WMO IPET-OWR

WMO Member Use of the CfRadial2 Data File Format

DRAFT

(Maps to Version 2 of CfRadial, 2017-03-08)

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4 Root group

4.1 Global attributes

Attribute name	Type	Convention	Description	IMID	WMO Use
Conventions	string	CF	Conventions string will specify “Cf/Radial”.	-	“Cf/Radial”
version	string	CF/Radial	CF/Radial version number (“2.0”)	-	“2.0”
title	string	CF	Short description of file contents	-	Example needed.
institution	string	CF	Where the original data were produced	-	**Mandatory**: Part 1 of WIGOS identifier. See below.
references	string	CF	References that describe the data or the methods used to produce it	-	Example needed
source	string	CF	Method of production of the original data	**1.5**	
history	string	CF	List of modifications to the original data	-	Example needed
comment	string	CF	Miscellaneous information	-	How can this be mandatory?
instrument_name	string	CF/Radial	Name of radar or lidar	**1.0**	“radar” or “lidar”
site_name	string	CF/Radial	Name of site where data were gathered	**1.1**	**Mandatory**: Part 4 of WIGOS identifier. See below.
scan_name	string	CF/Radial	Name of scan strategy used, if applicable	**1.4**	

Attribute name	Type	Convention	Description	IMID	WMO Use
scan_id	int	CF/Radial	Scan strategy id, if applicable. Assumed 0 if missing.	**-**	
platform_is_mobile	string	CF/Radial	"true" or "false" Assumed "false" if missing.	**2.6**	
ray_times_increase	string	CF/Radial	"true" or "false" Assumed "true" if missing. This is set to true if ray times increase monotonically throughout all of the sweeps in the volume.	**8.4**	**Discrepancy**: 8.4 is a "real", positive values="true". Not same as "scan_rate"
field_names	string[]	CF/Radial	Array of strings of field names present in this file.	**-**	Can be derived
time_coverage_start	string	CF/Radial	Copy of time_coverage_start global variable in 4.3.	**1.2**	
time_coverage_end	string	CF/Radial	Copy of time_coverage_end global variable in 4.3.	**1.3**	
simulated data	string	ODIM	"true" or "false" Assumed "false" if missing. Data in this file are simulated	**1.8**	

WIGOS identifier (to replace similar formulations in IM and DM)

The WIGOS identifier[1] structure consists of four parts.

Part 1 consists of an ISO 3166-1 three-digit numeric country code, or a value assigned by WMO.

Part 4, called "Local identifier", is the only part consisting of characters. Following the ODIM convention (Michelson et al., 2014), it is suggested as a best practice, but not required, that the local identifier be harmonized to a five-character string, where the first two

[1] http://wis.wmo.int/page=WIGOS-Identifiers

characters are the member country's ISO 3166-1 alpha 2 ccTLD[2] code (lower case), and the latter three characters are freely-selectable (also lower case). What this convention introduces in terms of redundancy, it more than compensates for in terms of clarity.

4.2 Global Dimensions

Dimension name	Description	IMID	WMO Use
sweep	The number of sweeps in the dataset	-	Table 2 in DM can be summed
frequency	Number of frequencies used	-	Assumed to be 1

4.3 Global variables

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
volume_number		int		Volume numbers are sequential, relative to some arbitrary start time, and may wrap.	-	What is this?
platform_type		string		Options are: *"fixed", "vehicle", "ship", "aircraft", "aircraft_fore", "aircraft_aft", "aircraft_tail", "aircraft_belly", "aircraft_roof", "aircraft_nose", "satellite_orbit", "satellite_geostat"* Assumed "fixed" if missing.	**2.6**	**Discrepancy**: 2.6 is a Boolean where "true" = moving "false" = fixed

[2] http://www.iso.org/iso/country_codes

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
instrument_type		string		Options are: "*radar*", "*lidar*" Assumed "*radar*" if missing.	**1.0**	
primary_axis		string		Options are: *"axis_z", "axis_y", "axis_x", "axis_z_prime", "axis_y_prime", "axis_x_prime".* See section 9 for details. Assumed "*axis_z*" if missing.	**-**	"axis_z"
time_coverage_start		string		UTC time of first ray in file. Resolution is integer seconds. The **time(time)** variable is generally computed relative to this time. Format follows ISO 8601: YYYY-MM-DDThh:mm:ssZ NOTE: the T is optional, any single character may be used in this location.	**8.2**	**Discrepancy**: 8.2 is a high-precision relative time, a "float64" time_coverage_start is 8.2 of the first acquired ray.
time_coverage_end		string		UTC time of last ray in file. Resolution is integer seconds. Format is: YYYY-MM-DDThh:mm:ssZ NOTE: the T is optional, any single character may be used in this location.	**8.2**	**Discrepancy**: 8.2 is a high-precision relative time, a "float64" time_coverage_end is 8.2 of the last acquired ray.
latitude		double	degrees_north	Latitude of instrument. For a mobile platform, this is a latitude at the start of the volume.	**2.1**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
longitude		double	degrees_east	Longitude of instrument. For a mobile platform, this is the longitude at the start of the volume.	**2.0**	
altitude		double	meters	Altitude of instrument, above mean sea level. For a scanning radar, this is the center of rotation of the antenna. For a mobile platform, this is the altitude at the start of the volume.	**2.2**	
altitude_agl		double	meters	Altitude of instrument above ground level. Omit if not known.	**2.4**	
sweep_group_names	(sweep)	string		Array of names for sweep groups. Allows the user to locate the sweep groups directly.	**-**	Can be derived when creating file. Is there a convention for this?
sweep_fixed_angles	(sweep)	float	degrees	Array of fixed angles for sweeps. This summarizes the fixed angles for all of the sweeps, so that a user does not need to read individual sweep groups to determine the fixed angles. The value should be copied from the fixed_angle attribute in the sweep groups.	**-**	Can be derived when creating file.
frequency	(frequency)	float	s-1	List of operating frequencies, in Hertz. In most cases, only a single frequency is used.	**3.5**	Single frequency assumed

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
status_xml		string		General-purpose XML string for storing any information that is not included in other parts of the data structure.	**1.6** **1.7**	Use to report when and how instrument has malfunctioned. If missing, instrument has not malfunctioned.

Currently not found in CfRadial2:

IMID	Description
2.3	Geodetic datum name
2.5	Magnetic declination at site
3.6	Transmitter type
3.7	Manufacturer name
3.8	Model name
3.9	Signal processor name
3.10	Signal processor version

5 Sweep groups

5.1 Sweep-specific Dimensions

Dimension name	Description	IMID	WMO Use
time	The number of rays.	-	Derived when creating file
range	The number of range bins	-	
prt	Number of prts used in pulsing scheme. Optional for fixed, staggered or dual Required for more complicated schemes.	**8.8**	Sum number of PRTs in 8.8
spectrum_groups	Number of spectrum groups in this sweep	-	TBD

5.2 Sweep coordinate variables

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
time	(time)	double	seconds	Coordinate variable for time. Time at center of each ray, in fractional seconds since time_coverage_start, or since time_reference if it exists.	**8.2**	
range	(range)	float	meters	Coordinate variable for range. Range to center of each bin.	-	Can be derived, not necessary to record for fixed instruments

Comment [DBM1]: unspecified

5.2.1 Attributes for time coordinate variable

Attribute name	Type	Value	IMID	WMO Use
standard_name	string	"time"	-	
units	string	"seconds since *YYYY-MM-DD*T*hh:mm:ssZ*", where the actual reference time values are used. This unit string is **absolutely required.** NOTE: the T is optional, any single character may be used in this location.	**8.2**	Time of first ray acquired in sweep
calendar	string	Defaults to "gregorian" if missing. Options are: "gregorian" or "standard", "proleptic_gregorian", "noleap" or "365_day", "all_leap" or "366_day", "360_day", "julian" See CF conventions for details.	-	"gregorian"

5.2.2 Attributes for range coordinate variable

Attribute name	Type	Value	IMID	WMO Use
standard_name	string	"projection_range_coordinate"	-	
long_name	string	"range_to_measurement_volume"	-	
units	string	"meters"	-	
spacing_is_constant	string	"true" or "false"	-	Assumed "true"
meters_to_center_of_first_gate	float	Start range in meters.	**5.5**	

Attribute name	Type	Value	IMID	WMO Use
meters_between_gates	float	Gate spacing in meters. Required if spacing_is_constant is "true". Not applicable otherwise.	**11.0**	
axis	string	"radial_range_coordinate"	-	

5.3 Sweep variables

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
sweep_number		int		The number of the sweep, in the volume scan. 0-based.	-	Derived based on acquisition order
sweep_mode		string		Options are: *"sector", "coplane",rhi", "vertical_pointing", "idle", "azimuth_surveillance", "elevation_surveillance", "sunscan", "pointing", "manual_ppi", "manual_rhi"*	**5.0**	
follow_mode		string		options are: *"none", "sun", "vehicle", "aircraft", "target", "manual"* Assumed "*none*" if missing.	-	"none"

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
prt_mode		string		Pulsing mode Options are: *"fixed", "staggered", "dual", "hybrid"*. Assumed "*fixed*" if missing. May also be more complicated pulsing schemes, such as HHVV, HHVVH etc.	**5.4**	
polarization_mode		string		Options are: *"horizontal", "vertical", "hv_alt", "hv_sim", "circular"* Assumed "*horizontal*" if missing.	**5.3**	
polarization_sequence	(prt)	string		This only applies if prt_mode is set to "hybrid". As an example, the form of it would be ['H','H','V','V','H'] for HHVVH pulsing.		Not applicable
fixed_angle		float	degrees	Target angle for the sweep. elevation in most modes azimuth in RHI mode	**5.1**	
rays_are_indexed		string		"true" or "false" Indicates whether or not the ray angles (elevation in RHI mode, azimuth in other modes) are indexed to a regular grid.	**-**	"true" if read-out angles are unavailable, otherwise "false"
ray_angle_res		float	degrees	If rays_are_indexed is "true", this is the resolution of the angular grid – i.e. the delta angle between successive rays.	**8.3**	If rays_are_indexed is "false", then this is the read-out angular dwell

Comment [DBM2]: Is this delta assumed if read-out angles are missing?

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
qc_procedures		string		Documents QC procedures per sweep.	**13.1** **13.2** **13.3**	Derived list of QC identifiers, e.g. IM Table 14
target_scan_rate		float	degrees/s	Intended scan rate for this sweep. The actual scan rate is stored according to section 4.8. This variable is optional. Omit if not available.	**5.2**	
scan_rate	(time)	float	degrees/s	Actual antenna scan rate. Set to negative if counter-clockwise in azimuth or decreasing in elevation. Positive otherwise.	**8.4**	
azimuth	(time)	float	degrees	Azimuth of antenna, relative to true north. The azimuth should refer to the center of the dwell.	**8.1**	Read-out?
elevation	(time)	float	degrees	Elevation of antenna, relative to the horizontal plane. The elevation should refer to the center of the dwell.	**8.0**	Read-out?
antenna_transition	(time)	byte		1 if antenna is in transition, i.e. between sweeps, 0 if not. If variable is omitted, the transition will be assumed to be 0 everywhere. Assumed 0 if missing.	**8.5**	
pulse_width	(time)	float	seconds		**8.7**	Scaling: 8.7 is in µs

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
calib_index	(time)	int		Index for the radar calibration that applies to this pulse width. See section 7.3.	-	Calibration groups are derived
rx_range_resolution	(time)	float	meters	Resolution of the raw receiver samples. If missing, assumed to be meters_between_gates (5.2.2). Raw data may be resampled before data storage.		Not available. Not needed?
prt	(time)	float	seconds	Pulse repetition time. For staggered prt, also see prt_ratio.	**8.8**	
prt_ratio	(time)	float		Ratio of prt/prt2. For dual/staggered prt mode.	**8.8**	Derived
prt_sequence	(time, prt)	float	seconds	Sequence of prts used. Optional for fixed, staggered and dual, which can make use of 'prt' and 'prt_ratio'. Required for more complicated pulsing schemes.	**8.8**	
nyquist_velocity	(time)	float	m/s	Unambiguous velocity. This is the effective nyquist velocity after unfolding. See also the field-specific attributes fold_limit_lower and fold_limit_upper, 5.6.	**8.9**	
unambiguous_range	(time)	float	meters	Unambiguous range	**8.10**	
n_samples	(time)	int		Number of samples used to compute moments	**8.11**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
spectrum_group_names	(spectrum_group)	string		Array of names of spectrum groups.	-	Derived

5.3.1 Attributes for azimuth(time) variable

Attribute name	Type	Value
standard_name	string	“ray_azimuth_angle”
long_name	string	“azimuth_angle_from_true_north”
units	string	“degrees”
axis	string	“radial_azimuth_coordinate”

5.3.2 Attributes for elevation(time) variable

Attribute name	Type	Value
standard_name	string	“ray_elevation_angle”
long_name	string	“elevation_angle_from_horizontal_plane”
units	string	“degrees”
axis	string	“radial_elevation_coordinate”

5.4 The georeference sub-group

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
latitude	(time)	double	degrees_north	Latitude of instrument.	**9.0**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
longitude	(time)	double	degrees_east	Longitude of instrument.	**9.1**	
altitude	(time)	double	meters	Altitude of instrument, above mean sea level. For a scanning radar, this is the center of rotation of the antenna.	**9.2**	
heading	(time)	float	degrees	Heading of the platform relative to true N, looking down from above.	**9.3**	
roll	(time)	float	degrees	Roll about longitudinal axis of platform. Positive is left side up, looking forward.	**9.4**	
pitch	(time)	float	degrees	Pitch about the lateral axis of the platform. Positive is up at the front.	**9.5**	
drift	(time)	float	degrees	Difference between heading and track over the ground. Positive drift implies track is clockwise from heading, looking from above. NOTE: not applicable to land-based mobile platforms.	**9.6**	
rotation	(time)	float	degrees	Angle between the radar beam and the vertical axis of the platform. Zero is along the vertical axis, positive is clockwise looking forward from behind the platform.	**9.7**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
tilt	(time)	float	degrees	Angle between radar beam (when it is in a plane containing the longitudinal axis of the platform) and a line perpendicular to the longitudinal axis. Zero is perpendicular to the longitudinal axis, positive is towards the front of the platform.	**9.8**	
eastward_velocity	(time)	float	m/s	EW velocity of the platform. Positive is eastwards.	**9.9**	
northward_velocity	(time)	float	m/s	NS velocity of the platform. Positive is northwards.	**9.10**	
vertical_velocity	(time)	float	m/s	Vertical velocity of the platform. Positive is up.	**9.11**	
eastward_wind	(time)	float	m/s	EW wind at the platform location. Positive is eastwards.	**9.12**	
northward_wind	(time)	float	m/s	NS wind at the platform location. Positive is northwards.	**9.13**	
vertical_wind	(time)	float	m/s	Vertical wind at the platform location. Positive is up.	**9.14**	
heading_rate	(time)	float	degrees/s	Rate of change of heading	**9.15**	
roll_rate	(time)	float	degrees/s	Rate of change of roll of the platform	**9.16**	
pitch_rate	(time)	float	degrees/s	Rate of change of pitch of the platform.	**9.17**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
georefs_applied	(time)	byte		1 if georeference information for mobile platforms has been applied to correct the azimuth and elevation. 0 otherwise. Assumed 0 if missing.	**8.6**	

5.5 The monitoring sub-group

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
radar_measured_transmit_power_h	(time)	float	dBm	Measured transmit power H polarization	**10.0**	
radar_measured_transmit_power_v	(time)	float	dBm	Measured transmit power V polarization	**10.1**	
radar_measured_sky_noise	(time)	float	dBm	Noise measured at the receiver when connected to the antenna with no noise source connected.	**10.2**	
radar_measured_cold_noise	(time)	float	dBm	Noise measured at the receiver when connected to the noise source, but it is not enabled.	**10.3**	
radar_measured_hot_noise	(time)	float	dBm	Noise measured at the receiver when it is connected to the noise source and the noise source is on.	**10.4**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
phase_difference_transmit_hv	(time)	float	degrees	Phase difference between transmitted horizontally and vertically-polarized signals as determined from the first valid range bins	10.5	
antenna_pointing_accuracy_elev	(time)	float	degrees	Antenna-pointing accuracy in elevation	10.6	
antenna_pointing_accuracy_az	(time)	float	degrees	Antenna-pointing accuracy in azimuth	10.7	
calibration_offset_h	(time)	float	dB	Calibration offset for the horizontal channel	10.8	
calibration_offset_v	(time)	float	dB	Calibration offset for the vertical channel	10.9	
zdr_offset	(time)	float	dB	ZDR offset (bias)	10.10	

5.6 Field data variables

NetCDF type	Byte width	Description
NC_UBYTE	1	scaled unsigned integer
~~ncbyte~~NC_BYTE	1	scaled signed integer
NC_USHORT	2	scaled unsigned integer
NC_SHORT~~short~~	2	scaled signed integer
NC_UINT	4	scaled unsigned integer

NetCDF type	Byte width	Description
NC_INT	4	scaled signed integer
NC_UINT64~~int~~	48	scaled unsigned integer
NC_INT64	8	scaled signed integer
NC_FLOAT~~float~~	4	floating point
NC_DOUBLE~~double~~	8	floating point

Attribute name	Type	Convention	Description	IMID	WMO Use
standard_name	string	CF	CF standard name for field. See section 8.	**12.0**	
Long_name	string	CF	Long name describing the field. Any string is appropriate. Although this is an optional attribute, its use is strongly encouraged.	**12.1**	CF-specific
Units	string	CF	Units for field	**12.2**	Section 8
_FillValue (or missing_value)	same type as field data	CF	Indicates data are missing at this range bin. Use of _FillValue is preferred. Only use one or the other.	**12.3**	For reflectivity data: 255.0 Conventions for other moments?
_Undetect	same as field data	ODIM	Indicates an area (range bin) that has been radiated but has not produced a valid echo	**12.4**	For reflectivity data: 0.0

Comment [DBM3]: “nodata” in ODIM

Comment [DBM4]: Preferable to “flag_values”?

Attribute name	Type	Convention	Description	IMID	WMO Use
scale_factor	float	CF	Float value = (integer value) * scale_factor + add_offset Only applies to integer types. Section 5.6.1.	-	**Mandatory**: According to DM Table 4. If unscaled values, then scale_factor=1.0
add_offset	float	CF	Float value = (integer value) * scale_factor + add_offset Only applies to integer types. Section 5.6.1.	-	**Mandatory**: According to DM Table 4. If unscaled values, then add_offset=0.0
coordinates	string	CF	Section 5.6.2.	-	"elevation azimuth range"
sampling_ratio	float	CF/Radial	Number of samples for this field divided by n_samples (see section 5.3). Assumed 1.0 if missing.	-	1.0
is_discrete	string	CF/Radial	"true" or "false" If "true", this indicates that the field takes on discrete values, rather than floating point values. For example, if a field is used to indicate the hydrometeor type, this would be a discrete field.	**12.5**	Use Section 5.6.7 "Legend XML" to represent IMID 12.6 and 12.7

Attribute name	Type	Convention	Description	IMID	WMO Use
field_folds	string	CF/Radial	"true" or "false" Used to indicate that a field is limited between a min and max value, and that it folds between the two extremes. This typically applies to such fields as radial velocity and PHIDP.	**-**	Derived according to variable
fold_limit_lower	float	CF/Radial	If field_folds is "true", this indicates the lower limit at which the field folds.	**8.9**	For VEL: -(value of 8.9) For others …
fold_limit_upper	float	CF/Radial	If field_folds is "true", this indicates the upper limit at which the field folds.	**8.9**	For VEL: +(value of 8.9) For others …
is_quality_field	string	CF/Radial	"true" or "false" "true" indicates this is a quality control field. If the attribute is not present, defaults to "false".	**12.8**	Assigned "true" if quality field
flag_values	array of same type as field data	CF	Array of flag values. These values have special meaning, as documented in flag_meanings.	**-**	Metadata for 16.31 or any other classification
flag_meanings	string[]	CF	Meaning of flag_values or flag_masks.	**-**	
flag_masks	array of same type as field data	CF	Valid bit-wise masks used in a flag field that is comprised of bit-wise combinations of mask values. See flag_meanings.	**-**	

Attribute name	Type	Convention	Description	IMID	WMO Use
qualified_variables	string[]	CF/Radial	Applicable if is_quality_field is "true". Array list of variables that this variable qualifies. Every field variable in this list should list this variable in its ancillary_variable attribute.	**13.0**	
ancillary_variables	string[]	CF	Array list of variables to which this variable is related. In particular, this is intended to list the variables that contain quality information about this field. In that case, the quality field will list this field in its qualified_variable attribute.	**12.9**	???
thresholding_xml	string	CF/Radial	Thresholding details. Supplied if thresholding has been applied to the field. This should be in self-descriptive XML. (See 5.6.6.)	**-**	(Many of DWD's ODIM extensions could be applied here)
legend_xml	string	CF/Radial	Legend details. Applies to discrete fields. Maps field values to the properties they represent. This should be in self-descriptive XML. (See 5.6.7.)	**12.6** **12.7**	

5.6.1 Use of scale_factor and add_offset

scale_factor and add_offset are required for ncbyte, short and int fields. They are not applicable to float and double fields.

float_value = (integer_value * scale_factor) + add_offset

5.6.2 Use of coordinates attribute

The “coordinates’ attribute lists the variables needed to compute the location of a data point in space.

For stationary platforms, the coordinates attribute should be set to:

“*elevation azimuth range*”

For mobile platforms, the coordinates attribute should be set to:

“*elevation azimuth range heading roll pitch rotation tilt*”

5.6.3 Use of flag values - optional

For all data sets, the **_FillValue** attribute has special meaning – see 3.5.

A field variable may make use of more than one reserved value, to indicate a variety of conditions. For example, with radar data, you may wish to indicate that the beam is blocked for a given gate, and that no echo will ever be detected at that gate. That provides more information than just using **_FillValue**.

The **flag_values** and **flag_meanings** attributes can be used in this case.

The **flag_values** attribute is a list of values (other than **_FillValue**) that have special meanings. It should have the same type as the variable.

The **flag_meanings** string attribute is an array of strings that indicate the meanings of each of the **flag_values**. If multi-word meanings are needed, use underscores to connect the words. For example you might use flag meanings of ‘no_coverage’ and ‘low_snr’ to distinguish between regions where the radar cannot see as opposed to regions where the signal is well below the noise.

5.6.4 Flag mask fields - optional

An integer-type field variable may contain values that describe a number of independent Boolean conditions. The field is constructed using the bit-wise OR method to combine the conditions.

In this case, the **flag_mask** and **flag_meanings** attributes are used to indicate the valid values in the field, and the meanings.

The **flag_masks** attribute is a list of integer values (other than **_FillValue**) that are bit-wise combinations valid for the field variable. It should have the same type as the variable.

The **flag_meanings** string attribute is an array of strings that indicate the meanings of each of the **flag_masks**. If multi-word meanings are needed, use underscores to connect the words.

5.6.5 Quality control fields - optional

Some field variables exist to provide quality information about another field variable. For example, one field may indicate the uncertainty associated with another field.

In this case, the field should have the **is_quality** string attribute, with the value set to “true”. If this attribute is missing, it is assumed to be “false”.

In addition, the field should have the **qualified_variables** string attribute. This is an array of field names that this field qualifies.

Each qualified field, in turn, should have the **ancillary_variables** string attribute. This is an array of fields that qualify it.

5.6.6 Thresholding XML

The thresholding_xml should contain self-explanatory information about any thresholding that has been applied to the data field, as in the following example:

```
<thresholding field="DBZ">
  <field_used>
    <name>NCP</name>
    <min_val>0.15</min_val>
  </field_used>
  <field_used>
     <name>SNR</name>
     <min_val>-3.0</min_val>
  </field_used>
  <note>NCP only checked if DBZ > 40</note>
</thresholding>
```

5.6.7 Legend XML

The legend_xml should contain self-explanatory information about the categories for a discrete field, as in the following example for particle type:

```
<legend label="particle_id">
  <category>
    <value>1</value>
    <label>cloud</label>
  <category>
  <category>
    <value>2</value>
    <label>drizzle</label>
  <category>
  .......
  .......
  <category>
    <value>17</value>
    <label>ground_clutter</label>
  <category>
</legend>
```

6 Spectrum groups

6.1 Spectrum-specific information on sweep

6.2 spectrum_index variable

6.3 Spectrum group dimensions

Dimension name	Description
index	Number of spectra stored in each spectrum variable in this group. This dimensions the number of indices used to locate the spectra, i.e. for the gates where the index is not -1.
sample	Number of samples in the spectra.

6.4 Spectrum field variables

NetCDF type	Byte width	Description
ncbyte	1	scaled signed integer
short	2	scaled signed integer
int	4	scaled signed integer
float	4	floating point
double	8	floating point

6.5 Spectrum field attributes

Attribute name	Type	Convention	Description
long_name	string	CF	Long name describing the field. Any string is appropriate. Although this is an optional attribute, its use is strongly encouraged.
standard_name	string	CF	CF standard name for field, or from section 8.
units	string	CF	Units for field
_FillValue or missing_value	same type as field data	CF	Indicates data are missing for a given sample. _FillValue is preferred.
scale_factor	float	CF	See section 5.6. Float value = (integer value) * scale_factor + add_offset. Only applied to integer types.
add_offset	float	CF	See section 5.6. Float value = (integer value) * scale_factor + add_offset. Only applied to integer types.
coordinates	string	CF	See section 5.6.2.
fft_length	int	CF/Radial	Length used to compute this spectrum

Attribute name	Type	Convention	Description
block_avg_length	int	CF/Radial	Number of block spectra averaged for each output spectrum.

7 Root group metadata groups

7.1 The radar_parameters sub-group

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
radar_antenna_gain_h	none	float	dBi	Nominal antenna gain, H polarization	**3.0**	
radar_antenna_gain_v	none	float	dBi	Nominal antenna gain, V polarization	**3.1**	
radar_beam_width_h	none	float	degrees	Antenna beam width H polarization	**3.2**	
radar_beam_width_v	none	float	degrees	Antenna beam width V polarization	**3.3**	
radar_receiver_bandwidth	none	float	s-1	Bandwidth of radar receiver	**3.4**	

7.2 The lidar_parameters sub-group

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
lidar_beam_divergence	none	float	milliradians	Transmit side	**4.0**	
lidar_field_of_view	none	float	milliradians	Receive side	**4.1**	
lidar_aperture_diameter	none	float	cm		**4.2**	
lidar_aperture_efficiency	none	float	percent		**4.3**	
lidar_peak_power	none	float	watts		**4.4**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
lidar_pulse_energy	none	float	joules		**4.5**	

7.3 The radarcalibration sub-group

7.3.1 Dimensions

Dimension name	Description	IMID	WMO Use
calib	The number of radar calibrations available	-	Derived, will depend on number of pulse widths in volume

7.3.2 Variables

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
calib_index	(time)	byte		Calibration index for each ray. Assumed 0 if missing.	-	Derived
time	(calib)	string	UTC	e.g. 2008-09-25 T23:00:00Z	**6.0**	
pulse_width	(calib)	float	seconds	Pulse width for this calibration	**6.1**	
antenna_gain_h	(calib)	float	dB	Derived antenna gain H channel	**6.2**	
antenna_gain_v	(calib)	float	dB	Derived antenna gain V channel	**6.3**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
xmit_power_h	(calib)	float	dBm	Transmit power H channel	**6.4**	
xmit_power_v	(calib)	float	dBm	Transmit power V channel	**6.5**	
two_way_waveguide_loss_h	(calib)	float	dB	2-way waveguide loss measurement plane to feed horn, H channel	**6.6**	
two_way_waveguide_loss_v	(calib)	float	dB	2-way waveguide loss measurement plane to feed horn, V channel	**6.7**	
two_way_radome_loss_h	(calib)	float	dB	2-way radome loss H channel	**6.8**	
two_way_radome_loss_v	(calib)	float	dB	2-way radome loss V channel	**6.9**	
receiver_mismatch_loss	(calib)	float	dB	Receiver filter bandwidth mismatch loss	**-**	Deprecated in CfRadial?
receiver_mismatch_loss_h	(calib)	float	dB	Receiver filter bandwidth mismatch loss H channel	**6.10**	
receiver_mismatch_loss_v	(calib)	float	dB	Receiver filter bandwidth mismatch loss V channel	**6.11**	
radar_constant_h	(calib)	float	m/mW dB units	Radar constant H channel	**6.12**	
radar_constant_v	(calib)	float	m/mW dB units	Radar constant V channel	**6.13**	
probert_jones_correction	(calib)	float	dB	Probert Jones antenna correction factor.	**6.14**	

Variable name	**Dimension**	**Type**	**Units**	**Comments**	**IMID**	**WMO Use**
dielectric_factor_used	(calib)	float		This is $\|K^2\|$ in the radar equation	**6.15**	
noise_hc	(calib)	float	dBm	Measured noise level H co-pol channel	**6.16**	
noise_vc	(calib)	float	dBm	Measured noise level V co-pol channel	**6.17**	
noise_hx	(calib)	float	dBm	Measured noise level H cross-pol channel	**6.18**	
noise_vx	(calib)	float	dBm	Measured noise level V cross-pol channel	**6.19**	
receiver_gain_hc	(calib)	float	dB	Measured receiver gain H co-pol channel	**6.20**	
receiver_gain_vc	(calib)	float	dB	Measured receiver gain V co-pol channel	**6.21**	
receiver_gain_hx	(calib)	float	dB	Measured receiver gain H cross-pol channel	**6.22**	
receiver_gain_vx	(calib)	float	dB	Measured receiver gain V cross-pol channel	**6.23**	
base_1km_hc	(calib)	float	dBZ	reflectivity at 1km for SNR=0dB noise-corrected H co-pol channel	**6.24**	
base_1km_vc	(calib)	float	dBZ	reflectivity at 1km for SNR=0dB noise-corrected V co-pol channel	**6.25**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
base_1km_hx	(calib)	float	dBZ	reflectivity at 1km for SNR=0dB noise-corrected H cross-pol channel	**6.26**	
base_1km_vx	(calib)	float	dBZ	reflectivity at 1km for SNR=0dB noise-corrected V cross-pol channel	**6.27**	
sun_power_hc	(calib)	float	dBm	Calibrated sun power H co-pol channel	**6.28**	
sun_power_vc	(calib)	float	dBm	Calibrated sun power V co-pol channel	**6.29**	
sun_power_hx	(calib)	float	dBm	Calibrated sun power H cross-pol channel	**6.30**	
sun_power_vx	(calib)	float	dBm	Calibrated sun power V cross-pol channel	**6.31**	
noise_source_power_h	(calib)	float	dBm	Noise source power H channel	**6.32**	
noise_source_power_v	(calib)	float	dBm	Noise source power V channel	**6.33**	
power_measure_loss_h	(calib)	float	dB	Power measurement loss in coax and connectors H channel	**6.34**	
power_measure_loss_v	(calib)	float	dB	Power measurement loss in coax and connectors V channel	**6.35**	
coupler_forward_loss_h	(calib)	float	dB	Coupler loss into waveguide H channel	**6.36**	

Variable name	**Dimension**	**Type**	**Units**	**Comments**	**IMID**	**WMO Use**
coupler_forward_loss_v	(calib)	float	dB	Coupler loss into waveguide V channel	**6.37**	
zdr_correction	(calib)	float	dB	corrected = measured + correction	**6.38**	
ldr_correction_h	(calib)	float	dB	corrected = measured + correction	**6.39**	
ldr_correction_v	(calib)	float	dB	corrected = measured + correction	**6.40**	
system_phidp	(calib)	float	degrees	System PhiDp, as seen in drizzle close to radar	**6.41**	
test_power_h	(calib)	float	dBm	Calibration test power H channel	**6.42**	
test_power_v	(calib)	float	dBm	Calibration test power V channel	**6.43**	
receiver_slope_hc	(calib)	float		Computed receiver slope, ideally 1.0 H co-pol channel	**6.44**	
receiver_slope_vc	(calib)	float		Computed receiver slope, ideally 1.0 V co-pol channel	**6.45**	
receiver_slope_hx	(calib)	float		Computed receiver slope, ideally 1.0 H cross-pol channel	**6.46**	
receiver_slope_vx	(calib)	float		Computed receiver slope, ideally 1.0 V cross-pol channel	**6.47**	

7.4 The lidarcalibration sub-group

7.5 The georeferenced_correction sub-group

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
azimuth_correction	none	float	degrees	Correction to azimuth values	**9.18**	
elevation_correction	none	float	degrees	Correction to elevation values	**9.19**	
range_correction	none	float	meters	Correction to range values	**9.20**	
longitude_correction	none	float	degrees	Correction to longitude values	**9.21**	
latitude_correction	none	float	degrees	Correction to latitude values	**9.22**	
pressure_altitude_correction	none	float	meters	Correction to pressure altitude values	**9.23**	
radar_altitude_correction	none	float	meters	Correction to radar altitude values	**9.24**	
eastward_ground_speed_correction	none	float	m/s	Correction to EW ground speed values	**9.25**	
northward_ground_speed_correction	none	float	m/s	Correction to NS ground speed values	**9.26**	
vertical_velocity_correction	none	float	m/s	Correction to vertical velocity values	**9.27**	
heading_correction	none	float	degrees	Correction to heading values	**9.28**	

Variable name	Dimension	Type	Units	Comments	IMID	WMO Use
roll_correction	none	float	degrees	Correction to roll values	**9.29**	
pitch_correction	none	float	degrees	Correction to pitch values	**9.30**	
drift_correction	none	float	degrees	Correction to drift values	**9.31**	
rotation_correction	none	float	degrees	Correction to rotation values	**9.32**	
tilt_correction	none	float	degrees	Correction to tilt values	**9.32**	

8 Standard names

8.1 Standard names for moments variables

Required: a convention for separating different versions of the same variable, e.g. in the simplest case uncorrected and corrected.

Required: a convention for separating horizontally-polarized and vertically-polarized variables. In ODIM there is TH, TV, DBZH, DBZV, VRADH, VRADV, and several others. Do we carry that over to this table, or introduce an another way?

Standard name	Short name	Units	Already in CF?	IMID	WMO Use
equivalent_reflectivity_factor	DBZ	dBZ	yes	**16.0**	
linear_equivalent_reflectivity_factor	Z	Z	no	**16.1**	
radial_velocity_of_scatterers_ away_from_instrument	VEL	m/s	yes	**16.2**	
doppler_spectrum_width	WIDTH	m/s	no	**16.3**	
log_differential_reflectivity_hv	ZDR	dB	no	**16.4**	
log_linear_depolarization_ratio_hv	LDR	dB	no	**16.5**	
log_linear_depolarization_ratio_h	LDRH	dB	no	**16.6**	
log_linear_depolarization_ratio_v	LDRV	dB	no	**16.7**	
differential_phase_hv	PHIDP	degrees	no	**16.8**	
specific_differential_phase_hv	KDP	degrees/km	no	**16.9**	
cross_polar_differential_phase	PHIHX	degrees	no	**16.10**	
cross_correlation_ratio_hv	RHOHV		no	**16.11**	
co_to_cross_polar_correlation_ratio_h	RHOHX		no	**16.12**	
co_to_cross_polar_correlation_ratio_v	RHOXV		no	**16.13**	
log_power	DBM	dBm	no	**16.14**	

Standard name	Short name	Units	Already in CF?	IMID	WMO Use
log_power_co_polar_h	DBMHC	dBm	no	**16.15**	
log_power_cross_polar_h	DBMHX	dBm	no	**16.16**	
log_power_co_polar_v	DBMVC	dBm	no	**16.17**	
log_power_cross_polar_v	DBMVX	dBm	no	**16.18**	
linear_power	PWR	mW	no	**16.19**	
linear_power_co_polar_h	PWRHC	mW	no	**16.20**	
linear_power_cross_polar_h	PWRHX	mW	no	**16.21**	
linear_power_co_polar_v	PWRVC	mW	no	**16.22**	
linear_power_cross_polar_v	PWRVX	mW	no	**16.23**	
signal_to_noise_ratio	SNR	dB	no	**16.24**	
signal_to_noise_ratio_co_polar_h	SNRHC	dB	no	**16.25**	
signal_to_noise_ratio_cross_polar_h	SNRHX	dB	no	**16.26**	
signal_to_noise_ratio_co_polar_v	SNRVC	dB	no	**16.27**	
signal_to_noise_ratio_cross_polar_v	SNRVX	dB	no	**16.28**	
normalized_coherent_power (Alias: signal_-quality_-index)	NCP (alias SQI)		no	**16.29**	
corrected_equivalent_reflectivity_factor	DBZc	dBZ	no	**-**	Need generalized convention for separating different versions of same variable
corrected_radial_velocity_of_scatterers_ away_from_instrument	VELc	m/s	no	**-**	
corrected_log_differential_reflectivity_hv	ZDRc	dB	no	**-**	
radar_estimated_rain_rate	RRR	mm/hr	no	**16.30**	Prefer to use "RR" with mm/hr units
rain_rate	RR	kg/m2/s	yes	**-**	
radar_echo_classification (should be used for PID, HCA, HID etc)	REC	legend	no	**16.31**	

8.2 Standard names for spectra variables

Standard name	Suggested short name	Units	Already in CF?
spectrum_of_copolar_horizontal_to_copolar_horizontal	SPEC_HH_HH*		no
spectrum_of_copolar_horizontal_to_crosspolar_vertical	SPEC_HH_VH*		no
spectrum_of_copolar_horizontal_to_copolar_vertical	SPEC_HH_VV*		no
spectrum_of_crosspolar_vertical_to_crosspolar_vertical	SPEC_VH_VH*		no
spectrum_of_crosspolar_vertical_to_copolar_vertical	SPEC_VH_VV*		no
spectrum_of_copolar_vertical_to_copolar_vertical	SPEC_VV_VV*		no