Questions & Answers Session Part 2

Please type your questions in the Question Box. We will try our best to answer all your questions. If we don't, feel free to email Amy Leibrand (leibranda@batelle.org) or Meredith Fritz (fritz@batelle.org).

Question 1: Changes in land use also can affect biomass as a source of energy, which perhaps could be identified from observations. Further, can you elaborate as to how movement of biomass could be observed and such transported biomass can be quantified? In other words, the dynamics of biomass movements compared to static biomass standing stocks (part of which is considered a biomass resource)?
Answer 1: NASA has been involved in various studies looking at vegetation, carbon stocks, and other forest-related metrics. Broadly, tools for monitoring biomass in an area might include Landsat imagery, NDVI (measure of 'greenness'), agricultural data from USDA, or other ground-based data from the U.S. Forest Service or others. NASA has also developed a biomass product based on estimates of aboveground terrestrial vegetation biomass and carbon storage for the U.S.; more information can be found here: https://carbon.nasa.gov/biomass.html
In another study, NASA developed maps of forest canopy height and distribution of branches and leaves in forests to understand biomass and carbon storage in forests. More information can be found here: Additionally, the GEDI mission includes sensors that collect detailed information on forest composition including canopy height and distribution of leaves and branches.
https://www.nasa.gov/feature/goddard/2020/nasa-forest-structure-mission-releases-first-data
Finally, more information on satellite-derived biomass products can also be seen here: https://lpvs.gsfc.nasa.gov/AGB/AGB_home.html.

Question 2: What is the approximate delay in real-time data? Asking for potential applications in assessing and predicting forest-fire trajectories.
Answer 2: Data latency is product and dataset dependent. NASA FIRMS (VIIRS and MODIS active fire data) distributes near real-time active fire data within three hours of satellite observation. Additional information on data latency for NASA products can be

found here: https://earthdata.nasa.gov/learn/backgrounders/data-latency. We will also include a link to FIRMS as well.

Question 3: Can you please show me a link to the R code you provided on slide 26, because I couldn't find this link?
Answer 3: The code is available on Github, including both R and Python code: https://github.com/giacfalk/hydropower_remotesensing

Question 4: What is the role of utilities in the geotechnical field?
Answer 4: Understanding the composition of soil, rock, and earth materials is important for infrastructure siting and route planning. Soil moisture data (from SMAP) may be of interest. Additionally, this is an area where hyperspectral imagery could be used.

Question 5: Any specific application on the oil and gas sector by EO data?
Answer 5: There has been somewhat limited application of NASA data in the oil and gas sector, however NASA has a methane source finder that includes methane datasets for viewing and download: https://methane.jpl.nasa.gov/. NASA also offers sensor solutions that may be applicable to the oil and gas industry through their technology transfer program: ttps://technology.nasa.gov/page/sensor-solutions-for-the-oil-and-ga. An example of NASA data being used to look at methane from the oil and gas industry can be seen here: http://sdg.iisd.org/news/nasa-confirms-methane-increase-linked-to-oil-and-gas-industry/
Another example of an application is: https://spinoff.nasa.gov/Spinoff2020/ee_3.html
NASA has also monitored carbon emissions, including from sources such as the oil and gas sector. More information on NASA's Carbon Monitoring System is here: https://carbon.nasa.gov/missions.html. Information on carbon dioxide measurements are here: https://climate.nasa.gov/vital-signs/carbon-dioxide/ and here: https://climate.nasa.gov/climate_resources/99/graphic-measuring-carbon-dioxide-from-space/

Question 6: Do you see other concrete applications of machine learning for assessing electricity restoration efforts?
Answer 6: Here are some case studies regarding use of machine learning for electricity restoration. The first example is the most concrete.

- Machine Learning in Support of Electric Distribution Asset Failure Prediction https://scholar.smu.edu/cgi/viewcontent.cgi?article=1096&context=datasciencereview
- Predicting power outages caused by extratropical storms https://nhess.copernicus.org/articles/21/607/2021/
- Quantifying Uncertainty in Machine Learning-Based Power Outage Prediction Model Training: A Tool for Sustainable Storm Restoration https://www.mdpi.com/2071-1050/12/4/1525
- Dissertation: Development of a distributed machine learning platform with feature augmented attributes for power system service restoration https://openrepository.aut.ac.nz/bitstream/handle/10292/11641/AlKarimM.pdf?sequence=5
- Machine Learning-based Service Restoration Scheme for Smart Distribution Systems with DGs and High Priority Loads https://ieeexplore.ieee.org/document/8849002

Question 7: Hello, has NASA EO data been used before for monitoring seismic activity?
Answer 7: NASA data has been used for monitoring the impact of earthquakes. NASA Advanced Rapid Imaging and Analysis (ARIA) uses radar and optical remote sensing, GPS and seismic observations to investigate earthquakes. With ARIA, maps of an earthquake can be made within a day to several days afterwards, depending on the availability of earliest post-earthquake radar observations. More information on ARIA can be found here: https://aria.jpl.nasa.gov/
Examples of ARIA being used in earthquake response include:

- https://www.jpl.nasa.gov/news/nasas-aria-team-maps-california-quake-damage
- https://www.jpl.nasa.gov/news/nasas-aria-team-helps-in-puerto-rico-quake-response

Question 8: What are the most [effective?] remote sensing methods that have been used for plant productivity analysis?
Answer 8: NASA's Primary Production products are designed to provide an accurate regular measure of the growth of the terrestrial vegetation. These include Net Primary Productivity and Gross Primary Productivity products from MODIS:

https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/science-domain/gpp-and-npp/.

Question 9: Which one is the best source to monitor soil moisture? What is the soil depth of the satellite measure?
Answer 9: SMAP (https://smap.jpl.nasa.gov/) and GRACE (https://www.nasa.gov/mission_pages/Grace/index.html) are great sources of soil moisture data. The Soil Moisture Active Passive (SMAP) mission is an orbiting observatory that measures the amount of water in the surface soil everywhere on Earth (measurements every 2-3 days). Different data parameters use different soil depths (e.g., for soil temperature. moisture). NASA's Gravity Recovery and Climate Experiment (GRACE) satellite mission has wetness/drought indicator maps for shallow groundwater and surface and root zone soil moisture. See more information here: https://earth.gsfc.nasa.gov/hydro/data/groundwater-and-soil-moisture-conditions-grace-data-assimilation

Question 10: Can nighttime lights alone be a source for identifying whether an area is electrified or not?
Answer 10: No, nighttime lights alone are not sufficient to tell whether an area is electrified or not. For example, generators that run or vehicle lights at night may make an area look electrified, when in fact it may not be. NTL data can be used together with regional-level data on population and land cover data. But NTL data alone can be a useful proxy in rural electrification projects, residential consumption, population fluctuations, and post disaster events. Other applications of NTL data include estimating population, assessing electrification of remote areas, monitoring disasters and conflict, and understanding biological impacts of increased light pollution.
More information the NTL product can be found here:
https://earthdata.nasa.gov/learn/backgrounders/nighttime-lights

Question 11: How reluctant are energy companies to adopt EO data?
Answer 11: Some utilities already use satellite data (and at very advanced levels), some do not. The degree to which a utility uses satellite data varies per utility depending on capacity, staffing, awareness, and other factors. Larger utilities have teams using EOs, drone-based data, ground-based data, and fine-resolution data purchased from the private sector. Greater awareness of the possibilities and role of EOs, as well as a

better understanding of resolution, uncertainty, and validation, will help increase EO use among the private sector and energy companies.

Question 12: Is there an application of remote sensing data in the Marginal Soil field?
Answer 12: Marginal land is land that is of little agricultural value because crops produced from the area would be worth less than any rent paid for access to the area. Land use data from MODIS and VIIRS as well as Landsat imagery could be used in the marginal soil field.

Question 13: Are there resources for the applications of remote sensing in Geothermal energy?
Answer 13: Satellite thermal imaging can be used for measuring and monitoring changes in geothermal areas. There is quite a bit of research about the use of remote sensing for this application; however, there is no one specific NASA product that is used. One example of assessing geothermal energy using NASA data is the use of Landsat 7 (L7) Enhanced Thematic Mapper Plus (ETM+) imagery for geothermal anomaly mapping. As well, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite has been used for geothermal prospecting in research applications by assessing nighttime temperatures in thermal areas.

Question 14: Are there any applications of SAR data being used for Energy Management?
Answer 14: Yes! Synthetic-aperture radar (SAR) satellite data can be used to monitor oil pipelines from a fine scale, including vegetation incursion, land subsidence, and construction activities. SAR data has been used to measure land subsidence and gauge threats to infrastructure by utilities. The private sector offers several options for SAR datasets, as does the European Space Agency (ESA)'s Sentinel, but NASA does not currently offer any SAR data. More information can be found from NASA here: https://earthdata.nasa.gov/learn/backgrounders/what-is-sar

Question 15: As EO satellite datasets are quite varied, its application requirements might be quite complex to be used? Most probably for designing and implementing for real time detection and monitoring of energy operations? How can this complexity be simplified?

Answer 15: It is complicated to use NASA EOs, particularly if you're new to remote sensing. In energy management, it can also be difficult because the most valuable applications combine various EO datasets, ground data, and other data sources. Efforts are being made to address barriers such as lack of awareness or understanding, with references such as the StoryMap, NASA EarthData, or Climate Resilience Toolkit. Interested parties should also start with ARSET trainings, webinars, or tutorials. While simplifying is important to increase users of EO data, it's important to not over-simplify important details associated with actionability (is the dataset actionable in terms of temporal and spatial resolution, coverage, etc.), uncertainty, validation, and other characteristics that must be known and understood in order to appropriately put the data into practice.

Question 16: Can Black Marble imagery be used to analyze forest fires at night?
Answer 16: Black Marble is playing a vital role in research on fires, and can be used to view images of forest fires at night. For example, NASA has used Black Marble to view wildfires in Australia (see here: https://www.nasa.gov/mission_pages/NPP/news/aus-fires.html). However, there are more appropriate tools for assessing wildfire, such as NASA FIRMS (https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms) since Black Marble can also pick up light from fishing boats, gas flaring, lighting, oil drilling, mining operations, or other sources of light. Both Black Marble and FIRMS utilize data from Suomi NPP VIIRS.

Question 17: For forest fires that happen at night, when making corrections to omit clouds covering the fire area, are there filters to account for the smoke produced by fires? Or is the smoke also "corrected out"? Asking because smoke drift is also useful in planning for fire protection and evacuation planning.
Answer 17: In the data provided through FIRMS (both MODIS and VIIRS: https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms) there are no filters to account for smoke, and smoke can obscure fire detections. Super-heated smoke plumes can also erroneously be detected as fire, though these are fairly rare.

Smoke and clouds appear differently depending on the data product (e.g., different colors in imagery). An example with more information is here: https://www.nasa.gov/feature/goddard/2020/from-smoke-going-round-the-world-to-aerosol-levels-nasa-observes-australias-bushfires.

NASA also has information on smoke plumes available here: https://earthdata.nasa.gov/earth-observation-data/near-real-time/hazards-and-disasters/smoke-plumes and more on fire and smoke here: https://www.nasa.gov/mission_pages/fires/main/index.html

MODIS land surface reflectance products also provide the ability to view high-resolution imagery of smoke from wildfires. MODIS estimates surface spectral reflectance as it would be measured at ground level in the absence of atmospheric scattering or absorption. Low-level data are corrected for atmospheric gases and aerosols. https://modis-land.gsfc.nasa.gov/surfrad.html

Question 18: Which machine learning techniques are supported by Google Earth Engine?
Answer 18: Machine Learning (ML) in Earth Engine is supported with:

- EE API methods in the ee.Classifier, ee.Clusterer, or ee.Reducer packages for training and inference within Earth Engine.
- Export and import functions for TFRecord files to facilitate TensorFlow model development. Inference using data in Earth Engine and a trained model hosted on Google's AI Platform is supported with the ee.Model package.

Training and inference using ee.Classifier or ee.Clusterer is generally effective up to a request size of approximately 100 megabytes. As a very rough guideline, assuming 32-bit (i.e. float) precision, this can accommodate training datasets that satisfy (where *n* is number of examples and *b* is the number of bands):

$$nb \leq (100 * 2^{20}) / 4$$

This is only an approximate guideline due to additional overhead around the request, but note that for $b = 100$ (i.e. you have 100 properties used for prediction), $n \cong 200{,}000$. Since Earth Engine processes 256x256 image tiles, inference requests on imagery must have $b < 400$ (again assuming 32-bit precision of the imagery). Examples of machine learning using the Earth Engine API can be found on the Supervised Classification page or the Unsupervised Classification page. Regression is generally performed with an ee.Reducer as described on this page, but see also ee.Reducer.RidgeRegression.

If you require more complex models, larger training datasets, more input properties or longer training times, then TensorFlow is a better option. TensorFlow models are developed, trained and deployed outside Earth Engine. For easier interoperability, the Earth Engine API provides methods to import/export data in TFRecord format. This facilitates generating training/evaluation data in Earth Engine and exporting them to a format where they can be readily consumed by a TensorFlow model. To perform prediction with a trained TensorFlow model, you can either export imagery in TFRecord format then import the predictions (also in TFRecord) to Earth Engine, or you can deploy your trained model to Google AI Platform and perform inference directly in Earth Engine using ee.Model.fromAiPlatformPredictor.

See the TensorFlow page for details and example workflows.

https://developers.google.com/earth-engine/guides/machine-learning

Question 19: We are working on the construction of 3D models of cities in Latin America in order to evaluate the shadows and radiation received by the roofs to install photovoltaic modules. Do you have any product that can help us with this issue?
Answer 19: NASA Prediction of Worldwide renewable Energy Resources (POWER) may be able to provide data applicable to this issue. The 4th session of this training series will focus on illustrative case studies of how POWER data are used for applications in solar energy, wind energy, and energy efficiency. NASA POWER can be accessed here: https://power.larc.nasa.gov/.

Question 20: With regard to lightning strikes do NASA satellites have any product that is specifically dedicated to cloud monitoring or possible lightning predictions?
Answer 20: Yes there are NASA products on lightning predictions. The NASA Global Hydrology Research Center (GHRC) provides information and datasets pertaining to lightning research: https://ghrc.nsstc.nasa.gov/lightning/. There are many lightning datasets available through NASA GHRC: https://ghrc.nsstc.nasa.gov/lightning/dataset-info.html.

Question 21: As nuclear power plants are highly dependent on water availability, does a NASA product or research exist on the risk at short time with water availability for each nuclear power plant on the globe?

Answer 21: Water is used for various purposes in nuclear power plants so water availability is indeed a significant issue, as we mentioned in both Sessions 1 and 2. Data sources could include global precipitation measurement (GPM), Advanced Microwave Scanning Radiometer 2 (AMSR2) surface rain rate data, groundwater data, soil moisture, rainfall, snow and ice, rivers and lakes, and others. The StoryMap has a section on surface water which will be helpful for this purpose: https://itcanbedone.maps.arcgis.com/apps/MapSeries/index.html?appid=f3f5aa31bd5f4eb7b3abe033a403ab4f. NASA also has information on freshwater availability: https://earthdata.nasa.gov/learn/toolkits/freshwater-availability

Question 22: How is remote sensing applied in the observation of migratory bird patterns? What satellites are used? And are there any current projects from NASA?
Answer 22: This link uses Landsat imagery for this particular application: https://earthobservatory.nasa.gov/images/86685/satellite-data-helps-migrating-birds

Question 23: Is there land under the ocean? If so, are there plate movements like the way there is for continents?
Answer 23: Yes, the seafloor is composed of tectonic plates. Oceanic plates are formed by divergent plate boundaries. These zones, located along mid-ocean ridges, represent areas where upwelling magma creates new oceanic crust. As lava flows from these volcanic ridges, it quickly cools, forming extrusive igneous rock. As oceanic plates subduct, they melt to form magma. There are key differences between continental plates and oceanic plates: https://sciencing.com/density-temperature-lithosphere-23341.html. NASA researchers have used remote sensing in the past to assess oceanic plates: https://www.jpl.nasa.gov/news/tectonic-plates-movements-studied-using-satellites.

Question 24: In this perspective, do you have any plans to support more composite index tools in those sectors, even though each user can take advantage of these tools individually?
Answer 24: NASA has an Image Composite Explorer (ICE) that allows users to select datasets for side-by-side comparison. Lots of datasets are available, sorted by categories such as atmosphere, energy, land, life, and ocean. For energy specifically, it includes global temperature anomaly, solar insolation, and net radiation. It can be found here: https://neo.sci.gsfc.nasa.gov/ Also, the Prediction Of Worldwide Energy

Resources (POWER) Data Access Viewer (DAV) provides integrated graphing capabilities of NASA Earth Observation data as time-series from multiple sources.

Question 25: What exactly is a microgrid?
Answer 25: A microgrid is a self-sufficient energy system that serves a discrete geographic footprint, such as a college campus, hospital complex, business center, or neighborhood. Within microgrids are one or more kinds of distributed energy (solar panels, wind turbines, combined heat & power, generators) that produce its power.

Question 26: Can we use the datasets available in open source tools like QGIS or python? If yes, is there any plan to give a demo?
Answer 26: Yes, some data can be used in QGIS and python. The Falchetta example uses Python and R code in Google Earth Engine. A demo is not planned at this time, but other ARSET courses may go into more detail with demos. This ARSET course on Use of Solar Induced Fluorescence and LIDAR to Assess Vegetation Change and Vulnerability contains a demonstration of a data prep script for subsetting GEDI data using Python.
https://appliedsciences.nasa.gov/join-mission/training/english/arset-use-solar-induced-fluorescence-and-lidar-assess-vegetation

NASA offers a variety of other tutorials for using their data with Python. See the following links:

- https://lpdaac.usgs.gov/resources/e-learning/
- https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+Python
- https://disc.gsfc.nasa.gov/information/howto?title=How%20to%20Read%20IMERG%20Data%20Using%20Python
- https://github.com/nasa?language=python

The examples of Prediction Of Worldwide Energy Resources (POWER) Application Programming Interface (API) integrations in Webinar 4.

Question 27: Is it possible to access google earth engine algorithms to view radiation and surface temperature data for photovoltaic solar panel projects?

Answer 27: I'm not sure if algorithms for temperature and radiation are available, but data certainly are. Here is a link to the data catalog. There may be open-source scripts available and APIs are available. Open-source code can be found on GitHub as well.

Data catalog: https://developers.google.com/earth-engine/datasets/catalog

Here is the developer guide: https://developers.google.com/earth-engine/guides

Prediction Of Worldwide Energy Resources (POWER) provides global pre-computed radiation and surface temperature data accessible via an Application Programming Interface (API). This will be shown in Webinars 3 & 4. Specifically we have examples on site assessments and monitoring photovoltaic solar panel installations.

Question 28: With NASA's tools, is it possible to study ocean currents to visualise the direction and concentration of debris islands (such as The Great Pacific Garbage Patch)?
Answer 28: GRACE has been used to monitor ocean currents. NASA scientists developed a way to isolate in the GRACE gravity data the signal of tiny pressure differences at the ocean bottom that are caused by changes in the deep ocean currents. ASTER has captured images of garbage islands.

https://www.nasa.gov/feature/jpl/nasa-finds-new-way-to-track-ocean-currents-from-space
https://earthobservatory.nasa.gov/images/90572/the-remote-paradise-with-a-plastic-problem

Question 29: What are the best resources/data sources for hydroelectric analysis? Is it only TOPEX/POSEIDON, NTL like the case study mentioned today?
Answer 29: The StoryMap featured in session 1 includes a section under the "Case Studies" tab specific to hydroelectric power and associated datasets: https://arcg.is/0SPqqK.

Question 30: In the perspective of energy security, do you have any energy sharing scenario optimization project considering natural, socio-economic, and political aspects?

Answer 30: Cybersecurity is an important component of energy resilience that we don't touch on in this presentation. McKinsey recently created a report about this topic, linked below. Some utilities have proprietary, valuable data and algorithms that they've put together to manage energy within their service area. As of now, there is no way for utilities to share these tools and it may not be of interest to utilities to share tools that they've made.
https://www.mckinsey.com/business-functions/risk/our-insights/the-energy-sector-threat-how-to-address-cybersecurity-vulnerabilities

Question 31: The POWER Project portal is up to date? Can we extract data from there?
Answer 31: Yes, the POWER solar irradiance and meteorological data is Near Real Time (NRT) available at the daily, monthly, annual, and climatological temporal levels. The data is available for download or direct integration into applications. We have examples in Webinars 3 & 4!

Question 32: Is there any model to predict net changes in solar energy (e.g., due to storms, rain, etc.) so that one can develop a forecast for the community?
Answer 32: The NASA Prediction Of Worldwide Energy Resources (POWER) project was initiated to improve upon the current renewable energy data set and to create new data sets from new satellite systems. The POWER project targets three user communities: (1) Renewable Energy, (2) Sustainable Buildings, and (3) Agroclimatology. The POWER project provides solar radiation data, and is being discussed in Webinars 3 & 4!

Question 33: Which data is available for developing pyrolysis of waste and energy generation? In terms of air pollution.
Answer 33: Data on aerosols may be helpful for looking at pyrolysis. You can visualize several air pollution parameters using EarthData (linked below) including aerosol index, aerosol optical depth, carbon monoxide, ozone, sulfur dioxide, and more.
https://earthdata.nasa.gov/earth-observation-data/near-real-time/hazards-and-disasters/air-quality