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Mitigating Mathane Emissions: From Science to Innovative Solutions

Methane in the Earth System: Natural Cycles and Future Changes

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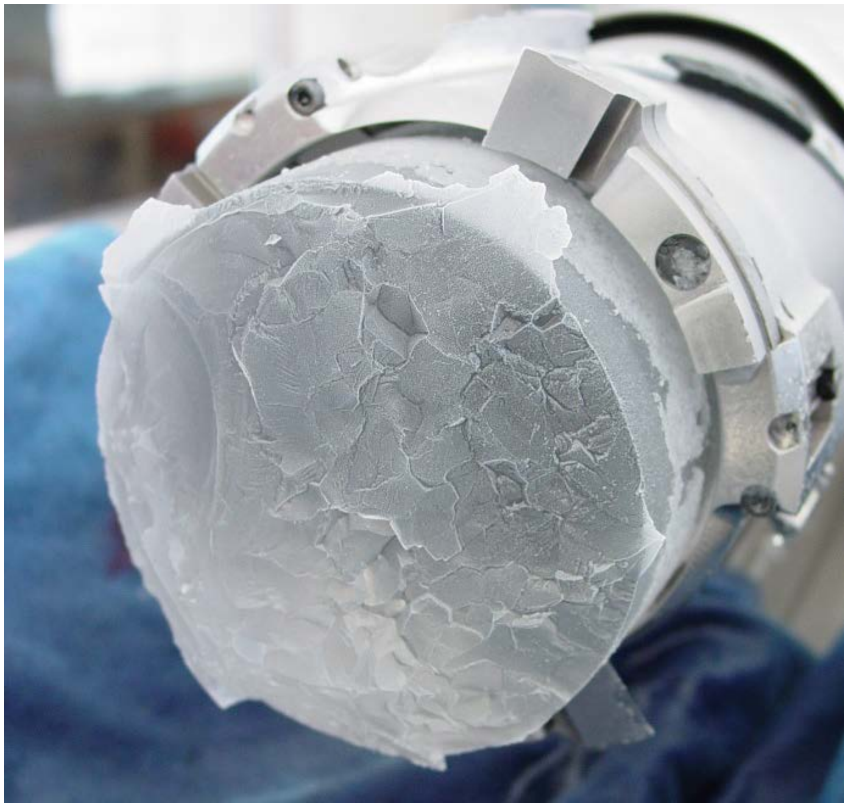
Thanks to Renato Sphani

Mitigating Mathane Emissions: From Science to Innovative Solutions

Methane in the Earth System: Natural Cycles and Future Evolution

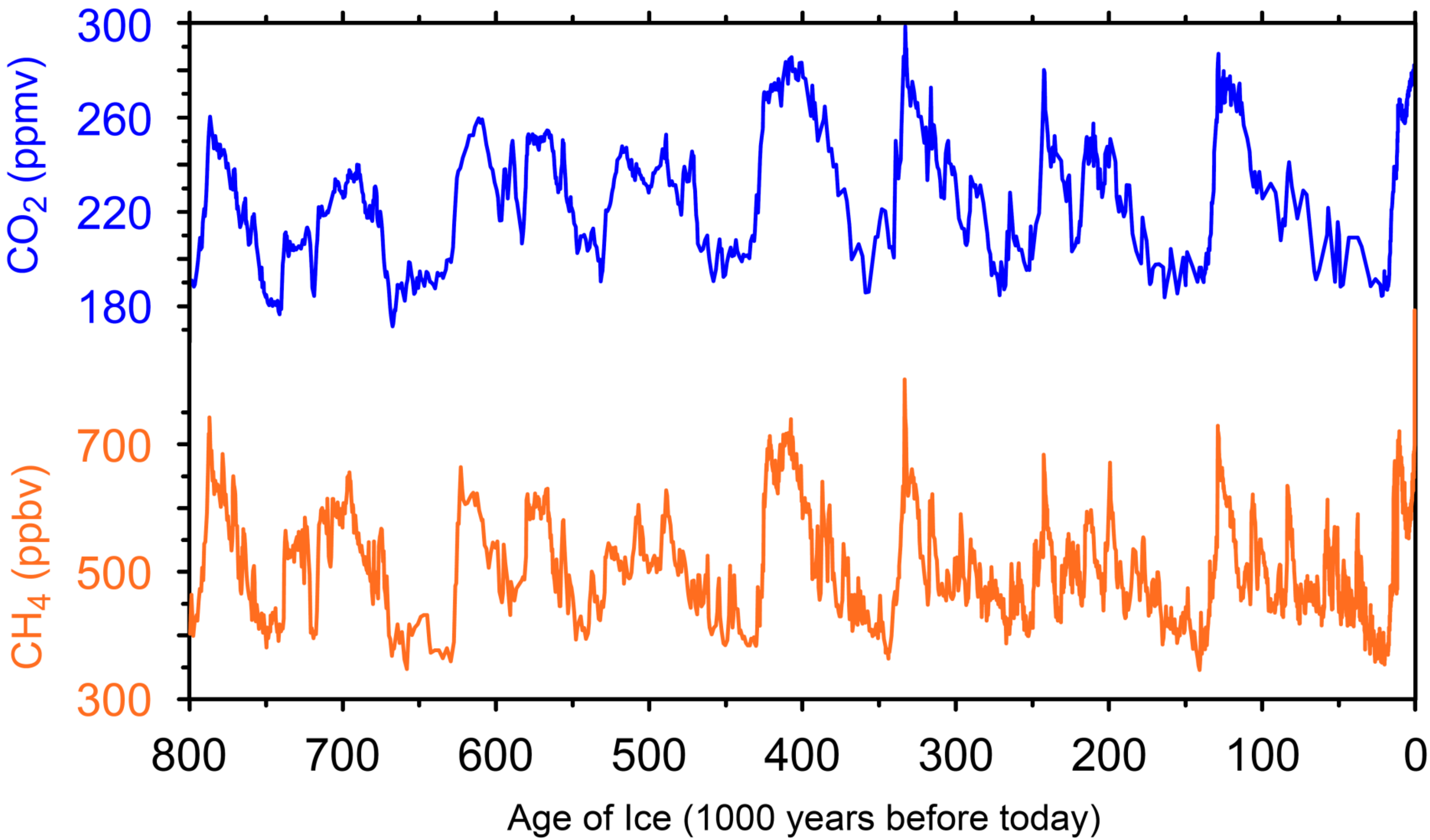
1. What the past tells us
2. The CH_4 cycle
3. Future changes – and surprises?
4. Conclusions

Antarctic ice cores provide greenhouse gas records



EPICA: 1995-2005

800,000 years of CO_2 and CH_4 variations



(Siegenthaler et al., 2005; Lüthi et al., 2008; Loulergue et al., 2008)

Anthropogenic increase of CO_2 , CH_4 , and N_2O

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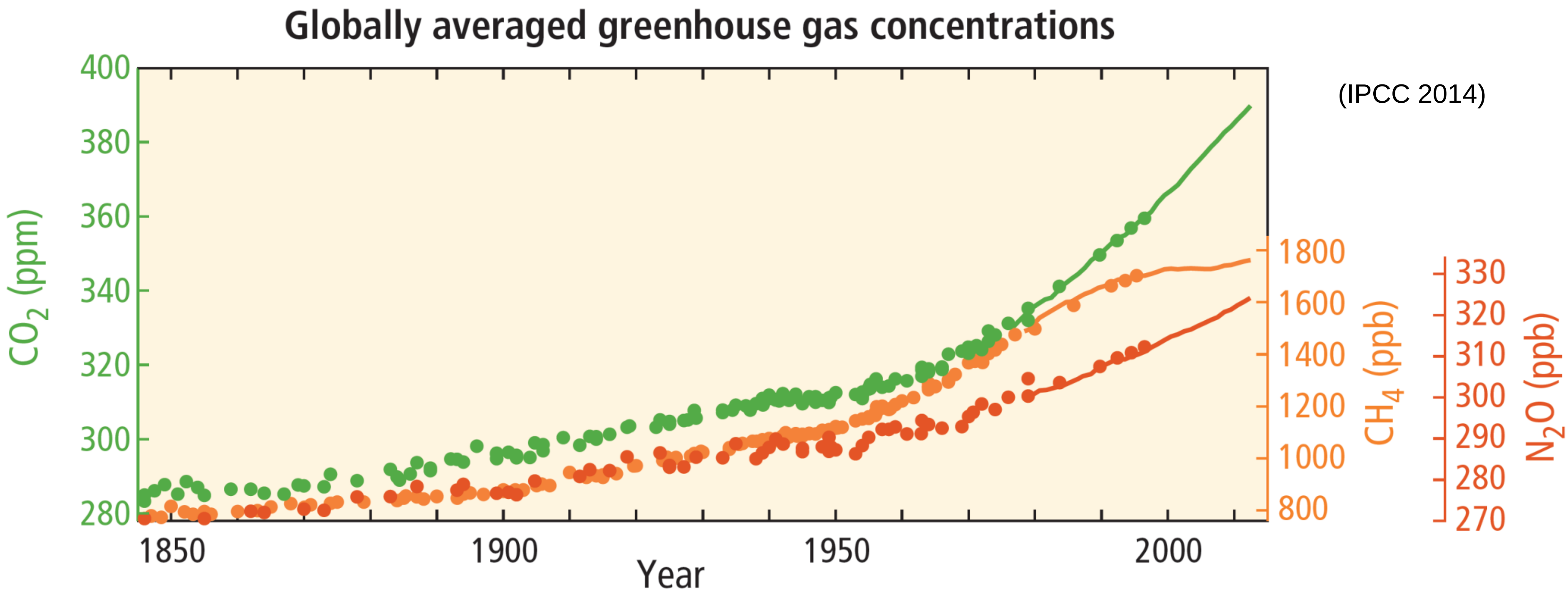

(IPCC 2014)

CO_2: 40%
CH_4: 150%
N_2O: 20%

higher than pre-industrial

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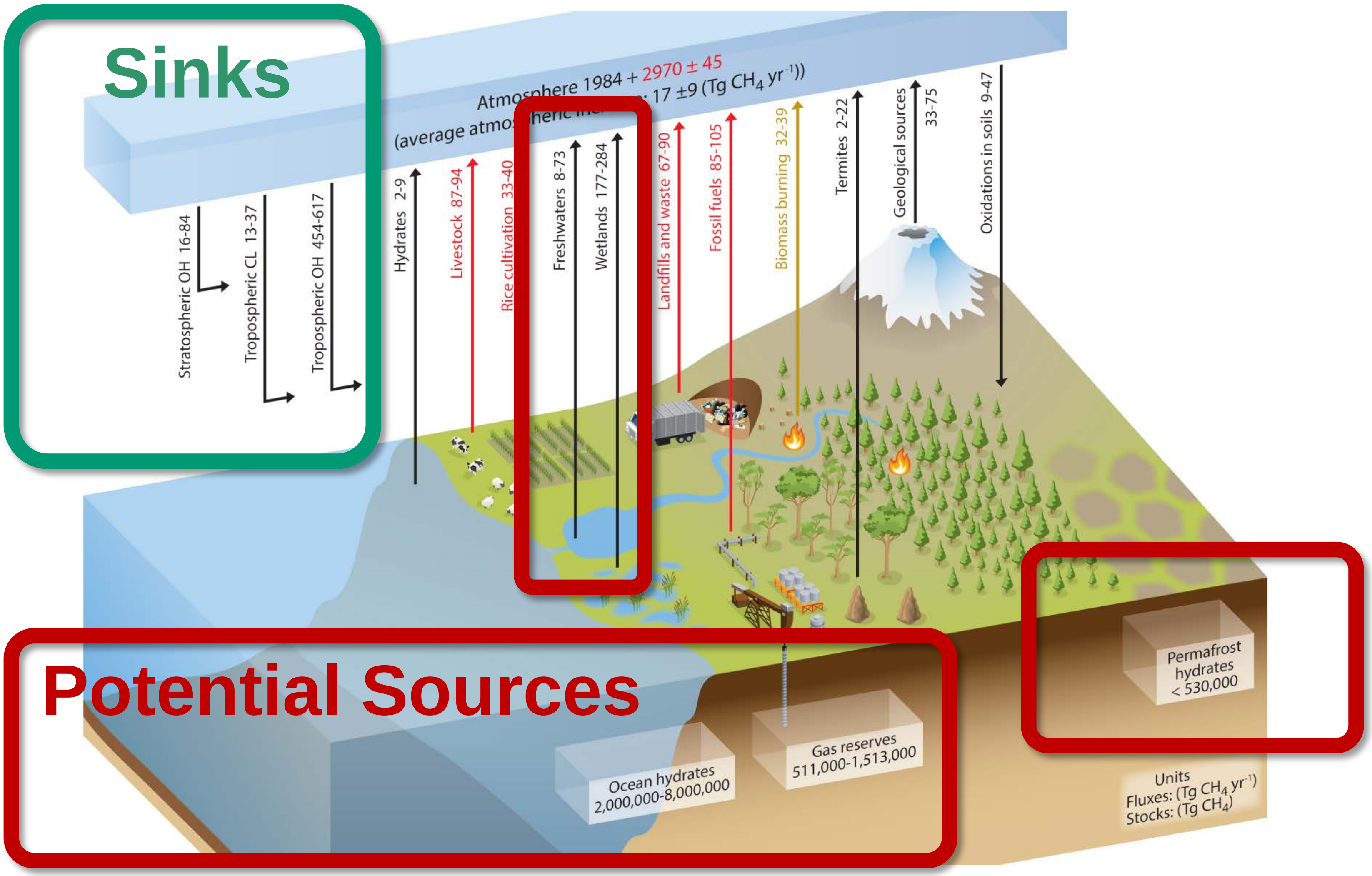

(IPCC, 2013, Fig. 6.2)

CH_4: The second most important anthropogenic GHG

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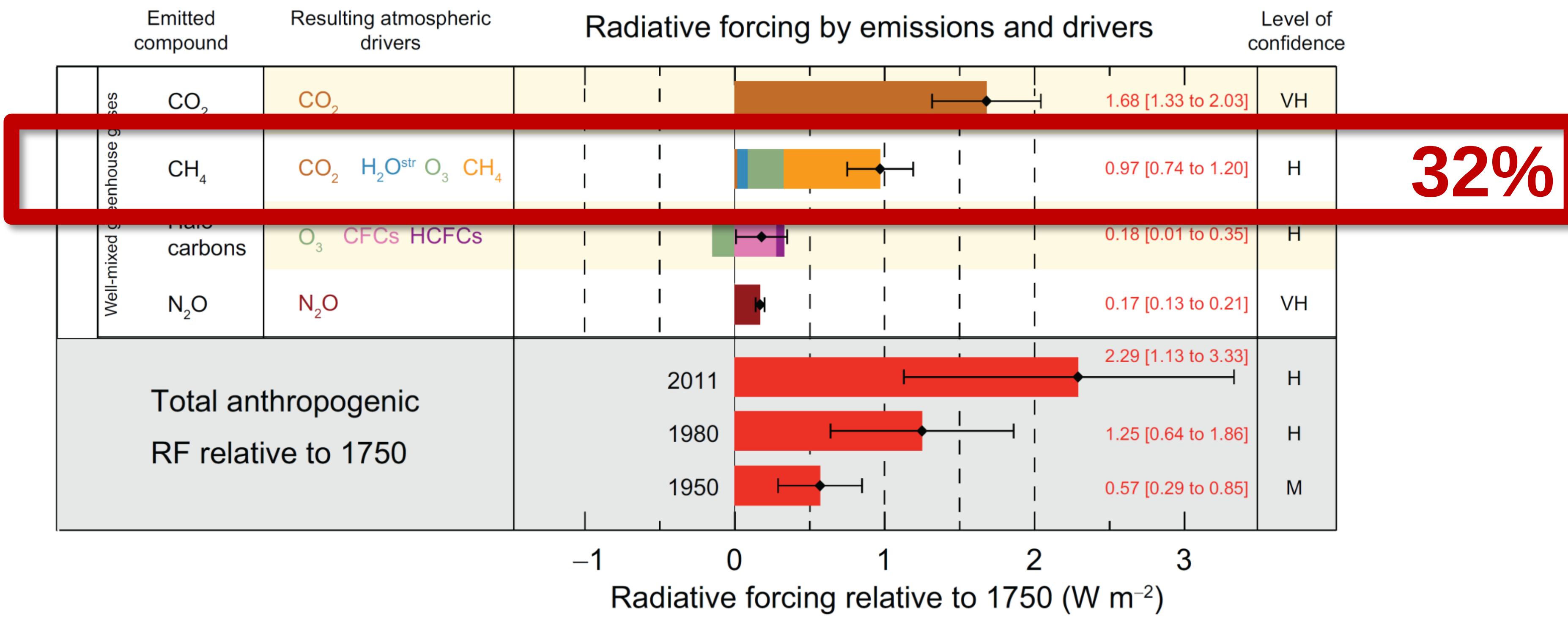

(IPCC, 2013, Fig. SPM.5 simplified)

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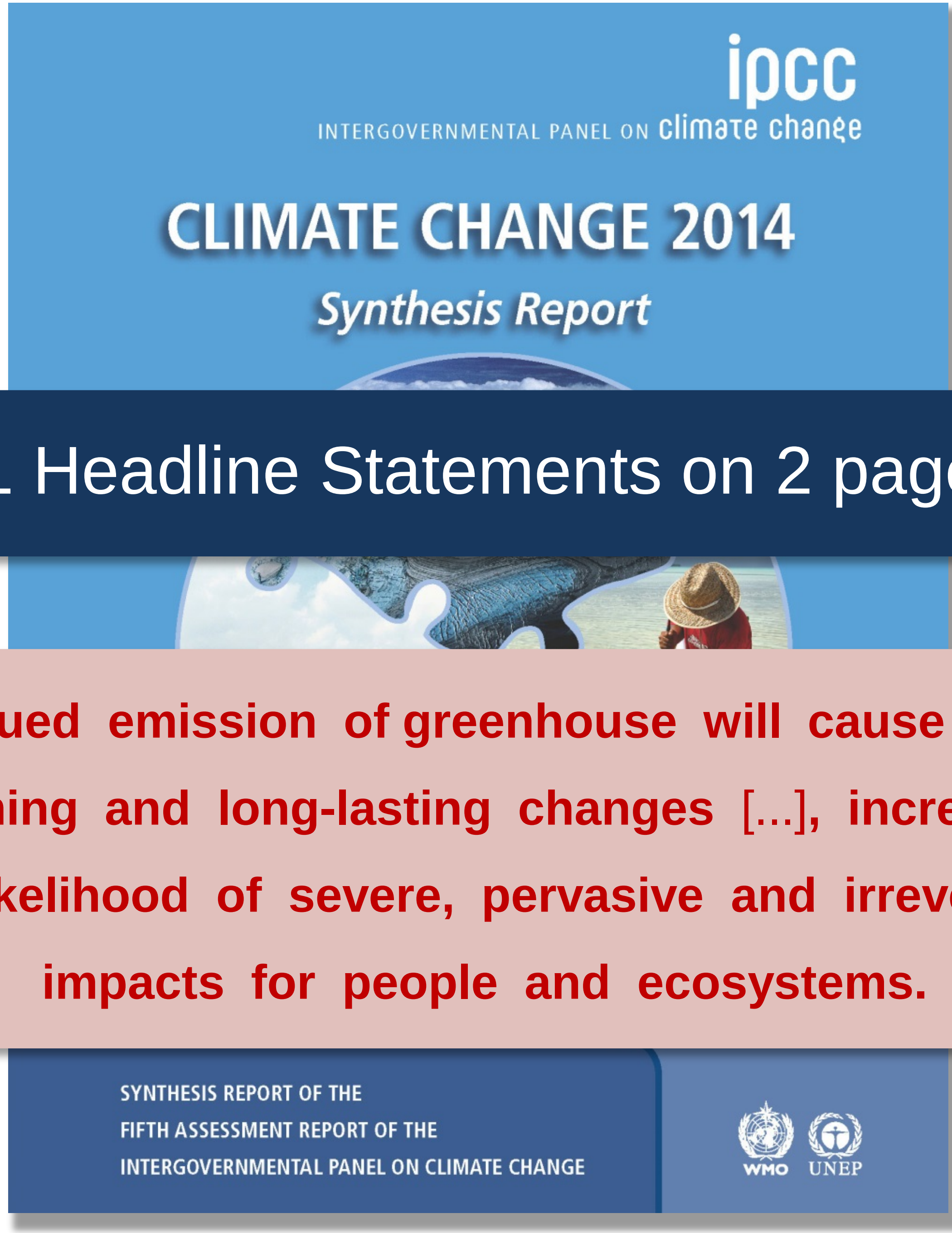
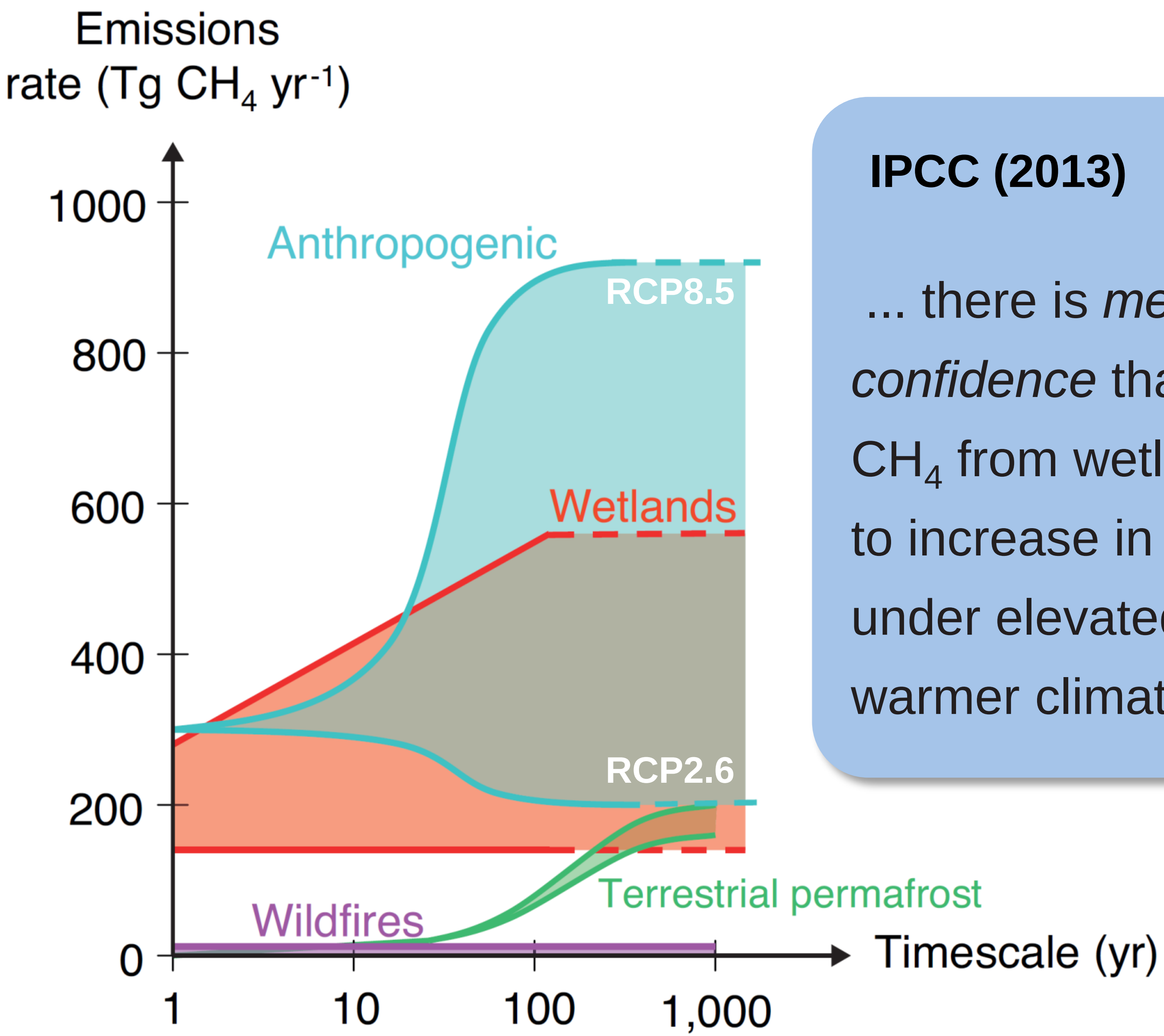


21 Headline Statements on 2 pages

Continued emission of greenhouse will cause further warming and long-lasting changes [...], increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.



(IPCC 2013, Fig. 6.36)

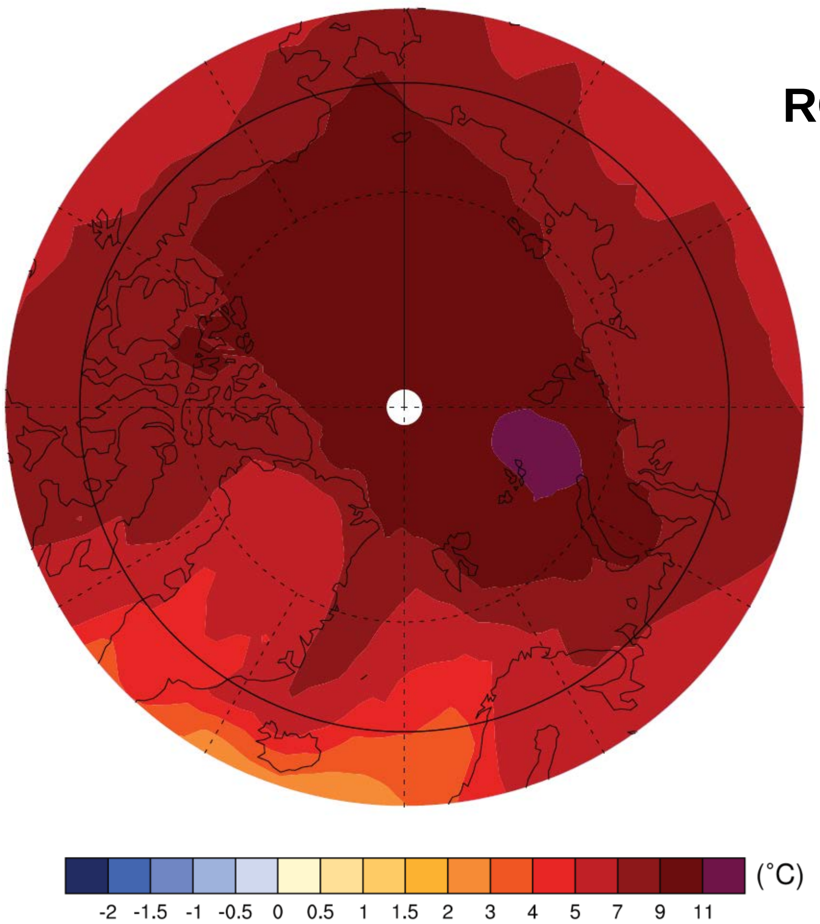
IPCC (2013)

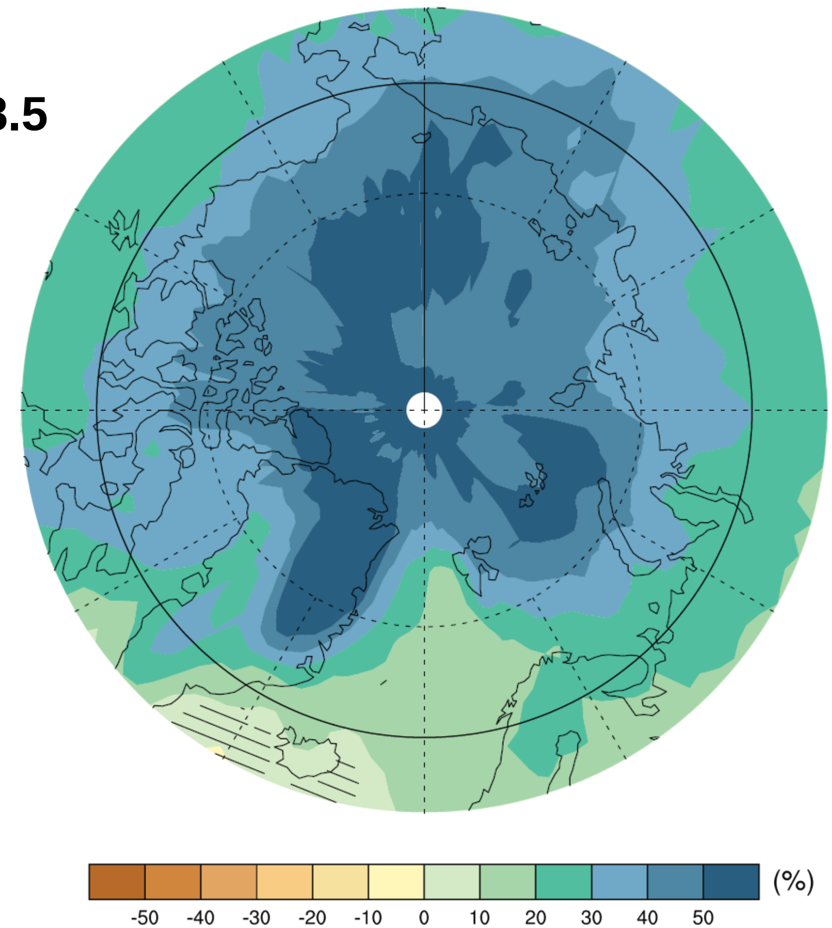
... there is *medium confidence* that emissions of CH_4 from wetlands are *likely* to increase in the future under elevated CO_2 and warmer climate.

Temperature change
2081-2100

Precipitation change
2081-2100

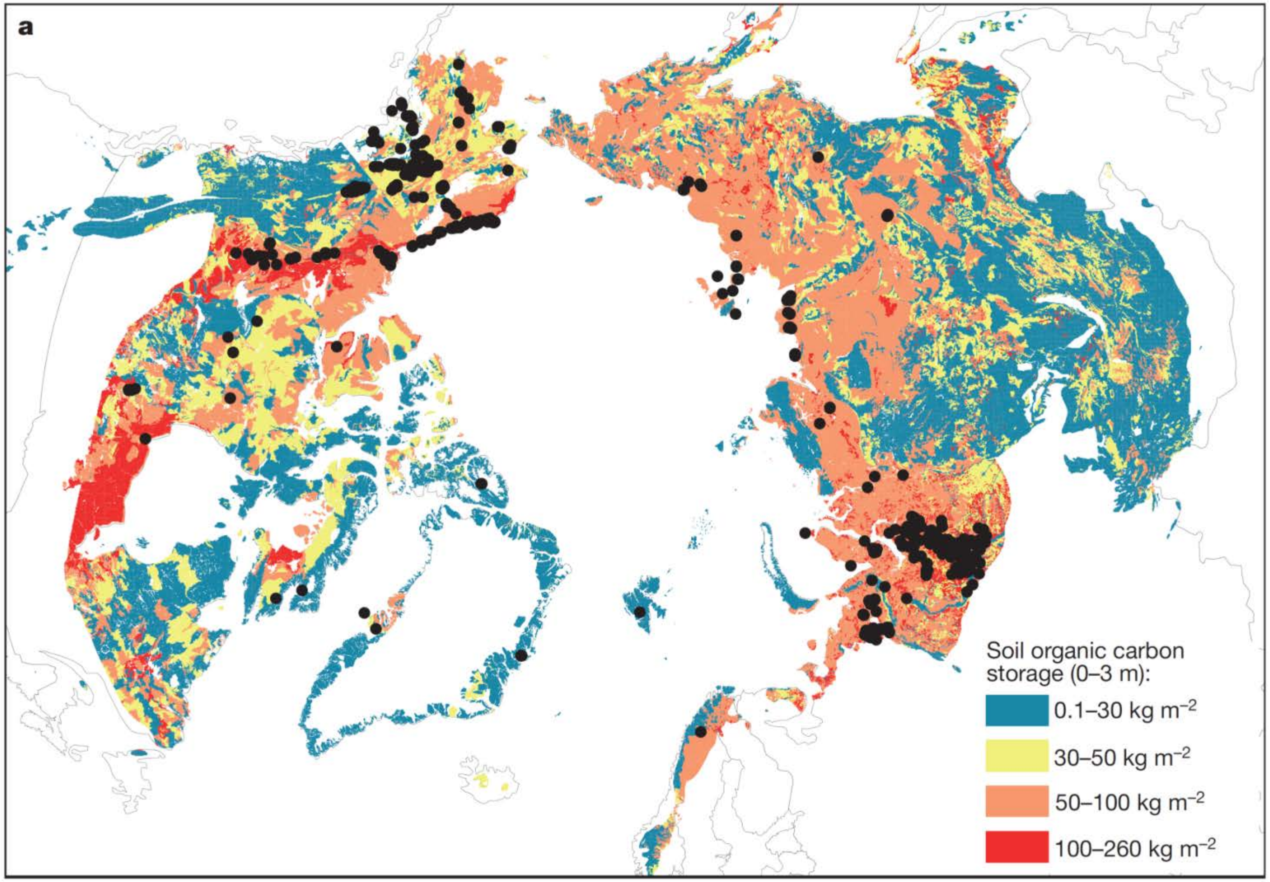
RCP8.5





IPCC 2013, Annex I

Carbon storage in Northern Hemisphere high latitudes



(Schuur et al., 2015, Nature)

Top 3-meter permafrost carbon pool: 1,035 ±150 GtC

Carbon storage in Northern Hemisphere high latitudes

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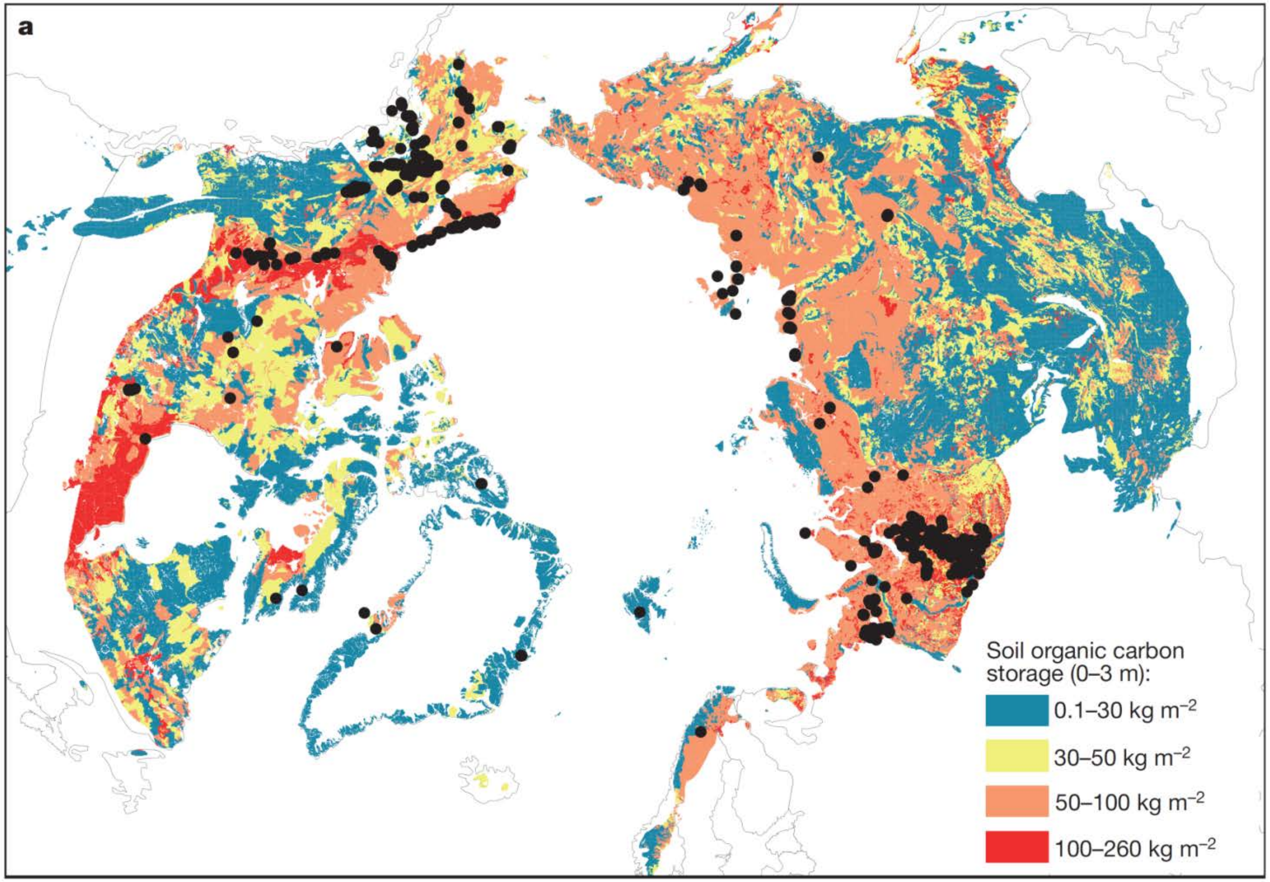

(Schuur et al., 2015, Nature)

Deep carbon pool in Yedoma region: **200 to 450 GtC**

Carbon release from thawing permafrost

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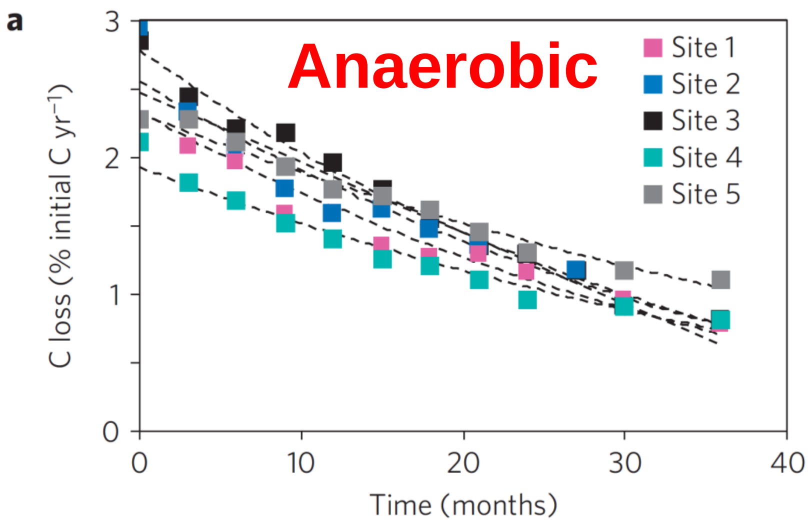
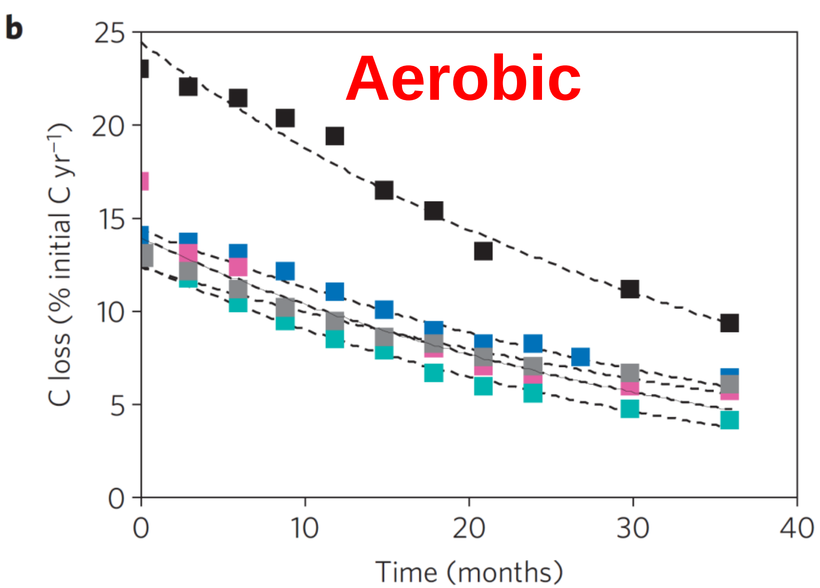
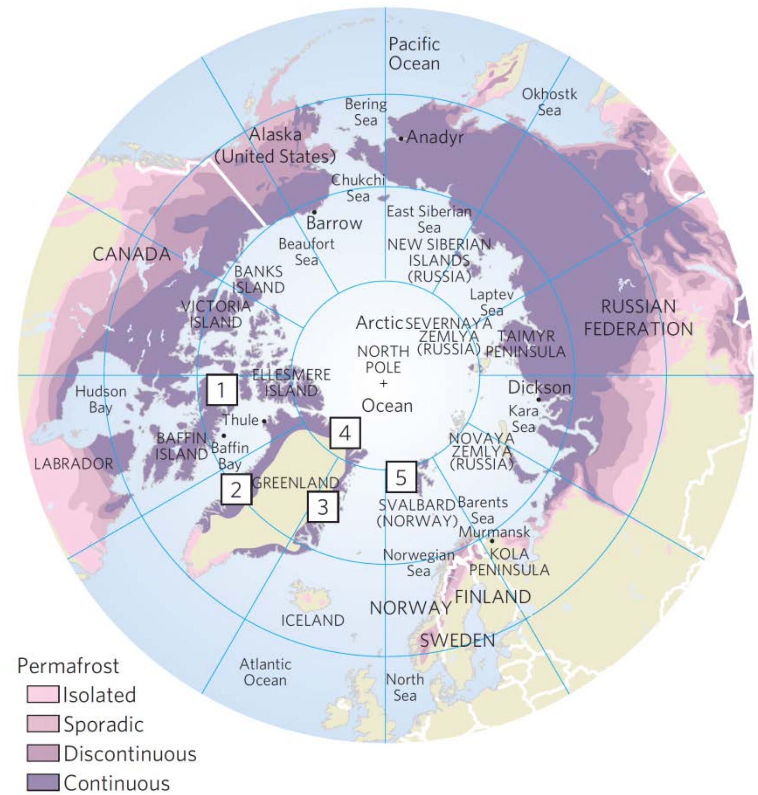


+ CH_4

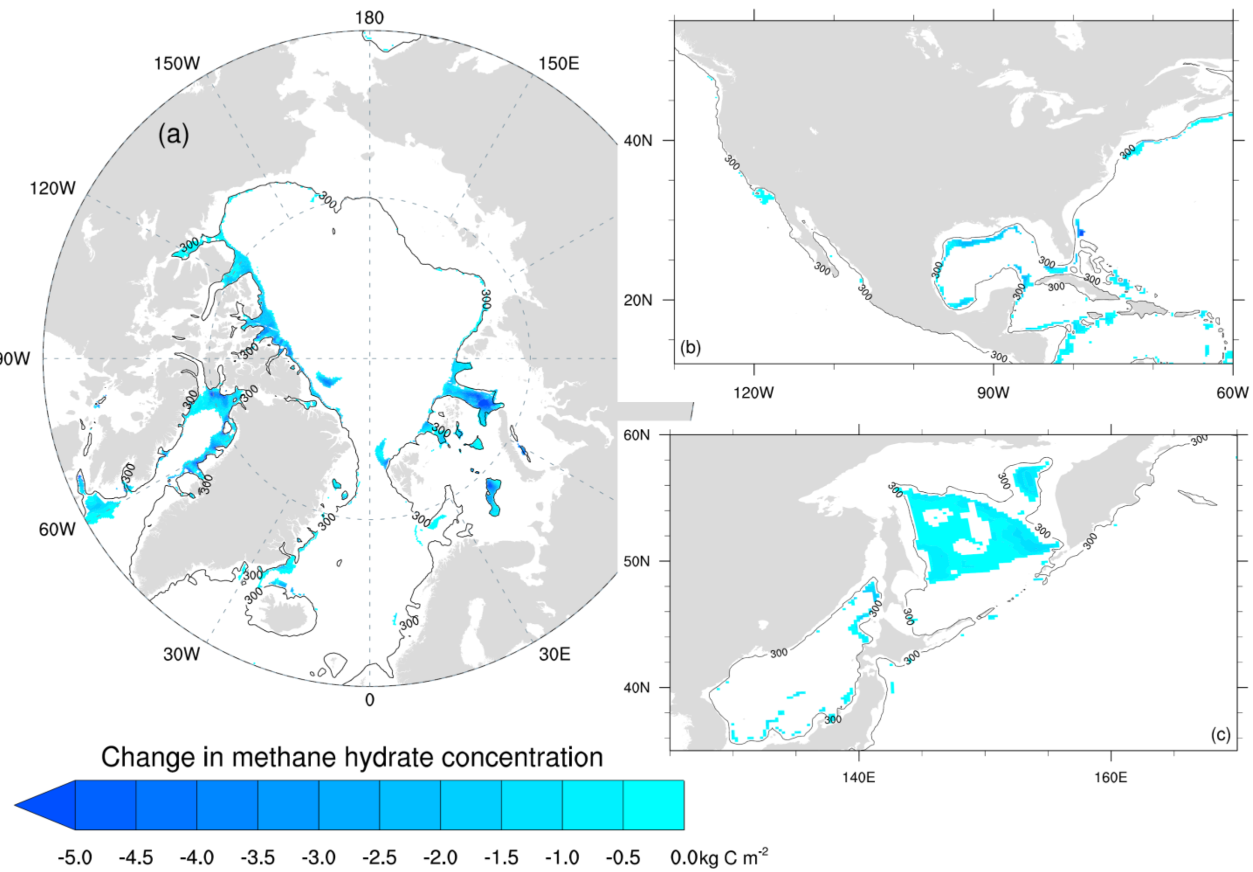


+ CO_2



Elberling et al., 2013

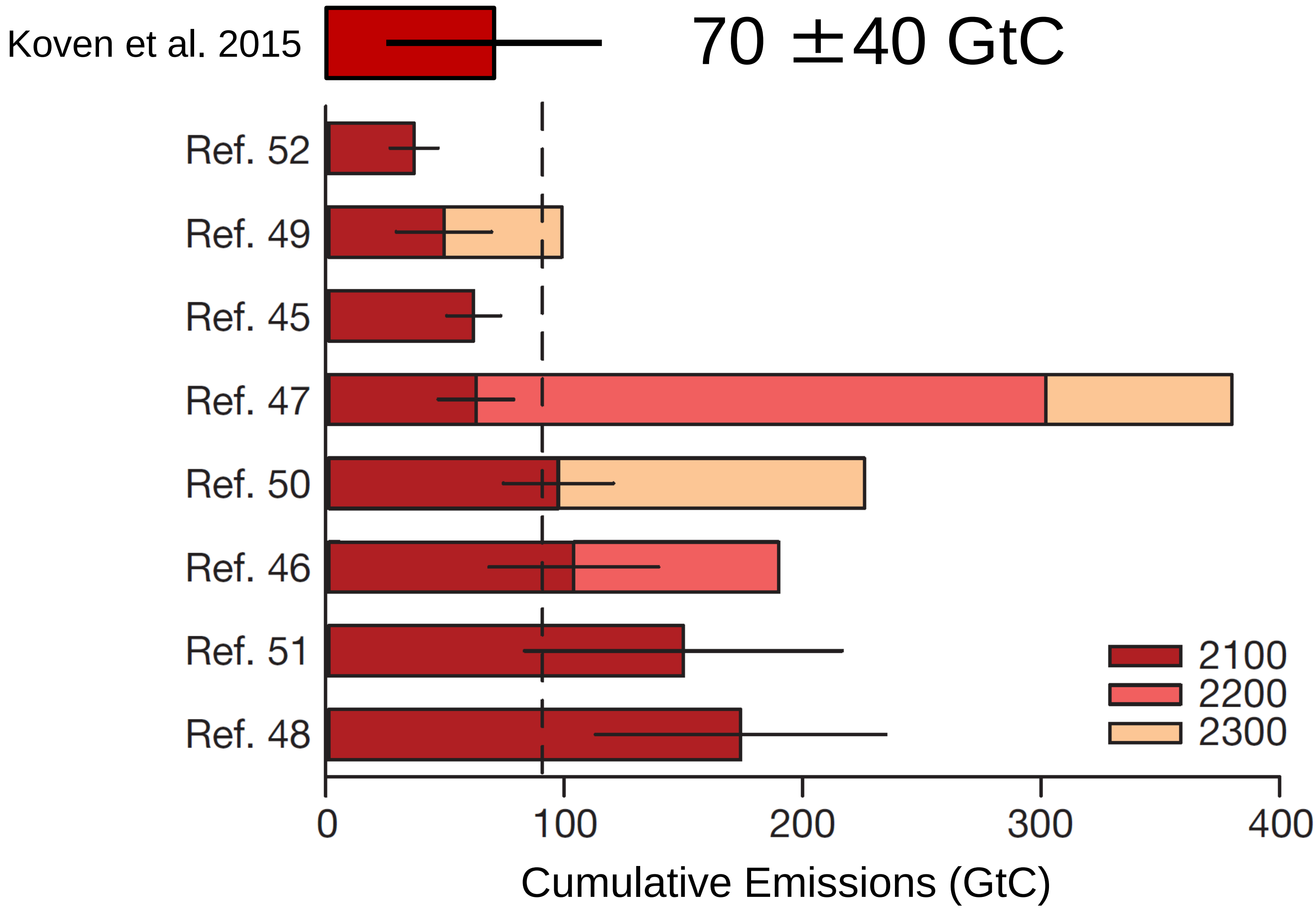
Carbon release from methane hydrates



(Kretschmer et al., 2015)

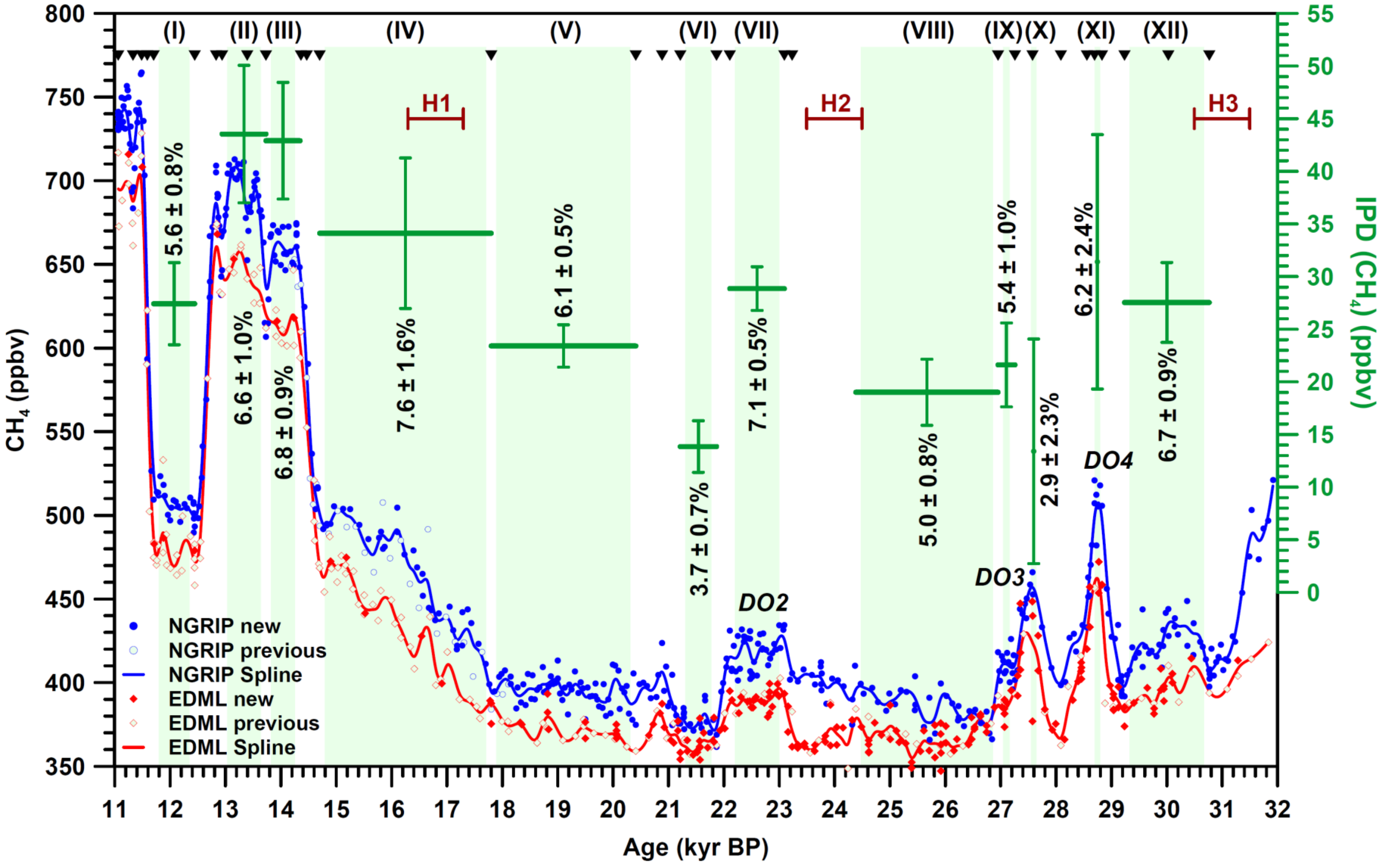
Methane hydrate inventory: >1,150 GtC

Carbon release from thawing permafrost

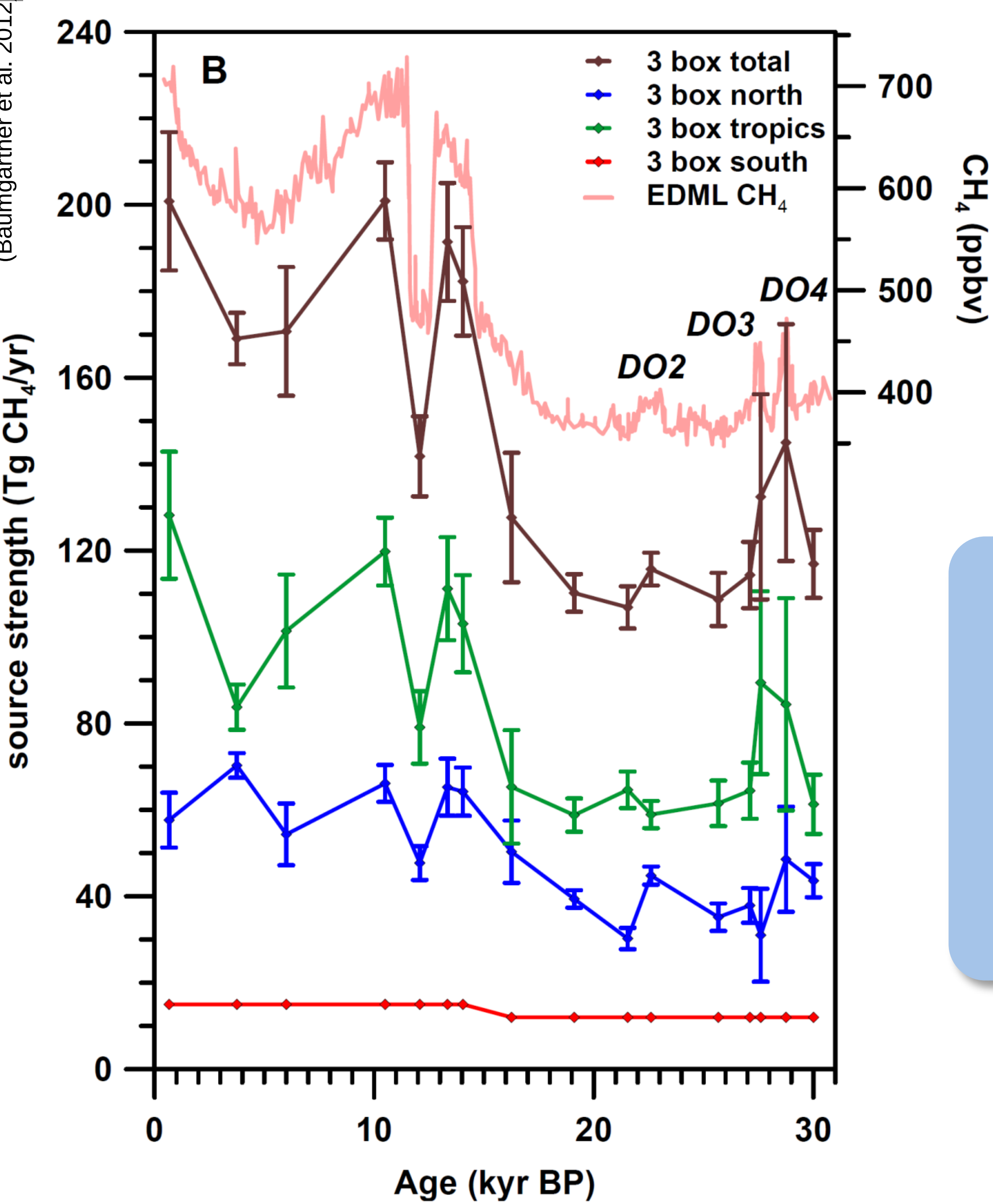


(Schuur et al., 2015, Nature)

Sources of methane changes in the past



Baumgartner et al., 2012



(Baumgartner et al. 2012)

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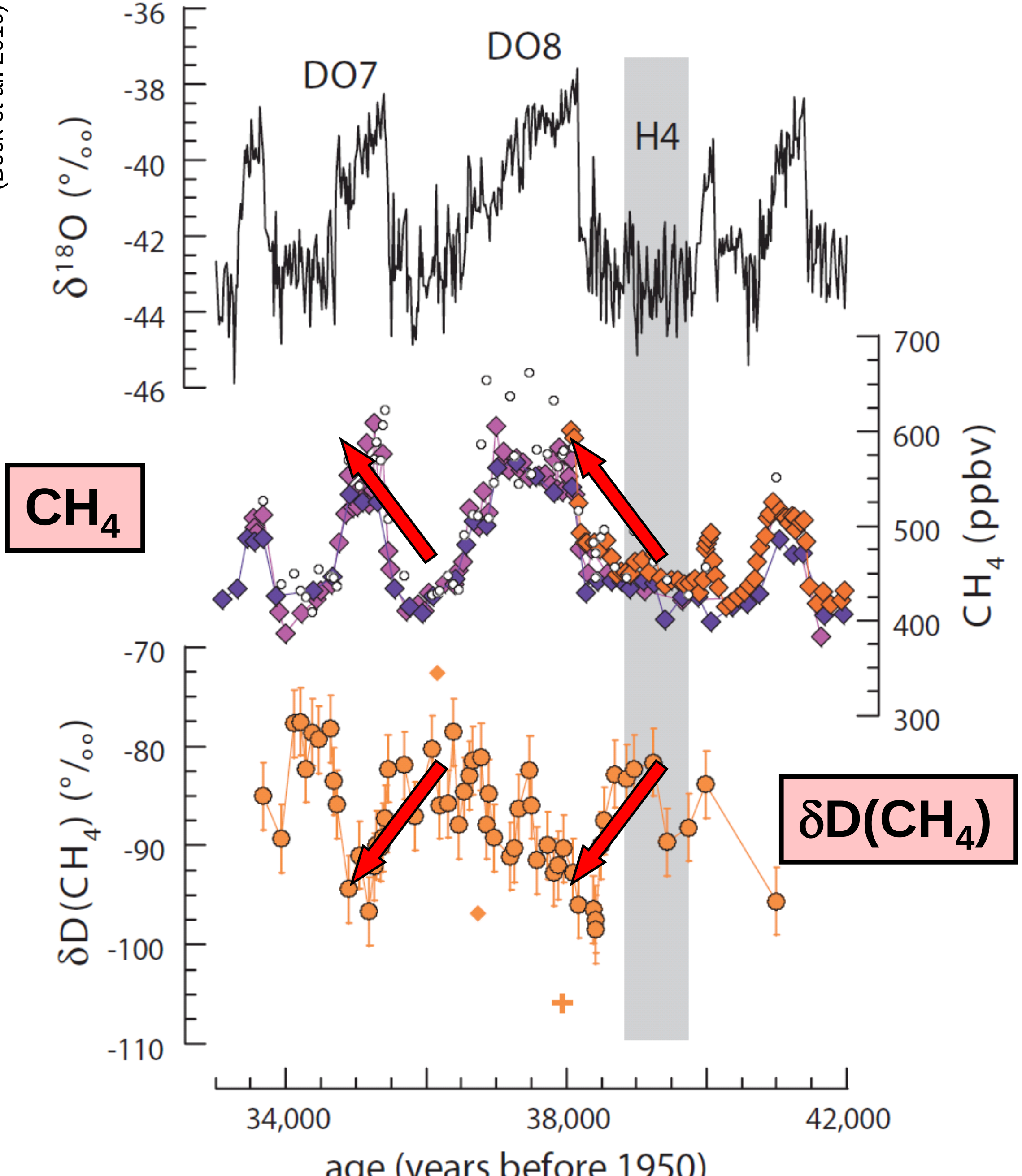
Interpolar Difference

release from tropics dominant

(Bock et al. 2010)



Isotopic signal of CH_4

fingerprint of

boreal wetlands

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Conclusions

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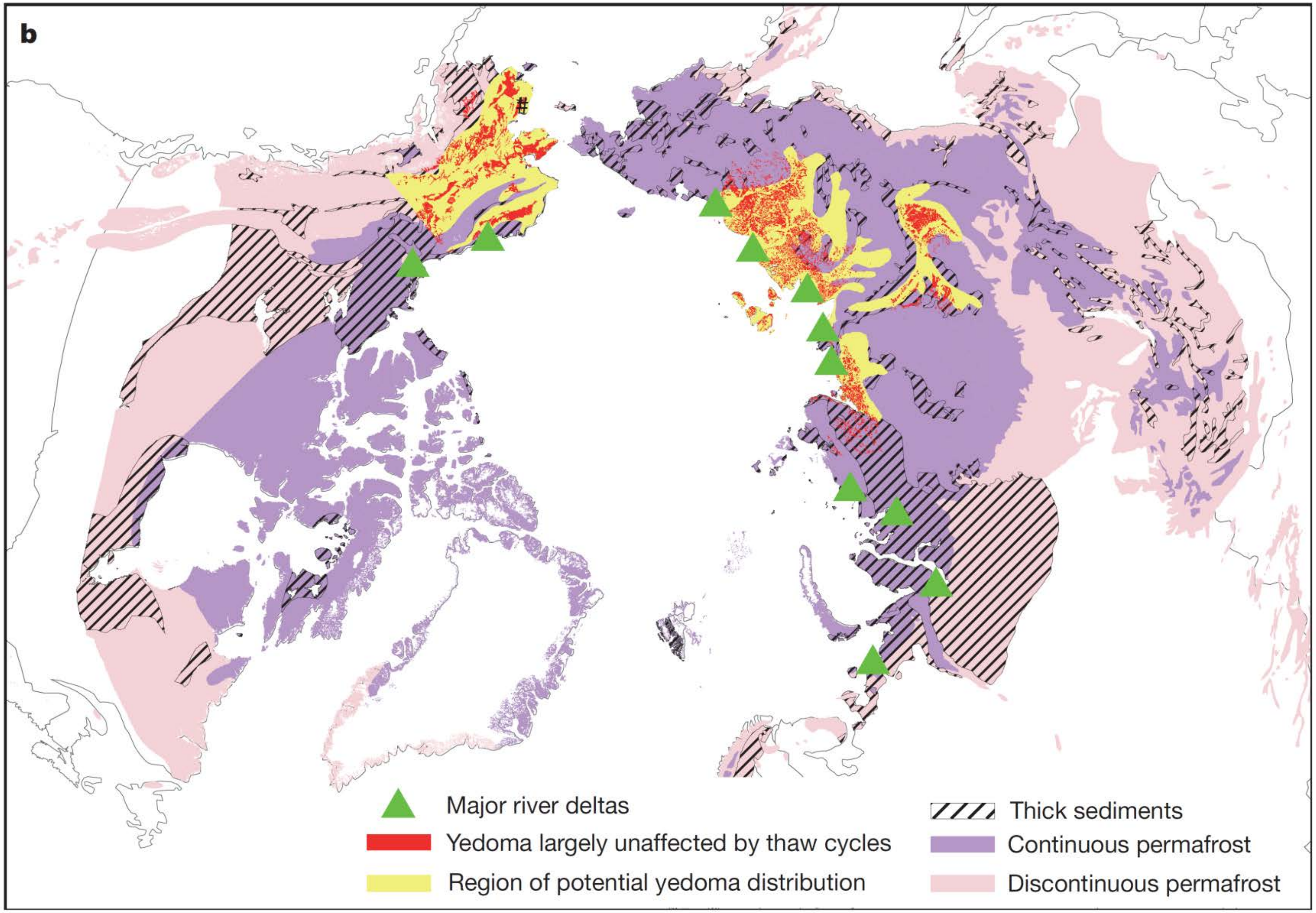
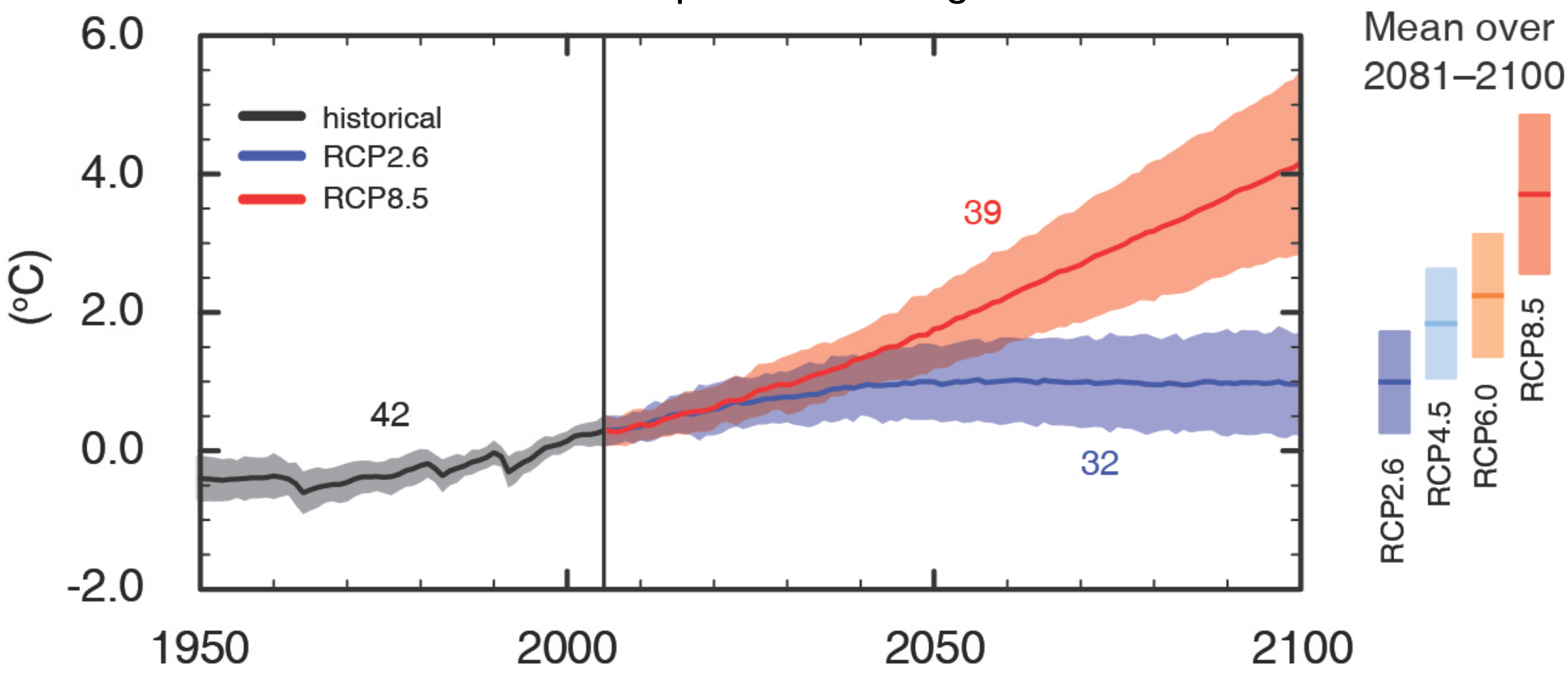
- IPCC 2013: Overall, there is *medium confidence* that emissions of CH_4 from wetlands are *likely* to increase in the future under elevated CO_2 and warmer climate.
- There is no indication currently, that carbon release will be catastrophic, neither from land nor from the ocean.
- Ocean warming releases negligible amounts of carbon from hydrates.
- Models do not consider carbon sequestration due to peatland growth in a warmer and wetter climate.
- Models remain incomplete and observations are limited in space and time. **Large uncertainties persist.**

Carbon storage in Northern Hemisphere high latitudes

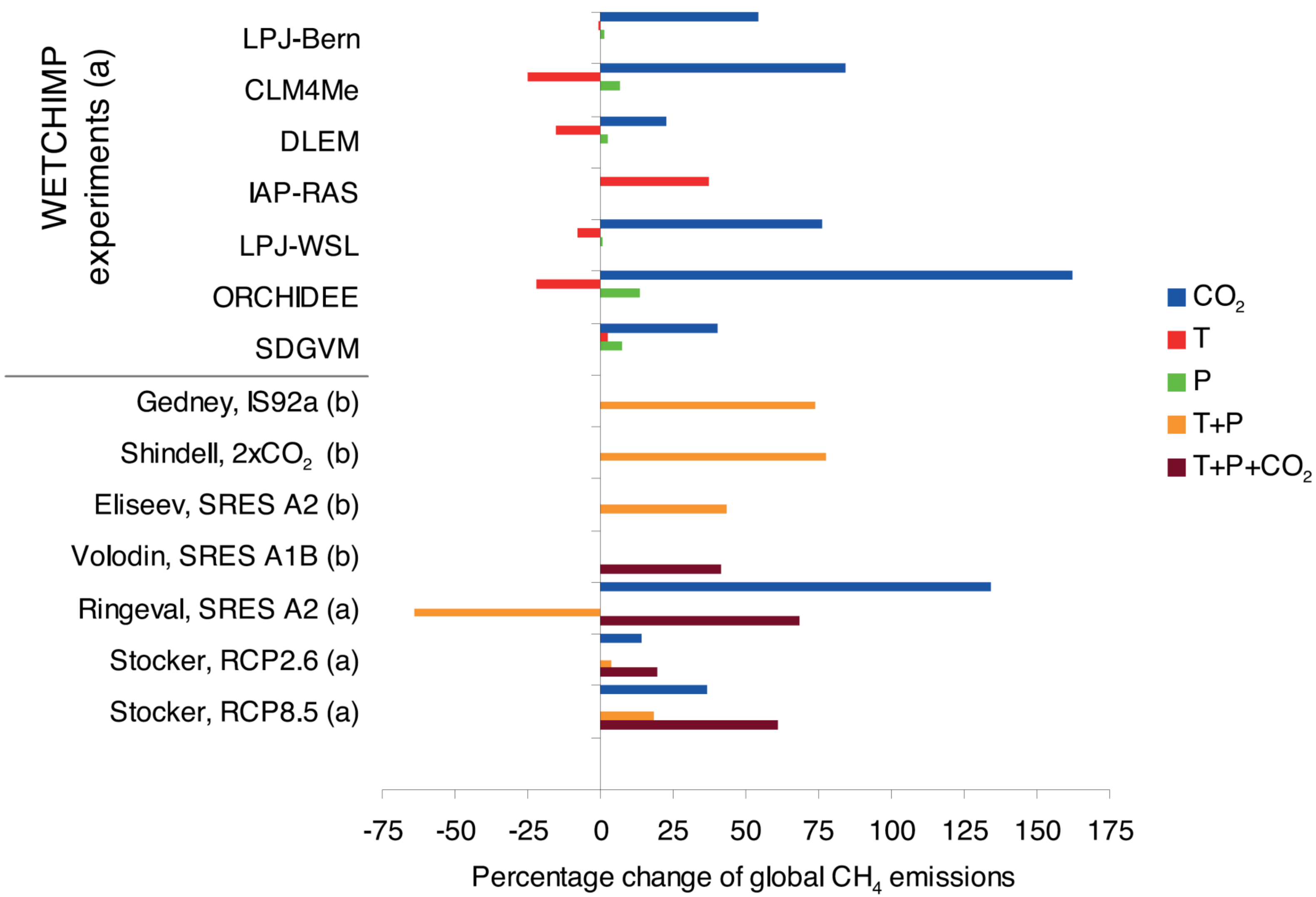


Global mean surface temperature change from 1986-2005

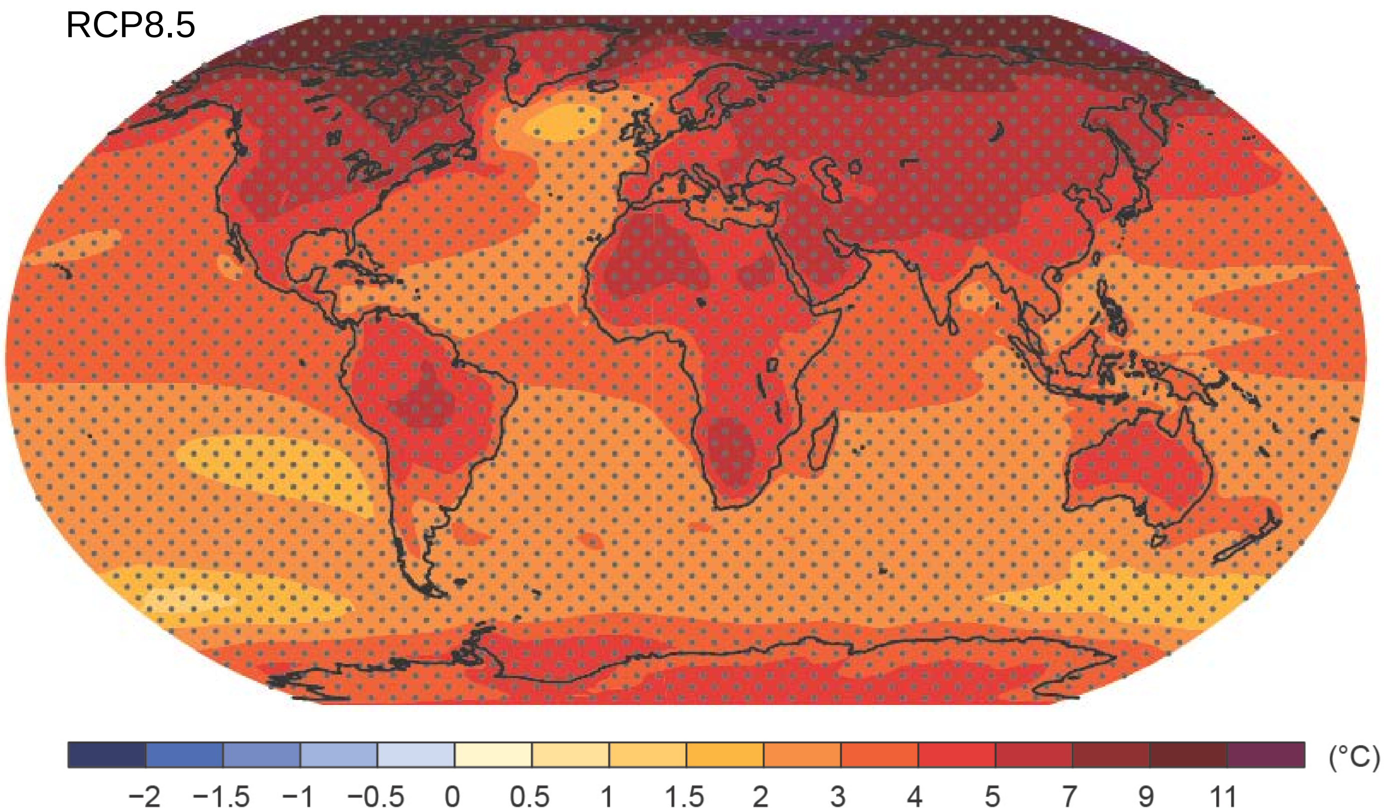


IPCC 2013, Fig. SPM.7a

Continued emissions will cause further warming and changes in all components of the climate system.


WETCHIMP experiments (a)
LPJ-Bern
CLM4Me
DLEM
IAP-RAS
LPJ-WSL
ORCHIDEE
SDGVM
Gedney, IS92a (b)
Shindell, 2xCO_2 (b)
Eliseev, SRES A2 (b)
Volodin, SRES A1B (b)
Ringeval, SRES A2 (a)
Stocker, RCP2.6 (a)
Stocker, RCP8.5 (a)
-75 -50 -25 0 25 50 75 100 125 150 175
Percentage change of global CH_4 emissions
CO_2
T
P
T+P
T+P+CO_2

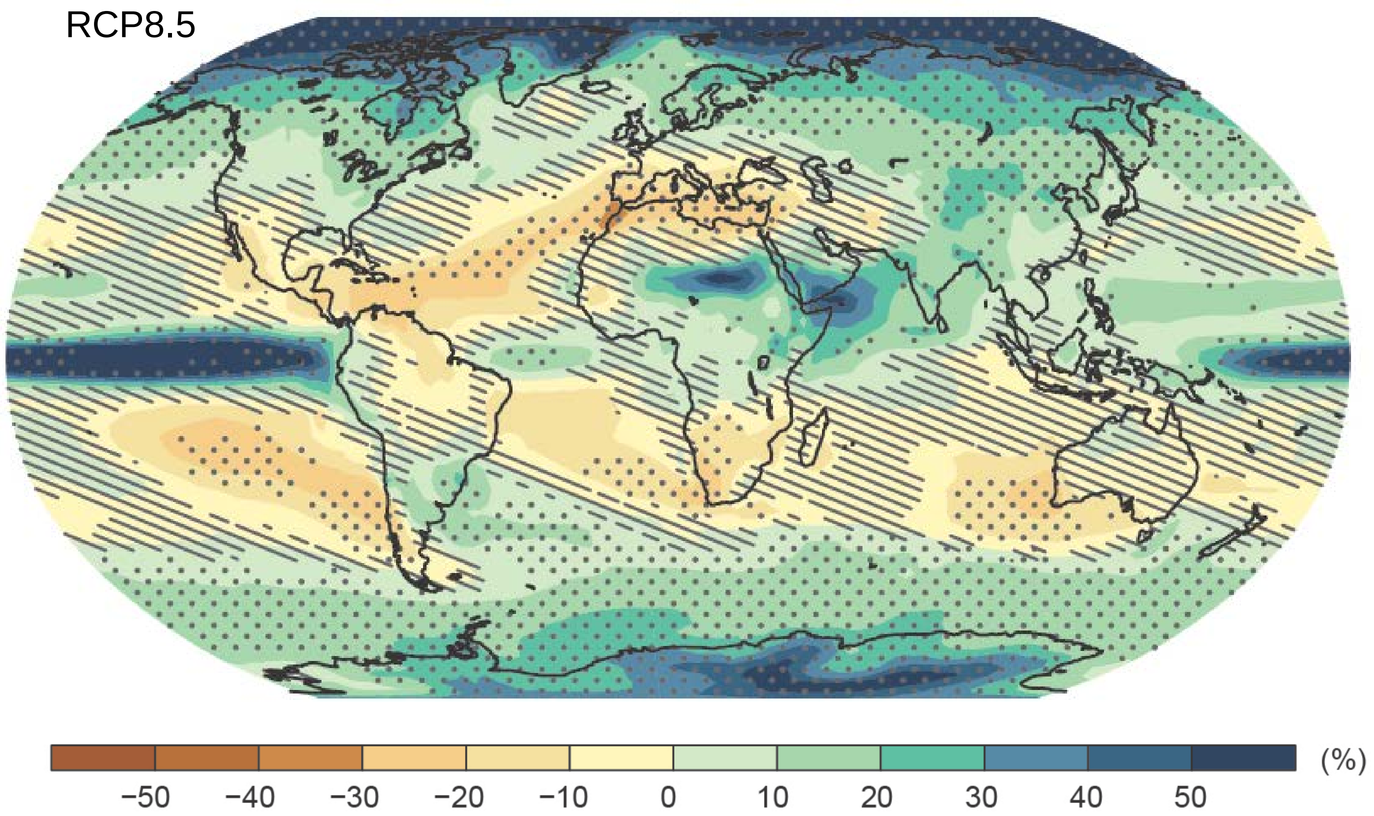
Change in average surface temperature (1986-2005 to 2081-2100)



IPCC 2013, Fig. SPM.8a

Continued emissions will cause further warming and changes in all components of the climate system.

Change in average precipitation (1986-2005 to 2081-2100)



IPCC 2013, Fig. SPM.8b

The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, [...]

Anthropogenic methane sources (2000s)

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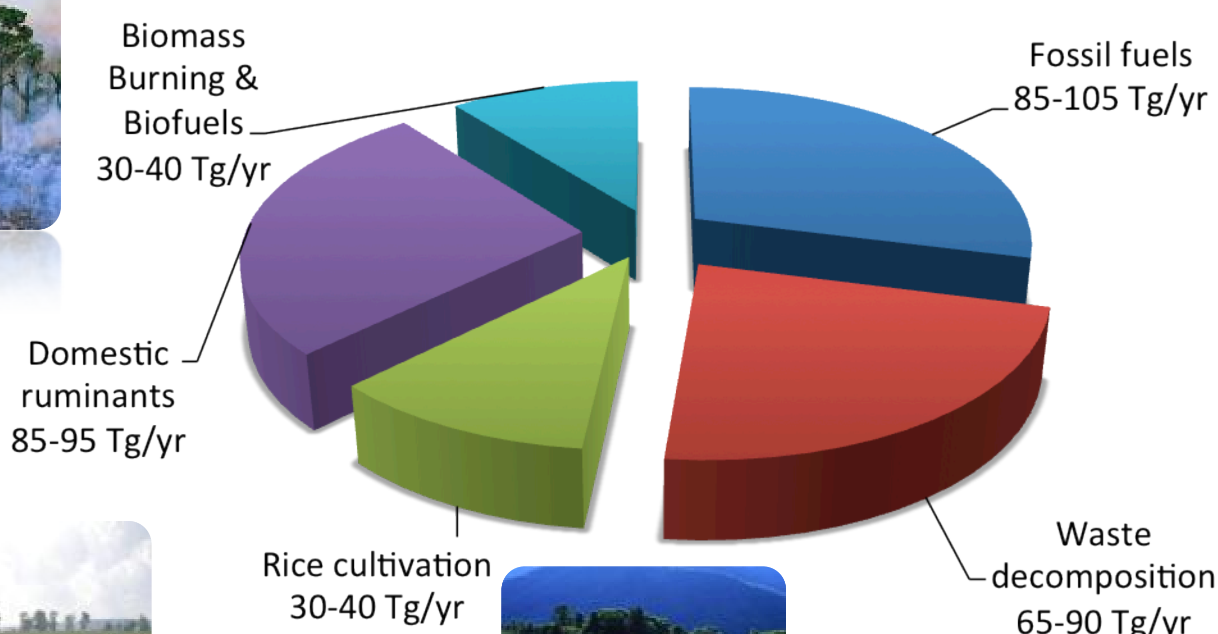
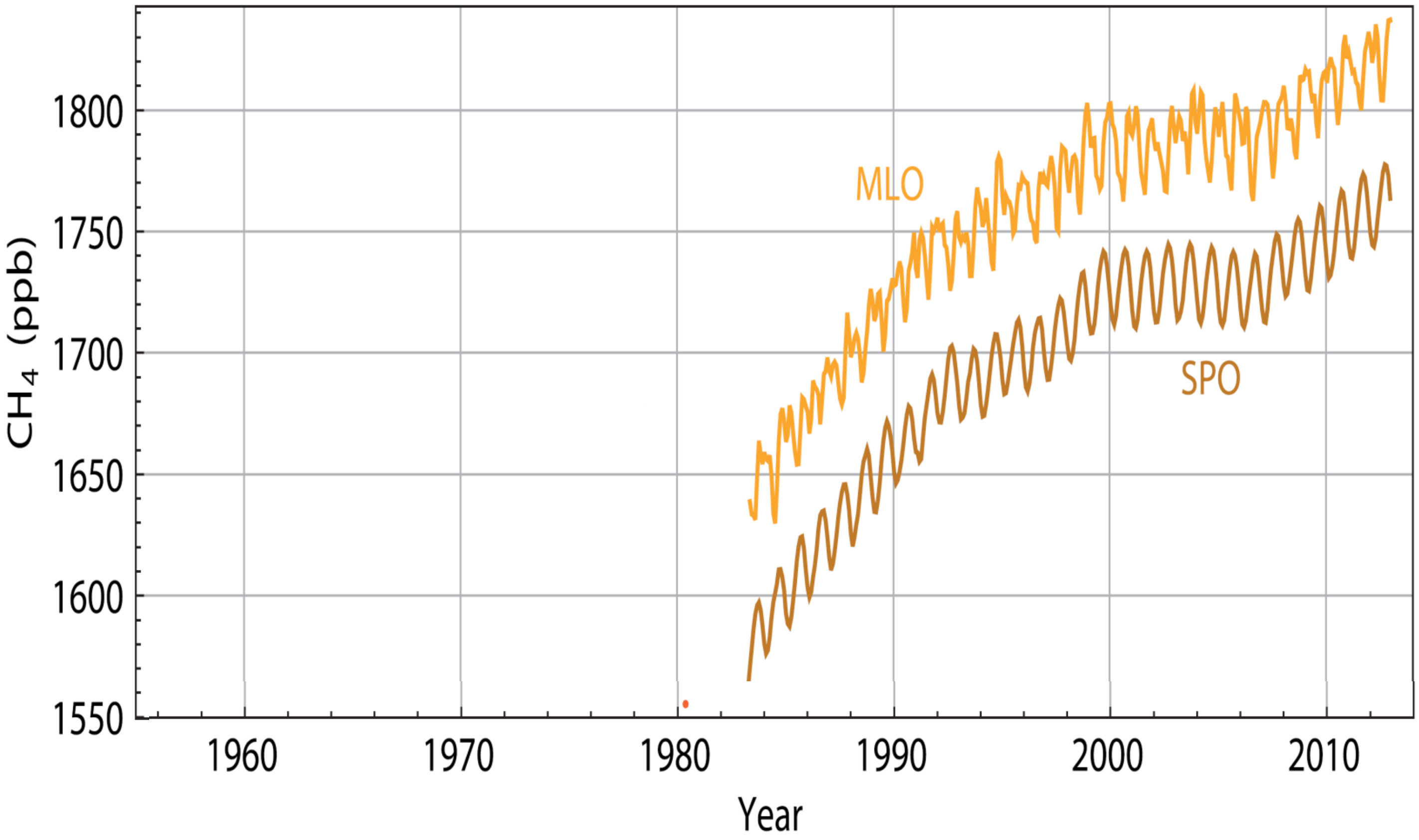


Global Carbon Project 2013; Figure based on Kirschke et al. 2013

The "methane pause" from 1998 to 2006



(IPCC, 2013, Fig. 6.3d)