Climate condition affects foliar nutrition in main European tree species

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Background

Foliar nutrition is an important indicator of tree vitality. It depends on the availability of nutrients and the uptake capacities of the trees, which are controlled by forest structure, soil and climate condition. Consequently, accounting for climate conditions can aid the interpretation of foliar chemistry measurements. Here, we compare the effects of atmospheric temperature and precipitation on main nutrients (N, P, K, Ca, Mg) concentrations, contents, and ratios as well as foliar mass.

Methods

Foliar data sampled between 1990 and 2017 on 97 intensive forest monitoring plots operated as part of the ICP Forests Level II programme by institutions of the German federal states is included in the study. Generalized additive models with the sampling year and the study site as factorial variables were used to identify the proportion of deviance that can be attributed to spatial and temporal variability.

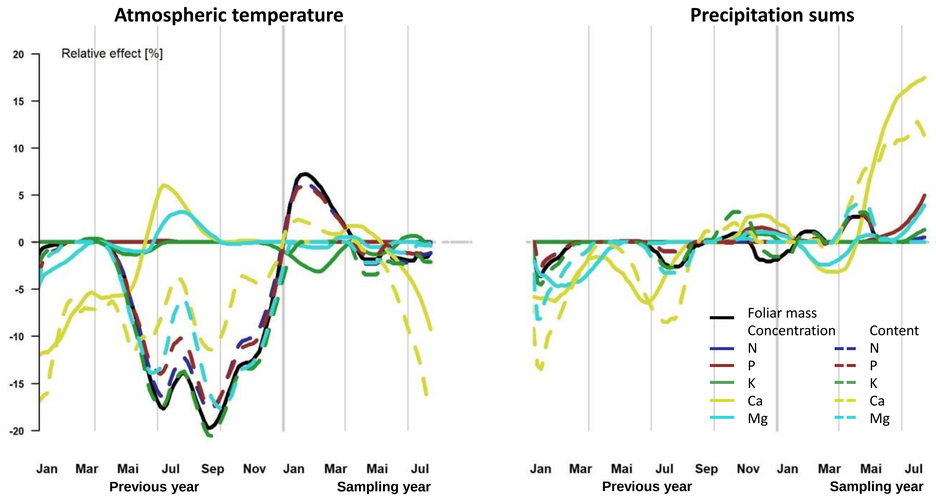
In a moving-window approach, a total of 2026 generalized linear mixed models with study site as a categorical random effect variable and either scaled mean atmospheric temperature or scaled precipitation sums of a given model interval as a fixed effect were run. The model intervals include periods between ten and 550 days, starting from the first day of the year preceding sampling to the 235th day of the sampling year. Results of the integrated effects for pine and oak are shown in graphic form.

Main findings

All foliar traits are affected by current or lagged climate conditions. N and P show weaker effects than Mg, K and Ca. Foliar mass is generally more sensitive to climate conditions than nutrient concentrations; nutrient contents are more strongly coupled to foliar mass than nutrient concentrations. The effects depend on tree species – no universal favourable climate conditions were found. In general, the most informative averaging periods of atmospheric temperature and precipitation are generally short (three months or less).

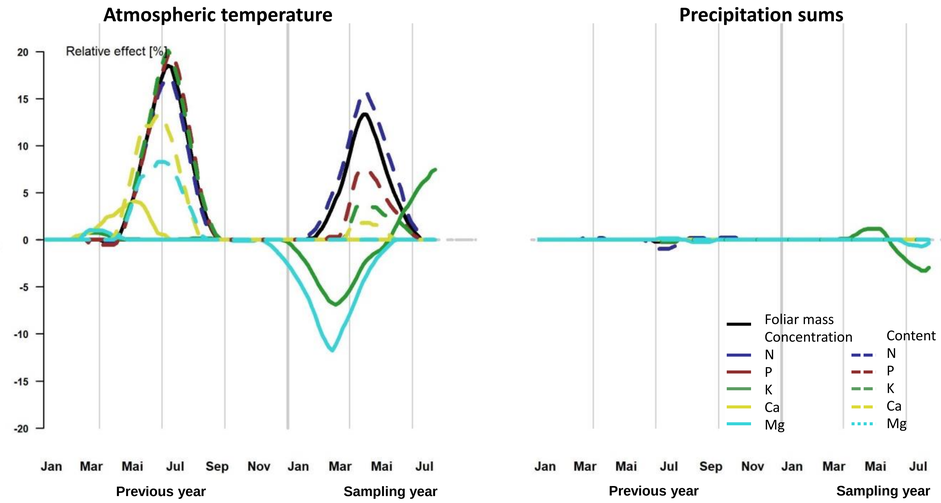
Whereas deviance explained by sampling year is low for all foliar parameters in oak, deviance explained by sampling year is higher than deviance explained by study site in pine. For all tree species, study site explains more deviance in nutrient ratios than in nutrient concentrations. Deviance explained by sampling year is generally low for nutrient ratios. The effect of climate condition on the N:P ratio were weakest of the studied parameters, making it the most robust indicator in studies comparing samples taken in years with different climatic conditions.

Scots pine



- Strong effect of lagged atmospheric temperature on foliar mass
- Opposing effects on nutrient concentrations and foliar mass hint at a dilution effect
- Summer precipitation of current year has notable effects on all five nutrient concentrations
- Ca is more sensitive to precipitation than other nutrients
- Sums over the entire vegetation period are less informative than shorter time intervals

Temperate oaks



- Less sensitive to climate condition than pine, possibly due to higher within tree nutrient buffering capacitites
- Effects of lagged climate conditions are of similar magnitude than climatic conditions in the sampling year
- Stronger effect of temperature than precipitation on K, Ca, and Mg
- Only weak effects of climate condition on N and P concentrations
- Nutrient contents follow same patterns as foliar mass

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Full study including results for European beech and Norway spruce submitted to *Ecological Indicators*