CLPX-Airborne: Multiband Polarimetric Scanning Radiometer (PSR) Imagery, Version 1

USER GUIDE

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Stankov, B. and A. J. Gasiewski. 2004. *CLPX-Airborne: Multiband Polarimetric Scanning Radiometer (PSR) Imagery, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/4BGJVT9XAM1V. [Date Accessed].

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National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

Data were collected using the NOAA Environmental Technology Laboratory (ETL) Polarimetric Scanning Radiometer (PSR) during a series of flights flown over the three CLPX mesoscale study areas (MSAs) in February 2002 (onboard a NASA DC-8 aircraft) and in February and March 2003 (onboard a NASA/WFF P-3B aircraft). This airborne multiband conical-scanning imaging radiometer system provides multiband polarimetric brightness temperature images using AMSR-E bands, at a spatial resolution representative of the topography and vegetation cover. The PSR/A system operated in conical scanning mode at an incidence angle of 55 degrees from nadir, the same as that of the AMSR-E instrument. Table 1 provides a summary of PSR/A scanhead channels.

Table 1. PSR/A scanhead imaging bands, polarizations, and beam-widths

Band (GHz)	**Polarizations**	**Beamwidth[1]**	**Δ T_{rms} (K) [2]**
10.6 - 10.8	v,h	8°	0.49
18.6 - 18.8	v,h	8°	0.49
21.4 - 21.7 (H_2O)	v,h	8°	0.49
36 - 38	v,h	2.3°	0.14
86 - 92	v,h	2.3°	0.14
9.6 - 11.5 uμm IR	v+h	7°	0.43
[1] Half-power beamwidth [2] 18 msec equivalent integration time, v & h			

In 2002, PSR imaging occurred during both low altitude (~14,000 - 15,000 ft MSL, ~2.3 km AGL [above ground level]) and high altitude (~33,000 - 39,000 ft MSL, 9 km AGL) flight lines over the three CLPX MSAs. In 2003, PSR imaging occurred at low altitude (~14,000 - 15,000 ft MSL [mean sea level], ~2.3 km AGL), except on the first day when, in order to avoid flying within the cloud, the P-3 climbed to 3.93 km AGL. Seven flight lines were flown over each MSA every time it was visited.

Table 2 summarizes the IOP1 flights in February 2002, and the IOP3 and IOP4 flights during February and March 2003.

Table 2. Summary of CLPX PSR Flights

Exp. Name	MSA(s) Imaged	Date	Obs. Times (UTC)	Tot. # of Fl. Lines	Avg. Fl. Alt (km AGL)	3 dB Resolution Range (m) at 37 and 89 GHz	3 dB Resolution Range (m) at 10, 18 and 21 GHz
CLPX02 (IOP1)	RE	2/19/02	21:18-22:35	7	2.45	88 - 209	308 - 728
	F	2/21/02	16:45-17:59	7	2.23	55 - 234	191 - 812
	RE	2/21/02	18:09-18:25	2	2.45	88 - 209	308 - 728
	NP	2/21/02	18:32-18:49	2	2.22	54 - 203	184 - 708
	NP	2/23/02	17:30-18:34	7	2.22	54 - 203	184 - 708
	RE	2/23/02	17:06-17:23	2	2.45	88 - 209	308 - 728
	F	2/23/02	16:37-16:57	2	2.23	55 - 234	191 - 812
CLPX03A (IOP3)	NP	2/22/03	18:35-20:35	7	3.93	184 - 334	642 - 1161
	NP, RE, F	2/23/03	17:35-21:37	21	2.18	65 - 215	229 - 749
	NP, RE	2/24/03	20:30-23:05	14	2.22	71 - 206	246 - 718
	NP, RE, F	2/25/03	17:30-21:00	21	2.18	65 - 215	229 - 749
CLPX03B (IOP4)	NP, RE, F	3/25/03	17:50-22:05	20	2.18	65 - 215	229 - 749
	NP, RE, F	3/30/03	18:10-22:30	22	2.18	65 - 215	229 - 749
	NP, RE, F	3/31/03	17:50-21:50	21	2.18	65 - 215	229 - 749
RE = Rabbit Ears, F = Fraser, NP = North Park							

Figures 1-3 show flight tracks, and the terrain traversed, during the three sorties on 19, 21, and 23 February 2002 during IOP1. Each flight line (marked in red) was assigned a serial number during data processing, and those numbers are indicated in black numbers on the figures. The serial

numbers are used in the data filenames. Figures 4-7 show flight tracks for the four IOP3 sorties, and Figures 8-10 show flight tracks for the three IOP4 sorties.

On 30 March 2003, two additional flight lines were flown over the Rabbit Ears MSA. Those two lines were flown at a 30º and 10º incidence angle from nadir, instead of the standard 55º. The serial numbers of these two lines are 0213 and 0214, respectively, in Figure 9.

Red lines – data collected with PSR scanning in conical mode
Grey lines – cross-track scanning during turns (for calibration)
Black numbers - line serial numbers

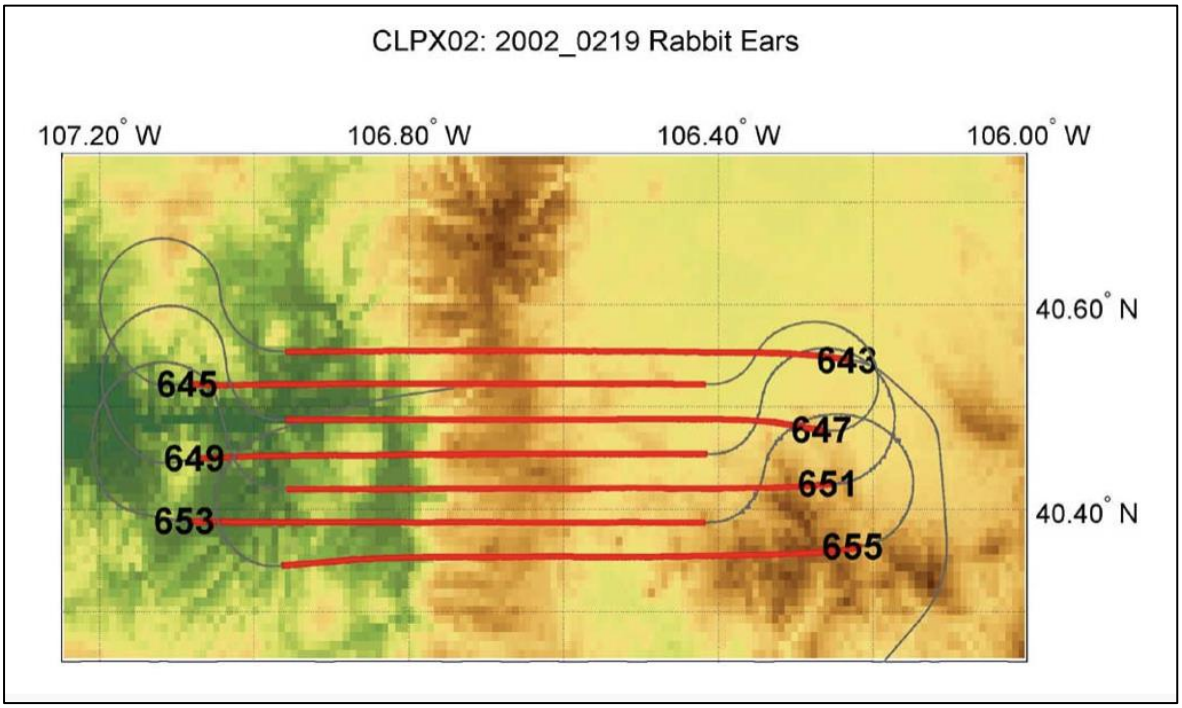


Figure 1 NASA DC-8 Flight tracks on 19 February 2002 at Rabbit Ears MSA.

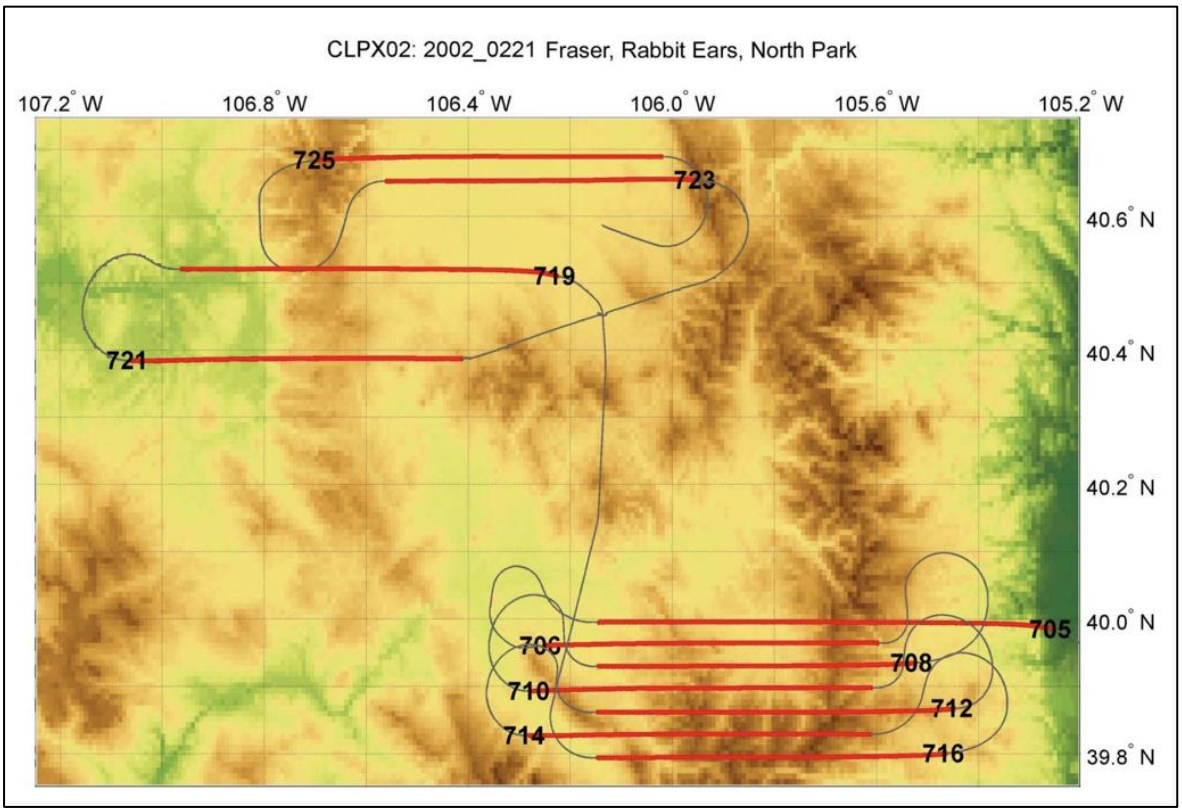


Figure 2 NASA DC-8 flight tracks on 21 February 2002 at North Park, Rabbit Ears, and Fraser MSAs.

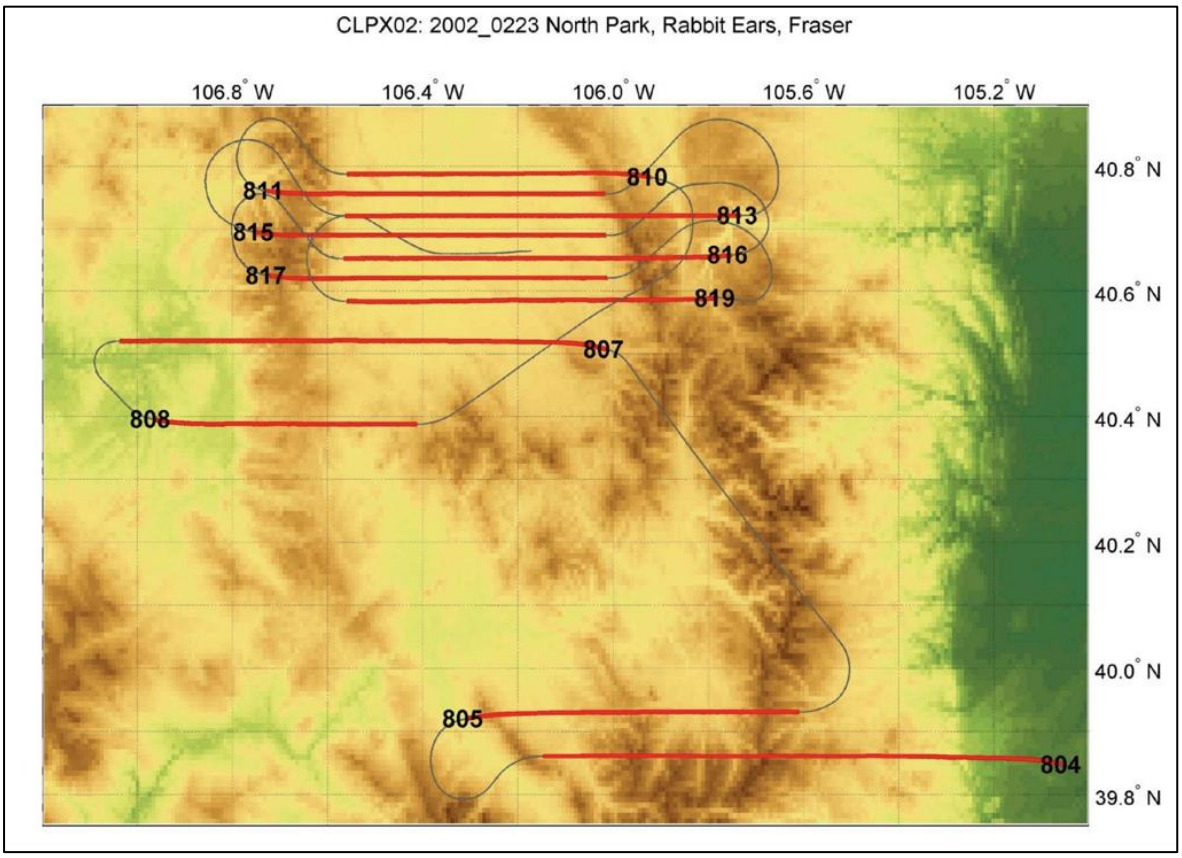


Figure 3 NASA DC-8 flight tracks on 23 February 2002 at North Park, Rabbit Ears, and Fraser MSAs.

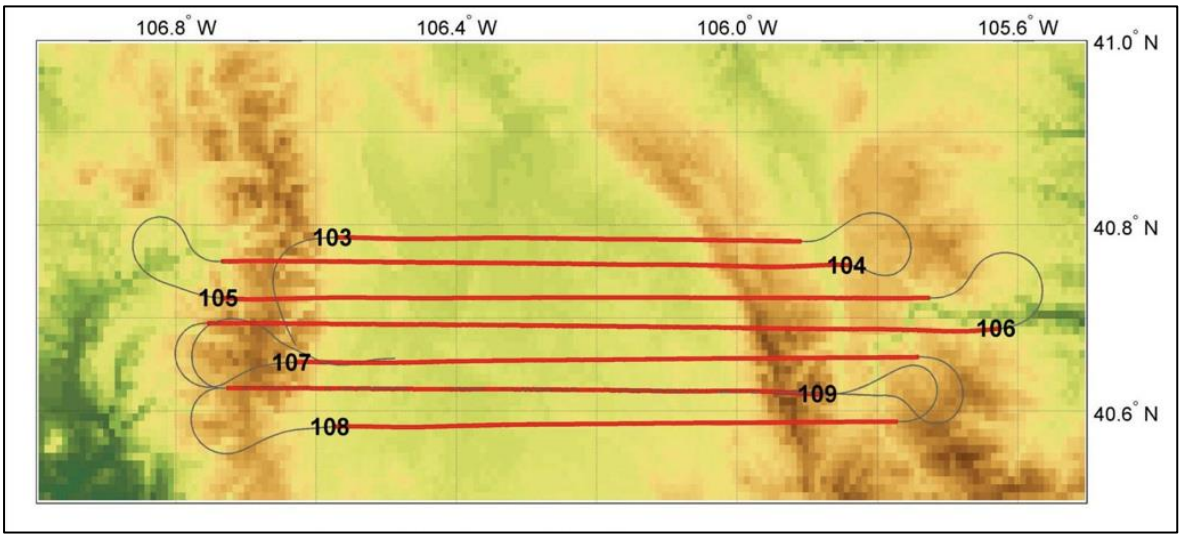


Figure 4 NASA P-3 flight tracks on 22 February 2003 at North Park MSA.

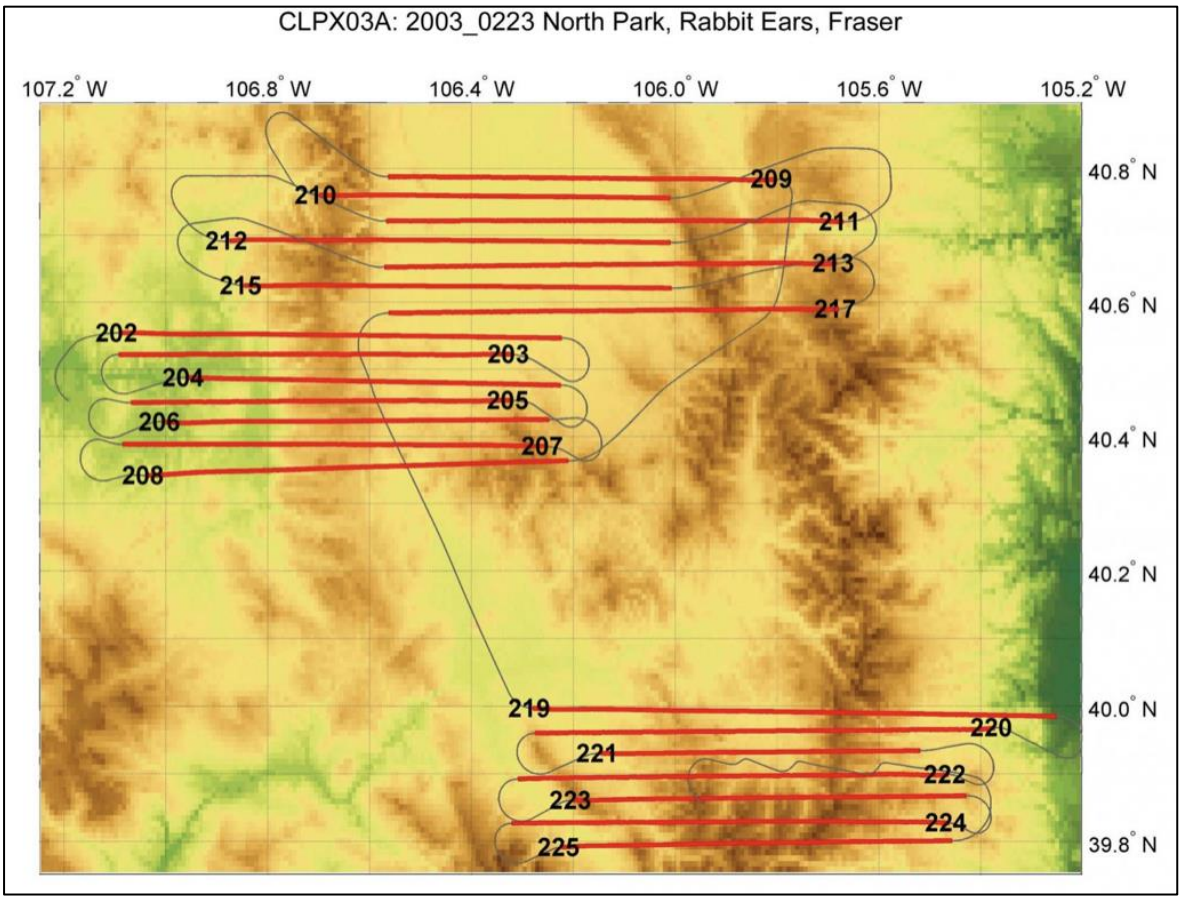


Figure 5 NASA P-3 flight tracks on 23 February 2003 at North Park, Rabbit Ears, and Fraser MSAs. Line colors same as Fig. 1.

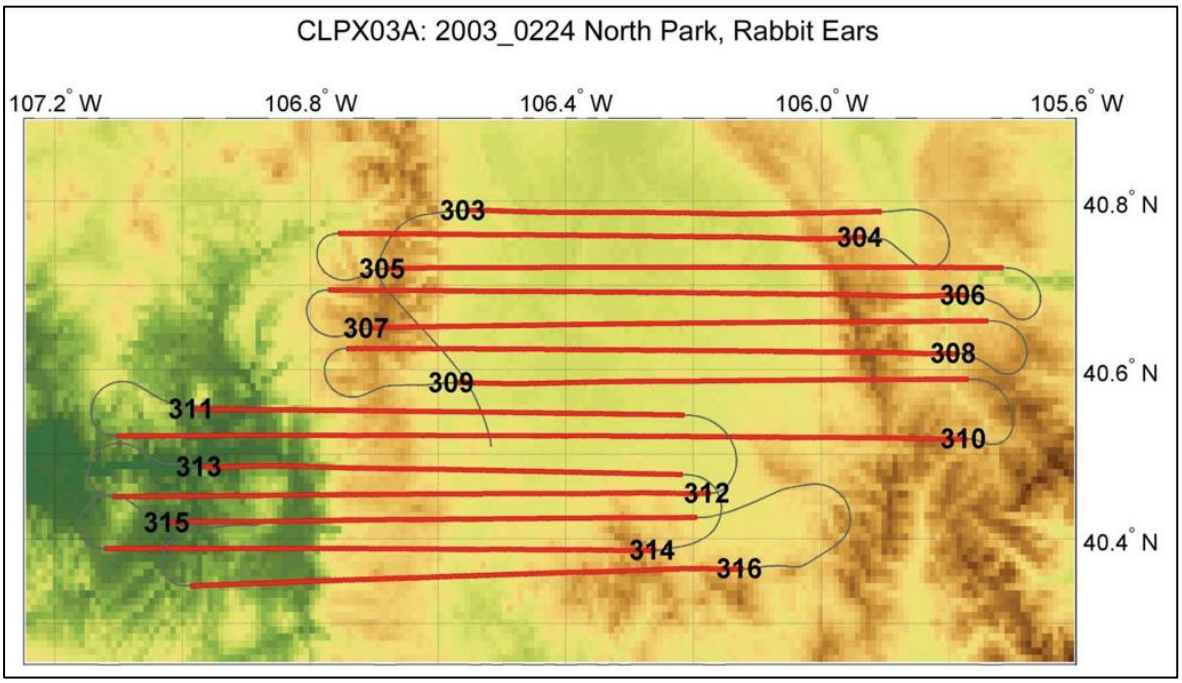


Figure 6 NASA P-3 flight tracks on 24 February 2003 at North Park and Rabbit Ears MSAs.

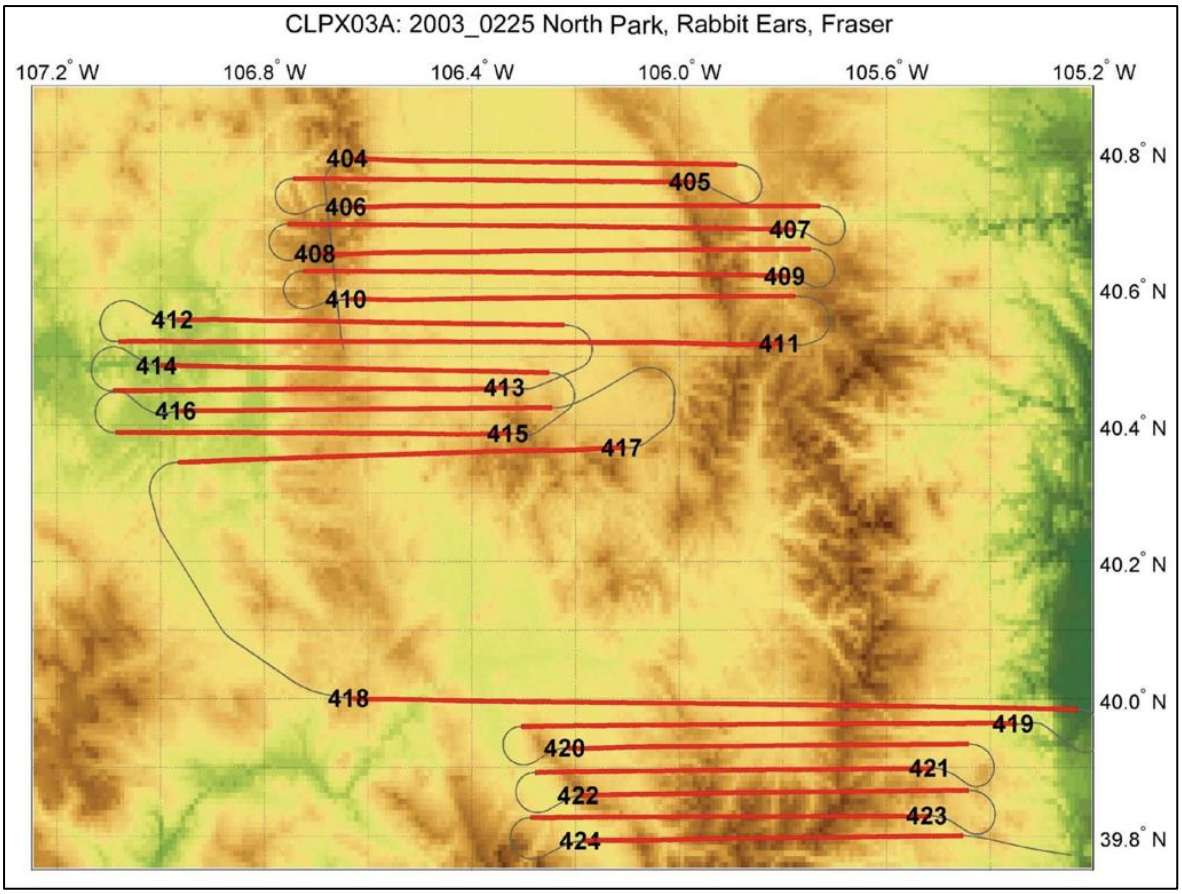


Figure 7 NASA P-3 flight tracks on 25 February 2003 at North Park, Rabbit Ears, and Fraser.

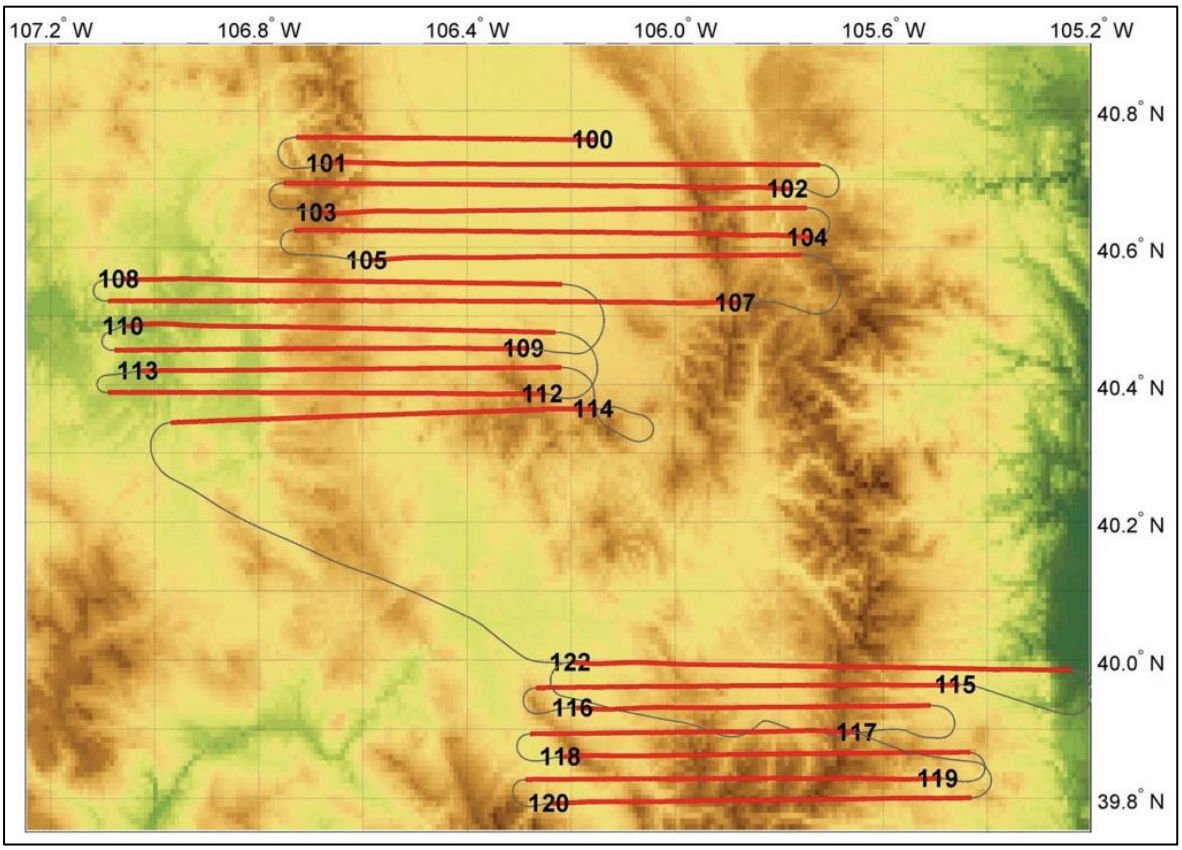


Figure 8 NASA P-3 Flight tracks on 25 March 2003 at North Park, Rabbit Ears, and Fraser MSAs.

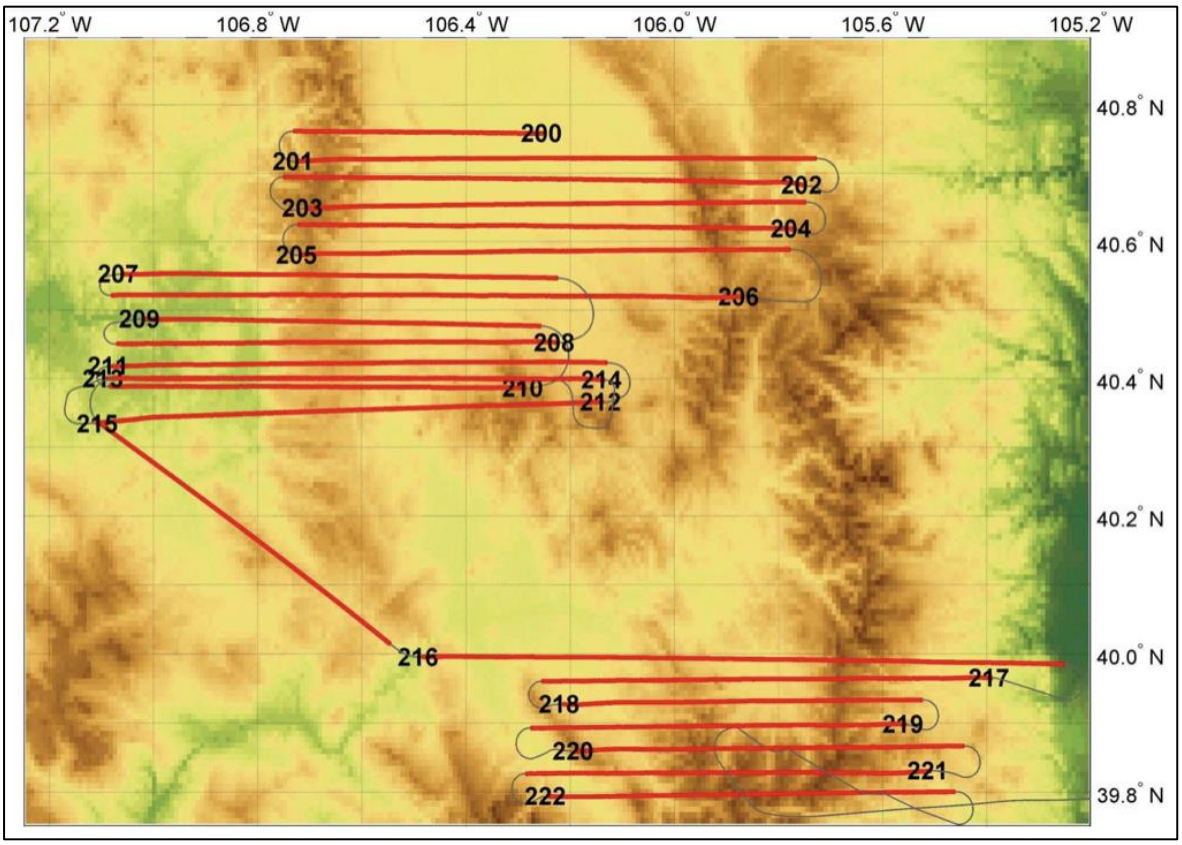


Figure 9 NASA P-3 Flight tracks on 30 March 2003 at North Park, Rabbit Ears, and Fraser MSAs.

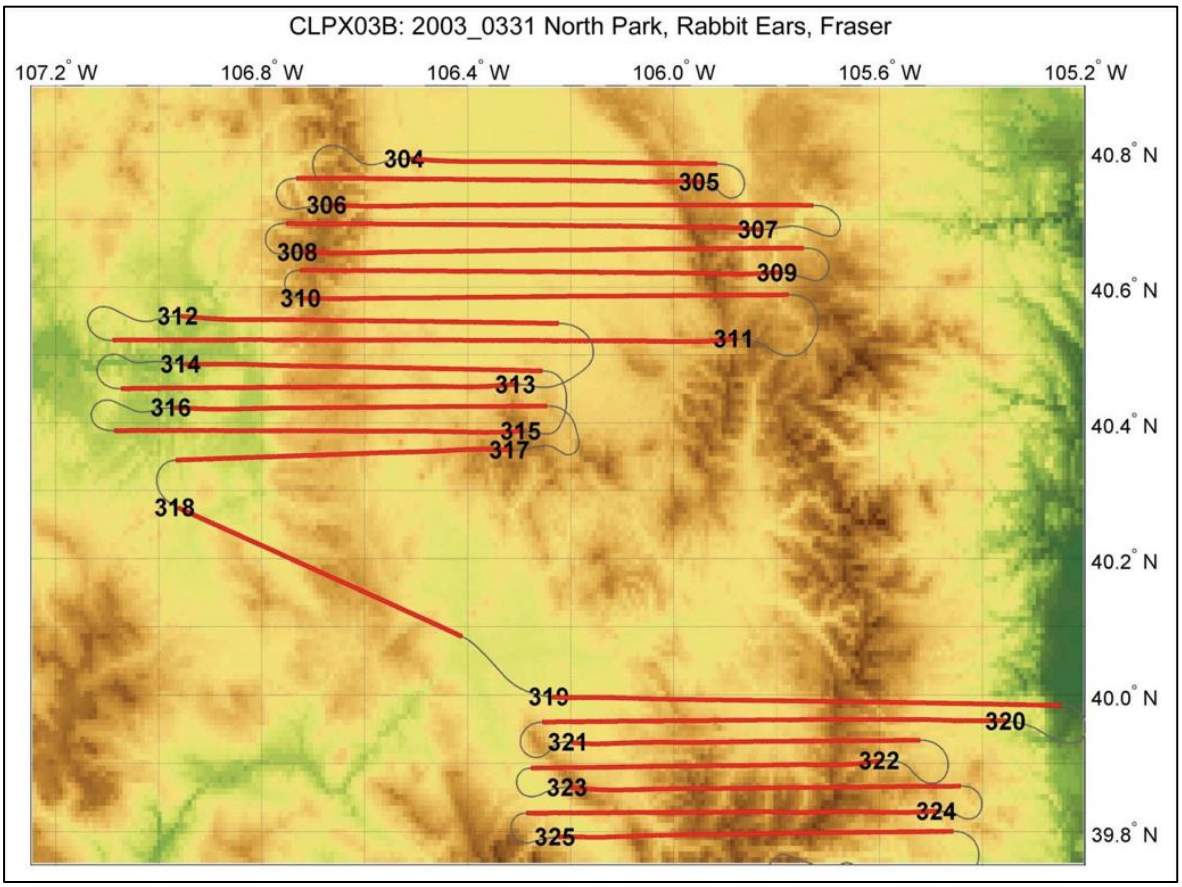


Figure 10 NASA P-3 Flight tracks on 31 March 2003 at North Park, Rabbit Ears, and Fraser MSAs

For Flight Summaries, see the Appendix.

1.1 Format

PSR/A data are available as MATLAB® files (*.mat) and binary files (*.bin) with associated ASCII headers. Missing data are identified by "-9999". All brightness temperatures are calibrated, and are in Kelvin. The data are geolocated with respect to 30-m resolution USGS terrain elevation data.

MATLAB files (e.g., L23Gqassss.mat, where ssss is the maneuver serial number) contain data organized in the following manner:

Table 4 Data type (order of variables in the third dimension).

Data Plane	Description
sceneL23Gqa(:,:,1)	10.7 GHz vert. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,2)	10.7 GHz horz. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,3)	18.7 GHz vert. polarization brightness temperature (T_B)

Data Plane	Description
sceneL23Gqa(:,:,4)	18.7 GHz horz. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,5)	21.5 GHz vert. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,6)	21.5 GHz horz. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,7)	37.0 GHz vert. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,8)	37.0 GHz horz. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,9)	89.0 GHz vert. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,10)	89.0 GHz horz. polarization brightness temperature (T_B)
sceneL23Gqa(:,:,11)	GPS altitude (feet)
sceneL23Gqa(:,:,12)	Time stamp (sec from the beginning of the day)
sceneL23Gqa(:,:,13)	Pixel terrain geolocated latitude (dd.ddd)
sceneL23Gqa(:,:,14)	Pixel terrain geolocated longitude (dd.ddd)
sceneL23Gqa(:,:,15)	Terrain height (m) at the pixel lat/lon

Additional variables present in each of the PSR/A CLPX02/IOP1 level 2.3Gqa files are:

ssn	Serial number of maneuver (see CLPX02/IOP1 data flight catalog)
firstday	Julian day on which the flight began
scanhead	Type of PSR scanhead (e.g., PSRA for CLPX02/IOP1)
description	Text string indicating PSR maneuver ID

Binary files (e.g., `L23Gqassss.bin`) contain data written out as a line of sequential points in the order described for the MATLAB files. Each binary file has an ASCII header file (e.g., `L23Gqassss.txt`) associated with it. An example of the ASCII header file follows:

Julian day at the beginning of the flight: 55
PSR scanhead type: PSRA
Maneuver serial number: 0304
Maneuver description: CL3A.DF003.M304.SLM.T_Conical
Size of sceneL23Gqa data matrix (numscans,numsamples,numchannels):
sceneL23Gqa(127,304,15)
Binary data file: \CLPX03A\2003_0224\level2.3Gqa\SL\L23Gqa0304.bin is written as real*8 (double) floating point; 64 bits

1.2 File and Directory Structure

```
CLPX02/
  2002_0219/
    level2.3Gqa/
```

```
      SL/
       L23Gqa0643.bin
       L23Gqa0643.mat
       L23Gqa0643.txt
            etc.
  2002_0221/
  2002_0223/
  CLPX02L23Gqa.log

CLPX03A/
  2003_0222/
    level2.3Gqa/
      SL/
       L23Gqa0103.bin
       L23Gqa0103.mat
       L23Gqa0103.txt
       etc.
  2003_0223/
  2003_0224/
  2003_0225/
  CLPX03AL23Gqa.log
CLPX03B/
  2003_0325/
    level2.3Gqa/
      SL/
       L23Gqa0100.bin
       L23Gqa0100.mat
       L23Gqa0100.txt
       etc.
  2003_0330/
  2003_0331/
  CLPX03BL23Gqa.log

dislpay_l23Gqa/
  ReadPSRBin&TxtFile.m
  displayl23Gqa.m
  flushlog.m
  includechans23Gqa.m
  jetclip.m
  mainshelldisp23Gqa.m
```

```
mapl23Gqa.m
navdist.m
readlog.m
request_params_23Gqa.m
```

1.3 File Naming Convention

Data are provided in directories by IOP (CLPX02 [IOP1], CLPX03A [IOP3], and CLPX03 [IOP4]). Subdirectories are named for the year, month, and date. For example, `2002_0219` is the directory for 19 February 2002. Within each directory, data files are named `L23Gqassss.bin`, `L23Gqassss.mat`, and `L23Gqassss.txt`, where ssss corresponds to a PSR serial number. "`L23`" represents Level2.3 PSR data, "`G`" stands for geolocated PSR data, "`q`" represents a "quality control" identifier, and "a" stands for a subset of PSR data provided to users.

The directory "`display_l23Gqa`" contains the MATLAB version 6.1 m-files necessary to render brightness temperature maps from the PSR data, and a file "ReadPSRBin&TxtFile.m" that shows the necessary steps to read a binary data file using MATLAB software. Information about using these files is given in the Software and Tools section of this document.

1.4 Spatial Coverage

Flights were flown over the Fraser, North Park, and Rabbit Ears MSAs of the CLPX study area. Flight lines are matched to data files in the Appendix of this document.

1.5 Temporal Coverage

Three flights were flown on 19, 21, and 23 February 2002 during IOP1. In 2003, four flights were flown on 22, 23, 24, and 25 February (IOP3) and three flights were flown on 25, 28 and 30 March during IOP 4. There were 10 sorties with 25 passes over the MSAs, totaling 28 hours and 3 minutes of flight lines.

1.6 Parameter or Variable

This data set provides multiband polarimetric brightness temperature images over three 25 x 25 km mesoscale study areas in Northern Colorado

1.6.1 Sample Data Record

The following is an example of PSR data.

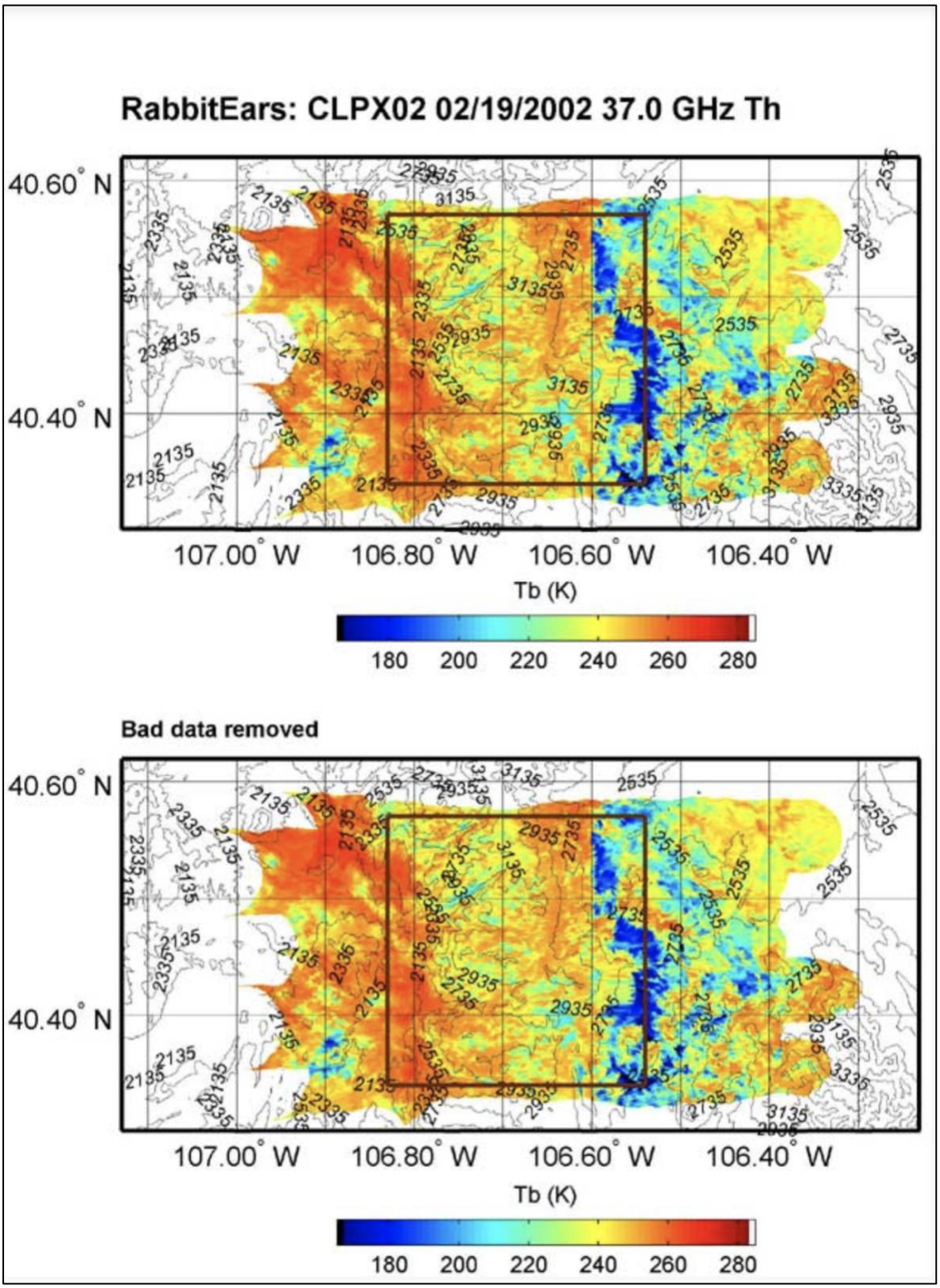


Figure 11 PSR image for 37 GHz channel on 19 February 2002 at Rabbit Ears MSA. Square in the center is the 25x25 km MSA area.

2 SOFTWARE AND TOOLS

MATLAB® software and Directory Structure for displaying PSR/A data.

The directory "`display_l23Gqa`" contains the MATLAB version 6.1 m-files necessary to render brightness temperature maps from the PSR data, and a file "ReadPSRBin&TxtFile.m" that shows the necessary steps to read a binary data file using MATLAB software. This should aid the user in designing their own data-reading routine using different software. The calibrated 2.3Gqa data should be organized in a series of subdirectories (one for each CLPX02, CLPX03A, and CLPX03B flight) in the following manner:

`experiment_directory\yyyy_mmdd\level2.3Gqa\sl\L23Gqaxxxx` where:

`experiment_directory` is the root name of the main directory (e.g. CLPX02)
`yyyy_mmdd` is a subdirectory indicating the year, month, and day of the beginning of data flight in UTC
`level2.3Gqa` is a subdirectory referring to the data level
`sl` is a subdirectory referring to straight and level maneuvers
`L23Gqaxxxx.mat` is a data file of type ".mat" corresponding to a maneuver with serial number xxxx.
`L23Gqaxxxx.bin` is a binary data file corresponding to a maneuver with serial number xxxx. It contains data identical to the data contained in the".mat" file and is associated with the header file **`L23Gqaxxxx.txt`**.

The MATLAB data and m-files delivered to NSIDC are organized as described above, and there is a `CLPXXXL23Gqa.log` file in each experiment_directory. The user should create a PSR directory on their computer and copy the data files into this directory. The following two steps should then be done:

1) edit the m-file named **`setrootdir.m`**, changing the variable "rootdir" to indicate the path to the directory **`experiment_directory`**

2) modify the MATLAB path (appended) using the "set path" command to include the subdirectory of mfiles in **`display_23Gqa`**.

To run the display m-files, issue the command "`mapl23Gqa`" in the MATLAB command window. The program will show the available dates for display, and the user is prompted to select a particular flight code. The program then lists all available maneuvers from the selected flight code by their serial numbers, and queries the user to select which file(s) is(are) to be displayed. The user can select the maneuver(s) by either the listed ordinal number or the associated

CLPX02/IOP1 maneuver serial number; for example, “sxxxx”. A group of maneuvers can be selected by indicating the range of ordinal numbers; for example, “2:13”. If more than one maneuver is selected, the program will ask if the user wants to spatially interpolate between adjacent maneuvers (e.g., using kridging) or overlay them on top of each other. If interpolation is selected, the program will automatically interpolate between the end of one maneuver and the beginning of the next. When the default option (overlay) is selected, no interpolation is performed and the data are overlaid, possibly overwriting data from previous maneuvers.

After loading the data for the selected maneuvers, the program queries the user for the channel (or set of channels) to be displayed. Several channel grouping options are provided in the command line. The next variables that can be selected are the minimum and maximum brightness temperatures for the range of the color map. If the minimum color temperature is defined by user, he/she will also be asked for the maximum; otherwise, the program will automatically assign those values. If auto-range calculation is selected, the program will attempt to fit a Gaussian probability distribution function to the brightness temperature histogram, and compute the color range individually for each channel using the Gaussian parameters along with a range factor. The range factor sets the color range relative to the mean by the indicated number of standard deviations. The range factor defaults to 0.6, but can be modified according to the needs of the user. Autocalculation is useful for scenes in which the brightness temperatures mostly fall within a narrow range of values.

The user can then display only a portion of the maneuver by selecting the scans to be displayed from all the scans available in the selected set of maneuvers. Here, for conical scanning, one full scan means one full rotation around the azimuth axis, and includes front and back looks. Next, the user can choose to produce either individual maps (i.e., one image for each channel) or a composite image of all channels and looks in a single map. Finally, the user has the option of selecting new latitude and longitude corners. If the user has installed the MATLAB Mapping Toolbox, he/she will also be asked to choose whether to include lines of individual U.S. states on the final map.

2.1 Quality Assessment

When interference occurred during calibration at either end of a flight line, it was possible that the data from either the whole line or from part of the line were out of calibration with the rest of the flight lines. When that happened, the investigators had two options: 1) change the calibrating software to look at all of the calibration during the entire flight together, and perform statistical analysis on the calibration looks to eliminate outliers and obtain uniform calibration for the entire

flight, or 2) manually remove data in the flight lines that were obviously out of calibration. The first option requires effort beyond the scope of this project. Thus, in this first version of delivered PSR data, the investigators manually removed data. Table 5, showing quality control statistics, summarizes the effects of the data-removal process.

There were 10 sorties with 25 flights over the MSAs, totaling 28 hours and 3 minutes of flying time. The total number of lines was 1,560 where the number of lines was obtained by multiplying the number of flight lines by the number of data channels. During data removal, entire lines were mostly removed but, in some cases, only part of the line was removed. This happened when the calibration occurred within the line or when calibration on one end of the line was out of calibration with respect to the other end's calibration. When this occurred, the investigators counted that line as half of the line in computing the quality control statistics. The largest number of removed lines occurred in February 2003, when the weather over the MSAs was cloudy. However, in those cases, the removed lines were mostly for the 89 GHz channel (both vertical and horizontal polarization) because this channel is known to be sensitive to clouds. Vertical polarization for the 18.7 and 21.5 GHz channels was also affected, but to much lesser extent.

Table 5 Data “Quality Control” Statistics.

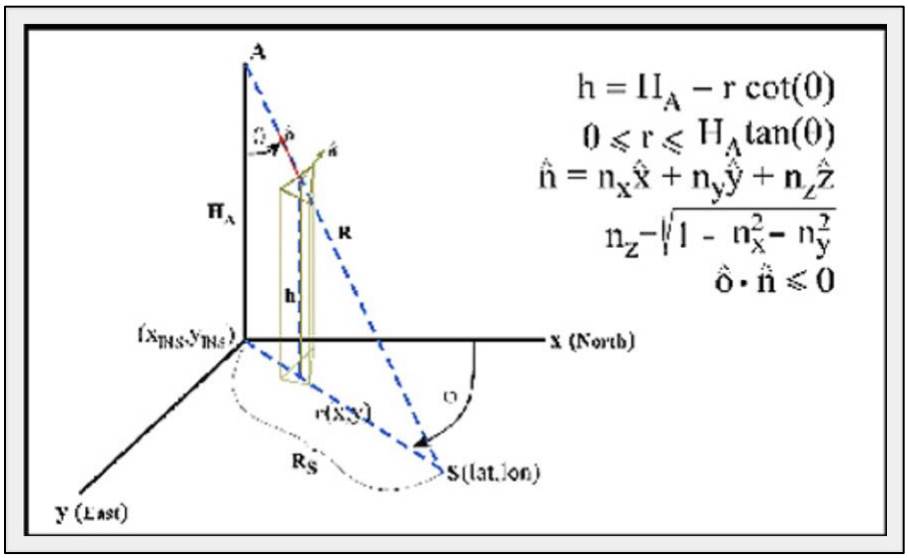
MSA Area	Date	Obs. Times (UTC)	Flight Duration	Tot. No. of lines*	No. of removed lines*	% removed lines
RE	02/19/02	21:18 - 22:30	1:12	70	11	15.7
NP RE F	02/21/02	16:45 - 18:50	2:05	110	8	7.3
NP RE F	02/23/02	16:37 - 18:46	2:09	110	10	9.1
NP	02/22/03	18:37 – 20:00	1:23	70	7	10.0
NP RE F	02/23/02	17:38 - 21:25	3:47	210	27	12.8
NP RE	02/24/03	20:36 - 22:58	2:22	140	23	16.4
NP RE F	02/25/03	17:30 - 20:56	3:26	210	33	15.7
NP RE F	03/25/03	17:50 - 22:17	3:27	210	10	4.8
NP RE F	03/30/03	18:12 - 22:29	4:17	220	10	4.5
NP RE F	03/31/03	17:51 - 21:46	3:55	210	8	3.8
TOTAL			28:30	1,560	147	9.4

3 DATA ACQUISITION AND PROCESSING

The PSR DC-8 configuration for CLPX 2002 (IOP1) and the NASA P-3 configuration for CLPX03A/IOP3 and CLPX03B/IOP4 used the NOAA PSR/A scanhead, operated in conical scanning mode at an incidence angle of 55 degrees from nadir (the same incidence angle as the AMSR-E sensor). During CLPX03B/IOP4, both the PSR/A and PSR/CX scanheads were installed on the P-3 aircraft. This pair of PSR scanheads provided the first full polarimetric and spectral simulation of the Aqua AMSR-E sensor.

3.1 PSR/A Geolocation Procedure

The following shows the geolocation calculation for PSR/A data:



Let

A = PSR location on the aircraft

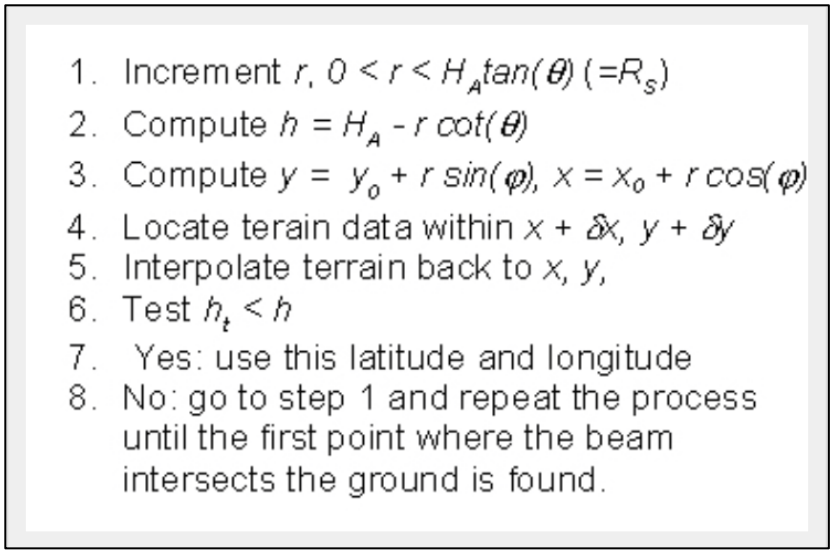
R = distance to the ground along the beam

θ = elevation angle

φ = azimuth angle

vector o = observation vector

vector n = normal to the plane where the beam hits the ground"



4 REFERENCES AND RELATED PUBLICATIONS

Stankov, B. Boba, Albin J. Gasiewski, Marian Klein, Vladimir Leuski, Bob L. Weber, Vladimir Irisov, Don Cline, and A. Yevgrafov. 2003. Airborne Measurement of Snow Cover Properties using the

Polarimetric Scanning Radiometer during the Cold Land Processes Experiments (CLPX02-03. IGARSS2003, July 21-25, Toulouse, France.)

Yueh, Simon H., William J. Wilson, and Steve Dinard. 2002. Polarimetric Radar Remote Sensing of Ocean Surface Wind. *IEEE Trans. Geosci. Remote Sens.* 40(4): 793-800.

4.1 Related Data Collections

All CLPX Data Sets

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6 DOCUMENT INFORMATION

6.1 Publication Date

24 August 2017

6.2 Date Last Updated

5 April 2021

APPENDIX – FLIGHT SUMMARIES

The following tables are flight catalogs of the PSR flight lines over the CLPX MSAs, and provide a description of maneuvers listed by PSR serial number. The tables include the maneuver ID assigned to a given maneuver by the PSR processing system, date, UTC time (start and stop), and position (start and stop). Flight catalog tables are also provided as tab-delimited ASCII files with the data.

The maneuver ID consists of several fields of information separated by dots. For example, the maneuver ID CL02.DF006.M600.SLH.T has the following interpretation:

CL02: CLPX02 (IOP1)
DF006: 6th data flight during CLPX02 (IOP1)
M600: maneuver serial number
SLH: maneuver type: straight and level, at high-altitude
SLM:straight and level at mid altitude
SLL: straight and level at low altitude
T: maneuver type (transect)

Table 1 2002 (CLPX02/IOP1) Flight Catalog

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00643	CL02.DF006.M643.SLM.T	02/19/02	21:18:14	21:24:55	40.546	106.227	40.554	106.959
00645	CL02.DF006.M645.SLM.T	02/19/02	21:29:53	21:35:56	40.522	107.079	40.522	106.417
00647	CL02.DF006.M647.SLM.T	02/19/02	21:39:17	21:45:40	40.477	106.259	40.487	106.960
00649	CL02.DF006.M649.SLM.T	02/19/02	21:50:48	21:56:48	40.450	107.069	40.454	106.415
00651	CL02.DF006.M651.SLM.T	02/19/02	22:01:08	22:07:35	40.425	106.251	40.420	106.959
00653	CL02.DF006.M653.SLM.T	02/19/02	22:12:51	22:18:57	40.388	107.083	40.388	106.419
00655	CL02.DF006.M655.SLM.T	02/19/02	22:23:13	22:30:02	40.364	106.220	40.345	106.964
00705	CL02.DF007.M705.SLL.T	02/21/02	16:45:20	16:53:27	39.985	105.253	39.995	106.147
00706	CL02.DF007.M706.SLL.T	02/21/02	16:57:59	17:04:06	39.960	106.252	39.964	105.596
00708	CL02.DF007.M708.SLL.T	02/21/02	17:09:33	17:15:16	39.934	105.525	39.929	106.148
00710	CL02.DF007.M710.SLL.T	02/21/02	17:19:54	17:26:04	39.893	106.275	39.898	105.608
00712	CL02.DF007.M712.SLM.T	02/21/02	17:30:39	17:37:09	39.867	105.446	39.861	106.148
00714	CL02.DF007.M714.SLM.T	02/21/02	17:41:44	17:47:56	39.827	106.284	39.829	105.610
00716	CL02.DF007.M716.SLM.T	02/21/02	17:53:11	17:59:31	39.801	105.462	39.794	106.149
00719	CL02.DF007.M719.SLM.T	02/21/02	18:09:28	18:16:17	40.511	106.224	40.521	106.964
00721	CL02.DF007.M721.SLM.T	02/21/02	18:19:44	18:25:42	40.384	107.062	40.387	106.414
00723	CL02.DF007.M723.SLM.T	02/21/02	18:32:40	18:38:09	40.654	105.949	40.653	106.563
00725	CL02.DF007.M725.SLM.T	02/21/02	18:43:33	18:49:41	40.684	106.695	40.689	106.020
00804	CL02.DF008.M804.SLM.T	02/23/02	16:37:08	16:47:10	39.847	105.053	39.861	106.147
00805	CL02.DF008.M805.SLM.T	02/23/02	16:51:16	16:57:43	39.920	106.309	39.931	105.610

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00807	CL02.DF008.M807.SLM.T	02/23/02	17:06:24	17:15:49	40.507	106.013	40.520	107.036
00808	CL02.DF008.M808.SLM.T	02/23/02	17:18:31	17:23:34	40.396	106.965	40.388	106.414
00810	CL02.DF008.M810.SLM.T	02/23/02	17:30:27	17:36:16	40.783	105.921	40.788	106.559
00811	CL02.DF008.M811.SLM.T	02/23/02	17:40:16	17:46:45	40.761	106.728	40.756	106.017
00813	CL02.DF008.M813.SLM.T	02/23/02	17:51:49	17:59:22	40.721	105.732	40.721	106.563
00815	CL02.DF008.M815.SLM.T	02/23/02	18:04:34	18:11:18	40.694	106.749	40.689	106.018
00816	CL02.DF008.M816.SLM.T	02/23/02	18:15:48	18:23:11	40.658	105.752	40.652	106.567
00817	CL02.DF008.M817.SLM.T	02/23/02	18:27:35	18:34:02	40.625	106.722	40.621	106.014
00819	CL02.DF008.M819.SLM.T	02/23/02	18:38:55	18:46:04	40.589	105.780	40.584	106.558

Table 2 2003 (CLPX03A/IOP3) Flight Catalog

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00103	CL3A.DF001.M103.SLM.T	02/22/03	18:37:55	18:43:06	40.787	106.572	40.782	105.908
00104	CL3A.DF001.M104.SLM.T	02/22/03	18:45:45	18:53:57	40.757	105.839	40.761	106.736
00105	CL3A.DF001.M105.SLM.T	02/22/03	18:56:48	19:04:38	40.721	106.735	40.721	105.726
00106	CL3A.DF001.M106.SLM.T	02/22/03	19:07:12	19:17:24	40.689	105.626	40.694	106.756
00107	CL3A.DF001.M107.SLM.T	02/22/03	19:19:39	19:26:36	40.652	106.630	40.658	105.741
00108	CL3A.DF001.M108.SLM.T	02/22/03	19:39:44	19:45:59	40.583	106.576	40.589	105.771
00109	CL3A.DF001.M109.SLM.T	02/22/03	19:48:26	19:55:57	40.618	105.881	40.625	106.728
00202	CL3A.DF002.M202.SLM.T	02/23/03	17:38:11	17:45:02	40.554	107.091	40.547	106.224
00203	CL3A.DF002.M203.SLM.T	02/23/03	17:47:37	17:55:32	40.522	106.321	40.522	107.093

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00204	CL3A.DF002.M204.SLM.T	02/23/03	17:57:43	18:03:34	40.488	106.960	40.476	106.225
00205	CL3A.DF002.M205.SLM.T	02/23/03	18:06:04	18:13:40	40.454	106.323	40.450	107.069
00206	CL3A.DF002.M206.SLM.T	02/23/03	18:16:10	18:22:12	40.422	107.007	40.425	106.248
00207	CL3A.DF002.M207.SLM.T	02/23/03	18:24:38	18:33:01	40.385	106.255	40.388	107.085
00208	CL3A.DF002.M208.SLM.T	02/23/03	18:35:21	18:41:56	40.342	107.039	40.364	106.211
00209	CL3A.DF002.M209.SLM.T	02/23/03	18:48:32	18:56:07	40.784	105.805	40.788	106.564
00210	CL3A.DF002.M210.SLM.T	02/23/03	19:00:28	19:05:50	40.760	106.700	40.756	106.010
00211	CL3A.DF002.M211.SLM.T	02/23/03	19:11:16	19:20:27	40.720	105.670	40.721	106.568
00212	CL3A.DF002.M212.SLM.T	02/23/03	19:26:28	19:33:11	40.691	106.875	40.689	106.010
00213	CL3A.DF002.M213.SLM.T	02/23/03	19:37:44	19:46:45	40.658	105.683	40.652	106.572
00215	CL3A.DF002.M215.SLM.T	02/23/03	19:52:32	19:59:04	40.625	106.847	40.621	106.007
00217	CL3A.DF002.M217.SLM.T	02/23/03	20:03:20	20:12:18	40.590	105.679	40.584	106.563
00219	CL3A.DF002.M219.SLM.T	02/23/03	20:19:49	20:27:54	39.997	106.280	39.985	105.252
00220	CL3A.DF002.M220.SLM.T	02/23/03	20:30:41	20:39:45	39.968	105.373	39.960	106.275
00221	CL3A.DF002.M221.SLM.T	02/23/03	20:41:56	20:46:53	39.930	106.146	39.934	105.519
00222	CL3A.DF002.M222.SLM.T	02/23/03	20:49:26	20:57:58	39.899	105.464	39.892	106.310
00223	CL3A.DF002.M223.SLM.T	02/23/03	21:00:02	21:06:15	39.861	106.199	39.867	105.428
00224	CL3A.DF002.M224.SLM.T	02/23/03	21:08:00	21:16:43	39.827	105.462	39.827	106.321
00225	CL3A.DF002.M225.SLM.T	02/23/03	21:18:36	21:24:48	39.791	106.223	39.801	105.456
00303	CL3A.DF003.M303.SLM.T	02/24/03	20:36:41	20:41:38	40.789	106.556	40.787	105.906
00304	CL3A.DF003.M304.SLM.T	02/24/03	20:44:23	20:52:44	40.757	105.934	40.761	106.757

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00305	CL3A.DF003.M305.SLM.T	02/24/03	20:54:21	21:01:41	40.720	106.682	40.721	105.716
00306	CL3A.DF003.M306.SLM.T	02/24/03	21:03:55	21:14:19	40.688	105.773	40.694	106.772
00307	CL3A.DF003.M307.SLM.T	02/24/03	21:15:52	21:23:18	40.649	106.707	40.658	105.739
00308	CL3A.DF003.M308.SLM.T	02/24/03	21:25:24	21:34:59	40.619	105.787	40.625	106.744
00309	CL3A.DF003.M309.SLM.T	02/24/03	21:37:24	21:43:32	40.584	106.574	40.589	105.770
00310	CL3A.DF003.M310.SLM.T	02/24/03	21:45:23	21:58:38	40.518	105.772	40.522	107.103
00311	CL3A.DF003.M311.SLM.T	02/24/03	22:00:51	22:06:44	40.553	106.980	40.546	106.214
00312	CL3A.DF003.M312.SLM.T	02/24/03	22:08:22	22:17:41	40.454	106.173	40.450	107.110
00313	CL3A.DF003.M313.SLM.T	02/24/03	22:20:00	22:25:53	40.485	106.969	40.476	106.217
00314	CL3A.DF003.M314.SLM.T	02/24/03	22:27:58	22:36:36	40.387	106.259	40.388	107.122
00315	CL3A.DF003.M315.SLM.T	02/24/03	22:38:40	22:45:05	40.419	107.019	40.425	106.195
00316	CL3A.DF003.M316.SLM.T	02/24/03	22:49:16	22:57:49	40.365	106.123	40.344	106.989
00404	CL3A.DF004.M404.SLM.T	02/25/03	17:30:44	17:36:45	40.791	106.633	40.782	105.889
00405	CL3A.DF004.M405.SLM.T	02/25/03	17:38:57	17:46:29	40.757	105.973	40.761	106.746
00406	CL3A.DF004.M406.SLM.T	02/25/03	17:48:26	17:55:48	40.720	106.636	40.721	105.728
00407	CL3A.DF004.M407.SLM.T	02/25/03	17:57:38	18:06:59	40.686	105.779	40.694	106.755
00408	CL3A.DF004.M408.SLM.T	02/25/03	18:08:33	18:16:17	40.651	106.696	40.658	105.748
00409	CL3A.DF004.M409.SLM.T	02/25/03	18:17:57	18:26:48	40.618	105.790	40.625	106.726
00410	CL3A.DF004.M410.SLM.T	02/25/03	18:28:39	18:35:42	40.584	106.635	40.589	105.776
00411	CL3A.DF004.M411.SLM.T	02/25/03	18:37:35	18:49:33	40.519	105.799	40.522	107.082
00412	CL3A.DF004.M412.SLM.T	02/25/03	18:51:36	18:57:43	40.554	106.970	40.546	106.222

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00413	CL3A.DF004.M413.SLM.T	02/25/03	19:00:13	19:07:13	40.454	106.330	40.450	107.092
00414	CL3A.DF004.M414.SLM.T	02/25/03	19:09:12	19:15:17	40.487	107.001	40.476	106.251
00415	CL3A.DF004.M415.SLM.T	02/25/03	19:17:24	19:24:40	40.387	106.324	40.389	107.087
00416	CL3A.DF004.M416.SLM.T	02/25/03	19:26:56	19:32:47	40.420	106.964	40.425	106.245
00417	CL3A.DF004.M417.SLM.T	02/25/03	19:36:37	19:44:48	40.366	106.104	40.345	106.967
00418	CL3A.DF004.M418.SLM.T	02/25/03	19:50:33	20:01:53	40.000	106.631	39.984	105.232
00419	CL3A.DF004.M419.SLM.T	02/25/03	20:04:30	20:13:36	39.963	105.349	39.960	106.304
00420	CL3A.DF004.M420.SLM.T	02/25/03	20:15:27	20:21:49	39.928	106.214	39.934	105.442
00421	CL3A.DF004.M421.SLM.T	02/25/03	20:23:48	20:30:50	39.899	105.510	39.893	106.278
00422	CL3A.DF004.M422.SLM.T	02/25/03	20:32:42	20:38:40	39.859	106.188	39.867	105.442
00423	CL3A.DF004.M423.SLM.T	02/25/03	20:40:45	20:47:51	39.830	105.515	39.827	106.287
00424	CL3A.DF004.M424.SLM.T	02/25/03	20:49:51	20:55:41	39.794	106.184	39.801	105.454

Table 3 2003 (CLPX03B/IOP4) Flight Catalog

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00100	CL3B.DF001.M100.SLM.T	03/25/03	17:50:23	17:57:24	40.758	106.152	40.761	106.728
00101	CL3B.DF001.M101.SLM.T	03/25/03	17:59:15	18:08:22	40.723	106.663	40.721	105.723
00102	CL3B.DF001.M102.SLM.T	03/25/03	18:10:20	18:22:14	40.686	105.777	40.694	106.753
00103	CL3B.DF001.M103.SLM.T	03/25/03	18:23:54	18:33:06	40.651	106.683	40.658	105.747
00104	CL3B.DF001.M104.SLM.T	03/25/03	18:34:18	18:46:25	40.615	105.739	40.625	106.732
00105	CL3B.DF001.M105.SLM.T	03/25/03	18:48:51	18:56:54	40.581	106.586	40.589	105.758

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00107	CL3B.DF001.M107.SLM.T	03/25/03	19:00:43	19:15:06	40.519	105.878	40.522	107.090
00108	CL3B.DF001.M108.SLM.T	03/25/03	19:16:19	19:24:35	40.554	107.063	40.546	106.217
00109	CL3B.DF001.M109.SLM.T	03/25/03	19:27:51	19:37:14	40.453	106.285	40.450	107.077
00110	CL3B.DF001.M110.SLM.T	03/25/03	19:38:18	19:46:22	40.485	107.054	40.476	106.231
00112	CL3B.DF001.M112.SLM.T	03/25/03	19:49:00	19:59:04	40.387	106.249	40.389	107.090
00113	CL3B.DF001.M113.SLM.T	03/25/03	20:00:26	20:08:15	40.420	107.026	40.425	106.219
00114	CL3B.DF001.M114.SLM.T	03/25/03	20:12:20	20:22:09	40.365	106.150	40.345	106.969
00115	CL3B.DF001.M115.SLM.T	03/25/03	20:45:34	20:55:12	39.964	105.455	39.960	106.267
00116	CL3B.DF001.M116.SLM.T	03/25/03	20:56:52	21:03:39	39.931	106.190	39.934	105.510
00117	CL3B.DF001.M117.SLM.T	03/25/03	21:06:37	21:14:28	39.896	105.645	39.893	106.278
00118	CL3B.DF001.M118.SLL.T	03/25/03	21:15:59	21:23:44	39.860	106.214	39.866	105.433
00119	CL3B.DF001.M119.SLM.T	03/25/03	21:25:20	21:35:05	39.829	105.489	39.827	106.287
00120	CL3B.DF001.M120.SLM.T	03/25/03	21:36:26	21:44:24	39.793	106.236	39.801	105.431
00122	CL3B.DF001.M122.SLM.T	03/25/03	21:56:23	22:05:47	39.996	106.195	39.986	105.239
00200	CL3B.DF002.M200.SLM.T	03/30/03	18:12:21	18:18:04	40.759	106.249	40.761	106.732
00201	CL3B.DF002.M201.SLM.T	03/30/03	18:19:00	18:29:13	40.717	106.726	40.721	105.727
00202	CL3B.DF002.M202.SLM.T	03/30/03	18:30:49	18:42:52	40.682	105.749	40.694	106.751
00203	CL3B.DF002.M203.SLM.T	03/30/03	18:44:15	18:54:17	40.649	106.708	40.658	105.747
00204	CL3B.DF002.M204.SLM.T	03/30/03	18:55:48	19:07:07	40.618	105.769	40.625	106.724
00205	CL3B.DF002.M205.SLM.T	03/30/03	19:08:04	19:17:55	40.580	106.720	40.588	105.777
00206	CL3B.DF002.M206.SLM.T	03/30/03	19:21:03	19:35:23	40.519	105.870	40.522	107.081

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00207	CL3B.DF002.M207.SLM.T	03/30/03	19:36:25	19:45:10	40.553	107.062	40.547	106.224
00208	CL3B.DF002.M208.SLM.T	03/30/03	19:47:16	19:57:15	40.453	106.224	40.451	107.072
00209	CL3B.DF002.M209.SLM.T	03/30/03	19:58:41	20:06:38	40.487	107.021	40.477	106.256
00210	CL3B.DF002.M210.SLM.T	03/30/03	20:08:38	20:18:04	40.386	106.285	40.389	107.086
00211	CL3B.DF002.M211.SLM.T	03/30/03	20:18:57	20:28:55	40.418	107.081	40.423	106.129
00212	CL3B.DF002.M212.SLL.T	03/30/03	20:30:18	20:41:44	40.366	106.136	40.336	107.112
00213	CL3B.DF002.M213.SLM.T	03/30/03	20:43:58	20:52:58	40.400	107.091	40.399	106.234
00214	CL3B.DF002.M214.SLM.T	03/30/03	20:55:59	21:06:54	40.398	106.134	40.400	107.077
00216	CL3B.DF002.M216.SLM.T	03/30/03	21:14:32	21:27:17	39.995	106.485	39.985	105.251
00217	CL3B.DF002.M217.SLM.T	03/30/03	21:30:15	21:40:19	39.965	105.389	39.960	106.255
00218	CL3B.DF002.M218.SLM.T	03/30/03	21:41:37	21:48:52	39.927	106.215	39.933	105.523
00219	CL3B.DF002.M219.SLM.T	03/30/03	21:50:17	21:58:42	39.898	105.555	39.893	106.276
00220	CL3B.DF002.M220.SLM.T	03/30/03	22:00:40	22:08:37	39.859	106.188	39.867	105.444
00221	CL3B.DF002.M221.SLM.T	03/30/03	22:10:22	22:19:22	39.831	105.507	39.827	106.286
00222	CL3B.DF002.M222.SLM.T	03/30/03	22:20:49	22:29:06	39.794	106.242	39.801	105.461
00304	CL3B.DF003.M304.SLM.T	03/31/03	17:51:15	17:56:58	40.790	106.516	40.783	105.916
00305	CL3B.DF003.M305.SLM.T	03/31/03	17:58:57	18:08:15	40.756	105.944	40.761	106.733
00306	CL3B.DF003.M306.SLM.T	03/31/03	18:10:05	18:19:03	40.721	106.668	40.721	105.729
00307	CL3B.DF003.M307.SLM.T	03/31/03	18:21:59	18:33:01	40.685	105.829	40.694	106.753
00308	CL3B.DF003.M308.SLM.T	03/31/03	18:34:33	18:43:55	40.652	106.724	40.658	105.748
00309	CL3B.DF003.M309.SLM.T	03/31/03	18:45:55	18:56:55	40.622	105.793	40.625	106.726

PSR Serial No.	Maneuver ID	Date	Maneuv. Start (UTC)	Maneuv. Stop (UTC)	Maneuv. Start °Lat. (N)	Maneuv. Start °Lon. (W)	Maneuv. Stop °Lat. (N)	Maneuv. Stop °Lon. (W)
00310	CL3B.DF003.M310.SLM.T	03/31/03	18:57:59	19:07:06	40.583	106.718	40.589	105.777
00311	CL3B.DF003.M311.SLM.T	03/31/03	19:10:12	19:23:42	40.523	105.876	40.522	107.089
00312	CL3B.DF003.M312.SLM.T	03/31/03	19:26:34	19:33:37	40.557	106.957	40.547	106.224
00313	CL3B.DF003.M313.SLM.T	03/31/03	19:36:32	19:45:36	40.456	106.301	40.450	107.074
00314	CL3B.DF003.M314.SLM.T	03/31/03	19:48:17	19:54:58	40.486	106.951	40.476	106.256
00315	CL3B.DF003.M315.SLM.T	03/31/03	19:57:14	20:06:37	40.388	106.290	40.388	107.087
00316	CL3B.DF003.M316.SLM.T	03/31/03	20:09:11	20:16:13	40.422	106.970	40.425	106.246
00317	CL3B.DF003.M317.SLM.T	03/31/03	20:19:06	20:26:39	40.360	106.313	40.345	106.967
00319	CL3B.DF003.M319.SLM.T	03/31/03	20:34:54	20:44:32	39.997	106.236	39.985	105.248
00320	CL3B.DF003.M320.SLM.T	03/31/03	20:47:24	20:57:59	39.962	105.349	39.960	106.255
00321	CL3B.DF003.M321.SLM.T	03/31/03	21:00:01	21:06:33	39.931	106.198	39.934	105.521
00322	CL3B.DF003.M322.SLM.T	03/31/03	21:09:02	21:17:02	39.904	105.595	39.893	106.277
00323	CL3B.DF003.M323.SLM.T	03/31/03	21:18:50	21:26:08	39.864	106.200	39.867	105.442
00324	CL3B.DF003.M324.SLM.T	03/31/03	21:27:55	21:37:21	39.830	105.483	39.827	106.286
00325	CL3B.DF003.M325.SLM.T	03/31/03	21:39:00	21:46:24	39.792	106.224	39.801	105.457