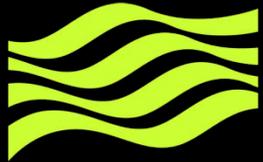




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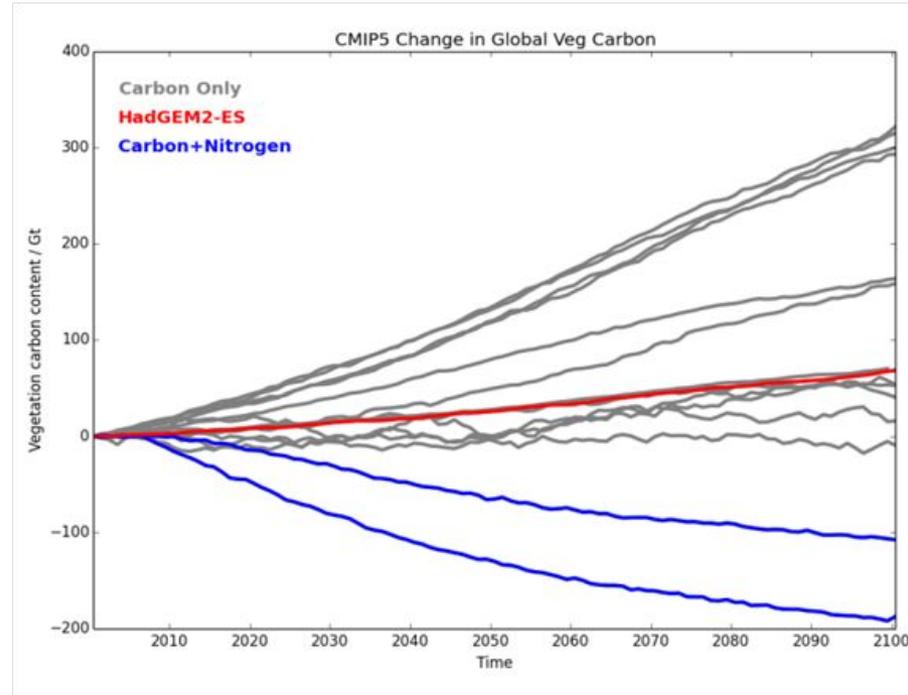
# Tundra carbon and nitrogen cycling

Eleanor Burke, Sarah Chadburn and Andy Wiltshire



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# Motivation

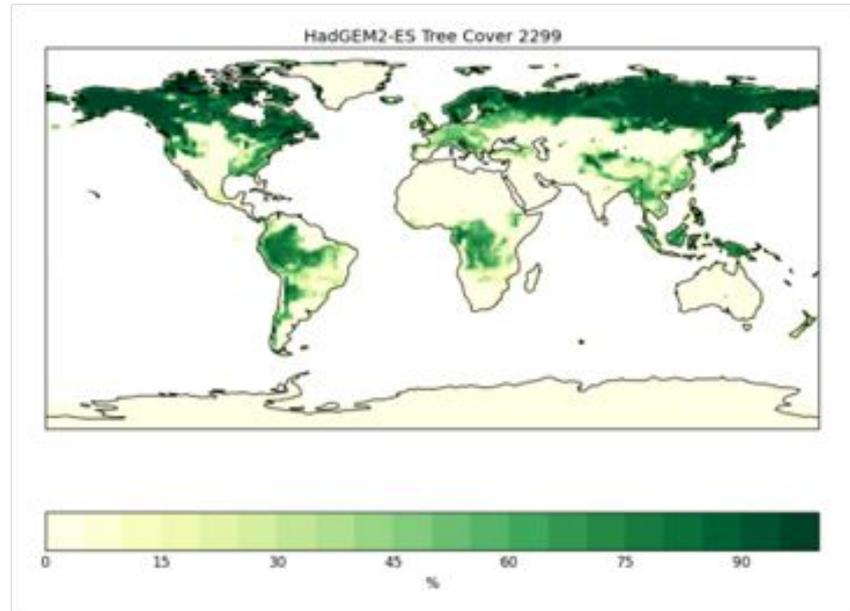


Carbon and nitrogen are both required for plant growth, but most CMIP5 models only include the C cycle. Those that additionally include N show different future pathways.



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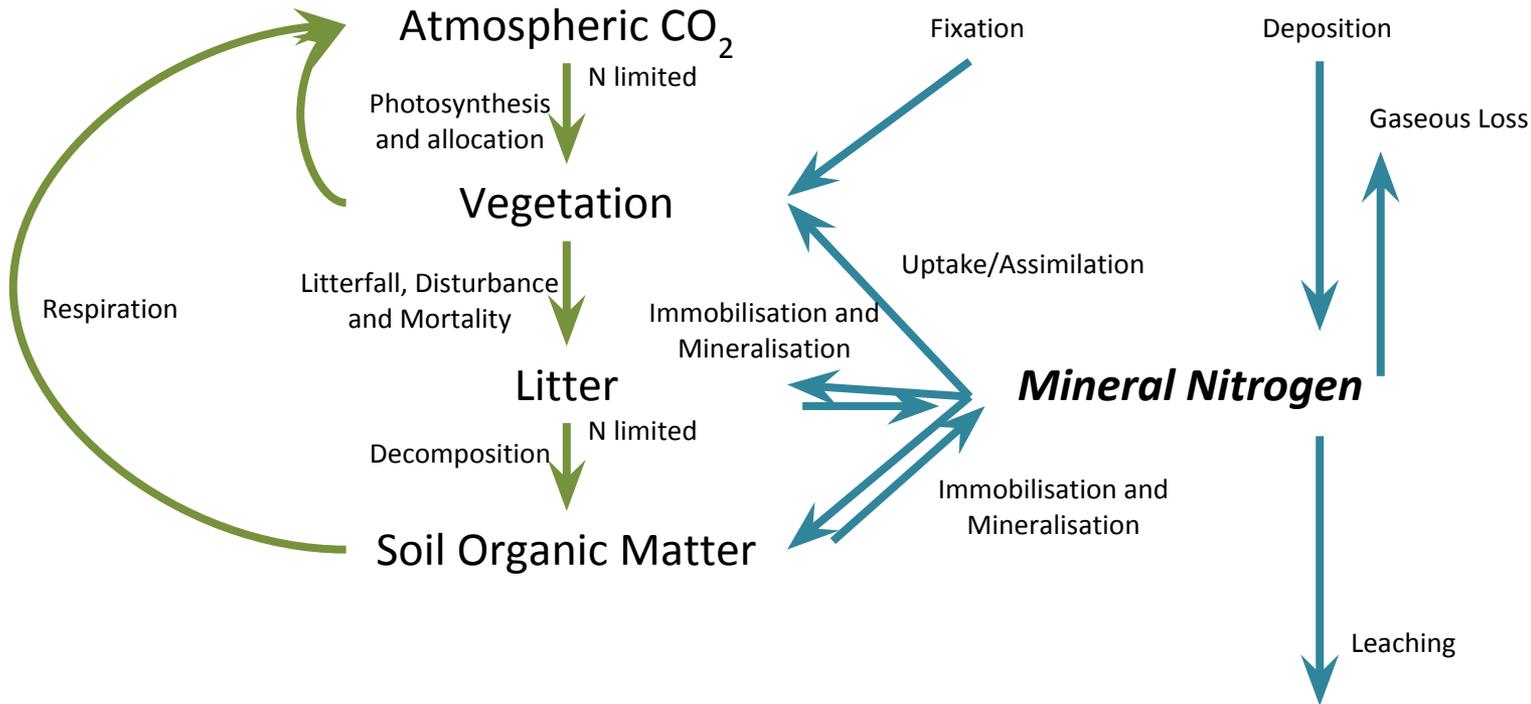
# Motivation



In the northern high latitudes there is a large model projected increase of vegetation.

How might including a representation of the nitrogen cycle impact this result?

# Coupled Terrestrial Carbon-Nitrogen Cycle

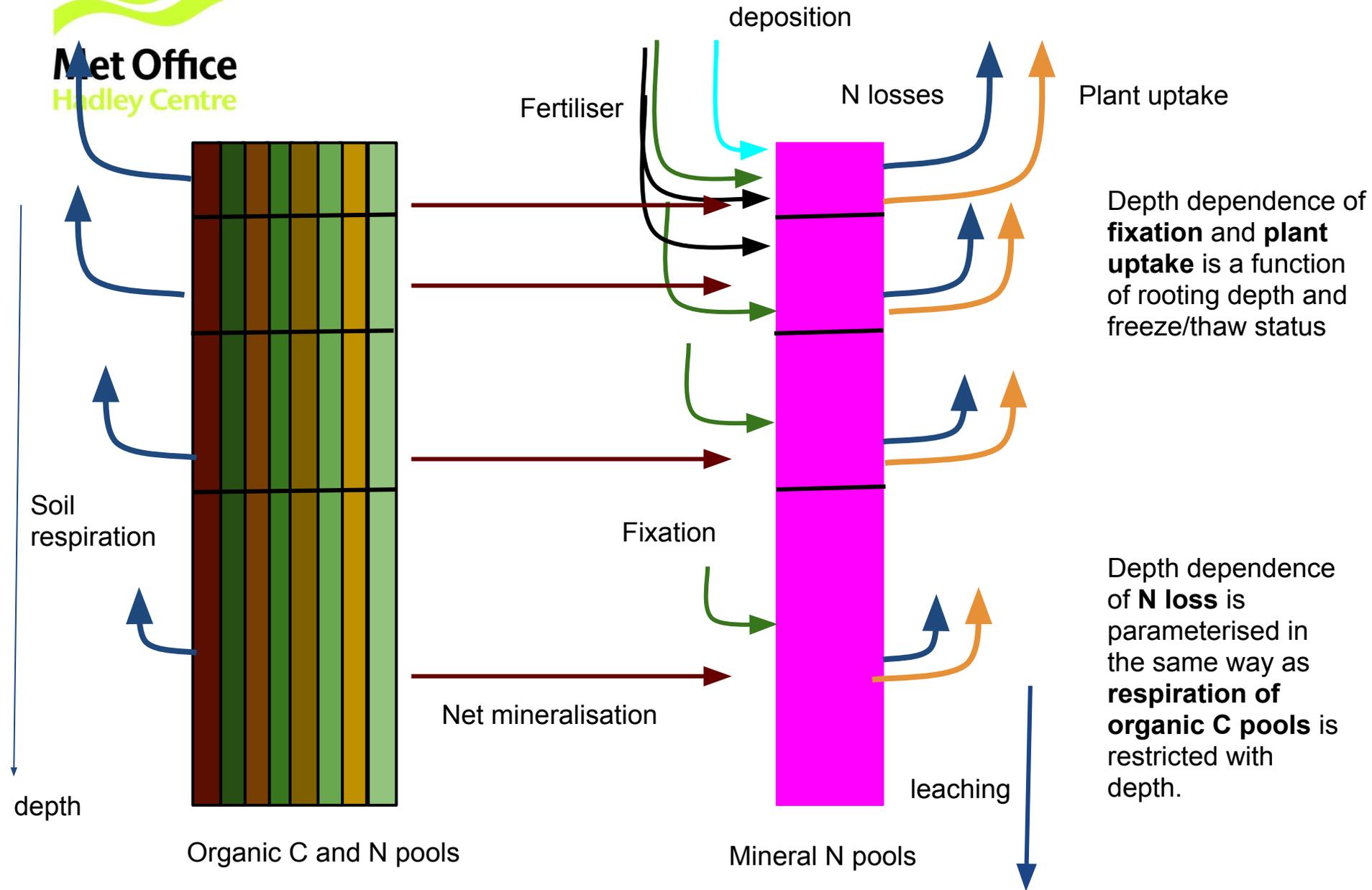


- Availability of mineral nitrogen limits assimilation of carbon and turnover of soil carbon



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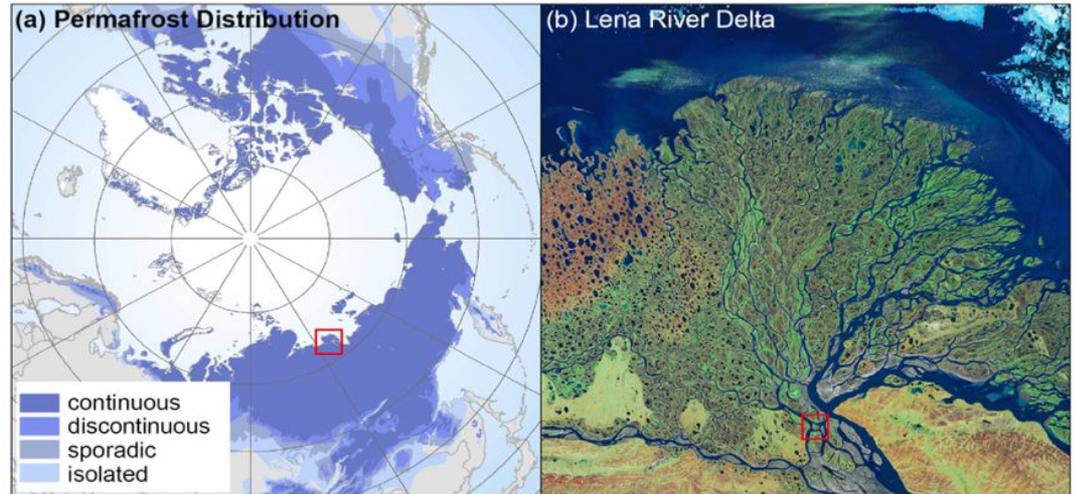
# Soil layering



# □ Samoylov Island, Siberia

Polygonal tundra.

Thick moss cover and much organic matter in the soil.



# Model simulations

Carbon-cycle only simulations - CMIP5 type model (**C-only**)

Carbon layered in soil biogeochemistry model (**C-layered**)



Carbon-nitrogen no layers in soil biogeochemistry model - UKESM type model (**CN-nolayers**)

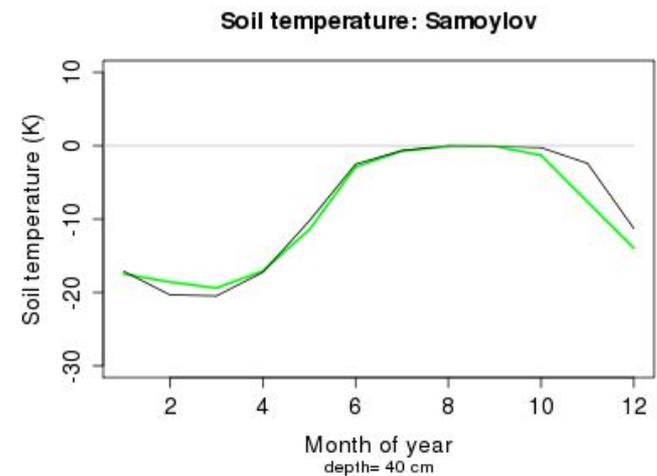
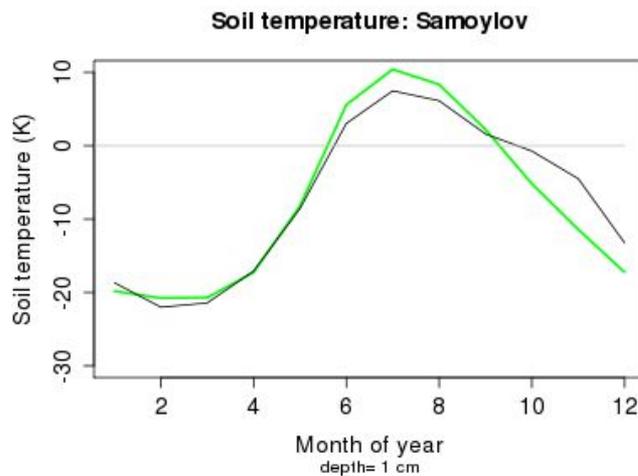
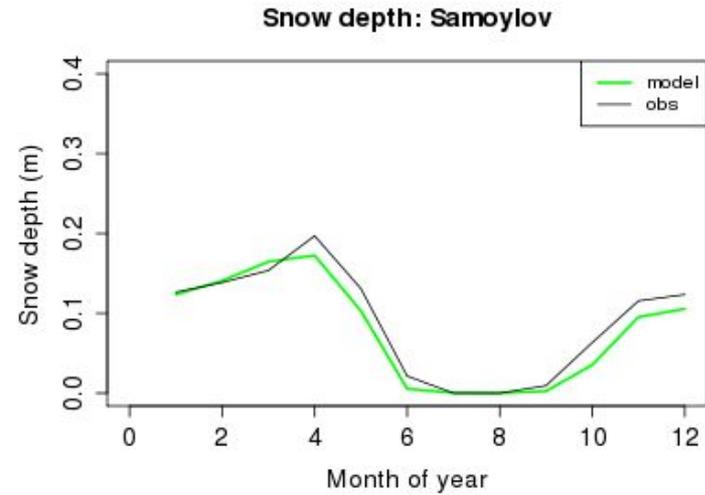
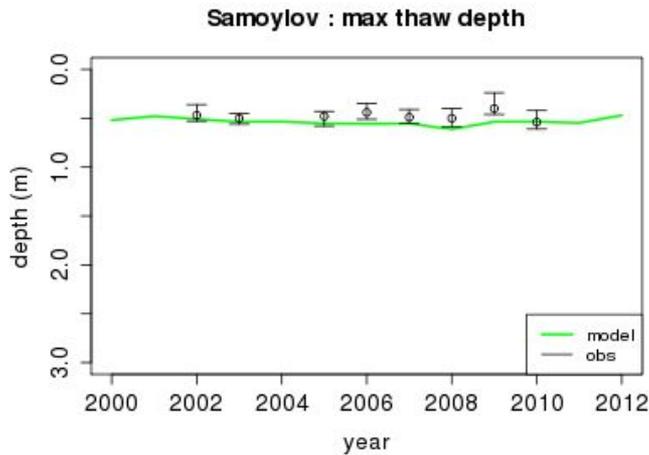


Carbon-nitrogen layered in soil biogeochemistry model - cutting edge model (**CN-layered**)



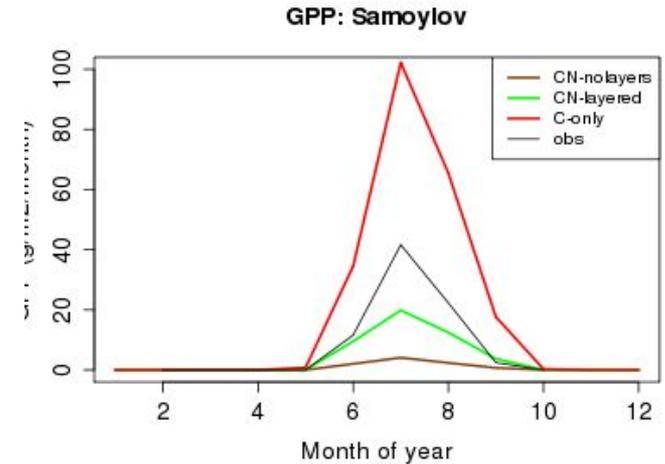
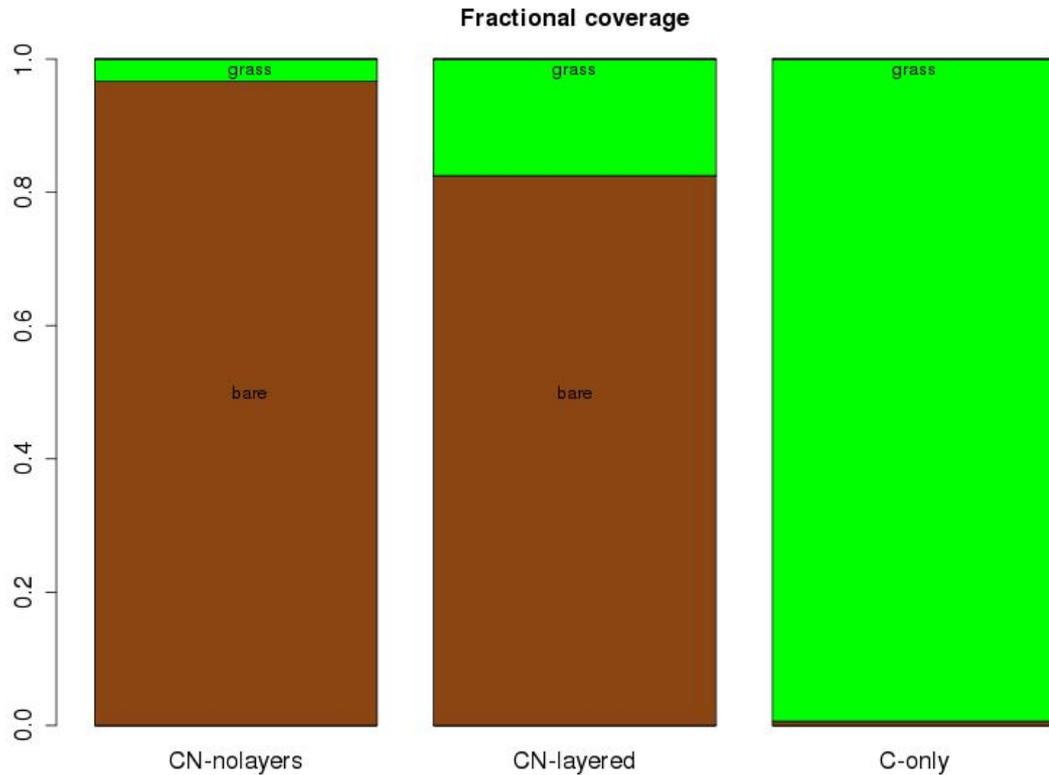
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# Physical simulations



Similar for all  
model versions

# Impact of nitrogen cycle on vegetation

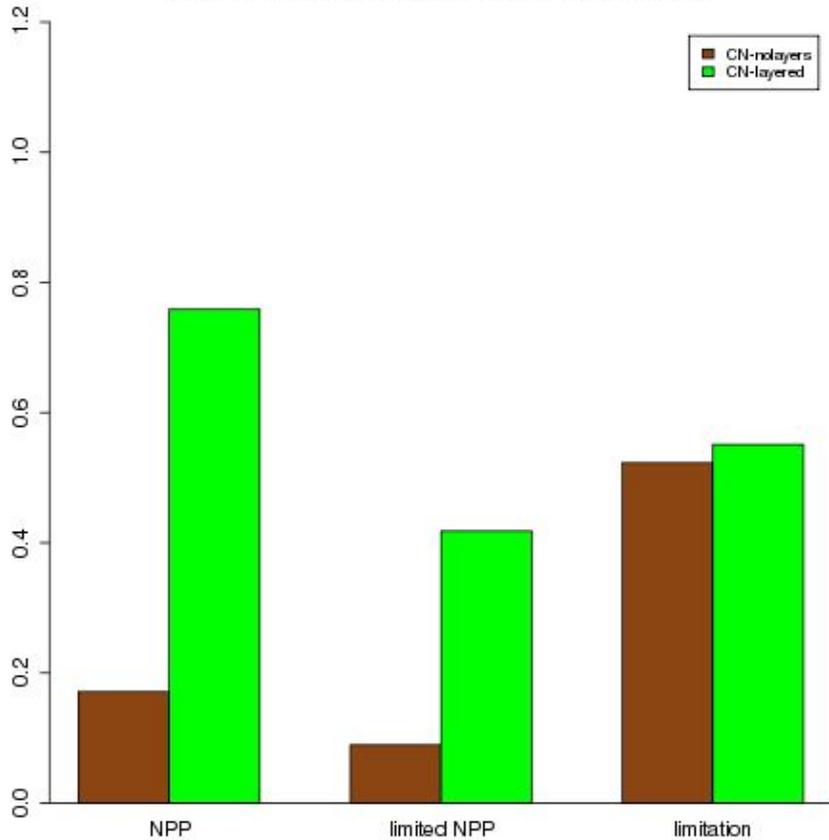




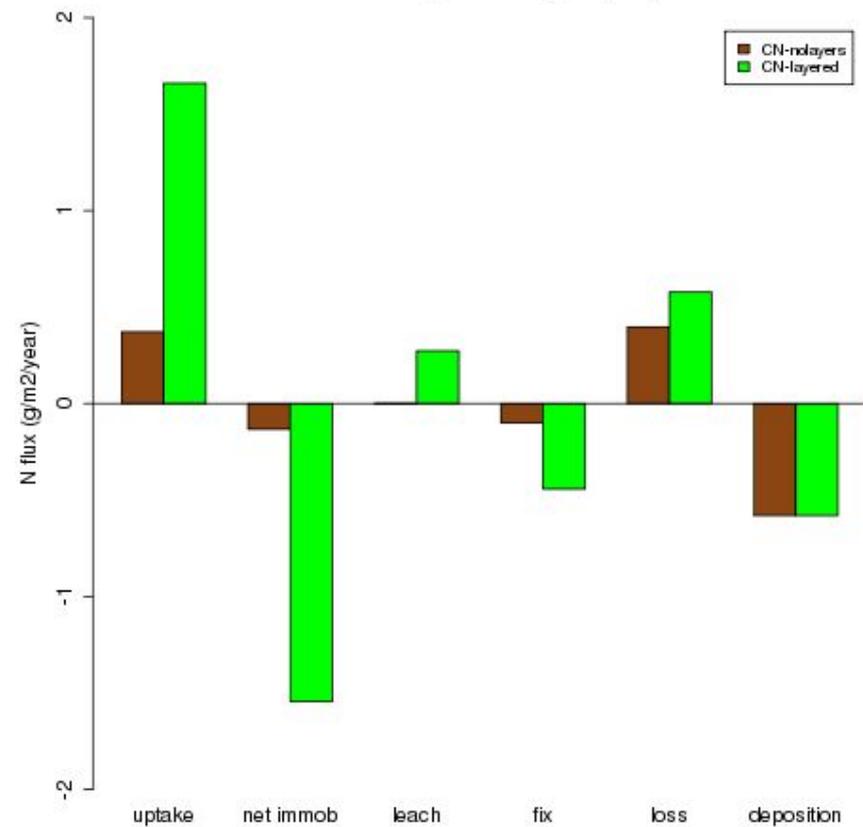
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# Vegetation and nitrogen

Net productivity (kg/m<sup>2</sup>/year) and limitation (fraction)

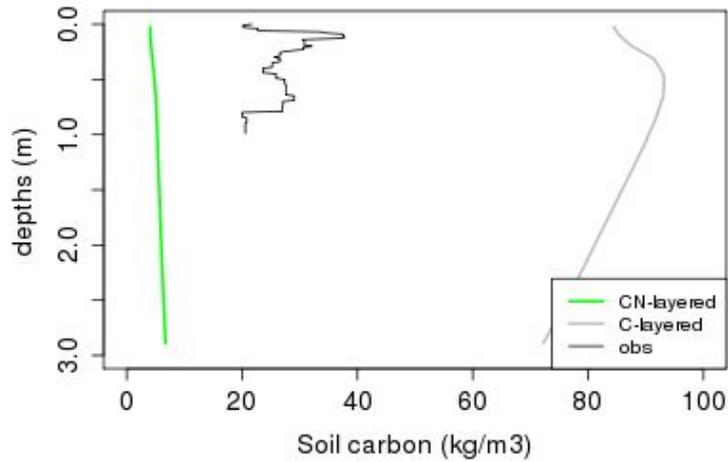


Annual nitrogen fluxes (g/m<sup>2</sup>/year)

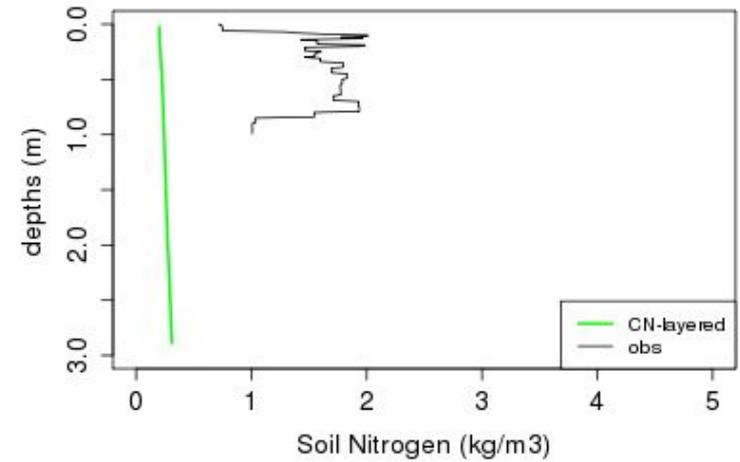


# Vertical soil carbon and nitrogen distribution

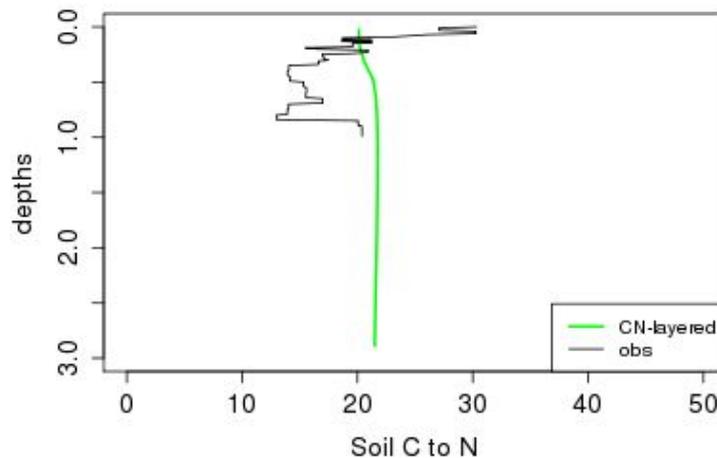
Samoylov: soil Carbon profile (kg/m<sup>3</sup>)



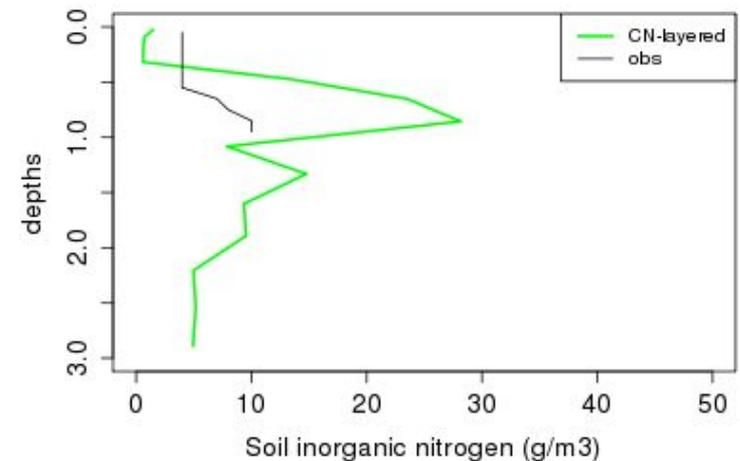
Samoylov: soil nitrogen profile (kg/m<sup>3</sup>)



Samoylov: soil C to N



Samoylov: soil inorganic nitrogen (g/m<sup>3</sup>)





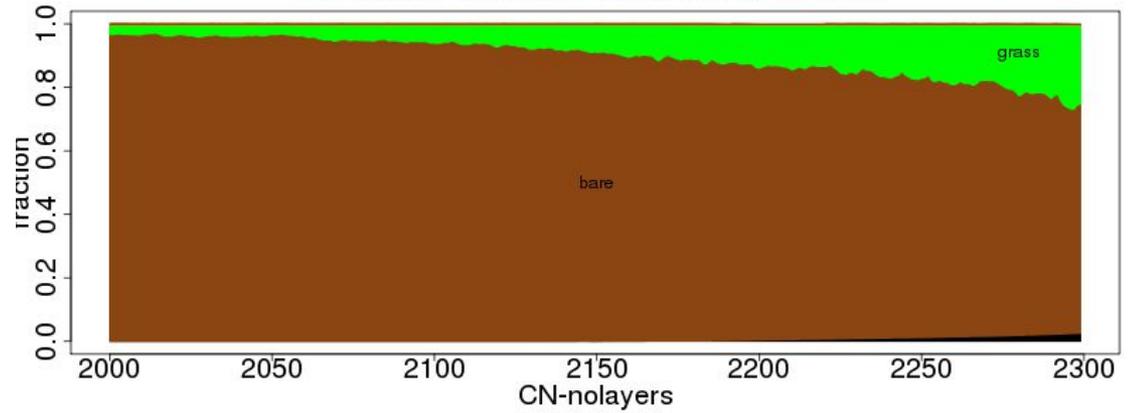
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# Soil carbon and nitrogen

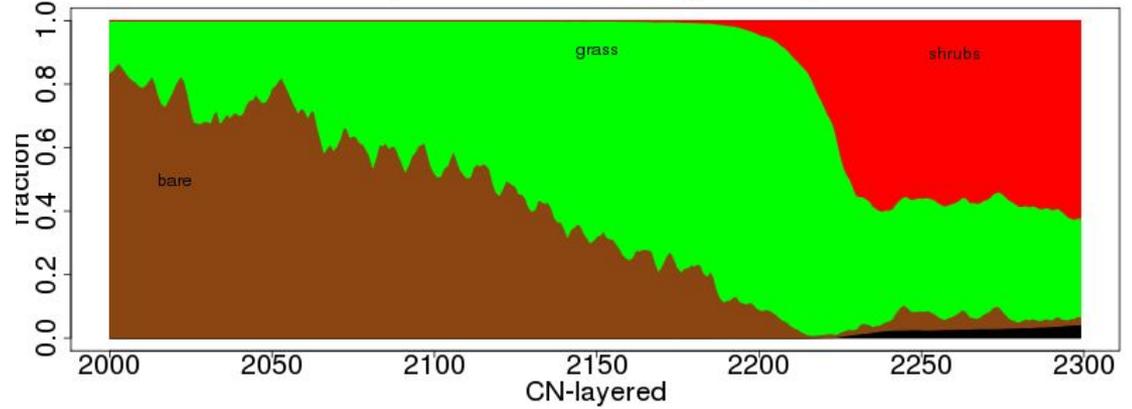
	Organic C (kg/m <sup>2</sup> )	Organic N (g/m <sup>2</sup> )	Mineral N (g/m <sup>2</sup> )
Observations	26	1545	6
C-nolayers	22		
C-layered	109		
CN-nolayers	0.02	1	0.03
CN-layered	6	272	15

# RCP8.5 projections of vegetation fraction

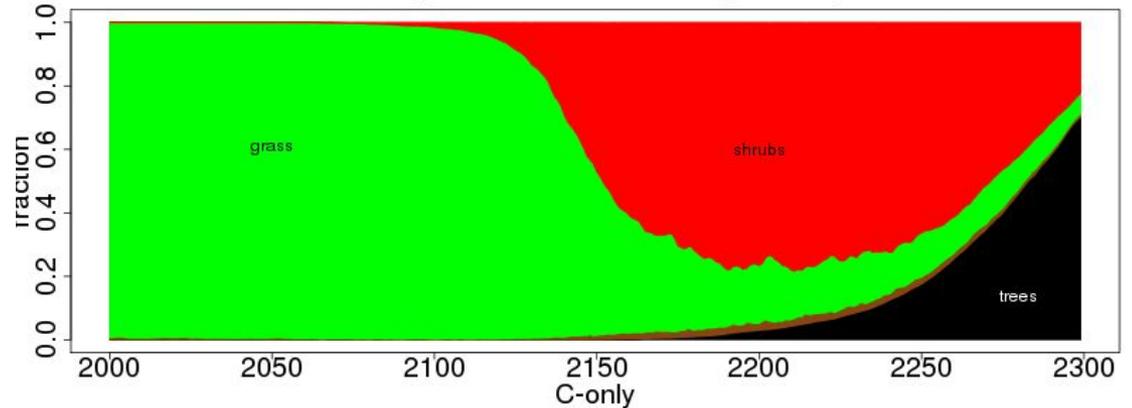
Samoylov: fractional coverage CN-nolayers



Samoylov: fractional coverage CN-layered



Samoylov: fractional coverage C-only





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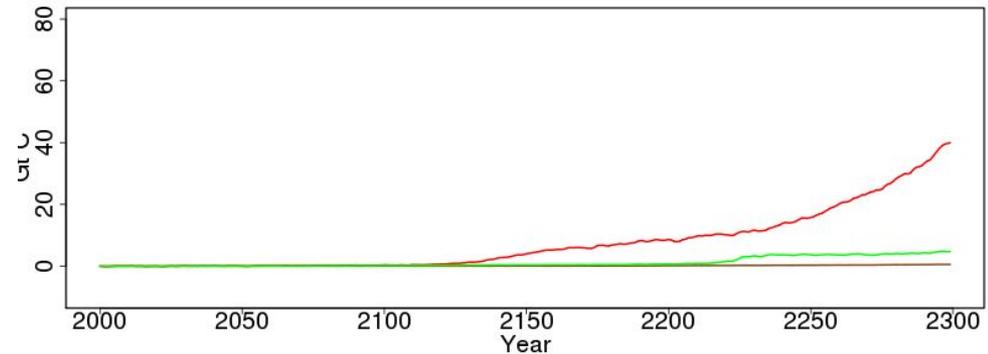
# RCP8.5 projections of tundra C

C-only and CN-layered follow very similar pathways!

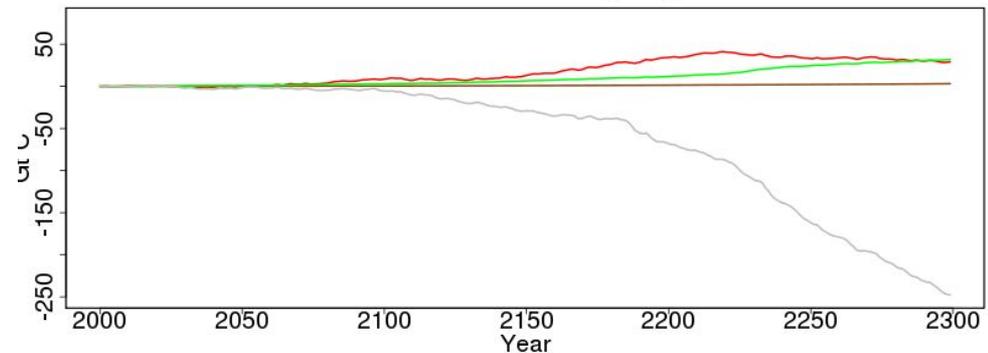
CN-no layered has far too little vegetation and soil carbon.

C-layered has a huge amount of soil carbon which is respired relatively quickly.

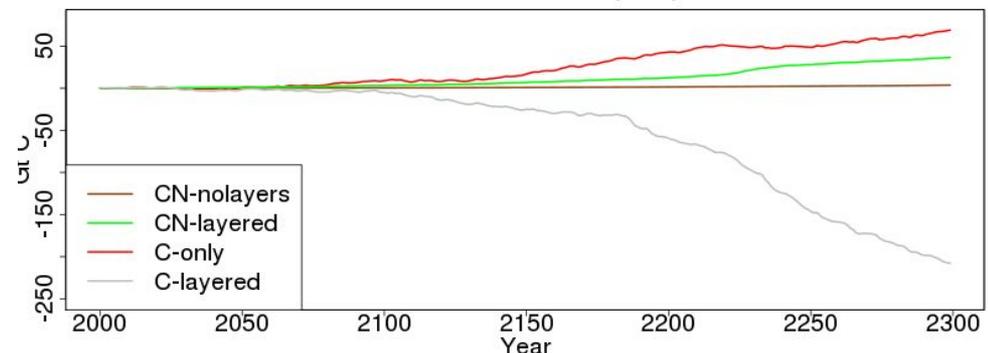
Tundra vegetation carbon (Gt C)



Tundra soil carbon (Gt C)



Tundra total carbon (Gt C)



# Conclusions

Extrapolating from one tundra site to the whole arctic tundra (8.5 million square km) and comparing CN-layered with C-only:

Including nitrogen cycle has reduced the tundra land sink in **2100 by 6 Gt C** (9 Gt C to 3 Gt C) and in **2300 by 33 Gt C** (69 Gt C to 36 Gt C).

The tundra remains a sink of carbon.

# Conclusions

JULES vn4.9 now includes a layered soil carbon and nitrogen biogeochemistry module. This is still under development and requires further evaluation (help welcome) so please contact me ([eleanor.burke@metoffice.gov.uk](mailto:eleanor.burke@metoffice.gov.uk)) if you wish to work with it.

These versions behave very differently and the vegetation may well need to be re-tuned for each version.