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SOWER (Soundings of Ozone and Water in the Equatorial Region): Cirrus observations in the tropical tropopause layer over the western Pacific

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A polarization lidar was continuously operated aboard the research vessel Mirai in the tropical western Pacific over three northern winters: at 2.0N, 138.0E during November and December 2001; at 2.0N, 138.5E during November and December 2002; and at 7.5N, 134.0E during December 2004 and January 2005. Intensive radiosonde soundings were made from the vessel at 3-h intervals during all three campaigns. The mechanisms that underlie the observed variations in cirrus in the tropical tropopause layer (TTL) are discussed from the viewpoint of large-scale dynamics and transport. During the 2001 campaign, the tropopause region was cold, but the TTL was often clear, with only some subvisual cirrus. Potential vorticity data and trajectories show that the TTL during this period was strongly affected by dry air transport from the northern midlatitude lower stratosphere. During the 2002 campaign, a packet of large-amplitude equatorial Kelvin waves was the primary control on the generation and disappearance of cirrus in the TTL. During the 2004-2005 campaign, a cold phase of large-scale waves resulted in cirrus generation in the TTL in late December of 2004, similar to that observed during the 2002 campaign. Outflow from the South Pacific Convergence Zone (SPCZ) caused optically thick cirrus in the TTL, particularly during early January 2005, when we also observed regular diurnal variations in cirrus development within the TTL, that is, apparent sedimentation during the nighttime. We investigated two possible controlling processes, namely, horizontal advection together with diurnal variations in convective activity within the SPCZ and diurnal variations in local temperature due to tides and gravity waves. In the equatorial western Pacific, equatorial Kelvin waves are the important dynamical process that controls cirrus variations in the TTL. Dry-air horizontal transport from the midlatitude lower stratosphere and wet-air vertical transport near the tropical convergence regions should also be considered in fully explaining the cirrus observations in the TTL.