INSTITUTIONEN FÖR GEOVETENSKAPER

# Impact of climate variability on dynamic groundwater storage in mid- to high latitude countries

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# Summary

Climate change will alter the hydrological cycle, potentially changing dynamic groundwater storage and increasing groundwater drought risk. Climate influences groundwater storage directly via changes in groundwater recharge, but groundwater drought responsiveness further depends on groundwater system characteristics. The aim of this thesis is to increase our understanding of how climate variability and groundwater system characteristics influence groundwater storage, in mid- and high latitude countries.

To address this aim, groundwater, precipitation and temperature data from Sweden and Finland between 1980 and 2010 was evaluated. Different hydroclimate regimes were compared to seasonal and inter-annual groundwater level fluctuations. Furthermore, the influence of groundwater system characteristics on groundwater drought responsiveness was assessed by analysing precipitation and groundwater level anomalies from Sweden, Finland and the Lower Fraser Valley (Canada). Correlation analysis between groundwater drought responsiveness and selected environmental properties was applied on Swedish data.

The main findings of this thesis are, first, that between 1980 and 2010, groundwater recharge became decreasingly driven by snowmelt in spring. Instead, recharge became increasingly influenced by winter rain and high evapotranspiration rates in spring. As a result, dynamic groundwater storage significantly decreased across the region, particularly in Finland. Second, inter-annual groundwater level trends, covering the same period, did not correspond to trends of increasing winter snowmelt and rainfall. Groundwater level trends instead showed stronger similarity to trends in wet days, i.e. frequency of days with precipitation. Furthermore, groundwater trends corresponded better to trends in the frost-free season, compared to trends found in the frost season. Third, variability in groundwater drought responsiveness could be partly explained by environmental properties, such as sediment type (sand, silt and till), groundwater level depth, climate and atmospheric teleconnections.

These findings suggest that within this century, annual groundwater recharge will decrease in the study areas, due to the projected increase in temperature and precipitation. However, this also depends on the effect of decreased ground frost on winter infiltration, and the balance between precipitation and evapotranspiration. Finally, the need for a holistic approach in groundwater drought characterisation is made apparent by the influence of climate and atmospheric teleconnections on groundwater drought responsiveness.



**Keywords**: climate change; time series analysis; groundwater statistics; Sweden; drought; cold region hydrogeology; groundwater memory