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Water balance and growth relations of a pine stand in a large lysimeter in Eastern Germany

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Forest ecosystems play an important role for the hydrological cycle, in particular for ground water recharge and catchment runoff. This paper focuses on the relations between water balance and growth variables of a pinus sylvestris stand on a large lysimeter in Colbitz, East Germany. The lysimeter is circular shaped and has a cross sectional area of 660 m2 and a depth of 4.30 m. The lysimeter was packed with a gravel layer of 30 cm thickness at the bottom and filled up to the top with sand. 2 year old pinus sylvestris plants were planted in 1974. Lysimeter drainage, precipitation, mean air temperature, relative humidity, wind speed and global radiation were recorded from 1974 until today. In 1995 the lysimeter was equipped with tensiometers and additional rainfall gauges to assess water flow dynamics within the lysimeter. The pine stand was thinned in spring 1995 and tree ring analysis were carried out at tree height of 0.3, 1,3, 3.3, 5.3, 7.3, 9.3, and 11.3 m. From this stem volume, stem diameter and height growth were estimated for single trees. Because of the daily records the water balance can be calculated at different temporal resolutions and related to annual tree growth parameters. Climatic data were used to determine daily potential evapotranspiration. Monthly, seasonal and annual values of precipitation, potential evapotranspiration and lysimeter drainage were correlated with growth variables. The climatic water balance of the growing season correlated well with annual height growth of single trees. This empirical analysis points to the relevant water balance and growth indicators for modeling the water balance growth relations. Water balance modelling was done by using simple mass balance relations to obtain a physical meaningful and at the same time simple model formulation. A simple single-store capacitance model using a simplified representation of vegetation growth successfully replicated observed annual and inter-annual trends. Errors in the timing of predicted drainage at sub-annual timescales were reduced, but not eliminated, by expansion to a multiple-store model incorporating snow processes, and reflect an inherent limitation of the capacitance model approach when applied to drainage prediction at sub-annual resolutions. In contrast to the simple bucket model, a wetting front model could describe the delay time between a marked change of the climatic boundary condition and the lysimeter outflow data.