SPRINT

Sorted **P**osition **R**adar **INT**erpolation

National Center for Atmospheric Research *
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SPRINT

SPRINT is a software program for the _S_orted _P_osition _R_adar _INT_erpolation into Cartesian space. This manual describes the "Batch Version" written in Fortran 77 and C programming languages for mainframe and workstation computers having UNIX operating systems.

NOTICE

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1. INTRODUCTION

The SPRINT batch processor is designed to interpolate volumetric, radar-space measurements collected at either constant elevation or azimuth angle (R,A,E), at constant coplane angle (R,A,C), and at constant track and altitude (airborne scans) to two- or three-dimensional Cartesian [(X,Y,E) or (X,Y,Z)], two- or three-dimensional Longitude-Latitude [(Lon,Lat,E) or (Lon,Lat,Z)] or coplane (X,Y,C) grids. For the coplane grid C is the coplane angle and for the two-dimensional Cartesian or Longitude-Latitude grids, E is the original constant elevation scan angle. The coplane grid is allowed only for interpolating original coplane scans, and the longitude-latitude grid is allowed only for surveillance or azimuthal sector scans at constant elevation angle by ground-based radars. A standard atmosphere or 4/3 earth radius approximation is used for all height calculations using the elevation angle and horizontal distance from the radar.

Miller and Strauch (1974) describe the coplane coordinate system. The computational procedure described in Mohr and Vaughan (1979) along with the batch version of the algorithm described by Mohr et al (1981) is used. Interpolation is done with a piece-wise-continuous, bilinear method with local unfolding of radial velocities. The program can process either Universal Format (UF) files ("tapes") as specified by Barnes (1980), ATD/RSF field format (FF) files produced by radar processors RP-7 and earlier, files in the DORADE format from airborne or ground-based radars, or WSR88D radar data in the National Climate Data Center (NCDC) Level II format for Exabyte tape. Up to 999 sweep files as produced by the NCAR/ATD SOLO program can also be used as input. During the interpolation, options include the derivation of radar reflectivity factor (dBZ) from the received power (dBm), the creation of a field with time in seconds from the beginning of the volume scan assigned to each output grid point, the creation of azimuth and elevation angle fields for synthesizing airborne measurements, the application of local velocity unfolding with the generation of an associated data quality field (QUAL), and two-dimensional filtering of the original radar measurements. The filtering can be done by specifying the form of the filter along with a filtering region either in radar range-azimuth coordinates (number of range gates by number of azimuth angles) or in Cartesian space (dimensions along and perpendicular to range). The local unfolding scheme and its characteristics are described in Miller et al (1986).

Output datasets produced by SPRINT may be edited, manipulated, synthesized and displayed using the CEDRIC Cartesian space processor (Mohr et al, 1986). Current memory sizing on most machines, both UNIX workstations and CRAYs allows the generation of grids that meet the following conditions: a) NUMX $\leq$ 256, b) NUMY $\leq$ 256, c) NUMZ $\leq$ 128, d) NUMX*NUMY*NUMZ $<$ 655360, and e) no more than 16 output fields in a single run. Violation of any one of these conditions is sufficient for SPRINT to disallow an interpolation. NUMX is the number of points along the X-direction, NUMY the number along the Y-direction, and NUMZ the number along the Z (vertical), C (coplane angle), or E (elevation angle) direction. If more fields are required, multiple runs *must* be made and the gridded datasets merged using CEDRIC. Summaries of both the INPUT and OUTPUT radar datasets are produced for every volume that is successfully interpolated. If a volume cannot be successfully processed, an error message is generated and the program moves on to the next requested volume.

SPRINT was written originally by Carl Mohr under the supervision and guidance of L. Jay Miller. Bill Anderson converted that software to run on the CRAYs and other UNIX-based machines. This involved the addition of C modules (mostly for input and output) that are called from Fortran. Bill added interpolations involving the coplane coordinate system as well as interpolations of RHI scans to Cartesian and constant elevation angle scans to two-dimensional Cartesian within the original scan surfaces. He also added the capability to read airborne DORADE format and interpolate these data to Cartesian grids.

Sherrie Fredrick has added reading of all known variants of the DORADE format, including sweep files generated by the ATD SOLO program, NEXRAD Level II data from NCDC and an explicit byte-swapping command to improve portability of the code to all platforms. L. Jay Miller added interpolations of surveillance or sector scans to longitude-latitude coordinates within the original constant elevation scan surfaces or within a set of constant height surfaces. Sherrie Fredrick is currently responsible for the continued programming aspects of the project, and L. Jay Miller is responsible for the overall direction and the scientific aspects. We request that you acknowledge NCAR/MMM as the source for this software package when it is used or referenced in any resulting research, publications, or subdistributions.

The following pages contain a detailed description of the commands that have been implemented in the batch version of SPRINT on the CRAYs at NCAR or most UNIX-based workstations. Also included are Appendices that briefly detail some of the attributes of the interpolation; for more details, see the references.

2. REFERENCES

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—— L.J. Miller, R.L. Vaughan and H.W. Frank, 1986: The merger of mesoscale datasets into a common Cartesian format for efficient and systematic analyses. *J. Atmos. and Ocean. Tech.*, **3**, 144-161.

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3. DESCRIPTION OF THE COMMAND SYNTAX

SPRINT commands consist of 80 character card image formats beginning with a keyword starting in column 1. Each card image is divided into 10, 8-character wide fields referred to in the documentation as parameter positions P1 thru P10. The keyword always occupies field 1. Fields 2-10 contain required parameters that are interpreted by the program as either floating-point (F8.0) or alphanumeric (A8) entities. These are designated as (F) and (A) respectively. Whether it contains a decimal point or not, an (F) parameter can be located anywhere within the columns of its designated parameter position field. (A) parameters *must* always be left justified. There also exists a hybrid entity (H) that is first examined as an (A) parameter and if it does not match a predetermined mnemonic, it is interpreted as an (F) parameter.

Four of the commands (FILTER, FXTABLE, INTERP and RADAR) initiate the formation of stacks consisting of multiple card images that contain additional information required by the commands. Each of these stacks *must* be terminated by an END command. END is a required mnemonic and must appear in the command keyword field P1.

User supplied comments may be inserted at any location within the SPRINT command deck and will appear in the printed output generated by the program. A SPRINT comment contains the letter "C" in column 1 of the 80 character card image and *must* be followed by at least two blanks (cols. 2 and 3). The contents of the remaining 77 columns are left to the discretion of the user. Any card image containing an asterisk "*" in column 1 will also be treated as a comment. Blank card images are NOT allowed.

3. DESCRIPTION OF THE COMMAND SYNTAX (cont'd)

Documentation for each command is as follows:

COMMAND—A brief description of the command, including how it might be used.

Command structure:

```
COMMAND P2       P3       P4       P5       P6       P7       P8       P9       P10
```

Parameter	Type	Name	A brief description of the parameter,
P2	(A)	AVALUE	A brief description of this parameter.
P3	(F)	FVALUE	A brief description of this parameter.
P4	(H)	HVALUE	A brief description of this parameter.
P5		UNUSED	++++++++++++++++++++
P6	(A)	AVALUE	A brief description of this parameter.
P7-8		UNUSED	++++++++++++++++++++
P9	(F)	FVALUE	A brief description of this parameter.
P10	(A)	IWINDO	Windowing specification for this command:

Although the card images specifying the commands and their parameters are processed in the order in which they appear, the commands are actually executed in an order determined by the program. All attributes defining how a particular time interval of radar measurements should be processed are developed with the available commands. Once these attributes are specified by the user, the **PROCESS** command will initiate execution of the user-supplied commands so that this command *must* be the last in the total job stack (see Appendix E for examples of how to set up a SPRINT run). The parameterizations and commands stay in effect until another command with the same name is encountered. Default values are used whenever a parameter field is left blank or if the information specified is erroneous. If a default value is not specified in the documentation, "blanks" will be supplied for an (A) field and 0.0 will be supplied for an (F) field. Some commands are required and *must* be provided by the user; others are optional. See the column labeled "Required" in the **SUMMARY OF SPRINT COMMANDS**. Whenever a command is left out of the SPRINT deck set up, the default values given in the documentation will be supplied internally should such information be required for processing.

If a fatal syntax or procedural error occurs, the program is designed to terminate with a lucid message indicating the nature of the problem. Examples of inconsistent or confusing program behavior will be gratefully accepted.

4. SUMMARY OF SPRINT COMMANDS

Command	Required*	Stack	Description of its functionality
AZIMUTH	No	No	Used to correct structural ambiguities along azimuth.
C	No	No	User supplied comment.
END	Yes*	No	Terminates a stack operation.
FILTER	No	Yes	Invokes 2-D filtering operations on data.
FLTERTH	No	No	Enables/disables flat earth mode.
FXTABLE	No	Yes	Specifies sweep numbers to discard from volume.
GRID	Yes*	No	Specifies the coordinates of the destination (X,Y,Z) grid when interpolating to 3-D Cartesian coordinate system.
GRIDXYZ	Yes*	No	Specifies the coordinates of the destination (X,Y,Z) grid when interpolating to 3-D Cartesian coordinate system.
GRIDCPL	Yes*	No	Specifies the coordinates of the destination (X,Y,C) grid when interpolating to a coplane coordinate system.
GRIDLLE	Yes*	No	Specifies the coordinates of the destination (L,L,E) grid when interpolating into the surface of the original constant elevation angle scan at horizontal locations specified as longitude and latitude.
GRIDLLZ	Yes*	No	Specifies the coordinates of the destination (L,L,Z) grid when interpolating to Longitude-Latitude-Height coordinate system.
GRIDPPI	Yes*	No	Specifies the coordinates of the destination (X,Y,E) grid when interpolating into the surface of the original constant elevation angle scan.
INPUT	Yes*	No	Provides information specific to an input tape to process.
INTERP	Yes*	Yes	Specifies the interpolation method and the fields to process.
LATLON	No	No	Provides explicit specification of the latitude and longitude hemispheres. Overrides all external sign conventions, forcing them to be consistent with SPRINT code for transforming between latitude-longitude and horizontal distances.
MACHSIZ	No	No	Provides explicit user-control over byte-swapping and computer word size.
ORIGIN	No	No	Provides a way to specify both origin and radar locations in terms of latitude and longitude. Useful for NEXRAD (WSR88D) locations from the file "nexrad_radar_sites.txt" which must be in the directory where SPRINT is executed.
OUTPUT	Yes*	No	Provides information specific to the Cartesian output file.
PROCESS	Yes*	No	Specifies time interval for processing the current input file.
QUIT	Yes*	No	Terminates the SPRINT run.
RADAR	No	Yes	Specifies input data format and calibration information.
RESET	No	No	Specifies tolerances and corrects ambiguities along range.

5. NEW FEATURES and FIXES

February, 1999:

1. A new command (FXTABLE) that allows the user to explicitly select the particular scans within a three-dimensional volume scan that are to be (not to be) processed. This command is useful for scans that do not have monotonically increasing constant scan angles, e.g. scans at elevation angles 0.5, 1.0, 0.5, 1.0, 2.0, 3.0, ... In this example the user can tell SPRINT not to process sweeps 1 and 2 or 3 and 4 so that a sequence 0.5, 1.0, 2.0, 3.0, ... would then be processed.

2. SPRINT now processes all data at negative elevation angles as well as scans containing only one elevation angle when doing interpolations to constant elevation angle surfaces.

3. Interpolations to longitude and latitude in addition to Cartesian grids, with the vertical axis being either elevation angle of the original scan or height. Use of longitude-latitude is currently restricted to ground-based radars scanning at constant elevation angles, either surveillance (360 deg) or azimuthal sectors.

4. NEXRAD Level II format from the National Climate Data Center (NCDC) can now be used as input. A special mnemonic following the UNIX convention for tape devices allows the input to be magnetic tape, rather than a disk file. When interpolating NEXRADs, the two files "nexrad_VCPs.txt" and "nexrad_unamb_rngs.txt" must be in the directory where SPRINT is executed, either as files or as soft links. The way Level II data is taken [e.g. reflectivity (DZ) at 0.5 deg, velocity (VE) and spectral width (SW) at 0.5 deg, DZ at 1.5 deg, then VE and SW at 1.5 deg, followed by all three at subsequent elevation angles] along with the fact that reflectivity and velocity range gates are not colocated in the low level scans requires that the reflectivity (DZ) and velocity (VE, SW) fields be interpolated to the same grid, but in separate runs of SPRINT. SPRINT determines which elevations contain which fields as a function of the particular Volume Coverage Pattern (VCP) that was executed at the WSR88D so a FXTABLE command is not required for these data. Since there are no actual names for the Level II data fields from NCDC, the program requires users to access these by the names DZ, VE, or SW.

5. All variants of the DORADE format can be read, including sweep files from the NCAR/ATD/RSF program SOLO. As many as 999 input files are now possible.

6. The user can specify both an origin latitude and longitude as well as the radar latitude and longitude using the ORIGIN command. This relaxes the previous requirement that the experiment had to be in an internal table. When using NEXRADs as either the radar or origin names, the file "nexrad_radar_sites.txt" must be in the directory where SPRINT is executed, either a file or as a soft link,

7. A new command (LATLON) overrides all external latitude-longitude sign conventions and forces them to be consistent with the SPRINT code for transforming between latitude-longitude and Cartesian distances. When used in conjunction with the ORIGIN command, no signs are necessary on the ORIGIN command to designate North (South) latitude or West (East) longitude.

8. The number of fields that can be interpolated has been increased from 8 to 16, and the total number of interpolated grid points has been increased from 512000 to 655360.

9. A new command (MACHSIZ) to enable or disable byte-swapping and for specifying the computer word size or number of bits that it uses for integers.

10. The INPUT command no longer requires a radar number (P6). SPRINT will assume CCOPE and CP-2 unless reset with the ORIGIN command.

DETAILS of SPRINT COMMANDS

Sorted **P**osition **R**adar **INT**erpolation

BATCH PROCESSOR for UNIX-BASED COMPUTERS

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AZIMUTH—Modifies radar input files that contain structural ambiguities along azimuth. It can be used to ensure a minimum nominal spacing when there are large gaps between consecutive beams in the azimuthal direction and can also be used to restrict the dataset to beams within an azimuth window. The azimuth filling procedure adds a fair amount of overhead to the interpolation and should only be used when satisfactory results cannot be otherwise obtained. The azimuth angles referred to by this command always mean azimuths in the horizontal plane, measured from true North. This command is OPTIONAL. *Note: This is a single card image command.*

Command structure:

```
AZIMUTH LAL      RAL      MAXGAP  SPACE   SCANTP  SCNDIR  AZCOR   BASANG
```

P2	(F)	LAL	Left clockwise azimuth limit (DEGREES). (DEFAULT = `0.0`). If `LAL=RAL=0.0`, no subsectioning along azimuth will be performed.)
P3	(F)	RAL	Right clockwise azimuth limit (DEGREES). (DEFAULT = `0.0`). If `LAL=RAL=0.0`, no subsectioning along azimuth will be performed.)
P4	(F)	MAXGAP	Maximum allowable gap between consecutive original beams (DEGREES). (DEFAULT = `0.0`); no filling is done.
P5	(F)	SPACE	Minimum nominal spacing between SPRINT supplied beams (DEGREES). This parameter is meaningful only if `MAXGAP` is not equal to zero. (DEFAULT = `1.0`)
P6	(A)	SCANTP	Forced scan type. This parameter is necessary only if SPRINT fails to correctly decide on its own: `SUR` surveillance mode (360° of scan); `SEC` a sector (< 360°) was scanned. (DEFAULT = `SEC`)
P7	(F)	SCNDIR	Forced scan direction. This parameter is necessary only when SPRINT fails to correctly decide on its own: < `0.0` counterclockwise; > `0.0` clockwise; `0.0` inactive, program decides. (DEFAULT = `0.0`)
P8	(F)	AZCOR	Azimuth correction to be applied to all beams. Resulting azimuth equals the azimuth from the radar input file plus AZCOR. (DEFAULT = `0.0`)
P9	(F)	BASANG	User supplied baseline angle for interpolations from a coplane coordinate system to a three-dimensional Cartesian coordinate system. This parameter is not used for interpolation from coplane to coplane. See the ANGXAX parameter on the GRIDCPL card for setting the baseline angle for those interpolations. (DEFAULT=value from the radar input file.)
P10		UNUSED	++++++++++++++++++++

C—Transmits user-supplied comments to an output file. This command is useful for including comments about the data flow and commands, or to comment out commands that are not to be executed. A SPRINT comment contains the letter "C" in column 1 of the 80-character card image and *must* be followed by at least two blanks (cols. 2 and 3). The contents of the remaining 77 columns are left to the discretion of the user. Any card image containing an asterisk "*" in column 1 will also be treated as a comment. *Note: This command is itself a single card image command, and it requires no parameters.*

Command structure:

```
C
```

END—Terminates a stack operation. It is used only in conjunction with stack definitions and *must* always appear following the last entry in the stack. An **END** command must always be present even if the stack contains one or no entries. **END** *cannot be used* to terminate SPRINT processing. **QUIT** is the appropriate command for program termination. *Note: This command is itself a single card image command, and it requires no parameters.*

Command structure:

```
END
```

FILTER—Invokes two-dimensional, spatial filtering operations on the radar measurements *before* they are interpolated, but after they are thresholded. This filtering is done within each radar sweep which consists of a two-dimensional surface of range and azimuth angle (or range and elevation angle for RHI scans). These filtered values are used as replacements at the original sampling locations, then the interpolation proceeds. The user specifies the filter radii in the range and azimuth (elevation) directions and the type of filter to use. The filter radii are specified either in radar space [range-angle, number of range gates and number of beams] or in Cartesian space [linear, distance in kilometers (km) along range and angle directions]. The domain within which filtering is done determines the characteristic scale sizes left in the data and the amount of CPU time necessary to do the filtering.

If filter radii are specified in radar space, the numbers of range gates and beams used is the same at all ranges from the radar so that errors are reduced roughly by the same amount everywhere. The variance of the output from equally-weighted, equal-variance measurements is their original variance divided by the number of samples used. However, scale sizes that are left in the data near the radar are smaller than those left at longer ranges since the linear distance over which filtering is done is also smaller. When the filter region is specified in Cartesian space, the extent of the filter domain remains the same everywhere so that near the radar more beams are included than are included far from the radar. This means that scale sizes present in the filtered data are the same everywhere; but, because more samples are included near the radar than farther away, the errors in filtered data are least near the radar. This equal-variance, unequal scale size or vice versa trade-off is a natural consequence of the uneven density of samples in radar space relative to a Cartesian or linear space.

The filter shape is controlled by the functional form (Uniform, Triangular, Cressman, Quadratic or Exponential) and the rate of decrease of the weight (controlled by R) as linear distance (r) increases from the current center point of the filter region. The choices for filter shape are:

$$
\begin{aligned}
Uniform: &\quad f(r) = 1.0 \\
Triangular: &\quad f(r) = 1 - (r/R) \\
\mathit{Cressman}: &\quad f(r) = (R^2 - r^2)/(R^2 + r^2) \\
\mathit{Quadratic}: &\quad f(r) = 1 - r^2/R^2 \\
\mathit{Exponential}: &\quad f(r) = \exp(-4r^2/R^2).
\end{aligned}
$$

All filters are zero beyond $r = R$, and they are isotropic in that the rate of decrease of filter weight is the same in both the range and angle directions. The quantity R is:

$$
\begin{aligned}
\mathit{Radii\ in\ Cartesian\ space}: &\quad R = \left[R_r^2 + R_a^2\right]^{1/2} \\
\mathit{Radii\ in\ Radar\ space}: &\quad R = \left[(R_r \delta S)^2 + (S R_a \delta A)^2\right]^{1/2},
\end{aligned}
$$

where R_r and R_a are radii in the range and azimuth (elevation) directions (interpreted as km if the radii are specified as Cartesian-space and as number of gates and beams if the radii are specified as radar-space), δS is the range gate spacing (km), δA is the beam spacing (radians), and S is slant range (km) from the radar.

The user needs to be especially careful with the size of radii in Cartesian space, as this operation can consume many minutes of computer time if the radii are large. A reasonable choice for Cartesian radii is the interpolation grid spacing since all wavelengths smaller than twice the grid spacing would then be eliminated. This command is a stack command and *must* be terminated with an **END** card. The stack consists of additional card images that allow the user to specify the fields to be filtered and specific options for each field.

Command structure:

```
FILTER  FLTSPACERNGDIST AZDIST
        FLDNAM  FLTYP   SPCPROC FILL
END
```

P2	(A)	FLTSPACE	Space where radii are specified. `RADR` indicates that the radii specified in P3 and P4 are in radar space, namely, number of range gates by number of beams; `CART` indicates that the radii specified in P3 and P4 are in Cartesian space, namely, km in range direction by km in azimuth (elevation) direction. (DEFAULT=None. This parameter must be specified.)
P3	(F)	RNGDIST	This parameter specifies the filter radius in the range direction, either in km or in number of range gates. Thus, the filter diameter in range will be twice RNGDIST. (DEFAULT=None. User must specify.)
P4	(F)	AZDIST	This parameter specifies the filter radius in the azimuth (elevation) direction, either in km or in number of beams. Thus, the filter diameter in azimuth (elevation) will be twice AZDIST. (DEFAULT=None. User must specify.)
P5-10		UNUSED	++++++++++++++++++++

FILTER –STACK of ADDITIONAL CARD IMAGES–

P2	(A)	FLDNAM	Name of field to be filtered. FLDNAM must correspond to a field on the input tape with the same name. (DEFAULT=None. This parameter must be specified.)
P3	(A)	FLTYP	Type of filter to be applied to field. Choices are: `UNI` for uniform filter; `TRI` for triangular filter; `CRE` for Cressman filter; `QUA` for quadratic filter; `EXP` for exponential filter. (DEFAULT=None. This parameter must be specified.)
P4	(A)	SPCPROC	Special processing options. Choices are: `UNFOLD` to locally unfold radial velocities before filtering; `LINEAR` to convert fields with dB or logarithmic units to linear units before filtering and back to logarithmic units after filtering; `NONE` to indicate that no special processing is to be done. (DEFAULT = `NONE`)
P5	(A)	FILL	Flag to indicate whether missing values at the original sampling locations are to be filled in or whether they are to be left missing. `FILL` fill in missing values with the filter-weighted sum of good values surrounding the missing one. `NOFILL` do not fill in missing values. (DEFAULT = `NOFILL`)
P6-10		UNUSED	++++++++++++++++++++

END This **END** command terminates the **FILTER** command stack.

FLTERTH—Enables or disables a flat earth mode. If enabled, coordinate transformations to three-dimensional Cartesian or Longitude-Latitude will not use curvature of the earth and radio wave refraction corrections in calculation of the height (Z). These corrections only affect interpolations from range-azimuth-elevation or range-azimuth-coplane to three-dimensional Cartesian and do not affect interpolations to a regular coplane coordinate system. In SPRINT, flat earth mode is disabled by default and is only enabled through the use of this command. *Note: This is a single card image command.*

Command structure:

```
FLTERTH OPTION
```

P2	(A)	OPTION	`ON` indicates that flat earth mode should be enabled. `OFF` indicates that flat earth mode should be disabled. (DEFAULT = `OFF`)
P3-10		UNUSED	++++++++++++++++++++

FXTABLE—Specifies a list of sweep numbers to either skip or accept. When "skipping," those numbers in the list will be excluded and those not in the list will be included in the interpolation. When "accepting", only those sweep numbers in the list will be used for interpolation; all others will be discarded. This command is useful for unusual scan strategies, where SPRINT might have trouble. For instance, SPRINT requires that the gate spacing be uniform across the entire volume scan. If there is a particular sweep where the spacing changes that sweep can be discarded. Also, if certain fixed angle sweeps are repeated, the user can selectively throw out the unwanted ones. The maximum number of entries in the list is twenty-seven (27). This table remains defined for the duration of the SPRINT execution, but it is only activated or deactivated with P10 of the **PROCESS** command. The table must be defined prior to the **PROCESS** command. For **RUNOVER** or **COMBINE**d volumes, the sweep number continues to increase as the additional physical volumes are added to the logical volume. Users should keep this fact in mind when skipping sweeps that cross over physical EOFs. This is a stack command and *must* be terminated with an **END** command.

Command structure:

```
FXTABLE OPTION
        SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM
        SWPNUM  SWPNUM  SWPNUM
END
```

P2	(A)	OPTION	Specify that the list contains sweep numbers to either skip or accept. `SKIP` skip the sweep numbers in the list, include the ones not in the list; `ACCEPT` accept the sweep numbers in the list, exclude the ones not in the list. (DEFAULT=None. The user must specify)
P3-10		UNUSED	++++++++++++++++++++

FXTABLE	–STACK of ADDITIONAL CARD IMAGES–

P2-10	(F)	SWPNUM	List of sweep numbers to `SKIP` or `ACCEPT`, according to P2 on the command line. The maximum size of the list is 27 or 3 card images. (DEFAULT=None. The user must specify)

END This **END** command terminates the **FXTABLE** command stack.

There are several **GRID*** ** commands available to the user, and these are are documented in detail in the following pages. Each variant controls the the type of output grid to which the input data points will be interpolated. Only one of the commands (**GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** can be used in a single input to be executed . *Note: These are all single card image commands.*

GRID or **GRIDXYZ** indicates that the resulting coordinate system is to be three-dimensional Cartesian (X,Y, and Z in km). Any volume scan can be interpolated to this kind of coordinate system, including airborne scans and any ground-based radar scans. This is the usual coordinate system that researchers choose to interpolate to because it is fairly easy to analyze and process data in this kind of coordinate system. These two variants of the **GRID** command are used when interpolating to a three-dimensional Cartesian grid from any scan currently known to SPRINT. When the angle of the positive X axis is 90 deg, X (Y) is distance in kilometers eastward (northward). Z is height (km) above mean sea level unless FLTERTH is enabled.

Interpolation of airborne Doppler radar scans: In order for an airborne interpolation to be performed, the ground track of the flight in the volume being interpolated must be reasonably close to a straight line (ground-track heading changes of less than 8 deg). The program cannot interpolate circular flying patterns or arbitrary flight patterns. Further, the altitude is assumed to be roughly constant, less than 0.5 km change. Currently both of these limits (TRACKCHECK_MAX,ALTCHECK_MAX) are set in a DATA statement in the AIRCHK.f routine. Appendix G gives some details on the interpolation algorithm for airborne scans, the assumptions used in the algorithm and consequences of the assumptions being invalid. The Y-axis is set to be along the ground track of the flight with (X,Y)=(0,0) at the starting location of the aircraft in the output grid volume. The aircraft then moves along the Y-axis in the positive direction. The angle of the X-axis is automatically set based on the track angle in the dataset, and will be out the right hand side of the aircraft when looking in the flight direction.

GRIDCPL indicates that the resulting coordinate system is to be regular two-dimensional Cartesian coplanes. See Appendix G for a more complete description of this coordinate system. Only scans taken in a coplane mode can be interpolated to this system. This coordinate system does have some advantages for scans taken in coplanes. Winds can be directly calculated in this coordinate system in a way that is slightly more accurate then if the data were interpolated to a Cartesian system and calculated in that system.

GRIDLLE indicates that the data is to be interpolated to horizontal projections, but within the original scan surface. The horizontal grid is longitude-latitude, with western longitudes as negative numbers. This option is only available for constant elevation angle scans from ground-based radars. Since this grid can be unequally spaced in the elevation angle direction, the specific elevation angles are taken from the E-level 10-word header rather from the more general equally spaced grids associated with the 510-word header.

GRIDLLZ indicates that the resulting coordinate system is to be longitude-latitude and height. Only ground-based surveillance or sector scans at several elevation angles can be interpolated to this kind of coordinate system. This system is similar to a more conventional XY-coordinate system, except with horizontal coordinates of longitude and latitude. In the western hemisphere the grid longitude will be negative, with the signed longitude increasing (decreasing magnitude) in moving eastward.

GRIDPPI indicates that the data is to be interpolated into the original scan surface and then projected into planes. This option is available only for constant elevation scans covering an azimuth sector or a full 360 deg. Since this grid can be unequally spaced in the elevation angle direction, the specific elevation angles are taken from the E-level 10-word header rather from the more general equally spaced grids associated with the 510-word header.

For constant elevation scans (**GRIDLLE** or **GRIDPPI** the following is done. First, a 2-D Longitude-Latitude or Cartesian horizontal grid is setup (as specified by the user). Imagine lines that go upwards in the Z-direction from each of the points. These lines will intersect each elevation scan at specific places that will be surrounded by original data values. Each intersection place will be surrounded by 4 points (two beams by two range gates). A bilinear interpolation is done in this constant elevation surface. The resulting value is projected downwards in the Z-direction (Long-Lat or X-Y held fixed) to the horizontal plane. This process is repeated for all points in the plane, and then for all elevation scans. The user must realize that the data in a given constant elevation angle plane are actually at different altitudes. SPRINT will tag each plane with an elevation angle to remind the user that the data is actually at a constant elevation angle, not a constant Z height. This coordinate system is often used for display purposes, the so-called plan-position indicator (PPI) scheme. Analysis options in CEDRIC in this kind of system are limited; however, CEDRIC includes options in the REMAP command to interpolate from LLE to LLZ or XYE to XYZ, where the complete suite of analysis options are available.

GRID or **GRIDXYZ**—Defines the three-dimensional Cartesian grid to which the radar data will be interpolated. The grid may not contain more than 256 grid points along either X or Y axes, and no more than 128 grid points along the vertical axis (Z, height above mean sea level unless FLTERTH is enabled). Each SPRINT run must have either a **GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** command. *Note: This is a single card image command.*

Command structure:

```
GRID    X1      X2      Y1      Y2      DELXY   Z1      Z2      DELZ    ANGXAX
GRIDXYZ X1      X2      Y1      Y2      DELXY   Z1      Z2      DELZ    ANGXAX
```

P2	(F)	X1	Beginning X-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P3	(F)	X2	Ending X-coordinate. (DEFAULT=This parameter must be specified.)
P4	(F)	Y1	Beginning Y-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P5	(F)	Y2	Ending Y-coordinate. (DEFAULT=This parameter must be specified.)
P6	(F)	DELXY	Grid spacing (km) along the X and Y axes. (DEFAULT = `1.0`)
P7	(F)	Z1	Beginning Z-coordinate (km MSL). (DEFAULT=This parameter must be specified.)
P8	(F)	Z2	Ending Z-coordinate (km MSL). (DEFAULT=This parameter must be specified.)
P9	(F)	DELZ	Grid spacing (km) along the Z axis. (DEFAULT = `1.0`)
P10	(F)	ANGXAX	Angle of X-axis clockwise from North, rotated about the origin of the output coordinate system. For most applications the default axis orientation of 90° (X: West to East, Y: South to North) should be used when interpolating. Subsequent Cartesian coordinate rotation translations can be easily performed using CEDRIC. This parameter is NOT active when interpolating from RHI scans. (DEFAULT = `90.0`)

GRIDCPL—Defines the coplane grid to which the radar data will be interpolated. The grid may not contain more than 256 grid points along either the X- or Y-axis, and not more than 128 grid points along the C-axis. The X- and Y-axes are linear distances in the coplanes. The spacing in coplane angles can be constant or at the original coplane angles. If P7-9 are left blank, then interpolations are done to the coplane angles that were originally scanned. Each SPRINT run must have either a **GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** command. *Note: This is a single card image command.*

Command structure:
```
GRIDCPL X1       X2       Y1       Y2       DELXY    C1       C2       DELC     ANGXAX
```

P2	(F)	X1	Beginning X-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P3	(F)	X2	Ending X-coordinate. (DEFAULT=This parameter must be specified.)
P4	(F)	Y1	Beginning Y-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P5	(F)	Y2	Ending Y-coordinate. (DEFAULT=This parameter must be specified.)
P6	(F)	DELXY	Grid spacing (km) along the X and Y axes. (DEFAULT = `1.0`)
P7	(F)	C1	Beginning coplane angle (Degrees). (DEFAULT=Beginning coplane angle of the input data.)
P8	(F)	C2	Ending coplane angle (Degrees). (DEFAULT=Ending coplane angle of the input data.)
P9	(F)	DELC	Coplane angle spacing (Degrees). (DEFAULT=Spacing of angles in the input data.)
P10	(F)	ANGXAX	Angle of X-axis clockwise from North, rotated about the origin of the output coordinate system. For all applications, the axis orientation should be the azimuth of a line perpendicular to the baseline joining two radars. (DEFAULT=This parameter must be specified.)

GRIDLLE—Defines the longitude-latitude grid to which the radar data will be interpolated. The grid may not contain more than 256 grid points along either the Longitude or Latitude axes, and not more than 128 fixed angles. The fixed angles are those of the dataset and will be picked up by SPRINT automatically. Sign conventions for the grid are West (East) longitude is negative (positive), and North (South) latitude is positive (negative). The signs associated with the longitude-latitude grid is not overridden by the LATLON command. Each SPRINT run must have either a **GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** command. *Note: This is a single card image command.*

Command structure:

```
GRIDLLE LON1     LON2     LAT1     LAT2     DEL-LL                                ANGXAX
```

P2	(F)	LON1	Beginning Longitude coordinate (deg) of the (Lon,Lat) grid. (DEFAULT=This parameter must be specified.)
P3	(F)	LON2	Ending Longitude coordinate. (DEFAULT=This parameter must be specified.)
P4	(F)	LAT1	Beginning Latitude coordinate (deg) of the (Lon, Lat) grid. (DEFAULT=This parameter must be specified.)
P5	(F)	LAT2	Ending Latitude coordinate. (DEFAULT=This parameter must be specified.)
P6	(F)	DEL-LL	Grid spacing (deg) along the Longitude and Latitude axes. (DEFAULT = `0.05`)
P10	(F)	ANGXAX	Angle of Longitude axis clockwise from North, rotated about the origin of the output coordinate system. (DEFAULT=Will always be 90 degrees.)

GRIDLLZ—Defines the longitude-latitude grid to which the radar data will be interpolated. The grid may not contain more than 256 grid points along either the Longitude or Latitude axis, and not more than 128 grid points along the Z-axis. Sign conventions for the grid are West (East) longitude is negative (positive), and North (South) latitude is positive (negative). The signs associated with the longitude-latitude grid is not overridden by the LATLON command. Each SPRINT run must have either a **GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** command. *Note: This is a single card image command.*

Command structure:

```
GRIDLLZ LON1    LON2    LAT1    LAT2    DEL-LL  Z1      Z2      DELZ    ANGXAX
```

P2	(F)	LON1	Beginning Longitude coordinate (deg) of the (Lon,Lat) grid. (DEFAULT=This parameter must be specified.)
P3	(F)	LON2	Ending Longitude coordinate. (DEFAULT=This parameter must be specified.)
P4	(F)	LAT1	Beginning Latitude coordinate (deg) of the (Lon, Lat) grid. (DEFAULT=This parameter must be specified.)
P5	(F)	LAT2	Ending Latitude coordinate. (DEFAULT=This parameter must be specified.)
P6	(F)	DEL-LL	Grid spacing (deg) along the Longitude and Latitude axes. (DEFAULT = `0.05`)
P7	(F)	Z1	Beginning Z-coordinate (km MSL). (DEFAULT=This parameter must be specified.)
P8	(F)	Z2	Ending Z-coordinate (km MSL). (DEFAULT=This parameter must be specified.)
P9	(F)	DELZ	Grid spacing (km) along the Z axis. (DEFAULT = `1.0`)
P10	(F)	ANGXAX	Angle of Longitude axis clockwise from North, rotated about the origin of the output coordinate system. (DEFAULT=Will always be 90 degrees.)

GRIDPPI—Defines the grid to which the radar data will be interpolated. The grid may not contain more than 256 grid points along either the X- or Y-axis, and not more than 128 fixed angles. The fixed angles are those of the dataset and will be picked up by SPRINT automatically. Each SPRINT run must have either a **GRID**, **GRIDXYZ**, **GRIDCPL**, **GRIDPPI**, **GRIDLLE**, or **GRIDLLZ** command. *Note: This is a single card image command.*

Command structure:

```
GRIDPPI X1       X2       Y1       Y2       DELXY                                ANGXAX
```

P2	(F)	X1	Beginning X-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P3	(F)	X2	Ending X-coordinate. (DEFAULT=This parameter must be specified.)
P4	(F)	Y1	Beginning Y-coordinate (km) of the (X,Y) grid. (DEFAULT=This parameter must be specified.)
P5	(F)	Y2	Ending Y-coordinate. (DEFAULT=This parameter must be specified.)
P6	(F)	DELXY	Grid spacing (km) along the X and Y axes. (DEFAULT = `1.0`)
P10	(F)	ANGXAX	Angle of X-axis clockwise from North, rotated about the origin of the output coordinate system. (DEFAULT=This parameter must be specified.)

INPUT—Supplies information specific to the next input file or dataset that is to be interpolated by SPRINT. This command is MANDATORY. Information about the radar and origin can be set independently by including the ORIGIN command. Names and positions set by the ORIGIN command will take precedence over those set by the INPUT command. *Note: This is a single card image command.*

Command structure:

```
INPUT   LUN     ITAPE   ISKP    IEXP    NUMRAD  IREWND  XRAD    YRAD    ZRAD
```

P2	(F)	LUN	Fortran logical unit number of the INPUT file. LUN must be predefined in the Job Control Language (JCL). If LUN="/rmt/#n", NEXRAD Level II data from NCDC that comes on Exabyte tape can be read directly from an Exabyte tape drive. The device number is # and "n" stands for no rewind. Reading from tape is not an option for any other data formats. (DEFAULT=This parameter must be specified.)
P3	(A)	ITAPE	Internal name of the input disk file (6-character maximum). This parameter is used solely for internal headers. Although this information is not required, it is useful in preserving the correspondence between radar input files and output listings.
P4	(F)	ISKP	Number of volumes to be skipped before reading. Each volume corresponds to a complete three-dimensional radar scan on a correctly written Universal or Field Format Radar Tape. (DEFAULT = `0.0`)
P5	(F)	IEXP	Experiment number. See Appendix C for a complete summary of available experiments and their associated radars. If `IEXP` < `0`, the experiment name will be NONE and the radar coordinates specified by parameters P8-10 of this command will be used. If `IEXP` is left blank, the CCOPE in Montana and CP-2 will be assumed unless an ORIGIN command is included.
P6	(F)	NUMRAD	Radar number. See Appendix C for a complete summary of available experiments and their associated radars. When `IEXP` < `0` and `NUMRAD` < `0` or left blank, the radar name NONE is assumed. A radar number from the SPRINT list can be used even though a valid experiment number is not specified.
P7	(A)	IREWND	Rewind option: `YES` reset file pointer to the file beginning before any processing is performed; `NO` do NOT reset pointers, file remains at its current position. (DEFAULT = `NO`)
P8	(F)	XRAD	X coordinate (km) of the radar in the three-dimensional Cartesian coordinate system where the Y-axis points along true North. This parameter is used only when `IEXP (P5)` < `0.0`
P9	(F)	YRAD	Y coordinate (km) of the radar in the three-dimensional Cartesian coordinate system where the Y-axis points along true North. This parameter is used only when `IEXP (P5)` < `0.0`
P10	(F)	ZRAD	Z coordinate (km MSL) of the radar. This parameter is used only when `IEXP (P5)` < `0.0`

INTERP—Specifies fields to be interpolated and the transformation methods to be employed. Refer to Appendix F for a brief description of the interpolation procedure. This is a stack command that consists of additional card images that allow the user to specify the fields to be interpolated and the associated field-specific operations to be employed. The field type is determined from the requested field name, following the table in Appendix B, and this field type controls how SPRINT interpretes parameters P3-10 in the stack of additional card images. No more than 16 output fields may be produced. The number of actual output fields can exceed the number specified since extra fields may be produced when doing special processing. For example, REFLECTIVITY fields may be derived from POWER fields with or without the POWER field being saved. If a VELOCITY field is locally unfolded, this also produces an associated field called QUAL. A field called TIME may be generated by SPRINT even though it is not explicitly present on the input tape. For interpolations from airborne platforms, users can produce azimuth (AZ) and elevation (EL) fields for use in deriving the winds with the synthesis command in CEDRIC.

Each field can be thresholded using another input field and before interpolation. The fields used for thresholding (e.g., signal to noise ratio) need NOT be interpolated themselves since this operation is done on a gate-by-gate basis in the original sampled data. However, no more than two different fields can be used for thresholding in a single INTERP stack, although different threshold limits can be set as often as necessary. Each card image in the stack corresponds to an input field to be interpolated, and it *must* be in the proper format according to the field type (FLDNAM in P2, see Appendix B). This command is MANDATORY. The stack *must* be terminated by an **END** command.

Command structure:

```
INTERP  METH    NGAVG   MINGPT  DISMAX  RNGC1   RNGC0   MINDEC
        FLDNAM  ITRANS  IDERIV  NAMDBZ  NAMTHR  LLIMIT  ULIMIT  SIDE
        FLDNAM  ITRANS                  NAMTHR  LLIMIT  ULIMIT  SIDE
        FLDNAM  IVLFLG  IUNFLD          NAMTHR  LLIMIT  ULIMIT  SIDE
        TIME
        FLDNAM                          NAMTHR  LLIMIT  ULIMIT  SIDE
END
```

P2 (A) METH — Interpolation method (letters beyond the first one are optional):
- `BI-LIN` successive bilinear interpolation;
- `CLOSEST` closest point selection.

(DEFAULT = `B`)

P3 (F) NGAVG — Fixed number of gates to average along range if `METH = B`. (DEFAULT = `0.0`) No range averaging will be performed.

P4 (F) MINGPT — Fixed number of good measurements required along range when range averaging is specified. (DEFAULT = `1.0`)

P5 (F) DISMAX — Maximum acceptable distance (km) to relocate a closest point estimate for either interpolation method. (DEFAULT=range gate spacing)

P6 (F) RNGC1 — If range averaging has been specified and this parameter is non-zero, the number of gates to average will be computed as a function of range using the following relation: # Gates = RNGC1 * Range (km) + RNGC0, where RNGC1 and RNGC0 are P6 and P7 respectively. The interpolation will NEVER permit the computed number of gates to be less than NGAVG as specified by P3. (DEFAULT=Range averaging will be determined by P3 and P4.)

P7 (F) RNGC0 — Constant term used when computing the number of gates to average as given in the description of P6.

P8	(F)	MINDEC	When the formulation given in the description of P6 is used, the minimum number of good measurements required along range will be MINDEC less than the computed value. The interpolation will NEVER accept fewer than MINGPT values as specified by P4. (DEFAULT = `1.0`)
P9-10		UNUSED	++++++++++++++++++++

—FLDNAM (P2) interpreted as POWER—P3-9 contain parameterization—

P2	(A)	FLDNAM	Name of the POWER field (8 character maximum). (DEFAULT=This parameter must be specified.)
P3	(A)	ITRANS	Units transformation option: `LINEAR` convert from dB scale to linear units prior to interpolation; `NO` no conversion, interpolate in logarithmic units. (DEFAULT = `NO`)
P4	(A)	IDERIV	REFLECTIVITY field derivation option: `TRANS` transform to REFLECTIVITY and delete the POWER field; `CREATE` create a REFLECTIVITY field and keep the POWER; `NONE` POWER field will be interpolated and saved, no REFLECTIVITY field will be produced from the POWER field. (DEFAULT = `NONE`)
P5	(A)	NAMDBZ	Name of the REFLECTIVITY field to be produced when IDERIV = `TRANS` or `CREATE`. (DEFAULT=This parameter must be specified if a REFLECTIVITY field is produced for output.)
P6	(A)	NAMTHR	Name of the field to use for thresholding. This field must be present on the input tape. (DEFAULT=No thresholding will be done if "blank")
P7	(A)	LLIMIT	Lower limit to be used for thresholding of data as specified by P9.
P8	(A)	ULIMIT	Upper limit to be used for thresholding of data as specified by P9.
P9	(A)	SIDE	Interpretation of thresholding limits: `INSIDE` set field to bad if NAMTHR $<$ LLIMIT or NAMTHR $>$ ULIMIT. `OUTSIDE` set field to bad if LLIMIT $\leq$ NAMTHR $\leq$ ULIMIT. (DEFAULT = `INSIDE`)
P10		UNUSED	++++++++++++++++++++

—FLDNAM (P2) interpreted as REFLECTIVITY—P3-9 contain parameterization—

P2	(A)	FLDNAM	Name of the REFLECTIVITY field (8 character maximum). (DEFAULT=This parameter must be specified.)
P3	(A)	ITRANS	Units transformation option: `LINEAR` convert from dB scale to linear units prior to interpolation; `NO` no conversion; interpolate in logarithmic units. (DEFAULT = `NO`)
P4-5		UNUSED	++++++++++++++++++++
P6	(A)	NAMTHR	Name of the field to use for thresholding. This field must be present on the input tape. (DEFAULT=No thresholding will be done if "blank")
P7	(A)	LLIMIT	Lower limit to be used for thresholding of data as specified by P9.
P8	(A)	ULIMIT	Upper limit to be used for thresholding of data as specified by P9.
P9	(A)	SIDE	Interpretation of thresholding limits: `INSIDE` set field to bad if NAMTHR $<$ LLIMIT or NAMTHR $>$ ULIMIT. `OUTSIDE` set field to bad if LLIMIT $\leq$ NAMTHR $\leq$ ULIMIT. (DEFAULT = `INSIDE`)
P10		UNUSED	++++++++++++++++++++

—FLDNAM (P2) interpreted as VELOCITY—P3-P10 contain parameterization—

P2	(A)	FLDNAM	Name of the REFLECTIVITY field (8 character maximum). (DEFAULT=This parameter must be specified.)
P3	(A)	IVLFLG	Option for setting all NCAR-flagged velocities to the "missing" data flag (-32768); otherwise they will be treated as useful estimates: `MISSING` set all NCAR-flagged velocities to "missing" or "bad" data; `GOOD` the NCAR flag bit will be ignored and all velocity estimates will be interpolated. (DEFAULT = `GOOD`)
P4	(A)	IUNFLD	Local velocity unfolding option. (See APPENDIX F for a complete description of this procedure.) In the case of the NEXRADs where the Nyquist velocity changes as the elevation angle increases, the velocities are first folded into the range of the smallest Nyquist and then locally unfolded using this smallest Nyquist velocity value. This procedure is not done when interpolating to the original constant elevation surfaces. Instead, these maintain the original Nyquist velocities and store the Nyquist in each level header. `UNFOLD` local unfolding will be employed and an output field called `QUAL` will be generated in addition to the interpolated velocity field. Only one `QUAL` field may be created in a single run. `QUAL` no unfolding is performed, but a corresponding `QUAL` field will be generated. Only one `QUAL` field may be created in a single run. `NO` the velocity field will be interpolated without modification. (DEFAULT = `NO`)

P5		UNUSED	++++++++++++++++++++
P6	(A)	NAMTHR	Name of the field to use for thresholding. This field must be present on the input tape. (DEFAULT=No thresholding will be done if "blank")
P7	(A)	LLIMIT	Lower limit to be used for thresholding of data as specified by P9.
P8	(A)	ULIMIT	Upper limit to be used for thresholding of data as specified by P9.
P9	(A)	SIDE	Interpretation of thresholding limits: `INSIDE` set field to bad if NAMTHR < LLIMIT or NAMTHR > ULIMIT. `OUTSIDE` set field to bad if LLIMIT ≤ NAMTHR ≤ ULIMIT. (DEFAULT = `INSIDE`)
P10		UNUSED	++++++++++++++++++++

—FLDNAM (P2) set to TIME—no parameterization required—

P2	(A)	FLDNAM	A field named `TIME` will be generated even though it may not be present on the input tape. If `TIME` is supplied as the name of a field to be interpolated, a field by that name will be created and will contain the time in seconds after the beginning of the scan for each output or interpolation grid location.

—FLDNAM (P2) set to AZ or EL—no parameterization required—

P2	(A)	FLDNAM	A field named `AZ` or `EL` will be generated and output. Azimuth is the angle between projection of radar beam into horizontal plane and true North. Elevation is the angle between radar beam and horizontal plane. These angles are needed when doing wind synthesis of airborne scans with the SYNTHESIS command in CEDRIC.

—FLDNAM (P2) interpreted as any OTHER FIELD—P6-9 contain parameterization—

P2	(A)	FLDNAM	Name of the OTHER field (8 character maximum). (DEFAULT=This parameter must be specified.)
P3-5		UNUSED	++++++++++++++++++++
P6	(A)	NAMTHR	Name of the field to use for thresholding. This field must be present on the input tape. (DEFAULT=No thresholding will be done if "blank")
P7	(A)	LLIMIT	Lower limit to be used for thresholding of data as specified by P9.
P8	(A)	ULIMIT	Upper limit to be used for thresholding of data as specified by P9.
P9	(A)	SIDE	Interpretation of thresholding limits: `INSIDE` set field to bad if NAMTHR < LLIMIT or NAMTHR > ULIMIT. `OUTSIDE` set field to bad if LLIMIT ≤ NAMTHR ≤ ULIMIT. (DEFAULT = `INSIDE`)
P10		UNUSED	++++++++++++++++++++

END This **END** command terminates the **INTERP** command stack.

LATLON—Allows explicit specification of the latitude and longitude hemispheres. This may be necessary if sign conventions do not follow the ones in the SPRINT code for doing latitude-longitude to horizontal distances and vice versa. The SPRINT internal convention uses positive for West longitude rather than negative which is more common. Note that the longitude-latitude grid (see **GRIDLLE** and **GRIDLLZ**) can extend into the other hemisphere, but simultaneous crossings of both latitude and longitude hemispheres are not allowed. Do not center a grid on a radar on the equator at 0 degrees longitude. Do the Northern and Southern hemispheres separately or the Western and Eastern ones. *Note: This is a single card image command.*

Command structure:
`LATLON  LATHEM  LONHEM`

P2	(A)	LATHEM	Specifies the latitude hemisphere. `NORTH` indicates that the radar is located at a Northern latitude. `SOUTH` indicates that the radar is located at a Southern latitude. (Default. If blank, the program assumes NORTH.)
P3	(A)	LONHEM	Specifies the longitude hemisphere. `WEST` indicates that the radar is located at a Western longitude. `EAST` indicates that the radar is located at a Eastern longitude. (Default. If blank, the program assumes WEST.)
P4-10		UNUSED	++++++++++++++++++++

MACHSIZ—Enables or disables byte-swapping and specifies computer word size. If the radar input data file is written and read on the same type of machine, then no byte-swapping is required. However, if the file was written on one type of machine and is being read on another type, then byte swapping is required. The word size for the particular machine where the program is being executed can also be specified. Most workstations and Linux PCs are 32-bit machines, while others such as CRAYs are 64-bit machine. There are two byte-numbering schemes: "little Endian" (e.g. DEC, where the last byte is the most significant one or bytes of a 32-bit integer word are numbered 4-3-2-1) and "big Endian" (e.g. SUN, where the first byte is the most significant one or the bytes of a 32-bit integer word are numbered 1-2-3-4). Here we will refer to these by the easier-to-remember names of DEC-like or SUN-like byte-numbering. PCs use the same byte numbering convention as DEC, while most other machines use the same one as SUN. The default assumption is that radar data was written on a SUN-like machine is being read on a SUN-like machine, i.e. byte-swapping is not required. The exception to this is COS-blocked radar data (Universal or ATD/Field format) from the NCAR Mass Store System which must always be byte-swapped when being read on a DEC-like machine. *Note: This is a single card image command.*

Command structure:
`MACHSIZ MACHRD  MACHWR  WORDSIZ`

P2	(A)	MACHRD	Specifies the type of machine on which data is being read. `DECRD` indicates that the radar data file is being read on a DEC-like machine, otherwise leave this parameter blank. (DEFAULT = `DECRD`)
P3	(A)	MACHWR	Specifies the type of machine on which data was written. `DECWRT` indicates that the radar data file was written on a DEC-like machine, otherwise leave this parameter blank. (DEFAULT = `blank`)
P4	(F)	WORDSIZ	Indicates the word size for the machine where the program is being executed, either 32- or 64-bit. If left blank, a 32-bit machine is assumed. (DEFAULT = `32.0`)
P5-10		UNUSED	++++++++++++++++++++

ORIGIN—Allows the user to specify the radar and origin locations in terms of latitudes, longitudes and altitudes rather than by Cartesian location (X, Y, Z) of the radar as done in the INPUT command or by means of an internal lookup table of past experiments and radars (See the INPUT command and Appendix C). The main purpose of this command is to have SPRINT look up NEXRAD locations in the file "nexrad_radar_sites.txt" which must be in the directory where SPRINT is executed. This file contains latitude-longitude information using the NEXRAD four character designation of the WSR88D radars. If this command is included, it always overrides information obtained with the INPUT command. Parameters 3-5 and 7-9 cannot be left blank except for the NEXRAD network (P2) and WSR88D radars (P6). *Note: This is a single card image command.*

Command structure:
```
ORIGIN  EXP-NAM RAD-NAM RAD-LAT RAD-LON RAD-ALT ORG-NAM ORG-LAT ORG-LON AZM(+X)
```

P2	(A)	EXP-NAM	Name of the experiment (network). If this parameter is either NEXRAD, NOWRAD, or WSR88D, and (ORG-LAT, ORG-LON) are left blank, the origin will be at the WSR88D radar site specified by the four character designation under RAD-NAM (P2). Alternatively the user can specify the location of the origin. For WSR88D radars their latitude, longitude, and altitude are taken from the radar latitude-longitude file according to RAD-NAM (P2). For other experiments and radars, the user can specify all latitude-longitude information to be used in determining the radar (X, Y, Z) location relative to the origin.
P2	(A)	RAD-NAM	Name of the radar. For WSR88D radars, this must be their four-character NWS designations.
P4	(F)	RAD-LAT	Latitude of the radar in degrees. No sign is required for North (South) latitude if the LATLON command is also included.
P5	(F)	RAD-LON	Longitude of the radar in degrees. No sign is required for West (East) longitude if the LATLON command is also included.
P6	(F)	RAD-ALT	Altitude of the radar in kilometers.
P7	(A)	ORG-NAM	Name of the radar. For WSR88D radars, this must be their four-character NWS designations. If ORG-NAM is left blank, the origin will be at the radar specified by (RAD-NAM, RAD-LAT, RAD-LON). If ORG-NAM is a WSR88D radar, then (ORG-LAT, ORG-LON) can be left blank and the program will use values from the radar latitude-longitude file.
P8	(F)	ORG-LAT	Latitude of the origin in degrees.
P9	(F)	ORG-LON	Longitude of the origin in degrees.
P10	(F)	AZM(+X)	Angle of the positive X-axis. If left blank, 90 degrees is used.

OUTPUT—Positions the output file, specifies the format for the output volumes, and writes the results of any subsequent interpolations to the output unit. There are currently two output format options. The first is called “COS blocked”, and is a format understood only by CRAYs; and the second is called “pure binary” and is a portable, self-describing format. Data files can be converted to the UNIDATA network Common Data Format (netCDF) in CEDRIC if needed for other applications. The pure binary format is understood by CEDRIC installed on all platforms, either SUN-like or DEC-like. The COS-blocked format exists mostly to maintain compatibility with previously archived CEDRIC and SPRINT output files. In both cases, multiple logical output volumes can be written to the same disk file.

Gridded data will be written to the file according to the 16-bit CEDRIC format described in APPENDIX D of this and the CEDRIC documentations. Each radar scan volume corresponds to a single volume of information recognizable by CEDRIC and will contain all interpolated fields. SPRINT will generate a name associated with each volume written to disk based on the date and the beginning time of the radar scan volume.

Initial positioning options of the OUTPUT unit for COS blocked files are:

BEG—the output disk file is positioned at the beginning;

ADD—the output file is scanned until a double EOF (denoting the end of information) is encountered and repositioned just ahead of the second file mark;

SKI—the output file is repositioned to its beginning and then positioned immediately after a specified number of files.

For CEDRIC pure binary files, the positioning options are:

BEG—the disk file is positioned at the beginning. Any volumes of data that may already exist in this file will be lost;

APP—the disk file will be positioned at the end for appending. With this option, the file referenced must already exist.

Once initial positioning has been performed all subsequent volumes will be written in consecutive order into the disk file. This command is MANDATORY. *Note: This is a single card image command.*

Command structure:

```
OUTPUT  LUN     NAMTAP  POS     NFSKIP  FEETSK  NAMSCI  NAMPRO  FORMAT
```

P2 (F) LUN — Fortran logical unit number of the OUTPUT tape. LUN *must* be predefined in the Job Control Language (JCL).
(DEFAULT=This parameter must be specified.)

P3 (A) NAMTAP — Name of the output disk file. This parameter is used solely for internal headers. Although this information is not required, it is useful for preserving the correspondence between files and the output listings of the runs that created them.
(DEFAULT = `UNKNOWN`)

P4 (A) POS — Initial positioning codes for the output file:
If the output file is “COS” blocked, then

`BEG` position at the beginning;
`ADD` add to the information already in the file;
`SKI` reposition to begining and skip NFSKIP volumes;

(DEFAULT=This parameter must be specified for “COS” blocked files.)

If the output file is “PURE” binary, then

`BEG` position at the beginning;
`APP` position at the end of all existing volumes and append.

(DEFAULT=This parameter must be specified for “PURE” files.)

P5	(F)	NFSKIP	Number of scan volumes to be skipped when `POS = SKI`. (DEFAULT = `0.0`)
P6	(F)	FEETSK	Number of feet skipped when either `ADD` or `SKI` is specified as the initial positioning code with POS. This information is available from the output listing of the SPRINT run that last wrote on the tape. Although this information is not crucial, it does aid SPRINT in determining when a user attempts to exceed the capacity of a 9-track, 6400 BPI tape. (DEFAULT = `0.0`)
P7	(A)	NAMSCI	Name of the investigator (8 character maximum). (DEFAULT = `NONE`)
P8	(A)	NAMPRO	Name of the experiment or project (4 character maximum). (DEFAULT = `COPE`)
P9	(A)	FORMAT	Output format for the data. There are two choices: `COS` the output will be COS blocked files; `PUR` the output will be pure binary files. (DEFAULT = `COS`)
P10		UNUSED	++++++++++++++++++++

PROCESS—Initiates the interpolation of radar fields based on the current information set constructed by all the previous commands in the job stream. Each **PROCESS** card designates the date to process, a beginning and ending analysis time, and the special type of volume processing that is to be performed (i.e. `RUNOVER, APPEND, COMBINE` or `NONE`). Any number of **PROCESS** commands may appear in a SPRINT run; however, any commands applicable to the processing step *must* appear prior to the **PROCESS** command. All dates and times on the **PROCESS** command are either in local time (e.g. MDT in CCOPE) or universal time (e.g. UT in HaRP). This command is MANDATORY. *Note: This is a single card image command.*

Command structure:

```
PROCESS IDATE   IBEGTM  IENDTM  IROV    SWPMOD  FIXTOL          TRANSIT TABLE
```

P2	(F)	IDATE	Date of data to be processed (YYMMDD). (DEFAULT=This parameter must be specified.)
P3	(F)	IBEGTM	Beginning time to process (HHMMSS). (DEFAULT = `000000.0`) NOTE: All volume scans with a beginning time between `IBEGTM` and `IENDTM` will be processed using the parameterization in effect when the process card was encountered.
P4	(F)	IENDTM	Ending time to process (HHMMSS). (DEFAULT = `240000.0`)
P5	(A)	IROV	Option for combining three dimensional volume scans that are physically separated in the input file. Remedies for two situations are available: `RUNOVER` used to merge the last volume in one file with the first volume on another. When `RUNOVER` is specified, the first volume that hits the end of the file and that is within the indicated time range is assumed to be part 1 of the first volume on the next **INPUT** file to be accessed. An **INPUT** command specifying the new file containing the remainder of the volume must immediately follow the **PROCESS** command. After the separated volume has been interpolated, the remaining volumes in the new file within the specified time range are processed normally. `APPEND` used to merge two or more consecutive input volumes that are in the same file or dataset. When this option is invoked *ALL* volumes with starting times within the current processing time range are treated as a single volume; `COMBINE` combines `RUNOVER` and `APPEND` functions (in that order) so that additional volumes continue to be appended so long as their beginning times are within the processing time range; `NONE` no special volume processing. (DEFAULT = `NONE`)
P6	(A)	SWPMOD	Method for determining the beginning and end of each elevation or coplane angle scan within a volume: `NUMBER` scans will be delineated using the logical sweep number (Word 10) on the Universal Format (UF) header; `FIXED` scans will be delineated using the nominal fixed angle of the scan on the tape header. A sequence of beams is considered to be part of the same scan so long as their elevation or coplane angles are within `FIXTOL` (see P7) degrees of the first beam in the sequence. The sweep number is ignored. (DEFAULT = `NUMBER`)

P7	(F)	FIXTOL	Tolerance (DEG) to use when `SWPMOD = FIXED`. (See P6). (DEFAULT = `0.0`)
P8		UNUSED	++++++++++++++++++++
P9	(A)	TRANSIT	Option to or not to process beams flagged as “in transition”: `YES AFT` beams that are flagged as transitional will be discarded after the end of sweep and volume detection code has processed them. `YES BEF` beams that are flagged as transitional will be discarded before the end of sweep and volume detection code has processed them. `NO` beams flagged as transitional will not be discarded and they will be processed like any other beams. (DEFAULT = `NO`)
P10	(A)	TABLE	Specifies whether or not a sweep number table is to be used for discarding specific sweeps from the volume scan. See the **FXTABLE** command for more information. If `TABLE = FXTABLE`, the previously defined table will be used. Any other character string in this position will cause SPRINT to ignore any table that might be defined.

QUIT—Terminates execution of SPRINT. This *must* be the last command in the current job stack. *Note: This command is itself a single card image command, and it requires no parameters.*

Command structure:

```
QUIT
```

RADAR—Specifies the input data format and the calibration information for the received power field. The calibration information can be specified either by providing a unit number of a file that contains the data or by listing the corresponding calibration data in a stack of card images. The data files must have a specific format. See an example file or contact us for information about the format. This command is not required for universal format data tapes. If this command is to also include the calibration data, then it is a stack command and *must* be terminated with an **END** command.

Command structure:

```
RADAR   DATFMT  CUNIT   CCOUNT  BLOCKING
        ICOUNT  DBMVAL
        ICOUNT  DBMVAL
        ICOUNT  DBMVAL
END
```

P2	(A)	DATFMT	Data format of the input volume. The current choices are: `UF` for universal format; `RP-7` for the ATD/RSF radar processor RP-7. This option will also invoke reading of RP-3 through RP-7 formats. `DORADE` for DORADE format from both airborne and ground-based radars as well as NCAR/ATD sweep files. `NEXRAD` for WSR88D, Level II format used for Exabyte tapes from the National Climate Data Center (NCDC). (DEFAULT = `UF`)
P3	(F)	CUNIT	Unit number of the calibration file that contains a mapping between counts and power in dBm. The file should also contain the radar constant. The FORTRAN unit number assigned in the Job Control Language *must* be greater than 10. (DEFAULT=no calibration file)
P4	(F)	CCOUNT	The number of card images within the following stack that will contain the counts and corresponding dBm values. (DEFAULT = `0.0`)
P5	(A)	BLOCKING	Indicates the type of record blocking present on the input file. Most workstations use 32 bits at the beginning and end of records, while CRAYs use 64 bits. These blocking words contain the length of the record in bytes and, for CRAYs, the type of record. The current choices are: `SUNFOR` for Sun Fortran blocking; `COS` for CRAY blocking; (DEFAULT = `COS`)

RADAR –STACK of ADDITIONAL CARD IMAGES–

If `CUNIT` is unspecified and `CCOUNT > 0.0`, then the number of card images that must follow is equal to the value of `CCOUNT`.

P2	(F)	ICOUNT	Processor counts.
P3	(F)	DBMVAL	Received power in dBm that corresponds to the counts in P2.
P4-10		UNUSED	++++++++++++++++++++

END This **END** command terminates the **RADAR** command stack.

RESET—Modifies radar input files that contain structural ambiguities along range and elevation or coplane. It can be used to subsection the data along range and to ensure that each beam contains the same number of gates in the same downrange positions from one beam to the next. The nominal fixed angle of each elevation or coplane scan can also be forced to be recalculated using this command if the file header values are suspect. **RESET** also permits the user to correct other erroneous housekeeping information associated with the Universal format input volumes. NOTE: GATCOR, GTSPAC, RADCON, and VNYQ are always present in correctly written Universal Format files, and do not need to be respecified if they are correct. This command is OPTIONAL. *Note: This is a single card image command.*

Command structure:

```
RESET   ELTOL   MNBEAM  RUSR1   RUSR2   GATCOR  GTSPAC  RADCON  VNYQ    IELSEL
```

P2	(F)	ELTOL	Fixed angle tolerance (DEGREES). Any beam whose nominal fixed angle (elevation, azimuth or coplane) differs by more than `ELTOL` from the actual scan angle will be discarded. For scans of constant elevation, the fixed angle is compared with the actual elevation angle. For scans of constant azimuth, the fixed angle is compared with the actual azimuth angle. For scans in constant coplanes, the elevation angle is calculated from the coplane fixed angle and azimuth and the result is compared with the actual recorded elevation angle. (DEFAULT = `360.0`) No beams will be discarded.
P3	(F)	MNBEAM	Minimum number of beams in a scan for it to be processed. Any constant elevation or coplane scan that contains fewer than `MNBEAM` acceptable beams will be discarded. (DEFAULT = `2.0`)
P4	(F)	RUSR1	Starting range (km). (DEFAULT=value in file header)
P5	(F)	RUSR2	Ending range (km). (DEFAULT=value in file header)
P6	(F)	GATCOR	Displacement correction to first gate (m). Distance to first gate = Value in file header + GATCOR (DEFAULT=value in file header)
P7	(F)	GTSPAC	Ignores the value in the input file header and uses this value as the gate spacing (m). (DEFAULT=value in file header)
P8	(F)	RADCON	Ignores the value(s) in the input file header and uses this value as the radar constant when calculating dBZ from any received power. (DEFAULT=value in file header)
P9	(F)	VNYQ	Ignores the value in the input file header and uses this value as the Nyquist velocity (M/S). (DEFAULT=value in file header)
P10	(A)	IELSEL	Method of fixed elevation or coplane angle selection: `MD=nnnnn` the mode method, fixed angle of each scan will be recomputed using the most frequently occurring angle of all beams except the first and last `nnnnn` beams. `nnnnn` is a 5 digit floating point value; `MN=nnnnn` mean method, fixed angle of each scan will be recomputed using the mean value of all beams except the first and last `nnnnn` beams. `nnnnn` is a 5 digit floating point value; (DEFAULT=value in the beam header)

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APPENDICES A-F

SPRINT—Sorted Position Radar INTerpolation

BATCH PROCESSOR for UNIX-BASED COMPUTERS

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APPENDIX A

+++++ A Summary listing of all SPRINT commands +++++
Names of parameters are listed

This is a summary of all SPRINT commands that have been documented in detail. In this summary, the *Command strructure* is emphasized. Following this summary listing are commands where values or different options have been substituted for the parameter names.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
AZIMUTH LAL     RAL     MAXGAP  SPACE   SCANTP  SCNDIR  AZCOR   BASANG
*
END
FILTER  FLTSPACERNGDIST AZDIST
        FLDNAM  FLTYP   SPCPROC FILL
END
FLTERTH OPTION
FXTABLE OPTION
        SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM  SWPNUM
        SWPNUM  SWPNUM  SWPNUM
END
GRID    X1      X2      Y1      Y2      DELXY   Z1      Z2      DELZ    ANGXAX
GRIDXYZ X1      X2      Y1      Y2      DELXY   Z1      Z2      DELZ    ANGXAX
GRIDCPL X1      X2      Y1      Y2      DELXY   C1      C2      DELC    ANGXAX
GRIDXYE X1      X2      Y1      Y2      DELXY                           ANGXAX
GRIDLLE LON1    LON2    LAT1    LAT2    DEL-LL                          ANGXAX
GRIDLLZ LON1    LON2    LAT1    LAT2    DEL-LL  Z1      Z2      DELZ    ANGXAX
INPUT   LUN     ITAPE   ISKP    IEXP    NUMRAD  IREWND  XRAD    YRAD    ZRAD
INTERP  METH    NGAVG   MINGPT  DISMAX  RNGC1   RNGC0   MINDEC
        FLDNAM  ITRANS  IDERIV  NAMDBZ  NAMTHR  LLIMIT  ULIMIT  SIDE
        FLDNAM  ITRANS                  NAMTHR  LLIMIT  ULIMIT  SIDE
        FLDNAM  IVLFLG  IUNFLD          NAMTHR  LLIMIT  ULIMIT  SIDE
        TIME
        FLDNAM                          NAMTHR  LLIMIT  ULIMIT  SIDE
END
LATLON  LATHEM  LONHEM
MACHSIZ MACHRD  MACHWR  WORDSIZ
ORIGIN  EXP-NAM RAD-NAM RAD-LAT RAD-LON RAD-ALT ORG-NAM ORG-LAT ORG-LON AZM(+X)
OUTPUT  LUN     NAMTAP  POS     NFSKIP  FEETSK  NAMSCI  NAMPRO  FORMAT
PROCESS IDATE   IBEGTM  IENDTM  IROV    SWPMOD  FIXTOL          TRANSIT TABLE
QUIT
RADAR   DATFMT  CUNIT   CCOUNT
        ICOUNT  DBMVAL
        ICOUNT  DBMVAL
        ICOUNT  DBMVAL
END
RESET   ELTOL   MNBEAM  RUSR1   RUSR2   GATCOR  GTSPAC  RADCON  VNYQ    IELSEL
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Parameter values rather than Names appear

These are examples of typical SPRINT command setups to interpolate radar scan volumes. Other simple examples with further explanation and how to actually run SPRINT on the NCAR CRAYs or UNIX workstations are included in Appendix E.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C       ----------------------------------------------------------
C       CP4/RP7 FEST    March 9, 1992  Sector scan from 1703-1705
C       ----------------------------------------------------------
INTERP  BI-LIN  0       1       0.2
        DMNE    NO      TRANS   DZDM    VRNE    -0.4    0.4     OUTSIDE
        VRNE    GOOD    UNFOLD          VRNE    -0.4    0.4     OUTSIDE
        SNR     NO                      VRNE    -0.4    0.4     OUTSIDE
        TIME
END
FILTER  CART    0.5     0.5
        DMNE    TRI     NONE    FILL
        VRNE    TRI     UNFOLD  FILL
        SNR     TRI     NONE    FILL
END
LATLON  NORTH   WEST
GRID    0.0     100.0   -40.0   80.0    0.5     0.5     3.2     0.3     148.3
RESET   1.0     50.0    0.0     90.0    0.0                             MN=20.0
AZIMUTH                 2.0     2.0                     0.0
RADAR   RP-7    61
OUTPUT  31      CP4/RP7 BEG     0       0       LJMILL  FEST    PURE    BEG
INPUT   11      4.1656  0       22      4       NO
MACHSIZ DECRD           32
PROCESS 920309. 170300. 171000. NONE    FIXED   0.2             YES
C       ----------------------------------------------------------
C       CP3/RP7 FEST    March 9, 1992  Sector scan from 1703-1705
C       ----------------------------------------------------------
INTERP  BI-LIN  0       1       0.2
        DMNE    NO      TRANS   DZDM    VRNE    -0.4    0.4     OUTSIDE
        VRNE    GOOD    UNFOLD          VRNE    -0.4    0.4     OUTSIDE
        SNR     NO                      VRNE    -0.4    0.4     OUTSIDE
        TIME
END
FILTER  CART    0.5     0.5
        DMNE    TRI     NONE    FILL
        VRNE    TRI     UNFOLD  FILL
        SNR     TRI     NONE    FILL
END
GRID    0.0     100.0   -40.0   80.0    0.5     0.5     3.2     0.3     148.3
RESET   1.0     50.0    0.0     90.0    0.0                             MN=20.0
AZIMUTH                 2.0     2.0                     0.0
RADAR   RP-7    62
OUTPUT  32      CP3/RP7 BEG     0       0       LJMILL  FEST    PURE    BEG
INPUT   21      3.1643  0       22      3       NO
PROCESS 920309. 170300. 171000. NONE    FIXED   0.2             YES
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Parameter values rather than Names appear

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C       ---------------------------------------------------------------
C       CP4/RP7 HaRP    July 19, 1990   5 coplane scans from 1615-1625
C       ---------------------------------------------------------------
INTERP  BI-LIN  0       1       0.2
        DMNE    LINEAR  TRANS   DZDM
        VRNE    GOOD    UNFOLD
        SNR     LINEAR
        TIME
END
FILTER  RADR    1.0     1.0
        DMNE    TRI     NONE    NO FILL
        VRNE    TRI     UNFOLD  NO FILL
        SNR     TRI     NONE    NO FILL
END
GRIDCPL 0.0     45.0    -30.0   15.0    0.3     0.5     29.9    1.4     52.9
RESET   0.25    50.0    0.0     75.0    -175.0                          MN=20.0
AZIMUTH                 2.0     2.0                     0.6
RADAR   RP-7    61
OUTPUT  31      CP4/RP7 BEG     0       0       LJMILL  HARP    PURE    BEG
INPUT   11      F05226  0       18      4       NO
PROCESS 900719. 161520. 162700. RUNOVER FIXED   0.15            YES
INPUT   12      F05227  0       18      4       NO
C       ---------------------------------------------------------------
C       CP3/RP7 HaRP    July 19, 1990   5 coplane scans from 1615-1625
C       ---------------------------------------------------------------
INTERP  BI-LIN  0       1       0.2
        DMNE    LINEAR  TRANS   DZDM
        VRNE    GOOD    UNFOLD
        SNR     LINEAR
        TIME
END
FILTER  RADR    1.0     1.0
        DMNE    TRI     NONE    NO FILL
        VRNE    TRI     UNFOLD  NO FILL
        SNR     TRI     NONE    NO FILL
END
GRIDCPL 0.0     45.0    -30.0   15.0    0.3     0.5     29.9    1.4     52.9
RESET   0.25    50.0    0.0     75.0    -240.0                          MN=20.0
AZIMUTH                 2.0     2.0                     0.5
RADAR   RP-7    62
OUTPUT  32      CP3/RP7 BEG     0       0       LJMILL  HARP    PURE    BEG
INPUT   21      F00623  0       18      3       NO
PROCESS 900719. 161520. 162700. NONE    FIXED   0.15            YES
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Interpolation of NEXRAD Level II format fields

This example shows how to interpolate NEXRAD Level II format fields to Cartesian horizontal positions within the original constant elevation angle scan surfaces. The radar and origin are set to the KEAX radar, and the data were put onto a SUN machine with Fortran record blocking and are being read on a DEC-like machine (byte-swapping is required). An interpolation of several volume scans is first done for the DZ field with output to unit 75, then these same volumes are interpolated for the VE and SW fields with output to unit 76. Note here that the input is rewound (P7=YES in the INPUT command) before the VE-SW interpolations. These separate DZ and VE-SW volumes can be combined into single DZ-VE-SW volumes with the READVOL and TRANSFER commands in the CEDRIC software package.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
*
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*       Interpolation of KEAX, the WSR88D radar located at Kansas City MO
*       (R,A,E) scans to (X,Y,E) Cartesian positions in constant E surfaces.
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*
*       NEXRAD format with SUN Fortran record blocking.  Byte-swapping required.
*       NEXRAD network. Radar/origin are KEAX.  North latitude, West longitude.
*
RADAR   NEXRAD                  SUNFOR
MACHSIZ DECRD           32
LATLON  NORTH   WEST
ORIGIN  NEXRAD  KEAX                                                    90.0
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0                       NO
INTERP  BI-LIN  0.0     1.0     0.0
        DZ
        AZ
        TIME
END
*       rae --> xye     KEAX (75)
OUTPUT  75      NCDC    BEG                                     PUR
GRIDPPI -480.0  480.0   -480.0  480.0   4.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            NO
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0                       YES
INTERP  BI-LIN  0.0     1.0     0.0
        VE      GOOD    UNFOLD
        SW
        AZ
        TIME
END
*       rae --> xye     KEAX (76)
OUTPUT  76      NCDC    BEG                                     PUR
GRIDPPI -480.0  480.0   -480.0  480.0   4.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Interpolation of NEXRAD Level II format fields

This example shows how to interpolate NEXRAD Level II format fields to Cartesian horizontal positions at several constant height surfaces. The radar is KEAX and the origin is set to the KICT radar. The data were originally put onto a SUN machine with Fortran record blocking and are being interpolated on a SUN-like machine. An interpolation of several volume scans is first done for the DZ field with output to unit 75, then these same volumes are interpolated for the VE and SW fields with output to unit 76. Note here that the input is rewound (P7=YES in the INPUT command) before the VE-SW interpolations. These separate DZ and VE-SW volumes can be combined into single DZ-VE-SW volumes with the READVOL and TRANSFER commands in the CEDRIC software package.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
*
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*       Interpolation of KEAX: (R,A,E) scans to (X,Y,Z) Cartesian positions.
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*
*       NEXRAD format with SUN Fortran record blocking.
*       NEXRAD network. Radar is KEAC and origin is KICT.
*       North latitude, West longitude.
*
RADAR   NEXRAD                  SUNFOR
ORIGIN  NEXRAD  KEAX                            KICT                    90.0
LATLON  NORTH   WEST
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0                       NO
INTERP  BI-LIN  0.0     1.0     0.0
        DZ
        AZ
        EL
        TIME
END
*       rae --> xyz     KEAX (75)
OUTPUT  75      NCDC    BEG                                     PUR
GRID    -480.0  480.0   -480.0  480.0   4.0     1.0     11.0    1.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0                       YES
INTERP  BI-LIN  0.0     1.0     0.0
        VE      GOOD    UNFOLD
        SW
        AZ
        EL
        TIME
END
*       rae --> xyz     KEAX (76)
OUTPUT  76      NCDC    BEG                                     PUR
GRID    -480.0  480.0   -480.0  480.0   4.0     1.0     11.0    1.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Interpolation of NEXRAD Level II format fields

This example shows how to interpolate NEXRAD Level II format fields to longitude-latitude positions within the original constant elevation angle scan surfaces. The origin is set to the KEAX radar. The data were originally put onto a SUN machine with Fortran record blocking and are being interpolated on a SUN-like machine. An interpolation of one volume scan is first done for the DZ field with output to unit 78, then this same volume is interpolated for the VE and SW fields and appended to unit 78. These separate DZ and VE-SW volumes can be combined into single DZ-VE-SW volumes with the READVOL and TRANSFER commands in the CEDRIC software package.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
*
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*       Interpolation of KEAX, the WSR88D radar located at Kansas City MO.
*       (R,A,E) scans to (L,L,E) longitude-latitude positions in constant
*       elevation angle surfaces.
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*
*       NEXRAD format with SUN Fortran record blocking.
*       Network is NEXRAD, radar is KEAX, and origin is KEAX.
*
RADAR   NEXRAD                  SUNFOR
ORIGIN  NEXRAD  KEAX                                                    90.0
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0
INTERP  BI-LIN  0.0     0.0     0.0
        DZ
        AZ
END
*       rae --> lle     KEAX (78)
OUTPUT  78      NCDC    BEG                                     PUR
GRIDLLE -99.75  -88.65  34.45   44.15   0.05
PROCESS 980525. 000000. 034900. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INTERP  BI-LIN  0.0     1.0     0.0
        VE      GOOD    UNFOLD
        SW
        EL
END
*       rae --> lle     KEAX (78)
OUTPUT  78      NCDC    ADD                                     PUR
GRIDLLE -99.75  -88.65  34.45   44.15   0.05
PROCESS 980525. 000000. 034900. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

+++++ Examples of SPRINT command setups +++++
Interpolation of NEXRAD Level II format fields

This example shows how to interpolate NEXRAD Level II format fields to longitude-latitude positions at several constant height surfaces. The radar and origin are KEAX. The data were put onto a SUN machine with Fortran record blocking and ftp'd to a DEC-like machine where the actual interpolation is done. An interpolation of several volume scans is first done for the DZ field with output to unit 79, then these same volumes are interpolated for the VE and SW fields with output to unit 80. Note here that the input is rewound (P7=YES in the INPUT command) before the VE-SW interpolations, though for the NEXRAD, rewinding is always done before the PROCESS command executes. These separate DZ and VE-SW volumes can be combined into single DZ-VE-SW volumes with the READVOL and TRANSFER commands in the CEDRIC software package.

```
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
*
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*       Interpolation of KEAX, the WSR88D radar located at Kansas City MO,
*       (R,A,E) scans to (L,L,Z) longitude-latitude positions at constant
*       constant height surfaces.
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
*
*       NEXRAD format with SUN Fortran record blocking, with byte-swapping.
*       NEXRAD network.  Radar/origin are KEAX.  North latitude, west longitude.
*
RADAR   NEXRAD                  SUNFOR
MACHSIZ DECRD           32
LATLON  NORTH   WEST
ORIGIN  NEXRAD  KEAX                                                    90.0
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0               NO
INTERP  BI-LIN  0.0     0.0     0.0
        DZ
        AZ
        EL
        TIME
END
*       rae --> llz     KEAX (79)
OUTPUT  79      NCDC    BEG                                     PUR
GRIDLLZ -99.75  -88.65  34.45   44.15   0.05    1.0     11.0    1.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            YES
*-------*-------*-------*-------*-------*-------*-------*-------*-------*-------
INPUT   11      NEXRAD  0               YES
INTERP  BI-LIN  0.0     1.0     0.0
        VE      GOOD    UNFOLD
        SW
        AZ
        EL
        TIME
END
*       rae --> llz     KEAX (80)
OUTPUT  80      NCDC    BEG                                     PUR
GRIDLLZ -99.75  -88.65  34.45   44.15   0.05    1.0     11.0    1.0
PROCESS 980525. 000000. 240000. NONE    NUMBER  0.15            YES
QUIT
P1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
```

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APPENDIX B

Valid Field Names and Types

SPRINT can read Universal Format (UF), certain ATD/FOF field formats (FF), DORADE (both regular and sweep files from airborne and ground-based radars), or NCDC Level II NEXRAD format as data input. The field formats currently supported are those from the NCAR ground-based radar processors RP3 through RP7. One advantage of using the field format rather than UF is that an extra format conversion step is avoided. However, it does mean that calibration files and a radar constant are required. We maintain a group of calibration files on the computers; these files also include our best estimate of the radar constant. These calibration files are required to convert certain radar processor output count fields to engineering units. See the **RADAR** command for information about these calibration files.

Universal Format radar field names contain 2 characters and have an associated 2-character edit code. These radar field names in SPRINT contain 4 characters that are constructed by concatenating the 2-character edit code to the 2-character field name. For example, if the UF field name was "VE" and its associated edit code was "NE" its name in SPRINT would be "VENE". SPRINT deduces the field type by examining the first two characters only. The two character combinations recognized by SPRINT and the associated field types are given below. Contact us if you wish to have any additional field mnemonics added to this list. Even if a field is not recognized by SPRINT, it may still be interpolated although no special processing can be employed that is specific to its type. `QUAL` and `TIME` are reserved names for specific fields that may be created by SPRINT. Care should be taken to avoid generating Universal format character combinations that produce these names.

NAMES FOR UNIVERSAL FORMAT RADAR DATA

POWER (dBM)	RADAR REFLECTIVITY (dBZ)	RADIAL VELOCITY (M/S)	STANDARD DEVIATION (M/S)	CORRELATION FUNCTION (-1 to 1)	TIME (Sec)	SNR (dB)
DM	DZ	VE	SW	CR	TI	SN
SM	SZ	VF	VA	CO	TM	
XM	SM	VU	SD	CF		
DB	ZR	VT	S2	NC		
	ZD,ZH,ZV	VR	SP			
	XH,XX,XZ					
	TY,TZ,TS,TT					
	SN,CZ,DR,KD					

Valid Field Names and Types (cont'd)

The possible field names for field format (FF) files are fixed and correspond to those fields that are measured and recorded by the radar processors. The user should contact NCAR/ATD for further information about the fields recorded for specific experiments and radars. Below is a list of possible field names; an asterik (*) after the name indicates that it is an unscaled count field. VEL is radial velocity from the primary wavelength, horizontal polarization, and VELV is the radial velocity from the primary wavelength, vertical polarization.

NAMES FOR ATD/RSF FIELD FORMAT RADAR DATA

POWER (dBM)	RADAR REFLECTIVITY (dBZ)	RADIAL VELOCITY (M/S)	STANDARD DEVIATION (M/S)	CORRELATION FUNCTION (-1 to 1)	TIME (Sec)	SNR (dB)
DM	DZ	VE	SW	CR	TI	SN
DMNE*	DZNE	VRNE	SWNE	NCP	TM	SNR
DBMXH	ZDR	VEL*	SPECW*			
DBMXV		VELV*				

There can be many more DORADE format radar field names compared to the UF and FF data sets, both for airborne and ground-based radars. The first two characters tend to follow UF and FF naming conventions, but the actual names can be more than 2-character ones. Because there are so many variables allowed for multi-parameter or polarization radars, we have not included any tables here for specific names. It is best to contact us for guidance when using DORADE format data, and we will add fields as they are used and recognized. Even if a field is not recognized by SPRINT, it may still be interpolated although no special processing can be employed that is specific to its type. QUAL, TIME, AZ, EL, and ROTANG are names reserved for specific fields that may be created by SPRINT. The azimuth and elevation angles are required for synthesizing airborne Doppler radar measurements.

The possible field names for the National Climate Data Center (NCDC) NEXRAD Level II format files are fixed and correspond to those fields that are measured, processed, and recorded on Exabyte tapes at the WSR88D radar sites. The only available fields are: DZ (reflectivity factor), VE (velocity in m/s) and SW (spectral width in m/s). Additionally, QUAL and TIME are reserved names for specific fields created by SPRINT. The QUAL field is generated when local unfolding of the velocities is done. Additionally, azimuth and elevation angle fields can be generated using the name AZ and EL.

APPENDIX C

Experiment and Radar List

The following experiment names and associated radars (the numbers are used as parameters P5 and P6 in the INPUT command) are recognized by SPRINT. The names in parentheses are the actual names in SPRINT. Contact us if you wish to have an additional experiment added to this list. Note: this list may not be complete. It is hard for us to keep up with all the experiments and radars associated with the experiments. Contact us if you see something that needs to be updated. An alternative is to use the ORIGIN command to enter experiment, radar, and origin names and positions (latitude-longitude) not in this list.

EXPERIMENT	EXPERIMENT NAME	RADARS
1	CCOPE	1: CHILL (CHIL) 2: CP-2 3: CP-3 4: CP-4 5: NOAA-C (NOAC) 6: NOAA-D (NOAD) 7: NOAA-K (NOAK) 8: SWR-75 (SKWR)
2	JAWS	2: CP-2 3: CP-3 4: CP-4
3	CYCLES	3: CP-3 4: CP-4
4	MAYPOLE-83	2: CP-2
5	LAKE SNOW-84	3: CP-3 4: CP-4
6	MAYPOLE-84	2: CP-2 4: CP-4
7	PHOENIX-84	3: CP-3 4: CP-4 5: NOAA-C (NOAC) 6: NOAA-D (NOAD)
8	NIMROD-78	1: CHILL (CHIL) 3: CP-3 4: CP-4
9	SOCORRO-84	3: CP-3 4: CP-4 5: NOAA-C (NOAC) 6: NOAA-D (NOAD)
10	PRESTORM-85	3: CP-3 4: CP-4 11: NOR 12: CIM
11	GALE-86	3: CP-3 4: CP-4

EXPERIMENT	EXPERIMENT NAME	RADARS
12	MIST-86	2: CP-2 3: CP-3 4: CP-4 9: FL-2 10: UND
13	CINDE-87	2: CP-2 3: CP-3 4: CP-4 5: NOAA-C (NOAC) 6: NOAA-D (NOAD) 9: FL-2 10: UND
14	GERMAN	13: POLD
15	TAMEX	4: CP-4 14: TOGA 15: CCAA
16	PROFS	2: CP-2
17	TDWR	9: FL-2 10: UND 16: SPAN
18	HARP	3: CP-3 4: CP-4
19	WISP-90	3: CP-3 18: MHR
20	WISP-91	1: CHILL (CHIL) 2: CP-2 3: CP-3 10: UND 18: MHR
21	CAPE	2: CP-2 3: CP-3 4: CP-4 9: FL-2 10: UND 17: MIT
22	FEST92	3: CP-3 4: CP-4
23	TOGA COARE	19: ELDA 20: ELDF
24	TRMM	21: MELB 22: DARW-TOGA (DART) 23: DARW-LAS (DARL)
25	DENVER	24: NEXRAD (KATX) 25: Wichita KS NEXRAD (KICT) 26: Denver CO NEXRAD (KFTG)

EXPERIMENT	EXPERIMENT NAME	RADARS
26	WISP-94	26: Denver CO NEXRAD (KFTG)
27	SCMS	2: CP-2
28	NONE	

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APPENDIX D

CEDRIC CARTESIAN FILE DESCRIPTION

SPRINT uses the CEDRIC file structure for its gridded-volume output. Instead of having a physical record structure, this disk file consists of an unblocked, continuous stream of bytes. It is written using the standard C input-output libraries. Information at the beginning of the file reveals how many logical volumes are contained in the file and what their starting byte addresses are relative to the beginning of the file. CEDRIC files are meant to be portable to most machines in use in the scientific community. The basic requirements are that the machine have C on it and that it represent integers using 2's complement. Several words at the beginning of the file indicate the byte ordering convention used by the machine that wrote the file. The machine reading the file will do any byte swapping necessary.

Below is a very brief description of the structure of CEDRIC files. It is not intended that this information be detailed enough that any routines can be written to read and write CEDRIC volumes. We can provide either guidance in that regard or an input-output software package. Associated with the file and logical volumes are headers described on the following pages.

FILE—a file consists of 1 or more VOLUMEs. At the beginning of the file is information about the number of VOLUMEs in the file, their byte addresses, and other descriptive information.

VOLUME—each volume contains a 3-dimensional set of radar FIELDs mapped to an ordered (X,Y,Z), (X,Y,C) or (X,Y,E) coordinate system. Volumes are associated with a fixed time of day and may contain a field with temporal information corresponding to each individual location. VOLUMEs are preceded by a 510-word logical record containing header information describing the characteristics of the volume. Within a VOLUME, the data corresponding to each radar FIELD is organized in LEVELs associated with either a constant height (Z), constant coplane angle (C), or constant elevation angle (E).

LEVEL—A constant Z-, C-, or E-level contains the data from each FIELD at that height or angle. LEVELs are preceded by a 10-word logical record containing header information describing the characteristics of the LEVEL. FIELD order is indicated in the VOLUME header. Within a LEVEL, the data from each field is contiguous; that is, all the data from Field 1 followed by all the data from Field 2 and so forth.

FIELD—Each field contains the information for a single parameter such as radial velocity, reflectivity, U-component, V-component, and so forth. Within a LEVEL, the data from each radar FIELD is organized as a two- dimensional FORTRAN array such that the lower left corner corresponds to the (1,1) element and the upper right corner corresponds to the (M,N) element; where M increases along the X-axis and N increases along the Y-axis. Each element of a FIELD is a 16-bit integer word.

ILLUSTRATION OF FILE STRUCTURE

```
FILE ...
 ·     VOLUME 1...
 ·          ·          LEVEL 1...
 ·          ·               ·        FIELD 1...
 ·          ·               ·             ·
 ·          ·               ·             ·
 ·          ·               ·             ·
 ·          ·               ·             ·
 ·          ·               ·             ·
 ·          ·               ·             ·
 ·          ·               ·        FIELD last
 ·          ·          LEVEL last
 ·          ·
 ·     VOLUME last
END of FILE
```

CEDRIC FILE HEADER

At the beginning of the file is a 1540-byte header which is followed by as many as 25 separate logical volumes. The file header contains a description of the separate logical volumes and items 3, 5-29, and 30-54 are updated each time a logical volume (items 61 onward) is appended to an existing output file. Those file, volume and level header words that are generated (or updated) during interpolations using SPRINT are listed as "SP"; those that are updated by CEDRIC are listed as "CD."

ITEMS	BYTES	TOTAL LENGTH	UPDATES	DESCRIPTION OF CONTENTS
1	1-4	4 chars	SP	ASCII character string "CED1"
2	5-8	32-bit word	SP	Indicates byte ordering convention of integers in the file (0 - Big Endian such as used by Sun Sparc and CRAY machines) (1 - Little Endian such as used by DEC and PC machines) **Note:** This word is always checked by SPRINT and CEDRIC and neither program allows new volumes to be appended to an existing file written on a machine with a different byte-ordering.
3	9-12	4 bytes	SP,CD	Contains the size in bytes of the entire CEDRIC file
4	13-16	4 bytes		Reserved for future use
5-29	17-116	25 32-bit words	SP,CD	Integer addresses that contain starting byte locations of the respective 25 logical volumes within the disk file. These addresses are all relative to the beginning of the disk file. If there are fewer than 25 logical volumes in the file, the unused byte-addresses will be filled with zeroes.
30-54	117-1516	25 56-char strings	SP,CD	Each character string will say something about its corresponding logical volume.
55-60	1517-1540	6 32-bit words		Reserved for future use.
61-85	$\geq$1541	$\leq$25 logical volumes	SP,CD	Contains a 510-word volume header followed by the data for that logical volume. The contents of individual volume headers are described below. Note that the output file contains only the actual number of volumes written. Thus, if only one CEDRIC logical volume is present, item 61 would be the highest one in the file.

CEDRIC VOLUME HEADER

The header for CEDRIC volumes consists of 510, 16-bit words that are to be interpreted as either two ASCII alphanumeric characters (A) or as signed integers (2's complement). Several of the integer values are scaled so that their true representation will be their integer value times or divided by this scaling factor. The two general scaling factors are: CF for angle scaling (a value of 64) and SF for general scaling (a value of 100). In the case of constant coplane- or elevation-angle interpolations, words 170-171 and 173 have the same meaning as constant-Z interpolations; however, the grid spacing (word 173) is the difference between the first two levels. Those volume header words that are updated by CEDRIC are listed as "CD;" those that are generated during interpolations using SPRINT are listed as "SP."

WORDS	TYPE	SCALING	UPDATES	DESCRIPTION OF CONTENTS
001-004	A		SP,CD	Tape catalogue number (6 char) or disk file name (8 char, 2 per word)
005-006	A		SP,CD	Program name (4 char, 2 per word)
007	A		SP,CD	Program version (2 char, 2 per word)
008-009	A		SP,CD	Project name (4 char, 2 per word)
010-012	A		SP,CD	Scientist name (6 char, 2 per word)
013-015	A		SP	Radar station or data origin (6 char, 2 per word)
016-017	A		SP	Output coordinate system (CRT, ELEV, CPL, LLE, LLZ) (4 char, 2 per word)
018-020	A		SP	Tape catalogue number (6 char, 2 per word); depends on computer installation
021-023	I	None	SP	Beginning date of radar volume (YYMMDD)
024-026	I	None	SP	Beginning time of radar volume (HHMMSS)
027-029	I	None	SP	Ending date of radar volume (YYMMDD)
030-032	I	None	SP	Ending time of radar volume (HHMMSS)
033-034	I	None	SP,CD	Coordinate origin: Latitude (DEG-MIN)
035	I	(*SF)	SP,CD	Coordinate origin: Latitude (SEC)
036-037	I	None	SP,CD	Coordinate origin: Longitude (DEG-MIN)
038	I	(*SF)	SP,CD	Coordinate origin: Longitude (SEC)
039	I	None	SP,CD	Z-coordinate of the origin: Height in meters (MSL); always 0.0
040	I	(*CF)	SP,CD	Degrees clockwise from North to positive X-axis
041-042	I	(*SF)	SP,CD	X,Y-coordinates of the origin (km)
043-044	A		SP,CD	Time zone (4 char,2 per word)
045-047	A		SP,CD	Job identification number (6 char, 2 per word)
048-050	A		SP,CD	Submitter's name (6 char, 2 per word)
051-054	A		SP,CD	Date of program run (MMDDYY); (8 char, 2 per word)
055-058	A		SP,CD	Time of program run (HHMMSS); (8 char, 2 per word)
059		Unused		
060	I	None		Tape edition number (Incremented by Edit2D)
061	I	None	SP,CD	Length of header record (always 510)
062	A		SP,CD	Computer installation (2 char, 2 per word)
063	I	None	SP,CD	Number of bits per data value (always 16)
064	I	None	SP,CD	Blocking mode (always 2)
065	I	None	SP,CD	Block size or physical record length (always 3200)
066	A		SP	Data set: subsectioned = "SU" or original = "OR"
067	I	None	SP,CD	Missing data flag (always -32768)
068	I	None	SP,CD	General scaling factor: SF = 100
069	I	None	SP,CD	Angle scaling factor: CF = 64
070		Unused		

CEDRIC VOLUME HEADER (cont'd)

WORDS	TYPE	SCALING	UPDATES	DESCRIPTION OF CONTENTS
071-074	A		SP	Input file label 1 (8 char, 2 per word)
075-078	A		SP	Input file label 2 (8 char, 2 per word)
079-082	A		SP	Input file label 3 (8 char, 2 per word)
083-086	A		SP	Input file label 4 (8 char, 2 per word)
087-090	A		SP	Input file label 5 (8 char, 2 per word)
091-094	A		SP	Input file label 6 (8 char, 2 per word)
095		Unused		
096	I	None	SP,CD	Number of data records per field per plane
097	I	None	SP,CD	Number of data records per plane
098	I	None	SP,CD	Number of data records per volume, excluding all headers
099	I	None	SP,CD	Total number of records per volume, including all headers
100	I	None	SP,CD	Total number of records per volume, excluding level headers
101-104	A		SP,CD	Volume scan designation (8 char, 2 per word)
105		Unused		
106	I	None	SP,CD	Number of planes in volume scan
107	I	(/SF)	SP	Volume scanned (km^3)
108	I	(/SF)	SP	Total number of sampling points
109	I	(*SF)	SP	Average sampling density (sample point per km^3)
110	I	None	SP	Number of samples integrated in time series
111	I	None	SP,CD	Physical volume number within disk file
112-115		Unused		
116-118	I	None	CD	Beginning date of the volume (YYMMDD)
119-121	I	None	CD	Beginning time of the volume (HHMMSS)
122-124	I	None	CD	Ending date of the volume (YYMMDD)
125-127	I	None	CD	Ending time of the volume (HHMMSS)
128	I	None		Volume Time (Sec)
129	I	None		Index Number-time (4)
130-131		Unused		
132-133	I	(*SF)		Minimum and maximum ranges of the volume scanned (km)
134	I	None	SP	Average number of gates per beam
135	I	None	SP	Average spacing of gates (m)
136-137	I	None	SP	Minimum and maximum number of gates
138		Unused		
139	I	None	SP	Index number for range (always 1)
140-141		Unused		
142-143	I	(*CF)		Clockwise minimum and maximum azimuths of the sweep (deg)
144	I	None		Average number of beams per scanned sweep
145	I	(*CF)		Average increment between beams per sweep (deg)
146-147	I	None		Minimum and maximum number of beams per sweep
148	I	None		Number of steps per beam (average over scanned volume)
149	I	None		Index number for azimuth angle (always 2)
150		Unused		

CEDRIC VOLUME HEADER (cont'd)

WORDS	TYPE	SCALING	UPDATES	DESCRIPTION OF CONTENTS
151	A		SP	Coplane (CO) or ppi (sector scan) (PP) flag
152-153	I	(*CF)	SP	Minimum and maximum elevation angle of the volume scanned (deg)
154	I	None	SP	Number of elevation angles scanned
155	I	(*CF)	SP	Average elevation angle between sweeps (deg)
156	I	(*CF)	SP	Average elevation angle (deg)
157	I	None	SP	Scan-direction indicator (+1 = from lowest to highest elevation angle)
158	I	(*CF)	SP	Baseline angle (CW from true North, coplane only)
159	I	None	SP	Index number for the angle scanned, either coplane or elevation (always 3)
160-161	I	(*SF)	SP,CD	X- or Longitude-coordinate: minimum and maximum values (km or deg)
162	I	None	SP,CD	X- or Longitude-coordinate: number of grid points
163	I	None	SP,CD	X- or Longitude-coordinate: grid spacing (m or 1000*deg)
164	I	None	SP,CD	X- or Longitude-coordinate: index number (0,1,2,3,4)
165-166	I	(*SF)	SP,CD	Y- or Latitude-coordinate: minimum and maximum values (km or deg)
167	I	None	SP,CD	Y- or Latitude-coordinate: number of grid points
168	I	None	SP,CD	Y- or Latitude-coordinate: grid spacing (m or 1000*deg)
169	I	None	SP,CD	Y- or Latitude-coordinate: index number (0,1,2,3,4)
170-171	I	(*SF)	SP,CD	Z-, C-, or E-coordinate; minimum and maximum values (m, deg, or deg)
172	I	None	SP,CD	Z-, C-, or E-coordinate: number of grid points
173	I	None	SP,CD	Z-, C-, or E-coordinate: quasi-vertical grid spacing. Internal values with units of km or deg are multiplied by 1000 before writing this word. CEDRIC divides this parameter by 1000 for use internally. In the case of constant coplane (C) or elevation (E) angle interpolations, which can be unevenly spaced, this word is the difference between the first two levels. The actual coordinates are contained in word 4 of the level header.
174	I	None	SP,CD	Z-, C-, or E-coordinate: index number (0,1,2,3,4)
175	I	None	SP,CD	Number of fields (Maximum of 25)
176-179	A		SP,CD	Name of first field (8 char, 2 per word)
180	I	None	SP,CD	Scaling factor for first field, actual value = value in file divided by scaling factor
181-184	A		SP,CD	Name of second field (8 char, 2 per word)
185	I	None	SP,CD	Scaling factor for second field, actual value = value in file divided by scaling factor
186-295	I	none	SP,CD	Scaling factors for remaining fields
296-299	A		SP,CD	Name of 25th field (8 char, 2 per word)
300	I	None	SP,CD	Scaling factor for 25th field, actual value = value in file divided by scaling factor

CEDRIC VOLUME HEADER (cont'd)

WORDS	TYPE	SCALING	UPDATES	DESCRIPTION OF CONTENTS
301	I	None	SP,CD	Number of grid points per field per plane
302	I	None	SP,CD	Number of landmarks
303	I	None	SP,CD	Number of radars
304	I	(*SF)	SP,CD	Nyquist velocity (if word 303 = 1)
305	I	(*SF)	SP,CD	Radar constant (if word 303 = 1)
306-308	A		SP,CD	Name of landmark #1, must be "ORIGIN" (6 char, 2 per word)
309-310	I	(*SF)	SP,CD	Landmark #1: (X,Y) coordinates (km), always (0,0)
311	I	None	SP,CD	Landmark #1: Z-coordinate (m), always (0)
312-314	A		SP,CD	Name of landmark #2; name of radar if word 303 = 1 (6 char, 2 per word)
315-316	I	(*SF)	SP,CD	Landmark #2 (X,Y) coordinates (km)
317	I	None	SP,CD	Landmark #2: Z-coordinate (m)
318-320	A		SP,CD	Name of landmark #3; name of 2nd radar if word 303 > 1 (6 char, 2 per word)
321-322	I	(*SF)	SP,CD	Landmark #3 (X,Y) coordinates (km)
323	I	None	SP,CD	Landmark #3: Z-coordinate (m)
324-395	A,I	See above	SP,CD	Information for remaining landmarks in the above order: [Name (three words) and XYZ (one word each)] for a maximum of 15 landmarks
396-510				—RESERVED FOR PROGRAM USE—

CEDRIC LEVEL HEADER

The header for CEDRIC levels consists of 10, 16-bit words that are to be interpreted as either two ASCII alphanumeric characters (A) or as signed integers (2's complement). Several of the integer values are scaled so that their true representation will be their integer value times or divided by this scaling factor. The general scaling factor is SF for general scaling (a value of 100). Header words that are updated by CEDRIC are listed as "CD"; those that are generated during interpolation using SPRINT are listed as "SP". Since interpolations to constant coplane angles (C deg) or constant elevation surfaces (E deg) may not be equally spaced, the current level information is always obtained from word 4 in the level header rather than from words 170-173 of the Volume Header. Constant E-level interpolations can only be organized in successive XY- or Longitude-Latitude planes of data at E-levels. Constant C-level interpolations are organized in successive XY-planes only. The Nyquist velocity for WSR88D radars changes as the elevation angle increases so the current E-level Nyquist is placed in word 010 of the CEDRIC LEVEL HEADER.

WORDS	TYPE	SCALING	UPDATES	DESCRIPTION OF CONTENTS
001	A		SP,CD	Always = "LE"
002	A		SP,CD	Always = "VE"
003	A		SP,CD	Always = "L "
004	I	(*1000)	SP,CD	For CRT or LLZ output: height coordinate of the plane or level (Z m)
		(*1000)	SP,CD	For CPL or ELEV output: only angular coordinate C or E deg is allowed
005	I	None	SP,CD	Plane (or level) number within the volume
006	I	None	SP,CD	Number of fields
007	I	None	SP,CD	Number of grid points per plane (or level)
008	I	None	SP,CD	Number of records per field
009	I	None	SP,CD	Number of records per plane
010	I	(*SF)	SP,CD	Nyquist velocity (used for NEXRADs)

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APPENDIX E

RUNNING SPRINT ON THE UNIX-BASED COMPUTERS AT NCAR

In order to use SPRINT on a UNIX-based computer, the user must construct an input deck with the appropriate UNIX shell script commands for accessing and disposing any datasets that are to be created or manipulated. The user is assumed to be reasonably familiar with the UNIX operating system and especially its commands and their structures. Those who are not familiar with UNIX should contact the Scientific Computing Division (SCD) at NCAR or their local computer maintainenance group for documentation or assistance. Alternatively, an excellent reference on writing UNIX Bourne shell scripts is:

Kernighan, B.W. and R. Pike, 1984: *The UNIX Programming Environment.* Prentice Hall.

The following is a complete template for setting up a SPRINT run,including the actual SPRINT command structure. Please refer to it for the remainder of this discussion. The first part of the script contains resource declarations. The amount of CPU time, the memory needed, and so forth are specified with the "QSUB" commands. Normally, a line that begins with a "#" is treated as a comment by the CRAY. However, one exception is when a line starting with a "# " is followed by "QSUB". In that case, the parameters immediately following the "QSUB" are passed to the batch processing utility as resource requests.

Following the resource declarations are the input dataset acquisitions. Each dataset or file is acquired from the Mass Store System (MSS) with the "msread" command and placed on the CRAY disks. These disk files must then be linked to FORTRAN unit numbers that will be used later when SPRINT executes. The SPRINT executable code must also be acquired from the MSS. Output volumes need to be linked as well before the execution of SPRINT.

After the listing of the SPRINT input card images comes the actual execution of the code. The information following the `QUIT` command can be used as a positioning guide when supplying the parameterization required by SPRINT commands, since any card images following the `QUIT` command are ignored. After execution, any output files are sent to the Mass Store with the "mswrite" command, and the accounting statistics are generated.

```
++++++++++A COMPLETE SCRIPT FOR RUNNING SPRINT ON THE NCAR CRAYs++++++++++

# QSUB -q econ      # put in economy queue
# QSUB -s /bin/sh   # use the Bourne shell
# QSUB -lT 5:00     # upper limit on CPU time for this script (here 5 min.)
# QSUB -lM 6Mw      # internal CRAY memory needed to run SPRINT
# QSUB -lF 25Mw     # upper limit on the sum of the sizes of files created
#                     by this script
# start accounting
ja

# move to large temporary directory since permanent directories are too small
cd $TMPDIR

# acquire the SPRINT executable ; no compiling necessary
msread -f BI SPRINT.e /ANDERSNB/SPRINT/SPRINT.e || exit
chmod +x SPRINT.e

# acquire input dataset from the Mass Store and link to fortran unit
msread wdaft11 /FOFDMG/DATA/HARP/CP3/F00622 || exit
ln -s wdaft11 fort.11

# link output volume to a fortran unit
ln -s wdaft20 fort.20
```

```
# a continuation of the CRAY script for running SPRINT
#
# get the radar calibration file
cp /u1/andersnb/cp3.cal
ln -s cp3.cal fort.14

# the following is the SPRINT input being redirected to SPRINT.inp
# input is terminated by 'EOFA'
cat > SPRINT.inp << EOFA
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
INPUT   11      19JUL02 0       18      3       YES
OUTPUT  20      90JUL19 BEG     0       0       LJMILL  HARP    PURE    BEG
RESET   0.25    50.0    0.0     75.0    -240.0                          MN=20.0
INTERP  BI-LIN  0       1       0.15
        DMNE    NO      TRANS   DZDM    SNR     -6.0    100.0
        VRNE    GOOD    UNFOLD
        TIME
        SNR     NO      LINEAR          SNR     -1.0    50.0
END
FILTER  CART    0.3     0.3
        DMNE    TRI     NONE    NO FILL
        VRNE    TRI     UNFOLD  NO FILL
        SNR     TRI     NONE    NO FILL
END
GRIDCPL 0.0     80.0    -60.0   60.0    1.0                             52.9
RADAR   RP-7    14
PROCESS 900719. 155400. 160200. NONE    FIXED   0.15            YES
QUIT
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
EOFA

# run the program
SPRINT.e < SPRINT.inp

# dispose the output file created by SPRINT
mswrite wdaft20 /ANDERSNB/TEST/output.mud retpd=90

# generate accounting statistics
ja -cst
exit
```

Following are four simple setups to illustrate some of the basic aspects of the SPRINT command structure. In all cases the above UNIX shell script or one very similar to it must surround the SPRINT commands. These setups are intended to convey some idea of how SPRINT commands are structured, and how they are executed. This command structure can be viewed as a high-level (higher than Fortran) programming language that allows the user to construct a whole set of input/output specifications, tailored to the user's needs.

+++++ Sample deck #1 +++++

Interpolate the reflectivity field only

The following deck accesses Universal Format Radar data from a single input file containing CP–2 data collected during the CCOPE experiment. The power field `DMNE` is interpolated and converted to a reflectivity field named `DZNE`. This will be the only field generated from each volume within the `PROCESS` time interval. The `INPUT` tape is assigned to unit `11` in the Job Control Language (JCL); a single `OUTPUT` tape is assigned to unit 20. The successive bilinear interpolation method is employed with NO gate averaging. The maximum distance to relocate a closest point estimate is set equal to the horizontal grid spacing of 1 km. The power field is left in LOG units for the interpolation. A three-dimensional Cartesian grid with 1 km spacing in the horizontal and 0.5 km spacing in the vertical is defined. Its orientation is West-to-East along X and South-to-North along Y. A summary of all input elevations and horizontal $Z-$planes will be produced for every successfully interpolated volume that starts within the `PROCESS` time period.

```
C
C       THESE ARE USER SUPPLIED COMMENTS !!!
C       INPUT IS TO BE READ FROM UNIT 11.
C       EXPERIMENT IS CCOPE (#1), RADAR IS CP-2 (#2).
C       NO VOLUMES ARE TO BE INITIALLY SKIPPED ON THE INPUT TAPE.
C
INPUT   11.     V12345  0.0     1.0     2.0
C
C       INTERPOLATED VOLUMES WILL BE WRITTEN TO UNIT 20 THAT IS ASSOCIATED
C       WITH V56789 IN THE JCL. INFORMATION WILL BE WRITTEN STARTING AT THE
C       BEGINNING OF THE TAPE. SCIENTIST NAME AND PROJECT NAME ARE ALSO
C       SUPPLIED FOR INFORMATIONAL PURPOSES.
C
OUTPUT  20.     V56789  BEG     0.0     0.0     MILLER  COPE
C
C       A SINGLE FIELD (DZNE) IS PRODUCED FOR OUTPUT. DMNE IS DISCARDED.
C
INTERP  BI-LIN  0.0
        DMNE    NO      TRANS   DZNE
END
C
C       X1      X2      Y1      Y2      DELXY   Z1      Z2      DELZ
C
GRID    60.0    110.0   0.0     50.0    1.0     1.0     15.0    0.5
C
C       ALL VOLUMES WITH STARTING TIMES BETWEEN 164104 AND 170530 WILL
C       BE PROCESSED. DATE OF THE DATA IS 8/1/81.
C
PROCESS 810801. 164104. 170530.
QUIT
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
```

+++++ Sample deck #2 +++++

Interpolation of relevant fields for Doppler analysis

The following deck is an expansion of Sample deck #1. In this example velocity `VFNE` and time `TIME` fields are also produced. Local velocity unfolding is invoked and all input velocities are treated as valid estimates. When unfolding is activated the `QUAL` field is also generated. This results in the maximum number of output fields being produced: `DZNE, VFNE, TIME`, and `QUAL` for this example. The `RESET` command has been added to toss out beams that deviate more than `0.5` deg from the fixed elevation angle; to toss out scans with fewer than `5` beams; and to force the gate spacing to be `150` meters. Range averaging is being applied in the interpolation procedure and `DMNE` is interpolated in `LINEAR` units.

```
C
INPUT   11.     V12345  0.0     1.0     2.0
OUTPUT  20.     V56789  BEG     0.0     0.0     MILLER  COPE
C
C       PLACE TOLERANCES ON THE ELEVATION INFORMATION AND RESET GATE SPACING
C       TO 150 METERS INSTEAD OF INVALID VALUE ON TAPE OF 149.
C
RESET   0.5     5.                              150.
C
C       TWO MORE ENTRIES HAVE BEEN ADDED TO THE STACK. THE UNFOLDED VELOCITY
C       FIELD VFNE ALSO PRODUCES A QUAL FIELD BY DEFAULT. TIME IS ALSO
C       GENERATED EVEN THOUGH IT DOES NOT EXIST AS AN ACTUAL INPUT FIELD ON
C       TAPE. 3 GATE AVERAGING (AT LEAST 2 GOOD) IS ALSO APPLIED.
C
INTERP  BI-LIN  3.0     2.0     1.0
        DMNE    LINEAR  TRANS   DZNE
        VFNE    GOOD    UNFOLD
        TIME
END
C
GRID    60.0    110.0   0.0     50.0    1.0     1.0     15.0    0.5
C
PROCESS 810801. 164104. 170530.
QUIT
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
```

+++++ Sample deck #3 +++++

Interpolating radar information that contains a variable number of gates/beam

The following procedures are similar to the processing performed in Sample deck #2 for another radar — CHILL. Note that the field names are different and that the RESET command has been used to expand every beam out to an equal number of gates and to correct the value of the Nyquist velocity as it appears on the INPUT tapes. Two INPUT tapes are used in this example and a pair of consecutive volumes are treated as one on the second tape using the APPEND feature on the PROCESS command.

```
C
INPUT   11.     V01234  0.0     1.0     1.0
OUTPUT  20.     V09999  BEG     0.0     0.0     MILLER  COPE
C
C      FORCE ALL BEAMS TO HAVE EQUAL NUMBER OF GATES OVER RANGE OF 40-100 KM.
C      GATE SPACING IS O.K. HERE BUT NYQUIST NEEDS TO BE SET TO 23.5
C
RESET   0.5     5.      40.     100.                            23.5
C
INTERP  BI-LIN  3.0     2.0     1.0
        DMNO    LINEAR  TRANS   DZCL
        VFNO    GOOD    UNFOLD
        TIME
END
GRID    60.0    110.0   0.0     50.0    1.0     1.0     15.0    0.5
C
PROCESS 810801. 164035. 165600.
C
C      NEXT STREAM OF INPUT DATA IS TO BE READ FROM V08777 ON UNIT 12
C
INPUT   12.     V08777  0.0     1.0     1.0
PROCESS 810801. 165600. 171520.
C
C      THE VOLUMES STARTING DURING THIS NEXT TIME PERIOD ARE TREATED AS ONE
C
PROCESS 810801. 171530. 171945. APPEND
C
C      RESUME NORMAL PROCESSING ON THE CURRENT TAPE (V08777 ON UNIT 12)
C
PROCESS 810801. 171950. 200000.
QUIT
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
```

+++++ Sample deck #4 +++++

Adding to the output tape and reconstructing volumes across tape boundaries

The following deck illustrates a deck that might be submitted after Sample deck #3. In this example the output datasets are added to the tape created in the previous example (V09999). The GRID is redefined in the middle of the desired time interval and an INPUT volume that was written across tape boundaries is reconstructed.

```
C
INPUT   11.     V05566  0.0     1.0     1.0
C
C       ADD THE OUTPUT OF THIS RUN TO AN EXISTING OUTPUT TAPE. THIS TAPE
C       MUST BE ACQUIRED IN THE JCL IN ORDER TO PRESERVE ITS PRIOR CONTENTS.
C       SUPPLY THE NUMBER OF EXISTING VOLUMES (8) AND FOOTAGE (1050) TO
C       ENSURE PROPER HOUSEKEEPING.
C
OUTPUT  20.     V09999  ADD     8.0     1050.   MILLER  COPE
C
RESET   0.5     5.      40.     100.                            23.5
C
INTERP  BI-LIN  3.0     2.0     1.0
        DMNO    LINEAR  TRANS   DZCL
        VFNO    GOOD    UNFOLD
        TIME
END
C
GRID    60.0    110.0   0.0     50.0    1.0     1.0     15.0    0.5
PROCESS 810801. 173000. 173800.
C
C       CHANGE THE GRID SPECIFICATIONS AND CONTINUE PROCESSING.
C
GRID    70.0    120.0   5.0     60.0    1.0     1.0     15.0    0.5
PROCESS 810801. 173800. 174300.
C
C       THE LAST VOLUME ON V05566 RUNS OVER ONTO THE NEXT TAPE SO RUNOVER
C       IS SPECIFIED ON THE PROCESS COMMAND. THE FIRST VOLUME ENCOUNTERED
C       IS ASSUMED TO BE PART 1 OF THE VOLUME TO BE RECONSTRUCTED. THE NEXT
C       COMMAND MUST BE INPUT. NORMAL PROCESSING CONTINUES FOR THE REMAINDER
C       OF V04433 AFTER RECONSTRUCTION OF THE VOLUME.
C
PROCESS 810801. 174301. 190000. RUNOVER
INPUT   12.     V04433  0.0     1.0     1.0
C
QUIT
C
C1......P2......P3......P4......P5......P6......P7......P8......P9......P10.....
C
```

APPENDIX F

RUNNING SPRINT ON YOUR OWN UNIX MACHINE

You can get older SPRINT binary copies off the anonymous ftp server (ftp.ucar.edu) by changing directories to radar/software/sprint. Files on the UCAR anonymous ftp server will no longer updated. Instead, we will maintain current source code for all MMM-developed programs on the MMM ftp server, a machine called box. This machine is outside the UCAR/NCAR firewall, but it is not an anonymous ftp server so it requires a login name and password. Contact L. Jay Miller (ljmill@ncar.ucar.edu) for instructions on accessing these files. We will only place current source code on this machine, with no new binary executables.

SPRINT runs on most any UNIX platform and requires about 35 MB of memory. Thus it is best suited for medium and upper end workstations or server class machines. Furthermore, since radar datasets typically require tens of megabytes of disk space, users should plan on running SPRINT on a machine with a large amount of disk available. The program takes about 7 minutes of CPU time on a Sun Sparc 2 for an input volume with 1200 beams and filtering options invoked.

SPRINT can read several different formats of radar data. The input files must be either Universal format (UF), ATD (Atmospheric Technology Division at NCAR) field format (FF), DORADE format for airborne or ground-based radars, or NCDC Level II format for NEXRAD Exabyte tapes. See the INPUT command on using NEXRAD tapes as input. However, we still recommend putting the NEXRAD data into disk files rather than using tape directly. The UF and FF data can be COS-blocked which is a type of blocking that exists on files on the NCAR Mass Storage System (MSS). Thus, if you acquire your files from the MSS over the network via MIGS (Masnet/Internet Gateway Server) or IRJE (Internet Remote Job Entry), you simply need to get the radar files in “transparent” form so that the blocking stays on there. If you have Universal or field format files that do not have this blocking (e.g., files from a non-NCAR radar or files extracted locally off of physical tape), you will have to convert them to have this blocking. We do not have programs to do this, but we can help in the conversion to COS-blocking if needed.

Once the blocking issue is settled, you need to make sure that your files are Universal format, ATD field format, DORADE, or NEXRAD. Universal format is a ”standard” format that was agreed upon years ago for exchanging radar data. All the data values are stored in scaled meteorological units. The DORADE format is a more recent one which will likely eventually replace the Universal format. It has enhanced features needed for airborne radars, but it is also being used for ground-based radars, especially polarimetric radars that have many more fields compared to more conventional Doppler radars. The Field Format is the in-house format that ATD used to record the data during field experiments with the CP2, 3 and 4 Doppler radars. Some data values (returned power) are stored as counts which SPRINT must convert to meteorological units (dBM) by using a calibration file. Universal format files take care of this issue when they are created from the field format files. The benefit of using the field format is that you can avoid the often time consuming conversion process and interpolate directly from the original dataset. The three NCAR/ATD radars are no longer in use, with CP2 10-cm multi-wavelength, Doppler radar being replaced in 1995 by the newer S-Pol 10-cm polarimetric radar.

A calibration file (necessary only when processing field format datasets), contains a radar constant and a list of counts with their corresponding power values in dBM. A file may contain multiple radar constants and lists, for example, if the radar processes power at more than one polarization. If you need to create your own, contact us for an example.

After the input data has been interpolated to a regular grid, the data are output in CEDRIC format. CEDRIC is the radar data analysis program that works on the gridded data. This format was designed to allow for very fast access and is portable across most UNIX platforms. We do have a suite of subroutines that users can use to read and write the CEDRIC format. Since CEDRIC is capable of converting disk files to netCDF, it is unlikely that SPRINT will ever output this format.

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APPENDIX G

COORDINATE SYSTEMS, INTERPOLATION, AND LOCAL UNFOLDING

1. Coordinate systems

a. Spherical

Ordinarily radars acquire measurements in a spherical coordinate system, consisting of a slant range, an azimuth angle, and an elevation angle. The convention is that azimuth is measured clockwise from true North and elevation angle is measured upward from the horizontal direction. The meteorological Cartesian coordinate system is usually defined with the positive Y-direction toward the North and the positive X-direction toward the East. The Z coordinate is height above mean sea level (MSL) so surfaces of constant Z are actually spheres. The conversion from radar spherical coordinates (R,A,E) to Cartesian (X,Y,Z) also requires that refraction of the radar beam be taken into account. This is usually done by using a 4/3 Earth radius in the geometric transformation rather than simply the Earth's radius. See Battan (1973) for an explanation of this transformation.

b. Coplane

This is only a brief discussion of the coplane coordinate system and how data taken in coplane space are processed in SPRINT. Users unfamiliar with the coplane coordinate system and its associated mathematics should examine Miller and Strauch (1974) and Appendix F in the CEDRIC documentation.

As a radar antenna rotates in azimuth, the elevation angle is continuously changed to keep the beam in a flat plane passing through the baseline joining two radars. This plane contains the intersecting beams from the two radars and the baseline. In this scanning scheme, measurements are taken at range-azimuth locations within each plane nearly simultaneously by the two radars, and then the two antennaes step to the next tilted coplane. The coplane angle is the angle formed by the tilted coplane and the horizonal plane through the radar positions, and it is measured upward from the horizontal tangent plane.

The gridded coplane coordinate system consists of three orthogonal directions: if you look in a direction from one radar toward the other (along the baseline between the radars) and with the region of intereset to your right then the positive X-direction is perpendicular and outward from the baseline toward the region of interest, the positive Y-direction is parallel to the baseline in the direction you are looking, and C remains the coplane angle. Within each coplane, X and Y constitute a two-dimensional Cartesian coordinate system. When data is taken at range-azimuth locations but still in coplane space, SPRINT will interpolate that data to a regular (X,Y) grid in coplane space.

2. Description of the interpolation scheme

a. Interpolation in Cartesian space

Each field selected for interpolation is converted independently of all other fields using original data values from the four beams (two on either side, above and below) surrounding each destination Cartesian location in space. Successive bilinear interpolation at the projection point on each elevation plane is performed; first along range and second across azimuth. A final linear interpolation is performed along elevation using the estimates at these projection points in order to produce a resultant value at the Cartesian location.

Whenever there is an insufficient number of "good" (i.e. $\neq$ bad data flag) radar space values to perform a bilinear interpolation at the projection point on an elevation plane, the closest value whether it be "good" or "bad" is selected instead. If either or both elevation planes contain a closest point value, the Cartesian location will receive its estimate from the nearer of the two.

In order for this hybrid technique to work, the user must specify a maximum distance (km) past which a "closest" point value should not be trusted as being representative. If this distance is exceeded along any one axis (range, azimuth, or elevation) the Cartesian location will receive a bad data flag. The user may also attempt to equalize the spatial resolution along range and azimuth by requesting that a fixed number of gates along each adjacent beam be averaged along range. When this option is exercised, the resultant mean estimates are assigned to the projection points on each beam in lieu of the values ordinarily produced by linear interpolation across two consecutive gates. The user must also specify the minimum number of "good" values along each beam to accept when averaging. If too few are present on either beam in an elevation plane, the closest value scheme is employed instead. All other aspects of the interpolation method remain the same when range averaging is invoked. Certain field types receive specialized treatment in SPRINT:

Velocity Fields

- All original velocities affecting a Cartesian location may be folded into the same Nyquist interval before any calculations are performed.
- *NCAR* flagged velocity fields may be considered as unedited data or they may be decimated so that their contents are treated as edited velocities.

dBm and dBZ Fields

- dBm and dBZ values may be converted to linear units before any calculations are performed.
- Whenever a dBm field is present, a dBZ field may be derived from it and saved.

b. Interpolation in coplane space

The interpolation to coplane space is done in a like fashion to the interpolation to Cartesian space from constant-elevation angle scans. The eight data points that form a curvilinear parallelepiped around the grid point are used in a bilinear/closest point scheme to arrive at a value for each field at the grid point. In the coplane case, the parallelepiped is defined by the azimuths in the coplane, the coplane angles and the range gate positions. The data is then written out in the regular coplane grid for further analysis.

The coplane method will allow calculations of the wind fields to be done at a later time in the coordinate system in which the data was taken. The user specifies the (X,Y) grid layout, as well as the coplane angle spacing, and the data is interpolated to the coplanes in which it was taken. If this option is selected, the interpolation becomes a two-dimensional interpolation. Alternatively, the user can interpolate from the coplane space directly to Cartesian (X,Y,Z) coordinates. The first is done by using the **GRIDCPL** command, and the latter is done by using either the **GRID** or the **GRIDXYZ** command.

Interpolation and analysis of data taken in coplane space is a two step process. First, SPRINT is used to interpolate the data to a regular coplane grid. The GRIDCPL card specifies the coplane grid to be used. Then, CEDRIC is used to calculate the wind fields in coplane space. Users can also use CEDRIC to interpolate to a three-dimensional Cartesian grid after the wind fields have been calculated. The data then is in a regular Cartesian grid and all the functions and operations available in CEDRIC can be used to manipulate and analyze the data. See the CEDRIC documentation for details about this second step.

3. Local unfolding of radial velocitites

This is a brief summary of material presented in Miller et al (1986). Two editing steps that are usually done before radial velocity data are interpolated include the unfolding of velocities that are ambiguous and the deletion of ones that are poor estimates (those mean values from low signal-to-noise power ratio regions or from broad velocity spectra). However, these steps can be postponed until after interpolation so long as poor estimates of velocity and folding can still be identified.

a. Rectification of folded radial velocities

The idea behind local (a small neighborhood of the output grid point) unfolding of folded radial velocities is the following. First, designate a local velocity estimate at each (x, y, z) point and then offset all velocities that affect that point so that they lie within the Nyquist interval of this initial estimate prior to interpolation. This is done independently at each interpolation grid point, and only represents a local resolution of velocity folding. The interpolated velocities can be subsequently unfolded in Cartesian space using global techniques.

The true (unfolded) radial velocity U at a (R,A,E) measurement point is

$$U = V + \kappa V_a; \qquad \kappa = 0, \pm 1, \pm 2, \ldots \tag{1}$$

where V is the measured quantity that may have been folded and is subject to measurement error, $V_a = 2V_n$ is the ambiguous velocity interval, and κ is the integer factor needed to remove Nyquist folding ambiguities from V. When the measured velocity differs by more than V_n from the value expected at the grid point, the integer folding factor in Eq (1) is non-zero and can be approximated by

$$K = \frac{U_e - V}{V_a} \tag{2a}$$

where U_e is a preliminary estimate of the true radial velocity at the (x, y, z) point. The appropriate integer unfolding factor is determined by

$$\kappa = \begin{cases} INT(K + 0.5), & \text{if } K \geq 0 \ , \\ INT(K - 0.5), & \text{if } K \leq 0 \ . \end{cases} \tag{2b}$$

where INT represents truncation toward zero. The quantity U_e is arbitrarily set to one of the measured input values in the neighborhood of the (x, y, z) point, and the remaining contributing values are unfolded using Eqs. (1) and (2).

Since U_e comes from the population of input samples that are contained within the Nyquist interval ($-V_n \leq V \leq V_n$, unless they have been previously unfolded), the values of κ determined by Eq (2) will be –1, 0, or +1. This is equivalent to assuming that the largest possible physical gradients of radial velocity that can occur are $V_a/(M-1)\Delta R$ in range, $V_a/R\Delta A \cos E$ in azimuth, and $V_a/R\Delta E$ in elevation, where ΔR, ΔA, and ΔE are the respective sampling increments. The sampling cell consists of M range gates and four adjacent beams, two in azimuth and two in elevation. Spatial gradients across the sampling cell larger than these will cause the true radial velocities to be spread over more than one V_a interval, leading to the requirement that some values of κ exceed unity. In this event which is uncommon provided the Nyquist velocity is large ($\sim$ 25m s^{-1}) and sampling locations are closely spaced ($\leq$ 1 km), the algorithm will obviously fail to interpolate an unbiased velocity value.

Radar velocity measurements from a range slab of thickness M gates centered at slant range R to the interpolation $xyz-$grid point are range-averaged to obtain estimates at each of four azimuth-elevation locations surrounding the $xyz-$grid point:

$$\hat{U}\left(A_j,\ E_k\right) = \sum_{m=1}^{M} U_m/M \ ,$$

where the U_m have been unfolded according to Eqs (1) and (2). The quantities A_j and E_k represent the respective azimuth and elevation angles of the beams. A caret ($\hat{}$) denotes either range-averaged or $xyz-$grid values, and quantities without a caret represent either measured or unfolded velocities at radar sampling locations. Following Mohr et al (1981), these range-averaged data are bilinearly interpolated using

$$\begin{aligned} \hat{U}\left(A, E\right) = &\left(\frac{E_{k+1} - e}{\Delta E}\right) \left[\hat{U}_j \left(\frac{A_{j+1} - A}{\Delta A}\right) + \hat{U}_{j+1} \left(\frac{A - A_j}{\Delta A}\right)\right]_k \\ &+ \left(\frac{E - E_k}{\Delta E}\right) \left[\hat{U}_j \left(\frac{A_{j+1} - A}{\Delta A}\right) + \hat{U}_{j+1} \left(\frac{A - A_j}{\Delta A}\right)\right]_{k+1} , \end{aligned} \tag{3}$$

where $\Delta E = E_{k+1} - E_k, \quad \Delta A = A_{j+1} - A_j$. The terms in brackets represent linear interpolations along azimuth at the k and $k+1$ elevation levels. Combining Eqs (1) and (3) in abbreviated form, the unfolded and interpolated radial velocity becomes

$$\hat{U}(x, y, z) = \sum_{A,E} (w\ V)_{jk} + V_a \sum_{A,E} (w\ \kappa)_{jk} \tag{4}$$

The first term on the right is the geometrically weighted sum of measured values, while the second term represents a weighted folding factor to correct for bias that would result if measured values were not locally unfolded before interpolation. The values of κ in Eq (4) are the ones that should be used to unfold (remove ambiguity from) the measured velocities. The error in the grid point value will be

$$\delta\hat{U} = \sum_{A,E}(w\delta V)_{jk} + V_a \sum_{A,E}(w\delta\kappa)_{jk}$$

for δV measurement errors in velocities and $\delta\kappa$ errors in the integer unfolding parameter.

If the radial velocities come from statistically similar populations having zero mean and equal variance random error $\sigma^2(V)$, the random error variance of the grid point estimate is, assuming no error in κ,

$$\sigma^2(\hat{U}) = \sigma^2(V)\frac{\sum w_{jk}^2}{M} \tag{5}$$

where the quantities w_{jk} are the geometric weighting factors in Eq (3). The sum of squares of the weights are computed during interpolation to provide a measure of the variance reduction associated with interpolation. If the grid point should happen to coincide with an original sample location, all the weights except one are zero and there is no variance reduction. If, however, the grid point is equidistant from all four sample locations, the sum of squares of weights is 0.25. Since all values of A, E are equally likely to occur, the expected value of $\sum w_{jk}^2$ is its areal average of 4/9. So long as measured velocities are locally unfolded according to Eqs (1) and (2), they can be interpolated without prior radar space editing.

b. Quality of the interpolated velocities.

Since the interpolation method is applied to all radar-measured velocities without prior editing, we need a way to determine the quality of the interpolated value. This measure can be used later in Cartesian space to reject unreliable velocities interpolated from radar measurements that are too noisy or bring attention to regions where local unfolding may have required a folding factor exceeding unity. When no signal is present covariance-measured radial velocities have variance $\sigma_n^2 = V_n^2/3$, so that large local variability should tell us when interpolated values are coming from an input population dominated by noise. Further, large spatial gradients of the measured velocities should also lead to significant variability. When neither of these conditions exist, the spread of unfolded velocities should be much smaller. Thus we compare the sample standard deviation $Std(U)$ of unfolded velocities to be used in the interpolation with the expected value of σ_n for white noise to determine the reliability of the interpolated velocity. A nondimensional velocity quality parameter

$$Q(x,y,z) = 1 - Std(U)/\sigma_n \tag{6}$$

is calculated. All measurements affecting a grid point estimate are locally unfolded using Eqs (1) and (2) and then their corresponding standard deviation $Std(U)$ is obtained.

The nondimensional velocity quality parameter Q is close to zero when all radial velocities are noise and it approaches unity as the spatial variability of the measured velocities decreases. Further, Q can become negative when the distribution of unfolded measurements is more clustered toward its extreme values with fewer estimates near the center velocity. The parameter Q reflects variability both from measurement errors in individual velocities as well as large spatial gradients in the true radial velocity field surrounding the interpolated grid point. It is, therefore, a better measure of the acceptability of grid point estimates than is the magnitude of the covariance function that is often used to determine reliability of individual measurements contributing to the interpolated estimate. More importantly, Q can be computed for all radar systems in the same way.

The quality field (Q) and the sum-of-weights field ($\sum w_{jk}^2$) in (5) are combined into a single field called QUAL for output by SPRINT. The signed quantity (Q) is multiplied by 100 and the decimal portion of this scaled result is truncated. The sum-of-weights field, which is in the range $0.25 \leq \sum w_{jk}^2 \leq 1.0$, replaces the truncated decimal fraction so that the output field QUAL is of the form:

$$\text{QUAL} = (Q \times 100) + \sum w_{jk}^2$$

The quantities $\sum w_{jk}^2$ and Q can be subsequently retrieved from QUAL by the following pair of operations:

$$\begin{aligned} \sum w_{jk}^2 &= ABS\big[MOD(QUAL, 1.0)\big] \\ Q &= \big[QUAL - MOD(QUAL, 1.0)\big]/100. \end{aligned}$$

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