EARLINET Data On-Fly Quality Control
V 2.0 – 15/11/2019

Nowadays, after the EARLINET database reshaping the Quality Control procedures are carried out exclusively *on-fly* during the uploading process.

There are two types of Quality Control procedures :

- *Basic quality control (BQC)*: technical quality control on the submitted product.
- *Advanced quality control (AQC)*: series of physical checks applied to the input product.

If one or more basic quality control fail the submitted product is *rejected* and a detailed feedback is shown to the data originator.
If the product overcomes the basic quality controls it is sent in batch to the advanced quality controls.
If the input product fails at least one advanced quality control the product is labeled as *Level 1* otherwise *Level 2*.

In following table are declared a series of quantity usefull to describe the quality controls implemented.

Field	**Description**
β	vertical profiles of aerosol backscatter coefficient
$\Delta\beta$	error on backscatter
$\beta_{peak}(\lambda)$	backscatter peak depending on wavelength
β_{dect}	backscatter minimum aerosol layer detection limit
β_{th}	backscatter threshold value
α	vertical profiles of aerosol extinction coefficient
$\Delta\alpha$	error on extinction
$\alpha_{peak}(\lambda)$	extinction peak depending on wavelength
α_{dect}	extinction minimum aerosol layer detection limit
α_{th}	extinction threshold value
S	lidar ratio
ΔS	error on lidar ratio
dh	dust layer height : defined as the lowest layer that generally contains most of the aerosol except special elevated layers (like Saharan dust etc.)
IB	Integrated backscatter
AOD	Aerosol optical depth

Basic quality controls

BQC-00

This procedure checks that each file contains the mandatory product :

- applies on b product files : variables *backscatter, error_backscatter* IS NOT NaN or NULL (has at least 1 valid value)

- applies on e product files : variables *extinction, error_extinction* IS NOT NaN or NULL (has at least 1 valid value)

BQC-01

Check for Undefined Variables and Global Attributes:

1. All array variables cannot be ALL undefined or negatives

2. If it is a b-file must contain the variables *backscatter, error_backscatter*

3. If it is an e-file must contain the variables *extinction, error_extinction*

4. If the *mixinglayerheight* is present must also be present the *aerosollayerheight*

5. *mixinglayerheight <= aerosollayerheight*

6. *aerosollayerheight > station_altitude*
   mixinglayerheight > station_altitude

7. If the following variables are present a control must be done :

   if *[volumedepolarization]* is present also must be *[error_volumedepolarization]*
   if *[particledepolarization]* is present also must be *[error_particledepolarization]*
   if *[watervapormixingratio]* is present also must be *[error_watervapor]*

8. The following *BYTE* and *FLOAT* variables are MANDATORY FOR THE NEW PRODUCTS with these specification (*this QC applies only to products with measurement start date-time subsequent to database release date*) :

   byte atmospheric_molecular_calculation_source **ALWAYS MANDATORY**
   byte error_retrieval_method(wavelength) **ALWAYS MANDATORY**

   if *backscatter* is present :

   a) *byte backscatter_evaluation_method*(wavelength) IS MANDATORY

      if *[backscatter_evaluation_method = 0]*
      ==> *byte raman_backscatter_algorithm(wavelength)* IS MANDATORY

      if *[backscatter_evaluation_method = 1]*
      ==> *byte elastic_backscatter_algorithm(wavelength)* IS MANDATORY

b) *byte backscatter_calibration_range_search_algorithm(wavelength)* IS MANDATORY

float backscatter_calibration_value(wavelength) IS MANDATORY
float backscatter_calibration_search_range(wavelength, nv) IS MANDATORY
float backscatter_calibration_range(wavelength, nv) IS MANDATORY

if *extinction* is present :

byte extinction_evaluation_algorithm(wavelength) IS MANDATORY

FOR EACH BYTE variables the VALUES are checked

9. The following global attributes are MANDATORY :

Conventions
title
source
references
history
station_ID
location
system
institution
measurement_start_datetime
measurement_stop_datetime
processor_name
PI
PI_affiliation
PI_email
Data_Originator
Data_Originator_affiliation
Data_Originator_email
hoi_system_ID
hoi_configuration_ID

10. Check if *measurement_start_datetime* and *measurement_stop_datetime* are valid

11. if variable *__SkippedFraction* is present check it is between *[0 , 1[*

BQC-02

checks if *(latitude, longitude, altitude)* of location are correct within the errors:
(latitude, longitude) +/- 0.05 degrees ==> 5 km
altitude +/- 60 m

Advanced quality controls

AQC-00

This procedure scans each profile and check that the error on the optical properties are positive for all defined value of the corresponding optical property.

A file does not pass the AQC-00 if at least for 1 error point is negative, zero or not defined, for defined optical property value.

AQC-01

This procedure scans each profile and check that the aerosol optical properties are positive within 3sigma, that there are not negative peaks and that very extreme values are present only in cirrus cloud cases.

- Check on backscatter :

  backscatter plus a Threshold value $\beta_{th} >= 0$
  OR abs(*backscatter*) < 3*$\Delta\beta$ (*error_backscatter)*
  backscatter < $\beta_{peak}(\lambda)$ (*Back_peak(Wavelength)*) if it does not belong to cirrus category

- Checks on extinction :

  extinction plus a Threshold value $\alpha_{th} >= 0$
  OR abs(*extinction*) < 3*$\Delta\alpha$ *(error_extinction)*
  extinction < $\alpha_{peak}(\lambda)$ (*Ext_peak(Wavelength))* if it does not belong to cirrus category.

For a first screening of unrealistic negative peak value,a value representative of an aerosol layer is used.
In particular :

$\beta_{th} = 5\ 10^{-7}\ m^{-1}\ sr^{-1}$
$\alpha_{th} = 2.5\ 10^{-5}\ m^{-1}$

These threshold values are set as 50 times the calibration value for the *1064nm*.
Wavelength and *IB* are scaled in the most conservative way, and threshold are keep constant over the different wavelengths.
Peak values had been set up studying the *pdf* of optical properties values for cirrus cases:
even for cirrus cases the probability of having $\alpha > 0.005\ m^{-1}$ is less than *5‰.*
Correspondingly a $\beta_{peak}(\lambda) = 1.7\ 10^{-4}\ m^{-1}\ sr^{-1}$ had set up assuming a lidar ratio of *30sr* (most conservative value) has been assumed.

AQC-02

Integrated quantities of the aerosol properties should be positive and not exceed very extreme values not realistic for aerosol layer cases. The aerosol optical depth AOD (without any assumption in the lowest troposphere, so evaluated only in the portion of atmosphere covered by the provided profile) should remain under an established threshold for data not belonging to the cirrus category.

AOD > 0

$AOD < AOD_{th}$ if it does not belong to cirrus category
The threshold values $AOD_{th} = 1.5$ had been set up studying the pdf of AOD for cirrus cases available on the EARLINET database until July 2016: even for cirrus cases the probability of having $AOD > 1.5$ is less than *5‰.*

The scaling with the wavelength had been set up in the most conservative way: considering that on average over Europe AERONET report 1.1-1.5 as typical Angstrom exponent, the threshold value was scaled with wavelength considering an Angstrom value of 0, so no wavelength dependence at all.

AQC-03

As for *AOD*, integrated quantities of the aerosol backscatter should be positive and not exceed very extreme values not realistic for aerosol layer cases. The aerosol integrated backscatter *IB* (without any assumption in the lowest troposphere, so evaluated only in the portion of atmosphere covered by the provided profile) should remain under an established threshold for data not belonging to the cirrus category.

$IB > 0$
$IB < IB_{th}$ if it does not belong to cirrus category

Starting from the *AOD* th discussed above, the $Ib_{th} = 0.05\ sr^{-1}$ is defined assuming a low (*30 sr*) lidar ratio value (most conservative choice) for converting extinction into backscatter and an Angstrom of 0 for scaling with the wavelength.

AQC-04

This procedure checks the Lidar Ratio *(S)* values when Extinction and Backscatter are provided in the same file (i.e. are provided at the same vertical resolution). Lidar ratio is defined as positive value and values are typically between *10* and *120 sr*. A wider window is defined for excluding not realistic values without constraining the pdf of the *S* values.

$S \in [0,200] sr$ within $3\Delta S$

However, lidar ratio is an intensive property so it is defined only where aerosols are significantly present. So the limit on *S* should be valid only where an aerosol layer is present, so where extinction and/or backscatter exceed a certain value that can be treat as a minimum aerosol layer detection limit and with a limited statistical uncertainty. In particular, the following check is performed:

If *extinction* > α_{dect} (Ext_dect(Wavelength)) AND (*error_extinction*/*extinction*) < *50%*
AND If *backscatter* > β_{dect} (Bck_dect(Wavelength)) AND (*error_backscatter*/*backscatter*) < *50%*

lidarratio must be beetween *[0 - 200] sr* in $3\Delta S$
$\beta_{dect} = 5\ 10^{-7}\ m^{-1}\ sr^{-1}$ and $\alpha_{dect} = 2.5\ 10^{-5}\ m^{-1}$
and where the uncertainty on extinction and backscatter is lower than *50%*.

AQC-05

checks on *volumedepolarization :*

abs(*volumedepolarization*) < *3*error_volumedepolarization*
AND *volumedepolarization* belongs to *[0,1]* within its error

AQC-06

checks on *particledepolarization* :

abs(*particledepolarization*) < *3*error_particledepolarization*
AND *particledepolarization* belongs to *[0,1]* within its error

AQC-07

checks on *watervapormixingratio :*

abs(*watervapormixingratio*) < *3*watervapormixingratio*
AND *volumedepolarization* belongs to *[0,100 g/kg]* within its error