

Response-Based Risk Assessment of Tropical Cyclone induced coastal flooding due to Storm Surge and Waves

Pablo Alonso-Alguacil¹, Beatriz Pérez-Díaz¹, Alba Ricondo², Laura Cagigal¹,
Fernando Méndez¹, Sonia Castanedo¹

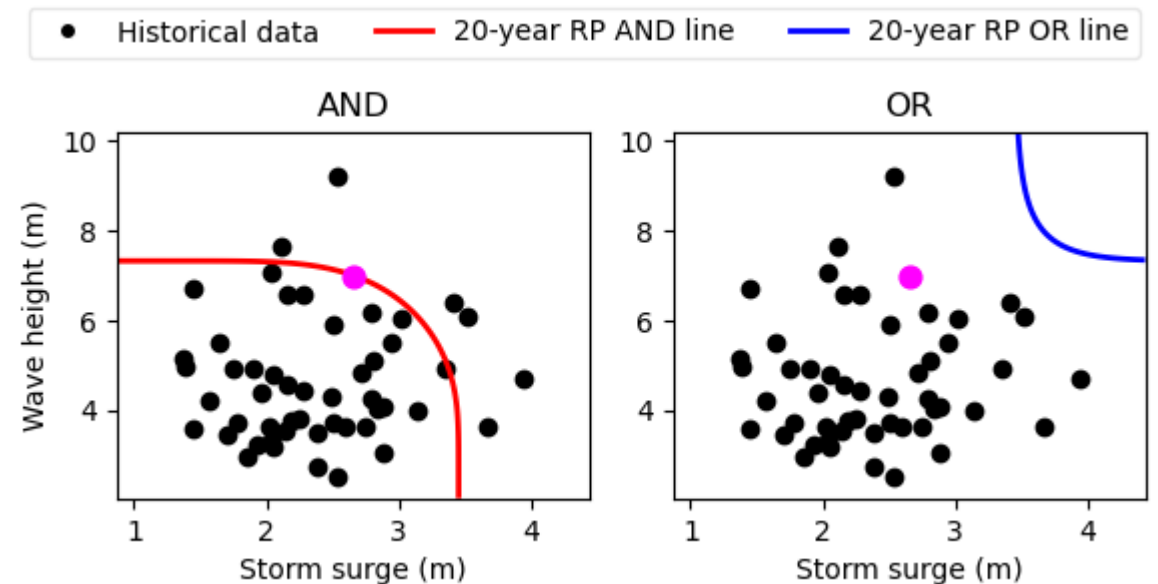
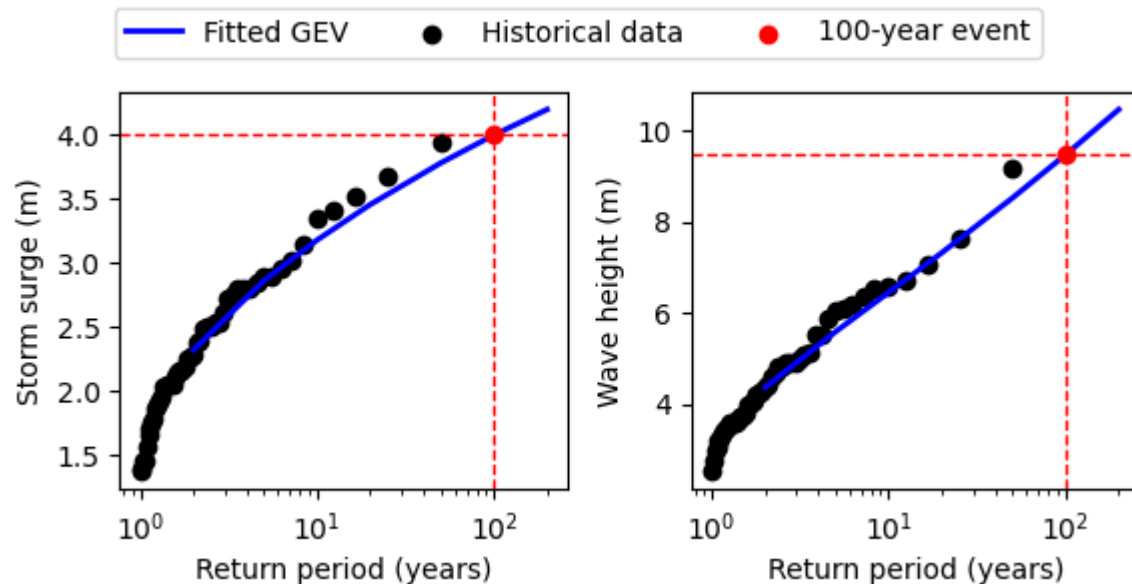
1. Universidad de Cantabria, Santander, Spain
2. Oregon State University, Corvallis, USA

Develop a **probabilistic response-based** framework to assess TC flood risk

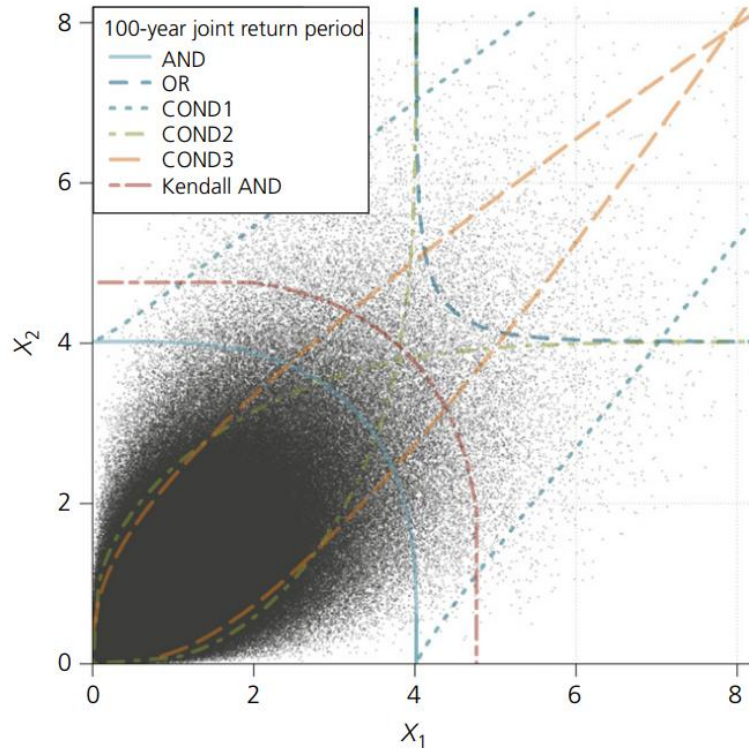
Traditionally, we design structures to withstand a 100-year RP event



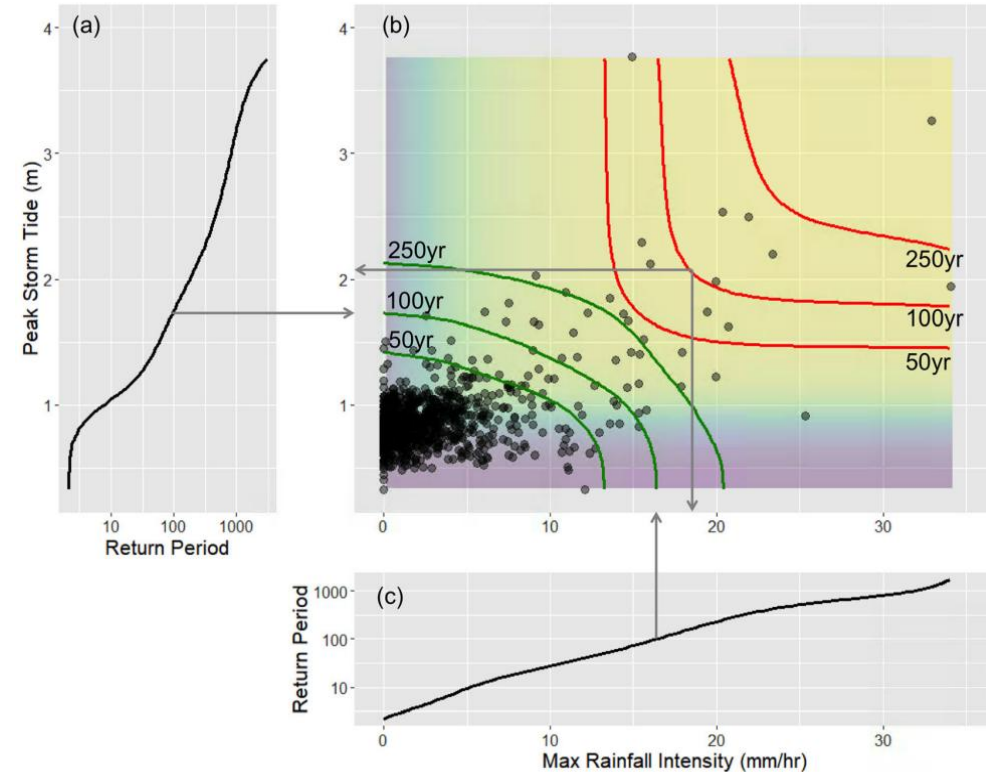
But reality is more complex than the univariate case



Develop a **probabilistic response-based** framework to assess TC flood risk



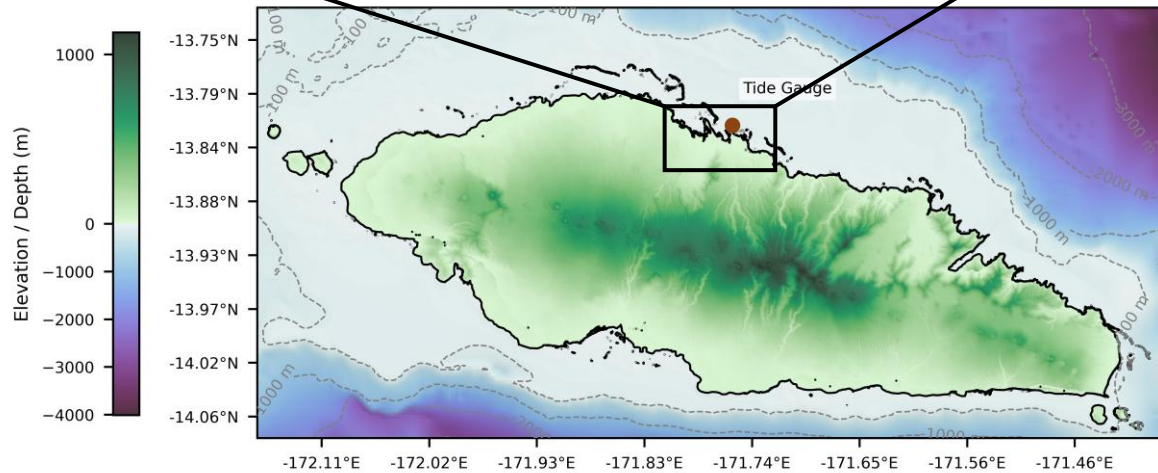
Gouldby et al., 2017 - Multivariate extreme value modelling of sea conditions around the coast of England



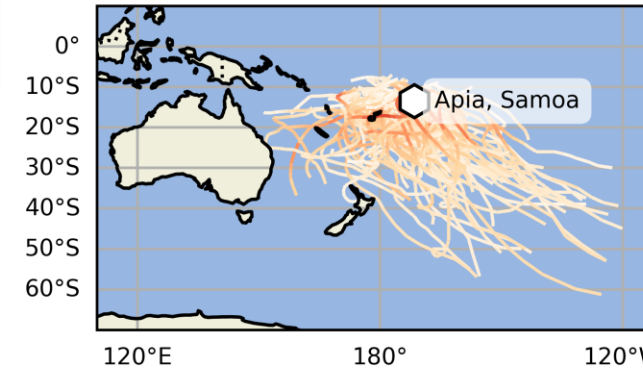
Gori et al., 2020 - Tropical Cyclone Compound Flood Hazard Assessment: From Investigating Drivers to Quantifying Extreme Water Levels

Study Site

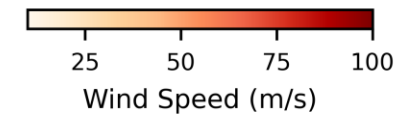
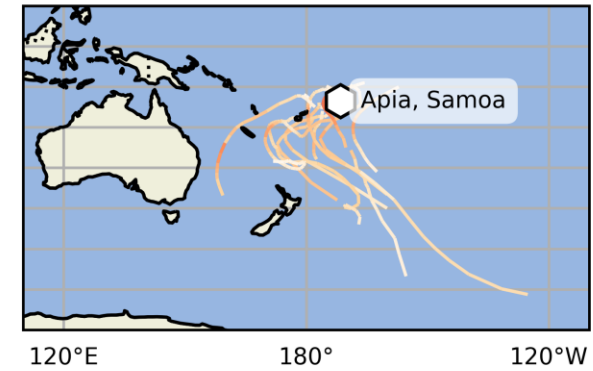
PCRAFI 2013



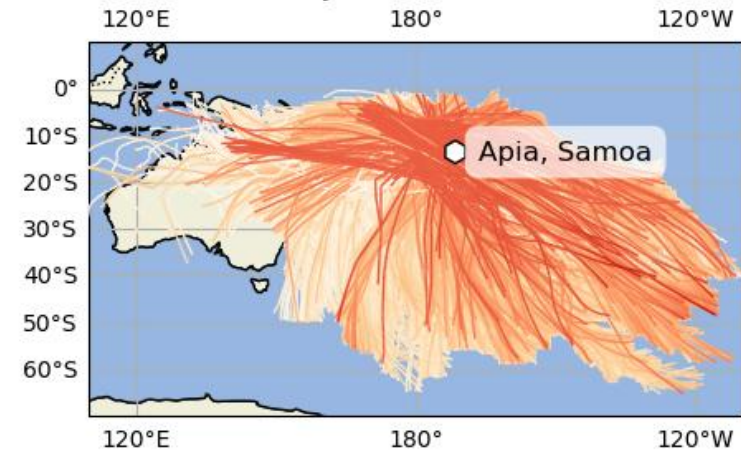
Historical Tracks



Historical Tracks Cat 5

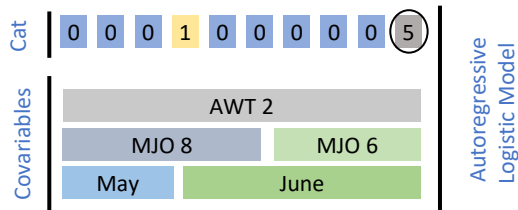


Synthetic Tracks

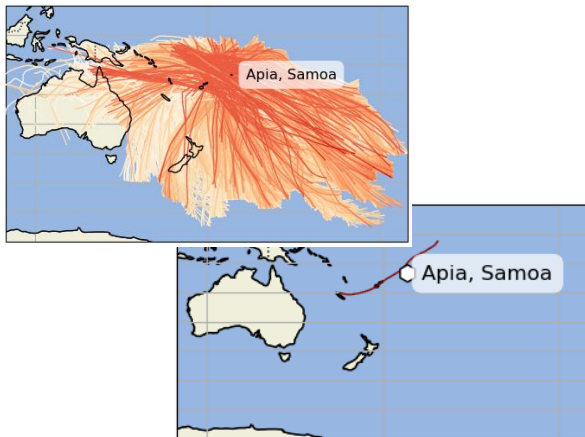


Tropical Cyclone Emulator

Synthetic Chronology of TC Categories

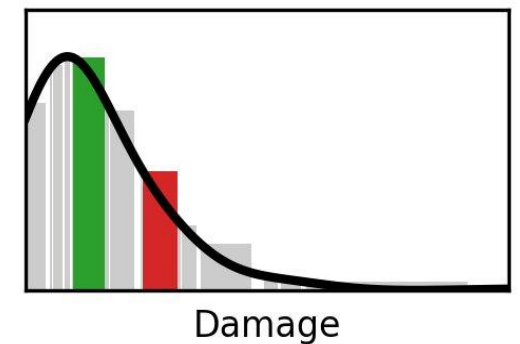


Random Sampling of TC tracks



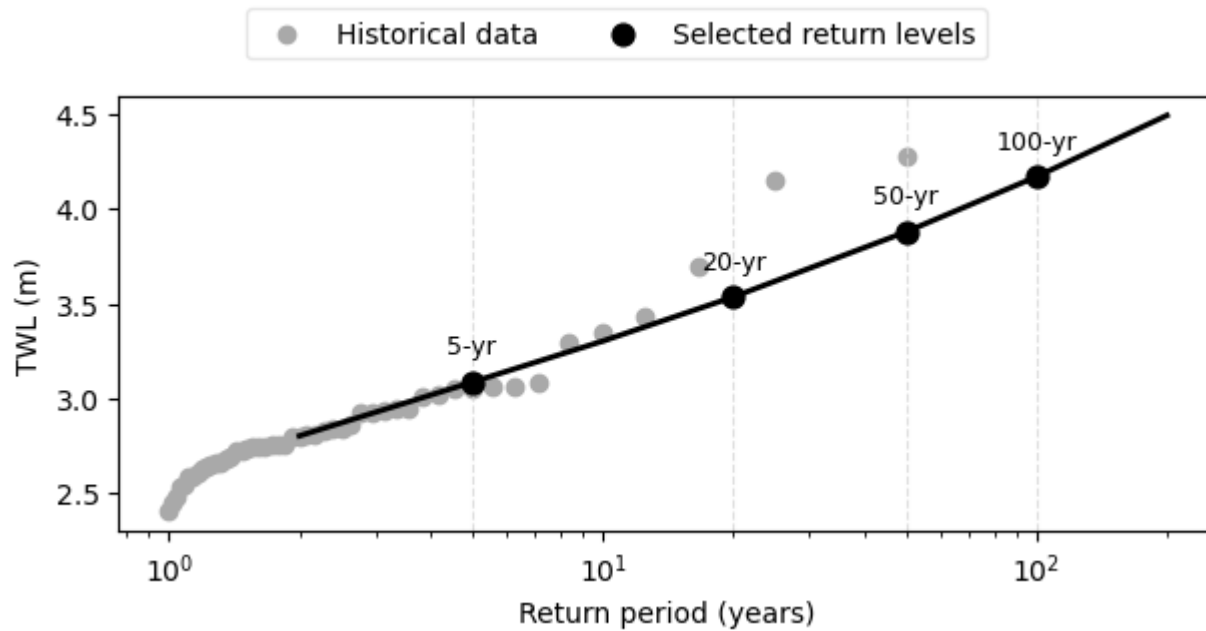
How many events do we
need to simulate to
characterize the risk and
how do we choose them ?

Risk Assessment



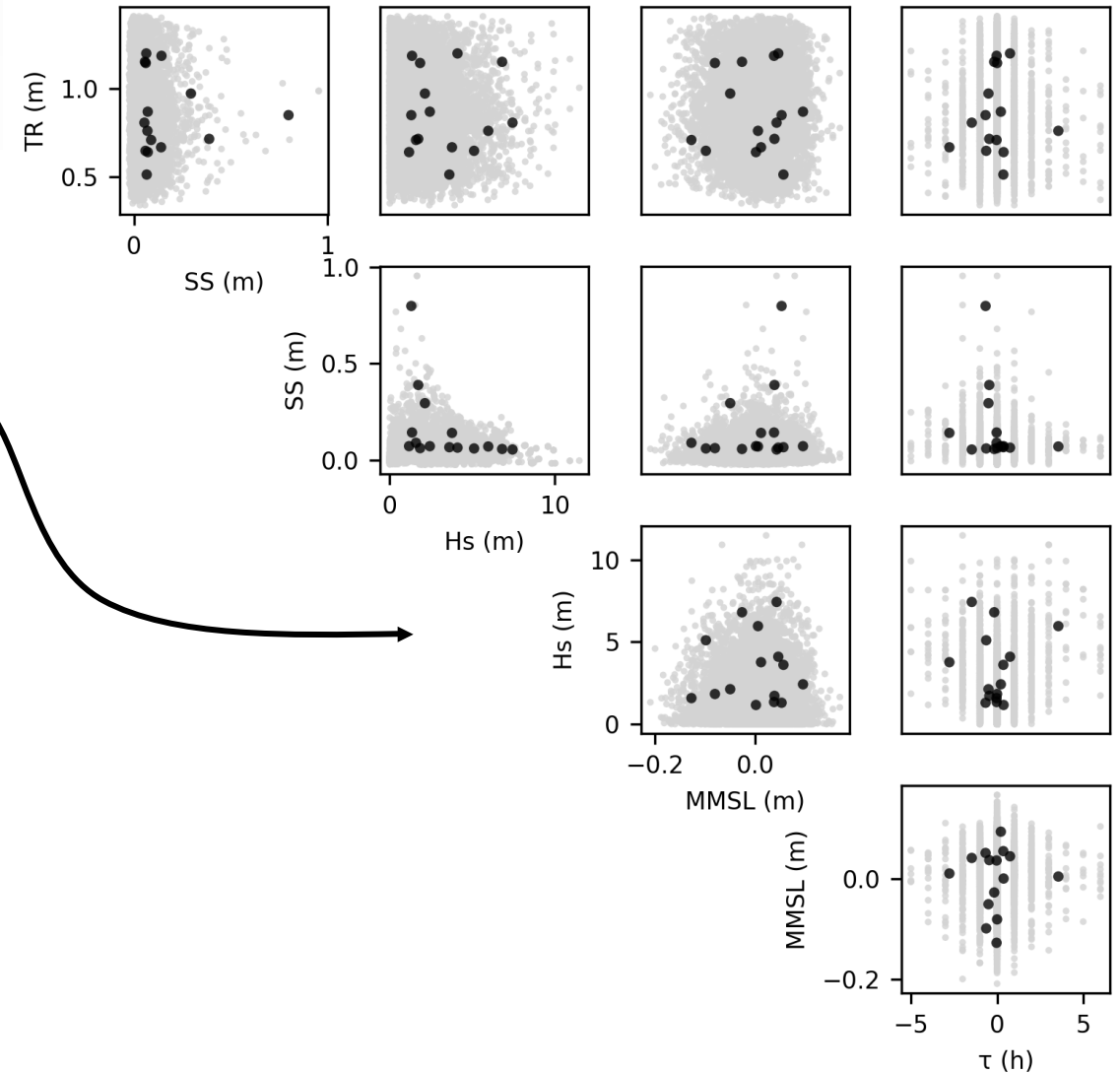
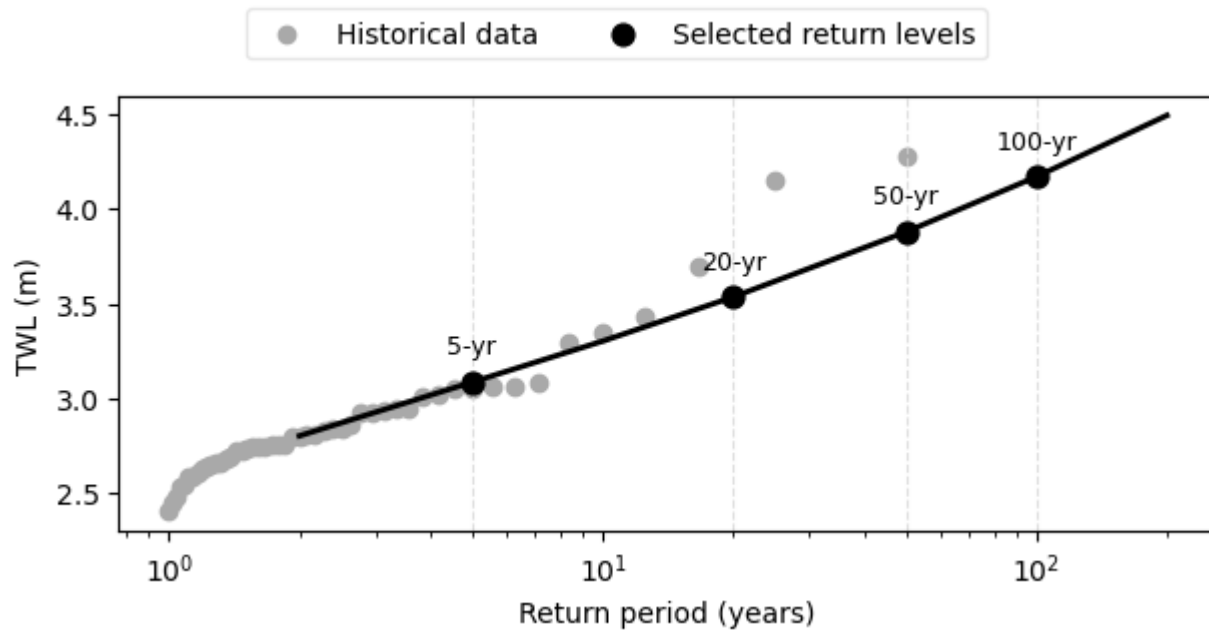
The offshore **Total Water Level** as an indicator of the event severity

$$TWL = SS + 0,2 * Hs + AT + MMSL$$

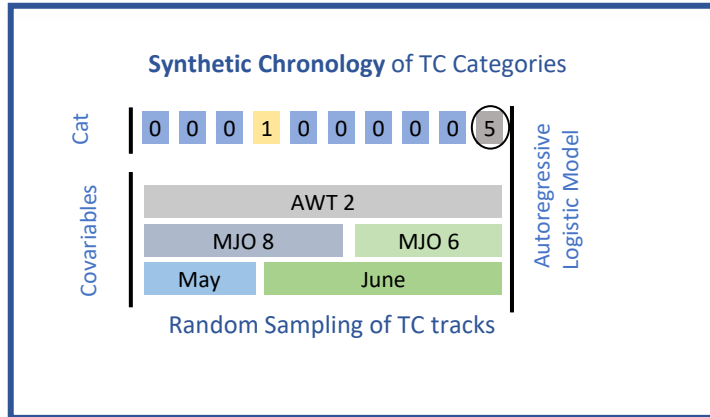


The offshore **Total Water Level** as an indicator of the event severity

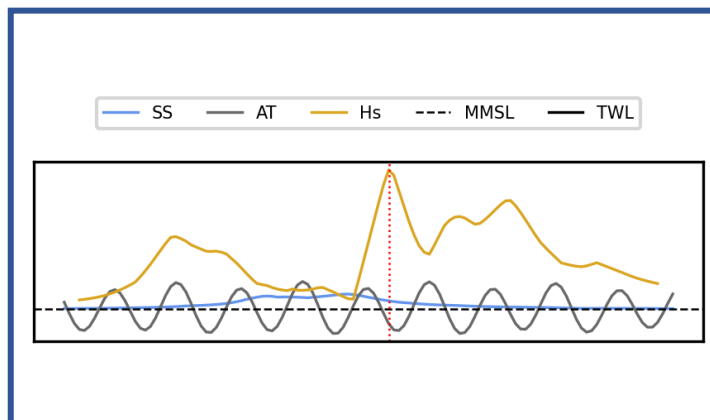
$$TWL = SS + 0,2 * Hs + AT + MMSL$$



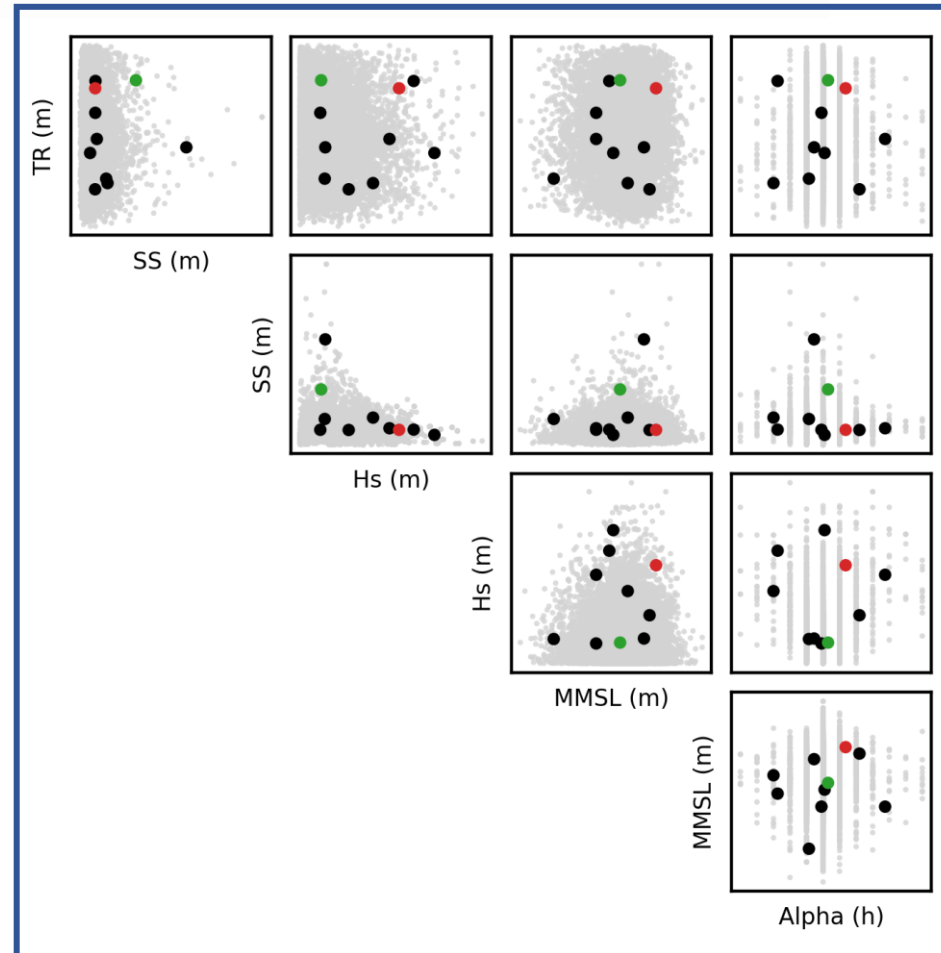
1. Tropical Cyclone Emulator



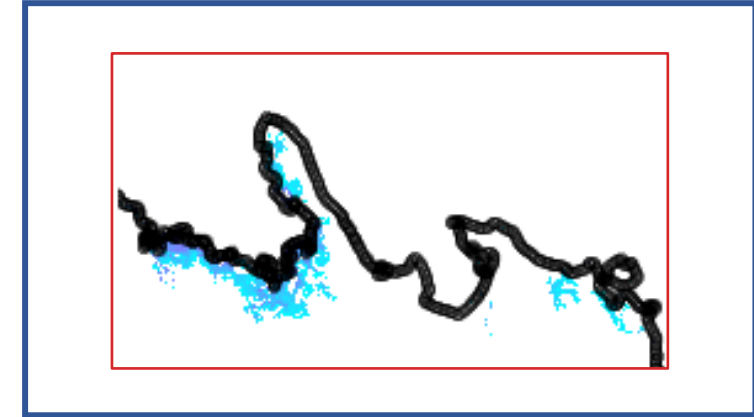
2. Offshore Hydrodynamics



3. Event Selection



4. Nearshore hydrodynamics



5. Risk Assessment



Emulator

Anderson et al., 2019
TC Category 0 0 0 0 0 1 0 0 0 0 0 0 5

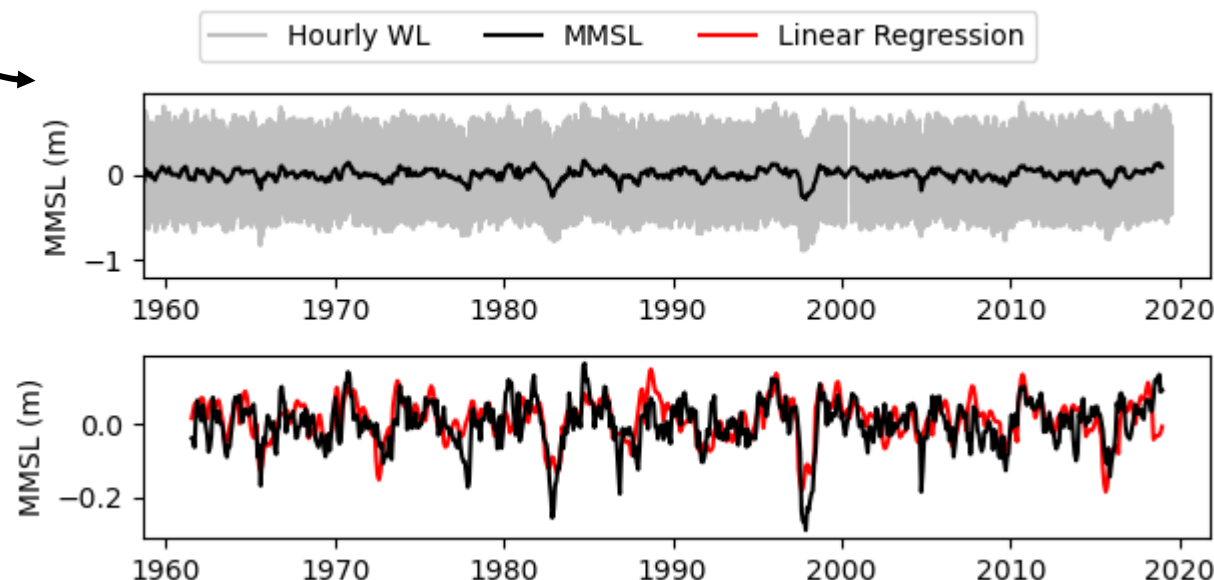
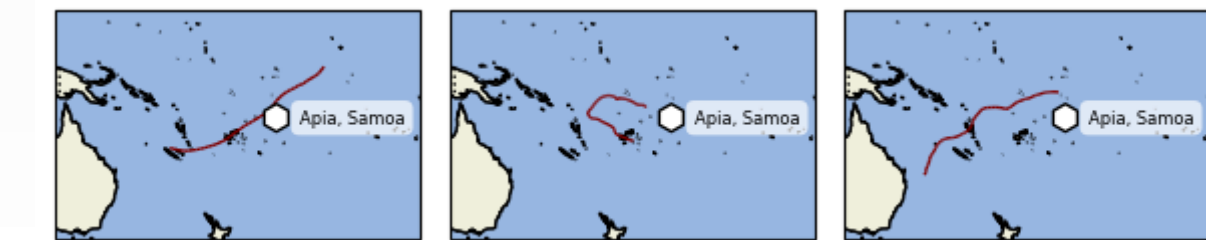
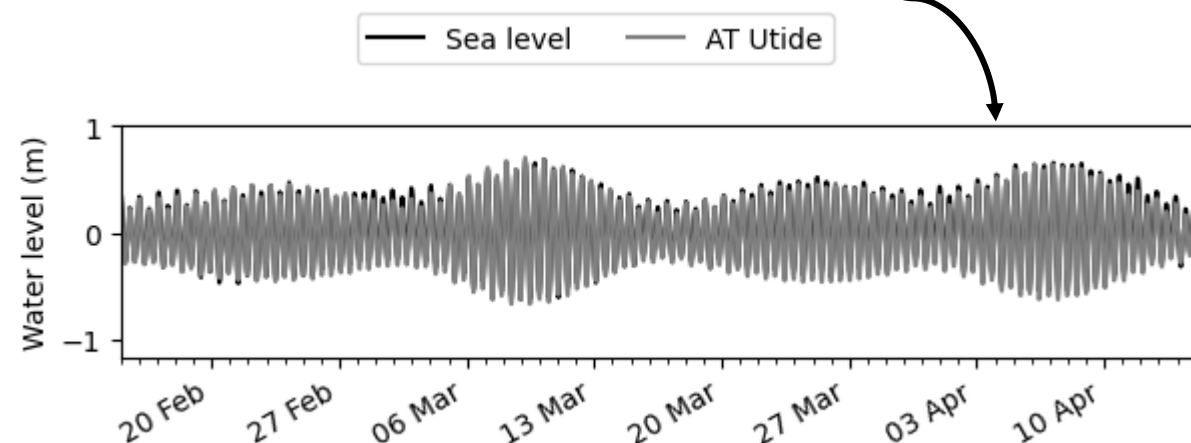
AWT AWT 2
MJO MJO 8 MJO 6
Seasonality May June

Autoregressive Model

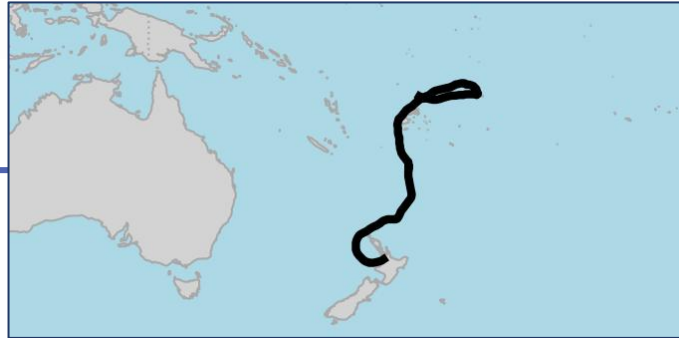
0 5 0 0 0 2 0 0 0 1 0 0 0

Synthetic Chronology
of TC Categories

$$TWL = \frac{SS + 0,2 * Hs}{TC \text{ Dependent}} + AT + MMSL$$

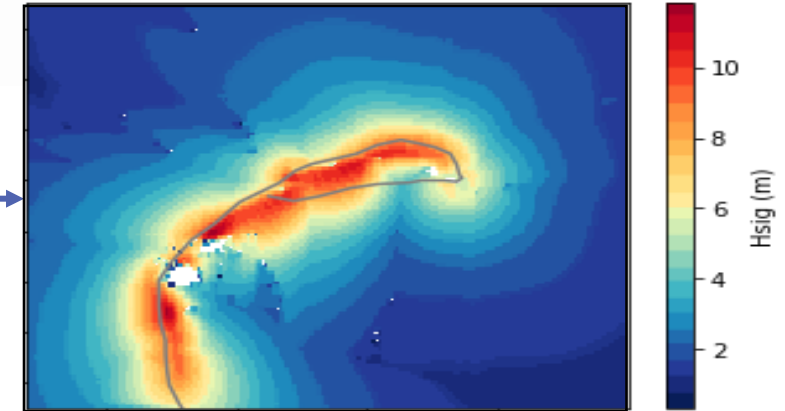


Parametric TC-Track



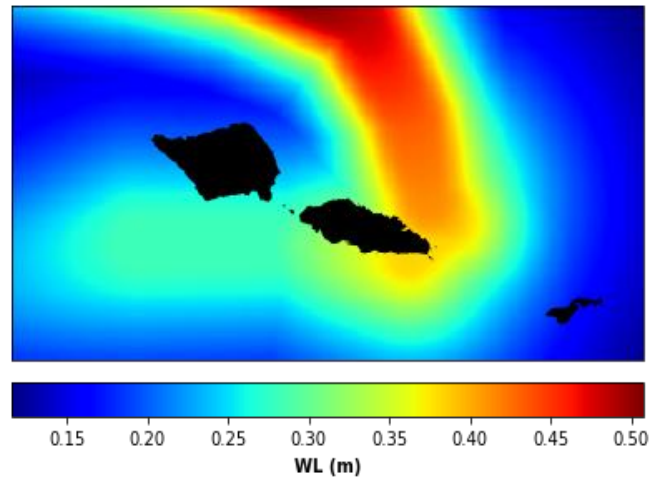
SHyTCWaves

Regional TC-Generated Waves



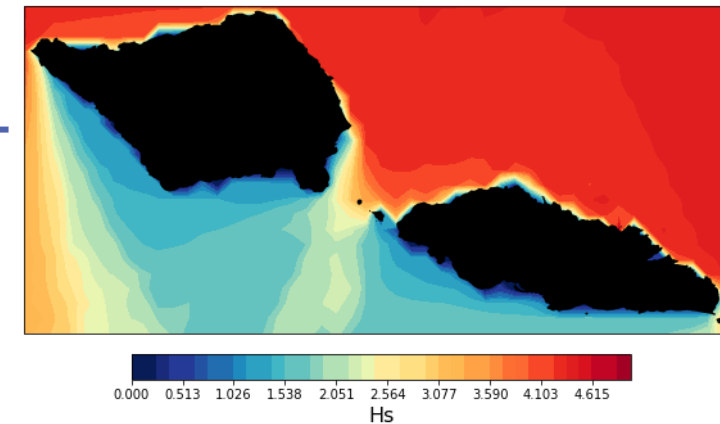
Inverse Barometer

Storm Surge



SS Hs, Tp, Dir

Local waves



BinWaves



Ocean Modelling

Volume 188, April 2024, 102341



SHyTCWaves: A stop-motion hybrid model to predict tropical cyclone induced waves

Sara O. van Vloten ^a, Laura Cagigal ^a , Beatriz Pérez-Díaz ^a, Ron Hoeke ^b,
Fernando J. Méndez ^a

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Ocean Modelling

Volume 189, June 2024, 102346



BinWaves: An additive hybrid method to downscale directional wave spectra to nearshore areas

Laura Cagigal ^a , Fernando J. Méndez ^a, Alba Ricondo ^a,
David Gutiérrez-Barceló ^b, Cyprien Bosserelle ^c, Ron Hoeke ^d

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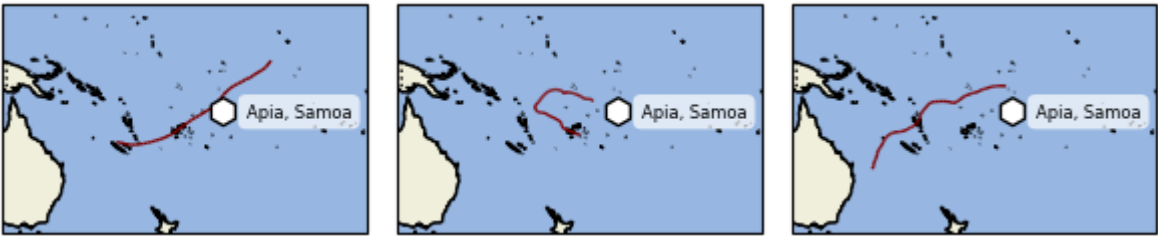
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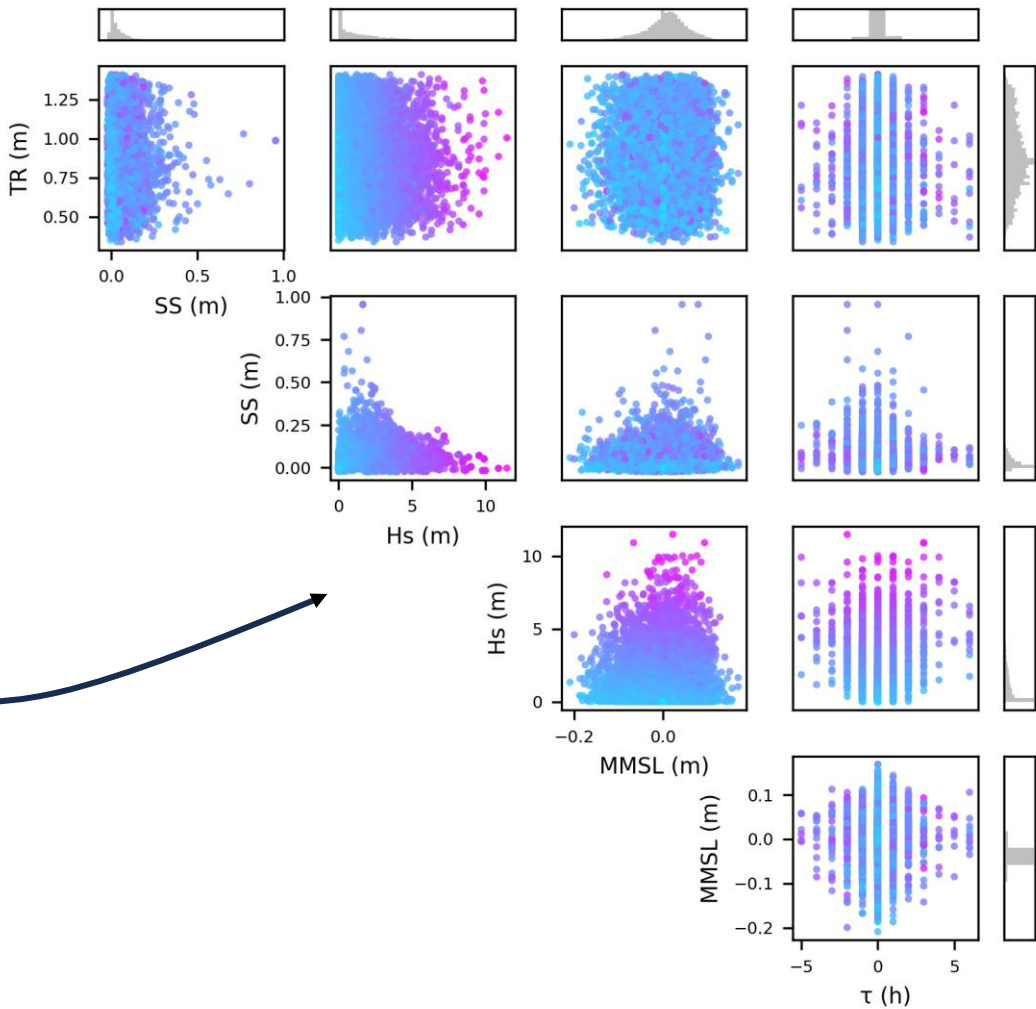
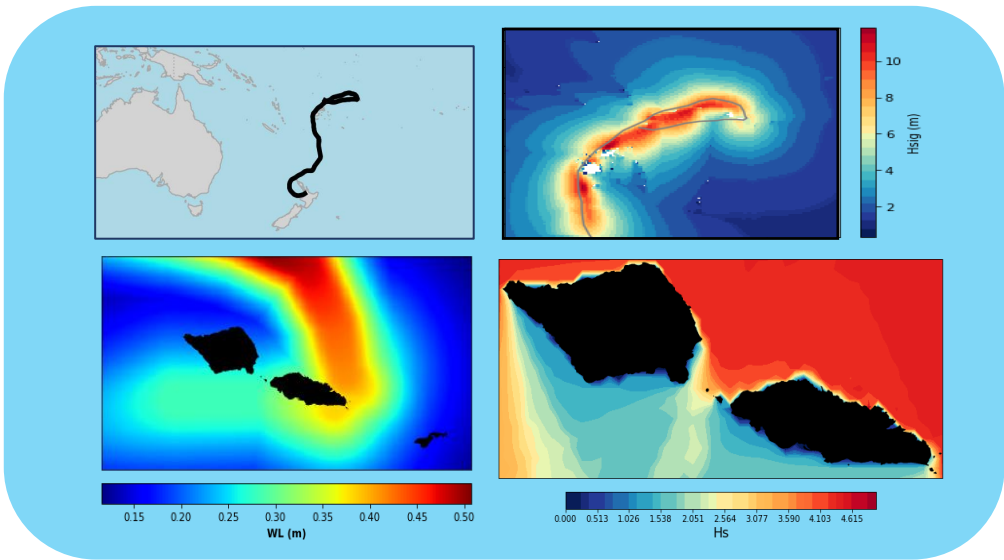
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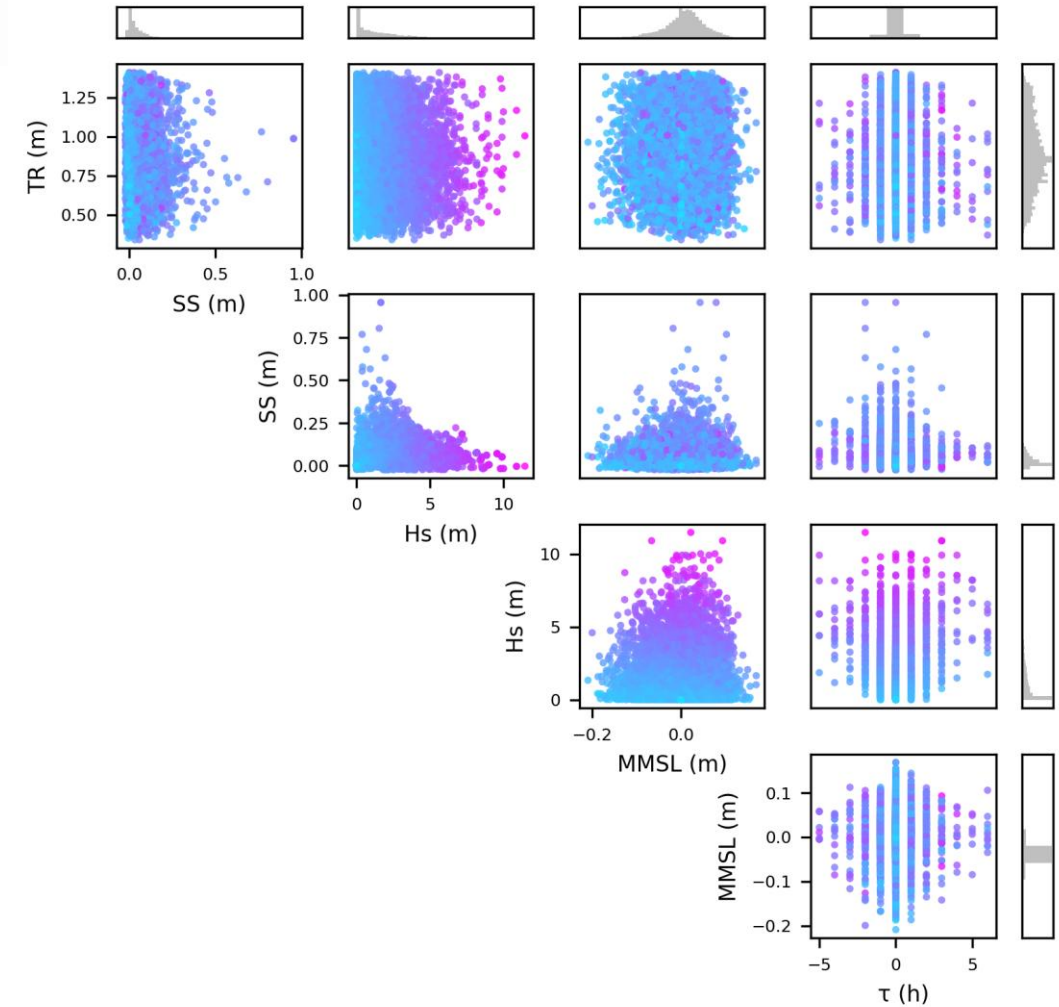
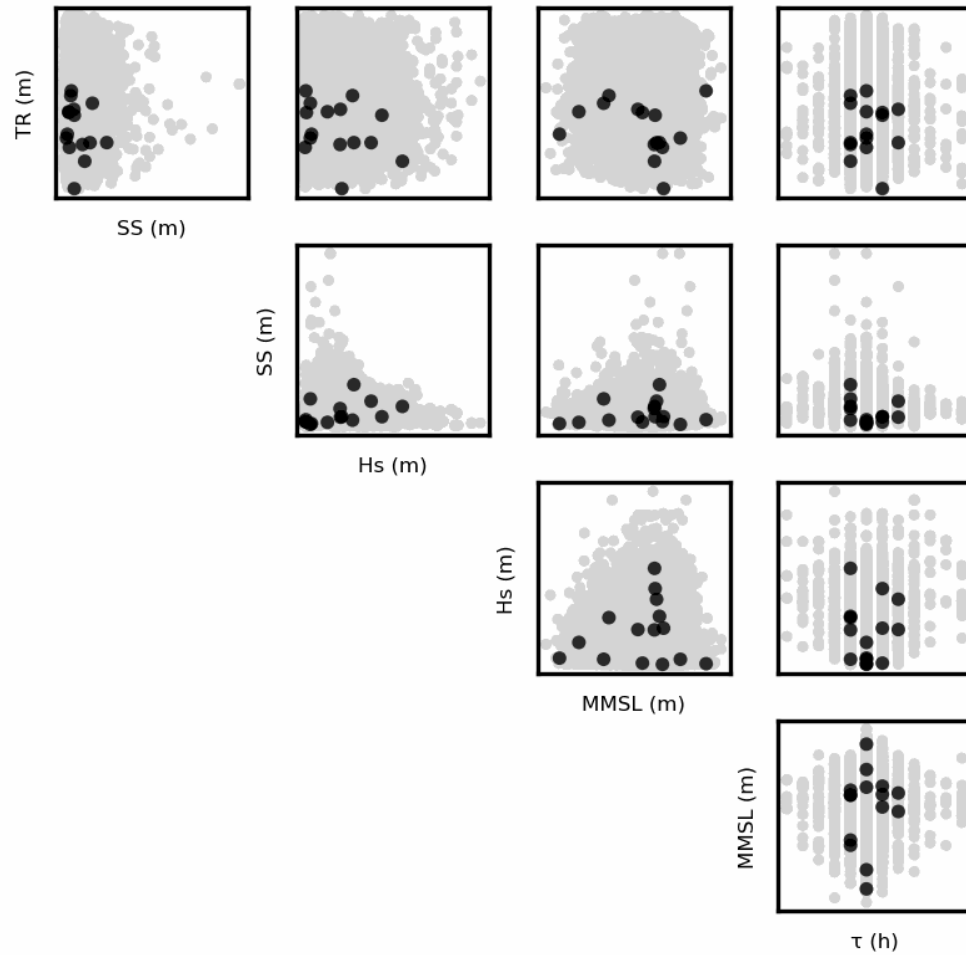
Synthetic Chronology of TC Categories



0 5 0 0 0 2 0 0 0 1 0 0 0

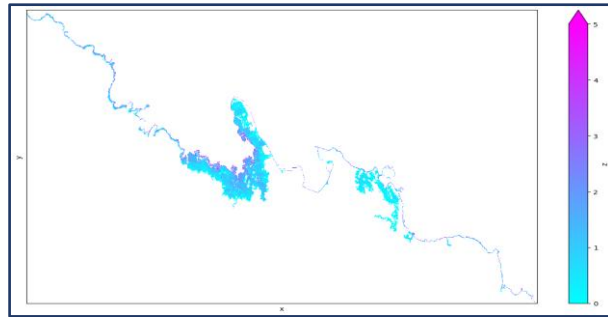


MDA + K-Means



4. TC-Induced Flooding

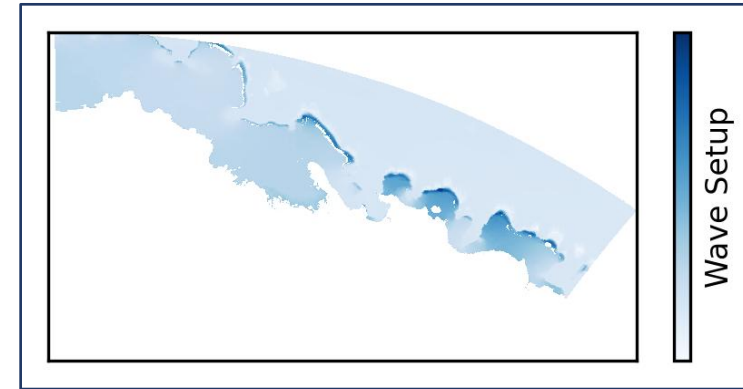
SFINCS



Wave Set-up

IG Wave

HyBeat



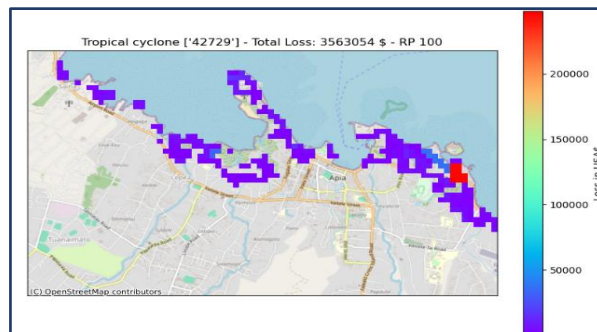
Zornoza-Aguado et al - 2024

Forced with
offshore conditions

5. Risk Assessment

RiskScape

Economic Losses



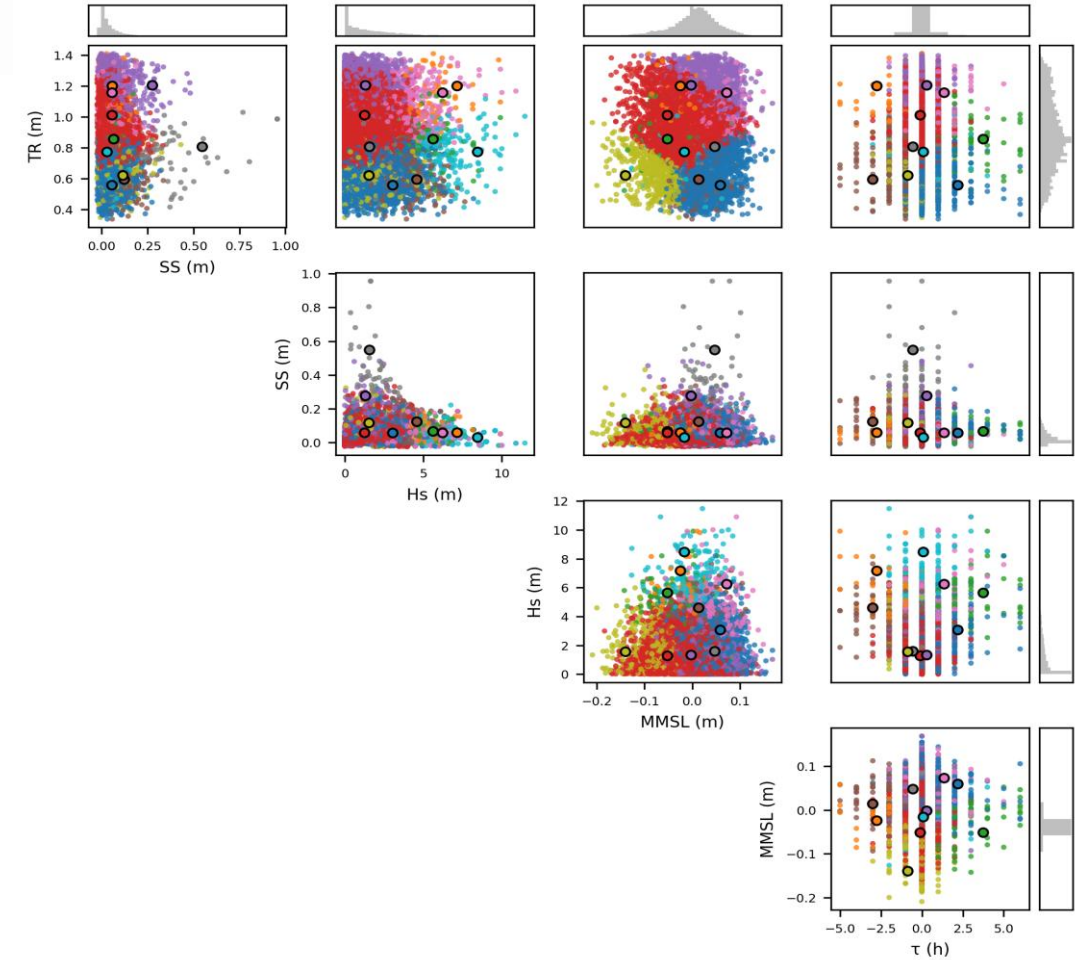
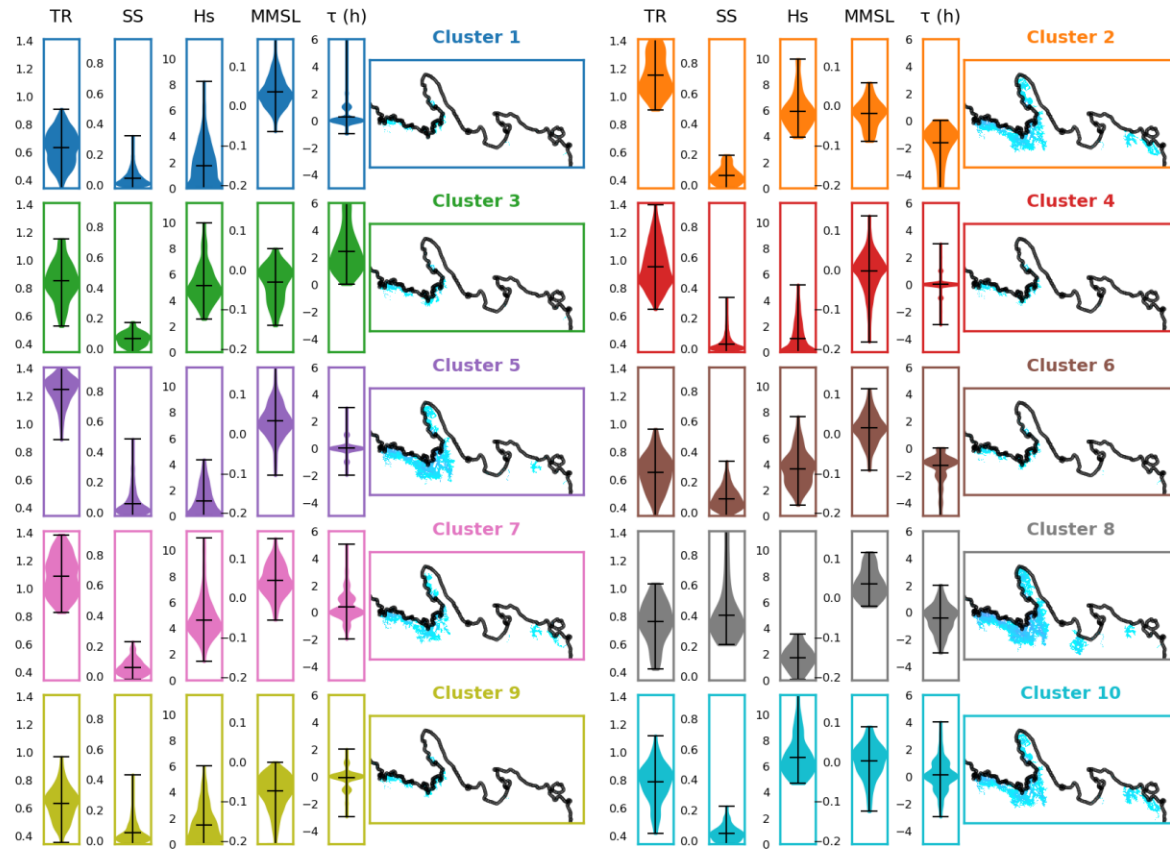
RiskScape

Paulik et al - 2023

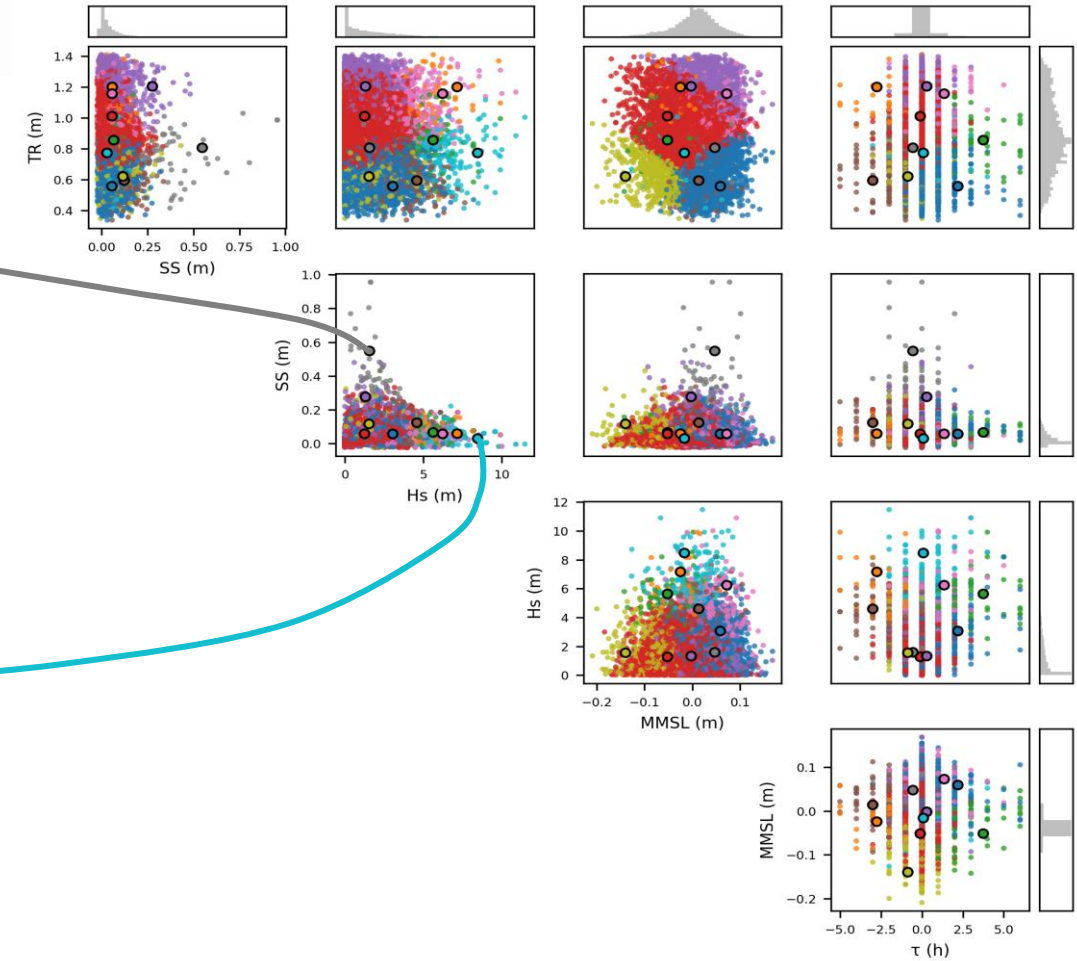
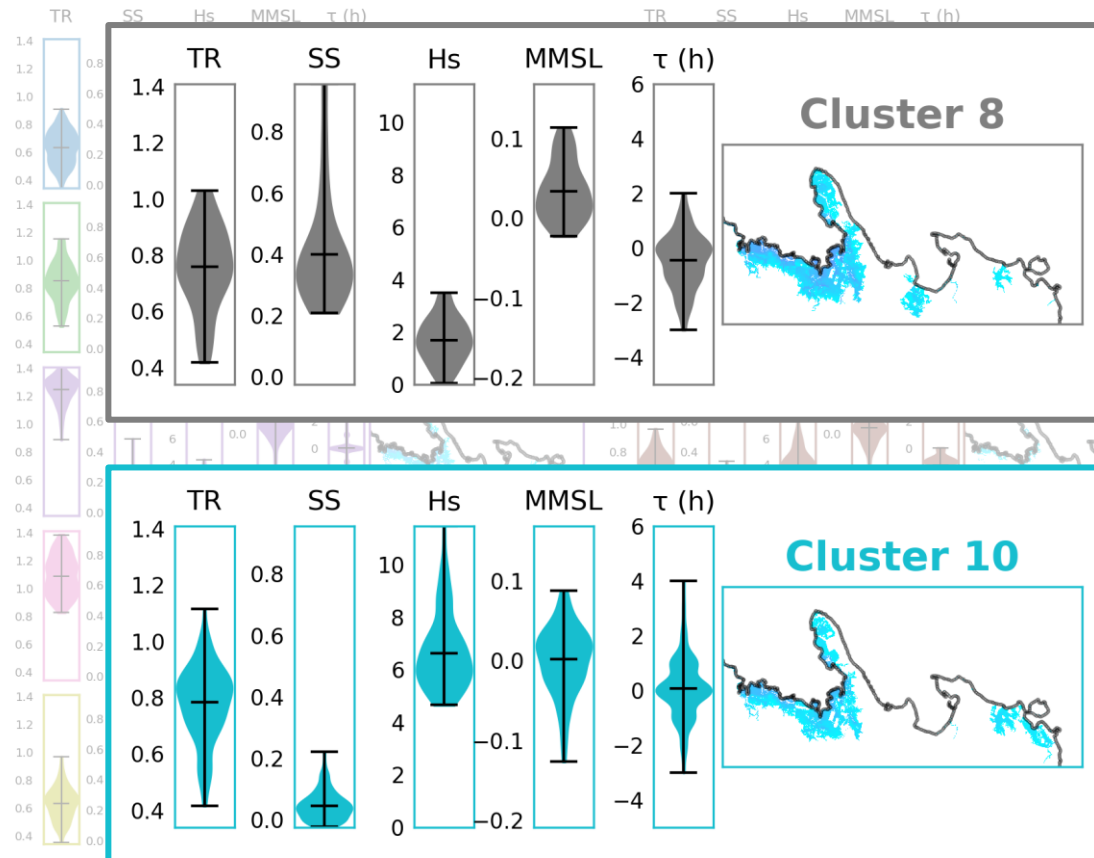
Exposure and Vulnerability



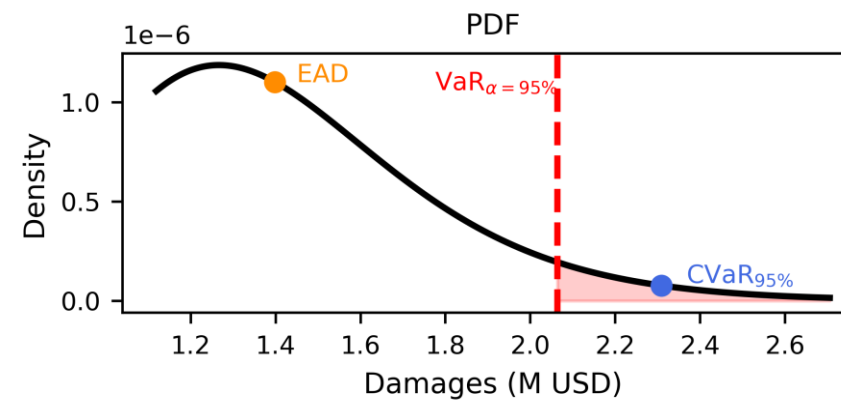
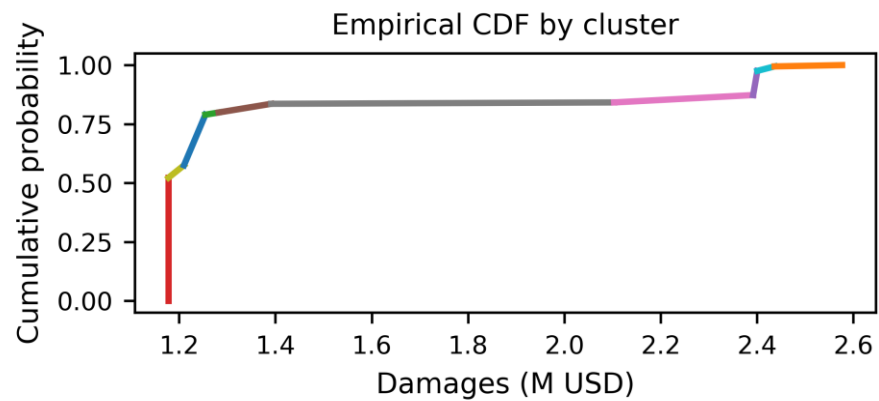
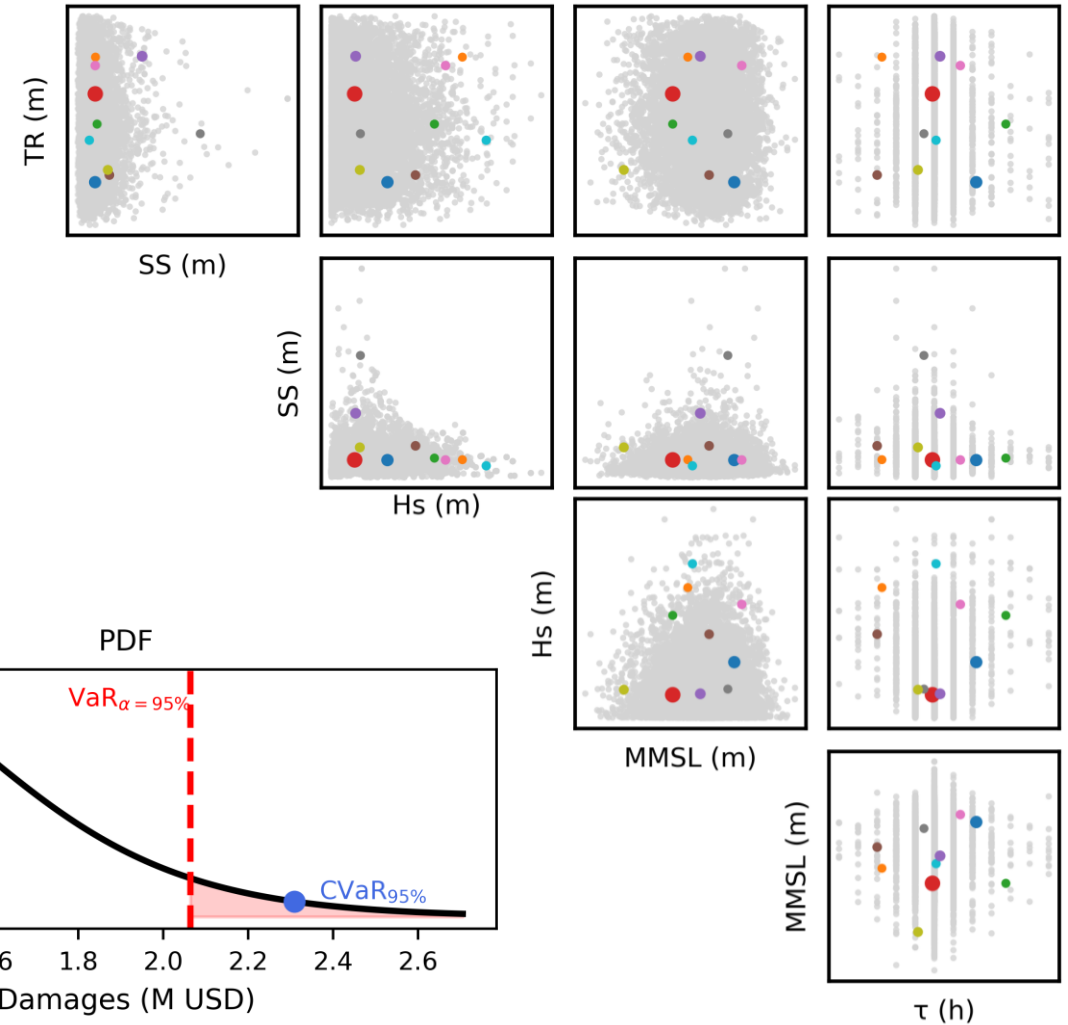
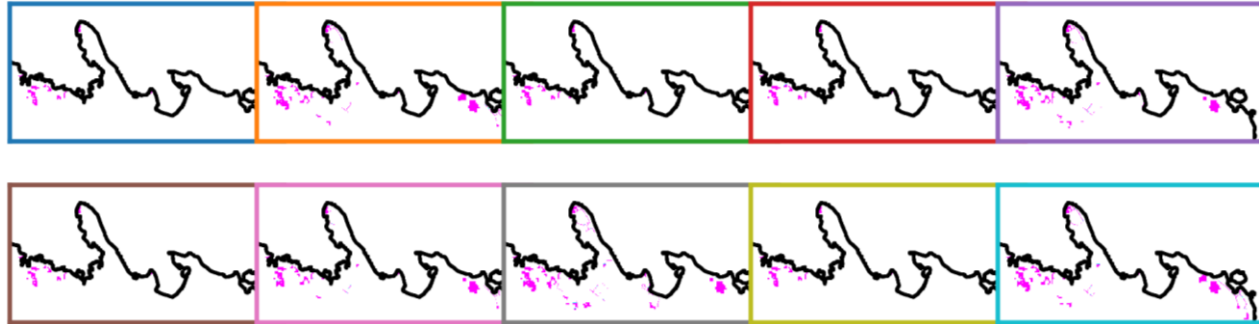
Cluster Representatives



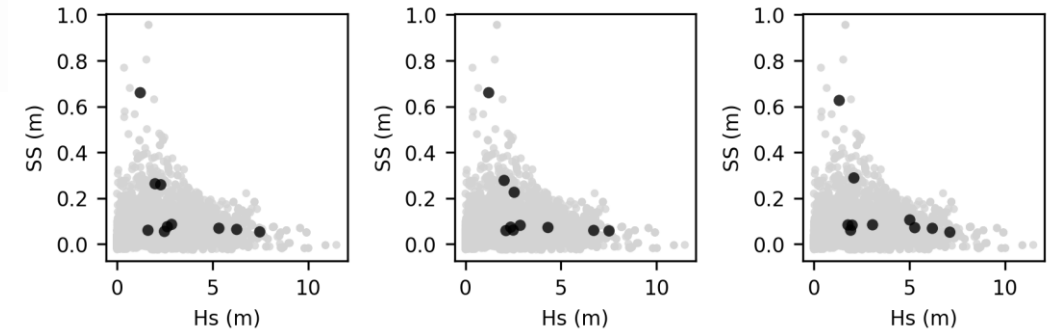
Cluster Representatives



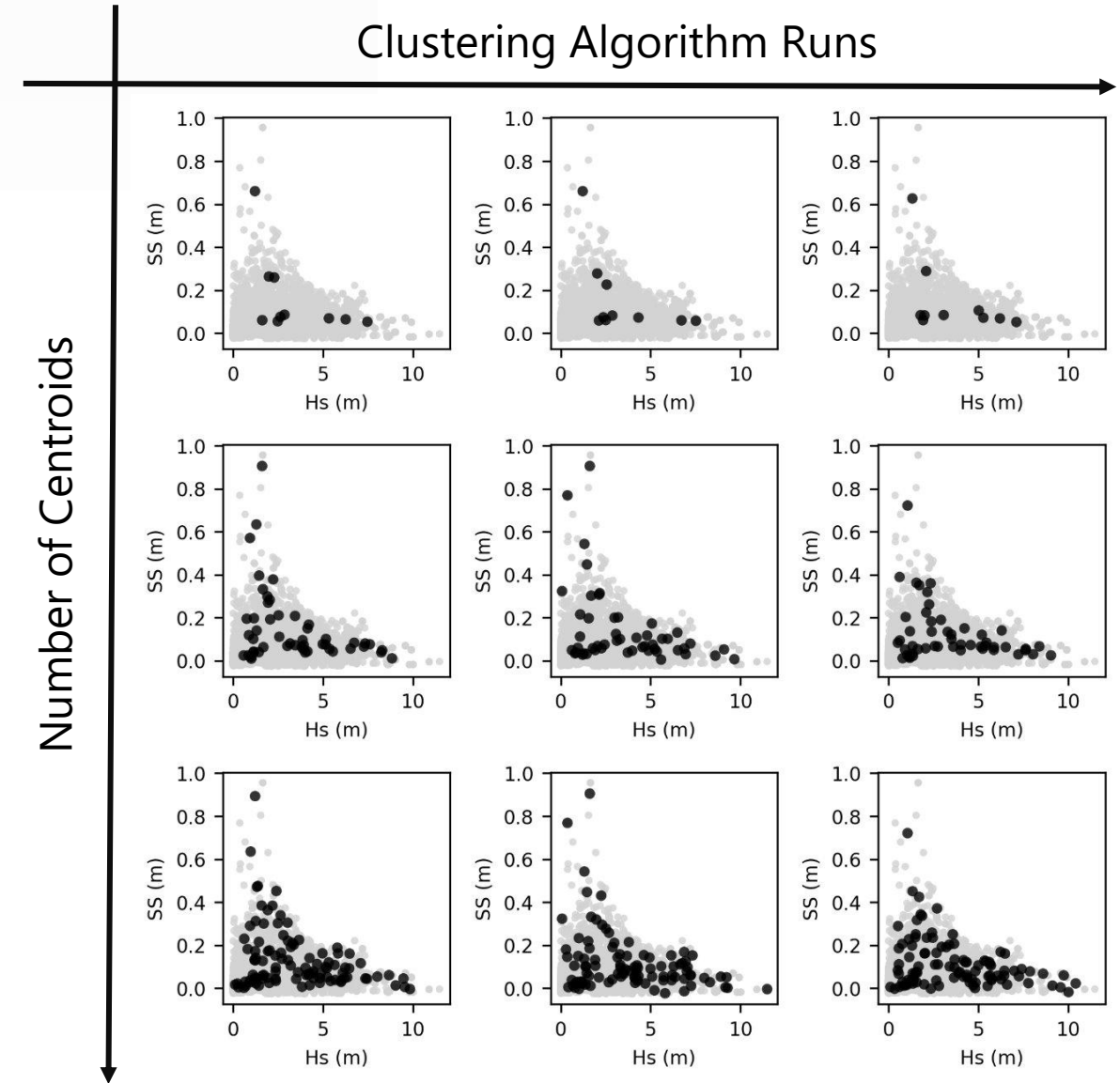
Risk Assessment



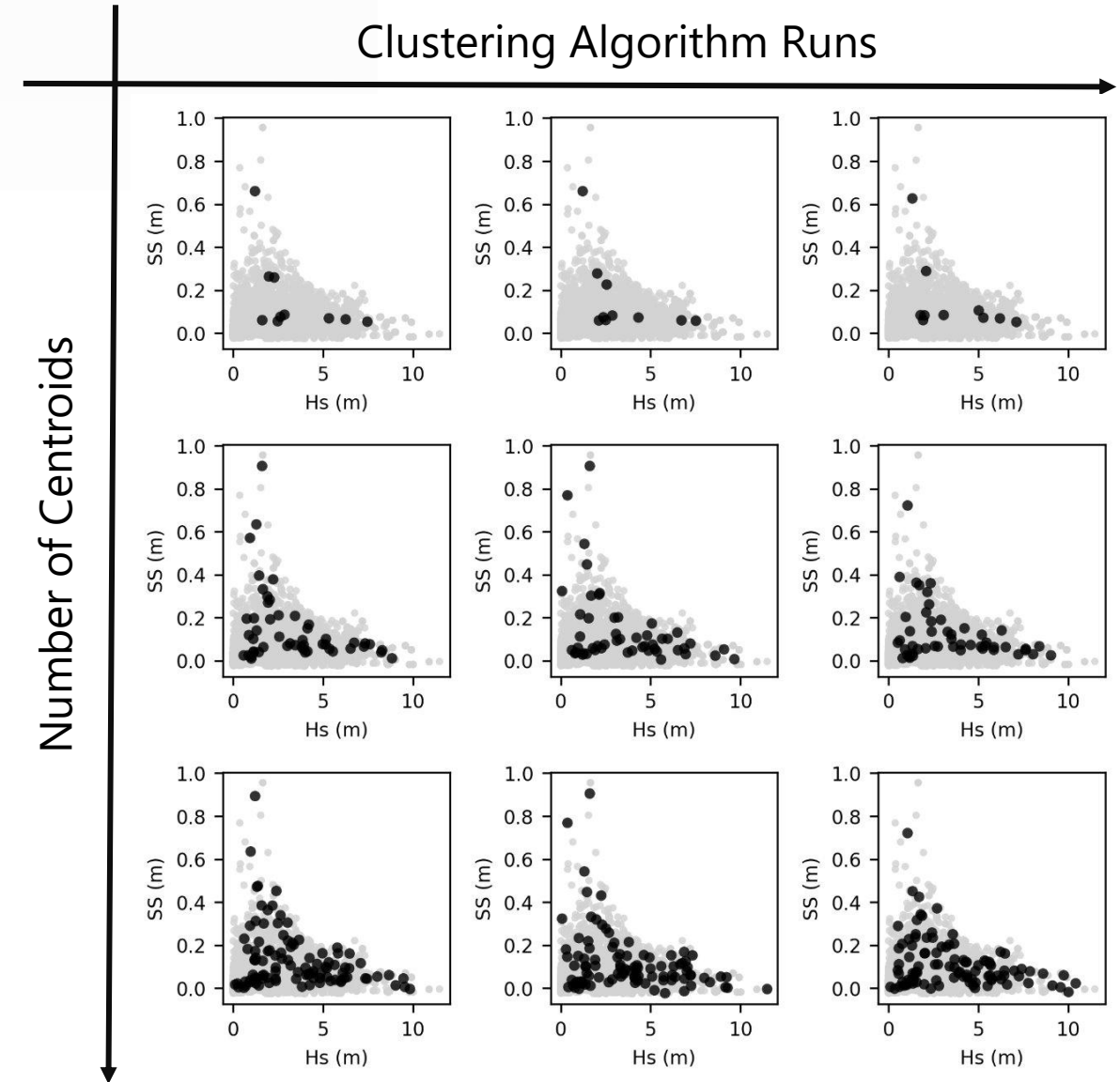
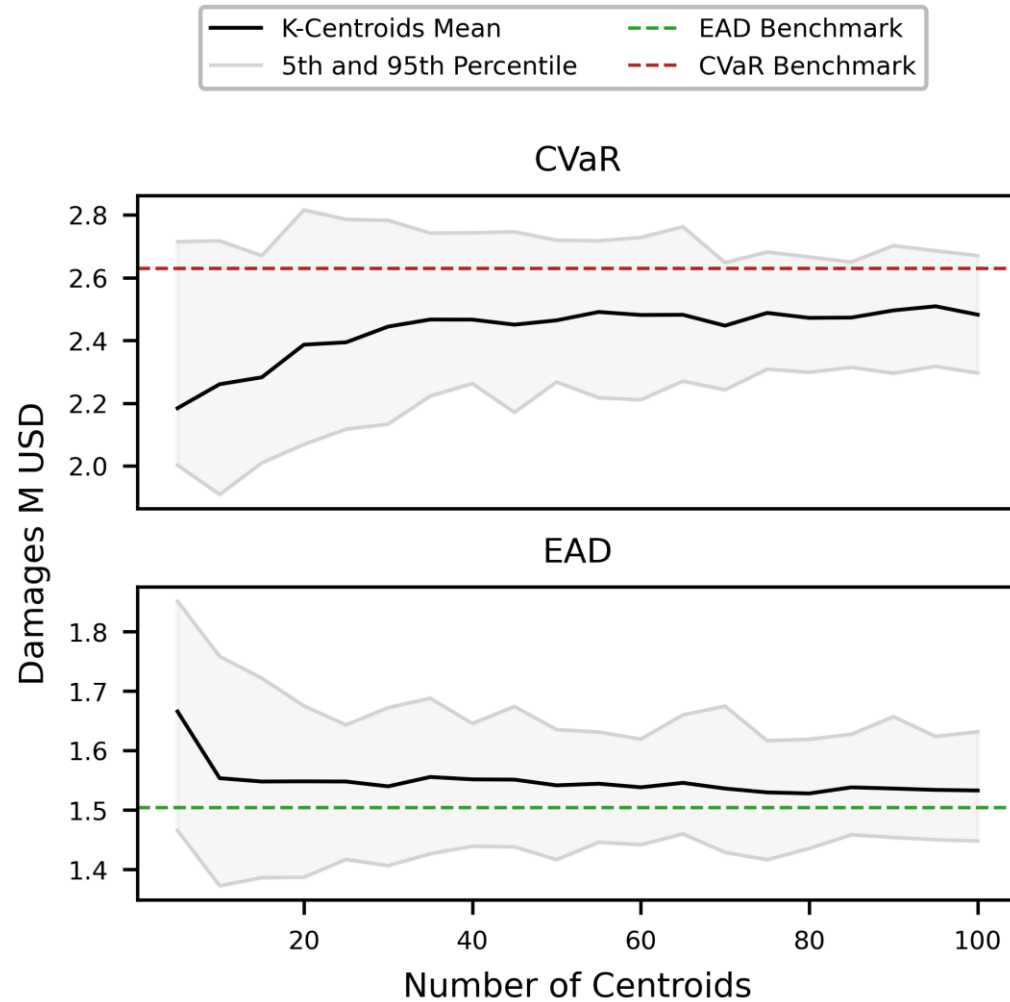
Clustering Algorithm Runs



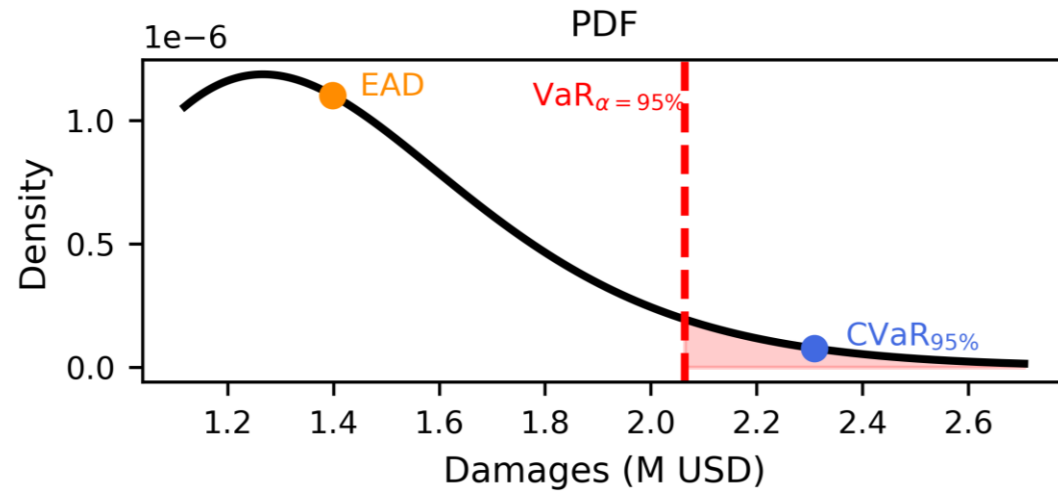
Cluster Results



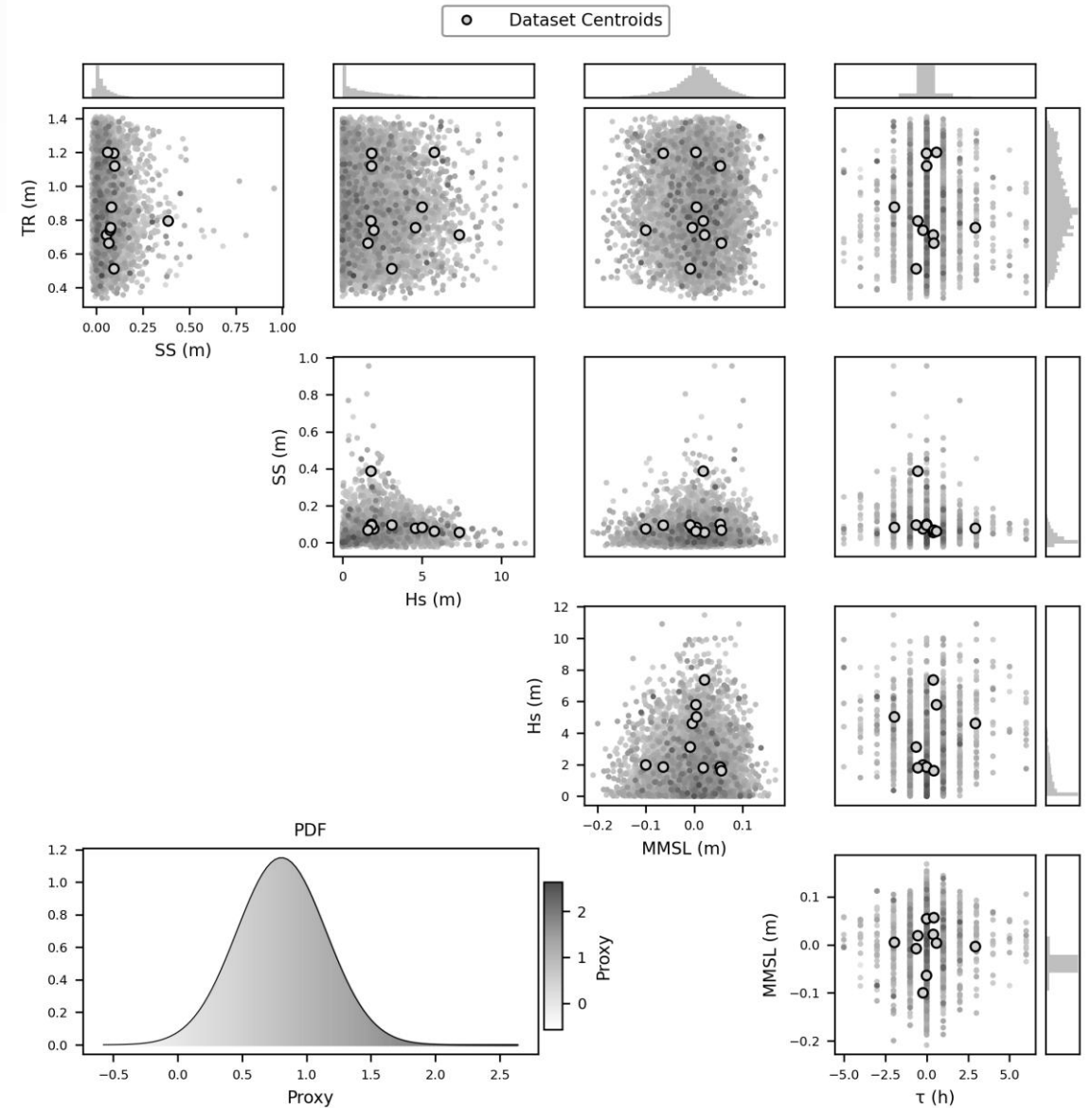
Cluster Results



Beta Theory



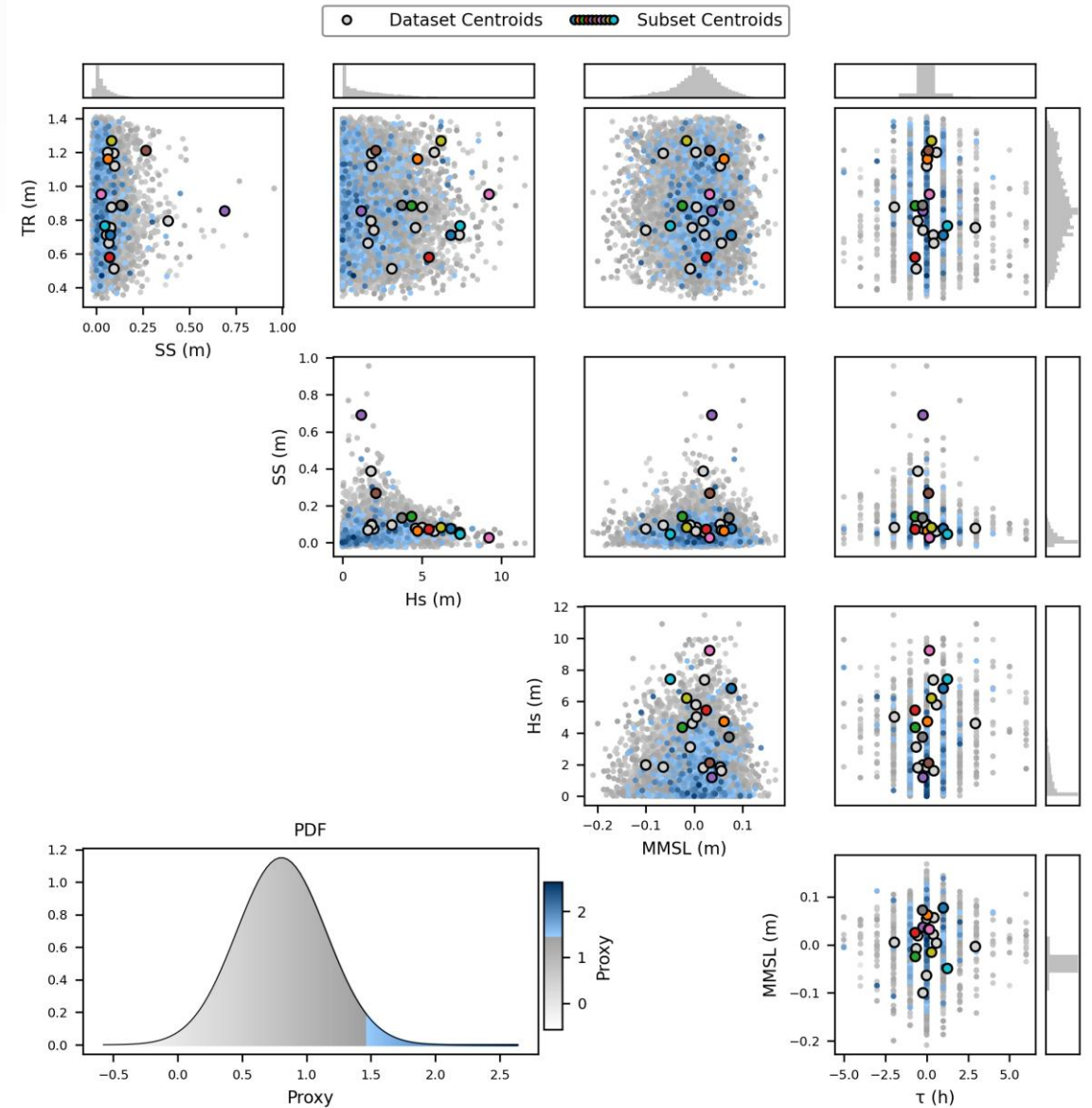
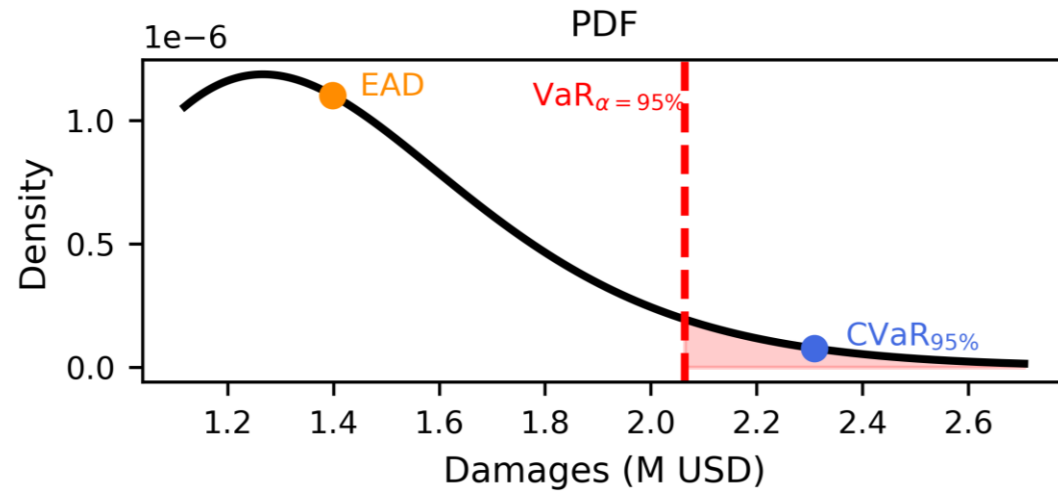
05/10/2025



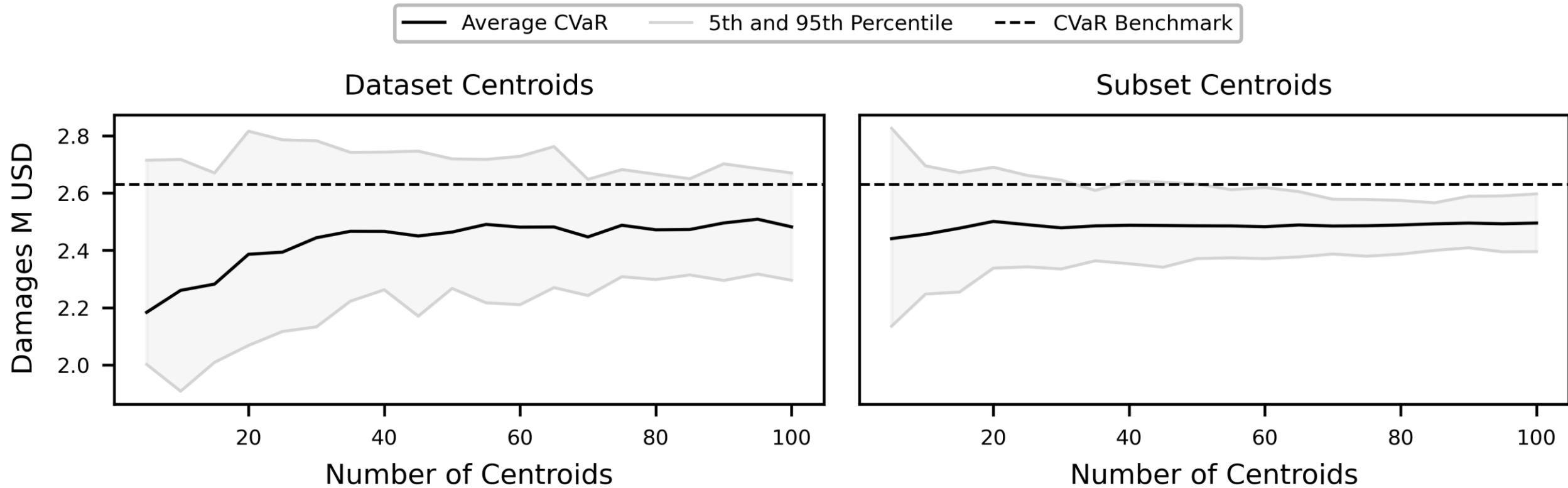
Results

21

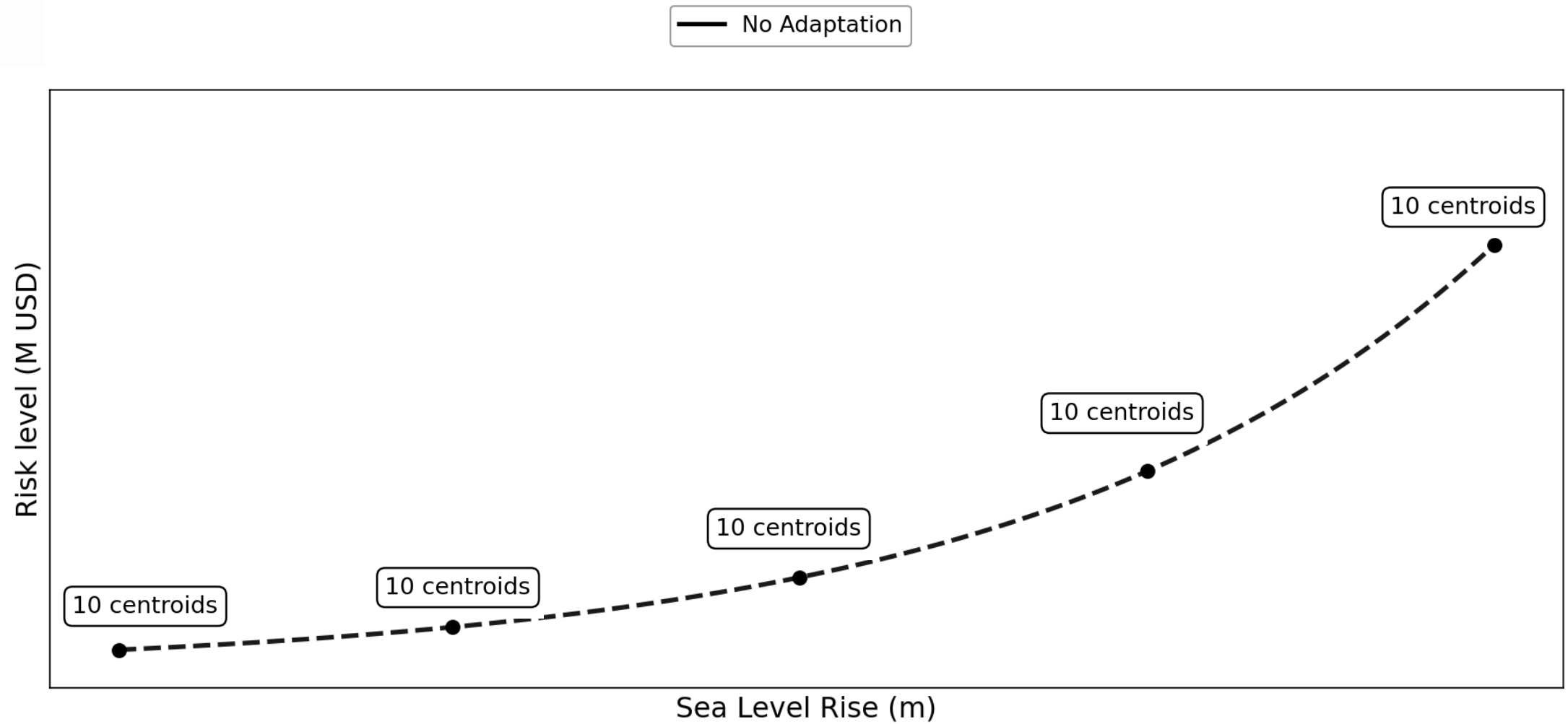
Beta Theory



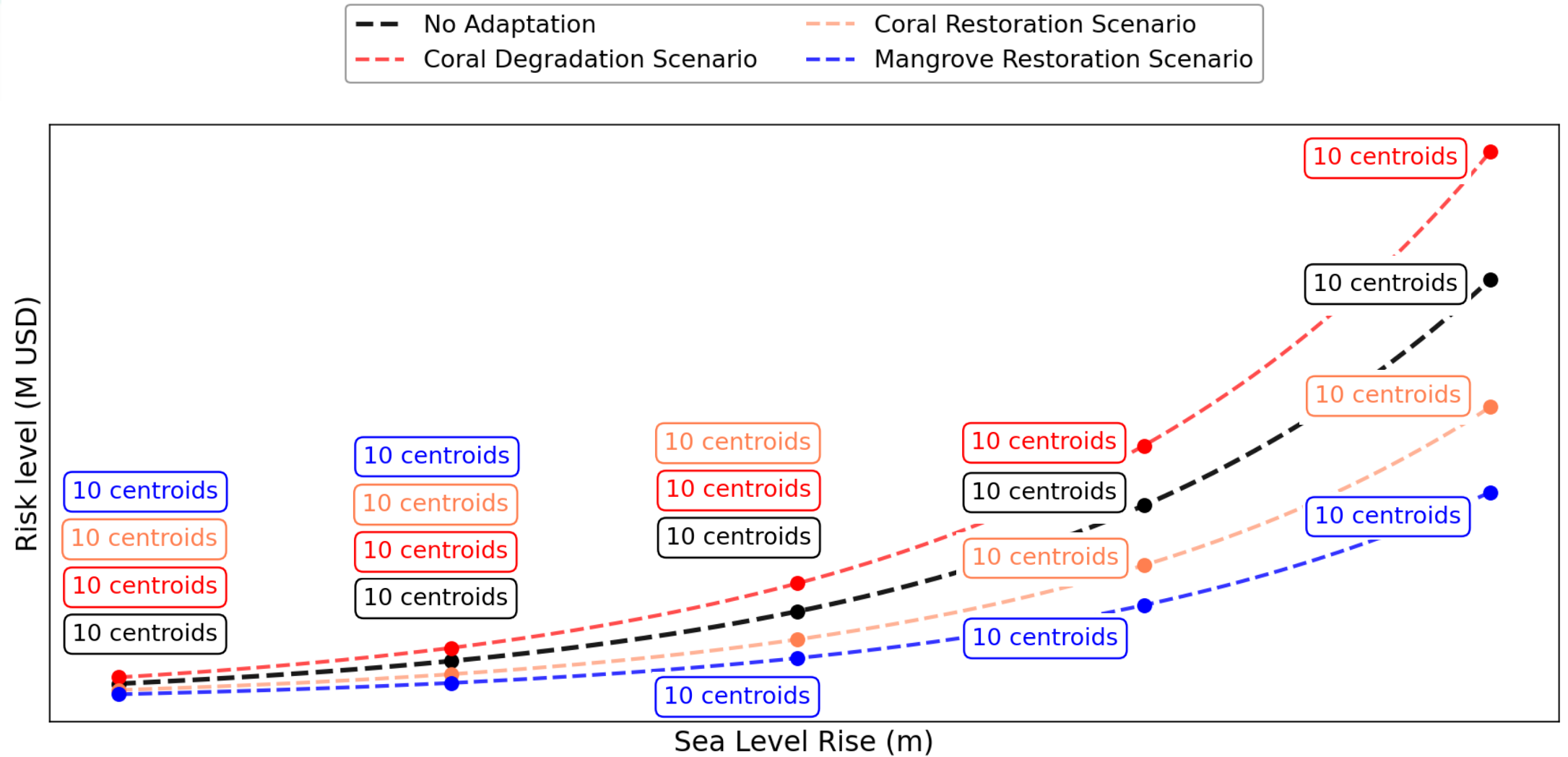
Beta Results



Future Steps



Future Steps



Acknowledgments

HyBay - Una Herramienta Eficiente Híbrida Para Valorar El Efecto De Medidas De Adaptación Al Cambio Climático En Estuarios Y Bahía (PID2022-141181OB-I00 - MCIN/AEI/10.13039/501100011033/ FEDER, UE)

ESCTP - Defense Regional Sea Level (DRSL) Database Transformation and Update

Perfect-Storm (2023/TCN/003 – Cantabria Government/FEDER, UE)

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CE4Flood (CPP2023-010627)

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