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Cryogrid modelling of permafrost temperature in the Maritime Antarctic (Barton Peninsula, King George Island)

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The temperature dynamics of permafrost is crucial for ecosystem processes in the ice-free areas of the Antarctic Peninsula, where a strong long-term warming trend with an increase of 3.4 ºC in the mean annual air temperature since 1950 has been recorded (Turner et al., 2020). The consequences of this warming on past and future permafrost degradation are still not fully understood, mainly due to the sparse spatial coverage and short time span of borehole data, only available after the mid to late 2000's (Vieira et al., 2010; Bockheim et al., 2013). The Cryogrid Community Model is an adaptable toolbox for simulating the ground thermal regime and the ice/water balance for permafrost (Westermann et al., 2017, 2022). The modular structure allows combinations of classes that represent the snow conditions and the subsurface materials. Here, permafrost temperatures from the 13 m depth King Sejong Station borehole (KSS), from Barton Peninsula, King George Island were used to assess the performance of Cryogrid and the quality of ERA5 forcing. For evaluating model performance, the setup was firstly used in its basic version with the GROUND_freeW_ubtf class, which considers a temperature boundary condition, for which air temperatures from KSS were used. Modifications to the stratigraphy and parameters were performed to achieve the strongest correlations and lower Mean Absolute Errors (MAE) between the simulated and observed ground temperature at nine depth levels. This approach allowed for the definition of the stratigraphy and parameters later used with the GROUND_freeW_seb_snow class, in which the surface energy balance scheme is included. The results show that ERA5 air temperature underestimates the records from KSS, especially during the summer, impacting the representation of surface warming. This deviation was corrected using linear regression corrected temperatures. The Cryogrid modelling results indicate an overestimation of the ground temperature during the thawing season and an underestimation during the freezing season, being the difference more pronounced at the surface. A strong correlation was shown between the simulated and measured ground temperatures in KSS down to 6 m depth (r>0.9) with MAE ranging from 0.4 to 0.9 ºC. Below 6 m the correlation weakens to 0.45 (13 m depth) due to differences in heat propagation and lack of temperature oscillation on the records when compared with the simulation. However, MAE values are residual, ranging from 0.1 to 0.2 ºC. The active layer thickness was overestimated in about 1 m. This research was funded by the project THAWIMPACT (FCT2022.06628.PTDC) and by CEG/IGOT (UIDP/00295/2020). Joana Baptista is funded by the FCT with a doctoral grant (2021.05119.BD).