FIT Student Research Colloquium

Sensitivity analysis of the model BIOME-BGC conducted on ecological forest state control sites (ÖWK) in Brandenburg

April 24th 2008
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Overview

- Process models vs. empirical models
- Introduction to BIOME-BGC
- Processes modelled by BIOME BGC
- Introduction to Sensitivity Analysis
- Study Area
- Methods
- Scenarios
- Results
- Discussion
- Literature

Process Models vs. Empirical models in the context of climate change

Empirical (yield) model

- Simple data requirements
- Parameters encapsulate effects of past climate, not changing climate
- Future growth based on measurements of historic growth
- Climate change is not adequately accomodated

Process model

- High degree of model complexity
- Mechanistic, physiolgical output
- Simplistic silvicultural manipulations
- Research purpose

What are forest process models?

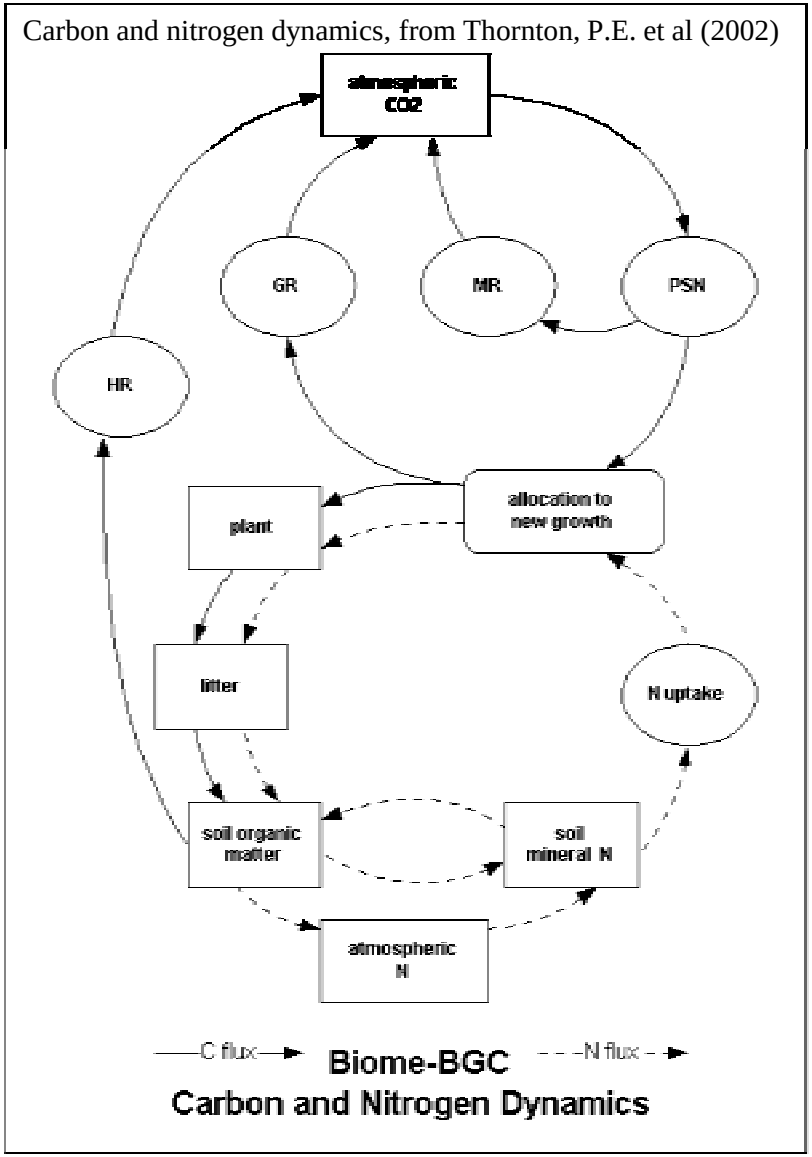
- Mathematical representations of biological systems that incorporate... physiological and ecological mechanisms into predictive algorythms (Johnsen et al. 2000)
- The models must be accurate over long time-periods under dynamic conditions of weather, changing stages of development and changing levels of resource availability

BIOME BGC

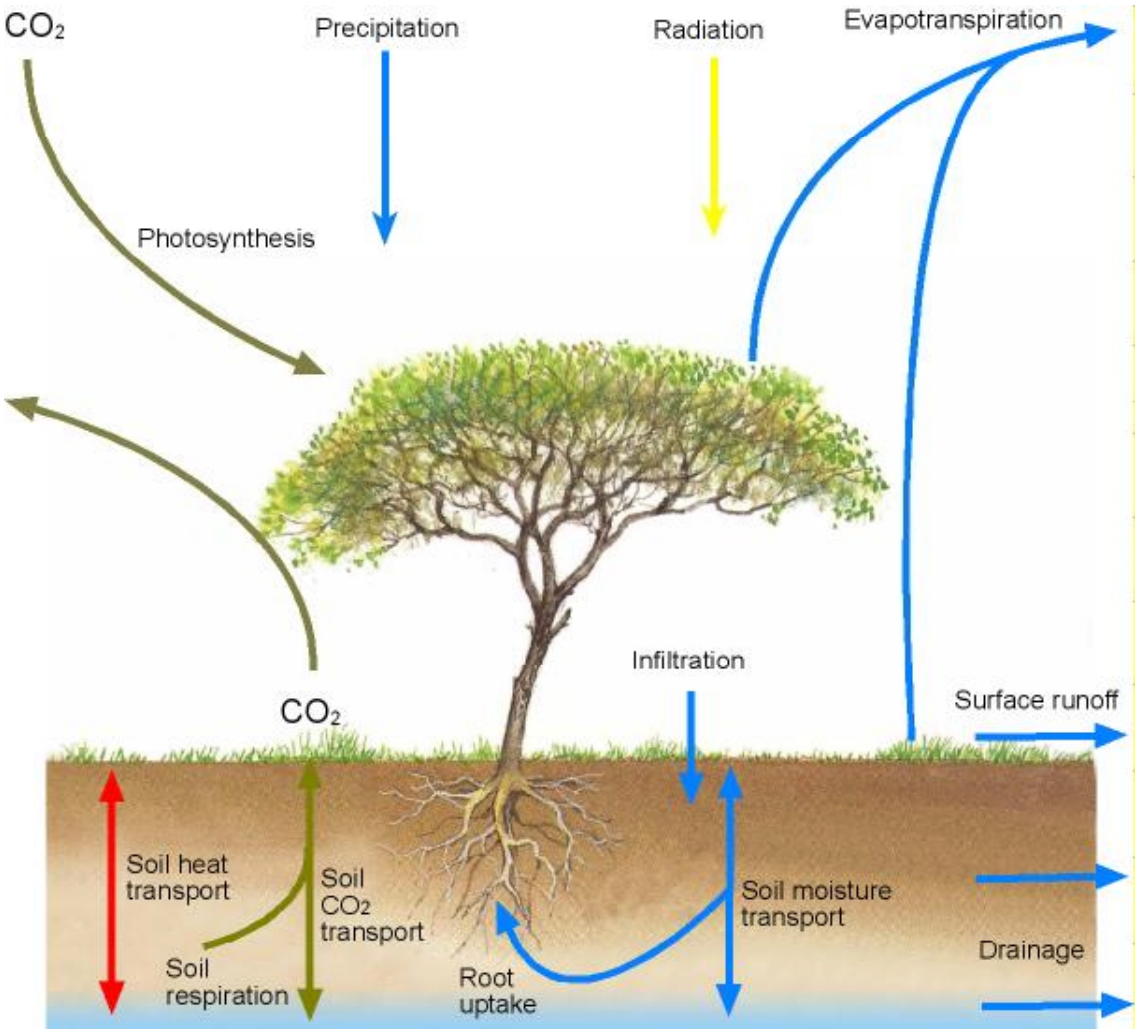
- Biome-BGC is a computer program (C++) that estimates fluxes and storage of energy, water, carbon, and nitrogen for the vegetation and soil components of terrestrial ecosystems.
- BIOME BGC was adapted by researchers at ZALF to consider species and site specific differences (+Integrated management module)
- Biome-BGC Version 4.1.1 was developed and is maintained by the Numerical Terradynamic Simulation Group, School of Forestry, The University of Montana, Missoula, Montana, USA. Additional information can be found on their web site at: http://www.ntsg.umt.edu/.

Processes in Biome-BGC

Carbon and nitrogen dynamics, from Thornton, P.E. et al (2002)



Global soil and vegetation process modelling



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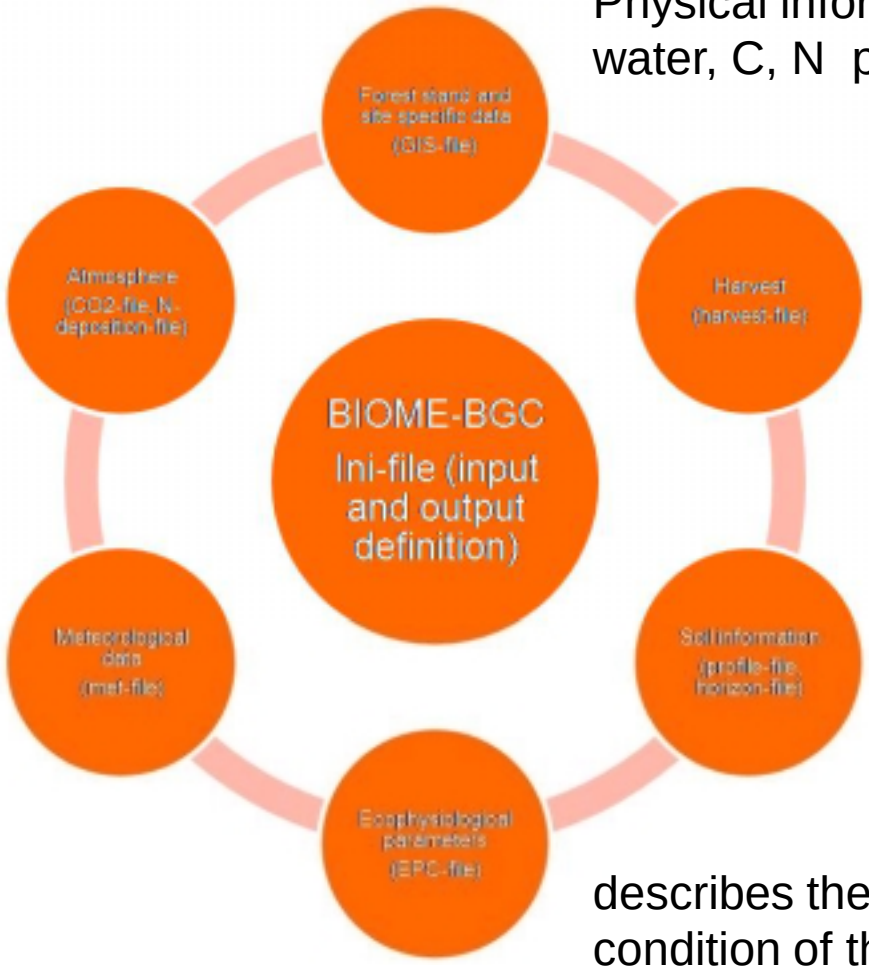
(source: http://www.bgc-jena.mpg.de)

Data flow chart of BIOME-BGC

Physical information: initial values of water, C, N pools

Annual CO2-values



holds daily values for temperature, precipitation, humidity, radiation and day length

describes the ecophysiological condition of the vegetation type

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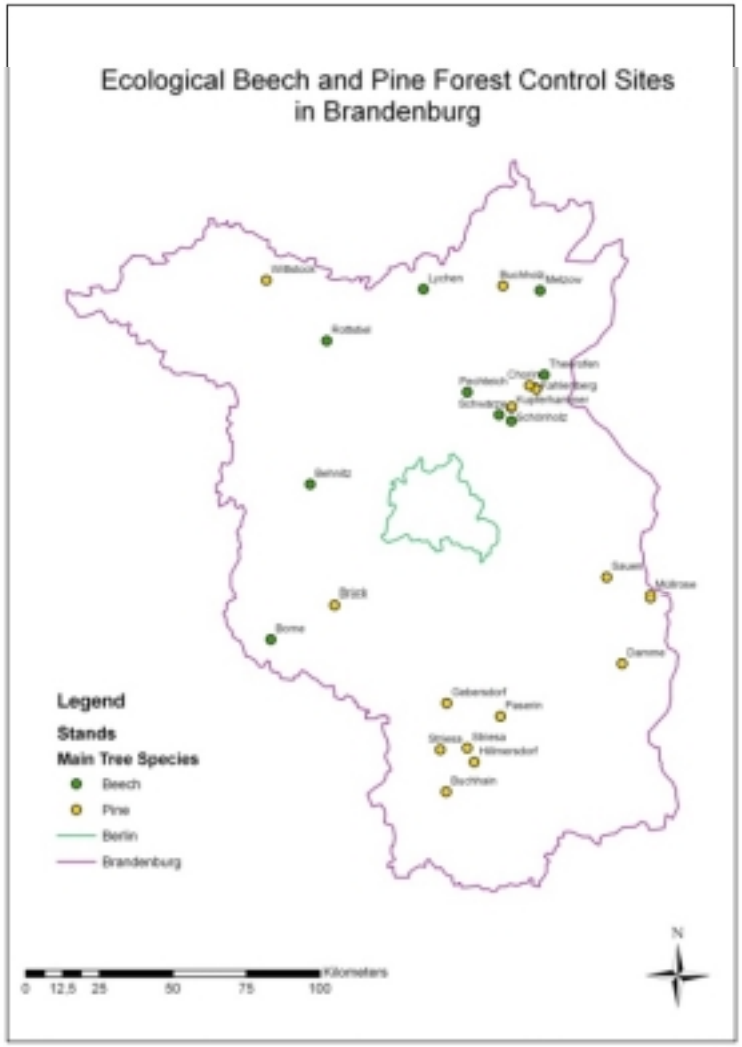
Why Sensitivity Analysis ?

Sensitivity Analysis gives answers:

- - how the model output depends upon the input parameters.
- - the accuracy necessary for a parameter
- - which parameters are useful

Study Area



- Data from Ecological Forest State Control Sites (ÖWK) was analyzed, prepared and processed for simulation with BIOME BGC
- 17 selected pine and 9 beech stands, which belong to a network of 141 Ecological Forest State Control Sites installed between 1986 and 1989

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Methods

- Sensitivity analysis to test how C/N-ratios in biomass compartments influence a set of modelled state and flux variables.
- C/N of leaves, fine root, litter, roots, life and dead wood
- Variables tested were stem growth and net primary production.

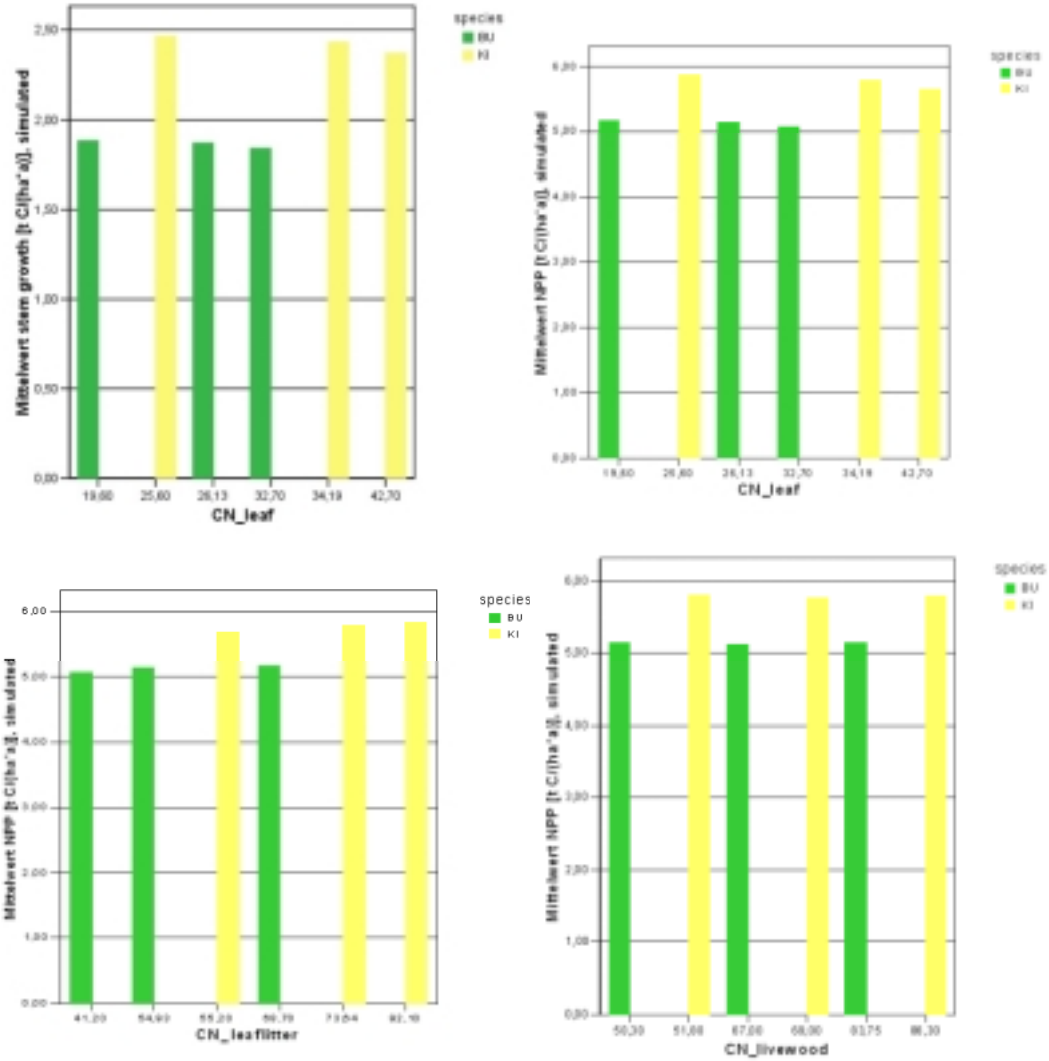
Scenarios

Beech													
Description	01_B_mean_CN_all.epc	02_B_low_CN_leaf.epc	03_B_high_CN_leaf.epc	04_B_low_CN_litter.epc	05_B_high_CN_litter.epc	06_B_low_CN_fineroots.epc	07_B_high_CN_fineroots.epc	08_B_low_CN_coarseroots.epc	09_B_high_CN_coarseroots.epc	10_B_low_CN_livewood.epc	11_B_high_CN_livewood.epc	12_B_low_CN_deadwood.epc	13_B_high_CN_deadwood.epc
C:N of leaves	26.13	**19.6**	**32.7**	26.13	26.13	26.13	26.13	26.13	26.13	26.13	26.13	26.13	26.13
C:N of leaf litter, after retranslocation	54.93	54.93	54.93	**41.2**	**68.7**	54.93	54.93	54.93	54.93	54.93	54.93	54.93	54.93
C:N of fine roots	69.9	69.9	69.9	69.9	69.9	**52.4**	**87.4**	69.9	69.9	69.9	69.9	69.9	69.9
C:N of coarse roots	165	165	165	165	165	165	165	**123.7**	**206.3**	165	165	165	165
C:N of live wood	67	67	67	67	67	67	67	67	67	**50.3**	**83.75**	67	67
C:N of dead wood	413	413	413	413	413	413	413	413	413	413	413	**309.8**	**516.25**
Pine													
Description	01_K_mean_CN_all.epc	02_K_low_CN_leaf.epc	03_K_high_CN_leaf.epc	04_K_low_CN_litter.epc	05_K_high_CN_litter.epc	06_K_low_CN_fineroots.epc	07_K_high_CN_fineroots.epc	08_K_low_CN_coarseroots.epc	09_K_high_CN_coarseroots.epc	10_K_low_CN_livewood.epc	11_K_high_CN_livewood.epc	12_K_low_CN_deadwood.epc	13_K_high_CN_deadwood.epc
C:N of leaves	34.19	**25.6**	**42.7**	34.19	34.19	34.19	34.19	34.19	34.19	34.19	34.19	34.19	34.19
C:N of leaf litter, after retranslocation	73.64	73.64	[illegible]54	**55.2**	**92.1**	73.64	73.64	73.64	73.64	73.64	73.64	73.64	73.64
C:N of fine roots	67.00	67	67	67	67	**50.3**	**83.8**	67	67	67	67	67	67
C:N of coarse roots	165.00	165	165	[illegible]65	165	165	165	**123.8**	**206.3**	165	165	165	165
C:N of live wood	69.00	69	69	69	69	69	69	69	69	**51.8**	**86.3**	69	69
C:N of dead wood	658.00	658	658	658	658	658	658	658	658	658	658	**493.5**	**822.5**

- Simulations time period 1981-2003 (22 years)
- Lychen (beech) and Kahlenberg (pine) were determined as reference sites
- Each C/N-ratio was shifted by 25 percent from the average keeping the other C/N-ratios constant

Results

- Pine and beech showed increased NPP and stem growth with decreasing C/N-ratios.
- Increasing C/N of litter and deadwood resulted in an increase of NPP and stem growth !?
- NPP and stem growth was most sensitive to changing C/N-ratios in the leaves.



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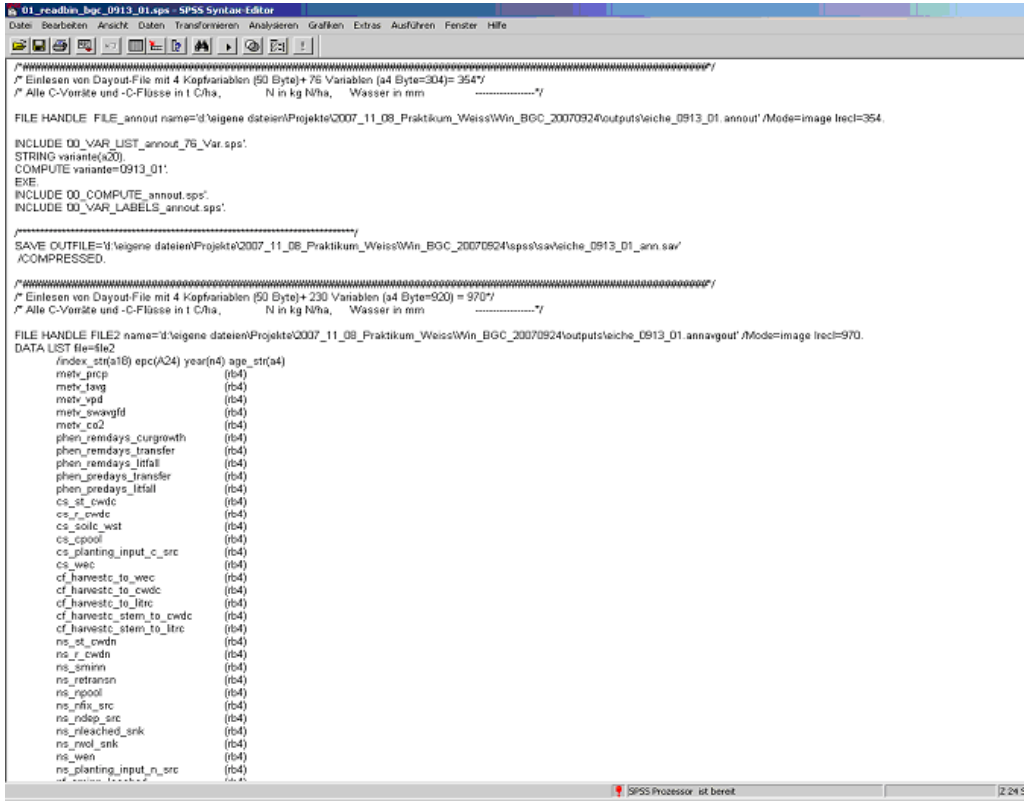
Discussion

- BIOME-BGC is very complex and incorporates a lot of parameters which limits the practical use.
- It represents key processes for tree growth like photosynthesis and respiration with high accuracy
- However, parameterization demands accurate estimates of key parameters.
- Good knowledge of soil and plant processes is necessary.
- Models like BIOME-BGC can help us understand how climate change effects forest productivity.



Thanks for your attention !

Any questions?

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Literature

- IPCC (Intergovernmental Panel on Climate Change) (2001) the Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). J.T.Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden and D. Xiaosu (Eds.) Cambridge University Press, UK. Pp 944.
- Johnsen, K. et al, 2000. Process Models as Tools in Forestry Research and Management, Forest Science 47, 2001.
- Kimmins, J.P., 1990. Modelling the sustainability of forest production and yield for a chainging and uncertain future, For.Chron. 66, 271-280.
- Scheffer/Schachtschabel, 1976. Lehrbuch der Bodenkunde, Verlag Ferdinand Enke Stuttgart.
- Seppelt, R., 2003. Computer-Based Environmental Management, Wiley-Vch.
- Thornton, P.E. et al (2002): Modelling and measuring the effects of disturbance history and climate on carbon and water budgets in evergreen needleleaf forests, Agricultural and Forest Meteorology 113 (2202), 185-222.
- Thornton, P.E., Law, B.E., Gholz, H.L., Clark, K.L., Falge, E., Ellsworth, D.S., Goldstein, A.H., Monson, R.K., Hollinger, D., Falk, M., Chen, J. and Sparks, J.P., 2002. Modeling and measuring the effects of disturbance history and climate on carbon and water budgets in evergreen needleleaf forests. Agricultural and Forest Meteorology 113: 185-222.
- von Gadow, Klaus, 2003. Waldstruktur und Wachstum, Universitätsdrucke Göttingen.

- Biome-BGC version 4.1.2 was provided by Peter Thornton at the National Center for Atmospheric Research (NCAR), and by the Numerical Terradynamic Simulation Group (NTSG) at the University of Montana. NCAR is sponsored by the National Science Foundation.

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