Project: **1464**

Project title: **CO2FORKlim**

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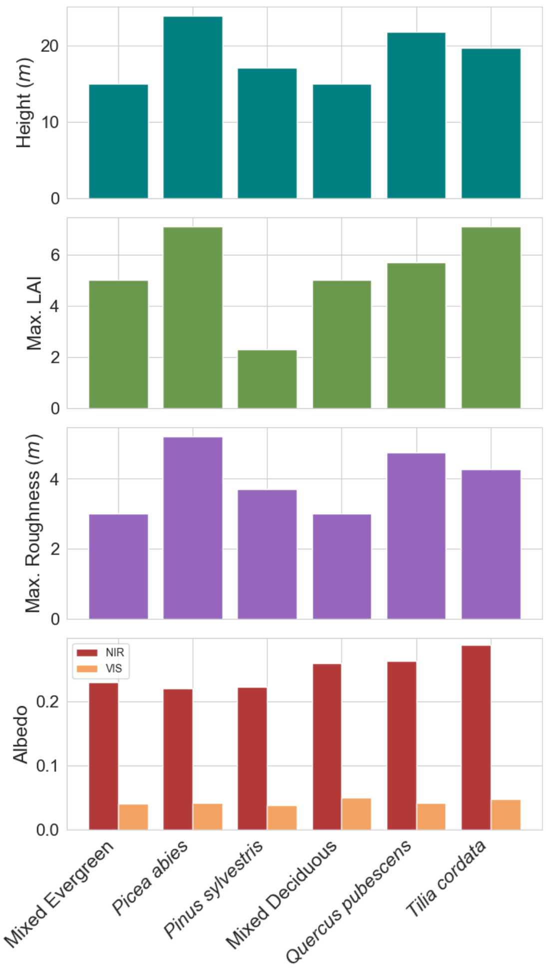
Report period: **2024-11-01 to 2025-10-31**

Project Overview

In the first project period we tried to identify tree species that, due to their biogeophysical characteristics, exhibit the best climate mitigation effects in different regions of Europe. For this purpose, we performed idealized afforestation simulations across a European domain with species-specific PFTs using ICON-XPP. In this report we present initial results from four monospecific afforestation scenarios compared with mixed forestation PFTs and a control run.

Methods

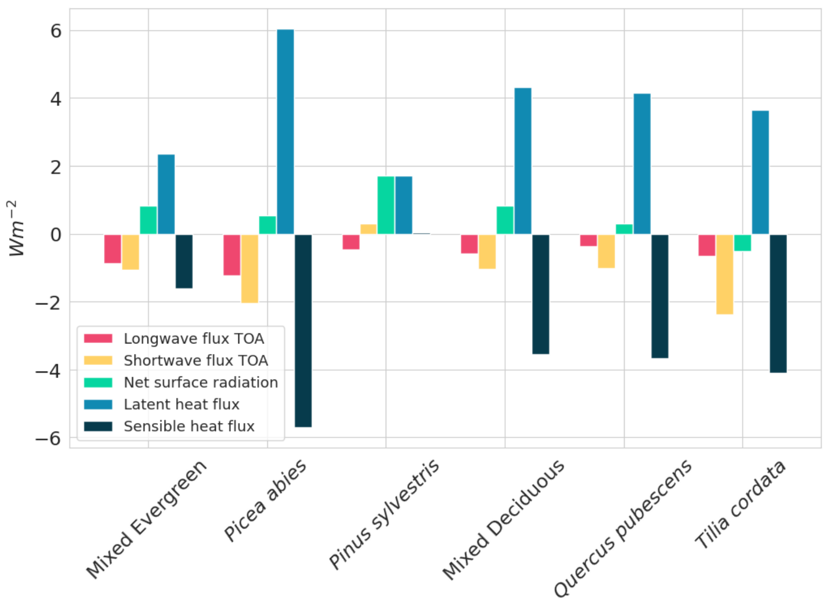


In these monospecific afforestation scenarios four variables have been adapted in order to represent the specific biogeophysical characteristics of four different tree species, namely picea abies, pinus sylvestris, quercus pubescens, and tilia cordata. The respective biogeophysical characteristics are the vegetation height, the maximum leaf area index (LAI) throughout the year, the maximum roughness length and the canopy albedo. Figure 1 shows how differently these biogeophysical characteristics vary among the individual tree species. For instance, picea abies is the highest tree and has consequently also the highest surface roughness length and LAI. Pinus sylvestris, on the contrary, has only a small height, surface roughness and LAI. Tilia cordata has a comparable LAI to picea abies, even though it is shorter in height. At the same time, however, tilia cordata has the highest albedo.

For these different tree species with their different biogeophysical characteristics global climate simulations were then carried out using ICON-XPP at 80 km resolution.

Figure 1: Species-specific characteristics of four deciduous tree types compared to those of the default 'mixed' plant functional types in ICON-XPP.

Results



In comparison to a control run in which the actual forest cover distribution in Europe is used, afforestation increases the latent heat fluxes and reduces the sensible heat fluxes, regardless of the tree species used for afforestation (Figure 2). The higher the LAI, the stronger the increase in latent heat fluxes. Tilia cordata is in this context an exception, as its high albedo resulted in lower energy input and, consequently, slightly lower latent heat fluxes were simulated despite its high LAI.

Figure 2: Radiative and heat flux differences compared to a control simulation for six afforestation scenarios. Values shown are averages over the initial simulation duration of five years.

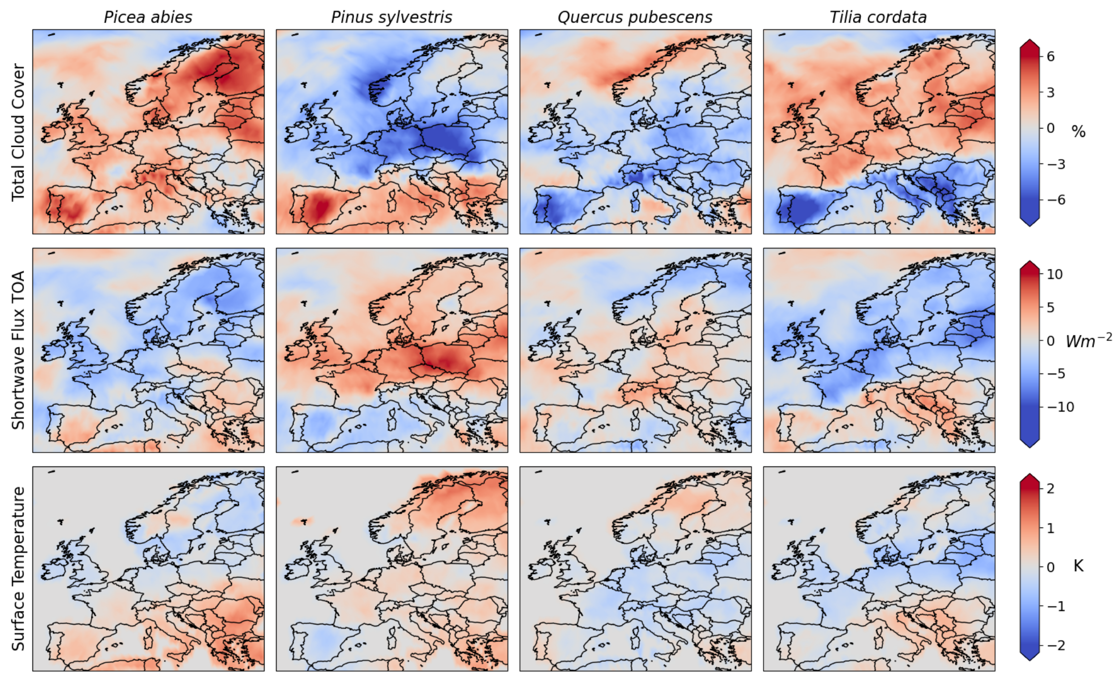


Figure 3: Difference maps comparing monospecific afforestation scenarios to their respective mixed forestation counterparts. Picea abies and Pinus sylvestris are compared to mixed evergreen, Quercus pubescens and Tilia cordata to mixed deciduous.

In Figure 3 the climatic response of monospecific forestation compared to mixed forestation is shown for the total cloud cover, the net shortwave radiation at the top of the atmosphere and the surface temperatures. Simulation results show that monospecific forestation differs from that of mixed forestation with significant geographic variation. Such variant climatic responses across species suggests that including species-specific information in modelling may be a path toward optimising afforestation strategies for climate benefit. Initial results indicate tilia cordata provides the strongest example of a species that may show improved climate mitigation potential.