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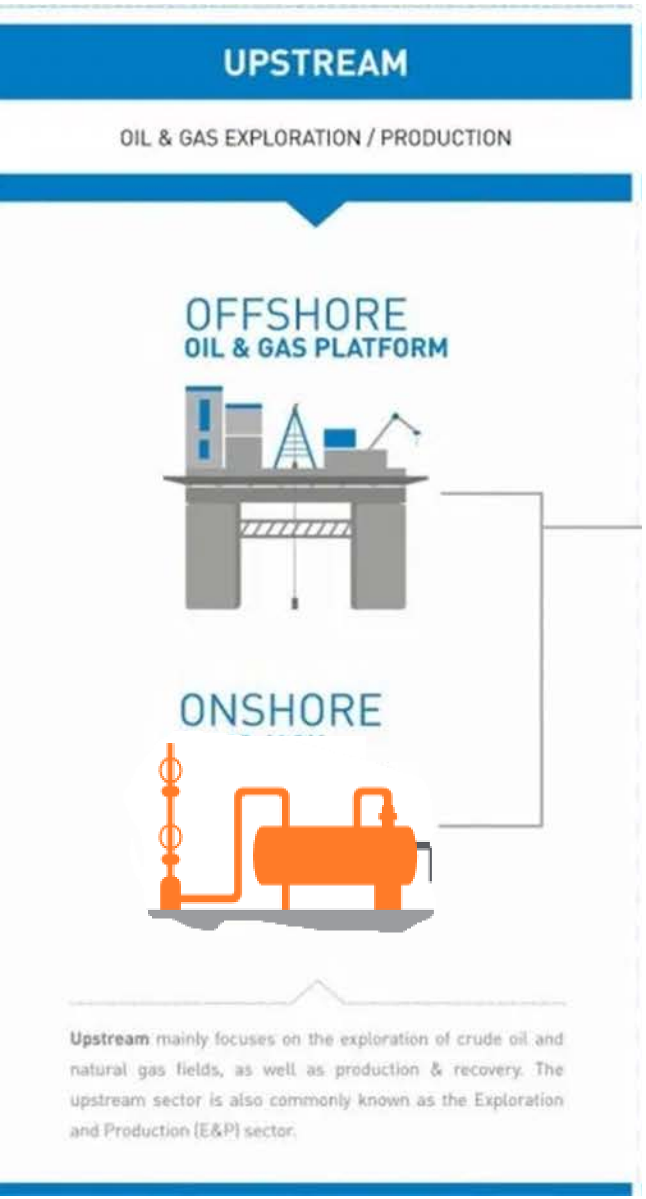
Fine scale measurements of methane from ground sources (QLD, NSW and NT)

Stakeholder Roundtable Group Meeting

Cindy Ong | Principal Research Scientist | 4 November 2019

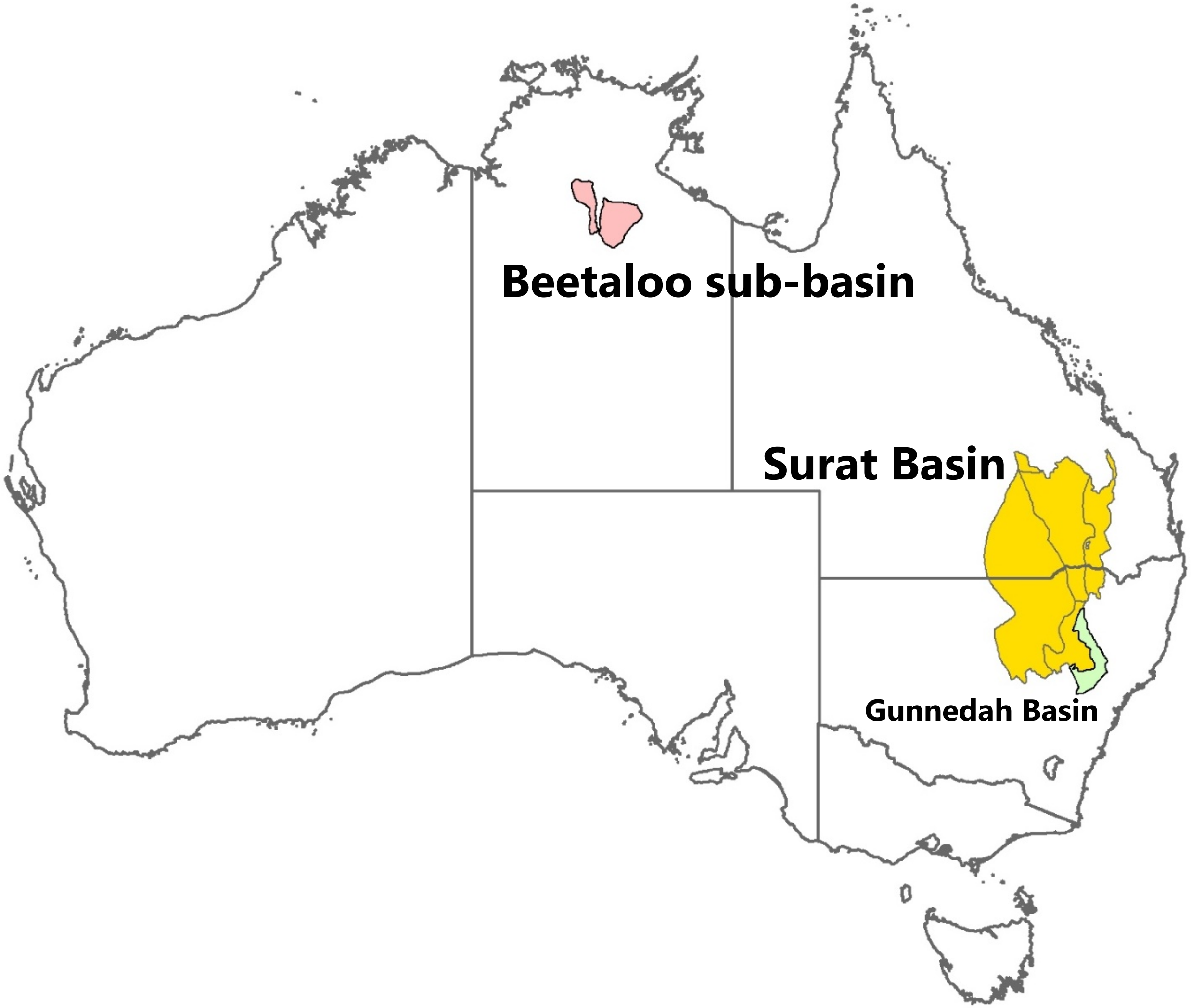
CSIRO | Australia Pacific LNG | QGC | origin | Santos | NSW Government | Australian Government Department of Industry, Innovation and Science | Supported by Government of South Australia | Queensland Government | Northern Territory Government | Pangaea Resources Pty Ltd



FOCUS: ONSHORE GAS

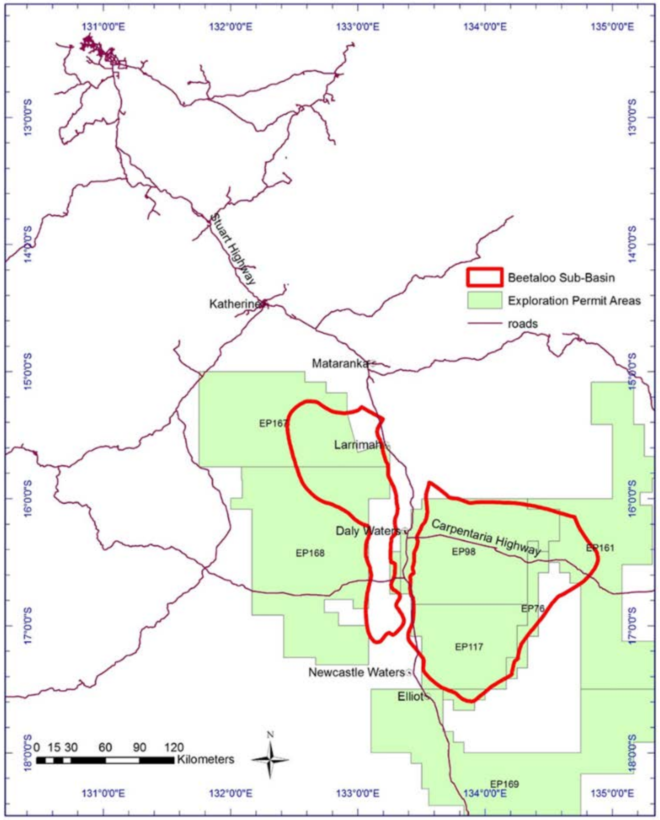
Fugitive Emissions: unintended releases of gas from industrial operations; includes exploration drilling, production testing and well completion, gas production activities, processing, transport, storage, transmission and distribution

Study Areas



Baseline Survey: Beetaloo Sub-Basin

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



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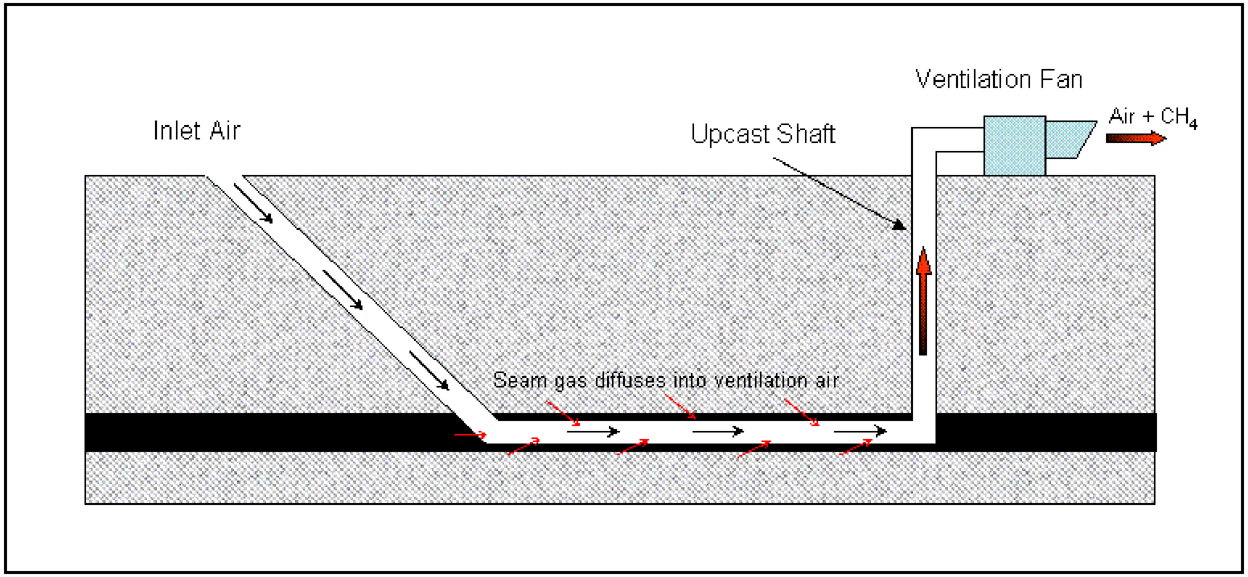
Concentration And Emission Rate?

- Gas analysers measure concentrations (ppm, ppb);
- 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)



Determining 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

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

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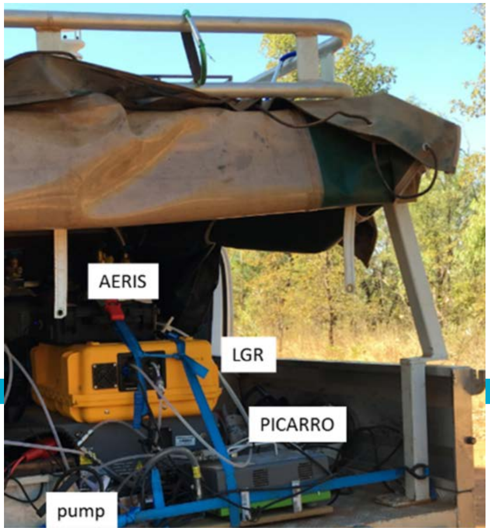
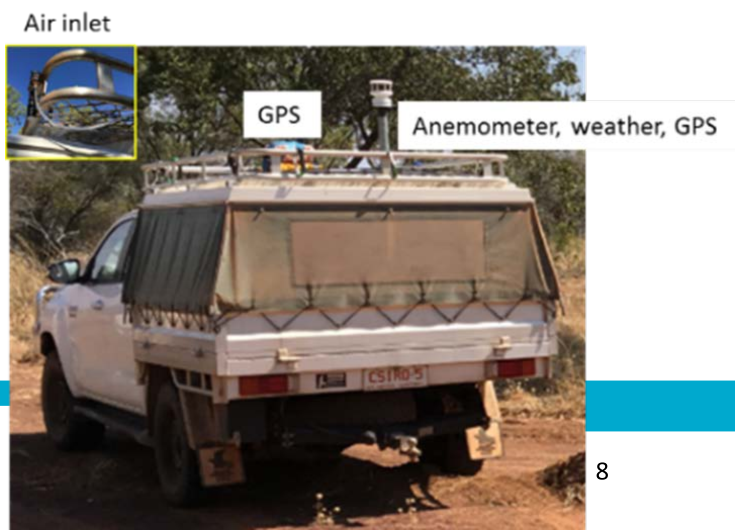
Mobile Surveys

- One of most widely used, reliable and well-developed techniques;
- Employ high sensitivity analysers deployed from 4WD drive;
- 3 mobile survey campaigns total ~15,000 km between July 2018 to February 2019.
  - 1^{st} campaign, dry season: total ~5,500 km between 29^{th} July – 10^{th} August 2018;
  - 2^{nd} campaign, fire season: ~5,300 km between 6^{th} – 15^{th} November 2018;
  - 3^{rd} campaign, wet season: ~4,050 km between 30^{th} January - 5^{th} February 2019





Summary of Mobile Survey in Beetaloo sub-basin

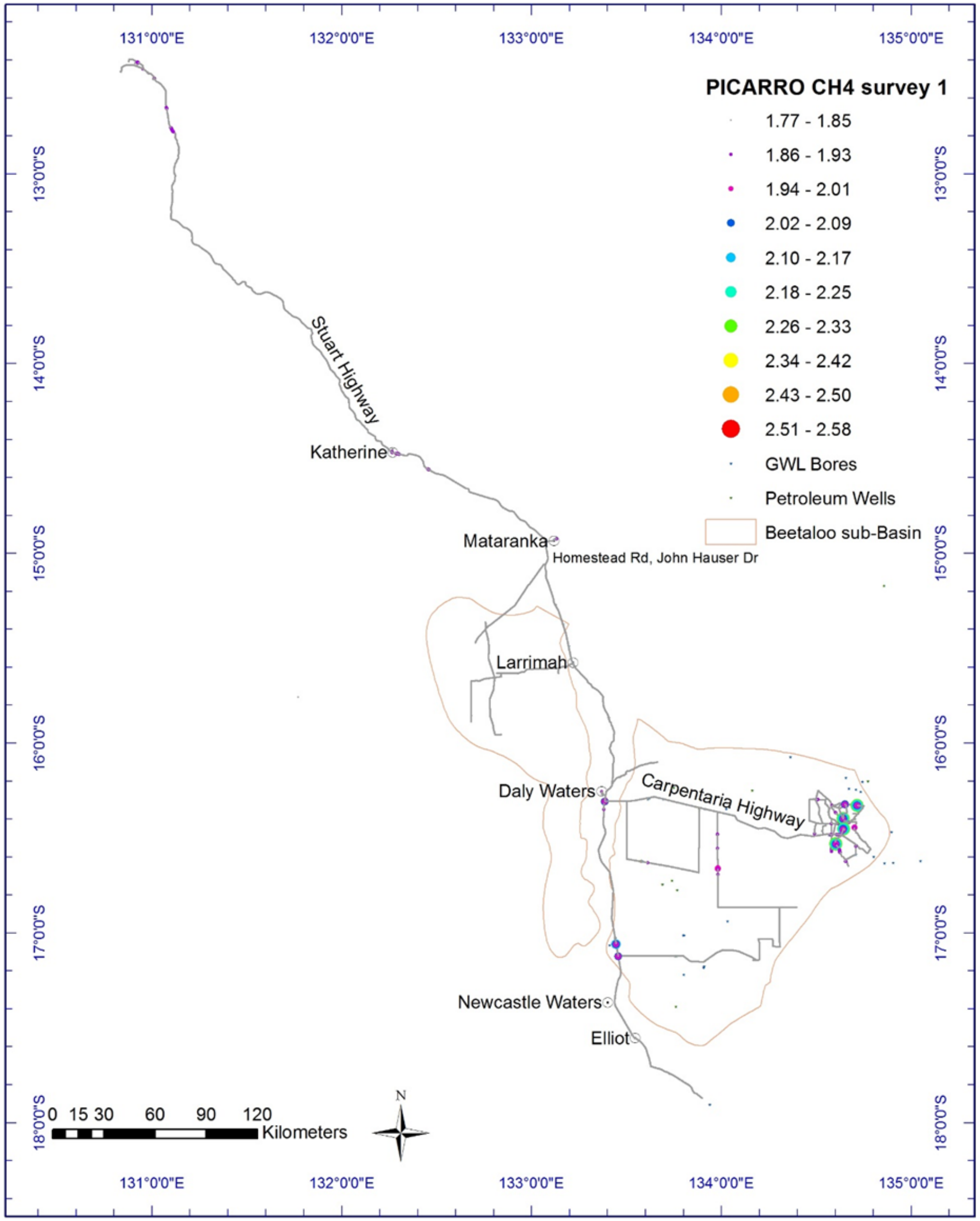
Average, median, standard deviation and maximum CH_4 concentration values measured during the three mobile survey campaigns

	Campaign 1 (LGR)	Campaign 2 (LGR)	Campaign 3 (LGR)
Average (ppm)	1.839	1.827	1.808
Median (ppm)	1.835	1.826	1.807
Standard deviation	0.019	0.013	0.017
Maximum (ppm)	2.604	2.206	2.920

Methane concentration measured at Cape Grim during survey periods

August 2018	November 2018	February 2019
1.826	1.820	1.798

Beetaloo Baseline: Dry Season (29th July – 10th Augus



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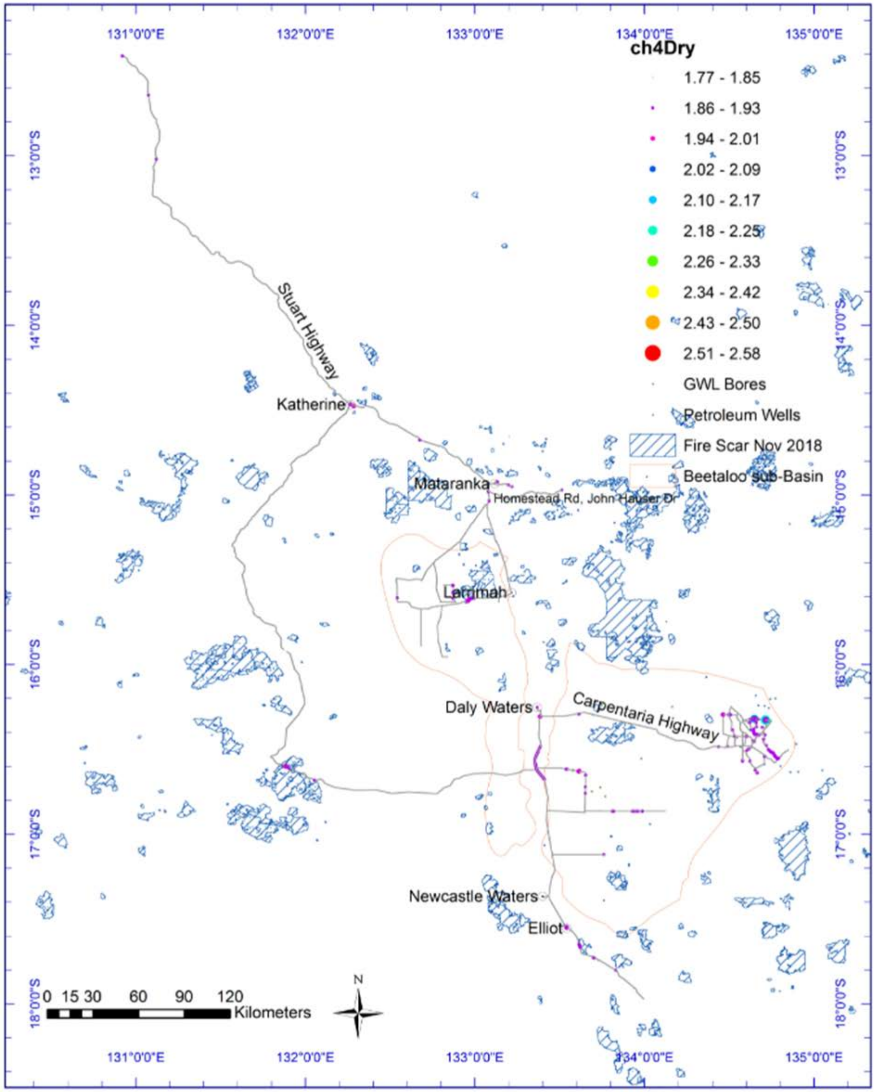
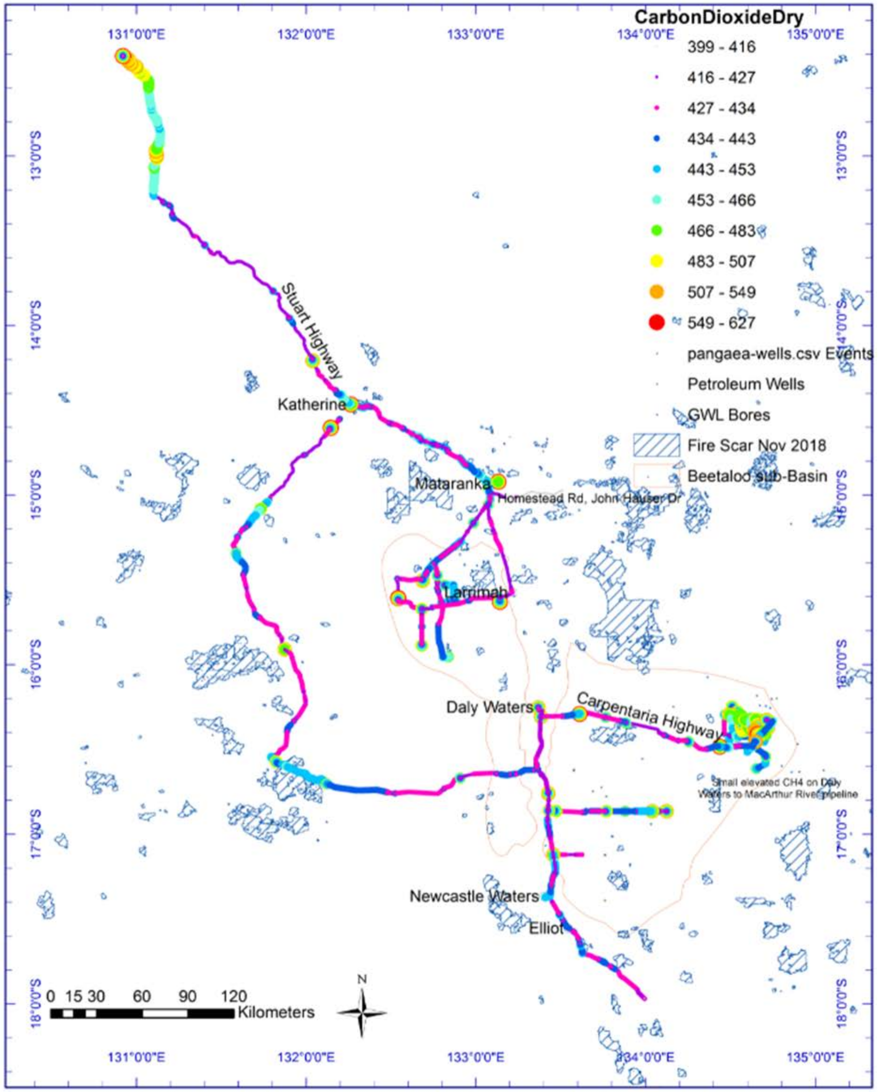
Beetaloo Baseline: Grazing Cattle

- 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

Beetaloo Baseline: Fires (6th – 15th November 2018)





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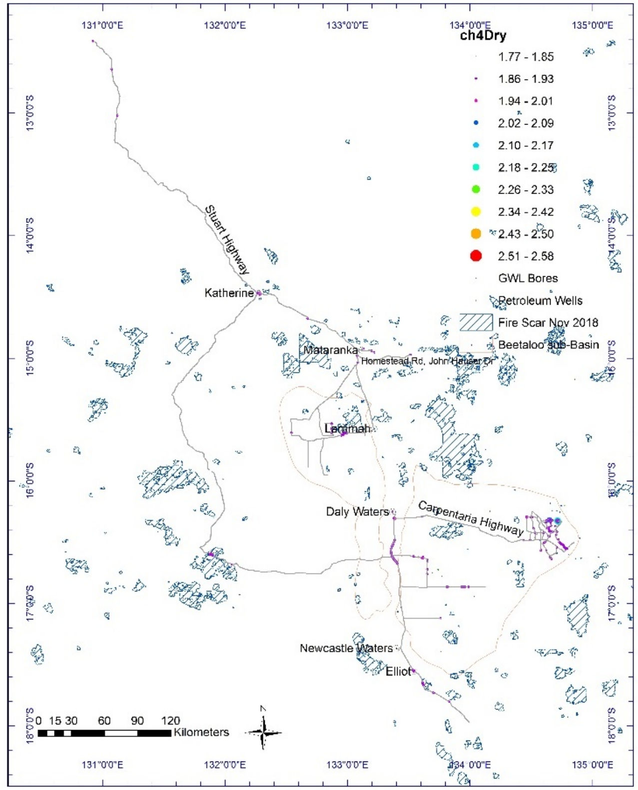
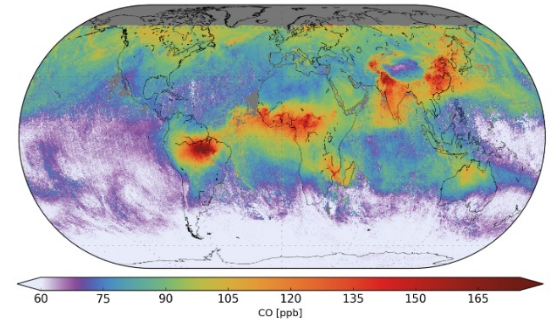
Fires

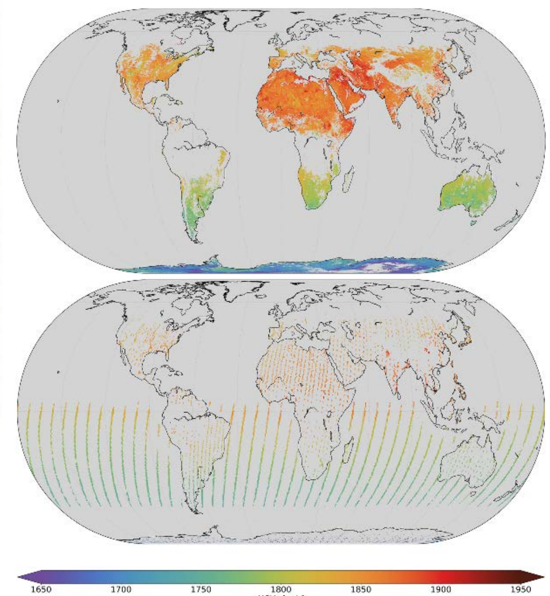
- Can be one of the largest sources of CH_4 emission;
- Spatially large, challenging to get close enough;
- Emission from fires currently estimated using satellite data and emission factors;
- Good candidate for GHG satellite with CH_4, CO, CO_2 capabilities;



CH4 from mobile survey compared to fire scar from satellite data



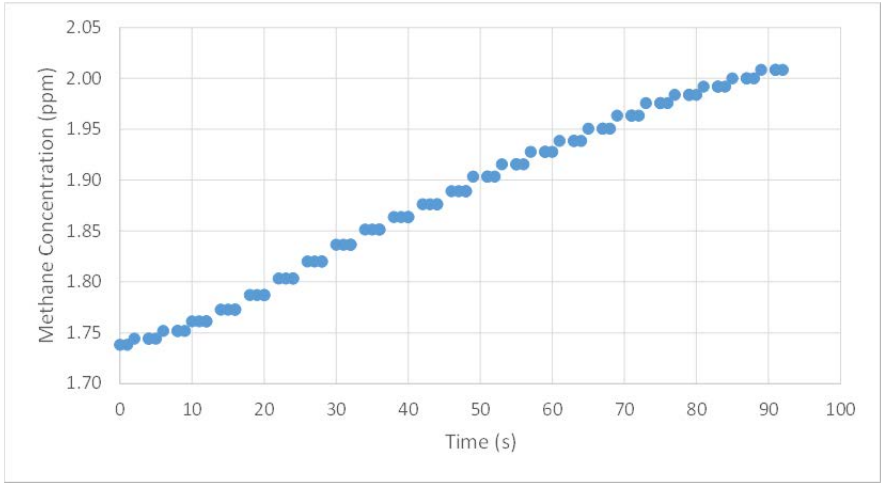
TROPOMI CO total column mixing ratio averaged from November 13th to 19th, 2017 (from Borsdorff et al., GRL 2018).



Global XCH4 distribution as obtained with TROPOMI (top) and GOSAT (bottom) measurements averaged over the period of 12 November to 30 December 2017 (from Hu, et al., AGU 2018)

Beetaloo Baseline: 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 $ha^{-1}yr^{-1}$))



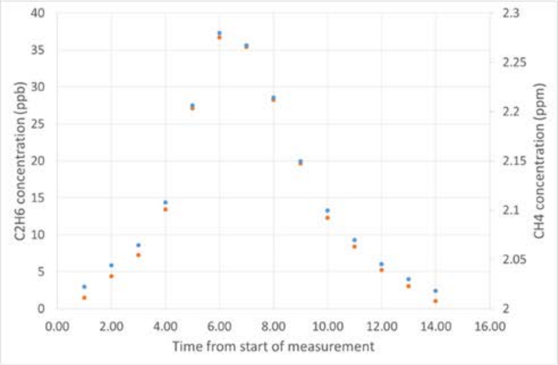
Beetaloo Baseline: Soils

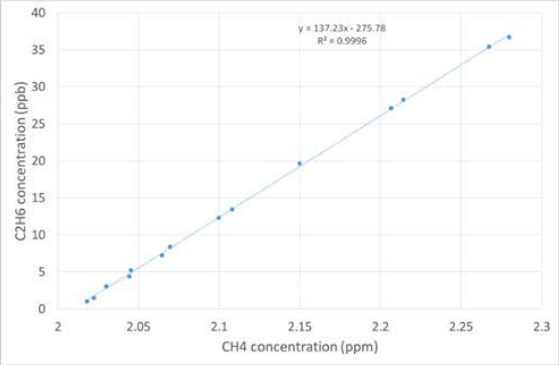
- Soil fluxes were measured at 8 sites throughout 3rd mobile campaign;
- Estimated emission sink for Beetaloo sub-Basin ~ approximately 4,200,000 kg CH_4 yr^{-1} based on Jamila et al. 2011: 1.52 kg CH_4 ha^{-1} yr^{-1}

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

Beetaloo Baseline: 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).





Beetaloo Baseline: 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

Beetaloo Baseline: 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;

Infrastructure

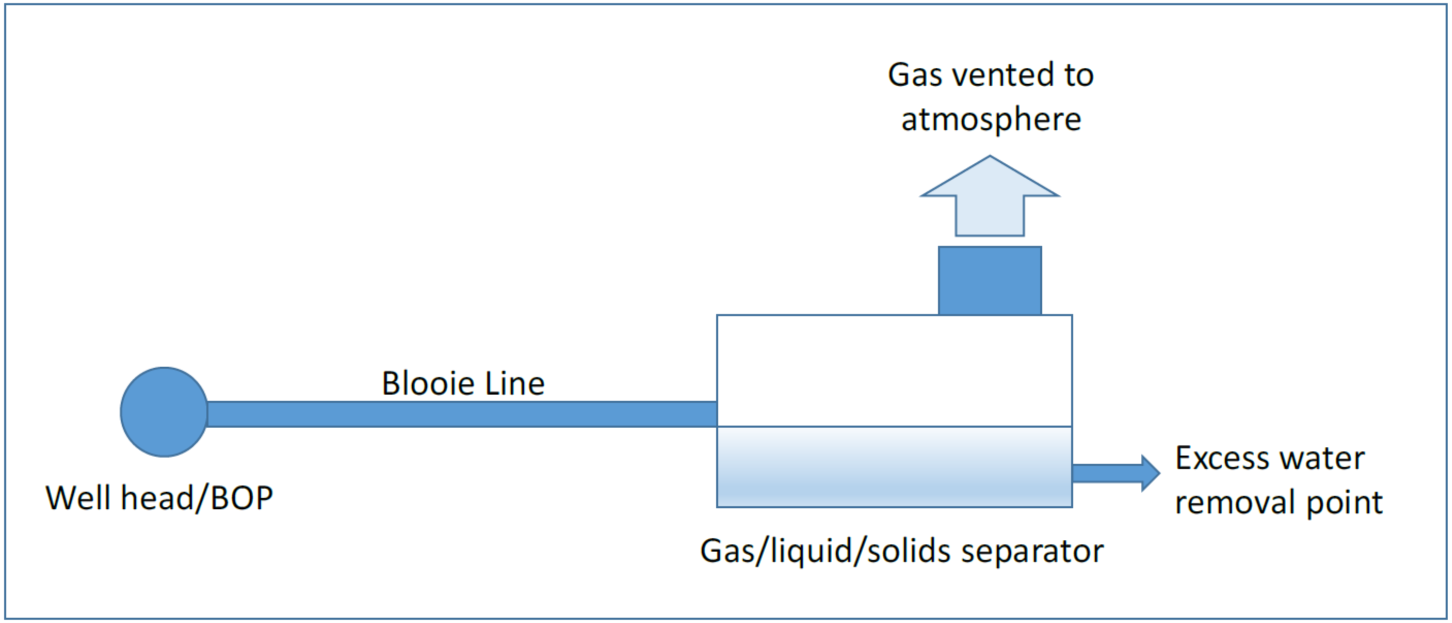
- CSG Wells;
- Wells Workover;
- Wells Completion;

Infrastructure: CSG Wells

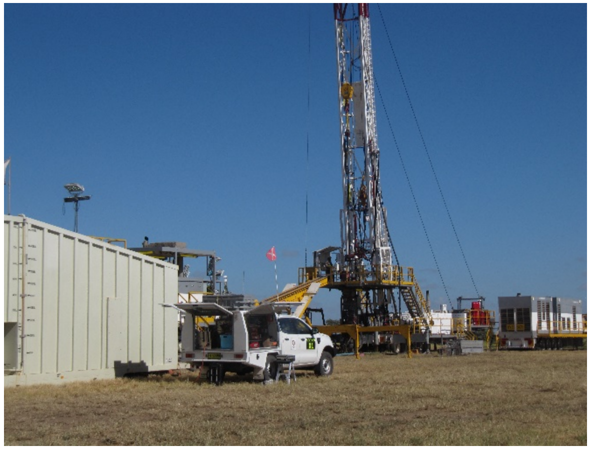
Year	No Wells	Location	Mean	Max	Comments
2013-14	43	NSW & QLD	5 L/min	67 L/min	<0.05 % production
2014-16	24	NSW	~ 5 L/min	33.8 L/min	
2019	300+	QLD	1.7 L/min	17.5 L/min	Preliminary from > ½ measurements

Infrastructure : CSG Well Workover Emissions

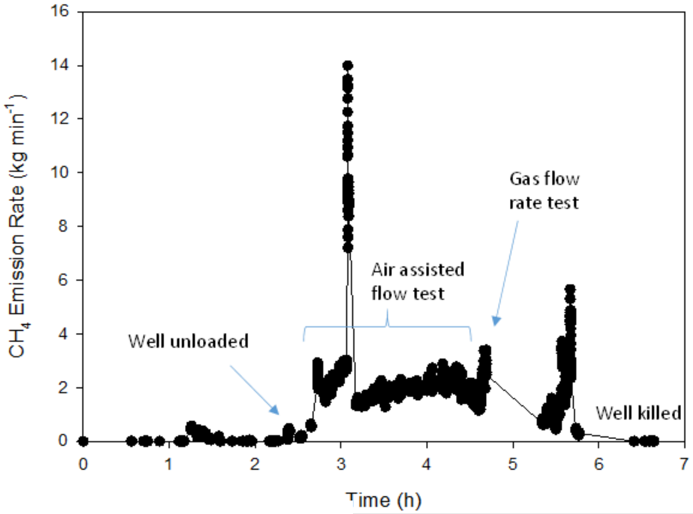
- Well cleaned to improve gas flow after some period of production
- One workover in 2015 - flushing the well with compressed air for 24 hours
  - Significant CH_4 since drilling fluid was not present; total amount vented was ~22 t;
  - CH_4 flow stopped when well was ‘killed’.
- Air injection is not typical for workovers
  - Likely that workovers without air injection have lower emissions;
  - Needs to be tested in the field.



Infrastructure: CSG Well Completion



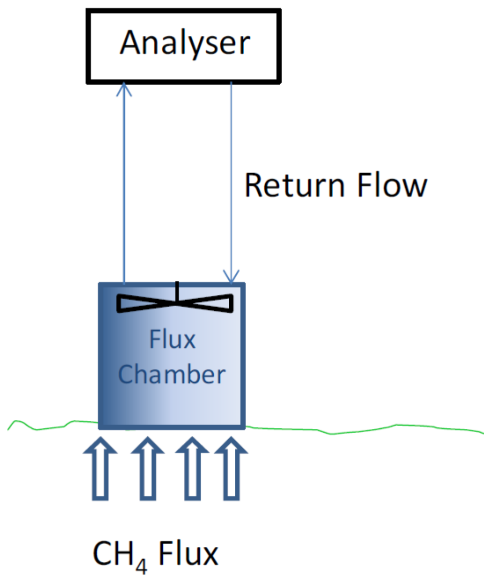
- Well completion activities; i.e. installation of water pump, tubing etc. into the well
- Emission measurements at 9 well sites in 2015-2016
  - Little or no emissions while well is filled with drilling fluid
  - Most emissions after unloading and during operations where air is injected into the well
  - Max emission from completion ~370 kg CH_4

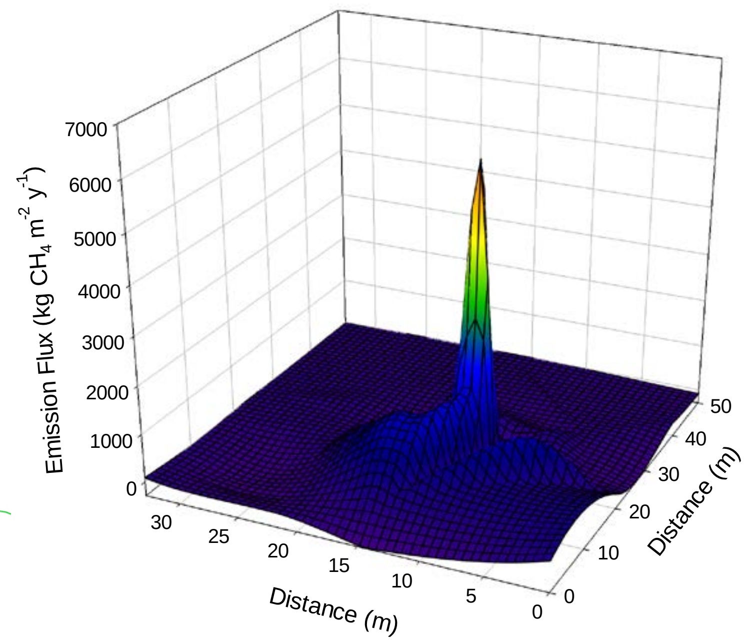


	Number of Wells	Mean Emission (kg CH_4)	Median Emission (kg CH_4)	Minimum Emission (kg CH_4)	Maximum Emission (kg CH_4)
Company A	4	128	98	0	315
Company B	5	175	126	25	373
Combined	9	154	126	0	373

Legacy: Surface Seeps (Abandoned Bores)

- Most emissions within about 2 x 2 m square
- Emission > 60 L min^{-1}
- Numerous other boreholes emission rates 0.1 to 100 L min^{-1}





Legacy: Surface Seeps (Source Unknown)

- Localised emission
  - No obvious source
  - Gas seeping from ground
  - Nearest CSG well > 2.5 km away
- Traversed to estimate flux
  - Up to 18 ppm CH_4
  - ~50 L min^{-1}

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Detection & Location Of Unknown Seepages

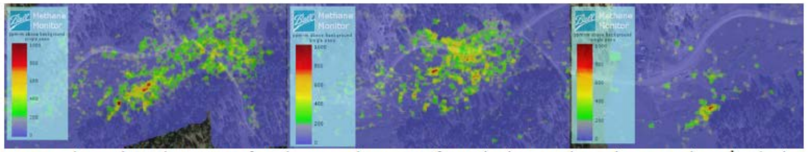


Figure 4: Site 1 plume images. Left and center plumes are from single-pass data taken on Feb. 26th. The image on the right is from the Feb. 27th flight. The color bars scale from 0 to 1,000 ppm-m.

Results from Fruitland Outcrop, San Juan Basin

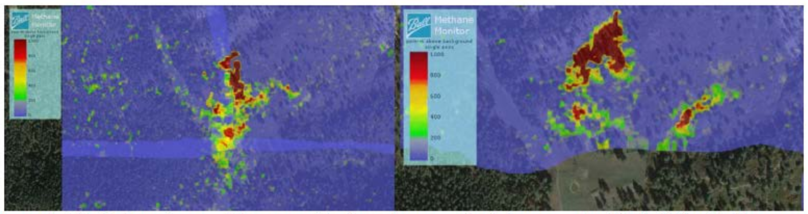


Figure 5: Site 2 plume images. The composite plume image on the left was captured Feb. 26th with three passes. The image on the right is from Feb. 27th and comes from a single overflight.

Table 1: Best effort estimation of CH4 flux for the detected sites. The values are total fluxes for each area.

			Estimated Flux (CFD)	
	Longitude	**Latitude**	**26-Feb**	**27-Feb**
Site 1	-107.65205	37.31519	19,200	6,000
Site 2	-107.64201	37.31267	48,000	72,000
Site 3	-107.65773	37.31390	7,200	7,200
Site 4	-107.66257	37.31504	2,400	N/A

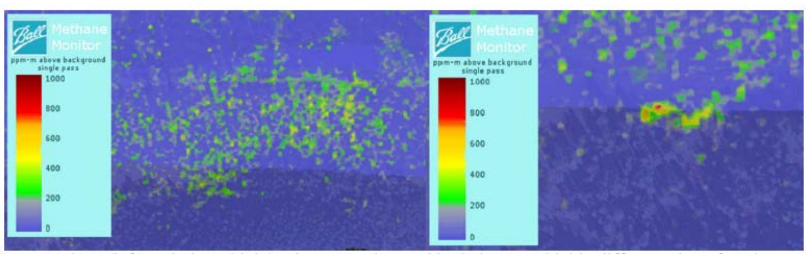
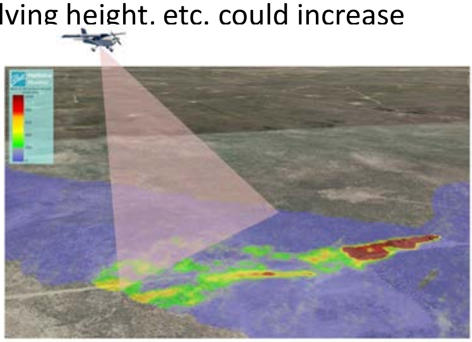
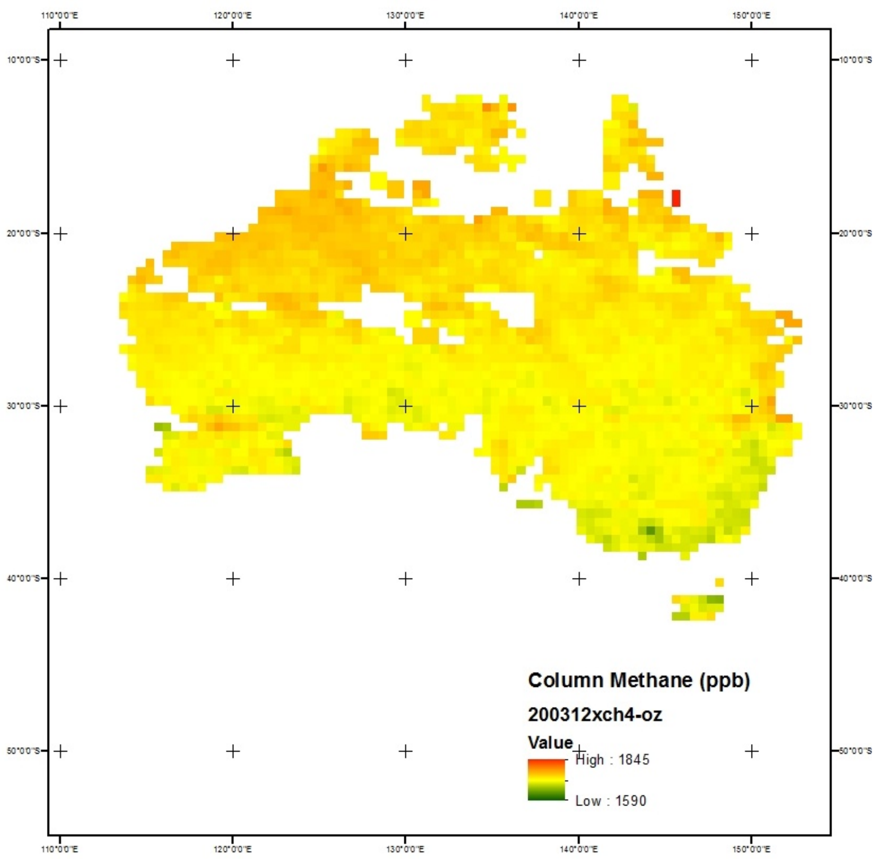


Figure 6: Site 3 (left) and Site 4 (right). Site 3 was observed both days as a highly diffuse region of methane with little structure. Site 4 was only seen Feb. 26th and had a definite seep source location

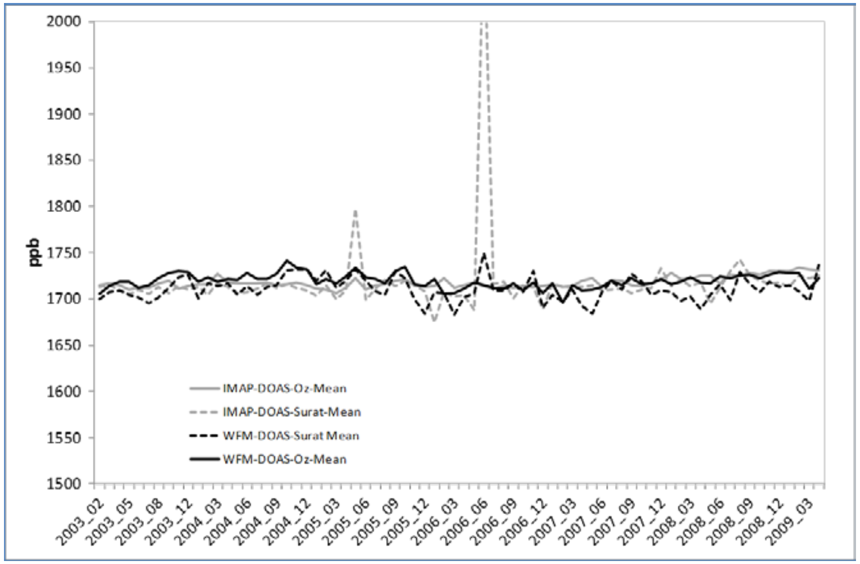
Note: Data were acquired at reduced sensitivities.
Could potentially double in sensitivities;
Different configurations such as lower flying height, etc. could increase detection

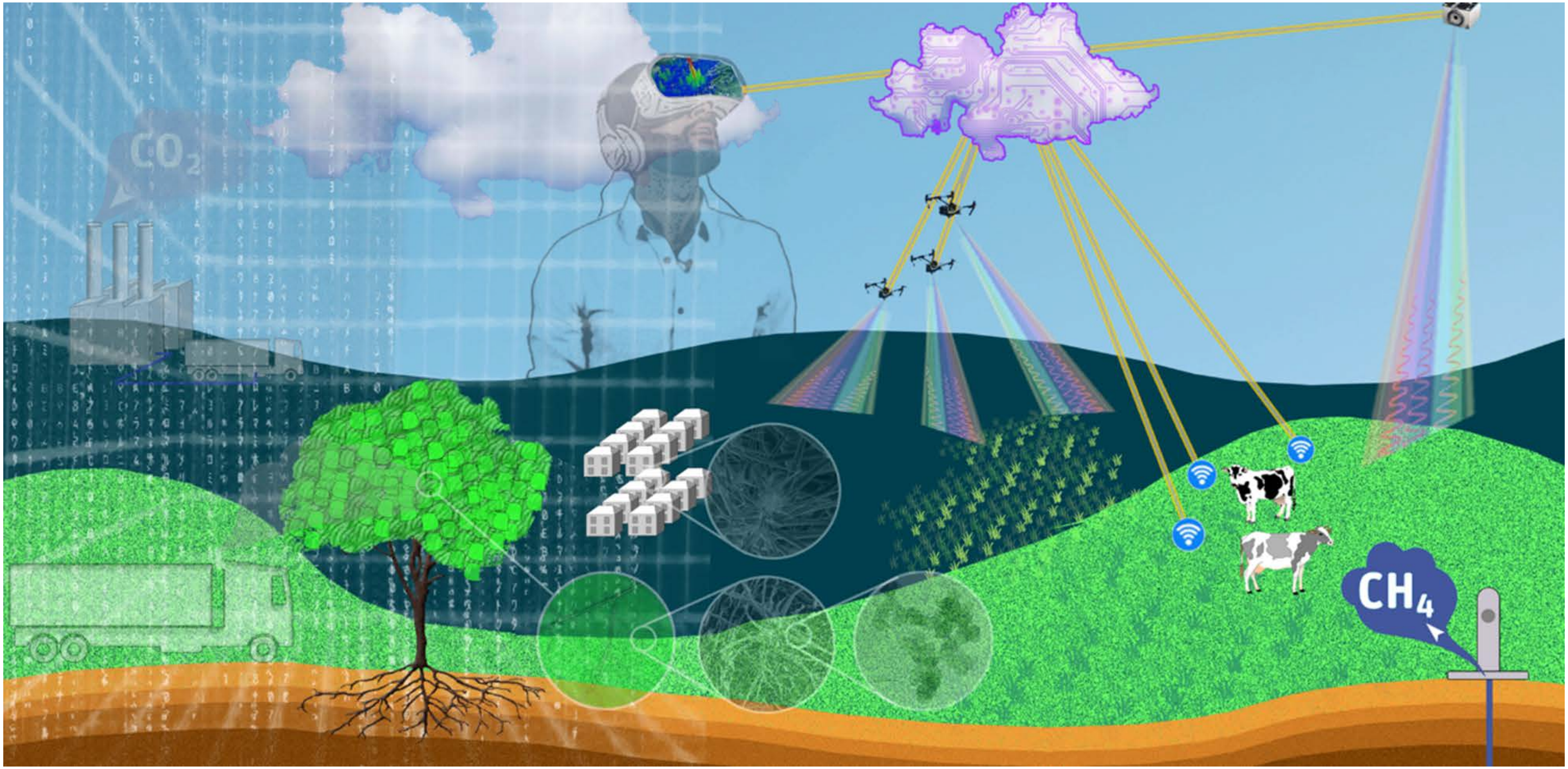


Regional Monitoring: Multi-Temporal



- 6 year of satellite (SCIAMACHY) data;
- Regional trends in Surat Basin compared to whole of Australia





CO2
CH4

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Thank you

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