Thank you for the support received by the JABBS Trust, Norbury Park Estate, the John Horseman Trust, Ecological Continuity Trust, Nerc, and the "HiFreq! EU Horizon 2020

Soil moisture and temperature dynamics in juvenile and mature forest as a result of tree growth, hydrometeorological forcings, and drought

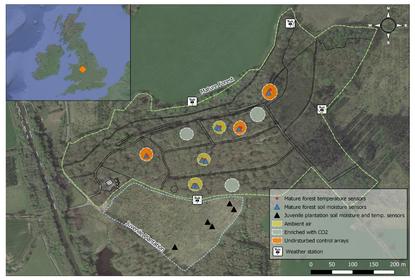
Introduction

- Forests represent a key global carbon store and afforestation is an important tool for sequestering atmospheric carbon. They also act as an important modulators of water, nutrients and energy fluxes across the soil-vegetation-atmosphere interface
- Afforested areas, with their increasingly complex soil hydrological processes and thermoregulation capacity, regulate soil moisture, which is the critical catchment template for flooding and drought
- However, long-term soil moisture and temperature dynamics during the stages of forest growth are poorly studied

Therefore, the aim of this research is
To gain a better understanding of the "timing" of a juvenile forest ecosystem to provide ecological services comparable to a mature woodland, and how internal dynamics and external disturbances can influence that process

Site

- The study site in Staffordshire, Central England, UK, consists of a mature forest patch hosting the BIFoR FACE and an adjacent juvenile forest plantation
- The mature forest is a deciduous woodland of 19 ha dominated by *Quercus robur* with average height of 25 m planted in 1850
- The juvenile forest is a 4.66 ha aggrading mixed-species deciduous woodland planted in 2014 over a farmland



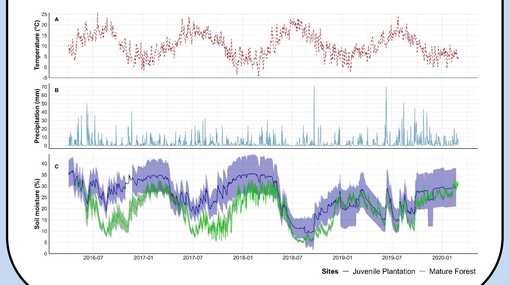
Data

- Soil moisture data at 0.10 cm for both sites **over the five-year time period 2016-2020**
- Soil temperature at 10 cm for both sites **over the five-year time period 2016-2020**
- Climatological data acquired for the time period 2016-2020 from the Shawbury weather station – UK Met Office
- Juvenile forest stand **tree growth and mortality across the period 2014-2021**

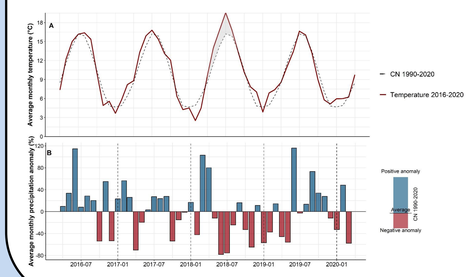
Methodology

- Seasonal and trend decomposition using LOESS (STL) procedure
- Response of the two forest ecosystems to single meteorological events of **5 and 20 mm** magnitude
- Canopy cover thermoregulation capacity in both analysed through the difference ΔT between air temperature and topsoil temperature
- **Two sample Kolmogorov-Smirnov test at significance level α of 5% and piecewise linear regression** to determine the effects of the drought on soil moisture dynamics

- Daily air temperature, precipitation, and 10 cm soil moisture observations for the juvenile plantation and mature forest

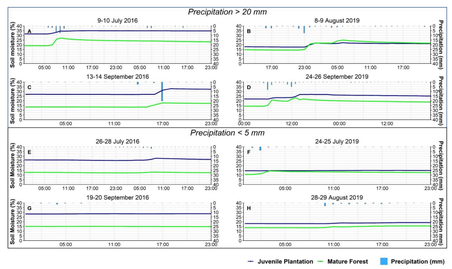


- Monthly averages of air temperature and precipitation in the research area in relation to the climatological normal (CN) calculated for the period 1990-2020

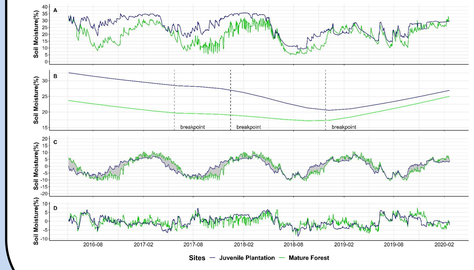


- Top soil temperature and air temperature differences observed in the mature forest and juvenile plantation

- Effect of specific precipitation events (20 and 5 mm) on soil moisture in mature forest and juvenile plantation



- Soil moisture time series decomposition in both forest ecosystems



SUM

- **Soil moisture dynamics of the juvenile plantation match** those of the mature forest in less than 10 years (KS test: D = 0.15, p-value = 0.2435). This is likely due to adaptation strategies of the plantation following the 2018 drought event
- **The drought act as a "renewal event"** eliminating previous soil moisture dynamic. This is well known in Mediterranean climate but not in temperate maritime climate, indicating then a **new-climate specific indication of climate change**
- Soil moisture dissimilarity between mature forest and juvenile plantation no longer significant (KS test: D = 0.12, p-value > 0.05) in 2019 after precipitation events > 20 mm
- **Thermal regulation capacity remaining dissimilar** between juvenile plantation and mature forest suggesting how other forest ecosystem functions take longer to establish

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EGU General Assembly 2023