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PRIMAVERA

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

Deliverable D6.3

Stream 1 future AMIP runs

Deliverable Title	Stream 1 future AMIP simulation	
Brief Description	Report on stream 1 future AMIP simulations completed	
WP number	6	
Lead Beneficiary	Rein Haarsma KNMI	
Contributors	Rein Haarsma Jon Seddon Malcolm Roberts	
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Dissemination Level/ Audience	PU	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
V1	23/09/2019	Rein Haarsma	

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1. Executive Summary

The stream 1 future AMIP simulations have been completed, post processed and uploaded to JASMIN. These simulations are made according to the HighResMIP protocol *highresSST-future*, that is outlined in Haarsma et al. (2016). HighResMIP and its protocol were initiated and developed by PRIMAVERA. The output of the stream 1 future AMIP simulations is CMORized according to the CMIP6 and HighResMIP requirements, quality checked and stored on JASMIN. Quality control is performed and the data is now ready for analyses. First results are becoming available. Deliverable D6.2 was submitted fall 2018, but because of the delay of the CMIP6 scenario forcings D6.3 for the future AMIP runs had to be suspended. These future AMIP runs *highresSST-future* are now completed.

The *highresSST-future* Stream1 simulations are available to all PRIMAVERA project members as well as selected individuals from the CLIVAR project working closely with PRIMAVERA scientists. It is presently being made publicly available on the Earth System Grid Federation (ESGF) data nodes, providing the basis for publications which will enter the IPCC AR6 report.

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)*	Y	
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)*		N
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)*	Y	
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)*		N
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)*		N
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)*		N
G	To engage with targeted end-user groups in key European economic sectors to strengthen their competitiveness, growth,		N

	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)*		N

3. Detailed Report

3.1 Model simulations

The stream 1 AMIP simulations follow the *highresSST-future* protocol of HighResMIP (Haarsma et al. 2016). HighResMIP and its protocol were initiated and developed by PRIMAVERA. *highresSST-future* are the Tier 3 simulations of HighResMIP for the period 1950-2104. The future SST sea-ice data set used in the *highresSST-future* simulations is stored at https://github.com/PRIMAVERA-H2020/HighResMIP-futureSSTSeaice and also available at input4MIPS https://esgf-node.llnl.gov/search/input4mips/. The data set has a horizontal and temporal resolution of ¼ degree and one day respectively. A schematic outline of the HighResMIP protocol and its different Tiers, including *highresSST-future* is given in Fig.1.
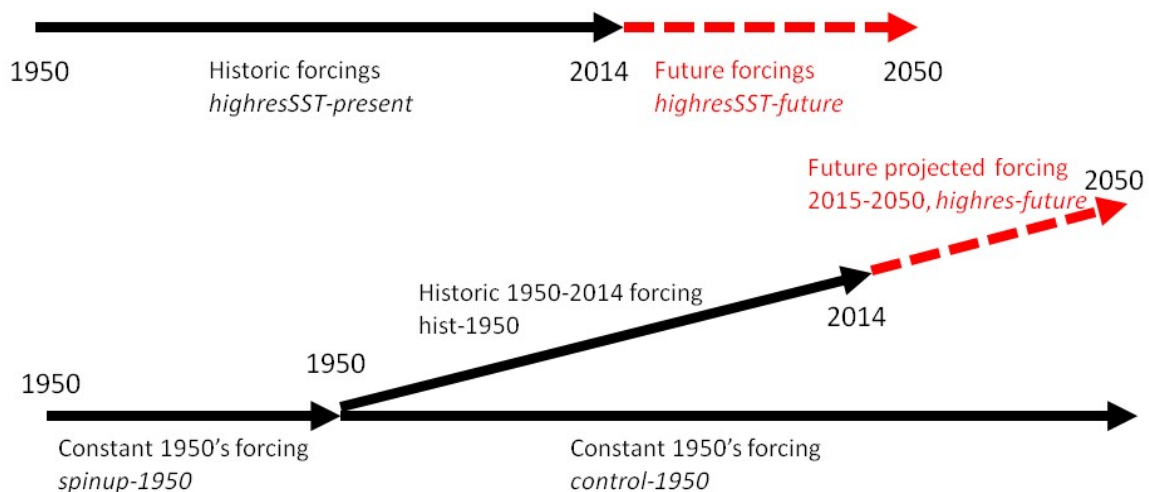

Figure 1. Schematic representation of the HighResMIP simulations. The stream 1 future AMIP simulations have been made according the highSST-future protocol.

The simulations have been made by the high and standard resolution of each PRIMAVERA model to allow the investigation of the added value of enhanced horizontal resolution.

Table 1 shows the PRIMAVERA models that have completed the *highresSST-future* Tier 3 simulations.

Causes of delay

The causes for the delay of the stream 1 historic AMIP runs were discussed in deliverable D6.2. The extra delay of the future AMIP runs was due to the delay in the CMIP6 concentration fields for the scenarios (SSP) for the future climate. They became available in November 2018.

3.2 Data

The data request for the *highresSST-future* simulations is equal to *highresSST-present* and described in the CMIP6 and HighResMIP data requests outlined by the Working Group on Climate Models (WGCM)

 https://earthsystemcog.org/projects/wip/CMIP6DataRequest.

The requested output data volume for HighResMIP is by far the largest (http://clipc-services.ceda.ac.uk/dreq/tab01_1_1.html) of all CMIP6 MIPs due to high spatial and temporal resolution of the data.

The PRIMAVERA data is uploaded to the JASMIN infrastructure of the Centre for Environmental Data Analysis (CEDA). It is hosted at the Science and Technology Facilities Council Rutherford Appleton Laboratory.

(http://www.ceda.ac.uk/projects/jasmin/).

Full details of JASMIN can be found at the JASMIN site http://www.jasmin.ac.uk/

The PRIMAVERA data available at JASMIN can be searched and queried using the Data Management Tool (DMT) https://prima-dm.ceda.ac.uk/, developed for PRIMAVERA. It is a graphic web based tool. The DMT's Variable Received Query can be used to search through the stream 1 AMIP data.

Because of the large amount of data the philosophy of PRIMAVERA for analyzing the data is to bring your script to the data instead bringing the data to your analysis. To facilitate this JASMIN has a set of scientific analysis servers and a batch processing cluster. For the PRIMAVERA partners the documentation of JASMIN, including training video's, is available from the PRIMAVERA wiki.

All PRIMAVERA data received at JASMIN is checked using the primavera-val tool (https://github.com/PRIMAVERA-H2020/primavera-val). This checks that the essential metadata is correct and that a random data point can be read, ensuring that the file has not been corrupted during transfer. Additionally, data that has been received since the CMIP6 PrePARE validation tool was released is also checked with PrePARE. PrePARE ensures that a file fully complies with the CMIP6 meta data standards. Files that were received before PrePARE was available will be checked

with PrePARE before publication on the Earth System Grid Federation (ESGF). Software has been developed to correct any meta data issues that are identified by PrePARE before submission to the ESGF.

All of the PRIMAVERA partners providing stream 1 data have now developed and optimised their own systems to interface to their HPCs, CMORize the data and transfer it to JASMIN. These systems are unique to each partner's own IT systems, although best practice was shared with other partners during the development. The use of these optimised systems will allow stream 2 data to be easily generated and shared amongst partners.

3.3 First analyses

Although PRIMAVERA data will be analysed for a wide range of weather and climate phenomena, an obvious new research area that can investigated with the PRIMAVERA simulations are tropical cyclones.

The analyses of tropical cyclones have been until now focused on the *highresSST-present* simulations. The analyses of the *highresSST-future* are presently being performed, but because these runs are recently finished no results are available yet. To give an impression of the quality of the simulations and the impact of resolution Fig. 3 shows tropical cyclone track density for the *highresSST-present* simulations. The *highresSST-future* simulations are a continuation of the *highresSST-present* simulations under the ssp8.5 scenario and will show the impact of climate change. This is presently under investigation.

Model	Institute	Country	Atmos
CMCC	CMCC	Italy	100 km 25 km
CNRM-CM6	CNRM-CERFACS	France	T127 (~ 100km) T359 (~35km)
EC-Earth3	KNMI/ BSC/ SMHI/ CNR	EU	T255 (~50km) T511 (~25km)
ECMWF-IFS	ECMWF	EU	Tco199 (~50km) Tco399(~25km)
ECHAM	MPI	Germany	T127 (~100km) T255 (~50km)
HadGEM-GC3.1	Met Office	UK	130km 60km 25km

Table 1. PRIMAVERA models and their resolutions (standard and high) that have performed the Tier 3, highresSST-present, simulations. The Met. Office. has performed those simulations for three resolutions (standard, medium and high).
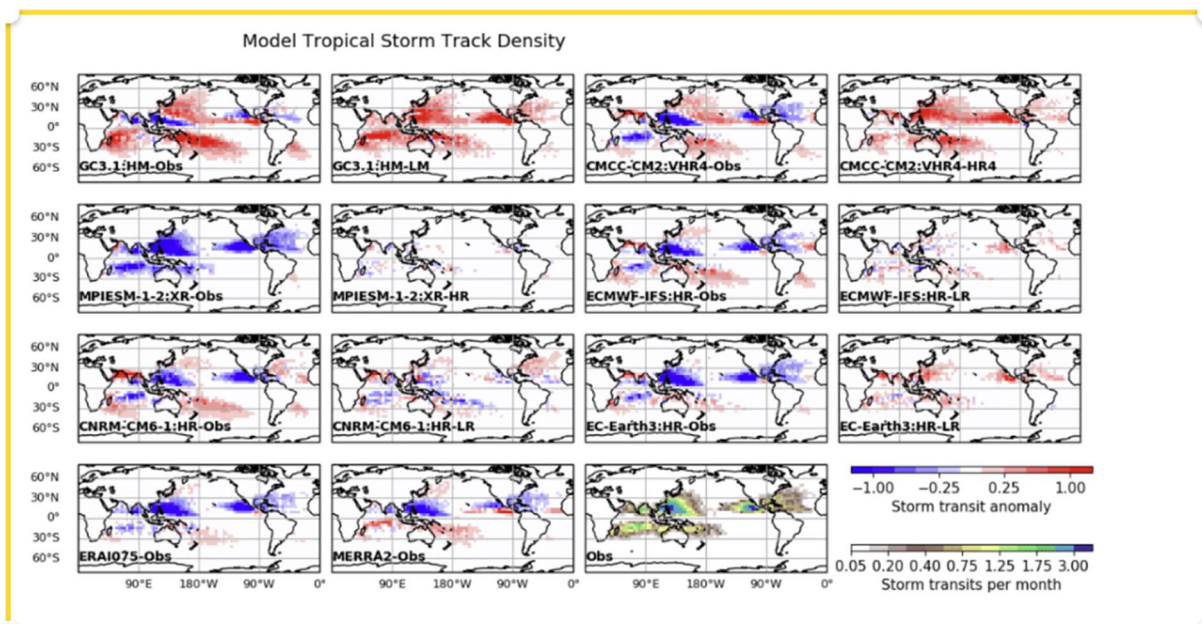

Fig. 3. Model tropical cyclone track density (storms transits per month per 4 degree cap): for each pair of models, the bias for the higher resolution model, and the difference between higher and lower resolution models, are shown respectively, compared to observations (last plot). The period used is 1979-2014. Note the two reanalyses products (ERA-interim, MERRA2). From Roberts et al. (submitted).

References

Haarsma RJ et al. (2016) High Resolution Model Intercomparison Project (HighResMIP v1.0) for CMIP6. Geoscientific Model Development, 9, 4185-4208, https://doi.org/10.5194/gmd-9-4185-2016

Roberts MJ et al. (2019) Impact of model resolution on tropical cyclone simulation using HighResMIP-PRIMAVERA multi-model ensemble. Submitted to J. Climate.