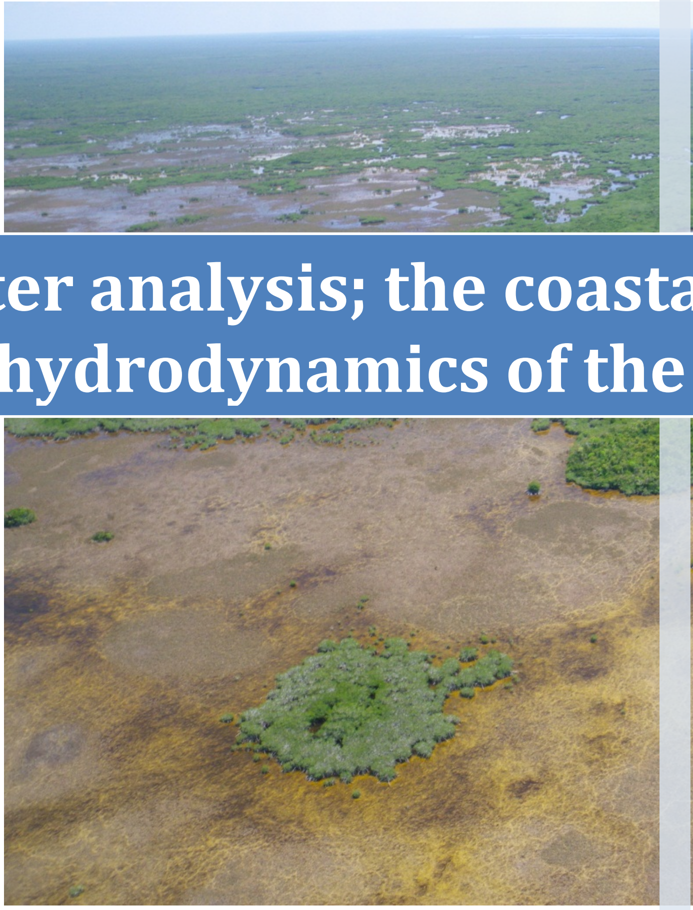

2012

Water analysis; the coastal estuary-marsh hydrodynamics of the Everglades, USA

Jan Auke Nicolaas Dijkwel

United States Geological Survey

Van Hall Larenstein, University of Applied Sciences

8/30/2012

University of Applied Sciences VAN HALL LARENSTEIN PART OF WAGENINGEN UR

USGS science for a changing world

Water analysis; the coastal estuary-marsh hydrodynamics of the Everglades, USA

Bachelor of Science

Thesis

Land and Water Management

August 2012

Jan Dijkwel

Velp, the Netherlands

United States Geological Survey

Van Hall Larenstein, University of Applied Sciences

Colophon

Jan Auke Nicolaas Dijkwel

08/30/2012

Internship organization:

United States Geological Survey
USGS-Southeast Ecology Science Center
Everglades Field Station
40001 SR 9336
Homestead, FL 33034

Student:

Jan Dijkwel
Student ID; 890723101
Land and Water Management
Tel: +31 (0)6 146 836 66
Email: jandijkwel@hotmail.com

Supervisor U.S. Geological Survey:

Gordon H. Anderson
Hydrologist

Supervisor Van Hall Larenstein, University of Applied Sciences:

Hans van den Dool
Land and Water Management

Internship period:

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In the first place, I want to thank all who helped me make this possible and supported me during this period. On behalf of myself, I want to thank Gordon Anderson and Karen Balentine of the United States Geological Survey for this opportunity and for sharing their knowledge during my stay in the Everglades. I also want to thank Hans van den Dool (Van Hall Larenstein) for the supervisory and knowledge from back in The Netherlands.

In addition, I would also like to thank David Lagomasino (Florida International University) for the help and time with the program MatLab. And thanks to all the others who helped me through the process of writing this report.

August 2012
Velp, the Netherlands

J.A.N. Dijkwel

Summary

To fulfill the demands for my Bachelor thesis (March to July 2012), I served an internship with the U.S. Geological Survey at Everglades National Park. Everglades National Park is situated on the southern tip of the Florida Peninsula. Everglades National Park is the only subtropical preserve in North America. It contains both temperate and tropical plant communities, including sawgrass prairies, mangrove and cypress swamps, pinelands, and hardwood hammocks, as well as marine and estuarine environments. The Shark River is the primarily drainage river for the Shark River Slough, that is situated up north of the actual river. From the north of the Shark River Slough, the freshwater flows into Everglades National Park. The water exits the park at the Gulf of Mexico on the southwest.

The objective for this project is to answer the research questions that are stated. The main objective is to find out what the water data indicates about the quality and quantity (salinity levels and water levels) of the years 2004 to 2011. This is relevant for the understanding of possible on-going changes in the Everglades. Therefore, research on water datasets of the Shark River is vital.

The main question of the project is:

What do the water-data (salinity, rainfall, ground- and surface water levels) indicate about the water quality and quantity of the years 2004 to 2011?

This project was conducted with a literature study, data collection, data analysis and interpretation. Existing study sites were used and the data of these corresponding sites were collected and analyzed by using programs like MatLab and Excel. From October the 1st till the 30th of September for every year (2004-2011) data is collected. This local data consists of groundwater levels, surface water levels and salinity levels of the same water levels.

Analysis of the data was done by using the program MatLab, the program can perform statistical analysis on water data. The program is used a lot for statistical analysis about water data.

Further interpretation of the observations is key to determine what is going on in the Everglades.

In conclusion there can be said that the water quality and quantity of the Shark River during the 7 years, almost do not change. The levels of salinity and the levels of ground- and surface water, show similar trends for every year. Just before the wet season starts, the highest salinity level are measured. The salinity levels in surface water in May/June have the highest values for every year for every Shark River site, ground and surface water levels, keep almost the same averages per year. Only the groundwater lags 2 months behind in the level changes of salinity.

Because the river is situated in a delta, the river has influences by tidal movements. For the site SH3, clear trends are noticeable. Especially the 14day, 28day, 180day and 365day trends are clear. The reason that there are 14day and 28day trends is because the influence of the Moon and the Sun. The other two trends, come from seasonal weather changes.

Concluding, the Everglades, the Shark River in particularly, is a dynamic environment. Salt- and freshwater, rainfall and tidal cycles are the most important influences in the area. The Everglades will always be an interesting topic for research projects about salinity and water data analysis.

Glossary

Slough	= A slough is a low-lying area of land that channels water through the Everglades. These marshy rivers are relatively deep and remain flooded almost year-round. Though they are the main avenue of water flow, the current remains leisurely, moving about 100 feet (30 meters) per day.
Forcings	= Influences from the outside, such as rainfall and urbanization.
Hydronamics	= Hydrologic dynamics of a certain area.
Ecotone	= Transition zone in the Everglades consisting of mangroves.
Correlogram	= A curve plotted to show the correlation between two mathematical values. (Autocorrelation graph)
Wateryear	= A wateryear starts at 10/01/year and ends at 09/20/year.
Dry season	= The dry season is the winter. The dry season starts around October and ends around the month May. During the wintertime there is almost no rainfall.
Wet season	= The wet season is in the summer. It starts around May and ends around the month October. During the summertime there is a lot of rainfall.
Stage	= Surface water level.
Gage	= A measuring point. (In English “gauge”)
DataforEVER	= An online-database of all the data that is collected in the Everglades National Park.
NAVD 88	= North American Vertical Datum, that is established in the year 1988. The NAVD 88 is the database that contains all the ground elevations in North America.
PPT	= Parts Per Thousand.
LTER	= Long Term Ecological Research

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1. Introduction

To fulfill the demands for my Bachelor thesis (March to July 2012), I served an internship with the U.S. Geological Survey at Everglades National Park. The United States Geological Survey (USGS) is a science organization that provides impartial information on the health of ecosystems and the environment, the natural hazards, the natural resources, the impacts of climate and land-use change.

For the study Land and Water Management at Van Hall Larenstein University of Applied Sciences, I will graduate with an assignment at the United States Geological Survey (USGS). The goal for my graduation project is to draw conclusions from analyses of USGS coastal water data collected 2004-2011 from five coastal gages located in the Shark River estuary/drainage. I used time-series analysis, spectral-analysis and autocorrelation techniques. This analysis will help the USGS scientists understand hydrologic patterns and trends, so they can use this analysis as useful information an as guidance for their future researches.

The Everglades is vulnerable of climate change. If the seasonal changes of flood and drought are changed, this will have devastated consequences for the flora and fauna in the Everglades National Park. Furthermore, climate change is attended by sea level rise. This probably leads to higher salinity levels, forced by tides. (Florida Coastal Everglades Long Term Ecological Research, 2012)[1]

The Everglades coastal system is under influence by both marine and freshwater. The monitoring and analysis of ground- and surface water levels, salinity and rainfall is vital to evaluating and managing the coastal ecosystem in Everglades National Park. That is why these following questions have been setup for this research.

The main question of the project is:

What do the water-data (salinity, rainfall, ground- and surface water levels) indicate about the water quality and quantity of the years 2004 to 2011?

To answer the main question, these sub questions are relevant:

1. *What are the ground and surface water salinity seasonal patterns?*
2. *How does surface and groundwater levels differ on site and with other sites?*
3. *How do tidal exchange, freshwater discharge and rainfall forcings influence hydrodynamics in the Shark River and adjacent mangrove-marsh communities?*

This project was conducted with literature study, data collection, data analysis and interpretation. Existing study sites were used and the data of these corresponding sites were analyzed by using programs like MatLab and Excel.

Results of the analysis should be an aid to understand sea level rise and seasonal hydrodynamics of the coastal Everglades ecosystem.

[1] Sources are referred by title and year; see bibliography, page 45.

The report begins with an introduction about the Everglades and the Shark River Slough. The project objectives and research questions are next. These explain what the project is really about. The methods are described in the next chapter. The results are found in the next chapter, all observations can be found in that chapter. The results are interpreted in Chapter 5. With all this in mind, a discussion was made, containing evaluation of the errors made during this project, plus a few recommendations. And at the end of this thesis conclusions were completed, giving answers on the research questions. For examples and clearer figures, consult the annexes.

2. Framework

Water in south Florida once flowed freely from the Kissimmee River to Lake Okeechobee and southward over low-lying lands to the estuaries of Biscayne Bay and Florida Bay. This shallow, slow-moving sheet of water covered almost 11,000 square miles, creating a variety of ponds, sloughs, sawgrass marshes, hardwood hammocks, and forested uplands. For thousands of years this complicated system evolved into a finely balanced ecosystem that formed the biological infrastructure for the southern half of the state. See figure 1. (National Park Service, 2012)

However, to early colonial settlers and developers the Everglades were potential farmlands. By the early 1900s, the drainage process began to transform wetland to land ready to be developed. The results of this were severely damaging to the ecosystem and the species it supported. (National Park Service, 2012)

With the support of many early conservationists Everglades National Park was established in 1947 to conserve the natural landscape and prevent further degradation of its land, plants, and animals.

Although the captivation of the Everglades has mostly stemmed from its unique ecosystem, an alluring human story of the Everglades is deeply entwined with its endless marshes, dense mangroves, towering palms, alligator holes, and tropical fauna. Various groups and people navigated through and wrestled with the watery landscape to make it home, and even to exploit its natural wonder at times. (National Park Service, 2012)

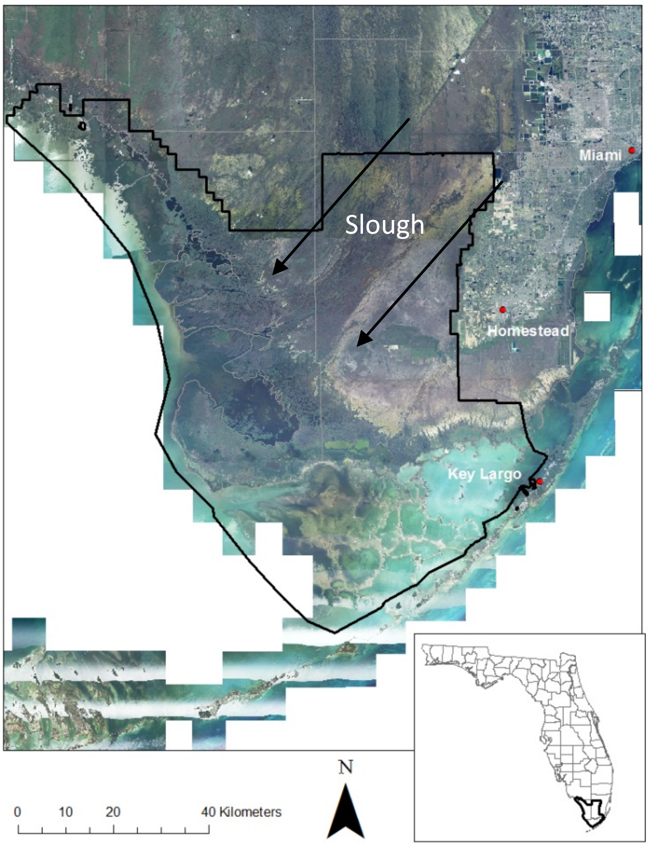


Figure 1; The Everglades, Florida

Everglades National Park has been designated a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Importance.

Everglades National Park is now situated on the southern tip of the Florida Peninsula. Everglades National Park is the only subtropical preserve in North America. It contains both temperate and tropical plant communities, including sawgrass prairies, mangrove and cypress swamps, pinelands, and hardwood hammocks, as well as marine and estuarine environments. The park is known for its rich bird life. It is the only place in the world where alligators and crocodiles exist side by side. (National Park Service, 2012)

The park is bounded by the Gulf of Mexico to the west, the Tamiami Trail and mostly state lands to the north and the Florida Keys to the south and southeast. It includes most of Florida Bay. Everglades National Park is a shallow basin tilted to the southwest and underlain by extensive

Pleistocene (the era before the Holocene) limestone. The park serves as a vital recharge area for the Biscayne Aquifer, a major source of freshwater for Miami and southeast Florida. It lies at the interface between temperate and subtropical America and between fresh and brackish water, shallow bays and deeper coastal waters. This creates a complex of habitats supporting a high diversity of flora and fauna. The most important trees are mangroves, taxa, slash pine and cypress. Prairies can be dominated by sawgrass, muhley grass, or cordgrass in coastal areas.

The Everglades is vulnerable of climate change concerning water. If the seasonal changes of flood and drought are changed, this will have devastated consequences for the flora and fauna in the Everglades National Park. Furthermore, climate change is attended by sea level rise. This probably leads to higher salinity levels, forced by tides. (Florida Coastal Everglades Long Term Ecological Research, 2012)

The Long Term Ecological Research (LTER) is and will study this important topic (the Everglades). This research involves all stakeholders and will be an important research for the Everglades and her problems containing every aspect that influences the National Park. (Florida Coastal Everglades Long Term Ecological Research, 2012)

2.1 Shark River Slough

A slough ("river of grass") is a low-lying area of land that channels water through the Everglades. These marshy rivers are relatively deep and remain flooded almost all year-round. Though they are the main avenue of mainly freshwater flow, the current remains leisurely, moving about 100 feet (30 meters) per day.

The Shark River is the primarily drainage river in the Everglades that begins at the end of the slough, see figure 2. From the north of the Shark River Slough, the freshwater flows into Everglades National Park. The water exits the park at the Gulf of Mexico on the southwest and the Florida Bay on the southeast side of the Peninsula. For the LTER, the estuarine ecotones of the Shark River Slough are of particular interest to the scientist who contribute to the research. Estuarine ecotones are the regions where freshwater mixes with saltwater and the grassy marshes give way to mangrove forests.

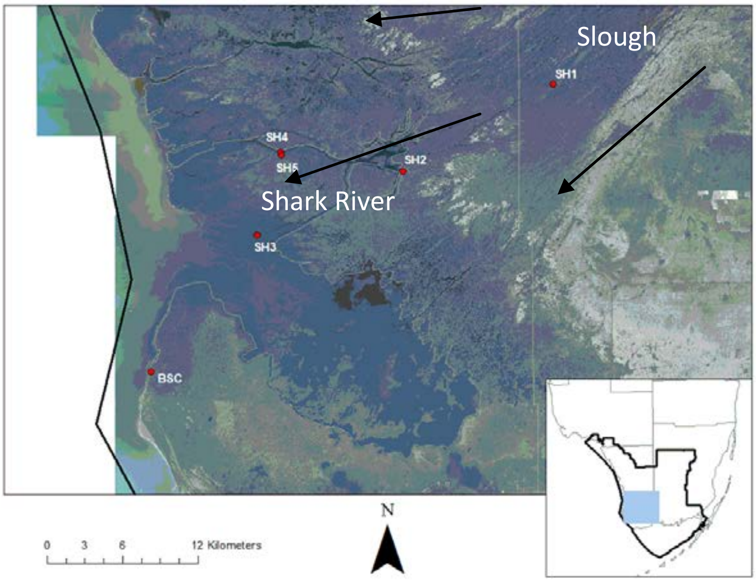


Figure 2; Flow direction, Shark River

Mangroves are salt-tolerant trees that dominate the forests near the creeks along the shoreline. The mangrove forests in the coastal area get flooded regularly. In the Everglades, the red mangrove, the white mangrove en the black mangrove can resist the large annual variation in salinity. Near the shoreline, the salinity of the water approaches the salinity of the sea. More inlands the salinity levels go down. (National Park Service, 2012)

One of the ecotones is a part of the Shark River Slough. All the gages that are used in this research are situated at the Shark River, south of the Shark River Slough and take also part in a bigger research project (the LTER).

2.2 Project Objectives

The Everglades coastal system is under influence by both marine and freshwater. The monitoring and analysis of ground- and surface water levels, salinity and rainfall is vital to evaluating and managing the coastal ecosystem in Everglades National Park. Monitoring and analyzing water levels en salinity levels are important for evaluating the ecotone in Everglades National Park. As written before, the LTER scientists find this the most important part of the Everglades.

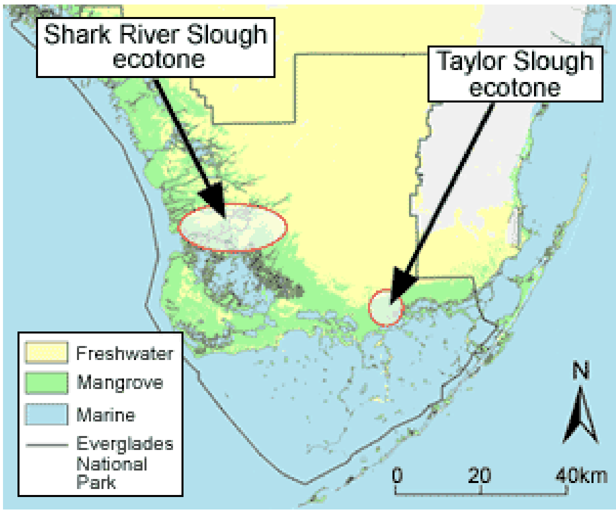


Figure 3; Position SRS, the Everglades

The objective for this project is to answer the research questions that are stated. The main objective is to find out what the water data says about the quality and quantity (salinity levels and water levels) of the years 2004 to 2011. This is relevant for the understanding of possible ongoing changes in the Everglades. So research on water datasets of the Shark River sites is vital.

2.3 Research question and sub questions

The main question of the project is:

What do the water-data (salinity, rainfall, ground- and surface water levels) indicate about the water quality and quantity of the years 2004 to 2011?

To answer the main question, these sub questions are relevant:

1. *What are the ground and surface water salinity seasonal patterns?*
2. *How does surface and groundwater levels differ on site and with other sites?*
3. *How do tidal exchange, freshwater discharge and rainfall forcings influence hydrodynamics in the Shark River and adjacent mangrove-marsh communities?*

The answers to these questions were based on analysis of long-term data collection.

3. Methods

This project was conducted with a literature study, data collection, data analysis and interpretation. Existing study sites were used and the data of these corresponding sites were collected and analyzed by using programs like MatLab and Excel.

3.1 Study sites

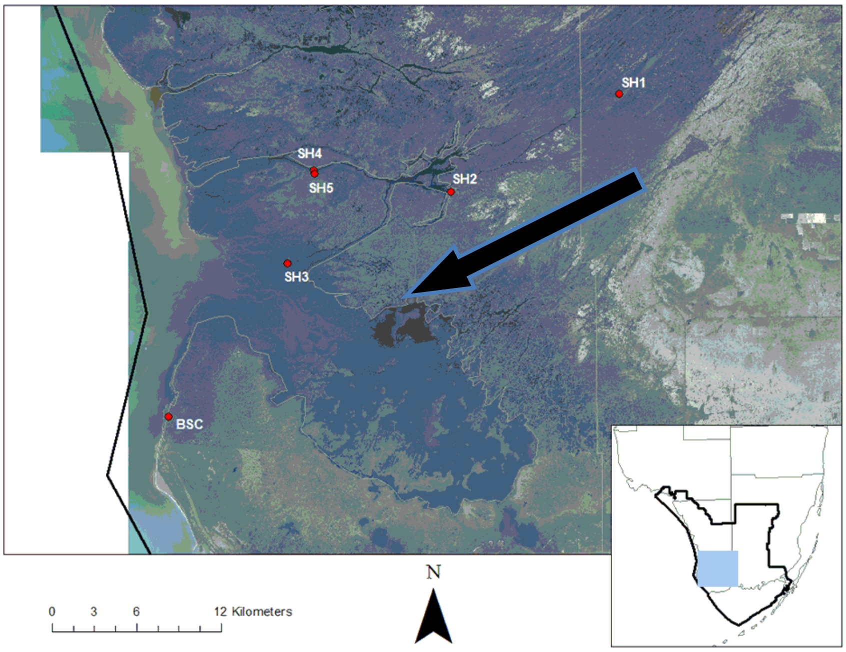


Figure 4; Study sites; The Everglades, Florida

The study sites are situated in the southwest of the National Park, The Everglades. On the figure on the right, the situation is shown. From the gage in the north (SH1) to the gage in the south (BSC), the distance is about 20 miles (30 km). During the way down southwest, the water will pass the gages in following order; the first gage is SH1, the second gage is SH2, the 3rd en 4th gages are named as SH4 and SH5. After these four gages, the water will pass SH3 (this is in the center of the inlet of the river, were salt- and freshwater gets mixed). The site BSC, is situated in the same line but is not connected with the water from the Shark River. The gage at Big Sable Creek (BSC) measures the seawater and water from the creek itself. And in that way it is separated from the other measuring sites.

For all the study sites that are used in this research, the ground elevation is known. All water level data is based on the North American Vertical Datum of 1988 (NAVD 88). From October the 1st till the 30th of September for every year (2004-2011) data is collected. This local data consists of groundwater level, surface water level and the salinity of the same water levels. For the gage at Big Sable Creek (BSC), this information is irrelevant because this gage does not measure groundwater levels or salinity ground water levels whatsoever. This gage measures the surface water level and salinity level for surface water. This gage is situated on a tidal creek near the shoreline of the Gulf of Mexico, and so the ground elevation constantly changes.

These values are the ground elevations of the sites based on the NAVD 88:

- SH1: -0.32 feet
- SH2: -0.52 feet
- SH3: -0.27 feet
- SH4: -0.37 feet
- SH5: -0.16 feet

Big Sable Creek (BSC)

The gage "BSC" is situated on the Big Sable Creek. This creek gets the name from the cape "Big Sable". This station is the closest station to the Gulf of Mexico. It has a big tidal influence. It almost has the same influences by the sea as gage SH3, but this site (BSC) is situated on water and the gage of site is located on the side of the river. The station (BSC) does not measure groundwater, because it has no well for it. So for water data, only surface water (and salinity) is used.

Shark River 1 (SH1)

SH1 is a freshwater site located in the Shark River Slough. It has a mixed vegetation community of sawgrass *(Cladium jamaicense)* and spikerush *(Eleocharis cellulose)*. This site is northernmost site that is used for this research. Here freshwater flows overland, coming from the north along a slight downward gradient of the Shark River Slough. Local precipitation also contributes the water input to the site SH1. Since SH1 is upstream of tidal influences, tidal forcings are not significant.

Shark River 2 (SH2)

The marsh-estuary transitional site SH2 is situated adjacent to Tarpon Bay and is characterized as an ecotone site. This is an area between the freshwater marsh and saline estuary in which the hydrodynamics are influenced by daily tides, freshwater flow, and local precipitation. Small red, white and black mangroves are present. Mangroves are key to the ecotone of the Shark River Slough.

Shark River 3 (SH3)

This station is the mangrove estuary site. This station is located just three miles northeast of the Gulf of Mexico. This site is under a big influence by the saltwater coming in to the Shark River, although the gages are situated on the land next to the river. With the tides coming in, the bank where the gage is placed becomes flooded. When the tides are low, the soil is still saturated with water but there is no "visible" water anymore.

Shark River (SH4)

This site is located in a tall mangrove forest and surface water is most influenced by periodic tidal forcings, especially during springtides. It is also influenced by local precipitation. This gage (next to the Shark River) and the station SH5 have the same distance towards the Gulf of Mexico, but SH5 is 1000 feet inland and is not as influenced by tidal forcings as SH4.

Shark River 5 (SH5)

SH5 is less influenced by the sea than SH4. Except for extreme tides and storm events. This site is more influenced by local precipitation and overland flow. Freshwater flows from the Shark River Slough are not significant because the sites are located on a coastal island. So, SH5 is actually isolated from the tidal creeks and Shark River Slough flow.

Tables of gage information:

Gages	BSC	SH1	SH2	SH3	SH4	SH5
Salinity GW		x	x	x	x	x
Salinity SW	x	x	x	x	x	x
Groundwater		x	x	x	x	x
Surface water	x	x	x	x	x	x

Table 1, Gage information; parameters

Gages	BSC	SH1	SH2	SH3	SH4	SH5
Fresh water		x				
Salt water	x			x	x	
Brackish water			x			x

Table 2, Gage information; water type.

Gages	BSC	SH1	SH2	SH3	SH4	SH5
River	x		x	x	x	
Land		x				x

Table 3, Gage information; land/river.

3.2 Data collection

Data is collected from October the 1st 2004 till the 30th of September 2011. This local data consists of groundwater level, surface water level and the salinity of the same water levels. From 2004 till 2011 is a total of 7 years. The data comes from different kinds of sources. For the data collection, DataForEVER is used. This is an online-database of all the data that is collected in the Everglades National Park. Not only data is based here, with this online-database additional statistics could be calculated.

For every year, for every gage, water levels (in foot, the English system) and salinity (in PPT (Parts Per Thousand)) levels were collected. These data sets can show interesting findings. Before the data was stored in the online database, the data is downloaded from the stations in the field. This was done by GPS (Global Positioning System) and transfer of data directly to the database at the corresponding field station.

During all the years of collecting data, missing values will sometimes appear. This has various reasons, but the main reason for this is broken equipment. For this project, missing data values (nulls) are integrated as zero values. This means that the missing data values became zeros (0's). And these zeros were included in the calculations during the analysis of the data series.

3.3 Data Analysis

Analyzing data can be done by lots of programs that can perform statistical analysis on water data. The programs used for this project are programs that have a good connection with analyzing the data that come from water measurement stations. For instance, to get a graph that shows information about the corresponding data, there are a lot of things to do before the graph will appear. But eventually the graph of, for example site Shark River 3 (SH3), ground water level (GWL) will show the time-series graph, spectral-analysis graph and autocorrelation graph.

All the analyzing is done with one program. Except the analysis-type "Exceedance curves". This program is called, MatLab and is a programming environment for algorithm development, data analysis, visualization, and numerical computation. MatLab can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis. For an example, see annex 4. (Mathworks, 2012)

To eventually have all the graphs and analysis completed, a few methods were used. These methods are the key for looking at water data in a way, that lots of information about certain trends, correlations en remarkable points will show. The following methods below were used for this research about the water data of the Shark River and Big Sable Creek.

3.3.1 Exceedance curves

In the Everglades there are lot of interactions between discharging and recharging of surface water. With graphs such as exceedance curves, there is a clear view of the water level during a period of time. Thus, an exceedance curve is a graph that represents the percent of time a specified discharge is equaled or exceeded. For every site and year, exceedance curves are used.

3.3.2 Autocorrelation

Autocorrelation shows how much correlation is present between lagged observations in the time-series. An example is, for seasons that come back every year, positive or negative curves can be seen. If these seasons keep the same curve every time (same amount of days), there is a good correlation between these seasons. This correlation comes to expression in the correlogram, where one can see monthly, seasonally and annually trends.

3.3.3 Spectral analysis

Instead of plotting the amplitude versus the time-domain, spectral-analysis is plotting the amplitude versus the frequency of the variable. Spectral-analysis is decomposing the original series into underlying sine and cosine functions of different frequencies, in order to fin monthly, seasonal, and annual cycles. So the resulting graph may show peaks that indicate cycle for a certain period of time.

3.3.4 Time-series

A definition of time-series is:

> *An ordered sequence of values of a variable at equally spaced time intervals. (Investopedia, 2012)*

So, a time series is simply a sequence of numbers collected at regular intervals over a period of time. These graphs are done for every year for every station. It gives a clear view of the data that is collected during the 7 years concerning this project.

4 Results

This chapter shows the results that came forth by using the program MatLab. The results contain information about time-series, spectral-analysis and autocorrelations. Also exceedance curves are included. The observations of the graphs are written below. The written texts refer to the graphs below. Per gage and site, the 7 year graphs are shown.

4.1 Big Sable Creek (BSC)

4.1.1 Surface water level (see figure 5)

- There is not a peak at 30 days (4week cycle of the moon), and also no peak for instance at 180 days (seasonal). That is really striking, because this gage has a lot of influence by the sea (Gulf of Mexico).
- The average water level is 0.8 foot below sea level. See figure 5.
- From late October to August 2006 there is no data. This is because of the hurricane.
- Just before equipment was lost, there was a water level of about 3 feet below sea level. See figure 5.
- Highest levels were measured during the wateryear of 2007, with levels of 0.5 foot above sea level. See figure 5.
- The driest periods are around the month February.
- The wettest periods are around the month October.

4.1.2 Salinity surface water level (see figure 6)

- The average salinity level is 35 Parts Per Thousand. This is directly related to salt seawater with an average of 35 PPT.
- From late October to August 2006 there is no data. This is because of the hurricane.
- A 400-day peak is visible in the spectral analysis graph.

There is no groundwater well so there is no data available for this site for Big Sable Creek.

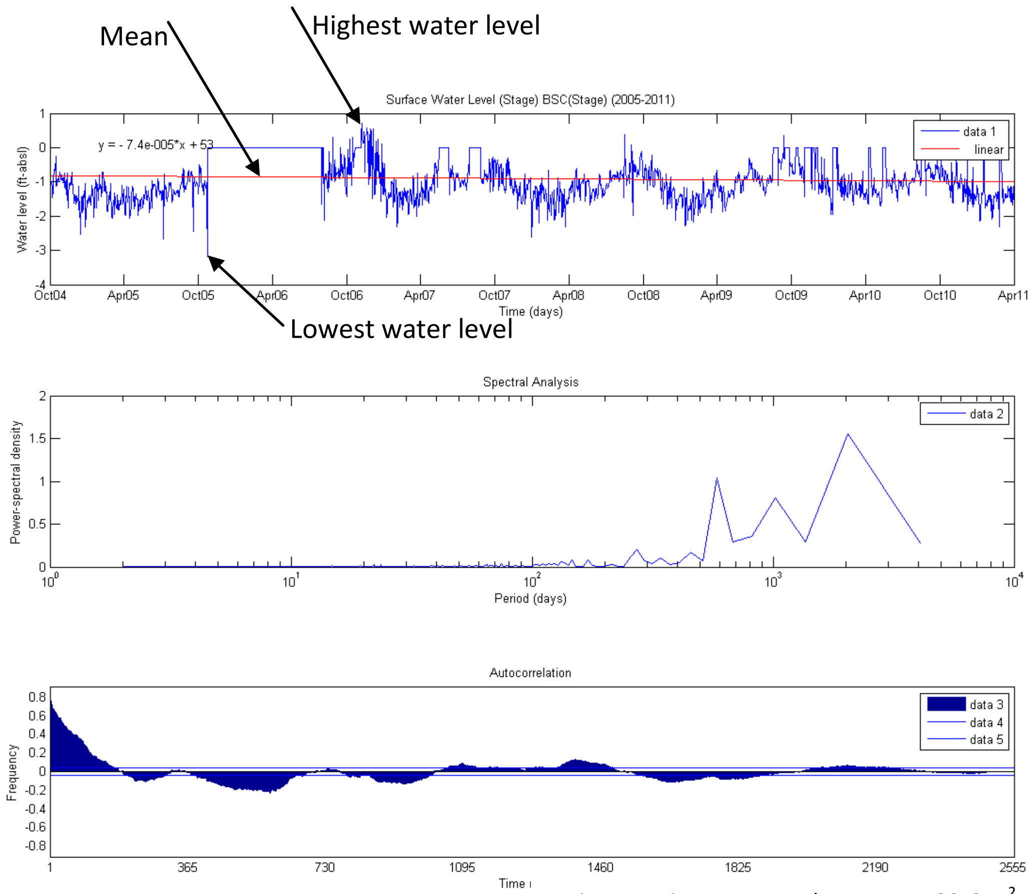


Figure 5; Time-s., spectral., autoco.; BSC, SW [2]

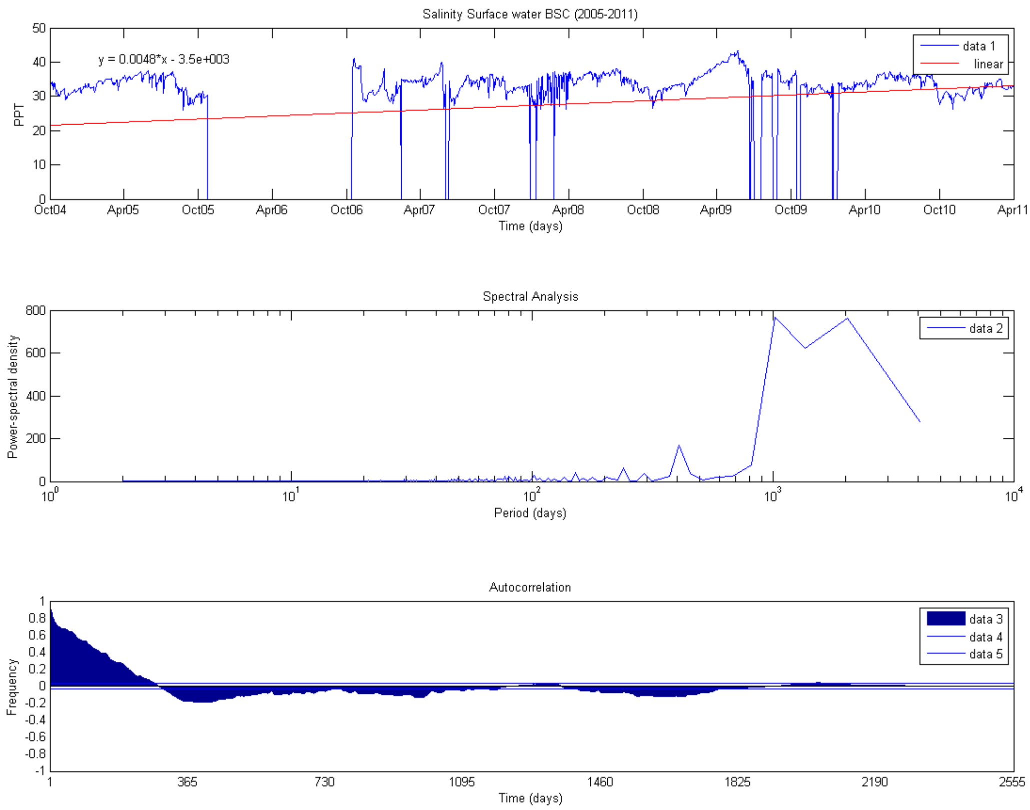


Figure 6; Time-s., spectral., autoco.; BSC SALSW

[2] For full title, see figure list page 7.

4.2 Shark River 1 (SH1)

4.2.1 Ground water level (see figure 7)

- In the beginning of the wateryear of 2005(October), the ground water level is 1.5 feet above sea level and in the beginning of wateryear 2011 the groundwater level is 1.8 feet above sea level.
- At the end of the wateryear of 2005 the water level is 2 feet above sea level and at the end of wateryear 2011 the water level is 1 foot above sea level.
- In the winter season you can see the groundwater level goes down. In the summer season you can see that the groundwater level goes up in the all-year graph.
- More and more fluctuation in the groundwater levels per year is present.
- Per wateryear you can't see any real patterns, looking at the spectral analysis, but looking at the 7year graph a 300 and 600day peak is present.
- The seasonal and yearly patterns are present in the 7year time-series graph (time-series graph). Seasonal patterns also in the correlogram, 180 days per season.
- From October 2008 till February 2009 there is no data.
- June and May are dry months.
- This gage fluctuates from 2.5feet(highest level) above sea level to about -0.8 feet (lowest level).

4.2.2 Salinity ground water level (see figure 8)

- In the wateryear of 2010, in the winter the salinity level is around the 0.75 parts per thousand. And becomes 0.5 PPT again in the early summer months. This is almost for every year.
- For the wateryear of 2006, there are really high values for the salinity, almost 1 PPT. These are the months before the hurricane.
- Salinity values keep stable during the years.
- The average salinity level during the years is around the 0.75 parts per thousand.
- No real clear peaks for the spectral analysis graphs.

4.2.3 Surface water level (see figure 9)

- Per wateryear you can't see any real patterns, looking at the spectral analysis.
- A clear peak at 600 days for the spectral analysis.
- For the wateryear 2010 the months of February, March and April have a really low surface water level. Just above the 0 feet.
- There are high water levels from July to January, around the 2 feet above sea level. For the low values the average is about 0 feet above sea level.
- Seasonal patterns can be found in the correlogram.

4.2.4 Salinity surface water level (see figure 10)

- In June for the wateryear 2005 there is a salinity level of 3 PPT and in the wateryear 2011 there is a peak with a value of 5 PPT.
- On average the salinity will rise from 0.2 PPT in October to about 0.6 PPT in April, May and June.
- There are not really clear trends to see.

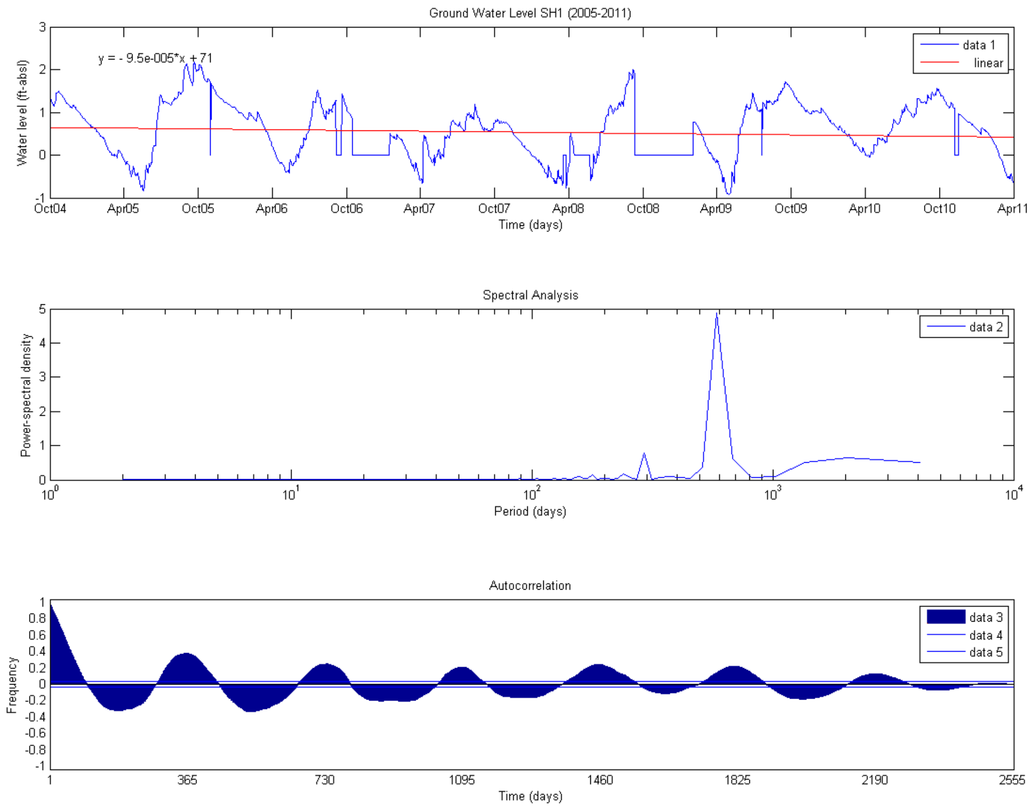


Figure 7; Time-s., spectral., autoco.; SH1 GW

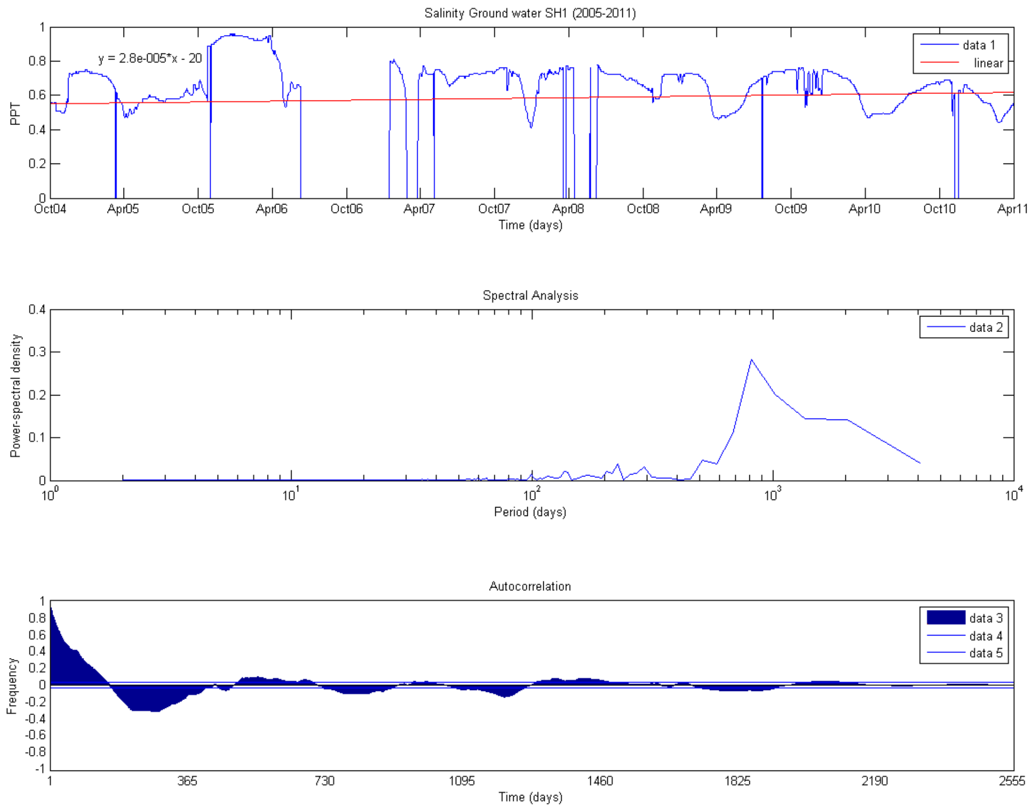


Figure 8; Time-s., spectral., autoco.; SH1 SALGW

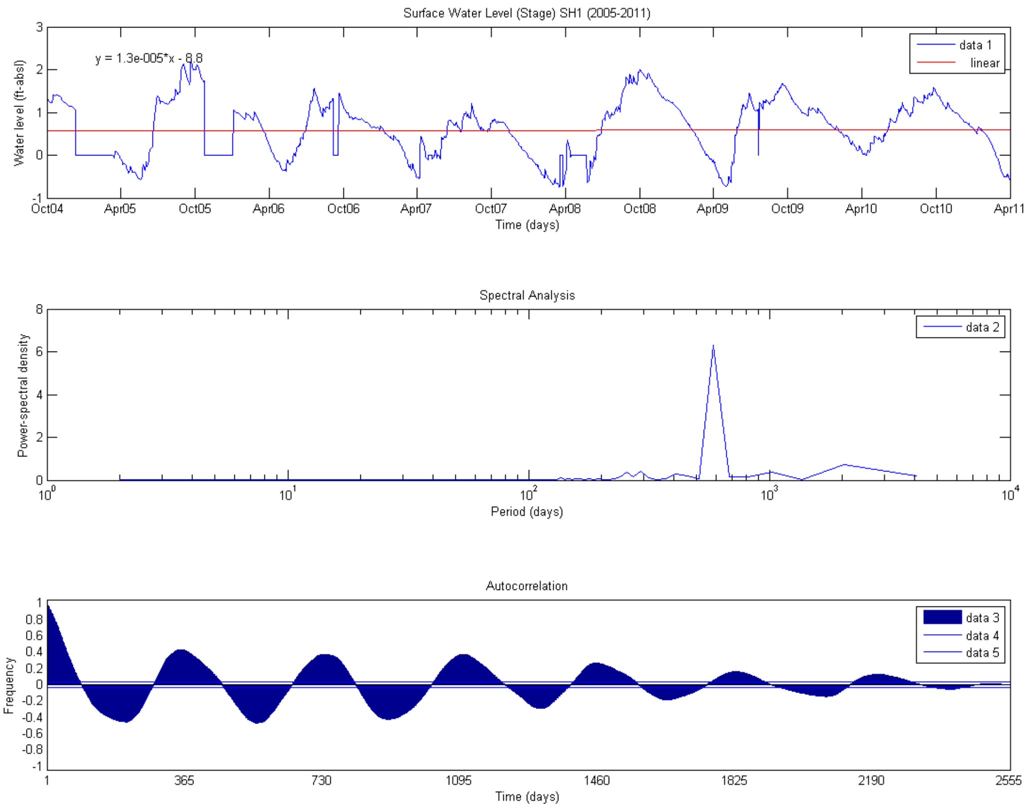


Figure 9; Time-s., spectral., autoco.; SH1 SW

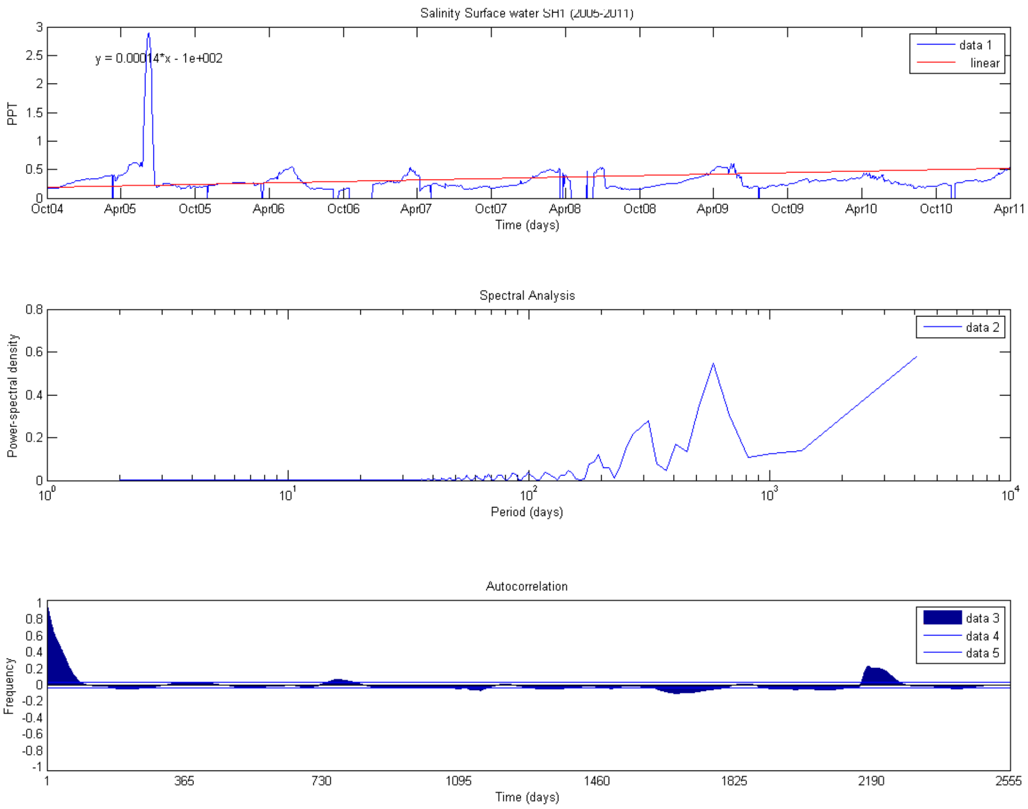


Figure 10; Time-s., spectral., autoco.; SH1 SALSW

4.3 Shark River 2 (SH2)

4.3.1 Ground water level (see figure 11)

- A peak is visible at around the 600 days; this means that every 600 days there is a trend in the water fluctuation.
- There is missing data from October 2008 till mid July 2009.
- The average water level is -0.25 foot under sea level.
- Between the maximum water level and the minimum water level is a distance of almost 2 feet.
- The lowest level is -1.2 feet and the highest levels are around the +0.6 foot over the 7 years.
- The seasonal and yearly patterns are present in the 7year time-series graph (time-series graph).
- All the years compared, they have a lot of similarities. There are no big differences.
- Seasonal patterns visible in the correlogram. Wet are positive values and dry are the negative values.

4.3.2 Salinity ground water level (see figure 12)

- The values for salinity go up during the 7 years.
- So you can say the ground water is getting saltier. From the year 2005 starting with 5 PPT to the year 2011 with an average of 10 PPT.
- This increase of salinity is because of a change in the position of the sensor in the groundwater well. Till 2007 the sensor was based 4 feet below ground elevation, after this the sensor was moved to 3 feet downwards.
- There are no real clear peaks in all of the spectral graphs.
- Deeper in the ground, there is more fluctuation in salinity levels.

4.3.3 Surface water level (see figure 13)

- There is almost no missing data, you can see the annual cycle real clear again.
- The dry and wet seasons are present. In the winter the
- The lowest values are in the driest months at the water years of 2008 and 2009, these years are slightly drier then the others.
- The surface water level stays the same during the years. With max values in October around the 0.3 foot above sea level. And minimum values in April with values around the -1.2 feet below sea level.
- Around the month May the water level will rise.
- There is a really clear 600-day peak.
- Clear seasonal pattern in the autocorrelation graph.

4.3.4 Salinity surface water level (see figure 14)

- For SH2 salinity surface water, the patterns are really clear.
- For around 180 days and 300 days, there are peaks. There is also a 600-day peak.
- You can see low values in the summer months (3 PPT) and high values (22 PPT) in winter months (the dry season) just before the groundwater level rises again.
- During the 7 years the salinity goes up. The water becomes saltier. The average salinity in 2005 is 5 parts per thousand and the wateryear of 2011 has an average of 7 parts per thousand.

- Clear seasonal pattern in the autocorrelation graph, the same as the surface water level.

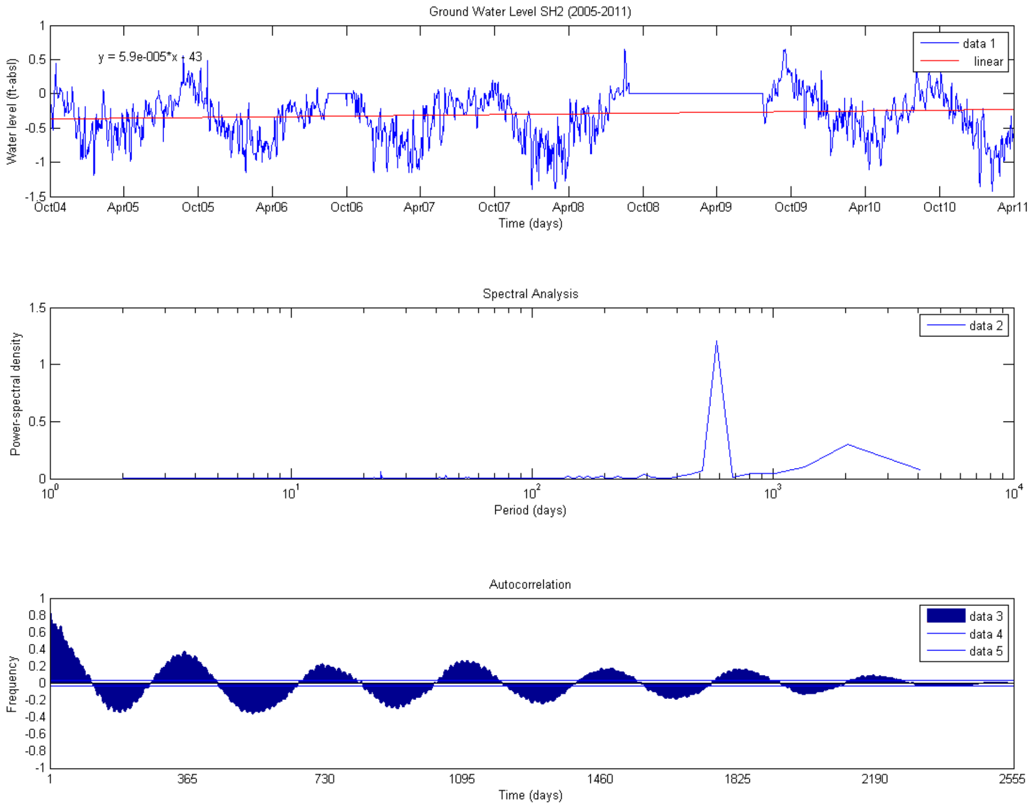


Figure 11; Time-s., spectral., autoco.; SH2 GW

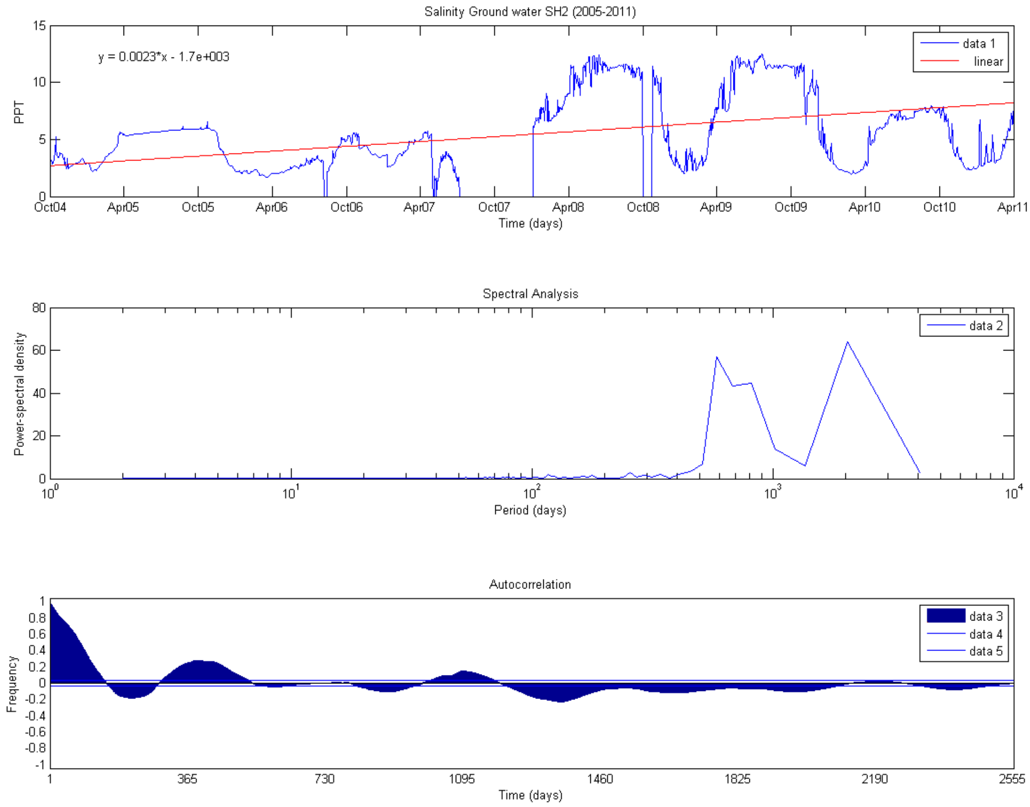


Figure 12; Time-s., spectral., autoco.; SH2 SALGW

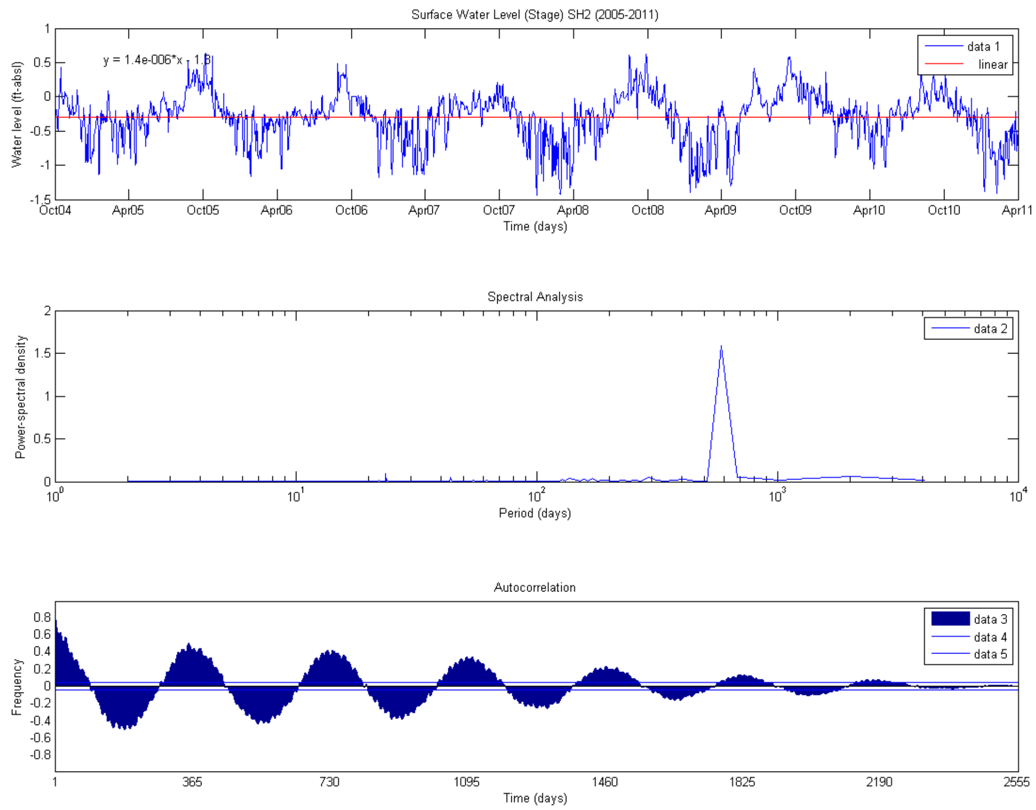


Figure 13; Time-s., spectral., autoco.; SH2 SW

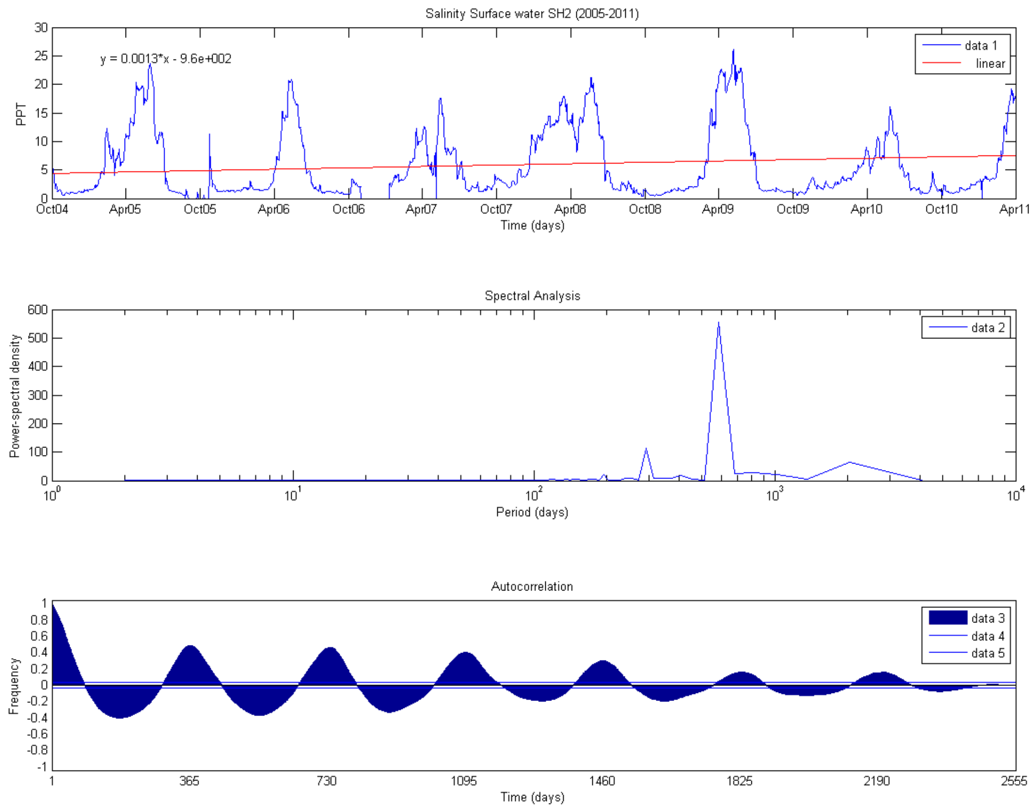


Figure 14; Time-s., spectral., autoco.; SH2 SALSW

4.4 Shark River 3 (SH3)

4.4.1 Ground water level (see figure 15)

- There are clear peaks of the tidal influence at this station. A 14-day peak is present and a strong tidal peak for 28 days is there as well.
- Almost for the entire wateryear of 2006 there is no data available, because the station was damaged by hurricane Wilma.
- In the 7year graph the annual and seasonal peaks are clearly visible. For the season it is around the 180 days and for the annual 365 days.
- The groundwater levels do not differ much from each other.
- The lowest water level was around the -1.8 feet below sea level in January 2008.
- The highest water level was around the 1 foot above sea level.
- The average water level is near the sea level (0 feet).

4.4.2 Salinity ground water level (see figure 16)

- The salinity levels stay the same, around the 25/30 parts per thousand (PPT). The red linear line is also based on the bad data for the year 2006. So this line is not entirely correct.
- Around the month April the salinity levels are the lowest.
- There are no real clear peaks in all of the spectral graphs.
- Almost for the entire wateryear of 2006 there is no data available, because the station was damaged by hurricane Wilma.

4.4.3 Surface water level (see figure 17)

- A lot of fluctuation at this site. This gage has the most influence of tidal changes of all the gages.
- You can see the 14-day cycle and the 28-day trend very clear. In almost every year they are present, except the year without data.
- In the 7-year graph of the surface water levels, the tidal influences are clearly visible with the related peaks.
- The wateryear 2010 was a wet year.
- The lowest levels are almost -1.5 feet below sea level and the highest level is around the +1 foot above sea level. On average the level is +0.1 foot above sea level.
- A 600-day trend is there as well.
- A lot of fluctuation visible in the correlogram, the seasonal pattern is also present.

4.4.4 Salinity surface water level (see figure 18)

- The average salinity value is 30 PPT (Parts Per Thousand).
- The months May and June have the highest salinity values. Values of 35 PPT.
- In July the high values drop slowly down to December. After December the values go up again.
- For the 7-year graph, you can see the 180-day peak (seasonal) and the yearly trend (365 days).
- A 600-day trend is visible at the spectral analysis graph.

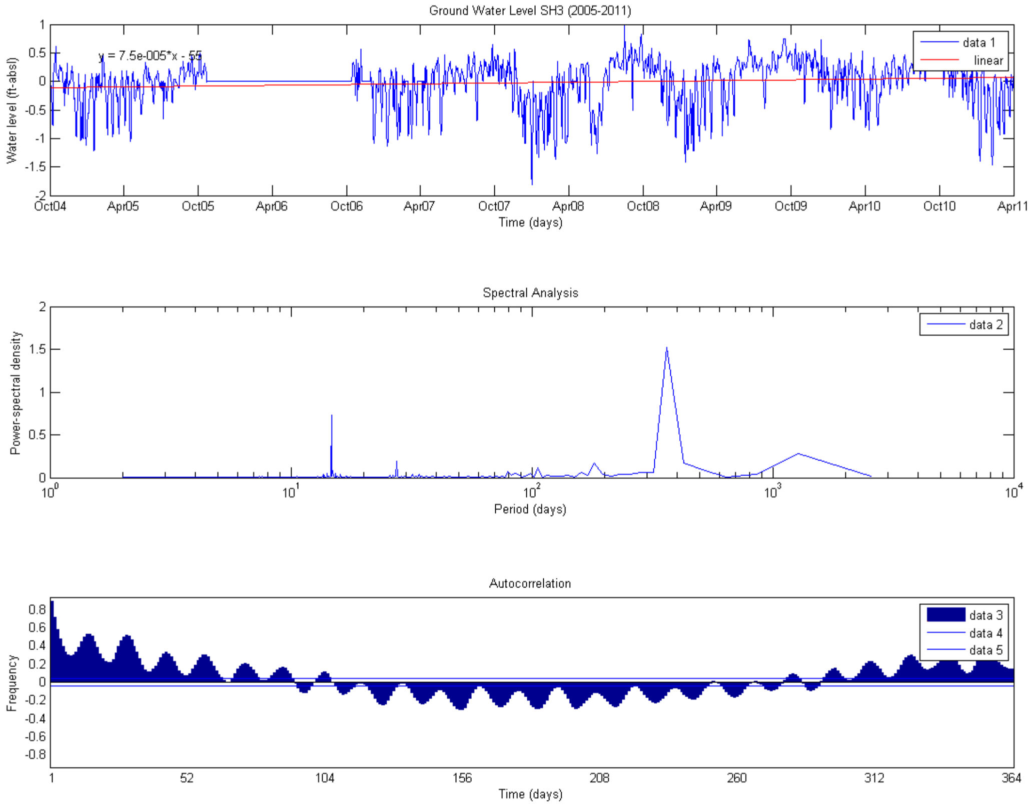


Figure 15; Time-s., spectral., autoco.; SH3 GW

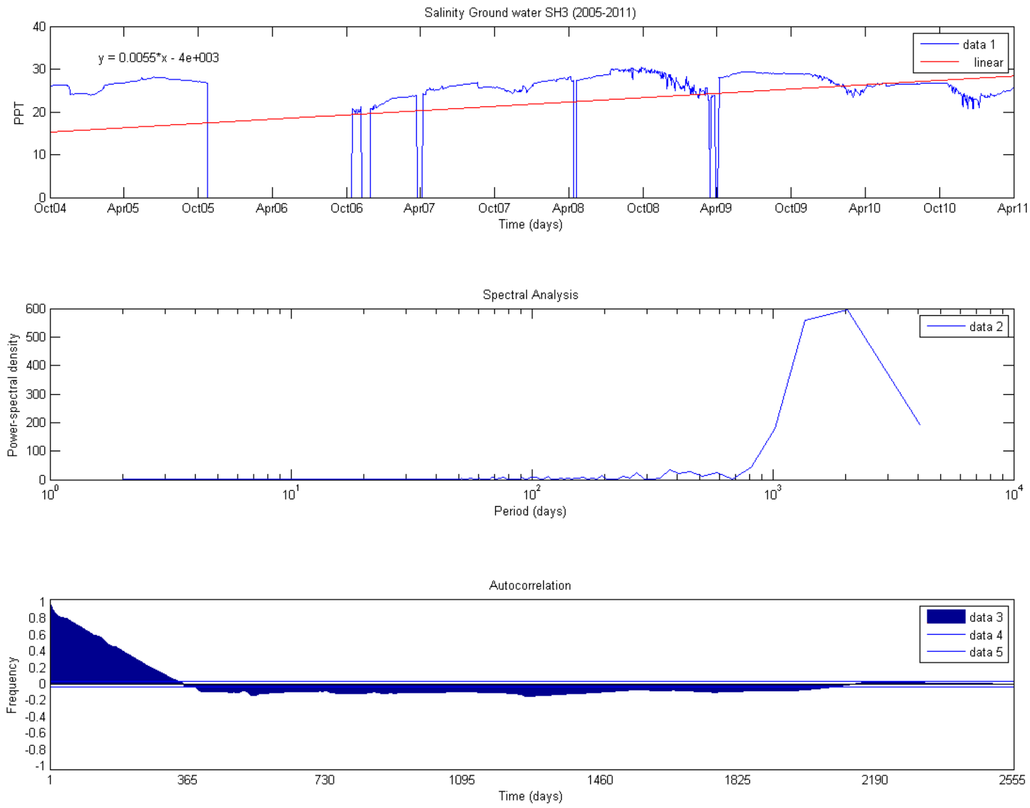


Figure 16; Time-s., spectral., autoco.; SH3 SALGW

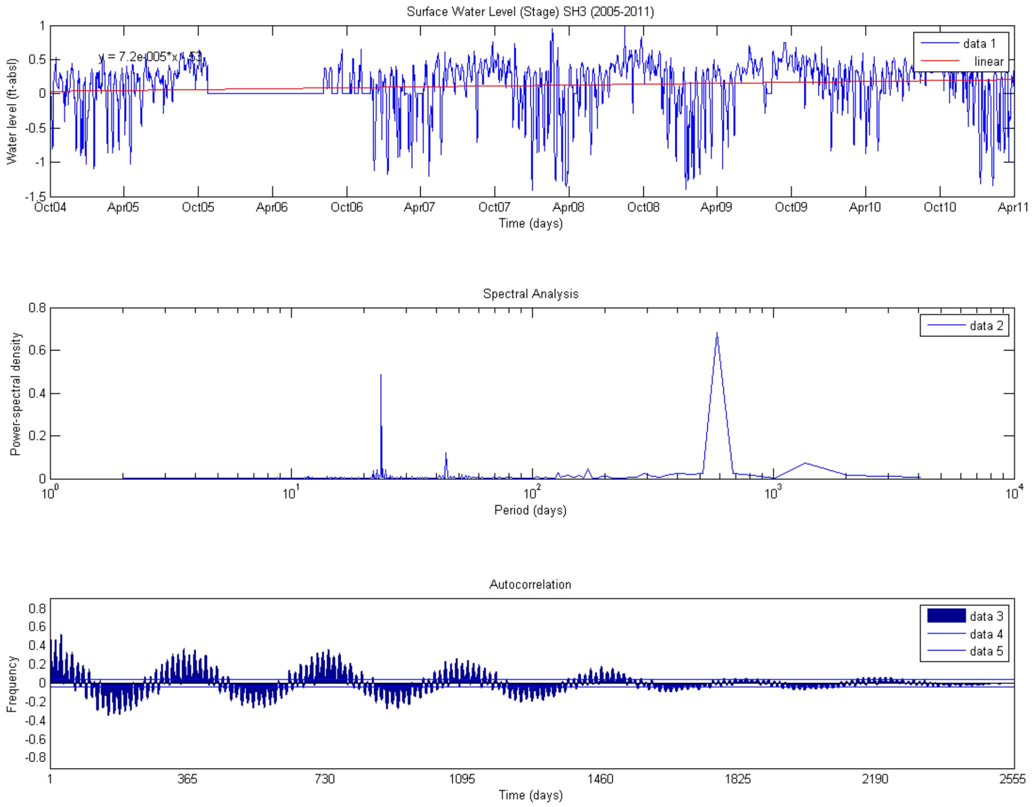


Figure 17; Time-s., spectral., autoco.; SH3 SW

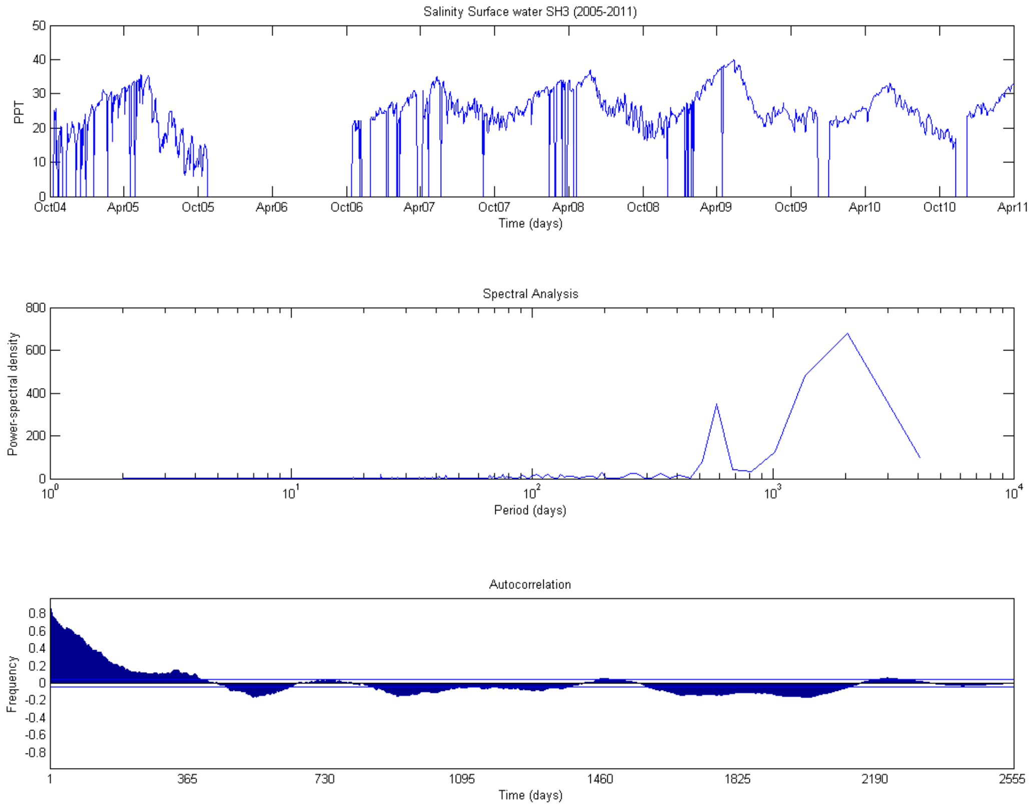


Figure 18; Time-s., spectral., autoco.; SH3 SALSW

4.5 Shark River 4 (SH4)

4.5.1 Ground water level (see figure 19)

- There is a high level peak at October 2005, 1.5 feet above sea level.
- You can see a bit of the tidal fluctuations.
- For every year there is a trend for every 40 days. This trend is visible in the 7-year graph too.
- A 600-day trend is visible at the spectral analysis graph.
- Per year for every 20 days there is a trend.
- The year 2009 has only data for the months October and November.
- The average water depth is +0.1 foot above sea level; the lowest values are around the 1 foot below sea level.
- Clear wet and dry seasons visible in the correlogram.

4.5.2 Salinity ground water level (see figure 20)

- The months May and June there are higher salinity levels than other months. This is because of the lack of fresh water. The values are at 18/20 PPT.
- A strong 600-day trend is visible at the spectral analysis graph.
- There are no peaks for the spectral analysis except the 600-day peaks.
- The low salinity values are around the 12 PPT.
- Clear wet and dry seasons visible in the correlogram.

4.5.3 Surface water level (see figure 21)

- High water level, just before the hurricane in October of the year 2005. There is a nice peak in the time series to show that. The water level of that particular moment is almost 1.9 feet above sea level.
- Almost no bad data. Some minor empty points.
- A 600-day trend is visible at the spectral analysis graph.
- The average water level is 0.1 foot above sea level.
- The dry moments are about 1.2 feet below sea level.
- March and April are the driest months.
- Clear wet and dry seasons visible in the correlogram.

4.5.4 Salinity surface water level (see figure 22)

- The year and seasonal characteristics are clear in the time-series graph.
- A 600-day trend is visible at the spectral analysis graph.
- The high salinity peaks reach the 40 Parts Per Thousand, the lowest salinity levels are around the 2 Parts Per Thousand.
- Big fluctuation in salinity values for this station.
- Wateryear 2009 has the highest values in salinity in the months April and May.
- The average salinity level is 13 PPT.
- Clear wet and dry seasons visible in the correlogram.

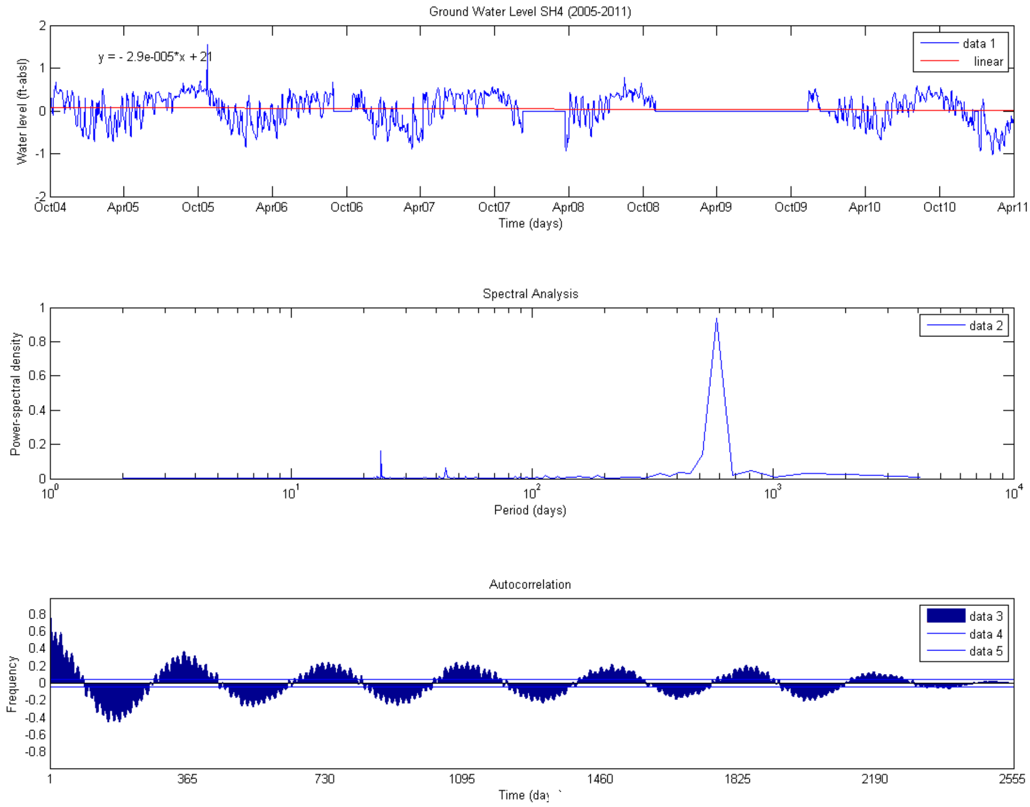


Figure 19; Time-s., spectral., autoco.; SH4 GW

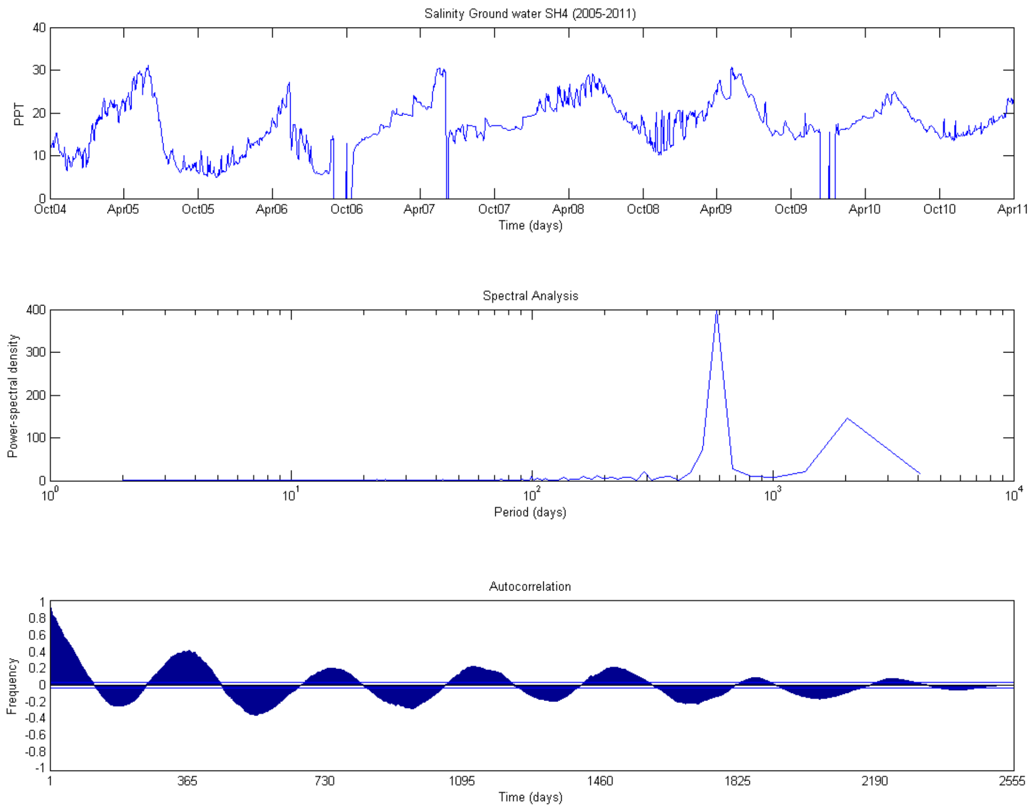


Figure 20; Time-s., spectral., autoco.; SH4 SALGW

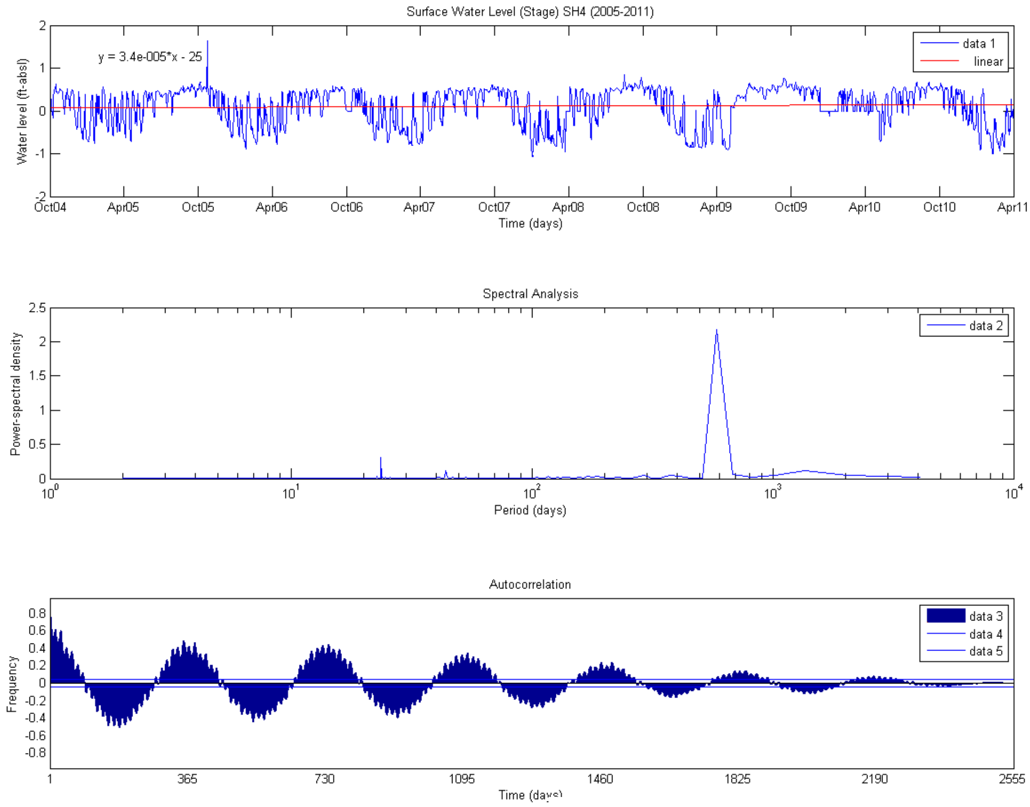


Figure 21; Time-s., spectral., autoco.; SH4 SW

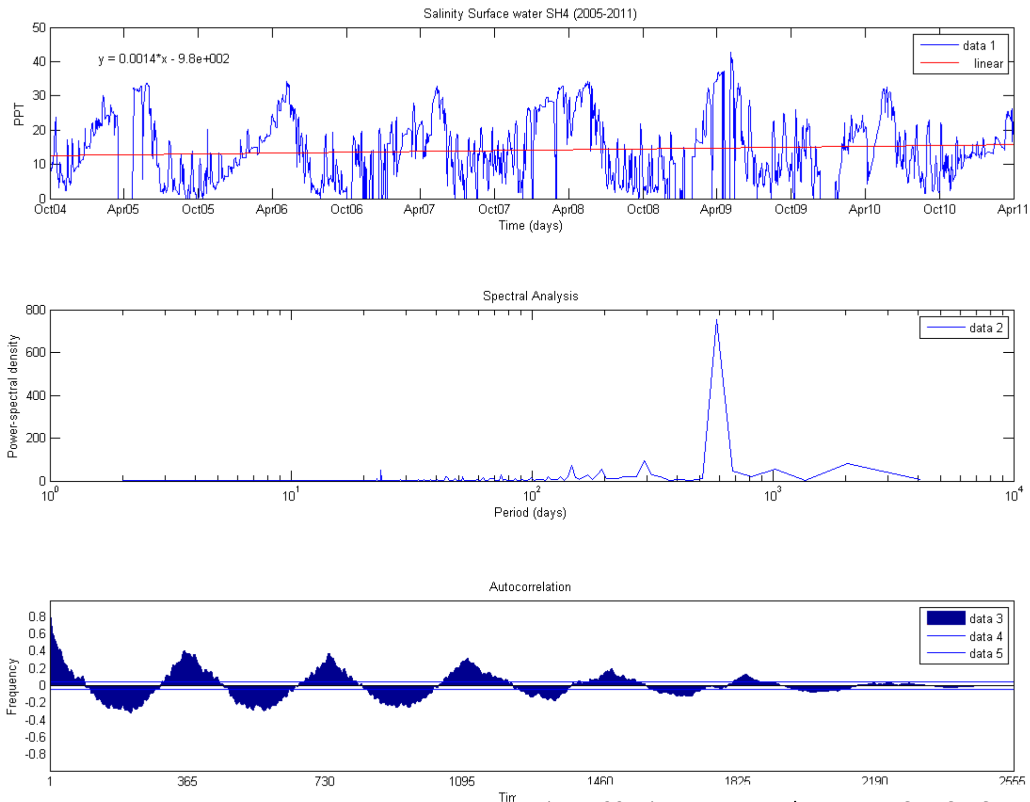


Figure 22; Time-s., spectral., autoco.; SH4 SALSW

4.6 Shark River 5 (SH5)

4.6.1 Ground water level (see figure 23)

- The seasonal patterns can be seen in the time-series graph.
- There is a little 600-day peak.
- There is almost no data for the calendar year 2009.
- The average groundwater level is 0.1 feet over the 7 years.
- The highest value is measured in late October 2005 with a peak of 1.8 foot above sea level.
- The lowest levels are around the month March and in the year 2008, the lowest levels where measured with values of around -1.2 foot below sea level.
- Seasonal pattern is present in the autocorrelation chart.

4.6.2 Salinity ground water level (see figure 24)

- This site is just 1000 feet away from SH4, but the salinity levels are around the 10 PPT.
- In July of 2005 the value of salinity was only 6 PPT. This is probably caused by the hurricane.
- There are peaks at 70 and 90 days.
- The salinity levels go slowly up during the period of 7 years. With 1 or 2 PPT over the 7 years.

4.6.3 Surface water level (see figure 25)

- This site has no tidal signal in the surface water.
- The hurricane peak can be seen in late October 2005.
- The seasonal and yearly patterns are present in the 7year time-series graph.
- The average water level is 0.2 feet above sea level.
- The lowest points are just before the summer season and have values of 0.8 foot below sea level.
- A 600-day trend is present.
- No tidal peaks whatsoever.
- Seasonal pattern is present in the autocorrelation chart.

4.6.4 Salinity surface water level (see figure 26)

- The salinity values have an average of 12 Parts Per Thousand.
- There extreme high values of salinity in the wateryear 2005 in the months of April, May and June. The salinity levels are around the 22 PPT with two peaks in late May with values of 32 PPT.
- In October 2005 the hurricane came and no data is available until August 2006.
- There a lot of peaks noticeable, all the between the 10^2 and 10^3.

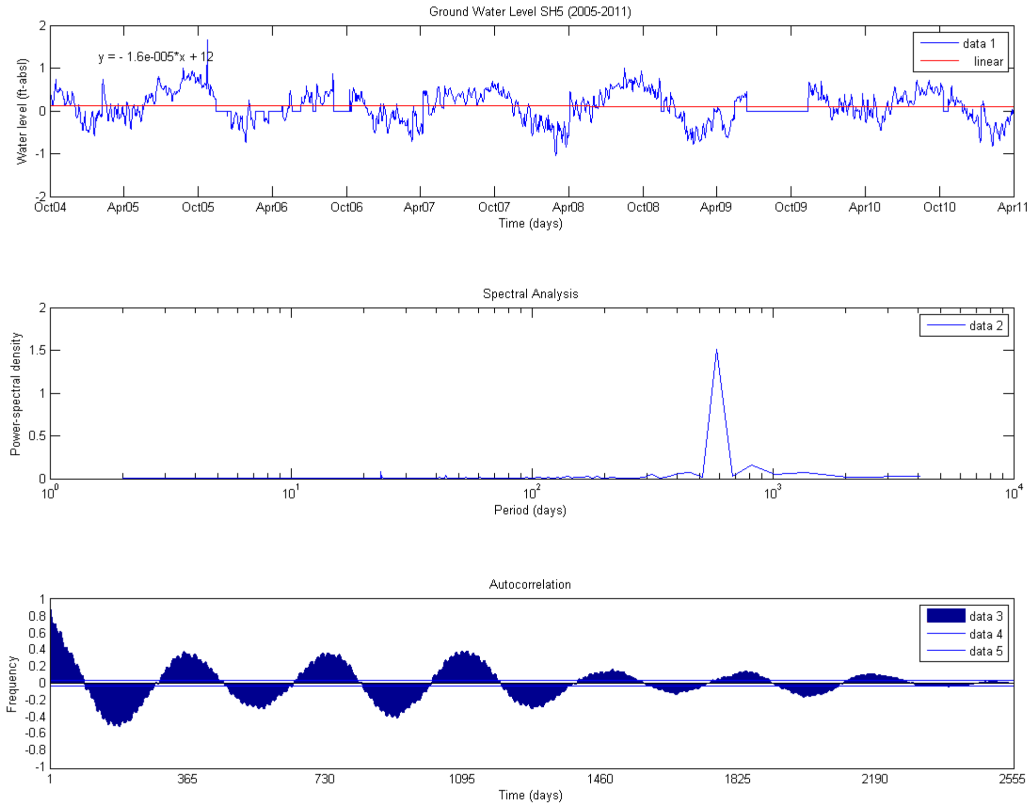


Figure 23; Time-s., spectral., autoco.; SH5 GW

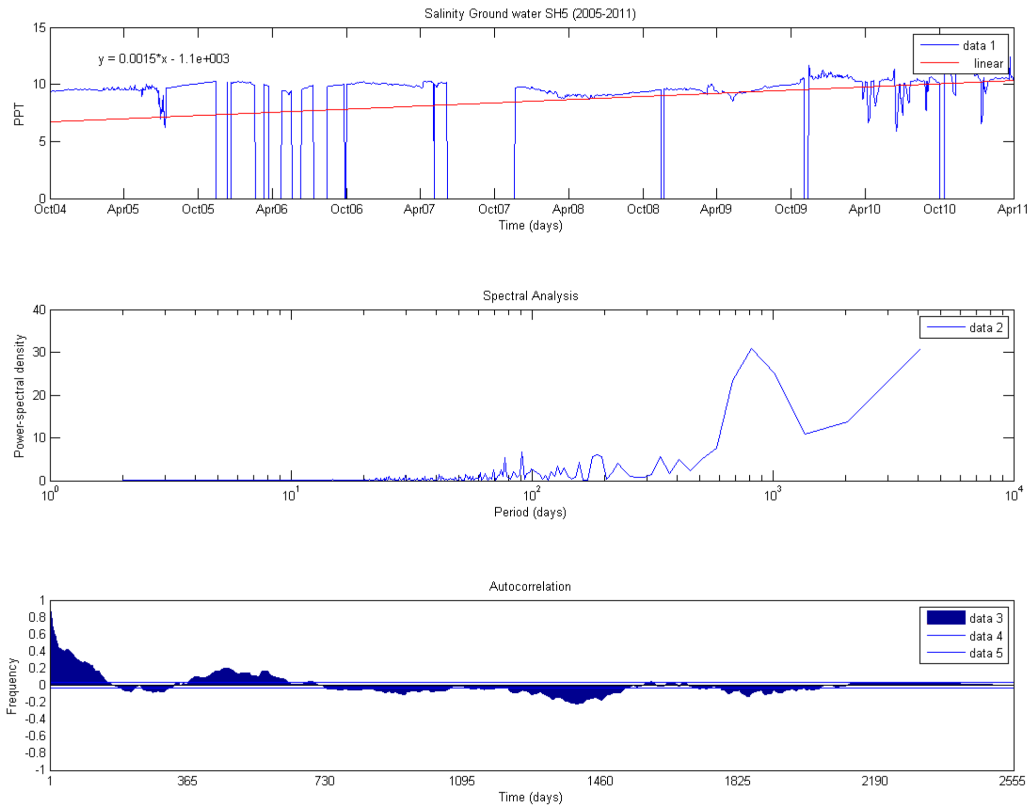


Figure 24; Time-s., spectral., autoco.; SH5 SALGW

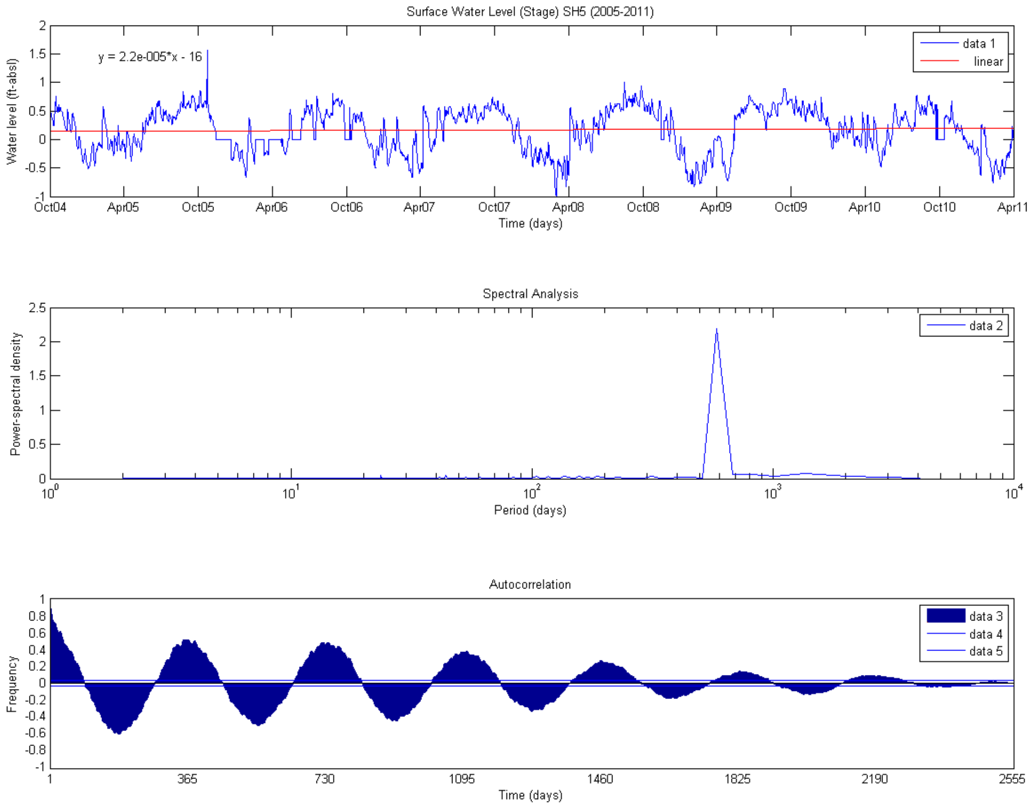


Figure 25; Time-s., spectral., autoco.; SH5 SW

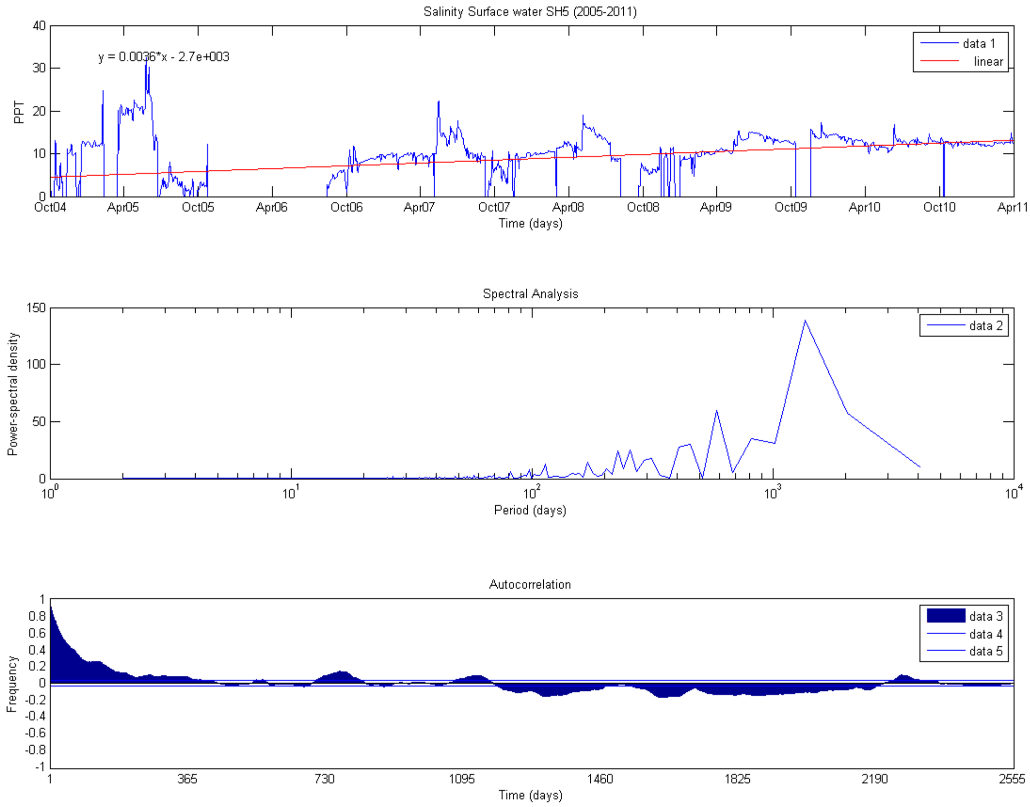


Figure 26; Time-s., spectral., autoco.; SH5 SALSW

4.7 Exceedance tables

Percentages in this table are below ground elevation; estimated from the exceedance graphs (the actual exceedance graphs are on the CD. For an example, see annex 5);

SH1	2005	2006	2007	2008	2009	2010	2011
GWL	10 %	3%	7%	20%	15%	0%	25%
STAGE	13%	4%	5%	20%	10%	0%	27%

SH2	2005	2006	2007	2008	2009	2010	2011
GWL	25%	35%	33%	40%	no data	20%	35%
STAGE	16%	15%	22%	30%	30%	12%	30%

SH3	2005	2006	2007	2008	2009	2010	2011
GWL	85%	65%	80%	78%	70%	68%	78%
STAGE	77%[3]	55%	67%	60%	55%	52%	55%

SH4	2005	2006	2007	2008	2009	2010	2011
GWL	75%	80%	80%	75%	86%	85%	86%
STAGE	60%	57%	60%	50%	55%	30%	58%

SH5	2005	2006	2007	2008	2009	2010	2011
GWL	47%	43%	50%	50%	63%	43%	55%
STAGE	55%	45%	35%	45%	47%	44%	34%

Table 4; Gage information, exceedance percentages

1. Wateryear 2010 was really wet; this is visible in the exceedance charts for SH1 GWL/STAGE, SH2 STAGE, SH3 GWL, SH4 STAGE, and SH5 STAGE. So especially for the surface water data, a wet wateryear is concluded.

2. The average rainfall in South Florida in that year was around the 1500 mm. Tropical storm Bonnie on July 23 and in late September; Nicole arrived in Florida (Tropical Storm). There were 3 severe thunderstorm events, and the winter was wetter and stormier than normal. Two big storms at February the 12th and February the 24th. On March the 29th a tornado ripped through South Florida.

3. Shark River 2 (SH2), Shark River 3 (SH3) and Shark River 4 (SH4), the stations near the river, the stage level of 2010 has high values. So for wateryear 2010 the percentages are low.

4. For site SH2 in wateryear 2009 there is no data due to problems (with the pressure transducer (measures groundwater levels (was installed in late July)) with the apparel at the stations.

[3] Green box refers to annex 5.

5. For the years 2006, 2007 and 2010, water levels were high at station SH1. SH1 is situated in the Shark River Slough and has a low ground elevation. So, water from adjacent area will flow in the dry months to this part of the shark river slough. This is why this station site has low percentages.

6. The groundwater is not really influenced by the rainfall and freshwater flow from the North.

7. For the groundwater level (GWL) for every site (except SH3), the water level exceeded the ground elevation less in 2011 than in 2005. But looking at all the years per site for the GWL, you can see some averages per site.

8. The surface water levels for the sites SH1 and SH2 are going down.

5. The hydronamics

Interpretation of the observations is key to determine what is going on in the Everglades. Below are the interpretations found that came forth from analyzing the water data of the existing sites. By using the research questions as guidance, the hydronamics are interpreted.

What are the ground and surface water salinity seasonal patterns?

Rainfall in the wet season will cause fresh water discharge. On average per year, 60 inches of rain falls down in Florida, including the Everglades. This freshwater influences the salinity levels, and in the graphs, lower values of salinity are measured during the wet season. During the dry season, higher salinity levels are measured.

Just before the wet season starts, the highest salinity level are measured. The salinity in surface water in May/June have the highest values every year for every Shark River site. This is because the freshwater flow is almost zero. So the salt will not dilute with the freshwater from the north. This does not count for the site on the Big Sable Creek, this site has almost no influence by freshwater.

The ground water lags behind for about 2 months after the high salinity in the surface water. You can see that the salinity gets less during the time. For SH1 for instance, the salinity levels get higher because there is less water to decompose with.

How does surface and groundwater levels differ on site and with the estuary?

For the two water levels (ground and surface water), there is a lag in the rising of water after drought periods are ending. Per wateryear is noticeable that the groundwater level about 1 or 2 months lag has. Especially for the site SH1, because the surface water still has to infiltrate after it flows overland. The groundwater level can already drop down.

For the site SH3 there is a lot of fluctuation in groundwater and surface water. This is because this site is under influence by the tidal cycles. This differs with the sites more inland. The tidal influences do not reach these sites.

The Shark River sites 4 and 5 have the same distance to the Gulf of Mexico but they still have different water level characteristics. This is because site SH5 is more inlands, and will not be flooded every flood tide. The study site SH4 is situated next to the river and get flooded every time there is a flood tide.

Another difference is the shape of the sinus graphs between groundwater levels and surface water levels. For groundwater level, the graphs have a more complete sinus function than the surface water level graphs. The bottom of the surface water level graphs does not completely go down. The surface water levels are shallower. Thus, the groundwater level graphs have a larger fluctuation in values, with deeper levels than for surface water.

Over the years the groundwater and surfacewater levels hardly change. The levels stay the same for the most sites for the 7 year dataset. So there is not enough indication to say that the sealevel rises.

How do tidal exchange, freshwater discharge and rainfall forcings influence hydrodynamics in the Shark River and adjacent mangrove-marsh communities?

On average the salinity levels in the surface water fluctuates more than for groundwater. Except for SH1, this site works the other way around. It has only influence by fresh water and this freshwater will mix with the salt. For all the other sites that are influenced by saltwater, fluctuation in the groundwater is less than in the surface water salinity levels.

For the years 2006, 2007 and 2010, water levels were high at station SH1. SH1 is situated in the Shark River Slough, just north of the Shark River and has a low ground elevation. So in the driest months, water from adjacent areas will flow to this part of the Shark River slough. This is also noticeable in the low salinity levels; these levels are around the 1 PPT.

The land gets more flooded than before. This probably because of the more rainfall in the last few wateryears. For the last 5 years, 3 years are wetter than those years before 2006.

The highest peaks in salinity and for surface water especially are probably caused by hurricanes, because surface water has an direct influence by rainfall and thus freshwater flows, salinity levels can vary more often and have some high levels during the years. The cause for SH1 salinity peak in the year 2005 is the hurricane Wilma. Because of this hurricane, saltwater came up the river and raised the salinity level.

Because the river is situated in a delta, the river has influences by tidal movements. For the site SH3, clear trends are noticeable. Especially the 14day, 28day, 180day and 365day trends are clear. The reason that there are 14day and 28day trends is because the influence of the Moon and the Sun, every two weeks the Moon and Sun are at a 90-degree angle to each other (first and third quarter moons). This is called Neap Tides and happens every two weeks. The other two cycles have the origin of being influenced by the seasons. The wet season brings a higher water level and in the dry season, low groundwater levels are noticeable.

6. Discussion

For this project I had a time span of 5.5 months. I began with this project in the beginning of March and ended in late August. During these months I worked for 4 months for the United States Geological Survey in The United States of America. These were the first 4 months of my graduation period. A major benefit was that I could work on this project with people who knew a lot of the Everglades and could help me. In the beginning, my supervisor and me set the planning for this project. But later on we came to the conclusion that some topics had to be skipped. The end result of this project differs from the planning and goals from my project plan.

During this project period I had to make decisions, some I regret and would have done differently and some I have chosen correctly. The wrong decisions that I have made are explained below.

Quality assurance and quality checking is not performed. This makes the first discussion point. And so this is about processing/working with the collected data. Getting the data and processing them in MatLab, I had to put these files in a format that MatLab could read. In some cases during the 7 years of data collection equipment broke. These “no data” points were recorded as 0 values. While changing the data into the correct format, I changed every null into a zero. This is incorrect and I had to change it into a different number that had correlation with these kind of data values. For instance, I could have changed the nulls in to 999, so it would not be a problem. But with this error in the entire process, out comings of the data are not 100% (probably 70 %) reliable and thus provisional.

Another discussion point is about working with the graphs in The Netherlands. Because I had no access to the program MatLab, I could not modify any data or graphs. In a lot of graphs there is a 600day trend visible. This is probably because not fully detrending the data with the program. Before the detrending there were more peaks, for instance tidal peaks, but after the detrending these peaks were gone.

7. Conclusion

With the interpretation and discussion in mind, the conclusion and recommendations are written below. It will answer the main research question that is setup for this research project .

What do the water-data (salinity, rainfall, ground- and surface water levels) indicate about the water quality and quantity of the years 2004 to 2011?

In conclusion there can be said that the water quality and quantity of the Shark River during the 7 years, almost stays the same. The levels of salinity en the levels of ground- and surface water, show similar trends.

The north part of the project area (near the site SH1) is the least influenced by saltwater coming from the Gulf of Mexico. How closer to the coast, how more the sites are influenced. The salinity levels go up. For sites such as BSC and SH3, salinity levels of 30-35 PPT. For the site BSC, the salinity levels almost even the salinity values of the ocean (35 Parts Per Thousand).

Just before the wet season starts, the highest salinity level are measured. The salinity levels in surface water in May/June have the highest values every year for every SH site. Over the years the groundwater and surface water levels hardly changes. The levels stay the same for the most sites for the 7 year dataset. With a dataset of 7 years, sealevel rise cannot be concluded.

Because the river is situated in a delta, the river has influences by tidal movements. For the site SH3, clear trends are noticeable. Especially the 14day, 28day, 180day and 365day trends are clear. The reason that there are 14day and 28day trends is because the influence of the Moon and the Sun. The other two trends, come from seasonal weather changes.

Rainfall is also of importance. The rain that falls (especially in the wet season) influences the quality of the water. It bring extra freshwater in the hydrologic system. Salinity levels will go down and sometimes areas, who are normally quite dry, will be wet.

Concluding, the Everglades, the Shark River in particularly, is a dynamic environment. Salt- and freshwater, rainfall and tidal cycles are the most important influences in the area. The Everglades will always be an interesting topic for research projects about salinity and water data analysis.

As a recommendation; it would be great that this study would be carried on in the future. These results can be used for further research. If there are still funds for research on the Shark River, research on data with a time span of 25 years (entire water data collection), will give lots of interesting and useful information but then on a larger scale. Another nice thing would be, that maybe someone is willing to rewrite my wrongs in a follow-up study. This will give a better and more accurate view on this subject. Especially the graphs will improve and with better graphs, that data and analysis will be more trustworthy.

Because there are almost no funds anymore from the government, a possibility is that the Florida International University will carry on with this research. If this would happen, it would be great to still gain information about the Shark River and its hydronamics. Maybe other students can carry on with the work and make a bigger and better research out of it. Connection between relevant studies such as mangrove studies near the Shark River can be used together, for a more clearer view of the Everglades water (and salinity) system.

Bibliography

- Mathevet, Thibault. 8 March 2012. Application of time-series analyses to the hydrological functioning of an Alpine karstic system: the case of Bange-L'eau-Morte.

- Vlaar, Theo. 20 March 2012. Hydrologic conditions of Shark River Estuary Everglades.

- United States Geological Survey. 16 April 2012.
  <www.usgs.gov>.

- National Park Service. 16 April 2012.
  <www.nps.gov/ever>.

- South Florida Information Access. 20 April 2012.
  <http://sofia.usgs.gov/>.

- Florida Coastal Everglades Long Term Ecological Research. 25 April 2012.
  <http://fcelter.fiu.edu/about_us/everglades/>.

- United Nations Educational, Scientific and Cultural Organization, World Heritage Convention. 1 May 2012.
  <http://whc.unesco.org/>.

- National Park Service. 10 May 2012.
  <http://www.nps.gov/ever/naturescience/freshwaterslough.htm>.

- Mathworks. 20 May 2012.
  <http://www.mathworks.com/products/matlab/>.

- Gage Data for EDEN Network. 1 June 2012.
  <http://sofia.usgs.gov/eden/stationlist.php>.

- NOAA, 2010 South Florida Weather Year in Review. 8 June 2012.
  <http://www.srh.noaa.gov/images/mfl/news/2010WxSummary.pdf>.

- Leiden University, Transformatie van tijdreeksen. 19 June 2012.
  <http://www.let.leidenuniv.nl/history/RES/VStat/html/les7.html#_1_5>.

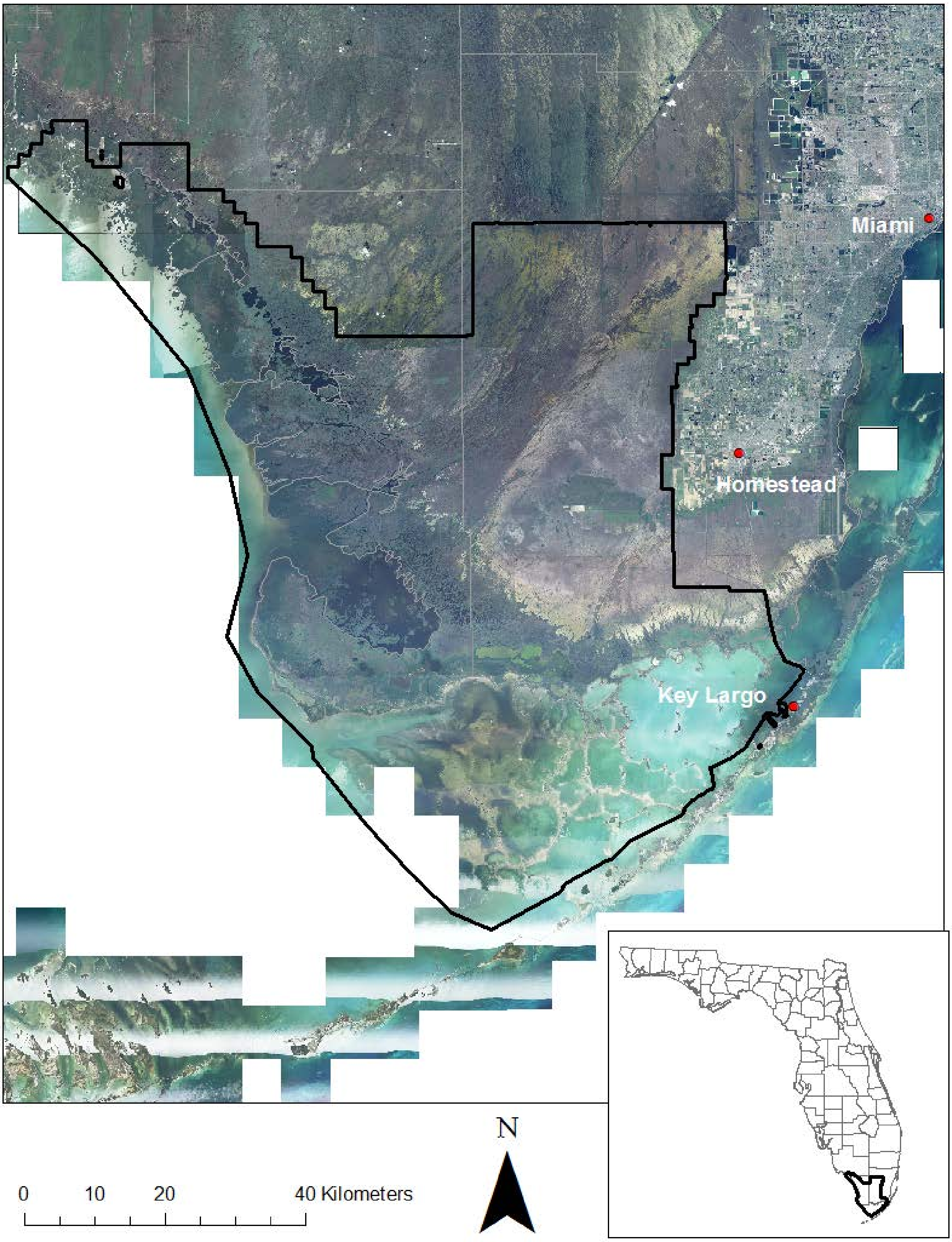
- Investopedia. 16 July 2012.
  <http://www.investopedia.com/terms/t/timeseries.asp#axzz1zTjkrjvN>.

- Encyclo, Online Encyclopedie. 16 July 2012.
  < www.encyclo.nl>.

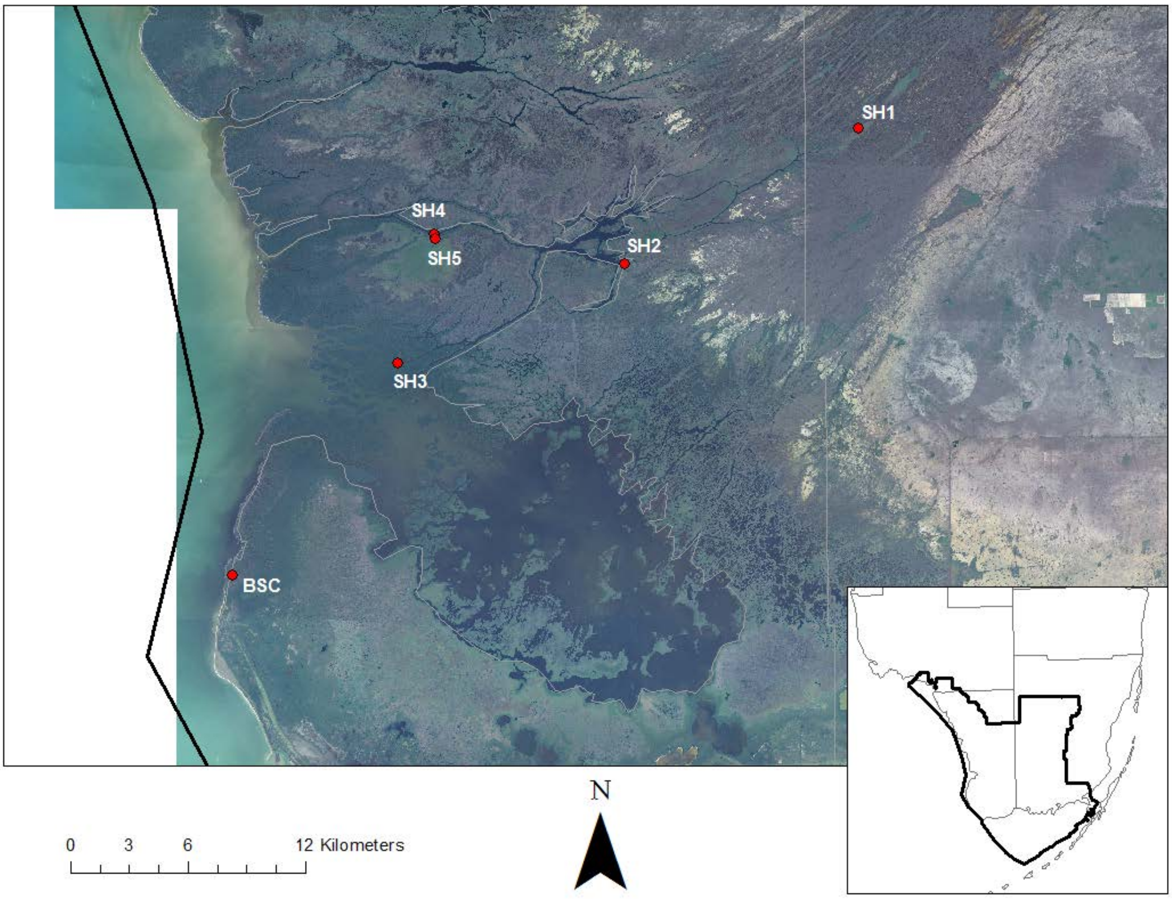
- Engineering Statistics Handbook. 11 August 2012.
  <http://www.itl.nist.gov/div898/handbook/pmc/section4/pmc41.htm>.

Annexes

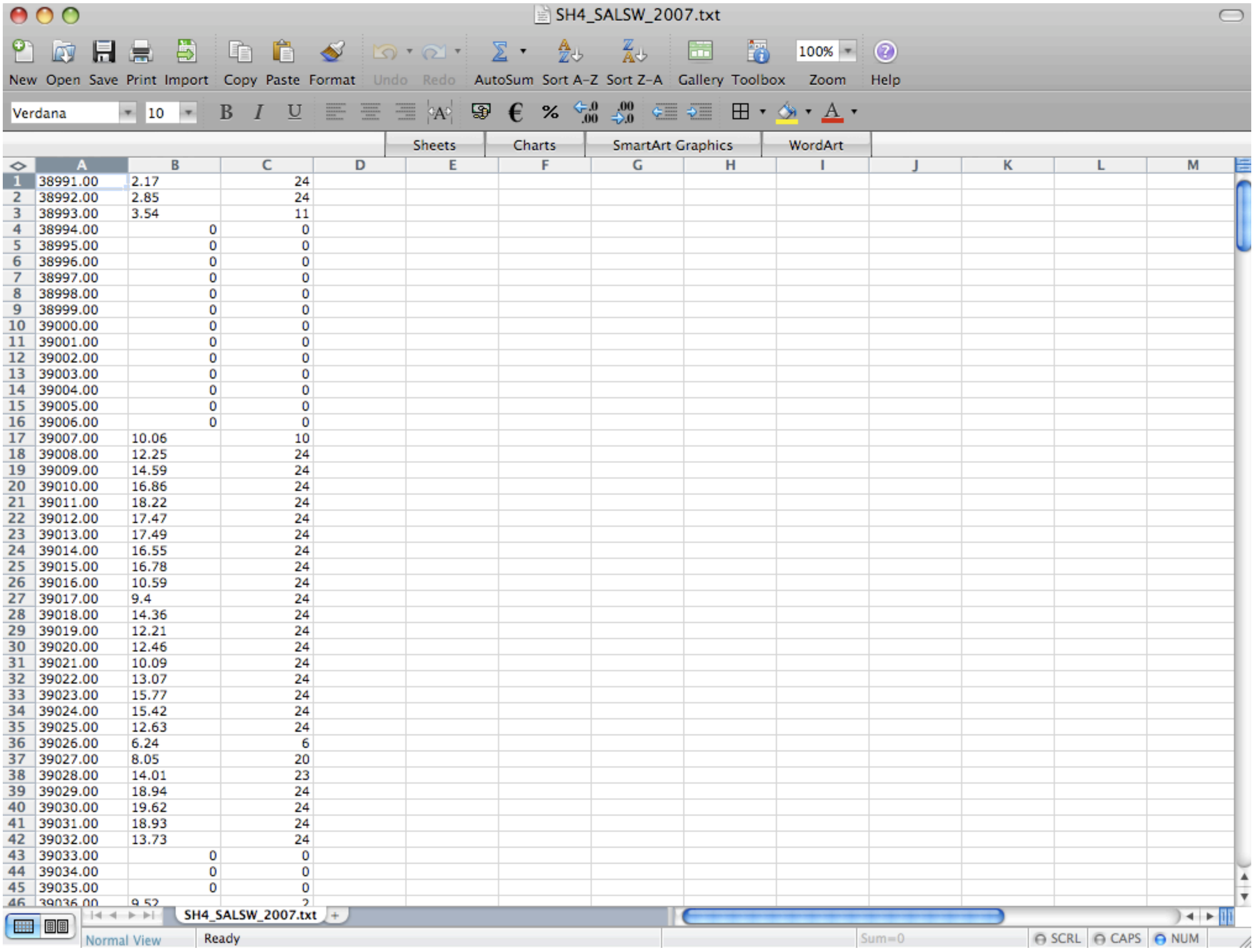
1. The Everglades, Florida



2. Study sites; the Everglades, Florida



3. Example of an Excel dataset



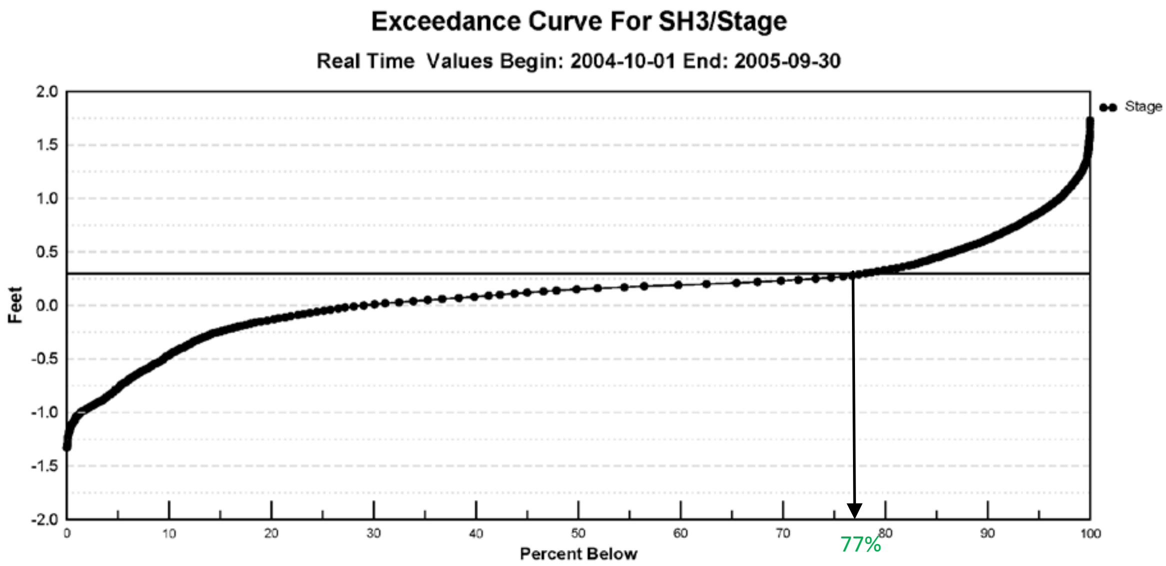
	A	B	C
1	38991.00	2.17	24
2	38992.00	2.85	24
3	38993.00	3.54	11
4	38994.00	0	0
5	38995.00	0	0
6	38996.00	0	0
7	38997.00	0	0
8	38998.00	0	0
9	38999.00	0	0
10	39000.00	0	0
11	39001.00	0	0
12	39002.00	0	0
13	39003.00	0	0
14	39004.00	0	0
15	39005.00	0	0
16	39006.00	0	0
17	39007.00	10.06	10
18	39008.00	12.25	24
19	39009.00	14.59	24
20	39010.00	16.86	24
21	39011.00	18.22	24
22	39012.00	17.47	24
23	39013.00	17.49	24
24	39014.00	16.55	24
25	39015.00	16.78	24
26	39016.00	10.59	24
27	39017.00	9.4	24
28	39018.00	14.36	24
29	39019.00	12.21	24
30	39020.00	12.46	24
31	39021.00	10.09	24
32	39022.00	13.07	24
33	39023.00	15.77	24
34	39024.00	15.42	24
35	39025.00	12.63	24
36	39026.00	6.24	6
37	39027.00	8.05	20
38	39028.00	14.01	23
39	39029.00	18.94	24
40	39030.00	19.62	24
41	39031.00	18.93	24
42	39032.00	13.73	24
43	39033.00	0	0
44	39034.00	0	0
45	39035.00	0	0
46	39036.00	9.52	2

4. Example of a MatLab program

Shark_river_m_file.m

```
%Power spectra
P_Uq11= 2.*A_Uq11.*A_Uq11;
P_Uq10= 2.*A_Uq10.*A_Uq10;
P_Uq09= 2.*A_Uq09.*A_Uq09;
P_Uq08= 2.*A_Uq08.*A_Uq08;
P_Uq07= 2.*A_Uq07.*A_Uq07;
P_Uq06= 2.*A_Uq06.*A_Uq06;
P_Uq05= 2.*A_Uq05.*A_Uq05;
P_Uqall=2.*A_Uqall.*A_Uqall;

%%Frequency vector
f_quake=0:1/dt_q/N_quake:(N_quake-1)/dt_q/N_quake;
f_all=0:1/dt_q/N_all:(N_all-1)/dt_q/N_all;
% f_green=0:1/dt_green/N_green:(N_green-1)/dt_green/N_green;
% %Period vector
T_quake= 1./f_quake(2:N_quake/2);
T_all= 1./f_all(2:N_all/2);



figure(1)%%%SALSW SH4 2011
h1=subplot (3,1,1); plot (M_Date11, uq11);
     title('Salinity Surface water SH4 (2011)');
     xlabel('Time (days)');
     ylabel('PPT');
set(h1,'position', [.1 .75 .8 .2]);
%      axis ([40452 40816 -2 2]);
%%%%%%%%%%%%%%
set(gca,'XTick',M_Date11(1:31:end))
datetick('x','mmmyy','keepticks')
%%%%%%%%%%%%%%

h2=subplot (3,1,2); semilogx (T_quake, P_Uq11(2:N_quake/2));
     title('Spectral Analysis');
     xlabel('Period (days)');
     ylabel('Power-spectral density');
set(h2,'position', [.1 .42 .8 .2]);

h3=subplot (3,1,3)
     acf_year= acf(uq11,y_year);
     title ('Autocorrelation')
     xlabel ('Time (days)')
     ylabel ('Frequency')
set(h3,'position', [.1 .08 .8 .2]);

%%%%%%%%%%%%%%%%
```

5. Example of an exceedance curve



6. CD with extra information added

For more information about this project, check the CD. The CD contains all the relevant information.