ENSO & AMO influences on coastal water levels and extremes

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Miami Beach: Perigean Spring Tide + 0.2 m NTR
October 7, 2010
Coastal weirs with a design elevation differential of 0.15 m (6 inches) in red.

Gradients of 1 : 16000
1 : 6000

Coastal weirs with a design elevation differential of 0.15 m (6 inches) in red.
S-29 Discharge Event

September 1, 2008
10:00 GMT

Tidal water level controls flood discharge

0.2 m NTR

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE
Water Supply Well Chloride Monitors

Davie, FL

G-2264
Casing Depth: 195'
Total Depth: 203'

Hallendale, FL

G-2478
Casing Depth: 197'
Total Depth: 202'
Surge Projection from Historical Data

Surge (NTR) height return levels from historical data (a) can be synthesized with projected sea level rise (b) (USACE) to assess expected changes in surge as sea level rises over time (next slide).

Return Levels from GEV fits to extreme water levels.

\[
F(x) = \exp\left\{ - \left[ 1 + \varepsilon \left( \frac{x - \mu}{\sigma} \right) \right]^{1/\varepsilon} \right\}
\]

Generalized Extreme Value Distribution (GEV)
Higher surges can be expected more frequently as sea level increases.

Historical Data Return Levels as a function of AMO
A Climate-related Problem: Storminess vs. Flood Control

AWP increases storm potential

AMO/AWP increases extreme coastal water levels


High coastal water levels infiltrate the aquifer and limit flood control capacity

AMO correlates with FL rainfall
ENSO (MEI) is expressed in the unsmoothed AMOI. Up to 50% of AMOI at discrete periods. A total of 79% over the ENSO band of 2 – 7 years.

Spectral coherence metric to identify AMOI EOF modes from MEI.

\[ R_i = 1 - \frac{\int \gamma_{MAE}^2(i) df}{\int \gamma_{MA}^2 df} \]
Examined coherence of

**AMOI : Sea Level Anomaly**

**AMOI(ENSO) : SLA**

**MEI : Sea Level Anomaly**

Sea Level Anomaly is the variation of monthly mean sea level with the average seasonal cycle and linear sea level trend removed.
AMOI is partially coherent (20 – 30%) with sea level anomalies (SLA) centered on 9 yr periods at Key West, Pensacola and Charleston.

NAO or PDO atmospheric teleconnections are discounted

Over the ENSO band 79% of AMOI is due to ENSO. Expression of ENSO in AMOI is driving nearly all of the AMOI – SLA variance. This accounts for 20 - 50% of total SLA variance at discrete periods (2 - 7 yr).

Temporal correlation lag of 6 months suggests ENSO forcing acts through atmospheric bridge expressed in unsmoothed AMOI.

Direct ENSO (MEI) to sea level anomaly coherence is weaker and expressed differently than for either the direct AMOI or AMOI(ENSO).

ENSO teleconnections expressed in Atlantic SST have a stronger coupling to North Atlantic sea level anomalies than ENSO teleconnections not related to SST (atmospheric).

Analysis based on the extreme values of the sea level anomalies (storm surges) is likely to find a stronger influence from direct MEI coupling.
A Climate-related Problem: Storminess vs. Flood Control

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High coastal water levels infiltrate the aquifer and limit flood control capacity
Recent research has shown that decadal-to-multidecadal (D2M) climate variability is associated with environmental changes that have important consequences for human activities, such as public health, water availability, frequency of hurricanes, and so forth. As scientists, how do we convert these relationships into decision support products useful to water managers, insurance actuaries, and others, whose principal interest lies in knowing when future climate regime shifts will likely occur that affect long-horizon decisions?
Figure 6. Distribution of the horizon ($t_2$) for an AMO regime shift as a function of risk level (% ordinate) given that $t_1$ years (abscissa) have elapsed since the last regime shift. Based on the gamma distribution with scale and shape parameters of 10.3 years and 1.93, truncated for...
AMO Dependent Surge Projection

AMO dependent surge return distributions (a) can be combined with a probabilistic AMO phase change framework (b) to project AMO dependent projections of surge return levels (next slide).

a)

![Graph showing return period vs. NTR for different AMO phases at Pensacola and Key West.]

b)

![Graph showing risk of future regime shift vs. years since last regime shift.]

(NOAA National Oceanic and Atmospheric Administration)
Changing from cool to warm AMO conditions significantly increases surge heights.

AMO dependent surge variability can be as large as decades of SLR.
A Climate Projection Decision Support Tool?

Climate Indices & Remote Sensing: Observation

Input to a Probabilistic Model of Climate Behavior: Forecast Climatology

Input to Scenario Uncertainty Projection: Forecast Climate

Scenario Based Climate Forecast

Model Based Inference

Decision Support

Goals

Constraints

Input to SLR & Rainfall Models: Forecast SLR & Rainfall

NOAA

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References


Wang C., et. al., Influences of the Atlantic Warm Pool on Western Hemisphere Summer Rainfall and Atlantic Hurricanes, JOURNAL OF CLIMATE, 19, pg. 3011 (2006)