# Question & Answer Session 4

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

Question 1: Which types of satellite images are suitable for analysis of Evapotranspiration for large study areas?
Answer 1: It depends on the application. Most of the examples provided rely on thermal imagery. Landsat and/or ECOSTRESS imagery could be a good tool for this particular application due to resolution.

Question 2: Does the evapotranspiration decrease before the growing seasons in crops?
Answer 2: Generally, yes. Net radiation is higher during the growing seasons, so there is more available energy to be used for ET.

Question 3: How can yield be predicted from ET for a particular area, say Africa?
Answer 3: Predicting yield, you need good observed yield from previous years. Machine and deep learning can be used with good previous data (training data). The community continues to develop these methods.

Question 4: I am not clear about the difference between potential evapotranspiration and actual evapotranspiration. Would you clarify the difference please?
Answer 4: Potential ET describes optimal conditions versus actual ET being more realistic of what is going on.

Question 5: Can we use interpolation methods to measure ET?
Answer 5: We do rely on interpolation to determine seasonal ET (data mining). One method is to use slightly less spatial resolution to fill in the gaps (because they have a higher temporal resolution).

Question 6: Is there any recent model to drive ET or energy balance with the absence of in-situ data? What is the best way to estimate ET using only remote sensing?

Answer 6: It is not fair to say that we don't need any in-situ data, some background is still necessary. In-situ data makes the methods more robust, but many examples don't rely on in-situ data. Utilizing multiple methods can give the best results.

Question 7: Given that the ground observation data are scarce in Africa, which models and RS approaches/data would provide good estimates of ET?
Answer 7: See answers in Q5 and Q6.

Question 8: What is a crop coefficient?
Answer 8: How effective a crop is at water use dynamics.
You can find a detailed explanation about the use of crop coefficients at:
http://www.fao.org/3/x0490e/x0490e09.htm#part%20b%20%20%20crop%20evapotranspiration%20under%20standard%20conditions

Question 9: Could you explain or any recommendation to estimate surface energy balance (i.e ET) using satellite data, specially for places that lack insufficient in-situ data?
Answer 9: Refer to Questions 6 & 7.

Question 10: The RS approach of estimating ET is good and well for estimating/determining potential ET than actual ET. Is that not? Essentially, the actual ET contains the soil moisture stress component in it. Could there be any way to include the soil moisture stress component, Ks, and compute the actual ET better?
Answer 10: RS approaches are estimating actual ET. Potential ET is computed from either in-situ meteorological observations or from modeled meteorological conditions (e.g., numerical weather prediction models, atmospheric reanalysis).

Question 11: In another Webinar, we were introduced to Landsat's Evapotranspiration product (EEFlux). In the presentation was an internet link. But it doesn't work at the moment. Where can I find this 30m EEFlux product?
Answer 11: http://eeflux-level1.appspot.com/

Question 12: Where can I download ET data?
Answer 12: Here are a few resources (not an exhaustive list):
I'd make a note though that a researcher should conduct a rigorous literature review before using any of these datasets so that they can choose which dataset is best for their applications based on the strengths and weaknesses of a given method.

MOD16: MODIS Evapotranspiration (RS-based Penman method):
https://modis.gsfc.nasa.gov/data/dataprod/mod16.php

GLEAM ET (Model with RS data assimilation):
https://www.gleam.eu/

GLDAS ET (Model):
https://ldas.gsfc.nasa.gov/gldas

SSEBop (RS-based method):
https://earlywarning.usgs.gov/ssebop/modis

If you are interested in ALEXI ET -- you can contact me at christopher.hain@nasa.gov.

Question 13: How is the land surface temperature measured under the trees/grasses?
Answer 13: We only look at the temperature of the bare soil and the canopy, not necessarily the land surface under the canopy.

Question 14: What are the differences between plant species when calculating ET using Landsat?
Answer 14: It depends on the method and vegetation. For an area that does not have a lot of detail, we typically use a general land cover classification.

Question 15: Alexi Water Accounting case study: What do negative days of water use mean? Does it reflect the past year of water use that is accumulated for the next year?
Answer 15: Those don't represent negative days, they represent days before the start of the growing season, so all crops were normalized to show water use from the start of the growing season on.

Question 16: Characteristic water use curves use the same days of growing period for all different crops, is this correct?
Answer 16: In an optimal sense, yes.

Question 17: In slide 25, which satellite do you use for MW and how to combine with ALEXI?
Answer 17: We use Ka band (37Ghz sensor) for analysis. Corrections are also made in the phase and amplitude of the microwave signal and microwave is coarser.

Question 18: In field level applications for decision making process, how can EDDI be used as the proxy? and how is it tied with ESI?
Answer 18: EDDI is primarily driven by potential ET for development of drought. Tied with ESI, it can also tell you what is happening at the plant level while EDDI tells you what is happening atmospherically.

Question 19: Can we get root zone soil moisture data for any region in India at high resolution or say for a crop- cotton cultivation in Maharashtra state? and how can we get high resolution crop specific vegetation images, say for time series cotton cultivation in a region of India or through geo-coordinates of India?
Answer 19: No. There is not a direct way to analyze root-zone soil moisture through any satellite currently. Modelling is still the primary way to observe root-zone soil moisture.

Question 20: There are several types of drought. Does ESI predict hydrological drought?
Answer 20: No. ESI is used primarily for agriculture and meteorology. If the drought is severe enough, it can be possible but not optimal.

Question 21: What is the time delay that we can expect between seeing a signal of plant stress in ESI (onset of stress conditions) and NDVI (actual plant damage)?
Answer 21: It depends on how rapidly the drought is evolving.

Question 22: What are the potential uses of Remote Sensing based ET monitoring for index crop insurance?
Answer 22: It depends. For smaller areas, it becomes harder to analyze due to resolution constraints, especially in areas with small field size.

Question 23: Majority of farmers in India have small holdings (2 acres or less on average). How can ET help them plan their crop rotation cycles?
Answer 23: Similar to previous question. With future sensors, it can become more viable, but is currently constrained by spatial resolution limits of current TIR sensors.

Question 24: Why is AVHRR not used in ALEXI to achieve a longer time series?
Answer 24: AVHRR does provide a longer period of record of moderate-resolution LST, however, due to issues with orbital drift in earlier AVHRR sensors, additional work is required to correct AVHRR observations for use in ALEXI. We are actively working on it so we can generate a longer time series of ET and ESI using ALEXI.

Question 25: Are ALEXI and ALEXI ESI available at the global level?
Answer 25: Yes. We run both ALEXI ET and ALEXI ESI in our applications at 5km. ESI is available at: http://catalogue.servirglobal.net/Product?product_id=198

ET data is available by contacting me at christopher.hain@nasa.gov

At times, in a dense forest, roots that can go down several meters, plants that reach the groundwater table can be affected. We can calculate from energy balance principles, and plants that reach groundwater will show up in the ET values.

Question 26: Is there a way to estimate ET, for deficit irrigation?
Answer 26: Yes, it is one of the main applications for ET.
You need to know in near real time what the crop actually needs. Hopefully this can help irrigation scheduling.

Question 27: Can DEMs play a role in estimating the crop coefficient?
Answer 27: Not to my knowledge. We incorporate DEMs in our models. Shading from terrain can affect the energy balance, so we must account for this by using DEMs.

Question 28: Can evapotranspiration be measured by SAR?
Answer 28: I don't believe so. SAR can help in areas with high cloud cover. It may also assist in characterizing the vegetation as inputs to models.

Question 29: One of your slides on ESI shows Greenland and the Sahara both as extremely dry, presumably for the same time range. With the difference in crops in these areas and ground conditions (soil/crop vs more ice or coniferous areas) how can users of ESI as indicators of drought or abundance of water differentiate this? Does ESI need to be used with current land cover/vegetation cover type? Also, what is the frequency (time scale) of the ESI data layer for users?
Answer 29: We do not run the model over bare soil and over Greenland. We use current information in our analysis. We use the 4 week and 12 week composite for ESI with 4 week being preferable for rapidly changing conditions and 12 week for longer term changes.

Question 30: Have there been any studies on whether crop yields have decreased after fallowing periods, specifically after fallowing of grass-hay or alfalfa lasting an entire season? Assuming you would use Alexi to determine crop yield or crop stress.

Answer 30: ET is a measure of water use. This can be used in some methods in the community of yield projection.

Question 31: Can you specify a fusion method for downscaling to Landsat?
Answer 31: We use STARFM within our modeling framework. More information about STARFM can be found at: https://ieeexplore.ieee.org/abstract/document/1661809

Question 32: Can you provide pointers to any documentation covering the ALEXI water accounting study?
Answer 32: The paper for this study is still in review, if you would like more information you can contact me at christopher.hain@nasa.gov

Question 33: Does topography have any effect on ET (slope of the terrain)?
Answer 33: Not directly.

Question 34: Do you ever use other ET equations like hargreaves as a backup check? If so, what other ET equations do you use since they range from simple to complex?
Answer 34: Open ET has several different models that run from simple to complex. Developers of these tools see that no model is perfect. A weighted average or ensemble of multiple models is the best method.

Question 35: How would you calculate ET in smallholder farms in developing countries where Landsat resolution may be coarse?
Answer 35: You can't. Spatial resolution is a constraint with open source data. 100 meters, possibly sharpened to 30 meters but that is the constraint. Commercial data helps but it costs money.

Question 36: Does ET have any connection to SIF? Which model would be the best to show this relationship?
Answer 36: ET does have a connection to SIF (Solar induced fluorescence). SIF shows stress and has been researched more in the past couple of years despite its course resolution.

Question 37: Could you explain again how STARFM is interpolating between the observations, and can the cap become too great to interpolate/estimate?
Answer 37: There is more uncertainty when it comes to gaps in the data. More clear sky retrievals = more certainty.

Question 38: What's the difference between ESI and Normalized Difference Water Index (NDWI), because both are information from water reflectance?
Answer 38: ESI is derived from the ALEXI model which uses changes in land surface temperature (TIR) to estimate the partitioning of sensible and latent heat flux. NDWI is based on optical reflectance wavelengths.

Question 39: Are there tools for evapotranspiration (for olives or grapes) in Spain?
Answer 39: The example from grapes in California, is to show how the model performs. Any of the models you saw today would be applicable to evaluate ET in Spain.

Question 40: Could evapotranspiration be measured every day, from a certain area?
Answer 40: There is no real constraint on observations. Observations are based on models. Progress towards real time analysis is possible.

Question 41: What are the possible mitigation techniques that you mentioned broadly in the case of having a heads up for drought in rain-fed crops?
Answer 41: Mitigation is limited if solely rainfed. These tools can still be useful to determine drought aid direction.

Question 42: How well can vegetation and precipitation data together with climatic oscillation indices be used to predict agricultural drought before the end of the growing season?
Answer 42: Looking at weekly and multi-weekly forecasts can help to provide some better certainty. Predictions do take some level of skill.

Question 43: In order to quantify consumptive use from irrigation water only, can you recommend a method for subtracting effective precipitation from the ET result?
Answer 43: It is hard to recommend a certain method due to uncertainty from ET and effective precipitation.