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НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

Монография в 5 томах

Том III Мониторинг и моделирование ландшафтов

В содружестве с Академией почвенного плодородия Митчерлиха (МИТАК), Паулиненауэ, Германия

Москва 2018
Main editors: Viktor G. Sychev and Lothar Mueller

NOVEL METHODS AND RESULTS OF LANDSCAPE RESEARCH IN EUROPE, CENTRAL ASIA AND SIBERIA

Monograph in 5 Volumes

Vol. III Landscape Monitoring and Modelling

With friendly support of the Mitscherlich Academy for Soil Fertility (MITAK), Paulinenaue, Germany

Moscow 2018

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Монография содержит информацию о самых современных методологиях и результатах в ландшафтных исследованиях. Она может быть использована в качестве руководства для исследователей, преподавателей, студентов и всех, кого интересует тема ландшафтной науки и смежных дисциплин. Монография является особо ценной информационной базой для лиц, принимающих решения на различных уровнях, от местных до международных органов по принятию решений. Приведенная в монографии информация представляет собой современный уровень ландшафтной науки в очень краткой форме.

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This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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Chapter III/62: MODELLING THE IMPACT OF FOREST CONVERSION ON GROUNDWATER RECHARGE UNDER A CHANGING CLIMATE

Глава III/62: Моделирование влияния конверсии лесов на питание подземных вод в условиях изменяющегося климата

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DOI 10.25680/9746.2018.54.92.255

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ABSTRACT. Groundwater recharge is an important factor for the landscape water balance. In forested catchments groundwater recharge is controlled by complex interactions between climate, soil and vegetation. In this paper we analysed the impact of forest management and climate change on groundwater recharge in a small forested lowland catchment in Germany. We used the water balance model WaSim-ETH with different forest development and climate change scenarios to distinguish between the impact of vegetation and climate on the groundwater recharge. The climate change scenario results show a decrease in groundwater recharge by 26% (REMO-B1) and 44% (REMO-A1B). Depending on the amount of conversion, the forest conversion from coniferous trees to broadleaf trees increases the groundwater recharge. Thus, the forest conversion helps to attenuate the impact of climate change to groundwater recharge.
INTRODUCTION

Currently, forest landscapes in North-East Germany are mostly dominated by pine monocultures. In the eastern parts of this region, the mean annual precipitation is low with about 600 mm. In addition, the predominant sandy soils have a low water storage capacity. Among these pine forests only a very small groundwater recharge occurs. The already limited groundwater recharge was significantly reduced by 113 mm/yr from 1958 to 2007 due to change in climate and conversions of the forest structure [1] with considerable consequences for the groundwater- and lake level.

Currently the regional forest administrations organized the expansion of the share of broad-leaved trees among mixed deciduous forest in future [2]. With a change of pine-dominated silviculture to broad-leaved species, long-term changes in groundwater recharge are expected. Because the long-term nature of a forest conversion, such a conversion and in consequence the groundwater recharge can be affected by changes in climate. Relevant climate projections suggest an increase of water scarcity for this region up to the year 2100 [3].

Many studies observed the influence of land use changes on the water balance of catchments. The most paired catchment studies analyse the impact of clear-cut or pronounced conversions from forest to agriculture [4]. Only a few consider actual forest conversions with their dynamic aspects.

In this paper, we analyse the impact of forest conversion on groundwater recharge in a lowland catchment of North-East Germany. We use a model-based approach with two forest conversion scenarios, which are based on realistic conditions, as they consider stand age of trees, economic rotation time and good silvicultural practice, as well as soil and climate conditions. Due to the long periods of the forest conversion, our approach takes into account the interactions with possible climatic changes. We quantified how the impacts of forest and climate amplify or attenuate each other.

MATERIAL AND METHODS

The study area is located in North-East Germany, about 50 km northeast of Berlin. Its hydrologic conditions and the hydrogeology are detailed in [1] and [5] respectively. Predominant soils are sandy Cambisols, in part clayey and Cambisol/Podzols. Forests are dominated by a pine monoculture (Pinus sylvestris) [1]. The climate is characterized by a long-term (1958–2007) mean precipitation of 529 mm/yr, a mean air temperature of 8.6 °C and a mean grass reference evapotranspiration after Penman-Monteith of about 570 mm/yr (at Angermünde, about 10 km southeast of the study area).

The future developments of groundwater recharge and water levels are governed by changes in climatic boundary conditions and a transition from pine monoculture to broad-leaved trees. The physically based and fully distributed water balance model WaSiM-ETH was used to investigate the impact of possible changes on the hydrologic cycle of the catchment. The used catchment model was build up, tested and successfully used to analyse changes in the past as presented in [1]. The combination of different forest development scenarios and climate scenarios was used to distinguish individual effects.

Possible developments of the water balance were simulated under the influence of climate change and forest conversion until 2100. The regionalised climate scenarios of the REMO-model A1B and B1 were used as climatic boundary conditions [6, 7]. Bias correction after [8] minimized systematic errors in the scenarios. Therefore observed time series for the control period 1951–2000 where compared with the
REMO-C20 climate data [9]. Differences in amount and frequency were used to adapt the future climate scenarios.

Two forest conversion scenarios, developed by [10] within the BMBF Research Project NEWAL-NET, were chosen as a basis for this study. Both scenarios are based on the observed forest status of the year 2006. They include five development states in 20-year-intervals starting 2020. One of these scenarios is the sustainable forest development, adapted to currently discussed climate change scenarios (ADAPT). The second forest scenario (CONT) delineates the continuous development following actual administrative rules. Both scenarios include a development from coniferous trees to broadleaf trees. But the conversion of forested area is in the ADAPT scenario much stronger than in the CONT scenario, 57% and 23% respectively. After the first 20-year period trees are cut at about 30% of forested area. In the next 20-year periods the cutting areas are smaller at about 15% of forested area.

Besides the two development scenarios ADAPT and CONT, a third scenario assumes that the forest stand structure remains unchanged since the reference year 2006 (STAT). Thus, changes in groundwater recharge over time will be induced only by climate change.

RESULTS AND DISCUSSION

Bias correction of climate scenarios. The precipitation in the control period (1951–2000) was 11% overestimated in the REMO-C20 (Tab. 1). The bias correction leads to a reduction of mean precipitation for the climate scenarios. The daily air temperature was in the REMO-C20 in average also higher than the observed one. In contrary relative humidity and sunshine duration were underestimated in the REMO-C20. Mean wind speed was well mapped. The differences between REMO-C20 and observed values underline the importance for bias correction as a first step using climate scenarios.
Table 1. Comparison of observed and modelled meteorological data (control period 1951 – 2000) and original and bias-corrected meteorological data (years 2001 – 2100) of REMO scenarios A1B and B1 in the study area

<table>
<thead>
<tr>
<th></th>
<th>REMO 20C</th>
<th>Obs.</th>
<th>A1B original</th>
<th>A1B bias corrected</th>
<th>A1B original</th>
<th>B1 bias corrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual precipitation in mm · yr⁻¹</td>
<td>678</td>
<td>609</td>
<td>689</td>
<td>719</td>
<td>646</td>
<td></td>
</tr>
<tr>
<td>Mean daily air temperature in °C</td>
<td>9.0</td>
<td>8.3</td>
<td>10.8</td>
<td>10.3</td>
<td>10.3</td>
<td>9.8</td>
</tr>
<tr>
<td>Mean relative air humidity in %</td>
<td>70</td>
<td>79</td>
<td>65</td>
<td>76</td>
<td>66</td>
<td>77</td>
</tr>
<tr>
<td>Mean relative sunshine duration in %</td>
<td>32</td>
<td>36</td>
<td>33</td>
<td>34</td>
<td>34</td>
<td>35</td>
</tr>
<tr>
<td>Mean Wind speed in m · s⁻¹</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Climate impact without forest conversion – STAT-scenario. With the assumption of a stationary forest vegetation over the whole modelling time the modelled mean groundwater recharge under the forest area decreases from 91 mm/yr (1958 - 2007) to 48 mm/yr and 65 mm/yr with REMO-A1B and REMO-B1 respectively (2008 - 2100). Only in the forests far from the groundwater table the evapotranspiration does not increase due to limited soil water storage, but the water stress during summer increases. Using the regionalised climate change scenarios, evaporation from lake surface increases more than 100 mm/yr, and a similar situation occurs in sufficiently water supplied wetlands.

![Figure 2 - Groundwater recharge of land use scenarios (STAT, CONT, ADAPT) and climate scenarios (A1B, B1) scenarios ADAPT and CONT.](image.png)

Impact of forest conversion. A forest conversion can have positive effects on groundwater recharge. The scenario CONT, which corresponds to the actual administrative rules for forest conversion, has already provided a 36 mm/yr higher groundwater recharge under the forest area as the scenario STAT with the stationary forest vegetation. The scenario ADAPT with an adaptable forest conversion has, compared to the scenario CONT, in average a 20 mm/yr and 45 mm/yr higher groundwater recharge after 2080 in the climate scenarios A1B and B1 respectively.

CONCLUSIONS
1. With the help of modelling we can distinguish between the impact of climate and vegetation changes on the groundwater recharge.
2. Climate change described by scenarios will decrease the groundwater recharge in the study area if no forest conversion was carried out.
3. An adapted forest conversion can stabilize the groundwater recharge.
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Chapter III/63: MODELLING FRESHWATER HABITATS AND THEIR MACROINVERTEBRATE COMMUNITIES
Глава III/63: Моделирование пресноводных сред обитания и их макробеспозвоночных сообществ

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ABSTRACT. For a simulation of freshwater habitats, it is important to link landscape and instream processes. Therefore, a methodology is developed to jointly simulate catchment, instream and habitat-defining processes at different scales. Hydrologic and hydraulic processes, as well as ecologic methods, are technically coupled and depicted in one simulation approach. The simulation results, which define the riverine habitat, have been validated across these different scales. The model framework allows the prediction of species occurrences, as well as the community structure based on the simulated environmental parameters from the landscape to the microhabitat. We show that the approach is applicable across different ecoregions and also list further challenges towards a holistic simulation of freshwater ecosystems.