OFFICE OF ENVIRONMENT & HERITAGE

Summer ozone episode from 11 to 12 February 2017

Ozone exceedances during extreme heatwave

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Published by:

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ISBN 978-1-925755-96-1
OEH 2019/0202
May 2019

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Analysis of a typical ozone exceedance event in coastal New South Wales, during an extreme heatwave on 10-11 February 2017

This analysis provides some insight into the occurrence of typical high ozone pollution events in the NSW Greater Metropolitan Region (GMR). The results are useful for understanding most high ozone pollution events in coastal cities in New South Wales, including Sydney.

Event description

During 9 to 12 February 2017, New South Wales experienced an extreme summer heatwave (BOM 2017). At least 93% of the State was 10°C warmer than average, on 11 February 2017. Liverpool, in Sydney south west, recorded maximum temperatures of 44ºC at 5pm on 10 February and 45ºC at 5pm and 6pm on 11 February 2017. An extensive ozone pollution event occurred in coastal cities of the NSW GMR, on 10-11 February 2017 (Figure 1, Figure 2). Ozone exceeded national standards at 13 of 16 ozone-monitoring stations in the NSW GMR, including eight of 10 sites in the Greater Sydney Region (Table 1).

- On 10 February 2017, exceedances occurred at stations in four coastal metropolitan regions: Lower Hunter, Central Coast, Sydney and Illawarra (Table 1,Figure 1).
- On 11 February 2017, exceedances occurred in three regions: Lower Hunter, Central Coast and Sydney (Table 1,Figure 2). Higher 1-hour and 4-hour ozone concentrations were recorded, than on the previous day, with the highest level (13.5 pphm) at Liverpool, in Sydney south west. Longer exceedance periods were recorded, with the episode at Chullora in Sydney east persisting for seven hours (Table 1).

Table 1 Ozone exceedances in the NSW Greater Metropolitan Region, 10–11 February 2017

Region	10 February 2017		11 February 2017	
	1-hour Ozone	4-hour Ozone	1-hour Ozone	4-hour Ozone
AQMN Station	**start time; duration (hours); maximum concentration (pphm)**			
Lower Hunter				
Wallsend		15:00; 1 h; 8.1	13:00; 1 h; 10.6	13:00; 4 h; 9.7
Central Coast				
Wyong	14:00; 2 h; 12.1	15:00; 4 h; 10.5		16:00; 2 h; 8.4
Sydney east				
Rozelle	12:00; 3 h; 11.4	13:00; 5 h; 10.9		
Earlwood	17:00; 1 h; 10.9	14:00; 2 h; 12.1		15:00; 5 h; 8.7
Lindfield	18:00; 1 h; 10.6	19:00; 2 h; 8.3		19:00; 2 h; 8.3

Region	10 February 2017		11 February 2017	
	1-hour Ozone	4-hour Ozone	1-hour Ozone	4-hour Ozone
Randwick	15:00; 2 h; 11.6	15:00; 4 h; 10.2	18:00; 1 h; 11.4	17:00; 5 h; 9.7
Chullora		14:00; 1 h; 8.3	13:00; 5 h; 11.4	14:00; 7 h; 11.0
Sydney north west				
Prospect		14:00; 2 h; 8.3	15:00; 2 h; 12.3	15:00; 4 h; 10.6
AQMN Station	**start time; duration (hours); maximum concentration (pphm)**			
St Marys	12:00; 2 h; 11.0	13:00; 3 h; 9.6	14:00; 2 h; 10.0	15:00; 1 h; 8.5
Sydney south west				
Liverpool			14:00; 3 h; 13.5	14:00; 5 h; 11.7
Illawarra				
Albion Park South	15:00; 2 h; 10.9	15:00; 3 h; 10.2		
Kembla Grange	16:00; 1 h; 11.3	15:00; 3 h; 9.4		
Wollongong	16:00; 1 h; 10.2	15:00; 3 h; 9.3		

Notes:
1. In this case study, O_3 is measured in parts per hundred million (pphm) by volume, that is, parts of pollutant per hundred million parts of air.
2. The equivalent AAQ NEPM 1-hour ozone standard is 10.0 pphm. The 4-hour ozone standard is 8.0 pphm.

Event analysis

During 9 to 12 February 2017, a slow-moving high-pressure ridge extended north west over New South Wales from the Tasman Sea (Figure 3). On 9 February 2017, the high-pressure ridge was located over eastern NSW, providing a consistent northerly to north-westerly synoptic flow over coastal regions. On 10 to 11 February 2017, these light and persistent westerly air flows transported hot and dry inland air over coastal NSW, leading to consecutive high-temperature days over the region. By 12 February 2017, a southerly change, accompanying the passage of a slow-moving trough/cold front, brought cooler weather conditions across coastal regions.

Ground level ozone forms from interactions between sunlight and emissions of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs), from sources such as motor vehicles and industry.

The synoptic configuration on 10 and 11 February 2017 reflected typical stable atmospheric conditions conducive to elevated photochemical pollution episodes in Sydney (Figure 3, Jiang et al. 2016a). In contrast, the synoptic conditions on 9 February 2017 were not favourable for the generation or build-up of ozone pollution, due to higher wind speeds which dispersed the precursor pollutants, NO_X and VOCs, offshore (Figure 3) (DECCW 2010, Jiang et al. 2016a, 2016b).

Figure 1 **Spatial distribution of daily maximum 4-hour rolling average ozone during 10 February 2017, showing exceedances were more intense nearer to the coast and extending to the Illawarra region (Circle sizes reflect ozone concentrations, Red shows exceedances or levels > 8pphm, and blue <= 8pphm.)**

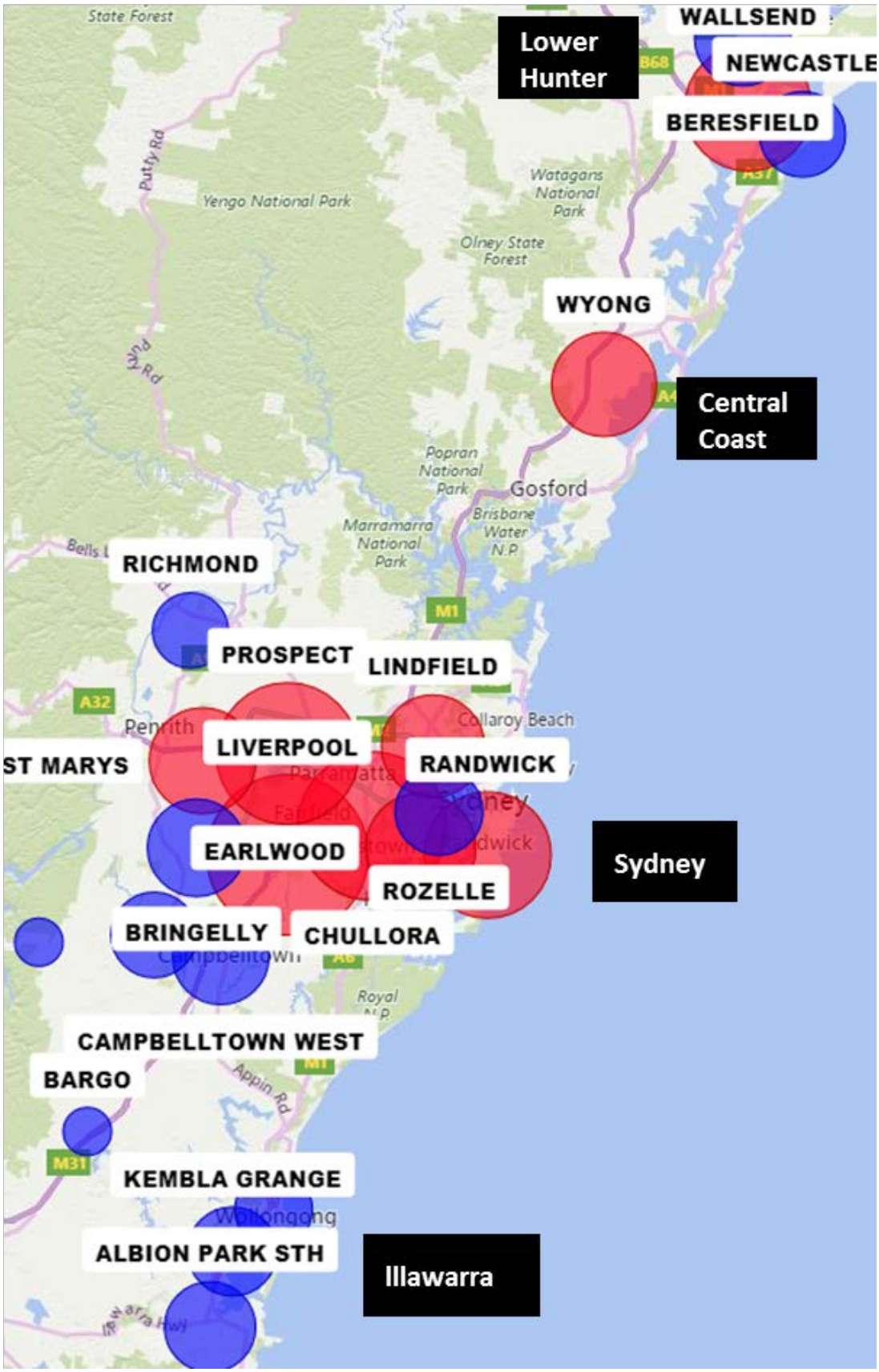

Figure 2 **Spatial distribution of daily maximum 4-hour rolling average ozone during 11 February 2017, showing exceedances were more intense in the central Greater Sydney Region Circle sizes reflect ozone concentrations, Red shows exceedances or levels > 8pphm, and blue <= 8pphm.)**

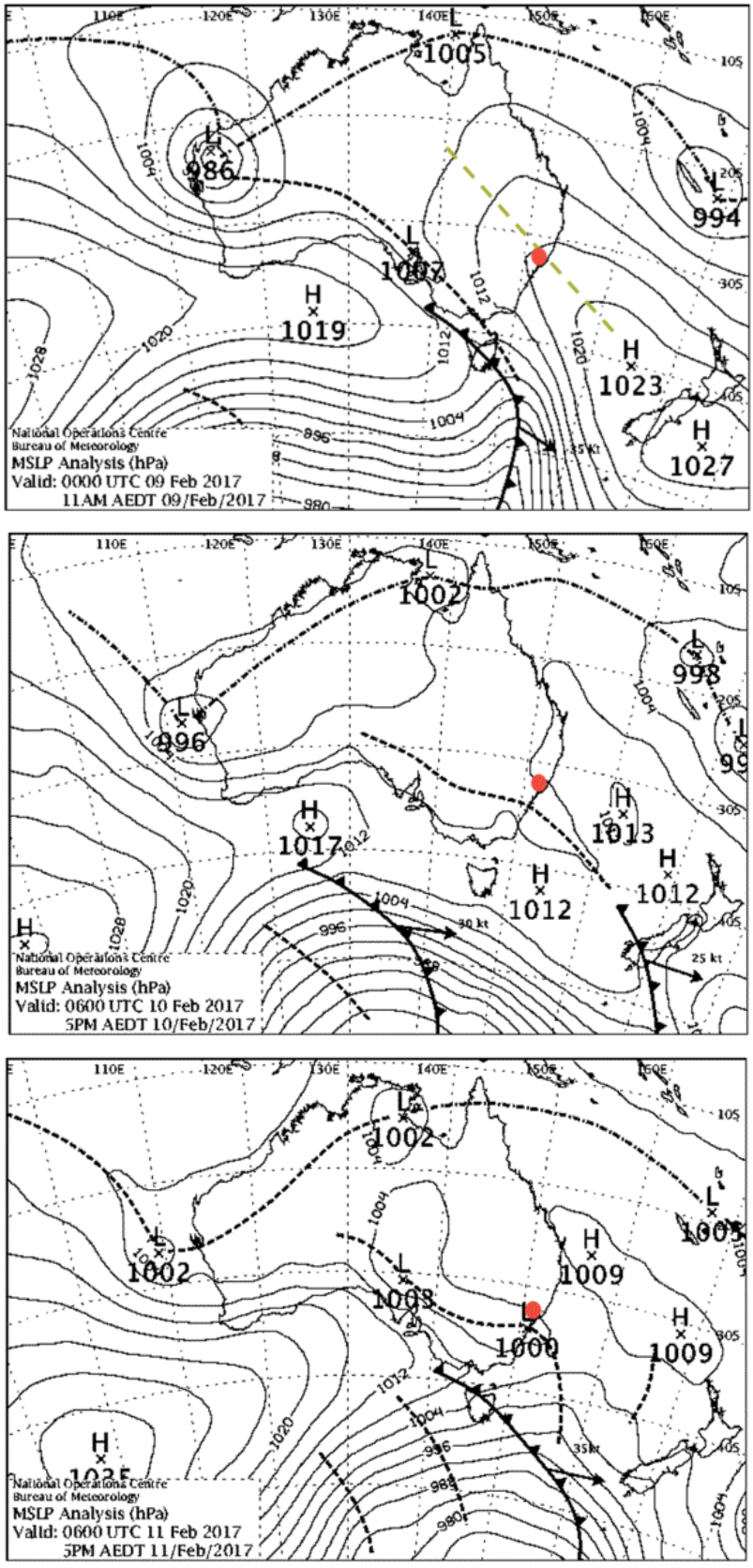

Figure 3 **Synoptic charts for 11am on 9 February (top), 5pm on 10 February (middle) and 5pm on 11 February 2017 (bottom), showing a persistent high-pressure system over the Tasman Sea, extending over northeast NSW (top, green line), and drawing hot air from central Australia into coastal areas (red dot). Source: Bureau of Meteorology**

Day 1, Thursday, 9 February 2017

On 9 February 2017, little ozone build-up occurred across the NSW GMR. Although conditions were hot and sunny, with temperatures above 30ºC, prevailing northerly to westerly winds dispersed ozone and ozone precursor pollutants offshore, and maximum levels reached up to six to seven pphm only (Figure 4).

Days 2 and 3, Friday and Saturday, 10 to 11 February 2017

During 10 to 11 February 2017, synoptic conditions created hot, sunny, calm conditions across NSW coastal regions. Daytime temperatures in Sydney exceeded 40˚C. High ozone concentrations, above the one-hour and four-hour standards, occurred in the afternoons on both days, coinciding with the onset of sea breezes and their progression inland (Figure 4 a, d).

Within the Greater Sydney Region, north-easterly sea breezes converged with weaker synoptic westerly air flows, creating calm conditions and blocking air pollutants from drifting offshore (Figure 5 and Figure 6). These blocking conditions accumulated ozone and precursor pollutants along the coast. High concentrations of precursor pollutants, hot sunny conditions and maximum temperatures above 40ºC accelerated the formation of ozone. This resulted in ozone exceedances at numerous coastal stations in the NSW GMR, from the Lower Hunter in the north to the Illawarra in the south (Figure 2).

Night-time ozone was generally low, due to limited availability of sunlight and ozone precursors NO_X and VOCs.

On Friday, 10 February 2017, early morning calm conditions helped the build-up of NO_X levels (Figure 4 c, e). High concentrations of precursor pollutants and high temperatures (above 40ºC) accelerated the formation of ozone. Light north-westerly winds transported ozone and ozone precursors towards Sydney east. Although Liverpool in Sydney south west recorded a maximum temperature of 44ºC at 5pm (Figure 4 a), Sydney south west experienced higher wind speeds than in the east and did not record ozone exceedances. In contrast, calmer conditions in Sydney east allowed the build-up of ozone and precursors NO_X and VOCs, leading to exceedances of the one-hour and four-hour ozone standards. As example, 4-hour ozone exceedances ranged from 12.1 pphm at Earlwood to 8.1 pphm at Wallsend (Table 1, Figure 2, Figure 4).

Five monitoring stations exceeded the one-hour and four-hour ozone standards (Sydney east: Rozelle, Earlwood, Lindfield and Randwick; Sydney north west: St Marys). Two sites exceeded the four-hour ozone standard (Sydney east: Chullora; Sydney north west (Prospect) (Table 1)).

On Saturday, 11 February 2017, local conditions were similar to the previous day, with higher temperatures across the Greater Sydney Region. Liverpool in Sydney south west recorded temperatures of 45ºC at 5pm and 6pm (Figure 4 a). The afternoon sea breezes penetrated further inland than on the previous day, transporting ozone and ozone precursor pollutants to the west. This led to the highest ozone exceedances in western regions of Sydney, with the maximum recorded at Liverpool. Elevated ozone levels persisted across the city for five to seven hours (Table 1, Figure 2, Figure 4, Figure 6).

Five monitoring stations exceeded the one-hour and four-hour ozone standard (Sydney east: Randwick and Chullora; Sydney north west: Prospect and St Marys; Sydney south west, Liverpool). Two sites exceeded the four-hour standard (Sydney east: Earlwood and Lindfield) (Table 1).

Day 4, Sunday, 12 February 2017

On Sunday, 12 February 2017, a southerly change, associated with the passage of a slow-moving cold front, brought relatively lower temperatures and higher wind speeds. Ozone levels were relatively lower across the Greater Sydney Region.

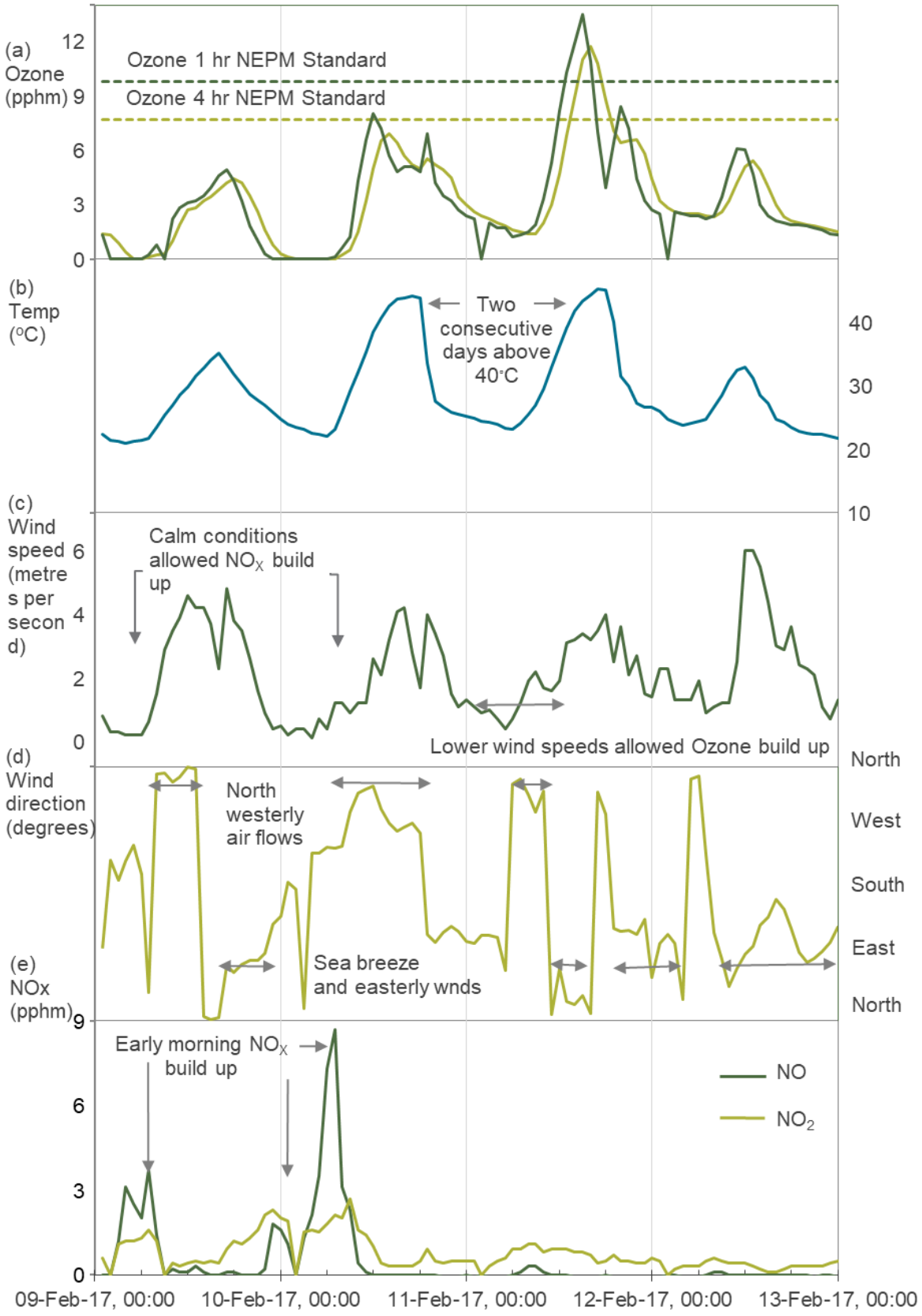

Figure 4 **Influence on ozone of low wind speeds, wind direction (calm and stable conditions), above 40°C maximum temperatures and high NO_X (ozone precursor pollutant) at Liverpool, during 9-12 February 2017**

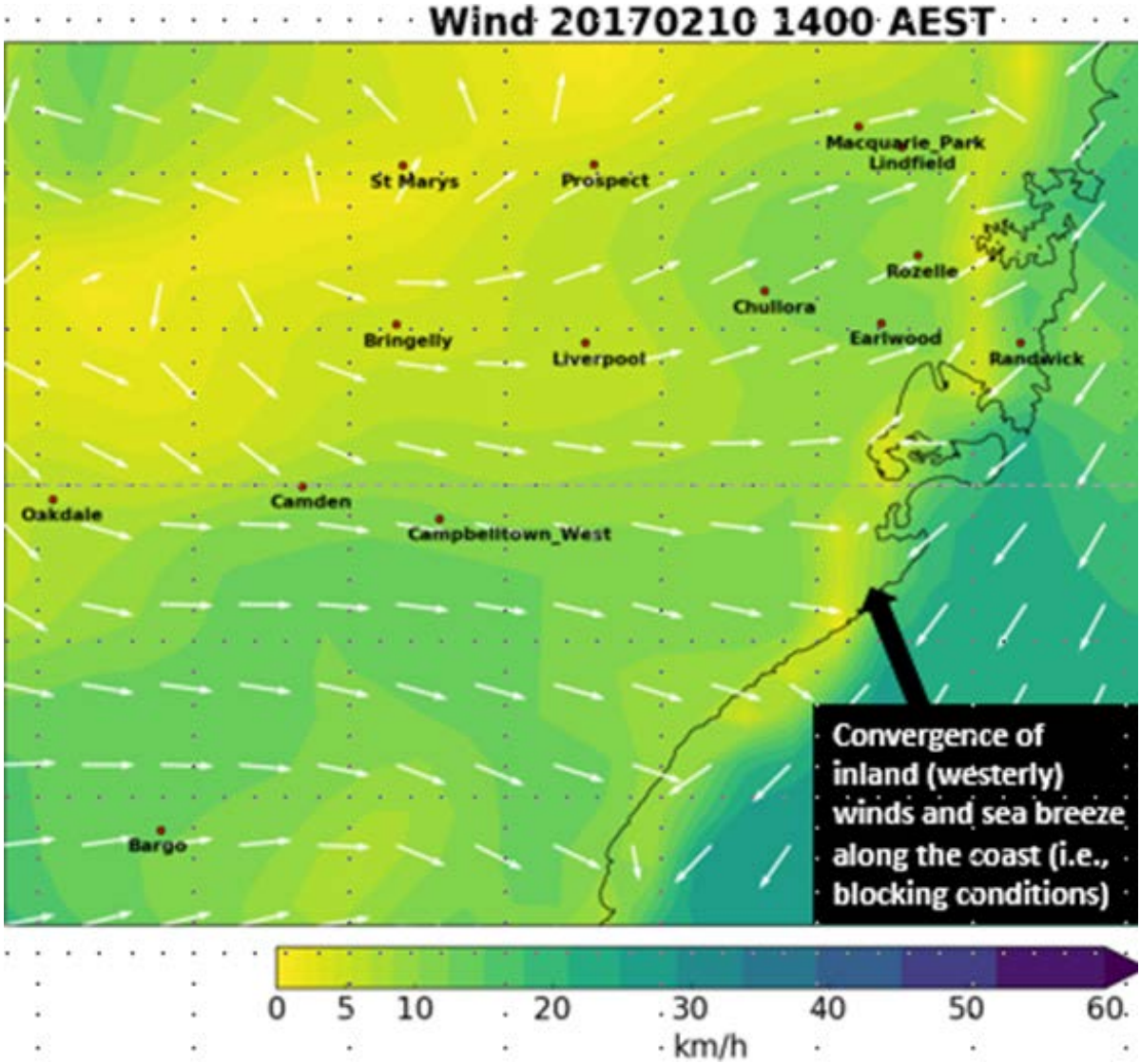

Figure 5 **Wind field plot for the Greater Sydney Region at 2pm on 10 February 2017, showing the easterly sea breeze and the inland westerly breeze converging near the coast. This blocking pattern persisted and combined with the calm conditions (yellow) to confine air pollution along the coast. Source: Bureau of Meteorology**

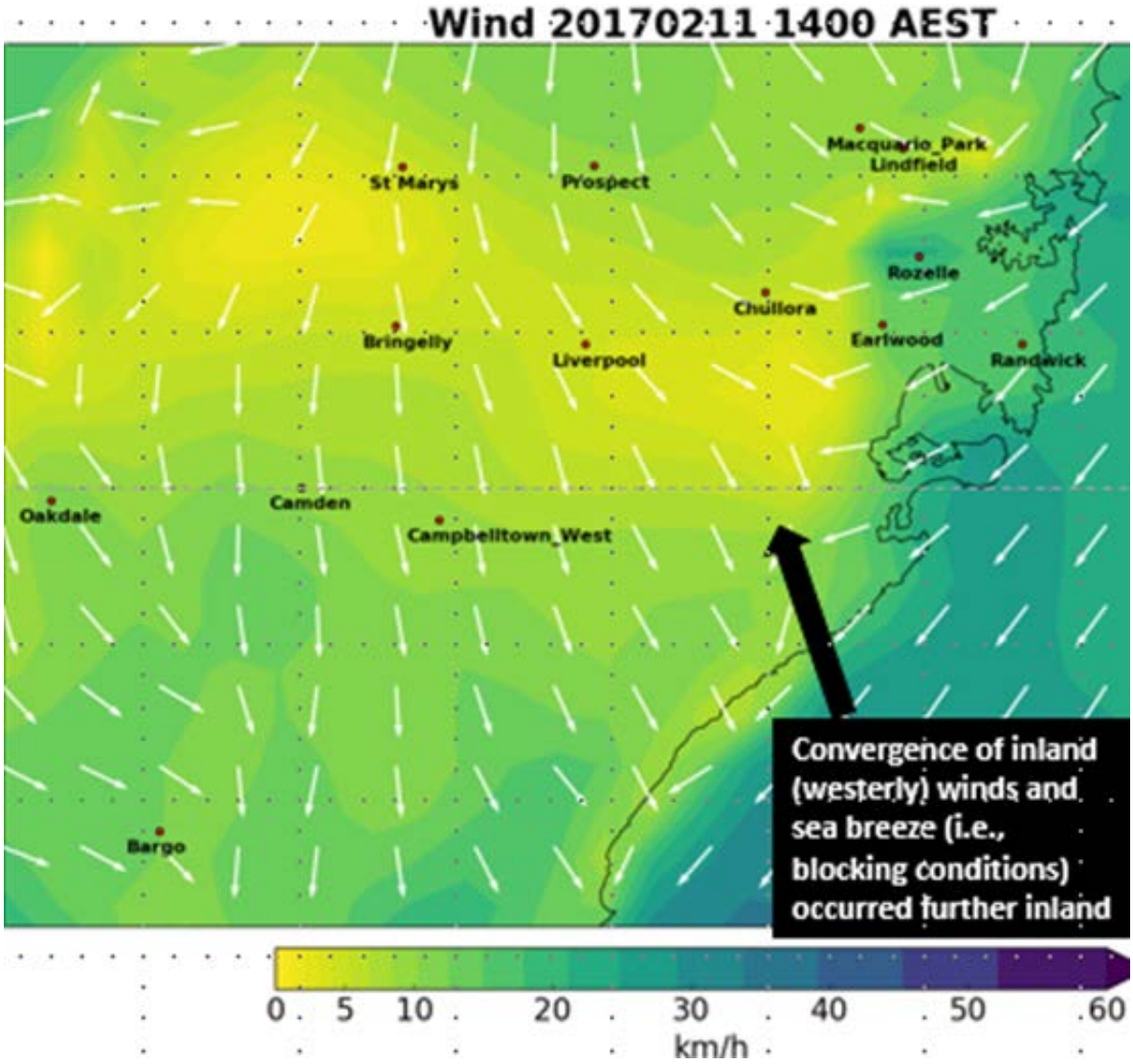

Figure 6 **Wind field plot for the Greater Sydney Region at 2pm on 11 February 2017, showing the easterly sea breeze and the inland westerly breeze converging near Chullora. The westward progression of the sea breeze led to higher levels of ozone pollution further inland, compared with the previous day. Source: Bureau of Meteorology**

Summary

An extensive ozone pollution episode was experienced across coastal NSW on 10 to 11 February 2017, during a severe four-day heat wave. The highest one-hour ozone concentration (13.5 pphm) was observed at Liverpool in south west Sydney on 11 February. The episode reflected the impact of local and synoptic meteorological configurations that typically lead to elevated ozone pollution in Sydney, or broadly across the NSW GMR. A slow-moving high-pressure ridge, extending north west over New South Wales from the Tasman Sea brought hot, sunny calm conditions, conducive to the formation and build-up of photochemical ozone across Sydney. Light north-westerly synoptic flows, converging with the north-easterly (afternoon) sea breezes, often determine the extent, location and duration of elevated ozone pollution in the region.

Further information on meteorology-ozone pollution relationships can be found in Jiang et al. (2016a, 2016b).

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