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Gas Industry Social and Environmental Research Alliance

Pre-Exploration Measurement and Monitoring of Background Landscape Methane Concentrations and Fluxes in the Beetaloo Sub-Basin, Northern Territory

GISERA Project G5

Cindy Ong | Principal Research Scientist | 9 August 2019

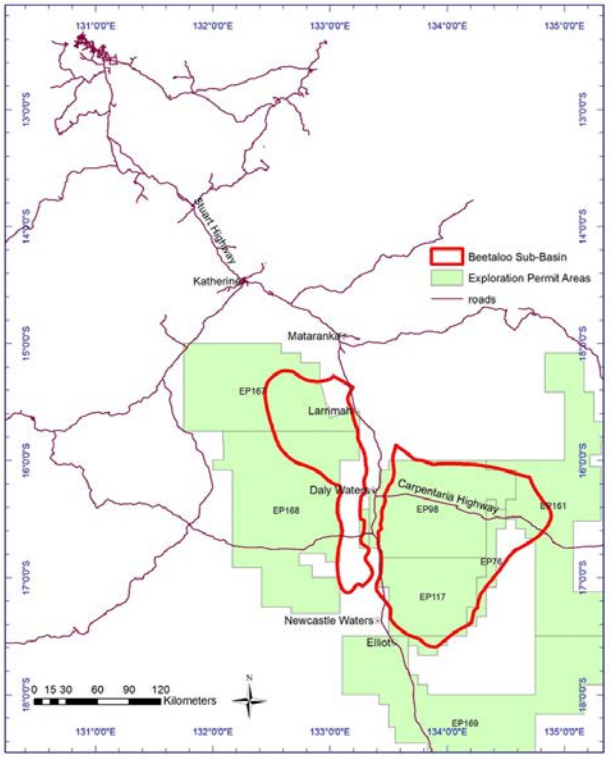
Supported by Government of South Australia

Background

- Scientific Inquiry into Hydraulic Fracturing in the Northern Territory (March 2018)
  - *"baseline monitoring of methane concentrations be undertaken for at least six months prior to the grant of any further exploration approvals. In areas where hydraulic fracturing has already occurred, the baseline monitoring should be undertaken at least a year prior to the grant of any production approvals"*

Aim

- Quantify background atmospheric concentration levels of methane in areas of the Beetaloo Sub-Basin that are of interest for exploration;
- Identify & locate sources of methane & where applicable and feasible, quantify the fluxes related to sources.

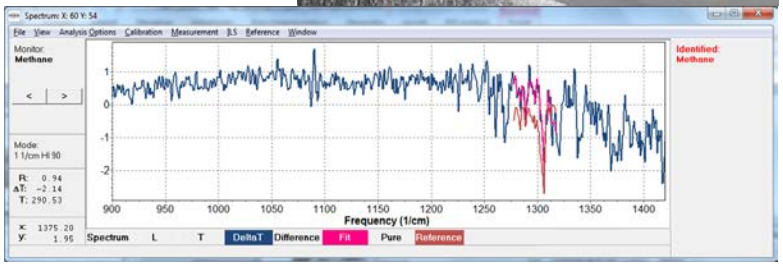


Background: Methods/Technologies For Measuring Emissions Measuring Emissions

- Ambient methane concentrations
  - Indicates leak or other source
    - Gas analysers;
    - Leak detectors;
    - Optical systems;
    - Remote sensing
      - Can show spatial distribution of sources
- Concentration varies with ambient conditions
  - Time of day;
  - Wind;
  - Distance from source;

http://www.flir.com.au/ogi/methane/

https://www.bruker.com/products/infrared-near-infrared-and-raman-spectroscopy/remote-sensing/hi-90/overview.html



http://www.picarro.com/products_solutions/trace_gas_analyzers/co_co2_ch4_h2o

http://www.lgrinc.com/analyzers/overview.php?prodid=23&type=gas

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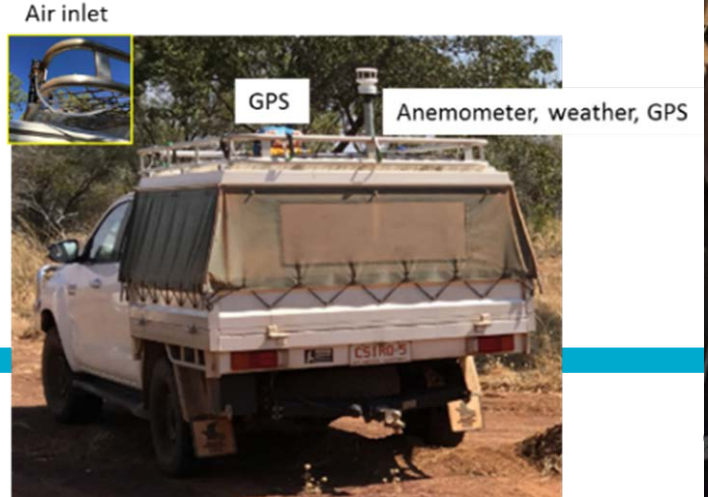
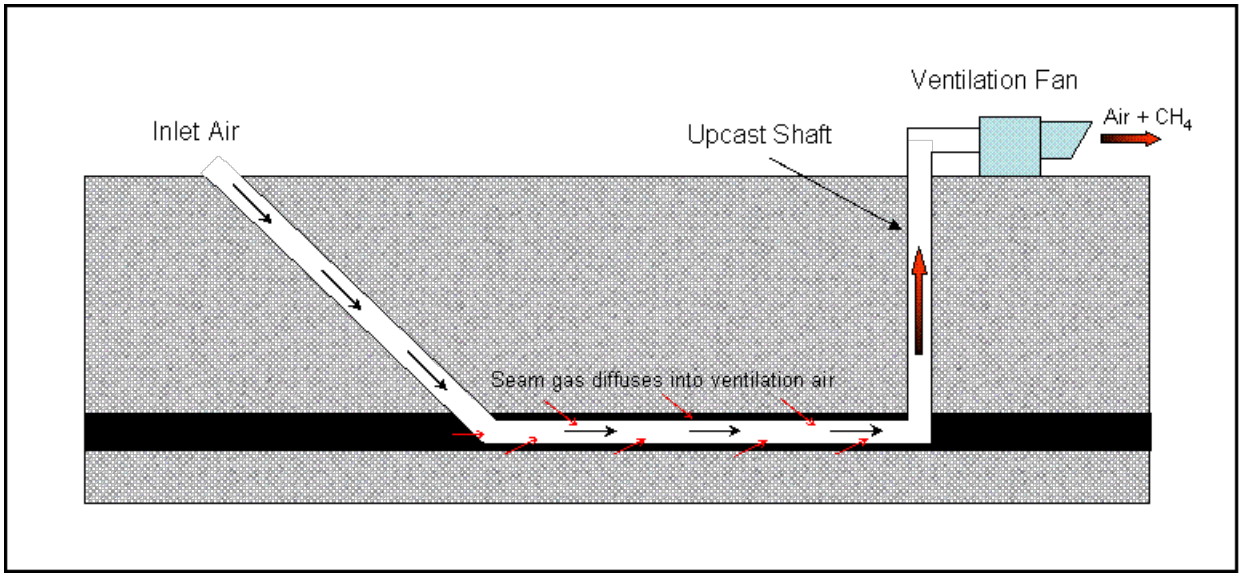
Background: Mobile Survey

- One of most widely used, reliable and well-developed techniques;
- Employ high sensitivity analysers deployed from 4WD drive;
- Advantages
  - Immediate deployment & with temporal acquisition allows accurate monitoring of concentrations & fluxes;
  - Capacity to travel over many thousands of kilometres => broad-scale measurement programs;
  - Allows detailed surveys of areas to be conducted to locate and identify sources;
  - Emission rate estimates possible when combined with local meteorological data and a simple plume dispersion model or tracer gas;
- Disadvantages
  - limited to trafficable roads and tracks;
  - surveys are periodic, not continuous – may not capture long term variations.



Background: Concentration and Emission Rate

- For greenhouse accounting we need to know emission rates
  - Emission Rate (kg s^{-1}) = Concentration (kg m^{-3}) x Flow (m^3 s^{-1})
- Relatively easy in pipes and ducts (e.g. underground coal mines)



Background: Quantification Of Emissions Rates

- More difficult with diffuse sources:
  - Open-cut coal mines
  - Agriculture
  - Gas fields
- Possible approaches
  - Top down – i.e. attempt to measure emissions over entire region
    - Atmospheric transport methods;
    - Includes all sources; complicates interpretation;
  - Bottom up – i.e. measure emissions from individual sources (e.g. wells) then add up to yield total emissions
    - May miss sources; provides information on emission routes

Background: Requirements

Baseline: Pre-activity detailed accounting of

- Regional ambient levels including temporal variations;
- Identification of present and potential sources of emission in the area of interest (and adjacent areas potentially influence by it);
  - Location
  - Quantification
    - Spatial-temporal variations
    - Concentration
    - Flux
- Is the backbone/foundation from which future monitoring program is to be built on.

Monitoring: Tracking variations from baseline

- At location where elevated values detected;
- At locations where elevated values may be induced by activities;
- Regional ambient temporal trends;

Background: Potential Sources of Methane Emissions in Beetaloo sub-Basin

Source	Spatial Scale S < 1m M 10-30 m L > 250 m	Individual Concentration	Cumulative Concentration	Temporal Variation	Location	Quantification method
Livestock (cattle)	Small	Small	Large	NA	Dispersed	Estimates using emission factors well established
Fires	Large	NA	Large	Dry	Unknown	Total GHG inferred from fires mapped from satellite – CH_4 not discriminated
Termites	Small	Small	Unknown	Wet	Dispersed	Not well understood
Wetlands	Medium	Unknown	Unknown	Wet	Not all well characterised	Not well understood
Natural geological seeps	Small	Small	Unknown	Unknown	Unknown, not well characterised	Development required for identification & location
Abandoned/old petroleum & mineral, water bores	Small	Small-medium	Unknown	Continuous	Some knowledge	As above; Monitoring methods established but not continuous
Future: Onshore operating wells	Small	Small	Unknown	Continuous	Well known	Monitoring methods established but not continuous
Future: Oshore operating infrastructure	Medium	Medium - large	Unknown	Continuous	Well known	Development required
Waste treatment facility	Medium	Small -Medium		NA	Well known	Methods well developed

Results: Mobile Survey Summary

- 3 mobile survey campaigns total ~15,000 km between July 2018 to February 2019.
  - 1st campaign, dry season: total ~5,500 km between 29th July – 10th August 2018;
  - 2nd campaign, fire season: ~5,300 km between 6th – 15th November 2018;
  - 3rd campaign, wet season: ~4,050 km between 30th January - 5th February 2019

Results: Summary of Mobile Survey

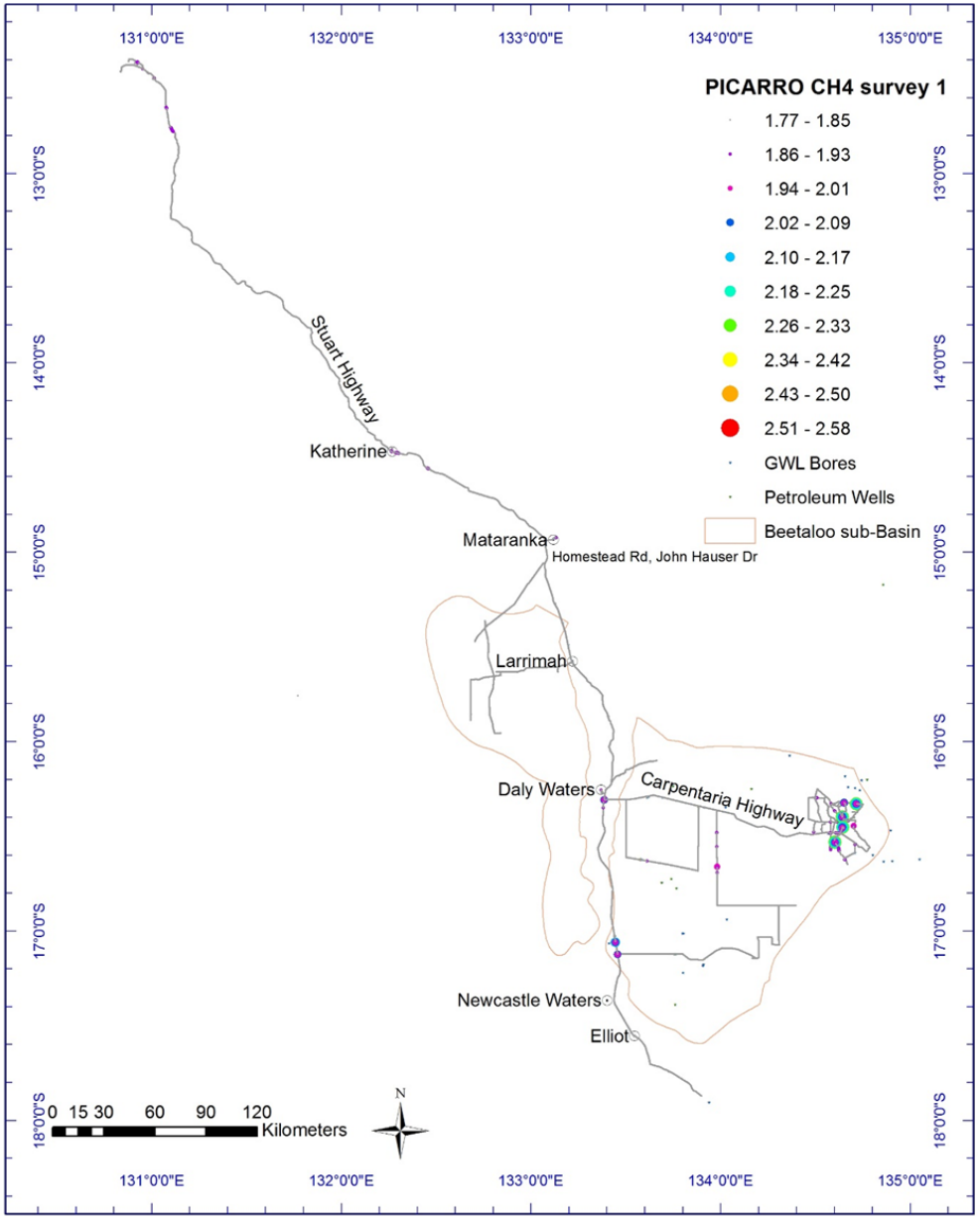
Average, median, standard deviation and maximum CH_4 concentration values measured during the three mobile survey campaigns

	Campaign 1 (LGR)	Campaign 2 (LGR)	Campaign 3 (LGR)	Campaign 1 (PICARRO)	Campaign 2 (PICARRO)	Campaign 3 (PICARRO)
Average (ppm)	1.839	1.827	1.808	1.817	1.811	1.796
Median (ppm)	1.835	1.826	1.807	1.813	1.811	1.795
Standard deviation	0.019	0.013	0.017	0.018	0.012	0.019
Maximum (ppm)	2.604	2.206	2.920	2.310	2.094	2.297

Methane concentration measured at Cape Grim during survey periods

August 2018	November 2018	February 2019
1.826	1.820	1.798

Results: Dry Season (29th July – 10th August 2018)

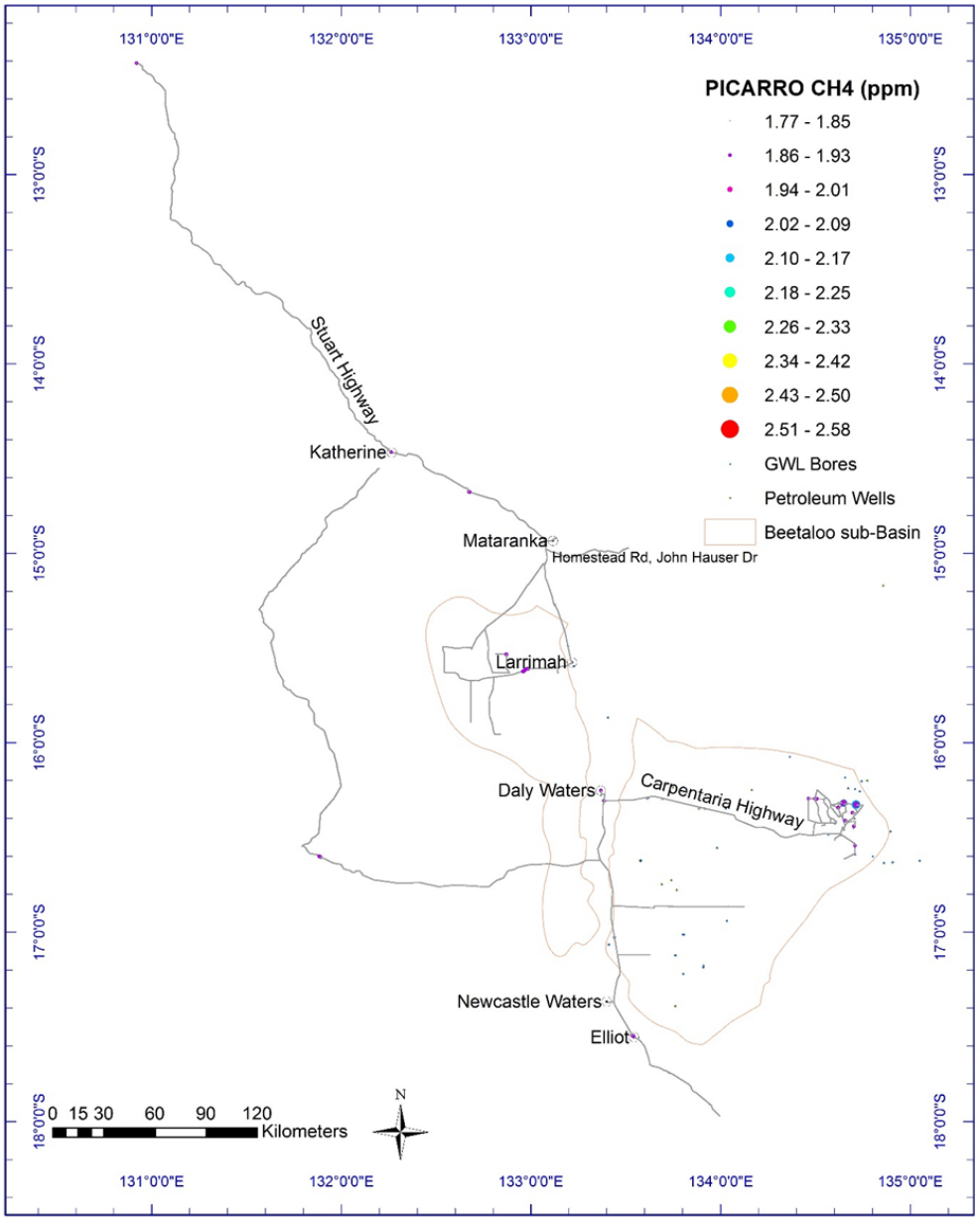


Beetaloo Baseline: Grazing Cattle

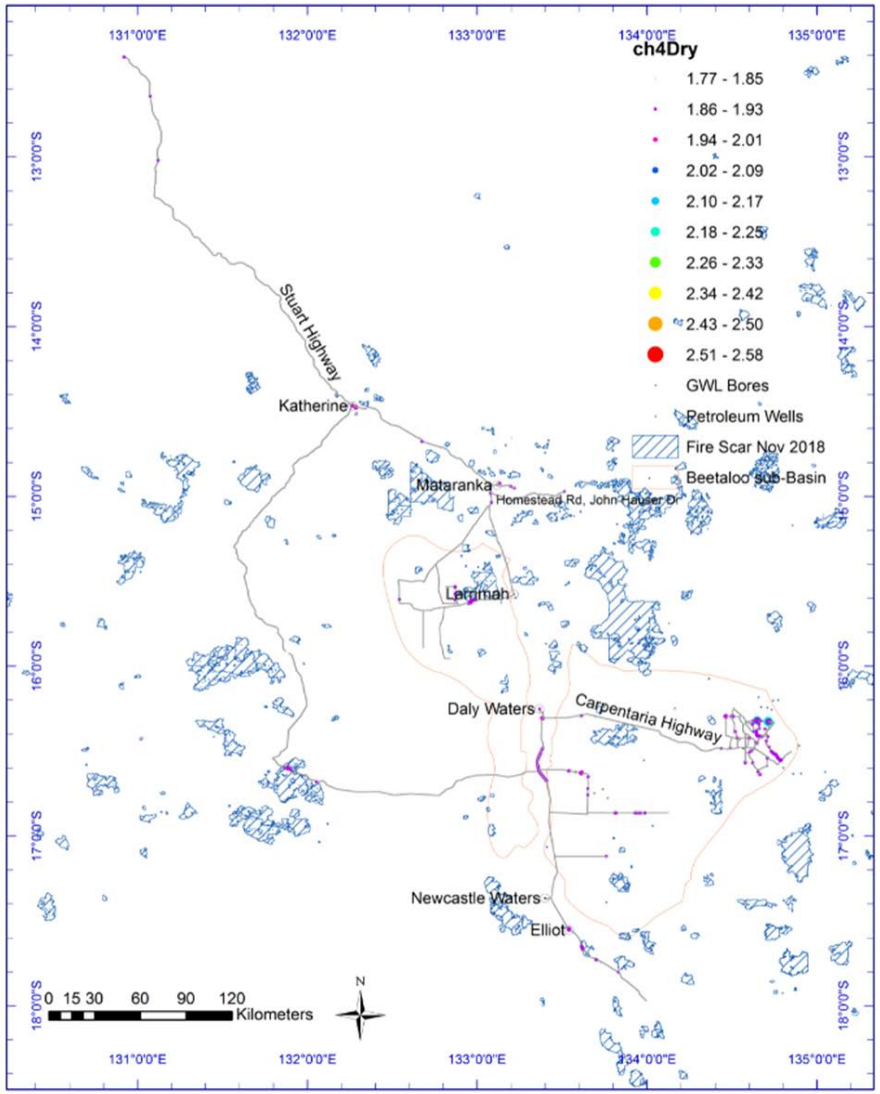
- Elevated concentrations from cattle
- Estimated total emission = 7,402,159 kg CH_4 yr^{-1} from 115K beast (NTCA, 2019)

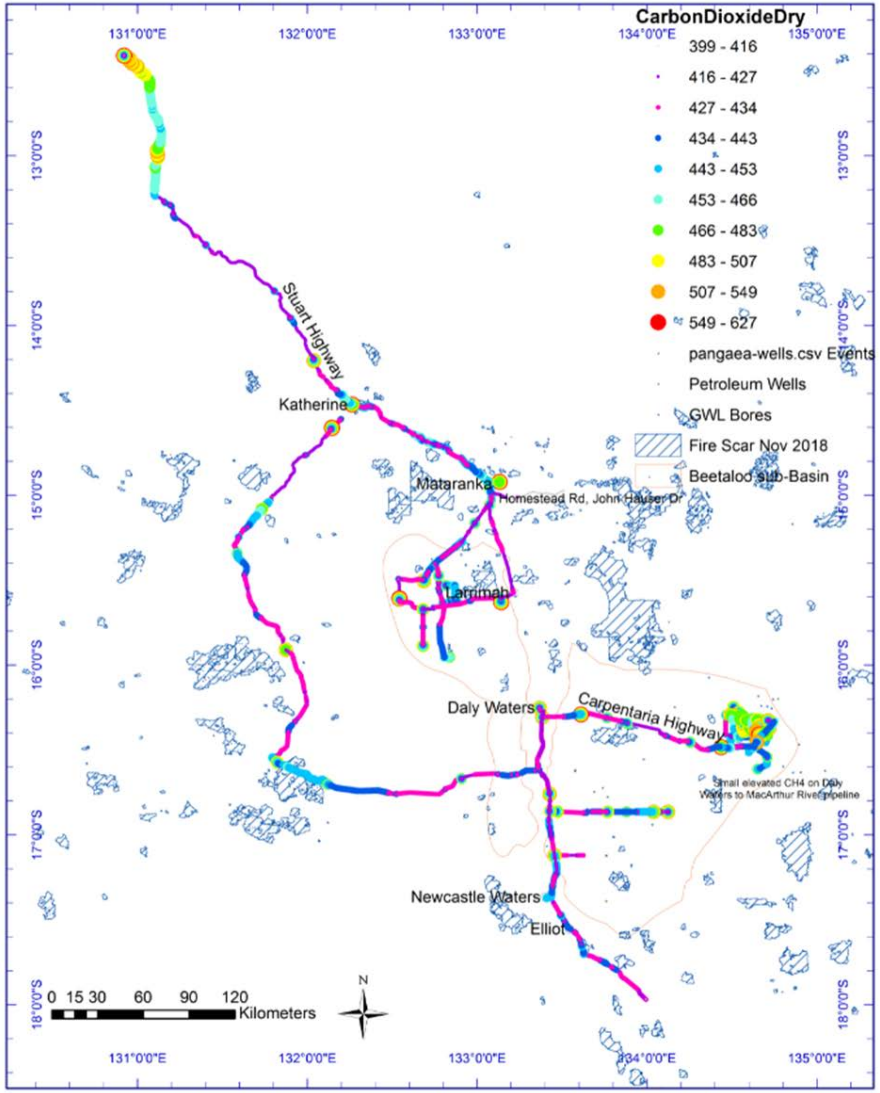
Average emission factors 54.75-73.00 kg CH_4 per beast per yr^{-1} Charmley et al. (2016) . The average of this, 63.88 kg yr^{-1} was used for the estimation

Results: Fire Season (6th – 15th November 2018)

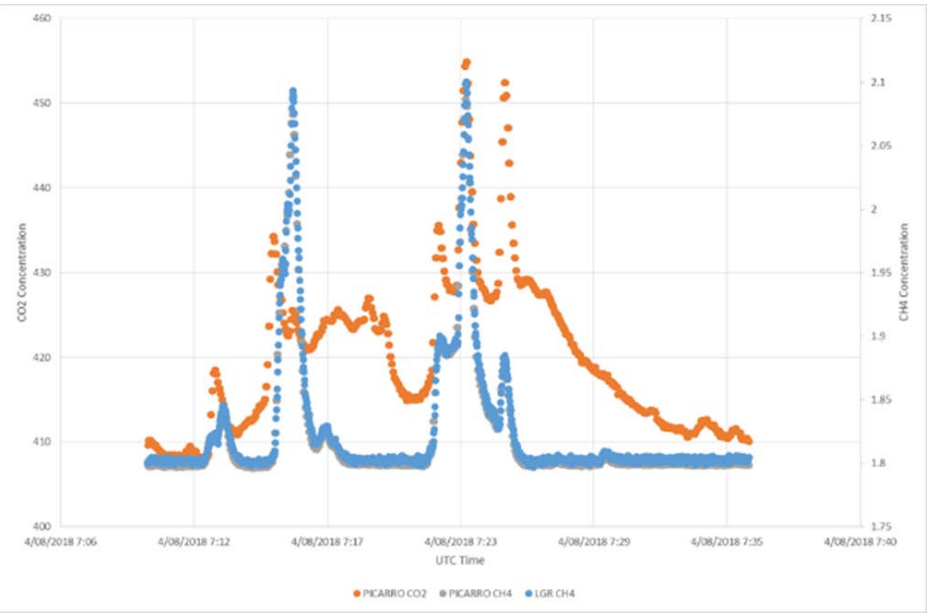


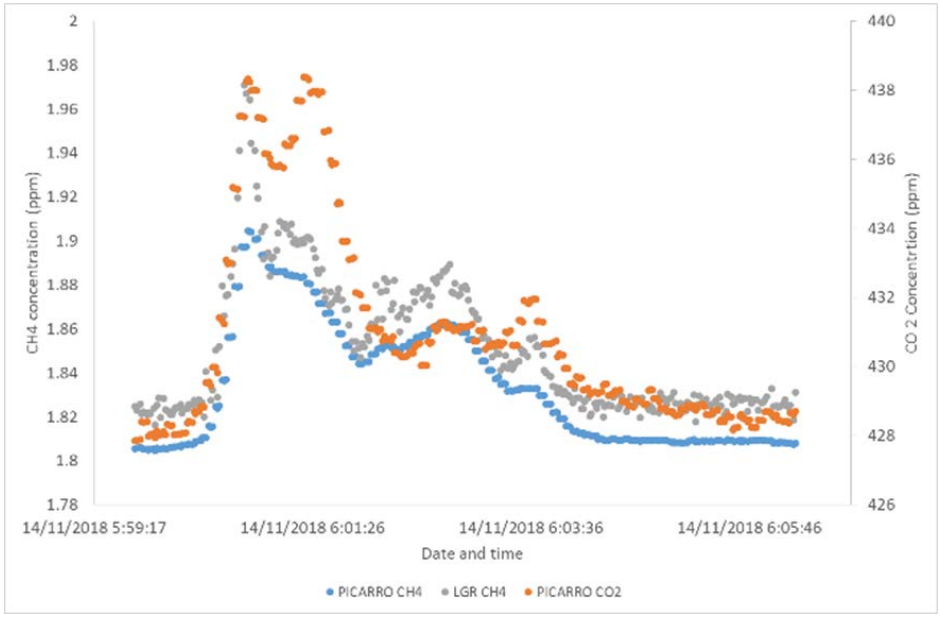
Results: Fires

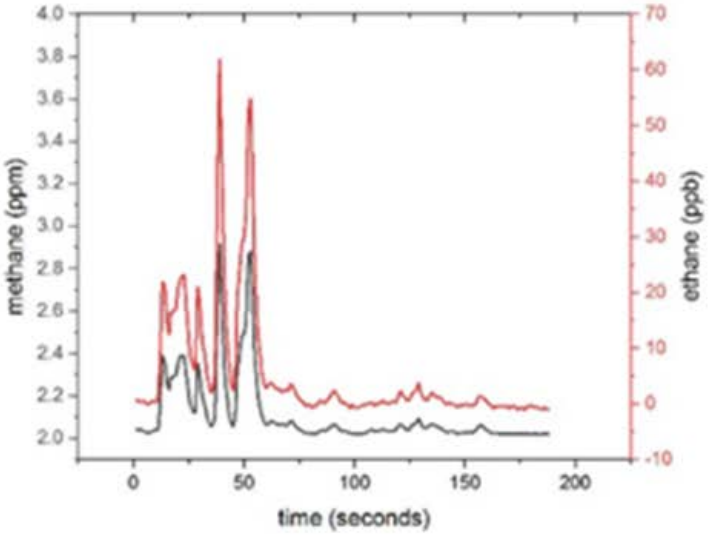


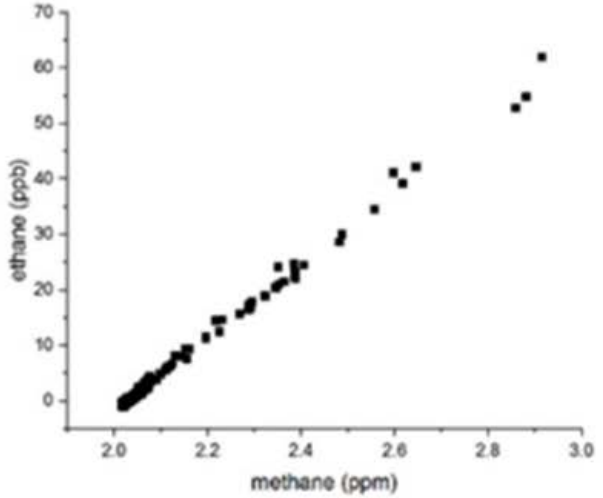


Results: Fire









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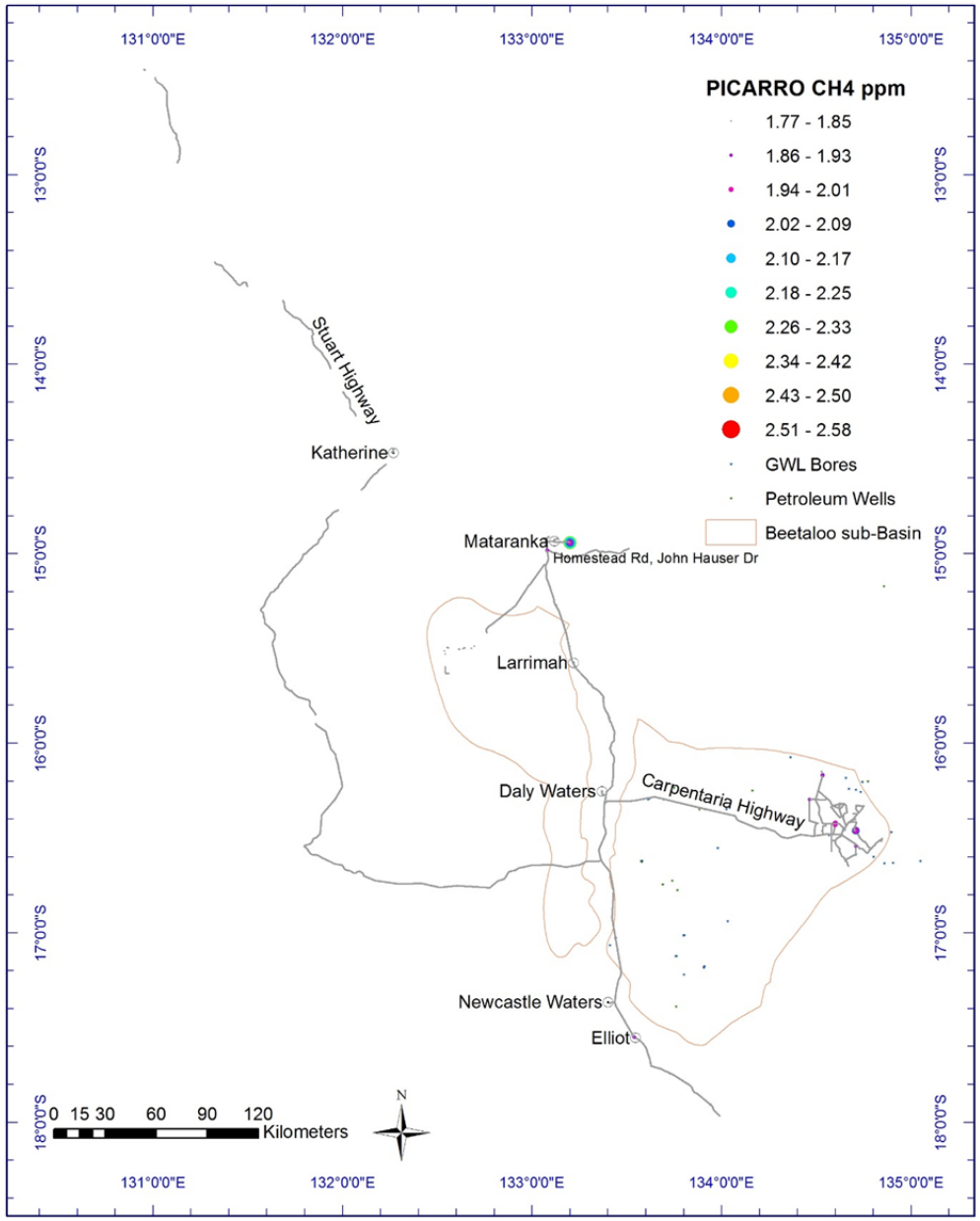
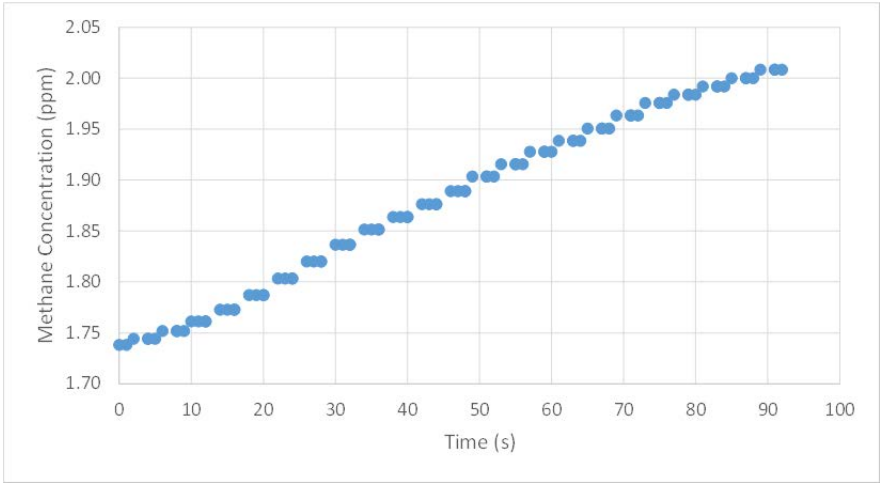
Results: Wet Season (30th January - 5th February 2019)



Results: Termites

- No elevated values detected during dry campaign;
- Elevated values detected during wet campaign;
- Emission rate estimated ~ 900,000 kg CH_4 yr^{-1} (based on (Jamali et al. 2011: 0.24 kg CH_4-C ha^{-1} yr^{-1} or 0.32 kg CH_4 $ha^{-1}yr^{-1}$)



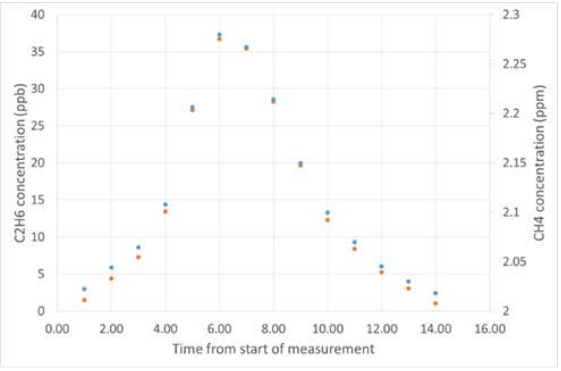
Results: Soils

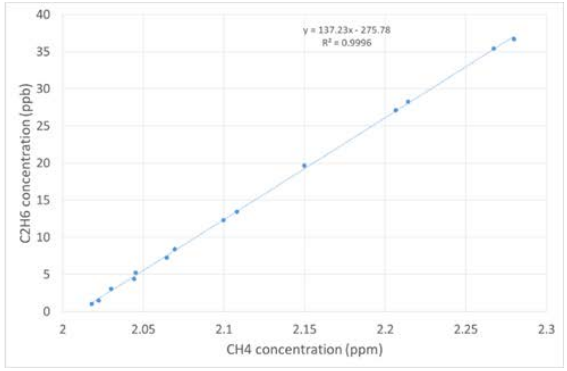
- Soil fluxes were measured at 8 sites throughout 3rd mobile campaign;
- Estimated emission sink for Beetaloo sub-Basin ~ approximately 4,200,000 kg CH_4 yr^{-1} based on Jamila et al. 2011: 1.52 kg CH_4 ha^{-1} yr^{-1}

Site Surface Description	Methane Emission Flux (mg CH_4 m^{-2} day^{-1})
Grassed edge of track – damp soil	-2.3
In free water on the grassed verge	-1.4
Dry ground without vegetation	-3.8
Dry ground without vegetation	0.5
Grassed edge of a large stagnant water body; Location 1	98.0
Grassed edge of a large stagnant water body; Location 2	5.1
Grassed edge of a large stagnant water body; Location 3	23.3
Stagnant water body – in the water	113

Results: Pipeline Riser

- Elevated values detected during all campaigns;
- Emission rates quantified during 3rd campaign - 43.8 kg CH_4 yr^{-1};
- 60-80 % of a cattle;
- Under threshold of NT's code of practice (5000 ppm at 150 mm).





Results: Petroleum Wells

- Visited or was close to 11 plugged & abandoned & suspended wells at least once during mobile survey campaigns;
- No elevated values measured

Birdum Creek

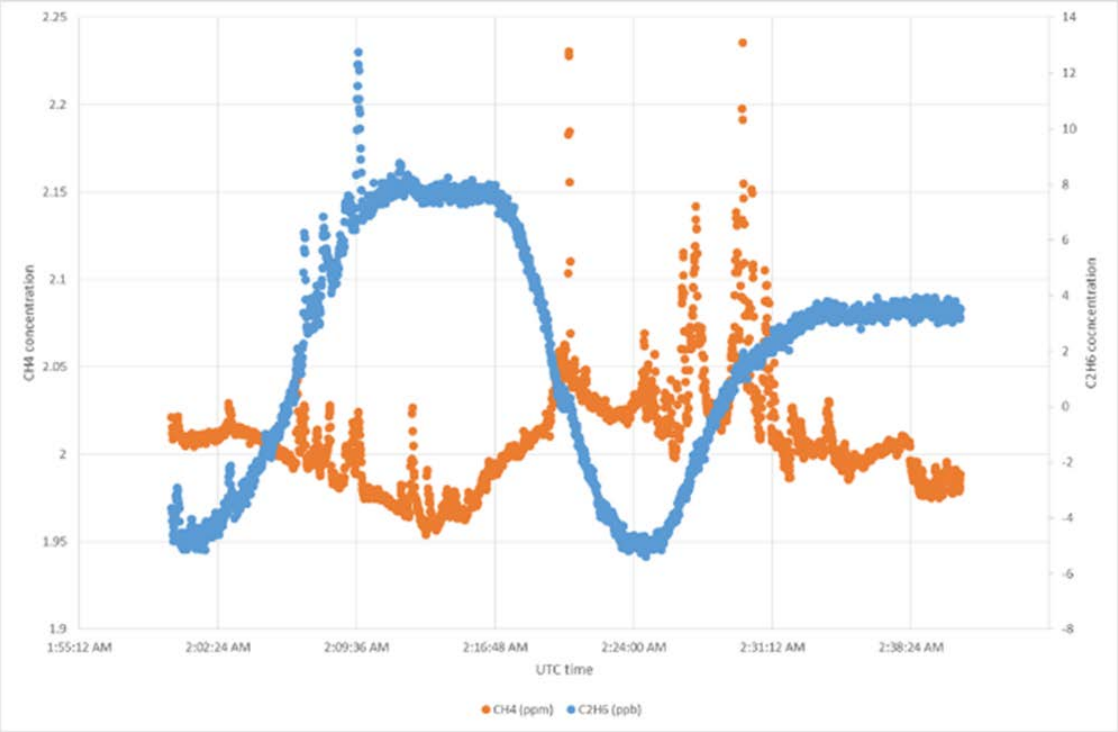
West Beetaloo 1

Results: Water Bores

- Visited or close to 25 bores at least once during 3 campaigns;
- No elevated values measured at most bores; small number have small levels above background but cattle close by; elevated values close of Daly Waters Motel bore near septic tank;

Results: Wetlands

- Small elevated values but not possible to get close enough in wet season



Findings, Implications, Further Work

- A comprehensive baseline encompassing the main potential sources of methane has been developed for the Beetaloo sub-Basin;
  - Provides a strong foundation for a methane emissions pre-exploration baseline;
  - Source of methane emission identified
    - Grazing cattle;
    - Townships;
    - A section of above-ground gas pipeline and associated valves;
    - Fires;
    - Termites;
    - Wetlands;
- No elevated values detected at PNA and suspended petroleum wells;

Findings, Implications, Further Work

- Gaps to be addressed in future;
  - **Recommendation 1:** Before drilling activities begin, comprehensive soil CH_4 baseline acquired around the well pad areas to capture natural background CH_4 emission of the surrounding area;
  - **Recommendation 2**: Collect methane measurements throughout the hydraulic fracturing operations to understand the emissions related to the hydraulic fracturing operations and related flow back – USA studies suggested potentially a significant source of CH_4;
  - **Recommendation 3**: Install remote monitoring stations according to recommendations 9.3 of the Scientific Inquiry to provide continuous monitoring of the operations of the infrastructure;
  - **Recommendation 4**: investigate remote sensing technology/methods including expanding on existing optical satellites data methods and, investigate new satellites that specifically measure GHG such as methane, carbon dioxide and carbon monoxide such as the European Space Agency's Sentinel-5P to reduce uncertainties in quantifying emissions related to fires & wetlands;
  - **Recommendation 5**: Local scale investigation of spring area and better quantification of emissions related to wetlands.

Acknowledgements

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Thank you

Cindy Ong
Principal Research Scientist

t +61 8 6436 8677
e cindy.ong@csiro.au
w gisera.org.au

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