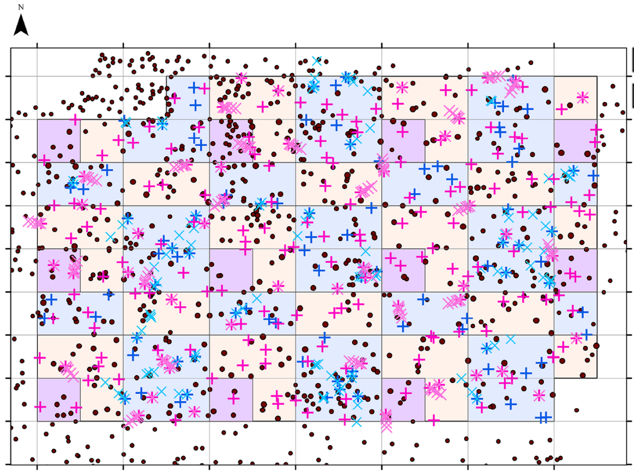

Figure 1. Experimental setup showing the 1 ha forest plot subdivided into a 10 m × 10 m grid, yielding 100 subplots, and the positions of the throughfall samplers (pink crosses) and 49 soil water content subplots (blue) measured in a stratified random design with transects (see Sect. 2 for more details). The figure was sourced from Metzger et al. (2017).CE8

At each location, we used soil moisture measurements an hour precedingCE11 the observed rain event ($\theta_{\mathrm{pre},ij}$) to characterize the soil initial moisture in the drained state and the maximum soil water content just after the rain event ($\theta_{\mathrm{post},ij}$) to characterize the post-event state. We also assessed the soil water content increase due to rainfall by calculating the change in the soil water content ($\Delta\theta_{ij}$) for each event j and each location i as follows:

$$\Delta\theta_{ij} = \theta_{\mathrm{post},ij} - \theta_{\mathrm{pre},ij}. \tag{2}$$

Positive values of $\Delta\theta_{ij}$ indicate a soil water content increase. In the following, we refer generally to $\Delta\theta$ (with indices omitted for simplicity) as "soil water content increase" or "soil moisture response" due to rainfall.

Equivalently to throughfall, we decomposed the soil water content into the event spatial median ($\hat{\theta}_{\mathrm{pre},j}$, $\hat{\theta}_{\mathrm{post},j}$) and relative deviations from that median ($\delta\theta_{\mathrm{pre},ij}$, $\delta\theta_{\mathrm{post},ij}$) with indices for event j and location i omitted for simplicity in the following. As for throughfall, using the relative deviations of the soil water content alongside the medians in the statistical models (see below) provides us with two independent measures for one variable: one relating to the spatial pattern ($\delta\theta_{\mathrm{pre},ij}$, $\delta\theta_{\mathrm{post},ij}$) and the other to the temporal variation ($\hat{\theta}_{\mathrm{pre},j}$, $\hat{\theta}_{\mathrm{post},j}$).

2.4 Canopy and soil property measurements

At the time of soil sensor installation, undisturbed soil samples were collected using metal ring cylindersCE12 with a volume of 100 cm^3. The distance between the sensor position and the soil sample collection was approximately 0.5 m. Soil properties were treated as if they were measured directly at the soil sensor location i. In order to determine the field capacity ($\theta_{\mathrm{FC},i}$), the samples were saturated, left to drain in a sandbox with a hanging water column imposing a pressure of −60 hPa for 72 h and then weighed. The soil cores were subsequently dried for 24 h at 105 °C and weighed again to obtain the dry weight ($m_{\mathrm{dry},i}$). The volumetric water content at field capacity ($\theta_{\mathrm{FC},i}$) was derived from the weight difference of the sample at −60 hPa and $m_{\mathrm{dry},i}$, assuming a density of water of $D_{\mathrm{w}} = 1\,\mathrm{g\,cm^{-3}}$CE13. Bulk density ($D_{\mathrm{bd},i}$) was calculated from the soil dry weight and volume. Soil apparent porosity (φ_i) was calculated from the bulk density and assuming a constant density of the soil mineral component ($D_{\mathrm{m}} = 2.66\,\mathrm{g\,cm^{-3}}$) as follows:

$$\varphi_i = 1 - \frac{D_{\mathrm{bd},i}}{D_{\mathrm{m}}}. \tag{3}$$

Macroporosity ($\theta_{\mathrm{MP},i}$, also called the air capacity or air-filled porosity) was then determined as follows:

$$\theta_{\mathrm{MP},i} = \cancel{1} - \theta_{\mathrm{FC},i}. \tag{4}$$

To characterize the canopy density, we counted the number of branches (canopy cover) above the throughfall samplers in 2014. However, these data were not available for soil water measurement locations.

2.5 Statistical analysis

All statistical analyses were processed with R (version 3.2.3; R Core TeamCE14, 2016TS4). For the geostatistical analysis (detailed below), we used the geoR (Ribeiro and Diggle, 2001), georob (Papritz and Schwierz, 2020) and gstat (Pebesma, 2004; Gräler et al., 2016) packages. Linear mixed-effects models were implemented using the lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages. The variance explained by fixed and random factors (conditional R^2) and by only fixed effects (marginal R^2; Naka-