Permafrost: climate-carbon interactions from the Pleistocene to the Anthropocene

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Subject

Permafrost - ground frozen for at least 2 consecutive years - covers large areas of high latitudes, particularly in the northern hemisphere. It plays a crucial role in the climate system: exchanges of heat, water and carbon with the atmosphere can alter the carbon cycle and the climate. In particular, the presence of permafrost can strongly modify the local seasonal cycle, which can favour the formation or melting of ice caps during glacial-interglacial cycles. Changes in permafrost extent are also likely to have influenced changes in atmospheric CO_2 concentration during glacial-interglacial periods, by storing or releasing carbon as the permafrost advances and retreats. Finally, there are still many uncertainties as to how permafrost will evolve in the future, which could have a lasting impact on the carbon cycle and climate over the next few thousand years.

To understand its role in past changes and anticipate its future impacts, it is necessary to simulate permafrost with numerical models interacting with climate and carbon cycle models. To this end, this thesis will focus on coupling a permafrost model (VAMPER) with a coupled climate-ice sheet-carbon model (iLOVECLIM model). Comparison with existing data for the modern period will validate the coupling. Secondly, simulations of permafrost evolution during past periods and comparison with existing data, particularly in terms of extension, will enable the model to be improved. During glacial-interglacial periods, the student will analyse interactions with climate, in order to assess the role of permafrost in the establishment and melting of the Northern Hemisphere ice caps. The student will also add the carbon cycle to the permafrost model to assess its role in past changes in CO_2 and atmospheric $\delta^{13}C$, a proxy for constraining carbon exchange. These developments, coupled with comparisons with paleo reconstructions, will help improve the model and ultimately assess the role of permafrost in future CO_2 and climate projections.