JULES and permafrost

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(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
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

Zackenberg: observations

Zackenberg: orgprofdeep

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# JULES simulations

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<td>Compressible deep organic soil, WATCH-GPCC precip (50 layers to 27.3 m)</td>
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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.

- Depth of zero annual amplitude
- Maximum summer thaw depth

Temperatures at Samoylov in 2007
Differences in annual mean temperatures (JULES)

Impact of soil layers
Impact of organic soils
Impact of precipitation

Tsoil (surf) – Tsoil (air)

Differences in annual mean temperature between the soil surface and 1.5 m height (deg C)

Tsoil (1m) – Tsoil (surf)

Differences in annual mean temperature between 1m and the soil surface (deg C)
Depth of zero annual amplitude (JULES)

Impact of changing soil levels

Impact of organic soils

Impact of precipitation

Model not deep enough

Model not deep enough

Recommended set up

Samoylov observations (others are not currently available)
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

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Annual amplitudes

Temperatures at Samoylov in 2007

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)
Impact of precipitation

Impact of organic soils

Impact of soil layers

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
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
Simulated changes in permafrost area from 1960-2009

Areas range from 13 to 28 million km\(^2\) (JULES 14.3 million km\(^2\))
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

1568 GtC in top 1m

1070 GtC in top 1m
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