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Mitigating Methane

Irreversible changes in the global CH_4 cycle under the heavy-mitigation SSP1-2.6 scenario

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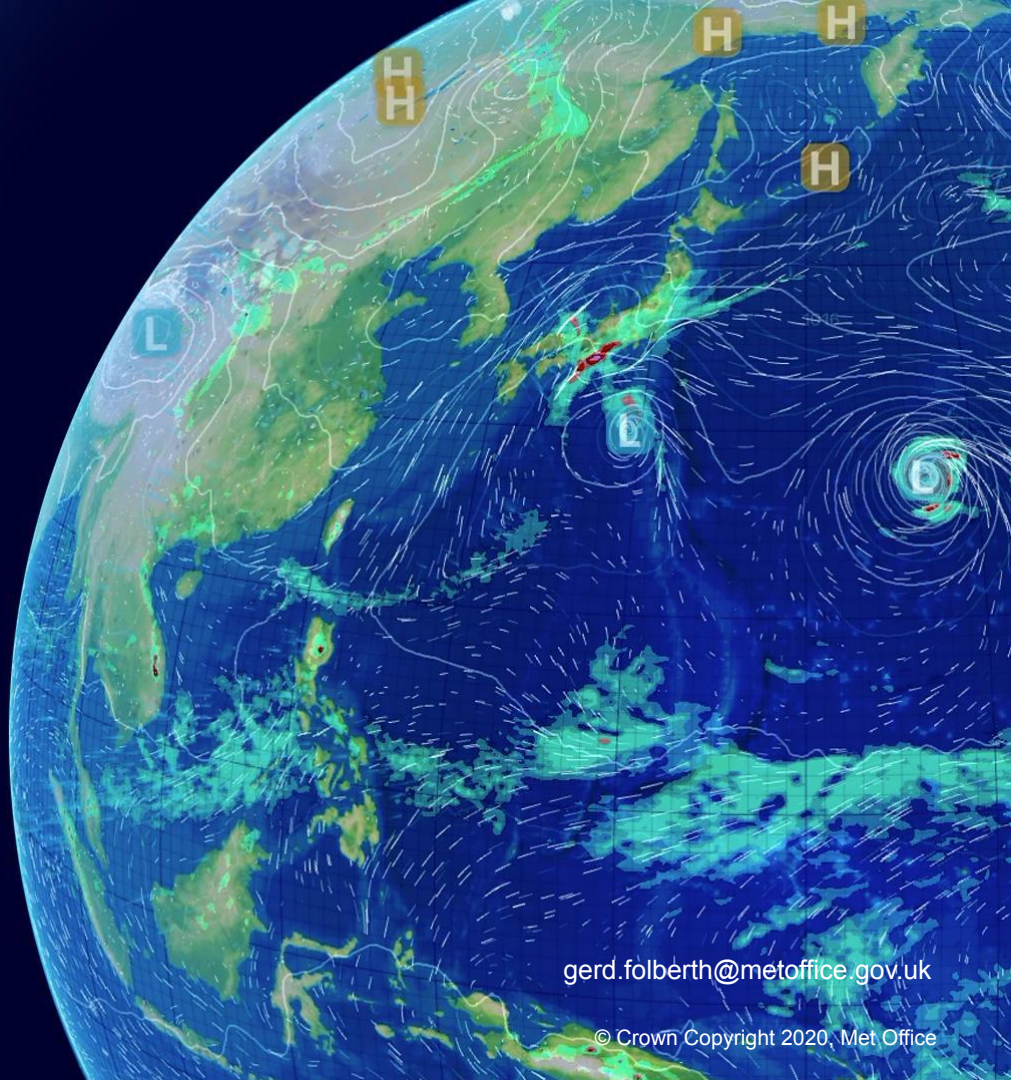

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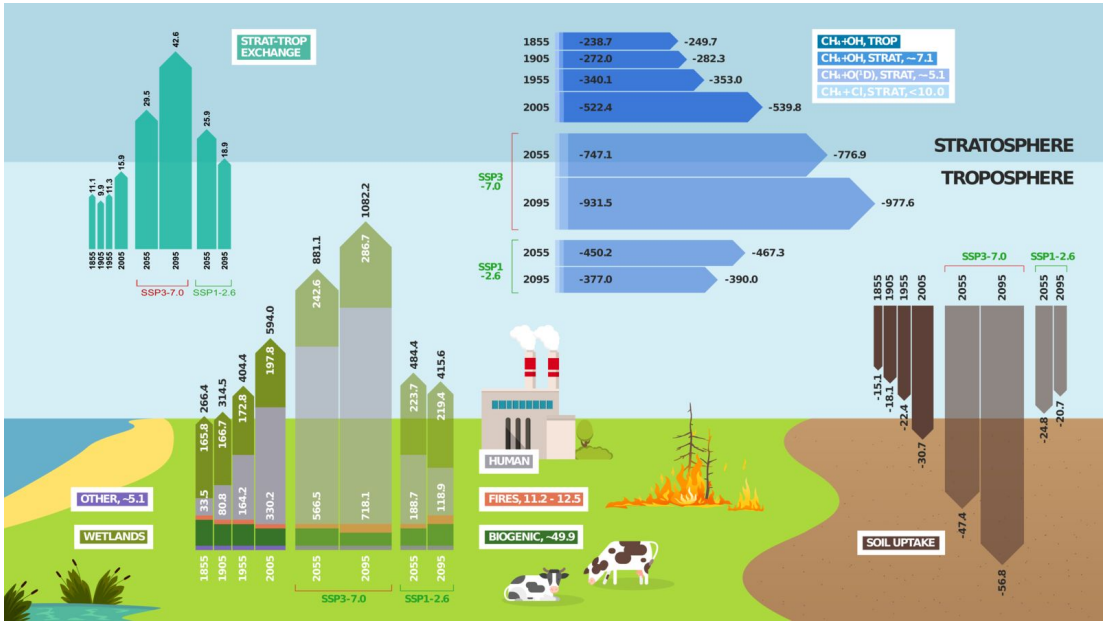
CH_4 Emissions Driven UKESM



Motivation: *Produce an interactive, fully coupled model of the methane cycle for process and mitigation research*.

UKESM 1.0 release configuration:

– prescribed CH_4 surface mole fractions

+ interactive CH_4 wetland emissions (cpld. to UKCA)

+ CH_4 prescribed anthropogenic and fire emissions

+ CH_4 soil uptake

+ residual CH_4 surface exchange flux diagnostic

250-Year Transient Simulation:

- PI-control simulation
- 3-member historic ensemble (1850-2014)
- SSP3-7.0 scenario simulation (2015-2100)
- SSP1-2.6 scenario simulation (2015-2100)

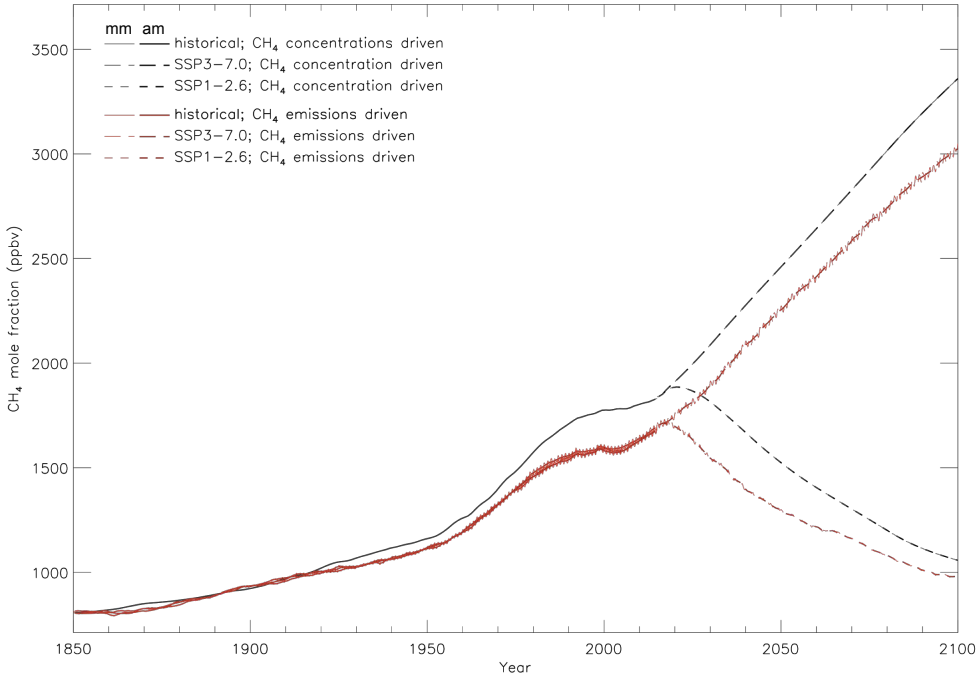
CH_4 Surface Mole Fraction – 1850 to 2100

CH_4 concentration-driven configuration
CH_4 emissions-driven configuration

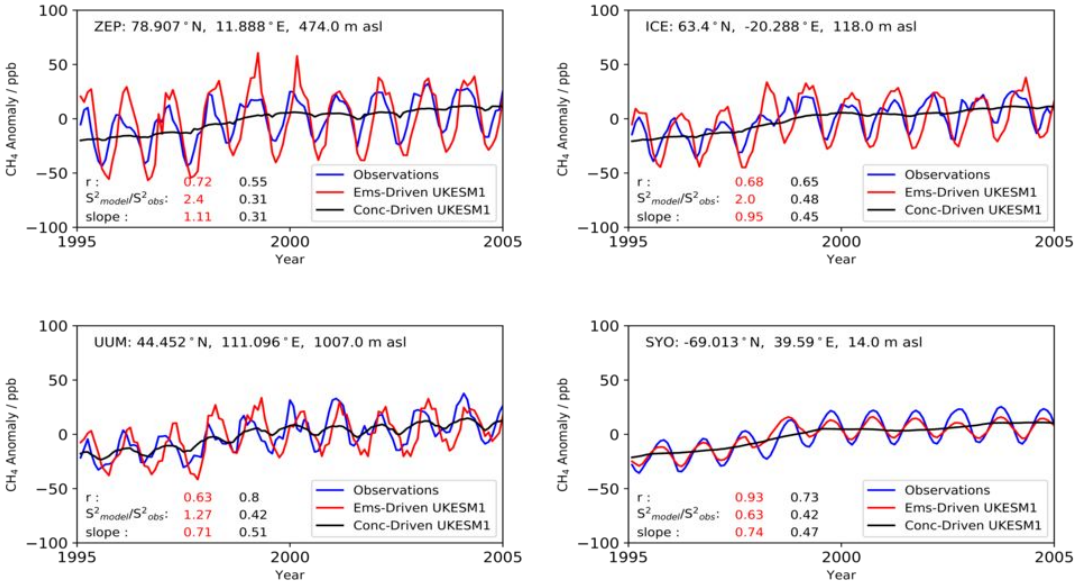
$\Delta CH_4(PI \rightarrow PD)$ = ~1,100 ppb
$\Delta CH_4(PI \rightarrow PD)$ = ~900 ppb

$Error_{\Delta(PI \rightarrow PD)}$ in 2014: approx. -200 ppb
$\%Error_{\Delta(PI \rightarrow PD)}$ in 2014: approx. -20%

similar CH_4 lifetime in both configurations



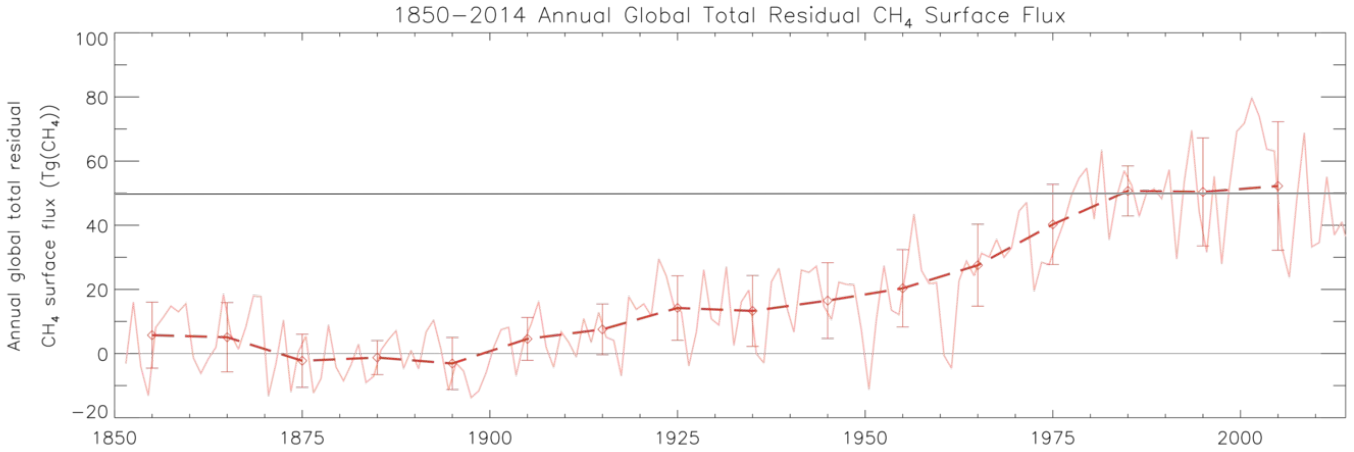
CH_4 Surface Mole Fraction Anomalies



observations: monthly mean flask CH_4 data (1995 to 2005) from NOAA GML Carbon Cycle Cooperative Global Air Sampling Network (Dlugokencky, E.J., et al., 1983-2019, Version: 2020-07, https://doi.org/10.15138/VNCZ-M766, 274 2020).

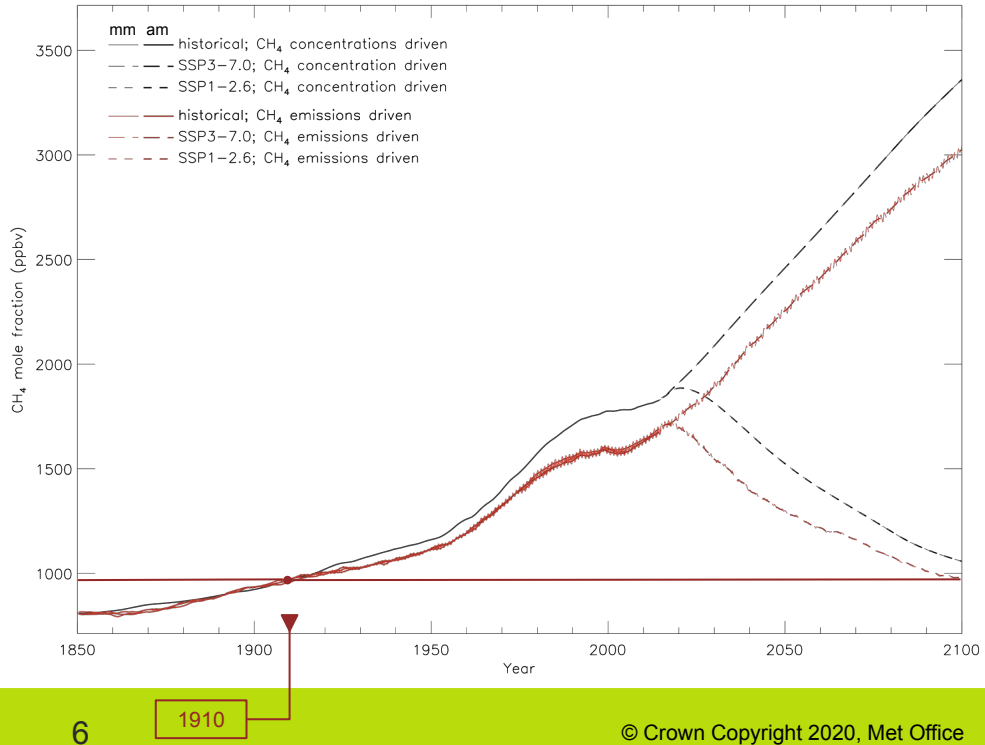
Residual CH_4 Surface Exchange Flux

$[CH_4]_{prsc.}$ - $[CH_4]_{inst.}$ → Δ_{CH4} (kg kg^{-1}) → F_{CH4} (kg m^{-2} s^{-1})



CH_4 Recovery under SSP1-2.6

	Atmospheric Methane Content	
	surface mole fraction	whole atmosphere burden
1910s	986 ppb	2675 Tg
2090s*	992 ppb (+1%)	2750 Tg (+3%)
	Main Methane Sources (Tg/yr)	
	wetlands	anthropogenic
1910s	169.3	91.6
2090s*	219.4 (+30%)	118.9 (+30%)
	Main Methane Sinks (Tg/yr)	
	CH_4+OH✦	Soil Uptake
1910	-287.7	-18.7
2090s*	-384.1 (+34%)	-20.7 (+11%)



*for SSP1-2.6
✦whole atmosphere

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Conclusions & Outlook

- We have developed a methane emissions-driven UKESM configuration
- This prototype version compares reasonably well with observations
- We show that even under aggressive mitigation options (SSP1-2.6) a complete reversal of the perturbations to the methane cycle since PI is unlikely. Methane still remains an excellent mitigation target.
- Emissions-driven methane cycle will become standard in future releases of UKESM (UMESM1.1, UKESM2.0)