Modeling GHG and hydrological conditions of peatlands by CoupModel

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History

- SOIL model (Jansson & Halldin, 1979)
- SOILN (Johnsson et al. 1987)
- CoupModel (Jansson & Moon, 2001)

Key characteristics

- One-dimensional, vertical layered soil profile including plant
- Strong physically based, thus applicable for all terrestrial ecosystems
- Focus on the user defined objective rather than a given scale of resolution in time and space.

Model is available free of charge:
http://www.coupmodel.com/

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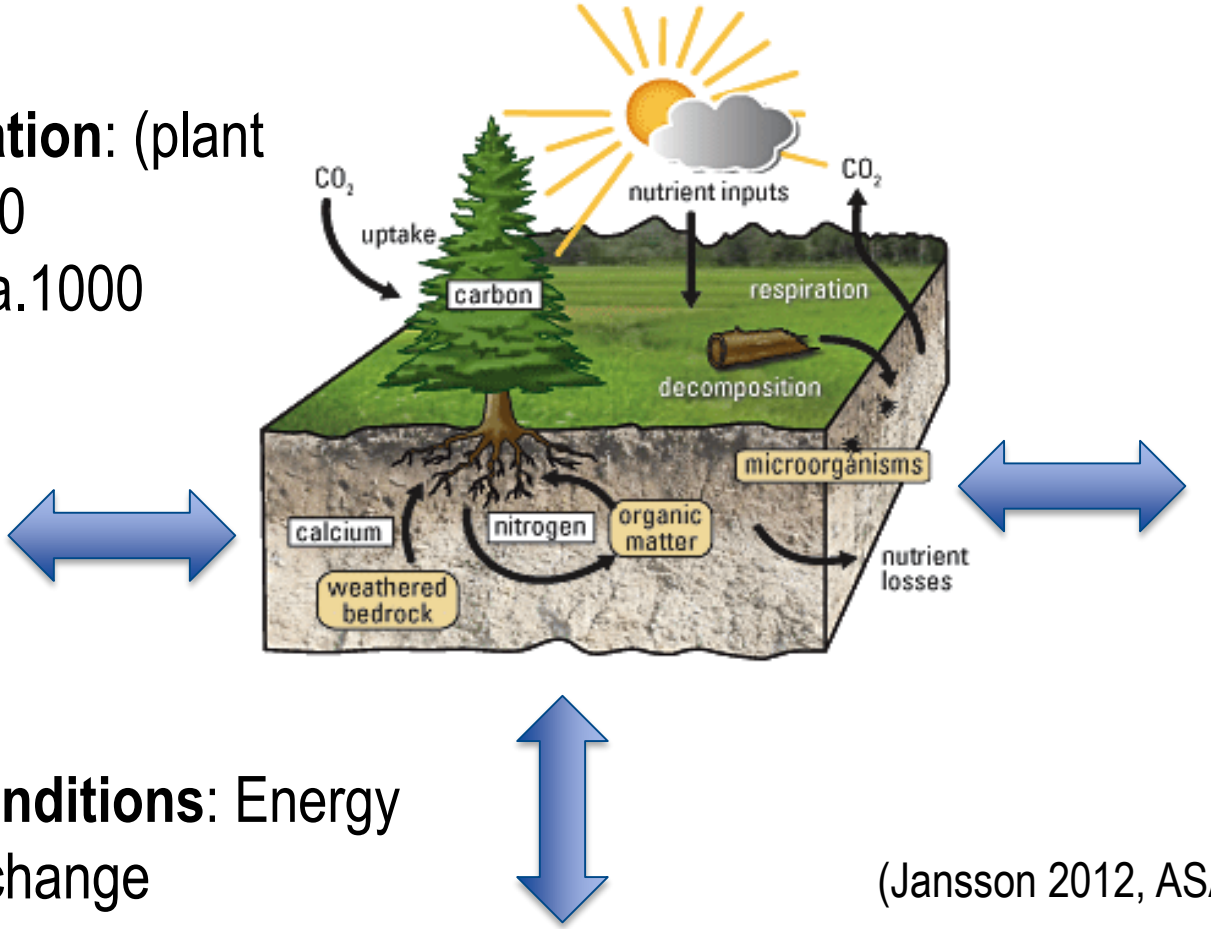
CoupModel

Forcing: global radiation, precipitation, air temperature, relative humidity, wind speed

Parameterization: (plant and soil) > 300
Variables: c.a.1000



Boundary conditions: Energy and mass exchange

(Jansson 2012, ASABE)

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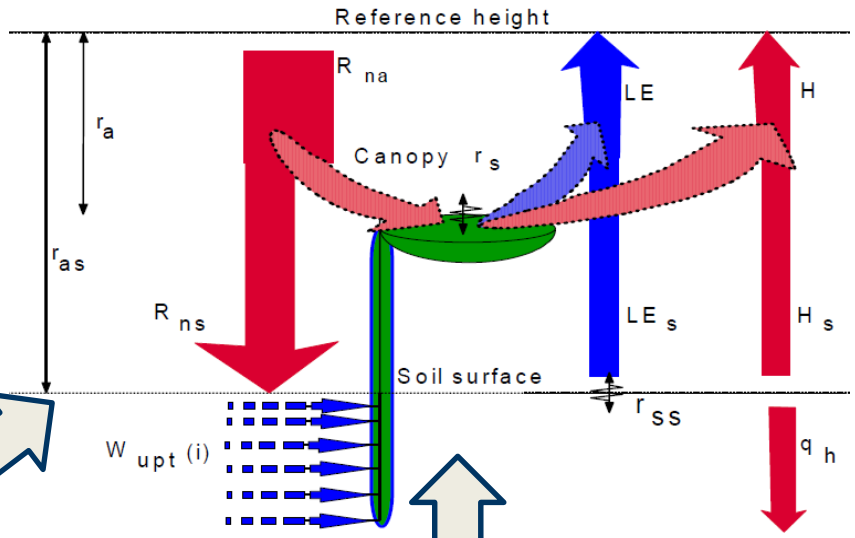
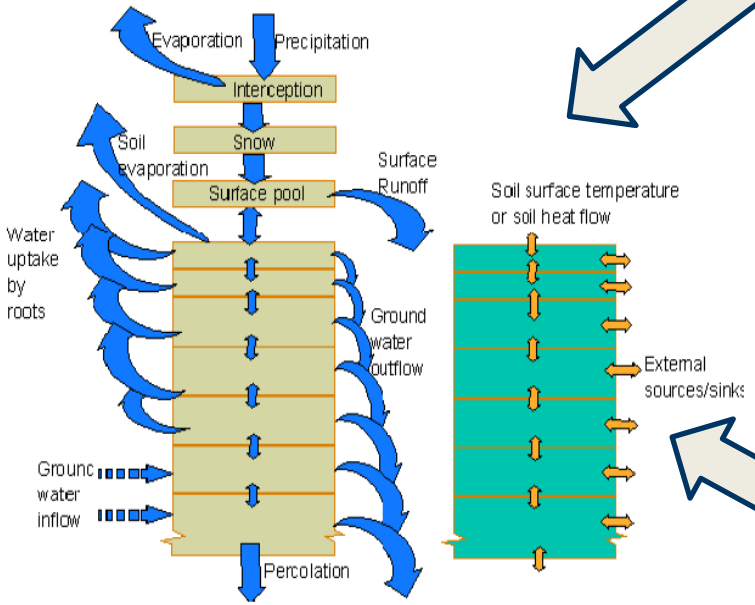
CoupModel

Coupled heat and mass transfer model for soil-plant-atmosphere systems

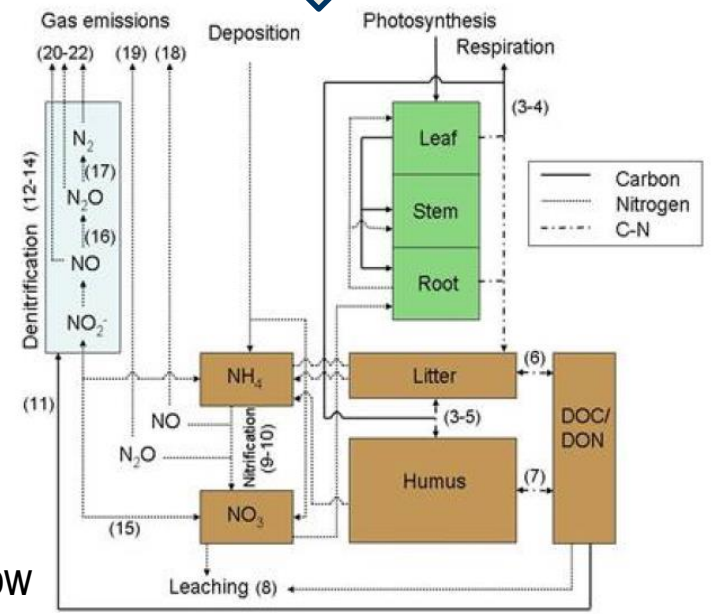
Atmosphere-soil interaction





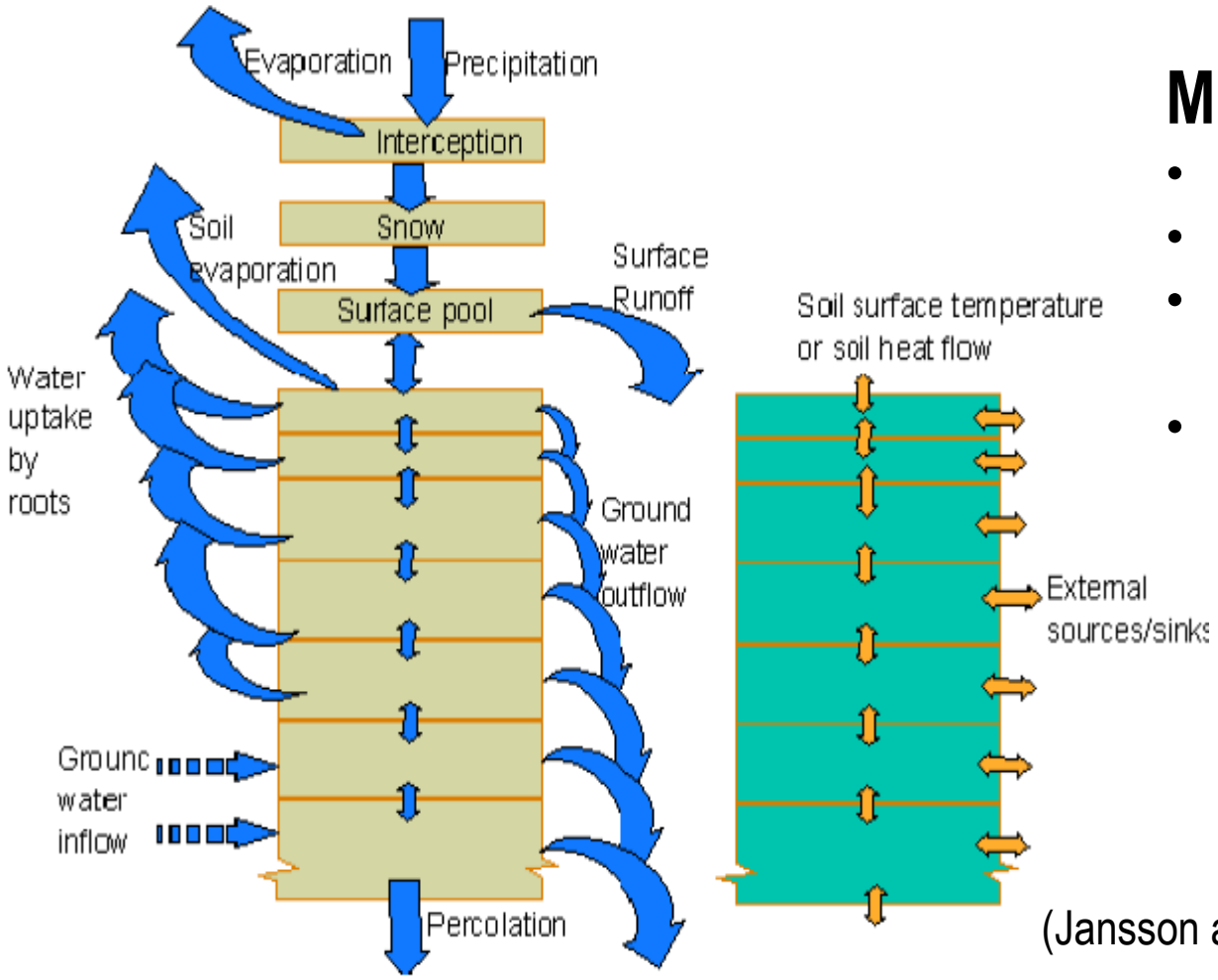
Water and heat flow

(Jansson and Karlberg, 2011)



C and N flow

Water and heat processes



Major inputs:

- Water retention curve
- Hydraulic conductivity
- Drainage level

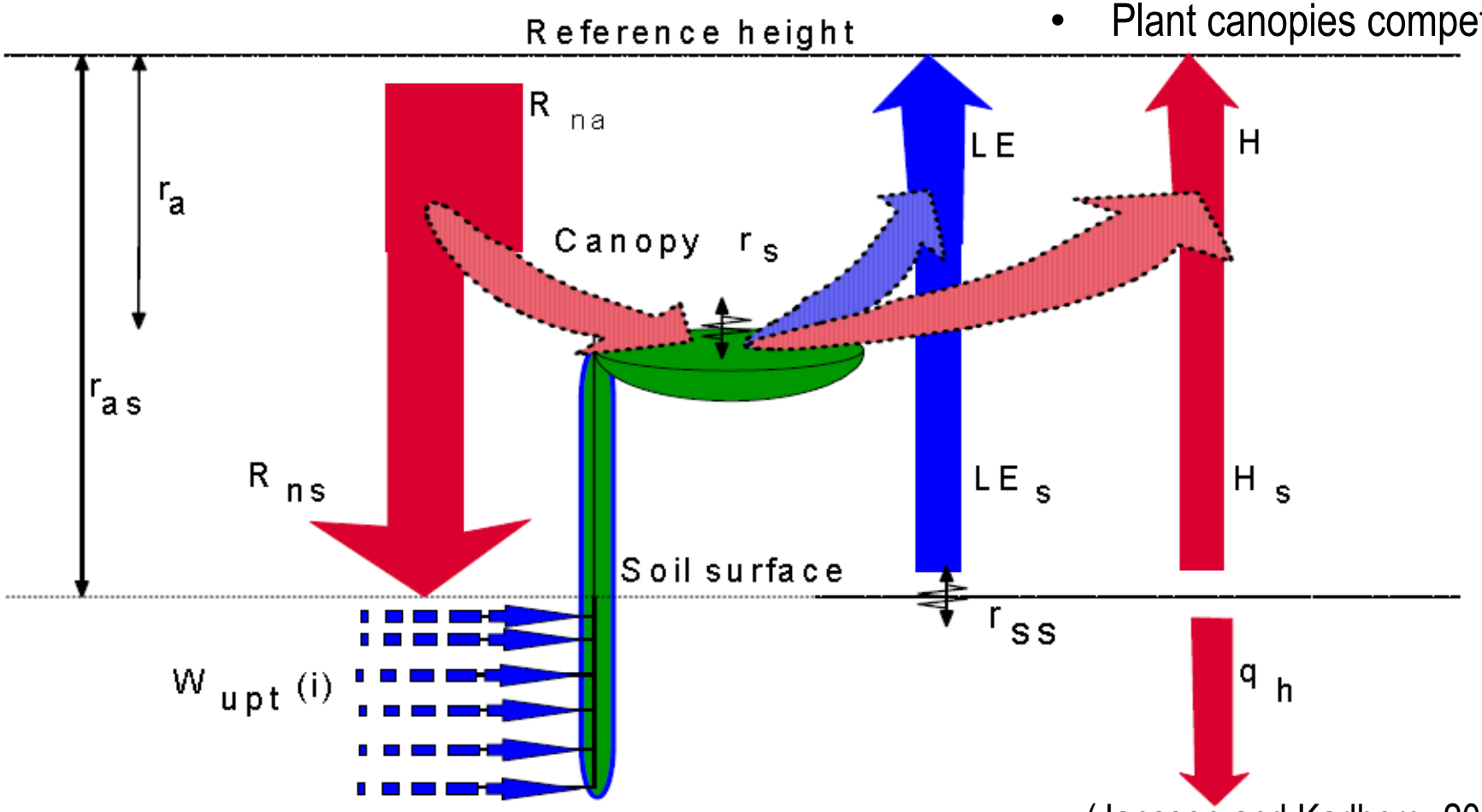
- Thermal conductivity including LE at thawing/melting

(Jansson and Karlberg, 2011)

Single/Multiple Big leaf Model

Major inputs:

- LAI
- Root distribution
- Surface/leaf resistance
- Plant cover influence aerodynamic conditions
- Plant canopies compete



(Jansson and Karlberg, 2011)

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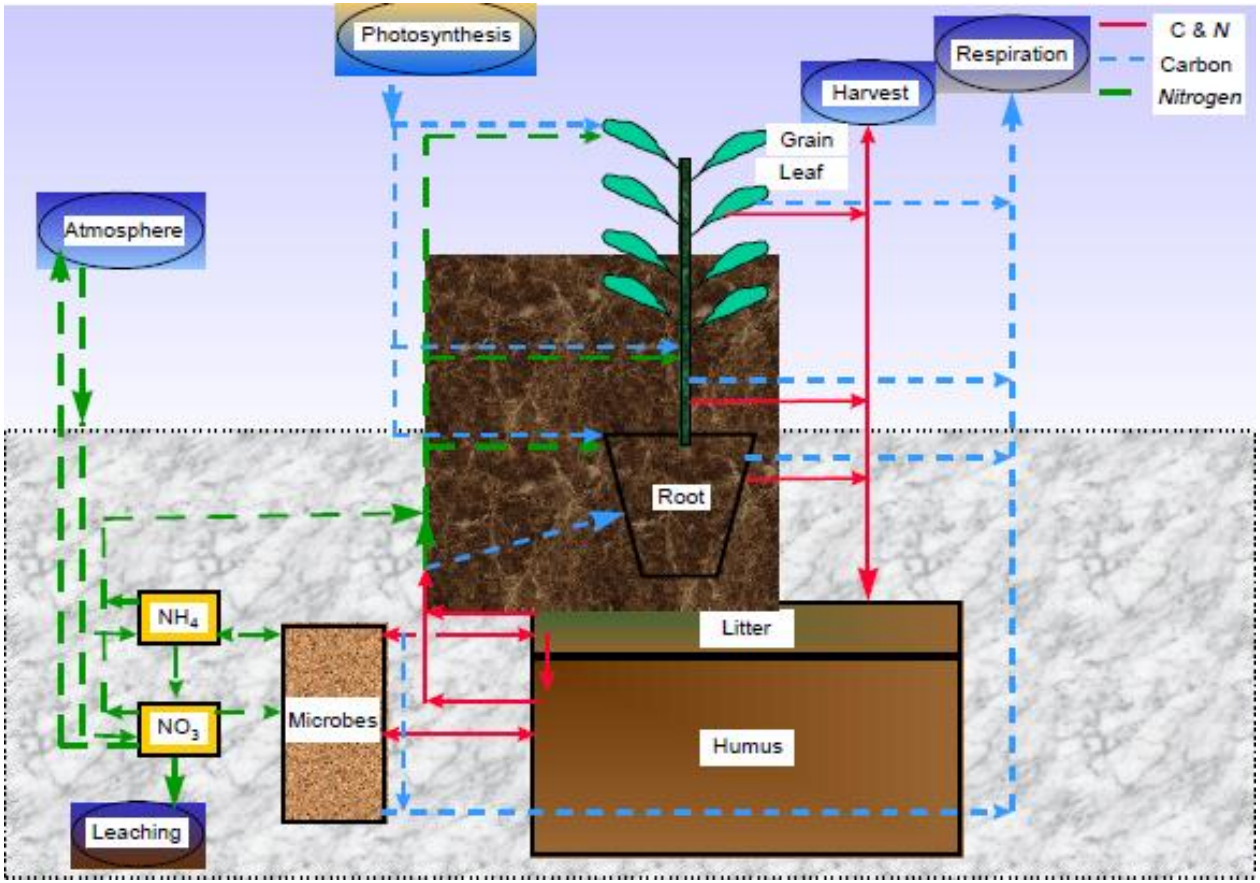
Carbon and Nitrogen processes

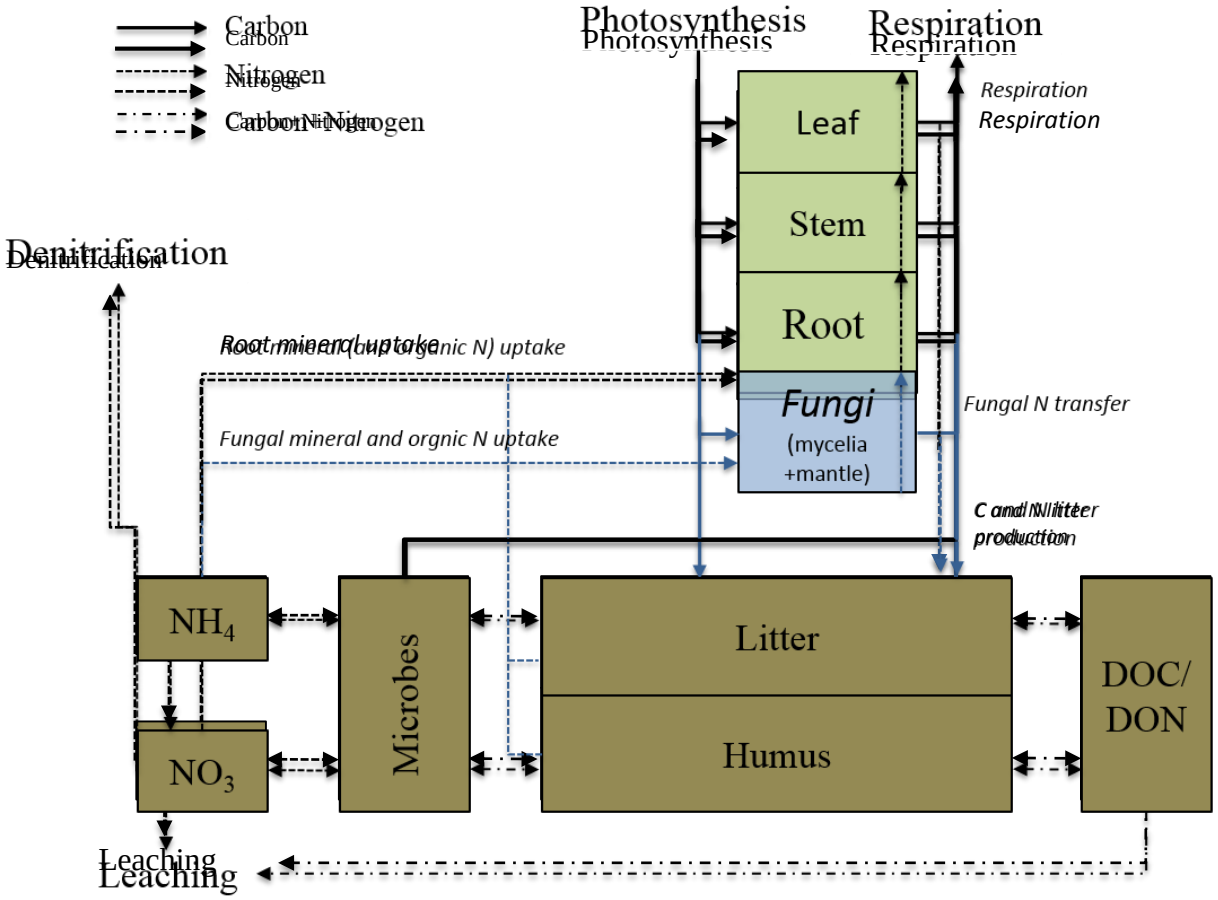


Major inputs:

- SOM pools
- Plant biomass pools
- Plant allocation pattern
- Plant nutrient uptake
- N deposition
- Plant management
- Soil management

(Jansson and Karlberg, 2011)

Ectomycorrhiza model (He et al. 2018, GMD)



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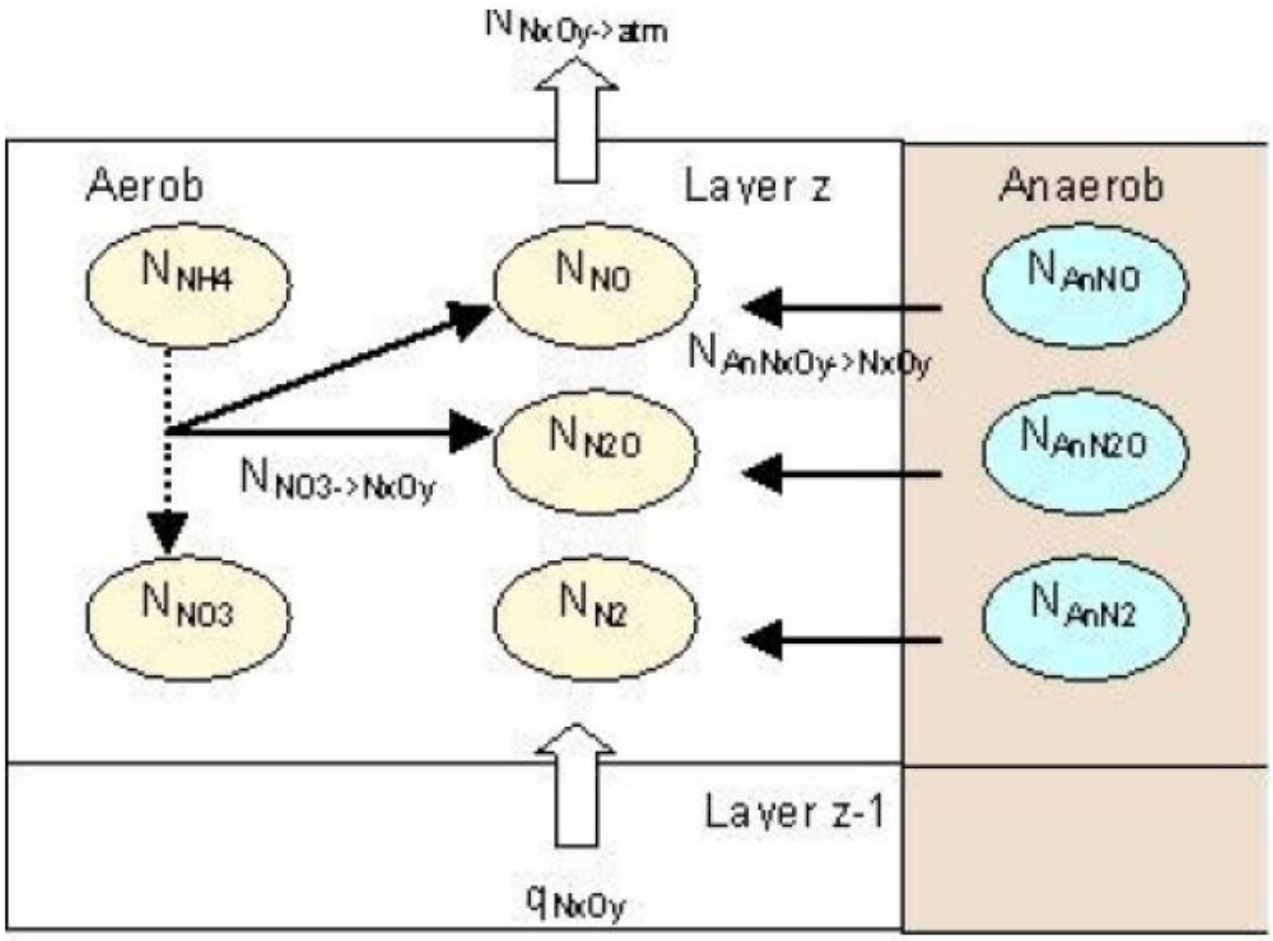
N_2O emission model (Norman et al. 2008, Ecological Modelling)



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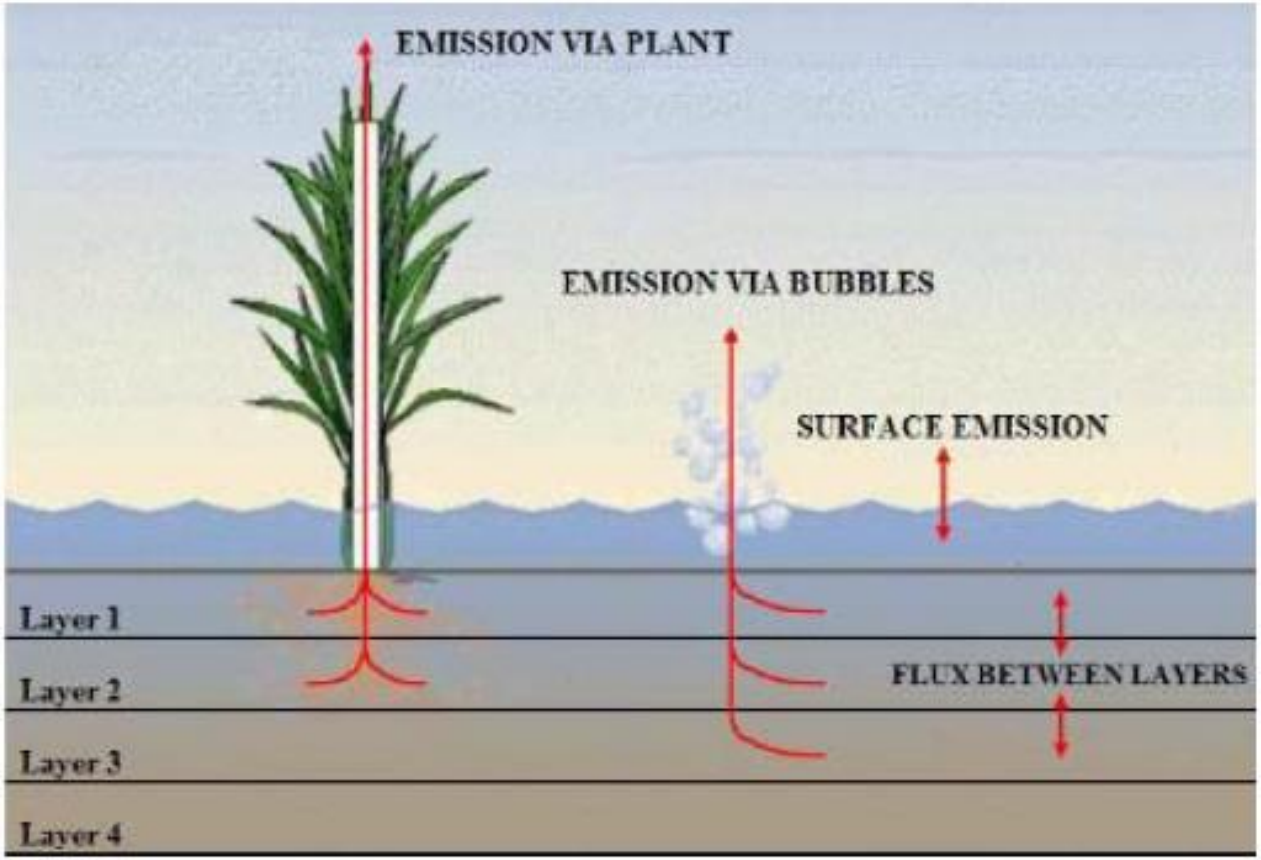
CH_4 emission model



(Jansson and Karlberg, 2011)

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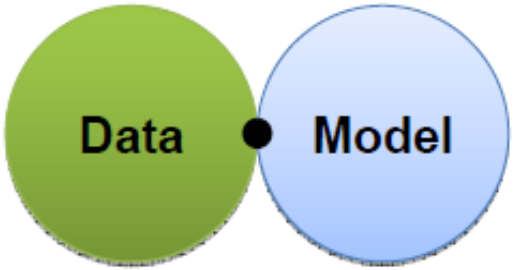
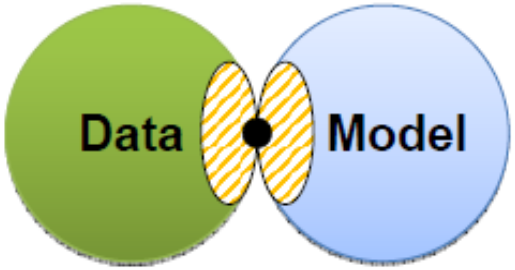
Handling uncertainty



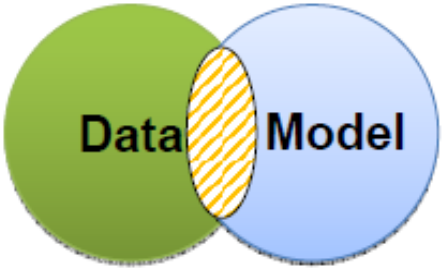
Deterministic



Probabilistic (stochastic) uncertainties

Statistical methods

Bayesian calibration



Possibilitstic uncertainties

Non-statistical (informal) methods

GLUE

(Juston, Phd thesis)

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Short summary of CoupModel

- One-dimensional, vertical layered soil profile
- Mechanistic model with many components:

  Energy, interaction with boundary layer meteorology

  heat including frozen soils

  Water, liquid, vapor and ice

´ C and N all the major processes

- A tool to play with various combinations of parameter and equations
- Uncertainty expressed as combination of model uncertainty and parameter uncertainties

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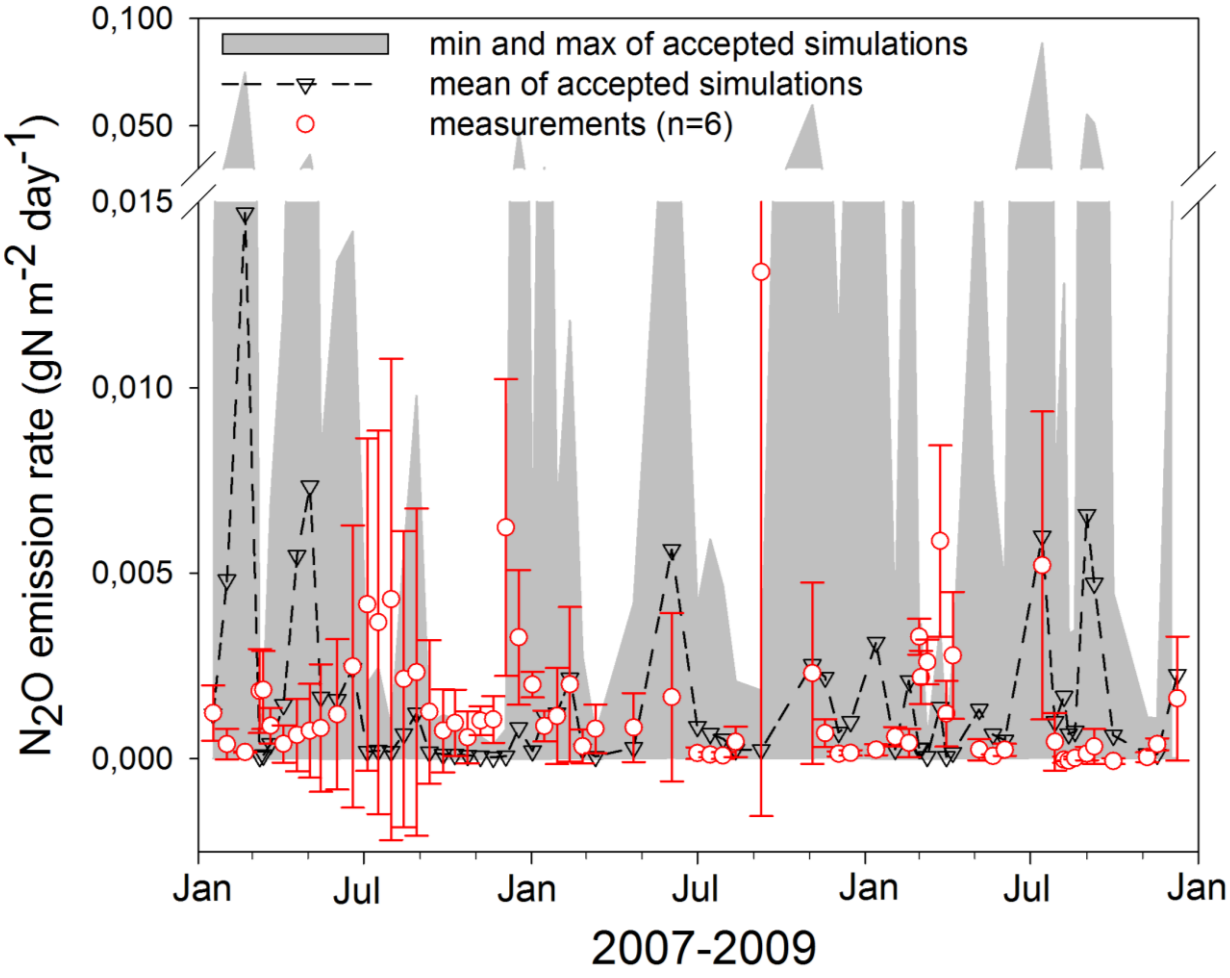
CoupModel performance on peatlands (R^2)

Ecosystem	Site	Ecosystem flux			Soil gas flux		Soil abiotics		
		H	LE	NEE	CO2	N2O	T	θ	GWL
Forests	Skogaryd	0.6	0.7	0.5		0.1	0.95	0.6	0.8
	Åsa			0.5	0.5		0.9		0.4
	Kalevansuo	0.5	0.6	0.6	0.4	0.05	0.96		0.5
	Lettosuo	0.6	0.7	0.5	0.6	0.04	0.94		0.6
Wetlands	Degerö Stormyr	0.6	0.5	0.4			0.95		0.4
	Lompolojänkkä			0.59	0.64		0.87		
	Auchencorth			0.55	0.38		0.89		
Restored	Horstermeer			0.48	0.45		0.91		
Grassland	Freisinger Moos			0.25	0.69		0.89		

N_2O emissions - Skogaryd



He et al., (2016) ecological modelling

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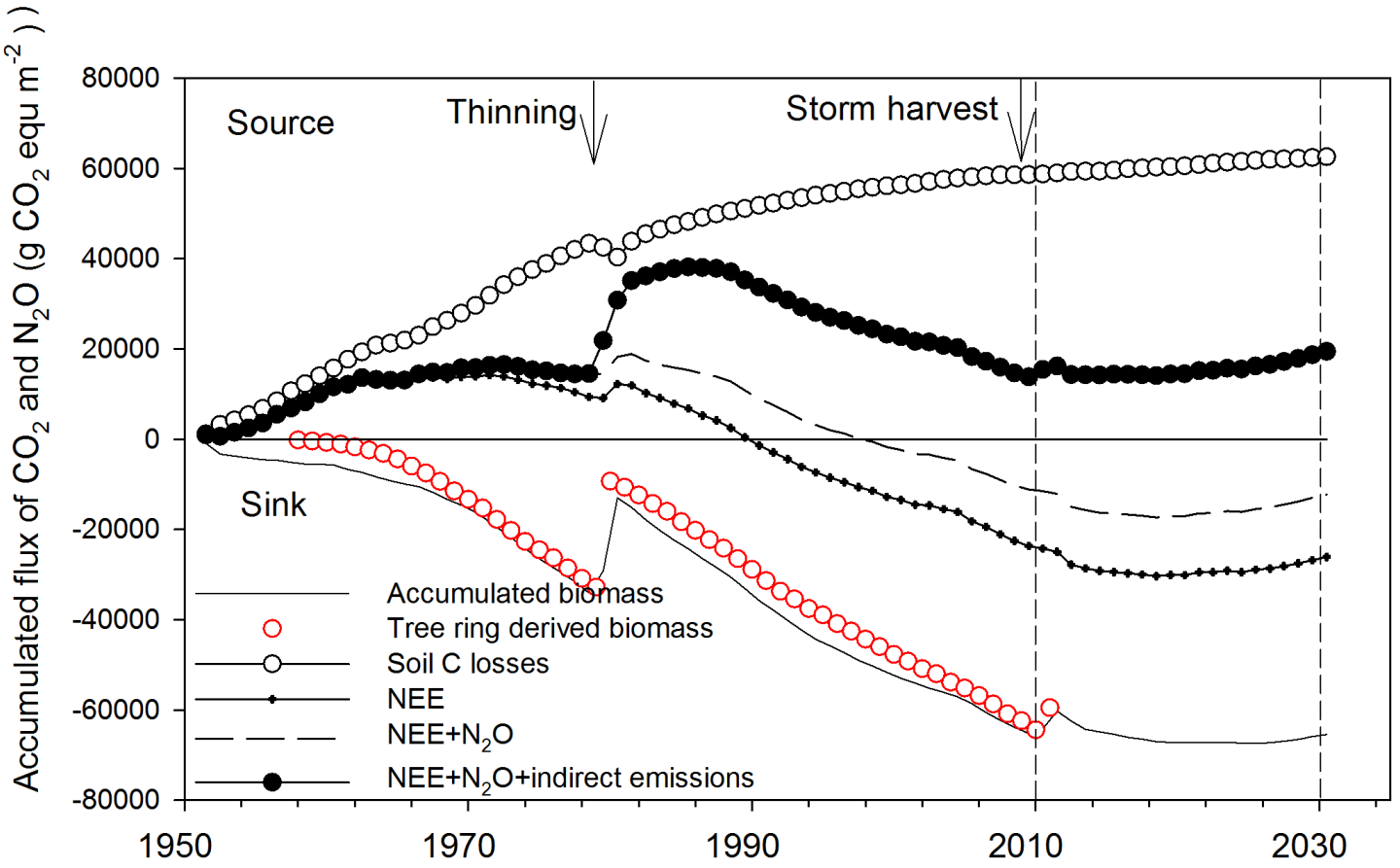
GHG balance over rotational period

(He et al., 2016 Biogeosciences)

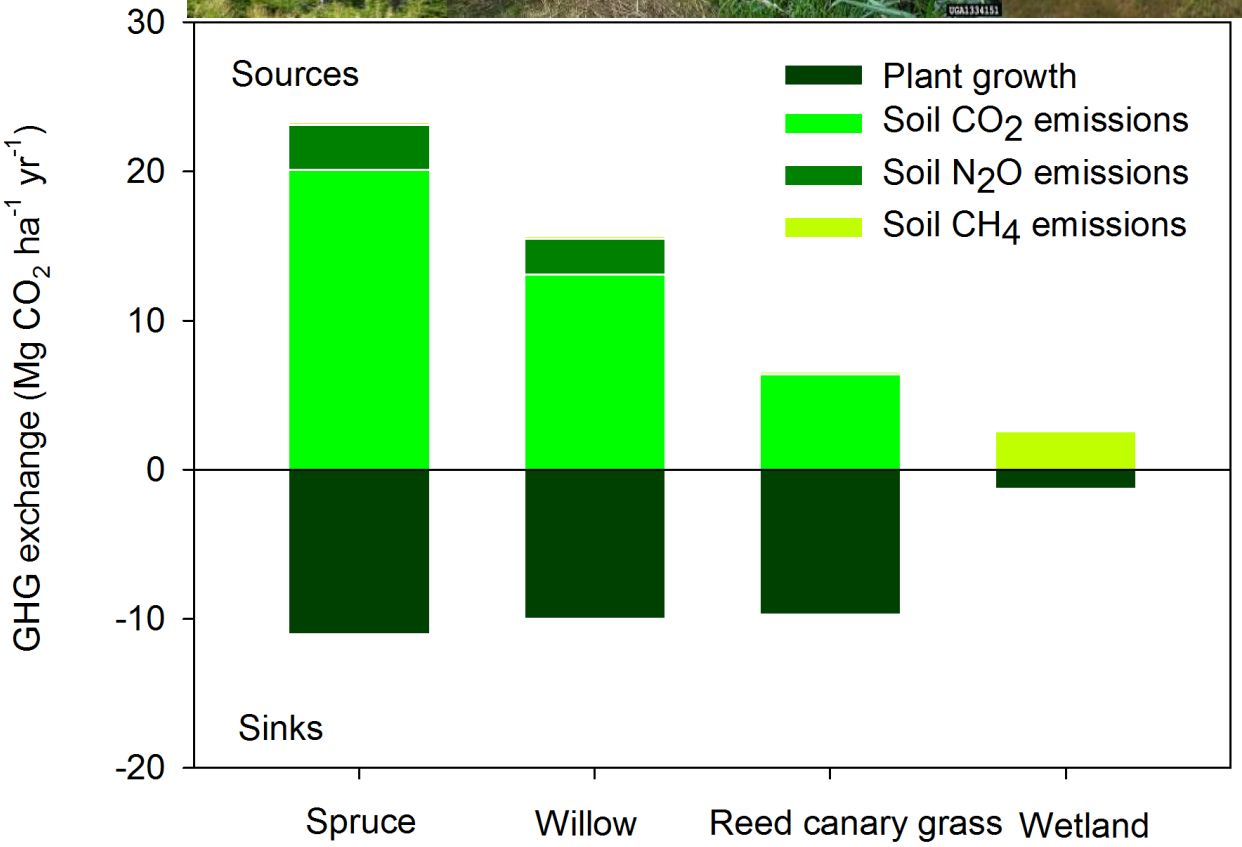


Forests on drained agricultural peatlands are a large GHG source

Scenario prediction

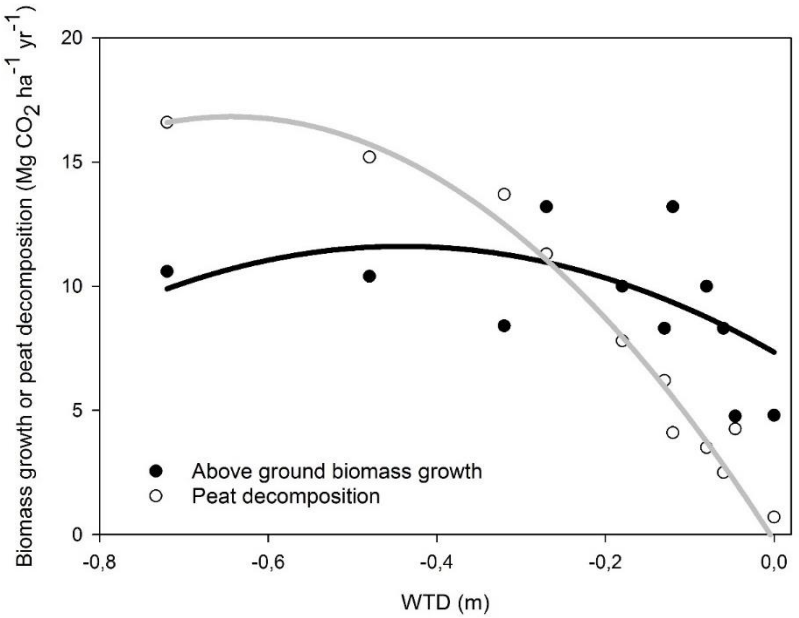
Average of 80 years

Increasing wetness



Reducing GHG emissions by land use change

Willow and Reed canary grass with intermediate water depth
Also economic feasibility



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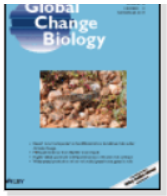

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Summary

- CoupModel has been tested to simulate the hydrology and associated CO_2 and N_2O emissions for a number of managed peatlands.
- The model is also capable to simulate most of human management practices both for plants and soil.