Australia Forest Wildfire Plume Transport: Integrated Ground Based Measurements and Satellite Analysis

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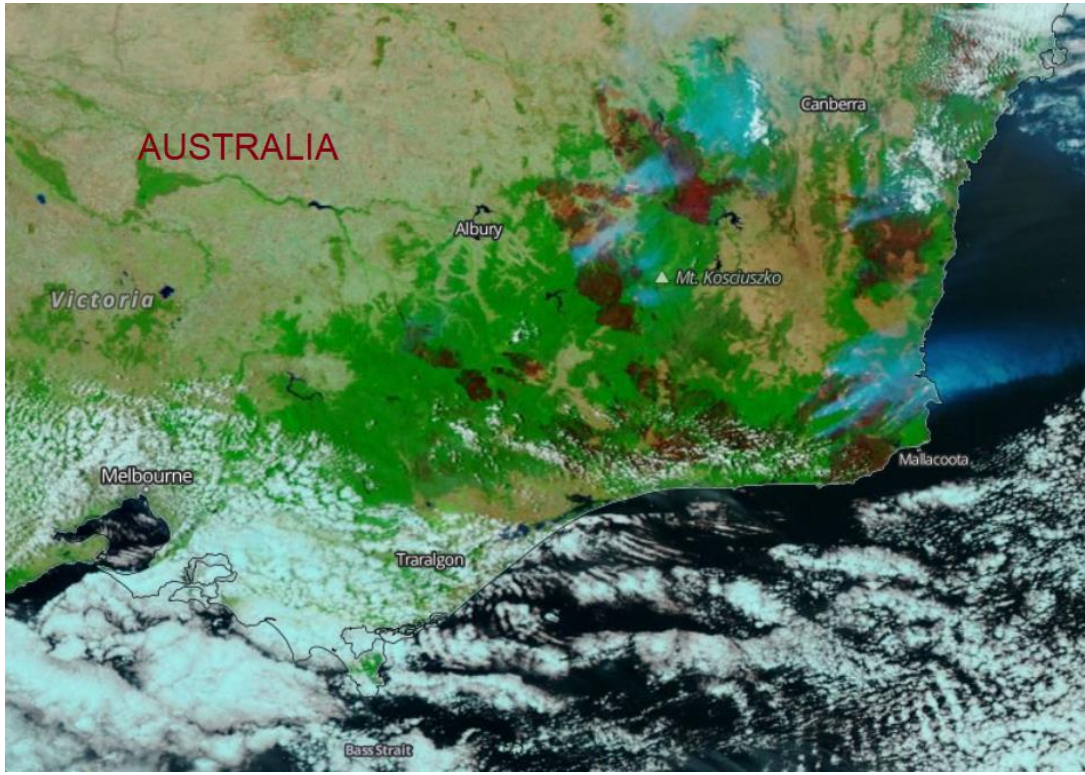
Background

- November 2019 to January 2020 (Summer) Southeast Australia faced devastating wildfires
- Resulting from highly flammable biota and short fall of precipitation in Australia
- Wildfires (bushfires) are connected with Australia's ecology and culture

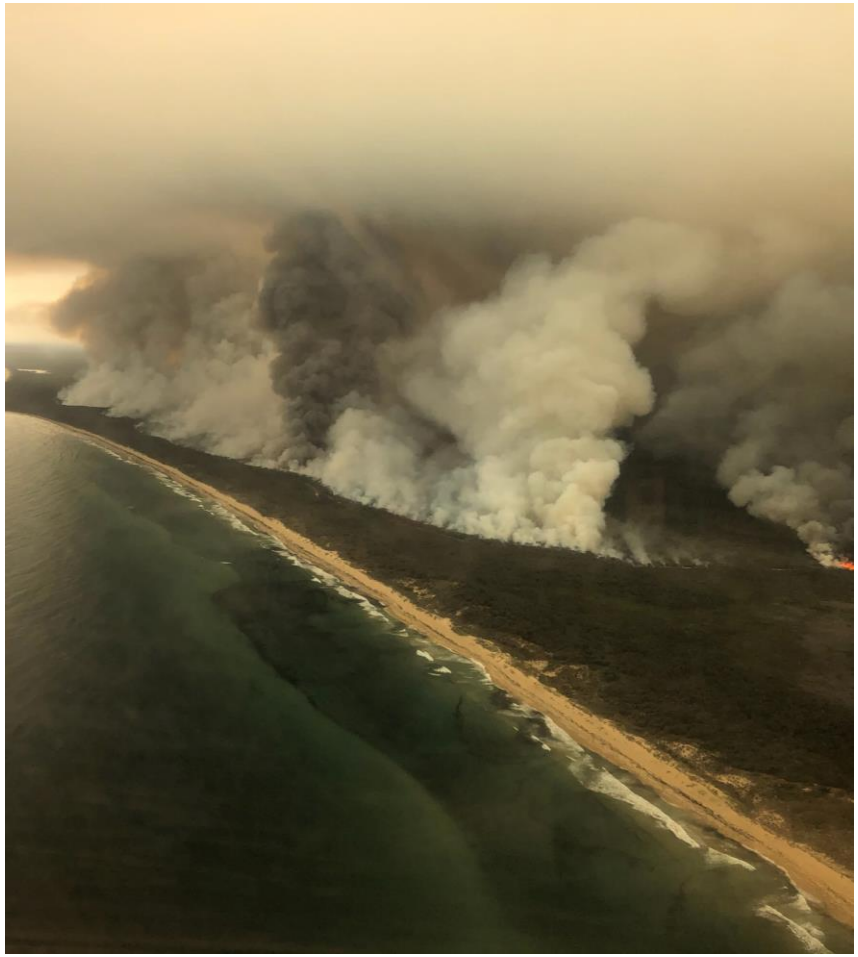
Introduction

- **These wildfires affect air quality and emit particulate matter including $PM_{2.5}$.**
- **In the past century, the occurrence of wildfires has increased.**



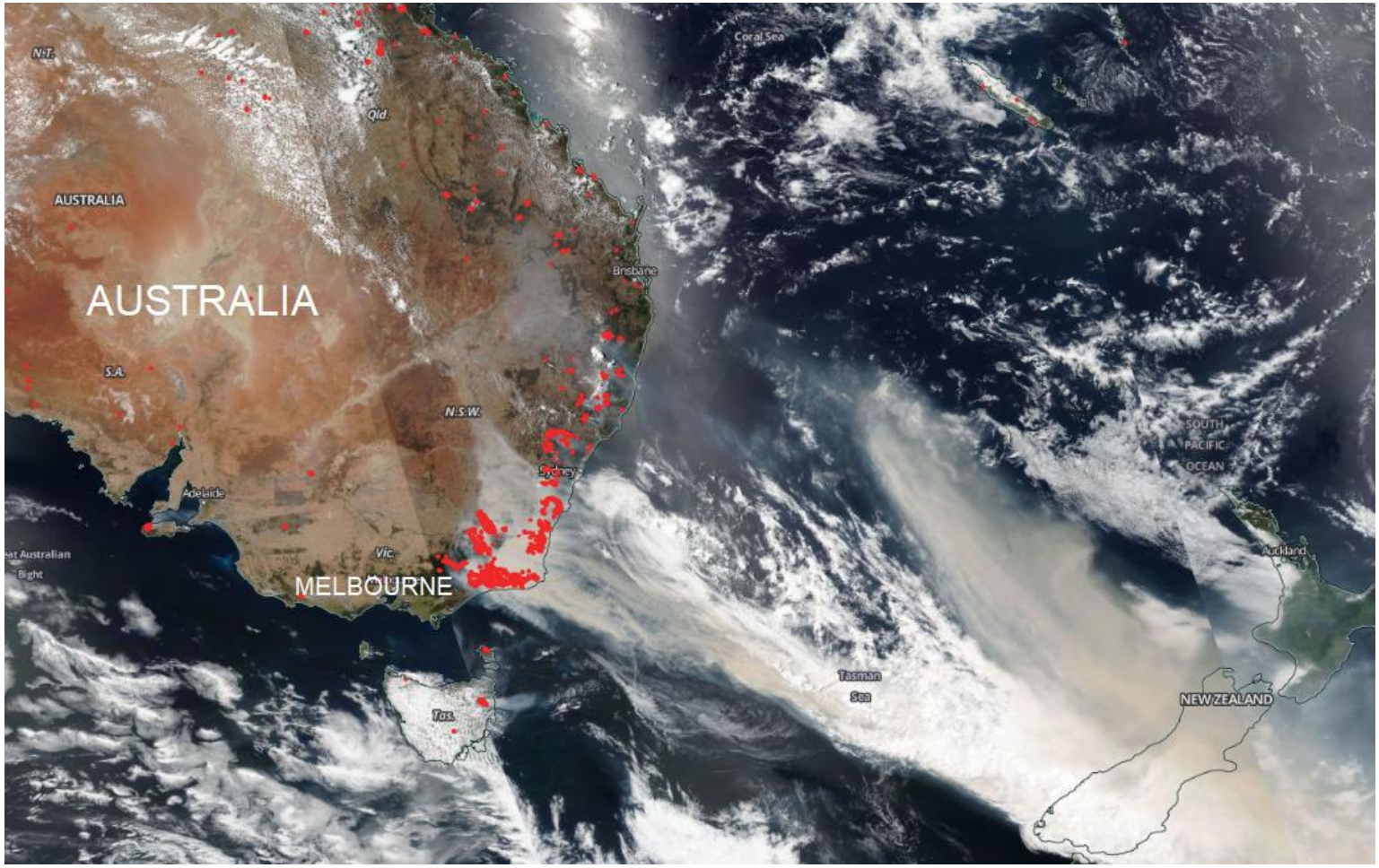
Objectives

- **Quantify $PM_{2.5}$ emissions from wildfires in Southeast Australia which occurred during 29th December 2019 to 4th of January 2020**
- **Coupling suite of satellite data products and ground-based measurements.**



Methods

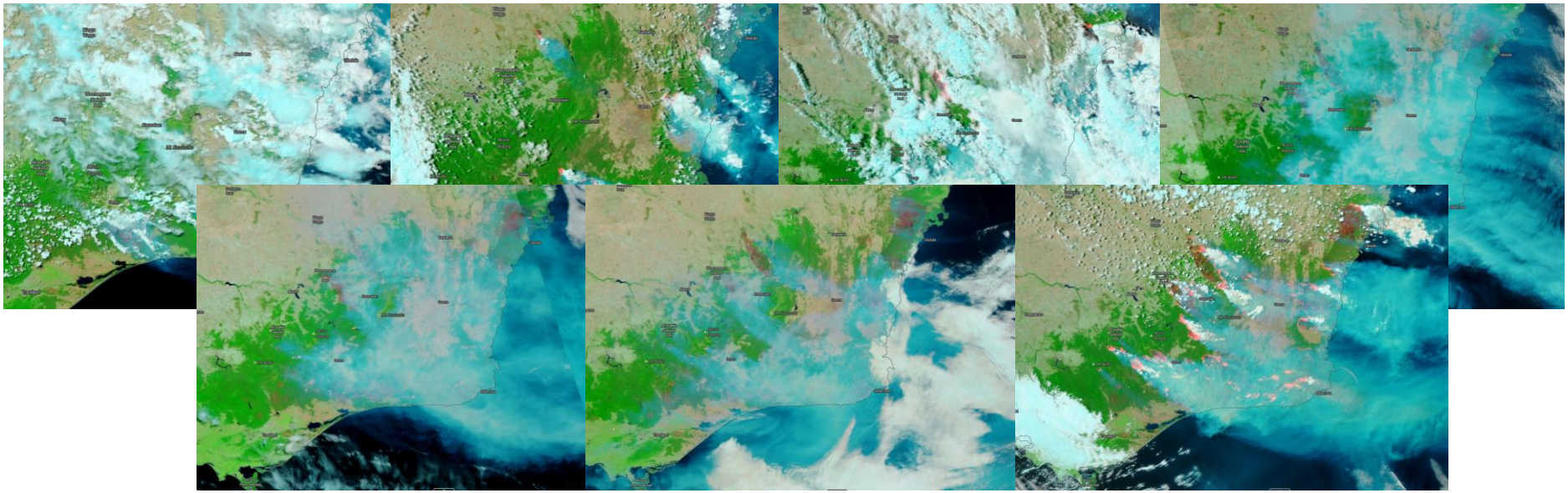
- **NASA's world view map for Australia**



Methods

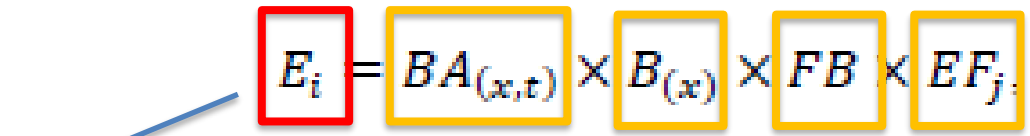
- NASA's world view map for Australia

  - MODIS active fire product



Methods

To calculate $PM_{2.5}$ emissions from burned biomass:



Emission of species i (in the case, $PM_{2.5}$)

Burned area at time t and location x

Biomass loading at location x

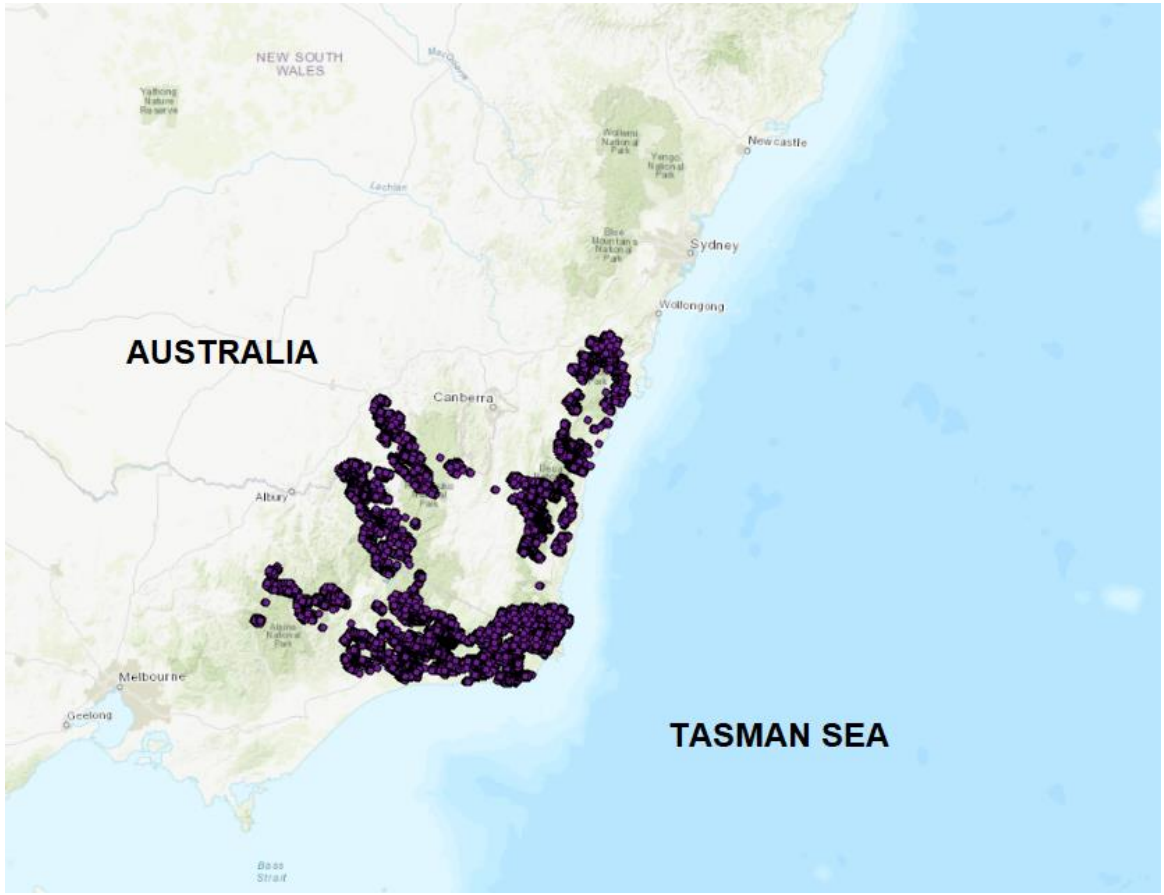
Fraction of that biomass burned in the fire

Emission factor of species i

Bray, C. D., Battye, W. H., & Aneja, V. P. (2019). The role of biomass burning agricultural emissions in the Indo-Gangetic Plains on the air quality in New Delhi, India. *Atmospheric Environment*, *218*, 116983. https://doi.org/10.1016/j.atmosenv.2019.116983

Methods

To determine burned area ArcGIS pro were used.



- **Purple points represents fire points**
- **Fire points come from NASA's Fire Information for Resource Management System (FIRMS)**

Methods

Southeast Australia air quality monitoring sites including $PM_{2.5}$

Results

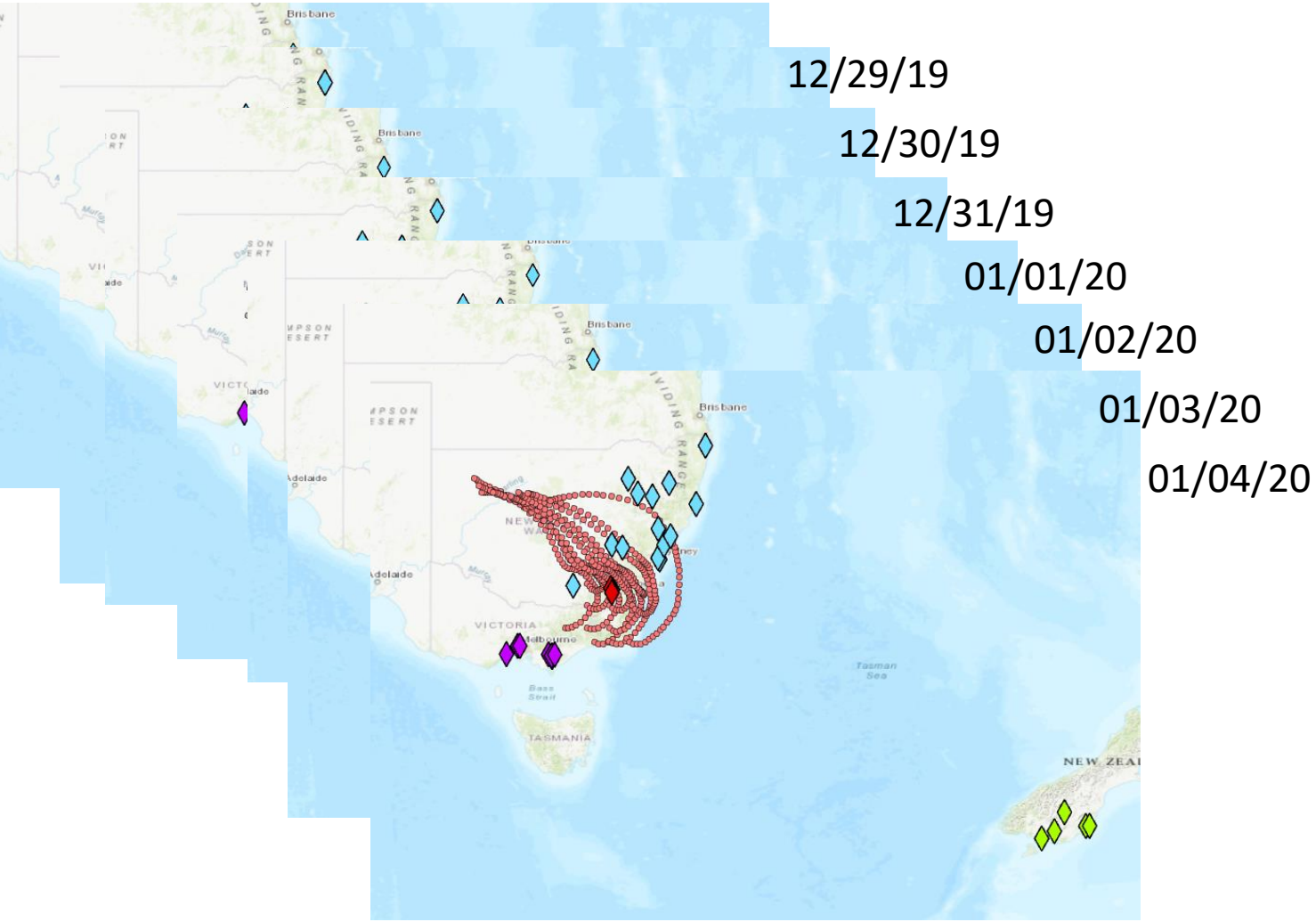
Emissions ; $E_i = BA_{(x,t)} \times B_{(x)} \times FB \times EF_j$.

Date	Total Burned Area (m^2)	Total Burned Area (hectare)	$PM_{2.5}$ (g)	$PM_{2.5}$ (g/hour)
12/29/2019	492,702,634	49,270	24,511,661,192	1,021,319,216
12/30/2019	3,871,025,009	387,103	199,552,797,256	8,314,699,886
12/31/2019	1,084,107,026	108,411	38,299,779,745	1,595,824,156
1/1/2020	1,019,020,038	101,902	27,701,504,278	1,154,229,345
1/2/2020	1,011,204,240	101,120	48,069,760,288	2,002,906,679
1/3/2020	1,465,314,115	146,531	71,587,065,556	2,982,794,398
1/4/2020	5,286,587,330		265,743,832,861	11,072,659,703
Total	**14,229,960,392**	**1,422,996**	**675,466,401,177**	**28,144,433,382**

Bray, C. D., Battye, W. H., & Aneja, V. P. (2019). The role of biomass burning agricultural emissions in the Indo-Gangetic Plains on the air quality in New Delhi, India. *Atmospheric Environment*, *218*, 116983. https://doi.org/10.1016/j.atmosenv.2019.116983

Results

Trajectories



12/29/19

12/30/19

12/31/19

01/01/20

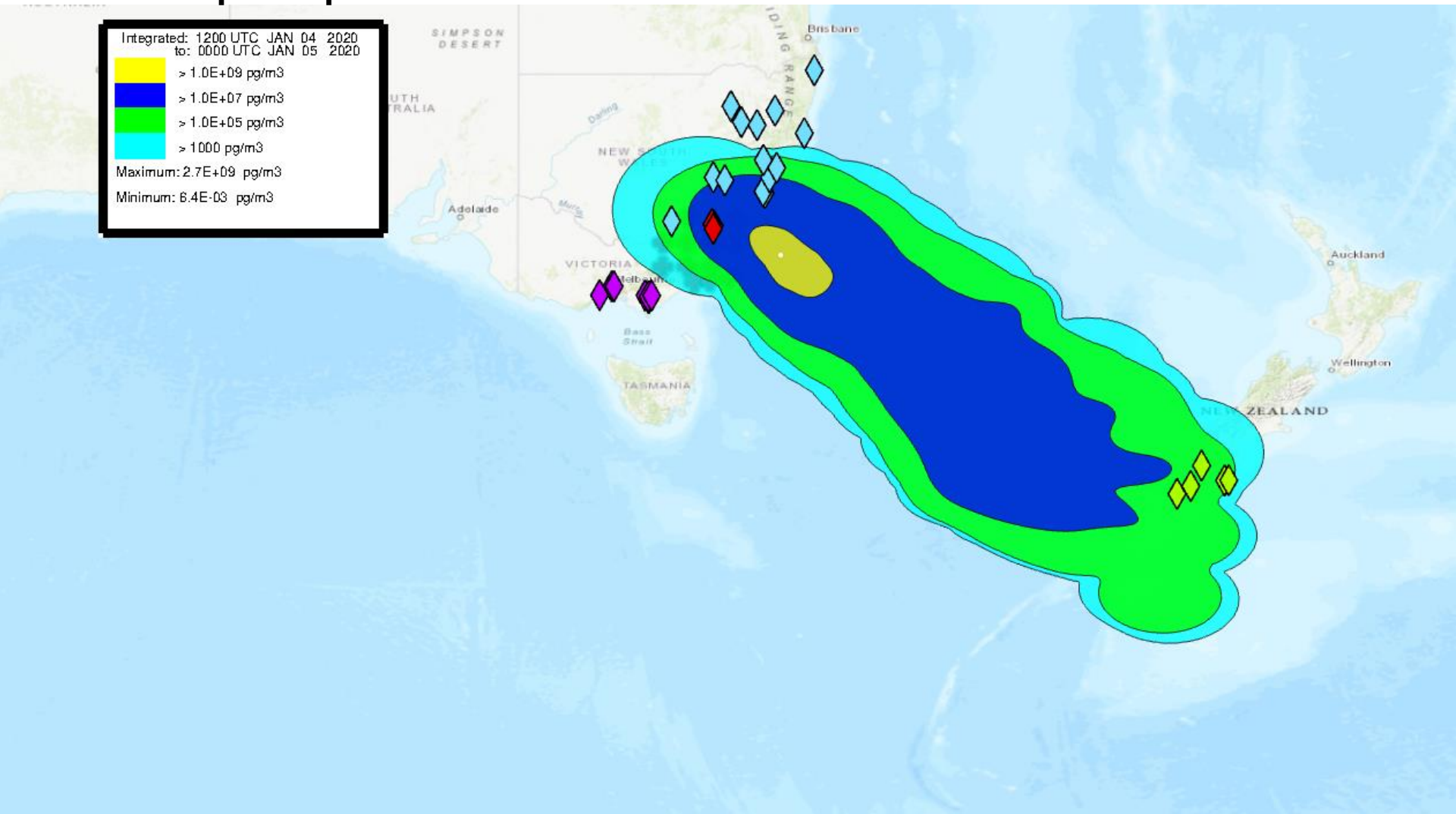
01/02/20

01/03/20

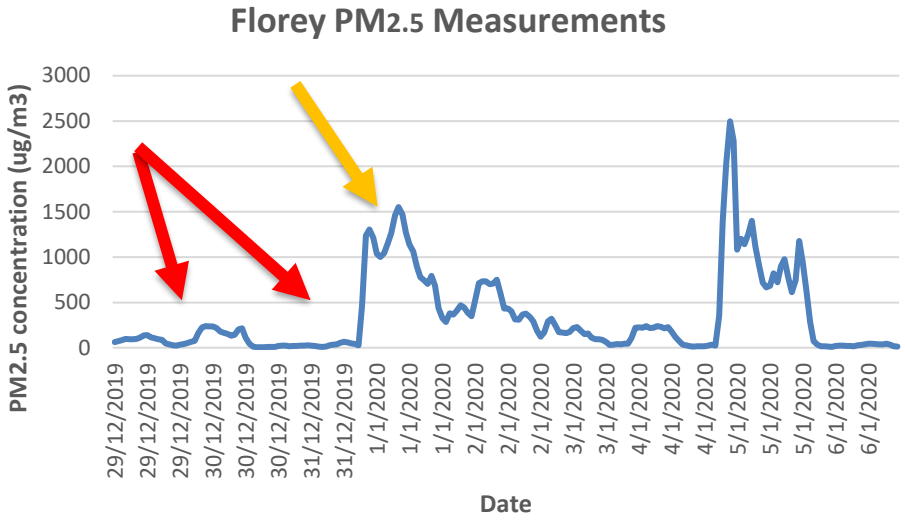
01/04/20

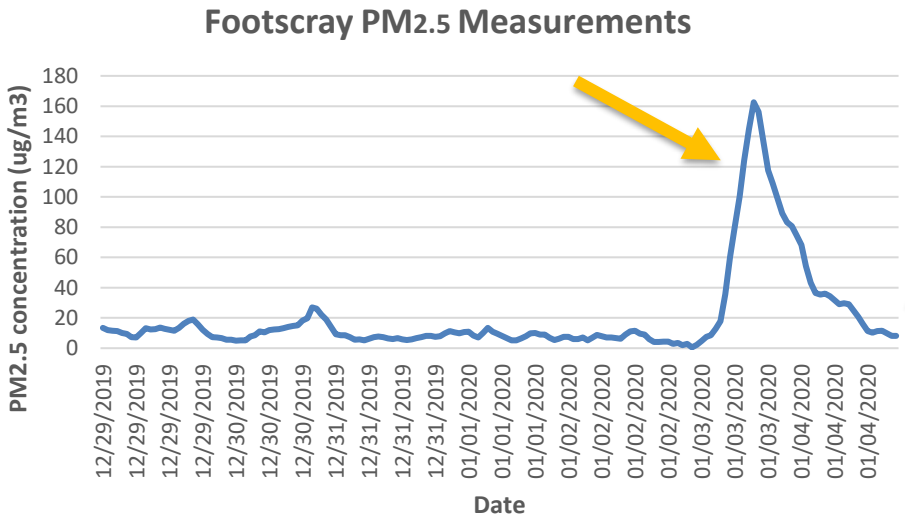
Results

As an example of plume distribution



Results


Florey PM2.5 Measurements
PM2.5 concentration (ug/m3)
3000
2500
2000
1500
1000
500
0
29/12/2019
29/12/2019
29/12/2019
30/12/2019
30/12/2019
30/12/2019
31/12/2019
31/12/2019
1/1/2020
1/1/2020
1/1/2020
2/1/2020
2/1/2020
2/1/2020
3/1/2020
3/1/2020
4/1/2020
4/1/2020
4/1/2020
5/1/2020
5/1/2020
5/1/2020
6/1/2020
6/1/2020
Date


Footscray PM2.5 Measurements
PM2.5 concentration (ug/m3)
180
160
140
120
100
80
60
40
20
0
12/29/2019
12/29/2019
12/29/2019
12/29/2019
12/30/2019
12/30/2019
12/30/2019
12/31/2019
12/31/2019
12/31/2019
12/31/2019
12/31/2019
01/01/2020
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01/02/2020
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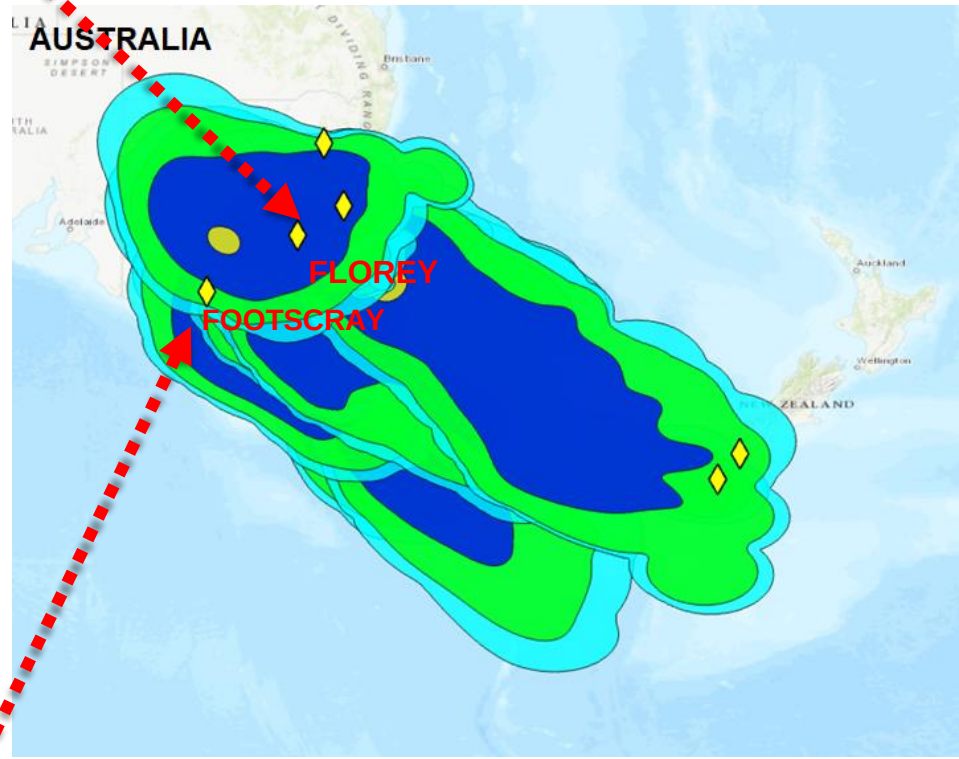
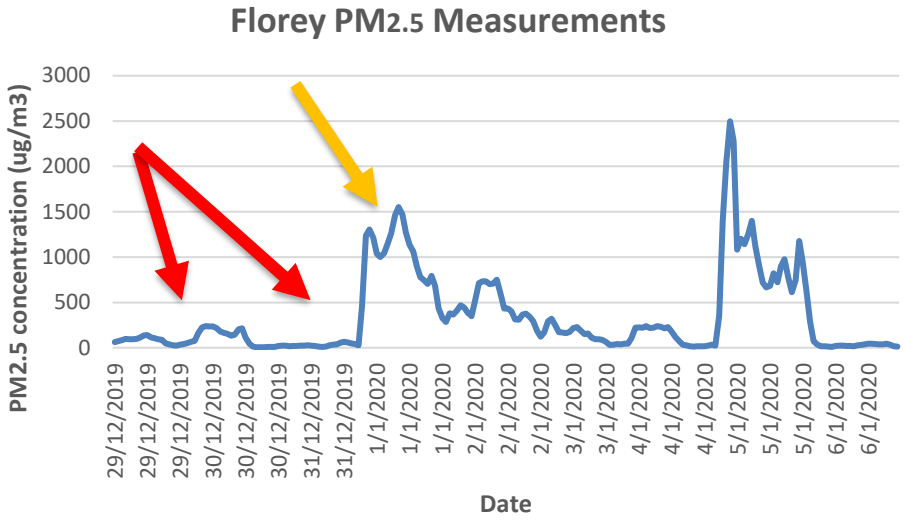
Date


AUSTRALIA
FLOREY
FOOTSCRAY
NEW ZEALAND

Results


Florey PM2.5 Measurements
PM2.5 concentration (ug/m3)
3000
2500
2000
1500
1000
500
0
29/12/2019
29/12/2019
29/12/2019
30/12/2019
30/12/2019
30/12/2019
31/12/2019
31/12/2019
1/1/2020
1/1/2020
1/1/2020
2/1/2020
2/1/2020
2/1/2020
3/1/2020
3/1/2020
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5/1/2020
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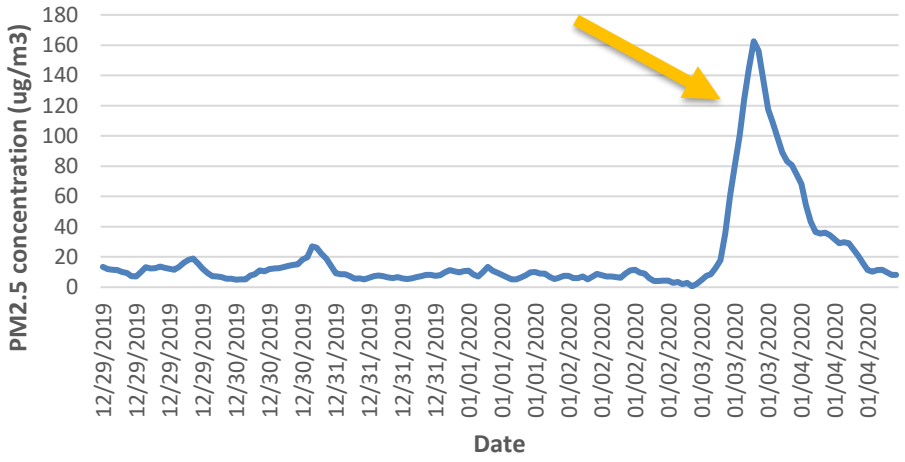
6/1/2020
Date


Footscray PM2.5 Measurements
PM2.5 concentration (ug/m3)
180
160
140
120
100
80
60
40
20
0
12/29/2019
12/29/2019
12/29/2019
12/29/2019
12/30/2019
12/30/2019
12/30/2019
12/31/2019
12/31/2019
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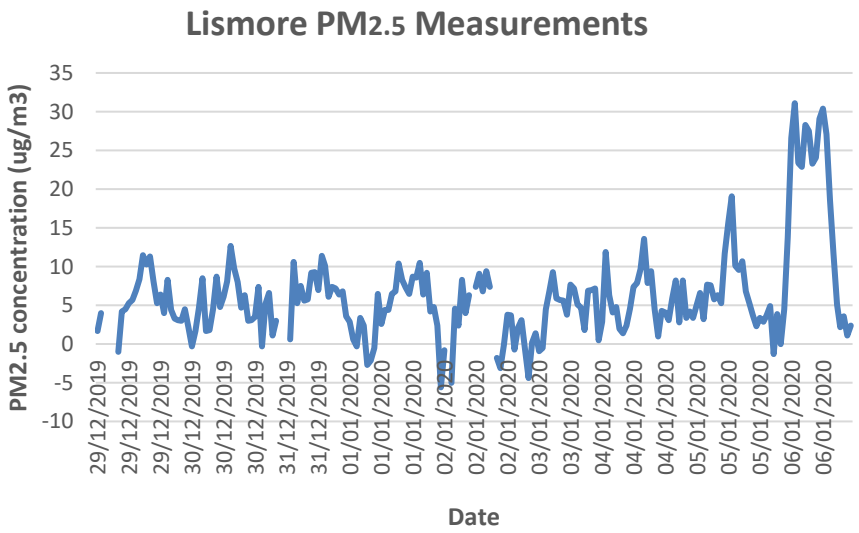
01/04/2020
Date


Lismore PM2.5 Measurements
PM2.5 concentration (ug/m3)
35
30
25
20
15
10
5
0
-5
-10
29/12/2019
29/12/2019
29/12/2019
30/12/2019
30/12/2019
30/12/2019
31/12/2019
31/12/2019
01/01/2020
01/01/2020
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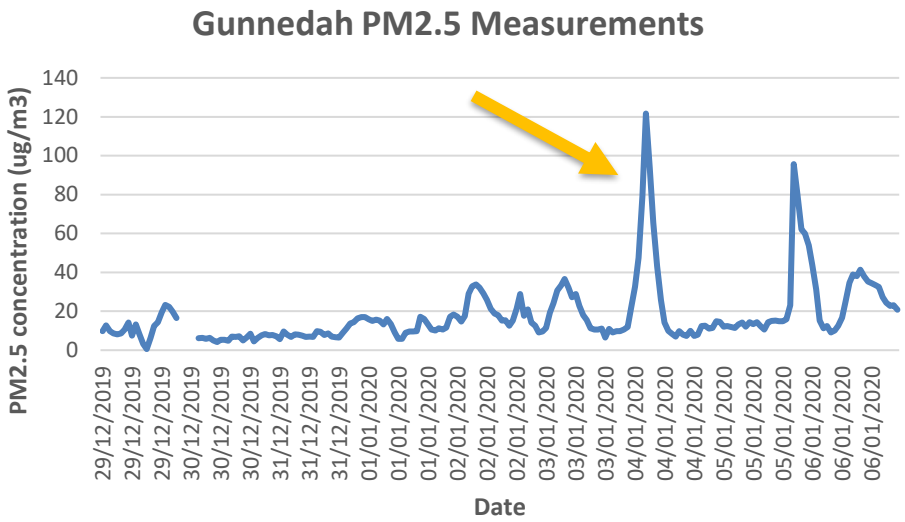
06/01/2020
Date

Results


Gunnedah PM2.5 Measurements
PM2.5 concentration (ug/m3)
140
120
100
80
60
40
20
0
29/12/2019
29/12/2019
29/12/2019
30/12/2019
30/12/2019
30/12/2019
31/12/2019
31/12/2019
31/12/2019
01/01/2020
01/01/2020
01/01/2020
02/01/2020
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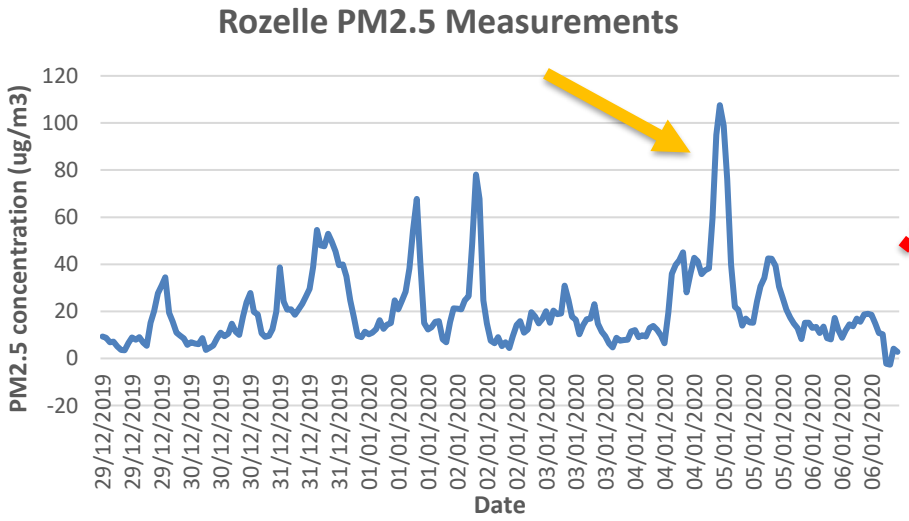
06/01/2020
Date


Rozelle PM2.5 Measurements
PM2.5 concentration (ug/m3)
120
100
80
60
40
20
0
-20
29/12/2019
29/12/2019
29/12/2019
30/12/2019
30/12/2019
30/12/2019
31/12/2019
31/12/2019
31/12/2019
01/01/2020
01/01/2020
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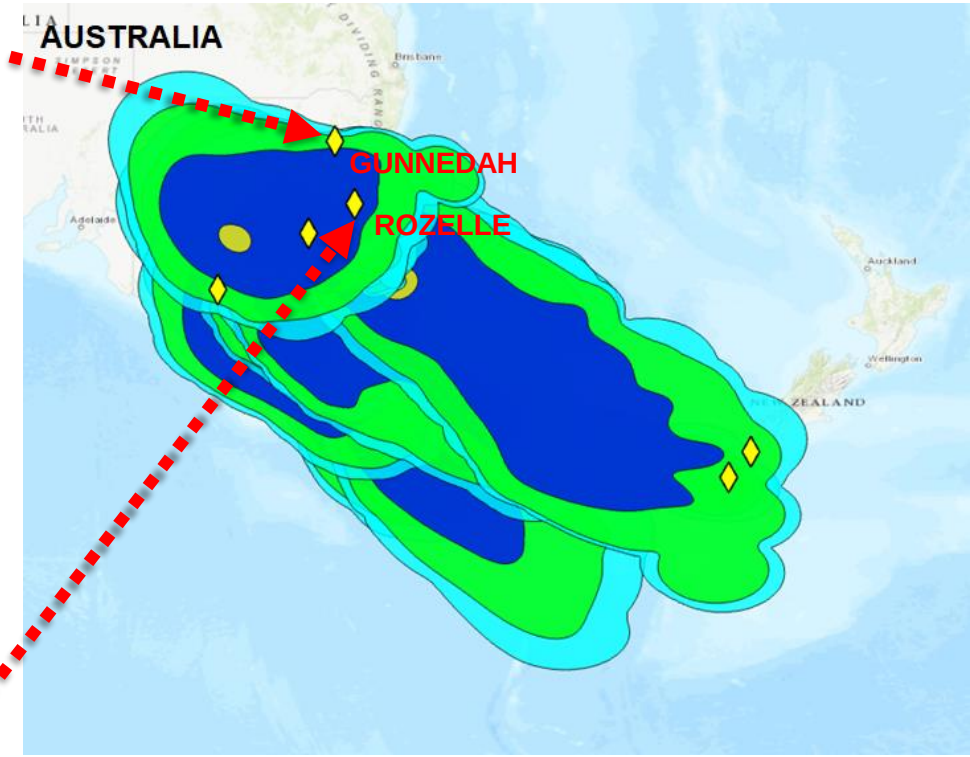
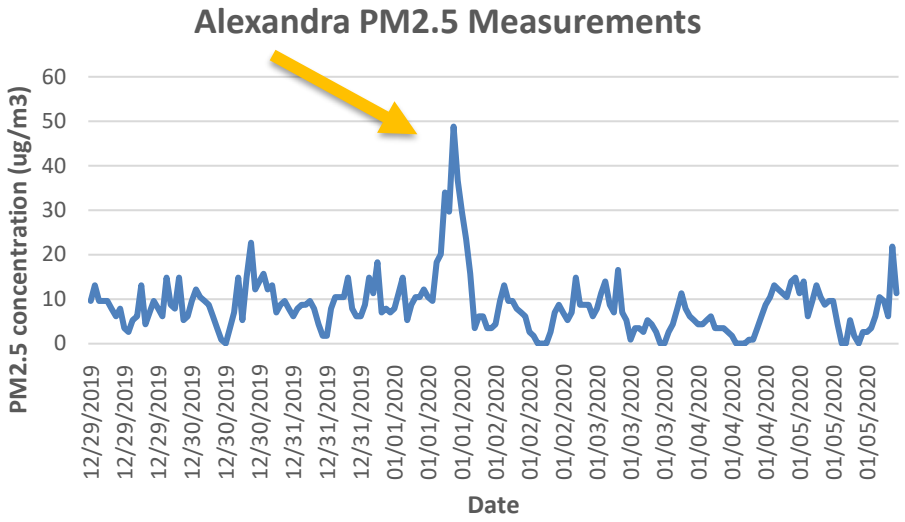
06/01/2020
Date


AUSTRALIA
GUNNEDAH
ROZELLE

Results


Alexandra PM2.5 Measurements
PM2.5 concentration (ug/m3)
60
50
40
30
20
10
0
12/29/2019
12/29/2019
12/29/2019
12/30/2019
12/30/2019
12/30/2019
12/31/2019
12/31/2019
12/31/2019
01/01/2020
01/01/2020
01/01/2020
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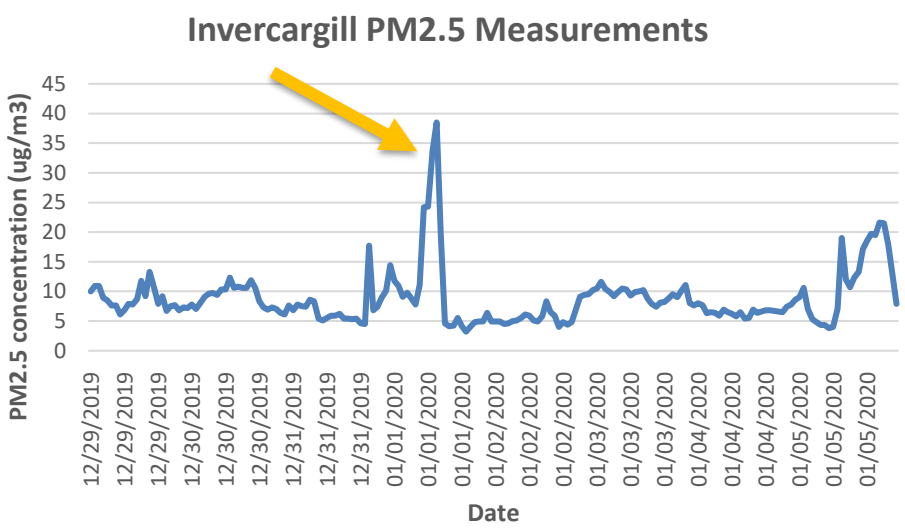
Date


Invercargill PM2.5 Measurements
PM2.5 concentration (ug/m3)
45
40
35
30
25
20
15
10
5
0
12/29/2019
12/29/2019
12/29/2019
12/30/2019
12/30/2019
12/30/2019
12/31/2019
12/31/2019
12/31/2019
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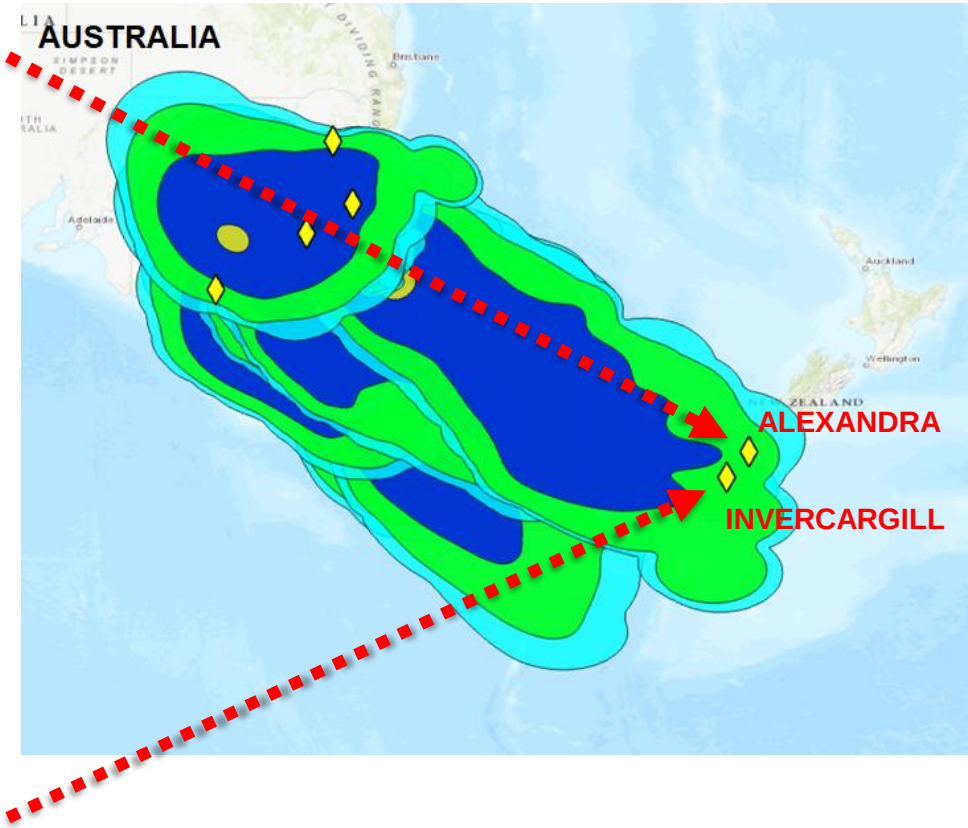
AUSTRALIA
ALEXANDRA
INVERCARGILL

Conclusion

- **Estimated the burn area, and $PM_{2.5}$ emission**
- **Good agreement between modeled $PM_{2.5}$ and measured PM2.5 concentration**
- **$PM_{2.5}$ concentration increases with plume arrival**
- **Coupled satellite and ground-based analysis provides a unique opportunity to determine downwind air quality.**

Acknowledgement

- I thank the Turkish government for providing me with support
- Thanks to NOAA Hysplit Program for the support provided
- Thanks to member of NCSU Air Quality Research Group
- Thanks to my lovely husband