EARLINET Level3 Data Product Catalogue
DATA PRODUCT CATALOGUE

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Version 2.0 -23.11.2022

5. APPENDIX B – DATA PRODUCT CATALOGUE

This appendix describes the content of Level 3 data files, including data format and organization. Following the standards adopted within EARLINET DC and in agreement with the whole ACTRIS database, Level 3 data are included in NetCDF files. Variables nomenclature and file format are aligned with those of pre-processed and processed ACTRIS aerosol remote sensing data.

The Level 3 data are centrally obtained by the ACTRIS aerosol remote sensing Data Center node of the CNR in Potenza. This allows the harmonization and reproducibility of the products.

a. File naming convention

File names for the Level 3 aerosol data follow this convention:

ACTRIS_AerRemSen_sss_Lev03_mmmmmm_ppp_ttt_vxx_qcyyy.nc

Where:

- *sss* is the station ID code;
- *mmmmmm* is the temporal aggregation (Annual=annual averages, Season=season averages, NorMon=normal month averages, NorSea=normal season averages);
- *pppp* is the period of the calculated averages. For seasonal and annual averages pppp is a year (i.e. pppp=2000), for normal monthly and normal seasonal averages pppp=0019;
- *ttt* is the product type (Int=integrated values, Pro=profile data, Lay=layer statistics);
- *vxx* version of the data product. Since this is the second release, it is v02;
- *qcyyy* is the version of the qc used for the evaluation of Level 3 data products (in this case, qc030).

b. Definition and meaning of the parameters

In this section, all the parameters reported in the Level 3 files are described. Some variables can be found only in a specific type of product, some others are present in all the Level 3 files.

i. Dimensions

In the next lines, the list of all dimensions in level 3 files is reported, together with the type of file where they are contained:

- *wavelength* (Int,Lay,Pro) provides the wavelength at which products are retrieved. It assumes one among the following three values: 355 nm, 532 nm, 1064 nm;
- *nv* (Int,Lay,Pro) assumes two integer values (1 and 2), and it is used following the cf convention whenever a bound is needed for some evaluation;
- *time* (Int,Lay,Pro) provides the reference period where aggregations are performed. More precisely it reports the middle time of the reference period (i.e., 23:59:59 of June 30th for annual files) It is expressed in seconds since 1970/1/1 00:00, and it assumes one value for annual files, four values for seasonal and normal seasonal files, and twelve values for normal monthly files;
- *n_char* (Int,Lay,Pro) allows the recording of the names of source files from which the Level 3 products are evaluated. It is an integer number which represents the number of characters used for the list of the source files;
- *stats* (Int,Pro) provides the type of statistics reported in the file (mean, statistical error mean (i.e. the mean of the statistical error of Level 2 data used in the aggregation for obtaining Level3 data),, median, standard deviation, number of values aggregated);
- *breaks* (Lay) provides the number of break points of the histogram related to a certain variable.

ii. Variables

In next sections, variables are reported, separately for each kind of files. More information about how these variables are computed can be found in the Appendix A. For each variable, the associated dimensions are listed inside the square brackets:

Integrated optical products:

In this section, variables related to the integrated optical products are reported:

- *integral_bounds* [nv] provides the portion of the vertical profiles where the variables are integrated: the entire profile or the aerosol boundary layer;
- *aerosol_optical_depth* [time,nv,wavelength,stats] is the integral over the altitude of the aerosol extinction profile;
- *integrated_backscatter* [time,nv,wavelength,stats] is the integral over the altitude of the aerosol backscatter profile;
- *lidar_ratio* [time,nv,wavelength,stats] is the ratio of the extinction coefficient to the backscatter coefficient;
- *aerosol_boundary_layer* [time,stats] is the altitude of the top of the lowest layer that typically contains the most of the aerosol, except special elevated layers like Saharan dust etc.;
- *h63_of_aerosol_optical_depth* [time,wavelength,stats] is the altitude below which 63% of the total integrated extinction profile is confined;
- *h63_of_integrated_backscsatter* [time,wavelength,stats] is the altitude below which 63% of the total integrated backscatter profile is confined;

- *center_of_mass* [time,nv,wavelength,stats] is the altitude of the punctual particle equivalent of a given object for application of Newton's laws of motion. It is estimated as the altitude weighted by the backscatter coefficient;
- *particle_depolarization* [time,nv,wavelength,stats] is the ratio of the perpendicular polarization component to the parallel component of the aerosol scattering;
- *angstrom_coefficient* [time,nv,stats] is a parameter that describes how the optical thickness of an aerosol depends on the wavelength;
- *time_bounds* [time,nv] provides the bound of the temporal interval where variables are aggregated;
- *latitude* [ ] gives the latitude coordinate of the station;
- *longitude* [ ] gives the longitude coordinate of the station;
- *source* [n_char] provides the list of the Level 2 files from which the current Level 3 file originates;
- *station_altitude* [ ] provides the altitude of the station (in meters, above sea level).

Layer products:

In this section, variables contained in the layer files are reported:

- *altitude_intervals* [breaks] provides the break point values of the frequency histograms related to the following variables: center of mass, base layer altitude, top layer altitude;
- *lidar_ratio_intervals* [breaks] provides the break point values of the lidar ratio frequency histogram;
- *extinction_intervals* [breaks] provides the break point values of the extinction frequency histogram;
- *backscatter_intervals* [breaks] provides the break point values of the backscatter frequency histogram;
- *particle_depolarization_intervals* [breaks] provides the break point values of the particle depolarization frequency histogram;
- *aerosol_optical_depth_intervals* [breaks] provides the break point values of the AOD frequency histogram;
- *integrated_backscatter_intervals* [breaks] provides the break point values of the integrated backscatter frequency histogram;
- *base_layer_altitude_frequency* [time,breaks] provides the frequencies of the base layer altitude values referred to the intervals given by the altitude_intervals variable;
- *top_layer_altitude_frequency* [time,breaks] provides the frequencies of the top layer altitude values referred to the intervals given by the altitude_intervals variable;
- *center_of_mass_altitude_frequency* [time,wavelength,breaks] provides the frequencies of the center of mass altitude values referred to the intervals given by the altitude_intervals variable;
- *lidar_ratio_frequency* [time,wavelength,breaks] provides the frequencies of the lidar ratio values referred to the intervals given by the lidar_ratio_intervals variable;
- *extinction_frequency* [time,breaks] provides the frequencies of the extinction mean values referred to the intervals given by the extinction_intervals variable;

- *backscatter_frequency* [time,breaks] provides the frequencies of the backscatter mean values referred to the intervals given by the backscatter_intervals variable;
- *particle_depolarization_frequency* [time,breaks] provides the frequencies of the particle depolarization values referred to the intervals given by the particle_depolarization_intervals variable;
- *aerosol_optical_depth_frequency* [time,breaks] provides the frequencies of the AOD values referred to the intervals given by the aerosol_optical_depth_intervals variable;
- *integrated_backscatter_frequency* [time,breaks] provides the frequencies of the integrated backscatter values referred to the intervals given by the integrated_backscatter_intervals variable;
- *time_bounds* [time,nv] provides the bound of the temporal interval where variables are aggregated;
- *latitude* [ ] gives the latitude coordinate of the station;
- *longitude* [ ] gives the longitude coordinate of the station;
- *source* [n_char] provides the list of the Level 2 files from which the current Level 3 file originates;
- *station_altitude* [ ] provides the altitude of the station (in meters, above sea level).

Profile products:

In this section, variables contained in the profile files are reported:

- *extinction* [altitude,time,wavelength,stats] provides the statistics about aerosol extinction values retrieved at a specific wavelength, within specific temporal and vertical ranges;
- *backscatter* [altitude,time,wavelength,stats] provides the statistics about aerosol backscatter values retrieved at a specific wavelength, within specific temporal and vertical ranges;
- *volume_depolarization* [altitude,time,wavelength,stats] provides the statistics about the volume depolarization ratio retrieved at a specific wavelength, within specific temporal and vertical ranges;
- *time_bounds* [time,nv] provides the bound of the temporal interval where variables are aggregated;
- *latitude* [ ] gives the latitude coordinate of the station;
- *longitude* [ ] gives the longitude coordinate of the station;
- *source* [n_char] provides the list of the Level 2 files from which the current Level 3 file originates;
- *station_altitude* [ ] provides the altitude of the station (in meters, above sea level).

iii. Attribute description

In this section, attributes are briefly described. The attributes of the variables are structured in such a way as to provide all needed information about units, corresponding names (if existing) in CF convention, FillValue, and in some cases a short description of the variable.

Global attributes are mainly information related to traceability of the data where is reported information about: software used to generate Level 3 products, the station to which Level 3 data refer, the data originator and data provider, and info about potential modification and versions of the Level 3 data. In particular, in agreement with the GEOMS definition (https://evdc.esa.int/documents/1/geoms-1.0.pdf), the Data Originator (DO) is the person that generated and quality controlled the data. Where no single DO exist, the DO_NAME and DO_AFFILIATION will hold the name of the entity responsible for the instrument, while the DO_ADDRESS and DO_EMAIL will contain the appropriate contact information. The DO may or may not be the same person as the PI.

c. File Examples

In the following sections, the detailed structure of the Level 3 annual files will be shown, as an example. The other Level 3 files which originate from a different temporal aggregation have a very similar structure.

i. Level 3 average integrated values file - NetCDF structure:

Dimensions:

- nv
- time
  - i) units: seconds since 1970-01-01T00:00Z
  - ii) long_name: Time
  - iii) calendar: gregorian
  - iv) axis: T
  - v) standard_name: time
  - vi) bounds: time_bounds
- wavelength
  - i) units: nm
  - ii) long_name: Wavelength of the transmitted laser pulse
- stats
  - i) long_name: statistics
  - ii) flag_value: 0,1,2,3,4
  - iii) flag_meaning: 0:mean, 1:statistical error mean, 2:median, 3:standard deviation, 4:number of values aggregated
- n_char

Variables:

- integral_bounds [nv] (type: bytes)

i) long_name: integral bounds of integrated values
ii) flag_value: 0,1
iii) flag_meaning: 0:total, 1:aerosol boundary layer

- aerosol_optical_depth [time,nv,wavelength,stats] (type: double)
  i) units: 1
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: aerosol optical depth
  iv) standard_name: atmosphere_optical_thickness_due_to_ambient_aerosol_particles
- integrated_backscatter [time,nv,wavelength,stats] (type: double)
  i) units: 1/sr
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: integrated_backscatter
- lidar_ratio [time,nv,wavelength,stats] (type: double)
  i) units: sr
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: aerosol extinction-to-backscatter ratio
- aerosol_boundary_layer [time,stats] (type: double)
  i) units: m
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: altitude of the upper bound of the aerosol planet boundary layer
- h63_of_aerosol_optical_depth [time,wavelength,stats] (type: double)
  i) units: m
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: altitude below which stays the 63% of the total aerosol optical depth
- h63_of_integrated_backscatter [time,wavelength,stats] (type: double)
  i) units: m
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: altitude below which stays the 63% of the total aerosol optical depth
- center_of_mass [time,nv,wavelength,stats] (type: double)
  i) units: m
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: center of mass
- particle_depolarization [time,nv,wavelength,stats] (type: double)
  i) units: 1
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: aerosol linear particle depolarization ratio
- time_bounds [time,nv] (type: double)
  i) units: seconds since 1970-01-01T00:00Z
- latitude [ ] (type: float)
  i) units: degrees_north
  ii) long_name: latitude of the station
  iii) standard_name: latitude
- longitude [ ] (type: float)
  i) units: degrees_east
  ii) long_name: longitude of the station

iii) standard_name: longitude

- source [n_char] (type: char)
  i) long_name: source files
  ii) description: List of level 2 files from which are retrieved values averaged in this file
- station_altitude [ ] (type: float)
  i) units: m
  ii) long_name: station altitude above sea level

Global attributes:

- processor_name: EAR_clim_v1.exe
- processor_version:
- processor_institution: CNR – IMAA
- system:
- location:
- institution:
- PI:
- PI_affiliation:
- PI_affiliation_acronym:
- PI_address:
- PI_phone:
- PI_email:
- data_originator: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_originator_affiliation_acronym: CNR – IMAA
- data_originator_address:
- data_originator_phone:
- data_originator_email: earlinetdb@actris.imaa.cnr.it
- data_provider: ACTRIS ARES
- data_provider_affiliation: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_provider_affiliation_acronym: CNR – IMAA
- data_provider_address:
- data_provider_phone:
- data_provider_email: earlinetdb@actris.imaa.cnr.it
- conventions: C.F. – 1.8
- references: link doc earlinet.org
- station_ID:
- __file_format_version:
- history: YYYY-MM-DD hh:mm:ss Generated by free software R, using package ncdf4
- title: Annual average integrated measurements – year YYYY

ii. Level 3 average layer values file – NetCDF structure:

Dimensions:

- nv
- time
  - i) units: seconds since 1970-01-01T00:00Z
  - ii) long_name: Time
  - iii) calendar: gregorian
  - iv) axis: T
  - v) standard_name: time
  - vi) bounds: time_bounds
- breaks
  - i) long_names: Histogram breaks
- wavelength
  - i) units: nm
  - ii) long_name: Wavelength of the transmitted laser pulse
- n_char

Variables:

- base_layer_altitude_frequency [time,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the base layer altitude values
  - iii) histogram_intervals: altitude_intervals
- top_layer_altitude_frequency [time,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the top layer altitude values
  - iii) histogram_intervals: altitude_intervals
- center_of_mass_altitude_frequency [time,wavelength,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the center of mass altitude values
  - iii) histogram_intervals: altitude_intervals
- lidar_ratio_frequency [time,wavelength,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the lidar ratio values
  - iii) histogram_intervals: lidar_ratio_intervals
- extinction_frequency [time,wavelength,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the extinction values
  - iii) histogram_intervals: extinction_intervals
- particle_depolarization_frequency [time,wavelength,breaks] (type: double)
  - i) _FillValue: 9.96920996838687e+36
  - ii) long_name: Frequency distribution of the linear particle depolarization ratio
  - iii) histogram_intervals: particle_depolarization_intervals

- aerosol_optical_depth_frequency [time,wavelength,breaks] (type: double)
  i) _FillValue: 9.96920996838687e+36
  ii) long_name: Frequency distribution of the aerosol optical depth values
  iii) histogram_intervals: aerosol_optical_depth_intervals
- integrated_backscatter_frequency [time,wavelength,breaks] (type: double)
  i) _FillValue: 9.96920996838687e+36
  ii) long_name: Frequency distribution of the integrated backscatter values
  iii) histogram_intervals: integrated_backscatter_intervals
- backscatter_frequency [time,wavelength,breaks] (type: double)
  i) _FillValue: 9.96920996838687e+36
  ii) long_name: Frequency distribution of the backscatter values
  iii) histogram_intervals: backscatter_intervals
- altitude_intervals [breaks] (type: double)
  i) units: m
  ii) description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- lidar_ratio_intervals [breaks] (type: double)
  i) units: sr
  ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- extinction_intervals [breaks] (type: double)
  i) units: 1/km
  ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- particle_depolarization_intervals [breaks] (type: double)
  i) units: 1
  ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- aerosol_optical_depth_intervals [breaks] (type: double)
  i) units: 1
  ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- integrated_backscatter_intervals [breaks] (type: double)
  i) units: $(10^3 sr)^{-1}$

ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.

- backscatter_intervals [breaks] (type: double)
  - i) units: 1/Mm*sr
  - ii) description: description: Histogram interval bounds are reported. The n-th value represents the lower bound of the n-th interval, while the higher bound is the (n+1)-th value, since intervals are adiacent. The last interval (n=20) has no higher bound, since it is right-open.
- time_bounds [time,nv] (type: double)
  - i) units: seconds since 1970-01-01T00:00Z
- latitude [ ] (type: float)
  - i) units: degrees_north
  - ii) long_name: latitude of the station
  - iii) standard_name: latitude
- longitude [ ] (type: float)
  - i) units: degrees_east
  - ii) long_name: longitude of the station
  - iii) standard_name: longitude
- source [n_char] (type: char)
  - i) long_name: source files
  - ii) description: List of Level 2 files from which are retrieved values averaged in this file
- station_altitude [ ] (type: float)
  - i) units: m
  - ii) long_name: station altitude above sea level

Global attributes:

- processor_name: EAR_clim_v1.exe
- processor_version:
- processor_institution: CNR – IMAA
- system:
- location:
- institution:
- PI:
- PI_affiliation:
- PI_affiliation_acronym:
- PI_address:
- PI_phone:
- PI_email:
- data_originator: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_originator_affiliation_acronym: CNR – IMAA

- data_originator_address:
- data_originator_phone:
- data_originator_email: earlinetdb@actris.imaa.cnr.it
- data_provider: ACTRIS ARES
- data_provider_affiliation: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_provider_affiliation_acronym: CNR – IMAA
- data_provider_address:
- data_provider_phone:
- data_provider_email: earlinetdb@actris.imaa.cnr.it
- conventions: C.F. – 1.8
- references: link doc earlinet.org
- station_ID:
- __file_format_version:
- history: YYYY-MM-DD hh:mm:ss Generated by free software R, using package ncdf4
- title: Annual distribution of layer optical values – year YYYY

iii. Level 3 average profile values file – NetCDF structure:

Dimensions:

- altitude
  - i) units: m
  - ii) long_name: Altitude
  - iii) axis: Z
  - iv) positive: up
  - v) standard_name: altitude
- time
  - i) units: seconds since 1970-01-01T00:00Z
  - ii) long_name: Time
  - iii) calendar: gregorian
  - iv) axis: T
  - v) standard_name: time
  - vi) bounds: time_bounds
- nv
- n_char
- wavelength
  - i) units: nm
  - ii) long_name: Wavelength of the transmitted laser pulse
- stats
  - i) long_name: statistics

ii) flag_value: 0,1,2,3,4
iii) flag_meaning: 0:mean, 1:statistical error mean, 2:median, 3:standard deviation, 4:number of profiles aggregated

Variables:

- extinction [altitude,time,wavelength,stats] (type: double)
  i) units: 1/m
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: aerosol particle extinction coefficient
  iv) standard_name: volume_extinction_coefficient_in_air_due_to_ambient_aerosol_particles
- backscatter [altitude,time,wavelength,stats] (type: double)
  i) units: 1/m*sr
  ii) _FillValue: 9.96920996838687e+36
  iii) long_name: aerosol particle backscatter coefficient
- volume_depolarization [altitude,time,wavelength,stats] (type: double)
  i) _FillValue: 9.96920996838687e+36
  ii) long_name: aerosol volume depolarization coefficient
- time_bounds [nv,time] (type: double)
  i) units: seconds since 1970-01-01T00:00Z
- source [n_char] (type: char)
  i) long_name: source files
  ii) description: List of Level 2 files from which are retrieved values averaged in this file
- latitude [ ] (type: float)
  i) units: degrees_north
  ii) long_name: latitude of the station
  iii) standard_name: latitude
- longitude [ ] (type: float)
  i) units: degrees_east
  ii) long_name: longitude of the station
  iii) standard_name: longitude
- station_altitude [ ] (type: float)
  i) units: m
  ii) long_name: station altitude above sea level

Global attributes:

- processor_name: EAR_clim_v1.exe
- processor_version:
- processor_institution: CNR – IMAA
- system:
- location:
- institution:

- PI:
- PI_affiliation:
- PI_affiliation_acronym:
- PI_address:
- PI_phone:
- PI_email:
- data_originator: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_originator_affiliation_acronym: CNR – IMAA
- data_originator_address:
- data_originator_phone:
- data_originator_email: earlinetdb@actris.imaa.cnr.it
- data_provider: ACTRIS ARES
- data_provider_affiliation: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale
- data_provider_affiliation_acronym: CNR – IMAA
- data_provider_address:
- data_provider_phone:
- data_provider_email: earlinetdb@actris.imaa.cnr.it
- conventions: C.F. – 1.8
- references: link doc earlinet.org
- station_ID:
- __file_format_version:
- history: YYYY-MM-DD hh:mm:ss Generated by free software R, using package ncdf4
- title: Annual average profile measurements – year YYYY

d. References

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