Part 1 Questions & Answers Session

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Carl Malings (carl.a.malings@nasa.gov) or Pawan Gupta (pawan.gupta@nasa.gov).

Question 1: What is the relevance of these measurements?
Answer 1: This was discussed in the presentation, starting on Slide 55.

Question 2: Explain its working principle.
Answer 2: This was discussed in the presentation, starting on Slide 31.

Question 3: What is measured in photometry?
Answer 3: Photometry is a measure of the intensity of light at specific wavelengths. AERONET uses Sun photometers, measuring the intensity of sunlight.

Question 4: Can you please elaborate how the water vapor column densities are used to calculate AOD from direct Sun measurements?
Answer 4: The total columnar water vapor amount (Precipitable Water, PW) is retrieved from the 940 nm direct Sun measurements in AERONET data. These PW values are then utilized to estimate the water vapor absorption in the 1020 nm band in order to compute more accurate AOD at 1020 nm.

Question 5: How does the DRAGON network work?
Answer 5: They are the same instrument as any other parmental AERONET station. The only difference is their deployment period and density. Everything else is the same as AERONET.

Question 6: What is the distance between the instruments in the DRAGON campaign? I'm interested in evaluating the MAIAC products provided with resolution of 1 km and I'm working on this.
Answer 6: It varies in different deployments. It depends on scientific objectives and measurement requirements of a particular field campaign. It can be a few kilometers to

tens of kilometers. DISCOVER-AQ in 2011 in the DC area was among the densest deployments with 40+ sites.

Question 7: Dragon Network question. Is this technique used to verify satellite observation responses for image pixel resolution (sensor pixel resolution limit)? I'm assuming that the spatiotemporal resolution of the ground-based and space-based platforms are different. A mini network with spatial footprint equivalence to a sensor pixel footprint?
Answer 7: If you want to capture small scale spatial variability, especially in urban areas, it's important to use a denser network like DRAGON. This allows you to compare a satellite pixel with multiple ground-based measurements, which results in a more robust comparison than using a single site.

Question 8: Is there any campaign which looks at AOD data at a few meters spatial resolution?
Answer 8: Not that I know of.

Question 9: What is the difference between passive and active remote sensing measurements?
Answer 9: Active remote sensing uses energy emitted by the instrument itself. Passive remote sensing relies on an external source of energy, which is typically the Sun. Later in this training series we'll be hearing more about both active and passive remote sensing instruments.

Question 10: What is the region of the world that needs these sun photometers? The African Desert, the Mediterranean region?
Answer 10: Africa, the Mediterranean, and Asia have a less dense network compared to the US and Europe.

Question 11: Is such data available for Kenya? I saw a dot covering East Africa.
Question 12: How many active AERONET sites are in India presently?
Answers 11-12: You can use the sitemap to take a look at where sites are located, and the AERONET website provides a list of active sites. We will cover these more in Part 2, next week.

Question 13: Are there any constraints in establishing as many AERONET sites as we want?
Question 14: How much does the whole installation of one unit cost? Is it fully automatic assuming solar and backup power are available along with internet connection?
Answers 13-14: It requires a lot of resources to set up and maintain an AERONET station. There is the initial investment as well as a long-term commitment from the hosting agency, including requirements to regularly ship the instruments back for calibration. Because every site is different, it is hard to estimate a typical cost. If you are interested, please contact pawan.gupta@nasa.gov or the AERONET team to discuss relevant costs and requirements for establishing a new site.

Question 15: How can one apply for more AOD sites in South Africa?
Answer 15: You can reach out to pawan.gupta@nasa.gov with your request.

Question 16: Is it preferable to put these instruments on high-altitude mountains or in urban areas? Why?
Answer 16: No preference. Both are valuable measurements.

Question 17: The AERONET inversion methods for the aerosols are available for young researchers to learn?
Answer 17: Yes, all algorithms are in published articles; these are listed on the AERONET website. Some of the codes are also in the open domain; we will see some examples of those in Part 2 next week.

Question 18: Can you recommend a publication that talks about the Sun/sky measurements and the inversion algorithm?
Answer 18: This will be covered in Part 2.

Question 19: Where can we find technical information about the instruments used in the different kinds of stations?
Answer 19: The AERONET website provides information about the network and instruments. If you click on a site on the map, it will bring up specific details about the site. We will learn more about how to use the AERONET website in Part 2, next week.

Question 20: How many instruments are in a site?

Answer 20: One.

Question 21: What level of accuracy do these instruments provide in measuring atmospheric gases and aerosols?
Question 22: Are there any known uncertainties in the AERONET AOD measurement?
Answer 21-22: They don't measure gas; in Part 3 next week we will cover the Pandora instruments which do measure gases. Aerosol optical depth accuracy is on the order of 0.01 in the visible spectrum to 0.02 in the UV spectrum, depending on the wavelengths. Single Scattering Albedo (absorption) is measured to an accuracy of 0.03 for moderate to high AOD. Size distribution measurements are quite accurate, with about 0.01 micron uncertainty for fine mode particle radius.

Question 23: How is measurement accuracy ensured across different sites?
Answer 23: Measurement accuracy is ensured by the AERONET calibration program, as described in the presentation (starting on slide 37).

Question 24: How long is the calibration period?
Answer 24: 12-16 months.

Question 25: Instruments are calibrated before sending to the locations. How did they maintain calibration? Is there any drift related to the optical sensors that could happen during the 12-18-month deployment?
Answer 25: The pre-deployment and post deployment calibrations are typically interpolated in time in order to account for the drift in calibration during the entire deployment.

Question 26: What are the operational time frames for these instruments? Do they operate year-round?
Answer 26: Depending on the location, the instruments can typically operate year-round. In very high latitudes, where there is little sunlight for large portions of the year, there can be long data gaps. Snow and ice might also cover the instrument, preventing operation. Finally, there may be gaps due to the instrument being away for calibration, although sometimes a replacement instrument is sent to ensure there are no gaps.

Question 27: How are regular calibration processes managed?
Question 28: How often are the instruments calibrated and maintained? What QA/QC procedures are in place for this, and what is the required frequency for maintenance and calibration?
Answer 27-28: This is answered during the presentation (starting on slide 37).

Question 29: How do the data collected from these instruments complement satellite data?
Question 30: How important is the integration of ground-based data with satellite observations for improving the accuracy of climate models and air quality?
Answers 29-30: We will cover comparisons of AERONET and satellite data more in Part 2.

Question 31: How can I get free satellite data?
Answer 31: Visit NASA Earthdata to search for and download satellite data for free.

Question 32: What does spectral band mean? Is it just one specific wavelength or is it a range?
Answer 32: They are channels with different central wavelengths. Each channel can have bandwidth of 10-20 nm.

Question 33: Why are only 4 out of 9 spectral channels used for the sky radiance measurement?
Answer 33: We are expanding to 6 channels. It requires more time and resources to use more channels.

Question 34: Why are the two wavelengths selected (500 nm or 550 nm), because of particles' optical properties?
Question 35: Why does AERONET use 500 nm for the representation of AOT of any site? Why not other wavelengths such as 675 nm or 870 nm?
Question 36: What is the technical reason for using a wavelength of 500 nm or 550 nm?
Question 37: How do we choose the wavelength to measure? Why 500 nm or 550 nm?
Answer 34-37: One reason why the 500 nm or 550 nm wavelengths (green part of the spectrum) are commonly used is that this is a wavelength where solar energy peaks.

Because of this, it is highly relevant when assessing climate forcing. Most satellite retrieval instruments are in this wavelength. However, AERONET provides AOD in 9 spectral channels.

Question 38: While I was exploring the data of AERONET, 550 nm wavelength had to be calculated later. Why is it not included if that is the frequent representation?
Answer 38: The 550 nm AOD is not measured by AERONET, however the 440, 500, 675 and 870 nm measurements can be used to spectrally interpolate (in logarithmic coordinates) to get the 550 nm AOD value.

Question 39: How is I_0 (top-of-atmosphere solar irradiance) measured? By another satellite?
Question 40: How can we figure out the I_0 in the top of the atmosphere?
Question 41: If using TOAR from satellite data to get AOD means need to verify with AERONET level 1.0?
Answer 39-41: Using the Langley method, as applied during calibration at Mauna Loa Observatory (see slide 39). The accuracy here is on the order of 0.25%.

Question 42: What would be the standard resolution of Sun and sky measurements from the Cimel photometers (ignoring post-processing, cloud screening, etc.)?
Answer 42: Spatially, these are considered to be point measurements. The temporal resolution is 5-15 minutes.

Question 43: Is it possible for AERONET to capture data from a local aerosol source? If yes, what is the minimum distance the source should be from the instrument for accurate detection, and what is the spatial resolution (in kilometers) at which AERONET captures AOD data?
Answer 43: AERONET provides “point” measurements, looking up from the surface of the Earth at a specific location. However, over small spatial scales, aerosol concentrations are typically similar. If the emissions from a local source happen to move in between the instrument and the sun, they can impact the AOD data. This will depend on wind conditions and the strength of the source.

Question 44: What about the impact of contaminations by some emissions close to the site of the Sun photometer?

Answer 44: Yes, sometimes the instruments require cleaning.

Question 45: What is the approximate spatial representativeness of each measurement? Although the measurement can be considered a point, have any studies on the spatial homogeneity of the optical products obtained by the Sun photometers been conducted?
Answer 45: There is a published study by Jing Li et al. (2016, JGR) titled "Reducing multisensor satellite monthly mean aerosol optical depth uncertainty: 1. Objective assessment of current AERONET locations" The spatial representativeness of each aerosol site varies both geographically and also seasonally.

Question 46: While the Sun photometer observes the aerosols between the instrument and the Sun, this angle is not actually perpendicular to the surface except at noon. Does that mean that the instrument actually observes the aerosols in the surrounding area also, particularly during the morning and evening when this angle is higher? Does this create mis-representation of AOD data in geospatial terms?
Answer 46: The Sun photometer does measure the slant path transmittance (which is then normalized to the vertical for computation of AOD), therefore the measurement is not strictly a point source measurement and the spatial representation does vary diurnally as solar zenith angle changes. The height of the aerosol layer is also a factor in how large an area is represented by these measurements.

Question 47: how does the spherical shape of the planet impact the PM2.5 and measurements?
Answer 47: It's hard to say; we only measure PM2.5 on Earth and Earth is (nearly) spherical. For satellite remote sensing, we need to account for the shape of the planet to figure out the exact position of satellites, to determine where they are looking at the Earth's surface to measure AOD.

Question 48: I do health effects of PM, and recent results point to PM1 as more closely related to adverse health effects than PM2.5. Also, PM1 would be better related to scattering. Why not consider PM1 too?
Answer 48: AERONET has more sensitivity to the size of fine-mode particles in the size distribution retrievals. With AOD we have similar sensitivity to both fine and coarse mode.

Question 49: What do we do in the Polar regions to measure the AOD of the column perpendicular to the surface? I mean not directed to the Sun.
Answer 49: We have greater accuracy in the Polar regions even though the optical depths are low there; this is due to the shallow angle to the sun, and therefore there is a longer path length through the atmosphere. However, measurements will be limited to a certain time of the year only.

Question 50: Why are there two collimators of a sun photometer and not only one? What is the purpose of the second?
Answer 50: There are two separate instruments: a silicon detector covers most channels, but for the longest wavelength (1640 nm), an indium gallium arsenide (InGaAs) detector is used.

Question 51: What is the standard working schedule of AERONET? It seems like the AERONET instrument has a motor on the sensor. How does AERONET decide its pointing zenith angle and direction angle? Does the global network use the same schedule?
Answer 51: The schedule is based on solar zenith angle, which the instrument calculates from its location and thye time. AOD measurements are made every 5 minutes, and sky scans are made each hour.

Question 52: Is there software to calculate the Armstrong Parameter or is it a manual calculation?
Answer 52: AERONET provides AE as a parameter. Part 2 for more details.

Question 53: Can the Angstrom Parameter be a negative value?
Answer 53: Yes, typically when large particles are dominating. Theoretically the lowest value is -0.2, but the network rarely observes anything below -0.1.

Question 54: how do you discriminate between absorbing and non absorbing aerosols?
Question 55: What is the influence of the presence of absorbing particles on the angstrom coefficient (if any)?
Answer 54-55: We have good sensitivity to the absorption magnitude between weakly and strongly absorbing aerosols. The optical depth needs to be moderate or high

(optical depth at 440 nm greater than 0.4) for such sensitivity. Absorbing particles can have an impact on the angstrom coefficient (typically less than about 10%), but the main driver of the angstrom coefficient is the spectral difference in scattering.

Question 56: MAIAC products are provided with AE in different wavelengths, there is a direct correlation between the two AE (AERONET and MAIAC). Or better, how can I compare them for aerosol size in a temporal analysis?
Answer 56: AERONET provides the AE for multiple pairs of wavelengths. MAIAC calculates the Angstrom Exponent for the Red (646 nm) and Blue (470 nm) channels (see Lyapustin et al., 2018).

Question 57: What happens when clouds are present in the atmosphere? Are they removed by algorithms or other methods?
Answer 57: Yes, clouds are detected by cloud masking algorithms and these data are discarded for aerosol retrieval. The cloud masking uses measurements taken with a 1 minute time interval; the standard deviation of these is calculated and a threshold is applied to detect clouds passing overhead (clouds are typically highly variable in time).

Question 58: Is the direct Moon measurement also screened for the clouds in the same way as they are done for the direct Sun measurements?
Answer 58: Yes, they are screened for clouds but the algorithm and criteria are a bit different due to absence of information at night. Daytime cloud screens are more accurate than nighttime.

Question 59: Is there an average on measurement between the day and night measurements?
Answer 59: Depending on your application, it might make sense to average the day and night measurements together. However, it is important to also understand how aerosols are changing throughout the day and night, and to account for the additional difficulties in cloud screening at night, as noted above.

Question 60: Since the network uses the sunlight and moonlight, what happens to the data recorded during special events such as solar, lunar, and total eclipses? The equipment shuts down during this time automatically?

Answer 60: The AERONET measurements are made during the solar and lunar eclipses, but these data are screened and therefore removed from the L1.5 and L2 datasets.

Question 61: What are the possible sources of sulfate aerosols?
Answer 61: Fossil fuel burning, biomass burning, volcanic eruption, etc.

Question 62: Can we correlate the Cimel data with some other type of data (Mass of Collected PM, Temperature, etc.), or what other parameters can we correlate it with?
Answer 62: Depending on the science question or application, you can or cannot do this.

Question 63: Can we calculate $PM_{2.5}$ from AOD?
Answer 63: Yes, please refer to an earlier ARSET training where we discuss this in more detail.

Question 64: Which is more accurate: AOD or $PM_{2.5}$ mass concentration?
Answer 64: These are measurements of different quantities; AOD measures the amount of light absorbed and scattered by aerosols in the atmosphere, and $PM_{2.5}$ is a measurement of the mass concentration of aerosols within a certain size range (less than 2.5 micrometers aerodynamic diameter). AOD and $PM_{2.5}$ can't be directly compared, although in many cases they are correlated.

Question 65: Is there any relationship between aerosol concentration and CO_2 concentration in the atmosphere?
Answer 65: Both CO_2 and AOD are typically elevated in biomass burning plumes for short time scales. However in general the CO_2 and AOD (or aerosol concentrations) are not correlated since CO_2 has a lifetime of centuries while aerosol has a much shorter lifetime (days to months).

Question 66: Is there any different output we will get from using principal plane and almucantar? And how do they differ and what are they suitable for?
Answer 66: This will be covered in Part 2.

Question 67: What is the spatial resolution of retrieved BRDF parameters? Which kind of products are provided?
Answer 67: No BRDF products are provided by AERONET.

Question 68: How do aerosols change in response to varying atmospheric conditions?
Answer 68: Changes of aerosols in response to atmospheric conditions are complex; in Part 1 of this prior ARSET training on air quality forecasting, we discuss some of the factors which impact aerosols.

Question 69: What do you say about the AOD data between the Forest and Saharan sites?
Answer 69: The AOD at Saharan sites is typically high and dominated by airborne mineral dust which are coarse (large) size particles, while the AOD at forested region sites (Amazon and Northern boreal forest) are often low except for episodic high levels that occur during forest fires which produce fine (small) size particles.

Question 70: Any site regarding AERONET OC?
Answer 70: Here is the website for AERONET-OC.