



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 Sean McCartney (sean.mccartney@nasa.gov).

Question 1: Why MODIS Aqua and not (also) Terra?

Answer 1: The reason we decided to use the MODIS land surface temperature (LST) product from the Aqua satellite, is that the Terra satellite has an equatorial crossing at 10:30 local time while Aqua has an equatorial crossing at 13:30 local time. Since land surface temperatures are typically highest in the afternoon, the Aqua mission is better suited for this analysis. Depending on the analysis you are interested in, you can use either Terra or Aqua MODIS for deriving daytime and nighttime historic land surface temperatures.

Question 2: How did you import Landsat to script section?

Answer 2: I'm not entirely sure what this question is asking. If you are trying to access the code, you can find each script as hyperlinks in the PDF of today's presentation. If you have any questions on each line of code, please refer to the commented sections for more information. If you have more questions feel free to reach out to me directly. (sean.mccartney@nasa.gov)

Question 3: Hi all, it is fantastic that the code is well commented. However, is there any documentation for the library that is being used?

Answer 3: For the code provided, we used the library of functions that come with the GEE API. For more information on the functions, refer to the API documentation under the Docs tab on the left side of the Code Editor.

Question 4: If we change the "aoi" by delineating our own rectangle, do we have to recalculate the lat & lon for map.setcenter? (I suppose otherwise the map display pans to Washington, DC all the time.)

Answer 4: Yes, whenever you change the area of interest (aoi) for your own study area, you will need to edit the long/lat degrees to set the map center on your own area of



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interest. This is one of the parameters each person will need to change in the script for their own study area.

Question 5: The script uses the thermal band which is heat reflected. What about surface emissivity for Landsat? Does that not contribute to the UHI?

Answer 5: One of the surface temperature auxiliary inputs for Landsat surface temperature is a global emissivity dataset derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) emissivity data.

ASTER is an instrument on the Terra satellite. Surface emissivity does influence urban heat island development as it's a measure of a surface's ability to shed heat, or emit long-wave (infrared) radiation. For this training we are focused on land surface temperature alone for deriving surface urban heat island intensity (SUHI).

Question 6: Is there some standard criteria/methodology to determine the extension of rural area with respect to the urban area or which is a proportion suggested? How do you define the areas to use as your rural and urban for the calculation of SUHI?

Answer 6: Most studies have adopted a relatively consistent approach for identifying urban areas—the areas classified as built-up land in land cover maps are considered urban areas. For the determination of rural areas, it is generally assumed that all areas within a certain range around the urban area are rural. In past studies, the most common methods were to set a buffer zone at a certain distance, such as 1–50 km. In the example provided in the script care was taken to delineate rural areas based on natural and suburban characteristics. However, regardless of which method is adopted, there is no widely recognized standard method.

Question 7: What does the point buffer do? Does the higher buffer mean a higher analysis area?

Answer 7: Yes, the greater the buffer area (in meters) the larger your area of analysis. If you increase the buffer size, be sure it is divisible by the spatial resolution of Landsat imagery (i.e., 30m), otherwise you will receive an error message. (E.g., `point.buffer(60)`; `point.buffer(90)`; `point.buffer(120)`; etc.)

Question 8: Is the time of the day equal across all the images?



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Answer 8: For each mission (e.g., Landsat 8) the local overpass time is the same for all images. This is the same for the Aqua mission as well.

Question 9: How does one ensure that the rural areas selected as a "comparison" to the urban area are not too far away, or too different in geography/elevation/etc., to be inaccurate for purposes of measuring urban heat island?

Answer 9: Care should be taken when delineating rural versus urban areas with varying elevation, as this will affect LST values. Also, delineating areas around large bodies of water will also influence LST values. When possible, delineate urban/rural bounds with similar elevation and geographies.

Question 10: Is it possible to integrate the LST information with humidity in order to build the urban heat islands? Is it possible to do it in a city that has no field measurements (i.e., lack of information with satellite information)?

Answer 10: It is possible to integrate LST information with humidity in order to build UHI. We did not cover this in today's training as we were focused on showing how to use Landsat Collection 2 surface temperature products for deriving SUHI, and also Aqua MODIS for deriving SUHI in day and night.

<https://www.earthdata.nasa.gov/learn/toolkits/disasters-toolkit/extreme-heat-toolkit>

Question 11: I want to measure a spot where the green cover is high and the other where the temperature is high. I am not able to locate my area, since it is a small area. What to do?

Answer 11: Make sure you change the basemap in the map window to satellite view to help delineate your green versus built up areas. You can also identify green areas using a vegetation index (e.g., NDVI). You can calculate vegetation indices using surface reflectance red and near infrared bands from Landsat missions. For more information refer to the links below:

<https://www.usgs.gov/landsat-missions/landsat-normalized-difference-vegetation-index>

https://developers.google.com/earth-engine/tutorials/tutorial_api_06

Question 12: Is it possible to download the calculated SUHI map as a raster?

Answer 12: Yes, the link below shows how to export your SUHI raster. The exports can



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be sent to your Google Drive account, to Google Cloud Storage, or to a new Earth Engine asset.

<https://developers.google.com/earth-engine/guides/exporting>

Question 13: For UHI assessment which LST product should I go for the Aqua MODIS or Terra MODIS?

Answer 13: See answer for Question 1.

Question 14: To apply the code for my area of interest, do I delete rural geometry and draw again, not create a new geometry, just edit rural or urban. I have an error (GeometryConstructors.MultiGeometry: Geometry coordinates do not have the same geodesic state. Specify an explicit geodesic state to reproject inputs.) What did I do wrong?

Answer 14: You can delete the polygons for aoi, urban, and rural—they were examples of delineated areas specific to Washington, DC. To apply the code for your own area of interest you will need to draw a new bounding box using the “Draw a rectangle” (or “Draw a shape”) feature in the map window for your aoi, and you’ll need to do the same for the urban and rural multipart polygons using the “Draw a shape” feature. Once they are drawn you will need to rename them so they match the variable names assigned in each script.

Question 15: Hello, I want to ask about LST calculation from Landsat 8 or 9. As you only used the thermal bands to depict LST. Isn't it necessary to calculate NDVI or FV or emissivity to go through the LAST equation?

Answer 15: This is one of the reasons we decided to hold this training on UHI. USGS released Collection 2 science products for Landsat 4-9. The science products contain surface temperatures already calculated so you no longer need auxiliary datasets (e.g., NDVI, FV, etc.) to calculate surface temperature on your own. The analysis ready data products make it easier to analyze LST and SUHI for one’s area of interest.

Question 16: GeometryConstructors.MultiGeometry: Geometry coordinates do not have the same geodesic state. Can you specify an explicit geodesic state to reproject inputs?



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Answer 16: Make sure you are drawing your own polygons for aoi, urban, and rural for your study area. If you create new polygons without deleting the ones provided in the script it might throw the error message you received.

<https://developers.google.com/earth-engine/apidocs/ee-algorithms-geometryconstructors-multigeometry>

Question 17: What is `var DATE_RANGE = ee.Filter.dayOfYear(182, 243);` 182 & 243, Specifically, what is 182 & 243?

Answer 17: 182 and 243 are days of the year. They are providing the date range to filter the image collection. You can learn more about days of the year at the link below:

<https://www.scp.byu.edu/docs/doychart.html>

Question 18: Can you please tell me more about selecting the area of interest? What are the parameters that particular area should have? If that area is too big, more in a linear fashion than a circular type, is it also good to select that area for study?

Answer 18: The important thing about selecting your area of interest is it contains both urban and rural windows within your study area. You do not need to use a rectangular polygon to delineate your aoi, you can use any shaped polygon that accurately captures and characterizes both urban and rural areas. If you have accurate land cover maps of your city and surroundings, they can be used as a guide to delineate your aoi.

<https://www.nature.com/articles/srep11160>

<https://www.sciencedirect.com/science/article/pii/S092427161830248X>

Question 19: How can we modify the layers of geometries? Add a new polygon?

Answer 19:

To edit the geometry layers, click on any of the polygons and edit the vertices.

To add a new polygon (or different geometry), click on “+new layer” under “Geometry Imports” and select from the options for point (i.e., marker), line, shape (i.e. polygon), or rectangle. You can then add a new polygon as an import.

Question 20: Hi. I'm no professional at scripting. When I went to run the script, it said "Point 20 is not defined", point 20 being "// Buffer the aoi by 30 meters to match the spatial resolution of a Landsat pixel.

`var aoi = point.buffer(30);"`



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Is there a guide for defining this?

Answer 20: See answer for Question 7.

Question 21: In India near the capital New Delhi satellite towns are getting more industrial. If I want to study that particular satellite town excluding the remaining area is it a good approach or I should take it as a whole UHI?

Answer 21: It depends on what questions you are asking. If you are interested in the SUHI between the satellite town and the surrounding rural area, you can select your study area accordingly. If the entirety of New Delhi is your study area then you can delineate the built up urban areas using a land cover map of the city as your reference.

Question 22: Using MODIS products from Aqua or Terra, what about the QC Day or Night values? Is there a threshold for all the regions? Also, what about the missing days due to cloud fraction? Is there a way to fill these missing data?

Answer 22: The QC day and night values in the MODIS scientific products give the user information on algorithm results for each pixel that can be viewed in a spatial context. The QC information tells if algorithm results were nominal, abnormal, or if other defined conditions were encountered for a pixel. The QC information should be used to help determine the usefulness of the LST data for a user's needs. One solution to filling in missing data for cloud and cloud shadow pixels is to use the 8-day LST MODIS product. It is the averaged LST for the MODIS daily product over eight days.

<https://lpdaac.usgs.gov/products/myd11a2v061/>

Question 23: Is it possible to download the calculated SUHI map as a raster?

Answer 23: See answer for Question 12.

Question 24: Can we use the same codes and play around with areas of our interest? Will those give the respective value difference of urban heating difference between rural and urban. Also, how do we know which part is rural or urban while labeling with polygons?

Answer 24: Yes, you are encouraged to use the code provided in today's training and adapt it for your own urban area of interest. The code has been commented throughout explaining which parameters you will need to change for your study area, as well as which imported geometries you will need to delineate as well. To learn which



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regions of your area of interest are urban versus rural, it is recommended to use a land cover map of the area to guide your decision making.

Question 25: Is there a systematic shift in the MODIS LST data? When analyzing a few different sites, it appears that LST is shifted east and south compared to the urban polygon I drew. This effect is most easily seen where land meets a large water feature, or where an urban area is surrounded by natural land covers.

Answer 25: This has to do with the projection of MODIS science products. MODIS land products are produced in the Sinusoidal tile grid. For more information on the Sinusoidal projection, refer to the link below:

<https://pro.arcgis.com/en/pro-app/latest/help/mapping/properties/sinusoidal.htm>

Question 26: I drew my rectangle to redefine my aoi, but I am not sure how to reset the lat/lon for my map center.

Answer 26: To find the longitude and latitude for your aoi, use the Inspector tab and click on a location from which to center your map. Click on the dropdown arrow under Point (Inspector tab) to find the longitude and latitude and edit the Map.setCenter arguments accordingly (e.g., lon, lat, zoom).

Question 27: Can I import a custom polygon (or points) in GIS formats (e.g. shapefile, KML) into GEE for use with the scripts?

Answer 27: Yes, refer to the links below to learn more:

https://developers.google.com/earth-engine/guides/table_upload

Question 28: Can you please advise the accuracy assessment for the LST calculation? Because MODIS and Landsat data are acquired on different days, the ST derived from these two satellites are not similar. In this case, will the range of ST be applied to assess the ST calculation accuracy?

Answer 28: There are many variables at play when you discuss comparing the accuracy of MODIS LST estimates with Landsat LST estimates. They are derived from different sensors with different spectral, spatial, and radiometric resolutions. The goal is not to compare the accuracy of each, especially when SUHI can change over the course of days and weeks. That is why we used in our examples the mean LST over certain date ranges (days of year & year range) to calculate the SUHI for each mission. The benefit of using Terra and Aqua MODIS for historic data is they both provide day



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and night LST, Landsat sensors only provide LST during the day. To learn more about the accuracy assessment of each sensor, refer to the links below:

<https://www.usgs.gov/media/files/landsat-8-9-collection-2-level-2-science-product-guide>

<https://www.usgs.gov/media/files/landsat-4-7-collection-2-level-2-science-product-guide>

https://lpdaac.usgs.gov/documents/118/MOD11_User_Guide_V6.pdf

Question 29: Can we integrate the LST information with humidity information derived from satellite imagery to build UI in cities that do not have field measurements?

Answer 29: See answer to Question 10.

Question 30: Question regarding nighttime temperature. My understanding is that remote sensing is passive? How does MODIS get a reading at night?

Answer 30: Not all remote sensing is passive. Active remote sensing systems are not dependent on the sun's electromagnetic radiation (EMR) or the thermal properties of the Earth. Active remote sensors create their own electromagnetic energy that is transmitted from the sensor toward the terrain, interacts with the terrain producing a backscatter of energy, and is recorded by the sensor's receiver. Examples of active sensors include RADAR, LiDAR, and SONAR.

Passive remote sensing systems record EMR that is **reflected** (e.g., visible and near-infrared light) or **emitted** (e.g., thermal infrared energy) from the surface of the Earth. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded. Passive instruments such as MODIS and Landsat Thermal Infrared Sensor (TIRS) are able to record emitted thermal infrared energy at night.

Question 31: How do you get the temperature range between 28-47 in Google Earth Engine in the script Landsat_LST_SUHI?

Answer 31: These values were selected by looking at the range of LST values in the histogram.

Question 32: Is SUHI intensity value a value for a certain area? Is it not a per pixel value?



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Answer 32: SUHI intensity is the mean value of all the pixels captured in the rural polygon(s) subtracted from the mean value of all the pixels captured in the urban polygon(s). It is not a per pixel value.

Question 33: Is it the case that the results lose quality if the urban and rural zones are too separated? It is the case for Lima (Peru) that its urban extent is huge and its rural areas are far from the city center.

Answer 33: The results will not lose quality so long as you carefully select the zones for your urban and rural areas. To help guide you when delineating your urban and rural zones, refer to an accurately made land cover map of Lima. It's not as important capturing the city center as it is capturing the built up area within the urban window.

Question 34: Is there a way to get the temperature value for a point on the map?

Answer 34: Yes, you can do so using the Inspector tab.

Question 35: Can we compute Land Surface Temperature in GEE if the boundary is not rectangular? Can the results be exported to multiple dimensional data such as NetCDF?

Answer 35: Yes, you can compute LST in GEE if the boundary is not rectangular. The example script we provided showed how to do so using a rectangular bounding box, but feel free to adapt the code for any geometry that is appropriate for your study area. Currently you cannot export results to multidimensional data such as NetCDF. You can export as a GeoTIFF, refer to the link below:

<https://developers.google.com/earth-engine/guides/exporting#configuration-parameters>

Question 36: How do you choose a good rural area? I am looking at the Phoenix metro area, and I am wondering if I should choose irrigated agricultural land, or mountains, desert, or all of the above?

Answer 36: Agricultural land and desert are both appropriate when selecting rural areas. Be careful when selecting zones with varying elevation when compared to urban areas as the adiabatic lapse rate will influence surface and air temperatures. There have been a number of studies on UHI in Phoenix and we recommend doing some literature review for which methodologies were applied in this city.



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Question 37: Can we use SRTM data to get temperature data based on elevation?

Answer 37: This is an interesting research question. I have not used SRTM to get temperature data based on elevation, but it's worth doing some literature review for publications that have. I see no reason why you can't.

Question 38: What is the role of albedo in UHI?

Answer 38: The difference in surface albedo between urban areas and rural areas is a major contributor to the differences in temperatures between the two locations. Increasing the albedo of surfaces in urban areas would help reduce the urban heat island effect.

Question 39: The cloud cover filter is at 20, I do not understand what the value that I place in this variable depends on.

Answer 39: The cloud filter has to do with the percentage of cloud cover in any Landsat or MODIS scene. In the examples provided in the script, we filtered every scene in the collection to those with cloud cover less than 20%. Since Landsat sensors and MODIS are optical sensors, and cannot observe reflectance data below cloud cover, it's important we filter these scenes to low cloudy days so we have imagery we can use.

Question 40: In the example we are seeing a fixed polygon for urban areas. If I am interested in a study extending to two to three decades, how should I define this urban polygon, as the urban expansion/sprawl may have taken place?

Answer 40: This is an interesting question. You could keep the delineated urban area polygon(s) consistent throughout the decades for your analysis, or adjust the polygon(s) as appropriate to match the urban growth. One way to go about doing this is to filter the study period per time step (e.g., 5-year, 10-year, 15-year, etc.), and see spatially where higher land surface temperatures are increasing over time. You could then increase the area of your urban polygon at time intervals matching observed increases in LST caused by built-up environments.

Question 41: In the first script, instead of deriving the mean is it possible to derive the 90th, or the 95th percentiles?

Answer 41: Yes, to derive standard deviations you will use the Reducer class in GEE. Refer to the link below to learn more:



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https://developers.google.com/earth-engine/guides/reducers_intro

Question 42: Once we have the script open in GEE (and saved to our list of scripts), how can we make changes to it? I'm trying to switch the location to NYC.

Answer 42: Once you have the script saved to a repository or folder in your Owner directory, you can change whatever parameters in the script you want and save it. GEE stores all scripts using Git, so you can go back to any previously saved version of the script you are working with. To change the parameters to NYC, you will need to know the long/lat of the city (hint: use the Inspector tool), and adjust the parameters in the script accordingly.

Question 43: I would like to know how to create a new AOI in Google Earth Engine mapping area by adding a new layer. I can only add a new layer of the point type, not a polygon type.

Answer 43: If you already have geometries defined and you can see them under the "Geometry Imports" section in the map window, click on "+ new layer" and then specify the rectangle, polygon, line, or marker feature you wish to add to the map layer.

Question 44: Is it necessary to filter the collections based on 20% cloud cover and leave only the ones with less than that? That 20% of cloud cover/cloud shadows could be spread all around the individual Landsat scene and isn't necessarily above our point of interest.

I commented that part of the code, and for my point the number of Landsat scenes increased, meaning that LST is also more representative?

Answer 44: Yes, you can absolutely do this. We demonstrated the cloud filter as a function in the script since certain geographies (i.e., tropical latitudes) tend to have a lot of cloud cover. The less than 20% cloud cover is relative to the entire scene and doesn't ensure the cloudy pixels are over your area of interest within the scene. Feel free to adapt the code in the script for your own analysis.

Question 45: Instead of "landsatST.mean();" can I use "landsatST.percentile(95);"?
Line 113 of Landsat_LST_SUHI.js

Answer 45: To derive standard deviations you will use the Reducer class in GEE. Refer to the links below to learn more, as well as the API documentation under the "Docs" tab in Earth Engine.



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https://developers.google.com/earth-engine/guides/reducers_intro

<https://developers.google.com/earth-engine/apidocs/ee-reducer-stddev#:~:text=ee.-,Reducer.,standard%20deviation%20of%20its%20inputs.>

Question 46: How can I edit the delineated AOI rectangle to focus on my study area? I can only draw the new one, but the original rectangle is still here.

Answer 46: You can delete the aoi rectangle provided in the script by clicking on it and deleting it.

Question 47: Please tell me how to export the UHI map?

Answer 47: The link below shows how to export your UHI raster. The exports can be sent to your Google Drive account, to Google Cloud Storage, or to a new Earth Engine asset.

<https://developers.google.com/earth-engine/guides/exporting>

Question 48: How can I find the coordinates of the new city that I want to study (of Map.setCenter)

Answer 48: To find the longitude and latitude for your aoi, use the Inspector tab and click on a location from which to center your map. Click on the dropdown arrow under Point (Inspector tab) to find the longitude and latitude and edit the Map.setCenter arguments accordingly (e.g., lon, lat, zoom).

Question 49: If I want to analyze SUHI at a neighborhood scale, which satellite product should I use? Does GEE have commercial products such as Planet?

Answer 49: Currently, surface temperature products with the highest spatial resolution are derived from Landsat Collection 2 scientific products. These are applicable at the neighborhood scale. This is why we demonstrated these products in Part 1 of the webinar series. GEE does not have surface temperature products derived from Planet.

Question 50: Is there a minimum number of polygons for urban and rural areas that can improve the calculations of LST? Or is it enough with one for each category?

Answer 50: Care should be taken to characterize urban and rural windows for your study area—there is no minimum or maximum number of polygons per se. Most studies



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have adopted a relatively consistent approach for identifying urban areas—the areas classified as built-up land in land cover maps are considered urban areas. For the determination of rural areas, it is generally assumed that all areas within a certain range around the urban area are rural. In past studies, the most common methods were to set a buffer zone at a certain distance, such as 1–50 km. In the example provided in the script care was taken to delineate rural areas based on natural and suburban characteristics. However, regardless of which method is adopted, there is no widely recognized standard method.