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The interplay of Atmospheric Rivers and topography on snowmelt induced landslides in Northern Anatolian Mountains (Türkiye)

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Landslides triggered by snowmelt, as one of the main hydrometeorological triggering factors, and their interaction with Atmospheric Rivers (ARs—long and narrow horizontal water vapor transport characterized by high water vapor content and strong low-level winds) and topographic conditions are not adequately elucidated. During the February–April 2022 period, extreme snowfalls in the Northern Anatolian Mountains, followed by a rapid snowmelt event, triggered more than 300 landslides. Accordingly, based on local and national news sources as well as public institution reports, an inventory was created by mapping 330 landslide events that occurred as a result of rapid snowmelt during this period. This landslide inventory compiled for the Northern Anatolia Region, one of the most susceptible regions in Europe, as well as Türkiye in terms of landslide events, provides a unique opportunity to understand the process dynamics underlying snowmelt-induced landslides. Revealing the combined and/or individual roles of meteorological weather events such as sudden temperature rises, heat waves, rain-on-snow events, and/or the foehn effect, associated with ARs or synoptic-scale weather events, in triggering these landslides is essential for better understanding possible such events in the near-future and to taking effective measures to mitigate socio-economic losses.

The spatio-temporal distribution of snowmelt, air temperature, and snow-water equivalent (SWE) variables at daily and monthly scales for the February to April 2022 period according to long-term climatology (1993–2022) as well as landslide events triggered by ARs were analyzed. Additionally, the impacts of altitude and slope steepness on the spatio-temporal distribution of landslide events were revealed. Over the study area during February–April 2022, both monthly SWE and snowmelt values had positive anomalies, while air temperature values showed positive anomalies only for February and April. The analysis of landslide events triggered by ARs based on a 5-day window for AR passages showed that ARs as a triggering factor were responsible for 62% of total landslide events. On the other hand, as time progressed during the period February–April 2022, an increase in the altitude and slope steepness values at which landslide events occurred gradually increased. In addition to a gradual escalation of landslide occurrences to higher altitudes with time, we observed that landslides are limited to around 800 m, which further suggested that this may be caused either by limited soil thickness cover above a certain altitude or by the air temperature

below the thawing degree.