



Using Earth Observations to Monitor Water Budgets for River Basin
Management
March 13-April 3

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

Question 1: Why are derivatives maps released in a lower resolution in HydroSHEDS?

Answer 1: All procedures were performed at 3 arc-second resolution. Yet for many applications, in particular continental or global assessments, coarser resolutions are desirable as they may significantly reduce calculation times while providing acceptable accuracy. HydroSHEDS therefore delivers various resolutions, from 3 arc-second to 5 minute. The coarser resolutions are all derived from the 3 arc-second data through upscaling:

https://hydrosheds.cr.usgs.gov/webappcontent/HydroSHEDS_TechDoc_v10.pdf

Also see <https://hydrosheds.cr.usgs.gov/quality.php>.

At higher resolution SRTM data accuracy matters -- which is affected by vegetation cover. Being a radar product, SRTM elevation values are influenced by vegetation and other surface effects, such as roughness, wetness, low backscatter signal at open water surfaces, and radar shadow (Freeman 1996). Small rivers with vegetation around are not resolved. This is one of the main reasons for lower resolution basin identification.

Question 2: Can we implement HydroSHEDS in Google Earth Engine (GEE)?

Answer 2: Yes. Once you have downloaded the data from the HydroSHEDS website, you can use the Asset Manager or command line interface (CLI) in GEE to upload datasets in the Shapefile format: <https://developers.google.com/earth-engine/importing>

Question 3: Does water stress means low a level of water?

Answer 3: Usually stress means higher demand than availability, but sometimes both extremes (floods and drought) are considered. If an area is flooded, that's stress in some sense. It depends on what source you're looking at and it's useful to look at the definition.



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Question 4: How can groundwater storage be obtained from RS observations?

Answer 4: By observing changes in Earth's gravity field, scientists can estimate changes in the amount of water stored in a region. NASA's GRACE satellites provide a more than 10 year-long data record for scientific analysis. GRACE notes the changes in Earth's gravity field for aspects of the surface and subterranean water column (terrestrial, soil moisture, ground water) since they contribute to gravity. By subtracting surface water you are able to estimate ground water. GRACE data is based on that. GRACE has returned data on some of the world's biggest aquifers and how their water storage is changing (Rodell and Famiglietti, 2001; Yeh et al., 2006; Rodell et al., 2007).

To access the data see:

1. <http://grace.jpl.nasa.gov/data/>
2. <http://geoid.colorado.edu/grace/>
3. <https://podaac.jpl.nasa.gov/GRACE-FO>

Question 5: I would like to know if soil moisture can be observed using dielectric properties from other radar instruments like Sentinel-1, or only by SMAP?

Answer 5: Please see: **Development and assessment of the SMAP enhanced passive soil moisture product** by Chan et al: <https://doi.org/10.1016/j.rse.2017.08.025>

Also, <https://ieeexplore.ieee.org/abstract/document/8127876> for SMAP and Sentinel-1. These two references show how soil moisture is derived from SMAP and Sentinel-1.

Question 6: We know how to measure evaporation, but how do we measure transpiration for a basin or some other places using remote sensing to get the area of different vegetation, and then to calculate the transpiration based on the properties of vegetation?

Answer 6: If you want evapotranspiration (ET) as you saw it in the presentation - it's not that easy. Transpiration varies a lot. It depends on what kind of vegetation there is. It's derived from RS in better coverage - you can derive vegetation coverage from Landsat or MODIS and that has been used to estimate transpiration in addition to evaporation. Surface energy balance is used in the case of ALEXI to derive transpiration. For both transpiration and evaporation you need to look at surface water as well.

Question 7: Is any of the data API enabled, i.e. available via rest services?

Answer 7: Yes. A synchronous REST interface was developed which utilizes the CMR API, allowing you to programmatically access data from the NSIDC Distributed Active



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Archive Center (DAAC) based on spatial and temporal filters, as well as the subsetting, reformatting, and reprojection services available through NASA Earthdata Search: <https://nsidc.org/support/how/how-do-i-programmatically-request-data-services>
GPM also has an application - refer to the PMM site: <https://pmm.nasa.gov/>

Question 8: How does one convert the spatial resolution from degrees to meters?

Answer 8: After opening your file in a GIS application (e.g. QGIS) you can reproject the file into a new coordinate reference system (CRS) from degrees to meters:

https://docs.qgis.org/2.8/en/docs/training_manual/vector_analysis/reproject_transform.html

Live: In QGIS, as said here, you can directly do it if you actually want to calculate each degree has different meters as latitudes change. Roughly, at the equator, a degree is about 100 km. You can convert that into meters. As you go up from the equator to the poles, area for each degree gets smaller and smaller, so you have to multiply that area by the cosine of latitude. In a GIS - the algorithms for each tool compute this for you.

Question 9: How to access information on the accuracy of satellite data?

Answer 9: Important question as it depends on the instrument from each satellite platform. If you know the name of the instrument you are interested in, you can search NASA websites to gain details on the accuracy, calibration, and validation of that specific instrument and the data products associated with that instrument. Validation is done on limited geographic regions (not everywhere). What we recommend is if you have in situ data and compare that with satellite data you can come up with your own accuracy assessment. But in general to know about validation, you can go to each mission's website, and there's usually a link for validation.

Question 10: Could Hydrosheds be used to monitor the shoreline position?

Answer 10: No. Since HydroSHEDS products were derived from the Shuttle Radar Topography Mission (SRTM) which was flown on an 11-day mission of the Space Shuttle Endeavour in February 2000, shoreline position was derived from this date. You could perhaps use elevation products derived from the ASTER instrument (flying on Terra) to look at current conditions. Again, in today's presentation, if you go down to the appendix in the slides, there are slides about SRTM and there's a slide about GDeX. GDeX can also provide ASTER elevation data, which you might be able to use for coastal/shoreline positions. <https://gdex.cr.usgs.gov>



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Question 11: Please could you provide any instruction how to download data from GRACE satellite data for GW analysis?

Answer 11: To download GRACE satellite data, search the GRACE Tellus website from NASA's Jet Propulsion Laboratory (JPL): <https://grace.jpl.nasa.gov/data/get-data/>
One can download HDF file/NetCDF files from the site. There's also an interactive site, which is available here:

<http://geoid.colorado.edu/grace/dataportal.html>. This site provides visualizations of GRACE data. You can do time series or maps, both by months and years.

Question 12: How can I prepare a soil map using FAO Soil data?

Answer 12: We described this in one of the earlier webinars when we introduced the VIC hydrological model (Variable Infiltration Capacity model). For that, there's info on how to get FAO soil data [at that webinar]:

<https://arset.gsfc.nasa.gov/water/webinars/VIC18>

Question 13: how to ensure the reliability of remote sensing and model data for water balance without reference ground dataset?

Answer 13: That is correct - for overall water balance, you have to know groundwater. You can get groundwater data from GRACE, and you'll see this in Session 2 when we look at the Nile river basin to look at the overall water balance. That assumption is there when you're looking at surface/subsurface using GLDAS. You're assuming variability of that groundwater is slower than the surface water. That's an assumption here as well.

Question 14: How can we deal with the spatial resolution differences between the different remote sensing products of the water budget components?

Answer 14: One way to do it is to interpolate to the lowest satellite resolution. If you have data at 10km from GPM and data from Landsat ET data at 30 m, you would upscale Landsat ET to 10 km and then use that. At the lowest resolution you can derive water budget. In the last session, we're going to use GLDAS - that's a water/energy balance model that integrates RS data and land surface parameterization so you have all processes at the same spatial resolution. It also uses in situ information and model processing - physics and dynamics is involved in that. That way, sometimes integrated systems like GLDAS may be more useful in deriving overall water budget components.



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Question 15: Jason has a specific path, how could you say that it is better than point data (in situ data)? I supposed if Jason could give image results? Please explain.

Answer 15: Two things here when we were talking about point data (in situ measurements). Yes, most satellites have their own field of view that's bigger than a point. That's one thing. Another thing is that when you look at larger regions, it's the same sensor going over. You have several lakes going over a country or region - Jason is the same altimeter looking at different lakes. So then, there's no difference in calibration between them - you can compare the heights or lake levels you get from the altimeter in Jason - it would be the same over different regions. If you have in situ measurements, different sites will have different characteristics, and you can't compare them since different instruments are measuring the data. That's true for rain gauges, stream gauges, etc. But the satellite is the same sensor, so it provides continuity. That's one positive point. But in a way you're right - all sensors are looking at a big footprint. It isn't a point measurement, it's integrated over a larger region.

Jason does give an image - if you look at the "Fundamentals of Remote Sensing" ARSET webinar, most satellites have Level 1 and Level 2 data derived from their sensors. L2 data are geophysical parameters at pixel- or orbit-levels. Level 3 data is based on a composite of these images/orbits so you have better spatial coverage. So depending on your application you either use Level 2 or Level 3. Level 2 would be footprint level - not a point, but higher resolution - Level 3 data would be like an image where you have composite data available.

Question 16: What products have been shown to have the highest 'skill' for drought and flood monitoring?

Answer 16: This is a tricky question - one product may not work the best everywhere. For example, from remote sensing, TRMM/GPM precipitation is very reliable in most parts of the world. But if you're in a mountainous region, there is more inaccuracy and you might need to combine it with in situ data. There are several projects out there, and we always recommend that for your own region it's good to validate - good to examine different products and come up with the one best for you. In most cases, though (this is [Amita's] personal opinion), you'll be able to see drought and flood - you'll be able to see dry or wet conditions. It's the magnitude - that's where you need to look for which data is the best for your region.



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Question 17: Precipitation is one component in water budget component, is it used to calculate runoff only or we are going to use both runoff and precipitation to estimate the basin budget?

Answer 17: In GLDAS precipitation is provided from observations (TRMM) and runoff is calculated by the model. So yes, we are going to look at both.

Question 18: When you are referring to evapotranspiration, is it the actual or potential? Can we estimate both?

Answer 18: It is referring to actual ET, but if you look at GLDAS as we will in upcoming sessions, potential evapotranspiration is available.

Question 19: I have a small project on the study of recharge system on urban catchment. Can anybody suggest any ideas on how the sub-surface water can be analyzed and studied?

Answer 19: GLDAS does have subsurface water derived from modeling + observations. The highest resolution is .25 degrees. You have to see whether that is sufficient or not for your catchment. Other than that you have to develop your own catchment model, and you can force that with remote sensing data.

Question 20: What method does it propose to estimate surface runoff using these geoinformation technologies?

Answer 20: The one we are going to discuss is from GLDAS model - it's a land surface model that uses both water and the energy balance at the land surface. As we saw all the weather inputs - precipitation input- is provided and processes are modeled. You get calculated runoff surface runoff and subsurface runoff. In the last week you'll see how to do this with GLDAS.

Question 21: Can we rely on the MODIS ET data? There are numerous publications indicating that It requires local calibration.

Answer 21: With any remote sensing data you use, it's recommended good practice to calibrate locally. Next week in the webinar we'll have someone who will talk about the Nile River Basin water budget and he'll show comparison of different ETs including MODIS and ALEXI. That's something that has to be done for all river basins you're interested in.



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Question 22: When there is a hydrological cycle in place from nature, then why do we need to conserve water when its quantity hydrological system is constant?

Answer 22: Water might remain constant as you're saying, but usage is increasing. Population is increasing, consumption of drinking water, agriculture expansion, irrigation, using groundwater, river water are all increasing. There are industries increasing that use water. So, it's not just the supply part, it's also the demand part that's been increasing. The same resources are now divided more than before, and that's why better management is required.

Question 23: Is it possible to delineate lowland river by this method?

Answer 23: If you look at the HydroSHED website, you'll see in the quality part in relatively low or flat areas there is more uncertainty. It also depends on the size of the river. When using data derived from SRTM radar, if a river is small and surrounded by vegetation it misses that. The number of factors for flat and lowland rivers - it's resolution, plus what is around it - all these things matter. How it's seen by SRTM depends on that. It may change for different regions and different rivers. If you look at the slide, that's why there's adjustment done for observed river path. They adjust HydroSHEDS data.

Question 24: Why did you extract a subset (sub-basins of Parana River basin) from hydrosheds you first created a buffer and didn't do just a simple clip?

Answer 24: We first buffered the Parana River basin before clipping because the extract tool in QGIS works differently than the Clip tool in ArcMap or ArcPro. This is a necessary step to ensure only sub-basins "within" the buffered shapefile are extracted for further analysis.

Question 25: How does rain from satellite compare with rain from numerical models like WRF mesoscale model? Is there any research about this?

Answer 25: There are quite a few publications if you search, where model observations are compared with rain gauges and satellite data. The important thing here is that it depends on the resolution, how you're comparing data - how high the resolution of GPM data - it's 1/10th of a degree - it depends what resolution your WRF model is running. How best WRF inputs are given is also important. It will depend on uncertainties in observations and models. In our case, in the last session, we'll show that GLDAS, that uses TRMM precipitation to force the model, and GPM IMERG data - they compare very well.



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Question 26: Will it be possible to estimate all the parameters we saw today to monitor water budgets for river basin management based on Sentinel-1 to 6?

Answer 26: Not sure you can measure precipitation using Sentinel data. You can derive land cover, so it'll help in deriving ET perhaps. Soil moisture can be obtained by combining with SMAP (as we have), but runoff will have to be calculated. So, precipitation and runoff would still have to be measured somehow.

Question 27: Are there any good suggestions for the validation of remote sensing data in regions with rare observation station?

Answer 27: This is a question that comes up all the time with new data, when you're using remote sensing data because there's nothing else. But how do you make sure how accurate it is? One thing you can do in that case is to have a qualitative understanding of the data such as if satellite is showing precipitation, do you get precipitation? Check how accurate it is - is it showing your experience can be relative to the data? If there are no quantitative observations, then the only way to compare is with qualitative experience of your region. Suppose you knew that in a certain year there was a major flood - you can go back and look at satellite data for that period to see if it's showing high rainfall compared to other years. There can be indirect - not validation - but confirmation of your experience.

NASA also has a program called GLOBE (<https://www.globe.gov/>). It works with international schools to provide certain instruments for free to measure weather data - provide rain gauges, soil moisture observations. If you're in a data-sparse region and have no surface observations, see if any schools in your area can work with NASA GLOBE and get some instruments in your area. There's a website where you can upload this information and it's compared with satellite data, so it's an indirect validation. <https://www.globe.gov/>

Question 28: How can one estimate the uncertainty of watershed water balance based on remote sensing data?

Answer 28: Usually all the sensors and products that come from remote sensing - they are validated on some observations. Not everywhere. Based on that, there may be some uncertainty level available - precipitation is within 10% or soil moisture is within 15%. Such error bars will be available. From next week we'll see from the Nile river basin that uncertainties are there and it's very quantitative estimation of these



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uncertainties is tricky and it depends on the region you're in. All different components have different resolutions and accuracy, so when you subtract to get total balance, there has to be uncertainty. For each region, that bar is different, and that's why local observations are important for calibrating remote sensing.

Question 29: What are some of the issues with using datasets from different satellites?

Answer 29: It's different temporal and spatial resolution and coverage. For example, MODIS is daily but Landsat is every 16 days. SMAP has global coverage every 3 days. TRMM+GPM with other satellites cover every 3 hrs - half hour data for GPM. So when you want to calculate water balance, you have to go with the lowest satellite resolution that you get the information from. So, doing analysis, you may have to upscale you're higher resolution data like ET or soil moisture. Landsat-based data is 30 m and rainfall is 10 km, so you have to upscale to get water budget data. You have to do further processing - this is one of the issues with different satellites. It's one of the reasons we'll focus on GLDAS for water balance, because it integrates observations in model processes so that you have an integrated picture with integrated grids. All the components - precipitation, ET, runoff, soil moisture, everything is available at the same spatial/temporal resolution.

Question 30: How can depth of any outlet such as lake can be found using remote sensing? So to estimate water budget in terms of volume?

Answer 30: This will not be directly available through remote sensing data.