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# Validation of aerosol optical depth uncertainties within the ESA Climate Change Initiative

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Uncertainty is a vital component of any climate data record as it provides the context with which to understand the quality of the data and compare it to other measurements. Therefore, pixel-level uncertainties are provided for all aerosol products that have been developed in the framework of the Aerosol_cci project within ESA's Climate Change Initiative (CCI). Validation of these estimated uncertainties is necessary to demonstrate that they provide a useful representation of the distribution of error. We propose a technique for the statistical validation of AOD (aerosol optical depth) uncertainty by comparison to high-quality ground-based observations and present results for ATSR (Along Track Scanning Radiometer) and IASI (Infrared Atmospheric Sounding Interferometer) data records.

AOD at 0.55 $\mu$m and its uncertainty was calculated with three AOD retrieval algorithms using data from the ATSR instruments (ATSR-2 (1995-2002) and AATSR (2002-2012)). Pixel-level uncertainties were calculated through error propagation (ADV/ASV, ORAC algorithms) or parameterization of the error's dependence on the geophysical retrieval conditions (SU algorithm). Level 2 data are given as super-pixels of 10 km x 10 km.

As validation data, we use direct-sun observations of AOD from the AERONET (AErosol RObotic NETwork) and MAN (Maritime Aerosol Network) sun-photometer networks, which are substantially more accurate than satellite retrievals. Neglecting the uncertainty in AERONET observations and possible issues with their ability to represent a satellite pixel area, the error in the retrieval can be approximated by the difference between the satellite and AERONET retrievals (herein referred to as "error"). To evaluate how well the pixel-level uncertainty represents the observed distribution of error, we look at the distribution of the ratio D between the "error" and the ATSR uncertainty. If uncertainties are well represented, D should be normally distributed and 68.3% of values should fall within the range [-1, +1]. A non-zero mean of D indicates the presence of residual systematic errors. If the fraction is smaller than 68%, uncertainties are underestimated; if it is larger, uncertainties are overestimated.

For the three ATSR algorithms, we provide statistics and an evaluation at a global scale (separately for land and ocean/coastal regions), for high/low AOD regimes, and seasonal and regional statistics (e.g. Europe, N-Africa, East-Asia, N-America). We assess the long-term stability of the uncertainty estimates over the 17-year time series, and the consistency between ATSR-2 and AATSR results (during their period of overlap).

Furthermore, we exploit the possibility to adapt the uncertainty validation concept to the IASI datasets. Ten-year data records (2007-2016) of dust AOD have been generated with four algorithms using IASI observations over the greater Sahara region [80°W - 120°E, 0°N - 40°N]. For validation, the coarse mode AOD at 0.55 $\mu$m from the AERONET direct-sun spectral deconvolution algorithm (SDA) product may be used as a proxy for desert dust. The uncertainty validation results for IASI are still tentative, as larger IASI pixel sizes and the conversion of the IASI AOD values from infrared to visible wavelengths for comparison to ground-based observations introduces large uncertainties.