Resource-use description in physiology-based models

16.06.2011

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Addressing resource-related(?) problems with a physiology-based ecosystem model

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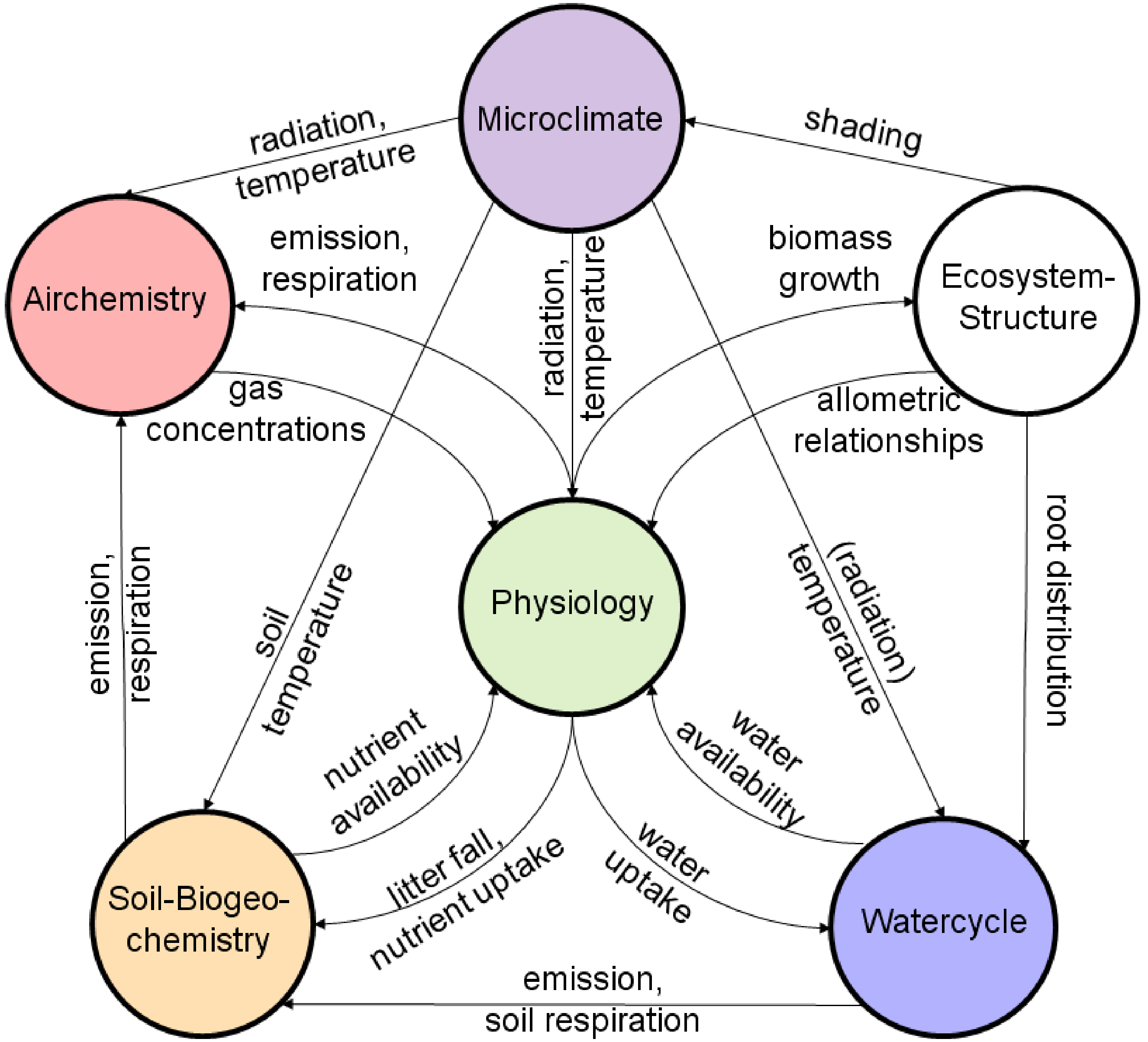
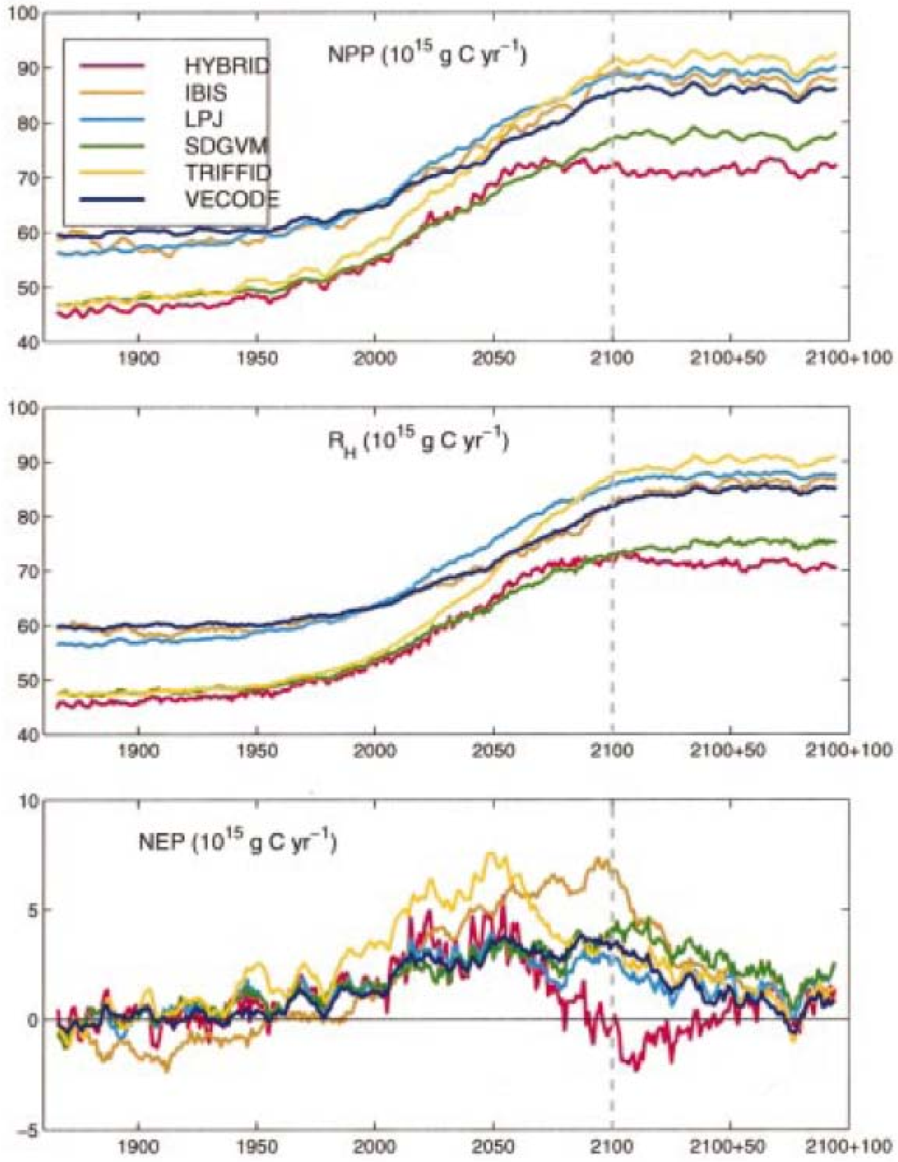
Definition: "physiology-based ecosystem model"

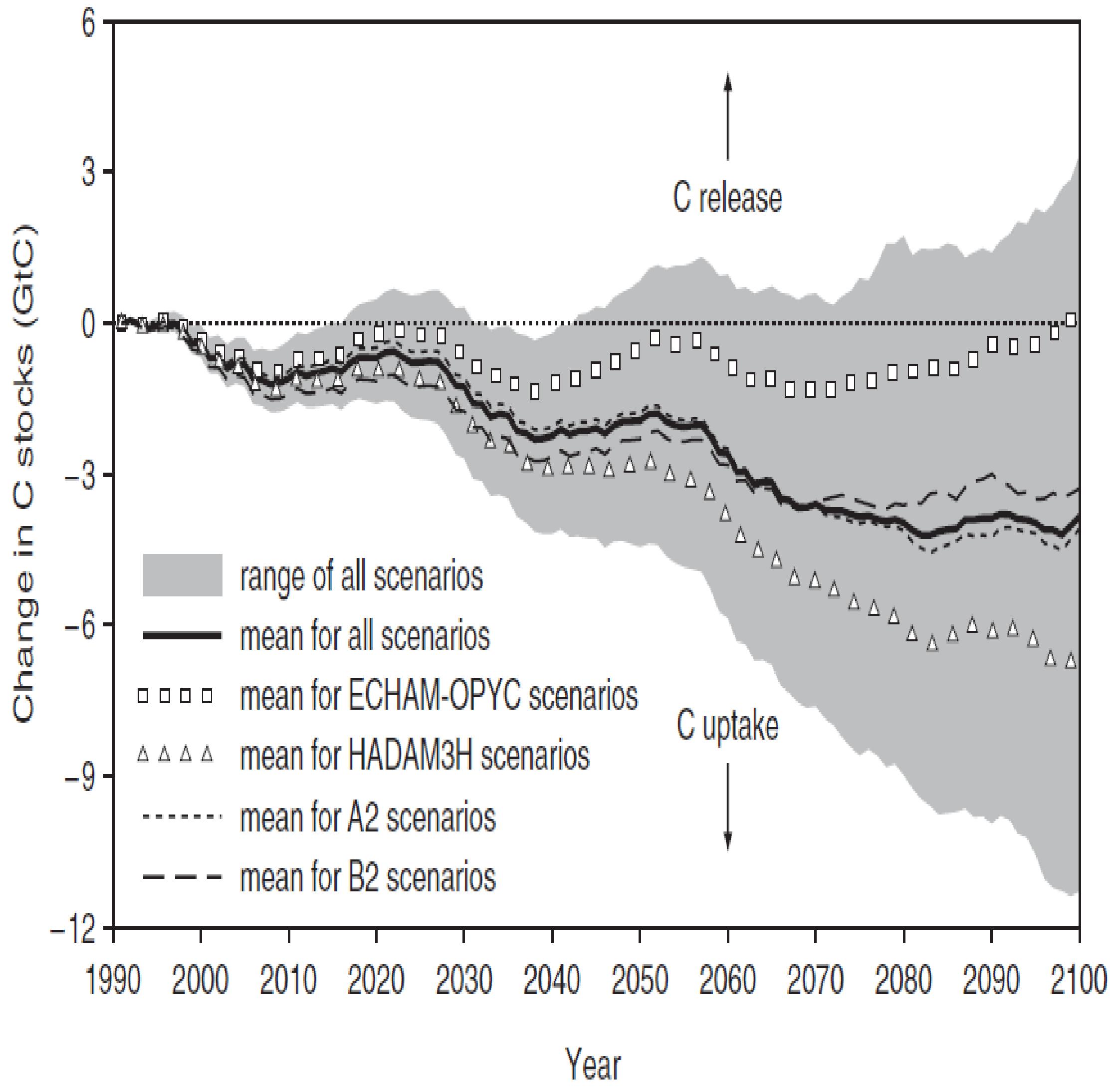


Resource
-Uptake
-Distribution
-Release

Definition: "problems"



(Cramer et al. 2001)



(Morales et al. 2005)

Definition: "problems"

Requirements:

1. Changes within the soil
   (microbes, storage changes)
2. Physiological adjustments
   (seasonal, inter-annual)
3. Interaction with other individuals
   (between species)
4. Response on disturbances

Modular Biosphere simuLation Framework (MoBiLE)

Empirical Canopy Model (ECM)

(Grote 2007, Holst et al. 2010)

Dynamic Treegrowth Model (M-TREEDYN)

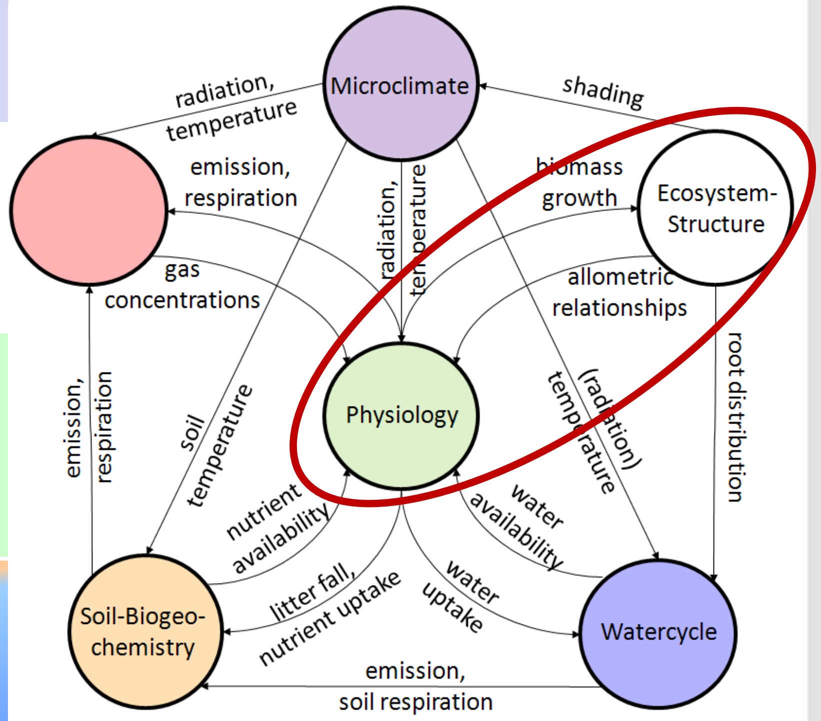
(Bossel et al. 1996, Grote et al. 2011)

Physiological Simulation Model (PSIM)

(Grote et al. 2009, 2010)

DeNitrification-DeComposition (DNDC)

(Li et al. 1992, 2000)

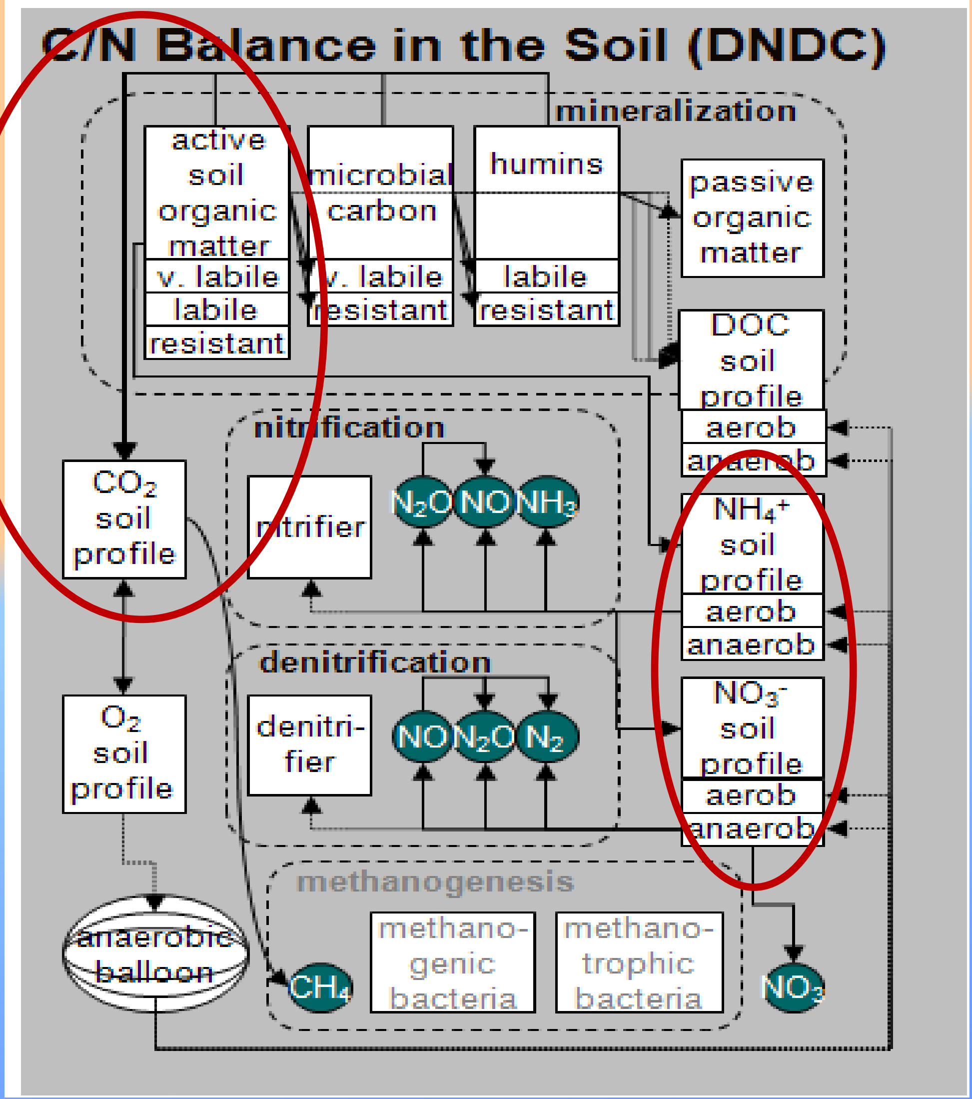


→ MoBiLE-PSIM

Modular Simulation Framework (MoBiLE)

DeNitrification-DeComposition (DNDC)

(Li et al. 1992, 2000)



Example: Interaction with soil → Höglwald/spruce

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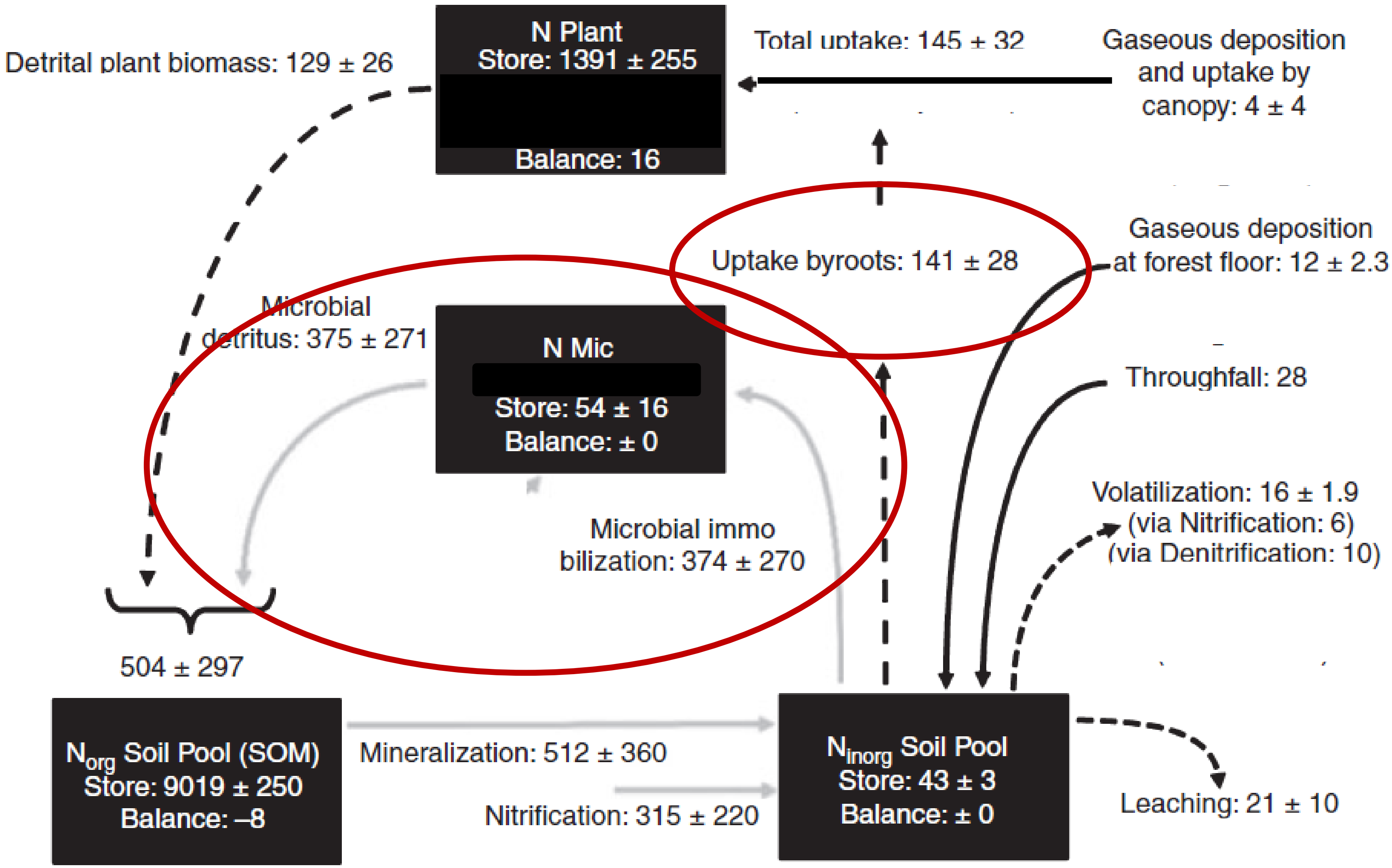
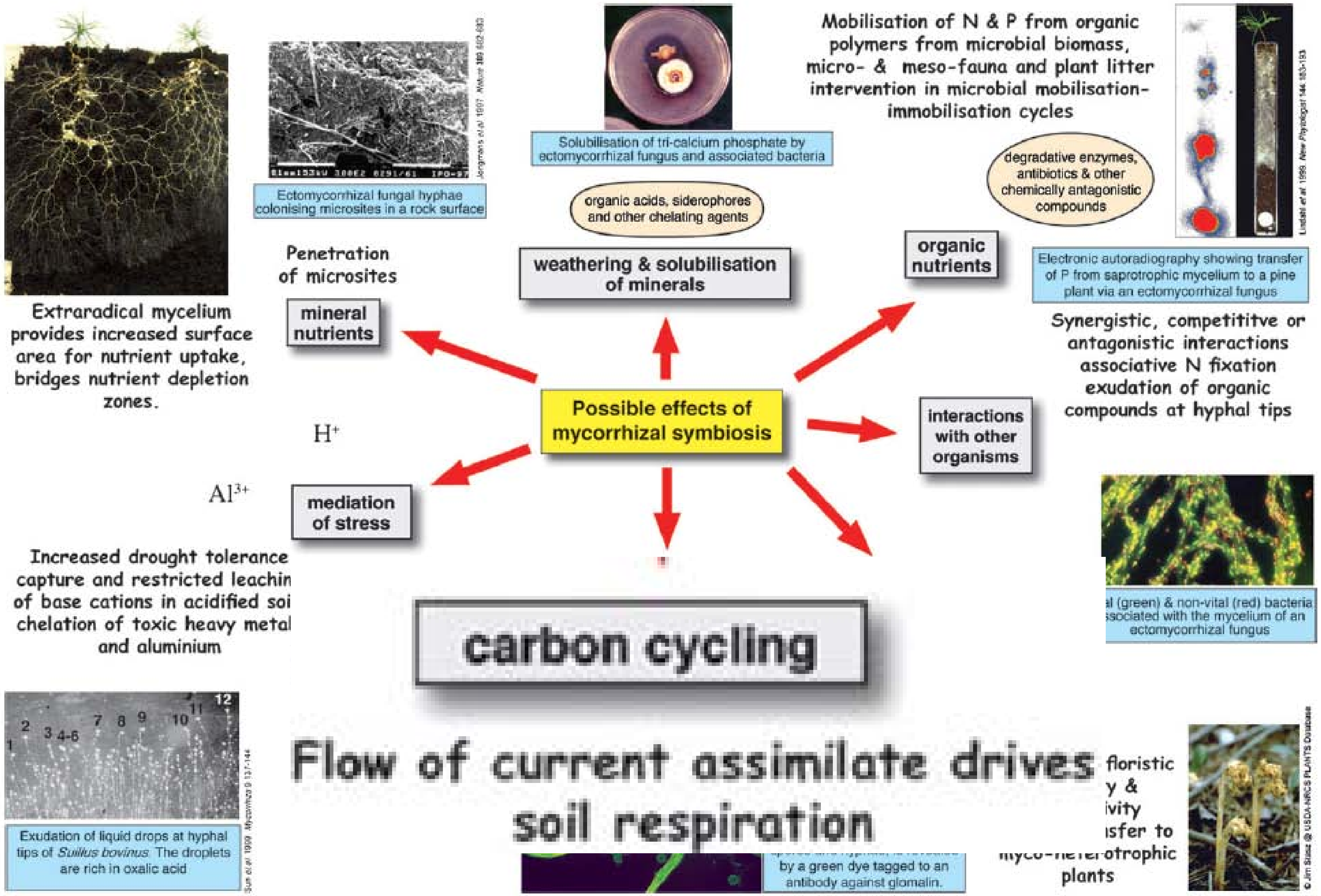


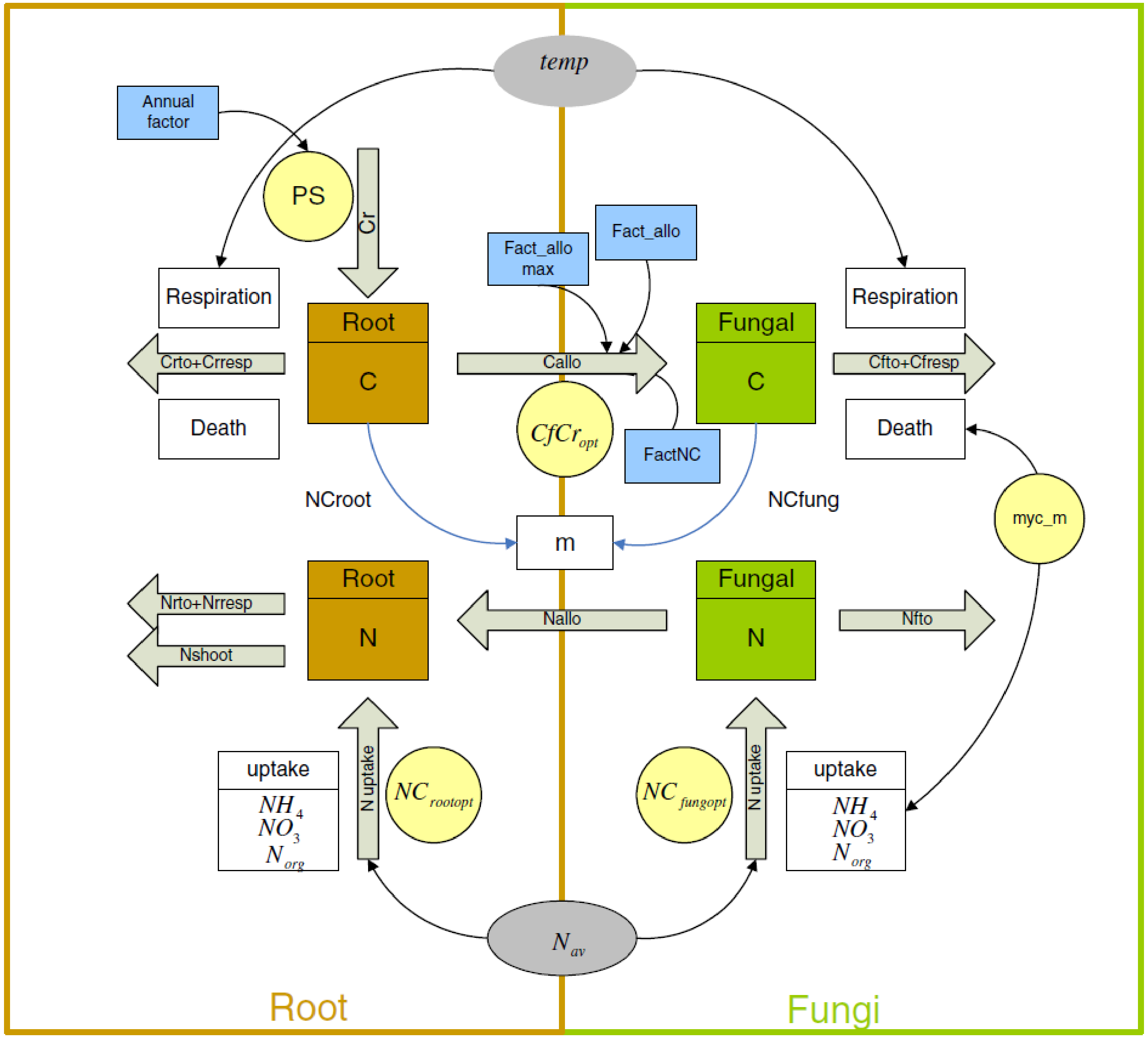
Kreutzer et al. 2009 (slightly modified, all values in kg N ha-1 resp. kg N ha-1 a-1)

Mycorrhiza



Finlay 2008

MYCOFON model



Meyer et al. 2010 (PS)

MYCOFON model

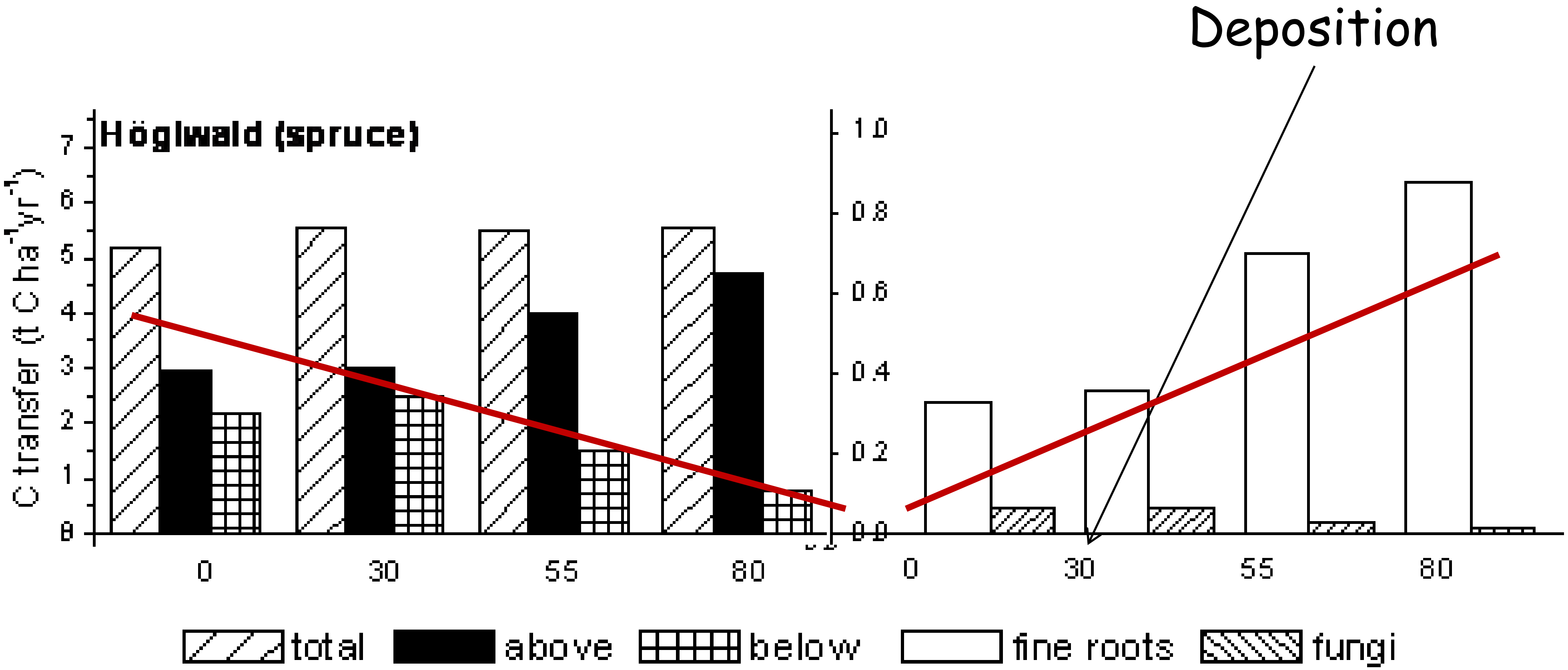
		Total N uptake*	Plant N supply*
1995	(normal)	231	158
1996	(dry)	237	155
1997	(wet)	271	182

*kg ha-1 a-1

→ N turnover increased app. 1.5 fold
(results are preliminary)

Meyer et al. subm (EJFR)

MYCOFON model



→ Belowground allocation decreases with N supply (results are preliminary)

Meyer et al. subm (EJFR)

Example: Physiological adjustments: Hesse/Beech

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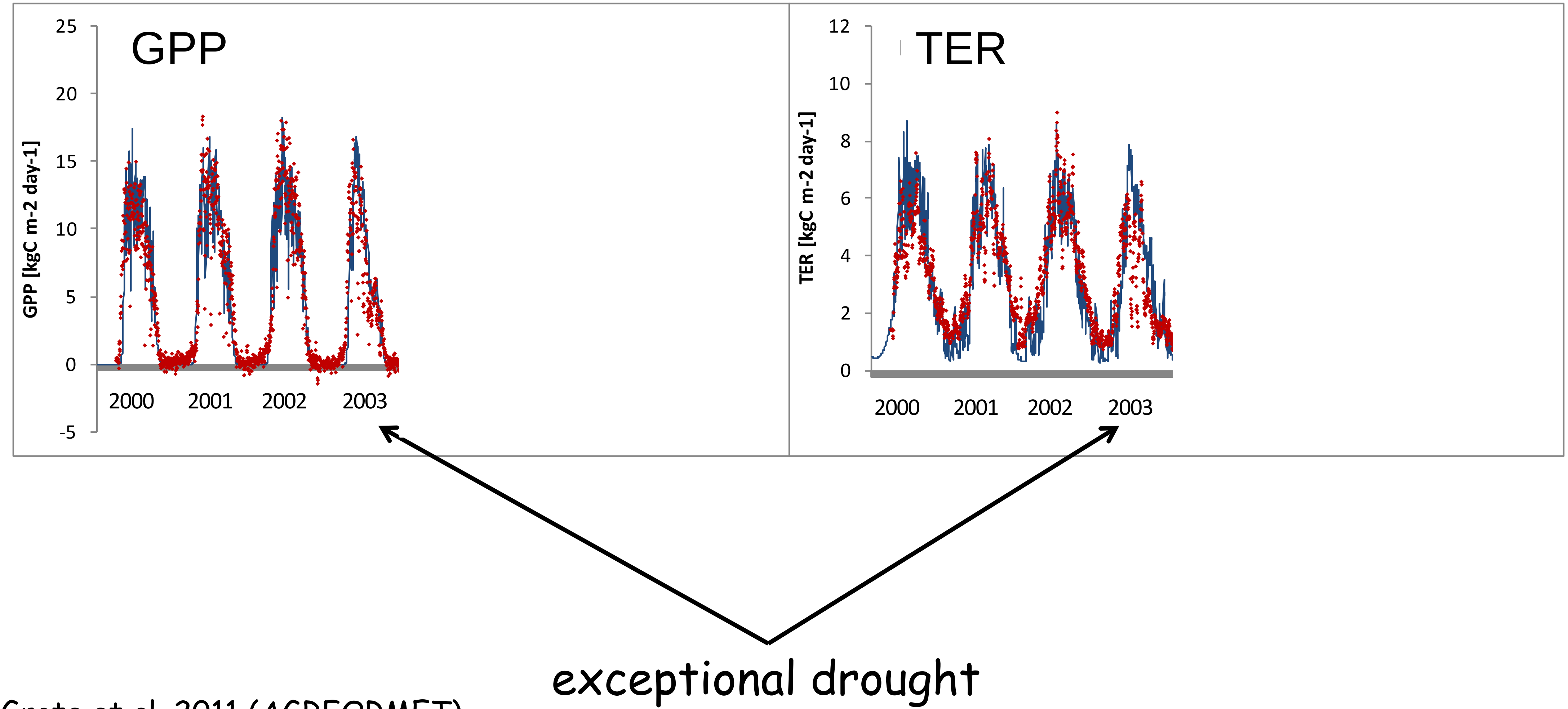
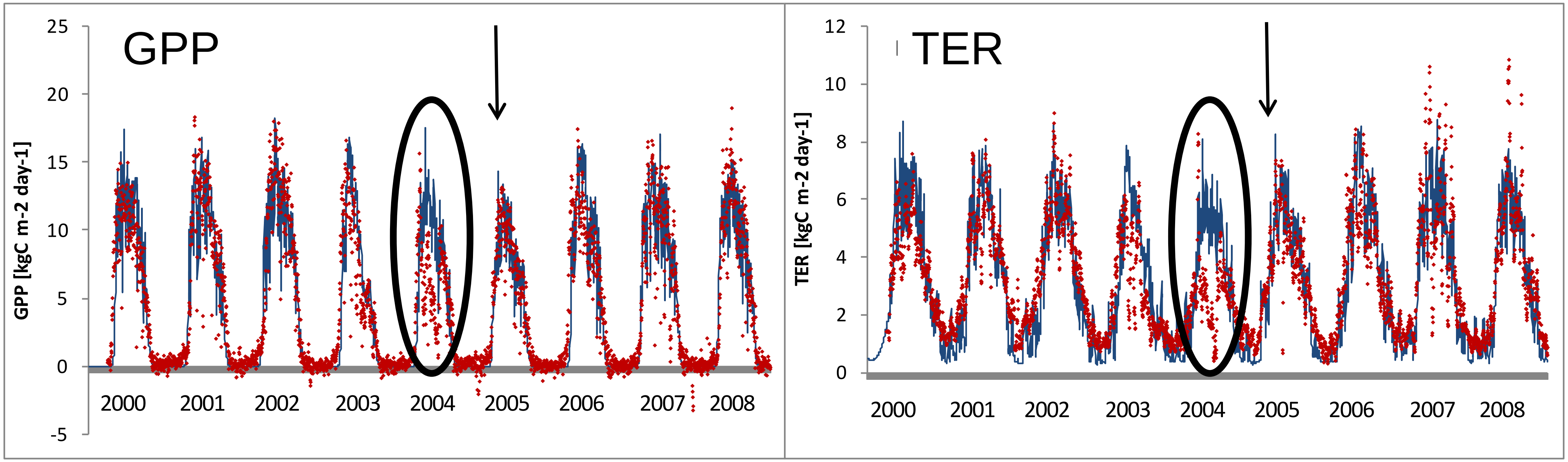
- Parameter adjusted to meet average annual NEE exchange
- Model constrained with forest inventory data
- Model evaluated with soil water and transpiration (1997-2002)



Grote et al. 2011 (AGRFORMET)

2. Results

Example: Physiological adjustments: Hesse/Beech



- Missing tissue destruction by weather extremes?
- Missing resource depletion related to soil processes?
- Both?

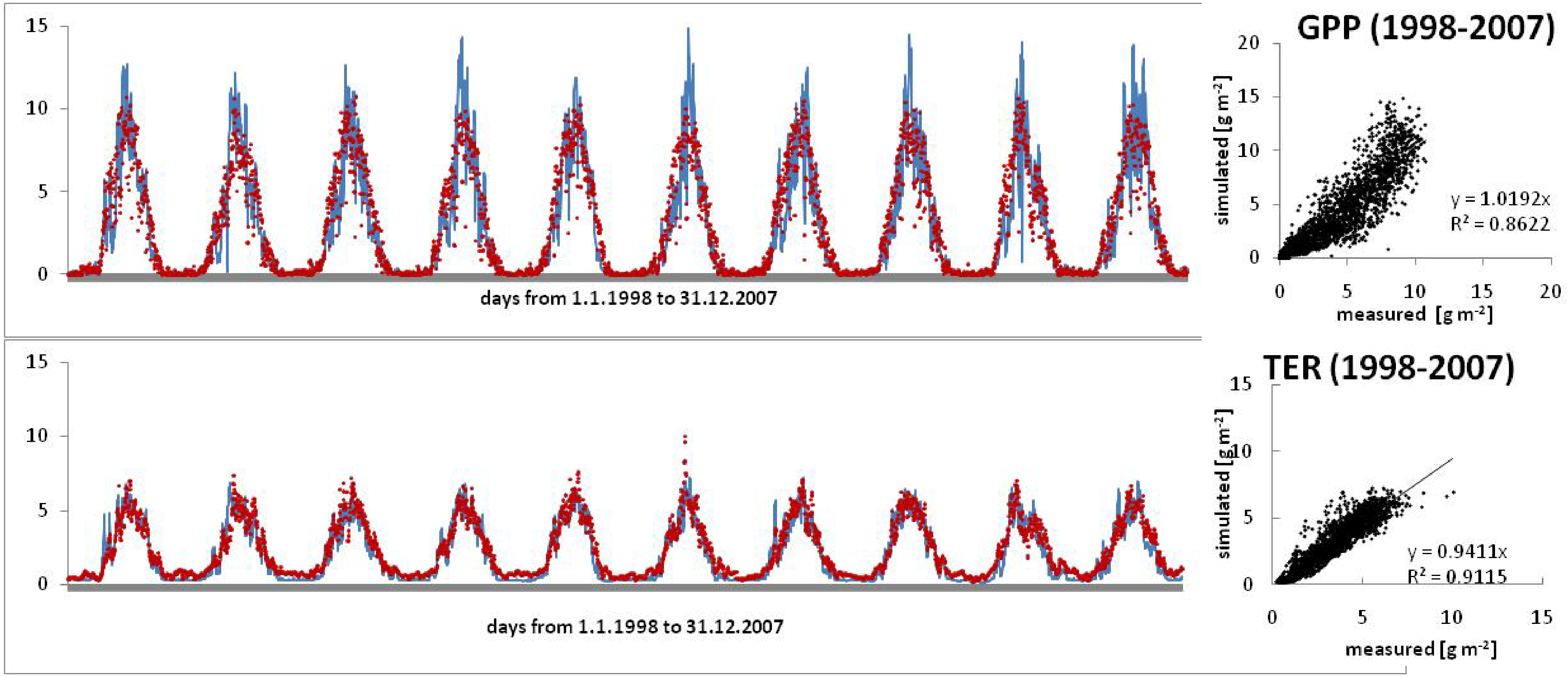
Grote et al. 2011 (AGRFORMET)

Example: Physiological adjustments: Hyytiälä/Pine

3. Results

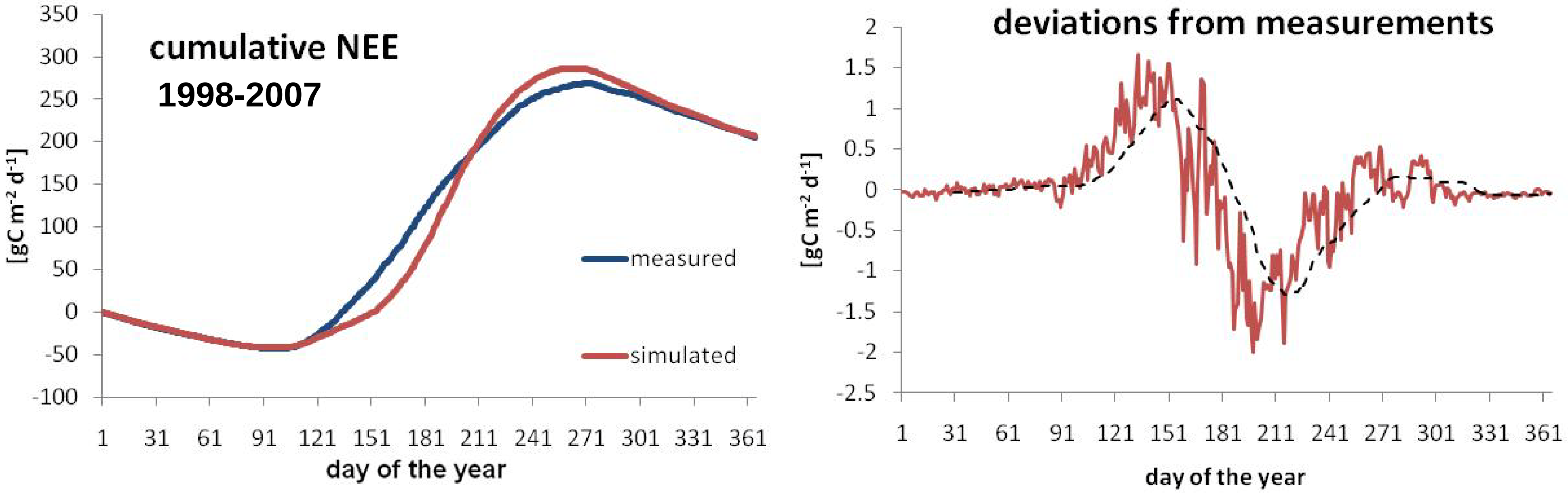
Example: Physiological adjustments: Hyytiälä

- Parameter adjusted to meet average annual NEE flux
  Note: Model includes evaluated phenology (litterfall)
  Note: Model considers empirical seasonality term (Mäkelä et al. 2004)



Grote et al. subm. (FORSYS)

Example: Physiological adjustments: Hyytiälä



- Seasonality of enzyme activity site specific?
- Missing influence of other plants?
- Both?

Grote et al. subm. (FORSYS)

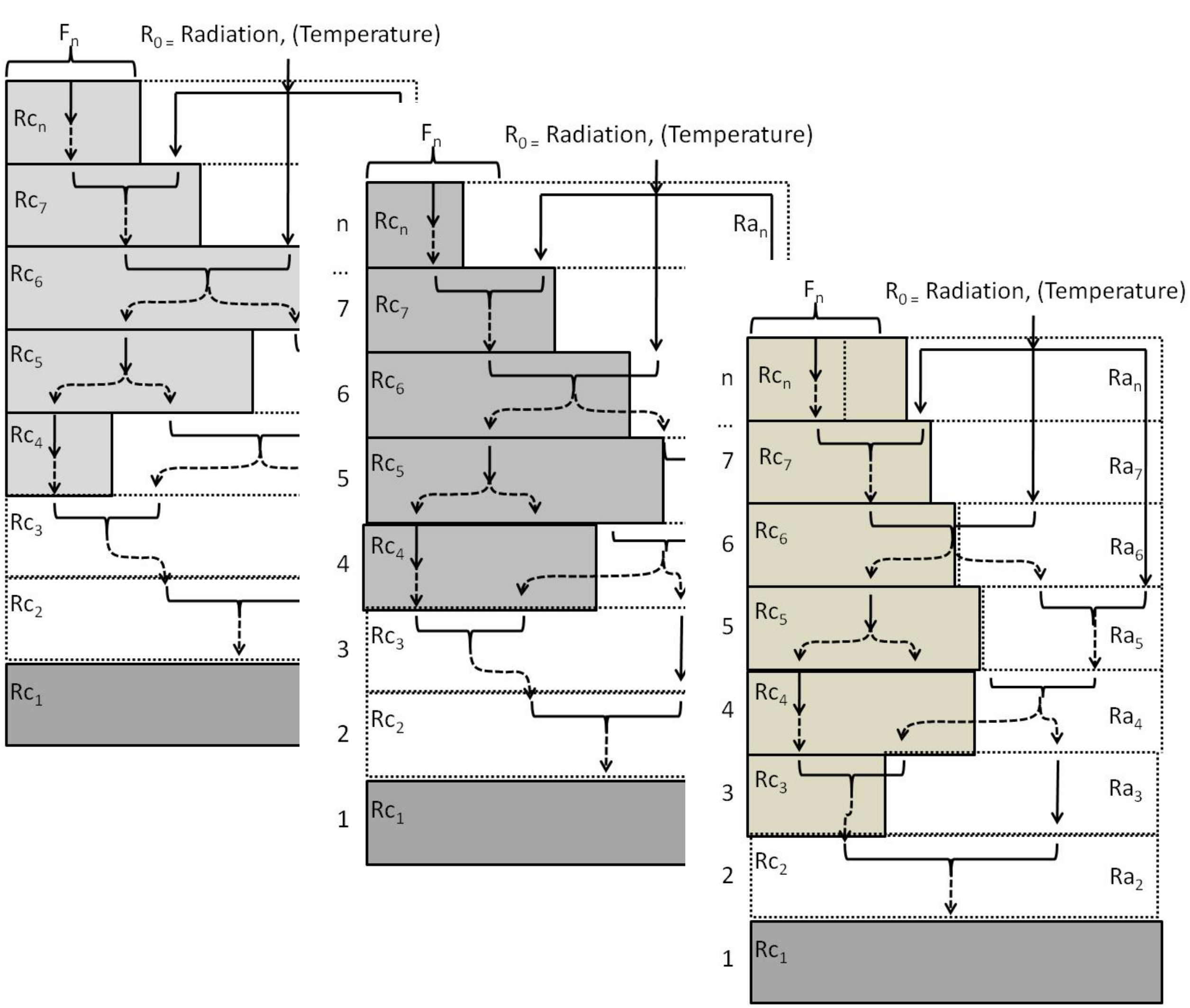
Example: Interaction between species: Hyytiälä

Several Species at different places

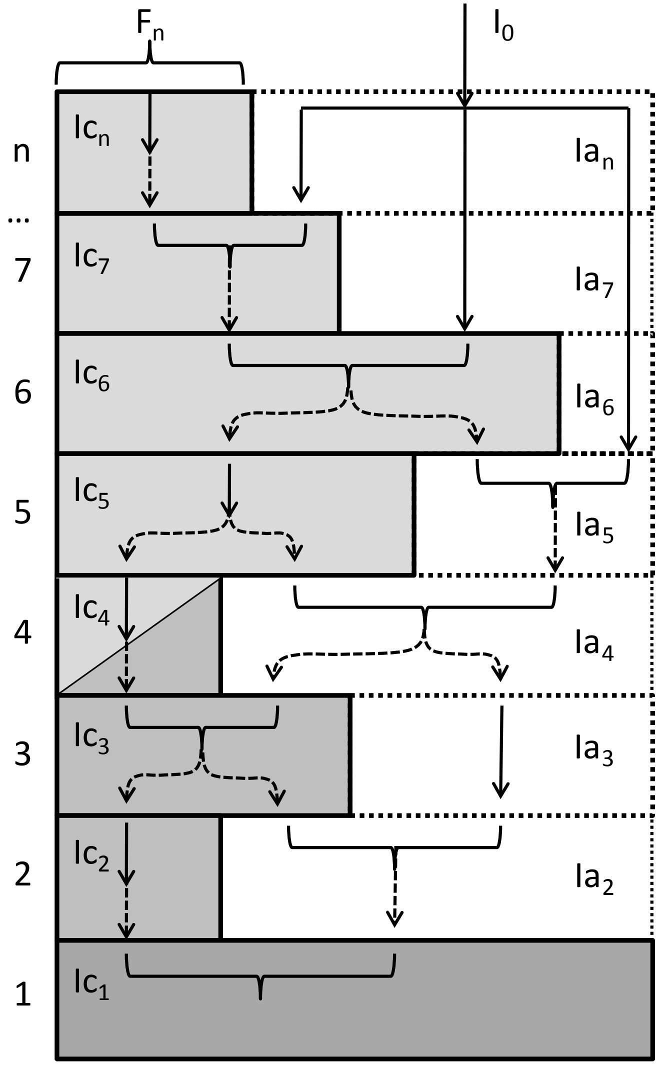
Overstory/Understory

Forest inventory includes significant amounts of spruces and birches!

Example: Interaction between species: Hyytiälä



Several Species of the same size
(WEIGHTED)



Overstory/Understory
(MIXED)

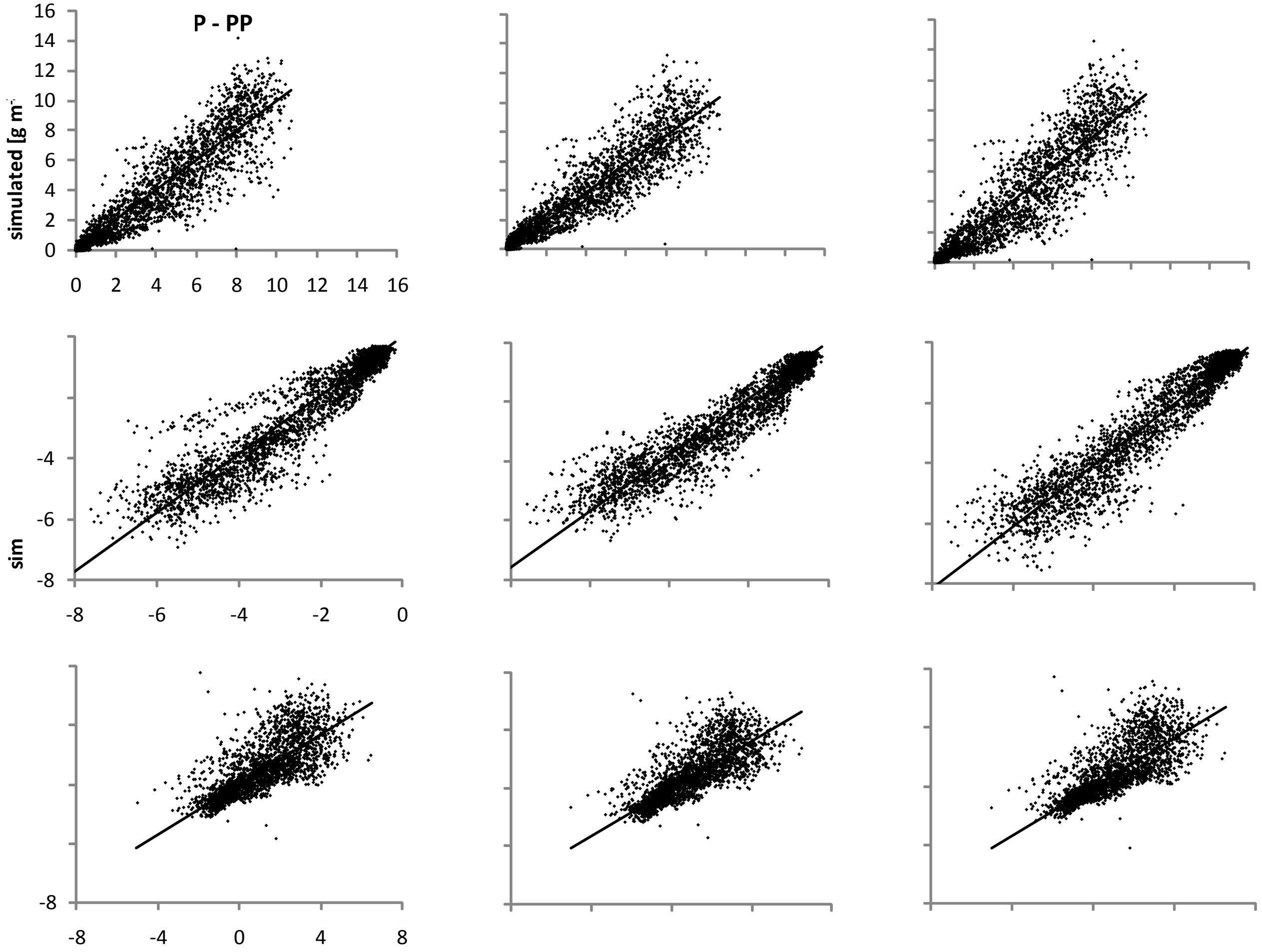
Example: Interaction between species: Hyytiälä

PURE PINE WEIGHTED MIXED

GPP

TER

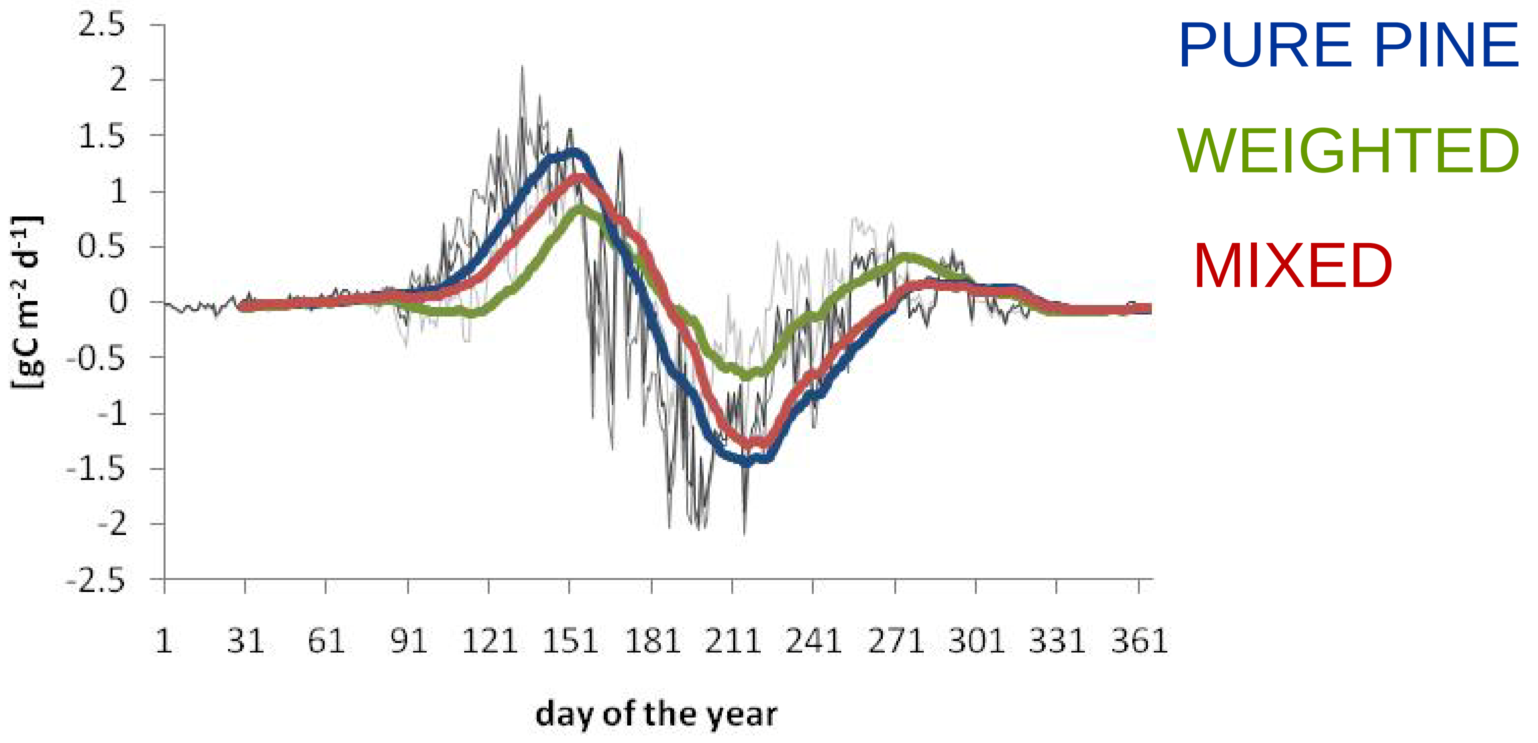
NEE



→ Best statistical results for WEIGHTED and MIXED simulations

Grote et al. subm. (FORSYS)

Example: Interaction between species: Hyytiälä



Best dynamical results for WEIGHTED simulations

- Stand structure matters!
- … and open questions still remain

Grote et al. subm. (FORSYS)

Major deficits considering long-term/one-generation modeling:

- Soil processes (mycorrhiza, phosphorus)
  (LeRoux et al. 2001, Landsberg 2003, Hobbie 2006, Fontes et al. 2010, McGuire & Treseder 2010)

- Acclimation, incl. Downregulation and long-term Damages
  (Constable & Friend 2000, LeRoux et al. 2001, Landsberg 2003, Litton et al. 2007 Hanson et al. 2004, Atkin et al. 2007, Leuzinger et al. 2011)

- Disturbances (i.e. fire, insects, management)
  (Thornton et al. 2002, Running 2008, Fontes et al. 2010, Seidl et al. 2011)

➢ (Short-term) Interaction between species/species groups
  (Moorcroft et al. 2003)

Physiologically-based models are not (yet) suitable for applications on long-term environmental changes

Major progress can be expected with new model approaches that consider an ecosystem as multi-organismic and describe species interaction.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