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A Coastal Microburst Wind Damage Survey and Observations

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ABSTRACT

A microburst occurred over the Sydney Northern Beaches. Microburst photographs and a field damage survey were used to map the scale, path and intensity of microburst outflows against the Enhanced Fujita Scale. Buoyancy was observed to play a primary role in the spread of microburst outflow with heavy cold air channeled along valley floors and losing momentum over rising topography. Damage surveys suggest a high velocity jet nature to the outflow with minimal turbulence mixing at ground level.

1. Introduction

A strong cold front crossed Greater Sydney 19th December 2021 as reported by the Bureau of Meteorology (2021). A 100 km/hr gust was recorded at Mount Boyce in the Blue Mountains with the front continuing to track 95km east-southeast across Sydney toward the Northern Beaches coastline, Figure 1. At Terry Hills 15:21 a 76.3 km/hr maximum gust from the WNW 286° was recorded associated with the dry cold front with air temperature dropping from 30.5°C to 20.1°C within 10 minutes and a near monthly low relative humidity of 40%. Sydney Airport aerological diagram data at 1pm indicated an unstable atmosphere with TT 50 and Lifted Index -2.6°C.

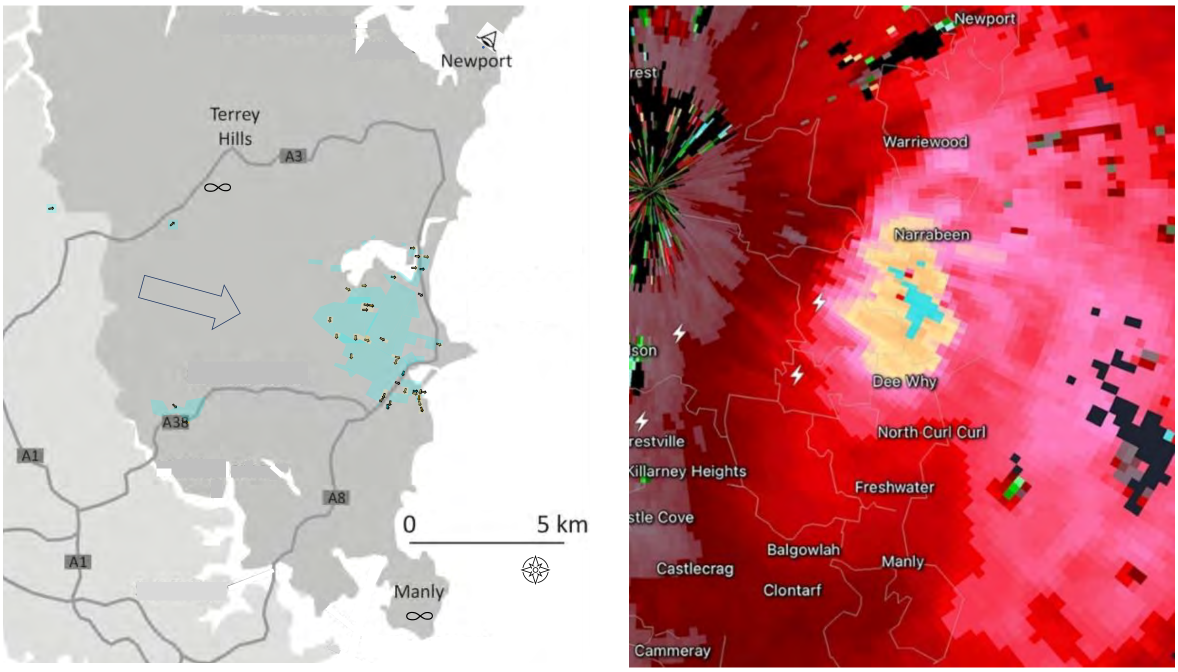

Figure 1. Sighted storm damage locations on Sydney Northern Beaches (L). Bureau of Meteorology via RadarScope velocity doppler radar image 15:34 19th December 2021 (R).

15:25

15:33

15:34

Figure 2. Narrabeen Lagoon microburst photographed from Newport by Moir[2] 19th December 2021

A series of thunderstorms formed over the Northern Beaches initially causing localised damage at Forestville before forming a microburst over Narrabeen lagoon. Rapid intensification is observed around 15:34 in velocity doppler images of Figure 1 with exceedance of the Terry Hills Nyquist velocity 94 km/hr.

The Narrabeen Lagoon microburst was captured in a sequence of photographs by Moir[2] taken from an apartment building rooftop in Newport, Figure 2. At 15:25 air in the vicinity of Narrabeen Lagoon is seen to updraft into the string flat base to the shelf cloud on the left side of the photo. Evaporation of rain falling into the dry cold front air (centre photo) further cools and increases air density thereby accelerating the downdraft vertically resulting in the microburst seen at 15:33 and 15:34, with outflow moving toward the left (note photo viewing angle in Figure 1).

2. Damage Survey

A damage survey of the built and natural environments was undertaken following the microburst. Notional Enhanced Fujita Scale (EF-Scale) damage categories were assigned to buildings based on observable damage indicators from the street or bush trails. EF-Scale is intended specifically to establish tornado damage however the general appearance of wind damage without reference to wind speed is known to be similar whether caused by tornado, cyclone or downburst, Womble (2009).

The State Emergency Service received almost 600 requests for assistance as reported by the Bureau of Meteorology (2021), and maps of call out and power outage locations published by the Northern Beaches Advocate (2021) provided some survey location guidance. Figure 1 and Figure 3 highlight the areas surveyed as accessed by car and mountain bike. The surveys were conducted between 20th December 2021 and 4th January 2022. Photographic evidence, aerial photography and videos in the media were also reviewed as part of the survey.

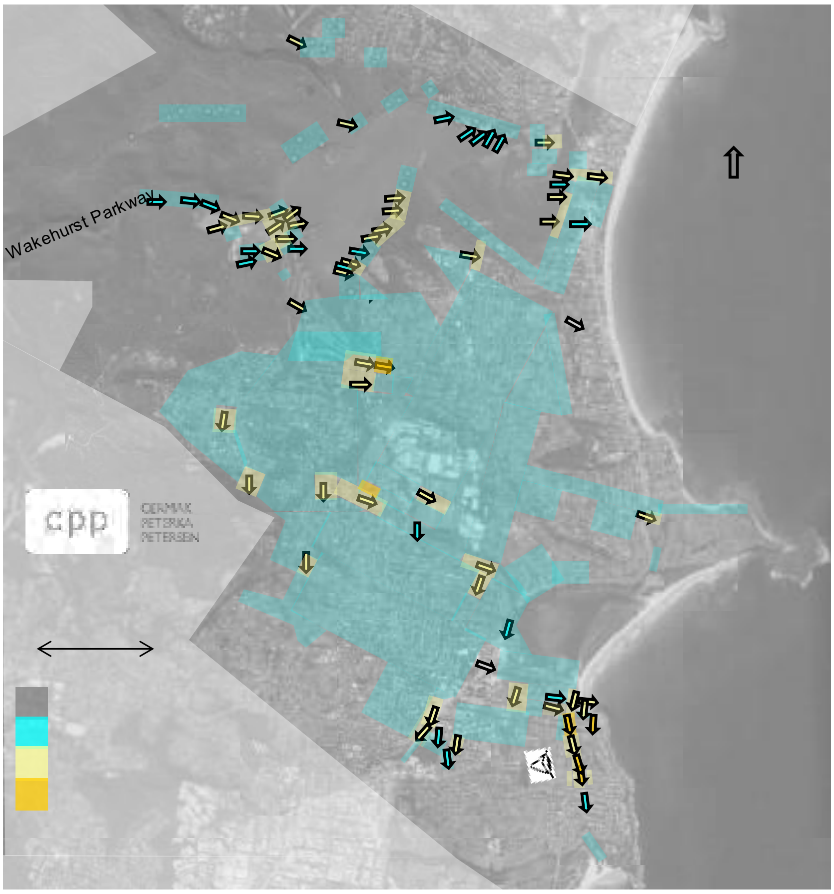

Figure 3. Estimated EF-scale damage ratings assigned to surveyed buildings and natural environment.

Figure 3 maps all observed damage rated against the EF-scale. Damage generally being assigned an EF0 or EF1 rating, and some isolated EF2 damage. Most EF0 damage evidence was medium to large branches snapped off large trees and EF1 small to large trees snapped or uprooted; the fallen trunks providing an indication of wind direction. Several roofs were blown from homes and apartments indicative of EF2 damage, e.g., Figure 5.

Author[1] witnessed the most severe property damage over the survey area within 24 hours of the storm and assigned the EF ratings consistently with previous surveys of other wind storm damage, e.g., Krupar, Mason & Glanville (2016). Some areas such as the Cromer golf course were not inspected until after considerable clean-up had occurred and if the damage was not witnessed first-hand or a via reliable photo/videos then it was not marked in Figure 3 with a direction arrow. Markers are included for each geo marked survey photo including EFU areas with no visible damage.

3. Field Observations

Topographic contours (sea level to 170m) are overlayed in Figure 4 with larger arrows providing an interpretation based on the study observations and photographs above. The initial microburst appears to have occurred with a stagnation point to the west of Narrabeen Lagoon in the reserve and over the Wakehurst Parkway valley, with an approximate initial footprint shown by the broken line.

Terrain was observed to play a primary role in the spread of the outflow. In 'Stage 1' the outflow appears to sink immediately into the Wakehurst Parkway and Narrabeen Sports Centre valley with the cold heavy high velocity flow staying below about 70m terrain height as evidenced by tree damage; buoyancy appearing to govern the outflow pattern. The outflow then appears to split in two directions; one path continuing over Narrabeen Lagoon and the other into the Cromer valley toward Dee Why.

Narabeen Lagoon outflow over the water surface is confined to the south by the rising terrain of Colloroy Plateau and impacts Narrabeen largely unimpeded. A relatively narrow corridor of maximum damage was observed from the eastern shore of Narrabeen Lagoon and along Albert Street falling a large Norfolk Island Pine near the North Narrabeen Surf Club resulting in a fatality.

The initial Cromer Valley outflow provided some evidence of a wake region formed in the lee of a promontory at the western end of the Narrabeen Sports Centre. Extensive tree damage was observed at lower elevations along the northern side of a promontory with evidence of a wake region immediately to the east of the promontory having little tree damage. Wake effects appeared to occur horizontally at low elevations around the promontory topographic feature with no evidence of high velocity flows moving over the promontory elevated terrain.

The Cromer valley outflow continues to channel along the valley alignment towards Dee Why with evidence of outflow losing momentum up the valley walls toward Collaroy Plateau and Naraweena. Damage impacts of outflow in the Cromer Valley was mostly EF0 and EF1. Generally, the greatest damage was observed downstream of long open fetches where flow could gain momentum near ground level.

In 'Stage 2' there is a wind direction change and velocity gain at the Dee Why Seawall just to the south of Dee Why Lagoon. Video footage including Severe Weather & News Australia (2021) taken from a building on The Strand at Dee Why Beach captures the change in wind direction and intensification. Initially a tree falling eastward then a directional change to the south with downward momentum in the wind visualised in the flow. Southbound Stage 2 Dee Why outflow continues to flow parallel to the Dee Why Coast causing EF1 and EF2 damage at some locations.

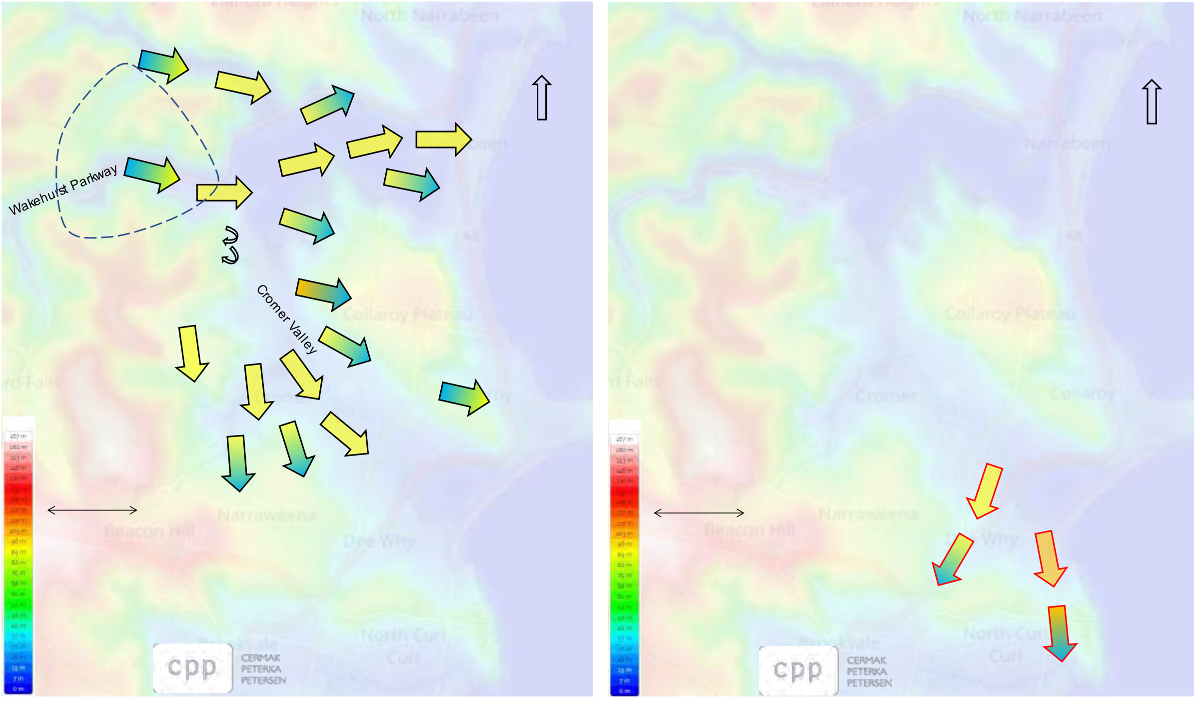

Figure 4: Flow interpretation from photos and survey damage overlayed on topographic contours.

Part of the initial Dee Why outflow is channeled between buildings lining The Strand to the south before lifting the roof from a 4-storey unit block on Pacific Parade as captured in video footage contained in the Northern Beaches Advocate (2021). Analysis of video footage approximates roof height wind speed in the order 40-50 m/s yet undisturbed gardens at ground level of the same building are seen in Figure 5. This suggests a localised jet nature to the outflow with minimal turbulence mixing at ground level. Roof debris was carried directly downstream with the rain laden outflow in a SSE direction causing some projectile impact damage to property.

Figure 5: Unit block on Pacific Pde lost its roof yet suffered no damage at ground level (L). Branches snapped from the central 1/3 of a Norfolk Island Pine (R).

High velocity flow continues over the headland, causing similar roof damage to a 2-storey home on Tasman Street near the hill crest. A relatively narrow arm of damage swathe over the headland perhaps a couple of house blocks wide was found, seemingly with jet flow skimming over the building rooftops where it could gain momentum. The greatest building damage was observed to homes protruding into the jet stream.

A vertical profile of observed damage over the Dee Why headland is mapped indicatively in Figure 6 based on the damage survey (note profile viewing angle in Figure 3). Branches snapped from several Norfolk Island Pine species provided in some cases a lower and upper bound to observed damage and supported a jet velocity profile hypothesis, Figure 5. The thin ribbon of outflow continued over the Dee Why headland then sunk downhill toward North Curl Curl Beach. Similar outflow characteristics can be observed in other media video footage of the event, e.g. Ralph (2021).

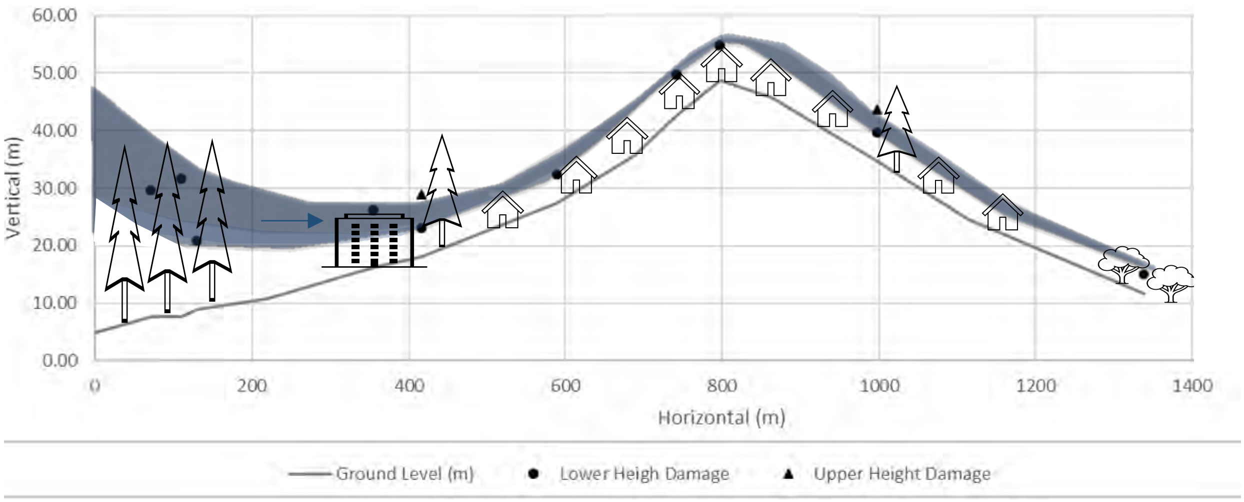

Figure 6: Estimated vertical outflow profile over the Dee Why headland based on damage survey.

4. Conclusions

Photographs and a field damage survey were used to map the scale, path and intensity of microburst outflows against the Enhanced Fujita Scale. Buoyancy was observed to play a primary role in the spread of microburst outflow with heavy cold air channeled along valley floors and losing momentum over rising topography. Localised damage to buildings and trees suggests a high velocity jet nature to the outflow with minimal turbulence mixing at ground level. Typically, the greatest damage was observed downstream of long open fetches where jet flow could gain momentum or where buildings and trees protruded into the jet stream skimming over rooftops.

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