Question & Answer Session 2

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 Amber McCullum (amberjean.mccullum@nasa.gov), Juan Torres-Pérez (juan.l.torresperez@nasa.gov) or Zachary Bengtsson (bengtsson@baeri.org).

Question 1: How can HDF format be converted to GeoTIFF format for further analysis on QGIS?
Answer 1: I don't think there is a straightforward way to do this conversion in QGIS. GDAL may have this capability, which can be linked to QGIS. You may need to use another software such as ENVI to conduct this conversion.

The raster tab in QGIS has tools to assign, extract, and warp (reproject) projections of data, which are powered by GDAL. Here is more information on GDAL HDF conversion: http://hdfeos.org/software/gdal.php

Question 2: What's the smallest area size we can use Hyperspectral data to process?
Answer 2: This depends on the sensor you are using. In part 1 (slide 31 in the pdf for the additional sensors) we discussed many hyperspectral sensors and their spatial resolutions. For example, Hyperion has a 30m spatial resolution, which is about the size of a baseball diamond, so you get one value for each band within a 30m square. HICO has a spatial resolution of 90m, etc.

Question 3: Hyperspectral Data for Land, could soil moisture be determined?
Answer 3: I don't think hyperspectral data is used for soil moisture, but SAR data can be used since it is ground penetrating. Check out the SMAP (Soil Moisture Active Passive) mission (although the spatial resolution is coarse), or other SAR sensors like Sentinel-1. SAR can penetrate the surface to a degree.

Here is a past ARSET training on soil moisture and Evaporation: https://appliedsciences.nasa.gov/join-mission/training/english/applications-remote-sensing-soil-moisture-and-evapotranspiration

We also have a lot of SAR trainings you can search for on the ARSET website. https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

Question 4: How are the bands of a future sensor determined? I am guessing based on inputs from the scientific community?
Answer 4: You are correct. The selection of specific bands, particularly for hyperspectral sensors is determined after a long process where the scientific community decides the number of bands, band width, spatial resolution of the sensor and architectural aspects of the sensor. Data collected from previous missions are also considered.

Question 5: What are the approaches to improving SNR of spaceborne Hyperspectral instruments for Earth observation or Planetary science missions? And which one is better: Classifier Support Vector Machine (SVM) or Random Forest (RF) for Hyperspectral Image Classification and why?
Answer 5: Reducing the signal to noise ratio in hyperspectral imagery can be a complex process. Last week we briefly mentioned some techniques such as Principal Component Analysis to identify bands that have high correlation, which can also help in identification of bands with lower SNR. Singular Spectral Analysis (similar to PCA but you can use nonstationary data for this) and wavelet analysis is another approach to reduce SNR. In some cases, the SNR is simply a function of the sensor, and cannot be avoided. Here are a few resources for further investigation:

- https://www.mdpi.com/2072-4292/10/3/482/htm
- https://www.techbriefs.com/component/content/article/tb/supplements/pit/features/articles/37674
- https://www.tandfonline.com/doi/full/10.1080/01431160802549344

When conducting an image classification, I recommend evaluating multiple techniques and then running an accuracy assessment to see which technique provides is most useful. Ground truth (in situ) measurements are highly recommended, having some ground-based data for supervised classifications, as this will improve your classification results. I really like Random Forests, and this is something we discussed in more detail in our land cover classification and accuracy assessment ARSET courses:

- https://appliedsciences.nasa.gov/join-mission/training/english/land-cover-classification-satellite-imagery
- https://appliedsciences.nasa.gov/join-mission/training/english/accuracy-assessment-land-cover-classification

Question 6: What type of classification are you using? Euclidean distance, SAM?
Answer 6: Does this question relate to the agricultural example or the Santa Monica Restoration example? We would need to contact the researchers.

- Here is the research article for the agriculture example: https://www.mdpi.com/2072-4292/10/12/2027

- From the article: “Crop types and crop growth stages were classified using linear discriminant analysis (LDA) and support vector machines (SVM) in the Google Earth Engine cloud computing platform using the 30 optimal HNBs (OHNBs).”

Question 7: How to perform PCA using QGIS or any open-source platform for remote sensed image? Do you have any plan to train on this in this training?
Answer 7: This is beyond the scope for this particular training. Yet, you may find some information on the QGIS site. For example, here’s the link for downloading a PCA plugin for QGIS: https://plugins.qgis.org/plugins/PrincipalComponents/

Question 8: Is the google earth engine code used to do the PCA and classification published somewhere?
Answer 8: You will want to look at the information available for the particular study this question is based on, but the Google Earth Engine Developers website typically provides basic information on how to complete these functions.

- Classification Tutorial: https://developers.google.com/earth-engine/guides/classification
- Principle Components: https://developers.google.com/earth-engine/guides/arrays_eigen_analysis

Question 9: It seems that the spectral shape of different crops on slide 10 look exactly the same, but that the magnitude is what is different, is that correct? How can you be sure that the resulting magnitude is correct after atmospheric correction?
Answer 9: Yes, While the shape of the spectral signatures might be similar the reflectance values are different at specific wavelengths, so the magnitude is important here. The researchers also used ground-based data to compare to the hyperspectral data for validation. This is not research I conducted, but you can find more information about the project in the paper here: https://www.mdpi.com/2072-4292/10/12/2027

Question 10: You are showing average spectra of cotton and corn. What is the variability around this mean spectra?
Answer 10: I am not sure, since this is not research I conducted specifically, I am assuming the researchers used some type of ensemble mean from multiple spectral plots. You can find more specific information about the project in the paper here: https://www.mdpi.com/2072-4292/10/12/2027

Question 11: How is a high level of SNR managed in comparison to multispectral data in hyperspectral processing?
Answer 11: See question 5

Question 12: Perennial pepperweed: to detect the flower, do you have to acquire the data at a very specific time?
Answer 12: Yes. Perennial pepperweed flowering typically occurs at its highest density in mid to late spring. It's important to keep plant phenology in mind when you're attempting to differentiate vegetation types, so make sure to keep the biology of target species in mind. Here is a link that provides more information about perennial pepperweed:
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410120.pdf

Question 13: You mentioned some limitations with mapping Lepedium - what would you say some of those limitations are?
Answer 13: Spatial extent is always something to consider, especially with RS imagery. Phenology is also a consideration. You need to understand when pepperweed blooms (mid to late spring) and gather imagery around the same time. See more information about pepperweed here:
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410120.pdf

Question 14: Can hyperspectral images differentiate between crops that are very similar, such as sorghum & maize?
Answer 14: I guess no, given how similar they are. If you have plants that are so spectrally similar, optical data will not be the most useful. Structurally different crops (height differences, etc.) can possibly be identified with SAR data. Based on this article, I think separating these similar crop types is difficult with hyperspectral data:
https://spj.sciencemag.org/journals/plantphenomics/2020/4216373/

Question 15: Is it possible to use hyperspectral data to identify different soil types (or soil characteristics; at least water content should be possible, I assume)? If so, probably only of exposed soils? How do you classify an atmospherically corrected Hyperion image? Is it necessary to have knowledge of MNF & Pixel purity index before classification? Or do we just define ROI on an atmospherically corrected image and classify it? Please explain in detail. Thanks.
Answer 15: Different soil types could potentially be distinguished if they are very different mineralogically, and they must be exposed soils as hyperspectral data are not ground penetrating, so if there is vegetation covering the soil the reflectance measurement will be of the vegetation. Mineral deposit differences can be detected, as

shown in a few of our examples. Hyperspectral data is not the best for soil moisture. I would recommend SMAP or Sentinel-1.

Question 16: Could information be gleaned about the size structure of soil particles?
Answer 16: SAR data will be needed here. Hyper would not be useful for that.

Question 17: Are the spectral signatures provided in resources, such as USGS, specific to hyperspectral data? If yes, are most spectral libraries based on hyperspectral data? Is it possible to use a hyperspectral signature with multispectral imagery?
Answer 17: Spectral signatures for a variety of sensors and land cover types are available through the USGS spectral library:
https://www.usgs.gov/labs/spec-lab/capabilities/spectral-library
You can create spec libraries with hyper and multi. Spectral libraries tend to be more useful for hyperspectral data when compared to multispectral data. Hyperspectral profiles tend to have much more detail when compared to multispectral profiles, so hyperspectral libraries may not be readily applicable for multispectral data.

Question 18: Could different ice conditions be determined?
Answer 18: I would recommend a different type of sensor for this such as ICEsat or GRACE. Here is a special issue about this topic:
https://www.mdpi.com/journal/remotesensing/special_issues/ice_sheet

Question 19: Volcanic debris flows: slope is affecting the 'reflectance'. How do you account for the dip?
Answer 19: I think the researchers used a DEM to establish the topographic variability in these slopes. And how it related to the different mineral deposits.

Question 20: Does Hyperion have an automated scene classification layer for e.g., clouds, haze, etc? Like the CSL layer for Sentinel 2?
Answer 20: Not that I am aware of. I think this is something that needs to be done by the individual researcher.

Question 21: Can all the steps in the demo be replicated with ArcGIS Pro? Or does QGIS provide better options for managing hyperspectral data?
Answer 21: Most of these steps, if not all, can also be run in ArcGIS Pro. We prefer to show the demos in QGIS because it is open source and available to anyone.

Question 22: How is an uncertainty commonly determined for hyper-spectral data?
Answer 22: The accuracy of hyperspectral data can be determined if you have ground based validation data. For example, if you are conducting an image classification, you

can use part of the ground-based data to classify the image and then part of the ground based data to run an accuracy assessment. We have two trainings on accuracy assessments for multispectral data, but the process will be similar:

- https://appliedsciences.nasa.gov/join-mission/training/english/land-cover-classification-satellite-imagery
- https://appliedsciences.nasa.gov/join-mission/training/english/accuracy-assessment-land-cover-classification

Question 23: Are there methods in google earth engine to apply atmospheric correction on Hyperion data?
Answer 23: Please refer to previous question and answer.

Question 24: Is there a free spectral library for plastic or anthropogenic waste?
Answer 24: Most researchers prefer to collect their own spectral data to build their libraries based on their specific needs. Particularly for plastics or anthropogenic wastes, the variation is quite large as it depends on the material type, color, time of exposure to environmental variables, etc. This is usually done with a field spectroradiometer. We are not aware of a library to which you refer.

Question 25: Is Hyperion data available for the whole globe?
Answer 25: No. For a quick view on where is Hyperion data available you may refer to: https://glovis.usgs.gov/app?fullscreen=0. More missions are coming along and will increase the overall hyperspectral footprint.

Question 26: I don't understand how RGB bands were assigned in the demo. How did he know which band number was which? And, continuing on that, QGIS automatically populated the Max value for each band after he chose them, but it did not set a minimum. Why is that not necessary?
Answer 26: RGB bands were assigned in the demo based on their place in the electromagnetic spectrum. The level 2 product used for the demo has assigned a number to each band, 196 bands passed quality control and were useful for analysis purposes. For the demo, the red band was around 620nm, the green band was around 550nm, and the blue band was around 460nm.
The maximum and minimum values in the plot shown through the value tool are for the Y axis of the graph which displays surface reflectance value of each pixel. The max changes per pixel based on these reflectance values. A minimum of 0 indicates no surface reflectance at a pixel.

Question 27: Is there any Open-Source workflow available to atmospherically correct EO-1 Hyperion data from L1 to L2?

Answer 27: I'm not aware of readily available open source/free workflows available for Hyperion atmospheric correction. Studies we reviewed tend to favor FLAASH, ACORN, and ATREM. However, there are options to attempt your own atmospheric corrections with openly available tools like NASA's SeaDAS or ESA's SNAP.

Question 28: Does hyperspectral sensor satellite have less swath than multispectral satellite?
Answer 28: Yes generally, see lecture 1. The more dense the data collection typically equals smaller swath area (due to data storage, processing, etc).

Question 29: Not clear what target path and row are. Could you please explain?
Answer 29: Target path and row identify an exact scene captured by a satellite. This is essentially the lat/long location of the image. Here is more info on this with a Landsat example: https://landsat.gsfc.nasa.gov/about/worldwide-reference-system

Question 30: Atmospheric correction is fundamental to the use of satellite data. Can you spend a bit more time explaining how to do it for hyperspectral products, or give us a resource to find out for ourselves please?
Answer 30: Here are a few resources on atmospheric correction:

- https://www.sciencedirect.com/science/article/abs/pii/S0034425709000741
- https://www.mdpi.com/2072-4292/10/11/1698

Question 31: Could hyperspectral images use to determine the surface albedo in the urban environment?
Answer 31: I do know that other sensors like MODIS have been used to examine surface albedo. I also think hyperspectral data have been used for albedo in limited locations here are a few resources:

- http://www2.hawaii.edu/~jmaurer/albedo/
- https://www.fs.fed.us/nrs/pubs/jrnl/2015/nrs_2015_burakowski_001.pdf

Question 32: What is the basic difference between FLAASH and ACORN algorithms?
Answer 32: Models may use different data sources to create their algorithms, and these platforms may only be available on certain machine (Mac, Windows, Linux, etc.). Here is a paper that does a good job of detailing FLAASH, ACORN, and ATREM: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.569.8864&rep=rep1&type=pdf

Question 33: Is Hyperion data available for the whole globe?

Answer 33: No. For a quick view on where is Hyperion data available you may refer to: https://glovis.usgs.gov/app?fullscreen=0. More missions are coming along and will increase the overall hyperspectral footprint.

Question 34: I may have missed this in the presentation but in QGIS processing of Hyperspectral data, how do you determine what values to give to each band (RGB)?
Answer 34: When creating an RGB image, you have the option to create a true color image or a quasi-true color image. Many satellites will specify which 3 bands to use to create a true color image. In the demo, we used bands from a surface reflectance data product roughly within the red, green, and blue portions of the visible spectrum to create a quasi-true color image.

Question 35: About the burned area calculation project you presented, do you have a link to a paper or literature of that in more detail? Burned area calculations is one of the most often asked features from our customers and this is also required for our model for prescribed burning.
Answer 35: I don't believe this project has been published. Here are a few links to the research:

- https://develop.larc.nasa.gov/2017/fall/SantaMonicaMountainsEcoII.html
- https://develop.larc.nasa.gov/2019/summer/SantaMonicaMountainsEcoIII.html

Question 36: Any index for water quality, sediment?
Answer 36: Hyperspectral data is frequently used for water quality assessment. Please join us next week for session 3 where we will go over applications for coastal and ocean study areas!

Question 37: Where can we find a database of spectral signatures by plant species already studied?
Answer 37: Spectral signatures for a variety of sensors and land cover types are available through the USGS spectral library:
https://www.usgs.gov/labs/spec-lab/capabilities/spectral-library

Question 38: Are any hyperspectral imagery sources already atmospherically corrected?
Answer 38: Not that I am aware of, most of these need to be atmospherically corrected by the user. There may be some instances where researchers have conducted the atmospheric correction and made those data available.

Question 39: How's about the deep learning application in hyperspectral processing, which is quite popular nowadays?

Answer 39: Yes. Deep learning, neural networks, etc. is being used more frequently in the remote sensing world. Here is a review paper of deep learning for hyperspectral imagery:
https://www.sciencedirect.com/science/article/pii/S0924271619302187

Question 40: Can you please provide further information about: (1) what the processes and steps of preprocessing for hyperspectral data are? and (2) why?
Answer 40: Pre-processing to account for the effects of things like water vapor in the atmosphere for example are very important to the use of remote sensing data. Also, remote sensing data are collected as radiance values, and often must be converted to reflectance. For multispectral imagery this is often done prior to download by the mission or the data service provider, but that is often not the case for hyperspectral data, so the user often needs to do these steps on their own. While this is a bit out of the scope for this training, please see previous links provided on tutorials for this.

Question 41: Do the atmospheric correction models: FLAASH, ACORN and ATREM work for all hyperspectral satellite sensors? These models require data from other sensor-sources for atmospheric correction (eg: profiles of temperature, pressure, relative humidity, etc.)?
Answer 41: These methods essentially use various atmospheric correction algorithms for specific sensors. Here is a review paper about each model and the requirements:
https://www.rese.ch/pdf/Bendor_OP-OMSD-1_india.pdf

Question 42: Is it possible to detect plastic waste pollution accumulations on land? If so what levels of accuracy?
Answer 42: Yes, in some cases plastic waste accumulations can be detected. Particularly for plastics or anthropogenic wastes, the variation is quite large as it depends on the material type, color, time of exposure to environmental variables, etc. This is usually done with a field spectroradiometer. During our Remote Sensing of Coastal Ecosystems from 2020, we mentioned a couple of studies where the researchers used field spectrometers to spectrally differentiate between some plastic materials that usually land on beaches.
Coastal Ecosystems Training Link: https://appliedsciences.nasa.gov/join-mission/training/english/remote-sensing-coastal-ecosystems

Question 43: Vegetation is very difficult to differentiate. Were the agricultural results compared with the same types of vegetation in another region of the world for global application and utility?

Answer 43: I believe the ground-based data from this research came primarily from seven agricultural regions in the US. You can find more specific information about the project in the paper here: https://www.mdpi.com/2072-4292/10/12/2027

Question 44: Are there more examples of models that use hyperspectral remote sensors to differentiate between different plant species?
Answer 44: There are many examples of the use of hyperspectral data for different plant species. You can also access the USGS spectral library for spectral signatures for a variety of sensors and land cover types are available through the:

- USGS Spectral Library: https://www.usgs.gov/labs/spec-lab/capabilities/spectral-library
- Here is the Global Hyperspectral Imaging Spectroscopy of Agricultural-Crops & Vegetation (GHISA) we mention in the lecture: https://www.usgs.gov/centers/wgsc/science/global-hyperspectral-imaging-spectroscopy-agricultural-crops-vegetation-ghisa?qt-science_center_objects=0#qt-science_center_objects
- Here is another review paper on hyperspectral data for plants: https://www.mdpi.com/2072-4292/12/1/113

Question 45: Is there a list available for all known hyperspectral datasets? There are many datasets referred in the training that are not available. If such a list is not available, could someone please build and share a list? Please include all the parameters of the datasets as spatial resolution, periodic refreshed or one-time scan, recurrence of periodic, spectral info, etc.
Answer 45: I am not aware of a comprehensive list of all hyperspectral sensors. We listed many in lecture 1, and there is a review paper where many of the non-NASA sensors are listed: Here is the article that outlines much of this information for reference: https://www.mdpi.com/2072-4292/10/2/157.

In terms of a spectral library, the USGS is a good starting point. Commonly, researchers prefer to build their own spectral libraries based on their specific needs and research goals. For coastal ecosystems (which we will cover next week) you can also refer to the SeaBASS depository: https://seabass.gsfc.nasa.gov/.

Question 46: When looking at vegetation species coverage, how do these studies deal with the changes in vegetation growth throughout the year? Is it safe to assume that relative coverage for each species is constant throughout the year?
Answer 46: This will depend largely on the vegetation species you are analyzing. Some vegetation species may lose their leaves over the winter or only flower in mid to late

spring (and so on). It's important to be familiar with the general phenology and biology of the vegetation species you are assessing. This means that you may have to limit your study period to seasonal scales, such as only looking at imagery from over the summer.

Question 47: Are there any issues with saturation in Hyperion over snow?
Answer 47: It looks like Hyperion has been used in limited cases for snow monitoring. The bands near 1033 nm were sensitive to the snow grain size in this article: https://www.mdpi.com/2072-4292/5/1/238/htm. I am not sure about oversaturation of Hyperion data over snow, but I do know Landsat has this issue.

Question 48: Can we use hyperspectral data to estimate crop water requirements?
Answer 48: I am not sure if there are any case studies of hyperspectral data being used in this way. However, hyperspectral remote sensing can be used to estimate vegetation health and, potentially, vegetation stress via drought indicators such as NDVI. If you are interested in using remote sensing data for soil moisture estimation, you might want to look at synthetic aperture radar (SAR) imagery. I would also suggest Landsat and ECOSTRESS for ET measurements. Check out the OpenET project that is tackling this issue for the western US, and we gave the ECOSTRESS information during session 1.

- https://openetdata.org/

Question 49: Are there any APIs available (similar to the TNM API provided by USGS) for hyperspectral data?
Answer 49: During this training, we went over EarthExplorer, which is an excellent way to search for and download Hyperion hyperspectral data. During the next session, the demo will cover/demo NASA OceanColor Web to search for and access HICO hyperspectral data. Other interfaces useful for obtaining hyperspectral data are GloVis (https://glovis.usgs.gov/) and NASA Earthdata (https://earthdata.nasa.gov/). Some of these have bulk download options available.

Question 50: If sulfur is related to bacteria, have any other elements been indicated related to the activity of other microorganism communities?
Answer 50: This is beyond the scope of my knowledge. However, remote sensing can be used to monitor things like harmful algal blooms (HABs) and nutrients in water.

Question 51: To derive chlorophyll, Turbidity, CDOM, nutrient level in water (nitrate and phosphate), which satellite/sensor/wavelength can be used?
Answer 51: We will cover some of this next week when we refer to the use of hyperspectral data for coastal and ocean ecosystems. Additionally, during the Remote Sensing of Coastal Ecosystems from 2020 (https://appliedsciences.nasa.gov/join-

mission/training/english/remote-sensing-coastal-ecosystems) we covered the assessment of water quality including a number of indices useful for some of the mentioned parameters.

Question 52: Would you share any protocol/guidance on collecting hyperspectral data through the field work to develop the data library and use them for cal/val or with other remote sensing data products?
Answer 52: Typically, a field spectroradiometer is used for these purposes. There are a number of commercially available spectroradiometers which vary in spectral resolution, sensitivity and obviously price, usually ranging from several thousand dollars to $10-20K. There are a number of aspects to consider when collecting field spectral data from different targets. For example, usually the data is collected within 1-2 hours of the satellite or sensor overpass, changes in the atmospheric composition (presence of clouds of different types or aerosols) might also affect the measurements and most times researchers use a diffuse surface panel (Spectralon) to correct for these atmospheric changes. Also, it is important to collect the spectra at a certain angle from the Sun rays so these do not interfere with the measurement and/or to avoid shadows. For statistical reasons, the more data you have from a specific target, the better you can characterize the intrinsic variation of that particular target. When working with let's say plant species, you need to consider the seasonality, whether they are perennial, annual, etc (phenology).

If you are dealing with underwater targets, there are only a few companies that have custom built underwater enclosures for the spectroradiometers. Also, one important aspect for underwater targets is to collect the data as close as possible to the satellite overpass since the water column constituents (sediments, plankton communities, etc) may vary constantly.

Question 53: Is there an open-source alternative to ENVI? Does ARSET have trainings available for ENVI?
Answer 53: there are options to attempt your own atmospheric corrections with openly available tools like NASA's SeaDAS or ESA's SNAP. Studies we reviewed tend to favor FLAASH, ACORN, and ATREM, which are used in ENVI. However, ARSET tends to steer away from using softwares that participants would need to buy, so I don't think we have any recent trainings that use ENVI in their demonstrations. We're always looking for suggestions on what to include in our trainings, so we will keep note of this!

Question 54: Is there a list available for all known hyperspectral datasets? There are many datasets referred in the training that are not available. If such a list is not available, could someone please build and share a list? Please include all the

parameters of dataset as spatial resolution, periodic refreshed or one-time scan, recurrence of periodic, spectral info, etc.
Answer 54: The short answer is no, not that we are aware of. In session 1 we provided many of the most popular sensors with these features. We also included a table for non-NASA sensors and upcoming data platforms. Here is the article that outlines much of this information for reference: https://www.mdpi.com/2072-4292/10/2/157

Question 55: What Path/Row system does Hyperion use? Is it WRS2 like Landsat?
Answer 55: Yes, EO-1 follows the WRS-2 path and row system. Here are more of the data details: https://lta.cr.usgs.gov/DD/EO1.html.

Question 56: Does Level-1R Hyperion data also include the geometric corrections applied to either Level-1Gst or Level-1T data?
Answer 56: Level 1R data products include the radiometric corrections applied to other level 1 data products. However, I don't believe that the same geometric corrections are applied to this data product. Level 1R products in HDF format are typically meant for further processing in a software like ENVI, where I believe this geometric orientation takes place. Short answer is no. That will need to be applied by the user.

Question 57: When looking at vegetation species coverage, how do these studies deal with the changes in vegetation growth throughout the year? Is it safe to assume that relative coverage for each species is constant throughout the year?
Answer 57: Vegetation growth and phenology are very important factors to consider when using hyperspectral data for distinguishing different species and vegetation health. My suggestion would be to have consistent measurements you are taking at the same time within the year to avoid variability related to the phenophase.

Question 58: How do you do Atmospheric correction to use Hyperion data? Any pointers to a processing code/script to do that?
Answer 58: This is a complex question. Models may use different data sources to create their algorithms, and these platforms may only be available on certain machines (Mac, Windows, Linux, etc.).

- Here is a paper that does a good job of detailing FLAASH, ACORN, and ATREM: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.569.8864&rep=rep1&type=pdf
- Review paper of algorithms: https://www.researchgate.net/publication/273768012_Evaluation_of_different_atmospheric_correction_algorithms_for_EO-1_Hyperion_imagery

Question 59: Do you plan to organize a webinar about advanced data processing techniques for hyperspectral data as well? Such as spectral band selection, dimension reduction techniques, spectral unmixing, etc.
Answer 59: As we prepare for upcoming hyperspectral missions (like PACE and SBG), we will likely consider more in-depth hyperspectral trainings. However, we don't currently have anything like this planned. We decide on topics in which to train based upon community input. Look for the survey at the end of this series.

Question 60: Is it possible to use SeaDAS with Hyperion data?
Answer 60: I'm not aware of any studies that use SeaDAS for Hyperion land data, but I believe Hyperion data can be displayed and manipulated in SeaDAS. However, I'm not sure of its capabilities in applying algorithms to Hyperion data.

Question 61: How time-consuming or challenging is it to do the atmospheric corrections?
Answer 61: Atmospheric corrections can be complex. There are atmospheric correction standard protocols, but these usually involve the use of proprietary software, like ENVI, that you must pay for. Take a look at some of the links posted in earlier questions that go over pros and cons of different models (like ACORN, ATREM, or FLAASH). The use of multispectral data already has these corrections applied so consider those for the time being. Some hyperspectral data will be in L2 (HICO) and we will demo that next week in Part 3. USGS LP DAAC URL: https://lpdaac.usgs.gov/

Question 62: Are any of the atmospheric correction algorithms open source? FLAASH and other atmospheric correction modules are available in ENVI, but must be purchased separately. Is there an alternative, free atmospheric correction tool that you can recommend in case our institution has not procured such modules? (e.g., ACOLITE?)
Answer 62: Aside from the potential of SeaDAS and SNAP, we don't have many suggestions for open-source atmospheric options. ACOLITE is a great suggestion, but I don't think ACOLITE contains the appropriate calibration values specific to Hyperion necessary for the most accurate atmospheric correction. However, you might be able to apply simple atmospheric corrections, like Rayleigh corrections, using ACOLITE.

Question 63: Are there additional trainings from ARSET that address atmospheric correction techniques?
Answer 63: Most of the datasets ARSET features in its trainings will not need atmospheric correction so this is a subject we have not covered.

Question 64: Is it possible to differentiate between fallow agricultural land and abandoned agricultural land?
Answer 64: There are differences in the spectral signatures of a fallowed field vs. one that is in production. If the fallowed field was bare ground, and there was some form of vegetation growing on the abandoned field, then you will also be able to determine the differences using a vegetation index like NDVI.

Question 65: What is the difference between L1R and L1Gst data?
Answer 65: L1Gst is radiance and geo corrections (GeoTIFF) and L1R does not have those added (and available in HDF format).

Question 66: Could hyperspectral data be useful (in the same way) for gas emission detection?
Answer 66: Methane emissions may have been detected but other remote sensing sources might be better suited for this type of analysis. ARSET has an Air Quality Team that produces trainings on emissions such as methane.

Question 67: Can I determine vegetation species in Arid and semi-arid coastal regions such as Red Sea coasts in Egypt?
Answer 67: Yes. These data have been used in a variety of ecosystems including arid/semi-arid. Be sure to consider spectral mixing in the pixels when dealing with systems at the land/coastal regions. Soil in sparsely vegetated regions also create issues.

Question 68: From the information downloaded, can it be coupled with information obtained through drones?
Answer 68: Yes! Drone data can provide much higher spatial resolution data for monitoring small-scale phenomena. Much drone data is either RGB, and some drone cameras have a red edge or near infrared bands as well.

Question 69: Can we use hyperspectral data to study beach grain size? How to deal with small targets within 30m hyperspectral pixels?
Answer 69: Not that I am aware of, you can examine larger scale changes to beach dynamics, but as you suggested the spatial resolution is something to consider.

Question 70: By looking over Hyperspectral data can we differentiate between deciduous trees and evergreen trees? Or is it temporal data that can help us differentiate, considering the fact that evergreen is green all year round?
Answer 70: Hyperspectral data could be used in the differentiation of deciduous and coniferous trees. But you're correct that you would likely want to capitalize on the fact

that coniferous trees would be more easily differentiated during late fall, winter, or early spring when deciduous trees have lost their leaves--as is typical in the use of multispectral imagery. Hyperspectral data might be able to add the extra dimension of identifying tree genus or even species within deciduous and coniferous categories.

Question 71: Do we relate healthy plants with the only chlorophyll level in leaves? Considering some plants don't have green leaves and are healthy? What are the other parameters for healthy vegetation?
Answer 71: There are other metrics for plant health and stress other than NDVI or comparisons of available green bands. If you are able to obtain ground data about focal plant health (at varying health levels) to compare with remotely sensed imagery, you can use spectral information to make your own profiles for determining the health of a plant type in your chosen study area. Evapotranspiration (ET) and soil moisture information can also be used for this assessment of vegetation health/stress. Take a look at this ECOSTRESS Evaporative Stress Index product: https://lpdaac.usgs.gov/documents/340/ECO4ESIALEXIU_ATBD_V1.pdf