ECOAZUL-MED climate service tool: supporting aquaculture, fishing and coastal tourism in the Spanish Mediterranean coasts

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Generate a climate service tool with information that allows anticipating the effects of climate change on aquaculture, fishing and tourism, assuming different emission scenarios for the next 40 years on the Spanish Mediterranean coast

Mediterranean region:

- Amplified warming signal to climate change (CC)
- Development of extreme weather events (future increase)

- Prone to suffer socioeconomic impacts derived from CC
- Importance of planning and management of the blue economy

Key sectors for the blue economy in Spain exposed to climate conditions

AQUACULTURE

More frequent heavy precipitation: damages of cages, favouring escapes

Sea water warming: increase pathogens etc.

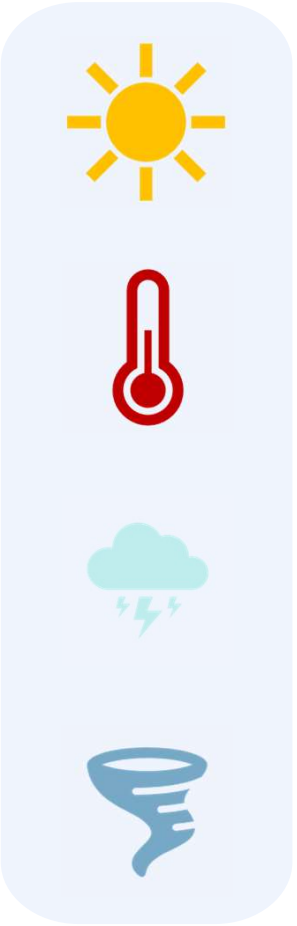
FISHING

Changes in water temperature, salinity, ocean currents:
Alterations in marine ecosystems, changes in the temporal distribution of commercial fish stocks etc., increasing fishing costs.

COASTAL TOURISM

Temperature increase and more frequent heat waves:
Decrease thermal comfort etc., reducing the n° of tourists.

Adaptation to possible negative impacts of climate change is crucial to ensure its sustainable development and must focus on informed decisions, based on knowledge of the future climate signal



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Holistic approach

Quantitative & qualitative research

The tool is adapted to needs and expectations from end-users

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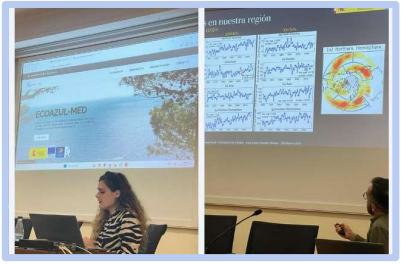
Quantitative research

Analysis of a selected, high-resolution, air-sea coupled ensemble of 4 models from the MED-CORDEX initiative, for the RCP4.5 and RCP8.5 scenarios

INSTITUTE	CNRM	LMD	CMCC	AWI/GERICS
Model characteristics				
RCSM name	CNRM-RCSM4	LMDZ-MED	COSMOMED	ROM
Driving GCM	CNMR-CM5	IPSL-CM5A-MR	CMCC-CM	MPI-ESM-LR
Med. Sea Model	NEMOMED8	NEMOMED8	NEMO-MFS	MPIOM
Ocean Res.	9-12 km	9-12 km	6-7 km	10-18 km
Num. of z-levels (ocean)	43	43	72	40
Atmosphere model	ALADIN-climate	LMDZ	CCLM	REMO
Atmosphere Res.	50 km	30 km	50 km	25 km
Coupling frequency	Daily	Daily	80 min	60 min
Numerical Simulations				
Spin up	130 years	40 years	25 years	56 years
Initial Conditions	MEDATLAS	MEDATLAS	MEDATLAS	MEDATLAS
CONTROL	1950-2005	1950-2005	1950-2005	1950-2005
RCP4.5	2006-2100	2006-2100	-	2006-2099
RCP8.5	2006-2100	2006-2100	2006-2099	2006-2099
References	Sevault et al. (2014)	L´ Hévéder et al. (2013)	Cavicchia et al. (2015)	Sein et al. (2015)

Qualitative research

Focus groups, questionnaires, surveys, workshops with end-users



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Inputs from stakeholders served to:

1. Decide the information to be included in the tool
2. Understand the implications of the results in the different sectors
3. Generate documents to be provided in the tool
4. Assess the usability of the tool
5. Test it works fine, before getting the final version

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ECOAZUL-MED Tool

Sea-surface temperature and salinity
Marine heat waves
Ocean currents (1000 m)

Ocean information

Atmospheric information

Maximum 2-m air temperature
Relative humidity
Accumulated precipitation
Heavy precipitation
Days with summer conditions
Atmospheric heat waves

https://ecoazul-med.com/en/

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Climate information	Oceanic Atmospheric
Emission scenario	RCP4.5 RCP8.5
Time period	2025-2034 2035-2044 2045-2054 2055-2064
Time frequency	Seasonal Monthly

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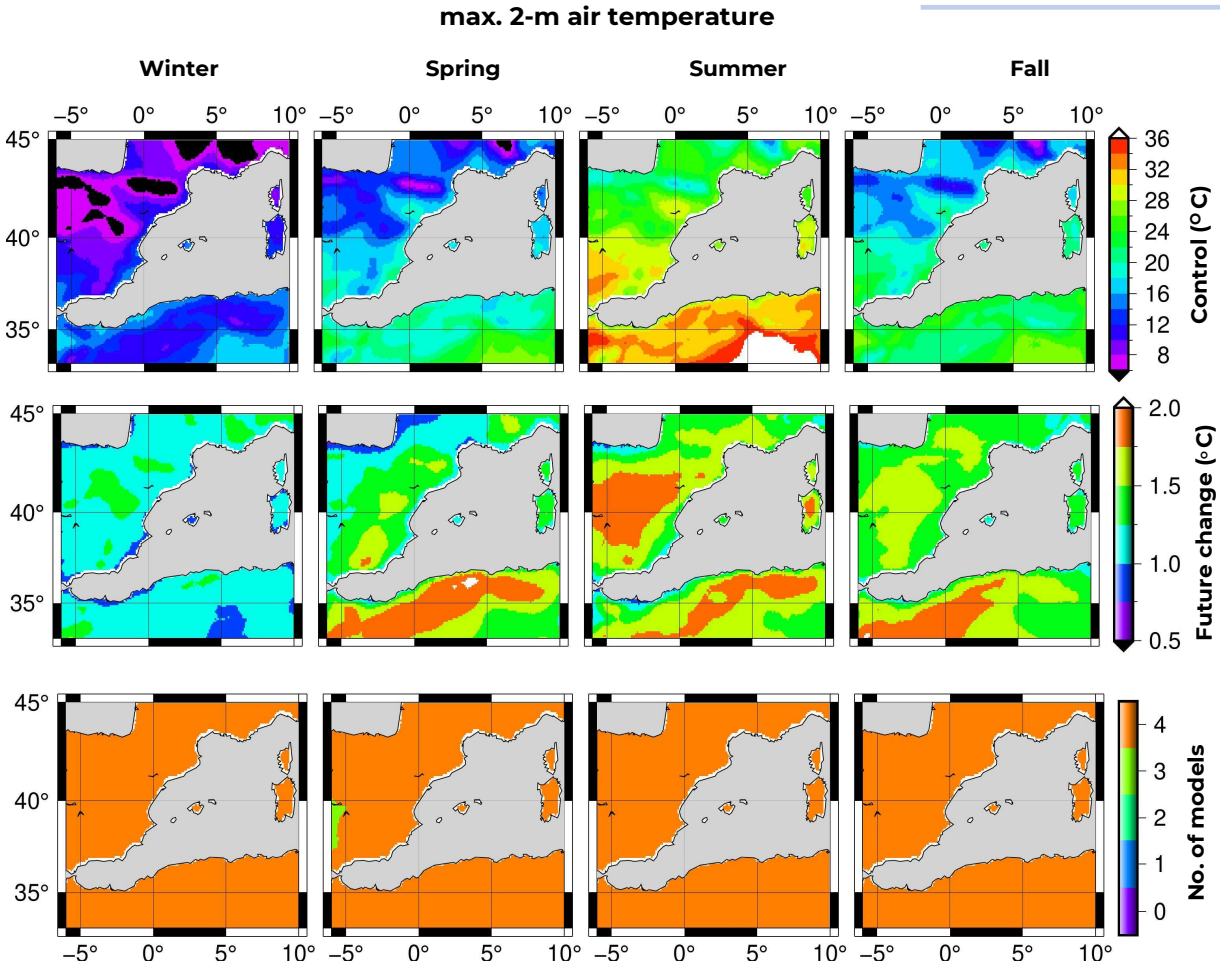
ECOAZUL-MED Tool

Climate information: Maximum 2-m air temperature

Emission scenario: RCP8.5

Time period: 2025-2034

Time frequency: Seasonal



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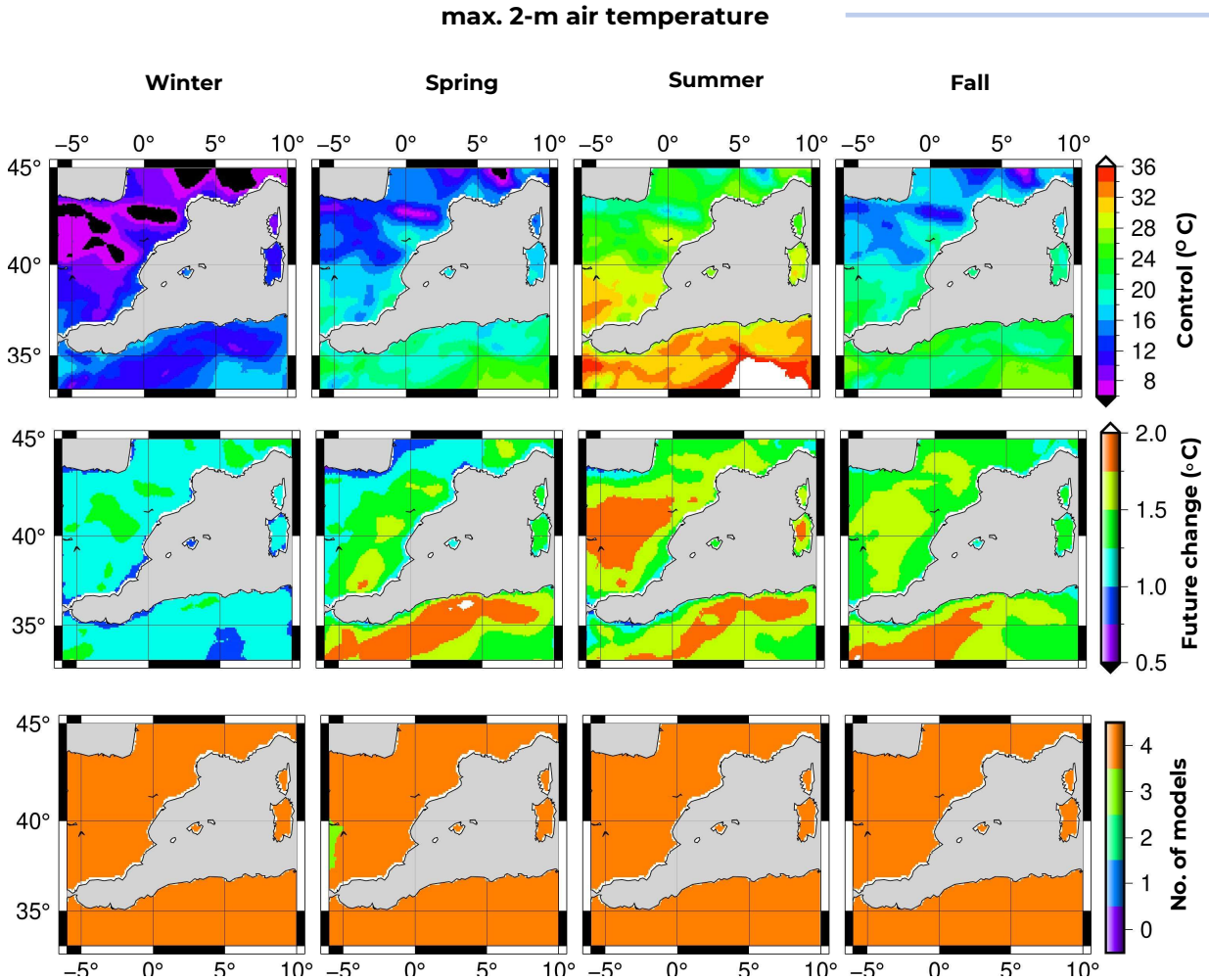
ECOAZUL-MED Tool

Seasonal average for the control time period (1976-2005)

Future change (2025-2034) relative to the control: + values indicate warming

N° of models from the ensemble (4) which project warming



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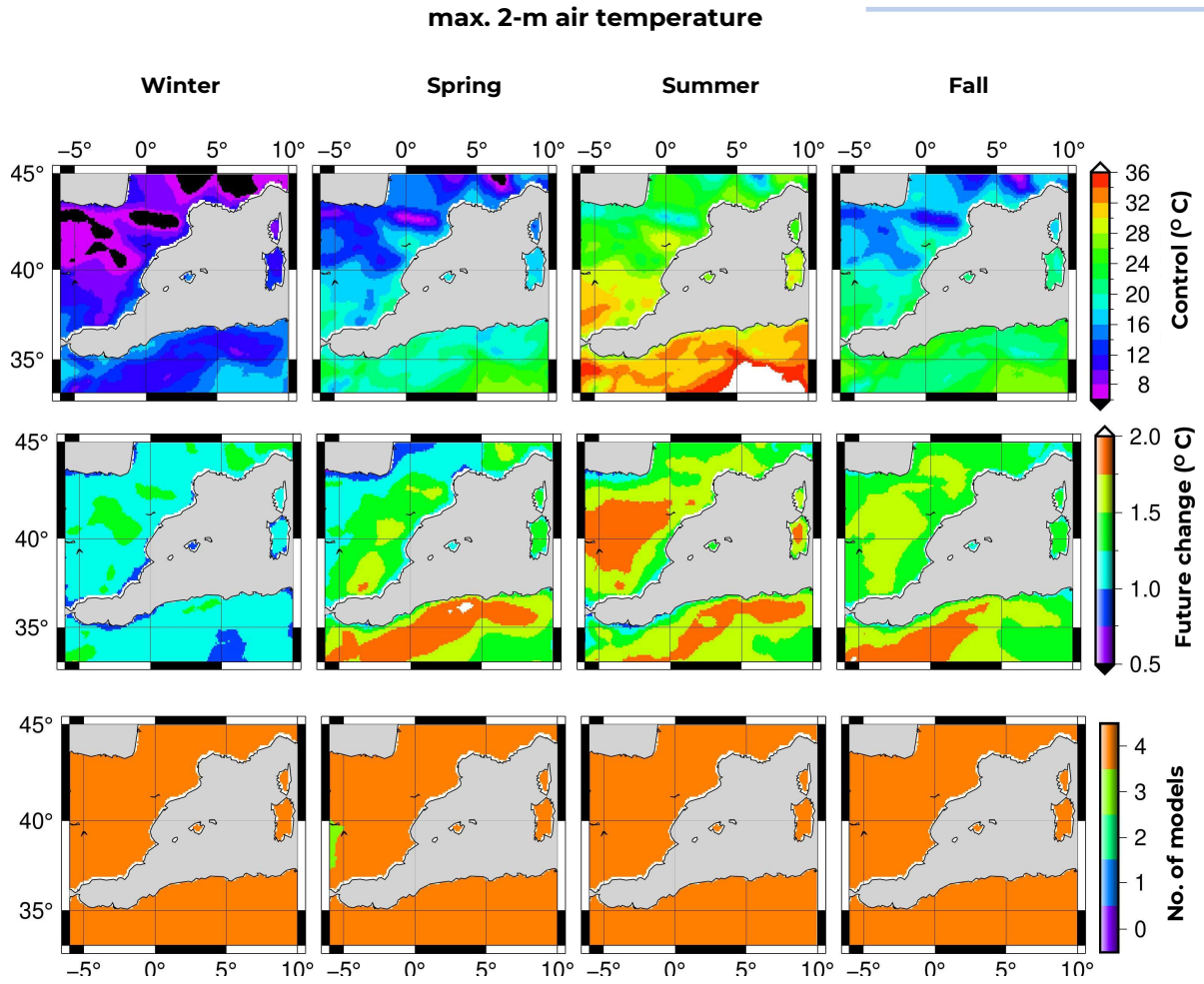
Seasonal average for the control time period (1976-2005)

Summer: max. daily temperature 1.5°C higher than in control summers

N° of models from the ensemble (4) which project warming



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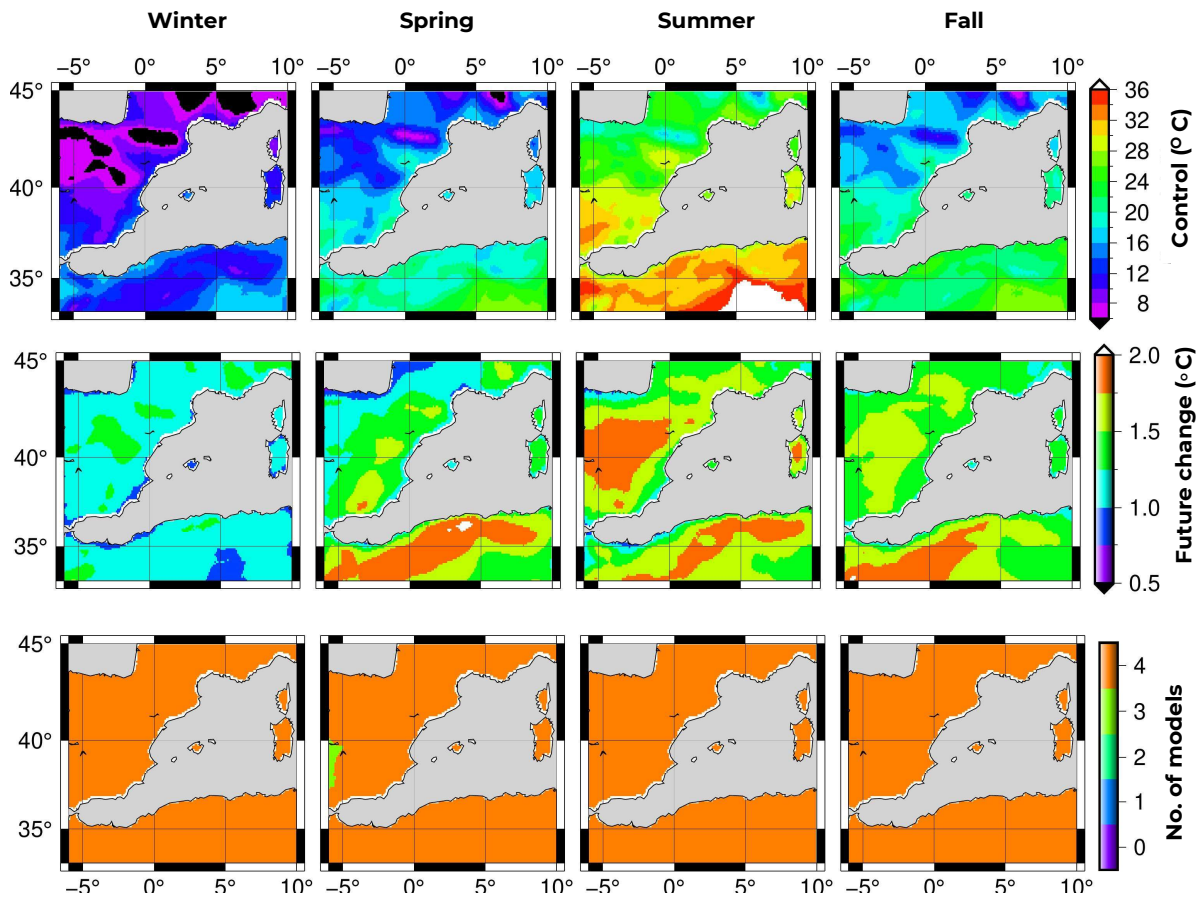
Seasonal average for the control time period (1976-2005)

Summer: max. daily temperature 1.5°C higher than in control summers

Values close to 4, indicate more robust results



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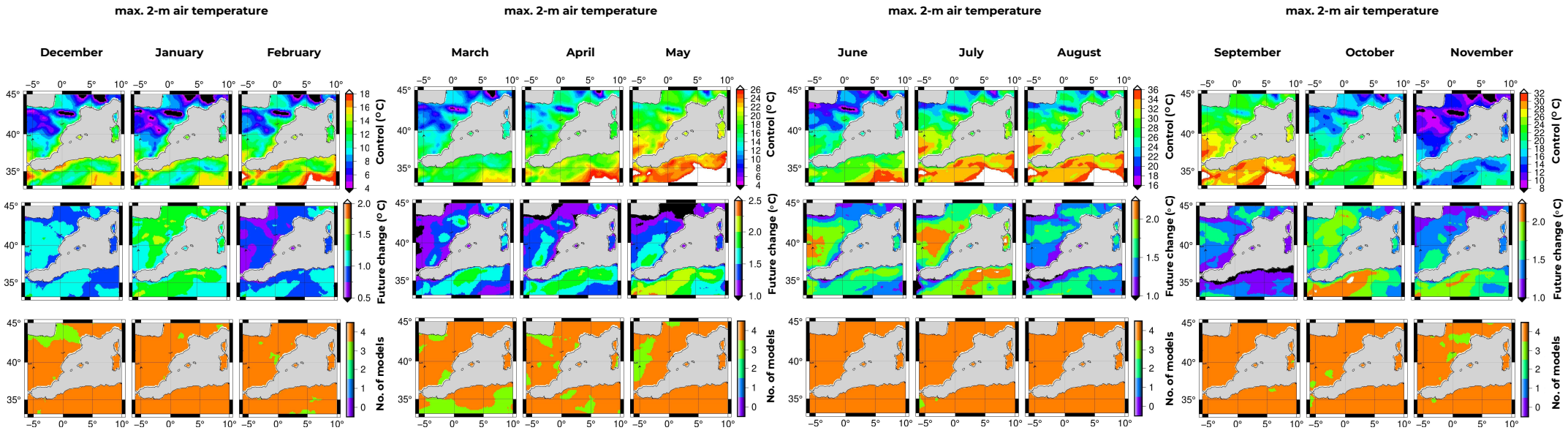
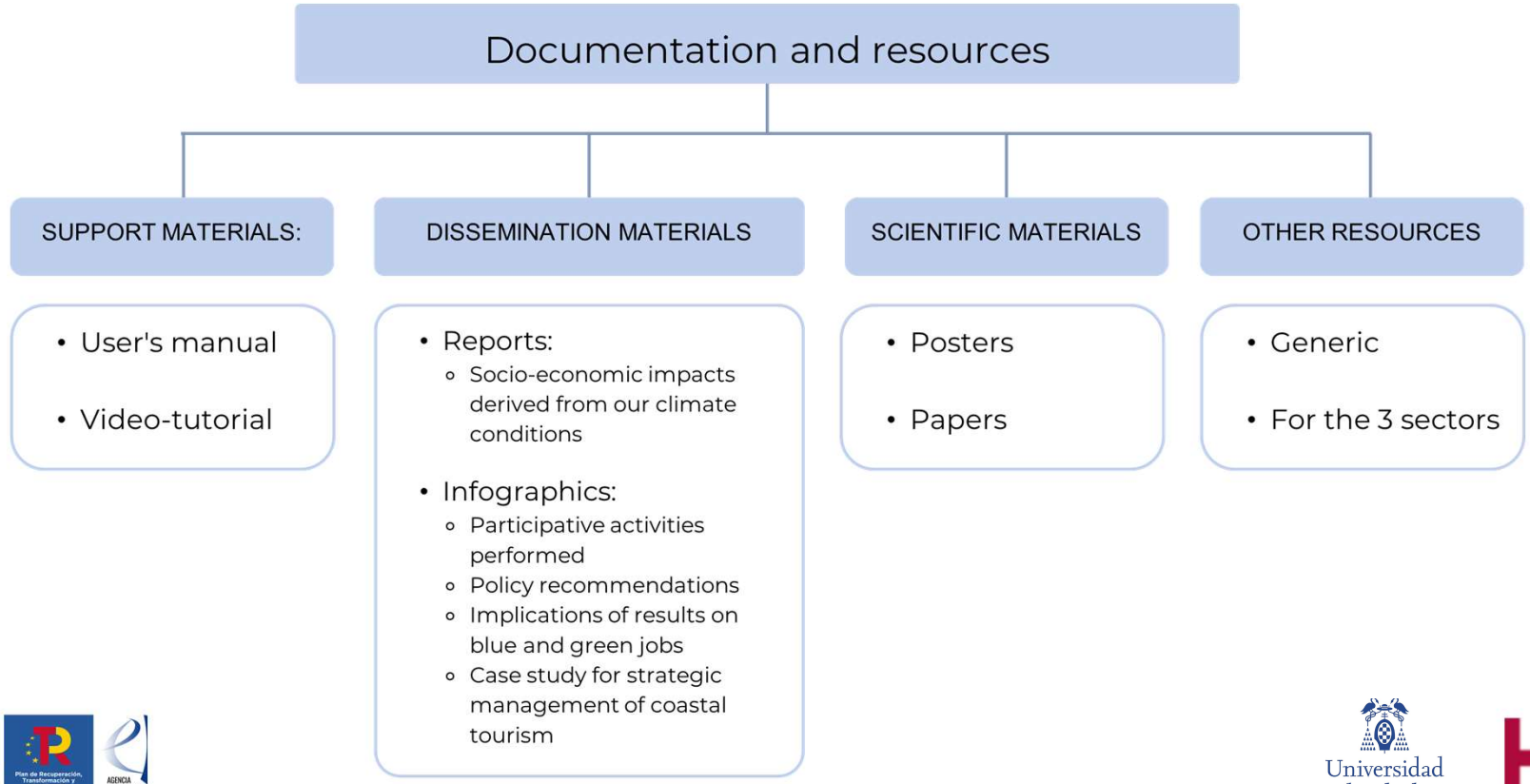
Equivalent to the previous figure, but computed with monthly frequency



To make the tool more usable and increase the user's literacy and awareness, it provides a compilation of resources with very direct messages for the different target audiences



To make the tool more usable and increase the user's literacy and awareness, it provides a compilation of resources with very direct messages for the different target audiences

Documentation and resources

SUPPORT MATERIALS:

- User's manual
- Video-tutorial

DISSEMINATION MATERIALS

- Reports:
  - Socio-economic impacts derived from our climate conditions
- Infographics:
  - Participative activities performed
  - Policy recommendations
  - Implications of results on blue and green jobs
  - Case study for strategic management of coastal tourism

SCIENTIFIC MATERIALS

- Posters
- Papers

OTHER RESOURCES

- Generic
- For the 3 sectors

Stakeholder inputs were taken into account for the creation of many materials!

CASE STUDY: Use of ECOAZUL-MED data for Strategic Planning of the Coastal Tourism

FUTURE CLIMATE CONDITIONS DERIVED FROM OUR TOOL

↑ **Summer maximum 2-m air temperature**	Thermal discomfort will enhance in summer
↑ **N° of days with heat wave conditions**	Heat waves could become the new normal
Subtle changes in precipitation	A proper management of water resources is key
↑ **N° of days with heavy precipitation**	Total precipitation is similar, but heavy precipitation increases

CASE STUDY: Use of ECOAZUL-MED data for Strategic Planning of the Coastal Tourism

FUTURE CLIMATE CONDITIONS DERIVED FROM OUR TOOL

- ↑ Summer maximum 2-m air temperature
- ↑ N° of days with heat wave conditions
- Subtle changes in precipitation
- ↑ N° of days with heavy precipitation

Less favourable conditions for the coastal tourism sector in summer

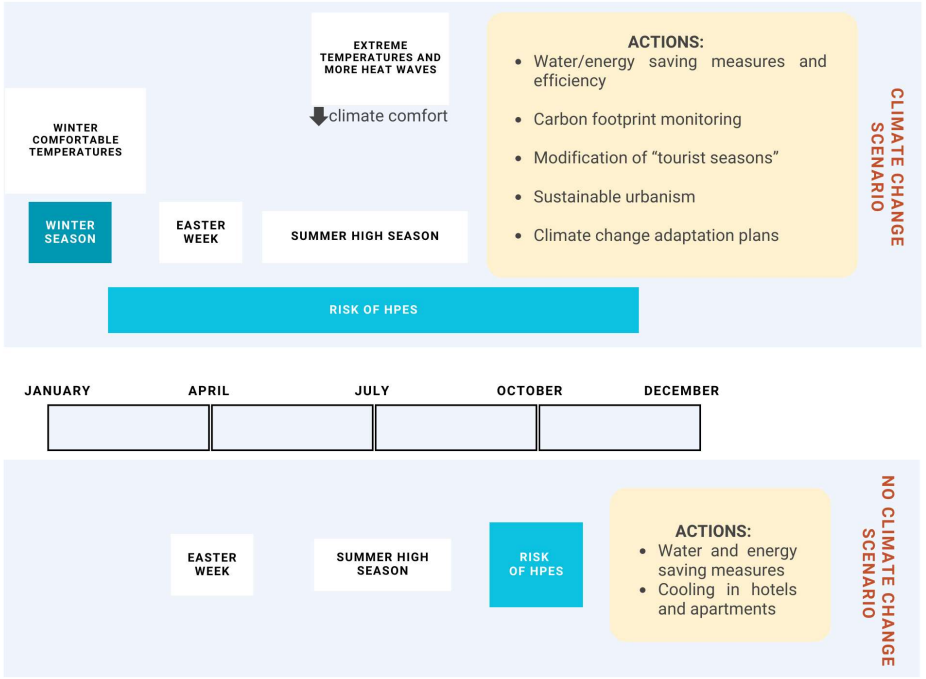
Changes for 2025–2034 are subtle, but highlight the need to implement adaptation measures

CASE STUDY: Use of ECOAZUL-MED data for Strategic Planning of the Coastal Tourism

IS IT FEASIBLE TO EXTEND THE HIGH TOURIST SEASON TO LATE SPRING-EARLY FALL?

- Extension of the high summer season towards April-May, September-October
- Maintenance of the Easter holidays
- Establishment of a winter tourist season because of anticyclonic conditions

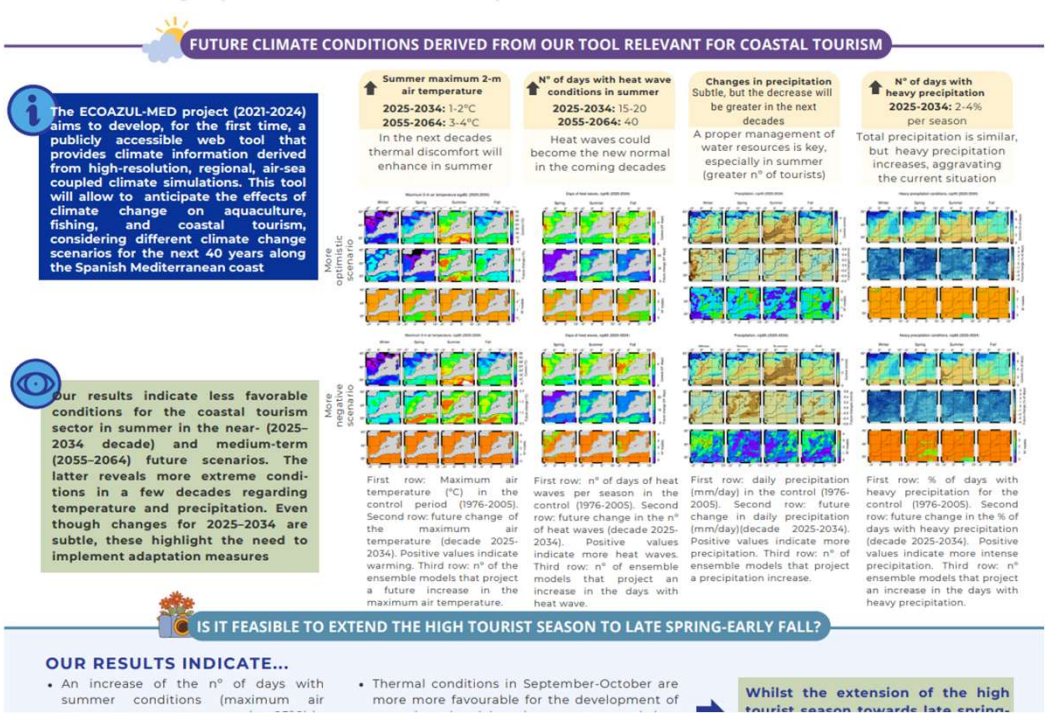
It may be doable, but the possible interferences between thermal comfort and heavy precipitation should be carefully examined.

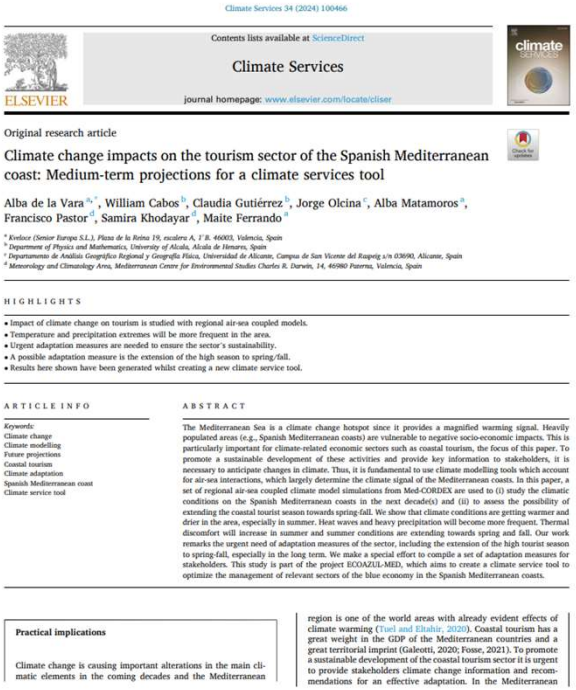


Based on: de la Vara et al. (2024). Climate change impacts on the tourism sector of the Spanish Mediterranean coast:Medium-term projections for a climate services tool. Climate Services, 34, 100466. https://doi.org/10.1016/j.cliser.2024.100466

CASE STUDY: Use of ECOAZUL-MED data for Strategic Planning of the Coastal Tourism

- More information about this case study is available in an infographic from the ECOAZUL-MED website, as well as in the corresponding paper




Climate Services 34 (2024) 100466

Contents lists available at ScienceDirect

Climate Services

journal homepage: www.elsevier.com/locate/cliser

Original research article

Climate change impacts on the tourism sector of the Spanish Mediterranean coast: Medium-term projections for a climate services tool

Alba de la Vara, William Cabos, Claudia Gutiérrez, Jorge Olcina, Alba Matamoros, Francisco Pastor, Samira Khodayar, Maite Ferrando

HIGHLIGHTS

- Impact of climate change on tourism is studied with regional air-sea coupled models.
- Temperature and precipitation extremes will be more frequent in the area.
- Urgent adaptation measures are needed to ensure the sector's sustainability.
- A possible adaptation measure is the extension of the high season to spring/fall.
- Results here shown have been generated whilst creating a new climate service tool.

ARTICLE INFO

Keywords:
Climate change
Climate modelling
Future projections
Coastal tourism
Climate adaptation
Spanish Mediterranean coast
Climate service tool

ABSTRACT

The Mediterranean Sea is a climate change hotspot since it provides a magnified warming signal. Heavily populated areas (e.g., Spanish Mediterranean coasts) are vulnerable to negative socio-economic impacts. This is particularly important for climate-related economic sectors such as coastal tourism, the focus of this paper. To promote a sustainable development of these activities and provide key information to stakeholders, it is necessary to anticipate changes in climate. Thus, it is fundamental to use climate modelling tools which account for air-sea interactions, which largely determine the climate signal of the Mediterranean coasts. In this paper, a set of regional air-sea coupled climate model simulations from Med-CORDEX are used to (i) study the climatic conditions on the Spanish Mediterranean coasts in the next decade(s) and (ii) to assess the possibility of extending the coastal tourist season towards spring-fall. We show that climate conditions are getting warmer and drier in the area, especially in summer. Heat waves and heavy precipitation will become more frequent. Thermal discomfort will increase in summer and summer conditions are extending towards spring and fall. Our work remarks the urgent need of adaptation measures of the sector, including the extension of the high tourist season to spring-fall, especially in the long term. We make a special effort to compile a set of adaptation measures for stakeholders. This study is part of the project ECOAZUL-MED, which aims to create a climate service tool to optimize the management of relevant sectors of the blue economy in the Spanish Mediterranean coasts.

Practical implications

Climate change is causing important alterations in the main climatic elements in the coming decades and the Mediterranean region is one of the world areas with already evident effects of climate warming (Tuel and Eltahir, 2020). Coastal tourism has a great weight in the GDP of the Mediterranean countries and a great territorial imprint (Galeotti, 2020; Fosse, 2021). To promote a sustainable development of the coastal tourism sector it is urgent to provide stakeholders climate change information and recommendations for an effective adaptation. In the Mediterranean

Based on: de la Vara et al. (2024). Climate change impacts on the tourism sector of the Spanish Mediterranean coast:Medium-term projections for a climate services tool. Climate Services, 34, 100466. https://doi.org/10.1(

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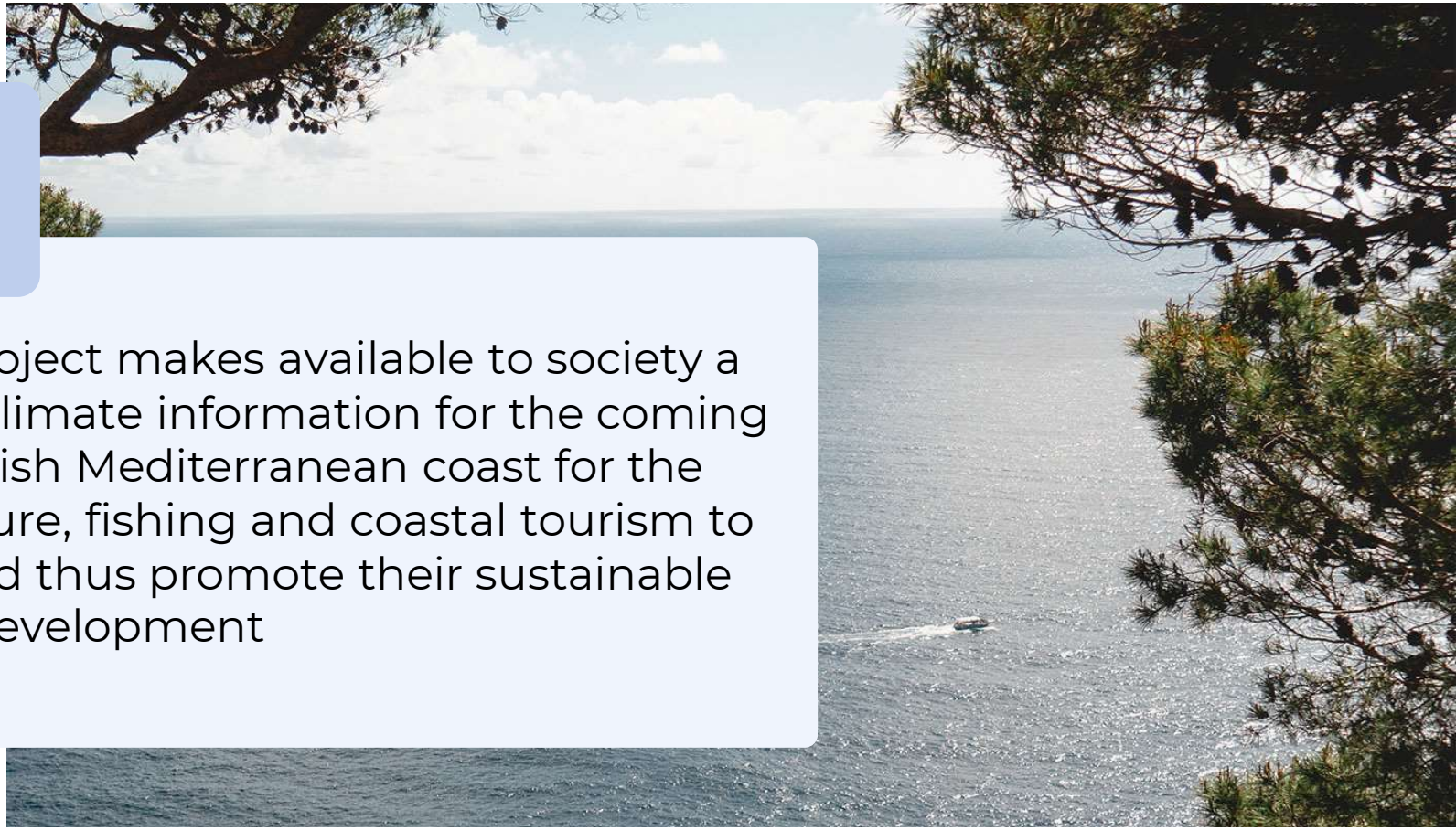
To sum up...



The ECOAZUL-MED project makes available to society a web tool that provides climate information for the coming decades on the Spanish Mediterranean coast for the adaptation of aquaculture, fishing and coastal tourism to climatic conditions and thus promote their sustainable development

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THANK YOU FOR YOUR ATTENTION

Any doubt?

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Participatory activities

1. Focus groups with actors from the different sectors to understand the influence of climate, as well as to discuss if preliminary information to be included in the tool was relevant and if other information could be included

2. Surveys (Delphi method) to assess potential socio-economic impacts of climate conditions derived from our tool on their sectors

3. Workshops with a general audience to assess the usability of the tool

4. Surveys to test the final version of the tool

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Model data

- Model data was either downloaded from the Med-CORDEX server or provided by the corresponding institution
- This ensemble was chosen because results from these simulations were used in previous works e.g., Darmaraki et al. (2019)
- We chose the RCP4.5 because it is a stabilisation scenario and the RCP8.5 because is the most radiative one and provides an amplified signal

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Model data

- Data was interpolated into a common grid of about 10 km with the Inverse Distance Weighting (IDW) method. This offers a good and fast performance with results comparable to other interpolation methods.

- Weights are proportional to the inverse of the distance (between data point and the prediction location)

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Detection of outliers

- Whilst the performance of the models has been individually validated in dedicated papers, we aim to identify possible model outliers for the studied variables within the RCSM's.

- Following de la Hoz et al. (2018), we use the mean square error (MSE) and the standard deviation (std). In particular, the MSE between the historical model data and the same period for the reanalysis was calculated.

- An outlier is defined as the RCSM for which the value of the MSE is out of the limits defined by the ensemble mean ± std of the MSE of all models times 1.5 (see e.g., Chaudhary and Lee, 2016). For all the ensemble members the criteria is met, which means that none of them is out of range for the selected variables.

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Atmospheric heat waves

•HWFI index. A heat wave is defined as a period of at least 6 consecutive days during which the daily maximum temperature is above the 90th percentile calculated with the control period using a 5-day moving average.

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Marine heat waves

Marine heat waves are defined as a period of at least 5 consecutive days during which the daily sea surface temperature is above the 90th percentile, calculated with the control period using a 5-day moving average.

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Heavy precipitation

Heavy precipitation conditions are met when daily accumulated precipitation exceeds the 90th percentile calculated with the control period.

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Case Study

- For this analysis, we first studied the maximum 2m air temperature, heat waves, precipitation and heavy precipitation patterns with a seasonal frequency.

- Then, to assess the possibility of extending the high tourist season towards late spring and early fall, we also examined precipitation, heavy precipitation, days with temperature above 25°C, and days with the SST above 18°C, which determines swim temperature.

- We find that in terms of temperature conditions, especially in the long term, late spring/early fall will be suitable for swimming and beach conditions, but care should be taken with heavy precipitation, since it tends to increase in frequency.

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Case Study

- We obtain an increase in the summer mean T2MAX between 1 and 2 ◦C for 2025–2034. In 2055–2064, the increase reaches up to 3–4 ◦C.

- The number of days with heat waves will increase in all studied seasons in the future. In summer, regardless of the scenario chosen, the increase can reach up to 15–20 days in the 2025–2034 decade. In the longer term (2055–2064), the rise in the number of days with heat wave conditions can reach up to 40 days or more.

- In 2025–2034, precipitation experiences small changes with respect to the control. Both scenarios project drier conditions regardless of the season.

- The % of days with high precipitation in 2025–2034 will experience a generalized increase that varies between 2 and 4 % per season regardless of the scenario.

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Study of socio-economic impacts

- We used the Delphi method, which is a projective technique that consists of interrogating agents with the help of successive questionnaires, to reveal convergences of opinions and deduce possible consensus (Crisp et al., 1997). A total of anonymous 13 agents, of which 5 belong to the coastal tourism sector, 4 to aquaculture and 4 to the fishing sector, participated. The online questionnaires contained quantitative answers, in which participants had to provide scores ranging from 1 to 5, and qualitative blocks, where they were able to elaborate their responses. After 2 rounds of questionnaires, we found consensus in the different points, or the information provided was sufficient to understand the causes for the dissent. The insights learnt from the analysis were compiled in a report which can be found on the ECOAZUL-MED website and was submitted to the participant stakeholders to raise awareness and inform them about the project and the results obtained for the three 3 sectors of interest.

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