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## Analysis of the spatial distribution and characteristics of the rock glaciers in the Ampato, Vilcanota and La Viuda Cordilleras southern and central Peru

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Rock glaciers (RG) are visual evidence of mountain permafrost, and are one of the most important geomorphological features in the Peruvian Andes. The main objective of this research was to determine the spatial distribution of RG, their degree of activity, as well as their morphological and climatic characteristics in Cordilleras Vilcanota (Southeast), Ampato (Southwest) and La Viuda (Center). For this study, we used high-resolution images from Google Earth-Pro, SASPlanet and a DEM ALOS PALSAR (12.5 m) to identify and digitize the RG based on their geomorphological attributes, and we derived the potential incoming solar radiation (PISR), based on the DEM. The WorldClim dataset (1970-2000) was used to determine the mean annual air temperature (MAAT) and the precipitation in the analyzed zones.

The Cordillera Ampato, with 139 RGs, presents the lowest minimum altitude of the RGs inventory (4537 m a. s. l.), the lowest MAAT (-0.4°C), lower slope (18°) and concentrates the highest PISR (1083 kWh/m<sup>2</sup>). The Cordillera Vilcanota concentrates a lower number of RGs (54), a higher minimum altitude of RGs (4733 m a. s. l.) and a relatively higher MAAT (1.9°C). Comparing both southern Cordilleras with respect to Cordillera central (La Viuda), it has the lowest amount of RG (8), a higher minimum altitude of RG (4747 m a. s. l.), higher slope (23°), higher MAAT (2.2°C) and lower persistence of snow cover. With regard to the RG activity, it was found that the quantity of active RG compared to inactive RG is in a proportion of 1.6 in Cordillera Ampato and 0.2 in Cordilleras Vilcanota and La Viuda.

Finally, the spatial distribution analysis shows that the greatest amount of RGs is located in the southern zone, decreasing towards the northern regions of Peru while the opposite occurs with the average MAAT of the RG, that is, the MAAT decreases as the RG moves to southern regions of Peru. On the other hand, the SW zone (dry climate) concentrates the largest amount of RG compared to the SE zone (wet climate). In addition, the topoclimatic parameters condition the formation of RG in the Cordilleras of study.

