
# Valuing Flexibility and Soft Instruments

## *for Sequential Decision Problems*

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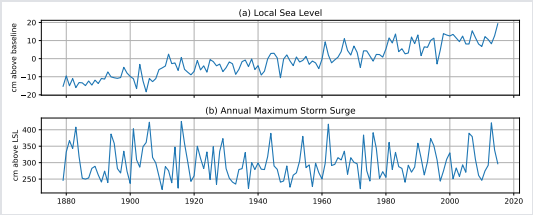
Applications to Energy and Infrastructure Planning

# Motivation

1. Static, not scalable (see Ansar et al., 2017)
2. Long-term performance sensitive to deep, dynamic uncertainties
3. Near-term performance sensitive to potentially predictable drivers

📷: Jonas de Carvalho on Wikipedia 🅭🅯, NAVFAC on Flickr 🅭, Bert Knottenbeld on Flickr 🅭🅯.

# Coastal adaptation under deep, dynamic uncertainty



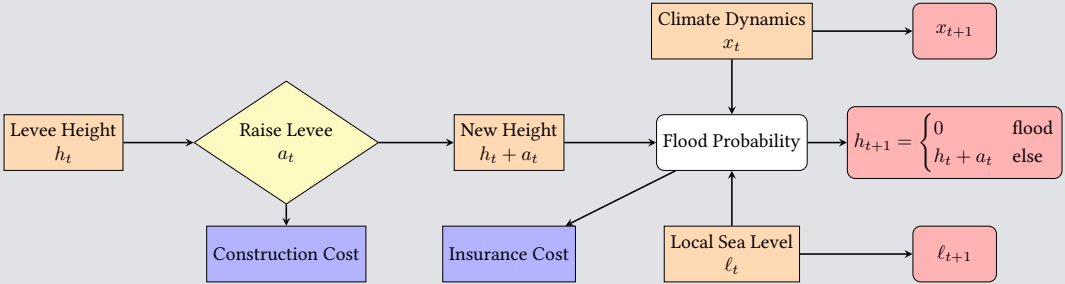

Historical flood data at Delfzijl, Netherlands from Oddo et al. (2017)

How high to raise the levees to minimize (a) cost of construction (b) insurance premium of residual risk (van Dantzig, 1956)

Sea level simulations from DeConto and Pollard (2016) and Kopp et al. (2014, 2017)

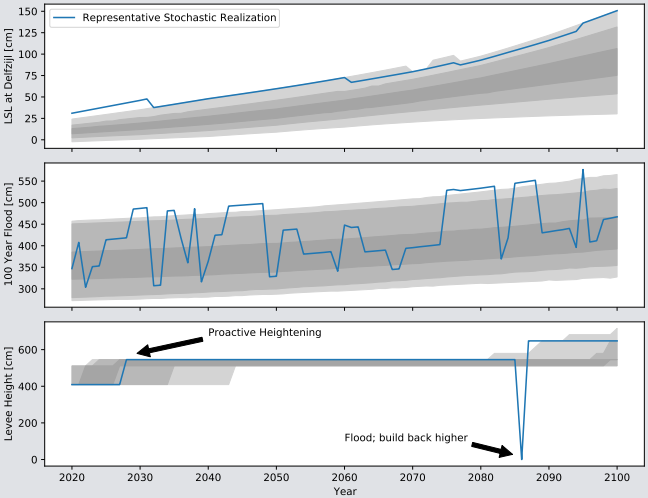
# Model schematic

Simple model ➔ computationally cheap ➔ optimize many times

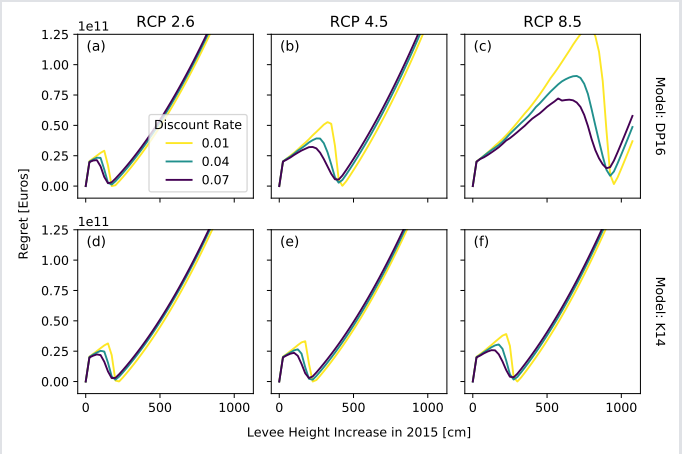



Discrete DP formulation with key inputs: (i) sequences of local sea level; (ii) symmetric Markov process for $x$; (iii) net discount rate.

# Large, distant, uncertain risks ≠ need for immediate structural investment



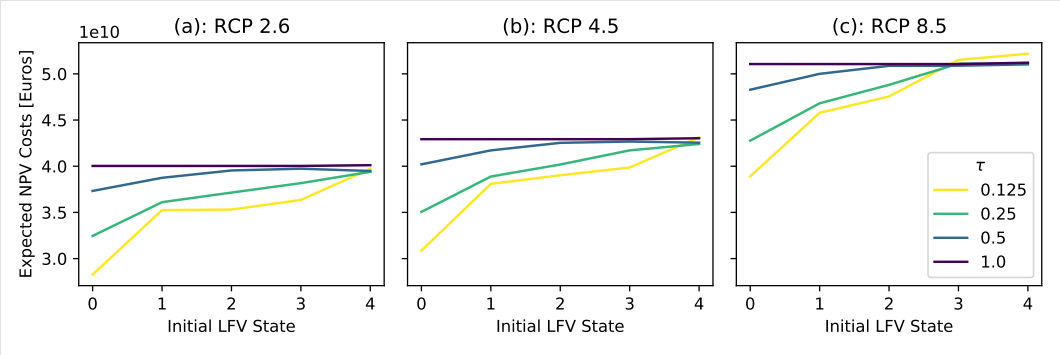
# The most robust decision today? Wait.




Difference between expected long-term costs and those of optimal decision, as a function of levee height increase in 2020, under model structure uncertainty.

$\tau = 1.0,\ x_0 = 4.$

# Climate predictability ↑ long-term costs ↓




Expected discounted total costs over the adaptation pathway as a function of RCP scenario, initial LFV state, and degree of climate predictability ($\tau$).
K14 physics, 4% discount rate.

# Conclusions

1. Static instruments optimized for one scenario perform poorly in others
2. Despite large SLR eventually, the investment decision dominated by near-term risks
3. Increased medium-range climate predictability enables more precise tailoring of soft instruments, lowering long-term costs
4. Static investments must meet near-term needs, not just long-term ones

# Next steps

**Applications** Instant construction is a strong assumption – more valid for building scale adaptation (e.g., home elevation; Zarekarizi et al., 2020)

**Engineering** Design systems that are intrinsically scalable

**Science** Improved seasonal to decadal (S2D) prediction

**Decisions** Optimization / policy search under model structure uncertainty

# Thanks to...

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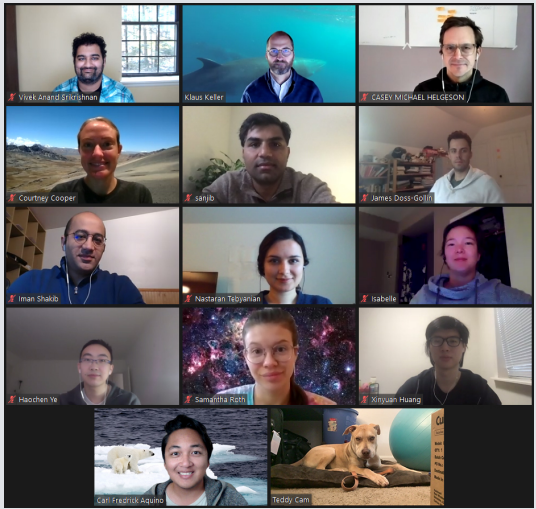
PSIRC Penn State Initiative for Resilient Communities



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## Thanks for your time!

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