Collaborative Project

CLIM-RUN

Climate Local Information in the Mediterranean region Responding to User Needs

WP2 New Climate modeling and analysis tools

Task 2.1: Analysis of climate information from existing projects

D2.2: Report on ongoing simulations

Project No. 265192– CLIM-RUN

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1. Introduction

Within the CLIM-RUN project will make use of the results from previous (ENSEMBLES, CIRCE, CECILIA, ACQWA) and new (CMIP5, COMBINE, CORDEX) climate change and prediction projects. The intention is to provide science advancements for the delivery of climate information. This deliverable, which is part of Task 2.1, lists some results from these datasets relevant to the Mediterranean region. These results are expected to support the targeted requested climate information for the different case studies such as tourism, forest fire, energy over different locations around the area. Different choices of time scales and data sets are illustrated depending on the stakeholder needs. The deliverable is linked to the milestones 4 and 5, which lists the available datasets for three types of simulations: the centennial scenario in the CMIP5 context and related projects, the decadal forecasts in the CMIP5 context and related projects and finally the regional climate change scenario in the context of CORDEX and related projects.

2. Climate predictions

A climate prediction is a statement about the future evolution of some aspect of the climate system, encompassing both forced and internally generated components. Slow components of the natural variability, associated mainly but not solely with the ocean state, can be predictable. Changes in the atmospheric composition also induce predictability. Uncertainty in near-term predictions is dominated, especially on regional scales, by internal variability and model uncertainty (Hawkins and Sutton, 2009; 2011).

There have been attempts to predict near-term climate variations by employing climate projections (i.e. with no information about the contemporaneous state of the climate system) performed as part of the different Coupled Model Intercomparison Projects (Roukolainen and Räisänen, 2007; Laepple et al., 2008). As a slightly more ambitious alternative, dynamical decadal prediction explores the ability of climate models to predict regional climate changes in the near future by exploiting both initial-condition information and changes in atmospheric composition (Smith et al., 2007: 2010; Keenlyside et al., 2008; Pohlmann et al., 2009; Mochizuki et al., 2010). The purpose of the initialization is to use the predictability of the internal variability with the goal of reducing the prediction error relative to that of the projections for as long as the initial-condition information persists in the climate system. The extent to which this goal is achievable depends on the quality of the initial conditions, particularly of the ocean state, the quality of the climate forecast system, and the initialization procedure. Skill improvements with initialization appeared in different regions depending on the forecast system considered, the North Atlantic being the common denominator.

Non-initialized predictions of regional temperature are statistically significantly skilful for most regions and forecast ranges due to the almost monotonic increase in temperature, pointing at the large role played by time-varying radiative forcing and a much smaller role of the initial conditions (van Oldenborgh et al., 2012; Doblas-Reyes et al., 2012). As for the Mediterranean region is concerned, the Atlantic multidecadal variability (AMV) is the dominant decadal ocean temperature oscillation over the North Atlantic (Trenberth and Shea, 2006), and it has been found to be skilfully predicted by current climate forecast systems, especially when initial conditions are taken into account (García-Serrano et al., 2012). Based on previous research (Mariotti and Dell'Aquila, 2011) observational evidence suggests the AMV may have a maximum impact on Mediterranean summer

(JJA) surface air temperature (not that obvious in DJF), while an impact on Mediterranean SST has been found all year round. This suggests a certain degree of interannual-to-decadal climate predictability in the Mediterranean, to the extent that the AMV is predictable.

An analysis of the predictive skill of a multi-model ensemble decadal prediction experiment has been used to illustrate the skill over the Mediterranean region. The decadal predictions were performed within the framework of the COMBINE (Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection) FP7 Project, and are part of the European contribution to the CMIP5 effort. A list of the models used for this analysis is reported in Table 1. Further details on the experimental setup and on the characteristics of the decadal prediction systems involved in this analysis are outlined in Bellucci et al. (2012).

Figure 1 shows maps of skill based on the anomaly correlation coefficient (hereafter ACC) for surface temperatures (combined SST/T2M). Although the models involved in the analysis are global, the figure focus on the regional-scale skill over the Mediterranean region. ACC is shown for forecast times 2-5 (top) and 6-9 (bottom) years, before (left) and after (right) trend-removal, and it has been diagnosed from the multi-model ensemble-mean prediction. The left panels show that the skill before removing a linear trend is large over most of the region, mostly exceeding a 95% statistical significance threshold, based on a simple Student's t-test (0.58). Skill is large over both land and ocean surfaces, and appears to be relatively insensitive to the selected lead-time interval.

After removing a linear trend from both predictions and observations, the ACC patterns reveal a drastic reduction in skill, with respect to the previous case. The drop in skill is particularly pronounced over continental Europe, exhibiting near-zero or negative ACC values. A notable exception is represented by a wide area including the Mediterranean Sea, north-eastern Africa and Middle-East (hereafter MAME), where significant residual predictability is found, with ACC values exceeding 0.6 for both 2-5 and 6-9 years.

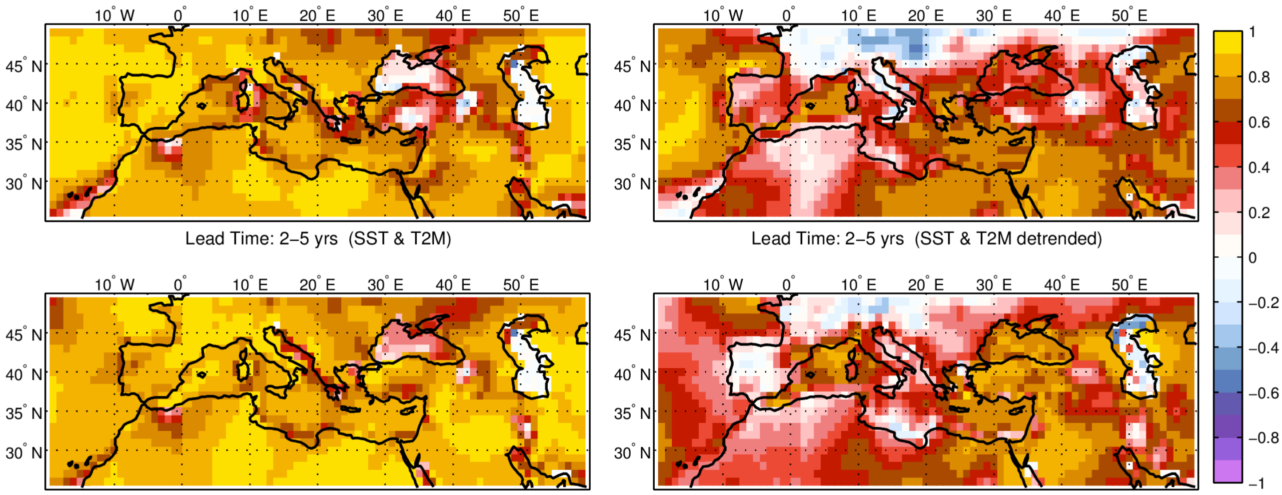

Figure 1. (Left) Multi-model ensemble mean anomaly correlation coefficient (ACC) maps for T2M over land and SST over the ocean, for lead-time periods (top) 2-5 and (bottom) 6-9 years. (Right) The corresponding maps after the long-term linear trends have been removed from both hindcasts and observations.

Institute	Dynamical Model	Resolution: AGCM | OGCM	Initialization Strategy	Initialized Components	Ensemble Size
Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) – **Italy**	CMCC-CM	0.7º - L31, 1.2º - L31	Full	Ocean	3
Royal Netherlands Meteorological Institute (KNMI) - **Netherlands**	EC-Earth	1.1º - L62, 1º L - L42	Full	Atmosphere-Land Ocean Sea-Ice	5
Swedish Meteorological and Hydro-logical Institute (SMHI) - **Sweden**	EC-Earth	1.1º - L62, 1º L - L42	Anomaly	Atmosphere-Land Ocean Sea-Ice	3
European Centre for Research and Advanced Training in Scientific Computation (CERFACS) / Météo-France-CNRM (MF-CNRM) – **France**	CNRM-CM5	1.4º - L31, 0.7º - L42	Full	Ocean	10
Max Planck Institute for Meteorology (MPI-M) - **Germany**	MPI-ESM-LR	1.9º - L47, 1.5º - L40	Anomaly	Ocean	10
Met Office Hadley Centre (MOHC) – **U.K.**	HadCM3	3.75º x 2.5º - L19, 1.25º - L20	Anomaly	Atmosphere-Land Ocean Sea-Ice	10

Table 1. The six decadal prediction systems of the COMBINE multi-model ensemble, the corresponding model used, spatial resolution (ocean / atmosphere), initialization method, initialized components, and ensemble size.

Based on this result, an index for the climatic variability over the MAME region has been defined as the near-surface air temperature (T2M) averaged over the region [20º-45ºN,10º-50ºE]. Then, the predictability featured by the MAME region is assessed in terms of ACC of the corresponding index at different forecast times (averaged over four years) for both the individual forecast systems and the multi-model ensemble mean (Fig. 2).

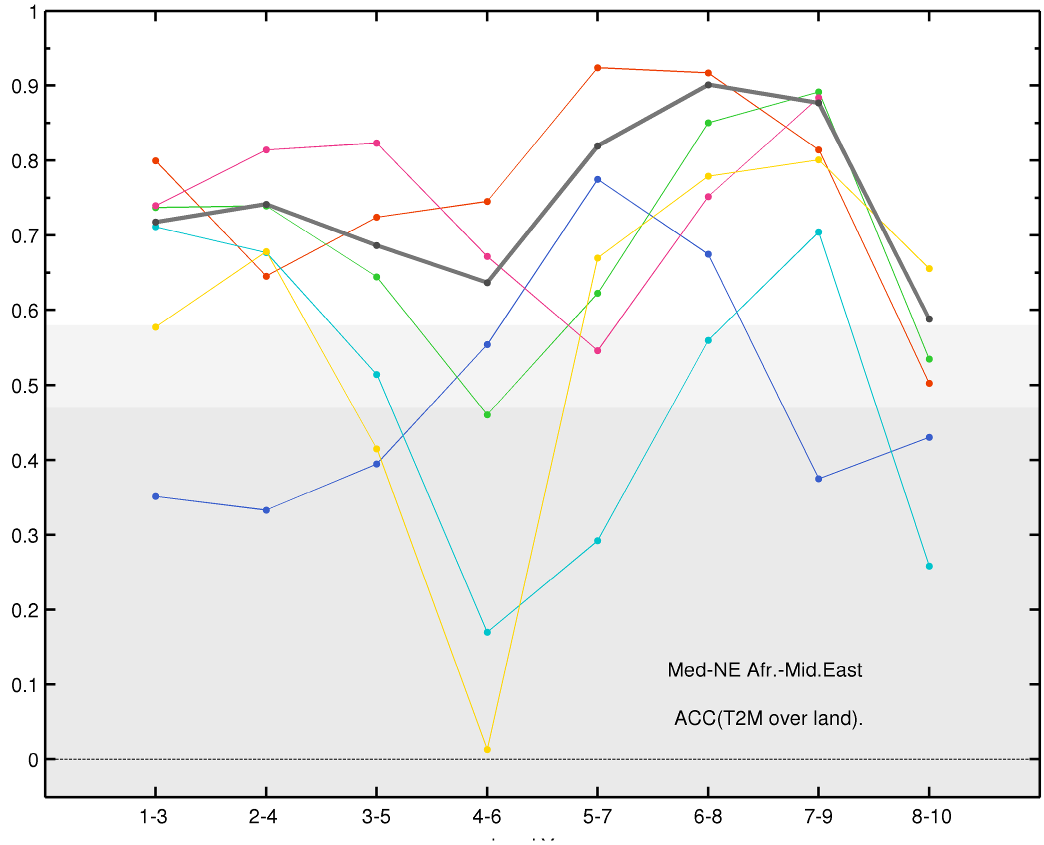

Figure 2. The ACC as a function of forecast time (four-year averages) for T2M averaged over an area including parts of the Mediterranean, NE Africa and Middle East [20-45N,10-50E], for the multi-model mean (black), CMCC-CM (blue), EC-Earth-KNMI (green), EC-Earth-SMHI (yellow), HadCM3 (purple) and CNRM-CM (red). The 90% and 95% statistical significance thresholds, based on a one-tailed Student's t-test, for nine independent points are also displayed (dark and light grey shading, respectively).

The near-surface air temperature over the MAME region features a high degree of predictability, with the multi-model displaying significant skill up to 10 years. Since near-surface temperature predictability over land is typically weak in current coupled models (Boer and Lambert, 2008), the large forecast skill found over the MAME region is suggestive of a possible remote oceanic influence that is correctly predicted. As mentioned above, the AMV is one of the candidates to explain the skill. This finding suggests the possibility for initialized decadal predictions to provide valuable information on near-term variability over the EM region, with added value with respect to standard uninitialized climate projections.

3. Climate projections

An assessment of CMIP5 models capability in reconstructing the present day climate for total precipitation over the Mediterranean region is provided, together with an evaluation of the expected changes for the 21st Century, under a warming climate. For this analysis, daily precipitation fields

from a sub-set of the CMIP5 multi-model ensemble, consisting of simulations of the 20th and 21st Century climate by 20 coupled ocean-atmosphere GCMs (Table 2) have been used.

The skill of CMIP5 models in reproducing the present climate has been assessed against daily data from the Global Precipitation Climatology Project (GPCP, Bolvin et al., 2009; hereafter "observations") over the period 1997-2005. For the evaluation of models precipitation response to global warming, two periods have been considered: 1966-2005 (hereafter PRESENT), corresponding to the last part of the 20th century historical simulation (forced with observed GHG concentrations, volcanic and anthropogenic aerosols and solar variability) and 2061-2100 (hereafter FUTURE), which has been run under RCP8.5 emission scenario conditions (Riahi et al., 2011; Taylor et al., 2012). The horizontal resolution of the atmospheric component of the analysed models ranges from 0.75º to 3.5º. For comparison purposes, CMIP5 model outputs have been interpolated on the 1ºx1º GPCP horizontal grid. Only precipitation over land is considered.

In Figure 1, boreal winter (DJF) and summer (JJA) mean precipitation for the 1997-2005 period is shown, for GPCP (left panels) and the CMIP5 multi-model ensemble average (right panels).

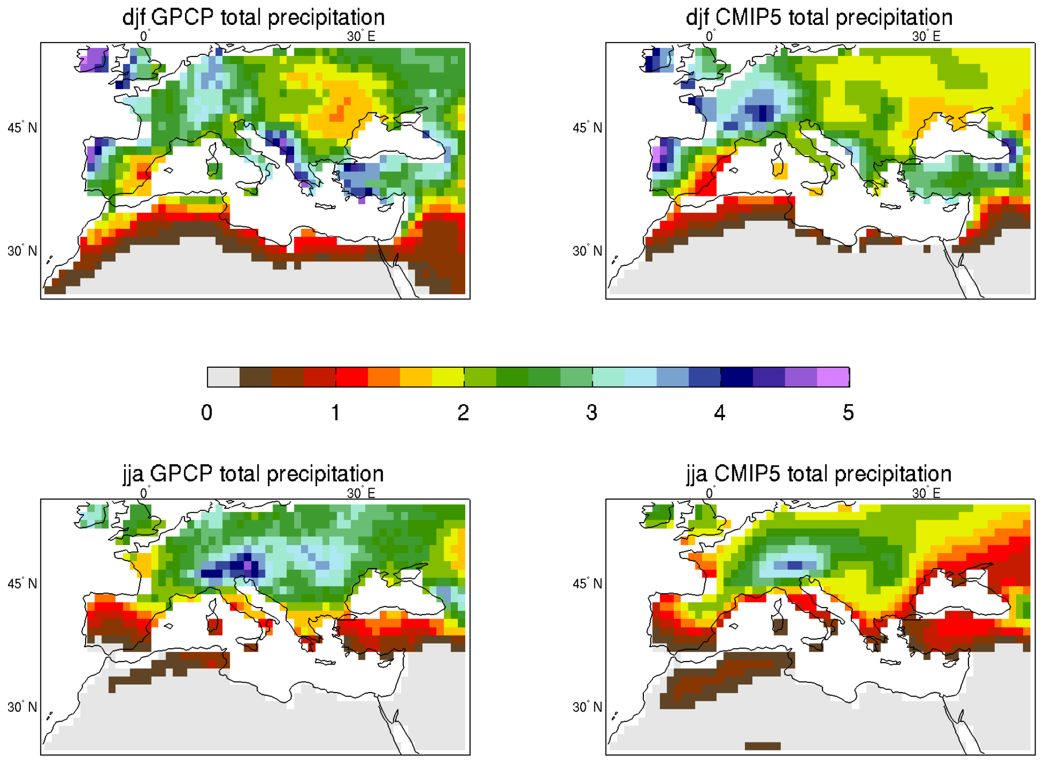

Figure 1. Winter (DJF, top) and summer (JJA, bottom) mean precipitation for the 1997-2005 period from GPCP (left) and CMIP5 (ensemble average over 20 models; right). Units are mm/day.

The comparison shows an overall reasonable agreement between models and observations, involving not only large-scale structures, but also some of the observed regional features. Major discrepancies are found over Eastern Europe (particularly for JJA), where models tend to underestimate the observed rainfall climatology.

Figure 2 shows the difference between FUTURE and PRESENT mean DJF and JJA climatological precipitation (expressed as % of the PRESENT baseline). Both increasing precipitation over central and northern Europe and decreasing precipitation over the southern Mediterranean area (with local maxima over northern Africa) are expected for the cold season (DJF). A rainfall decline is projected for the summer season (JJA), with a local intensification over south-western Europe (most notably, the Iberian Peninsula) approaching a 40% decrease. The detected changes of mean precipitation for the end of the 21st Century in CMIP5 models are largely consistent with previous findings based on CMIP3 models (Giorgi and Bi, 2009), despite the substantial differences in model configuration and GHG-emission scenarios, confirming the Mediterranean area as a primary climate change "hot-spot" (Giorgi, 2006).

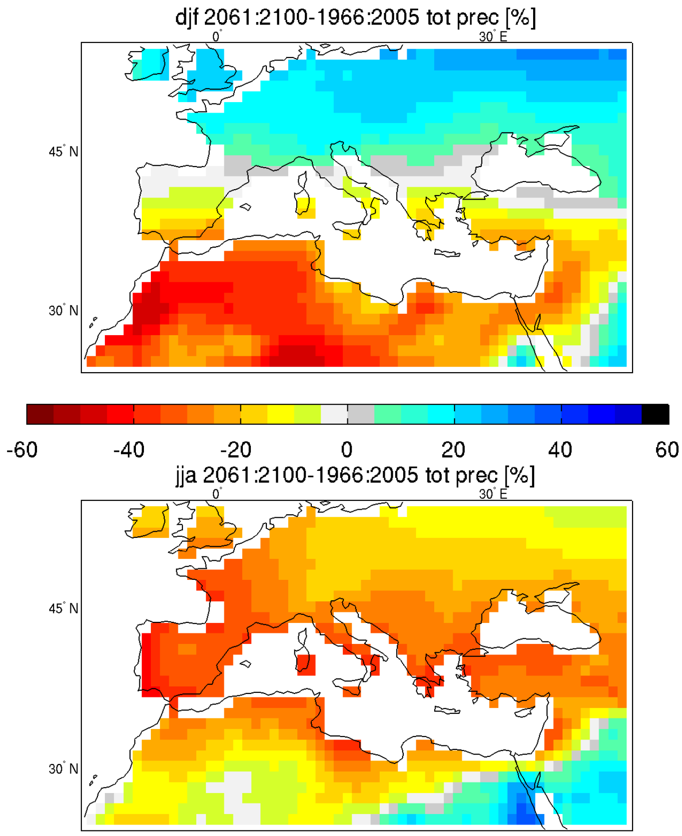

Figure 2. Ensemble average precipitation change in (top) DJF and (bottom) JJA for 2061-2100 with respect to 1966-2005 in the RCP8.5 scenario. Units are % of 1966-2005 value.

Model name	Horiz. Atmo. Res. (no. of grid-pts)	Institute (Institute ID)
BNU-ESM	64 x 128	College of Global Change and Earth System Science, Beijing Normal University (GCESS)
CCSM4	**192 x 288**	National Center for Atmospheric Research (NCAR)
CMCC-CESM	48 x 96	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)

CMCC-CMS	96 x 192	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)
CMCC-CM	**240 x 480**	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)
CNRM-CM5	**128 x 256**	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique (CNRM- CERFACS)
CSIRO-Mk3-6-0	96 x 192	Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence (CSIRO-QCCCE)
CanESM2	64 x 128	Canadian Centre for Climate Modelling and Analysis (CCCMA)
FGOALS-s2	108 x 128	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences (LASG-IAP)
GFDL-CM3	90 x 144	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
GFDL-ESM2G	90 x 144	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
GFDL-ESM2M	90 x 144	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
HadGEM2-CC	**145 x 192**	Met Office Hadley Centre (MOHC)
HadGEM2-ES	**145 x 192**	Met Office Hadley Centre (MOHC)
INM-CM4	**120 x 180**	Institute for Numerical Mathematics (INM)
IPSL-CM5A-MR	**143 x 144**	IPSL-CM5A-LR Institut Pierre-Simon Laplace (IPSL)
MIROC5	**128 x 256**	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology (MIROC)
MPI-ESM-MR	96 x 192	Max Planck Institute for Meteorology (MPI-M)
MRI-CGCM3	**160 x 320**	Meteorological Research Institute (MRI)
NorESM1-M	96 x 144	Norwegian Climate Centre (NCC)

Table 2. CMIP5 models used in the climate projection analysis.

4. Regional simulations

5. References

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