The last deglaciation (over the last 23,000 years), which marked the transition between the last glacial and present interglacial period, was punctuated by a series of rapid (centennial and decadal) climate changes. Numerical climate models are useful for investigating mechanisms that underpin these events, especially now that – due to availability of increased computational power – some of the complex models can be run over the period of multiple millennia. In this project, with aid of the MPI-ESM (ECHAM6.3/MPIOM) and complementary models, we aim to perform transient simulations of the last deglaciation in order to quantify contributions of different climatic factors, e.g. greenhouse gas concentrations, orbital parameters, continental ice sheets, etc., to rapid climate changes during the last deglaciation (PalMod 1-3-1, AWI). We also aim at quantifying the synergetic effects of these factors. In addition, our project will also provide a platform for further model-data and model-model intercomparisons.

Additionally, in this proposed project various sensitivity studies of the Last Glacial Maximum (LGM, about 26 to 21 ka BP: 1000 years before present) shall be performed on seasonal to interannual time scales with the MPI-ESM (ECHAM6.3/MPIOM) and the latest version of the state-of-the-art atmosphere-ocean-ice coupled model (ECHAM6.3/FESOM) with unstructured mesh and high resolution in the ocean (PalMod 1-3-1, AWI). The resolution of the atmospheric model is in both cases T63L47. In addition, hosing experiments will be performed with ECHAM6.3/FESOM (0.15 Sv and 1 Sv) by adding freshwater flux at the North Atlantic subpolar region (Ruddiman-Belt, between 50°N and 70°N) and the coastal zone of the Laurentide Ice Sheet (LIS). In the case of ECHAM6.3/MPIOM similar hosing experiments will be performed for North Atlantic Ocean and North Atlantic Ocean + South Atlantic Ocean, but due to the coarser resolution the hosing region will be the North Pacific Ocean (50°N to 60°N, 145°W-160°W) and the same latitude range in the North Atlantic Ocean rather than at a more specific ocean region. The evaluation of the influence of the hosing on the climate in two different climate models is the basis for an evaluation and robustness of such effects in the framework of PalMod. The model results will be analyzed with respect to the variations of the Atlantic Overturning Circulation (AMOC) and its possible effects on the North Atlantic sea surface temperature, the Arctic sea ice, and other climate-related variables.

Furthermore, temporal changes in palaeo-topography and palaeo-bathymetry, that are not the subject of the priorly mentioned simulations but an important boundary condition for palaeo-simulations, will be addressed in ensemble simulations over the last 100.000 years for one-dimensional (PalMod-1-1-3, GFZ) and three-dimensional (PalMod-1-2-4, GFZ) geometries. These changes during a glacial cycle are caused by the elastic and viscoelastic deformations of the solid earth due to ice and water mass redistribution and the eustatic change of sea level – the so-called glacial-isostatic adjustment (GIA). An expected outcome of these simulations is an estimate of the predicted range due to structural features of the Earth's body and uncertainties therin as due to the history of ice sheet distribution during this time. TThe achieved results will serve as an important boundary condition and reference data set for climate simulations in the further stages of the PalMod project.

As future stages of the research in PalMod critically depend on the availability of an Earth System Model that is coupled to an ice sheet model, we also aim at coupling the Parallel Ice Sheet Model (PISM) to the MPI-ESM (PalMod 1-1-2, AWI). In this framework, spinups of the Northern and Southern Hemisphere Atmosphere – Ocean – Ice Sheet – System will be performed. Additionally, a parameterization for the grounding-line dynamic of coarse-resolution large scale ice sheet models, based on time slice simulations with different resolutions, will be derived (PalMod 1-2-1, AWI). This knowledge is pivotal for the upcoming modelling of the coupled Atmosphere – Ocean – Ice Sheet – System.

Overall, this BMBF-funded project, that will start at the 1st of January 2016, will provide an unprecedented opportunity to understand underlying mechanisms of rapid climate changes during the last deglaciation, shedding light on future projections that consider anthropogenic effects. The goal of the sensitivity studies of this project is a better understanding of the palaeoclimate, as derived with a high resolution model, and a comparison with the other palaeoclimate-studies of the simulation of deglaciation that are based on a relatively low resolution ocean model. Insight into the evolution of the Earth Surface as a necessary boundary condition for the climate simulations, provision of a coupled ice sheet model, and parameters that enable the simulation of the combined lithosphere/mantle – ice sheet – climate system will be a starting point for following climate simulations in PalMod.