The 100-year flood seems to be changing. Can we really tell?

Robert L. Ceres Jr.,

Chris E. Forest, and Klaus Keller

Rebuildbydesign.org

Contact: ceforest@psu.edu

Designing Risk Management solutions are Complicated by:

- Long lifespans
- High cost
- Non-stationary risk
  - Demographics
  - Sea level
  - Weather

Approaches to Risk Mitigation

Traditional

- Estimate risk
- Design to a Standard
- Add Margin
- Build
- Hope for the best

Adaptive

- Estimate risk
- Design to a Standard
- Build
- Look for Signposts
- Reassess
- Implement Planned Response

- We need “signposts,” but…

  will we see them in time?

Our main question:

If we prescribe an increasing risk scenario, when can we detect the changes in 100-yr storm surge?

Ceres, R.L., Forest, C.E. & Keller, K. Climatic Change (2017)

Observation System Simulation Experiment (OSSE)

Real World:

Laws of Nature → Reality → Observations → Learning

Model World:

Nature State → Nature Runs → Observations → Learning

Experimental Design

- “Laws of Nature” (OSSE “Nature States”) are a GEV distributions with changing (non-stationary) parameters over time.

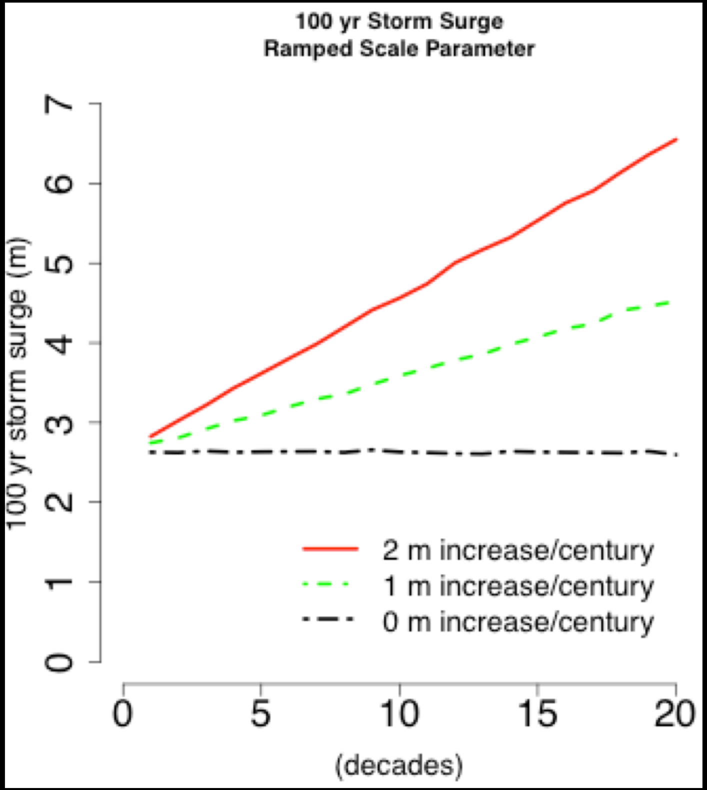
- “Reality” (OSSE “Nature Runs”) are simulated peak surge levels drawn from the Nature State.

- Observations are estimated 100-year surge levels use Generalized Extreme Value Analysis.

$$f(x;\mu,\sigma,\xi) = \frac{1}{\sigma}\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{\left(\frac{-1}{\xi}\right)-1} exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{\frac{-1}{\xi}}\right\}$$

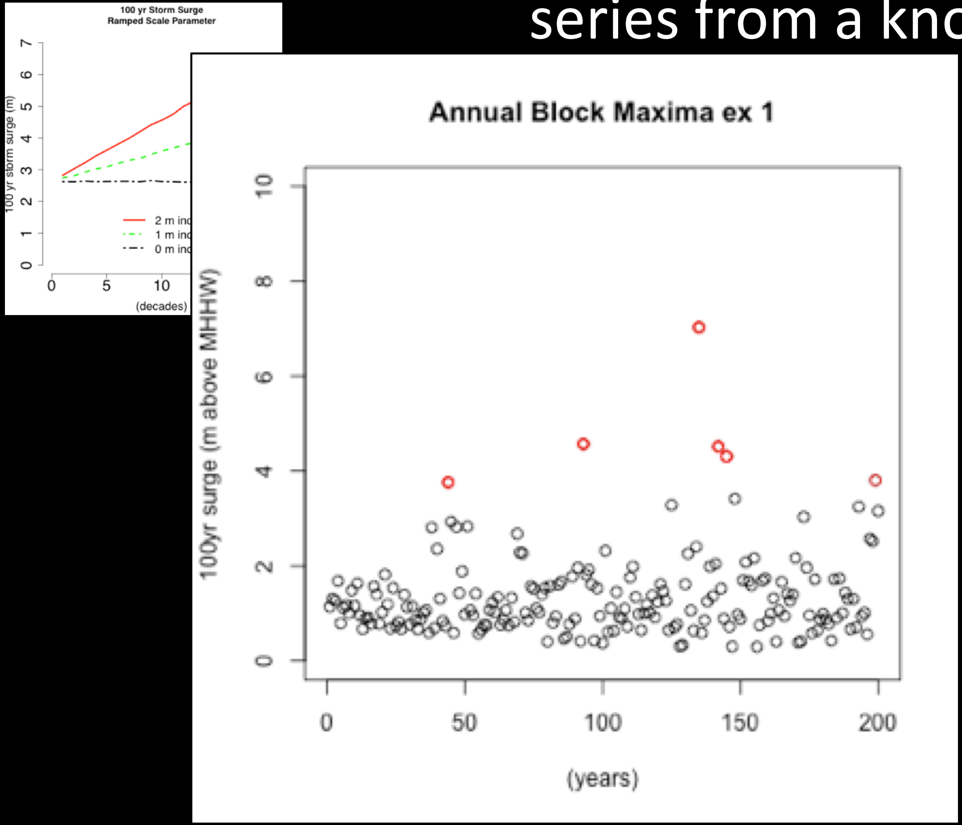
- E1-E4 Nature States with increasing 100-year flood
- 100k Nature Runs per Nature State
- 4 detection models
  a) $\sigma=\sigma_o$, $\mu=\mu_0$, $\xi=\xi_0$
  b) $\sigma(t)=\sigma_o+\alpha t$, $\mu=\mu_0$, $\xi=\xi_0$
  c) $\mu(t)=\mu_o+t\beta$, $\sigma=\sigma_o$, $\xi=\xi_0$
  d) $\sigma(t)=\sigma_o+\alpha t$, $\mu(t)=\mu_o+t\beta$, $\xi=\xi_0$

Contact: ceforest@psu.edu



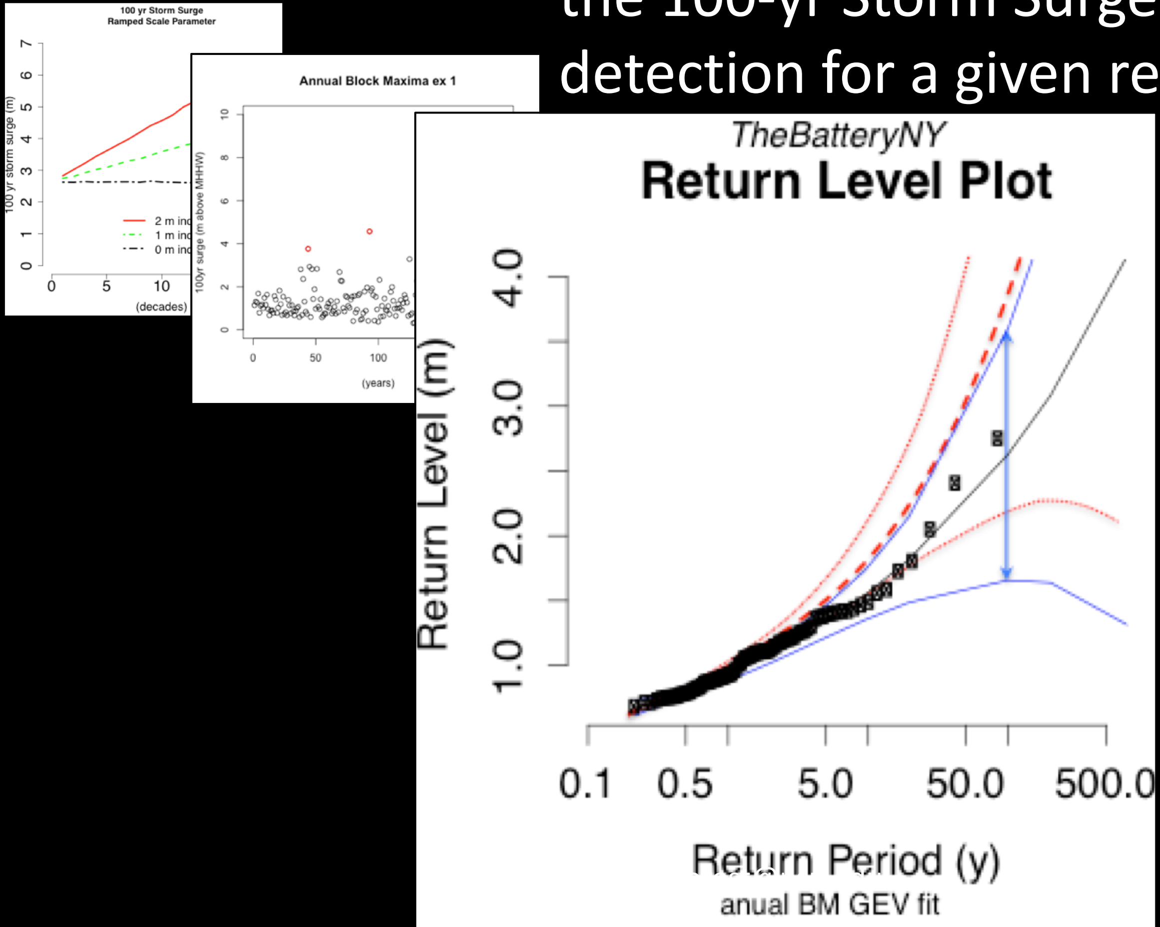
Prescribed an increasing 100-yr Storm Surge by varying the GEV parameters to define "Nature States"

Generate a single Storm Surge time series from a known "Nature State"

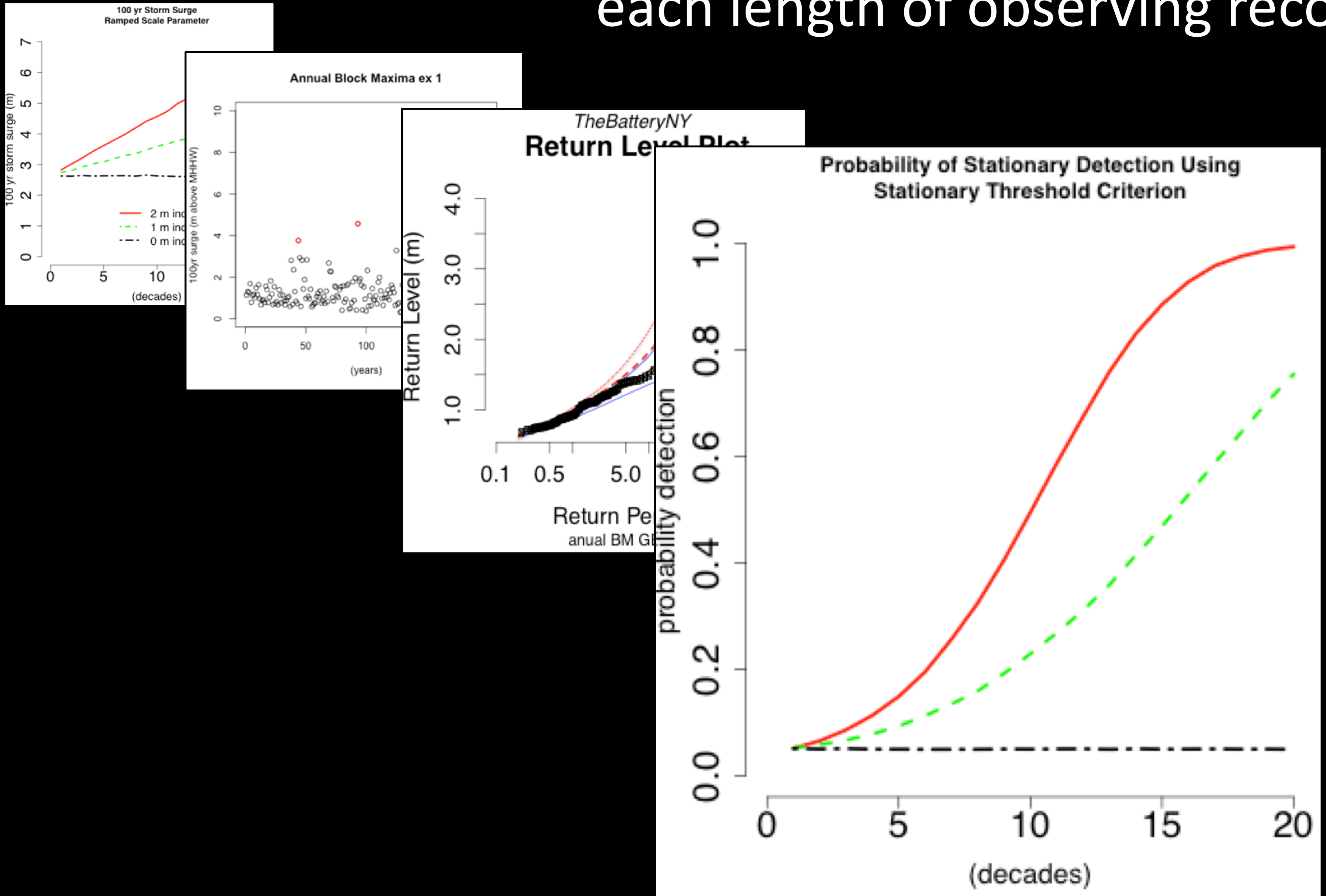


Contact: ceforest@psu.edu

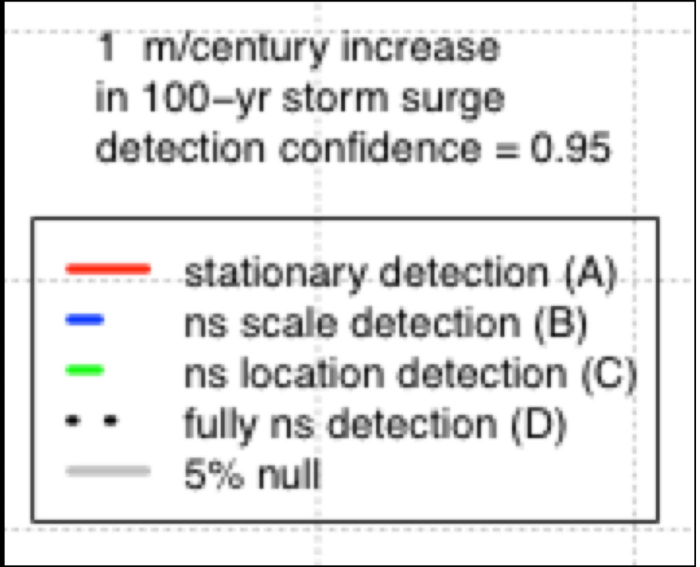
For each new "observation", we estimate the 100-yr Storm Surge and check for detection for a given record length

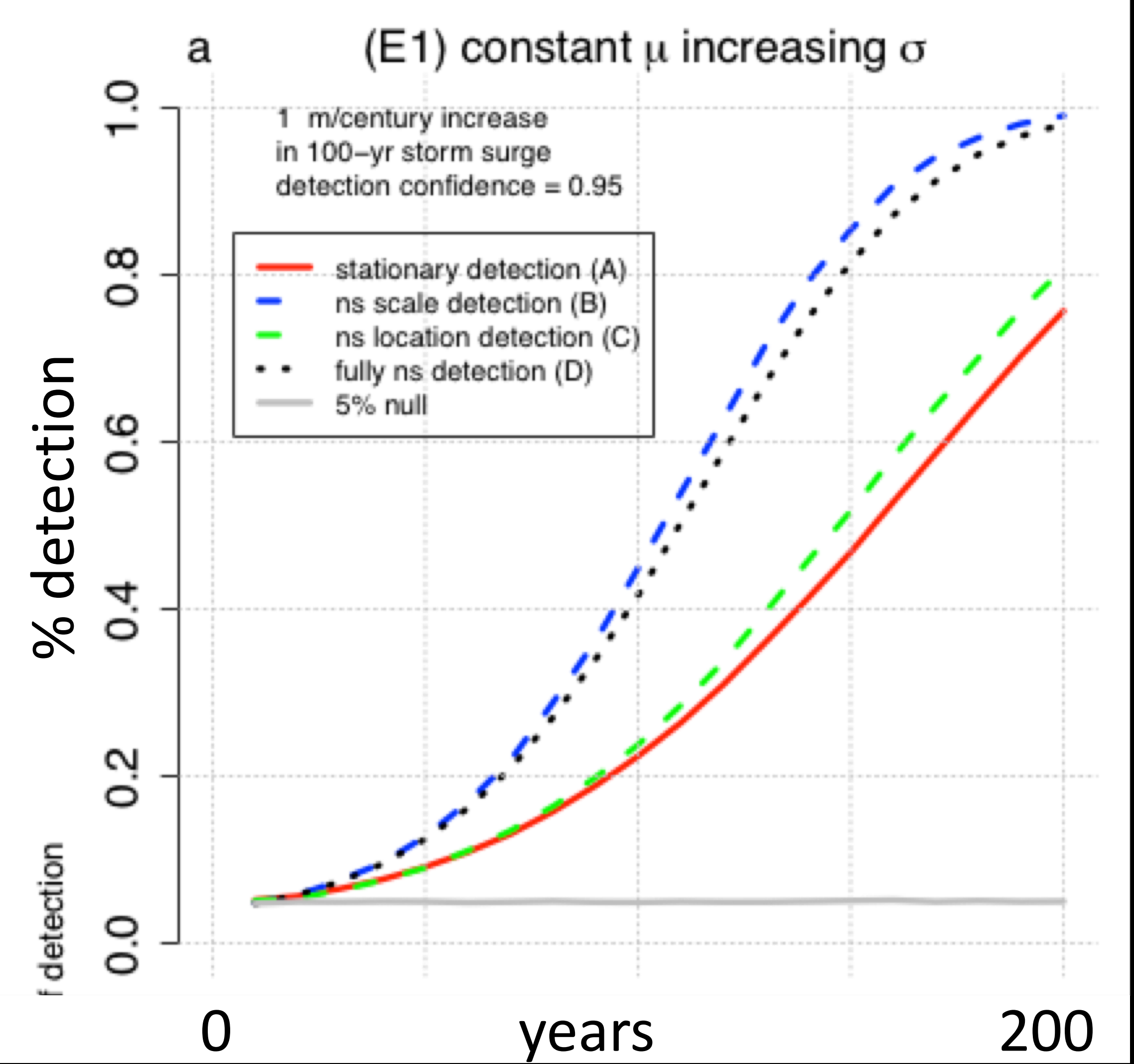


Generate detection statistics for each length of observing record

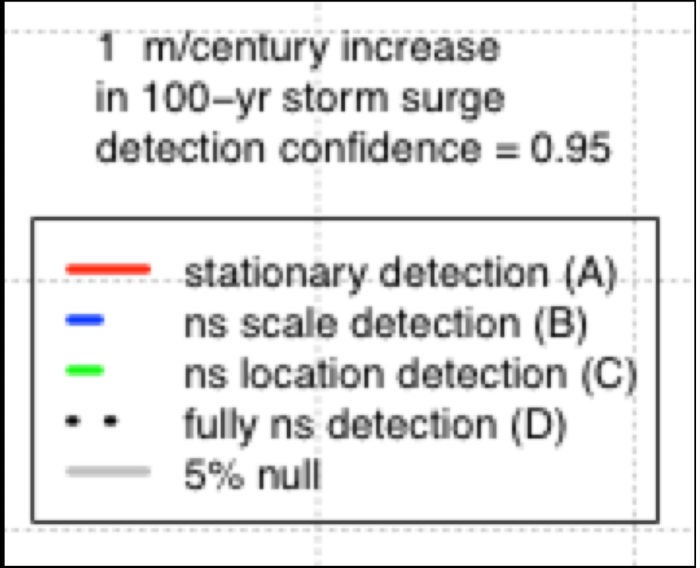


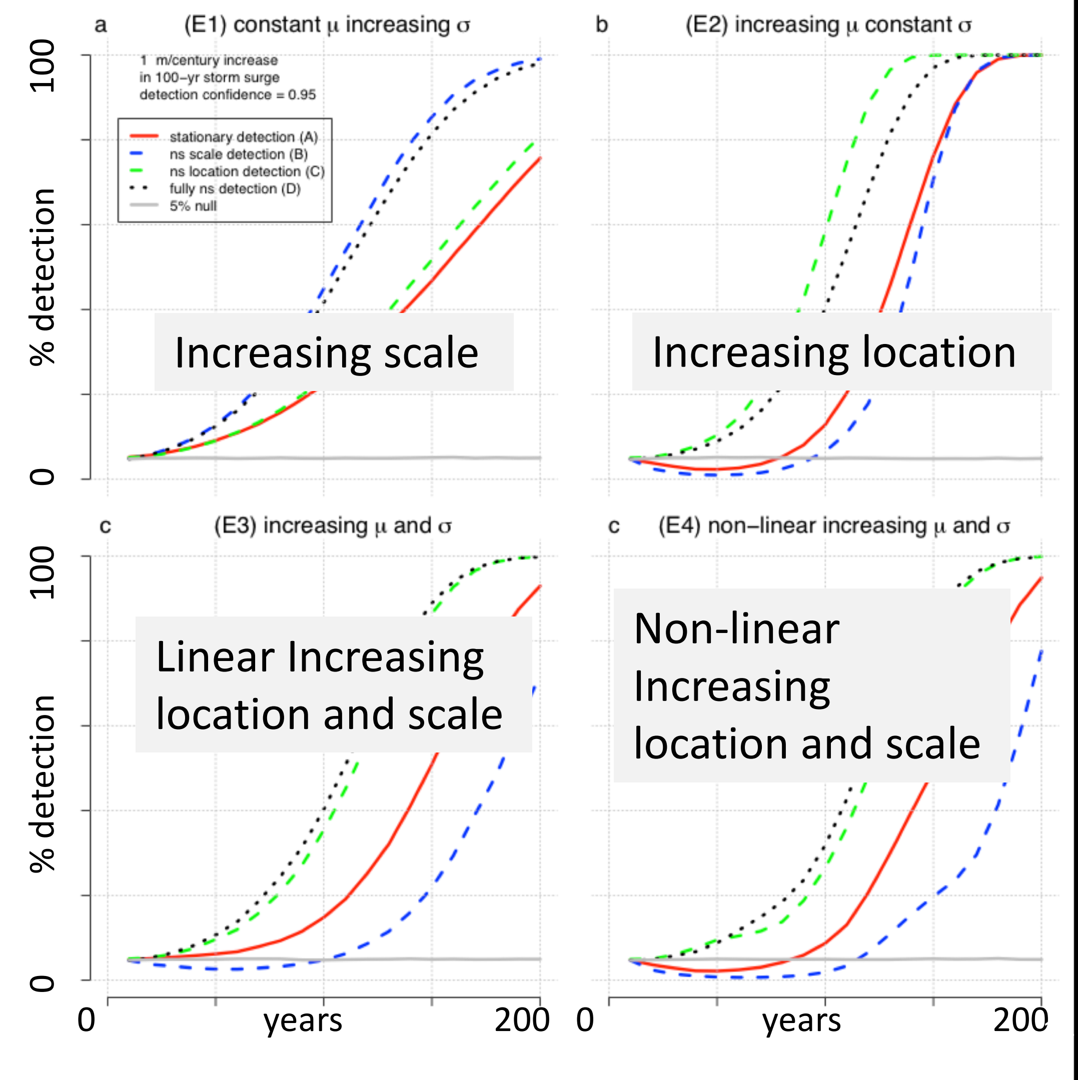
The Detection Model matters for success estimates





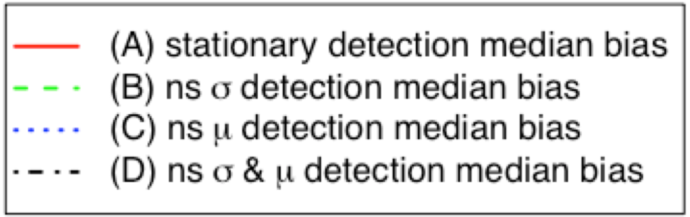
The Detection Model matters for success estimates

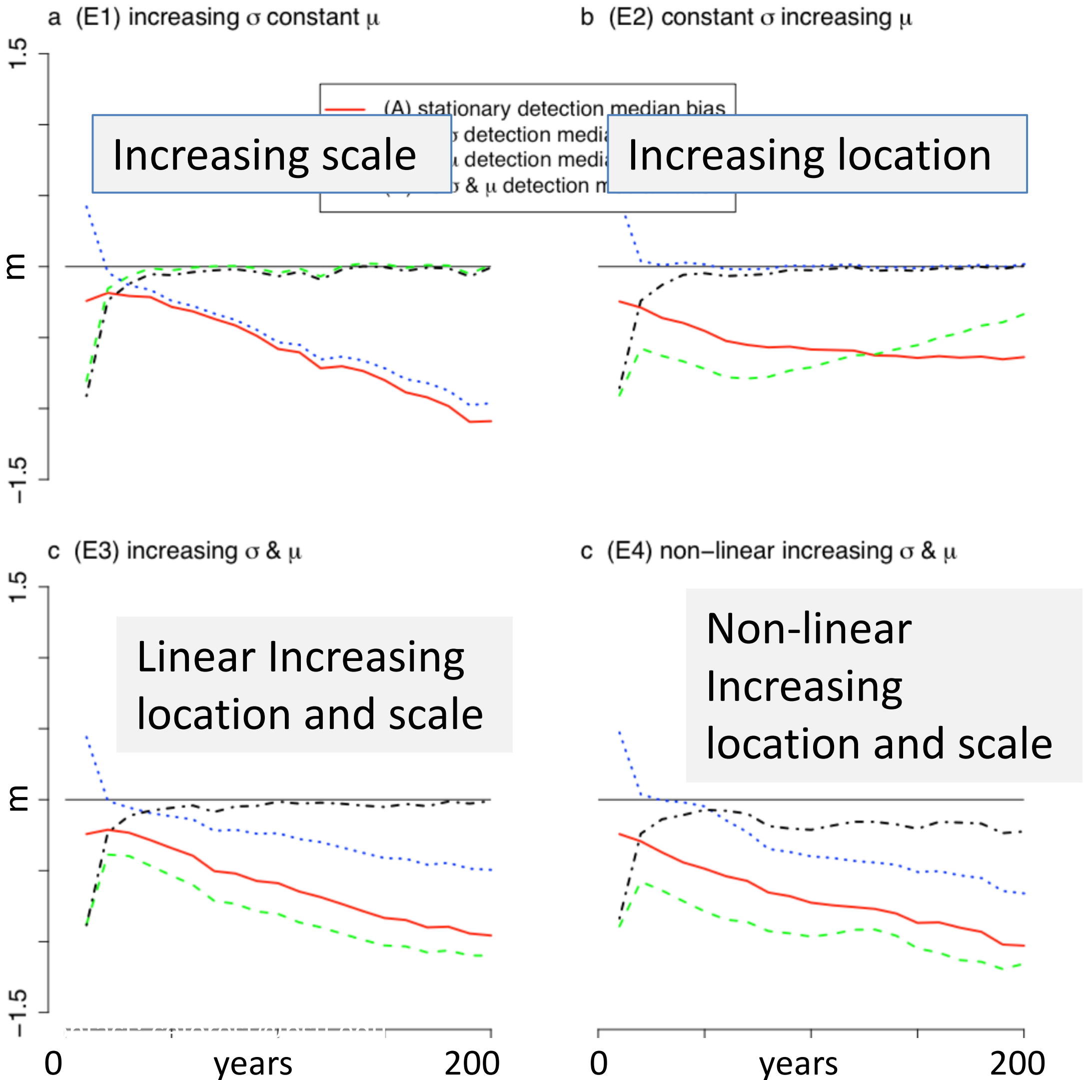




Do we estimate biases in detected median values?

Yes.





Conclusions

- We can detect changes to the hundred year storm surge, but…

- mismatch between the Nature State and the observation model biases our estimates, which,

- Introduces additional uncertainty that is usually not considered.

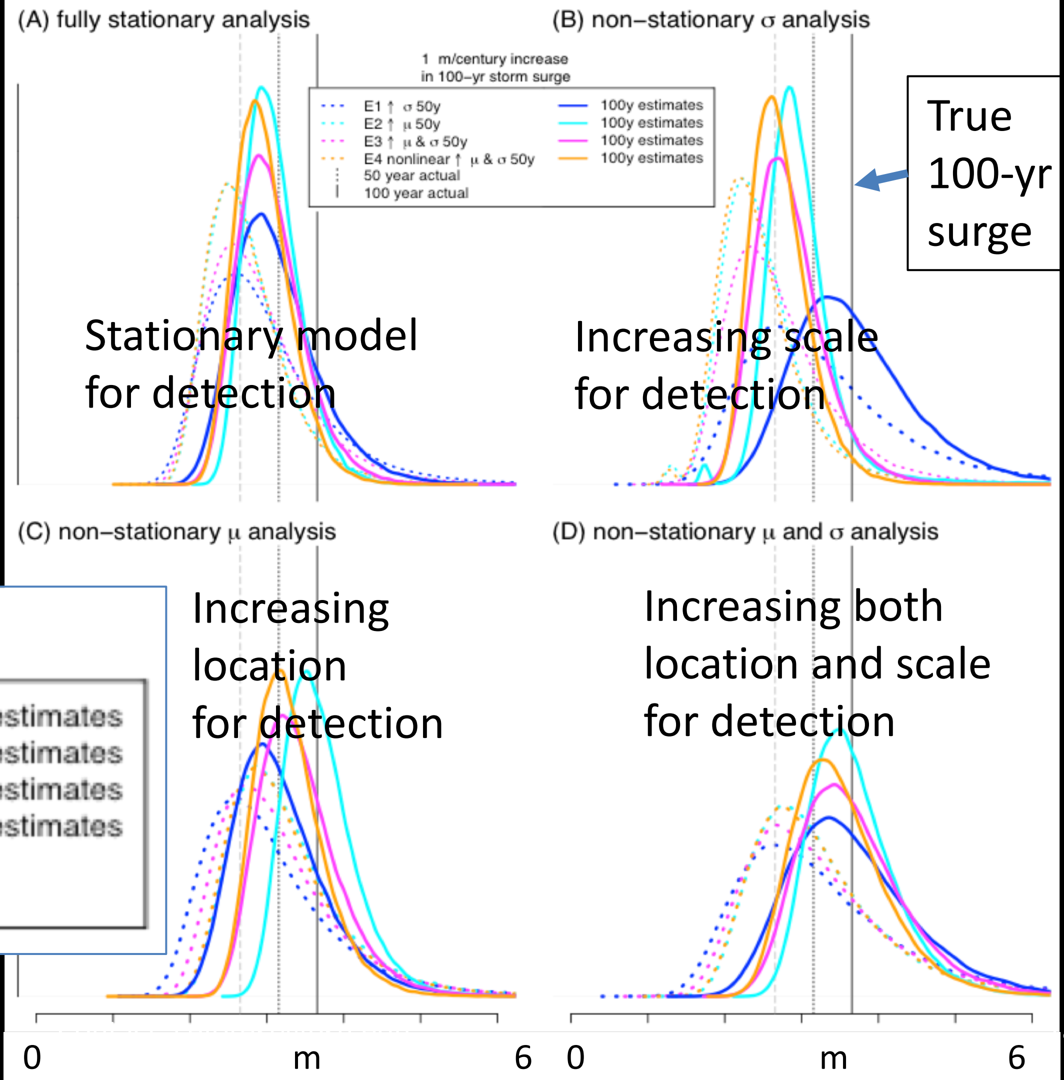
Contact: ceforest@psu.edu

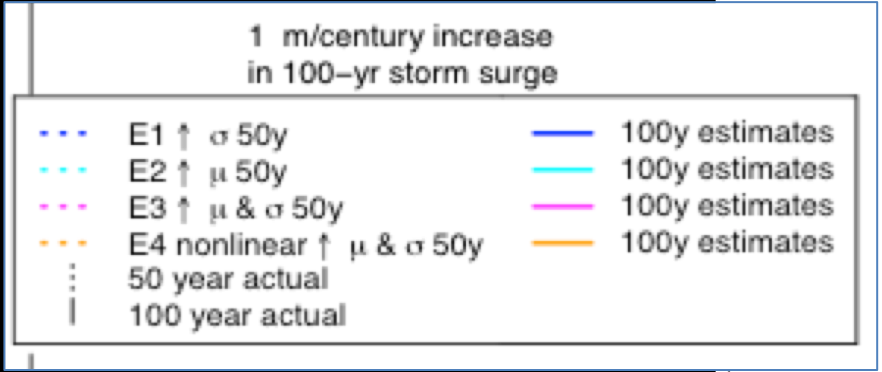
- Ceres, R.L., Forest, C.E. & Keller, K. Climatic Change (2017) 145: 221. https://doi.org/10.1007/s10584-017-2075-0

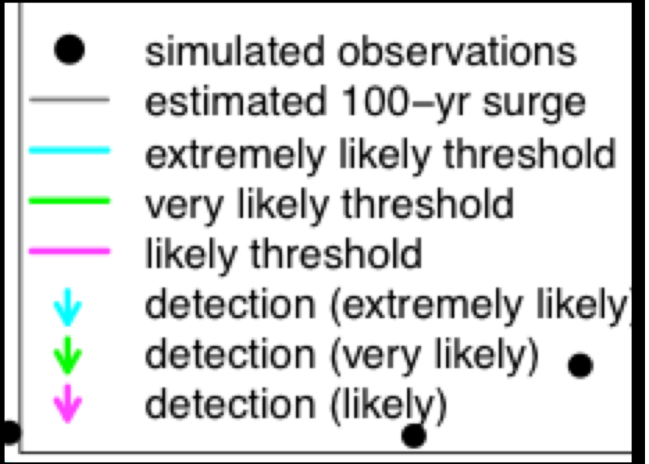
- Acknowledgements

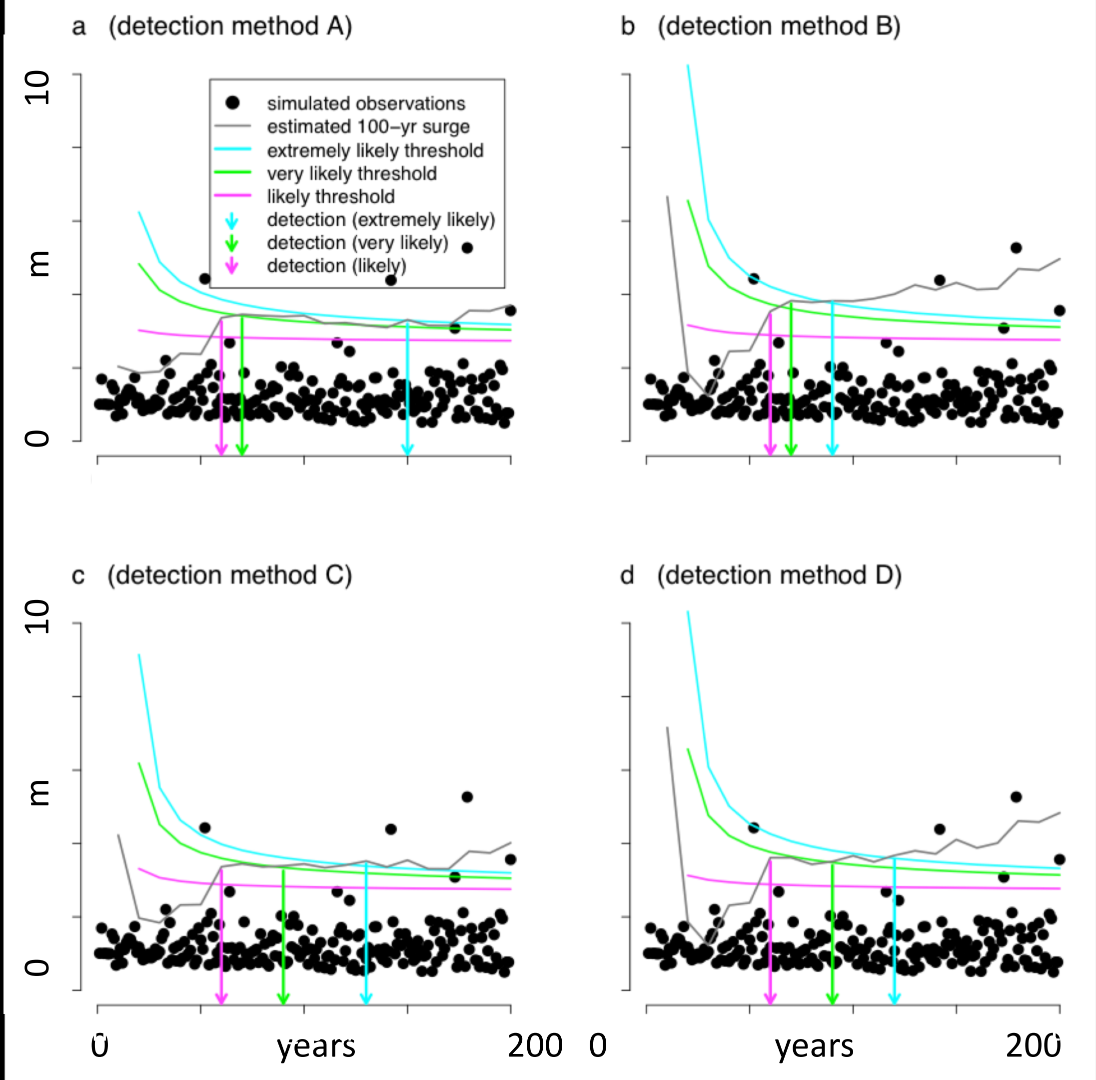
  - M. Tingley, M. Haran, B. Lee, G. Garner, and R. Lempert for many useful discussions.
  - This research was partially supported by the National Science Foundation (NSF) through the Network for Sustainable Climate Risk Management (SCRiM) under NSF cooperative agreement GEO-1240507 and the Penn State Center for Climate Risk Management. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

And…
We also estimate biases in detected values.






simulated observations
estimated 100–yr surge
extremely likely threshold
very likely threshold
likely threshold
detection (extremely likely)
detection (very likely)
detection (likely)


a (detection method A)
b (detection method B)
c (detection method C)
d (detection method D)
simulated observations
estimated 100–yr surge
extremely likely threshold
very likely threshold
likely threshold
detection (extremely likely)
detection (very likely)
detection (likely)
10
m
0
0
years
200