Application of the process based forest model 4C for analysis of hydrological fluxes at Level II sites in Brandenburg

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Introduction

The objective of the Pan-European Programme for Intensive and Continuous Monitoring of Forest Ecosystems (Level II) is the investigation of state and development of forests under the influence of air pollution, and climatic factors. Corresponding model investigations can support the analysis of the extensive data. Furthermore, the data from such intensive monitoring plots are a good basis for model validation.

Model Tool

The succession model **4C** (Fig. 1) describes the growth dynamics depending on climate and deposition (see also poster "*Sensitivity of Simulated Forest Growth to Changes in Climate and Atmospheric CO_2*").

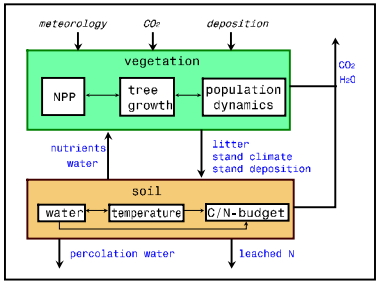


Figure 1: *Structure of model 4C*

The soil model of 4C consists of a water, temperature, and carbon/ nitrogen submodel. Following the soil horizons the soil is divided into layers of varying thickness. The demand of trees for water and nutrients is satisfied according to the root distribution in the soil layers.

Short characteristic of soil submodels

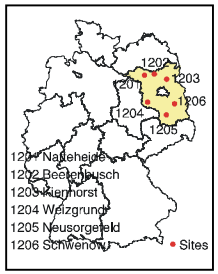
Driving forces: air temperature, net precipitation, and N deposition beneath the canopy

Soil water: percolation model with soil texture depending percolation parameter

Soil temperature: one-dimensional heat conduction equation considering specific heat capacity, bulk density and actual water content

C/N turnover: mineralisation and nitrification of different compartments of organic matter influenced by water content, soil temperature, and pH

Validation of Soil Water Model



At six Level II sites with managed pine forest stands in Brandenburg, Germany (Figure 2) the soil water submodel has been validated with measurements from 1996 – 1999. The site-specific parameters are derived from the soil profiles; the pine stands are initialised with inventory data from 1994. Driving forces are daily, meteorological data measured on a clearing in the forest.

Figure 2: *Level II sites in Brandenburg*

Figure 3 shows exemplarily the comparison between simulated and measured water content in 20 and 70 cm depth at the site Natteheide in North Brandenburg.

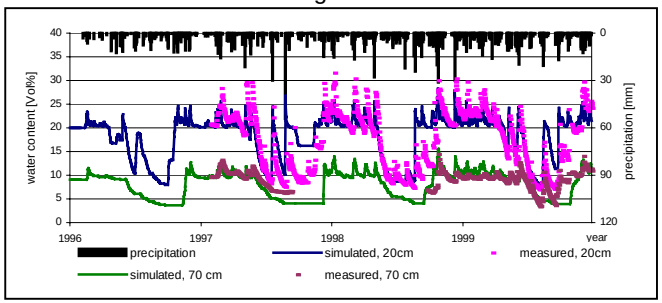


Figure 3: *Simulated and measured water content in two depths and precipitation at the pine forest site Natteheide, 1996-1999*

The model reproduces the general pattern in soil water content as well as the minima and maxima. However, during high precipitation events the comparison shows the need of further improvements in percolation and uptake modelling.
For the other five sites similar results have been obtained (see table below with correlation coefficient between measured and simulated values).

Depth	1201	1202	1203	1204	1205	1206
20cm	0.78	0.64	0.82	0.80	0.81	0.74
70cm	0.75	0.72	0.90	0.80	0.70	0.52

Water budget

All six sites are stocked with managed pine forests on sandy soils, partly with some loam or clay. Differences exist in age, stand density and rooting depth and therefore in the water holding capacity of the rooting zone.

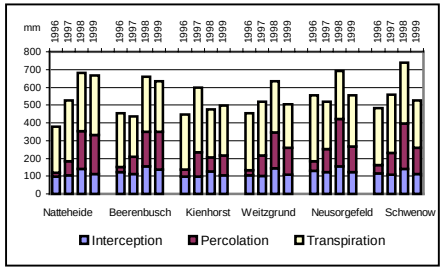


Figure 4: *Simulated yearly water budget of six sites in Brandenburg*

In Figure 4 the inter-annual variability of the relation of simulated water budget components can be seen. In dry years the percolation percentage of water budget is higher than in wet years. The oldest stand Kienhorst has the lowest percolation because the transpiration is clearly higher (61%) than at the other sites (51-56%) and the site has the lowest precipitation.

A second simulation was carried out with a reduction of precipitation of 20% at all sites. The results underline the effect mentioned above. There is a little increase in percentage of interception (+4%) and transpiration (+3%) and a decrease in percolation (-7%). Figure 5 shows the changes in respective means for all sites.

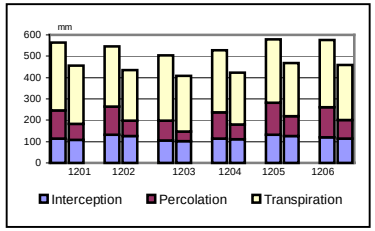


Figure 5: *Simulated yearly water budget (mean of period 1996-1999)*
I – with measured meteorological data
II – with precipitation reduction (20%)

The model **4C** is able to simulate the water budget in forests realistically. The presented analyses point out the importance of model application for the evaluation of water balances in forests under changing environmental conditions.

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