FINNISH METEOROLOGICAL INSTITUTE

EU Life+ MONIMET

LIFE12 ENV/FI/000409

Soil-vegetation-atmosphere model calibration and validation for mapping climate change effects in boreal zone

Tuula Aalto

LifeMonimet LIFE12 ENV/FI/000409

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Life

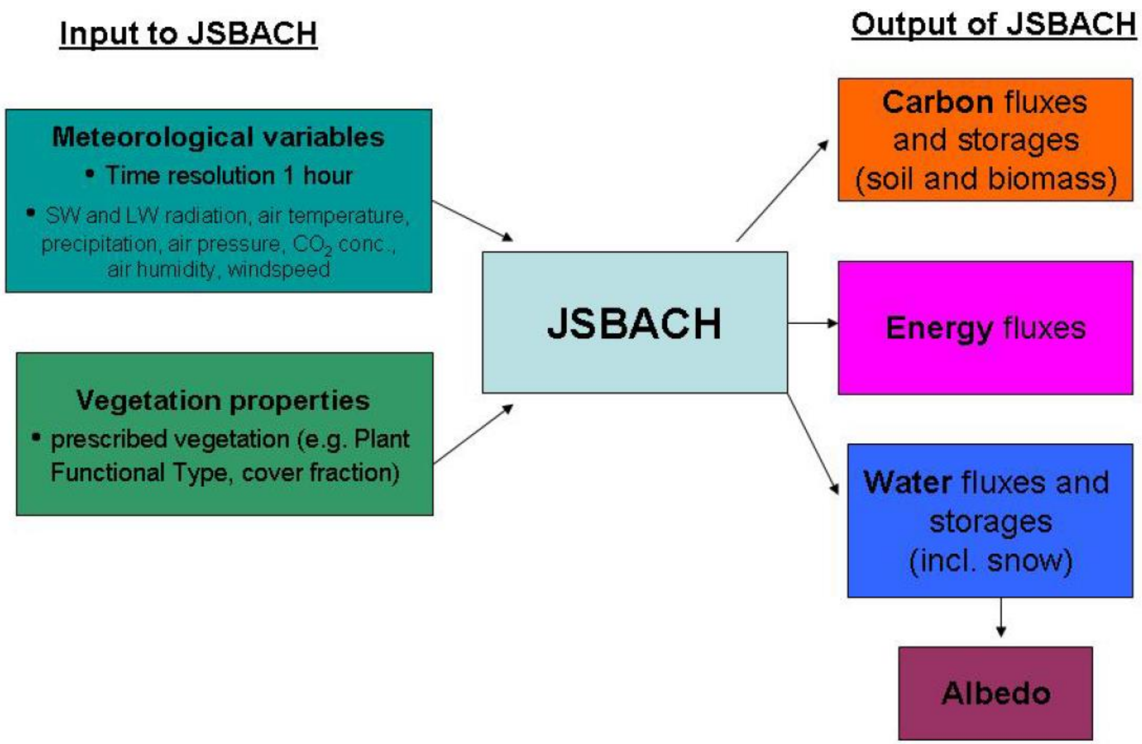
In order to make good predictions of the climate change impacts we need models which are calibrated for the boreal region

In MONIMET we use two models to predict vegetation and soil carbon and water storages and exchange between surface and atmosphere

In calibrations we use data that has been collected during MONIMET project and previous projects.

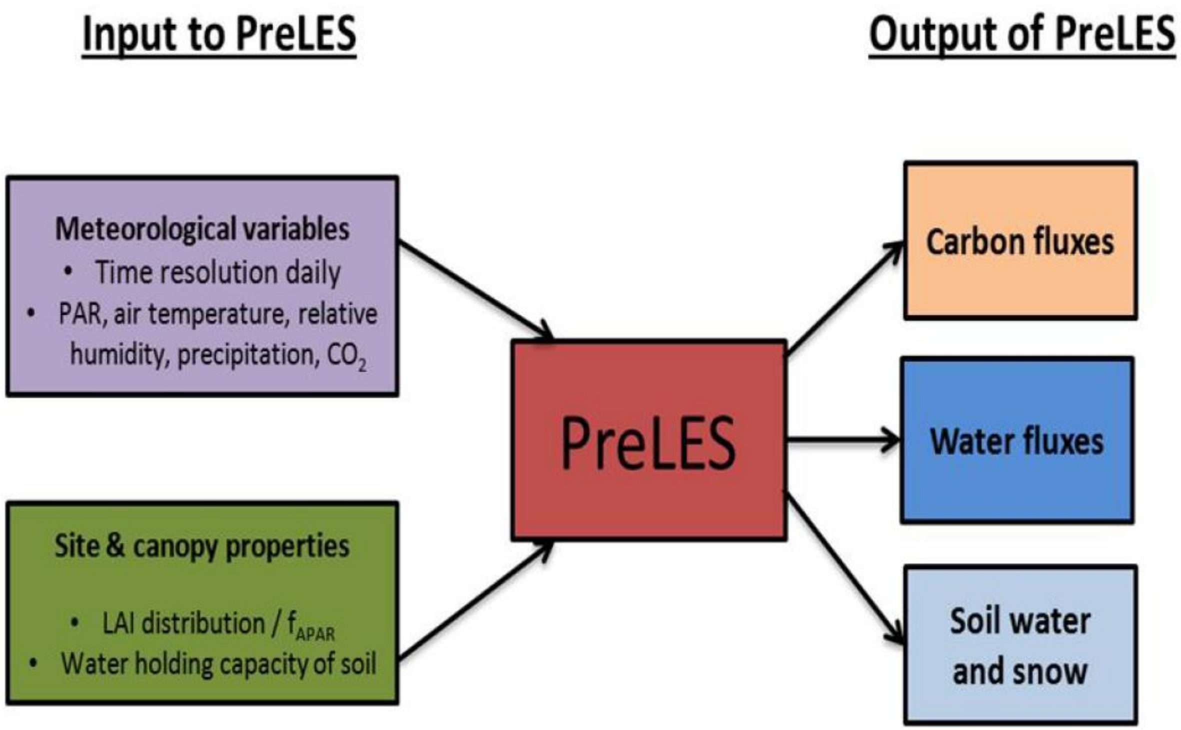
JSBACH model

is the land surface component of MPI-ESM Earth System Model developed in Max-Planck-Institute, Germany,
in use at FMI (contact: T. Aalto) and UHEL (contact: T. Vesala)

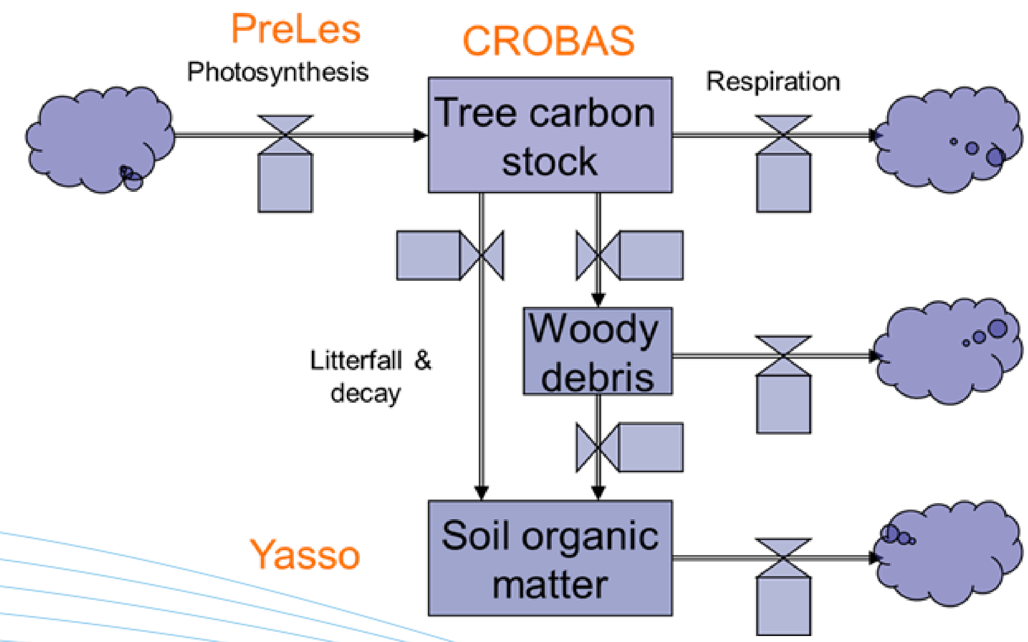


PRELES model

for canopy photosynthesis, hydrology and soil water content
developer contact: A. Mäkelä, UHEL, M. Peltoniemi, LUKE
MONIMET: F. Minunno



During MONIMET, PreLES is linked with CROBAS model for tree growth



Current status of the work:

Calibrate and validate forest models in the Boreal region.

PreLES calibration:

PreLES is a simple model and we tested if it can be used to estimate carbon and water fluxes of coniferous forests at regional scale.

We compared multi-site vs. site-specific calibrations to test if one generic calibration is able to cover the spatial variability.

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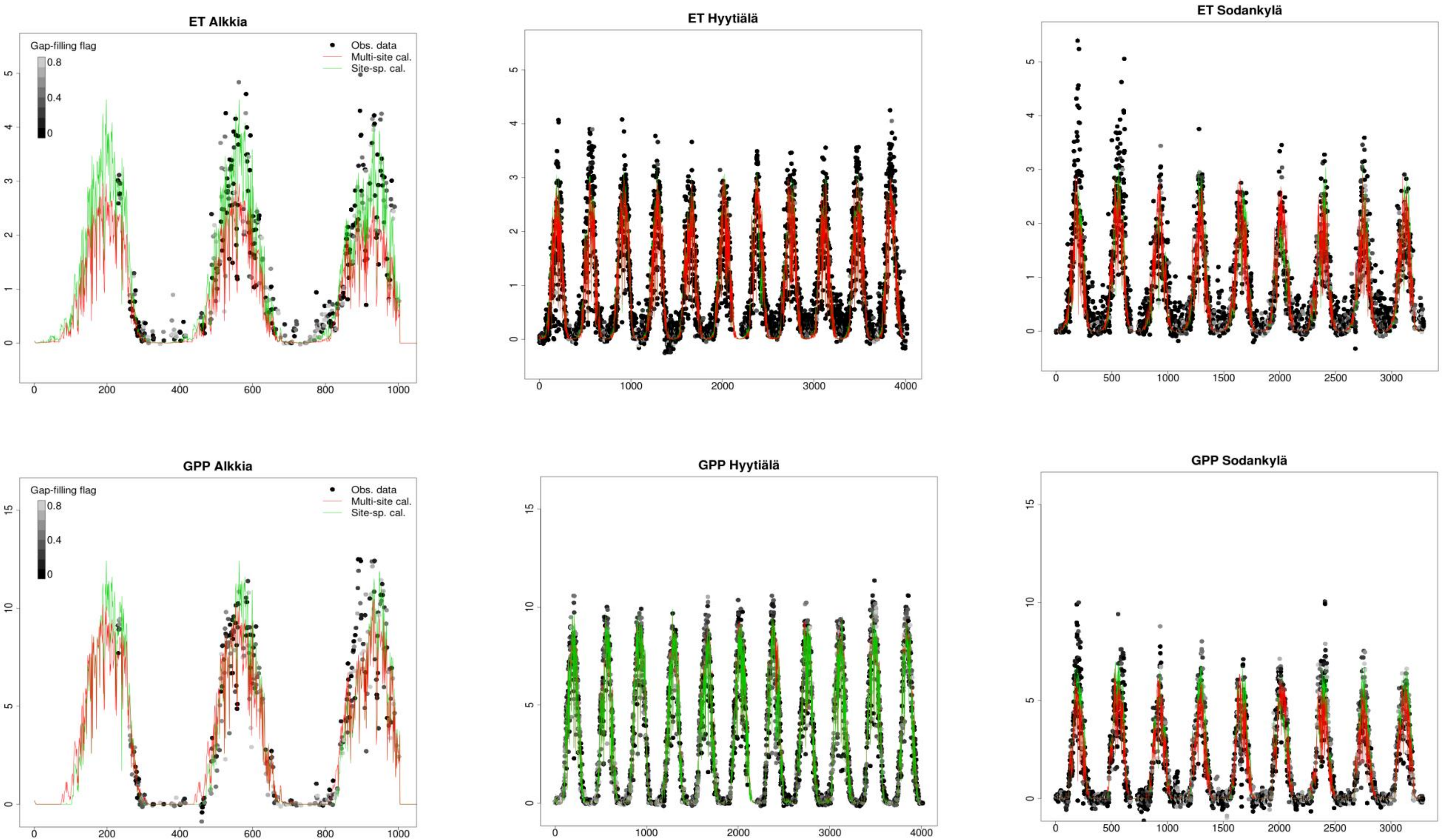
ET and GPP observed & simulated data



Model – data mismatch

ET

	Multi-site		Site-specific	
	R2	Slope	R2	Slope
Hyytiälä	0.88	0.90	0.89	0.91
Sodankylä	0.75	0.78	0.80	0.81
Alkkia	0.83	**0.63**	0.85	0.88
Kalevansuo	0.91	0.88	0.91	0.89
CarboAge 12yr	0.71	0.78	0.75	0.71
CarboAge 75yr	0.88	0.81	0.92	0.89
Skyttorp	0.72	0.85	0.72	0.80
Flakaliden	**0.69**	0.86	0.72	0.79
Skattasen	0.89	0.73	0.90	0.88
Norunda	0.81	0.88	0.85	0.86

GPP

	Multi-site		Site-specific	
	R2	slope	R2	slope
Hyytiälä	0.95	0.97	0.96	0.96
Sodankylä	0.89	0.81	0.91	0.89
Alkkia	0.89	0.78	0.89	0.88
Kalevansuo	0.95	0.96	0.95	0.96
CarboAge 12yr	0.72	0.74	0.84	0.87
CarboAge 75yr	0.93	1.06	0.95	0.98
Skyttorp	0.81	0.84	0.81	0.86
Flakaliden	**0.62**	0.76	**0.67**	**0.60**
Skattasen	0.91	0.78	0.91	0.92
Norunda	0.90	0.99	0.90	0.92

We concluded that PreLES can reliably predict carbon and water fluxes at regional scale.

Linking PRELES and CROBAS

Model calibration and up-scaling

We are analysing three different calibrations:

a single site Hyytiälä (Hyyt_cal);

permanent sample plot data (PSP_cal);

national forest inventory data (NFI_cal).

Quality of the data

Diversity of the data

CROBAS PSP calibration:

Data from 47 permanent sample plots (PSP).

The model was calibrated for 3 species: Scotch pine, Norway spruce and Birch.

Data included: Basal area (B), diameter at breast height (D), stand height (H), height of the crown (Hc), stand volume (V), foliage biomass (Wf), stem biomass (Ws)

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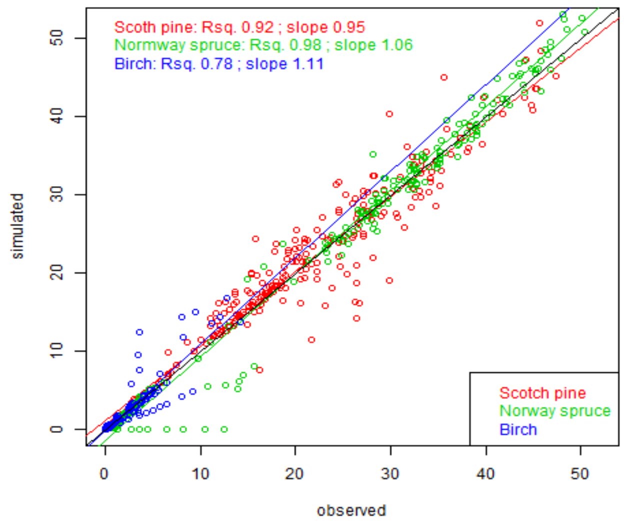
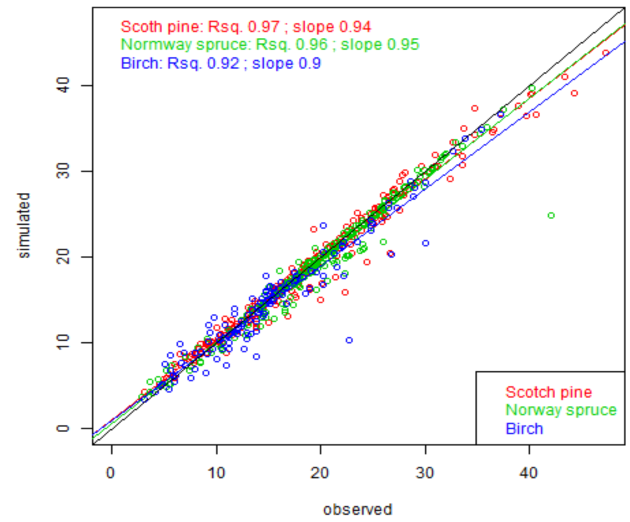
Bridging CROBAS

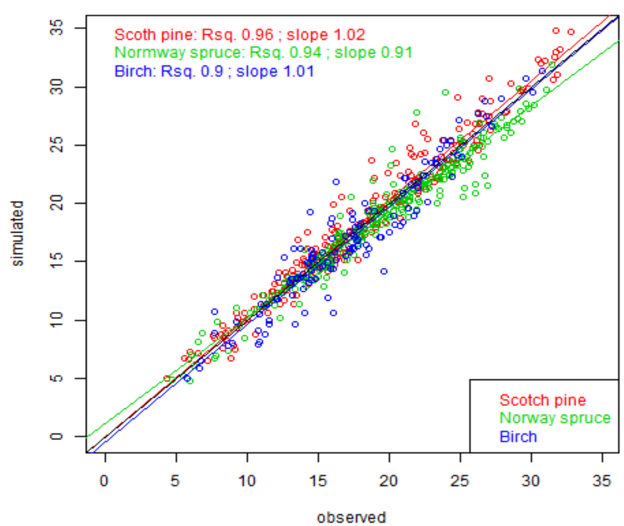
Basal area



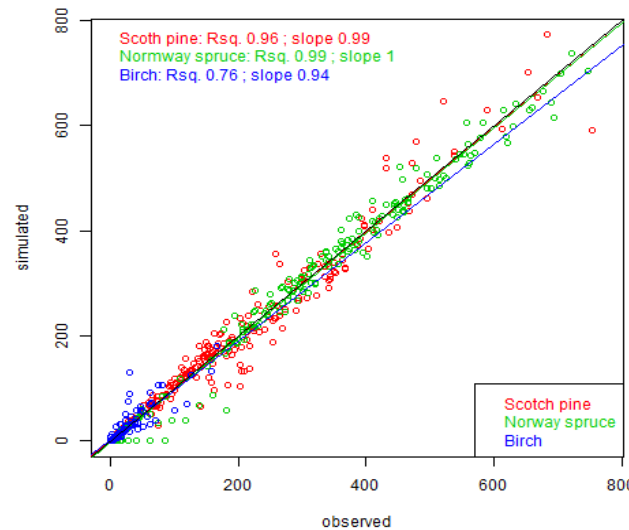
Diameter



Stand height

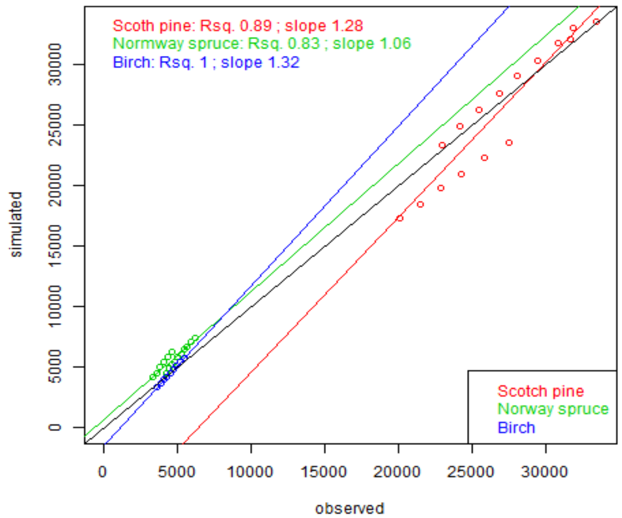


Stand volume

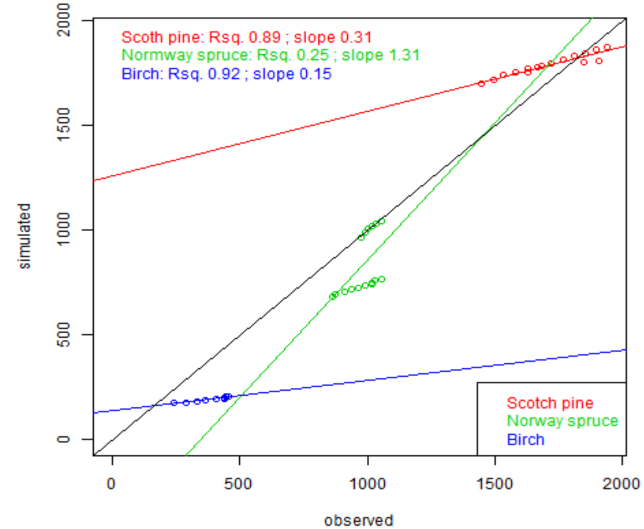


CROBAS calibration

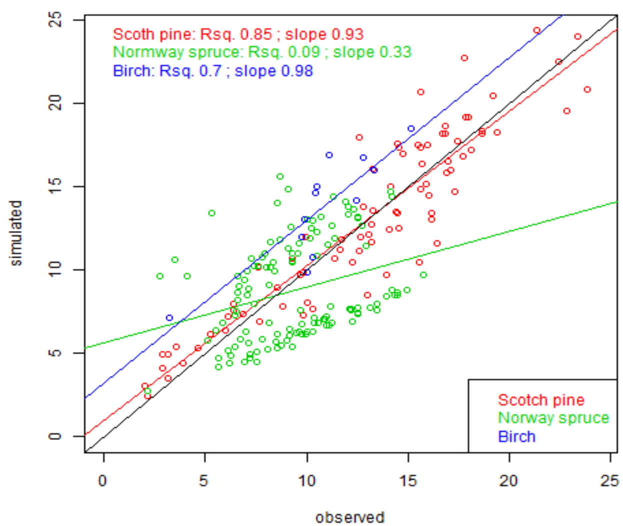
Stem biomass



Foliage biomass



Crown height



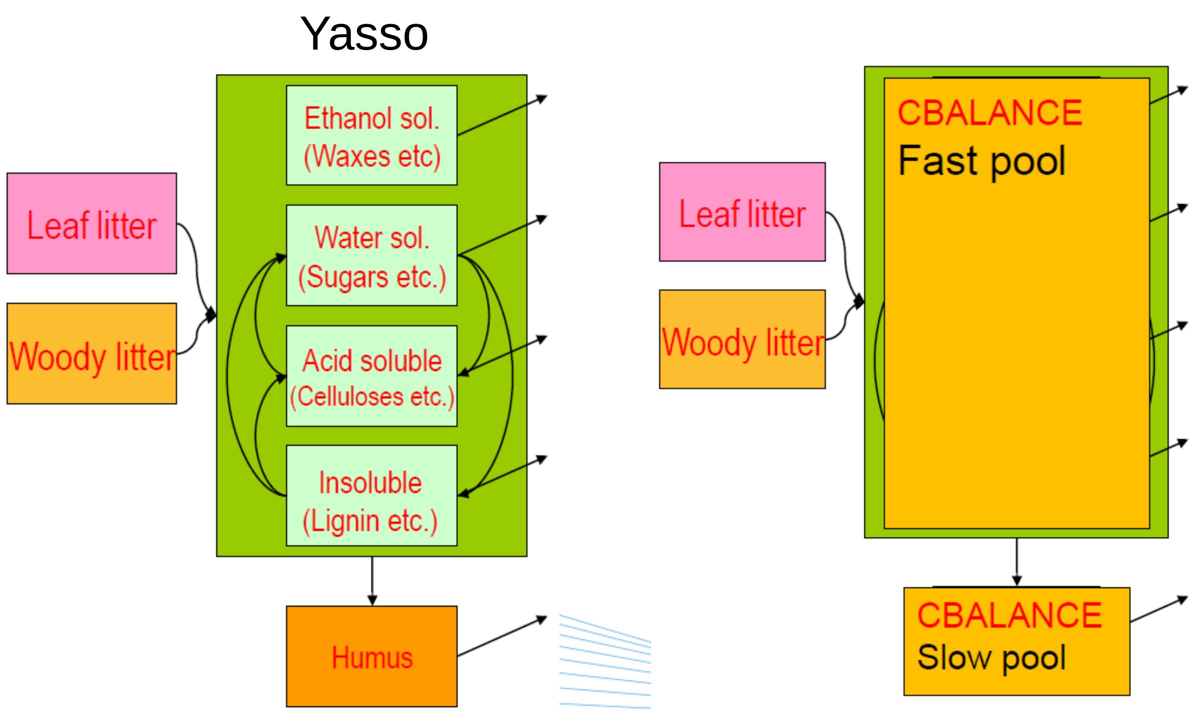
At the moment we are working on:

- ✓ Improving species interaction;
- ✓ Improving natural mortality;
- ✓ Integrate standard management routines.

Next steps:

- ✓ Coupling with the soil carbon model (YASSO);
- ✓ Regional analysis;
- ✓ Climate change impact on boreal forests and uncertainty analysis.

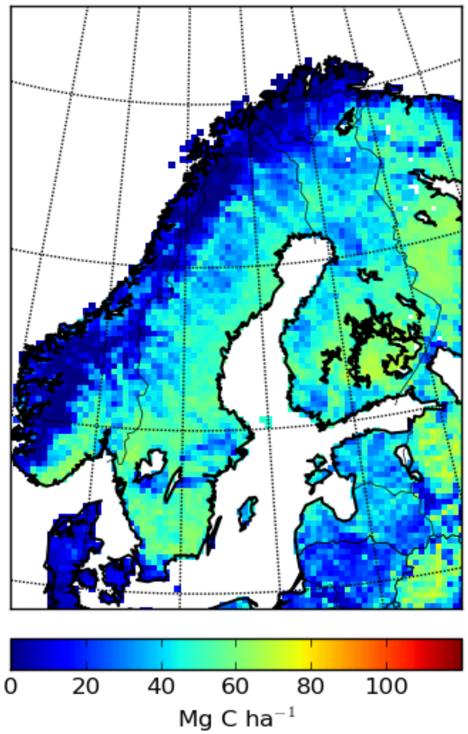
JSBACH soil carbon module CBALANCE has been replaced with Yasso (developer contact: Jari Liski / SYKE, FMI: T.Thum, T.Markkanen, T. Aalto)



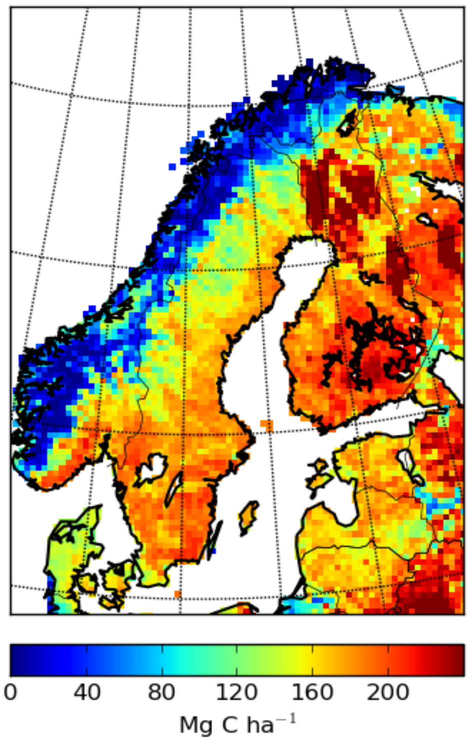
July 2011

Soil carbon pools

Yasso

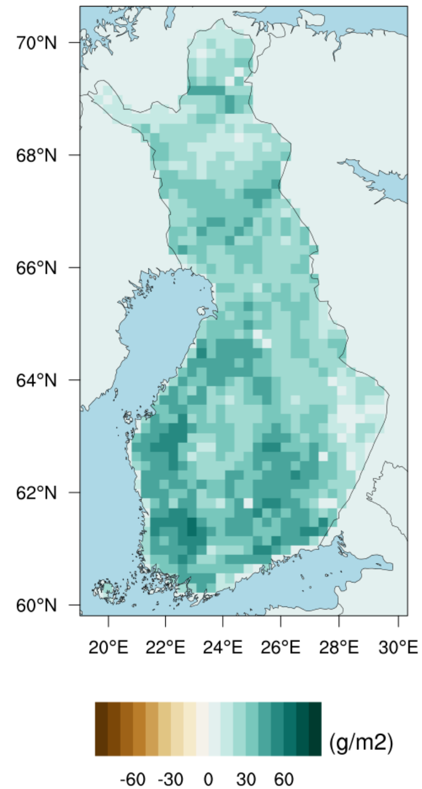


CBALANCE

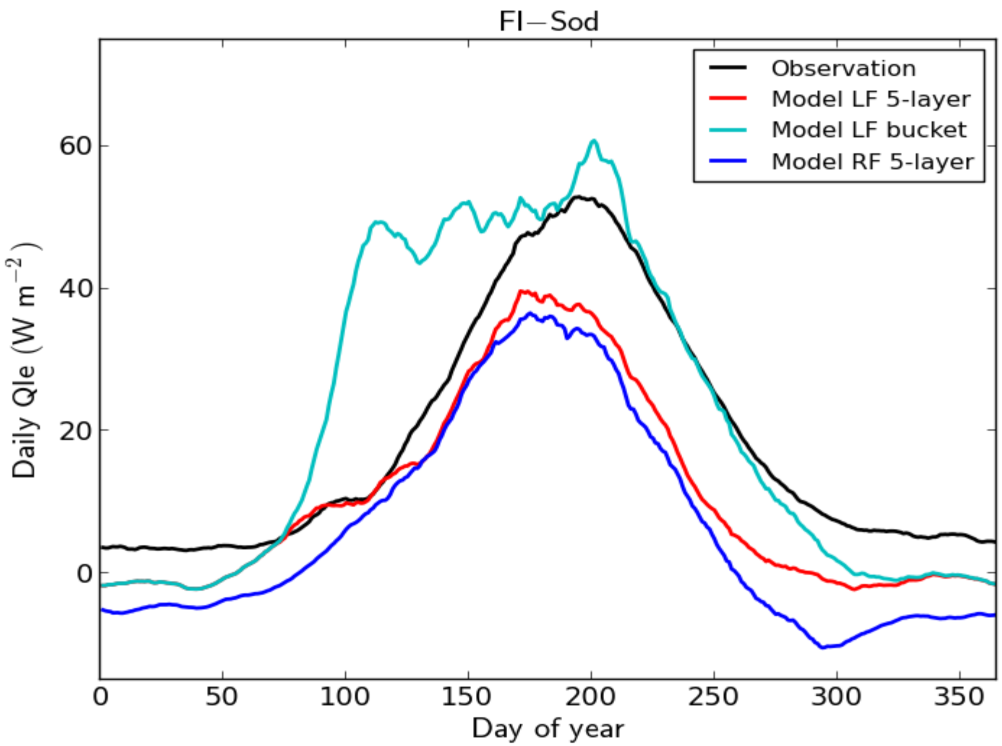


Soil respiration

Yasso – CBAL



JSBACH 5-layer soil moisture formulation has been adopted, replacing 1-layer (bucket) soil moisture. (Figure by T.Thum)



Latent heat flux
at Sodankylä
according to model & obs

Constraining MPI-ESM/JSBACH model hydrological, evapotranspiration and phenology parameters with eddy covariance measurements

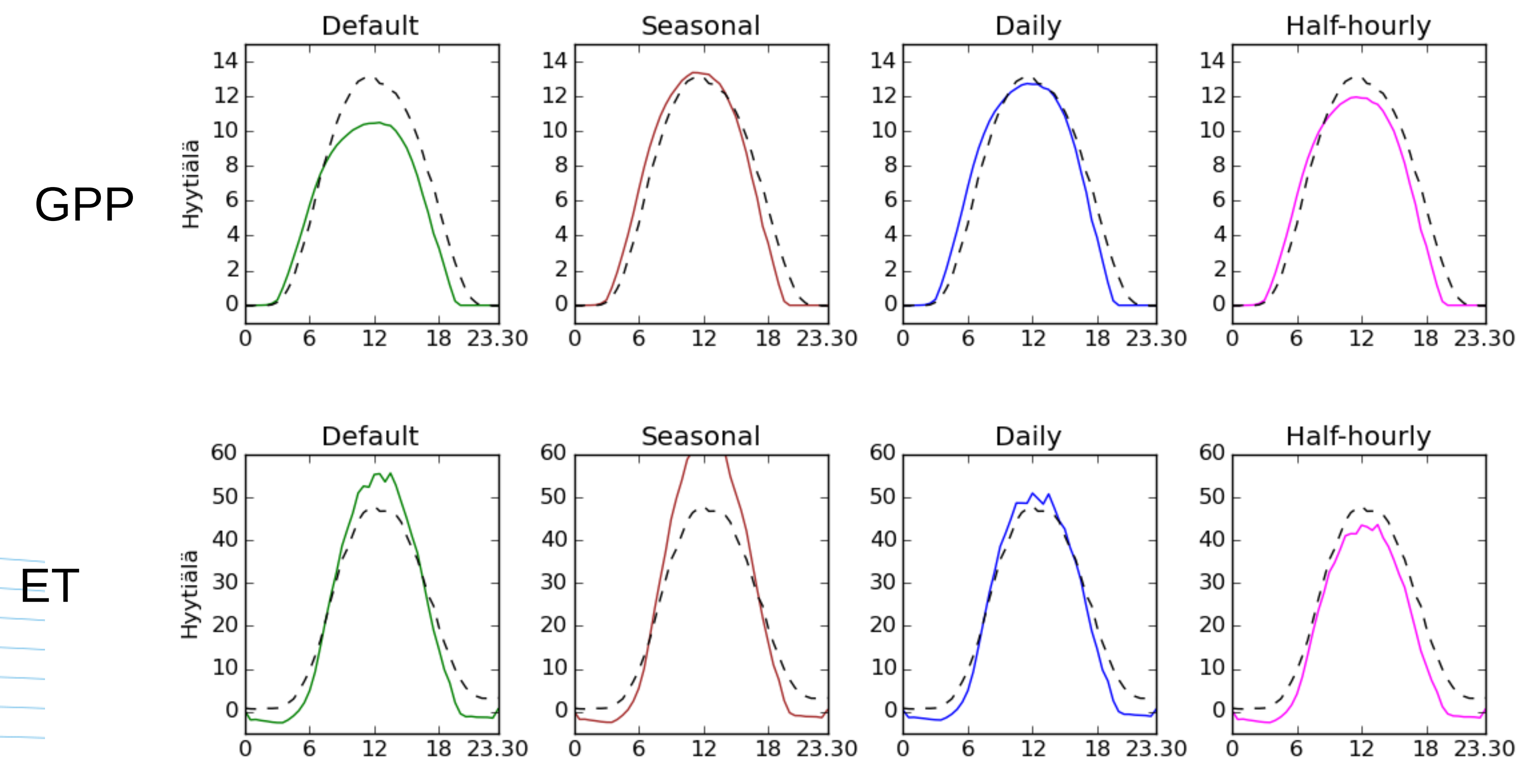
J Mäkelä, J Susiluoto,T Markkanen, S Hagemann, T Aalto

- Observations: Hyytiälä and Sodankylä GPP and ET fluxes.
- Use Monte Carlo methods (Metropolis algorithm) to opimize parameters

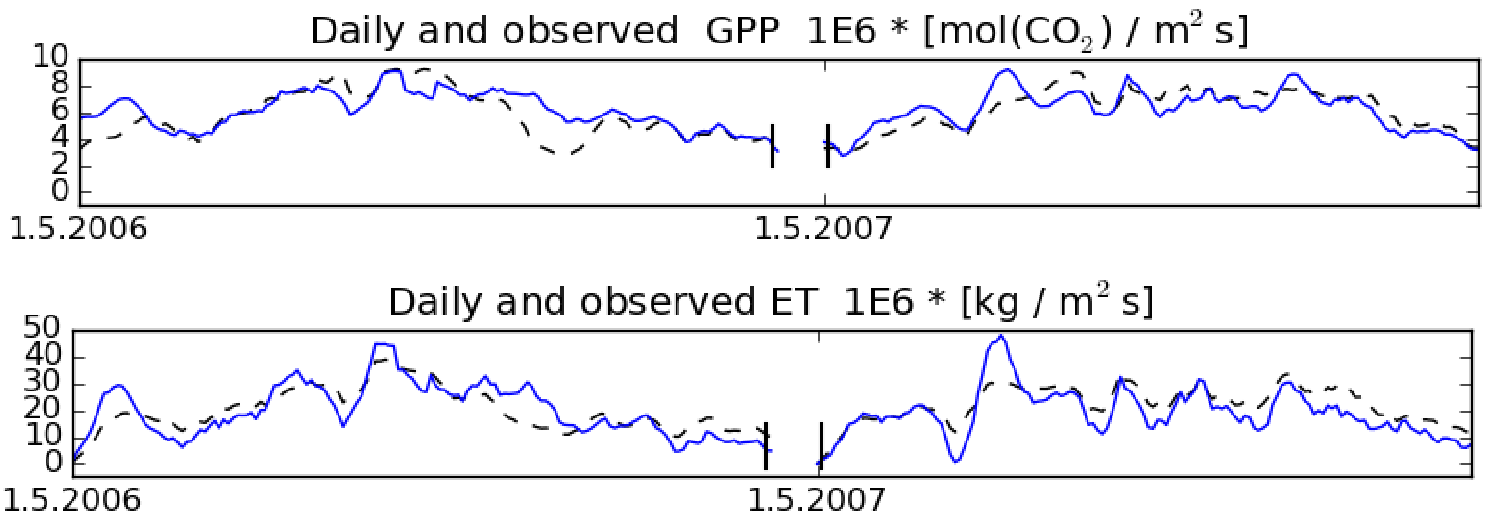
Description	
ALPHA	Quantum efficiency for photon capture.
alt_temp	LoGro phenology: alternating temperature.
CarboxRate	Maximum carboxylation rate at 25 Celsius (coupled with maximum electron transport rate at 25 Celsius with a factor of 1.9).
cb	Stability parameter near neutrality.
chill_decay	LoGro phenology: decay of critical heat sum.
crit_snow_depth	Depth for correction of surface temperature for snow melt.
cvinter	Snow interception parameter.
FCI1C3	Ratio of C3-plant internal/external CO_2 concentration.
heatsum_min	LoGro phenology: minimum value of critical heat sum.
heatsum_range	LoGro phenology: maximal range of critical heat sum.
MaxLAI	Maximum (all-sided) leaf area index.
moist_crit_fract	Fraction of soil moisture above which transpiration is not affected by soil moisture stress.
moist_wilt_fract	Fraction of soil moisture at permanent wilting point.
rhum_fract	Relative humidity parameter.
skin_res_max	Maximum water content of the skin reservoir of bare soil.
t_pseudo_soil	LoGro phenology: memory loss of pseudo soil temperature.
veg_fract	Fraction of vegetative soil in grid cell.
zwdcri	Critical value above which fast drainage occurs.

Hyytiälä

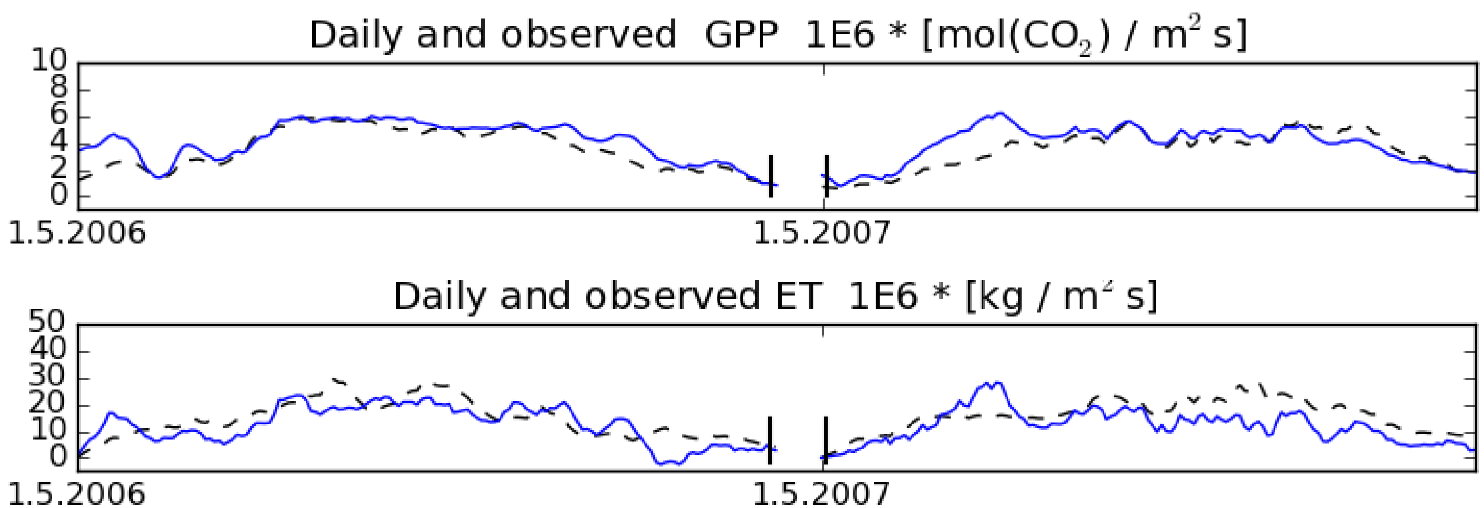
- calibration years 2000 – 2004
- different levels of parameter tuning



Hyytiälä, validation

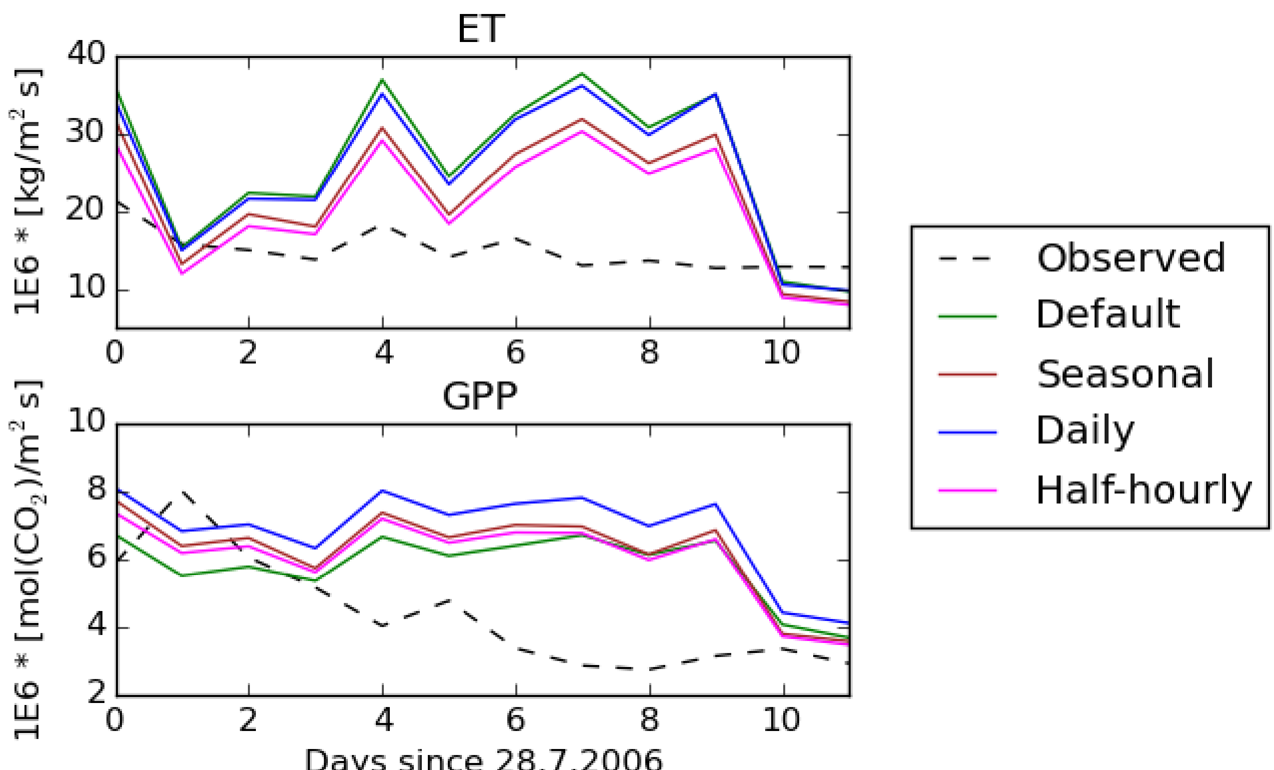


Sodankylä, validation



Fairly good performance for both sites using Hyytiälä calibration

Drought period in 2006
when optimisation was not successful



Need to look at model conductance formulations

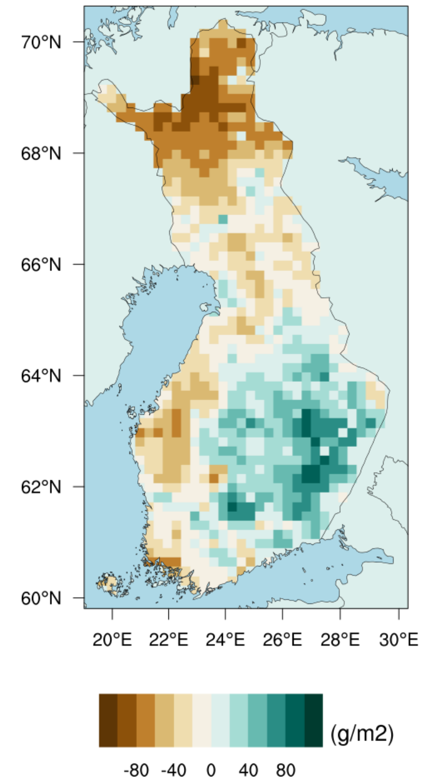
On-going work:

Calibrating spring and autumn development
using delayed temperature effect (state of acclimation),
fluorescence, snow data & webcams

How much the new model developments
affect regional carbon balance,
GPP, RE and ET?

How can the results be converted
to model uncertainty estimates?

Model GPP using LAI from remote sensing
vs. LAI from JSBACH model, July 2006



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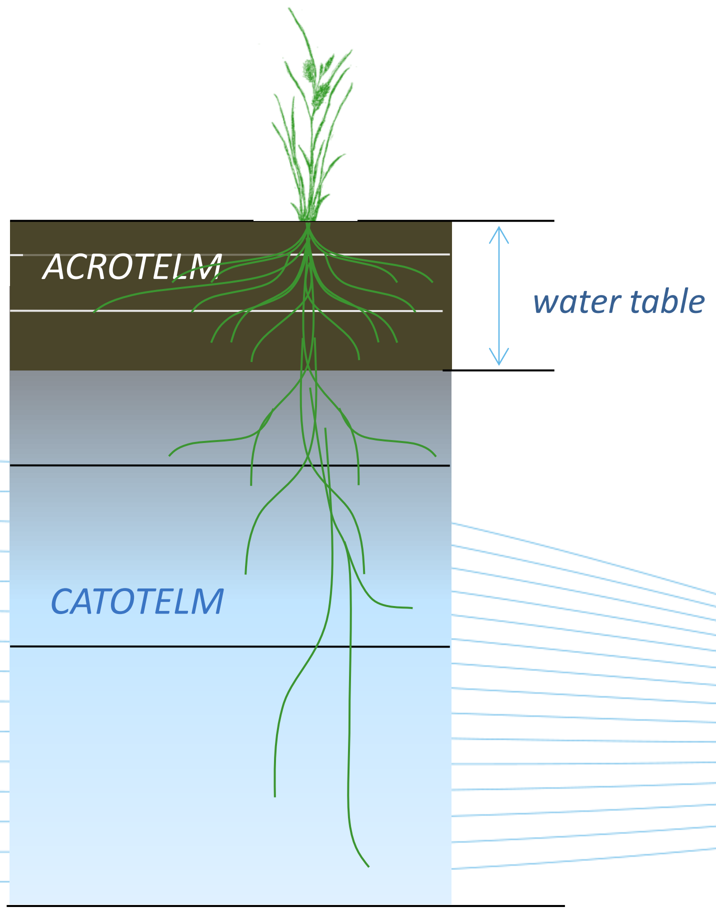
JSBACH methane model

M. Raivonen, S. Smolander, J. Mäkelä, L. Backman, J. Susiluoto, T. Markkanen, T. Aalto, T. Vesala

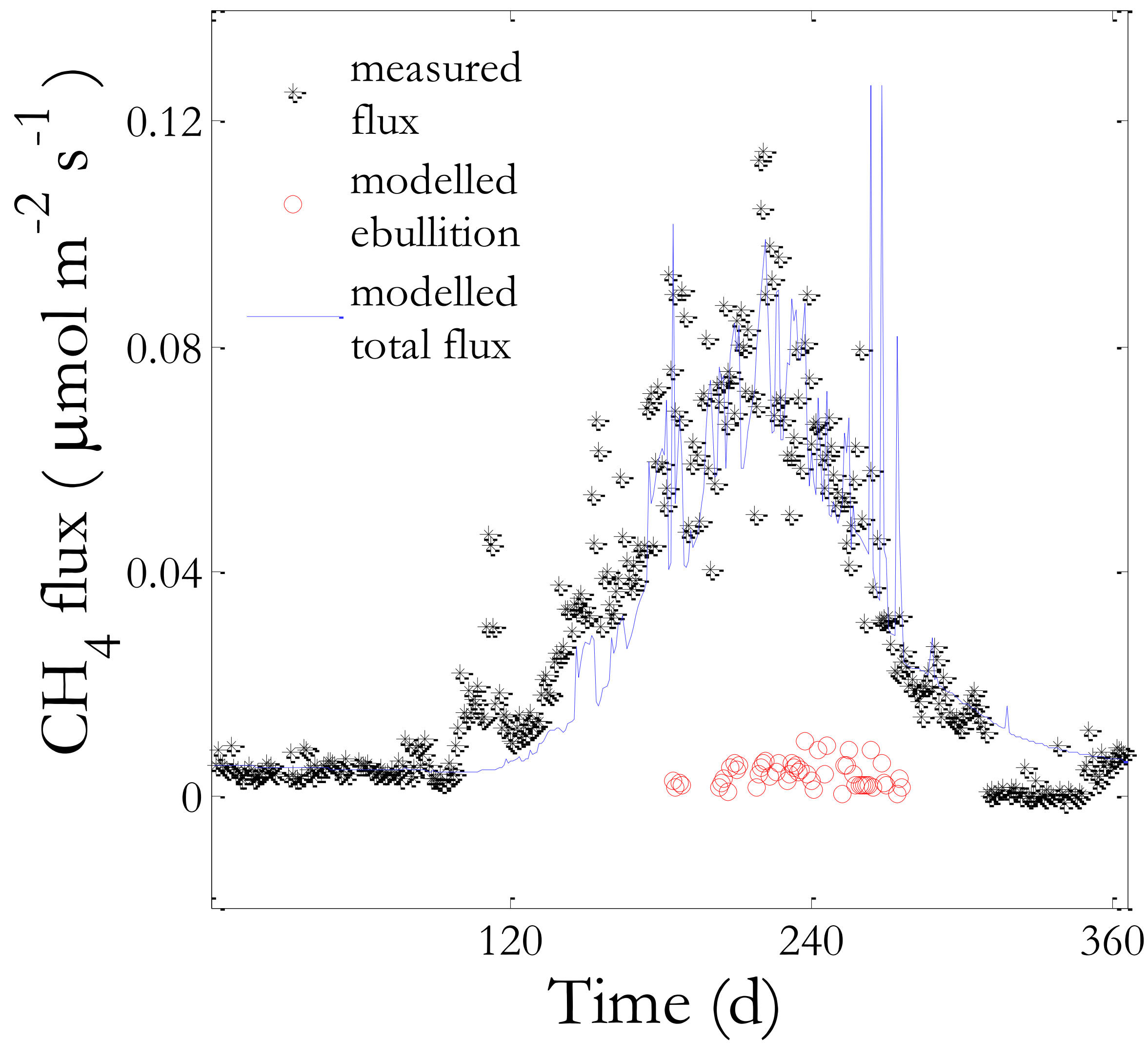


New model for simulating CH4 production and transport in peatlands

- diffusion in air / water filled porous media
- transport via plants
- ebullition
- production from anoxic respiration
- oxidation (a Michaelis-Menten formulation)

Acrotelm & catotelm respiration & peatland thickness come from PEATBALANCE model

Siikaneva wetland nearby Hyytiälä



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Optimising methane model parameters

J. Susiluoto, M. Raivonen, J. Mäkelä, L. Backman, T. Vesala, T. Aalto

parameter	description	units	default	MAP
por	porosity of peat	-	0.8	0.88
peat_air_coeff	diffusion factor in peat-air	-	0.1	0.18
peat_water_coeff	diffusion factor in peat-water	-	0.1	0.68
V_R0	oxygen respiration parameter	[mol m^{-3}(peat) s^{-1}]	4e-5	5.5e-5
K_R0	oxygen respiration parameter	[mol m^{-3}(water)]	0.22	0.23
delta_E_R	oxygen respiration parameter	[J mol^{-1}]	5e4	4.05e4
K_O2	methane oxidation parameter	[mol m^{-3}(water)]	0.33	0.084
K_CH4	methane oxidation parameter	[mol m^{-3}(water)]	0.44	0.076
delta_E_oxid	methane oxidation parameter	[J mol^{-1}]	5e4	14.6e4
lambda_root	root decay length	[m^{-1}]	0.2517	0.38
root_tortuosity	root "twistedness"	-	1.5	2.3
f_exu	fraction of NPP carbon ⇒ CH4	-	0.5	0.34
root_km	root-ending area per root biomass	[m^2 kg^{-1}]	0.085	0.056
exu_pool_turnovertime	exudate pool turnover time	[s]	1.21e6	0.45e6
ebu_hl	ebull. half-life of dissolved methane	[s]	1800	3600

Table 1: parameters, default values, and MAP estimates

Optimisation by Monte Carlo method using Siikaneva CH4 flux measurements from 3 calibration years

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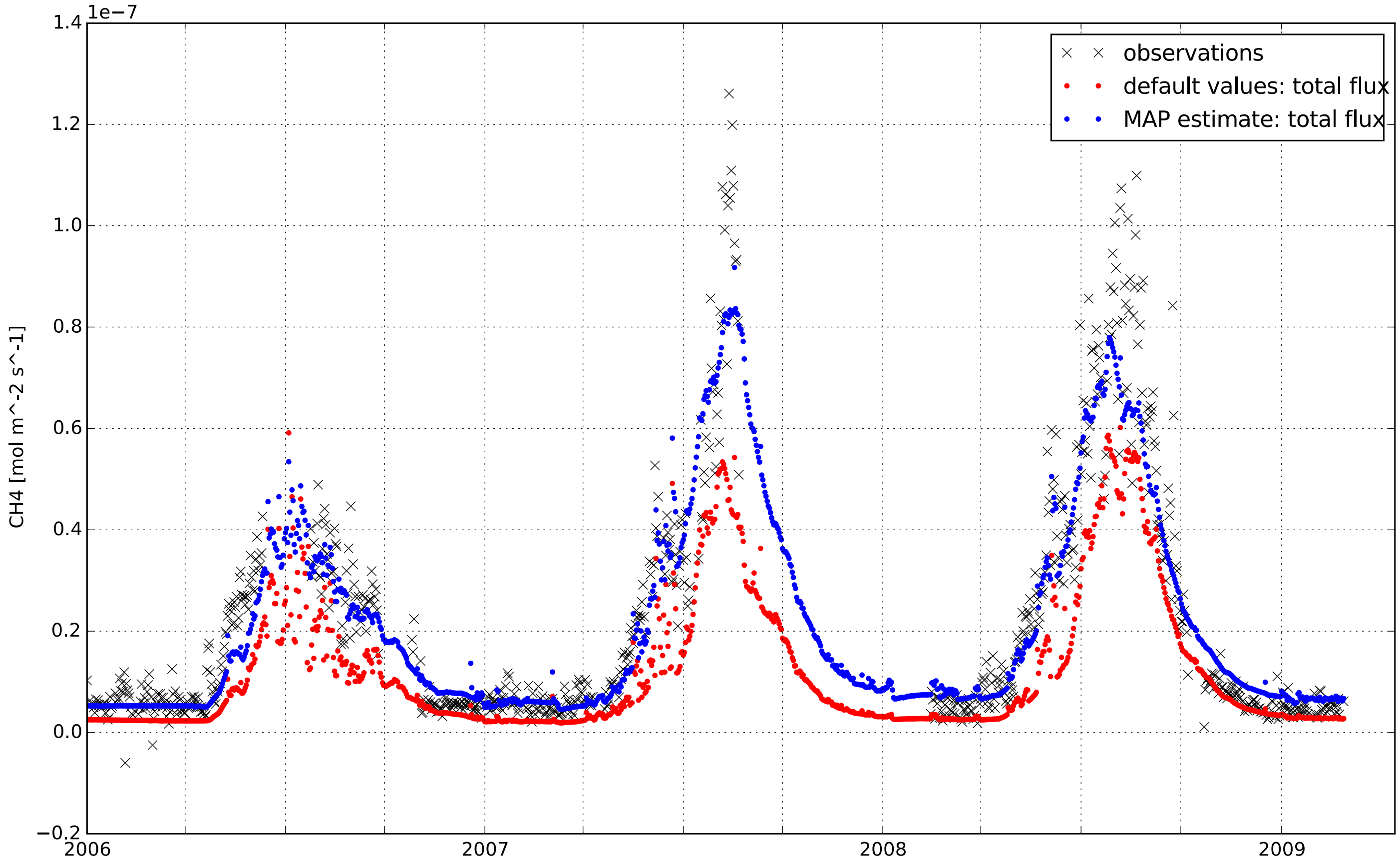
Optimised fluxes (cal period)



On-going work

- Methane model one-site set-up is ready
- Parameter optimisations continue -> more wetland sites
- Regional runs