Description of the Cloud Layer Experiment (CLEX), Field Phase, Surface Data Archive

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DEPARTMENT OF ATMOSPHERIC SCIENCE

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1.0 Introduction

The purpose of this report is to serve as a user's guide to those who wish to access data collected by ground based instrumentation operated at the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed (CART) site near Lamont, OK during the field phase of the Cloud Layer Experiment (CLEX). The field phase took place during the period from June 20 to July 1, 1996. Only a brief discussion of the purpose of CLEX and its other components will be given here. The main goal is to provide instructions for accessing the various datasets collected at the ARM CART during CLEX.

2.0 Background

The CLEX is a DOD funded experiment conducted by the Center for Geosciences at the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU). Three main goals of CLEX focus on middle level cloudiness; they are:

1) To investigate methods to improve detection of cloud top and cloud base from satellite and supporting observations;

2) To investigate the role of radiation in the formation, maintenance and dissipation of middle level cloud systems;

3) To examine possible improvement to medium range forecasts through input of improved diagnosis of middle level cloud features.

2.1 The field experiment

In order to provide data to validate efforts toward the goals of CLEX a field experiment was conducted during the period from June 20 to July 1 of 1996. The field experiment consisted of several components that may be characterized by the nature of their data collection activity. These included:

Satellite visible, IR and microwave data provided by GOES, NOAA and DMSP platforms;

Aircraft in situ data provided by the NCAR King Air and the NASA DC8, each operating a suite of instruments designed to probe the clouds' physical and microphysical state;

Surface instrumentation based at the ARM CART site and instrumentation provided by the Automated Surface Observations System (ASOS).

The field experiment included data collection over a wide geographical region bounded approximately on the west by the US coastline, on the east by the eastern edge of Oklahoma, on the north by the state of Alaska and on the south by the region of central Texas. The primary surface field activity was conducted near Lamont, OK at the ARM CART site and the data collected at this activity are the focus of this report.

2.2 Activity at ARM CART

During the last part of June 1996, the Department of Atmospheric Science at Colorado State University deployed a team of scientists, engineers and graduate students to the ARM CART IDP#3 Site (36.617 N, 97.485W) in support of the DOD CLEX effort. As part of the overall effort the Desert Research Institute (DRI) and the Department of Meteorology at Pennsylvania State University (PSU) were contracted to provide microwave radiometer soundings and cloud radar imagery respectively in support of CLEX. Both DRI and PSU were collocated with the CSU team except for two one day excursions by the DRI mobile radiometer van to Moline, KS on June 24 and to Paris, TX on June 26. Figure 1a shows the layout of the CART site and Figure 1b indicates the locations of the CLEX associated instrumentation at the IDP #3 site, which is in the northern most part of the site slightly west of center.

Data collected by CSU included: surface meteorological data (temperature, relative humidity, wind speed and direction); surface radiation consisting of the upwelling and downwelling, solar, near infrared and infrared (IR), hemispheric flux densities; temperature/moisture profiles from balloon borne radiosondes; IR window zenith pointing radiances; IR zenith pointing 1.0 cm^{-1} spectral radiances; solar and near IR, direct beam flux densities; and laser ceilometer cloud ceiling height. These data have been supplemented by data that are routinely collected at the ARM CART under the auspices of the Department of Energy ARM Program and include; atmospheric temperature/moisture profiles from balloon borne radiosondes; cloud ceiling from a Micro Pulse Lidar (MPL) system; and atmospheric, total column water vapor and liquid water from a microwave radiometer system. The current state of each of these sets of data is described below and instructions on where the data may be accessed given. The DRI data consisted of the total column liquid water and water vapor. The PSU data include raw and calibrated 94 Mhz radar returns and raw velocity counts.

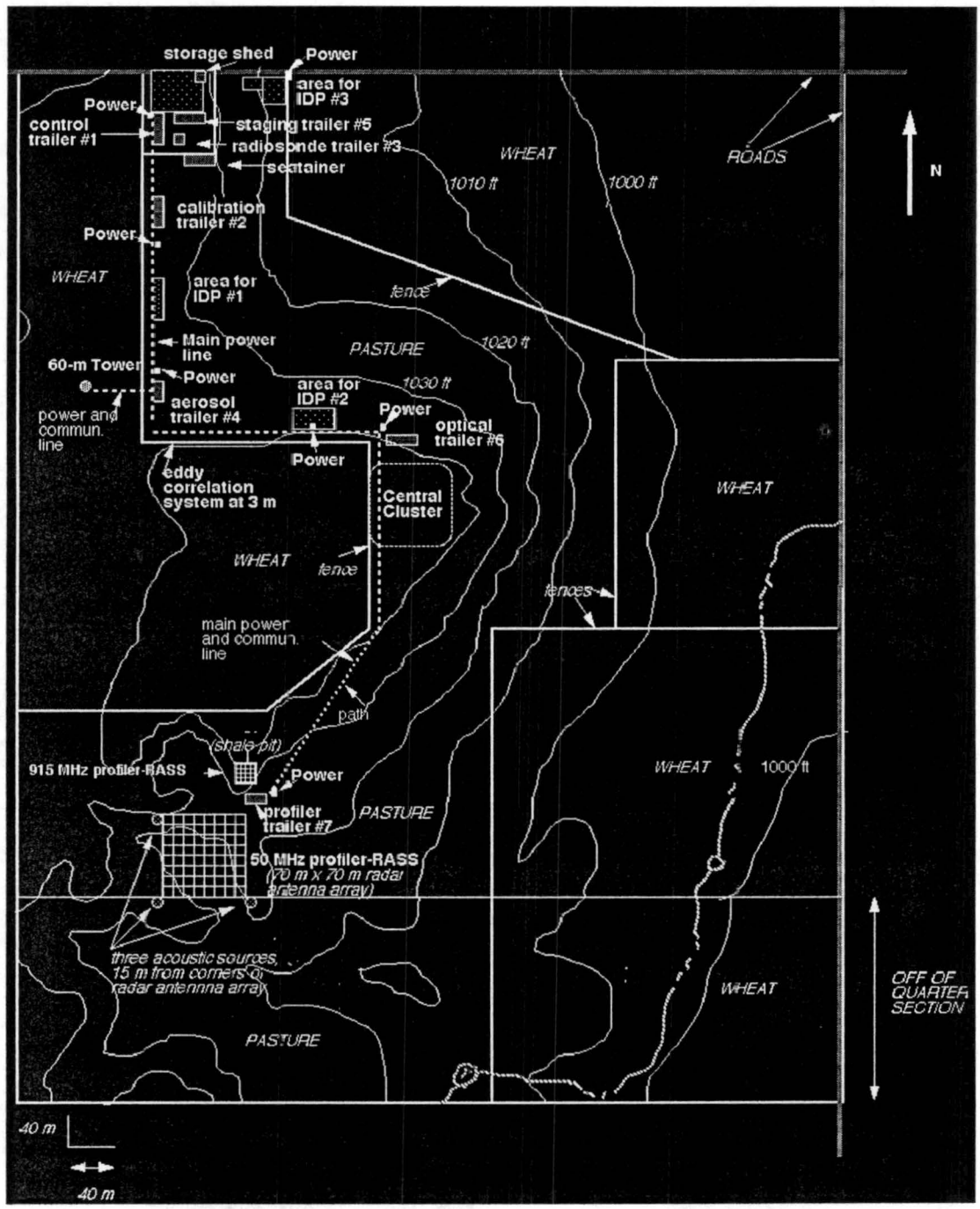

Figure 1a Location of instrumentation at the Central Facility Southern Great Plains ARM CART Site

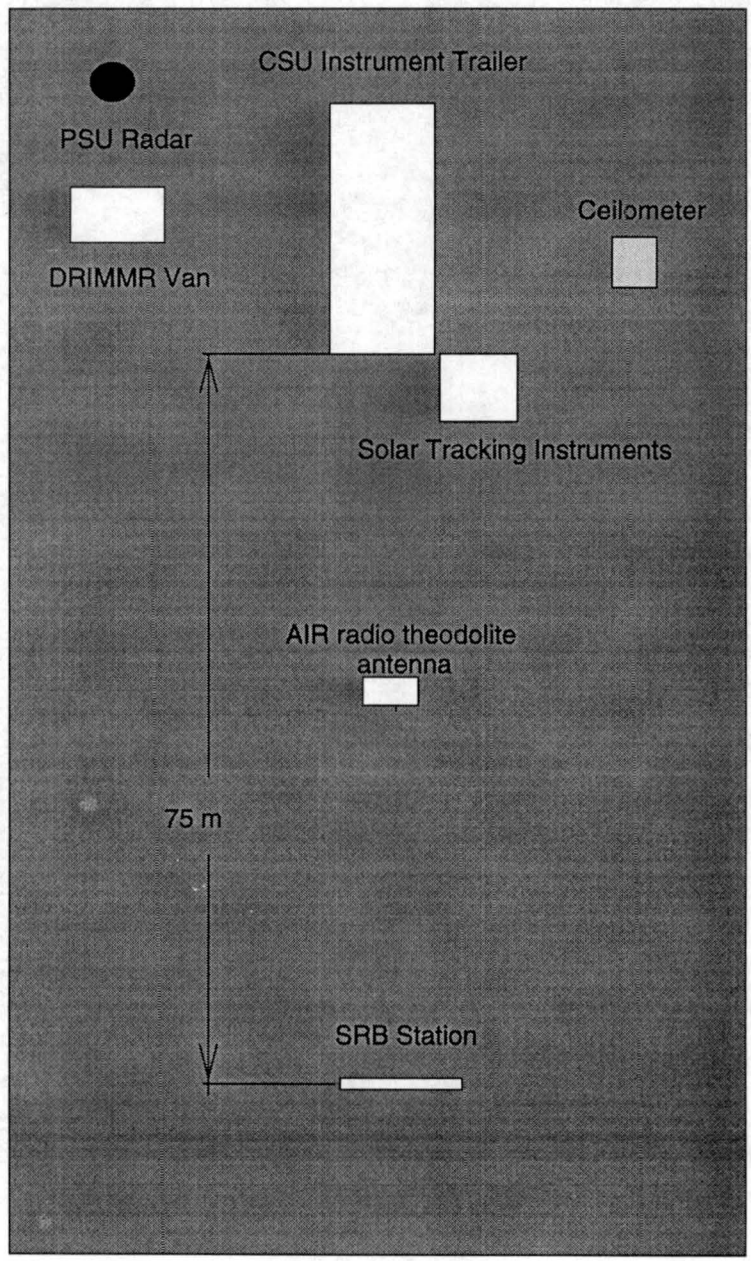

Figure 1b. Depiction of the placement of CSU/DRI/PSU instrumentation in IDP#3 during CLEX

3.0 Description of the surface data archive

All of the sets of data mentioned above have been through an initial processing phase wherein calibration coefficients have been applied and the results are given in the final physical units. Some of the data have undergone quality control; however, at the date of the writing of this report, not all data have been quality checked, except for obvious data sets that are in error. Individual bad data points have not been removed at this point, and in no way has any attempt been made to correct data not collected by CSU. The process of quality control will continue for some time as each data set is used and compared with other results which might at some point call the results into question. Thus, investigators should utilize these data with the understanding that they may be providing the initial scientific scrutiny and any discrepancies should be directed to the authors of this report.

All of the data that were either collected by the CSU/PSU/DRI team or the subset of data from ARM CART activity are archived on a public ftp site on the Cooperative Institute for Research in the Atmosphere (CIRA) computer system. The instructions for accessing the data are given in section 4.0 below. What follows is a listing of the data and examples of several of the data sets, although it is not the purpose of this report to provide a hardcopy of every data set.

3.1 Surface radiation data (clex/csucarte/surfrad)

The downwelling and upwelling radiation streams near the surface were collected with Eppley upward looking and downward looking, hemispheric pyranometers and pyrgeometers mounted at a height of 4 feet above the ground. The surrounding horizon was virtually free of obstruction except for the ARM CART buildings that were far enough away so as not to produce significant effects in the data. Figure 2 is a photograph of the Eppley instruments on their mount. The data are found in the clex/csucarte/surfrad directory at the ftp.cira site. There is one file for each day of observation. There are 9 fields of data. Data has been recorded at 30 second intervals. Each is an average of 15 individual points sampled every 2 seconds. The infrared irradiance, measured by the Eppley PIR instruments, have been corrected for dome-sink temperature differences. The file structure and times for which data are available are listed in Table 1 below.

Data Fields
1. Day of June, 1996
2. UTC Time (hhmm)
3. Seconds
4. PIR 1: Downwelling infrared (3.0 to 50 μm) irradiance (W/m^2)
5. PIR 2: Upwelling infrared (3.0 to 50 μm) irradiance (W/m^2)
6. PSP 1: Downwelling (0.28-2.8 μm) irradiance (W/m^2)
7. PSP 2: Downwelling (0.698-2.8 μm) irradiance (W/m^2)
8. PSP 3: Upwelling (0.28-2.8 μm) irradiance (W/m^2)
9. PSP 4: Upwelling (0.698-2.8 μm) irradiance (W/m^2)

Day	Data Available (UTC hhmm:ss)
21	0004:41-2359:41
22	0000:11-2359:41
23	0000:11-0253:41, 1234:41-2359:41
24	0000:11-1156:41, 1227:13-1606:43, 1640:43-2359:43
25	0000:13-1512:43. 1516:13-2359:43
26	0000:13-2359:43
27	0000:13-2359:43
28	0000:13-1255:13, 1256:13-2359:43
29	0000:13-1402:13

Table 1. List of available surface radiation data

Figure 3 depicts the radiation streams measured near the surface for June 25, 1996, a day characterized by clear sky conditions during the early morning changing to broken low level cloudiness by mid morning under cirrus overcast. The complete set of plots of the surface measured radiation may be found in the Appendix. During the experiment the calibration of the Eppley pyrgeometers was checked using a simple field blackbody source at ambient temperature. The calibrations indicated that the sensitivity assigned to each pyrgeometer was nearly exact; resulting in deviations of nominally 2.0 watts m^{-2} between the measured and expected blackbody emission.

Figure 2. Photograph of the Eppley radiometers used on the SRB station at CART ARM during CLEX.

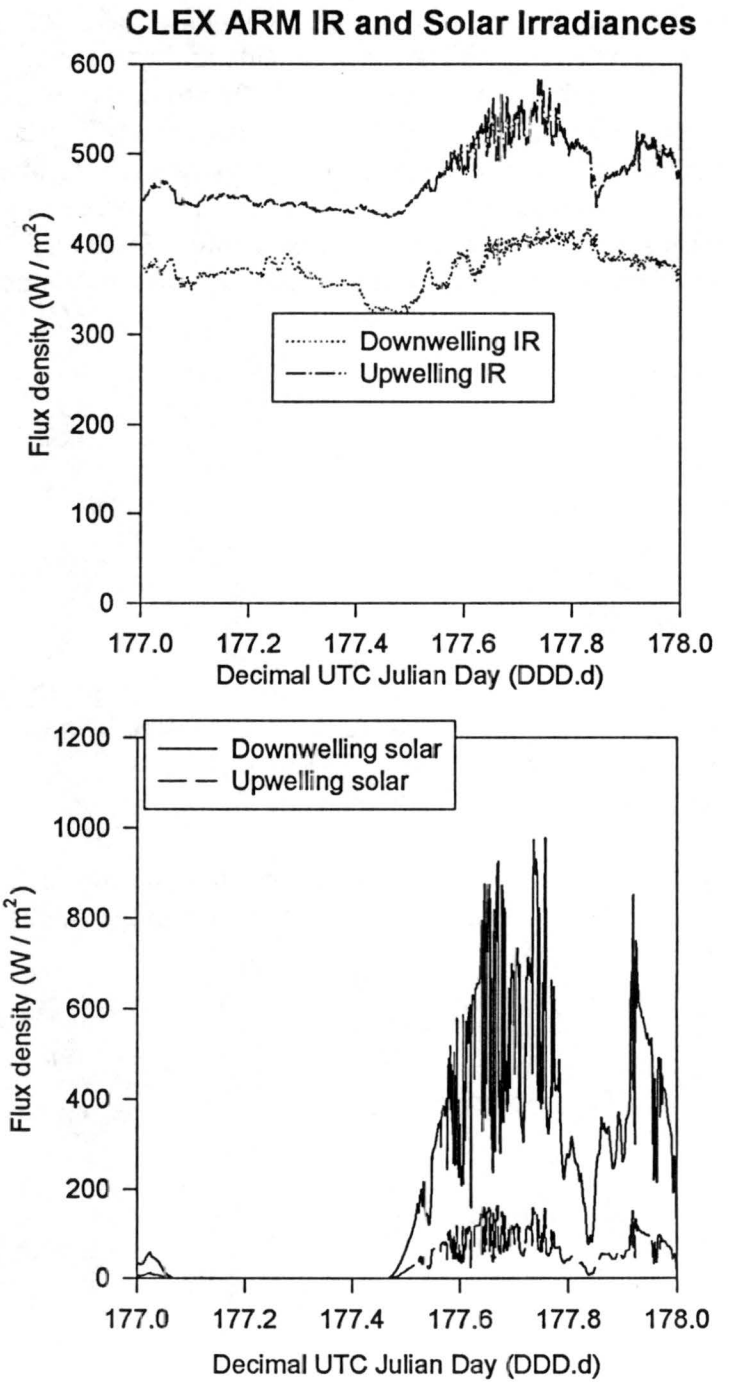

Figure 3. IR (top) and solar (bottom) radiation flux densities measured at IDP#3 on June 25, 1996 during CLEX.

3.2 Surface meteorology data (clex/csucarte/surfmet)

The surface meteorology data were collected using standard instruments mounted on a tripod base. The wind speed and direction were measured with an RM Young model 05103 wind monitor. The temperature and relative humidity probes were of a thermistor design manufactured by Campbell Scientific Inc., (model 207 probes protected in a radiation shield). Figure 4 shows a photograph of the surface meteorology station. The surface meteorology data fields may be found in the /clex/csucarte/surfmet directory at the ftp.cira site. Surface meteorology data consists of six fields stored in a comma delimited text file. Measurements were taken at 30 second intervals. Every three minutes, the six most recent measurements were averaged and recorded, giving data points at three minute intervals.

Surface meteorology fields consist of:

Decimal julian day,
Wind speed average m/s,
Wind direction average degrees (N = 0),
Temperature average C,
Relative humidity average %,
Barometric pressure[1] (mb)

Measurements were taken on nine days, each of which are stored in a separate file named as: m062196.txt through m062996.txt. Missing data are designated by a value of -6999. On 6/28/96, an hour of data was lost, between 16:33 and 17:39 UTC. These missing data points are not shown in m062896.txt.

Figure 5 depicts a daily record of the typical conditions at IDP#3 during CLEX. The complete record of the meteorological parameters may be found in the Appendix.

[1] Although pressure was measured at the IDP3 site, the data appear to be in error and should not be relied upon unitl the discrepancies are resolved.

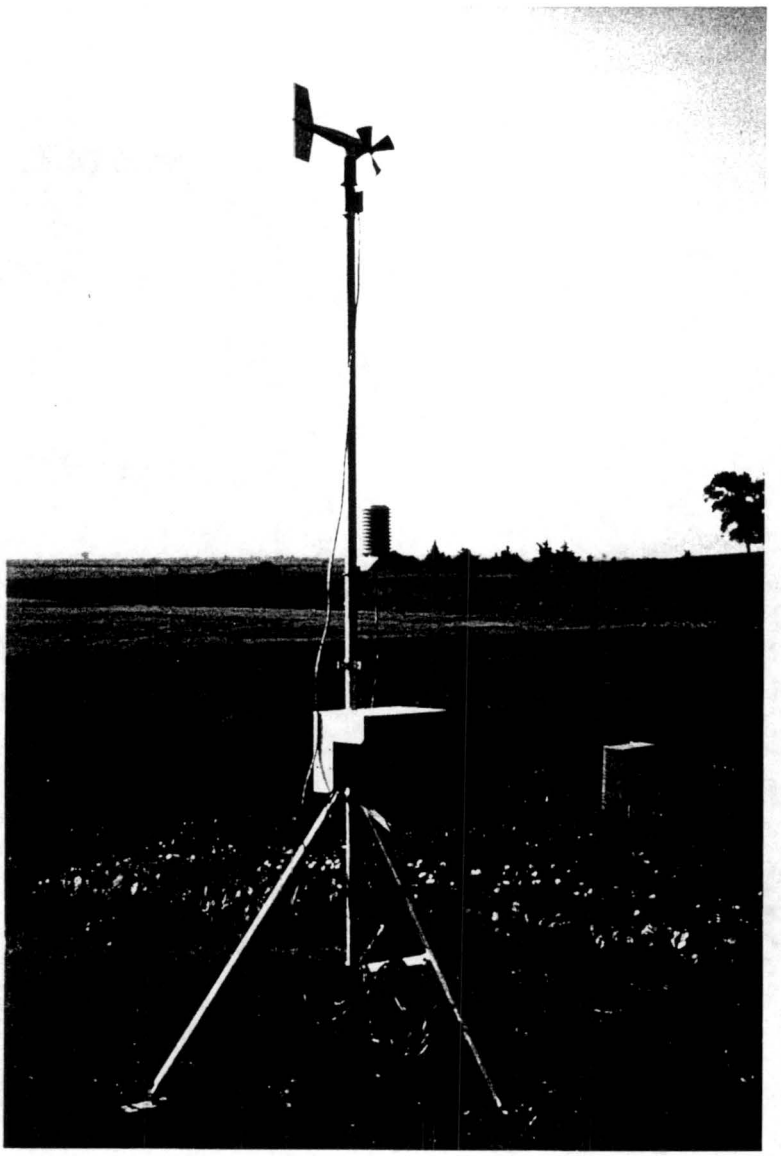

Figure 4. Photograph of the surface meteorology instruments deployed at CART ARM during CLEX

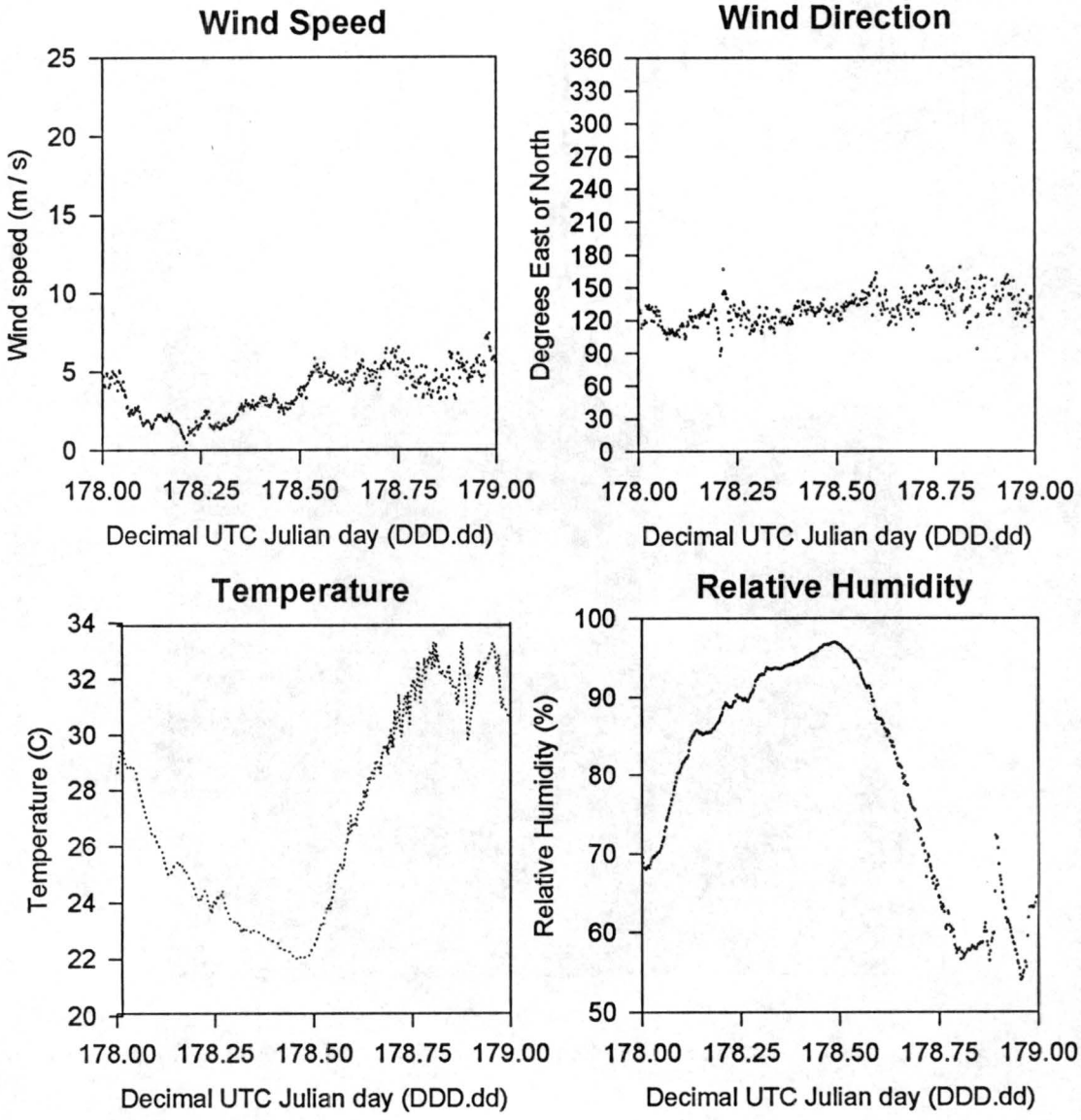

Figure 5. Wind speed, wind direction, temperature and relative humidity measured at IDP#3 on June 26,1996 during CLEX

3.3 IR Window Radiances (/clex/csucarte/prt6)

A Barnes Engineering PRT6 radiometer was deployed during much of CLEX to provide a highly temporally resolved record of the downwelling IR window radiance. The PRT6 was used sparingly at first during the experiment.. This was due to the lack of favorable cloud conditions and to the initial mode of deployment outside of the instrument trailer. On June 26 the instrument was deployed inside the trailer viewing the zenith radiances through a protected aluminum mirror and thus could be operated on a more continuous basis. The instrument was calibrated by comparing its voltage signal to the calibrated IR radiance from a Bomem MB100 interferometer integrated across the bandpass of the PRT6 (895 to 935 cm^{-1}). Figure 6 depicts the calibration points applied to the PRT6 before and after deployment with the mirror. The data from the PRT6 may be found on the ftp.cira site under the directory /clex/csucarte/prt6. There are two columns of data; the decimal UTC day and downwelling window radiance in W / cm^2 str. The file names generally correspond to the date on which the data file was written to disk. Below is a list of the available data in each file.

File name	Start time	End time
jn20p04.asc	172.961	172.961
jn20p07.asc	172.975	172.976
jn21p07.asc	173.682	173.683
jn22p01.asc	174.609	174.610
jn22p02.asc	174.630	174.832
jn22p16.asc	174.886	174.980
jn23p01.asc	175.466	175.595
jn23p02.asc	175.629	175.687
jn23p03.asc	175.702	175.860
jn23p04.asc	175.901	175.974
jn23p05.asc	175.994	176.048
jn24p01.asc	176.501	176.667
jn25p01.asc	177.654	177.684
jn26p01.asc	178.466	178.648
jn26p02.asc	178.696	178.744
jn26p03.asc	178.783	178.834
jn27p01.asc	178.853	179.566
jn27p02.asc	179.588	179.634
jn28p01.asc	179.757	180.439
jn28p02.asc	180.458	180.674
jn28p03.asc	180.731	180.765
jn29p01.asc	180.777	181.562

Table 2. List of PRT6 data filenames and the corresponding beginning and ending times of data collection given in UTC decimal day

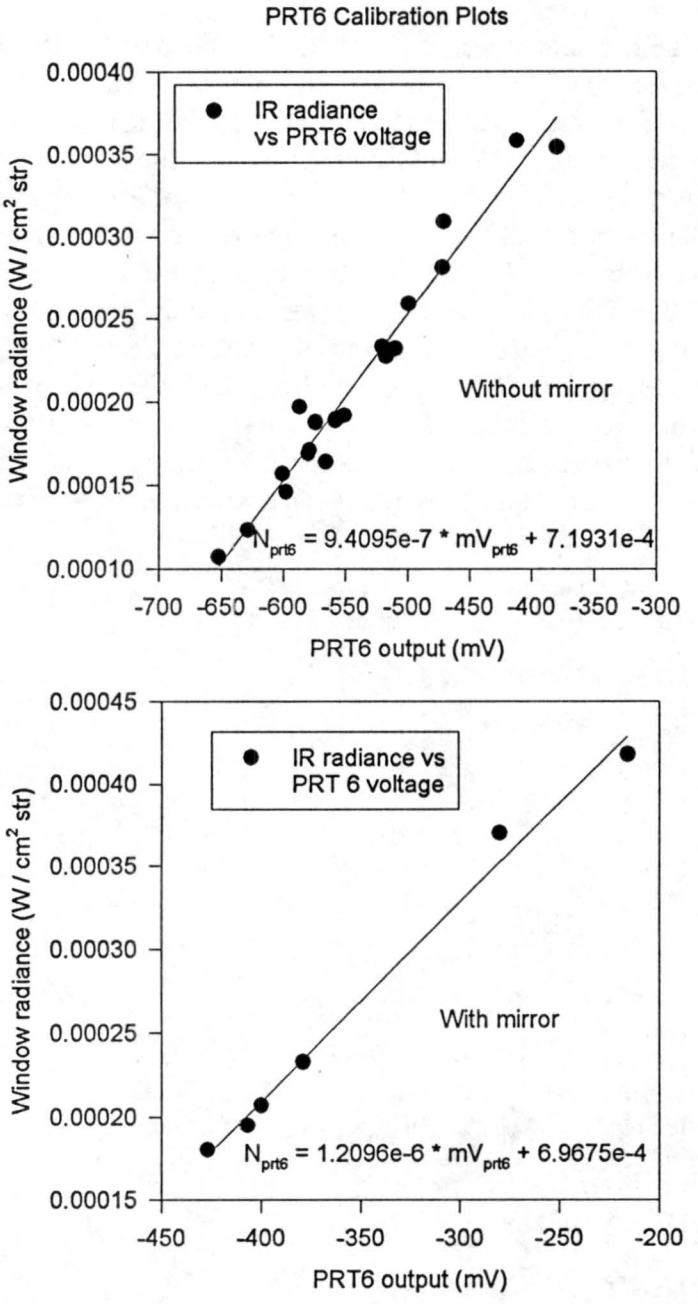

Figure 6. Plots of the calibrations applied to the PRT6 output voltage for conversion to IR window radiance before (top) and after (bottom) the PRT6 instrument viewed the zenith sky through the mirror.

Figure 7 displays the PRT6 radiance data that have been converted to an effective radiating temperature plotted with the cloud ceiling height derived from the ARM Micro

Pulse Lidar. The plot indicates that although the lidar and PRT6 were separated by approximately 275 meters, good correspondence between ceiling heights and radiating temperatures result, at least for this case.

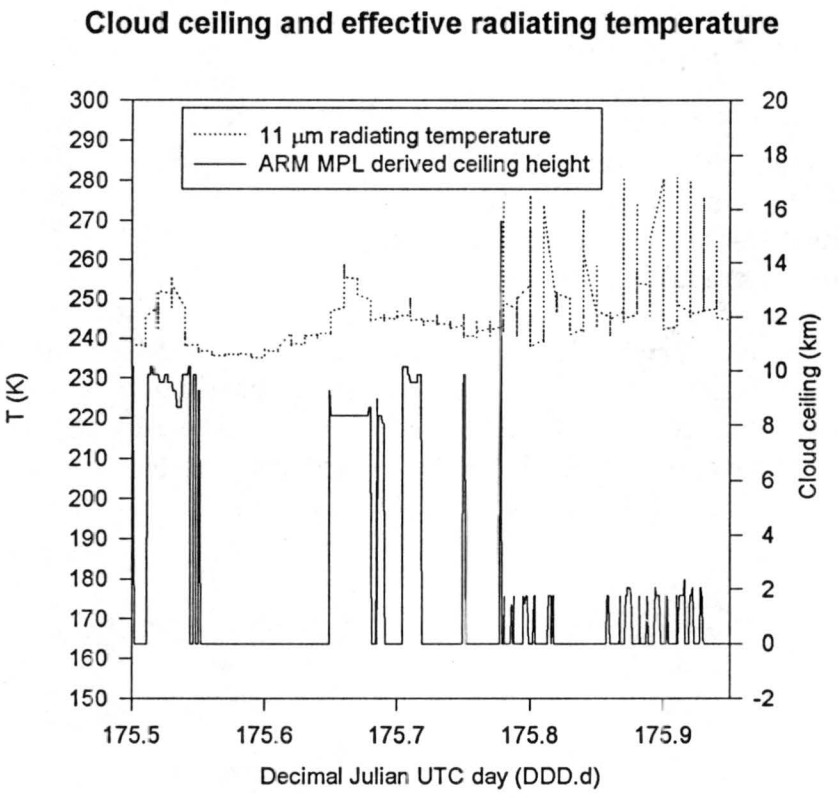

Figure 7. PRT6 derived effective radiating temperature and MPL derived cloud ceiling height for June 23, 1996 at the ARM CART during CLEX.

3.4 Direct beam solar irradiances (/clex/csucarte/dirsol)

Observations of the direct beam solar flux density were taken at the ARM CART during CLEX for most of the periods when CSU personnel were at the site. The observations were made with Eppley Normal Incidence Pyrheliometers (NIPs). One instrument viewed the solar spectrum from 0.28 to 2.8 μm while the other view the solar spectrum in the 0.698 to 2.8 μm region. Direct solar radiation data consists of 5 fields stored in a comma delimited text file. These data may be found on the ftp.cira site in the /clex/csucarte/dirsol directory. Measurements were taken at one second intervals. Every five seconds, the five most recent measurements were averaged and standard deviations calculated, giving data points at five second intervals.

Direct solar radiation fields:

Decimal UTC Julian day,
Total direct solar radiation average W/m**2,
Total direct solar radiation std. dev. W/m**2,
Near IR direct solar radiation average W/m**2,
Near IR direct solar radiation std.dev. W/m**2.

Measurements were taken on eight days, each of which are stored in a separate file: s062196.txt through s062896.txt Missing data are designated by a value of -6999. On 6/28/96, only total direct solar radiation was measured. No near IR measurements were taken. An example of the total (0.28 to 2.8 μm) and near IR solar direct irradiance data is shown below in Figure 8. The entire set of plots is given in the Appendix.

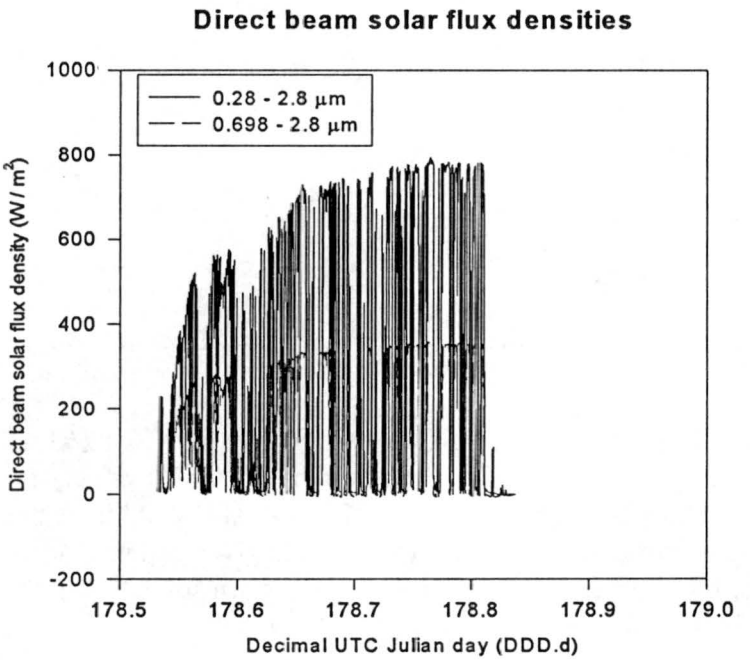

Figure 8. Direct beam solar 0.28-2.8 μm and 0.698-2.8 μm flux densities measured on June 26,1996 at IDP#3 during CLEX.

3.5 Upper Air soundings from CSU AIR radiotheodolite (/clex/csucarte/csusonde)

During CLEX, one of the main functions of the surface phase of the field experiment was to obtain timely soundings of the troposphere to be utilized for comparison with and calibration of microwave satellite data. It was intended that the sondes would be launched in coordination with satellite overpasses to provide the most timely product possible. This procedure was followed up until June 24, when the AIR radiotheodolite receiver system malfunctioned during a sounding. Thus, this data record is far from what was anticipated. Nevertheless the soundings which were obtained are archived at the ftp.cira site under the directory /clex/csucarte/csusonde. Table 3 is a list of the sounding files. The file names are indicative of the UTC Julian day and time of sonde launch

MMDDHHmm.DAT
06231606 DAT
06240028 DAT
06241343 DAT
06241654 DAT
06202304 DAT
06211443 DAT
06211454 DAT
06211711 DAT
06212359 DAT
06212311 DAT
06221317 DAT
06221629 DAT
06222359 DAT

Table 3. List of the files containing the CSU launched sondes.

3.6 Upper air sounding from the ARM Central Facility launches (/clex/armsonde)

In order to compensate for the lack of data provided by the CSU system, the upper air sounding data from sondes launched from the ARM Central Facility have been archived with the CLEX data. The list of data files so archived is given in Table 4 below. The files may be found at the ftp.cira site under the directory /clex/armsonde. Within each filename one can find the UTC day and time of launch.

sgpsondewrpnC1.a1.yyMMdd.hhmm00.prn	sgpsondewrpnC1.a1.yyMMdd.hhmm00.prn
sgpsondewrpnC1.a1.960601.053000.prn	sgpsondewrpnC1.a1.960619.112900.prn
sgpsondewrpnC1.a1.960603.112900.prn	sgpsondewrpnC1.a1.960619.143000.prn
sgpsondewrpnC1.a1.960603.142900.prn	sgpsondewrpnC1.a1.960619.172800.prn
sgpsondewrpnC1.a1.960603.173000.prn	sgpsondewrpnC1.a1.960619.202600.prn
sgpsondewrpnC1.a1.960603.202600.prn	sgpsondewrpnC1.a1.960620.052900.prn
sgpsondewrpnC1.a1.960604.052900.prn	sgpsondewrpnC1.a1.960620.142900.prn
sgpsondewrpnC1.a1.960604.112900.prn	sgpsondewrpnC1.a1.960620.172900.prn
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sgpsondewrpnC1.a1.960605.173000.prn	sgpsondewrpnC1.a1.960622.053000.prn
sgpsondewrpnC1.a1.960605.202500.prn	sgpsondewrpnC1.a1.960624.113000.prn
sgpsondewrpnC1.a1.960606.053000.prn	sgpsondewrpnC1.a1.960624.150900.prn
sgpsondewrpnC1.a1.960606.113200.prn	sgpsondewrpnC1.a1.960624.172600.prn
sgpsondewrpnC1.a1.960606.143000.prn	sgpsondewrpnC1.a1.960624.202500.prn
sgpsondewrpnC1.a1.960606.172300.prn	sgpsondewrpnC1.a1.960625.053000.prn
sgpsondewrpnC1.a1.960607.113000.prn	sgpsondewrpnC1.a1.960625.113000.prn
sgpsondewrpnC1.a1.960607.143000.prn	sgpsondewrpnC1.a1.960625.142500.prn
sgpsondewrpnC1.a1.960607.172500.prn	sgpsondewrpnC1.a1.960625.172700.prn

sgpsondewrpnC1.a1.960607.202700.prn
sgpsondewrpnC1.a1.960608.053000.prn
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sgpsondewrpnC1.a1.960612.112900.prn
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sgpsondewrpnC1.a1.960614.202800.prn
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sgpsondewrpnC1.a1.960617.113000.prn
sgpsondewrpnC1.a1.960617.143000.prn
sgpsondewrpnC1.a1.960617.173000.prn
sgpsondewrpnC1.a1.960617.202500.prn
sgpsondewrpnC1.a1.960618.052900.prn
sgpsondewrpnC1.a1.960618.112800.prn
sgpsondewrpnC1.a1.960618.142800.prn
sgpsondewrpnC1.a1.960618.172400.prn
sgpsondewrpnC1.a1.960618.202900.prn
sgpsondewrpnC1.a1.960619.053100.prn
sgpsondewrpnC1.a1.960625.202400.prn
sgpsondewrpnC1.a1.960626.053000.prn
sgpsondewrpnC1.a1.960626.113000.prn
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sgpsondewrpnC1.a1.960626.202900.prn
sgpsondewrpnC1.a1.960627.112900.prn
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sgpsondewrpnC1.a1.960702.172500.prn
sgpsondewrpnC1.a1.960702.202900.prn
sgpsondewrpnC1.a1.960703.052800.prn
sgpsondewrpnC1.a1.960703.113000.prn
sgpsondewrpnC1.a1.960703.172400.prn
sgpsondewrpnC1.a1.960703.202400.prn
sgpsondewrpnC1.a1.960704.053000.prn
sgpsondewrpnC1.a1.960704.112900.prn
sgpsondewrpnC1.a1.960704.143000.prn
sgpsondewrpnC1.a1.960704.172800.prn
sgpsondewrpnC1.a1.960704.202700.prn
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sgpsondewrpnC1.a1.960705.203000.prn
sgpsondewrpnC1.a1.960706.053300.prn

Table 4. Listing of the files containing the data of the sondes launched at the ARM Central Facility.

These ASCII files contain the height, pressure, temperature and relative humidity. In addition to these soundings, the data from the ARM sondes launched at the Central Facility during the months of August and September, 1996 have been archived at the ftp.cira site under the /clex/armsonde2 directory. These data however are archived in a netcdf format and have been "gtared" into their individual archives. During CLEX there was a persistent high pressure dome over the Southern Great Plains region. The upper air thermodynamic structure was remarkably constant as documented in Figure 9, which shows the averages of sonde data for the period during the field phase of the CLEX. The

data from sondes launched at similar launch times during CLEX make up each average. The scheduled launch times are (0530, 1130, 1430, 1730 and 2030 UTC).

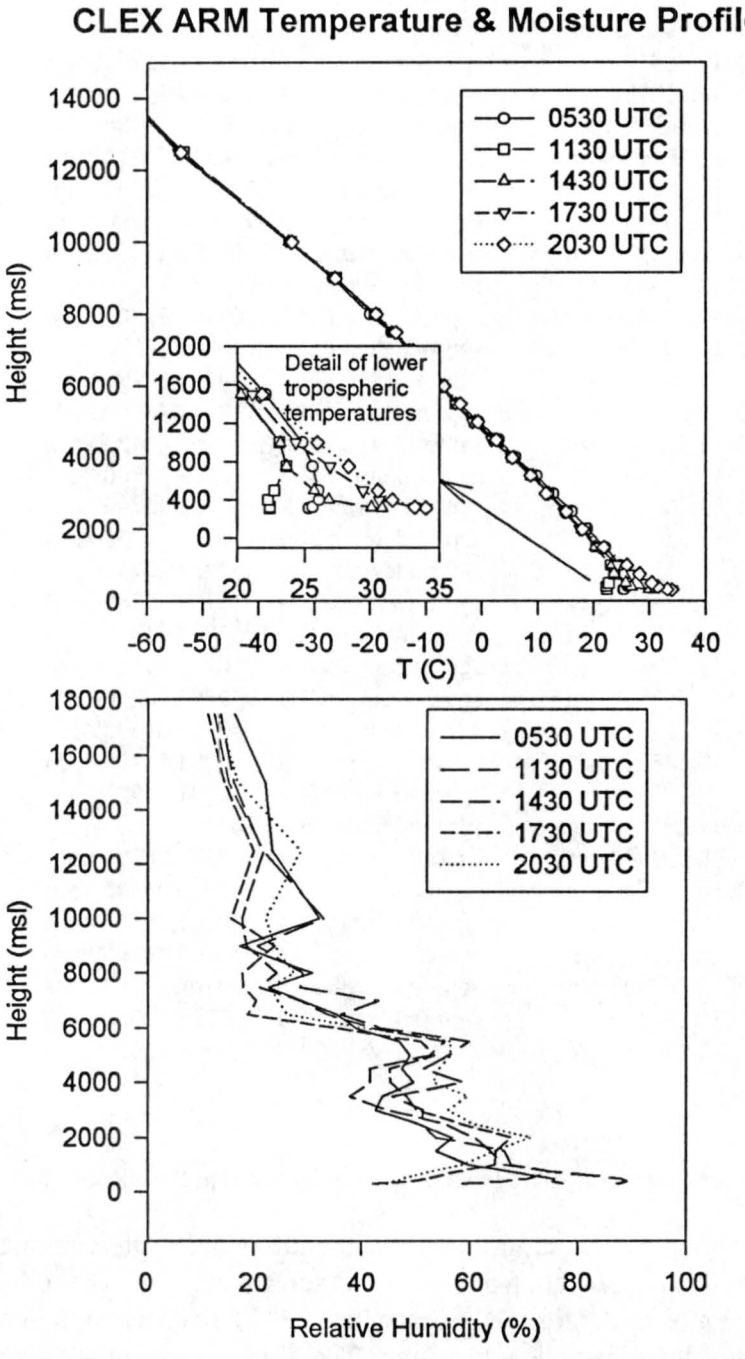

Figure 9. Averages of the temperature (top) and relative humidity (bottom) profiles at each standard launch time (0530, 1130, 1430, 1730 and 2030) taken at the ARM Central Facility during CLEX

3.7 ARM Micro Pulse Lidar derived Cloud Ceiling (/clex/armmpl)

The best indication of the cloud ceiling height during CLEX is provided by data from the ARM Micro Pulse Lidar Facility that was located at the instrumentation site about 300 m south of the IDP#3 site. The MPL operates at a wavelength of 523 nm. The data from the MPL was provided to the Geoscience Center by the ARM data archive. There are two types of files; one contains detailed signal and engineering records of the MPL, the other a derived cloud ceiling height. It is the latter of these that is of immediate interest to CLEX users and these files may be accessed at the ftp.cira site under the directory /clex/armmpl. These files contain the height of detected cloud base as a function of the decimal UTC Julian day. Figure 10 below shows is an example of the data and the plots for the all of the CLEX activity at ARM are contained in the Appendix.

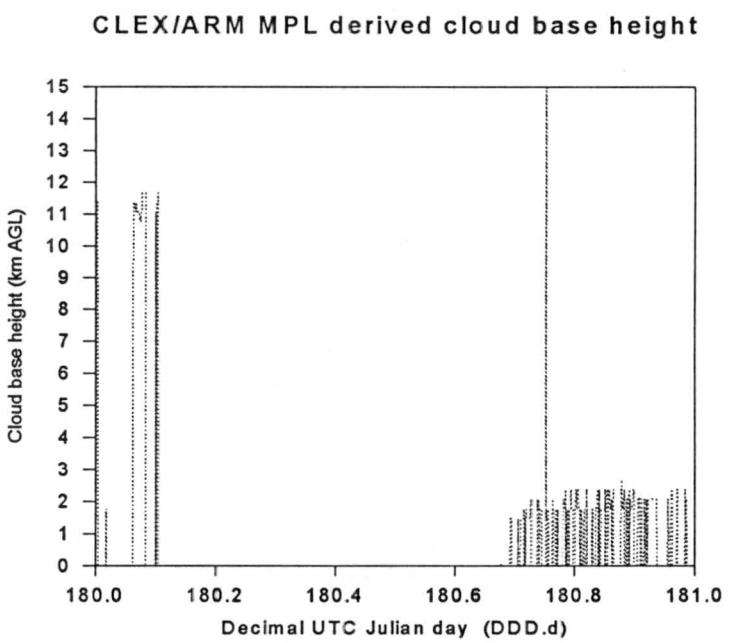

Figure 10. Cloud ceiling height derived from the ARM MPL during CLEX at the ARM CART site

3.8 IR downwelling spectral radiance (/clex/csucarte/irspectra)

During CLEX, several spectra of the downwelling IR radiance were collected using a Bomem Inc. model MB100 interferometer. The timing of the spectra was selected to provide calibration data for the PRT6 radiometer and for deducing the IR emittance of the cloud cover. The spectra consist of downwelling radiances at a spectral resolution of 1.0 cm^{-1} in the 400 to 2000 (25 to 5 μm) portion of the spectrum. All spectra were collected with the instrument viewing the atmosphere at the zenith. Table 5 below contains a list of spectra filenames, the time the spectra was measured and the time of the nearest launch of a radiosonde from the ARM Central Facility site. Each file contains two columns of data; the first is the wavenumber of the radiance and the second the spectral radiance in units of W / cm^2 sr cm^{-1}.

mmdds##	hh.mm	hh.mm	mmdds##	hh.mm	hh.mm
jn20s01	21.415	20.26	jn24s04	13.141	13.43
jn20s04	23.031	23.04	jn24s07	14.115	13.43
jn20s07	23.239	23.04	jn24s10	16.142	16.54
jn21s01	14.561	14.54	jn24s13	16.194	16.54
jn21s04	15.041	14.54	jn24s19	16.303	16.54
jn21s07	16.223	17.11	jn24s22	16.355	16.54
jn22s01	14.374	13.17	jn24s25	16.412	16.54
jn22s04	14.430	13.17	jn26s01	12.225	11.30
jn22s07	16.113	16.29	jn26s07	12.344	11.30
jn22s10	16.435	16.29	jn26s10	12.446	11.30
jn22s13	23.415	23.59	jn26s13	14.054	14.26
jn22s16	24.011	23.59	jn26s16	14.271	14.26
jn23s01	12.254	13.17	jn26s19	16.372	17.27
jn23s04	12.464	13.17	jn26s22	19.544	20.29
jn23s07	12.583	13.17	jn27s01	14.543	14.27
jn23s10	14.191	13.17	jn27s04	15.302	14.27
jn23s13	15.572	16.06	jn27s10	17.266	17.28
jn23s16	16.062	16.06	jn28s01	12.433	11.30
jn23s19	16.160	16.06	jn28s04	12.560	11.30
jn23s22	16.384	16.06	jn28s10	15.501	14.28
jn23s25	16.560	16.06	jn28s13	17.281	17.26
jn24s01	13.076	13.43			

Table 5. MB100 spectra filename, time (hh.mm UTC) the spectra was taken and time of the nearest launch of a radiosonde from the ARM Central Facility Site.

Figure 11 is a depiction of a spectrum collected on June 24 under clear sky conditions. Also plotted is the nearly coincident calculated (MODTRAN2) spectrum. The upper portion of the figure is the total spectrum while the lower portion shows the window region only.

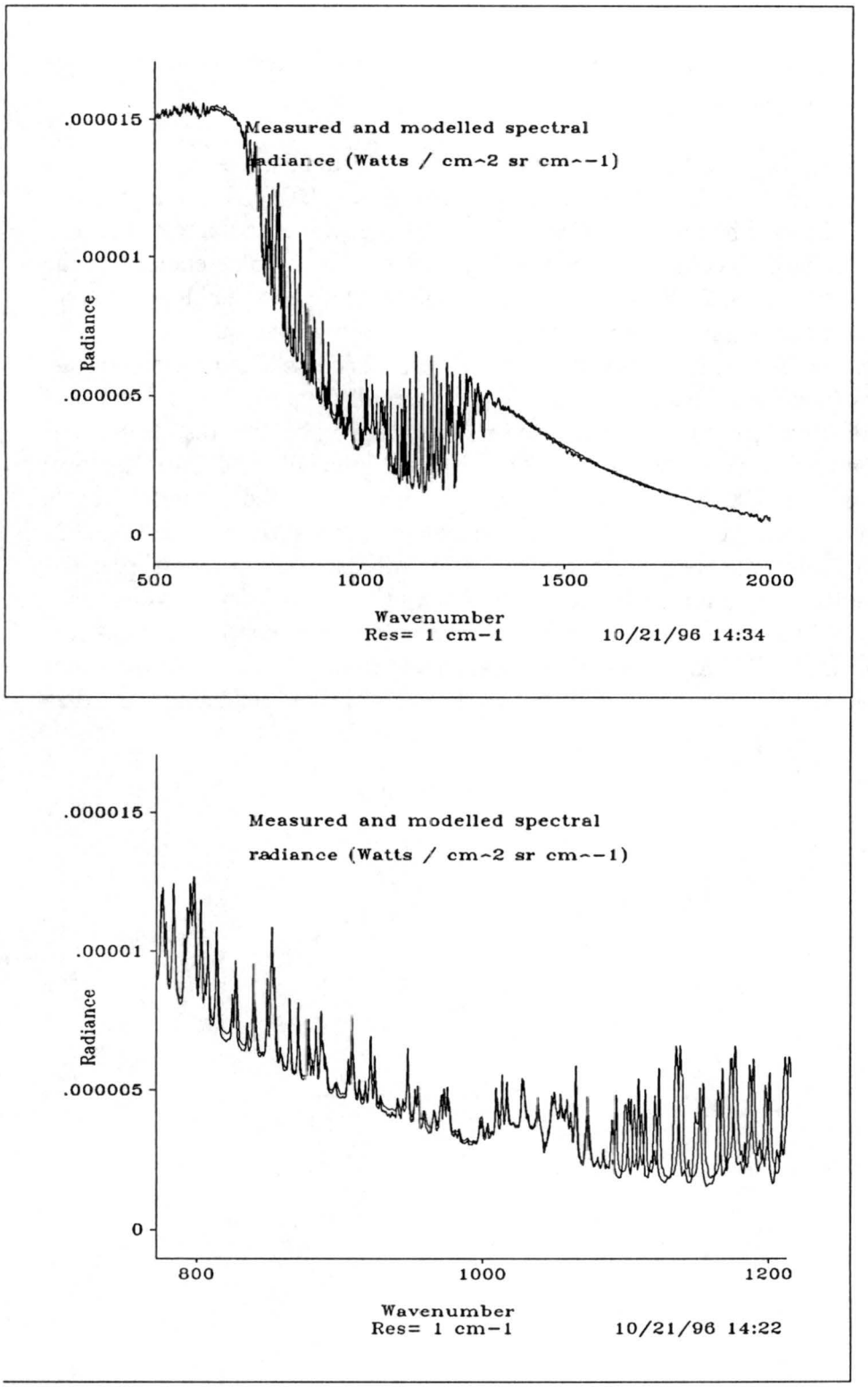

Figure 11. Spectrum of the downwelling radiance field on June 24, 1996 at CART. Top of figure shows the complete IR spectrum and bottom shows the window region only.

3.9 Desert Research Institute and ARM microwave radiometer retrievals (/clex/dridata and /clex/armmicro)

Total column water vapor and liquid water were retrieved from passive microwave radiometry measured by both the Desert Research Institute's (DRI) Mobile Microwave Radiometer (MMR) and by the ARM Central Facility Microwave Radiometer that operated in a routine data collection mode during CLEX. The radiometers receive the emitted signals centered at 20.6 and 31.6 GHz to which water vapor and liquid water respectively contribute most strongly. Radiosondes are used to calibrate the measurements to column water vapor amounts. Figure 12 shows a comparison of the retrieved vapor (upper) and liquid (lower) column amounts for June 23 for the two microwave radiometer systems. A complete set of the vertical column results may be found in the Appendix. Note that on June 24 and June 26 the DRIMMR was deployed to Moline, KS and Paris, TX respectively. Thus, these data are plotted separately for the two instruments. Also, the DRIMMR did not take data on the 20th, 28th, 29th and 30th of June so only ARM data are presented. The DRIMMR also took azimuthal scan data which is not plotted here but is available on the fpt.cira site in directory /clex/dridata. The ARM microwave data are available on the same site under the /clex/armmicro directory. The data are in an ASCII format. There is a readme file in each directory describing the data file contents. Table 6 contains a list of the filenames of files containing these data.

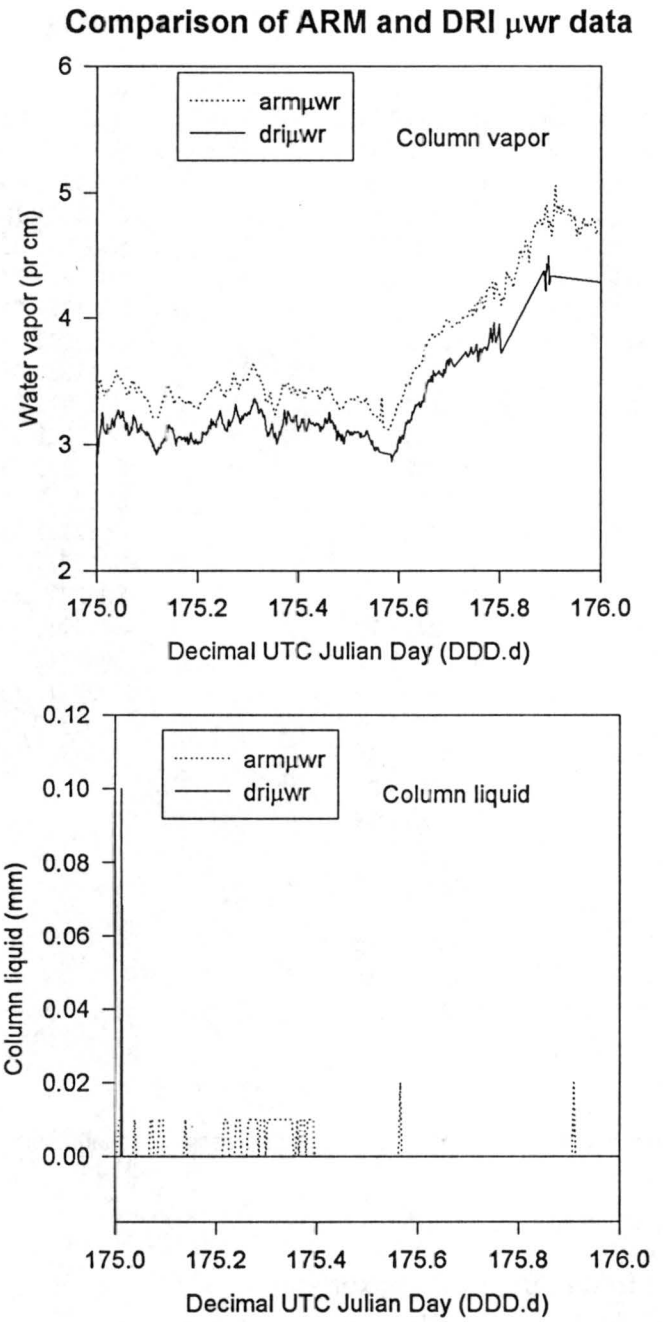

Figure 12. Comparison of the total column liquid water and water vapor retrieved from the ARM and DRI passive microwave radiometers for June 23, 1996 at IDP#3.

A list of the files containing the DRI microwave radiometer data for the vertical mode R and the scanned mode S and the ARM data may be found in Table 6 below.

ARM microwave radiometer filenames sgp5mwravgC1.c1. yyMMdd.000500.prn	DRI vertical RMMddhh.mm	DRI scanned SMMddhh.mm
sgp5mwravgC1.c1.960620.000500.prn	R062100.00	S062117.56
sgp5mwravgC1.c1.960621.000500.prn	R062118.11	S062118.01
sgp5mwravgC1.c1.960622.000500.prn	R062123.42	S062220.19
sgp5mwravgC1.c1.960623.000500.prn	R062200.00	S062221.05
sgp5mwravgC1.c1.960624.000500.prn	R062218.12	S062221.10
sgp5mwravgC1.c1.960625.000500.prn	R062218.41	S062221.25
sgp5mwravgC1.c1.960626.000500.prn	R062223.00	S062221.34
sgp5mwravgC1.c1.960627.000500.prn	R062223.40	S062221.55
sgp5mwravgC1.c1.960628.000500.prn	R062223.45	S062222.03
sgp5mwravgC1.c1.960629.000500.prn	R062300.01	S062222.08
sgp5mwravgC1.c1.960630.000500.prn	R062314.00	S062222.23
	R062317.29	S062222.31
	R062321.15	S062222.33
	R062321.21	S062317.15
	R062323.57	S062711.13
	R062413.21	S062711.30
	R062416.06	S062711.39
	R062421.18	S062711.49
	R062421.26	S062712.01
	R062500.00	S062712.13
	R062512.41	S062712.25
	R062514.59	
	R062603.03	
	R062612.15	
	R062613.40	
	R062613.55	
	R062700.00	
	R062702.18	
	R062710.36	
	R062710.49	

Table 6. List of ARM Central Facility, DRI vertical mode and DRI scanned mode microwave radiometer data files.

3.10 Penn State Cloud Radar Data (/clex/psudata) or (http://aero.essc.psu.edu/datasets/clex1/)

A 94 GHz, bistatic, Doppler cloud radar was operated at IDP#3 by the Department of Meteorology at Pennsylvania State University. The radar was operated whenever there was the possibility for radar returns from any type of cloud. Several types of data were processed in both image and calibrated data format. The data may be accessed from the web pages at Pennsylvania State University at the url (http://aero.essc.psu.edu/datasets/clex1/). By "surfing" up the web to (http://wwwarc.essc.psu.edu/papers/papers.html) one can access a publication entitled: "An Evaluation of a 94-GHz Radar for Remote Sensing of Cloud Properties," by

Clothiaux *et al.*, which provides extensive description of the data processing applied to the radar data. Data are archived according to the type of data provided; basically data files or image files, then further into the type of processing applied to the raw returns. The following list in Table 7 provides the directory structure.

Directory name	Description of data
94r2r.cfsgp.clex1.a0	Rapid systems reflectivity raw
94r2r.cfsgp.clex1.b0	Rapid systems binary cloud mask
94r2r.cfsgp.clex1.c0	Rapid systems reflectivity dBZe
94l2r.cfsgp.clex1.a0	Lassen systems reflectivity raw
94l2v.cfsgp.clex1.a0	Lassen systems velocity raw

Table 7. List of directories containing the data and image files collected by the PSU radar at CLEX/ARM

Each of these directory names may be found under the "gif" group of images or under the "data" group of netCDf data files. These data may also be accessed from the ftp.cira site under /clex/psudata and then under either the data of gif directories. Figure 13 below shows one of the raw reflectivity data files collected on June 25, 1996 at 1916 UTC.

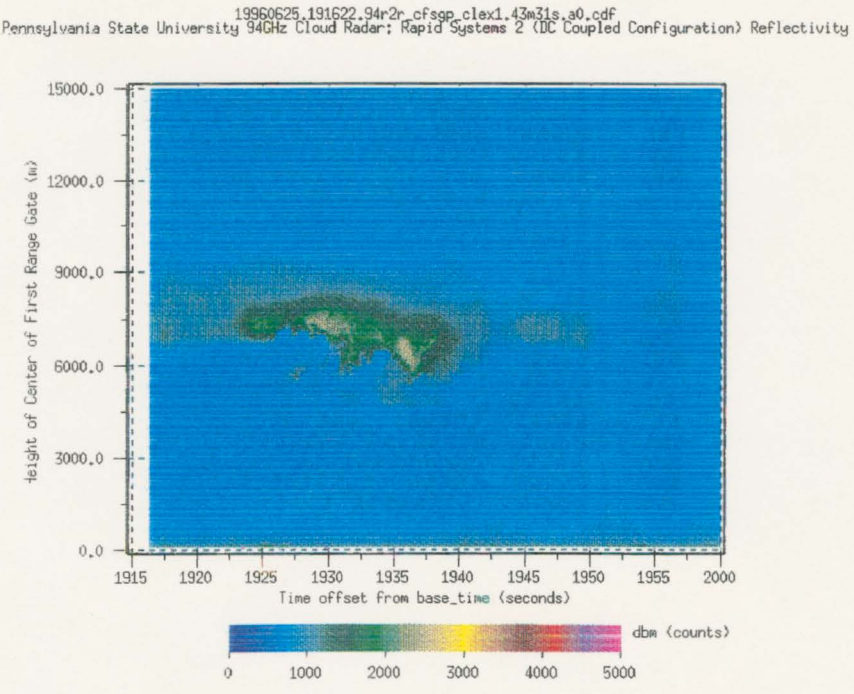

Figure 13. Raw reflectivity collected on June 25, 1996 at the CART ARM for CLEX by PSU radar

4.0 Accessing the data from CLEX/ARM CART

For each data set described above, the directory in which it resides has been given. These directories are summarized in Table 8 below.

Data set name (directory at ftp.cira)	Description of data	File Format
Surface radiation data (clex/csucarte/surfrad)	Downwelling & Upwelling total solar, near IR solar and IR hemispheric irradiances at IDP#3	ASCII
Surface meteorology data (clex/csucarte/surfmet)	Temperature, relative humidity, wind speed and direction at IDP#3	ASCII
Direct beam solar irradiances (clex/csucarte/dirsol)	Solar and near IR solar direct beam irradiances at IDP#3	ASCII
Downwelling IR spectra (/clex/irspectra)	Downwelling 1.0 cm^{-1} IR spectra at IDP#3	ASCII
Upper Air soundings from CSU AIR radiotheodolite (/clex/csucarte/csusonde)	Soundings taken at selected satellite overpass times at IDP#3	ASCII
Upper air soundings from the ARM Central Facility launches (/clex/armsonde)	Soundings taken at scheduled launch times at the ARM Central Facility from June 1 to July 7, 1996	ASCII
Supplementary upper air soundings from ARM Central Facility (/clex/armsonde2)	Soundings taken at scheduled launch times at the ARM Central Facility from August 1 to September 30, 1996	(netcdf).tgz
ARM Micro Pulse Lidar derived Cloud Ceiling (/clex/armmpl)	Ceiling height derived from the ARM Micro Pulse Lidar	ASCII
DRI Microwave Radiometer water vapor/liquid (/clex/dridata)	Column water liquid and vapor from IDP#3, Moline KS and Paris, TX	ASCII
PSU cloud radar profiles (/clex/psudata) and also at (http://aero.essc.psu.edu/datasets/clex1)	Time/height cross sections of cloud reflected radar at IDP#3	gif & netcdf
ARM Microwave Radiometer water vapor/liquid (/clex/armmwr)	Column water liquid and vapor from the ARM instrument trailer site	ASCII

Table 8. Summary list of the data sets collected at CLEX/ARM CART, their directory and the data formats

Access to any of these data may be gained through an ftp file transfer from the ftp.cira site. To gain access, start your ftp process and at the *ftp* prompt type, "open". Then at the next prompt type"ftp.cira.colostate.edu". At the *login* prompt type, "ftp". At the *password* prompt type your email address. To access a particular data set type, "cd directory", where directory stands for any of the directory names found in the parenthesis in column 1 of Table 8 above. You may change to a local directory on your own computer system, (one that already exists) by typing, "lcd mydirectory" where mydirectory stands for the full path of the directory where you want the data to be transferred on your system. If you are accessing file of binary data type, "bin", if not this is not necessary. To list the files in the directory type, "ls". To get files one at a time type, "get filename", where filename is the name of the desired file. To download all files in a directory first type, "prompt" which puts the ftp transfer in a non-interactive or non-prompting mode. Then type, "mget *". All files in the current directory will be transferred to your computer.

APPENDIX

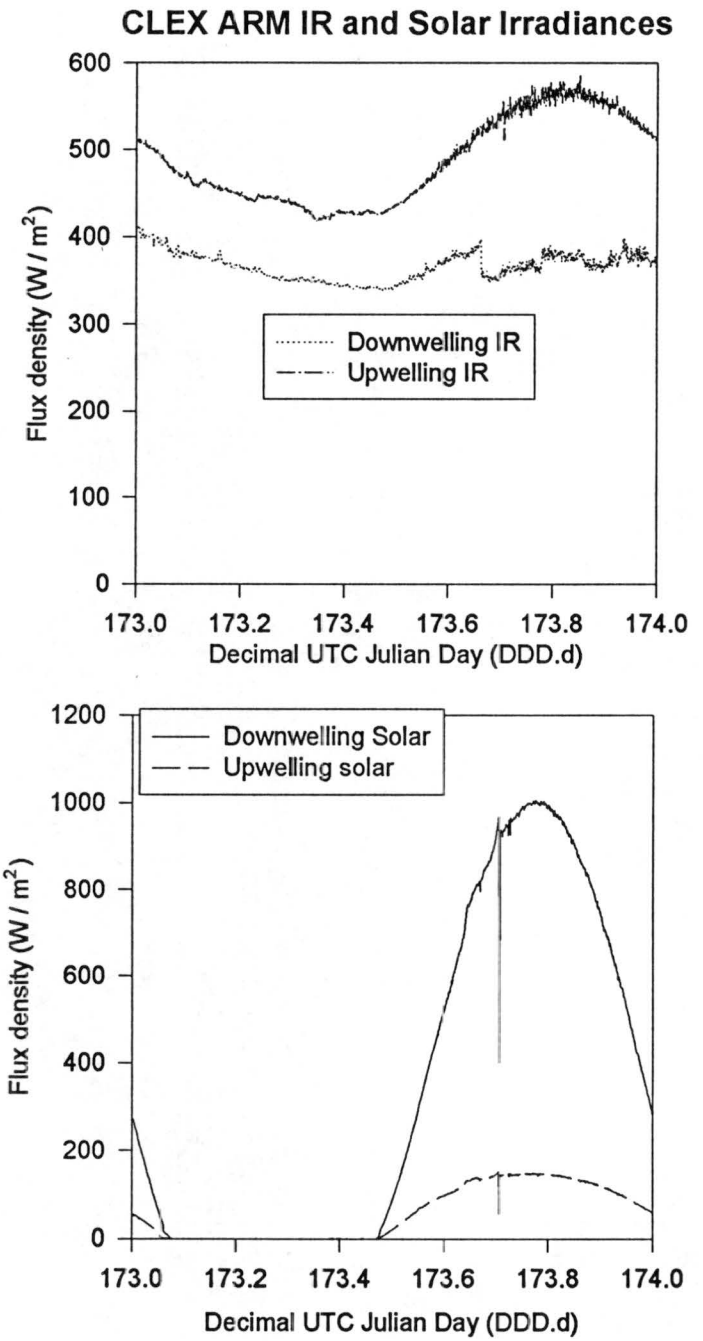

Figure A1. Surface radiation measurements IR (top) and Solar (bottom) for June 21, 1996

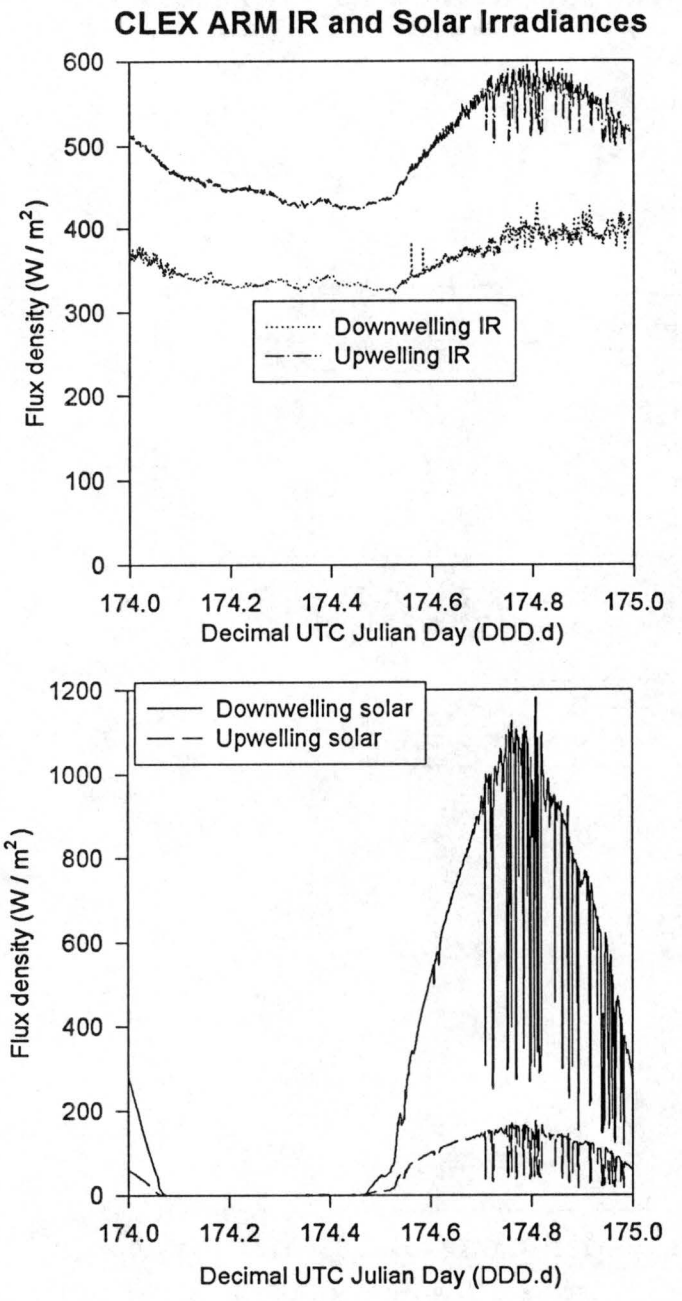

Figure A2. Surface radiation measurements IR (top) and Solar (bottom) for June 22, 1996

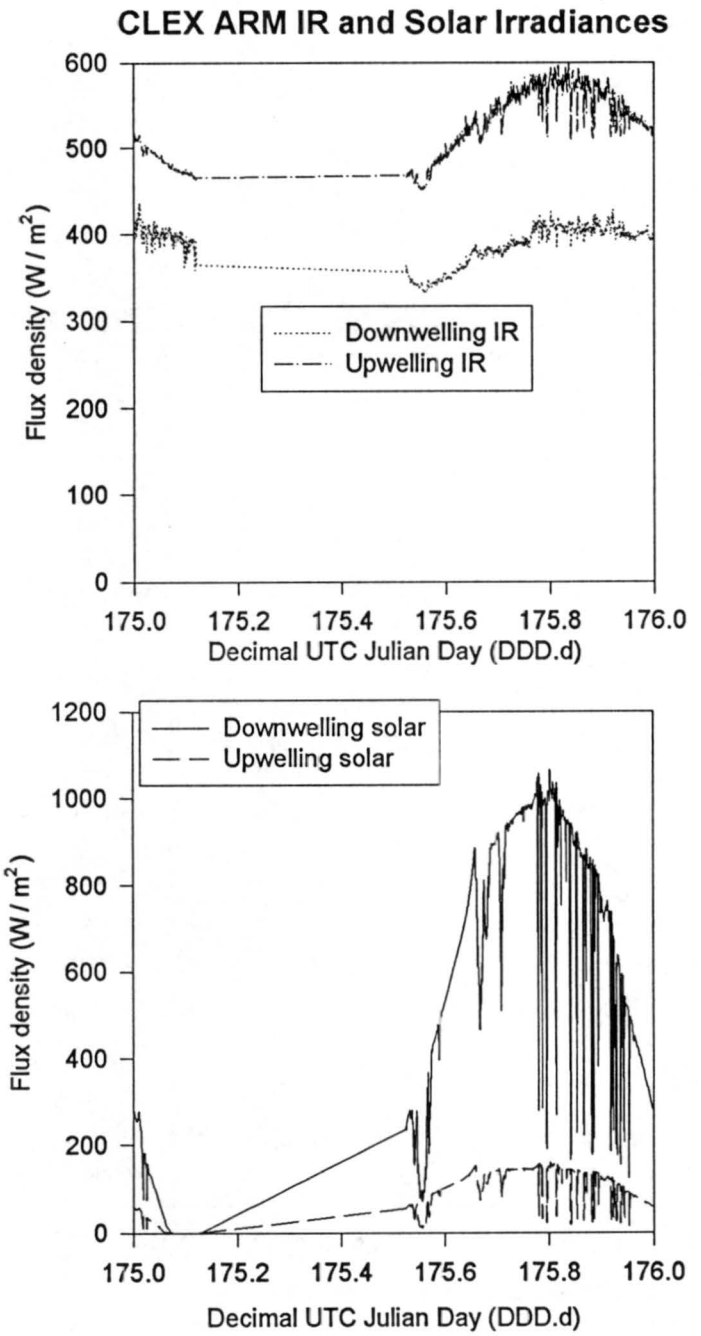

Figure A3. Surface radiation measurements IR (top) and Solar (bottom) for June 23, 1996

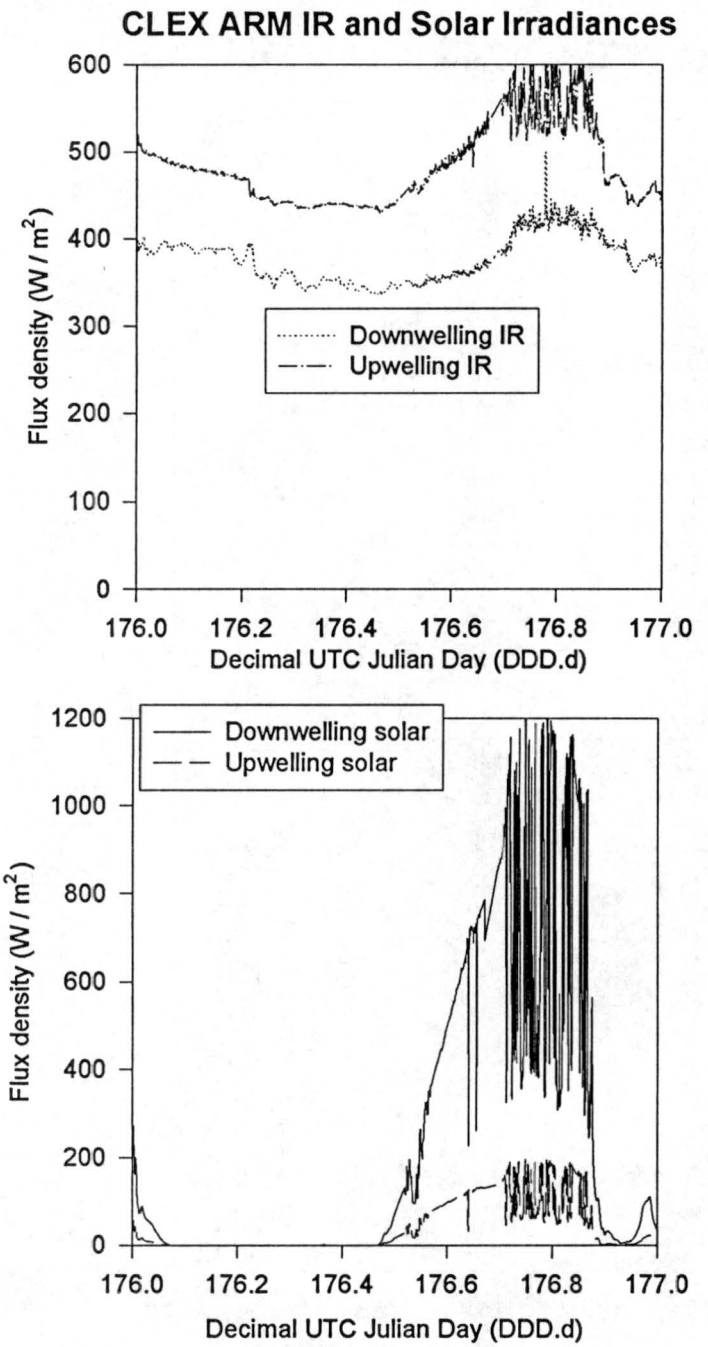

Figure A4. Surface radiation measurements IR (top) and Solar (bottom) for June 24, 1996

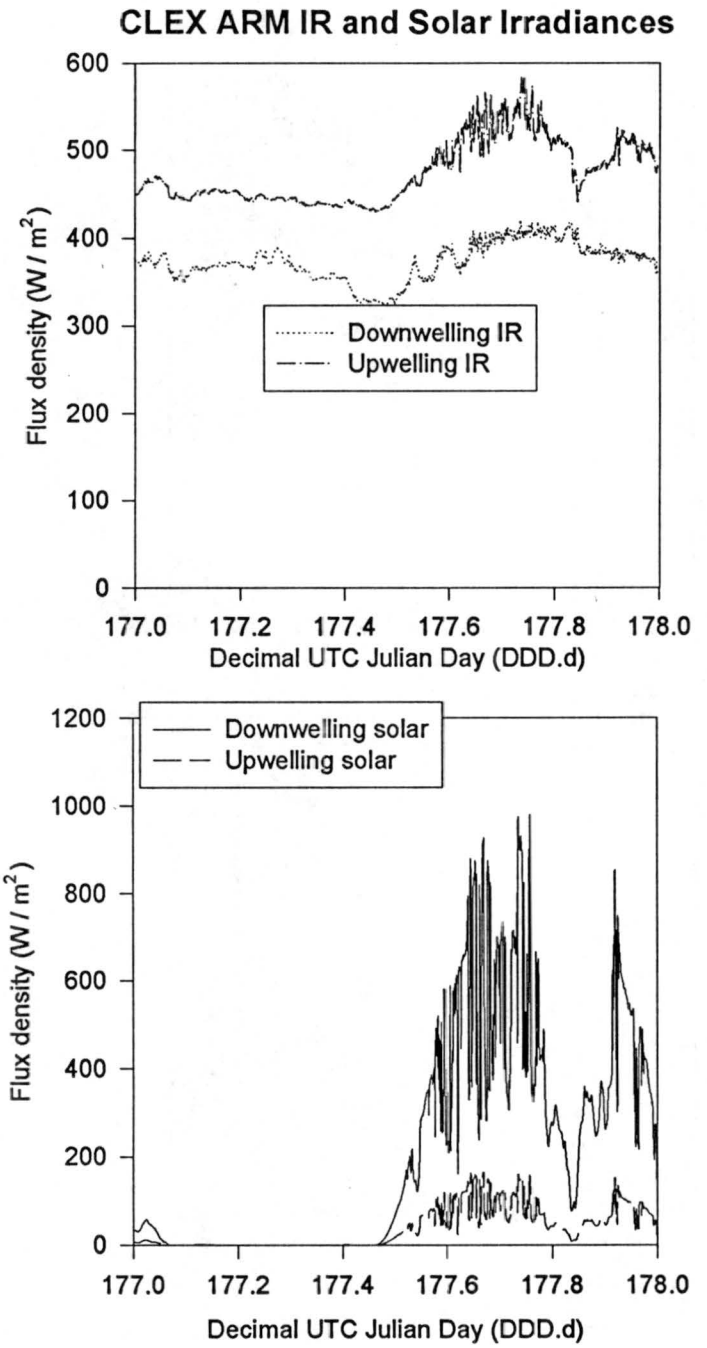

Figure A5. Surface radiation measurements IR (top) and Solar (bottom) for June 25, 1996

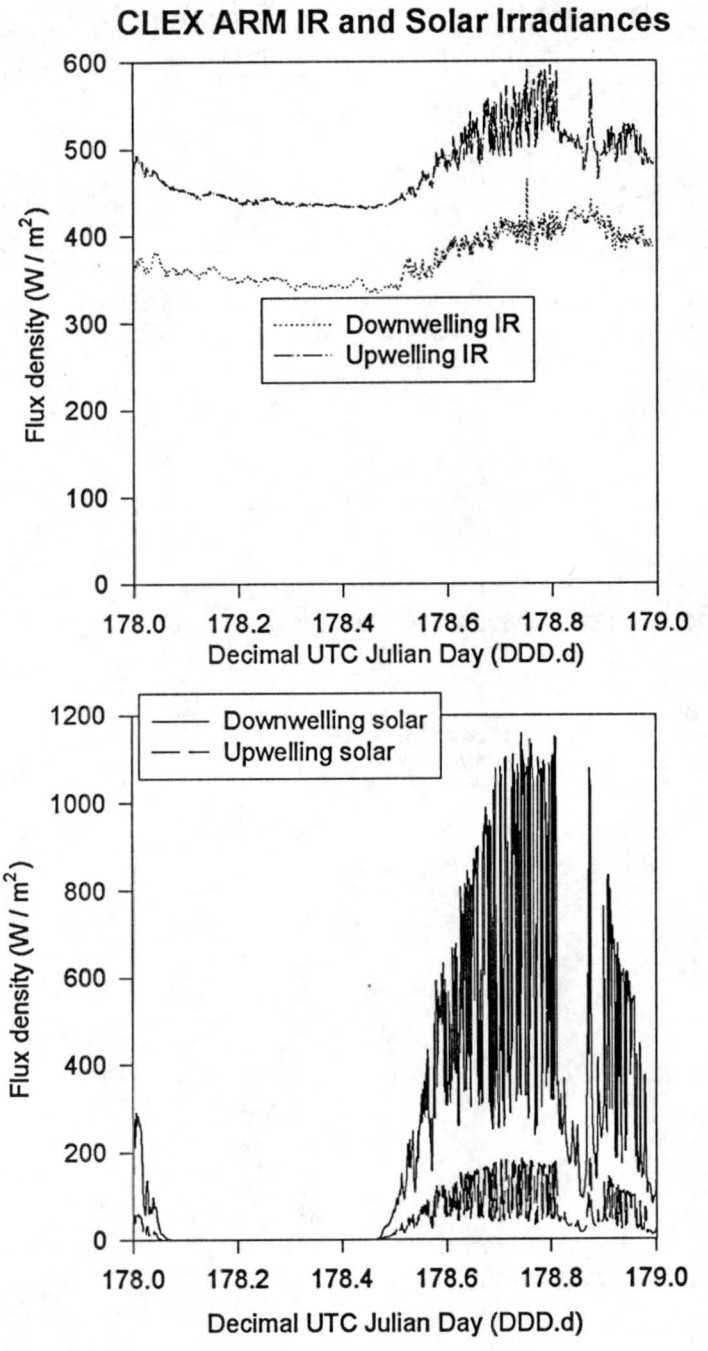

Figure A6. Surface radiation measurements IR (top) and Solar (bottom) for June 26, 1996

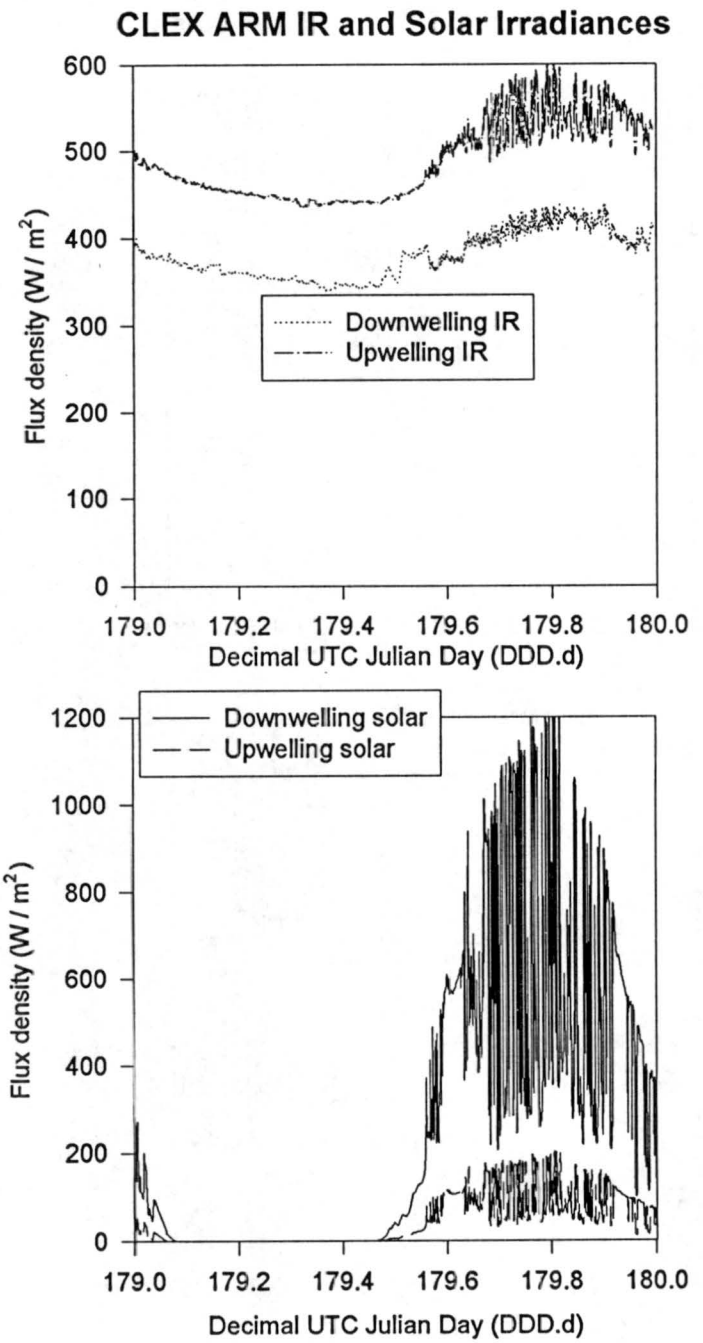

Figure A7. Surface radiation measurements IR (top) and Solar (bottom) for June 27, 1996

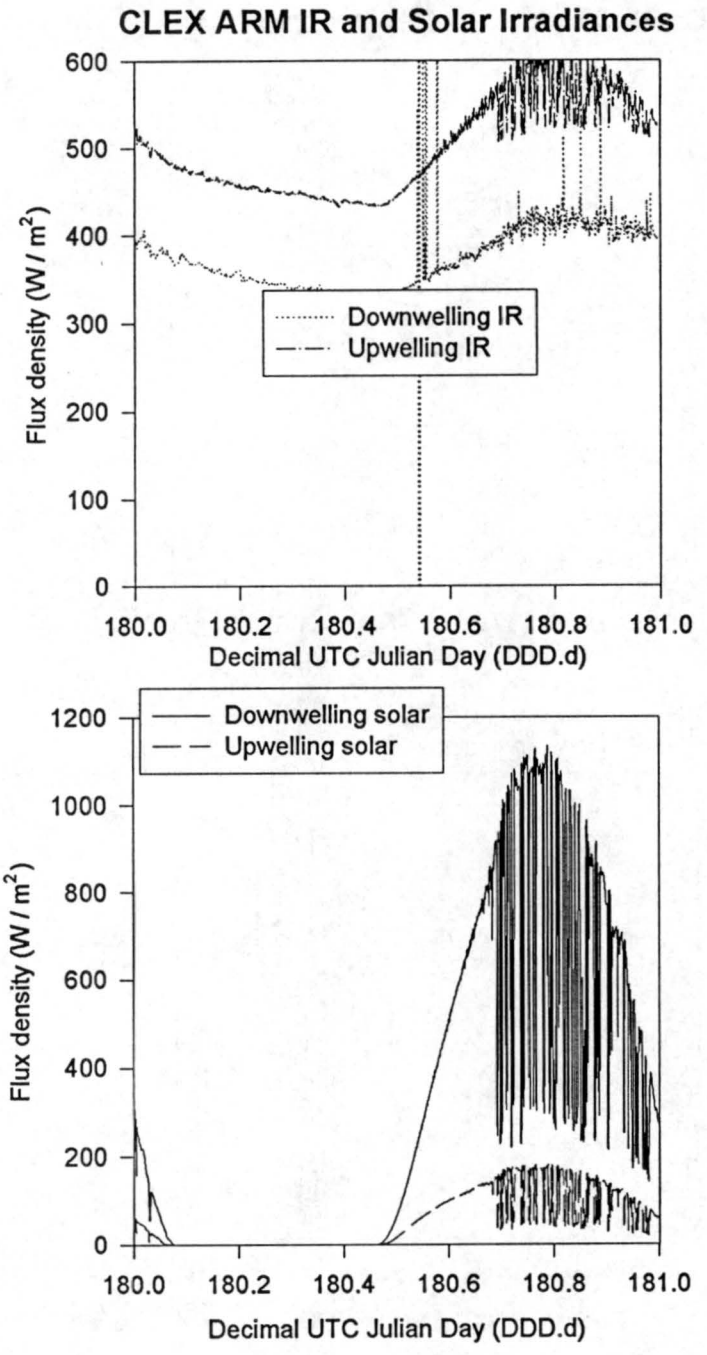

Figure A8. Surface radiation measurements IR (top) and Solar (bottom) for June 28, 1996

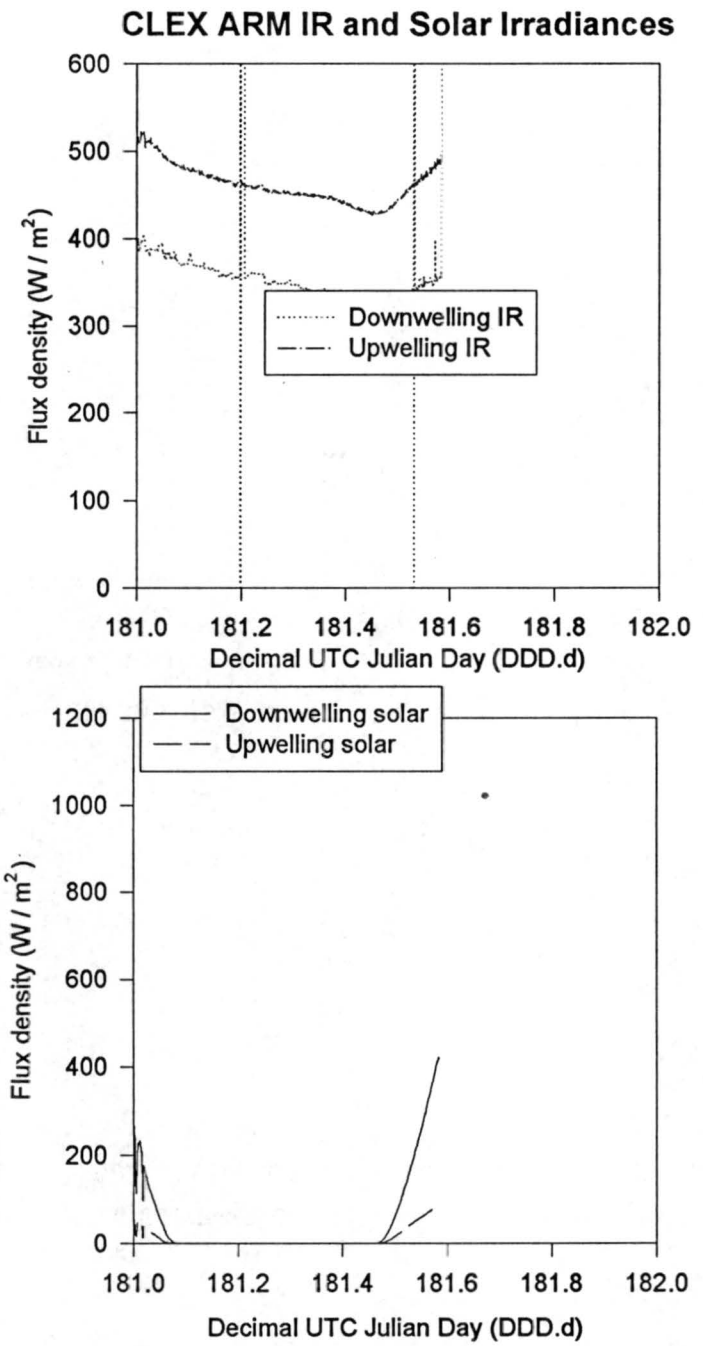

Figure A9. Surface radiation measurements IR (top) and Solar (bottom) for June 29, 1996

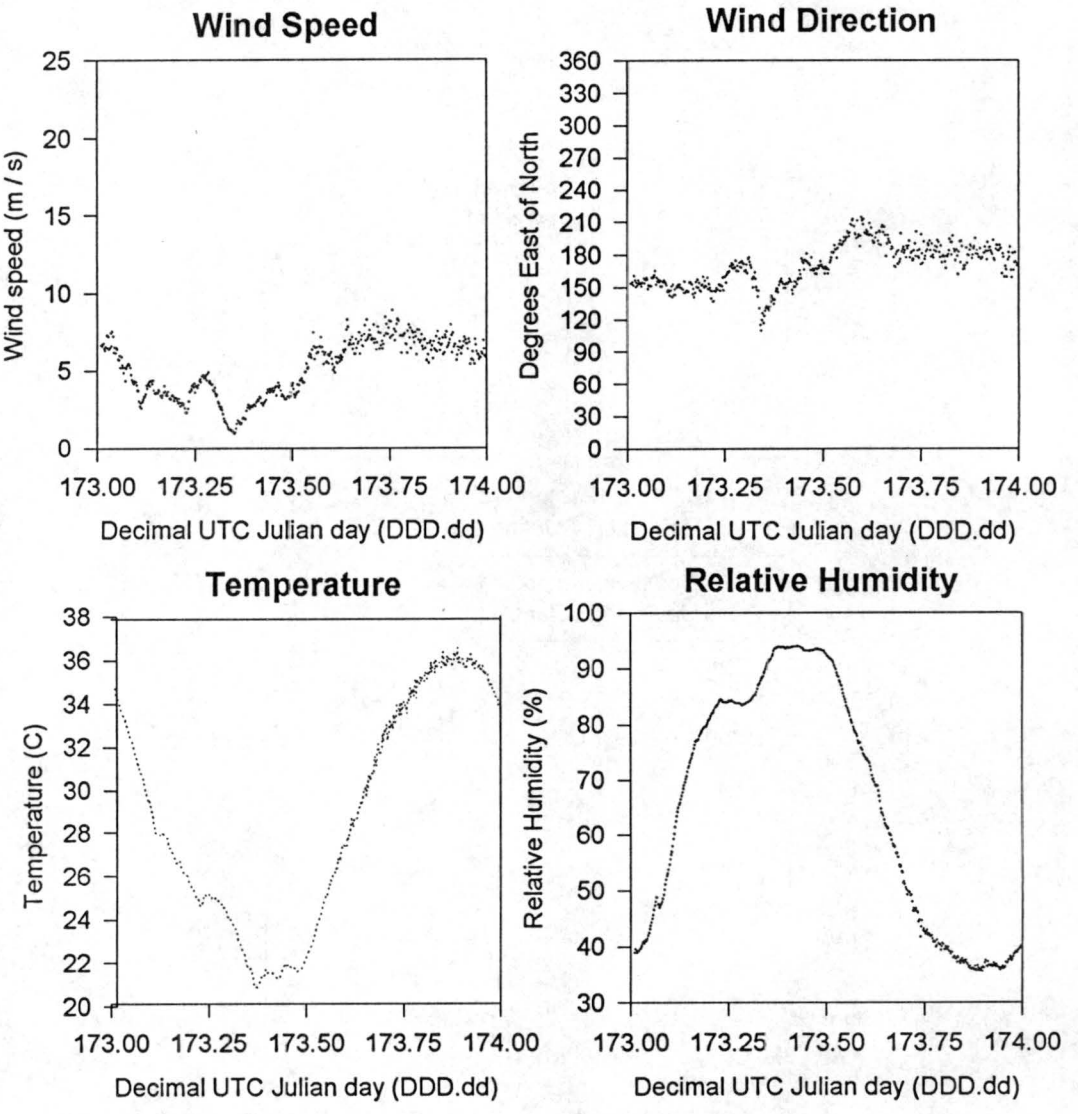

Figure A10. Wind speed, wind direction, temperature and relative humidity for June 21, 1996

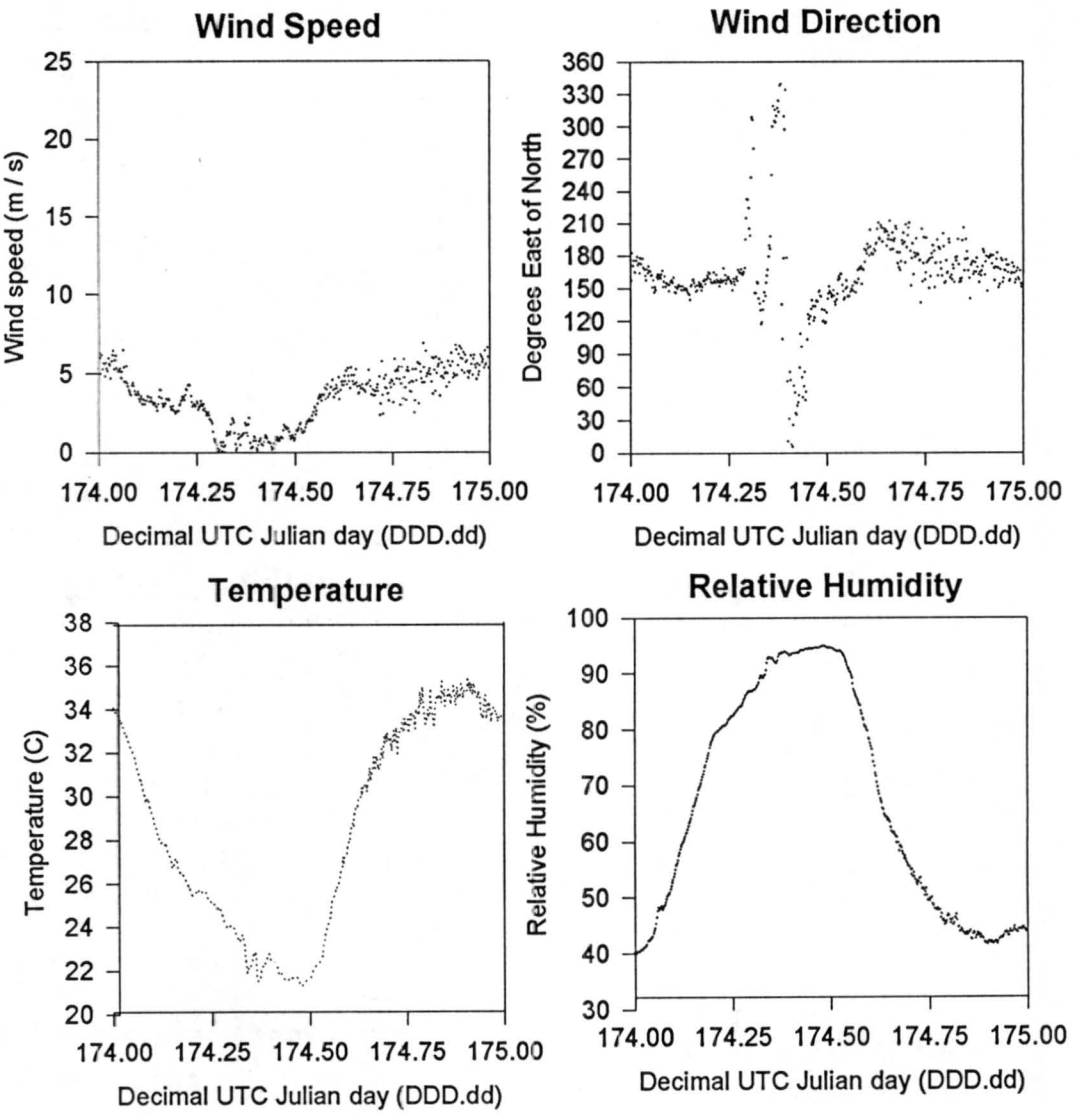

Figure A11. Wind speed, wind direction, temperature and relative humidity for June 22, 1996

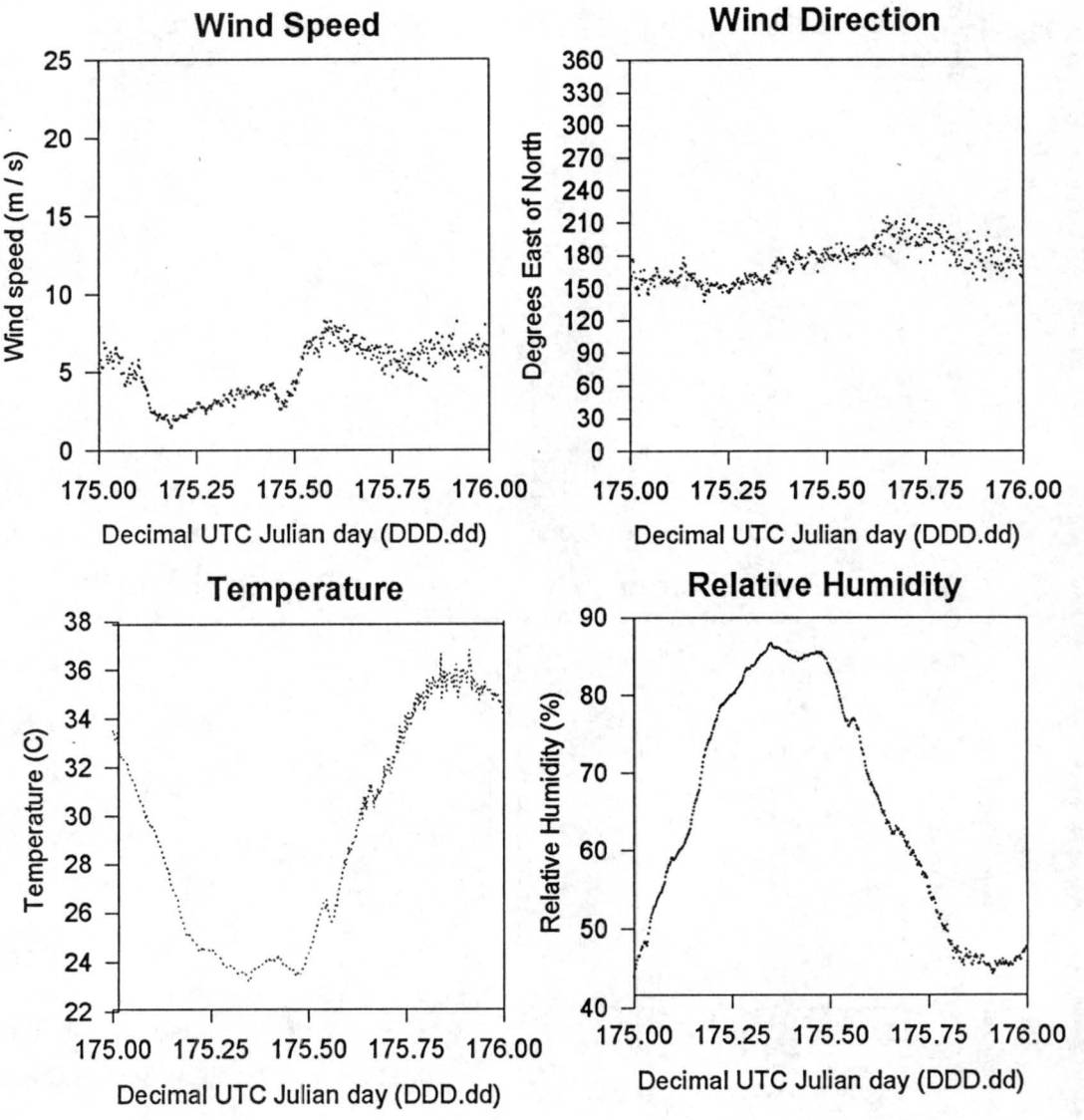

Figure A12. Wind speed, wind direction, temperature and relative humidity for June 23, 1996

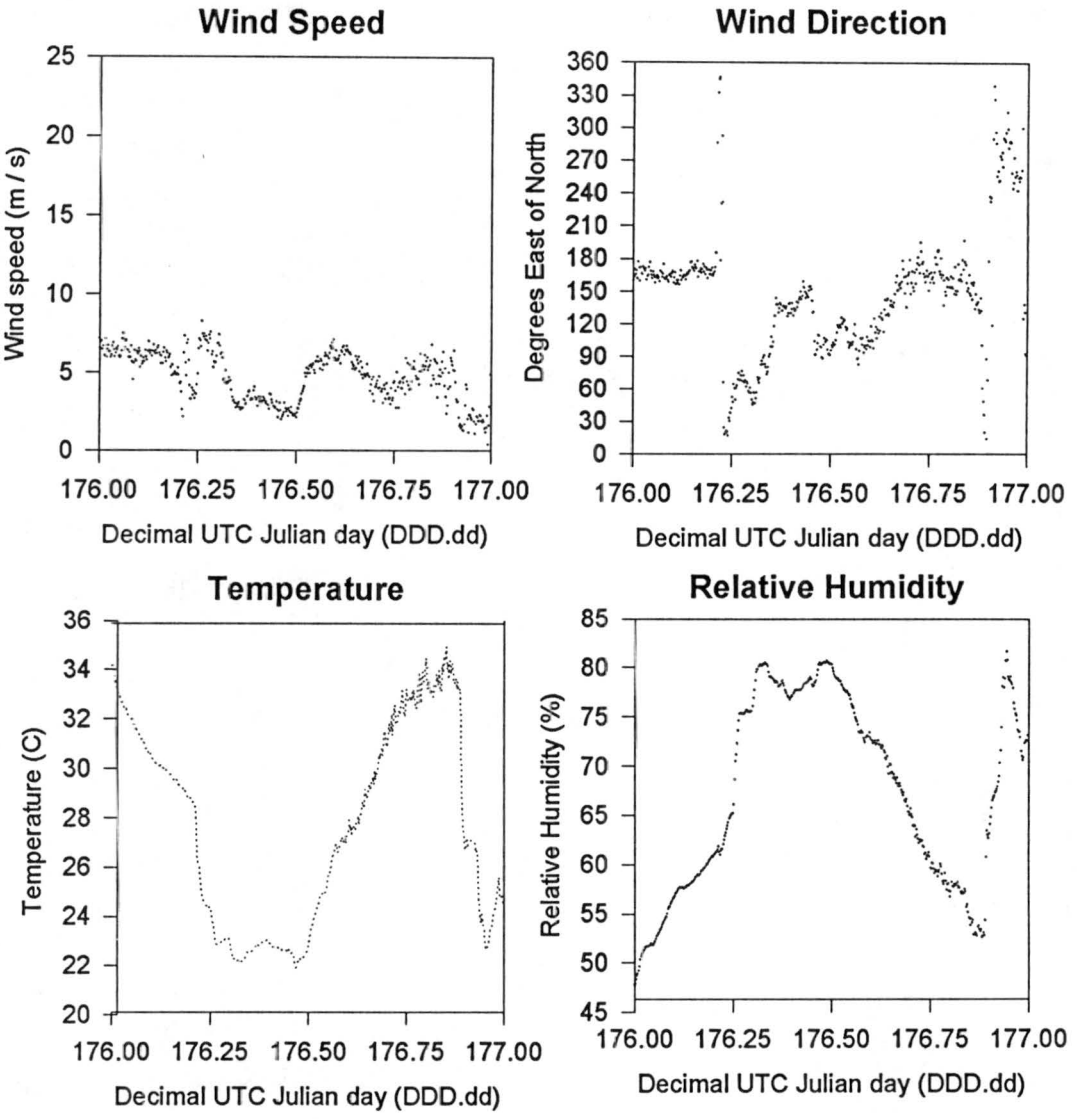

Figure A13. Wind speed, wind direction, temperature and relative humidity for June 24, 1996

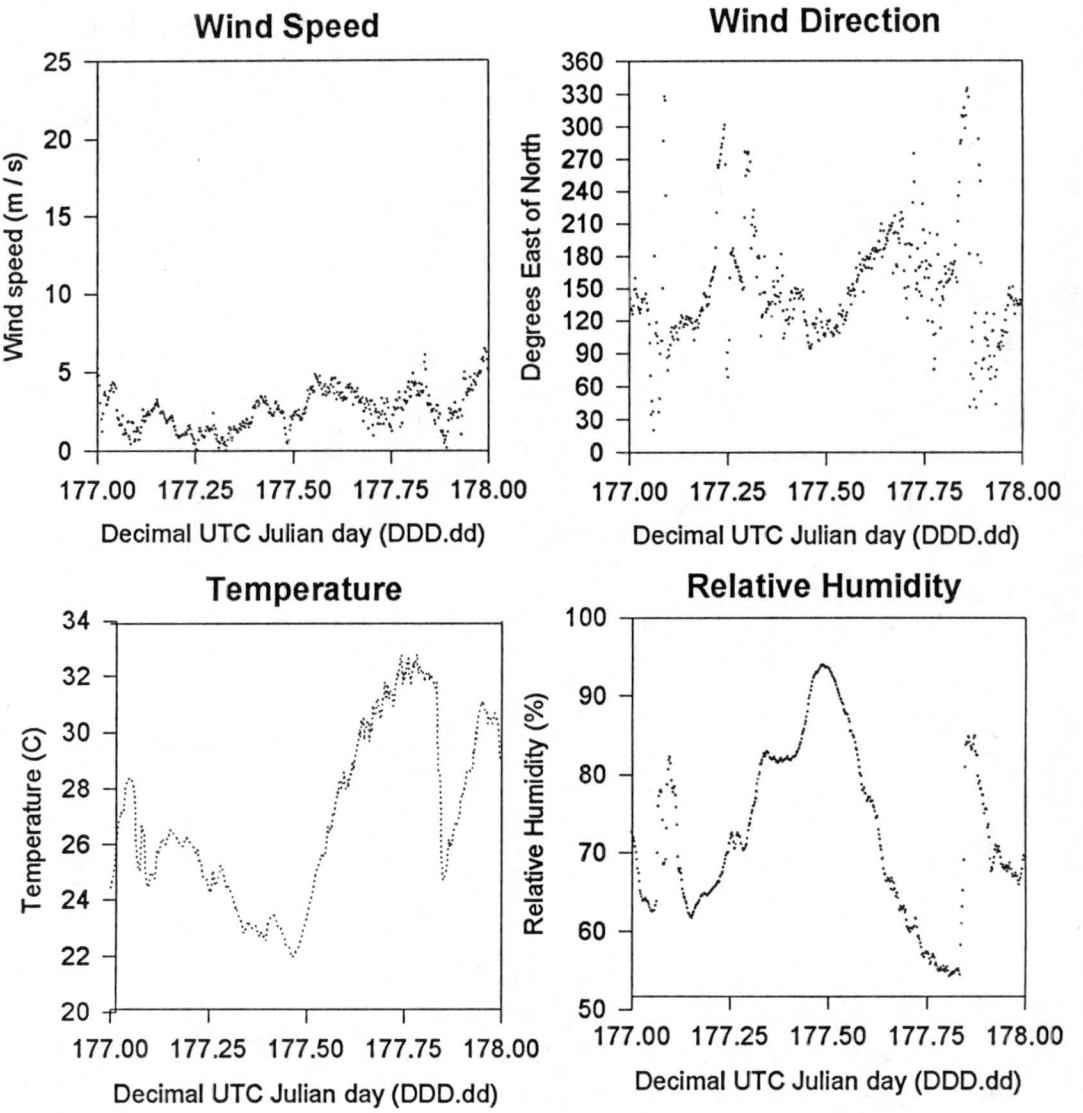

Figure A14. Wind speed, wind direction, temperature and relative humidity for June 25, 1996

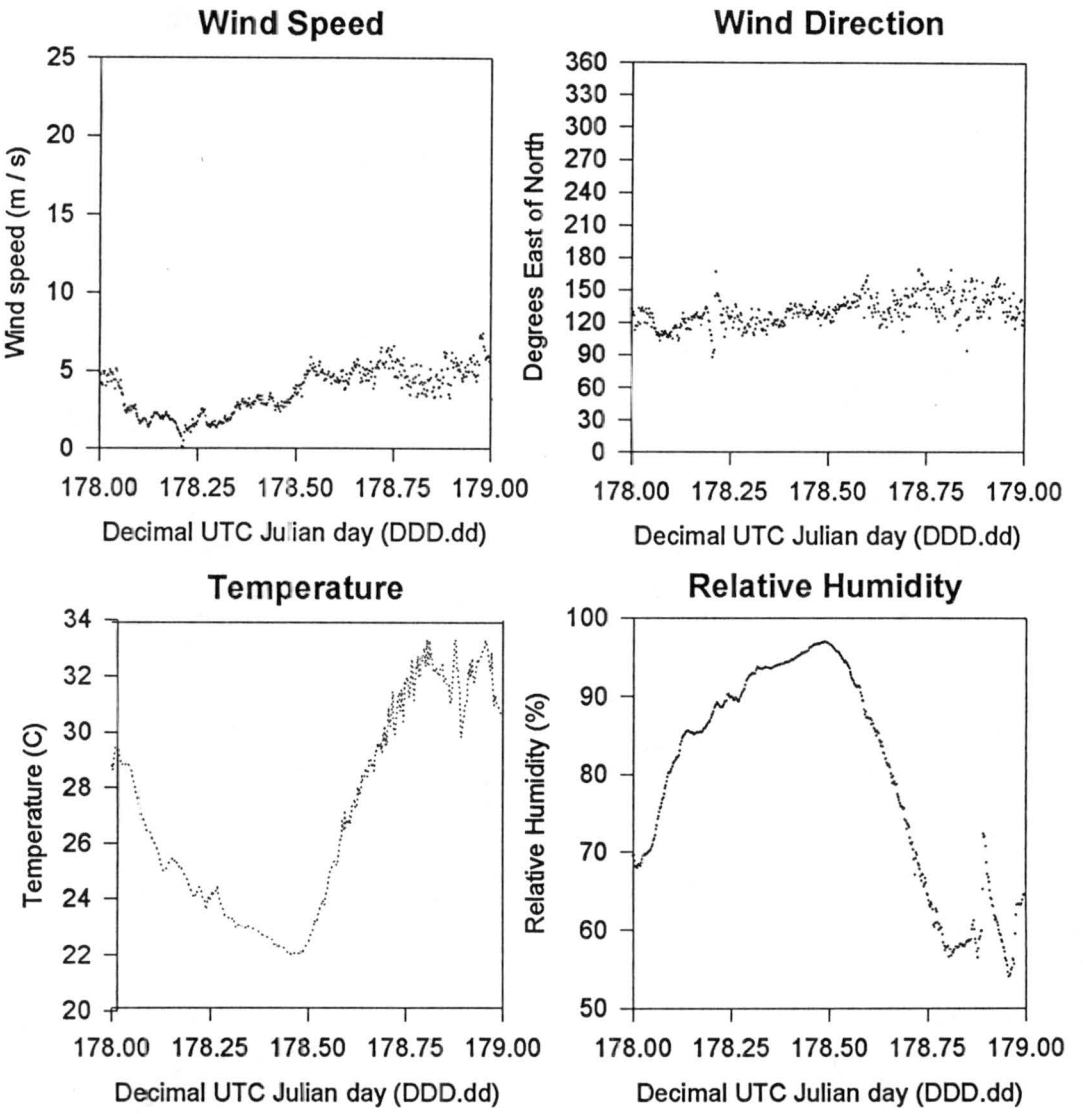

Figure A15. Wind speed, wind direction, temperature and relative humidity for June 26, 1996

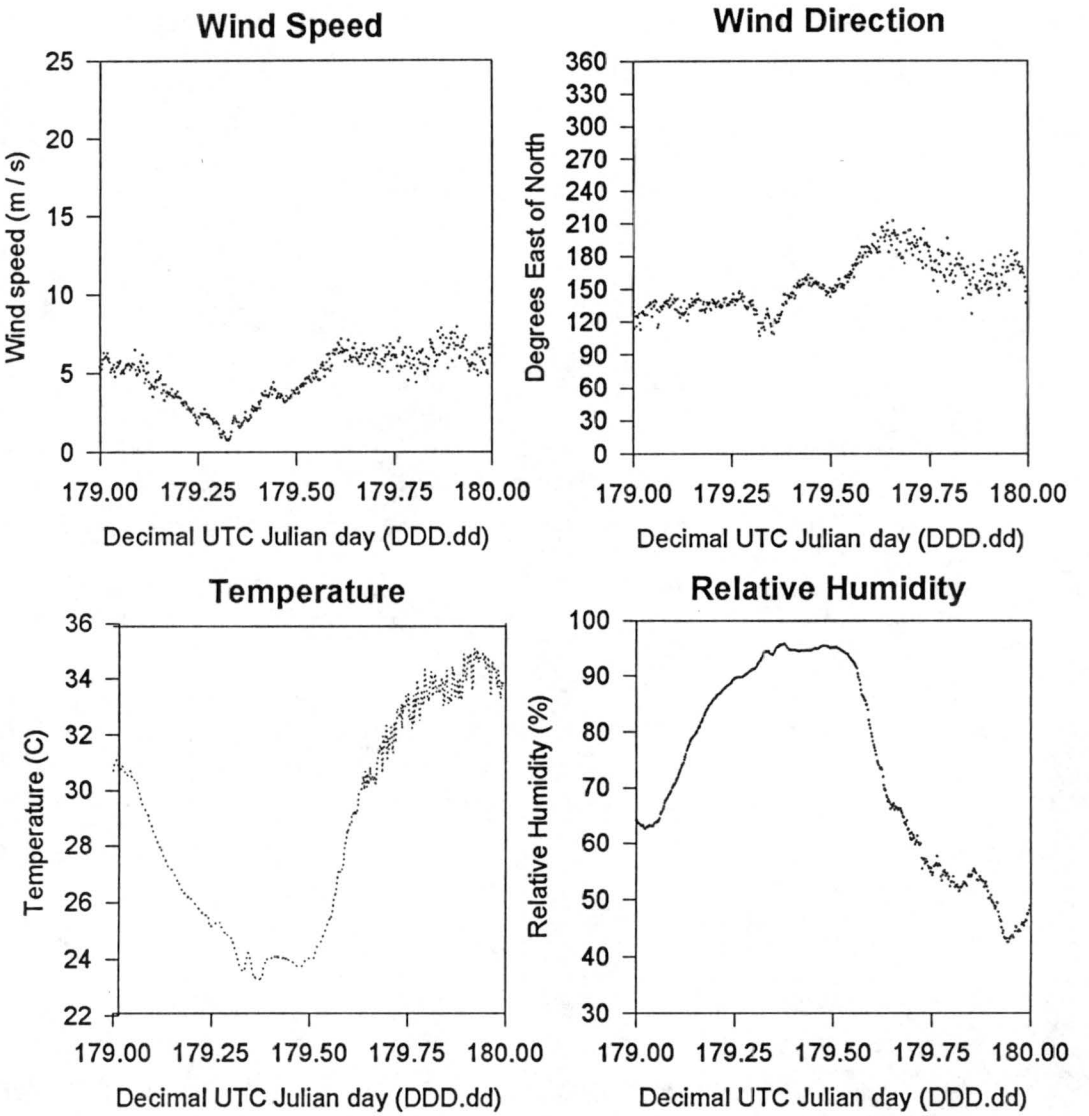

Figure A16. Wind speed, wind direction, temperature and relative humidity for June 27, 1996

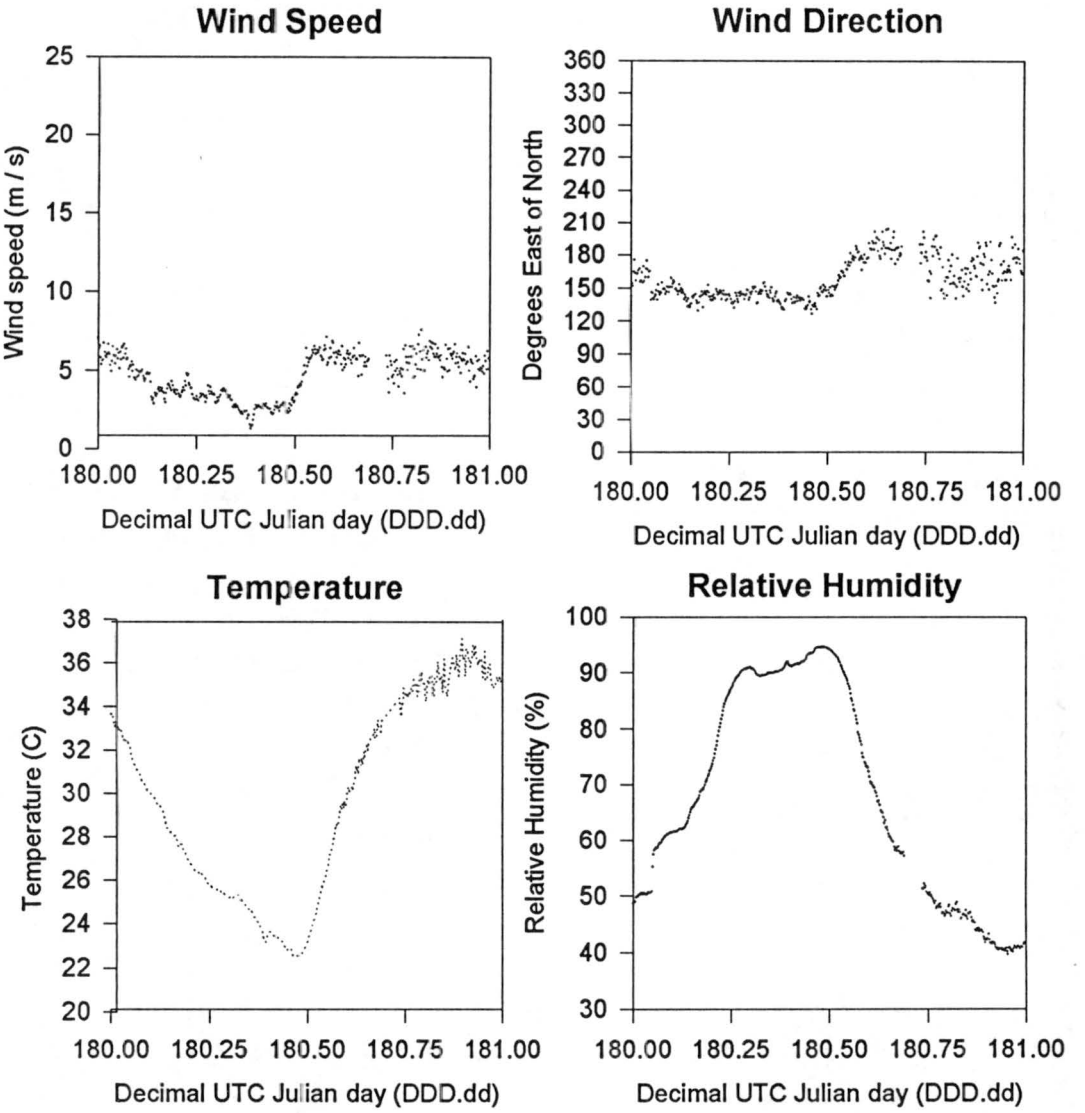

Figure A17. Wind speed, wind direction, temperature and relative humidity for June 28, 1996

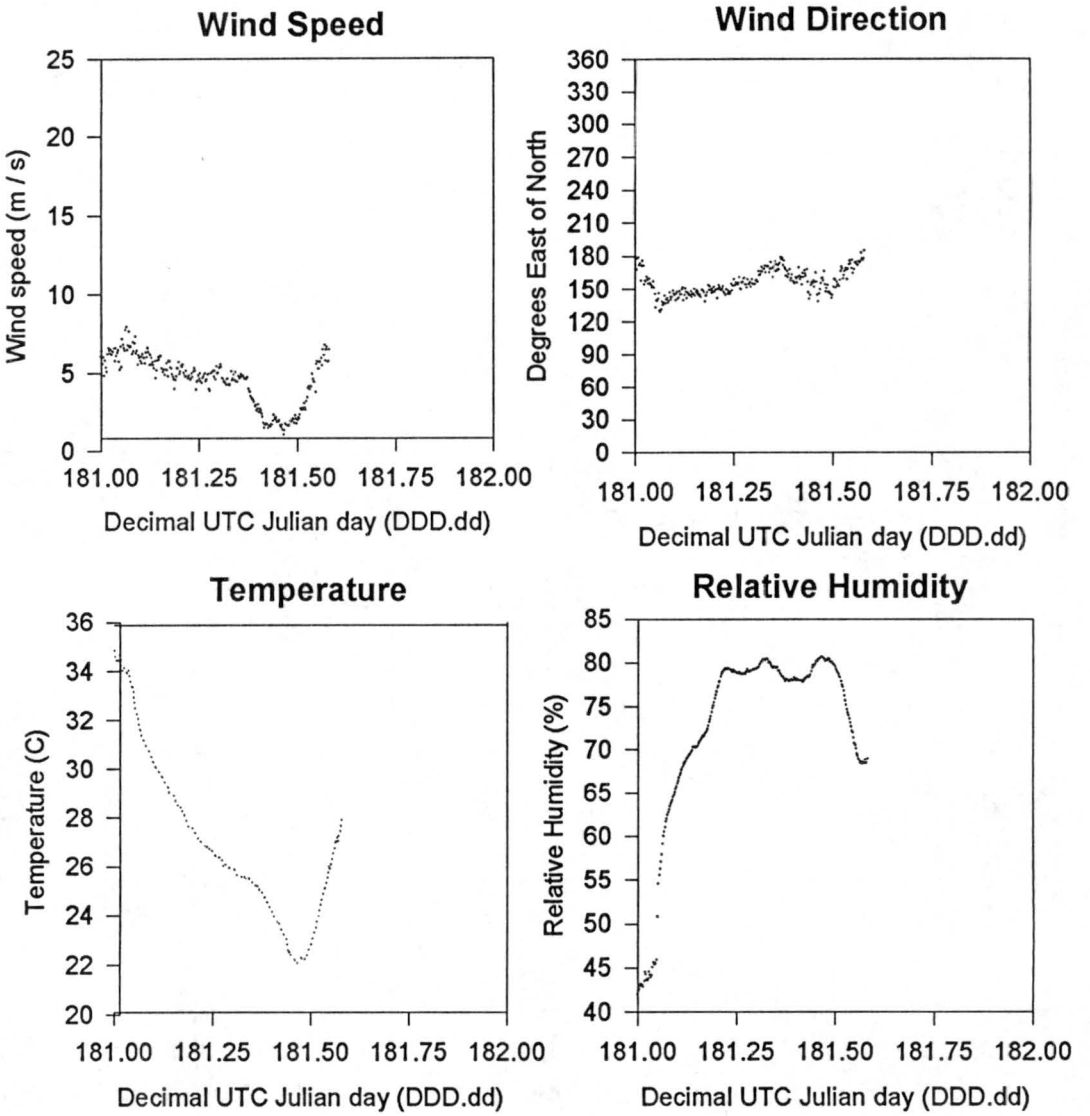

Figure A18. Wind speed, wind direction, temperature and relative humidity for June 29, 1996

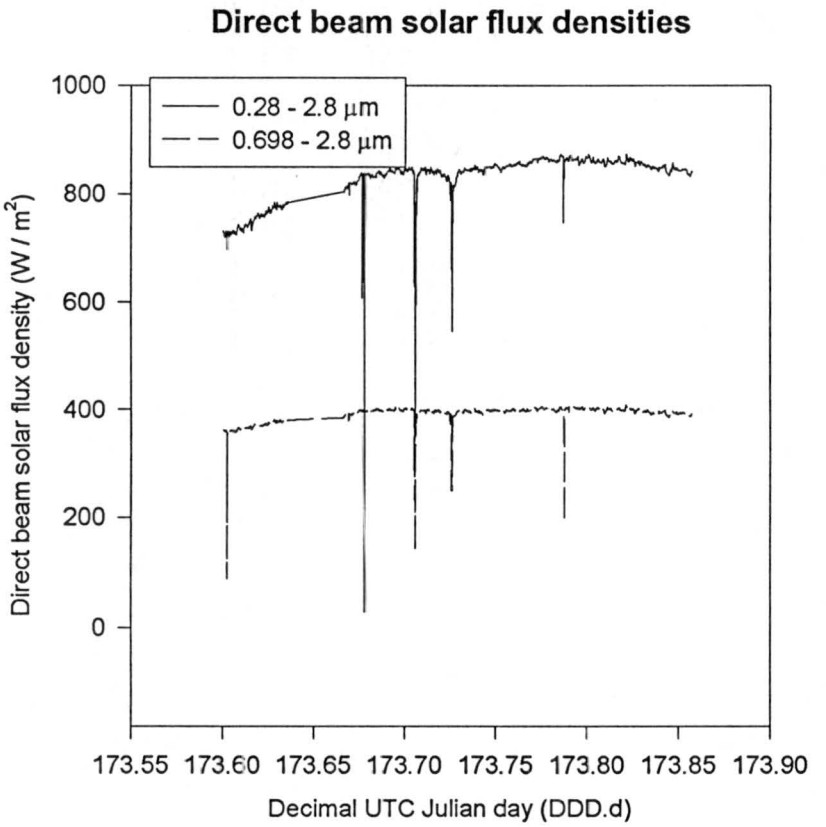

Figure A19. Direct beam near IR and total solar irradiances for June 21, 1996

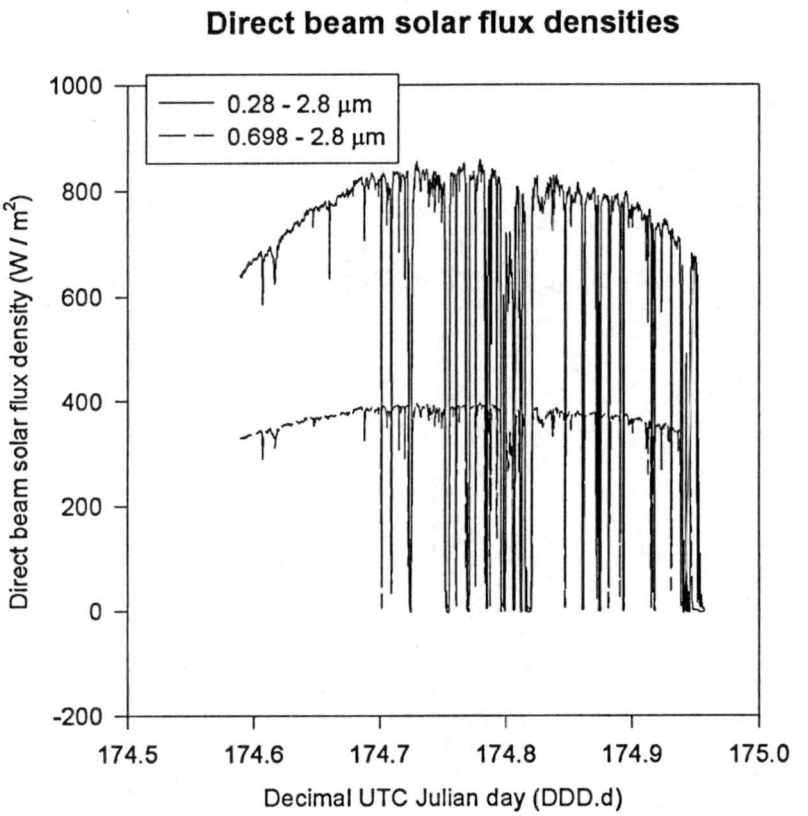

Figure A20. Direct beam near IR and total solar irradiances for June 22, 1996

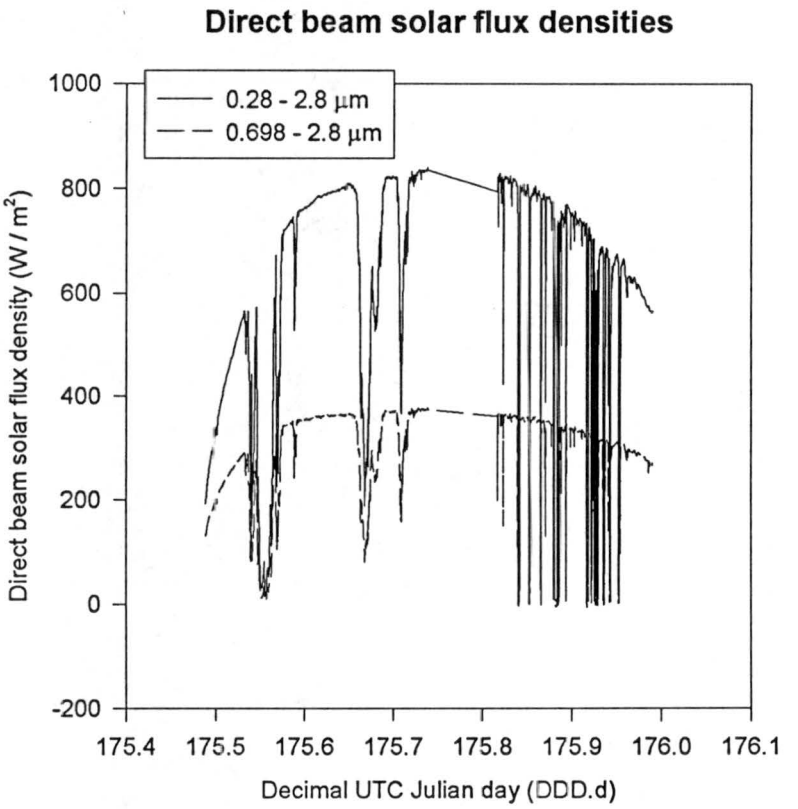

Figure A21. Direct beam near IR and total solar irradiances for June 23, 1996

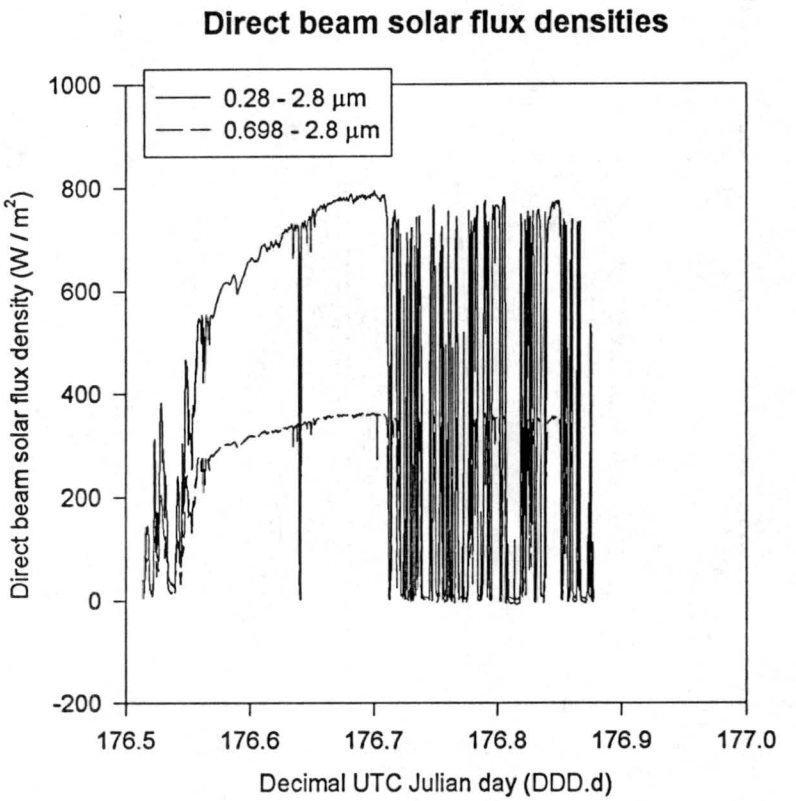

Figure A22. Direct beam near IR and total solar irradiances for June 24, 1996

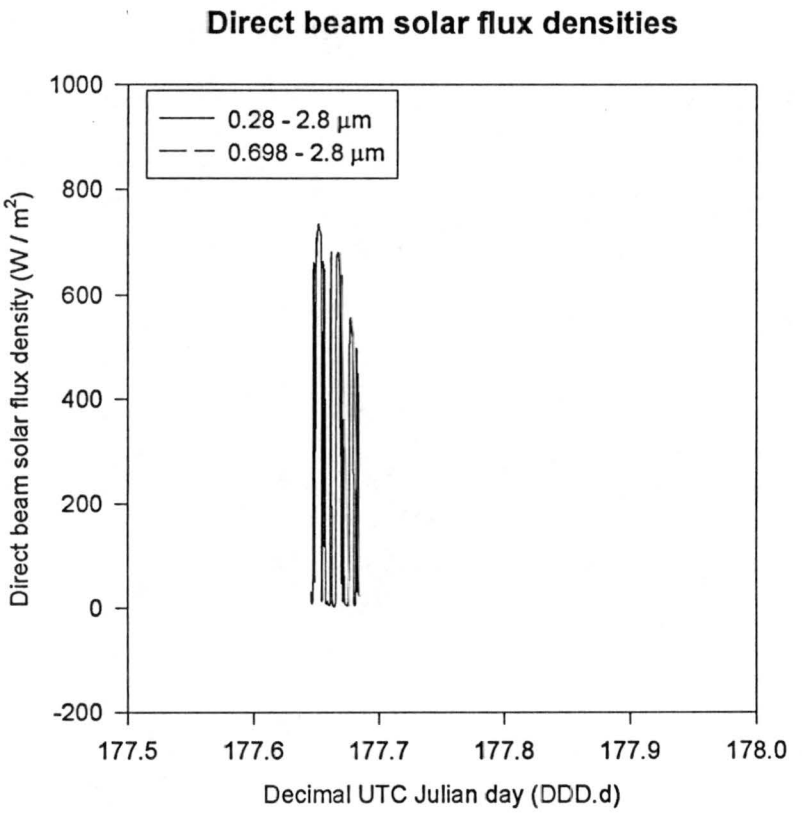

Figure A23. Direct beam near IR and total solar irradiances for June 25, 1996

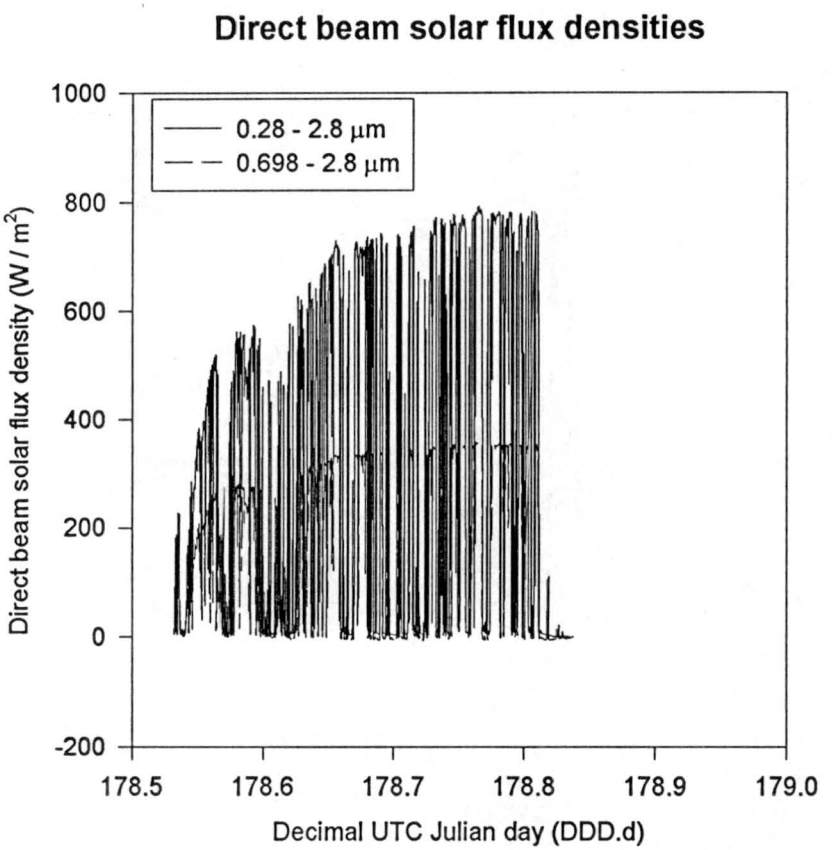

Figure A24. Direct beam near IR and total solar irradiances for June 26, 1996

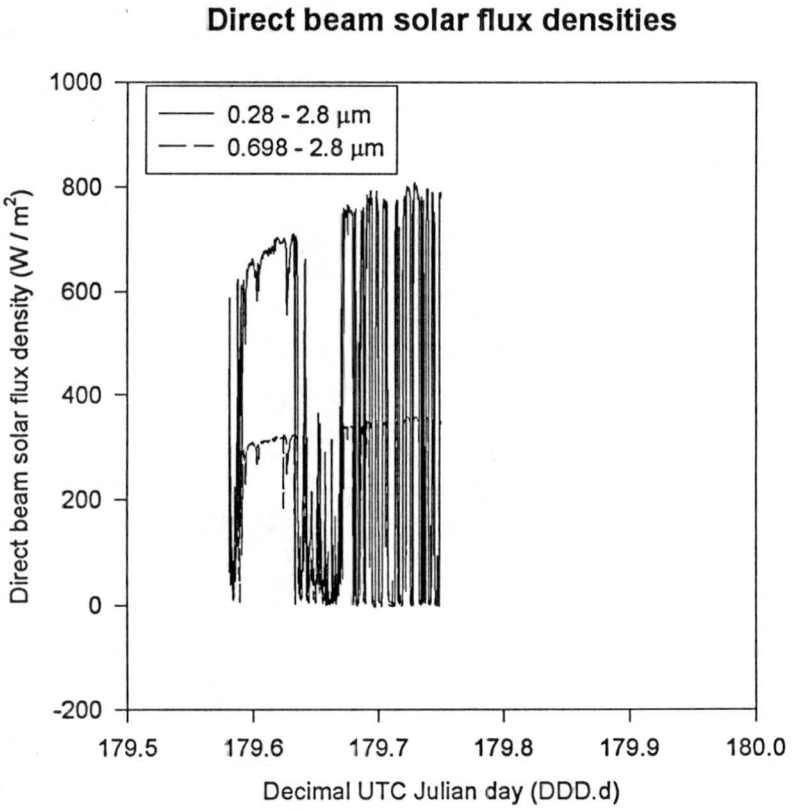

Figure A25. Direct beam near IR and total solar irradiances for June 27, 1996

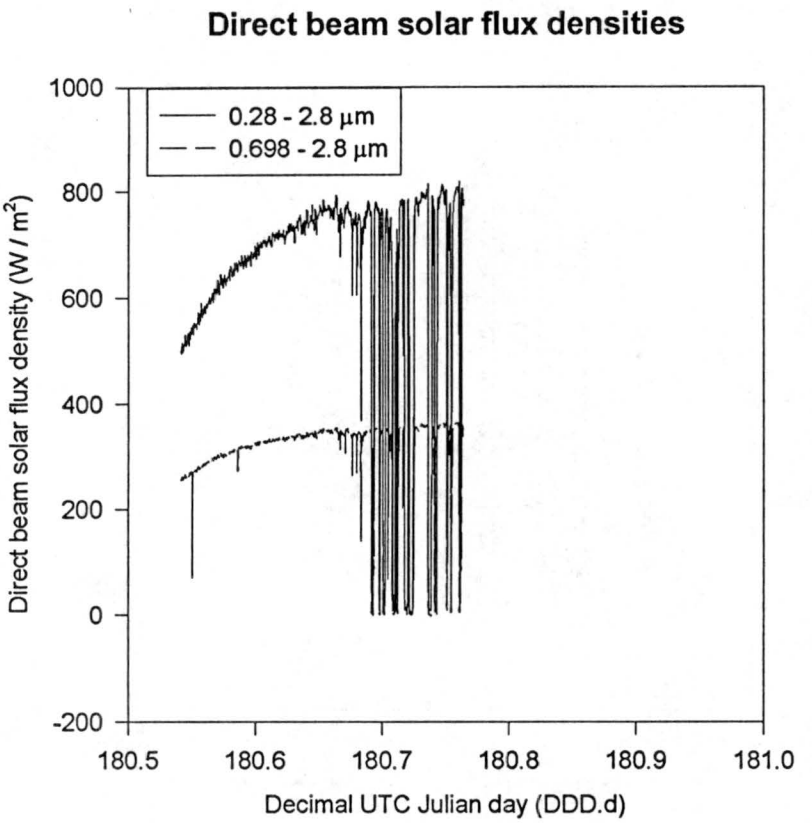

Figure A26. Direct beam near IR and total solar irradiances for June 28, 1996

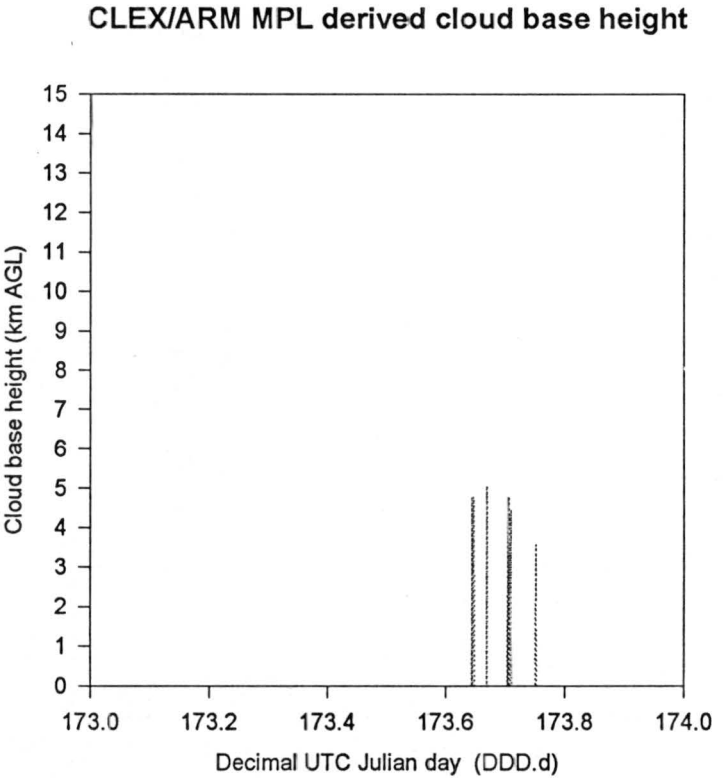

Figure A27. Cloud ceiling height derived from MPL measurements on June 21, 1996

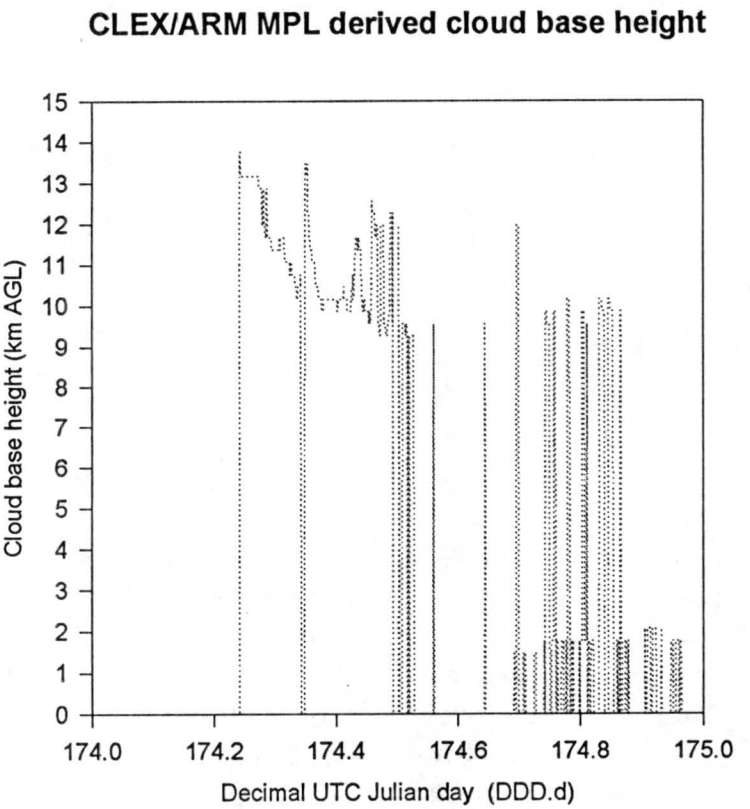

Figure A28. Cloud ceiling height derived from MPL measurements on June 22, 1996

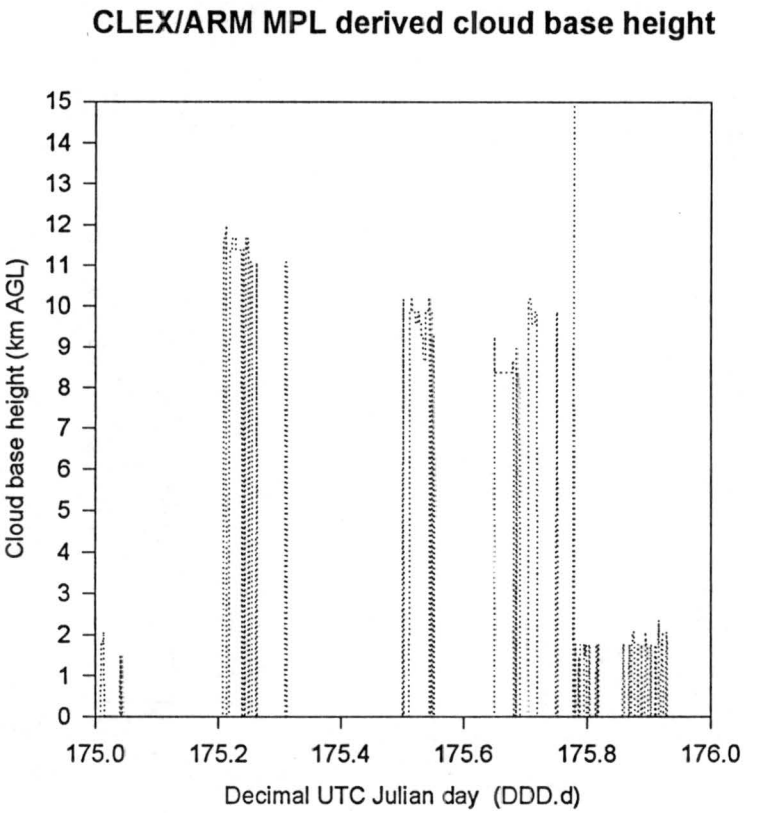

Figure A29. Cloud ceiling height derived from MPL measurements on June 23, 1996

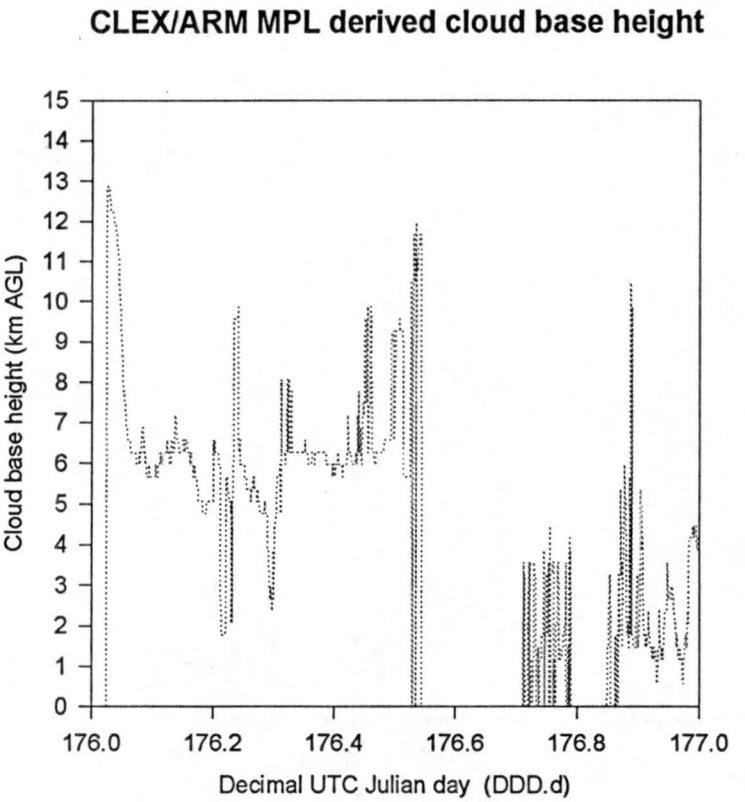

Figure A30. Cloud ceiling height derived from MPL measurements on June 24, 1996

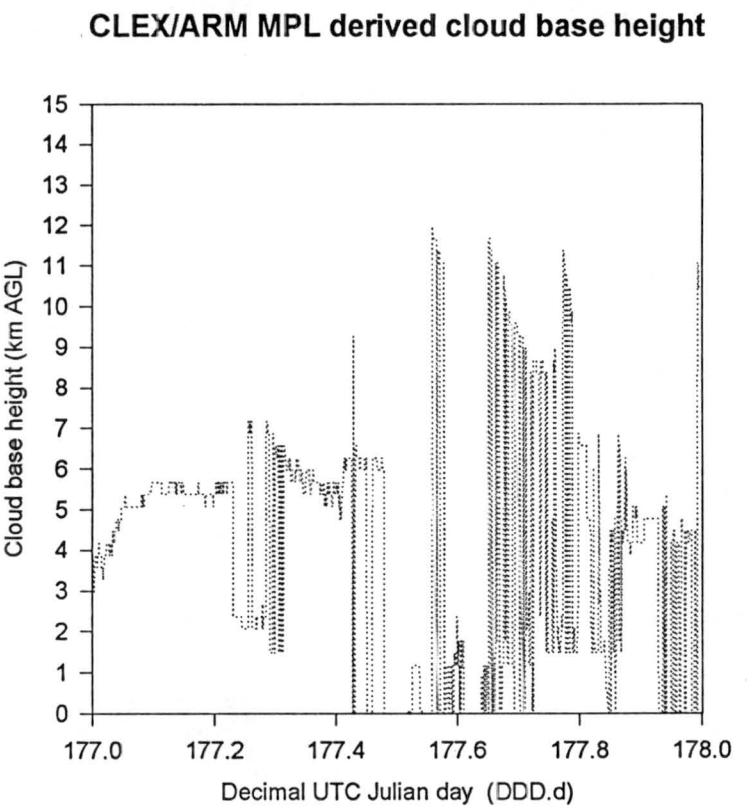

Figure A31. Cloud ceiling height derived from MPL measurements on June 25, 1996

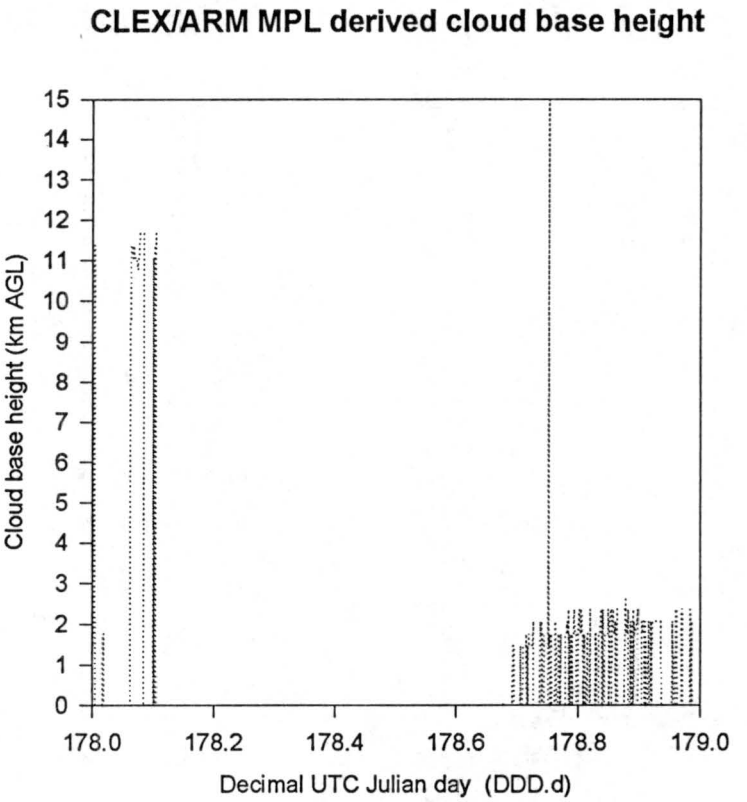

Figure A32. Cloud ceiling height derived from MPL measurements on June 26, 1996

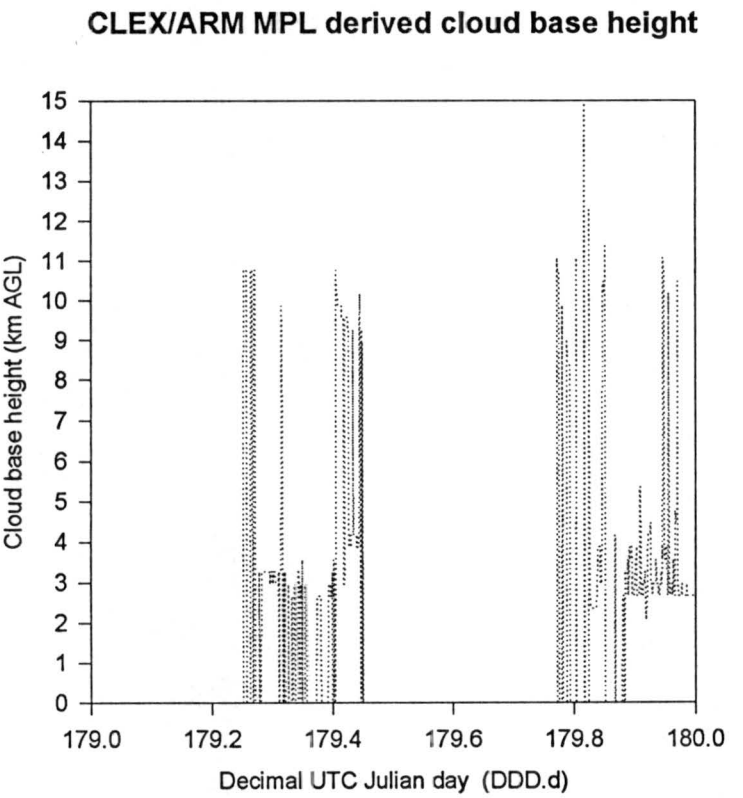

Figure A33. Cloud ceiling height derived from MPL measurements on June 27, 1996

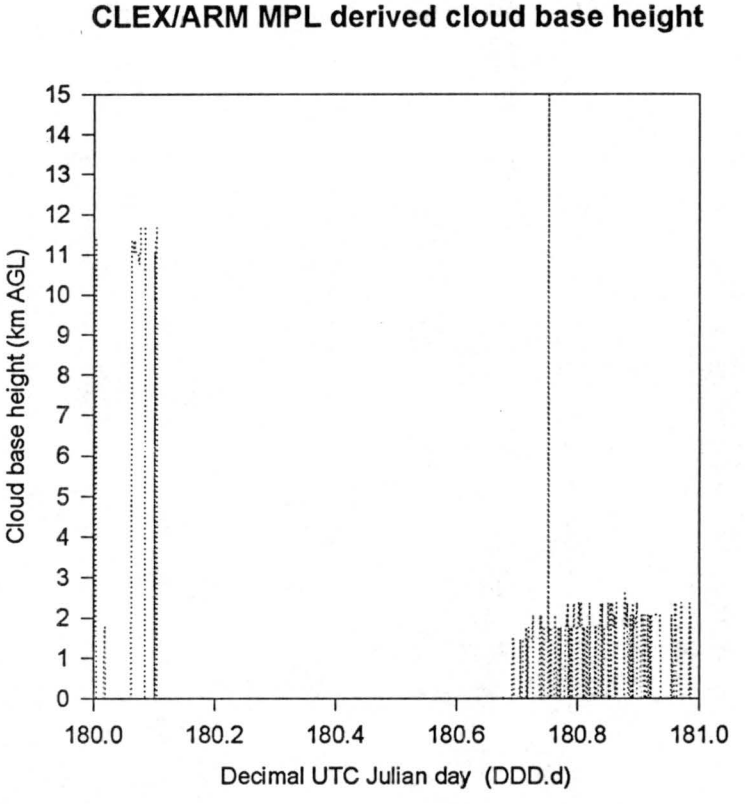

Figure A34. Cloud ceiling height derived from MPL measurements on June 28, 1996

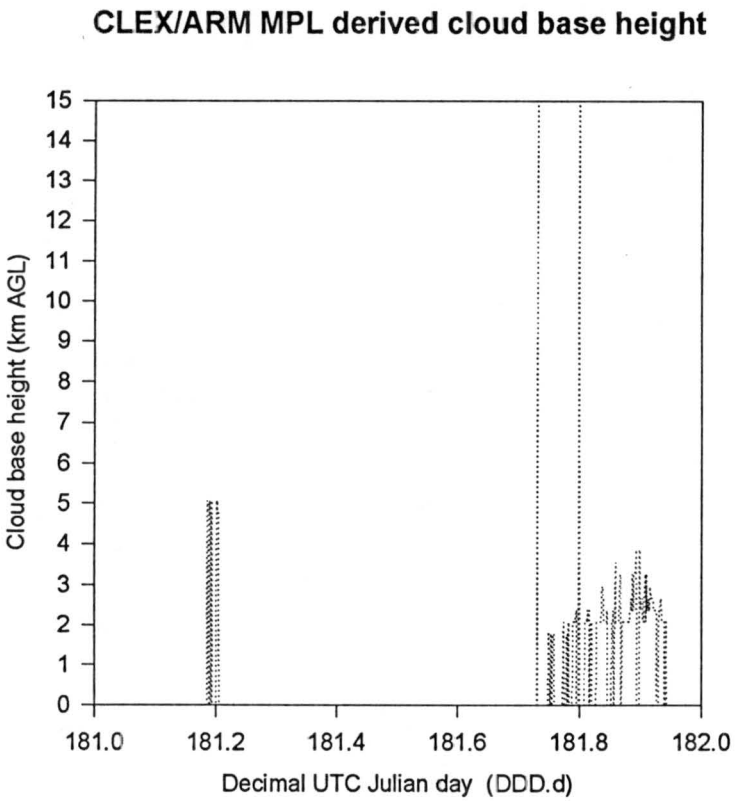

Figure A35. Cloud ceiling height derived from MPL measurements on June 29, 1996

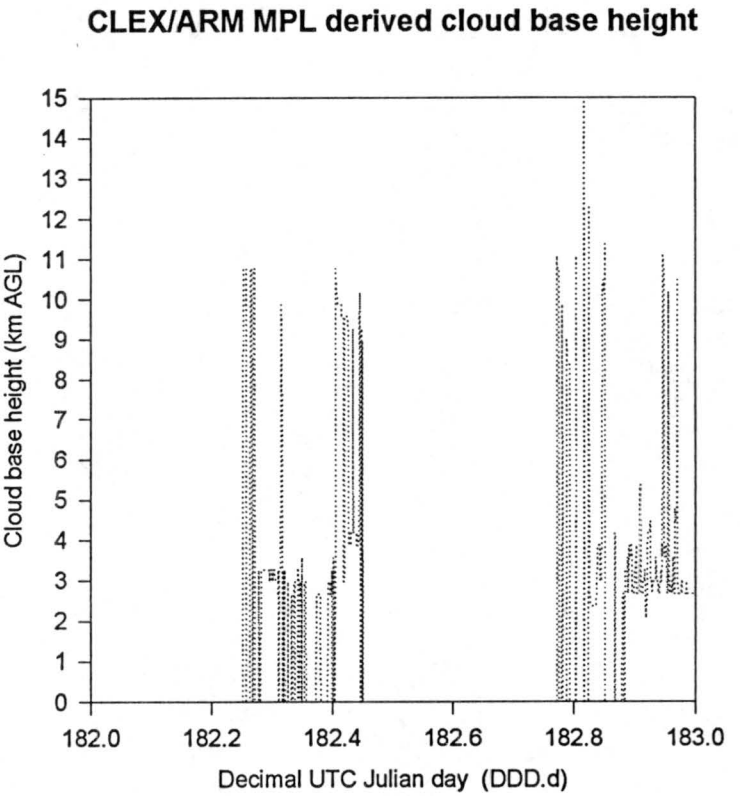

Figure A36. Cloud ceiling height derived from MPL measurements on June30, 1996

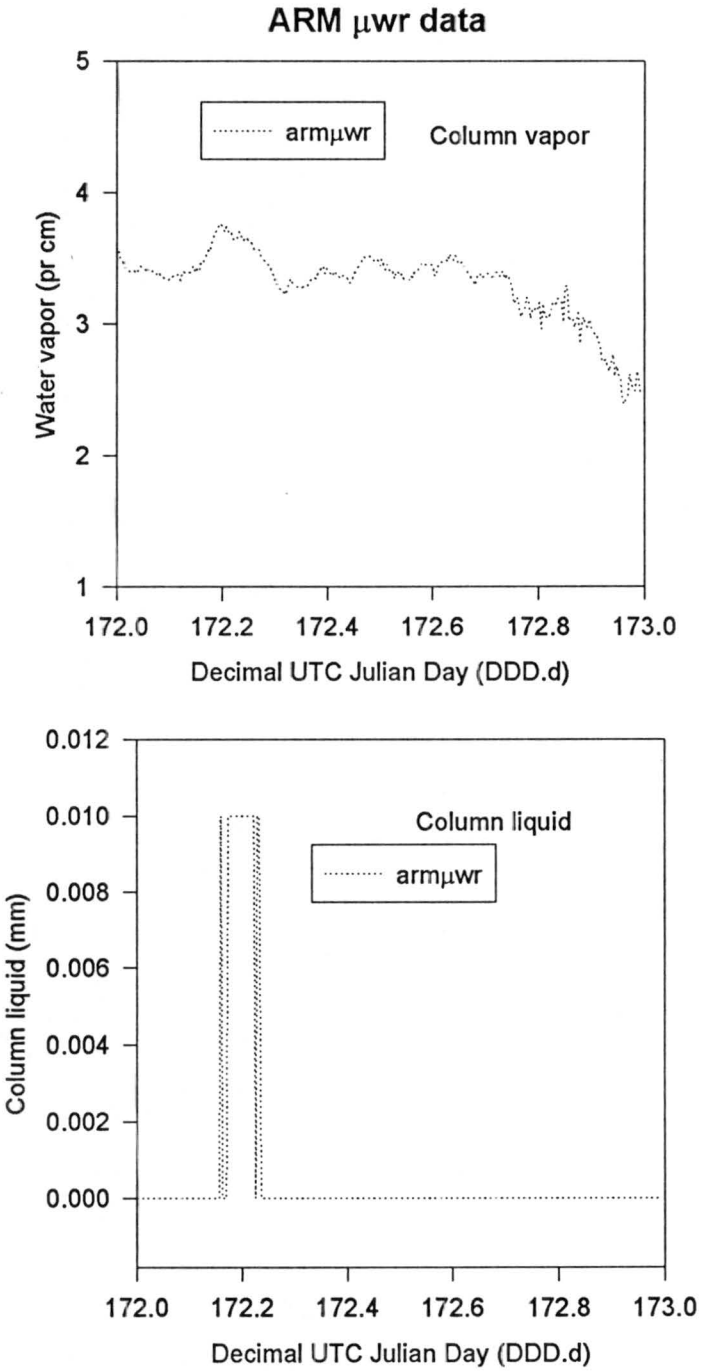

Figure A37. Total column water vapor (top) and liquid water (bottom) for June 20, 1996

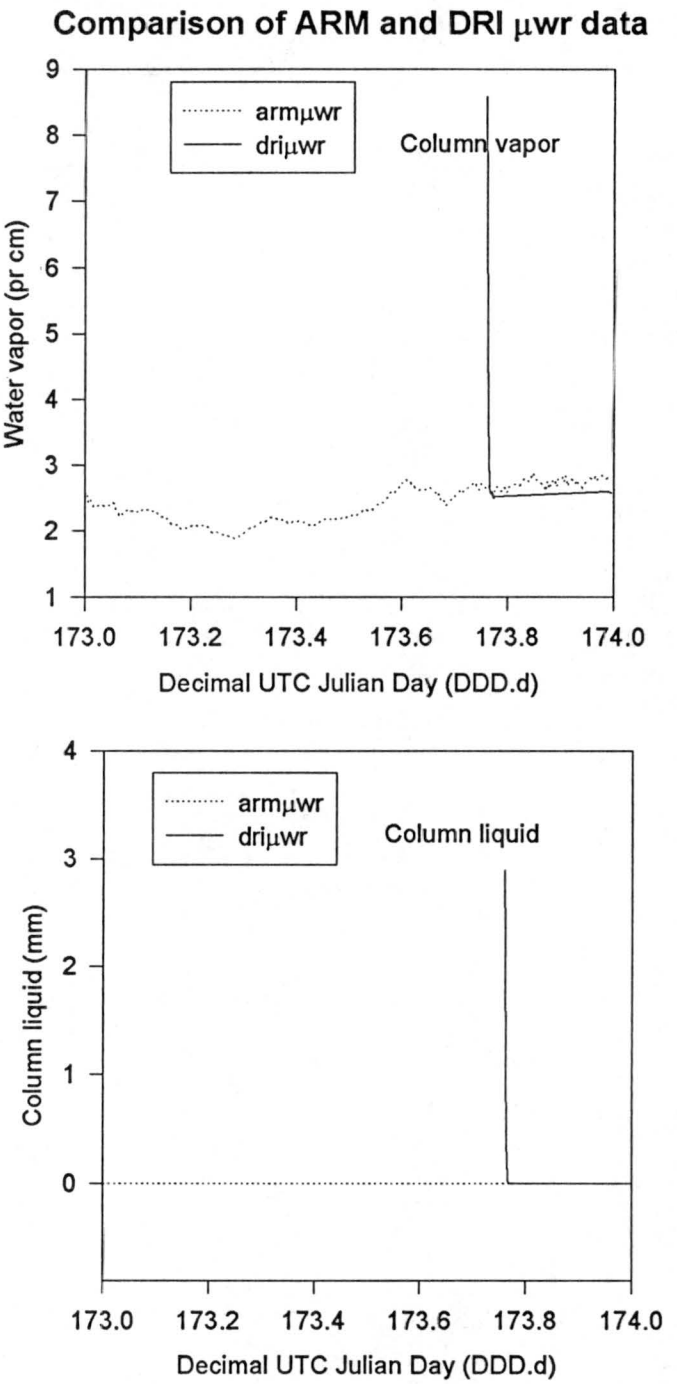

Figure A38. Total column water vapor (top) and liquid water (bottom) for June 21, 1996

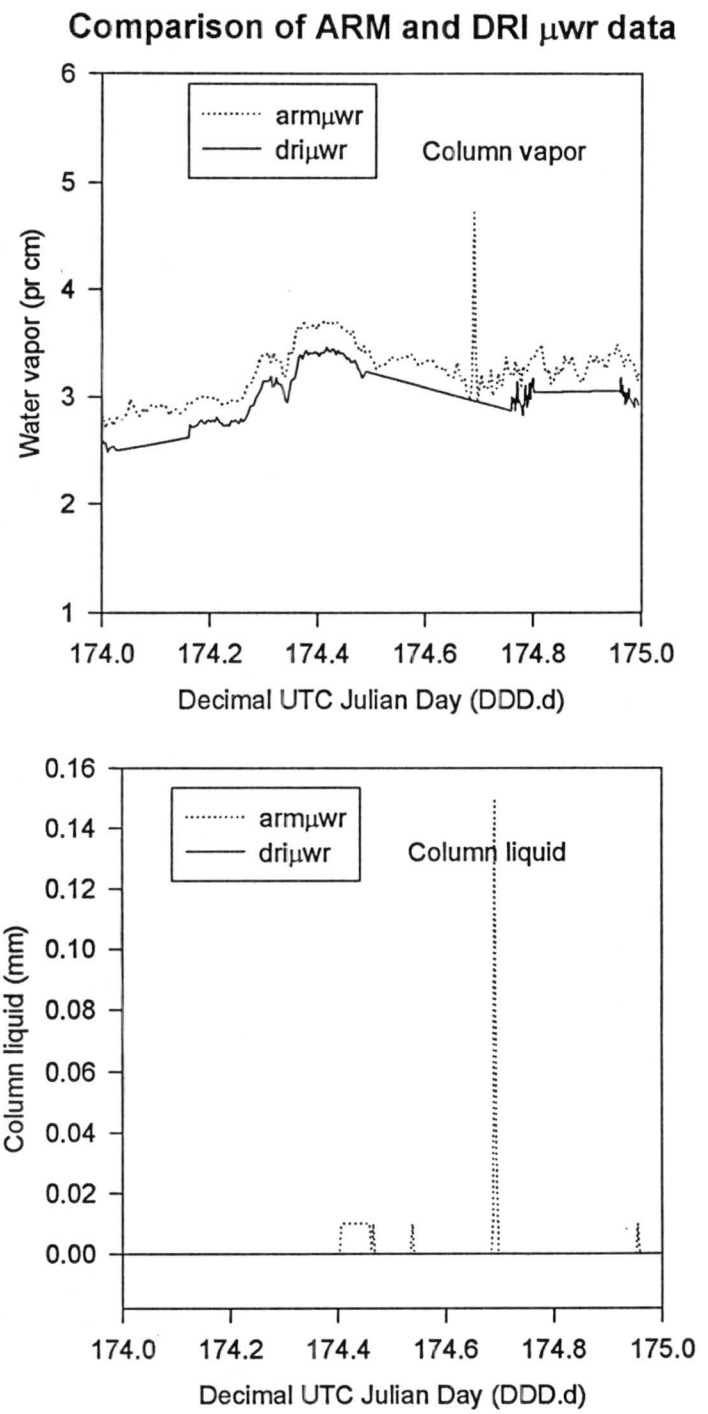

Figure A39. Total column water vapor (top) and liquid water (bottom) for June 22, 1996

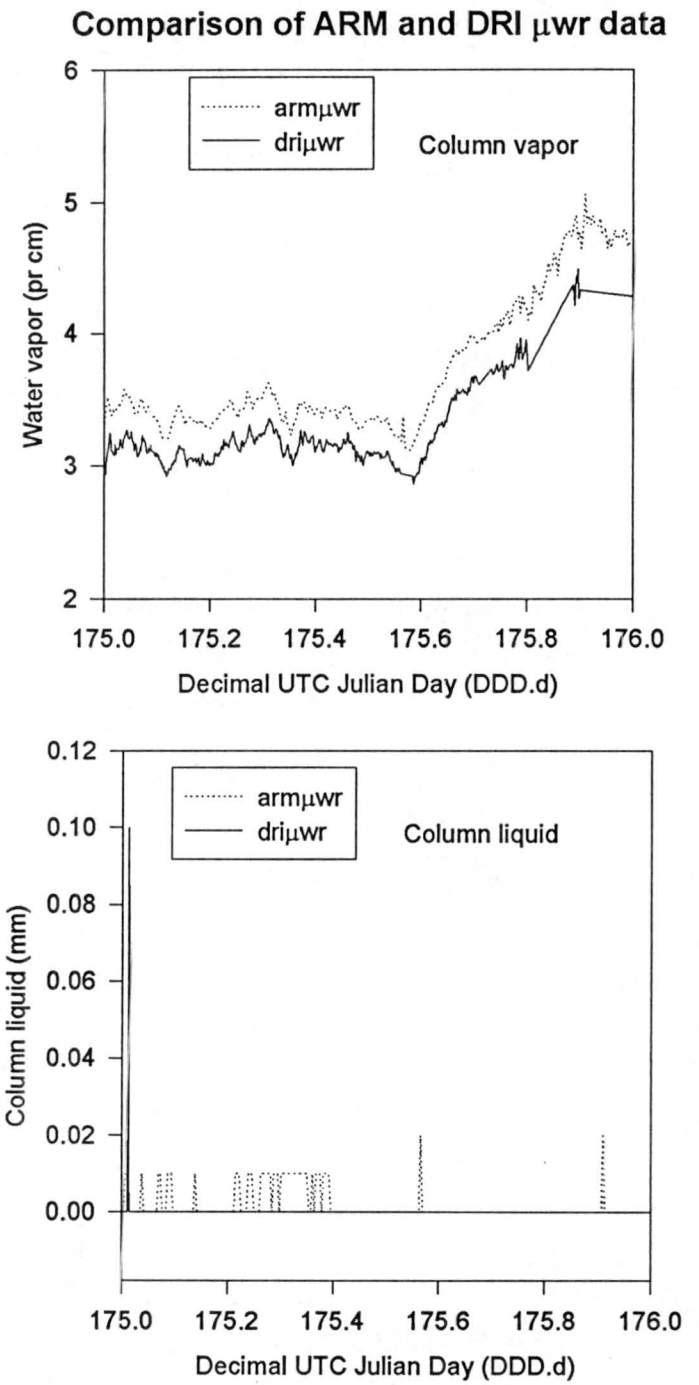

Figure A40. Total column water vapor (top) and liquid water (bottom) for June 23, 1996

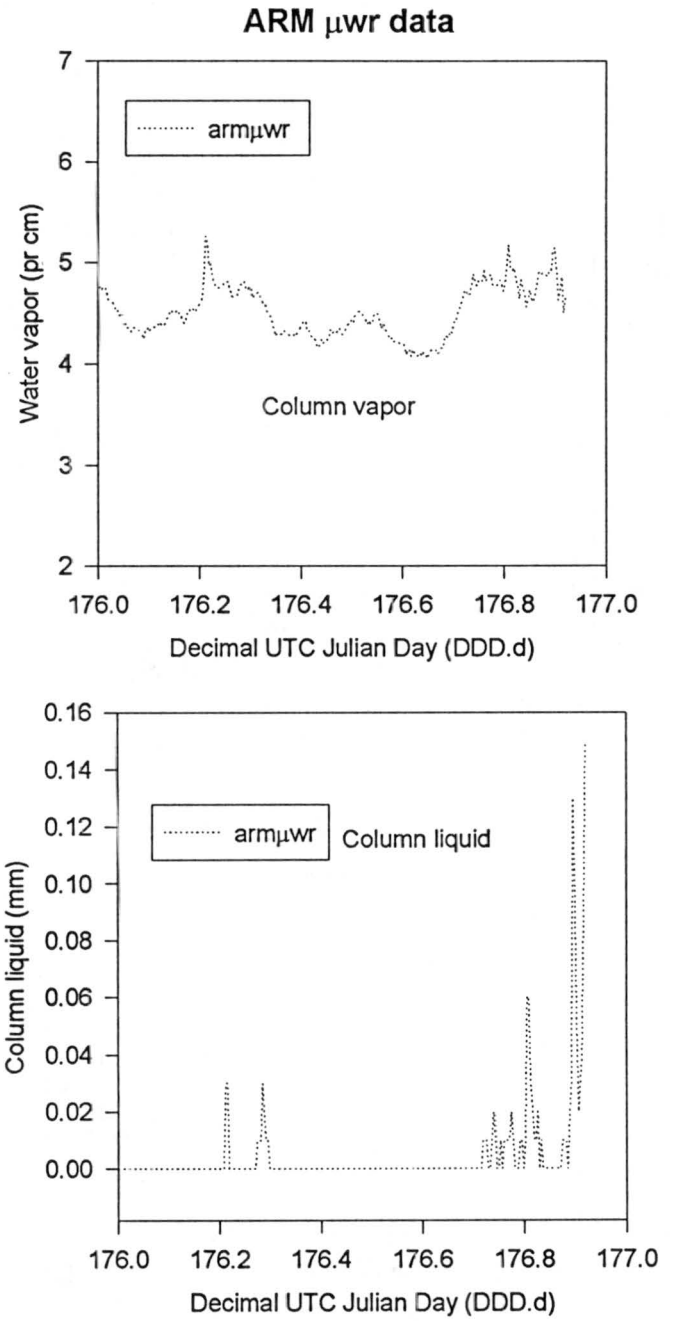

Figure A41. Total column water vapor (top) and liquid water (bottom) for June 24, 1996

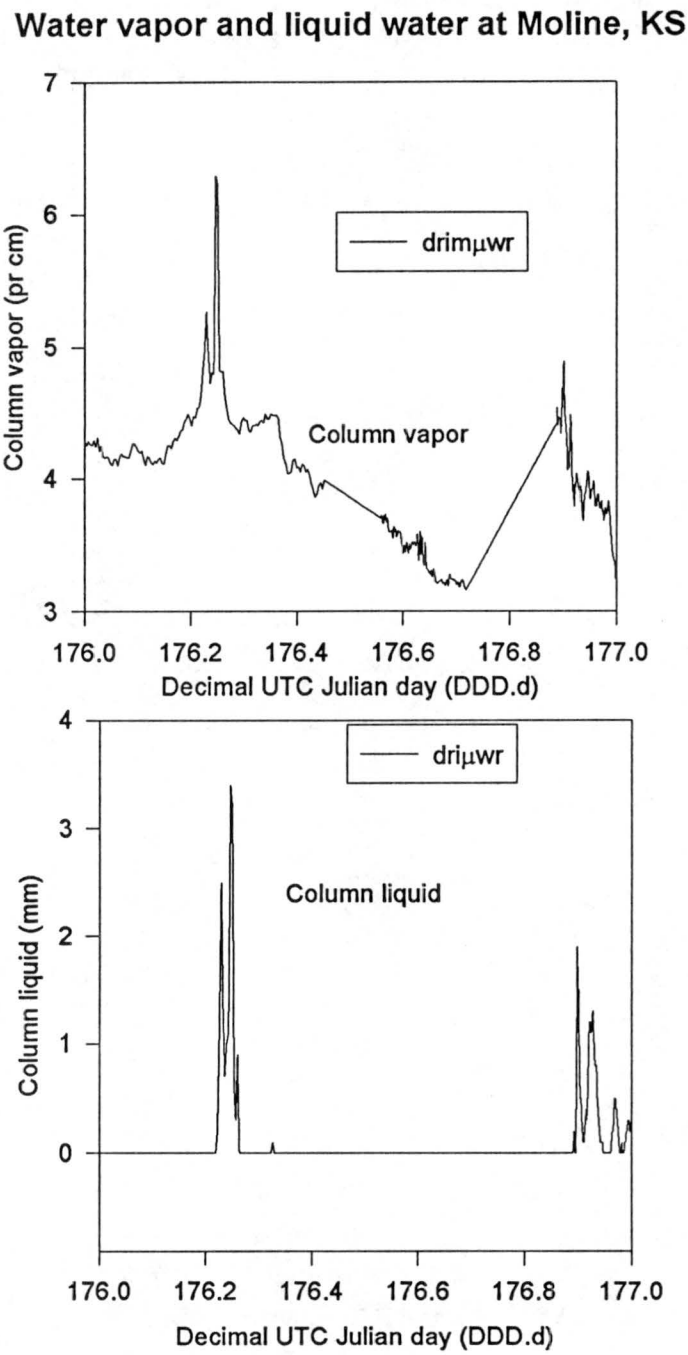

Figure A42. Total column water vapor (top) and liquid water (bottom) for June 24, 1996

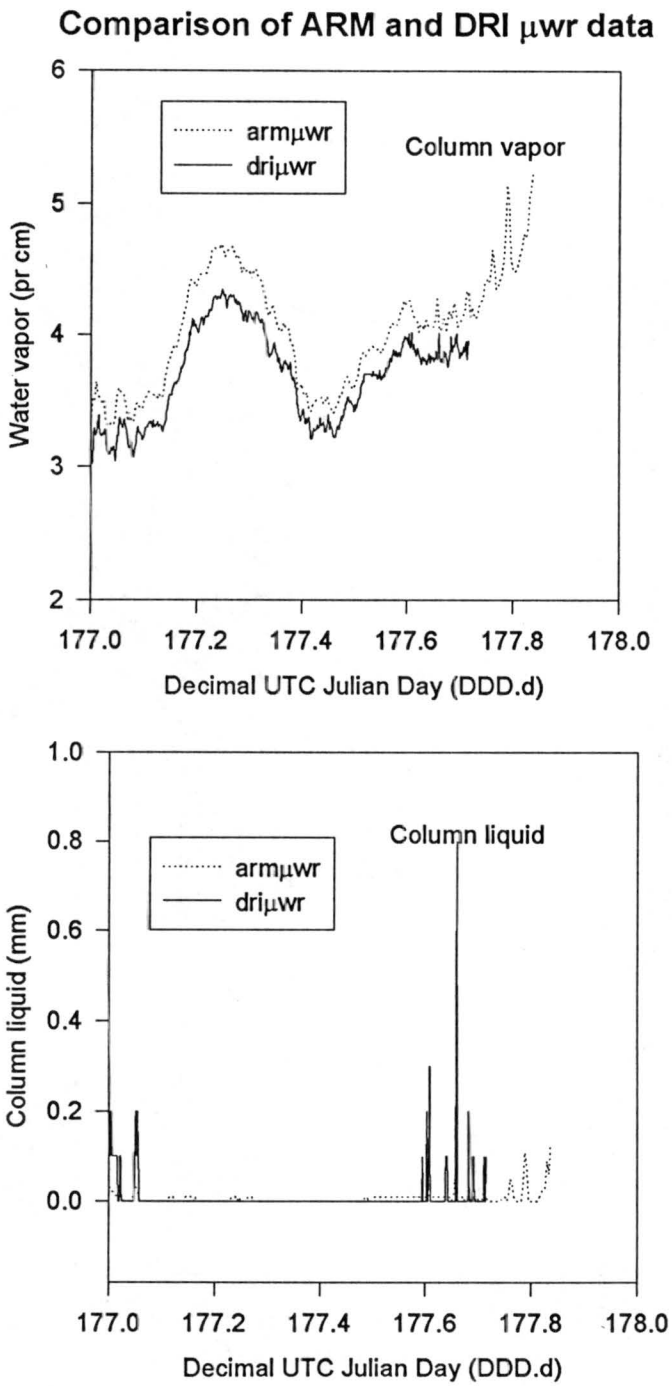

Figure A43. Total column water vapor (top) and liquid water (bottom) for June 25, 1996

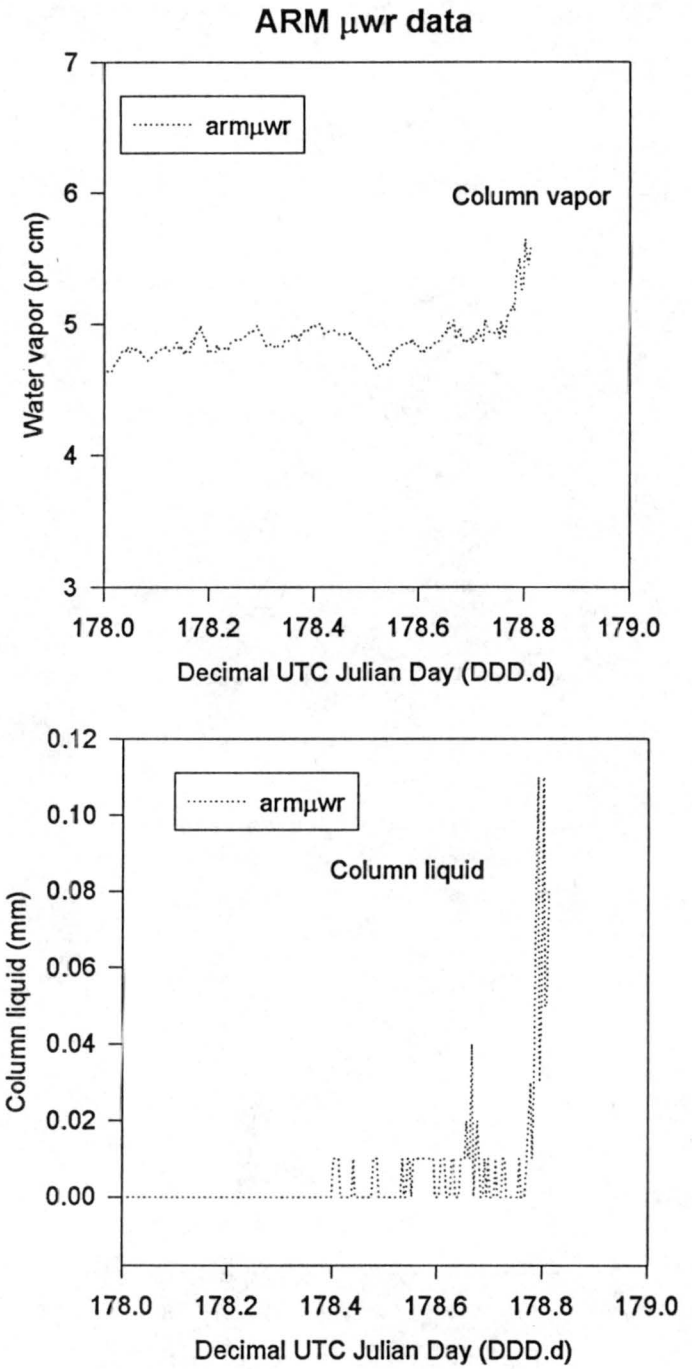

Figure A44. Total column water vapor (top) and liquid water (bottom) for June 26, 1996

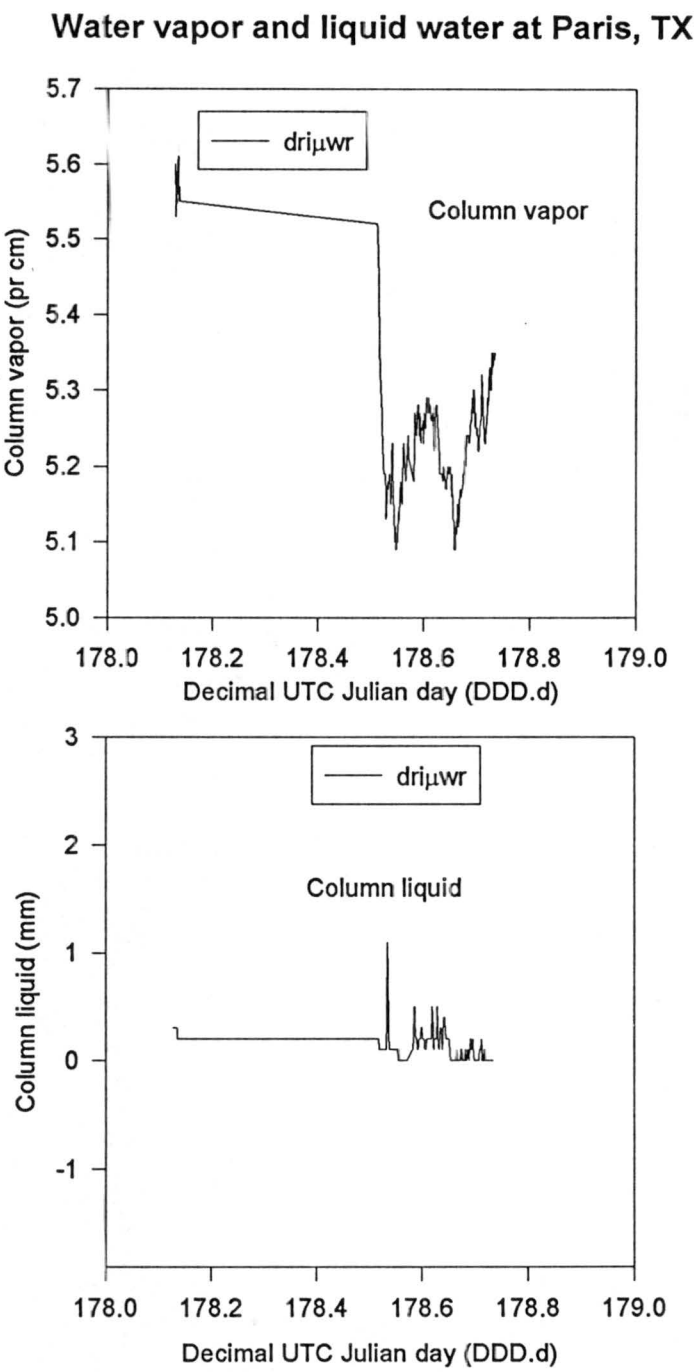

Figure A45. Total column water vapor (top) and liquid water (bottom) for June 26, 1996

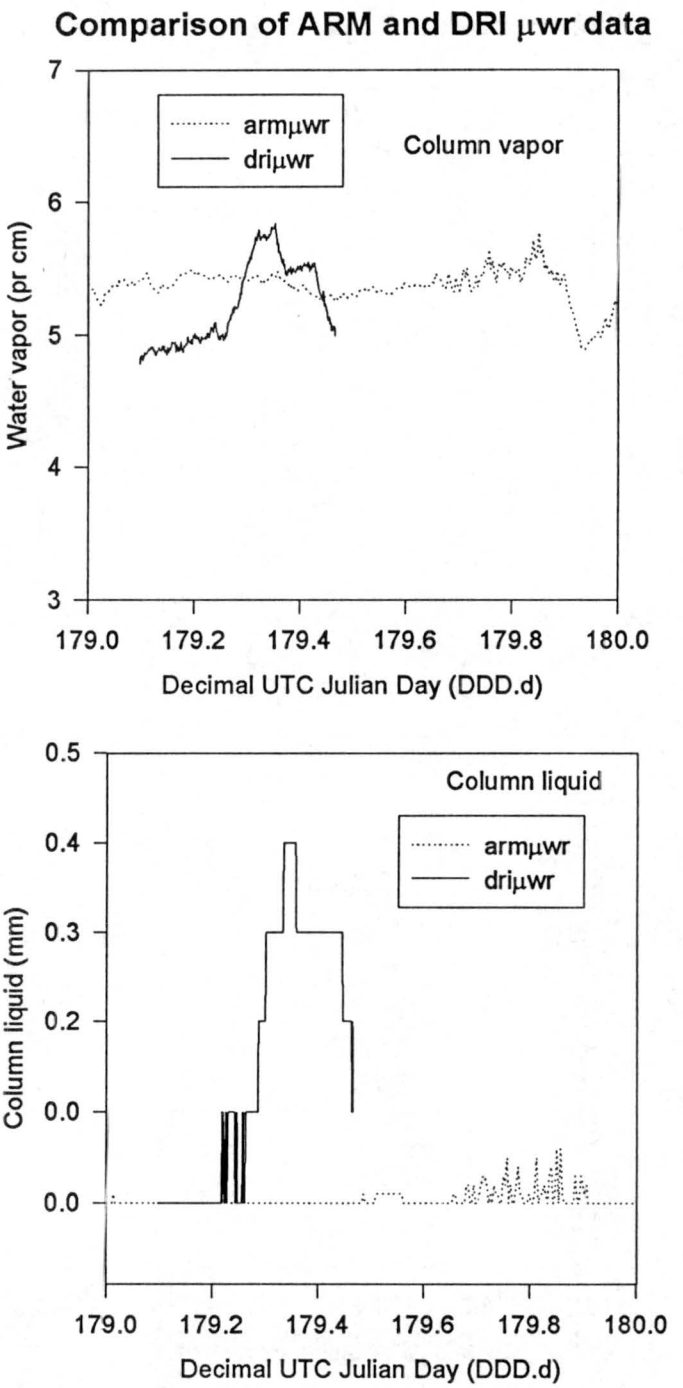

Figure A46. Total column water vapor (top) and liquid water (bottom) for June 27, 1996

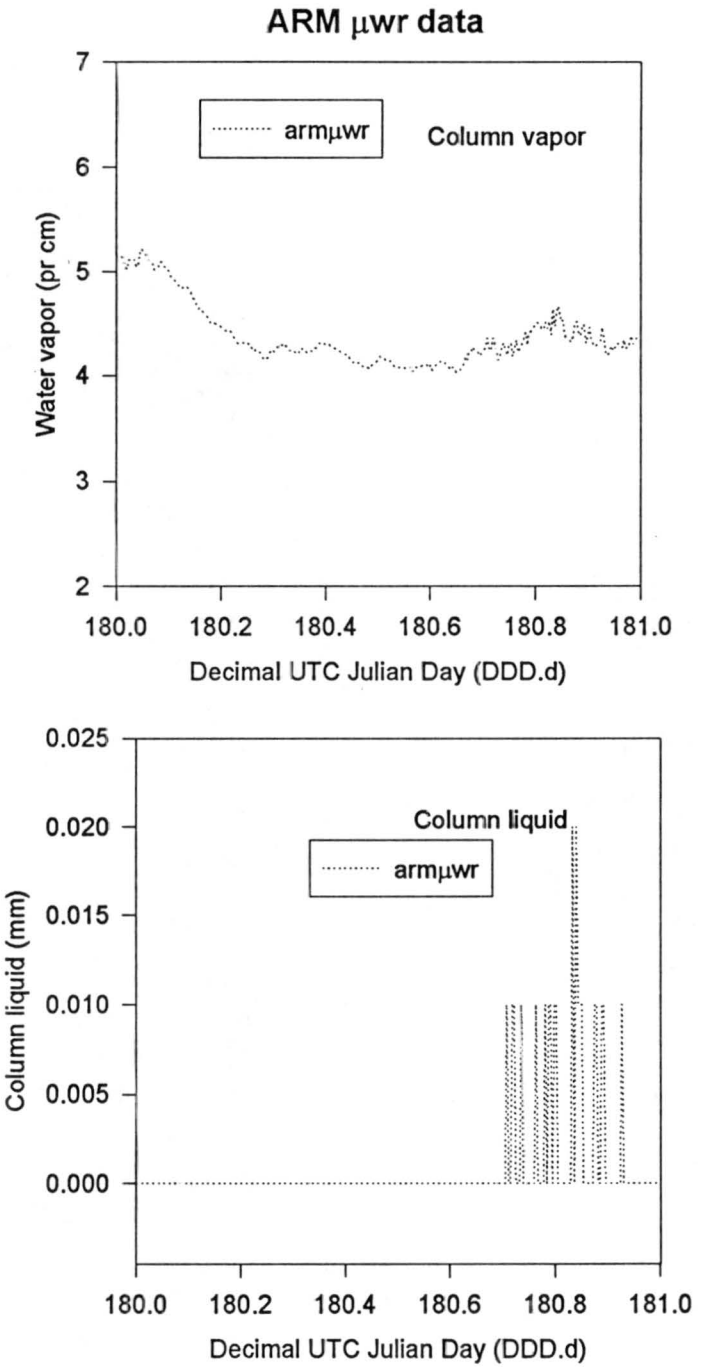

Figure A47. Total column water vapor (top) and liquid water (bottom) for June 28, 1996

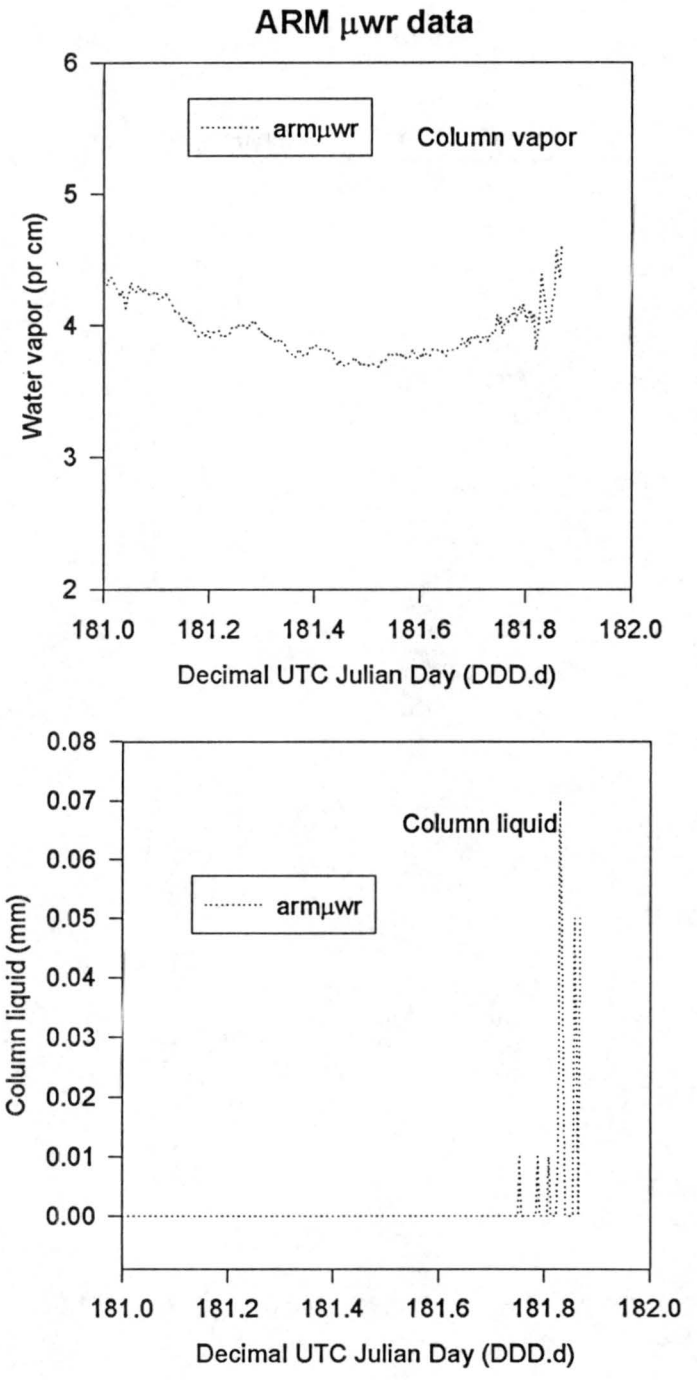

Figure A48. Total column water vapor (top) and liquid water (bottom) for June 29, 1996

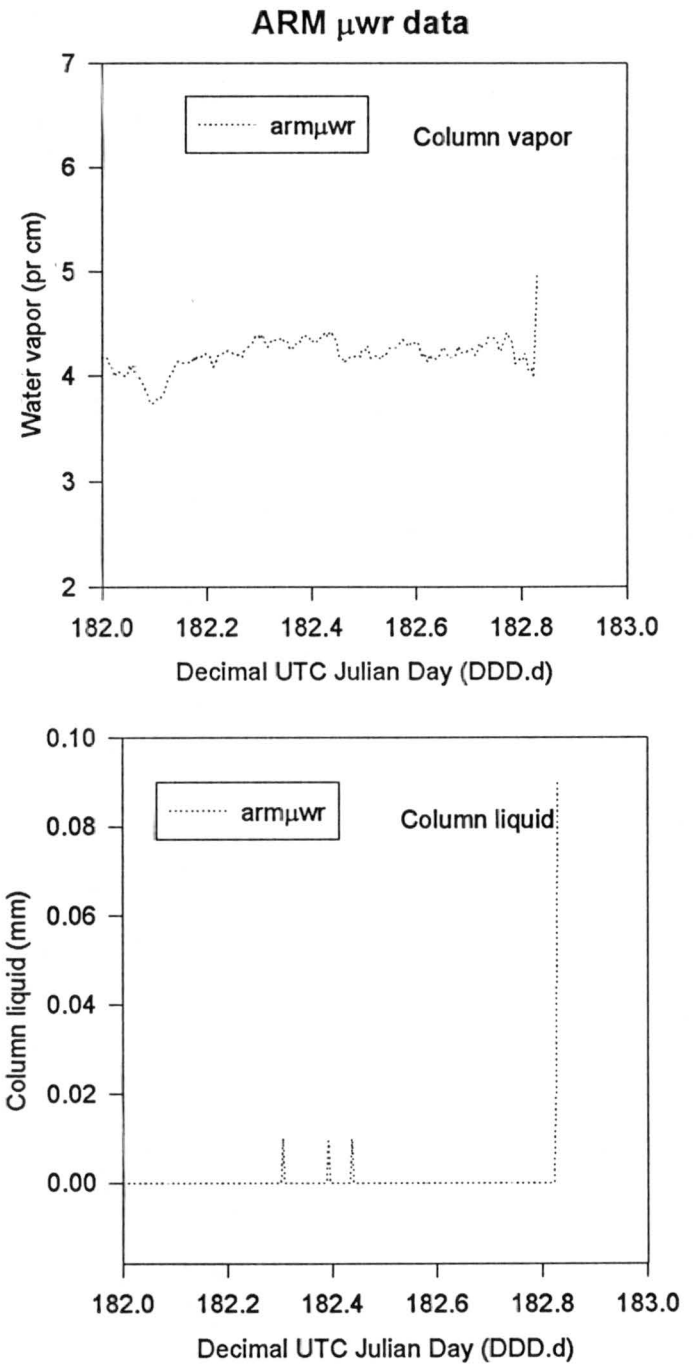

Figure A49. Total column water vapor (top) and liquid water (bottom) for June 30, 1996