The effect of soil fertility on the spatial variability of budburst phenology in Europe

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Résumé

Since the demonstration that the spring phenology of deciduous trees advances in response to the rising temperatures within climate change, the topic has received a lot of attention. While this heightened attention lead to an incredible increase in our understanding how chilling in winter and warming in spring drives budburst timing, it has also opened new questions. Recent studies showed that only about 50% of the spatial long-term variability in budburst timing can be explained by these well examined climatic drivers. Non-climatic, spatially explicit factors (such as local tree biodiversity, density, soil fertility) could affect budburst phenology either directly, or in interaction with meteorological factors, and can thereby explain parts of this yet unexplained spatial variability. In the study presented here, we focus on the effects of soil fertility by examining if soil fertility affects i) parts of the spatial variability in spring phenology not yet explained by known meteorological drivers and ii) the advancement of phenological timings since 1955. We examine three different phenological timings, the start (Leaf unfolding start, LUst), mid-point (budburst date, BBd) and end (Leaf unfolding end, LUen) of the budburst period. We combined detailed, long-term spring phenology observations (provided by the ICPforest network and RENECOFOR) and long-term meteorological data (E-OBS) to configure two types of background models for 121 sites across Europe and each phenological timing for various tree species. Firstly, spatial pheno-meteorological models from which we extract the site-specific residuals representing the remaining variability. Secondly, temporal models from which we extract the slopes which represent the adaption of the phenological timings to the changes in climate. We then tested both the residuals and the slopes against a sophisticated soil fertility index, configured from soil chemistry samples taken directly at the sites. This index does not only characterize soil fertility via nutrient availability, but also considers that fertility is also limited by different factors in different places. The residual analysis showed that the overall budburst period is initiated later, and finalized earlier, than estimated by the meteorological factors alone in sites of higher soil fertility, leading to an overall shortened budburst period. We also find that shifts in temporal adaption in phenological timings affect the start, but not the end, of the budburst period. Both these effects are found across all species, albeit with certain species-specific differences. These findings could improve current phenology models which form a considerable part of land-surface models which in turn form a basic part of current climate models.

Mots-Clés: phenology, budburst, forest ecology

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