EUROPEAN FOREST INSTITUTE

Effect of the model choice for simulating soil carbon stocks and stock changes: comparison of four soil models

Patrick Faubert, Esther Thürig, Marcus Lindner, Mikko Peltoniemi, Taru Palosuo, Oleg Chertov, Alexander Komarov, Alexey Mikhailov, Felicitas Suckow, Petra Lasch, Martin Wattenbach, Pete Smith, Pia Gottschalk

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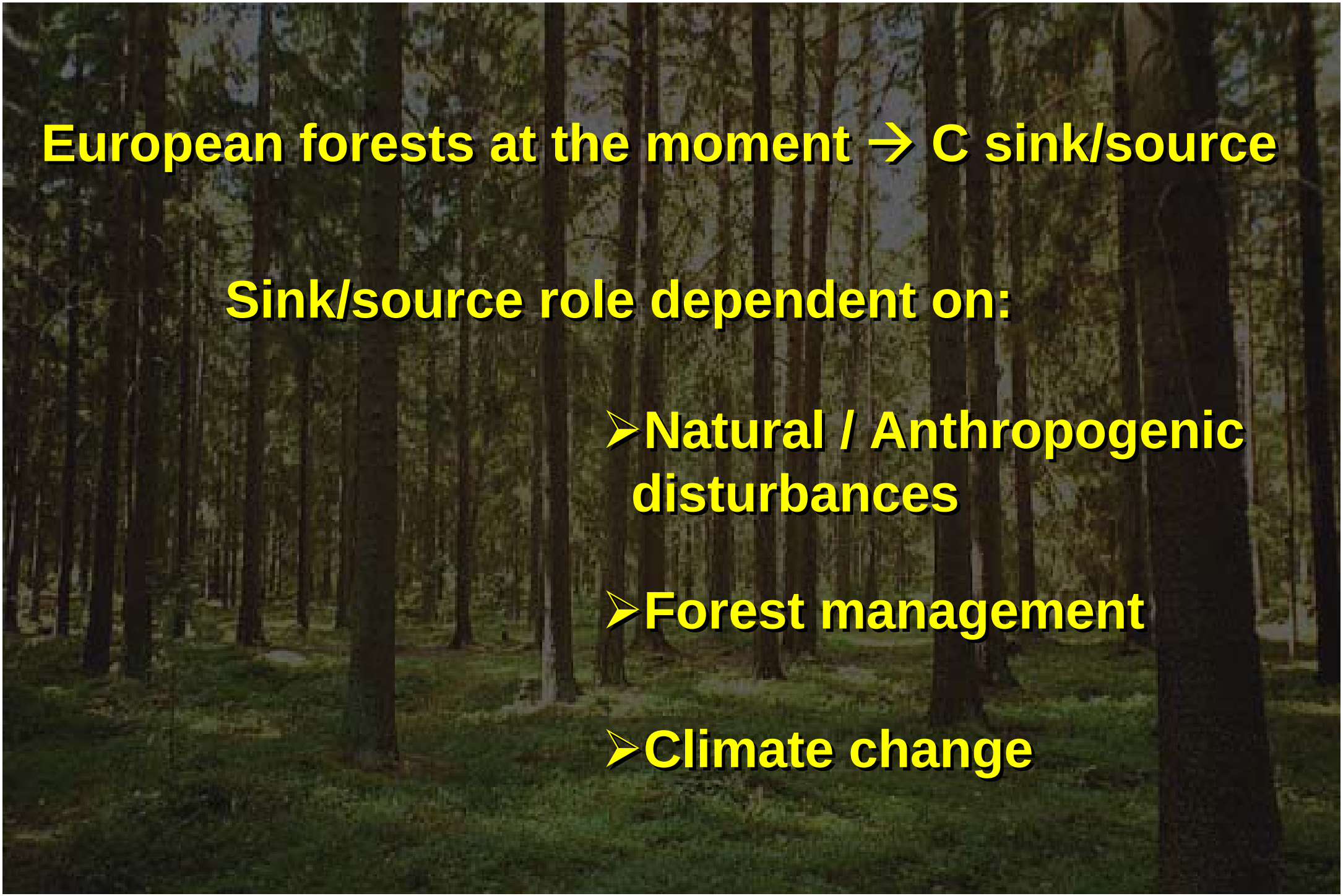
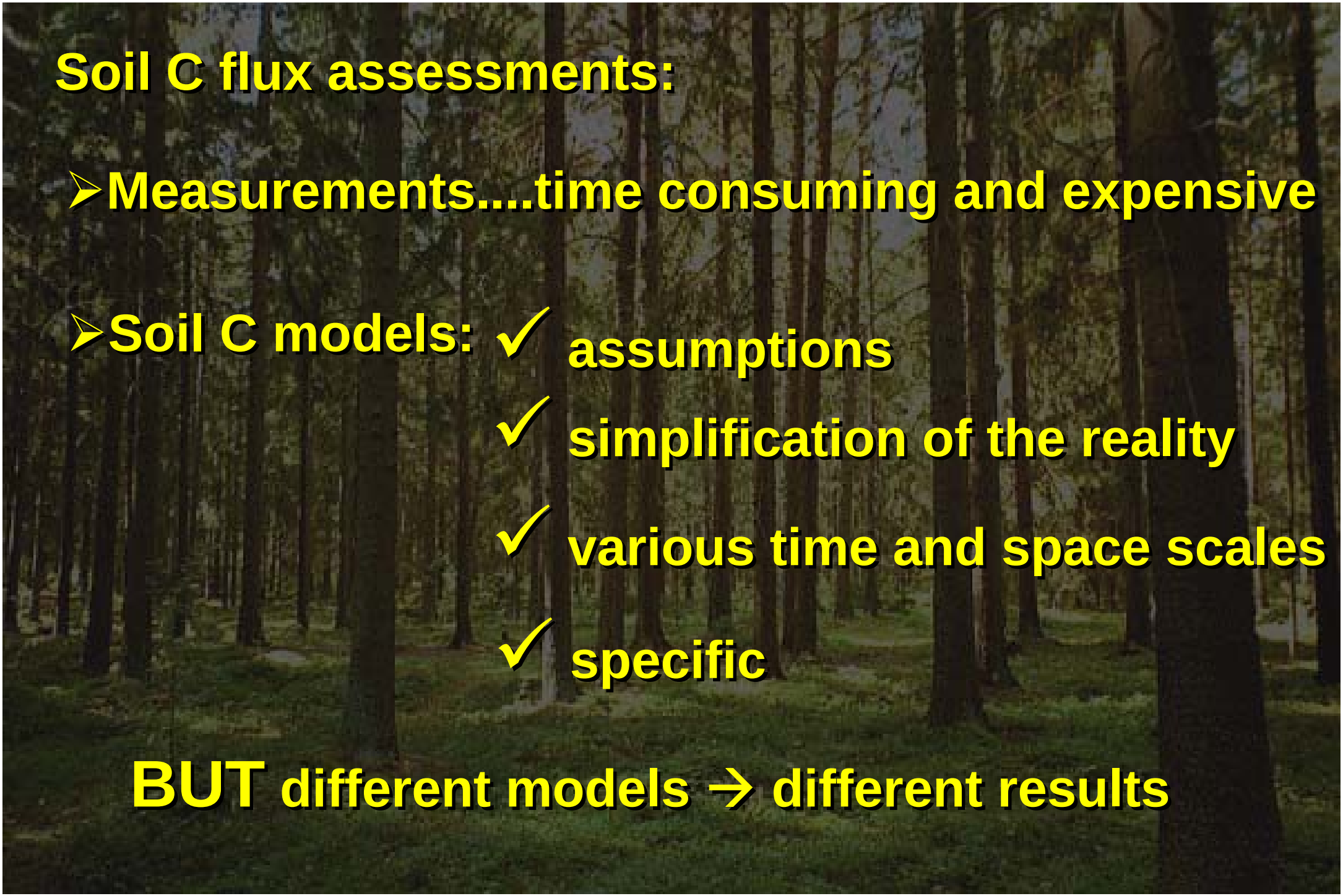

European forests at the moment → C sink/source
Sink/source role dependent on:
➢Natural / Anthropogenic disturbances
➢Forest management
➢Climate change


Soil C flux assessments:
➢Measurements....time consuming and expensive
➢Soil C models:
✓ assumptions
✓ simplification of the reality
✓ various time and space scales
✓ specific
BUT different models → different results

Objective

Evaluation of model effects on the assessment of C stocks and stock changes in forest soils

Research questions

- What is the effect of the initialization of C stocks on the simulation of the soil C fluxes?
- How does the choice of the model affect the stock change assessment?

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Material and methods

- Comparison of 4 soil C models
  - FORESEE - 4C
  - ROMUL
  - Rothamsted Carbon Model – RothC
  - Yasso

Material and methods

- Comparison of 4 soil C models

  - FORESEE - 4C: ✓ Process-based

    ✓ Simulations down to rooting depth

    ✓ Daily soil C dynamic

Material and methods

- Comparison of 4 soil C models

  - ROMUL: ✓ Process-based

    ✓ Simulations down to 1 m

    ✓ Monthly soil C dynamic

Material and methods

- Comparison of 4 soil C models

➢ Rothamsted Carbon Model – RothC:

✓ Process-based

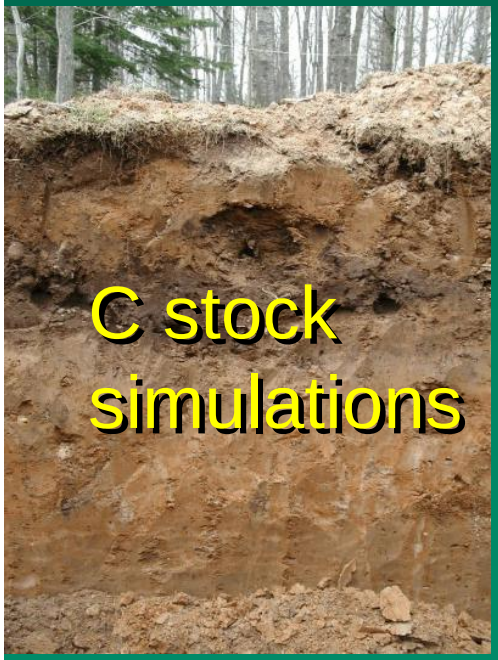
✓ Simulations down to 40 cm

✓ Monthly soil C dynamic

Material and methods

- Comparison of 4 soil C models
  - Yasso: ✓ Dynamic soil C model
    ✓ Simulations down to 1 m
    ✓ Yearly soil C dynamic

Simulation set-up



20 years

4C

EFIMOD

4C soil

ROMUL

RothC

Yasso

Total soil C

C organic layer

C mineral soil

Study sites

FIN-VT-pine

FIN-MT-pine

DE-Cho-pine

FIN-MT-spruce

FIN-OMT-spruce

DE-Aug-spruce

Study sites

	FIN-VT-pine	FIN-MT-pine	FIN-MT-spruce	FIN-OMT-spruce	DE-Aug-spruce	DE-Cho-pine
Stand and soil data	NFI: permanent plots				Yield table Digital soil maps	Permanent plots
Moisture/ nutrient	Subxeric	Mesic	Mesic	Rich	Wet/ moderate	Dry/ moderate
Stand age	36	75	55	65	80	50
Basal area m^{-2} ha^{-1}	22	31	28	25	43	38

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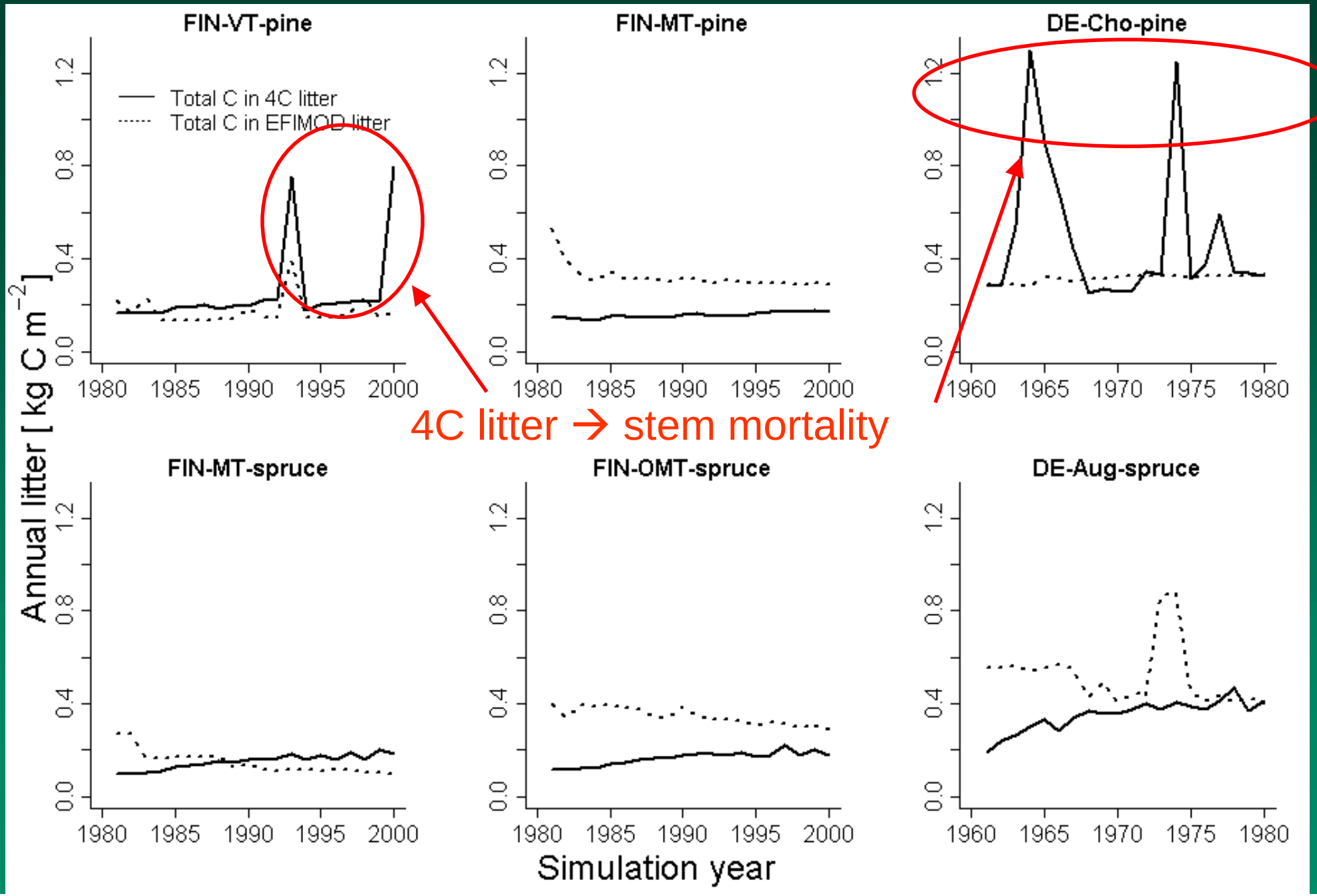
Initial C stocks [kg C m^{-2}]

	FIN-VT-pine	FIN-MT-pine	FIN-MT-spruce	FIN-OMT-spruce	DE-Aug-spruce	DE-Cho-pine
4C / ROMUL :						
Measured total soil C	3.4	4.1	4.4	11.2	9.5	10.7
Depth (cm)	←	40	→		95	200
RothC :						
Measured C in mineral soil down to 40 cm	1.9	2.4	3.2	9.7	1.9	6.4

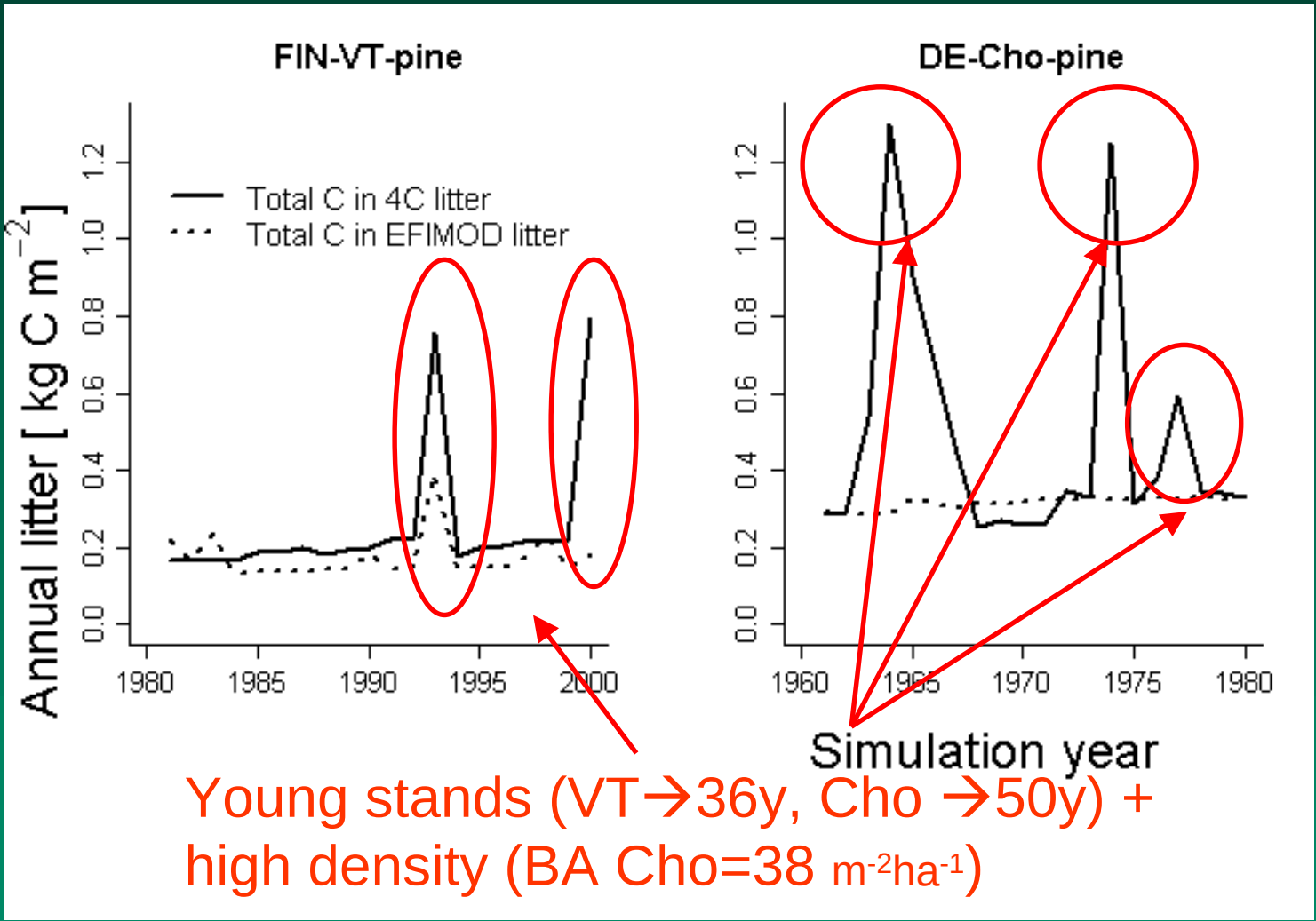
Initial C stocks [kg C m^{-2}] - Yasso

	FIN-VT-pine	FIN-MT-pine	FIN-MT-spruce	FIN-OMT-spruce	DE-Aug-spruce	DE-Cho-pine
1- Average 4C litter	5.6	3.6	4.6	5.4	7.7	12.0
Average EFIMOD litter	4.3	7.6	4.0	10.2	11.4	7.6
2-	Young stand			Rich soil	Old stand	Rich soil
Stand litter	2.7 ↓	3.7	4.9	7.2 ↓	12.5 ↑	5.7 ↓
Measured C	3.4	4.1	4.4	11.2	9.5	10.7
Stand age	36	75	55	65	80	50

Litter time series – 4C and EFIMOD

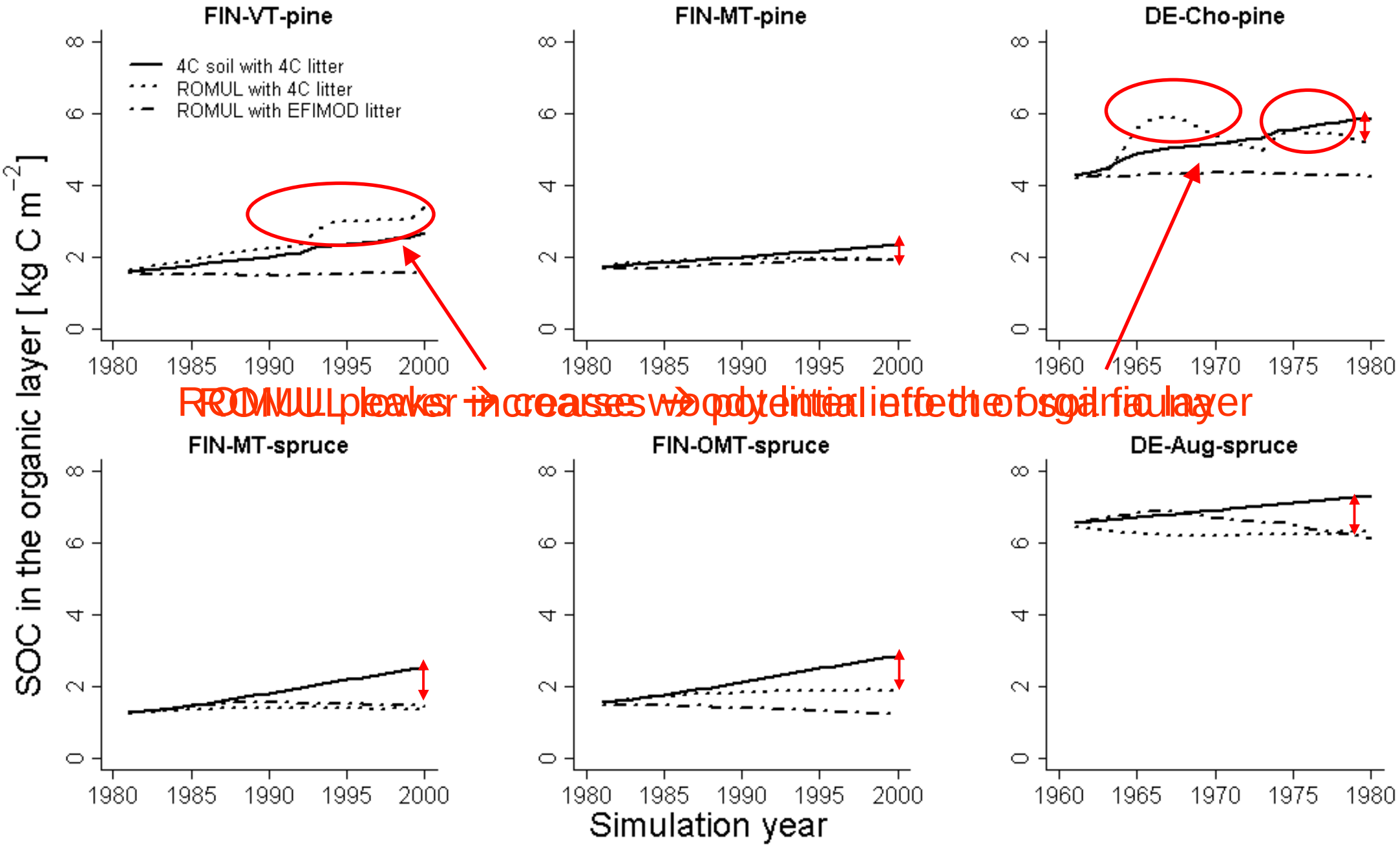


Litter time series – 4C and EFIMOD



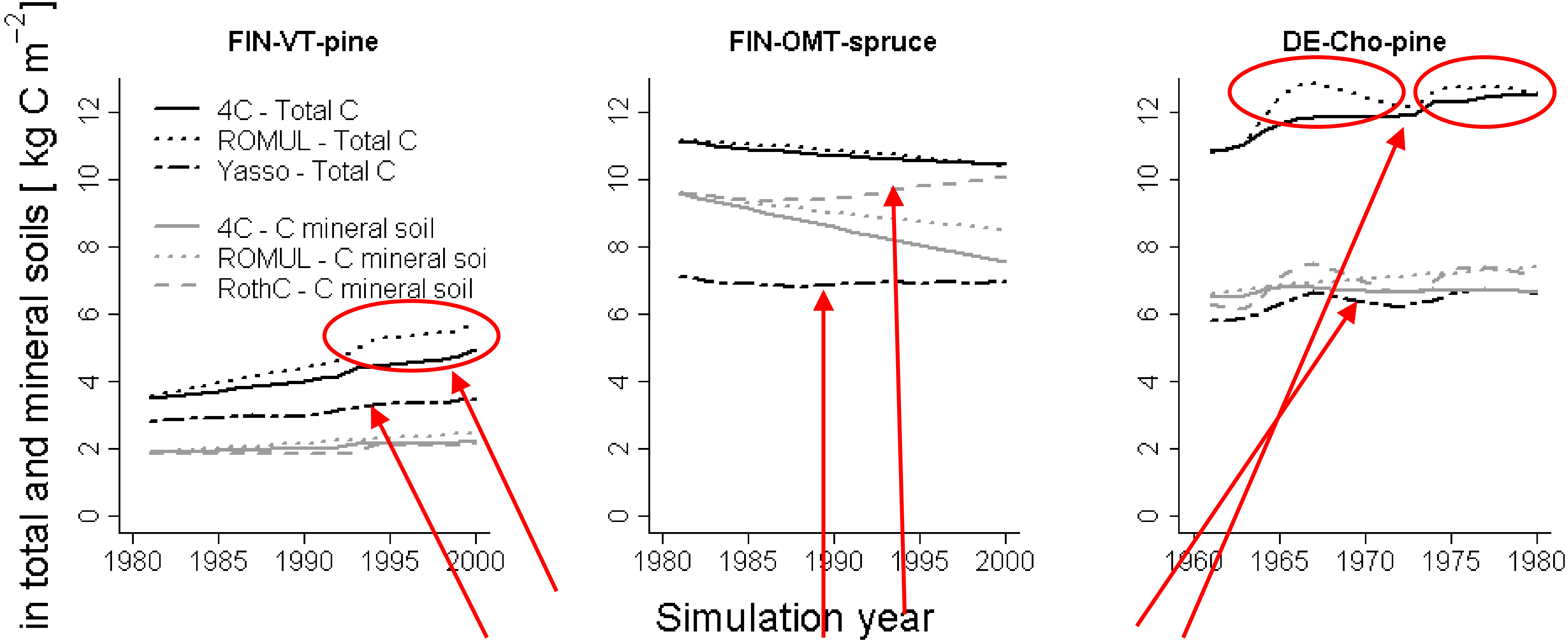
Young stands (VT→36y, Cho →50y) +
high density (BA Cho=38 $m^{-2}ha^{-1}$)

C in the organic layer



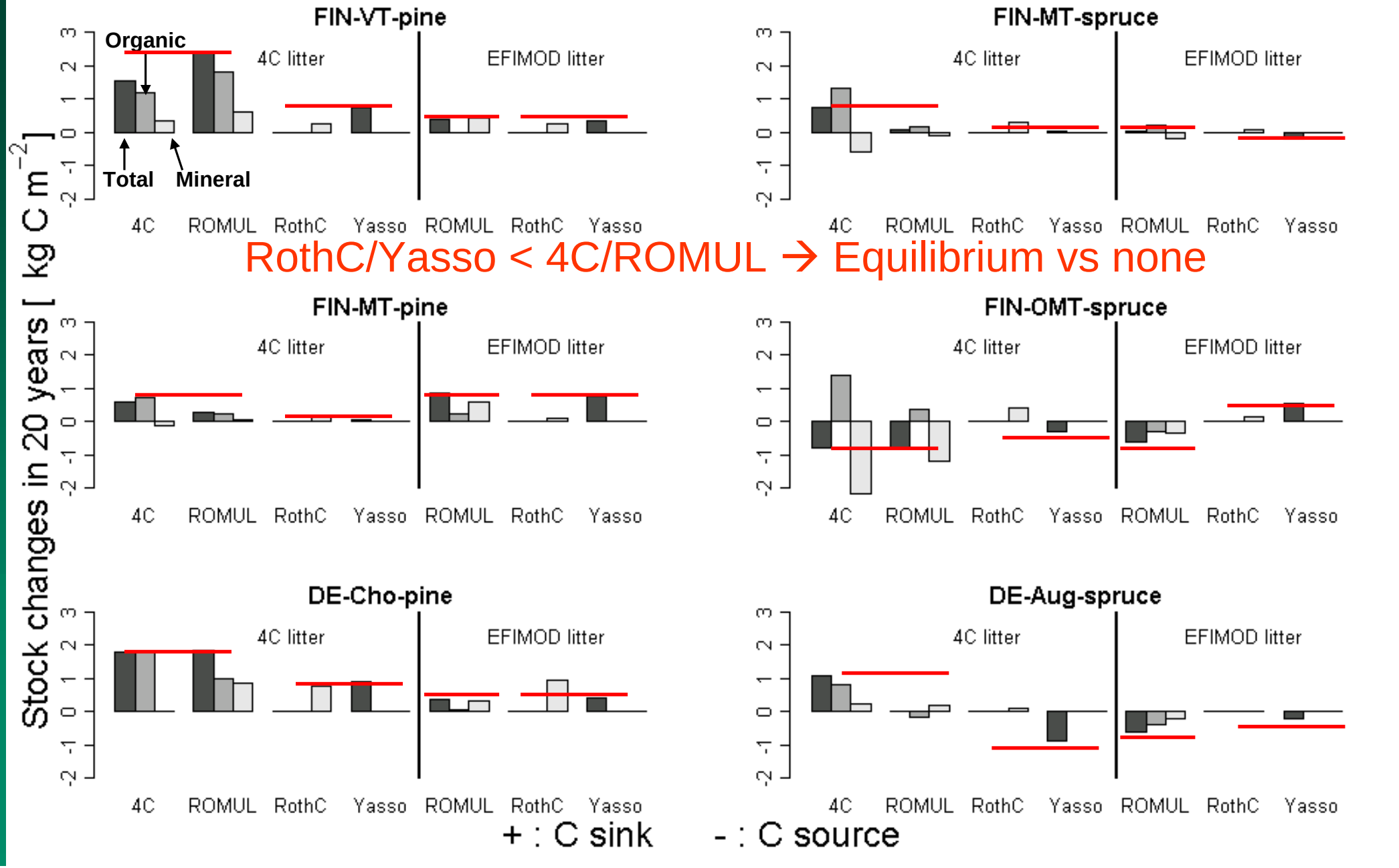
ROMUL leaves increases potential for the soil fauna layer

C in total soil and mineral layer: 4C litter



RothC: hig[illegible] total C (11.2)

C stock changes in 20 years



RothC/Yasso < 4C/ROMUL → Equilibrium vs none

Annual C stock changes [g C m^{-2} a^{-1}]

Median values	Total soil C	C mineral layer	Minimum total C	Maximum total C
All combinations (sites/model/ litter)	18.1	7.8	-44.4	120.5
4C	145%			
ROMUL	-49%			
RothC		87%		
Yasso	-49%			

→ High sensitivity of the model choice

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Conclusion

What is the effect of the initialization of C stocks on the simulation of the soil C fluxes?

- Initialization with measured soil C if available

  → 4C and ROMUL similar trends for total soil C

- Initialization with litter input: easily available

  →Yasso: forest soils often not in equilibrium with the actual stand

Conclusion

How does the choice of the model affect the stock change assessment?

- High sensitivity
  - Annual stock changes different from –49% to 145%
- Simulations on small vs. large scales
  - On small scales, high accuracy with detailed data
  - On large scales, detailed data are often not available
  - ➔ Data availabilty strongly influences the model choice

Further research

- Comparison with long-term soil C measurements

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Thank you for
your attention !
Kiitos seurasta !
Photo: Martin Nikl