Milestone MS10.12: Description of the new ACTRIS Level2 aerosol profile data

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Objectives

The objective of this document is to describe the new ACTRIS Level2 aerosol profile data which are being implementing on the EARLINET/ACTRIS database thanks to the reshaping of the database and based on the development made within the corresponding networking activity (WP2).
As described in some previous documents (D2.1 - Documentation on the structure of the level-based EARLINET data processing chain and MS10.9- Description of the ACTRIS Level1, Level2 and Level3 aerosol profile data), the ACTRIS aerosol profile database is facing a complete reshape *in a more user oriented approach* but still in continuity with the past. The deliverable D2.1 describes the main concept behind this reshaping, while the MS10.9 provides information about how these new products will be implemented and handled with related data curation.
This document focuses on the new ACTRIS Level 2 data for the aerosol remote sensing component, i.e. the fully quality control data resulting from aerosol lidar observations. The main aspects underlying the Level 2 data release is the traceability and QC application on the Level 1 data. Therefore, these specific aspects and how these are traced into the data itself are described in particular in the current document, together with a short description of the variables and their physical meaning.

The complete description into details of all data products in terms of variables, names and so on is out of the scope of the present document and will be delivered together with the effective data product delivery.

The current document firstly provides an update of the description of the structure of the new EARLINET database and of the EARLINET data processing workflow. Then the Level 2 data are described and finally examples for Level 2 EARLINET data products are reported.

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General description of the new EARLINET database

The general structure of the new EARLINET database has been updated in order to be harmonized with the ACTRIS Data Center concept paper developed within ACTRIS PPP H20202 project (https://www.actris.eu/Portals/46/Documentation/ACTRIS%20PPP/Deliverables/Public/WP4_D4.1_M12.pdf?ver=2018-02-28-131240-023) .
Following the definition of ACTRIS data levels: **Level 0** data are raw data at native resolution including metadata necessary for the next level processing; **Level 1** data are calibrated and quality assured data with minimum level of quality control; **Level 2** data are approved and fully quality controlled data product or variable and then **Level 3** data are products derived by post-processing of Lev0-1-2 ACTRIS data and /or from other sources. No Level 1.5 is defined.

Because of this agreed definition, the data product classification reported in D2.1 and MS10.9 has been slightly redefined as follows and reported in Figure 1:

- the ***Level 1***datasets are not quality checked, except for format aspects, and therefore released as soon as data originators submit them to the database. Afterwards, all the Level 1 data pass through quality check procedures. Data originators are informed about data not passing these procedures. The Level 1 data are suitable for RRT and NRT data release and are depending on the specific data type subject to use restrictions and rules.
- All Level1 data are object of fully Quality Control procedures. The foreseen QC procedures are related to: quality assurance tests performed at instrument level, updates of the atmospheric assumed parameters and more relevant QC test of the retrieved atmospheric aerosol properties. Only the data that passed the quality checks go in to the ***Level 2*** which is therefore the ***quality checked*** data level.
- Finally, the ***Level 3*** data contain ***climatological datasets*** retrieved from the Level2 optical products.

Both Level 1 and Level 2 data contains the following data products:

Pre-processed lidar data, i.e. range-corrected signals derived from the raw lidar data acquired at each station for each detection channel of the lidar system corrected for instrumental effects (for example, dead-time, partial overlap between laser beam and receiving system, trigger delay, etc.)
Specifically, there are:

pre-processed low resolution lidar data, i.e. pre-processed lidar data consisting in range corrected signals corrected for instrumental effects and averaged on a certain temporal window. These data will be the inputs to retrieve aerosol optical properties and moreover, they are useful for synergy with other instruments like for example photometers.

pre-processed high resolution lidar data: these are pre-processed lidar data at the time and vertical resolution of the Level 0 products. These data provide calibrated timeseries of total attenuated backscatter and volume depolarization profiles and are of interest for synergies with continuous operating instruments like the ones in Cloudnet/ACTRIS component

The pre-processed lidar data are the base for the retrieval of the optical properties products, which are:

single-wavelength optical property profiles: these products are the main ones and are generated in continuity with the past. In particular, aerosol extinction and backscatter profiles as well as particle and volume linear depolarization ratio profiles are reported at their best vertical resolution in separated files.

multi-wavelength optical property profiles: this product contains the vertical profiles of all the optical properties referring to the same temporal window and to same effective vertical resolution. This new product is envisaged in order to take the most from the multi-wavelength capabilities widely available within the network.

layer products: provide information about each identified layer in terms of the base, top and thickness of each identified layer as well as mean, median, standard deviation and mean statistical error for each measured optical property. Moreover, integrated quantities inside each layer and columnar ones will be reported for extensive optical properties.

Additionally, a further Level 1 product is related to the **cloud masking**: this product provides an high resolution cloud-mask which is essential for filtering out the data before the application of aerosol retrievals algorithm.

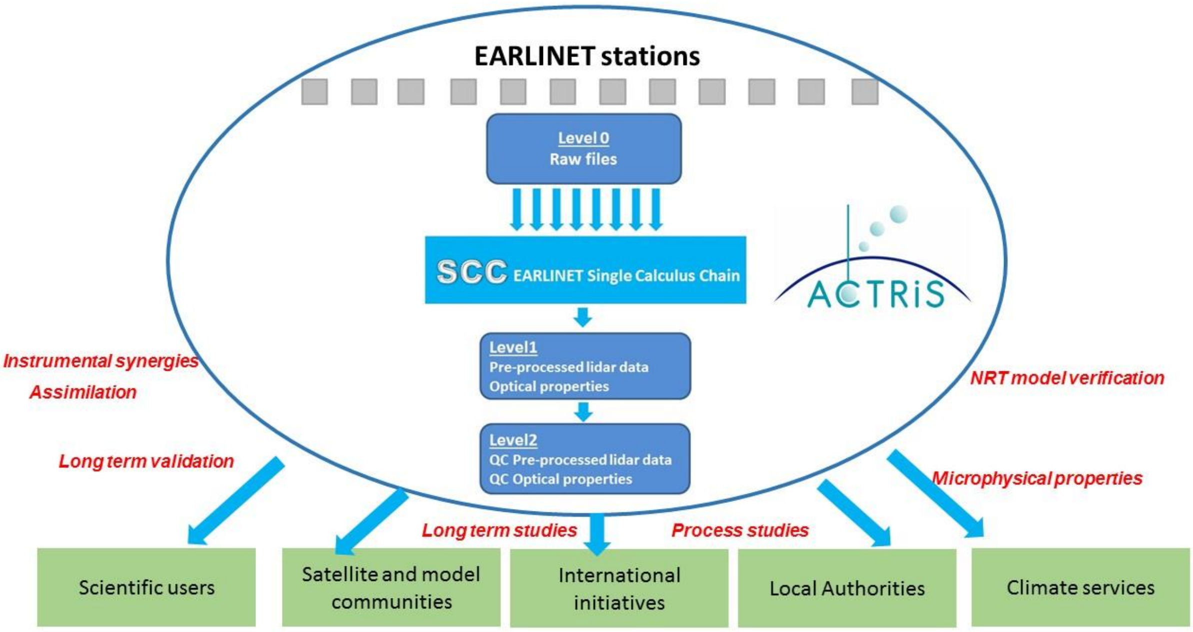

Fig.1: The new structure of the EARLINET database and its links to user communities.

A schema of the new structure of the EARLINET database is given in Figure 1, where also the links to different user communities are reported. The steps in between the different Levels of Figure 1 are schematically described in Fig 2 referring to the Single Calculus Chain (SCC). The Single Calculus Chain (SCC) is open source software for analyzing aerosol lidar data to obtain aerosol optical property profiles from raw data. The ACTRIS RI provides the SCC to the EARLINET data originator support for a centralized data processing in order to accomplish the fundamental need of coordinated lidar network to have an optimized and automatic tool providing high-quality aerosol property profiles. Main concepts of the SCC are automatic calculation of aerosol optical products in a full traceable and quality-controlled way. However data originators can even use their own data processing from raw data to aerosol optical properties using well documented quality-assured retrieval under the Data Originator responsibility. These data undergo the QC check procedures as well.

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Raw data collected at the EARLINET stations in the original acquisition data format are converted in an common netCDF data format. All information needed for the steps forward in the processing chain are annotated into the file or in a specific SCC database.
The raw data are submitted to the SCC by the Data Originator through **SCC web interface**. Through the SCC interface, Data Originator can interact with the SCC database, which is a relational database handling the large number of input parameters needed for the retrievals of aerosol optical products from raw lidar signals. Two different types of parameters are needed: experimental (which are mainly used to correct instrumental effects) and configurational (which define the way to apply a particular analysis procedure). This information is the outcome of the QA and is provided by the calibration centre. The SCC web interface allows the monitoring of the processing status of each measurement.
The submitted raw signals are processed through the **Pre-processor module (ELPP: EARLINET Lidar Pre-Processor).** The ELPP module implements the corrections to be applied to the raw lidar signals before they can be used to derive aerosol optical properties. Following the QA procedures, some instrumental effects are corrected. Level 1 pre-processed data are stored in internal SCC archive and on ACTRIS DC. Raw signals are also ingested by the **High resolution pre-processor module (HiRELPP: High Resolution EARLINET Lidar Pre-Processor)** which delivers high resolution Level 1 pre-processed data. The HiRELPP outputs are ingested by a Cloud-Mask module providing high resolution cloud-masks. Low resolution Level 1 pre-processed data (ELPP outputs) are then processed through the **Optical processor module (ELDA: EARLINET Lidar Data Analyser).** ELDA enables the retrieval of particle backscatter coefficients, the calculation of particle extinction coefficient and finally the computation of particle and volume linear depolarization profiles. All the optical products are written in netCDF files in the agreed DC format and constitute the Level 1 optical processed data.
For aerosol remote sensing stations which are also equipped with microwave radiometer and cloud radar, the Level 1 pre-processed data are also an input data for the cloud profile data unit.
Then the data are submitted to the ACTRIS aerosol remote sensing DC database. **On fly QC procedures** run directly during the submission phase. These procedures control that the file contents are compliant with the agreed file structure. Additional scientific controls check that all the mandatory products are reported into the files. All data passing the on-fly QC are uploaded on the DC as Level 1 products. **Off-line QC procedures** are run systematically every 3 months. The data originator receives feedback of the outcome of the QC. This feedback mechanism potentially allows to discover and address instrumental issues, with links to the TC. All the data compliant to all the QC requirements (both pre-processed and processed data) are made available as Level2 data.
Additionally, the Level 2 lidar data are combined with photometer data at co-located sites for offering the access (among the others) to aerosol volume concentration profiles which is potentially of great interest for different users, like modellers, and local, national and international authorities

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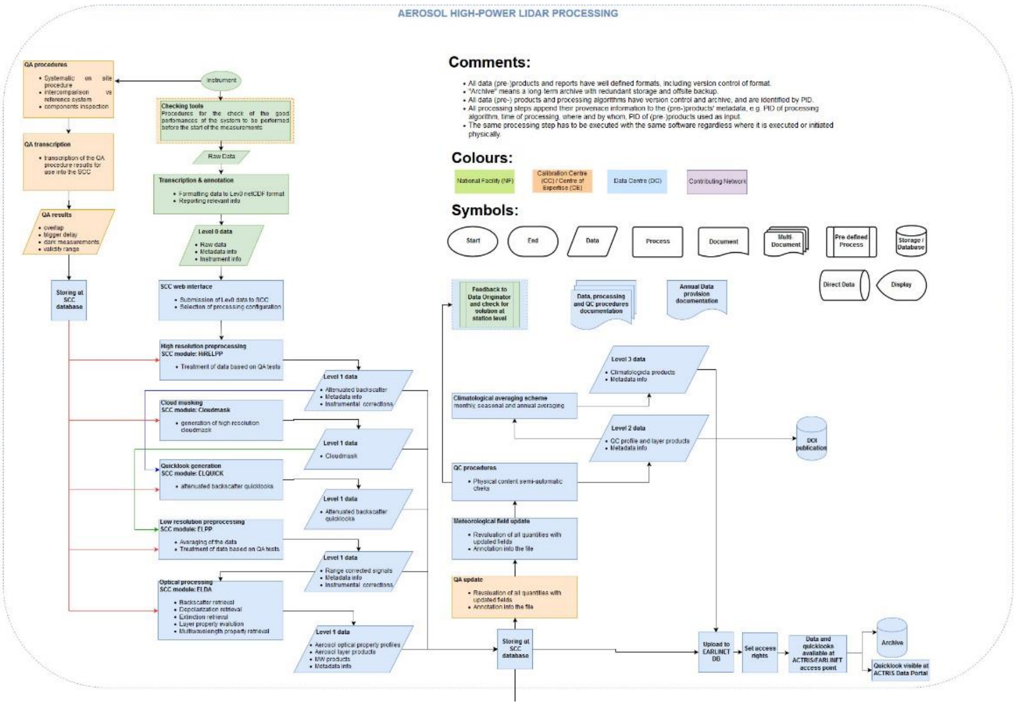

Figure 2: Workflow diagram for processing of EARLINET aerosol profiles data. In italics and bounded by dotted lines are reported processing steps under development.

All the data products are in netCDF format which is commonly and widely used within the environment and climate domain. The CF compliance is envisaged for all the products but more in particular for the Level 1, Level 2 and Level 3 data, in order to foster a wide use of the EARLINET data within the climate modeling community.

The name of the variables and attributes within the Level 2 (as well as Level1 and Level3 data) has been modified with respect to what reported in MS10.9 taking into consideration the CF compliance.
Additionally, the traceability of QC procedures as well as the versioning of the data file has been implemented in the structure of the new Level 2 products. Of course, the EARLINET database is undergoing a correspondingly reshaping for handling QC and versioning, and only when this will be completed the effective transition to the new Level 2 (and Level 1) data will be possible.
In the following, the structure of the different types of new Level 2 data is shown through the header of the corresponding netCDF file.

Preprocessed EARLINET products

Preprocessed low resolution products

```
dimensions:
        time = 2 ;
        nv = 2 ;
```

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```
		height = 1044 ;
		channel = 4 ;
		depolarization = 1 ;
		angle = 1 ;
variables:
		double latitude ;
			latitude:units = "degrees_north" ;
		double longitude ;
			longitude:units = "degrees_east" ;
		double station_altitude ;
			station_altitude:units = "m" ;
			station_altitude:long_name = "station altitude above see level" ;
		double height(angle, height) ;
			height:units = "m" ;
			height:long_name = "altitude above see level" ;
			height:positive = "up" ;
			height:axis = "Z" ;
		double range(height) ;
			range:units = "m" ;
			range:long_name = "lidar range scale" ;
		double laser_pointing_angle(angle) ;
			laser_pointing_angle:units = "degrees" ;
			laser_pointing_angle:long_name = "laser pointing angle with respect to the zenith" ;
		int laser_pointing_angle_of_profiles(time) ;
			laser_pointing_angle_of_profiles:long_name = "index of scan angle at which each
single raw profile has been detected" ;
		int shots(time) ;
			shots:long_name = "accumulated laser shots" ;
		uint64 time(time) ;
			time:units = "seconds since 1970-01-01T00:00:00Z" ;
			time:long_name = "time" ;
			time:calendar = "standard" ;
			time:axis = "T" ;
			time:bounds = "time_bounds" ;
		uint64 time_bounds(time, nv) ;
			time_bounds:units = "seconds since 1970-01-01T00:00:00Z" ;
		byte cloud_mask_type ;
			cloud_mask_type:flag_mask = 0b, 1b, 2b ;
			cloud_mask_type:flag_meanings = "no-cloudmask-available, manual-cloudmask,
automatic-cloudmask" ;
		byte cloud_mask(time, height) ;
			cloud_mask:valid_range = 0b, 7b ;
			cloud_mask:flag_value = 1b, 2b, 4b ;
			cloud_mask:flag_meanings = "unknown-cloud, cirrus-cloud, water-cloud" ;
		double cloud_fraction(time, height) ;
			cloud_fraction:valid_range = 0., 1. ;
			cloud_fraction:long_name = "fraction of cloud contamination" ;
		double atmospheric_temperature(angle, height) ;
			atmospheric_temperature:units = "K" ;
			atmospheric_temperature:long_name = "atmospheric temperature" ;
```

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```
        double atmospheric_pressure(angle, height) ;
                atmospheric_pressure:units = "mbar" ;
                atmospheric_pressure:long_name = "atmospheric pressure" ;
        byte atmospheric_molecular_calculation_source ;
                atmospheric_molecular_calculation_source:flag_value = 0b, 1b, 2b, 3b, 4b ;
                atmospheric_molecular_calculation_source:flag_meanings = "US standard
atmosphere,radiosounding,ecmwf,icon-iglo-12-23,gdas" ;
        string atmospheric_molecular_calculation_source_file ;
                atmospheric_molecular_calculation_source_file:long_name = "Name of the file used
to calculate molecular profiles" ;
        string range_corrected_signal_channel_name(channel) ;
                range_corrected_signal_channel_name:cf_role = "timeseries_id" ;
                range_corrected_signal_channel_name:long_name = "channel name for range
corrected signal timeseries" ;
        int hoi_channel_ID(channel) ;
                hoi_channel_ID:long_name = "SCC channel ID" ;
        double range_corrected_signal_emission_wavelength(channel) ;
                range_corrected_signal_emission_wavelength:units = "nm" ;
                range_corrected_signal_emission_wavelength:long_name = "emission wavelength
used to measure the range corrected signal" ;
        double range_corrected_signal_detection_wavelength(channel) ;
                range_corrected_signal_detection_wavelength:units = "nm" ;
                range_corrected_signal_detection_wavelength:long_name = "detection wavelength
at which the range corrected signal is measured" ;
        byte range_corrected_signal_range(channel) ;
                range_corrected_signal_range:valid_range = 0b, 7b ;
                range_corrected_signal_range:flag_mask = 1b, 2b, 4b ;
                range_corrected_signal_range:flag_meanings = "near-range far-range ultra-near-
range" ;
        byte range_corrected_signal_scatterers(channel) ;
                range_corrected_signal_scatterers:valid_range = 0b, 15b ;
                range_corrected_signal_scatterers:flag_mask = 1b, 2b, 4b, 8b ;
                range_corrected_signal_scatterers:flag_meanings = "particle nitrogen oxygen water-
vapour" ;
        byte range_corrected_signal_detection_mode(channel) ;
                range_corrected_signal_detection_mode:valid_range = 1b, 3b ;
                range_corrected_signal_detection_mode:flag_mask = 1b, 2b ;
                range_corrected_signal_detection_mode:flag_meanings = "analog, photoncounting"
;
        double polarization_crosstalk_parameter_g(channel) ;
                polarization_crosstalk_parameter_g:long_name = "polarization crosstalk parameter
G" ;
        double polarization_crosstalk_parameter_g_statistical_error(channel) ;
                polarization_crosstalk_parameter_g_statistical_error:long_name = "statistical error
on polarization crosstalk parameter G" ;
        double polarization_crosstalk_parameter_g_systematic_error(channel) ;
                polarization_crosstalk_parameter_g_systematic_error:long_name = "systematic
error on polarization crosstalk parameter G" ;
        double polarization_crosstalk_parameter_h(channel) ;
```

```
		polarization_crosstalk_parameter_h:long_name = "polarization crosstalk parameter
H" ;
	double polarization_crosstalk_parameter_h_statistical_error(channel) ;
		polarization_crosstalk_parameter_h_statistical_error:long_name = "statistical error
on polarization crosstalk parameter H" ;
	double polarization_crosstalk_parameter_h_systematic_error(channel) ;
		polarization_crosstalk_parameter_h_systematic_error:long_name = "systematic
error on polarization crosstalk parameter H" ;
	byte polarization_channel_geometry(channel) ;
		polarization_channel_geometry:valid_range = 0b, 2b ;
		polarization_channel_geometry:flag_value = 0b, 1b, 2b ;
		polarization_channel_geometry:flag_meanings = "not-
applicable,transmitted,reflected" ;
	byte polarization_channel_configuration(channel) ;
		polarization_channel_configuration:valid_range = 1b, 15b ;
		polarization_channel_configuration:flag_mask = 1b, 2b, 4b, 8b ;
		polarization_channel_configuration:flag_meanings = "0-degrees,90-degrees,+45-
degrees,-45-degrees" ;
	double overlap_correction_function(channel, angle, height) ;
		overlap_correction_function:long_names = "overlap function used to correct the
range corrected signal" ;
	double range_corrected_signal(channel, time, height) ;
		range_corrected_signal:long_name = "uncalibrated range corrected signal" ;
		range_corrected_signal:ancillary_variables =
"range_corrected_signal_emission_wavelength range_corrected_signal_detection_wavelength
range_corrected_signal_range range_corrected_signal_scatterers
range_corrected_signal_detection_mode range_corrected_signal_statistical_error" ;
	double range_corrected_signal_statistical_error(channel, time, height) ;
		range_corrected_signal_statistical_error:long_name = "statistical error of
uncalibrated range corrected signal" ;
	double atmospheric_molecular_extinction(channel, angle, height) ;
		atmospheric_molecular_extinction:units = "m-1" ;
		atmospheric_molecular_extinction:long_name = "calculated atmospheric molecular
extinction at emission wavelength" ;
	double atmospheric_molecular_trasmissivity_at_emission_wavelength(channel, angle,
height) ;
		atmospheric_molecular_trasmissivity_at_emission_wavelength:long_name =
"calculated atmospheric molecular trasmissivity at emission wavelength" ;
	double atmospheric_molecular_trasmissivity_at_detection_wavelength(channel, angle,
height) ;
		atmospheric_molecular_trasmissivity_at_detection_wavelength:long_name =
"calculated atmospheric molecular trasmissivity at detection wavelength" ;
	double atmospheric_molecular_lidar_ratio(channel) ;
		atmospheric_molecular_lidar_ratio:units = "sr" ;
		atmospheric_molecular_lidar_ratio:long_name = "calculated atmospheric molecular
lidar ratio at emission wavelength" ;
	int depolarization_calibration_index(channel) ;
		depolarization_calibration_index:long_names = "depolarization index to use to
calibrate channel" ;
	double polarization_gain_factor(depolarization) ;
```

```
                    polarization_gain_factor:long_name = "reflected to transmitted polarization channel gain factor (eta*)" ;
          double polarization_gain_factor_statistical_error(depolarization) ;
                    polarization_gain_factor_statistical_error:long_name = "statistical error on reflected to transmitted polarization channel gain factor" ;
          double polarization_gain_factor_systematic_error(depolarization) ;
                    polarization_gain_factor_systematic_error:long_name = "systematic error on reflected to transmitted polarization channel gain factor" ;
          double polarization_gain_factor_correction(depolarization) ;
                    polarization_gain_factor_correction:long_name = "reflected to transmitted polarization channel gain factor correction (K)" ;
          double polarization_gain_factor_correction_statistical_error(depolarization) ;
                    polarization_gain_factor_correction_statistical_error:long_name = "statistical error on reflected to transmitted polarization channel gain factor correction" ;
          double polarization_gain_factor_correction_systematic_error(depolarization) ;
                    polarization_gain_factor_correction_systematic_error:long_name = "systematic error on reflected to transmitted polarization channel gain factor correction" ;
          byte polarization_calibration_type(depolarization) ;
                    polarization_calibration_type:valid_range = 0b, 3b ;
                    polarization_calibration_type:flag_value = 1b, 2b ;
                    polarization_calibration_type:flag_meanings = "automatic,manual" ;
          double atmospheric_molecular_depolarization_ratio(depolarization, angle, height) ;
                    atmospheric_molecular_depolarization_ratio:long_name = "calculated atmospheric molecular depolarization ratio" ;

// global attributes:
                    :Conventions = "CF-1.7" ;
                    :title = "low resolution SCC L1 product" ;
                    :source = "lidar surface observation" ;
                    :references = "G. D\'Amico, A. Amodeo, H. Baars, I. Binietoglou, V. Freudenthaler, I. Mattis, U. Wandinger, and G. Pappalardo Atmos. Meas. Tech., 8, 4891-4916, doi:10.5194/amt-8-4891-2015, 2015" ;
                    :location = "Hohenpeissenberg, Germany" ;
                    :institution = "DWD Meteorological Observatory Hohenpeissenberg" ;
                    :system = "RALPH" ;
                    :hoi_system_ID = 140 ;
                    :measurement_ID = "20180705oh00" ;
                    :measurement_start_datetime = "2018-07-05T00:30:00Z" ;
                    :measurement_stop_datetime = "2018-07-05T02:30:00Z" ;
                    :comments = "bb arsl NA, ci>10000m gnd" ;
                    :elpp_version = "7.00" ;
```

Preprocessed high resolution products

```
dimensions:
          time = 240 ;
          nv = 2 ;
          height = 1577 ;
```

```
        channel = 3 ;
        depolarization = 1 ;
        angle = 1 ;
variables:
        double height(angle, height) ;
                height:units = "m" ;
                height:long_name = "altitude above see level" ;
                height:positive = "up" ;
                height:axis = "Z" ;
        double laser_pointing_angle(angle) ;
                laser_pointing_angle:units = "degrees" ;
                laser_pointing_angle:long_name = "laser pointing angle with respect to the zenith" ;
        int laser_pointing_angle_of_profiles(time) ;
                laser_pointing_angle_of_profiles:long_name = "index of scan angle at which each
single raw profile has been detected" ;
        int shots(time) ;
                shots:long_name = "accumulated laser shots" ;
        uint64 time(time) ;
                time:units = "seconds since 1970-01-01T00:00:00Z" ;
                time:long_name = "time" ;
                time:calendar = "standard" ;
                time:axis = "T" ;
                time:bounds = "time_bounds" ;
        uint64 time_bounds(time, nv) ;
                time_bounds:units = "seconds since 1970-01-01T00:00:00Z" ;
        double latitude ;
                latitude:units = "degrees_north" ;
        double longitude ;
                longitude:units = "degrees_east" ;
        double station_altitude ;
                station_altitude:units = "m" ;
                station_altitude:long_name = "station altitude above see level" ;
        string attenuated_backscatter_channel_name(channel) ;
                attenuated_backscatter_channel_name:cf_role = "timeseries_id" ;
                attenuated_backscatter_channel_name:long_name = "channel name for attenuated
backscatter timeseries" ;
        double attenuated_backscatter_emission_wavelength(channel) ;
                attenuated_backscatter_emission_wavelength:units = "nm" ;
                attenuated_backscatter_emission_wavelength:long_name = "emission wavelength
used to measure the attenuated backscatter" ;
        double attenuated_backscatter_detection_wavelength(channel) ;
                attenuated_backscatter_detection_wavelength:units = "nm" ;
                attenuated_backscatter_detection_wavelength:long_name = "detection wavelength
at which the attenuated backscatter is measured" ;
        byte attenuated_backscatter_range(channel) ;
                attenuated_backscatter_range:valid_range = 0b, 7b ;
                attenuated_backscatter_range:flag_mask = 1b, 2b, 4b ;
                attenuated_backscatter_range:flag_meanings = "ultra-near-range near-range far-
range" ;
        byte attenuated_backscatter_scatterers(channel) ;
```

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```
attenuated_backscatter_scatterers:valid_range = 0b, 15b ;
attenuated_backscatter_scatterers:flag_mask = 1b, 2b, 4b, 8b ;
attenuated_backscatter_scatterers:flag_meanings = "particle nitrogen oxygen water-vapour" ;
double atmospheric_background(channel, time) ;
atmospheric_background:units = "m-3 sr-1" ;
atmospheric_background:long_name = "mean atmospheric background calculated from lidar signal" ;
atmospheric_background:ancillary_variables = "atmospheric_background_stdev atmospheric_background_sterr atmospheric_background_min atmospheric_background_max" ;
double atmospheric_background_stdev(channel, time) ;
atmospheric_background_stdev:units = "m-3 sr-1" ;
atmospheric_background_stdev:long_name = "standard deviation of atmospheric background calculated from lidar signal" ;
double atmospheric_background_sterr(channel, time) ;
atmospheric_background_sterr:units = "m-3 sr-1" ;
atmospheric_background_sterr:long_name = "standard error of atmospheric background calculated from lidar signal" ;
double atmospheric_background_min(channel, time) ;
atmospheric_background_min:units = "m-3 sr-1" ;
atmospheric_background_min:long_name = "minimum atmospheric background calculated from lidar signal" ;
double atmospheric_background_max(channel, time) ;
atmospheric_background_max:units = "m-3 sr-1" ;
atmospheric_background_max:long_name = "maximum atmospheric background calculated from lidar signal" ;
double attenuated_backscatter_calibration(channel, time) ;
attenuated_backscatter_calibration:long_name = "constant used to calibrate the attenuated backscatter" ;
attenuated_backscatter_calibration:ancillary_variables = "attenuated_backscatter_calibration_statistical_error" ;
double attenuated_backscatter_calibration_statistical_error(channel, time) ;
attenuated_backscatter_calibration_statistical_error:long_name = "statistical error of attenuated backscatter calibration" ;
double attenuated_backscatter(channel, time, height) ;
attenuated_backscatter:units = "m-1 sr-1" ;
attenuated_backscatter:long_name = "attenuated backscatter" ;
attenuated_backscatter:ancillary_variables = "attenuated_backscatter_emission_wavelength attenuated_backscatter_detection_wavelength attenuated_backscatter_range attenuated_backscatter_scatterers attenuated_backscatter_statistical_error attenuated_backscatter_calibration" ;
double attenuated_backscatter_statistical_error(channel, time, height) ;
attenuated_backscatter_statistical_error:units = "m-1 sr-1" ;
attenuated_backscatter_statistical_error:long_name = "statistical error of attenuated backscatter" ;
string volume_linear_depolarization_ratio_channel_name(depolarization) ;
volume_linear_depolarization_ratio_channel_name:cf_role = "timeseries_id" ;
volume_linear_depolarization_ratio_channel_name:long_name = "channel name for volume linear depolarization ration timeseries" ;
double volume_linear_depolarization_ratio_wavelength(depolarization) ;
```

volume_linear_depolarization_ratio_wavelength:units = "nm" ;
volume_linear_depolarization_ratio_wavelength:long_name = "wavelength at which the volume linear depolarization ratio is calculated" ;
byte volume_linear_depolarization_ratio_range(depolarization) ;
volume_linear_depolarization_ratio_range:valid_range = 0b, 7b ;
volume_linear_depolarization_ratio_range:flag_mask = 1b, 2b, 4b ;
volume_linear_depolarization_ratio_range:flag_meanings = "ultra-near-range near-range far-range" ;
byte volume_linear_depolarization_ratio_scatterers(depolarization) ;
volume_linear_depolarization_ratio_scatterers:valid_range = 0b, 15b ;
volume_linear_depolarization_ratio_scatterers:flag_mask = 1b, 2b, 4b, 8b ;
volume_linear_depolarization_ratio_scatterers:flag_meanings = "particle nitrogen oxygen water-vapour" ;
double volume_linear_depolarization_ratio(depolarization, time, height) ;
volume_linear_depolarization_ratio:long_name = "volume linear depolarization ratio" ;
volume_linear_depolarization_ratio:ancillary_variables = "volume_linear_depolarization_ratio_wavelength volume_linear_depolarization_ratio_range volume_linear_depolarization_ratio_scatterers volume_linear_depolarization_ratio_statistical_error" ;
double volume_linear_depolarization_ratio_statistical_error(depolarization, time, height) ;
volume_linear_depolarization_ratio_statistical_error:long_name = "statistical error of volume linear depolarization ratio" ;

// global attributes:
:Conventions = "CF-1.6" ;
:title = "high resolution SCC L1 product" ;
:source = "lidar surface observation" ;
:references = "G. D\'Amico, A. Amodeo, H. Baars, I. Binietoglou, V. Freudenthaler, I. Mattis, U. Wandinger, and G. Pappalardo Atmos. Meas. Tech., 8, 4891-4916, doi:10.5194/amt-8-4891-2015, 2015" ;
:location = "Hohenpeissenberg, Germany" ;
:institution = "DWD Meteorological Observatory Hohenpeissenberg" ;
:system = "RALPH" ;
:hoi_system_ID = 154 ;
:measurement_ID = "20180709oh00" ;
:measurement_start_datetime = "2018-07-09T06:00:00Z" ;
:measurement_stop_datetime = "2018-07-09T08:00:00Z" ;
:comments = "bb arsl NA, skc" ;
:hirelpp_version = "1.00beta" ;
:history = "2018-07-10T14:26:27Z: hirelp -d sccdevelopment -m 20180709oh00 -c hirelpp.config" ;

Cloud masking products

Cloud masking is only available as Level 1 product because at the time being no QC procedures are planned for this product, however for the sake of completeness an example of the structure of this product is reported below.

```
dimensions:
        time = 240 ;
        height = 1447 ;
variables:
        int time(time) ;
                time:units = "seconds since 1970-1-1" ;
                time:long_name = "measurement time" ;
        float height(height) ;
                height:units = "m" ;
                height:long_name = "Height above sea level" ;
                height:positive = "up" ;
        double station_altitude ;
                station_altitude:_FillValue = 9.96920996838687e+36 ;
                station_altitude:long_name = "station altitude above sea level" ;
                station_altitude:units = "m" ;
        double latitude ;
                latitude:_FillValue = 9.96920996838687e+36 ;
                latitude:units = "degrees_north" ;
        double longitude ;
                longitude:_FillValue = 9.96920996838687e+36 ;
                longitude:long_name = "degrees_east" ;
        byte automatic_cloud_mask(time, height) ;
                automatic_cloud_mask:_FillValue = -127b ;
                automatic_cloud_mask:long_name = "Automatic cloud mask" ;
                automatic_cloud_mask:flag_values = 0, 1 ;
                automatic_cloud_mask:flag_meaning = "no-cloud cloud" ;

// global attributes:
                :Conventions = "CF-1.7" ;
                :title = "\'Automatic cloud mask\'" ;
                :cloudmask_version = "0.2.0" ;
                :measurement_ID = "20180709oh00" ;
                :hoi_system_ID = 154 ;
                :measurement_start_datetime = "2018-07-09T06:00:00Z" ;
                :measurement_stop_datetime = "2018-07-09T08:00:00Z" ;
                :institution = "DWD Meteorological Observatory Hohenpeissenberg" ;
                :system = "RALPH" ;
                :comments = "bb arsl NA, skc" ;
                :source = "lidar surface observation" ;
                :location = "Hohenpeissenberg, Germany" ;
                :automatic_mask_channels = "oh011" ;
```

Processed aerosol profile products

Single-wavelength and multi-wavelength optical property profiles

In the following an example of header for a backscatter netcdf file is reported. The same structure applies for the extinction and multiwavelength optical property profile.

```
dimensions:
	altitude = 961 ;
	time = 1 ;
	wavelength = 1 ;
	nv = 2 ;
variables:
	double altitude(altitude) ;
		altitude:long_name = "height above sea level" ;
		altitude:units = "m" ;
		altitude:axis = "Z" ;
		altitude:positive = "up" ;
		altitude:standard_name = "altitude" ;
	uint64 time(time) ;
		time:long_name = "time" ;
		time:units = "seconds since 1970-01-01T00:00:00Z" ;
		time:axis = "T" ;
		time:standard_name = "time" ;
		time:bounds = "time_bounds" ;
		time:calendar = "gregorian" ;
	uint64 time_bounds(time, nv) ;
		time_bounds:units = "seconds since 1970-01-01T00:00:00Z" ;
	double vertical_resolution(wavelength, time, altitude) ;
		vertical_resolution:long_name = "effective vertical resolution according to
Pappalardo et al., appl. opt. 2004" ;
		vertical_resolution:units = "m" ;
	byte cloud_mask(wavelength, time, altitude) ;
		cloud_mask:long_name = "1: unknown-cloud, 2: cirrus-cloud, 4: water-cloud" ;
	byte cirrus_contamination ;
		cirrus_contamination:long_name = "0: not-available, 1: no-cirrus, 2: cirrus-detected"
;
	byte error_retrieval_method ;
		error_retrieval_method:long_name = "0: Monte-Carlo, 1: error propagation" ;
	byte evaluation_method ;
		evaluation_method:long_name = "0: Raman, 1: elast bsc" ;
	byte raman_backscatter_method ;
		raman_backscatter_method:long_name = "0: via backscatter ratio" ;
	byte backscatter_calibration_range_search_method ;
		backscatter_calibration_range_search_method:long_name = "0: minimum of signal
ratio, 1: minimum of elast. signal" ;
	double backscatter(wavelength, time, altitude) ;
		backscatter:long_name = "aerosol backscatter coefficient" ;
		backscatter:units = "1/(m*sr)" ;
		backscatter:ancillary_variables = "error_backscatter vertical_resolution" ;
		backscatter:coordinates = "longitude latitude" ;
		backscatter:_FillValue = 9.96920996838687e+36 ;
	double error_backscatter(wavelength, time, altitude) ;
		error_backscatter:long_name = "absolute statistical uncertainty of backscatter" ;
```

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```
		error_backscatter:units = "1/(m*sr)" ;
		error_backscatter:coordinates = "longitude latitude" ;
		error_backscatter:_FillValue = 9.96920996838687e+36 ;
	byte cirrus_contamination_source ;
		cirrus_contamination_source:long_name = "0: not-available, 1: user-provided, 2: 
automatic-calculated" ;
	byte atmospheric_molecular_calculation_source ;
		atmospheric_molecular_calculation_source:long_name = "0: US standard 
atmosphere, 1: radiosounding, 2: ecmwf, 4: icon-iglo-12-13, 8: gdas" ;
	string atmospheric_molecular_calculation_source_file ;
		atmospheric_molecular_calculation_source_file:long_name = "name of the file used 
to calculate molecular extinction" ;
	float latitude ;
		latitude:long_name = "latitude of station" ;
		latitude:units = "degrees_north" ;
		latitude:standard_name = "latitude" ;
	float longitude ;
		longitude:long_name = "longitude of station" ;
		longitude:units = "degrees_east" ;
		longitude:standard_name = "longitude" ;
	float station_altitude ;
		station_altitude:long_name = "station altitude above sea level" ;
		station_altitude:units = "m" ;
	float backscatter_calibration_value ;
		backscatter_calibration_value:long_name = "assumed backscatter-ratio value in 
calibration range" ;
	float backscatter_calibration_search_range(nv) ;
		backscatter_calibration_search_range:long_name = "altitude range wherein 
calibration range is searched" ;
	float wavelength(wavelength) ;
		wavelength:long_name = "wavelength of the transmitted laser pulse" ;
		wavelength:units = "nm" ;
	float zenith_angle ;
		zenith_angle:long_name = "laser pointing angle with respect to the zenith" ;
		zenith_angle:units = "degrees" ;
	int shots ;
		shots:long_name = "accumulated laser shots" ;
	float backscatter_calibration_range(nv) ;
		backscatter_calibration_range:long_name = "altitude range where calibration was 
calculated" ;
	double volume_depolarization(wavelength, time, altitude) ;
		volume_depolarization:long_name = "volume_linear_depolarization_ratio" ;
		volume_depolarization:ancillary_variables = "error_volume_depolarization 
vertical_resolution" ;
		volume_depolarization:coordinates = "longitude latitude" ;
		volume_depolarization:_FillValue = 9.96920996838687e+36 ;
	double error_volume_depolarization(wavelength, time, altitude) ;
		error_volume_depolarization:long_name = "absolute statistical uncertainty of 
volume_depolarization" ;
		error_volume_depolarization:coordinates = "longitude latitude" ;
```

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```
                error_volume_depolarization:_FillValue = 9.96920996838687e+36 ;
        double particle_depolarization(wavelength, time, altitude) ;
                particle_depolarization:long_name = "particle_linear_depolarization_ratio" ;
                particle_depolarization:ancillary_variables = "error_particle_depolarization
vertical_resolution" ;
                particle_depolarization:coordinates = "longitude latitude" ;
                particle_depolarization:_FillValue = 9.96920996838687e+36 ;
        double error_particle_depolarization(wavelength, time, altitude) ;
                error_particle_depolarization:long_name = "absolute statistical uncertainty of
particle_depolarization" ;
                error_particle_depolarization:coordinates = "longitude latitude" ;
                error_particle_depolarization:_FillValue = 9.96920996838687e+36 ;

        int quality_control_level ;
                quality_control_level:long_name = "Quality Control Level" ;
                quality_control_level:flag_values = 0, 1, 2 ;
                quality_control_level:flag_meanings =
"File_does_not_overcome_one_or_more_on_fly_quality_control
File_does_overcome_all_on_fly_quality_control_but_fails_one_or_more_technical_quality_control
File_does_overcome_all_technical_quality_control_and_phisical_quality_control " ;
                quality_control_level:version = "1.1" ;
                quality_control_level:references = "https://www.earlinet.org/index.php?id=125" ;
        int technical_quality_control ;
                technical_quality_control:long_name = "Technical Quality Control" ;
                technical_quality_control:valid_range = 0, 2047 ;
                technical_quality_control:flag_masks = 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 ;
                technical_quality_control:flag_meanings =
"Check_if_files_on_database_contains_data Check_STATIONID_DATETIME_WAVELENGTH
Check_Filename_Format Check_File_Extension Check_for_Undefined_Variables
Check_Coordinates_Consistency
Check_if_Climatology_Measurements_had_been_made_on_Monday_and_Thursday
Cirrus_Consistency_1 Cirrus_Consistency_2 Cirrus_Consistency_3 Calipso_Overpasses_Consistency" ;
                technical_quality_control:references = "https://www.earlinet.org/index.php?id=125"
;
        int physical_quality_control ;
                physical_quality_control:long_name = "Physical Quality Control" ;
                physical_quality_control:valid_range = 0, 11 ;
                physical_quality_control:flag_masks = 1, 2, 8 ;
                physical_quality_control:flag_meanings = "Checks_for_Negative_Errors
Negative_Peaks Check_on_IB " ;
                physical_quality_control:references = "https://www.earlinet.org/index.php?id=125" ;


// global attributes:
                :measurement_number = "20180701oh01" ;
                :system = "RALPH" ;
                :institution = "DWD Meteorological Observatory Hohenpeissenberg" ;
                :location = "Hohenpeissenberg" ;
                :comments = "bb arsl NA, skc" ;
                :processing_software = "ELPP version: 7.000; ELDA version: 3.2.6" ;
```

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```
:title = "Profiles of aerosol optical properties" ;
:source = "Ground based LIDAR measurements" ;
:references = "Project website at http://www.earlinet.org" ;
:measurement_start_datetime = "2018-07-01T21:00:00Z" ;
:measurement_stop_datetime = "2018-07-01T23:00:00Z" ;
:history = "2016-02-08T09:12:04Z : File uploaded on Earlinet database\r\n 2018-06-14T23:59:00Z : File reformatted to follow the CF-1.7 conventions" ;
```

Layer products

No updates respect to the MS10.9 are currently available, because this kind of product is a step forward in the chain of the new EARLINET database and it will be implemented after the release of the new EARLINET database version.

Conclusions

This document describes Level 2 (and Level 1) products which will be implemented in the EARLINET database by the end of the ACTRIS-2 project. Both the structure and the classification scheme of Level 2 EARLINET products have to be modified with respect to previous plans to be compliant with:

- ACTRIS Data Center concept as reported in ACTRIS PPP H2020 project;
- CF convention;
- FAIR principles;
- interoperability and traceability standards under definition in ENVRIplus.

The effective provision of all these data through the database are constrained by the complete reshape of the relational database underlying the EARLINET datacenter. The effective implementation of the new EARLINET database structure including QC traceability and versioning is planned by end of 2018.

References

D2.1: Structure of the level-based EARLINET data processing chain,– ACTRIS-2 project, L.Mona, M. Fiebig, G. D'Amico, F. Amato, U. Wandinger, H. Baars

MS10.9- Description of the ACTRIS Level1, Level2 and Level3 aerosol profile data,– ACTRIS-2 project, L.Mona, F. Amato, G. D'Amico

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