

Uncertainties in Long-term Shoreline Projections: Unravelling the Role of Sea-Level Rise and Equilibrium Modelling Assumptions

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Sandy Beaches



Zand Motor, Netherlands (www.dezandmotor.nl)



Truc Vert, France (photo by V. Marieu)

Morphodynamics driven by several processes
on different temporal/spatial scale
(e.g. wave action, sea-level change, wind, etc.)



Maronti, Italy (photo by G. Cozzuto)

Shoreline Projections

In a context of climate change, the spatial heterogeneity of sea-level rise, wave-climate change, time scales of adaptation, and vulnerability of coastal communities raises the need for shoreline projections with their related uncertainties that provide full support to risk-informed decision making process.

Hinkel et al., (2019)

Critical need for reliable shoreline predictions



Source: Nils Drønen, blog DHI group, 'How technology is helping professionals manage coastal erosion successfully', 2018

Uncertainties

Uncertainties in modelling future shoreline change

Future climatic factors
(e.g. SLR and wave climate)



e.g.

- Future climate change scenario
- Ice sheet melting dynamics
- Global climate circulation modelling

Modelling approach



e.g.

- Model assumptions
- Calibration of free parameters
- Data availability

Little research effort has been made towards addressing uncertainties in shoreline projections.

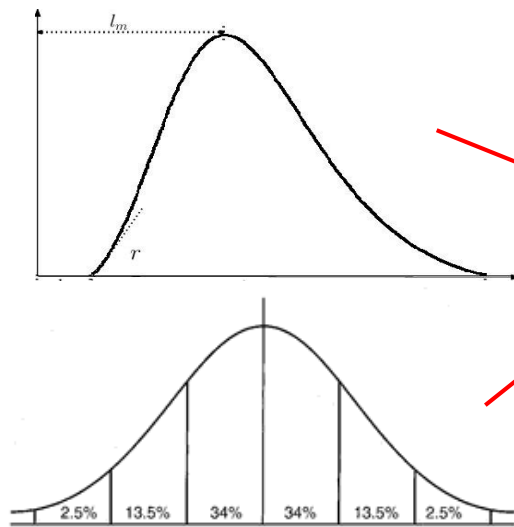


Need to investigate the role and impact of the several sources of uncertainties in shoreline projections.

Method

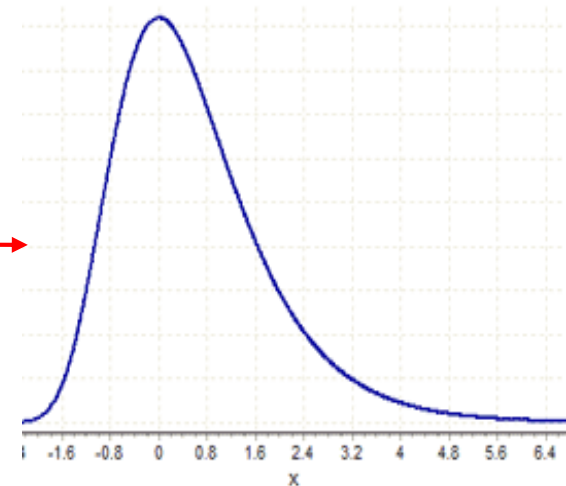
Uncertainty propagation

Uncertain input variables



Shoreline evolution model

Uncertain shoreline projections at a given time



What is the relative impact of the uncertainties in the input variables on the shoreline projections?

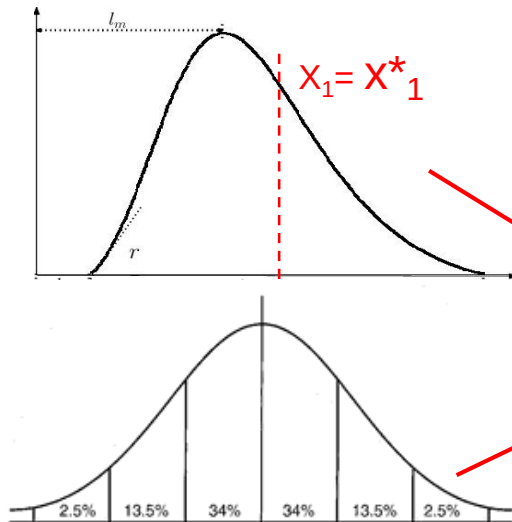
Method

Global Sensitivity Analysis (Saltelli et al., 2008)

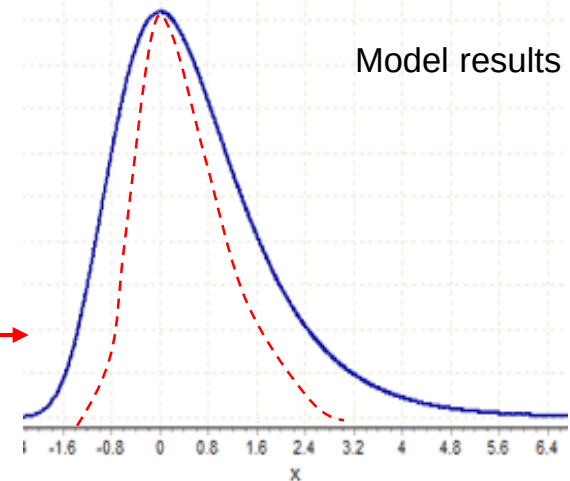
“How would the variance of the results change if we learned the true value of x_1 ?”

1st order Sobol' index

$$S_i^I = 1 - \frac{E[V(Y | x_i^*)]}{V_y}$$

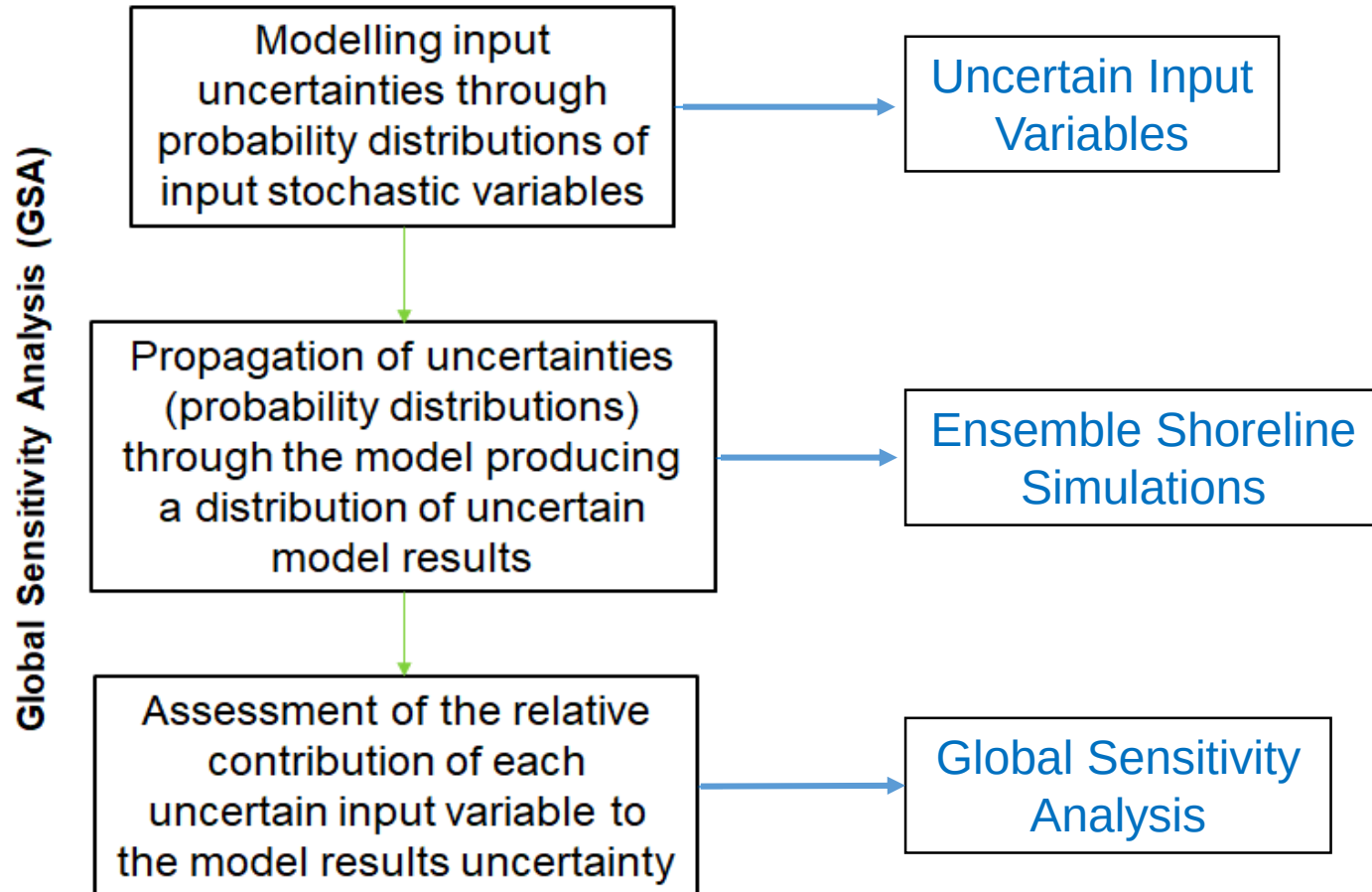


Shoreline evolution model



Global Sensitivity Analysis

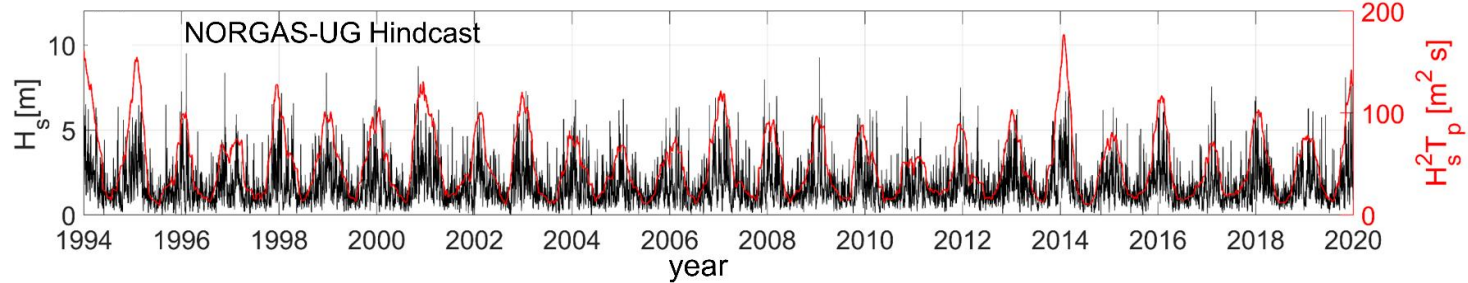
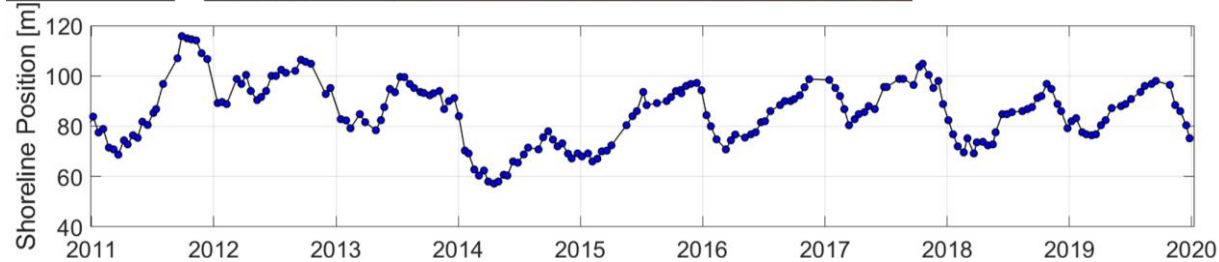
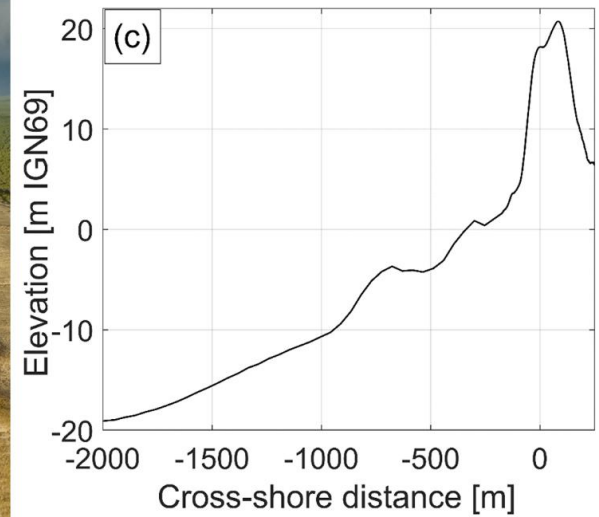
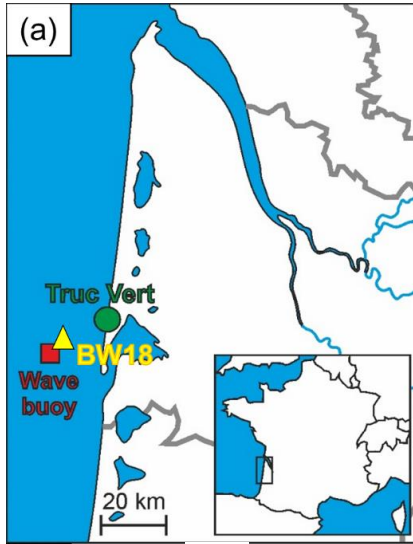
Method



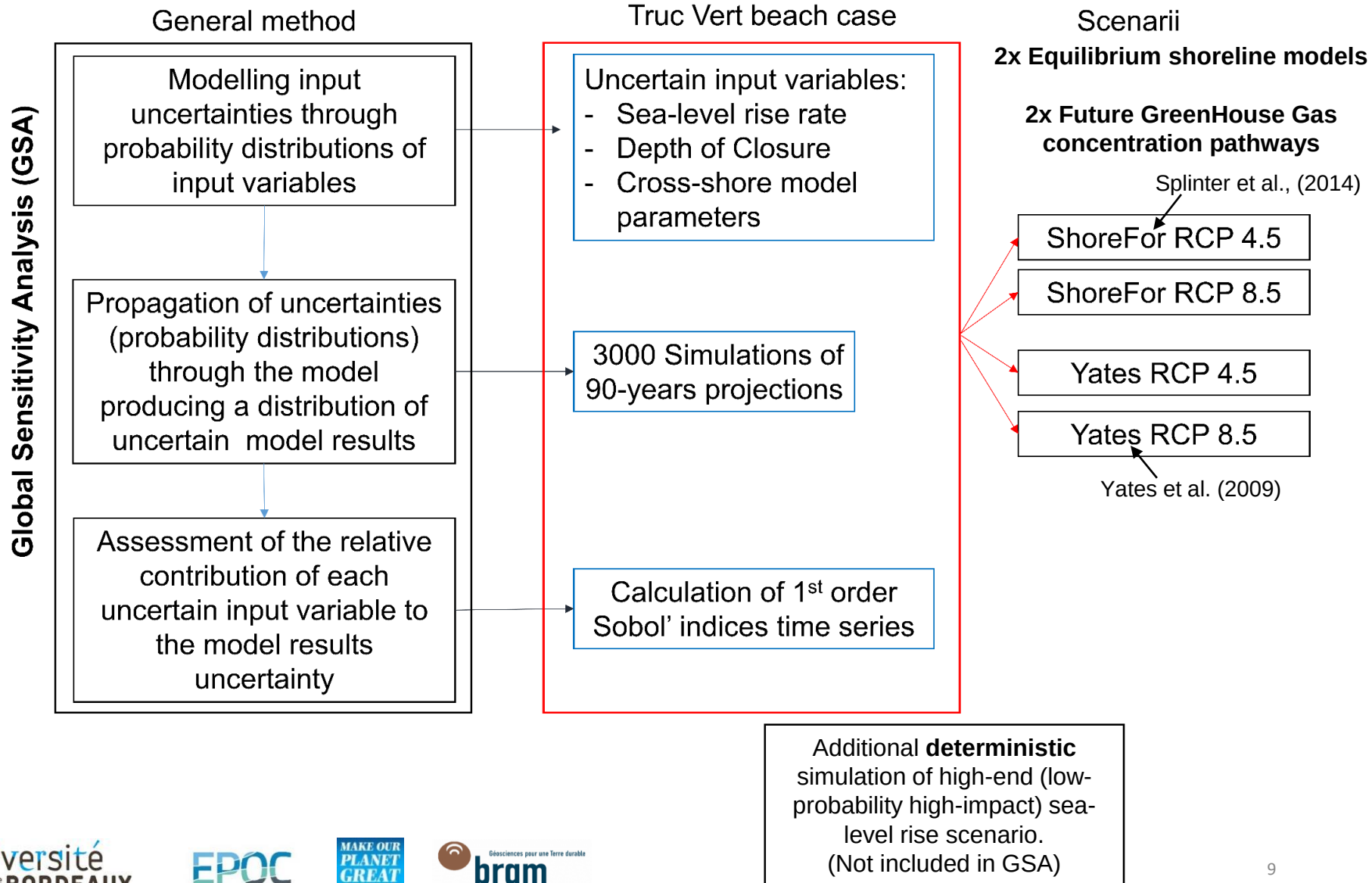
D'Anna et al. (2020)

Case of study

Truc Vert beach (South-West France)

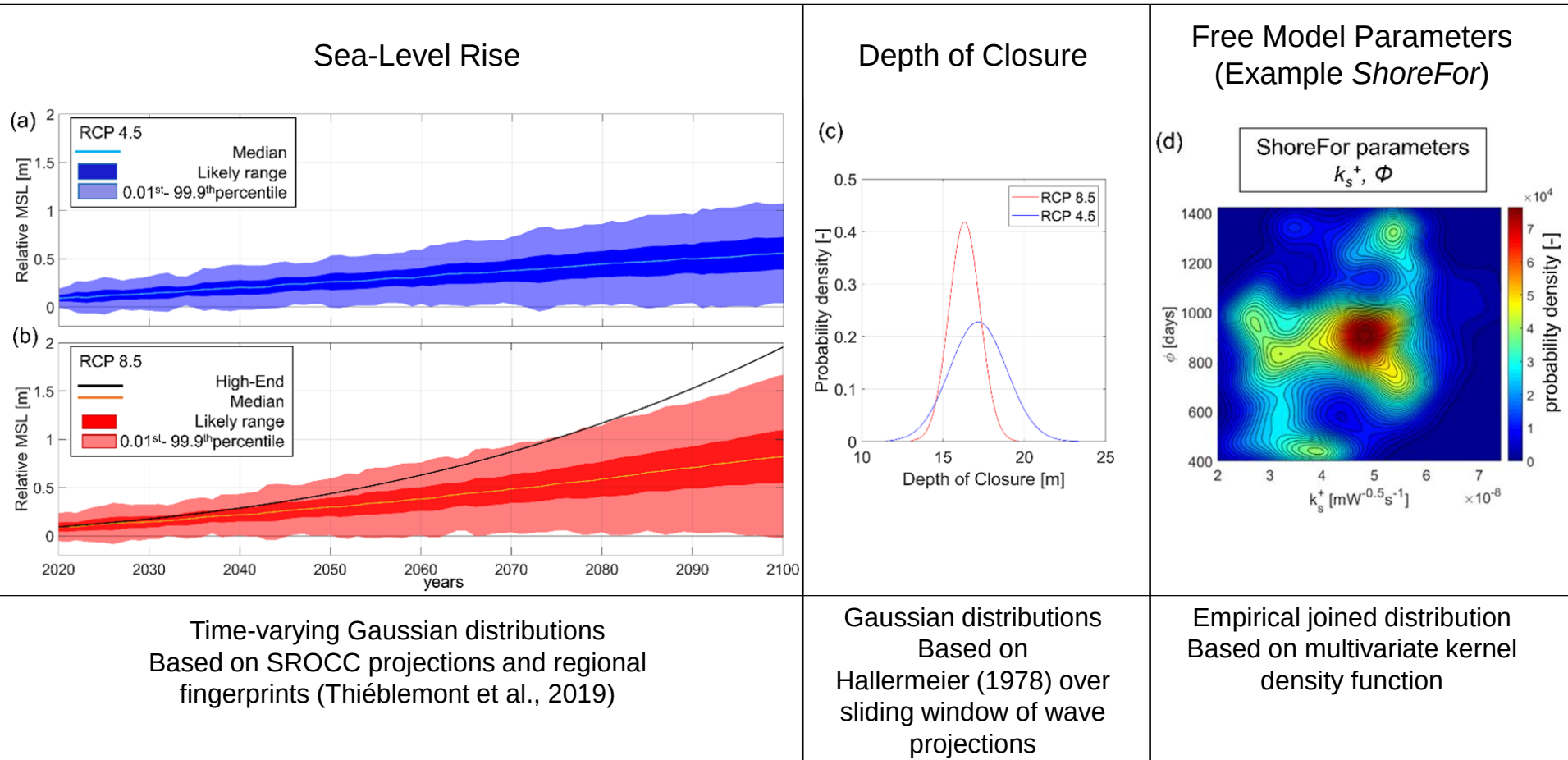


Case of study



Case of study

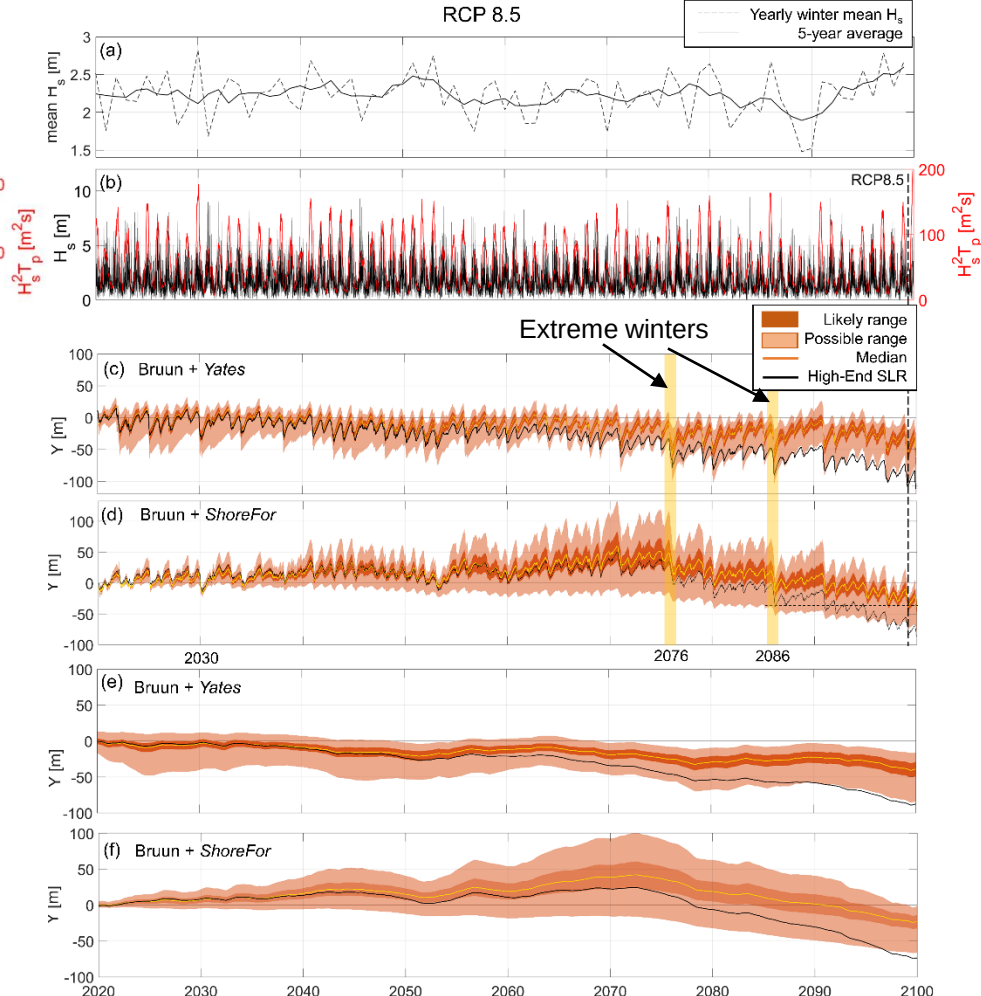
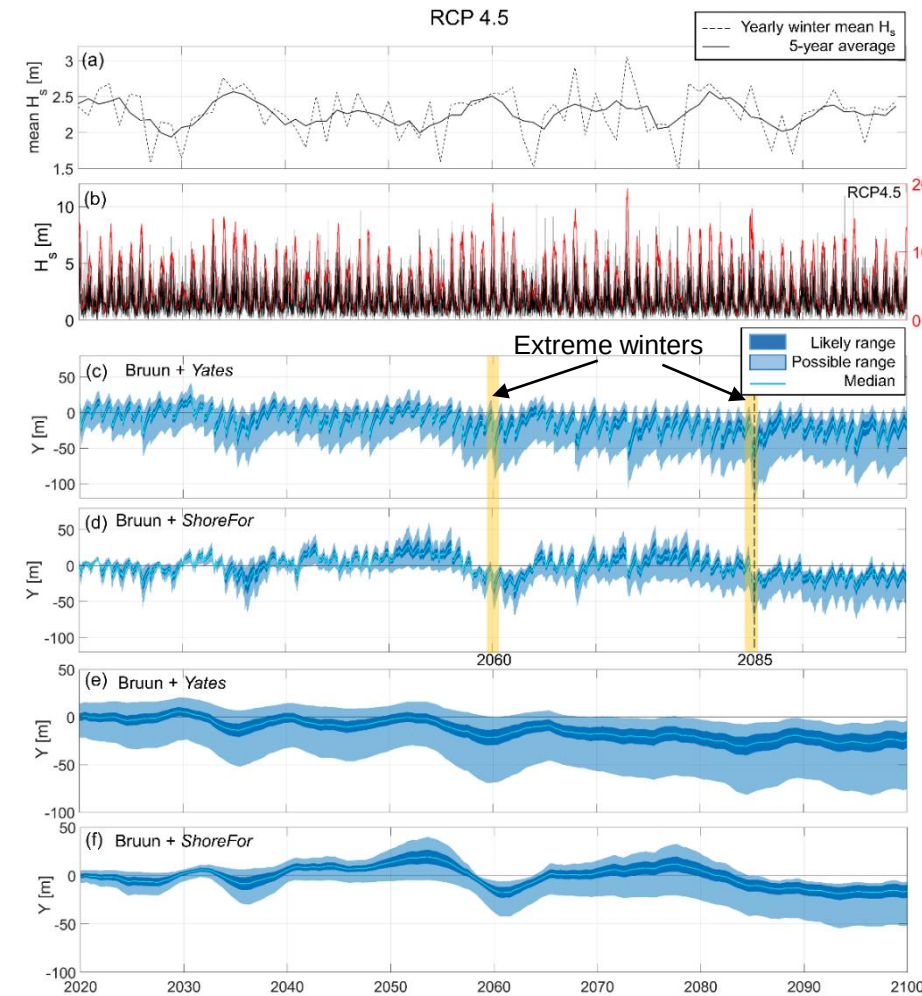
Input probability distributions



Results

Ensemble Shoreline Projections

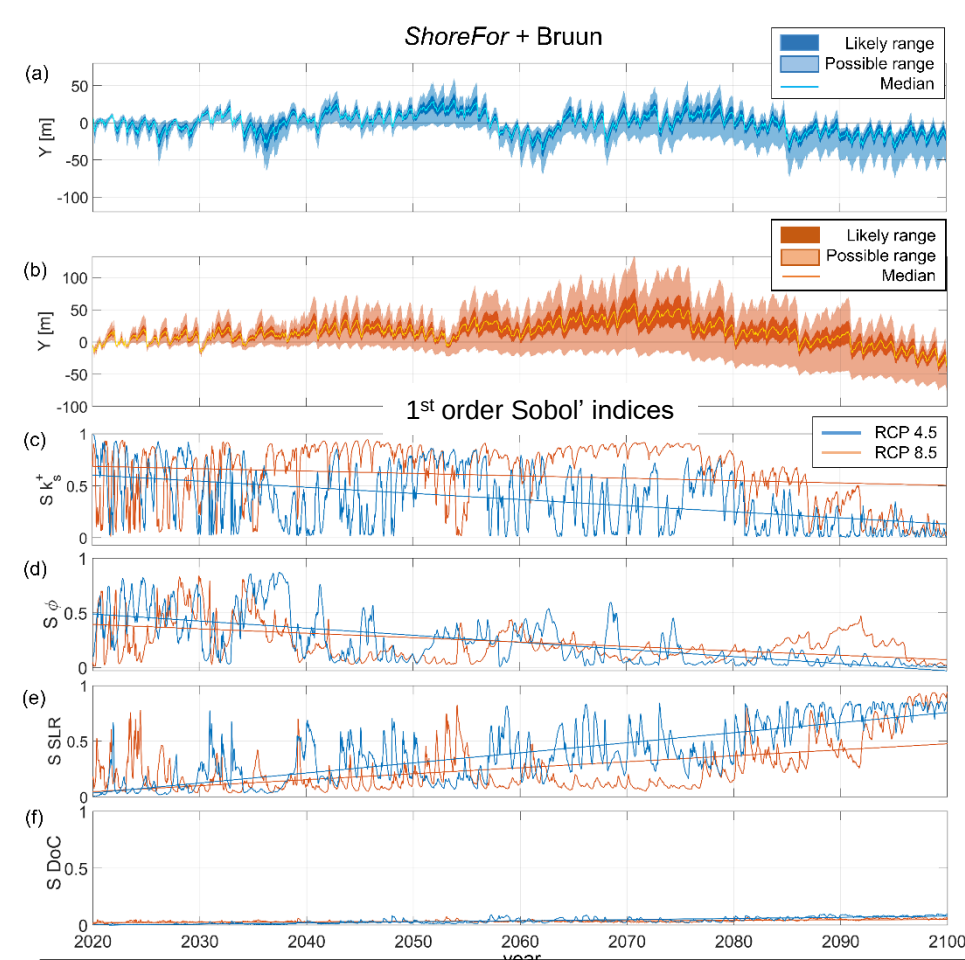
Likely range = variance of the ensemble
Possible range = min-max of the ensemble



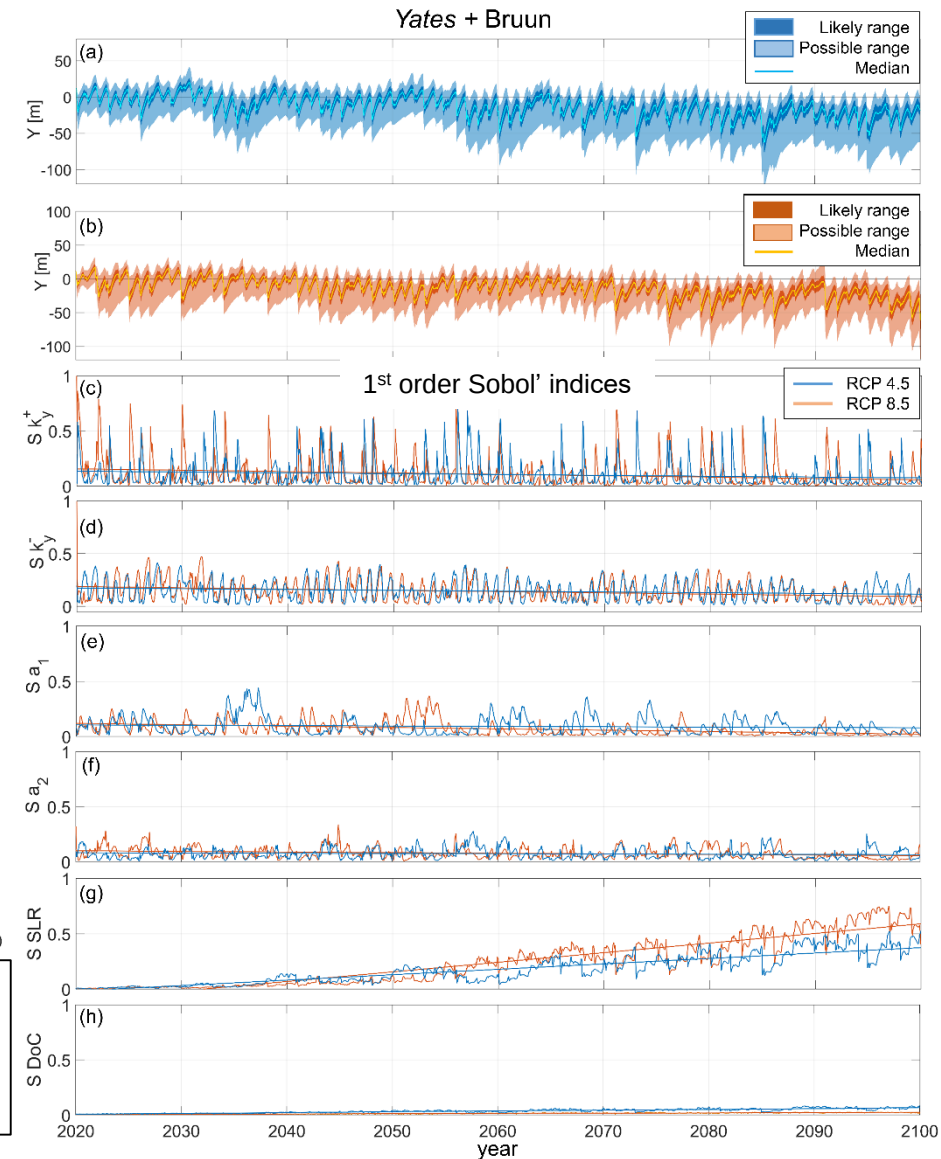
The results obtained with the two different modelling approaches (*ShoreFor* and *Yates*) show similar seasonal and interannual shoreline cycles, although with different amplitudes and variances.

Results

Global Sensitivity Analysis



Uncertainties in shoreline projections are initially driven by uncertainties in model free parameters, with the effects of SLR uncertainties only emerging in the second half of the 21st century...



Results

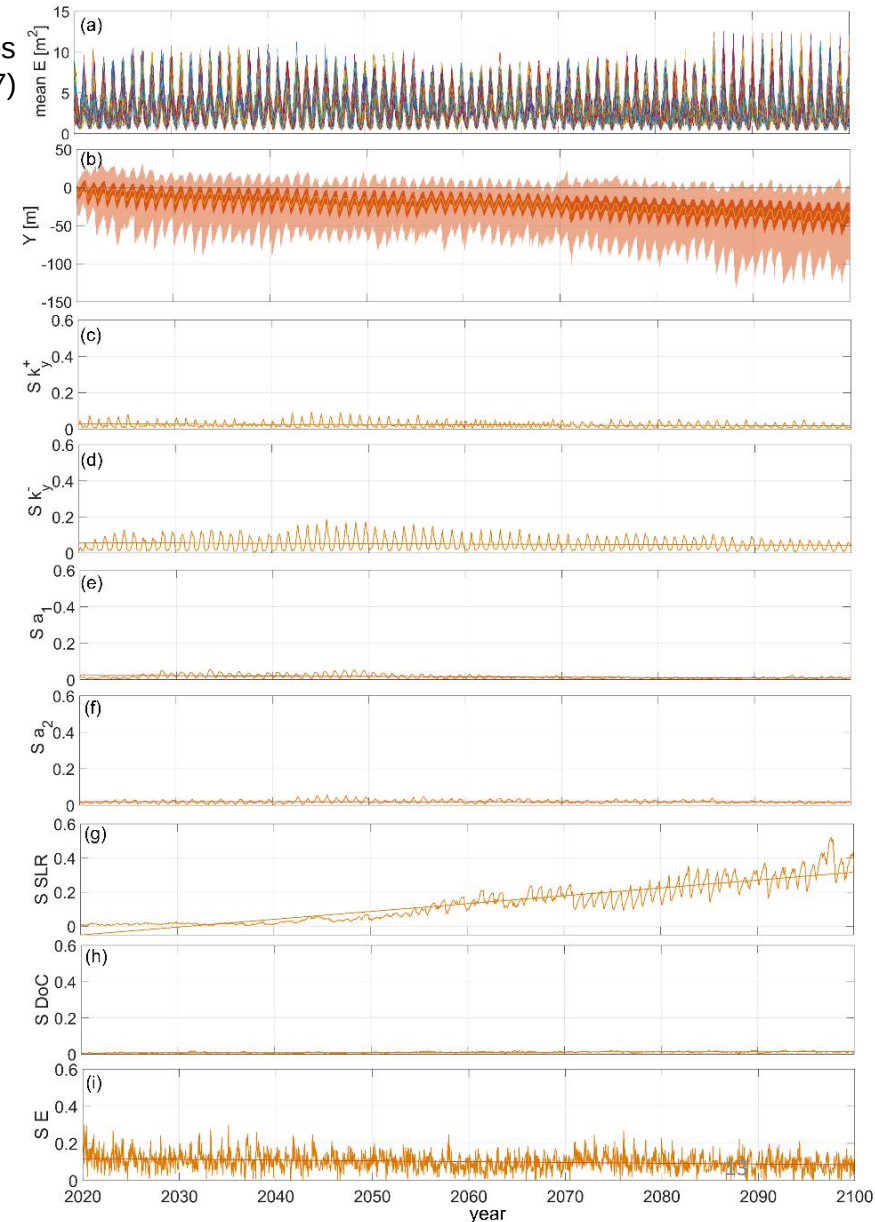
Test Global Sensitivity Analysis ensemble waves

...However, the time evolution of relative effects of SLR and model parameters uncertainties on shoreline projections is related to the forcing wave climate variability.

It is important to account for uncertainties related to the temporal distribution of wave energy, and therefore the need of ensembles of synthetic wave time series that account for the inherent variability of the wave climate is emphasized.

Ensemble wave series
(Davidson et al., 2017)

Yates + Bruun RCP 8.5 (ensemble waves)



Acknowledgements

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