Supporting Information for the manuscript

Increasing flooding hazard in coastal communities due to rising sea level: Case study of Miami Beach, Florida

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The supplementary information include the following sections:

S1: Virginia Key Tide Gauge Record

The Virginia Key (VK) tide gauge station started operating in 1994 and acquired a 16 years long sea level height record with 6 minutes sampling rate, which provide a full and detailed description of the two daily tide cycle (green line in Figure S1). However, some of the station's early data is available only as in monthly average format. NOAA also provides a time series of predicted sea level height based on astronomical tides (blue line in Figure S1). The predicted and observed sea level heights oscillate at the same phase and have similar amplitudes. However often there is a systematic offset between the observed and predicted series, as shown in the example in Figure S1, where the observed sea level heights are 10-15 cm higher than the predicted values. In addition, NOAA provides values of the highest and lowest heights of the twice-daily tide cycles. The highest and lowest daily tide values are termed HH and LL, respectively, and the highest and lowest values of the second daily tide are termed H and L, respectively. In this study, we use the daily highest tide values (HH) in the temporal and time series analyses, as the HH values are most indicative of flooding events, more than the commonly used daily or monthly mean sea level height.

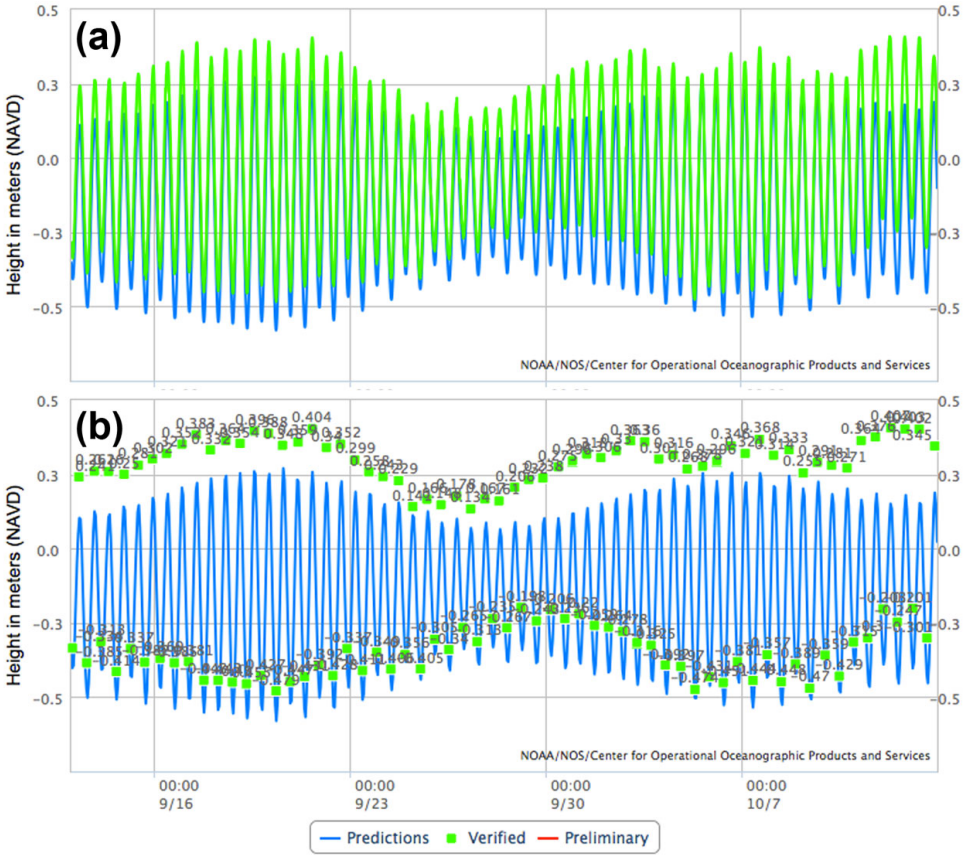

Figure S1: Predicted and observed tide gauge records of a month (9/13/2013-10/13/2013) long measurements at the Virginia Key station. (a) Observed values are plotted at the 6-minute sampling rate. (b) The observed tide range envelope is plotted using the highest and lowest tide values (H, HH, L, and LL). [Source: NOAA tide gauge website].

S2: Best-fit analyses

Estimating the rate of sea level change from the daily HH time series is a challenging task, because the time series contains various periodicities, as well as high noise level. We applied three best-fit models to extract the long-term average rate. The first model assumed linear rate change, second assumed linear and annual changes, and the third linear, annual, and semi-annual. The three best-fit analyses yielded slightly different results from one another. The linear model indicated an average sea level rise of 4.9±0.4 mm/yr, the linear and annual model yielded a rate of 4.3±0.3 mm/yr, and the linear, annual and semi-annual 4.1±0.3 mm/yr (Figure S2). These results suggest that our ability for estimating the long-term rate depends on the assumed periodicities included in the best-fit model. As the VK time series indicates a non-linear trend, we applied the linear, annual and semi-annual best-fit analysis to various lengths of the time series. We incremented the series' starting point by two years and kept end point at the end of 2013 (Figure S3). Our results indicate systematically increasing rates from 4.3±0.3 mm/yr for the 1998-2013 series to 8.6±0.6 mm/yr for the 2004-2013 series and, hence, suggest a significant acceleration in the rate of SLR since 2004.

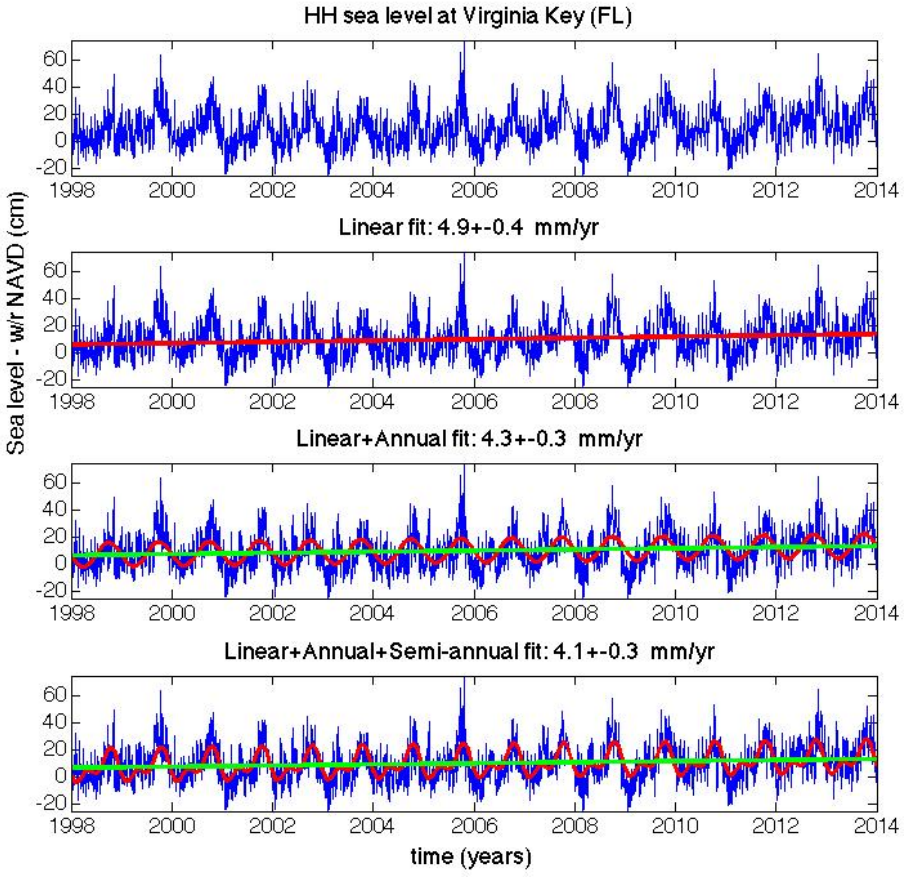

Figure S2: Virginia Key daily HH time series (upper) and best-fit slope estimate using linear (second), linear and annual (third), and linear, annual, and semi-annual model (bottom).

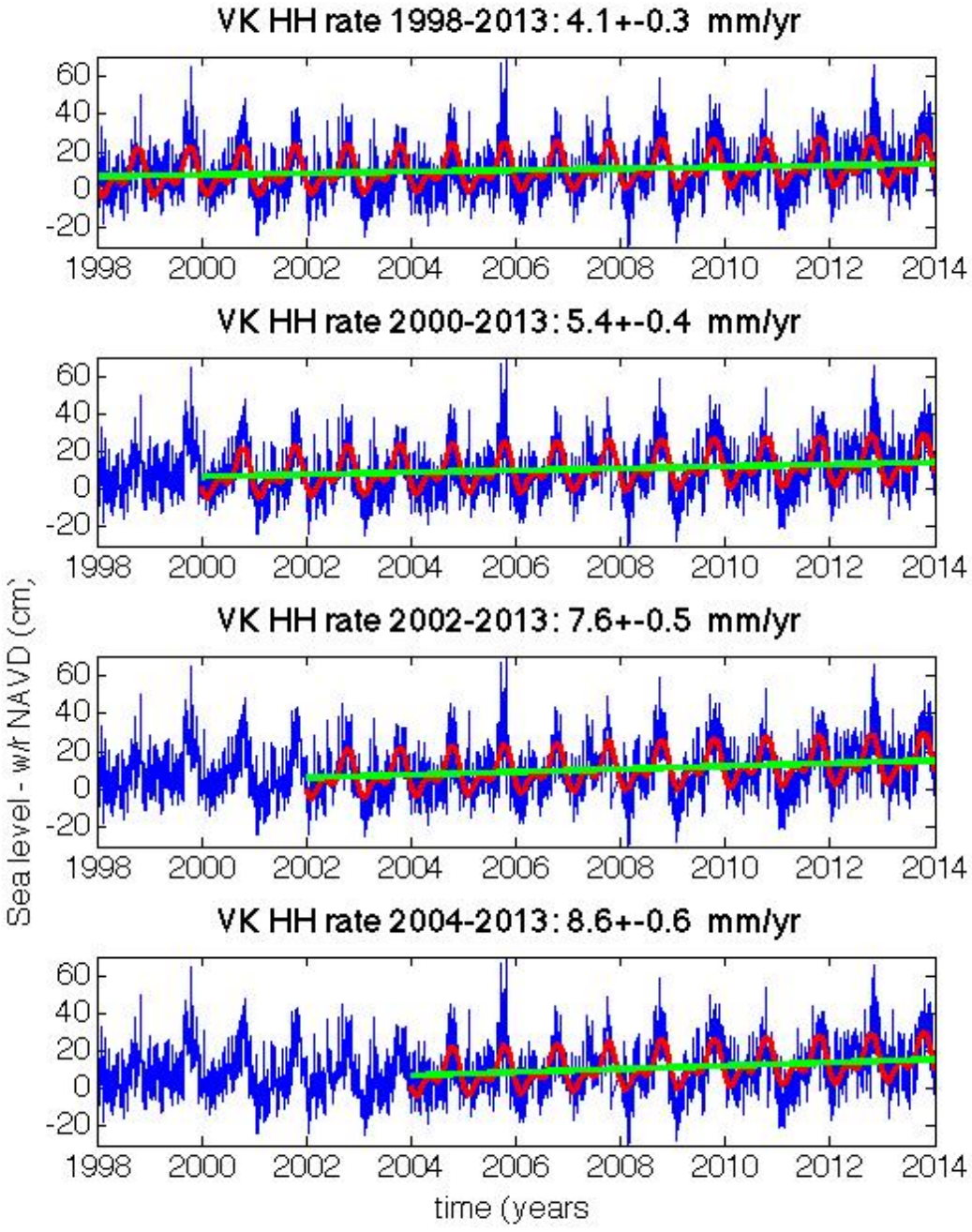

Figure S3: Best-fit slope estimate of the Virginia Key daily HH time series applying the linear, annual, and semi-annual model for different time spans of the series.

S3: Time-varying Trend Identification

A logical definition of the trend of a time series has always been subjected to discussion. While many researchers may consider a straight line fitting to the time series when they read or hear the word 'trend', there have been several logical or physical justifications, other than convenience, for why pre-determined functional forms (such as a straight line, an exponential function, etc.) should be selected. Recently, Wu et al. (2007) provided a logically consistent definition of trend, which is an intrinsically fitted monotonic function or a function in which there can be at most one extremum within a given data span. They have also developed a family of methods (Huang et al., 1998; Huang and Wu, 2008; Wu and Huang, 2009; Wu et al., 2009) using natural waveforms to adaptively and temporally locally separate natural waveforms of different timescales and thereby obtain the secular trend upon which no more oscillatory component can be defined. This family of methods includes the empirical mode decomposition (EMD) (Huang et al., 1998), the ensemble empirical mode decomposition (EEMD)(Huang and Wu, 2008; Wu and Huang, 2009), and the multi-dimensional ensemble empirical mode decomposition (MEEMD) (Wu et al., 2009) These methods have been widely used in climate sciences (e.g., Franzke, 2009; Ji et al., 2014; Qian et al., 2010; Ruzmaikin and Feynman; 2009; Wu et al., 2011). The unique advantages of EEMD for determining trend were recently summarized by Franzke (2014).

An example of obtaining time-varying trend of a time series using EEMD is given in Figure S4. In this figure, the daily sea level data of VK is decomposed into ten oscillatory components and a secular trend. Since the EMD/EEMD method is based on removing amplitude and frequency modulated oscillatory wave (often called mono-component in signal processing literatures) from a time series, the highest frequency riding-wave can be defined and separated first from the time series. The second highest frequency oscillatory wave of the time series is then identified and separated from the remainder of the time series. Similarly, oscillatory waves of lower and lower frequency can be separated level by level until a remainder curve that is either monotonic or contains at most one interior extremum. This remainder is the time-varying secular trend of the time series. Since the decomposition process does not use any pre-determined basis functional form, the whole decomposition process is adaptive to data. The obtained oscillatory components are determined by data but not by any pre-determined functional form. It has also been demonstrated that decomposition is quite temporally local (Huang and Wu, 2008; Wu and Huang, 2009; Wu et al., 2009; Franzke, 2009; Ji et al., 2014).

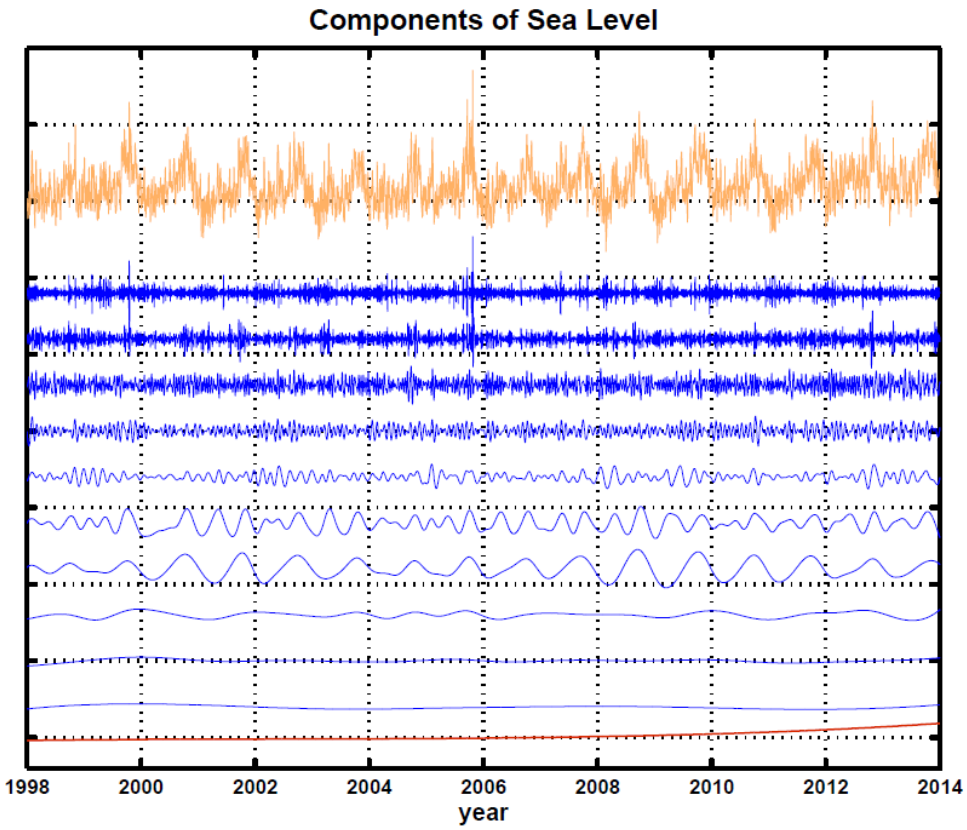

Figure S4: EEMD decomposition of the daily sea level data of Virginia Key. The original data is plotted in brown; components of high to low frequencies in blue; and the time-varying trend in red. In the plot, the relative scale of the original data and its components are preserved.

Since EMD/EEMD is adaptive and temporally local, each EMD/EEMD components have a better chance to catch physical nature of variability and change of a time series. As is well known, the local sea level at any locations of the Earth should reflect mostly the variability of local tide and thereby must contain important cycles such as semimonthly tide, monthly tide, semiannual tide, and annual cycle caused by cyclic changes of the relative positions of the Earth, the Moon, and the Sun. Figure S5 illustrates an enlarged portion of Figure S4. Clearly, semimonthly tide (C_3), monthly tide (C_4), semiannual tide (C_6), annual tide (C_7) are all well identified, although not perfect. The fifth component (C_5) has in general significantly smaller amplitude and corresponds to no known physical process and is likely resulted from noise in data. It can also be identified that the amplitudes of semimonthly and monthly tides are modulated by semiannual and annual cycles: when annual and semiannual tides are at their peaks, the amplitude of semimonthly and monthly tides appear have larger amplitude.

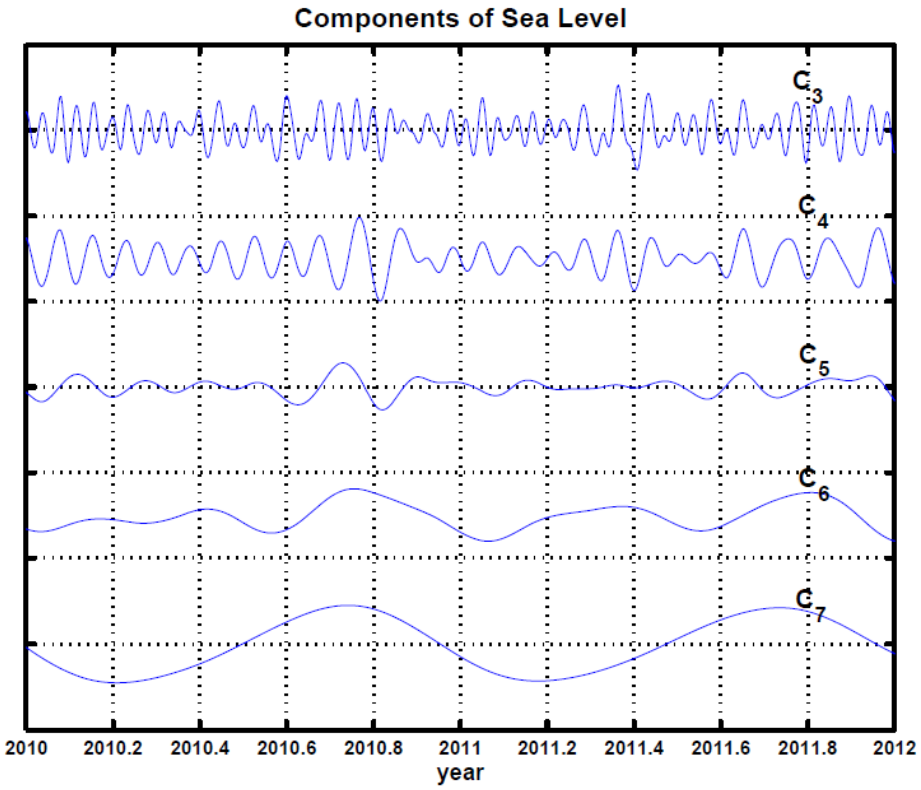

Figure S5: An enlarged portion of Figure S4.

Various reconstructions of the sea level of VK are plotted Figure S6 to illustrate how well various sums of low frequency components and the secular trend represent the variability and change of the sea level of VK on different timescales. Clearly, these lines serve, at least visually appealing, as wonderful fits to data on various timescales. This is not surprising, because the EMD/EEMD algorithm has already implied that a natural fitting method with fitting curves of different timescales determined adaptively by the nature of data. It is also arguable that such a fitting minimized the least absolute distance rather than the widely used least square. This advantage allows the trend to reflect more accurately the acceleration of the sea level rise, as showed in Figure S6. It is evident that the rising of the VK sea level before 2004 are negligibly small but has accelerated since.

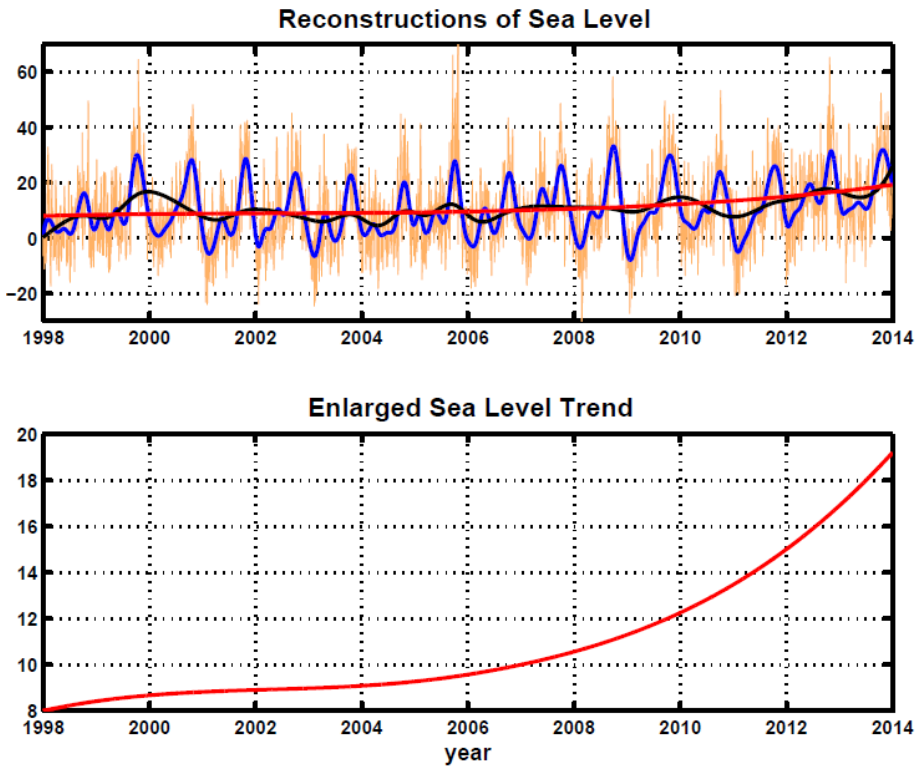

Figure S6: Reconstruction of the sea level data of Virginia Key from EEMD components. In the upper panel, the original data is plotted in brown; trend in blue; the sum of interannual and lower frequency components in black (including the secular trend); and the sum of semiannual and lower frequency components (including the secular trend) in blue. In the lower panel, the enlarged trend is plotted.

A related issue is that the noise contained in the data could lead to errors in the estimated secular trend of the sea level rise of Virginia Key. In this study, we use the method proposed by Wu et al.[12] to estimate the uncertainty of the calculated secular trend. In this method, a random sampling approach is used, by replacing a value at any day with a randomly selected value from its 15-day neighborhood (with 7 days at both sides) and then recalculate the secular trend. This approach can theoretically provide more than 5830^{15} different time series. Since the size of the neighborhood is more than two orders of magnitude smaller than the data length, it is anticipated that the true secular trend should not be affected by this approach if the data contains only signal. Any change of the secular trend of the re-sampled data is more likely caused by noise. It can be also verified that the results of the uncertainty being estimated in this study is not sensitive to the size of the pre-determined neighborhood as long as the neighborhood is smaller than a month.

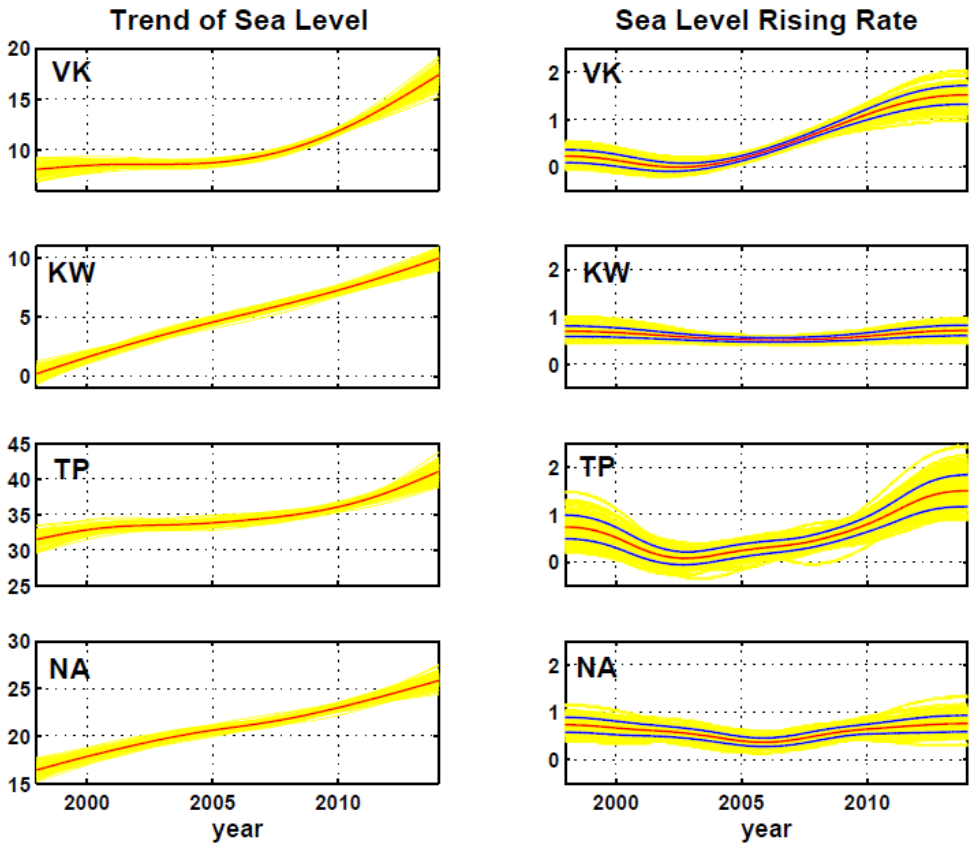

Figure S7: Uncertainties of secular trends and their changing rates. In all panels, individual yellow lines correspond to a trend (left panels) and their changing rates (right panels) estimated from re-sampled time series. In the left panels, the red lines are the mean trends for four different stations. In the right panels, the red lines are instantaneous changing rates of the secular trends; and the corresponding blue lines give the one-standard-deviation upper and lower bounds of the changing rate. VK represents Virginia Key, KW Key west, TP Trident Pier, and NA Naples.

Figure S7 presents uncertainty estimates, in which 1000 re-samples are used. It is clear that the uncertainty toward two ends of the data range is relatively larger. This is understandable, as any temporally local analysis method suffers some degree of end-effect. Compared with other methods, the locality of EEMD is much smaller and so its uncertainty at two ends of the data range. The largest (smallest) standard deviations for Virginia Key (VK), Key West (KW), Trident Pier (TP), and Naples (NA) are 0.20 (0.05), 0.11 (0.04), 0.34 (0.12), and 0.18 (0.08) cm, respectively.

References

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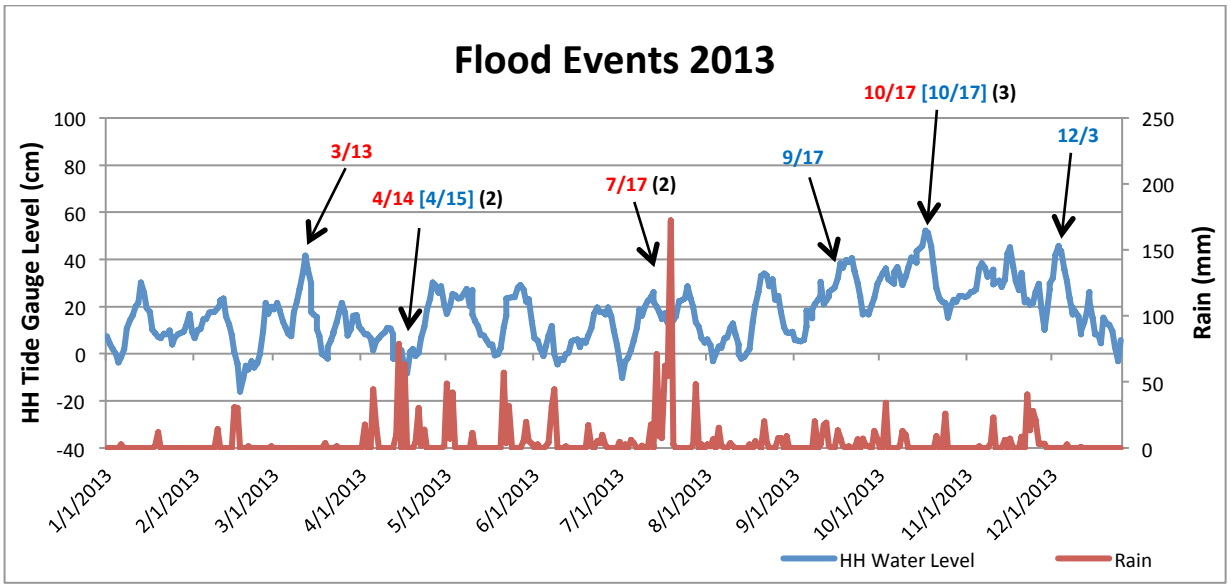
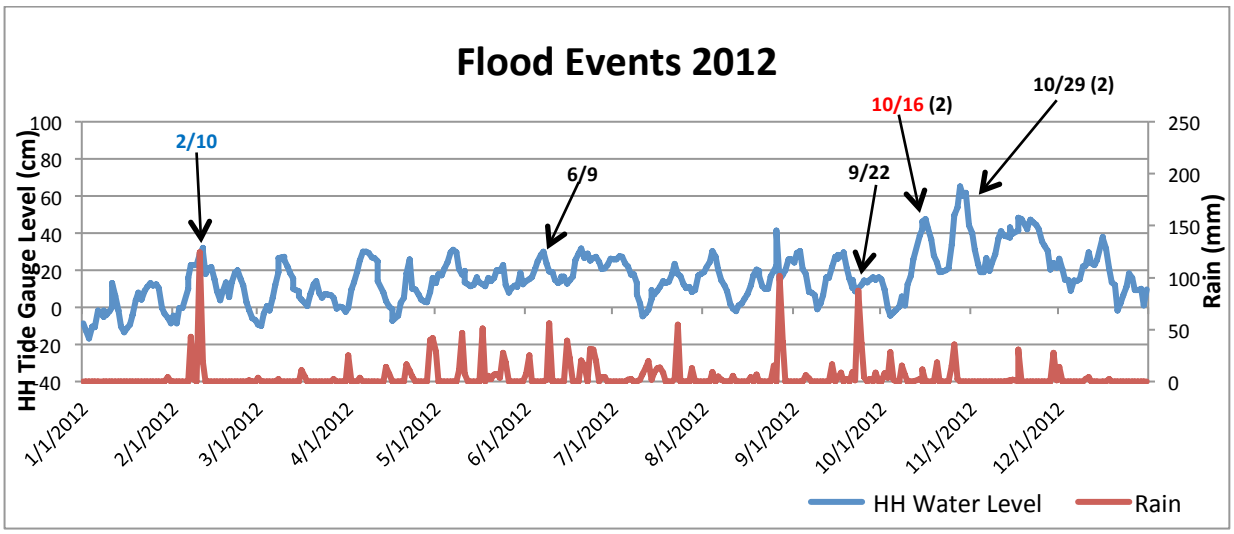
S4: Temporal data and cross-reference analysis of flooding events in Miami Beach

In order to identify the time and cause of flooding events in Miami Beach, we cross-referenced five data sources: tide gauge, rain gauge, media reports, insurance claims, and photo documentation. We conducted the analysis on a yearly basis. For each year, we plotted the Virginia Key HH record (blue), rain record (brown – NOAA station, Green – SFWMD station). We, then, tagged the date of each event based on the media report (red text), insurance claim (black text), and photo documentation (blue text). All reported events are listed for each year in the table below the figure illustrating the cross-reference analysis.



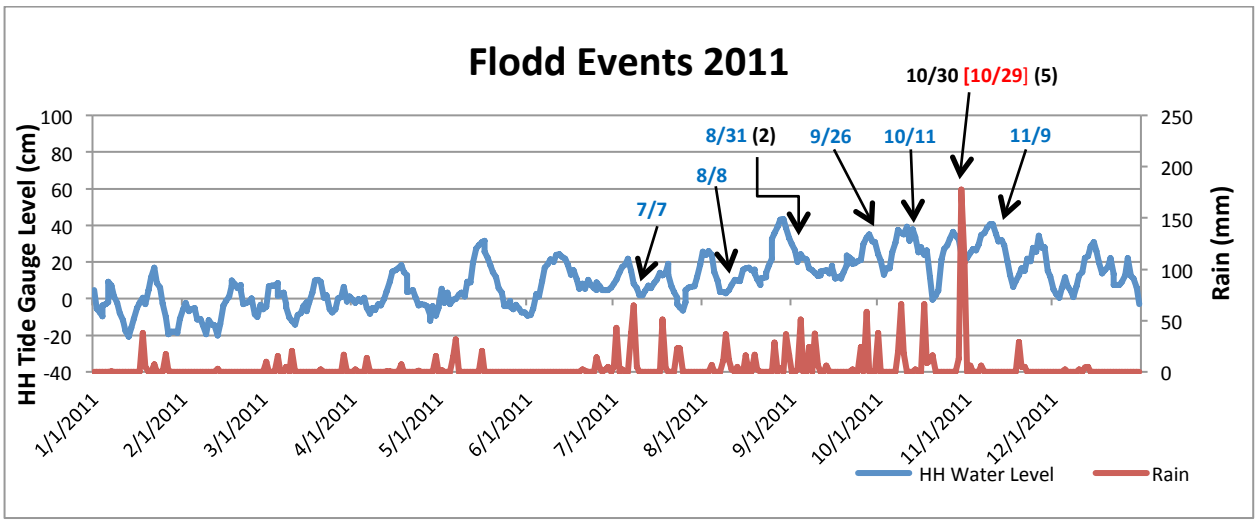
Miami Beach Flood Events 2013					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles.					
Other details: • NA					
AVG HH: 162.8173	STD HH: 126.4034	AVG LL: -519.154	STD LL: 104.4876		
Description of Marked Events					
Area	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Alton RD	None	City of Miami Beach	12/3/2013	1	1
Alton and Other Miami Beach	Floods Tides	7 News	10/18/2013	1	1
Alton and 10th St	Flooding Tide	Miami Herald	10/17/2013	1	
Alton and 9th	None	City of Miami Beach	10/17/13	1	
Alton and 10th St	None	City of Miami Beach	9/17/2013	1	1
Alton Area - 17th Street and 23rd Street and Collins	Flood from Storm	7 News WSVN.com	7/18/2013	1	1
Alton Road	Three Days of Downpour - Summer Flooding	Miami Herald	7/17/2013	1	
Lenox and 14th (other parts)	Rain	City of Miami Beach	4/15/2003	1	1
Alton Area - South Beach Video	Flood without Much rain	You Tube Video	4/14/2013	1	
Alton and other parts of South Beach	Flooding	New Times	3/13/2013	1	1
Total				**10**	**6**



Miami Beach Flood Events 2012			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: • NA			
AVG HH: 160.5071	STD HH: 137.3514	AVG LL: -519.441	STD LL: 112.792

Description of Marked Events

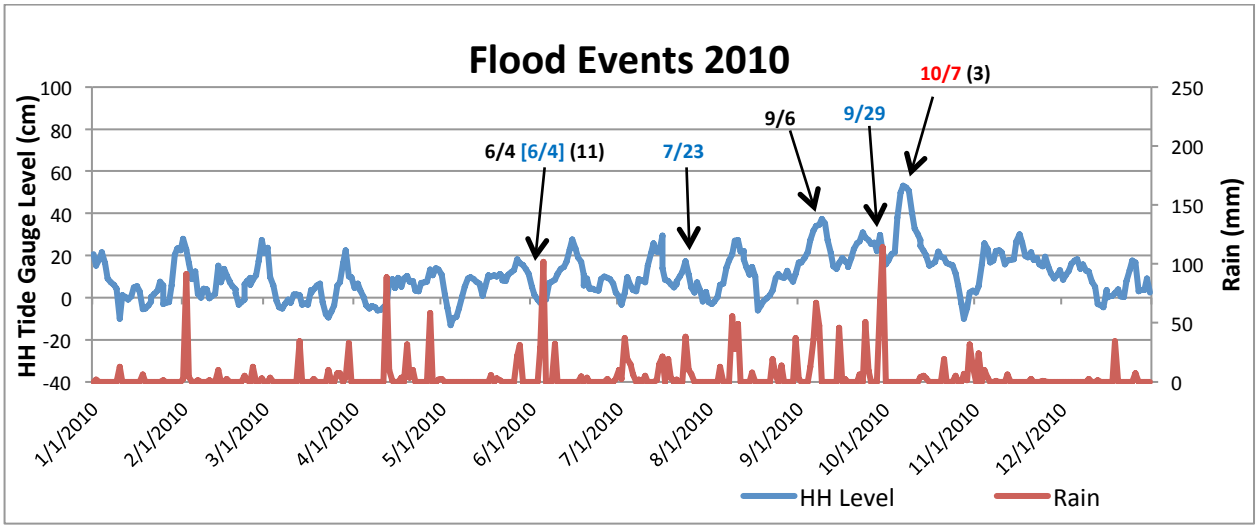
Area or Coordinates	Cause Given by Article	Source	Date	Number of Claims / Reports	Number of Events
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/29/2012**	**2**	**1**
Alton Road and Purdy Avenue	Annual autumnal high tides - flood without any rain. **(3 days Flooded)**	CBS Miami	**10/17/2012**	**1**	**1**
Alton Road	Flooding High Tides	South Florida Business Journal	**10/16/2012**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/22/2012**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/9/2012**	**1**	**1**
Middle and North Beach	Rain	City of Miami Beach	**2/10/12**	**1**	**1**
Total				**7**	**5**



Miami Beach Flood Events 2011			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: • NA			
AVG HH: 98.73088	STD HH: 138.8575	AVG LL: -579.27	STD LL: 132.2831

Description of Marked Events

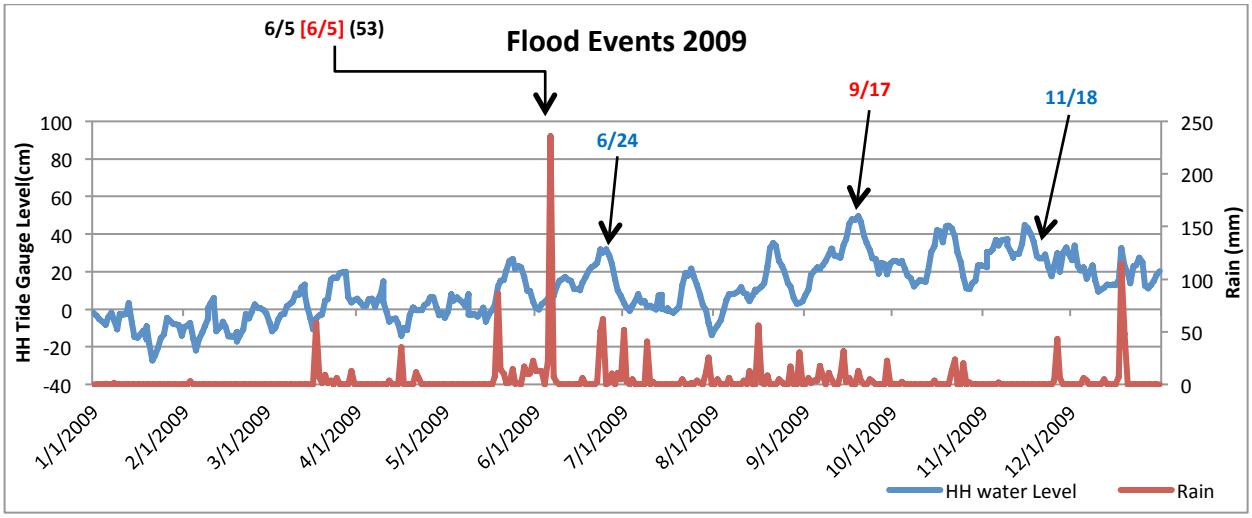
Area	Cause Given by Article	Source	Date	Number of Claims or Reports	Number of Events
West Ave (and other locations)	Tides	City of Miami Beach	11/9/11	1	1
Miami Beach	Flood Loss	Miami-Dade Public Works	10/31/2011	1	1
Miami Beach	Flood Loss	Miami-Dade Public Works	10/30/2011	4	
Alton Area Collins and 17th Street	Flooding from Rains - Busted Pipe?	NBC 6 South Florida	10/29/2011	1	
Miami Beach	Flood Loss	Miami-Dade Public Works	10/29/2011	1	
8th and West Ave (and other locations)	Tides	City of Miami Beach	10/11/2011	1	1
5th and Michigan Ave (and other locations)	Rain	City of Miami Beach	9/26/11	1	1
700 Block West Ave (and other locations)	High Tides	City of Miami Beach	9/1/2011	1	1
Dade Blvd and Sunset Harbor (and other locations)	High Tides	City of Miami Beach	8/31/2011	1	
4730 N Bay Rd	Rain	City of Miami Beach	8/8/2011	1	1
Hawthrone Ave – 85th and 86th (other locations)	Rain	City of Miami Beach	7/7/2011	1	1
Total				**14**	**7**



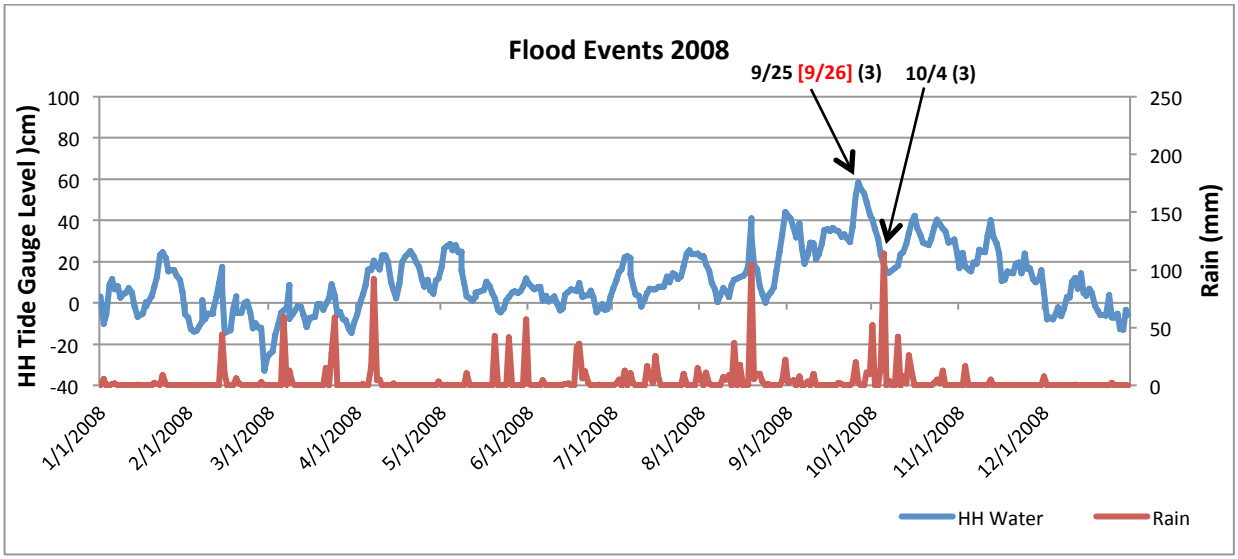
Miami Beach Flood Events 2010			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: • Tropical Depression Nicole: 9/28/2010 – 9/29/2010 (Moved off-coast from Southeast and passed East of Miami Beach on 9/30/2010)			
AVG HH: 106.9462	STD HH: 108.1258	AVG LL: -568.737	STD LL: 97.79167

Description of Marked Events

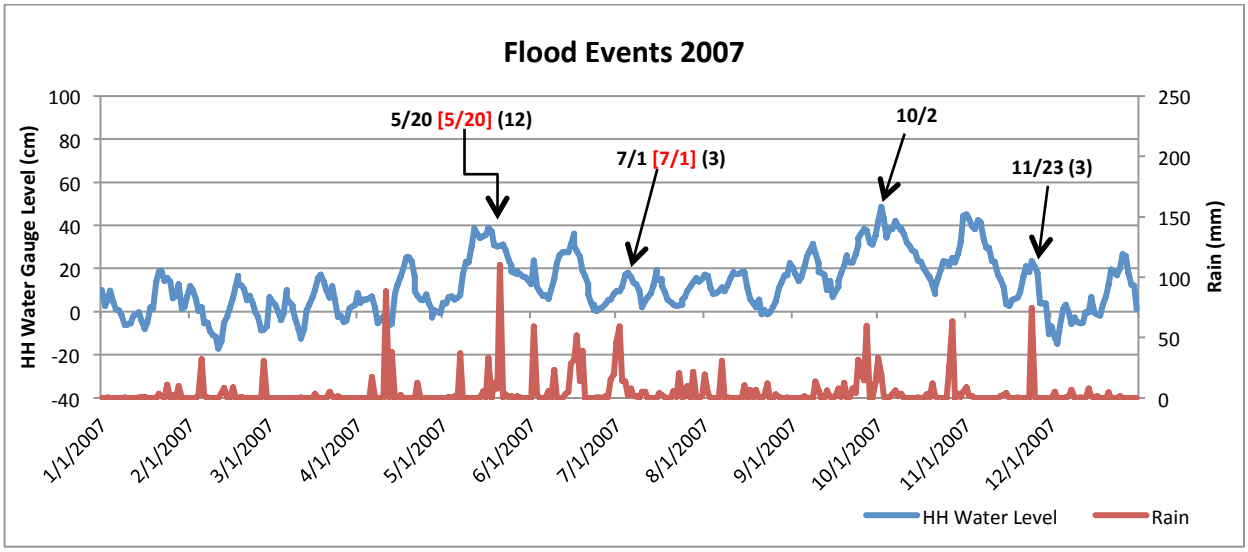
Area or Coordinates	Cause Given by Article	Source	Date	Number of Claims / Reports	Number of Events
Alton Area - West Ave and 6th Street	Flooding Tides	Bella Isle Blog	10/9/2010	1	1
Alton West Ave	Flooding Tides Lunar	UM-Database Miami Harold	10/8/2010	1	
Alton and Hollywood	High Tide Flooding	7News WSNV.com	10/7/2010	1	
Sunset and Bay RD	Storm	City of Miami Beach	9/29/2010	1	1
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/6/2010**	1	1
Rue Granville & Marseille Dr (other locations)	Tropical Depression 16	City of Miami Beach	7/23/2010	1	1
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/4/2010**	10	1
Alton and Lincoln	Rain	City of Miami Beach	6/4/2010	1	
Total				**17**	**5**



Miami Beach Flood Events 2009					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: • NA					
AVG HH: 110.2408	STD HH: 153.6652	AVG LL: -559.668	STD LL: 146.4564		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
8th St and West Ave (and other locations)	Tide Flex	City of Miami Beach	**11/18/2009**	**1**	**1**
Alton Area- West End Ave	Flooding Lunar Tide	Transit Miami.com	**9/17/2009**	**1**	**1**
2344 N. Bay Rd	None	City of Miami Beach	**6/24/2009**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/13/2009**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/12/2009**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/9/2009**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/8/2009**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/6/2009**	**6**	
Alton Area - Miami Beach	Floods Rains (golf-ball-size-hail)	Fox News	**6/6/2009**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/5/2009**	**38**	
Alton and 8th St	Flooding	Random Pixels	**6/5/2009**	**1**	
Alton Area - South Beach	Flooding	D.A.D.E	**6/5/2009**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/1/2009**	**2**	
Total				**56**	**4**



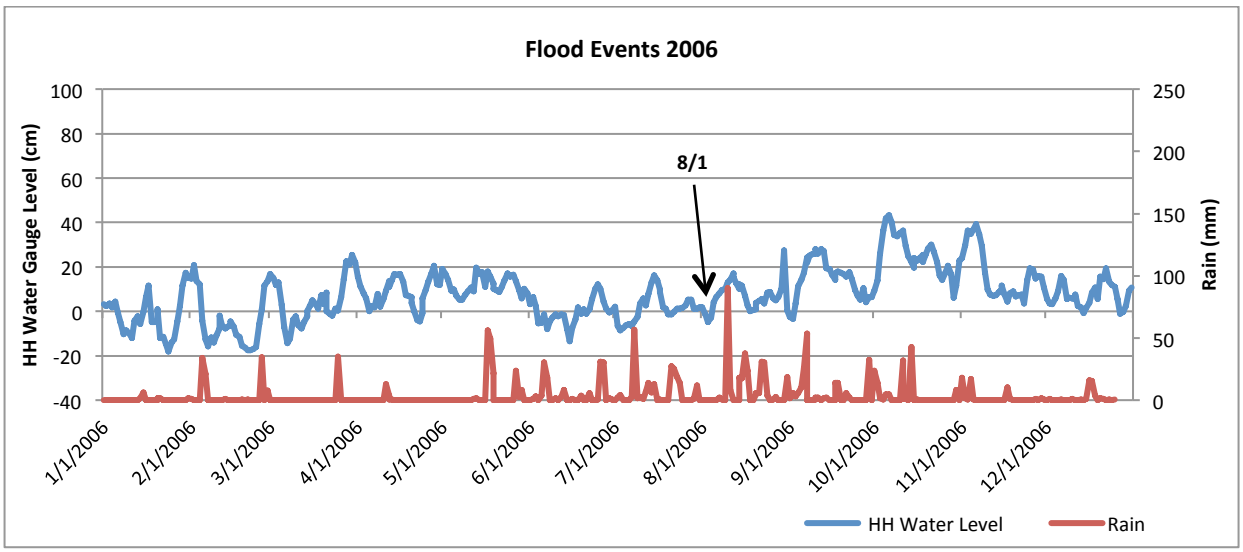
Miami Beach Flood Events 2008					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: • NA					
AVG HH: 108.9576	STD HH: 151.5903	AVG LL: -552.212	STD LL: 142.8208		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/4/2008**	**3**	**1**
Miami Beach	High Tide	Hurricane Harbor	**9/26/2008**	**1**	**1**
Miami Beach	High Tide	Wonderground.com	**9/26/2008**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/25/2008**	**1**	
Total				**5**	**2**



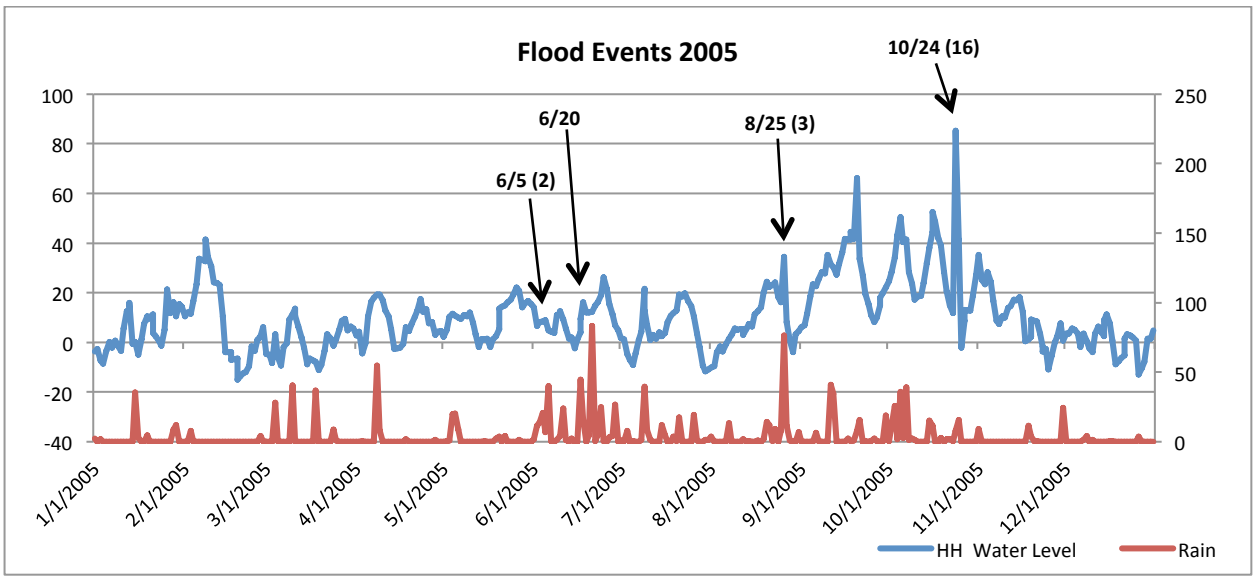
Miami Beach Flood Events 2007			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Red labeled flood events retrieved from internet articles. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: • NA			
AVG HH: 122.9107	STD HH: 124.4526	AVG LL: -542.942	STD LL: 117.8093

Description of Marked Events

Area or Coordinates	Cause Given by Article	Source	Date	Number of Claims / Reports	Number of Events
Miami Beach	Flood Loss	Miami-Dade Public Works	**11/23/2007**	**3**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/2/2007**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**7/10/2007**	**1**	**1**
Miami Beach	Flooding	YouTube Video	**7/1/2007**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**7/1/2007**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**5/20/2007**	**8**	**1**
Alton and 14th	Flooding Lots of Rain	South Beach Condo Blog	**5/20/2007**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**5/19/2007**	**2**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**5/16/2007**	**1**	
Total				**19**	**4**



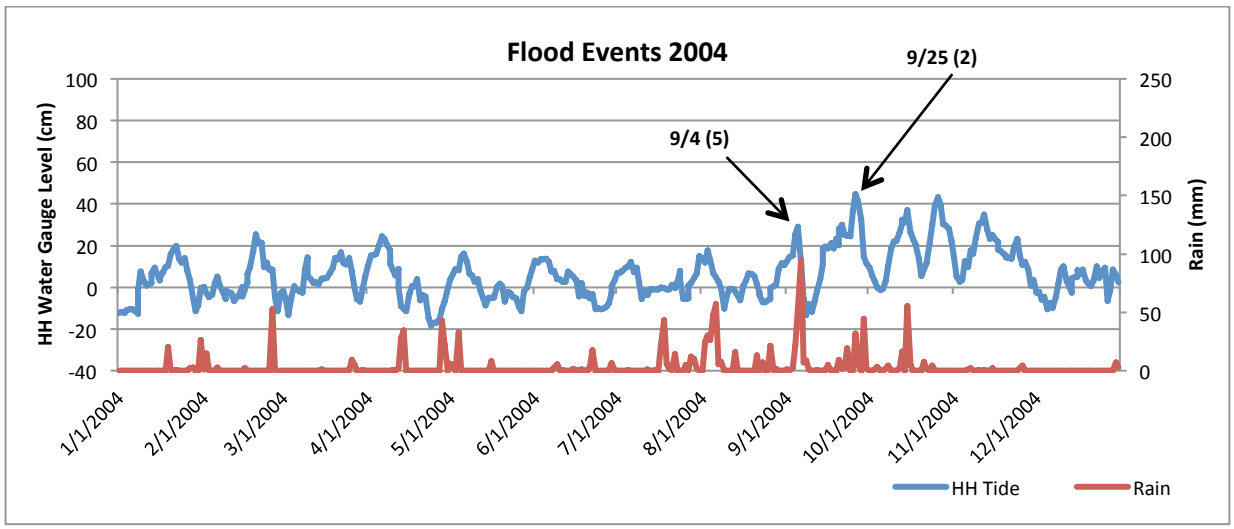
Miami Beach Flood Events 2006					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other Details: NA					
AVG HH: 77.70822	STD HH: 115.8268	AVG LL: -580.436	STD LL: 107.6983		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	**8/1/2006**	**1**	**1**
Total				**1**	**1**



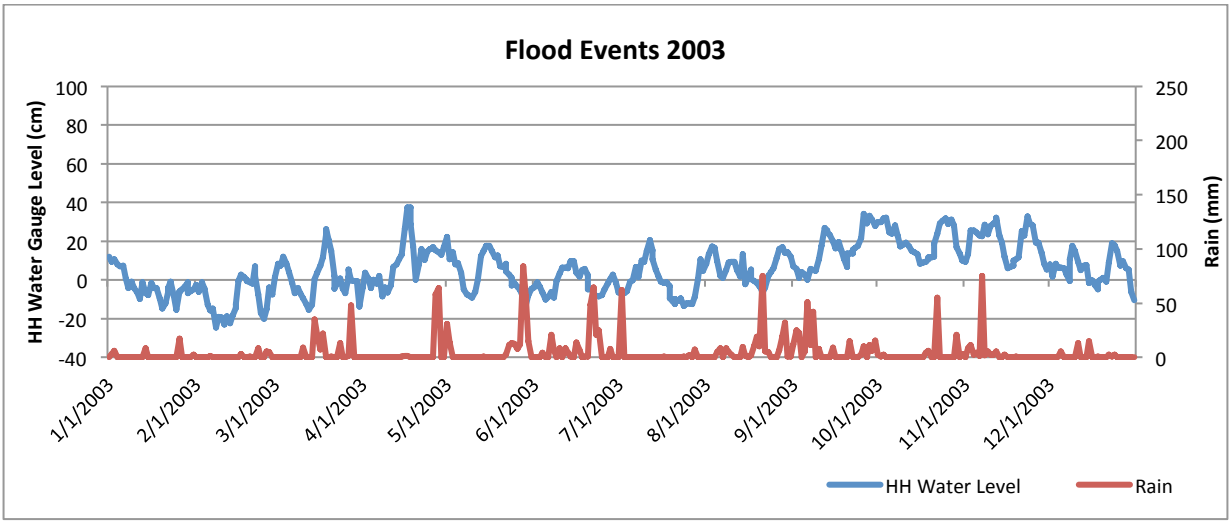
Miami Beach Flood Events 2005			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: • Tropical Storm Katrina: 8/23/2005 – 8/30/2005 (West to East Landfall on Miami Beach on 8/25/2005) • Hurricane Wilma: 10/15/2005 – 10/24/2005 (East to West Landfall on Miami Beach on 10/24/2005			
AVG HH: 101.3789	STD HH: 135.3222	AVG LL:-556.738	STD LL: 115.2443

Description of Marked Events

Area or Coordinates	Cause Given by Article	Source	Date	Number of Claims / Reports	Number of Events
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/25/2005**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/24/2005**	**15**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**8/26/2005**	**2**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**8/25/2005**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/20/2005**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/6/2005**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**6/5/2005**	**1**	
Total				**22**	**4**

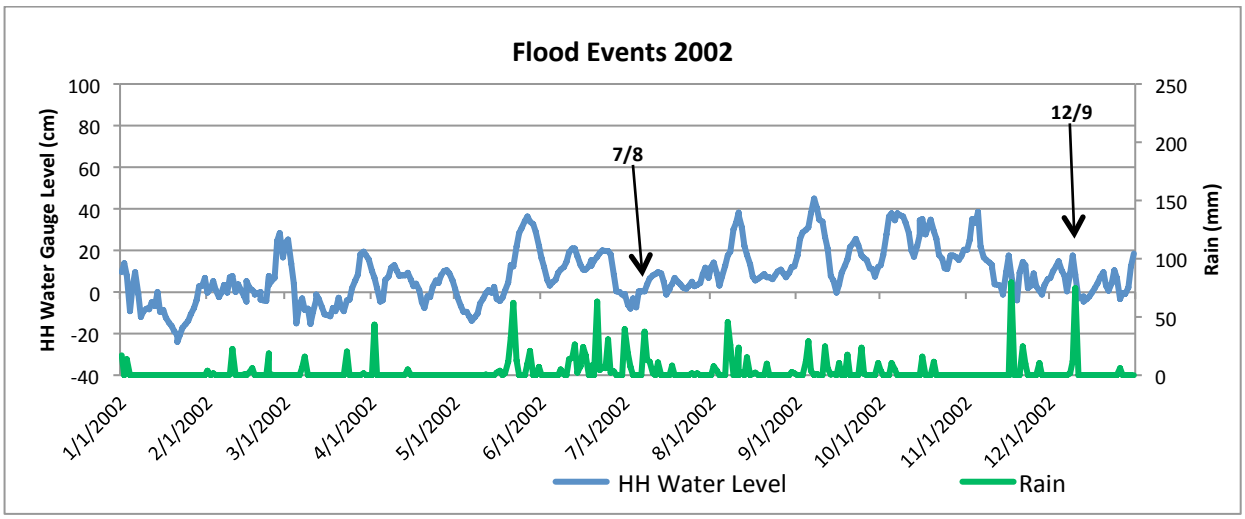


Miami Beach Flood Events 2004					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: NA					
AVG HH: 60.68555	STD HH: 117.6354	AVG LL:-598.89	STD LL: 106.6143		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/26/2004**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/25/2004**	**1**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/5/2004**	**2**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/4/2004**	**2**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**9/3/2004**	**1**	
Total				**7**	**2**

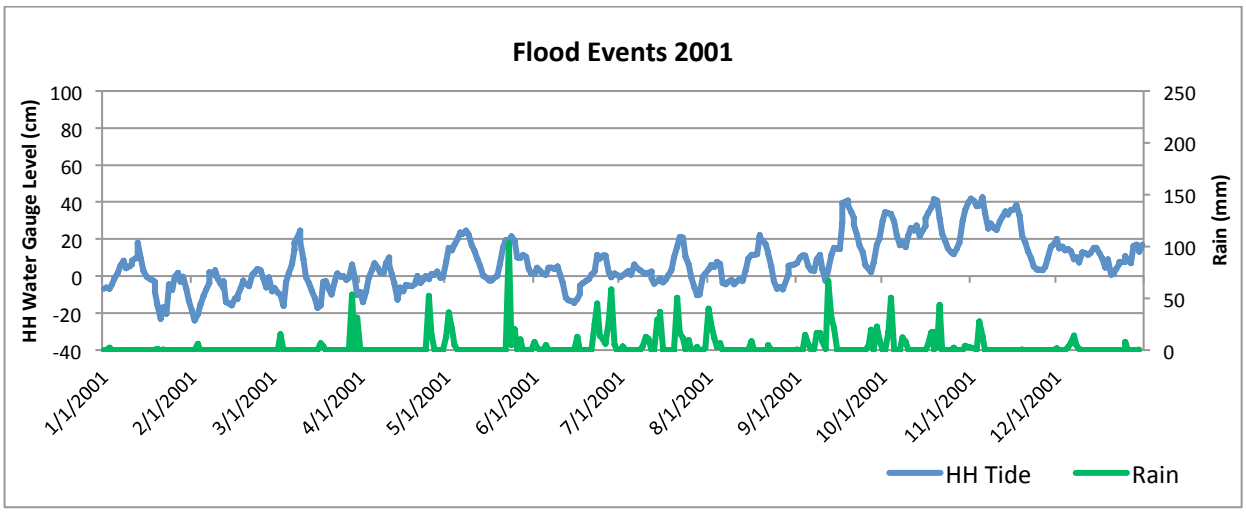


Miami Beach Flood Events 2003			
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.			
Other details: NA			
AVG HH: 58.50425	STD HH: 125.8222	AVG LL: -603.581	STD LL: 119.0803

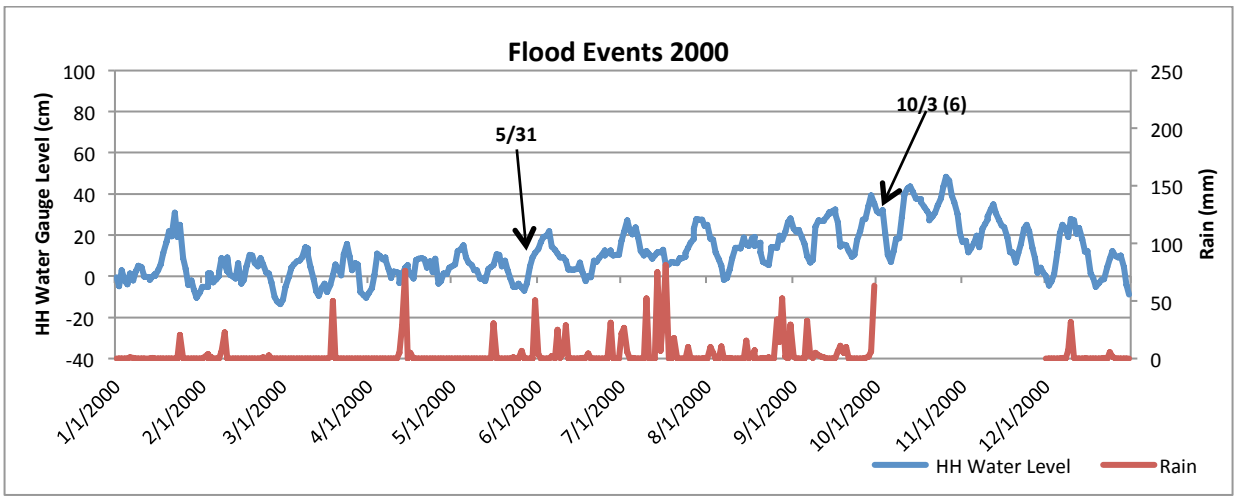
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
No recorded flood events				**0**	**0**



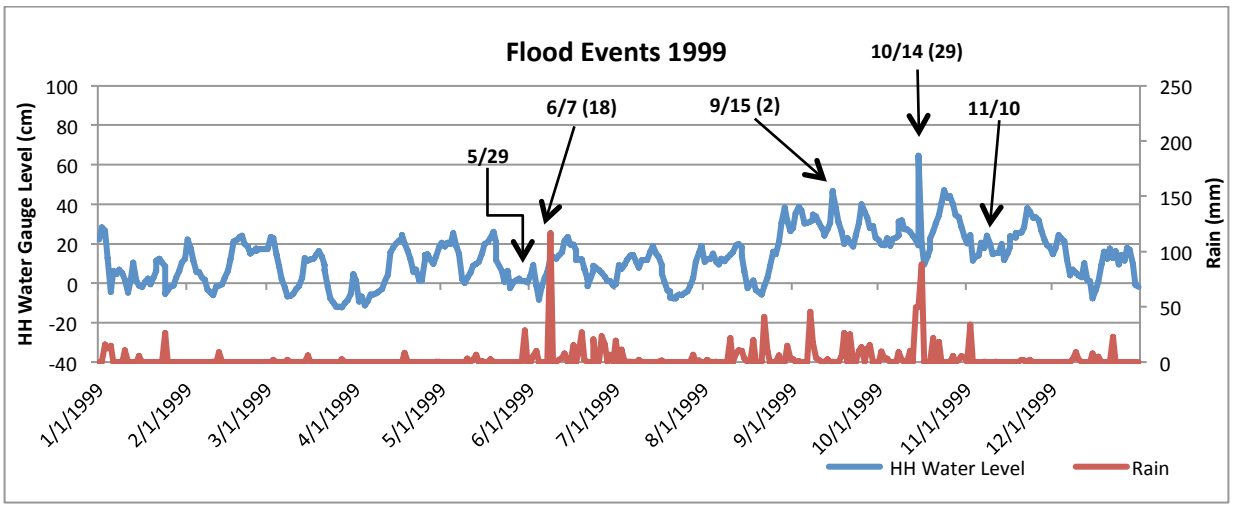
Miami Beach Flood Events 2002					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. **Rain data retrieved from SFWMD Rain Station at Miami Beach.** Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: NA					
AVG HH: 86.82436	STD HH: 127.5395	AVG LL: -582.636	STD LL: 114.1011		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	**12/9/2002**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**7/8/2002**	**1**	**1**
Total				**2**	**2**



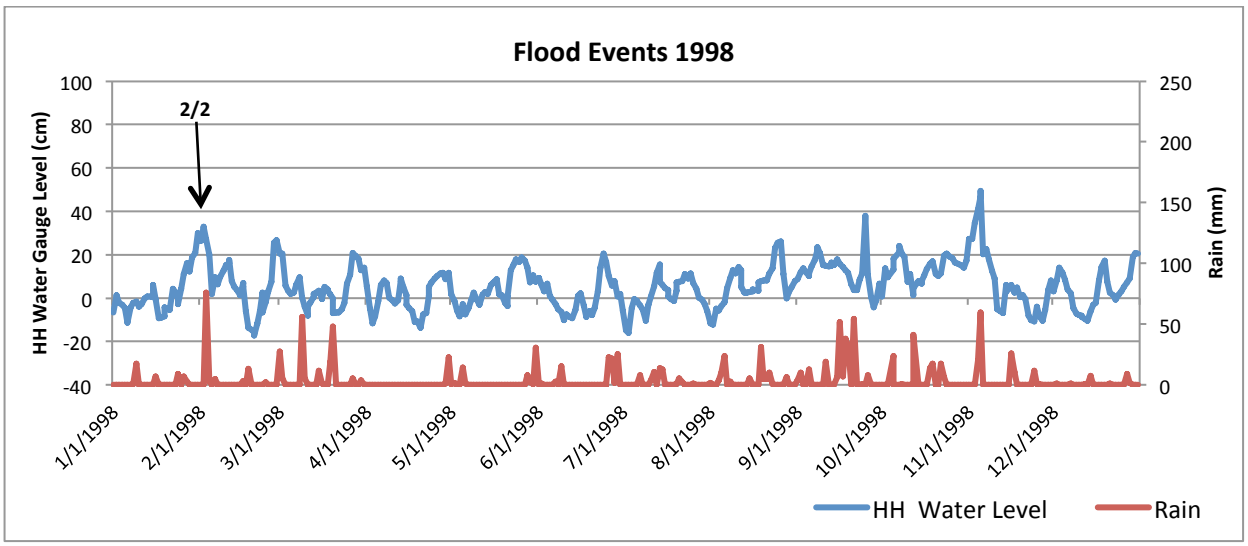
Miami Beach Flood Events 2001					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. **Rain data retrieved from SFWMD Rain Station at Miami Beach.** Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: NA					
AVG HH: 70.97159	STD HH: 136.4827	AVG LL: -597.008	STD LL: 125.9091		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
No recorded flood events					



Miami Beach Flood Events 2000					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: NA					
AVG HH: 112.3768	STD HH: 121.6456	AVG LL: -566.384	STD LL: 109.1986		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/4/2000**	**1**	**1**
Miami Beach	Flood Loss	Miami-Dade Public Works	**10/3/2000**	**5**	
Miami Beach	Flood Loss	Miami-Dade Public Works	**5/31/2000**	**1**	**1**
Total				**7**	**2**



Miami Beach Flood Events 1999					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: • Tropical Strom Harvey: 9/19/1999 -9/22/1999 West to East landfall on Miami Beach on 9/21/1999) • Hurricane Irene: 10/12/1999 – 10/19/1999 (East to West landfall on Miami Beach on 9/15/1999)					
AVG HH: 129.6572	STD HH: 127.7059	AVG LL: -550.47	STD LL: 117.3307		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami Dade Public Works	**11/10/1999**	**1**	**1**
Miami Beach	Flood Loss	Miami Dade Public Works	**10/16/1999**	**4**	**1**
Miami Beach	Flood Loss	Miami Dade Public Works	**10/15/1999**	**24**	
Miami Beach	Flood Loss	Miami Dade Public Works	**10/14/1999**	**1**	
Miami Beach	Flood Loss	Miami Dade Public Works	**9/16/1999**	**1**	**1**
Miami Beach	Flood Loss	Miami Dade Public Works	**9/15/1999**	**1**	
Miami Beach	Flood Loss	Miami Dade Public Works	**6/8/1999**	**13**	**1**
Miami Beach	Flood Loss	Miami Dade Public Works	**6/7/1999**	**5**	
Miami Beach	Flood Loss	Miami Dade Public Works	**5/29/1999**	**1**	**1**
Total				**51**	**5**



Miami Beach Flood Events 1998					
HH tide gauge data retrieved from NOAA Tide Station at Virginia Key. Rain data retrieved from NOAA Rain Station at Miami Beach. Black Labeled Flood Events are insurance claims retrieved from Miami Dade County Public Works.					
Other details: NA					
AVG HH: 56.33144	STD HH: 104.0482	AVG LL: -622.886	STD LL: 91.47611		
Description of Marked Events					
Area or Coordinates	**Cause Given by Article**	**Source**	**Date**	**Number of Claims / Reports**	**Number of Events**
Miami Beach	Flood Loss	Miami-Dade Public Works	2/2/1998	**1**	**1**
Total				**1**	**1**