Methane Source Attribution Challenges in the Surat Basin, Australia

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CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Oil and Gas Methane Science Studies

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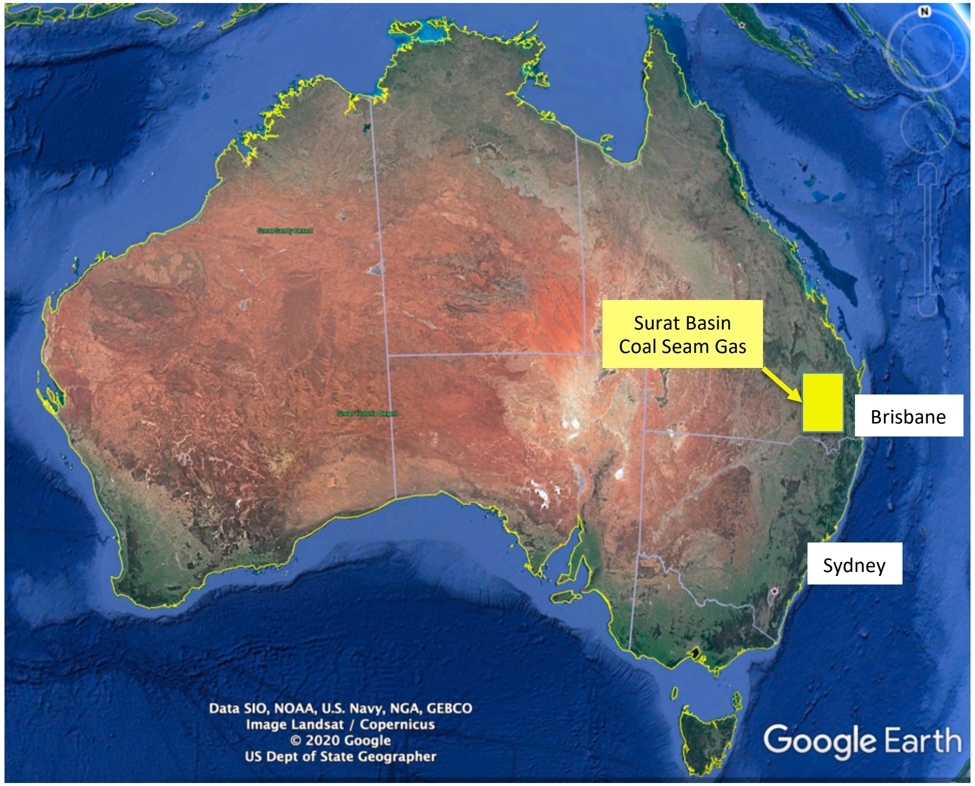
This project is part of the CCAC Methane Science Studies

Study Background



The Surat Basin is one of the largest coal seam gas (CSG) developments in the world. It is anticipated that when fully developed there will be over 20,000 CGS wells and supporting infrastructure. In 2018 the total gas produced was 8912 Mm^3. (data.qld.gov.au).

Our study area extends north west of Toowoomba and covers an area of approximately 200 km x 200 km.

There are limited emission data in the public domain:

- CSIRO Surat Basin tower inversion study (Luhar et al. 2018).
- Katestone bottom-up inventory (appendix Luhar et al. 2018).
- Ground-based measurement surveys (See Nisbet et al. (2020) for 2014 Google Earth displays of the methane emissions in the region. https://doi.org/10.1029/2019RG000675

Study Aim

- Our overall aim of the CCAC Methane Science Study in the Surat Basin is to quantify the methane emissions from coal seam gas production and processing. However, in the Surat Basin there are many sources of methane. The primary source of methane based on the 2018 CSIRO / Katestone study is cattle (a combination of feedlot and grazing cattle). See Luhar et al. (2018).

- To correctly apportion methane emissions to each sector from our airborne measurements we need to be able to separate contributions from all sources. This is being achieved using a combination of:
    - Ground surveys using a car-mounted LGR greenhouse gas analyzer
    - Airborne surveys using a wing-mounted LGR greenhouse gas analyzer
    - Isotopic chemical analyses of ground and airborne collected air samples

- We have also collated our own bottom-up inventory using IPCC and Australian Government emission factors applied to public domain production data for gas, coal, agricultural and urban sources. This inventory was tabulated to guide both the airborne- and ground-based studies.

- This presentation covers how we characterized the isotopic chemistry of methane for all primary sources and demonstrates the need for comprehensive quality control steps.

- During spring in Queensland the ground surface is rapidly warmed after sunrise. The warm ground heats the air near the ground surface and this air rises rapidly and mixes with the fresh background air (mean [CH_4] = 1.8015 ppm, 2*Std Dev = 0.0008. Established using 2500 LGR greenhouse gas analyzer measurements, calibrated to CSIRO southern ocean air standard 1.80055 +/- 0.00007 ppm). **The maximum concentration recorded for our airborne collected grab bag samples was 1.864 ppm** (collected 130 m above a feedlot). **We show that with rigorous quality control we can use $\delta^{13}C\_CH_4$ and δD_CH_4 to assist with source apportionment.** The error in the reported δD is ± 1.5 ‰; in $\delta^{13}C$ ± 0.08 ‰ for the bag samples.

Background – Gas Wells

A tiny portion of the > 4000 wells in our region of study.

Background– Typical Gas Facilities

There are 27 CSG facilities: gas compressor stations and processing plants.

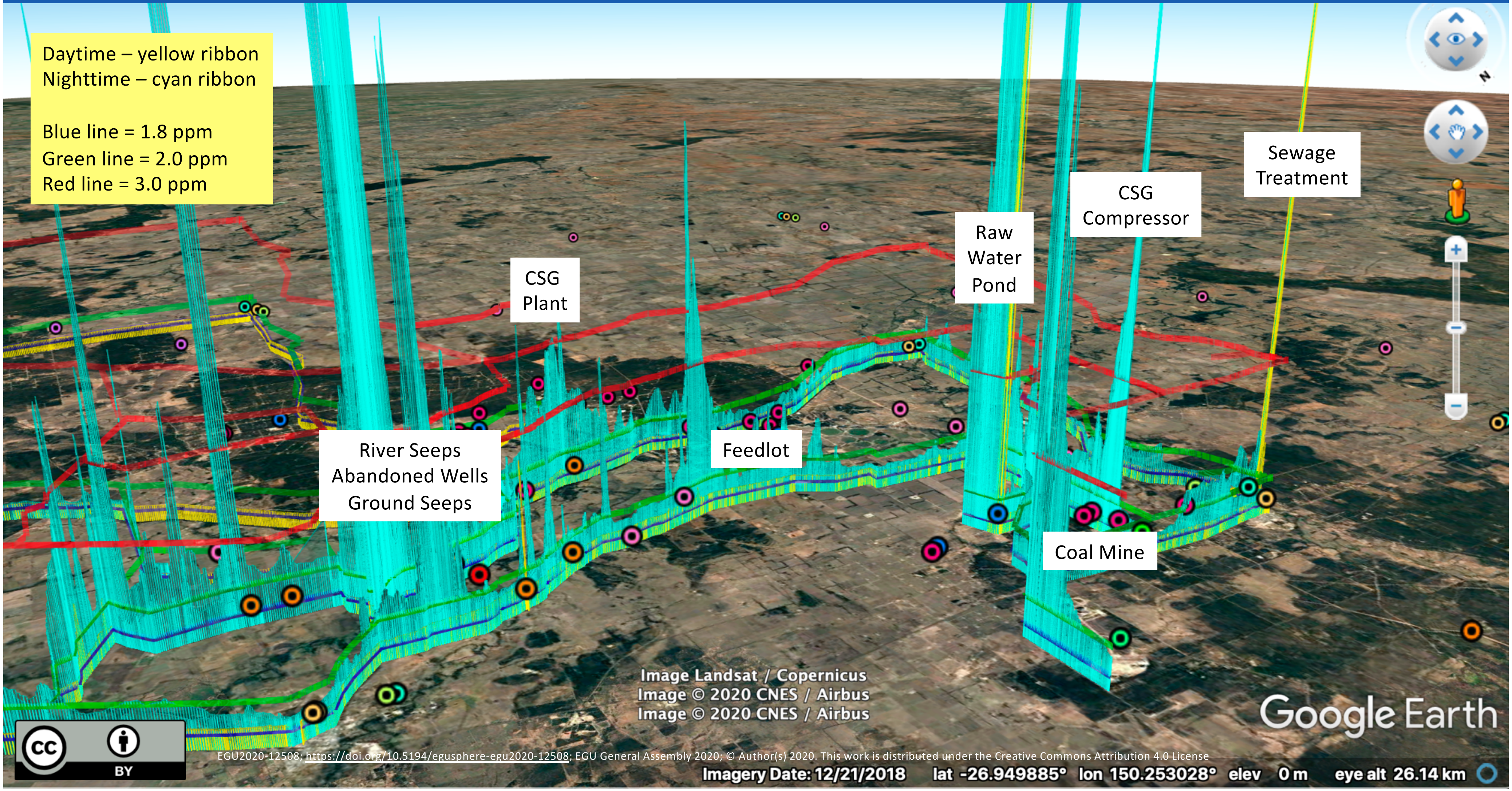
In addition to emissions from the CSG facilities, we have mapped emissions from the water pipeline high point vents and the raw water holding ponds.

Background – Feedlot

There are 55 cattle feedlots in the area. The largest feedlot can hold 70,000 animals.
Many of the feedlots use the groundwater produced in association with extracting the gas.

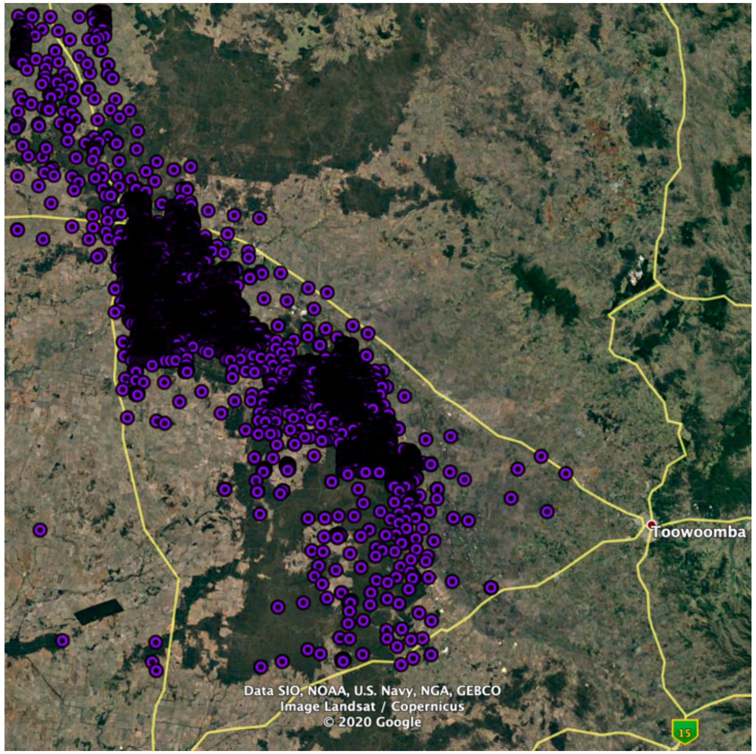
There are also 1.8 million grazing cattle throughout the region.

Many sources have high nighttime methane mole fraction plumes

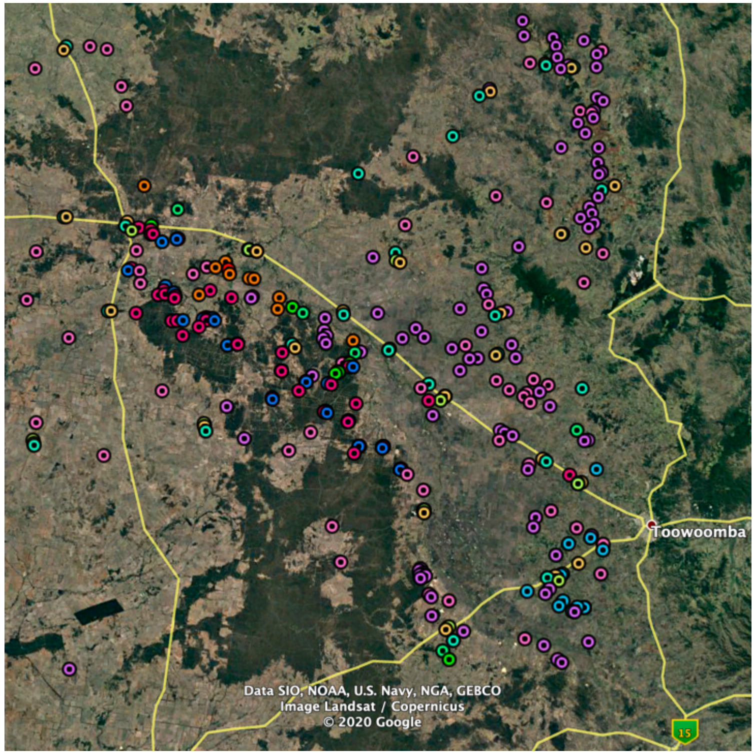


Inventory - Point Sources of Methane

Over 4600 wells have been drilled in the study region as part of exploration and development operations, and in 2018 there were approximately 1300 producing wells in the study area.

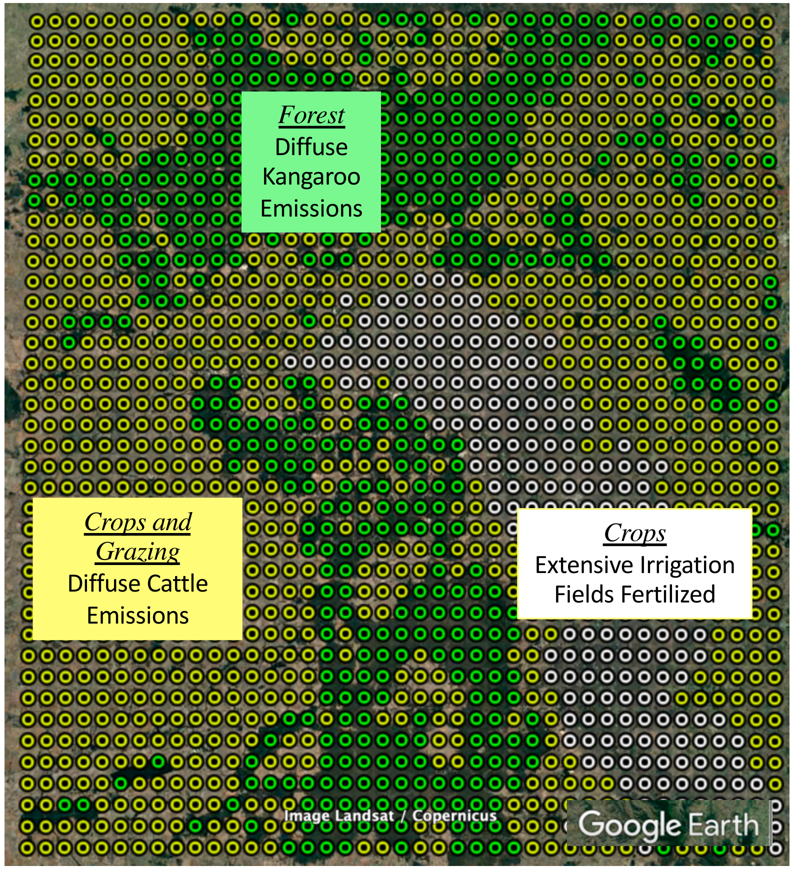


Approximately 300 methane point sources have been identified from Google Earth, government data sets, listed companies' annual reports, and environmental impact statements.



Sources:
CSG plants
CSG compressor facilities
CSG raw water ponds
Coal mines
Power stations
Ground seeps of unknown origin
Historical exploration wells seeps
River gas seeps
Cattle feedlots
Piggeries
Poultry farms
Landfills
Waste-water treatment plants
Domestic wood fires
Mixed urban emissions

Inventory – Diffuse Sources of Methane

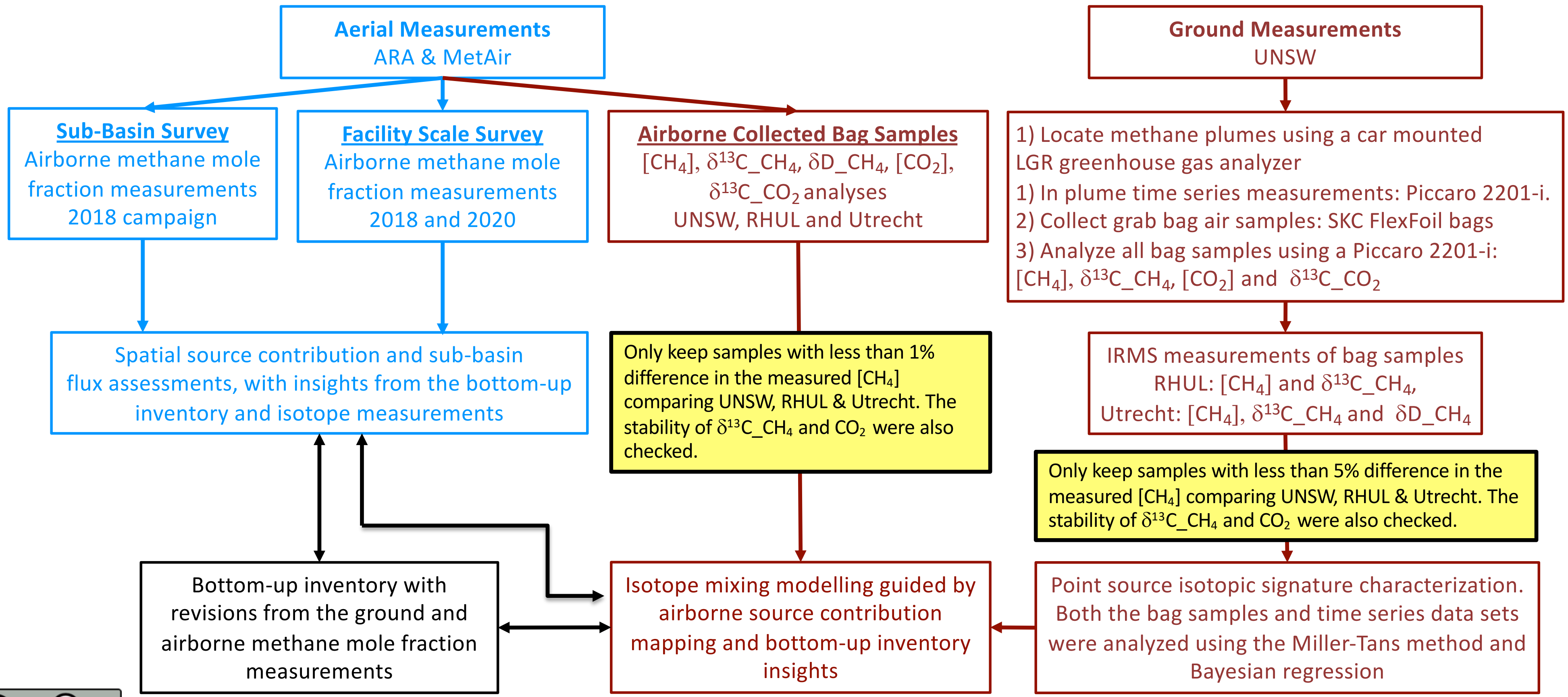


Methodology Workflow for Source Apportionment

Red text and boxes – Isotope study

Blue text and boxes – Airborne methane flux quantification. See Neininger et al. (2020) https://doi.org/10.5194/egusphere-egu2020-10993

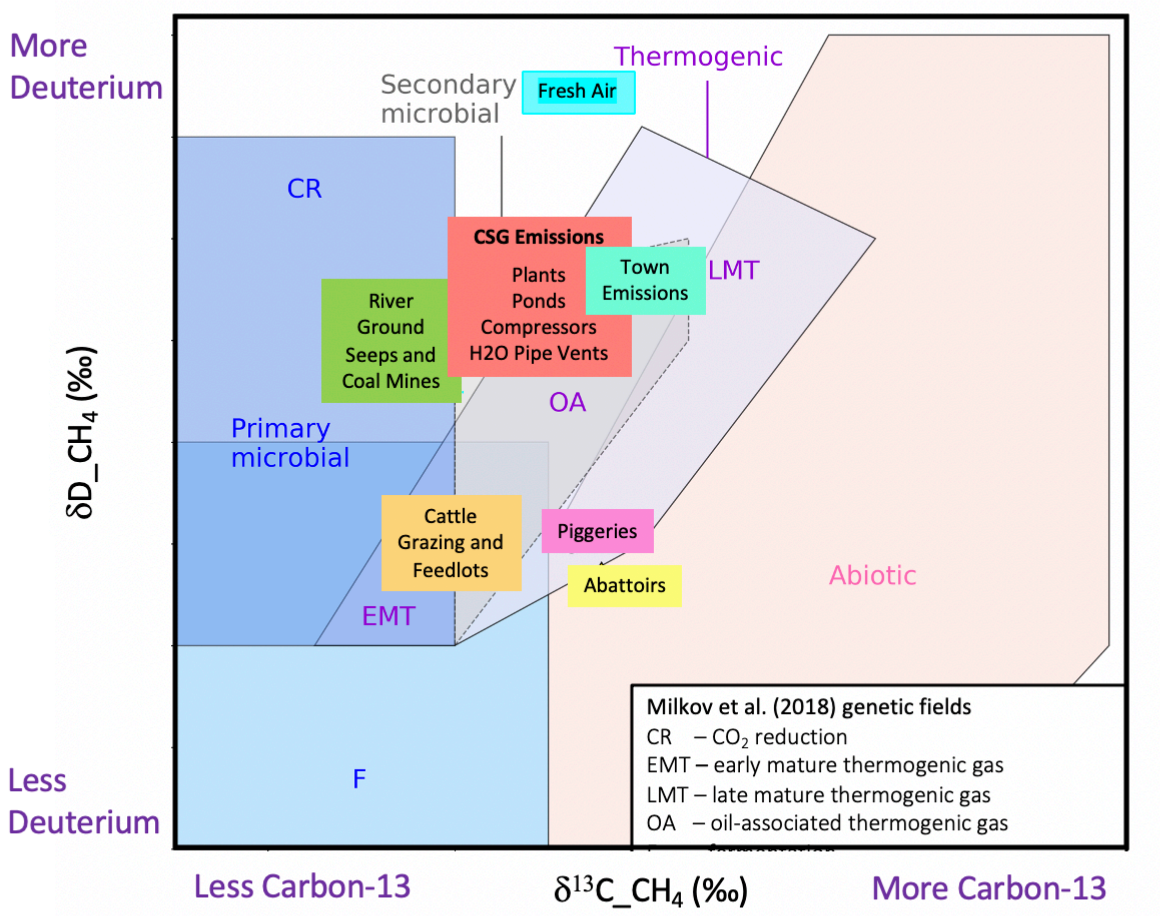
Black boxes and text – Inventory using IPCC & Australian Government emission factors



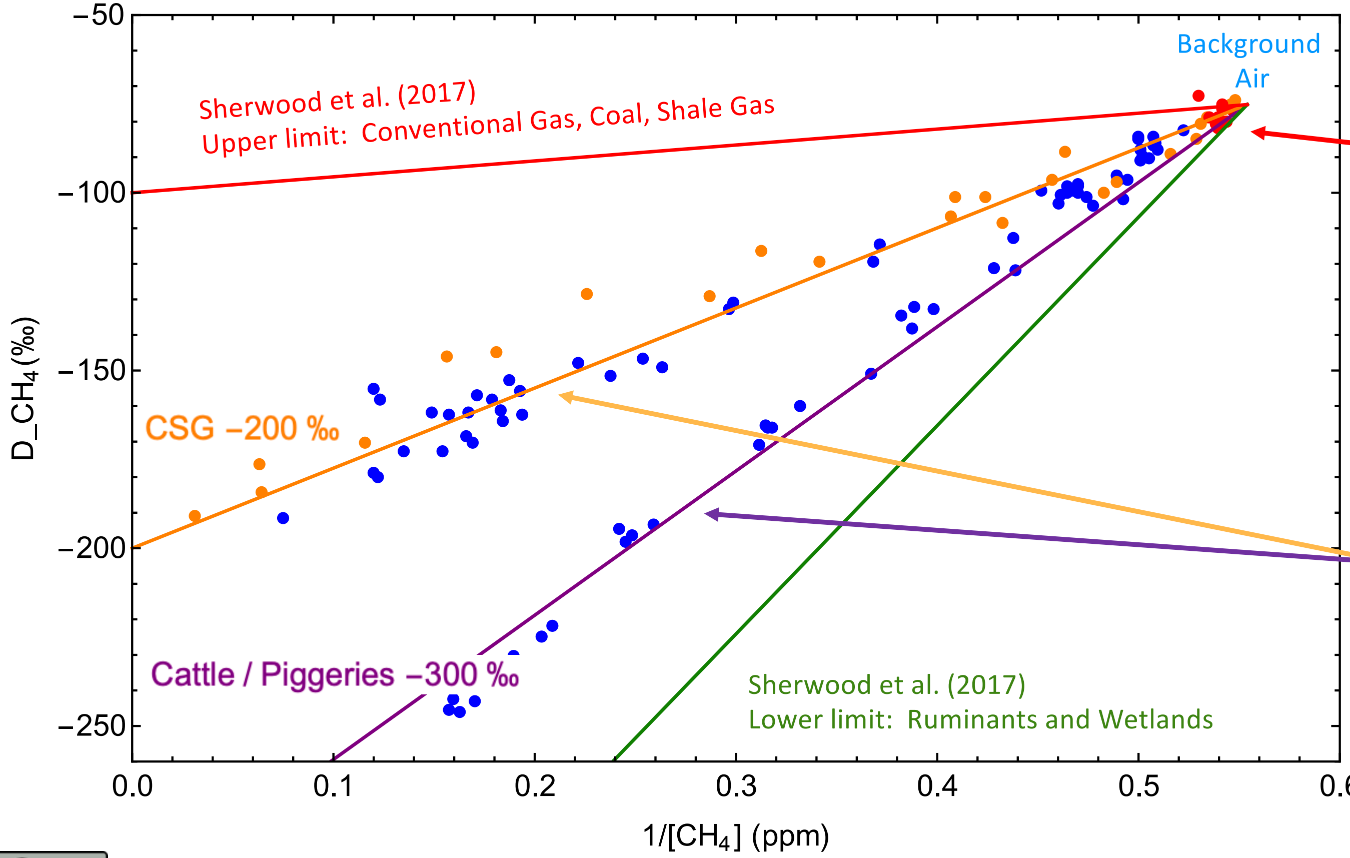
Dual Isotope Plot

The scatterplot of δD_CH_4 vs $\delta^{13}C\_CH_4$ highlights good separation of sources based on the chemistry of the plume samples.

It is clear in the graph that CSG activity emissions and cattle emissions form distinct clusters. When there is clear end-member chemistry we can use mixing models to apportion contributions.



Deuterium Keeling Plot – Ground and Airborne Samples



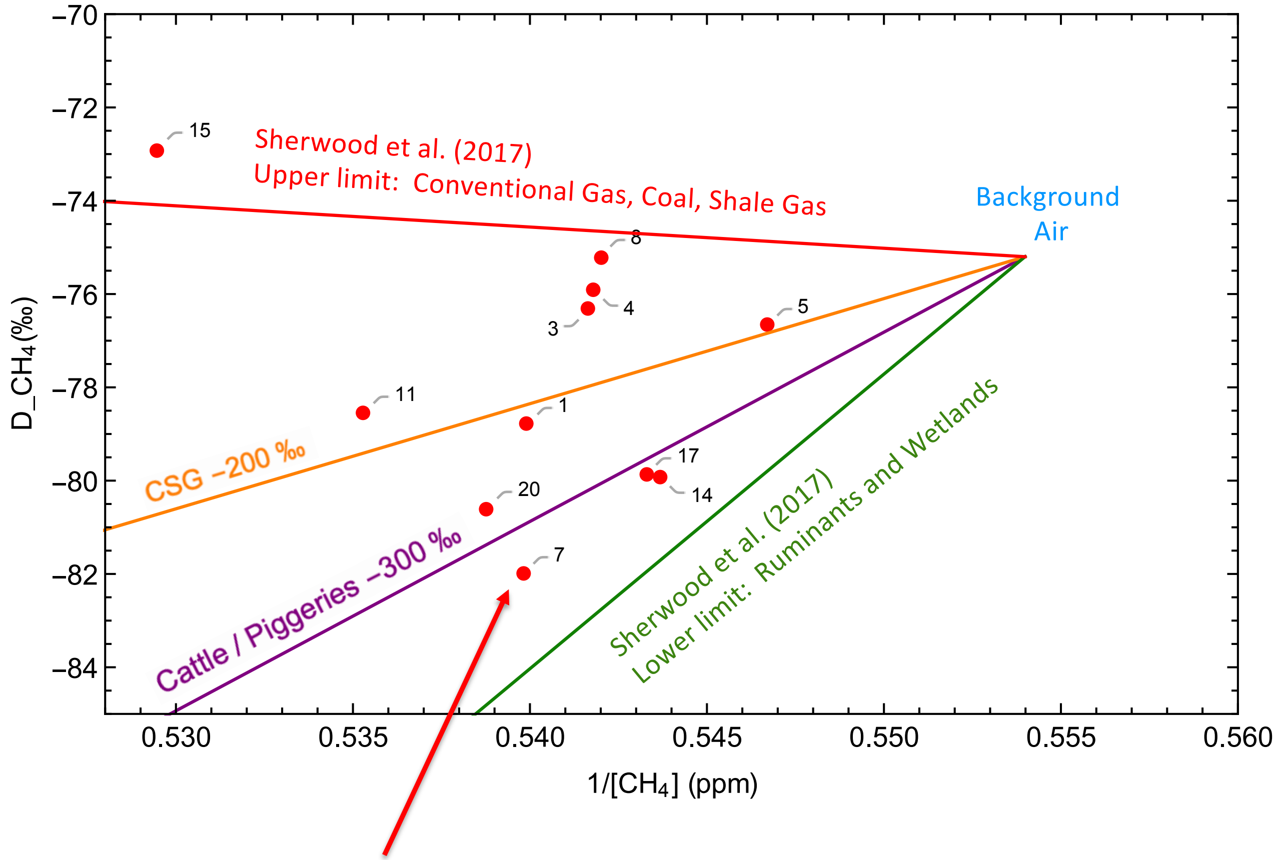
All the airborne collected samples plot close to "background air"

The Keeling function lines for Cattle/Piggeries and CSG were determined from the ground samples.

Orange points - 2018 bag samples

Blue points - 2019 bag samples

Deuterium Keeling Plot – Airborne Samples



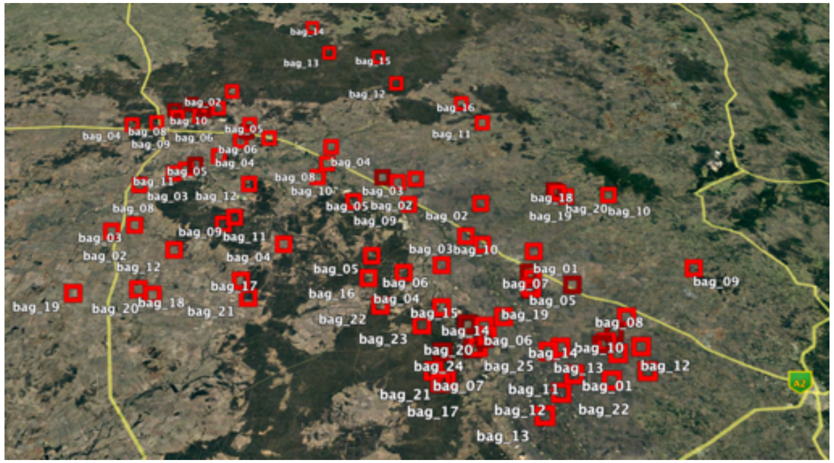
As an example, on the next slide we look closely at potential sources for this bag.

Airborne Bag Samples – Isotope Mixing Modelling for Source Apportionment

Ongoing Task – Modelling the Airborne FlexFoil Bag Samples

Air Sample = a.Cattle + b.CSG + c.Others + d.Background
$\delta^{13}C\_CH_4$ = ?? ‰
δD_CH_4 = ?? ‰

Cattle	CSG	Others ?	Background
$\delta^{13}C\_CH_4$ = -?? ‰	$\delta^{13}C\_CH_4$ = -?? ‰	$\delta^{13}C\_CH_4$ = -?? ‰	$\delta^{13}C\_CH_4$ = -?? ‰
δD_CH_4 = -?? ‰	δD_CH_4 = -?? ‰	δD_CH_4 = -?? ‰	δD_CH_4 = -?? ‰



Location of airborne FlexFoil bag samples

The idea of apportionment is schematically simple, but because of the equivalent solutions it is a complex task and depends on many variables, including, but not limited to:

- Distance from source
- Elevation
- Wind speed and direction
- Concentration at source
- Rate of release at source
- Pulsed or continuous
- In-plume vs well-mixed air
- And many more

Acknowledgement

Aim: To Reduced Short-Lived Climate Pollutants

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http://ccacoalition.org/en/activity/oil-and-gas-methane-science-studies