Questions & Answers Session 1

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 Sean McCartney (sean.mccartney@nasa.gov), Amita Mehta (amita.v.mehta@nasa.gov) or Erika Podest (erika.podest@jpl.nasa.gov).

Question 1: Can we use Landsat 8 to calculate rice production in Nigeria ?
Answer 1: Yes, there have been several studies using Landsat TM, ETM+, and OLI to map rice cultivated rice area and yield. Most studies have used NDVI time series and in situ data to calculate empirically or mechanistically the yield based on regional statistics. New methods are using SAR data and a fusion of SAR and optical to calculate rice production in other parts of the world.

Question 2: How can we work on pesticides in crop monitoring?
Answer 2: Arthropod pest outbreaks occur in crops initially exposed to abiotic stress, such as drought or sub-optimal crop management regime. Growing Degree Days (GDD) can also inform the management of pesticides by knowing when arthropods emerge, and this information can be derived from remote sensing variables.

Question 3: In Indian states like Ogun or Himachal Pradesh, is it possible to use MODIS data? It seems the spatial resolution and classification would be difficult.
Answer 3: It depends, if there is a lot of intercropping in Himachal Pradesh with mixed row crops among cereal crops, the spectral mixing of these different crops will not lend itself to coarse resolution sensors such as MODIS. You will need moderate to high resolution platforms/sensors such as Landsat OLI and Sentinel along with accurate in situ data.

Question 4: What kind of non-commercial satellites can be used in precision agriculture and how can we apply remote sensing techniques to precision agriculture?
Answer 4: This is a challenge since precision agriculture depends on UAVs, sensors on field-based agricultural equipment, and sensors in the soil. Non-commercial satellite-based sensors do not have the spatial resolution for precision agriculture. Sentinel 2 has a 10 m spatial resolution which is applicable for field-level monitoring, but is still a challenge for precision agricultural applications.

Question 5: Can you share any NASA training related to insects, especially migratory pests like locust and other pests?
Answer 5: NASA SERVIR is currently collaborating with agencies in Africa to produce a locust monitoring service:
https://www.servirglobal.net/ServiceCatalogue/details/5bd0337f51ebdcae7968336e

Other programs such as GEOGLAM Crop Monitor are monitoring global crops and tracking spread of locust outbreaks in Africa and the Middle East:
https://cropmonitor.org/

FAO also has a locust watch website to aid with early warning of locust infestation:
http://www.fao.org/ag/locusts/en/activ/DLIS/satel/index.html

Question 6: When we are discussing evapotranspiration (ET) using remote sensing for measuring ET, which ET does it actually provide, the actual ET, or the potential ET?
Answer 6: As we will see in Part 4 of this webinar series, ET is derived from RS-based thermal and/or water balance data. So both actual and potential ET are derived.

Question 7: Are there satellites and sensors used specifically for plant disease?
Answer 7: There have been a number of research efforts in this area, using UAVs and satellite data. Biophysical variables such as LAI can be correlated with in situ data to determine the impact diseases on plants. The key with plant disease is having timely and accurate in situ data and the best spectral, temporal, and spatial data derived from various platforms.

Question 8: What are applications of VIIRS in agriculture?
Answer 8: VIIRS surface reflectance products are used to create Vegetation Indices to observe phenology, crop area, crop yield, etc. They can be used to derive FAPAR & LAI useful for determining GPP, as well as LST.

Question 9: Can you please guide me from where to get data with corrected/filled stripes caused by Scan Line Corrector (SLC) failure of Landsat 7?
Answer 9: Unfortunately this is a permanent issue with the Landsat ETM+ scanner. If possible we recommend using Landsat 5 TM and Landsat 8 OLI data.

Question 10: In fAPAR product of MODIS, does it calculate PAR first?
Answer 10:

1. https://lpdaac.usgs.gov/products/mcd15a2hv006/

2. https://lpdaac.usgs.gov/documents/90/MOD15_ATBD.pdf

3. https://lpdaac.usgs.gov/documents/2/mod15_user_guide.pdf?_ga=2.20641531.291777946.1586198069-1309219922.1563372308

Question 11: How can we make a spectrum graph of rice for an area?
Answer 11: Most image processing and GIS software provide tools to map spectral profiles of different land cover in imagery using training sites of pure pixels (e.g. rice).

The USGS recently released the Global Hyperspectral Imaging Spectral-library of Agricultural crops (GHISA). This hyperspectral library of agricultural crops is developed for all major world crops and was collected by the USGS and partnering volunteer agencies from around the world. Crops include wheat, rice, barley, corn, soybeans, cotton, sugarcane, potatoes, chickpeas, lentils, and pigeon peas, which together occupy about 65% of all global cropland areas.
https://lpdaac.usgs.gov/products/ghisaconusv001/

Question 12: All of these satellites and sensors are okay for monitoring large areas, but today decision makers need local information to support local problems. Your opinion about it?
Answer 12: The highest spatial resolution imagery freely available from non-commercial providers currently are from Sentinel-2 MSI and Sentinel-1 C-band products at 10m resolution. There has been robust research and operational use of coarse resolution data (>30 m) to observe large areas of homogenous cropland. However, cropland found in a lot of the world involves smaller intercropped fields which can not be differentiated with the current resolutions of freely available space-based sensors. UAVs and commercial satellite imagery combined with ground data can provide this information to meet the challenges at the local level, but are cost prohibitive for most of the world.

Question 13: I've used EVI for monitoring densely forested areas before but not for agriculture. In which situations does EVI provide an advantage over NDVI in agricultural applications?
Answer 13: EVI can correct for variations in solar incidence angle, atmospheric conditions, and signals from the ground cover. EVI can also better capture differences in heavily vegetated areas.

Question 14: Given the numerous satellites and sensors available and their uses, is there a key that can be used to filter all these? For example, I may be interested in vegetation health at a spatial resolution of 30m or less...what are my options? Or perhaps I might be interested in precipitation or perhaps soil moisture, etc. A key or simple online questionnaire that guides the end user to some satellite/sensor options and how to get at the data would be helpful.
Answer 14: The Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) has worked to continuously refine the requirements needed for agricultural monitoring as the state of missions, science, and practice evolve. Below is a link to their EO data requirements:
http://earthobservations.org/geoglam.php?t=eo_data_coordination&s1=eodc_about

Question 15: Will this series cover the use of optical and radar data for monitoring of tree-based crops (i.e. coconut, rubber etc.)?
Answer 15: No, this webinar will not be covering the monitoring of tree-based crops. ARSET will be hosting a forest mapping and monitoring webinar using SAR data starting **May 12th**. We hope you will register for this advanced webinar:
Forest Mapping and Monitoring with SAR Data
https://arset.gsfc.nasa.gov/land/webinars/forest-mapping-sar

Question 16: For horticultural production, with important separation between plants, the NDVI may not be the most suitable index with the resolution of, for example, MODIS or even Landsat 8. Would there be any index that might be suitable for monitoring horticultural production for smaller plots? Perhaps SAVI?
Answer 16: Where NDVI outputs tend to vary with soil color, soil moisture, and saturation effects from high-density vegetation, the Soil-adjusted Vegetation Index (SAVI) could be more appropriate. SAVI minimizes soil brightness and is particularly useful in circumstances where soil quality varies substantially within a single given area

of interest. For smaller plots the higher spatial spatial resolution sensors will be the best to experiment using both vegetation indices.

Question 17: How accurately can RS products help to estimate crop yield?
Answer 17: There has been a lot of research done in this area over the past decades. The first approach is based on the light-use-efficiency approach (Monteith, 1977) in which biomass is proportional to the total amount of absorbed photosynthetically active radiation (APAR) throughout a growing season. A second approach is to use crop simulation models to predict crop yields, with the remote sensing measurements used to adjust inputs or parameters for the model on a pixel-by-pixel basis. A third approach is to use a regression-based model that relates yield to a single quantity, such as a VI or FAPAR estimated on a specific date, usually NDVI at peak of season. Accuracies vary depending on a number of factors, such as the accuracy of the crop mask used, uncertainties inherent in the model, and access to in situ data and official crop statistics.

Question 18: Can you please explain slide 62? P,L,C,X,Ku, and Ka bands are all longer wavelengths?
Answer 18: The microwave bands discussed on slide 62 have much longer wavelengths than the visible and near infrared wavelengths discussed from the optical instruments on earlier slides. Please refer to ARSET's Fundamentals of Remote Sensing training as well as the other links provided below to learn more:
https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing
https://science.nasa.gov/ems/06_microwaves
https://science.nasa.gov/ems

Question 19: What are your thoughts on the Venus satellite for Ag?
Answer 19: It's very exciting. The spatial resolution of 5 m, revisit time of 2 days, and spectral resolution (VNIR) make it great for agricultural monitoring. Currently the satellite is observing select sites around the world which makes it inappropriate as an operational satellite.

Question 20: Which satellites are best suited for calculating evapotranspiration/crop water requirements on a daily basis?
Answer 20: MODIS and VIIRS provide 1-2 day coverage and can be used to calculate ET on a daily basis. There are also efforts in data fusion to get better daily ET. Here is a

paper for example: https://doi.org/10.1016/j.agrformet.2013.11.001. Also, here is some more information getting daily ET using data from multiple satellites: https://hyspiri.jpl.nasa.gov/downloads/2010_Workshop/day1/day1_13_Anderson_HyspIRI_2010_anderson.pdf. The last week of the webinar will focus entirely on ET.

Question 21: Which MODIS LST product between Aqua and Terra is better to use?
Answer 21: It depends on what time you are trying to obtain observations. Terra has ~10:30 am daily overpass and Aqua ~1:30 pm daily overpass. Terra also has ~10:30 pm nightly overpass and Aqua ~1:30 am nightly overpass. The earlier in the day temperatures will be on average lower (Terra) and in the afternoon temperatures on average will be higher (Aqua). The opposite is true at night. This information can help you decide what product is better for your needs.

Question 22: How can we find the exact time stamp for satellites like Landsat and Terra/Aqua overpass for a particular area?
Answer 22: The exact acquisition start and stop times for each scene are listed in the metadata file that is included in the Landsat product, and also displayed on EarthExplorer. Landsat data acquisition times are expressed in Greenwich Mean Time (GMT). The Terra/Aqua overpass is also listed in the metadata file associated with each product.

Question 23: Which is the most suitable sensor to measure the degradation of a grassland?
Answer 23: Currently, the most used sensor to monitor grasslands, and their degradation, is the MODIS instrument on the Terra and Aqua satellites. Surface reflectances are used to calculate vegetation indices to assess grassland conditions. The spatial resolution of 250 m to 1 km allows for regional to national monitoring on a daily basis. Since MODIS vegetation products have a record extending for 20 years, they are very useful in calculating anomalies in grassland and vegetation health.

GEOGLAM RAPP provides an online spatial data platform for assessing the condition of rangeland and pasture productivity using MODIS vegetation indices: http://map.geo-rapp.org/

Question 24: By what technique can the products of different sensors be merged?

Answer 24: There are a number of techniques, some of which we'll be going into greater detail in part 4 of this webinar series when discussing evapotranspiration. There is a lot of literature on this and below are a couple links.
Methods range from fusing optical data from different instruments, such as the Harmonized Landsat Sentinel (HLS) - https://hls.gsfc.nasa.gov/algorithms/ as was discussed earlier in the webinar - and fusing radar and optical data, as described in the article below.
https://www.mdpi.com/2072-4292/9/2/119
Challenges include spatial coregistration, BRDF normalization, spectral coregistration, as well as a number of other factors.

Question 25: Are you going to cover SMOS?
Answer 25: In this webinar series we will not be covering the Soil Moisture and Ocean Salinity (SMOS) mission. This is an ESA mission using a passive L-band radiometer similar to the SMAP mission. It launched in 2009 and has a spatial resolution of 35 km with a 1-3 day revisit time. To learn more about this mission you can refer to this link:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos

Question 26: Will this series cover remote sensing applications in the Early Warning System for Vector-Borne Diseases?
Answer 26: No, we will not be covering this topic but we are including some links below for more information:
https://www.annualreviews.org/doi/10.1146/annurev-ento-010715-023819
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0092538

Question 27: Is it possible to merge radar and optical sensor products?
Answer 27: Yes, it is possible. The goal of multi-sensor (radar & optical) image fusion seeks to combine information from different images to obtain more inferences than can be derived from a single sensor. There have been a number of projects carried out for agricultural applications:
https://www.tandfonline.com/doi/full/10.1080/01431161.2019.1569791?casa_token=NDs5gy3zPVQAAAAA%3Acn6CBTAzZGeXu8DoodMhNxxGOIIY-eed5QVpMyZeDm8ShLcaHtiOkr3RsJXRSwBseGWXgICOXmh0TQ

Question 28: For the SNAP program in all its versions, the toolbox soil moisture has been removed, how can you install the toolbox soil moisture?

Answer 28: I have the latest version of SNAP installed (v7.0) and the SMOS box is there. The tools can be found under: View→Tool Windows→SMOS

Question 29: Is there any freely available data that could be used to monitor vegetation regeneration on a very precise scale as we could do with a LIDAR?
Answer 29: Moderate SAR imagery (~10 m) and optical imagery (10 m) can be applied for monitoring stages of vegetation regeneration with a relatively high spatial and temporal resolution. Two other missions to look into are the GEDI (https://gedi.umd.edu/mission/mission-overview/) and IceSat-2 (https://icesat-2.gsfc.nasa.gov/) missions, though both have a coarser spatial resolution.

Question 30: What is the difference between top of atmosphere (TOA) reflectance and raw satellite imagery?
Answer 30: Raw scenes contain imagery with digital numbers (DNs) that represent scaled radiance as an unsigned integer. They are pixel values that have not been calibrated into physically meaningful units and have had no radiometric or geometric correction applied. Raw digital numbers (DN) can be converted to TOA reflectance. Equations rescale the data based on sensor specific information and remove the effects of differences in illumination geometry (different solar angle, Earth-sun distance) and are georeferenced. https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products

Question 31: Is there another data source of free satellite images, I mean other than NASA or ESA, like Brazilian or Indian Space Agencies? What do you recommend?
Answer 31: There are a number of public providers of freely available satellite imagery. Selecting the appropriate imagery really depends on what scientific question you are trying to answer. Below are links to data providers.
NASA: https://search.earthdata.nasa.gov/search
National Oceanic and Atmospheric Administration: https://www.ncdc.noaa.gov/
Canadian Space Agency: https://www.asc-csa.gc.ca/eng/open-data/access-the-data.asp
Copernicus Open Access Hub (ESA): https://scihub.copernicus.eu/
Indian Space Research Organization: https://bhuvan.nrsc.gov.in/bhuvan_links.php
Brazil's National Institute for Space Research: http://www.dgi.inpe.br/catalogo/
Japan Aerospace Exploration Agency: https://www.eorc.jaxa.jp/ALOS/en/aw3d30/

Question 32: Could you make some light on Sun Induced Fluorescence signals as it emerges as a novel indicator for vegetation monitoring?
Answer 32: Solar-induced chlorophyll fluorescence (SIF) is regarded as a powerful proxy for photosynthesis as it is linked to the electron transport in the light reactions of photosynthesis. SIF is a weak electromagnetic signal (spectrally smooth double-peak feature with maximum values in the red and far red) emitted from excited chlorophyll *a* molecules after absorption of photosynthetically active radiation.
Data can be obtained from the following missions.

OCO-2 mission:
https://daac.ornl.gov/VEGETATION/guides/Global_High_Res_SIF_OCO2.html

Tropomi: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018GL079031

https://www.sciencedirect.com/science/article/pii/S0034425719301816

Question 33: Which are the main tools to estimate yield of crops such as wheat, maize, soybean, or sunflower?
Answer 33: There has been a lot of research done in this area over the past decades. The first approach is based on the light-use-efficiency approach (Monteith, 1977) in which biomass is proportional to the total amount of absorbed photosynthetically active radiation (APAR) throughout a growing season. A second approach is to use crop simulation models to predict crop yields, with the remote sensing measurements used to adjust inputs or parameters for the model on a pixel-by-pixel basis. A third approach is to use a regression-based model that relates yield to a single quantity, such as a VI or FAPAR estimated on a specific date, usually NDVI at peak of season. Accuracies vary depending on a number of factors, such as the accuracy of the crop mask used, uncertainties inherent in the model, and access to in situ data and official crop statistics.

Question 34: How do you classify crops using Sentinel without ground data? We have just a crop calendar.
Answer 34: Phenological Data - Since the vegetation appearance changes quickly in the course of the phenological cycle, a high observation density particularly in key phenological stages may be promising to optimize the separation of crop types.

Growing Degree Days (GDD) - Can be applicable in regions of the planet where temperature is a limiting factor in plant growth. Machine learning and deep learning methods have proven successful as well.

Question 35: How would you determine crop type using optical data? What is the best location to determine the NDVI ranges and growing season?
Answer 35: If you have no in situ data, you can test the feasibility of labeling groups of pixels based on temporal trends of their NDVI values. The logic is that NDVI curves of pixels representing the same crop type will have similar characteristics and can therefore be grouped together and labeled. Much research has found that the highest correlation between NDVI and yield of crops occurs at the height of the growing season when NDVI values and photosynthetic activity of plants are at their relative maximum.

Question 36: What do you think about the Sat Cubes? Is NASA going to build one and make the algorithms free?
Answer 36: CubeSats (or SmallSats), offer opportunities to conduct scientific investigations and technology demonstrations in space in such a way that is cost-effective, timely, and relatively easy to accomplish. They open the door for governments, commercial companies, educational institutions, and non-profit organizations to space science and exploration.
NASA's CubeSat Launch Initiative provides opportunities for small satellite payloads built by universities, high schools, and non-profit organizations to fly on upcoming launches to the ISS.
Researchers are using CubeSats to detect in-season crop nitrogen stress in crops:
https://ieeexplore.ieee.org/document/8950295
CubeSats are great as they provide timely, high spatial, multispectral data for a range of applications. The drawback is the sensors are not nearly as well calibrated as say MODIS or OLI instruments.

Question 37: Is there satellite data available that can measure soil moisture content at deeper depth >1m?
Answer 37: SMAP provides soil moisture up to 1m in depth. GLDAS provides soil moisture in the top 2 meters. Both of these products are derived using a model and hence are estimates of soil moisture at those depths rather than direct observations.

Question 38: Which RS satellite mission(s) can be used to estimate daily crop evapotranspiration in Africa? For each of them, kindly inform on:

i) whether it is reference or potential ET;
ii) evapotranspiration calculation formula(e) used;
iii) resolution (spatial and temporal);
iv) sources (internet) and time range of data;
v) level of processing of the available data;
v) level of accuracy of estimations, from previous studies.

Answer 38: You are in luck because we will cover this topic in the series! Please join us for week 4 of the webinar series to learn all about ET. ARSET also held a training on this subject in 2016. You can access those materials here: Applications of Remote Sensing to Soil Moisture and Evapotranspiration

Question 39: Are there any missions other than CHIRPS for long term precipitation?
Answer 39: There is a combined TRMM and GPM precipitation product (IMERG) available that extends from 2000-present. Please visit the ARSET webinar on IMERG for more information: Advanced Webinar: Applications of GPM IMERG Reanalysis for Assessing Extreme Dry and Wet Periods

Question 40: What kind of software is the best for processing MODIS-11 data? Will you show us some practical examples on how to analyze RS data with respect to their application for agriculture?
Answer 40: There is a number of image processing software out there to process and analyze MOD-11 data. Some open source (and open access) options are QGIS, Google Earth Engine, Python, and R. Some commercial options are ArcPro, ENVI, ERDAS, and TerrSet. As this is an Introductory Webinar the aim is to provide you with the knowledge and comprehension of using satellite imagery for agricultural applications. The goal is to build on this introductory agricultural training in subsequent webinar series with more advanced training where participants will apply and evaluate the lessons through practical examples.

Question 41: Is there any study mapping irrigated versus rainfed crops?
Answer 41: There have been many studies mapping irrigated versus rainfed crops. We are including some links below for your reference:
https://www.sciencedirect.com/science/article/pii/S0303243415000240

https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2017GL075733
https://ieeexplore.ieee.org/abstract/document/8897883
https://www.mdpi.com/2072-4292/10/9/1495

Question 42: Are you aware of NASA or USDA doing R&D on using aerial drones to ground-truth crop forecasting models relying on remote sensing data?
Answer 42: I am not aware of any use of drones, either by NASA or the USDA, to ground truth crop forecasting models relying on satellite imagery.