Google Earth Engine: MODIS Land Surface Temperature (LST) Training
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CONTENTS

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MODIS Land Surface Temperature (LST)
The Moderate Resolution Imaging Spectroradiometer (MODIS) is an instrument carried by NASA's Aqua and Terra satellites. It captures images of Earth's surface in 1-2 day intervals in 36 spectral bands. The spatial resolution is 1000m, and the data extends from March 5, 2000 to the present. MODIS images can be used to analyze land surface changes over time, including land surface temperature.

Why was it developed?
This Google Earth Engine map displays global land surface temperature over a user-input short-term period. The tool also provides land surface temperature (LST) long-term and short-term time series for a user-specified region.

What is the tool used for?
The tool is used for analysis of global land surface temperature trends, with possible applications to climate change, agriculture, vector-borne diseases, etc.

What can the current tool not be used for?
The Terra and Aqua satellites were launched in 1999 and 2002, respectively. Therefore, the tool can only be used for analyzing temperature data from March 5, 2000 to the present, with about a month delay between satellite imaging and availability of data. It cannot be used for future temperature projections.

1.1 Definition

The Google Earth Engine – MODIS LST tool can be modified to output a time-series of LST for a user-defined region. This region can be defined through use of the geometry tool shown in the image below. This section will go through an example for Brazil.

The region is imported into the map through the following code:

```
// Import region
var region = geometry;
```

Alternatively, a region can be selected using Google Fusion Tables. Specific countries can be accessed from the 'Countries.csv' Google Fusion Table available publicly at: https://www.google.com/fusiontables/data?docid=1tdSwUL7MVpOauSgRzqVTOwdfy17KDbw-1d9omPw#rows:id=1. The code below selects Brazil from this file. Other data layers can be uploaded to Google Fusion Tables and accessed similarly, or public tables can be searched at: https://research.google.com/tables.

```
//Choose country using GEE Feature Collection
var region = ee.FeatureCollection('ft:1tdSwUL7MVpOauSgRzqVTOwdfy17KDbw-
1d9omPw').filterMetadata('Country', 'equals', 'Brazil');
```

This layer is then added to the map, showing the outline of the country.

```
//Add region outline to layer - for selected countries
Map.addLayer(region)
```


Following this region selection, the MODIS LST day and night image collections are uploaded into Google Earth Engine (GEE), as follows:

```
// Collect bands and scale
var modisLSTday = ee.ImageCollection('MODIS/MOD11A2').select('LST_Day_1km');
var modisLSTnight = ee.ImageCollection('MODIS/MOD11A2').select('LST_Night_1km');
```

The imported MODIS Land Surface Temperature data is expressed in degrees Kelvin. It is then converted to degrees Celsius, for both the day and night datasets.

```
var modLSTday = modisLSTday.map(function(img) {
  return
img.multiply(0.02).subtract(273.15).copyProperties(img,['system:time_start','syst
em:time_end']);
});
var modLSTnight = modisLSTnight.map(function(img) {
  return
img.multiply(0.02).subtract(273.15).copyProperties(img,['system:time_start','syst
em:time_end']);
});
```

The Google Earth Engine – MODIS LST tool provides a map of short-term (1 year) average LST, a time series of long-term (14 year) average LST, and a time series of short-term (1 year) average LST. These long and short-term periods can be input by the user for a desired analysis period by manipulating the code below, where collection05 is the long-term period and collection01 is the short-term period.

```
// Select dates
var collection05night = ee.ImageCollection(modLSTnight.filterDate('2000-01-01',
'2016-03-31'));
var collection05day = ee.ImageCollection(modLSTday.filterDate('2000-01-01',
'2015-03-31'));
var collection01night = ee.ImageCollection(modLSTnight.filterDate('2015-01-01',
'2015-12-31'));
var collection01day = ee.ImageCollection(modLSTday.filterDate('2015-01-01',
'2015-12-31'));
```

Finally, the MODIS LST data sets are "clipped" to the user-specified region, in order to be displayed only in that region.

```
//Clip to Specified Region
var clipped05night = collection05night.mean().clip(region)
var clipped05day = collection05day.mean().clip(region)
var clipped01night = collection01night.mean().clip(region)
var clipped01day = collection01day.mean().clip(region)
```

The LST time series are then charted and display in the GEE Console. In this case, all of Brazil is too large a region for Google Earth Engine to create a time series. Therefore, a smaller region must be chosen through use of the geometry tool (or a uploading a district shapefile), here called 'small_region' and shown in purple: (*NOTE – Rename 'geometry' import to 'small_region'*)



```
// Charts Long-Term Time Series
var TS5 = Chart.image.series(collection05night, small_region,  ee.Reducer.mean(),
1000, 'system:time_start').setOptions({
        title: 'LST Long-Term Time Series',
        vAxis: {title: 'LST Celsius'},
});
print(TS5);


// Charts Short-Term Time Series
var TS1 = Chart.image.series(collection01night, small_region,  ee.Reducer.mean(),
1000, 'system:time_start').setOptions({
        title: 'LST Short-Term Time Series',
        vAxis: {title: 'LST Celsius'},
});
print(TS1);
```

LST Long-Term Time Series

LST Short-Term Time Series
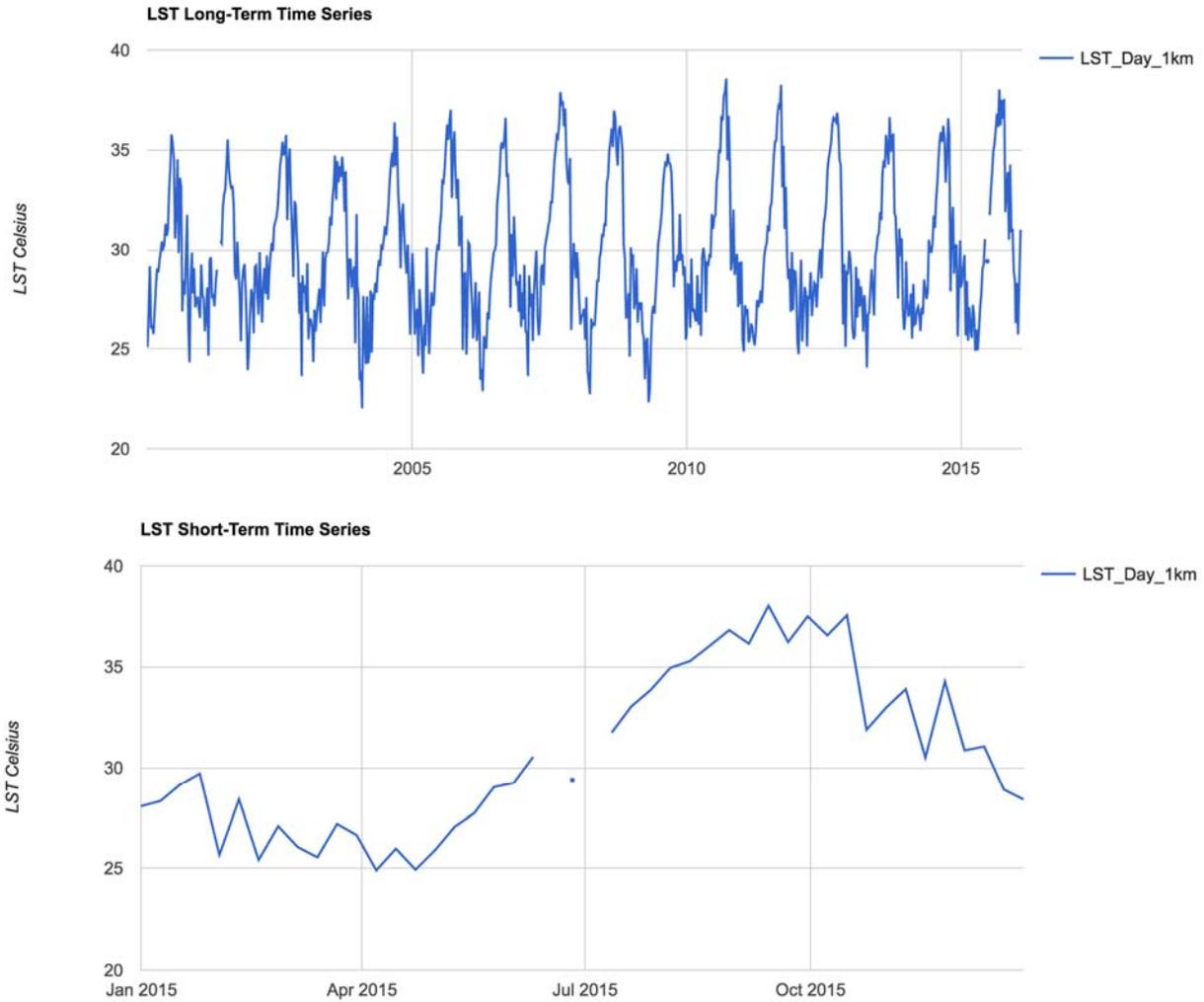
Finally, the map center is set and the short-term temperature data is added to the GEE map, at a range from 0 to 40°C, on a scale of color palette: blue, green, yellow, orange, red. Other color codes can be found at: http://www.nthelp.com/colorcodes.htm.

```
//Set Center of Map and Add Clipped Image Layer
Map.setCenter(-50, -10, 3); //lat, long, zoom
Map.addLayer (clipped01day, {'min': 0, 'max': 40, 'palette':"
0000ff,32cd32,ffff00,ff8c00,ff0000 "});
```


0°C   8°C   16°C   24°C   32°C   40°C
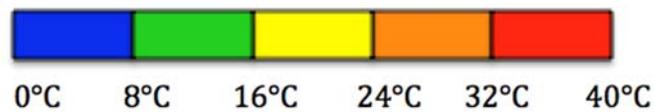
1.2 Interpretation

The MODIS Land Surface Temperature map runs on a scale of 0 to 40°C, where blue indicates colder values and red indicates warmer values. White indicates values in the middle of the spectrum, around 20°C.

The temperature values displayed on the map are average daytime temperatures over a short-term period ('collection01day'). The LST time series charts display average nighttime LST over time for the user-specified geometrical "small region".

1.3 Access

The Google Earth Engine – MODIS LST Code can be accessed at https://code.earthengine.google.com/92604f4d86082e68e3dfbb2fbe598e81. Google Earth Engine access can be requested through the form at https://signup.earthengine.google.com.

1.4 Analyses
Users can choose to map average daytime or nighttime temperatures over a short-term or long-term period, as desired. The user can also choose to chart time series for average daytime or nighttime LST over any specified time periods.

1.5 Case Study – Brazil
Brazilian epidemiologists want to assess the length and timing of the most recent severe drought event in Brazil, in order to understand the relationship with potential outbreaks of dengue.
The answer can be obtained by selecting Brazil as the target country from the Google Fusion Table 'Country.csv' feature collection. The most recent drought in Brazil occurred in January 2015, so the user could input January 2015 as the short-term time series and the 2014-2015 period as the long-term time series:

```
// Select dates
var collection05night = ee.ImageCollection(modLSTnight.filterDate('2014-01-01',
'2015-12-31'));
var collection05day = ee.ImageCollection(modLSTday.filterDate('2014-01-01',
'2015-12-31'));
var collection01night = ee.ImageCollection(modLSTnight.filterDate('2015-01-01',
'2015-01-31'));
var collection01day = ee.ImageCollection(modLSTday.filterDate('2015-01-01',
'2015-01-31'));
```
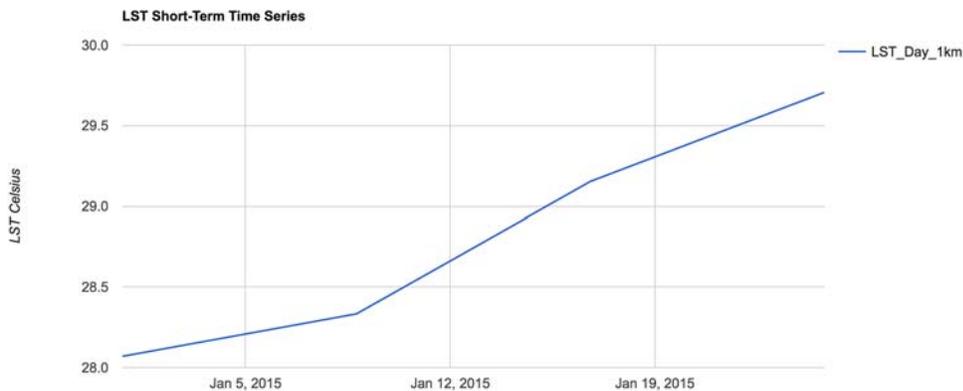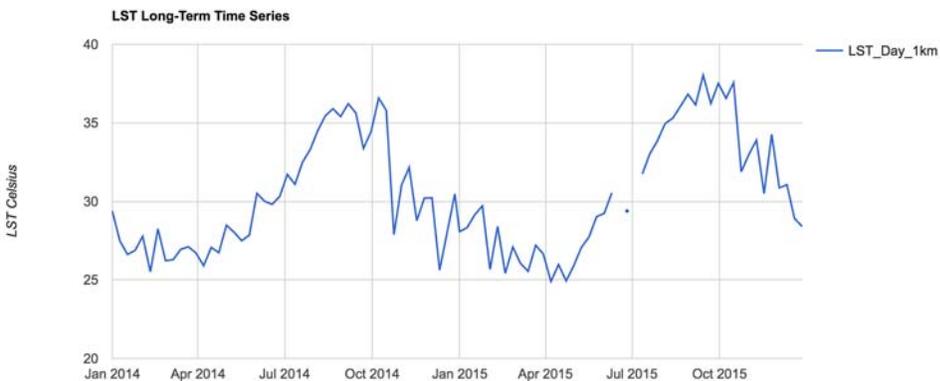

1.6 Exercise

Epidemiologists Brazil want to assess the most recent dry season in order to better prevent future outbreak of dengue. The dry winter season extends from about June to November. What was the temperature like during the season in 2002?

```
// Select dates
var collection05night = ee.ImageCollection(modLSTnight.filterDate('2000-01-01',
'2003-12-31'));
var collection05day = ee.ImageCollection(modLSTday.filterDate('2000-01-01',
'2003-12-31'));
var collection01night = ee.ImageCollection(modLSTnight.filterDate('2002-01-01',
'2002-12-31'));
var collection01day = ee.ImageCollection(modLSTday.filterDate('2015-01-01',
'2002-12-31'));
```

LST Long-Term Time Series

LST Short-Term Time Series
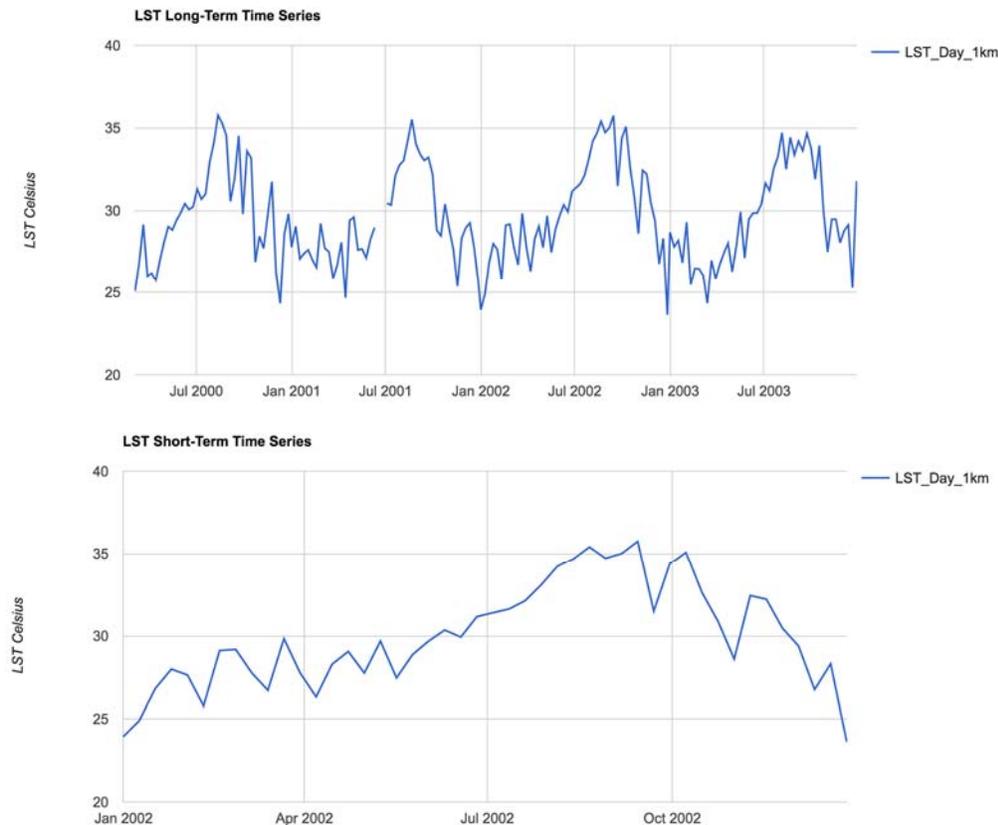
Answer: 2000-2002 show peak temperatures over 35°C during the dry season. During 2002, the peak land surface temperatures were reached during the August-September range. Temperatures rose most steadily during July-August, and a short rise occurred again in October after a temporary drop in temperatures during September. This trend of temperatures rising during July-August and peaking in August-October appears to be consistent over the longer time series of 2000-2003.

1.7 Summary

The Google Earth Engine – MODIS Land Surface Temperature (LST) code is to be used in assessment of historical temperatures. It enables the user to access information on any time scales between March 2000 and the present, at any location either input by country or by geometrical selection of a region.

1.8 References

"Land Surface Temperature and Emissivity Daily L3 Global 1 Km Grid SIN." Land Processes Distributed Active Archive Center (LANDAAC) - MOD11A1. USGS, n.d. Web. 20 Apr. 2016.

"Late Dry Season Fires in Brazil : Natural Hazards." NASA Earth Observatory. N.p., n.d. Web. 20 Apr. 2016.

"MODIS: Moderate Resolution Imaging Spectroradiometer." NASA Goddard Space Flight Center. N.p., n.d. Web. 20 Apr. 2016.

"Vancutsem, C., Ceccato*, P., Dinku, T., Connor, S.J. (2010). Evaluation of MODIS Land surface temperature data to estimate air temperature in different ecosystems over Africa. *Remote Sensing of Environment*, 114(2): 449-465