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Developing a freshwater ice thickness model for the Northern Hemisphere

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The cryosphere integrates climate variations over a wide temporal and spatial scale through its direct connection to the surface energy budget, the water cycle, and surface gas exchanges. As one of the eight cryospheric components, freshwater ice (defined here as river and lake ice) reflects temporal variations in climate. Moreover, such variations can have a wide range of implications, given that freshwater ice plays important roles in the biological, chemical, hydrologic, and geomorphological functions of freshwater ecosystems, as well as being significant to a number of socio-economic systems, particularly on-ice transport. Assessing the broad-scale implications of changes to freshwater ice requires a comprehensive understanding of its areal coverage and volume; an assessment that remains to be conducted, particularly for the Northern Hemisphere where it is such a major landscape feature. To address this need, a GIS-based analysis of the large-scale spatial and temporal characteristics of freshwater ice has been undertaken. Specifically, a GIS-based degree-day ice-growth model has been embedded in a GIS analytical procedure. To achieve accurate modelling of ice conditions across a broad range of hydro-climatic regions, this study has generated regionally representative ice-growth coefficients. Coefficients were defined separately for rivers and lakes by comparing modelled and observed peak ice thickness data within each hydro-climatic region across the Northern Hemisphere. Data were compiled to include a range of river and lake sites from multiple Northern countries including Canada, Alaska, Finland, Sweden, and Russia. The ERA-40 gridded reanalysis temperature dataset is used to derive accumulated freezing degree-days for across the Northern Hemisphere, as input to the model. Further research is being conducted to derive coefficients suitable for varying water body size, including rivers of large width and steep slope where rate of ice growth will be slowed, as well as very large lakes where heat storage plays a dominant role in ice growth. With a full suite of ice-growth coefficients defined, it will be possible to conduct the first quantification of the area and volume of freshwater ice for the Northern Hemisphere using the GIS-based ice thickness model.