WP6- NA6: WP "Integration, outreach, and sustainability"
Deliverable D6.23:

Report Higher level data product: Satellite & surface data integration tool

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SUMMARY

"Higher level products" have been proposed during the AeroCom/ACTRIS workshop in Hamburg, October 2014, as a way to provide the synthesis of these for advanced use: ACTRIS Secondary Datasets are derived from primary ACTRIS data by e.g. averaging, filtering of events, interpolation of data etc. ACTRIS secondary data sets and project data tools can also include codes, algorithms and software used to generate ACTRIS primary or secondary data. The ACTRIS/AeroCom web interface for satellite and surface data provides freely accessible information where those data can be investigated together and consistently.

Passive remote sensing satellite sensors are used to quantify column integrated quantities such as aerosol optical depth, Angstroem coefficient, and more difficult absorption optical depth. This can be compared in particular to ground based measurements of column quantities, e.g. sun photometer observations (e.g. Holzer-Popp 2013; De Leeuw et al., 2013).

Active remote sensing instruments such as the CALIOP lidar may reveal the vertical structure of aerosol layers in addition to quantitative information about the aerosol amount and aerosol type (Winker et al. 2013). This is of interest to compare and explore together with ground based lidar measurements (Mona et al., 2009, Pappalardo et al 2010, Amiridis et al., 2015).

Common to all satellite derived aerosol information is the interference of water clouds, which prevent full observation of aerosol fields. Gaps occur also in night time, in hemispheric winter conditions and due to missing scanning capacity of the satellite sensors. Co-located satellite and surface site observation are therefore rather limited at times and statistical tests are needed to understand if this scarce sampling causes systematic bias or deterioration of correlation. Sampling for prolonged periods of time over several years, multi-annual and seasonal averages can serve as a more stable way to bring such data together.

Here we describe infrastructure that is developed, maintained and available using data from ACTRIS. This is accessible via the ACTRIS data portal (http://actris.nilu.no/Content/Resources/AeroCom/SurfaceSatellite/). It has two components:

a) Comparison of new and more common satellite retrieval products (ATSR, MERIS) with sun photometer data from ACTRIS/PHOTONS. The infrastructure has been used, servicing the esa-cci aerosol project, to evaluate different versions of new algorithms for aerosol retrievals from ESA satellites (http://www.esa-aerosol-cci.org). Recently a reprocessing of ten years of ATSR has been evaluated and has shown large consistency with Aeronet data.

b) Comparison of vertical profiles of aerosol extinction from CALIOP with ACTRIS lidar derived aerosol extinction profiles over Europe. The climatology from ACTRIS/EARLINET data, presented in ACTRIS deliverable D6.21, is used and compared to seasonal averaged from CALIOP.

Comparison of aerosol retrieval products with column integrated ACTRIS data

The comparison and evaluation of daily gridded satellite retrieval products using ACTRIS/AEROCOM tools is done with the nearest satellite pixel value on a 1 x 1 degree grid. The corresponding daily mean sun photometer values are used globally and regionally, excluding mountain sites. The evaluation with the ACTRIS/AEROCOM tools provides bias, histograms, scatter plots, time series graphs, zonal mean comparisons, and score tables. This analysis includes all reported pixels regardless of quality flags or confidence indicators.

To quantify performance of different versions from new satellite algorithms reference surface data sets are compiled from sun photometer data. Aerosol optical properties of high quality are provided by the ground-based sun-/sky photometer networks of AERONET, ACTRIS/AERONET-EUROPE, SKYnet and GAW (Holben, 2001). In contrast to aerosol remote sensing from space these ground based transmission measurements require no a-priori assumption of aerosol absorption or radiative background, which in consequence allows to determine consistently several aerosol optical and microphysical properties. The error e.g. in retrieved aerosol optical depth has been estimated by Dubovik et al., (2002) to be 0.01, or 10-20% for larger AOD values. Even though limited to the land based observation sites, having now access to almost a decade of sun-/sky-photometer data provides the possibility to establish solid statistics with at least one complete yearly cycle at more than 200 sites. We use total AOD at different wavelengths, fine and coarse mode AOD and the Angstroem coefficient from the direct sun observation and its retrieval from AERONET, level 2, version 3. Our reference dataset consists of daily averaged sun photometer data per parameter.

The web interface (http://actris.nilu.no/Content/Resources/AeroCom/SurfaceSatellite/) gives free access to scatter plots, histograms, scores, time series, bias visualisation on a map or as a function of latitude summarize overall skill, which can help in ranking retrieval quality. Comparisons are made for the globe and regionally e.g. for North Africa, Europe, China, India, North America. Time series of aerosol optical depth at Aeronet sites are displayed showing all available data, exhibiting thus gaps on either the satellite or surface instrument side.

Several aerosol retrieval products are accessible via the web interface from the following satellite instruments: AATSR, ATSR, MERIS, Parasol/Polder, MODIS AQUA, MODIS TERRA, MISR, CALIOP. Depending on the coverage comparisons are available from 1996 onwards to present day. Figure 1 shows an example for an ACTRIS site, Potenza, where retrievals from the ESA cci product AATSR is compared to MISR and MODIS. Higher coverage from MODIS is apparent, but all three retrievals capture the summer and autumn maximum in AOD.

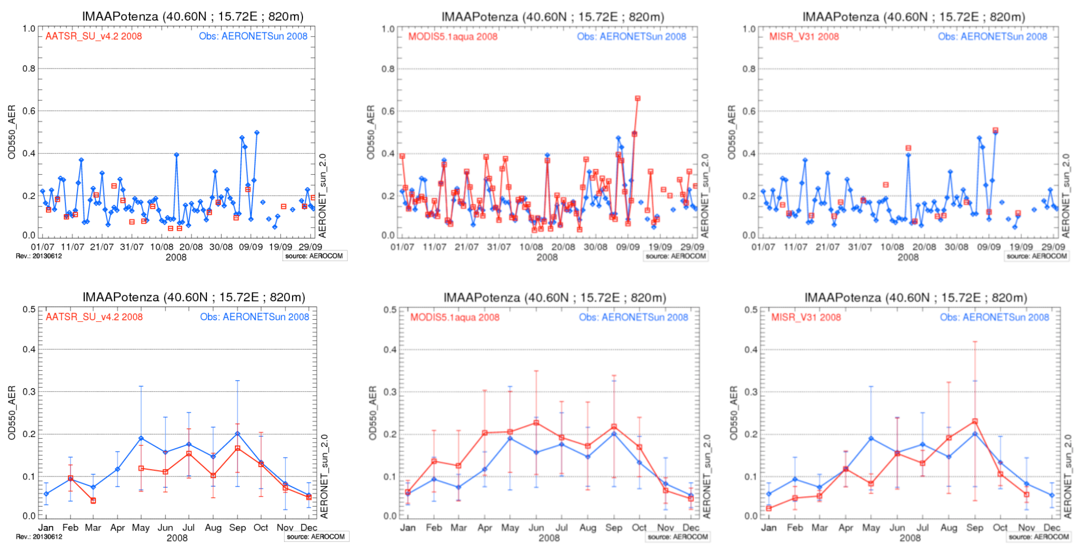

Figure 1: Time series of aerosol optical depth at Potenza, 2008. Compared are Aeronet and three satellite retrievals (AATSR, MODIS-aqua, MIRS). Above are daily AOD July-September plotted. Below are monthly means constructed from daily data.

Comparison of aerosol extinction profile from ACTRIS/Earlinet and CALIOP

For vertical aerosol profiles from satellites we use a 1x1 degree gridded version of the Koffi et al. 2012, CALIOP, aerosol product. The CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) Layer product has been used for a multi-model evaluation of the vertical distribution of aerosols. Annual and seasonal aerosol extinction profiles had been compared over 13 sub-continental regions representative of industrial, dust, and biomass burning pollution, from CALIOP 2007-2009 observations and from AeroCom (Aerosol Comparisons between Observations and Models) 2000 simulations. The mean extinction profiles derived from CALIOP layer products provide consistent regional and seasonal specificities and a low inter-annual variability.

The quality control, data workup, and climatology from ACTRIS/EARLINET data is described in ACTRIS deliverable D6.21.

The work by Koffi et al. showed that robust regional average aerosol profiles can be found from CALIOP. When CALIOP data are aggregated on a 1x1 degree level, and when then the nearest grid point is used to be compared to Earlinet, comparison becomes more difficult. The most meaningful comparison is possible for seasonal averages against the EARLINET climatology.

Figure 2 shows an example from six years of CALIOP data, summer JJA averaged, against the long term climatological summer profile of aerosol extinction at IFT/Leipzig. The compared profiles illustrate the interannual variability in data coverage from CALIOP. However, they also show, that the average aerosol extinction at 532nm in the lower troposphere is probably not systematically biased in CALIOP over central Europe. For the upper troposphere, above ca 3 km altitude, the EARLINET data show higher aerosol extinction values, which could point to a missing sensitivity of CALIOP to low aerosol extinction levels.

The developed infrastructure component allows further investigations and research to improve better understanding of aerosol dispersion in the troposphere, combining high quality ACTRIS surface with satellite data.

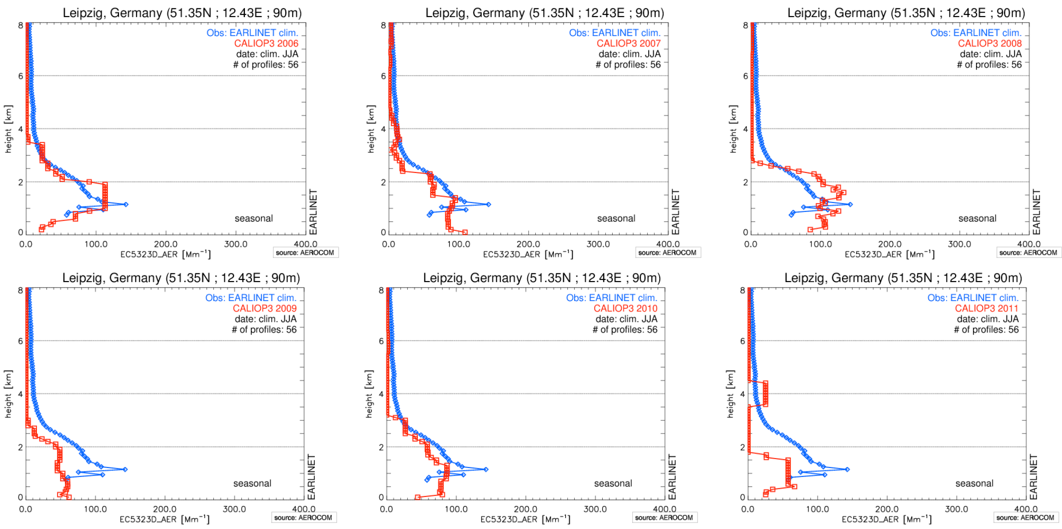

Figure 2: Mean summer profiles of aerosol extinction from 2006-2011 CALIOP near Leipzig against a climatological mean profile from EARLINET at Leipzig/IFT. Images are from the ACTRIS/AEROCOM satellite-surface web interface.

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