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The State of the Art and Science of Coastal Engineering

A Design-Life Based Approach To Multi-Hazard Risk Analysis

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Outline

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2. Approach
3. Methodology
4. Results: Meteorological and Sea Level Rise Risk
5. Results: Tsunami and Sea Level Rise Risk
6. Discussion
7. Conclusion

Motivation:

What natural hazards will impact California small craft harbors in the future?

TSUNAMI
(E.G. CURRENT SPEED)
(SEE KEEN ET AL., 2017)

TSUNAMI
(E.G. SURFACE ELEVATION);
METEOROLOGICAL; SEA LEVEL RISE

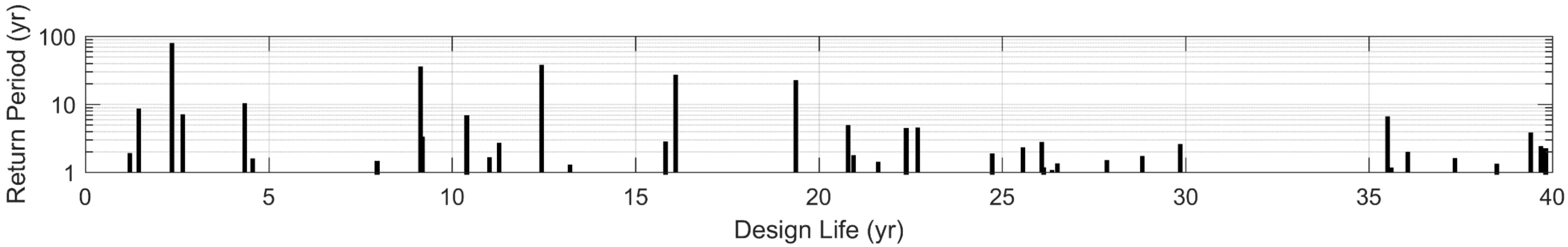
WINTER SWELL; HARBOR RESONANCE

Approach:

Meteorological water level, **tsunami (e.g. surface elevation)** and **sea level rise** will all impact a harbor at various points during the harbor's service life.

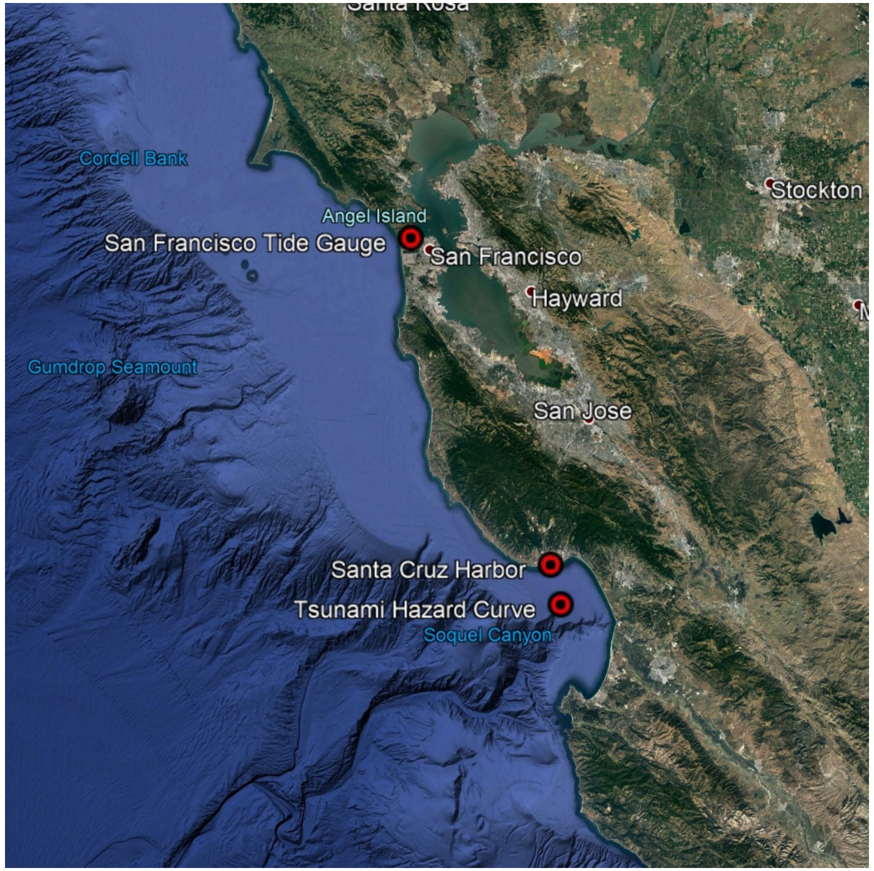
Let's consider how these 3 hazards are distributed over the harbor's design life (***i.e. hazard***), how the events impact the harbor (***i.e. vulnerability***), and the cumulative consequences (***i.e. risk***).

Assuming a random distribution of events, we can generate a time series of extreme events within a harbor's design life. Assessing the hazard at each time and iterating will help quantify multi-hazard specific risk over the design life.

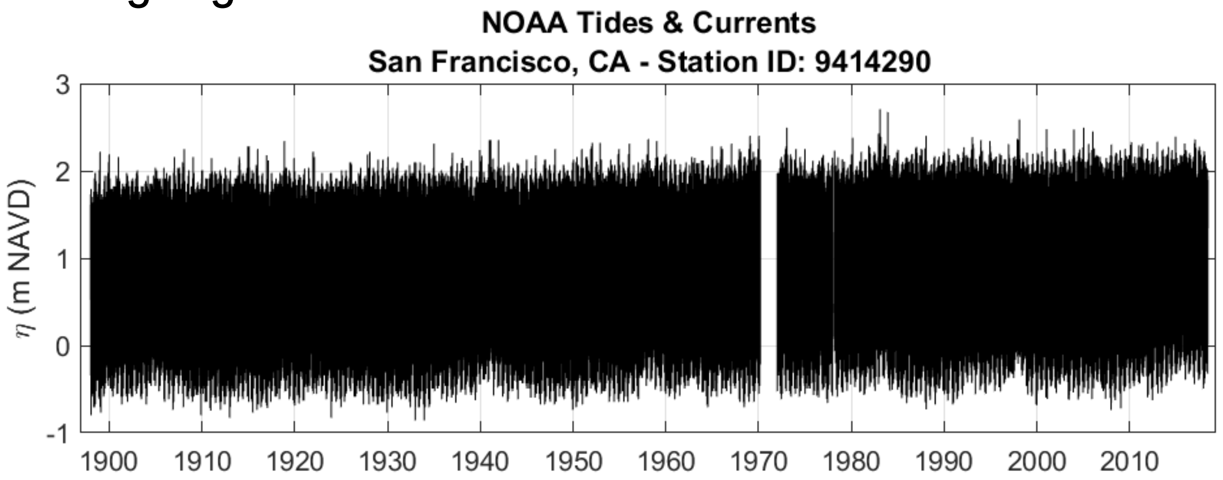


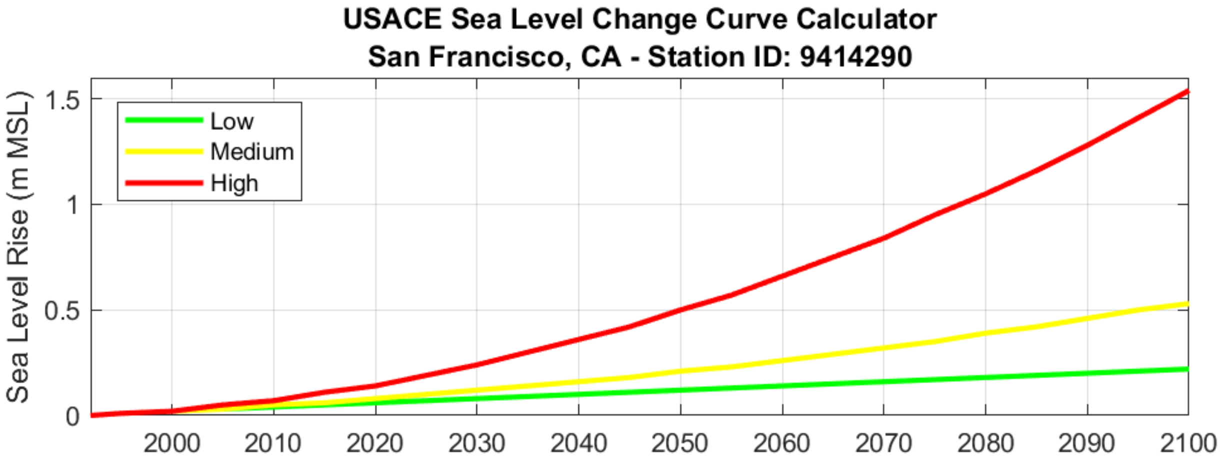
Case Study: Santa Cruz Harbor

Let's compare **meteorological water level, tsunami** and **sea level rise** risk for Santa Cruz Harbor. But first we need to decompose a tide gauge!



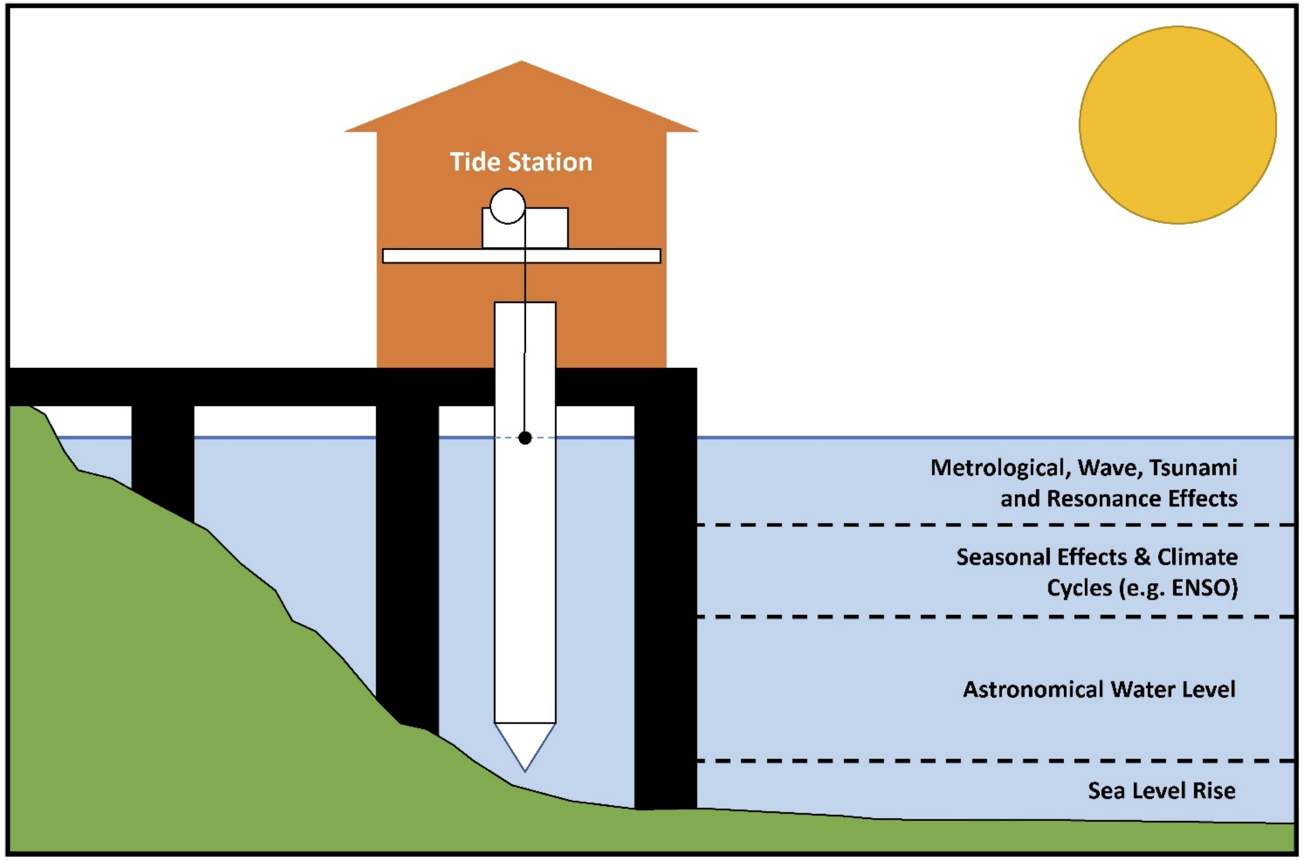
Source: Google Earth





What’s contained in an NOAA tide gauge?

1. Astronomical water level
2. Seasonal effects & climate cycles (e.g. ENSO)
3. Meteorological water level
4. Wave effects
5. Historical tsunami
6. Historical sea level rise



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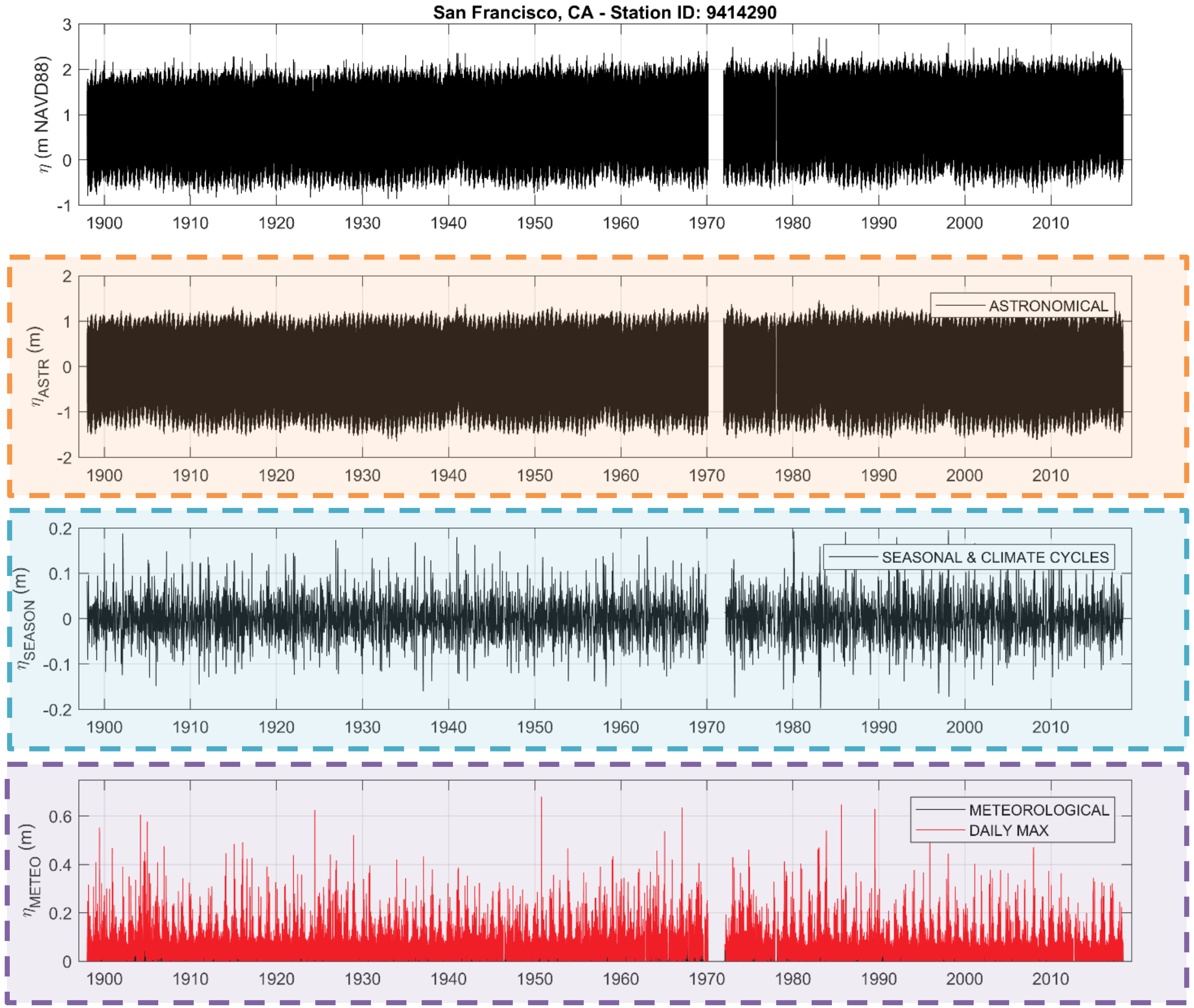
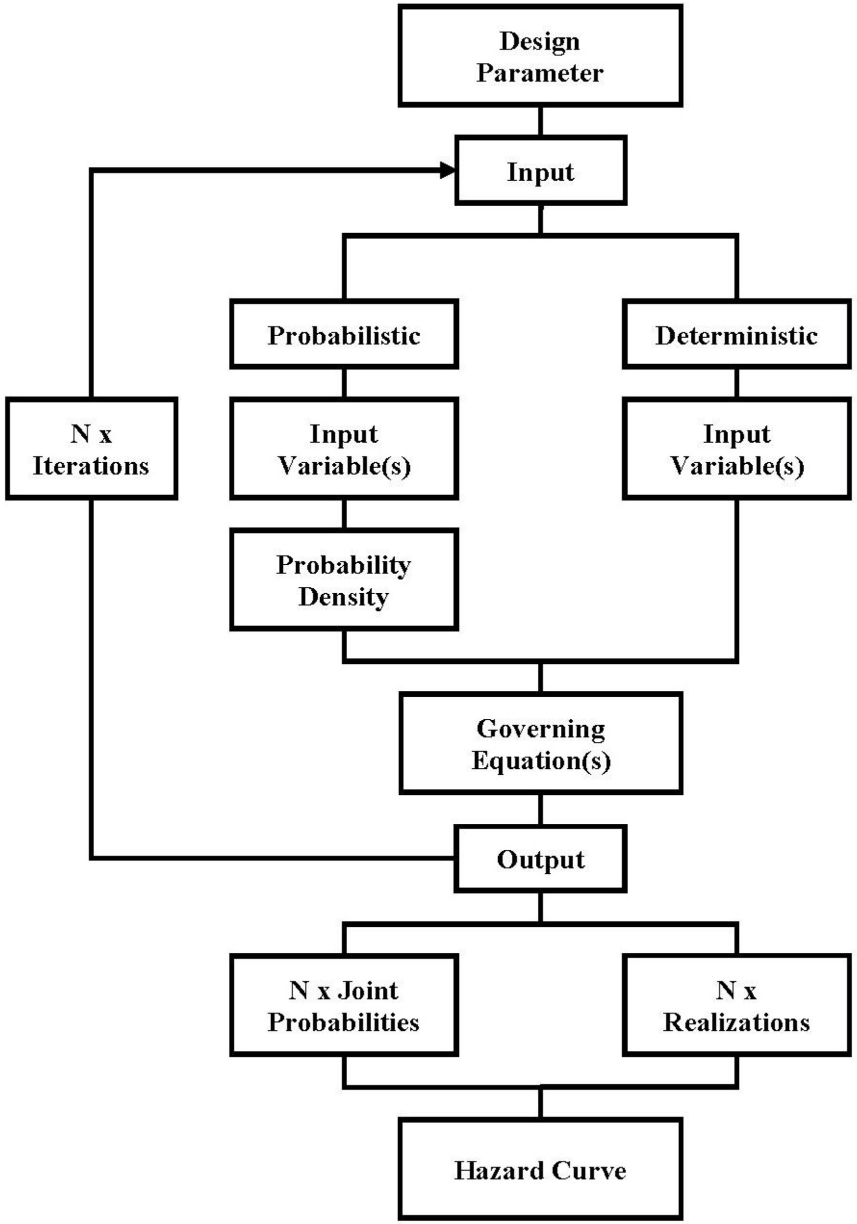
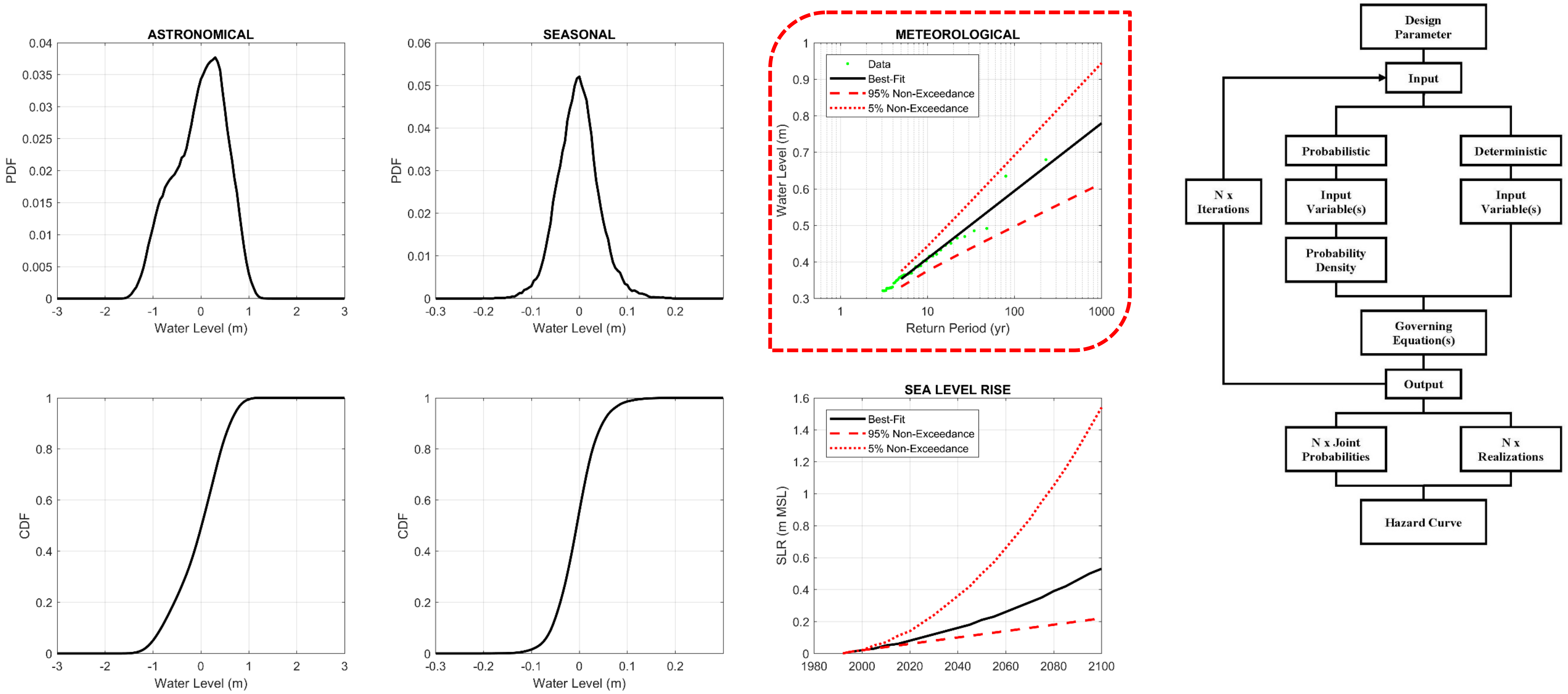


Probabilistic *Hazard* Estimate

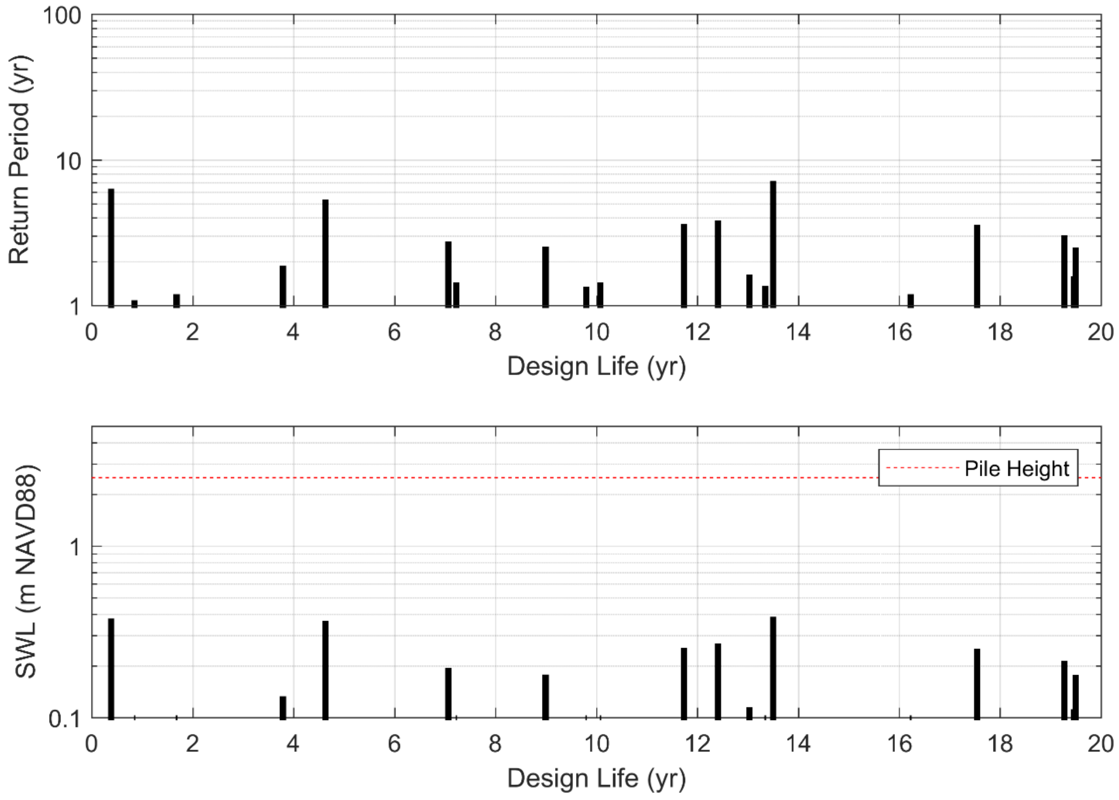
- Geist and Parsons (2006) & Geist and Lynett (2014)
- Probabilistic analysis of hazard (PHA) provides a means to incorporate natural uncertainties, model uncertainties and errors into the hazard assessment
- To do this, we conceptually separate a "return period storm" and a hazard "recurrence period"
- So… for a metocean-determined storm return period there is really a distribution of possible impacts that a unique "return period storm" might cause

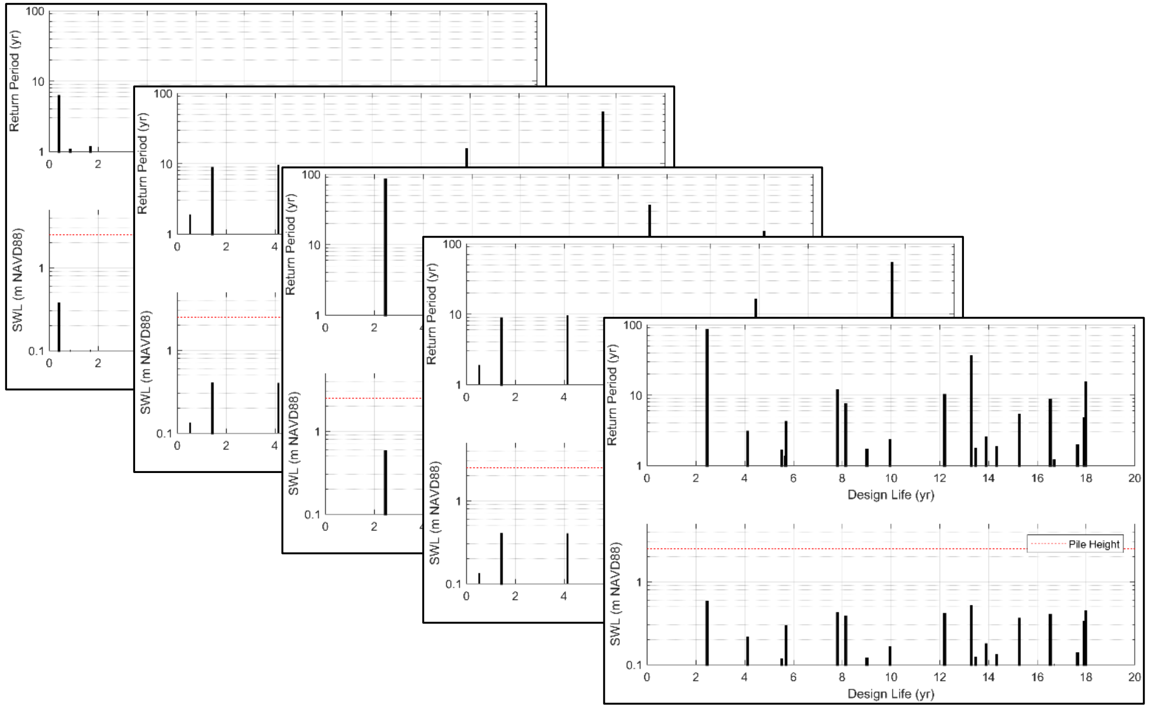


Meteorological and Sea Level Rise *Hazard*: A Monte Carlo Based Approach



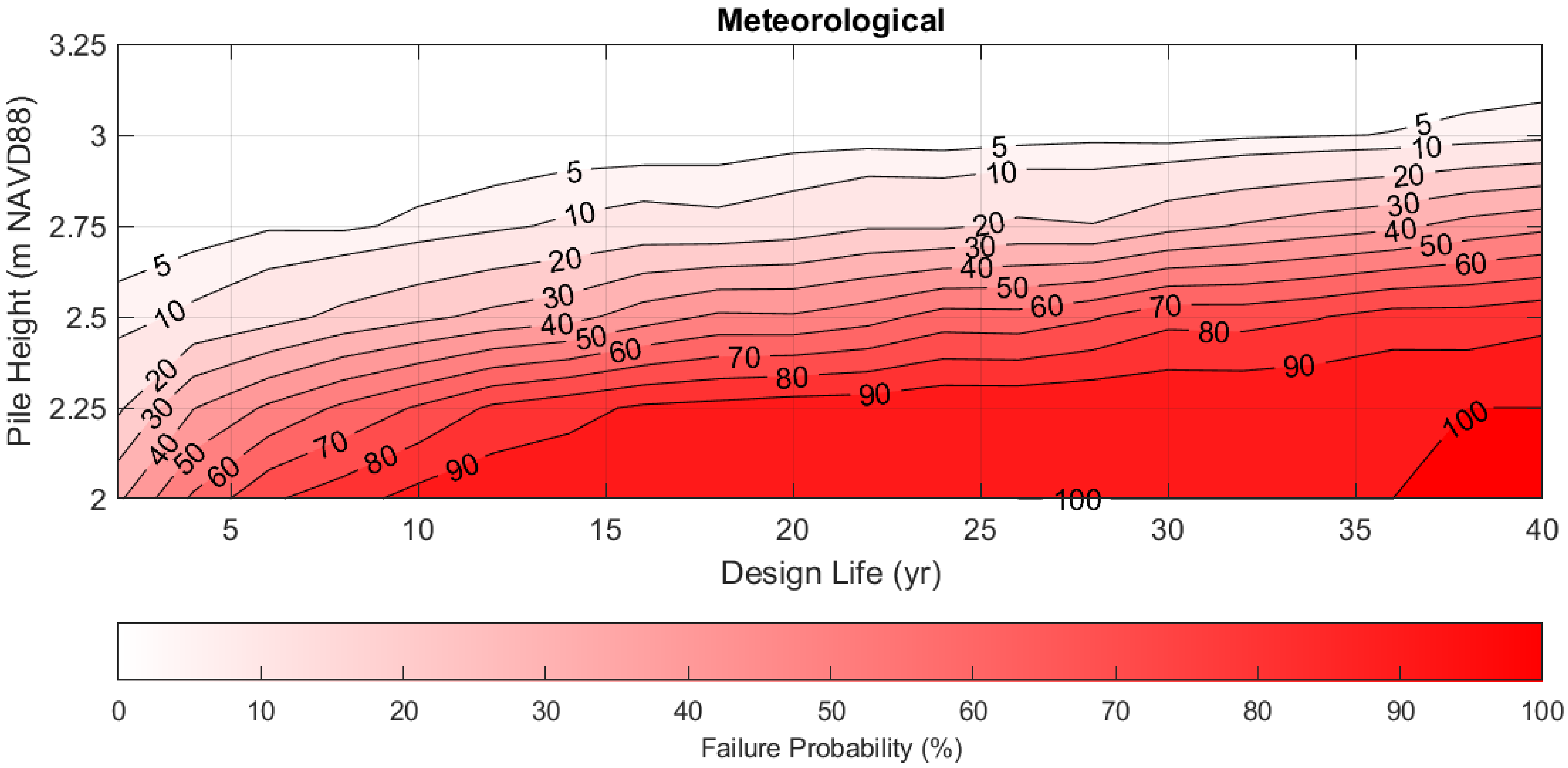
Meteorological and Sea Level Rise *Risk*: A Monte Carlo Based Approach



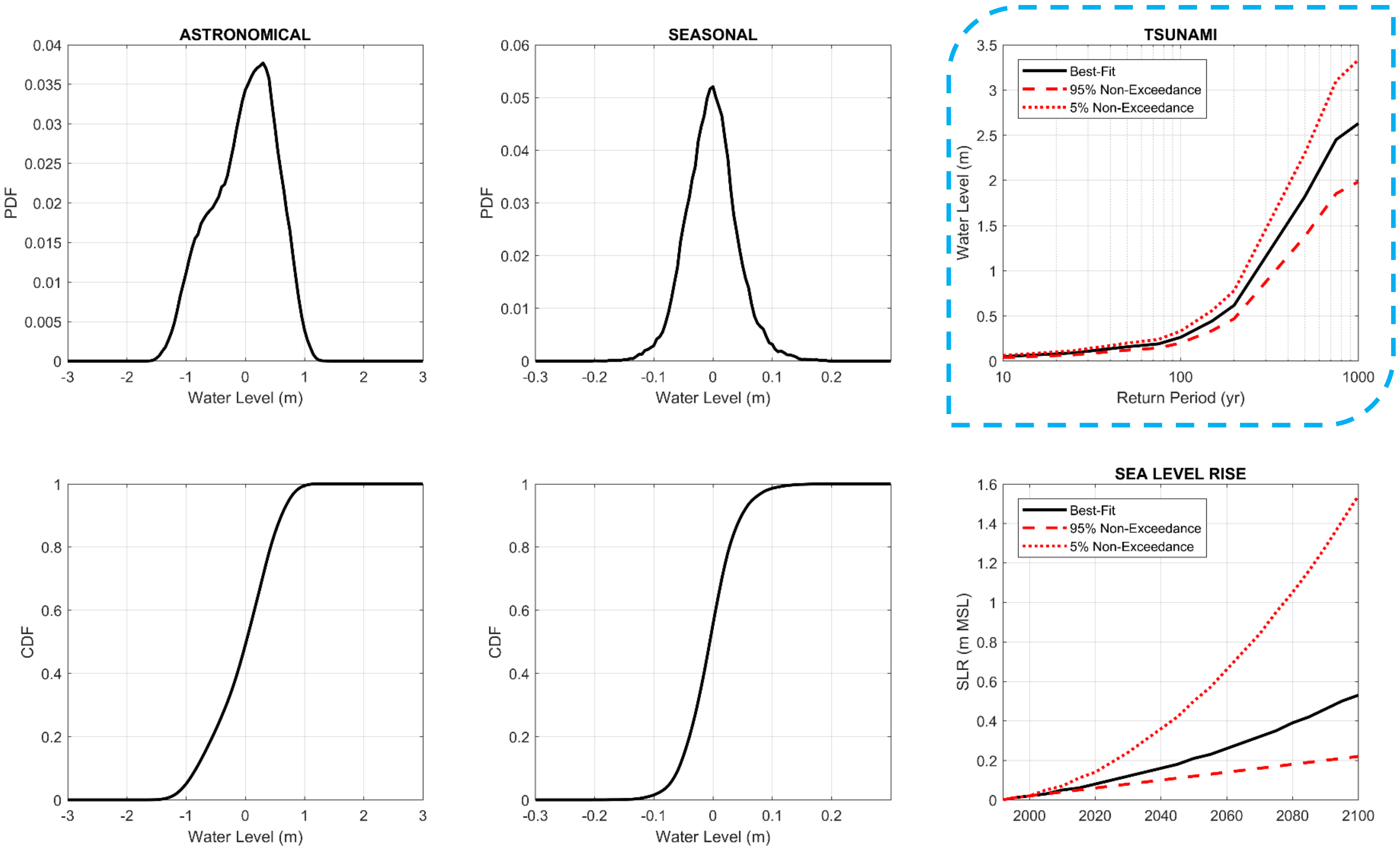


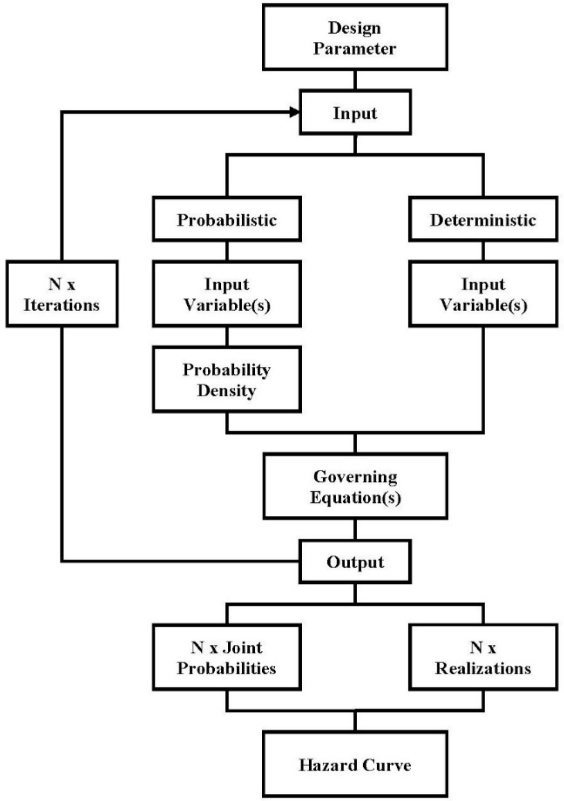
Results:

Meteorological and Sea Level Rise *Risk* (Failure Probability)



Tsunami and Sea Level Rise *Hazard*: A Monte Carlo Based Approach





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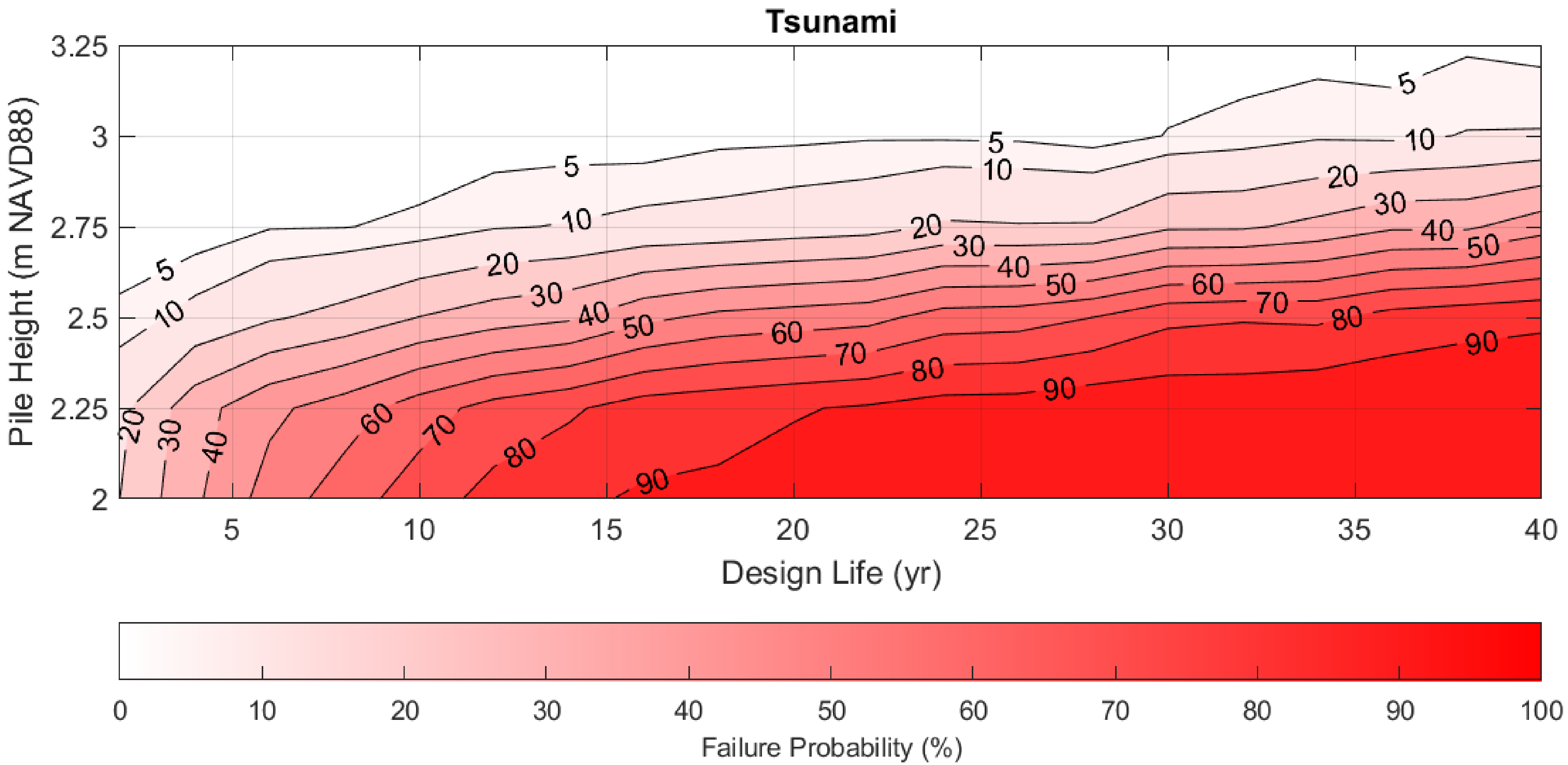
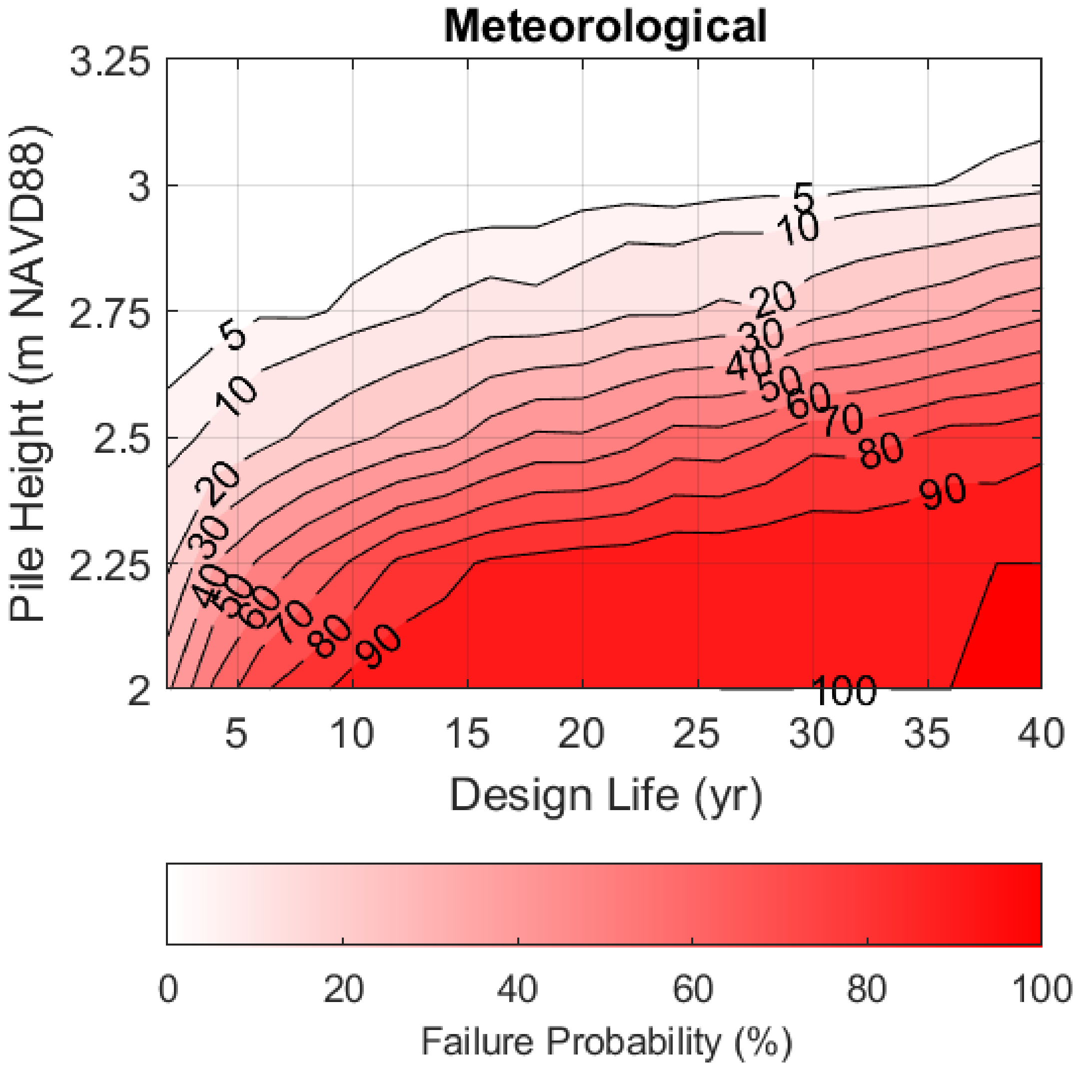
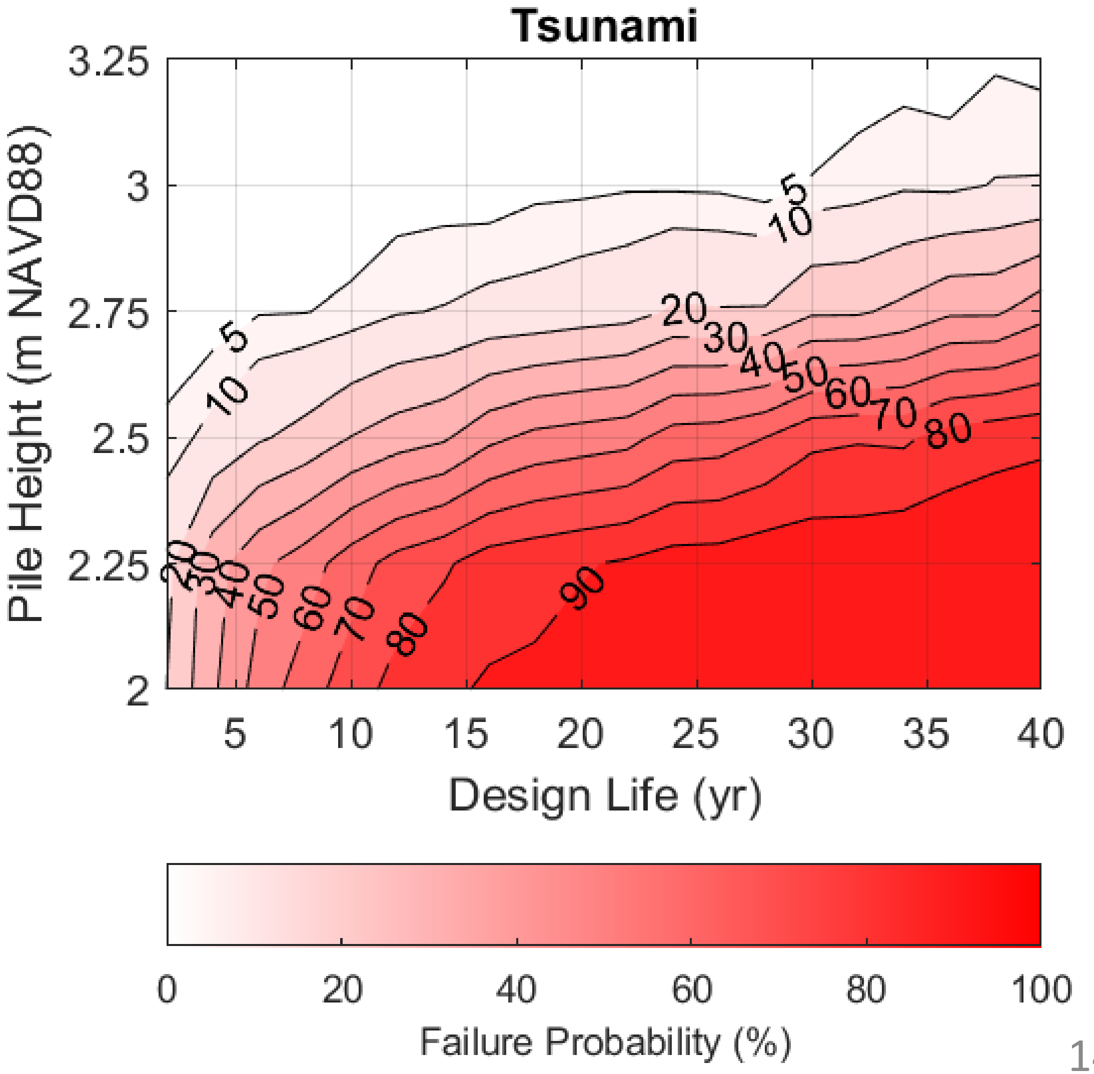


Results:

Meteorological, Tsunami and Sea Level Rise *Risk* (Failure Probability)



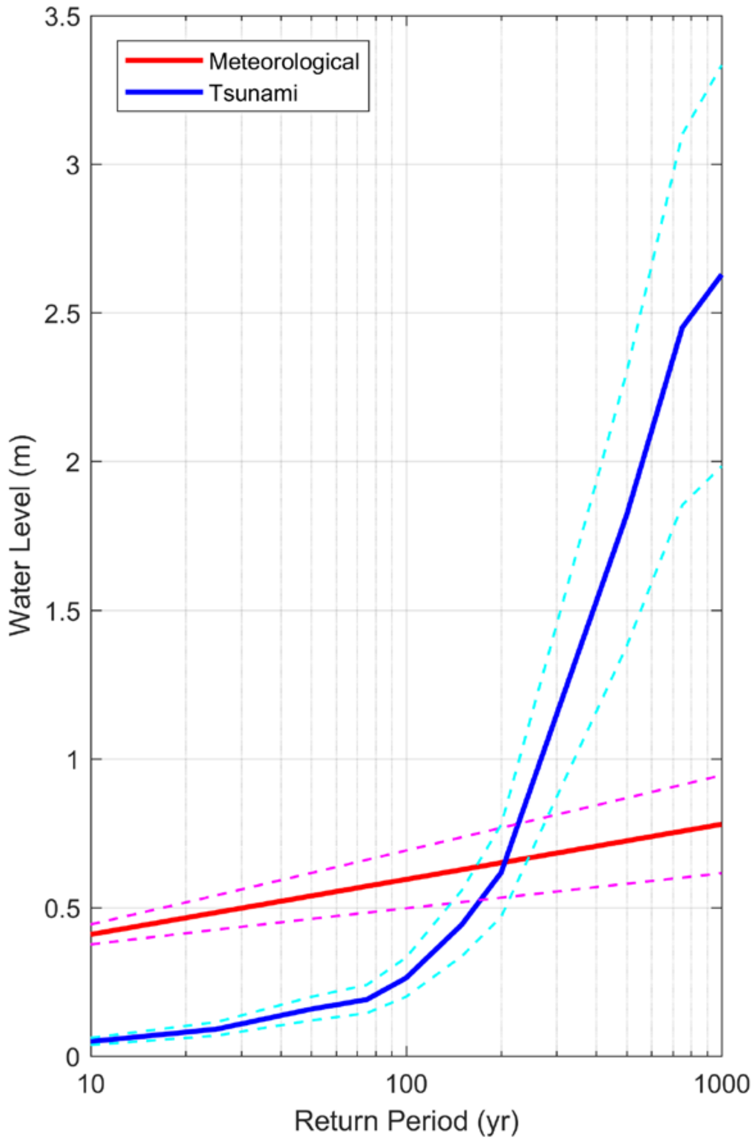


Discussion:

- Methodology identifies differences in **meteorological** vs. **tsunami** risk during a harbor's design life.
  1) 1st half – **meteorological** risk > **tsunami** risk
  2) 2nd half - **tsunami** risk > **meteorological** risk
  3) **Sea level rise** increases relative risk of hazards

- Design life approach can be generalized to a variety hazard/vulnerability relationships.

- Method does not consider "recovery" but could be included for hazards where failure is not binary (**i.e. tsunami current speed**).



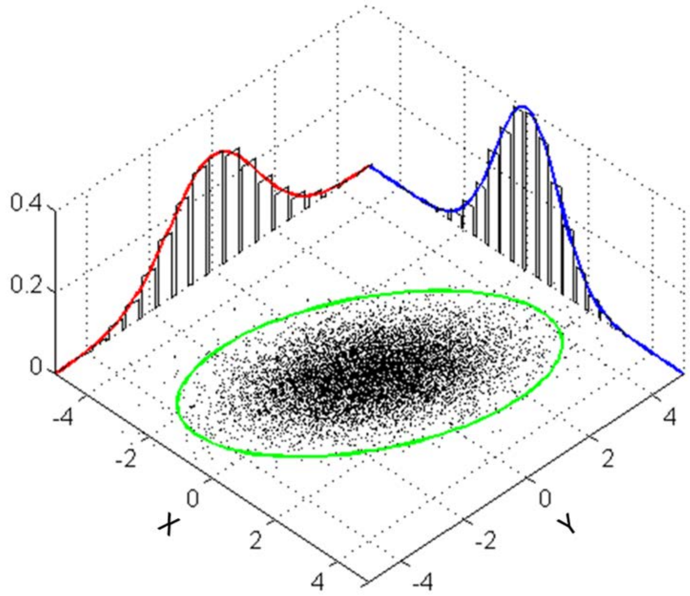
Conclusion:

- **Motivation**: What natural hazards will impact California small craft harbors in the future?

- **Approach**: Generate a time series of extreme events within a harbor's design life. Assessing the ***hazard*** at each time and iterating will help quantify multi-hazard specific ***risk*** over the design life.

- Methodology identifies differences in **meteorological** vs. **tsunami** risk during a harbor's design life. **Sea level rise** increases relative risk of hazards.

- Design life approach can be generalized to a variety ***hazard/vulnerability*** relationships to identify ***risk***.



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