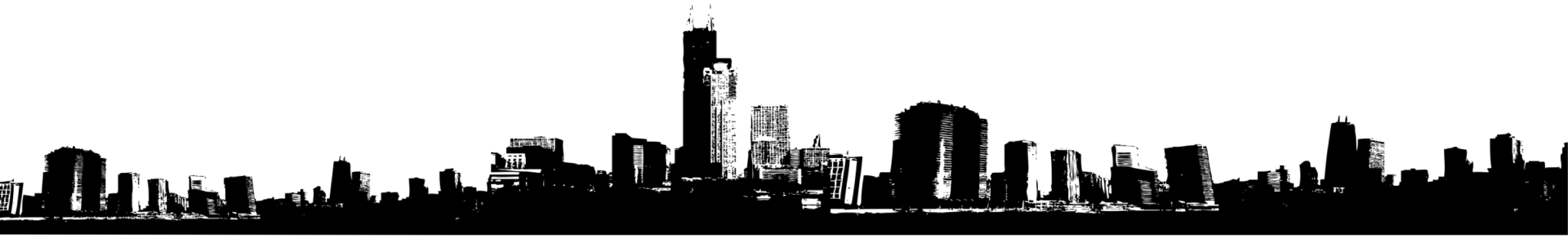
Urban Methane Surveys – A Case Study Where Isotope Measurements Guided Source Attribution



Bryce F.J. Kelly[1], Xinyi Lu (Lexie)[1], Zoë M. Loh[2] and Rebecca E. Fisher[3]

1) School of Biological, Earth and Environmental Sciences, UNSW Sydney, 2052, NSW, Australia
2) CSIRO Oceans & Atmosphere, Aspendale, Victoria, 3195, Australia
3) Royal Holloway, University of London, Egham Hill, Egham, Surrey TW20 0EX, United Kingdom

EGU Sharing Geoscience Online | May 2020

Content

01 Introduction

02 Methods

03 Preliminary Results

04 Key Insights

EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

Introduction: Methane Sources in Melbourne

Melbourne is Australia's second largest city with a population approaching 5 million people. It has grown rapidly since founded ~200 years ago.

This has left legacy potential methane (CH_4) sources. For example, the gas distribution system has piping ranging from modern to 100 years old (common in unrenovated houses from early last century); landfills that use to be on the city fringe are now surrounded by new housing developments.

Fig. 1. Methane sources in Melbourne.

Major potential urban sources include: the gas distribution network, landfills, wastewater treatment plant, appliances in houses (heaters, stoves, hot-water systems), wood burning heaters, and urban wetlands (Figure 1). Our research demonstrates that mobile surveying is a highly efficient way to identify and locate previously unknown CH_4 sources.

EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

Methods — Ground Surveying

Mobile laboratory for source detection.

Teflon Tube Inlet

AtlasLink GPS
Location to 15 cm

LGR Greenhouse Gas Analyser
-CH_4 and CO_2 mole fraction
-High flow rate for driving speed plume mapping

Fig. 2. Setup of the Los Gatos Research (LGR) ultra-portable greenhouse gas analyser for mobile measurements of CH_4 and CO_2 mole fractions. Measurements were georeferenced using a Hemisphere GPS linked to the instrument.

Methods — Air Sampling and Analysing

Grab bag samples were collected in the plume. These air samples were then analysed using the Picarro G2201-i cavity ring-down spectrometer (CRDS) for CH_4 mole fraction ($[CH_4]$) and stable carbon isotope ratios ($\delta^{13}C\text{-}CH_4$).

Fig. 3. Samples were collected in 3L SKC FlexFoil Plus bags.

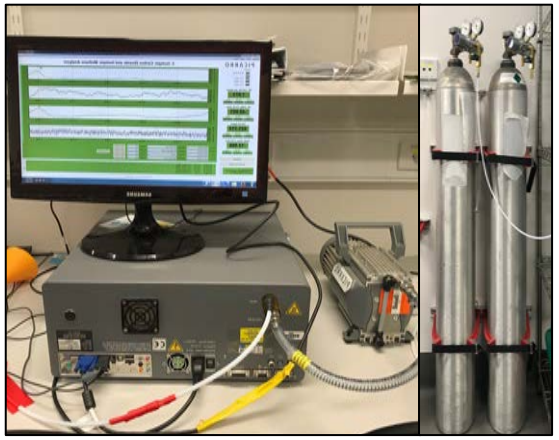


Fig. 4. Laboratory analysis was performed using Picarro G2201-i CRDS.

The $\delta^{13}C$ value of each individual source was determined by the Miller-Tans plot approach (Miller and Tans, 2003) using Bayesian linear regression.

Preliminary Results: Mapping Methane in Melbourne

UNSW and CSIRO performed field campaigns in July 2019 and March 2020 to identify and characterise major CH_4 sources. Fig. 5 shows routes of over 26 km surveyed during both daytime and nighttime in south eastern Melbourne.

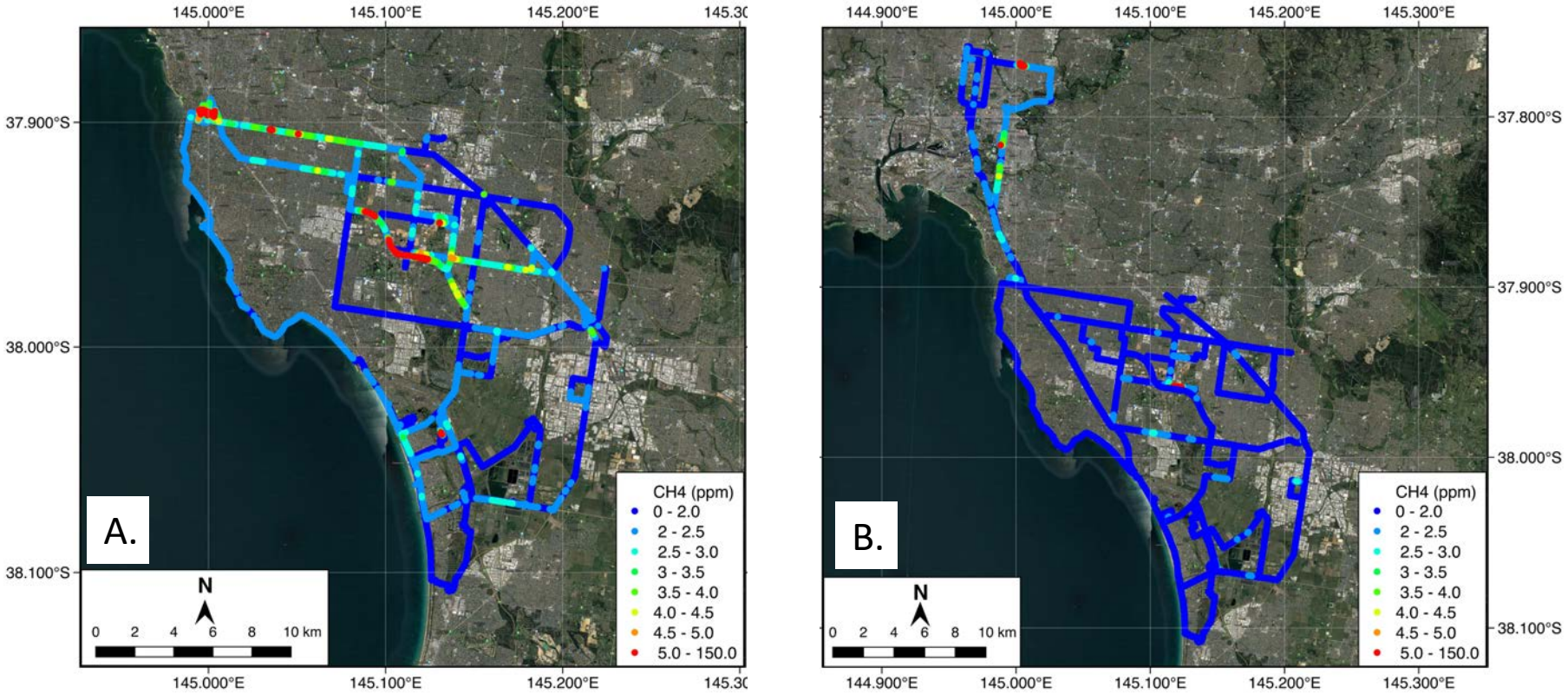


Fig. 5. Methane mole fraction in Melbourne in July 2019 (A) and March 2020 (B). Plotted using QGIS.

Preliminary Results: Diel CH_4 Mole Fraction Comparison

We repeated part of the survey at different time of day during campaigns. The background [CH_4] level was higher at midnight than midmorning. After sunset, the formation of the nocturnal boundary layer reduces the volume of air into which the fugitive emissions mix. This results in a higher background methane mole fraction.

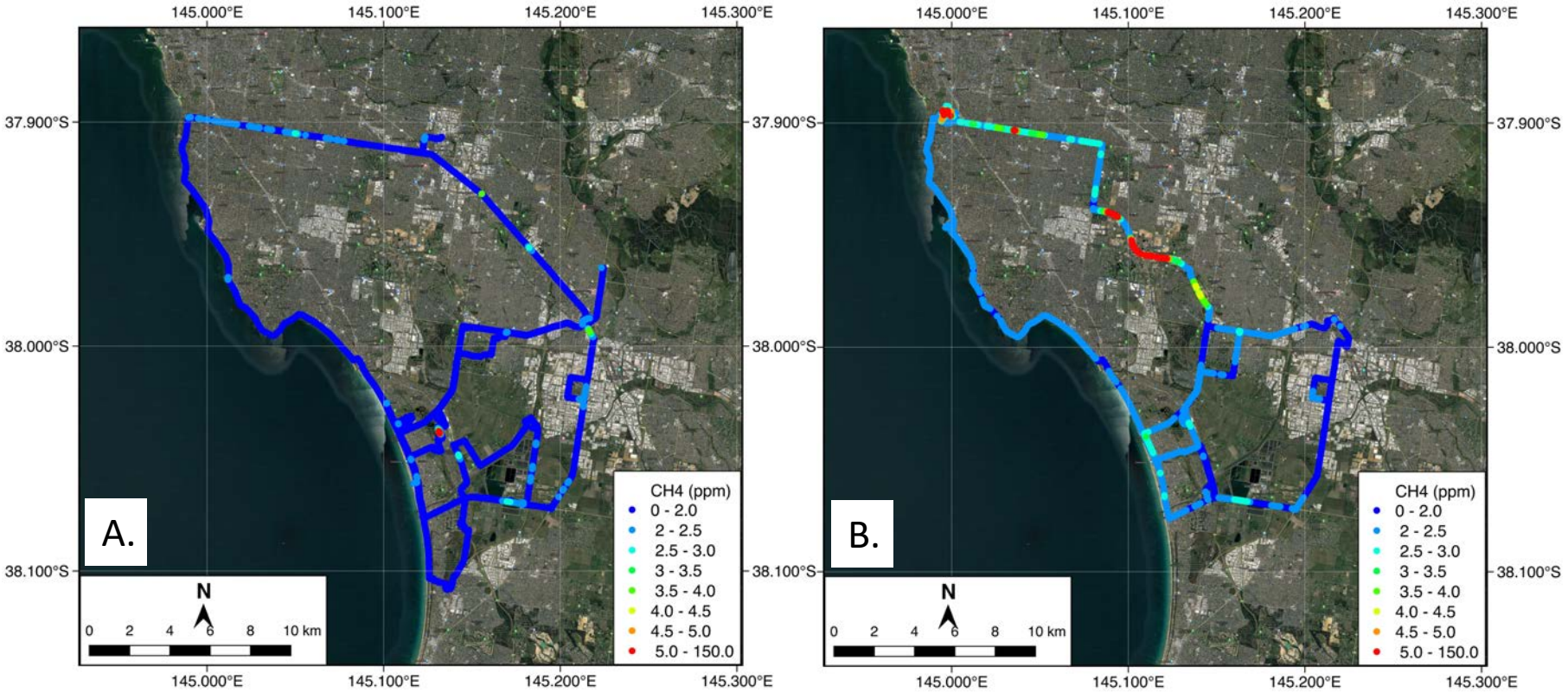


Fig. 6. Daytime (A) and nighttime (B) methane mole fraction in Melbourne, July 26, 2019. Plotted using QGIS.

Preliminary Results: Plume Mapping

The ground surveying covered the south eastern area of Melbourne. Here we use the Google Earth to display captured CH_4 mole fraction, this allows the gas plumes to be geospatially visualized and verified once plumes are isotopically analysed. Daytime survey is shown in yellow and nighttime survey is shown in cyan.

The overall measured mole fraction of methane ranged from 1.83 to 147 ppm in 2019 and from 1.83 to 26 ppm in 2020. Several methane sources were detected. Samples of air were collected from within the plumes shown in the Google Earth display. These samples were then analysed using a Picarro 2201-i analyser.

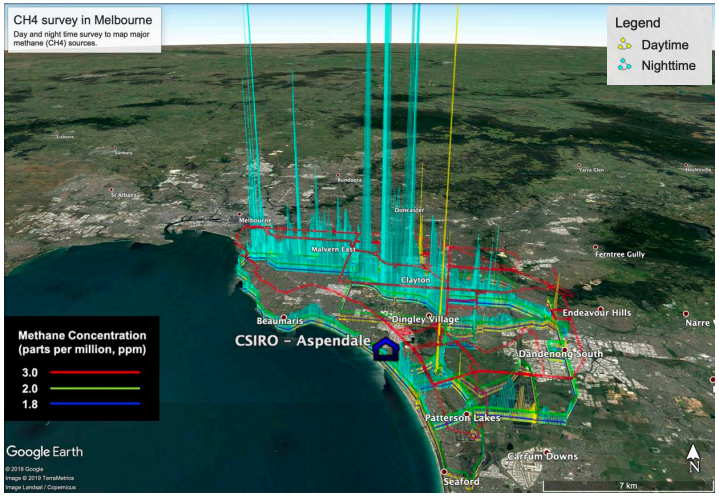


Fig. 7. Please see details in page 9.

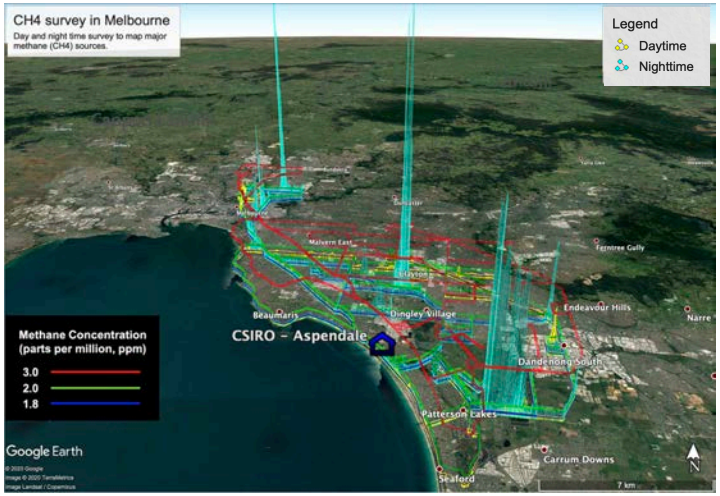


Fig. 8. Please see details in page 10.

Preliminary Results: Sampled Plumes in 2019

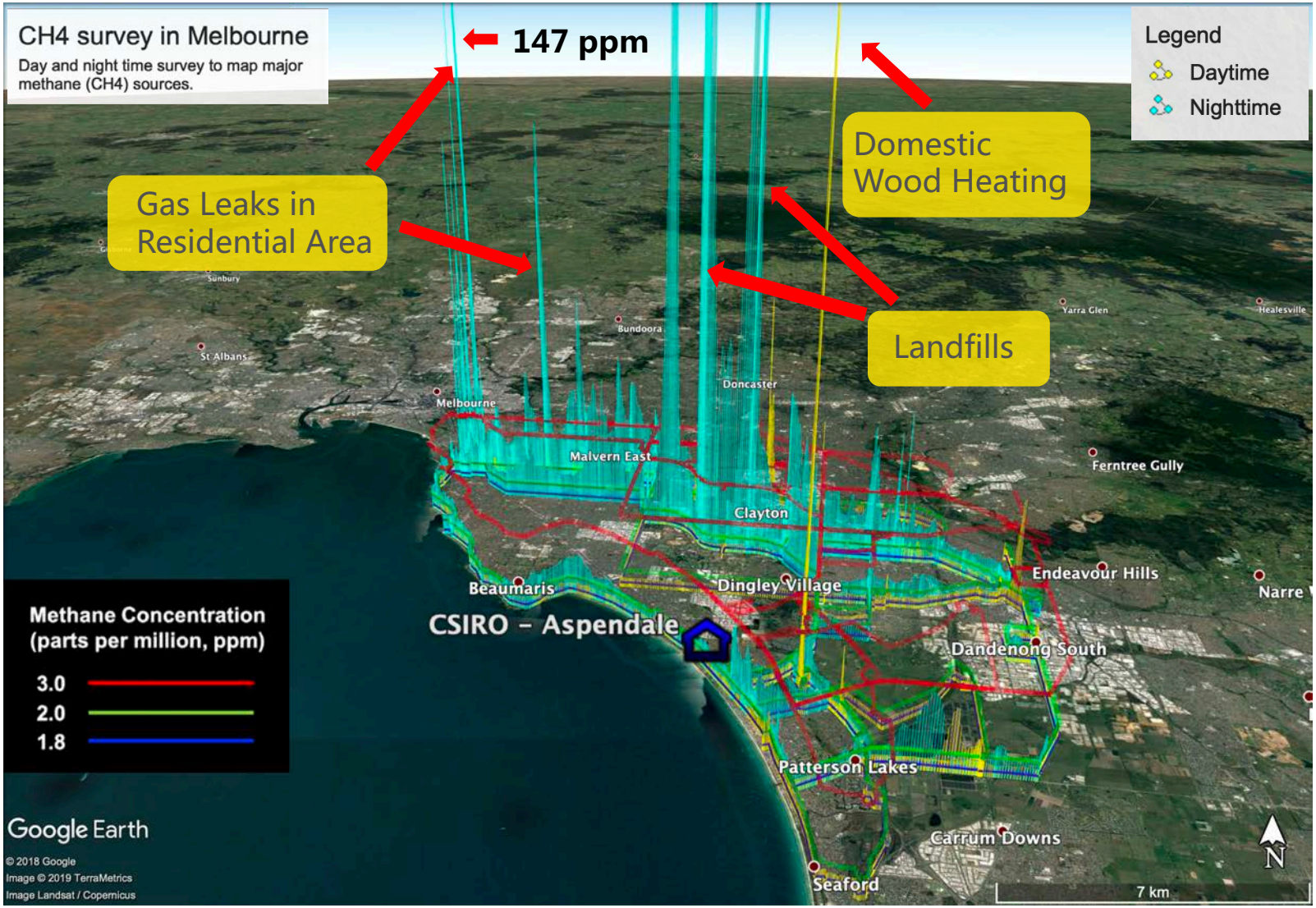


Fig. 7. Methane mole fraction in Melbourne, July 2019. Surveys during daytime and nighttime are plotted in yellow and cyan. Base map is from Google Earth.

Preliminary Results: Sampled Plumes in 2020

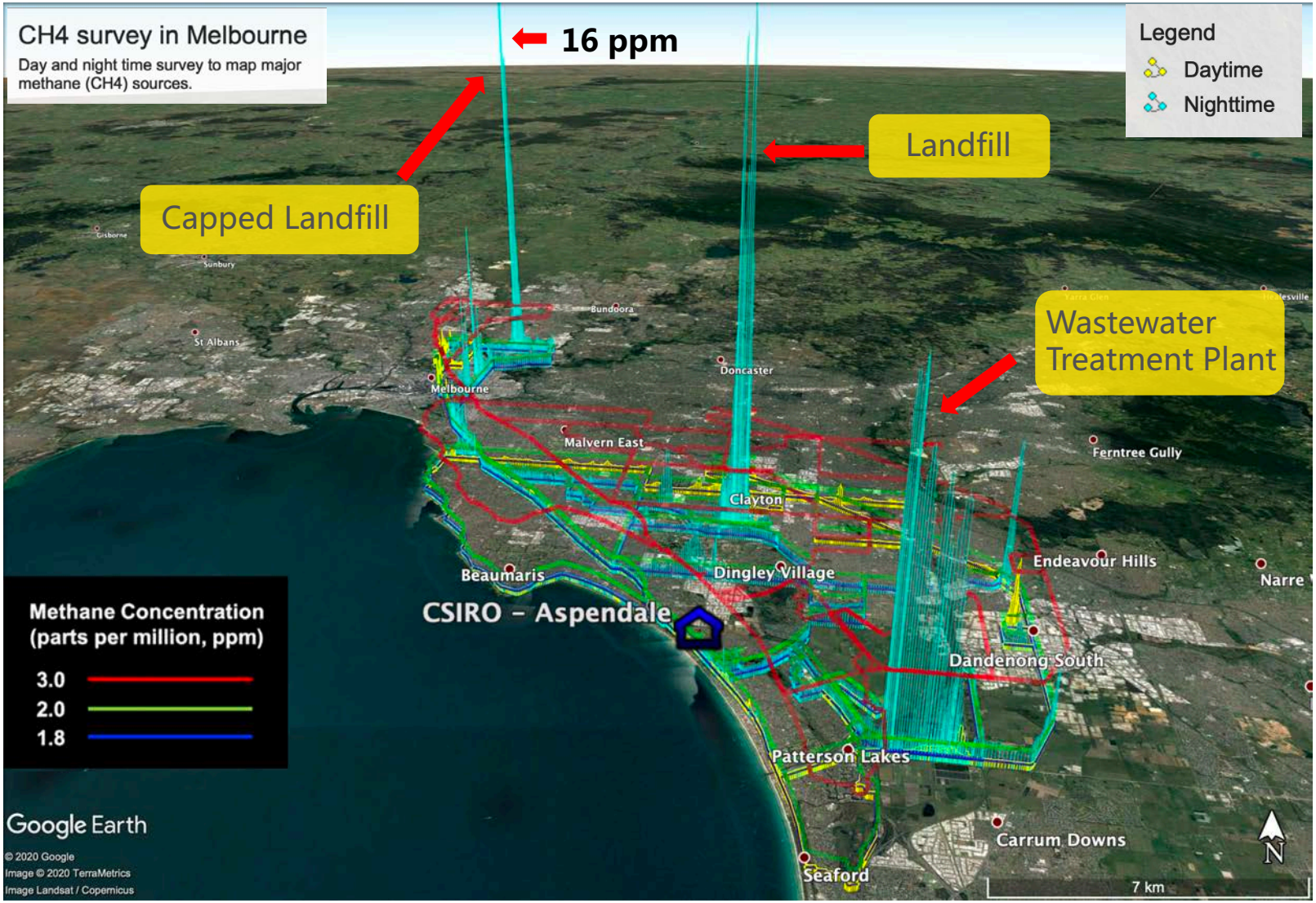


Fig. 8. Methane mole fraction in Melbourne, March 2020. Surveys during daytime and nighttime are plotted in yellow and cyan. Base map is from Google Earth.

Preliminary Results: Methane Isotopic Signatures

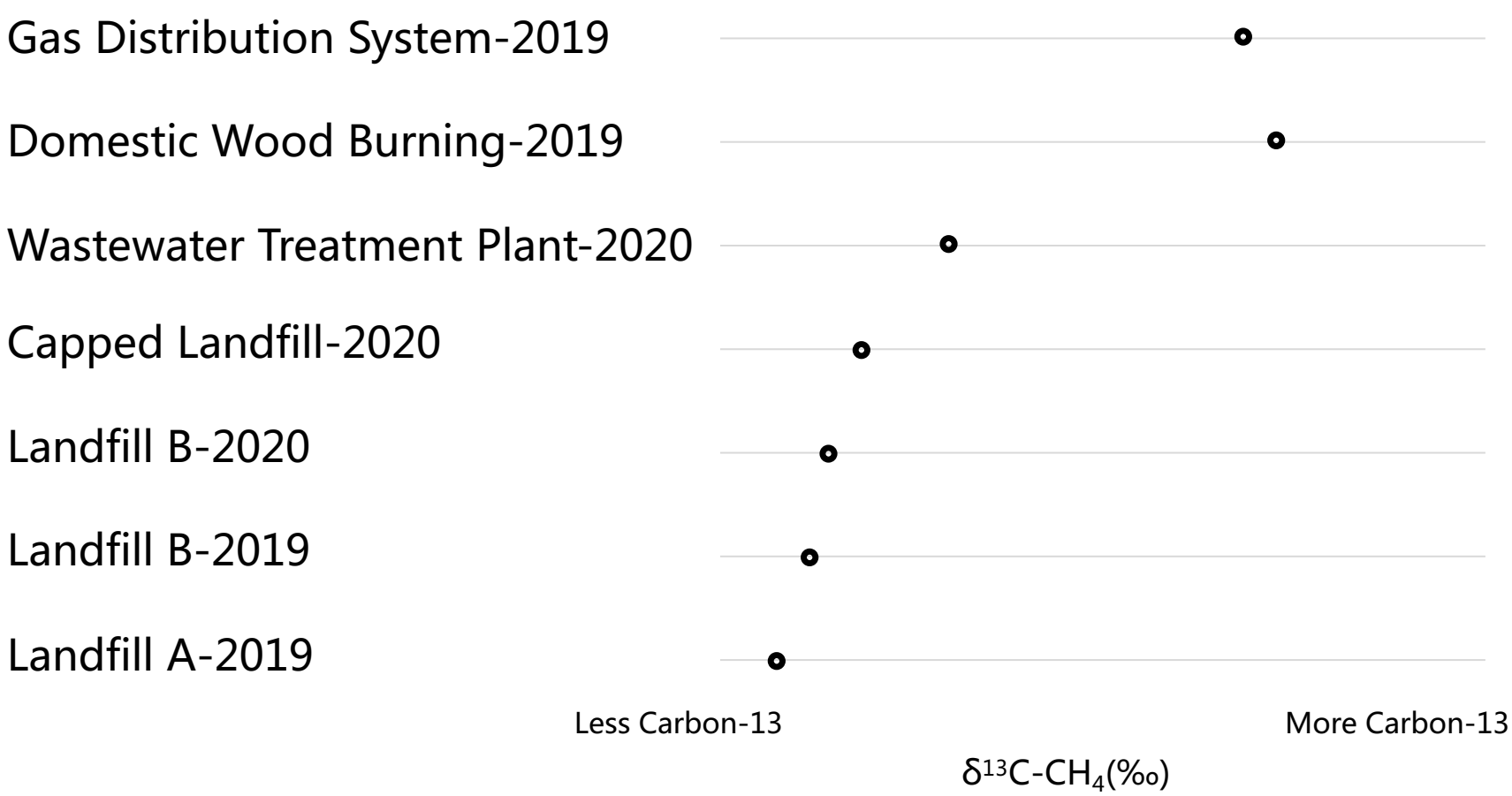
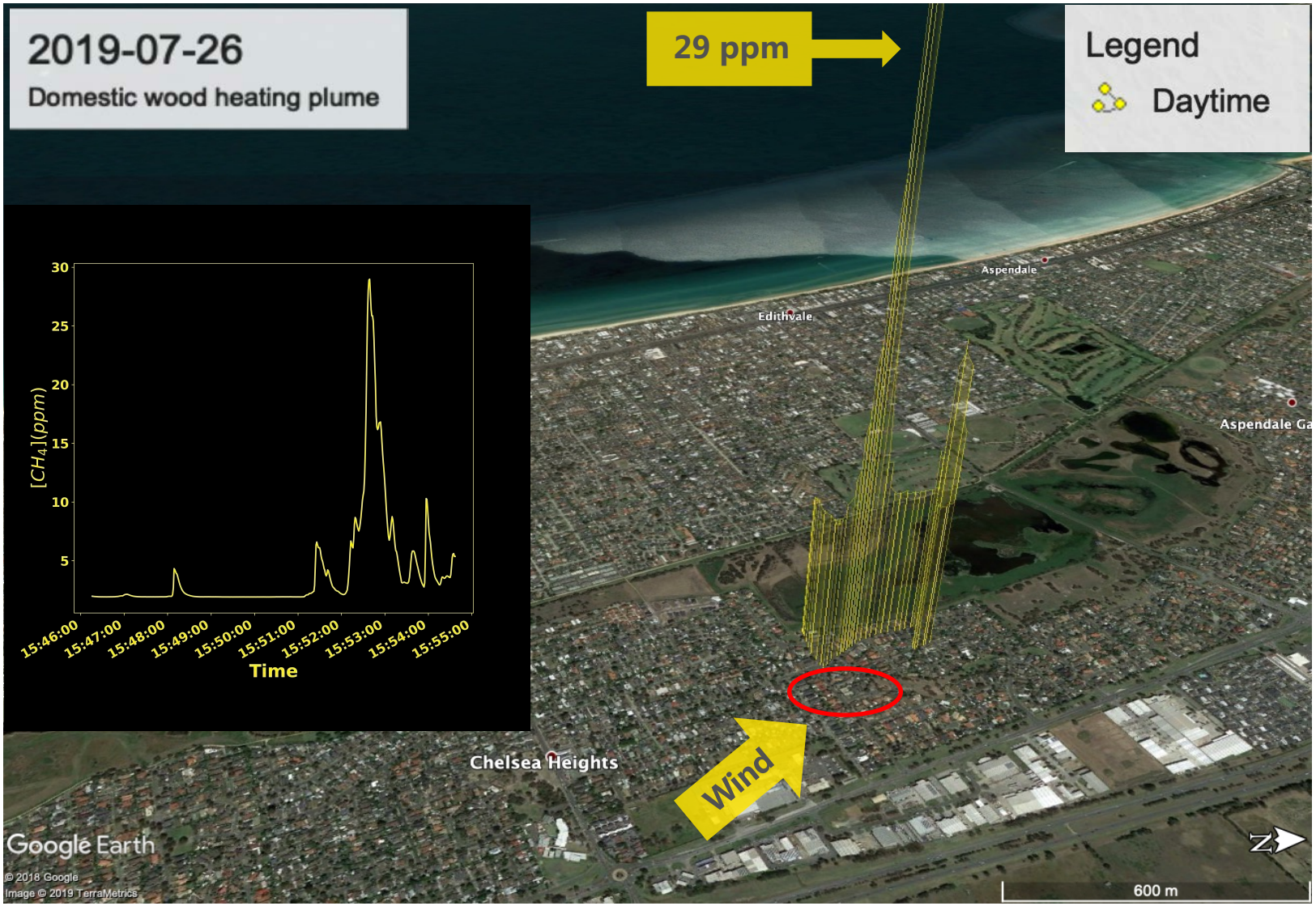


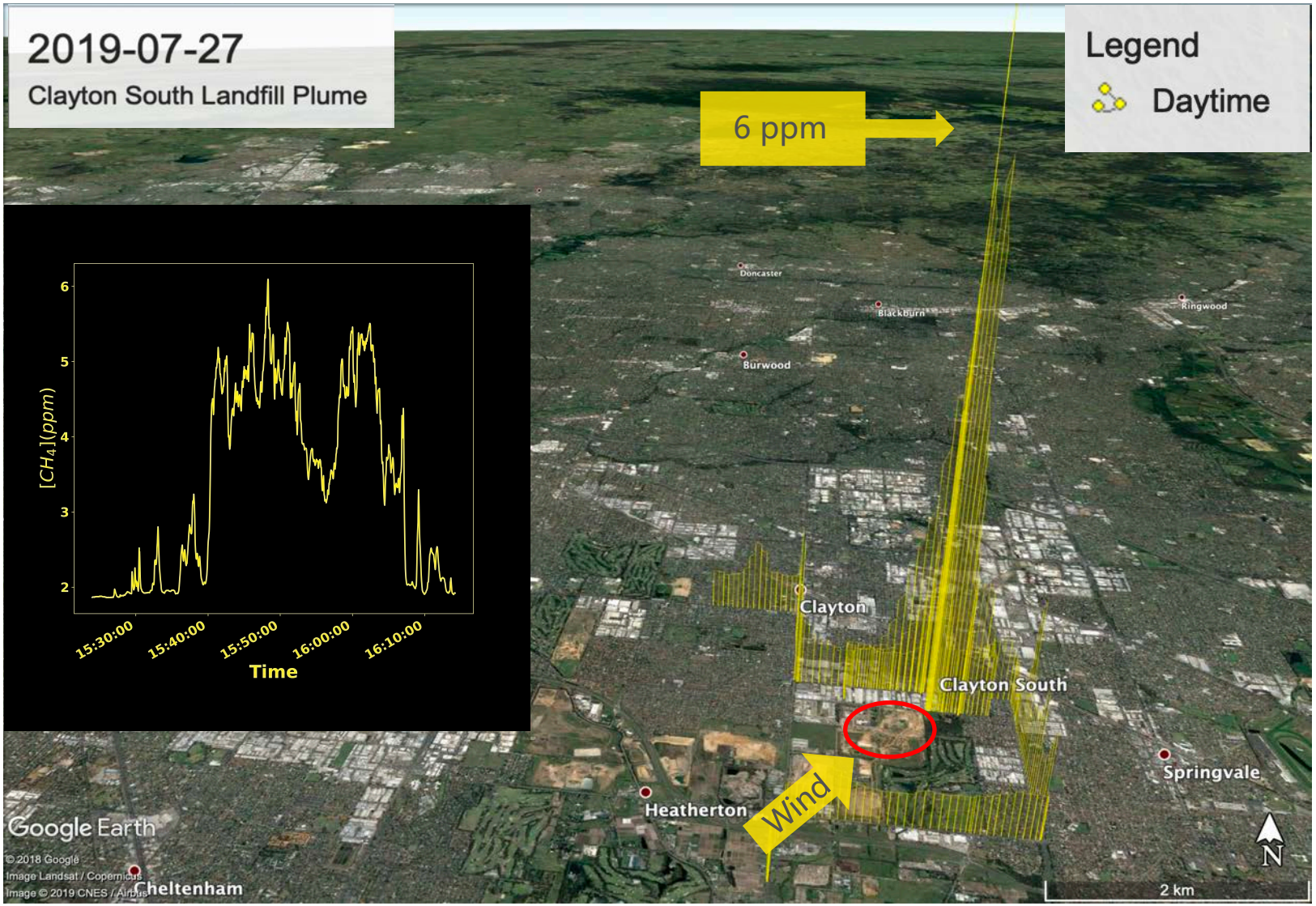
Fig. 9. Methane isotopic signatures of sampled sources.

Example — Domestic Wood Heating



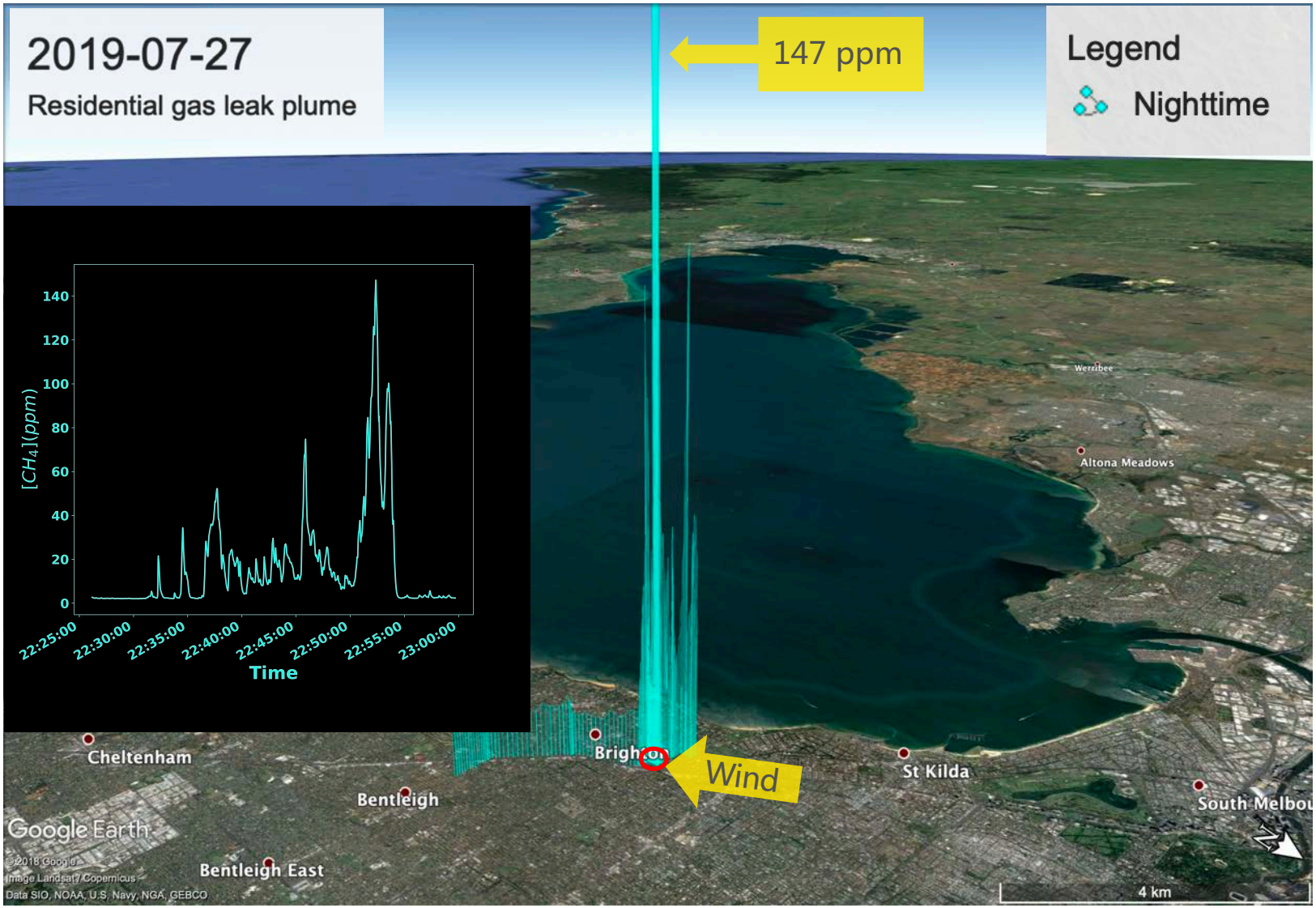
EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

Example — Landfill A



EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

Example — Residential Gas Leak



Key Insights

Surveying during nighttime provides better opportunity for plume mapping and isotope analysis in an urban environment.

Mobile survey coupled with isotopic measurement is a highly efficient way to identify and locate previously unknown CH_4 sources.

There is a need to further investigate the difference between bottom-up inventory emissions estimates and top-down measurements from surveys like this one.

EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

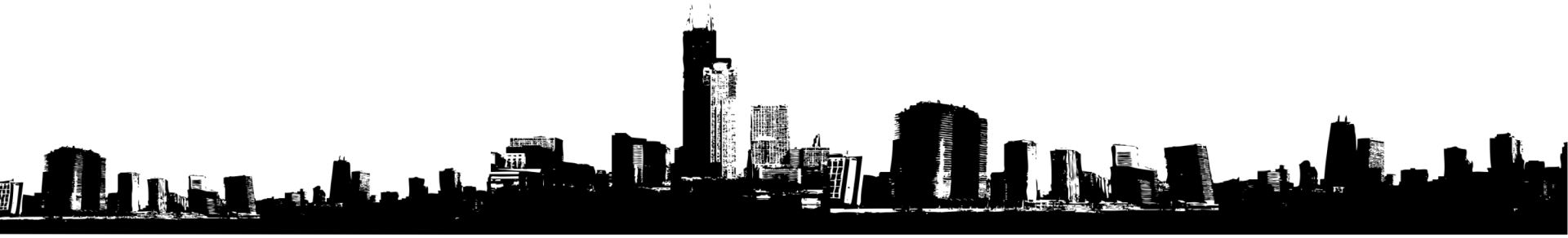
Future Work

Future work aim to combine the insights from the mobile methane survey results with the year-long methane observations recorded at CSIRO Oceans & Atmosphere, Aspendale, to quantify the rate and duration of emissions from various sources, and to determine which sources should be prioritised for mitigation actions.

EGU2020-12475; https://doi.org/10.5194/egusphere-egu2020-12475; EGU General Assembly 2020;

Acknowledgement

Financial support was provided by UNSW Sydney - Science Faculty Equipment Grant Scheme, the CSIRO Postgraduate Scholarship program, and the UNSW / China Scholarship Council program.



Thanks!

Contact: bryce.kelly@unsw.edu.au lexie.xinyilu@student.unsw.edu.au
zoe.loh@csiro.au r.e.fisher@rhul.ac.uk