# Temporal tidal change on the north-western European continental Shelf


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## Main Research Questions

1. **What are the main past changes in tidal characteristics on the north western European continental shelf?**
2. **What factors contribute to these changes and what is their respective contribution?**
3. What future tidal changes can be expected on the north western European continental shelf over the next 100 years, what are the dominant factors and what are their associated risks?
4. What are the potential impacts on submersion and sediment mobility?

## Context

Tides make up part of extreme high sea level, and so an understanding of factors driving tidal change is important for coastal flood management and coastal evolution

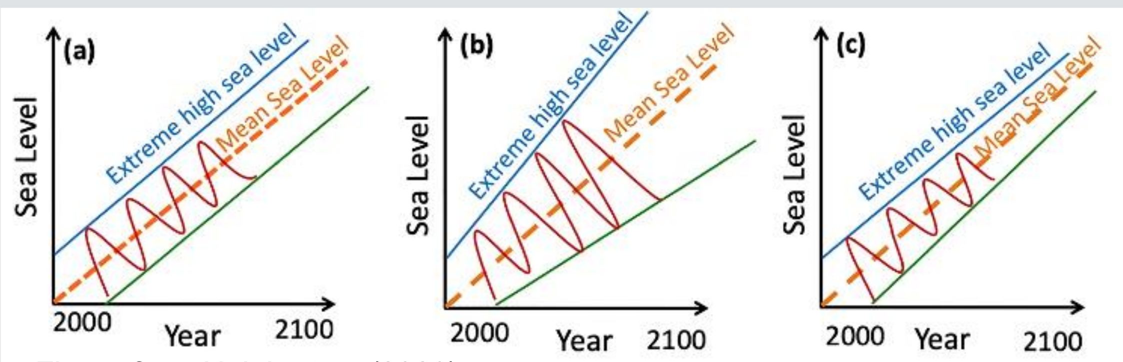


Figure from Haigh et al, (2020)

Tides are changing due to non astronomical factors (Haigh, 2020), and whilst several physical processes have been identified that can influence tides. **The studies have not quantified the respective effects of the multiple factors on past or future changes.**

The aim of this project is therefore to determine drivers of tidal change, their respective contributions, future tidal change, and the risks associated.

Identified potential factors driving tidal change include:

| Identified driver | Justification |
|---|---|
| Mean Sea Level (MSL) change | Changes resonance characteristics of basin and bottom friction (Idier et al, 2017) |
| Wind speed ($U^2$) | Wind and pressure interact with tidal water level through advection in shallow water equations (Haigh et al, 2020) |
| Wave power ($P$) | Changes bottom friction (Hashemi and Neil, 2015) |
| Inverse barometer (proxy of storm surges) ($IB$) | Similar to waves, and also based on numerical simulations of tide-surge interactions (Idier et al, 2012, Idier et al, 2019, Flather and Williams, 2000) |
| Stratification ($\Delta\rho 200'$) | Transfers energy from barotropic to baroclinic tide or vice versa (Colossi and Munk (2006)) |

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## Methodology

### Tidal data

Hourly sea level recorded by tide gauges obtained from and validated by SHOM

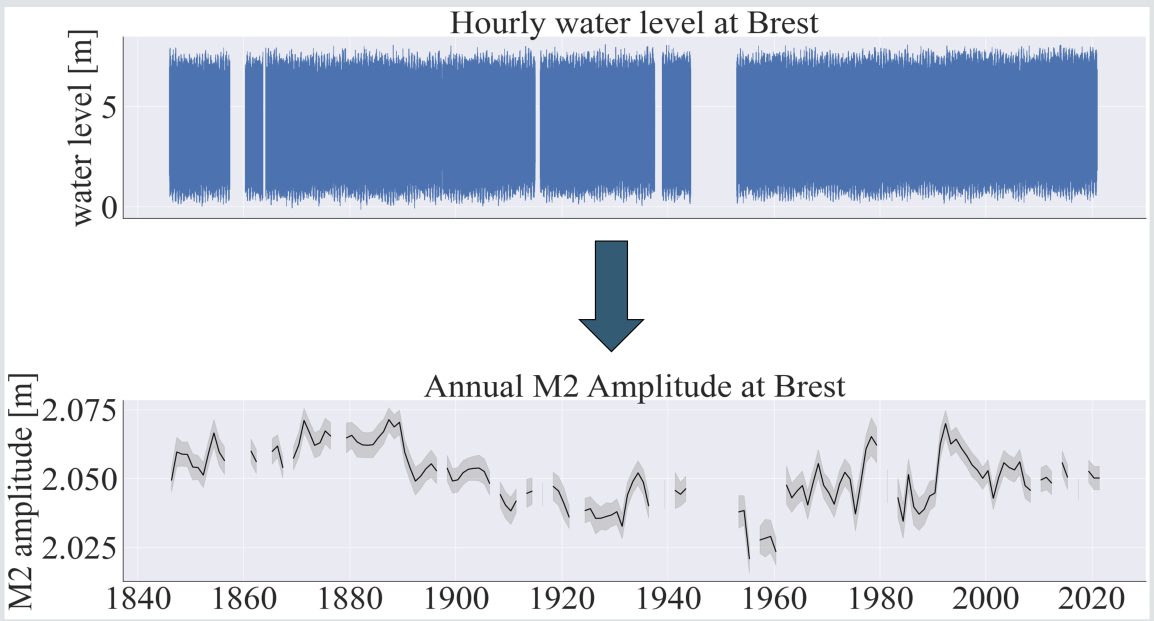
### Data filtering

Data filtering parameters were established through analysis of minimum, maximum and mean gap length in data records, and number of gaps present.

### Identifying changes

UTide (Codiga, 2011) Tidal harmonic Analysis (THA) Software used on windowed annual sections of the tide gauge data to estimate the amplitudes of tidal components on an annual scale.

(Methodology was applied to 4 study sites: Brest, Le Conquet, Saint-Malo and Dunkerque)




### Driver data

- Wind speed, wave power, inverse barometer
  - ERA reanalysis datasets on monthly scale
  - Each split into annual mean and annual standard deviation (noted as $\overline{x}$ = mean, $\sigma_x$= standard deviation)
- Stratification
  - Temperature/depth profiles taken from Yamaguchi and Suga 2019
- MSL change
  - Average water level at each window

### Constructing multivariate linear models

Tidal change models are constructed using all possible combinations of variables in the form:

$$\Delta CST_{amp} = \alpha\Delta x_1 + \beta\Delta x_2 \ldots$$

Where:

$\Delta CST_{amp}$ = change in tidal amplitude

$x$ = driver data

$\alpha, \beta, etc.$ = coefficients

Potential models are selected using Bayes Information Criterion (BIC):

$$BIC = k\ln(n) - 2\ln(\hat{L})$$

Where:

$n$ = number of observation datapoints

$k$ = the number of regressors (with the inclusion of the intercept)

$\hat{L}$= the maximised value of the log likelihood function, defined as

$$\hat{L} = p(y\,|\hat{\theta}, M)$$

Where

$p$ = a probability mass function

$\hat{\theta}$ = the parameters that maximise the likelihood function

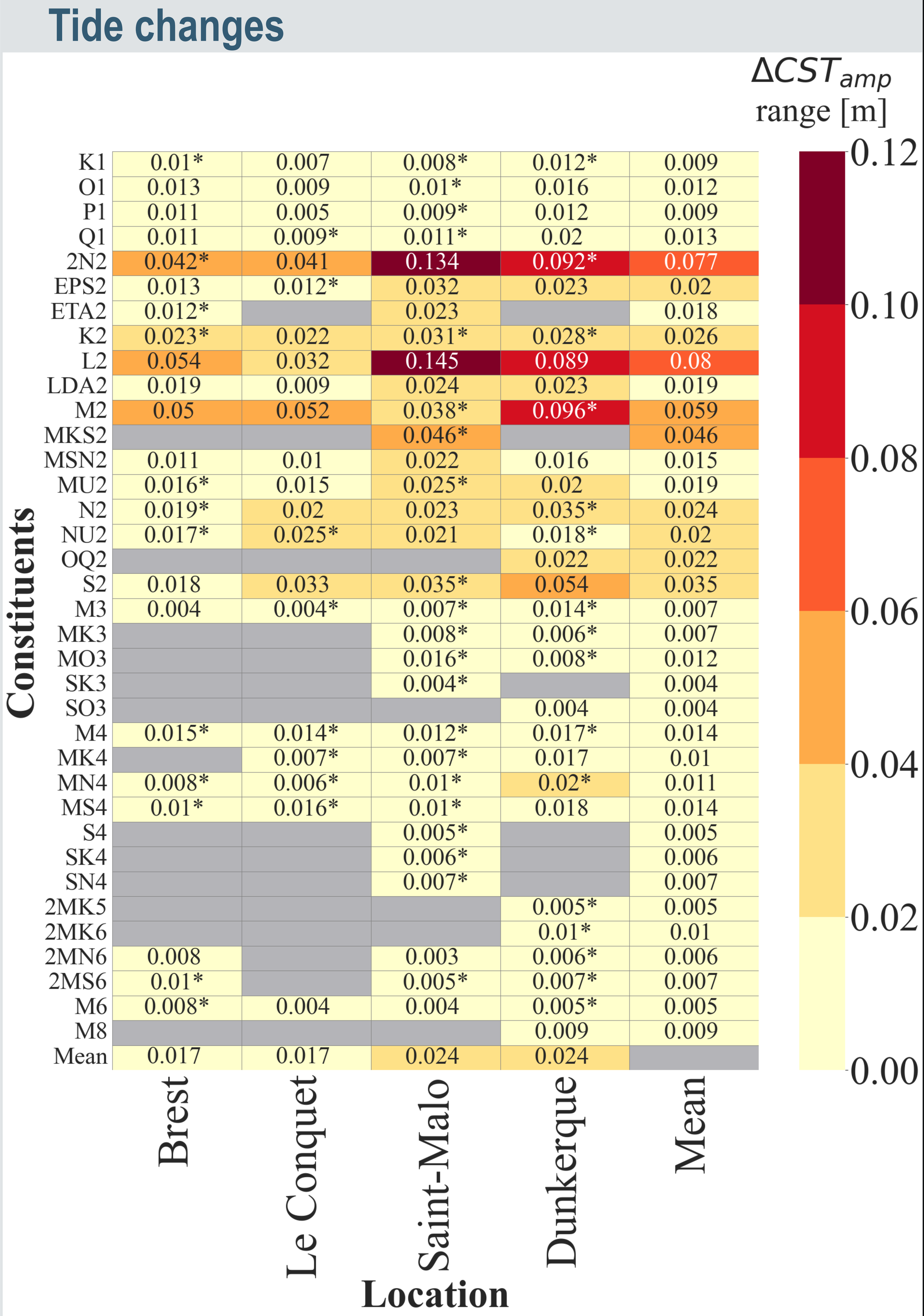
$M$ = the model being assessed

$y$ = the observed data.

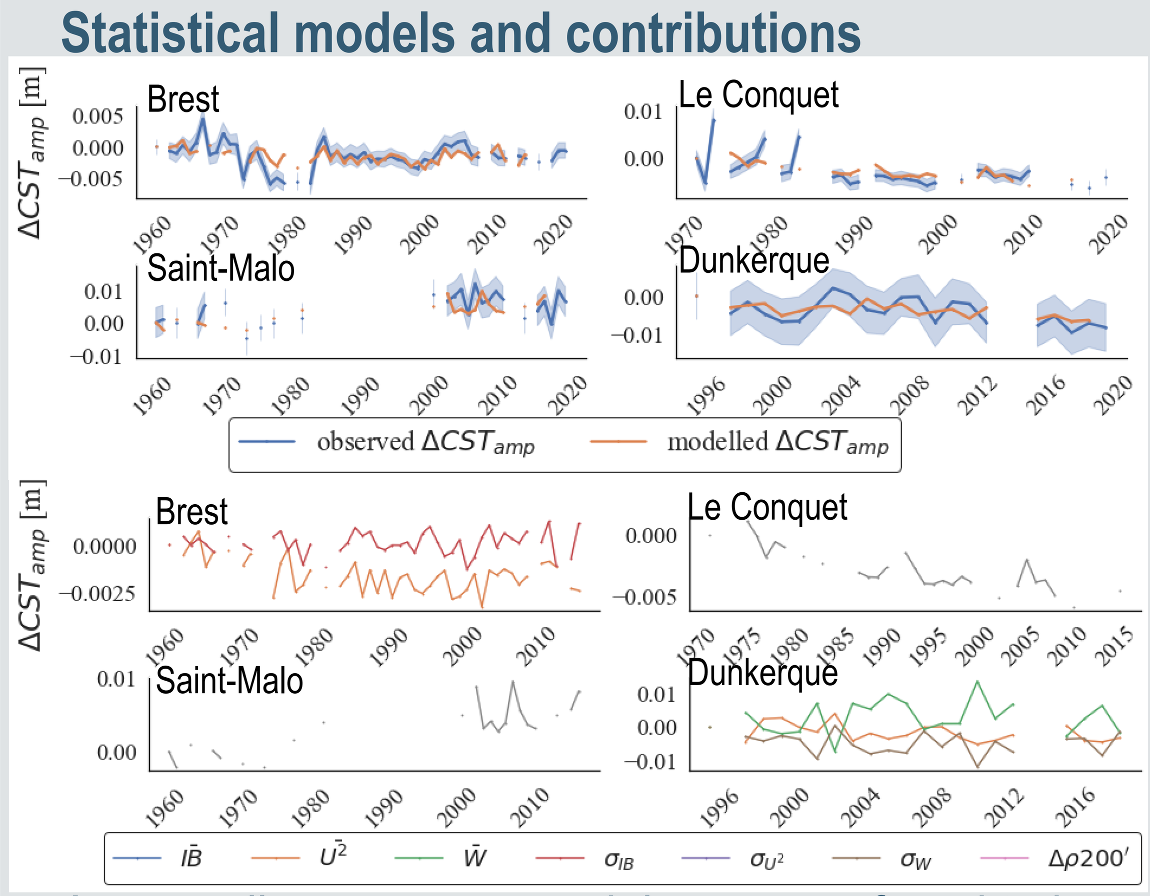
*$R^2$ is also considered, negative $R^2$ models are discarded*

## Current Results

### Tide changes




### Statistical models and contributions




Among all $\Delta CST_{amp}$ models, $IB$ was found to be the most commonly occurring driver

## Future Work

Current results suggest atmospheric storm surges play a key role in tidal characteristic changes on an annual scale.

The next phase of this work will rely on hydrodynamic numerical modelling to investigate this.

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