

Automating the TeraScan Image Process for Creation of NOAA AVHRR Data Products

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I. INTRODUCTION

Abstract-During the summer of 2002 the Center of Excellence in Remote Sensing Education and Research (CERSER) was established on the campus of Elizabeth City State University. It is the intent of CERSER to develop innovative and relevant research collaboration focused on coastal, ocean, and marine research. The project represents a joint effort by the Office of Naval Research (ONR), the MU-SPIN Office of Goddard Space Flight Center (GSFC), the National Oceanic and Atmospheric Administration (NOAA) and SeaSpace.

In addition to providing remotely sensed Advanced Very High Resolution Radiometer (AVHRR) and Sea Wide Field-of-View Sensor (SeaWiFS) data for research projects during the summer and academic year, CERSER maintains a website which displays and archives data that has been captured and processed. Since the establishment of the CERSER lab, data has been processed, annotated and converted into tiff files manually by using a series of TeraScan and LINUX commands. This process is time consuming and requires a person to physically be at the TeraScan Machine.

The objective of this project was to automate the process of creating NOAA AVHRR products. The TeraScan Product Generation System was utilized to create a visible and sea surface temperature image. This was accomplished by first creating a 'master' of North Carolina and Virginia. A 'master' is a TeraScan dataset that delimits a geographical area of the earth and specifies a map projection and a pixel resolution to the area. The 'master' was used for the sea surface temperature product. Visible images were processed from the complete raw AVHRR data.

A script was also created which would process raw AVHRR data from the passdisk. A script is a sequence of commands linked together to automatically run when initiated. A script can be initiated by running it from the command line or by linking the processing to TeraCapCon (TeraScan Capture Control).

Once passes are captured on the passdisk the script processes the image and generates a picture product. Each image, overlaid with a coastal boundary, gridlines, a wedge and a legend, is converted into a tagged image file format (tiff) file and automatically distributed to the server using file transfer protocol (ftp). Automating the image process eliminates the need for an individual to manually process images, and insures that the CERSER webpage is current.

TeraScan is an integrated system of hardware and software designed for automated reception of data from meteorological and environmental satellites and for processing the data into images and data overlay [9]. This versatile system can be configured for the reception and processing of many different types of data from a variety of types of satellites. Data and data products received can then be displayed with the TeraScan viewer called TeraVision. In addition, they can be automatically distributed to any number of local or off-site destinations across the network. The types of data that TeraScan can receive and process are x-band and l/s-band data from polar-orbiting satellites and l-band data from geostationary satellites [9].

There are several basic components of the hardware for a TeraScan receiving and processing system. This system consists of an antenna, a receiver, a bit and frame synchronizer, computer workstation, global positioning system (GPS) and an uninterruptible power supply (UPS) [9]. The antenna is used for satellite signal interception. A fixed-direction antenna is used for high resolution data reception from geostationary satellites. For high-resolution data reception from polar-orbiting satellites, a tracking antenna is used, its size depends on the telemetry to be received. The receiver tunes to the correct satellite signal frequency and separates the sensor data. Regenerating the bit stream against noise, the bit synchronizer also extracts the clock which is a timing pulse added to the signal on the satellite to enable synchronization of the reception system with the satellite transmitter. The frame synchronizer then divides the continuous bit stream into meaningful data block known as frames [9]. With the aid of TeraScan software, the computer workstation schedules and controls data reception for processing data into products, and displaying and distributing data and data products, which can include tape drives or other storage devices for archiving data. Lastly, the GPS supplies position and time to the system while the UPS protects the system from power surges and keeps the system up and running in the event of a power outage.

TeraScan is supported on two platforms, Sun Solaris and RedHat Linux, by SeaSpace. Its software is based on the UNIX operating system[9]. There is a special format for data files, called TeraScan Data Format (TDF). This format is very versatile and capable of assimilating a

wide variety of data types, shapes, and sizes TeraScan has more than 500 command-line functions for the reception and processing of satellite data. A set of daemons run continuously and manages the automated operations of the system [3]. A few of the daemons are **tsched**, **terapgsd**, **waitd** and **wherami**.

- **tsched**- manages all the processes involved in the automatic reception of direct-broadcast satellite data: (1) updates the data reception schedule on a daily basis; (2) checks the reception schedule for upcoming satellite passes; and (3) at the appropriate time, initiates satellite data reception and subsequent archiving and post-capture processing [3].
- **terapgsd**- distributes data products produced by TeraPGS [3].
- **waitd**- monitors arrival of data in specified directories and then initiates processing [3].
- **whereami**- gets the location from the GPS and updates the system location if needed [3].

The TeraScan system that is used in the Center of Excellence in Remote Sensing Education and Research (CERSER) lab receives data from the National Oceanic and Atmospheric Administration (NOAA) and OrbView satellites. Both are L-/S-band polar-orbiting satellites. The primary sensor for the NOAA satellite is the imager known as Advanced Very High Resolution Radiometer (AVHRR) and the Sea-viewing Wide Field-of-View (SeaWiFS) is the OrbView sensor. These instruments make calibrated measurements of visible, near infrared, and infrared radiation from the Earth and its atmosphere [9]. There are various NOAA satellites with five different channels. Each channel records radiation over a narrow band of wavelengths. The NOAA satellite data received is real time while with the OrbView data is on a two-week delayed licensed mode.

When receiving data from the NOAA satellites, this information has to be processed, annotated, and converted into tiff files manually by using a series of TeraScan commands. Typically this process is time consuming and requires the user to physically be at the TeraScan Machine. Thus, the goal of this project was to automate the process or steps taken to process, and annotate an image. Each image will be overlaid with a coastal boundary, gridlines, a wedge, and a legend. After being overlaid the image is converted into a tagged image file format (tiff) file and automatically distributed to the server using file transfer protocol (ftp). Automating the image process will not only keep the CERSER webpage current but also will reduce the time spent processing the information manually.

II. REVIEW OF LITERATURE

Telemetries

The research and operational communities have begun to really understand to importance of having satellite data, due to the increased availability of low-cost direct terminals. This increase has led to the expansion of SeaSpace's user base. In addition, the influx of new users with new applications continues to influence the growth of the TeraScan family products [4]. TeraScan's collaboration with SeaSpace keeps them up to date on trends in the community and user requirements for TeraScan. There are two research partnerships that recently happened in the past year, which are with the University of New Mexico's Center for Rapid Environmental Assessment and Terrain Evaluation (CREATE), and the Sino-American Cooperative Laboratory for Remote Sensing, based at the Nanjing Institute for Earth and Information Sciences [4].

An important new trend is the drive towards "open architecture" systems, which is a broad term that means anything from "open source" (e.g. Linux itself) to published interfaces [4]. This system gives users the flexibility and control they need to meet their needs. For example, earth science researchers want to be able to write their own algorithms and data viewers, exchange data sets, and so forth. TeraScan is now making the TDF file specification publicly available and releasing source code for the TDF libraries. TDF is now the major standard for remote sensing data. The goal of TeraScan is to be available in a broader set of disciplines [4].

The data received from satellites is very important. The Naval Oceanographic Office generates sea surface temperature from Geostationary Operational Environmental Satellites (GOES) [4]. The coverage of the GOES data is not global; clouds can obstruct the satellite infrared radiometer's view of the ocean surface, making it impossible to calculate sea surface temperature. However, GOES can view a location once every 15 minutes; increasing the likelihood of viewing that scene when it is obstructed by clouds [4].

Remote Sensing of the Environment: An Earth Resource Perspective

Scientists in the field or instruments placed in the field can perform the collection of data. These methods provide data for physical, biological, and social science research. However, there is always room for error that may be introduced during the *in situ* or *in-place* data collection process [2]. The scientist can actually change the characteristics of the area being sampled during the data-collection process. Bias procedures also influence the amount of error produced when collecting data. Method-

produced error is the use of a biased sampling design or the systematic, improper use of a piece of equipment[2].

It is possible to collect information about an object or geographic area from a distant vantage point using a specialized instrument. Also known as Remote Sensing, this term has been clearly defined by the American Society for Photogrammetry and Remote Sensing (ASPRS): “photogrammetry and remote sensing are the art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery and digital representations of energy patterns derived from non-contact sensor systems”[2].

Remote sensing is performed using a sensor, which is able to obtain very specific information about an object or the geographic extent of a phenomenon[2]. There is an electromagnetic energy emitted from the object or geographic area, which must be measured and developed into information using visual or digital image processing techniques.

There are many advantages of using remote sensing techniques. This technique is “*unobtrusive*” in that it does not disturb the object or area of interest, which is a very important consideration when conducting research. Remote sensing are programmed to collect data systematically, and as a result this can remove the sampling bias introduced in some *in situ* investigations. When conditions are carefully controlled, remote sensing can provide fundamental biophysical data, including: x, y location, z elevation or depth, biomass, temperature, and moisture content over very large geographic areas rather than just single point observations [2].

Although, remote sensing is a useful technique there are limitations. The greatest limitation is that it is oversold meaning that it will not provide all the information needed for conducting physical, biological, or social science; it simply provides some spatial, spectral, and temporal information of value [2]. Also, humans control the machine by calibrating the sensor and selecting the platform, furthermore human error may be introduced in the process. In addition, the sensor itself emits electromagnetic radiation that can be intrusive and affect the area of interest [2].

III. DATA AND METHODS

Creating a script

The TeraScan software is a UNIX-based operating system, which has GUI (Graphical User Interface) as well as a shell for commands [9]. Various commands were used when creating a script. A script is simply a program that runs the functions that are given when processing data. A sequence of commands are linked together into the script so that the whole sequence can be run automatically simply by initiating the script [9]. The script was initiated by running the script from the command line.

The TeraScan system receives data from various satellites different times of the day. This is known as a “pass”. To see what passes were currently on the pass disk we used the command **lspass**, which shows the satellite numbers, date and time, and the number of data lines [9]. The next step was to choose a pass to ingest and convert it from raw format into a set-up known as TeraScan Data Format (TDF)[9]. This would be the first step in image processing. The TeraScan function called **hrptin** was run.

The area of study for the project was the North Carolina and Virginia boundaries. A master or area of interest was created for processing the data. When the TeraScan function **master** was typed it created a master using the commands or uses a file that was created previously in the directory [9]. Next the command **hrptin** was run again and included the master that was created. Now the images were checked for noisy data. Noisy data is data missing from the raw images that are received. To prevent this from happening the **outliers** command was run, which replaced the data outside the threshold with the median of surrounding pixels [9]. Figure 1.1 gives an example of image with noisy data. In the next step sea surface temperature (SST) was calculated with NOAA data by running a function called **nitpix** [9]. A lookup table method in TeraScan is used with this function for each satellite made available. In this case the multi-channel method was used because it was the most commonly used.

When creating a SST image there may be some pixels and land area that need to be excluded out of the image. With the function **emathp** the land areas were masked out for the SST images [9]. Then image was registered to a master so that the image is exactly the same size as master we created. This was done by running a function called **fastreg** [9]. To automate the process added overlays were added to the images. Before the insertion overlays into the images one first had to scale the images to byte values by running the **imscale** function for visible channels. Then a coastline, wedge-which assigns values to the pixels in the image, and a legend, was added by using functions **coast**, **wedge**, and **legend**. These images were converted into a tagged image file format (tiff) file. To complete the processing images were injected (**xinject**) all the overlays that were created into the image and also exported (**expim**) them to create a tiff file. Once all commands were run the command **audit** was used to generate a script [9]. Figure 1.2 gives an example of the script. The script then had to debug until it ran properly.

Creating a PGS Job

TeraPGS, the TeraScan Product Generator System, is a system designed for generating and distributing TeraScan products according to user specification [10]. This product generator system was used in developing the pgs jobs to process raw AVHRR data from a passdisk. The pgs job help determine what kind of products to make and TeraPGS scripts also generate products from pgs_ingested

whole_pass datasets stored in subdirectories of the \$DATADIR directory [10]. Pgs jobs and scripts produce the same products, but the difference is that the pgs job is

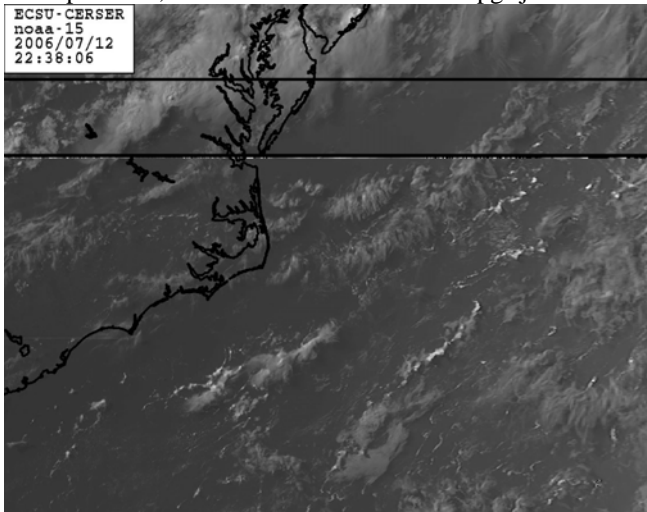


Figure 1.1

```

ure06.csh - WordPad
File Edit View Insert Format Help
#! /bin/csh -f

hrptin \
  hrpt_types='avhrr' \
  on_pass_disk='yes' \
  pass_number='3' \
  channels='1 2 3 4 5' \
  fix_missing='yes' \
  sharpen='y' \
  calibrate='yes' \
  temp_units='celsius' \
  byte_output='no' \
  full_report='no' \
  solar_corr='no' \
  geo_correct='y' \
  delta_line='1' \
  delta_sample='1' \
  use_master='n' \
  start_time='00:00:00' \
  num_lines='6000' \
  start_sample='1' \
  num_samples='2048' \
ure.avhrr

set STATUS = $status
if ($STATUS != 0) exit $STATUS

echo "**** Done with hrptin ****"

outliers \
  include_vars= \
  box_dims='3 3' \
  min_good_vals='3' \
  threshold='10 10 6 4 4' \

```

Figure 1.2

TeraPGS runs automatically when a pass is ingested on the system, while a script have to be initiated and can serve as a backup when TeraPGS is not working properly.

IV. RESULTS

The automation of the image process may take time due to constraints and system problems that need to be taken care of immediately to ensure that the images processed will automatically be distributed to the server via ftp. It is also important to document the commands used and problems faced upon the completion of the project. SeaSpace Corporation is a distributor of the TeraScan system and provides customer support in understanding the environment with the use of its products. As images were processed TeraPGS was opened to set up an automatic generation of images or a TDF. The name template was also modified so that when an image is processed it will display the date, time and name of the file. The TeraPGS distribution scripts were modified using the master that was created as well as the passwords for the ftp transfers in both distribution files.

After attempting to correct some of the errors, there were still problems generating products with TeraPGS. PGS jobs that were created worked when sending to the directory on the system, but not when ftp to windows system in Lester Hall. To track down delivery issues with the images it was suggested by SeaSpace to edit the script that was created and to view the *.distr files. This provided any information as to whether the products are being delivered or if there might be a problem in reaching the intended destination. SeaSpace support suggested that they gain remote login access to the system so that they would be able to diagnose the problem. The TeraScan system was upgraded to 3.2.1. This was done to resolve the problem with TeraPGS and to improve SST products. With the new version it will gave the ability to ingest data from the noaa-18 satellite that we could not process in the earlier version.

V. CONCLUSIONS

TeraPGS uses “ncftp”, which is a command-line user interface program that runs on a large number of platforms, for its ftp process to another ftp host. For example, if one is trying to automatically ftp products from the TeraScan system to the destination ftp host at ECSU, there may be a problem in the handshake process because the ftp host is not set up for ncftp.

After correcting most of the system problems picture products could be generated for the website. Figures 2.1-2.4 show picture products generated from the script. Although these products were created, it was incapable to ftp the automated images to the server because the pgs jobs were having problems. A documentation book was created throughout our process of automating the system. The

documentation booklet includes passwords, IP addresses, usernames, for the CERSER and SeaSpace, and commands that were run and how to upgrade the system.

VI. FUTURE RECOMMENDATIONS

Due to the fact that the ftp host is running Windows, the TeraScan system and the ftp host are not compatible with each other. Currently the TeraScan system in the ECSU's CERSER lab is running on RedHat Linux. It is recommended to change the current TeraScan operating system from RedHat Linux to different UNIX-based system because RedHat does not support TeraScan upgrade to 3.3.

Another alternative approach would be to download the ncftp software onto the Windows system on the host server so that it would allow PGS to ftp images to the server. This will assume that both platforms are compatible for ftp.

ACKNOWLEDGEMENTS

The 2006 URE-OMSS TeraScan team would like to thank Mrs. Keisha Wilkins for her assistance and dedication to the team and the project. Also to be acknowledged are Mr. Tony Burunoff, technical support team at SeaSpace Corporation, Dr. Linda Hayden, Principal Investigator of the ONR/NRTS program at Elizabeth City State University, The Office of Naval Research, NOAA, and the CERSER center on the campus of Elizabeth City State University for their sponsorship.

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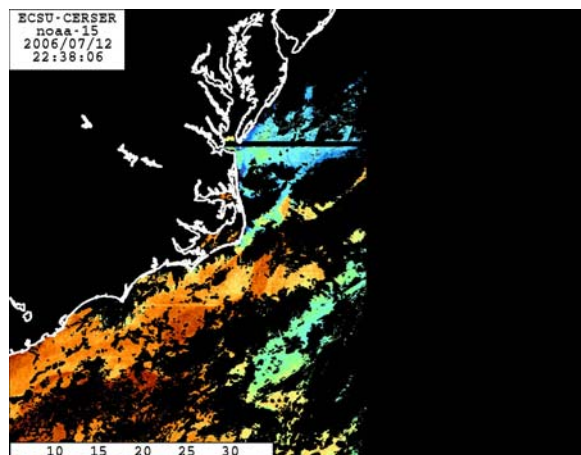


Figure 2.1 SST Image

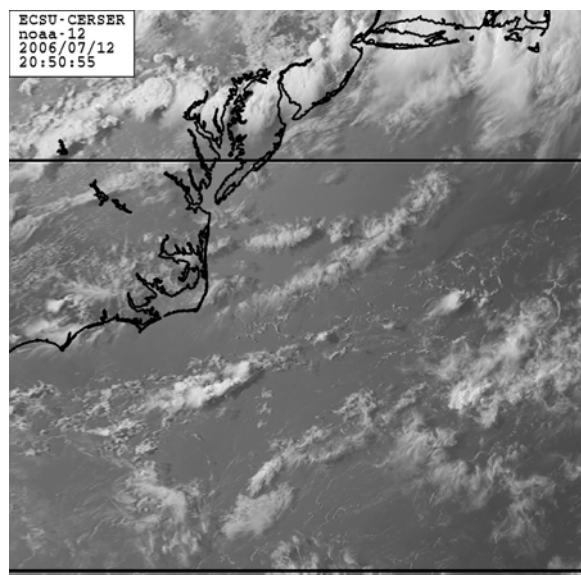


Figure 2.2 Visible Image with missing lines.

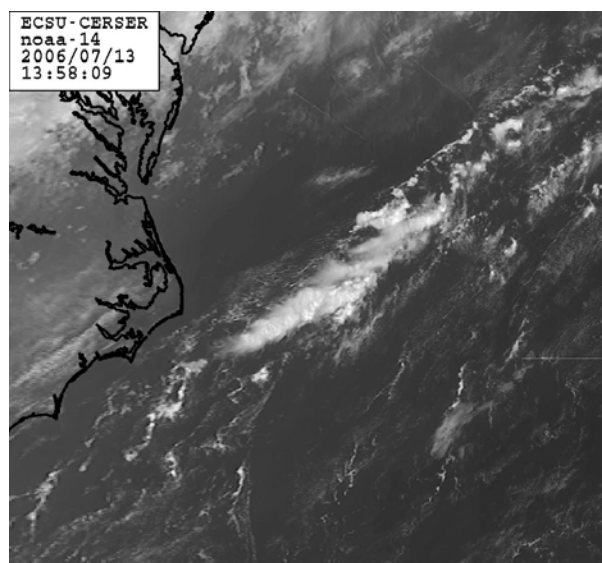


Figure 2.3 Visible Image

ECSU-CERSER
noaa-18
2006/07/16
18:43:13

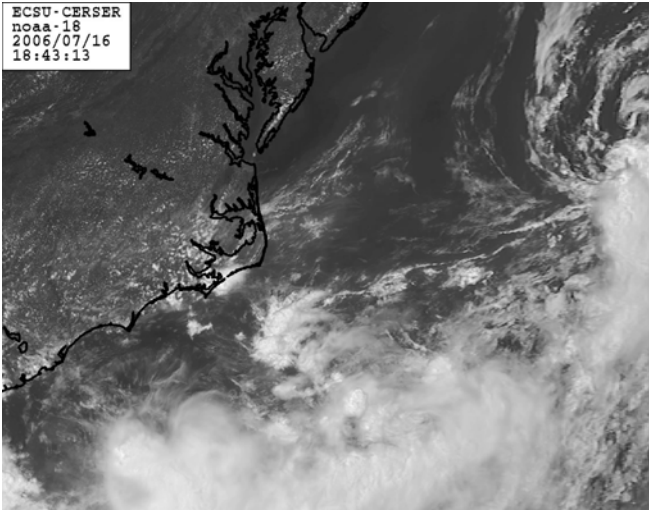


Figure 2.4 Visible Image with clouds evident.