# ACTRIS In Situ Aerosol: Guidelines for Manual QC of AE33 absorption photometer data

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The manual data QC is performed on the level 0 data, i.e. the raw data output, augmented with essential discovery and use metadata, and brought to a standardised data format. For the purpose of manual QC, temporary level 1 and 2 data versions are produced from the initial level 0 version. When performing manual QC for a given time period of data, e.g. a year for an annual submission of data, the parameters contained in the level 0, 1, or 2 data listed below are to be plotted as time series, and visually inspected in intervals of maximum 2 weeks at a time. Data sequences exhibiting issues are to be flagged with an appropriate flag contained in this list:

#### Group 0: Valid data

Fla g	Validit y	Description
000	V	Valid measurement

## Group 1: Exception flags for accepted, irregular data

Flag	Validity	Description
110	V	Episode data checked and accepted by data originator. Valid measurement

## Group 3: Flags for aggregated datasets (used for level 1.5 & 2 only)

Fla g	Validit y	Description
390	V	Data completeness less than 50%
392	V	Data completeness less than 75%
394	V	Data completeness less than 90%

## Group 5: Chemical problem

Fla g	Validit y	Description
559	V	Unspecified contamination or local influence, but considered valid

#### Group 6: Mechanical or instrumental problem

Fla	Validit	Description	
g	у		
640	V	nstrument internal relative humidity above 40%	
686	I	Invalid due to zero check. Used for Level 0	

## Group 9: Missing flags

Fla g	Validit y	Description
999	Μ	Missing measurement, unspecified reason

Regardless in which data level the issue is found, the flags are added to the initial level 0 data version, thereby producing level 0a (manually QCed level 0) as output of the QC process.

The flags for aggregated datasets in group 3 apply only to levels 1.5 and 2. They indicate which fraction of the averaging period is covered by active sample time of the instrument.

The following parameters are to be inspected for the following issues:

## Level 0:

## 1. Confirm instrument settings and calibration

These actions are to confirm that all necessary calibrations have been performed and related instrument settings have been considered and their documentation updated. The volume reference of concentration data must be given in the level 0 header data. The AE33 uses constant reference conditions of temperature and pressure, which are selected in the firmware. These STP conditions, T0 and P0, must be given in level 0 meta data. The AE33 does not measure ambient temperature and pressure. An external sensor must be connected to the serial ports to measure ambient conditions. The mass absorption cross sections used in the instrument must be specified in level 0 header data, as they are editable. It is recommended to use values of 18.47, 14.54, 13.14, 11.58, 10.35,7.77 and 7.19 m<sup>2</sup>/g for the seven wavelengths (c.f. AE33 manual). It should be verified that the last flow test was within 5% of the set point.

## 2. Instrument status

Check the instrument status. Status messages other than normal operation (no error and no warning) and filter change should be checked and data flagged accordingly.

## 3. Periods of baseline checks

AE33 does not perform autonomous baseline measurements. Periods with manually performed baseline measurements using an external filter must be marked with the corresponding flag (686).

The purpose of the measurement is to determine the signal-to-noise ratio of the instrument and to detect potential leaks. The internal baseline measurement after each filter change is not applicable for this purpose.

## 4. Sample pressure and temperature

AE33 does not measure ambient temperature and pressure without connecting to an external sensor.

## 5. Sample relative humidity at inlet (sensors not built in to AE33)

Sample relative humidity varies with ambient relative humidity and the temperature difference between ambient and lab. The sample should be dried so that the sample has RH < 40% already at the instrument inlet. If RH is higher, apply flag 640. Since the AE33 does not measure RH, it is valid to measure the humidity at the inlet of another device that is located at the same common aerosol inlet and under similar conditions.

## 6. Sample flow

Sample flow through the instrument inlet should be constant. The sample flow should typically be 5 l/min and shall not vary. Flow variations directly affect the signal to noise

ratio. Spikes in the flow inevitably lead to outliers in equivalent black carbon concentrations. Periods showing problems with the flow must be flagged.

## 7. Visual QC of equivalent black carbon concentrations

This needs to be inspected on 2 scales, logarithmic and linear. Spikes are discovered on the logarithmic plot, and investigated using the station log and trajectory / backward plume analysis. Instrumental malfunctions are flagged with 999, local influence with 559, other episodes (dust, wildfires, long-range transport, ...) with 110. The linear plot displays data around or just below 0. At values near the detection limit, some noise around or below 0 is normal and expected. When averaging to hourly means, this noise cancels out to positive values around the detection limit. Note, that the noise increases with increasing filter loading. Negative spikes to values below the noise level are invalid and need to be removed (flag 999).

# 8. Filter type (only applicable to AE33)

It is mandatory to report the filter tape and respective multiple scattering correction factors in level 0 header data which have actually been used while collecting the data. Also make sure to verify the correct multiple scattering correction factor in the instrument settings. The recommended filter type is M8060 with a multi-scattering correction factor FF=1.39. For other filter types, please check the appendix. Add scattering correction factor and leakage factor to the Nasa-ames header. Further instrument settings to be reported in the header:

- timebase (as orig. time res.)
- nominal flow rate
- maximum attenuation
- leakage factor zeta
- compensation threshold attenuation 1
- compensation threshold attenuation 2
- compensation parameter k min
- compensation parameter k max

## 9. Calculation of light absorption coefficients

The light absorption coefficient is calculated by multiplying the measured equivalent soot mass concentration with the mass absorption coefficient. The values of the mass absorption coefficients are given in the AE33 settings and must be specified in level 0 header data.

## 10. Visual QC of absorption coeffcient

This needs to be inspected on 2 scales, logarithmic and linear. Spikes are discovered on the logarithmic plot, and investigated using the station log and trajectory / backward plume analysis. Instrumental malfunctions are flagged with 999, local influence with 559, other episodes (dust, wildfires, long-range transport, ...) with 110. The linear plot displays data around or just below 0. At values near the detection limit, some noise around or below 0 is normal and expected. When averaging to hourly means, this noise cancels out to positive values around the detection limit. Negative spikes to values below the noise level are invalid and need to be removed (flag 999). These negative spikes are often caused by changes in flow or humidity, e.g. during the initial filter spot zero measurement.

## Level 1:

## 1. Calculation of light absorption coefficients

The light absorption coefficient is calculated from the loading corrected equivalent black carbon concentration provided by the instrument (not the equivalent black carbon concentrations based on the 2 individual filter spots). The light absorption coefficient is calculated by multiplying the measured equivalent soot mass concentration with the mass absorption coefficients (SG) and divided by the harmonization factor H\* with a value of 1.76 for filters of type M8060.

$$b_{abs}^{AE33} = \frac{eBC \times SG}{H^*}$$

For other filter types or for further information on the harmonization factor, see Appendix B.

# Level 2:

## 1. Absorption coefficients

These are plotted on a linear scale for the region around 0. If negative spikes have been flagged correctly in level 0, the level 2 data don't exhibit negative values. If this is the case nevertheless, the flagging of the level 0 data needs to be revisited and corrected for the time sequence concerned. A new temporary level 2 data file is produced, and verified that the negative data have vanished.

## Appendix A: Examples of Conditions requiring flagging



Example 1:

Time series of absorption coefficients from AE31 from January to July 2020. Values are often close to or below detection limit. The detection limit (red line) is defined as twice the standard deviation of the instruments noise). On July 16, one data point was far below the detection limit.





Comparison with MAAP confirms the low concentrations and run of absorption coefficients.



absorption coefficients, mean and percentiles for all wavelength

Percentiles of AE31 absorption coefficients show that there is high variability within hourly averaged data. The variability in MAAP is much lower indicating that it is not an aerosol effect but an instrument issue.

Variability can be seen in all 7 wavelength. Possible reasons could be fast changing humidity in AE31 inlet or unstable flow rate. Without level 0 we can only speculate.

Example 2:

The following example from a test phase for NRT data transmission shows problems caused by air conditioning. Data are are at level 0 with one minute time resolution.



High noise during daytime is caused be the periodically switching. High noise during the day is caused by the periodic air conditioning. A solution would be to protect the inlet against direct blowing of cool air.



A problem with a valve. The device status and valve status of the AE33 should be used to check for correct operation. A following filter change solved the problem.

After a filter change, the time series of the individual channels should be looked at. It seems that for some time after a filter change the UV channel is too high compared to the other values.

## Appendix B: Harmonization factors for AE33

The harmonization factor H\* is defined by

$$H^* = \frac{b_{abs}^{AE33}}{b_{abs}^{MAAP}}$$

To derive H\*, absorption coefficients from AE33 are interpolated to 637 nm. The MAC values used for conversion from eBC to absorption coefficients are:

- MAAP: MAC = 6.6 m<sup>2</sup>/g at 670 nm and 6.6\*1.05 m<sup>2</sup>/g at 637 nm
- AE33 : MAC corresponds to the SG-values given in the AE33 setup file for the seven wavelengths (e.g. SG5=10.35 m<sup>2</sup>/g at 660 nm)

The following harmonisation factors were get from field measurements:

Filter	H*	FF
M8060	1.76	1.39
M8020	2.21	1.57

Before taking measurements, make sure you have set the correct multi-scattering filter factor (FF) in the AE33!

Harmonized AE33 absorption coefficients then are calculated by:

$$b_{abs}^{AE33} = \frac{eBC \times SG}{H^*}$$

This equation can be used for all wavelengths. Therein eBC is the equivalent black carbon concentration with dual spot correction reported by the instrument and SG is the value of the mass specific absorption coefficient for the corresponding wavelength.

Note on the relation between H\*and C<sub>0</sub> Old definition of C<sub>0</sub>:  $C_0 = b_{atn}/b_{abs}^{MAAP}$ AE33 internal calculation:  $b_{atn} = eBC \times SG \times FF$ Combining all equations results to:  $C_0 = FF \times H^*$ 

Note on the multi-scattering correction factor

In the manual, the multi-scattering correction factor is labelled with the symbol *C*. To avoid confusion with  $C_0$ , the filter factor has been labelled *FF* in this document.