AERONET Annual Review

Colleagues, your AERONET sun and sky scanning network has continued to be a valued resource for basic aerosol research, satellite validation, global and regional aerosol model validation and synergism with field campaigns, in situ and RS observations. Following is my tome on our current state, issues we are facing and plans for the future.

****Note**** Wayne Newcomb, our good friend and primary person responsible for keeping instruments functional network wide and maintaining the swapout rotation through the system among many other things, has made progress in his battle with cancer. After two weeks on life support and multiple surgeries, he's breathing on his own, talking and is annoyed that he wasn't able to vote. We're encouraged by his determination and strength. We need everyone's help to fill the void left by his absence. We especially need everyone's support to keep their equipment running in the field. Please see the proactive site manager section under '3.0 Issues'.

1.0 Introduction and News

I'm very happy to announce the third AERONET workshop and conference to be held in mid August 2009 at or near Hangzhou, China. Although the details will be forthcoming in the months ahead, the plan is for a combined technical and training forum and aerosol science conference that will emphasize surface, airborne and satellite research with several themes. Our host and organizer will be Prof. Jiang Hong of Zhejiang Forestry University and facilitated by Prof. Zhanqing Li of the University of Maryland.

There are ~450 instruments registered in the network. We have three primary types of measurements, direct sun, sky and sea surface that are taken by modifications of essentially the same instrument but result in three categories: Aerosols, aerosols plus polarization and aerosols plus water leaving radiances. This results in a complicated mixture of old plus new instruments each with their own spectral, radiometric and observational characteristics. All of these factors result in more complicated calibration, maintenance, troubleshooting, processing, archiving, web development, data distribution and verification of data and retrievals. It also means that more products are available to the community.

We've restructured the AERONET website to include access and descriptions of the normalized water leaving radiance observations called AERONET 'Ocean Color' (AERONET-OC) led by Giuseppe Zibordi, AERONET 'solar flux' observations (SolRAD-NET) with pyranometer measurements coincident with AERONET aerosol

observations the effort led by Joel Schafer and AERONET 'Maritime Aerosol', a database of Microtops handheld sunphotometer AOD observations taken on ships of opportunity and led by Alexander Smirnov. All of these databases are conveniently available thru the 'Synergy Tool' in addition to many others (including MPLNET led by Judd Welton) that are related to aerosols and have co-location with AERONET. David Giles coordinates this web-based synergy. Please see the '5.0 Related Initiatives' section for further details.

Although I often times speak for our long time collaborators PHOTONS under the 'AERONET' banner, PHOTONS (http://loaphotons.univ-lille1.fr/photons/) has their own calibration facility, website and data access enhancements. The database is identical to that available through the AERONET website thus insuring uniformity across the network. We welcome our Spanish colleagues RIMA that is now taking on a similar roll. All processing is centralized at GSFC.

2.0 Calibration

Calibration is the foundation of the program. Procedures, techniques, and algorithms are well standardized including Langley Plot calibrations, sphere calibrations, and inter-calibrations. RIMA as a full partner in the calibration process works particularly closely with PHOTONS who will manage the reference instruments calibrated at the AEMET Izana Observatory on Tenerife, Canary Islands. Thus field instruments will be calibrated at three sites, Goddard, USA, Carpentras, France in cooperation with Meteofrance and Autilla del Pino near Palencia, Spain.

It is fundamental that field instruments be calibrated annually. Please work with Goddard, PHOTONS and RIMA staff to insure that the annual schedule is met.

3.0 The Issues:

Proactive Site Managers

With ~450 instruments scattered around the world, managed by people of vastly different skill levels and interests, languages, time zones and available communication devices, we rely very heavily on those folks in the field to keep the instruments operating well. Overall this past year has shown an increase in the number of unresolved problems in field instruments owing to many factors including aging equipment, a large turnover in field personnel, increasing ratio of instruments to AERONET staff and increasing complexity of equipment. To improve the data collection we ask the following of the site managers:

> **Weekly: Check that the cimel points to the sun and that the transmitter is sending data** (for those that have transmitters). If not, try to fix it and/or contact either Alex Tran (Alex.K.Tran@nasa.gov) 301 614 6634 or Don Ho (An_Ho@ssaihq.com) for AERONET managed sites or Isabelle Jankowiak (isabelle.jankowiak@univ-lille1.fr) for PHOTONS managed sites. If we can get this to happen I estimate a large increase in useable data over the current situation. For those that are doing more than this-please keep it up.

Aging Instruments
For those who can afford it, I strongly recommend retiring instruments purchased before year 2002 and replacing them with new digital instruments.

Upgrade old instruments to digital electronics. This is much less expensive but does mean relying on old components that continue to age with little dignity.

Network growth:
There are more instruments in the network than either PHOTONS or AERONET can adequately handle with the current staffing and budgets. I recommend:

- Old instruments should be retired when possible [except at key sites and where they are still working well.]
- Non performing sites should be decommissioned.
- No new sites in N. America and Europe will be accepted without decommissioning an existing site.
- Petitions for new sites in any location must be reviewed by a Joint AERONET/PHOTONS committee. Currently this is a very informal process.

Temperature trends (Typically not a major issue):
Temperature corrections have been based on either manufacturer sensor temperature dependence curves or 10-15 year-old temperature trends measured for a limited number of instruments (average of 18 Cimels). Recent concerns with some 870 nm filters manufactured by Spectragon Inc. have shown a temperature dependence that departed from the detector dependence. These filters are being purged from the network. Given that PHOTONS and AERONET have the facilities for temperature trend analysis, all instruments are now required to have at least one spectral temperature dependence evaluation that will be done as they are returned for calibration and maintenance.

Data communication:
Approximately 50% of the problems we have with the AERONET system stem from using the Data Collection System (DCS) and the solar panel charging system. The new instruments and upgraded old instruments can automatically dump data to a PC for uploading to AERONET via the internet if the Cimel is within 50 m of the PC. This method provides exceptional data recovery however it brings new problems particularly in correctly time stamping the Cimel data. Incorrect time stamping can possibly render the data useless for research since the wrong solar zenith angles and path lengths will be computed. Also the set up for auto downloading to a PC is not straight forward and can only be used if the infrastructure is available.

Which Model instruments are recommended for AERONET?
The CE 318N-EBS9 is the preferred instrument as it has the largest spectral range (340 to 1640 nm) and with apparently all the filter issues resolved, and it performs extremely well. The second choice is the CE 318N-EMB9 that has a less expensive InGAs detector that has sensitivity over a shorter spectral range, thus 1240 nm is substituted for 1640 nm.

The SeaPRISM is a CE318 N-VBM9 with a somewhat different filter configuration with wavelengths selected for ocean chlorophyll detection. This instrument type is only deployed at over-water platforms.

Polarization Instruments:
The mono-spectral polarization measurements taken for most of the duration of the program are of suspect quality due to degradation of the plastic polarizer filters. None have been quality assured nor have we developed a procedure for that. The new mono-polarization instruments have improved stability of the polarizer due to a physical change in the position of the polarizer filters in the optical train. The applicability of these polarized data have not been demonstrated although the PHOTONS group is working in this direction. All early version mono-polarizer instruments will eventually be converted to standard aerosol instruments as we feel that having a larger spectral range is more important than a single spectral polarization.

The dual filter wheel multi-spectral polarizer instrument (318N-EDPS9) is still under development, thus is not operational. Several such instruments are included in the network on an experimental basis. Calibration procedures are not finalized, measurement protocols are not finalized, data downloading procedures are not clear and the long term fidelity of the instrument requires improvement. An announcement will be made when these issues are resolved and the instrument can be operationally included in the network. Please contact PHOTONS for specific details of current research efforts with this instrument.

4.0 Future Developments

Planned New Model Generation:
Cimel is developing a new instrument that will integrate the sensor head, control box and robot into a modular unit thus reducing the number of cables. It is planned to have GPS, air pressure, large memory and processing/programming capability. It will also be adaptable to a variety of communication sources. The instrument will be phased into operations first by developing a control box that will drive existing robots and digital sensor heads. A prototype is planned for evaluation by the end of 2009. This is an excellent development. We'll announce if and when this instrument is incorporated into AERONET.

Add on memory module:
An add on module is being developed by a vendor that will capture, store and time stamp the data as it is collected. The module will have GPS time stamping, have sufficient memory to store over a year of data. It will not interfere with the routine satellite or internet transmission of the data. This potentially will save ~15% of the data that is otherwise lost or compromised through the DCS and internet systems. Both are expected to be available by the end of the year and we hope will be affordable. This is a very important development.

Version 3:

Improvements in the measurements, processing code and potential new products dictates a version 3 release probably by the middle of 2009. We are working on the following that may be released in Ver. 3 and some as part of the enhancement of Ver. 2.

AOD:

Improved Cloud screening-

We've known for some time that the automatic cloud screening at times compromises good data particularly the relatively large uncertainty and temporal variability in the UV channels. We're currently examining some simplified approaches to implement improvements. There is a month's long assessment period to understand the nuances of any change in the resultant AODs that in turn have implication on the inversion products since AOD is an input for the processing. This becomes more complicated as some channels may be retained as level 2 and others not.

Temperature dependences-

We're beginning to develop a spectral temperature coefficient database founded on laboratory thermal measurements of the photometer to correct all channels but primarily for the Si and InGAs 1020 nm channel rather than use the manufactures published thermal response of the detectors. Some 870 nm filters have a temperature dependence that we are purging from the network.

1240 channel-

Some new instruments have a 1240 nm channel taken with an InGAs detector. Although it appears will be a very good channel, we've not yet developed the algorithms to correct for gaseous absorptions nor do we have a full suite of reference instruments to calibrate this channel. Thus this channel will, for the present, be calibrated only when the resources are available and raised to level two when all criteria are met.

Inversion products:

Principal Plane-

We're currently examining the retrievals from the principal plane (PP) measurements taken throughout the day that would close the gap between morning and afternoon almucantars. So far the early results seem promising. If that is the final analysis, the PP inversions with the standard four spectral channels will likely be released before Ver. 3.

More spectral sky channels-

The new instruments make additional spectral almucantar and PP measurements of sky radiance. These data are being inverted in different combinations to assess their value relative to the standard 4 spectral inversions. This may lead to improved inversion products.

Polarization-

Alexander Sinyuk and friends are incorporating polarization into the RT inversion code. This should improve the fine mode retrievals and the utilization of 380 nm sky radiances in retrievals.

Z. Li and team from PHOTONS are researching sky polarization measurements, both mono and multi-spectral to improve retrievals. A first short paper describing this new instrument as well as preliminary aerosol retrievals will be submitted before end 2008.

Surface Albedo-
A. Sinyuk is examining joint satellite-AERONET retrieved surface albedo as an alternative to the current Moody plus ecosystem type BRDF approach.

We are exploring the Parasol BRDF seasonal measurements as a second alternative input for the inversion.

Uncertainty estimates-
The long awaited uncertainty estimates from the almucantar inversion products will only be released with version 3 due to issues of reprocessing and incorporation of changes in the input AOD, the tao*m acceptance criteria for the higher order products that will be part of version 3 and more realistic estimates of surface albedo uncertainty. Also this needs to be reformulated for PP retrieval products.

Lidar backscatter ratio-
The lidar backscatter ratio (S) is computed from level 2 products and is expected to be available by December from the website. The depolarization ratio is an intermediary product from the inversion but has not been saved. This will be saved as a level 1.5 product beginning approximately January 2009 for analysis. Both of the above will be recomputed in V. 3 with uncertainty estimates.

5.0 Related initiatives:

SolRad-Net (http://solrad-net.gsfc.nasa.gov/) continues to expand providing broadband solar flux data from pyranometers at selected AERONET sites. Nominally these data are collected at 1 minute intervals providing a very important synergy between aerosol and ground-based solar flux observations. As with AERONET, data are contributed by our colleagues and are in the public domain. Access is similar to AERONET through the data tool on the solrad-net webpage.

Marine Aerosol Network (MAN) has matured into an ongoing oceanic aerosol optical depth monitoring network linked to AERONET calibration and using handheld Microtops sun photometers on ships of opportunity. A rather visually and technologically spectacular webpage (http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html) provides access to these data. The data are also contributed by our colleagues and are in the public domain.

Ocean Color (AERONET-OC), provides the additional capability of measuring the radiance emerging from the sea (i.e., water-leaving radiance) with modified sun-photometers installed on offshore platforms like lighthouses, oceanographic and oil towers. AERONET-OC is instrumental in satellite ocean color validation activities through standardized measurements a) performed at different sites with a single measuring system and protocol, b) calibrated with an identical reference source and method, and c) processed with the same code. These products are now level 2 quality assured.

MPLNET-Although not part of AEORNET operations or research, we are closely affiliated with this program and have made the commitment to locate an AERONET site with each MPLNET lidar. The NASA Micro-Pulse Lidar Network (MPLNET) is a federated network of Micro-Pulse Lidar (MPL) systems designed to measure aerosol and cloud vertical structure continuously, day and night, over long time periods required to contribute to climate change studies and provide ground validation for satellite sensors in the Earth Observing System (EOS) and related aerosol modeling efforts. Most MPLNET sites are co-located with AERONET sites. These joint super sites provide both column and vertically resolved aerosol and cloud data, such as: optical depth, single scatter albedo, size distribution, aerosol and cloud heights, planetary boundary layer (PBL) structure and evolution, and profiles of extinction and backscatter.

The AERONET Data Synergy Tool has continued to evolve with the incorporation of solar flux from the Solar Radiation Network (SolRad-Net) and ocean color from AERONET-Ocean Color ground-based networks. Furthermore, AQUA-MODIS, TERRA-MODIS, SeaWiFS and other satellite products available through **GIOVANNI** have been linked to the Data Synergy Tool to compliment the modeled (GOCART, backtrajectories) and observational data (Rapid response, MPLNET and NOGAPS) data.