Questions & Answers Part 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 Forrest Melton (forrest.s.melton@nasa.gov) or Amita Mehta (amita.v.mehta@nasa.gov).

Question 1: Is the OpenET database updated in real-time?
Answer 1: Monthly data is typically updated within 2-3 weeks and no later than 6 weeks after the end of each month. Daily data is usually updated within 3-8 days of satellite overpass, and the OpenET team is currently testing a workflow for near real-time daily data that will provide daily data within 24-72 hours of satellite overpass.

Question 2: Is the OpenET data available only in the USA? If so, how can I study similar data in countries in Asia?
Answer 2: OpenET is currently only available for the Western US and the team is currently producing data for OpenET Collection 2.0 that will also include the Mississippi Alluvial Plain. We are currently working with international partners in pilot studies in Brazil (with Dr. Anderson Ruhoff) and other regions. For assessing ET in Asia, data from other NASA sensors (MODIS, ECOSTRESS) would be worth evaluating.

Question 3: How different/improved are the OpenET estimates from the Dynamic Global Vegetation Models (DGVMs)?
Answer 3: We have not yet compared data from OpenET against estimates of ET from DGVMs. OpenET provides data at a spatial scale of 30 x 30m, and the satellite data allows us to calculate ET from all sources (precipitation, applied water, and shallow groundwater). As a result, we don't have to make assumptions about irrigation or use modeled irrigation estimates to calculate ET.

Question 4: Great data tool! Will these data be available for use in Google Earth Engine? Is there a release date?
Answer 4: We will start by submitting data from OpenET Collection 2 for 2016-2020 to the Google Earth Engine public data catalog this summer, and will continue to add data as the OpenET data archive grows.

Question 5: Which model is the best for estimating ET while plotting against NDVI?
Answer 5: In general, the SIMS model will most closely track NDVI. However, for quantifying ET, we would currently recommend using the ensemble ET value and/or evaluating ET from multiple individual models for new applications.

Question 6: Would you expect that OpenET could be useful to estimate evaporation in covers without vegetation (e.g., open water, moist/dry soil, covered or not with stubble from previous crops)? How would you expect OpenET to perform with other vegetation types (not crops) like dry forests?
Answer 6: Yes, we would expect data from OpenET to be useful for bare soil, stubble, etc. We are still evaluating OpenET data for open water evaporation.

Question 7: How is OpenET different from the MODIS ET product?
Answer 7: OpenET has a higher spatial resolution (30 x 30m) and provides data from an ensemble of six models that use both energy balance and reflectance-based approaches to calculate ET.

Question 8: Was there a separate accuracy assessment for non-croplands?
Answer 8: Yes, approximately 50% of the sites (72 out of 142 sites) used in the OpenET accuracy assessment were from non-agricultural sites. Results from this analysis are currently in preparation for submission, and a summary of results will be added to https://openetdata.org/accuracy.

Question 9: Do you apply surface energy budget closure correction to the flux tower ET estimates before comparing with the OpenET estimates?
Answer 9: Yes, energy balance closure corrections were made using the energy balance ratio approach. Please see Melton et al., 2021 and Volk et al., 2021 for details.

https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12956

https://joss.theoj.org/papers/10.21105/joss.03418.pdf

Question 10: What is the resolution of the data?
Answer 10: Spatial resolution is 30 x 30m (0.22 acres) per pixel. Data is available at daily, monthly and annual timescales.

Question 11: Is it possible to get an insight into the algorithm used to generate data in OpenET?
Answer 11: Yes, please see https://openetdata.org/methodologies/ and https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12956 for a summary, and links to the key papers describing methods used in each model. We are also working on creating open source repositories for each model. For example, see https://github.com/Open-ET/openet-ssebop and https://github.com/et-brasil/geeSEBAL.

Question 12: Do any other countries have anything similar to OpenET?
Answer 12: Yes, three examples come to mind: I know Australia maintains a system called Irrisat (https://www.irrisat.com/en/home-2), and Anderson Ruhoff is leading planning for an ET mapping system for Brazil that builds on the OpenET framework. UN FAO is also developing the WaPOR dataset for Africa and the Near East (https://www.fao.org/3/ca9894en/CA9894EN.pdf). The ET data is WaPOR is generated using the SEBAL model, and the OpenET ensemble includes geeSEBAL.

Question 13: With the example of the farmer that has saved water using OpenET, has he achieved the decrease in use because he has supplied water only for the plant and not for the underground? Can you explain which component of the ET equation he has decreased?
Answer 13: In the example given, the farmer is using the ET data to manage the irrigation system to match the volume of applied irrigation to the volume of water lost through ET. As a result, the farmer has been able to reduce pumping and save water on electricity. It's important to note that this doesn't necessarily mean that ET has been reduced. In fact, we've found examples where making improvements to the irrigation system (such as switching from flood to sprinkler) increased the crop uniformity and yield, and as a result the total actual ET increased because there was much more uniform and consistent crop canopy (although the ET/ton of yield decreased). Using satellite-based ET from OpenET or other sources is really important when evaluating the impact of investments on irrigation efficiency on consumptive water use. This can be especially valuable when combined with information on applied water from meters.

Question 14: For the forest management example, I have not understood what they have done to get a more resilient forest. Can you explain all the actions that they have done and how which action was justified by OpenET data?

Answer 14: The Salt River Project is conducting mechanical forest thinning and other forest treatments to reduce wildfire risk in the watershed. They are using OpenET to evaluate changes in evaporative stress and overall ET to understand how different practices are impacting the hydrology in the watershed.

Question 15: It would be incredible to replicate this for my own country - I wonder what the resources needed would be? What are the essential data variables and what's the global coverage of the satellite data?
Answer 15: The satellite data provides global coverage, but with two Landsat satellites we only obtain one satellite observation every 8 days for most locations on the Earth's surface, so persistent cloud cover can be problematic for some regions. We can combine the satellite with national or global gridded meteorological data to map ET for most locations globally. However, it is often valuable to have local weather data from agricultural weather stations to check for any biases in the gridded meteorological data. It's also helpful to have local flux tower measurements for use in accuracy assessments for key crops or land cover types in a region.

To help challenges associated with persistent cloud cover, the science community is working on different approaches for using daily thermal infrared data at coarser spatial scales from sensors like VIIRS with Landsat to produce a daily LST at scales in the range of 30-100m. For example, see https://www.sciencedirect.com/science/article/pii/S0034425720304259.

Question 16: How is KC value calculated by NDVI?
Answer 16: For details on the approach used by SIMS to compute a Kc from NDVI, please see Pereira et al., 2020 and/or the SIMS Use Manual.

Question 17: How do you think this method will perform with sparse vegetation?
Answer 17: OpenET should generally perform well for areas with sparse vegetation, but we have observed greater disagreement in ET estimates for barren/sparsely vegetated land cover types. And since the absolute ET values are low, even relatively small absolute errors (for example, 0.5 to 1.0 mm/day) can translate into larger percent errors. Improving the accuracy of ET estimates for shrublands and forests are two priority research topics for the OpenET team.

Question 18: At this point in its development, would you say that the OpenET estimates of open water evaporation are better than using other existing gridded ET estimates?
Answer 18: The OpenET team is currently working on evaluations of OpenET data over open water, and we haven't yet made comparisons against estimates from other sources.

Question 19: Are there experiences of the OpenET project in the rain-fed conditions (e.g., in the United States' 17 states)?
Answer 19: Yes, a number of our flux tower sites were over rain-fed agriculture.

Question 20: Have you tested this technology in arid desert environments? How does accuracy behave in different environments like deserts/forests?
Answer 20: Please see the answer above about sparsely vegetated land cover types.

Question 21: In general, what is the relation between ET and amount of irrigation water? If ET goes up, should I reduce the cropwater?
Answer 21: The relationship between ET and applied water can be complex. If ET goes up, that definitely does **not** mean irrigation needs to be reduced (in fact, it could mean that the crop was previously water stressed). ET measures the amount of water that is removed from the root zone and transferred to the atmosphere through the process of evapotranspiration. The objective of data-driven irrigation that uses ET information is to more closely match the amount of applied water to a field to the water consumed through ET over a specific time period to minimize unintentional leaching and/or runoff. And of course, agricultural producers also have to account for irrigation system type, distribution uniformity, salinity management and leaching fraction, and other factors.

Question 22: How accurate are ET data when the agricultural fields are switching from intensive agriculture to agroforestry or equivalent, mixing trees with different cultures?
Answer 22: We haven't evaluated this situation yet, but I would expect the accuracies to be comparable to the accuracies observed for irrigated agriculture and forested land cover types.

Question 23: Are you going to utilize ECOSTRESS data for OpenET?
Answer 23: ECOSTRESS is a fantastic instrument. One challenge for OpenET is that ECOSTRESS collects land surface temperature (LST) data at different times of day

(whereas Landsat collects data at roughly the same time each day), so each model has to be modified to account for the time of satellite overpass. The team is currently evaluating improvements that might be achieved through integration of ECOSTRESS data to determine if this should be implemented for all models. Longer term, we see benefits in being able to integrate LST data from multiple satellites collected at times throughout the day, and will be working to support this capability.

Question 24: The processing extent seems too small if a larger area is required. What can be done to scale up the area extent?
Answer 24: The 'Custom Area' data summaries from the Data Explorer are computed on the fly, so the extent is limited to ensure that all users can access the data and quickly receive results for fields of interest. Access to data for larger areas will be supported through the API and the custom reporting tools. The API is currently being tested by partners prior to public release later this year, with the Custom Reporting tools scheduled for public availability soon after.

Question 25: Does a high ET rate indicate a high groundwater potential?
Answer 25: Not necessarily. OpenET measures ET from all sources (precipitation, irrigation, and access to shallow groundwater). However, outside of irrigated agricultural lands, if annual ET is quite a bit higher than total annual precipitation, that can be an indication that vegetation has access to groundwater.

Question 26: Hi! Thanks so much for the talk. Do the models used to estimate ET from the satellite data use vegetation type maps and vegetation property parameters? Is that correct? Are these re-estimated from satellite data at similar timesteps?
Answer 26: Some of the models use land cover maps as inputs, and many of the land cover maps are also generated from satellite data, though typically at intervals ranging from 1-5+ years. The SIMS model also uses information on crop type as an input to separate annual and perennial crops, and uses both state-level crop type dataset and data from the USDA Cropland Data Layer which is updated annually using satellite data.

Question 27: How do you address vegetation shading influencing the remotely sensed ET estimate?
Answer 27: Good question. Many of the models include functions to correct for self-shading within the canopy. Some of the modeling teams are also testing additional

functions to correct for very specific shading issues, such as shading of the interrow for mature orchard crops at the time of satellite overpass.

Question 28: Can OpenET data be used in addition to other datasets for crop yield estimations/predictions?
Answer 28: Yes, I would think that would be a good application of satellite-based ET from OpenET and other sources.

Question 29: Did you conduct any comparison between ET from OpenET and WaPOR?
Answer 29: No, not yet, since the spatial coverage of OpenET and WaPOR don't overlap. However, the ET data from WaPOR is calculated using a model that is based on SEBAL developed by Wim Basiaanssen, and the OpenET model ensemble includes geeSEBAL, which is an implementation of SEBAL.

Question 30: In continuation to question #9, can you share the links of the OpenET journal articles?
Answer 30: Yes.

Melton et al., 2021: https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12956

Volk et al., 2021: https://joss.theoj.org/papers/10.21105/joss.03418.pdf

Question 31: Could you envision using the OpenET tool for urban development with the goal of addressing urban heat islands?
Answer 31: Yes, although I would think that for this application, it might be more efficient to start with the Land Surface Temperature (LST) measurements directly.

Question 32: Where are the field boundaries coming from?
Answer 32: The field boundaries are coming from publicly available sources, including state-level field boundary datasets and the last publicly available USDA Common Land Unit dataset.

Question 33: What is the time lag between measurements and reporting (when I can view it on the portal)? Is monthly the finest time resolution we can expect? Is there any plan to increase this?
Answer 33: Monthly data is typically updated within 2-3 weeks and no later than 6 weeks after the end of each month. Daily data is usually updated within 3-8 days of satellite overpass, and the OpenET team is currently testing a workflow for near real-time daily data that will provide daily data within 24-72 hours of satellite overpass.

Question 34: Can you spatially aggregate ET based on a user-specified shapefile?
Answer 34: This will be supported via the OpenET API and Custom Reporting Tools later this year.

Question 35: Is there a way to draw custom areas for download in OpenET?
Answer 35: This will be supported via the OpenET API and Custom Reporting Tools later this year.

Question 36: Does OpenET allow users to download data from the entire world or just the USA?
Answer 36: OpenET currently only provides data for the Western U.S.

Question 37: Are the codes for the different models available to the public to compute ET in regions outside the OpenET scope?
Answer 37: Please see https://openetdata.org/methodologies/ and https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12956 for a summary of the data inputs and methods, and links to the key papers describing methods used in each model. We are also working on creating open-source repositories for each model. For example, see https://github.com/Open-ET/openet-ssebop and https://github.com/et-brasil/geeSEBAL.

Question 38: Could you talk a bit more about how the irrigation water use was incorporated in the ET estimates? What's the data source? Is it field measurements?

Answer 38: OpenET does not use or collect any information on applied irrigation. OpenET calculates total actual ET using the satellite-driven models, which utilize either an energy-balance approach or a reflectance-based approach to compute ET.

Question 39: Moving from estimated ET to irrigation needs, what are the planned inputs that will be included to estimate these needs? Are there any concerns related to local data needs/tailoring or results?
Answer 39: There are many factors! Irrigation system type, distribution uniformity, salinity management and leaching fraction, etc. Our current approach emphasizes use of the OpenET API to integrate satellite-based ET data into existing irrigation scheduling software tools being developed by extension agencies and commercial sector partners.

Question 40: In FAO 56 they advised to rely on local data to calculate ET. Is that because it's issued several years ago before remote sensing data?
Answer 40: Local data from agricultural weather stations is still valuable for checking for (and correcting) biases in reference ET data computed from gridded meteorological products. Local measurements of ET from flux towers or water balance studies are also valuable in assessing the accuracy of data from OpenET or other satellite-based sources of ET data.

Question 141: Is daily ET available?
Answer 41: Yes, daily data will be added to the Data Explorer soon, and will also be accessible through the API.

Question 42: **What is the key variable driving the variation across the ET models in OpenET?**
Answer 42: Good question! The biggest differences likely stem from the different approaches used to compute sensible heat flux within the different energy balance models.

Question 43: **How do you determine reference ET (grass of 12 cm height) using OpenET?**
Answer 43: Reference ET data is also available from OpenET under the ‘Additional Variables’ tab in the graphs. Reference ET is computed following the ASCE Penman-Monteith equation from the gridMET gridded meteorological data.