# Regionally downscaled projections of the Mediterranean Sea for the 21st century

*Tomas Lovato , Momme Butenschön, Simona Masina*

*Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), Italy*

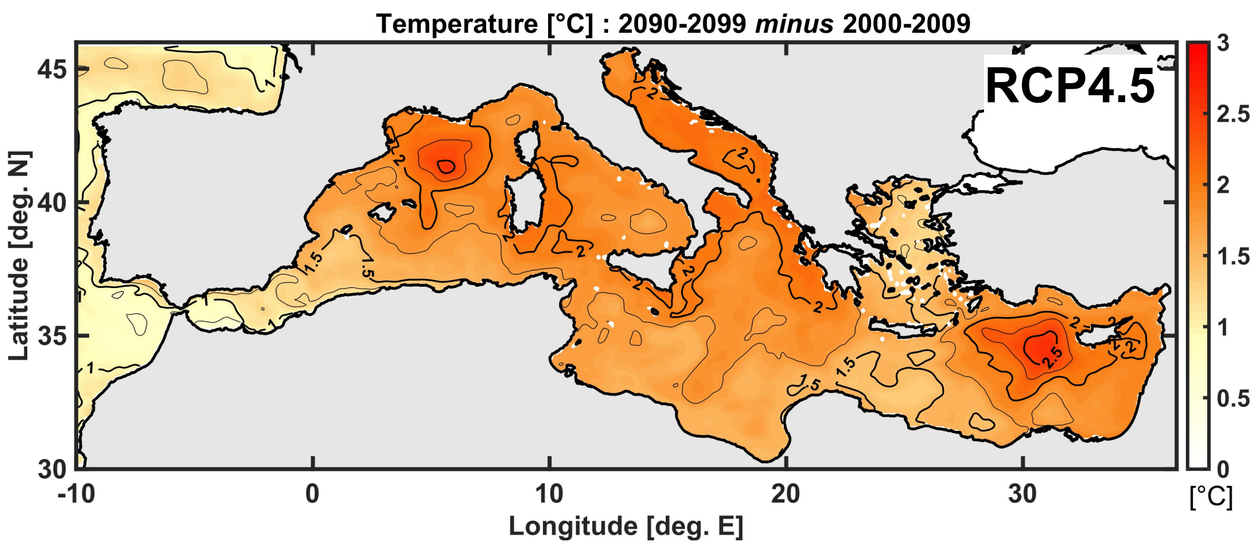
cmcc Euro-Mediterranean Center on Climate Change

**Introduction** The CMIP initiative has produced an ample set of ensemble projections of the Earth System to assess climate change and its impacts at global scale that have led to considerable progress of our knowledge at the larger scale of global budgets, but have shown considerable shortcomings in providing robust information at regional to local level. While these limitations have been identified in a number of studies, only few downscaled ocean simulations exist to evaluate climate change impacts at resolutions that are crucial to support adequate implementation of climate change mitigation and adaptation measures.

***Two contrasting projections based on the CMIP5 scenarios RCP4.5 and RCP8.5 are provided in order to assess the vulnerability of the system and compared to Earth system Models (ESM) projections from the CMIP archive in order to highlight the added value of the regional high resolution products.***

**Regional modelling of future scenarios** The ocean general circulation model used to generate regional projections is NEMO (Madec, 2008) and it was implemented following Oddo et al. (2009). Overall, the model grid has a regular horizontal resolution of 1/16 of degree (~6.5 km) and 72 vertical levels (from 3 to 350 m). Atmospheric forcings, runoffs, and lateral boundary conditions are taken from the AOGCM model CMCC-CM (Scoccimarro et al., 2011) and are prescribed using a bias correction method as in Lovato et al. (2013).

**Mediterranean temperature changes by 2100** The increase of temperatures under both scenarios in comparison to present day conditions will affect the entire basin (Fig. 1), mostly affected are the Levantine and Adriatic basins. In particular the Mediterranean Sea will experience much larger changes with respect to the neighbouring Atlantic region.



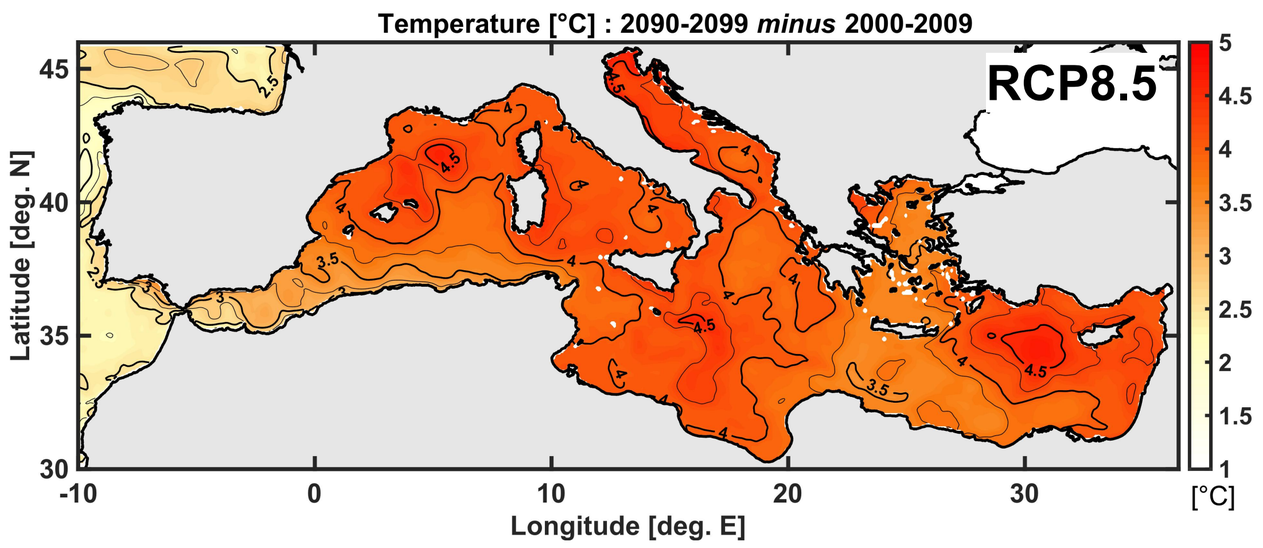
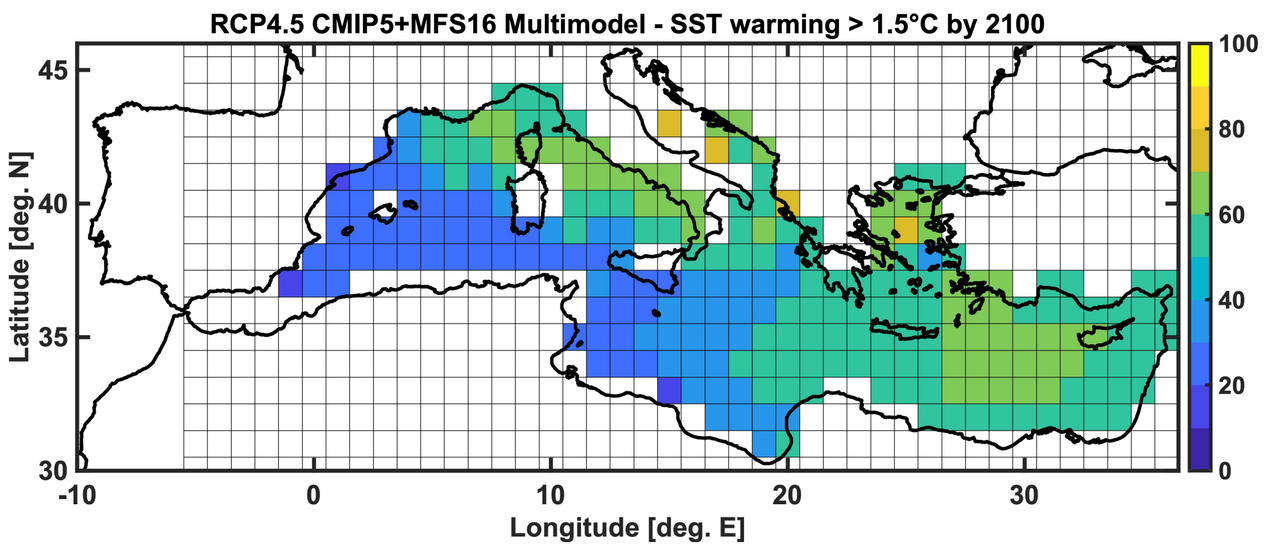




**Figure 1.** Distribution of surface temperature anomalies (°C) under RCP4.5 (left) and RCP8.5 (right) computed as the difference between mean values of 2090-2099 and 2000-2009 periods. The two plots have different colour range.

**Exceedances of critical thresholds** A multi-model ensemble composed by CMIP5 ESMs for RCP4.5 and RCP8.5 scenarios was analysed to evaluate the exceedance by 2100 of SST thresholds (Fig. 2), showing that sea surface temperature in central and eastern Mediterranean will exceed the critical value of 1.5ºC in more than 60% of model projections even under the lowest RCP4.5, while for the highest RCP8.5 virtually the entire basin exceeds even 3ºC of warming emissions for the majority of considered models.



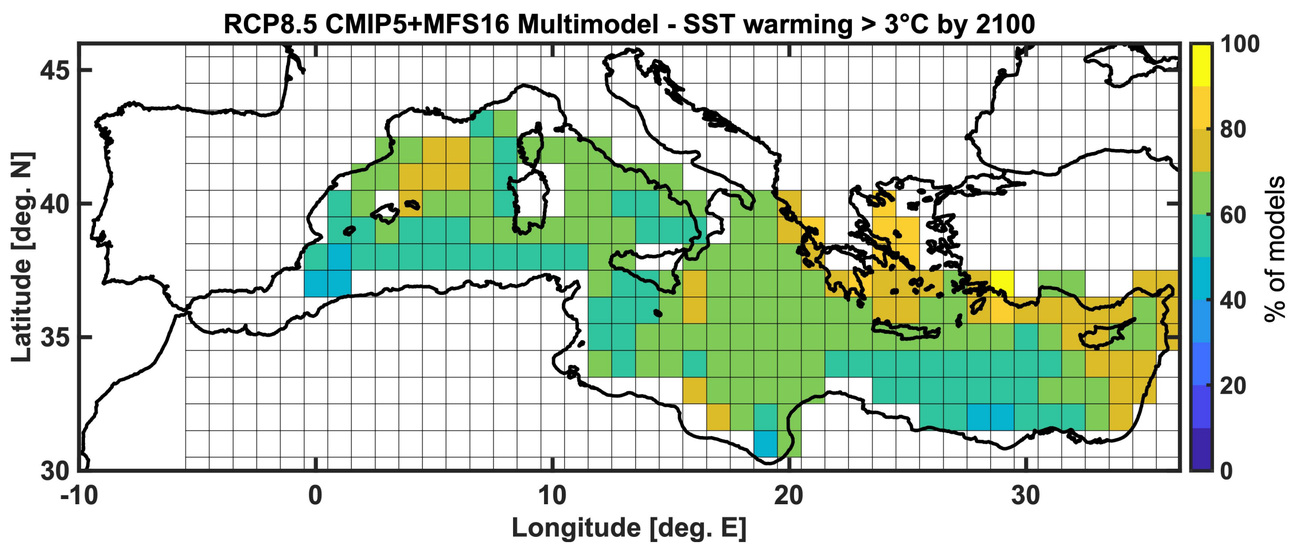
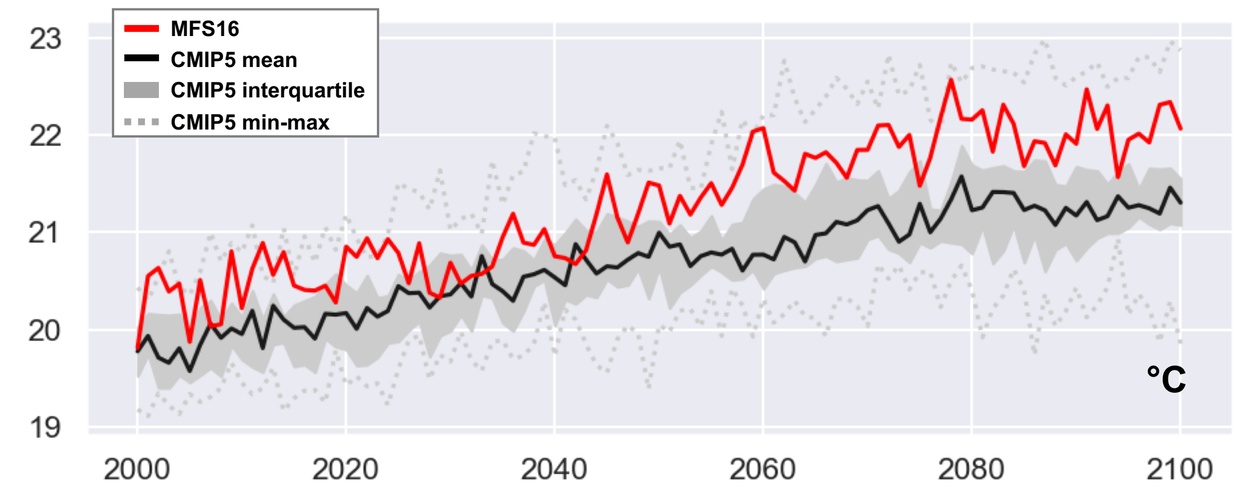




**Figure 2. E**xceedance of surface temperature thresholds of 1.5°C for RCP4.5 (left, 8 ESM) and 3°C for RCP8.5 (right,10 ESM) by 2100 with respect to present conditions, indicated as percentage of models in the ensemble.

**Basin scale projection trends** Both high-resolution MFS16 and CMIP5 ESMs ensemble show a good agreement on the tendency of future SST evolution over the Mediterranean basin (Fig. 3), with the first showing a high mean variability after 2050 that is still consistent with the ensemble spread of CMIP5 climate projections.



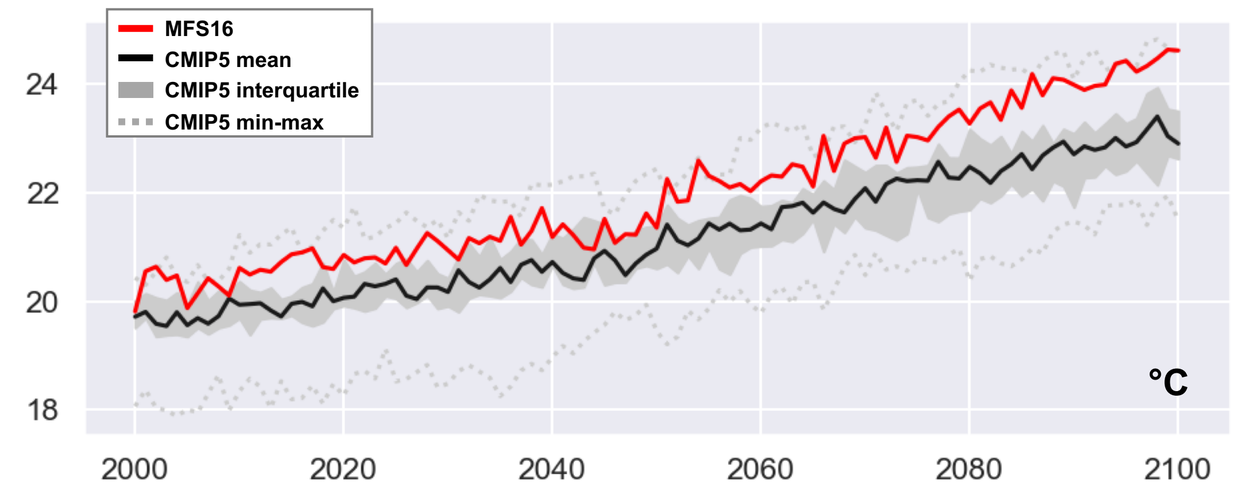




**Figure 3.** Mediterranean basin mean SST(°C) evolution under RCP4.5 (left) and RCP8.5 (right) from MFS16 simulations (red) and CMIP5 ESMs ensemble, with mean (black), interquartile (shaded area) and min-max (dotted) ranges.

**REFERENCES** **Madec, G**. (2008). NEMO Ocean Engine. Note du Pole de Modelisation Institute Pierre-Simone Lapalce No. 27 (IPSL), France. **Oddo**, P., Adani, M., Pinardi, N., Fratianni, C., Tonani, M., and Pettenuzzo, D. (2009). A nested atlantic-mediterranean sea general circulation model for operational forecasting. Ocean Sci. 5, 461–473. doi: 10.5194/os-5- 461-2009 **Scoccimarro**, E., Gualdi, S., Bellucci, A., Sanna, A., Fogli, P. G., Manzini, E., et al. (2011). Effects of tropical cyclones on ocean heat transport in a high-resolution coupled general circulation model. J. Clim. 24, 4368–4384. doi: 10.1175/2011JCLI4104.1 **Lovato**, T., Vichi, M., and Oddo, P. (2013). High resolution simulations of Mediterranean Sea physical oceanography under current and scenario climate conditions: model description, assessment and scenario analysis. CMCC Res. Pap. 1–26. doi: 10.2139/ssrn.2637861

mail to tomas.Lovato@cmcc.it