JULES and permafrost

Eleanor Burke and Sarah Chadburn

(plus many others who will be appropriately acknowledged in any subsequent publications)

Contents

- Site specific simulations using JULES (including recent developments described by Sarah)

- Brief introduction to the permafrost RCN network model inter-comparison project to which JULES has contributed simulations

- Layered soil carbon within JULES

Met Office
Hadley Centre

PAGE21 site simulations

PAGE21 is an EU project designed to bring experimentalists and modelers together (always interesting).

Sites

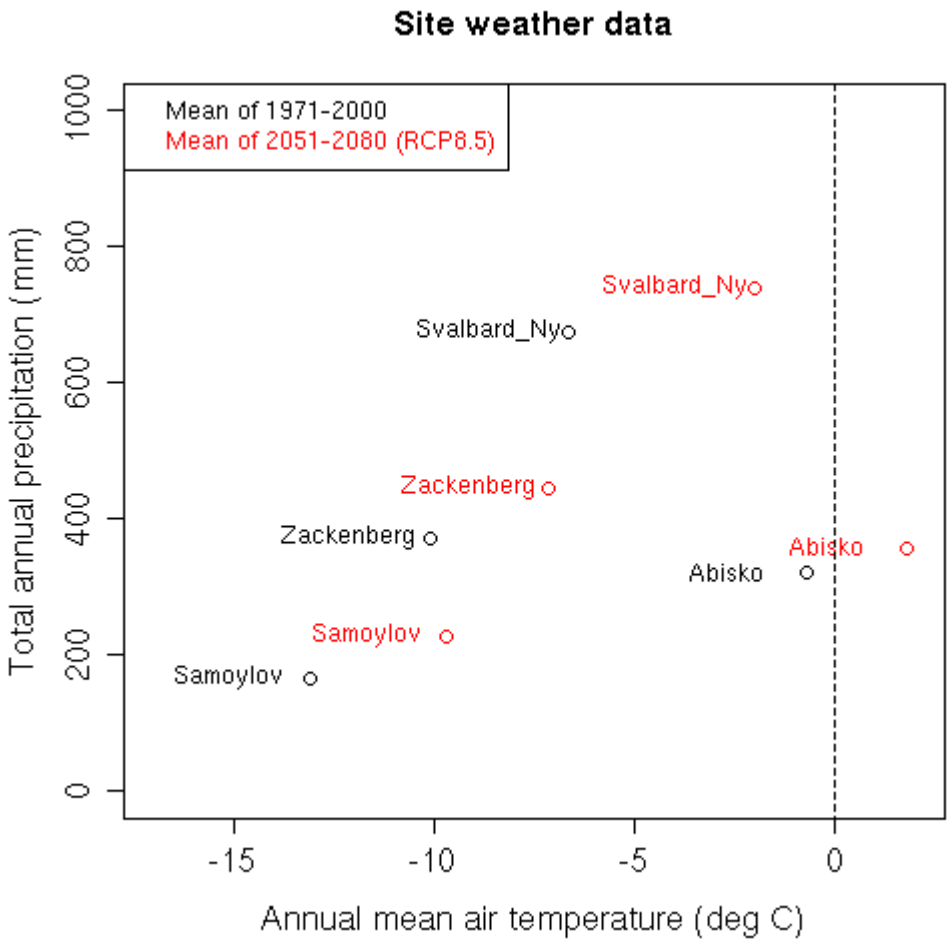
Experimentalists should provide the data we require to drive and evaluate the models.

Abisko and Samoylov have very wet soils with lots of moss cover. High organic matter content.

Zackenberg has drier soils with sparser shrubs.

Svalbard has a large proportion of bare soil.

Site weather



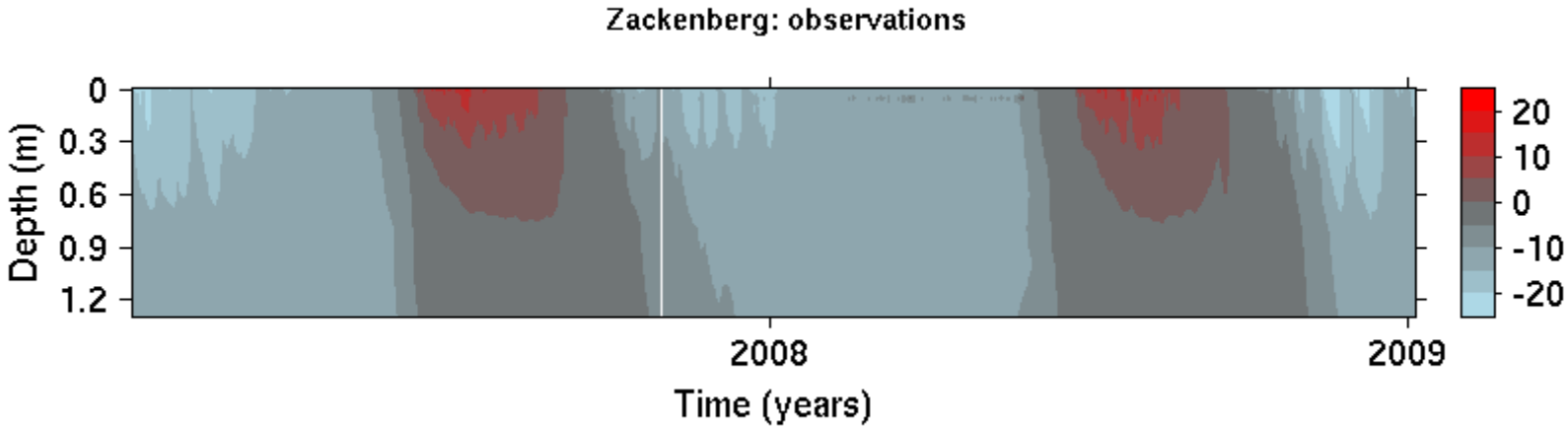
Site weather is based on WATCH/WFDEI 3-hourly global data available at 0.5 degree resolution.

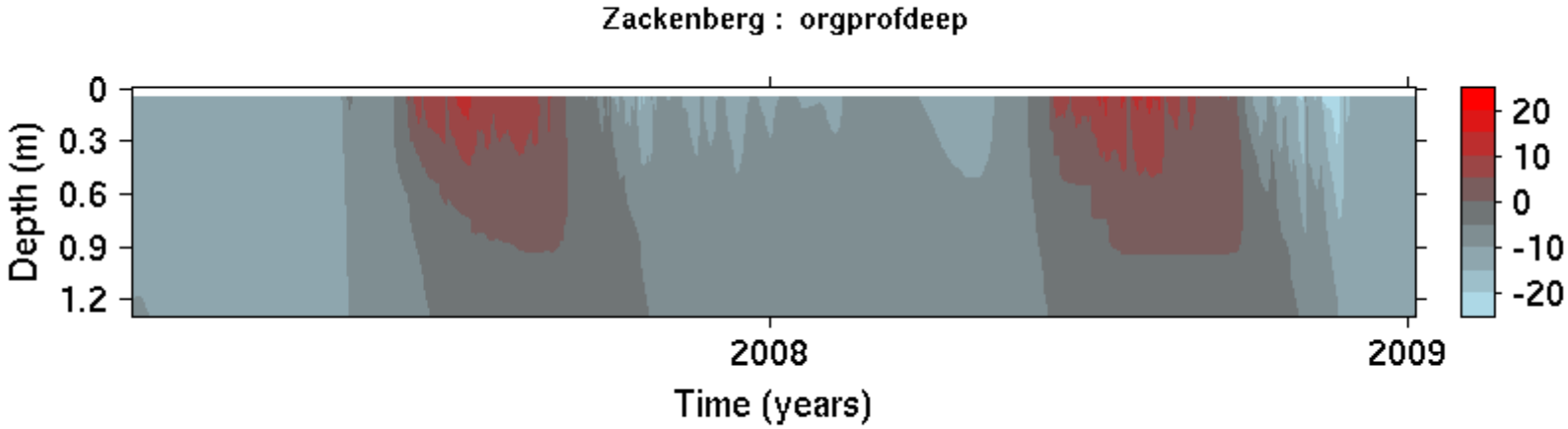
WATCH data is bias-corrected using local meteorological sites for the times data are available.

Three different precipitation data sets: Shown – WATCH precipitation is bias corrected using observations of lying snow.
Also have WATCH-GPCC and WATCH-CRU original precipitation

Future projections are based on the CCSM4 anomalies used in the permafrost RCN model Intercomparison project

Soil temperatures - Zackenberg



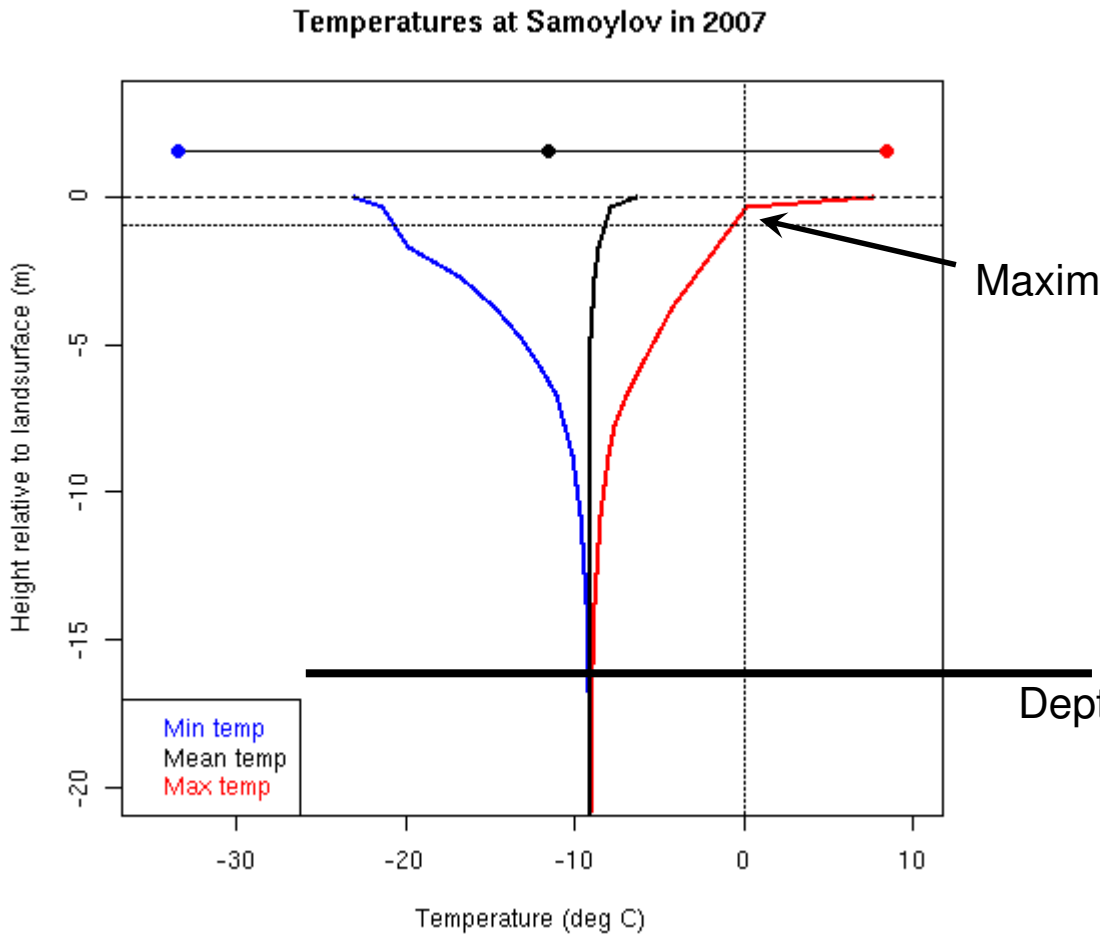


JULES simulations

Simulation	Description
std	Mineral soil with standard layers (4 layers to 3 m)
JSBstd	Mineral soil with JSBach layers (5 layers to 9.83 m)
ORCstd	Mineral soil with ORCHIDEE layers (11 layers to 88.2 m)
orgprofstd	Compressible organic soil with standard layers (4 layers to 3 m)
deep	Deep mineral soil (50 layers to 27.3 m)
orgprofdeep	Compressible deep organic soil (50 layers to 27.3 m)
CRUprecip	Compressible deep organic soil, WATCH-CRU precip (50 layers to 27.3 m)
GPCCprecip	Compressible deep organic soil, WATCH-GPCC precip (50 layers to 27.3 m)

Observed temperatures at Samoylov

Set of metrics defined for each site and each model simulation based on the shape of these curves calculated from monthly data



Maximum summer thaw depth

Depth of zero annual amplitude

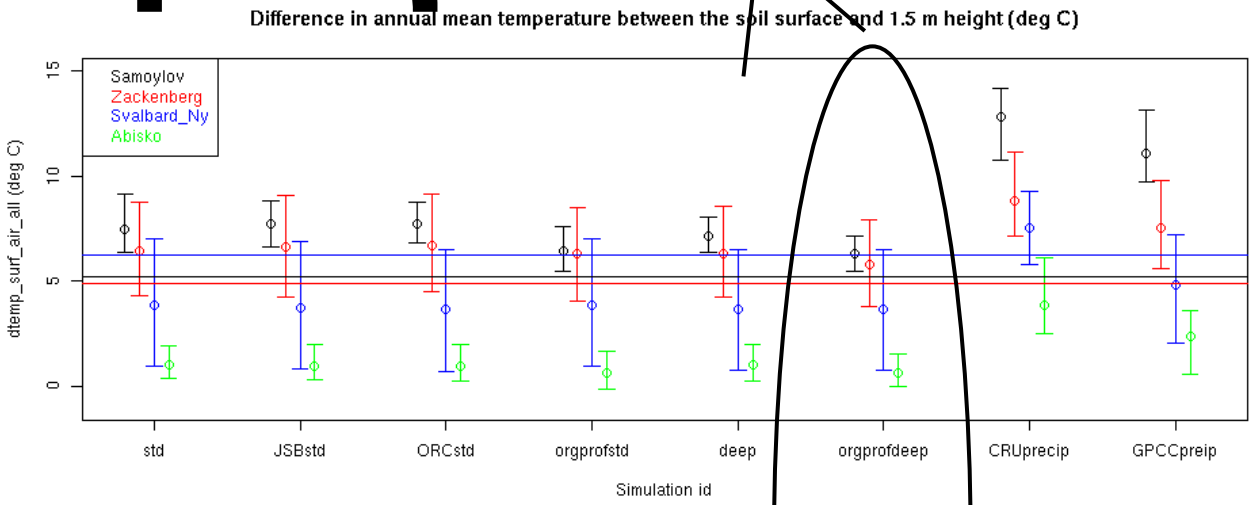
Differences in annual mean temperatures (JULES)

Impact of soil layers

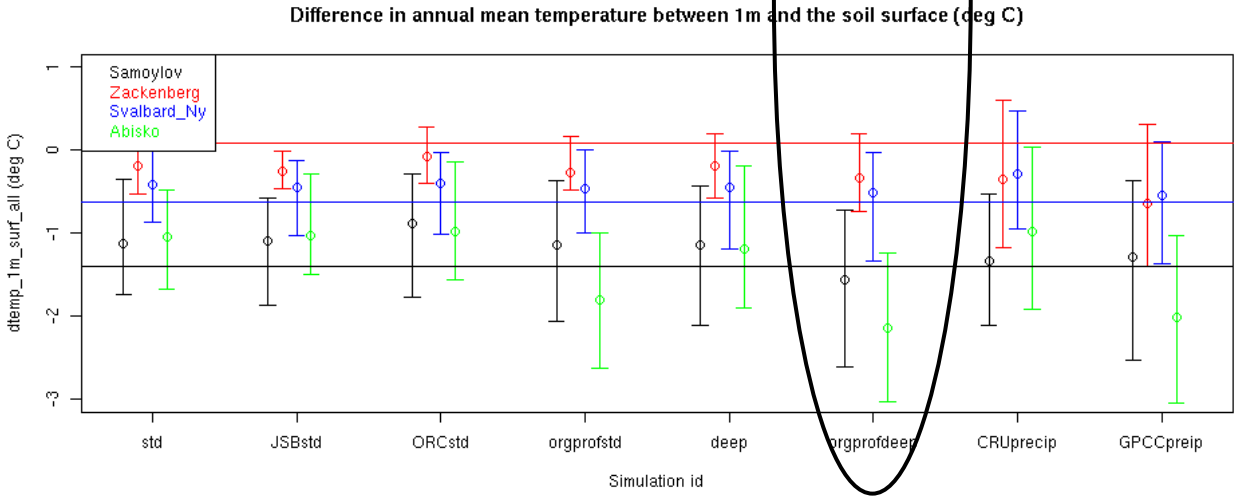
Impact of organic soils

Impact of precipitation

Tsoil (surf) – Tsoil (air)



Tsoil (1m) – Tsoil (surf)

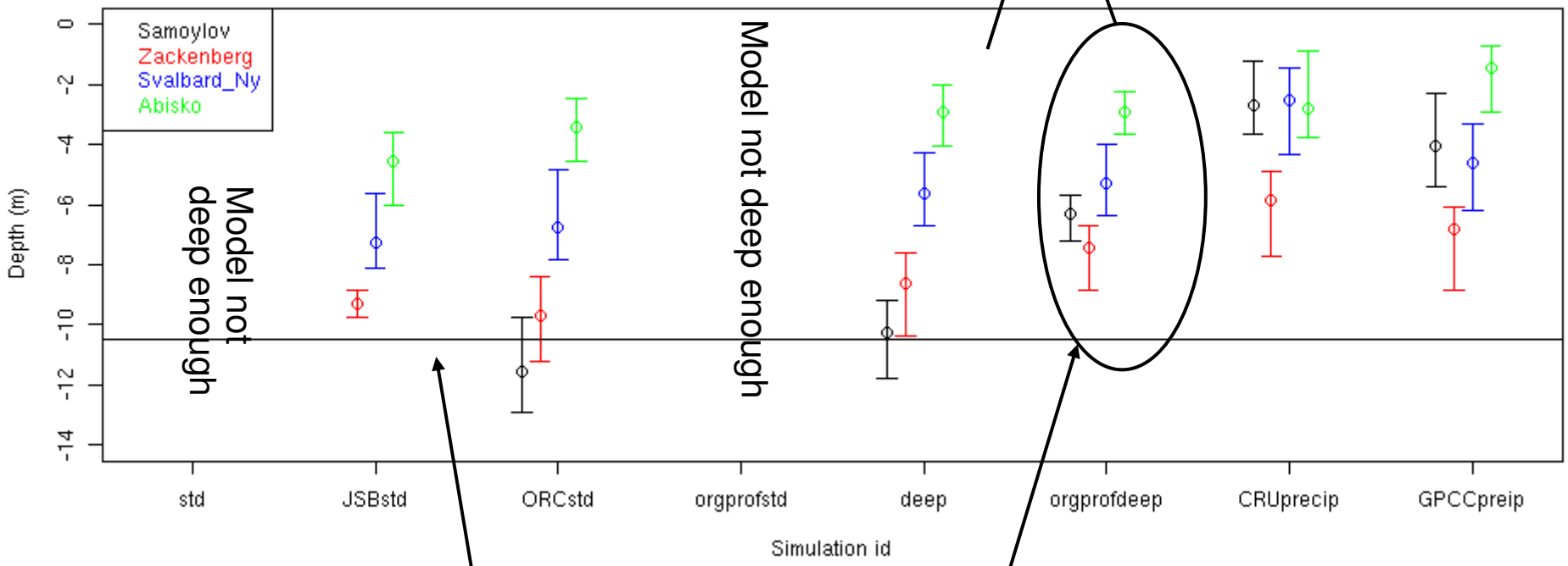


Depth of zero annual amplitude (JULES)

Impact of changing soil levels

Impact of organic soils

Impact of precipitation



Samoylov observations (others are not currently available)

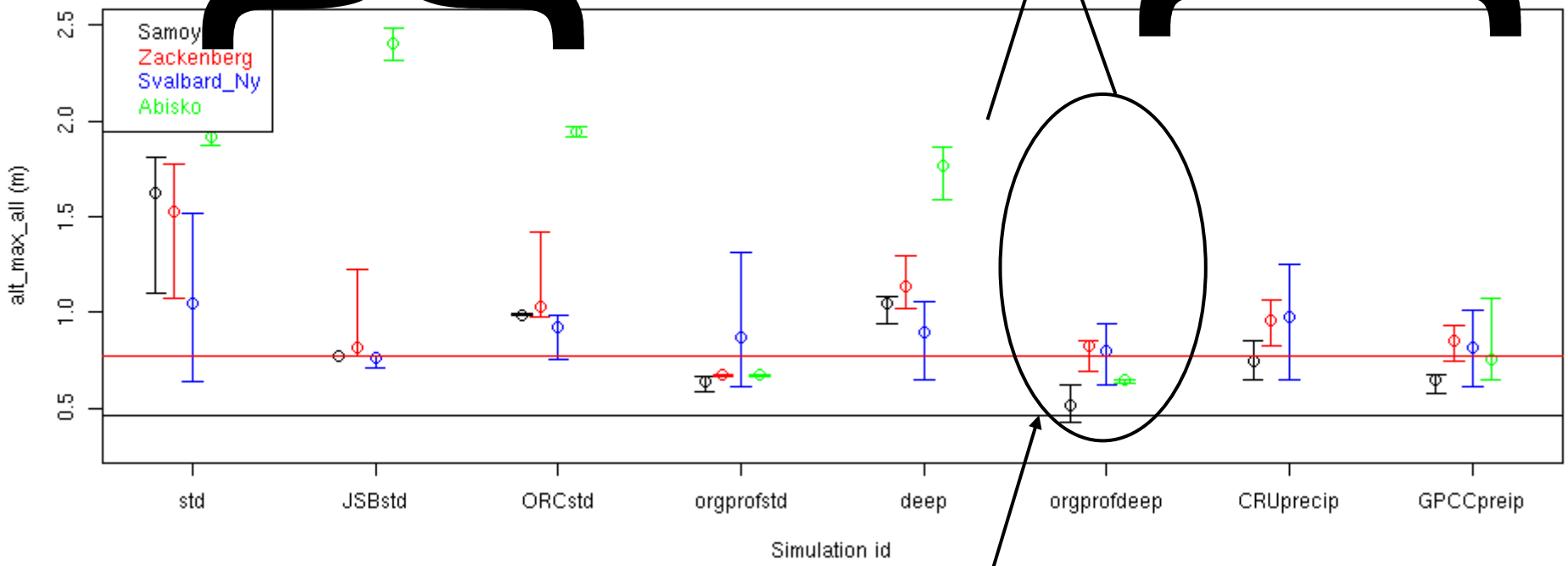
Recommended set up

Maximum thaw depth

Impact of changing soil levels

Impact of organic soils

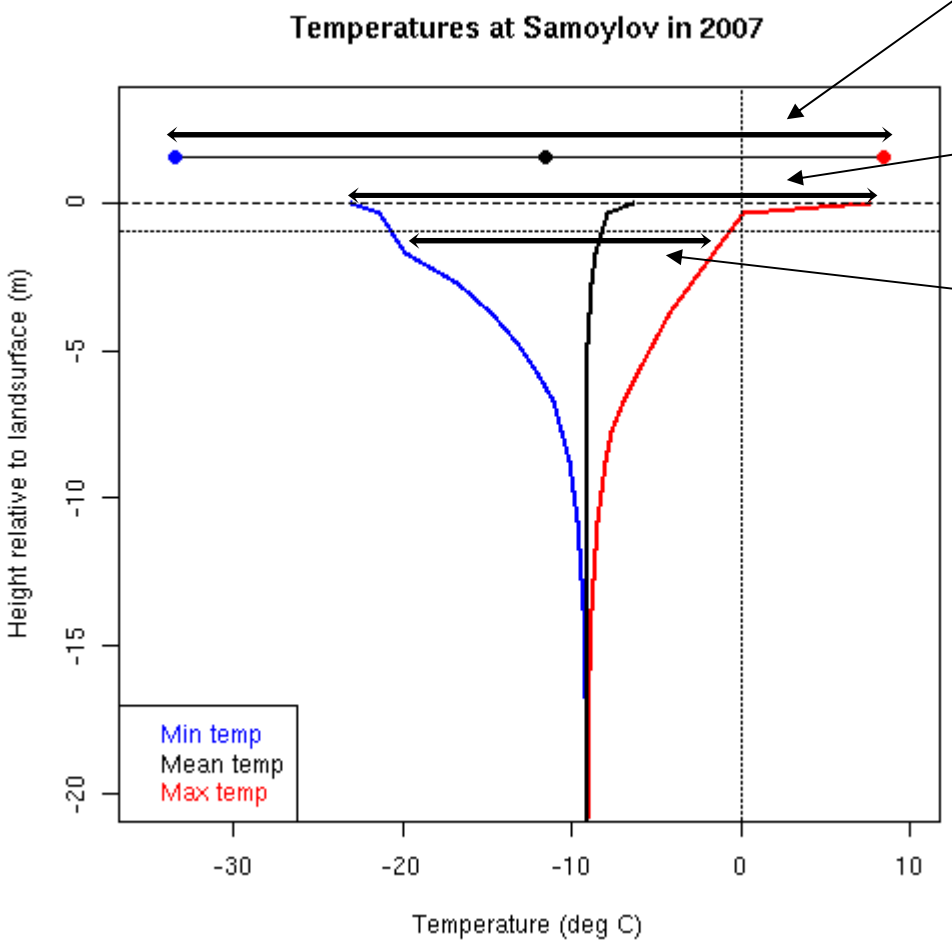
Impact of precipitation



Observations are horizontal lines, coloured for each site

Recommended set up

Annual amplitudes



Annual amplitude at 1.5m (air temperature)

Annual amplitude at the surface

Annual amplitude at 1 m

Ratio of annual amplitude at 1m to the surface < 1.0 (soil thermal conductivity)

Ratio of annual amplitude at surface to 1.5 m air temperature (surface insulation)

Annual amplitude ratios (JULES)

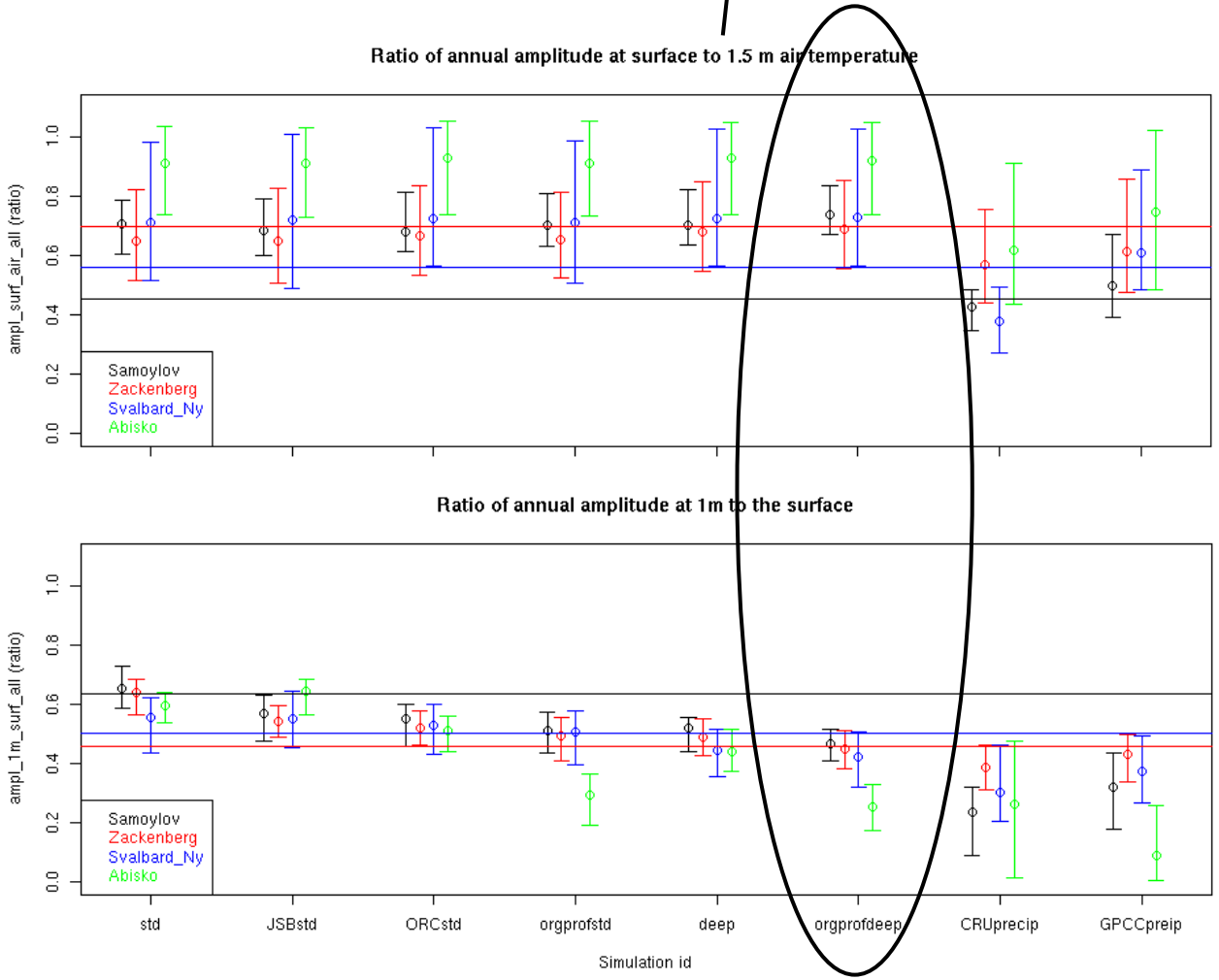
Impact of soil layers

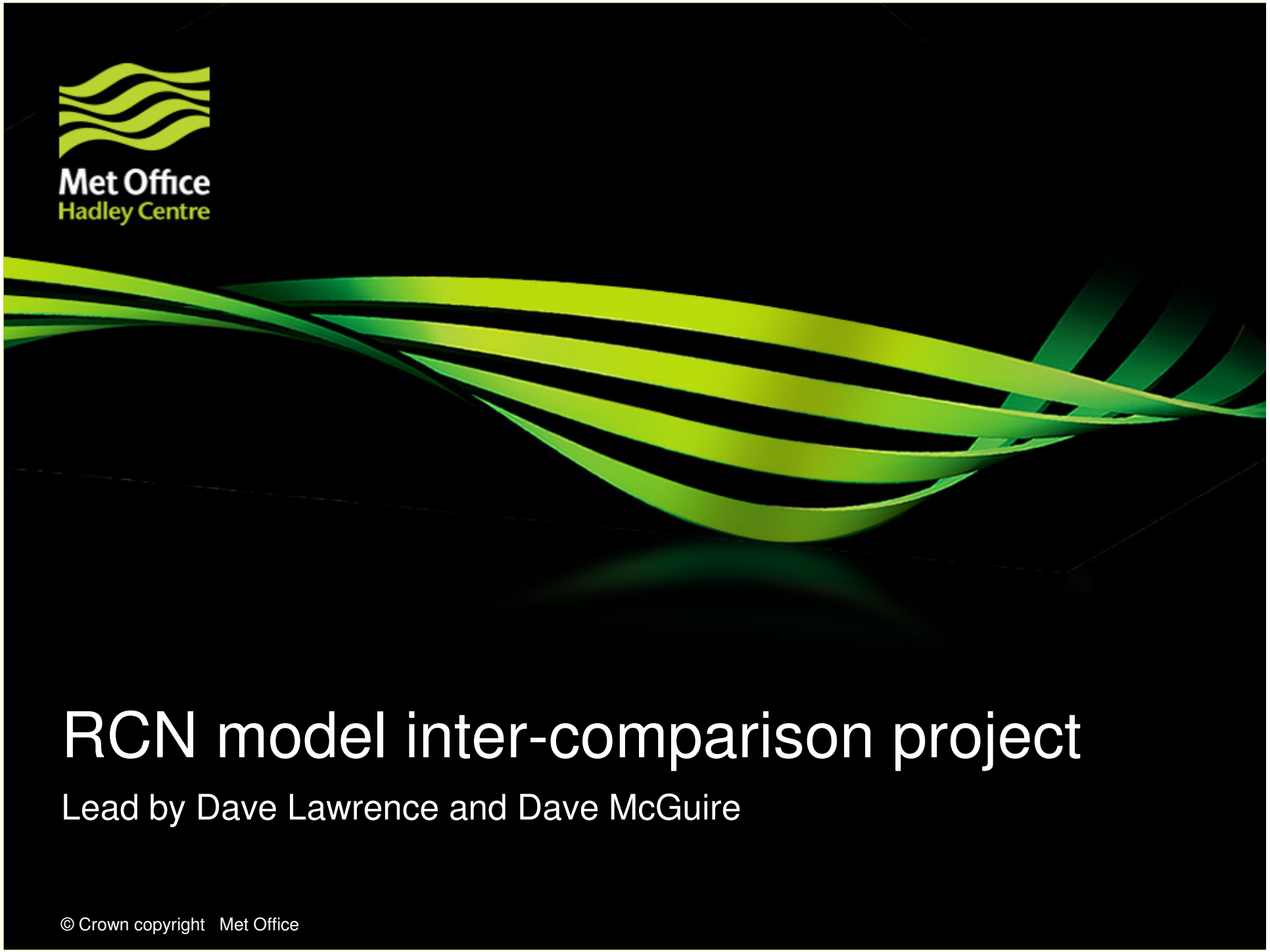
Impact of organic soils

Impact of precipitation

Ratio of annual amplitude at soil surface to the annual amplitude of air temperature from monthly mean data

Ratio of annual amplitude at 1m to annual amplitude at the soil surface from monthly mean data

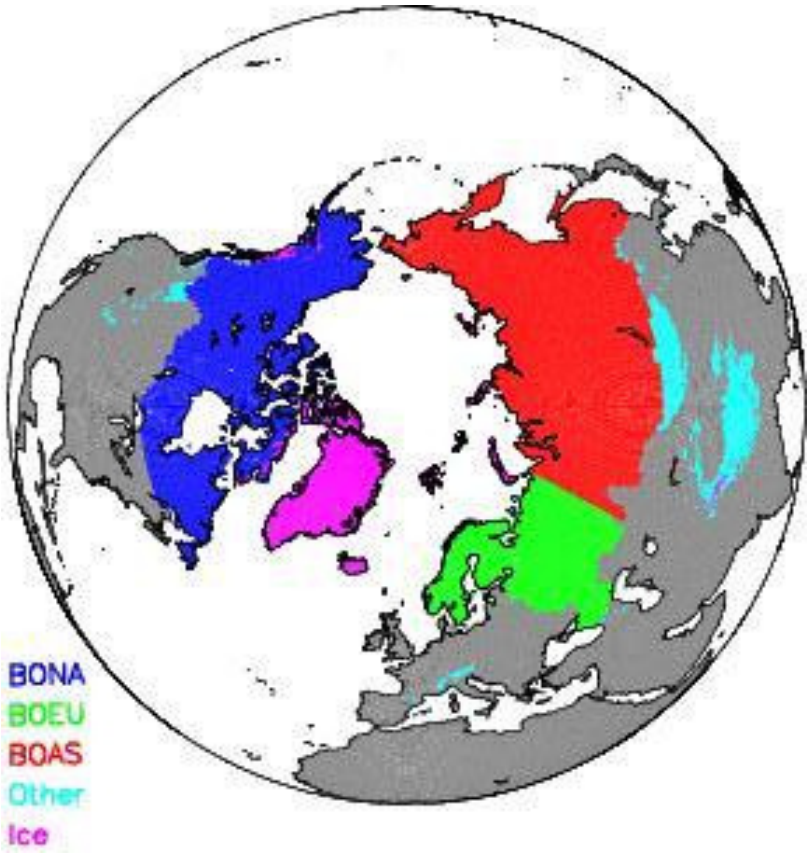




RCN model inter-comparison project

Lead by Dave Lawrence and Dave McGuire

Permafrost RCN model integration working group - Product 1



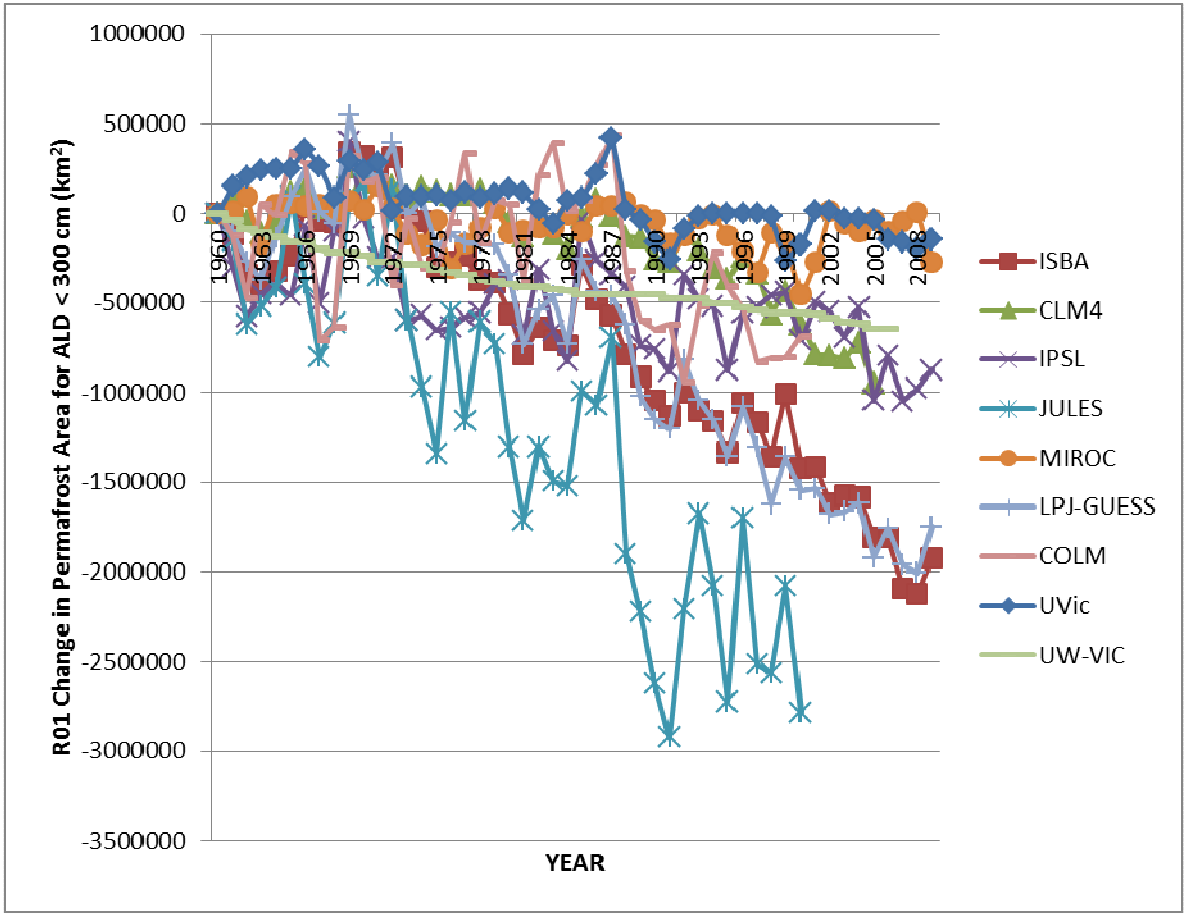
A retrospective assessment of the vulnerability of permafrost carbon in the earth system: comparison of dynamics among process-based models

Large scale model simulations with results averaged over regions shown

9 different models participated and data is available. JULES was run globally and relevant regions were extracted (no land use)

Different people doing different analyses

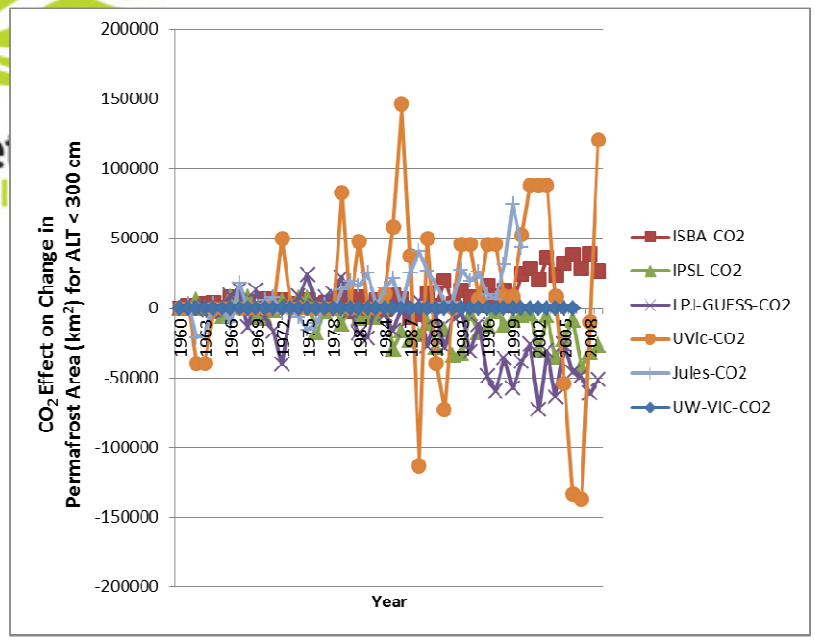
Permafrost area

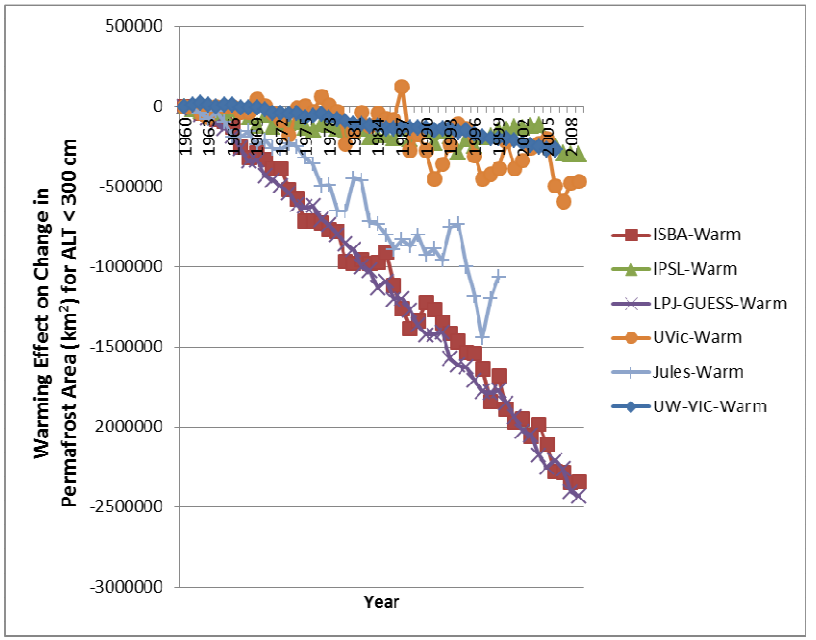


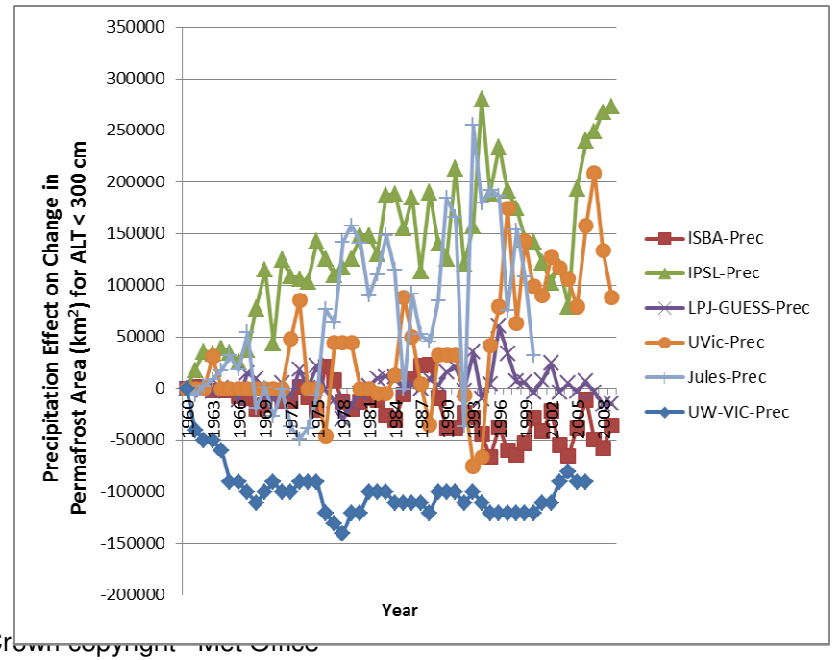
Simulated changes in permafrost area from 1960-2009

Areas range from 13 to 28 million km² (JULES 14.3 million km²)

Permafrost sensitivity to change



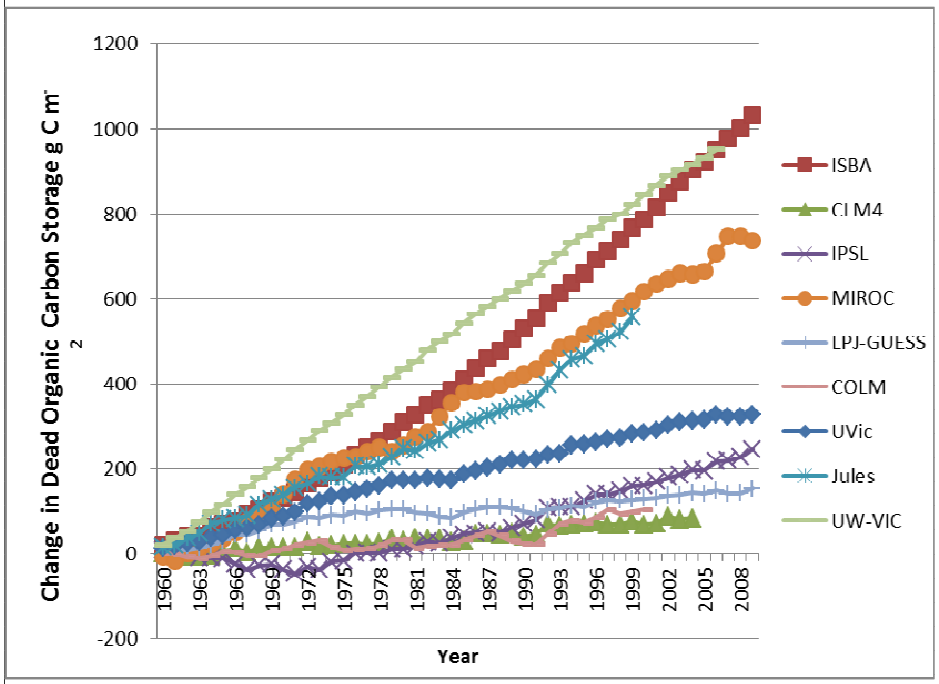




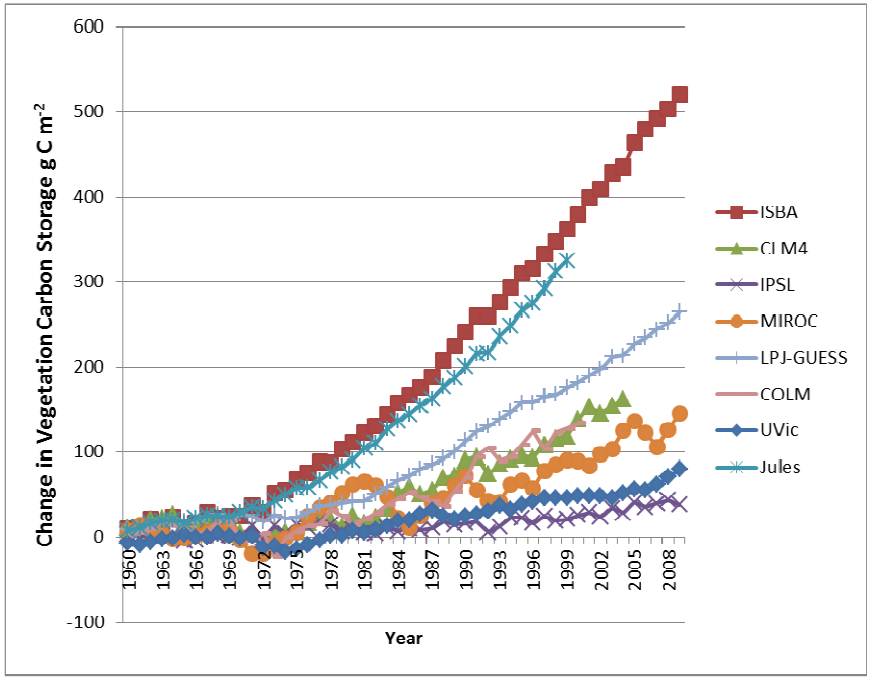
The sensitivity of simulated changes in permafrost area to changes in temperature, atmospheric carbon dioxide, and precipitation from 1960-2009.

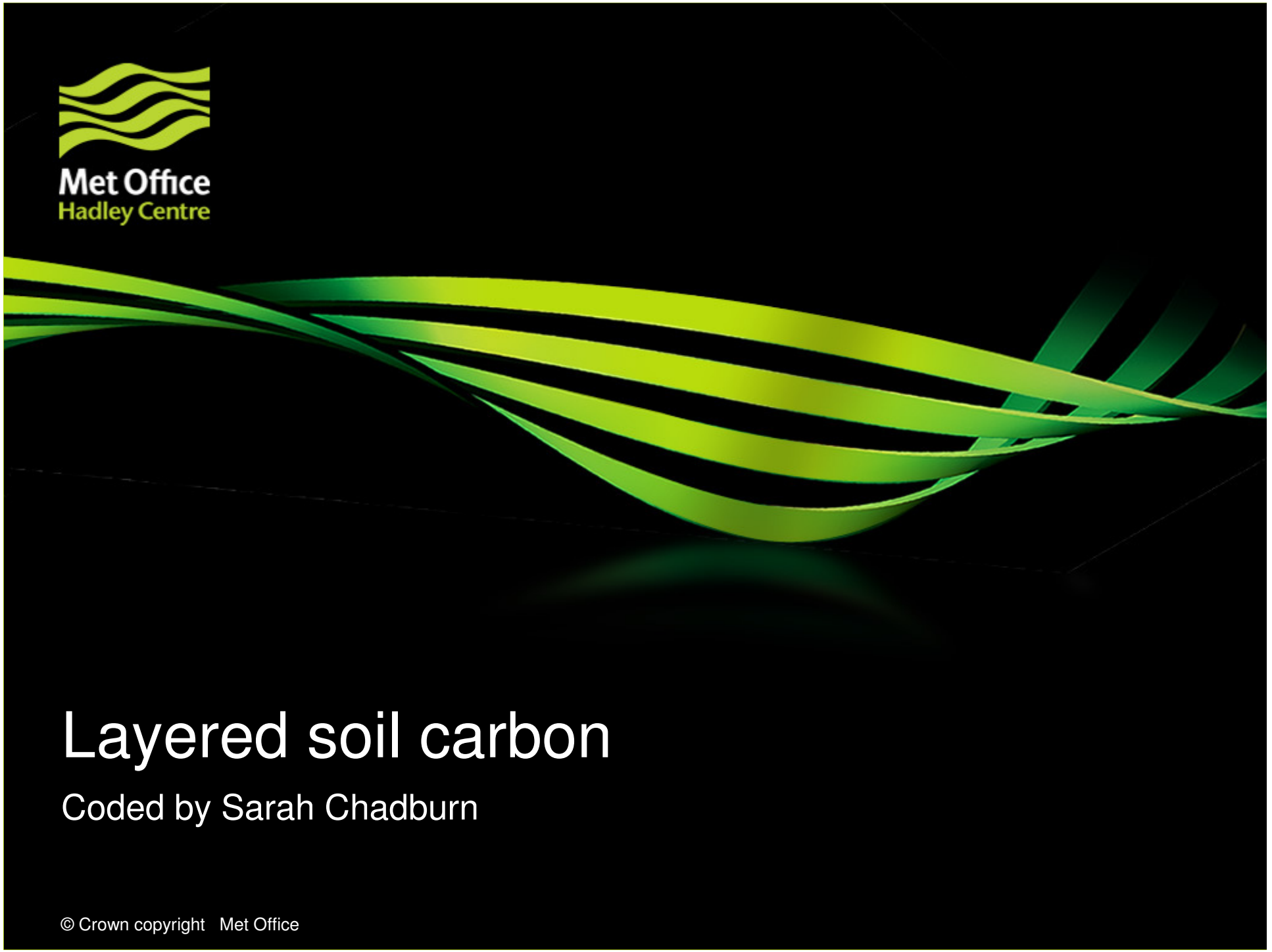
Soil and vegetation carbon for the northern high latitudes

Soil carbon



Vegetation carbon





Layered soil carbon

Coded by Sarah Chadburn

Layered soil carbon description

- Discretised version of the 4 pool RothC model already used within JULES.

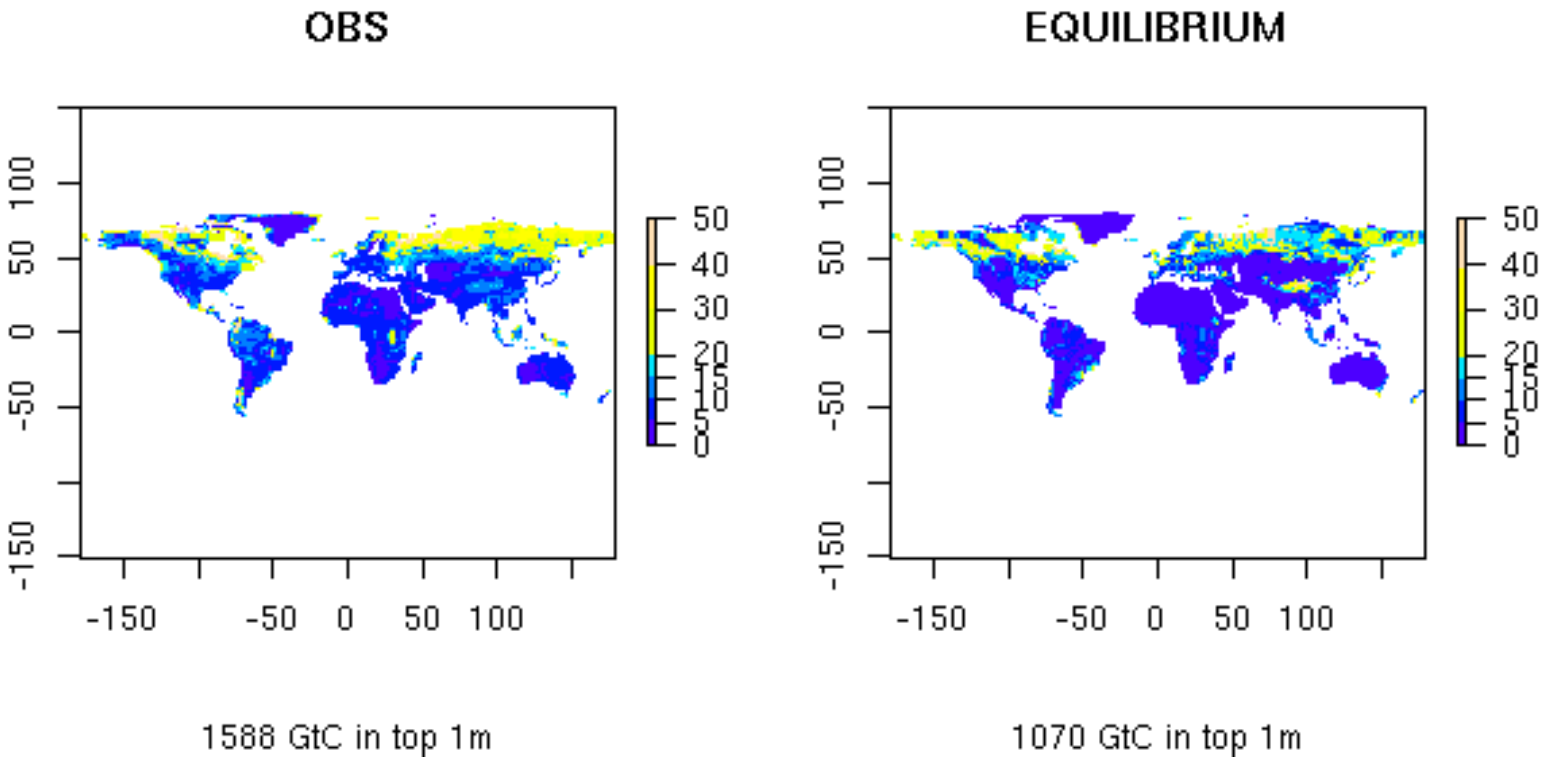
- Litter input to the soil profile decreases exponentially with increasing depth

- Soil respiration decreases exponentially with increasing depth

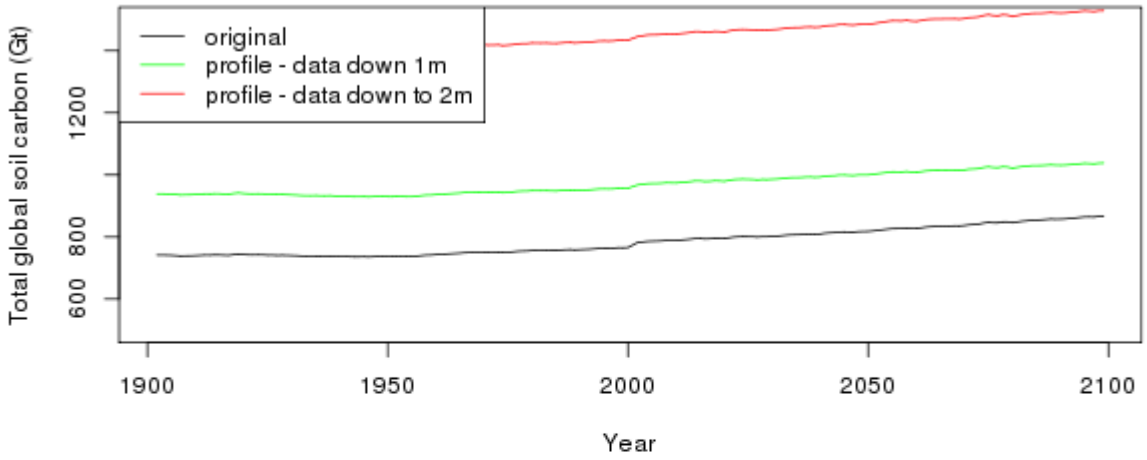
- Mixing is constant throughout the soil profile (this needs to be revisited to take into account its depth dependence and permafrost soils)

- Equilibrium code available to approximately spin up the initial soil carbon state outside JULES.

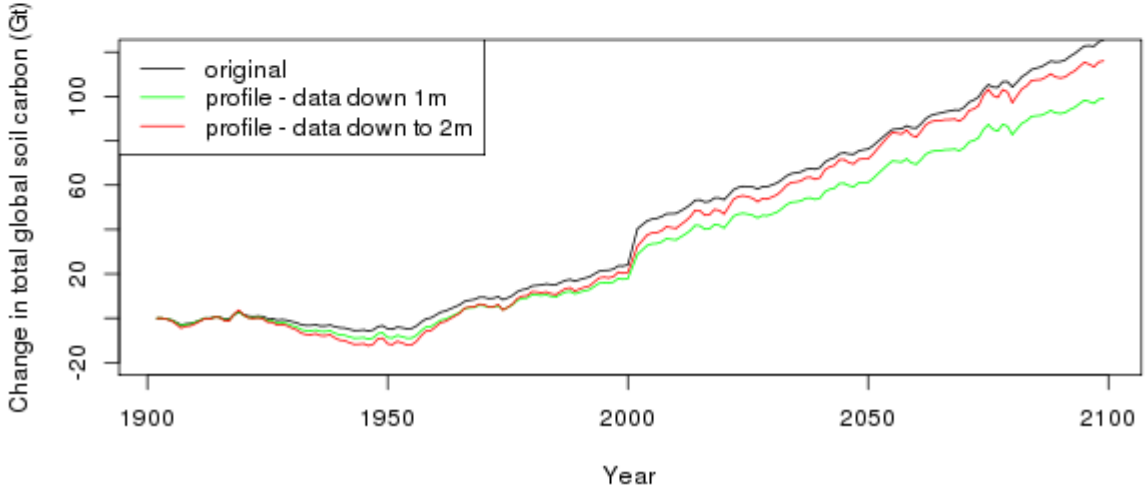
Equilibrium initialisation



Evolution of global soil carbon

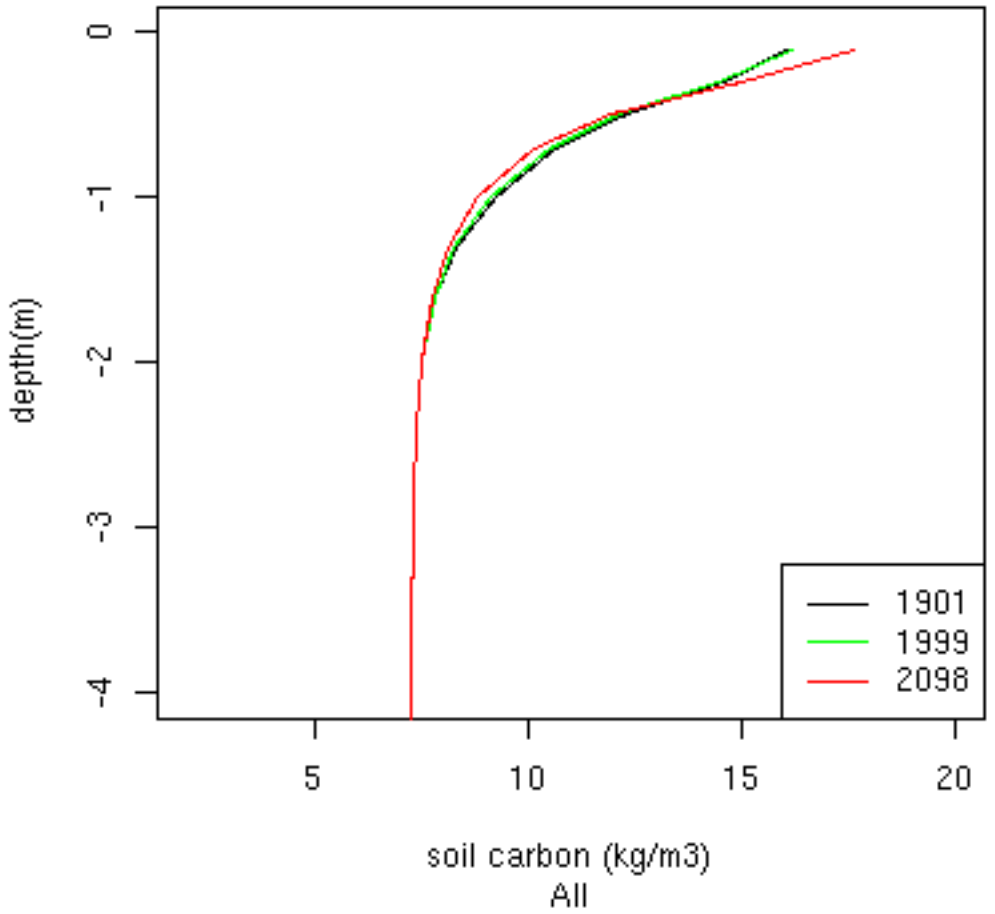


RCP8.5 future scenario

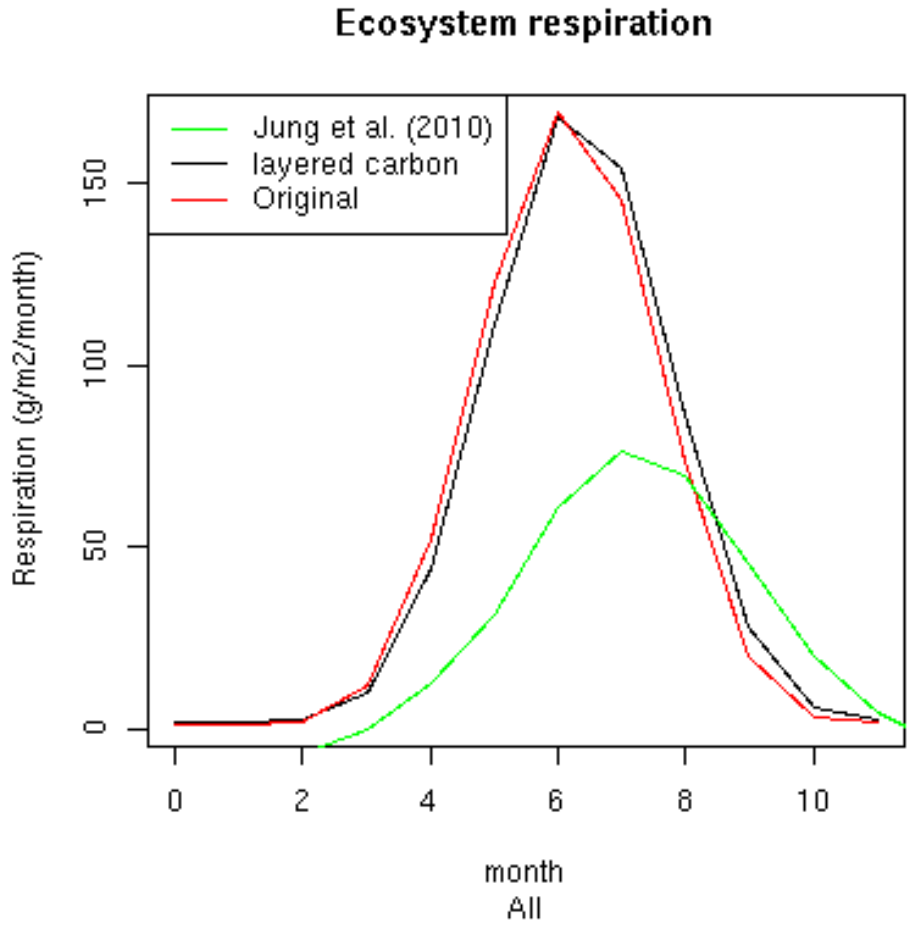


Profile soil carbon in northern high latitudes

Mixing needs to be modified to reduce soil carbon at depth



Little impact on the seasonal cycle of ecosystem respiration in the northern high latitudes



Conclusions

Simulations underway for permafrost affected sites still hopeful for more data, sites and models to participate.

Permafrost RCN project has lots of high latitude land surface model runs (JULES globally) for the present and for future scenarios which are available for analysis

Layered soil carbon in JULES is currently under development. This will enable an initial assessment of the permafrost carbon response to climate change.

Questions and answers