Wind observation around tops of midlatitude cirrus clouds by VHF Doppler radar and lidar

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Cirriform clouds (cirrus, cirrostratus, cirrocumulus) exist in the upper troposphere consist almost entirely of ice particles, and play a significant role in regulating the radiation balance of the earth-atmosphere system. However, their radiative effects are not sufficiently quantified due to scarcity of observations. Spaceborne and ground-based lidar observations have been carried out to know time and spatial distributions of cirriform clouds and to quantify their microphysical properties. Especially, ground-based lidars are able to observe microphysical properties of cirriform clouds with high time and vertical resolutions.

Dynamical processes are important to understand microphysical processes of clouds. VHF Doppler radars observe height profiles of vertical and horizontal winds by receiving echoes from fluctuations of refractive index and hence have the capability to directly observe them both in clear and cloudy regions. At the Shigaraki MU Observatory, Japan (34°51'N, 136°06'E), Research Institute for Sustainable Humanosphere (RISH), Kyoto University has been operating the VHF (46.5 MHz) Doppler radar named as the Middle and Upper Atmosphere Radar (hereafter MU radar) and Rayleigh/Raman lidar. Because the MU radar is designed to detect very weak echoes in the mesosphere and ionosphere, the MU radar is able to observe wind profiles in the upper troposphere with high time and vertical resolutions. Further, because the lidar installed at Shigaraki is designed to observe vertical profile of temperature up to the mesosphere, the lidar is able to detect tops of cirriform clouds in the upper troposphere. Therefore a combination of the MU radar and the lidar is useful for observing wind motions in and around the cirriform clouds in the upper troposphere.

Figure shows an observational results obtained by the MU radar and the lidar. At several hundred meters above tops of cirrus clouds, eastward wind significantly increased with altitude. Radiosondes launched from the Shigaraki MU Observatory showed that static stability also increased with altitude at several hundred meters above tops of cirrus clouds (not shown). Such wind motions around tops of cirrus clouds has been shown for the first time. Further observations to clarify relations between dynamical and microphysical processes of cirriform clouds will be carried out in the near future.

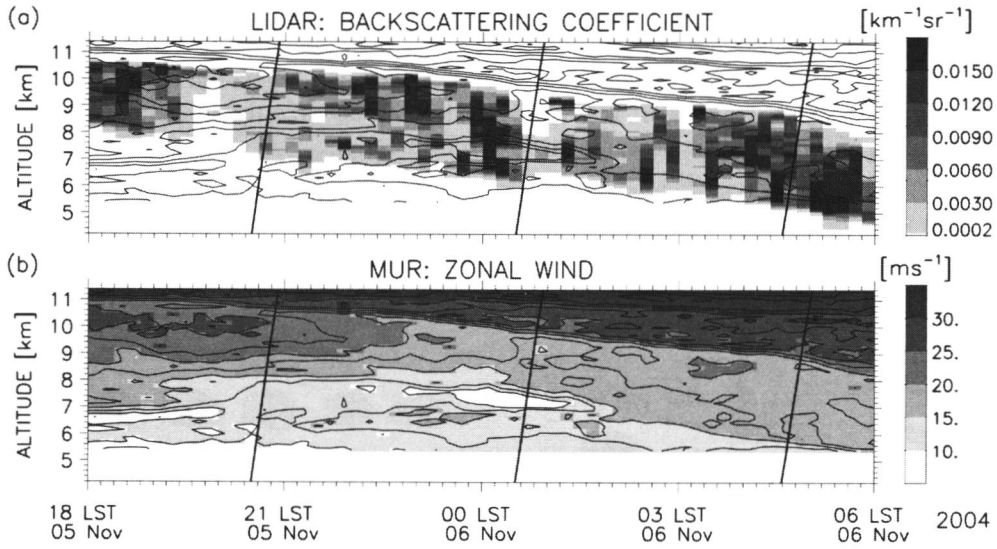

Figure: Shaded areas indicate time-altitude plot of (a) backscattering coefficient observed by the lidar and (b) zonal wind observed by the MU radar from 1800 LST 5 to 0600 LST November 2004. Thin contours indicate zonal wind plotted with 2.5 m s^{-1} intervals. Three thick curves indicate the altitudes of radiosondes.