Forecasting seasonal sea levels for the U.S. Southeast Coast: opportunities and challenges

Matthew J. Widlansky\(^1\), Philip R. Thompson\(^1\), Mark A. Merrifield\(^2\), Xiaoyu Long\(^1\), H. Annamalai\(^1\), Arun Kumar\(^3\), John J. Marra\(^3\), William V. Sweet\(^3\), Eric Leuliette\(^3\), and Gary T. Mitchum\(^4\)

\(^1\)University of Hawaii, \(^2\)Scripps Institute of Oceanography, \(^3\)NOAA, \(^4\)University of South Florida

Sea surface height anomalies (satellite measured)
1) Tropical Pacific Islands: Skillful real-time seasonal forecasts

http://uhslc.soest.hawaii.edu/sea-level-forecasts/

Developed with support from:

MAPP
Modeling, Analysis, Predictions, and Projections

OOMD
Ocean Observing and Monitoring Division

Multimodel Ensemble Sea Level Forecasts for Tropical Pacific Islands

*J. Applied Meteorology and Climatology (2017)*

Matthew J. Wdiansky, John J. Marra, Md. Rashed Chowdhury, Scott A. Stephens, Elaine R. Miles, Nicolas Fauchereau, Claire M. Spillman, Grant Smith, Grant Beard, and Judith Wells
Objective: Reduce the residual between predicted tides and observed water levels by forecasting relative sea level changes on seasonal timescales.

Honolulu sea levels +20 to +30 cm above astronomical tidal predictions during April 2017

- Tidal prediction
- Tide gauge observation
- Residual (observation minus prediction)
- Extreme low (5%)
- Extreme high (5%)

High tide floods beaches, roads on Oahu; what's behind the deluge of water?

Waikiki Friday Night
Fireworks cancelled

Waikiki
April 28, 2017
1) Anomalies persist for about a month
2) Maximum water levels during Sep–Nov
3) Florida Current/Gulf Stream transport?

EXPLAINING EXTREME EVENTS OF 2015

From A Climate Perspective

6. IN TIDE'S WAY: SOUTHEAST FLORIDA'S SEPTEMBER 2015 SUNNY-DAY FLOOD

William V. Sweet, Melisa Menendez, Ayisha Ginz, Jayantha Obeyesekere, Joseph Park, and John J. Marka

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Goal: provide an outlook in June for whether the October sea level will be above/below normal.
1) Tide gauges and coastal sea surface heights are correlated from Yucatan Peninsula to Cape Hatteras

2) Offshore forcing (Rossby waves) of coastal sea levels (Boundary waves)

3) Sea level annual cycle modulator
How does the coastal sea level rise in Charleston and Miami during the same month?

And, is there an opportunity for regional seasonal forecasting?

Modified from Calafat et al. (2018) hypothesis
Sea levels are correlated along the Southeast Coast

**Data:**

- Six tide gauges (composite).
- Satellite altimetry (gridded).

Monthly anomalies, 12-month seasonal cycle removed.
Bandpass filtering (8–16 month) to retain the “sea level annual cycle modulator”.

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Offshore-to-coastal processes?
Constructing a statistical model

Ideally, we would have a reliable *dynamical* model of the offshore variability (red box). But, instead we have an EOF decomposition, which can be used with a variety of *statistical* models.

**Patterns of variability (10 EOFs)**

**Time series of variability (1 of 10 PCs)**

**Model “A”**

Multiple linear regression (lagged 0–11 months)

\[ X = [PC_1, PC_2, \ldots, PC_{10}] \]

\[ \hat{Y}_{0:11} = b_{0:11}(1) \cdot xPC_1 + b_{0:11}(2) \cdot xPC_2 + \cdots + b_{0:11}(10) \cdot xPC_{10} \]
Training, validating, and forecasting

- Training
- Forecasting
- "sea level annual cycle modulator"

8–16 month filter

Seasonal forecast and uncertainty?
Total water level forecast? (Tide + Trend + Forecast)
Alert thresholds? (5% “Yellow”, 1% “Red”)
3) Challenges for the Southeast U.S.

• Complicated ocean dynamics along the continental slope and shelf?
• Less predictable climate modes (e.g., compared to El Niño in the Pacific)?
• Severe model drifts.

NOAA’s dynamical climate forecast model (CFSv2) works in the Pacific but it is broken in the Atlantic.
Sea surface height

Satellite measured

Ocean data assimilation

Climate Forecast System, lead 0 months

CFSv2 model bias

Real Time Multiple Ocean Reanalysis Intercomparison

https://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html
CFSv2 skill is worse than persistence in Atlantic

Persistence (satellite)

April forecast starts for October (lead 6 months)

Forecast (CFSv2 vs. satellite)

High upper limit of predictability —if model bias is reduced— is an opportunity.
ECMWF’s dynamical seasonal forecast model (OCEAN5/ORAs5) initializes much closer to observed.
More than tides.

Tidal flooding

Worse when it rains.

Sunny-day flooding

Or, worse?

Nuisance flooding

Recurrent flooding

Forecast

Thank you

Matthew Widlansky
mwidlans@hawaii.edu