Impacts of climate change on water balance of forest sites in Rhineland-Palatinate / Germany

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Introduction

It is expected that global climate change will influence the water balance of forest stands in Rhineland-Palatinate (SW-Germany) and consequently their biomass productivity. The regional forest agency in Rhineland-Palatinate uses precipitation as primary climate parameter to detect the water balance degree of a site. It is assumed, that the existing correlation between climate parameters and water balance should be revised in order to assess the impact of climate change.

Methodology

Because appropriate measured data is not available, a model based approach is developed in cooperation with forestry specialists, which allows to integrate the impact of climate change on water balance degree and quasi on biomass productivity in forest management planning.

At first the WaSiM-ETH 8.2 model is parameterised for a standard tree species (100-year old beech), while exposition, slope and available water capacity (AWC) is varied (fig.1). Simulations are restricted to a single cell. The main goal is to resemble natural variations in a plausible way.

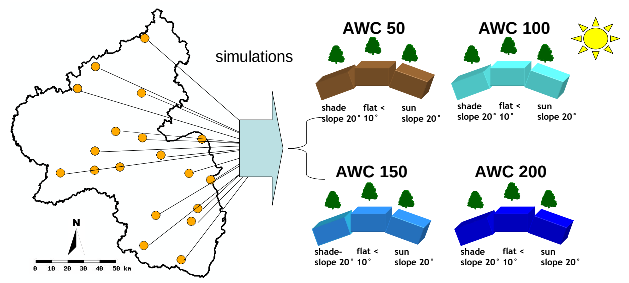

fig.1: scheme for simulation of stand variations in Rhineland-Palatinate with WaSiM-ETH 8.2

Data sets of the German meteorological service (DWD) are used to quantify the current site reactions. Accordingly, WETTREG projections (2050/2100) for Rhineland-Palatinate are used to indicate the spectrum of climate change.

Furthermore different drought stress indices are applied to the simulated water balance time series. The drought stress indices help quantifying the intensity, duration and frequency of dehydration periods.

Results

With the chosen parameterisation different water balance conditions can be simulated (fig.2–fig.4). A site with a high available water capacity dries out less intense in case of aridity than a site with low ones. For a south-exposed site the soil water deficit becomes higher than for a north-exposed site of the same slope.

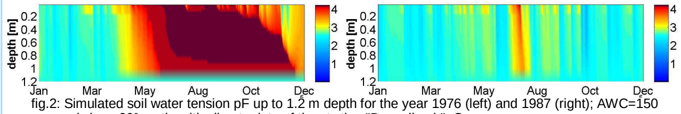

fig.2: Simulated soil water tension pF up to 1.2 m depth for the year 1976 (left) and 1987 (right); AWC=150 mm and slope 20° south, with climate data of the sta tion "Deuselbach", Germany

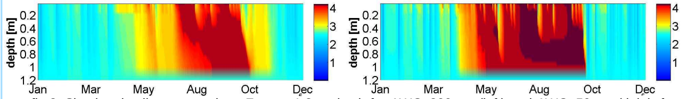

fig.3: Simulated soil water tension pF up to 1.2 m depth for AWC=200mm (left) and AWC=50mm (right), for slope 20° south in 1982, with climate data of the st ation "Deuselbach", Germany

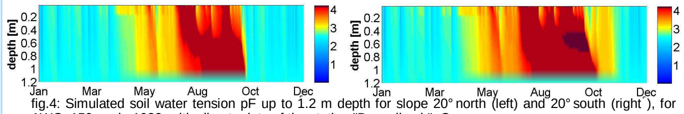

fig.4: Simulated soil water tension pF up to 1.2 m depth for slope 20° north (left) and 20° south (right), for AWC=150mm in 1982, with climate data of the station "Deuselbach", Germany

All indices detect years with drought stress but there are clear differences in characteristics. Index BWD15, BWd9 and pF are more selective in contrary to ETDiff (fig.5, fig.6). By combining different indices it is possible to detect the character of drought stress.

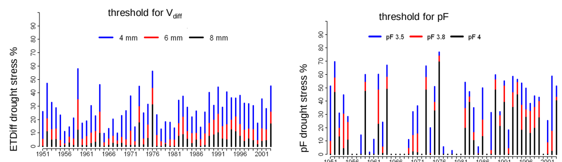

fig.5: drought stress indices ETDiff (left) and pF (right), for a site with a slope of 20°, south-expos ition and an available water capacity of 150 mm; period 1951 to 2003; climate station "Deuselbach", Germany.

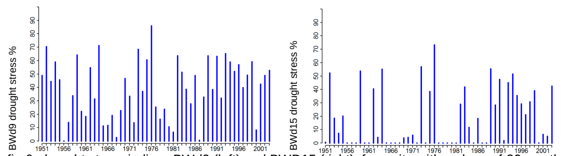

fig.6: drought stress indices BWd9 (left) and BWD15 (right), for a site with a slope of 20, south-exposition and an available water capacity of 150 mm; period 1951 to 2003; climate station "Deuselbach", Germany.

Exemplarily calculations for future scenarios (Wettreg, A1normal, 2061-2100) show for BWd9 a clear shift to higher frequencies of drought periods in comparison to reference scenario (fig.7). Today's fresh forest conditions on a soil with 100 mm AWC will be found in future (2061–2100) on a soil with 200 mm AWC, after the Wettreg scenario A1normal (fig.8). Very fresh stands will be delayed up to 3.5 steps, while very dry stands will be delayed up to 2.5 steps for the Wettreg scenario A1normal (2061–2100).

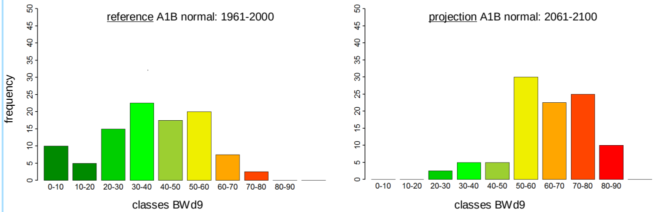

fig.7: Histogram of drought stress index BWd9 for **left**: simulations with reference climate data (1951 - 2000) and **right**: simulations with climate projections (2061-2100); slope of 20°, south-exposition and AWC=150 mm; climate station Deuselbach", Germany.

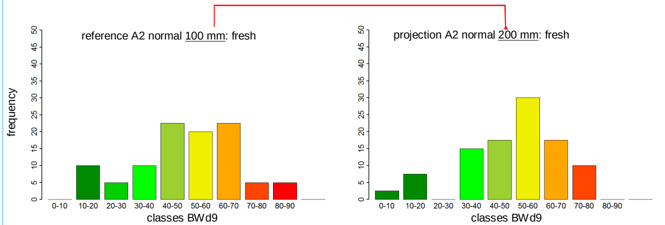

fig.8: Histogram of drought stress index BWd9 for **left**: simulations with reference climate data (1951 - 2000) for AWC=100mm and **right**: simulations with climate projections (2061-2100) for AWC=200 mm; slope of 20°, south-exposition, climate station Deuselbach", Germany.

Outlook

- comparison of drought stress results with measured biomass productivity data in order to detect best fitting index, simulations for Level2-stands
- transfer of plot based simulation results to Rhineland-Palatinate in dependency on temperature and precipitation
- simulations with further soil types and different land uses
- automatically classification of simulation results (frequency of drought stress) to water balance degrees

References

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