Spatio-temporal modelling and climate risk mitigation proposals in marine aquaculture

An example of analysis of the thermal risk associated with Bayesian modeling in the province of Alicante.

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Introduction

Mitigation and adaptation to climate change must be a priority in sectors that depend to a large extent on the conditions of natural ecosystems, such as marine aquaculture [3].

The project ModEsta within the ThinkinAzul program has the following objectives:

- Spatially analyse the climate risk through accumulated anomalies of different oceanographic variables.
- Spatio-temporally define risk associated with extreme events that may affect aquaculture facilities in the coastal environment.
- Generate predictive models of climate risk for localities where aquaculture is developed that define the probability of experiencing conditions that negatively affect production.

Objectives

- Define the climatic risk of the localities where aquaculture can be developed.
- Preliminary analysis of extreme events. In particular, spatio-temporal analysis of the maximum sea surface temperature range reached in the DANA season.
- Preliminary temporal analysis of the temperature in the Alicante Province coast and model comparison.

Material and Methods

The oceanographic data have been obtained from the **COPERNICUS** database (https://www.copernicus.eu/en), with a processing level of L4. The study area is the Province of Alicante and its surroundings which covers 50 km offshore from the Ebro Delta to Murcia.

Some initial descriptive analysis have been made:

I. The **maximum yearly difference of sea surface temperature (range) in the DANA season** (from September until November) of the coast from the Ebro Delta to Murcia has been modelled by a **spatio-temporal hierarchical Bayesian model** [1,2]:

$$Y_{it} \sim Gamma\left(\mu_{it}, \sigma_e^2\right),$$
$$\mu_{it} = \beta_0 + \xi(x_i, t),$$

where $\xi(x_i, t)$ is a random effect that changes in time with first order autoregressive dynamics and spatially correlated.

II. The stationary time series of the **month maximum sea surface temperature (SST)** of different points of the coast of Alicante have been studied to see if there are differences between the **extreme values**.

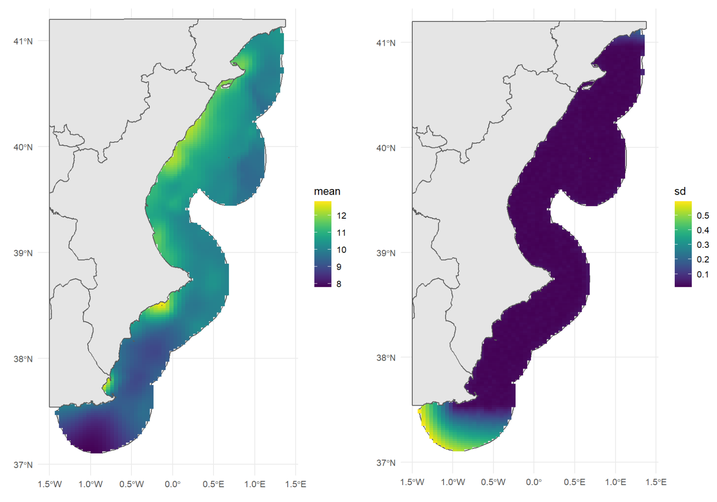
The **models** used to fit and predict the data are:

- **ARIMA(1,1,1)(0,1,1)$_{12}$**
- **LSTM** (Deep learning method)

Then the trends of each series and their predictions are shown.

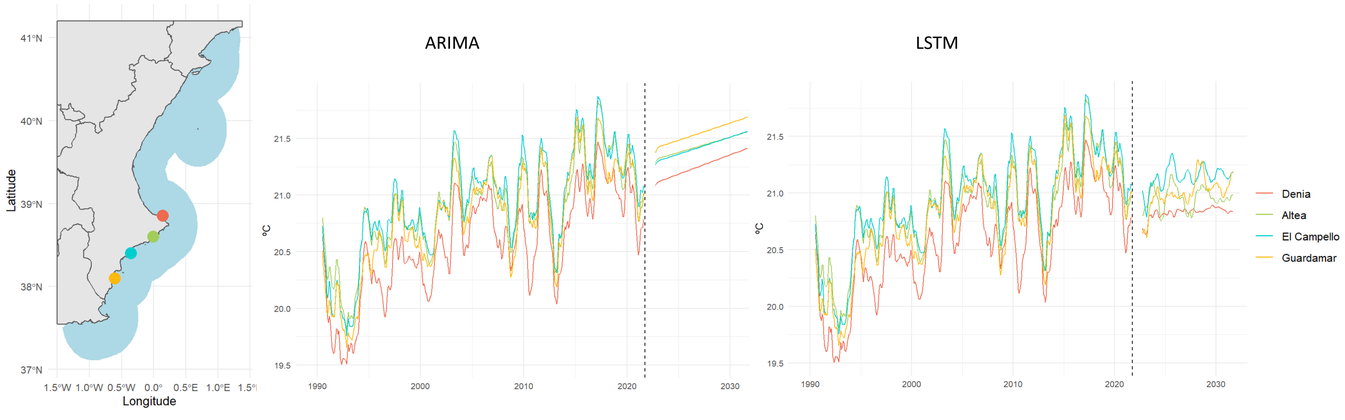
Results I

Mean and standard deviation of the posterior prediction of <u>maximum range of temperature change</u> in 2021.



Results II

Comparison of the <u>maximum month value of the SST trend</u> estimated with the ARIMA and LSTM models and their predictions for 10 years.



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Conclusions and ongoing work

Spatially differences are behold and the tendency of the trend is to continue rising. Moreover, in some areas the temperature is already higher and the risk of extreme events is greater.

Further studies will involve:

- Spatio-temporal approach using hierarchical spatial Bayesian statistical modeling.
- Modelization with dynamic time series.
- Unsupervised scalable statistical method for identifying extreme events.
- Functional analysis.

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