CLIFFTOP: Climate feedbacks from wetlands and permafrost thaw in a warming world

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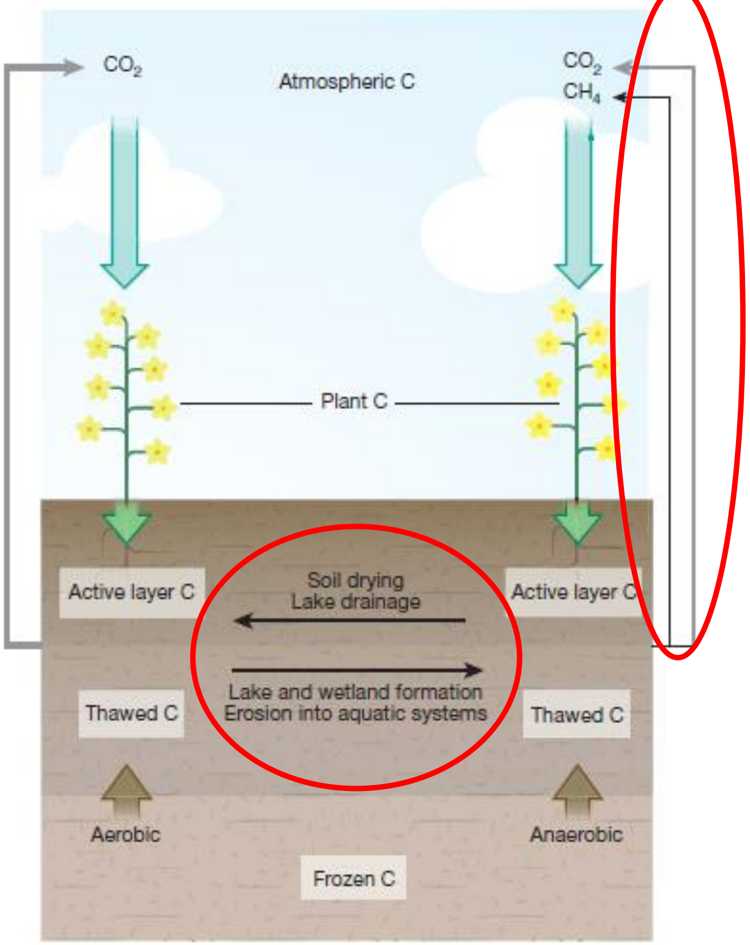
NERC-BEIS Workshop

London, 11th September 2018

Natural methane feedbacks from wetlands and permafrost thaw

- Frozen organic soils are a major carbon pool (1300 Gt C), larger than that of the atmosphere
- Current analyses assume permafrost carbon released as CO_2
- 2-3% of carbon released as CH_4 $\rightarrow$ enhanced climate impact (Schuur et al., 2015)
- Additional processes to consider/add



Schuur et al., Nature, 2015

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CLIFFTOP: Objectives, approach and deliverables

Overall objectives

- To assess Arctic carbon releases that are not included in current climate analyses,
- To quantify the corresponding climate feedbacks and the impact of these additional emissions on allowed human emissions to stabilise at 1.5 °C or 2 °C.

Use JULES land surface model and IMOGEN climate emulator

- By accounting for these additional feedbacks, how much more do we restrict the allowable human emissions to achieve the 1.5 °C and 2 °C stabilisation goals?
- Is there a significant difference in 1.5 °C *vs.* 2 °C stabilisation in terms of methane and permafrost carbon emissions, and permafrost thaw - how much benefit would there be to staying below 1.5°C?
- How large are the remaining uncertainties?

Outputs

- Publication(s) for use in IPCC Special Report
- *JULES methane wetland emission estimates used in GCP CH_4 Budget (Saunois et al., Earth System Science Data Discussions, 2016)*

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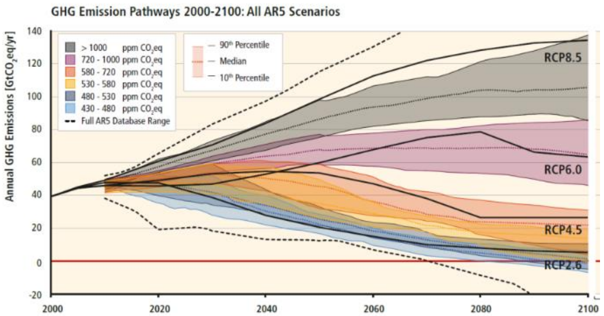
IMOGEN intermediate complexity climate emulator



Prescribed Anthropogenic Emissions

Atmospheric Composition

Simple Ocean Uptake Model

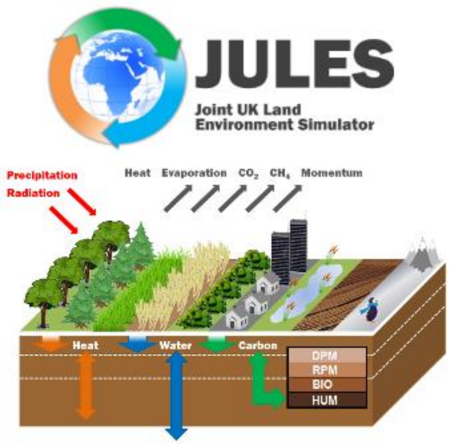
Energy Balance Model

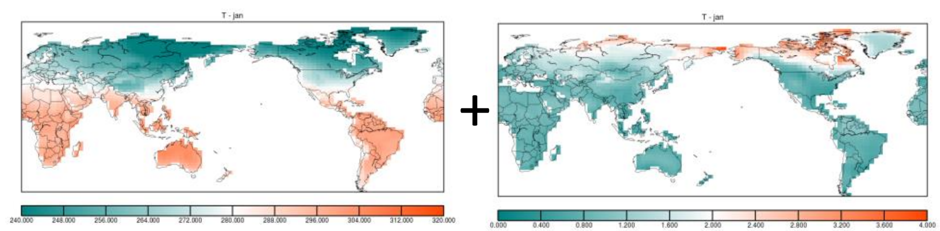
JULES Estimates Land Carbon Exchange

IMOGEN

Global Warming

Pattern Scaling of Met Data from 34 GCMs



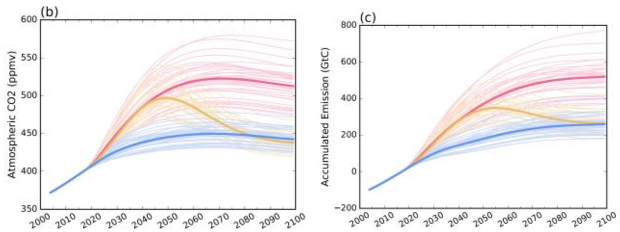


Climatology

ΔT x Anomaly

Huntingford et al., 2010
Geoscientific Model Development, 3, 679–687.

Inverse version of IMOGEN



Derived Anthropogenic Emissions

Atmospheric Composition

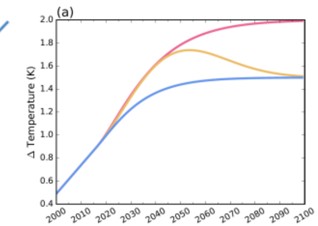
Simple Ocean Uptake Model

Inverted Energy Balance Model

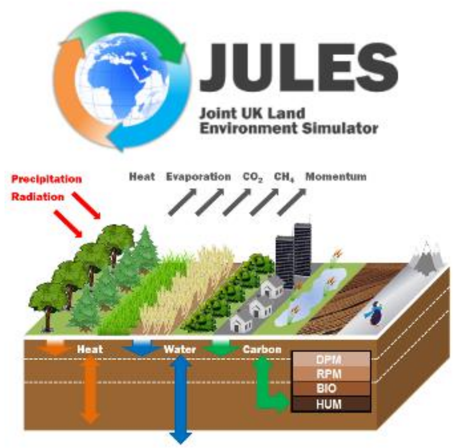
JULES Estimates Land Carbon Exchange

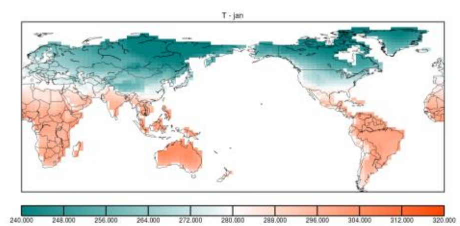
IMOGEN^{-1}

Prescribed Global Warming



Pattern Scaling of Met Data from 34 GCMs





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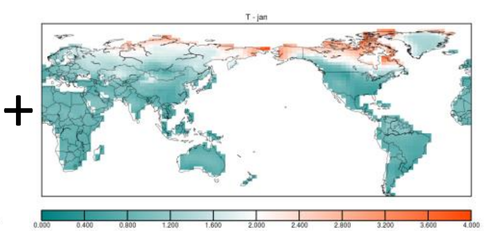

Climatology

ΔT x Anomaly

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Comyn-Platt, Hayman, Huntingford, et al., 2018:. "Permafrost and natural methane feedbacks limit emission budgets to 1.5 or 2.0°C of warming", Nature Geoscience.

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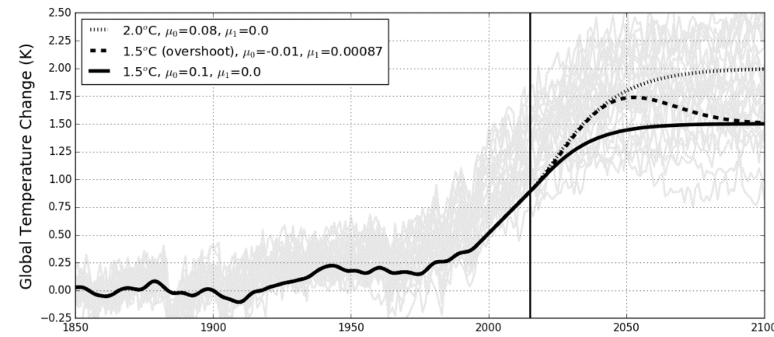
Common Baseline Scenario for CLIFFTOP, CLUES and MOC1.5

IMOGEN configuration

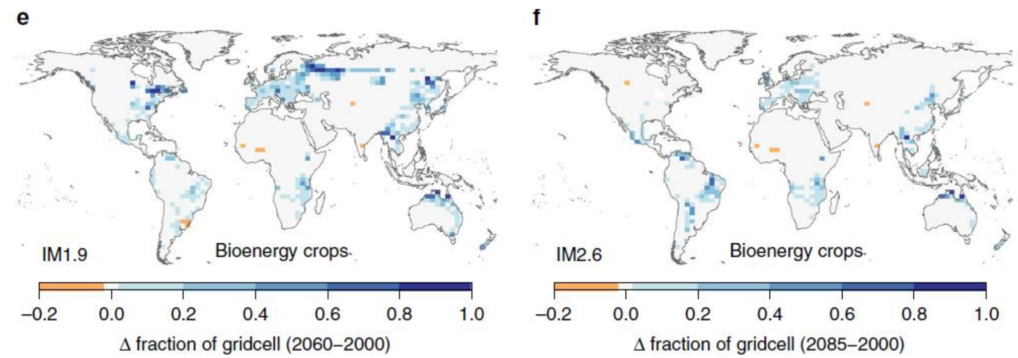
- Inverted form
- Same 3 temperature profiles
  a. 1.5°C by 2100
  b. 1.5°C by 2100 with overshoot
  c. 2.0°C by 2100



Project-specific focus

<u>CLIFFTOP</u>

- Permafrost
- Soil carbon
- Wetlands and wetland methane

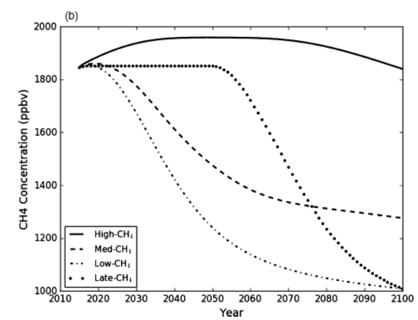


<u>CLUES1.5</u>

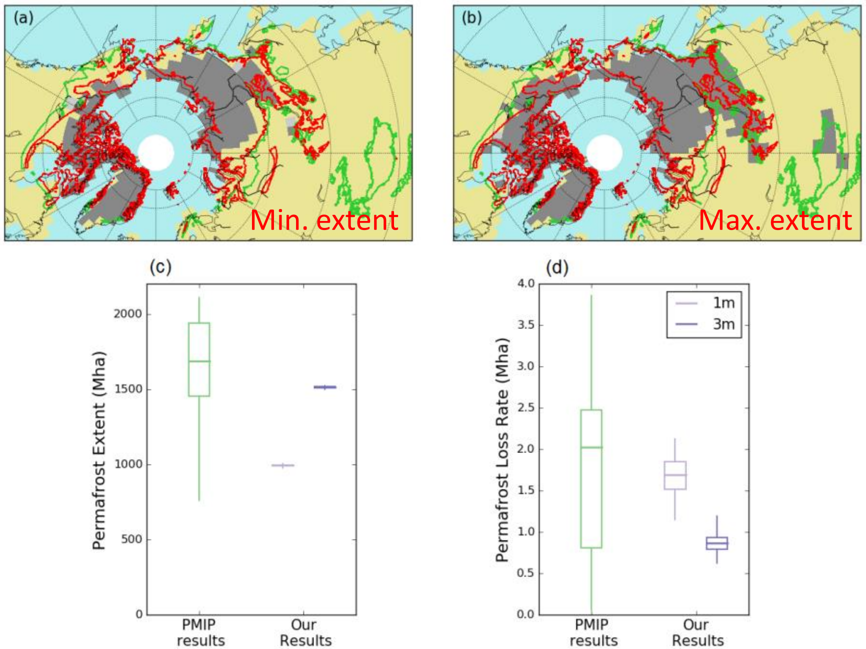
- LULUC projections, especially for BECCS, afforestation/ reforestation
- 13 vegetation types

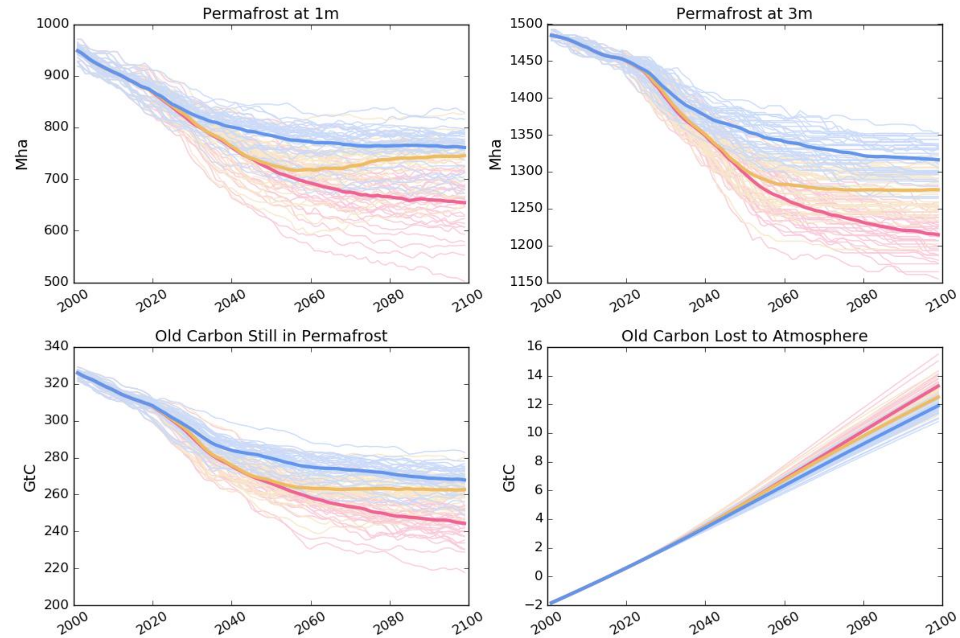
<u>MOC1.5</u>

- Mitigation of anthropogenic methane emissions
- Impact of vegetation ozone damage on carbon uptake



CLIFFTOP Results: Permafrost areal extent





Profile	1m Permafrost Area Loss (Mha)	3m Permafrost Area Loss (Mha)	Permafrost carbon entering active CC (GtC)	Permafrost carbon loss to the atmosphere (GtC)
1.5°C	119 (110-132)	138 (122-154)	43.1 (40.0-46.3)	11.9 (11.6-12.2)
1.5°C (overshoot)	133 (119-148)	176 (156-200)	48.7 (45.6-51.2)	12.5 (12.1-13.0)
2°C	202 (185-232)	239 (226-257)	67.3 (61.9-72.0)	13.3 (12.8-13.8)

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Note: Permafrost thaw effects on carbon cycle not fully realised at 2100

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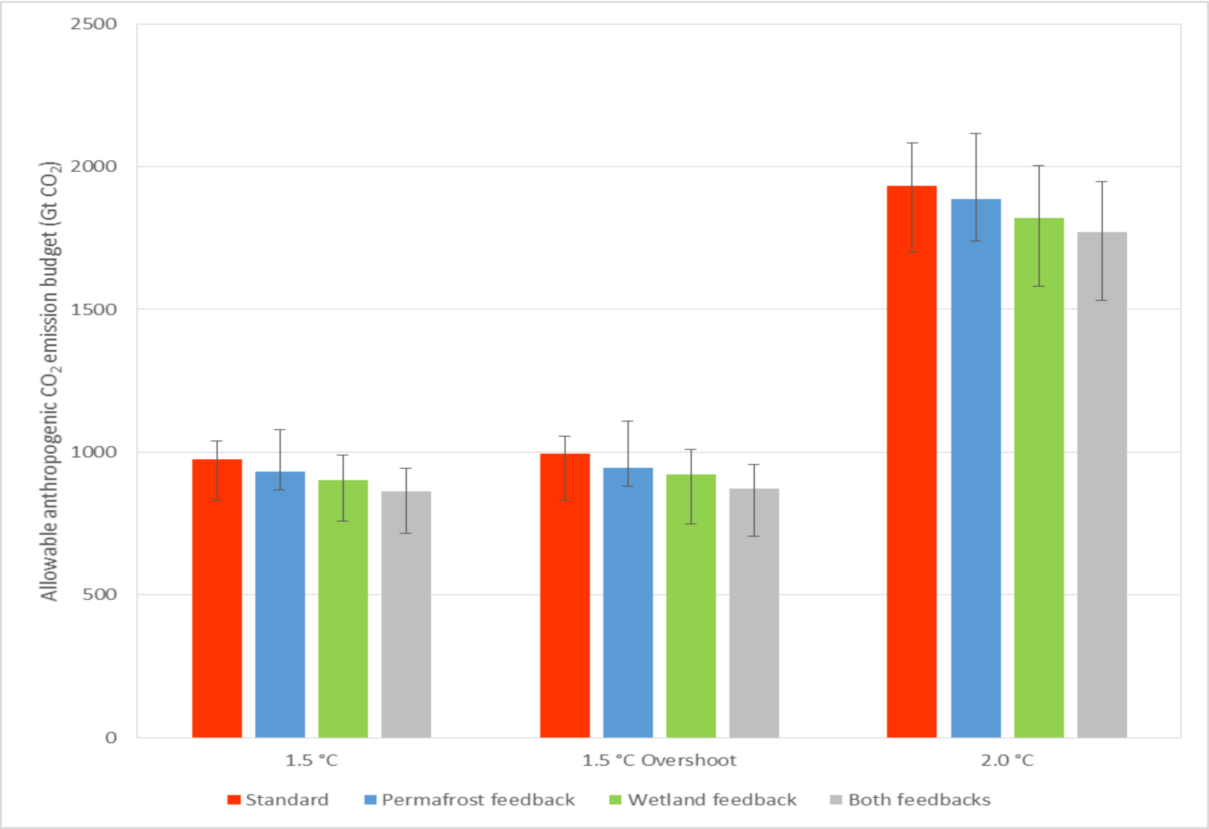
CLIFFTOP Results: Impact on Permissible Anthropogenic Emissions

Change
from 2015



Baseline Scenario	975 (832-1038)	994 (832-1056)	1932 (1701-2083)	GtCO_2
With Permafrost & Methane Feedbacks	862 (715-942)	873 (704-957)	1771 (1532-1947)	GtCO_2
% Change	12 (9-15)%	12.5 (9-15)%	8.5 (6-10)%	

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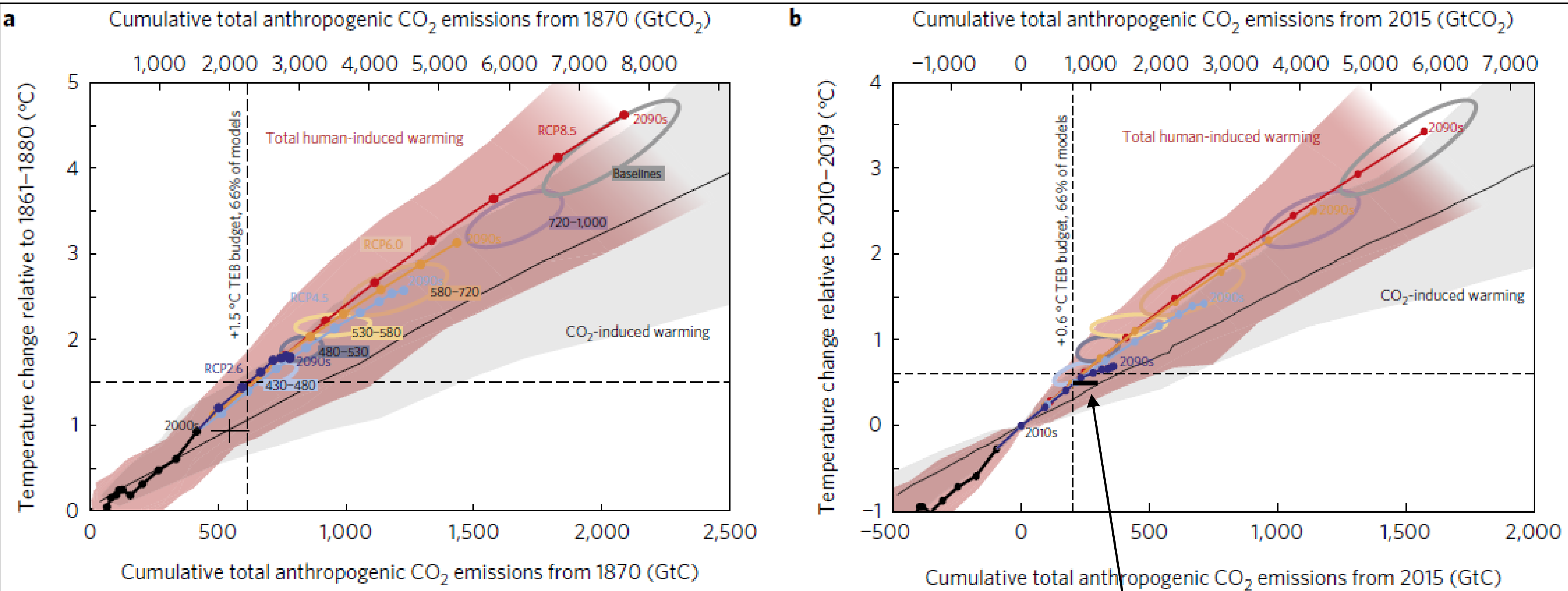
Remaining carbon budgets



Source: Millar et al., 2017: Nature Geoscience

This work: 227-283 GtC (2015-2100)
Offset for clarity

Papers, Synthesis & Impact

CLIFFTOP

- ✓ Paper published - Comyn-Platt et al., 2018: Nature Geoscience, 11, 568–573.
- ✓ Cited in IPCC Special Report on 1.5°C Warming
- ✓ Made available for use in IPCC Special Report on the Oceans & Cryosphere
- ✓ Input provided to Tyndall report for BEIS on NERC Warming programme

Additional NERC Funding to March 2018 for impact activities for CLIFFTOP, CLUES1.5 and MOC1.5

- ✓ Synthesis paper on 3 projects to compare different options: BECCS vs methane
- ✓ Production of project policy cards
- ✓ Bespoke policy briefing to BEIS, CCC, Defra

Thawing permafrost and natural wetlands can make it more difficult to limit global warming

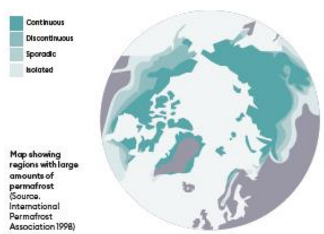
A warming climate will trigger extra, but natural, emissions of carbon dioxide and methane into the atmosphere. These gases arise from thawing permafrost and warming wetlands. As both gases are greenhouse gases, they add to those emitted from the burning of fossil fuels by humans. These mechanisms are well known. They are typically not considered when estimating the allowable human carbon emissions that correspond to particular warming levels.

For a 1.5°C warming target, we estimate the inclusion of thawing permafrost and of wetland emissions reduces the allowable human carbon emissions by around 116 $GtCO_2$.

What this research is about

The majority of countries have agreed to set targets to limit dangerous climate change. The Paris Agreement sets a target of restricting warming to 2°C above pre-industrial temperatures, with a further aspirational target of 1.5°C. The question then becomes: what emissions from fossil fuels are compatible with these temperature targets? These are called "allowable global carbon emissions".

The CLIFFTOP project calculates how the amount of allowable global carbon emissions is affected by permafrost thaw and wetland emissions in a warming world by 2100. Permafrost is soil or rock that is below freezing temperature. In a warming world, this thaws, and the previously frozen organic carbon can be released into the atmosphere as carbon dioxide (mainly) and methane (minor but this is amplified by its greater warming potential). Similarly, wetlands, which cover a significant fraction of the Earth's land surface, will release more methane as the planet warms.



Map showing regions with large amounts of permafrost (Source. International Permafrost Association 1998)

1 - *Permafrost*

Key Messages

- Natural carbon and methane climate feedbacks from wetlands and permafrost thaw are important
- For stabilisation at 2°C warming, the permissible anthropogenic fossil carbon budget is reduced by 161 Gt CO_2 or 8.5 (6-10)% by inclusion of these feedbacks
- These feedbacks become more important for stabilisation at lower temperature targets: 12 (9-15)% for stabilisation at 1.5°C warming
- There is little difference between stabilisation at 1.5°C warming with an overshoot to 1.75°C and without the overshoot.