Questions & Answers Session 3

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 Amita Mehta (amita@umbc.edu) or Sean McCartney (sean.mccartney@nasa.gov).

Question 1: How do you find the density of in-situ gauges required to calibrate the remote sensed data?
Answer 1: (Ibrahim) Actually, in this exercise, we have not calibrated the RS data. We calibrated the SWAT model to simulate the streamflow. We calibrated the streamflow output of the SWAT model to the observed streamflow measured by our partners in the Mekong region. So, we used as an exercise two experiments. We drove the SWAT model with in situ data that we obtained from different sources in the Mekong region. Then also we drove the SWAT model with the RS data. We compared the results. What we have found is that the RS data is able to simulate the streamflow better than the in situ gauges because the density of the gauges is very poor in the region. Variability isn't captured. So the RS data products were able to basically give us a better estimate of overall streamflow output. We assessed that by comparing the output from both model scenarios with the observed streamflow we obtained from partners.

Question 2: How does the level of LULC classification affect the performance of the SWAT model?
Answer 2: Yes - this is a very good question because the classification of LULC affects the calculation of water balance components. As we know, in SWAT we're simulating streamflow output and this output is a function of the ET and a function also of the groundwater. With the addition of more realistic classes of LCLU, we will be able to calculate ET and other variables with more certainty. If you have a broad classification of agriculture land vs. having a detailed classification of agricultural land, this means a very significant difference in calculating ET. As you know here, we have rice, some areas they use multiple crops. We'd like to be able to calculate ET accurately and this will result in simulating streamflow outflow accurately. The more we have LULC classes and subclasses types of forests, this will basically help in getting us better results in simulating streamflow output.

Question 3: Does the flood inundation approach using MODIS NDVI confuse flooded areas with say rice fields?
Answer 3: The near real time flood detection component was undertaken by a researcher, Aakash Ahamed. The detection algorithm uses a rolling, 8 day NDVI which changes dynamically depending on the day of interest. It does take into account seasonal variations. Permanent water bodies are masked out (more detail can be seen in the full text here). But there may be some confusion over ephemeral water bodies or water bodies with suspended sediment, or could potentially be partially flooded fields. This is an area of ongoing area of research, with plans to acquire in-situ field imagery to better constrain water bodies that may not be as easily distinguished from space.

Question 4: Do you also look at flood benefits to soil in agricultural areas, ecological benefits for flood adapted ecosystems, etc?
Answer 4: Yes, we have honed the ability to identify LULC classes with relevant agriculture. When tied with our updated SWAT model, we can more accurately estimate model states and fluxes of interest such as turbidity, soil moisture, soil temperature, etc.

Question 5: How is the flood depth estimated with the TINs?
Answer 5: This is a method we found in the literature to broadly estimate inundation, discussed in slides 30-31. The process involves overlaying the detected flood extent onto a digital elevation model (in this case, the MERIT DEM). We generate points around the perimeter of the detected extent, and extract the land surface elevation at those points. These points are then used to produce a triangulated irregular network (TIN) to give an estimate of flood surface elevation. From there we subtract the underlying DEM to get an estimate of flood depths. For more detail, see the method described by Cham et al. 2015.

Question 6: How did you derive the value for maximum damage per unit in category i (si)?
Answer 6: (Perry) These were units we found regionally derived values from the literature (see: Leenders et al. 2009 and Giang et al. 2009). We wanted to be able to find established values that were created for areas in Thailand and Vietnam. We're broadly applying those values throughout the basin which has its own uncertainties and assumptions in it. That's an area of future research - to constrain locally and regional values for each country and community.

Question 7: One important issue is regarding the replicability of this excellent work in other latitudes. Are the developed tools open-source and available to other agencies? How these interactions of NASA/SERVIR with other partners would work to extend the utility of your work?
Answer 7: (Ibrahim) Yes - this is a fantastic question. Our work can be replicated and it's also open source. As we have said, this is available in github. The main objective of this work is to be used by other agencies and people. The NASA access - this is a tool that can extract, reformat, and could use weather and climate data everywhere. If you have a watershed shapefile, you upload that to the URL. Or if you are an R user, download the package, and give the link to this watershed, and automatically the tool will do all the work. It will go and fetch the data from the NASA server, it will reformat, extract for desired timespan, and then it will produce files to be ingested into any modeling environment. This also has a climate change dimension - if you wanted to do a climate change study and look at analysis from different climate models/scenarios, you can plug these inputs and it will do the work for you. It will get you air temperature for the specific model/timespan you would like. Also with the SWAT online - it is available on github also. It is not only customized for lower Mekong. The framework is able to be applied everywhere. If you have a SWAT model in any area you have the platform and you put the data from your model into the platform and it will basically do the same functions you saw in the video. You can visualize inputs, analyze outputs. It's a fantastic tool that can be used in a wide range of applications.

Question 8: With reference to cyclone Idai which has recently hit Mozambique, what is the time that is needed to identify areas of safety that a disaster response team could use in rescues from a data analysis point of view? If we consider that at the time of the cyclone there is limited ground truthed data for calibration, how would you use the remote sensing data to calculate timely disaster responses?
Answer 8: This is a great question but ultimately there may be no single answer. In general, the period following a disaster has the highest uncertainties and is where information about the impact and extent is most valuable. Here, data becomes a time-critical resource where the sooner information is available the better. In such cases, near real-time (NRT) data like those made available through LANCE may be the best available (though imperfect due to things like cloud cover) until higher-resolution or ground-truthed data is produced. For this analysis, detected flood extents could be produced as new MODIS imagery is made available (~3 hour latency) which could then

be used to generate the socioeconomic impact assessment shortly thereafter. While our products are not currently functioning in Mozambique, the methodology described here could be readily applied to other regions, providing the flood detection algorithm is tuned to that locality, and land cover / depth-damage information is available.

Question 9: Can you please share some recommended references on using SAR to map flood surface extent (instead of MODIS) as this is a better option for rainfed flooding?
Answer 9: (Perry) The flood detection tools used in this work relied mostly on MODIS due to the rapid revisit time (twice daily) and low latency (~3 hours) afforded by the NASA LANCE system. There are some notable limitations with this sensor -- namely that it can't penetrate cloud cover -- which SAR would improve upon. One possible resource for using SAR to map surface flooding would be ARSET's previous training on "SAR for Flood Mapping," by Dr. Erika Podest. For those just beginning to use SAR data, a good resource would be the Committee on Earth Observation Satellites (CEOS) primer, which discusses general applications including flooding.

Question 10: Can we derive from satellite data the actual topography without the water volume of rivers and lakes?
Answer 10: Good question. Bathymetry of rivers and lakes is an ongoing research objective.

Question 11: What is the impact of Drainage density of the basin? how we can measure it? how we can judge the suitability of Drainage density value to rainwater harvesting applications?
Answer 11: Drainage density can be estimated by simply using mapped streams within the watershed. Typically, a hydrologic model is not needed to calculate this metric, however, it would be interesting to calculate precipitation over the region of interest and assess by drainage density to investigate rainwater harvesting capabilities

Question 12: What are the effects of the land cover changes on water balance components in your assessment?
Answer 12: (Ibrahim) Yes, land cover changes do affect the water balance components. Our partners at Mekong River Commission have explored the impacts of the LULC on their SWAT model estimates. This work is ongoing. However, we can

state that any land cover changes would change ET and related modeled states and fluxes related to ground infiltration and groundwater storage.

Question 13: How did you use HAZUS (USGS hazard) calculator?
Answer 13: (Perry) We used a damage framework similar to HAZUS. We wanted to use a method that had been regionally applied in the Mekong basin before as a way to standardize flood impacts across different events and time scales. So while the framework we used was not the same as HAZUS, it operates on similar principles (i.e. using depth-damage curves for different land cover types, infrastructures). The Standard Model that we used had several published case studies in the region which is why we elected to use that over HAZUS, which is better suited for domestic (US) case studies, but we can provide detail on the methodology as needed.

Question 14: How can the result be used to infer a future prediction or an early warning for subsequent years?
Answer 14: Good question. We addressed this question in our paper exploring scerario analysis on streamflow dynamics. Please see the following publications for more details.

Mohammed, I., J. Bolten, R. Srinivasan, and V. Lakshmi. 2018. "Improved Hydrological Decision Support System for the Lower Mekong River Basin Using Satellite-Based Earth Observations." Remote Sensing, 10 (6): 885 [10.3390/rs10060885]

Mohammed, I. N., J. D. Bolten, R. Srinivasan, and V. Lakshmi. 2018. "Satellite observations and modeling to understand the Lower Mekong River Basin streamflow variability." Journal of Hydrology, 564: 559-573 [10.1016/j.jhydrol.2018.07.030]

Question 15: In MRC for forecasting purposes, TRMM-3h, SRE, CSRE and HEST are used to retrieve observed rainfall and GFAS, ACCESSG and ICON are used to get forecasted rainfall. Would you recommend other products (e.g. IMERG)?
Answer 15: He highly recommend GPM IMERG data. We have a paper in review that is looking at assessing satellite precipitation over some watersheds in the LMB.

Question 16: Considering similarity of various agricultural land use can we use supervised classification to improve mapping or what is the best approach to

distinguish land use when LANDSAT color is in the same range (buffer strips vs pasture) or canopy over river stream?
Answer 16: Excellent question! Please see the following paper for more details.

Spruce, J., J. Bolten, R. Srinivasan, and V. Lakshmi. 2018. "Developing Land Use Land Cover Maps for the Lower Mekong Basin to Aid Hydrologic Modeling and Basin Planning." Remote Sensing, 10 (12): 1910 [10.3390/rs10121910]

Question 17: Can NASA access be helpful to calculate sediment load along the floodplain?
Answer 17: NASA access is simply a tool for helping reformat satellite data for SWAT and other models. Estimation of sediment load is possible in our updated SWAT model.

Question 18: Can the SWAT model predict future water budget or climate change scenarios in a river basin? Can it detect seasonality of extreme climate events?
Answer 18: Yes, given properly downscaled climate forecasts. Our NASA Access tool enables compatible climate data with SWAT.

Question 19: When assessing the flood depth via the comparison between the DEM and the TIN network, what is the maximum accuracy we can expect?
Answer 19: The accuracy we can expect using this method is a function of the quality of data available. For this analysis, we use the MERIT DEM because due to our geographic requirements and its improved vertical accuracy for low-terrain regions. Despite these improvements, the resolution of this DEM (90 meters) means that some of the finer landscape details will be lost. The dataset information page notes that there are still non-negligible height errors, so the depth and damage information generated by this method can more appropriately be viewed as a heatmap of *potential* damages for further investigation. A greater degree of accuracy could be attained using a higher-resolution map (for instance, in the US where the USGS National Elevation Dataset is available, or using LIDAR).

Question 20: For modeling MRC indeed uses SWAT but for its forecasts MRC uses URBS. Do you think MRC forecasts would be improved if SWAT would be used instead of URBS?
Answer 20: Good question. We are unable to comment on that at this time.

Question 21: In your analysis you compared the performance of simulated streamflow when using RS derived rainfall maps and in situ rainfall maps and found the RS derived maps were giving better results. Did you analyze to which extent the RS derived rainfall maps were consistent with the ground measures when looking at the specific locations/cells where the rain gauges are situated?
Answer 21: Good question. Yes, we did a comparison of rainfall intensity and dynamics from both the satellite-based and in-situ precipitation gauge data, however, we have yet to publish this in detail.

Question 22: Are the SWAT calibration and validation periods you used prior to Chinese dams operating in the Upper Mekong Basin? If yes, to what extent are your results valid now and could you already integrate the main dam design and operating rules parameters?
Answer 22: Yes, you can integrate reservoir operations in SWAT. We are currently doing this assessment with our Conservation International partners.

Question 23: The Mekong River Commission (MRC) also developed a 2015 LULC layer (based on 2003 data). Can you explain why you used year 2010 data, and if this data uses the same land cover types as the 2003 MRC data?
Answer 23: No, our product is very different. Our 2010 LULC dataset was carefully calibrated and validated for Mekong-specific agriculture and growing seasons, validated with millions of data points, and was based on a well-established land cover product methodology led by our NASA land cover mapping specialist. The value of our multi-sensor approach and robust validation has been vetted and found to be superior to previously available LULC datasets. Please see the following publication for more details.

Spruce, J., J. Bolten, R. Srinivasan, and V. Lakshmi. 2018. "Developing Land Use Land Cover Maps for the Lower Mekong Basin to Aid Hydrologic Modeling and Basin Planning." Remote Sensing, 10 (12): 1910 [10.3390/rs10121910]

https://arset.gsfc.nasa.gov/water/webinars/2019-river-basin

Question 24: How can we get soil data like soil type and texture ?
Answer 24: We used the Harmonized World Soil Database

Related ARSET Training: Applications of Remote Sensing to Soil Moisture & Evapotranspiration

Question 25: Is the underlying data for Spruce or Mohammed et al. available, including at the sub-basin scale, and would this allow for estimates of sub-basin water balance?
Answer 25: Yes, please see these papers for more details.

Mohammed, I. N., J. D. Bolten, R. Srinivasan, et al. 2018. "Ground and satellite based observation datasets for the Lower Mekong River Basin." Data in Brief, 21: 2020-2027 [10.1016/j.dib.2018.11.038]

Spruce, J., J. Bolten, R. Srinivasan, and V. Lakshmi. 2018. "Developing Land Use Land Cover Maps for the Lower Mekong Basin to Aid Hydrologic Modeling and Basin Planning." Remote Sensing, 10 (12): 1910 [10.3390/rs10121910]

Question 26: What's the time step of the model run?
Answer 26: The time step for the calibrated Lower Mekong River Basin SWAT model run is daily.

Question 27: Is it possible to run the model with hourly time step to capture flood? Peaks?
Answer 27: From a theoretical point of view you can set up a SWAT model to work with an hourly time step and that depends on data availability, watershed size, and computing power.
Looking at the Lower Mekong River Basin SWAT model which covers about 700,000 km^2 in drainage area example here, we think that from a logistical point of view using an hourly time step would not be feasible. Our aim here is to leverage a model that can be used by regional partners at their local sites. Therefore, we think that running an hourly time step model at the Lower Mekong scale would be challenging for our local stakeholders and regional partners. In addition, we have not received any hourly time step streamflow data from our regional partners to pursue that modeling route at our computing facilities here in the US.

Question 28: Can you provide a practical tutorial (video) on SWAT operation for streamflow simulation?

Answer 28: The following videos were created by Purdue University, in collaboration with Texas A&M, with funding from EPA:
https://swat.tamu.edu/workshops/instructional-videos/

Question 29: How to use the local data (rainfall, temperature, etc.) as SWAT input?
Answer 29: Amita: My familiarity with SWAT is only a little bit. It's an Arc-based model if you want to use station data. I will give you the SWAT website, because there's an excellent manual, and they provide in-person training to set up SWAT for your own region: https://swat.tamu.edu/

Question 30: How to download soil type data from NASA? What is the accuracy?
Answer 30: They're actually from the FAO website: http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/en/ World Soil Database: http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/

Question 31: Is there a link to the Tethys platform?
Answer 31: The Tethys apps can be found at the following link:
http://tethys-servir.adpc.net/apps/

Question 32: What could be the general workflow to download climatic data and modeling in RStudio? what packages could be used for that type of analysis?
Answer 32: Sorry, we do not sure RStudio.

Question 33: Is there any groundwater module in SWAT and can we integrate GRACE data in it to predict groundwater flooding.
Answer 33: Not at this time.

Question 34: Is it possible to apply this same model in an area affected by muddy flooding?
Answer 34: The flood detection system was designed by a researcher, Aakash Ahamed, and uses a seasonal NDVI signature to determine newly inundated land (see more details here). There are limitations to this method, as discussed in the presentation, and one of them would be waters with significant amounts of suspended sediment which may not register as flooded using this NDVI approach. There are currently efforts to acquire in-situ field imagery to help constrain water bodies that may not be as easily distinguished from space, but that is an area of ongoing research.

Question 35: Is there any other model other than SWAT?
Answer 35: Yes, there are several other hydrological models to choose from. This work aimed to provide updates to a widely-used model (i.e., SWAT) by calibrating with an updated LULC map and integrating satellite observations.

Question 36: How much time did you require to set up the Mekong modelling system?
Answer 36: The flood detection system required a significant amount of development time, both to build the infrastructure that downloads new MODIS data and processes it, but also for the verification and validation of the results. Once established, the system is designed to ingest new imagery automatically to produce the flood detection, which is then fed into the damage assessment module to produce the impact analysis. In theory, the same system could be readily applied to other areas of the world, providing the detection algorithm is regionally tuned and local depth-damage relationships are available.

Question 37: Would you account for people's lives in the Damage Assessment Loss?
Answer 37: The damage assessment framework does not currently include valuations for the cost of human life. That would be an example of an “intangible” cost that is not as easily quantified using this standardized system. More comprehensive damage assessments do commonly include indirect impacts (e.g. loss of income, decreased economic productivity, etc.) and intangible impacts (e.g. loss of human life, impacts to education, etc.) but those are outside the scope of this specific type of study, which is focused on producing rapid estimates in the wake of an event.