Statistical properties of cloud liquid water path at Barrow, Alaska and at the Greenland Summit Station

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Abstract

In 2006 the Atmospheric Radiation Measurement Program deployed a high-frequency microwave radiometer in Barrow, Alaska to help improve the retrieval of water vapor and liquid water path. The G-Band radiometer has been collecting data for seven years now and retrieval of water vapor and liquid water path from this instrument have been developed. The vapor retrievals have an uncertainty of ~0.3 mm and the liquid water path retrievals have an estimated uncertainty of 8 g/m^2 (compared to the 25 g/m^2 of the two-channel MWR). The retrievals provide improved information on the presence of small amount of liquid water especially in supercooled clouds.

In this poster we use data from the microwave radiometers, radiosondes, and Vaisala ceilometer to analyze seven years (2006-2012) of improved liquid water path in Barrow, AK from GVR measurements. We compare them with three years (2010-2012) of liquid water path derived from the microwave radiometers at the Summit station in Greenland.

The GVR Dataset

The GVR (183±1,3, 7,14 GHz) deployed in Barrow, Alaska has been producing continuous data since November 2006. The data used in this study have been screened for rain contamination, averaged over 1 minute, and temporally matched to the MWR data. Because of the higher sensitivity of the GVR channels to liquid water and water vapor, the retrievals have very low noise levels. The precipitable water vapor (PWV) retrieval uncertainty is ~0.3 mm and the liquid water path (LWP) uncertainty is ~8 g/m^2 providing a better quantification of LWP in mixed phase clouds where the amount of liquid water is usually very small. Fig. 1 shows the LWP time series from the MWR (13 years, red) and the GVR (7 years, black). Fig. 2 shows monthly median LWP (2006-2012) from the GVR.

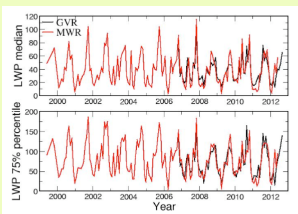

Fig. 1

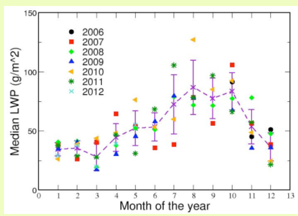

Fig. 2

LWP is strongly correlated to cloud fraction suggesting that small amounts of liquid are present throughout the year. Fig. 3 shows the seasonal trends of LWP from 13 years of MWR data (bias removed) and 7 years of GVR data. LWP plays an important role in the radiation budget of the Arctic, however the quantification of LWP in mixed-phase clouds has been a challenging task. For example Fig. 4 shows that the amount of liquid water in clouds during the month of May is strongly correlated with the date of the initiation of spring melt (usually in June) in Barrow.

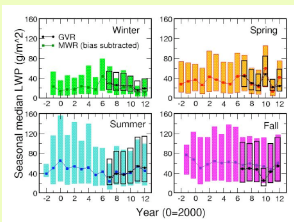

Fig.3

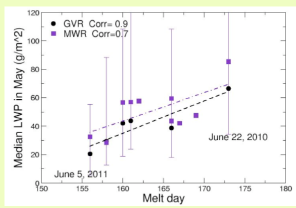

Fig. 4

Comparison with Retrievals at the Greenland Summit Station

LWP retrievals at the Greenland Summit station have an uncertainty of ~5 g/m2, comparable to the GVR retrieval uncertainty. The long time series (3 years) of continuous data provides an opportunity to analyze properties of Arctic clouds at the two sites. Fig. 5 shows the dependence of LWP (median) on cloud temperature at the two sites.

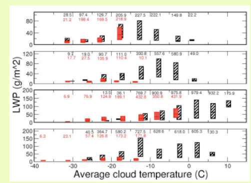

Fig. 5

Fig. 5 shows that the LWP in Barrow generally increases with cloud temperature. At the Summit station the LWP is lower in all seasons and especially in Spring and Fall. At both sites small amounts of LWP (less than 20 g/m^2) are found at temperatures between -35° and -30° C. Fig. 6 shows some additional differences between the two sites. At the Summit station in winter and spring there is a [illegible] only clouds (75% of cases), although the average and minimum cloud temperatures are similar at the two sites. The fraction of cloud cases in which liquid water is detected is shown in Fig. 7 as a function of cloud temperature.

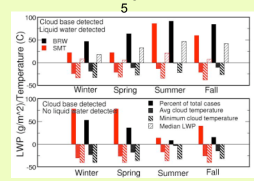

Fig. 6

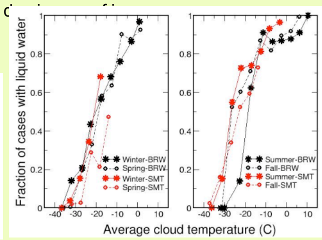

Fig. 7

The occurrence of LWP in relation to cloud-base height is shown in Fig. 8 (Barrow) and 9 (Summit). At both sites the majority of cloud bases where liquid is detected are located in the first km, however in Barrow LWP between 50 and 100 g/m^2 is detected in about 20-30% of cases when the cloud base is between 2 and 3 km. At Summit only 10% of the cases have detectable LWP when the cloud base is between 1 and 2 km. Above 2 km only a negligible amount of cases have any detectable LWP.

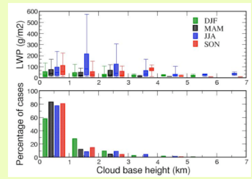

Fig.8: Barrow

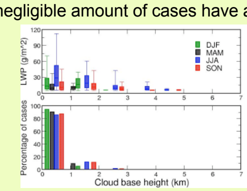

Fig. 9: Summit