

Climate change and hydrological extreme events - Risks and perspectives for water management

1. Background

The recent accumulation of extreme hydrological events in Bavaria and Québec has stimulated scientific and also societal interest. In addition to the challenges of an improved prediction of such situations and the implications for the associated risk management, there is as yet no confirmed knowledge whether and how climate change contributes to the magnitude and frequency of hydrological extreme events and how regional water management could adapt to the corresponding risks.



Fig. 1: Recent flood situations in Bavaria (left: Danube river, June 2013, © sueddeutsche.de) and Québec (right: Richelieu river, May 2011, © canada.com)

The ClimEx project investigates the effects of climate change on meteorological and hydrological extreme events and implications for water management in Bavaria and Québec. It comprises three major components: CLIMATE, HYDROLOGY and HIGH PERFORMANCE COMPUTING (HPC).

2. Study areas and general approach

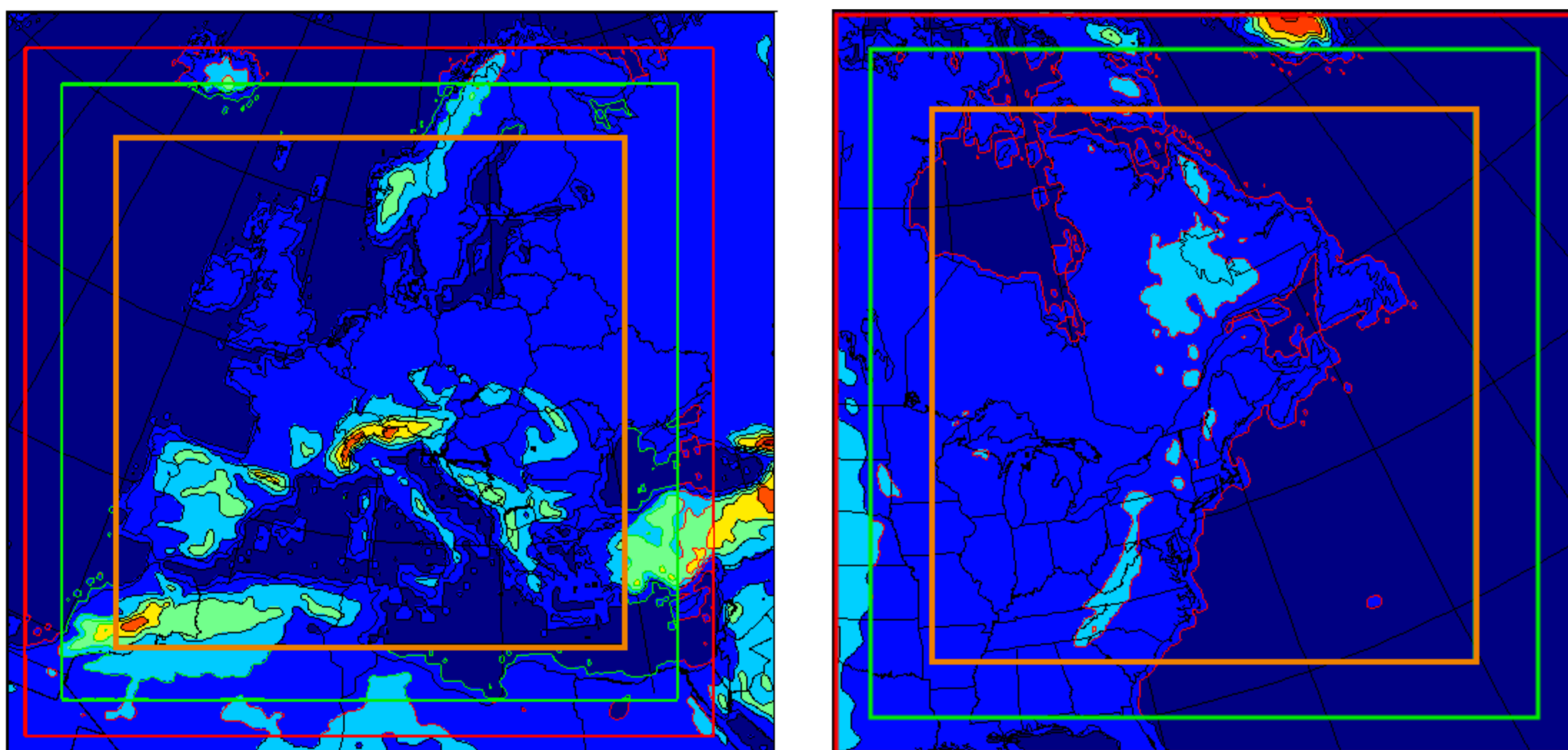


Fig. 2: CRCM5 topography [in meters] from a preliminary computational domain of 380x380 grid points centered on Bavaria (left) and Québec (right). The area within the green square encompasses the free domain, available for analysis, which excludes the surrounding nesting zone. The domain of interest for hydrological analysis is highlighted in orange.

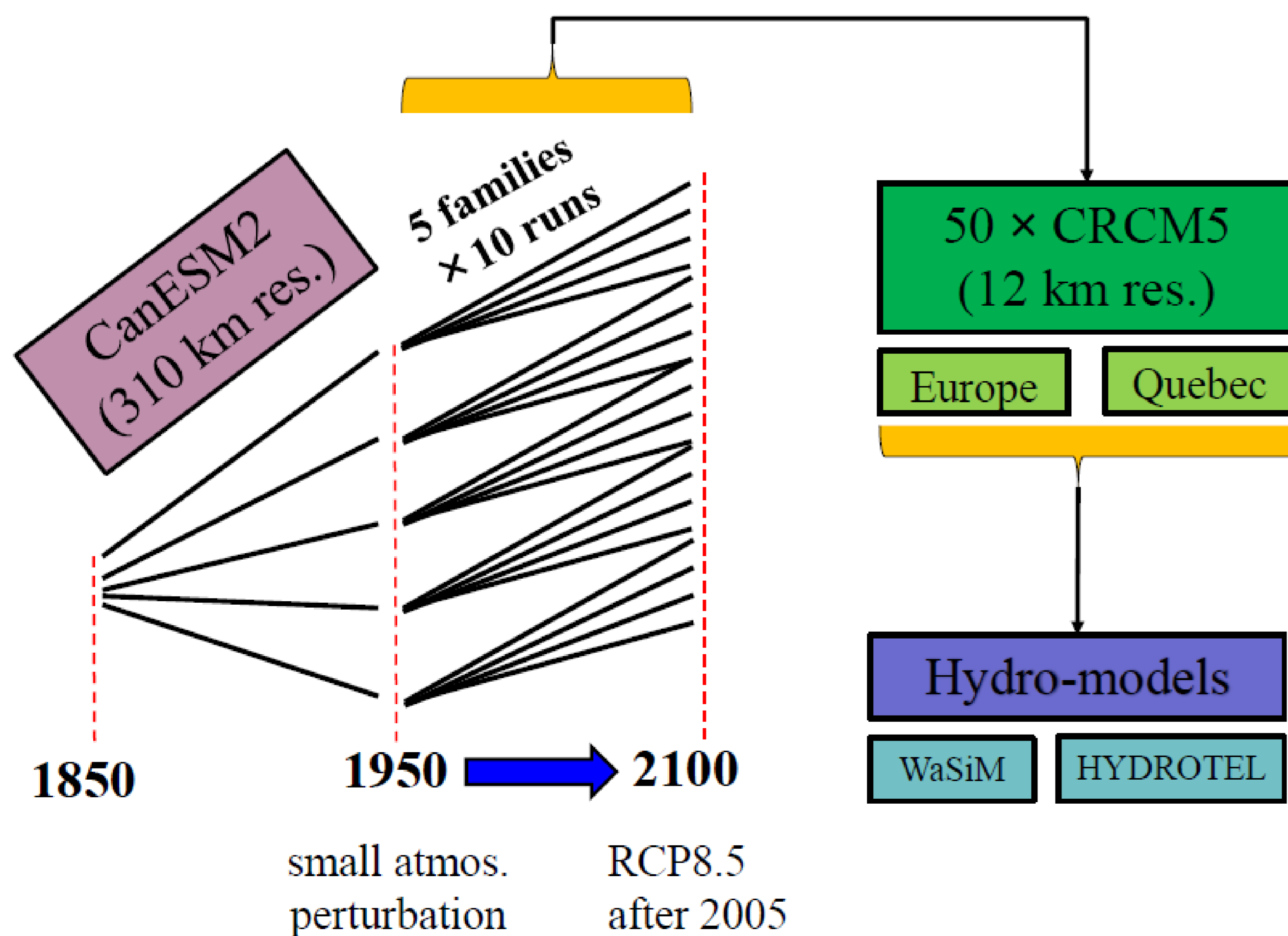


Fig. 3: Modeling scheme in ClimEx: a) CanESM2 generation to drive CRCM5 over Europe and Québec, b) Post-processed CRCM5 runs driving hydrological models to simulate extreme events at the catchment scale.

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3. The ClimEx modules

(1) The CLIMATE module builds on the development of a large ensemble of high resolution data (12km) of the CRCM5 RCM for Central Europe and North-Eastern North America, downscaled from 50 members of the CanESM2 GCM. The dataset will additionally contain the available data from the Euro-CORDEX project to account for the assessment of both natural climate variability and climate change. The large ensemble with several thousand model years provides the potential to catch rare extreme events and improve the process understanding of extreme events with return periods of 1000+ years.

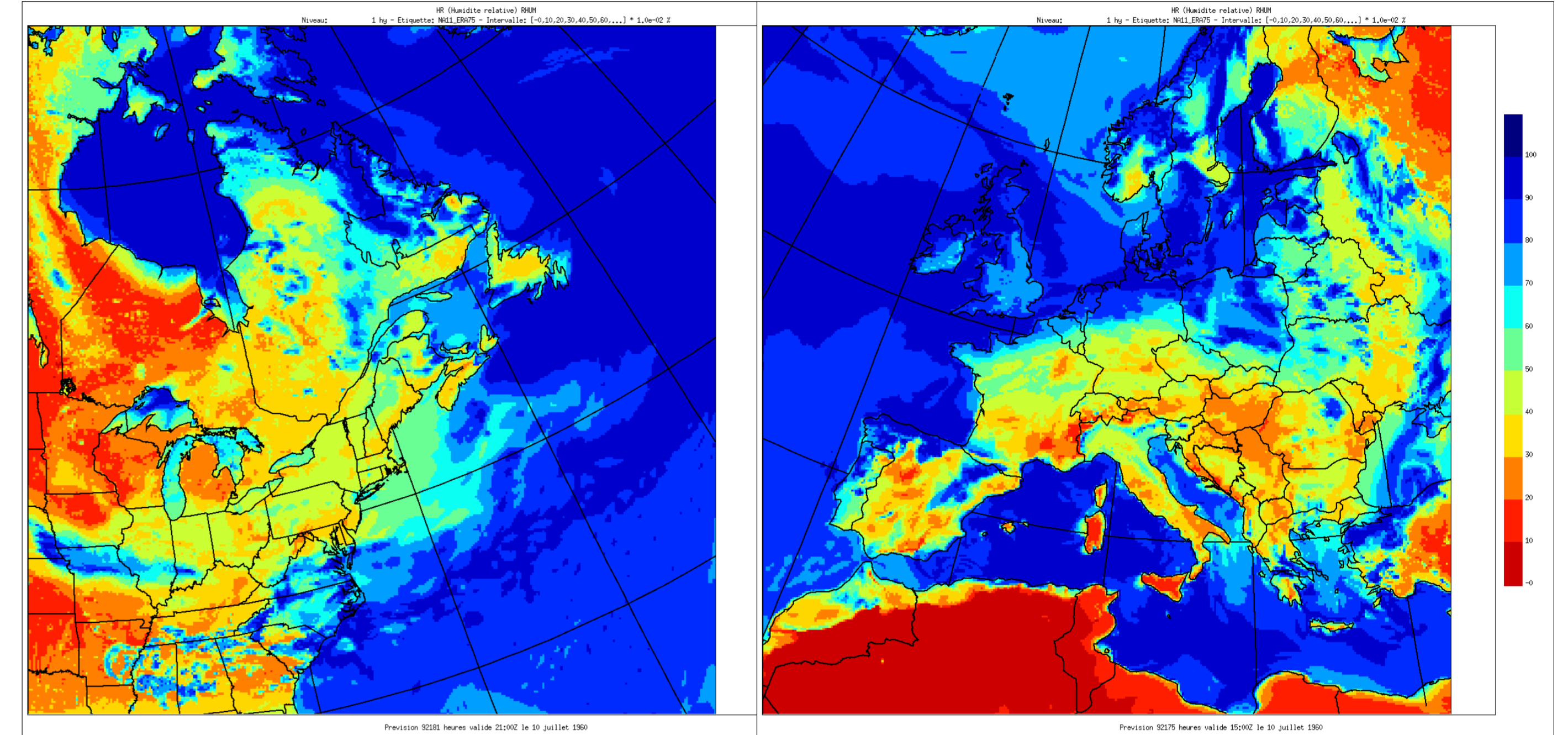


Fig. 4: Snapshot of surface relative humidity (in %) as simulated by the CRCM5 over the Québec (left) and European domain (right) for a day in July 1960

(2) The HYDROLOGY module focuses on modeling the major catchments in Bavaria and Southern Québec in high temporal and spatial resolution using physically based hydrological models. The simulations form the basis for in depth analysis of hydrological extreme events based on the inputs from the large climate model dataset and hydrological modeling considerations, such as ideal model resolution in space and time.

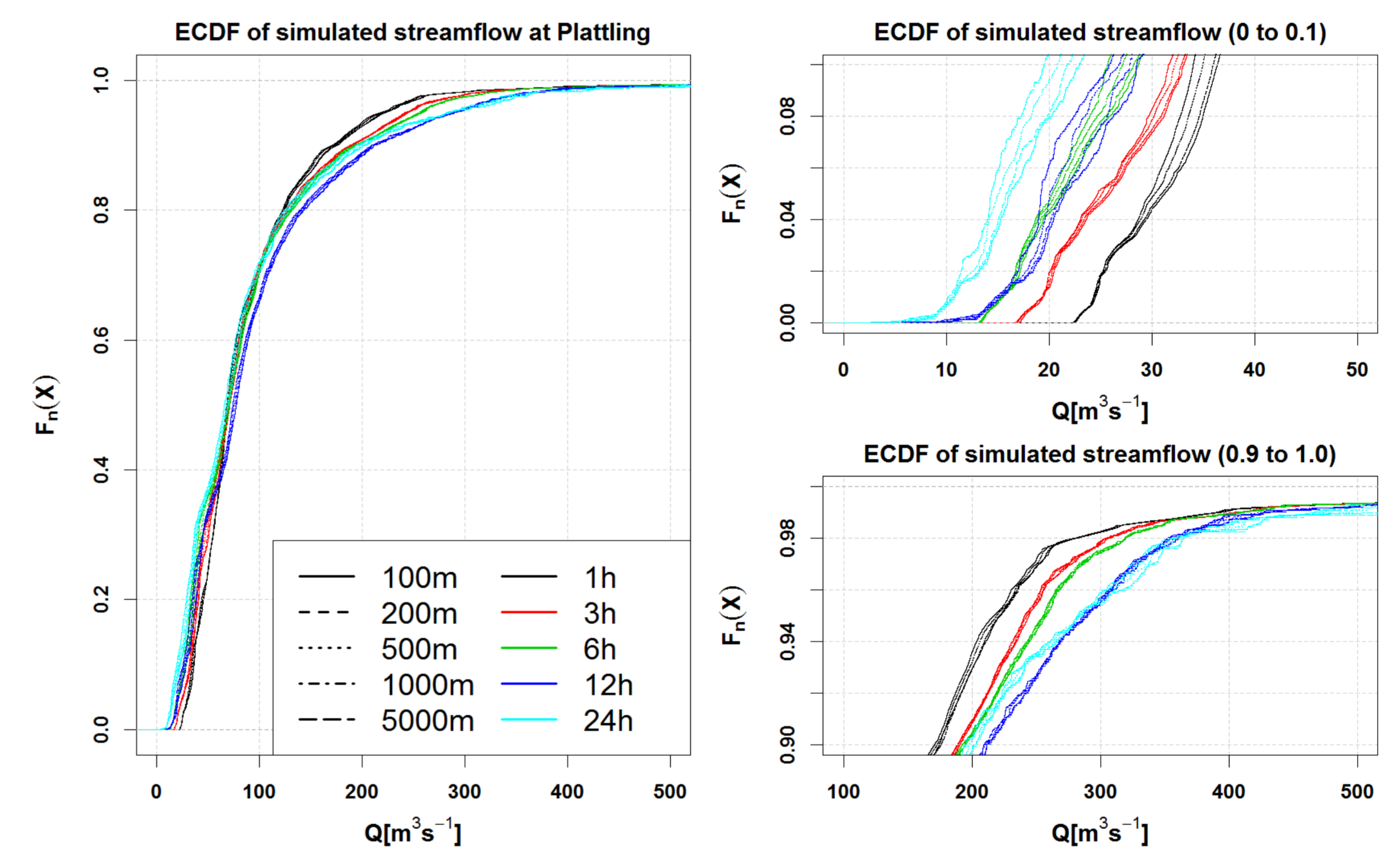


Fig. 5: A hydrological model is applied for the Isar river in various scale combinations. The ECDF of the simulated runoff at gauge Plattling for 2005 shows that temporal and spatial scaling have a strong effect on the distribution of streamflow. The choice of temporal scale has a considerable higher impact when it comes to extreme flows as the lower- (0 to 0.1) and uppermost (0.9 to 1) percentiles illustrate.

(3) In order to enhance efficiency for these analyses the third project component deals with the consolidation, coupling, and optimization of the two previous modules. Therefore, the LRZ provides its expertise in HPC and data management to consolidate all available software tools in a common interface. The great demands of computation power for modeling climate and hydrology in parallel are met by the application of the LRZ's HPC SuperMUC.

