HORIZON 2020

THEME SC5-2017

European Climate Prediction system

(Grant Agreement 776613)

European Climate Prediction system (EUCP)

Deliverable D3.2

Assessment and Optimisation of the Convection-Permitting Regional Climate Models (CP-RCMs)

Deliverable Title	*Fully assessed CP-RCMs for the simulation of high-impact events*	
Brief Description	Report on the evaluation of very high-resolution regional climate models (defined in D3.1) for the simulation of high impact weather events against high-resolution observational data sets. Since at the time of the original submission deadline, not all simulations were completed, here we present only preliminary results. More detailed analysis will follow later (summer 2019)	
WP number	3	
Lead Beneficiary	*Filippo Giorgi, UNESCO-ICTP*	
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Nature of the Deliverable	√	*R – Report*
		P – Prototype
		D - Demonstrator
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Dissemination Level/ Audience	√	*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
1.0	20/03/2019	Nikolina Ban	Created
2.0	15/05/2019	Nikolina Ban	Update based on comments from Christoph Schär , Jesus Vergara-Temprado and Danijel Belušić
3.0	17/05/2019	Nikolina Ban	Update based on comments from Jason Lowe

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1. Executive summary

The overarching objective of the European Climate Prediction (EUCP) system is to develop an innovative European regional ensemble climate prediction system based on a new generation of improved and higher-resolution climate models, covering timescales from seasons to decades initialised with observations, and designed to support taking practical and strategic climate adaptation and mitigation decisions on local, national and global scales. To accomplish these objectives, EUCP consists of several work packages. Here we present a deliverable from Work Package 3 (WP3): "Demonstrator of high impact weather in a changing climate on regional and local scales".

The main goal of WP3 is to produce a portfolio of high impact extreme meteorological events at the pan-European level using convection-permitting regional climate model (CP-RCMs) runs at horizontal grid spacings of 1.5-3.0 km for both historical and future periods up to a temporal horizon of 40 years. The produced data will not only be analysed in WP3, but it will be provided to WP4 for impact analysis, WP2 for generating PDFs of climate changes in extreme events, and to WP5 for use in the seamless projection activities. In total, 10 modelling groups with seven regional climate models are participating in this WP.

The first deliverable of WP3 (D3.1) has presented the simulation strategy for the experiments that are being conducted in WP3, while in this deliverable (D3.2) we report on the preliminary analysis of CP-RCM simulations driven by ERA-Interim reanalysis. The main objective of the deliverable D3.2 is to report on the assessment of the CP-RCM for the simulation of extreme events in the present climate.

Although most of the runs over the Alpine region – the mandatory region for all groups – are completed, delays are experienced for other regions covering other parts of Europe. The delay is mostly due to switching from the event-based simulation approach as initially planned to continued decade-long simulation as reported in deliverable D3.1. This switch in simulation strategy requires significantly larger computational resources and provides much more data than initially planned. Thus, instead of full assessment of the CP-RCMs, in this report we present the status of ERA-Interim driven experiments and some preliminary results from the assessment of precipitation in available simulation data.

Qualitative analysis shows that the models exhibit very similar precipitation patterns over all domains, although some biases and differences exist. These will be further analysed in order to gain a deeper understanding of these differences. A more detailed analysis will be presented in an upcoming report, which is due in summer 2019.

2. Project objectives

The deliverables D3.1 and D3.2 have contributed to the following EUCP objectives (Description of Action, Section 1.1):

No.	Objective	Yes	No
1	Develop an ensembles climate prediction system based on high-resolution climate models for the European region for the near-term (~1-40 years)	√	
2	Use the climate prediction system to produce consistent, authoritative and actionable climate information		
3	Demonstrate the value of this climate prediction system through high impact extreme weather events in the near past and near future	√	
4	Develop, and publish, methodologies, good practice and guidance for producing and using EUCP's authoritative climate predictions for 1-40 year timescales	√	

3. Detailed report

3.1 Introduction

During the first one and a half years of the project, WP3 has defined a strategy to perform CP-RCM simulations covering most of Europe and has defined how to assess climate changes in the future climate. This strategy has been reported in the previous WP3 deliverable D3.1. The major deviation from the initial plan is to conduct continuous decade-long simulations over all domains, instead of a series of event-based shorter simulations. The revised approach has many advantages, like avoiding issues with the initialization of soil-moisture in the models, providing the feasibility to assess different types of the extreme events and being less affected by the role that internal variability might play in simulating only single events. However this approach requires more time and computational resources to complete the simulations, so this has caused a delay in completing the simulations.

Era-Interim driven experiments, i.e. simulations of present-day climate, were initially anticipated to be complete by the end of April 2019 over all domains, but this target has now been shifted to the summer of 2019. Thus instead of presenting here a detailed assessment of the CP-RCM runs, we only show preliminary results. However, a detailed assessment will be delivered after all runs are completed in summer 2019.

In the next two subsections, we provide the status of Era-Interim driven runs and preliminary analysis conducted with the available simulation data.

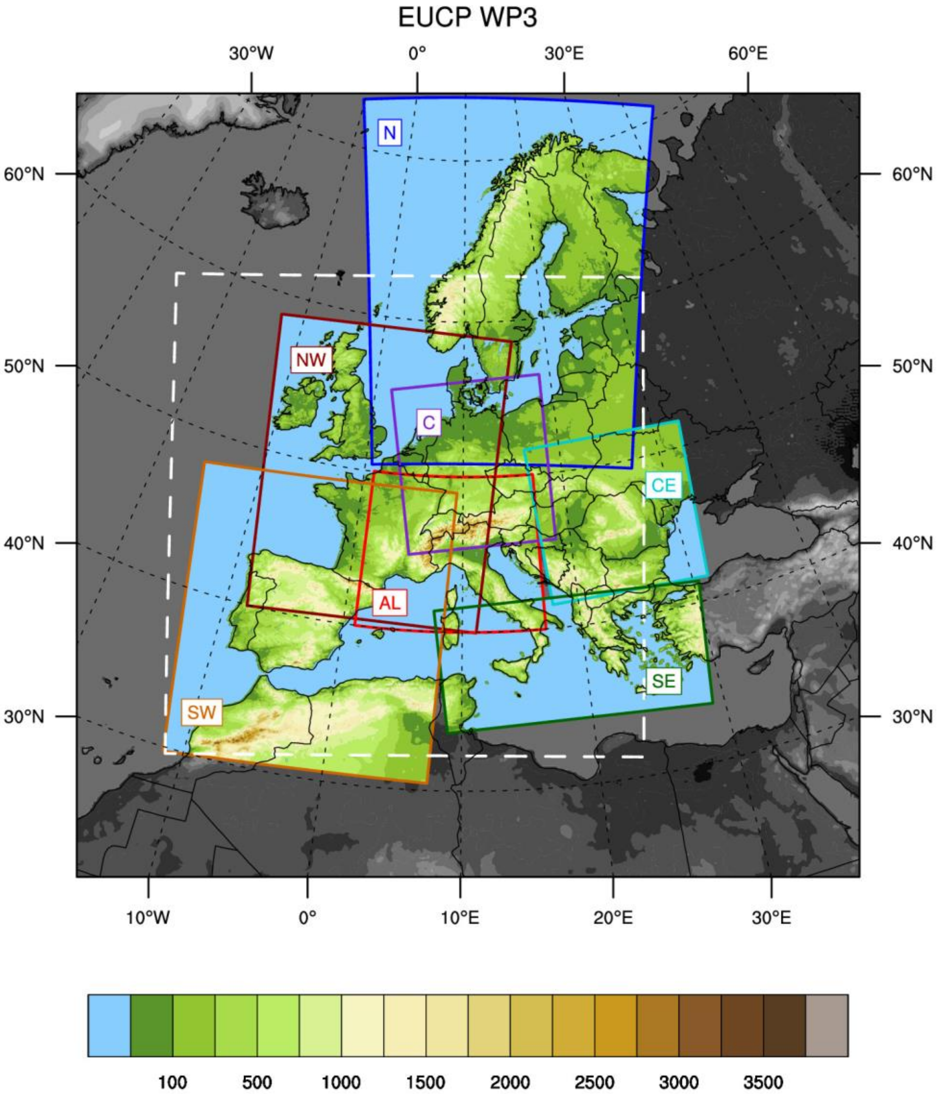

Figure 1: Set of domains used for CP-RCM simulations. In addition to the sub-continental domains covered by the modelling groups, the dashed box indicates the European domain used by ETH and UKMO.

3.2 Status of the experiments

The status of the ERA-Interim driven CP-RCM for different institutes and domains is presented in Table 1. Most of the simulations over the mandatory Alpine region for the 10-year long period (2000-2009) have been completed or are expected to complete within one month, while simulations over other domains are expected to complete in the second half of 2019.

Table 1: Status of the ERA-Interim experiments for different institutions and domains. Green colour denotes the simulations that have been completed for the mandatory 10-year long period (2000-2009).

GROUP	MODEL	GRID SPACING (km)	Domain / Simulation Status / Planned End	Completed period
CMCC	CCLM	3	ALP / Finished	2000-2009
			NW / Running / June 2019	2000-2005
CNRM	AROME41t1	2.5	ALP / Finished	2000-2009
			NW / Finished	2000-2009
DMI/SMHI	HCLIM38-AROME	3	ALP / Finished	2000-2009
			N / Finished	2000-2009
SMHI	HCLIM38-AROME	3	CE / Finished	2000-2009
KNMI	HCLIM38-AROME	2.5	ALP / Finished	2000-2009
			NW / Running / August 2019	-
ETHZ	CCLM-GPU	2.2	a) ALP / Finished	2000-2009
			b) Europe v1 / Finished	2000-2009
			Europe v2 / Running / June 2019	2000-2006
GERICS	REMO	3	ALP / Running / June 2019	2000-2005
			C / Finished	2000-2009
			N / Running / June 2019	2000-2005
ICTP	RegCM4	3	ALP / Finished	2000-2009
			CE / Running / June 2019	2000-2006
			SE / Running / June 2019	2000-2005
IPSL	WRF	3	ALP / Running / May 2019	2000-2008
			SW / In preparation / End 2019	-
UKMO	UM	2.2	Europe / Finished	2000-2009 (2012)

3.3 Preliminary Analysis

In this section, we present some preliminary analysis conducted on the available simulation data from Table 1. For the Alpine domain, most of the groups have completed 10-year long simulation, while for the other domains simulations are still running. Thus the analysis is based on different simulation lengths (from 6-10 years of data) for different institutes/models for different domains. The main aim is not to present quantitative performance measures, but to qualitatively look how well the patterns of precipitation are captured by CP-RCM models.

Prior to doing the analysis and to make the results comparable, all simulations have been remapped to a common grid with a grid spacing of 3.0 km over Europe using conservative remapping. In addition to simulation data, we also use the observational data of precipitation at daily and hourly time scale. Daily precipitation data is available at a horizontal resolution of 5.0 km over the Alpine region for a period 1971-2008. This data set is based on daily rain gauge station data, and is presented in Isotta et al. (2014). Hourly precipitation data, available for a shorter period (2003-2010) and over the area of Switzerland, is presented in Wüest et al. (2010). The latter data set is based on a combination of station and radar data. For analysis, we take the observational period that overlaps with the targeted simulation period (2000-2009).

Mean daily summer and winter precipitation are presented in Figures 2 and 3, respectively, for the observations and simulations of different groups/models over the Alpine region. Both, summer and winter seasons are characterized by more precipitation over higher orography. These spatial patterns are quite well captured by all models, although some overestimate/ underestimate the total precipitation amount. Most of the models tends to overestimate mean precipitation over higher elevations, but part of this bias is likely related to shortcomings of the observational data set, which are due to the sparseness of stations at high elevations, the systematic rain gauge under catch, and the analysis methodology (Isotta et al., 2014). Comparison between different models/groups reveals that the WRF model run by CNRS/IPSL shows quite large underestimation of mean precipitation in summer, while in winter it performs much better than in summer. In the winter season RegCM model run by UNESCO/ICTP and In the summer season CCLM-GPU model run by ETHZ, show the largest amount of precipitation over the Alps in comparison to other models/groups and thus have the largest overestimation of mean precipitation when compared to observations.

Analysis of heavy daily precipitation (Figure 4), defined as a 99th percentile of all events (corresponding roughly to the heaviest event per season) in the autumn season shows quite good agreement between models and observations. The spatial patterns of intense precipitation are captured quite well by all models. Comparison between the models/groups shows that the RegCM model run by UNESCO/ICTP shows a higher intensity of heavy precipitation over the Mediterranean and southern parts of the Alps.

Heavy hourly summer precipitation, defined as 99.9th percentile of all hours, is shown in Figure 5. Summer precipitation is characterized by intense short-lived convective events as captured by the different models. However, the intensity of heavy summer precipitation differs quite a lot between different models. While most of the models tend to overestimate the intensity of precipitation, the WRF model run by IPSL is underestimating the intensity of heavy precipitation over Switzerland and shows much smaller intensity than the other models. This underestimation is found for the summer season only, while in other seasons that model shows very similar results to the others. At the moment the reasons for these differences are unknown, and they are currently undergoing further analysis.

In addition to the Alpine region, in Figure 6 we show mean daily precipitation in summer over the other regions indicated in Figure 1. Comparison of different domains with the simulations over almost entire Europe suggests qualitative agreement of the simulation of spatial patterns of daily summer precipitation.

In general, this qualitative analysis shows that all models are able to capture the spatial patterns of precipitation quite well, both on daily and hourly time scales and in all seasons, therefore making them suitable for the purpose of this work package, although some differences between models and biases exist, which should be investigated further.

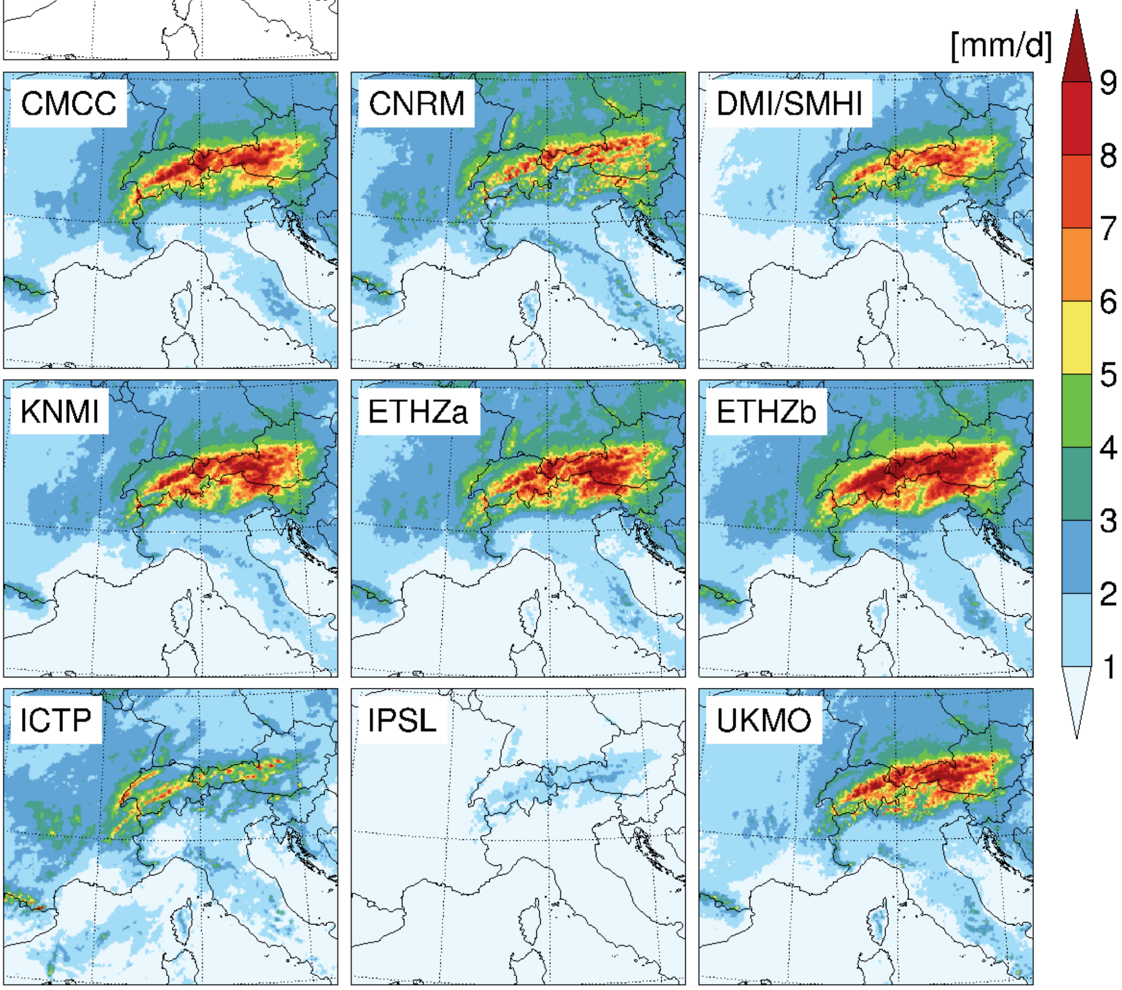

Figure 2: Mean daily summer precipitation over the Alpine region obtained from EURO4M-APGD observations (Obs; Isotta et al., 2014) and different CP-RCM models run by different institutes. The mean precipitation is calculated over the completed 10-year long period (or a shorter period if not yet completed, see Table1).

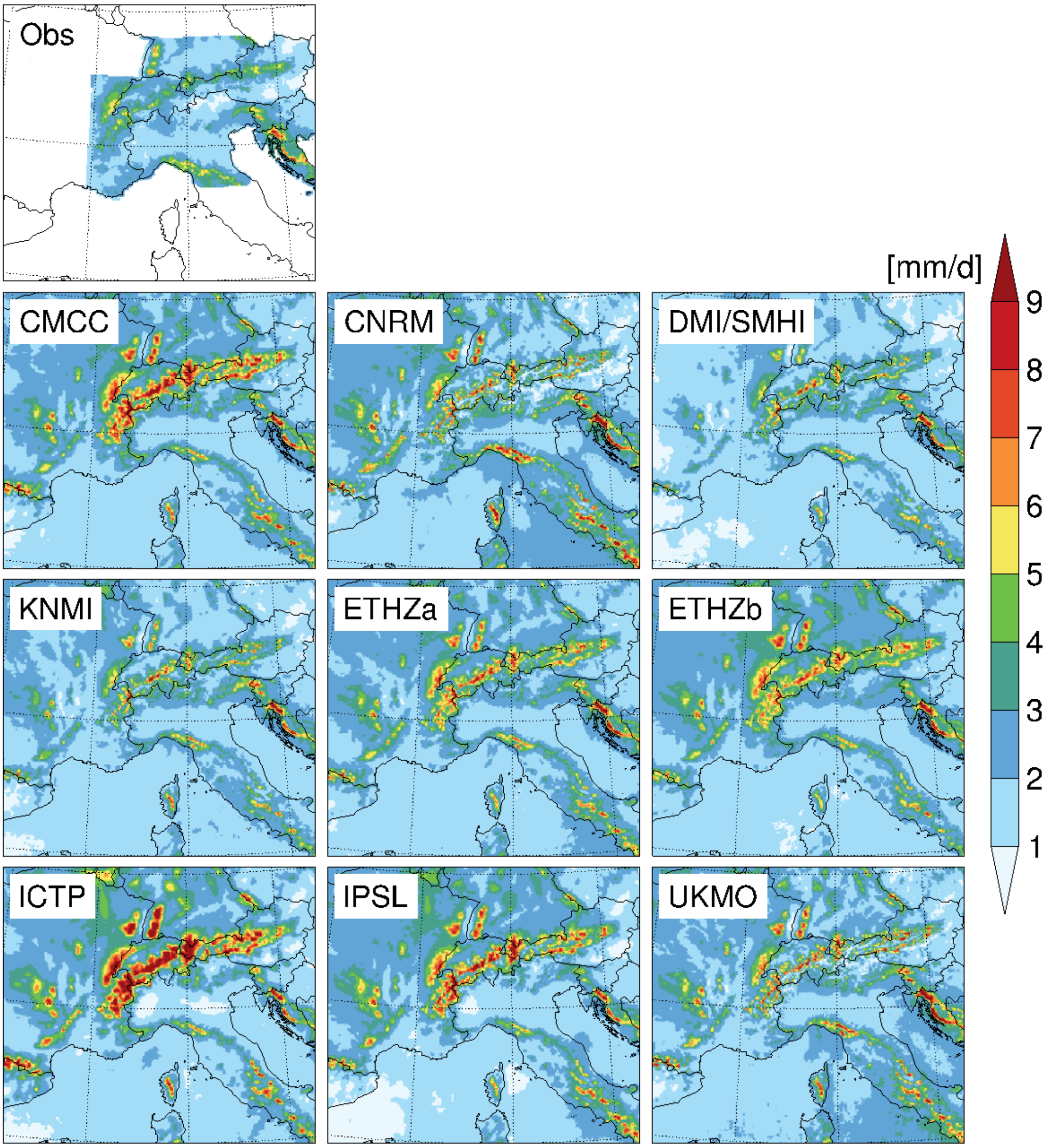

Figure 3: As Figure 2, but for mean daily winter precipitation.

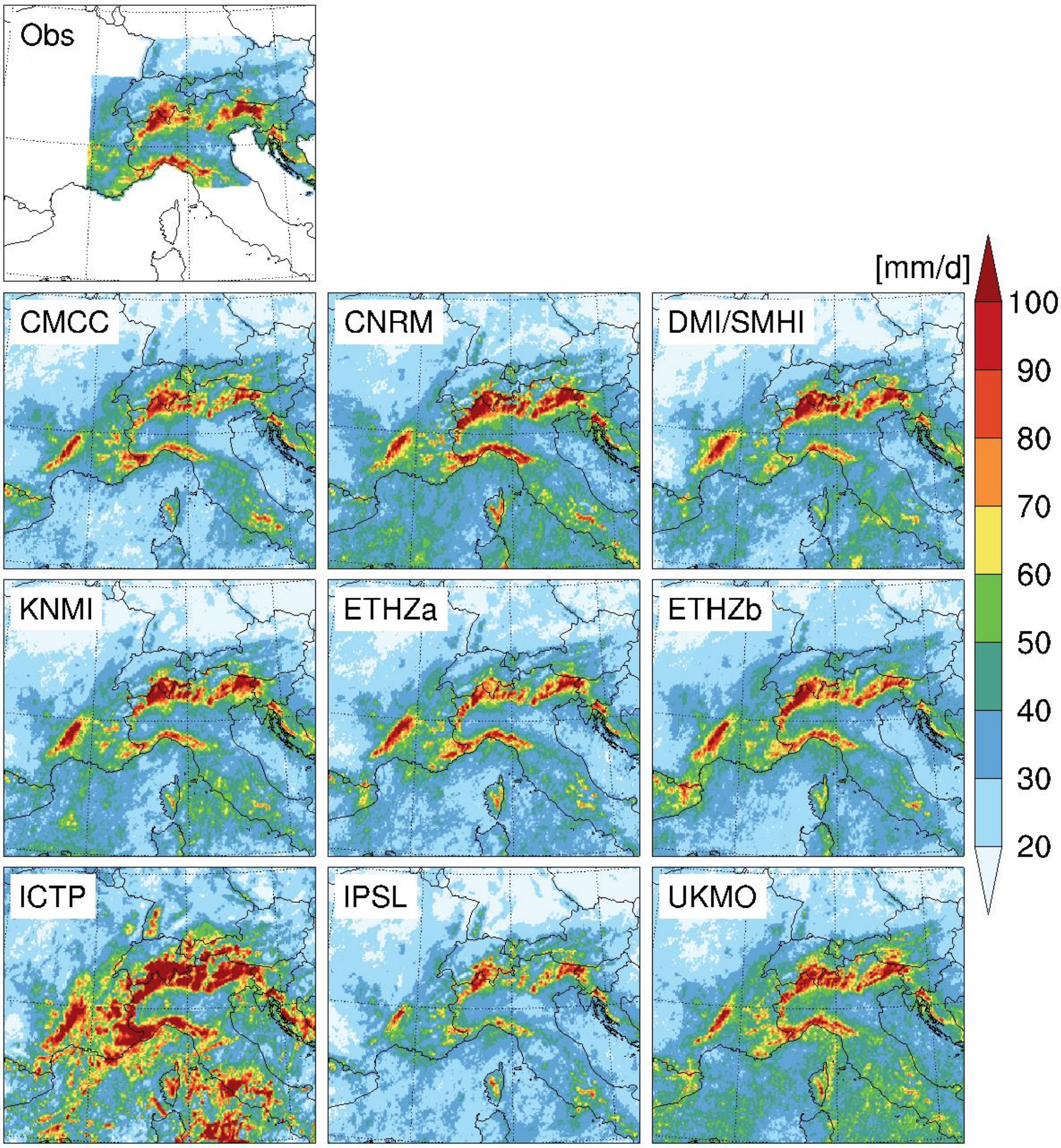

Figure 4: As Figure 2, but for heavy daily precipitation in the autumn season. Heavy daily precipitation is defined as a 99th percentile of all days and roughly corresponds to the heaviest event per season.

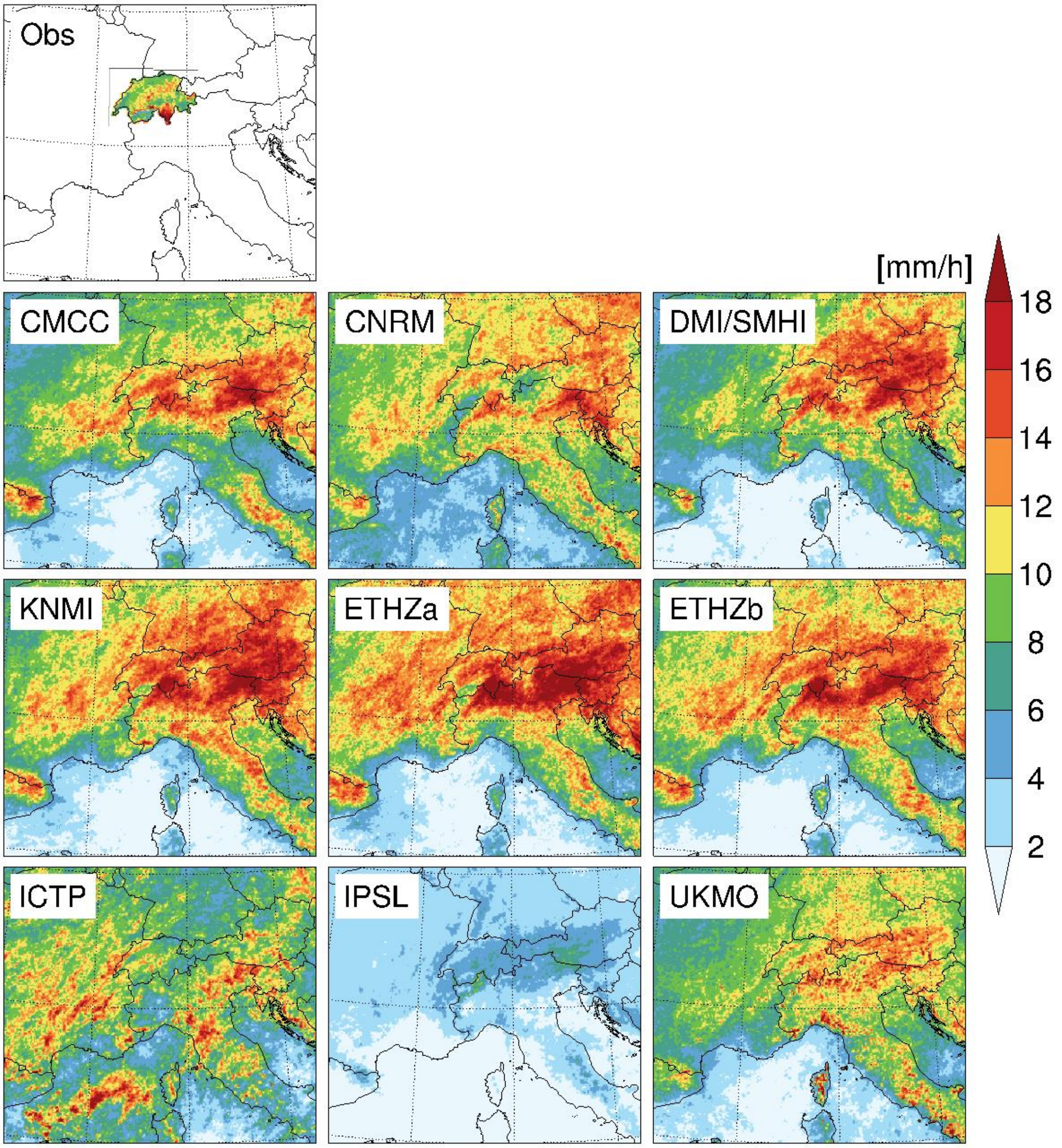

Figure 5: Heavy hourly summer precipitation obtained in observations and CP-RCM simulations. Heavy hourly precipitation is defined as a 99.9th percentile of all hours. The results are shown over the mandatory Alpine domain, and for the periods indicated in Table 1. Observations (top panel) are calculated using hourly observational data from Wüest et al., 2010.

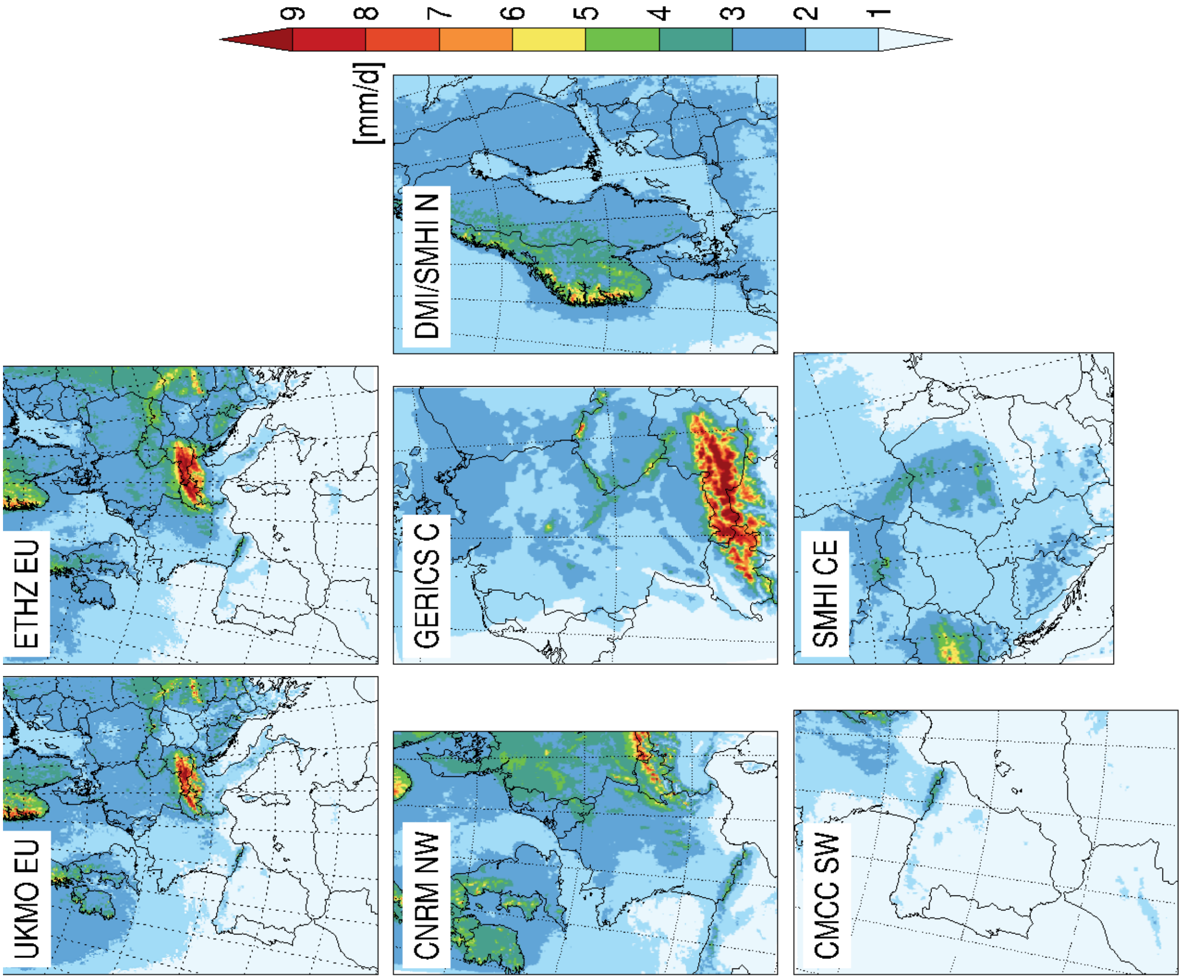

Figure 6: Mean daily summer precipitation over different domains presented in Table 1 and Figure 1. The results are calculated for the domains and periods where simulations are available as presented in Table 1.

3.4 Outlook

After completing all simulations, the results will be further analysed in more detail and presented in a longer analysis report (to be submitted in summer 2019). We plan a detailed comparison of the simulation results against available high-resolution observations, and against the driving intermediate or coarse-resolution model simulations. The above-presented biases and differences between the CP-RCM simulations will be further analysed to gain a deeper understanding. Furthermore, extreme precipitation, frequency and intensity of precipitation, and a mean diurnal cycle of precipitation frequency and intensity will be analysed for different seasons.

In addition, several groups are taking the initiative to lead the writing of publications that will analyse these simulations from different viewpoints and objectives. ETHZ is planning a publication on detailed validation and intercomparison of daily and hourly precipitation, while CNRS/IPSL is conducting an analysis on the initiation and triggering of convection in CP-RCM.

4. Lessons Learnt and links Built

Although some of the results are still in the pipeline, the availability of 10-year-long simulations (rather than merely case-study simulations as originally planned) is simplifying the analysis of the simulations. With the current set of simulations, some general statements about model biases will become feasible.

During the first 1.5 years of the project a close collaboration has been established with WP4 and WP5, in order to better accommodate data requests from those working packages.

In order to complete the next deliverable (D3.3 - Fully assessed multi-model based ensemble of simulations of high impact weather events for the historical and near future period), the preparations of scenario simulations have started. They will be used to access the climate change signal of extreme events.

5. References

Isotta, F. A., Frei, C., Weilguni, V. , Perčec Tadić, M. , Lassègues, P. , Rudolf, B. , Pavan, V., Cacciamani, C. , Antolini, G. , Ratto, S. M., Munari, M. , Micheletti, S. , Bonati, V. , Lussana, C. , Ronchi, C. , Panettieri, E. , Marigo, G. and Vertačnik, G. (2014), The climate of daily precipitation in the Alps: development and analysis of a high-resolution grid dataset from pan-Alpine rain-gauge data. Int. J. Climatol., 34: 1657-1675. doi:10.1002/joc.3794

Wüest, M. , Frei, C. , Altenhoff, A. , Hagen, M. , Litschi, M. and Schär, C. (2010), A gridded hourly precipitation dataset for Switzerland using rain-gauge analysis and radar-based disaggregation. Int. J. Climatol., 30: 1764-1775. doi:10.1002/joc.2025