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# **pyrad library reference for users**

***Release 0.1.0***

**meteoswiss-mdr**

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## PROCESSING FLOW CONTROL (PYRAD.FLOW)

Functions to control the Pyrad data processing flow

<code>main(cfgfile[, starttime, endtime, ...])</code>	Main flow control.
<code>main_rt(cfgfile_list[, starttime, endtime, ...])</code>	main flow control.

`pyrad.flow.main` (*cfgfile*, *starttime=None*, *endtime=None*, *trajfile=""*, *trajtype='plane'*, *flashnr=0*, *infostr=""*, *MULTIPROCESSING\_DSET=False*, *MULTIPROCESSING\_PROD=False*, *PROFILE\_MULTIPROCESSING=False*)

Main flow control. Processes radar data off-line over a period of time given either by the user, a trajectory file, or determined by the last volume processed and the current time. Multiple radars can be processed simultaneously

### Parameters

**cfgfile** [str] path of the main config file

**starttime, endtime** [datetime object] start and end time of the data to be processed

**trajfile** [str] path to file describing the trajectory

**trajtype** [str] type of trajectory file. Can be either 'plane' or 'lightning'

**flashnr** [int] If larger than 0 will select a flash in a lightning trajectory file. If 0 the data corresponding to the trajectory of all flashes will be plotted

**infostr** [str] Information string about the actual data processing (e.g. 'RUN57'). This string is added to product files.

**MULTIPROCESSING\_DSET** [Bool] If true the generation of datasets at the same processing level will be parallelized

**MULTIPROCESSING\_PROD** [Bool] If true the generation of products from each dataset will be parallelized

**PROFILE\_MULTIPROCESSING** [Bool] If true and code parallelized the multiprocessing is profiled

`pyrad.flow.main_rt` (*cfgfile\_list*, *starttime=None*, *endtime=None*, *infostr\_list=None*, *proc\_period=60*, *proc\_finish=None*)

main flow control. Processes radar data in real time. The start and end processing times can be determined by the user. This function is intended for a single radar

### Parameters

**cfgfile\_list** [list of str] path of the main config files

**starttime, endtime** [datetime object] start and end time of the data to be processed

**infostr\_list** [list of str] Information string about the actual data processing (e.g. 'RUN57'). This string is added to product files.

**proc\_period** [int] period of time before starting a new processing round (seconds)

**cronjob\_controlled** [Boolean] If True means that the program is started periodically from a cronjob and therefore finishes execution after processing

**proc\_finish** [int or None] if set to a value the program will be forced to shut down after the value (in seconds) from start time has been exceeded

#### Returns

**end\_proc** [Boolean] If true the program has ended successfully

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## DATASET PROCESSING (PYRAD . PROC)

Initiate the dataset processing.

### 2.1 Auxiliary functions

<i>get_process_func</i> (dataset_type, dsname)	Maps the dataset type into its processing function and data set format associated.
<i>process_raw</i> (procstatus, dscfg[, radar_list])	Dummy function that returns the initial input data set
<i>process_save_radar</i> (procstatus, dscfg[, ...])	Dummy function that allows to save the entire radar object
<i>process_fixed_rng</i> (procstatus, dscfg[, ...])	Obtains radar data at a fixed range
<i>process_fixed_rng_span</i> (procstatus, dscfg[, ...])	For each azimuth-elevation gets the data within a fixed range span and computes a user-defined statistic: mean, min, max, mode, median
<i>process_roi</i> (procstatus, dscfg[, radar_list])	Obtains the radar data at a region of interest.
<i>process_grid</i> (procstatus, dscfg[, radar_list])	Puts the radar data in a regular grid
<i>process_azimuthal_average</i> (procstatus, dscfg)	Averages radar data in azimuth obtaining and RHI as a result

### 2.2 Echo classification and filtering

<i>process_echo_id</i> (procstatus, dscfg[, radar_list])	identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Precipitation
<i>process_birds_id</i> (procstatus, dscfg[, radar_list])	identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Birds
<i>process_clt_to_echo_id</i> (procstatus, dscfg[, ...])	Converts clutter exit code from rad4alp into pyrad echo ID
<i>process_echo_filter</i> (procstatus, dscfg[, ...])	Masks all echo types that are not of the class specified in keyword <i>echo_type</i>
<i>process_cdf</i> (procstatus, dscfg[, radar_list])	Collects the fields necessary to compute the Cumulative Distribution Function
<i>process_filter_snr</i> (procstatus, dscfg[, ...])	filters out low SNR echoes
<i>process_filter_visibility</i> (procstatus, dscfg)	filters out rays gates with low visibility and corrects the reflectivity
<i>process_outlier_filter</i> (procstatus, dscfg[, ...])	filters out gates which are outliers respect to the surrounding

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<code>process_hydroclass(procstatus, dscfg, ...)</code>	Classifies precipitation echoes
<code>process_melting_layer(procstatus, dscfg, ...)</code>	Detects the melting layer
<code>process_filter_vel_diff(procstatus, dscfg, ...)</code>	filters out range gates that could not be used for Doppler velocity estimation
<code>process_zdr_column(procstatus, dscfg, ...)</code>	Detects ZDR columns

## 2.3 Phase processing and attenuation correction

<code>process_correct_phidp0(procstatus, dscfg, ...)</code>	corrects phidp of the system phase
<code>process_smooth_phidp_single_window(..., ...)</code>	corrects phidp of the system phase and smoothes it using one window
<code>process_smooth_phidp_double_window(..., ...)</code>	corrects phidp of the system phase and smoothes it using one window
<code>process_kdp_leastsquare_single_window(..., ...)</code>	Computes specific differential phase using a piecewise least square method
<code>process_kdp_leastsquare_double_window(..., ...)</code>	Computes specific differential phase using a piecewise least square method
<code>process_phidp_kdp_Vulpiani(procstatus, dscfg)</code>	Computes specific differential phase and differential phase using the method developed by Vulpiani et al.
<code>process_phidp_kdp_Kalman(procstatus, dscfg)</code>	Computes specific differential phase and differential phase using the Kalman filter as proposed by Schneebeli et al.
<code>process_phidp_kdp_Maesaka(procstatus, dscfg)</code>	Estimates PhiDP and KDP using the method by Maesaka.
<code>process_phidp_kdp_lp(procstatus, dscfg, ...)</code>	Estimates PhiDP and KDP using a linear programming algorithm.
<code>process_attenuation(procstatus, dscfg, ...)</code>	Computes specific attenuation and specific differential attenuation using the Z-Phi method and corrects reflectivity and differential reflectivity

## 2.4 Monitoring, calibration and noise correction

<code>process_correct_bias(procstatus, dscfg, ...)</code>	Corrects a bias on the data
<code>process_correct_noise_rhohv(procstatus, dscfg)</code>	identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Precipitation
<code>process_rhohv_rain(procstatus, dscfg, ...)</code>	Keeps only suitable data to evaluate the 80 percentile of RhoHV in rain
<code>process_zdr_precip(procstatus, dscfg, ...)</code>	Keeps only suitable data to evaluate the differential reflectivity in moderate rain or precipitation (for vertical scans)
<code>process_zdr_snow(procstatus, dscfg, radar_list)</code>	Keeps only suitable data to evaluate the differential reflectivity in snow
<code>process_estimate_phidp0(procstatus, dscfg, ...)</code>	estimates the system differential phase offset at each ray
<code>process_sun_hits(procstatus, dscfg, radar_list)</code>	monitoring of the radar using sun hits

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<code>process_selfconsistency_kdp_phidp(..., ...)</code>	Computes specific differential phase and differential phase in rain using the selfconsistency between Zdr, Zh and KDP
<code>process_selfconsistency_bias(procstatus, dscfg)</code>	Estimates the reflectivity bias by means of the selfconsistency algorithm by Gourley
<code>process_time_avg_std(procstatus, dscfg[, ...])</code>	computes the average and standard deviation of data.
<code>process_occurrence(procstatus, dscfg[, ...])</code>	computes the frequency of occurrence of data.
<code>process_occurrence_period(procstatus, dscfg)</code>	computes the frequency of occurrence over a long period of time by adding together shorter periods
<code>process_monitoring(procstatus, dscfg[, ...])</code>	computes monitoring statistics
<code>process_gc_monitoring(procstatus, dscfg[, ...])</code>	computes ground clutter monitoring statistics
<code>process_time_avg(procstatus, dscfg[, radar_list])</code>	computes the temporal mean of a field
<code>process_weighted_time_avg(procstatus, dscfg)</code>	computes the temporal mean of a field weighted by the reflectivity
<code>process_time_avg_flag(procstatus, dscfg[, ...])</code>	computes a flag field describing the conditions of the data used while averaging
<code>process_time_stats(procstatus, dscfg[, ...])</code>	computes the temporal statistics of a field
<code>process_time_stats2(procstatus, dscfg[, ...])</code>	computes the temporal mean of a field
<code>process_colocated_gates(procstatus, dscfg[, ...])</code>	Find colocated gates within two radars
<code>process_intercomp(procstatus, dscfg[, ...])</code>	intercomparison between two radars
<code>process_intercomp_time_avg(procstatus, dscfg)</code>	intercomparison between the average reflectivity of two radars

## 2.5 Retrievals

<code>process_signal_power(procstatus, dscfg[, ...])</code>	Computes the signal power in dBm
<code>process_rcs(procstatus, dscfg[, radar_list])</code>	Computes the radar cross-section (assuming a point target) from radar reflectivity.
<code>process_rcs_pr(procstatus, dscfg[, radar_list])</code>	Computes the radar cross-section (assuming a point target) from radar reflectivity by first computing the received power and then the RCS from it.
<code>process_snr(procstatus, dscfg[, radar_list])</code>	Computes SNR
<code>process_l(procstatus, dscfg[, radar_list])</code>	Computes L parameter
<code>process_cdr(procstatus, dscfg[, radar_list])</code>	Computes Circular Depolarization Ratio
<code>process_rainrate(procstatus, dscfg[, radar_list])</code>	Estimates rainfall rate from polarimetric moments
<code>process_vol_refl(procstatus, dscfg[, radar_list])</code>	Computes the volumetric reflectivity in $10\log_{10}(\text{cm}^2 \text{ km}^{-3})$
<code>process_bird_density(procstatus, dscfg[, ...])</code>	Computes the bird density from the volumetric reflectivity

## 2.6 Doppler processing

<code>process_dealias_fourdd(procstatus, dscfg[, ...])</code>	Dealiases the Doppler velocity field using the 4DD technique from Curtis and Houze, 2001
<code>process_dealias_region_based(procstatus, dscfg)</code>	Dealiases the Doppler velocity field using a region based algorithm

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<code>process_dealias_unwrap_phase</code> (procstatus, dscfg)	Dealiases the Doppler velocity field using multi-dimensional phase unwrapping
<code>process_wind_vel</code> (procstatus, dscfg[, radar_list])	Estimates the horizontal or vertical component of the wind from the radial velocity
<code>process_windshear</code> (procstatus, dscfg[, ...])	Estimates the wind shear from the wind velocity
<code>process_vad</code> (procstatus, dscfg[, radar_list])	Estimates vertical wind profile using the VAD (velocity Azimuth Display) technique

## 2.7 Time series functions

<code>process_point_measurement</code> (procstatus, dscfg)	Obtains the radar data at a point location.
<code>process_qvp</code> (procstatus, dscfg[, radar_list])	Computes quasi vertical profiles, by averaging over height levels PPI data.
<code>process_rqvp</code> (procstatus, dscfg[, radar_list])	Computes range defined quasi vertical profiles, by averaging over height levels PPI data.
<code>process_svp</code> (procstatus, dscfg[, radar_list])	Computes slanted vertical profiles, by averaging over height levels PPI data.
<code>process_evp</code> (procstatus, dscfg[, radar_list])	Computes enhanced vertical profiles, by averaging over height levels PPI data.
<code>process_time_height</code> (procstatus, dscfg[, ...])	Produces time height radar objects at a point of interest defined by latitude and longitude.

## 2.8 Trajectory functions

<code>process_trajectory</code> (procstatus, dscfg[, ...])	Return trajectory
<code>process_traj_atplane</code> (procstatus, dscfg[, ...])	Return time series according to trajectory
<code>process_traj_antenna_pattern</code> (procstatus, dscfg)	Process a new array of data volumes considering a plane trajectory.
<code>process_traj_lightning</code> (procstatus, dscfg[, ...])	Return time series according to lightning trajectory
<code>process_traj_trt</code> (procstatus, dscfg[, ...])	Processes data according to TRT trajectory

## 2.9 COSMO data

<code>process_cosmo</code> (procstatus, dscfg[, radar_list])	Gets COSMO data and put it in radar coordinates
<code>process_cosmo_lookup_table</code> (procstatus, dscfg)	Gets COSMO data and put it in radar coordinates using look up tables computed or loaded when initializing
<code>process_cosmo_coord</code> (procstatus, dscfg[, ...])	Gets the COSMO indices corresponding to each cosmo coordinates
<code>process_hzt</code> (procstatus, dscfg[, radar_list])	Gets iso0 degree data in HZT format and put it in radar coordinates
<code>process_hzt_lookup_table</code> (procstatus, dscfg)	Gets HZT data and put it in radar coordinates using look up tables computed or loaded when initializing
<code>process_hzt_coord</code> (procstatus, dscfg[, ...])	Gets the HZT indices corresponding to each HZT coordinates

`pyrad.proc.get_process_func(dataset_type, dsname)`

Maps the dataset type into its processing function and data set format associated.

### Parameters

**dataset\_type** [str] The following is a list of data set types ordered by type of output dataset with the function they call. For details of what they do check the function documentation:

**‘VOL’ format output:** ‘ATTENUATION’: process\_attenuation ‘AZI\_AVG’: process\_azimuthal\_average ‘BIAS\_CORRECTION’: process\_correct\_bias ‘BIRDS\_ID’: process\_birds\_id ‘BIRD\_DENSITY’: process\_bird\_density ‘CDF’: process\_cdf ‘CDR’: process\_cdr ‘CLT\_TO\_SAN’: process\_clt\_to\_echo\_id ‘COSMO’: process\_cosmo ‘COSMO\_LOOKUP’: process\_cosmo\_lookup\_table ‘DEALIAS\_FOURDD’: process\_dealias\_fourdd ‘DEALIAS\_REGION’: process\_dealias\_region\_based ‘DEALIAS\_UNWRAP’: process\_dealias\_unwrap\_phase ‘ECHO\_FILTER’: process\_echo\_filter ‘FIXED\_RNG’: process\_fixed\_rng ‘FIXED\_RNG\_SPAN’: process\_fixed\_rng\_span ‘HYDROCLASS’: process\_hydroclass ‘HZZ’: process\_hzz ‘HZZ\_LOOKUP’: process\_hzz\_lookup\_table ‘KDP\_LEASTSQUARE\_1W’: process\_kdp\_leastsquare\_single\_window ‘KDP\_LEASTSQUARE\_2W’: process\_kdp\_leastsquare\_double\_window ‘L’: process\_l ‘NCVOL’: process\_save\_radar ‘OUTLIER\_FILTER’: process\_outlier\_filter ‘PHIDP0\_CORRECTION’: process\_correct\_phidp0 ‘PHIDP0\_ESTIMATE’: process\_estimate\_phidp0 ‘PHIDP\_KDP\_KALMAN’: process\_phidp\_kdp\_kalman ‘PHIDP\_KDP\_LP’: process\_phidp\_kdp\_lp ‘PHIDP\_KDP\_VULPIANI’: process\_phidp\_kdp\_vulpiani ‘PHIDP\_SMOOTH\_1W’: process\_smooth\_phidp\_single\_window ‘PHIDP\_SMOOTH\_2W’: process\_smooth\_phidp\_double\_window ‘PWR’: process\_signal\_power ‘RAINRATE’: process\_rainrate ‘RAW’: process\_raw ‘RCS’: process\_rcs ‘RCS\_PR’: process\_rcs\_pr ‘RHOHV\_CORRECTION’: process\_correct\_noise\_rhohv ‘RHOHV\_RAIN’: process\_rhohv\_rain ‘ROI’: process\_roi ‘SAN’: process\_echo\_id ‘SELFCONSISTENCY\_BIAS’: process\_selfconsistency\_bias ‘SELFCONSISTENCY\_KDP\_PHIDP’: process\_selfconsistency\_kdp\_phidp ‘SNR’: process\_snr ‘SNR\_FILTER’: process\_filter\_snr ‘TRAJ\_TRT’: process\_traj\_trt ‘VAD’: process\_vad ‘VEL\_FILTER’: process\_filter\_vel\_diff ‘VIS\_FILTER’: process\_filter\_visibility ‘VOL\_REFL’: process\_vol\_refl ‘WIND\_VEL’: process\_wind\_vel ‘WINDSHEAR’: process\_windshear ‘ZDR\_PREC’: process\_zdr\_precip ‘ZDR\_SNOW’: process\_zdr\_snow

**‘COLOCATED\_GATES’ format output:** ‘COLOCATED\_GATES’: process\_collocated\_gates

**‘COSMO\_COORD’ format output:** ‘COSMO\_COORD’: process\_cosmo\_coord ‘HZZ\_COORD’: process\_hzz\_coord

**‘GRID’ format output:** ‘GRID’: process\_grid

**‘INTERCOMP’ format output:** ‘INTERCOMP’: process\_intercomp ‘INTERCOMP\_TIME\_AVG’: process\_intercomp\_time\_avg

**‘ML’ format output:** ‘ML\_DETECTION’: process\_melting\_layer

**‘MONITORING’ format output:** ‘GC\_MONITORING’: process\_gc\_monitoring ‘MONITORING’: process\_monitoring

**‘OCCURRENCE’ format output:** ‘OCCURRENCE’: process\_occurrence ‘OCCURRENCE\_PERIOD’: process\_occurrence\_period ‘TIMEAVG\_STD’: process\_time\_avg\_std

**‘QVP’ format output:** ‘EVP’: process\_evp ‘QVP’: process\_qvp ‘rQVP’: process\_rqvp ‘SVP’: process\_svp ‘TIME\_HEIGHT’: process\_time\_height

**‘SPARSE\_GRID’ format output:** ‘ZDR\_COLUMN’: process\_zdr\_column

**‘SUN\_HITS’ format output:** ‘SUN\_HITS’: process\_sun\_hits

**‘TIMEAVG’ format output:** ‘FLAG\_TIME\_AVG’: process\_time\_avg\_flag  
‘TIME\_AVG’: process\_time\_avg ‘WEIGHTED\_TIME\_AVG’: process\_weighted\_time\_avg  
‘TIME\_STATS’: process\_time\_stats ‘TIME\_STATS2’: process\_time\_stats2

**‘TIMESERIES’ format output:** ‘POINT\_MEASUREMENT’: process\_point\_measurement  
‘TRAJ\_ANTENNA\_PATTERN’: process\_traj\_antenna\_pattern  
‘TRAJ\_ATPLANE’: process\_traj\_atplane  
‘TRAJ\_LIGHTNING’: process\_traj\_lightning

**‘TRAJ\_ONLY’ format output:** ‘TRAJ’: process\_trajectory

**dsname** [str] Name of dataset

### Returns

**func\_name** [str or processing function] pyrad function used to process the data set type

**dsformat** [str] data set format, i.e.: ‘VOL’, etc.

`pyrad.proc.process_attenuation` (*procstatus, dscfg, radar\_list=None*)

Computes specific attenuation and specific differential attenuation using the Z-Phi method and corrects reflectivity and differential reflectivity

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**ATT\_METHOD** [float. Dataset keyword] The attenuation estimation method used. One of the following: ZPhi, Philin

**fzl** [float. Dataset keyword] The default freezing level height. It will be used if no temperature field name is specified or the temperature field is not in the radar object. Default 2000.

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_azimuthal_average` (*procstatus, dscfg, radar\_list=None*)

Averages radar data in azimuth obtaining and RHI as a result

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**gridconfig** [dictionary. Dataset keyword] Dictionary containing some or all of this keywords: xmin, xmax, ymin, ymax, zmin, zmax : floats

minimum and maximum horizontal distance from grid origin [km] and minimum and maximum vertical distance from grid origin [m] Defaults -40, 40, -40, 40, 0., 10000.

**hres, vres** [floats] horizontal and vertical grid resolution [m] Defaults 1000., 500.

**latorig, lonorig, altorig** [floats] latitude and longitude of grid origin [deg] and altitude of grid origin [m MSL] Defaults the latitude, longitude and altitude of the radar

**wfunc** [str] the weighting function used to combine the radar gates close to a grid point. Possible values BARNES, CRESSMAN, NEAREST\_NEIGHBOUR Default NEAREST\_NEIGHBOUR

**roif\_func** [str] the function used to compute the region of interest. Possible values: dist\_beam, constant

**roi** [float] the (minimum) radius of the region of interest in m. Default half the largest resolution

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the gridded data

**ind\_rad** [int] radar index

`pyrad.proc.process_bird_density(procstatus, dscfg, radar_list=None)`

Computes the bird density from the volumetric reflectivity

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**sigma\_bird** [float. Dataset keyword] The bird radar cross section

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_birds_id(procstatus, dscfg, radar_list=None)`

identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Birds

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_cdf` (*procstatus, dscfg, radar\_list=None*)

Collects the fields necessary to compute the Cumulative Distribution Function

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_cdr` (*procstatus, dscfg, radar\_list=None*)

Computes Circular Depolarization Ratio

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_clt_to_echo_id` (*procstatus, dscfg, radar\_list=None*)

Converts clutter exit code from rad4alp into pyrad echo ID

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_colocated_gates` (*procstatus, dscfg, radar\_list=None*)

Find colocated gates within two radars

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types



**h\_tol** [float. Dataset keyword] Tolerance in altitude difference between radar gates [m]. Default 100.

**latlon\_tol** [float. Dataset keyword] Tolerance in latitude and longitude position between radar gates [deg]. Default 0.0005

**vol\_d\_tol** [float. Dataset keyword] Tolerance in pulse volume diameter [m]. Default 100.

**vismin** [float. Dataset keyword] Minimum visibility [percent]. Default None.

**hmin** [float. Dataset keyword] Minimum altitude [m MSL]. Default None.

**hmax** [float. Dataset keyword] Maximum altitude [m MSL]. Default None.

**rmin** [float. Dataset keyword] Minimum range [m]. Default None.

**rmax** [float. Dataset keyword] Maximum range [m]. Default None.

**elmin** [float. Dataset keyword] Minimum elevation angle [deg]. Default None.

**elmax** [float. Dataset keyword] Maximum elevation angle [deg]. Default None.

**azrad1min** [float. Dataset keyword] Minimum azimuth angle [deg] for radar 1. Default None.

**azrad1max** [float. Dataset keyword] Maximum azimuth angle [deg] for radar 1. Default None.

**azrad2min** [float. Dataset keyword] Minimum azimuth angle [deg] for radar 2. Default None.

**azrad2max** [float. Dataset keyword] Maximum azimuth angle [deg] for radar 2. Default None.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [radar object] radar object containing the flag field

**ind\_rad** [int] radar index

`pyrad.proc.process_correct_bias` (*procstatus, dscfg, radar\_list=None*)

Corrects a bias on the data

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type to correct for bias

**bias** [float. Dataset keyword] The bias to be corrected [dB]. Default 0

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_correct_noise_rhohv` (*procstatus, dscfg, radar\_list=None*)

identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Precipitation

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The data types used in the correction

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_correct_phidp0` (*procstatus, dscfg, radar\_list=None*)  
corrects phidp of the system phase

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] The minimum range where to look for valid data [m]

**rmax** [float. Dataset keyword] The maximum range where to look for valid data [m]

**rcell** [float. Dataset keyword] The length of a continuous cell to consider it valid precip [m]

**Zmin** [float. Dataset keyword] The minimum reflectivity [dBZ]

**Zmax** [float. Dataset keyword] The maximum reflectivity [dBZ]

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_cosmo` (*procstatus, dscfg, radar\_list=None*)  
Gets COSMO data and put it in radar coordinates

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**keep\_in\_memory** [int. Dataset keyword] if set keeps the COSMO data dict, the COSMO coordinates dict and the COSMO field in radar coordinates in memory

**regular\_grid** [int. Dataset keyword] if set it is assume that the radar has a grid constant in time and there is no need to compute a new COSMO field if the COSMO data has not changed

**cosmo\_type** [str. Dataset keyword] name of the COSMO field to process. Default TEMP

**cosmo\_variables** [list of strings. Dataset keyword] Py-art name of the COSMO fields. Default temperature

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_cosmo_coord` (*procstatus, dscfg, radar\_list=None*)

Gets the COSMO indices corresponding to each cosmo coordinates

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**cosmopath** [string. General keyword] path where to store the look up table

**model** [string. Dataset keyword] The COSMO model to use. Can be cosmo-1, cosmo-2, cosmo-7

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_cosmo_lookup_table` (*procstatus, dscfg, radar\_list=None*)

Gets COSMO data and put it in radar coordinates using look up tables computed or loaded when initializing

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**lookup\_table** [int. Dataset keyword] if set a pre-computed look up table for the COSMO coordinates is loaded. Otherwise the look up table is computed taking the first radar object as reference

**regular\_grid** [int. Dataset keyword] if set it is assume that the radar has a grid constant in time and therefore there is no need to interpolate the COSMO field in memory to the current radar grid

**cosmo\_type** [str. Dataset keyword] name of the COSMO field to process. Default TEMP

**cosmo\_variables** [list of strings. Dataset keyword] Py-art name of the COSMO fields. Default temperature

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_dealias_fourdd` (*procstatus, dscfg, radar\_list=None*)

Dealiases the Doppler velocity field using the 4DD technique from Curtis and Houze, 2001

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**filt** [int. Dataset keyword] Flag controlling Bergen and Albers filter, 1 = yes, 0 = no.

**sign** [int. Dataset keyword] Sign convention which the radial velocities in the volume created from the sounding data will will. This should match the convention used in the radar data. A value of 1 represents when positive values velocities are towards the radar, -1 represents when negative velocities are towards the radar.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_dealias_region_based(procstatus, dscfg, radar_list=None)`

Dealiases the Doppler velocity field using a region based algorithm

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**interval\_splits** [int, optional] Number of segments to split the nyquist interval into when finding regions of similar velocity. More splits creates a larger number of initial regions which takes longer to process but may result in better dealiasing. The default value of 3 seems to be a good compromise between performance and artifact free dealiasing. This value is not used if the interval\_limits parameter is not None.

**skip\_between\_rays, skip\_along\_ray** [int, optional] Maximum number of filtered gates to skip over when joining regions, gaps between region larger than this will not be connected. Parameters specify the maximum number of filtered gates between and along a ray. Set these parameters to 0 to disable unfolding across filtered gates.

**centered** [bool, optional] True to apply centering to each sweep after the dealiasing algorithm so that the average number of unfolding is near 0. False does not apply centering which may results in individual sweeps under or over folded by the nyquist interval.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_dealias_unwrap_phase(procstatus, dscfg, radar_list=None)`

Dealiases the Doppler velocity field using multi-dimensional phase unwrapping

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**unwrap\_unit** [{ 'ray', 'sweep', 'volume' }, optional] Unit to unwrap independently. 'ray' will unwrap each ray individually, 'sweep' each sweep, and 'volume' will unwrap the entire volume in a single pass. 'sweep', the default, often gives superior results when the lower sweeps of the radar volume are contaminated by clutter. 'ray' does not use the

gatefilter parameter and rays where gates are masked will result in poor dealiasing for that ray.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_echo_filter(procstatus, dscfg, radar_list=None)`

Masks all echo types that are not of the class specified in keyword `echo_type`

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**echo\_type** [int] The type of echo to keep: 1 noise, 2 clutter, 3 precipitation. Default 3

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_echo_id(procstatus, dscfg, radar_list=None)`

identifies echoes as 0: No data, 1: Noise, 2: Clutter, 3: Precipitation

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_estimate_phidp0(procstatus, dscfg, radar_list=None)`

estimates the system differential phase offset at each ray

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] The minimum range where to look for valid data [m]

**rmax** [float. Dataset keyword] The maximum range where to look for valid data [m]

**rcell** [float. Dataset keyword] The length of a continuous cell to consider it valid precip [m]

**Zmin** [float. Dataset keyword] The minimum reflectivity [dBZ]

**Zmax** [float. Dataset keyword] The maximum reflectivity [dBZ]

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_evp` (*procstatus, dscfg, radar\_list=None*)

Computes enhanced vertical profiles, by averaging over height levels PPI data.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**lat, lon** [float] latitude and longitude of the point of interest [deg]

**latlon\_tol** [float] tolerance in latitude and longitude in deg. Default 0.0005

**delta\_rng, delta\_azi** [float] maximum range distance [m] and azimuth distance [degree] from the central point of the evp containing data to average. Default 5000. and 10.

**hmax** [float] The maximum height to plot [m]. Default 10000.

**hres** [float] The height resolution [m]. Default 250.

**avg\_type** [str] The type of averaging to perform. Can be either “mean” or “median” Default “mean”

**nvalid\_min** [int] Minimum number of valid points to consider the data valid when performing the averaging. Default 1

**interp\_kind** [str] type of interpolation when projecting to vertical grid: ‘none’, or ‘nearest’, etc. Default ‘none’. ‘none’ will select from all data points within the regular grid height bin the closest to the center of the bin. ‘nearest’ will select the closest data point to the center of the height bin regardless if it is within the height bin or not. Data points can be masked values If another type of interpolation is selected masked values will be eliminated from the data points before the interpolation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the EVP and a keyboard stating whether the processing has finished or not.

**ind\_rad** [int] radar index

`pyrad.proc.process_filter_snr` (*procstatus, dscfg, radar\_list=None*)

filters out low SNR echoes

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**SNRmin** [float. Dataset keyword] The minimum SNR to keep the data.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_filter_vel_diff` (*procstatus, dscfg, radar\_list=None*)  
filters out range gates that could not be used for Doppler velocity estimation

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**SNRmin** [float. Dataset keyword] The minimum SNR to keep the data.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_filter_visibility` (*procstatus, dscfg, radar\_list=None*)  
filters out rays gates with low visibility and corrects the reflectivity

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**VISmin** [float. Dataset keyword] The minimum visibility to keep the data.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_fixed_rng` (*procstatus, dscfg, radar\_list=None*)  
Obtains radar data at a fixed range

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of strings. Dataset keyword] The fields we want to extract

**rng** [float. Dataset keyword] The fixed range [m]

**RngTol** [float. Dataset keyword] The tolerance between the nominal range and the radar range

**ele\_min, ele\_max, azi\_min, azi\_max** [floats. Dataset keyword] The azimuth and elevation limits of the data [deg]

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the data and metadata at the point of interest

**ind\_rad** [int] radar index

`pyrad.proc.process_fixed_rng_span(procstatus, dscfg, radar_list=None)`

For each azimuth-elevation gets the data within a fixed range span and computes a user-defined statistic: mean, min, max, mode, median

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of strings. Dataset keyword] The fields we want to extract

**rmin, rmax** [float. Dataset keyword] The range limits [m]

**ele\_min, ele\_max, azi\_min, azi\_max** [floats. Dataset keyword] The azimuth and elevation limits of the data [deg]

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the data and metadata at the point of interest

**ind\_rad** [int] radar index

`pyrad.proc.process_gc_monitoring(procstatus, dscfg, radar_list=None)`

computes ground clutter monitoring statistics

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**excessgatespath** [str. Config keyword] The path to the gates in excess of quantile location

**excessgates\_fname** [str. Dataset keyword] The name of the gates in excess of quantile file

**datatype** [list of string. Dataset keyword] The input data types

**step** [float. Dataset keyword] The width of the histogram bin. Default is None. In that case the default step in function `get_histogram_bins` is used

**regular\_grid** [Boolean. Dataset keyword] Whether the radar has a Boolean grid or not. Default False

**val\_min** [Float. Dataset keyword] Minimum value to consider that the gate has signal. Default None

**filter\_prec** [str. Dataset keyword] Give which type of volume should be filtered. None, no filtering; keep\_wet, keep wet volumes; keep\_dry, keep dry volumes.

**rmax\_prec** [float. Dataset keyword] Maximum range to consider when looking for wet gates [m]

**percent\_prec\_max** [float. Dataset keyword] Maxim percentage of wet gates to consider the volume dry

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns



**new\_dataset** [Radar] radar object containing histogram data

**ind\_rad** [int] radar index

`pyrad.proc.process_grid` (*procstatus, dscfg, radar\_list=None*)

Puts the radar data in a regular grid

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**gridconfig** [dictionary. Dataset keyword] Dictionary containing some or all of this keywords: xmin, xmax, ymin, ymax, zmin, zmax : floats

minimum and maximum horizontal distance from grid origin [km] and minimum and maximum vertical distance from grid origin [m] Defaults -40, 40, -40, 40, 0., 10000.

**hres, vres** [floats] horizontal and vertical grid resolution [m] Defaults 1000., 500.

**latorig, lonorig, altorig** [floats] latitude and longitude of grid origin [deg] and altitude of grid origin [m MSL] Defaults the latitude, longitude and altitude of the radar

**wfunc** [str] the weighting function used to combine the radar gates close to a grid point. Possible values BARNES, CRESSMAN, NEAREST\_NEIGHBOUR Default NEAREST\_NEIGHBOUR

**roif\_func** [str] the function used to compute the region of interest. Possible values: dist\_beam, constant

**roi** [float] the (minimum) radius of the region of interest in m. Default half the largest resolution

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the gridded data

**ind\_rad** [int] radar index

`pyrad.proc.process_hydroclass` (*procstatus, dscfg, radar\_list=None*)

Classifies precipitation echoes

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**HYDRO\_METHOD** [string. Dataset keyword] The hydrometeor classification method. One of the following: SEMISUPERVISED

**RADARCENTROIDS** [string. Dataset keyword] Used with HYDRO\_METHOD SEMISUPERVISED. The name of the radar of which the derived centroids will be used. One of the following: A Albis, L Lema, P Plaine Morte, DX50

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_hzt` (*procstatus, dscfg, radar\_list=None*)

Gets iso0 degree data in HZT format and put it in radar coordinates

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**keep\_in\_memory** [int. Dataset keyword] if set keeps the COSMO data dict, the COSMO coordinates dict and the COSMO field in radar coordinates in memory

**regular\_grid** [int. Dataset keyword] if set it is assume that the radar has a grid constant in time and there is no need to compute a new COSMO field if the COSMO data has not changed

**cosmo\_type** [str. Dataset keyword] name of the COSMO field to process. Default TEMP

**cosmo\_variables** [list of strings. Dataset keyword] Py-art name of the COSMO fields. Default temperature

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_hzt_coord` (*procstatus, dscfg, radar\_list=None*)

Gets the HZT indices corresponding to each HZT coordinates

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**cosmopath** [string. General keyword] path where to store the look up table

**radar\_list** [list of Radar objects] Optional. list of radar objects

### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_hzt_lookup_table` (*procstatus, dscfg, radar\_list=None*)

Gets HZT data and put it in radar coordinates using look up tables computed or loaded when initializing

### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] arbitrary data type

**lookup\_table** [int. Dataset keyword] if set a pre-computed look up table for the COSMO coordinates is loaded. Otherwise the look up table is computed taking the first radar object as reference

**regular\_grid** [int. Dataset keyword] if set it is assume that the radar has a grid constant in time and therefore there is no need to interpolate the COSMO field in memory to the current radar grid

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_intercomp` (*procstatus, dscfg, radar\_list=None*)  
intercomparison between two radars

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**coloc\_data\_dir** [string. Dataset keyword] name of the directory containing the csv file with colocated data

**coloc\_radars\_name** [string. Dataset keyword] string identifying the radar names

**azi\_tol** [float. Dataset keyword] azimuth tolerance between the two radars. Default 0.5 deg

**ele\_tol** [float. Dataset keyword] elevation tolerance between the two radars. Default 0.5 deg

**rng\_tol** [float. Dataset keyword] range tolerance between the two radars. Default 50 m

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing a dictionary with intercomparison data and the key “final” which contains a boolean that is true when all volumes have been processed

**ind\_rad** [int] radar index

`pyrad.proc.process_intercomp_time_avg` (*procstatus, dscfg, radar\_list=None*)  
intercomparison between the average reflectivity of two radars

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**coloc\_data\_dir** [string. Dataset keyword] name of the directory containing the csv file with colocated data

**coloc\_radars\_name** [string. Dataset keyword] string identifying the radar names

**azi\_tol** [float. Dataset keyword] azimuth tolerance between the two radars. Default 0.5 deg

**ele\_tol** [float. Dataset keyword] elevation tolerance between the two radars. Default 0.5 deg

**rng\_tol** [float. Dataset keyword] range tolerance between the two radars. Default 50 m

**clt\_max** [int. Dataset keyword] maximum number of samples that can be clutter contaminated. Default 100 i.e. all

**phi\_excess\_max** [int. Dataset keyword] maximum number of samples that can have excess instantaneous PhiDP. Default 100 i.e. all

**non\_rain\_max** [int. Dataset keyword] maximum number of samples that can be no rain. Default 100 i.e. all

**phi\_avg\_max** [float. Dataset keyword] maximum average PhiDP allowed. Default 600 deg i.e. any

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing a dictionary with intercomparison data and the key “final” which contains a boolean that is true when all volumes have been processed

**ind\_rad** [int] radar index

`pyrad.proc.process_kdp_leastsquare_double_window` (*procstatus, dscfg, radar\_list=None*)  
Computes specific differential phase using a piecewise least square method

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rwinds** [float. Dataset keyword] The length of the short segment for the least square method [m]

**rwindl** [float. Dataset keyword] The length of the long segment for the least square method [m]

**Zthr** [float. Dataset keyword] The threshold defining which estimated data to use [dBZ]

**vectorize** [Bool. Dataset keyword] Whether to vectorize the KDP processing. Default false

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_kdp_leastsquare_single_window` (*procstatus, dscfg, radar\_list=None*)  
Computes specific differential phase using a piecewise least square method

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rwind** [float. Dataset keyword] The length of the segment for the least square method [m]

**vectorize** [bool. Dataset keyword] Whether to vectorize the KDP processing. Default false

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_1` (*procstatus, dscfg, radar\_list=None*)

Computes L parameter

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_melting_layer` (*procstatus, dscfg, radar\_list=None*)

Detects the melting layer

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_monitoring` (*procstatus, dscfg, radar\_list=None*)

computes monitoring statistics

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**step** [float. Dataset keyword] The width of the histogram bin. Default is None. In that case the default step in function `get_histogram_bins` is used

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [Radar] radar object containing histogram data

**ind\_rad** [int] radar index

`pyrad.proc.process_occurrence` (*procstatus, dscfg, radar\_list=None*)

computes the frequency of occurrence of data. It looks only for gates where data is present.

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- regular\_grid** [Boolean. Dataset keyword] Whether the radar has a Boolean grid or not. Default False
- rmin, rmax** [float. Dataset keyword] minimum and maximum ranges where the computation takes place. If -1 the whole range is considered. Default is -1
- val\_min** [Float. Dataset keyword] Minimum value to consider that the gate has signal. Default None
- filter\_prec** [str. Dataset keyword] Give which type of volume should be filtered. None, no filtering; keep\_wet, keep wet volumes; keep\_dry, keep dry volumes.
- rmax\_prec** [float. Dataset keyword] Maximum range to consider when looking for wet gates [m]
- percent\_prec\_max** [float. Dataset keyword] Maxim percentage of wet gates to consider the volume dry

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_occurrence_period(procstatus, dscfg, radar_list=None)`  
 computes the frequency of occurrence over a long period of time by adding together shorter periods

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- regular\_grid** [Boolean. Dataset keyword] Whether the radar has a Boolean grid or not. Default False
- rmin, rmax** [float. Dataset keyword] minimum and maximum ranges where the computation takes place. If -1 the whole range is considered. Default is -1

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_outlier_filter(procstatus, dscfg, radar_list=None)`  
 filters out gates which are outliers respect to the surrounding

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types

**threshold** [float. Dataset keyword] The distance between the value of the examined range gate and the median of the surrounding gates to consider the gate an outlier

**nb** [int. Dataset keyword] The number of neighbours (to one side) to analyse. i.e. 2 would correspond to 24 gates

**nb\_min** [int. Dataset keyword] Minimum number of neighbouring gates to consider the examined gate valid

**percentile\_min, percentile\_max** [float. Dataset keyword] gates below (above) these percentiles (computed over the sweep) are considered potential outliers and further examined

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_phidp_kdp_Kalman(procstatus, dscfg, radar_list=None)`

Computes specific differential phase and differential phase using the Kalman filter as proposed by Schneebeli et al. The data is assumed to be clutter free and continuous

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**parallel** [boolean. Dataset keyword] if set use parallel computing

**get\_phidp** [boolean. Dataset keyword] if set the PhiDP computed by integrating the resultant KDP is added to the radar field

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_phidp_kdp_Maesaka(procstatus, dscfg, radar_list=None)`

Estimates PhiDP and KDP using the method by Maesaka. This method only retrieves data in rain (i.e. below the melting layer)

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] The minimum range where to look for valid data [m]

**rmax** [float. Dataset keyword] The maximum range where to look for valid data [m]

**rcell** [float. Dataset keyword] The length of a continuous cell to consider it valid precip [m]

**Zmin** [float. Dataset keyword] The minimum reflectivity [dBZ]

**Zmax** [float. Dataset keyword] The maximum reflectivity [dBZ]

**fzl** [float. Dataset keyword] The freezing level height [m]. Default 2000.

**ml\_thickness** [float. Dataset keyword] The melting layer thickness in meters. Default 700.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_phidp_kdp_Vulpiani` (*procstatus, dscfg, radar\_list=None*)

Computes specific differential phase and differential phase using the method developed by Vulpiani et al. The data is assumed to be clutter free and monotonous

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rwind** [float. Dataset keyword] The length of the segment [m]

**n\_iter** [int. Dataset keyword] number of iterations

**interp** [boolean. Dataset keyword] if set non valid values are interpolated using neighbouring valid values

**parallel** [boolean. Dataset keyword] if set use parallel computing

**get\_phidp** [boolean. Dataset keyword] if set the PhiDP computed by integrating the resultant KDP is added to the radar field

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_phidp_kdp_lp` (*procstatus, dscfg, radar\_list=None*)

Estimates PhiDP and KDP using a linear programming algorithm. This method only retrieves data in rain (i.e. below the melting layer)

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**fzl** [float. Dataset keyword] The freezing level height [m]. Default 2000.

**ml\_thickness** [float. Dataset keyword] The melting layer thickness in meters. Default 700.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_point_measurement` (*procstatus, dscfg, radar\_list=None*)

Obtains the radar data at a point location.



**Parameters**

- procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing
- dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:
- datatype** [string. Dataset keyword] The data type where we want to extract the point measurement
  - latlon** [boolean. Dataset keyword] if True position is obtained from latitude, longitude information, otherwise position is obtained from antenna coordinates (range, azimuth, elevation).
  - truealt** [boolean. Dataset keyword] if True the user input altitude is used to determine the point of interest. if False use the altitude at a given radar elevation *ele* over the point of interest.
  - lon** [float. Dataset keyword] the longitude [deg]. Use when *latlon* is True.
  - lat** [float. Dataset keyword] the latitude [deg]. Use when *latlon* is True.
  - alt** [float. Dataset keyword] altitude [m MSL]. Use when *latlon* is True.
  - ele** [float. Dataset keyword] radar elevation [deg]. Use when *latlon* is False or when *latlon* is True and *truealt* is False
  - azi** [float. Dataset keyword] radar azimuth [deg]. Use when *latlon* is False
  - rng** [float. Dataset keyword] range from radar [m]. Use when *latlon* is False
  - AziTol** [float. Dataset keyword] azimuthal tolerance to determine which radar azimuth to use [deg]
  - EleTol** [float. Dataset keyword] elevation tolerance to determine which radar elevation to use [deg]
  - RngTol** [float. Dataset keyword] range tolerance to determine which radar bin to use [m]
- radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

- new\_dataset** [dict] dictionary containing the data and metadata at the point of interest
- ind\_rad** [int] radar index

`pyrad.proc.process_qvp(procstatus, dscfg, radar_list=None)`

Computes quasi vertical profiles, by averaging over height levels PPI data.

**Parameters**

- procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing
- dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:
- datatype** [string. Dataset keyword] The data type where we want to extract the point measurement
  - angle** [int or float] If the radar object contains a PPI volume, the sweep number to use, if it contains an RHI volume the elevation angle. Default 0.
  - ang\_tol** [float] If the radar object contains an RHI volume, the tolerance in the elevation angle for the conversion into PPI
  - hmax** [float] The maximum height to plot [m]. Default 10000.
  - hres** [float] The height resolution [m]. Default 50

**avg\_type** [str] The type of averaging to perform. Can be either “mean” or “median” Default “mean”

**nvalid\_min** [int] Minimum number of valid points to accept average. Default 30.

**interp\_kind** [str] type of interpolation when projecting to vertical grid: ‘none’, or ‘nearest’, etc. Default ‘none’ ‘none’ will select from all data points within the regular grid height bin the closest to the center of the bin. ‘nearest’ will select the closest data point to the center of the height bin regardless if it is within the height bin or not. Data points can be masked values If another type of interpolation is selected masked values will be eliminated from the data points before the interpolation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the QVP and a keyboard stating whether the processing has finished or not.

**ind\_rad** [int] radar index

`pyrad.proc.process_rainrate(procstatus, dscfg, radar_list=None)`

Estimates rainfall rate from polarimetric moments

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**RR\_METHOD** [string. Dataset keyword] The rainfall rate estimation method. One of the following: Z, ZPoly, KDP, A, ZKDP, ZA, hydro

**alpha, beta** [float] factor and exponent of the R-Var power law  $R = \alpha * Var^{\beta}$ . Default value depending on RR\_METHOD. Z (0.0376, 0.6112), KDP (None, None), A (None, None)

**alphaz, betaz** [float] factor and exponent of the R-Z power law  $R = \alpha * Z^{\beta}$ . Default value (0.0376, 0.6112)

**alphazr, betazr** [float] factor and exponent of the R-Z power law  $R = \alpha * Z^{\beta}$  applied to rain in method hydro. Default value (0.0376, 0.6112)

**alphazs, betazs** [float] factor and exponent of the R-Z power law  $R = \alpha * Z^{\beta}$  applied to solid precipitation in method hydro. Default value (0.1, 0.5)

**alphakdp, betakdp** [float] factor and exponent of the R-KDP power law  $R = \alpha * KDP^{\beta}$ . Default value (None, None)

**alphaa, betaa** [float] factor and exponent of the R-Ah power law  $R = \alpha * Ah^{\beta}$ . Default value (None, None)

**thresh** [float] In hybrid methods, Rainfall rate threshold at which the retrieval method used changes [mm/h]. Default value depending on RR\_METHOD. ZKDP 10, ZA 10, hydro 10

**mp\_factor** [float] Factor by which the Z-R relation is multiplied in the melting layer in method hydro. Default 0.6

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_raw` (*procstatus, dscfg, radar\_list=None*)

Dummy function that returns the initial input data set

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_rcs` (*procstatus, dscfg, radar\_list=None*)

Computes the radar cross-section (assuming a point target) from radar reflectivity.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**kw2** [float. Dataset keyowrd] The water constant

**pulse\_width** [float. Dataset keyowrd] The pulse width [s]

**beamwidthv** [float. Global keyword] The vertical polarization antenna beamwidth [deg].  
Used if input is vertical reflectivity

**beamwidthh** [float. Global keyword] The horizontal polarization antenna beamwidth  
[deg]. Used if input is horizontal reflectivity

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_rcs_pr` (*procstatus, dscfg, radar\_list=None*)

Computes the radar cross-section (assuming a point target) from radar reflectivity by first computing the received power and then the RCS from it.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**antenna\_gain** [float. Global keyword] The antenna gain [dB]

**txpwrv** [float. Global keyword] The transmitted power of the vertical channel [dBm]. Used  
if input is vertical reflectivity

**mflossv** [float. Global keyword] The matching filter losses of the vertical channel. Used if  
input is vertical reflectivity

**radconstv** [float. Global keyword] The vertical channel radar constant. Used if input is vertical reflectivity

**lrxv** [float. Global keyword] The receiver losses from the antenna feed to the reference point. [dB] positive value Used if input is vertical reflectivity

**ltxv** [float. Global keyword] The transmitter losses from the output of the high power amplifier to the antenna feed. [dB] positive value Used if input is vertical reflectivity

**lradomev** [float. Global keyword] The 1-way dry radome losses [dB] positive value. Used if input is vertical reflectivity

**txpwrh** [float. Global keyword] The transmitted power of the horizontal channel [dBm]. Used if input is horizontal reflectivity

**mflossh** [float. Global keyword] The matching filter losses of the vertical channel. Used if input is horizontal reflectivity

**radconsth** [float. Global keyword] The horizontal channel radar constant. Used if input is horizontal reflectivity

**lrxh** [float. Global keyword] The receiver losses from the antenna feed to the reference point. [dB] positive value Used if input is horizontal reflectivity

**ltxh** [float. Global keyword] The transmitter losses from the output of the high power amplifier to the antenna feed. [dB] positive value Used if input is horizontal reflectivity

**lradomeh** [float. Global keyword] The 1-way dry radome losses [dB] positive value. Used if input is horizontal reflectivity

**attg** [float. Dataset keyword] The gas attenuation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_rhohv_rain` (*procstatus*, *dscfg*, *radar\_list=None*)

Keeps only suitable data to evaluate the 80 percentile of RhoHV in rain

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] minimum range where to look for rain [m]. Default 1000.

**rmax** [float. Dataset keyword] maximum range where to look for rain [m]. Default 50000.

**Zmin** [float. Dataset keyword] minimum reflectivity to consider the bin as precipitation [dBZ]. Default 20.

**Zmax** [float. Dataset keyword] maximum reflectivity to consider the bin as precipitation [dBZ] Default 40.

**ml\_thickness** [float. Dataset keyword] assumed thickness of the melting layer. Default 700.

**fz1** [float. Dataset keyword] The default freezing level height. It will be used if no temperature field name is specified or the temperature field is not in the radar object. Default 2000.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_roi` (*procstatus, dscfg, radar\_list=None*)

Obtains the radar data at a region of interest.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the data and metadata at the point of interest

**ind\_rad** [int] radar index

`pyrad.proc.process_rqvp` (*procstatus, dscfg, radar\_list=None*)

Computes range defined quasi vertical profiles, by averaging over height levels PPI data.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**anglenr** [int] The sweep number to use. It assumes the radar volume consists on PPI scans

**hmax** [float] The maximum height to plot [m]. Default 10000.

**hres** [float] The height resolution [m]. Default 2.

**avg\_type** [str] The type of averaging to perform. Can be either “mean” or “median” Default “mean”

**nvalid\_min** [int] Minimum number of valid points to accept average. Default 30.

**interp\_kind** [str] type of interpolation when projecting to vertical grid: ‘none’, or ‘nearest’, etc. Default ‘nearest’ ‘none’ will select from all data points within the regular grid height bin the closest to the center of the bin. ‘nearest’ will select the closest data point to the center of the height bin regardless if it is within the height bin or not. Data points can be masked values If another type of interpolation is selected masked values will be eliminated from the data points before the interpolation

**rmax** [float] ground range up to which the data is intended for use [m]. Default 50000.

**weight\_power** [float] Power p of the weighting function  $1/(\text{abs}(\text{grng}-(\text{rmax}-1))^{*p}$  given to the data outside the desired range. -1 will set the weight to 0. Default 2.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the QVP and a keyboard stating whether the processing has finished or not.

**ind\_rad** [int] radar index

`pyrad.proc.process_save_radar (procstatus, dscfg, radar_list=None)`

Dummy function that allows to save the entire radar object

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_selfconsistency_bias (procstatus, dscfg, radar_list=None)`

Estimates the reflectivity bias by means of the selfconsistency algorithm by Gourley

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**fzl** [float. Dataset keyword] Default freezing level height. Default 2000.

**rsmooth** [float. Dataset keyword] length of the smoothing window [m]. Default 1000.

**min\_rhohv** [float. Dataset keyword] minimum valid RhoHV. Default 0.92

**max\_phidp** [float. Dataset keyword] maximum valid PhiDP [deg]. Default 20.

**ml\_thickness** [float. Dataset keyword] Melting layer thickness [m]. Default 700.

**rceil** [float. Dataset keyword] length of continuous precipitation to consider the precipitation cell a valid phidp segment [m]. Default 1000.

**dphidp\_min** [float. Dataset keyword] minimum phase shift [deg]. Default 2.

**dphidp\_max** [float. Dataset keyword] maximum phase shift [deg]. Default 16.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_selfconsistency_kdp_phidp (procstatus, dscfg, radar_list=None)`

Computes specific differential phase and differential phase in rain using the selfconsistency between Zdr, Zh and KDP

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of strings. Dataset keyword] The input data types

**rsmooth** [float. Dataset keyword] length of the smoothing window [m]. Default 1000.

**min\_rhohv** [float. Dataset keyword] minimum valid RhoHV. Default 0.92

**max\_phidp** [float. Dataset keyword] maximum valid PhiDP [deg]. Default 20.

**ml\_thickness** [float. Dataset keyword] assumed melting layer thickness [m]. Default 700.

**fzl** [float. Dataset keyword] The default freezing level height. It will be used if no temperature field name is specified or the temperature field is not in the radar object. Default 2000.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_signal_power` (*procstatus*, *dscfg*, *radar\_list=None*)

Computes the signal power in dBm

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**mflossv** [float. Global keyword] The matching filter losses of the vertical channel. Used if input is vertical reflectivity

**radconstv** [float. Global keyword] The vertical channel radar constant. Used if input is vertical reflectivity

**lrxv** [float. Global keyword] The receiver losses from the antenna feed to the reference point. [dB] positive value Used if input is vertical reflectivity

**lradomev** [float. Global keyword] The 1-way dry radome losses [dB] positive value. Used if input is vertical reflectivity

**mflossh** [float. Global keyword] The matching filter losses of the vertical channel. Used if input is horizontal reflectivity

**radconsth** [float. Global keyword] The horizontal channel radar constant. Used if input is horizontal reflectivity

**lrxh** [float. Global keyword] The receiver losses from the antenna feed to the reference point. [dB] positive value Used if input is horizontal reflectivity

**lradomeh** [float. Global keyword] The 1-way dry radome losses [dB] positive value. Used if input is horizontal reflectivity

**attg** [float. Dataset keyword] The gas attenuation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_smooth_phidp_double_window` (*procstatus, dscfg, radar\_list=None*)  
corrects phidp of the system phase and smoothes it using one window

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing  
**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:  
    **datatype** [list of string. Dataset keyword] The input data types  
    **rmin** [float. Dataset keyword] The minimum range where to look for valid data [m]  
    **rmax** [float. Dataset keyword] The maximum range where to look for valid data [m]  
    **rcell** [float. Dataset keyword] The length of a continuous cell to consider it valid precip [m]  
    **rwinds** [float. Dataset keyword] The length of the short smoothing window [m]  
    **rwindl** [float. Dataset keyword] The length of the long smoothing window [m]  
    **Zmin** [float. Dataset keyword] The minimum reflectivity [dBZ]  
    **Zmax** [float. Dataset keyword] The maximum reflectivity [dBZ]  
    **Zthr** [float. Dataset keyword] The threshold defining wich smoothed data to used [dBZ]  
**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output  
**ind\_rad** [int] radar index

`pyrad.proc.process_smooth_phidp_single_window` (*procstatus, dscfg, radar\_list=None*)  
corrects phidp of the system phase and smoothes it using one window

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing  
**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:  
    **datatype** [list of string. Dataset keyword] The input data types  
    **rmin** [float. Dataset keyword] The minimum range where to look for valid data [m]  
    **rmax** [float. Dataset keyword] The maximum range where to look for valid data [m]  
    **rcell** [float. Dataset keyword] The length of a continuous cell to consider it valid precip [m]  
    **rwind** [float. Dataset keyword] The length of the smoothing window [m]  
    **Zmin** [float. Dataset keyword] The minimum reflectivity [dBZ]  
    **Zmax** [float. Dataset keyword] The maximum reflectivity [dBZ]  
**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output  
**ind\_rad** [int] radar index

`pyrad.proc.process_snr` (*procstatus, dscfg, radar\_list=None*)  
Computes SNR

**Parameters**



**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**output\_type** [string. Dataset keyword] The output data type. Either SNRh or SNRv

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_sun_hits` (*procstatus, dscfg, radar\_list=None*)  
monitoring of the radar using sun hits

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] minimum range where to look for a sun hit signal [m]. Default 50000.

**hmin** [float. Dataset keyword] minimum altitude where to look for a sun hit signal [m MSL]. Default 10000. The actual range from which a sun hit signal will be search will be the minimum between rmin and the range from which the altitude is higher than hmin.

**delev\_max** [float. Dataset keyword] maximum elevation distance from nominal radar elevation where to look for a sun hit signal [deg]. Default 1.5

**dazim\_max** [float. Dataset keyword] maximum azimuth distance from nominal radar elevation where to look for a sun hit signal [deg]. Default 1.5

**elmin** [float. Dataset keyword] minimum radar elevation where to look for sun hits [deg]. Default 1.

**nbins\_min** [int. Dataset keyword.] minimum number of range bins that have to contain signal to consider the ray a potential sun hit. Default 10.

**attg** [float. Dataset keyword] gaseous attenuation. Default None

**max\_std\_pwr** [float. Dataset keyword] maximum standard deviation of the signal power to consider the data a sun hit [dB]. Default 2.

**max\_std\_zdr** [float. Dataset keyword] maximum standard deviation of the ZDR to consider the data a sun hit [dB]. Default 2.

**az\_width\_co** [float. Dataset keyword] co-polar antenna azimuth width (convoluted with sun width) [deg]. Default None

**el\_width\_co** [float. Dataset keyword] co-polar antenna elevation width (convoluted with sun width) [deg]. Default None

**az\_width\_cross** [float. Dataset keyword] cross-polar antenna azimuth width (convoluted with sun width) [deg]. Default None

**el\_width\_cross** [float. Dataset keyword] cross-polar antenna elevation width (convoluted with sun width) [deg]. Default None

**ndays** [int. Dataset keyword] number of days used in sun retrieval. Default 1

**coeff\_band** [float. Dataset keyword] multiply coefficient to transform pulse width into receiver bandwidth

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**sun\_hits\_dict** [dict] dictionary containing a radar object, a sun\_hits dict and a sun\_retrieval dictionary

**ind\_rad** [int] radar index

`pyrad.proc.process_svp` (*procstatus, dscfg, radar\_list=None*)

Computes slanted vertical profiles, by averaging over height levels PPI data.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**angle** [int or float] If the radar object contains a PPI volume, the sweep number to use, if it contains an RHI volume the elevation angle. Default 0.

**ang\_tol** [float] If the radar object contains an RHI volume, the tolerance in the elevation angle for the conversion into PPI. Default 1.

**lat, lon** [float] latitude and longitude of the point of interest [deg]

**latlon\_tol** [float] tolerance in latitude and longitude in deg. Default 0.0005

**delta\_rng, delta\_azi** [float] maximum range distance [m] and azimuth distance [degree] from the central point of the svp containing data to average. Default 5000. and 10.

**hmax** [float] The maximum height to plot [m]. Default 10000.

**hres** [float] The height resolution [m]. Default 250.

**avg\_type** [str] The type of averaging to perform. Can be either “mean” or “median” Default “mean”

**nvalid\_min** [int] Minimum number of valid points to consider the data valid when performing the averaging. Default 1

**interp\_kind** [str] type of interpolation when projecting to vertical grid: ‘none’, or ‘nearest’, etc. Default ‘none’ ‘none’ will select from all data points within the regular grid height bin the closest to the center of the bin. ‘nearest’ will select the closest data point to the center of the height bin regardless if it is within the height bin or not. Data points can be masked values If another type of interpolation is selected masked values will be eliminated from the data points before the interpolation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the svp and a keyboard stating whether the processing has finished or not.

**ind\_rad** [int] radar index

`pyrad.proc.process_time_avg` (*procstatus, dscfg, radar\_list=None*)

computes the temporal mean of a field

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- period** [float. Dataset keyword] the period to average [s]. Default 3600.
- start\_average** [float. Dataset keyword] when to start the average [s from midnight UTC]. Default 0.
- lin\_trans: int. Dataset keyword** If 1 apply linear transformation before averaging

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_time_avg_flag(procstatus, dscfg, radar_list=None)`  
 computes a flag field describing the conditions of the data used while averaging

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- period** [float. Dataset keyword] the period to average [s]. Default 3600.
- start\_average** [float. Dataset keyword] when to start the average [s from midnight UTC]. Default 0.
- phidpmax: float. Dataset keyword** maximum PhiDP

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [Radar] radar object

**ind\_rad** [int] radar index

`pyrad.proc.process_time_avg_std(procstatus, dscfg, radar_list=None)`  
 computes the average and standard deviation of data. It looks only for gates where data is present.

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- regular\_grid** [Boolean. Dataset keyword] Whether the radar has a Boolean grid or not. Default False
- rmin, rmax** [float. Dataset keyword] minimum and maximum ranges where the computation takes place. If -1 the whole range is considered. Default is -1
- val\_min** [Float. Dataset keyword] Minimum reflectivity value to consider that the gate has signal. Default None

**filter\_prec** [str. Dataset keyword] Give which type of volume should be filtered. None, no filtering; keep\_wet, keep wet volumes; keep\_dry, keep dry volumes.

**rmax\_prec** [float. Dataset keyword] Maximum range to consider when looking for wet gates [m]

**percent\_prec\_max** [float. Dataset keyword] Maxim percentage of wet gates to consider the volume dry

**lin\_trans** [Boolean. Dataset keyword] If True the data will be transformed into linear units. Default False

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_time_height` (*procstatus, dscfg, radar\_list=None*)

Produces time height radar objects at a point of interest defined by latitude and longitude. A time-height contains the evolution of the vertical structure of radar measurements above the location of interest.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The data type where we want to extract the point measurement

**lat, lon** [float] latitude and longitude of the point of interest [deg]

**latlon\_tol** [float] tolerance in latitude and longitude in deg. Default 0.0005

**hmax** [float] The maximum height to plot [m]. Default 10000.

**hres** [float] The height resolution [m]. Default 50

**interp\_kind** [str] type of interpolation when projecting to vertical grid: 'none', or 'nearest', etc. Default 'none' 'none' will select from all data points within the regular grid height bin the closest to the center of the bin. 'nearest' will select the closest data point to the center of the height bin regardless if it is within the height bin or not. Data points can be masked values If another type of interpolation is selected masked values will be eliminated from the data points before the interpolation

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the QVP and a keyboard stating whether the processing has finished or not.

**ind\_rad** [int] radar index

`pyrad.proc.process_time_stats` (*procstatus, dscfg, radar\_list=None*)

computes the temporal statistics of a field

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**period** [float. Dataset keyword] the period to average [s]. Default 3600.

**start\_average** [float. Dataset keyword] when to start the average [s from midnight UTC]. Default 0.

**lin\_trans: int. Dataset keyword** If 1 apply linear transformation before averaging

**stat: string. Dataset keyword** Statistic to compute: Can be mean, std, min, max. Default mean

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_time_stats2` (*procstatus, dscfg, radar\_list=None*)  
computes the temporal mean of a field

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**period** [float. Dataset keyword] the period to average [s]. Default 3600.

**start\_average** [float. Dataset keyword] when to start the average [s from midnight UTC]. Default 0.

**lin\_trans: int. Dataset keyword** If 1 apply linear transformation before averaging

**stat: string. Dataset keyword** Statistic to compute: Can be median, mode, percentileXX

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_traj_antenna_pattern` (*procstatus, dscfg, radar\_list=None, trajectory=None*)

Process a new array of data volumes considering a plane trajectory. As result a timeseries with the values transposed for a given antenna pattern is created. The result is created when the LAST flag is set.

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries]

**datatype** [list of string. Dataset keyword] The input data types

**antennaType** [str. Dataset keyword] Type of antenna of the radar we want to get the view from. Can be AZIMUTH, ELEVATION, LOWBEAM, HIGHBEAM

**par\_azimuth\_antenna** [dict. Global ekyword] Dictionary containing the parameters of the PAR azimuth antenna, i.e. name of the file with the antenna elevation pattern and fixed antenna angle

**par\_elevation\_antenna** [dict. Global keyword] Dictionary containing the parameters of the PAR elevation antenna, i.e. name of the file with the antenna azimuth pattern and fixed antenna angle

**asr\_lowbeam\_antenna** [dict. Global keyword] Dictionary containing the parameters of the ASR low beam antenna, i.e. name of the file with the antenna elevation pattern and fixed antenna angle

**asr\_highbeam\_antenna** [dict. Global keyword] Dictionary containing the parameters of the ASR high beam antenna, i.e. name of the file with the antenna elevation pattern and fixed antenna angle

**target\_radar\_pos** [dict. Global keyword] Dictionary containing the latitude, longitude and altitude of the radar we want to get the view from. If not specifying it will assume the radar is collocated

**range\_all** [Bool. Dataset keyword] If the real radar and the synthetic radar are co-located and this parameter is true the statistics are going to be computed using all the data from range 0 to the position of the plane. Default False

**rhi\_resolution** [Bool. Dataset keyword] Resolution of the synthetic RHI used to compute the data as viewed from the synthetic radar [deg]. Default 0.5

**max\_altitude** [float. Dataset keyword] Max altitude of the data to use when computing the view from the synthetic radar [m MSL]. Default 12000.

**latlon\_tol** [float. Dataset keyword] The tolerance in latitude and longitude to determine which synthetic radar gates are co-located with real radar gates [deg]. Default 0.04

**alt\_tol** [float. Dataset keyword] The tolerance in altitude to determine which synthetic radar gates are co-located with real radar gates [m]. Default 1000.

**pattern\_thres** [float. Dataset keyword] The minimum of the sum of the weights given to each value in order to consider the weighted quantile valid. It is related to the number of valid data points

**data\_is\_log** [dict. Dataset keyword] Dictionary specifying for each field if it is in log (True) or linear units (False). Default False

**use\_nans** [dict. Dataset keyword] Dictionary specifying whether the nans have to be used in the computation of the statistics for each field. Default False

**nan\_value** [dict. Dataset keyword] Dictionary with the value to use to substitute the NaN values when computing the statistics of each field. Default 0

**radar\_list** [list of Radar objects] Optional. list of radar objects

**trajectory** [Trajectory object] containing trajectory samples

#### Returns

**trajectory** [Trajectory object] Object holding time series

**ind\_rad** [int] radar index

`pyrad.proc.process_traj_atplane` (*procstatus, dscfg, radar\_list=None, trajectory=None*)

Return time series according to trajectory

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**data\_is\_log** [dict. Dataset keyword] Dictionary specifying for each field if it is in log (True) or linear units (False). Default False

**ang\_tol** [float. Dataset keyword] Factor that multiplies the angle resolution. Used when determining the neighbouring rays. Default 1.2

**radar\_list** [list of Radar objects] Optional. list of radar objects

**trajectory** [Trajectory object] containing trajectory samples

#### Returns

**trajectory** [Trajectory object] Object holding time series

**ind\_rad** [int] radar index

`pyrad.proc.process_traj_lightning` (*procstatus*, *dscfg*, *radar\_list=None*, *trajectory=None*)

Return time series according to lightning trajectory

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**data\_is\_log** [dict. Dataset keyword] Dictionary specifying for each field if it is in log (True) or linear units (False). Default False

**ang\_tol** [float. Dataset keyword] Factor that multiplies the angle resolution. Used when determining the neighbouring rays. Default 1.2

**radar\_list** [list of Radar objects] Optional. list of radar objects

**trajectory** [Trajectory object] containing trajectory samples

#### Returns

**trajectory** [Trajectory object] Object holding time series

**ind\_rad** [int] radar index

`pyrad.proc.process_traj_trt` (*procstatus*, *dscfg*, *radar\_list=None*, *trajectory=None*)

Processes data according to TRT trajectory

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**time\_tol** [float. Dataset keyword] tolerance between reference time of the radar volume and that of the TRT cell [s]. Default 100.

**alt\_min, alt\_max** [float. Dataset keyword] Minimum and maximum altitude of the data inside the TRT cell to retrieve [m MSL]. Default None

**radar\_list** [list of Radar objects] Optional. list of radar objects

**trajectory** [Trajectory object] containing trajectory samples

#### Returns

**trajectory** [Trajectory object] Object holding time series

**ind\_rad** [int] radar index

`pyrad.proc.process_trajectory` (*procstatus, dscfg, radar\_list=None, trajectory=None*)

Return trajectory

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

**trajectory** [Trajectory object] containing trajectory samples

**Returns**

**new\_dataset** [Trajectory object] radar object

**ind\_rad** [int] None

`pyrad.proc.process_vad` (*procstatus, dscfg, radar\_list=None*)

Estimates vertical wind profile using the VAD (velocity Azimuth Display) technique

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [string. Dataset keyword] The input data type

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_vol_refl` (*procstatus, dscfg, radar\_list=None*)

Computes the volumetric reflectivity in  $10\log_{10}(\text{cm}^2 \text{ km}^{-3})$

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**freq** [float. Dataset keyword] The radar frequency

**kw** [float. Dataset keyword] The water constant

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_weighted_time_avg` (*procstatus, dscfg, radar\_list=None*)

computes the temporal mean of a field weighted by the reflectivity

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing



**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [list of string. Dataset keyword] The input data types
- period** [float. Dataset keyword] the period to average [s]. Default 3600.
- start\_average** [float. Dataset keyword] when to start the average [s from midnight UTC]. Default 0.

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [Radar] radar object

**ind\_rad** [int] radar index

`pyrad.proc.process_wind_vel` (*procstatus, dscfg, radar\_list=None*)  
Estimates the horizontal or vertical component of the wind from the radial velocity

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [string. Dataset keyword] The input data type
- vert\_proj** [Boolean] If true the vertical projection is computed. Otherwise the horizontal projection is computed

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_windshear` (*procstatus, dscfg, radar\_list=None*)  
Estimates the wind shear from the wind velocity

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

- datatype** [string. Dataset keyword] The input data type
- az\_tol** [float] The tolerance in azimuth when looking for gates on top of the gate when computation is performed

**radar\_list** [list of Radar objects] Optional. list of radar objects

**Returns**

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_zdr_column` (*procstatus, dscfg, radar\_list=None*)  
Detects ZDR columns

**Parameters**

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_zdr_precip` (*procstatus, dscfg, radar\_list=None*)

Keeps only suitable data to evaluate the differential reflectivity in moderate rain or precipitation (for vertical scans)

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**ml\_filter** [boolean. Dataset keyword] indicates if a filter on data in and above the melting layer is applied. Default True.

**rmin** [float. Dataset keyword] minimum range where to look for rain [m]. Default 1000.

**rmax** [float. Dataset keyword] maximum range where to look for rain [m]. Default 50000.

**Zmin** [float. Dataset keyword] minimum reflectivity to consider the bin as precipitation [dBZ]. Default 20.

**Zmax** [float. Dataset keyword] maximum reflectivity to consider the bin as precipitation [dBZ] Default 22.

**RhoHVmin** [float. Dataset keyword] minimum RhoHV to consider the bin as precipitation Default 0.97

**PhiDPmax** [float. Dataset keyword] maximum PhiDP to consider the bin as precipitation [deg] Default 10.

**elmax** [float. Dataset keyword] maximum elevation angle where to look for precipitation [deg] Default None.

**ml\_thickness** [float. Dataset keyword] assumed thickness of the melting layer. Default 700.

**fzl** [float. Dataset keyword] The default freezing level height. It will be used if no temperature field name is specified or the temperature field is not in the radar object. Default 2000.

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index

`pyrad.proc.process_zdr_snow` (*procstatus, dscfg, radar\_list=None*)

Keeps only suitable data to evaluate the differential reflectivity in snow

#### Parameters

**procstatus** [int] Processing status: 0 initializing, 1 processing volume, 2 post-processing

**dscfg** [dictionary of dictionaries] data set configuration. Accepted Configuration Keywords:

**datatype** [list of string. Dataset keyword] The input data types

**rmin** [float. Dataset keyword] minimum range where to look for rain [m]. Default 1000.

**rmax** [float. Dataset keyword] maximum range where to look for rain [m]. Default 50000.

**Zmin** [float. Dataset keyword] minimum reflectivity to consider the bin as snow [dBZ]. Default 0.

**Zmax** [float. Dataset keyword] maximum reflectivity to consider the bin as snow [dBZ]. Default 30.

**SNRmin** [float. Dataset keyword] minimum SNR to consider the bin as snow [dB]. Default 10.

**SNRmax** [float. Dataset keyword] maximum SNR to consider the bin as snow [dB]. Default 50.

**RhoHVmin** [float. Dataset keyword] minimum RhoHV to consider the bin as snow. Default 0.97

**PhiDPmax** [float. Dataset keyword] maximum PhiDP to consider the bin as snow [deg]. Default 10.

**elmax** [float. Dataset keyword] maximum elevation angle where to look for snow [deg]. Default None.

**KDPmax** [float. Dataset keyword] maximum KDP to consider the bin as snow [deg]. Default None

**TEMPmin** [float. Dataset keyword] minimum temperature to consider the bin as snow [deg C]. Default None

**TEMPmax** [float. Dataset keyword] maximum temperature to consider the bin as snow [deg C]. Default None

**hydroclass** [list of ints. Dataset keyword] list of hydrometeor classes to keep for the analysis. Default [2] (dry snow)

**radar\_list** [list of Radar objects] Optional. list of radar objects

#### Returns

**new\_dataset** [dict] dictionary containing the output

**ind\_rad** [int] radar index



## PRODUCTS GENERATION (PYRAD . PROD)

Initiate the products generation.

### 3.1 Auxiliary functions

`get_dsformat_func`

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### 3.2 Product generation

<code>generate_occurrence_products(dataset, prdcfg)</code>	generates occurrence products. Accepted product types:
<code>generate_cosmo_coord_products(dataset, prdcfg)</code>	generates COSMO coordinates products. Accepted product types:
<code>generate_sun_hits_products(dataset, prdcfg)</code>	generates sun hits products. Accepted product types:
<code>generate_intercomp_products(dataset, prdcfg)</code>	Generates radar intercomparison products. Accepted product types:
<code>generate_colocated_gates_products(dataset, ...)</code>	Generates colocated gates products. Accepted product types:
<code>generate_time_avg_products(dataset, prdcfg)</code>	generates time average products. Accepted product types:
<code>generate_qvp_products(dataset, prdcfg)</code>	Generates quasi vertical profile-like products.
<code>generate_vol_products(dataset, prdcfg)</code>	Generates radar volume products. Accepted product types:
<code>generate_timeseries_products(dataset, prdcfg)</code>	Generates time series products. Accepted product types:
<code>generate_monitoring_products(dataset, prdcfg)</code>	generates a monitoring product.
<code>generate_grid_products(dataset, prdcfg)</code>	generates grid products. Accepted product types:
<code>generate_traj_product(traj, prdcfg)</code>	Generates trajectory products. Accepted product types:
<code>generate_ml_products(dataset, prdcfg)</code>	Generates melting layer products. Accepted product types:

`pyrad.prod.generate_colocated_gates_products (dataset, prdcfg)`

**Generates colocated gates products. Accepted product types:**

**‘WRITE\_COLOCATED\_GATES’:** Writes the position of the co-located gates in a csv file

All the products of the ‘VOL’ dataset group

**Parameters**

**dataset** [tuple] radar objects and colocated gates dictionary

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

**Returns**

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_cosmo_coord_products(dataset, prdcfg)`

**generates COSMO coordinates products. Accepted product types:**

**‘SAVEVOL’:** Save an object containing the index of the COSMO model grid that corresponds to each radar gate in a C/F radial file.

**Parameters**

**dataset** [tuple] radar object containing the COSMO coordinates

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

**Returns**

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_grid_products(dataset, prdcfg)`

**generates grid products. Accepted product types:**

**‘CROSS\_SECTION’:** Plots a cross-section of gridded data

**User defined parameters:**

**coord1, coord2:** dict The two lat-lon coordinates marking the limits. They have the keywords ‘lat’ and ‘lon’ [degree]. The altitude limits are defined by the parameters in ‘rhiImageConfig’ in the ‘loc’ configuration file

**‘LATITUDE\_SLICE’:** Plots a cross-section of gridded data over a constant latitude. User defined parameters:

**lon, lat:** floats The starting point of the cross-section. The ending point is defined by the parameters in ‘rhiImageConfig’ in the ‘loc’ configuration file

**‘LONGITUDE\_SLICE’:** Plots a cross-section of gridded data over a constant longitude. User defined parameters:

**lon, lat:** floats The starting point of the cross-section. The ending point is defined by the parameters in ‘rhiImageConfig’ in the ‘loc’ configuration file

**‘SAVEVOL’:** save the gridded data in a C/F radial file **‘SURFACE\_IMAGE’:** Plots a surface image of gridded data.

**User defined parameters:**

**level:** int The altitude level to plot. The rest of the parameters are defined by the parameters in ‘ppiImageConfig’ and ‘ppiMapImageConfig’ in the ‘loc’ configuration file

**Parameters**

**dataset** [grid] grid object

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**None or name of generated files**

`pyrad.prod.generate_intercomp_products(dataset, prdcfg)`

**Generates radar intercomparison products. Accepted product types:**

**‘PLOT\_AND\_WRITE\_INTERCOMP\_TS’:** Writes statistics of radar intercomparison in a file and plots the time series of the statistics. User defined parameters:

**‘add\_date\_in\_fname’:** **Bool** If true adds the year in the csv file containing the statistics. Default False

**‘sort\_by\_date’:** **Bool** If true sorts the statistics by date when reading the csv file containing the statistics. Default False

**‘rewrite’:** **Bool** If true rewrites the csv file containing the statistics. Default False

**‘npoints\_min’:** **int** The minimum number of points to consider the statistics valid and therefore use the data point in the plotting. Default 0

**‘corr\_min’:** **float** The minimum correlation to consider the statistics valid and therefore use the data point in the plotting. Default 0.

**‘PLOT\_SCATTER\_INTERCOMP’:** Plots a density plot with the points of radar 1 versus the points of radar 2 User defined parameters:

**‘step’:** **float** The quantization step of the data. If none it will be computed using the Py-ART config file. Default None

**‘WRITE\_INTERCOMP’:** Writes the instantaneously intercompared data (gate positions, values, etc.) in a csv file.

**‘WRITE\_INTERCOMP\_TIME\_AVG’:** Writes the time-averaged intercompared data (gate positions, values, etc.) in a csv file.

#### Parameters

**dataset** [tuple] values of colocated gates dictionary

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_ml_products(dataset, prdcfg)`

**Generates melting layer products. Accepted product types:**

**‘ML\_TS’:** Plots and writes a time series of the melting layer, i.e. the evolution of the average and standard deviation of the melting layer top and thickness and the the number of rays used in the retrieval. User defined parameters:

**dpi:** **int** The pixel density of the plot. Default 72

**‘SAVE\_ML’:** Saves an object containing the melting layer retrieval information in a C/F radial file

All the products of the ‘VOL’ dataset group

#### Parameters

**dataset** [dict] dictionary containing the radar object and a keyword stating the status of the processing

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_monitoring_products(dataset, prdcfg)`

generates a monitoring product. With the parameter 'hist\_type' the user may define is the product is computed for each radar volume ('instant') or at the end of the processing period ('cumulative'). Default is 'cumulative'. Accepted product types:

**'ANGULAR\_DENSITY': For a specified elevation angle, plots a 2D histogram** with the azimuth angle in the X-axis and the data values in the Y-axis. The reference values and the user defined quantiles are also plot on the same figure User defined parameters:

**anglenr: int** The elevation angle number to plot

**quantiles: list of floats** The quantiles to plot. Default 25., 50., 75.

**ref\_value: float** The reference value

**vmin, vmax** [floats or None] The minimum and maximum values of the data points. If not specified they are obtained from the Py-ART config file

**'CUMUL\_VOL\_TS': Plots time series of the average of instantaneous** quantiles stored in a csv file. User defined parameters:

**quantiles: list of 3 floats** the quantiles to compute. Default 25., 50., 75.

**ref\_value: float** The reference value. Default 0

**sort\_by\_date: Bool** If true when reading the csv file containing the statistics the data is sorted by date. Default False

**rewrite: Bool** If true the csv file containing the statistics is rewritten

**add\_data\_in\_fname: Bool** If true and the data used is cumulative the year is written in the csv file name and the plot file name

**npoints\_min: int** Minimum number of points to use the data point in the plotting and to send an alarm. Default 0

**vmin, vmax: float or None** Limits of the Y-axis (data value). If None the limits are obtained from the Py-ART config file

**alarm: Bool** If true an alarm is sent

**tol\_abs: float** Margin of tolerance from the reference value. If the current value is above this margin an alarm is sent. If the margin is not specified it is not possible to send any alarm

**tol\_trend: float** Margin of tolerance from the reference value. If the trend of the last X events is above this margin an alarm is sent. If the margin is not specified it is not possible to send any alarm

**nevents\_min: int** Minimum number of events with sufficient points to send an alarm related to the trend. If not specified it is not possible to send any alarm

**sender: str** The mail of the alarm sender. If not specified it is not possible to send any alarm



**receiver\_list: list of str** The list of emails of the people that will receive the alarm.. If not specified it is not possible to send any alarm

**‘PPI\_HISTOGRAM’: Plots a histogram of data at a particular** elevation angle. User defined parameters:

**anglenr: int** The elevation angle number to plot

**‘SAVEVOL’: Saves the monitoring data in a C/F radar file. The data** field contains histograms of data for each pair of azimuth and elevation angles

**‘VOL\_HISTOGRAM’: Plots a histogram of data collected from all the** radar volume. User defined parameters:

**write\_data: bool** If true the resultant histogram is also saved in a csv file. Default True.

**‘VOL\_TS’: Computes statistics of the gathered data and writes them in** a csv file and plots a time series of those statistics. User defined parameters:

**quantiles: list of 3 floats** the quantiles to compute. Default 25., 50., 75.

**ref\_value: float** The reference value. Default 0

**sort\_by\_date: Bool** If true when reading the csv file containing the statistics the data is sorted by date. Default False

**rewrite: Bool** If true the csv file containing the statistics is rewritten

**add\_data\_in\_fname: Bool** If true and the data used is cumulative the year is written in the csv file name and the plot file name

**npoints\_min: int** Minimum number of points to use the data point in the plotting and to send an alarm. Default 0

**vmin, vmax: float or None** Limits of the Y-axis (data value). If None the limits are obtained from the Py-ART config file

**alarm: Bool** If true an alarm is sent

**tol\_abs: float** Margin of tolerance from the reference value. If the current value is above this margin an alarm is sent. If the margin is not specified it is not possible to send any alarm

**tol\_trend: float** Margin of tolerance from the reference value. If the trend of the last X events is above this margin an alarm is sent. If the margin is not specified it is not possible to send any alarm

**nevents\_min: int** Minimum number of events with sufficient points to send an alarm related to the trend. If not specified it is not possible to send any alarm

**sender: str** The mail of the alarm sender. If not specified it is not possible to send any alarm

**receiver\_list: list of str** The list of emails of the people that will receive the alarm.. If not specified it is not possible to send any alarm

### Parameters

**dataset** [dictionary] dictionary containing a histogram object and some metadata

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_occurrence_products(dataset, prdcfg)`

**generates occurrence products. Accepted product types:**

**‘WRITE\_EXCESS\_GATES’:** Write the data that identifies radar gates with clutter that has a frequency of occurrence above a certain threshold. User defined parameters:

**quant\_min:** float Minimum frequency of occurrence in percentage to keep the gate as valid.  
Default 95.

All the products of the ‘VOL’ dataset group

#### Parameters

**dataset** [tuple] radar object and metadata dictionary

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_qvp_products(dataset, prdcfg)`

Generates quasi vertical profile-like products. Quasi vertical profiles come from azimuthal averaging of polarimetric radar data. With the variable ‘qvp\_type’ the user decides if the product has to be generated at the end of the processing period (‘final’) or instantaneously (‘instant’) Accepted product types:

All the products of the ‘VOL’ dataset group

#### Parameters

**dataset** [dict] dictionary containing the radar object and a keyword stating the status of the processing

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_sun_hits_products(dataset, prdcfg)`

**generates sun hits products. Accepted product types:**

**‘PLOT\_SUN\_HITS’:** Plots in a sun-radar azimuth difference-sun-radar elevation difference grid the values of all sun hits obtained during the processing period

**‘PLOT\_SUN\_RETRIEVAL’:** Plots in a sun-radar azimuth difference-sun-radar elevation difference grid the retrieved sun pattern

**‘PLOT\_SUN\_RETRIEVAL\_TS’:** Plots time series of the retrieved sun pattern parameters User defined parameters:

**dpi:** int The pixel density of the plot. Default 72

**add\_date\_in\_fname:** Bool If true the year is added in the plot file name

**‘WRITE\_SUN\_HITS’:** Writes the information concerning possible sun hits in a csv file

**‘WRITE\_SUN\_RETRIEVAL’:** Writes the retrieved sun pattern parameters in a csv file. User defined parameters:

**add\_date\_in\_fname:** Bool If true the year is added in the csv file name

All the products of the ‘VOL’ dataset group

#### Parameters

**dataset** [tuple] radar object and sun hits dictionary

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_time_avg_products(dataset, prdcfg)`

**generates time average products. Accepted product types:** All the products of the ‘VOL’ dataset group

#### Parameters

**dataset** [tuple] radar objects and colocated gates dictionary

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**filename** [str] the name of the file created. None otherwise

`pyrad.prod.generate_timeseries_products(dataset, prdcfg)`

**Generates time series products. Accepted product types:**

**‘COMPARE\_CUMULATIVE\_POINT’: Plots in the same graph 2 time series of** data accumulation (typically rainfall rate). One time series is a point measurement of radar data while the other is from a co-located instrument (rain gauge or disdrometer) User defined parameters:

**dpi: int** The pixel density of the plot. Default 72

**vmin, vmax: float** The limits of the Y-axis. If none they will be obtained from the Py-ART config file.

**sensor: str** The sensor type. Can be ‘rgage’ or ‘disdro’

**sensorid: str** The sensor ID.

**location: str** A string identifying the location of the disdrometer

**freq: float** The frequency used to retrieve the polarimetric variables of a disdrometer

**ele: float** The elevation angle used to retrieve the polarimetric variables of a disdrometer

**ScanPeriod: float** The scanning period of the radar in seconds. This parameter is defined in the ‘loc’ config file

**‘COMPARE\_POINT’: Plots in the same graph 2 time series of** data . One time series is a point measurement of radar data while the other is from a co-located instrument (rain gauge or disdrometer) User defined parameters:

**dpi: int** The pixel density of the plot. Default 72

**vmin, vmax: float** The limits of the Y-axis. If none they will be obtained from the Py-ART config file.

**sensor: str** The sensor type. Can be ‘rgage’ or ‘disdro’

**sensorid: str** The sensor ID.

**location: str** A string identifying the location of the disdrometer

**freq: float** The frequency used to retrieve the polarimetric variables of a disdrometer

**ele: float** The elevation angle used to retrieve the polarimetric variables of a disdrometer

**‘COMPARE\_TIME\_AVG’:** Creates a scatter plot of average radar data versus average sensor data.

User defined parameters:

**dpi: int** The pixel density of the plot. Default 72

**sensor: str** The sensor type. Can be ‘rgage’ or ‘disdro’

**sensorid: str** The sensor ID.

**location: str** A string identifying the location of the disdrometer

**freq: float** The frequency used to retrieve the polarimetric variables of a disdrometer

**ele: float** The elevation angle used to retrieve the polarimetric variables of a disdrometer

**cum\_time: float** Data accumulation time [s]. Default 3600.

**base\_time: float** Starting moment of the accumulation [s from midnight]. Default 0.

**‘PLOT\_AND\_WRITE’:** Writes and plots a trajectory time series.

User defined parameters:

**ymin, ymax: float** The minimum and maximum value of the Y-axis. If none it will be obtained from the Py-ART config file.

**‘PLOT\_AND\_WRITE\_POINT’:** Plots and writes a time series of radar data at a particular point

User defined parameters:

**dpi: int** The pixel density of the plot. Default 72

**vmin, vmax: float** The limits of the Y-axis. If none they will be obtained from the Py-ART config file.

**‘PLOT\_CUMULATIVE\_POINT’:** Plots a time series of radar data accumulation at a particular point. User defined parameters:

**dpi: int** The pixel density of the plot. Default 72

**vmin, vmax: float** The limits of the Y-axis. If none they will be obtained from the Py-ART config file.

**ScanPeriod: float** The scanning period of the radar in seconds. This parameter is defined in the ‘loc’ config file

**‘PLOT\_HIST’:** plots and writes a histogram of all the data gathered during the trajectory processing

User defined parameters:

**step: float or None** The quantization step of the data. If None it will be obtained from the Py-ART config file

**‘TRAJ\_CAPPI\_IMAGE’:** Creates a CAPPI image with the trajectory position overplot on it. User defined parameters:

**color\_ref: str** The meaning of the color code with which the trajectory is plotted. Can be ‘None’, ‘altitude’ (the absolute altitude), ‘rel\_altitude’ (altitude relative to the CAPPI altitude), ‘time’ (trajectory time respect of the start of the radar scan leading to the CAPPI)

**altitude: float** The CAPPI altitude [m]

**wfunc: str** Function used in the gridding of the radar data. The function types are defined in `pyart.map.grid_from_radars`. Default ‘NEAREST\_NEIGHBOUR’

**res: float** The CAPPI resolution [m]. Default 500.

#### Parameters

**dataset** [dictionary] radar object

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**no return**

`pyrad.prod.generate_traj_product(traj, prdcfg)`

**Generates trajectory products. Accepted product types:**

**‘TRAJ\_MAP’:** Plots the trajectory on a lat-lon map with the altitude color coded

**‘TRAJ\_PLOT’:** Plots time series of the trajectory respect to the radar elevation, azimuth or range

User defined parameters:

**‘datatype’:** **str** The type of parameter: ‘EL’, ‘AZ’, or ‘RANGE’

**‘TRAJ\_TEXT’:** Writes the trajectory information in a csv file

#### Parameters

**traj** [Trajectory object]

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**None**

`pyrad.prod.generate_vol_products(dataset, prdcfg)`

**Generates radar volume products. Accepted product types:**

**‘CDF’:** plots and writes the cumulative density function of data

User defined parameters:

**quantiles: list of floats** The quantiles to compute in percent. Default None

**sector: dict** dictionary defining the sector where to compute the CDF. Default is None and the CDF is computed over all the data May contain:

**rmin, rmax: float** min and max range [m]

**azmin, azmax: float** min and max azimuth angle [deg]

**elmin, elmax: float** min and max elevation angle [deg]

**hmin, hmax: float** min and max altitude [m MSL]

**vismin: float** The minimum visibility to use the data. Default None

**absolute: Bool** If true the absolute values of the data will be used. Default False

**use\_nans: Bool** If true NaN values will be used. Default False

**nan\_value: Bool** The value by which the NaNs are substituted if NaN values are to be used in the computation

**filterclt: Bool** If True the gates containing clutter are filtered

**filterprec: list of ints** The hydrometeor types that are filtered from the analysis. Default empty list.

**‘BSCOPE\_IMAGE’: Creates a B-scope image (azimuth, range)**

**User defined parameters:**

**anglenr** [int] The elevation angle number to use

**‘CAPPI\_IMAGE’: Creates a CAPPI image**

**User defined parameters:**

**altitude: flt** CAPPI altitude [m MSL]

**wfunc: str** The function used to produce the CAPPI as defined in `pyart.map.grid_from_radars`. Default ‘NEAREST\_NEIGHBOUR’

**cappi\_res: float** The CAPPI resolution [m]. Default 500.

**‘FIELD\_COVERAGE’: Gets the field coverage over a certain sector**

**User defined parameters:**

**threshold: float or None** Minimum value to consider the data valid. Default None

**nvalid\_min: float** Minimum number of valid gates in the ray to consider it valid. Default 5

**ele\_res, azi\_res: float** Elevation and azimuth resolution of the sectors [deg]. Default 1. and 2.

**ele\_min, ele\_max: float** Min and max elevation angle defining the sector [deg]. Default 0. and 30.

**ele\_step: float** Elevation step [deg]. Default 5.

**ele\_sect\_start, ele\_sect\_stop: float or None** start and stop angles of the sector coverage. Default None

**quantiles: list of floats** The quantiles to compute in the sector. Default 10. to 90. by steps of 10.

**AngTol: float** The tolerance in elevation angle when putting the data in a fixed grid

**‘FIXED\_RNG\_IMAGE’: Plots a fixed range image**

**User defined parameters:**

**AngTol** [float] The tolerance between the nominal angles and the actual radar angles. Default 1.

**ele\_res, azi\_res: float or None** The resolution of the fixed grid [deg]. If None it will be obtained from the separation between angles

**vmin, vmax** [float or None] Min and Max values of the color scale. If None the values are taken from the Py-ART config file

**‘FIXED\_RNG\_SPAN\_IMAGE’: Plots a user-defined statistic over a fixed range image** User defined parameters:

**AngTol** [float] The tolerance between the nominal angles and the actual radar angles. Default 1.

**ele\_res, azi\_res: float or None** The resolution of the fixed grid [deg]. If None it will be obtained from the separation between angles

**stat** [str] The statistic to compute. Can be ‘min’, ‘max’, ‘mean’, ‘mode’. Default ‘max’

**‘HISTOGRAM’: Computes a histogram of the radar volum data**

**User defined parameters:**

**step: float or None** the data quantization step. If none it will be obtained from the Py-ART configuration file

**write\_data: Bool** If true the histogram data is written in a csv file

**‘PLOT\_ALONG\_COORD’: Plots the radar volume data along a particular** coordinate User defined parameters:

**colors: list of str or None** The colors of each plotted line

**mode: str** Plotting mode. Can be ‘ALONG\_RNG’, ‘ALONG\_AZI’ or ‘ALONG\_ELE’

**value\_start, value\_stop: float** The starting and ending points of the data to plot. According to the mode it may refer to the range, azimuth or elevation. If not specified the minimum and maximum possible values are used

**fix\_elevations, fix\_azimuths, fix\_ranges: list of floats** The elevations, azimuths or ranges to plot for each mode. ‘ALONG\_RNG’ would use fix\_elevations and fix\_azimuths ‘ALONG\_AZI’ fix\_ranges and fix\_elevations ‘ALONG\_ELE’ fix\_ranges and fix\_azimuths

**AngTol: float** The tolerance to match the radar angle to the fixed angles Default 1.

**RngTol: float** The tolerance to match the radar range to the fixed ranges Default 50.

**‘PPI\_CONTOUR’: Plots a PPI countour plot**

**User defined parameters:**

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**anglenr: float** The elevation angle number

**‘PPI\_CONTOUR\_OVERPLOT’: Plots a PPI of a field with another field** overplotted as a contour plot. User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**anglenr: float** The elevation angle number

**‘PPI\_IMAGE’: Plots a PPI image. It can also plot the histogram and the** quantiles of the data in the PPI. User defined parameters:

**anglenr: float** The elevation angle number

**plot\_type: str** The type of plot to perform. Can be ‘PPI’, ‘QUANTILES’ or ‘HISTOGRAM’

**step: float or None** If the plot type is ‘HISTOGRAM’, the width of the histogram bin. If None it will be obtained from the Py-ART config file

**quantiles: list of float or None** If the plot type is ‘QUANTILES’, the list of quantiles to compute. If None a default list of quantiles will be computed

**‘PPI\_MAP’: Plots a PPI image over a map. The map resolution and the** type of maps used are defined in the variables ‘mapres’ and ‘maps’ in ‘ppiMapImageConfig’ in the loc config file. User defined parameters:

**anglenr: float** The elevation angle number

**‘PROFILE\_STATS’: Computes and plots a vertical profile statistics.** The statistics are saved in a csv file User defined parameters:

**heightResolution: float** The height resolution of the profile [m]. Default 100.

**heightMin, heightMax: float or None** The minimum and maximum altitude of the profile [m MSL]. If None the values will be obtained from the minimum and maximum gate altitude.

**quantity: str** The type of statistics to plot. Can be ‘quantiles’, ‘mode’, ‘regression\_mean’ or ‘mean’.

**quantiles: list of floats** If quantity type is ‘quantiles’ the list of quantiles to compute. Default 25., 50., 75.

**nvalid\_min: int** The minimum number of valid points to consider the statistic valid. Default 4

**make\_linear: Bool** If true the data is converted from log to linear before computing the stats

**include\_nans: Bool** If true NaN values are included in the statistics

**fixed\_span: Bool** If true the profile plot has a fix X-axis

**vmin, vmax: float or None** If fixed\_span is set, the minimum and maximum values of the X-axis. If None, they are obtained from the Py-ART config file

**‘PSEUDOPPI\_CONTOUR’: Plots a pseudo-PPI countour plot**

User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**angle: float** The elevation angle at which compute the PPI

**EleTol: float** The tolerance between the actual radar elevation angle and the nominal pseudo-PPI elevation angle.

**‘PSEUDOPPI\_CONTOUR\_OVERPLOT’: Plots a pseudo-PPI of a field with another field over-plotted as a contour plot** User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**angle: float** The elevation angle at which compute the PPI

**EleTol: float** The tolerance between the actual radar elevation angle and the nominal pseudo-PPI elevation angle.

**‘PSEUDOPPI\_IMAGE’: Plots a pseudo-PPI image. It can also plot the histogram and the quantiles of the data in the pseudo-PPI.** User defined parameters:

**angle: float** The elevation angle of the pseudo-PPI

**EleTol: float** The tolerance between the actual radar elevation angle and the nominal pseudo-PPI elevation angle.



**plot\_type: str** The type of plot to perform. Can be 'PPI', 'QUANTILES' or 'HISTOGRAM'

**step: float or None** If the plot type is 'HISTOGRAM', the width of the histogram bin. If None it will be obtained from the Py-ART config file

**quantiles: list of float or None** If the plot type is 'QUANTILES', the list of quantiles to compute. If None a default list of quantiles will be computed

**'PSEUDOPPI\_MAP': Plots a pseudo-PPI image over a map. The map** resolution and the type of maps used are defined in the variables 'mapres' and 'maps' in 'ppiMapImageConfig' in the loc config file. User defined parameters:

**angle: float** The elevation angle of the pseudo-PPI

**EleTol: float** The tolerance between the actual radar elevation angle and the nominal pseudo-PPI elevation angle.

**'PSEUDORHI\_CONTOUR': Plots a pseudo-RHI countour plot**

User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key 'contour\_values' or from the minimum and maximum values of the field with an assumed division of 10 levels.

**angle: float** The azimuth angle at which to compute the RPI

**AziTol: float** The tolerance between the actual radar azimuth angle and the nominal pseudo-RHI azimuth angle.

**'PSEUDORHI\_CONTOUR\_OVERPLOT': Plots a pseudo-RHI of a field with** another field over-plotted as a contour plot User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key 'contour\_values' or from the minimum and maximum values of the field with an assumed division of 10 levels.

**angle: float** The azimuth angle at which to compute the RPI

**AziTol: float** The tolerance between the actual radar azimuth angle and the nominal pseudo-RHI azimuth angle.

**'PSEUDORHI\_IMAGE': Plots a pseudo-RHI image. It can also plot the** histogram and the quantiles of the data in the pseudo-RHI. User defined parameters:

**angle: float** The azimuth angle at which to compute the RPI

**AziTol: float** The tolerance between the actual radar azimuth angle and the nominal pseudo-RHI azimuth angle.

**plot\_type: str** The type of plot to perform. Can be 'RHI', 'QUANTILES' or 'HISTOGRAM'

**step: float or None** If the plot type is 'HISTOGRAM', the width of the histogram bin. If None it will be obtained from the Py-ART config file

**quantiles: list of float or None** If the plot type is 'QUANTILES', the list of quantiles to compute. If None a default list of quantiles will be computed

**'QUANTILES': Plots and writes the quantiles of a radar volume**

User defined parameters:

**quantiles: list of floats or None** the list of quantiles to compute. If None a default list of quantiles will be computed.

**write\_data: Bool** If True the computed data will be also written in a csv file

**fixed\_span: Bool** If true the quantile plot has a fix Y-axis

**vmin, vmax: float or None** If fixed\_span is set, the minimum and maximum values of the Y-axis. If None, they are obtained from the Py-ART config file

#### **‘RHI\_CONTOUR’: Plots an RHI countour plot**

User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**anglenr: int** The azimuth angle number

#### **‘RHI\_CONTOUR\_OVERPLOT’: Plots an RHI of a field with another field** over-plotted as a contour plot User defined parameters:

**contour\_values: list of floats or None** The list of contour values to plot. If None the contour values are going to be obtained from the Py-ART config file either with the dictionary key ‘contour\_values’ or from the minimum and maximum values of the field with an assumed division of 10 levels.

**anglenr: int** The azimuth angle number

#### **‘RHI\_IMAGE’: Plots an RHI image. It can also plot the** histogram and the quantiles of the data in the RHI. User defined parameters:

**anglenr: int** The azimuth angle number

**plot\_type: str** The type of plot to perform. Can be ‘RHI’, ‘QUANTILES’ or ‘HISTOGRAM’

**step: float or None** If the plot type is ‘HISTOGRAM’, the width of the histogram bin. If None it will be obtained from the Py-ART config file

**quantiles: list of float or None** If the plot type is ‘QUANTILES’, the list of quantiles to compute. If None a default list of quantiles will be computed

#### **‘RHI\_PROFILE’: Computes and plots a vertical profile statistics out of** an RHI. The statistics are saved in a csv file User defined parameters:

**rangeStart, rangeStop: float** The range start and stop of the data to extract from the RHI to compute the statistics [m]. Default 0., 25000.

**heightResolution: float** The height resolution of the profile [m]. Default 100.

**heightMin, heightMax: float or None** The minimum and maximum altitude of the profile [m MSL]. If None the values will be obtained from the minimum and maximum gate altitude.

**quantity: str** The type of statistics to plot. Can be ‘quantiles’, ‘mode’, ‘regression\_mean’ or ‘mean’.

**quantiles: list of floats** If quantity type is ‘quantiles’ the list of quantiles to compute. Default 25., 50., 75.

**nvalid\_min: int** The minimum number of valid points to consider the statistic valid. Default 4

**make\_linear: Bool** If true the data is converted from log to linear before computing the stats

**include\_nans: Bool** If true NaN values are included in the statistics

**fixed\_span: Bool** If true the profile plot has a fix X-axis

**vmin, vmax: float or None** If fixed\_span is set, the minimum and maximum values of the X-axis. If None, they are obtained from the Py-ART config file

**‘SAVEALL’: Saves radar volume data including all or a list of user-** defined fields in a C/F radial or ODIM file User defined parameters:

**file\_type: str** The type of file used to save the data. Can be ‘nc’ or ‘h5’. Default ‘nc’

**datatypes: list of str or None** The list of data types to save. If it is None, all fields in the radar object will be saved

**physical: Bool** If True the data will be saved in physical units (floats). Otherwise it will be quantized and saved as binary

**compression: str** For ODIM file formats, the type of compression. Can be any of the allowed compression types for hdf5 files. Default gzip

**compression\_opts: any** The compression options allowed by the hdf5. Depends on the type of compression. Default 6 (The gzip compression level).

**‘SAVESTATE’: Saves the last processed data in a file. Used for real-** time data processing

**‘SAVEVOL’: Saves one field of a radar volume data in a C/F radial or** ODIM file User defined parameters:

**file\_type: str** The type of file used to save the data. Can be ‘nc’ or ‘h5’. Default ‘nc’

**physical: Bool** If True the data will be saved in physical units (floats). Otherwise it will be quantized and saved as binary

**compression: str** For ODIM file formats, the type of compression. Can be any of the allowed compression types for hdf5 files. Default gzip

**compression\_opts: any** The compression options allowed by the hdf5. Depends on the type of compression. Default 6 (The gzip compression level).

**‘SAVE\_FIXED\_ANGLE’: Saves the position of the first fix angle in a** csv file

**‘TIME\_RANGE’: Plots a time-range plot**

User defined parameters:

**anglenr: float** The number of the fixed angle to plot

**‘WIND\_PROFILE’: Plots vertical profile of wind data (U, V, W** components and wind velocity and direction) out of a radar volume containing the retrieved U,V and W components of the wind, the standard deviation of the retrieval and the velocity difference between the estimated radial velocity (assuming the wind to be uniform) and the actual measured radial velocity. User defined parameters:

**heightResolution: float** The height resolution of the profile [m]. Default 100.

**heightMin, heightMax: float or None** The minimum and maximum altitude of the profile [m MSL]. If None the values will be obtained from the minimum and maximum gate altitude.

**min\_ele: float** The minimum elevation to be used in the computation of the vertical velocities. Default 5.

**max\_ele: float** The maximum elevation to be used in the computation of the horizontal velocities. Default 85.

**fixed\_span: Bool** If true the profile plot has a fix X-axis

**vmin, vmax: float or None** If fixed\_span is set, the minimum and maximum values of the X-axis. If None, they are obtained from the span of the U component defined in the Py-ART config file

#### Parameters

**dataset** [dict] dictionary with key radar\_out containing a radar object

**prdcfg** [dictionary of dictionaries] product configuration dictionary of dictionaries

#### Returns

**The list of created fields or None**

`pyrad.prod.get_prodcfg(dsformat, dsname, dstype)`  
maps the dataset format into its processing function

#### Parameters

**dsformat** [str] dataset group. The following is a list of dataset groups with the function that is called to generate their products. For details about what the functions do check the function documentation:

'VOL':	generate_vol_products	'COLOCATED_GATES':	generate_collocated_gates_products
'COSMO_COORD':	generate_cosmo_coord_products	'GRID':	generate_grid_products
'INTERCOMP':	generate_intercomp_products	'ML':	generate_ml_products
'MONITORING':	generate_monitoring_products	'OCCURRENCE':	generate_occurrence_products
'QVP':	generate_qvp_products	'SPARSE_GRID':	generate_sparse_grid_products
'SUN_HITS':	generate_sun_hits_products	'TIMEAVG':	generate_time_avg_products
'TIMESERIES':	generate_timeseries_products	'TRAJ_ONLY':	generate_traj_product

#### Returns

**func** [function] pyrad function used to generate the products

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## INPUT AND OUTPUT (PYRAD . IO)

Functions to read and write data and configuration files.

### 4.1 Reading configuration files

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<code>read_config(fname[, cfg])</code>	Read a pyrad config file.
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### 4.2 Reading radar data

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<code>get_data(voltime, datatypesdescr, cfg)</code>	Reads pyrad input data.
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---

### 4.3 Reading cosmo data

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<code>cosmo2radar_data(radar, cosmo_coord, cosmo_data)</code>	get the COSMO value corresponding to each radar gate using nearest neighbour interpolation
<code>cosmo2radar_coord(radar, cosmo_coord[, ...])</code>	Given the radar coordinates find the nearest COSMO model pixel
<code>hzt2radar_data(radar, hzt_coord, hzt_data[, ...])</code>	get the HZT value corresponding to each radar gate using nearest neighbour interpolation
<code>hzt2radar_coord(radar, hzt_coord[, ...])</code>	Given the radar coordinates find the nearest HZT pixel
<code>get_cosmo_fields(cosmo_data, cosmo_ind[, ...])</code>	Get the COSMO data corresponding to each radar gate using a precomputed look up table of the nearest neighbour
<code>get_iso0_field(hzt_data, hzt_ind, z_radar[, ...])</code>	Get the height over iso0 data corresponding to each radar gate using a precomputed look up table of the nearest neighbour
<code>read_cosmo_data(fname[, field_names, celsius])</code>	Reads COSMO data from a netcdf file
<code>read_cosmo_coord(fname[, zmin])</code>	Reads COSMO coordinates from a netcdf file
<code>read_hzt_data(fname[, chy0, chx0])</code>	Reads iso-0 degree data from an HZT file

---

### 4.4 Reading other data

<code>read_last_state(fname)</code>	Reads a file containing the date of acquisition of the last volume processed
<code>read_status(voltime, cfg[, ind_rad])</code>	Reads rad4alp xml status file.
<code>read_rad4alp_cosmo(fname, datatype[, ngates])</code>	Reads rad4alp COSMO data binary file.
<code>read_rad4alp_vis(fname, datatype)</code>	Reads rad4alp visibility data binary file.
<code>read_excess_gates(fname)</code>	Reads a csv files containing the position of gates exceeding a given percentile of frequency of occurrence
<code>read_colocated_gates(fname)</code>	Reads a csv files containing the position of colocated gates
<code>read_colocated_data(fname)</code>	Reads a csv files containing colocated data
<code>read_timeseries(fname)</code>	Reads a time series contained in a csv file
<code>read_ts_cum(fname)</code>	Reads a time series of precipitation accumulation contained in a csv file
<code>read_monitoring_ts(fname[, sort_by_date])</code>	Reads a monitoring time series contained in a csv file
<code>read_intercomp_scores_ts(fname[, sort_by_date])</code>	Reads a radar intercomparison scores csv file
<code>get_sensor_data(date, datatype, cfg)</code>	Gets data from a point measurement sensor (rain gauge or disdrometer)
<code>read_smn(fname)</code>	Reads SwissMetNet data contained in a csv file
<code>read_smn2(fname)</code>	Reads SwissMetNet data contained in a csv file with format station,time,value
<code>read_disdro_scattering(fname)</code>	Reads scattering parameters computed from disdrometer data contained in a text file
<code>read_sun_hits(fname)</code>	Reads sun hits data contained in a csv file
<code>read_sun_hits_multiple_days(cfg, time_ref[, ...])</code>	Reads sun hits data from multiple file sources
<code>read_sun_retrieval(fname)</code>	Reads sun retrieval data contained in a csv file
<code>read_solar_flux(fname)</code>	Reads solar flux data from the DRAO observatory in Canada
<code>read_selfconsistency(fname)</code>	Reads a self-consistency table with Zdr, Kdp/Zh columns
<code>read_antenna_pattern(fname[, linear, twoway])</code>	Read antenna pattern from file
<code>read_meteorage(fname)</code>	Reads METEORAGE lightning data contained in a text file.
<code>read_lightning(fname[, filter_data])</code>	Reads lightning data contained in a text file.
<code>read_lightning_traj(fname)</code>	Reads lightning trajectory data contained in a csv file.
<code>read_lightning_all(fname[, labels])</code>	Reads a file containing lightning data and co-located polarimetric data.
<code>read_trt_scores(fname)</code>	Reads the TRT scores contained in a text file.
<code>read_trt_data(fname)</code>	Reads the TRT data contained in a text file.
<code>read_trt_traj_data(fname)</code>	Reads the TRT cell data contained in a text file.
<code>read_trt_cell_lightning(fname)</code>	Reads the lightning data of a TRT cell.
<code>read_trt_info_all(dir)</code>	Reads all the TRT info files
<code>read_trt_info(fname)</code>	Reads the TRT info used for thundertracking and contained in a text file.
<code>read_thundertracking_info(fname)</code>	Reads the TRT info used for thundertracking
<code>read_rhi_profile(fname[, labels])</code>	Reads a monitoring time series contained in a csv file
<code>read_histogram(fname)</code>	Reads a histogram contained in a csv file
<code>read_quantiles(fname)</code>	Reads quantiles contained in a csv file
<code>read_profile_ts(fname_list, labels[, hres, ...])</code>	Reads a collection of profile data file and creates a time series

Continued on next page

Table 4 – continued from previous page

<code>read_histogram_ts(fname_list, datatype[, t_res])</code>	Reads a collection of histogram data file and creates a time series
<code>read_quantiles_ts(fname_list[, step, qmin, ...])</code>	Reads a collection of quantiles data file and creates a time series
<code>read_ml_ts(fname)</code>	Reads a melting layer time series contained in a csv file

## 4.5 Writing data

<code>write_ts_lightning(flashnr, time_data, ...)</code>	writes the LMA sources data and the value of the collocated polarimetric variables
<code>send_msg(sender, receiver_list, subject, fname)</code>	sends the content of a text file by email
<code>write_alarm_msg(radar_name, param_name_unit, ...)</code>	writes an alarm file
<code>write_last_state(datetime_last, fname)</code>	writes SwissMetNet data in format datetime,avg_value, std_value
<code>write_smn(datetime_vec, value_avg_vec, ...)</code>	writes SwissMetNet data in format datetime,avg_value, std_value
<code>write_trt_info(ids, max_rank, nscans, ...)</code>	writes TRT info of the thundertracking
<code>write_trt_cell_data(traj_ID, yyyymmddHHMM, ...)</code>	writes TRT cell data
<code>write_trt_cell_scores(traj_ID, ...)</code>	writes TRT cells scores
<code>write_trt_cell_lightning(cell_ID, cell_time, ...)</code>	writes the lightning data for each TRT cell
<code>write_rhi_profile(hvec, data, nvalid_vec, ...)</code>	writes the values of an RHI profile in a text file
<code>write_field_coverage(quantiles, values, ...)</code>	writes the quantiles of the coverage on a particular sector
<code>write_cdf(quantiles, values, ntot, nnan, ...)</code>	writes a cumulative distribution function
<code>write_histogram(bin_edges, values, fname[, ...])</code>	writes a histogram
<code>write_quantiles(quantiles, values, fname[, ...])</code>	writes quantiles
<code>write_ts_polar_data(dataset, fname)</code>	writes time series of data
<code>write_ts_cum(dataset, fname)</code>	writes time series accumulation of data
<code>write_monitoring_ts(start_time, np_t, ...[, ...])</code>	writes time series of data
<code>write_excess_gates(excess_dict, fname)</code>	Writes the position and values of gates that have a frequency of occurrence higher than a particular threshold
<code>write_intercomp_scores_ts(start_time, stats, ...)</code>	writes time series of radar intercomparison scores
<code>write_collocated_gates(coloc_gates, fname)</code>	Writes the position of gates collocated with two radars
<code>write_collocated_data(coloc_data, fname)</code>	Writes the data of gates collocated with two radars
<code>write_collocated_data_time_avg(coloc_data, fname)</code>	Writes the time averaged data of gates collocated with two radars
<code>write_sun_hits(sun_hits, fname)</code>	Writes sun hits data.
<code>write_sun_retrieval(sun_retrieval, fname)</code>	Writes sun retrieval data.
<code>write_fixed_angle(time_data, fixed_angle, ...)</code>	writes an output file with the fixed angle data

## 4.6 Auxiliary functions

<code>map_hydro(hydro_data_op)</code>	maps the operational hydrometeor classification identifiers to the ones used by Py-ART
<code>map_Doppler(Doppler_data_bin, Nyquist_vel)</code>	maps the binary METRANET Doppler data to actual Doppler velocity
<code>get_save_dir(basepath, procname, dsname, prdname)</code>	obtains the path to a product directory and eventually creates it
<code>make_filename(prdtype, dstype, dsname, ext_list)</code>	creates a product file name
<code>generate_field_name_str(datatype)</code>	Generates a field name in a nice to read format.
<code>get_fieldname_pyart(datatype)</code>	maps the config file radar data type name into the corresponding rainbow Py-ART field name
<code>get_fieldname_cosmo(field_name)</code>	maps the Py-ART field name into the corresponding COSMO variable name
<code>get_field_unit(datatype)</code>	Return unit of datatype.
<code>get_file_list(datadescriptor, starttime, ...)</code>	gets the list of files with a time period
<code>get_trtfile_list(basepath, starttime, endtime)</code>	gets the list of TRT files with a time period
<code>get_new_rainbow_file_name(master_fname, ...)</code>	get the rainbow file name containing datatype from a master file name and data type
<code>get_datatype_fields(datadescriptor)</code>	splits the data type descriptor and provides each individual member
<code>get_dataset_fields(datasetdescr)</code>	splits the dataset type descriptor and provides each individual member
<code>get_datetime(fname, datadescriptor)</code>	Given a data descriptor gets date and time from file name
<code>find_raw_cosmo_file(voltime, datatype, cfg)</code>	Search a COSMO file in netcdf format
<code>find_hzt_file(voltime, cfg[, ind_rad])</code>	Search an ISO-0 degree file in HZT format
<code>_get_datetime(fname, datagroup[, ftime_format])</code>	Given a data group gets date and time from file name

## 4.7 Trajectory

<code>Trajectory(filename[, starttime, endtime, ...])</code>	A class for reading and handling trajectory data from a file.
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## 4.8 TimeSeries

<code>TimeSeries(desc[, timevec, timeformat, ...])</code>	Holding timeseries data and metadata.
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**class** `pyrad.io.TimeSeries` (*desc, timevec=None, timeformat=None, maxlength=None, datatype=""*)  
Bases: `object`

Holding timeseries data and metadata.

### Attributes

**description** [array of str] Description of the data of the time series.

**time\_vector** [array of datetime objects]

**timeformat** [how to print the time (default:)] 'Date, UTC [seconds since midnight]'

**dataseries** [List of `_dataSeries` object holding the] data



## Methods

<code>add_dataserries(label, unit_name, unit[, ...])</code>	Add a new data series to the timeseries object.
<code>add_timesample(dt, values)</code>	Add a new sample to the time series.
<code>plot(fname[, ymin, ymax])</code>	Make a figure of a time series
<code>plot_hist(fname[, step])</code>	Make histograms of time series
<code>write(fname)</code>	Write time series output

### `__class__`

alias of `builtins.type`

### `__delattr__ ($self, name, /)`

Implement `delattr(self, name)`.

### `__dict__ = mappingproxy({'__module__': 'pyrad.io.timeseries', '__doc__': "\n Holding`

### `__dir__ ($self, /)`

Default `dir()` implementation.

### `__eq__ ($self, value, /)`

Return `self==value`.

### `__format__ ($self, format_spec, /)`

Default object formatter.

### `__ge__ ($self, value, /)`

Return `self>=value`.

### `__getattr__ ($self, name, /)`

Return `getattr(self, name)`.

### `__gt__ ($self, value, /)`

Return `self>value`.

### `__hash__ ($self, /)`

Return `hash(self)`.

### `__init__ (desc, timevec=None, timeformat=None, maxlength=None, datatype="")`

Initialize the object.

### Parameters

**desc** [array of str]

**timevec** [array of datetime]

**timeformat** [specifies time format]

**maxlength** [Maximal length of the time series]

**num\_el** [Number of values in the time series]

### `__init_subclass__ ()`

This method is called when a class is subclassed.

The default implementation does nothing. It may be overridden to extend subclasses.

### `__le__ ($self, value, /)`

Return `self<=value`.

### `__lt__ ($self, value, /)`

Return `self<value`.

**\_\_module\_\_** = 'pyrad.io.timeseries'

**\_\_ne\_\_** (\$self, value, /)  
Return self!=value.

**\_\_new\_\_** (\$type, \*args, \*\*kwargs)  
Create and return a new object. See help(type) for accurate signature.

**\_\_reduce\_\_** (\$self, /)  
Helper for pickle.

**\_\_reduce\_ex\_\_** (\$self, protocol, /)  
Helper for pickle.

**\_\_repr\_\_** (\$self, /)  
Return repr(self).

**\_\_setattr\_\_** (\$self, name, value, /)  
Implement setattr(self, name, value).

**\_\_sizeof\_\_** (\$self, /)  
Size of object in memory, in bytes.

**\_\_str\_\_** (\$self, /)  
Return str(self).

**\_\_subclasshook\_\_** ()  
Abstract classes can override this to customize issubclass().

This is invoked early on by abc.ABCMeta.\_\_subclasscheck\_\_(). It should return True, False or NotImplemented. If it returns NotImplemented, the normal algorithm is used. Otherwise, it overrides the normal algorithm (and the outcome is cached).

**\_\_weakref\_\_**  
list of weak references to the object (if defined)

**add\_dataserie**s (label, unit\_name, unit, dataserie=None, plot=True, color=None, linestyle=None)  
Add a new data series to the timeseries object. The length of the data vector must be the same as the length of the time vector.

**add\_timesample** (dt, values)  
Add a new sample to the time series.

**plot** (fname, ymin=None, ymax=None)  
Make a figure of a time series

**plot\_hist** (fname, step=None)  
Make histograms of time series

**write** (fname)  
Write time series output

**class** pyrad.io.**Trajectory** (filename, starttime=None, endtime=None, trajtype='plane', flashnr=0)  
Bases: `object`

A class for reading and handling trajectory data from a file.

#### Attributes

**filename** [str] Path and name of the trajectory definition file

**starttime** [datetime] Start time of trajectory processing.

**endtime** [datetime] End time of trajectory processing.

**trajtype** [str]

Type of trajectory. Can be 'plane' or 'lightning'

**time\_vector** [Array of datetime objects] Array containing the trajectory time samples

**wgs84\_lat\_deg** [Array of floats] WGS84 latitude samples in radian

**wgs84\_lon\_deg** [Array of floats] WGS84 longitude samples in radian

**wgs84\_alt\_m** [Array of floats] WGS84 altitude samples in m

**nsamples** [int]

Number of samples in the trajectory

**\_swiss\_grid\_done** [Bool] Indicates that conversion to Swiss coordinates has been performed

**swiss\_chy, swiss\_chx, swiss\_chh** [Array of floats] Swiss coordinates in m

**radar\_list** [list] List of radars for which trajectories are going to be computed

**flashnr** [int] For 'lightning' only. Number of flash for which trajectory data is going to be computed. If 0 all all flashes are going to be considered.

**time\_in\_flash** [array of floats] For 'lightning' only. Time within flash (sec)

**flashnr\_vec** [array of ints] For 'lightning' only. Flash number of each data sample

**dBm** [array of floats] For 'lightning' only. Lightning power (dBm)

## Methods

<i>add_radar</i> (radar)	Add the coordinates (WGS84 longitude, latitude and non WGS84 altitude) of a radar to the radar_list.
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<i>calculate_velocities</i> (radar)	Calculate velocities.
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<i>get_end_time</i> ()	Get time of last trajectory sample.
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<i>get_samples_in_period</i> ([start, end])	"
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<i>get_start_time</i> ()	Get time of first trajectory sample.
--------------------------	--------------------------------------

**\_\_class\_\_**

alias of builtins.type

**\_\_delattr\_\_** (\$self, name, /)

Implement delattr(self, name).

**\_\_dict\_\_** = **mappingproxy**({'\_\_module\_\_': 'pyrad.io.trajectory', '\_\_doc\_\_': "\n A class

**\_\_dir\_\_** (\$self, /)

Default dir() implementation.

**\_\_eq\_\_** (\$self, value, /)

Return self==value.

**\_\_format\_\_** (\$self, format\_spec, /)

Default object formatter.

**\_\_ge\_\_** (\$self, value, /)

Return self>=value.

**\_\_getattr\_\_** (\$self, name, /)

Return `getattr(self, name)`.

**\_\_gt\_\_** (*\$self, value, /*)  
Return `self > value`.

**\_\_hash\_\_** (*\$self, /*)  
Return `hash(self)`.

**\_\_init\_\_** (*filename, starttime=None, endtime=None, trajtype='plane', flashnr=0*)  
Initialize the object.

#### Parameters

**filename** [str] Filename containing the trajectory samples.

**starttime** [datetime] Start time of trajectory processing. If not given, use the time of the first trajectory sample.

**endtime** [datetime] End time of trajectory processing. If not given, use the time of the last trajectory sample.

**trajtype** [str] type of trajectory. Can be plane or lightning

**flashnr** [int] If type of trajectory is lightning, the flash number to check the trajectory. 0 means all flash numbers included

**\_\_init\_subclass\_\_** ()  
This method is called when a class is subclassed.

The default implementation does nothing. It may be overridden to extend subclasses.

**\_\_le\_\_** (*\$self, value, /*)  
Return `self <= value`.

**\_\_lt\_\_** (*\$self, value, /*)  
Return `self < value`.

**\_\_module\_\_** = `'pyrad.io.trajectory'`

**\_\_ne\_\_** (*\$self, value, /*)  
Return `self != value`.

**\_\_new\_\_** (*\$type, \*args, \*\*kwargs*)  
Create and return a new object. See `help(type)` for accurate signature.

**\_\_reduce\_\_** (*\$self, /*)  
Helper for pickle.

**\_\_reduce\_ex\_\_** (*\$self, protocol, /*)  
Helper for pickle.

**\_\_repr\_\_** (*\$self, /*)  
Return `repr(self)`.

**\_\_setattr\_\_** (*\$self, name, value, /*)  
Implement `setattr(self, name, value)`.

**\_\_sizeof\_\_** (*\$self, /*)  
Size of object in memory, in bytes.

**\_\_str\_\_** (*\$self, /*)  
Return `str(self)`.

**\_\_subclasshook\_\_** ()  
Abstract classes can override this to customize `issubclass()`.

This is invoked early on by `abc.ABCMeta.__subclasscheck__()`. It should return `True`, `False` or `NotImplemented`. If it returns `NotImplemented`, the normal algorithm is used. Otherwise, it overrides the normal algorithm (and the outcome is cached).

#### **`__weakref__`**

list of weak references to the object (if defined)

#### **`_convert_traj_to_swissgrid()`**

Convert trajectory samples from WGS84 to Swiss CH1903 coordinates

#### **`_get_total_seconds(x)`**

Return total seconds of `timedelta` object

#### **`_read_traj()`**

Read trajectory from file

#### **`_read_traj_lightning(flashnr=0)`**

Read trajectory from lightning file

#### **Parameters**

**flashnr** [int] the flash number to keep. If 0 data from all flashes will be kept

#### **`_read_traj_trt()`**

Read trajectory from TRT file

#### **`add_radar(radar)`**

Add the coordinates (WGS84 longitude, latitude and non WGS84 altitude) of a radar to the `radar_list`.

#### **Parameters**

**radar** [pyart radar object] containing the radar coordinates

#### **`calculate_velocities(radar)`**

Calculate velocities.

#### **`get_end_time()`**

Get time of last trajectory sample.

#### **`get_samples_in_period(start=None, end=None)`**

” Get indices of samples of the trajectory within given time period.

#### **`get_start_time()`**

Get time of first trajectory sample.

#### **`pyrad.io.add_field(radar_dest, radar_orig)`**

adds the fields from `orig` radar into `dest` radar. If they are not in the same grid, interpolates them to `dest` grid

#### **Parameters**

**radar\_dest** [radar object] the destination radar

**radar\_orig** [radar object] the radar object containing the original field

#### **Returns**

**field\_dest** [dict] interpolated field and metadata

#### **`pyrad.io.cosmo2radar_coord(radar, cosmo_coord, slice_xy=True, slice_z=False, field_name=None)`**

Given the radar coordinates find the nearest COSMO model pixel

#### **Parameters**

**radar** [Radar] the radar object containing the information on the position of the radar gates

**cosmo\_coord** [dict] dictionary containing the COSMO coordinates

**slice\_xy** [boolean] if true the horizontal plane of the COSMO field is cut to the dimensions of the radar field

**slice\_z** [boolean] if true the vertical plane of the COSMO field is cut to the dimensions of the radar field

**field\_name** [str] name of the field

#### Returns

**cosmo\_ind\_field** [dict] dictionary containing a field of COSMO indices and metadata

`pyrad.io.cosmo2radar_data(radar, cosmo_coord, cosmo_data, time_index=0, slice_xy=True, slice_z=False, field_names=['temperature'])`  
get the COSMO value corresponding to each radar gate using nearest neighbour interpolation

#### Parameters

**radar** [Radar] the radar object containing the information on the position of the radar gates

**cosmo\_coord** [dict] dictionary containing the COSMO coordinates

**cosmo\_data** [dict] dictionary containing the COSMO data

**time\_index** [int] index of the forecasted data

**slice\_xy** [boolean] if true the horizontal plane of the COSMO field is cut to the dimensions of the radar field

**slice\_z** [boolean] if true the vertical plane of the COSMO field is cut to the dimensions of the radar field

**field\_names** [str] names of COSMO fields to convert (default temperature)

#### Returns

**cosmo\_fields** [list of dict] list of dictionary with the COSMO fields and metadata

`pyrad.io.find_hzt_file(voltime, cfg, ind_rad=0)`  
Search an ISO-0 degree file in HZT format

#### Parameters

**voltime** [datetime object] volume scan time

**cfg** [dictionary of dictionaries] configuration info to figure out where the data is

**ind\_rad** [int] radar index

#### Returns

**fname** [str] Name of HZT file if it exists. None otherwise

`pyrad.io.find_raw_cosmo_file(voltime, datatype, cfg, ind_rad=0)`  
Search a COSMO file in netcdf format

#### Parameters

**voltime** [datetime object] volume scan time

**datatype** [str] type of COSMO data to look for

**cfg** [dictionary of dictionaries] configuration info to figure out where the data is

**ind\_rad** [int] radar index

#### Returns

**fname** [str] Name of COSMO file if it exists. None otherwise

`pyrad.io.generate_field_name_str (datatype)`

Generates a field name in a nice to read format.

#### Parameters

**datatype** [str] The data type

#### Returns

**field\_str** [str] The field name

`pyrad.io.get_cosmo_fields (cosmo_data, cosmo_ind, time_index=0, field_names=['temperature'])`

Get the COSMO data corresponding to each radar gate using a precomputed look up table of the nearest neighbour

#### Parameters

**cosmo\_data** [dict] dictionary containing the COSMO data and metadata

**cosmo\_ind** [dict] dictionary containing a field of COSMO indices and metadata

**time\_index** [int] index of the forecasted data

**field\_names** [str] names of COSMO parameters (default temperature)

#### Returns

**cosmo\_fields** [list of dict] dictionary with the COSMO fields and metadata

`pyrad.io.get_data (voltime, datatypesdescr, cfg)`

Reads pyrad input data.

#### Parameters

**voltime** [datetime object] volume scan time

**datatypesdescr** [list] list of radar field types to read. Format :  
[radarnr]:[datagroup]:[datatype],[dataset],[product] 'dataset' is only specified for data groups 'ODIM', 'CFRADIAL' and 'ODIMPYRAD'. 'product' is only specified for data groups 'CFRADIAL' and 'ODIMPYRAD' The data group specifies the type file from which data is extracted. It can be:

'RAINBOW': Proprietary Leonardo format 'COSMO': COSMO model data saved in Rainbow file format 'DEM': Visibility data saved in Rainbow file format

'RAD4ALP': METRANET format used for the operational MeteoSwiss data. To find out which datatype to use to match a particular METRANET field name check the function 'get\_datatype\_meteoranet' in pyrad/io/io\_aux.py

'RAD4ALPCOSMO': COSMO model data saved in a binary file format. Used by operational MeteoSwiss radars

'RAD4ALPDEM': Visibility data saved in a binary format used by operational MeteoSwiss radars

'RAD4ALPHYDRO': Used to read the MeteoSwiss operational hydrometeor classification

'RAD4ALPDOPPLER': Used to read the MeteoSwiss operational dealiased Doppler velocity

'ODIM': Generic ODIM file format. For such types 'dataset' specifies the directory and file name date convention. Example: ODIM:dBZ,D{%Y-%m-%d}-F{%Y%m%d%H%M%S}. To find out which datatype to use to match

a particular ODIM field name check the function ‘get\_datatype\_odim’ in `pyrad/io/io_aux.py`

‘MXPOL’: MXPOL (EPFL) data written in a netcdf file

‘CFRADIAL’: CFRadial format with the naming convention and directory structure in which Pyrad saves the data. For such datatypes ‘dataset’ specifies the directory where the dataset is stored and ‘product’ specifies the directory where the product is stored. Example: CFRADIAL:dBZc,Att\_ZPhi,SAVEVOL\_dBZc

‘ODIMPYRAD’: ODIM file format with the naming convention and directory structure in which Pyrad saves the data. For such datatypes ‘dataset’ specifies the directory where the dataset is stored and ‘product’ specifies the directory where the product is stored. Example: ODIMPYRAD:dBZc,Att\_ZPhi,SAVEVOL\_dBZc

‘RAINBOW’, ‘RAD4ALP’, ‘ODIM’ and ‘MXPOL’ are primary data file sources and they cannot be mixed for the same radar. It is also the case for their complementary data files, i.e. ‘COSMO’ and ‘RAD4ALPCOSMO’, etc. ‘CFRADIAL’ and ‘ODIMPYRAD’ are secondary data file sources and they can be combined with any other datagroup type. For a list of accepted datatypes and how they map to the Py-ART name convention check function ‘get\_field\_name\_pyart’ in `pyrad/io/io_aux.py`

**cfg: dictionary of dictionaries** configuration info to figure out where the data is

#### Returns

**radar** [Radar] radar object

`pyrad.io.get_dataset_fields` (*datasetdescr*)

splits the dataset type descriptor and provides each individual member

#### Parameters

**datasetdescr** [str] dataset type. Format : [processing level]:[dataset type]

#### Returns

**proclevel** [str] dataset processing level

**dataset** [str] dataset type, i.e. dBZ, ZDR, ISO0, ...

`pyrad.io.get_datatype_fields` (*datadescriptor*)

splits the data type descriptor and provides each individual member

#### Parameters

**datadescriptor** [str] radar field type. Format : [radar file type]:[datatype]

#### Returns

**radarnr** [str] radar number, i.e. RADAR1, RADAR2, ...

**datagroup** [str] data type group, i.e. RAINBOW, RAD4ALP, ODIM, CFRADIAL, COSMO, MXPOL ...

**datatype** [str] data type, i.e. dBZ, ZDR, ISO0, ...

**dataset** [str] dataset type (for saved data only)

**product** [str] product type (for saved data only)

`pyrad.io.get_datetime` (*fname, datadescriptor*)

Given a data descriptor gets date and time from file name



**Parameters****fname** [str] file name**datadescriptor** [str] radar field type. Format : [radar file type]:[datatype]**Returns****fdatetime** [datetime object] date and time in file name`pyrad.io.get_field_unit (datatype)`

Return unit of datatype.

**Parameters****datatype** [str] The data type**Returns****unit** [str] The unit`pyrad.io.get_fieldname_cosmo (field_name)`

maps the Py-ART field name into the corresponding COSMO variable name

**Parameters****field\_name** [str] Py-ART field name**Returns****cosmo\_name** [str] Py-ART variable name`pyrad.io.get_fieldname_pyart (datatype)`

maps the config file radar data type name into the corresponding rainbow Py-ART field name

**Parameters****datatype** [str] config file radar data type name**Returns****field\_name** [str] Py-ART field name`pyrad.io.get_file_list (datadescriptor, starttime, endtime, cfg, scan=None)`

gets the list of files with a time period

**Parameters****datadescriptor** [str] radar field type. Format : [radar file type]:[datatype]**starttime** [datetime object] start of time period**endtime** [datetime object] end of time period**cfg: dictionary of dictionaries** configuration info to figure out where the data is**scan** [str] scan name**Returns****filelist** [list of strings] list of files within the time period`pyrad.io.get_iso0_field (hzt_data, hzt_ind, z_radar, field_name='height_over_iso0')`

Get the height over iso0 data corresponding to each radar gate using a precomputed look up table of the nearest neighbour

**Parameters****hzt\_data** [dict] dictionary containing the HZT data and metadata

**hzt\_ind** [dict] dictionary containing a field of HZT indices and metadata

**z\_radar** [ndarray] gates altitude [m MSL]

**field\_name** [str] names of HZT parameters (default height\_over\_iso0)

#### Returns

**iso0\_field** [list of dict] dictionary with the height over iso0 field and metadata

`pyrad.io.get_new_rainbow_file_name(master_fname, master_datadescriptor, datatype)`  
get the rainbow file name containing datatype from a master file name and data type

#### Parameters

**master\_fname** [str] the master file name

**master\_datadescriptor** [str] the master data type descriptor

**datatype** [str] the data type of the new file name to be created

#### Returns

**new\_fname** [str] the new file name

`pyrad.io.get_save_dir(basepath, procname, dsname, prdname, timeinfo=None, timeformat='%Y-%m-%d', create_dir=True)`  
obtains the path to a product directory and eventually creates it

#### Parameters

**basepath** [str] product base path

**procname** [str] name of processing space

**dsname** [str] data set name

**prdname** [str] product name

**timeinfo** [datetime] time info to generate the date directory. If None there is no time format in the path

**timeformat** [str] Optional. The time format.

**create\_dir** [boolean] If True creates the directory

#### Returns

**savedir** [str] path to product

`pyrad.io.get_sensor_data(date, datatype, cfg)`  
Gets data from a point measurement sensor (rain gauge or disdrometer)

#### Parameters

**date** [datetime object] measurement date

**datatype** [str] name of the data type to read

**cfg** [dictionary] dictionary containing sensor information

#### Returns

**sensordate, sensorvalue, label, period** [tuple] date, value, type of sensor and measurement period

`pyrad.io.get_trtfile_list(basepath, starttime, endtime)`  
gets the list of TRT files with a time period

#### Parameters

**datapath** [str] directory where to look for data

**starttime** [datetime object] start of time period

**endtime** [datetime object] end of time period

#### Returns

**filelist** [list of strings] list of files within the time period

`pyrad.io.hzt2radar_coord(radar, hzt_coord, slice_xy=True, field_name=None)`

Given the radar coordinates find the nearest HZT pixel

#### Parameters

**radar** [Radar] the radar object containing the information on the position of the radar gates

**hzt\_coord** [dict] dictionary containing the HZT coordinates

**slice\_xy** [boolean] if true the horizontal plane of the HZT field is cut to the dimensions of the radar field

**field\_name** [str] name of the field

#### Returns

**hzt\_ind\_field** [dict] dictionary containing a field of HZT indices and metadata

`pyrad.io.hzt2radar_data(radar, hzt_coord, hzt_data, slice_xy=True, field_name='height_over_iso0')`

get the HZT value corresponding to each radar gate using nearest neighbour interpolation

#### Parameters

**radar** [Radar] the radar object containing the information on the position of the radar gates

**hzt\_coord** [dict] dictionary containing the HZT coordinates

**hzt\_data** [dict] dictionary containing the HZT data

**slice\_xy** [boolean] if true the horizontal plane of the COSMO field is cut to the dimensions of the radar field

**field\_name** [str] name of HZT fields to convert (default height\_over\_iso0)

#### Returns

**hzt\_fields** [list of dict] list of dictionary with the HZT fields and metadata

`pyrad.io.interpol_field(radar_dest, radar_orig, field_name, fill_value=None, ang_tol=0.5)`

interpolates field field\_name contained in radar\_orig to the grid in radar\_dest

#### Parameters

**radar\_dest** [radar object] the destination radar

**radar\_orig** [radar object] the radar object containing the original field

**field\_name: str** name of the field to interpolate

**fill\_value: float** The fill value

**ang\_tol** [float] angle tolerance to determine whether the radar origin sweep is the radar destination sweep

#### Returns

**field\_dest** [dict] interpolated field and metadata

`pyrad.io.make_filename` (*prdtype, dstype, dsname, ext\_list, prdcfginfo=None, timeinfo=None, timeformat='%Y%m%d%H%M%S', runinfo=None*)  
creates a product file name

**Parameters**

**timeinfo** [datetime] time info to generate the date directory  
**prdtype** [str] product type, i.e. 'ppi', etc.  
**dstype** [str] data set type, i.e. 'raw', etc.  
**dsname** [str] data set name  
**ext\_list** [list of str] file name extensions, i.e. 'png'  
**prdcfginfo** [str] Optional. string to add product configuration information, i.e. 'el0.4'  
**timeformat** [str] Optional. The time format  
**runinfo** [str] Optional. Additional information about the test (e.g. 'RUN01', 'TS011')

**Returns**

**fname\_list** [list of str] list of file names (as many as extensions)

`pyrad.io.map_Doppler` (*Doppler\_data\_bin, Nyquist\_vel*)  
maps the binary METRANET Doppler data to actual Doppler velocity

**Parameters**

**Doppler\_data\_bin** [numpy array] The binary METRANET data

**Returns**

**Doppler\_data** [numpy array] The Doppler velocity in [m/s]

`pyrad.io.map_hydro` (*hydro\_data\_op*)  
maps the operational hydrometeor classification identifiers to the ones used by Py-ART

**Parameters**

**hydro\_data\_op** [numpy array] The operational hydrometeor classification data

**Returns**

**hydro\_data\_py** [numpy array] The pyart hydrometeor classification data

`pyrad.io.read_antenna_pattern` (*fname, linear=False, twoway=False*)  
Read antenna pattern from file

**Parameters**

**fname** [str] path of the antenna pattern file  
**linear** [boolean] if true the antenna pattern is given in linear units  
**twoway** [boolean] if true the attenuation is two-way

**Returns**

**pattern** [dict] dictionary with the fields angle and attenuation

`pyrad.io.read_colocated_data` (*fname*)  
Reads a csv files containing colocated data

**Parameters**

**fname** [str] path of time series file

**Returns**

**rad1\_time, rad1\_ray\_ind, rad1\_rng\_ind, rad1\_ele, rad1\_azi, rad1\_rng,**  
**rad1\_val, rad2\_time, rad2\_ray\_ind, rad2\_rng\_ind, rad2\_ele, rad2\_azi,**  
**rad2\_rng, rad2\_val** [tuple] A tuple with the data read. None otherwise

`pyrad.io.read_colocated_gates(fname)`

Reads a csv files containing the position of colocated gates

**Parameters**

**fname** [str] path of time series file

**Returns**

**rad1\_ray\_ind, rad1\_rng\_ind, rad1\_ele, rad1\_azi, rad1\_rng,**  
**rad2\_ray\_ind, rad2\_rng\_ind, rad2\_ele, rad2\_azi, rad2\_rng** [tuple] A tuple with the  
 data read. None otherwise

`pyrad.io.read_config(fname, cfg=None)`

Read a pyrad config file.

**Parameters**

**fname** [str] Name of the configuration file to read.

**cfg** [dict of dicts, optional] dictionary of dictionaries containing configuration parameters  
 where the new parameters will be placed

**Returns**

**cfg** [dict of dicts] dictionary of dictionaries containing the configuration parameters

`pyrad.io.read_cosmo_coord(fname, zmin=None)`

Reads COSMO coordinates from a netcdf file

**Parameters**

**fname** [str] name of the file to read

**Returns**

**cosmo\_coord** [dictionary] dictionary with the data and metadata

`pyrad.io.read_cosmo_data(fname, field_names=['temperature'], celsius=True)`

Reads COSMO data from a netcdf file

**Parameters**

**fname** [str] name of the file to read

**field\_names** [str] name of the variable to read

**celsius** [Boolean] if True and variable temperature converts data from Kelvin to Centigrade

**Returns**

**cosmo\_data** [dictionary] dictionary with the data and metadata

`pyrad.io.read_disdro_scattering(fname)`

Reads scattering parameters computed from disdrometer data contained in a text file

**Parameters**

**fname** [str] path of time series file

#### Returns

**date, precip\_type, lwc, rr, zh, zv, zdr, ldr, ah, av, adiff, kdp, deltaco, rhohv** [tuple] The read values

`pyrad.io.read_excess_gates(fname)`

Reads a csv files containing the position of gates exceeding a given percentile of frequency of occurrence

#### Parameters

**fname** [str] path of time series file

#### Returns

**rad1\_ray\_ind, rad1\_rng\_ind, rad1\_ele, rad1\_azi, rad1\_rng, rad2\_ray\_ind, rad2\_rng\_ind, rad2\_ele, rad2\_azi, rad2\_rng** [tuple] A tuple with the data read. None otherwise

`pyrad.io.read_histogram(fname)`

Reads a histogram contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**hist, bin\_edges** [tuple] The read data. None otherwise

`pyrad.io.read_histogram_ts(fname_list, datatype, t_res=300.0)`

Reads a collection of histogram data file and creates a time series

#### Parameters

**fname\_list** [str] list of files to read

**datatype** [str] The data type (dBZ, ZDR, etc.)

**t\_res** [float] time resolution [s]. If None the time resolution is taken as the median

#### Returns

**tb\_in\_edges, bin\_edges, data\_ma, datetime\_arr[0]** [tuple] The read data. None otherwise

`pyrad.io.read_hzt_data(fname, chy0=255.0, chx0=-160.0)`

Reads iso-0 degree data from an HZT file

#### Parameters

**fname** [str] name of the file to read

**chy0, chx0:** south west point of grid in Swiss coordinates [km]

#### Returns

**hzt\_data** [dictionary] dictionary with the data and metadata

`pyrad.io.read_intercomp_scores_ts(fname, sort_by_date=False)`

Reads a radar intercomparison scores csv file

#### Parameters

**fname** [str] path of time series file

**sort\_by\_date** [bool] if True, the read data is sorted by date prior to exit

#### Returns

**date\_vec, np\_vec, meanbias\_vec, medianbias\_vec, quant25bias\_vec,  
quant75bias\_vec, modebias\_vec, corr\_vec, slope\_vec, intercep\_vec,  
intercep\_slope1\_vec** [tuple] The read data. None otherwise

**pyrad.io.read\_last\_state** (*fname*)

Reads a file containing the date of acquisition of the last volume processed

#### Parameters

**fname** [str] name of the file to read

#### Returns

**last\_state** [datetime object] the date

**pyrad.io.read\_lightning** (*fname, filter\_data=True*)

Reads lightning data contained in a text file. The file has the following fields:

flashnr: (0 is for noise) UTC seconds of the day Time within flash (in seconds) Latitude (decimal degrees) Longitude (decimal degrees) Altitude (m MSL) Power (dBm)

#### Parameters

**fname** [str] path of time series file

**filter\_data** [Boolean] if True filter noise (flashnr = 0)

#### Returns

**flashnr, time\_data, time\_in\_flash, lat, lon, alt, dBm** [tuple] A tuple containing the read values. None otherwise

**pyrad.io.read\_lightning\_all** (*fname, labels=['hydro [-]', 'KDPc [deg/Km]', 'dBZc [dBZ]', 'Rho-HVc [-]', 'TEMP [deg C]', 'ZDRc [dB]']*)

Reads a file containing lightning data and co-located polarimetric data. fields:

flashnr time data Time within flash (in seconds) Latitude (decimal degrees) Longitude (decimal degrees) Altitude (m MSL) Power (dBm) Polarimetric values at flash position

#### Parameters

**fname** [str] path of time series file

**labels** [list of str] The polarimetric variables labels

#### Returns

**flashnr, time\_data, time\_in\_flash, lat, lon, alt, dBm,**

**pol\_vals\_dict** [tuple] A tuple containing the read values. None otherwise

**pyrad.io.read\_lightning\_traj** (*fname*)

Reads lightning trajectory data contained in a csv file. The file has the following fields:

Date UTC [seconds since midnight] # Flash Flash Power (dBm) Value at flash Mean value in a 3x3x3 polar box Min value in a 3x3x3 polar box Max value in a 3x3x3 polar box # valid values in the polar box

#### Parameters

**fname** [str] path of time series file

#### Returns

**time\_flash, flashnr, dBm, val\_at\_flash, val\_mean, val\_min, val\_max,**

**nval** [tuple] A tuple containing the read values. None otherwise

`pyrad.io.read_meteorage(fname)`

Reads METEORAGE lightning data contained in a text file. The file has the following fields:

date: date + time + time zone lon: longitude [degree] lat: latitude [degree] intens: amplitude [kilo amperes] ns: number of strokes of the flash mode: kind of localization [0,15] intra: 1 = intra-cloud , 0 = cloud-to-ground ax: length of the semi-major axis of the ellipse [km] ki2: standard deviation on the localization computation ( $Ki^2$ ) ecc: eccentricity (major-axis / minor-axis) incl: ellipse inclination (angle with respect to the North,  $+90^\circ$  is

East) [degrees]

sind: stroke index within the flash

#### Parameters

**fname** [str] path of time series file

#### Returns

**stroke\_time, lon, lat, intens, ns, mode, intra, ax, ki2, ecc, incl,**

**sind** [tuple] A tuple containing the read values. None otherwise

`pyrad.io.read_ml_ts(fname)`

Reads a melting layer time series contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**dt\_ml, ml\_top\_avg, ml\_top\_std, thick\_avg, thick\_std, nrays\_valid,**

**nrays\_total** [tuple] The read data. None otherwise

`pyrad.io.read_monitoring_ts(fname, sort_by_date=False)`

Reads a monitoring time series contained in a csv file

#### Parameters

**fname** [str] path of time series file

**sort\_by\_date** [bool] if True, the read data is sorted by date prior to exit

#### Returns

**date, np\_t, central\_quantile, low\_quantile, high\_quantile** [tuple] The read data. None otherwise

`pyrad.io.read_profile_ts(fname_list, labels, hres=None, label_nr=0, t_res=300.0)`

Reads a collection of profile data file and creates a time series

#### Parameters

**fname\_list** [str] list of files to read

**labels** [list of str] The data labels

**hres** [float] Height resolution

**label\_nr** [int] the label nr of the data that will be used in the time series



**t\_res** [float] time resolution [s]. If None the time resolution is taken as the median

#### Returns

**tbin\_edges, hbin\_edges, np\_ma, data\_ma, datetime\_arr[0]** [tuple] The read data. None otherwise

`pyrad.io.read_quantiles(fname)`  
Reads quantiles contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**quantiles, values** [tuple] The read data. None otherwise

`pyrad.io.read_quantiles_ts(fname_list, step=5.0, qmin=0.0, qmax=100.0, t_res=300.0)`  
Reads a collection of quantiles data file and creates a time series

#### Parameters

**fname\_list** [str] list of files to read

**step, qmin, qmax** [float] The minimum, maximum and step quantiles

**t\_res** [float] time resolution [s]. If None the time resolution is taken as the median

#### Returns

**tbin\_edges, qbin\_edges, data\_ma, datetime\_arr[0]** [tuple] The read data. None otherwise

`pyrad.io.read_rad4alp_cosmo(fname, datatype, ngates=0)`  
Reads rad4alp COSMO data binary file.

#### Parameters

**fname** [str] name of the file to read

**datatype** [str] name of the data type

**ngates** [int] maximum number of range gates per ray. If larger than 0 the radar field will be cut accordingly.

#### Returns

**field** [dictionary] The data field

`pyrad.io.read_rad4alp_vis(fname, datatype)`  
Reads rad4alp visibility data binary file.

#### Parameters

**fname** [str] name of the file to read

**datatype** [str] name of the data type

#### Returns

**field\_list** [list of dictionaries] A data field. Each element of the list corresponds to one elevation

`pyrad.io.read_rhi_profile(fname, labels=['50.0-percentile', '25.0-percentile', '75.0-percentile'])`  
Reads a monitoring time series contained in a csv file

#### Parameters

**fname** [str] path of time series file

**labels** [list of str] The data labels

**Returns**

**height, np\_t, vals** [tuple] The read data. None otherwise

`pyrad.io.read_selfconsistency(fname)`

Reads a self-consistency table with Zdr, Kdp/Zh columns

**Parameters**

**fname** [str] path of time series file

**Returns**

**zdr, kdpzh** [arrays] The read values

`pyrad.io.read_smn(fname)`

Reads SwissMetNet data contained in a csv file

**Parameters**

**fname** [str] path of time series file

**Returns**

**smn\_id, date, pressure, temp, rh, precip, wspeed, wdir** [tuple] The read values

`pyrad.io.read_smn2(fname)`

Reads SwissMetNet data contained in a csv file with format station,time,value

**Parameters**

**fname** [str] path of time series file

**Returns**

**smn\_id, date, value** [tuple] The read values

`pyrad.io.read_solar_flux(fname)`

Reads solar flux data from the DRAO observatory in Canada

**Parameters**

**fname** [str] path of time series file

**Returns**

**flux\_datetime** [datetime array] the date and time of the solar flux retrievals

**flux\_value** [array] the observed solar flux

`pyrad.io.read_status(voltime, cfg, ind_rad=0)`

Reads rad4alp xml status file.

**Parameters**

**voltime** [datetime object] volume scan time

**cfg: dictionary of dictionaries** configuration info to figure out where the data is

**ind\_rad: int** radar index

**Returns**

**root** [root element object] The information contained in the status file

`pyrad.io.read_sun_hits (fname)`

Reads sun hits data contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**date, ray, nrng, rad\_el, rad\_az, sun\_el, sun\_az, ph, ph\_std, nph, nvalh,**

**pv, pv\_std, npv, nvalv, zdr, zdr\_std, nzdr, nvalzdr** [tuple] Each parameter is an array containing a time series of information on a variable

`pyrad.io.read_sun_hits_multiple_days (cfg, time_ref, nfiles=1)`

Reads sun hits data from multiple file sources

#### Parameters

**cfg** [dict] dictionary with configuration data to find out the right file

**time\_ref** [datetime object] reference time

**nfiles** [int] number of files to read

#### Returns

**date, ray, nrng, rad\_el, rad\_az, sun\_el, sun\_az, ph, ph\_std, nph, nvalh,**

**pv, pv\_std, npv, nvalv, zdr, zdr\_std, nzdr, nvalzdr** [tuple] Each parameter is an array containing a time series of information on a variable

`pyrad.io.read_sun_retrieval (fname)`

Reads sun retrieval data contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**first\_hit\_time, last\_hit\_time, nhits\_h, el\_width\_h, az\_width\_h, el\_bias\_h,**

**az\_bias\_h, dBm\_sun\_est, std\_dBm\_sun\_est, sf\_h,**

**nhits\_v, el\_width\_v, az\_width\_v, el\_bias\_v, az\_bias\_v, dBmv\_sun\_est,**

**std\_dBmv\_sun\_est, sf\_v,**

**nhits\_zdr, zdr\_sun\_est, std\_zdr\_sun\_est,**

**sf\_ref, ref\_time** [tuple] Each parameter is an array containing a time series of information on a variable

`pyrad.io.read_thundertracking_info (fname)`

Reads the TRT info used for thundertracking

#### Parameters

**fname** [str] Name of the file containing the info

#### Returns

**A tuple containing the read values. None otherwise. The read values are**

**id, max\_rank, nscans\_Xband, time\_start, time\_end**

`pyrad.io.read_timeseries (fname)`

Reads a time series contained in a csv file

### Parameters

**fname** [str] path of time series file

### Returns

**date , value** [tuple] A datetime object array containing the time and a numpy masked array containing the value. None otherwise

`pyrad.io.read_trt_cell_lightning(fname)`

Reads the lightning data of a TRT cell. The file has the following fields:

traj\_ID yyyyymmddHHMM lon lat area RANKr nflashes flash\_dens

### Parameters

**fname** [str] path of the TRT data file

### Returns

**A tuple containing the read values. None otherwise**

`pyrad.io.read_trt_data(fname)`

Reads the TRT data contained in a text file. The file has the following fields:

traj\_ID yyyyymmddHHMM

Description of ellipsis: lon [deg] lat [deg] ell\_L [km] long ell\_S [km] short ell\_or [deg] orientation area [km2]

Cell speed: vel\_x [km/h] vel\_y [km/h] det [dBZ]: detection threshold RANKr from 0 to 40 (int)

Lightning information: CG- number (int) CG+ number (int) CG number (int) %CG+ [%]

Echo top information: ET45 [km] echotop 45 max ET45m [km] echotop 45 median ET15 [km] echotop 15 max ET15m [km] echotop 15 median

VIL and max echo: VIL [kg/m2] vertical integrated liquid content maxH [km] height of maximum reflectivity (maximum on the cell) maxHm [km] height of maximum reflectivity (median per cell)

POH [%] RANK (deprecated)

standard deviation of the current time step cell velocity respect to the previous time: Dvel\_x [km/h] Dvel\_y [km/h]

cell\_contour\_lon-lat

### Parameters

**fname** [str] path of the TRT data file

### Returns

**A tuple containing the read values. None otherwise**

`pyrad.io.read_trt_info(fname)`

Reads the TRT info used for thundertracking and contained in a text file.

### Parameters

**fname** [str] path of the TRT info file

### Returns

**A tuple containing the read values. None otherwise. The read values are**

**trt\_time, id, rank, nscans, azi, rng, lat, lon, ell\_l, ell\_s, ell\_or,  
vel\_x, vel\_y, det**

`pyrad.io.read_trt_info_all (dir)`

Reads all the TRT info files

#### Parameters

**dir** [str] directory where the files are stored

#### Returns

**A tuple containing the read values. None otherwise. The read values are**

**trt\_time, id, rank, nscans, azi, rng, lat, lon, ell\_l, ell\_s, ell\_or,  
vel\_x, vel\_y, det**

`pyrad.io.read_trt_scores (fname)`

Reads the TRT scores contained in a text file. The file has the following fields:

traj ID max flash density time max flash density rank max flash density max rank time max rank

#### Parameters

**fname** [str] path of the TRT data file

#### Returns

**A tuple containing the read values. None otherwise**

`pyrad.io.read_trt_traj_data (fname)`

Reads the TRT cell data contained in a text file. The file has the following fields:

traj\_ID yyyyymmddHHMM

lon [deg] lat [deg] ell\_L [km] long ell\_S [km] short ell\_or [deg] orientation area [km2]

vel\_x [km/h] cell speed vel\_y [km/h] det [dBZ] detection threshold RANKr from 0 to 40 (int)

CG- number (int) CG+ number (int) CG number (int) %CG+ [%]

ET45 [km] echotop 45 max ET45m [km] echotop 45 median ET15 [km] echotop 15 max ET15m [km] echotop 15 median VIL [kg/m2] vertical integrated liquid content maxH [km] height of maximum reflectivity (maximum on the cell) maxHm [km] height of maximum reflectivity (median per cell) POH [%] RANK (deprecated)

Standard deviation of the current time step cell velocity respect to the previous time: Dvel\_x [km/h]

Dvel\_y [km/h]

cell\_contour\_lon-lat

#### Parameters

**fname** [str] path of the TRT data file

#### Returns

**A tuple containing the read values. None otherwise**

`pyrad.io.read_ts_cum (fname)`

Reads a time series of precipitation accumulation contained in a csv file

#### Parameters

**fname** [str] path of time series file

#### Returns

**date, np\_radar, radar\_value, np\_sensor, sensor\_value** [tuple] The data read

`pyrad.io.send_msg(sender, receiver_list, subject, fname)`

sends the content of a text file by email

#### Parameters

**sender** [str] the email address of the sender

**receiver\_list** [list of string] list with the email addresses of the receiver

**subject** [str] the subject of the email

**fname** [str] name of the file containing the content of the email message

#### Returns

**fname** [str] the name of the file containing the content

`pyrad.io.write_alarm_msg(radar_name, param_name_unit, date_last, target, tol_abs, np_trend, value_trend, tol_trend, nevents, np_last, value_last, fname)`

writes an alarm file

#### Parameters

**radar\_name** [str] Name of the radar being controlled

**param\_name\_unit** [str] Parameter and units

**date\_last** [datetime object] date of the current event

**target, tol\_abs** [float] Target value and tolerance

**np\_trend** [int] Total number of points in trend

**value\_trend, tol\_trend** [float] Trend value and tolerance

**nevents: int** Number of events in trend

**np\_last** [int] Number of points in the current event

**value\_last** [float] Value of the current event

**fname** [str] Name of file where to store the alarm information

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_cdf(quantiles, values, ntot, nnan, nclut, nblocked, nprec_filter, noutliers, ncdf, fname, use_nans=False, nan_value=0.0, filterprec=[], vismin=None, sector=None, datatype=None, timeinfo=None)`

writes a cumulative distribution function

#### Parameters

**quantiles** [datetime array] array containing the measurement time

**values** [float array] array containing the average value

**fname** [float array] array containing the standard deviation

**sector** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_colocated_data(coloc_data, fname)`

Writes the data of gates colocated with two radars

#### Parameters

**coloc\_data** [dict] dictionary containing the colocated data parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_colocated_data_time_avg(coloc_data, fname)`

Writes the time averaged data of gates colocated with two radars

#### Parameters

**coloc\_data** [dict] dictionary containing the colocated data parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_colocated_gates(coloc_gates, fname)`

Writes the position of gates colocated with two radars

#### Parameters

**coloc\_gates** [dict] dictionary containing the colocated gates parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_excess_gates(excess_dict, fname)`

Writes the position and values of gates that have a frequency of occurrence higher than a particular threshold

#### Parameters

**excess\_dict** [dict] dictionary containing the gates parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_field_coverage(quantiles, values, ele_start, ele_stop, azi_start, azi_stop, threshold, nvalid_min, datatype, timeinfo, fname)`

writes the quantiles of the coverage on a particular sector

#### Parameters

**quantiles** [datetime array] array containing the quantiles computed

**values** [float array] quantile value

**ele\_start, ele\_stop, azi\_start, azi\_stop** [float] The limits of the sector

**threshold** [float] The minimum value to consider the data valid

**nvalid\_min** [int] the minimum number of points to consider that there are values in a ray

**datatype** [str] data type and units

**timeinfo** [datetime object] the time stamp of the data

**fname** [str] name of the file where to write the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_fixed_angle(time_data, fixed_angle, rad_lat, rad_lon, rad_alt, fname)`  
writes an output file with the fixed angle data

#### Parameters

**time\_data** [datetime object] The scan time

**fixed\_angle** [float] The first fixed angle in the scan

**rad\_lat, rad\_lon, rad\_alt** [float] Latitude, longitude [deg] and altitude [m MSL] of the radar

**fname** [str] The name of the file where to write

#### Returns

**fname** [str] the name of the file containing the content

`pyrad.io.write_histogram(bin_edges, values, fname, datatype='undefined', step=0)`  
writes a histogram

#### Parameters

**bin\_edges** [float array] array containing the histogram bin edges

**values** [int array] array containing the number of points in each bin

**fname** [str] file name

**datatype :str** The data type

**step** [str] The bin step

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_intercomp_scores_ts(start_time, stats, field_name, fname,  
rad1_name='RADAR001', rad2_name='RADAR002',  
rewrite=False)`

writes time series of radar intercomparison scores

#### Parameters

**start\_time** [datetime object or array of date time objects] the time of the intercomparison

**stats** [dict] dictionary containing the statistics

**field\_name** [str] The name of the field

**fname** [str] file name where to store the data

**rad1\_name, rad2\_name** [str] Name of the radars intercompared

**rewrite** [bool] if True a new file is created

#### Returns

**fname** [str] the name of the file where data has written



`pyrad.io.write_last_state(datetime_last, fname)`  
 writes SwissMetNet data in format datetime, avg\_value, std\_value

#### Parameters

**datetime\_last** [datetime object] date and time of the last state

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_monitoring_ts(start_time, np_t, values, quantiles, datatype, fname, rewrite=False)`  
 writes time series of data

#### Parameters

**start\_time** [datetime object or array of date time objects] the time of the monitoring

**np\_t** [int or array of ints] the total number of points

**values: float array with 3 elements of array of arrays** the values at certain quantiles

**quantiles: float array with 3 elements** the quantiles computed

**datatype** [str] The data type

**fname** [str] file name where to store the data

**rewrite** [bool] if True a new file is created

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_quantiles(quantiles, values, fname, datatype='undefined')`  
 writes quantiles

#### Parameters

**quantiles** [float array] array containing the quantiles to write

**values** [float array] array containing the value of each quantile

**fname** [str] file name

**datatype: str** The data type

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_rhi_profile(hvec, data, nvalid_vec, labels, fname, datatype=None, timeinfo=None, sector=None)`  
 writes the values of an RHI profile in a text file

#### Parameters

**hvec** [float array] array containing the altitude in m MSL

**data** [list of float array] the quantities at each altitude

**nvalid\_vec** [int array] number of valid data points used to compute the quantiles

**labels** [list of strings] label specifying the quantities in data

**fname** [str] file name where to store the data

**datatype** [str] the data type

**timeinfo** [datetime object] time of the rhi profile

**sector** [dict] dictionary specyng the sector limits

#### Returns

**fname** [str] the name of the file where data has been written

`pyrad.io.write_smn(datetime_vec, value_avg_vec, value_std_vec, fname)`  
 writes SwissMetNet data in format datetime,avg\_value, std\_value

#### Parameters

**datetime\_vec** [datetime array] array containing the measurement time

**value\_avg\_vec** [float array] array containing the average value

**value\_std\_vec** [float array] array containing the standard deviation

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_sun_hits(sun_hits, fname)`  
 Writes sun hits data.

#### Parameters

**sun\_hits** [dict] dictionary containing the sun hits parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_sun_retrieval(sun_retrieval, fname)`  
 Writes sun retrieval data.

#### Parameters

**sun\_retrieval** [dict] dictionary containing the sun retrieval parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_trt_cell_data(traj_ID, yyyyymmddHHMM, lon, lat, ell_L, ell_S, ell_or, area, vel_x, vel_y, det, RANKr, CG_n, CG_p, CG, CG_percent_p, ET45, ET45m, ET15, ET15m, VIL, maxH, maxHm, POH, RANK, Dvel_x, Dvel_y, cell_contour, fname)`

writes TRT cell data

#### Parameters

**traj\_ID, yyyyymmddHHMM, lon, lat, ell\_L, ell\_S, ell\_or, area,**

**vel\_x, vel\_y, det, RANKr, CG\_n, CG\_p, CG, CG\_percent\_p, ET45,**

**ET45m, ET15, ET15m, VIL, maxH, maxHm, POH, RANK, Dvel\_x,**

**Dvel\_y, cell\_contour:** the cell parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_trt_cell_lightning` (*cell\_ID, cell\_time, lon, lat, area, rank, nflash, flash\_density, fname*)

writes the lightning data for each TRT cell

#### Parameters

**cell\_ID** [array of ints] the cell ID

**cell\_time** [array of datetime] the time step

**lon, lat** [array of floats] the latitude and longitude of the center of the cell

**area** [array of floats] the area of the cell

**rank** [array of floats] the rank of the cell

**nflash** [array of ints] the number of flashes/sources within the cell

**flash\_density** [array of floats] the flash/source density

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_trt_cell_scores` (*traj\_ID, flash\_density\_max\_time, flash\_density\_max\_rank, nflashes\_max\_list, area\_flash\_max\_list, flash\_density\_max, rank\_max\_time, rank\_max, fname*)

writes TRT cells scores

#### Parameters

**traj\_ID** [array of ints] The ID of the cells

**flash\_density\_max\_time** [array of date times] The time at which the maximum flash density was reached for each cell

**flash\_density\_max\_rank** [array of floats] The rank when the maximum flash density was reached for each cell

**nflashes\_max\_list** [array of ints] the number of flashes when the max flash density was reached

**area\_flash\_max\_list** [array of floats] The area when the max flash density was reached

**flash\_density\_max** [array of floats] The maximum flash density for each cell

**rank\_max\_time** [array of datetime] the time at wich the maximum rank of each cell was reached

**rank\_max** [array of float] the rank when the maximum rank of each cell was reached

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_trt_info` (*ids, max\_rank, nscans, time\_start, time\_end, fname*)

writes TRT info of the thundertracking

#### Parameters

**ids, max\_rank, nscans, time\_start, time\_end:** array the cell parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_ts_cum(dataset, fname)`  
writes time series accumulation of data

#### Parameters

**dataset** [dict] dictionary containing the time series parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

`pyrad.io.write_ts_lightning(flashnr, time_data, time_in_flash, lat, lon, alt, dBm, vals_list, fname, pol_vals_labels)`  
writes the LMA sources data and the value of the colocated polarimetric variables

#### Parameters

**flashnr** [int] flash number

**time\_data** [datetime object] flash source time

**time\_in\_flash** [float] seconds since start of flash

**lat, lon, alt** [float] latitude, longitude [deg] and altitude [m MSL] of the flash source

**dBm** [float] flash power

**vals\_list** [list of arrays] List containing the data for each polarimetric variable

**fname** [str] the name of the file containing the content

**pol\_values\_labels** [list of strings] List containing strings identifying each polarimetric variable

#### Returns

**fname** [str] the name of the file containing the content

`pyrad.io.write_ts_polar_data(dataset, fname)`  
writes time series of data

#### Parameters

**dataset** [dict] dictionary containing the time series parameters

**fname** [str] file name where to store the data

#### Returns

**fname** [str] the name of the file where data has written

## PLOTTING (PYRAD . GRAPH)

Functions to plot graphics.

### 5.1 Plots

<i>plot_surface</i> (grid, field_name, level, ...)	plots a surface from gridded data
<i>plot_latitude_slice</i> (grid, field_name, lon, ...)	plots a latitude slice from gridded data
<i>plot_longitude_slice</i> (grid, field_name, lon, ...)	plots a longitude slice from gridded data
<i>plot_latlon_slice</i> (grid, field_name, coord1, ...)	plots a croos section crossing two points in the grid
<i>plot_ppi</i> (radar, field_name, ind_el, prdcfg, ...)	plots a PPI
<i>plot_ppi_contour</i> (radar, field_name, ind_el, ...)	plots contour data on a PPI
<i>plot_ppi_map</i> (radar, field_name, ind_el, ...)	plots a PPI on a geographic map
<i>plot_rhi</i> (radar, field_name, ind_az, prdcfg, ...)	plots an RHI
<i>plot_rhi_contour</i> (radar, field_name, ind_az, ...)	plots contour data on an RHI
<i>plot_bscope</i> (radar, field_name, ind_sweep, ...)	plots a B-Scope (angle-range representation)
<i>plot_fixed_rng</i> (radar, field_name, prdcfg, ...)	plots a fixed range plot
<i>plot_fixed_rng_span</i> (radar, field_name, ...)	plots a fixed range plot
<i>plot_time_range</i> (radar, field_name, ...)	plots a time-range plot
<i>plot_rhi_profile</i> (data_list, hvec, fname_list)	plots an RHI profile
<i>plot_along_coord</i> (xval_list, yval_list, ...)	plots data along a certain radar coordinate
<i>plot_field_coverage</i> (xval_list, yval_list, ...)	plots a time series
<i>plot_density</i> (hist_obj, hist_type, ...[, ...])	density plot (angle-values representation)
<i>plot_cappi</i> (radar, field_name, altitude, ...)	plots a Constant Altitude Plan Position Indicator CAPPI
<i>plot_traj</i> (rng_traj, azi_traj, ele_traj, ...)	plots a trajectory on a Cartesian surface
<i>plot_pos</i> (lat, lon, alt, fname_list[, ax, ...])	plots a trajectory on a Cartesian surface
<i>plot_quantiles</i> (quant, value, fname_list[, ...])	plots quantiles
<i>plot_histogram</i> (bin_edges, values, fname_list)	computes and plots histogram
<i>plot_histogram2</i> (bin_centers, hist, fname_list)	plots histogram
<i>plot_antenna_pattern</i> (antpattern, fname_list)	plots an antenna pattern
<i>plot_timeseries</i> (tvec, data_list, fname_list)	plots a time series
<i>plot_timeseries_comp</i> (date1, value1, date2, ...)	plots 2 time series in the same graph
<i>plot_monitoring_ts</i> (date, np_t, cquant, ...)	plots a time series of monitoring data
<i>plot_scatter_comp</i> (value1, value2, fname_list)	plots the scatter between two time series
<i>plot_intercomp_scores_ts</i> (date_vec, np_vec, ...)	plots a time series of radar intercomparison scores
<i>plot_ml_ts</i> (dt_ml_arr, ml_top_avg_arr, ...[, ...])	plots a time series of melting layer data

Continued on next page

Table 1 – continued from previous page

<code>plot_sun_hits(field, field_name, fname_list, ...)</code>	plots the sun hits
<code>plot_sun_retrieval_ts(sun_retrieval, ..., ...)</code>	plots sun retrieval time series series
<code>get_colobar_label(field_dict, field_name)</code>	creates the colorbar label using field metadata
<code>get_field_name(field_dict, field)</code>	Return a nice field name for a particular field
<code>_plot_time_range(rad_time, rad_range, ..., ...)</code>	plots a time-range plot

`pyrad.graph.get_colobar_label (field_dict, field_name)`  
creates the colorbar label using field metadata

**Parameters**

**field\_dict** [dict] dictionary containing field metadata

**field\_name** [str] name of the field

**Returns**

**label** [str] colorbar label

`pyrad.graph.get_field_name (field_dict, field)`  
Return a nice field name for a particular field

**Parameters**

**field\_dict** [dict] dictionary containing field metadata

**field** [str] name of the field

**Returns**

**field\_name** [str] the field name

`pyrad.graph.plot_along_coord(xval_list, yval_list, fname_list, labelx='coord', labely='Value', labels=None, title='Plot along coordinate', colors=None, linestyle=None, ymin=None, ymax=None, dpi=72)`  
plots data along a certain radar coordinate

**Parameters**

**xval\_list** [list of float arrays] the x values, range, azimuth or elevation

**yval\_list** [list of float arrays] the y values. Parameter to plot

**fname\_list** [list of str] list of names of the files where to store the plot

**labelx** [str] The label of the X axis

**labely** [str] The label of the Y axis

**labels** [array of str] The label of the legend

**title** [str] The figure title

**colors** [array of str] Specifies the colors of each line

**linestyles** [array of str] Specifies the line style of each line

**ymin, ymax: float** Lower/Upper limit of y axis

**dpi** [int] dots per inch

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_antenna_pattern` (*antpattern*, *fname\_list*, *labelx*='Angle [Deg]', *linear*=False, *twoway*=False, *title*='Antenna Pattern', *ymin*=None, *ymax*=None, *dpi*=72)

plots an antenna pattern

#### Parameters

**antpattern** [dict] dictionary with the angle and the attenuation  
**value** [float array] values of the time series  
**fname\_list** [list of str] list of names of the files where to store the plot  
**labelx** [str] The label of the X axis  
**linear** [boolean] if true data is in linear units  
**linear** [boolean] if true data represents the two way attenuation  
**titl** [str] The figure title  
**ymin, ymax: float** Lower/Upper limit of y axis  
**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_bscope` (*radar*, *field\_name*, *ind\_sweep*, *prdcfg*, *fname\_list*)  
 plots a B-Scope (angle-range representation)

#### Parameters

**radar** [Radar object] object containing the radar data to plot  
**field\_name** [str] name of the radar field to plot  
**ind\_sweep** [int] sweep index to plot  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_cappi` (*radar*, *field\_name*, *altitude*, *prdcfg*, *fname\_list*, *save\_fig*=True)  
 plots a Constant Altitude Plan Position Indicator CAPPI

#### Parameters

**radar** [Radar object] object containing the radar data to plot  
**field\_name** [str] name of the radar field to plot  
**altitude** [float] the altitude [m MSL] to be plotted  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot  
**save\_fig** [bool] if true save the figure. If false it does not close the plot and returns the handle to the figure

#### Returns

**fname\_list** [list of str or]

**fig, ax** [tuple] list of names of the saved plots or handle of the figure and axes

`pyrad.graph.plot_density` (*hist\_obj*, *hist\_type*, *field\_name*, *ind\_sweep*, *prdcfg*, *fname\_list*, *quantiles*=[25.0, 50.0, 75.0], *ref\_value*=0.0, *vmin*=None, *vmax*=None)  
density plot (angle-values representation)

#### Parameters

**hist\_obj** [histogram object] object containing the histogram data to plot

**hist\_type** [str] type of histogram (instantaneous data or cumulative)

**field\_name** [str] name of the radar field to plot

**ind\_sweep** [int] sweep index to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**quantiles** [array] the quantile lines to plot

**ref\_value** [float] the reference value

**vmin, vmax** [float] Minimum and maximum extend of the vertical axis

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_field_coverage` (*xval\_list*, *yval\_list*, *fname\_list*, *labelx*='Azimuth (deg)', *labely*='Range extension [m]', *labels*=None, *title*='Field coverage', *ymin*=None, *ymax*=None, *xmeanval*=None, *ymeanval*=None, *labelmeanval*=None, *dpi*=72)  
plots a time series

#### Parameters

**xval\_list** [list of float arrays] the x values, azimuth

**yval\_list** [list of float arrays] the y values. Range extension

**fname\_list** [list of str] list of names of the files where to store the plot

**labelx** [str] The label of the X axis

**labely** [str] The label of the Y axis

**labels** [array of str] The label of the legend

**title** [str] The figure title

**ymin, ymax** [float] Lower/Upper limit of y axis

**xmeanval, ymeanval** [float array] the x and y values of a mean along elevation

**labelmeanval** [str] the label of the mean

**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_fixed_rng` (*radar*, *field\_name*, *prdcfg*, *fname\_list*, *azi\_res*=None, *ele\_res*=None, *ang\_tol*=1.0, *vmin*=None, *vmax*=None)  
plots a fixed range plot

#### Parameters



**radar** [radar object] The radar object containing the fixed range data

**field\_name** [str] The name of the field to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**azi\_res, ele\_res** [float] The nominal azimuth and elevation angle resolution [deg]

**ang\_tol** [float] The tolerance between the nominal and the actual radar angle

**vmin, vmax** [float] Min and Max values of the color scale. If None it is going to be taken from the Py-ART config files

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_fixed_rng_span(radar, field_name, prdcfg, fname_list, azi_res=None, ele_res=None, ang_tol=1.0, stat='max')`  
 plots a fixed range plot

**Parameters**

**radar** [radar object] The radar object containing the fixed range data

**field\_name** [str] The name of the field to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**azi\_res, ele\_res** [float] The nominal azimuth and elevation angle resolution [deg]

**ang\_tol** [float] The tolerance between the nominal and the actual radar angle

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_histogram(bin_edges, values, fname_list, labelx='bins', labely='Number of Samples', titl='histogram', dpi=72)`  
 computes and plots histogram

**Parameters**

**bin\_edges** [array] histogram bin edges

**values** [array] data values

**fname\_list** [list of str] list of names of the files where to store the plot

**labelx** [str] The label of the X axis

**labely** [str] The label of the Y axis

**titl** [str] The figure title

**dpi** [int] dots per inch

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_histogram2(bin_centers, hist, fname_list, labelx='bins', labely='Number of Samples', titl='histogram', dpi=72, ax=None, fig=None, save_fig=True, color=None, alpha=None, invert_xaxis=False)`  
 plots histogram

**Parameters**

**bin\_centers** [array] histogram bin centers  
**hist** [array] values for each bin  
**fname\_list** [list of str] list of names of the files where to store the plot  
**labelx** [str] The label of the X axis  
**labely** [str] The label of the Y axis  
**titl** [str] The figure title  
**dpi** [int] dots per inch  
**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created  
**ax** [Axis] Axis to plot on. if fig is None a new axis will be created  
**save\_fig** [bool] if true save the figure. If false it does not close the plot and returns the handle to the figure  
**color** [str] color of the bars  
**alpha** [float] parameter controlling the transparency  
**invert\_axis** [bool] If true inverts the x axis

**Returns**

**fname\_list or fig, ax: list of str** list of names of the created plots

```
pyrad.graph.plot_intercomp_scores_ts(date_vec, np_vec, meanbias_vec, medianbias_vec,  
                                     quant25bias_vec, quant75bias_vec, mode-  
                                     bias_vec, corr_vec, slope_vec, intercep_vec, inter-  
                                     cep_slope1_vec, fname_list, ref_value=0.0, np_min=0,  
                                     corr_min=0.0, labelx='Time UTC', titl='RADAR001-  
                                     RADAR002 intercomparison', dpi=72)
```

plots a time series of radar intercomparison scores

**Parameters**

**date\_vec** [datetime object] time of the time series  
**np\_vec** [int array] number of points  
**meanbias\_vec, medianbias\_vec, modebias\_vec** [float array] mean, median and mode bias  
**quant25bias\_vec, quant75bias\_vec: 25th and 75th percentile of the bias**  
**corr\_vec** [float array] correlation  
**slope\_vec, intercep\_vec** [float array] slope and intercep of a linear regression  
**intercep\_slope1\_vec** [float] the intercep point of a inear regression of slope 1  
**ref\_value** [float] the reference value  
**np\_min** [int] The minimum number of points to consider the result valid  
**corr\_min** [float] The minimum correlation to consider the results valid  
**labelx** [str] The label of the X axis  
**titl** [str] The figure title

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_latitude_slice` (*grid, field\_name, lon, lat, prdcfg, fname\_list*)  
plots a latitude slice from gridded data

**Parameters**

**grid** [Grid object] object containing the gridded data to plot  
**field\_name** [str] name of the radar field to plot  
**lon, lat** [float] coordinates of the slice to plot  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_latlon_slice` (*grid, field\_name, coord1, coord2, prdcfg, fname\_list*)  
plots a cross section crossing two points in the grid

**Parameters**

**grid** [Grid object] object containing the gridded data to plot  
**field\_name** [str] name of the radar field to plot  
**coord1** [tuple of floats] lat, lon of the first point  
**coord2** [tuple of floats] lat, lon of the second point  
**fname\_list** [list of str] list of names of the files where to store the plot

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_longitude_slice` (*grid, field\_name, lon, lat, prdcfg, fname\_list*)  
plots a longitude slice from gridded data

**Parameters**

**grid** [Grid object] object containing the gridded data to plot  
**field\_name** [str] name of the radar field to plot  
**lon, lat** [float] coordinates of the slice to plot  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

**Returns**

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_ml_ts` (*dt\_ml\_arr, ml\_top\_avg\_arr, ml\_top\_std\_arr, thick\_avg\_arr, thick\_std\_arr, nrays\_valid\_arr, nrays\_total\_arr, fname\_list, labelx='Time UTC', titl='Melting layer time series', dpi=72*)  
plots a time series of melting layer data

**Parameters**

**dt\_ml\_arr** [datetime object] time of the time series  
**np\_vec** [int array] number of points  
**meanbias\_vec, medianbias\_vec, modebias\_vec** [float array] mean, median and mode bias

**quant25bias\_vec, quant75bias\_vec:** 25th and 75th percentile of the bias  
**corr\_vec** [float array] correlation  
**slope\_vec, intercep\_vec** [float array] slope and intercep of a linear regression  
**intercep\_slope1\_vec** [float] the intercep point of a linear regression of slope 1  
**ref\_value** [float] the reference value  
**np\_min** [int] The minimum number of points to consider the result valid  
**corr\_min** [float] The minimum correlation to consider the results valid  
**labelx** [str] The label of the X axis  
**titl** [str] The figure title

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_monitoring_ts` (*date, np\_t, cquant, lquant, hquant, field\_name, fname\_list, ref\_value=None, vmin=None, vmax=None, np\_min=0, labelx='Time [UTC]', labely='Value', titl='Time Series', dpi=72*)  
plots a time series of monitoring data

#### Parameters

**date** [datetime object] time of the time series  
**np\_t** [int array] number of points  
**cquant, lquant, hquant** [float array] values of the central, low and high quantiles  
**field\_name** [str] name of the field  
**fname\_list** [list of str] list of names of the files where to store the plot  
**ref\_value** [float] the reference value  
**vmin, vmax** [float] The limits of the y axis  
**np\_min** [int] minimum number of points to consider the sample plotable  
**labelx** [str] The label of the X axis  
**labely** [str] The label of the Y axis  
**titl** [str] The figure title  
**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_pos` (*lat, lon, alt, fname\_list, ax=None, fig=None, save\_fig=True, sort\_altitude='No', dpi=72, alpha=1.0, cb\_label='height [m MSL]', titl='Position', xlabel='Lon [Deg]', ylabel='Lat [Deg]', limits=None, vmin=None, vmax=None*)  
plots a trajectory on a Cartesian surface

#### Parameters

**lat, lon, alt** [float array] Points coordinates  
**fname\_list** [list of str] list of names of the files where to store the plot  
**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created

**ax** [Axis] Axis to plot on. if fig is None a new axis will be created

**save\_fig** [bool] if true save the figure if false it does not close the plot and returns the handle to the figure

**sort\_altitude** [str] String indicating whether to sort the altitude data. Can be 'No', 'Lowest\_on\_top' or 'Highest\_on\_top'

**dpi** [int] Pixel density

**alpha** [float] Transparency

**cb\_label** [str] Color bar label

**titl** [str] Plot title

**limits** [tuple or None] The limits of the field to plot

#### Returns

**fname\_list** [list of str or]

**fig, ax** [tuple] list of names of the saved plots or handle of the figure an axes

`pyrad.graph.plot_ppi(radar, field_name, ind_el, prdcfg, fname_list, plot_type='PPI', titl=None, step=None, quantiles=None, save_fig=True)`  
 plots a PPI

#### Parameters

**radar** [Radar object] object containing the radar data to plot

**field\_name** [str] name of the radar field to plot

**ind\_el** [int] sweep index to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**plot\_type** [str] type of plot (PPI, QUANTILES or HISTOGRAM)

**titl** [str] Plot title

**step** [float] step for histogram plotting

**quantiles** [float array] quantiles to plot

**save\_fig** [bool] if true save the figure. If false it does not close the plot and returns the handle to the figure

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_ppi_contour(radar, field_name, ind_el, prdcfg, fname_list, contour_values=None, linewidths=1.5, ax=None, fig=None, save_fig=True)`  
 plots contour data on a PPI

#### Parameters

**radar** [Radar object] object containing the radar data to plot

**field\_name** [str] name of the radar field to plot

**ind\_el** [int] sweep index to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot  
**contour\_values** [float array] list of contours to plot  
**linewidths** [float] width of the contour lines  
**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created  
**ax** [Axis] Axis to plot on. if fig is None a new axis will be created  
**save\_fig** [bool] if true save the figure if false it does not close the plot and returns the handle to the figure

#### Returns

**fname\_list** [list of str or]  
**fig, ax** [tuple] list of names of the saved plots or handle of the figure an axes

`pyrad.graph.plot_ppi_map(radar, field_name, ind_el, prdcfg, fname_list)`  
 plots a PPI on a geographic map

#### Parameters

**radar** [Radar object] object containing the radar data to plot  
**field\_name** [str] name of the radar field to plot  
**ind\_el** [int] sweep index to plot  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_quantiles(quant, value, fname_list, labelx='quantile', labely='value', titl='quantile', vmin=None, vmax=None, dpi=72)`  
 plots quantiles

#### Parameters

**quant** [array] quantiles to be plotted  
**value** [array] values of each quantile  
**fname\_list** [list of str] list of names of the files where to store the plot  
**labelx** [str] The label of the X axis  
**labely** [str] The label of the Y axis  
**titl** [str] The figure title  
**vmin, vmax: float** Lower/Upper limit of data values  
**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_rhi(radar, field_name, ind_az, prdcfg, fname_list, plot_type='RHI', titl=None, step=None, quantiles=None, save_fig=True)`  
 plots an RHI

#### Parameters

**radar** [Radar object] object containing the radar data to plot

**field\_name** [str] name of the radar field to plot

**ind\_az** [int] sweep index to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**plot\_type** [str] type of plot (PPI, QUANTILES or HISTOGRAM)

**titl** [str] Plot title

**step** [float] step for histogram plotting

**quantiles** [float array] quantiles to plot

**save\_fig** [bool] if true save the figure. If false it does not close the plot and returns the handle to the figure

#### Returns

**fname\_list** [list of str] list of names of the created plots

**fig, ax** [tuple] list of names of the saved plots or handle of the figure an axes

```
pyrad.graph.plot_rhi_contour(radar, field_name, ind_az, prdcfg, fname_list, con-
                             tour_values=None, linewidths=1.5, ax=None, fig=None,
                             save_fig=True)
```

plots contour data on an RHI

#### Parameters

**radar** [Radar object] object containing the radar data to plot

**field\_name** [str] name of the radar field to plot

**ind\_az** [int] sweep index to plot

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**contour\_values** [float array] list of contours to plot

**linewidths** [float] width of the contour lines

**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created

**ax** [Axis] Axis to plot on. if fig is None a new axis will be created

**save\_fig** [bool] if true save the figure if false it does not close the plot and returns the handle to the figure

#### Returns

**fname\_list** [list of str or]

**fig, ax** [tuple] list of names of the saved plots or handle of the figure an axes

```
pyrad.graph.plot_rhi_profile(data_list, hvec, fname_list, labelx='Value', labely='Height
                             (m MSL)', labels=['Mean'], title='RHI profile', colors=None,
                             linestyle=None, vmin=None, vmax=None, hmin=None,
                             hmax=None, dpi=72)
```

plots an RHI profile

#### Parameters

**data\_list** [list of float array] values of the profile  
**hvec** [float array] height points of the profile  
**fname\_list** [list of str] list of names of the files where to store the plot  
**labelx** [str] The label of the X axis  
**labely** [str] The label of the Y axis  
**labels** [array of str] The label of the legend  
**title** [str] The figure title  
**colors** [array of str] Specifies the colors of each line  
**linestyles** [array of str] Specifies the line style of each line  
**vmin, vmax: float** Lower/Upper limit of data values  
**hmin, hmax: float** Lower/Upper limit of altitude  
**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_scatter` (*bin\_edges1, bin\_edges2, hist\_2d, field\_name1, field\_name2, fname\_list, prdcfg, metadata=None, lin\_regr=None, lin\_regr\_slope1=None, rad1\_name='RADAR001', rad2\_name='RADAR002'*)

2D histogram

#### Parameters

**bin\_edges1, bin\_edges2** [float array2] the bins of each field  
**hist\_2d** [ndarray 2D] the 2D histogram  
**field\_name1, field\_name2** [str] the names of each field  
**fname\_list** [list of str] list of names of the files where to store the plot  
**prdcfg** [dict] product configuration dictionary  
**metadata** [str] a string with metadata to write in the plot  
**lin\_regr** [tuple with 2 values] the coefficients for a linear regression  
**lin\_regr\_slope1** [float] the intercept point of a linear regression of slope 1  
**rad1\_name, rad2\_name** [str] name of the radars which data is used

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_scatter_comp` (*value1, value2, fname\_list, labelx='Sensor 1', labely='Sensor 2', titl='Scatter', axis=None, metadata=None, dpi=72, ax=None, fig=None, save\_fig=True, point\_format='bx'*)

plots the scatter between two time series

#### Parameters

**value1** [float array] values of the first time series  
**value2** [float array] values of the second time series  
**fname\_list** [list of str] list of names of the files where to store the plot



**labelx** [str] The label of the X axis

**labely** [str] The label of the Y axis

**titl** [str] The figure title

**axis** [str] type of axis

**metadata** [string] a string containing metadata

**dpi** [int] dots per inch

**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created

**ax** [Axis] Axis to plot on. if fig is None a new axis will be created

**save\_fig** [bool] if true save the figure if false it does not close the plot and returns the handle to the figure

**point\_format** [str] format of the scatter point

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_sun_hits` (*field, field\_name, fname\_list, prdcfg*)  
plots the sun hits

#### Parameters

**radar** [Radar object] object containing the radar data to plot

**field\_name** [str] name of the radar field to plot

**altitude** [float] the altitude [m MSL] to be plotted

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_sun_retrieval_ts` (*sun\_retrieval, data\_type, fname\_list, labelx='Date', titl='Sun retrieval Time Series', dpi=72*)  
plots sun retrieval time series series

#### Parameters

**sun\_retrieval** [tuple] tuple containing the retrieved parameters

**data\_type** [str] parameter to be plotted

**fname\_list** [list of str] list of names of the files where to store the plot

**labelx** [str] the x label

**titl** [str] the title of the plot

**dpi** [int] dots per inch

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_surface` (*grid, field\_name, level, prdcfg, fname\_list*)  
plots a surface from gridded data

#### Parameters

**grid** [Grid object] object containing the gridded data to plot  
**field\_name** [str] name of the radar field to plot  
**level** [int] level index  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_time_range(radar, field_name, ind_sweep, prdcfg, fname_list)`  
plots a time-range plot

#### Parameters

**radar** [Radar object] object containing the radar data to plot  
**field\_name** [str] name of the radar field to plot  
**ind\_sweep** [int] sweep index to plot  
**prdcfg** [dict] dictionary containing the product configuration  
**fname\_list** [list of str] list of names of the files where to store the plot

#### Returns

**fname\_list** [list of str] list of names of the created plots

`pyrad.graph.plot_timeseries(tvec, data_list, fname_list, labelx='Time [UTC]', labely='Value',  
labels=['Sensor'], title='Time Series', period=0, timeformat=None,  
colors=None, linestyle=None, markers=None, ymin=None,  
ymax=None, dpi=72)`  
plots a time series

#### Parameters

**tvec** [datetime object] time of the time series  
**data\_list** [list of float array] values of the time series  
**fname\_list** [list of str] list of names of the files where to store the plot  
**labelx** [str] The label of the X axis  
**labely** [str] The label of the Y axis  
**labels** [array of str] The label of the legend  
**title** [str] The figure title  
**period** [float] measurement period in seconds used to compute accumulation. If 0 no accumulation is computed  
**timeformat** [str] Specifies the tvec and time format on the x axis  
**colors** [array of str] Specifies the colors of each line  
**linestyle** [array of str] Specifies the line style of each line  
**markers: array of str** Specify the markers to be used for each line  
**ymin, ymax: float** Lower/Upper limit of y axis  
**dpi** [int] dots per inch

**Returns**

**fname\_list** [list of str] list of names of the created plots

```
pyrad.graph.plot_timeseries_comp(date1, value1, date2, value2, fname_list, labelx='Time
[UTC]', labely='Value', label1='Sensor 1', label2='Sensor
2', titl='Time Series Comparison', period1=0, period2=0,
ymin=None, ymax=None, dpi=72)
```

plots 2 time series in the same graph

**Parameters**

**date1** [datetime object] time of the first time series

**value1** [float array] values of the first time series

**date2** [datetime object] time of the second time series

**value2** [float array] values of the second time series

**fname\_list** [list of str] list of names of the files where to store the plot

**labelx** [str] The label of the X axis

**labely** [str] The label of the Y axis

**label1, label2** [str] legend label for each time series

**titl** [str]

The figure title

**period1, period2** [float] measurement period in seconds used to compute accumulation.  
If 0 no accumulation is computed

**dpi** [int] dots per inch

**ymin, ymax** [float] The limits of the Y-axis. None will keep the default limit.

**Returns**

**fname\_list** [list of str] list of names of the created plots

```
pyrad.graph.plot_traj(rng_traj, azi_traj, ele_traj, time_traj, prdcfg, fname_list, rad_alt=None,
rad_tstart=None, ax=None, fig=None, save_fig=True)
```

plots a trajectory on a Cartesian surface

**Parameters**

**rng\_traj, azi\_traj, ele\_traj** [float array] antenna coordinates of the trajectory [m and deg]

**time\_traj** [datetime array] trajectory time

**prdcfg** [dict] dictionary containing the product configuration

**fname\_list** [list of str] list of names of the files where to store the plot

**rad\_alt** [float or None] radar altitude [m MSL]

**rad\_tstart** [datetime object or None] start time of the radar scan

**surface\_alt** [float] surface altitude [m MSL]

**color\_ref** [str] What the color code represents. Can be 'None', 'rel\_altitude', 'altitude' or 'time'

**fig** [Figure] Figure to add the colorbar to. If none a new figure will be created

**ax** [Axis] Axis to plot on. if fig is None a new axis will be created

**save\_fig** [bool] if true save the figure if false it does not close the plot and returns the handle to the figure

**Returns**

**fname\_list** [list of str or]

**fig, ax** [tuple] list of names of the saved plots or handle of the figure an axes

---

## UTILITIES (PYRAD . UTIL)

Functions to read and write data and configuration files.

## 6.1 Radar Utilities

<i>get_data_along_rng</i> (radar, field_name, ..., ...)	Get data at particular (azimuths, elevations)
<i>get_data_along_az</i> (radar, field_name, ..., ...)	Get data at particular (ranges, elevations)
<i>get_data_along_ele</i> (radar, field_name, ..., ...)	Get data at particular (ranges, azimuths)
<i>get_ROI</i> (radar, filename, sector)	filter out any data outside the region of interest defined by sector
<i>rainfall_accumulation</i> (t_in_vec, val_in_vec)	Computes the rainfall accumulation of a time series over a given period
<i>time_series_statistics</i> (t_in_vec, val_in_vec)	Computes statistics over a time-averaged series.
<i>join_time_series</i> (t1, val1, t2, val2[, dropnan])	joins time_series.
<i>get_range_bins_to_avg</i> (rad1_rng, rad2_rng)	Compares the resolution of two radars and determines if and which radar has to be averaged and the length of the averaging window
<i>find_ray_index</i> (ele_vec, azi_vec, ele, azi[, ...])	Find the ray index corresponding to a particular elevation and azimuth
<i>find_rng_index</i> (rng_vec, rng[, rng_tol])	Find the range index corresponding to a particular range
<i>find_nearest_gate</i> (radar, lat, lon[, latlon_tol])	Find the radar gate closest to a lat,lon point
<i>find_neighbour_gates</i> (radar, azi, rng[, ...])	Find the neighbouring gates within +-delta_azi and +-delta_rng
<i>find_colocated_indexes</i> (radar1, radar2, ...)	Given the theoretical elevation, azimuth and range of the co-located gates of two radars and a given tolerance returns the indices of the gates for the current radars
<i>get_target_elevations</i> (radar_in)	Gets RHI target elevations
<i>get_fixed_rng_data</i> (radar, field_names, fixed_rng)	Creates a 2D-grid with (azi, ele) data at a fixed range
<i>get_fixed_rng_span_data</i> (radar, field_names)	Creates a 2D-grid with (azi, ele) data representing a user-defined statistic over a fixed range span
<i>time_avg_range</i> (timeinfo, avg_starttime, ...)	finds the new start and end time of an averaging
<i>get_closest_solar_flux</i> (hit_datetime_list, ...)	finds the solar flux measurement closest to the sun hit

Continued on next page

Table 1 – continued from previous page

<code>create_sun_hits_field(rad_el, rad_az, ...)</code>	creates a sun hits field from the position and power of the sun hits
<code>create_sun_retrieval_field(par, field_name, ...)</code>	creates a sun retrieval field from the retrieval parameters
<code>compute_quantiles(field[, quantiles])</code>	computes quantiles
<code>compute_quantiles_from_hist(bin_centers, hist)</code>	computes quantiles from histograms
<code>compute_quantiles_sweep(field, ray_start, ...)</code>	computes quantiles of a particular sweep
<code>compute_2d_hist(field1, field2, field_name1, ...)</code>	computes a 2D histogram of the data
<code>compute_1d_stats(field1, field2)</code>	returns statistics of data
<code>compute_2d_stats(field1, field2, ...[, ...])</code>	computes a 2D histogram and statistics of the data
<code>compute_histogram(field, field_name[, ...])</code>	computes histogram of the data
<code>compute_histogram_sweep(field, ray_start, ...)</code>	computes histogram of the data in a particular sweep
<code>belongs_roi_indices(lat, lon, roi)</code>	Get the indices of points that belong to roi in a list of points
<code>compute_profile_stats(field, gate_altitude, ...)</code>	Compute statistics of vertical profile
<code>compute_directional_stats(field[, avg_type, ...])</code>	Computes the mean or the median along one of the axis (ray or range)
<code>project_to_vertical(data_in, data_height, ...)</code>	Projects radar data to a regular vertical grid
<code>quantiles_weighted(values[, weight_vector, ...])</code>	Given a set of values and weights, compute the weighted quantile(s).

`pyrad.util.belongs_roi_indices (lat, lon, roi)`

Get the indices of points that belong to roi in a list of points

#### Parameters

**lat, lon** [float arrays] latitudes and longitudes to check

**roi** [dict] Dictionary describing the region of interest

#### Returns

**inds** [array of ints] list of indices of points belonging to ROI

**is\_roi** [str] Whether the list of points is within the region of interest. Can be 'All', 'None', 'Some'

`pyrad.util.compute_1d_stats (field1, field2)`

returns statistics of data

#### Parameters

**field1, field2** [ndarray 1D] the two fields to compare

#### Returns

**stats** [dict] a dictionary with statistics

`pyrad.util.compute_2d_hist (field1, field2, field_name1, field_name2, step1=None, step2=None)`

computes a 2D histogram of the data

#### Parameters

**field1, field2** [ndarray 2D] the radar fields

**field\_name1, field\_name2** [str] field names

**step1, step2** [float] size of the bins

**Returns**

**H** [float array 2D] The bi-dimensional histogram of samples x and y

**xedges, yedges** [float array] the bin edges along each dimension

`pyrad.util.compute_2d_stats` (*field1, field2, field\_name1, field\_name2, step1=None, step2=None*)  
computes a 2D histogram and statistics of the data

**Parameters**

**field1, field2** [ndarray 2D] the two fields

**field\_name1, field\_name2:** **str** the name of the fields

**step1, step2** [float] size of bin

**Returns**

**hist\_2d** [array] the histogram

**bin\_edges1, bin\_edges2** [float array] The bin edges

**stats** [dict] a dictionary with statistics

`pyrad.util.compute_directional_stats` (*field, avg\_type='mean', nvalid\_min=1, axis=0*)  
Computes the mean or the median along one of the axis (ray or range)

**Parameters**

**field** [ndarray] the radar field

**avg\_type:** **str** the type of average: 'mean' or 'median'

**nvalid\_min** [int] the minimum number of points to consider the stats valid. Default 1

**axis** [int] the axis along which to compute (0=ray, 1=range)

**Returns**

**values** [ndarray 1D] The resultant statistics

**nvalid** [ndarray 1D] The number of valid points used in the computation

`pyrad.util.compute_histogram` (*field, field\_name, bin\_edges=None, step=None, vmin=None, vmax=None*)  
computes histogram of the data

**Parameters**

**field** [ndarray 2D] the radar field

**field\_name:** **str or none** name of the field

**bins\_edges:** **ndarray 1D** the bin edges

**step** [float] size of bin

**vmin, vmax** [float] The minimum and maximum value of the histogram

**Returns**

**bin\_edges** [float array] interval of each bin

**values** [float array] values at each bin

`pyrad.util.compute_histogram_sweep` (*field, ray\_start, ray\_end, field\_name, step=None*)  
computes histogram of the data in a particular sweep

**Parameters**

**field** [ndarray 2D] the radar field

**ray\_start, ray\_end** [int] starting and ending ray indexes

**field\_name: str** name of the field

**step** [float] size of bin

#### Returns

**bin\_edges** [float array] interval of each bin

**values** [float array] values at each bin

`pyrad.util.compute_profile_stats` (*field, gate\_altitude, h\_vec, h\_res, quantity='quantiles', quantiles=array([0.25, 0.5, 0.75]), nvalid\_min=4, std\_field=None, np\_field=None, make\_linear=False, include\_nans=False*)

Compute statistics of vertical profile

#### Parameters

**field** [ndarray] the radar field

**gate\_altitude: ndarray** the altitude at each radar gate [m MSL]

**h\_vec** [1D ndarray] height vector [m MSL]

**h\_res** [float] height resolution [m]

**quantity** [str] The quantity to compute. Can be ['quantiles', 'mode', 'regression\_mean', 'mean']. If 'mean', the min, max, and average is computed.

**quantiles** [1D ndarray] the quantiles to compute

**nvalid\_min** [int] the minimum number of points to consider the stats valid

**std\_field** [ndarray] the standard deviation of the regression at each range gate

**np\_field** [ndarray] the number of points used to compute the regression at each range gate

**make\_linear** [Boolean] If true the data is transformed into linear coordinates before taking the mean

**include\_nans** [Boolean] If true NaN will be considered as zeros

#### Returns

**vals** [ndarray 2D] The resultant statistics

**val\_valid** [ndarray 1D] The number of points to compute the stats used at each height level

`pyrad.util.compute_quantiles` (*field, quantiles=None*)  
computes quantiles

#### Parameters

**field** [ndarray 2D] the radar field

**ray\_start, ray\_end** [int] starting and ending ray indexes

**quantiles: float array** list of quantiles to compute

#### Returns

**quantiles** [float array] list of quantiles

**values** [float array] values at each quantile

`pyrad.util.compute_quantiles_from_hist` (*bin\_centers, hist, quantiles=None*)  
computes quantiles from histograms



**Parameters**

**bin\_centers** [ndarray 1D] the bins  
**hist** [ndarray 1D] the histogram  
**quantiles: float array** list of quantiles to compute

**Returns**

**quantiles** [float array] list of quantiles  
**values** [float array] values at each quantile

`pyrad.util.compute_quantiles_sweep(field, ray_start, ray_end, quantiles=None)`  
 computes quantiles of a particular sweep

**Parameters**

**field** [ndarray 2D] the radar field  
**ray\_start, ray\_end** [int] starting and ending ray indexes  
**quantiles: float array** list of quantiles to compute

**Returns**

**quantiles** [float array] list of quantiles  
**values** [float array] values at each quantile

`pyrad.util.create_sun_hits_field(rad_el, rad_az, sun_el, sun_az, data, imgcfg)`  
 creates a sun hits field from the position and power of the sun hits

**Parameters**

**rad\_el, rad\_az, sun\_el, sun\_az** [ndarray 1D] azimuth and elevation of the radar and the sun respectively in degree  
**data** [masked ndarray 1D] the sun hit data  
**imgcfg: dict** a dictionary specifying the ranges and resolution of the field to create

**Returns**

**field** [masked ndarray 2D] the sun hit field

`pyrad.util.create_sun_retrieval_field(par, field_name, imgcfg, lant=0.0)`  
 creates a sun retrieval field from the retrieval parameters

**Parameters**

**par** [ndarray 1D] the 5 retrieval parameters  
**imgcfg: dict** a dictionary specifying the ranges and resolution of the field to create

**Returns**

**field** [masked ndarray 2D] the sun retrieval field

`pyrad.util.find_colocated_indexes(radar1, radar2, rad1_ele, rad1_azi, rad1_rng, rad2_ele, rad2_azi, rad2_rng, ele_tol=0.5, azi_tol=0.5, rng_tol=50.0)`

Given the theoretical elevation, azimuth and range of the co-located gates of two radars and a given tolerance returns the indices of the gates for the current radars

**Parameters**

**radar1, radar2** [radar objects] the two radar objects

**rad1\_ele, rad1\_azi, rad1\_rng** [array of floats] the radar coordinates of the radar1 gates

**rad2\_ele, rad2\_azi, rad2\_rng** [array of floats] the radar coordinates of the radar2 gates

**ele\_tol, azi\_tol** [floats] azimuth and elevation angle tolerance [deg]

**rng\_tol** [float] range Tolerance [m]

#### Returns

**ind\_ray\_rad1, ind\_rng\_rad1, ind\_ray\_rad2, ind\_rng\_rad2** [array of ints] the ray and range indexes of each radar gate

`pyrad.util.find_nearest_gate(radar, lat, lon, latlon_tol=0.0005)`

Find the radar gate closest to a lat,lon point

#### Parameters

**radar** [radar object] the radar object

**lat, lon** [float] The position of the point

**latlon\_tol** [float] The tolerance around this point

#### Returns

**ind\_ray, ind\_rng** [int] The ray and range index

**azi, rng** [float] the range and azimuth position of the gate

`pyrad.util.find_neighbour_gates(radar, azi, rng, delta_azi=None, delta_rng=None)`

Find the neighbouring gates within +-delta\_azi and +-delta\_rng

#### Parameters

**radar** [radar object] the radar object

**azi, rng** [float] The azimuth [deg] and range [m] of the central gate

**delta\_azi, delta\_rng** [float] The extend where to look for

#### Returns

**inds\_ray\_aux, ind\_rng\_aux** [int] The indices (ray, rng) of the neighbouring gates

`pyrad.util.find_ray_index(ele_vec, azi_vec, ele, azi, ele_tol=0.0, azi_tol=0.0, nearest='azi')`

Find the ray index corresponding to a particular elevation and azimuth

#### Parameters

**ele\_vec, azi\_vec** [float arrays] The elevation and azimuth data arrays where to look for

**ele, azi** [floats] The elevation and azimuth to search

**ele\_tol, azi\_tol** [floats] Tolerances [deg]

**nearest** [str] criteria to define wich ray to keep if multiple rays are within tolerance. azi: nearest azimuth, ele: nearest elevation

#### Returns

**ind\_ray** [int] The ray index

`pyrad.util.find_rng_index(rng_vec, rng, rng_tol=0.0)`

Find the range index corresponding to a particular range

#### Parameters

**rng\_vec** [float array] The range data array where to look for

**rng** [float] The range to search

**rng\_tol** [float] Tolerance [m]

#### Returns

**ind\_rng** [int] The range index

`pyrad.util.get_ROI (radar, fieldname, sector)`

filter out any data outside the region of interest defined by sector

#### Parameters

**radar** [radar object] the radar object where the data is

**fieldname** [str] name of the field to filter

**sector** [dict] a dictionary defining the region of interest

#### Returns

**roi\_flag** [ndarray] a field array with ones in gates that are in the Region of Interest

`pyrad.util.get_closest_solar_flux (hit_datetime_list, flux_datetime_list, flux_value_list)`

finds the solar flux measurement closest to the sun hit

#### Parameters

**hit\_datetime\_list** [datetime array] the date and time of the sun hit

**flux\_datetime\_list** [datetime array] the date and time of the solar flux measurement

**flux\_value\_list: ndarray 1D** the solar flux values

#### Returns

**flux\_datetime\_closest\_list** [datetime array] the date and time of the solar flux measurement closest to sun hit

**flux\_value\_closest\_list** [ndarray 1D] the solar flux values closest to the sun hit time

`pyrad.util.get_data_along_azi (radar, field_name, fix_ranges, fix_elevations, rng_tol=50.0, ang_tol=1.0, azi_start=None, azi_stop=None)`

Get data at particular (ranges, elevations)

#### Parameters

**radar** [radar object] the radar object where the data is

**field\_name** [str] name of the field to filter

**fix\_ranges, fix\_elevations: list of floats** List of ranges [m], elevations [deg] couples

**rng\_tol** [float] Tolerance between the nominal range and the radar range [m]

**ang\_tol** [float] Tolerance between the nominal angle and the radar angle [deg]

**azi\_start, azi\_stop: float** Start and stop azimuth angle of the data [deg]

#### Returns

**xvals** [list of float arrays] The ranges of each rng, ele pair

**yvals** [list of float arrays] The values

**valid\_rng, valid\_ele** [float arrays] The rng, ele pairs

`pyrad.util.get_data_along_ele (radar, field_name, fix_ranges, fix_azimuths, rng_tol=50.0, ang_tol=1.0, ele_min=None, ele_max=None)`

Get data at particular (ranges, azimuths)

**Parameters**

**radar** [radar object] the radar object where the data is  
**field\_name** [str] name of the field to filter  
**fix\_ranges, fix\_azimuths: list of floats** List of ranges [m], azimuths [deg] couples  
**rng\_tol** [float] Tolerance between the nominal range and the radar range [m]  
**ang\_tol** [float] Tolerance between the nominal angle and the radar angle [deg]  
**ele\_min, ele\_max: float** Min and max elevation angle [deg]

**Returns**

**xvals** [list of float arrays] The ranges of each rng, ele pair  
**yvals** [list of float arrays] The values  
**valid\_rng, valid\_ele** [float arrays] The rng, ele pairs

`pyrad.util.get_data_along_rng(radar, field_name, fix_elevations, fix_azimuths, ang_tol=1.0, rmin=None, rmax=None)`

Get data at particular (azimuths, elevations)

**Parameters**

**radar** [radar object] the radar object where the data is  
**field\_name** [str] name of the field to filter  
**fix\_elevations, fix\_azimuths: list of floats** List of elevations, azimuths couples [deg]  
**ang\_tol** [float] Tolerance between the nominal angle and the radar angle [deg]  
**rmin, rmax: float** Min and Max range of the obtained data [m]

**Returns**

**xvals** [list of float arrays] The ranges of each azi, ele pair  
**yvals** [list of float arrays] The values  
**valid\_azi, valid\_ele** [float arrays] The azi, ele pairs

`pyrad.util.get_fixed_rng_data(radar, field_names, fixed_rng, rng_tol=50.0, ele_min=None, ele_max=None, azi_min=None, azi_max=None)`

Creates a 2D-grid with (azi, ele) data at a fixed range

**Parameters**

**radar** [radar object] The radar object containing the data  
**field\_name** [str] The field name  
**fixed\_rng** [float] The fixed range [m]  
**rng\_tol** [float] The tolerance between the nominal range and the actual radar range [m]  
**ele\_min, ele\_max, azi\_min, azi\_max** [float or None] The limits of the grid [deg]. If None the limits will be the limits of the radar volume

**Returns**

**radar** [radar object] The radar object containing only the desired data

`pyrad.util.get_fixed_rng_span_data(radar, field_names, rmin=None, rmax=None, ele_min=None, ele_max=None, azi_min=None, azi_max=None)`

Creates a 2D-grid with (azi, ele) data representing a user-defined statistic over a fixed range span

#### Parameters

**radar** [radar object] The radar object containing the data

**field\_name** [str] The field name

**rmin, rmax** [float] The range limits [m]. If None the entire coverage of the radar is going to be used

**ele\_min, ele\_max, azi\_min, azi\_max** [float or None] The limits of the grid [deg]. If None the limits will be the limits of the radar volume

#### Returns

**radar** [radar object] The radar object containing only the desired data

`pyrad.util.get_range_bins_to_avg(rad1_rng, rad2_rng)`

Compares the resolution of two radars and determines if and which radar has to be averaged and the length of the averaging window

#### Parameters

**rad1\_rng** [array] the range of radar 1

**rad2\_rng** [datetime] the range of radar 2

#### Returns

**avg\_rad1, avg\_rad2** [Boolean] Booleans specifying if the radar data has to be average in range

**avg\_rad\_lim** [array with two elements] the limits to the average (centered on each range gate)

`pyrad.util.get_target_elevations(radar_in)`

Gets RHI target elevations

#### Parameters

**radar\_in** [Radar object] current radar object

#### Returns

**target\_elevations** [1D-array] Azimuth angles

**el\_tol** [float] azimuth tolerance

`pyrad.util.join_time_series(t1, val1, t2, val2, dropnan=False)`

joins time\_series. Only of package pandas is available otherwise returns None.

#### Parameters

**t1** [datetime array] time of first series

**val1** [float array] value of first series

**t2** [datetime array] time of second series

**val2** [float array] value of second series

**dropnan** [boolean] if True remove NaN from the time series

#### Returns

**t\_out\_vec** [datetime array] the resultant date time after joining the series

**val1\_out\_vec** [float array] value of first series

**val2\_out\_vec** [float array] value of second series

```
pyrad.util.project_to_vertical (data_in, data_height, grid_height, interp_kind='none',
                                fill_value=-9999.0)
```

Projects radar data to a regular vertical grid

## Parameters

**data\_in** [ndarray 1D] the radar data to project

**data\_height** [ndarray 1D] the height of each radar point

**grid\_height** [ndarray 1D] the regular vertical grid to project to

**interp\_kind** [str] The type of interpolation to use: 'none' or 'nearest'

**fill\_value** [float] The fill value used for interpolation

## Returns

**data\_out** [ndarray 1D] The projected data

```
pyrad.util.quantiles_weighted(values, weight_vector=None, quantiles=array([0.5]),  
                               weight_threshold=None, data_is_log=False)
```

Given a set of values and weights, compute the weighted quantile(s).

```
pyrad.util.rainfall_accumulation(t_in_vec, val_in_vec, cum_time=3600.0, base_time=0.0,
                                  dropnan=False)
```

Computes the rainfall accumulation of a time series over a given period

## Parameters

**t\_in\_vec** [datetime array] the input date and time array

**val\_in\_vec** [float array] the input values array [mm/h]

**cum\_time** [int] accumulation time [s]

**base\_time** [int] base time [s]

**dropnan** [boolean] if True remove NaN from the time series

## Returns

**t\_out\_vec** [datetime array] the output date and time array

**val\_out\_vec** [float array] the output values array

**np\_vec** [int array] the number of samples at each period

`pyrad.util.time_avg_range` (*timeinfo*, *avg\_starttime*, *avg\_endtime*, *period*)  
finds the new start and end time of an averaging

## Parameters

**timeinfo** [datetime] the current volume time

**avg\_starttime** [datetime] the current average start time

**avg\_endtime: datetime** the current average end time

**period: float** the averaging period

## Returns

**new\_starttime** [datetime] the new average start time

**new\_endtime** [datetime] the new average end time

`pyrad.util.time_series_statistics(t_in_vec, val_in_vec, avg_time=3600, base_time=1800,  
method='mean', dropnan=False)`

Computes statistics over a time-averaged series. Only of package pandas is available otherwise returns None

#### Parameters

**t\_in\_vec** [datetime array] the input date and time array

**val\_in\_vec** [float array] the input values array

**avg\_time** [int] averaging time [s]

**base\_time** [int] base time [s]

**method** [str] statistical method

**dropnan** [boolean] if True remove NaN from the time series

#### Returns

**t\_out\_vec** [datetime array] the output date and time array

**val\_out\_vec** [float array] the output values array





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