

Long Term Trends of Freeze – Thaw Cycles in North America, Europe and Asia

Krzysztof MIGAŁA✉, Małgorzata WIECZOREK, Marek KASPRZAK,
and Andrzej TRACZYK

University of Wrocław, Institute of Geography and Regional Development, Wrocław, Poland

✉ krzysztof.migala@uwr.edu.pl

Abstract

This study analyses changes in the frequency of freeze-thaw cycles in high-latitude and mountainous regions of the Northern Hemisphere. The aim is to evaluate thermal conditions conducive to frost weathering processes, considering the spatial variability of climate characteristics and trends observed over the period 1971–2020. We selected 30 meteorological stations representing polar, alpine, subpolar oceanic, and subarctic climates. Using daily mean and extreme air temperatures, we calculated long-term averages for the number of freeze-thaw days (FTD), ice days (ID), frost-free days (FFD), and other related parameters. These metrics formed the basis for clustering the stations to identify similarities in climatic conditions favourable to frost-related processes. As a result, the stations were grouped into four distinct clusters. Our analysis indicates that global warming contributes to a universal decline in the number of ID. However, trends in FTD vary: they are increasing in the coldest regions and decreasing in the warmest ones. Notably, long-term trends in FTD exhibit significant variability, influenced by seasonal changes, climate zone, proximity to oceans, and regional orographic features. In winter, warming leads to more frequent freeze-thaw cycles and increased occurrences of “rain-on-snow” events and the formation of various surface ice deposits such as hoarfrost, glaze ice, and black ice.

Received 15 September 2025

Accepted 20 October 2025