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

HARMONIA CA21119

Deliverable 3.1a

Outcomes of the 1st Workshop on aerosol products, with potential academic and operational agencies' users, dealing with climate effects, aerosol forecasting, air quality, renewable energy and urban environments

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1. Introduction

The first workshop of the working Group (WG) 3 of the COST action Harmonia took place in Athens, Greece on the 19th of September 2023 between 9:00 and 17:00 LT. The venue was accommodated in the historical building of the Academy of Athens (Figure 1). Eleven invited speakers gave oral presentations covering a variety of subjects related, directly or indirectly, to the aerosol optical properties ground-based remote sensing.

Figure 1. (a) The building of the Academy of Athens, Greece, (b) Group photo of the participants, (c) the meeting

2. Summary of the agenda

The agenda of the meeting is shown in Table 1.

Table 1. *Final agenda of the WG3 workshop held in Athens, Greece*

09:00 - 09:15	*Registration*
09:15 - 09:30	*Welcome and introduction to the Academy of Athens (**Christos Zerefos, Academy of Athens**)*
09:30 - 10:00	*Aerosol effects in radiative transfer as seen through the paintings of the great masters (**Christos Zerefos, Academy of Athens**)*
10:00 - 10:20	*Aerosol and Dust users experience from InDUST (**Sara Basart, WMO**)*
10:20 - 10:40	*Global aerosols and radiative effects (**Stephan Kinne, MPIMET**)*

11:10 - 11.30	*Assimilation of aerosol observations within CAMS (**Melanie Ades, ECMWF Online**)*
11:30 - 11:50	*Validation of satellite-based aerosol products (**MariLiza Koukouli, AUTH**)*
10:40 - 11.10	*Coffee Break*
11:50 - 12:10	*Aeolous and aerosols (**Vassilis Amiridis, NOA**)*
12:10 - 12:30	*Aerosol observation for the aviation sector (**Olympia Vasardani, Hellenic Civil Aviation Authority**)*
12:30 - 12:50	*Use of aerosol properties for solar energy modeling (**Philippe Blanc, Armines Paris Tech**)*
13:00 - 14:30	*Break and tour*
14:30 - 14:50	*ACTRIS aerosol RI (**Africa Barreto, AEMET**)*
14:50 - 15:10	*Aerosol observations in Brewer Network (**Alberto Redondas, AEMET**)*
15:10 - 15:30	*Dust aerosols regime across various spatiotemporal scales based on remote sensing observations (**Antonis Gkikas, Academy of Athens**)*
15.30 - 17.00	*Discussion and Conclusions*

3. Summary of the presentations and minutes

Brief description of each presentation and the minutes are provided below.

The presentations and the videos of the workshop can be found at the following links:

https://youtube.com/playlist?list=PLfpGabTFZWpWgWwetjkHNGRpDrKJHb4no&si=nV44EdojoGDbrv8x

https://harmonia-cost.eu/webinars

Presentation #1: C. Zerefos, Academy of Athens

Title: Aerosol effects in radiative transfer as seen through the paintings of the great masters

- *"Harmony is everywhere" in arts, but not only*
- *Volcanic aerosols that have affected the Earth's climate significantly in the past have been captured in art:*
    - *"Little Ice Age" in the 1750s -> can't be explained without aerosols, and actually due to very intense volcanic activity.*
    - *1816 Tambora eruption, took 2 to 3 years to "clean out" from the sky – 1816 is known as "the year without a summer".*
- *Zerefos et al. used red to green ratio in sunset paintings to "translate" to aerosol optical depth (500nm range). They identified years of eruptions and years of clean air.*
- *Plot of DVI (dust veil index) vs AOD estimated from paintings and high correlation was found!*
- *For the study, data from more than 800 paintings were used.*
- *The Tetsis experiment: a famous painter went to an island and painted the sunset during a dust event and during aerosol-free days. AOD from the paintings was well correlated to instrument observations.*
- *More information about this can be found in the relevant papers by C. Zerefos et al.*

<u>Questions</u>

M. Koukouli: Was Hunga Tonga a case of a huge eruption that affected the stratosphere?

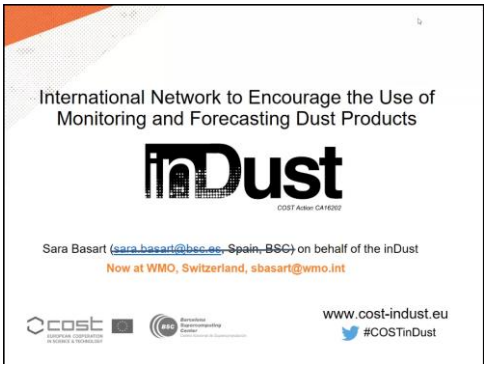
C. Zerefos: Hunga Tonga (underwater erruption) was the event of the millennium. It ejected a huge amount of fresh aerosols and sulfur directly to the stratosphere. It increased the humidity in the stratosphere, and the large amount of water vapor that is still probably there, spreading around the globe, might be responsible for the severe Antarctic ozone reduction (in spring) in the last years.

F. Marenco: Can desert dust be also observed in the paintings?

C. Zerefos: Dust does not stay so long as ash in the stratosphere, which produces these colorful sunsets; Sahara dust happens every year, associated with wind (hamseen in arab language means 50 days of danger if you live in Sahara), but these events can also produce very red sunsets; could also find info on those from paintings but it is more recurring.

Presentation #2: S. Basart, WMO

Title: Dust users experience from InDUST



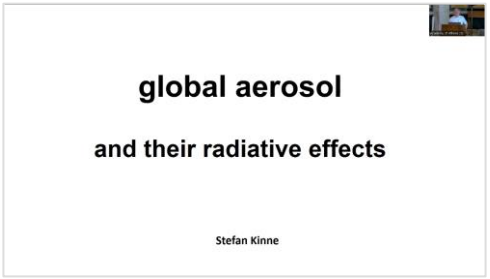
- *Showed pictures from different amazing dust events and mentions their impacts (on snow, airports, circulation, …)*
- *Brief presentation of the InDUST action (participants, goals, etc)*
- *InDust core business was user engagement – to understand their needs and propose useful solutions How? Workshops, meetings, dissemination material (not aimed at scientists only), webinars, etc.*
- *Mentioned the different community papers done.*

- *Dust catalogue with all products that are available to assess dust in the atmosphere (needs to be updated…)*
- *Policy impacts through FAIRMODE (EC), ADPIM/ESCAP, UNEP, ANCCD, WHO (AQ guidelines 2021), WMO (through SDS-WAS), UN Coalition for Combating Sand and Dust Storms*
- *Network contributed to the redesign of the website of the BSC SDS-WAS dust.aemet.es*
- *WMO GAW: Supports research enabling atmospheric composition services; framework is to identify societal needs; dust aerosols are one of them, but also wildfires, air pollution, etc.*
- *WMO GAW has gathered experts in observations, modelling, research, etc. (more than 300)*
- *GAW activities include observations, intercomparisons – need harmonized data*
- *All InDUST products can be found in the web-site.*

No questions

Presentation #3: Stefan Kinne, MPI

Title: Global aerosols and radiative effects



- *General discussion: Tropospheric aerosols, not including these last years' big events.*

- *Showed pictures of different aerosol types – We should remember that lifetime is usually a few days in the troposphere, with high variability in time and space.*
- *Optical properties answer key questions: AOD (how much they are?), AAOD (via SSA) (how absorbing they are?), AODfine (pollution, biomass) / AODcoarse (sea salt, dust) (what is their size?)*
- *Observations of these properties from photometers were combined and then expanded to monthly statistics with patterns from global modelling, to get full coverage of different aerosol types. Based on the defined aerosol types and component properties, spectral aerosol properties were also defined.*
- *To create the climatology: splitted the total AOD between big and small particles then split coarse mode in dust and sea salt, and fine mode in sulfate, organic carbon, and black carbon. Annual maps were shown, also presenting estimates of the anthropogenic component.*
- *Provided the link where the MAC climatology is available for download/presented the available products.*
- *Applications: Applied the climatology in a radiative transfer scheme to estimate aerosol radiative effects (solar and IR). Aerosols vs no aerosol simulations for the present to estimate total aerosol impact; aerosols now vs aerosols 1850 simulations to estimate the anthropogenic aerosol impact. Looked at seasonality, look at impacts of different aerosol types, impact on top-of-atmosphere, surface, thermal and solar parts of the spectrum, trends, …*
- *Aerosol radiative effects are small with respect to clouds. Indirect radiative forcing of aerosols (via cloud impact) is very small with respect to total aerosol effect.*
- *How to use photometric measurements, what properties needed? AOD and AAOD for fine and coarse mode particles from ground-based measurements. Then the measurements should be linked to satellite data and modelling! Pick regional representative sites, not mountains or ships; Provide data at satellite overpass times; Connect with satellite and modelling communities.*

Questions

V. Amiridis: Recent results show super-coarse mode aerosol particles, so AERONET should expand to IR in order to detect the impact of these coarse mode aerosols; How are you doing the typing and where do the uncertainties come from? How new techniques like active remote sensing would help to bring more information in your climatology? Do you see that?

S. Kinne: Active is very important especially for aerosols-cloud colocations for indirect effect estimate; Also, for dust altitude it is important to get it correct – need to link local measurements to global scale - global coverage by satellites. CALIPSO moves only on a track – now we have very good CALIPSO measurements. Earthcare will be very nice because different instruments are collocated (lidar, radar and photometer)

Aerosol typing uncertainty: typing was done using fine vs coarse, absorbing vs non absorbing, and some info on dust size from coarse mode absorption.

C. Zerefos: Most data was presented as climatological information for the brightening period. How does the current data compare to the period after World War II to 1980?

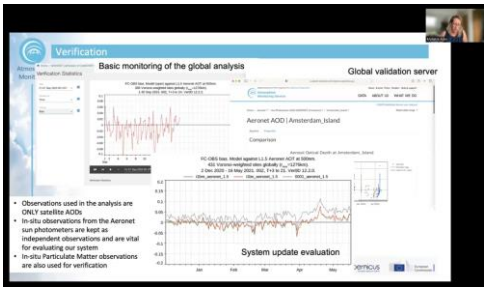
S. Kinne: Since 1980 the cooling has remained constant (direct effect) even though the aerosol increased because sulfate was reduced; Negative trends in China since 2010. Global cooling was ramping up from 1850 to 1980 and since then aerosols are generally decreasing (brightening).

C. Zerefos: I was surprised by the values over the ocean. Aerosol effects over the ocean may be underestimated?

S. Kinne: Let's discuss during the break.

Presentation #4: Melanie Ades, ECMWF

Title: Assimilation of aerosol observations within CAMS



- *Data assimilation: observation data is constraining the model, but is only at specific times / locations, often total aerosols - need to combine model and observations to get as much as possible information.*
- *When combining data and model they try to do it in optimal way (statistics sense) – minimize error and/or maximize probability of the analysis better matching observations. CAMS uses ECMWF's 4-D assimilation system – update also "first guess" based on observations, but also try to optimize the emissions.*
- *Showed equations of the data assimilation methodology – they try to minimize distance between observation and model, weighted by uncertainty in observations.*
- *Aerosols: 16 variables, different size bins for some aerosols such as sea salt and dust (3 bins each), nitrate and OC BC (2 bins)*
- *Examples and challenges in aerosol analyses: CAMS has 12 assimilation windows. Inputs to CAMS: (for aerosols) satellite total AOD + emissions from another model for fires + anthropogenic emissions from inventories. Ground based observations to verify the model prediction.*
- *Impact of using observations on the forecast (comparison with AERONET) for case study: AOD biased low without assimilation, biased high with assimilation, but 4 days forecast is highly improved.*
- *Comparison with EMEP and IMPROVE ground observations PM2.5 -> mixed result.*
- *Currently assimilating satellites: VIIRS, MODIS, PMAP, only over ocean (for all) – when differences between those it is difficult for the model to deal with it – so currently only monitoring SLSTR, not assimilating.*
- *Currently no information on altitude of aerosols. Also, currently model different aerosol parameters, but minimize total AOD with respect to observations – example if*

there was no dust in the model in a place, then the assimilation says you have to increase AOD, it will increase another aerosol type.

- *Testing dust AOD assimilation (from IASI) -> makes it better.*
- *Only satellites are assimilated. AERONET and in situ are very important for verification of the model output – many are used for monitoring – or to check updates of the model.*
- *Global reanalysis (consistent model) updated every 6 months -> can look at anomalies -> Available at atmosphere data store.*
- *Main challenges: Diversity in satellite retrievals; poor constraint on vertical structure; poor constraint on speciation*

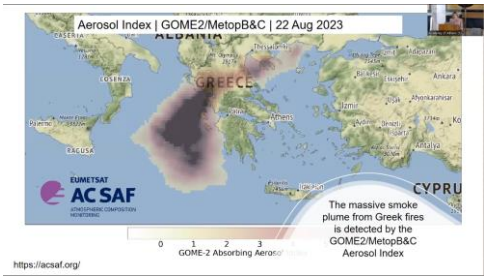
Questions

S. Solomos: What kind of measurements from photometric network would you expect?

M. Ades: If using the data for assimilation then no more data is available for independent validation; We are looking in the EARLINET network for vertical structure; main constraint is that assimilation data are needed within 3 hours from the observation. Not necessary to have data so quickly for validation. Observations not available so quickly used only for thorough validation in longer periods, e.g., for algorithm upgrades.

Presenter#5: MariLiza Koukouli, AUTH

Title: Validation of satellite-based aerosol products



- *Validation of aerosol layer height*

- *VIIRS info: 1.5 hours difference between consecutive satellite overpasses makes plumes to be "non continuous" – not so important for fires.*
- *Showed how satellites mis-identify for clouds the thickest parts (highest AOD) of aerosol plumes (example of the 2023 Greek wildfires).*
- *Polar orbiting satellites measuring aerosol load: Today data from GOME-2, and from TROPOMI, also CALIPSO (even if not working anymore), and MODIS and VIIRS.*
- *GOME-2 absorbing aerosol height (AAH) is already an operational product: first identifies aerosols through absorbing aerosol index (AAI), when that index is higher than some value, then the algorithm produces an estimate of height.*
- *TROPOMI AAH also operational (6 years), shows effective aerosol height (where extinction is stronger), single layer assumption.*
- *CALIOP: provides aerosol typing with quite significant accuracy, and vertical distribution.*
- *LIDAR is used for validation (EARLINET).*
- *Showed an example of a smoke plume over Italy, CALIOP showed two separate plumes, which were actually different aerosol types. HYSPLIT shows that the plumes come from America.*
- *Shows a second example that satellites can't distinguish between different layers.*
- *Geostationary sensors: GEMS, TEMPO*

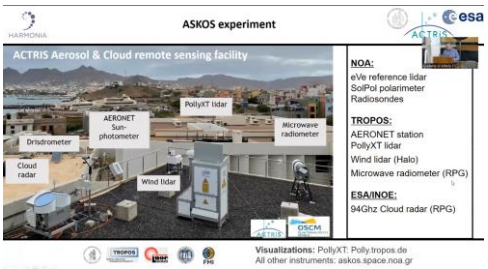
<u>*Questions*</u>

V. Amiridis: What is the added value of these ALH (because they don't come with AOD) for model assimilation for example?

M. Koukouli: Gives example of SO2 in gas eruptions, which used to be placed by defaults at 5km height, while including the height improved drastically the models; same is expected for aerosols relatively soon.

Presenter#6: Vassilis Amiridis, NOA

Title: Aeolous and aerosols



- *EU satellite missions related to vertical aerosol profiling: Present: ASKOS experiment for AEOLUS cal/val; Future: EARTHCare.*
- *Both are Earth explorers, i.e., short term missions to explore possibilities for future instruments.*
- *Aeolus is a wind mission, but as secondary product it provides aerosol and cloud product.*
- *Showed instruments in ACTRIS station in CAPO Verde, including a special lidar, the eVe polarization lidar and other instruments that were there during the ASKOS campaign.*
- *JATAC campaign cluster for Aeolus Cal/val. Aeolus dust was underestimated – Aeolus underestimates concentration for non-spherical particles – up to 40% underestimation for dust.*
- *L2A+ ESA project to try to correct for this, also use information from CAMS.*
- *Example of dust product assimilation, using LIVAS for the Godzilla episode clearly shows that the model in free run does not at all reproduce the long-range transport through south America, which is then more correct when assimilating the LIVAS data – profiles are important because that allows to have aerosol altitude correctly and model transport better. Assimilation also improves the wind fields.*
- *Also showed assimilation for the wind product.*
- *We will try to bridge multi-wavelengths gaps between different missions using LIVAS. We want to upgrade eVe system to make it compatible with EARTHCare.*

Questions

S. Solomos: Why the biggest differences in wind fields are over Africa and the Atlantic Ocean?

V. Amiridis: Most probably because these are the dust affected regions.

Presenter#7: Olympia Vasardani, NKUA/HCAAA

Title: Aerosol observations for aviation sector

- *Aviation sector users: aircraft and engine manufacturers and maintenance, airlines companies, air traffic service providers, flight crew, etc.*
- *ASA collaborates with international bodies that provide information/ has classified information in three Tiers (essential, additional, not for aviation purposes).*
- *Mostly natural aerosols related to safety and aviation hazards: volcanic ash, fire, dust – most important currently is volcanic ash because of meting point of the minerals in it (far below engine temperature) -> any observation is of very high value.*
- *The decision to fly or not after all warnings lies in the hands of the operator.*
- *No on-board detection system is able to provide information on how to avoid volcanic ash cloud: mainly because sensors are too short scaled relative to the phenomenon.*
- *Example of Etna eruption 12 March 2021 – simulation of volcanic ash dispersion was wrong because the winds were wrong – leading to issuing wrong alerts - Assimilation of AEOLUS made it better.*
- *Wildfire smoke: mainly indirect impacts on aviation.*

- *For dust: some similarities with volcanic & wildfire ash but also differences – air traffic mainly affected close to airports/ impact on the mid- to long-term aircraft engine operability.*
- *Improvements expected for dust: improve forecasts, information for diurnal variability, vertical variability, resolve properties such as particle density & composition.*
- *User's needs: Translate weather related info to thresholds & constraints. Timely forecasts and updates, accurate information near the airports.*

Questions

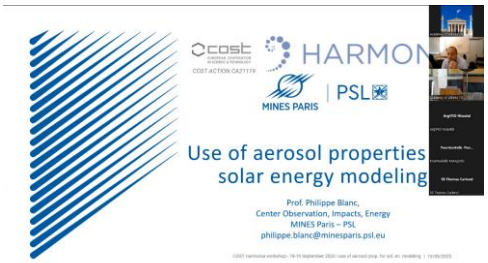
S. Basart: How forecast are used in the workflow of information in traffic management?

O. Vasardani: Actually, she is not sure. For sure there is a need for a good forecast of visibility.

S. Basart: It is there already in SDS WAS

Presenter#8: Philippe Blanc, Armines Paris Tech

Title: Use of aerosol properties for solar energy modeling



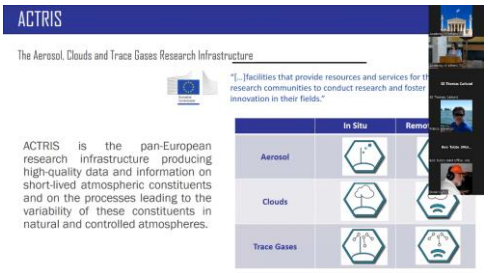
- *Heliosat 4 – based on 2 modules MCCLEAR and MCCLOUD, both based on libRadtran DISORT.*
- *Assumption of separability: all sky irradiance = clear sky (MCCLEAR) + cloud modification factor.*

- *MCCLEAR is now operational service of CAMS providing global coverage since 2004 up to day-2, surface irradiance data with various time resolutions.*
- *Comparisons of MCCLEAR irradiance with in-situ measurements in Shangai (China) much better when used CAMS aerosols than when just using aerosol climatology.*
- *Look at impact of uncertainty in AOD (CAMS) on DNI -> can be up to 20-30% in some cases (India, Indonesia, China, Sahara, …) but in most other areas it is better.*
- *MCCLEAR model to do forecast, based on CAMS forecast day +1 to day +3 -> clear improvement when integrating WV, and aerosols from CAMS.*
- *Extension of MCCLEAR to spectral from broadband. For key wavelengths line by line + Kato bands for the rest of the solar spectrum.*
- *Circumsolar radiation: DNI not well defined. Use of simple model to extend MCCLEAR to deal with this issue.*
- *Want to go from irradiance to radiance for better quantification of the irradiance at tilted surfaces – of interest for many different systems – use pre-calculated look up tables to achieve it.*
- *How do we use sun-photometric measurements? For local validation / calibration (if seems "good enough") of CAM aerosol products.*
- *Requirements relative to sun-photometric measurements: There is a need for higher spatial density in zones where it is needed (i.e., Qatar, Morocco), notably in cities (photovoltaic development).*
- *Need high resolution AERONET measurements – can use fish-eye cameras from the ground to assess aerosols.*

No questions

Presenter#9: Africa Barreto, AEMET

Title: ACTRIS aerosol Research Infrastructure



- *ACTRIS pan-European research infrastructure – more than 120 stations, EU legal entity since April 2023 (EC approved ACTRIC consortium) – means now ACTRIS program is sustainable and meant to be operating for a long time.*
- *6 topical centers incl.: aerosol in situ, aerosol remote sensing etc.; 8 central facilities, 157 variables, 144 measurement techniques*
- *National facilities: can be exploratory platforms or observational platforms. Observational Platforms are for long-term monitoring.*
- *Data Center (portal) actris.nilu.no -> access for free (non-commercial).*
- *Another portal for near real time aerosol in-situ data is EBAS (ebas.nilu.no). Data base since 1980, data since 1970.*
- *Four different data levels.*
- *ACTRIS also does training, about 30 courses during 2020-2022 with a total of more than 1500 attendees.*
- *Innovation support, collaboration with private sector.*
- *ACTRIS science conference 13-16 May 2024 in Rennes, France.*

<u>Questions</u>

S. Vandenbussche: Do you have specific needs or recommendations about sun-photometric networks or data with respect to ACTRIS point of view?

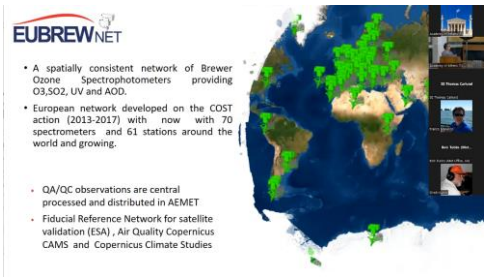
A. Barreto: ACTRIS and HARMONIA are in the "same fight" in harmonizing and so on so we should work together.

V. Spyridonov: Is there any policy for the participation of developing countries in this program? Is the platform only for observational products or does it also involve modelling?

A. Barreto: About the developing countries, as far as they belong in Europe they can participate, not yet if they are not in Europe, not a goal of the ACTRIS project; important tool for modellers, a lot of iterations, but including modelling data is not a goal of ACTRIS.

Presenter#10: Alberto Redondas, AEMET

Title: Aerosol observations in Brewer Network



- *EUBrewnet (Brewer network) – spatially consistent with the network of BREWER spectrophotometers for columnar O3 and SO2, AOD and spectral UV; was developed on a COST action 2013-2017 with now 70 spectrophotometers at 61 stations; everything is centrally processed.*
- *Submitting data to WOUDC, NDACC, EVDC.*
- *Evaluated in GAIA-CLIM, gave maturity score rather high for many things. Only low scores are in security and user-feedback.*
- *DOI: for each station, each product – changes when data is updated.*
- *Training courses for Operators.*
- *EUBrewnet supports monitoring in A5 countries.*

- *Under development: ozone uncertainty determination, new ozone and UV products.*
- *AOD in EUBrewnet: paper in ACP 2018.*
- *Examples of campains, calibration, etc.*
- *Comparison with AERONET in campaigns – comparison is good for some instruments, not for all, still trying to understand why.*
- *Example of the measured AOD during the forest fires at Izana; algorithm filter removes the high AOD values, remove the filter and you get all the values and better comparison to AERONET.*

Questions

L. Doppler: Do you use the same algorithm as IOS?

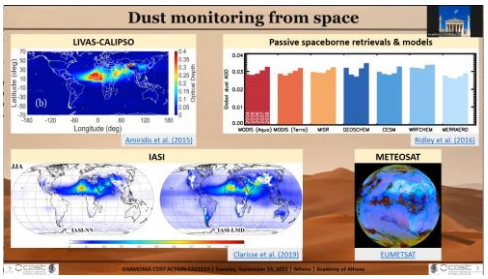
A. Redondas: No, probably not, probably similar but not common.

L. Doppler: Do you use the GW basic routine or a retrieval algorithm for the Langley plot method?

A. Redondas: It is a retrieval algorithm.

Presenter#11: Antonis Gkikas, Academy of Athens

Title: Dust aerosols regime across various spatiotemporal scales based on remote sensing observations



- *Introduction for dust transport pathways, and the role of dust in different processes.*

- *MIDAS data set: synergy of passive remote sensing and reanalysis products; MODIS-Aqua + Merra-2 daily 2003-2017 columnar dust OD at 550nm; spatial resolution 0.1°x0.1°.*
- *Starting with MODIS-Aqua AOD, use MERRA-2 and LIVAS dust fraction to retrieve dust fraction from MODIS, then final MIDAS dust product is validated against AERONET and compared to Merra-2 and LIVAS.*
- *DOD derived from AERONET: AE<0.75 (coarse particles), SSA675-SS440>0 (to discriminate dust from sea salt); Fine dust particles are ignored.*
- *Generally, very good agreement between MIDAS DOD and AEERONET DOD; Fine dust is ignored from this AERONET DOD leading to MIDAS having a small positive bias in some areas.*
- *Maximum DOD at Bodélé; Moderate to high DODs in the western Sahara, Middle East and Taklamakan Desert; Signals of transport over Tropical Atlantic and Pacific Oceans.*
- *Transport over the Atlantic is most intense in June, July, August.*
- *Much weaker dust loads over the southern hemisphere.*
- *Positive DOD trends (2003 -2017) over western Sahara; Negative DOD trends over the Bodélé depression.*
- *MIDAS was assimilated in the MONARCH model. There was an improvement in model results.*
- *Upcoming: Temporal expansion until the end of 2022; Processing MODIS-Terra retrievals; Trends in the Mediterranean; assimilation experiments.*
- *MIDAS data is available at ZENODO.*

Questions

S. Vandenbussche: Do you have specific needs or recommendations about sun-photometric networks?

A. Gkikas: *More observations for SSA to discriminate dust – sea salt.*

M. Koukouli: *Merra 2 as first step, any plan to increase spatial resolution?*

A Gkikas: *It is possible by applying downscaling, could be done.*

M. Koukouli: *Why Merra 2 and not CAMS?*

A Gkikas: *Now we are focusing on expanding the dataset, we can test in the future.*

Discussion

S. Solomos: *Important to have user requirements and to engage more people.*

S. Kazadzis: *Community needs to find out different users and identify the needs from users – remind requirements from Stefan and answers to it partly: absorption AOD not easy, not available from space; reminds from solar sector: desert dust areas most promising for solar production but also most affected by dust – distance between mirror and central point can be high and extinction in this horizontal path could be very high; inDust cost action was very important – here we try to find out users – WMO has long term effort to link modelers to observers; Harmonia has 2 parts – hardcore calibration and so on, and also the users, who do not only want AOD at 550, but many other things; Loop between users and data providers.*

M. Koukouli: *Again loop thing, including validation in there – all aspects are important – passive sensors: can't do much about spatial resolution (TROPOMI is the best) but maybe could do something about temporal mismatch (for validation) & also vertical profiles of aerosols from GB, at satellite overpass times – would like also to not have to transfer AODs 550 to 500 or the other way or any other – would like to see harmonization of wavelength.*

S. Kinne: *Confirms harmonization of wavelength is so important because assumptions are done to convert (could use a model) – 550nm would be great; was used in modelling for a long time; first important that we agree on these properties that we need and the resolution that people need – encourage to talk to modelers and satellite community (e.g., AEROCOM, AEROSAT) also says that giving data to modelers might help finding out that*

something is wrong in the data. Need to have priorities on how the data is useful, not get caught on little details – could define a few properties for which we would like to advance.

A. Redondas: Nobody uses UV AOD (Stefan: yes people do) – should we keep trying to produce UV AOD in EUBrewnet?

S. Kazadzis: Accurate UV AOD is necessary to explain trends in the UV in order of a few percent. Also to extrapolate aerosols in the UV regions where aerosol properties are very uncertain.

S. Basart: As COST action chair: need exercise to prioritize because too much on the table and takes time that we are not paid for, need to try to align with things already there such as ACTRIS, WMO; Trying to provide robust data that can be used for assessment by any type of authority; this requires integrating different data sets and quality assured data! Platform to intercompare (suggestion): aerocom (detail: WMO is advisor, facilitator, not user).

S. Kazadzis: Presentations showed some things still alive from previous COST actions (EUBrewnet and MIDAS, inDust) – reminds link with models and satellite community, mentions GRASP as separation between coarse and fine, maybe can further be applied also to TROPOMI at some point.

A. Gkikas: How to manage the different information from different instruments.

Stefan: what do you think can be done on how to manage this data? Sometimes you need models to help in comparing data)

S. Kinne: We have to have a goal for the next steps, set up a list of things to do.

S. Kazadzis: HARMONIA must also provide people less experienced some useful information – this is a different aspect of the COST action, not just talking to "the highest levels".

S. Solomos and S. Vandenbussche: Yes, such a list is being compiled, was one of the goals of this workshop – to get this started.

S. Kinne: If people are too shy to ask or propose things, then they should write it down and send an e-mail.

B. Torres: We should get initiatives to involve more ground-based measurements with modelers; Concerning involvement of satellite data to modelers, it is probably out of the scope of this action; GRASP validation usually done by EUMETSAT.

S. Basart: Modelers are using AERONET because it's the only data set accessible, clear, quality assured, documented, etc. Also, as modeller most of the work they have is to format data coming from observations to be able to use it.

M. Koukouli: Confirms – we need the "ground-based truth" – also reminds example of AI using 90% of AERONET for training and 10% for validation.

S. Solomos: Different needs from different communities, e.g., solar wants rooftop with high repeat time; other like satellite validation need more validation points (local sensors) – we need to prioritize.

S. Kinne: Any suggestion what data is needed for aerosol species – MODIS has coarse/fine mode information?

M. Ades: Angela did work on coarse and fine mode but results were not conclusive and. We should work further – MODIS coarse/fine not been used really – would not assimilate AERONET in the system; new challenges brought in by for example aerosol layer height.

S. Vandenbussche: Putting in also the TIR satellite data coming in, but no validation data available.

4. Conclusions

Based on the above discussion we tried to summarize the main suggestions recommendations of the users ground based measurements in Table 1.

Table 1. User needs

Modelers	• *Need for harmonized ground-based measurements.* • *The measurements should be linked to satellite data and modelling.*

	• *Pick regional representative sites, not mountains or ships to set up new observational sites.* • *Provide real time data at satellite overpass times.* • *Try to connect with satellite and modelling communities.* • *Need for AOD and Absorption AOD for fine and coarse mode particles from ground-based measurements.* • *Expand the measurements of the aerosol properties in the IR.* • *More observations for aerosol absorption (SSA).*
Assimilation of CAMS products	• *AERONET and in situ are very important for verification of the model output but not for assimilation. Satellite information is used for assimilation.* • *Information for the vertical aerosol profile and type is needed (can be provided from active sensors).*
Energy	• *There is a need for higher spatial density in zones where it is needed (i.e., Qatar, Morocco), notably in cities (photovoltaic development).* • *Need for high resolution measurements.* • *Involve more passive sensors, e.g., fish-eye cameras from the ground, to assess aerosols.*
Aviation	• *Accurate ground-based measurements near the airports, especially relative to dust.* • *More information for the aerosol vertical profile.* • *Main challenge is to translate measurement information to thresholds & constraints.*