Monte-Carlo climate-based multivariate emulator for coastal flooding

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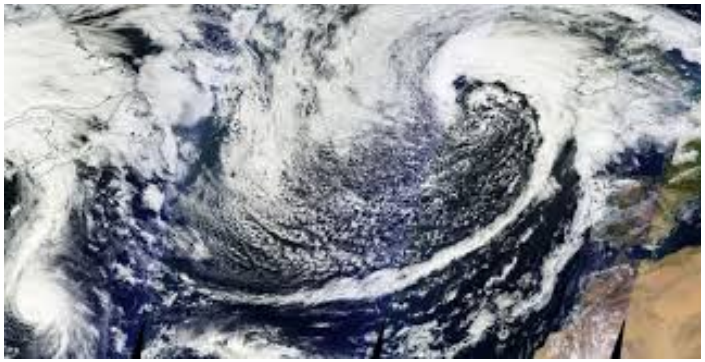
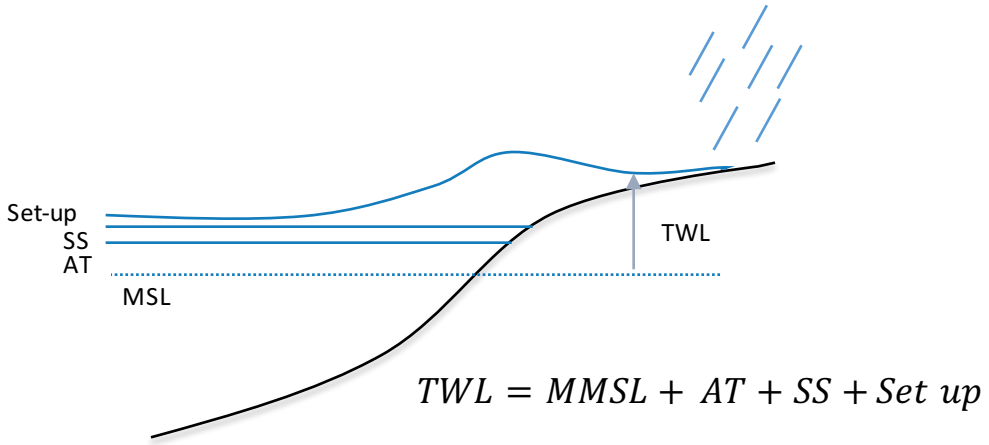
Key West, Florida, USA, Nov 10, 2015

Introduction

$$\text{Risk} = \int \text{Probability} \times \text{Consequences}$$

Multivariate nature of climate event





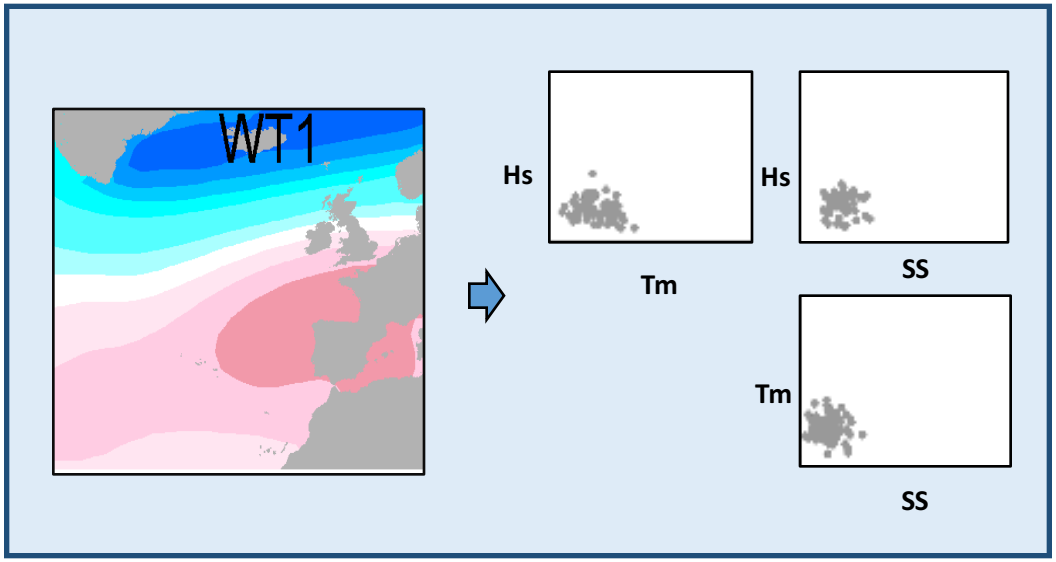
COMPOUND EVENT

(1) The extremeness of the impact rather than variables or events it depends on;
(2) The requirement of multiple variables or events on which the impact depends
(3) The role of statistical dependence

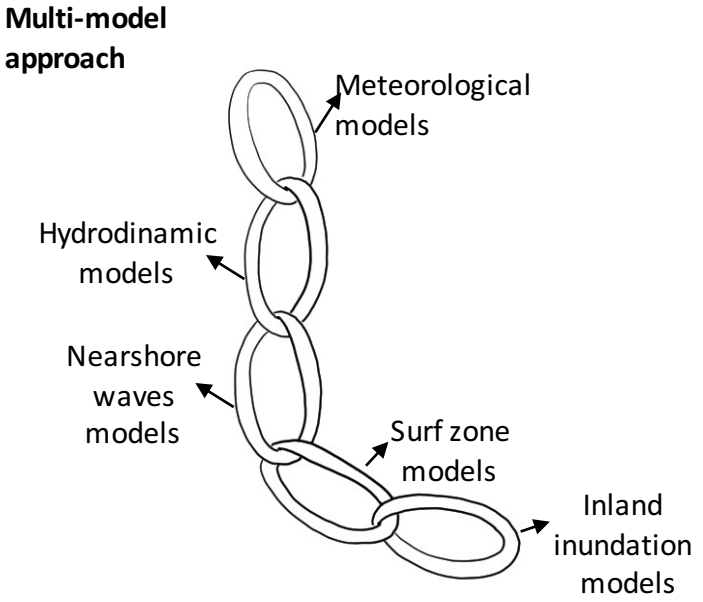
Leonard et al (2014)

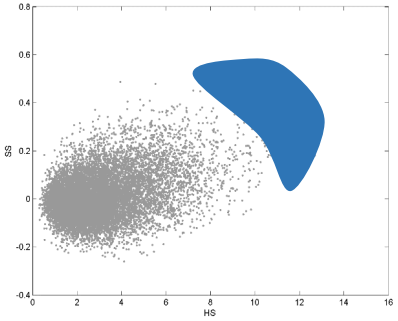
Objectives

1) Extrapolation of the joint density function of the variables that influence coastal flooding taking into consideration climate variability

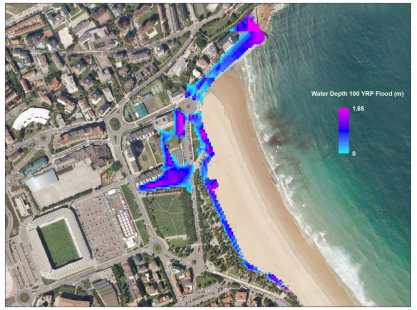


2) Downscaling to coastal flood risk assessment

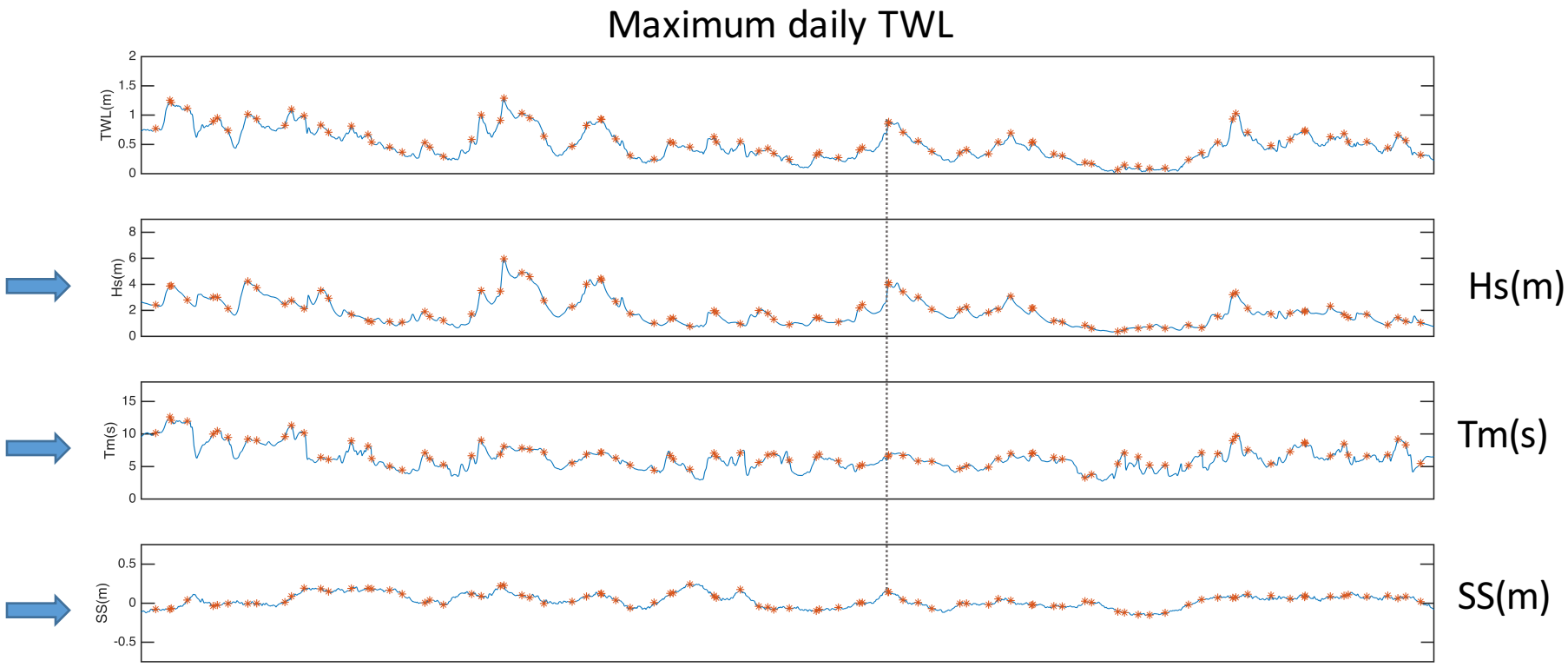


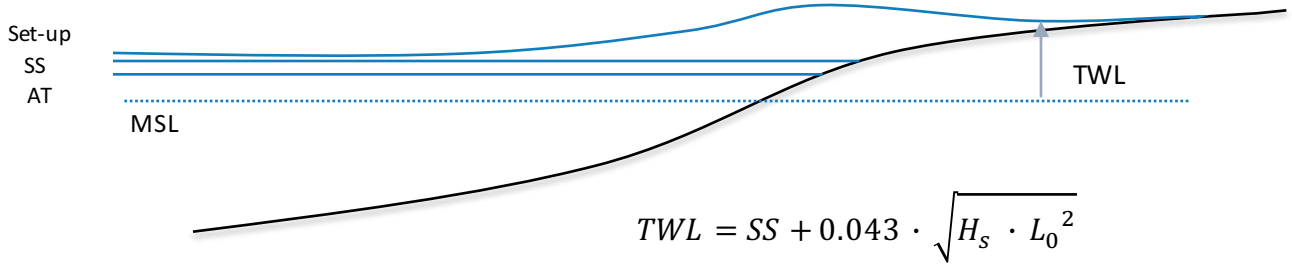


$$\text{Risk} = \int \text{Probability} \times \text{Consequences}$$



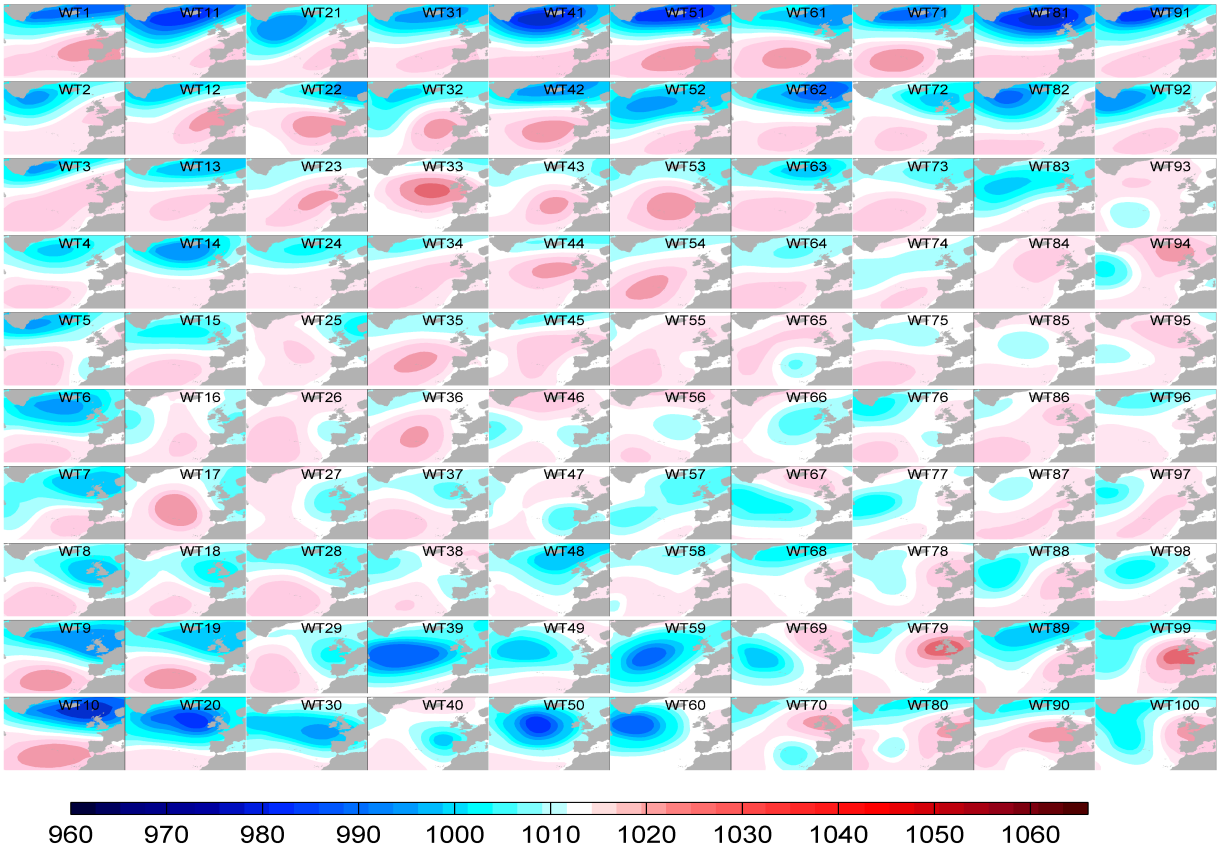
Predictand



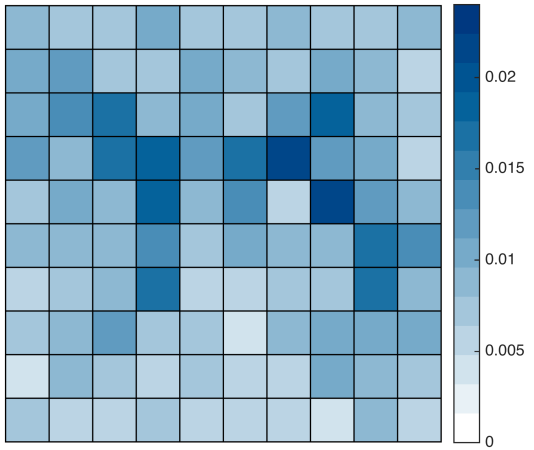


$$TWL = SS + 0.043 \cdot \sqrt{H_s \cdot {L_0}^2}$$

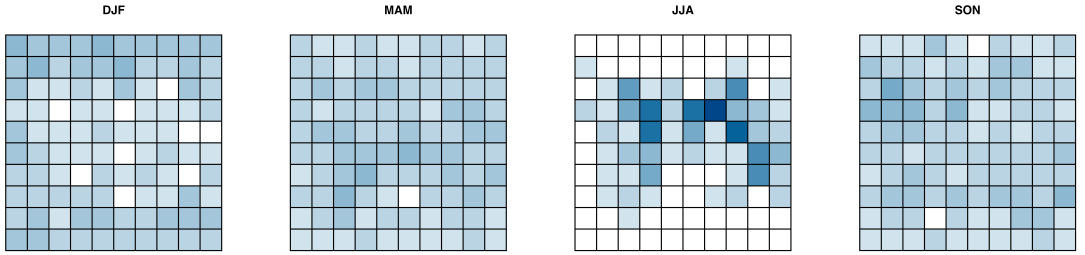
Weather type classification



Annual probabilities



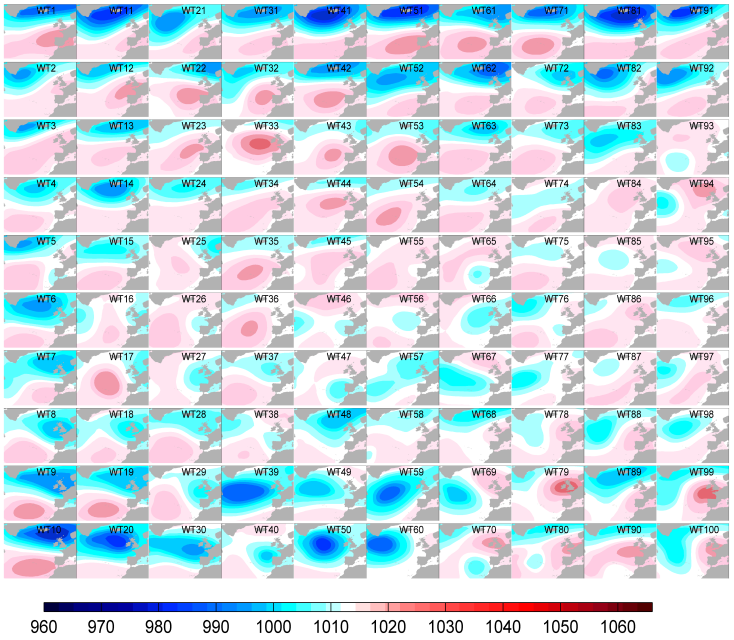
Seasonal probabilities



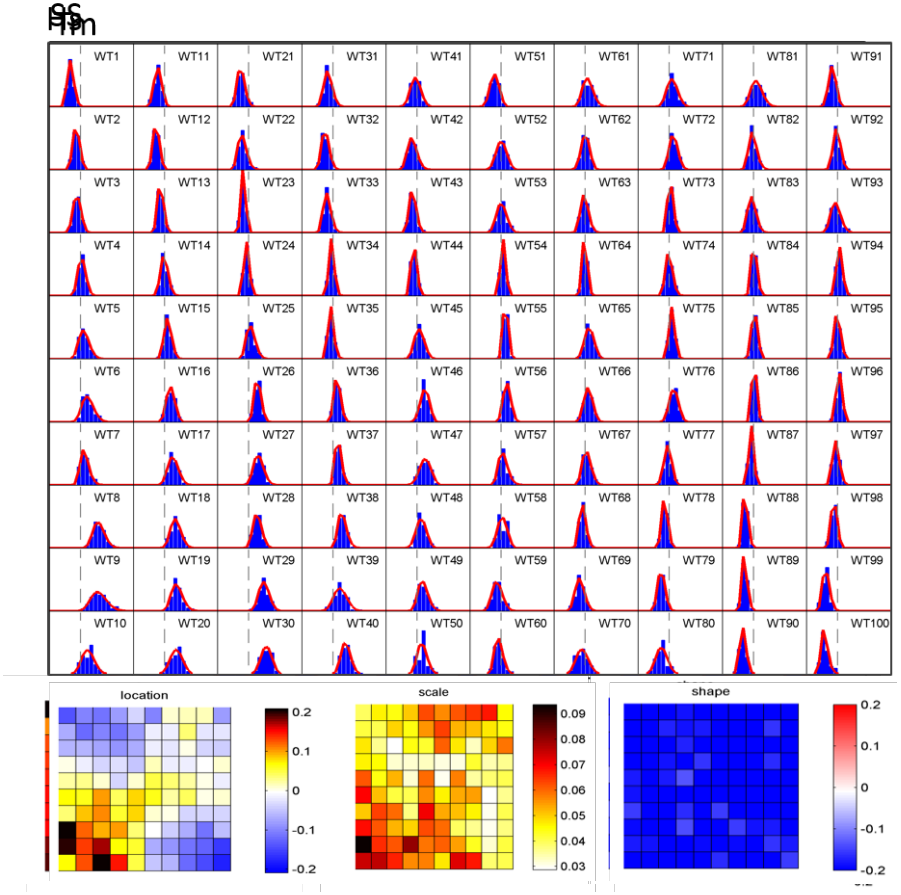
(Camus et al., JGR 2014)

(Camus et al., OD submitted)

Marginal distributions associated to each WT

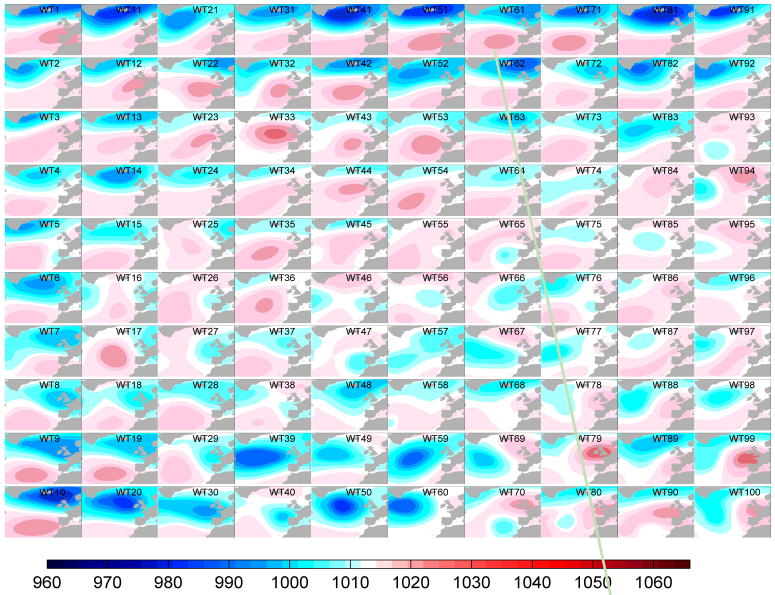


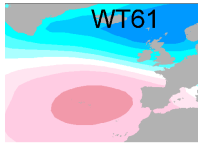
$$F(y) = \exp\left\{-\left[1 + \xi\left(\frac{y-\mu}{\psi}\right)\right]^{\frac{-1}{\xi}}\right\};$$

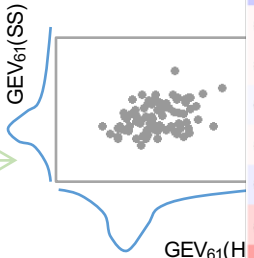


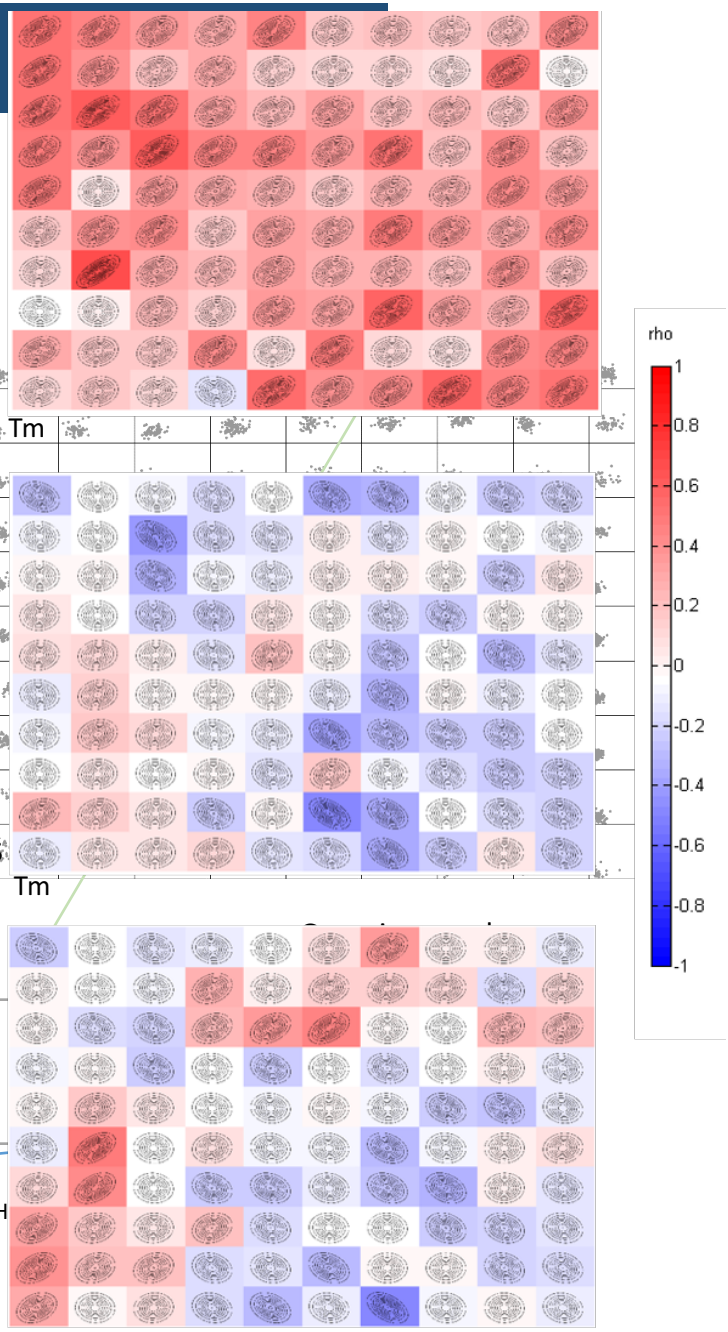
μ ψ ξ

Dependence structure



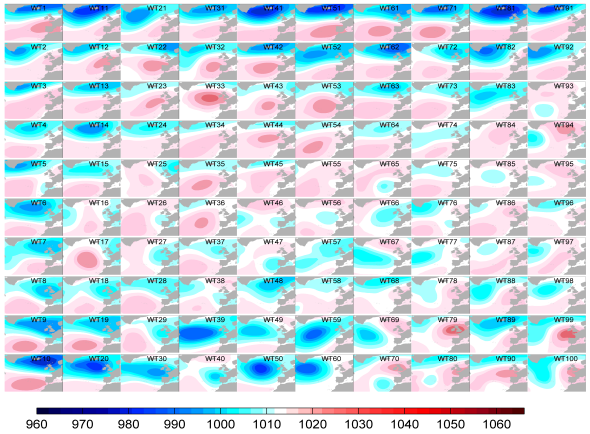


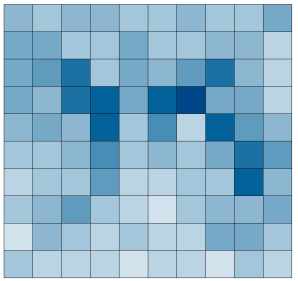


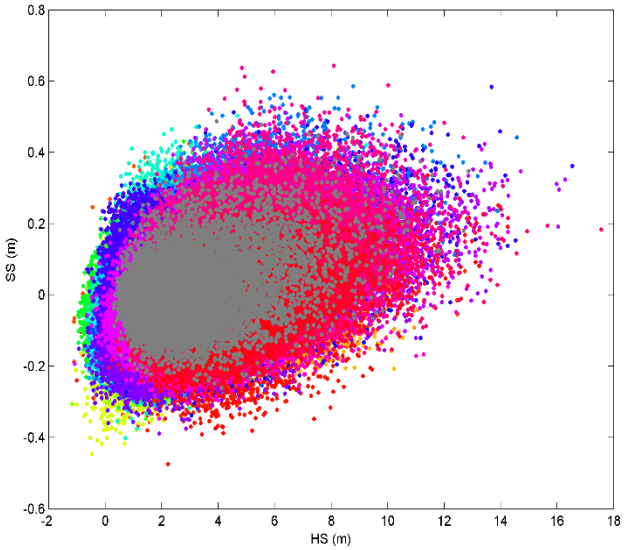


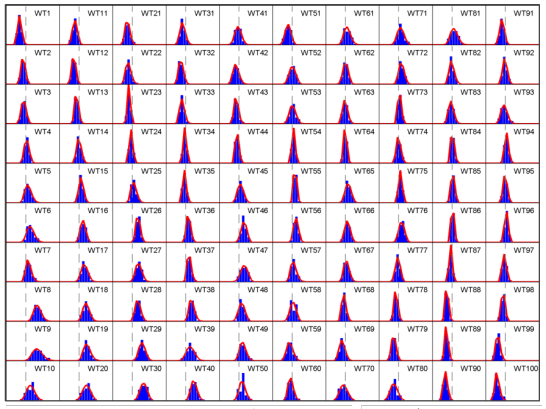
Correlation in Gaussian copula

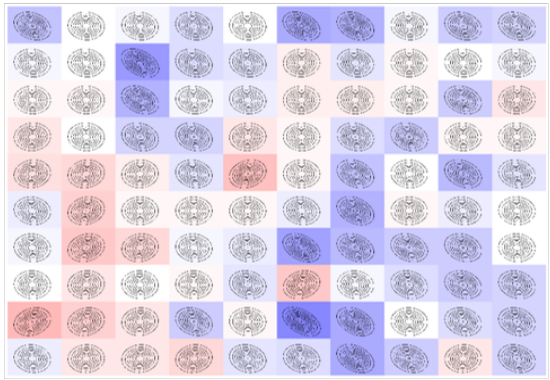
Multivariate Simulation





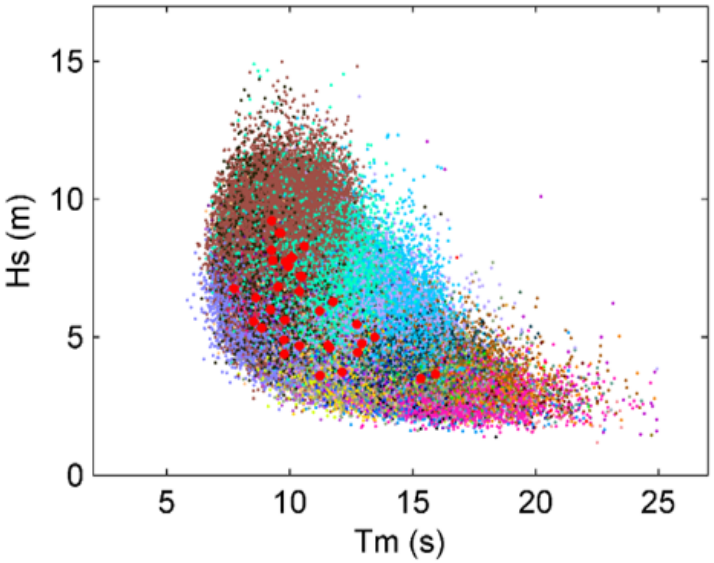


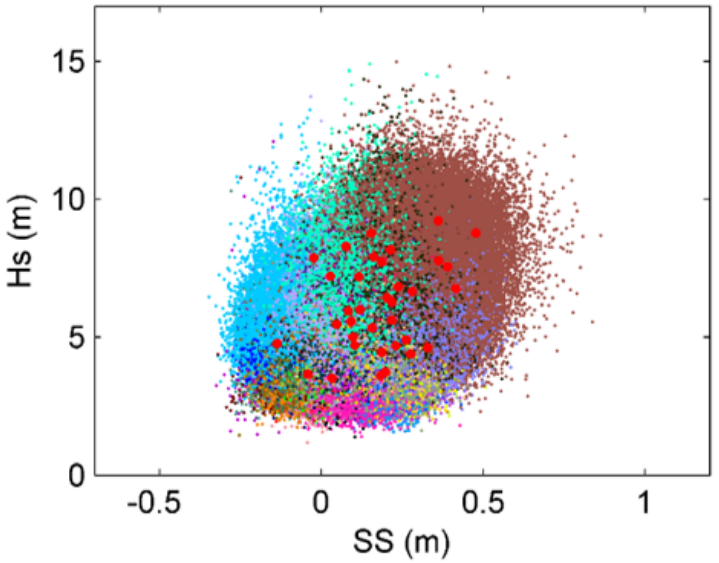




Climate Emulator

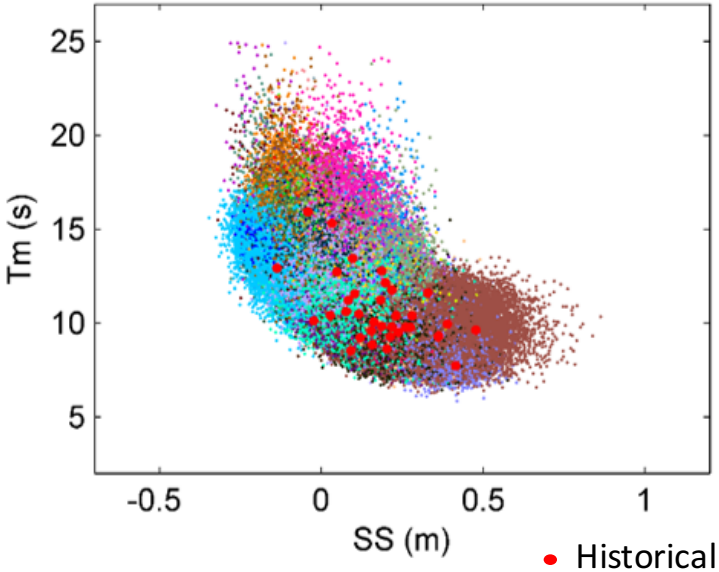
Multivariate Simulation





450.000 simulated years

WT of origin

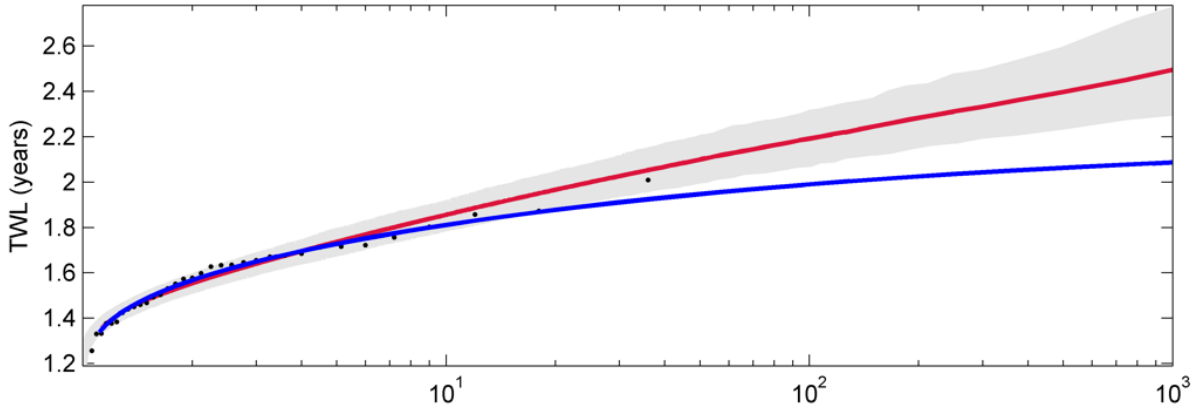


• Historical data

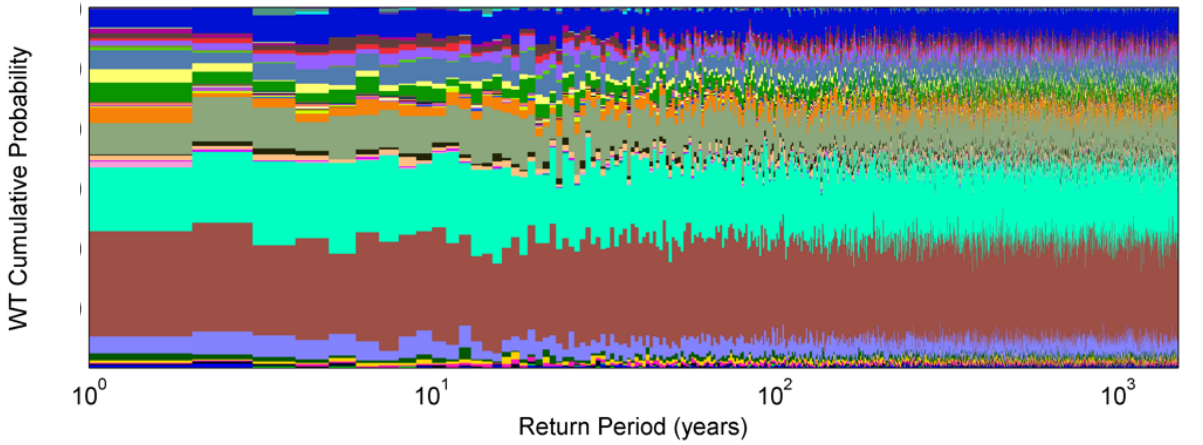
Multivariate Simulation

Univariate Stationary Gev

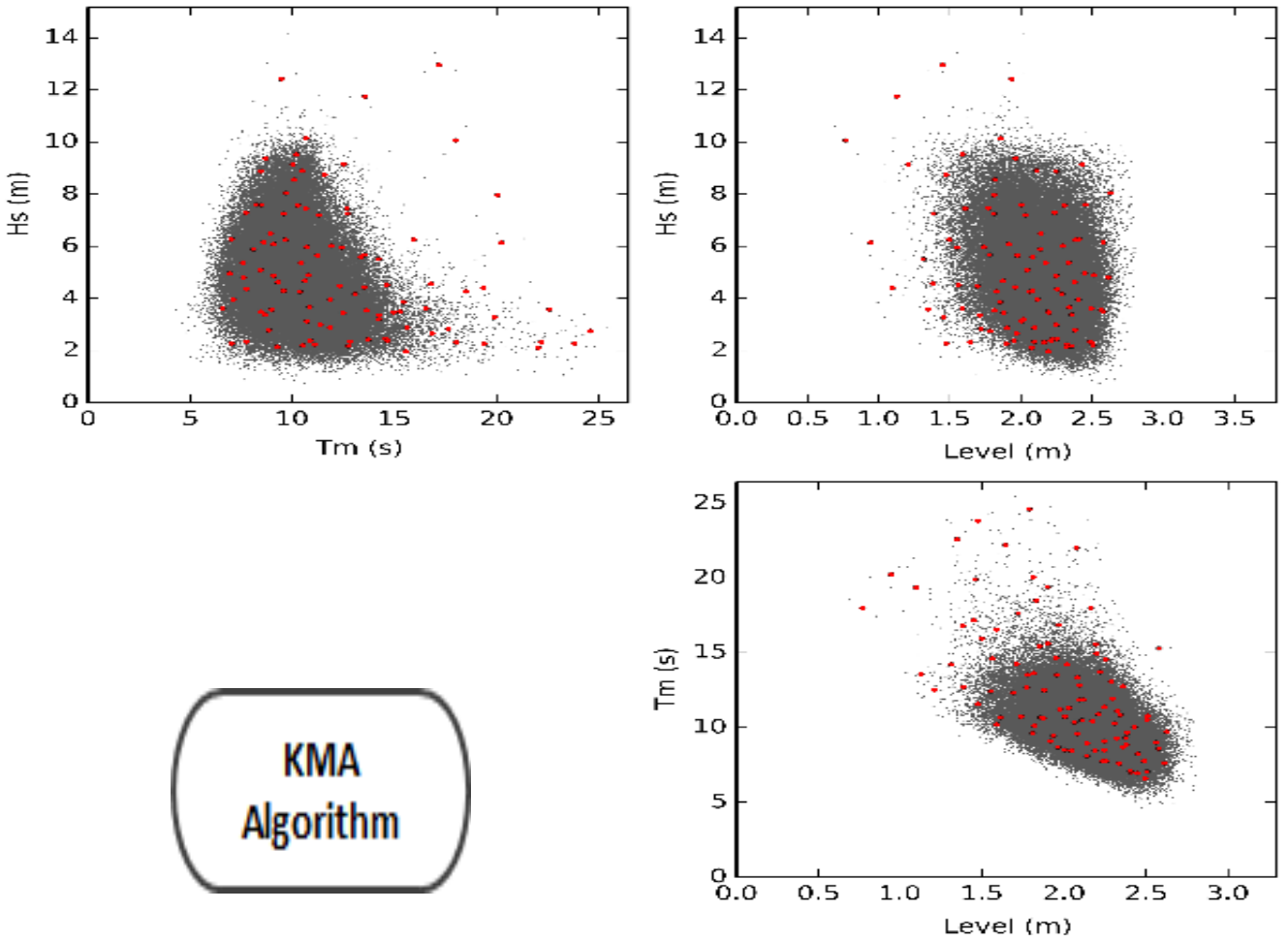
Non-stationary Gev
Multivariate simulation



WT of origin



Coastal flood – Risk assessment

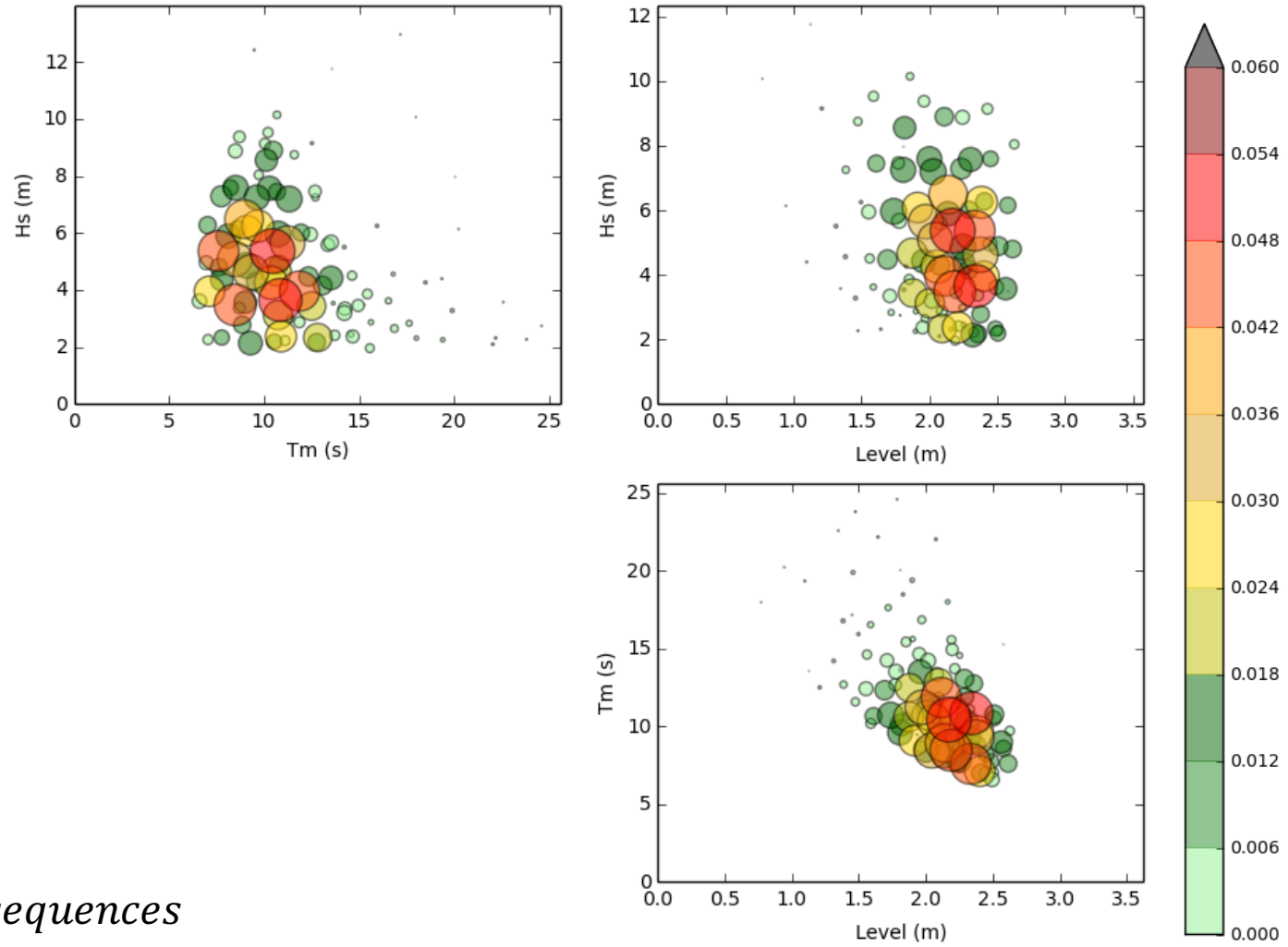


KMA Algorithm

$$R = \int prob \cdot consequences$$

Coastal flood – Risk assessment

Ocurrence probability of each cluster of annual maxima, p_i Sum(p_i)=1



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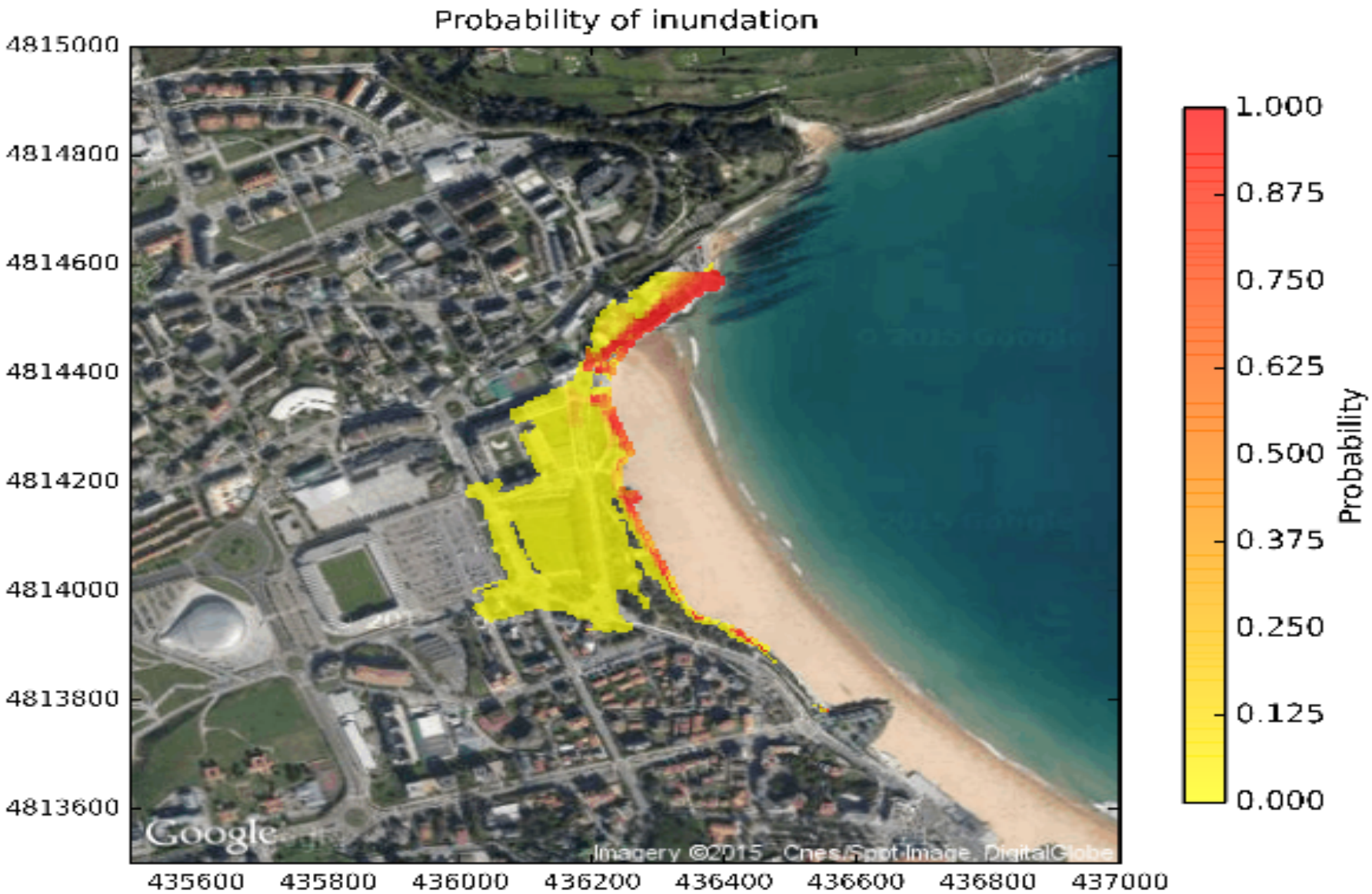
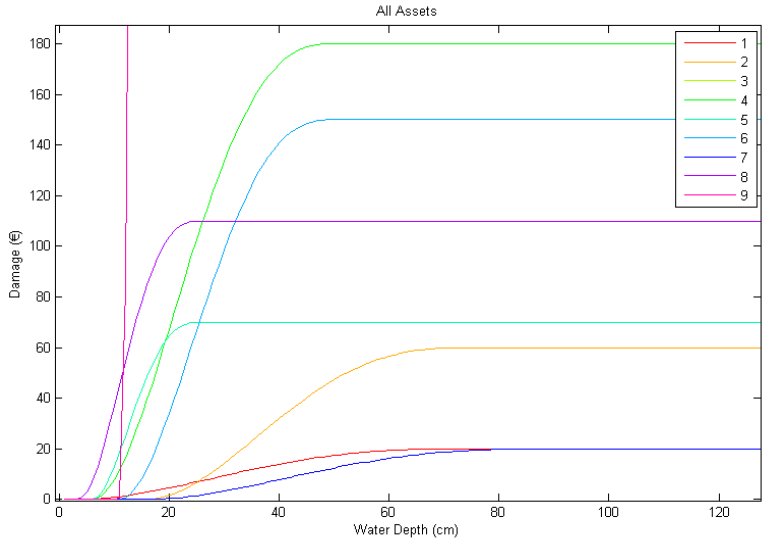


Damage Model

Based on local data and expert judgment
Beta CDF-type damage curve

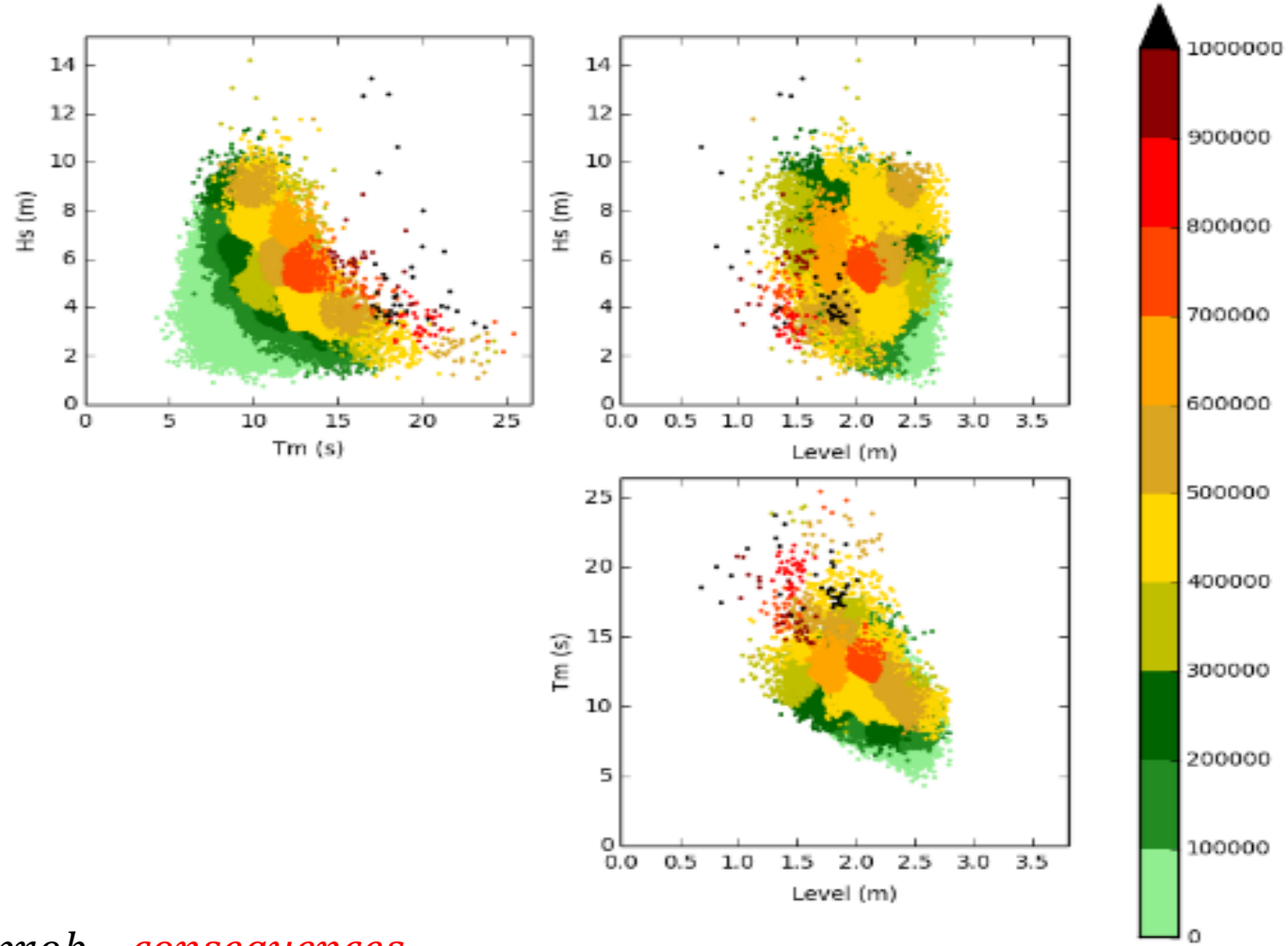
$$Damage_{unit\,i} = AssetValue_i * CDF((x - x_{mini})/(x_{maxi} - x_{mini}))$$



Code	Description	Uses	Thres holds (cm)	Maximum depth (cm)	Damage waves/de pth	Indirect Damage	Asset Value (€/m2)
001	Urban Park-Garden	Recreational	5	150	(W) (D)	No	20
002	Urbanized pedestrian walk	Recreational	30	150	(W)	No	60
003	Business/Commercial	Economics/c onsumer Supply	20	100	(D)	Yes	150
004	Residential areas	Residence	10	100	(D)/(W)	Yes	180
005	Residential areas	Parking	10	50	D	Yes	70
006	Hotels	Touristic	20	100	D	Yes	150
007	Parking	Services	30	180	D	Yes	20
008	Sporting activities	Services	5	50	D	Yes	110
009	Electric infrastructure	Infrastructure	20	100	(D)	Yes	20.000

Coastal flood – Risk assessment

Associated damage to each simulated event (€)



$$R = \int prob \cdot consequences$$

Conclusions

- Coastal floods are **climate-related events of multivariate nature**. The combination of non-extreme conditions of different variables may produce an extreme impact.

- The **extrapolation of the joint density function** of the variables that influence coastal flooding **based on weather patterns** allows the analysis of extremes conditions in different time periods outside of the calibration one.

- Information of the probability of **the hazard must be combined with the consequence** information in order to obtain the potential losses due to flooding.

- The use of **metamodels and a simplified inundation model** allows to overcome computational constraints and therefore no assumptions on the joint probability density function are needed.

Acknowledgement

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