NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

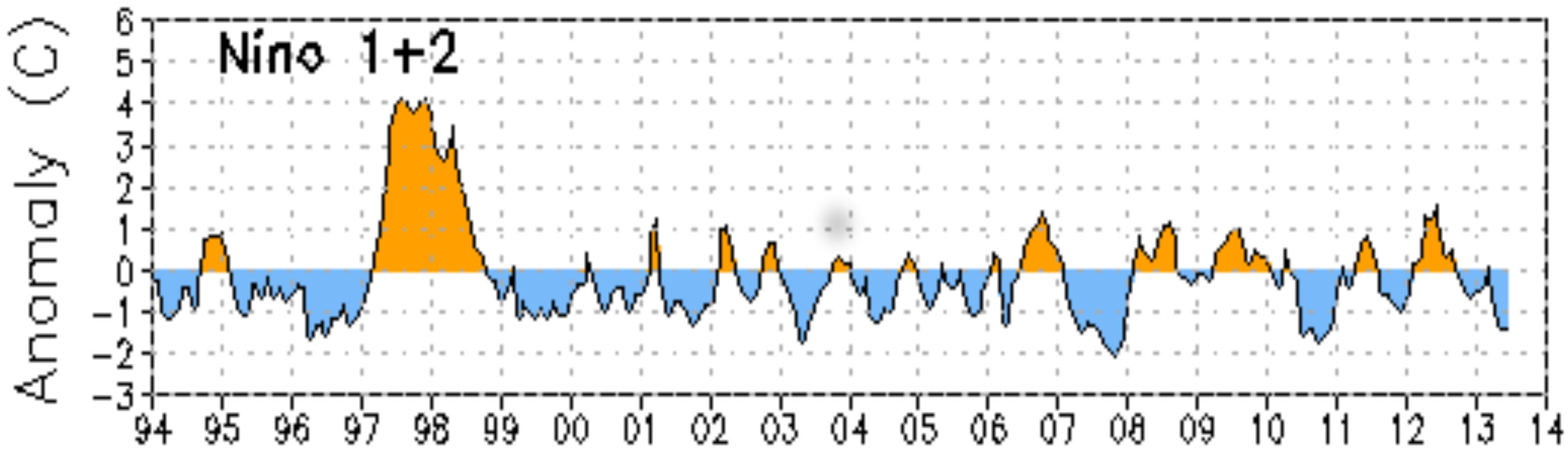
ENSO & AMO influences on coastal water levels and extremes

U.S. AMOC/U.K. RAPID International Science Meeting
July 16 – 19 2013

Joseph Park, PhD, PE, NOS/CO-OPS
Gregory Dusek, PhD, NOS/CO-OPS

GLOBAL CENTRE

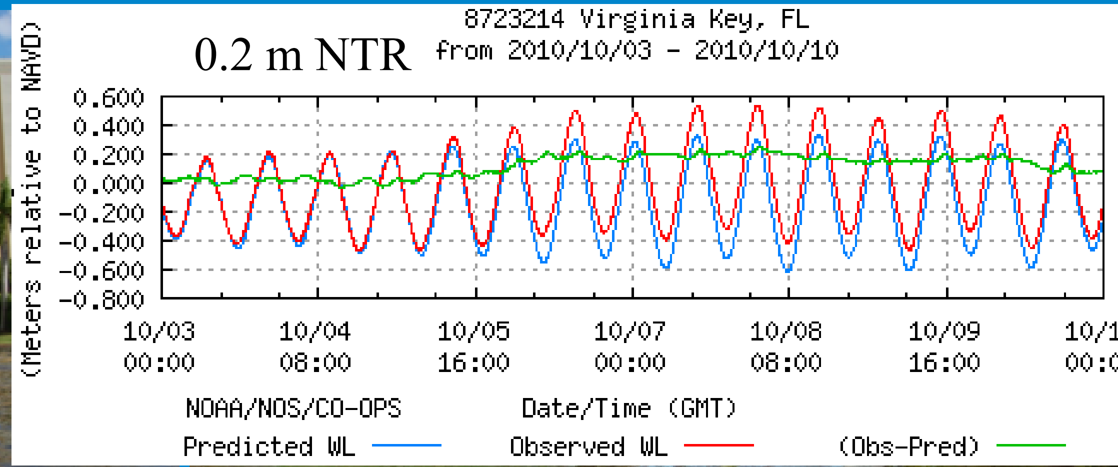
on Disaster Risk and Poverty

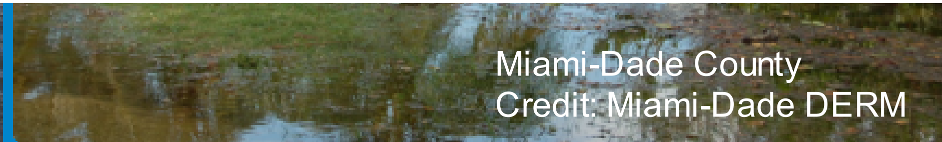


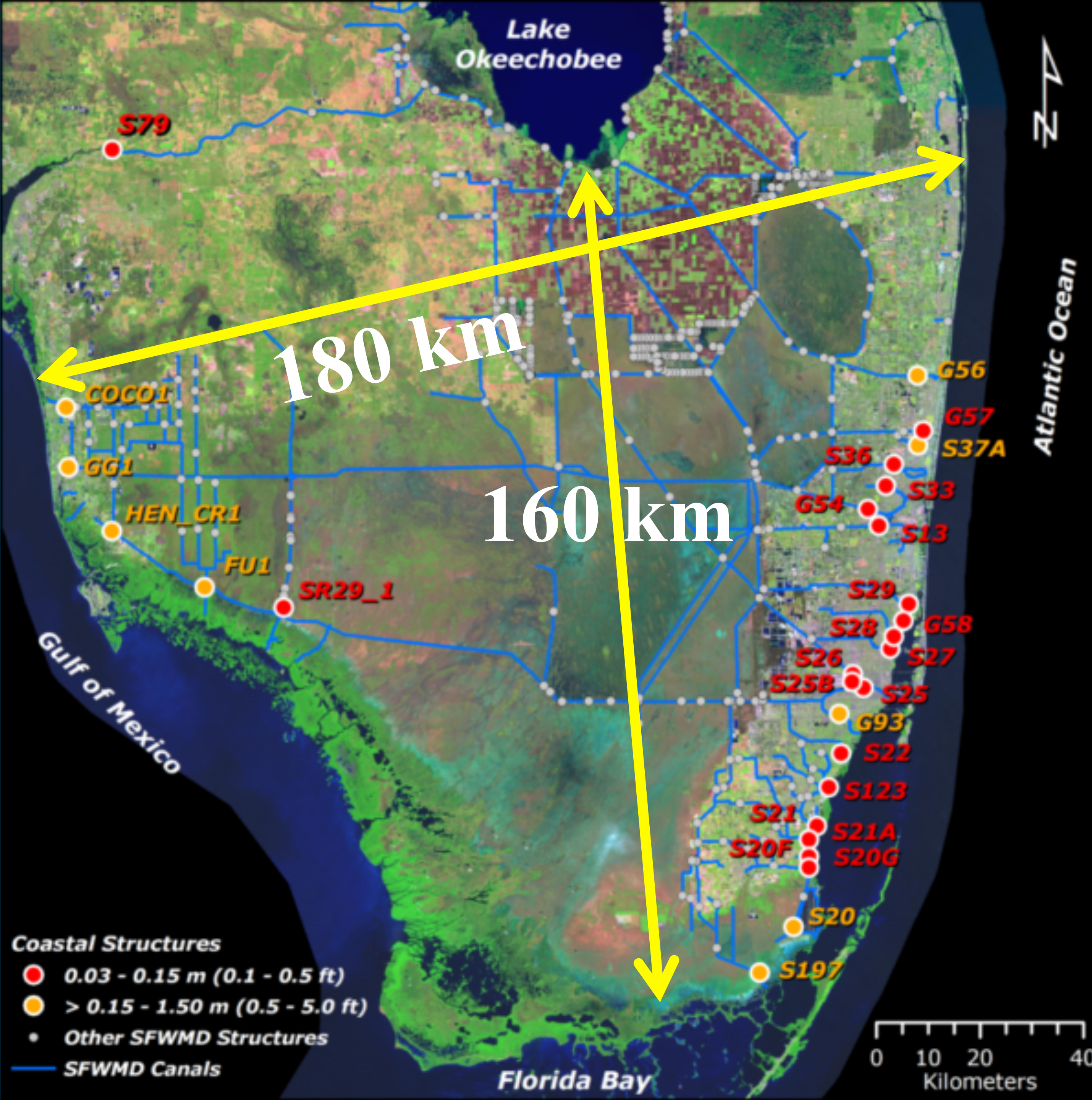
GlobalAgRisk, Inc.
Funded by USAID, the Bill & Melinda Gates Foundation, the United Nations Development Programme, and GIZ.

Norfolk VA: Mayflower Road at High Tide November 2009

Miami Beach: Perigean Spring Tide + 0.2 m NTR
October 7, 2010





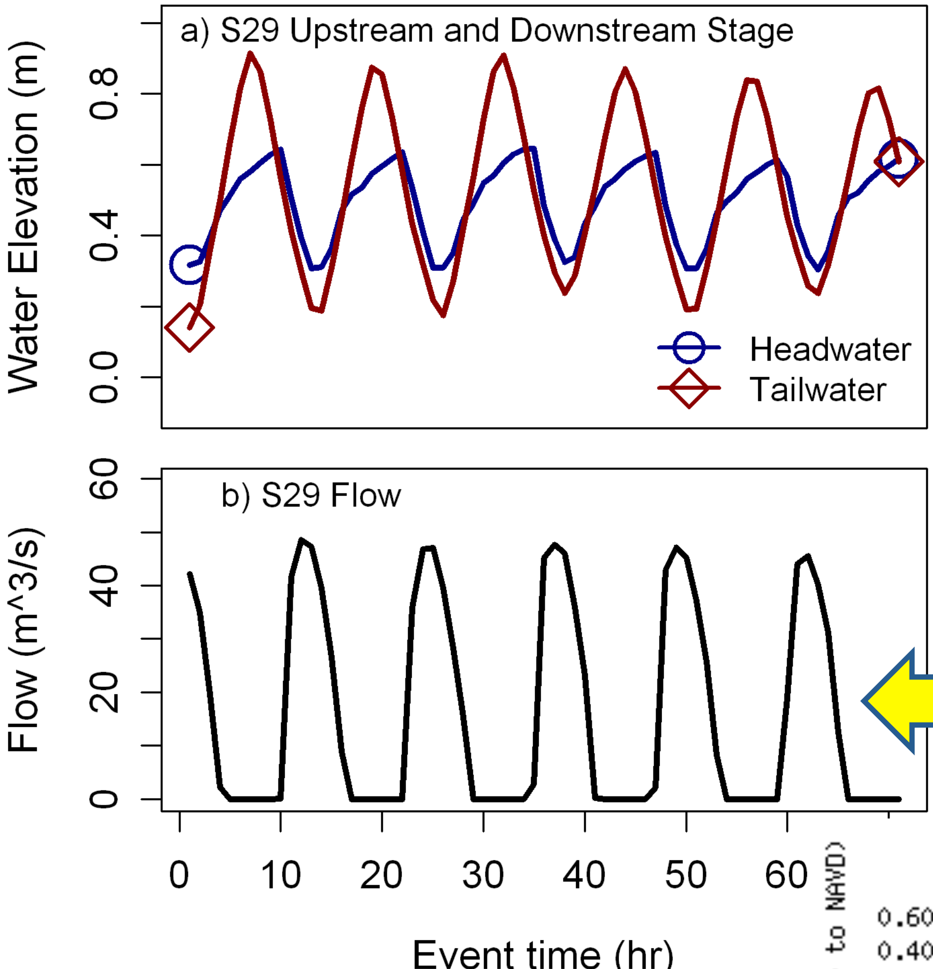


Gradients of
1 :16000
1 : 6000

Coastal weirs with a design elevation differential of 0.15 m (6 inches) in red

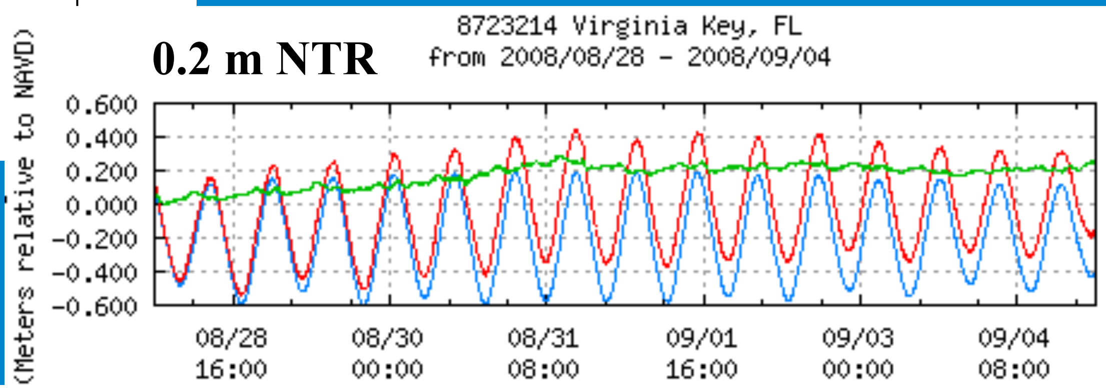
South Florida Water Management District
sfwmd.gov

S-29 Discharge Event



September 1, 2008
10:00 GMT

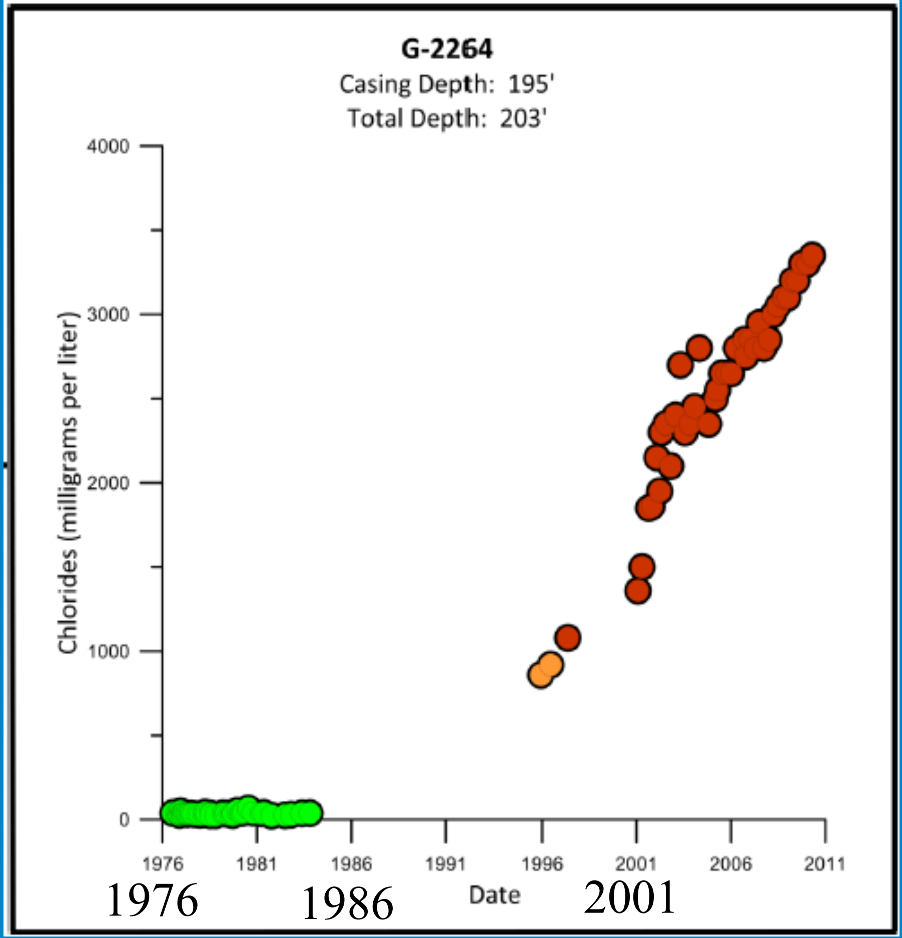
0.2 m NTR



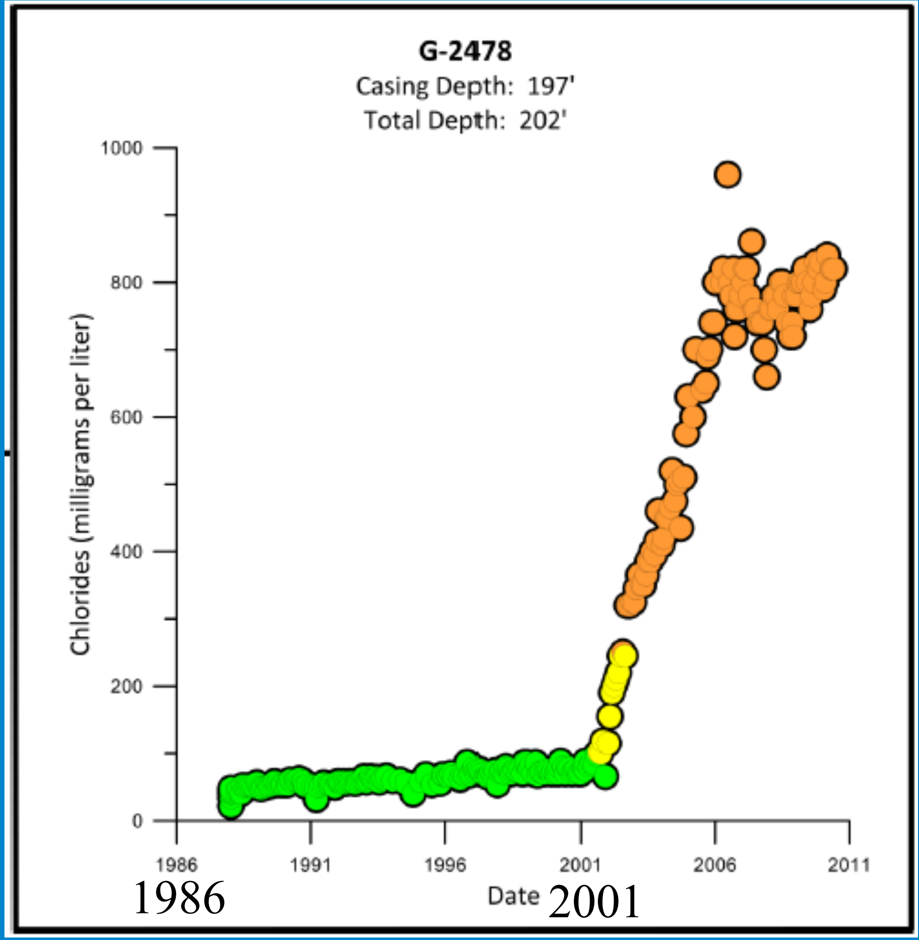
Tidal water level controls flood discharge

Water Supply Well Chloride Monitors

Davie, FL



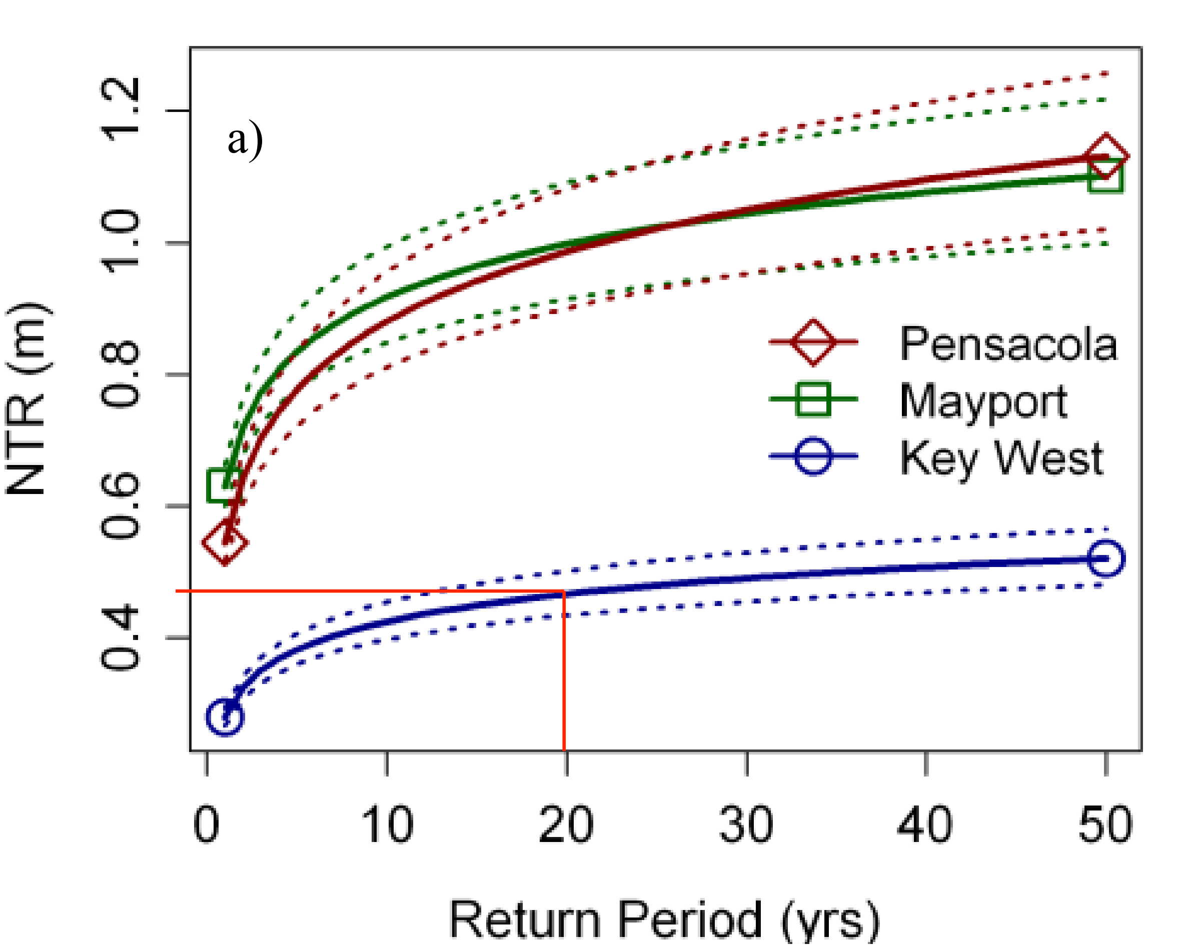
Hallendale, FL



Surge Projection from Historical Data

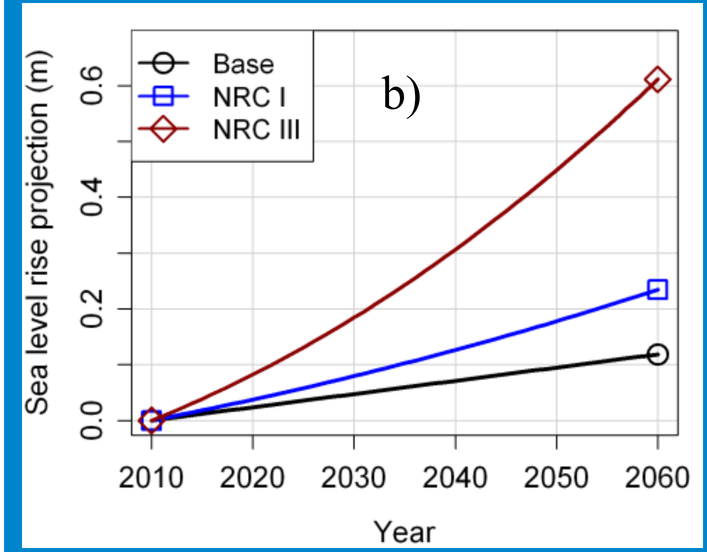
Surge (NTR) height return levels from historical data (a) can be synthesized with projected sea level rise (b) (USACE) to assess expected changes in surge as sea level rises over time (next slide).

Return Levels from GEV fits to extreme water levels.



Generalized Extreme Value Distribution (GEV)

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



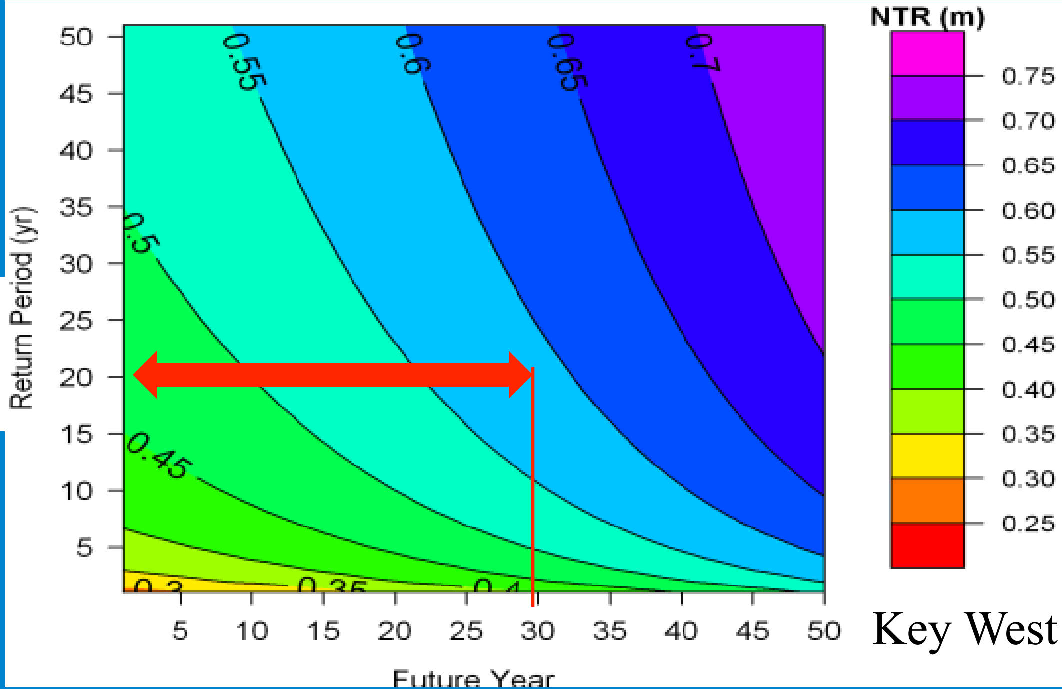
Projected SLR

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

Surge Projection from Synthesis of Historic Data and SLR Scenario

$$F(NTR,t) = \exp\left\{-\left[1+\varepsilon\left(\frac{NTR-(\mu+R(t))}{\sigma}\right)\right]^{-1/\varepsilon}\right\}$$

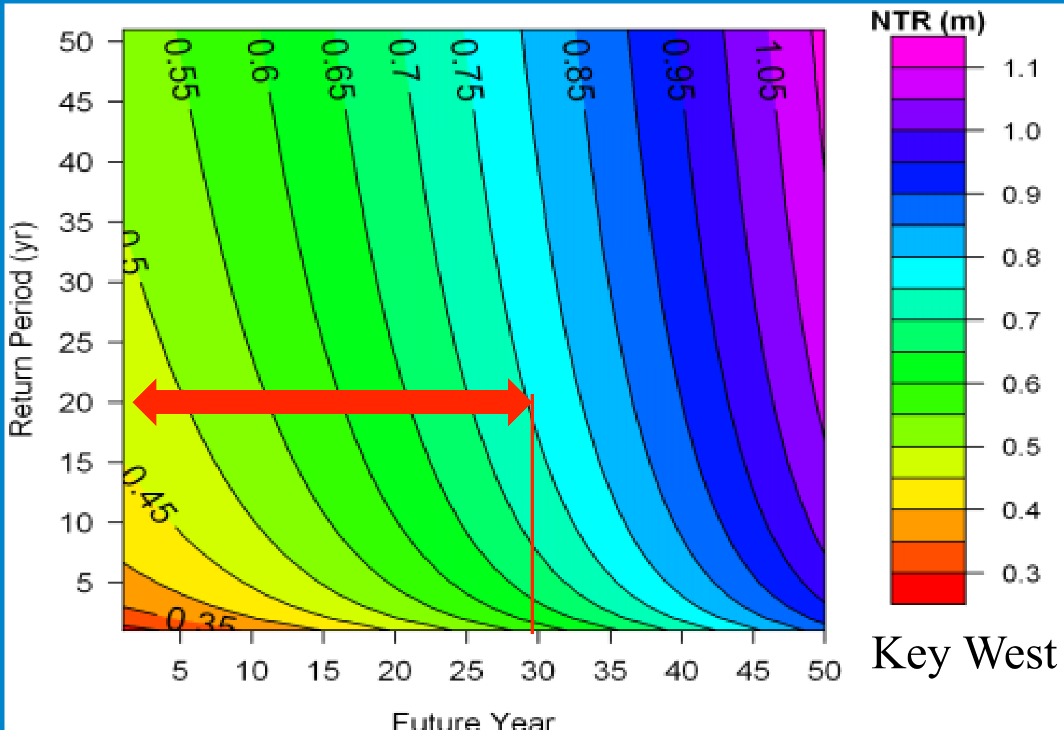
NRC I



Key West

Higher surges can be expected more frequently as sea level increases.

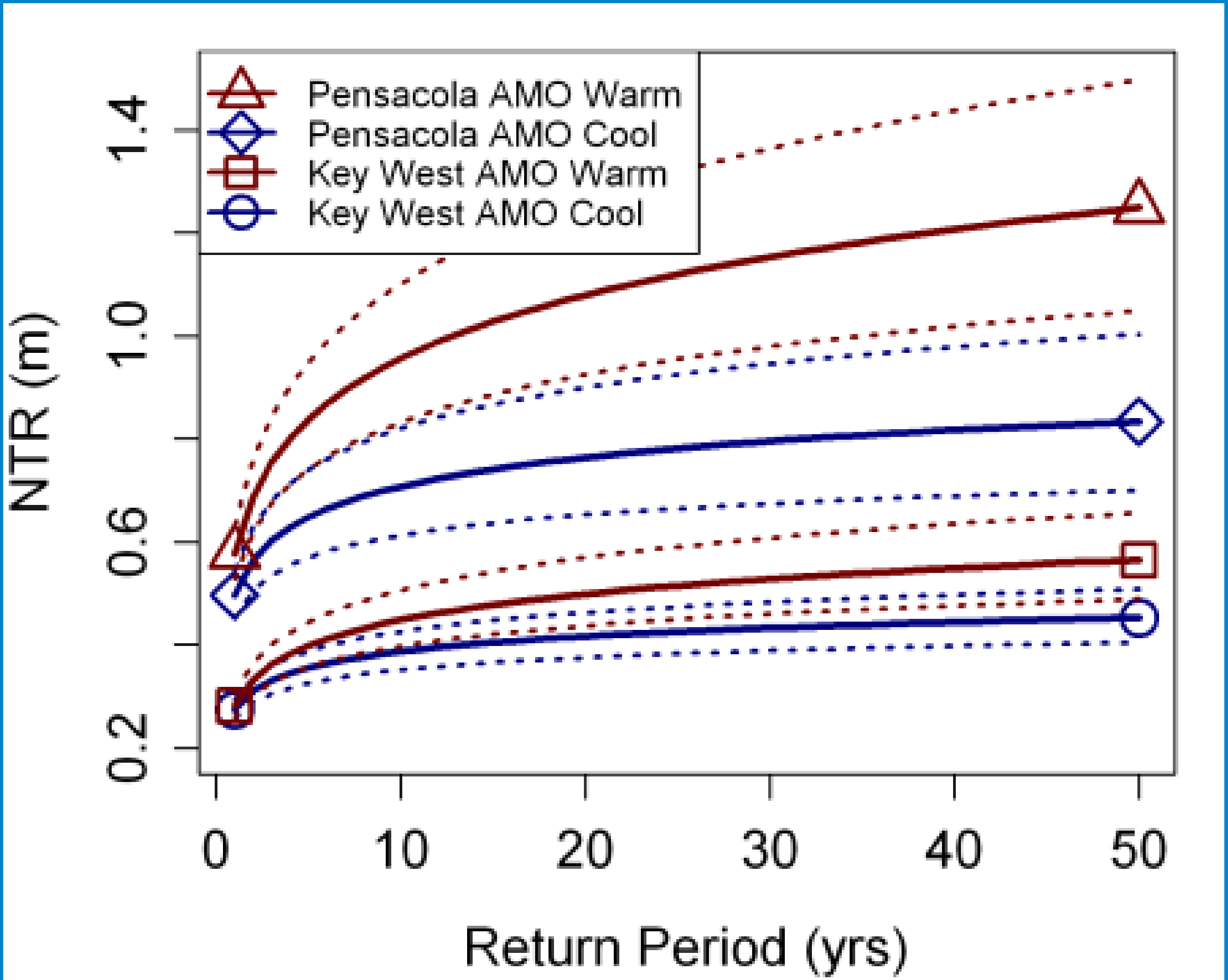
NRC III



Key West

Park, J., Obeysekera, J., Barnes, J., Irizarry, M., Trimble P., Winifred Park-Said, Storm surge projections and implications for water management in South Florida, Climatic Change (special issue on sea level rise in Florida), (2011) 107:109–128

Historical Data Return Levels as a function of AMO



A Climate-related Problem: Storminess vs. Flood Control

AWP increases storm potential

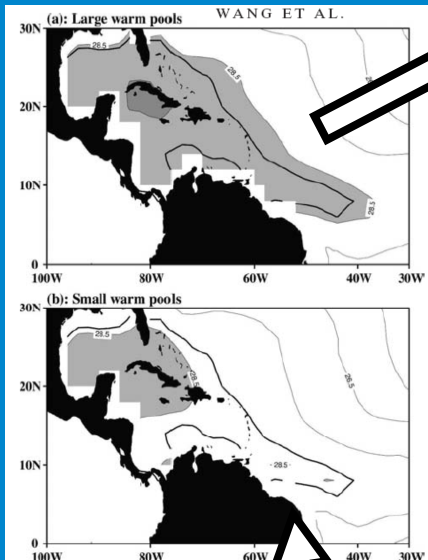


FIG. 4. SST composites of (a) large Atlan... ...rm pools and (b) small Atlantic warm pools during ASO. Th... ...k contour represents ASO climatological SST warmer than ...C.

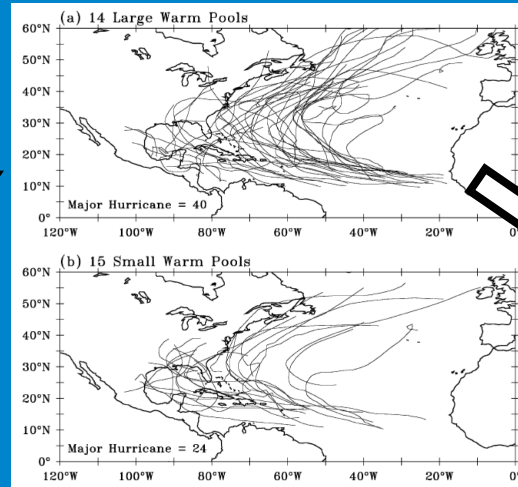
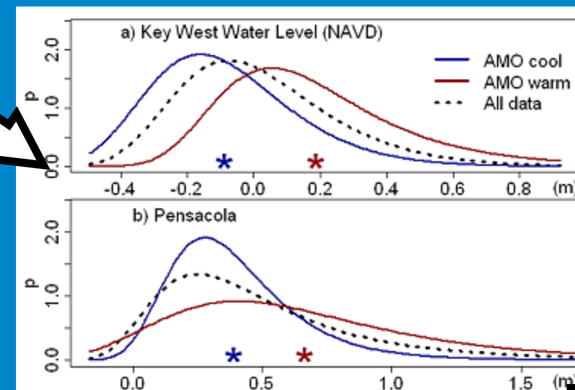


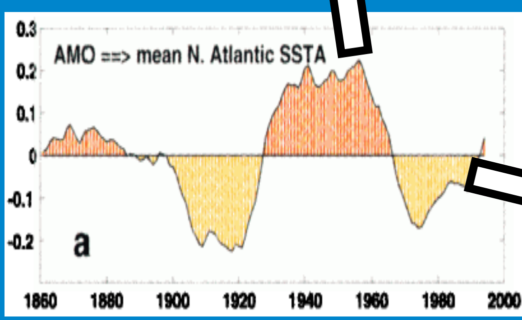
FIG. 12. Atlantic major hurricane tracks for (a) 14 years of large Atlantic warm pools and (b) 15 years of small Atlantic warm pools.

AMO/AWP increases extreme coastal water levels

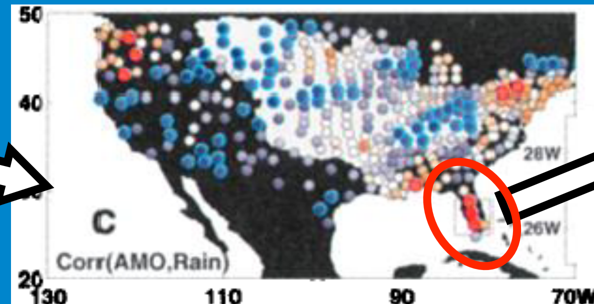


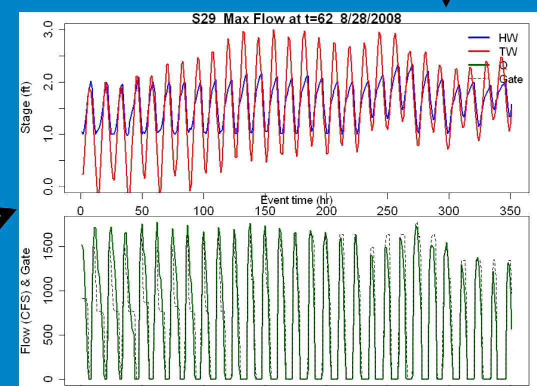
A 'Wicked' Problem: Rittel HWJ, Webber M., Dilemmas in a general theory of planning. Policy Sci 4(2): 155–169 (1973)

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



AMO correlates with FL rainfall

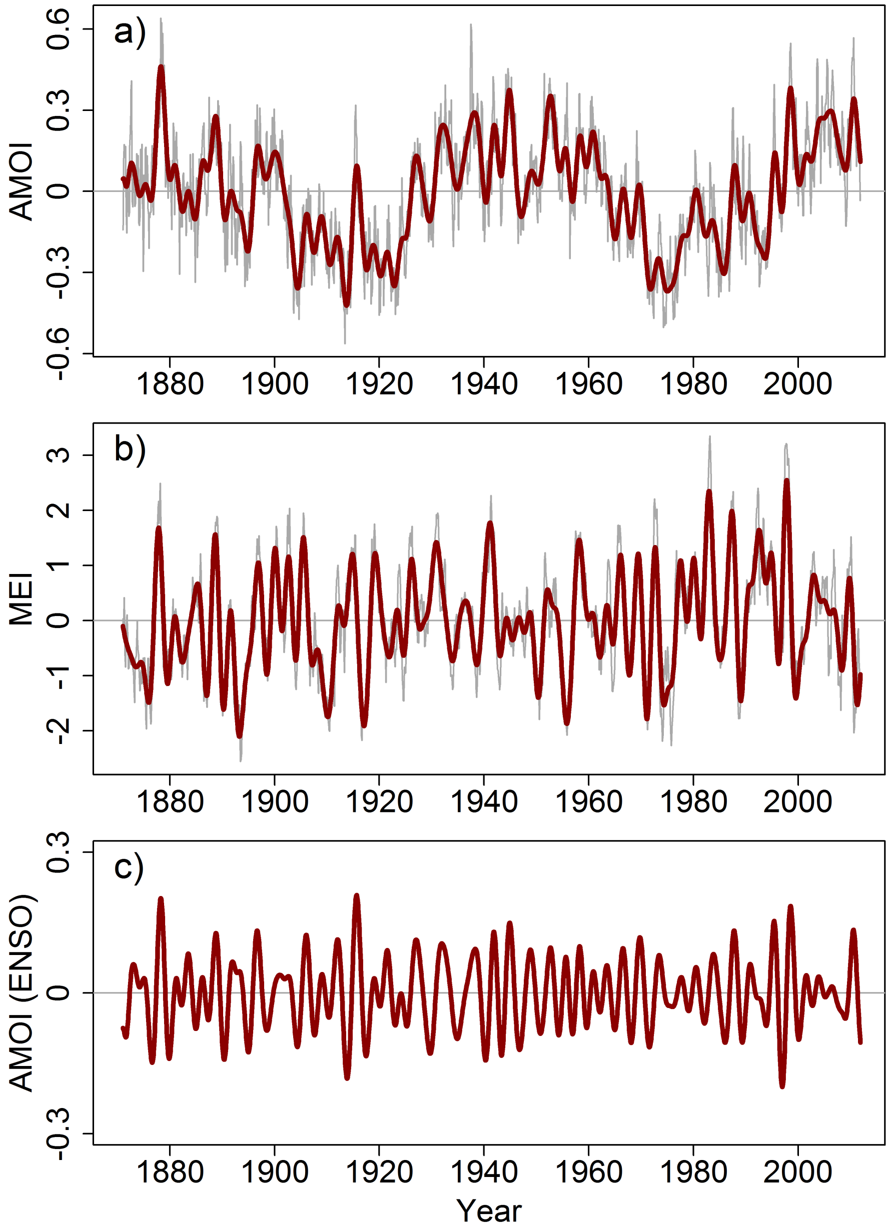


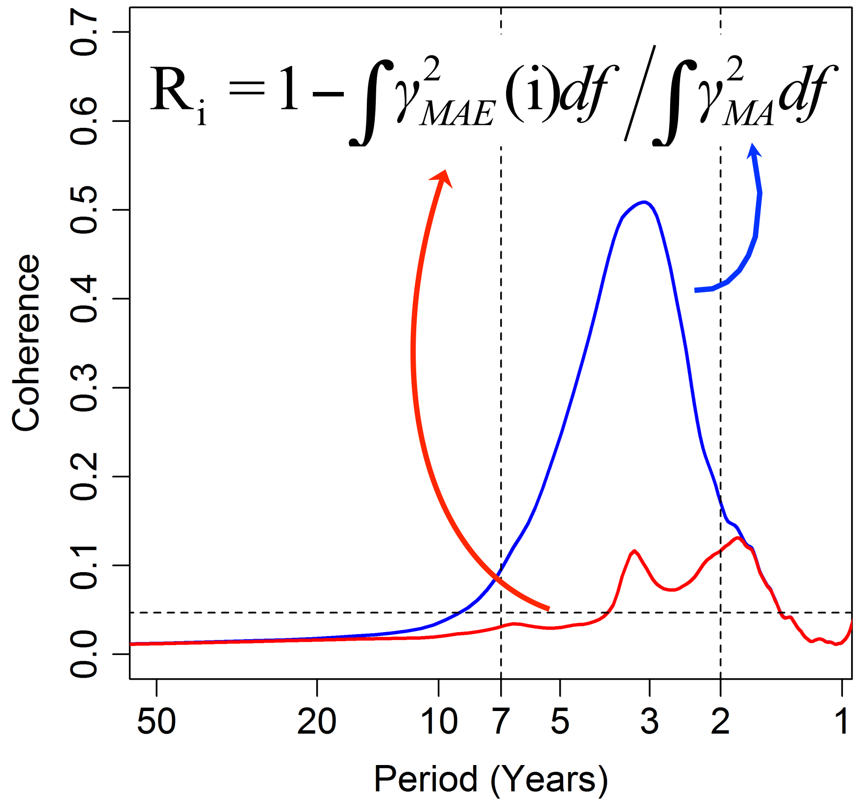


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

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.





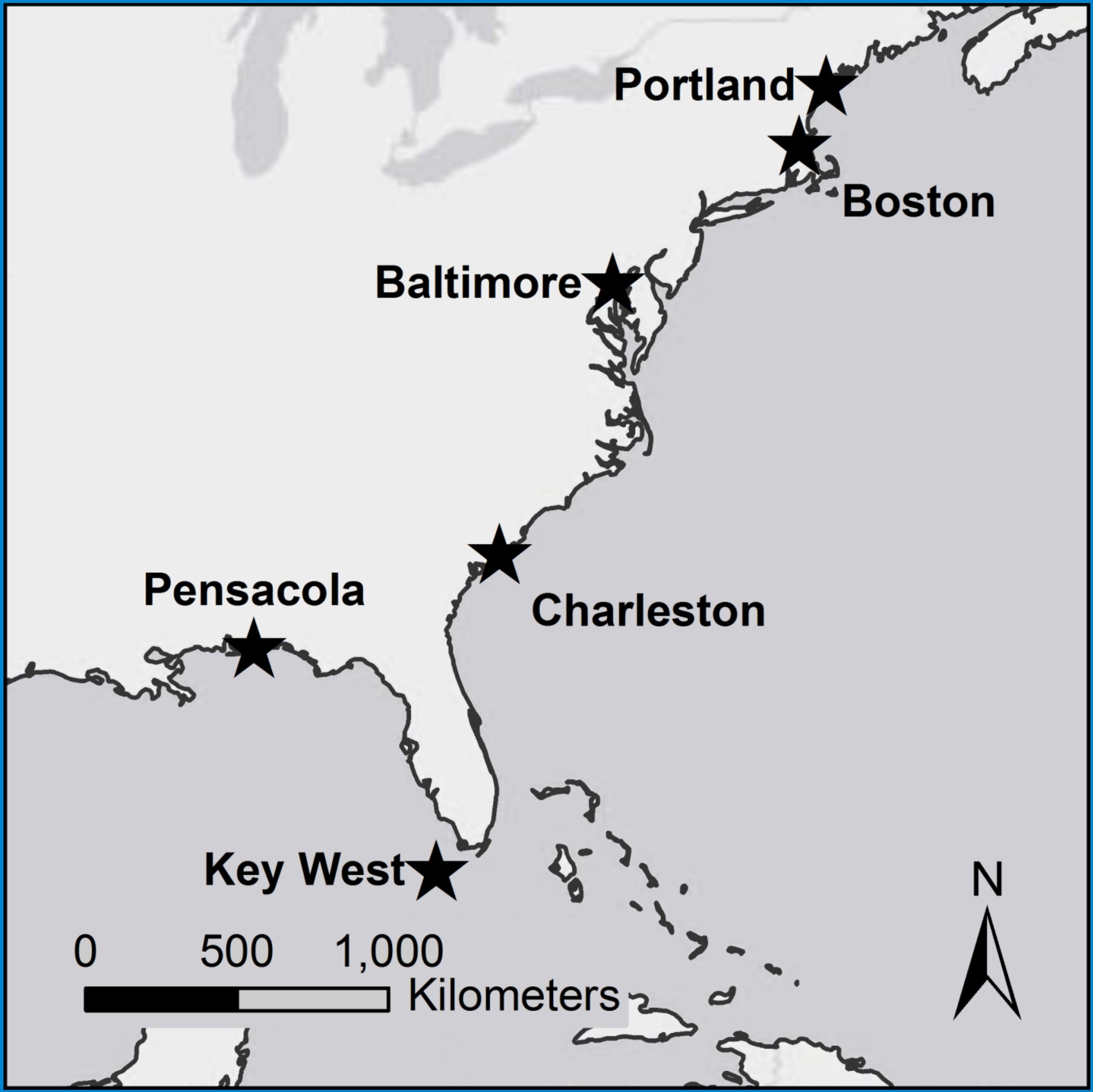
Examined coherence of

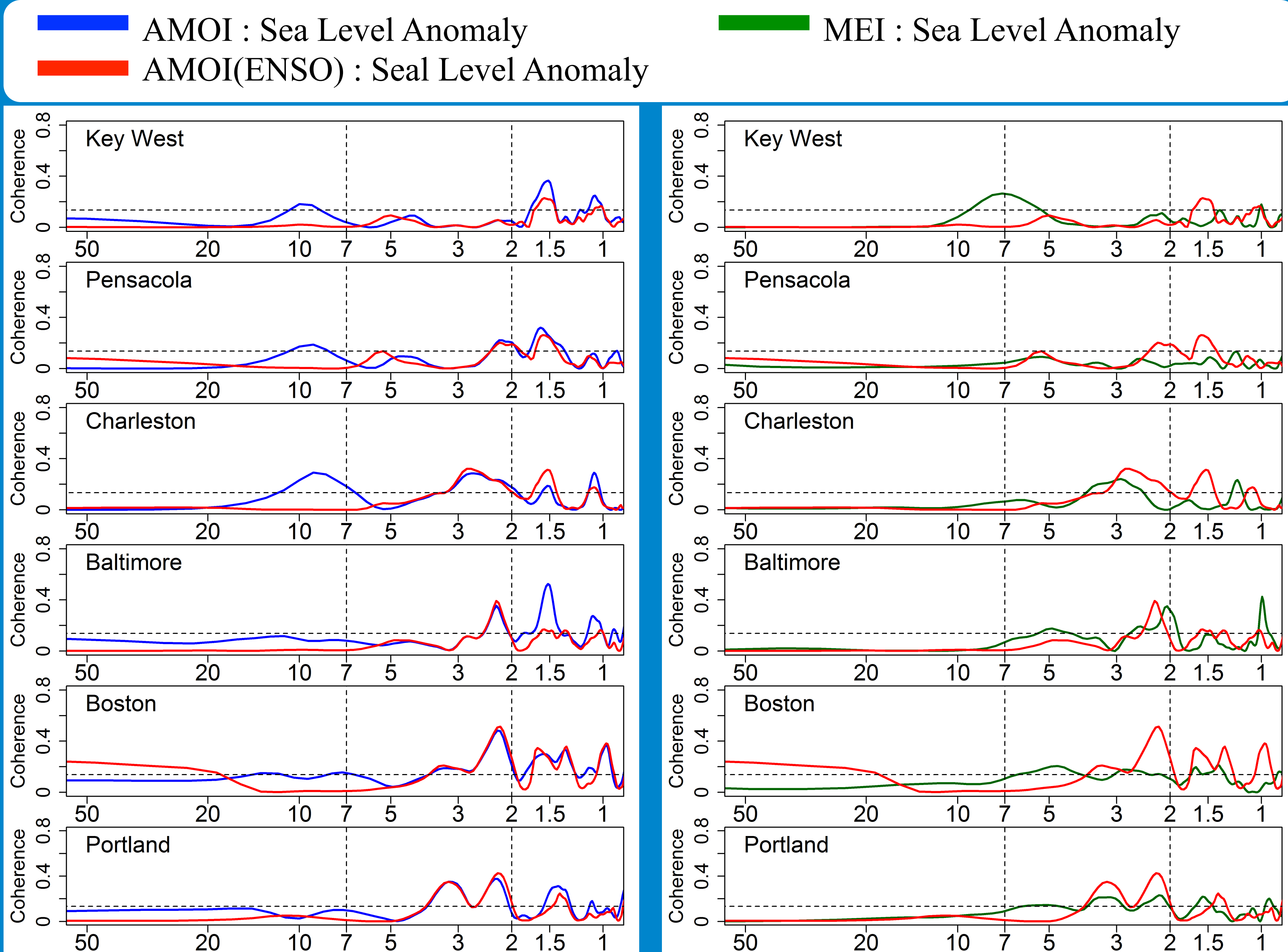
AMOI : Sea Level Anomaly

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 : Sea Level Anomaly
AMOI(ENSO) : Seal Level Anomaly
MEI : Sea Level Anomaly
Key West
Pensacola
Charleston
Baltimore
Boston
Portland
Coherence
0
0.4
0.8
50
20
10
7
5
3
2
1.5
1

- 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

AWP increases storm potential

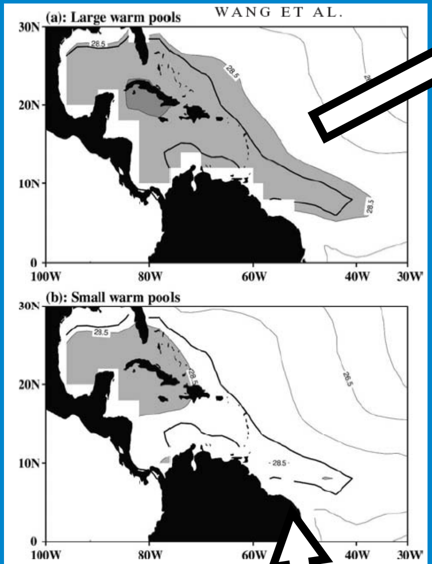


FIG. 4. SST composites of (a) large Atlan... ...rm pools and (b) small Atlantic warm pools during ASO. Th... ...k contour represents ASO climatological SST warmer than ...C.

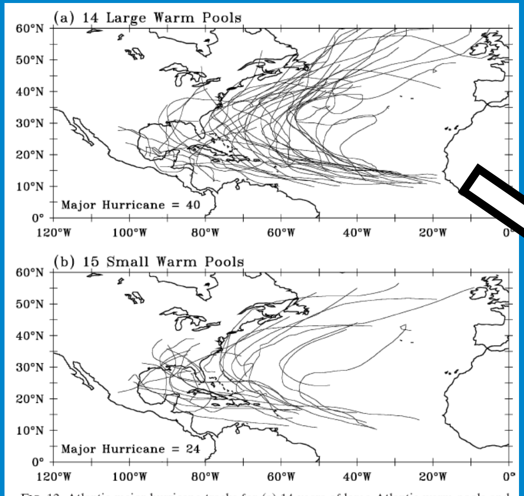
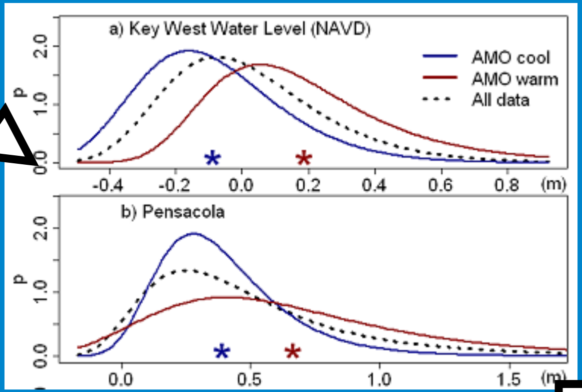


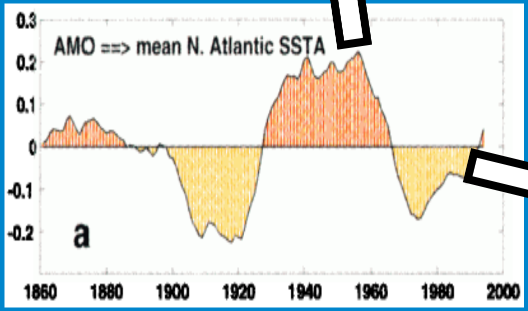
FIG. 12. Atlantic major hurricane tracks for (a) 14 years of large Atlantic warm pools and (b) 15 years of small Atlantic warm pools.

AMO/AWP increases extreme coastal water levels

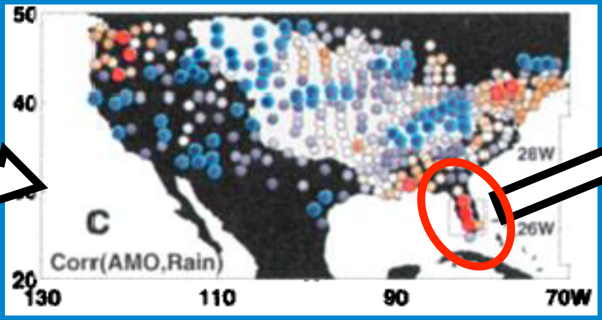


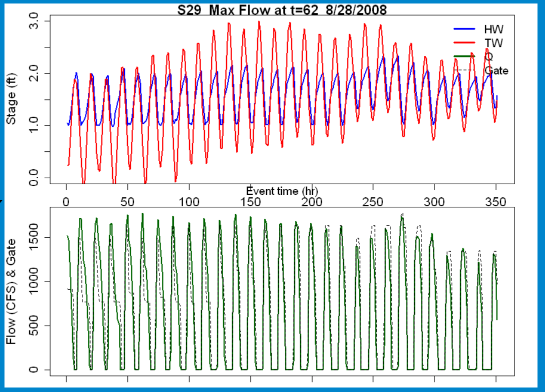
A 'Wicked' Problem: Rittel HWJ, Webber M., Dilemmas in a general theory of planning. Policy Sci 4(2): 155–169 (1973)

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



AMO correlates with FL rainfall





INTERNATIONAL JOURNAL OF CLIMATOLOGY **26**: 885–895 (2006)
PROJECTING THE RISK OF FUTURE CLIMATE SHIFTS

DAVID B. ENFIELD
NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL 33149, USA
LUIS CID-SERRANO
Statistics Department, Universidad de Concepci´on, Concepci´on, Chile

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?

ENFIELD & CID-SERRANO, INTERNATIONAL JOURNAL OF CLIMATOLOGY **26**: 885–895 (2006)

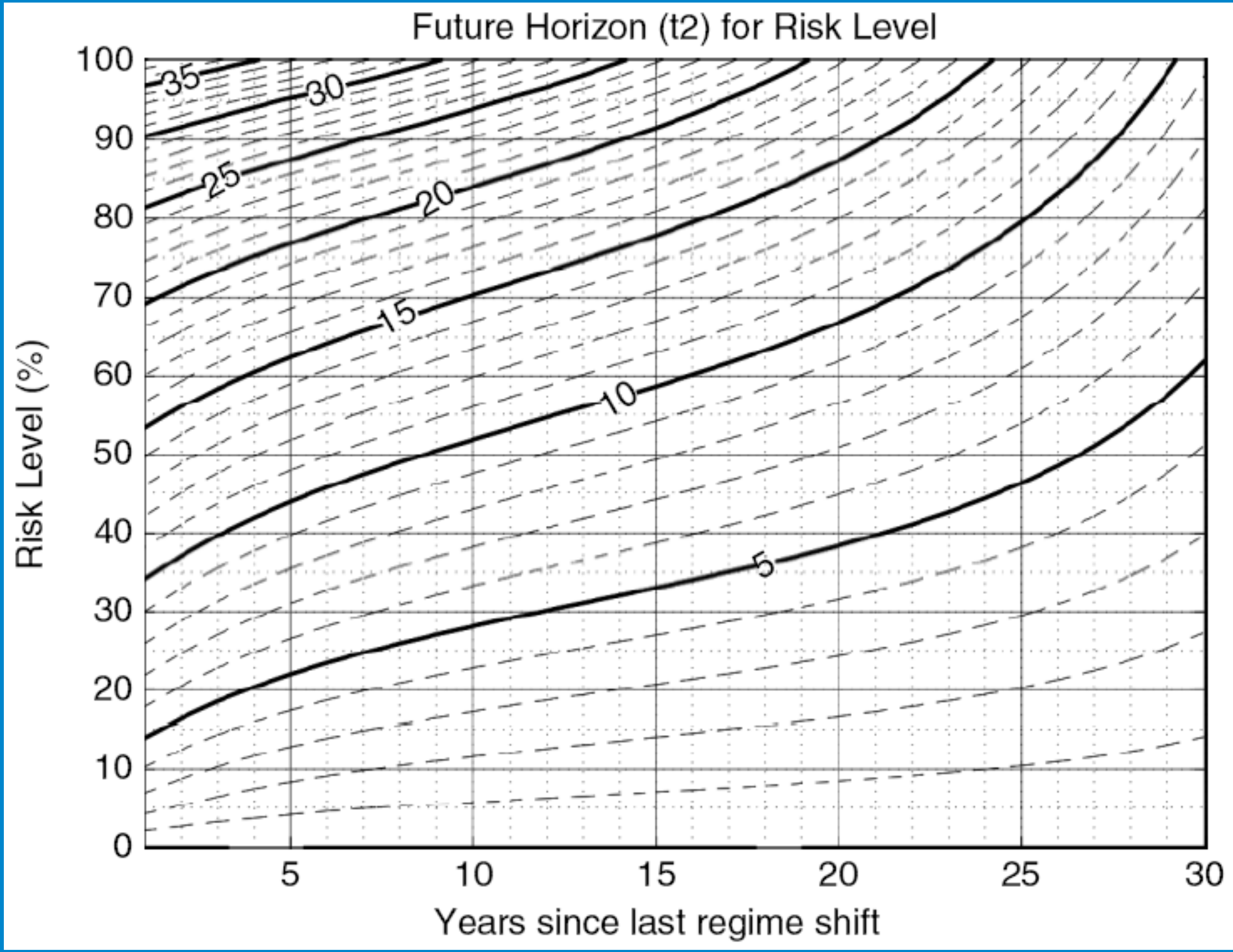
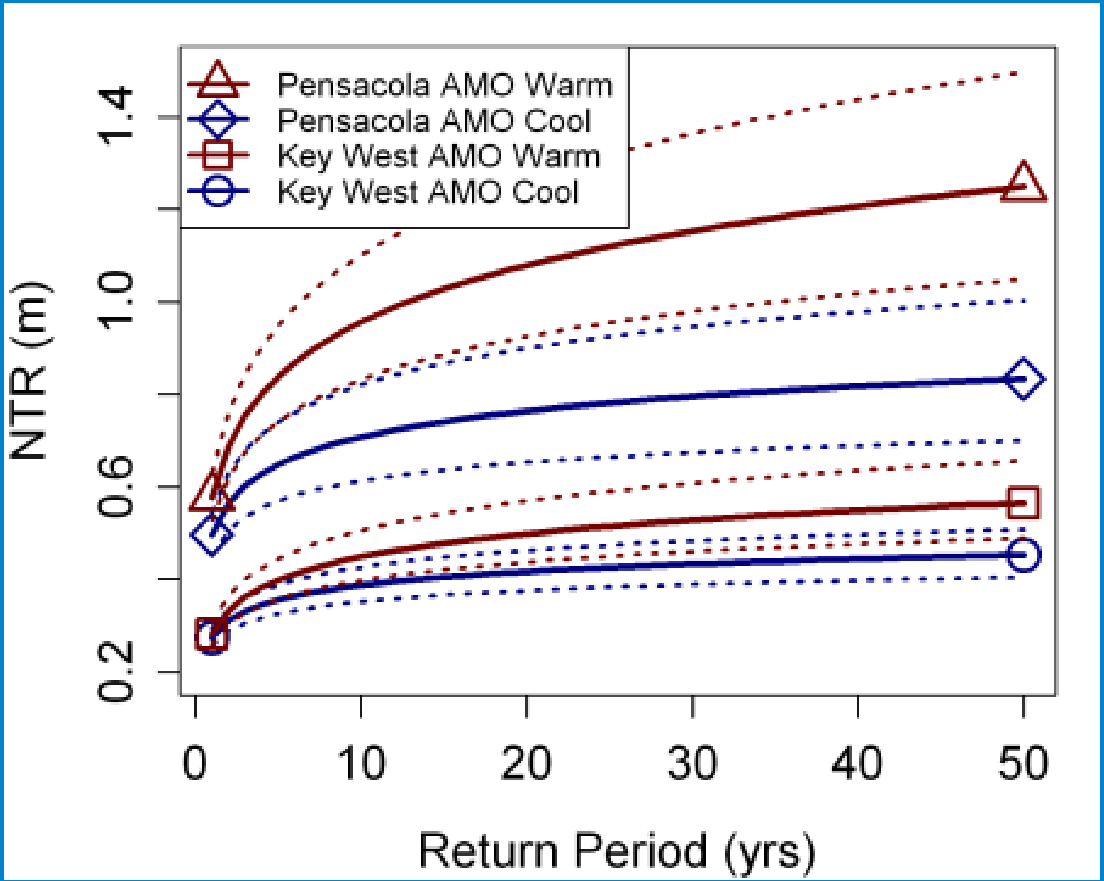


Figure 6. Distribution of the horizon (*t*2) for an AMO regime shift as a function of risk level (%, ordinate) given that *t*1 years (abscissa) have elapsed since the last regime shift. Based on the gamma distribution with scale and shape parameters of 10.3 years and 1.93, truncated for

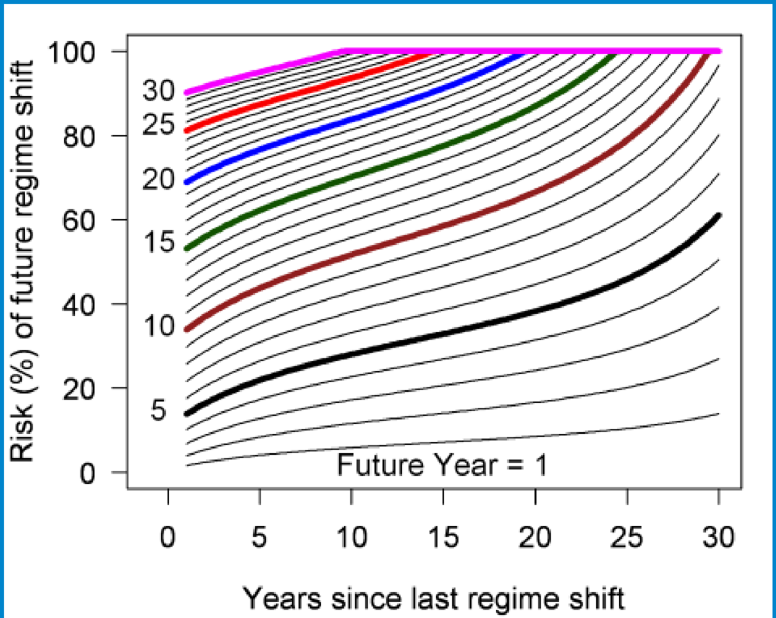
AMO Dependent Surge Projection

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)

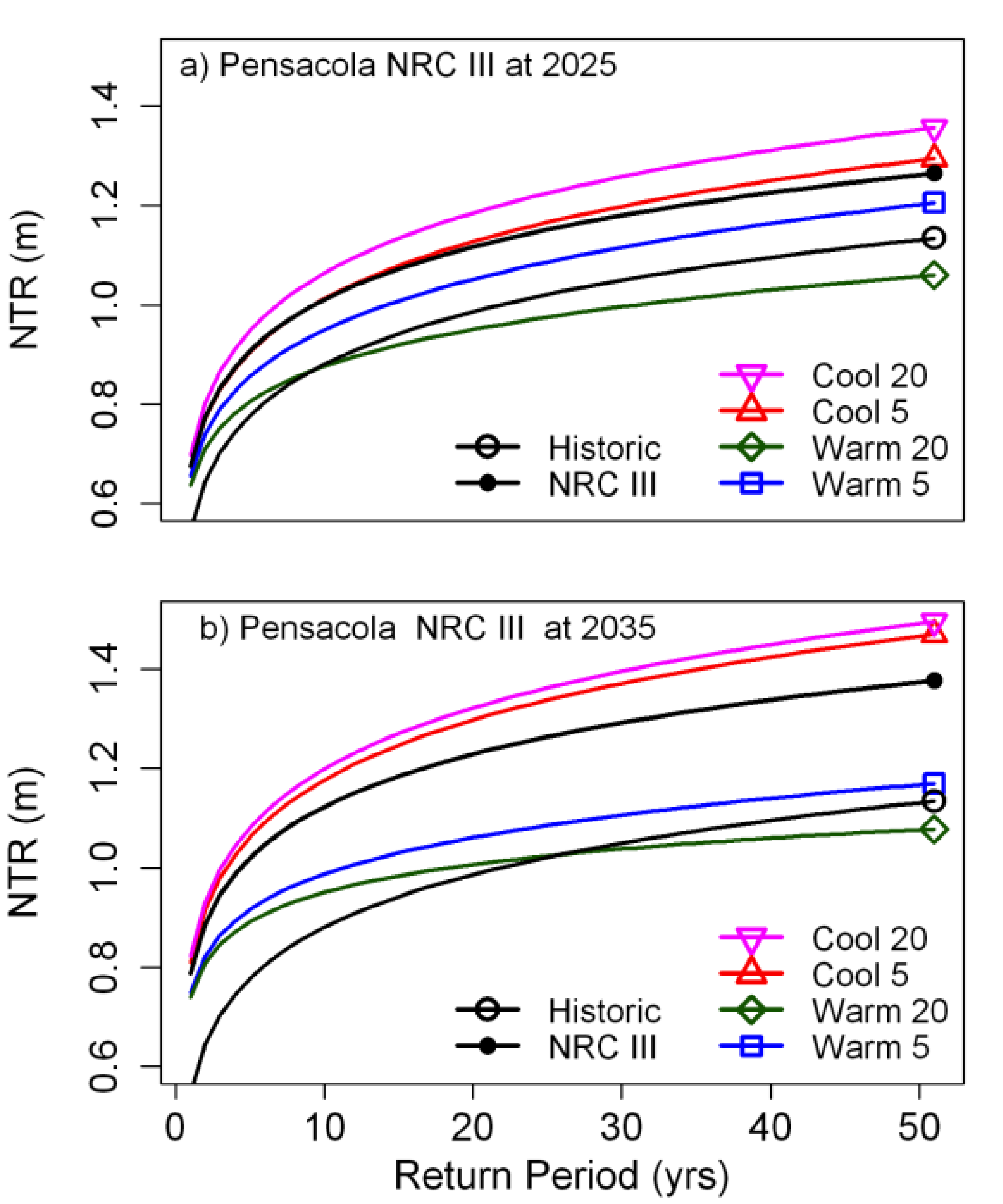


b)



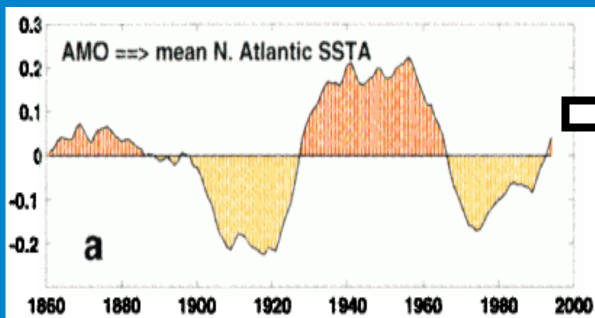
Changing from cool to warm AMO conditions significantly increases surge heights.

AMO dependent surge variability can be as large as decades of SLR.

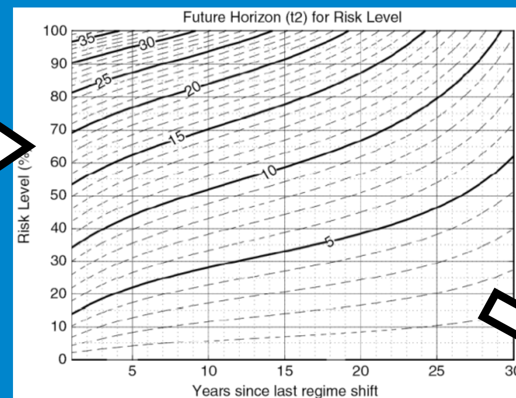


A Climate Projection Decision Support Tool ?

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

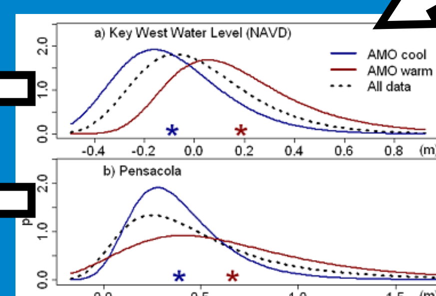
Ω

Model Based Inference

Goals Constraints

Φ

Decision Support



Input to SLR & Rainfall Models : Forecast SLR & Rainfall

References

Enfield, D. B., Mestas-Nunez, A. M., and Trimble, P. J.: The Atlantic Multidecadal Oscillation and its relationship to rainfall and river flows in the continental U.S., Geophys. Res. Lett., 28, 2077–2080 (2001)

Enfield DB, Cid-Serrano L., Projecting the risk of future climate shifts. Int J Climatol 26(7):885–895 (2006)

Park, J., Dusek G. ENSO components of the Atlantic multidecadal oscillation and their relation to North Atlantic interannual coastal sea level anomalies, Ocean Science, 9, 535-543 (2013)

Park, J., Obeysekera, J., Barnes, J., Irizarry, M., Trimble P., Storm surge projections and implications for water management in South Florida, Climatic Change (special issue on sea level rise in Florida), 107:109–128 (2011)

Park, J., Obeysekera, J., Barnes, J., Temporal Energy Partitions of Florida Extreme Sea Level Events as a function of Atlantic Multidecadal Oscillation, Ocean Science, 6, 587-593, (2010)

Park, J., Obeysekera, J., Barnes, J., Irizarry, M., Park-Said, W., Climate Links and Variability of Extreme Sea Level Events at Key West, Pensacola, and Mayport Florida, ASCE Journal of Port, Coastal, Waterway and Ocean Engineering, 136 (6), 350-356, (2010)

Rittel HWJ, Webber MM, Dilemmas in a general theory of planning. Policy Sci 4(2):155–169 (1973)

Sweet W. V. and Zervas C., Cool-Season Sea Level Anomalies and Storm Surges along the U.S. East Coast: Climatology and Comparison with the 2009/10 El Niño, Monthly Weather Review (139) 2290–2299 (2011)

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)