Using Multiple Instruments to Better Understand Wind Profiler Observations of the Stratocumulus-Topped Marine Boundary Layer

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Introduction

Clouds affect Earth’s energy budget as they reflect, absorb, or emit solar and terrestrial radiation. Of particular interest are marine stratocumulus (Sc) clouds because of their dynamic and persistent coverage near western coasts of continents. The enigmatic structure and life cycle of the stratocumulus cloud deck in the subtropical Pacific Ocean (Figure 1) plays a critical role in the dynamics of the ocean-atmosphere system as well as in the global energy balance (Harrison et al., 1999). The tops of marine Sc, to a first approximation, coincide with the top of the marine boundary layer (MBL). Both the height of the MBL and the thickness of the Sc vary in space and time and these values are dependent on the vertical structure of the atmosphere as well as radiative processes within the atmosphere. Unfortunately both the height and thickness of the Sc are poorly monitored by satellites. In

Data

The data used in this research was collected during cruises conducted in part of the Five American Climate Study (5ACS). Wind profiler radars, columnar, and radiometer along with other instruments were deployed on the R/Vs Ronald H. Brown (Fall) and Ko Ma Mi (Spring) cruises in the east Pacific Ocean during the fall of 2003 and during the spring in the southern Pacific in 2004.

First Approach

Our first approach used data from the Fall 2000 cruise, which included full instrument set the Co-200 profiler and in situ flux instruments. This approach generated additional questions without answering the original one.

The Bianco et al. (2006) boundary layer (BL) height algorithm is a widely applied technique which uses the lookup table approach to estimate the height of the roughness sub-layer from the wind profiler and employs a fLeith-based picking procedure to estimate the height of the inertial sub-layer from the RL. For the wind profiler height estimates, various modifications were made to the algorithm, such as the one by the author of the original algorithm. The algorithm was altered to use 34 hours of data instead of the daytime-only and the statistical confidence estimates were increased. The height of the roughness sub-layer was calculated based on the profile reflectivity, vertical velocity, and spectral width. The estimated heights closer to the ground are probably wrong, while the estimated heights near 1000m could be consistently correct.

Second Approach

Our second approach used data from the Fall 2004 cruise. We used new instruments, and the algorithm, focusing on 16 days during which the ship was in a region with fairly high monthly averaged Sc (Figure 2) and during when the profiler reflectivity exhibited significant variability. The data collected during the Fall 2004 cruise. This approach has given some inconsistency results while focusing on one particular puff.

Figure 3 shows reflectivity, vertical velocity, and spectral width on November 2, 2004. Also displayed is a graph of ship position through the day. 36 hour is used as the ship was a minute later than the

The relative humidity sounding are shown again in Figure 5. Please note the top and bottom of the inversion marked by red bar. The structure of the MBL is clearly shown when the echoes of the sharp gradient or a light gray are identified by the profiler is in the middle of the inversion, but at 17 and 15 UTC it was not the same height as the inversion top but never above it.

Resolved and Unresolved Issues

The goal of this study was to identify the tops of marine Sc using data from a subset of instruments deployed during research cruises in the southern Pacific (16 October-17 November 2003 and 10 October-14 November 2004). The approach was to use additional instruments and not just the wind profiler. The general approach, which used more instruments and has less assumptions, gave more initial access. However, it was also revealed at least one additional parameter for those who wish to automate the detection of the Sc top.

Figure 1 highlights part of the November 3, 2004, case study, revealing additional features. In Figure 1 an eddy was observed to be oriented to the left-hand side of the MBL. The wind profiler shows a strong vertical velocity of precipitation below 25 UTC. At 17 UTC the MBL is still but near the top lower inversion shows up. This appears to be an internal boundary layer, probably a downdraft of the Sc top, which is not yet resolved. Features like this could make it harder to develop an MBL detection algorithm.

References


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