Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

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Introduction of grass-clover crops as biogas feedstock in cereal-dominated crop rotations

Part I: Effects on soil organic carbon and food production

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9th International Conference *LCA of Food*, San Francisco, USA, 8-10 October 2014

The basic project ideas

- Introduction of grass-clover crops can have a dual function as biogas feedstock and soil organic carbon (SOC) contributor

- Changes of crop rotation can influence the overall sustainability of the biomass production system substantially

Why important?

- Loss of soil organic carbon (SOC), erosion and compaction are the main processes threatening soil fertility throughout the EU
  (EC 2002; Soilservice 2012)
- Intensively cultivated clay soils have in Swedish studies been shown to give up to 20% decreasing food crop harvest yields due to soil compaction and reduced soil organic matter content
  (Arvidsson and Håkansson 1991)
- Farms in regions with no/low animal production lack options for adding additional organic material for SOC improvements

Mechanisms

- Loss of SOC contributes e.g. to…
  …reduction of nutrient holding capacity (decrease of crop yields)
  …reduction of soil biodiversity
  …reduction of water infiltration capacity (increased run-off and erosion)

  …thus strongly influencing soil fertility and crop yields negatively

- Agricultural soils can act either as carbon sinks, or, if SOC is declining, as contributors to greenhouse gas emissions

Case farm

Case farm *Wrams Gunnarstorp*,

southern Sweden (56°6'N 12°58'E)

650 ha of medium to heavy clay soil (up to 65% clay)

SOC content ~2%

Crop rotation

Reference scenario

4-year crop rotation typical for the region
Conventional cultivation, mineral fertilizer
Year 1 - winter oilseed rape
Year 2 - winter wheat
Year 3 - winter wheat
Year 4 - oats

Grass-clover scenarios

One year in a five year crop rotation

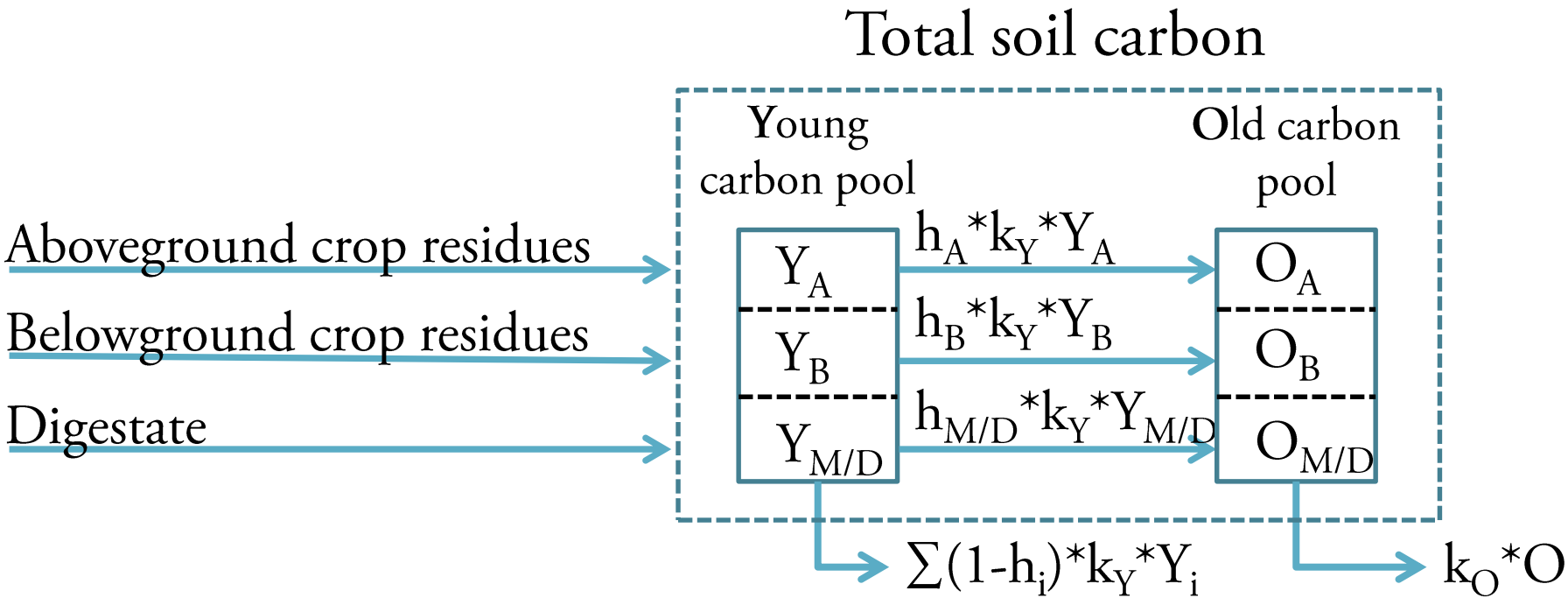
Two years in a six year crop rotation

Soil carbon changes

- Diffcult to measure directly (annual fluctuations, soil heterogeneity)
- Long-term experiments are used

➔ SOC model to estimate changes

Soil carbon balance model - ICBM



(Andrén and Kätterer 1997; Kätterer and Andrén 2001).

Model calibration

Long-term SOC field experiment

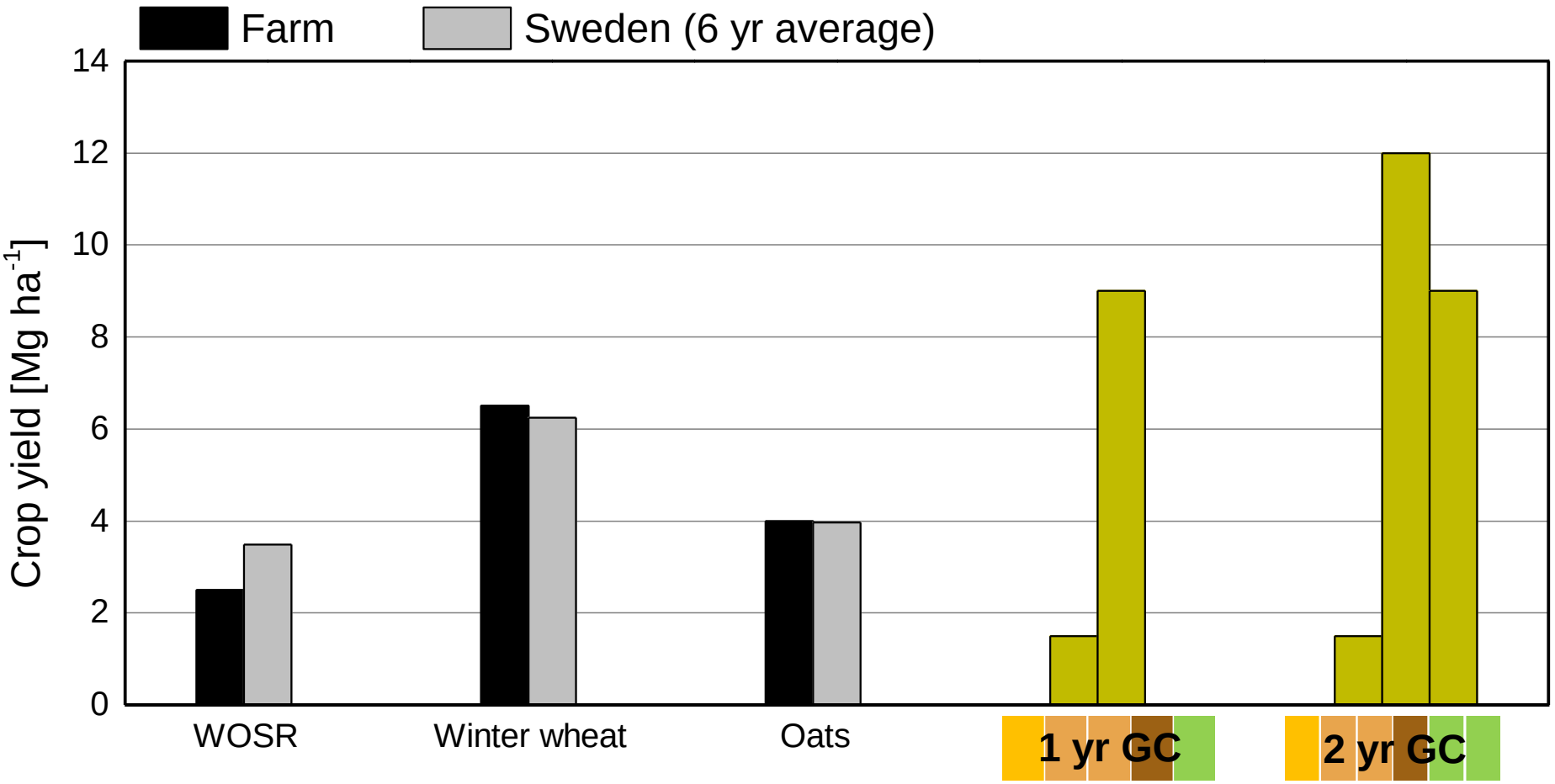
Ekebo, southern Sweden (55°59’N, 12°52’E)

Started 1957, ongoing

- Prediction power was optimized by changing the mineralization rate of old carbon pool

- Food crop yields are based on commercial yields
- Grass-clover crop yields were obtained from field experiments

Crop yields



Amount of residues

- Calculated backwards from harvestable biomass (grains, seeds, grass-clover biomass)

- Two different methodologies

Parameter	IPCC
Belowground crop residues	Unlimited
Time span for calculation of average annual carbon changes	20 years

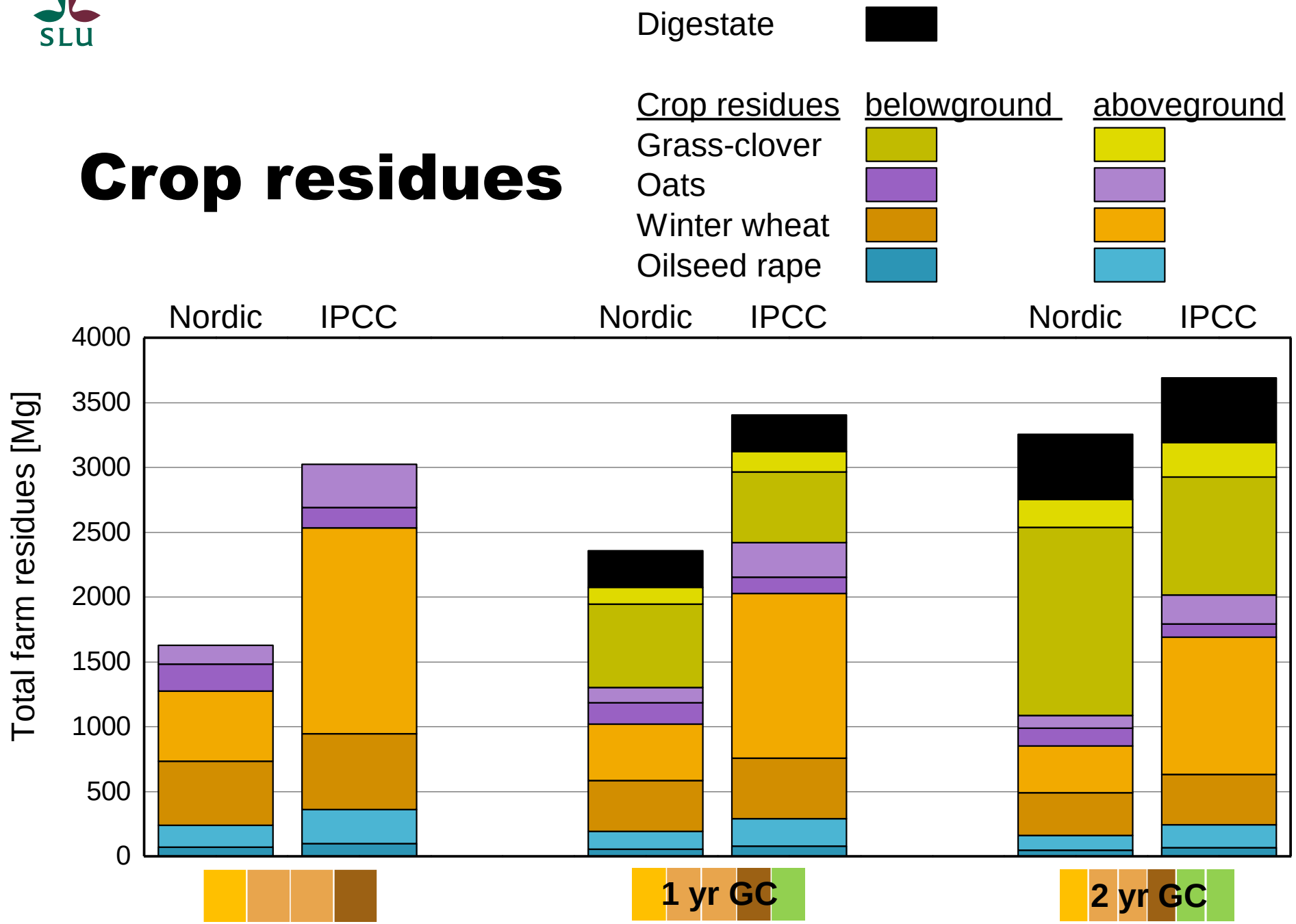
Amount of residues

- Calculated backwards from harvestable biomass (grains, seeds, grass-clover biomass)

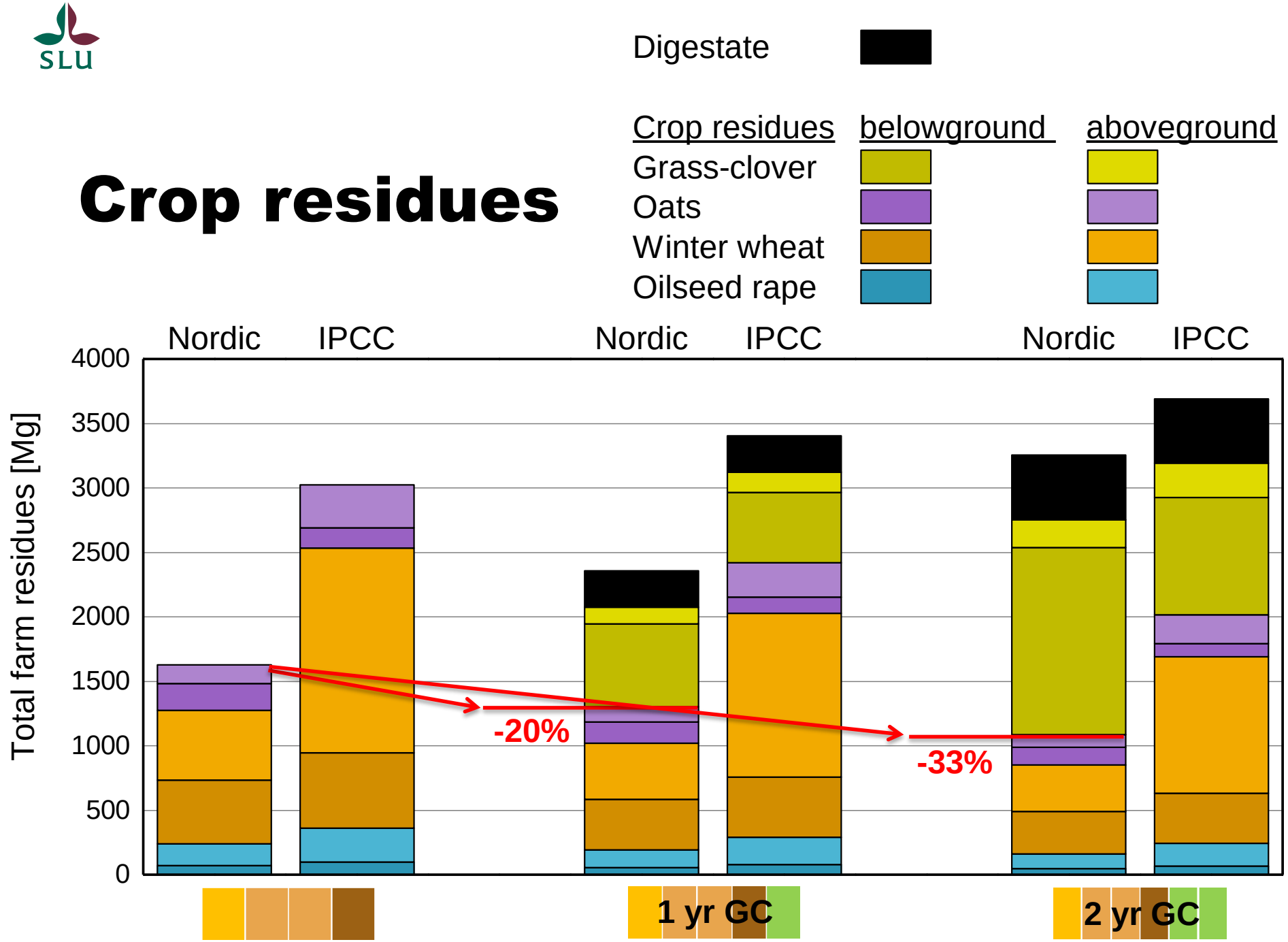
- Two different methodologies

Parameter	Nordic base case	IPCC alternative case
Belowground crop residues	Limited to 6 t ha^{-1} of DM; extra root residues	Unlimited
Time span for calculation of average annual carbon changes	40 years	20 years

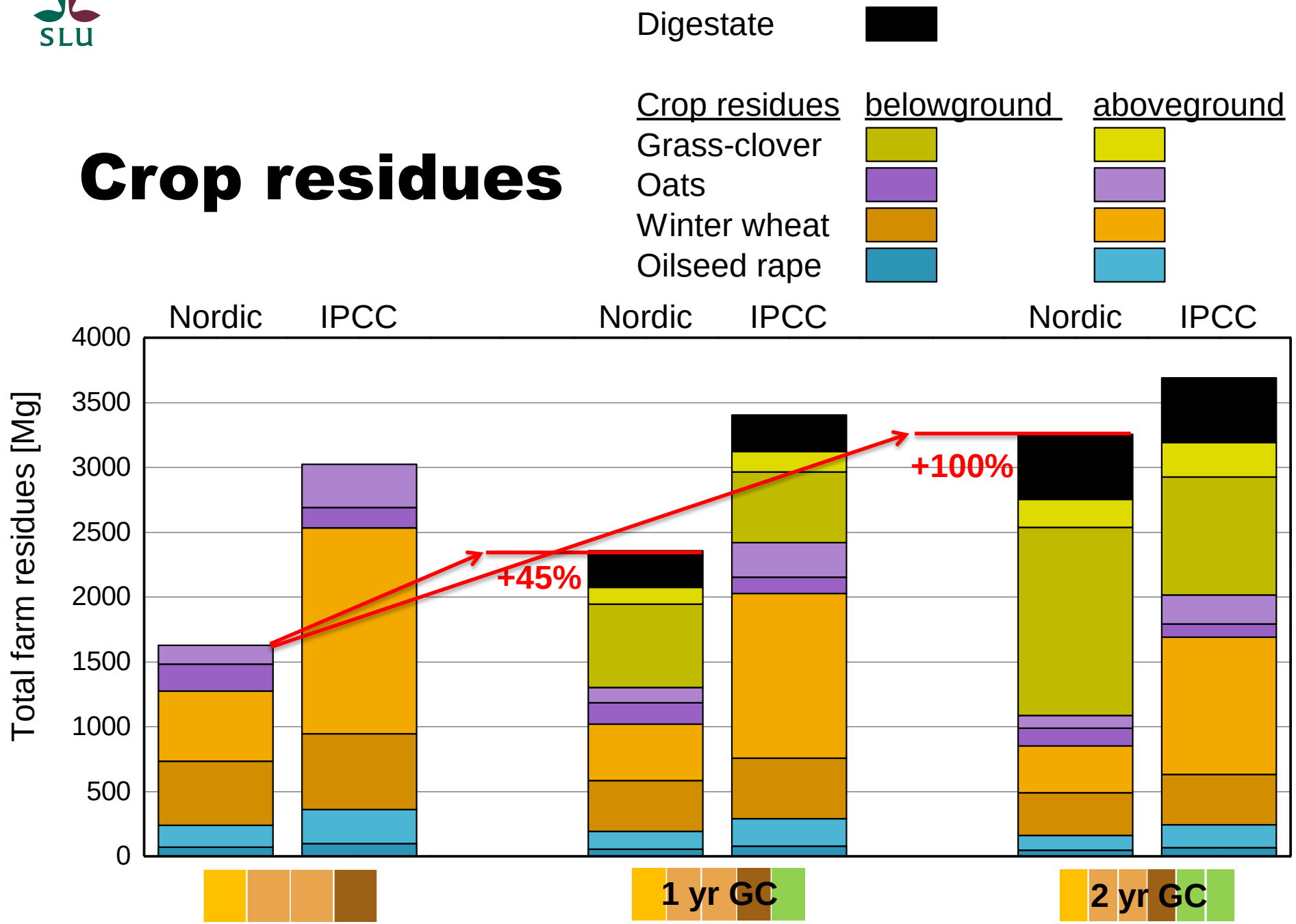
Crop residues



Crop residues

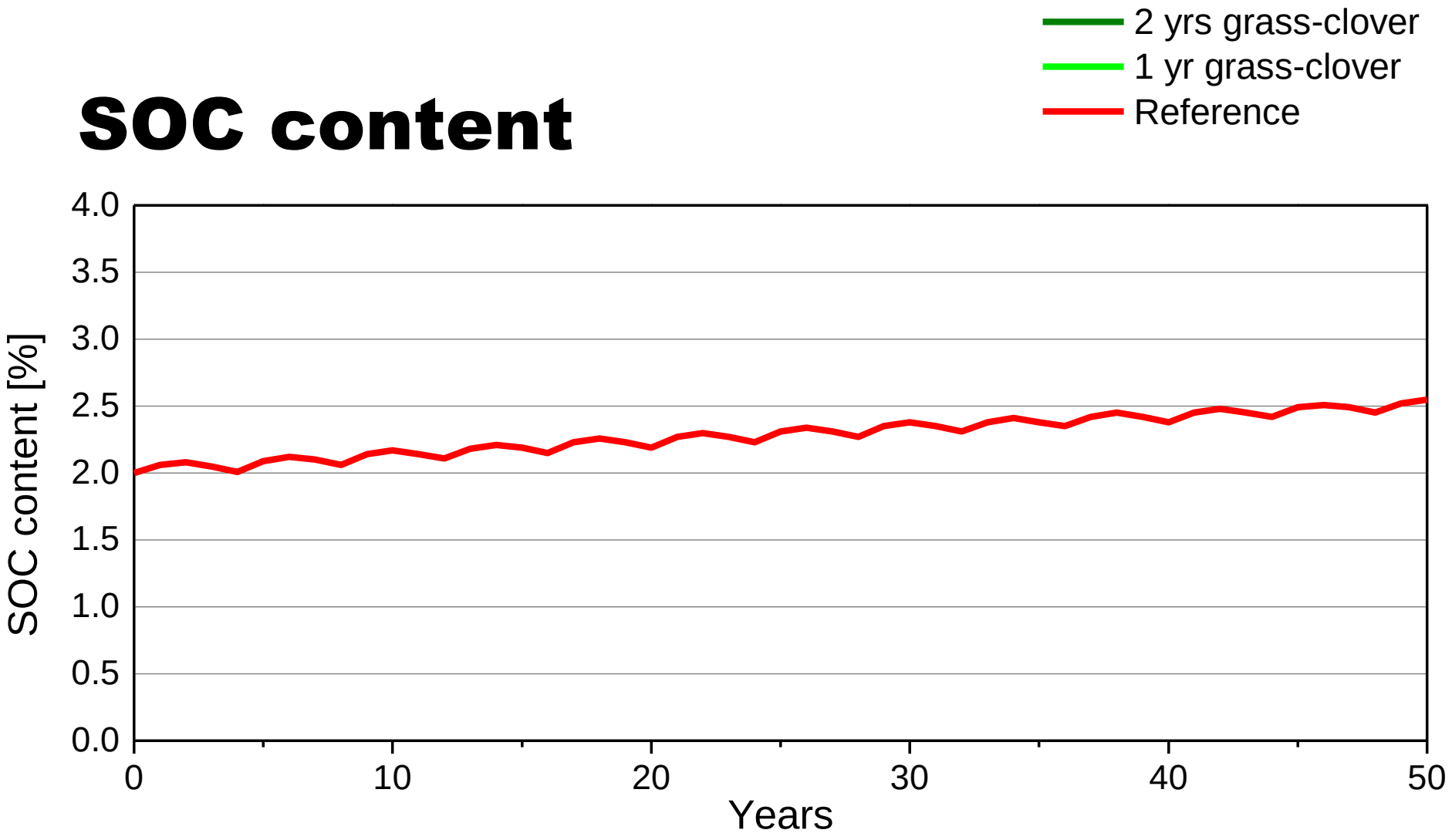


Crop residues



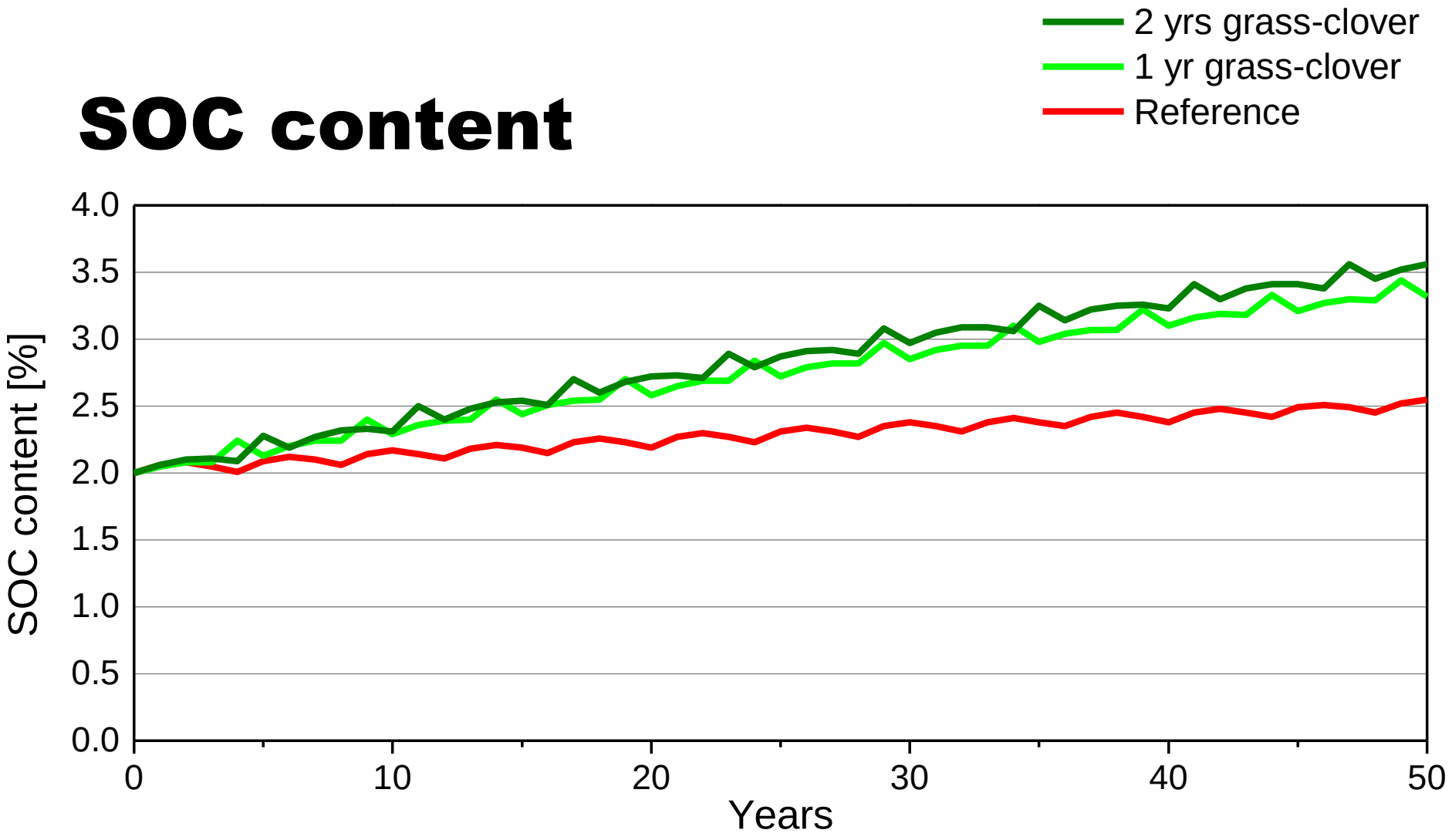
Results

SOC content



- Based on Nordic constraints

SOC content



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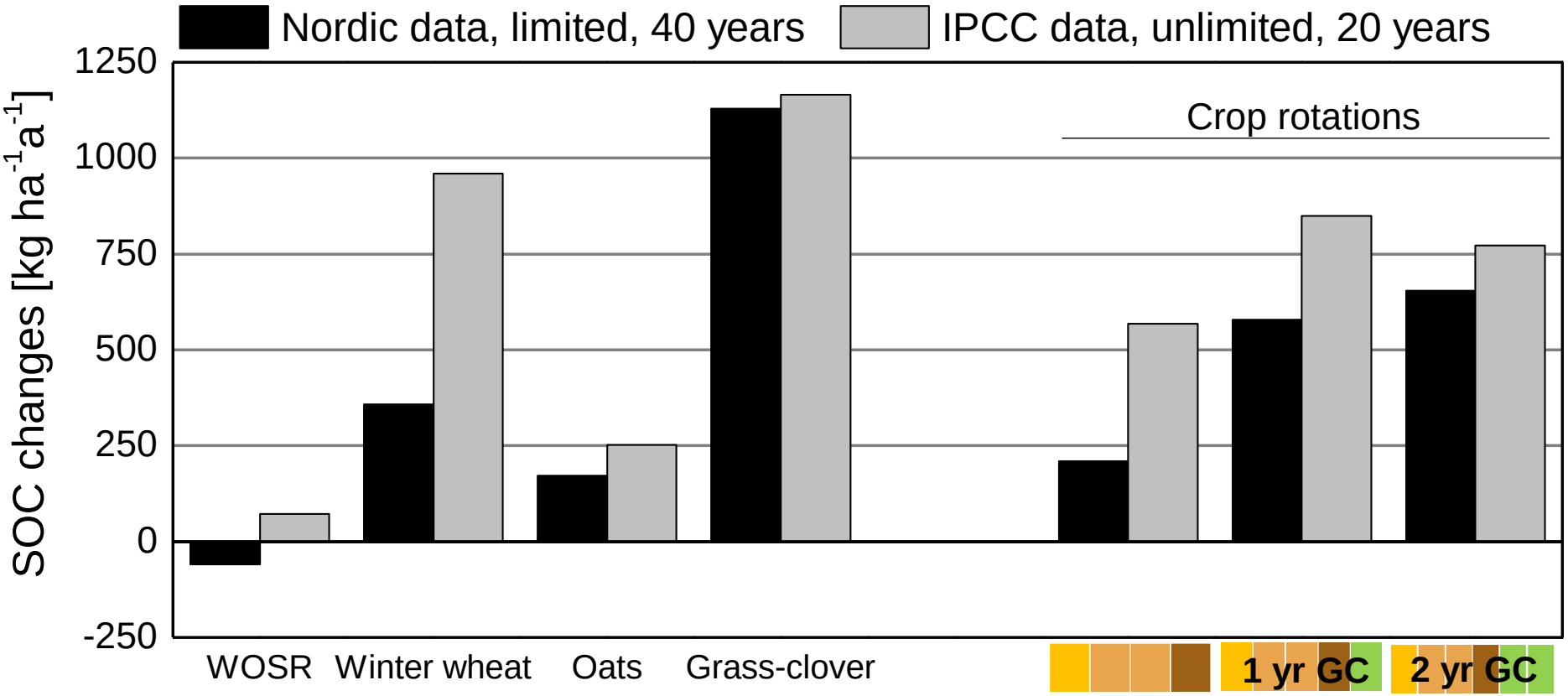
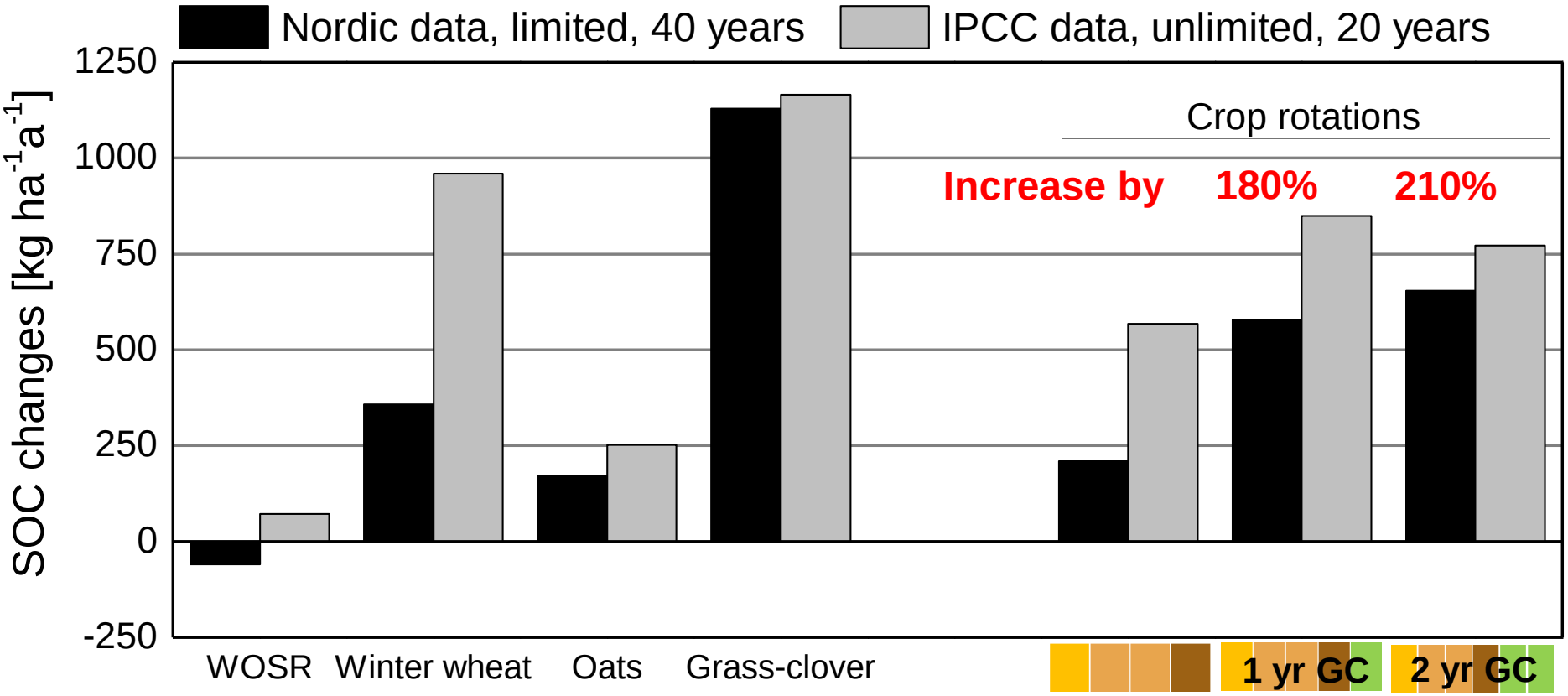
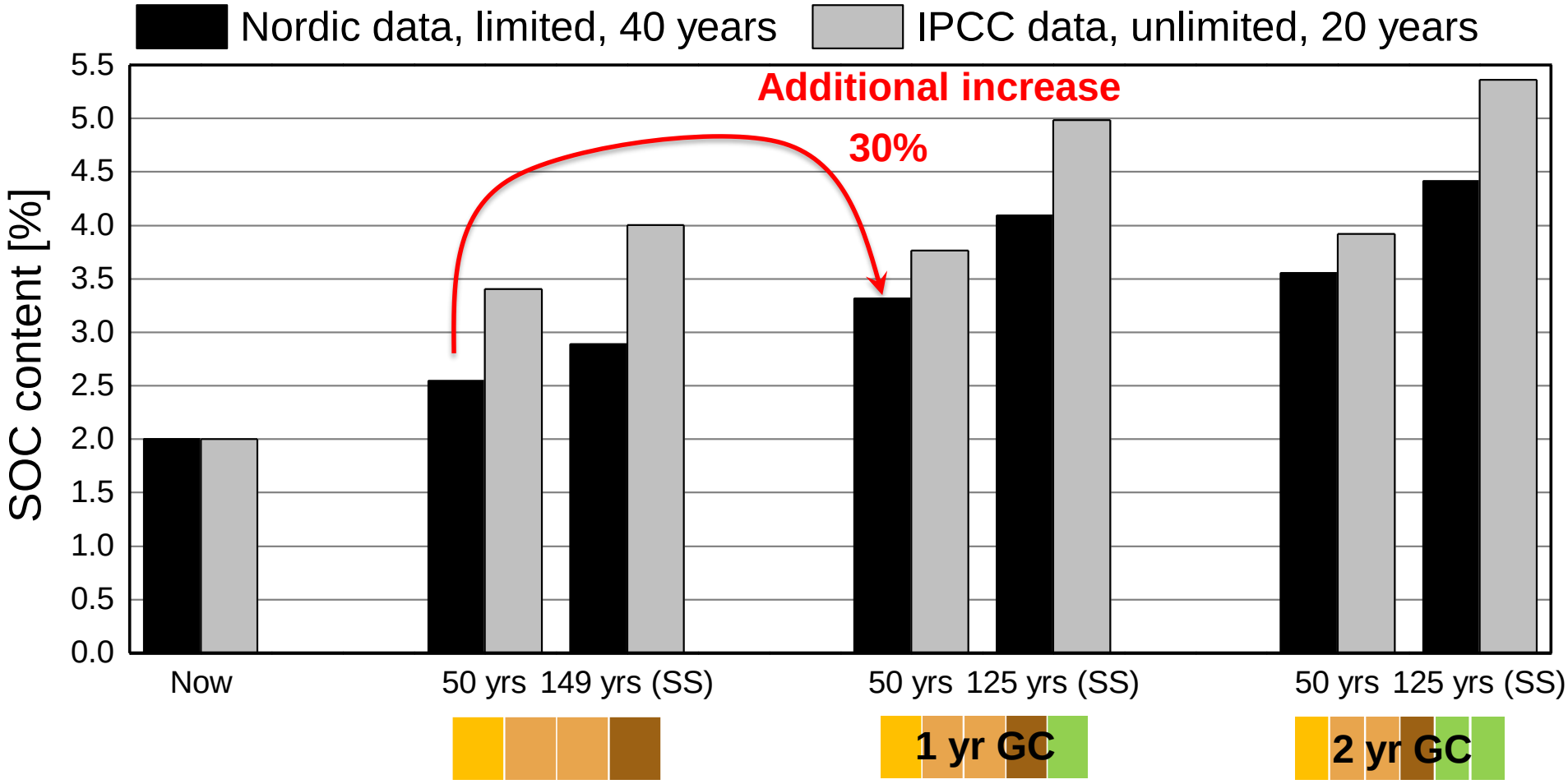
Annual SOC changes



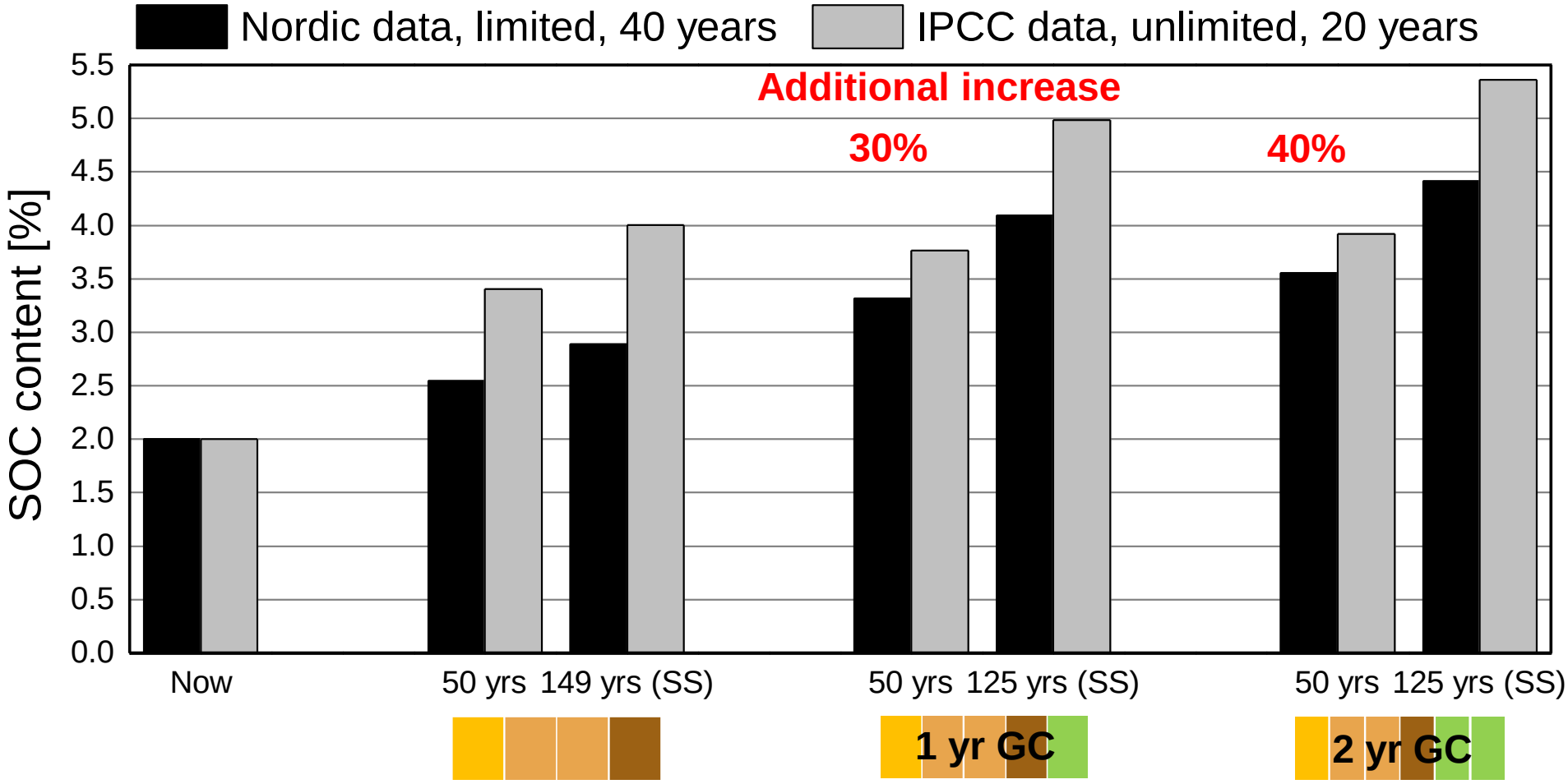
Annual SOC changes



Long-term SOC changes

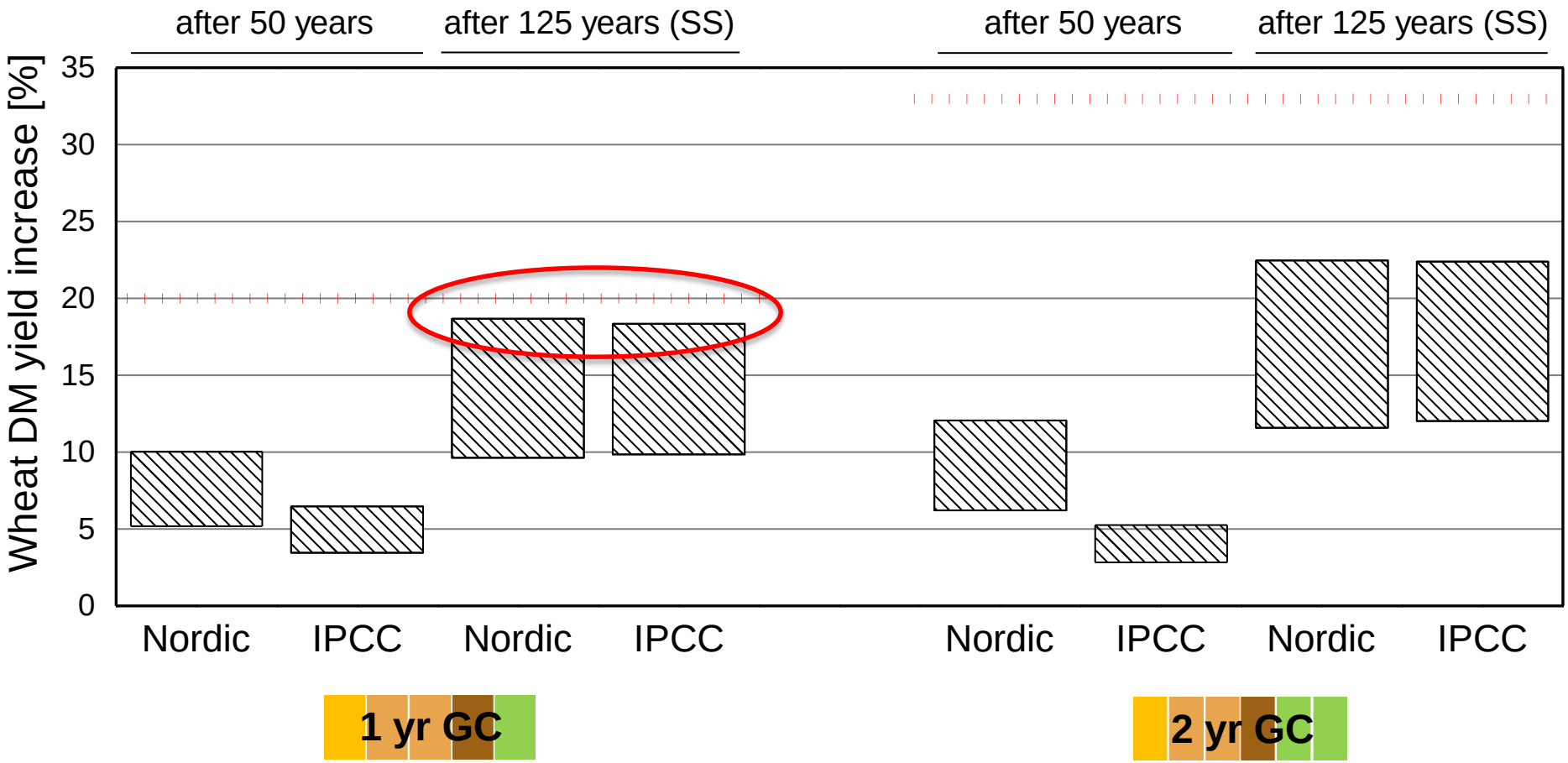


Long-term SOC changes



Upper/lower value based on DM yield increase of 0.4-0.8 t ha^{-1} $\%_{SOC}^{-1}$ (Lal 2004)

Wheat yield impact



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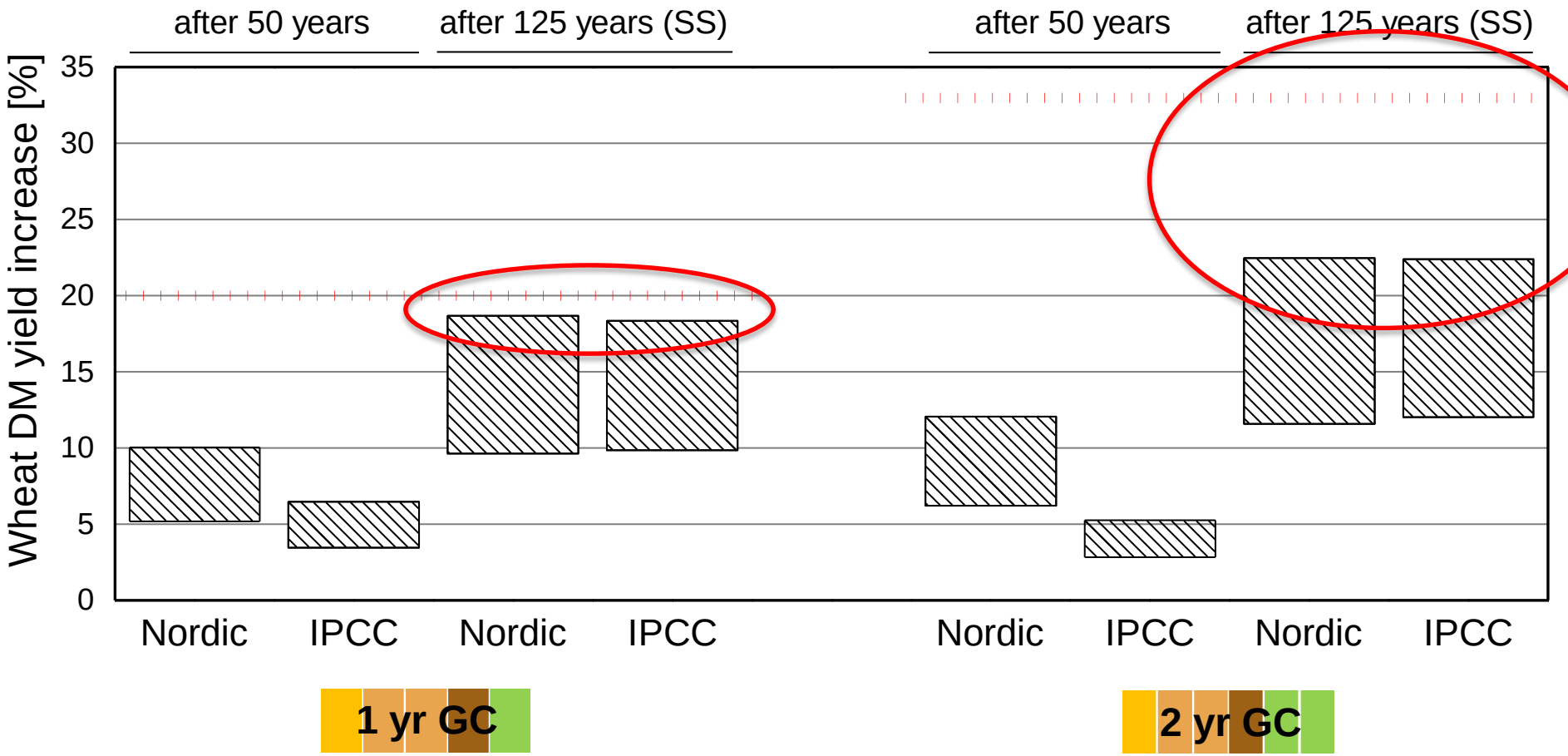

Conclusions I

- Grass-clover is a potent crop mixture for SOC accumulation in clay soils
- Indication that initial food production losses can be (partly) compensated

Conclusions II

- Integrating energy feedstock production with food production feasible
- View on whole crop rotation is important; single-crop assessments may give a skewed picture
- Sustainability of both food and agricultural energy production may be improved

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Thank you!

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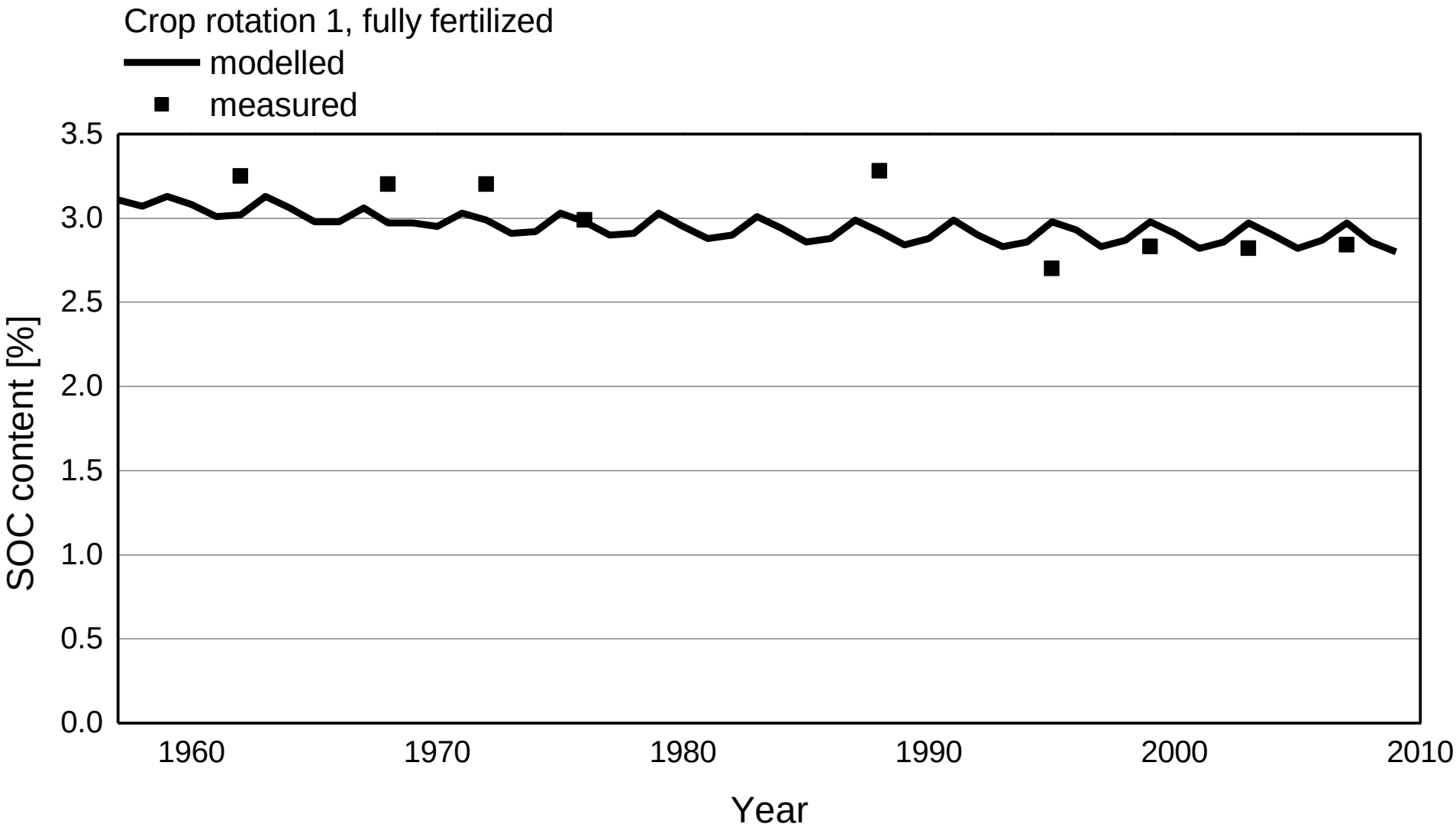
Model calibration



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