Impact of the evolution of the sea surface temperature on the coasts of the Valencia Region

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Introduction

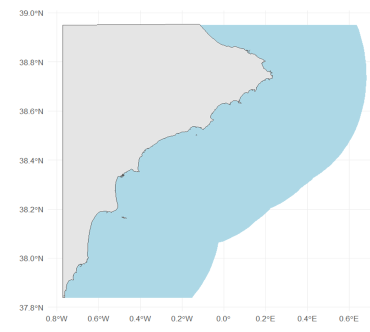
Aquaculture is affected by environmental instability produced by unstable phenomenons such as the sea surface temperature (SST).

Applying the peak over the threshold (POT) method we analyzed the extreme events defined as the SST occurrences surpassing the threshold 24 ºC

Data

The oceanographic data have been obtained from the COPERNICUS database with a processing level of L4.

The study area is the Province of Alicante which covers 50 km offshore.



Conclusions and Ongoing work

This methodology allows us to effectively capture systematic variations in the data. The analysis reveals **temporal variation** in the random effects of the three models: **particularly pronounced during the summer and early autumn seasons**, showing a significant positive effect during months with elevated temperatures. Additionally, the random effect exhibits **spatial variability** across different locations, indicating a changing pattern over time.

By utilizing this methodology, we are able to evaluate the probability of exceeding thresholds and quantify their magnitude. These findings provide estimations of marine areas that demonstrate the highest stability.

Ongoing work:

First, develop a **joint modelling** approach combining the Gamma-Bernoulli-GP models to obtain SST predictions along with the threshold exceedance. This joint modelling framework allows us to simultaneously analyse both variables.

To enhance computational efficiency and enable the analysis of longer time series data, we aim to **reduce the number of latent Gaussian random fields** by grouping together months that exhibit similar spatial patterns. These fields will interact with the monthly temporal nodes, reducing the model dimension without compromising accuracy.

Bibliography

Opitz, T., Huser, R., Bakka, H. *et al.* INLA goes extreme: Bayesian tail regression for the estimation of high spatio-temporal quantiles. *Extremes* **21**, 441–462 (2018). https://doi.org/10.1007/s10687-018-0324-x

Modelization

The spatio-temporal Bayesian hierarchical approach is similar to Opitz et al. 2018 with an inference method based on INLA structured in three steps:

I. **SST** is modelled assuming a Gamma distribution that varies in space and time:

$$Y_{st} \sim Gamma(\mu_{st}, \sigma^2),$$
$$\mu_{st} = \beta_0^I + W^I(\boldsymbol{s}, t).$$

where $W^I(\boldsymbol{s}, t)$ is a spatially correlated random effect that changes in time with first order random walk.

Then, using the threshold 24ºC, we computed the **threshold positive exceedances** normalized by the posterior mean SST values estimated ($\hat{Y}_{st}$):

$$Y_{st}^+ = \frac{Y_{st} - 24}{\hat{Y}_{st}} \mid Y_{st} > 24\,.$$

II. The **rate** of positive threshold exceedances is modelled assuming a Bernoulli distribution that varies in space and time:

$$Z_{st} = \mathbb{1}\{Y_{st} > 24\},$$

$$Z_{st} \sim Bernoulli(p_{st}),$$
$$logit(p_{st}) = \beta_0^{II} + W^{II}(\boldsymbol{s}, t),$$

where $W^{II}(\boldsymbol{s}, t)$ is a spatially correlated random effect that changes in time with first order random walk.

III. The **size** of positive threshold exceedances is modelled assuming a Generalized Pareto (GP) distribution parametrized in terms of its median ($q_{0.5}$) that varies in space and time and the tail index ξ assumed constant:

$$Y_{st}^+ \sim GP(q_{0.5_{st}}, \xi),$$
$$\log(q_{0.5_{st}}) = \beta_0^{III} + W^{III}(\boldsymbol{s}, t),$$

where $W^{III}(\boldsymbol{s}, t)$ is a spatially correlated random effect that changes in time with first order random walk. PC default prior is assigned to ξ.

All models are fitted with the SPDE approach with PC priors for the parameters range and marginal standard deviation σ of the Mátern field:

- $P(\text{range} < 0.7) = 0.5,$
- $P(\sigma > 1) = 0.01.$

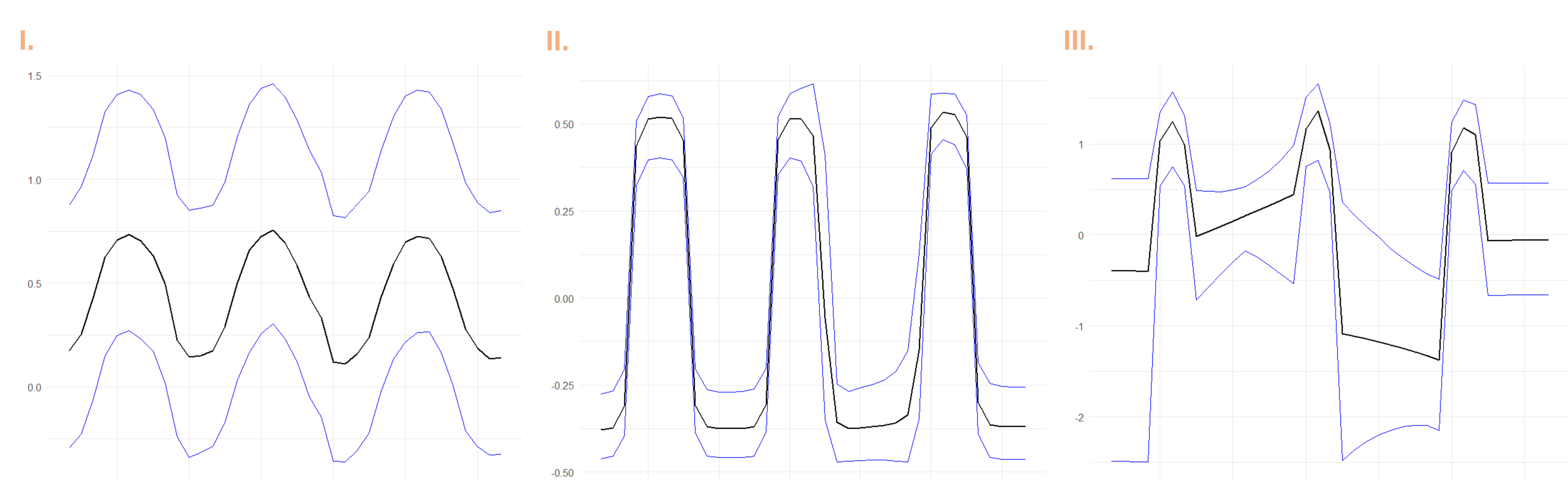
Results

Posterior distribution of hyperparameters

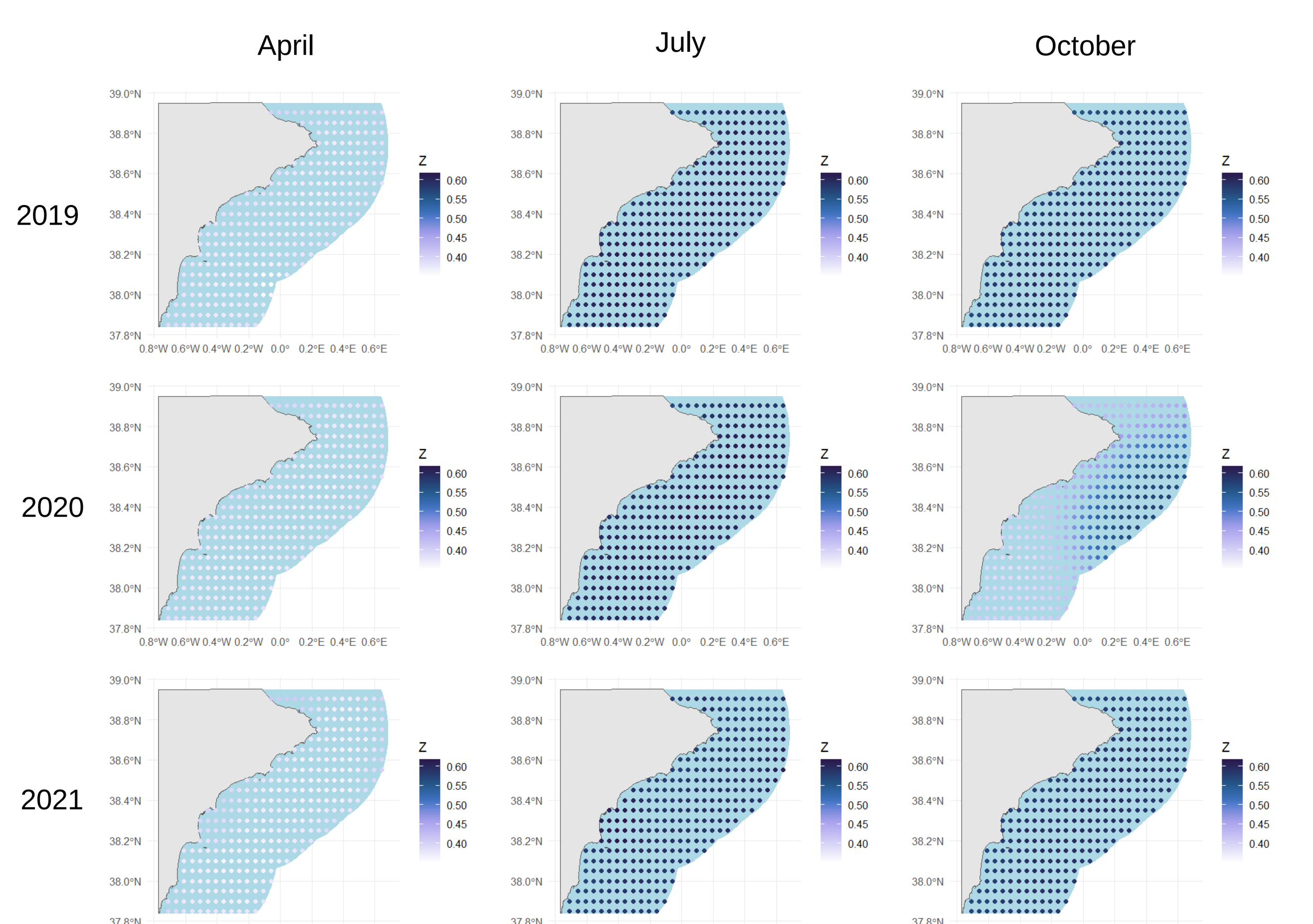
II.	Mean	Sd	0.025-quantile	0.5-quantile	0.975-quantile	Mode
range	0.74152	0.04633	0.65554	0.73965	0.83780	NA
σ	0.65551	0.02913	0.60012	0.65481	0.71486	NA

III.	Mean	Sd	0.025-quantile	0.5-quantile	0.975-quantile	Mode
ξ	0.00067	0.00075	0.00005	0.00044	0.00267	0.00055
range	0.54776	0.04121	0.47097	0.54627	0.63312	0.54483
σ	2.11510	0.11356	1.90217	2.11144	2.34917	2.09630

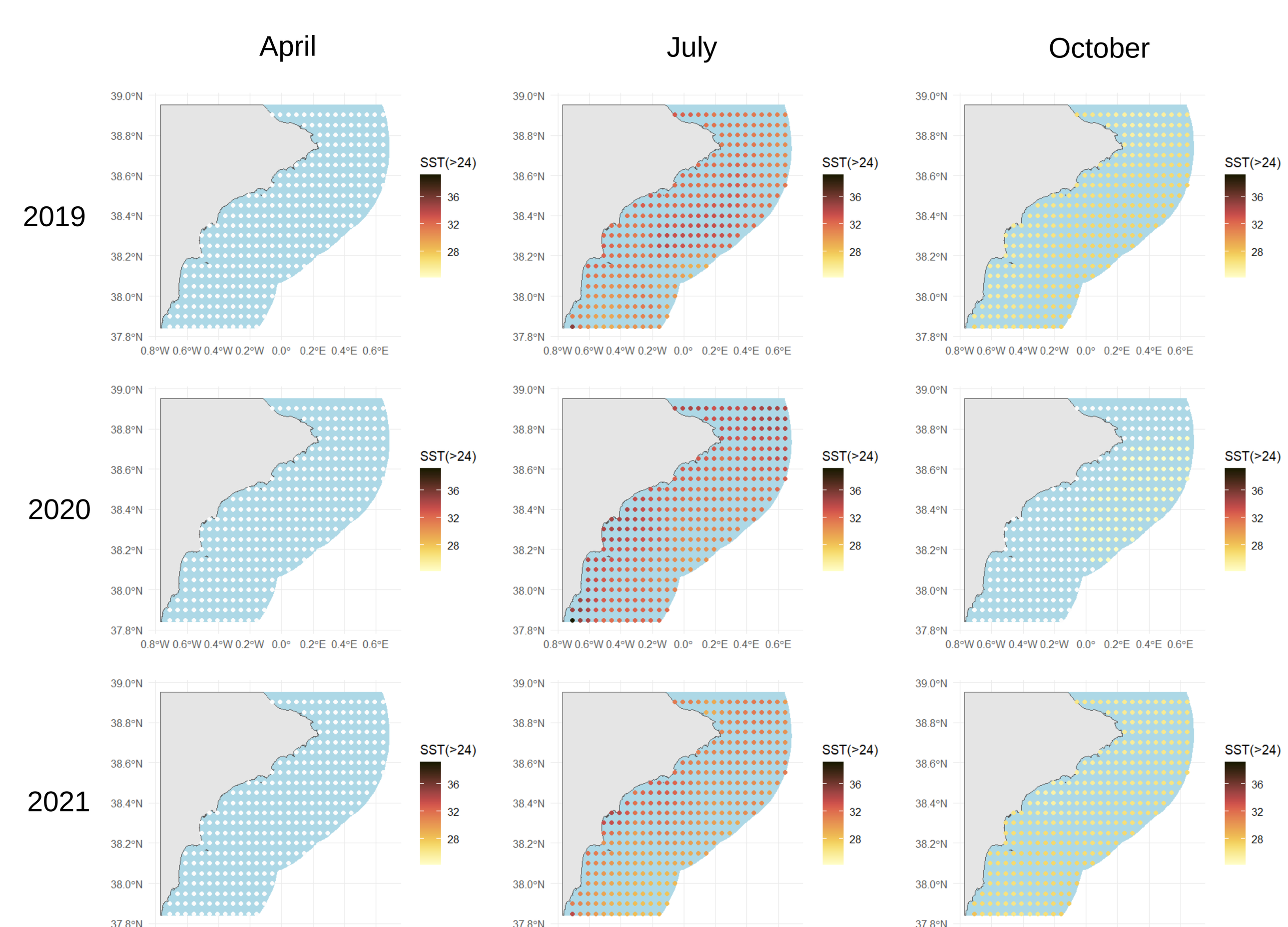
Temporal variation in random effects: posterior means and 95% pointwise credible intervals



II. Rate of positive threshold exceedances



III. SST with threshold positive exceedances size predictions of the 0.95-quantile



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