

Analyzing Long-Term Drought Effects on Land Surface Temperature and Vegetation Using NOAA Satellite Data

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Abstract—Analyzing the effects of Drought in the Northeastern North Carolina area with NOAA satellite products to determine a correlation between Land Surface Temperature and Vegetation. The Palmer Drought Severity Index (PDSI) data sets for summer 2002 -2013, provided by the State Climate Office of North Carolina NC CRONOS database, provided evidence that since 2007 the northern coastal plain of North Carolina has been experiencing a long-term summer drought. Summer is defined as the months between late June to late September.

Utilizing Elizabeth City State University's (ECSU) 1.5m L-band SeaSpace ground station the team received live Advanced Very High Resolution Radiometer (AVHRR) imagery from NOAA polar orbiting satellites each day for the month of June. The primary goal of this research was to observe the correlation between land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) due to long-term drought using NOAA satellite data. In the month of June 2016, the team collected imagery data through the SeaSpace© TeraScan® system and produced LST and NDVI. Various GPS locations were selected in Northeastern North Carolina of different biomes such as swamp lands, grasslands, and farmlands. The team collected and utilized data in the areas of Camden County, Gates County, Pasquotank County, and Perquimans County. Using the SeaSpace Graphical User Interface (GUI) TeraVision®, The data points of each product at the various biome locations were analyzed for daily and weekly averages.

Using the GPS locations found in United States Geological Survey (USGS) of the swamps lands, grasslands, and farmlands were entered and saved as survey points in TeraVision's GUI. All of the passes in the month of June that were received and processed into LST and NDVI products at the direct broadcast ground station at ECSU were loaded into TeraVision. The values were then extracted from each of the points and evaluated by their biome specific location for LST and NDVI. With Excel the team conducted analysis for daily trends, regional trends, biome trends, and weekly trends.

Keywords—Land Surface Temperature, TeraScan, Vegetation, TeraScan, TeraVision, USGS

I. INTRODUCTION

TeraScan is a combination of hardware and software designed for automated reception of data from meteorological/environmental satellites and for processing the data into images and data overlays. Images and overlays are of a special format called TeraScan Data Format (TDF) and can be displayed with the TeraScan GUI TeraVision. These data files can be used to produce images in various formats.

Different types of satellite data can be received from both the hardware and software that is installed on the computer. These satellite data types include: X Band Data from Polar Orbiting Satellites, L/S Band Data from Polar Orbiting Satellites, and L Band Data from Geostationary Satellites. Droughts clog wells and fills them with water from the rain, which is harmful to grassland, farmland, and vegetation production. Without NOAA satellites droughts could be hard to see and manage. Next within future efforts to collect and analyze the effects the long-term summer drought within these Northeastern counties.

A. TeraVision

TeraVision is a Graphical User Interface (GUI) that is a part of TeraScan, in which the user to include annotations, overlays, and image enhancement of different parts of the image [1] can manipulate the images, in the form of TDF

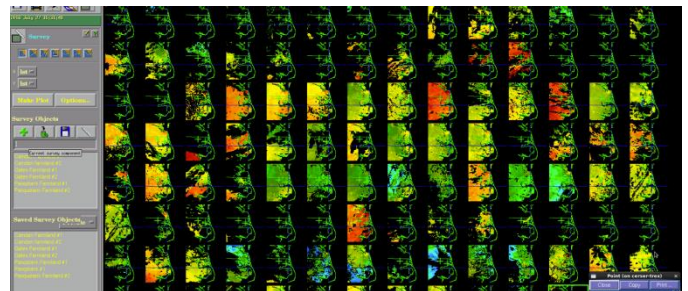


Fig. 1. Infrared of land surface temperature using TeraVision

The team's objective was to analyze how long-term drought in summer months' affected vegetation and land surface temperature in the Pasquotank, Perquimans, Camden and Gates county areas. The team chose to focus on the summer month of June. Satellite data can have data degradation at the near and far edges. Therefore the team only downloaded daytime orbits with a minimum elevation of 55 degrees.

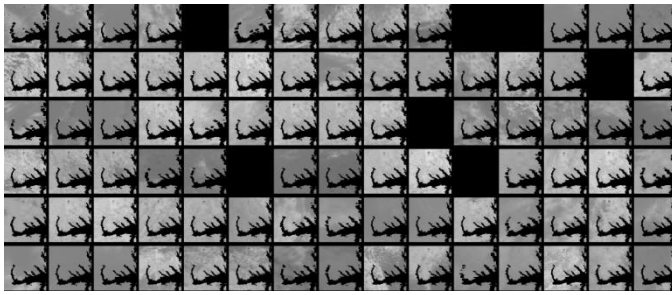


Fig. 2. NDVI

During the “configproc” a series of conversions took place to convert TXT files into TXT files and TDF files into PTS files. A TDF file is the original satellite data format, TDF is a common data format, and TDF is a TeraScan Data Format. After the file was converted into a TDF file, a calculation with the different channels was applied to create both Land-Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) products. LST used level-2 and level-3 data in an algorithm designed specifically for the MODIS instruments. The NDVI equation was equal to the quantity of the infrared channel minus the near-red channel divided by the quantity of the infrared plus the near-red channels [3]. This equation made the product “greener” to differentiate the differences in dense vegetation and low vegetation.

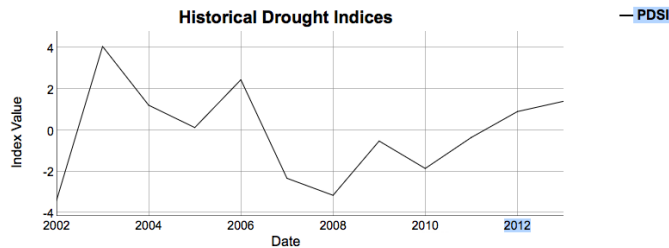


Fig. 3. The PDSI drought since 2007

B. Polar Orbit

Polar-orbiting satellites provide a more global view of Earth; circling at near-polar inclination (the angle between the equatorial plane and the satellite orbital plane a true polar orbit has an inclination of 90 degrees). Orbiting at an altitude of 700 to 800 km, these satellites cover best the parts of the world most difficult to cover in-situ.

The National Oceanic and Atmospheric Association (NOAA) is the satellite we use for our project. NOAA has multiple satellite but we focus on various ones, which are NOAA-15, 18,19. NOAA-15 was launched May 13, 1998 with a period of 101 minutes. NOAA-18 was launched May 20, 2005 with a period of 102 minutes. NOAA-19 was launched February 6, 2009 with a period of 102 minutes. They orbit over the earth and they use a whiskbroom technique to collect imagery information. Then when the satellite passes over our ground station satellite transmits the information to receiving station.

From 2002 until now, SeaSpace has provided equipment to Elizabeth City State University, in the form of an east coast training site and data center, which continues to foster

established research collaboration. The equipment gained from SeaSpace Corporation thus far includes two 5.0m Geostationary L-Band antennas, and a one 1.5m L-band antenna, with the associated acquisition and processing servers. In September of 2014, a new acquisition was made by Elizabeth City for new SeaSpace hardware and software for Dixon Patterson Hall on Elizabeth City State University’s Campus. Dixon Patterson Hall, which houses the new acquisition of Hardware and Software, had to be prepared and documented before SeaSpace subcontractors could arrive and install new software and hardware, purchased by Elizabeth City State University. Therefore, there needed to be proper documentation of past installation of equipment in the recent years.

The monitoring systems provided SeaSpace attaches a visualization station with a 24 and 42-inch widescreen monitor to each of the visualization stations. This hardware specification is also for all of the Visualization stations in room 228 and room 229 [6]. The monitoring systems will be able to do what the Visualizations stations do, but will be able to display the information on a 24 and 42-inch screen.

C. TRES

The TeraScan Rapid Environmental Extreme (TRES) is processing computer provided by SeaSpace. The TRES processing computer is a Dell R720E, 16 core E5 2667 3.30 GHz, with 128GB RAM, a 12x1.2 TB 10K SAS HDD, with a Dual PS [6].

D. TeraVault

The TeraScan TeraVault is provided by SeaSpace Corporation. The TeraVault has 60 TB (RAW) of storage. Accompanying the TeraVault specifications includes: a 4U, 2 controllers each with X4 1 Gigabit NIC+ 1 mgmtctlr, 60 Drive Bays, X20 3 TB disks, C20 connector, Dual PS, and a Rapid controller [6]. The TeraVault will hold the raw data incoming from the TRES software, which is collecting the whole, pass data sets [6].

E. UPS Assy

SeaSpace Corporation provides the Uninterruptible Power Source (UPS) Assy. The UPS Assy houses a 1500 VA, 220VAC, and 2U Rack mount. There are a total of two UPS machines, with four possible racks/outlets. One of the racks will be for the GOES East connection, and one for the GOES West connection. The TRES and the TeraVault already have a UPS [6].

II. METHODOLOGY

During the month of June 2016 (DOY, images collected United States Geological Survey’s Earth Explorer to collect different biomes according to GPS location for Camden, Pasquotank, Perquimans, and Gates counties in the month of June 2016. The biomes recorded were: 1) swamp 2) forest 3) farmland 3) and 4) grassland to determine if there was a temperature variation. Three National Oceanic and Atmospheric Administration (NOAA) satellites were used to collect the data NOAA-15, NOAA-18, and NOAA-19. Using the National Oceanic and Atmospheric Administration’s

satellites, the team was able to access the_data for LST and NDVI products for June 2016.

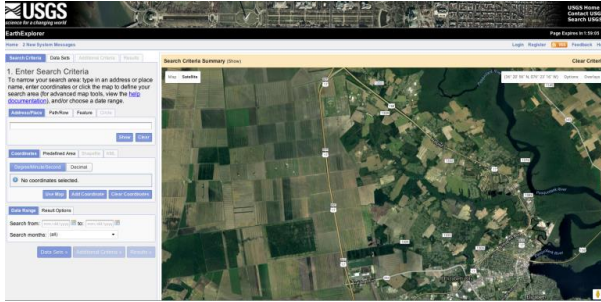


Fig. 4. USGS coordinates were plotted from the area of interest

The United States Geological Survey (USGS) was account created to download images from Earth explorer (USGS). Earth Explorer was utilized to distinguish each biome. Satellite data was viewed to distinguish of the different biome such as grassland, farmland, and swamp. Next GPS coordinates were documented of each biome in each county. Afterwards, latitude and longitude points were converted to decimal format enabling TeraScan to process. Archived passes for June from the processed folder.

The TeraVision Graphical User Interface (GUI) was used to extract the value and passes from June 2016 were loaded into the GUI. The extracted values for the Land Surface Temperature and the Normalized Difference Vegetation Index (NDVI) from each of county were placed into an excel spreadsheet based on date, time, and location.

```
active: yes
function: hrpt_lst
min_sun_elevation: 10
input_directory: products/tdf/whole_pass/hrpt
input_files: 20*.avhrr
output_files: 20*.lst
save_directory: products/tdf/whole_pass/hrpt
save_files: 20*.lst
scrub_max_files:
scrub_max_mbytes:
scrub_age_hours: 480
```

Figure 5 RAW LST files from “configproc”

```
[NDVI]
active: yes
function: hrpt_ndvi
min_sun_elevation: 10
input_directory: products/tdf/whole_pass/hrpt
input_files: 20*.avhrr
output_files: 20*.ndvi
save_directory: products/tdf/whole_pass/hrpt
save_files: 20*.ndvi
scrub_max_files:
scrub_max_mbytes:
scrub_age_hours: 480
```

Fig. 5. NDVI files from “configproc”

Then compare the biomes in different counties for NDVI and LST, then do a comparison for the whole region.

```
[Local-LST]
cover_area: Local
cover_percent: 60
input_directory: products/tdf/whole_pass/hrpt
input_files: 20*.lst
remap_variables: *
output_template: %yyyy.%mdd.%hhmm.%satel.lst
save_directory: products/tdf/Local/avhrr/lst
save_files: 20???.?????.?????.*.lst
```

Fig. 6. RAW Local LST files

```
[Local-NDVI]
cover_area: Local
cover_percent: 60
input_directory: products/tdf/whole_pass/hrpt
input_files: 20*.ndvi
remap_variables: *
output_template: %yyyy.%mdd.%hhmm.%satel.ndvi
save_directory: products/tdf/Local/avhrr/ndvi
save_files: 20???.?????.?????.*.ndvi
```

Fig. 7. The RAW local NDVI files

The SeaSpace TeraScan Configuration protocol file “configproc” (shown in figures 5, 6, 7, 8) was used to produce the products of received passes from the NOAA satellites. “Ecsuure2016” was the output file for the data retrieved. During the month of June passes from the following day and the weekend passes were automatically updated into the file.

```
2016.0620.2242.noaa-15.ndvi 2016.0714.2329.noaa-18.ndvi
2016.0620.2304.noaa-18.ndvi 2016.0715.1153.noaa-18.ndvi
2016.0621.1129.noaa-18.ndvi 2016.0715.1853.noaa-19.ndvi
2016.0621.1825.noaa-19.ndvi 2016.0715.2137.noaa-18.ndvi
2016.0621.2006.noaa-19.ndvi 2016.0715.2219.noaa-15.ndvi
2016.0621.2217.noaa-15.ndvi 2016.0715.2317.noaa-18.ndvi
2016.0621.2253.noaa-18.ndvi 2016.0716.1141.noaa-18.ndvi
2016.0622.1117.noaa-18.ndvi 2016.0716.1842.noaa-19.ndvi
2016.0622.1814.noaa-19.ndvi 2016.0716.2305.noaa-18.ndvi
2016.0622.1954.noaa-19.ndvi 2016.0717.1129.noaa-18.ndvi
2016.0622.2241.noaa-18.ndvi 2016.0717.1831.noaa-19.ndvi
2016.0623.1105.noaa-18.ndvi 2016.0717.2012.noaa-19.ndvi
2016.0623.1942.noaa-19.ndvi 2016.0717.2253.noaa-18.ndvi
2016.0622.1117.noaa-18.lst 2016.0715.2317.noaa-18.lst
2016.0622.1814.noaa-19.lst 2016.0716.1141.noaa-18.lst
2016.0622.1954.noaa-19.lst 2016.0716.1842.noaa-19.lst
2016.0622.2241.noaa-18.lst 2016.0716.2305.noaa-18.lst
2016.0623.1105.noaa-18.lst 2016.0717.1129.noaa-18.lst
2016.0623.1942.noaa-19.lst 2016.0717.1831.noaa-19.lst
2016.0623.2229.noaa-18.lst 2016.0717.2012.noaa-19.lst
2016.0624.1054.noaa-18.lst 2016.0717.2253.noaa-18.lst
2016.0624.1931.noaa-19.lst 2016.0718.1118.noaa-18.lst
2016.0624.2218.noaa-18.lst Camden
2016.0624.2242.noaa-15.lst Camdenfarmland.tdf
2016.0625.1043.noaa-18.lst gates
2016.0625.1223.noaa-18.lst landsurfacepoints.csv
```

Fig. 8. Updated LST passes

III. FUTURE WORK

To further this project the team devised an alternative way to automate the data points using Python programming language. Finish the remaining passes from the different biomes in each

county. Process the point file coordinates based on each county and biome in an Excel spreadsheet. Convert the .txt files into a TDF, followed by converting the TDF files into point files. Also, test the point files accuracy by using python to take the point files and organized the files. Moving forward should have a biologist help with delineation of the graphed data to make a conclusion on the results.

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