Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: E-COST-GRANT-CA21119-2952ce1c

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Details of the STSM

Title: Homogenization of Sun, Star and Lunar Photometer Measurements in the Arctic

Start and end date: 13/11/2023 to 18/11/2023

Description of the work carried out during the STSM

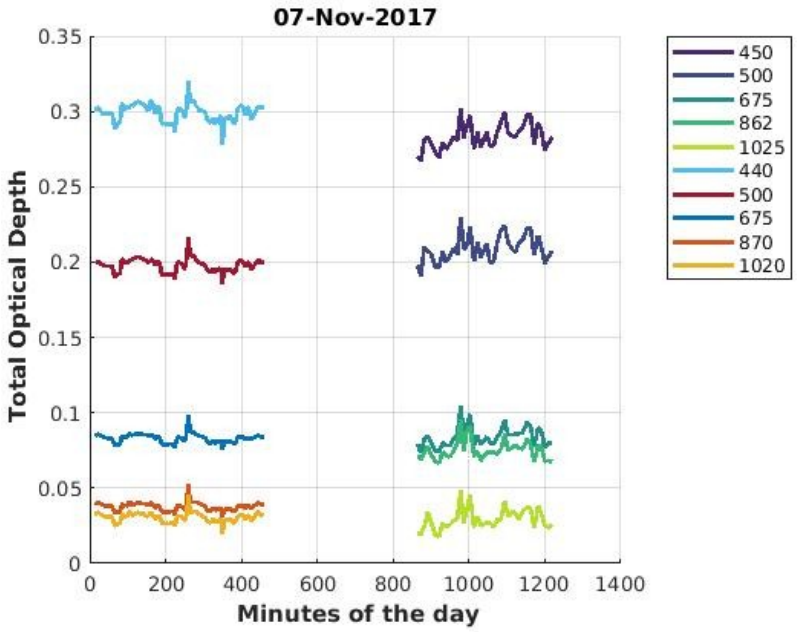
The University of Valladolid (UoV) and Alfred-Wegener-Institute (AWI) are the only two research facilities, which perform long-term aerosol observations by remote sensing on Svalbard, 79°N, at the German-French research station AWIPEV. While UoV operates a combined sun and moon photometer, AWI has two instruments from other manufacturers, one measuring the optical depth based on sunlight, the other one with stars. The aims of the STSM were:

1. A better understanding of error propagation within the validation process of the different instruments since the UoV is the European calibration center for AERONET and has a large and very variable expertise of photometer evaluation for various sights worldwide
2. A homogenized data set for sun, star and moon photometers from 2002 – 2023
3. Strategy for evaluating star photometer measurements according to AERONET standards
4. Homogenization of the validation process for a better comparison of all three instruments of both research facilities. Since sun photometry is only possible during March to September and moon photometry is limited to just a few days within a lunar cycle, the star photometer fills an important gap for the annual circle of Aerosol Optical Depth (AOD)
5. Future plans for combined AOD measurements on sight in tight cooperation between AWI and UoV
6. Introduction to GRASP, a web-based platform to invert remote sensing data for micro physical properties of aerosols. The company behind GRASP is also located at the campus of the UoV

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

Description of the STSM main achievements and planned follow-up activities

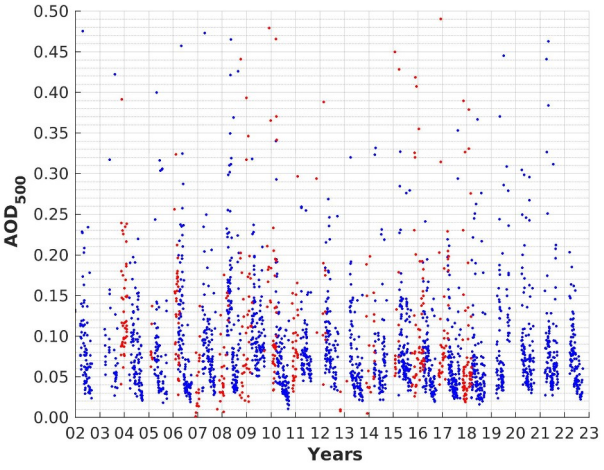
We focused most on star photometer measurement because at AWI we do not have an expert for this instrument and tried to understand the measuring results together. The instrument also has an internal data evaluation code, which was used so far by AWI as a black box. But we faced the problem, that some of the final processed data by this program didn't look good, we tried to understand the validation process and adjust it to the AERONET standard for a better comparison between instruments at that sight as well as internationally.



By using the so-called Langley-Method instead of the implemented Two-Star-Method we obtained calibration values for 2017, with which we continued the processing and following comparison. We also faced the problem, that during Two-Star-Measurements, which the instrument uses for calculating calibration values, the air mass of the lower star arches over sufficient numbers of magnitude, while the higher star barely changes its air mass throughout an hourly long measurement period. By analyzing the data without any available documentation and within intense discussions based on personal experiences we were able to interpret the data from the black box of the evaluation code and were able to reproduce these values by only using the raw signal based on counts of the spectrometer of the detector.

With Langley-Method we obtained Total Optical Depths (TOD) of the low star with a small uncertainty and high star with a significantly larger one. By forcing the TOD of the lower star to be the same for the higher one we obtained good results for the exemplary day of winter 2017 (see Figure left). The measurements in the afternoon were performed by the star photometer (green colors), while the lunar photometer was operating during the morning hours (blue and red colors) on a very clear day of the 07-Nov-2017. Since the wave-lengths do not exactly match, the result is slightly different but all in all the measurements agree very well with each other. Based on this result we will continue to evaluate the past two decades of star photometer data after applying a yearly found calibration constant to each winter.

The results of the star photometer will be combined with star photometer data (see Figure with preliminary results on the right). While the blue points represents median AOD values, which are already cloud-screend according to the AERONET algorithm with small changes regarding thresholds for sun photometer, the red points of the star photometer fill very well the gaps during polar night, even though no cloud-screening was applied to these. In future times, the star photometer data shall be also cloud-screend based on AERONET with small modifications due to different temporal



resolutions of the instruments.

The main goal for the harmonization of the data will point towards a scientific publication in a peer-reviewed journal about two decades of photometer data throughout the entire year as a part of my dissertation, which is about physical properties of Arctic aerosol. Key points will be the evolution of the Arctic Haze, a time of early spring with a high aerosol load, temporal changes of the AOD during late summer and autumn due to wild fires in the northern hemisphere. It is also planned to publish the entire harmonized data set of both photometers on a data repository, like PANGAEA (www.pangaea.de).

The stay at the University of Valladolid also increased the trust in the sun and star photometers of AWI, since very similar results were obtained, even tough the star photometer can not be transported to calibration centers, like Valladolid or Izana, Canary Islands, where usually sun photometers are calibrated and the celestial objects pass through more air mass while rising in the mornings.

Another point within the cooperation between AWI and UoV are future campaigns and the purchasing of potentially new instruments without a too large redundancy but with the possibility of increasing the knowledge of Arctic aerosols as well as learning about the possibilities of the inversion code GRASP for future data evaluations including Raman, Doppler and Micro Pulse Lidars of different wavelengths.