SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Deltares

Forecasting shellfish aquaculture in a changing climate

Selecting typical years for ocean model scenarios

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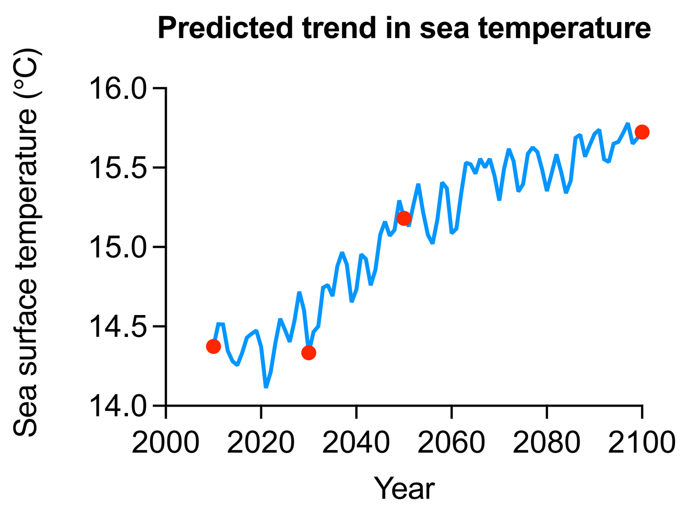
1 Introduction

- Climate change scenarios are increasingly integrated in numerical models to project future environmental conditions
- However, fully coupled biophysical-ecosystem models are computationally intensive, requiring long calculation times
- Hence, there is a need to select specific years for model simulations, rather than using a time series

Challenges in selecting a representative year

- Due to variability between years, selecting a single year can be challenging
- How can we select a representative year with a systematic approach to reduce bias and enhance the reliability of model predictions?



2 Methods

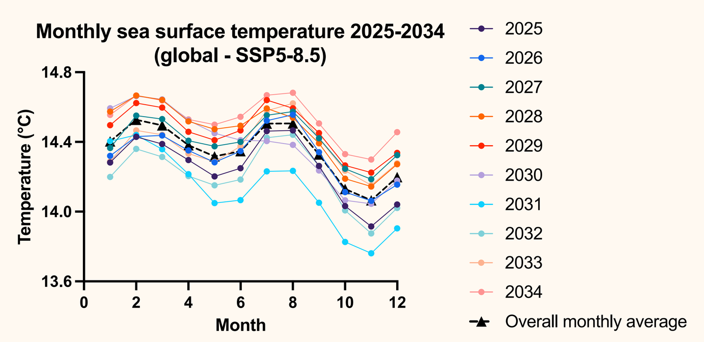
Existing approaches

- Existing approaches, such as Typical Meteorological Year, aim to create a "synthetic" year by selecting the most typical months from a time series
- Its main drawback is that, by focusing on average months, it smooths out variability and fails to capture extreme events

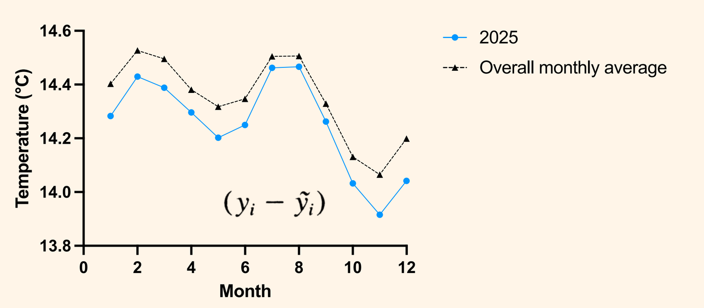
Our proposed methodology

- We propose a method based on the statistical analysis of single or multiple variables (e.g. temperature, precipitation) over a time series (10-20 years or more)

calculate monthly average over the entire time series



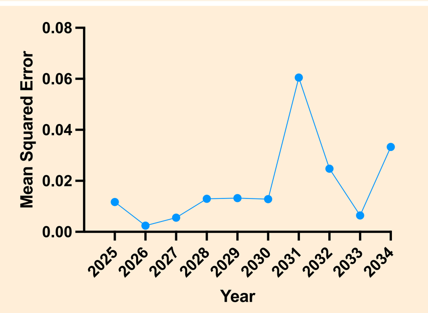
calculate difference (residual) between each year's monthly value and the overall monthly average



sum the squared residuals to obtain Mean Squared Error (MSE)

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

select year with the lowest MSE



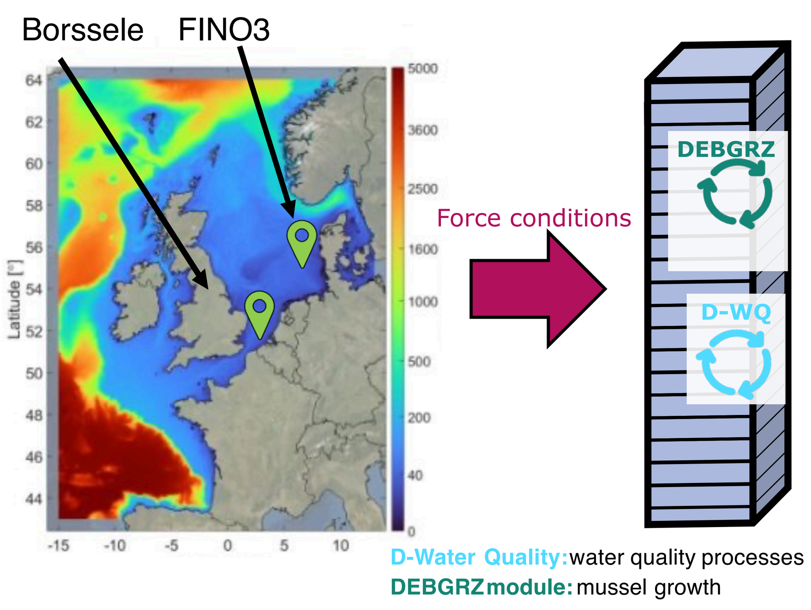
3 Results on representative year selection

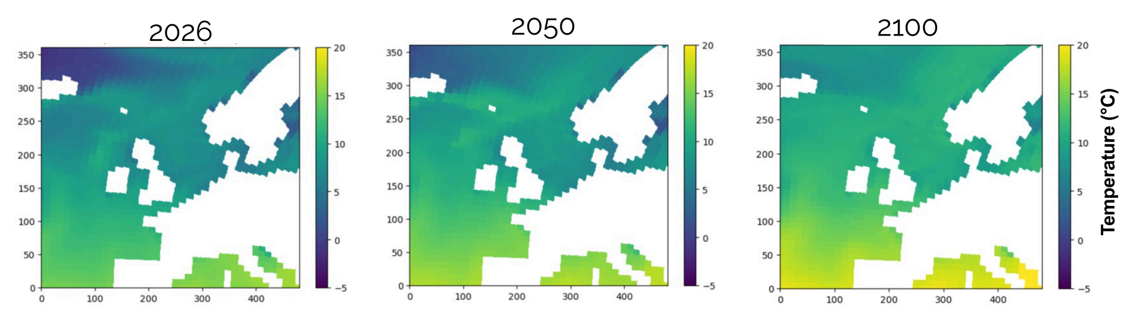
- The method can be used to select representative years for either single or multiple variables, by selecting the lowest combined MSE
- Between 2025-2034, 2026 is the most representative year for both temperature and precipitation
- Note: data from all variables should come from the same selected year, to avoid "cherry-picking"

Year	Temperature MSE	Precipitation MSE
2025	0.012	2.2E-13
2026	0.003	8.66E-14
2027	0.006	5.09E-14
2028	0.013	1.17E-13
2029	0.013	1.22E-13
2030	0.013	6.48E-14
2031	0.060	1.07E-13
2032	0.025	1.92E-13
2033	0.007	1.34E-13
2034	0.034	1.16E-13

4 Predicting the effects of climate change on mussel growth

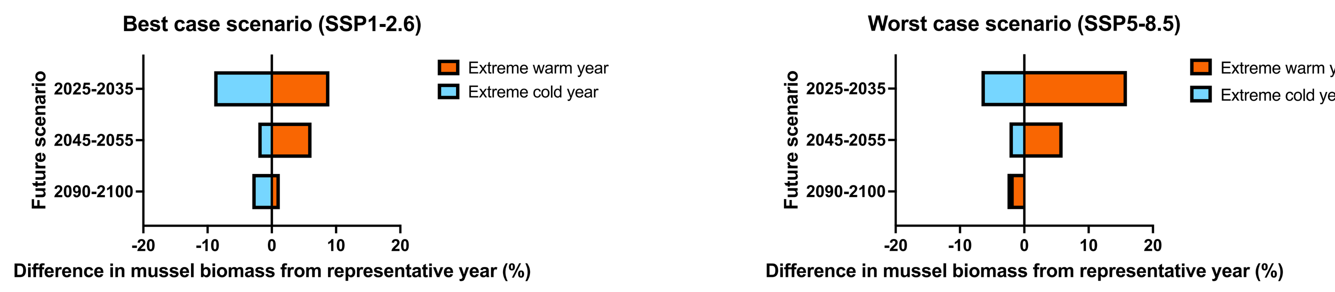
- The mussel growth model (DEB module integrated in Delft3D-FM (Troost et al., 2010; Deltares, 2023) was applied to two offshore wind park locations (Borssele, FINO3)
- A 1DV column model based on future temperature predicted from the CMCC-ESM2 model (Lovato et al., 2022) and the forcing conditions from the 3D – Dutch Continental Shelf Model (DCSM) was used



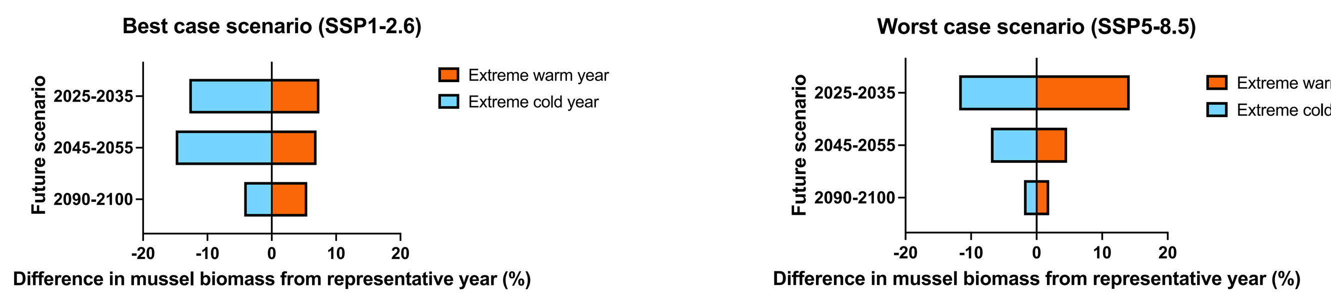


Input sea temperature data (Lovato et al., 2022) used for the mussel model simulations under scenario SSP5-8.5

Borssele



FINO3



- **Growth prediction:** Extreme years show up to **+-15% difference** compared to representative years
- **Location:** Impact of temperature is greater in FINO3 than in Borssele
- **Long-term trends:** with longer-term predictions, difference between selected years decreases

Conclusions and future work

- The presented method can systematically **identify representative years** in a time series; works with multiple variables, spatial subsets, and variable weights
- Modeling can inform aquaculture farmers on potential positive/negative **climate change impacts on mussel yield**
- Future work: expanding the model to **3D simulations** for the North Sea, combining aquaculture upscaling and climate change scenarios

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GitHub repository with scripts for representative year identification

References

Deltares, 2023. https://content.oss.deltares.nl/delft3d/D-Water_Quality_Processes_Technical_Reference_Manual.pdf

Troost, T. A., et al. (2010).Modelling Shellfish Growth with Dynamic Energy Budget Models: An Application for Cockles and Mussels in the Oosterschelde (Southwest Netherlands) Philos. Trans. R. Soc. B: Biological Sciences 365(1557): 3567–77.

Lovato, T., et al. (2022). CMIP6 simulations with the CMCC Earth system model (CMCC-ESM2). Journal of Advances in Modeling Earth Systems 14.3: e2021MS002814.

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