Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Aerosols

## Aerosol light extinction vertical profile

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| --- | --- | --- | --- | --- | --- |
| **Name** | Aerosol light extinction vertical profile | | | | |
| **Definition** | Spectrally dependent sum of aerosol particle light scattering and absorption coefficients per unit of geometrical path length. | | | | |
| **Unit** | dimensionless | | | | |
| **Note** | As proxy where extinction profiles are not available a very useful information is the Aerosol Layer Height layer derived from lidar or thermal instruments | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km | Extinction profiles are retrieved by lidar observations so they typically refer to punctual observations. The reported value in terms of horizontal resolution are here mutuated from the AOD . | G | 50 |  |
| B | 100 |
| T | 500 |
| **Vertical Resolution** | km | Effective vertical resolution depends on the aerosol load strongly. The reported values refer to aerosol extinction @532 nm larger than 2.5 10-2 km-1 | G | 0.2 |  |
| B | 1 |
| T | 2 |
| **Temporal Resolution** | day | All the indicated averaging times are assumed to be representative | G | 60 |  |
| B | 180 |
| T | 360 |
| **Timeliness** | day |  | G | 0.03 |  |
| B | 6 |  |
| T | 12 |  |
| **Required Measurement Uncertainty** | % | Uncertainty is dependent on the atmospheric aerosol load.  These relative uncertainties refer to extinction values @532nm  larger than 2.5 10-2 km-1 | G | 10 | The reference value above (2.5 10-2 km-1), to which the uncertainity and stability and vertical resolution requirements apply, are related to the presence of aerosol. The value of 2.5 10-2 km-1 @532nm has been estimated within ACTRIS/EARLINET as indicative of the presence of an aerosol layer (ref : QC documentation available at [www.earlinet.org](http://www.earlinet.org/)) |
| B | 20 |
| T | 30 |
| **Stability** | % /decade | These percentages refer to extinction values @532nm  larger than 2.5 10-2 km-1. | G | 5 | Stability for users requirements for this quantity are estimated from the corresponding AOD: for AOD the required stability is one half of the required uncertainty. This criterion has been adopted also for the aerosol extinction (which is the profiling analogue of AOD). |
| B | 10 |
| T | 15 |
| **Standards and References** | Samset, B. H., and G. Myhre, Climate response to externally mixed black carbon as a function of altitude, J. Geophys. Res. Atmos., 120, 2913–2927,, doi:10.1002/2014JD022849, 2015.  Pappalardo, G., Amodeo, A., Apituley, A., Comeron, A., Freudenthaler, V., Linné, H., Ansmann, A., Bösenberg, J., D'Amico, G., Mattis, I., Mona, L., Wandinger, U., Amiridis, V., Alados-Arboledas, L., Nicolae, D., and Wiegner, M.: EARLINET: towards an advanced sustainable European aerosol lidar network, Atmos. Meas. Tech., 7, 2389–2409, <https://doi.org/10.5194/amt-7-2389-2014>, 2014.  Welton, E.J., J. R. Campbell, J. D. Spinhirne, and V. S. Scott. Global monitoring of clouds and aerosols using a network of micro-pulse lidar systems, Proc. SPIE, 4153, 151-158, 2001.  Welton, E.J. K.J. Voss, H.R. Gordon, H. Maring, A. Smirnov, B. Holben, B. Schmid, J.M. Livingston, P.B. Russell, P.A. Durkee, P. Formenti, M.O. Andreae.  Ground-based Lidar Measurements of Aerosols During ACE-2: Instrument Description, Results, and Comparisons with other Ground-based and Airborne Measurements, Tellus B, 52, 635-650, 2000.  Anderson, T. L., R. J. Charlson, D. M. Winker, J. A. Ogren, and K. Holmén, Mesoscale variations of tropospheric aerosols, J. Atmos. Sci., 60, 119– 136, 2003.  Shimizu, A., T. Nishizawa, Y. Jin, S.-W. Kim, Z. Wang, D. Batdorj and N. Sugimoto, Evolution of a lidar network for tropospheric aerosol detection in East Asia, Optical Engineering. 56 (3), 031219, 2016. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| The extinction is dimensionless but not so the extinction coefficient (which is meant here). The unit is 1/m (or more convenient 1/km).  temp. resolution: values do not match the corresponding requirements of the AOD. Average values of 60, 180, 360 days will translate into more or less equal profiles.  Could there simply be a mismatch of requirements of the temporal resolution and the timeliness ?  Harald Flentje, Ina Mattis and Werner Thomas | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| I suggest to split the requirements for the troposphere and the stratosphere since different processes are important and this implies different scales | |

### Comment 3

|  |  |
| --- | --- |
| Author:Angela Benedetti | Email: [angela.benedetti@ecmwf.int](mailto:angela.benedetti@ecmwf.int) |
| I believe that the requirements for the horizontal resolution are not appropriate. It is mentioned that the extinction profiles are retrieved by lidars which have a much higher spatial resolution. I would suggest 3km for Goal, 5km for Breakthrough and 10km for threshold. The temporal resolution seems also quite coarse. Is it because long time-averages are needed for representativeness over a specific region? I would suggest lowering the Goal to 30 days, the Breakthrough to 60 days and the Threshold to 90 days (seasonal average).  I have also a comment on the units: normally extinction coefficient is reported in m-1. Here it is implied that an integral over a vertical layer has been performed. Perhaps that is not needed and the ECV could retain its "natural" units? | |

## Aerosol light extinction vertical profile

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Multi-wavelength Aerosol Optical Depth | | | | |
| **Definition** | Multi-wavelength AOD is the spectral dependent aerosol extinction coefficient integrated over the geometrical path length.(see note) | | | | |
| **Unit** | dimensionless | | | | |
| **Note** | Aerosol Optical Depth quantifies the extinction of the radiation while propagating in an aerosol layer and reflects the aerosol loading information in the view of remote sensing measurement. AOD varies with wavelength and this variation is related to the aerosol size and type. The GAW guidelines recommend AOD be measured at 3 or more wavelengths among 368, 412, 500, 675, 778, and 862 nm with a bandwidth of 5nm.    1) under some assumptions of aerosol models and surface reflectances, spectral-dependence of AOD permits retrieval of Fine-AOD and Coarse-AOD, defined as the fraction of total aerosol optical depth attributed to the “non-dust” and "dust" aerosols, respectively, which are important parameters to distinguish aerosol type.  2) The absorption aerosol optical depth(AAOD) is the fraction of AOD related to light absorption and is defined as AAOD=(1−ωo)×AOD where ωo is the column integrated aerosol single scattering albedo. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 50 |  |
| B | 100 |  |
| T | 500 |  |
| **Vertical Resolution** | N/A |  | G |  | Column integrated |
| B |  |
| T |  |
| **Temporal Resolution** | day |  | G | 0.01 | All averages assumed to be representative |
| B | 1 |
| T | 30 |
| **Timeliness** | day |  | G | 1 |  |
| B | 7 |  |
| T | 30 |  |
| **Required Measurement Uncertainty** | %  or AOD |  | G | 2% or 0.01 |  |
| B | 5% or 0.015 |  |
| T | 10% or 0.03 |  |
| **Stability** | %/decade or  AOD/decade |  | G | 0.05 |  |
| B | 2% or 0.01 |  |
| T | 5% or 0.02 |  |
| **Standards and References** | Levy, R. C., Mattoo, S., Munchak, L. A., Remer, L. A., Sayer, A. M., Patadia, F., and Hsu, N. C.: The Collection 6 MODIS aerosol products over land and ocean, Atmos. Meas. Tech., 6, 2989–3034, <https://doi.org/10.5194/amt-6-2989-2013>, 2013    CIMO-WMO report No 1019, “Abridged final report with resolutions and recommendations”, 2006    Giles, D. M., Sinyuk, A., Sorokin, M. G., Schafer, J. S., Smirnov, A., Slutsker, I., Eck, T. F., Holben, B. N., Lewis, J. R., Campbell, J. R., Welton, E. J., Korkin, S. V., and Lyapustin, A. I.: Advancements in the Aerosol Robotic Network (AERONET) Version 3 database – automated near-real-time quality control algorithm with improved cloud screening for Sun photometer aerosol optical depth (AOD) measurements, Atmos. Meas. Tech., 12, 169–209, <https://doi.org/10.5194/amt-12-169-2019>, 2019    Cuevas, E., Romero-Campos, P. M., Kouremeti, N., Kazadzis, S., Räisänen, P., García, R. D., Barreto, A., Guirado-Fuentes, C., Ramos, R., Toledano, C., Almansa, F., and Gröbner, J.: Aerosol optical depth comparison between GAW-PFR and AERONET-Cimel radiometers from long-term (2005–2015) 1 min synchronous measurements, Atmos. Meas. Tech., 12, 4309–4337, <https://doi.org/10.5194/amt-12-4309-2019>, 2019    Kazadzis, S., Kouremeti, N., Nyeki, S., Gröbner, J., and Wehrli, C.: The World Optical Depth Research and Calibration Center (WORCC) quality assurance and quality control of GAW-PFR AOD measurements, Geosci. Instrum. Method. Data Syst., 7, 39-53, <https://doi.org/10.5194/gi-7-39-2018>, 2018a.    Kazadzis, S., Kouremeti, N., Diémoz, H., Gröbner, J., Forgan, B. W., Campanelli, M., Estellés, V., Lantz, K., Michalsky, J., Carlund, T., Cuevas, E., Toledano, C., Becker, R., Nyeki, S., Kosmopoulos, P. G., Tatsiankou, V., Vuilleumier, L., Denn, F. M., Ohkawara, N., Ijima, O., Goloub, P., Raptis, P. I., Milner, M., Behrens, K., Barreto, A., Martucci, G., Hall, E., Wendell, J., Fabbri, B. E., and Wehrli, C.: Results from the Fourth WMO Filter Radiometer Comparison for aerosol optical depth measurements, Atmos. Chem. Phys., 18, 3185-3201, <https://doi.org/10.5194/acp-18-3185-2018>, 2018b.    Schutgens, N., Tsyro, S., Gryspeerdt, E., Goto, D., Weigum, N., Schulz, M., and Stier, P.: On the spatio-temporal representativeness of observations, Atmos. Chem. Phys., 17, 9761–9780, <https://doi.org/10.5194/acp-17-9761-2017>, 2017. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| The "goal stability" is give as 0.05 %/decade but either the threshold (0.02) and breakthrough values (0.01) are then too high or the goal value is too low.  Harald Flentje, Ina Mattis, Werner Thomas | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| - Note: the definition of fine/coarse mode AOD as "dust" / "non-dust" is not taking sea salt into account, which should also be part of the coarse mode AOD  - adaptation - suggested explanation: AOD can be used as proxy for PM values (in regions / periods with homogeneous vertical profile and aerosol type) -then a higher spatial resolution is needed  - extremes - suggested explanation: aerosol episodes (e.g. Sahara dust events, fire events) often cover larger areas - therefore AOD with the proposed resolution can be useful | |

### Comment 3

|  |  |
| --- | --- |
| Author:Angela Benedetti | Email: [angela.benedetti@ecmwf.int](mailto:angela.benedetti@ecmwf.int) |
| I believe the requirements on horizontal resolution are a bit too conservative. I would suggest 10km for Goal, 50km for Breakthrough and 100km for Threshold. This is particularly relevant for regional extremes. | |

## Aerosol Chemical Composition

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Aerosol Chemical Composition | | | | |
| **Definition** |  | | | | |
| **Unit** | µg m-3 | | | | |
| **Note** | For climate applications, only the main components of the aerosol composition are relevant, i.e. influencing the aerosol hygroscopic properties and refractive index. Total inorganic, Elemental Carbon (EC) and Organic Carbon (OC)  mass concentrations are, in a first approximation, sufficient.  As a proxy for the chemical composition, the absorption Ångström exponent (AAE), which describes the wavelength variation in aerosol absorption, can be used.  The AAE is significantly influenced by particle size, shape, and chemical composition | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 50 | Horizontal definition based on Anderson et al., 2003 |
| B | 100 |
| T | 500 |
| **Vertical Resolution** | km |  | G | 1 | Information on both single point AND integrated column are valuable as a threshold. More precise information can be obtained by using a profile at 5km resolution (breakthrough) or 1 km (Goal). |
| B | 5 |
| T | Column integrated or single point |
| **Temporal Resolution** | day | All averages assumed to be representative | G | 0.04 |  |
| B | 1 |
| T | 30 |
| **Timeliness** | day |  | G | 0.04 |  |
| B | 1 |  |
| T | 365 |  |
| **Required Measurement Uncertainty** | % |  | G | 10 |  |
| B | 20 |
| T | 30 |
| **Stability** | % /decade |  | G | 1 |  |
| B | 1 |
| T | 2 |
| **Standards and References** | Anderson, T. L., R. J. Charlson, D. M. Winker, J. A. Ogren, and K. Holmén, Mesoscale variations of tropospheric aerosols, J. Atmos. Sci., 60, 119– 136, 2003.  Aas, W., Mortier, A., Bowersox, V. et al. Global and regional trends of atmospheric sulfur. Sci Rep 9, 953 (2019) doi:10.1038/s41598-018-37304-0.  Putaud, J. P., Raes, F., Van Dingenen, R., Brüggemann, E., Facchini, M. C., Decesari, S., Fuzzi, S., Gehrig, R., Hüglin, C., Laj, P., Lorbeer, G., Maenhaut, W., Mihalopoulos, N., Müller, K., Querol, X., Rodriguez, S., Schneider, J., Spindler, G., Ten Brink, H., Tørseth, K., and Wiedensohler, A.: European aerosol phenomenology – 2: chemical characteristics of particulate matter at kerbside, urban, rural and background sites in Europe, Atmos. Environ., 38, 2579–2595, 2004. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| The resolution of species seems to be inadequate. The class "total inorganic" will comprise sea salt, dust and also volcanic ash" with rather different optical and chemical properties. Models can (already) do better and the climate impact of the species is also not the same.  Timeliness: A goal value of 0.04 days seems to be too ambitious.  Stability: Goal and Breakthrough values are the same (1%/decade).  Harald Flentje, Ina Mattis, Werner Thomas | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| Note: I suggest to generalize: A combination of different properties which can be measured can be used as a proxy to estimate large scale features of the chemical composition, e.g. size (from Extinction Angström exponent or Fine Mode fraction), absorption (from SSA or AAOD), absorption colour (Absorption Angström exponent), particle shape (Depolarisation). The caveat is that there are conflicting definitions of such composition types. Therefore any such estimated characterization needs to be associated with a clear definition how a certain aerosol type was characterized (which variables with which thresholds) and this should be part of the metadata in a product file. | |

### Comment 3

|  |  |
| --- | --- |
| Author:Angela Benedetti | Email: [angela.benedetti@ecmwf.int](mailto:angela.benedetti@ecmwf.int) |
| I concur with the comments already posted - this generic classification of composition is not very useful. The note seems to imply that only absorbing species are important for climate applications. In reality, it is the relative amount of absorbing versus scattering species that are relevant for the climatic impact of aerosols. I agree with Thomas' suggestions to have a combination of different properties that are measurable, instead of this generic "aerosol chemical composition". The requirements will need to be revisited depending on what proxy are used. | |

## Number of Cloud Condensation Nude

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| --- | --- | --- | --- | --- | --- |
| **Name** | Number of Cloud Condensation Nuclei | | | | |
| **Definition** | Number of aerosol particles which can activate to a cloud  droplet at a given supersaturations of water. CCN is often indicated as a percent of the total CN for specific supersaturation typical of atmospheric cloud formation. | | | | |
| **Unit** | dimensionless | | | | |
| **Note** | CCN depends on the supersaturation. Whenever provision of CCN for a range of supersaturation is not available, a typical value of 0.5% can be used as typical supersaturation under atmospheric conditions.    The CCN number concentration can be approximated by the fraction of particles larger than a given diameter from the particle number size distribution, generally the number of particles larger than 100 nm, which provide a good approximation of particles activated at « typical » supersaturation. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 50 | Horizontal definition based on Anderson et al., 2003, Sun et al., 2019 and Laj et al., submitted |
| B | 100 |
| T | 500 |
| **Vertical Resolution** | km |  | G | 1 | Information on both single point AND integrated column are valuable as a threshold. More precise information can be obtained by using a profile at 5km resolution (breakthrough) or 1 km (Goal). |
| B | 5 |
| T | Column integrated or single point |
| **Temporal Resolution** | day | All averages assumed to be representative | G | 0.5 |  |
| B | 1 |
| T | 30 |
| **Timeliness** | day |  | G | 0.04 |  |
| B | 1 |  |
| T | 365 |  |
| **Required Measurement Uncertainty** | % |  | G | 10 |  |
| B | 20 |
| T | 30 |
| **Stability** | % /decade |  | G | - | Stability difficult to evaluate as no trend in CCN are currently available |
| B | - |
| T | - |
| **Standards and References** | Anderson, T. L., R. J. Charlson, D. M. Winker, J. A. Ogren, and K. Holmén, Mesoscale variations of tropospheric aerosols, J. Atmos. Sci., 60, 119– 136, 2003.  Fanourgakis, GS, Kanakidou, M, Nenes, A, Bauer, SE, Bergman, T, Carslaw, KS,  Grini, A, Hamilton, DS, Johnson, JS, Karydis, VA, Kirkevag, A, Kodros, JK, Lohmann, U, Luo, G, Makkonen, R, Matsui, H, Neubauer, D, Pierce, JR, Schmale, J, Stier, P, Tsigaridis, K, van Noije, T, Wang, HL, Watson-Parris, D, Westervelt, DM, Yang, Y, Yoshioka, M, Daskalakis, N, Decesari, S, Gysel-Beer, M, Kalivitis, N, Liu, XH, Mahowald, NM, Myriokefalitakis, S. Schrodner, R, Sfakianaki, M, Tsimpidi, AP, Wu, MX, Yu, FQ, “Evaluation of global simulations of aerosol particle and cloud condensation nuclei number, with implications for cloud droplet formation,” Atmos. Chem. Phys., 19, 8591-8617 DOI:10.5194/acp-19-8591-2019, 2019.  Schmale, J., Henning, S., Henzing, J.S., Keskinen, H., Sellegri, K., Ovadnevaite, J., Bougiatioti, A., Kalivitis, N., Stavroulas, I., Jefferson, A., Park, M., Schlag, P., Kristensson, A., Iwamoto, Y., Aalto, P., Äijälä, M., Bukowiecki, N., Decesari, S., Ehn, M., Frank, G., Fröhlich, R., Frumau, A., Herrmann, E., Holzinger, R., Kos, G., Kulmala, M., Mihalopoulos, N., Motos, G., Nenes, A., O’Dowd, C.D., Paramonov, M., Petäjä, T., Picard, D., Poulain, L., Prévôt, A.S.H., Swietlicki, E., Pöhlker, M., Pöschl, U., Artaxo, P., Brito, J., Carbone, S., Wiedensohler, A., Ogren, J., Matsuki, A., Yum, S.S., Stratmann, F., Baltensperger, U. and Gysel, M. (2017) What do we learn from long-term cloud condensation nuclei number concentration, particle number size distribution and chemical composition at regionally representative observatories? Sci. Data 4:170003, doi: 10.1038/sdata.2017.3. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| Note: I suggest to add: where no other data are available, fine mode AOD can be used as a qualitative proxy for CCN and Dust AOD as proxy for IN (ice nuclei) | |

## Aerosol Number Size Distribution

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Aerosol Number Size Distribution | | | | |
| **Definition** | The particle number size distribution (PNSD) describes the number of particles in multiple specified size ranges. | | | | |
| **Unit** | dimensionless | | | | |
| **Note** | The PNSD can provide information about formation processes such as new particle formation, aerosol transport as well as aerosol types. PNSD can be directly measured in-situ or retrieved under some assumptions from AOD-related measurements or light extinction vertical profile measurements.    As proxy where aerosol number size distribution, the extinction (scattering) Angstrom exponent, defined as the dependence of ln(AOD) (or ln(σsp)) on ln(λ) can be used as a qualitative indicator of aerosol particle size distribution. Values around 1 indicate a particle size distribution dominated by coarse mode aerosol such as typically associated with mineral dust and sea salt. Values of about 2 indicate particle size distributions dominated by the fine aerosol mode (usually associated with anthropogenic sources and biomass burning).  The total number of particles (i.e., condensation nuclei (CN)) is the integrative of PNSD over all size ranges. It can be used to derive PNSD under some assumption.    Number of particles below 20 nm (in diameter) are highly variable due to the process of New Particle Formation and have little direct radiative impact.  Requirement for aerosol number size distribution ideally is provided for the full spectrum (15 nm- 15 μm) (defined as goal). Very important climate application can be made with knowledge of PNSD into 2 size ranges (fine and coarse), defined as Threshold). Knowledge of PNSD into  4 size ranges (ultrafine, Aitken, Accumulation and coarse) is defined as breakthrough. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 50 | Horizontal definition based on Anderson et al., 2003, Sun et al., 2019 and Laj et al., submitted |
| B | 100 |
| T | 500 |
| **Vertical Resolution** | km |  | G | 1 | Information on both single point AND integrated column are valuable as a threshold. More precise information can be obtained by using a profile at 5km resolution (breakthrough) or 1 km (Goal). |
| B | 5 |
| T | Column integrated or single point |
| **Temporal Resolution** | day | All averages assumed to be representative | G | 0.04 |  |
| B | 1 |
| T | 30 |
| **Timeliness** | day |  | G | 0.04 |  |
| B | 2 |  |
| T | 365 |  |
| **Required Measurement Uncertainty** | % |  | G | 5 |  |
| B | 10 |
| T | 20 |
| **Stability** | % /decade |  | G | 1 |  |
| B | 2 |
| T | 5 |
| **Standards and References** | Laj et al., A global analysis of climate-relevant aerosol properties retrieved from the network of GAW near-surface observatories, submitted to AMT  Anderson, T. L., R. J. Charlson, D. M. Winker, J. A. Ogren, and K. Holmén, Mesoscale variations of tropospheric aerosols, J. Atmos. Sci., 60, 119– 136, 2003.  Sun, J., W. Birmili, M. Hermann, T. Tuch, K. Weinhold, G. Spindler, A. Schladitz, S. Bastian, G. Löschau, J. Cyrys, J. Gu, H. Flentje, B. Briel, C. Asbach, H. Kaminski, L. Ries, R. Sohmer, H. Gerwig, K. Wirtz, F. Meinhardt, A. Schwerin, O. Bath, N. Ma, A. Wiedensohler, Variability of black carbon mass concentrations, sub-micrometer particle number concentrations and size distributions: results of the German Ultrafine Aerosol Network ranging from city street to High Alpine locations, Atmospheric Environment, Volume 202, 2019, Pages 256-268, ISSN 1352-2310, <https://doi.org/10.1016/j.atmosenv.2018.12.029>.  Wiedensohler, A., Birmili, W., Nowak, A., Sonntag, A., Weinhold, K., Merkel, M., Wehner, B., Tuch, T., Pfeifer, S., Fiebig, M., Fjäraa, A. M., Asmi, E., Sellegri, K., Depuy, R., Venzac, H., Villani, P., Laj, P., Aalto, P., Ogren, J. A., Swietlicki, E., Williams, P., Roldin, P., Quincey, P., Hüglin, C., Fierz-Schmidhauser, R., Gysel, M., Weingartner, E., Riccobono, F., Santos, S., Grüning, C., Faloon, K., Beddows, D., Harrison, R., Monahan, C., Jennings, S. G., O'Dowd, C. D., Marinoni, A., Horn, H.-G., Keck, L., Jiang, J., Scheckman, J., McMurry, P. H., Deng, Z., Zhao, C. S., Moerman, M., Henzing, B., de Leeuw, G., Löschau, G., and Bastian, S.: Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions, Atmos. Meas. Tech., 5, 657–685, <https://doi.org/10.5194/amt-5-657-2012>, 2012. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| The "goal timeliness" of 0.04 days seems to be rather low. One day should be acceptable. Maybe a copy/paste error from the temporal resolution above ?  Timeliness: A breakthrough value of 2 days and a threshold value of 365 days sounds unbalanced.  Harald Flentje, Ina Mattis, Werner Thomas | |

## Aerosol Single Scattering Albedo

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Aerosol Single Scattering Albedo | | | | |
| **Definition** | The Aerosol Single Scattering Albedo (ω0 or SSA) ratio of particle light scattering coefficient to the particle light extinction coefficient.  ω0 is defined as σsp/σep, or σsp/(σsp+ σap) where (σep), is the volumetric cross-section for light extinction and is commonly called the particle light extinction coefficient typically reported in units of Mm-1 (10-6 m-1). It is the sum of the particle light scattering (σsp) and particle light absorption coefficients (σap), σep = σsp + σap . All coefficients are spectrally dependent. | | | | |
| **Unit** | dimensionless | | | | |
| **Note** | Purely scattering aerosol particles (e.g., ammonium sulfate) have values of 1, while very strong absorbing aerosol particles (e.g., black carbon) may have values of around 0.3 at 550nm.  The absorption aerosol optical depth(AAOD) is fraction of AOD related to light absorption and is defined as AAOD= (1−ωo)×AOD where ωo is the column integrated single scattering albedo. Under some circumstances, AAOD at 550 nm is not as highly uncertain as SSA (in particular for low AOD) and can be used as ECV proxy for absorption. By part of the community AAOD is regarded better suited than SSA which is highly uncertain at low AOD. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 50 | Anderson et al., 2003  Laj et al., submitted) |
| B | 200 |
| T | 500 |
| **Vertical Resolution** | km |  | G | 1 | Information on both single point AND integrated column are valuable as a threshold. More precise information can be obtained by using a profile at 5km resolution (breakthrough) or 1 km (Goal). SSA is not directly measurable as integrated column or profile but can be retrieved under some assumptions. |
| B | 5 |
| T | Column Integrated/ or single point |
| **Temporal Resolution** | day |  | G | 0.01 | All averages assumed to be representative |
| B | 1 |
| T | 30 |
| **Timeliness** | day |  | G | 1 |  |
| B | 7 |  |
| T | 30 |  |
| **Required Measurement Uncertainty** | % |  | G | 2 | % on particle size  (% on total number) |
| B | 5 |
| T | 20  (10) |
| **Stability** | % /decade |  | G | 0.005 | Stability difficult to assess due to lack of clear trends observed |
| B | 2 |
| T | 5 |
| **Standards and References** | Laj et al., A global analysis of climate-relevant aerosol properties retrieved from the network of GAW near-surface observatories, submitted to AMT  Collaud Coen et al., Multidecadal trend analysis of aerosol radiative properties at a global scale, submitted to ACP  Sherman, J. P., Sheridan, P. J., Ogren, J. A., Andrews, E., Hageman, D., Schmeisser, L., Jefferson, A., and Sharma, S.: A multi-year study of lower tropospheric aerosol variability and systematic relationships from four North American regions, Atmos. Chem. Phys., 15, 12487–12517, <https://doi.org/10.5194/acp-15-12487-2015>, 2015.  Schutgens, N., Tsyro, S., Gryspeerdt, E., Goto, D., Weigum, N., Schulz, M., and Stier, P.: On the spatio-temporal representativeness of observations, Atmos. Chem. Phys., 17, 9761–9780, <https://doi.org/10.5194/acp-17-9761-2017>, 2017. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| Some doubts about the "goal stability" of 0.005%/decade, whereas breakthrough and threshold values are a lot more relaxed. Maybe a mixture of absolute and percentage values ?  Required Measurement Uncertainty: Unclear what is meant by "% on particle size" or % on total number in this context  Harald Flentje, Ina Mattis, Werner Thomas | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| The uncertainty requirement seems to be copied from particle size distributions - at least the old values from GCOS-200 should be added here as goal (absolute: 0.03) | |

### Comment 3

|  |  |
| --- | --- |
| Author:Angela Benedetti | Email: [angela.benedetti@ecmwf.int](mailto:angela.benedetti@ecmwf.int) |
| The horizontal resolution seems too coarse. I would suggest lowering the Goal to 10km, the Breakthrough to 50km and Threshold to 100km. | |

## Aerosol Layer Height

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Aerosol Layer Height | | | | |
| **Definition** | See note | | | | |
| **Unit** |  | | | | |
| **Note** | Measurements of the aerosol vertical distribution are highly valuable for radiative forcing studies, [e.g., Haywood and Boucher, 2000]. The aerosol vertical distribution can be measured by ground-based or spacebased active remote sensing techniques using LIDAR measurements through the measurement of the light extinction profile vertical profile (already an ECV product) or by simpler backscatter profiles. Identification of aerosol layer scan also be performed by in-situ measurements of aerosol properties (optical or physical) using aircrafts, drone or onboard instrumented balloons. Passive satellite remote sensing of aerosol layer height can by far not provide the same level of detail as active remote sensing but can add an important extension compared to active remote sensing in terms of spatial coverage. It is a product from a number of spaced-based instrument such as TROPOMI.  However, the definition of Aerosol Layer Height is not unambiguous and may differ depending on the technique used the retrieval. In TROPOMI the Aerosol Layer Height is defined as the mid pressure of an assumed aerosol block layer using absorption features of molecular O2 column. From a lidar perspective, the aerosol layer height is linked to the peak of extinction coefficient. Achieving agreement between retrieved aerosol height from real O2 A band measurements and Lidar measurements is challenging and depends on ad hoc assumptions.  Definition of an ECV would require unambiguous definition which at present would be best defined based on the knowledge of the vertical profile of aerosol extinction coefficient, already defined as ECV.  This is the reason why we recommend ALH to be included as a proxy for the vertical aerosol extinction profile rather than a full ECV product. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** |  |  | G |  |  |
| B |  |
| T |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |
| T |  |
| **Temporal Resolution** |  |  | G |  |  |
| B |  |
| T |  |
| **Timeliness** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** |  |  | G |  |  |
| B |  |
| T |  |
| **Stability** |  |  | G |  |  |
| B |  |
| T |  |
| **Standards and References** | Haywood, J. and Boucher, O. (2000) Estimates of the Direct and Indirect Radiative Forcing Due to Tropospheric Aerosols: A Review. Reviews of Geophysics, 38, 513-543.  <https://doi.org/10.1029/1999RG000078> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Werner Thomas | Email: [Werner.Thomas@dwd.de](mailto:Werner.Thomas@dwd.de) |
| We support the usage of this quantity only as a proxy for the aerosol extinction profile.  Some doubts about this statement here: From a lidar perspective, the aerosol layer height is linked to the peak of extinction coefficient  In most cases the peak of the extinction profile will be in the boundary layer but won't indiciate a lofted aerosol layer that is meant here.  Harald Flentje, Ina Mattis, Werner Thomas | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Popp | Email: [thomas.popp@dlr.de](mailto:thomas.popp@dlr.de) |
| Note: following should be added: Also thermal infrared spectrometers (e.g. IASI) allow to retrieve dust aerosol layer height (or even a coarse profile with 2-3 points in the troposphere). As for TROPOMI there are different definitions is use (averaged extinction profile or averaged geometric profile). | |

### Comment 3

|  |  |
| --- | --- |
| Author:Angela Benedetti | Email: [angela.benedetti@ecmwf.int](mailto:angela.benedetti@ecmwf.int) |
| The horizontal resolution seems too coarse. I would suggest lowering the Goal to 10km, the Breakthrough to 50km and Threshold to 100km. | |