Part 2 Question & Answer Session A

Please type your questions in the Slido/Question & Answer Box. We will try our best to get to all your questions. If we don't, feel free to email Caterina Mogno (caterina.mogno@nasa.gov) or Amy Huff (amy.huff@noaa.gov). This document will be shared to the training webpage within one week.

1. **Can you clarify the time of the RGB composite of TEMPO? As I understand it is not a single picture coast-to-coast but rather a composite of successive scans.**
   The TEMPO true color RGB composite images are generated from TEMPO L1b RAD granules. That means the RGB granule observation times are identical to the TEMPO L2 granule observation times (e.g., TEMPO L2 NO2, AODALH, ADP granules). As explained in Part 1 of the training, each full TEMPO scan is divided into granules, and it takes approximately 1 hour for a full TEMPO scan (each granule takes 6-7 minutes). Typically, there are 9 granules in a full TEMPO scan, but it varies by time of day and TEMPO operations. On AerosolWatch, we plot all of the available granules in each TEMPO scan. The time indicated on AerosolWatch changes when a new TEMPO scan begins.

2. **Question: How does aerosol layer height help determine whether smoke is reaching the ground or remaining higher in the atmosphere?**
   TEMPO ALH of 0-2 km indicates that the aerosol layer is likely within the boundary layer, while an ALH >3 km indicates that the aerosol layer is probably above the boundary layer. An ALH of ~2-3 km means the aerosols may be in the boundary layer. These are approximate values, so we recommend looking at the AirNow surface PM2.5 monitors as well, since they are definitive measurements of whether smoke (or dust) is reaching the ground.

3. **Question: Is Aerosol Layer Height (ALH) computed as the mid-point altitude between the top and bottom of the aerosol plume?**
   TEMPO ALH is the height at which the aerosol extinction (from scattering and absorption of 550 nm light) is a maximum; this is not necessarily the middle of the plume.

4. **Question: How can TEMPO, GOES-R/ABI, and GEMS observations complement one another to improve aerosol monitoring?**
   The section on "TEMPO Aerosol Products" in Part 1 of the training explains how TEMPO and ABI observations complement each other to enhance aerosol monitoring. GEMS observations cover Asia so there is no overlap in terms of spatial coverage but the combination of TEMPO, ABI and GEMS aerosol observations can help provide more spatial coverage globally.

5. **Question: Between geostationary instruments like GOES-R/ABI and TEMPO, and polar-orbiting products like MAIAC and TROPOMI, which one is considered the best primary tool for detecting and tracking dust storms?**
   The best sensor or sensors depends on the spatial extent of the dust storm. For detecting and tracking dust storms, the strength of TEMPO and ABI is their high temporal resolution (more frequent observations). The VIIRS instrument on the NOAA-20 and NOAA-21 polar-orbiting satellites also measures Smoke/Dust Mask, so it is possible to detect and track dust storms with polar-orbiting satellites. But the polar-orbiting satellites only make 1-2 observations per day at low and mid-latitudes, making it challenging to track dust storms that occur on a sub-daily timescale. The TEMPO and ABI AOD products can provide additional insight, and MAIAC provides high-quality AOD which can be used for tracking AOD within dust storms.

6. **Question: Do polar orbiting satellites have greater overlap closer to the north pole, so maybe MODIS could be used to get a better view of very high latitudes with closer to hourly time resolution?**
   Yes, that's correct. LEO polar-orbiting satellites typically complete an orbit in about 90 minutes, so at very high latitudes you can get multiple overpasses per day. VIIRS imagery from the NOAA-20 and -21 polar-orbiting satellites is available on AerosolWatch for northern Canada and Alaska.

7. **TEMPO and the AerosolWatch GOES-West view don't cover Hawai‘i. For smoke monitoring in Hawai‘i (e.g., the 2023 Maui fires), what's the best option: GOES-18 ABI Full Disk AOD/ADP from NODD, VIIRS from NOAA-20/21, or something else? Are there plans to add a Hawai‘i/Pacific domain to AerosolWatch?**
   The smoke plumes from the 2023 Maui fires were not well retrieved by ABI or VIIRS, unfortunately. The plumes were geographically small and there were a lot

of clouds present that interfered with the aerosol retrievals. In general, however, you could try GOES-West (GOES-18) ABI GeoColor, AOD, and ADP Smoke/Dust Mask, and NOAA-20 & -21 VIIRS true color RGB, AOD, and ADP Smoke/Dust Mask. The VIIRS products have higher spatial resolution (750 m at nadir) but only 1-2 observations per day for Hawai'i, while the ABI products have lower spatial resolution (2 km at nadir) but observations every 5-10 minutes, depending on the product and whether you use the ABI Full Disk or CONUS sector products.

8. **Question: Since TEMPO and GOES-R ABI provide complementary information about smoke and dust, how can we reliably determine whether an aerosol plume is actually affecting ground-level air quality when satellite-estimated PM2.5, ground-based AirNow observations, and aerosol layer height products show different results?**
   Ground-based AirNow monitor observations are the definitive determination of whether an aerosol plume is affecting ground-level concentrations. However, near real-time AirNow PM2.5 data can contain outliers or spuriously high concentration measurements that are removed later during quality control. Usually these anomalously high observations are easy to identify, since true color imagery or AOD will indicate the absence of smoke or dust plumes.

   TEMPO estimated PM2.5 uses the ground-based AirNow PM2.5 observations in the GWR model, so at locations where the monitors are, the AirNow and satellite-estimated PM2.5 will be the same. The TEMPO estimated PM2.5 product also incorporates TEMPO ALH, so you should expect similar patterns in ALH and hourly estimated PM2.5.

9. **Question: If two locations have the same Aerosol Optical Depth (AOD), could their surface PM2.5 concentrations still be very different? What role does aerosol height play?**
   Because AOD is a vertical column measurement, it does not convey any information about the altitude where aerosols are located. So yes, two locations could have the same AOD value, but different surface PM2.5 concentrations. A reasonable approximation is if TEMPO ALH is >3 km, the aerosol layer is likely lofted above the boundary layer and is not impacting surface PM2.5. In contrast, if TEMPO ALH is ≤2 km, aerosols are probably in the boundary layer and therefore may be impacting surface PM2.5.

The composition of the aerosols also plays a role in their optical properties (like AOD). There is a ARSET training "Estimating Surface PM2.5 Using Satellite Data and Other Information Sources" which covers the relationship between PM2.5 and AOD in more detail (in Part 1 of that training).

10. **Why on estimated hourly PM2.5 were there some gaps with no data even on places that AirNow points were available?**
    Estimated PM2.5 is derived from ABI and TEMPO AOD retrievals. If there is no AOD retrieved for a certain location, then PM2.5 cannot be estimated. The most common reason why AOD is not retrieved is because of cloud cover.

11. **Question: Can hourly TEMPO and GOES-R ABI observations help us anticipate where a smoke plume will travel next, or are additional meteorological data necessary?**
    You may be able to anticipate where a smoke plume will travel by watching it move over time (GOES-R ABI, with its higher temporal resolution, is usually best for this) and extrapolating where it might go next. Meteorological data can also be helpful here, though.

    AerosolWatch has a trajectories feature that uses NAM (North American Model) numerical weather prediction model output to predict the 3-dimensional forward movement of areas of high AOD 48 hours into the future in 3-hour increments.

12. **Question: During an intense dust storm, why might satellites fail to retrieve aerosol information precisely where the dust is thickest?**
    The TEMPO aerosol algorithms use the ABI Cloud Mask Level 2 product to identify clouds. Clouds are an unfavorable condition for aerosol retrievals, meaning where there are clouds, we can't retrieve AOD, ALH, or Smoke/Dust Mask. The Cloud Mask can misidentify thick aerosols, like smoke or dust, as a cloud. Therefore, aerosol retrievals aren't even attempted, because the algorithm is being "told" by the Cloud Mask that those pixels correspond to clouds. This is a very tricky, well-known problem for all satellite aerosol algorithms, and lots of research is being done to find a good solution.

13. **Question: In the slides, it is highlighted that the TEMPO AOD algorithm utilizes the smoke/dust mask to select the correct aerosol model and**

achieve more accurate AOD retrievals. From a physical-optical perspective, how does the algorithm handle ambiguity in model selection during mixed transport events (e.g., wildfire smoke overlapping with windblown dust), and what are the main uncertainties this introduces into the final AOD product? How would the data be interpreted if there were simultaneous smoke and dust events?

The TEMPO Smoke/Dust Mask currently does not have the capability to identify mixed plumes, or aerosol types other than smoke and dust. The algorithm only retrieves smoke or dust for a given pixel, not a mixture of types. This binary aerosol type detection carries over to the AOD algorithm. If the Smoke/Dust Mask classifies the aerosol as smoke, the AOD retrieval uses the smoke model, and vice versa. In the situation of mixed smoke and dust plumes, the AOD uncertainty arises mainly from the uncertainty in the aerosol model selection, i.e., there is no single correct aerosol model.

14. **What are the main limitations when tracking fast-moving dust storms using GOES-R ABI, and how does TEMPO's hourly temporal resolution help overcome them?**

    In Part 1, the strengths and limitations for each product from TEMPO and ABI were highlighted. TEMPO's hourly resolution does not help "overcome" the limitations of ABI, because ABI aerosol products have higher temporal resolution (5-10 minutes for ABI vs 1 hour for TEMPO). Dust RGB imagery is available from ABI but not TEMPO, which is a major advantage because Dust RGB is available day and night and can be used to track dust storms that continue after sunset or start before sunrise. In addition, the Dust Mask from ABI is more accurate over water. The strengths of TEMPO for monitoring dust storms come from TEMPO's UV observations, which enhance AOD (more accurate retrievals of dust) and the Dust Mask (retrieves the relative intensity of dust - thick vs thin). We recommend using all the available products for dust monitoring from both TEMPO and ABI for your area of interest.

15. **Can the PM2.5 estimates provided by AerosolWatch be considered suitable for epidemiological applications, beyond alerting purposes? If so, what are the sensitivity, precision, accuracy, and detection limits of the PM2.5 mass concentration surface estimates and how do they compare with reference ground-monitoring networks?**

A full description of the hourly estimated TEMPO PM2.5 algorithm, including the validation process and results, is given in the paper by Zhang et al.

In addition, an ARSET training covering the theoretical approaches and key datasets to estimate historical PM2.5 from AOD is also available: 'Estimating Surface PM2.5 Using Satellite Data and Other Information Sources'

16. **Question: Why is ABI not as good as TEMPO for detecting dust?**
This was explained in Part 1 of the training. The TEMPO AOD algorithm inputs the TEMPO Smoke/Dust Mask and uses it to select the appropriate aerosol model, which in turn leads to more accurate AOD retrievals of dust compared to ABI AOD, which uses a different method to select the aerosol model in its algorithm.

17. **Question: Is the ABI dust mask based on the DUST RGB retrieval?**
No.

18. **Question: Are the daily and hourly "Satellite PM2.5" under "Surface PM2.5" really surface layer PM2.5? Is there an ATBD for these estimates?**
Yes, they are really surface layer PM2.5 concentration estimates. We have written an ATBD, and it will be released at the same time the TEMPO aerosol products become operational, expected in Spring 2027. In the interim, the paper by Zhang et al. about the TEMPO and ABI PM2.5 algorithm may answer your questions.

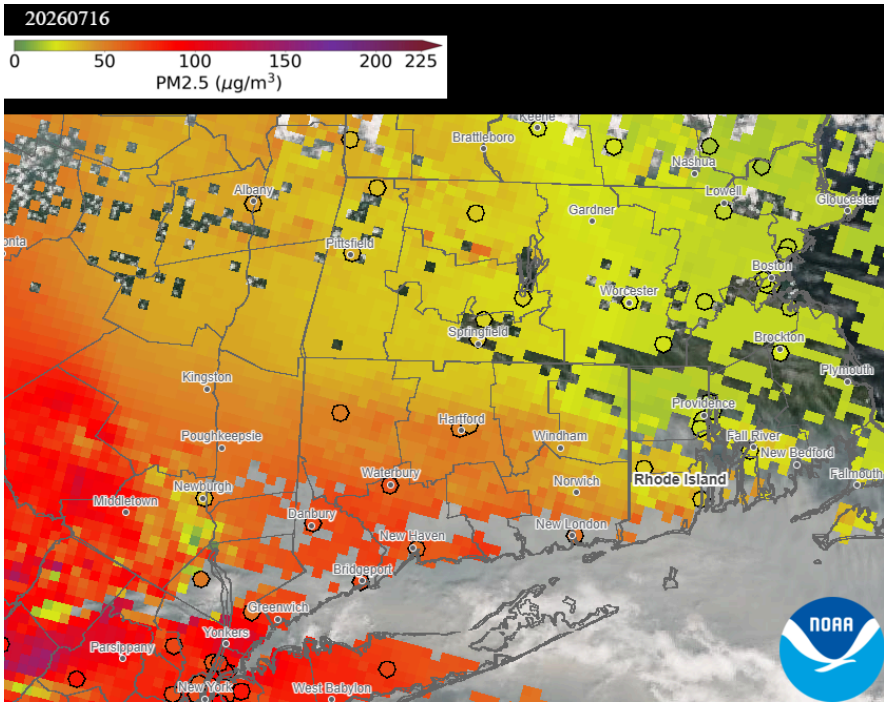
19. **Question: Smoke can remain aloft in one region but reach the surface further downwind. What atmospheric processes cause aerosols to descend and begin affecting surface air quality?**
The main processes that cause aerosol to degrade air quality involve downward vertical transport (such as large-scale subsidence) and boundary layer (PBL) dynamics. Daytime entrainment mixes aloft smoke to the surface, where a shallow nocturnal PBL traps the pollutants closer to the surface. Gravitational settling is not really important for smoke, which is mostly made of small and light particles. However, for larger and heavier particles like dust, gravity actively pulls them down from aloft to the surface, worsening surface air quality (especially PM10) before the particles eventually settle on the ground.

20. **Question: Is aerosol indirect or direct?**
    Aerosol Optical Depth is a remotely-sensed measurement of the optical abundance of aerosols in the atmospheric column. In this sense, it is an "indirect" measurement of the abundance of aerosols in the atmosphere, compared to a ground-based air quality monitor, which would be a "direct" measurement of aerosol concentration at a specific location.

    You may be interested in our new course, Fundamentals of Remote Sensing for Air Quality, to learn more about remote sensing of aerosols

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21. **Question: The PM2.5 in Connecticut was orange-red on July 16, 2026 (https://portal.ct.gov/deep/news-releases/news-releases---2026/deep-forecasts-elevated-levels-of-fine-particulate-for-wednesday-through-thursday). .. how come it shows moderate in the Aerosol Watch?**
    The images shown in the Connecticut DEEP press release (the provided URL) are the air quality forecast, not the observed PM2.5. Think of it like a weather forecast: the air quality forecast is what is predicted for the public (like the high temperature), and the observed PM2.5 is what actually occurred. Also, be aware of the averaging time period when looking at air quality forecasts and observations. The PM2.5 air quality forecasts in the US are for a 24-hour (daily) average. AerosolWatch shows the 1-hour average (hourly) and 24-hour (daily) observed PM2.5 from both satellites and the AirNow regulatory monitors. I pasted the observed daily PM2.5 below for Connecticut on July 16, 2026, for your reference; you can see that indeed, the forecast was verified for most of the state.



22. Why display ground-level sensor PM2.5 data in AQI and not raw PM2.5? Wouldn't raw PM2.5 data correlate better with the smoke data from satellite imagery?

AerosolWatch does display the AirNow ground-level sensor PM2.5 data, as well as the satellite estimated PM2.5, in PM2.5 concentration (micrograms per cubic meter, μg/m^3). The color map is scaled to match the colors of the AQI, approximately, as a decision aid for users. Please look at the legend for the PM2.5 layers, and you will see the units.

23. Question: Can we remove Cloud cover in AerosolWatch website with any filter?

No; clouds are part of the satellite observations and can't be removed. For many products (such as AOD) areas with significant cloud contamination are masked out. But there is no way to "remove" clouds from an image to "see through" them.

24. Question: When you selected TEMPO on the right, do you need to de-select the GOES-East first?

No; the TEMPO data will overlay on the GOES-East ABI imagery. The products below in the selection menu will overlay the products above. So TEMPO will

overlay GOES-East or -West ABI, and NOAA-21 will overlay TEMPO. If you select the TEMPO True Color RGB, this will overlay the GOES-East GeoColor without you needing to turn that layer off. However, I recommend turning layers off that you aren't using because that helps the AerosolWatch website run more smoothly, and also you won't get confused about which product you're looking at.

25. **Question: What do you set as a best animation time?**
    This really depends on what you are looking at. About 1500-2000 UTC are typically daylight hours for most of North America, so these might be "best" in terms of illumination. For efficiency, picking an interval of 2 to 3 hours usually ensures the best performance of the AerosolWatch website.

26. **Question: Since AOD scale/legend is capped at 1, does that mean when AOD >1 it is all lumped into the top of that scale (red)?**
    The valid range of TEMPO and ABI AOD values is [-0.05, 5]. Most of the time, however, AOD values in North America <1. On AerosolWatch, the colormap for plotting AOD is set to range from 0 to 1, and AOD values >1 are displayed using the same color as AOD=1 (red). If AOD was displayed at the full range (0-5), it would be difficult to distinguish between different AOD levels at more typical values for the US (0-1). This scaling choice makes it easier to distinguish regions of high AOD at a glance.

27. **Is there a way to export time-lapse views as a GIF directly from the viewer, or do users currently need to export individual still images from each timestamp and assemble these into a GIF post-download?**
    On AerosolWatch, you can save a GIF animation directly. Get the animation time period and product imagery all set the way you want, and then in the center top of the page, click on the little blue button that has a camera on it ("Save animation"). Your cursor will turn into a + sign, which you can use to draw a rectangle around the region you'd like to save. Once you're ready, hit "Submit" in the "Save Image" box on the left. A new browser tab will open and your animation will load. It may take a minute to load. Once it's loaded, you can right click to save or copy the GIF animation file.

28. **Can you change the default one-step key to allow for more steps? as it is now after 4 steps it goes back to the initial step. It would be desirable to add more steps to fill one or two hour windows in steps.**
    Yes! In the center top of the page, click on the little blue button that has a clock on it; the "select animation range" window will open. You can select the Start and End times to set the period of the animation. We recommend only selecting 2-3 hours at a time, however, to ensure best performance of the AerosolWatch website.

29. **AerosolWatch still lists SNPP VIIRS. With SNPP data delivery ending Nov 1, 2026, will NOAA-20/21 VIIRS products fully replace it on AerosolWatch, including the daily surface PM2.5 estimate?**
    AerosolWatch switched over to NOAA-21 in place of SNPP on July 20, 2026. If you look at any days on AerosolWatch since July 20, you will see NOAA-21 as a menu option, not SNPP. And we changed the inputs to the daily PM2.5 estimates from SNPP & NOAA-20 AOD to NOAA-21 & NOAA-20 AOD on the same date.

30. **For a small civic alert app, is there a programmatic way (API or image tiles) to pull AerosolWatch imagery, or should we build from NODD ABI files on Amazon Web Services (AWS) directly?**
    No, AerosolWatch is not designed with that type of functionality. If you need imagery for your app, we recommend you generate the images yourself using data from the NODD. You can access ABI data via the NODD on AWS (Amazon) or GCS (Google); no registration or cloud accounts are needed.

31. **Will you be adding the ability to change the colorbar settings for the AOD and PM2.5 products or are they fixed?**
    They are fixed. NASA Worldview does have more flexibility in that regard.

32. **Any plans to add TROPOMI Aerosol Index? I only see CO.**
    For the time being, only TROPOMI CO is available on AerosolWatch. However, TROPOMI Aerosol Index is available on NOAA's JSTAR Mapper website, with global coverage.

33. **Question: Can data (AOD, ALH) be downloaded from this website?**
    No, AerosolWatch is not designed with that type of functionality.

You can download ABI AOD data via NOAA's Open Data Dissemination (NODD) program from AWS (Amazon) or GCS (Google); no registration or cloud accounts are needed.

TEMPO products are not yet operational, so the TEMPO AOD and ALH data cannot be downloaded at all yet. The products are expected to become operational in the Spring of 2027; at that time, the data files will be available from NASA Earthdata.

34. **Question: Can these tools track smoke from burnings in Central America and southern Mexico over the southern coastal states? Same question for Saharan dust over the southern coastal states?**
    The GOES-East ABI Full Disk sector covers Central and South America. In the upper-right corner of AerosolWatch, click on the little green button labeled "Full Disk" (next to the default "CONUS" button) to switch to the GOES-East ABI full-disk imagery.

    TEMPO does not provide coverage over southern Mexico.

35. **Question: Is there any plan to include the PM2.5 small sensor layer from the AirNow fire and smoke map at any point for additional surface PM2.5 information?**
    No, not at this time. We use the hourly and daily AirNow monitor data files on the AirNowTech website, and these files do not include the small sensor measurements.