summer, the MBL inversion strength is only weakly stronger in the summer because of a negative feedback from the cloud-top altitude. Summertime MBL clouds are more homogeneous and are associated with lower surface latent heat flux than those in the winter. (4) Seasonal variations of low-cloud properties from summer to winter resemble the downstream stratocumulus-to-cumulus transition of MBL clouds in terms of MBL depth, cloud-top and cloud-base heights, inversion strength, and spatial homogeneity. (5)The observed variation of low clouds from summer to winter is attributed to the much larger seasonal cooling of the free-tropospheric air temperature than that of the sea surface temperature. These results provide a test case to understand and simulate the marine boundary layer clouds in climate models.

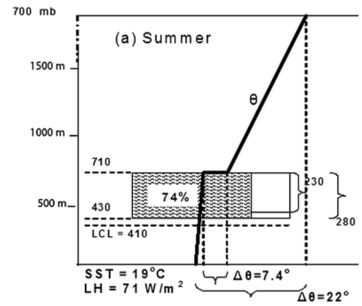

Image (a). Seasonal contrast of marine boundary-layer clouds between (a) summer (above) and (b) winter (below) off the California coast. Shown are cloud amount in the shaded box, cloud top and base heights and lifting condensation level (LCL) to the left, and cloud thickness and adiabatic liquid water thickness to the right of the cloud box.

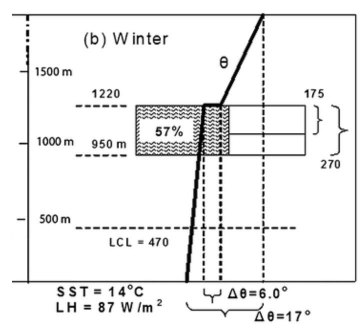

Image (b). The thick lines in both images represent vertical profiles of potential temperature. Shown at the bottom are SST, latent heat flux (LH), lower-tropospheric stability, and inversion strength.

Reference(s)

Lin W, M Zhang, and N Loeb. 2009. "Seasonal variation of the physical properties of marine boundary layer clouds off the California coast." Journal of Climate, 22, doi:10.1175/2008JCLI2478.1.

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Working Group(s)

Cloud Modeling, Cloud Properties