Recently, we could observe many important effects of climate warming driven by rising atmospheric CO_2 concentrations. In particular northern polar region experiences severe changes. Surface air temperatures in the northern high latitudes increased approximately twice stronger than the global average. Sea ice cover in the Arctic Ocean has been shrinking dramatically in the last decades. It will further deepen climate warming because sea ice reflects more sunlight than the ocean. Internation Panel on Climate Change established several scenarios that project possible socio-economic changes thigh might happen by the end of this century. Based on these scenarios Earth system models simulate possible future climate changes that we might experience in the coming decades. According to the simulated results, it is likely that by the year 2050 the Arctic Ocean will be seasonally ice-free. This will have, in many aspects, very important implications for society. Therefore, it is essential to study possible changes in the northern polar region to better understand future climate changes in the northern high latitudes in the next decades.

Clouds play a very important role in the climate system. They can both reflect incoming short wave radiation (sunlight) as well as emit back to the surface trapped terrestrial LW radiation. Furthermore, clouds by reflecting part of incoming short wave radiation influence surface albedo feedback. Below the clouds, surface albedo feedback is different than in the same location but with clouds absent (so called cloud masking effect). Our knowledge about clouds net effect on the Earth's climate is still uncertain. Furthermore, Earth system models provide diverging results on cloud's impact on the northern polar climate under different-than-today CO_2 levels.

One of the best counterparts of future climate is the early Eocene (~55-50 Ma) greenhouse climate. Reconstructed CO_2 levels during the early Eocene are similar to those that can be present in the atmosphere at the end of this century. Moreover, geological data indicate no sea ice in the Arctic Ocean during the early Eocene. Recently, an international program (DeepMIP, https://www.deepmip.org/) has been established that aims to compare early Eocene climate simulations carried out by different Earth system models in order to find robust features and differences across the ensemble and eventually better understand future climate at the end of this century.

The main goal of this project is to investigate the effect of cloud feedbacks forced by CO_2 level increase on the summer surface air temperature changes over the Arctic Ocean in the early Eocene. In the proposed project we plan to use a relatively novel method (APRP) that allow us to estimate short wave cloud feedback on the surface air temperature changes caused by CO_2 level changes. This method allows us to decompose the effect of clouds feedbacks into separate factors such as cloud fraction changes or how cloud reflectance of incoming sunlight will change under rising CO_2 levels. Furthermore, thanks to this method we can investigate the cloud masking effect on surface albedo feedback. Thus we can compare, in the absence of sea ice, the effects of surface albedo feedback on the surface air temperatures in the Arctic region in the cloud-free and all-sky conditions. Furthermore, we plan to include future climate simulations to compare early Eocene with future results. This will help us to better understand climate changes in the northern polar region that will happen in the coming decades forced by rising CO_2 concentrations in the atmosphere.

Moreover, thanks to the multi-model approach we will be able to compare simulated cloud feedbacks in different Earth system models. This will help us provide physical explanations that lead to differences across the model ensemble and assess model performance and cloud parametrization. This is essential for accurate future climate simulations as many Earth system models in the comparison participate in the future climate simulations in the framework of International Panel on Climate Change.