Lab and Questions & Answers Session 2

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.v.mehta@nasa.gov) or Sean McCartney (sean.mccartney@nasa.gov).

Question 1: What is the meaning of the numbers in slide 13 of the Exercise 2? Specifically 32760, 32767 and 0?
Answer 1: These are fill values for non-vegetated pixels, which the MOD16 team didn't calculate ET.
Fill value, out of the earth 32767
Water body 32766
Barren or sparsely vegetated 32765
Permanent snow and ice 32764
Permanent wetland 32763
Urban or Built-up 32762
Unclassified 32761
For more information refer to the link provided below:
User's Guide MODIS Global Terrestrial Evapotranspiration (ET) Product

Question 2: Is this process applicable for the perennial river (like Ganges) where water flows also through the melting of glaciers as GRACE data is covering the melting of ice components also?
Answer 2: Yes, GRACE provides estimates of total water (surface and groundwater). Melting of glaciers would be included in GRACE data.

Question 3: Precipitation is 0.1 degree and ET is 500 m. All the water budget components are in different resolutions, so how are you doing the water balance? Is zonal statistics a solution?
Answer 3: We are only looking at basin or sub-basin averages. You can interpolate all the data sets to the same resolution but that is not adding any new information - and may introduce inaccurate spatial information. That is why we are not looking at the spatial pattern of the water components - just basin integrated numbers. The

precipitation, ET, and TWS rasters are seasonal accumulations. Through the zonal statistics we are taking spatial means of these seasonal totals. Then we multiply the mean water quantities by the sub-basin areas to get the total water amount.

Question 4: Earlier, Sean had demonstrated using a range of values for wet and dry seasons, but used a different range of values for each file, then classified them into 10 classes. If there is going to be a math calculation, shouldn't these range of values be the same from dry vs wet layers?
Answer 4: The range of values used for symbolizing the dry and wet layers was only for visualization. It does not change the values of the raster files and will not affect the calculations when running Raster Calculator. You may use your own range of values and color ramp of your choice -- this was for demonstration only.

Question 5: Why are we not downscaling the GRACE datasets?
Answer 5: We can downscale the GRACE data, but that would just be creating interpolated raster, not creating or adding new information, and the assumption would be that the water storage changes linearly within each grid. That may introduce inaccuracies.

Question 6: Isn't it better to calculate volumetric P and ET using a cumulative product sum (having pixel size and rates for each pixel) instead of using mean rate values for each subbasin?
Answer 6: Because the data have different spatial resolutions we are taking this approach.

Question 7: What are these water storage units? Is it metrics? If so, can we have imperial units?
Answer 7: The units are Billion Cubic Meters -- you can convert them into imperial units.

Question 8: I am having trouble adding the Limpopo River basin shapefile. The shapefile I got from the website does not have an attribute value in the shapefile.
Answer 8: Once you calculate the statistics you should see the Attribute Table. Which version of QGIS are you using? Please check the top option bar -- you may see the Attribute Table there.

Question 9: For TWS do you only have to do it for one season or for both dry and wet seasons?
Answer 9: You will do it for both the seasons. We had GRACE data missing for a dry season month. For missing months, you can take the mean for multiple months over several years (i.e. Sept. 2016 was missing so take the mean for Sept. 2011-2015).

Question 10: Why did we reclassify value range? ET addition is not clear.
Answer 10: This was done so that we can add all the rasters in QGIS for each season. Having different values for missing or undefined data would make the analysis unwieldy.

Question 11: I do not see the "Reclassify values" in the processing toolbox on the QGIS 3.14.1 pi version. There are two options that are Reclassify by layer or table.
Answer 11: We will look into this issue. If you are unable to locate the tool one suggestion is to use v3.12. You can also use the Reclassify by Table as an option.

Question 12: In homework 2 of week 2, it says I have to email the .csv file, so do I have to email the attribute table after the calculation is done?
Answer 12: Yes, please save the Attribute Table as a csv file and send via the email address given in the homework form.

Question 13: In QGIS 3.14, How do I enable Google under QuickMap Services?
Answer 13: Click on the web → QuickMapServices → Google. If you don't see QuickMap Service you will have to install the plugin.

Question 14: What will be the ideal size of a water basin to optimize output results so that it can be justified while writing an article?
Answer 14: The GRACE data cannot resolve watersheds smaller than ~150000 km^2. We will see next week that you can use certain land surface models with higher resolutions but have to be careful about how to get the groundwater information from these models.

Question 15: What is the best way to calculate Discharge using remote sensing? And is there any other equation for water budgets or not?

Answer 15: The water balance equation is there -- precipitation minus evapotranspiration minus water storage should provide discharge in theory. But in reality it results from the differences among the other water components -- small residual value after subtracting bigger water components -- where data have uncertainties. So the resulting value should be validated with in situ stream gauge data to assess how accurate the remote sensing-based discharge values are.

Question 16: For a closed basin, having a large lake at the center that gets inflows from all upstream subbasins, is that true to say a portion of TWS is due to lake level change in the calculation period? What other considerations should be taken into account in such cases?
Answer 16: If there is no other underground flow of water you may attribute TWS change to the lake level change -- but GRACE data can not provide vertical layers -- it is change in terrestrial water from surface to ground. It may be useful to compare time series of lake levels with GRACE TWS anomalies on a month-by-month basis to see if there is any correlation between them.

Question 17: I want to calculate the water budget for a river basin of 10,000 km^2. Is it possible?
Answer 17: Not with GRACE data. We will see next week how GLDAS models can help do that to a certain extent.

Question 18: How much uncertainty does the estimation of evapotranspiration using MODIS data have?
Answer 18: See below for a link to the MOD16 User's Guide:
User's Guide MODIS Global Terrestrial Evapotranspiration (ET) Product

Question 19: How certain is the water budget? How can we decrease the uncertainty, or what data can be used for a more accurate result?
Answer 19: We will discuss this next week when we have looked at model-based water budget components. A combination of remote sensing, land hydrology model, and in situ observations all help in first characterizing uncertainties. Then ensemble modeling with assimilated remote sensing and in situ data may help. This has to be done regionally -- no one solution is good globally!

Question 20: Will the results change if you use satellite images with different pixel resolution?
Answer 20: It is possible with differences in resolution.

Question 21: Is the original ET in cm?
Answer 21: Not originally, no.

Question 22: Can we use this method of estimating evapotranspiration for any basin for a research work? Is this method accurate?
Answer 22: Is method referring to dataset? For research, you can use these datasets for your work, albeit they are not the most accurate. Incorporating other factors can increase your accuracy.

Question 23: On page 16 of the lab doc, it says to sum up 13 reclassified rasters. Shouldn't it be 26?
Answer 23: It is 13 rasters per season (dry and wet seasons).

Question 24: Why is there not soil hydrophysical data related to all water balance calculations. It's not a gap in this methodology? At least data as SOILGROIDS or HWSD.
Answer 24: GRACE data integrates soil moisture and groundwater data.

Question 25: Is there any easy way to get validation data of ET in forested areas?
Answer 25: OpenET will have multiple products in 2021 and you can utilize those.

Question 26: What about regional recharges to shallow aquifers that affect the revap factor in ET calculations?
Answer 26: No, it is not included. The uncertainty will be present.

Question 27: How close are GRACE data to real values? Are there some studies to demonstrate it?
Answer 27: There are references to GRACE data uncertainty (2-3 cm) in our previous webinar: https://arset.gsfc.nasa.gov/water/webinars/GRACE

Question 28: Is hyperspectral imagery being employed in Water Budget Monitoring? If so, does Spectral Unmixing have any significance in Water budget analysis?
Answer 28: I am not aware of studies that use hyperspectral imagery for water budget monitoring.