# Questions & Answers Session Part 6

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 our trainers Juan Torres-Perez (juan.l.torresperez@nasa.gov) and Zach Bengtsson (bengtsson@baeri.org).

Question 1: How sensitive is NDVI in regrowth areas (i.e., especially pixel saturation issues)?
Answer 1: It depends on the type of vegetation common within your area, but NDVI is usually pretty sensitive to green-up resulting from vegetation regrowth. It also depends on the sensor that you're using. For example, Landsat's 30 m resolution NDVI may be more sensitive in your area because of its higher spatial resolution. You'll also remember that we went over a couple of other vegetation indices, like the Enhanced Vegetation Index (EVI) and Soil Adjusted Vegetation Index (SAVI). These might be more appropriate depending on the density of vegetation expected in your particular study area. NDVI is a good place to start. Pixel saturation can be challenging among most satellites, but high-resolution imagery can help.

Question 2: The GWIS website has MODIS & VIIRS Near Real Time (NRT) Burnt Area data. Can you explain the methodology and algorithm for obtaining this data? Is Burnt Area calculated from only one postfire image and one pre-fire image? Is the quality of NRT much worse from the monthly product?
Answer 2: Burnt area information generated in the GWIS NRT product is based on the combined use of thermal anomalies from MODIS and VIIRS sensors for delineating single fire perimeters, which are then used to estimate the burnt area caused by the fires. GWIS uses the active fire detection provided by the NASA FIRMS (Fire Information for Resource Management System). This product relies more on thermal anomaly data rather than surface reflectance of burned areas, which makes it a less reliable assessment of burned area than the MODIS monthly product. This MODIS product is created using a burned area algorithm that classifies burned areas after the fire has extinguished. Analysts that create this product will assess its quality to make sure burned area classifications are as accurate as possible. For more information about this, follow this link: https://gwis.jrc.ec.europa.eu/about-gwis/technical-background/rapid-damage-assesment

With NRT products, you are looking more at the perimeter of hotspots, but not the overall burned area. It is good for rapid response, but quality control is minimal and can be less reliable than a product such as MODIS.

Question 3: Which instrument is best for calculating the severity of burn percentage in the high vegetation area and those areas which have hotter climates?
Answer 3: The most commonly used sensor for assessing burn severity in our experience is the Landsat series. The 30m resolution of Landsat and available standard operating procedure are usually sufficient for burn severity mapping needs, but you may need to adjust your thresholding of the differenced NBR values to more appropriately capture the magnitude of vegetation loss in your study area. You can take a look here to see a brief summary of how the Monitoring Trends in Burn Severity project does this mapping: https://www.mtbs.gov/mapping-methods. With a high vegetation area with hotter climates, the overall vegetation is not covered within the burn severity.

Question 4: Is the Normalized Burned Index formula the same as Normalized Difference Drought Index? Can we find NHI with Landsat 8 data?
Answer 4: The normalized burn ratio is different from the Normalized Difference Drought Index. I'm not sure which calculation you are speaking of in particular, but the drought index I'm familiar with uses NDVI and the Normalized Difference Water Index. You can find more information on this here: https://www.gisagmaps.com/nddi-drought-assessment/
We also don't typically recommend hotspot analysis with Landsat 8 data, since Landsat does not have many thermal bands and the temporal resolution of a 16 day revisit is not sufficient for capturing many during-fire metrics. Refer to Parts 3 & 4 for more information relating to hotspots and active fire monitoring.

Question 5: How quickly is dNBR assessed after a fire and published?
Answer 5: This depends on the area in question. Some procedures will say you should wait a number of months post-fire to ensure fire related vegetation mortality is captured. If you're interested in a full assessment of total vegetation damage and loss post fire, you'll likely want to wait a couple of weeks to months. The MTBS project even waits to publish burn severity maps at a yearly timescale to ensure mapping is done correctly. When doing a final burn severity assessment, you need to make sure there are no remaining active fires and/or smoldering. You also need information on your area of study pre-fire to do a proper assessment.

Question 6: What is the formula for the Relativized Difference Normalized Burn Ratio? How is the formula different from dNBR?
Answer 6: dNBR = pre-fire. NBR = post-fire. In contrast, RdNBR = dNBR/root square of the absolute value of (pre-fire NBR/1000). The reasoning behind it is to remove the potential biases of pre-fire vegetation. Here's a paper from Miller et al (2009) that explains the differences in detail and compares RdNBR to other three measures of fire severity:
https://www.fs.fed.us/psw/publications/knapp/psw_2009_knapp(miller)001.pdf
RdNBR is not necessarily the best approach for mapping burn severity, so that is why we did not cover it in extensive detail.

Question 7: Could you please tell me how to conduct a water repellency test in the field?
Answer 7: This isn't really within the scope of this training, but essentially, more water repellent soil is seen as more severely burned. Follow this link for more info on how the US Forest Service does this: https://www.fs.fed.us/rm/pubs/rmrs_rn033.pdf. There are a couple different methods of conducting a water repellency test, but it depends on your area and needs.

Question 8: What went wrong with the VIIRS sensors, causing the product to fail in identifying burned areas at the edges of inland water bodies and at high latitudes (which was not an issue with MODIS)?
Answer 8: Development of burned area algorithms can be a lengthy process of trial and error. Nothing necessarily went wrong with the VIIRS sensors, the data is just newer and processing methods are still being refined. It's important to note that the VIIRS product is still in version 1, while the MODIS product is in its 6th version. MODIS has just been more refined over the years, being that it is a more established product, but VIIRS just needs more time to meet that standard.

Question 9: Which factors might "alter" the signal provided by NBR?
Answer 9: Bare soil present before a fire may be captured as burned landscape with the NBR. But typically land cover mapping prior to a fire can exclude these areas from burned area estimates. Vegetation removal through human activities (e.g., deforestation) can also play a role.

Question 10: Is the RdNBR only effective for pre-fire tall trees? What about low shrubs that are completely burned?

Answer 10: The RdNBR should be effective for a variety of vegetated landscapes, but it's not always appropriate. I would imagine that the relative difference within each pixel in a shrubland ecosystem might be challenging to capture with the RdNBR as opposed to a forest ecosystem with more detected vegetation types. We have not used this too much in the past, but it is something worth exploring.

Question 11: Have these (NBR, etc.) been validated? How was the validation process?
Answer 11: The NBR procedure has been validated over the course of many case studies. The effectiveness of this process varies between landscapes and burn severities. It's important to do your own validation process if possible. This could include visiting the burned area to collect ground data for comparison to the NBR values within a pixel. If you can get measurements from the area itself, it can help with your validation. NBR is the better method for this type of analysis. It is also good to do some field investigation as well and use high resolution imagery if you can to assist.

Question 12: If it is not possible to create cloud-free post-fire mosaic (operational monitoring), then how can I avoid the misclassification of burned pixels in cloud shadow and plowed fields areas? Are there any methods and algorithms that will solve this issue? (I want to automate the process of operational Burnt Area extraction from Sentinel-2 images, by calculating dBAIS2 between one post-fire and one pre-fire image.)
Answer 12: This depends on your methodology and your use case with optical imagery. If you can, use imagery that has cloud cover less than 20 percent. With cloud shadow, that is something you'll want to take into account. Attempt to classify these cloud shadow pixels (through classification or other means) and exclude them from your analysis. For plowed field areas, you could also exclude those out of your analysis to isolate land cover types that could potentially be misclassified. This is slightly easier since existing land use maps may help you to indicate the extent of agricultural areas. Take a look at some of the recent work being completed on Sentinel-2 imagery shadow detection for agriculture cover types: [https://www.mdpi.com/2072-4292/13/6/1219/pdf](https://www.mdpi.com/2072-4292/13/6/1219/pdf)

Question 13: Can you talk about pros and cons of other indices (e.g., RBR)? Also, what factors does one need to consider when choosing between the various indices for burn severity mapping?
Answer 13: The major index we discussed for burned severity mapping was the Normalized Burn Ratio (NBR) and the differenced NBR (dNBR). A pro when using these methods is that they are commonly used for burned area and burn severity mapping,

resulting in established operating procedures and quality control methods. However, one aspect you might find difficult with this type of analysis is thresholding the dNBR to determine burn severity within your own area. There are suggestions of how to do this in the literature and with the tools we've discussed within this session for mapping burn severity. The relativized differenced NBR (RdNBR) may also be useful if you are working across a landscape with varying vegetation type and density, but its use is somewhat less established than dNBR. The RBR (relativized burn ratio) is a bit out of the scope of our training, but here is a publication highlighting its usefulness compared to traditional NBR methods: https://www.mdpi.com/2072-4292/6/3/1827.

Question 14: Is the Landsat 8 Burned Area product only available over the US?
Answer 14: At this time, the Landsat Burned Area product is only available for the US. This may change as fires continue to increase as a global threat due to climate change. Products from other sensors, like Sentinel-2, may also help to fill geographic gaps in higher resolution burned area mapping. You may also want to see how the Landsat 8 product is created to aid in your own burned area mapping. You can find data product specifications here: https://www.usgs.gov/core-science-systems/nli/landsat/landsat-burned-area?qt-science_support_page_related_con=0#qt-science_support_page_related_con.

Question 15: As I see, there are so many programs, tools, apps to study, detect, and interpret the fire risk, so, my question is: Taking into consideration all this "Observation, Detection, and Analysis" fire risk, is there also a Prevent Tool or Department to avoid all this damage before starting or before a fire becomes a great danger?
Answer 15: This is beyond the scope of this training series. It would depend on the country, its local agencies, monitoring programs they might have, etc. In terms of prevention, it varies on where in the world you happen to be. There is no one single way to approach fire mitigation. Keep in mind that fires are also a natural occurrence which aid in ecosystem processes. One management method that is used to prevent abnormally severe fires is prescribed burning. Follow this link to see how the US Forest Service approaches this issue: https://www.fs.usda.gov/managing-land/prescribed-fire

Question 16: In recent years, climate change increased the severity and number of fires. How can you use Remote Sensing to understand how climate change has impacted the severity and intensity in a specific region?
Answer 16: Refer back to session 1 of this series. The instructors of this session covered remotely sensed products that provide information about climate parameters, such as humidity and temperature, that are useful in the long term monitoring of fire-

related climate conditions. Matching this type of data with burned area and burn severity information can help you visualize potential relationships between climate and fire frequency/intensity. For example, you might note that your area experienced years of higher than normal temperature and lower than normal humidity, which could provide clues as to why a particular fire season experienced abnormally high fire frequency and/or severity.

Question 17: Is there an assumption that post fire vegetation regrowth consists of similar species to what was burned in the fire?
Answer 17: When an area is burned, vegetation will recolonize an area according to secondary successional stages. Using the example of a simple forest ecosystem, you would see smaller plants grow first (like grasses and wildflower), then larger shrubs, then young trees, then more mature vegetation (larger trees etc.). Initial vegetation regrowth typically does not look the same as vegetation before the fire. Refer to the chart on slide 32 of this presentation for a visual example of this.

Question 18: How accurate is the Sentinel-1 data for mapping the burned savanna (assuming low vegetation)?
Answer 18: Not a lot of validation has been done with this example. In terms of accuracy, you may want to take these results with a grain of salt since radar data has not been used as much with burn mapping and burn severity (compared to optical data). You'll likely see more methods and improvements surfacing in the coming years for SAR post-fire applications. Take a closer look at the example case study we showed on slide 30: [https://www.mdpi.com/2072-4292/12/1/49](https://www.mdpi.com/2072-4292/12/1/49).

Question 19: Does NBR give insight into biomass? (I assume biomass is a factor in burn severity.) If not, how might one assess biomass with remote sensing data?
Answer 19: NBR is not necessarily a good tool for measuring biomass. While it can be good for mapping vegetation regrowth extent and vegetation health, it's difficult to obtain an accurate biomass assessment without vegetation structure information. Refer to Part 2 when we referenced vegetation structure remote sensing methods and data types. LiDAR is typically used for biomass analysis, since it provides accurate information about vegetation height and density. LiDAR data is usually only available for certain areas depending on where airborne data is collected by local or regional natural resource management agencies.

Question 20: Is there any tool to check or monitor real-time fires around the Globe?

Answer 20: There are many tools for this. Refer to Parts 3 & 4 for more information regarding active fire monitoring. Tools such as NASA FIRMS and GWIS are great options for looking at near real-time fires. The MODIS & VIIRS NRT product (available in GWIS) is a good way to locate a fire and its extent quickly.

Question 21: For the NBR formula to be implemented by Landsat 8 or Sentinel-2, can we use the DN value directly or do we need to convert it to reflectance?
Answer 21: If you can, use surface reflectance since this will eliminate most of the influences of the atmosphere. You can download pre-processed surface reflectance data from Landsat, and I believe Sentinel-2 also has available surface reflectance products. Here is a link to Landsat product information: https://www.usgs.gov/core-science-systems/nli/landsat/landsat-surface-reflectance?qt-science_support_page_related_con=0#qt-science_support_page_related_con.

Question 22: Sentinel-2 images are available at levels 1 and 2 depending on the level of atmospheric correction. Does this atmospheric correction significantly affect NBR values? Do we have to use level 2 for better results?
Answer 22: Refer to Q21. With Top of Atmosphere (TOA) reflectance, proceed with caution, but analysis with TOA can be informative.

Question 23: Does the FMT Fire Mapping tool work globally or is it only US?
Answer 23: The FMT works globally and is only limited by the availability of Landsat imagery within your region of interest. This is not much of a limiting factor, considering the global spatial coverage of Landsat.

Question 24: Many thanks for this excellent presentation. Is the FMT tool restricted to fires in US territory, or is it global? Thanks a lot!
Answer 24: Refer to Q23. FMT can be used globally. You might also find the UN Spider trainings mentioned on slide 29 of this session helpful.

Question 25: How accurate is the MODIS and VIIRS Burned Area product (in terms of commission and omission errors) for CEAS grasslands? Is it possible to detect Burnt Areas through SAR imagery in grasslands?
Answer 25: I can’t necessarily speak to the accuracy of MODIS & VIIRS for CEAS grasslands. There are some caveats to VIIRS in terms of use cases and overall accuracy, being a newer data product. But the MODIS product is considered very reliable in the assessment of burned areas. The case study provided in the presentation utilized SAR imagery on grassland areas. Refer to Q18.

Question 26: Does the "LANDFIRE: Disturbance Data" provide other disturbance types such as hurricanes, beetle infestation, etc.? Does the dataset/website have a manual?
Answer 26: In the presentation, the disturbance layer provides information on different disturbance layers you can utilize. The links on the site will provide you with more information. You may want to take a look at: https://landfire.gov/disturbance.php where there is information on the specifics about the disturbance data and the full collection of data layers available through LANDFIRE. The site also has a FAQ section you can refer to.

Question 27: Are there any methods to prevent forest fires?
Answer 27: This question is beyond the scope of the presentation. A potential example could be prescribed burning. Refer to Q15.

Question 28: Is there any particular reason to use the NBR index (as opposed to NDVI, for example) to assess vegetation regrowth post-fire?
Answer 28: There is no particular reason to use NBR over NDVI. If you are utilizing dNBR for your analysis, then NBR will likely be easy to calculate for your area at various post-fire timescales as well. NDVI does a great job of assessing greenness, so this can be a more direct way of sensing vegetation.

Question 29: Do you recommend all studies that use burn severity or veg. regrowth products also complete some ground truthing? Or are these products robust enough to be used stand-alone in some cases?
Answer 29: Many of these products can be used in standalone cases. Regardless of available ground data, remote sensing can be informative. However, ground-based data allows for validation and accuracy assessment. This ground-based data can also be used to train imagery analysis to map landscape conditions in a way that more closely represents ground conditions. If possible, you should always explore the inclusion of field data in your analysis.

Question 30: Would you recommend Hysplit trajectory analysis as a tool to examine airflow prior to a fire and/or movement of smoke post-fire, or is it better to use a remote sensing tool specifically developed for these purposes?
Answer 30: The Hysplit trajectory analysis is a good way to map air movement over an area, as we saw in the Mexico City case study portion of the presentation. Feel free to email us (contact info in the slides) if you have further questions about this, and we can forward any questions to our guest speaker, Blanca Rios.

Question 31: Is it possible to use burnt area products to determine wildfire susceptibility of an area? Or only active fire products can be used for this?
Answer 31: When referring to wildfire susceptibility within an area, look at Parts 1 & 2 of this training for more information. Active fire products are good for during-fire measurements.

Question 32: Where can we get Landsat Level-3 Burned Area (BA) Science Product Algorithm description and, maybe, implementation code?
Answer 32: Here's the website from the USGS for Landsat Burned Area Product where more info can be found including a document describing the algorithm used:
https://www.usgs.gov/core-science-systems/nli/landsat/landsat-burned-area?qt-science_support_page_related_con=0#qt-science_support_page_related_con

Question 33: With regard to the case study it was really interesting to see the various data sets used to come up with post fire vegetation analysis and its Air quality impact. Since there are many parameters to deal with while analysing such a case study, what are the key challenges to link up the pre-, during-, and post-fire analysis? How can this study be utilized by local authorities in preparing emergency response plans?
Answer 33: I would say the key challenge to linking all of this is figuring out how each data product fits together to answer a research question. In this case, burned area and land cover products were used to examine where and what fires burned on key dates in May 2019. Then, air movement modeling was completed to examine the trajectory of smoke dispersal from burn events to Mexico City. Air quality was then assessed in Mexico City to provide information about the pollutant impacts likely resulting from fire smoke. In this simplistic description, we obtain information about the source of the air pollution (fires west of Mexico City and associated sources of fuel), the mechanism in which air pollution was transported to Mexico City, and the ultimate impact of air quality in Mexico City. In the end, Blanca and her colleagues were able to identify sources of the regional pollution, the type of fuel burned in the fires, and the predominant transport patterns of pollutants, in accordance with their study objectives. It's typically best to determine your research goals and work to see which products and methods will best allow you to answer your questions, rather than attempting to bring everything we have gone over throughout this series together in a single study. In this case study, local authorities in Mexico City now have more information about what to expect when nearby regions burn and can better plan air quality advisories and emergency responses when fires in similar geographic regions occur.

Question 34: How do you distinguish the transported wildfire smoke (aerosols,CO) from the urban plumes?
Answer 34: We would need to forward this question to Blanca Rios, but I believe the air quality assessment for various parameters (CO, PM2.5, etc.) during fire events was compared to average air quality conditions experienced in previous years to determine the relative influence of smoke transport. Feel free to email us for further clarification.

Question 35: What are the drawbacks or difficulties in using SAR data as opposed to optical imagery when trying to map burn severity or vegetation regrowth?
Answer 35: Refer to Q18 & Q25. The use of SAR data for burn severity mapping is relatively new compared to the use of optical data. This means that research on the efficacy of SAR data for burn severity mapping is currently behind that of optical data. This will likely change as SAR data becomes more widely used for this purpose. For vegetation regrowth, the situation is similar. SAR data is a great option for mapping vegetation, but methods currently in use tend to favor the use of optical data given its prevalence in vegetation assessment standard operating procedures.

Question 36: Why does the MCD64A1 product have a lag of 2-3 months?
Answer 36: The product has this lag so that analysts can process the data, apply the burned area algorithm to imagery, and complete quality control assessments. It’s also important to wait weeks or months after a fire to assess the final burned area to ensure burning is complete throughout the burn scar and vegetation mortality resulting from fire injury is recorded within the burned area assessment.

Question 37: You have demonstrated that SAR C-Band can detect the burnt areas with a 20x20 m2 pixel resolution. Has there been any study using X-Band with 3x3 m2 resolution in order to have higher resolution? Is it bringing more information, knowing that a fire is never limited to 20x20 m2?
Answer 37: The spatial resolution of a sensor dictates the area of each pixel within imagery. Higher spatial resolution typically results in more accurate assessment of burned areas simply because more information is recorded by the sensor. I’m not aware of any studies using X-band for this purpose, but you might be interested in this article which covers SAR data fire applications and mentions past studies which have examined X-band radar: [https://www.nature.com/articles/s41598-019-56967-x](https://www.nature.com/articles/s41598-019-56967-x).

Question 38: If the fire was covered by a cloud during-fire (I mean absence of thermal anomalies), will a Burnt Area be determined in the final BA Product (MCD64 or VIIRS BA Product) for that territory?
Answer 38: Burned area is determined post-fire. So there is usually enough cloud-free post-fire imagery to calculate burned area, especially since MODIS and VIIRS have high temporal resolution. It's important to note that burned area can be calculated weeks after a fire takes place, not immediately after burning ends.

Question 39: Is the mentioned HYSPLIT model only applicable to active fire hotspots or is it applicable to burnt areas as well?
Answer 39: The HYSPLIT model is used for mapping air movement, which makes it a great tool for assessing smoke transport and resulting air quality impacts. Here is more info about HYSPLIT: https://www.arl.noaa.gov/hysplit/hysplit/.

Question 40: How persistent is the "water repellent layer"? Does it last forever or break down in a few years?
Answer 40: The water repellent layer does not last forever. The persistence of this layer depends on soil composition and burn severity. This study completed in the Colorado Front Range found that fire-induced soil water repellency progressively weakened and became statistically undetectable within a year after burning:
https://www2.nrel.colostate.edu/assets/nrel_files/labs/macdonald-lab/pubs/Post-fire_soil_water_repellency.PDF

Question 41: What are the alternatives to the mentioned HYSPLIT approach?
Answer 41: HYSPLIT was used to model air movement to examine smoke transport patterns, so another platform that models the trajectory of air parcels may be sufficient for your needs. Recommendation of other specific models is beyond the scope of this session.