This publication is part of PTQ2020-011287, funded by MCIN/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR.

ECOAZUL - MED

User Manual

ALBA DE LA VARA

This publication is part of grant PTQ2020-011287, funded by MCIN/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR

Index

1. Introduction

1.1. Introduction

The Mediterranean region is considered a climate change hotspot by the scientific community because it provides an amplified warm climate signal (Giorgi, 2006). Additionally, this region is highly prone to the development of extreme weather events (e.g., atmospheric and marine heatwaves, cyclones with tropical characteristics also known as medicanes, or torrential rainfall). In the coming decades, climate models project an increase in the frequency and/or intensity of these events (Darmaraki et al., 2019; González-Alemán et al., 2019; IPCC, 2019). These factors make the densely populated Mediterranean coasts, such as the eastern Spanish coast, susceptible to negative impacts on the blue economy, leading to consequent socioeconomic losses. It is worth noting that the blue economy, defined as economic activities related to seas and oceans, is an essential source of wealth and prosperity for the Mediterranean, providing opportunities for growth, employment, and investment. Specifically, aquaculture, fishing, and coastal tourism are relevant sectors of the blue economy due to their contribution to social and economic development along the Mediterranean Spanish coast. Therefore, developing a strategic vision for the sustainable development of these climate-dependent sectors, as well as ensuring policies and actions aimed at promoting the blue economy, are of vital importance in the current context of climate change.

The ECOAZUL-MED project has the general objective of generating, for the first time, a public-use web tool that provides climate information from high spatial resolution, coupled, regional climate simulations. This tool will enable the anticipation of climate change effects on aquaculture, fishing, and coastal tourism, assuming different emission scenarios for the next 40 years on the Spanish Mediterranean coast. This will allow companies, public administration, and other stakeholders to access relevant climate information, facilitating the planning of these economic activities and highlighting the need for innovation in them for adaptation to climate change and its potential mitigation in the coming decades along the Spanish coast, which is essential for ensuring their sustainable development.

The added value of this project compared to similar ones lies in three pillars: (i) the use of high-resolution coupled regional climate models, which makes downscaling dynamic and physically coherent, unlike when global models are used and downscaling is statistical or when atmospheric or oceanic regional models alone are used for downscaling; (ii) working with both oceanic and atmospheric variables over land; (iii) paying attention to extreme weather phenomena capable of causing significant socioeconomic damage, such as heatwaves and heavy precipitation.

This document describes the functionalities of the web tool generated within the framework of the ECOAZUL-MED project, which provides climate information to anticipate the effects of climate change on aquaculture, fishing, and coastal tourism, assuming different emission scenarios for the next 40 years on the Spanish Mediterranean coast.

1.2. Contact

ECOAZUL-MED has been developed by Alba de la Vara at the company Kveloce within the framework of the Torres Quevedo Grant PTQ2020-011287.

adelavara@kveloce.com +34 963 25 02 93

1.3. Functionalities

The ECOAZUL-MED web tool:

- Provides society with information from climate simulations related to (i) sea-surface temperature; (ii) sea-surface salinity; (iii) marine currents (direction and speed) down to a depth of 1000 m; and (iv) marine heatwaves, for the marine component. On the other hand, (i) maximum air temperature at 2 meters; (ii) relative humidity of the air; (iii) precipitation; (iv) heavy precipitation; and (v) atmospheric heatwaves, for the atmospheric component.

- Offers the desired information for two IPCC (Intergovernmental Panel on Climate Change) climate change RCP **(Representative Concentration Pathway)** scenarios: RCP4.5 and RCP8.5. RCP4.5 is chosen as a stabilization scenario and RCP8.5 as a more extreme scenario, which is expected to provide an amplified climate change signal (see Figure 1S in the Supplement).

- Provides information for the time interval from 2025 to 2064.

- Offers averaged data with seasonal and monthly frequency for the time period chosen by the user, as well as the robustness of the obtained results.

- Allows visualization of the results in a graphical format.

2. Methodology

2.1. Climate Models Used

To generate the data offered by the tool, variables from an ensemble of four coupled regional models (Regional Climate System Models; RCSMs) have been used: CNRM-RCSM4, LMDZ-MED, COSMOMED, and ROM, whose configuration is detailed in Table 1. These data have been provided by four different institutes participating in the **Med-CORDEX** coordinated modeling initiative for the Mediterranean region. The simulations provide data from 1950 to 2005 for historical experiments and from 2006 to 2100 for future projections, assuming the **IPCC** RCP (Representative Concentration Pathways) scenarios RCP4.5 and RCP8.5. On one hand, RCP4.5 is chosen because it corresponds to a stabilization scenario and is therefore expected to be the most realistic. On the other hand, RCP8.5 is chosen because it is the most radiative and provides a more amplified climate signal (see Figure 1G in the Glossary of Terms and Abbreviations section). All models use boundary conditions from **CMIP5** (the fifth phase of the Coupled Model Intercomparison Project). The configuration of these simulations is presented in the corresponding articles shown in Table 1, and their results have been used in previous works (e.g., Darmaraki et al., 2019). The control period is the 30-year interval from 1976 to 2005. The future time period presented in the tool spans from 2025 to 2064 and is analyzed decadal (2025-2034; 2035-2044; 2045-2054; 2055-2064).

INSTITUTION	CNRM	LMD	CMCC	AWI/GERICS
Model Characteristics				
Model Name RCSM	CNRM-RCSM4	LMDZ-MED	COSMOMED	ROM
Driving GCM	CNMR-CM5	IPSL-CM5A-MR	CMCC-CM	MPI-ESM-LR
Mediterranean Sea Regional Model	NEMOMED8	NEMOMED8	NEMO-MFS	MPIOM
Ocean Resolution	9-12 km	9-12 km	6-7 km	10-18 km
Number of Vertical Levels (Ocean)	43	43	72	40
Atmospheric Model	ALADIN-climate	LMDZ	CCLM	REMO
Atmospheric Resolution	50 km	30 km	50 km	25 km
Coupling Frequency	Daily	Daily	80 minutes	60 minutes
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)

Table 1. Summary of the simulations used in this work. More details on the initial conditions of MEDATLAS can be found in Rixen et al. (2005). GCM refers to Global Climate Model.

2.2. Data Processing

Since the variables have different spatial resolutions (horizontal and/or vertical) depending on the model (see Table 1), a series of interpolations to a common grid is carried out after downloading each one:

- For all variables, a horizontal interpolation to a common grid with a spatial resolution of approximately 10 km is performed. To carry out this downscaling, which is necessary given the tool's climate service applications, we use the Climate Data Operators **(CDO)** package. Specifically, the REMAPDIS operator, which by default uses 4 source values to interpolate the destination value. Therefore, the REMAPDIS operator is essentially the implementation of the inverse distance weighting (IDW) method with 4 source points and the power set to 1.

- Marine currents, in addition to being interpolated to a common horizontal grid, are **vertically interpolated** to have these variables available at common vertical levels. For this, a linear interpolation is performed using the **INTLEVEL** operator at 50, 500, and 1000 meters depth, the vertical levels offered by the tool for the case of currents.

2.3. Calculations Performed

All results presented in the tool have been calculated using the ensemble mean of the models (see Table 1). Specifically, the models considered for each case are:

- **Control (1976-2005):** CNRM-RCSM4, LMDZ-MED, COSMOMED, ROM.
- **RCP4.5 Scenario (2025-2064):** CNRM-RCSM4, LMDZ-MED, ROM.
- **RCP8.5 Scenario (2025-2064):** CNRM-RCSM4, LMDZ-MED, COSMOMED, ROM.

The robustness associated with the obtained results is assessed by calculating the number of ensemble models that show a future change with respect to the control period with a specific sign, in this case, the number of models whose future change (future minus control) has a positive sign. This means that if the ensemble of models projects an increase in a given variable, the more models that project a change of this sign, the more robust the signal, and vice versa. If the change is negative, the fewer models projecting an increase, the more robust the signal. It is important to remember that the RCP4.5 scenario uses an ensemble of 3 models, and the RCP8.5 scenario uses an ensemble of 4 models.

The following describes the variables and post-processes included in the tool, as well as the initial variable and the information calculated to produce the graphs available in the tool.

1. Maximum Air Temperature

Initial Variable:

- Daily maximum air temperature at 2 meters (°C).

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the daily maximum air temperature at 2 meters, in °C.
- Seasonal and monthly changes, in °C, for the different future periods relative to the control period (decadal anomaly).
- Robustness of these results, in number of models.

2. Atmospheric Heatwaves (HWF Index):

Initial Variable:

- Daily maximum air temperature at 2 meters (°C).

Calculated Information:

- Seasonal and monthly averages (April-May and September-October) for the control period (1976-2005) of the number of days in which the heatwave criterion is met. A heatwave is defined as a period of at least 6 consecutive days during which the daily maximum temperature is above the 90th percentile calculated using the control period with a 5-day moving average. Results are given in number of days per period. It is important to note that the number of days in a season (sum of the number of days in the corresponding months) is approximately 90, depending on the season.

- Seasonal and monthly changes, in number of days, for the different future periods relative to the control period (decadal anomaly). Results are given in number of days per period.

- Robustness of these results, in number of models.

3. Days with Summer Conditions:

Initial Variable:

- Daily maximum air temperature at 2 meters (°C).

Calculated Information:

- Seasonal and monthly averages (April-May and September-October) for the control period (1976-2005) of the number of days with summer conditions in the period. Summer days are defined as those in which the daily maximum air temperature at 2 meters exceeds 25°C. Results are given in number of days per period. It is important to note that the number of days in a season (sum of the number of days in the corresponding months) is approximately 90, depending on the season.

- Seasonal and monthly changes, in number of days, for the different future periods relative to the control period (decadal anomaly). Results are given in number of days per period.

- Robustness of these results, in number of models.

4. Daily Accumulated Precipitation:

Initial Variable:

- Daily accumulated precipitation (mm/day).

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the daily accumulated precipitation, in mm/day.

- Seasonal and monthly changes, in mm/day, for the different future periods relative to the control period (decadal anomaly).

- Robustness of these results, in number of models.

5. Heavy precipitation:

Initial Variable:

- Daily accumulated precipitation (mm/day).

Calculated Information:

- Seasonal and monthly averages (April-May and September-October) for the control period (1976-2005) of the % of days in which the daily accumulated precipitation exceeds the 90th percentile calculated using the control period. For the calculation of the 90th percentile, precipitation values below 0.1 mm/day are excluded. Results are given as % of days per period.

- Seasonal and monthly changes, in % of days per period, for the different future periods relative to the control period (decadal anomaly).

- Robustness of these results, in number of models.

6. Relative Humidity:

Initial Variable:

- Relative humidity of the air (%).

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the relative humidity of the air, in %.

- Seasonal and monthly changes, in parts per unit (ppu), for the different future periods relative to the control period (decadal anomaly).

- Robustness of these results, in number of models

7. Sea-surface Temperature:

Initial Variable:

- Sea-surface temperature (°C).

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the sea-surface temperature, in °C.

- Seasonal and monthly changes, in °C, for the different future periods relative to the control period (decadal anomaly).

- Robustness of these results, in number of models

8. Sea-surface Salinity:

Initial Variable:

- Sea-surface salinity, practical salinity units (psu).

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the sea-surface salinity, in psu.
- Seasonal and monthly changes, in psu, for the different future periods relative to the control period (decadal anomaly).
- Robustness of these results, in number of models.

9. Ocean Currents:

Initial Variable:

- Components u and v of the velocity of ocean currents from 0 to 1000 m (m/s), provided at 50, 500, and 1000 m depth.

Calculated Information:

- Seasonal and monthly averages for the control period (1976-2005) of the direction (arrows) and magnitude of ocean currents (colors), in m/s.
- Seasonal and monthly changes for the different future periods relative to the control period (decadal anomaly) of the direction and magnitude of resulting velocity (m/s) in the future.
- Robustness of these results, in number of models.

10. Marine Heatwaves:

Initial Variable:

- Daily sea-surface temperature (°C).

Calculated Information:

- Seasonal and monthly averages (April-May and September-October) for the control period (1976-2005) of the number of days in which the marine heatwave condition is met. A marine heatwave is defined as a period of at least 5 consecutive days during which the daily sea-surface temperature exceeds the 90th percentile calculated using the control period with a 5-day moving average. Results are given in number of days with marine heatwave conditions per period. It is important to note that the number of days in a season (sum of the number of days in the corresponding months) is approximately 90, depending on the season.

- Seasonal and monthly changes, in number of days with marine heatwave conditions, for the different future periods relative to the control period (decadal anomaly).
- Robustness of these results, in number of models.

3. Access to the Project Website

Enter the following address into your browser to access the project website, through which you can access the web tool for downloading climate information:

https://ecoazul-med.com

The tool is free, so you will have access to all its functionalities for free.

3.1. Home Page

This screen presents the elements as shown in Image 1.

In the **top bar**, you will find contact information (phone number and email).

In the **upper left corner**, there is the project logo. Clicking on it will return you to the home screen.

In the **upper right corner**, there is a menu with four navigation buttons: the project, tool, documentation and resources, and contact. These will be described in detail later.

In the **central block of the screen**, there is a brief description of the project and a direct access to the informative section "the project", and secondly, a direct access to the "tool", from which you can download information.

In the **lower central area**, there is a section of news related to the ECOAZUL-MED project.

In the **lower left corner,** there is the logo of Kveloce, the company where the project was developed, as well as contact information.

In the **lower right corner**, there are the logos of the funding entities for this project.

3.2. Navigation Menu: Project, Tool, Documentation, and Contact

In the upper right corner, you will find the navigation menu with the following sections:

- The **Project**: Clicking here will take you to an informative section about the project, including its objectives, a brief description of the involved sectors, information about the climate signal in the study area, the relevance of adaptation measures, methodology, and the added value of the ECOAZUL-MED project compared to others. In the "involved sectors" section, there are 3 buttons that provide access to policy recommendations on adaptation for each sector.

- **Tool**: This section provides access to the climate tool from which you can download information. This block will be described in detail later in Section 3.3. **Before proceeding with data download, it is recommended to thoroughly read this User Manual.**

- **Documentation and Resources**: This section allows you to download documentation related to the project. In particular, the current User Manual, Outreach Materials developed during the project (infographics, a policy recommendations document, a document on potential socio-economic impacts associated with the climate conditions derived from this study, green employment, etc.), and Scientific Materials (posters, scientific articles). Additionally, in the resources section, links to materials that may be of interest to these 3 sectors are provided.

- **Contact**: This section offers the possibility to contact the project team to resolve any questions or concerns.

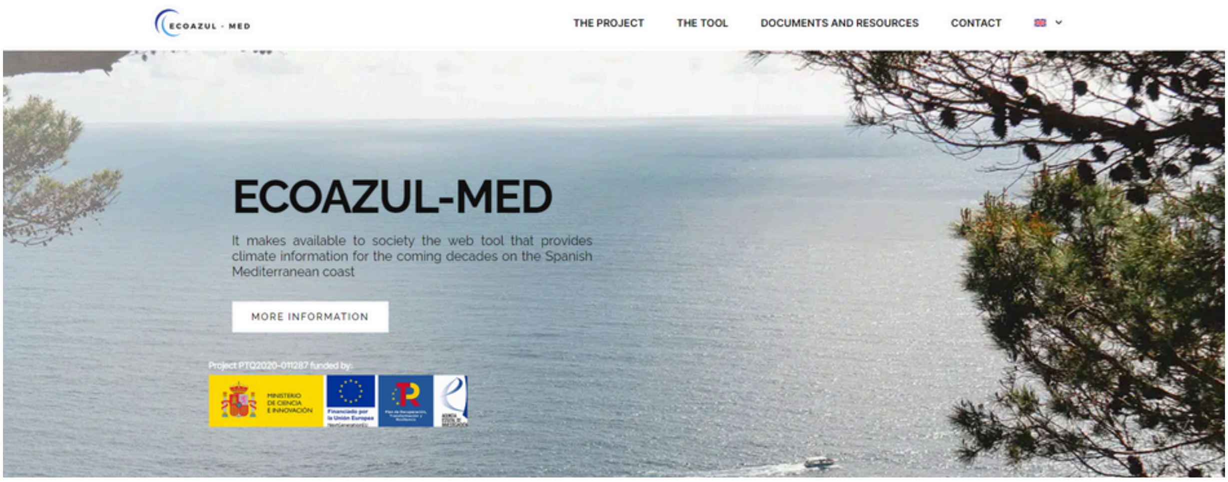


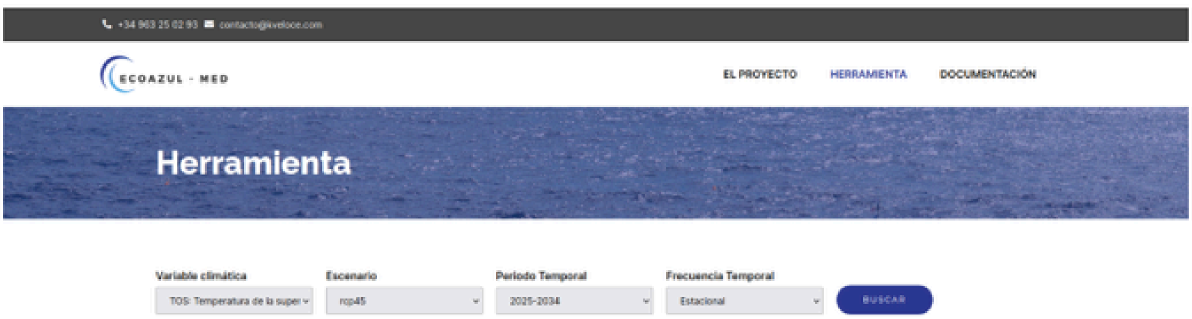
Image 1. Home Screen Configuration

3.3. The Tool

3.3.1. Accessing the Tool

To access the tool, you must first click on the "TOOL" button located in the upper right corner, or from the home screen, click on the "GO TO TOOL" button.

Here, the following menu will appear:



3.3.2. Downloading Information

Here, the user must first use the drop-down menus and click on the options they desire:

- **Climate information:** sea-surface temperature, sea-surface salinity, ocean currents, marine heatwaves, relative air humidity, maximum air temperature at 2 meters, daily accumulated precipitation, days with summer conditions (daily maximum exceeds 25°C), atmospheric heatwaves.

- **Scenario**: as mentioned earlier, RCP4.5 and RCP8.5 are available.

- **Temporal period:** the period of interest must be decadal and extends from 2025 to 2034, with available decades being 2025-2034, 2035-2044, 2045-2054, 2055-2064.

- **Temporal frequency:** this can be seasonal or monthly.

Next, click the "CALCULATE" button to proceed with the download of the corresponding graph(s).

It is important to remember that prior to downloading and interpreting graphs, it is recommended to thoroughly read this User Manual. You can access it by clicking on the "view User Manual" option. A brief video tutorial on downloading information from the tool is also provided, accessed by clicking on "view video tutorial", as well as a practical example of tool usage applied to the tourism sector under "Case Study". Additionally, access to policy recommendations that may support interpreting the results is provided by clicking on the corresponding buttons for each sector.

3.3.3. Interpreting Downloaded Graphs

Next, the structure and content of the graphs will be explained, depending on whether their frequency is seasonal or monthly.

- **Seasonal Frequency:** In this case, the graph will have a structure as shown below in Figure 1.

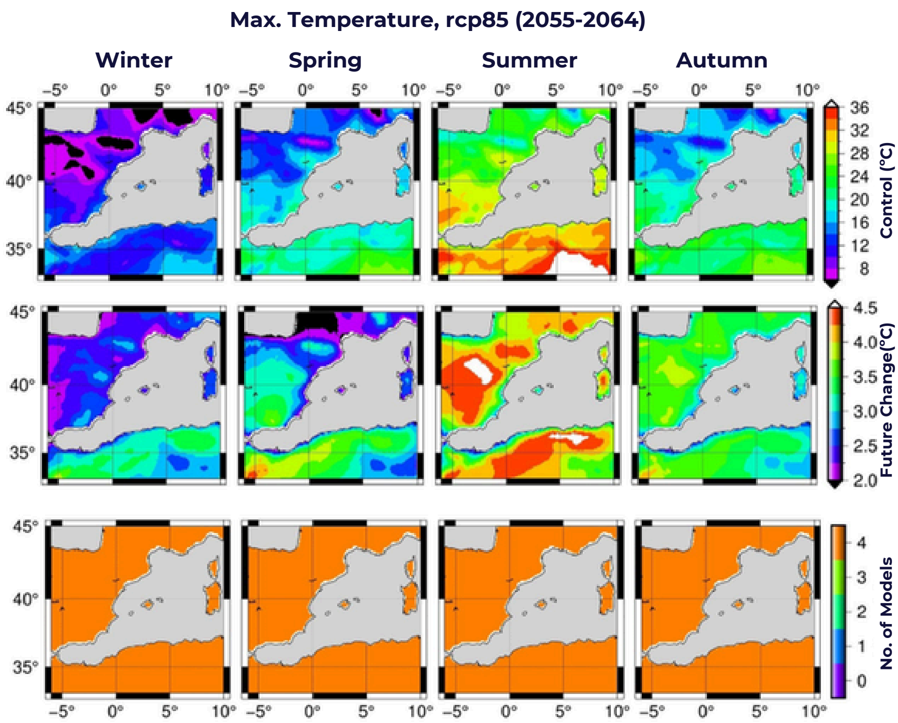


Figure 1. Layout of elements in a graph with seasonal information on maximum daily air temperature at 2 meters

Figure 1 shows, for the RCP8.5 scenario: In the first row, the **seasonal average** of maximum air temperature at 2 meters, in °C, for the **control period (1976-2005)**. In the second row, the **future seasonal change** in maximum air temperature at 2 meters, in °C, for the decade 2055-2064 relative to the control period (future value minus control value), where a positive sign indicates a future temperature increase. In the third row, the **number of models in the ensemble projecting a positive sign change** is presented. In seasonal graphs, winter is defined by the months of December, January, and February; spring by March, April, and May; summer by June, July, and August; autumn by September, October, and November.

It is important to note that all calculations have been carried out considering the ensemble of models mentioned in Table 1 **(in the RCP4.5 scenario there are 3, and in the RCP8.5 scenario there are 4).** In this case, therefore, the extended orange color across the entire area of interest indicates that all models (the 4 models in the ensemble) project an increase in maximum air temperature at 2 meters, regardless of the season, making the projected increase robust. In the case of a decrease in future values in any climatic variable, the results will be more robust the fewer models projecting an increase, and the agreement will be maximum when, in this case, no model projects an increase (number of models in the graph equals 0).

- Monthly Frequency: In this case, the graph will have a structure as shown below in Figure 2.

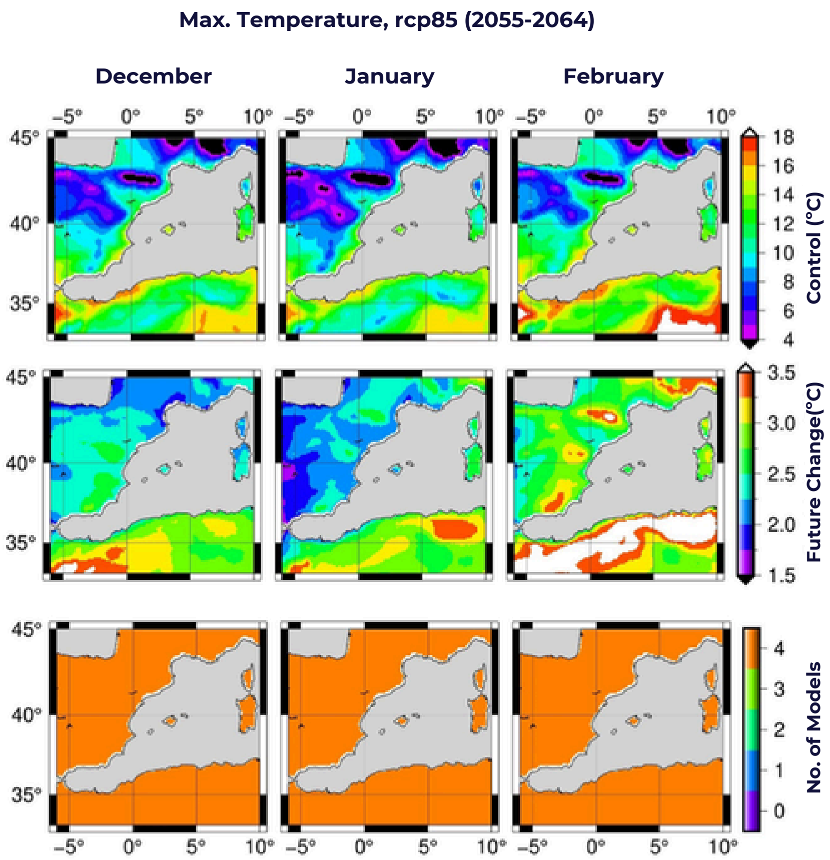


Figure 2. Layout of elements in a graph with monthly information on maximum air temperature at 2 meters for winter months

Figure 2 is equivalent to Figure 1 but with values calculated for winter months (December, January, and February). The user can also access data for the winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and autumn (September, October, and November) months, as shown in Figures 3, 4, and 5, presented below.

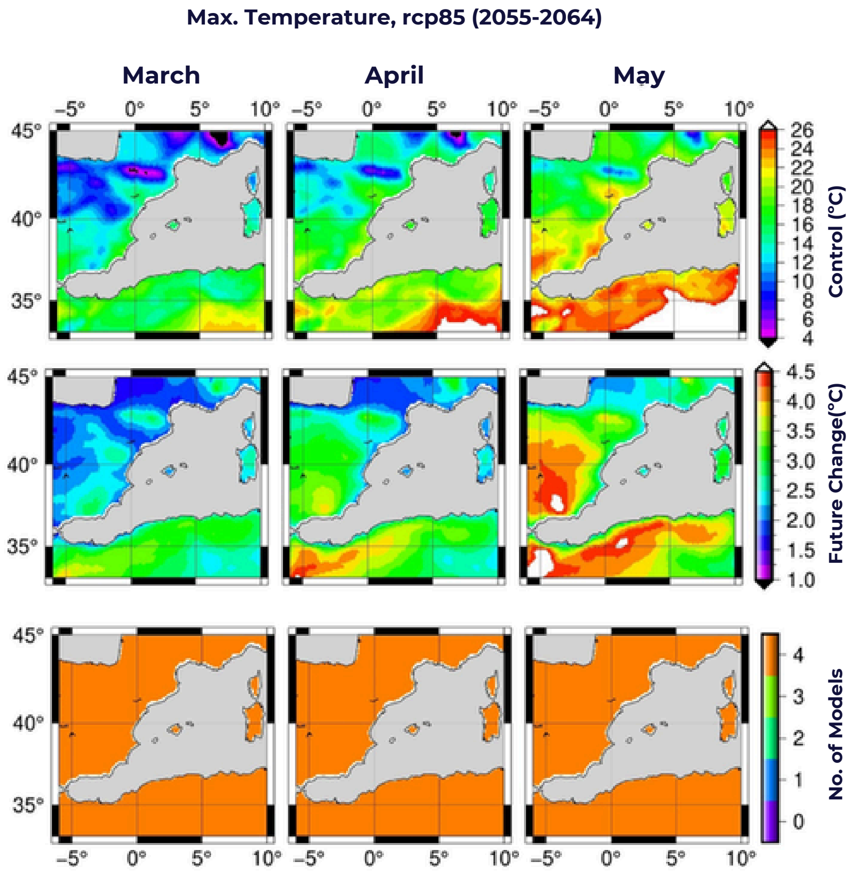


Figure 3. Layout of elements in a graph with monthly information on maximum air temperature at 2 meters for spring months

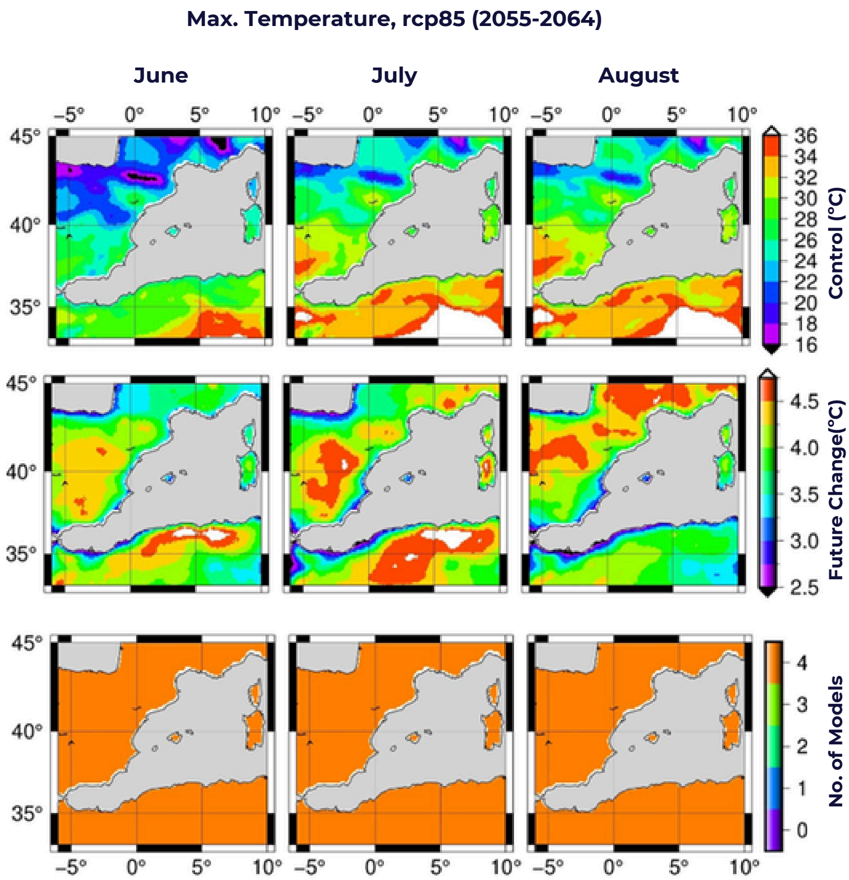


Figure 4. Layout of elements in a graph with monthly information on maximum air temperature at 2 meters for summer months

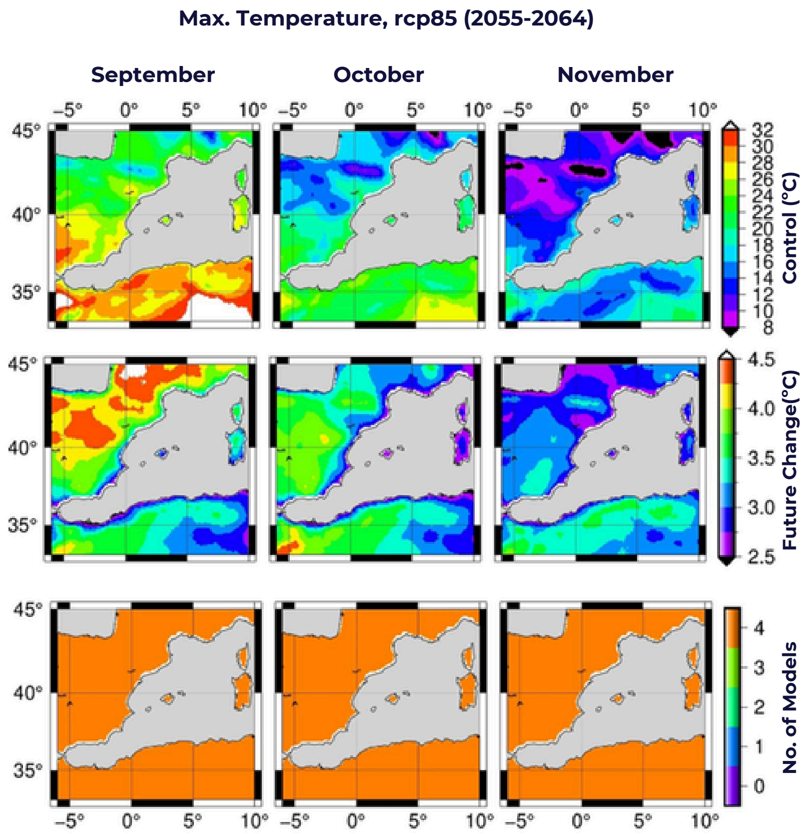


Figure 5. Layout of elements in a graph with monthly information on maximum air temperature at 2 meters for autumn months

3.3.4. Important Considerations

Color Scales

Some color scales located on the graphs have colored triangular ends. This indicates that values outside the upper and lower limits of the scale will appear on the graph with the tone corresponding to the color of the triangle at the respective end.

Currents

For currents, in the seasonal case, Figure 6 shows, for the RCP8.5 scenario and the chosen depth (50 m): In the first row, the seasonal average of the velocity module of the currents (colors, m/s) and their direction (arrows) for the control period (1976-2005). In the second row, the future seasonal change of the velocity module for the decade 2055-2064 relative to the control (m/s) and the direction of the currents in that decade (not their change). In the third row, the number of models in the ensemble projecting a positive sign change (increase) in the velocity module in the future is presented. In this case, in areas (mainly coastal) where the velocity module decreases in the future and there is a slowdown, the results presented will be more robust the fewer models projecting an increase. In these areas, mostly one model or none project an increase. This same structure applies to graphs with monthly data.

Although the arrows have been added to indicate the direction of the current, their length is proportional to the velocity of the current. The scaling of the currents has been done with the same criterion for each specific depth (50 m, 500 m, 1000 m).

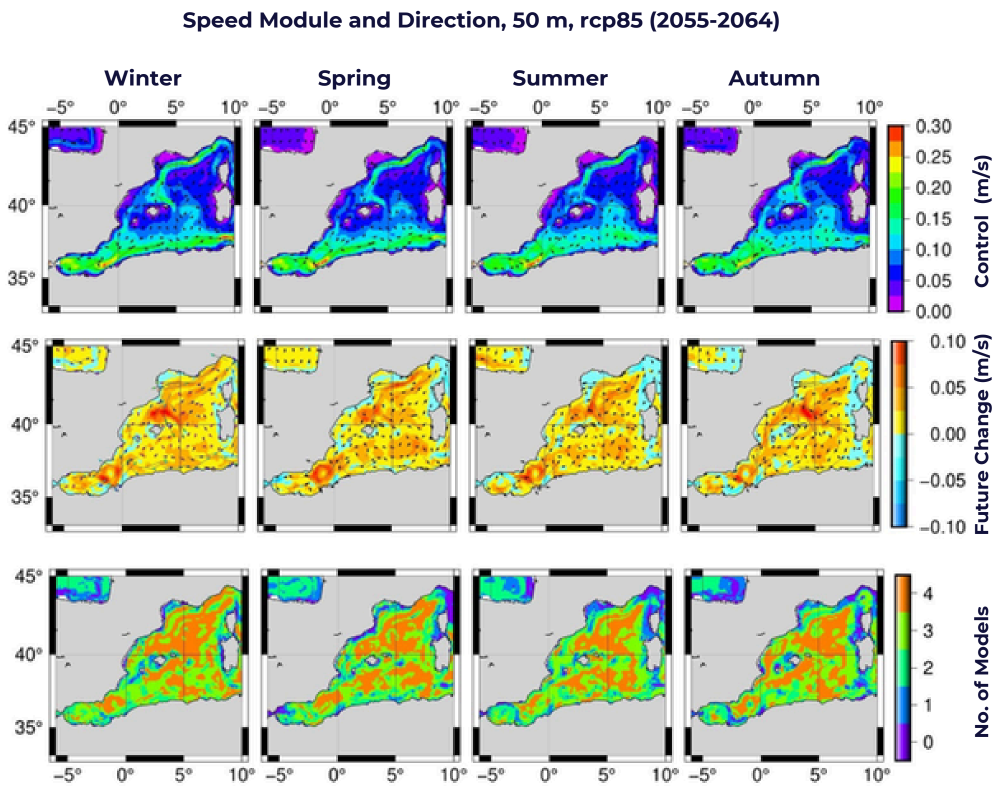


Figure 6. Layout of elements in a graph with seasonal information on the module and velocity of currents at a depth of 50 m

Number of Days with Summer Conditions, heavy precipitation, and Heatwaves

It's important to note that for the number of days with summer conditions, heavy precipitation, and heatwaves (both atmospheric and marine), data can be downloaded with seasonal frequency, and in the case of monthly frequency, graphs are available showing values for the months of April-May and September-October, as shown in Figure 7. This is because this information becomes particularly relevant in the months adjacent to summer, so the focus is on them.

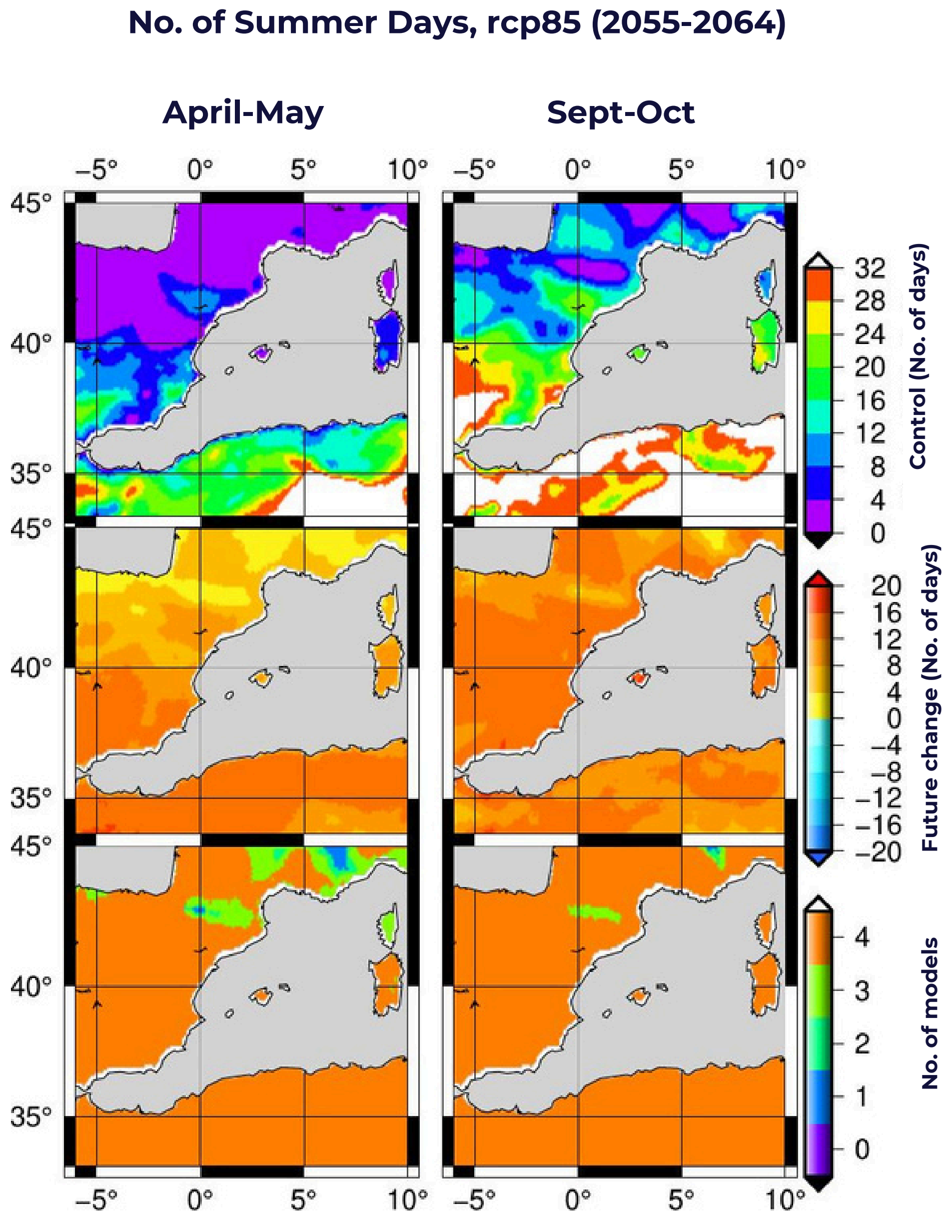


Figure 7. Layout of elements in a graph with monthly information for the months of April-May and September-October, respectively

Similar to previous cases, this figure shows, for the RCP8.5 scenario: In the first row, the seasonal average (April-May and September-October, respectively) of the number of days with summer conditions for the control period (1976-2005). In the second row, the future seasonal change for the decade 2055-2064 relative to the control period. In the third row, the number of models in the ensemble projecting a positive sign change is presented.

Below, Figures 8, 9, and 10 show the equivalent graphs for heavy precipitation, atmospheric heatwaves, and marine heatwaves, respectively.

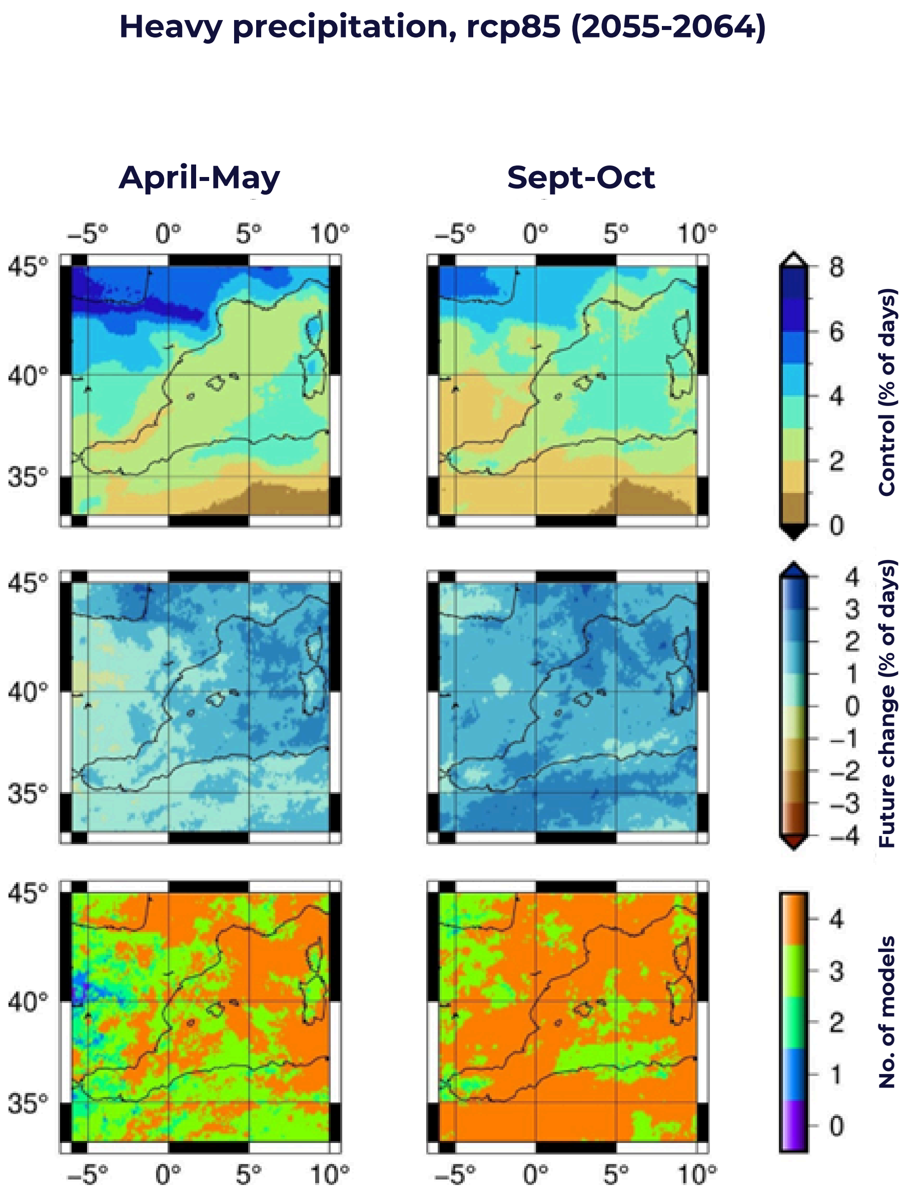


Figure 8. Equivalent to Figure 7, but for the number of days with heavy precipitation

Heatwave days, rcp85 (2055-2064)

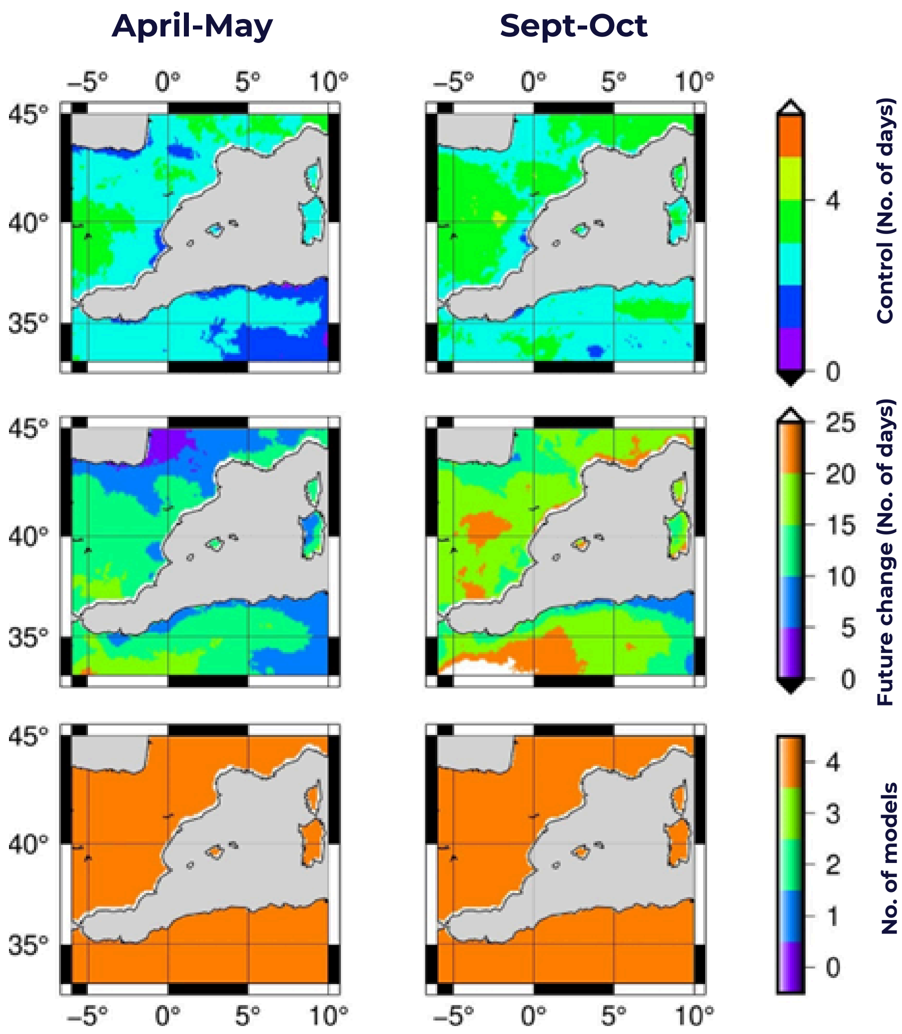


Figure 9. Equivalent to Figure 7, but for the number of days of atmospheric heatwaves

Heatwave days, rcp85 (2055-2064)

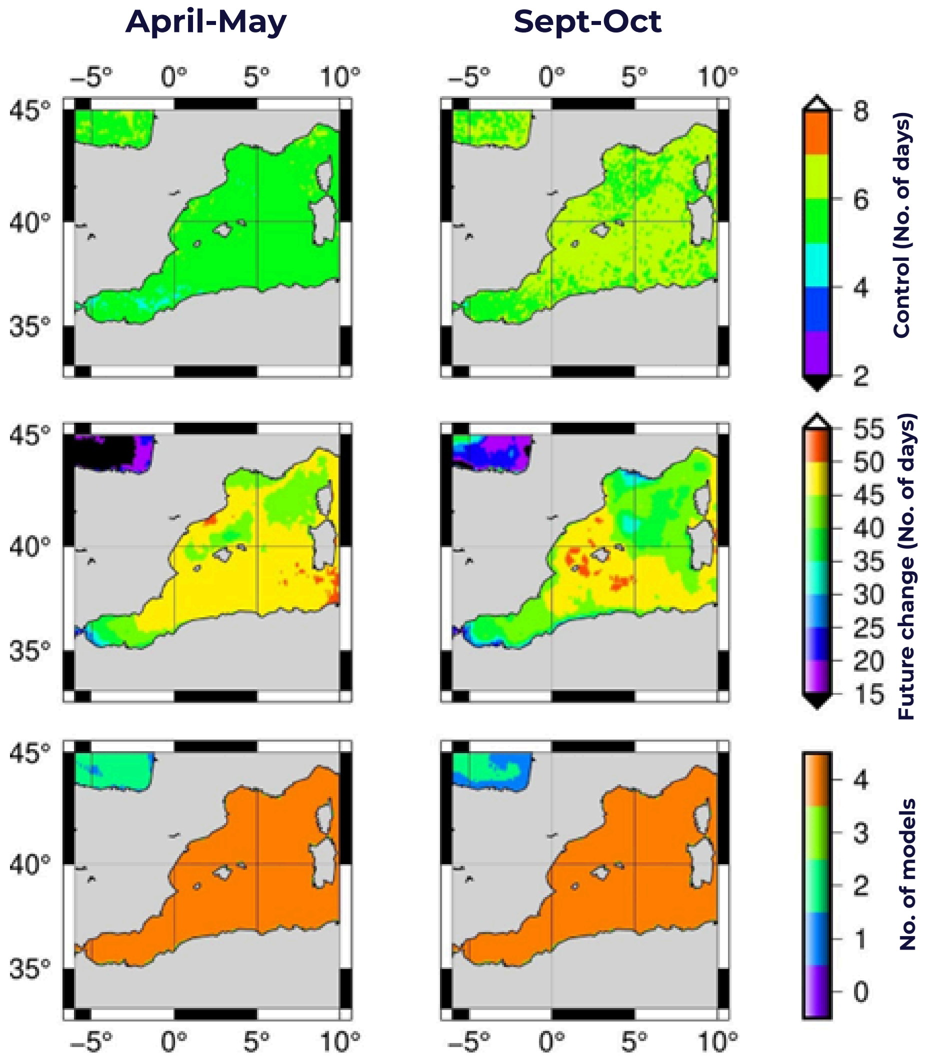


Figure 10. Equivalent to Figure 7, but for marine heatwaves

4. Glossary of Terms and Abbreviations

- **CMIP5:** Coupled Model Intercomparison Project Phase 5 (https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip5).
- **Day with Summer Conditions**: A day when the daily maximum temperature exceeds 25°C.
- IPCC (Intergovernmental Panel on Climate Change): The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to provide comprehensive assessments of scientific, technical, and socio-economic knowledge about climate change, its causes, potential impacts, and response strategies.
- **Atmospheric Heatwaves** (HWFI; heat wave frequency index): A heatwave is defined as a period of at least 6 consecutive days in which the daily maximum temperature exceeds the 90th percentile of maximum temperature.
- **Marine Heatwaves:** A period of at least 5 consecutive days during which the daily sea-surface temperature is above the 90th percentile.
- **heavy precipitation:** Considered to occur when daily precipitation exceeds the 90th percentile of daily precipitation calculated for a reference period.
- **RCP (Representative Concentration Pathway):** Refers to the different pathways of greenhouse gas concentration adopted by the IPCC (see Figure 1G). These pathways describe various possible future climate scenarios, all of which are considered possible depending on greenhouse gas emissions in the coming years.

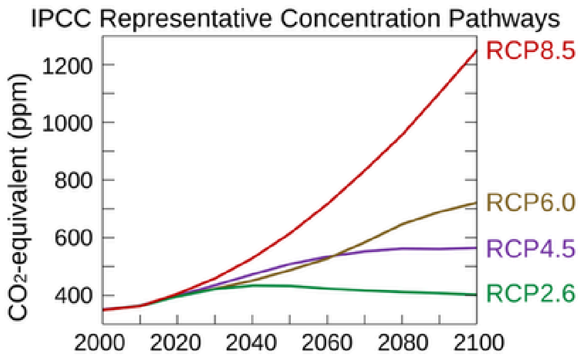


Figure 1S. Evolution of CO2 equivalent concentration, in ppm, for different emission scenarios until 2100.

5. References

Cavicchia, L., Gualdi, S., Sanna, A., Oddo, P. et al., 2015. The regional ocean-atmosphere coupled model COSMO-NEMO_MFS. CMCC Research Paper, RP0254.

Darmaraki, S., Somot, S., Sevault, F., Nabat, P., Narvaez, W. D. C., Cavicchia, L., Djurdjevic, V., Li, L., Sannino, G., Sein, D.V. (2019) Future evolution of marine heatwaves in the Mediterranean Sea. Climate Dynamics, 53(3), 1371-1392. https://doi.org/10.1007/s00382-019-04661-z.

Giorgi, F. (2006) Climate Change Hot-Spots. Geophysical Research Letters, 33(8). https://doi.org/10.1029/2006GL025734

González-Alemán, J.J., Pascale, S., Gutierrez-Fernandez, J., Murakami, H., Gaertner, M.A., Vecchi, G.A. (2019) Potential increase in hazard from Mediterranean hurricane activity with global warming. Geophysical Research Letters, 46(3), 1754-1764. https://doi.org/10.1029/2018GL081253.

IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)].

L'Hévéder, B., Li, L., Sevault, F., Somot, S., 2013. Interannual variability of deep convection in the Northwestern Mediterranean simulated with a coupled AORCM. Clim. Dyn. 41(3–4), 937–960. https://doi:10.1007/s00382-009-0691-8.

Rixen, M., Beckers, J.M., Levitus, S., Antonov, J., Boyer, T., Maillard, C, Fichaut, M., Balopoulos, E., Iona, S., Dooley, H. et al., 2005. The Western Mediterranean Deep Water: a proxy for climate change. Geophys. Res. Lett. 32(12). https://doi.org/10.1029/2005GL022702.

Sein, D.V., Mikolajewicz, U., Gröger, M., Fast, I., Cabos, W., Pinto, J.G., Hagemann, S., Semmler, T., Izquierdo, A., Jacob, D., 2015. Regionally coupled atmosphere-ocean-sea ice-marine biogeochemistry model ROM: 1. description and validation. J. Adv. Model Earth Syst. 7, 268–304. https://doi.org/10.1002/2014MS000357.

Sevault, F., Somot, S., Alias, A., Dubois, C., Lebeaupin-Brossier, C., Nabat, P., Adloff, F., Déqué, M., Decharme, B., 2014. A fully coupled Mediterranean regional climate system model: design and evaluation of the ocean component for the 1980–2012 period. Tellus A: Dyn. Meteorol. Oceanogr. 66, 23967. https://doi.org/10.3402/tellusa.v66.23967.

Funding

This publication is part of the grant PTQ2020-011287, funded by MCIN/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR.

Acknowledgments

We would like to thank the following individuals and institutions for their efforts in sharing with us the results of the simulations used to generate the graphics offered in this tool: Florence Sevault (CNRM), Laurent Li (Laboratoire de Météorologie Dynamique, LMD), Giovanni Zizzi (Centro Euro-Mediterraneo sui Cambiamenti Climatici, CMCC), and Dmitry Sein (Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, AWI).

The calculations presented here were carried out using CDO, and the figures were created using GMT. We thank Paul Meijer for his assistance with the use of GMT. Also, the Kveloce team for their support throughout the project, and William Cabos and Claudia Gutiérrez for their advice and assistance in data processing.

We also thank Rubén Vázquez for his assistance in generating some files used for data checks. Additionally, we appreciate the collaboration of all individuals and institutions who participated in the participatory activities conducted during the project.