Emulation of Radar Data from ARPS Model Data
User Guide for CASA Radar Data Emulator

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Introduction

This document describes a set of programs for creating simulated radar data from gridded numerical weather prediction model data. Specifically the data from ARPS model history files. The programs have the following features:

1) Ability to simulate meteorological radar data from S-band to X-band
2) Flexibility in describing radar pulse characteristics
3) Single or dual-pulse processing
4) User-defined numerical evaluation intervals to control accuracy and runtime.
5) X-band attenuation
6) Reflectivity noise estimate based on processing details
7) Velocity noise estimate based on SNR, estimated spectrum width and number of samples
8) Velocity folding based on actual or fixed Nyquist velocity.
9) Beam blockage by terrain
10) Sector scanning either in initial processing or by separate sectorizing program
11) Output as binary files or NetCDF files suitable for display by WDSS-II

Building and Running the Programs

Program Description

The package consists of three programs

1) radaremul: reads one or more ARPS model history files and creates as output either a binary file with a volume of simulated radar data or sequence of netCDF files each containing a single variable at a single elevation angle.
2) radsector: reads the simulated radar output of radaremul (either binary or netCDF) and creates new files covering a specified sector within user-specified azimuth limits.
3) radarpltncar: Plots radar data (reflectivity or radial velocity) PPI's from binary files or netCDF files. radarpltncar outputs graphics as an NCARgraphics gmeta file (use idt to view). radarpltpost outputs graphics as a Postscript file (use ggv to view).

Each program will be described in detail in the following sections.

Required Data Files

The program reads output files from the ARPS model. These data may be high-resolution forecasts initialized with or simulations of atmospheric features. ARPS model files consist of two types, the static grid-base file, denoted as runname.fffgrdbas, where "fff" is the file format (e.g., "hdf "for hdf files, "bin" for binary files), and the time dependent file, denoted as runname.fffTTTTTT, where T is the six-digit number representing the number of seconds in the run since the initial time. In both cases runname is a string containing the runname. The runname string is assigned by the user or automated process which created the forecast. Generally, runname might contain abbreviations for the case being simulated, the time and the resolution, but there is no set convention.

The grid-base file contains information about the grid, its location on the earth, the map projection used, the vertical distribution of grid points, and the height of the terrain. It also contains information about the base-state, which is the mean distribution of the state variables in the model. The base state remains constant during the model run.

The time-dependent file contains information about the atmosphere as it develops as a function of time.

Programs exist to convert many NCEP model forecasts to the ARPS model grid (ext2arps in the ARPS model software package) and also to convert WRF forecasts to the ARPS model grid (wrf2arps).

Building the programs

An automated *make* script utilizing the Unix *make* utility is used to build the programs. The executable file is created in the *bin* directory below the top directory of the ARPS model software package. Issue the following command from the top directory of the ARPS software package containing the *radaremul* source code:

makearps [option flags] radaremul

where *[option flags]* represents one of the following combinations of option flags:

a) *-io hdf*
   This builds a version of the radar emulator that is able to read ARPS history files in the HDF format, but due to the incompatibility between netCDF and HDF libraries it cannot write the netCDF files. So, netCDF option is disabled automatically (*-io nonetcdf*). The binary volume writer is employed and the user must run *radsector* to creat the netCDF files from the binary volume file. This is the default option (if no io flags are specified).
b) *–io netcdf*
   This combination of builds a version of radaremul that can read binary files and write netCDF files directly. HDF option will be disabled automatically (*-io nohdf*). So the program cannot read ARPS history files in HDF format.
c) *–d*
   This flag can be added to the makearps command to build a debug version of the program (no optimization and certain debug information is retained during the run). Compile time is reduced, but runtime is significantly longer without optimization.

d) *–opt N (N=0,1,2 or 3)*
opt flag is added to specify the level of optimization. 3 is the default.

Similarly for *radsector*,
makearps [option flags] radsector, where the option flags are the same as for *radaremul*.

a) *–io netcdf* (implies *–io nohdf*)
This combination of builds a version of *radsector* that can read binary files and write netCDF files directly
b) *–d*
This flag can be added to the *makearps* command to build a debug version of the program without optimization. Runtime for this program is not significantly improved with optimization.
c) *–opt N (N=0,1,2 or 3)*
opt flag is added to specify the level of optimization. 3 is the default

And for *radarpltncar* and *radarplotpost*
makearps [option flags] radarpltncar
makearps [option flags] radarpltncar

a) *–io netcdf*
This combination of builds a version of *radsector* that can read netCDF files
b) *–d*
This flag can be added to the *makearps* command to build a debug version of the program without optimization. Runtime for this program is not significantly improved with optimization.
c) *–opt N (N=0,1,2 or 3)*
opt flag is added to specify the level of optimization. 3 is the default

Running the Remapping Program

To run the radar emulator issue the following command, from the top level directory:
bin/radaremul < input/radaremul.input >! radaremul.output

Where the file `radaremul.input` is the input file for *radaremul*, containing several Fortran 90 NAMELIST blocks. A sample input file is provided in the ARPS distribution as `input/radaremul.input`. A complete list of NAMELIST blocks and NAMELIST variables, with sample and suggested values is included in the Appendix of this document.

Creating netCDF sector files

To create netCDF sector files from the binary radar volume data or from netCDF files containing sectors larger than those desired, issue the following command from the top level directory:

bin/radsector Filename [-indir input_directory] -outdir output_directory -azimbgn beginning_azimuth -azimend ending_azimuth

Where *Filename* is the binary file output of *radaremul*. The default input directory is the present working directory, unless a full file path is specified in *Filename*. The beginning and ending azimuths are to be given in clockwise order, even if the data were collected with the radar spinning in the opposite direction. The azimuth limits can cross zero (North). For example,

-azimbgn 340 –azimend 20

Gives a 40 degree sector centered at due North, while

-azimbgn 20 –azimend 340

selects a 320 degree sector, centered due South.

Running the Plotting Program

bin/radarpltncar < input/radarplt.input

or

bin/radarpltpost < input/radarplt.input

Description and Theoretical Bases for Emulation Algorithms

Steps in processing:

1. Calculate the effective horizontal beamwidth from the antenna beamwidth, rotation rate and number of samples used in moment calculations.
   The effective beamwidth is found from the solution of the following equation as described in Section 7.8 of Doviak and Zrnic' (1993):

   $$erf\left[2\sqrt{\ln 4}\left(\theta_{ef}/\theta_{w6}\right)\right] - erf\left[2\sqrt{\ln 4}\left(\theta_{ef} - \alpha M T_s\right)/\theta_{w6}\right] - 0.5 erf\left[\sqrt{\ln 4}\left(\alpha M T_s/\theta_{w6}\right)\right] = 0$$

   Where

   $$erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x \exp(-\xi)\, d\xi$$

An iterative method is used to find a solution for the two (positive and negative) solutions and the beamwidth is the difference between those solutions. A threshold of 10-6 is used to detect convergence to zero.

2. Average each of the model wind components from the model's staggered u-v-w grid to the model's scalar grid points. A simple average is used to find the value at the scalar point, midway between adjacent wind points.
3. Estimate reflectivity from model hydrometeor variables (mixing ratios of rain, snow and hail).
4. Estimate hydrometeor terminal velocity from the model hydrometeor variables.
5. Calculate the elevation angle and azimuth angle to each of the scalar grid points, using the 4/3rds earth approximation.
6. Using the model winds, terminal velocities, and viewing angle from the radar, calculate the radial velocities at each scalar point.
7. For all elevation angles and azimuths and range gates:
    a. Calculate the range of points on the Cartesian grid to consider based on the beamwidth and range gate size at this range. The vertical limit to the averaging volume is determined by the angular beamwidth and the elevation angles at each vertical-level (as determined in Step 5).
    b. Over this volume of points accumulate weighted sums and a data counter for weighted reflectivity and velocity:

    Reflectivity:

$$\eta = \frac{\sum_{vol} |W(r)|^2 f^4(\theta,\phi)\eta_{i,j,k}}{\sum_{vol} |W(r)|^2 f^4(\theta,\phi)}$$

    Radial Velocity:

$$v = \frac{\sum_{vol} v_{i,j,k} |W(r)|^2 f^4(\theta,\phi)\eta_{i,j,k}}{\sum_{vol} |W(r)|^2 f^4(\theta,\phi)\eta_{i,j,k}}$$

    Range weighting, from Doviak and Zrnic' (1993), Eq. 11.118

$$|W(r)|^2 = \exp\left[-(r-r_0)^2/2\sigma_r^2\right]$$

    Where, from Doviak and Zrnic' , Eq. 5.76:

$$\sigma_r^2 = (0.35c\tau/2)^2$$

    Azimuth and elevation weighting, Wood and Brown (1997), Eq. A.3

$$f^4(\theta,\phi) = \exp\left\{-4\ln 4\left[\left(\frac{\theta_{i,j,k}-\theta_0}{\theta}\right)^2 + \left(\frac{\phi_{i,j}-\phi_{i,j}}{\phi}\right)^2\right]\right\}$$

Where the count of data in the sums is fewer than a user-specified limited (default:3), then an interpolated value (tri-linear) is used in place of the weighted averages.
c. Calculate mean moments from the weighted sums

8. Accounting for beam-blockage and ground clutter

9. Calculate reflectivity and velocity noise.
There are two options for noise, a Guassian distribution with a fixed dBZ value or a noise value based on the radar operating characterstics and signal-to-noise ratio of the signal.
   a. The reflectivity noise in dB from the radar operating characteristics is calculated (Doviak and Zrnić 1993):

$$\sigma_z = 1 + \sqrt{\frac{1}{N_I}\left(\left(1+\frac{1}{S_n}\right)^2 + \left(\frac{1}{S_n}\right)^2\right)}$$

where N_I is the number of independent samples, and S_n is the signal-to-noise ratio which is calculated via the familiar weather radar equation (e.g. Doviak and Zrnic' 1993, Eq. 4.35),

$$S_n = \frac{S}{R_n} = \frac{P_{const} Z_e}{R_n r^2}$$

$$P_{const} = \frac{\pi^5 10^{-17} P_t g^2 g_s \tau \theta_1^2 |K_w|^2}{6.75x2^{14}(\ln 2)\lambda^2}$$

where R_n is the receiver noise in mW (specified in the input file as dBm), Pt is the transmitter power (W) g is the antenna gain, gs is the receiver gain, t is the pulse length (μs), Ze is the reflectivity in mm^6/m, r is the range in km and λ is the wavelength in cm.

N_I is estimated from two user inputs, the number of samples, N, and a value for the degree of independence of the signal, I.

$N_I = NI$

where $0 < I \leq 1$

This is converted to a reflectivity factor noise through the inverse of the weather radar equation.

   b. The radial velocity noise is calculated from.

10. Write binary data files or NetCDF files for reading by WDSS-II.

<u>*Attenuation*</u>

Sensitivity

$$Z_{\min} = \frac{CP_r R^2 \lambda^2 L}{P_t G^2 \tau \theta^2 \left| K_w^2 \right|}$$

Table 1

Parameter	Symbol	Input Variable	Value (CASA NetRad)	Value (NEXRAD)	Units
Wavelength	λ		3	10	cm
Antenna Beamwidth	θ		1.8	0.9	degrees
Antenna Gain	G		38		dB
Range	R		0-30	0-230	km
Transmitter Power	Pt		25	250	kW
System Losses	L		20	20	dB
Receiver Noise	Pmin		-106.2	-130.0	dBm
Pulse Length	τ		typical	typical	μs
Dielectric Constant of Water	|Kw2|		0.93	0.93	

Nyquist Velocity

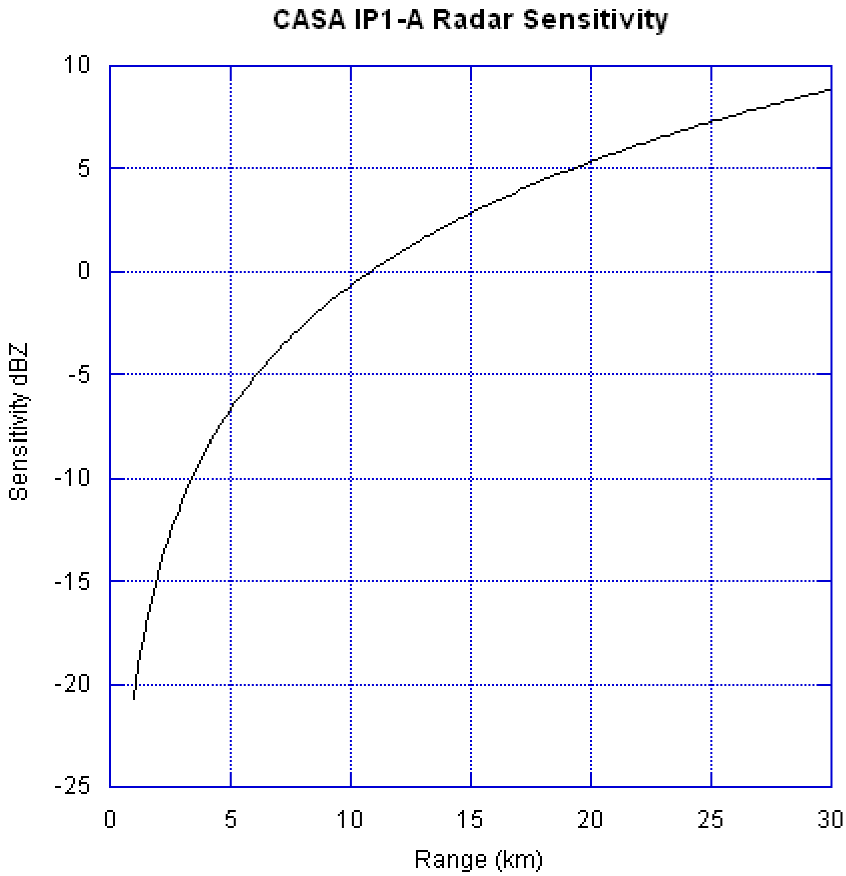
The Nyquist, or maximum unambiguous, velocity, Va, is calculated from the wavelength, l, and pulse-repetition time, Ts, based on the following equation for single-pulse mode

$$V_a = \frac{\lambda_s}{4T_s}$$

And for dual-pulse mode, with the first pulse repetition time Ts1 and second pulse repetition time Ts2:

$$V_a = \frac{\lambda}{4\left(T_{s2} - T_{s1}\right)}$$

Optionally the Nyquist velocity can be set manually for testing, or to create a field without any velocity folding (by setting an artificially high Nyquist velocity). See the description for input variables *nyqopt* and *vnyquist*.



Reflectivity Noise Estimation

Reflectivity noise is based on the signal-to-noise ratio (SNR). SNR is calculated from the returned power, the radar equation. Radar hardware specifications such as transmitted power, antenna gain, receiver mis-match loss, receiver noise are specified in the input file. Sample values of these parameters are shown in Table 1.

Radar	NEXRAD	TDWR	CASA NetRad
Wavelength (cm)	10.5	10.5	3.2
Transmit Power (W)	250000.	200000.	25000.
Antenna Gain (dB)	38.	30	30
Receiver Loss (dB)	5.0	5.0	5.0
Receiver Noise (dBm)	-100	-100	-100.

Radial Velocity Noise Estimation

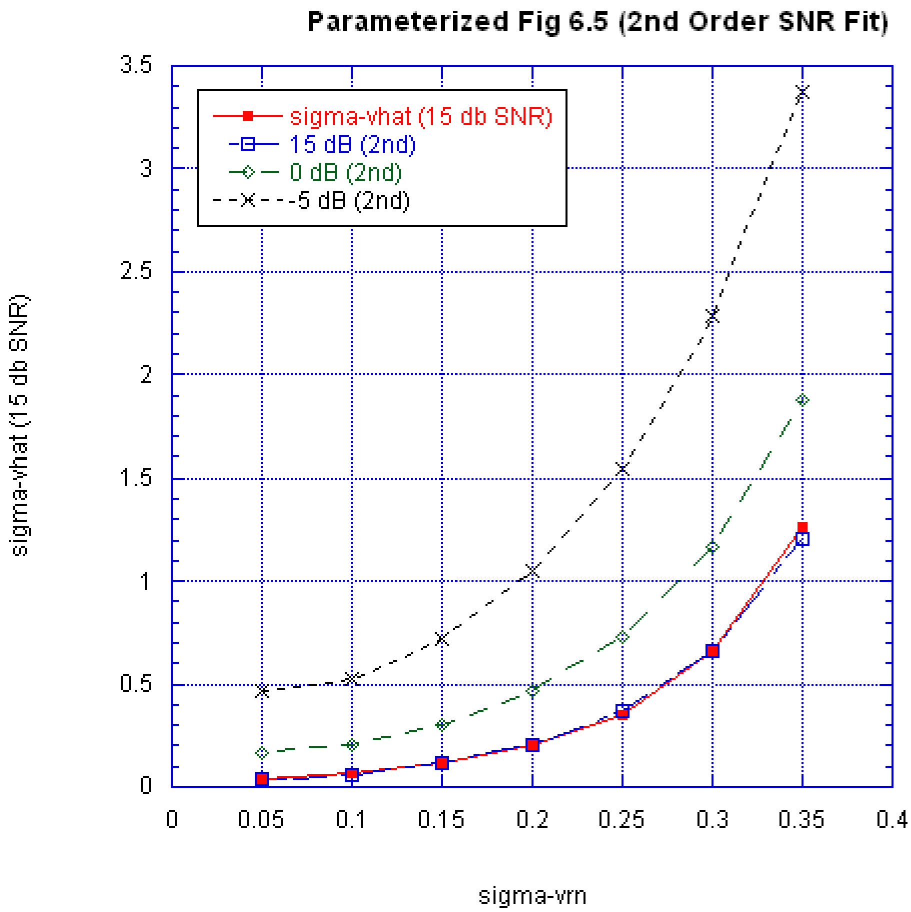


Fig. 2 Parameterization of Fig 6.5 of Doviak and Zrnic', 1993.

References:

Doviak, R.J. and D.S. Zrnic', 1993: *Doppler Radar and Weather Observations, 2nd Ed.*, Academic Press, 562 pp.

Wood, V.T. and R.A. Brown, 1997: Effects of radar sampling on single-Doppler velocity signatures of mesocyclones and tornadoes. *Wea. Forecasting*, **12**, 928-938.

Input variables: radaremul

Model Output History File Information (&history_data)

Parameter	Definition/Purpose	Options/Suggested Values
hinfmt	History data dump format option. 1 : unformatted binary data 2 : formatted ASCII data 3 : NCSA HDF4 format data 4 : Packed binary data 5 : Savi3D visualization package; 6 : Binary allowing data point skip 7 : NetCDF format 8 : Packed NetCDF format 9 : GrADS data 10 : GRIB data 11 : Vis5D data	Commonly: hinfmt=3
hdmpinopt	Indicates the way history data files are specified. 1 : Data are at a constant time interval given start and end times. The files names are constucted using ARPS history data naming convention given file header (runname plus directory name in arps). Used for processing a long sequence of files 2 : Data files are explicitly named. Commonly used for processing 1 to 10 files.	Commonly: hdmpinopt=2
hdmpheader	History data file name header (not including '.' at the end), corresponding to runname plus directory name. (Used only for hdmpinopt=1.)	Example: hdmpheader= '/data/may20/may20a'

Parameter	Definition/Purpose	Options/Suggested Values
hdmptrailer	Character string (if any) that follows the time in the history file name. Usually it is for version number, grid number etc. Note: DO NOT include '.gz' associated with file compression. If none, set to null string: ‘’. (Used only for hdmpinopt=1.)	Example: hdmpftrailer='.g01.01'.
tintv_dmpin	Time interval (seconds) between history data dumps used (Used only for hdmpinopt=1.)	Example: tintvdmpin=300..
tbgn_dmpin	Time (seconds into model run) at which input history data begins. (Used only for hdmpinopt=1.)	Example: tintvdmpin=300..
tend_dmpin	Time (seconds into model run) at which input history data ends. (Used only for hdmpinopt=1.)	Example: tintvdmpin=300..
grdbasfn	Path and name of model grid-base file. (Used only for hdmpinopt=2.)	..
nhisfile	Number of history files named. (Used only for hdmpinopt=2.)	
hisfile(i)	Path and name(s) of history files to process. (Used only for hdmpinopt=2.)	

Grid Adjustment Options
(&grid_adj)

Parameter **Definition/Purpose** **Options/Suggested Values**

adjctr	Adjust center of grid. 0 : Use ctrlat and ctrlon from data file 1 : Use ctrlatem and ctrlonem specified in this namelist block Note that the specified grid center is valid at time=0, if there is a umove, vmove associated with the model data, that grid movement will be applied after the ctrlat adjustment to allow storm movement with time.	adjctr=0
ctrlatem	Center latitude (degrees North) Used only for adjctr = 1	ctrlatem=35.0
ctrlonem	Center longitude (degrees East) Used only for adjctr = 1	ctrlonem=-98.0
adjhgt	Adjust grid point heights 0 Use heightsfrom data file 1 Adjust all heights using hgtoffset Needed when model run is done using AGL heights and radaremul uses MSL heights.	adjhgt=0
hgtoffset	Height offset (m) to add to all heights in model grid. Used only when adjhgt=1	hgtoffset=340.
adjmove	Adjust grid movement 0 : Use grid movement (if any) from data file 1 : Reset grid movement	Typical: adjmove=0
umovein	Grid movement in the x-direction (ms^{-1} Eastward)	Example: umovein=3.

vmovein	Grid movement in the y-direction (ms^{-1} Northward)	Example: vmovein=14.

Output Options
(&output_opts)

Parameter	Definition/Purpose	Options/Suggested Values
ifmt	Format of output 1 Binary dump for plotting 2 NetCDF file for WDS-II Input (compile with -io net)	ifmt=1.
creidx	creidx Create Index File Containing NetCDF filenames? (for ifmt=2) 0 : No 1 : Yes	creidx=1.
ipktyp	netCDF packing type use ipktyp=1 Used only for ifmt=2	Use ipktyp=1.
nbits	NetCDF pack bits	Use nbits=16
outdir	Output directory name	dirname='./radar'
nsmvort	Number of times to smooth vorticity field.	dirname='./radar'
wrtuaref	Write separate file containing unattenuated reflectivity? 0 : No 1 : Yes	Wrtuaref=0
wrtuavel	Write separate file containing unattenuated velocity? 0 : No 1 : Yes	Wrtuavel=0

wrtvort	Write separate file containing vertical vorticity interpolated to radar gate? Useful for verification of radial velocity signatures. 0 : No 1 : Yes	wrtvort=1

Radar Hardware Specification (&radar_specs)

Parameter	**Definition/Purpose**	**Options/Suggested Values**
radname	Radar name	Example for Cyril, OK radname='KCYR'
locopt	Location Specification Option 1: Use radar lat,lon to get x,y 2: Use radar x,y to get lat, lon	Example: Locopt=2
radlat	Radar latitude (degrees North) Used only when locopt=1	Example for Cyril: radlat=35.0
radlon	Radar longitude (degrees East) Used only when locopt=1	Example for Cyril: radlon=-98.0
xrad	Radar x coordinate (km) Used only when locopt=2	Example: radx=15.0
yrad	Radar y coordinate (km) Used only when locopt=2	Example: rady=20.0
radelv	Radar elevation (m MSL) Used only when locopt=1	Example for Cyril radelv=350.

Latitude and Longitudes for Sample Radars in Oklahoma

Site Name	Site ID	Latitude	Longitude	Feedhorn Elevation

Oklahoma City (NEXRAD)	KTLX	35.3331	-97.2778	389.4
Frederick (NEXRAD)	KFDR	34.3622	-98.9764	400.9
Enid/Vance (NEXRAD)	KVNX	36.7408	-98.1275	378.9
FAA OKC TDWR	KOKC	37.2759	-97.5104	373.4
Chickasha NetRad	KSAO	35.0314	-97.95611	355.4
Rush Springs NetRad	KRSP	34.8128	-97.93056	435.9
Lawton NetRad	KLWE	34.6239	-98.27083	396.2
Cyril NetRad	KCYR	34.8740	-98.25212	445.3

wavelen	Radar wavelength (cm)	wavelen=10.5 (NEXRAD) wavelen=3.2 (NetRad)
beamwid	Antenna pattern half-power beamwidth (degrees)	Beamwid=0.9 (NEXRAD) beamwid=1.8 (NetRad)
pwrxmit	Transmitter peak power (Watts) (Used to calculate SNR for error estimation)	pwrxmt=250000. (NEXRAD) pwrxmt=25000. (NetRad)
gaindb	Antenna gain (dB)	gaindb=30. (NEXRAD) Pwrxmt=38. (NetRad)
lossdb	Receiver/system mismatch loss (dB)	lossdb=5. (NEXRAD) lossdb=5. (NetRad)

Radar Operating Mode Description (&radar_op)

nelev	Value to assign to missing data	rmisval=-99900.
vcp	NEXRAD velocity coverage pattern number. Use 0 for NetRad and to use custom elevation angles, specified below.	rmisval=-99900.

elev(i)	Elevation angles (i=1,…nelev)	rmisval=-99900.
ngate	Number of range gates	Typical: ngate=300
gatesp	Range gate spacing (m)	Typical: gatesp=100.
rotdir	Antenna rotation direction 1 : Clockwise -1 : Counterclockwise 2 : Alternating, beginning clockwise -2 : Alternating, beginning counter-clockwise	Typical: rotdir=1
rotropt	Rotation rate calculation option 1: Fixed rotation rate specified by rotrate, and delaz calculated from rotrate, PRT and npulse 2: Fixed azimuthal sampling (delaz) with rotation rate calculated from PRT and npulse	Typical: rotropt=1.
rotrate	Antenna rotation rate (degrees/sec)	Typical: rotrate=18.
delaz	Azimuth sampling interval (degrees) Used only when rotropt=2	Typical: delaz=1.0
azim1	Beginning azimuth of sector scan.	Typical: azim1=0.0

azim2	Ending azimuth of sector scan azim1 and azim2 must be specified in a clockwise order even if scanning is done counterclockwise. Use azim2=azim1 to scan entire circle.	Typical: azim2=0.0
unifpuls	Uniform Pulse Form Option 0: Pulse forms specified individually by tilt number 1: Uniform pulse form for all tilts specfied in index 1. Applies to pulse length, width, PRT and npulse	Typical: unifpuls=1
dualprf	Dual PRF Option 0: Single PRF 1: Dual PRF	Typical: dualprf=0 (NEXRAD) dualprf=1 (NetRad)
pulseopt	Pulse Specification Option 1: Specify pulse length in seconds 2: Specify pulse width in meters	Typical: pulseopt=1
pulselen1	Pulse length (seconds) (first PRF) One for each elevation angle unless unifpuls=1, then just a single value at index=1	pulselen1(1)= (NEXRAD) pulselen1(1)= (NetRad)
pulselen2	Pulse length (seconds) (second PRF) One for each elevation angle unless unifpuls=1, then just a single value at index=1 Used only for dual-PRF mode	pulselen2(1)= (NetRad)
pulsewid1	Pulse width (meters) (first PRF) One for each elevation angle unless unifpuls=1, then just a single value at index=1	pulsewid1(1)= (NEXRAD) pulsewid1(1)= (NetRad)
pulsewid2	Pulse length (meters) (second PRF) One for each elevation angle unless unifpuls=1, then just a single value at index=1 Used only for dual-PRF mode	pulsewid2(1)= (NetRad)

prt1	First pulse repetition time (seconds)	prt1=1.06e-03 (NEXRAD) prt1=1.0e-03 (Netrad)
prt2	Second pulse repetition time (seconds) Used only in dual-PRF mode.	prt1=1.06e-03 (NEXRAD) prt1=1.0e-03 (Netrad)
npulse1	Number of samples used to compute moments. First PRF.	Typical: npulse=76 (NEXRAD) npulse=64 (Netrad)
npulse2	Number of samples used to compute moments. Second PRF. Used only in dual-PRF mode.	Typical: npulse=76 (NEXRAD) npulse=64 (Netrad)

Emulation Specification (&emul_specs)

Parameter	**Definition/Purpose**	**Options/Suggested Values**
nptsazm	Number of points to use to integrate the beam-weighting function in the azimuth direction.	nptsazm > 4
nptselv	Number of points to use to integrate the beam-weighting function in the elevation direction.	nptselev> 4
nptsrng	Number of points to use to integrate the beam-weighting function in the range direction.	nptsrng > 4
evalwid	Multiple of beamwidth for search radius in calculating beam-weighting integral	Recommended 1.5 > evalwid > 2.0
refmin	Minimum reflectivity for velocity integration.	refmin=0.

rngmin	Minimum range of data (m from radar) to report	rngmin=100.
kntrmin	Minimum number of grid potins for valid weighted average of reflectivity	Recommended kntrmin = 3
kntvmin	Minimum number of grid potins for valid weighted average of reflectivity	Recommended kntvmin = 3
attenopt	Attenuation option 0 : No attenuation 1 : X-band attenuation	Typical: attenopt=0 (NEXRAD) attenopt=1 (NetRad)
senstvopt	Data with attenuated signal strength less than estimated radar sensitivity are set to missing. 0 : No sensitivity thresholding 1 : Apply X-band sensitivity thresholding	Typical: senstvopt=0 (NEXRAD) senstvopt=1 (NetRad)
rferropt	Reflectivity Error Option 0 : No added reflectivity error 1 : Use fixed reflectivity error, sigmarf 2 : Calculate reflectivity error based on SNR	Typical: rferropt=2
rferrloi	Level of independence of samples assumed for rferropt=2 0.0 < rferrloi <= 1.0 1.0 indicates samples are completely independent	Typical: rferrloi=0.5
sigmarf	Standard deviation of error for reflectivity (dBZ) Use 0 for no added Gaussian error	Typical: sigmarf=1.0
vrerropt	Radial Velocity Error Option 1 : Use fixed vr error, sigmavr 2 : Calculate vr based on estimated SNR, estimated spectrum width and number of samples..	Typical: vrerropt=2

samploi	Level of independence of samples assumed for SNR-based error 0.0 < samploi <= 1.0 1.0 indicates pulse samples are completely independent	Typical: samploi=0.5
stdvrmul	Multiplier converting standard deviation of velocities used in evaluating beam integral to an estimate of spectrum width for use in vrerropt=2.	Typical: stdvrmul=1.5
sigmavr	Standard deviation of error for velocity (m/s). Base standard deviation of error for velocity for vrerropt=2	Typical: sigmavr=1.0
tmadvopt	Option to advance time with each tilt to simulate time change during volume scan. 0: time for all tilts same as forecast file time 1: advance time by timeincr seconds for each tilt (default) 2 : advance time by number of seconds actual tilt scan would take function of sector size and rotation rate.	Typical: tmadvopt=1
timeincr	Time increment (seconds) for tmadvopt=1	Typical: timeincr=1.0
rmisval	Value to assign for missing data	rmisval=-99900.
rngfval	Value to assign for range-folded data.	rngfval=-99901.
nyqstopt	Nyquist Velocity option 1 : Used fixed Nyquist Velocity 2 : Use calculated Nyquist Velocity, based on PRT	Typical: nyqstopt=2

vnyquist	Nyquist velocity (ms^{-1}), one per elevation angle. Used when nyqstopt=1 Use large positive value for no Nyquist folding.	Typical: vnyquist=35.