FUTMON
forest monitoring for the future

The carbon budget of level II plots under present and future climate

Hubert Jochheim & Michael Janott

zalf Leibniz-Centre for Agricultural Landscape Research
Institute of Landscape Systems Analysis
Eberswalder Str. 84, 15374 Müncheberg, Germany

a Life+ co-financed project for the "Further Development and Implementation of an EU-level Forest Monitoring System".

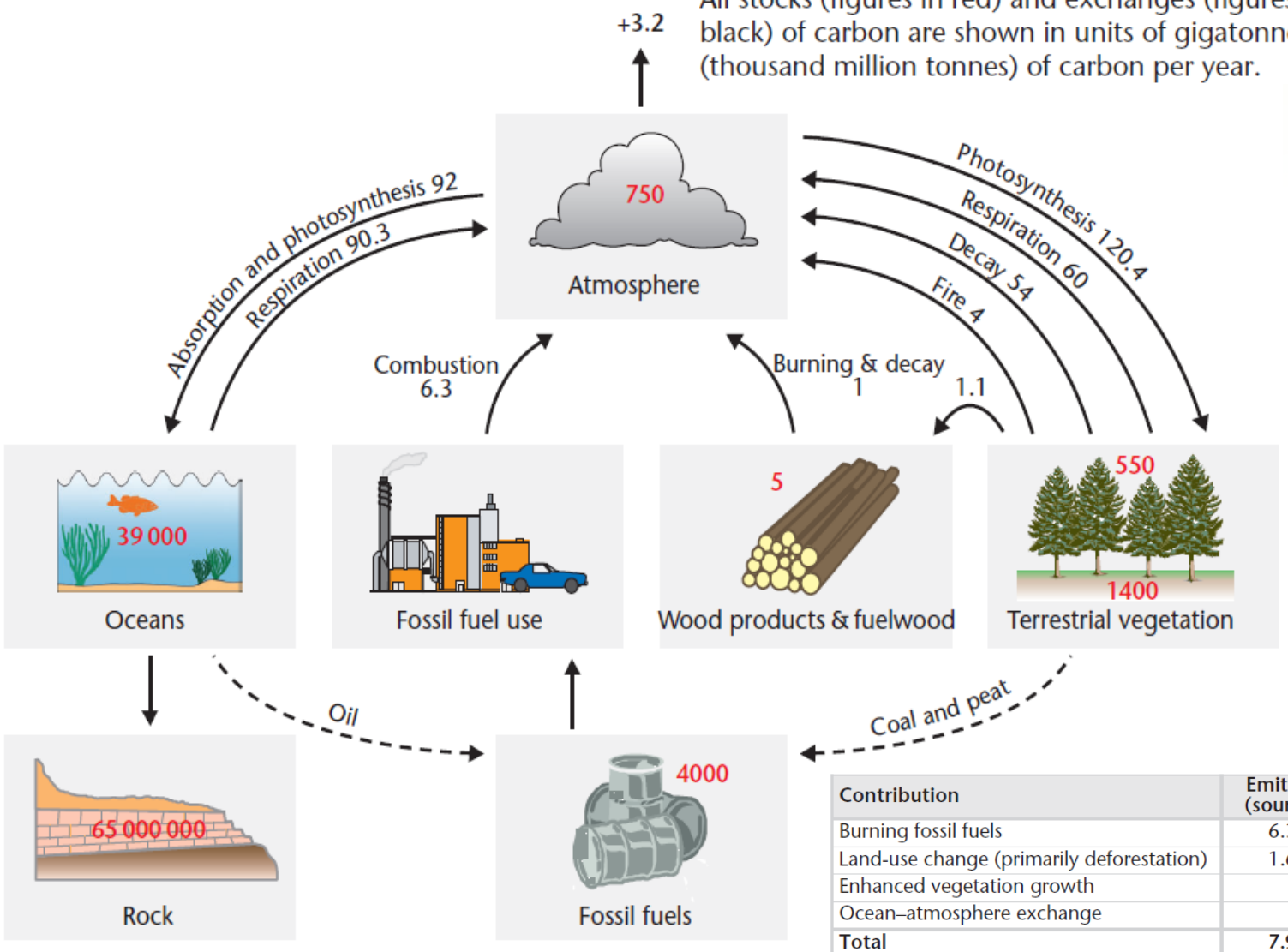
The project coordination centre is situated at the Institute for World Forestry, Hamburg, Germany.

Outline

1. Introduction and objectives
2. Methods
   a) BIOME-BGC (Vers. ZALF)
   b) Data
3. Simulation results
   a) Examples of model calibration
   b) Carbon budget of forests under present climate
   c) Development of C budget under changing climate
4. Discussion and conclusions

Global carbon budget

All stocks (figures in red) and exchanges (figures in black) of carbon are shown in units of gigatonnes (thousand million tonnes) of carbon per year.



Contribution	Emitted (source)	Absorbed (sink)
Burning fossil fuels	6.3	
Land-use change (primarily deforestation)	1.6	
Enhanced vegetation growth		3.0
Ocean–atmosphere exchange		1.7
Total	**7.9**	**4.7**
Balance	**3.2**	

Broadmeadow & Matthews 2003

Questions

Questions

- Are the level II plots suitable to investigate the carbon budget of forests?
- How much carbon is stored and turned over in forests of level II plots?
- How does carbon storage develop under expected future climate conditions?

BIOME-BGC (vers. ZALF)

BIOME-BGC (version ZALF)

Derived from BIOME-BGC (vers. 4.2)

- Source: Running et al., Thornton et al. 2002, http://www.ntsg.umt.edu/
- Aim: Simulation of water, carbon, and nitrogen budget of terrestrial biomes
- Scale: Biomes, regional – global application

Extensions implemented in BIOME-BGC (vers. ZALF)

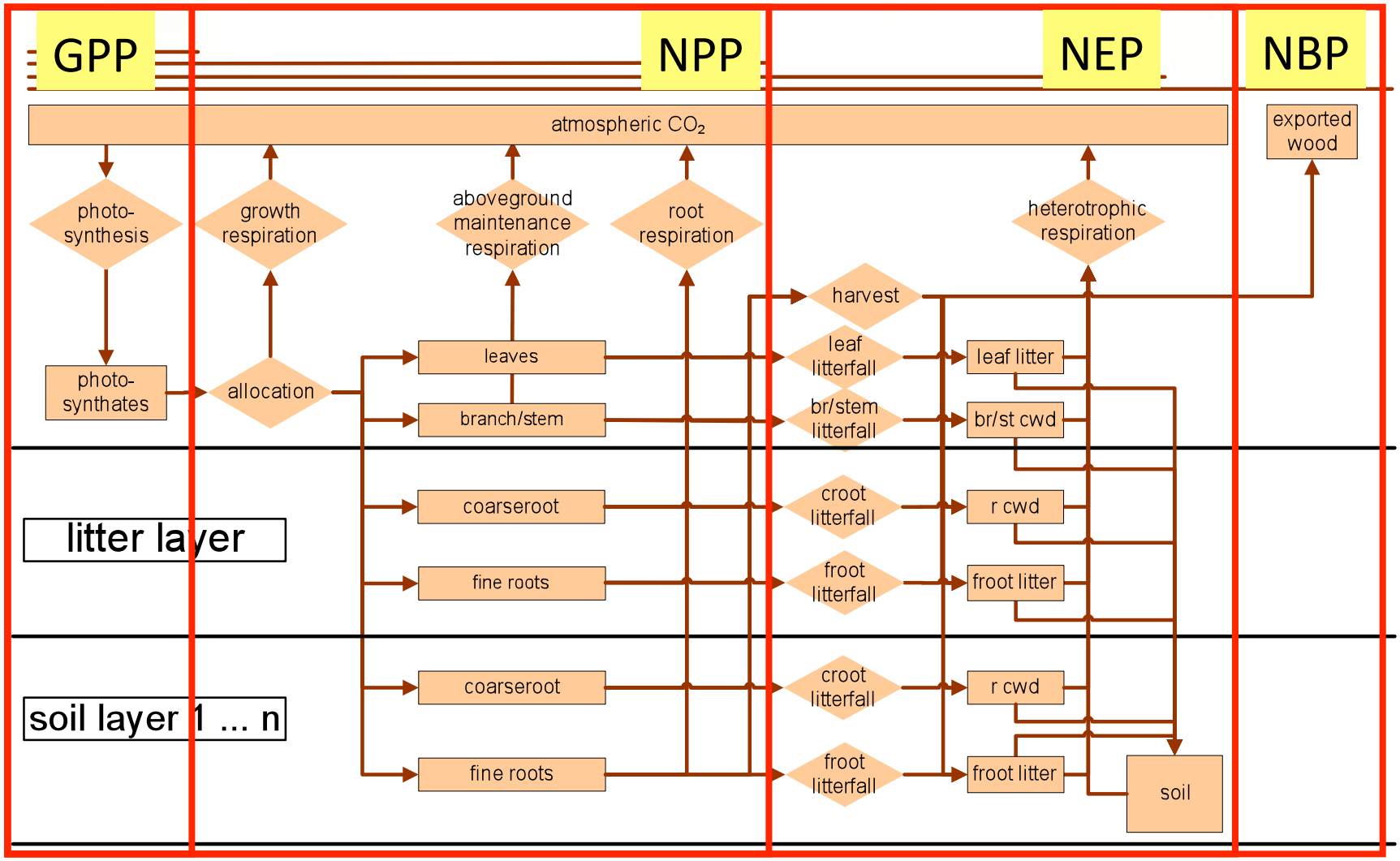
➔ Improved species and site specificity

➔ New scale: forest ecosystem, plot - region

- Forest management (thinning, clear cut, planting)
- Multi-layered soil water, soil C, temperature
- Multiple species, multiple canopy layers
- Phenology (leaf flushing, leaf and needle litterfall)
- Vertical root growth
- Stand hydrology (evaporation, transpiration)
- Decomposition in hydromorphic soils
- CO_2 effects to stomata conductivity

Carbon compartments and fluxes of BIOME-BGC (vers. ZALF)

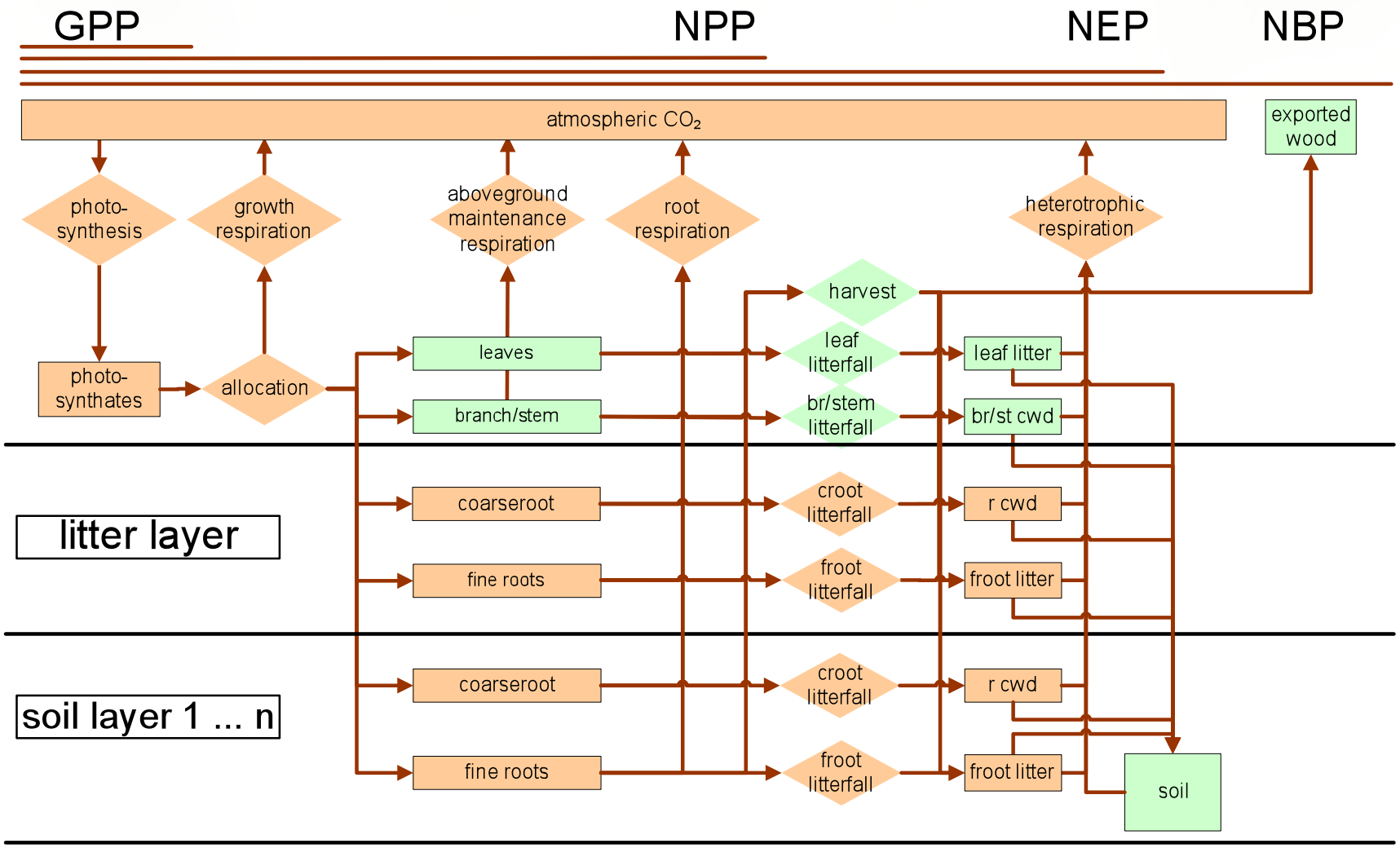
BIOME-BGC (version ZALF)



Carbon compartments and fluxes of BIOME-BGC (vers. ZALF)

measured on Level II plots

BIOME-BGC (version ZALF)



Input data for BIOME-BGC (vers. ZALF)

Input data

Boundary conditions

- meteorology, CO_2, N deposition
- forest management rules (16)
- soil parameters

Initial values

- carbon pools in plant, litter and soil compartments

Model parameters

- physiological model parameters (75)

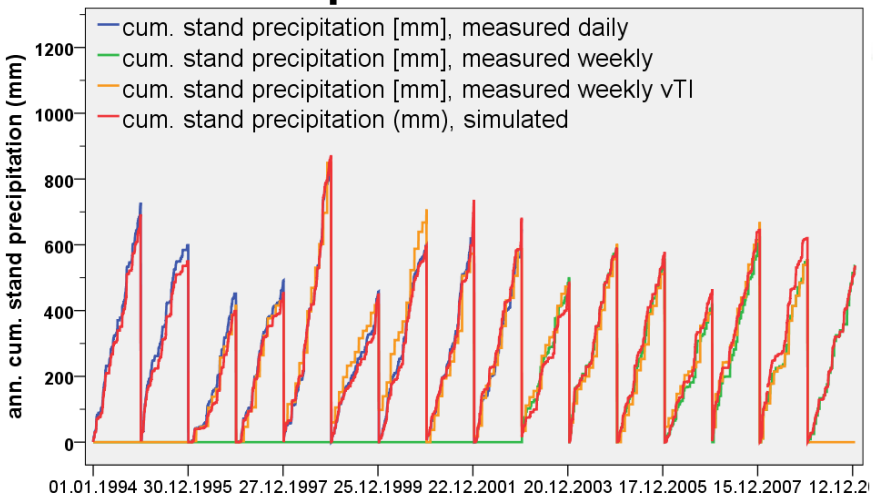
Calibration / Validation data

- stand internal meteorology
- soil hydrology
- C-pools and –fluxes / forest growth / litterfall

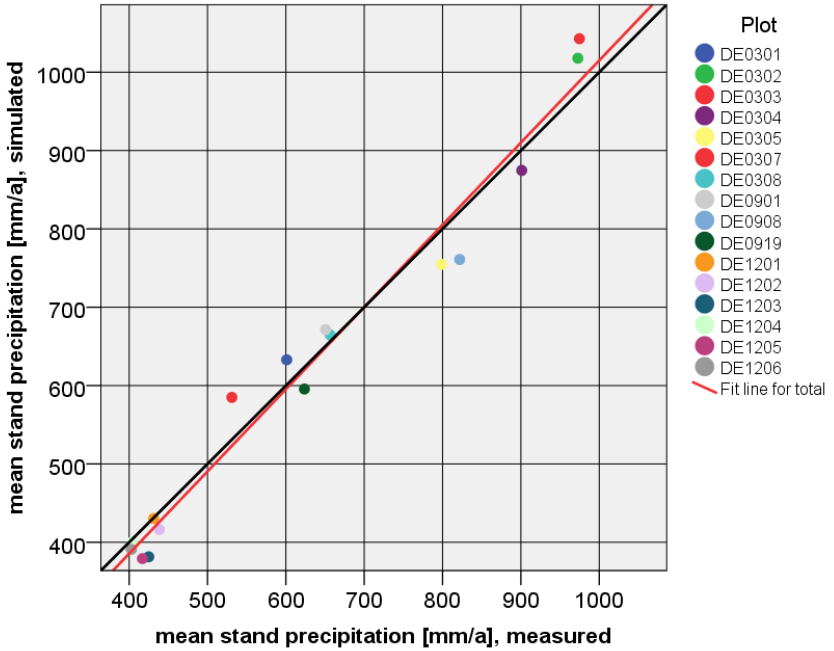
Model calibration – stand precipitation

Model calibration

plot DE0307

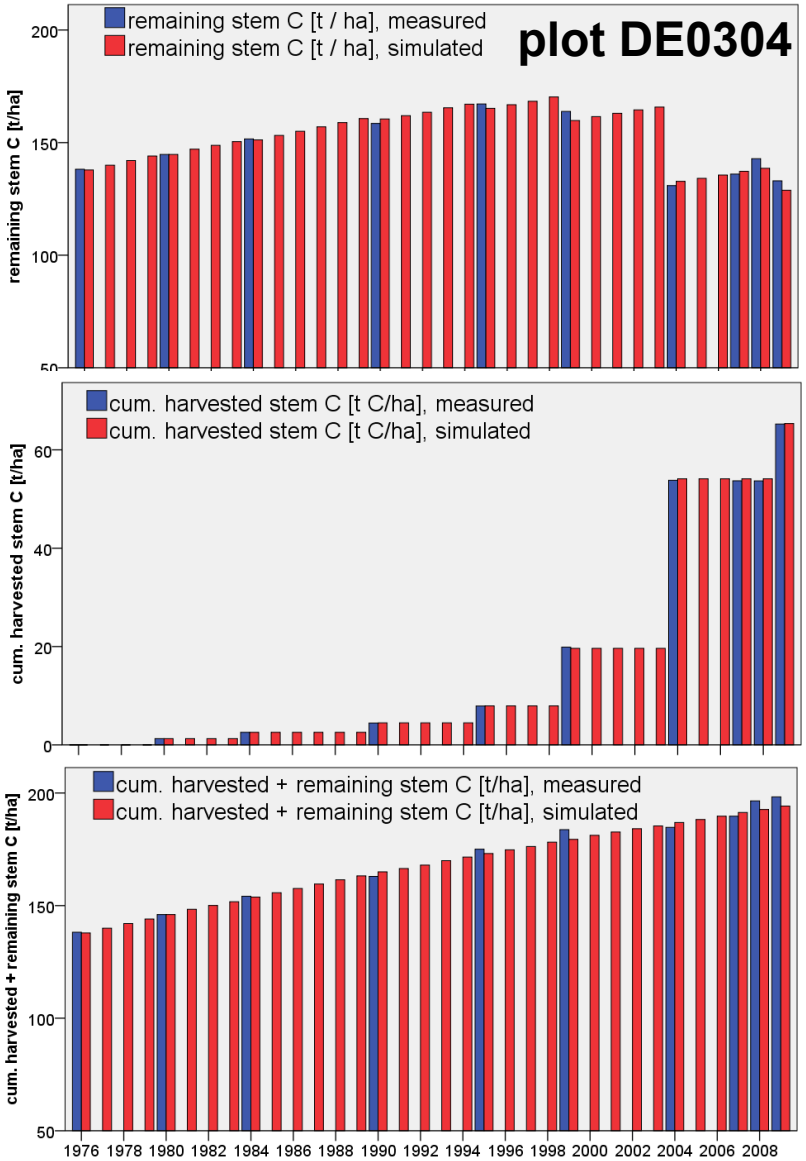


16 plots



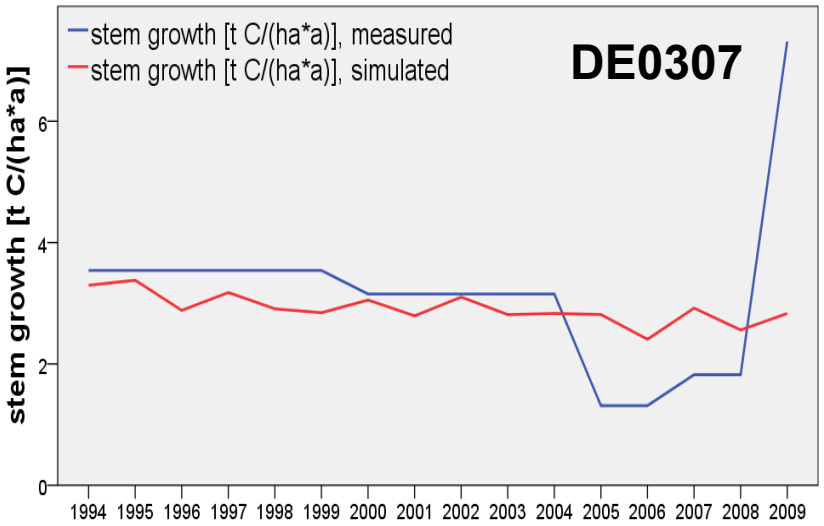
Model calibration - stem carbon

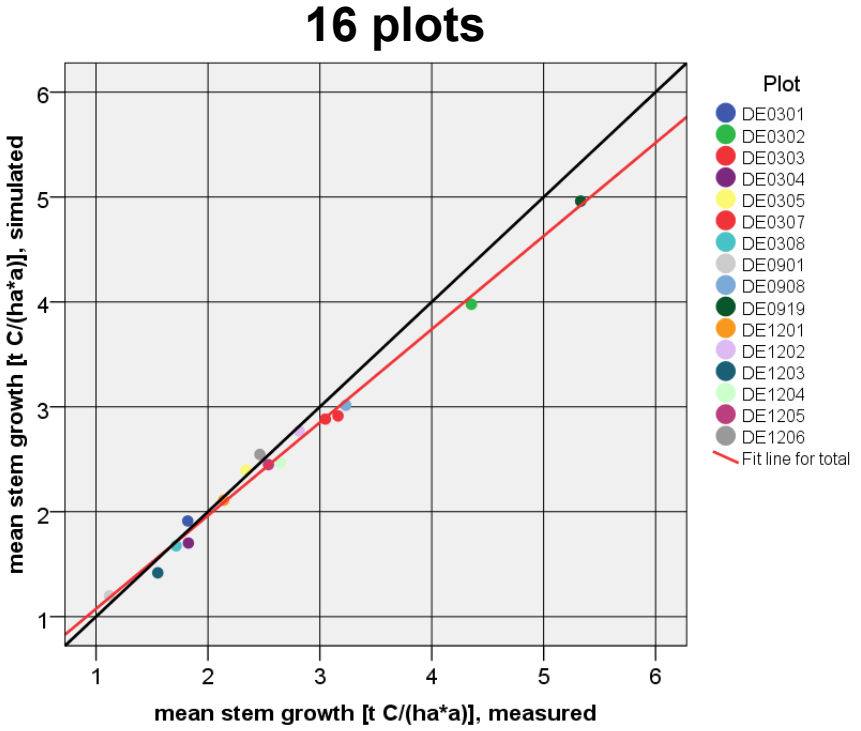
Model calibration



Model calibration – tree growth

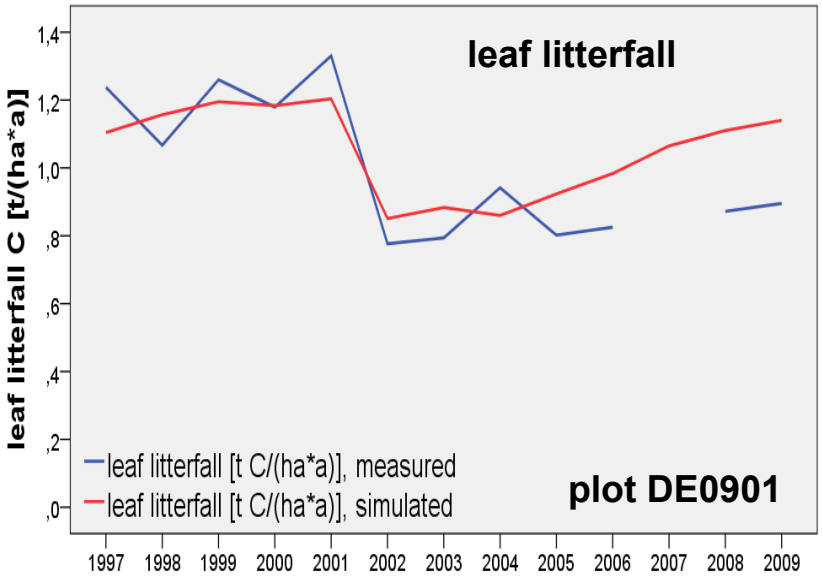
Model calibration

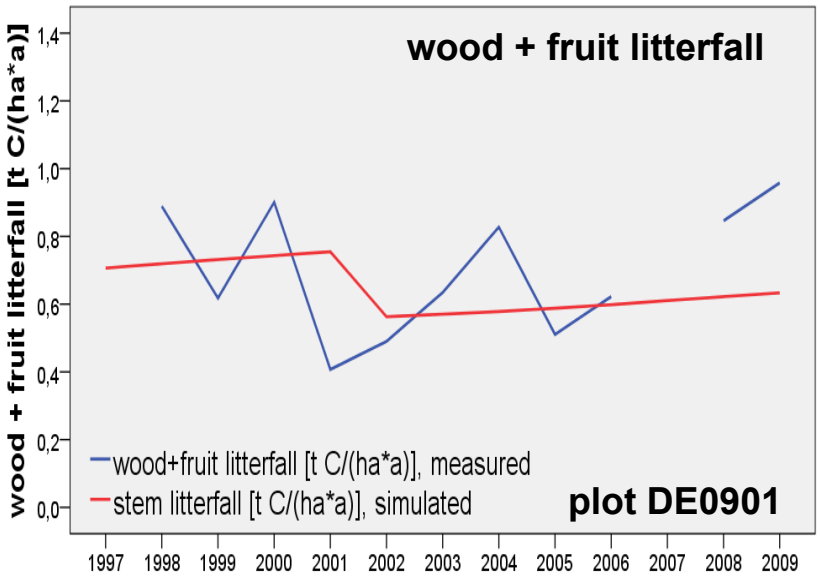




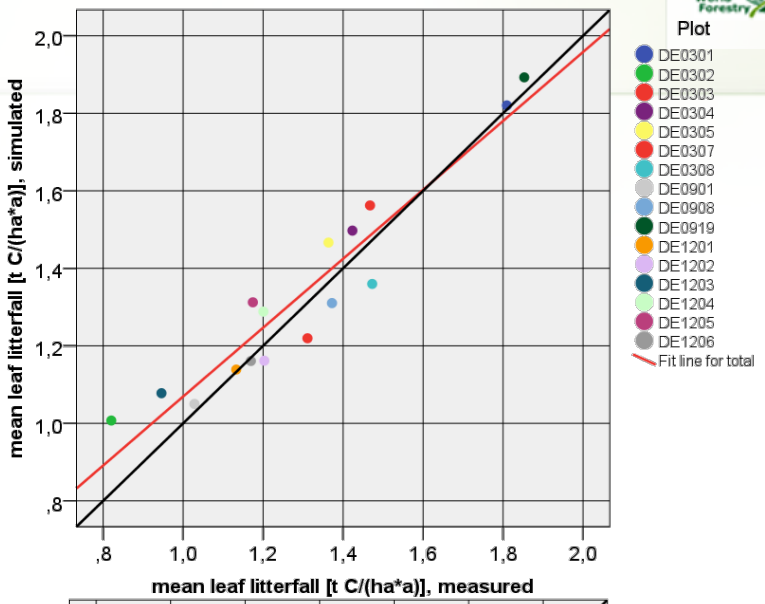
Model calibration – litterfall

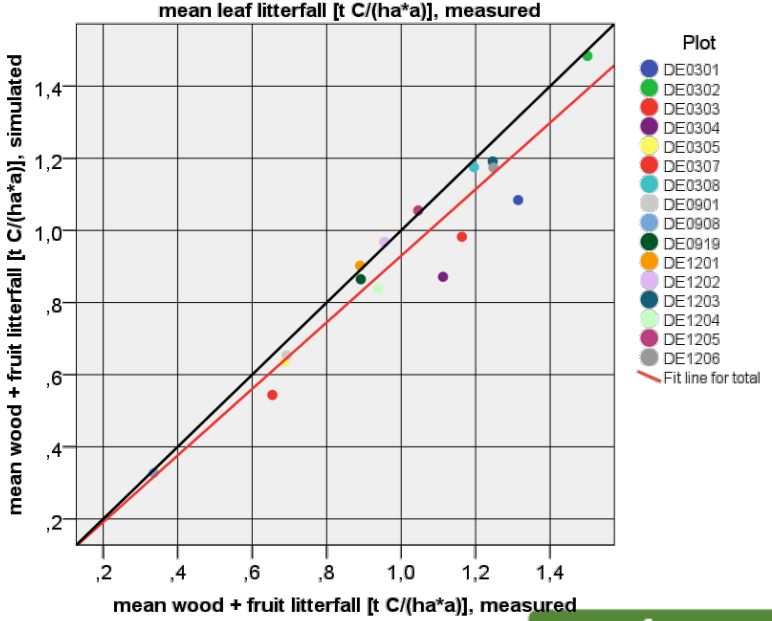
Model calibration





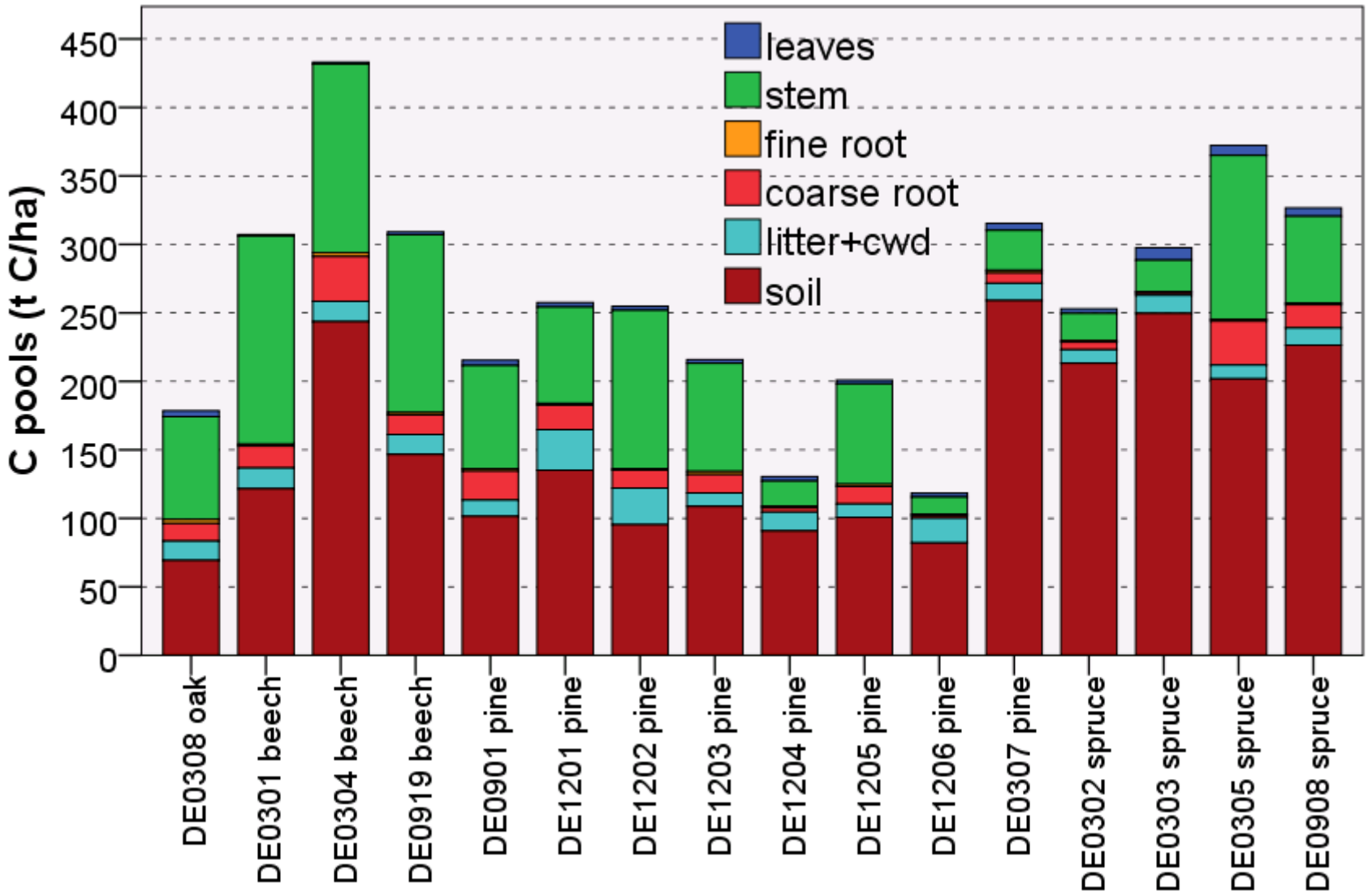
16 plots





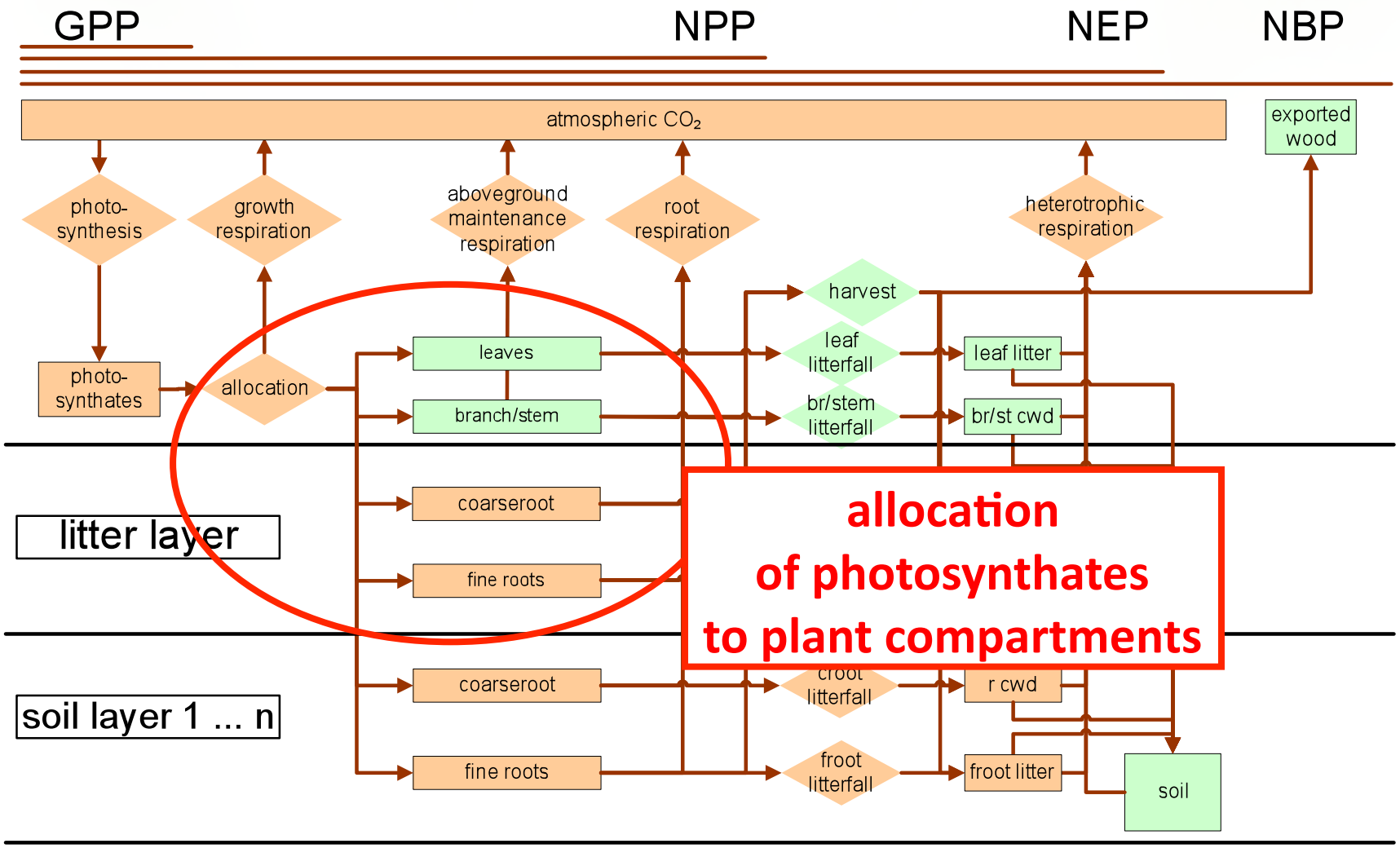
Carbon pools

Results - present C-balance



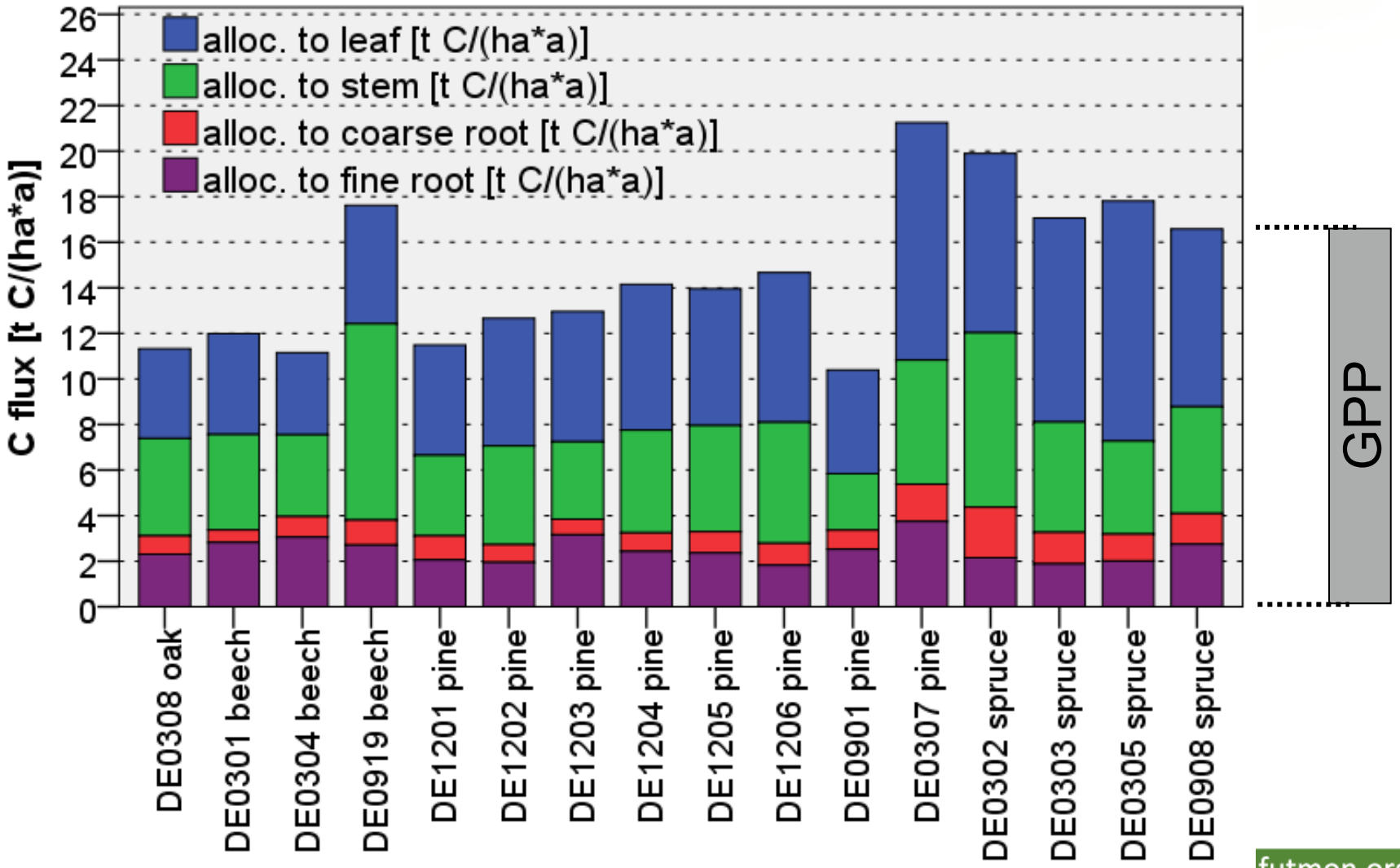
Carbon compartments and fluxes of BIOME-BGC (vers. ZALF)

Results - present C-balance



Carbon allocation to plant compartments

Results - present C-balance



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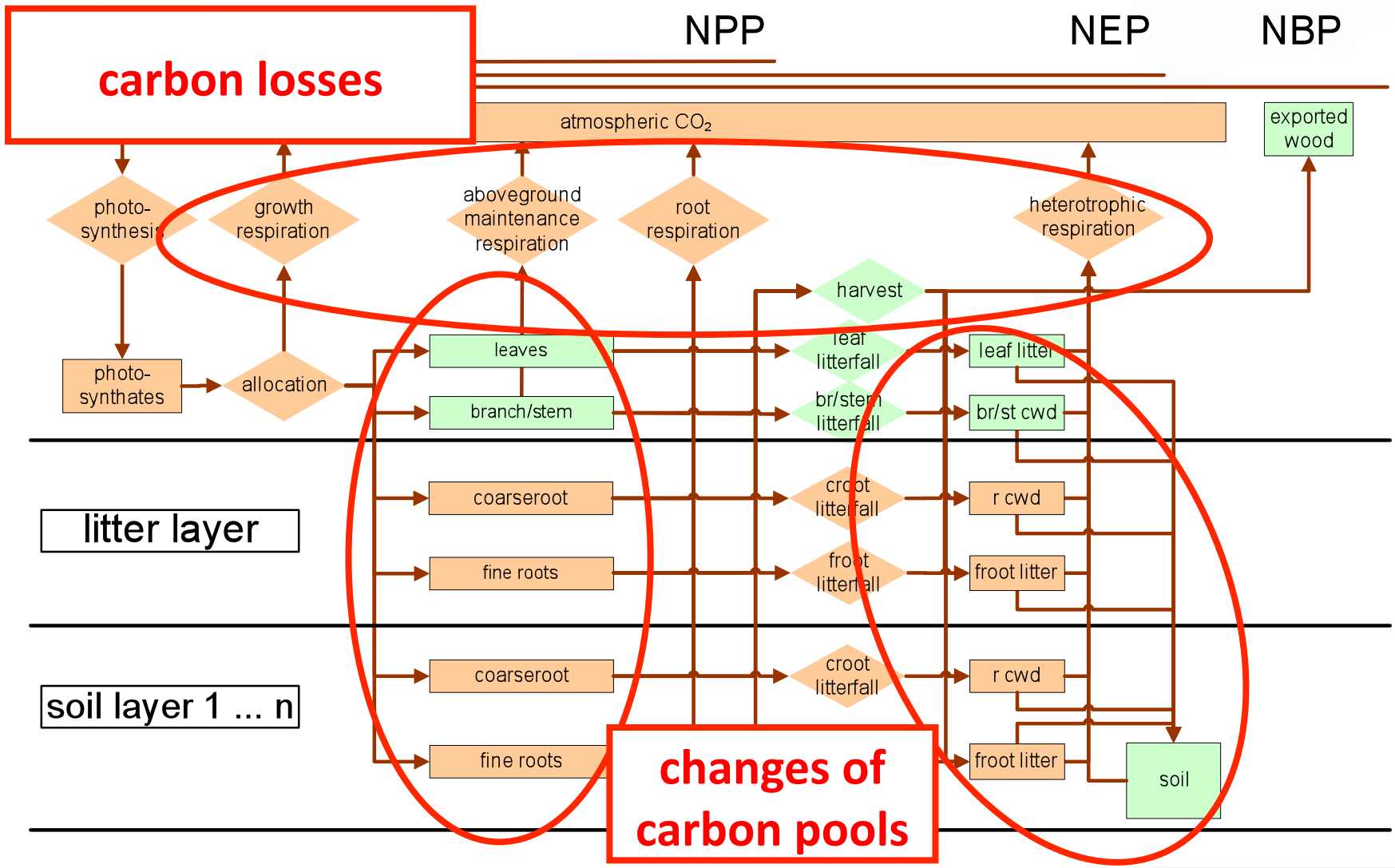
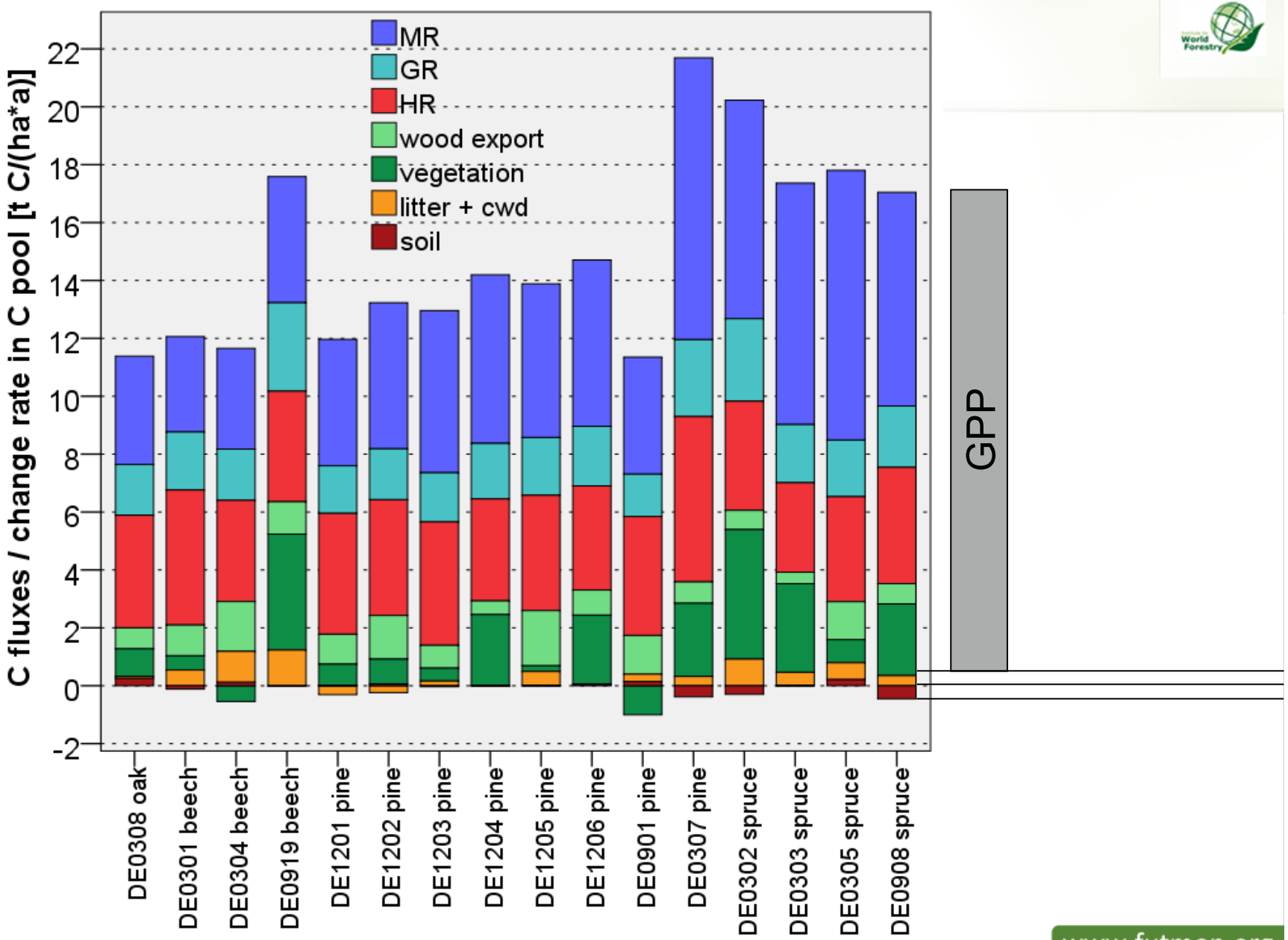


Carbon losses and changes of carbon pools

Results - present C-balance



Carbon losses and changes of carbon pools

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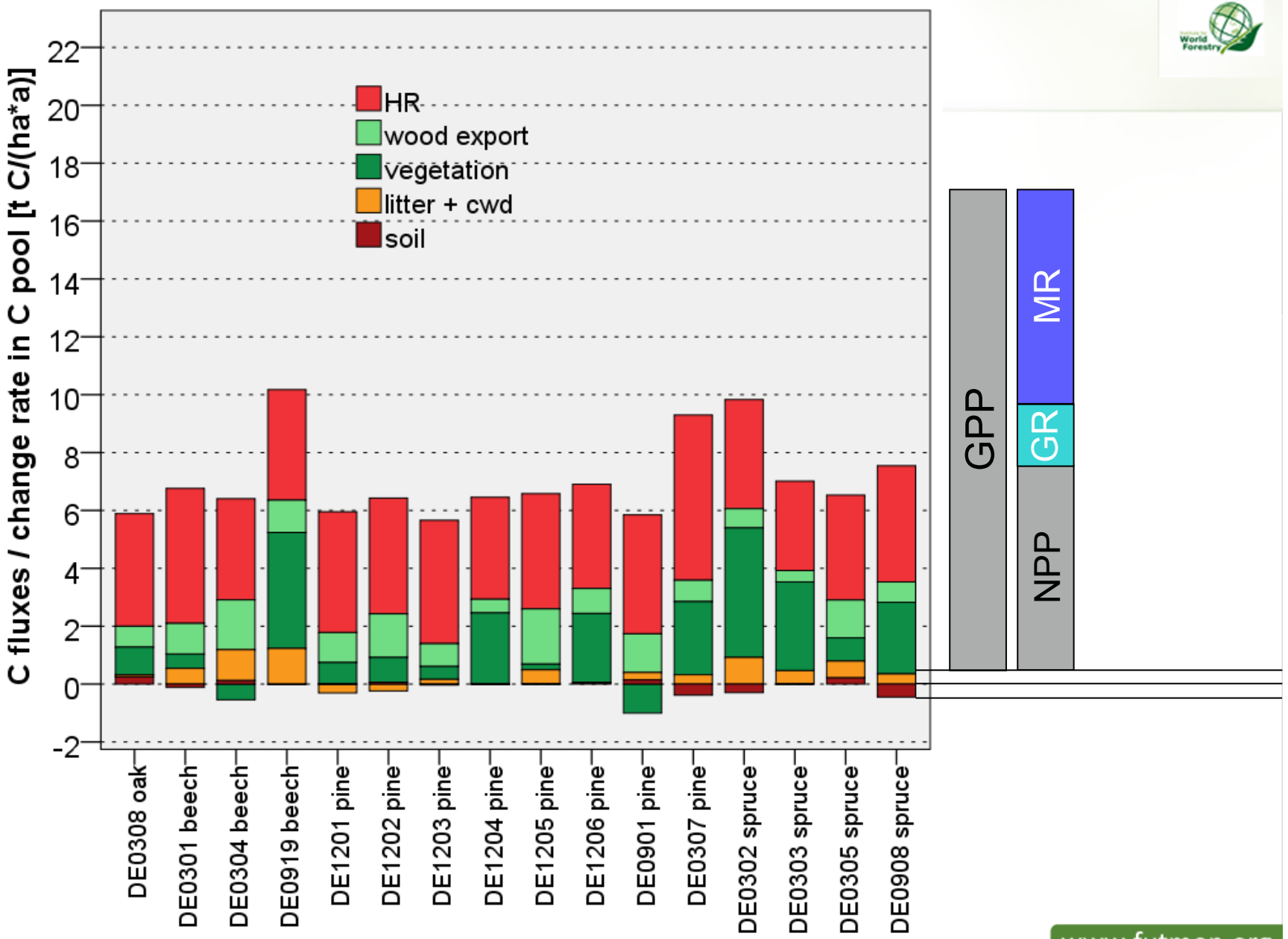

Carbon losses and changes of carbon pools

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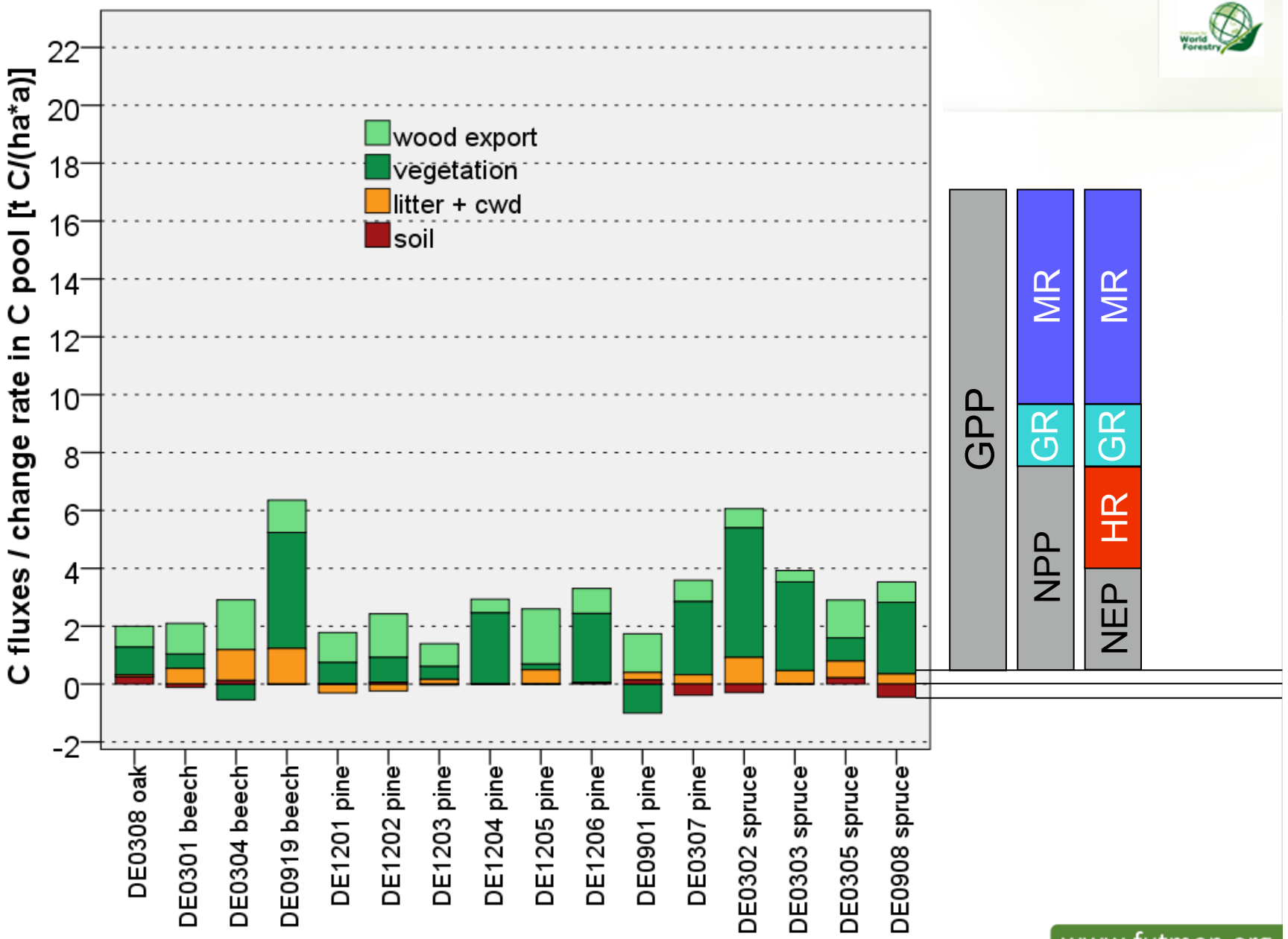

Carbon losses and changes of carbon pools

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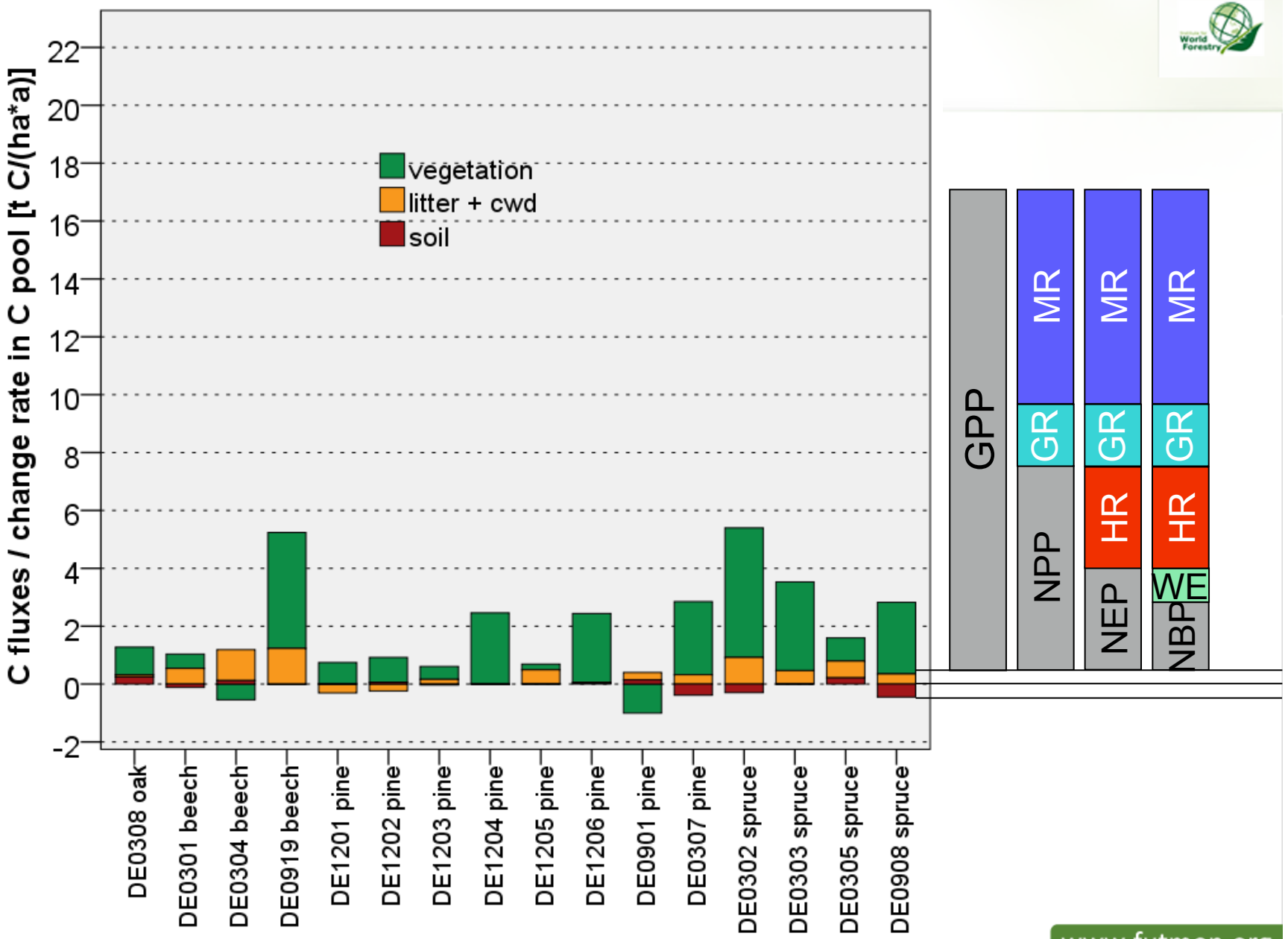


Climate projections

Climate projections

Source: Olschofsky (vTI)

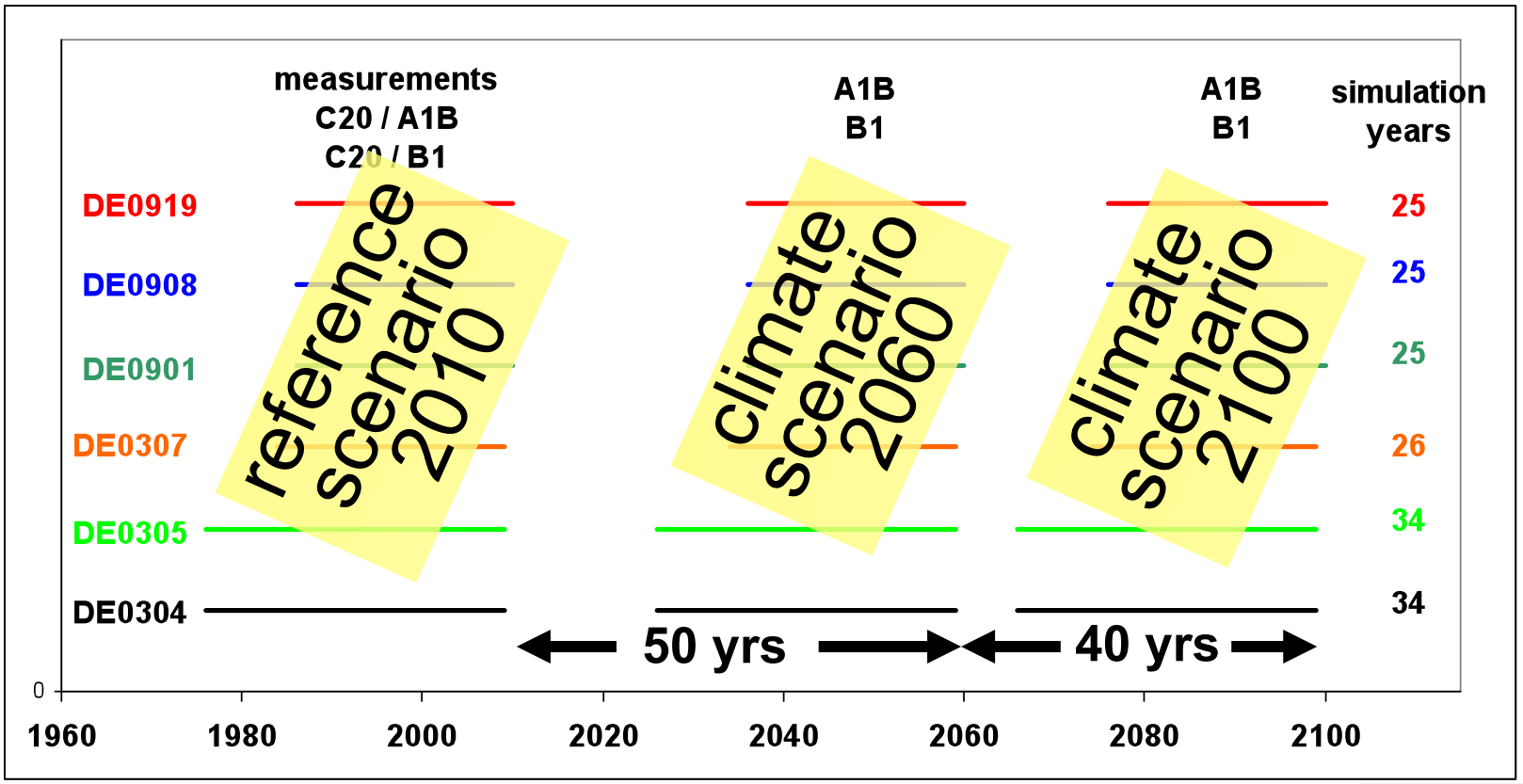
- IPCC-SRES emission scenarios → **A1B, B1**
- Global climate model → **ECHAM5**-MPI-OM
- Regionalization model → **CLM**
- Adaption to plot → using **measured** data and **CRU** data

Application of climate projections

Simulation setup

- application of different climate projections
- identical initial values per plot and scenario
- identical N deposition per plot and scenario
- identical number of simulation years per plot and scenario

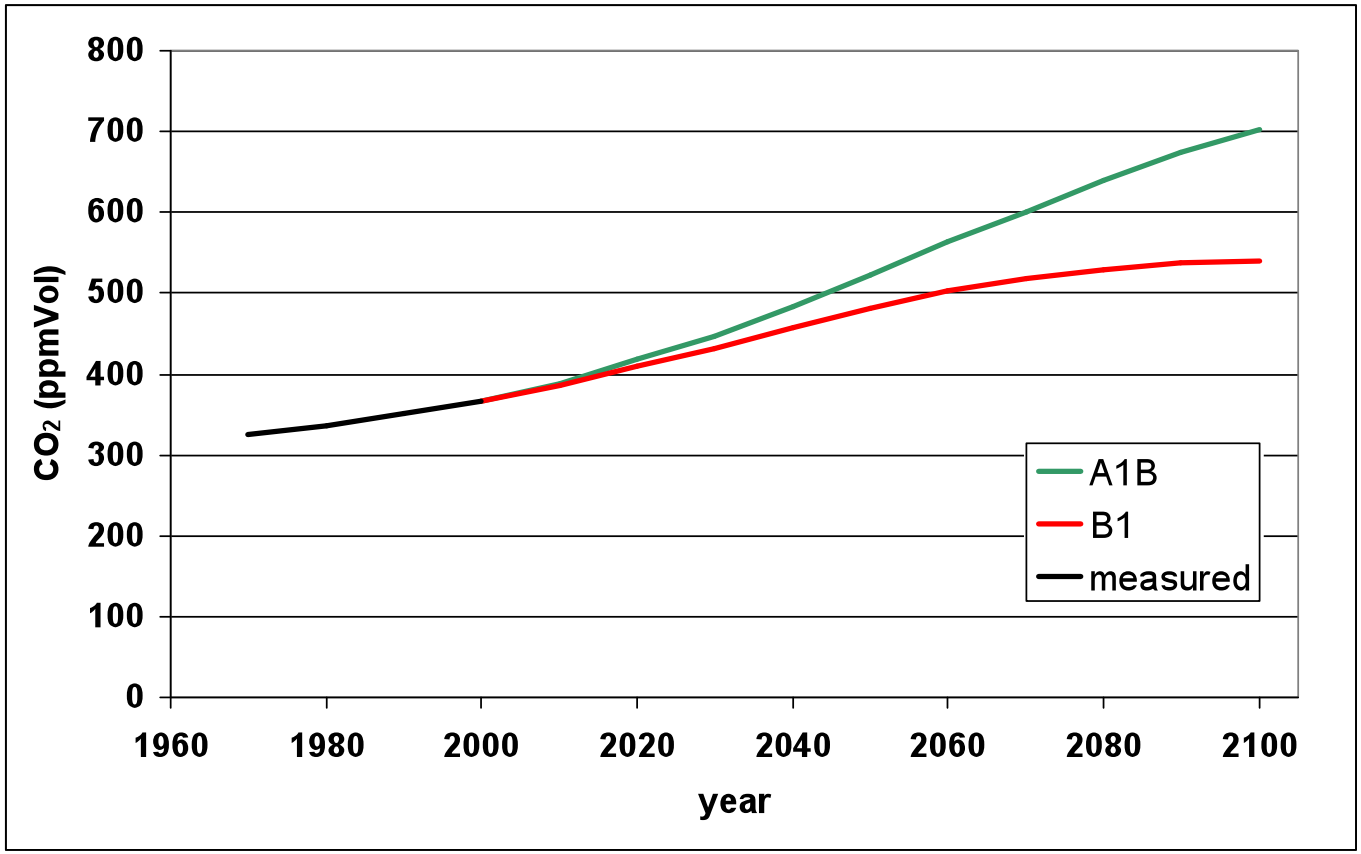
Climate projections



CO_2 concentrations

Source: Mauna Loa (1970-2010)

IPCC-SRES emission scenarios (2011-2100)



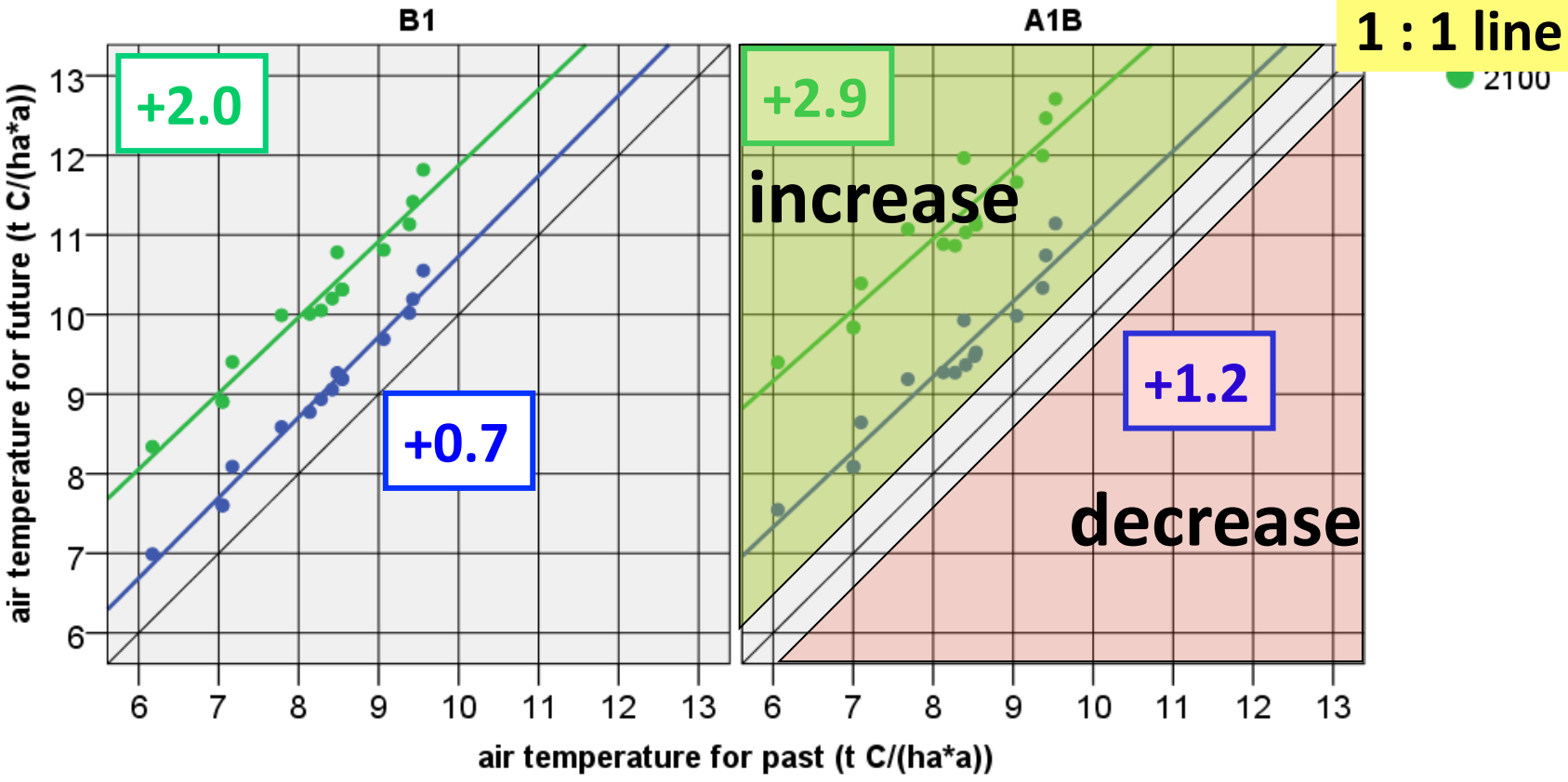
Climate projections

Temperature - present vs. future

Climate projections

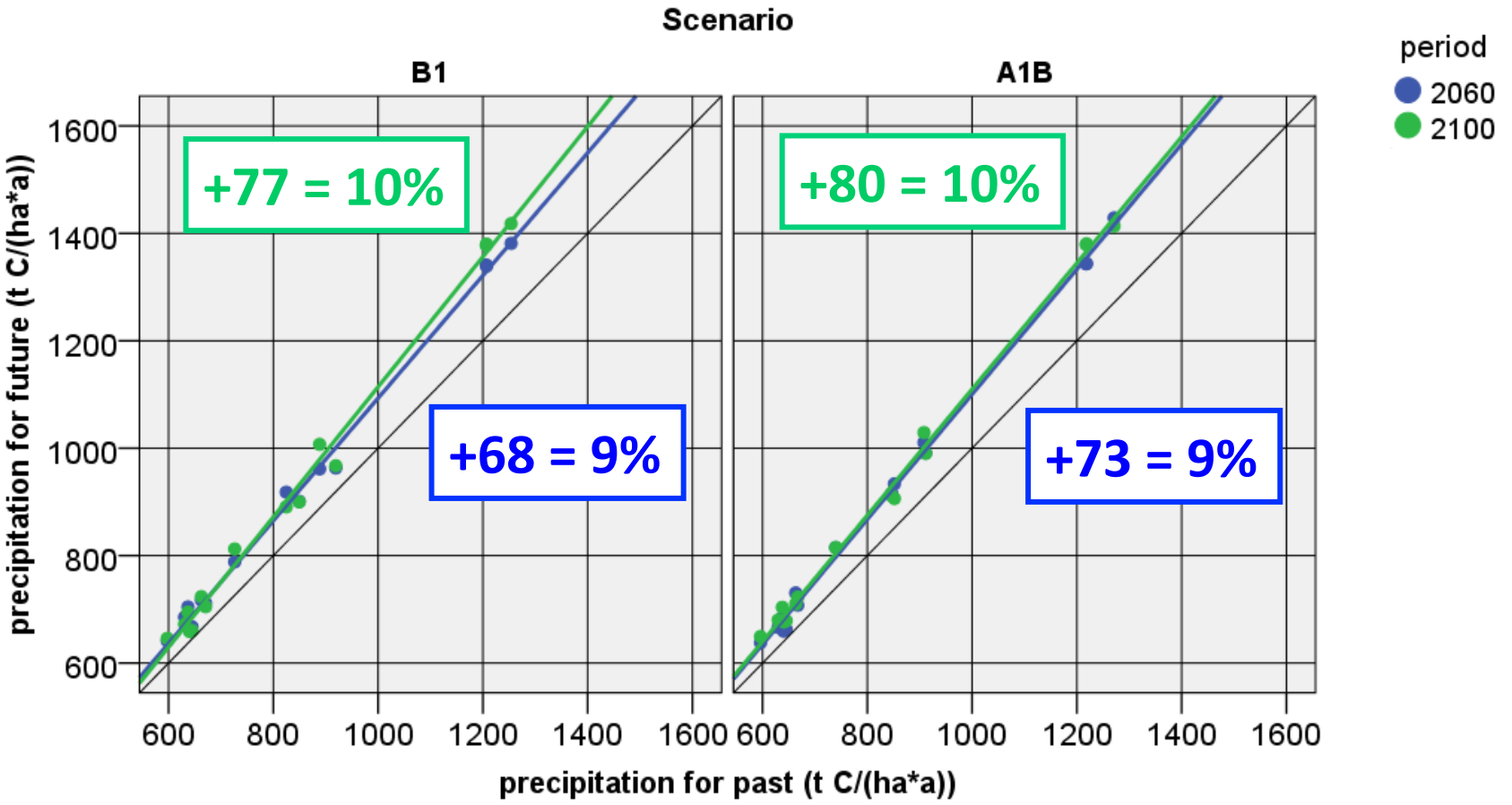
climate scenario = reference scenario

1 : 1 line



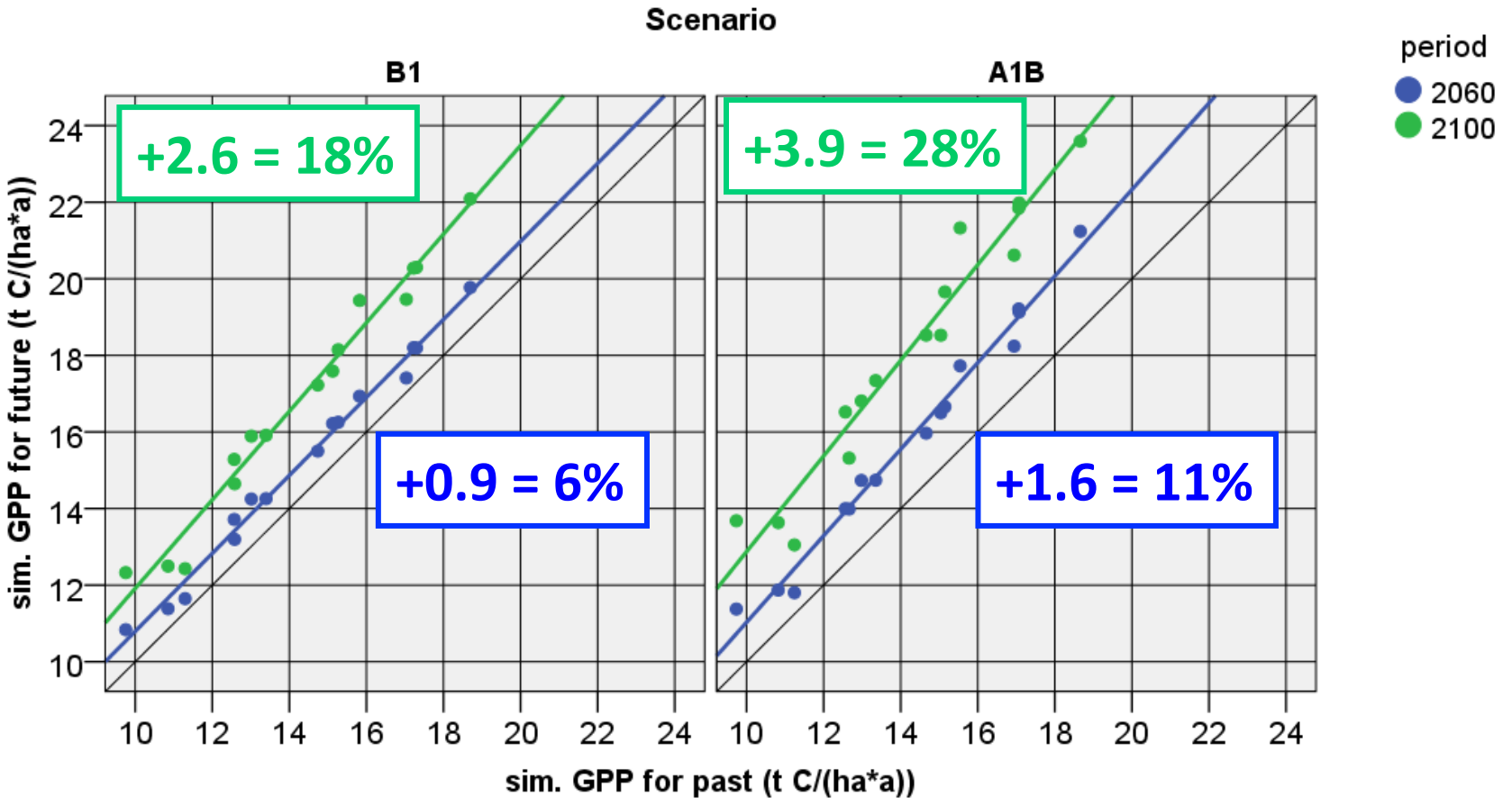
Precipitation - present vs. future

Climate projections



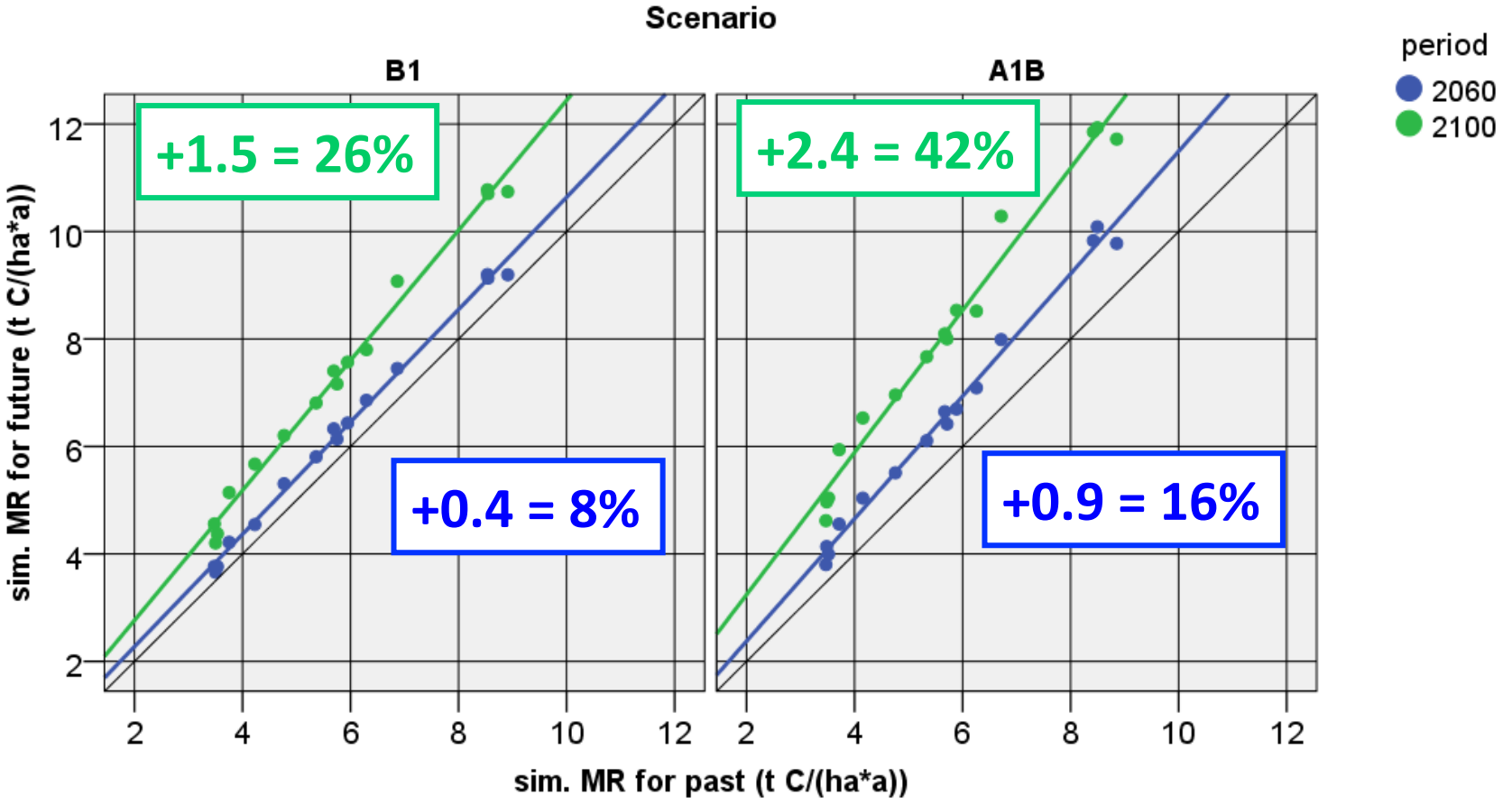
Gross Primary Production - present vs. future

Results on Climate Projections



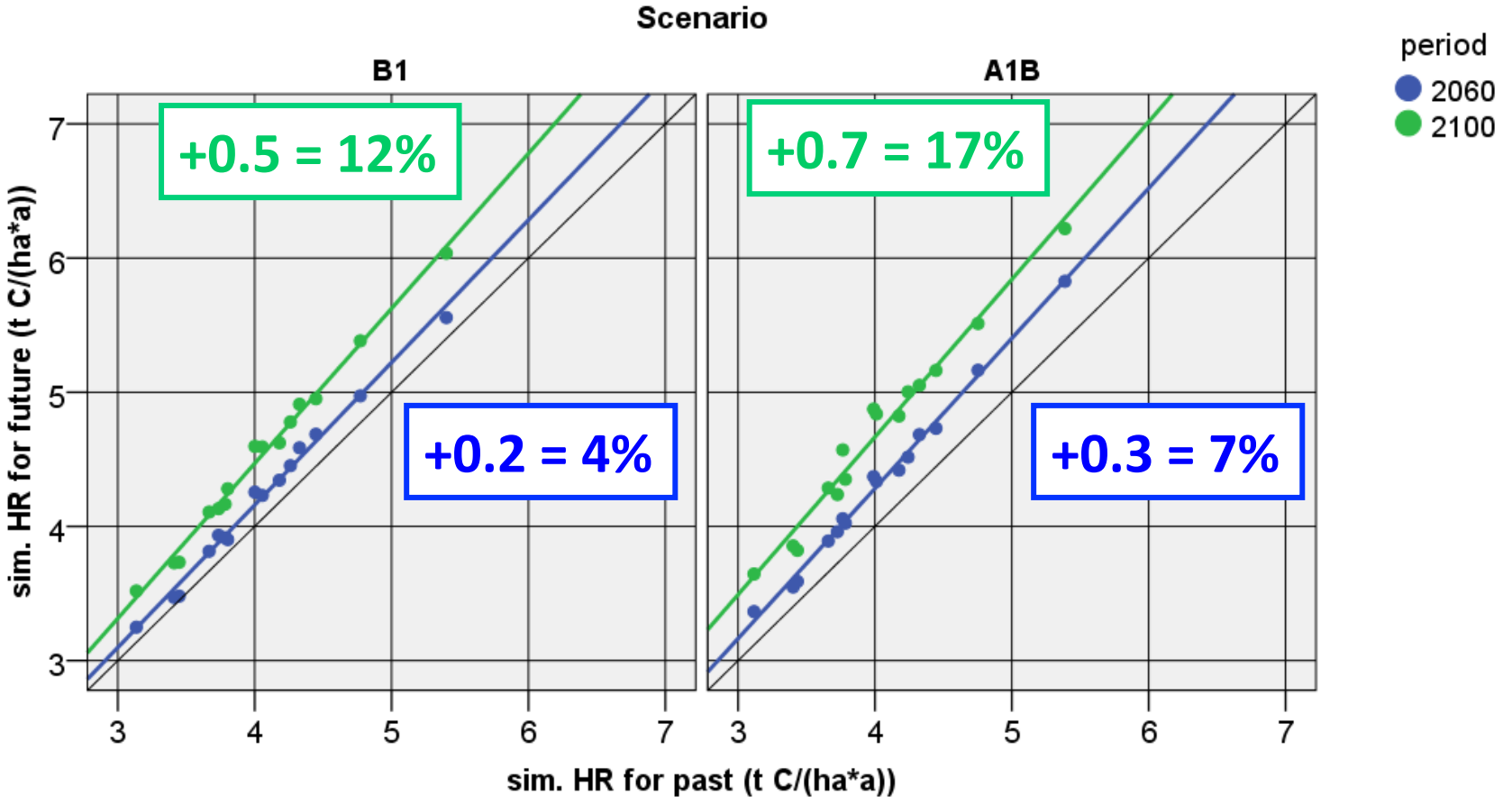
Maintenance Respiration - present vs. future

Results on Climate Projections



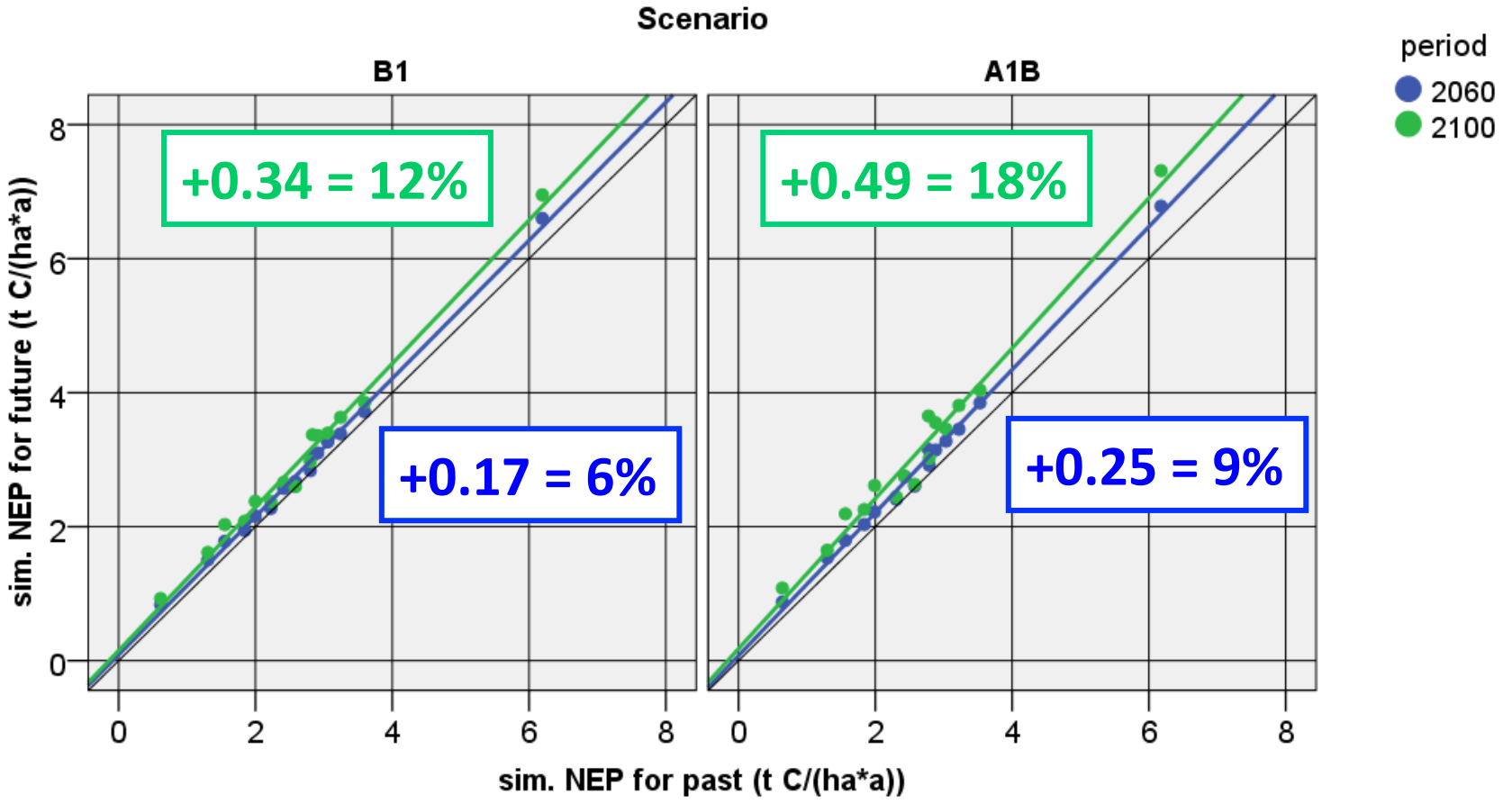
Heterotrophic Respiration - present vs. future

Results on Climate Projections



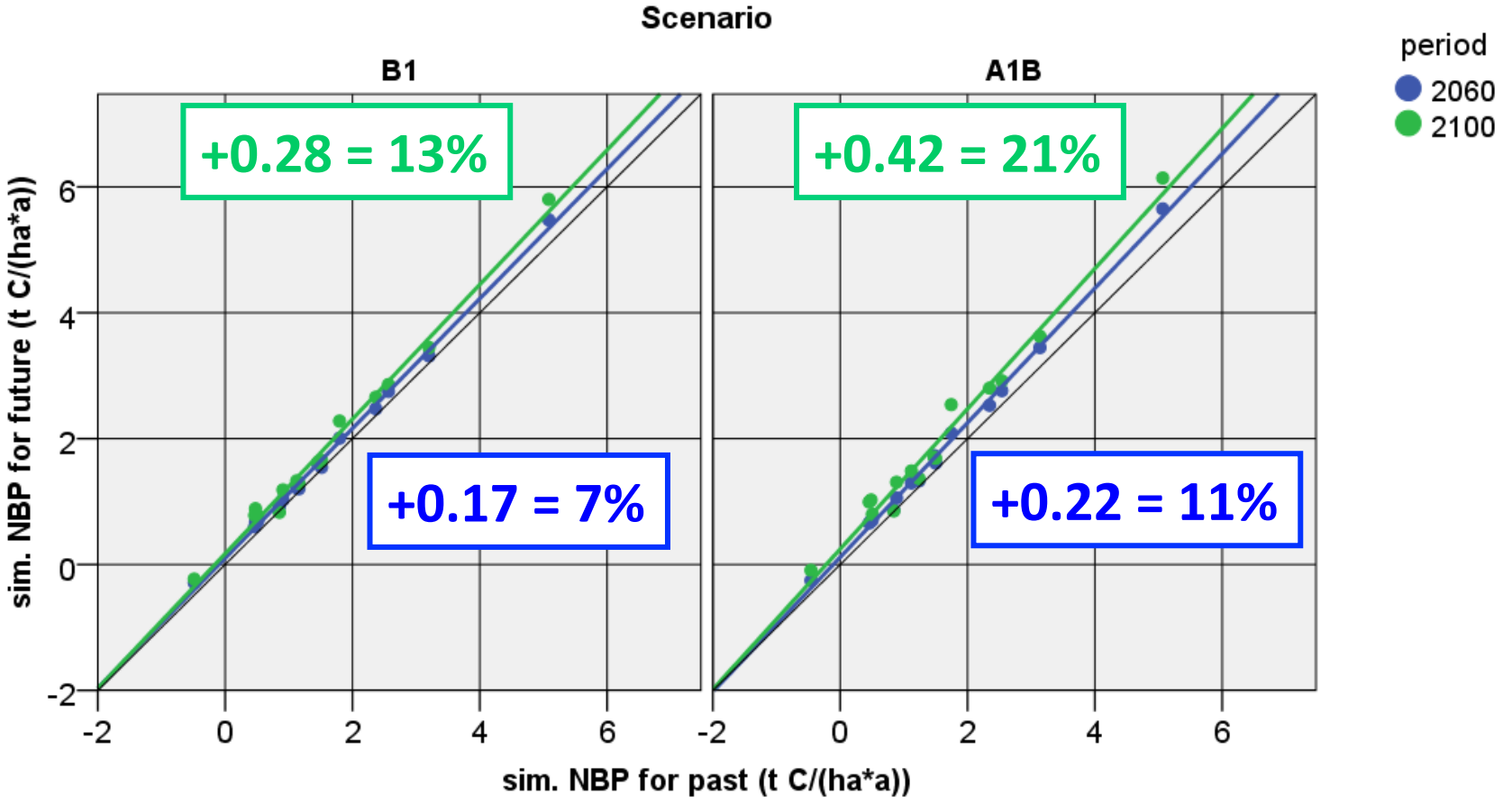
Net Ecosystem Production - present vs. future

Results on Climate Projections



Net Biome Production - present vs. future

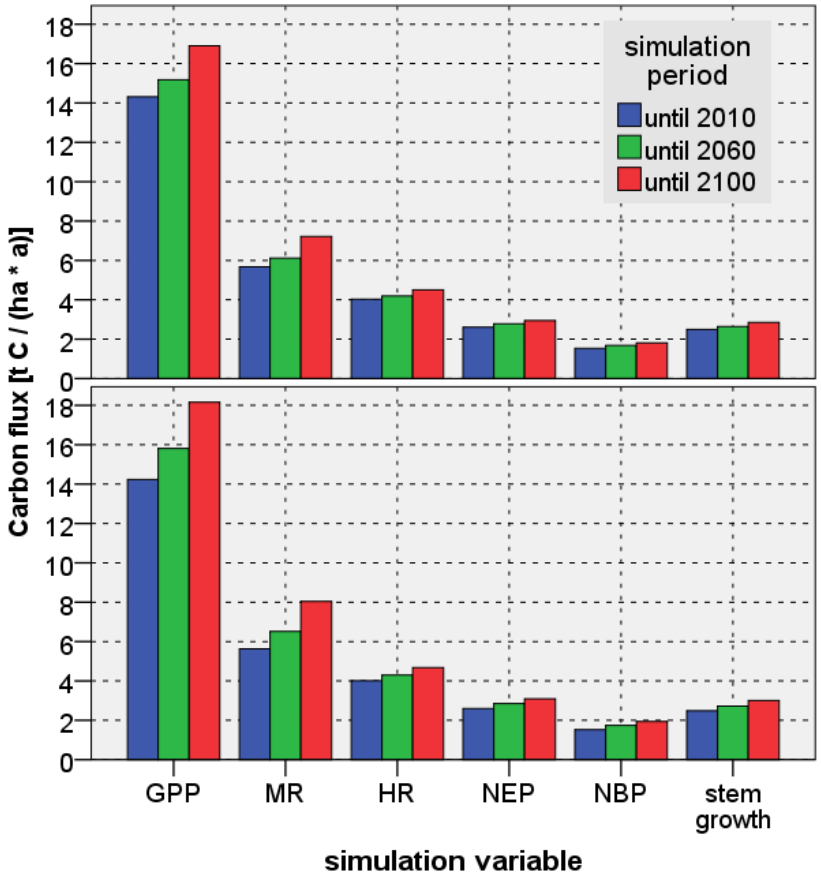
Results on Climate Projections



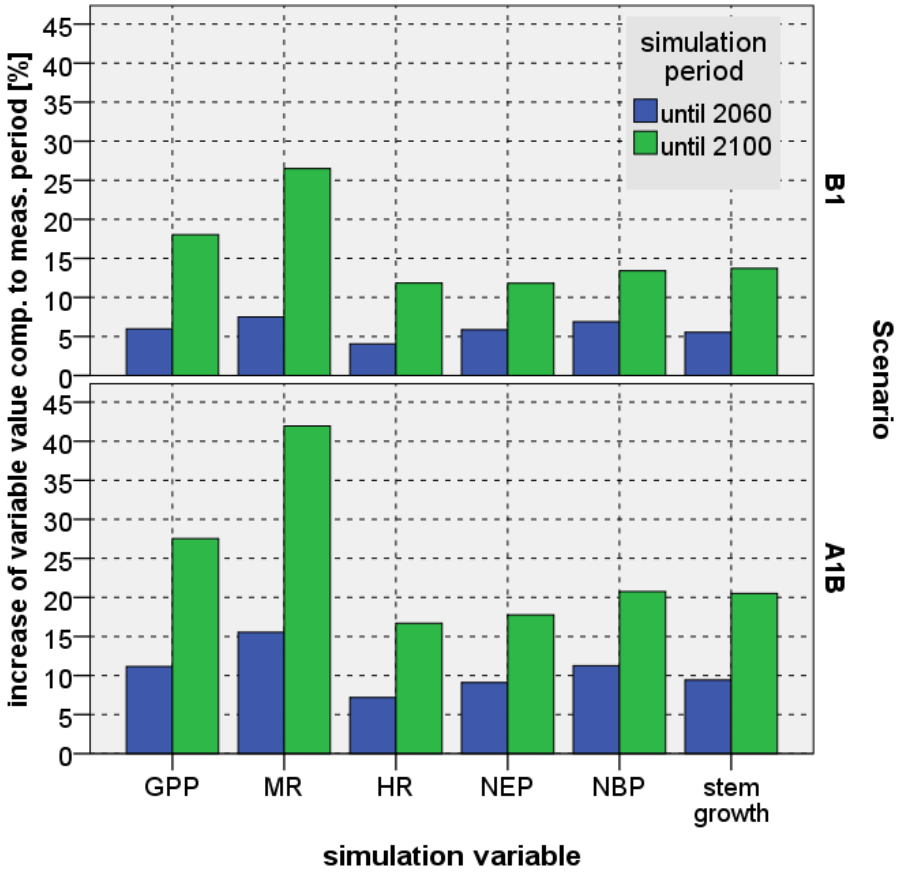
Climate Projections - summary

Results on Climate Projections

Carbon flux (t C/(ha*a))



Changes compared to reference scenario (%)



Factors of reliability of simulation results

Discussion

- Model assumptions (fructification, disturbances)
- Model user
- Quality of input data for model calibration
- Quality of climate projections

How reliable are the simulation results?

Discussion

- Hydrology → relatively certain
- Stem and leaf growth → relatively certain
- Root turnover → uncertain
- Trend of SOM stock → uncertain

Conclusions – simulation results on carbon budget

Conclusions

- The simulated forests react as carbon sinks under the present climate conditions (one exception).
- The C sink function was simulated to increase under future climate conditions.
- Carbon losses caused by diseases, insect attacks or forest fire are not considered.

Conclusions – data and simulations

Conclusions

- The “core plots” of the FutMon project provide valuable data for calibrating dynamic simulation models on carbon budgets of forest ecosystems.
- The carbon budget can not completely be measured, modeling can fill these gaps.
- Simulation of carbon budgets using measured data is an intensive analysis of data consistency and helps to improve data quality.
- The data may offer some hints for further model development.

Recommendations

Conclusions

➔ **Assess the uncertainty of the models**

- Sensitivity analysis
- Uncertainty analysis
- Simulations using an ensemble of climate projections
- Model comparison

➔ **Enhance the reliability by additional measurements**

- Soil respiration
- NEE (combined with Euroflux towers)
- Root turnover
- Time series of SOC and CWDC

➔ **Apply calibrated models to Level I plots in order to produce representative data for Europe's forests**

Thank you
for your attention