



Precipitation Variability in Finland and Relationships with Climate Teleconnection Indices

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Annual, seasonal, and monthly variations in precipitation over Finland during the period 1911-2011 were evaluated using spatially interpolated monthly precipitation records at 237 stations with more than 10 years data (of which 166 stations with over 30 year data). The non-parametric Mann-Kendall test and Fourier series method were used to determine significant historical trends and cyclic patterns in precipitation, respectively. Further, relationships between precipitation variability and different climate teleconnection indices were analyzed based on Spearman's correlation coefficient (rho). At 5% significance level ($p < 0.05$), the annual precipitation over Finland increased by 0.93 (mm/year), and associated strongly with the East Atlantic/West Russia (EA/WR) pattern ($\rho = -0.41$). However, there were spatial differences between regions from north to south and east to west. Time cycle (λ) for annual precipitation was estimated about 180 years ($R^2 = 0.19$), and year 1966 was indicated as turning point from negative (dry) to positive (wet) phase. Analysis of seasonal precipitation indicated increasing trends for both winter by 0.51 (mm/year) and autumn by 0.48 (mm/year), while no clear trend was found for spring and summer precipitation ($p > 0.05$). The most significant correlation of winter precipitation was found with the North Atlantic Oscillation (NAO) index ($\rho = 0.59$, $p < 0.05$). The Scandinavia (SCA) pattern was the most significant teleconnection index influencing the precipitation variations in both spring ($\rho = -0.40$, $p < 0.05$) and summer ($\rho = -0.35$, $p < 0.05$) seasons. There was a strong negative relationship between autumn precipitation and the EA/WR pattern ($\rho = -0.25$, $p < 0.05$). The time cycles of seasonal precipitation were about 188 years for winter, 4 years for spring, 6 years for summer, and 135 year for Autumn, where $R^2 > 0.10$. Monthly precipitation analysis determined significant increasing trends for January, February, March, November, and December months, and no clear trend for the other months. Maximum increasing trend was for January by 0.23 (mm/year) and minimum increasing was found for November by 0.14 (mm/year). The precipitation variability in January, February, May, June, August, September and October showed strong negative correlation the SCA pattern. The NAO was the main teleconnection index affecting precipitation in March and December, while precipitation in April and July was strongly in relation to the EA/WR pattern. The East Atlantic (EA) pattern was the most significant teleconnection index that influenced precipitation in November. Periodicity analysis of monthly precipitation indicated long time cycles for December-April ($120 < \lambda < 225$ years), and short time cycles for May-November ($2 < \lambda < 8$ years). Results clearly indicate that precipitation patterns have changed in Finland during last decades and precipitation is controlled by various climate teleconnections, which has major influence on water resources and management.

Keywords: Precipitation, trend, teleconnection indices, cyclic pattern, Finland