ESA Aerosol_cci+ Highlights

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The ESA Climate Change Initiative project Aerosol_cci+ (2019 – 2022) focuses on the improvement of two retrieval algorithms for AOD and Fine-Mode AOD for the dual view sensor line (ATSR-2, AATSR, SLSTR-A / -B):

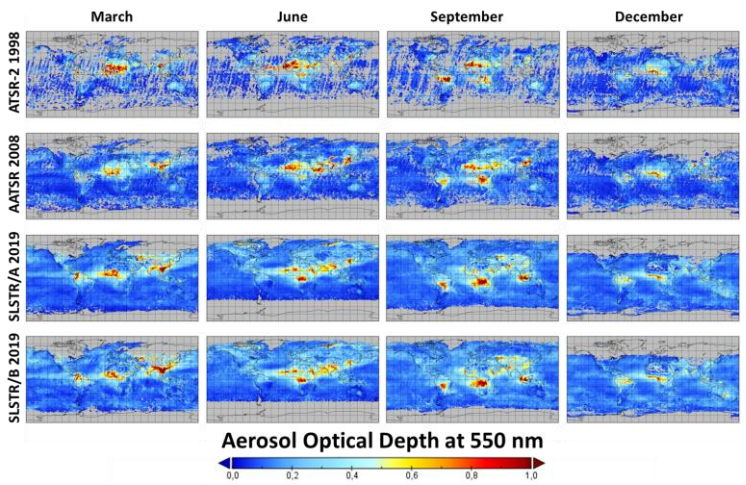
- Swansea: mature algorithm from Aerosol_cci2
- Rayference: innovative algorithm adapted from SEVIRI CISAR algorithm

Furthermore, the project will conduct two user case studies to demonstrate the value of the datasets for different applications

- MPI: climate science - aerosol modelling / radiative forcing
- ECMWF: climate services - data assimilation for reanalysis and forecasting

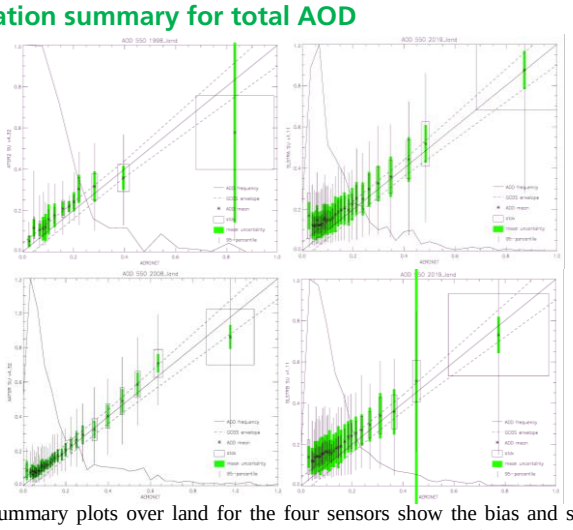
So far, Aerosol_cci+ has processed its initial test datasets (**A**) for 4 months for all four sensors with the mature algorithm and conducted a comprehensive product validation and inter-comparison which will serve as basic reference for two development cycles in the project. Furthermore, an initial user assessment was made to identify strengths and weaknesses of these datasets.

A: Initial test dataset from Aerosol_cci+ for the 4 dual view sensors



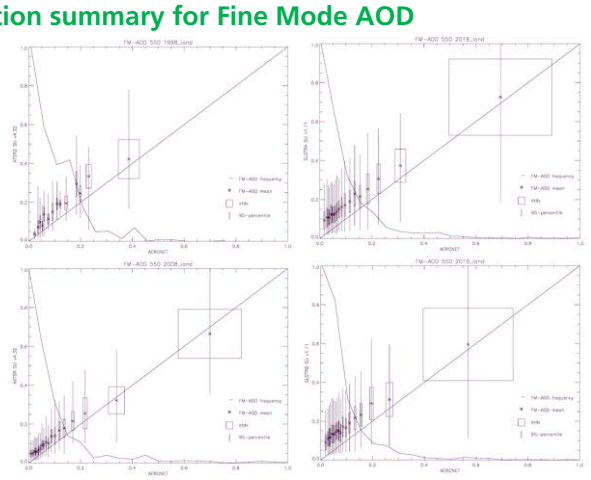
Monthly mean AOD maps for one month per season (the 4 columns) show the reduced coverage of ATSR-2 (upper line), similar dominant patterns between the years 1998 (1st line: ATSR-2), 2008 (2nd line: AATSR) and 2019 (3rd and 4th line: SLSTR onboard Sentinel-3A and -3B) and indications of year-year variabilities.

B: Validation summary for total AOD



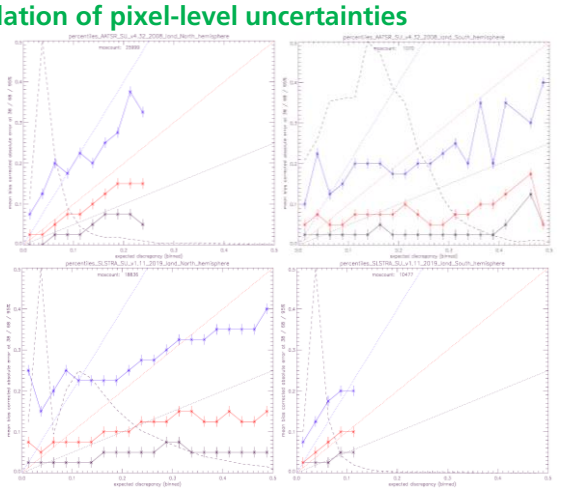
Validation summary plots over land for the four sensors show the bias and standard deviation of retrieved AOD values versus the AERONET ground-based reference as function of AOD; additionally average uncertainties per bin are indicated in green. AATSR (lower left) performs best, while for ATSR-2 (upper left) statistics are weaker due to fewer AERONET measurements in the 1990s. Both SLSTR (right) show a positive bias (especially for low AOD) and larger uncertainties.

C: Validation summary for Fine Mode AOD



Validation summary plots over land for the four sensors show the bias and standard deviation of retrieved FM-AOD values versus the AERONET ground-based reference as function of FM-AOD; a general over-estimation of Fine Mode AOD is found.

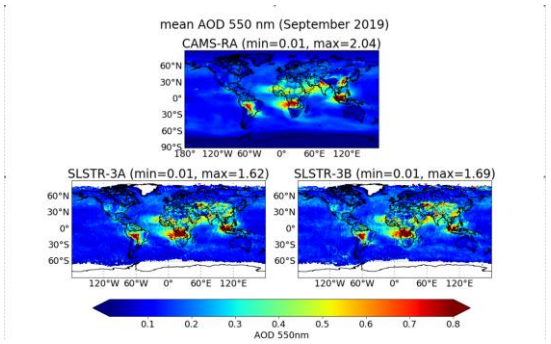
D: Validation of pixel-level uncertainties



Expected discrepancies (the squared sum of pixel-level and AERONET uncertainties) are statistically compared to best estimates of the true error against AERONET measurements after Sayer, et al., 2020. The analysis shows overall meaningful prognostic uncertainties which are useful to differentiate “good” and “bad” pixels, but also confirms differences in the uncertainty performance between the two hemispheres and the ATSR / SLSTR sensors due to observing geometry: 38% (black), 68% (red) and 95% (blue) percentiles follow the theoretical dashed lines in the figure for AATSR (SLSTR-3A) / in the Northern (Southern) hemisphere.

E: Initial user assessment

Monthly comparisons of both SLSTR datasets to the CAMS reanalysis show general good agreement, e. g. in September in the main biomass burning features in South America, Africa and Indonesia, but with larger SLSTR AOD for Central and East Asia.



Among other applications, Aerosol_cci2 data records have been used

- to tie the CAMS reanalysis to reality (Innes, et al., ACP 2019),
- in a multi-sensor merged satellite reference for modeling (Sogacheva, et al., 2020),
- to constrain stratosphere / troposphere modeling (Brühl, et al., 2018) and
- to benchmark CMIP5 models (Lauer, et al., RSE, 2017)

Validation and inter-comparison to AERONET ground-based reference and other satellite aerosol products (MODIS, MISR, POLDER) was conducted by two independent team members (DLR and FMI). This analysis covered (**B**) total Aerosol Optical Depth (AOD) and (**C**) Fine Mode AOD (FM-AOD) and specifically looked at the prognostic pixel level uncertainties in the products (**D**).

The initial user assessment (**E**) shows promising agreement to the CAMS reanalysis. Several potential applications of Aerosol_cci+ datasets were shown by the predecessor Aerosol_cci2 project.

Aerosol_cci+ continues actively contributing to the International Satellite Aerosol Science Network AEROSAT (coordination of annual meetings, implementation of selected AEROSAT community experiments, e. g. developing multi-sensor merged data records). Aerosol_cci+ took a leading role in three publications of AEROSAT and the Climate Change Initiative (**F**).

The results of algorithm development and qualification will be made available via joint partnership to the routine climate record processing in the Copernicus Climate Change Service (C3S).

F: Publications with Aerosol_cci+ leading role

Sogacheva, L., Popp, T., Sayer, A. M., Dubovik, O., Garay, M. J., Heckel, A., Hsu, N. C., Jethva, H., Kahn, R. A., Kolmonen, P., Kosmale, M., de Leeuw, G., Levy, R. C., Litvinov, P., Lyapustin, A., North, P., Torres, O., and Arola, A.: Merging regional and global aerosol optical depth records from major available satellite products, Atmos. Chem. Phys., 20, 2031–2056, https://doi.org/10.5194/acp-20-2031-2020, 2020.

Sayer, A. M., Govaerts, Y., Kolmonen, P., Lipponen, A., Luffarelli, M., Mielonen, T., Patadia, F., Popp, T., Povey, A. C., Stebel, K., and Witek, M. L.: A review and framework for the evaluation of pixel-level uncertainty estimates in satellite aerosol remote sensing, Atmospheric Measurements and Techniques, 13, 373–404, https://doi.org/10.5194/amt-13-373-2020, 2020.

Popp Thomas, Michaela I. Hegglin, Rainer Hollmann, Fabrice Ardhuin, Annett Bartsch, Ana Bastos, Victoria Bennett, Jacqueline Boutin, Michael Buchwitz, Emilio Chuvieco, Philippe Ciais, Wouter Dorigo, Darren Ghent, Richard Jones, Thomas Lavergne, Christopher Merchant, Benoit Meyssignac, Frank Paul, Shaun Quegan, Tracy Scanlon, Marc Schröder, Stefan Simis, Ulrika Willén, Consistency of satellite climate data records for Earth system monitoring, Bulletin of the American Meteorological Society, accepted for publication / online pre-release published, DOI 10.1175/BAMS-D-19-0127.1, 2020.

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