Faculty of Science

Modelled soil carbon dynamics after **afforestation of croplands** in Denmark

- can field level **agricultural management records** help explain model performance?
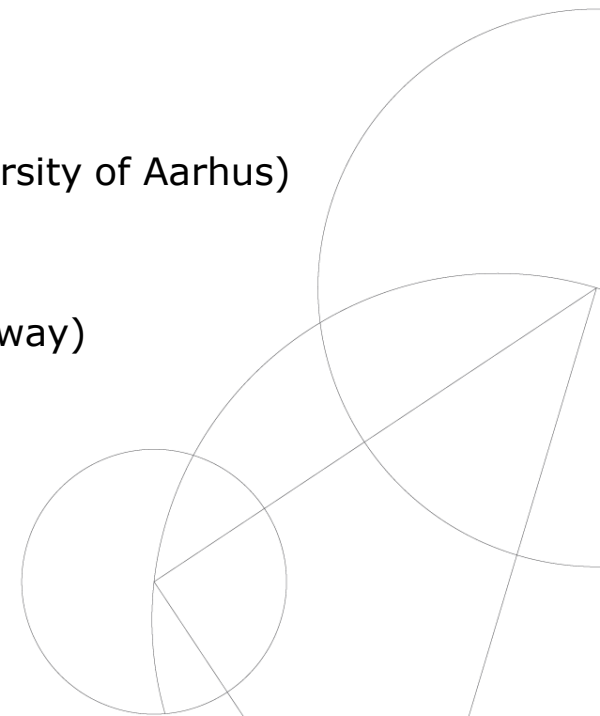
Lise Dalsgaard (NIBIO)
Lars Vesterdal and Inge Stupak (University of Copenhagen)
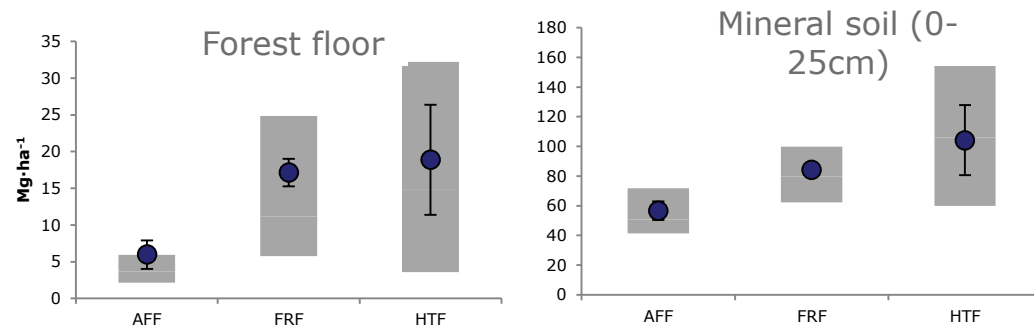Arezoo Taghizadeh-Toosi, Lars Elsgaard and Jørgen E. Olesen (University of Aarhus)

Faculty of Science

C-stocks expected to increase after afforestation

Adjacent sites:

Cropland

Forest

Forest floor

Mineral soil (0-25cm)

AFF: afforestation on cropland
FRF: forest remaining forest
(HTF: Afforestation on heathland/moist grassland)

N=Ca. 400 plots in two systematic national soil inventories; KN and NFI)
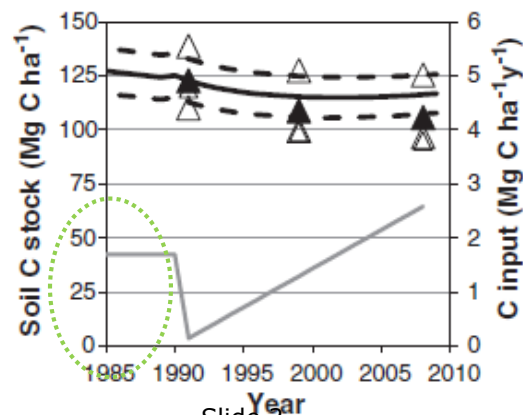
- Magnitude and direction of SOC changes in model vs. observations – in diverse situations of cropland management and forest?
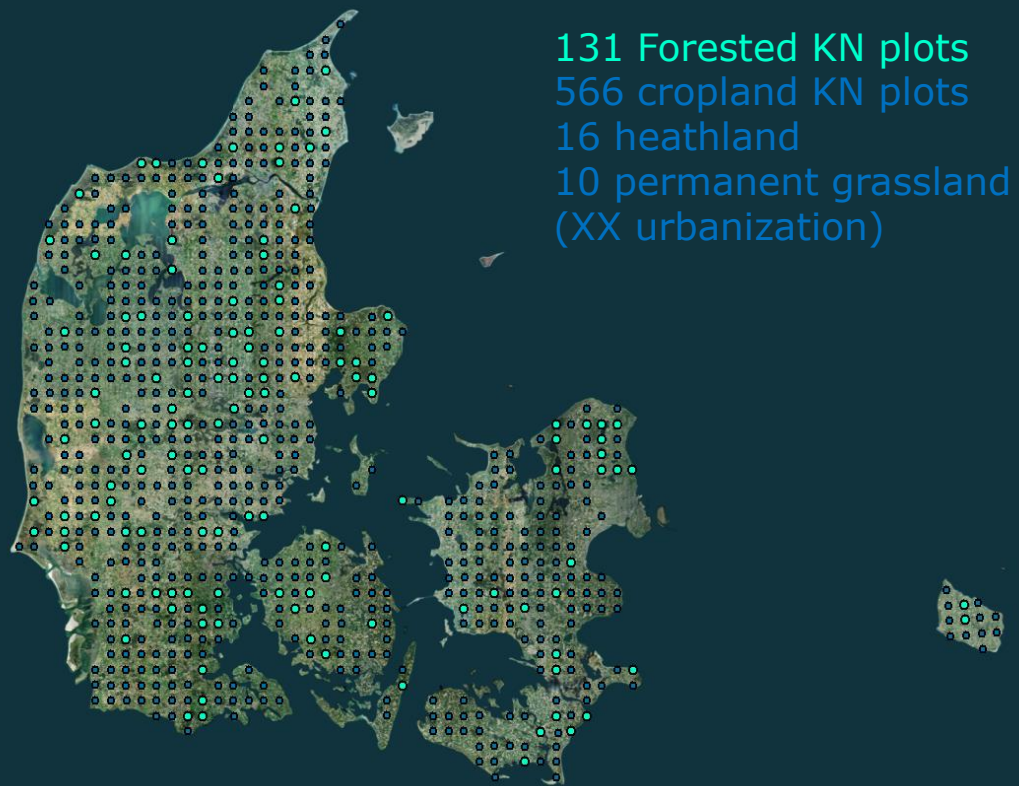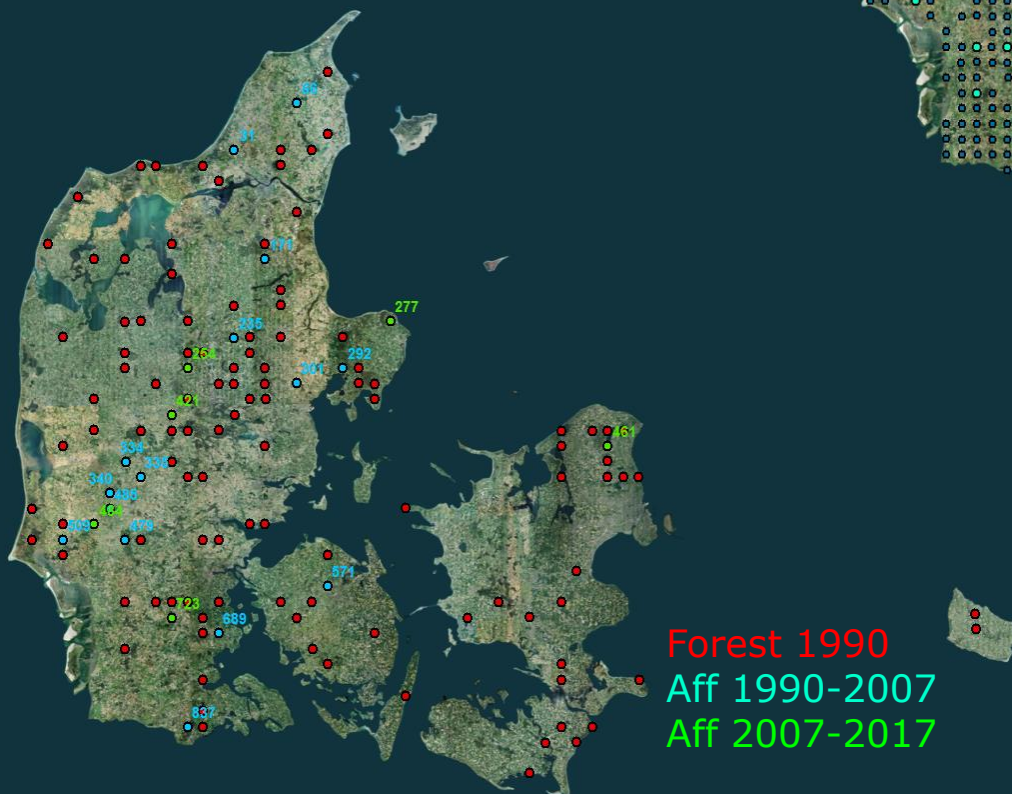- Importance of cropland management?

Karhu et al. 2011

Slide 2

The Nitrate Grid

7x7 km established 1986
SOC sampled:
- 1990
- 2007-2009
- 2017-2018

N=21 LUC from agriculture to forest

131 Forested KN plots
566 cropland KN plots
16 heathland
10 permanent grassland
(XX urbanization)

LUC verified by aerial photos

Forest 1990
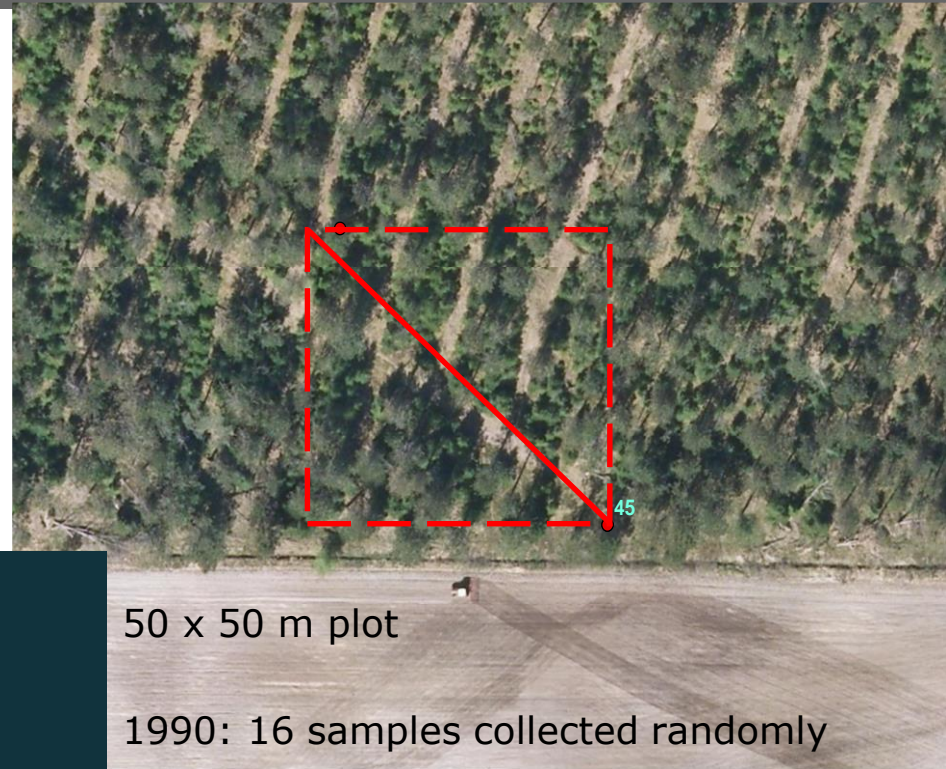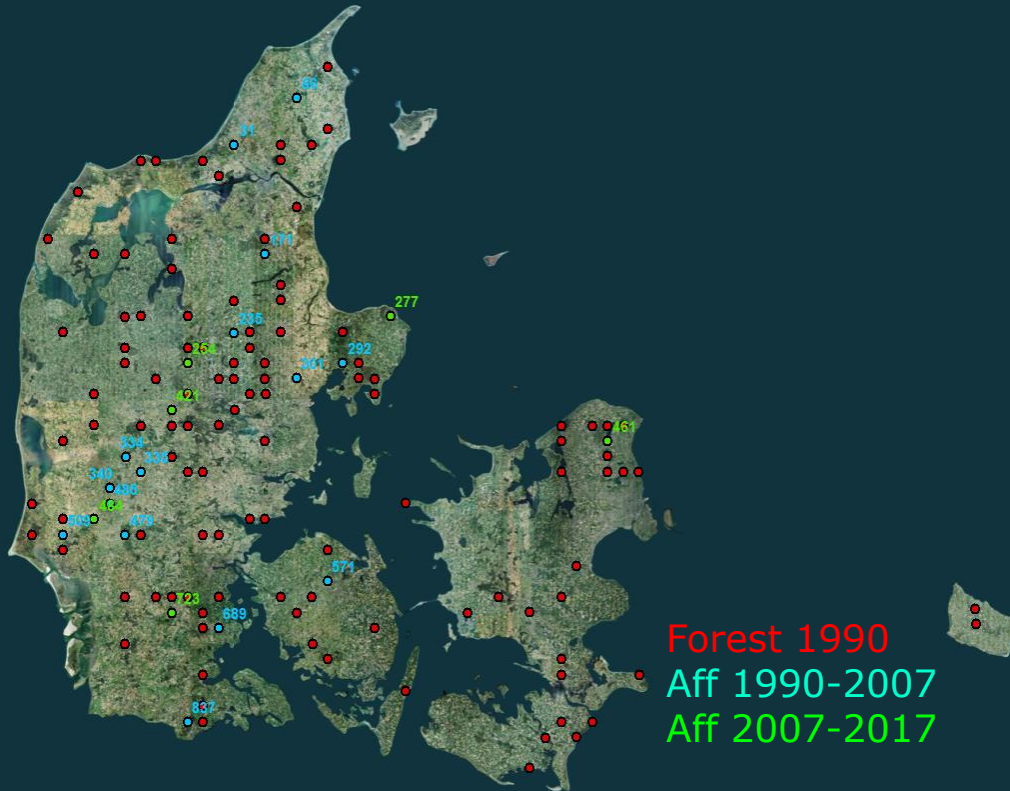Aff 1990-2007
Aff 2007-2017

1995   2015

The Nitrate Grid

7x7 km established 1986
SOC sampled:
- 1990
- 2007-2009
- 2017-2018

N=21 LUC from agriculture to forest

50 x 50 m plot

1990: 16 samples collected randomly

2007-08: 10 samples collected along diagonal transect

2017-18: 10 samples collected in the same spots along transects

Forest floor (frames)
Mineral soil 5 layers:
0-10, 10-25, 25-50, 50-75, 75-100

Forest 1990
Aff 1990-2007
Aff 2007-2017

Research questions

- Will Yasso15 simulate SOC changes in the direction and magnitude of observed changes?

- Is model performance related to cropland management prior to afforestation:
    - manure and fertilizer input of C, N
    - grassland frequency over time

⇨ out of our comfort zone –
details in agriculture management
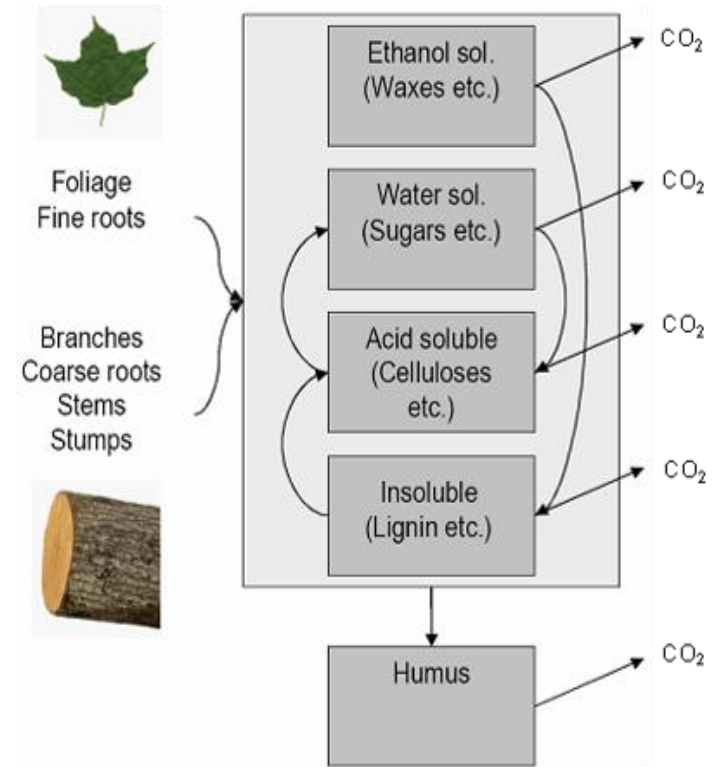
Yasso15 (Yasso -> Yasso20, Viscari et al. 2020, 2021)
Worldwide data on litter decomposition, SOC stocks, NPP
Measurable carbon pools

Data to feed the model

Observational data where possible
Literature, expert judgement where necessary
Uncertainties included
4 scenarios (fine roots, initialization)

Biomass   ->   allocation   ->   residues / turnover rates   ->   quality
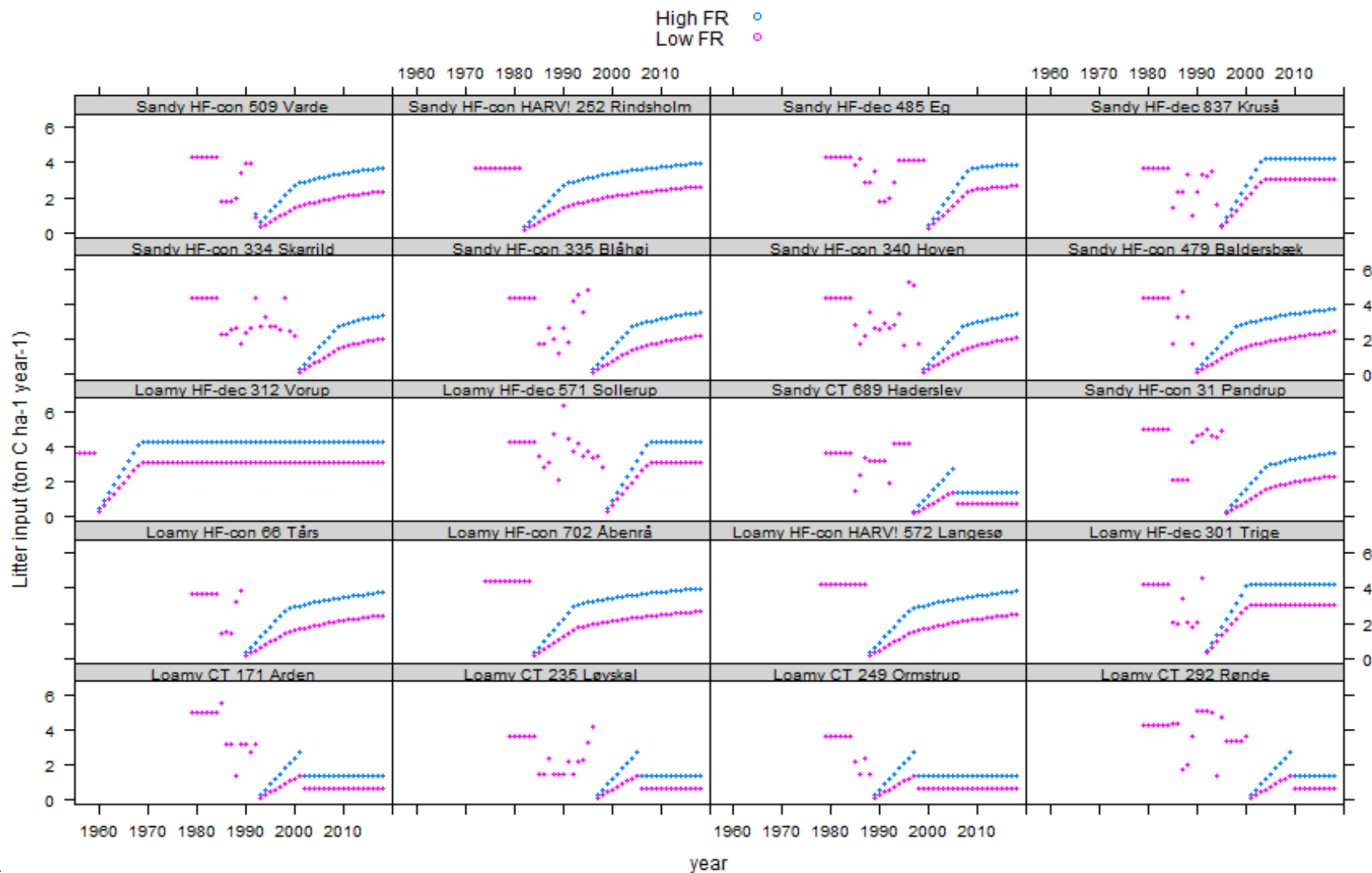
Agriculture

- 28 crops, 5 soil classes, 9 manure types
- Expert judgement for straw treatment and manure (fresh weight-to-carbon)
- National crop allocation models with site specific adjustments (58-83%)

Forest

- 20 tree species incl. ornamental
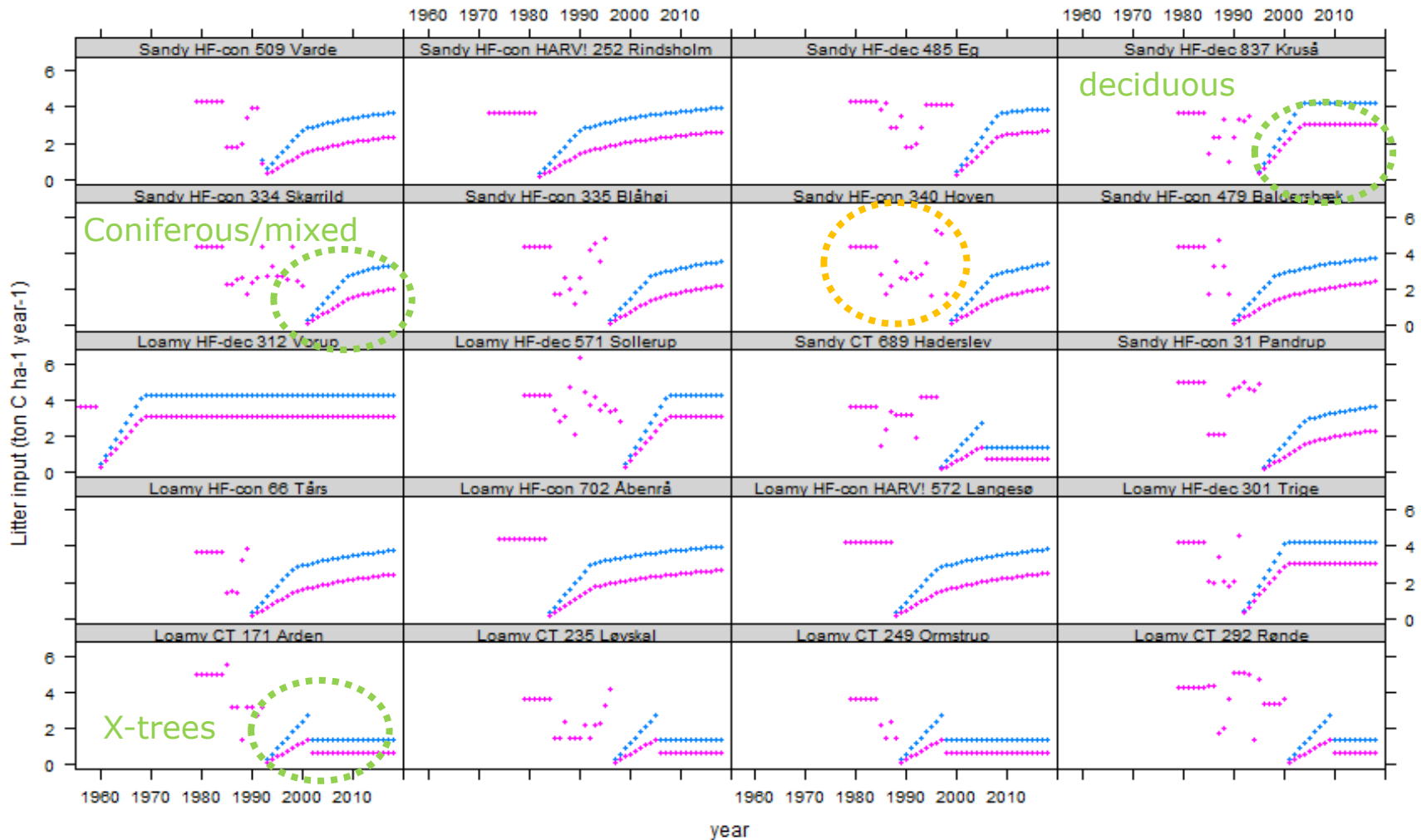- Stand age driving litter input
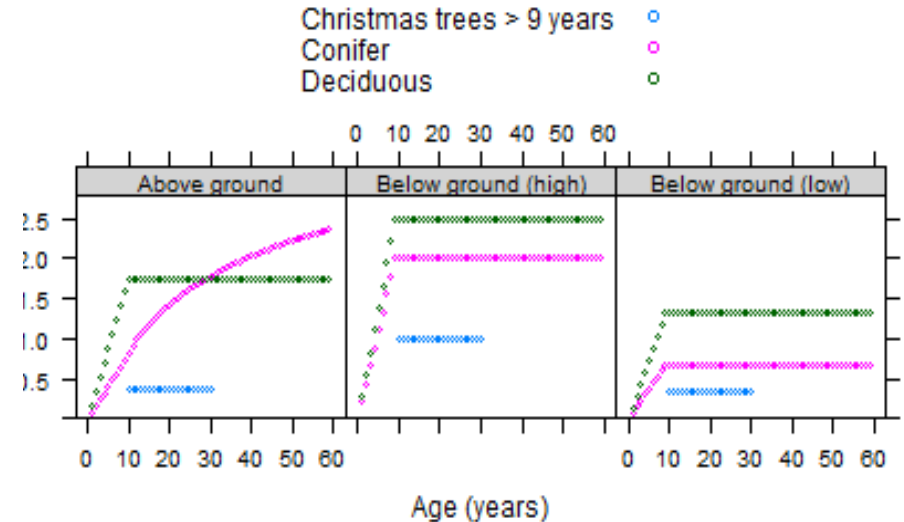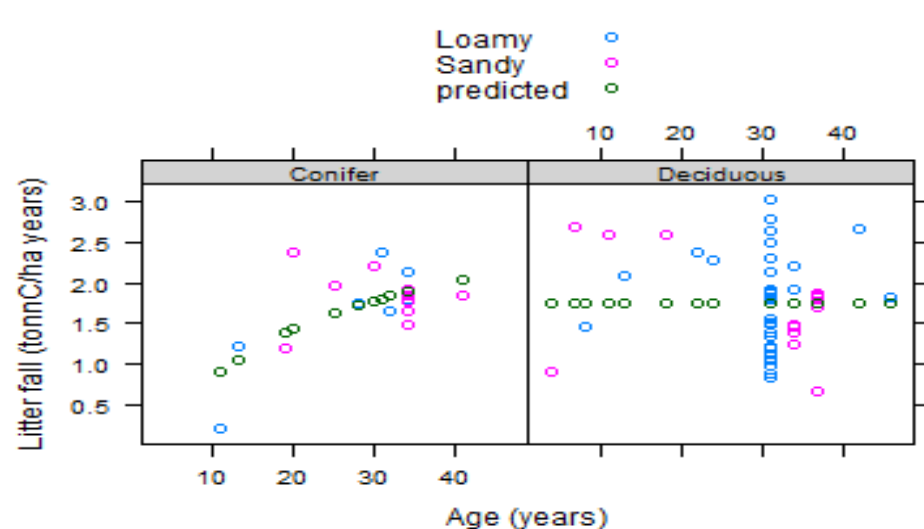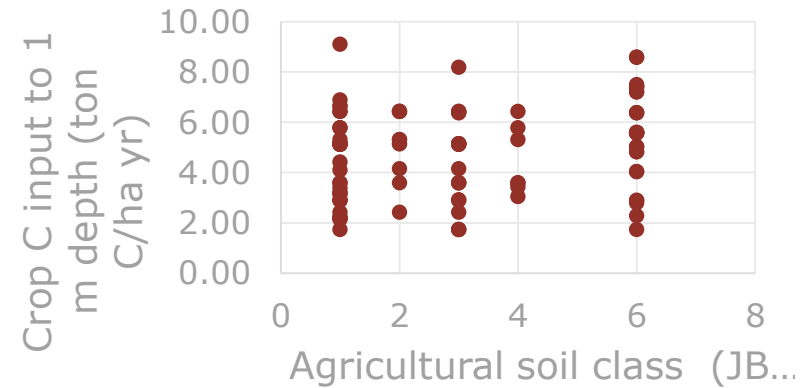
Resulting agriculture and forest C inputs

Resulting agriculture and forest C inputs

High interannual variability in crop input

Forest input steady increase or constant

Mean simulated and measured SOC – high and low fine root

Model mean SOC

forest floor + 0-100 cm ○
High FR ○
Low FR ○
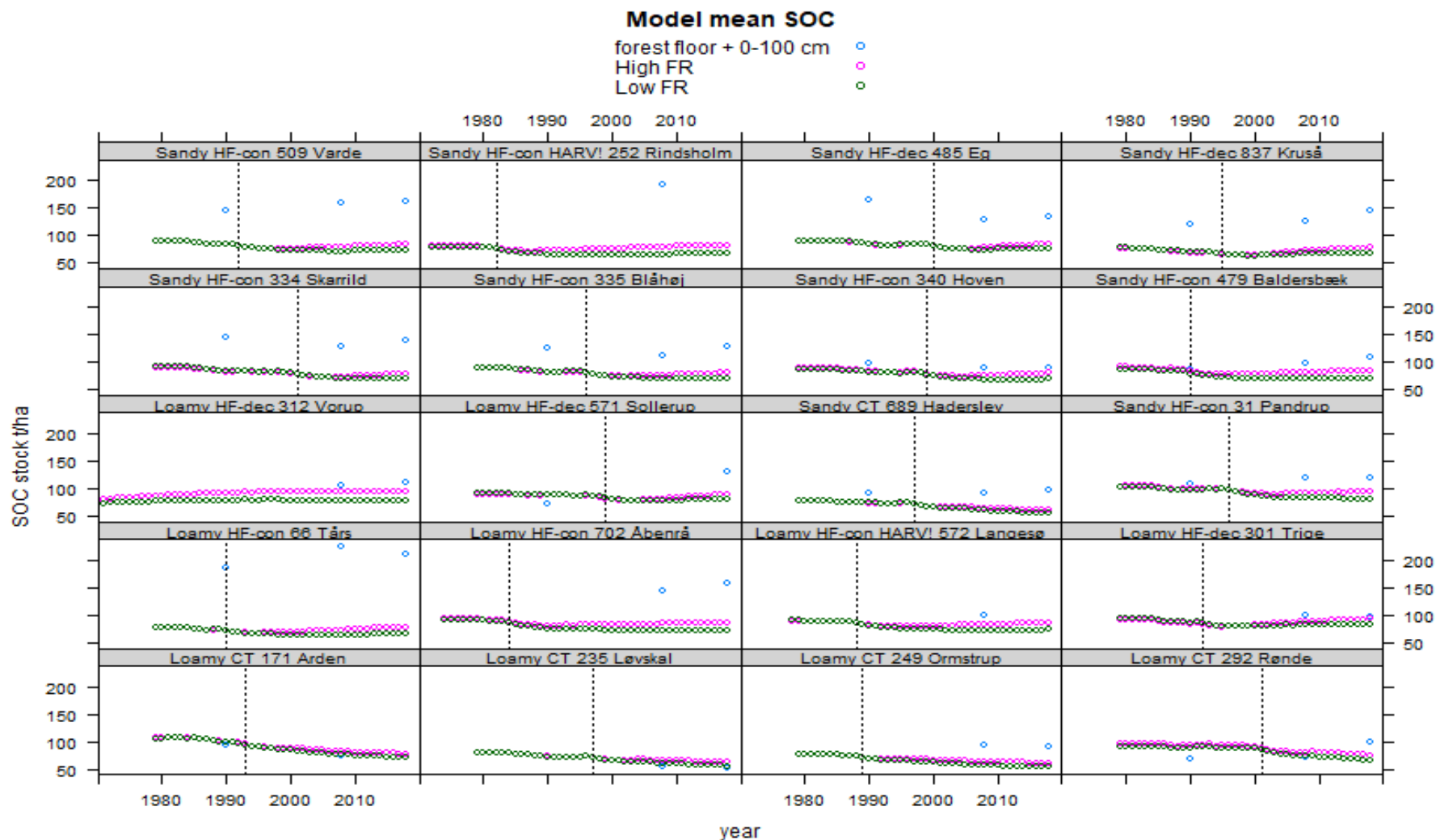
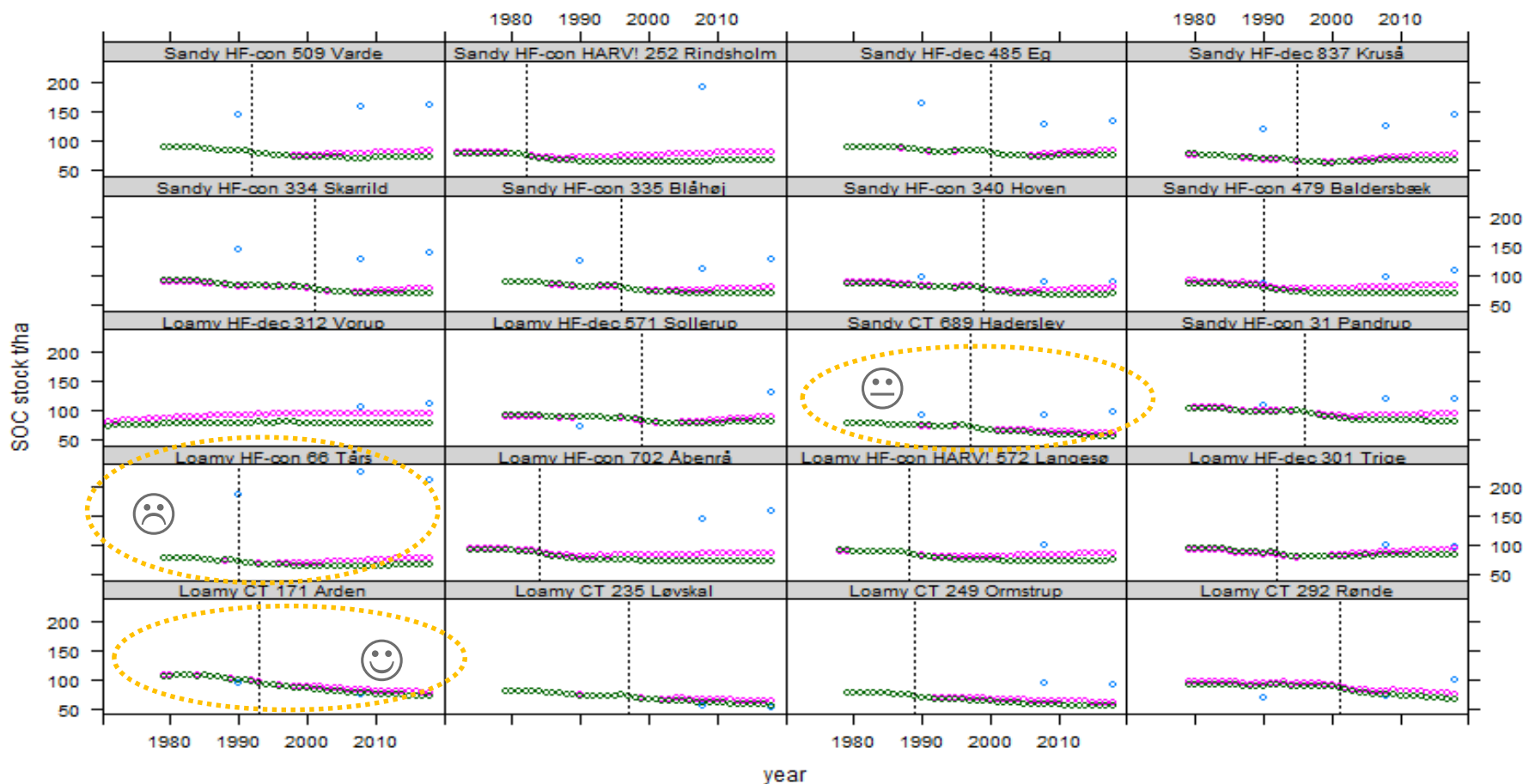# Mean simulated and measured SOC – high and low fine root scenario

High vs. low forest fine root input important in the long run, but less so in the short term

Spin-up initialization

Simulated and measured SOC – upper and lower 95% confidence limits for "low fine root" scenario

Low fine root turnover forest
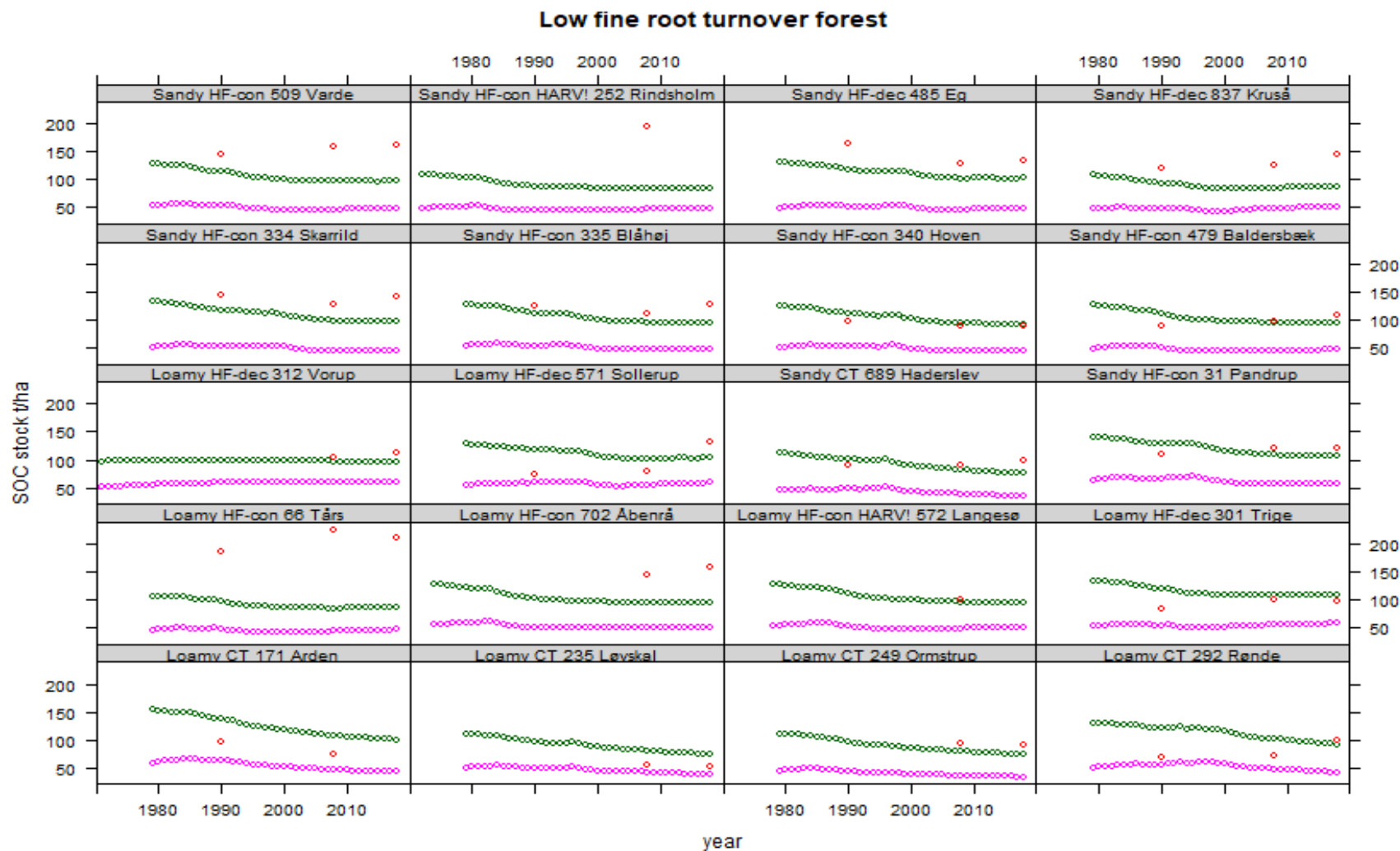
Observed and simulated stocks across the dataset

Low model stocks compared to measured
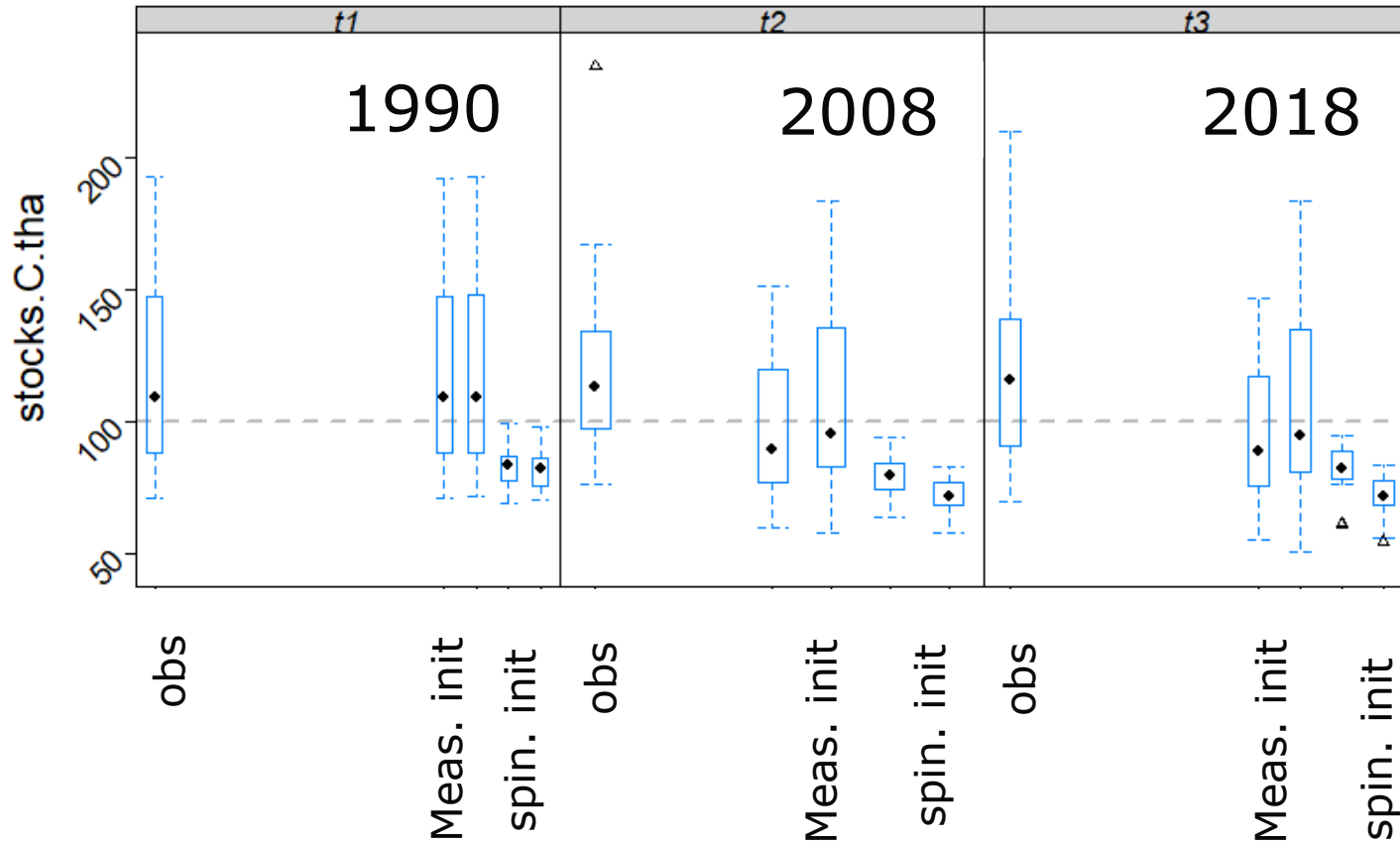
Observed and simulated changes across the dataset
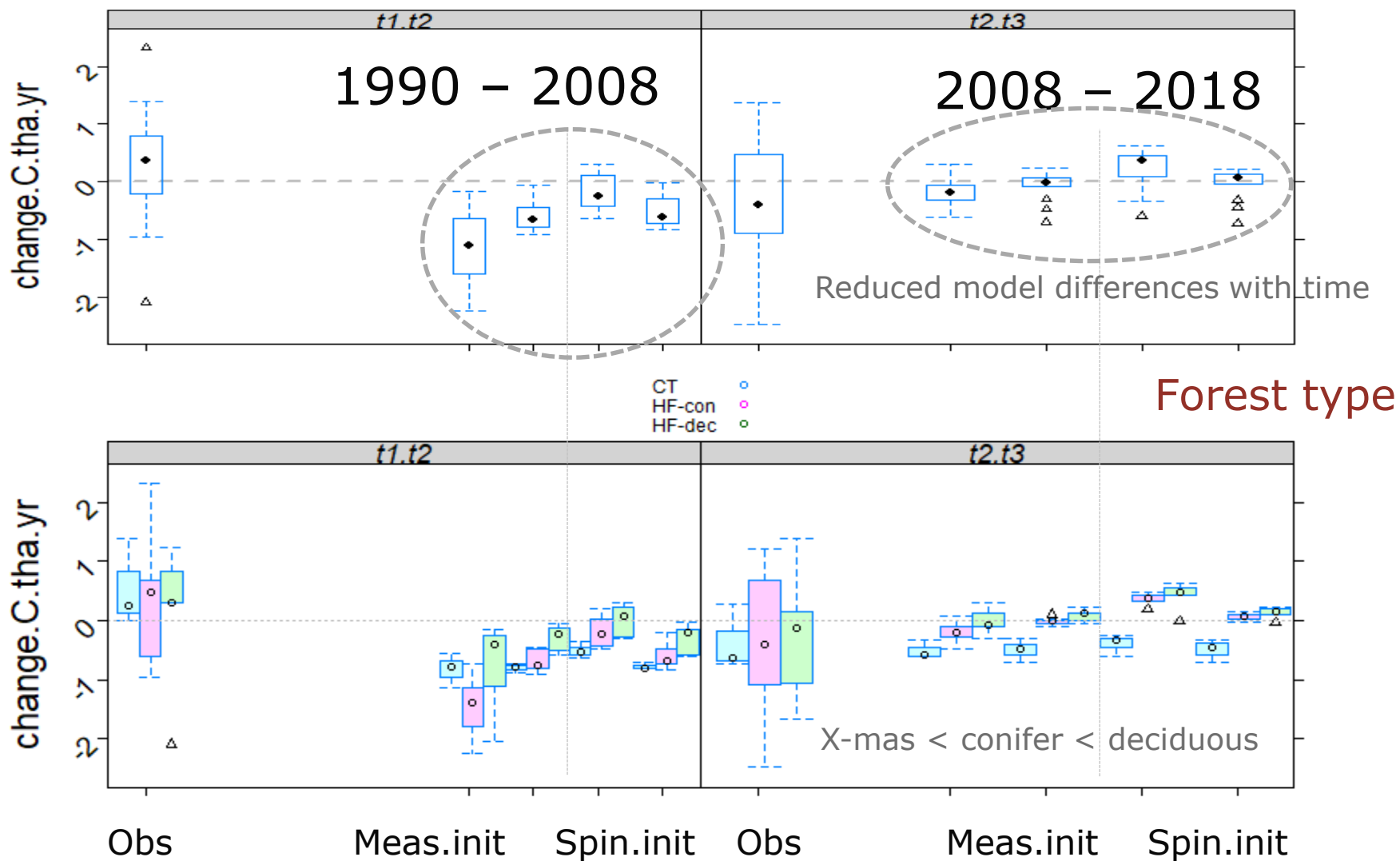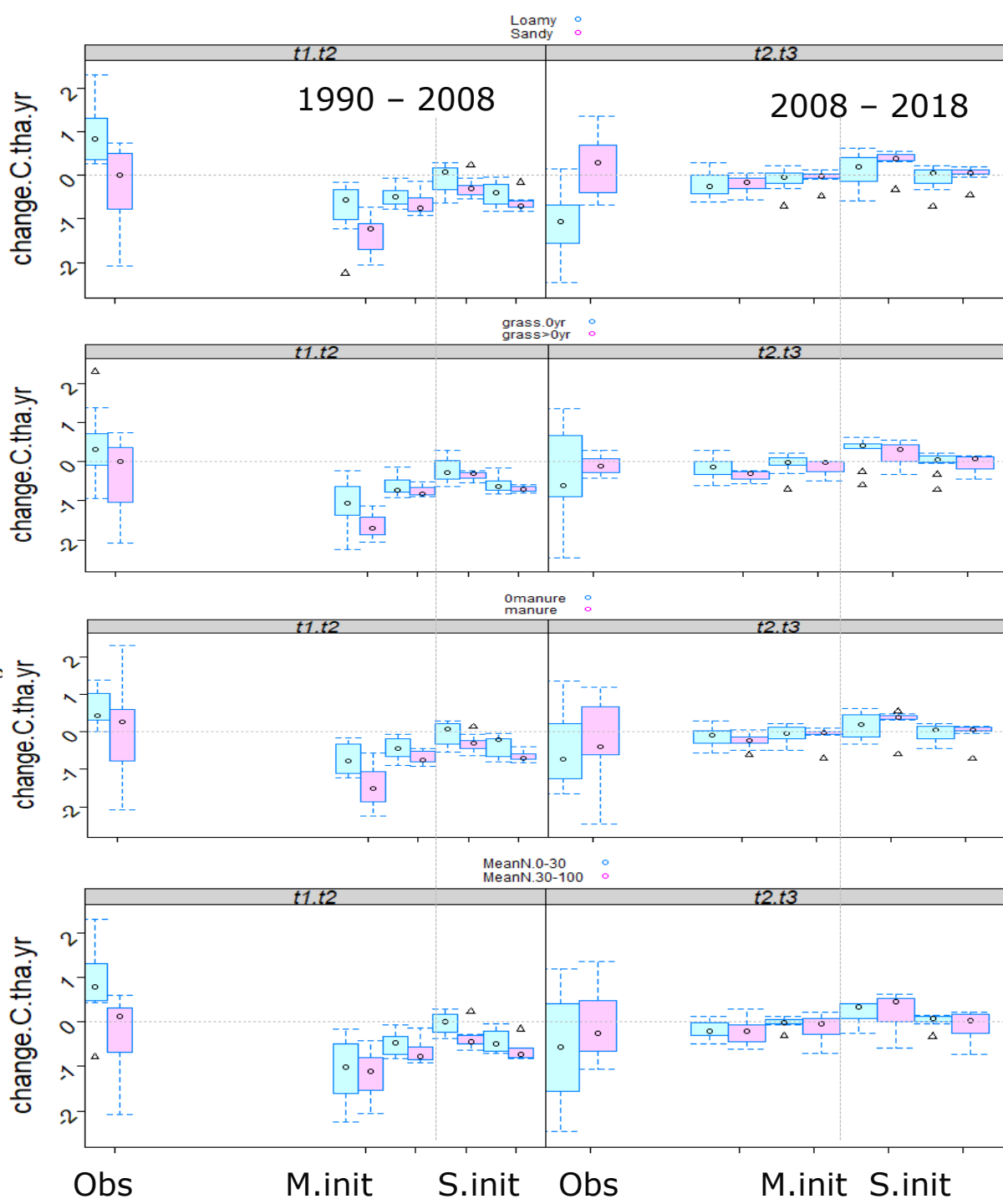
Soil type:
Early: losses in sandy more pronnounced
Late: accumulation in sandy (meas not sim?)

+/-grazing:
Early: losses in grazed more pronnounced?
Late: sustained in model?, not measured

+/-manure:
Early: losses with manure more pronnounced?
Late: effect not sustained

N-application:
Early: losses with high N more prounnounced
Late: effect not sustained

Model performance and site characteristics

- Individual management variables are expected to be correlated!
- A regional agric mgm system <-> individual variables (manure, N, grazing, texture)
- PCA used to define a «regional management system»
- Combine with linear mixed model (yet to be finalized -> few observations!)

09/10/2021
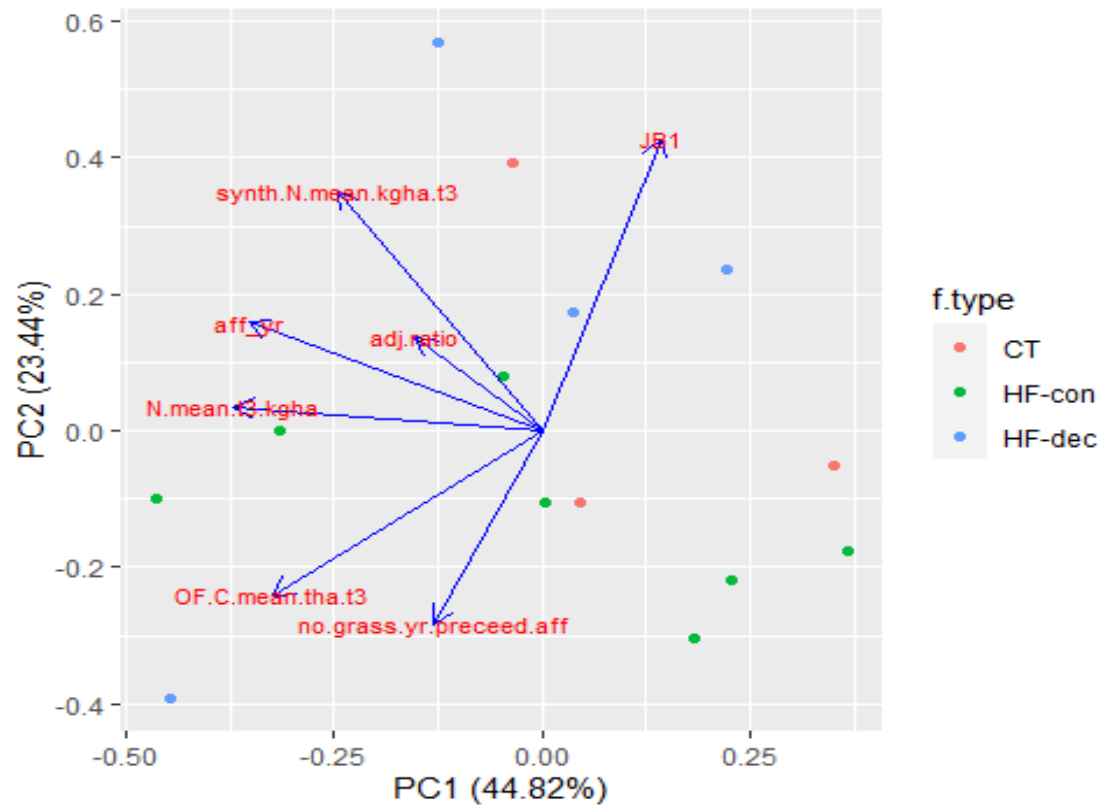
Conclusions

- Low model stocks compared to measured
- High vs. low forest fine root input important in the long run, but less so in the short term
- For changes: Reduced model differences with time, pronnounced in short term
- **Few observations** -> changes in general not statistically significant but **TRENDS** indicate that:
- Lowest accumulation (higher losses) in x-mas trees than high forest consistent for measurements and models
- Soil type:
    - Early: losses in sandy more pronnounced
    - Late: accumulation in sandy (meas but not sim?)
- +/-grazing:
    - Early: losses in grazed more pronnounced?
    - Late: sustained in model?, not in measured
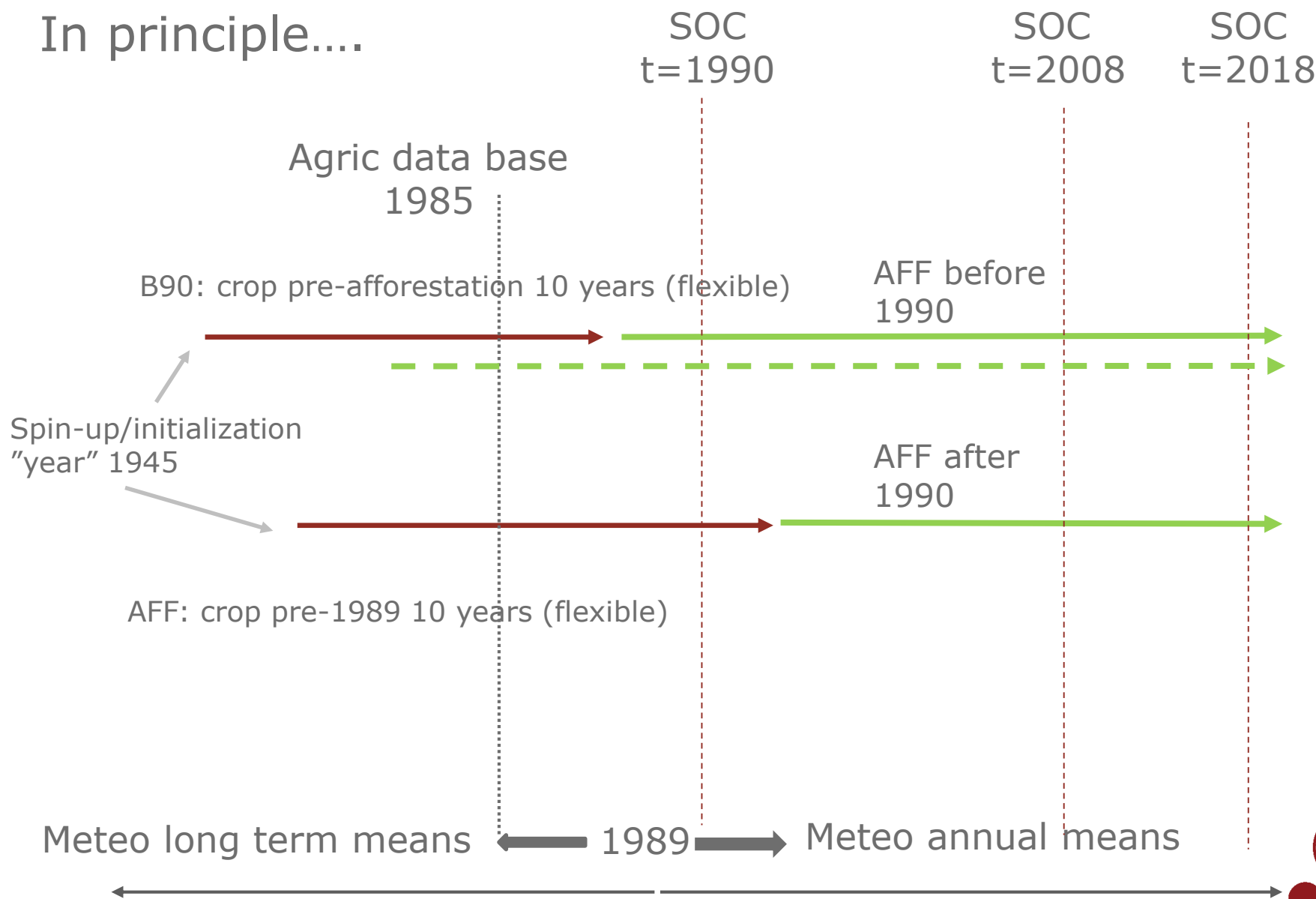- +/-manure:
    - Early: losses with manure more pronnounced?
    - Late: effect not sustained
- N-application:
    - Early: losses with high N more prounnounced
    - Late: effect not sustained
- Regional agric. Mgm. Systems can be defined (PCA) -> statistical analyses to be finalized

- **THANK YOU** ☺

In principle....

SOC
t=1990

SOC
t=2008

SOC
t=2018

Agric data base
1985

B90: crop pre-afforestation 10 years (flexible)

AFF before
1990

Spin-up/initialization
"year" 1945

AFF after
1990

AFF: crop pre-1989 10 years (flexible)

Meteo long term means ← 1989 → Meteo annual means

Agricultural conditions for spin-up prior to farmer reports
Initial conditions…."year 1945"

Carbon input estimates used for spin-up (tonC/ha year).

Agricultural soil class	Organic fertilizer		Wheat crop	Permanent grass	Barley crop	Agricultura crop	Total (crop + fertilizer)
1	0.5		3.0	6.6	2.0	3.9	4.4
2	0.5		3.5	7.8		4.5	5.0
3	0.5		2.5	5.4	1.6	3.1	3.6
4	0.5		2.5	5.4	1.6	3.1	3.6
5	0.2		3.8	6.3	2.3	4.1	4.3
6	0.1		3.8	6.3	2.3	4.1	4.2
7	0.1		4.0	6.3	2.5	4.3	4.4