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Uncertainty effects caused by different/limited temporal sampling and cloud occurrence in trend estimate of cloud-free AOTs retrieved from polar-orbiting satellite observations

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Long-term accumulated records of aerosol optical thickness (AOT) retrieved from several satellite observations during the past decade are enable to estimate the global and regional trends in atmospheric aerosol in many studies. However, despite significant advances in sensor calibration and retrieval accuracy, still considerable uncertainties can cause an inevitable error in the trend estimates. Most of all, the uncertainties caused by different/limited temporal sampling and cloud occurrence have hardly been discussed in previous studies. In this study, using the resampled data from real-time AERONET Level 2.0 AOTs, it is demonstrated that the limited/different temporal sampling can result in significant errors ranging from -156.3% to +399.2% between "ideal satellite-derived trend" and "actual trend". The cloud occurrence prevents to retrieve cloud-free AOT and therefore damages the statistical representativeness of monthly means. It can bring a clear spatial division or discontinuity in the trend estimates between land and surrounding ocean areas where cloud frequently occurs. This study presents a new approach to minimize the uncertainties by use of weighted least squares regression and multiple satellite-derived AOTs from the space-born instruments (MODIS-Terra, MISR-Terra, SeaWiFS- OrbView-2, and MODIS-Aqua), and thereby provides more convincing trend estimates in atmospheric aerosols. The significant decrease in the cloud-free AOT is estimated over Western Europe (i.e. by up to about -6.59$\pm$5.30% per year from 2003 to 2008). In contrast, a statistically significant increase is observed over East China (about +5.66$\pm$4.14% per year in the same period) and it can be attributed to both the increase in industrial output and the Asian desert dust.