INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **25**: 1749–1766 (2005)
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/joc.1217

SENSITIVITY OF FROST OCCURRENCE TO TEMPERATURE VARIABILITY IN THE EUROPEAN ALPS

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Received 25 August 2004
Revised 13 May 2005
Accepted 13 May 2005

ABSTRACT

In this study, we set out to investigate the linkage of frost frequency to monthly mean temperature and its sensitivity to temperature changes. According to other related studies, the linkage between frost frequency and monthly mean temperature is approximated month per month via hyperbolic tangent functions. These models are validated using three validation experiments including split sample tests and temporal cross-validation. As there are quality-checked station data in Austria, whose temporal resolution and length allow for such a validation procedure, the validation experiments are conducted there.

After the performance of the empirical models is evaluated and found adequate, the hyperbolic tangent approach is applied to about 500 stations within the so called Greater Alpine region (GAR), which extends from about 4 °E to 18 °E and from 44 °N to 49 °N. Using these models, it is possible to derive the sensitivity of frost frequency for any location for which the annual temperature cycle is known. This strategy is explicitly demonstrated for the Po Plain, where vertical temperature profiles on a monthly base are on hand as well as in Austria, where spatially high resolved maps of monthly mean temperature are available. Moreover, at stations for which long-term homogenised series of monthly mean temperature are available, reconstructions of frost frequency via the empirical models are done, returning to historical periods where no measurements of minimum temperature exist.

On the basis of these findings, the impact of a possible future warming can be assessed, which is essential with regard to glaciers, permafrost and avalanches. Reduction in frost might bring positive economic aspects for agriculture, but negative consequences for low level skiing areas. Copyright © 2005 Royal Meteorological Society.

KEY WORDS: frost variability; frost sensitivity; hyperbolic tangent functions; reconstruction; Greater Alpine region; homogenised temperature

1. INTRODUCTION

Since the late nineteenth century, mean surface temperatures have increased at the global scale by approximately 0.6 °C (Jones and Moberg, 2003). In the Alpine region, the temperature increase has been more than twice as much (Böhm *et al*., 2001; OcCC, 2003). At the same time, findings from several regions attest that frost frequency (FF) has decreased (a frost day is a day with a minimum temperature below 0 °C) and, hence, the frost-free seasons have been extended. However, the quantitative effects are rather different. Cooter and LeDuc (1994) found that the frost-free season in the northeastern United States has increased by almost 11 days since 1950. In Austria observations indicate a reduction of the frost season by 17 days in the flat eastern region (Vienna) and by 22 days in the high Alpine region around the mountain peak station of Sonnblick (3100 m altitude) during the twentieth century. Observations in the city of Milano, located in

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