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

Question 1: In an urban area, what criteria do you consider for choosing places to collect air temperature and humidity data with data loggers? In identifying UHI, is it necessary to collect air temperature and humidity data from rural areas also?
Answer 1: Currently, we've only collected land surface temperature from satellites. To collect air temperature, you need to include both high and low intensity urban areas. Also, air temperature and humidity in rural areas are also needed to quantify UHI intensity.

Question 2: How can we get access to the code the presenter (i.e. Dr. Xian) mentioned "applicable to study urban heat islands in other cities"?
Answer 2: We have developed programs to process land surface temperature from Landsat, to automatically process temperature data. The current program focused on calculating land surface temperature annual status and trends. In the future, we will release these programs (code) to other users. Please refer to the USGS site for release. This code should be applicable to regions around the globe: https://www.usgs.gov/core-science-systems/nli/landsat/landsat-collection-2-surface-temperature

Question 3: For a city experiencing temporal floods, how do you estimate the actual LST and or UHI for planning or mitigation purposes?
Answer 3: The intention for our UHI monitoring is to estimate UHI condition in many cities. When there are Landsat records (clear records), we can estimate LST.

Question 4: What is the method used to Pansharpen the thermal data using the optical bands? In particular, do you use land cover in the process?
Answer 4: We do not use landcover.

Question 5: Why did the UHI intensity and hotspot decrease in 2016 compared to 1986 from the Sioux Falls city center (Dr. Xian)?
Answer 5: If you look at annual temperature estimates, it uses all clear Landsat records. We are looking at historical trends.

Question 6: On slide 23 you showed UHI intensity for Sioux Falls in 2016 where stripes of colder LST are noticeable. I guess you used Landsat 7 who has scan line error because of which part of data is lost. Why didn't you use Landsat 8 instead? In addition to that, how big of a problem is using Landsat 7 data?
Answer 6: When we process LST from Landsat we use all available data. If we did not have Landsat 8 data, we would supplement with Landsat 7. The program processes seasonal and annual means. The error did not have a large effect.

Question 7: Over Chicago, while the LST patterns observed by Landsat and Ecostress look similar, the absolute LST levels and contrast seems different. Are the observed differences related to the local observation time, or are they related to instrumental and/or processing effects?
Answer 7: They are indeed related to local observation time. ECOSTRESS collects ~ 0730 and Landsat a few hours later so the Landsat LST was slightly higher.

Question 8: In slide 25, the R squared doesn't show a significant relationship between Temp min and 90 Percentile hot days. How can you explain this?
Answer 8: It is not significant in Atlanta for the current analysis. This was from one a weather station. We don’t expect every station to show the same patterns.

Question 9: In Kevin Gallo’s presentation, slide 7, he shows the VIIRS land surface type product. But VIIRS is not on GOES correct? I'm asking because I would like to learn how to create the graph on the right on slide 8.
Answer 9: This is correct, the VIIRS derived land surface type product was used because there currently isn’t a similar GOES derived product. This is an example of the advantage of using multiple sensors. The data used in the graph on the right were extracted from the GOES LST products based on the latitude and longitude values associated with the land surface types displayed in the VIIRS land surface type product.

Question 10: How did you calculate ECOSTRESS?

Answer 10: We don't do any calculations ourselves. It was very limited processing (geoprocessing, etc). Please see the ARSET ECOSTRESS webinar for more information on ECOSTRESS data: https://appliedsciences.nasa.gov/join-mission/training/english/new-sensor-highlight-ecostress

Question 11: Given the GOES platform Advanced Baseline Imager's (ABI) 5-min acquisition frequency, any plans to generate LST at sub-hourly frequency? Even just for heat wave periods?
Answer 11: The possibility of observations of LST at greater frequencies may be possible as there are other ABI data and products acquired at greater frequencies during, for example, severe weather events. I will relay this suggestion to the GOES program staff as it certainly deserves consideration. A great suggestion, thank you.

Response from NOAA GOES program: Increasing both temporal and spatial resolutions is a topic that is actively being addressed. In making these decisions, bandwidth and system processing constraints must be considered. Unfortunately, unlimited bandwidth and compute power are not available to make all products at full temporal and spatial resolution, so requests must be addressed, and priorities weighed. In order for us to have a requirement for something like this we would need a formal request from an operational NOAA user. One improvement underway related to the LST product is that it will soon be available for the entire full disk area at the same 2km resolution presently available for the conterminous USA, at an hourly interval. If there are additional product questions, they may be directed to SPSD.Userservices@noaa.gov

Question 12: Is it important to relate dry or wet seasons to higher or lower LST?
Answer 12: This would most likely depend on the context of the area being studied. In Huntsville, we looked at LST in the summer because we were interested in looking at how the hotter temperatures during the summer would intersect with the urban heat island effect, but in some contexts it may make sense to also compare dry vs. wet seasons.

Question 13: For the Huntsville example, what were the age and health characteristics of the high vulnerability areas?
Answer 13: The age and health characteristics that we looked at to determine heat vulnerability were the percentage of the population over 65 years in age and rates of

diabetes, asthma, hypertension, COPD, and obesity. The most vulnerable census tracts in Huntsville had an average LST of nearly 90 °F with relatively high percentages of the other health variables. The census tract with the highest vulnerability score has around 40% people over 65 and obesity, 52% hypertension, 11% COPD and asthma, and 20% diabetes.

Question 14: Can you post the URL for the story map 'Hunting for Heat in Huntsville'?
Answer 14: The story map is still in the process of going through export control through NASA DEVELOP so that it can be publicly accessed. We will let the team at ARSET know as soon as the story map is made available so that they can pass it along.

Question 15: Dr. Xian, can you please explain the method you used to generate the albedo map for an urban area?
Answer 15: This was not from our work, but the MODIS estimate of albedo used NLCD.

Question 16: Given the 16-day revisit frequency of Landsat and the issue identified with differential cloud-related missingness, was there any attempt to account for seasonality or use a higher temporal frequency sensor like MODIS to weight the summary?
Answer 16: In Huntsville, we used Landsat 5 and Landsat 8 instead of a higher frequency sensor like MODIS mostly due to the spatial resolution. For our project, we were more concerned with having higher spatial resolution than having higher temporal resolution, and the missing data due to cloud-masking was an issue only in one of the years we studied, so we didn't look to include another sensor to overcome this problem. In terms of seasonality, we only looked at the summer months (June through August) in an effort to keep our analyses consistent.

Question 17: What is the unit of Vulnerability?
Answer 17: For the Huntsville project, vulnerability was determined by combining several variables using PCA analysis, so the vulnerability itself does not have a unit. The first PCA used LST, NDVI, and NDBI to create a Heat Exposure Index. The second PCA used the age and health data to create a Heat Sensitivity Index. These were then combined in a final PCA to create our Heat Vulnerability Index. The resulting value is a score *without a unit*. For context, the most vulnerable tract had a HVI score of 5.01 while the one of the least vulnerable tracts had a score of -3.55.

Question 18: Do you have R code for the Huntsville, Alabama research in a public repository?
Answer 18: The R code used for the heat vulnerability index was a modified code that was created by another DEVELOP participant. Unfortunately it is currently not available to the public as it has not gone through DEVELOP's software release protocols.

Question 19: How is SLC-off correction implemented in the LST product?
Answer 19: The Huntsville team chose to use only Landsat 5 and Landsat 8 to avoid the SLC-off correction requirement.

Question 20: How can one create an LST product comparable to the ARD LST product product for cities outside the USA? Are there any references or journal articles describing the processes/algorithms?
Answer 20:
You can use the procedure demonstrated in Session-1 using GEE.
Please see the following: https://www.usgs.gov/media/files/landsat-provisional-surface-temperature-product-guide. The following references can also be found from this site --
Cook, M., Schott, J. R., Mandel, J., & Raqueno, N. (2014). Development of an operational calibration methodology for the Landsat thermal data archive and initial testing of the atmospheric compensation component of a Land Surface Temperature (LST) Product from the archive. Remote Sensing, 6(11), 11244-11266. http://dx.doi.org/10.3390/rs61111244

Question 21: What is the difference between LST and Atmospheric temperature in relation to the urban heat island?
Answer 21: LST refers to the Land Surface Temperature, which is the temperature of the land surfaces. LST is correlated with, but not the same as, atmospheric or air temperature. The air temperature is the temperature actually experienced by individuals, but LST is commonly used in remote sensing projects because it is easily calculated from Landsat. See Part 1 of this series for more information of these terms.

Question 22: So the amount of scenes used per year, to find annual average LST, varies? For example, some years have 12 scenes, some have 8, others have 20, etc?

Answer 22: This is correct for the Huntsville's team project. Each year could have a slightly different number of scenes depending on data availability throughout the time period we were looking at (June-August). Xian: we used all available clear records (clear record annual mean) and also varies annually.

Question 23: Also, were any adjustments made to calculations for LST because you are using different satellites (a mix of Landsat 5 and 8)?
Answer 23: The Huntsville team did not make any adjustments to the outputs from Landsat 5 and 8. Landsat 5 and Landsat 8 have slightly different wavelength ranges associated with the bands, but we did not notice any major differences over our study area. However, if we had more time to work on the project, we would have calibrated the images to ensure that there were no differences that affected our analysis. Xian: For Landsat LST we use a calibration method to make it comparable from different sensors.

Question 24: In cloudy places (as tropical cities) it is very difficult to use Landsat due to its temporal resolution. Sometimes only one or two cloud free images are available. What is your recommendation for tropical cities?
Answer 24: We used all Landsat observations including L5, L7, and L8 year around. That increases temporal coverage of LST. Also, in many cases, clouds do not cover the entire study extent. Our method can use any pixel that is cloud-free to calculate annual means. If you have zero observations year around, other satellite records are needed (e.g. MODIS) yet they have a more coarse spatial resolution. Landsat 9 is launching in a year so hopefully that can reduce the temporal resolution.

Question 25: Why are there blue stripes in the first subplot (slide 23)?
Answer 25: These stripes are caused by Landsat 7 scan line error.

Question 26: Regarding the homework, does the term "land cover" mean something different than "land surface"?
Answer 26: In the homework land surface is referring to land surface temperature. Land cover describes characteristics of the land surface such as impervious surfaces, forest, agriculture, water, etc.

Question 27: Is/will Landsat Analysis Ready Data (ARD) be available on GEE?

Answer 27: GEE is using a different grid to handle satellite data. Landsat ARD (USA) currently is provided by USGS. In the future, Google may incorporate.

Question 28: What is GOES temporal resolution globally?
Answer 28: The NOAA GOES series of satellite data are not available globally. There are other Geostationary satellites with their own unique spatial coverage, spatial resolution, and temporal resolution for their available data.

Question 29: Can emissivity be transferred between urban man-made landscapes?
Answer 29: Emissivity is related to the physical properties of the material.

Question 30: How many Landsat images did you use in order to ensure a good accuracy in trend analysis?
Answer 30: We obtained the mean temperature of summers (June, July, and August) for the years we selected and most years have over 5 Landsat images in their calculation. Some Landsat images had more cloud cover than others so averaging over the entire summer helped fill in any data gaps.

Question 31: What should be the ideal distance of rural buffer zone from the urban core while calculating UHI intensity, using LST data?
Answer 31: People are using a buffer zone of 1-50 km from the center of the city. Longer than 5km is suggested. Too large, too much area outside of urban areas may be included.

Question 32: How sensitive is LST to emissivity? The many widely used emissivity retrieval methods with NDVI seem quite coarse. In other words, do variations in emissivity impact the LST estimate a lot?
Answer 32: Most emissivity values are derived from the ASTER instrument (100 spatial resolution).

Question 33: What is the best methodology for validating Landsat LST data?
Answer 33: Sampling stations to collect ground samples when the satellite is passing over that area.

Question 34: I am wondering if there are studies on effects of different types of green infrastructures (trees, shrubs, grass, green roofs/green walls) on UHI mitigation?

Answer 34: https://ccap.org/resource/the-value-of-green-infrastructure-for-urban-climate-adaptation/

https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect

Question 35: Why was there such a large difference in the temperature ranges between the Landsat LST and the ECOSTRESS LST images in the first presentation given that they were on the same day?
Answer 35: This is due to the local observation time. ECOSTRESS collects ~ 0730 and Landsat a few hours later so the Landsat LST was slightly higher.

Question 36: Can we use cloud removal techniques in the cloud covered data to study LST?
Answer 36: We averaged over the entire summer as a technique.

Question 37: Has the work of the third presentation been published yet? If so, please provide the reference. Thanks.
Answer 37: The DEVELOP project has not been published in any way. DEVELOP requires an export control process before anything can be released to the public, but we will let ARSET know when shareable things (like our story map) are made public. We can tweet it out, so follow us! @NASAARSET

Question 38: In addition to calculating emissivity from the NDVI, could you indicate all further preprocessing steps to derive LST?
Answer 38: The LST equation we used

$$LST = \frac{BT}{\left(1 + \left(0.0000115 * \left(\frac{BT}{0.01438}\right) * \log(E)\right)\right)}$$

Question 39: Why not use a machine learning method to fuse satellite imagery data together and get rid of spatial and temporal limitations instead of waiting for upcoming satellites? This is very important when you want to have a nighttime LST with a better spatial resolution in some specific hours and days when normally there is no available Landsat imagery for LST calculation.
Answer 39: There are fusion techniques to get the higher resolutions.

Question 40: Based on the typical urban heat island system of cities, has your research looked into the context of reciprocal green urban area to be planned/other measures to reduce/negate the impact of the urban heat island?
Answer 40: Not yet, but we are extending the scope of our studies.

Question 41: Should we always treat remotely sensed LST as the surface temperature of the canopy top, like tree crown top surface, roof, etc.?
Answer 41: Yes, it would be the temperature of the canopy top.

Question 42: What about the experience of download from large resolution satellite images for the high resolution ones in order to observe the city from its surroundings into inner urban areas? Is it possible to integrate products of different resolutions in order to have a picture both for metropolitan planning and local urban design?
Answer 42: This is certainly possible, with care. For example, in addition to differences in spatial resolution that would require attention, there may be differences between the sensors in time (or date) of observation and the wavelengths of the remotely sensed data (and algorithms) used to derive the land surface temperature.

Question 43: Has the Huntsville study been published, and if so, could you share a link to the manuscript?
Answer 43: No it has not been published yet because it is still going through NASA export control. This process takes anywhere from a few months to a year and a half. We are looking into submitting to a journal or a publication at the university.

Question 44: Does the NOAA weather and climate toolkit have worldwide LST data available?
Answer 44: No, not currently. Only the NOAA operational GOES data (that includes primarily North, Central, and South America) are included within the Toolkit. Other Geostationary sensors are positioned over other areas of the Earth and may have LST available through their data archive and distribution facilities. GOES South and Central America LST data products will soon be available at a 1 hour temporal resolution and 2 km spatial resolution similar to the data currently available for the Conterminous USA.

Question 45: Is there any option to map air temperature data or any database that we could utilize for comparing LST and air temperature data? I mean comparing LST and air temperature data with a resolution of Landsat 8 or even better resolution?

Answer 45: Weather station data correlation studies could be conceivable given data availability.

Question 46: How does the UHI analysis take into account the different operating system/production system of industrial areas? The morning and evening representation may not necessarily represent the correct situation, which will depend on the production shift of the industrial areas?
Answer 46: Fly over time versus industrial activity time. This poses an interesting study. One would be mindful of this in their work.

Question 46: During the studies on UHI over different cities, is there any effect of wind speed and direction and is it found to affect the LST/Surface UHI?
Answer 46: Through our studies, we did not find any correlation between wind speed / direction and surface temperature, but this could be something that would be interesting to look into further with in situ data!