Quantifying methane fluxes in the Hunter Valley through Fourier Transform Infrared Spectrometry and a Gaussian plume dispersion model

Mackenzie A. Purtill-Wright[1,2], Nicholas M. Deutscher[1], Nicholas Jones[2], Hasan Nawaz[1], Bryce F.J. Kelly[3], Stephen J. Harris[3,4], Methane Hunter Team[5]

[1]Environmental Futures Research Centre, School of Science, University of Wollongong, NSW, Australia; [2]Centre for Atmospheric Chemistry, School of Mathematics & Physics, University of Wollongong, NSW, Australia; [3]School of Biological Earth & Environmental Sciences, University of New South Wales, NSW, Australia; [4]UNEP's International Methane Emissions Observatory, Paris, France; [5]All team members who contributed to instrument setup, data collection and analysis.

Introduction

- Atmospheric methane (CH_4) concentrations have increased by more than 17% over the past four decades [1].
- In Australia, coal production is a major CH_4 source, with emissions typically estimated from activity data and fugitive emission factors rather than direct atmospheric observations.
- Previous studies [2] report significant discrepancies between observed and reported emissions, suggesting that CH_4 emissions may be underestimated.
- Although surface coal production has increased, Australia's reported fugitive emissions have not increased on a relative basis (Figure 1).
- The Hunter Valley, NSW, has an extensive fossil fuel industry (Figure 2), which includes BHP's Mt Arthur mine, the largest open-cut coal mine in New South Wales.

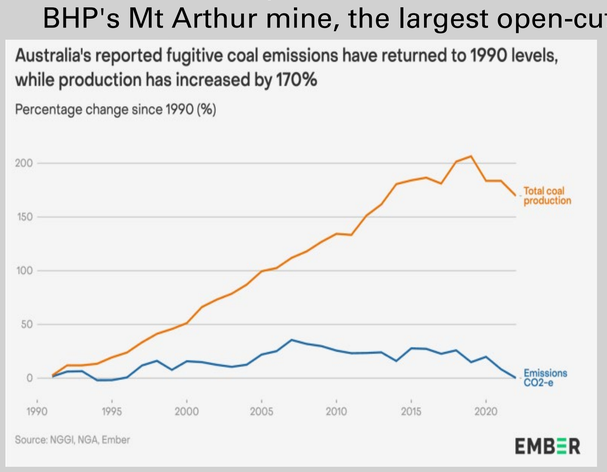

Figure 1. Australia's fugitive coal emissions compared to the total coal production, since the 1990s [3].

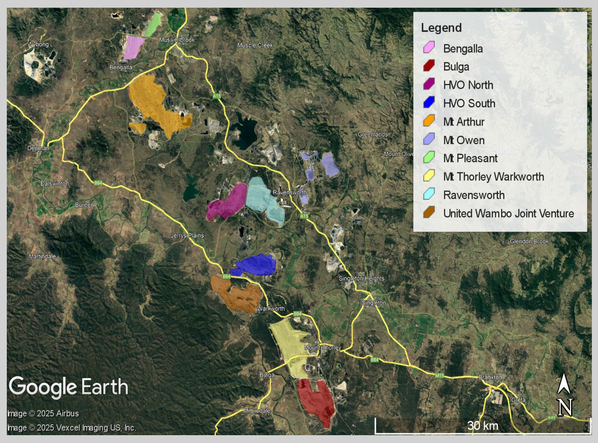

Figure 2. Locations of open-cut coal mines in the Hunter Valley, NSW.

Methods and Objectives

- Deployed a network of EM27/SUN spectrometers upwind and downwind across the Hunter Valley (Figure 3), NSW, to retrieve total column-averaged dry-air CH_4 mole fractions (XCH_4).
- Estimated CH_4 emission fluxes from open-cut coal mines using differential column measurements and a Gaussian plume dispersion model and compared results with facility-reported emissions.
- Meteorological inputs were obtained from the Bureau of Meteorology (BoM) Scone Airport monitoring site.

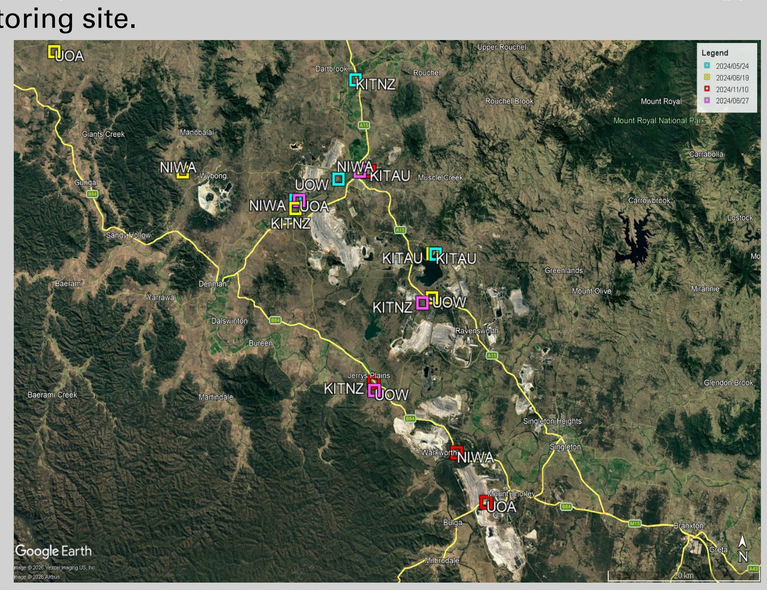

Figure 3. Locations of EM27/SUN instruments on each measurement campaign day.

Methane Plume Detection and Emission Modelling in 2024 Campaigns

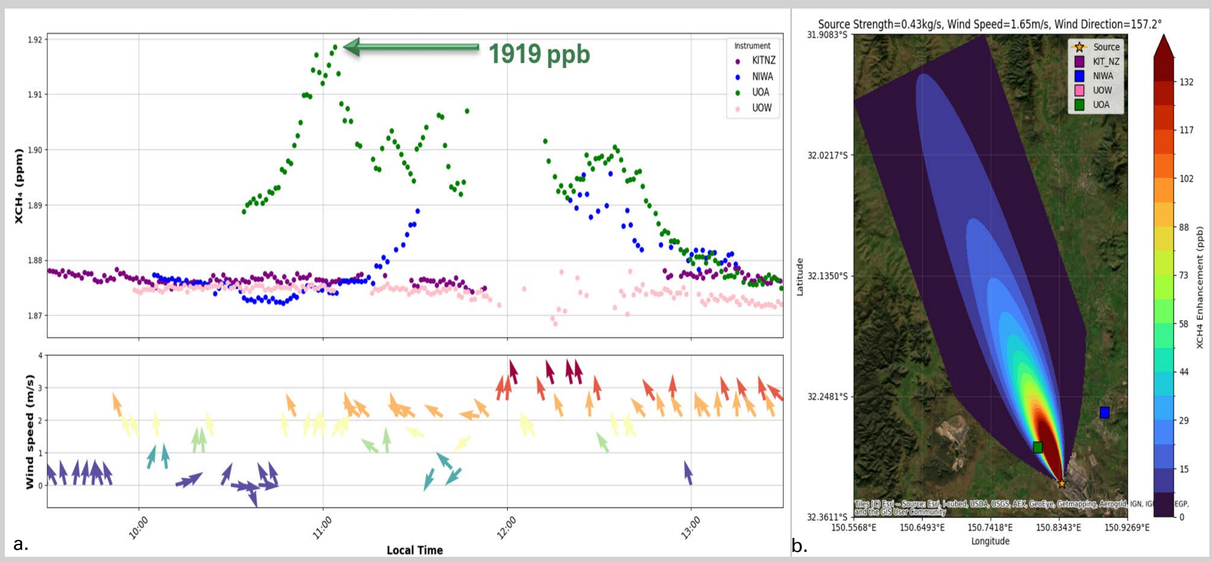

*Figure 1. (a) The top panel presents XCH_4 registered by the EM27/SUN instruments on the **24th May 2024** in the Hunter Valley. The bottom panel represents the associated three-minute-averaged wind speed and direction from the BoM Scone Airport site. (b) Gaussian plume simulation for the **24th May 2024**, from the **Mt Arthur facility.***

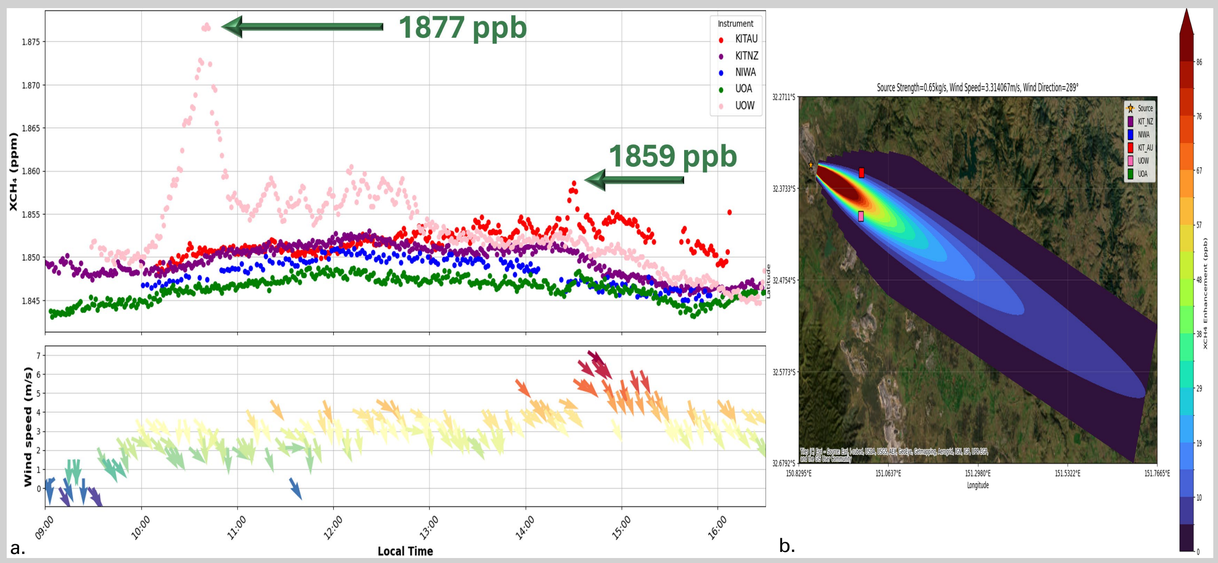

*Figure 2. (a) The top panel presents XCH_4 registered by the EM27/SUN instruments on the **19th June 2024** in the Hunter Valley. The bottom panel represents the associated three-minute-averaged wind speed and direction from the BoM Scone Airport site. (b) Gaussian plume simulation for the **19th June 2024**, from the **Mt Arthur facility.***

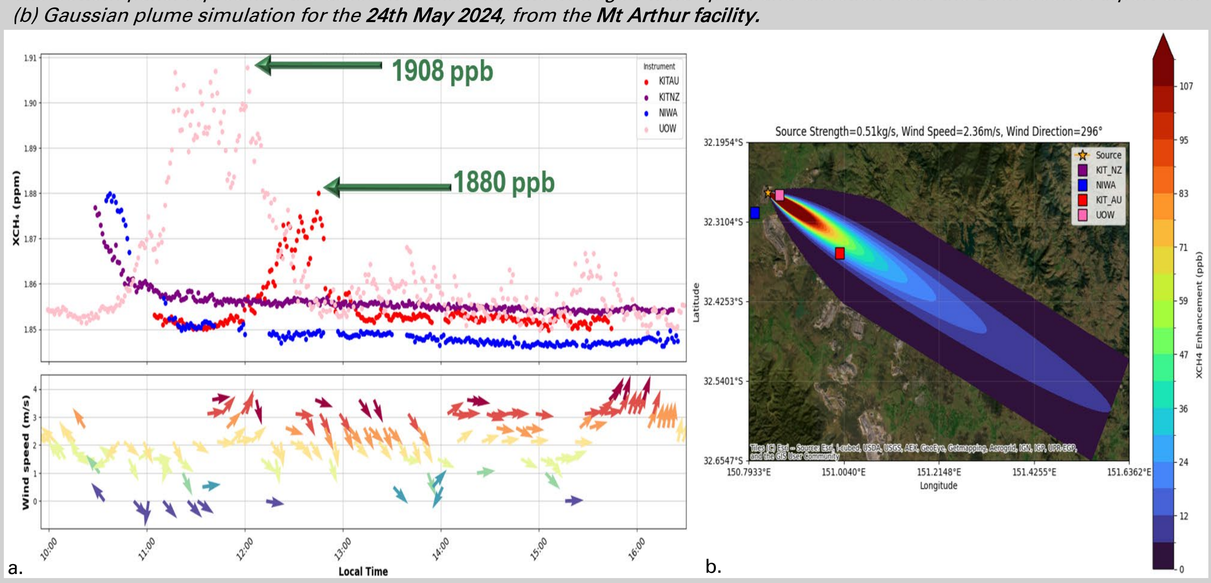

*Figure 3. (a) The top panel presents XCH_4 registered by the EM27/SUN instruments on the **27th June 2024** in the Hunter Valley. The bottom panel represents the associated three-minute-averaged wind speed and direction from the BoM Scone Airport site. (b) Gaussian plume simulation for the **27th June 2024**, from the **Bengalla facility.***

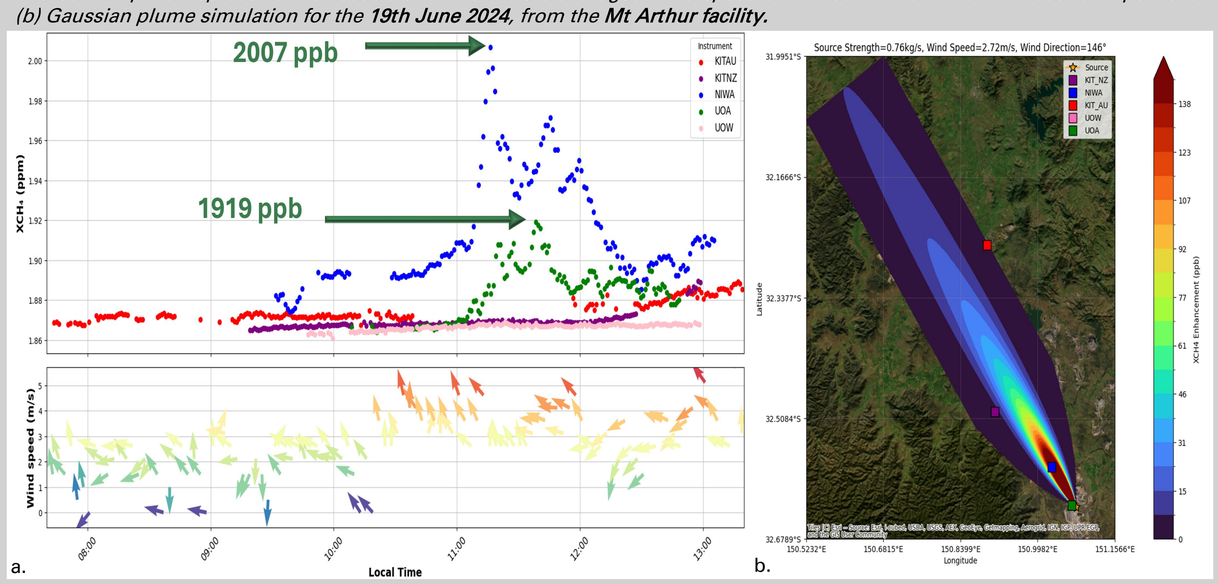

*Figure 4. (a) The top panel presents XCH_4 registered by the EM27/SUN instruments on the **10th November 2024** in the Hunter Valley. The bottom panel represents the associated three-minute-averaged wind speed and direction from the BoM Scone Airport site. (b) Gaussian plume simulation for the **10th November 2024**, from the **Mt Thorley Warkworth facility.***

Results

Date (2024)	Modelled CH_4 Source Strength	Reported CH_4 Source Strength [4]
24th May	1550±140 kg/hr	162 kg/hr
19th June	2340±220 kg/hr	162 kg/hr
27th June	1840±180 kg/hr	1680 kg/hr
10th November	2740±150 kg/hr	2495 kg/hr

- **24th May:** UOA instrument registered an enhancement of 44 ppb above background. The source was attributed to the Mt Arthur mine.
- **19th June:** UOW and KITAU instruments registered an enhancement of 30 ppb and 11 ppb above background, respectively. The source was attributed to the Mt Arthur mine
- **27th June:** UOW and KITAU instruments registered an enhancement of 51 ppb and 24 ppb above background, respectively. The source was attributed to the Bengalla facility.
- **20th November:** NIWA and UOA instruments registered an enhancement of 138 ppb and 51 ppb above background, respectively. The source was attributed to the Mt Thorley Warkworth Facility

Conclusions

- Modelled emissions from the Mt Arthur Coal mine were substantially higher than reported values, indicating that current reporting methods may underestimate CH_4 emissions.
- Uncertainties arise from the assumptions associated with a simplified Gaussian plume model and the presence of other nearby sources; however, the large discrepancy underscores the need for emission reconciliation.
- Future work will incorporate advanced dispersion models, such as FLEXPART, and improved meteorological modelling, such as WRF, to improve accuracy and strengthen emission estimates.

References

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