Improved isotopic characterisation of methane emissions from biomass burning

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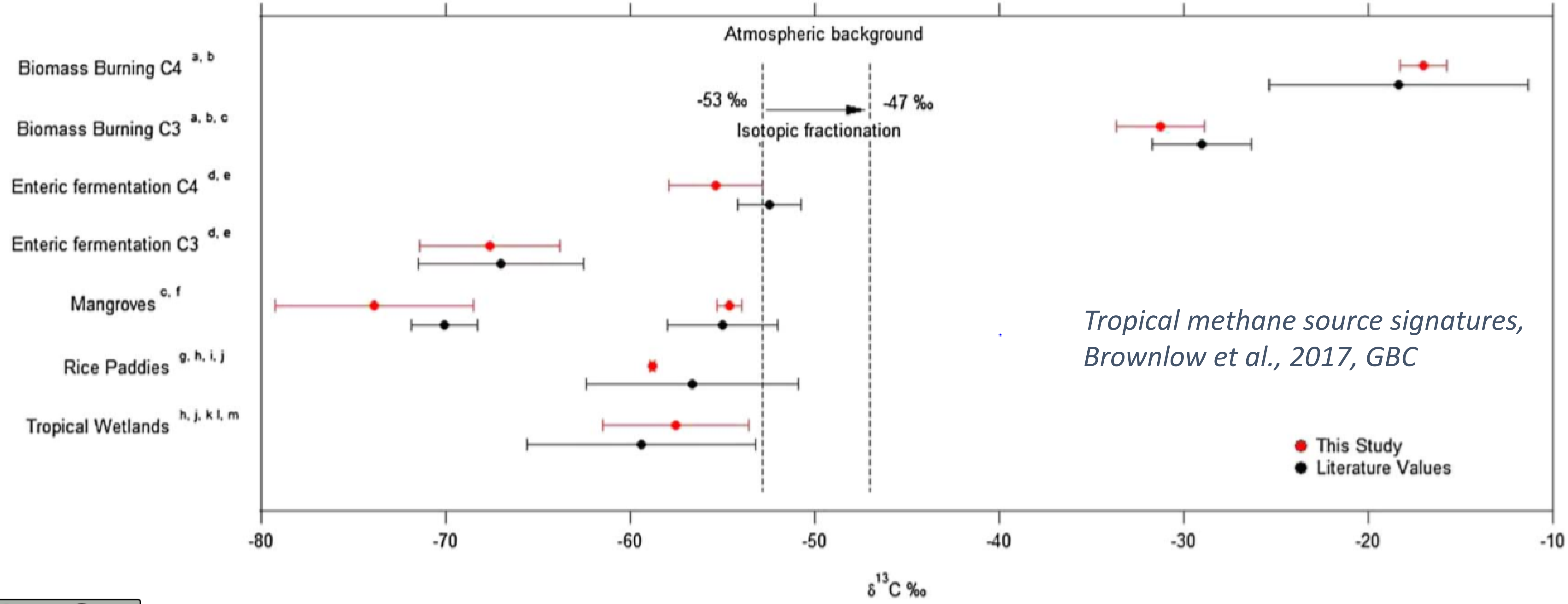
Methane δ^{13}C isotopic source signatures

Most methane isotopic source signature measurements are from local scale ground based measurements of individual sources.

Biomass burning methane emissions are very enriched in ^{13}C compared with other methane sources.

Large range in isotopic signatures - can we constrain these better for global modelling?

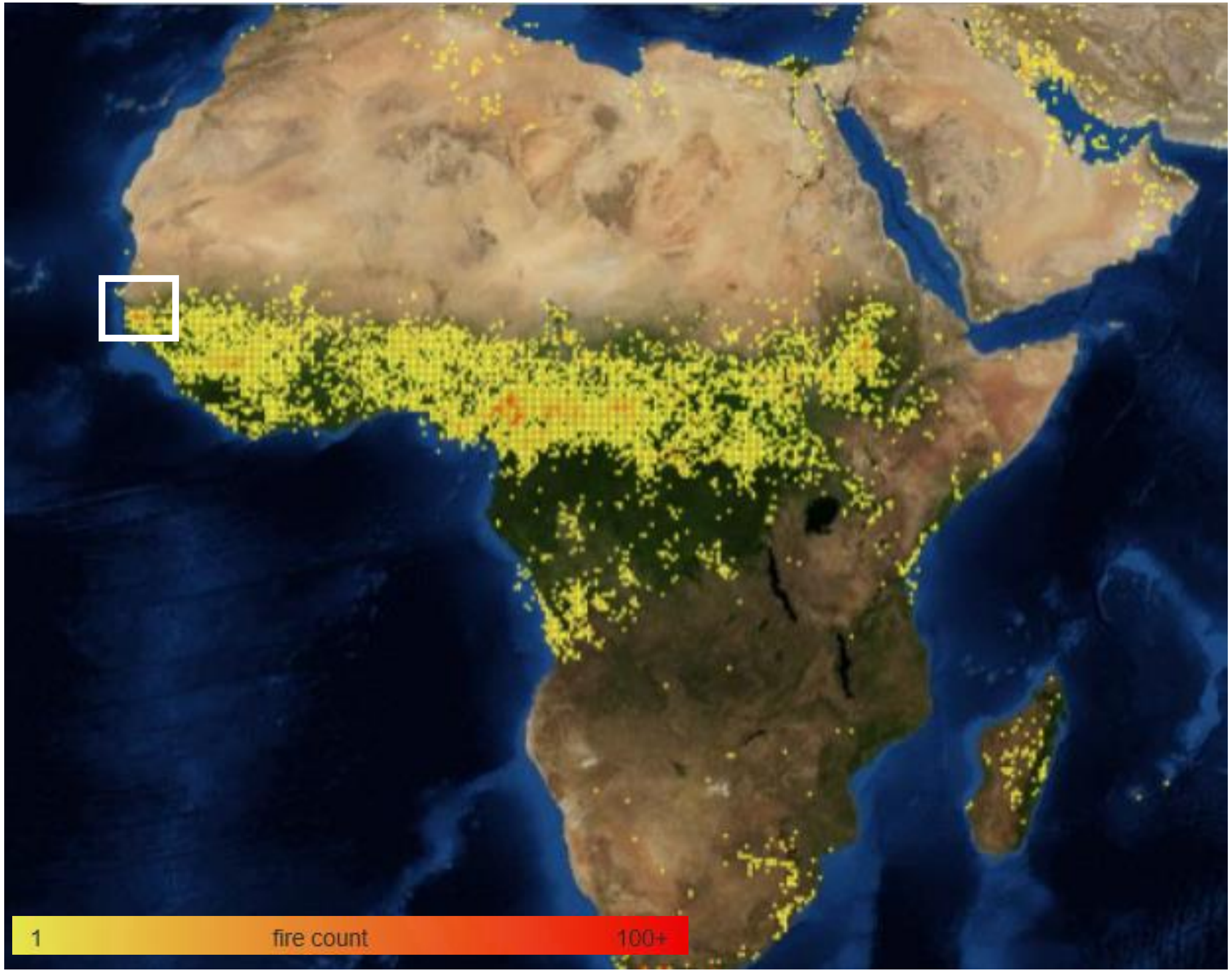


Tropical methane source signatures, Brownlow et al., 2017, GBC

Flight campaigns (FAAM)

- Methane emissions in Senegal and Uganda have recently been studied using the FAAM Bae 146 research aircraft.
- Onboard instrumentation included real time measurements of meteorology and mole fractions of CH_4 and CO_2 (LGR FGGA), C_2H_6, CO and O_3.
- Whole air sample (WAS) flasks for VOCs (Univ. York) and methane $\delta^{13}C$ using GC-IRMS (RHUL)

Senegal flight campaign, February/March 2017

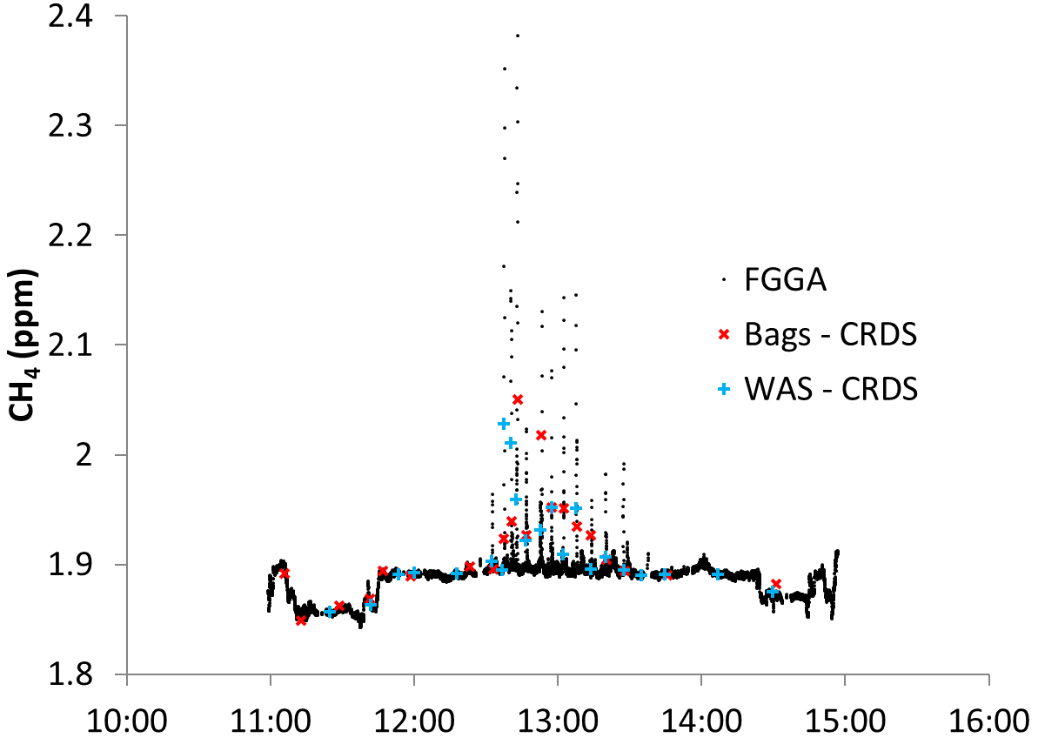


Aimed to quantify and isotopically characterise emissions of methane from biomass burning using airborne measurements.

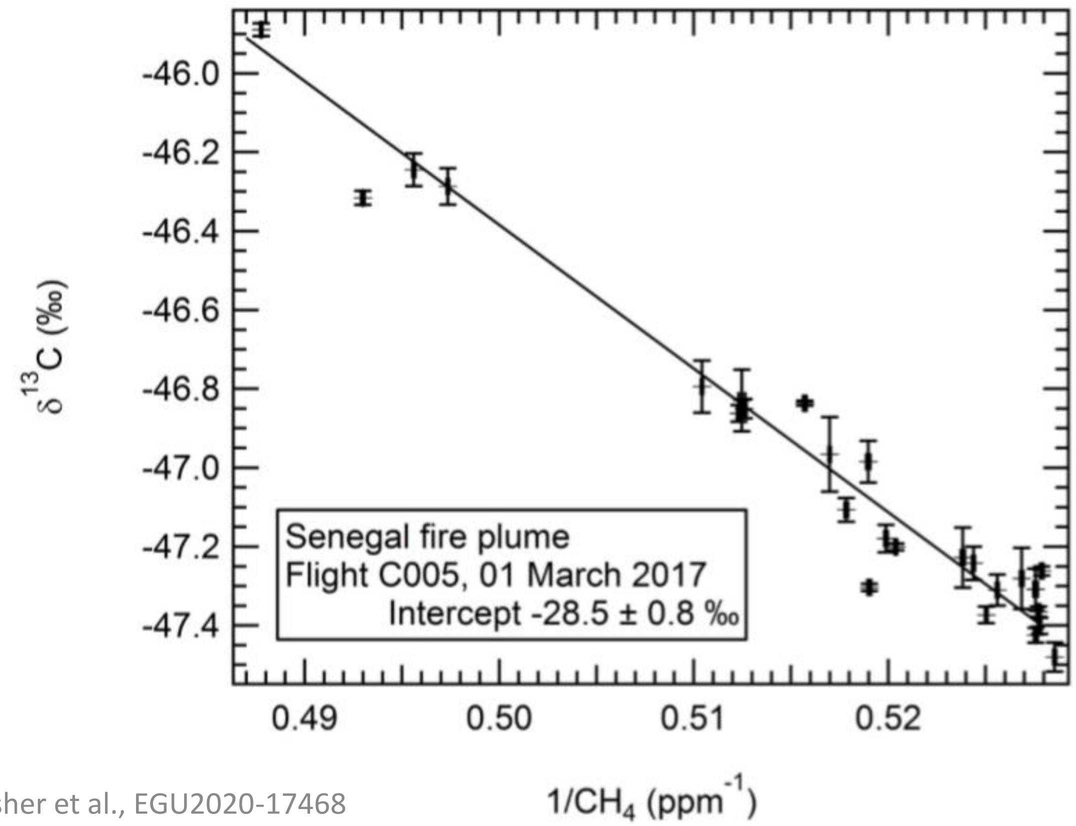
Modis fire map (VIIRS) for 28/2/17 to 01/3/17

Senegal: Identifying isotopic signature of the methane plume

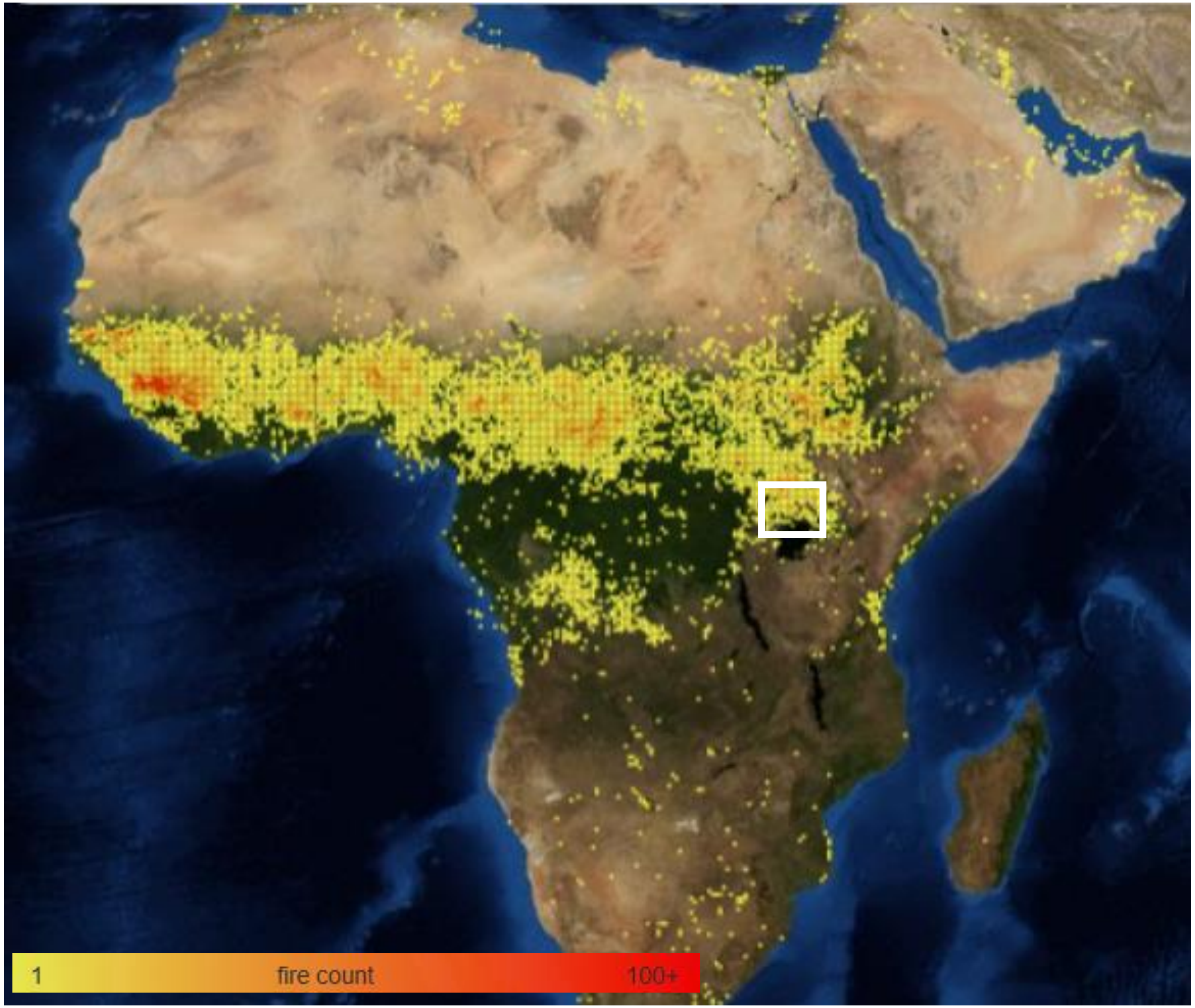
Air samples were collected in the CH_4 peaks for later isotopic analysis



- Keeling plots are used to identify the isotopic signature of methane elevations observed during the flight.
- y axis intercept is the source signature of emissions.
- In this case the methane source (Savannah biomass burning) had an isotopic signature of -28.5 ± 0.8‰ (predominantly C3 vegetation burning)



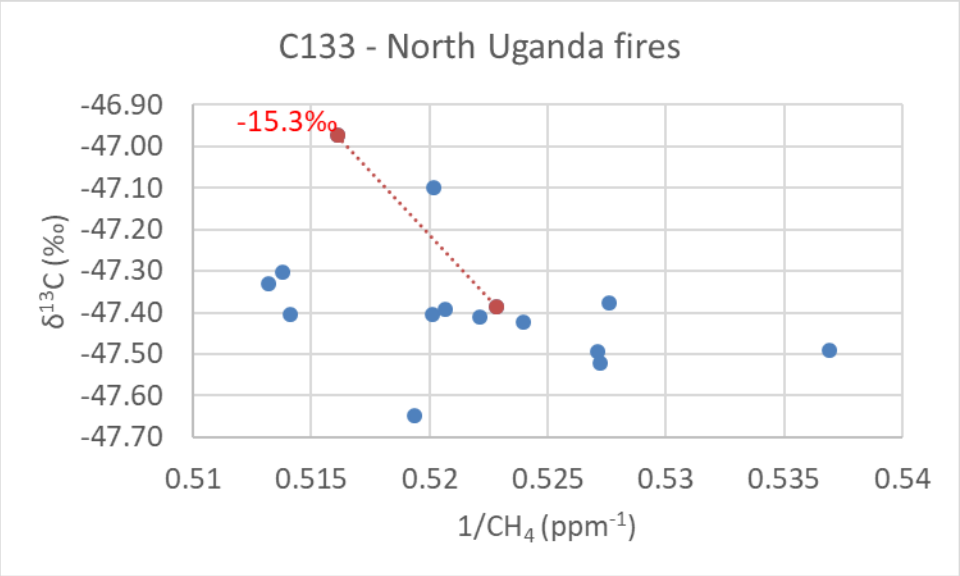
Uganda flight campaign, January 2019

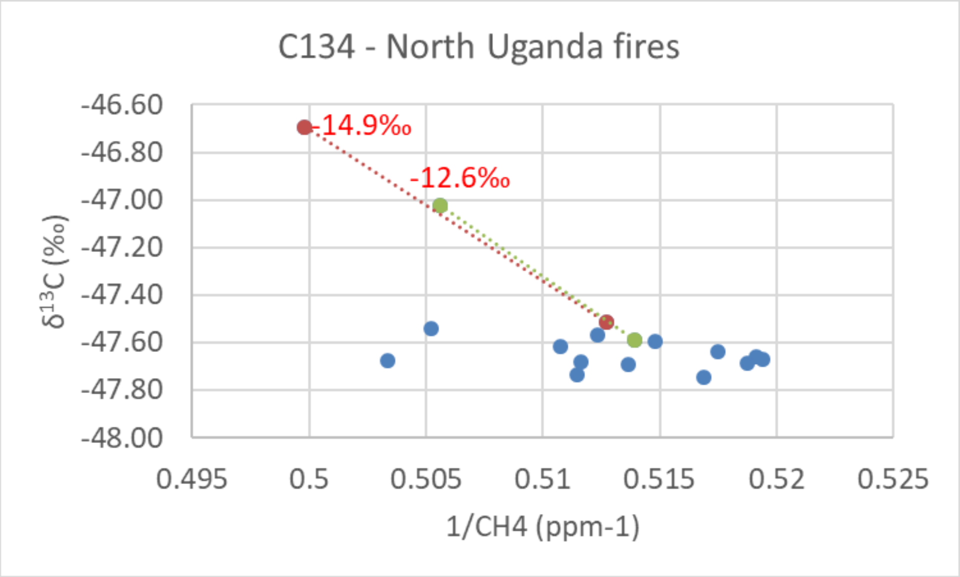


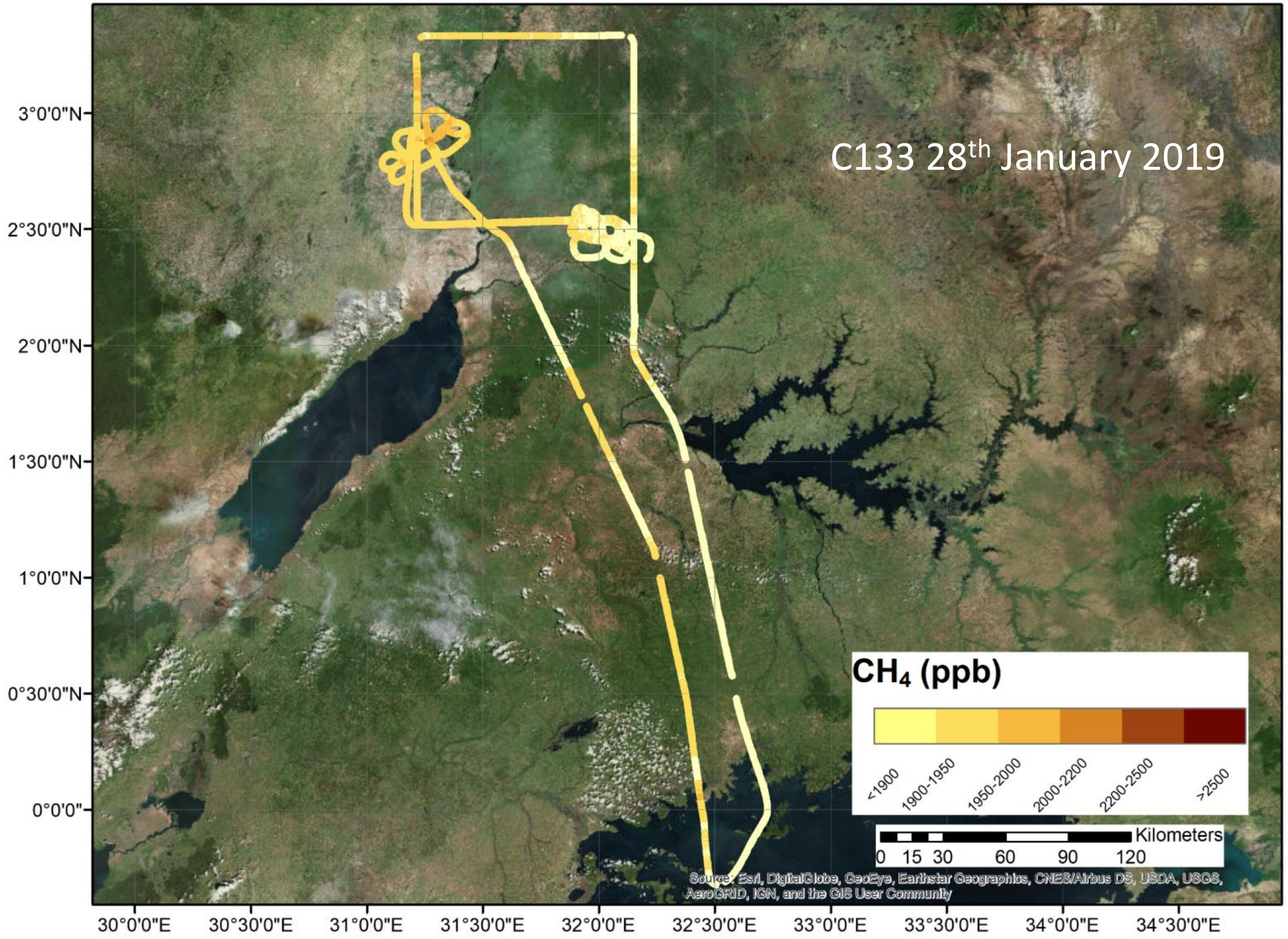
Modis fire map (VIIRS) for 27/1/19 to 28/1/19

Aimed to identify and isotopically characterise sources of methane in Uganda (wetland and biomass burning) using airborne measurements

Northern Uganda fires







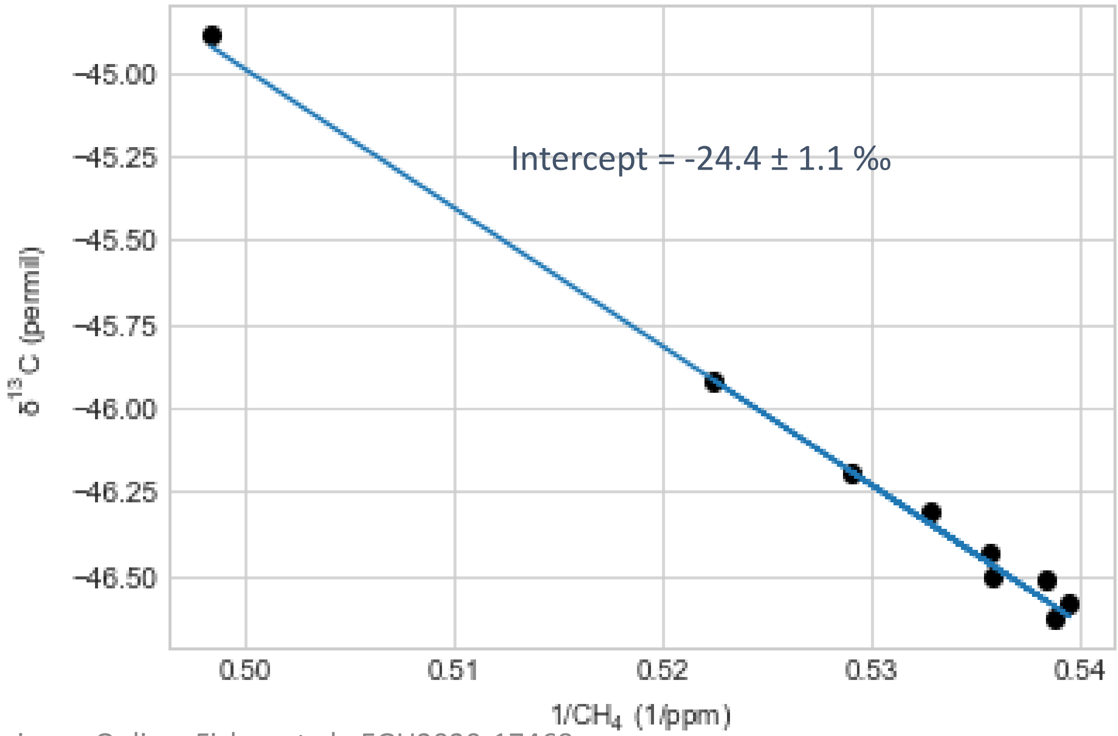
Mix of methane sources (fires and wetland). 2 point plots used to identify signature for fire plumes (with background point collected just outside the plume)

More enriched isotopic signature than Senegal, suggests C4 vegetation burning?

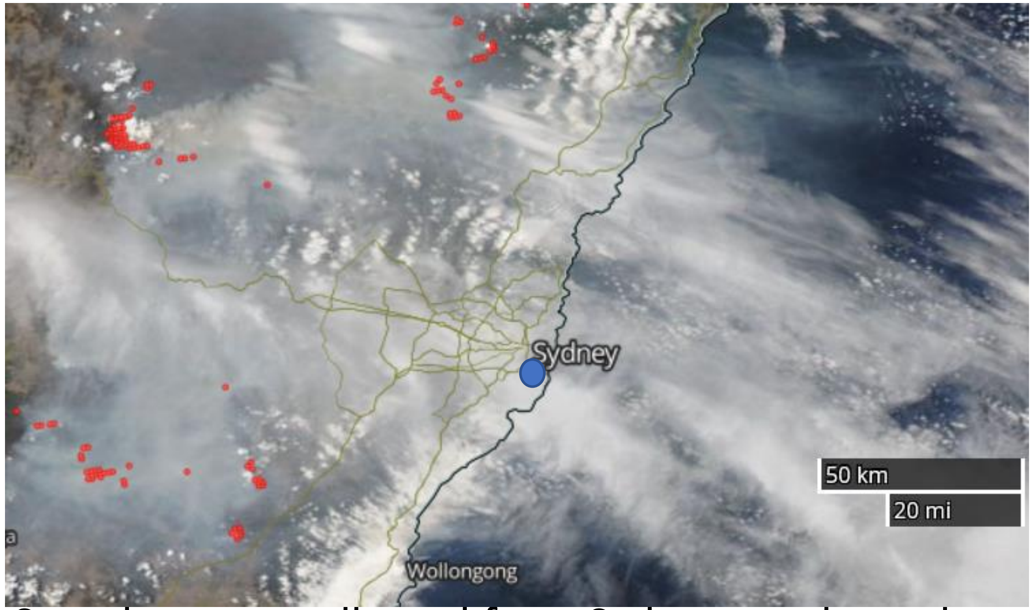
Ground based sampling of methane emissions from biomass burning

Air samples for methane isotopic characterisation have also been collected from the ground in methane plumes downwind of fires

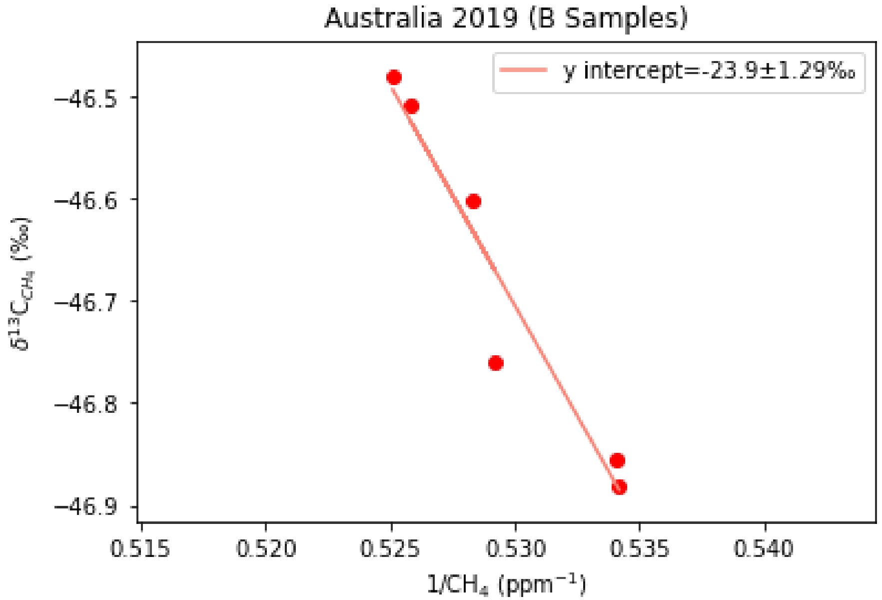
e.g. Pilliga, NSW, Australia – close to source. Samples collected in February 2016.

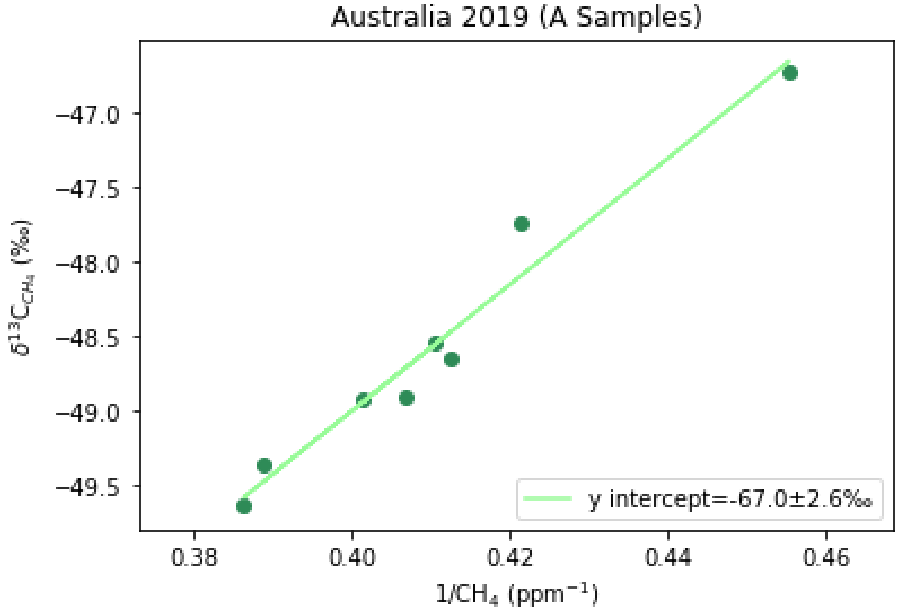


December 2019 fires, NSW Australia



Left NASA EOSDIS Worldview map for 12th December 2019 (Aqua/MODIS corrected reflectance and fire map). The sampling site is shown by the blue circle.





CH_4 Keeling plots for Sydney on 2nd December 2019 (Set B, top) and 12th December 2019 (Set A, bottom)

Samples were collected from Sydney, on days when the smoke plumes from fires 50 to 100 km away came across the city.

Samples collected on 2nd December 2019 (set B) gave an isotopic signature of -23.9 ± 1.3 ‰, but the Keeling plot from 12th December 2019 was unexpectedly depleted in ^{13}C, showing a biogenic rather than combustion source signature.

We are looking into reasons for this. Did the thick smoke plume across the city trap more methane than usual from other sources in the boundary layer, or did transport affect the isotopic signature of the methane in the plume?

Conclusions

- Combustion sources of methane are very enriched in ^{13}C, so interannual differences in global emissions could cause shifts in global methane isotopic signature.
- Flight campaigns in Senegal in February/March 2017 allowed isotopic characterisation of methane in fire plumes. In Uganda (January/February 2019), fires and wetland were co-located so isotopic characterisation of fire plumes was more complicated.
- Ground based sampling was carried out downwind of Sydney fires in December 2019. Results require further investigation – both isotopically enriched and depleted methane plumes were identified.

Acknowledgements

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For more information about the project and blogs of recent field campaigns see:

https://moya.blogs.bris.ac.uk/

Twitter @moya_nerc

We acknowledge the use of imagery from the NASA Worldview application (https://worldview.earthdata.nasa.gov), part of the NASA Earth Observing System Data and Information System (EOSDIS).