Analyses of forest ecosystems response to climate change at Level II monitoring sites

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Background

In the framework of the Forest Focus project '*Calibration and validation of simulation models using measurements at intensive monitoring plots and scenario analysis to the impact of climate change on the carbon budget of forest ecosystems*' a collaboration between PIK, ZALF and LFE was established for a comparative model-based analysis of forest ecosystems at the monitoring plots of the Level II programme. The main objective of the project is to investigate how the use of Level II data for model tests and model applications aiming at the understanding of forest carbon budgets can be enhanced.

The forest dynamics model 4C

The forest dynamics model 4C (Lasch et al. 2005) was used to analyse the carbon balance of forest stands under current climate and climate change scenarios. 4C simulates the water, carbon and nutrient budget in the forest ecosystem including soil as well as stand dynamics described i.e. by litter fall, height and diameter growth depending on environmental conditions. The model was successfully applied for analyses at the Level II plots in Brandenburg (Suckow et al. 2001; Suckow et al. 2002), Saxony (Suckow et al. 2003) and Baden-Württemberg (Suckow et al. 2005).

Sites and data

A variety of forest stands at Level II sites in Brandenburg, Lower Saxony and Bavaria were selected. Data from obligatory and facultative measurements were available from the Level II database (BFH, Hamburg) as well as directly from the operating institutions (LFE, Eberswalde, LFW, Freising, NW-FVA, Göttingen). For the following analyses 3 sites were selected, described in Table 1.

Table 1: Site and stand characteristics of selected Level II monitoring sites

Site	Species	Location	Soil type	Age	DBH	HO	N
Kienhorst (1203)	Pine	Brandenburg	Podzol	90 (1994)	32.8	24.	371
Solling (304)	Beech	Lower Saxony	Dystric Cambisol	131 (1980)	42.1	29.1	230
Flossen-bürg (908)	Spruce	Bavaria	Haplic Podzol	75 (1995)	30.2	25.3	511

Validation of stand dynamics

For the plots Kienhorst and Solling measured data of aboveground biomass and foliage litter fall for several years were available from the Level II data base at BFH (1994- 2004) as well as from additional measurements which are not stored in the data base (Solling: 1981- 2004). We initialised the site Kienhorst with stand data from 1994 and Solling with stand data from 1980 and ran 4C-simulations for 11 and 24 years respectively. The comparison of measured and simulated data is presented graphically (Fig. 1and 2).

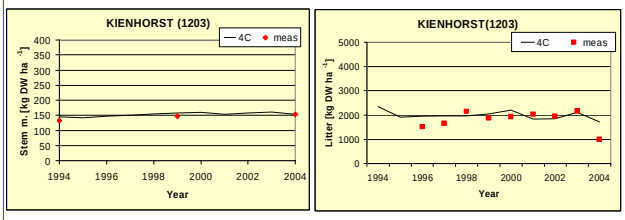


Fig. 1 Comparison of measure and simulated stem biomass and annual foliage litter fall (1994-2004)

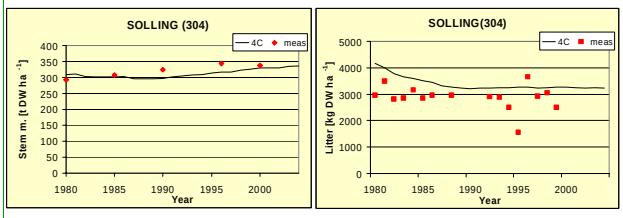
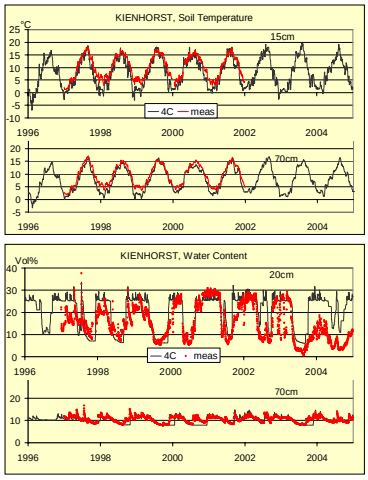


Fig. 2 Comparison of measured and simulated stem biomass and annual foliage litter fall (1980-2004)

Validation of water fluxes/ soil temperature



Continuous measurements of soil water and temperature are an important means for testing the simulation of soil humidity and temperature that control mineralization rates and growth limitation through water availability.

The validation of the soil temperature and water budget simulated by 4C is exemplified at the site Kienhorst (Fig. 3). The perennial series of measurements represent a variety of meteorological conditions and 4C is essentially able to reproduce these measurements.

Deviations of measured from simulated soil water and temperature dynamics are sensitive to parameterization of soil physical properties. Addition of measurements of these properties to the standard program would increase the value of the data base a lot.

Fig. 3 Comparison of measured and simulated soil temperature (above) and water content (below) in 15 resp. 20cm and 70 cm depth (1996-2004)

Conclusion

- Data from the obligatory measurements at the level II plots are suitable for the validation of models describing short-term processes in forest models like soil water and soil temperature, and stand dynamics.
- For the evaluation of models of carbon fluxes and stand dynamics the measurements should be intensified (litter fall, soil water and temperature at representative sites) and additional measurements (soil physical properties) included respectively.

Carbon stock changes under climate change

Climate scenarios and simulation experiments

Table 2 Climate characteristics of scenarios

	1203 (Kienh.)		908 (Flossenb.)	
Climate	Friedrichswalde		Mähring	
	T [°C]	P [mm]	T [°C]	P [mm]
CC	8.2	583	5.8	849
Sc1	9.9	561	7.4	762
Sc2	**9,9**	**556**	**7.5**	**784**
Sc3	9,9	561	7.5	787

The used 3 climate scenarios for 2 assigned meteorological stations were generated for the BMBF-project GLOWA-Elbe II at PIK using the global trend of about 2 K temperature increase until 2055. Sc2 was classified as the most probably scenario, CC represents the current climate 1951-2002 (Table 2).

The climate change scenarios were combined with the assumed increase in atmospheric CO_2. The model 4C was run 52 years (1951-2002; 2004-2055) with the stand initialisation from 1999 (Flossenbürg) and 2004 (Kienhorst) without simulation of management interventions. Final carbon stocks of soil, deadwood and stem biomass were compared (Fig. 4).

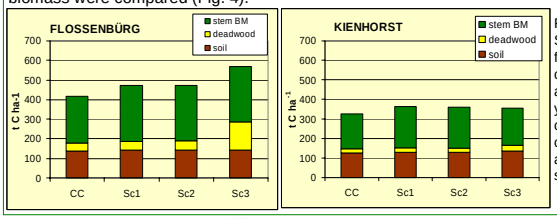


Fig. 4 Simulated final state of carbon pools after 52 years under current climate (CC) and 3 climate scenarios

The final total carbon budget and the annual accumulation rates of carbon in the soil and stems increased under climate change in comparison to the baseline climate simulation for both sites (Fig. 5).

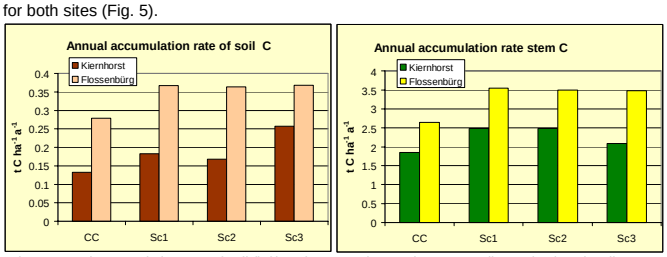


Fig. 5 Annual accumulation rate of soil (left) and stem carbon under current climate (CC) and 3 climate scenarios for Kienhorst and Flossenbürg

Conclusion

- In the near future (several decades) increasing atmospheric CO_2 in combination with longer growing seasons lead to scenarios of increased wood production and C-stocks even if water availability decreases slightly.
- Measurements of aboveground carbon turnover (litter fall) as well as investigations of decomposition of litter and soil organic carbon and belowground biomass turnover are suitable for further model analyses.

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