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PRIMAVERA

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PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment

Deliverable D*6.6*

Stream 2 Future AMIP runs

Deliverable Title		
Brief Description	*Complete and deliver the AMIP-II runs with forcings according to HighResMIP scenario for the period of integration 2015-2050 using the updated model configurations for Stream 2 (D6.6).*	
WP number	WP6	
Lead Beneficiary	**Cerfacs**	
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		P - Prototype
		D - Demonstrator
		O - Other
Dissemination Level/ Audience	x	*PU - Public*
		PP - Restricted to other programme participants, including the Commission services
		RE - Restricted to a group specified by the consortium, including the Commission services
		CO - Confidential, only for members of the consortium, including the Commission services

Version	**Date**	**Modified by**	**Comments**
version 1	27/09/2019	L. Terray	Initial draft
version 2	07/10/2019	L. Terray	Final version

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1. Executive Summary

Here we provide a brief summary of stream 2 AMIP future experiments that have been completed by the PRIMAVERA groups. We also describe with some detail the preliminary work leading to the making of the future sea surface temperature (SST) and sea-ice concentration (SIC) datasets used to force the atmospheric models.

2. Project Objectives

With this deliverable, the project has contributed to the achievement of the following objectives (DOA, Part B Section 1.1) WP numbers are in brackets:

No.	Objective	Yes	No
A	To develop a new generation of global high-resolution climate models. *(3, 4, 6)*		
B	To develop new strategies and tools for evaluating global high-resolution climate models at a process level, and for quantifying the uncertainties in the predictions of regional climate. *(1, 2, 5, 9, 10)*		
C	To provide new high-resolution protocols and flagship simulations for the World Climate Research Programme (WCRP)'s Coupled Model Intercomparison Project (CMIP6) project, to inform the Intergovernmental Panel on Climate Change (IPCC) assessments and in support of emerging Climate Services. *(4, 6, 9)*	X	
D	To explore the scientific and technological frontiers of capability in global climate modelling to provide guidance for the development of future generations of prediction systems, global climate and Earth System models (informing post-CMIP6 and beyond). *(3, 4)*		
E	To advance understanding of past and future, natural and anthropogenic, drivers of variability and changes in European climate, including high impact events, by exploiting new capabilities in high-resolution global climate modelling. *(1, 2, 5)*	X	
F	To produce new, more robust and trustworthy projections of European climate for the next few decades based on improved global models and advances in process understanding. *(2, 3, 5, 6, 10)*	X	
G	To engage with targeted end-user groups in key European economic sectors to strengthen their competitiveness, growth, resilience and ability by exploiting new scientific progress. *(10, 11)*		
H	To establish cooperation between science and policy actions at European and international level, to support the development of effective climate change policies, optimize public decision making and increase capability to manage climate risks. *(5, 8, 10)*		

3. Detailed Report

In order to clarify the contribution that different models (and resolutions) play in the uncertainty of future projections, HighResMIP proposed a future simulation with given SST and sea-ice forcing that are reasonable for this period under a specific forcing scenario (SSP5-RCP8.5). Future atmosphere-only simulations for the period 2015– 2050 have thus been carried out in the past months (these are Tier 3 experiments of the HighResMIP project) by different groups. Although the future period suggested by the HighResMIP protocol covers the entire present century, the PRIMAVERA simulations had to be restricted to the mid-century (2050), mostly for computational and storage space reasons.

The future SST and sea-ice forcing datasets have to be produced for the future period. The method broadly follows the methodology of Mizuta et al. (2008), enabling a smooth, continuous transition from the present day into the future. The rate of future warming is derived from an ensemble mean of CMIP5 RCP8.5 simulations, while the interannual variability is derived from the historic 1950–2014 period.

Here is a description of how these datasets have been constructed. Note that for CMIP6, the future is 2015 onwards. We had planned to use observed HadISST2 data up to 2017, but for reasons beyond our control this is no longer possible, so the first real future year is 2016. We first describe the observed dataset then the models that have been used to infer the SST and SIC climate change signal.

Observations: The HadISST2.2 SST and sea-ice concentration (Kennedy et al. 2017) is used for the 1950-2014 HighResMIP highresSST-present experiment. This is a daily, ¼° dataset. We have used the variability derived from this dataset, together with the future change from a set of CMIP5 coupled model simulations (of the historic period and the RCP8.5 future period), to construct the future SSTs and SICs to 2050. Details about the extraction of daily variability and the treatment of the links between SST and SIC can be found here: (https://docs.google.com/document/d/1nIGeDaU40jO5ZLKVDDs0bdEIxjdno7J4nRV4__7hnvw/edit).

CMIP5 Models: ACCESS1-0: CSIRO-BOM; ACCESS1-3: CSIRO-BOM; GFDL-CM3: NOAA-GFDL; IPSL-CM5A-LR: IPSL; IPSL-CM5A-MR: IPSL; MPI-ESM-MR: MPI-M; CNRM-CM5: CNRM-CERFACS; HadGEM2-ES: MOHC.

These include the models that Massonnet et al. (2012) suggested to have represented the Arctic sea-ice variability in the most realistic way, together with three additional models which have Arctic sea-ice decline at a similar rate to these others. All the data was also available on the CEDA platform (as part of the CMIP5 archive).
The full SST datasets for the CMIP5 models, combining the historic simulations (1850-2005) with the RCP8.5 simulations (2006-) were constructed as monthly mean datasets for the period 1950-2100 on their native ocean grids. We need to use the ocean grid in order to obtain the actual SST under sea-ice (rather than the surface temperature above sea-ice).

For each dataset, we calculated the mean monthly cycle with 10 years on either side of 2015, so that on average the anomaly in 2015 is zero (remember that 2016 is the first future year). We then removed this mean monthly cycle from all years, to produce a monthly anomaly dataset. The next step was to extrapolate on land from ocean values for all models ensuring that no new max/min values were created. We then used a zonal 1-2-1 filter (3 times) to remove 2Δx "Gibbs" structures (present in some of the models, in particular in the tropics).

Each model data was then interpolated to a common 1x1 degree grid using simple bilinear remapping. A multi-model average was then constructed to make a multi-model mean monthly anomaly field over 1950-2100. The multi-mode mean time series were then low-pass filtered to remove short-term variability (such as that related to ENSO for instance) and interpolated to the 0.25x0.25 HadISST2.2 grid, before being masked on land points. This trend data was added to the historic variability from HadISST2.2 to make the future SST and SIC datasets. Special attention was given to smoothing the transition between the end of the observed period (will be end of 2015) and the start of the calculated data (again see (https://docs.google.com/document/d/1nIGeDaU40jO5ZLKVDDs0bdEIxjdno7J4nRV4__7hnvw/edit).

Table 1 shows the different simulations performed by the different groups and the status and completion of the data post-processing workflow. All data from the three groups that have generated additional members have been cmorized and are (or will be in the coming weeks) available on the DMT for analysis.

References:

Kennedy, J., H. Titchner, N. Rayner, M. Roberts, 2017: *input4MIPs.MOHC.SSTsAndSeaIce. HighResMIP.MOHC-HadISST-2-2-0-0-0*. Version *20170505*.Earth System Grid Federation. (https://doi.org/10.22033/ESGF/input4MIPs.1221)

Mizuta, R., Adachi, Y., Yukimoto, S., and Kusunoki, S.: Estimation of the future distribution of sea surface temperature and sea ice using the CMIP3 multi-model ensemble mean, Tech. Rep. 56, 28 pp., Meteorol. Res. Inst., Tsukuba, Japan, 2008.

Massonnet, F., Fichefet, T., Goosse, H., Bitz, C. M., Philippon-Berthier, G., Holland, M. M., and Barriat, P.-Y.: Constraining projections of summer Arctic sea ice, The Cryosphere, 6, 1383–1394, https://doi.org/10.5194/tc-6-1383-2012, 2012.

4. Lessons Learnt

As discussed extensively throughout the project, the focus of Stream 2 was to provide enough ensemble members to support a robust analysis of the potential added value of high versus low resolution on the quantification of uncertainties in future projections (see Figure 1 which illustrates the spread in atmospheric circulation changes purely due to internal atmospheric variability). While it was not possible to have additional members for all models, we managed to have three groups with new members so a robust estimation of the influence of internal variability on future projections can be performed (in particular due to the extra realizations by Cerfacs and MOHC).

5. Links Built

The achievement of the atmosphere-only stream 2 simulations will contribute to the completion of PRIMAVERA deliverables dealing with future projections (in particular D5.4). It will also contribute to the multi-model analysis that will be performed for the whole of HighResMIP.

Tables:

Table 1: Status of PRIMAVERA Stream 2 – highresSST-future simulations.

D6.6 : PRIMAVERA Stream 2 - highresSST-future

Model name	*PRIMAVERA Partner*	*number of additional members planned*	*Length of each member (years)*	*Period Covered*	*member runs completed*	*members cmorized*	*members available on DMT (mark with an asterix members completed)*	*Remarks*
AWI-CM-1-1-LR	AWI	0						
AWI-CM-1-1-HR	AWI	0						
CMCC-CM2-HR4	CMCC	0						
CMCC-CM2-VHR4	CMCC	0						
CNRM-CM6-1	CERFACS	9	36	2015-2050	r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2, r6i1p1f2, r7i1p1f2, r8i1p1f2, r9i1p1f2, r10i1p1f2	r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2, r6i1p1f2, r7i1p1f2, r8i1p1f2, r9i1p1f2, r10i1p1f2		will be directly published on ESGF@CNRM datanode in next weeks
CNRM-CM6-1-HR	CERFACS	9	36	2015-2050	r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2, r6i1p1f2, r7i1p1f2, r8i1p1f2, r9i1p1f2, r10i1p1f2	r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2, r6i1p1f2, r7i1p1f2, r8i1p1f2, r9i1p1f2, r10i1p1f2		will be directly published on ESGF@CNRM datanode in next weeks
EC-Earth3P		2	36		r3i1p1f1		**r3i1p1f1***	
EC-Earth3P-HR		2	36		r2i1p1f1, r3i1p1f1		**r2i1p1f1, r3i1p1f1***	
ECMWF-IFS-LR	ECMWF	0						
ECMWF-IFS-MR	ECMWF	0						
ECMWF-IFS-HR	ECMWF	0						
HadGEM3-GC31-LM	MOHC	4	36		r1i2p1f1, r1i3p1f1, r1i14p1f1, r1i15p1f1	r1i2p1f1, r1i3p1f1	**r1i2p1f1*, r1i3p1f1***	
HadGEM3-GC31-MM	MOHC	2	36		r1i2p1f1, r1i3p1f1	r1i2p1f1, r1i3p1f1	**r1i2p1f1*, r1i3p1f1***	
HadGEM3-GC31-HM	MOHC	2	36		r1i2p1f1, r1i3p1f1	r1i2p1f1, r1i3p1f1	**r1i2p1f1*, r1i3p1f1***	
MPI-ESM1-2-HR	MPI	0						
MPI-ESM1-2-XR	MPI	0						

Figures:

Figure 1: Sea Level pressure trends – modelling and observations.

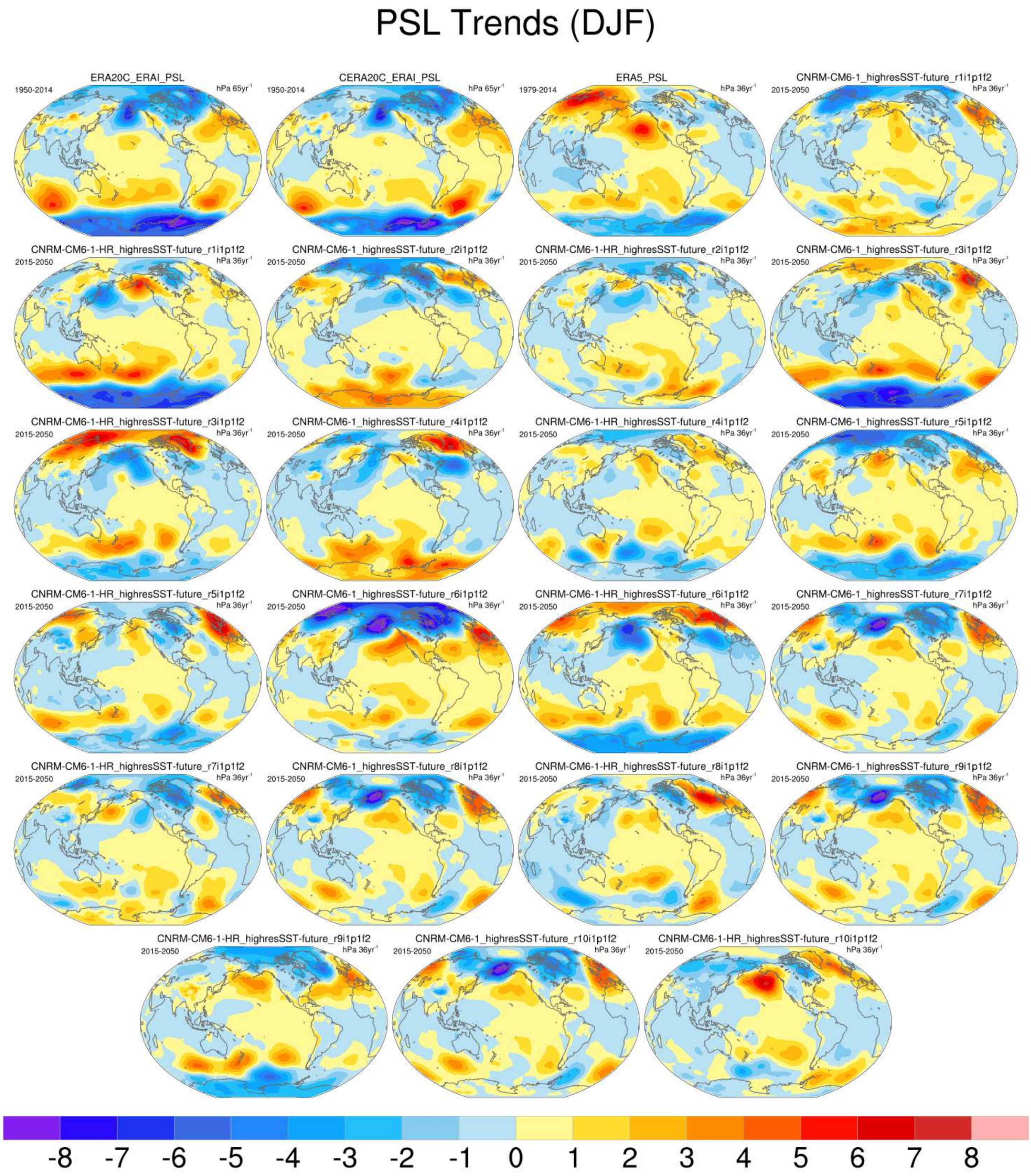

Figure 1: Winter mean sea level pressure trends for observations over different past periods and for all 10 members of both LR and HR future (2015-2050) CNRM-CM6-1 simulations (unit for models is hPa 36yr^{-1}).