ARSCL Cloud Statistics – A Value-Added Product

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Introduction

The active remote sensing of cloud layers (ARSCLs) value-added product (VAP) combines data from active remote sensors to produce an objective determination of cloud location, radar reflectivity, vertical velocity, and Doppler spectral width. Information about the liquid water path (LWP) in these clouds and the frequency of precipitation is available from the microwave water radiometer (mwrlos) and the Surface Meteorological instruments (SMET, Surface Meteorological Observing Station [SMOS], or present weather sensor [PWS]). To aid in the comparison of these fields with output from cloud resolving models and for other data analysis activities, a VAP has been created that performs statistical analysis of these data. Frequency distributions are computed and written in an output file in a manner that facilitates user flexibility. The structure enables users to quickly compute statistics for multiples of the half-hour and daily analysis periods that are the baseline for the statistical computations. Output for the 6-hour and daily periods is also provided in graphical format, which allows quick, cursory analysis of the statistical characteristics of the cloud data.

Algorithm

The primary input data is from the ARSCL output, which includes cloud location, radar reflectivity, vertical velocity, and Doppler spectral width. The LWP in these clouds and the frequency of precipitation is available from the mwrlos and the Surface Meteorological instruments (SMET, SMOS, or PWS, depending on the site). Table 1 lists the input data stream names and the fields used for each site. Table 2 shows the bins used in the VAP to calculate the frequency distribution of all the fields.

The arsclstat1mill VAP produces two output netCDF files with 30-minute and daily statistics of the cloud properties. The output fields are the same in both files. Table 3 lists the output fields and their units and descriptions. Figure 1 shows the data flow of the arsclstat1mill VAP.

Table 1. Input Platforms and Fields

ARM Site	Input Data Streams	Input Fields
Southern Great Plains (SGP)	arscl1cloth	Heights ReflectivityBestEstimate MeanDopplerVelocity SpectralWidth qc_ReflectivityClutterFlag CloudLayerBottomHeightMplCloth CloudLayerTopHeightMplCloth qc_CloudLayerTopHeightMplCloth CloudBaseBestEstimate
	Mwrlos	Liq wet_window
	Smos	Precip
Tropical Western Pacific	arscl1cloth	Same as SGP site
	Mwrlos	Same as SGP site
	Smet	precip_mean
North Slope of Alaska	arscl1cloth	Same as SGP site
	Mwrlos	Same as SGP site
	Pws	precip_rate

Table 2. Bins for Frequency Distribution

Bin Name	Bin Min	Bin Max	Bin Width	Total # of bins
bins_CloudThickDist	0	13000	45	266
bins_CloudBaseHt	0	20000	1000	21
bins_CloudReflectDist	-50	25	1	76
bins_LWPDist	0.1	2	0.05	39
bins_DopplerVelDist	-10	20	1	31
bins_SpecWidthDist	-2	8	1	11

Results

Cloud Reflectivity Distribution

Figure 2 shows cloud reflectivity distributions at SGP C1 on March 2, 2000. Figures 2a to 2c show the cloud reflectivity distribution of low cloud (0-2 km), mid-level cloud (2-6 km), and high cloud (6 km and up), respectively. Figure 2a shows no low-level cloud between 0000 and 0600 hours, which is also shown as the white area in Figure 2e. Figure 2d shows millimeter wave cloud radar (MMCR) data availability, where pink means missing data. This figure shows no data collected between 1830 and

2100 hours, this is shown on the 6-hour statistics plots (Figures 2a-2c and Figure 2f) as the 71% MMCR data availability.

Table 3. arsclstat1mill VAP Output Fields and Descriptions

Field Name	Units	Description
base_time	Seconds	Seconds since 1970-1-1 0:00:00 0:00
time_offset	Seconds	Time offset from base_time
Heights	m AGL	Height of measured value
bins_CloudThickDist	m AGL	Bins of cloud thickness
bins_CloudBaseHt	m AGL	Bins of cloud base height
bins_CloudReflectDist	dBZ	Bins of cloud reflectivity
bins_LWPDist	mm	Bins of liquid water path
bins_DopplerVelDist	m/s	Bins of Doppler velocity
bins_SpecWidthDist	m/s	Bins of spectral width
ntotal	none	Total Possible Observations
mmcr_avail	%	MMCR Data Availability
prct_echo	%	Percent of cloud echo
total_num_profiles	none	Total number of profiles
num_cloudy_profiles	none	Number of cloudy profiles
Cloud_Thickness_Distribution	none	Number of observations in every 30-minute (or 24- hour) in each cloud thickness bin
Cloud_Thickness_Vs_BaseHeight_Dist	none	# of obs. in every 30-min (or 24-hr) in each cloud thickness bin, sorted by base height of 1 km each from 0 – 20 km
Cloud_Reflectivity_Distribution	none	# of Obs. in every 30-min (or 24-hr) in each reflectivity bin
Frequency_of_Precipitation	none	Frequency of precipitation
LWP_Distribution	none	# of Obs. in every 30-min (or 24-hr) in each LWP bin
Doppler_Velocity Distribution	none	# of Obs. in every 30-min (or 24-hr) in each Doppler velocity bin
Spectral_Width_Distribution	none	# of Obs. in every 30-min (or 24-hr) in each spectral width bin

Cloud Thickness Distribution

Figure 3 shows the 6-hour cloud thickness distribution at SGP C1 on March 2, 2000. The statistics are done as a function of cloud base height. Figures 3a, b, and c show the cloud thickness distribution with the cloud base heights from 0 to 2 km, 2 to 6 km, and above 6 km respectively. Figure 3d shows the same statistics but for all the clouds. The cloud thickness was calculated using the cloud base height and cloud top height provided by the ARSCL VAP and summarized for all the ten layers. Figure 4 shows similar plots as Figure 3, but for the daily statistics of the cloud thickness distributions.

Cloud Doppler Velocity and Spectral Width Distribution

Same statistics are also done for the Doppler velocity and spectral width distributions. Figure 5 and 6 are 6-hour statistics for Doppler velocity and spectral width respectively.

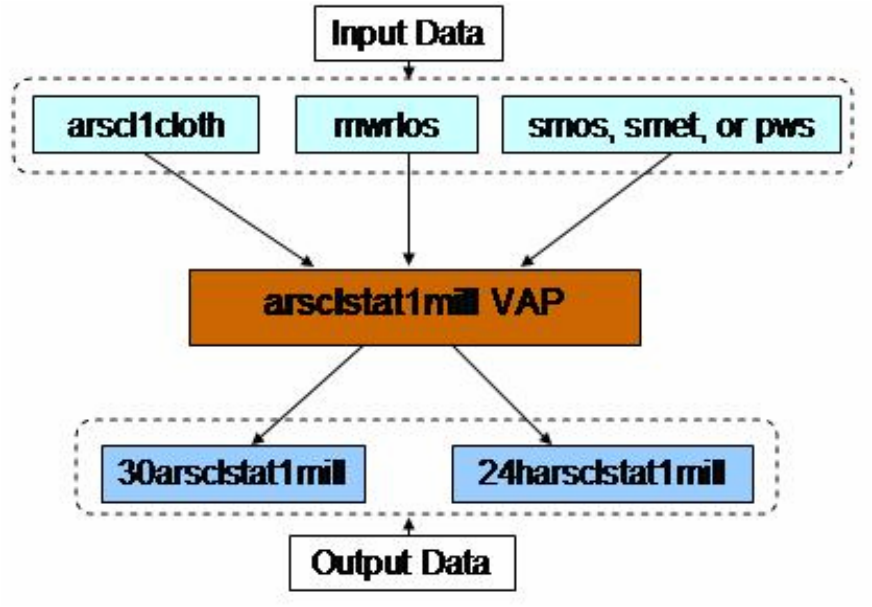

Figure 1. arsclstat1mill VAP data flow.

Liquid Water Path Distribution and Frequency of Precipitation

Figure 7 shows the LWP distribution. The top plot is the 6-hour statistics and the lower plot is the daily statistics. Figure 8 shows the frequency of distribution and the percentage of the cloud occurrence. The top plot is the half-hour statistics and the bottom plot is the daily statistics for the whole month of March 2000.

Summary

The ARSCL Statistics VAP is designed to run at all ARM sites and facilities. It produces two output netCDF files containing half-hour and daily statistics of the cloud properties, respectively, and corresponding graphs like those displayed here. The initial version of this VAP will soon be released. A sample of the VAP output for the March 2000 intensive operational period (IOP) at the SGP site is available upon request from the authors.

Future products for this VAP will include monthly, seasonal, and yearly statistics of cloud properties. Input from the user communities will also be considered in the development of future products for later versions of this VAP.

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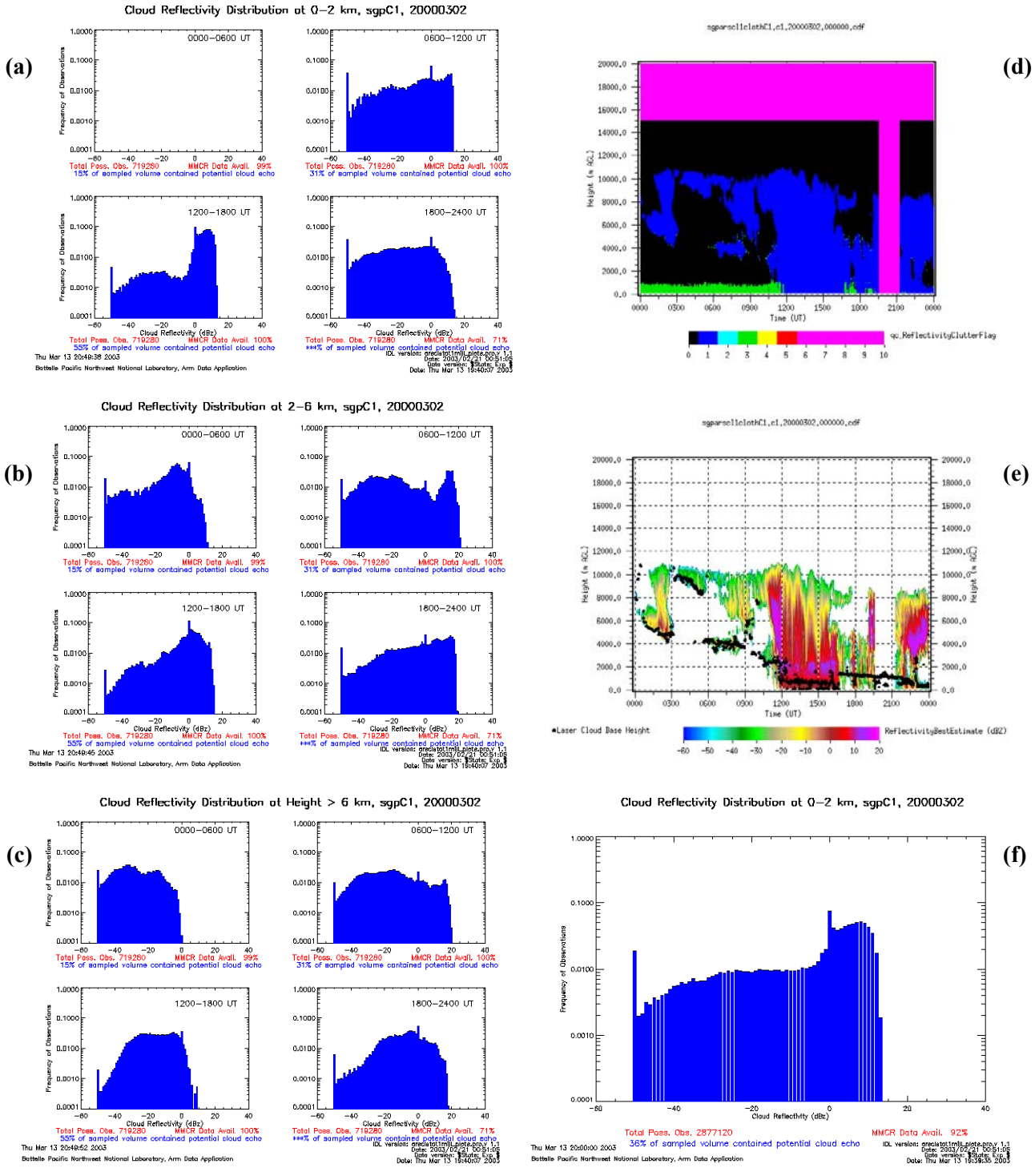


Figure 2. Cloud reflectivity distribution at SGP C1 on March 2, 2000. (a - c) 6-hour statistics at 0-2 km, 2-6 km, and above 6 km, (d) MMCR reflectivity clutter flag, (e) MMCR best estimate of hydrometeor reflectivity, and (f) daily statistics of reflectivity distribution at 0-2 km. The daily statistics for 2-6 km and above 6 km are also done but not shown here.

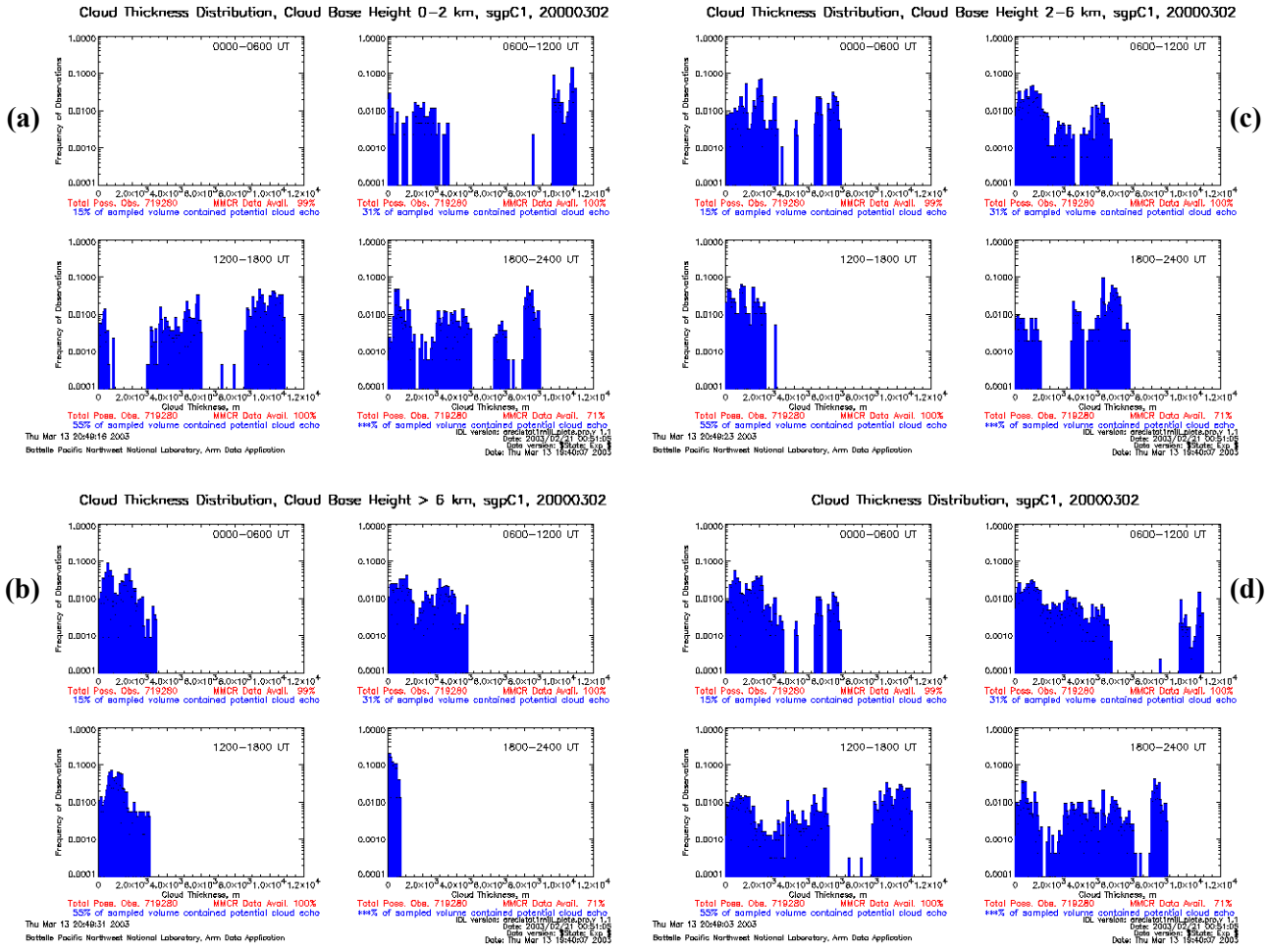


Figure 3. 6-hour cloud thickness distribution at SGP C1 on March 2, 2000. (a) 0-2 km, (b) 2-6 km, (c) above 6 km, and (d) statistics for all heights

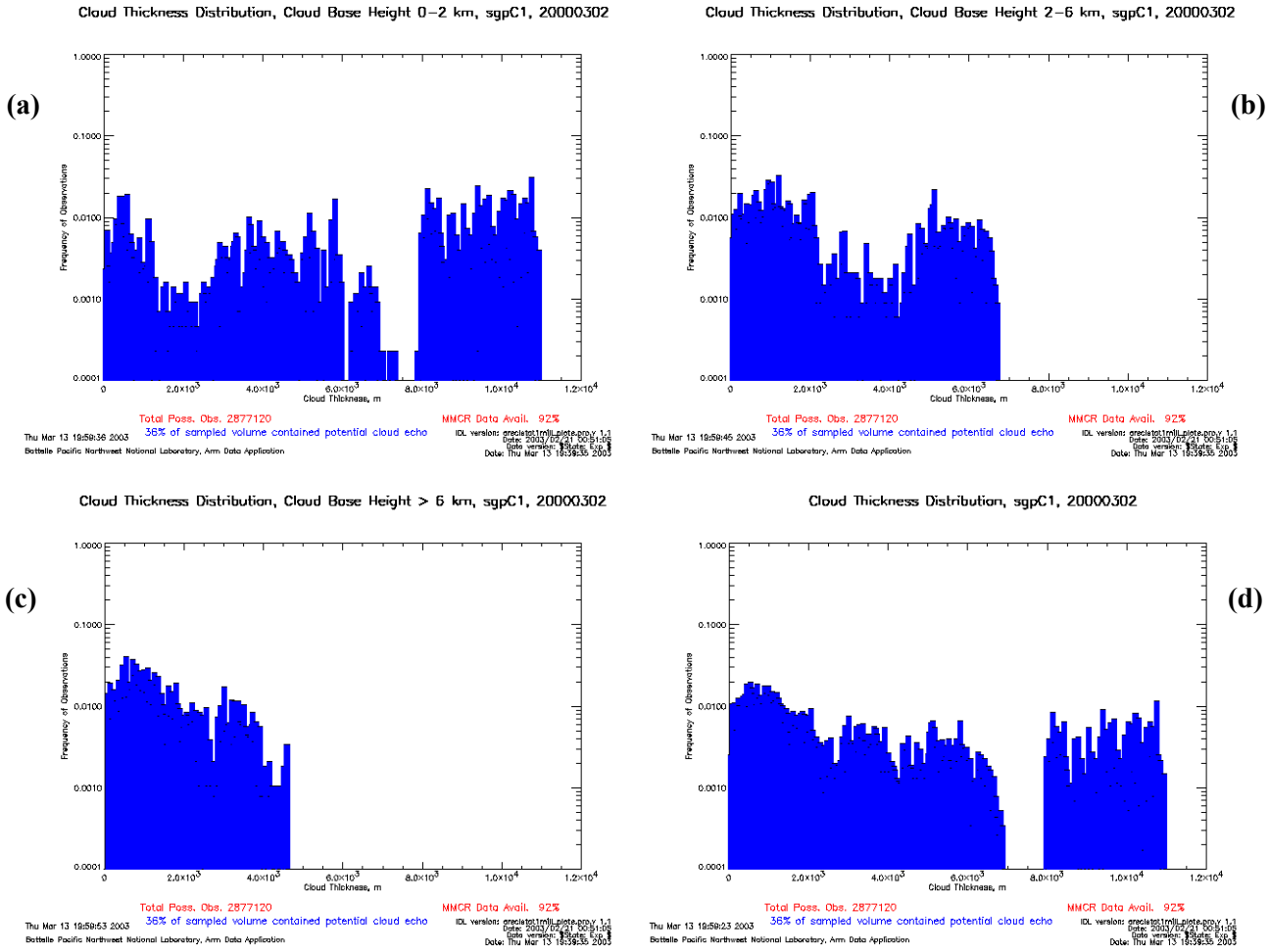
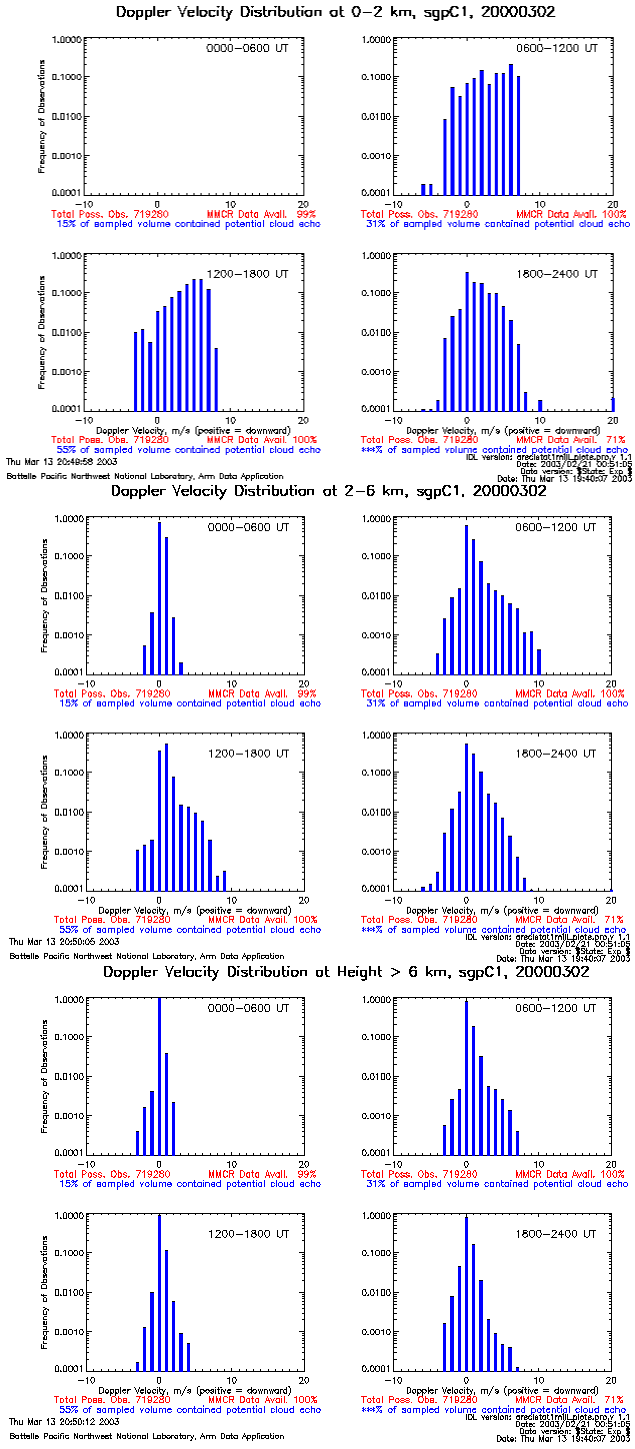


Figure 4. Daily cloud thickness distribution at SGP C1 on March 2, 2000. (a) 0-2 km, (b) 2-6 km, (c) above 6 km, and (d) daily statistics for all heights.



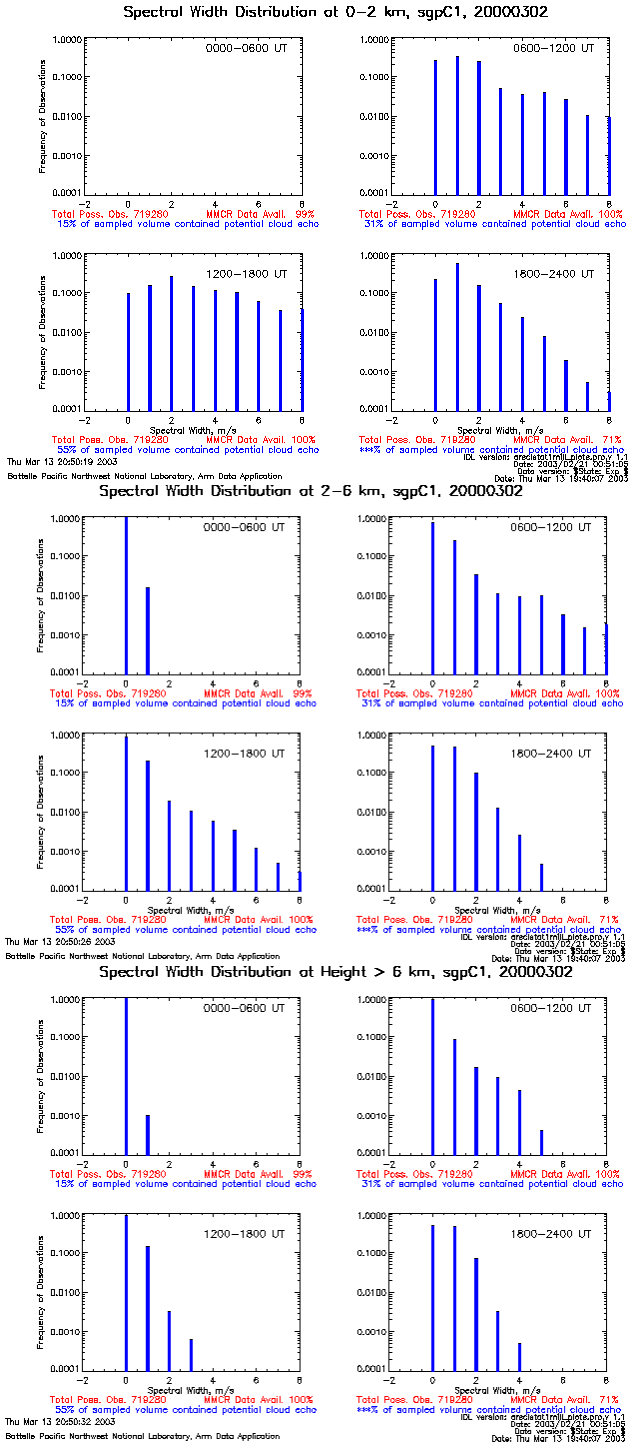
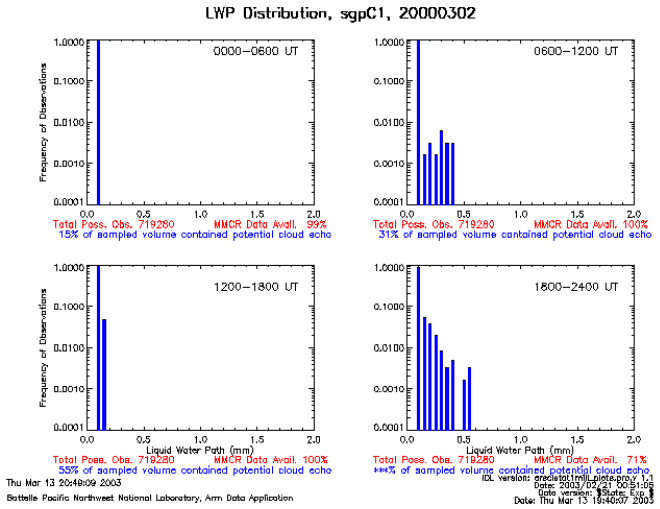


Figure 5. Doppler velocity distribution at SGP C1 on March 2, 2000. From top to bottom: 6-hour statistics at 0-2 km, 2-6 km, and above 6 km. Daily statistics for the same heights are also done but not shown here.

Figure 6. Spectral width distribution at SGP C1 on March 2, 2000. From top to bottom: 6-hour Statistics at 0-2 km, 2-6 km, and above 6 km. Daily statistics for the same heights are also done but not shown here.



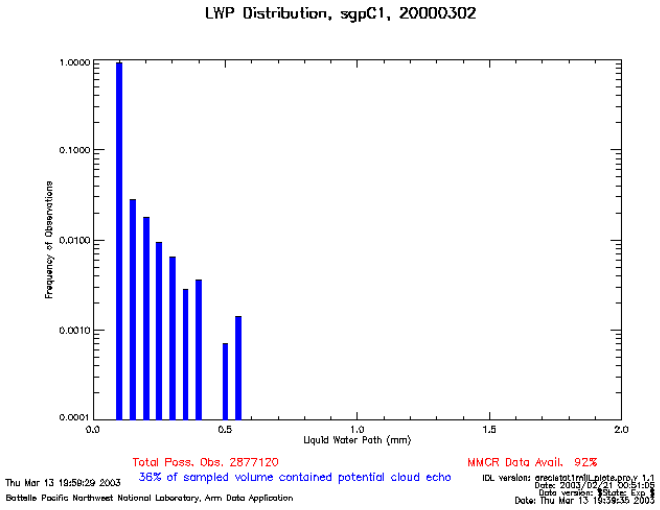
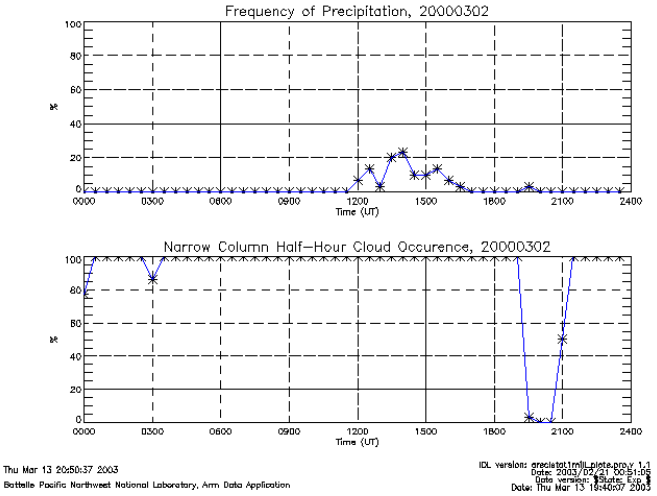


Figure 7. LWP distribution at SGP C1, March 2, 2000. Top plot: half-hour statistics; bottom plot: daily statistics.



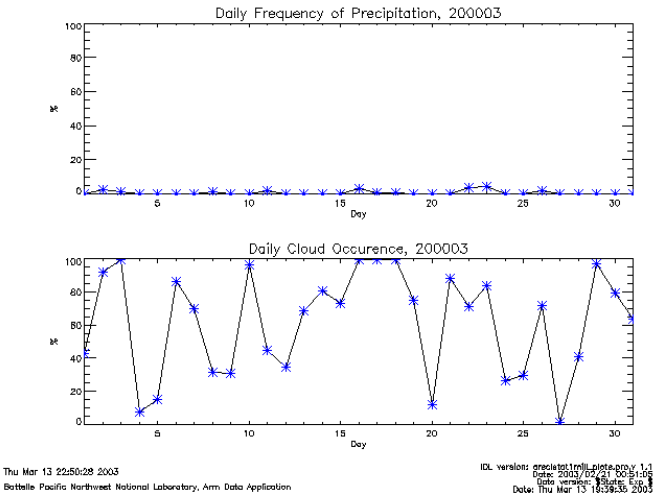


Figure 8. Frequency of precipitation at SGP C1. Top plot: half-hour statistics on March 2, 2000; bottom plot: daily statistics for March 2000.