

Forest Ecohydrological Sensor Network

Capturing spatio-temporal dynamics of hydrological fluxes and processes in a forest ecosystem

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Introduction

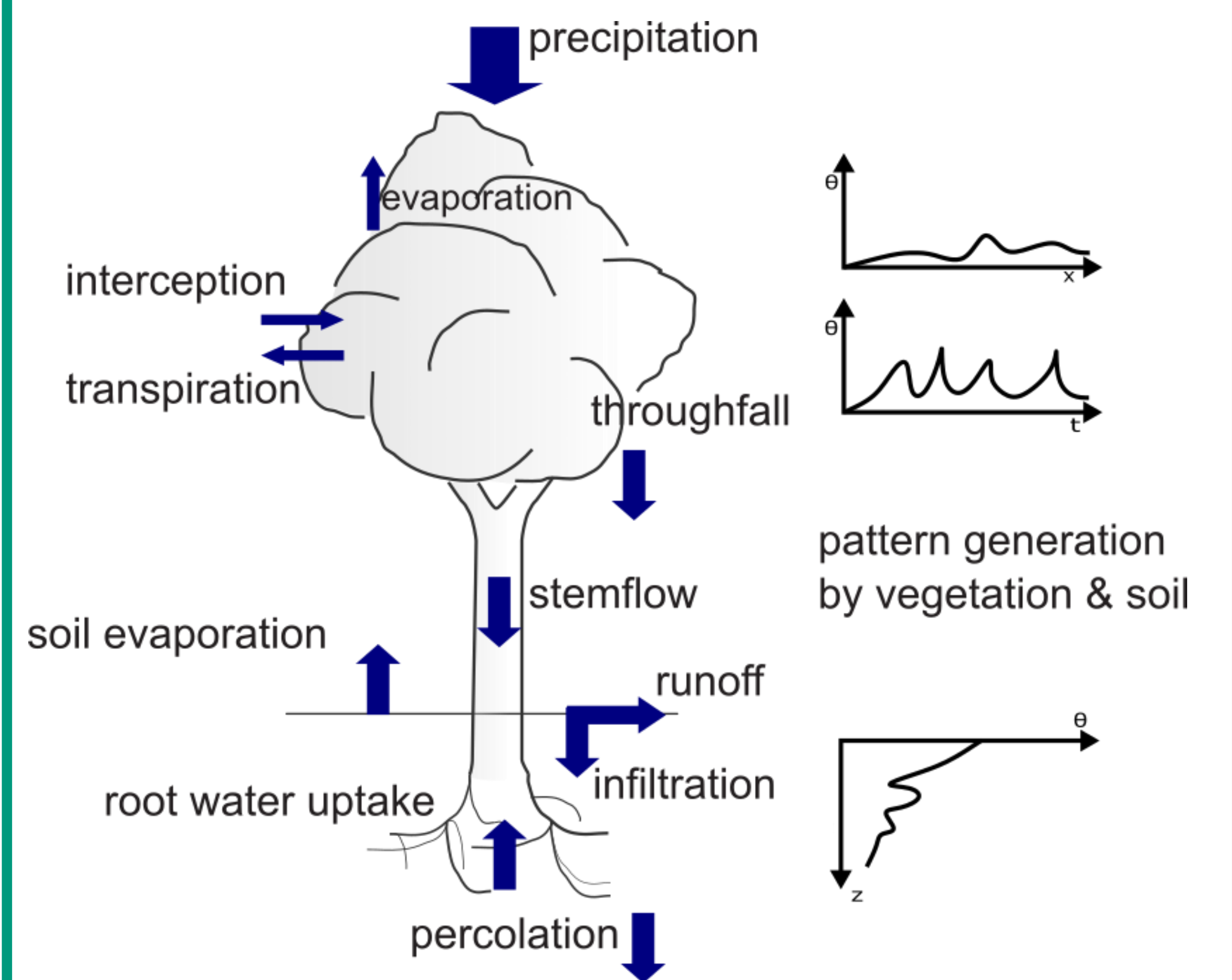
- ◆ **Hydrological fluxes** in forests are **spatially heterogeneous** and **temporally variable**
- ◆ **Precipitation redistribution** by vegetation and soil **creates patterns** which may cascade through hydrological cycle and further feedback on plant water usage
- ◆ **Detailed quantification** of flux heterogeneities across scales remains **measurement challenge**

Objectives

With a novel in-situ measurement infrastructure we aim a deepened understanding of:

- ◆ **Spatio-temporal dynamics of ecohydrological fluxes and processes** in different forest ecosystems
- ◆ **Effects of rainfall redistribution** in heterogeneous forest stands on **soil moisture patterns**, their temporal persistence and depth propagation
- ◆ **Effects of tree transpiration and root water uptake** on **soil moisture** patterns and dynamics

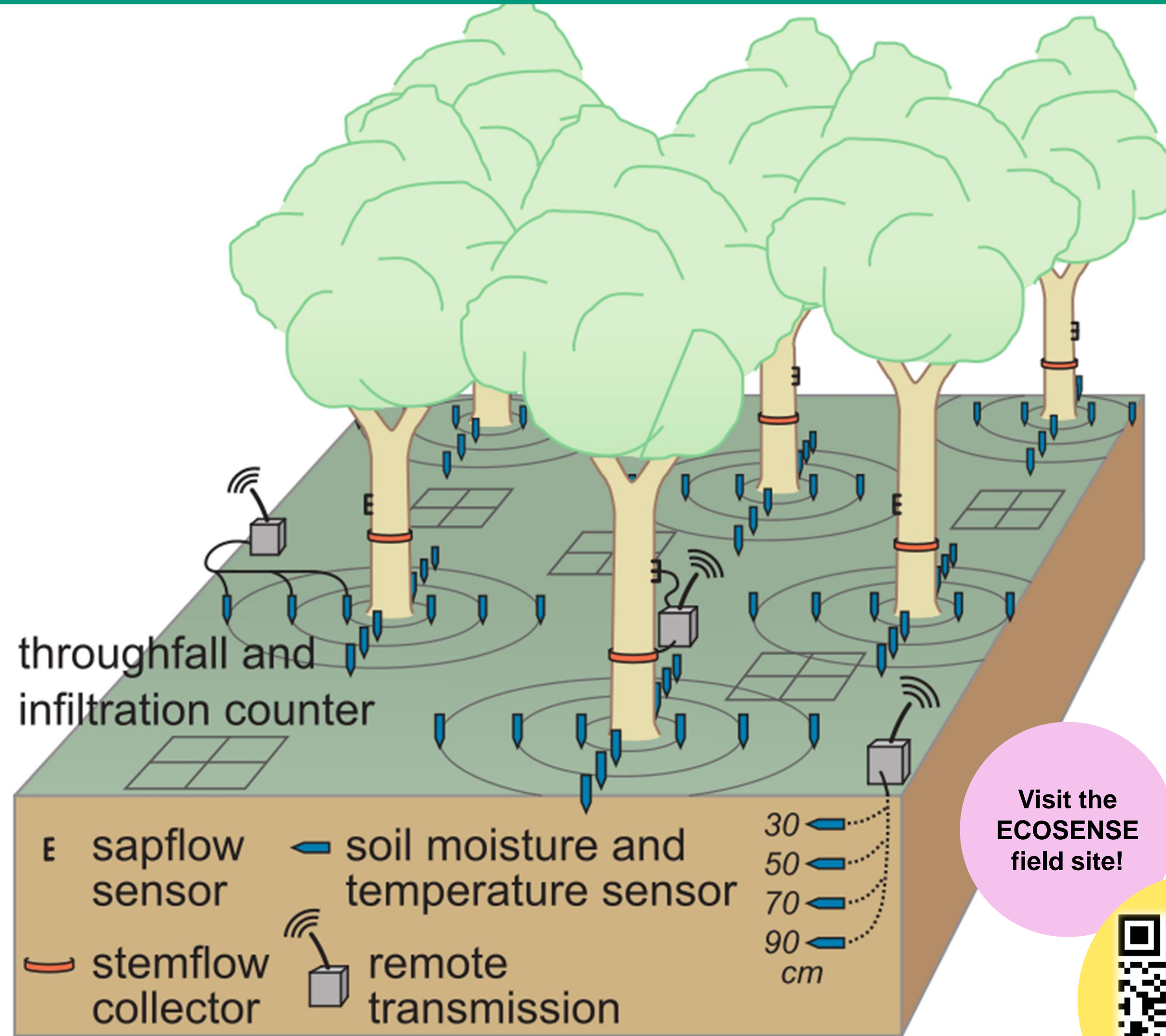
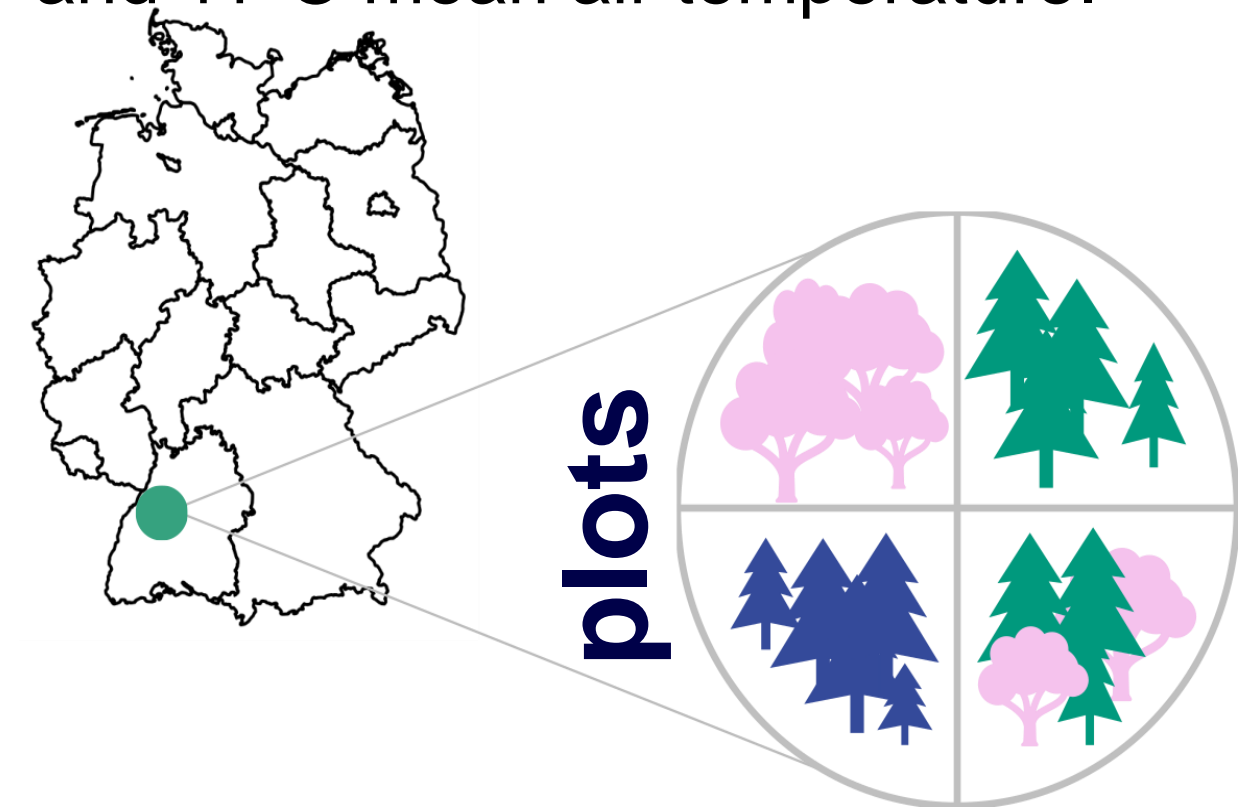
Hydrology in Forests



Ecohydrological Sensor Network

Study site

- ◆ ECOSENSE experimental forest at Ettenheim between the Rhine valley and the Black Forest.
- ◆ Pure forest stand of beech, Douglas & silver fir and mixed stand of beech and Douglas fir (50-70 yrs).
- ◆ Podsoles and luvisols on sandstone.
- ◆ Annual precipitation of 820 mm and 11°C mean air temperature.



- ◆ 480 **soil moisture** sensors near surface and in depth profiles
- ◆ 54 **sap flow** sensors
- ◆ 60 **throughfall and infiltration** boxes (including 240 tipping bucket counters)
- ◆ 12 **stem flow** measurements
- ◆ 4 **throughfall** troughs
- Measurement design:
 - ◆ Tailored design of **grids, transects & random positions** to observe different spatial resolution and process dependencies
 - ◆ **Continuous measurements** of all fluxes and states
 - ◆ **Real-time data transmission**
 - ◆ Large **complementary database** for ECOSENSE site available: soil ecology, meteorology, plant physiology, remote sensing, forestry.

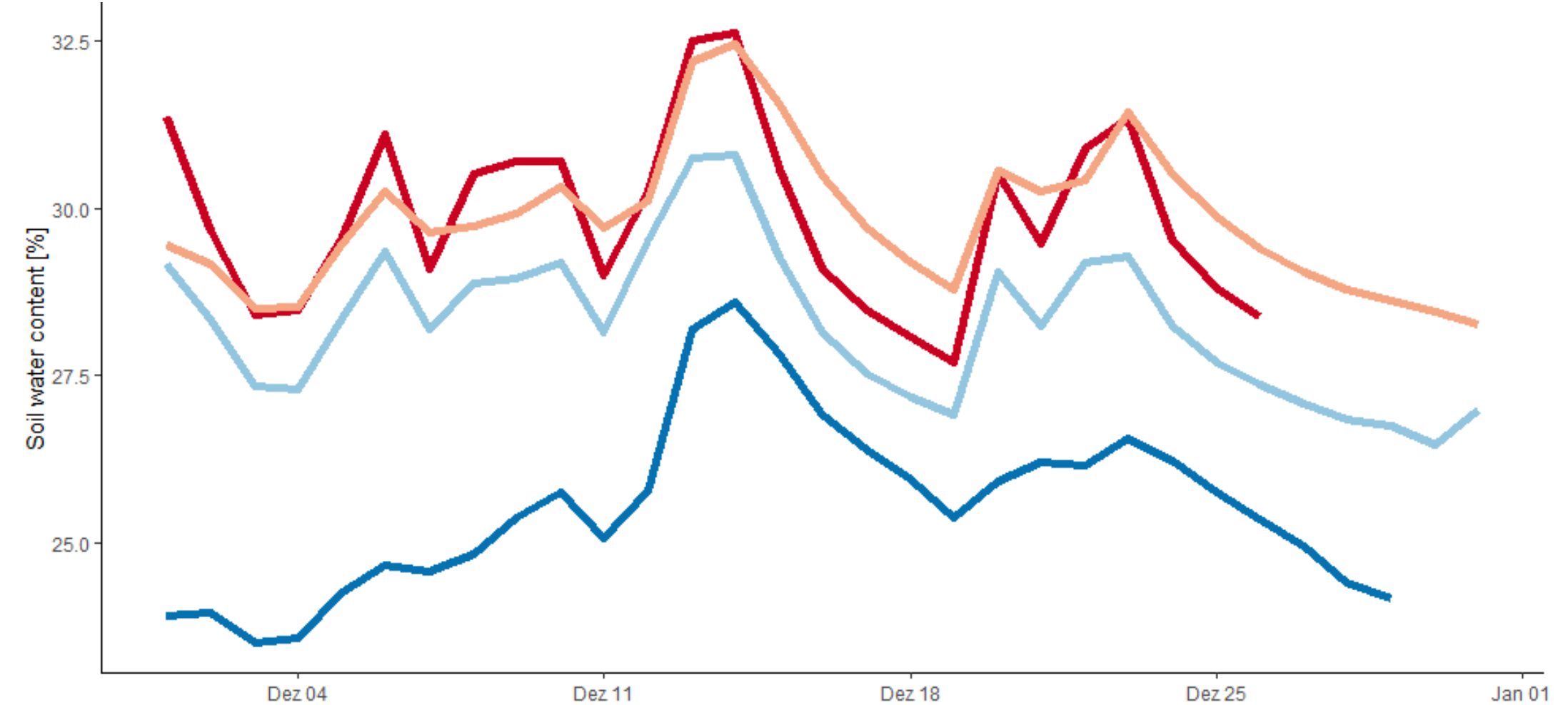
Experimental set-up

First Results

Data analysis

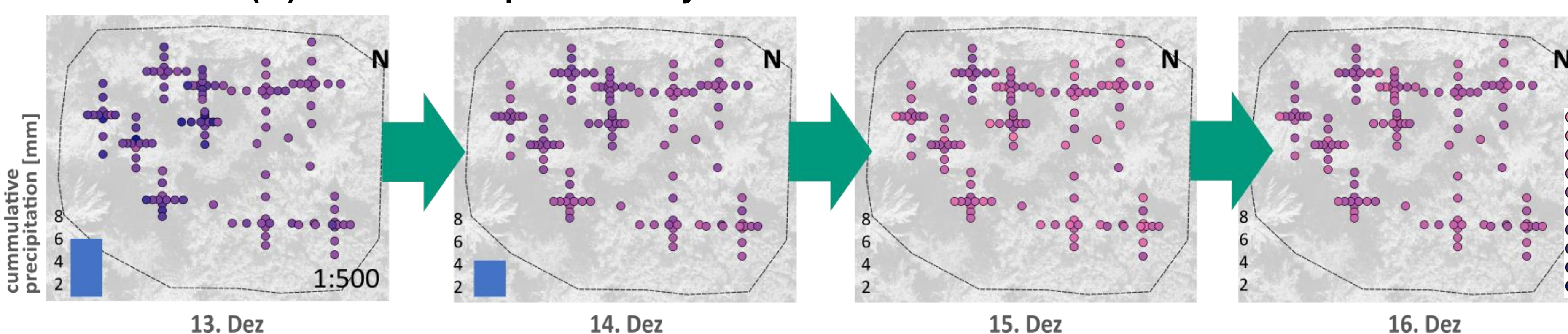
- ◆ **Geostatistical analysis: Spatio-temporal analysis** from events to long-term dynamics from tree to plot scale
- ◆ Aim: Data driven models to derive ecohydrological fluxes

Daily median soil water content near surface in the four plots (beech, Douglas fir, silver fir, beech & Douglas fir) during December 2023



- ◆ Within a mixed stand soil water content near the surface increases **spatially heterogeneous** during precipitation
- ◆ **Canopy** of the mixed stand **redistributes rain**: positions below Douglas fir show higher change of soil water content than positions below beeches
- ◆ Changes of soil water content below Douglas fir and beech during the days after rain indicate **varying percolation rates**

Spatio-temporal dynamics of near-surface soil moisture during and after a rain event in a mixed stand (beech & Douglas fir) in December 2023 at the ECOSENSE field site - colour indicate the change of soil moisture (%) in relation to previous day median



Next Steps

- ◆ Compare measured **throughfall, stemflow & soil moisture** patterns
- ◆ Determine influence of rainfall redistribution by the canopy
- ◆ Characterize **relation of tree transpiration, root water uptake & soil moisture** variability for different tree species
- ◆ Investigate **facilitative and competitive interaction** among different tree species and/or individuals
- ◆ Identify persisting **hot spots** and the **dominating controls** under dry & wet conditions

Detailed analysis

References: DWD (2024): Klimakarten Deutschland