Changes in Sea Surface Temperature, Chlorophyll, and Ice Coverage in the Hudson Bay Region: May and June 2001 — 2012

Abstract

Global warming is a topic of concern into the foreseeable future. To add to our knowledge of the extent of this process, our team: The Sea Surface Temperature (SST) team, chose to examine trends in sea temperature, sea chlorophyll and sea ice within Hudson.

All data was obtained from two sensors and primarily from each June from 2003 – 2012. The June data was a composite data consisting of measurements obtained when pixels in the scene were visible. This data was windowed and processed for the regions of interest.

Results indicate some general trends and some correlations between temperature and chlorophyll. However, due to the limited amount of data used as part of this study, we were unable to make conclusive statements regarding the long-term trends of the data.

This work proved valuable in terms of improving our ability to process remotely sensed data and to further enhance our understanding of image processing techniques applicable to remote sensing research. While our results our inconclusive, we acquired a greater appreciation of the complexity and the study of global warming as expressed in the yearly activity of sea ice, sea surface temperature and sea chlorophyll.

Introduction

The Sea Surface Temperature (**SST**) Team shall describe trends in sea temperature, sea chlorophyll , and sea ice using Hudson Bay as a primary region of interest.

This objective has the following goals:

- Demonstrate Image Processing Techniques with IDRISI
- Identify common processing issues and how to resolve them

Our work focuses on data collected using the following NASA remote sensor systems:

- Advanced Very High Resolution Radiometer (**AVHRR**)
- Moderate Resolution Imaging Spectroradiometer (**MODIS**)

Data

Image spatial resolution of 4km by 4km raster images

- Post-process MODIS and AVHRR data to degree Celsius
- MODIS-AQUA Chlorophyll data was measured in units of g/m^3
- Temperature data was chosen to be in the 11μm wavelength at night
- MODIS-AQUA and AVHRR monthly composite images of SST and chlorophyll were downloaded for the month of June for the years between 2003 to 2012
- AVHRR monthly composites were available for the years between 2003 through 2009.
- MODIS-Terra monthly composite images of Sea Ice were assessed for the month of May between the years of 2001 through 2005

Methodology

Sea Ice

- Windowed out Hudson Bay Area, then re-classed the images
- Masked land/sea ice = 1, water = 0
- Determined from this the frequency of the water pixels, increase in water pixels equated to a decrease in sea ice, and an decrease in water pixels equated to an increase in sea ice.

Cholophyll

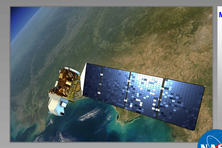
- Download data from NASA Ocean Color Website
- Windowed to Hudson Bay
- Sampled six regions across the bay from which to study average June chlorophyll concentrations for the 10 year period
- Profile average chlorophyll concentrations within these regions

MODIS-AQUA SST

- Download data from NASA Ocean Color Website
- Extract Temperature Scaling Equation from HDF
- Import files into IDRISI using HDF Import Tool
- Project each image to Lat/Longitude system
- Scale to Celsius using equation in step two
- Create Land Mask and OVERLAY image
- WINDOW Hudson Bay region
- Perform temperature profile
- Present results

AVHRR SST

- Imported and projected to (lat./long)
- Windowed SST images to study area.
- Create Masked land for each image
- Generate and analyze image histogram
- Determined if 0 quality value in quality image matches sea ice mask
- Converted SST images from degree Kelvin to degree Celsius
- Profile image



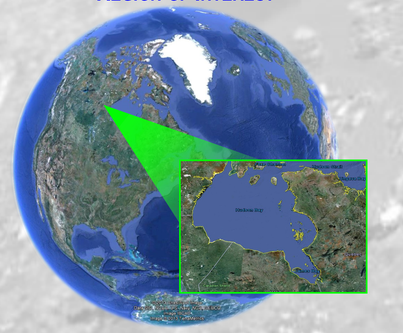
MODIS *Moderate Resolution Imaging Spectroradiometer*

- Launched in May 2002
- Equatorial Crossing daily at 1330 hours
- Sun Synchronous , Near-Polar Orbit (98°)
- IFOV of 250 m (2 bands), 500 m (5 bands), 1000 m (29 bands)
- Spectroradiometer measures 36 bands between 0.4 - 14.5 µm.

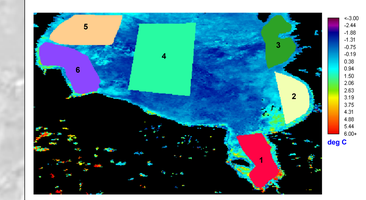
AVHRR *Advanced Very High Resolution Radiometer*

- Launched October 1978.
- 4-channel radiometer carried on TIROS-N
- 5-channel radiometer, on NOAA-7 Launched June 1981
- 6 channel radiometer on NOAA-15 launched in May 1998.

Region of Interest

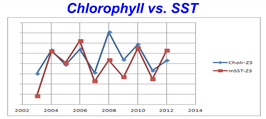


Hudson Bay
SST and Chlorophyll Sample Zones

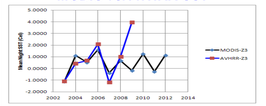


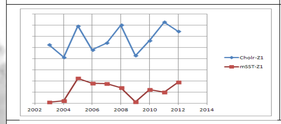
Sample Zone Comparisons

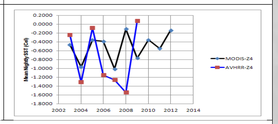
Chlorophyll vs. SST



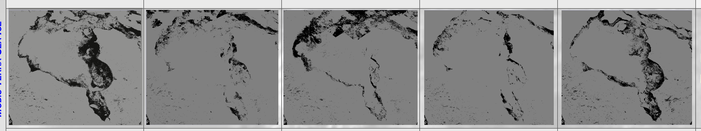
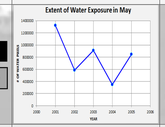
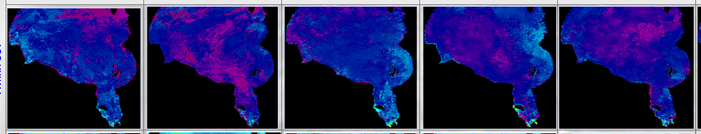
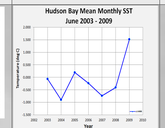
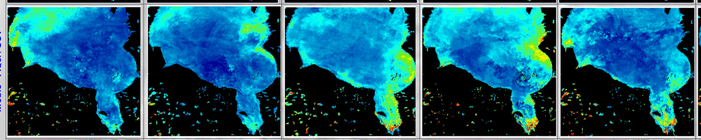
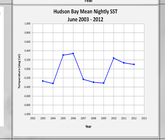
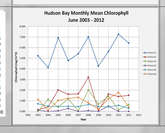
MODIS vs. AVHRR SST







- **Sample zone three showed a strong correlation between temperature and chlorophyll**
- **Overall, there was a weak correlation between MODIS/AVHRR SST, and Chlorophyll/SST.**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean Profile	Results
Modis Terra Sea Ice														• The noise in the image made it difficult to differentiate land, sea ice and water. • Results indicate a negative trend. However, five years is not sufficient to identify climatic trends. • There was insufficient data to identify the cause of the change in yearly sea ice in the region.
	In the images of Hudson Bay, the color of the sea ice and land are the same (gray). Water is black in the image. Looking at the image you can see the outline of Hudson Bay determined by the black pixels.													
Avhrr SST														• Slight positive trend • Fluctuating temperature over the seven year period • 2009 average temperature suggests problem with sensor calibration or data
	The following images represent monthly composites of Hudson Bay taken from MODIS and AVHRR sensors in the month of June. AVHRR images were only available for the years between 2003 through 2009. The second and third row represent sea surface temperature, and the fourth represents chlorophyll. The mean monthly values for each year are illustrated in the *Results* column.													
Modis- Aqua SST														• Demonstrate Image Processing Techniques with IDRISI • Hudson Bay's nightly sea surface temperature differs between MODIS AQUA and AVHRR satellites • AQUA mean trend suggest a slight flux and cooler trend in temperature through 2003 – 2012 • Overall, MODIS AQUA temperature and chlorophyll has a weak correlation with an exception in Zone 3, which showed a strong trend in mean levels.
Modis- Cholophyll														• James Bay (Zone 1) in the southeastern portion of Hudson Bay, had almost an order of magnitude greater chlorophyll content than the other zones studied. • Prominent three-year cyclic chlorophyll concentrations in Zone 1 • Slight positive trend evident in Zone 1

Conclusion

In summary, we have demonstrated image processing techniques using IDRISI and data from two remote sensing platforms, MODIS and AVHRR. Our work focused on sea surface temperature and chlorophyll levels in the Hudson Bay region. These two parameters are important in understanding the bay's ecosystem, ice melt, and may give scientists more information about global warming.

We've compared SST from these platforms over the region of interest. Our results indicate varying degrees of agreement between the two platforms. In some regions of Hudson Bay, both platforms showed a similar monthly trend in mean SST with certain years differing by 1 degree Celsius. AVHRR has shown a large increase in temperature between 2008 and 2009 in all our sampled regions. The differences between MODIS and AVHRR have been documented in other research projects. These differences may come from cloud cover, water vapor, terrestrial dust, and volcanic activity (Zhenglong Li, 2006). Other causes may be the time of the satellite pass over Hudson bay.

Comparison of the monthly MODIS SST and chlorophyll levels, within the six zones, suggest a lack of direct correlation between them. However, the third sample zone (North East corner) has shown a strong correlation. The general lack of correlation between sea surface temperature and chlorophyll concentration suggests that there are other factors that contribute more strongly than just temperature. These could include nutrient flow from freshwater and other types of aquatic flora that may have significant activity across a range of temperatures.

This effort serves as preliminary work for further research. A similar approach can be applied to other seasons, such as late summer and winter. Multi-seasonal assessment would provide a profile on how temperature changes throughout the year. Additionally, studies encompassing periods of time longer than ten years are necessary to accurately identify environmental trends and their causes.

Work Cited

NASA. *Ocean Level 3 Standard Mapped Image Products.* June 2010. Site: http://oceancolor.gsfc.nasa.gov/DOCS/Ocean_Level-3_SMI_Products.pdf

O. Brown and P. Minnett. *MODIS Infrared Sea Surface Temperature Algorithm. Algorithm Theoretical Basis Document Version 2.0.* Under Contract Number NAS5-31361. 1999

Ocean Color MODIS Data site: NASA: site: http://oceancolor.gsfc.nasa.gov/cgi/l3

P.J. Minnett et al. *Sea-surface temperature measured by the Moderate Resolution Imaging Spectroradiometer (MODIS),* 0-7803-7536-X (C) 2002

This project was a collaboration by Ram B. Chhetri, Stephen Coppola, Stephen LoChirco, Harry Simpson, and Dave Strohschein for the class, *Introduction to Digital Image Processing*, Department of Geography, taught by Dr. Stephen Young.

View this presentation online by scanning the QR code:

Salem State University

DGL