

Boundary Layer Rolls Observed Above and Below a Jet in a Marine Boundary Layer

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Abstract

We have flown a coherent Doppler wind lidar (DWL) on the Cirpas Twin Otter off the California coast near Monterey since 2003. One scientific purpose of these flights is to understand the relationship between the turbulent fluxes measured on the aircraft or on other platforms and the observed structure of the marine boundary layer (MBL). Two common features are found in the MBL flow: (1) a strong jet at approximately 200 m above the sea surface; and (2) organized large eddies (OLE) in the form of roll vortices that are approximately aligned along the mean wind direction. On two flights (April 13, 2007 and September 30, 2012), the DWL data indicated that roll OLE existed simultaneously both above and below the jet. The DWL winds suggest that the OLE in these layers are sometimes independent and sometimes connected. Standard flux data are obtained on the Twin Otter at flight level, which is nominally 300 m. The 10 Hz wind and temperature data exhibit variability at spatial scales corresponding to the OLE wavelength. We have constructed a nonlinear theoretical model that includes triad wave-wave interactions to test the hypothesis that rolls could form both above and below the jet. This model shows that this is possible and that the rolls in the two layers could have unique characteristics compared to standard boundary layer rolls. The model further shows that the rolls above and below the jet are due to separate instabilities that interact. This is consistent with the observations of both connected and independent OLE above and below the jet. Contrast-enhanced DWL line-of-sight winds. Jet maximum 200 m below aircraft.

Typical resonant triad solution for rolls above and below a PBL jet.