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Spatial and temporal analyses of long time series in phenological observations from Norway related to temperature

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Several phenophases at sites along Norway (from about 58^o N to nearly 70^o N) were observed in the period 1928 - 1972. At a few sites these observation continued until 1977. The present analysis is mainly on long-term series of various plant phenophases in both herbs and woody plants. In all species the time for first flowering was observed, in woody plants often also the time of first leaf bud burst, autumn colouring, and leaf fall.

Temperatures were expected to be the most important climatic factor for development of all plant phenophases, although locally day lengths (particularly the 24 hour day light in parts of the summer in the north of the country) and precipitation may also be of influence. Correlation analyses between temperatures and time for phenophases were performed using Pearson correlation coefficient. The significance of the trends for some of the phenophases is calculated by the non-parametric Mann-Kendall test and by a linear trend test as well. The temporal variations of the phenophases are visualized by low pass Gaussian filters, whereas spatial patterns of Norway are shown cartographically by interpolation techniques and analyses in ArcGIS. Particularly for *Betula* the trends observed in the study period are compared with recent trends found by analyses of satellite images for the 1982 to 2002 period.

It is obvious that the high temperature period of the 1930's generally caused e.g. early bud burst of woody plants. The analysis by Gaussian smoothing technique showed later spring phenophases for most sites and species in the early 1940's, mid 1950's and late 1960's, when temperatures were lower, particularly in the southern part of the

country. Generally, there is slightly more than 10 year between extreme maximums (late) and minimums (early) of the curves. The linear trend analysis showed slightly earlier spring for all the observation stations, except the northernmost site, during the 1928 to 1972 period. All observations ended in 1977, which means before the present increased growing season in most parts of Europe, also due to influence by man. The recent trends, revealed by remote sensing for the 1982 to 2002 period, indicate a more than two week earlier spring in the lowland in southern Norway and in maritime areas of central Norway, but a stable or even weakly delay trend in alpine parts and in northernmost Norway. The strong altitudinal and latitudinal variations in Norway may cause possibilities for regional differences in earliness and variations in trends and in cyclic variations in various parts of the country, and are analyzed in the paper.