Simulated $\delta^{13}CH_4$ from high-latitude wetlands

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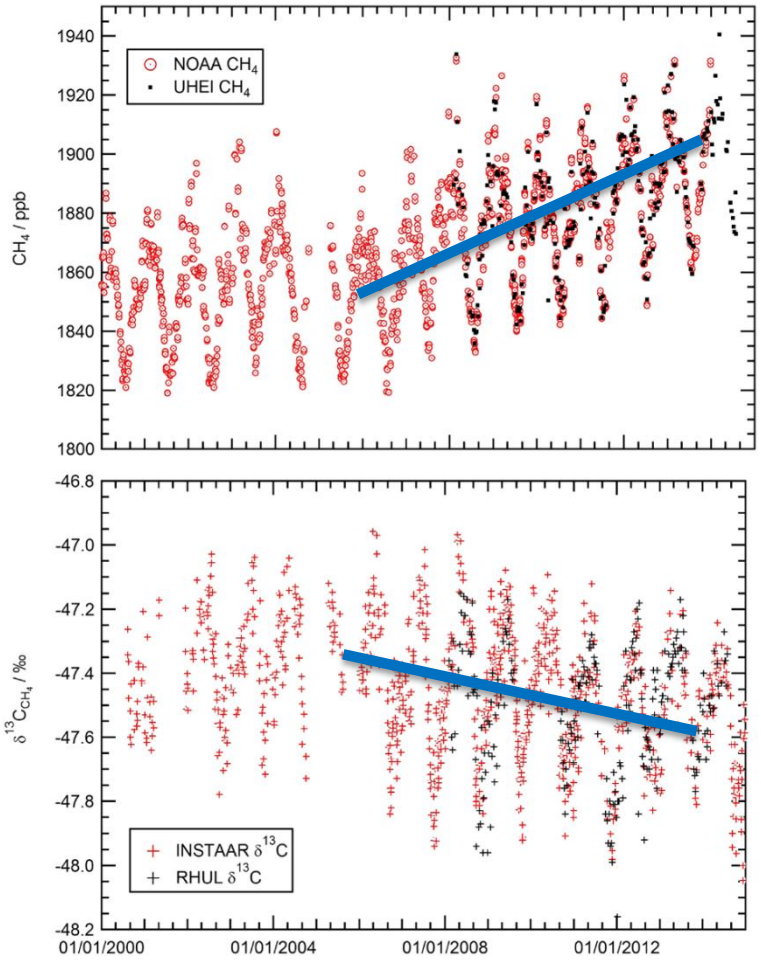
Global Methane Cycle

- Atmospheric methane is increasing but becoming isotopically "lighter" (i.e. depleted in $^{13}CH_4$)
- Isotopic measurements help to discriminate CH_4 sources:
  - Atmosphere: -47‰
  - Oil & Gas extraction: -35‰ to -45‰
  - Wetlands: -58‰ to -90‰
  - Biomass burning: -25‰ to -30‰
- Inverse atmospheric modelling for sources and sinks assimilate $\delta^{13}CH_4$
  - Small variations in atmosphere
  - Larger range in methane source signatures, but typically assume a single value for each source
- What is the effect on the retrieved source estimates if we incorporate more realistic wetland types (flux and source signature)?

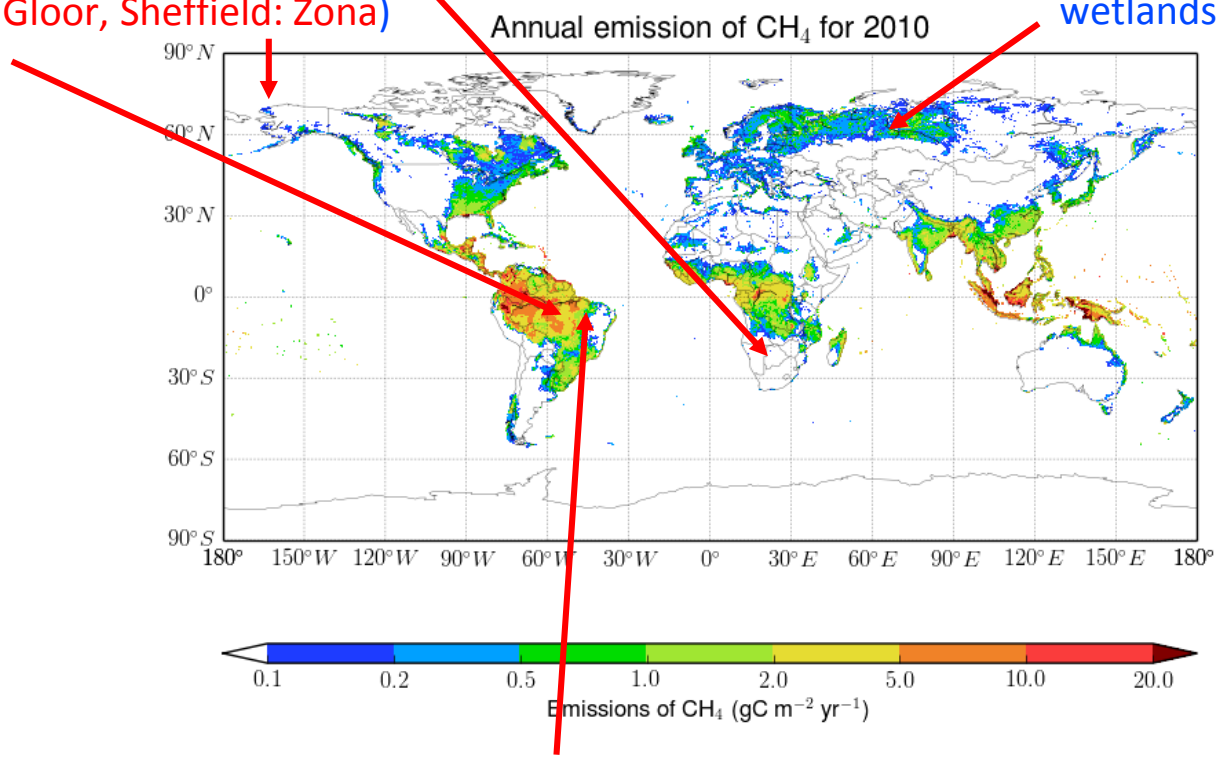


Nisbet et al., GBC, **30**, 2016

NERC Global Methane Highlight Topic - MOYA

CEH Wallingford/Met Office: New estimates of wetland methane flux

- Improved parameterisation of the Q_{10} temperature response using data from the tropics and high northern latitudes (CEH: Skiba Leeds: Gloor, Sheffield: Zona)
- Comparison with top-down estimates (Edinburgh: Palmer)
- Isotopic signatures from wetlands (Bristol: Ganesan)



- Representation of methane from tropical forest wetlands (Open University: Gauci)

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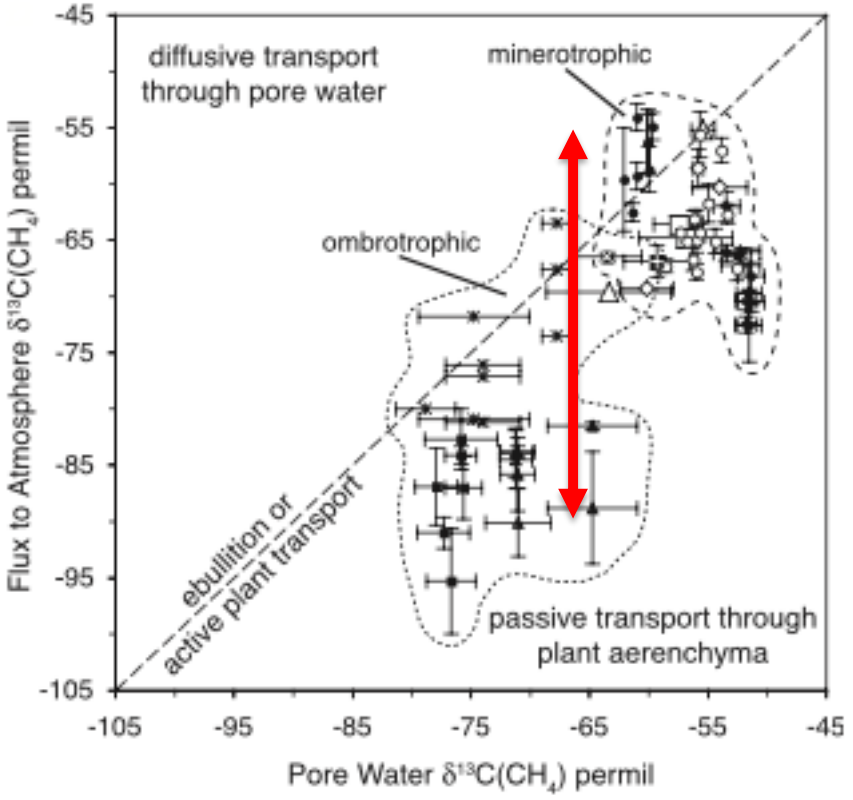
Wetland isotopic methane signatures

Different wetland types have

- Varying source signatures
  - Ombotrophic (bog) ~-85‰
  - Minerotrophic (fen) ~-60‰

- Varying fluxes
  - Fens have higher fluxes than bogs (Turetsky et al., GCB, **20**, 2014)



Hornibrook et al., 2009

JULES Wetland Methane Scheme

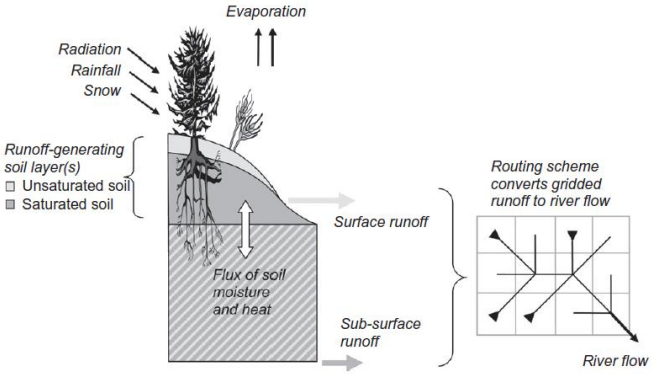
- JULES Wetlands Scheme based on TOPMODEL approach (Gedney and Cox, 2003)

- Predicts the distribution of sub-grid scale water table depth and wetland fraction (f_w) from the overall soil moisture and the sub-grid scale topography

- Methane flux from wetlands (F^w_{CH4} ; Gedney et al., GRL, 2004):

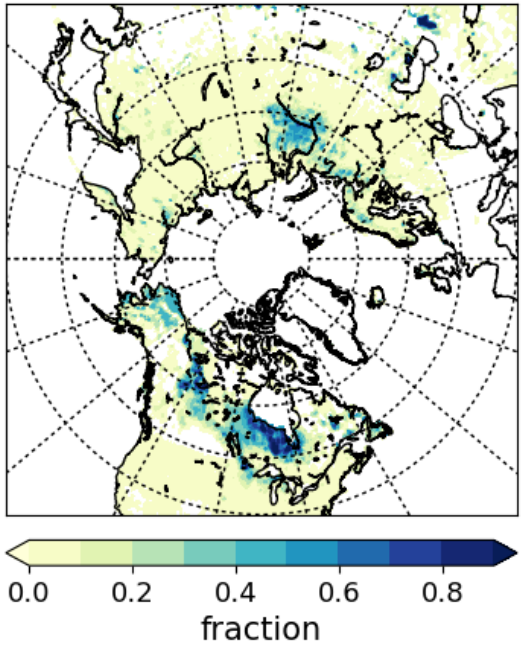
$$F^w_{CH4} = k_{CH4} * f_w * C_s * Q_{10}(T_{soil})^{(T_{soil}-T_0)/10}$$

- JULES now has 3 methods to specify substrate carbon, C_s: (i) soil carbon, (ii) NPP, (iii) soil respiration

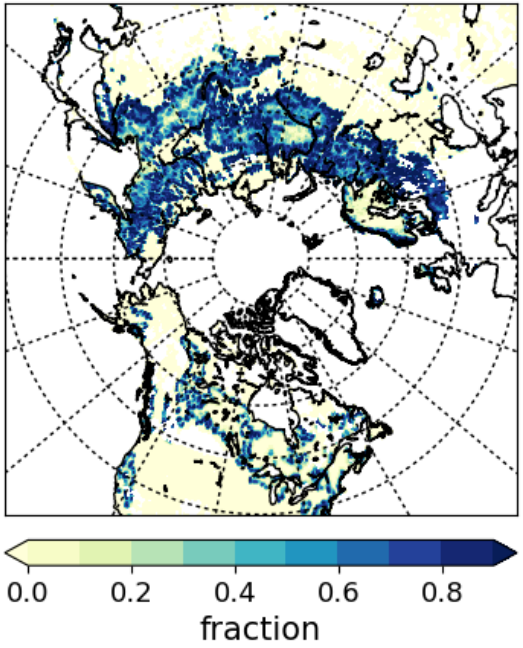


Adding $^{13}CH_4$ to the JULES Wetland Methane Scheme

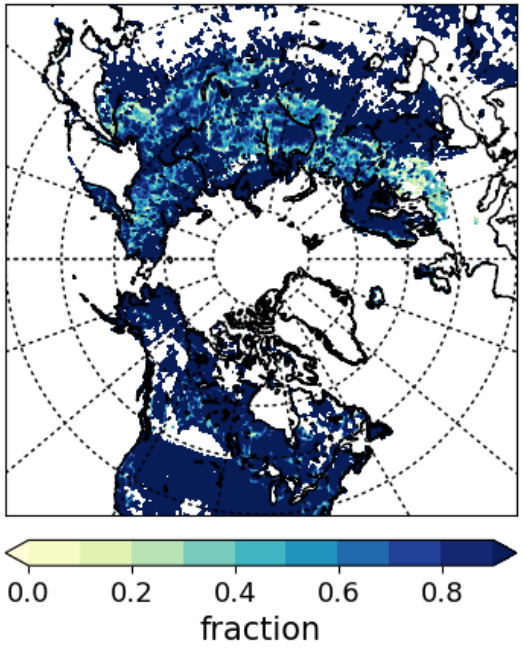
- Initial focus on boreal wetlands
- Separate bogs and fens using soil pH: bogs – acidic; fens – alkaline
- Harmonized World Soil Database
- Regional differences (e.g., Alaska more fen, Scandinavia mixture)



Wetland fraction
Kaplan et al.,



Bog fraction



Fen fraction

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Map of boreal wetland $\delta^{13}CH_4$ signatures

- Methane flux from bogs (F^b_{CH4})

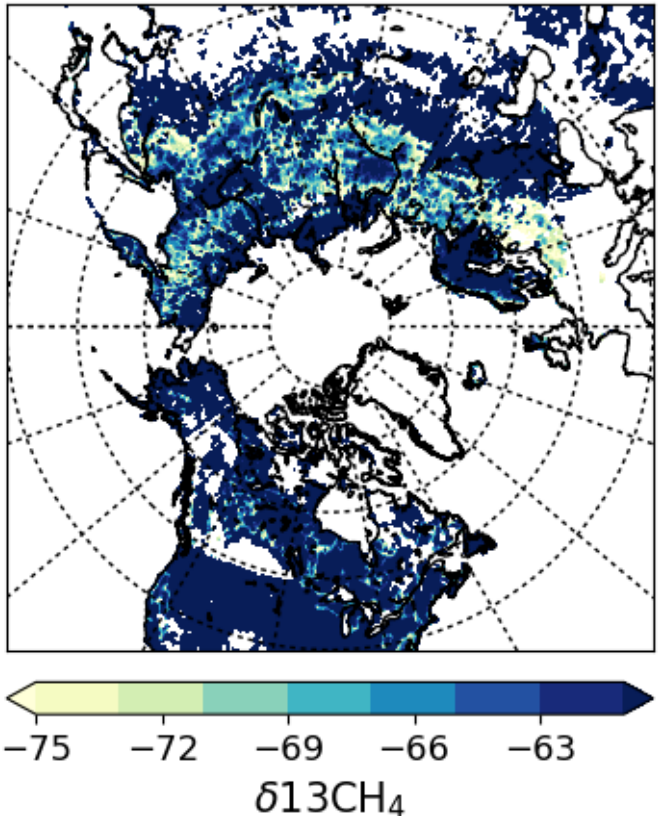
  $F^b_{CH4} = f_w * f_b * A_b * Q_{10}(T_{soil})^{(T_{soil}-T_0)/10}$

  with equivalent expression for fen

- $\delta^{13}CH_4$ source signature map based on wetland fraction, bog/fen fraction and varying sources signatures
  - Regional differences

- Temperature terms from JULES using measured bog/fen Q_{10}'s
  - Q_{10}'s collated from 71 sites (Turetsky et al, 2014)
  - bogs =2.6; poor fen = 1.7; rich fen = 2.0

- Preliminary results

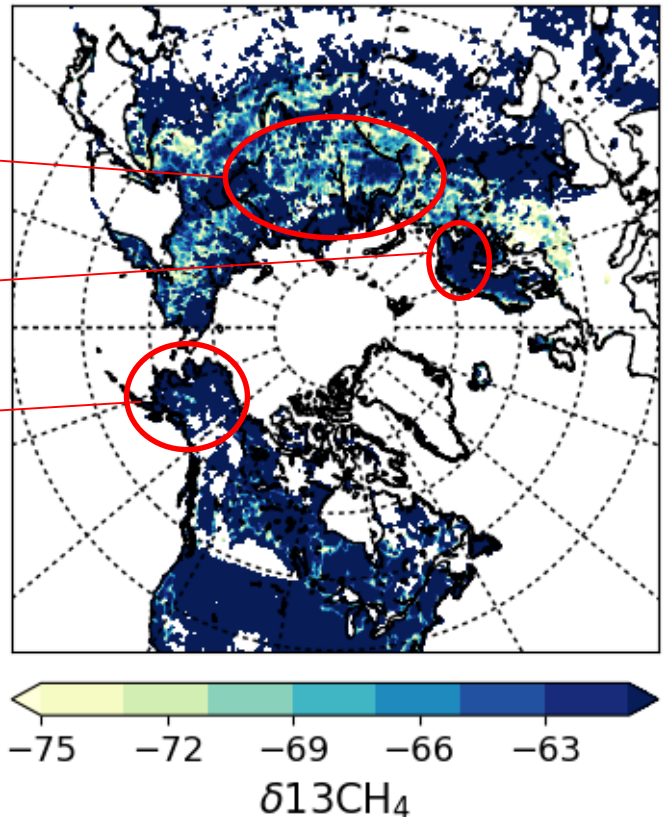


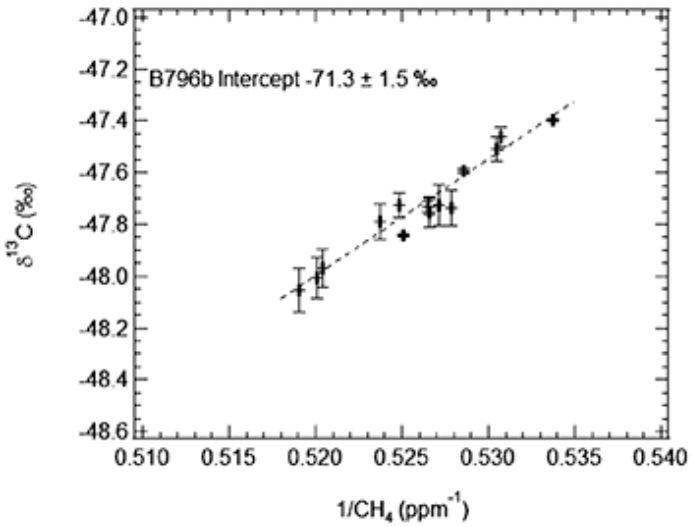
Evaluation of the boreal wetland $\delta^{13}CH_4$ signatures

Keeling plots from aircraft measurements

Indicate regional source signature

- Siberia regional signature
  -70 to -78 ‰ (France et al., 2016, Umezawa et al., 2012)
- Scandinavia regional signature
  ~ -70‰ (Fisher et al., 2017)
- Alaska regional signature
  ~ -63‰ (Umezawa et al., 2012)





Fisher et al., GBC, **31**, 2017

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Next steps and future work

- Simulate $\delta^{13}CH_4$ at atmospheric measurement sites using NAME Lagrangian atmospheric transport model
- Modelled $\delta^{13}CH_4$ at site will be flux and sensitivity weighted contribution of the source signature
- How well do the modelled compare to observed regional source signatures?
- What is the impact of including wetland types on inversions using atmospheric $\delta^{13}CH_4$ values?

NAME sensitivity map for aircraft observation in Alaska