HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers

HARMONIA CA21119

Deliverable 5.3b

Annual review of progress/achievements towards deliverables during MC meetings

Authors Kyriakoula Papachristopoulou, Anca Nemuc, Ioannis-Panagiotis Raptis, Stelios Kazadzis

Date 30 October 2024

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

1. Introduction

It is the overall objective of the WG5 to establish mechanisms to disseminate the outcomes of the HARMONIA COST Action (CA21119) WG1-4 activities towards measurement improvement, new techniques and measurement approaches to aerosol scientists and instrument users (inside and outside the HARMONIA consortium). The main targets are:

-Present HARMONIA results to various structures dealing with aerosol measurements, including aspects of the entire processing chain; from measurement to end-user products.

-Disseminate and communicate scientific results and end user aerosol related activities towards different audiences (scientists, public, industry, government bodies).

-Exchange and combine software and hardware user tools among partners towards retrieval improvements.

-Publish scientific results of HARMONIA collaboration to peer reviewed journals, conferences, and reports.

This deliverable describes the progress, the achievements and all the networking activities towards the five deliverables of the second year of the action, based on the discussions during the MC and the corresponding WG meetings. The five deliverables of the second year of the Harmonia action come from WG1, WG2 and WG5 and are respectively:

D1.2: Report on the differences and uncertainties related to standard products provided from already existing analysis algorithms.

D2.2: List of possible improvements on the quality of solar, lunar and stellar photometry instrumentation.

D2.3: Collaborate and report on the links of metrology MAPP project results and measurement accuracy and uncertainty improvements and ML and CC use for data Harmonization.

D5.1: Share the recordings and the presentations of the training School on solar, lunar, stellar radiation-based techniques.

D5.2: Share the recordings and the presentations of the training School to aerosol measurement scientists and operators.

It was decided (MC vote) that the Deliverables D1.3, D3.1b and D4.1a of the second year are transferred to the next year, related to the activities that will take place in the third year of the action.

2. Annual review for 2nd year deliverables

2.1 Deliverable D1.2

The main objective of the WG1 is the homogenization and harmonization of global aerosol measurements and retrievals. To achieve this goal networking is a key aspect since different instruments/networks and related algorithms have to be unified. The cooperation and the knowledge exchange inside the HARMONIA and specifically inside the WG1 aims to create a scientific roadmap on worldwide homogenization of aerosol properties' measurements including calibration, standard operation, quality assurance and control procedures and post processing.

Aiming for the homogenization of aerosol retrievals, it is an important step to identify first the differences among different instruments and networks. Hence, the second deliverable of WG2 (D1.2) is:

Deliverable D1.2: "Report on the differences and uncertainties related to standard products provided from already existing analysis algorithms."

This deliverable deals with the differences between network retrieval methods, cloud screening, etc. and during the third MC meeting in Reykjavik it was presented the modified name of the deliverable, that better fulfils the Action's objectives compared to the one selected at the proposal stage (back in 2021):

Deliverable D1.2: "Differences and harmonization possibilities in AOD retrieval methods."

The first structure of the deliverable was discussed during the first WG1 meeting of the second year (online, Mar. 2024). Two axes were decided, and specifically to give an overview of differences in:

a) retrieval methods

b) and cloud screening methods

among the three main networks: GAW, SkyNet and AERONET. Regarding **retrieval methods**, the differences arise from the different post processing of the measurements, and the measurements itself. This first part will be focused on how from total optical depth the aerosol optical depth (AOD) is retrieved and how different networks deal with ozone (O_3), NO_2, Rayleigh scattering, airmass, etc., and which is the impact on the uncertainty. Regarding **cloud screening**, the overview will be on the different methods applied and the associated error and uncertainty analysis. Two possible directions were decided for this overview: 1) by performing a literature review of the subject or/and 2) work on real data the methodologies.

The working steps for analyzing real data for the task related to the retrieval methods were presented and discussed with the WG1 members:

Step 1: to ask PI of the stations having couples PFR-Cimel or Cimel-Prede or Prede-PFR, how long they have a dataset useful for comparison and if they already started a comparison study.

This information was available from the previous Action's deliverables and the shared spreadsheet with information regarding the stations for synergies (CIMEL – PFR -Prede sheet). The same information for campaigns was available at D1.1.

Step 2: At the stations where comparison is possible, directions to analyze the differences were given.

Step 3: Reprocess again the data of PFR, Cimel or Prede with a common retrieval method (same airmass formula, same Rayleigh formula and pressure value, same O3 amount, same NO2 amount) and look if the differences from the above graphics were artifacts or instrument based. The differences at this stage will be only due to measurement issues such as pointing, FOV, etc.

For the overview of differences in cloud screening methods relevant literature was proposed and WG1 leaders prompted WG1 members to contact them for their ideas. At the end of the meeting, the WG1 leaders proposed relevant STSM or VMs topics which were available at the sheet "PROJECTS" at the "know each other" shared document. The interested WG members could fill the document and apply for the grant. Finaly WG members were prompted to suggest new projects or add any information to the already mentioned projects, that finally could be part of the deliverables.

In the third MC meeting in Reykjavik (May 2024), it was presented what has already been done and which are the next steps in terms of collaborations and related grants (VM, STSM) towards D1.2. It was discussed that several grants from the first two years of the Action could contribute to the D1.2 and during the WG1 meeting in Reykjavik apart from the discussion, the WG1 members expressed their interest in grants directly related to the Action's D1.2.

The possible structure of the D1.2 was presented, including the following three main chapters:

- Comparison Prede-Cimel-PFR regarding retrieval methods
- Cloud-screening/flagging methods
- High spectral resolved AOD/ UV-AOD (Brewer and BTS)

The chapter of the comparison Prede-Cimel-PFR, starts with the section of Lindenberg (DWD/MOL-RAO) long-term (2013-2024) dataset, which is an extension to a long-term time series of the project 2 of the Sky over Berlin school. This was a study with 8 trainees involved and supervisor WG1 leader Lionel Doppler. In this project AOD datasets from the Lindenberg station were utilized from all the three instruments and the differences were analyzed between the three main aerosol photometry networks (Cimel-AERONET, PFR-GAW and Prede-SkyNet). The second section is the same comparison for SCILLA Campaign (Lindenberg 2020) that had both sun and moon photometers. Then, the comparison is extended to other stations with at least two instruments. In this section, results from the STSM of Simone Pulimeno in Valladolid are included. The last section of this chapter is the

impact of air mass, rayleigh scattering and trace gas absorption on AOD and aerosol properties retrievals in sun photometry.

The chapter of cloud screening methods applied to AOD monitoring with photometers, starts with a section which introduces the Cloud screening/flagging methods used in photometer networks (solar) of AERONET, SKYNET and GAW-PFR. Then the Schenziger and Kreuter (2021) cloud screening method (solar) and the STSM of Verena Schenzinger (Innsbruck → Davos 2023) is included. The next section is dedicated to Camera and broadband measurements algorithms for cloud flagging (solar) which is based on the results of the STSM from Claudia Frangipani (CNR Bologna → DWD Lindenberg 2024) for cloud screening at Lindenberg using Camera – Broadband radiation – Photometer instruments. In addition, a section for the Synergy of sun photometer and spectroradiometer for cloud flagging algorithms assessment (solar) is included based on the study of Masoom et al. (2024). At the end of the chapter, a section for the cloud screen at Lunar (PFR, Cimel and Prede) and Stellar photometry is included. Parts of this section are based on the STSM of Gaurav Kumar on lunar photometry and STSM of Sandra Graßl on lunar and star photometry.

Finally, the chapter of the high spectral resolved AOD / UV-AOD has two parts. At the first one the different retrieval methods of UV AOD from Brewer and BTS instruments are described. For the Brewer AOD retrieval methods among others the IOS (International Ozone Services Inc.) and the EUBREWNET (Aemet/Izana) Brewer-AOD methods are described. In addition, AOD measurements with Brewers at different measuring sites are presented. Here, it is included the study for long-term AOD retrievals with Brewers in Slovakia, based on the ITC Conference grant of Peter Hrabčák. The second part is dedicated to the high spectral AOD by giving a review of the existing methods and instruments. There are different sections for describing the methods to retrieve AOD with BTS, with EKO and with PSR and applications on different sites.

2.2 Deliverable D2.2

The objective of the WG2 is to improve aerosol measurements using solar-, lunar- and star photometry, breaking new grounds for aerosol retrieval techniques

including calibration improvement (via S.I. traceable related standardization results), hardware and software improvement actions. The exchange of knowledge and experience among manufacturers, calibration and data processing related scientists and users by establishing a network through HARMONIA, are the foundations for those improvements. The exploitation of existing measurement experimental data for different aerosol environments is one of the main sources of information for investigating and suggesting improvements of aerosol photometry measurement. The second deliverable of the WG2, provides a list of those improvements:

Deliverable D2.2: "List of possible improvements on the quality of solar, lunar and stellar photometry instrumentation."

The first ideas for the deliverable were discussed during the first meeting of WG2 of the second year (online, March 2024). As a first step was proposed to identify existing studies on instrument improvements. Then to perform research regarding the state of the art of the existing measurement systems and list of main "incompatibilities" and "compatibilities" between them, to understand the gaps in order to list possible improvements. The following systems were listed along with the available datasets and interested WG members (people to involve from "know each other" shared document):

- Stellar and lunar photometers measurements
- Aircraft and sun photometry campaigns
- Network photometers and other instruments
- Brewer and photometers
- Pandora and photometers

A repository was created and presented during the meeting to list the possible projects that could be related to a grant, where interested WG members could propose their availability and if they have other ideas. This repository is the second sheet Project proposals of the "know each other" shared document. This sheet had the title of the project proposals, the topic, the duration of the work, if this would be related with a STSM, a VM or it is only a collaboration, the WGs interested, the

deadline for the proposals, the status of the project, the proposers and the interested people. During the meeting, participants expressed their interest in different topics.

During the third MC meeting in Reykjavik (May 2024), the 18 proposed projects were presented, and it was asked by the PIs of the projects to add the status information, if it is started or not. Up then, the collaboration has started for 6 projects and after the WG meeting in Reykjavik new collaborations started. There were also WG members that select a project, and for these projects it was discussed during the WG meeting which are the needs, the different sites that were suggested for the studies, and which may be possible problems that may be encountered.

The final structure of deliverable D2.2 is based on different projects (those listed in the excel file), VMs, STSMs, papers, participations in conferences like the HARMONIA session at EMS2024, or independent analysis that the WG2 leaders considered relevant D2.2.

The first chapter addresses improvements in solar based techniques. It includes the Cimel CE318 sunphotometer, the Prede POM radiometer and a study towards the harmonization of calibration techniques and all of these are based on the results of studies presented at the HARMONIA session of EMS 2024. This chapter also covers studies applying machine learning and cloud computing methods to photometry (VM related study) and for aerosol optical depth retrievals from ground-based solar irradiance measurements. Finally, there are studies dealing with post-processing improvements.

The second chapter covers the improvements on the lunar/stellar based techniques. It starts with the current status of the stellar and lunar techniques. Then the Cimel CE318 and the Prede POM lunar models are presented based on studies presented also in EMS 2024. There is also a section presenting the evaluation of current lunar techniques in Valencia (Spain) site.

The synergies with airborne based techniques are explored in the third chapter. The current status of the airborne-based techniques is reviewed in the beginning. It follows a study investigating the use of UAV-based techniques for the improvement of vertical profiling (results of VM grant). There is also a study that explores the use

of aircraft data for the improvement of AERONET and SKYNET ground-based measurements.

In the fourth chapter, the current efforts on the validation and harmonization of lower-cost techniques (e.g. of multifilter rotating shadowband radiometer (MFRSR) AODs) with established networks. The last chapter of D2.2 details multi-instrumental analyses of long-term aerosol, clouds and radiation trends for deferent sites (in Slovakia, Italy and Spain) and from different instruments.

2.3 Deliverable D2.3

The third deliverable of the WG2 is:

Deliverable D2.3: "Collaborate and report on the links of metrology MAPP project results and measurement accuracy and uncertainty improvements and ML and CC use for data Harmonization."

During the first meeting of WG2 of the second year (online, March 2024) the work plan towards D2.3 was discussed. For the links with the MAPP project Stelios Kazadzis will contribute to this. For the second part of this deliverable two steps were proposed. As a first step, research for the state of the art to be conducted for works already available on the application of Machine Learning (ML) and Cloud Computing (CC) techniques on solar, lunar and stellar photometry. Then, to choose a dataset of at least three years from photometers and apply ML and CC for a) cloud screening, b) filling temporal gaps before long term trends and for c) aerosol classification. Iveta Steinberga expressed her interest for this second part.

Two VM grants contribute to compiling D2.3. The first one was conducted by Stelios Kazadzis and it was to report on the links of metrology (MAPP) project results and Harmonia objectives on calibration and uncertainty. The second one was conducted by Iveta Steinberga and it had to do with the second part of the deliverable related to machine learning techniques applied to photometry.

2.4 Deliverable D5.1& D5.2

The objective of the WG5 is to increase the dissemination of the produced outcomes of the WG1-4 activities of the HARMONIA COST Action, to aerosol scientists,

instrument users and other HARMONA participants inside and outside the HARMONIA consortium, towards measurement improvement, new techniques and measurement approaches, sharing of protocols etc. thus contributing to the objectives of the Action.

The MC of the CA21119 decided to organize in 2024 a training school especially designed for young researchers to better understanding the solar, lunar, stellar radiation-based techniques, along with one dedicated to aerosol measurement scientists and operators. The following deliverables of WG5:

D5.1: "Share the recordings and the presentations of the training School on solar, lunar, stellar radiation-based techniques."

D5.2: "Share the recordings and the presentations of the training School to aerosol measurement scientists and operators."

are dedicated to sharing the recordings and the presentations of these schools. The results of the training schools contribute to the main objective of HARMONIA Action:

"Establish a mechanism in order to: introduce to aerosol scientists and instrument users, the outcome of the homogenization, the SOPs and the new techniques and measurement improvements."

Two VM grants contribute to compiling D5.1 and D5.2. The first one from Anca Nemuc was for the report on the training School on solar, lunar, stellar radiation-based techniques. The second one from Kyriakoula Papachristopoulou was for the report on the training School to aerosol measurement scientists and operators. Both deliverables 5.1 and 5.2 were combined to a common document.

References

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