Lőrinc Mészáros (1,2), Frank van der Meulen (2), Geurt Jongbloed (2), Ghada El Serafy (1,2)

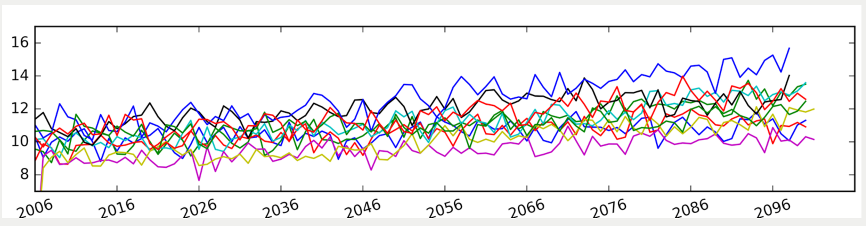
(1) Deltares, Boussinesqweg 1, 2629HV Delft, The Netherlands

(2) Delft University of Technoloy, Mekelweg 2, 2628 CD Delft, The Netherlands

A stochastic weather generator to enrich existing climate change scenarios and quantify uncertainties in marine and coastal ecosystems

Background

Studies addressing climate change impacts on coastal ecosystems often make use of a low- (RCP2.6), moderate- (RCP4.5) or high climate scenario (RCP8.5), without taking into account further **uncertainties in these scenarios**.



Climate change projection of temperature at the Wadden Sea (yearly means of 10 scenarios)

In this research a methodology is proposed to **generate further synthetic climate scenarios**, based on the available datasets, for a better representation of climate change induced uncertainties. The methodology builds on Regional Climate model (RCM) scenarios provided by the EURO-CORDEX experiment.

Methodology

In order to generate new scenarios of climate variables, a **hierarchical time series model** was developed. This parameterized time series model includes:

- linear trend component (T),
- seasonal ompontent (S) with varying amplitude and time shift,
- multiplicative residual term ($\sqrt{V}\,E$).

The seasonal shape (φ^S) is derived with the non-parametric Locally Weighted Scatterplot Smoothing (LOWESS), and the multiplicative residual term includes the smoothed variance of residuals and independent and identically distributed noise.

The model parameters are:

- trend intercept (α) and trend slope (β),
- amplitude of the seasonal shape (A^S),
- amplitude of residual shape (A^V),
- time shift in seasonality (τ),
- variance of the noise (σ^2).

$$y(t) = \alpha + \beta\,\tau(t) + \Sigma A^S \varphi^S (\tau(t)-(j-1))\,(\tau(t)) + \sqrt{\Sigma A^V \varphi^V (\tau(t)-(j-1))(\tau(t))} * E(\tau(t))$$

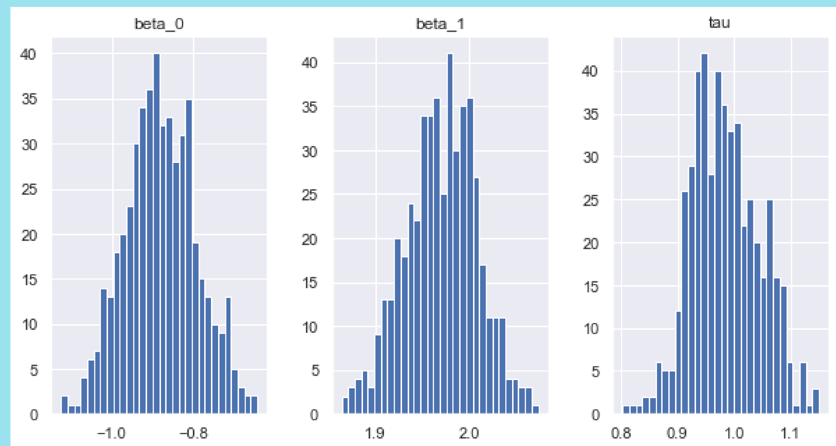
Results

The hierarchical time series model accurately describes the main features of the climate change projection data:

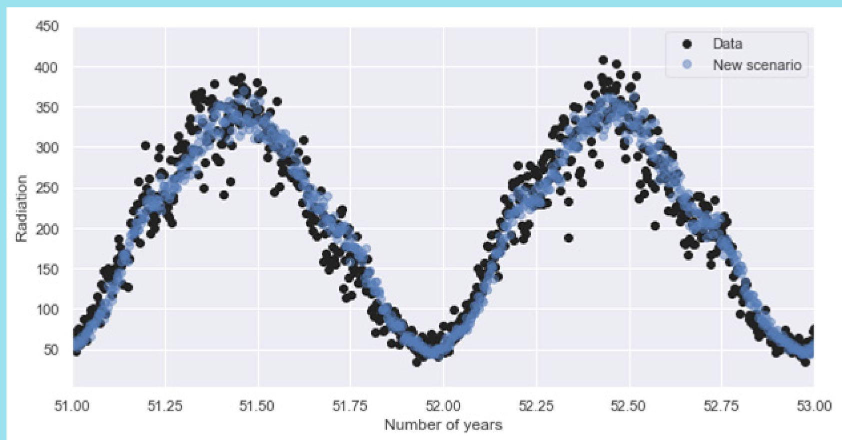
- linear trend
- seasonal variability
- time shift in seasonal pattern

The posterior distributions of the time series model parameters were estimated through Bayesian parameter estimation with Markov chain Monte Carlo sampling (eg. Gibbs sampler).

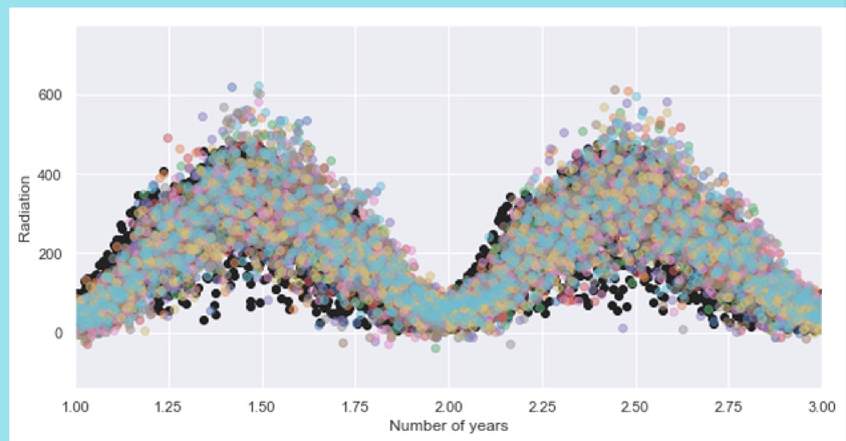
By drawing samples from the model parameter distributions numerous **new representative synthetic scenarios were generated**



Posterior distribution of time series model parameters derived with Gibbs sampling



Average of original radiation projection scenarios (black) against the average of synthetic radiation scenarios (blue)



Original radiation projection scenarios (black) and synthetic radiation scenarios (coloured)

Conclusions

- A generic hierarchical time series model was developed which is **able to describe different climate variables**
- The **parametrization of the time series** model allows the generation of new synthetic climate scenarios
- Instead of few equiprobable scenarios, numerous scenarios can be used for **stochastic modelling** to quantify uncertainties

Recommendations

- Generated **synthetic climate scenarios can feed into numerical- or statistical models** that relate climate variables to ecosystem variables,
- **Probabilistic simulation should be conducted** to further propagate the climate changed induced uncertainties to marine and coastal ecosystem indicators.

Acknowledgments

This work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727277

www.deltares.nl

for more information
lorinc.meszaros@deltares.nl

Address
P.O. box 177
2600 MH Delft, The Netherlands