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BLACK SUMMER 2019–20 RESEARCH
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VICTORIAN BUSHFIRE CASE STUDIES

Preliminary reconstruction of the eastern Victorian Black Summer Fires, November 2019 – February 2020

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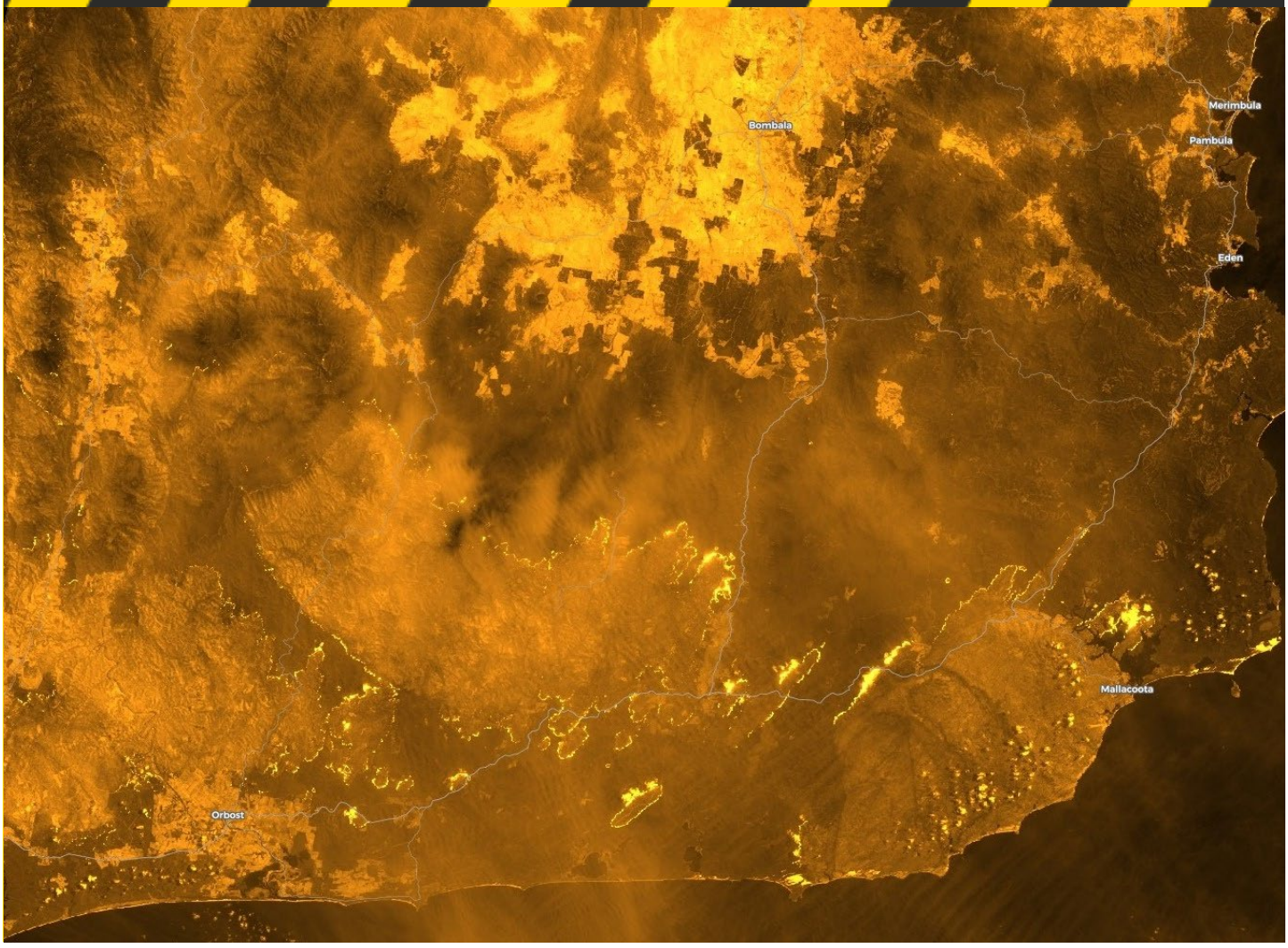
Natural Systems Analytics



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This research was part of the Bushfire and Natural Hazards Cooperative Research Centre's Black Summer research program, funded by the Australian Government and the CRC to investigate key issues from the 2019-20 bushfire season.

EXECUTIVE SUMMARY

Understanding the interaction of weather, fuels and landscape is essential in determining the propagation and spread of bushfires. The fires of Black Summer in Victoria burnt 1.5 million hectares and continued for three months. This project has systematically collected multiple sources of information and begun a reconstruction of the bushfire spread and behaviour for most fires for this period. With this information, it is now possible to show what occurred and when. From this, it is then possible to investigate why it happened and be able to better predict future occurrences.

This study has

- Mapped the progression of 95% of the area burnt by the Black summer fires. 44 fires had their progression mapped and 33 of these reached greater than 100 hectares
- Begun preliminary investigation into
    - the contributing factors to their development
    - the weather conditions that were present
    - documenting some of the key fire behaviour
    - scoping the influence of previous fire
- Provided an initial chronological summary containing data that is verifiable and consistent
- Provided data for many additional studies that will improve fire behaviour models, defining uncertainty in predictions, and improving prevention, preparedness, and response
- Identified further work and research opportunities that include
    - documenting the weather in eastern Victoria and improving understanding and forecasts
    - consideration of upper-level weather and fire weather interactions (eg PyroCu/Cb)
    - use of satellite for situational awareness and post fire analysis
    - improving and validating fire models
    - improving tools for fire behaviour analysts
    - providing a template for capture and storage of base level data to undertake reconstructions of future fires

INTRODUCTION

The Victorian Black Summer Fires took place in thousands of locations. The largest and longest running were in the east of the State. From the small towns of Walwa, Corryong and Cudgewa in the far northeast, to the settlements of Sarsfield and Clifton Creek in the south, to the border communities of Genoa, Bonang, and Mallacoota and to the alpine villages of Cobungra, Dinner Plain and Anglers Rest, all were impacted by the fire. The fires continued from November to March, with some communities affected or threatened multiple times. The residents of Reedy Flat had been under direct threat three times before the new year of 2020 arrived.

Tens of thousands of residents were directly affected with many fighting to protect their homes and communities. Firefighter numbers were bolstered with western and central Victorian, interstate, and overseas professional and volunteer firefighters. For those involved it was difficult to take in the multitude of events. Specific events were imprinted from one's own experience, but a broad overview and logical chronology was not possible. Residents, farmers, land management staff, business owners and contractors having survived were then faced with recovery and rebuilding which continues to this day.

This report examines fires in Eastern Victoria during the months of November to March that were not readily controlled. It should be noted that the great majority of the November fires were controlled. The studied fires represent around 96% of the area burnt in Victoria in the 2019/20 fire season. Records from Fireweb show a total of 1,505,500 hectares burnt in Victoria from 1162 reported fires. This report has examined 1,445,600 hectares of this total. 44 fires had their progression mapped and 33 of these reached greater than 100 hectares.

DELWP District/State	Area Burnt (ha)
OVENS	105,500
SNOWY	645,500
TAMBO	436,800
UPPER MURRAY	222,700
VICTORIA SUBTOTAL	**1,445,600**
NSW	332,500
TOTAL	**1,778,100**

TABLE 1: AREA BURNT BY DISTRICT AND STATE MAPPED AND EXAMINED IN THIS PROJECT

A number of fires continued their spread into NSW. These areas have been included in the report.

Many more details of planning, preparedness, and response can be found in the Victorian IGEM report into the 2019/20 fires (IGEM, 2020).

This includes a summary of the antecedent weather conditions, a description of the fire footprint characteristics, and a description of data sources used. It then presents a summary of the fire ignitions and descriptions of the fire progressions in chronological order. These are based principally on the fire progression mapping and are augmented with imagery and photos. A preliminary investigation into the weather parameters and resultant fire behaviour is also shown. Where possible and relevant information on the suppression strategy and actions is available, this is also included.

The mapping and documentation in this study have been used to examine the fires from ignition to containment. It has not just focused on when fires were active, but how and when they were bought under control.

AIMS

This report aims to provide an overview of the majority of the 2019/20 Black Summer Fires in Victoria and then focus on key events of heightened fire behaviour. The report and accompanying documents and data will be available for fire scientists, firefighters, managers, trainers and interested members of the public. Many of those involved in the fires maintained a narrow focus on their immediate circumstance and were not across the detail of fires occurring elsewhere.

The data collected and presented is from reliable sources and has a high level of spatial and temporal accuracy. Pictures, imagery, and maps can assist in understanding but do not adequately convey the smoke, dust, destruction, fatigue, stress and loss.

Above all this document is a record of events and a resource for improving bushfire prevention, preparedness, response, and recovery. This may take the form of further research, improved training, additional tools for prediction or better understanding of how a changing climate is rewriting the way we need to view fire.

METHODOLOGY

This project is predominantly a data collection and mapping exercise. Around eighty percent of the work has been to interpret and accurately digitise line scans and satellite images to produce a spatial dataset of fire perimeters with accompanying metadata. This has been done for the selected the fires from ignition to containment.

The project also provides:

- an overview of seasonal and long-term climate influences, collate weather data, fire reports, photographs, and other available data into an easily accessible data archive, and
- an examination in greater detail of specific days of increased fire behaviour to look at the conditions and mechanisms that influenced the propagation and spread.

This work can then be used to identify further studies. This may include assessment and improvement of fire models, training and education, and assessment and review of prevention response and suppression activities.

NAMING CONVENTIONS

This report using the DELWP fire names and is based on the fire District and the order in which it occurs. In essence this is simple enough, but complications do occur:

- A single fire may be identified by two or more districts and be given an individual name and number. This may or may not be rationalised to one single fire
- A going fire in another State or district may be given a unique name and number when it crosses a border e.g., Green Valley Talmalmo (NSW) became Upper Murray – Walwa when it crossed into Victoria and the portion that entered Tambo Districts was called Buenba Pheasant Creek Tk.
- Occasionally a fire is never named. This occurs in the heat of battle when multiple fires are going, visibility is limited or when a smaller fire is likely to be overrun.
- Spot fires are sometimes given fire names e.g., Buchan South– Mt Elizabeth was a spot fire from the Ensay-Ferntree Fire.
- When fires merge, the name may change to better represent the area.
- Fire Complex titles such as Tambo Complex and Snowy Complex may take on the name of an existing fire e.g., Tambo 35 became Tambo Complex and Snowy Complex was given a new number and included Mt Coopracambra, Banana Track and the Snowy District part of the Tambo Complex.

This report makes the effort to follow the conventions and maintain consistency with DELWP fire reports and FireWeb.

OTHER PROJECT OUTPUTS

In addition to this report there will be an archive of supporting data, working documents, photographs, and imagery. This will be provided to the BNHCRC, DELWP and CFA to be kept in their data storage or archives.

BACKGROUND

IMPACTS

The IGEM report *The Inquiry into the 2019–20 Victorian fire season: Phase 1 Community and sector preparedness for and response to the 2019–20 fire season* (IGEM, 2020) states the following impacts:

- 1,505,500 hectares burnt
- 5 fatalities in Victoria
- 458 houses impacted (405 destroyed, 53 damaged)
- 32 business buildings destroyed/damaged
- 745 properties registered for clean up
- ~6800 livestock killed
- 831 hectares of plantation burnt

FIRES EXAMINED

Figure 1 shows the fires examined in this study. The names of the major final fires have been included.

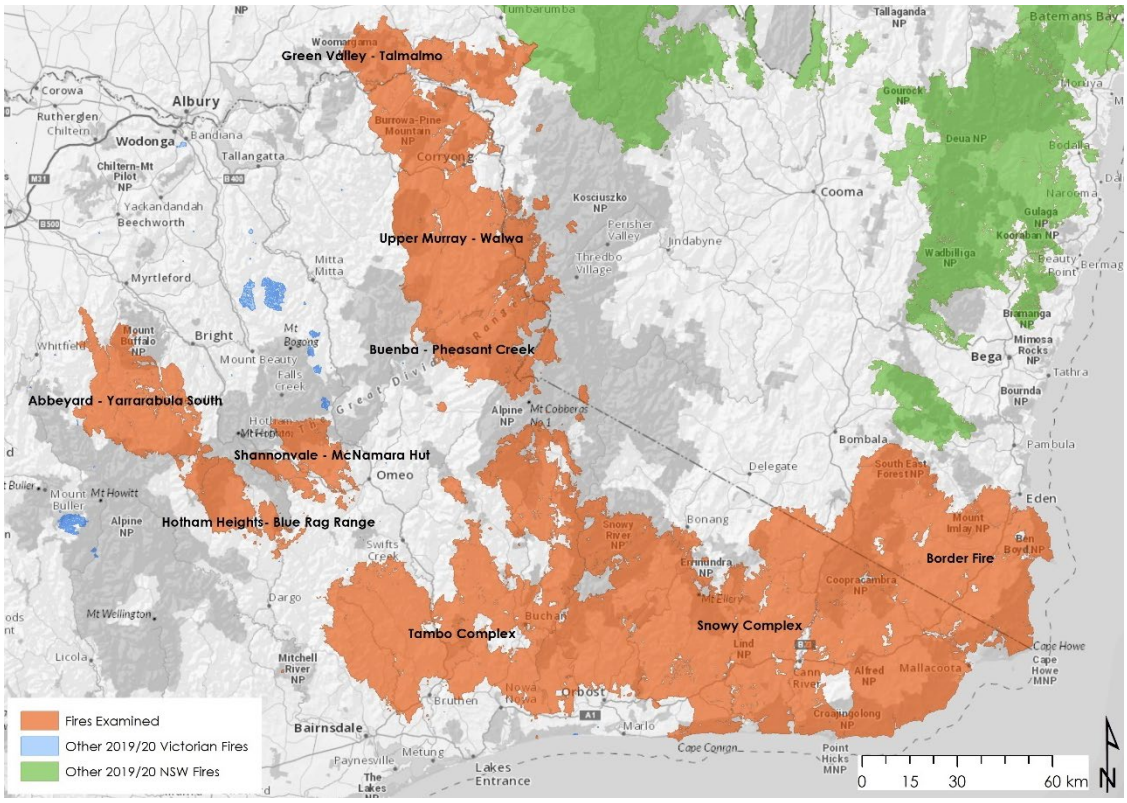


FIGURE 1: 2019/20 BUSHFIRES SHOWING FIRES EXAMINED IN THIS REPORT

SEASONAL AND LONG-TERM CLIMATE INFLUENCES

The frequency and severity of bushfires is increasing. The drivers of this are complex and not constant. The increasing trend is clear and has been forecast for at least twenty years. Anthropogenic climate changes

caused by increased greenhouse gasses, overlayed with variation caused by influences on climate variability. These include El Nino- La Nina, Southern Annular Mode and the Indian Ocean Dipole. The overall trend is showing increased drought, warmer minimum, mean and maximum temperatures, and less rainfall in all seasons. (BOM, 2020)

Global Warming and Climate Change

Scientific evidence for human-induced climate change is unequivocal (IGEM, 2020) with predictions made in 1992 proving correct. Human activity is contributing to climate change and is predicted to continue with bushfire impacts expected to worsen.

In Australia, the CSIRO has been preparing climate change predictions since 1987 and from 1992 these were closely tied to the Intergovernmental Panel on Climate Change (IPCC). These studies identified increases in temperature and decreased rainfall resulting in greater fire risk. The latest State of the Climate Report 2020 prepared by the Bureau of Meteorology (BOM) and CSIRO identifies the following areas relevant to East Gippsland and North East Victoria:

- Cool season rainfall decline in southern and eastern Australia to continue likely leading to more time spent in drought.
- Warmer temperatures with more heatwaves and fewer cool days
- Longer fire seasons and more dangerous fire weather

Fire risk is predicted to worsen as global warming continues. In the 2020 NSW Bushfire Inquiry (NSW BI, 2020)the Bushfire Research Hub stated that:

> *"if current climate trends continue then the fire weather conditions experienced during the 2019-20 fire season will become increasing likely. Interannual variability remains significant, so we can expect to see increases in the mildest and the most extreme seasons. On current trends many of the records set during the 2019-20 season are set to be broken in the next 1-2 decades".*

El Nino

Much of Eastern Victoria and in particular Gippsland had experienced years of below average rainfall. The role of El Nino is unclear. Although positive, ENSO remained in the neutral phase (between -0.8 and 0.8). It is possible that there may have been residual effects of the previous El Nino represented as long term drought. Figure 2 shows the ENSO index values relative to the time the fires were active.

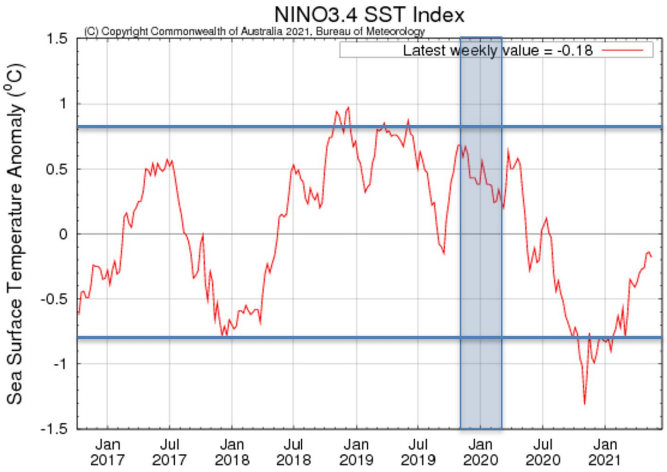


FIGURE 2: EL NINO SOUTHERN OSCILATION INDEX (ENSO)- VALUES ABOVE 0.8 ARE CONSIDERED POSITIVE AND WOULD RESULT IN AN EL NINO BEING DECLARED

Indian Ocean Dipole (IOD)

The Indian Ocean dipole refers to sea surface temperatures in the western and eastern Indian ocean A positive IOD is associated with drier and warmer than average conditions in central and south-eastern Australia during the winter and spring. The IOD was positive in 2018 and near record levels in 2019 (see Figure 3).

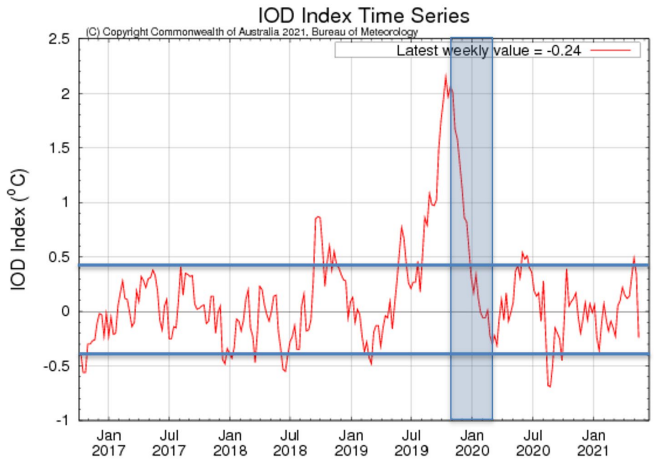


FIGURE 3: INDIAN OCEAN DIPOLE (2017 -2021) SHOWING THE STRONGLY POSITIVE VALUES LEADING UP TO THE START OF FIRES IN NOVEMBER 2019 – VALUES ABOVE 0.4 ARE CONSIDERED POSITIVE

Sudden Stratospheric Warming and negative Southern Annular Mode

Increased warming of the atmosphere over Antarctica, known as sudden stratospheric warming (over the months of October to December 2019), led to the weakening of the polar vortex, resulting in more negative conditions in the Southern Annular Mode (SAM).

This increased the likelihood of below average rainfall and higher temperatures. In a negative SAM phase, the path of westerly winds shifts to the north in summer. This means less moist onshore flow from the east, and typically decreases rainfall and increases temperatures over south-eastern Australia. SAM returned to a neutral phase in January 2020

OBSERVED CLIMATE VARIABLES

Temperature Extremes

The Bureau of Meteorology keeps records of temperatures and can calculate the amount that minimum, mean, and maximum temperatures deviate from the long-term average. Figure 4 shows deciles for min, mean and max temperatures for the months of November and December. It shows that mean and max temperatures were above the long-term average in November. In December, minimums were above average and the mean very much above average and the maximums very much above average in east Gippsland and highest on record in Northeast Victoria.

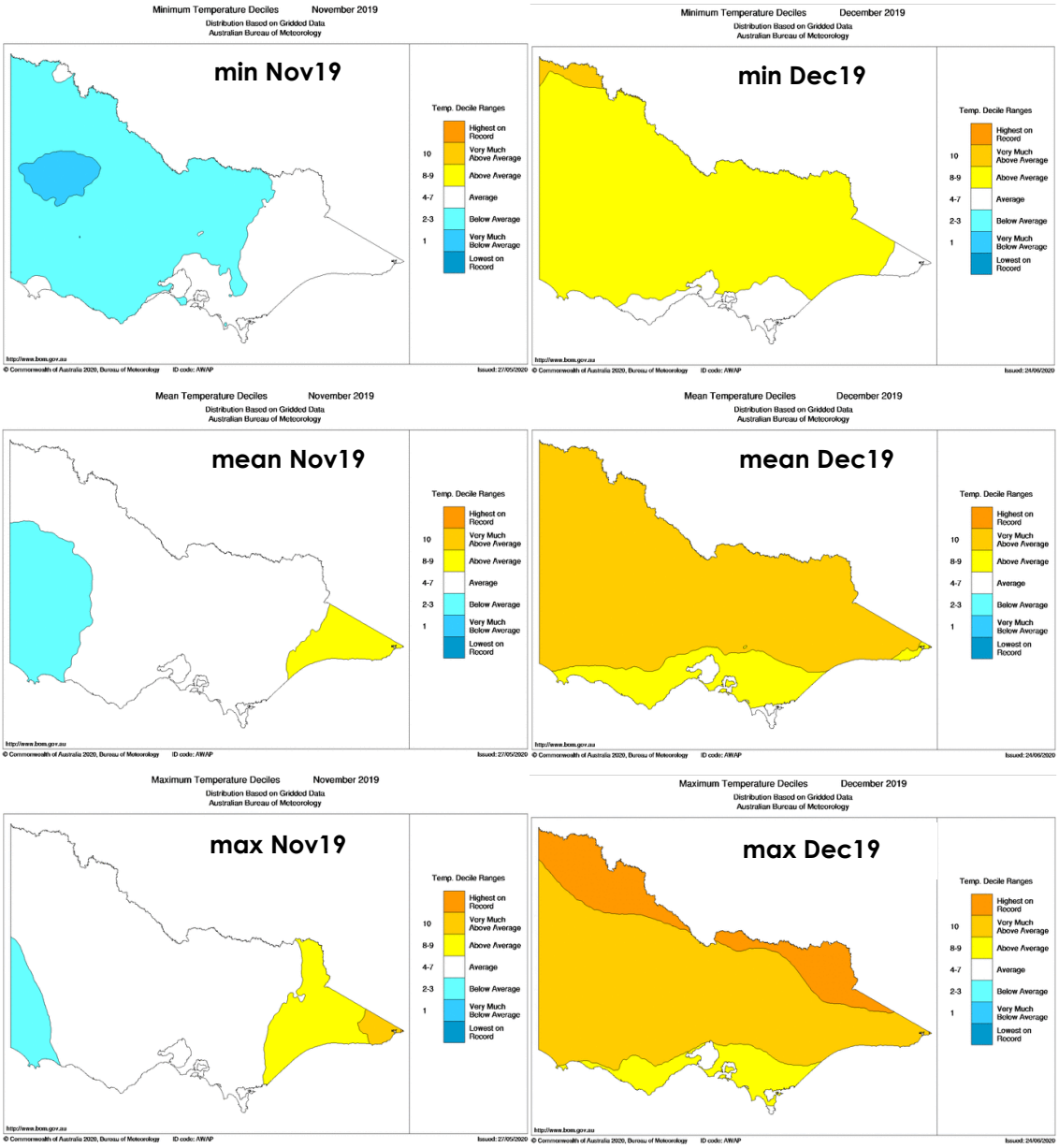


FIGURE 4: MINIMUM, MEAN AND MAXIMUM TEMPERATURE DECILES FOR NOVEMBER AND DECEMBER

Figure 5 shows the deciles for the 2019 year compared to all available records for all years. Temperatures in the fire footprint area were either

the highest on record or very much above average. The records for January 2020 were also examined and these were all classes as "above average'.

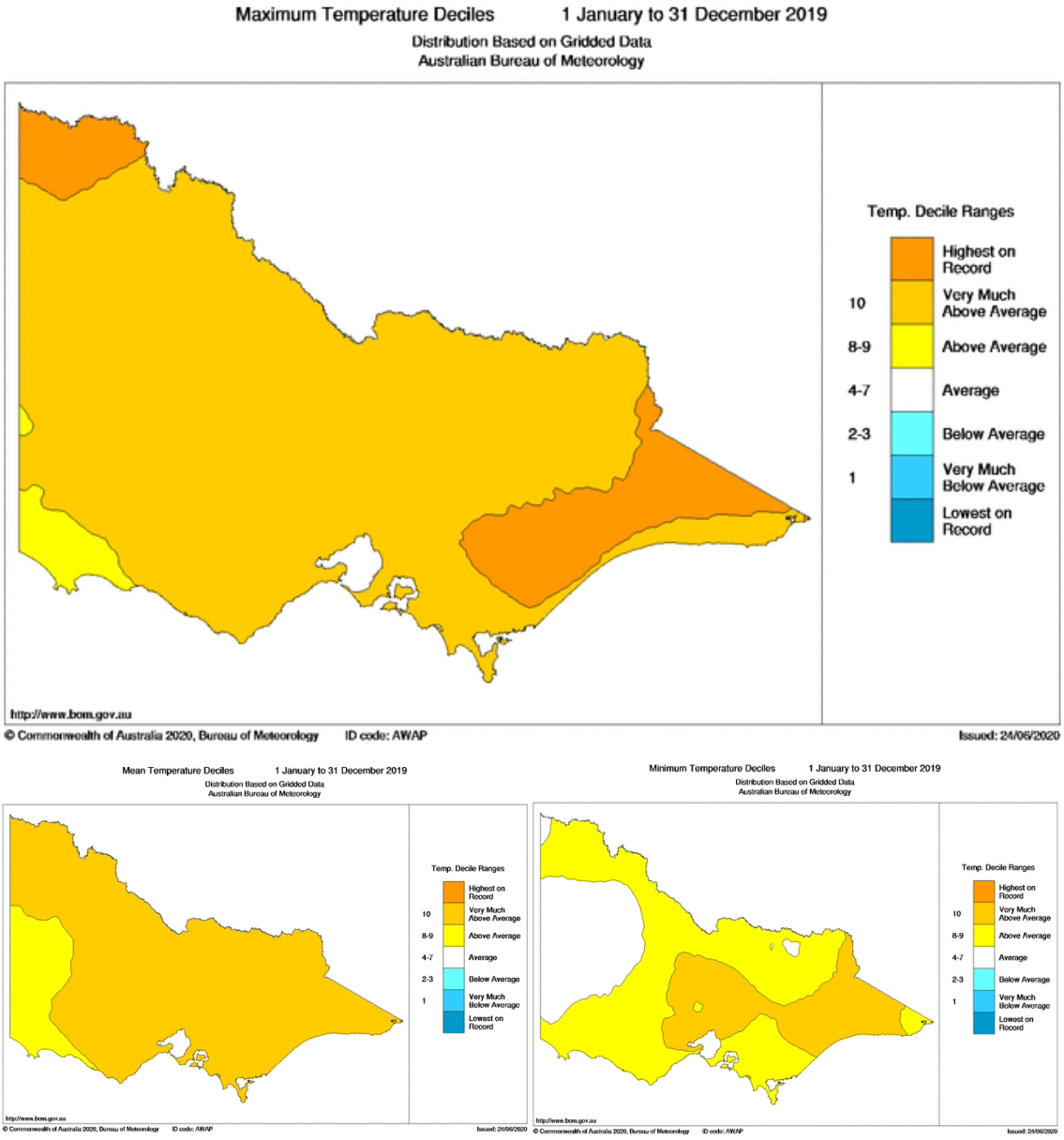


FIGURE 5: MAXIMUM, MEAN AND MINIMUM TEMPERATURE DECILES FOR 2019 (HTTP://WWW.BOM.GOV.AU/JSP/AWAP/TEMP/ARCHIVE.JSP?COLOUR=COLOUR&MAP=MAXDECILE&YEAR=2019&MONTH=12&PERIOD=12MONTH&AREA=VC)

Drought

Much of eastern Victoria was in a prolonged drought. Figure 6 shows the rainfall deciles that compare accumulated rainfall totals for 12, 24, 36, & 48 months against the long-term average. Areas of East Gippsland were in a record-breaking drought. Under drought conditions fine fuels were readily available and coarse fuels were also more readily combustible. This created hotter fires with a greater energy release, caused fires to remain alight longer and to be more difficult to extinguish and black out. Consequently, traditional fire suppression strategies and tactics proved less effective.

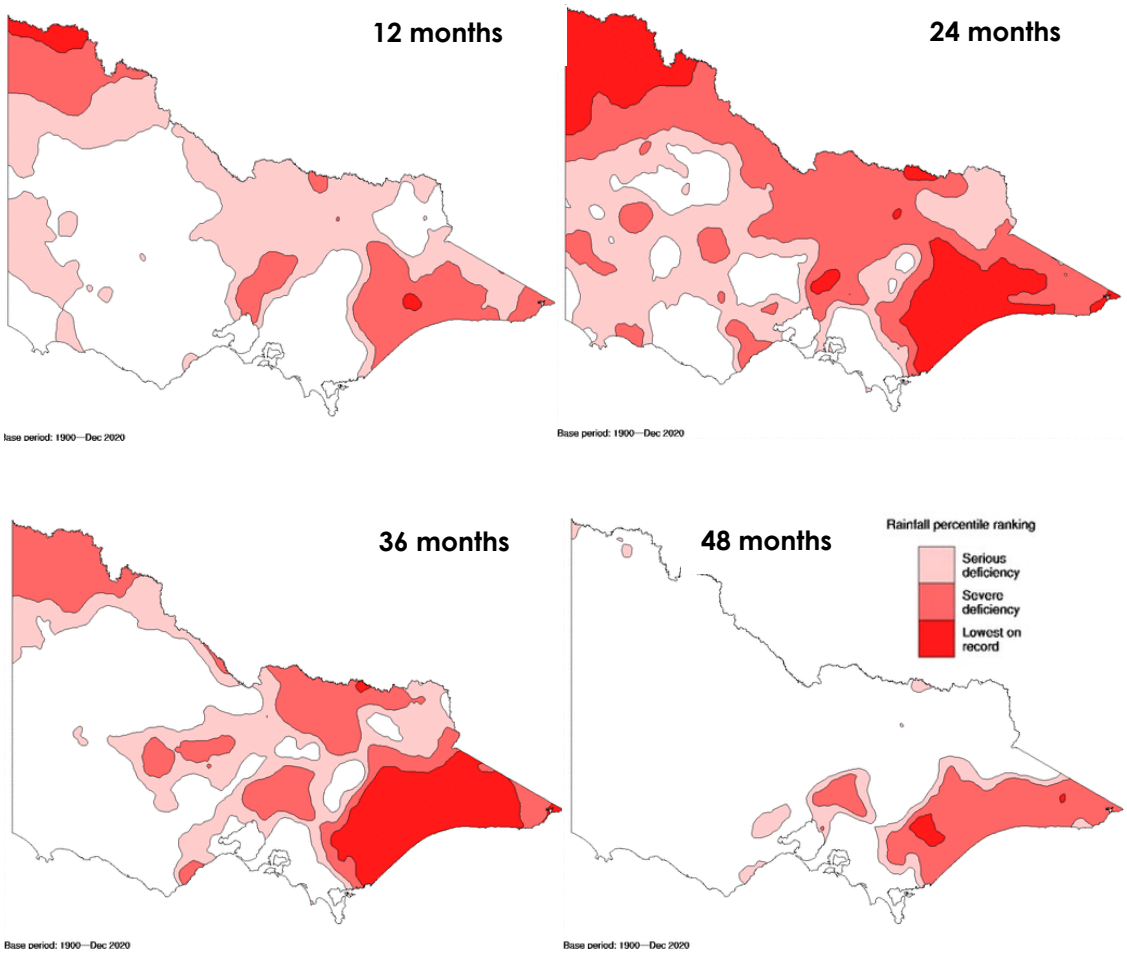


FIGURE 6: 12 (2019) , 24(2018&2019), 36 (2017-2019) AND 48 (2016—2019) MONTH RAINFALL DEFECIENCY FOR VICTORIA
HTTP://WWW.BOM.GOV.AU/CLIMATE/MAPS/RAINFALL/?VARIABLE=RAINFALL&MAP=DECILE&PERIOD=24MONTH&REGION=VC&YEAR=2019&MONTH=12&DAY=31

Fire Danger Extremes

The forest fire danger index (FFDI) combines the main parameters describing fire behaviour. These are fuel dryness (drought factor and relative humidity), air temperature and wind speed. Figure 7 andFigure 8 show that the FFDI ranges for November were very much above average or highest on record. For the month of December, the FFDIs were highest on record.

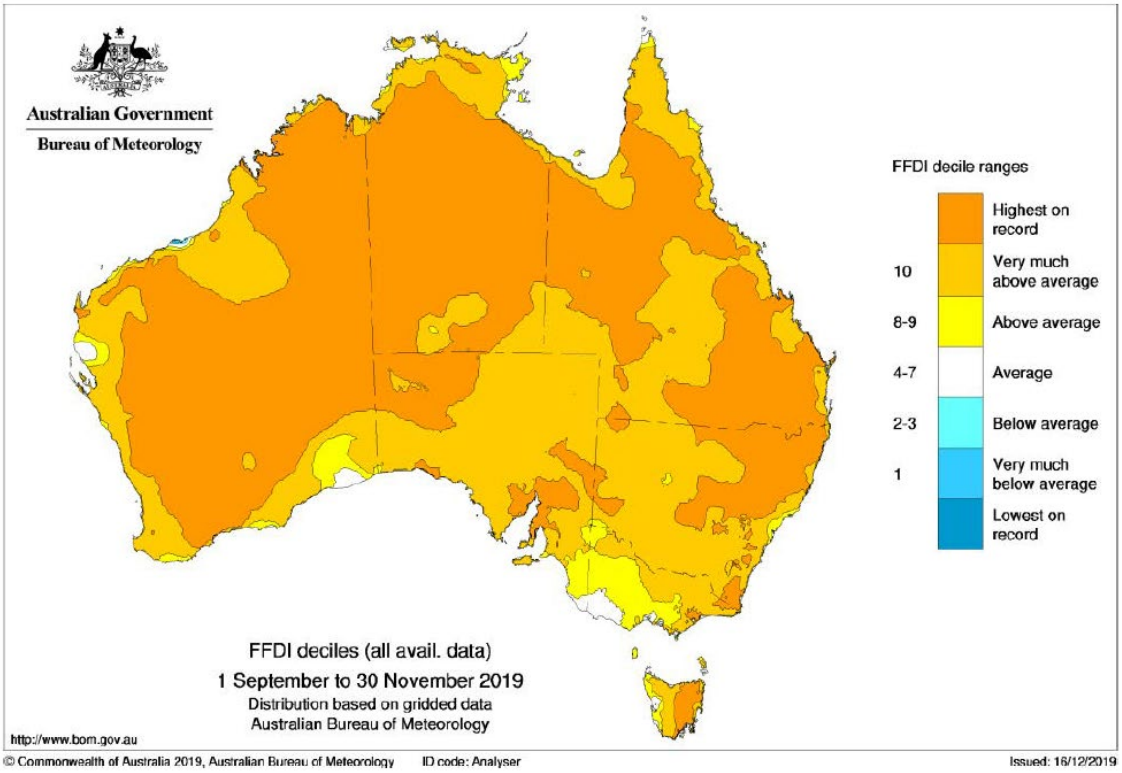


FIGURE 7: FFDI DECILES NOVEMBER 2019 (BOM, 2019)

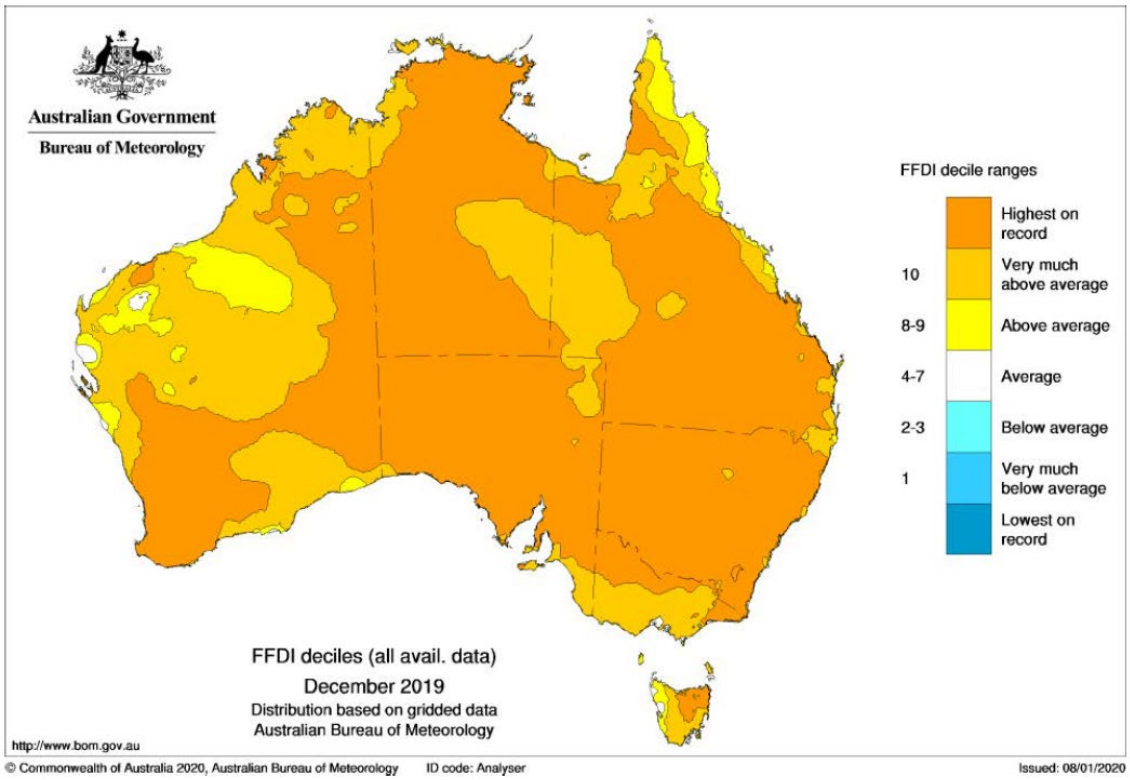


FIGURE 8: FFDI DECILES DECEMBER 2019 (BOM, 2020)

Keech Byram Drought index (KBDI) and Forest Fire Danger Index (FFDI)

The Keech Byram Drought Index is an empirical model that provides an estimate of soil dryness (moisture deficiency). The number indicates the amount of rainfall in mm that would be required to reduce the index to

zero or saturation. Anything above 62 is considered serious and above 100 is extreme. Figure 9 shows that there was an almost continual increase until the 20th of January 2020 at the six representative stations shown.

It is likely that the KBDI is an underprediction. The KBDI is reset to zero over winter if there is a rainy period with 150 to 200 mm rainfall within one week. This threshold was only just reached in East Gippsland, however the preceding years of drought meant that the soil was not saturated. In early December fuel moisture contents of 5% were recorded on the W Tree Yalmy fire.

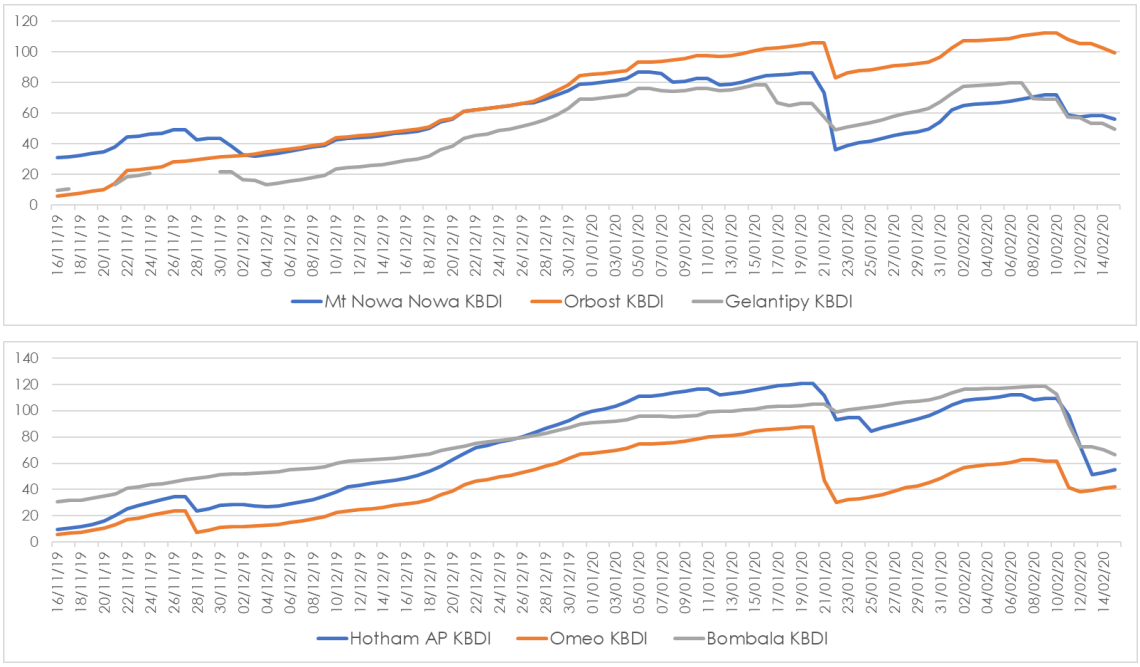


FIGURE 9: DAILY DROUGHT INDEX (KBDI) FOR SIX REPRESENTATIVE AWS LOCATIONS

Figure 10 shows the Forest Fire Danger Index for the six representative stations only reached the severe (FFDI 50-74) rating on two (Mt Hotham, Mt Nowa Nowa, Orbost, Omeo), three (Gelantipy), and Bombala on eleven occasions. For most days the fire danger was within or below the very high rating (FFDI 25-49). Bombala was the only station that reached the Code Red/Catastrophic rating (FFDI >100)

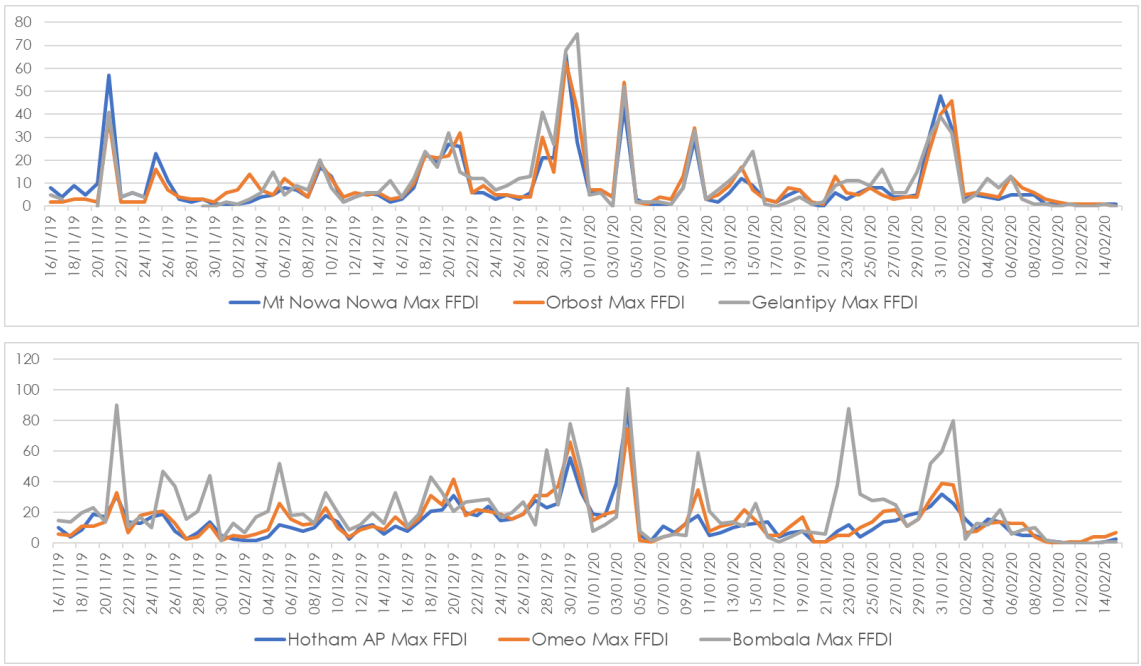


FIGURE 10: DAILY MAXIMUM FOREST FIRE DANGER INDEX (FFDI) FOR SIX REPRESENTATIVE AWS LOCATIONS

FIRE FOOTPRINT CHARACTERISTICS

General Description

In Northeast Victoria and East Gippsland there are many forested foothills that lead rugged mountainous alpine areas. The region is covered by large areas of normally cool, moist temperate forest such as alpine ash, but the predominant vegetation is the drier sclerophyll forest found at lower altitude, on drier slopes and on the extensive coastal plain that stretches into NSW. Moist gullies are filled with tree ferns and in Gippsland, warm temperate rainforest.

The Alpine area is high by Australian standards, reaching over 1,900 metres. There are many steep slopes making access exceedingly difficult across much of the region. On the high plains, low alpine vegetation and snow gums predominate across the middle of the highest ranges providing the environment for winter snow-based recreation and summer tourism. These alpine areas continue into NSW along the Great Dividing Range.

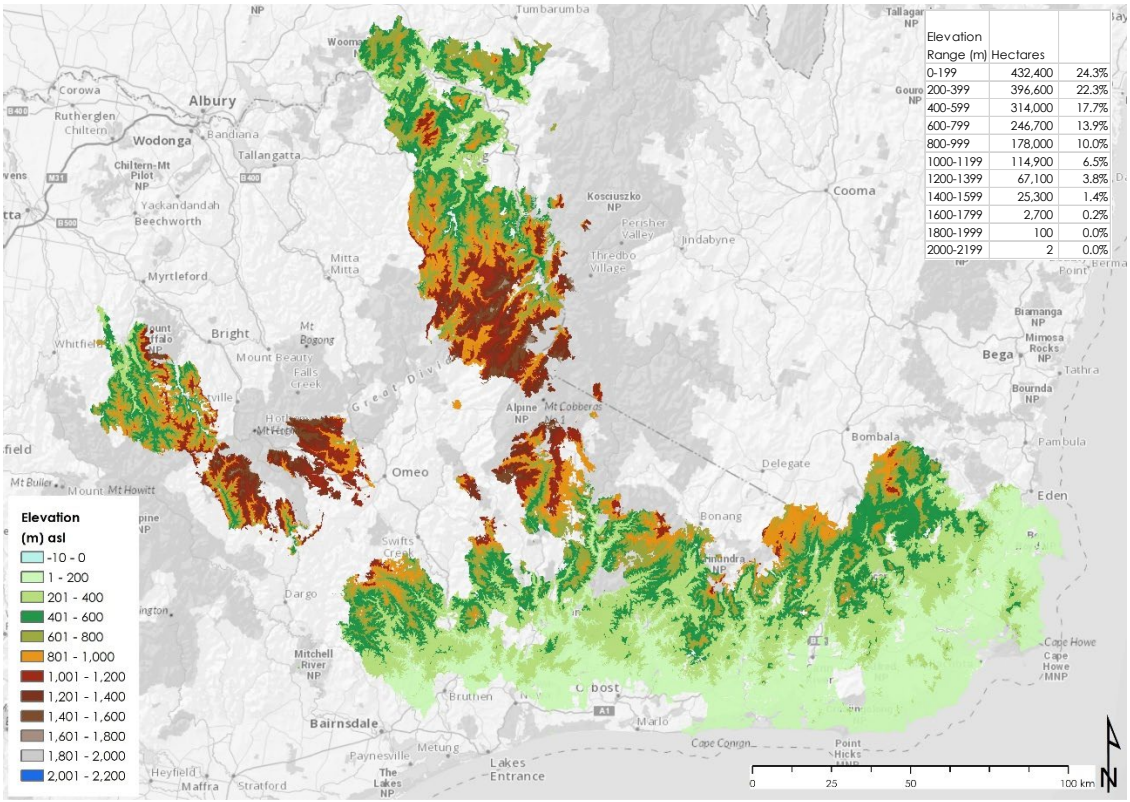
From the alpine areas to the north and south there are forested mountain ridges interspersed with long river valleys, many of which contain scattered, isolated farming communities that are frequently exposed to high levels of fire risk.

The valleys to the north gradually open out into rolling hills and fertile plains to the west. The valleys to the south gradually widen to become coastal plains across much of Gippsland, although at the easternmost end, the forested ranges extend almost to the sea.

The population of East Gippsland is relatively low and mostly confined to small coastal towns around a predominantly public estate of forested land. Small pockets of agriculture are interspersed within the steeper terrain.

Elevation

Figure 11 shows the elevation range for the footprint of fires examined. Around two thirds of the fire area occurred below 600m. Interestingly most of the fire ignition that burnt this area started above 600m in steep remote and inaccessible terrain.



Elevation Range (m)	Hectares	
0-199	432,400	24.3%
200-399	396,600	22.3%
400-599	314,000	17.7%
600-799	246,700	13.9%
800-999	178,000	10.0%
1000-1199	114,900	6.5%
1200-1399	67,100	3.8%
1400-1599	25,300	1.4%
1600-1799	2,700	0.2%
1800-1999	100	0.0%
2000-2199	2	0.0%

FIGURE 11: ELEVATION RANGES FOR THE FIRE FOOTPRINT

Fuel Types

These have been broadly classified using the Victorian and NSW Phoenix fuel types and are shown in Figure 12. The predominant fuel type burnt was dry sclerophyll forest, with some areas of grazing land, wet sclerophyll, alpine, heathy and softwood plantation.

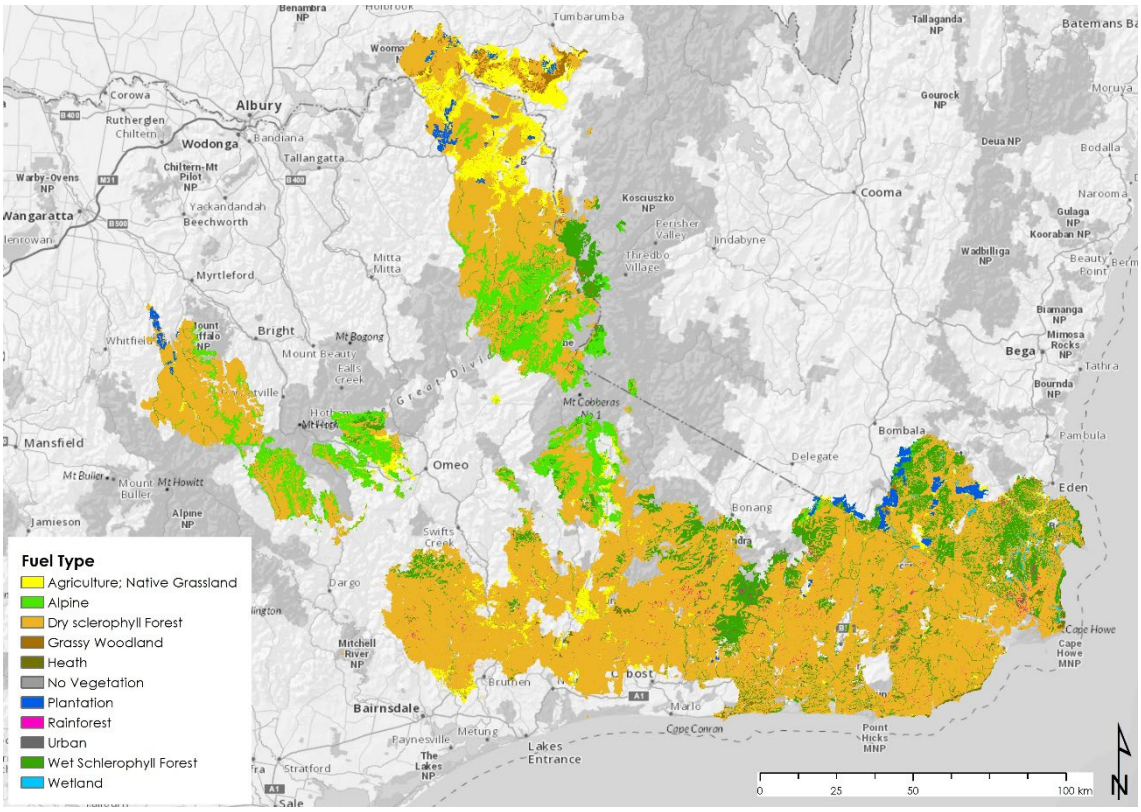


FIGURE 12: FUEL TYPES FOR THE FIRE FOOTPRINT BASED ON PHOENIX FUEL TYPES

DELWP Land and Fire Districts

The Department of Environment Land Water and Planning (DELWP) fire districts are used for fire management, response and fire naming.

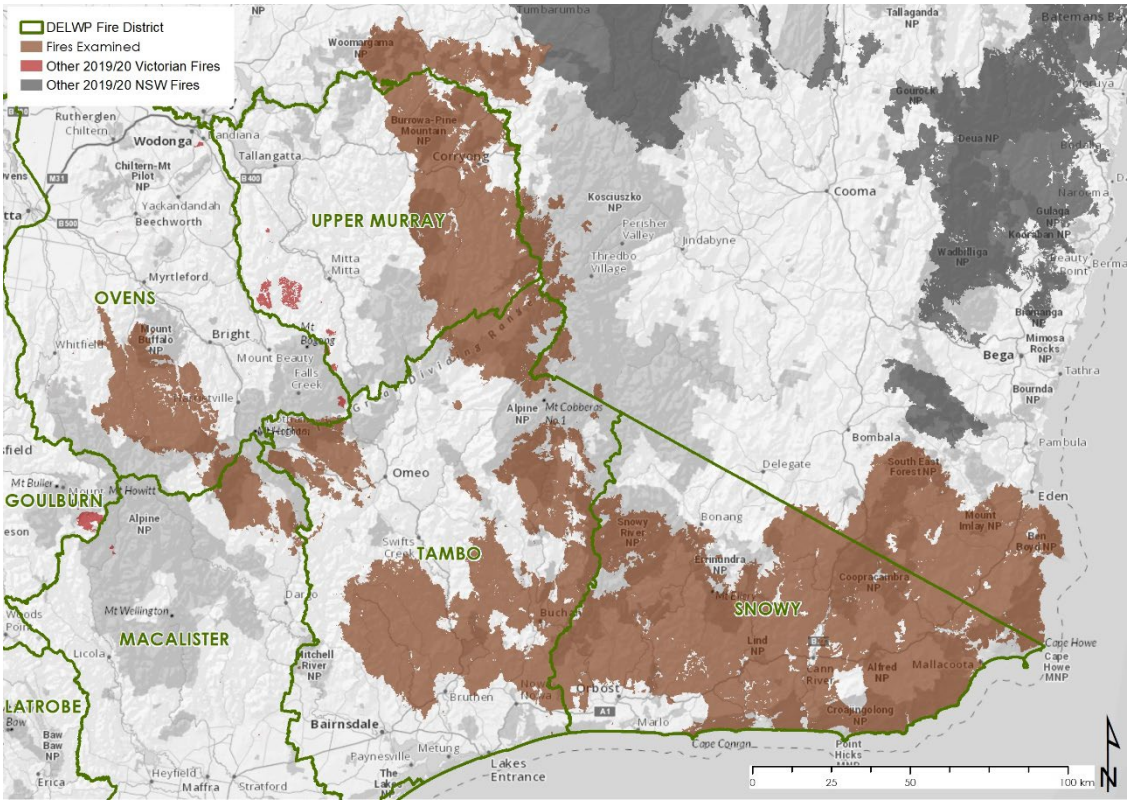


FIGURE 13: DELWP LAND AND FIRE DISTRICTS (THESE ARE LINKED TO FIRE NAMES)

Local Government Areas

Local Government areas can be seen in Figure 14. Member of the public will be more familiar with these and much of the recovery efforts are focussed at this level.

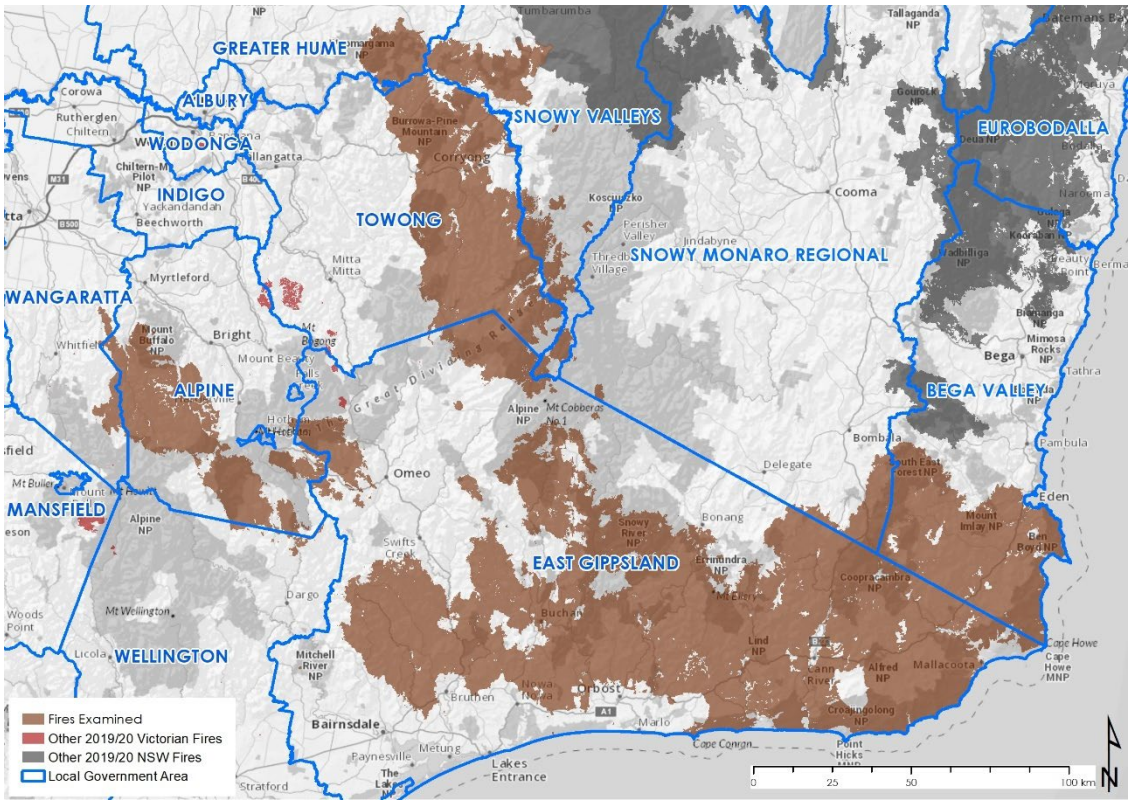


FIGURE 14: LOCAL GOVERNMENT AREAS AND THE FIRE FOOTPRINT

Recent Bushfires and Planned Burning

An overview of bushfires and planned burns conducted in Victoria can be seen in Figure 15. A similar format is used in the progression maps contained in this report. The influence of earlier fuel treatments and bushfire is considered later in this report. A preliminary analysis of this can be found on page 189.

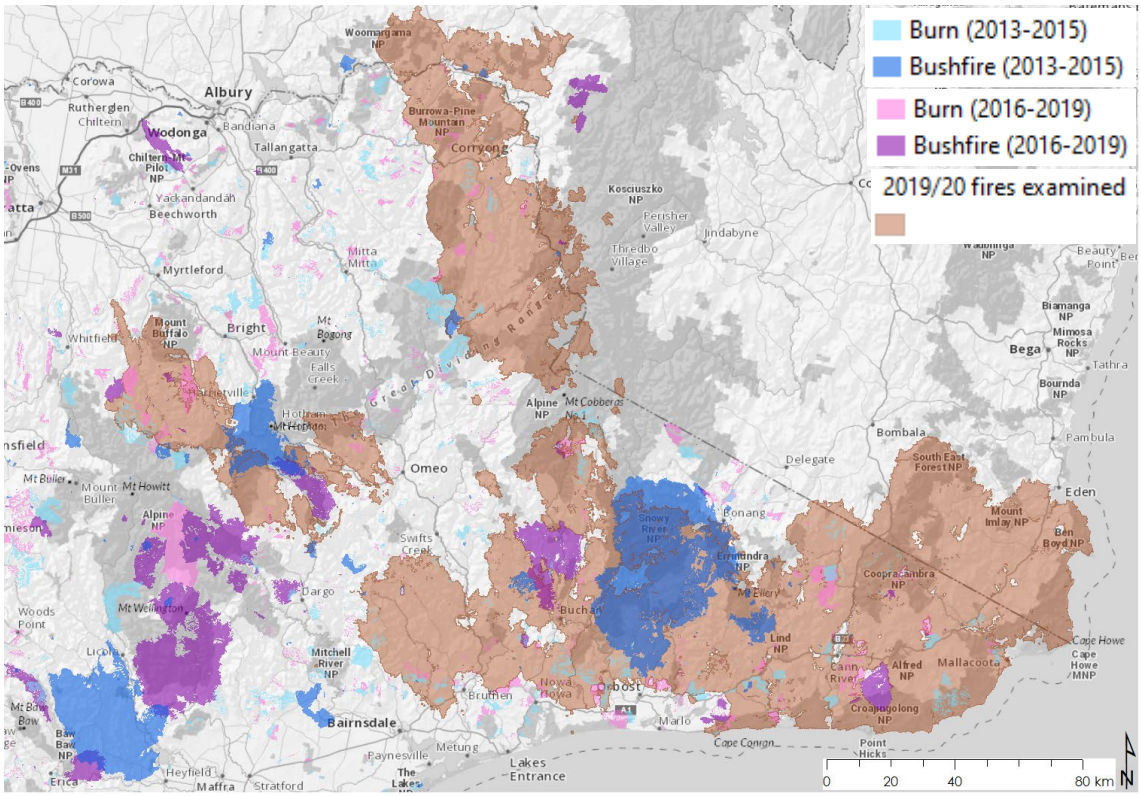


FIGURE 15: RECENT BUSHFIRE AND PLANNED BURNING FOR VICTORIA FOR THE LAST SEVEN YEARS

DATA SOURCES

WEATHER STATION DATA

Weather observations for the fire footprint and adjacent areas are available from the Bureau of Meteorology Automatic Weather Stations (AWS) and DELWP/CFA Portable Automated Weather Station (PAWS). Non-government weather stations provide a secondary source of information. Figure 16 shows the weather station locations and fire footprint.

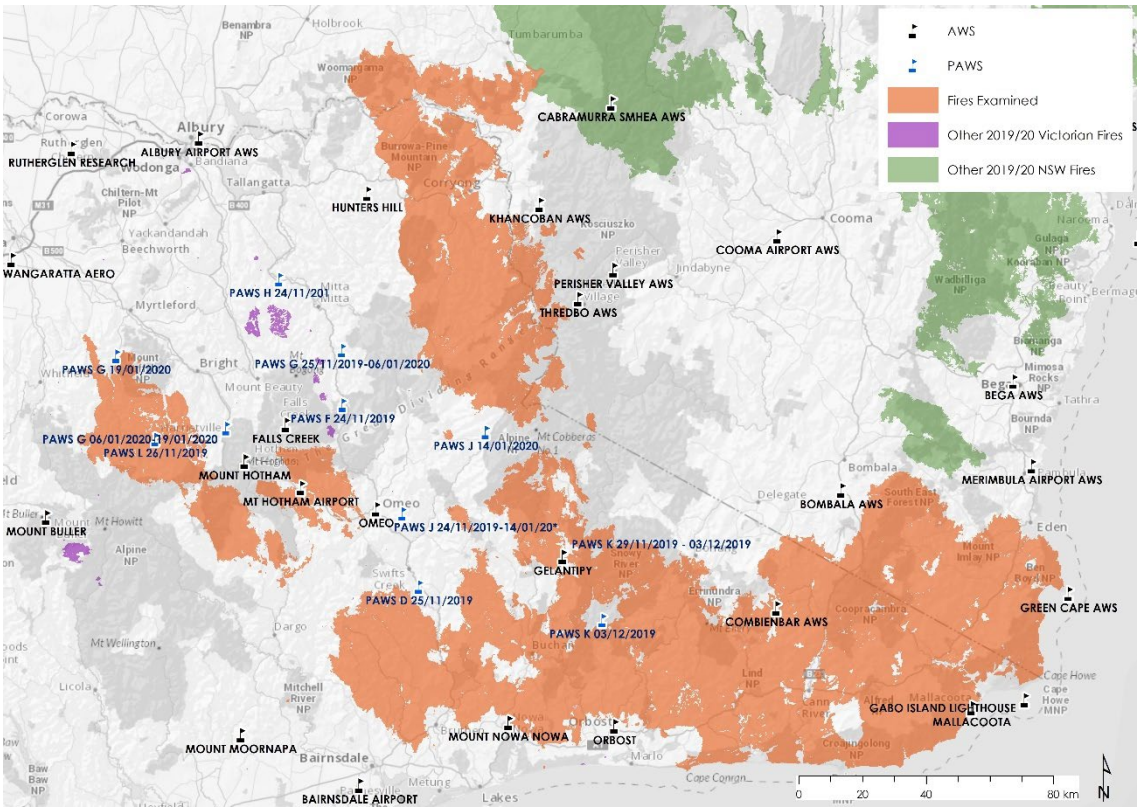


FIGURE 16: WEATHER OBSERVATION SITES – AWS AND PAWS (INCLUDING DATE/S OF OPERATION)

A number of these stations were impacted by the fires or lost power. This has resulted in missing observations and the loss of calculations of KBDI and hence FFDI. Where possible the FFDI has been recalculated using the gridded weather drought factor.

AIRBORNE SENSORS

Line scanners using infrared and shortwave infrared provide on call spatially correct data and have been used extensively in documenting the fires. AIG (Aerial intelligence Gathering) using military grade infrared and visual tools have been used in conjunction with the line scans examples of these can be seen in Figure 17 and Figure 18. Outside of Victoria the AIG is knows as SIG (Special Intelligence Gathering).

Air observer photos are now provided with the time and geospatial location. There are also many air crew photos that add to the picture and may not be included in the records.

FIGURE 17: AIG SHOWING SPOTFIRES AT THE TOWONG RACECOURSE ON THE 4TH OF JANUARY 2020

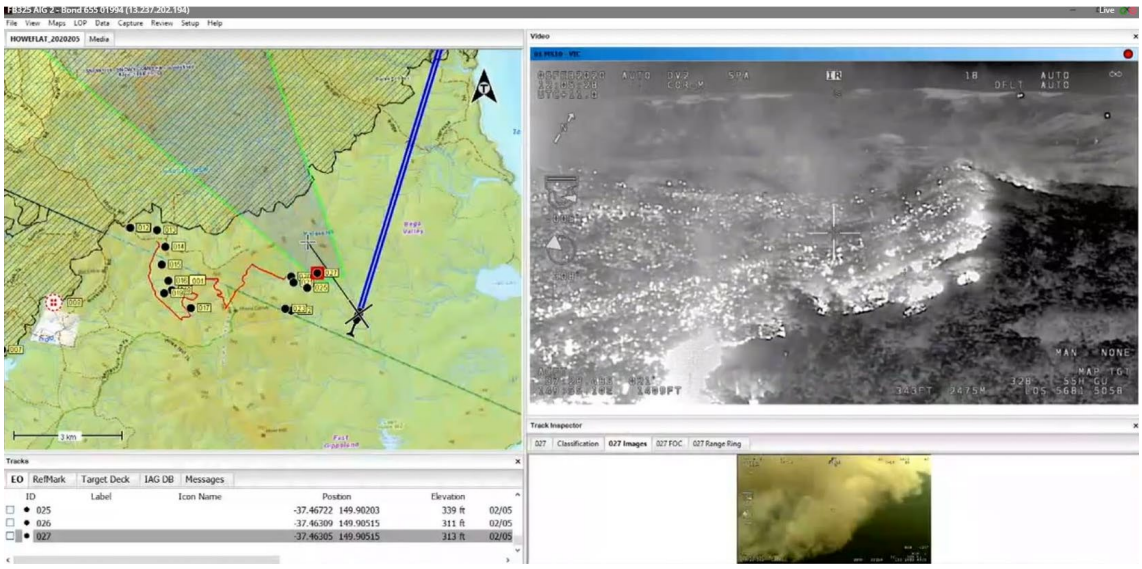


FIGURE 18: AIG WEB FEED FOR 05 FEBRUARY 2020 – MAPPING THE FIRE RUN AT HOWE FLAT (FIREBIRD 325)

SATELLITE AND RADAR

Satellite based sensors such as Himawari, Landsat7&8 and Sentinel 2A & 2B, provide a huge data resource at differing resolutions and timescales. Himawari provides 10-minute frequency and 10-20 minute latency with both true colour and infrared bands. Examples of this are shown in Figure 19. The resolution is coarse (0.5-1.0km)

Sentinel is available every 5 days and Landsat every 16 days. The IR and SWIR bands can see through smoke but not cloud or very dense smoke plumes. The resolution is between 10 and 30 metres. Landsat also has two

thermal bands. Sentinel was generally available for use 3-5 hours after its 1100hrs mission was complete. Figure 20 shows examples from Landsat.

Radar can provide detailed information about the plume and can show it in three dimensions. The use of the Bairnsdale radar for the Gippsland fires should be considered for further analysis.

Hotspot data is also available. For this report, the raw Himawari SWIR data was used in preference to this. The Himawari data shows cloud and plumes, whereas the hotspot data only shows hotspots that meet a threshold and their intensity. Hotspot data is also available at finer resolution than Himawari from the MODIS, NOAA and VIIRS satellites but at a much longer time scale between passes.

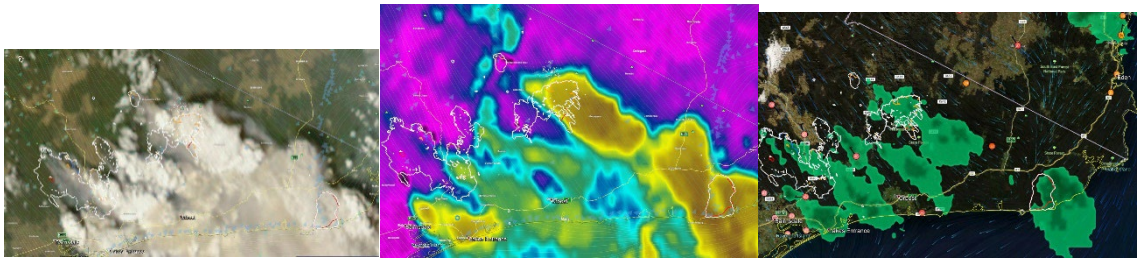


FIGURE 19: EXAMPLES OF WEATHER SATELLITE AND RADAR OUTPUTS – (LEFT)HIMAWARI TRUE COLOUR, (MIDDLE) ENHANCED IR, (RIGHT) RADAR FOR THE AFTERNOON OF THE 30TH OF DECEMBER (WEATHERZONE AND WEATHER UNDERGROUND)

The enhanced infrared image interprets greyscale IR images and correlates the values with temperature. The pixels represent a particular temperature range. Traditionally the temperature of clouds is associated with their height, so highlighting certain temperature ranges is useful for estimating the height of the observed clouds and hence smoke plumes and heat generated by active fire. The precision of these temperature measurements is within one or two degrees Celsius. Images coloured in this way are known as 'false colour' images. (see http://www.bom.gov.au/australia/satellite/about_images.shtml)

There is a great potential to use these false colour techniques combined with the SWIR data to provide real time visualisations and post fire analysis. The use of band combinations to show various weather phenomena is common in meteorological circles and should be further investigated for use in fire monitoring.

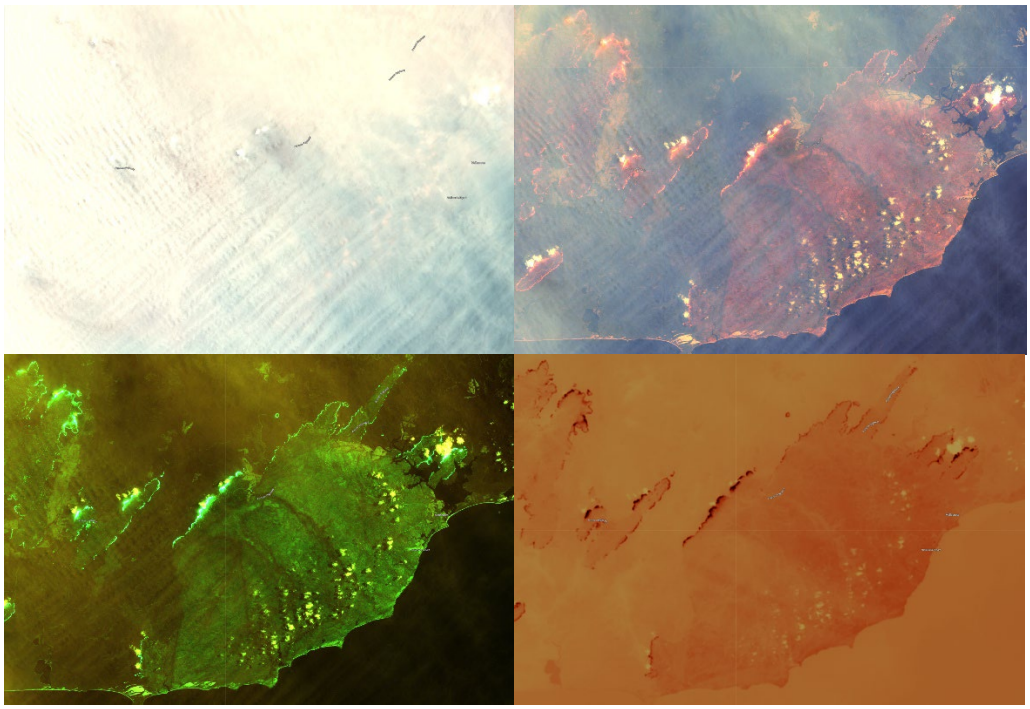


FIGURE 20: LANDSAT IMAGES FROM 1ST OF JANUARY 2020 – CLOCKWISE FROM TOP LEFT: FALSE COLOUR INFRARED, NEAR INFRARED/SHORT WAVE INFRARED COMPOSITE, THERMAL, AND SHORTWAVE INFRARED COMPOSITE (USGS AND EO BROWSER)

PHOTOGRAPH AND VIDEO

There is likely to be tens of thousands of photographs and videos and many will include a time and GPS location. None the less, finding the original image and with the data (location and time) still being present has proved to be a challenge. It is often necessary to go back to the source as copying and editing removes the original file information. Photos have been included in the report where possible. Sometimes only an estimate of time can be given.

SITUATION REPORTS AND LOGS

Situation reports from Fireweb have formed the basis of a narrative and have been compiled into situation summaries complete with maps and photographs. There has not been a great deal of individual consultation and viewing of fire logs. At this stage, the project has focussed on all fires at a broader scale with some finer scale investigations. This situation summary format could provide a template for the documentation of all major fires.

SOCIAL MEDIA

Facebook, Twitter, and Instagram all provide a record of events. These include eyewitness accounts, photographs, and videos.

MEDIA SERVICES

Local and national media companies often have readily available records of events. Of particular use is the viewer/subscriber photographs which can often be found months and years after the event.

WEATHER OBSERVATION AND FORECAST WEBSITES AND FEEDS

Weather websites such as the BOM, Weatherzone and Weather Underground provide almost real time information in a graphical user interface where layers can be combined to build up visualisation of what happened, is happening and is about to happen. This includes forecast data, AWS observations, radar, satellite, wind streamlines etc. Many of the images shown in the report were captured at the time of the fires. Some datasets such as hotspots and Himawari bands are available at LandgateFirewatchPro (https://firewatch-pro.landgate.wa.gov.au/), Geoscience Australia or Himawari Real time viewer (https://himawari8.nict.go.jp/).

The BOM also have an extensive internal archive, but this can only be accessed by BOM staff. Getting to the level of detail required to determine the detailed weather scenario will need BOM specialist input. This project has identified the potential to look at the major fire days and investigate the weather at each location.

THE FIRES

This section provides an overview of the fires and their causes and growth. It then details each fire in terms of weather and fire progression showing maps, photographs, and charts of weather and fire behaviour indices. Fires are detailed individually in chronological order; however, this is complicated by fires merging and occurring concurrently. There will be occasions where the weather summary may apply to more than one fire and some cross-referencing will be necessary.

The maps are based on definitive line scans and satellite images and the date and time are reflective of the time of image. This means that some fire runs are captured hours or days after the event. Where cloud and smoke plumes obscured the area to be mapped this will be stated.

Photographs are included to show fire behaviour, fuel and weather, and the firefighting effort. Imagery in the form of satellite and line scan has also been used to show the fire spread.

IGNITIONS

Figure 21 shows the number of ignitions that occurred from November 2019 to end of January 2020 (Source DELWP Fireweb). There were two significant lightning events where around 50 new starts occurred. This stretched resources in November and was far worse over the New Year period.

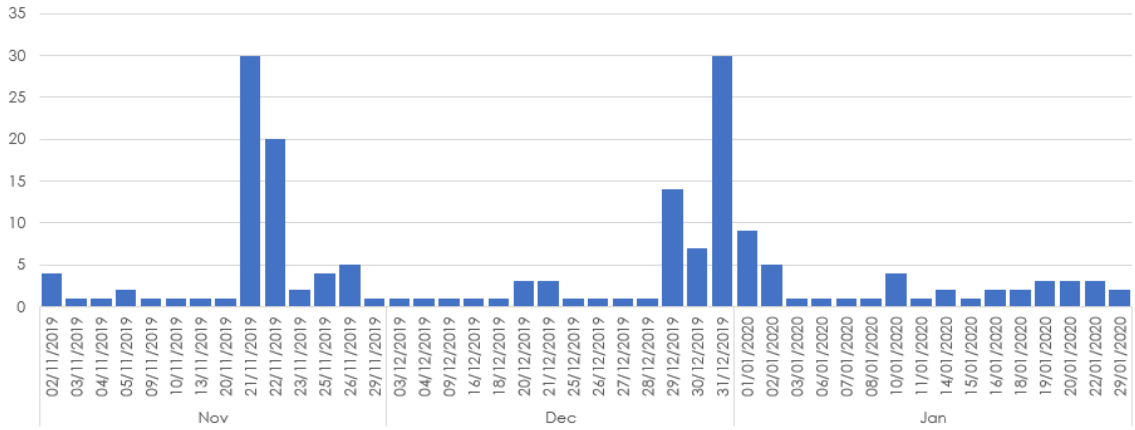


FIGURE 21 NUMBER OF FIRE STARTS MACALISTER, OVENS, SNOWY, TAMBO AND UPPER MURRAY DELWP FIRE DISTRICTS

For the area and time of interest covered in this report, lightning was responsible or suspected for all but one of the ignitions. Several fires were created for management reasons (when a fire crossed from one DELWP District to another). There were also fires that were caused by spot fires from a fire caused by lightning. A list of fires and their cause can be found in Appendix Two: List of Fires.

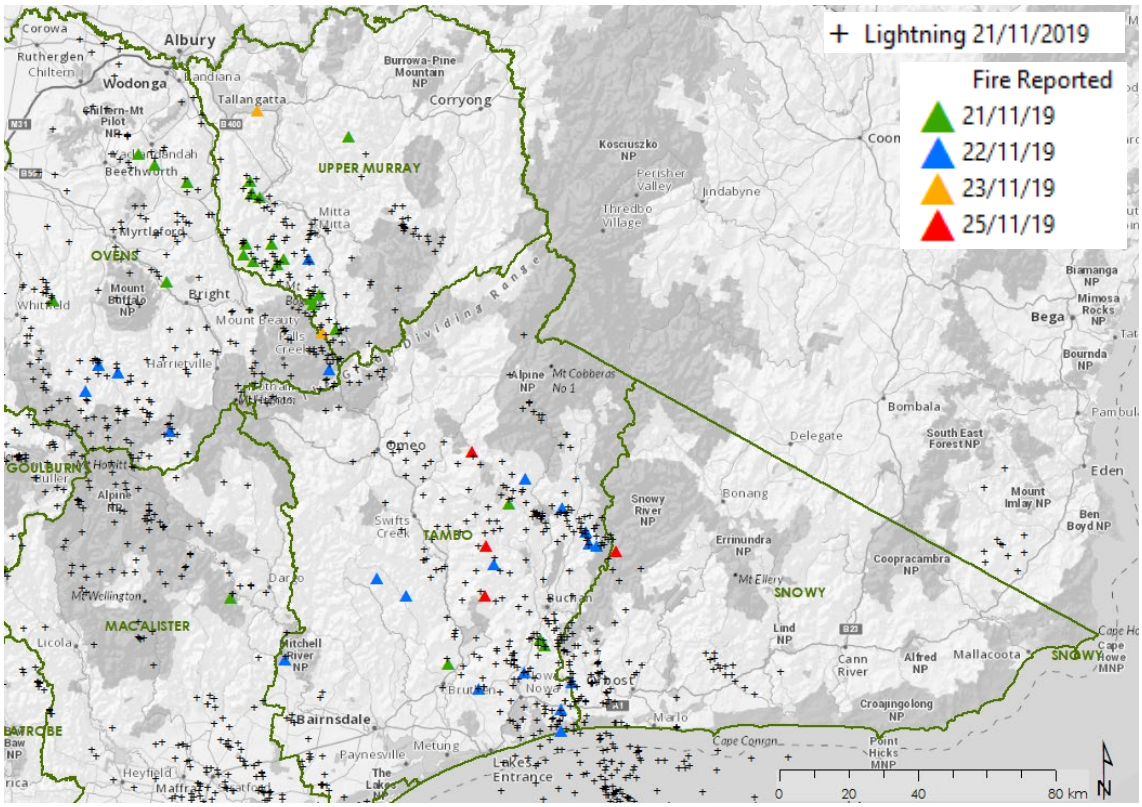


FIGURE 22:CLOUD TO GROND LIGHTNING STRIKES AND NEW FIRE STARTS FROM LIGHTNING 21ST NOVEMBER TO 25TH NOVEMBER

Lightning was recorded from 1400 to 2300hrs on the 21st of November 2019. Around 1000hrs ground strikes were recorded in the Macalister, Ovens, Upper Murray, Tambo, and Snowy districts – this resulted in 51 recorded ignitions that were detected from the 21st to 25th of November.

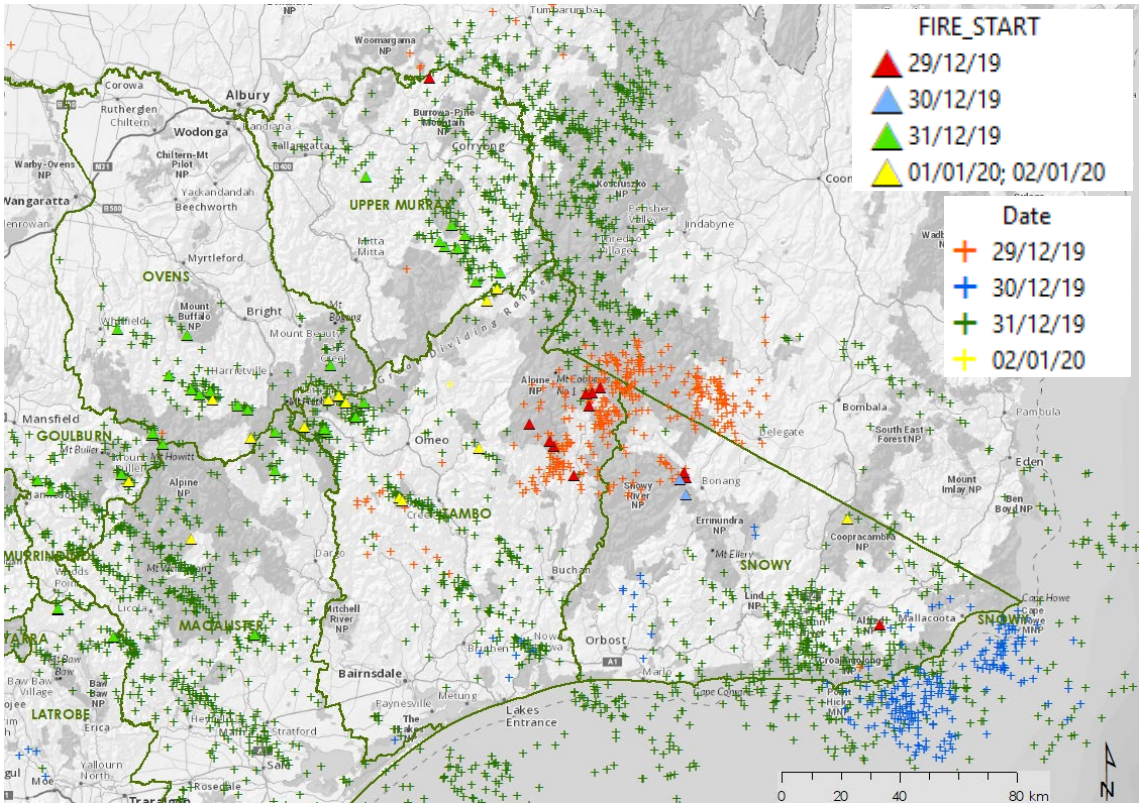


FIGURE 23: CLOUD TO GROUND LIGHTNING STRIKES AND NEW FIRE STARTS IN VICTORIA FROM LIGHTNING 29TH OF DECEMBER TO 31ST OF DECEMBER

The second major lightning event that caused ignitions occurred in late December and can be seen in Figure 22. The first band of lightning occurred on the 29th of December from 1530hrs to 1800hrs and resulted in the Green Valley - Talmalmo fire and several fires in the Bonang Gelantipy area. The cause of the Snowy 09 – Banana Track fire remains a mystery. No lightning tracker data could be found for the start of this fire for the 29th or the previous days. The absence of this is not definitive, but suggests other causes should be considered.

On the 31st of December several bands of lightning occurred. Impacts occurred in alpine areas at around 1300hrs and then at 1500hrs adjacent to UM26 fire footprint. This resulted in multiple ignitions

Points to note:

- Nearly all lightning on the 30th of December was associated with PyroCb development.
- Some of the lightning south of the divide and fire footprints on the 31st of December in Tambo and Snowy Fire Districts is associated with PyroCb. There was no lightning recorded in the area shown for the 1st and 2nd of January.
- Fire starts on the 1st and 2nd of January were not picked up until then but most likely started on the 31st of December.
- NSW fire starts are not shown in this figure except for the Upper Murray 26 fire. This is shown where the Green Valley - Talmalmo fire crossed into Victoria (not at the point of origin).

AREA BURNT BY DATE

Figure 24 shows the cumulative area burnt for the fires examined. Up until the 30th of December under 200,000 hectares had been burnt as the Gippsland fires steadily increased. The area had increased to around 700,000 hectares with the major fire runs of the 30th and 31st of December. Significant increases occurred on the 4th into the 5th of January although the exact extent of this was not able to be determined until smoke and cloud cleared. In hindsight it is estimated that by the morning of the 5th of January 1.2 million hectares had been burnt. There were additional fire runs in the Errinundra and Border areas after this date, however much of the growth in fire area resulted from unburnt areas within the broad fire area being allowed to burn out or being controlled by backburning.

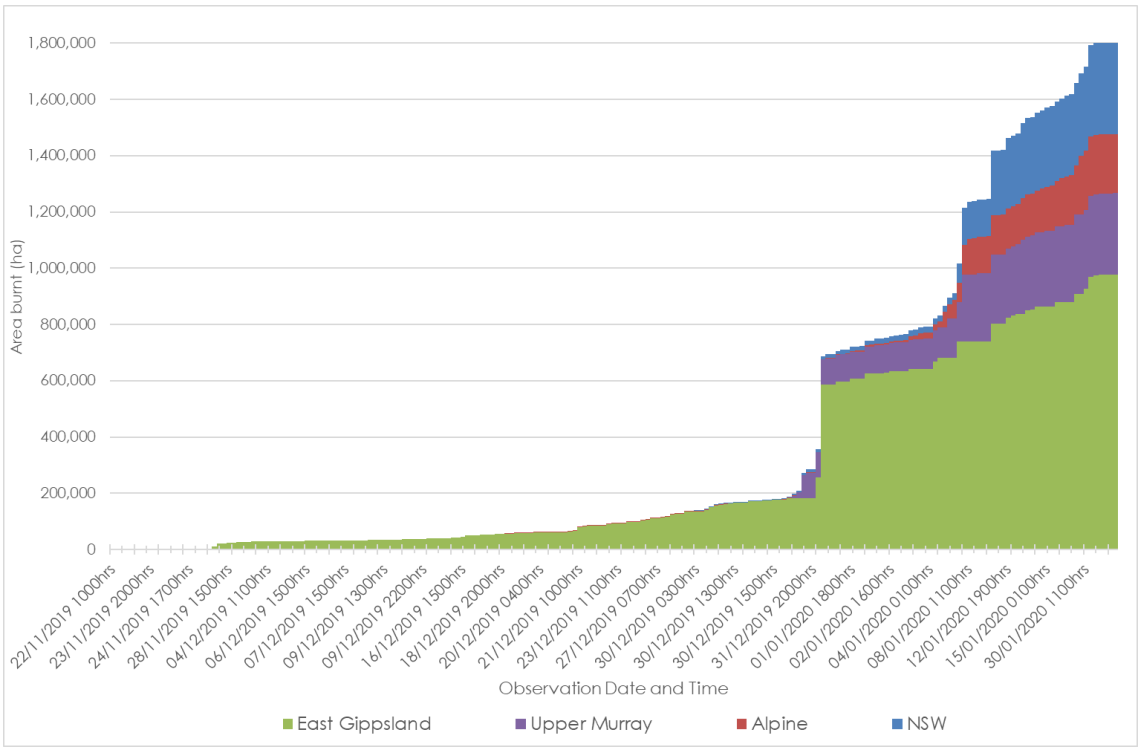


FIGURE 24: CUMULATIVE AREA BURNT BY OBSERVATION TIME AND DATE

TAMBO 31 - BRUTHEN – SIX MILE TRACK: 22ND NOVEMBER TO 21ST OF DECEMBER 2019

Area burnt by Date

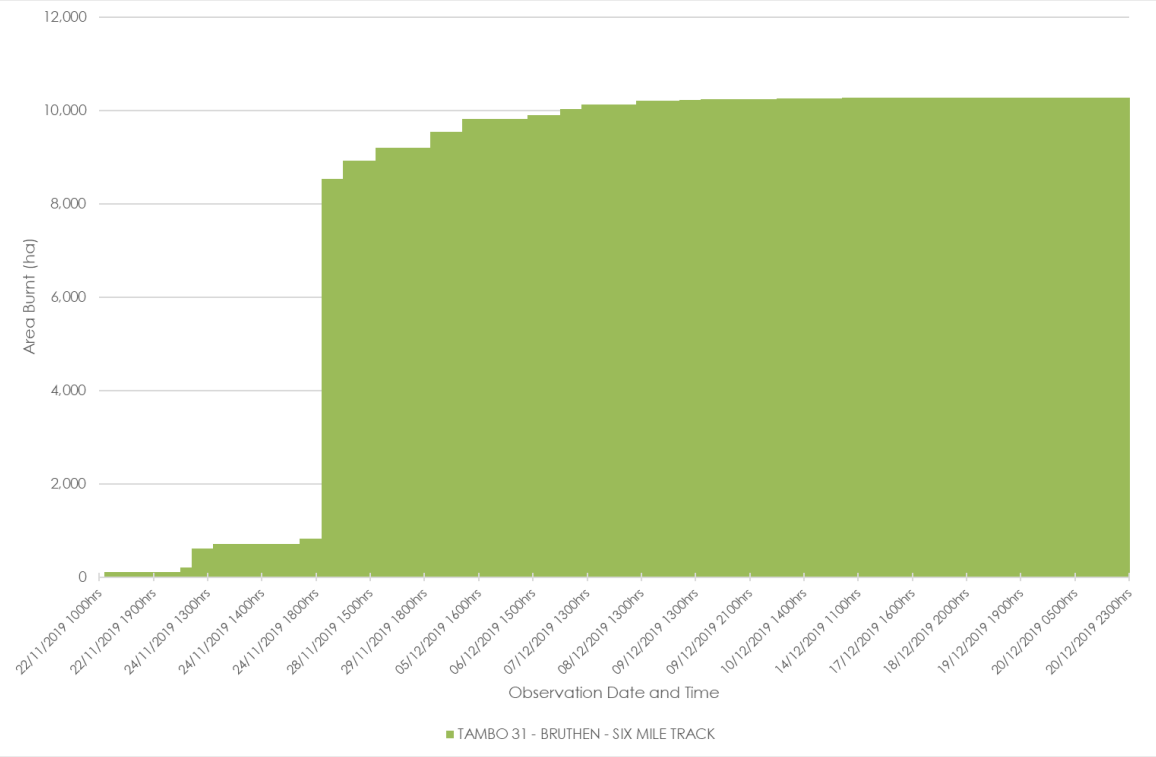


FIGURE 25: AREA GROWTH OF BRUTHEN - SIX MILE FIRE

Weather for the 21st and 25th of November

By any measure the weather for the 21st of November was unusual for that month. Melbourne (Olympic Park) recorded 40.9 °C on 21 November, equalling the highest November temperature for the city (on 27 November 1894, at the old Observatory site) (http://www.bom.gov.au/climate/current/month/vic/archive/201911.melbourne.shtml). A large blocking high in the Tasman Sea directed hot dry NNW winds over the central and eastern areas of Victoria with a strong and gusty westerly change impacting in the evening, with wind speeds lessening overnight and tending south westerly by the next day.

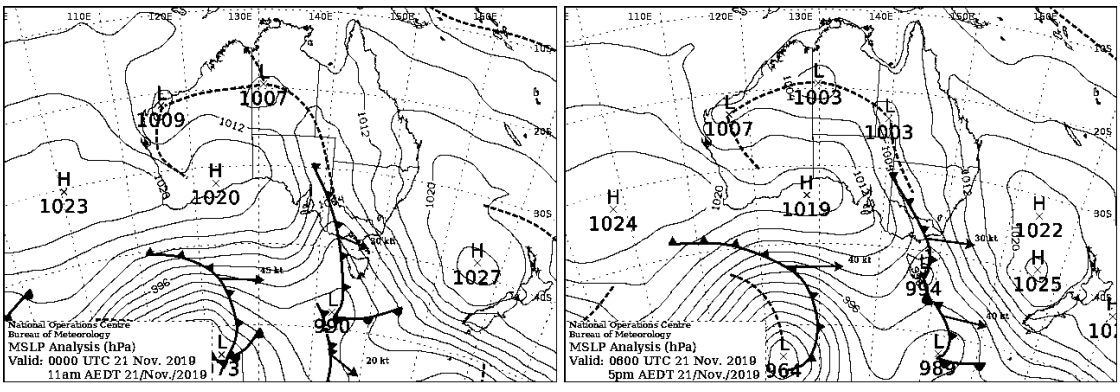


FIGURE 26: SYNOPTIC CHARTS 1100HRS TO 1700HRS 21ST OF NOVEMBER 2019

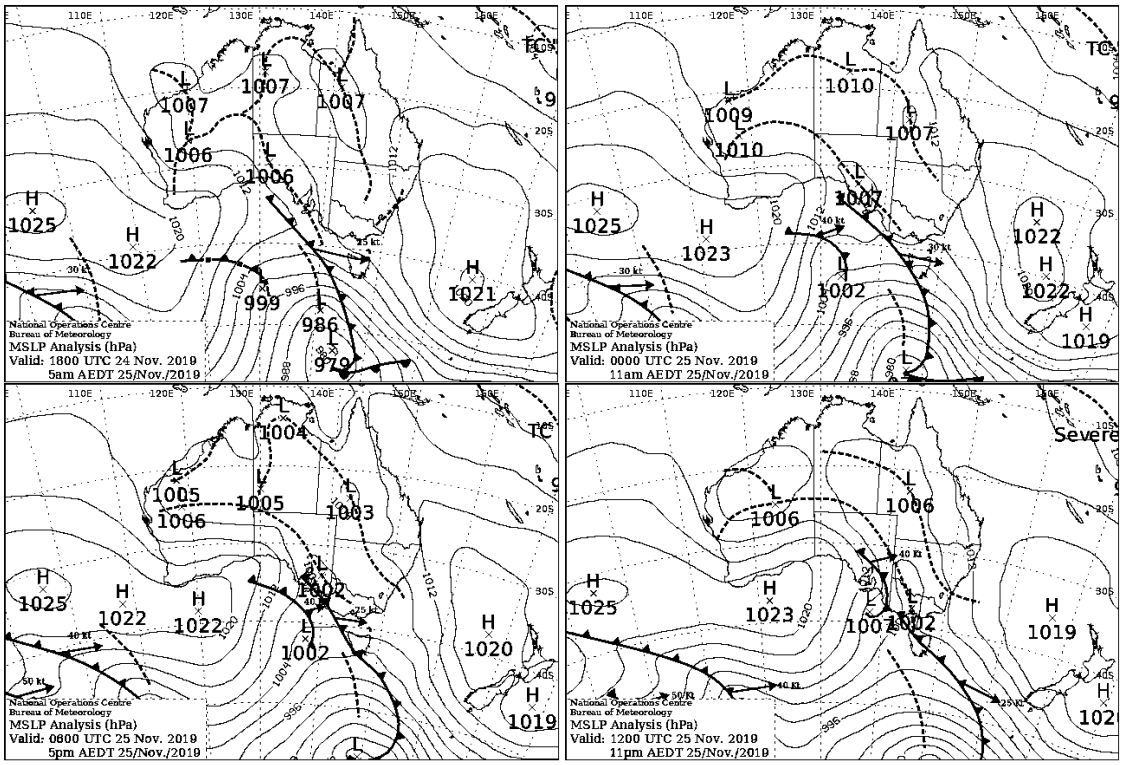


FIGURE 27: SYNOPTIC CHARTS 0500HRS TO 2300HRS 25TH OF NOVEMBER 2019

Figure 28 and Figure 29 show the weather for the 21st and 25th of November for Mt Nowa Nowa. This site is located 13km east of the ignition.

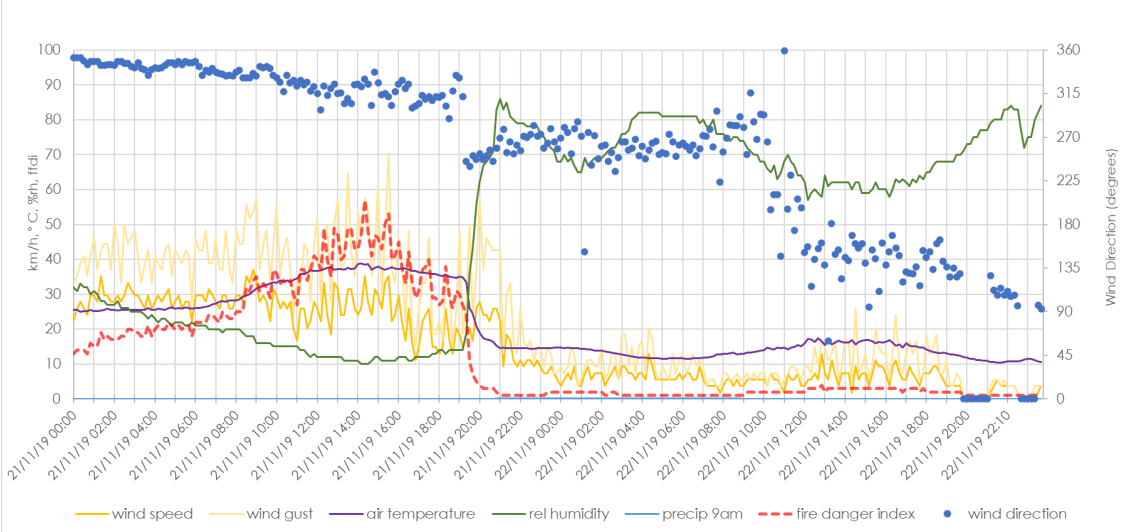


FIGURE 28: MT NOWA NOWA AWS READINGS FOR THE 21ST AND 22ND OF NOVEMBER 2019

The 21st of November was the first spike day of the season and the FFDI reached 57. Dry lightning arrived with the front and a strike close to the ignition site was recorded on the lightning tracker at 2025hrs. The FFDIs were low on the 22nd and by 1400hrs a mild easterly wind had begun. Records show that on the 21st the KBDI was 34.7 with drought factor of 7.1. The KBDI appears to have underpredicted the fuel dryness. The KBDI had reached zero due to several heavy rainfall events over winter, but this did not mean that the soils were saturated. The years of drought

meant this rainfall either ran off or was absorbed, however the upper layers of soil remained in moisture deficit (pers comm Greg McCarthy).

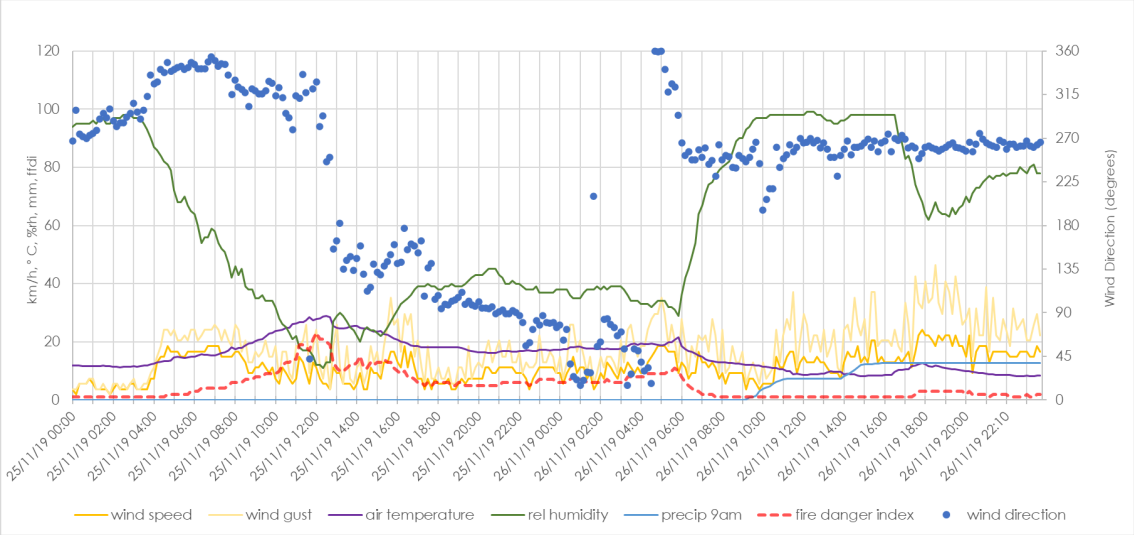


FIGURE 29: MT NOWA NOWA AWS READINGS FOR THE 25TH AND 26TH OF NOVEMBER 2019

On the 25th of November a hot dry north westerly drove up temperatures and reduced the humidity resulting in a peak FFDI of 23. The wind swung south-easterly just before 1300hrs as a sea breeze developed. After 1700hrs a southerly arrived. Initially the humidity rose with the arrival of the sea breeze but fell again until after 1700hrs. By 0600hrs on the 26th of November, the humidity began to rise steadily, and the winds turned strongly to the west. Rain started at 1000hrs and 12.6mm was recorded.

Fire Progression

The Tambo 31 - Bruthen – Six Mile fire started from a lightning strike on the 21st of November 2019. It was first reported at 0855hrs on the 22nd of November and grew quickly to 100 hectares with an uphill run (Figure 30A).

On the 25th of November, the fire made a major run to the northwest, spotting ahead of itself (Figure 30B). This was followed by a run to the northeast. Direct attack was not possible. The fire size was estimated to be 1750 hectares by 1350hrs. By midafternoon, the fire had spotted west of the Tambo River and was threatening private assets north of Bruthen. Figure 31and Figure 32 show the impact of the sea breeze which was later followed by a frontal wind change. By 2055hrs the fire had crossed west of the Great Alpine Road, closing the road and isolating communities above the fire. By 0600hrs on the 26th of November, the relative humidity rapidly rose, and rain arrived with 12.6mm being recorded at Mt Nowa Nowa. When the cloud cleared a line scan showed the fire had grown to 8540 hectares. This can be seen in Figure 35.

Consolidation of boundaries continued into December. Milder conditions allowed backburning operations and tracking of the fire edge. Occasional rain and showers slowed operations but also lessened fire behaviour. Figure 36 shows the fire suppression efforts from the 27th of November until the 6th of December 2019. The 2019 planned burn to the south provided an excellent fire break and assisted with the fire control. This has been documented in a local case study (pers. Comm. Brad Fisher)

FIGURE 30: (A) 22ND NOVEMBER 2019 1425HRS (AIR OBSERVER) (B) 25TH NOVEMBER 2019 (EMV FACEBOOK) ~1300HRS

FIGURE 31: LOOKING EAST TOWARD THE FIRE - PRE-FRONTAL CLOUD, LOW LEVEL INVERSION, CONVECTION COLUMN AND SEABREEZE AT 1414HRS - FROM WISELEIGH (BRAD FISHER)

FIGURE 32: SEABREEZE IMPACTING ON THE FIRE AT 1424HRS - FROM WISELEIGH OVER THE TAMBO FLATS AND BRUTHEN (BRAD FISHER)

The exact weather conditions that occurred on the afternoon and evening of the 25th of November have been identified for further study by meteorologists.

FIGURE 33: BACKBURNING ALONG KENNY RD NEAR THE CORNER OF IRONBARK ROAD 2000HRS 28TH NOVEMBER 2019

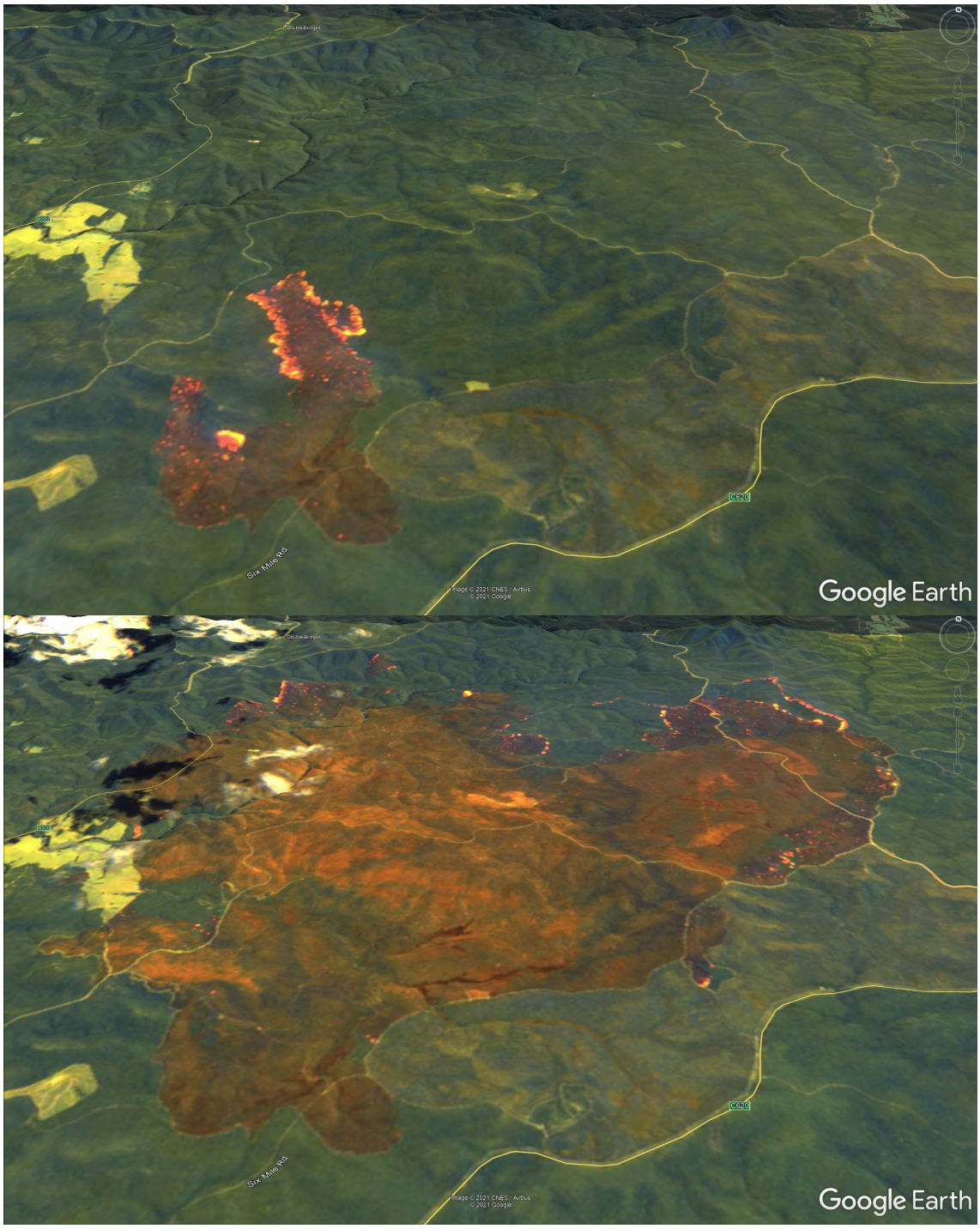


FIGURE 34: SENTINEL 2 NIR SWIR IMAGES FROM THE 24TH AND 29TH OF NOVEMBER OVERLAID ON GOOGLER EARTH.

Figure 34 provides a three-dimensional representation of the fire spread, topography, suppression (backburning and direct attack) and the location of the previous fuel reduced area.

Fire progression maps can be seen in Figure 35 to Figure 37. The final burning out of areas within the perimeter can be seen in Figure 37. The fire was declared contained on the 19th of December with an area of 10,307ha. On the morning of the 21st of December, it was impacted by the Tambo 31 Barmouth Spur - Marthavale fire which led to the merging

of these two fires with the Ensay Ferntree fire. These all went on to become the Tambo Complex.

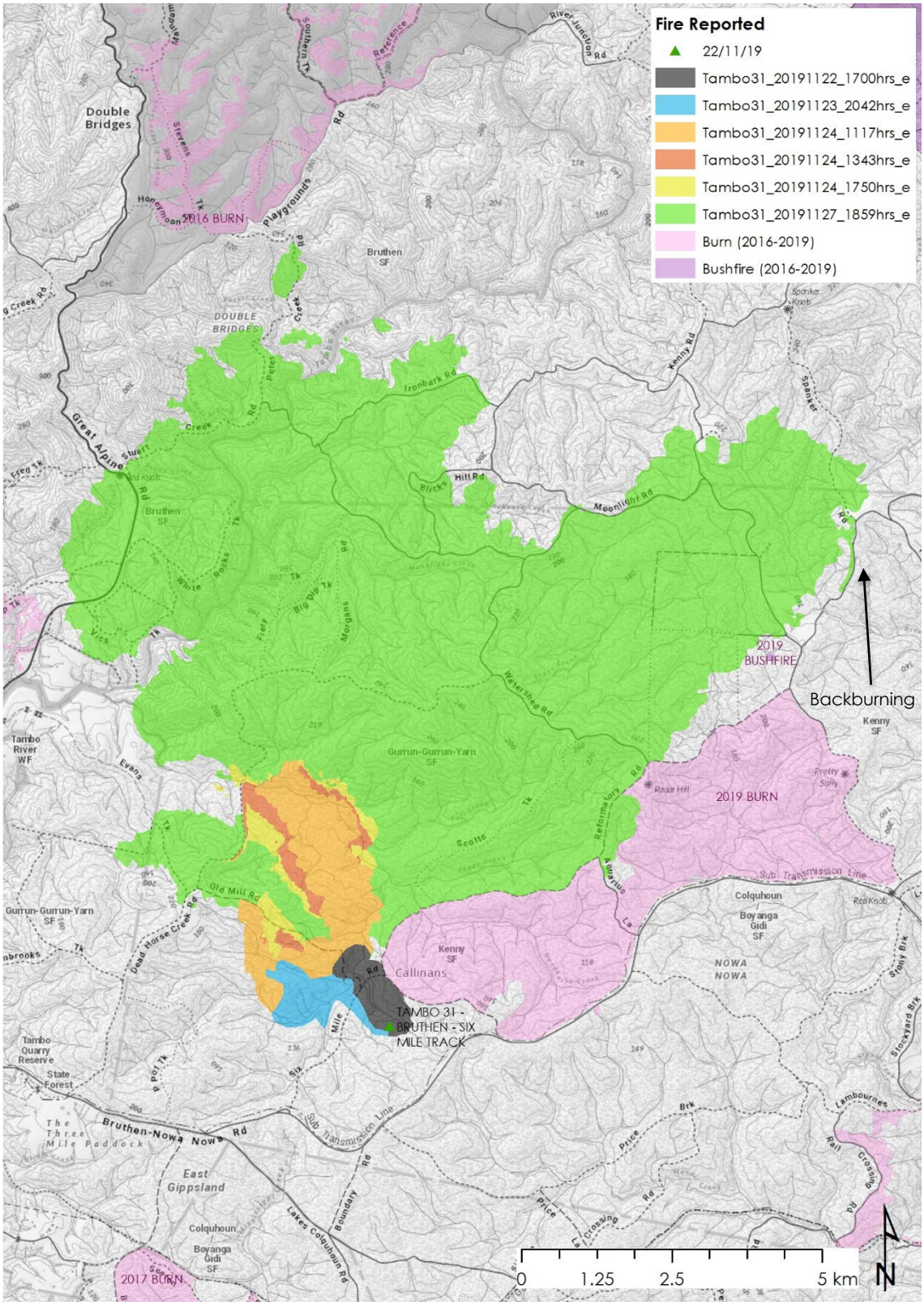


FIGURE 35: FIRE PROGRESSION BRUTHEN – SIX MILE BUSHFIRE 22ND NOVEMBER TO 27TH NOVEMBER 2019 (MAJOR RUN TO NNW OCCURRED ON 25TH BUT WAS NOT SCANNED UNTIL 27TH)

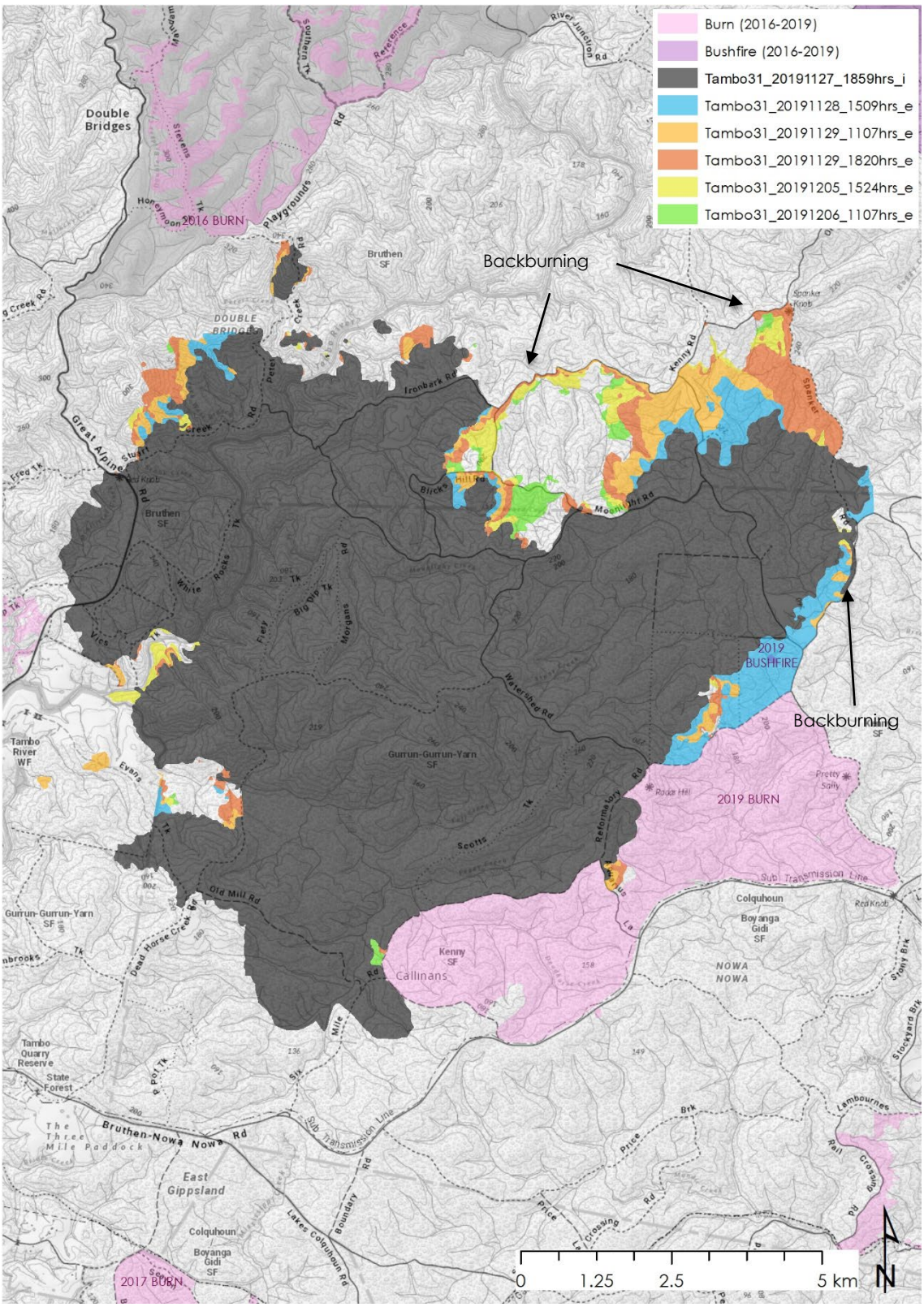


FIGURE 36: FIRE PROGRESSION BRUTHEN – SIX MILE BUSHFIRE 27TH NOVEMBER TO 6TH OF DECEMBER 2019

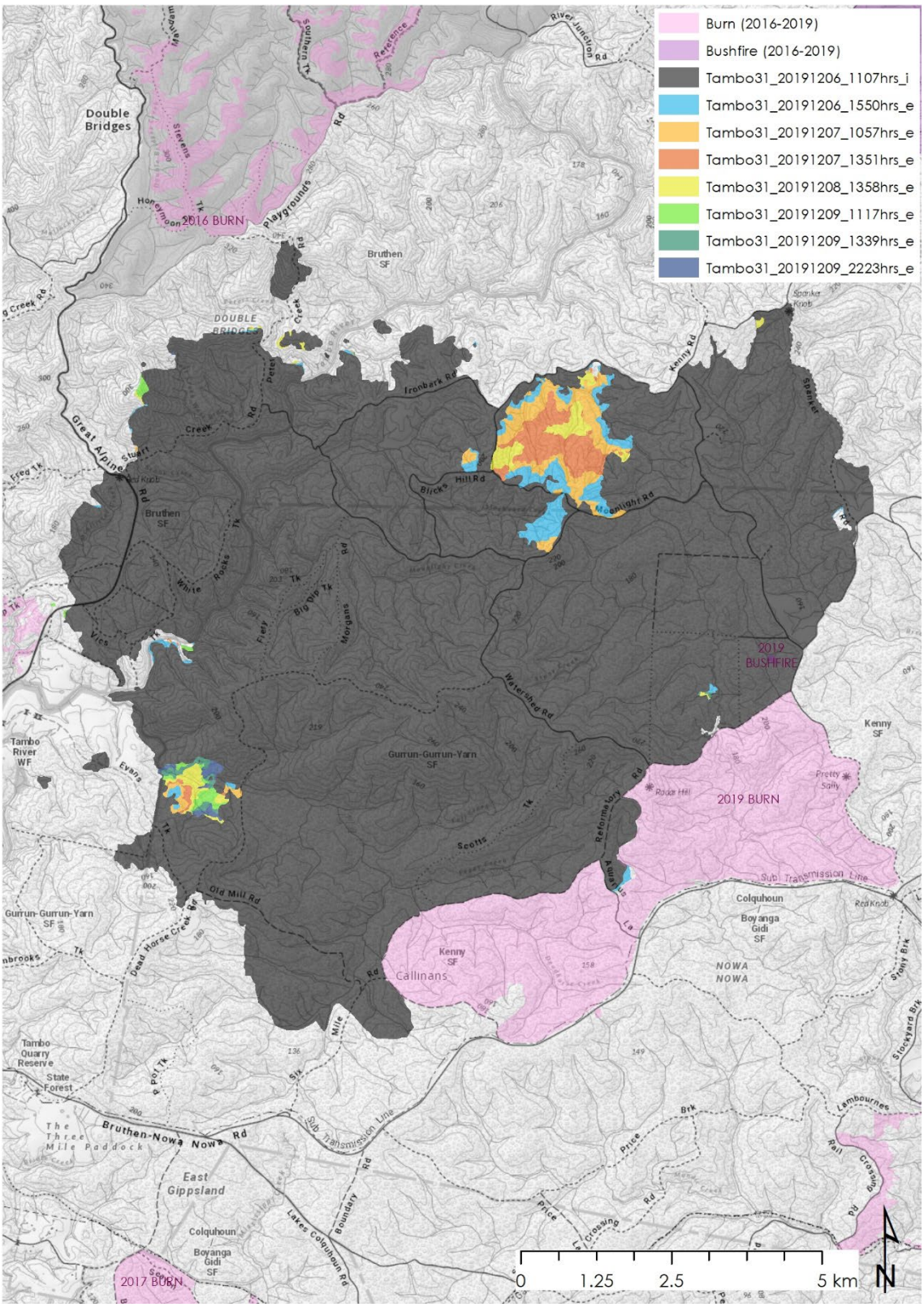


FIGURE 37: FIRE PROGRESSION BRUTHEN – SIX MILE BUSHFIRE 6TH DECEMBER TO 9TH OF DECEMBER 2019

TAMBO 35 – BARMOUTH SPUR – MARTHAVALE: 22ND NOVEMBER TO 30TH DECEMBER 2019

Initial Fire Progression

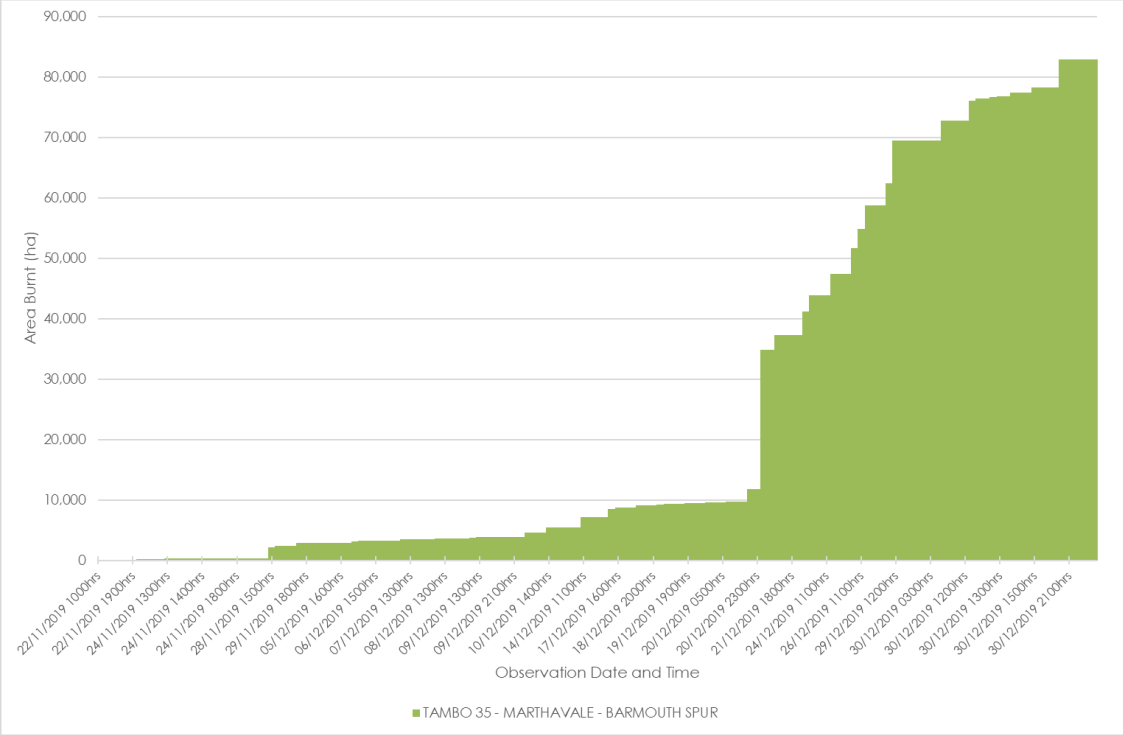


FIGURE 38: FIRE GROWTH BY OBSERVATION DATE AND TIME

The Barmouth Spur - Marthavale fire was first reported at 1035hrs on the 22nd of November 2019. By the end of the day the fire was 74 hectares in size. On the morning of the 23rd of November crews arrived on site, experienced difficult terrain, and active fire behaviour. By 2000hrs direct attack had failed and the fire had increased to 230ha.

The fire expanded significantly on the 25th of November with crown fires and spotting. An ongoing battle continued into December with increasing dryness. High fuel moisture in drainage lines that had stopped early runs of the fire now failed and the fire reignited and spread further. Figure 40 and Figure 41 show the initial stages of the fire. Early on gullies stopped the run of fire, backburning was used where practicable, and blocking fire was used on ridgetops to limit spread. Air attack focused on support for ground crews and limiting spread.

At 1554hrs on the 9th of December the fire jumped control lines to the northwest and ran uphill with 5-6 metre flame heights. By 1826hrs the fire had grown to 4050ha. The fire spotted north of Engineers Road backing down into very steep country. Suppression was difficult but the edge was eventually contained (see Figure 42 and Figure 43).

FIGURE 39: BARMOUTH SPUR – MARTHAVALE FIRE 1707HRS 23RD OF NOVEMBER (MIKE IRVINE)

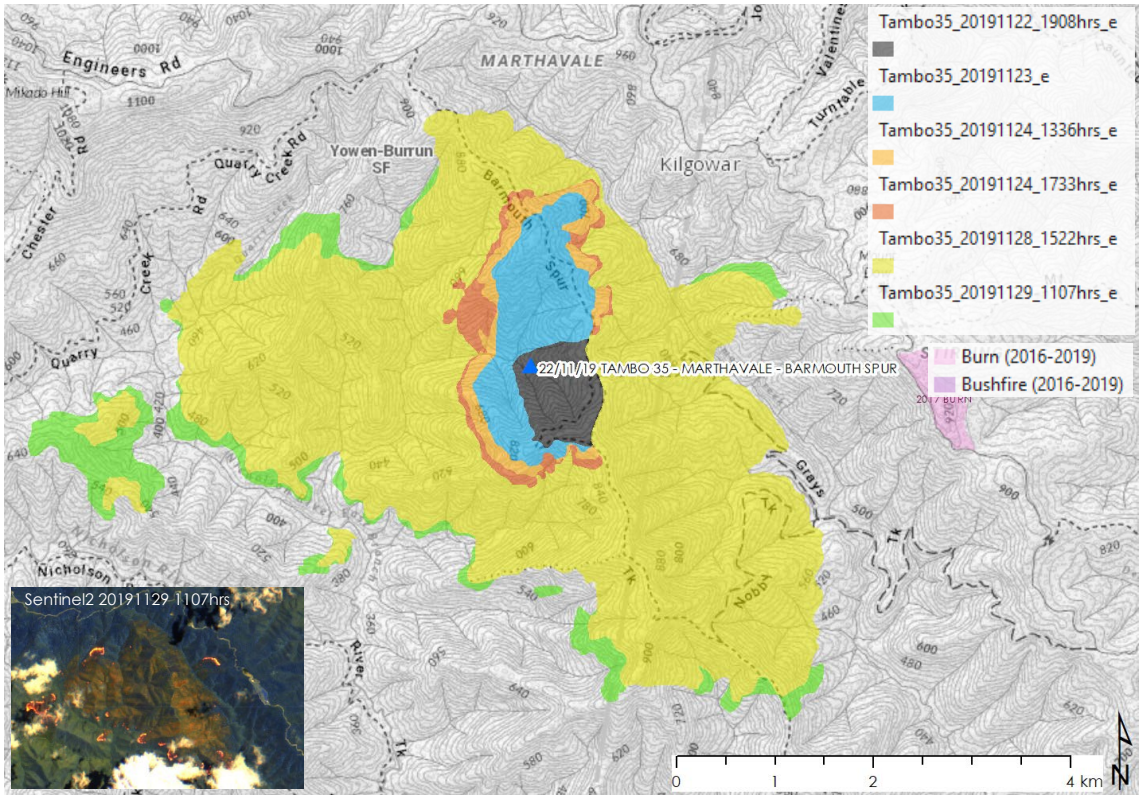


FIGURE 40: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 22ND NOVEMBER TO 29TH OF NOVEMBER 2019

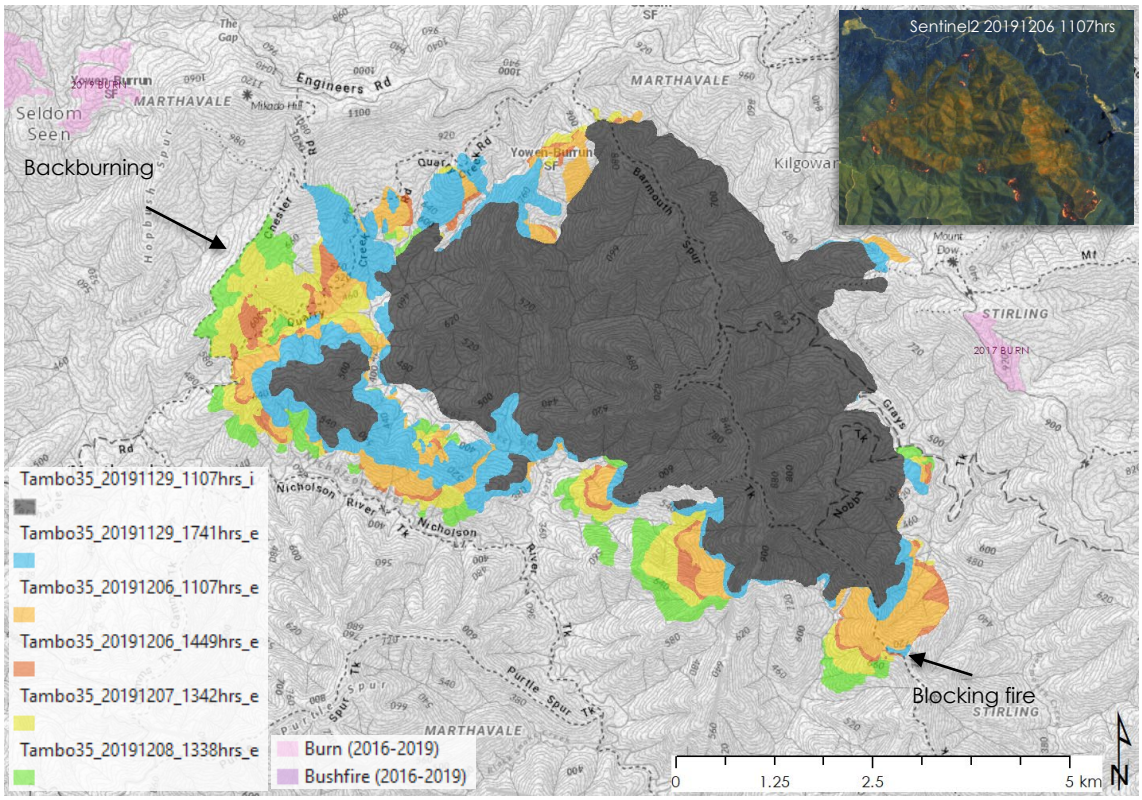


FIGURE 41: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 29TH OF NOVEMBER TO 8TH OF DECEMBER 2019

On the 11th of December backburning commenced on existing roads and some purpose-built breaks. Backburning was completed on the 14th of December and the area was burnt out by the 18th. This can be seen in Figure 42 and Figure 44. Also, on the 18th of December a section of the fire in the headwaters of Barmouth Creek reignited and spotted across Engineers Rd to the north of the fire (see Figure 45). The breakout continued to expand, despite air and ground resources. This was the source of the major run on the night of the 20th into the 21st of December.

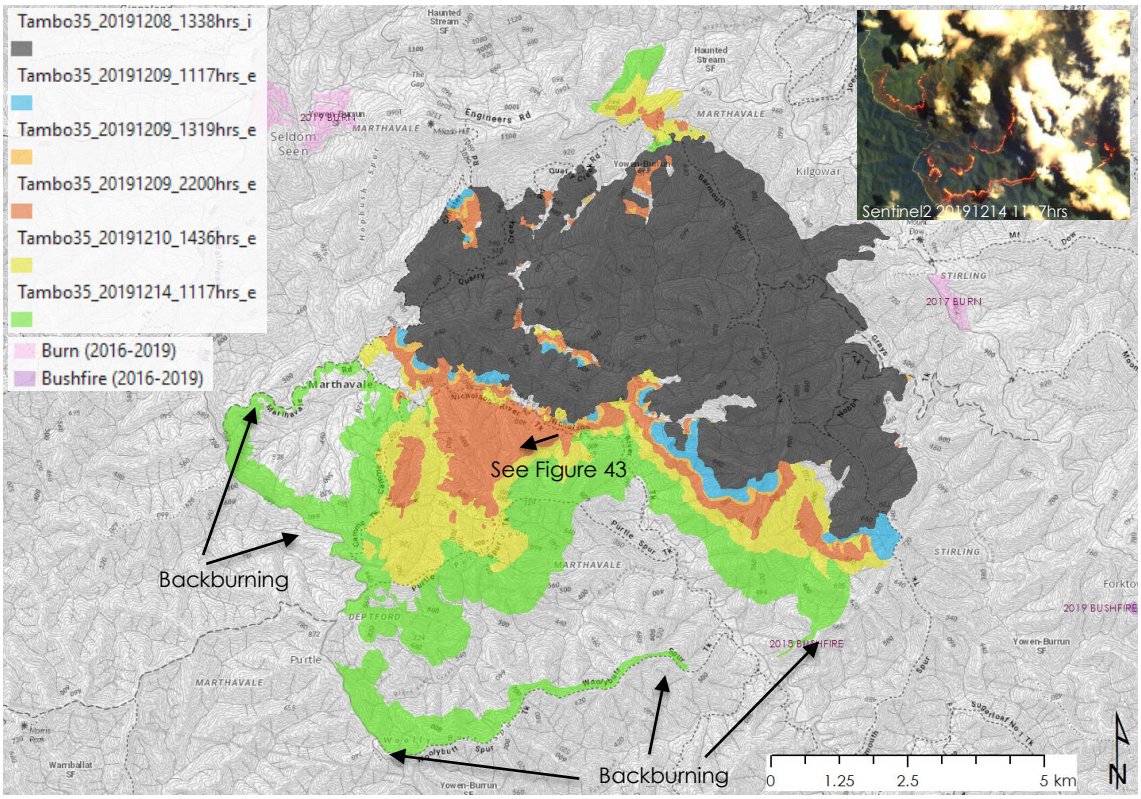


FIGURE 42: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 8TH OF DECEMBER TO 14TH OF DECEMBER 2019

FIGURE 43: BARMOUTH SPUR – MARTHAVALE BUSHFIRE 1647HRS 9TH OF DECEMBER 2019 (SEE ARROW IN FIGURE 42)

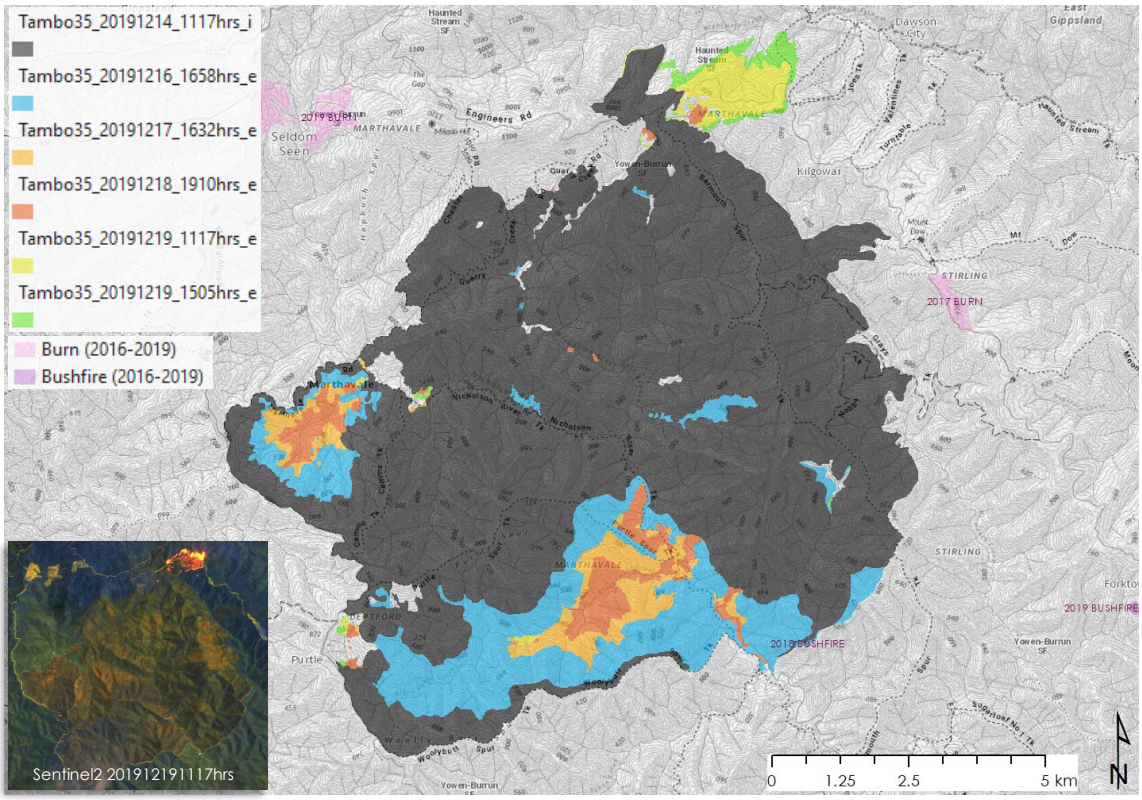


FIGURE 44: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 14TH OF DECEMBER TO 19TH OF DECEMBER 2019

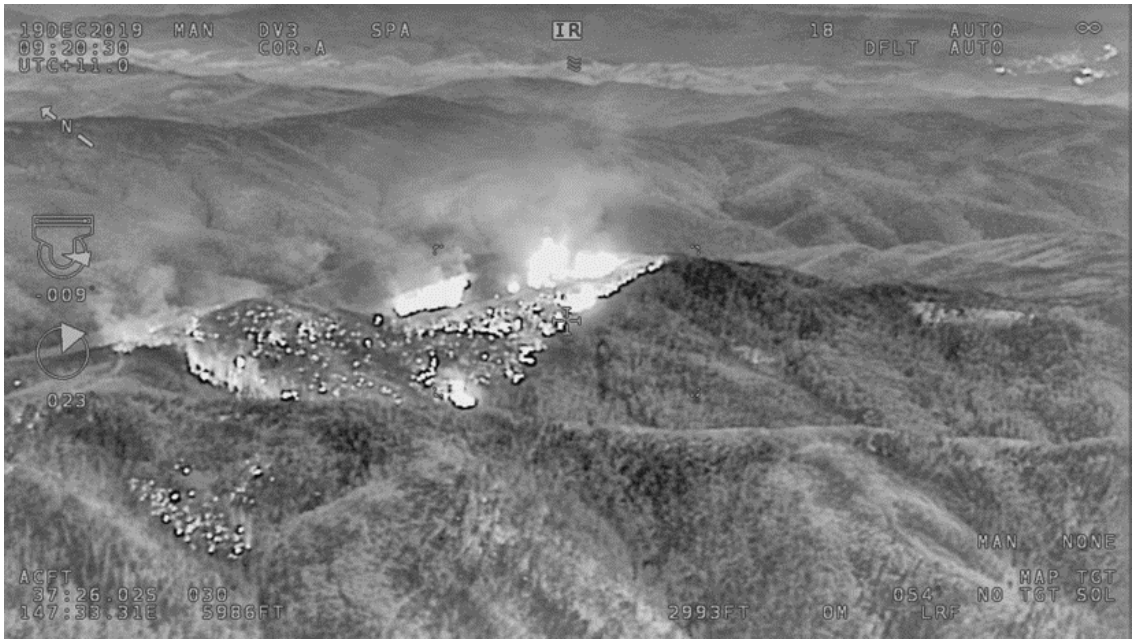


FIGURE 45: AIG IMAGE SHOWING THE EXPANSION OF THE FIRE NORTH OF BARMOUTH CREEK 0920HRS 19TH OF DECEMBER 2019 – LOOKING NORTHWEST TOWARD ENSAY AND REEDY CREEK

Fire Progression 20th to 29th of December 2019

A major fire run of around 35km occurred on the afternoon and evening of the 20th and early morning of the 21st of December 2019. A preliminary investigation is included in the next section. Following this breakout significant backburning and burning out was undertaken, however conditions on the 30th of December caused further breakouts and significant impacts.

Weather for the 20th and 21st of December 2019

Figure 46 shows the lead up to the breakout. The high centred to the southwest of the fire pushed southerly and easterly winds over the fire ground before moving east and causing hot and dry northerly winds

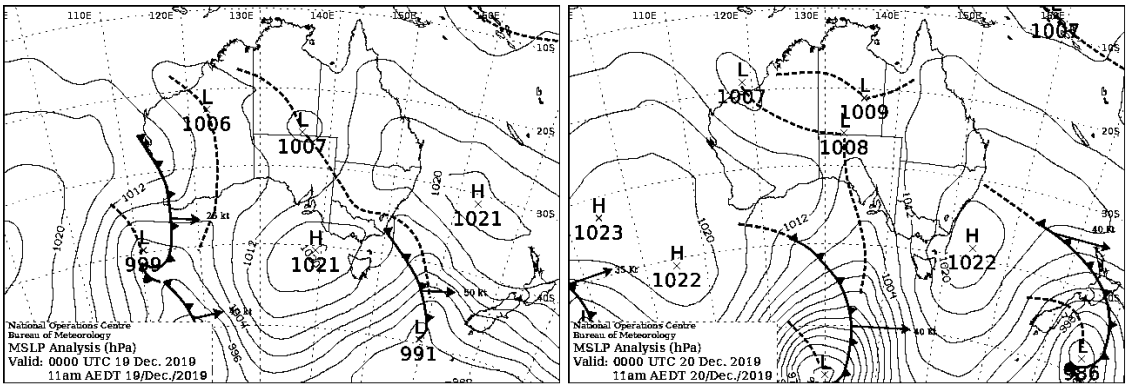


FIGURE 46: SYNOPTIC PATTERN IN THE LEADUP TO THE FIRE RUN 1100HRS 19TH AND 20TH DECEMBER.

Figure 47 shows the synoptic pattern from 1700hrs on the 20th to 1100hrs on the 21st of December. The hot dry northerlies remained overnight prior to a prefrontal trough arriving at around 0500hrs before the winds shifted WSW.

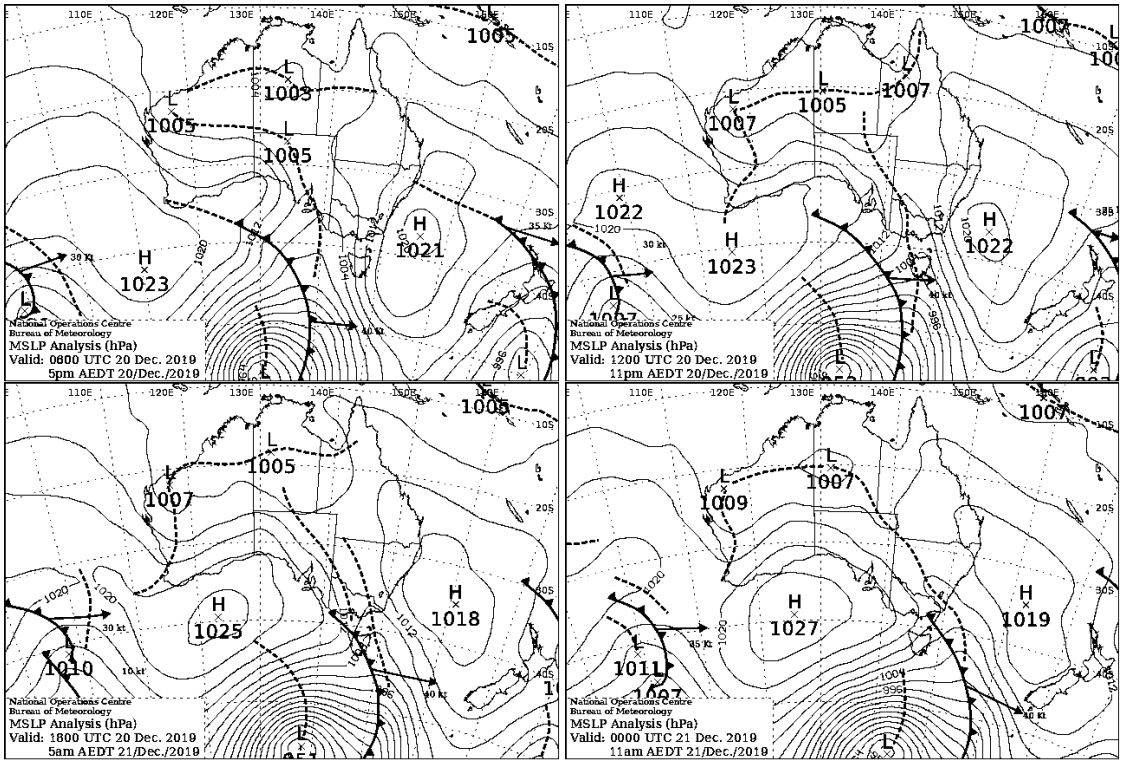


FIGURE 47: SYNOPTIC CHARTS 1700HRS 20TH DECEMBER 2019 TO 1100HRS 21ST OF DECEMBER

There was no weather station in proximity and at a similar elevation to where the breakout occurred. The fire began its run in a very exposed location above 900m elevation. Figure 48, Figure 49 and Figure 50 show 48 hours of data commencing from 0900hrs on the 19th of December for PAWS D (Doctors Flat), Mt Nowa Nowa, and PAWS J (Splitters Range). The red arrow shows the time the run was most active.

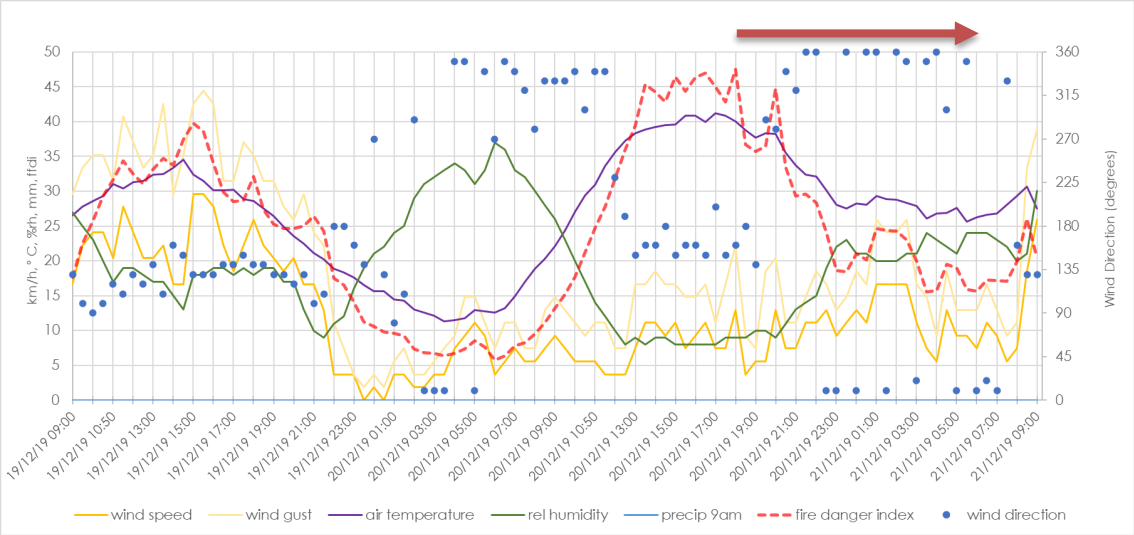


FIGURE 48: PAWS D DATA (286M ELEVATION) FOR 0900HRS ON THE 19TH TO 21ST OF DECEMBER 2019

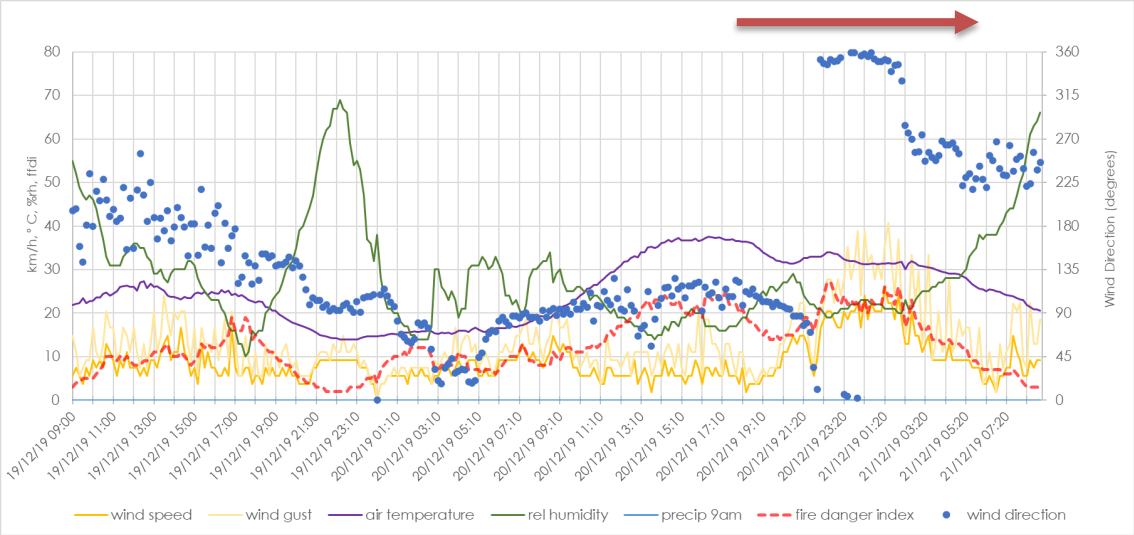


FIGURE 49: MT NOWA NOWA AWS DATA FOR 0900HRS ON THE 19TH TO 21ST OF DECEMBER 2019

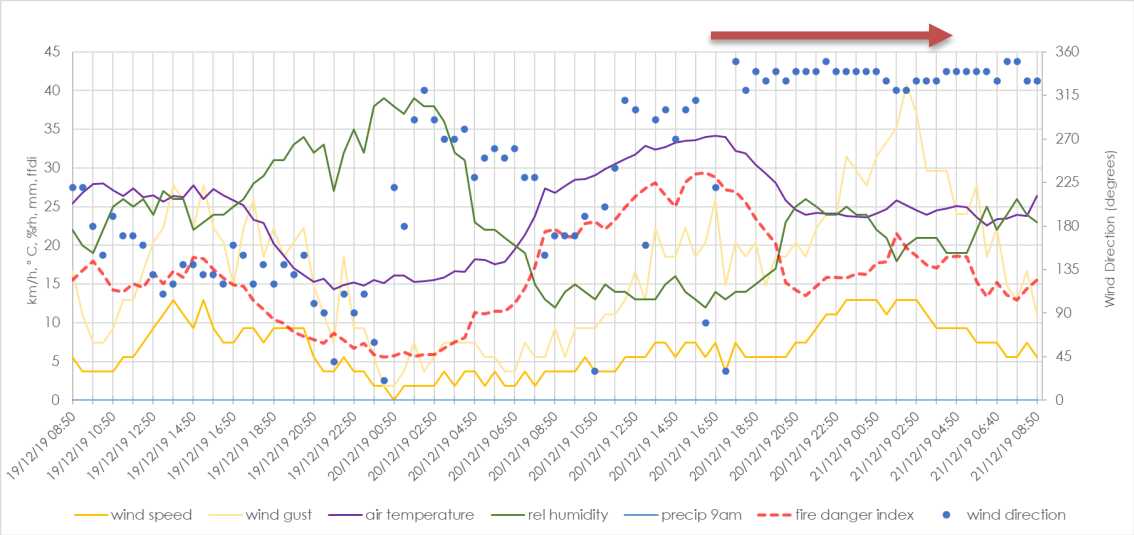


FIGURE 50: PAWS J (1280M ELEVATION) DATA FOR 0900HRS ON THE 19TH TO 21ST OF DECEMBER 2019

Further study of the weather is required; however, it is possible to infer that at low elevations a sea breeze (PAWS D and Mt Nowa Nowa) was

present and that upper levels the north-westerlies persisted and mixed down overnight. These winds had sustained gusts of 30-40km/h before and during the change which arrived at Mt Nowa Nowa at 0320hrs. This wind change is consistent with the sections of the fire below Dogtown and Tambo Crossing where many spot fires occurred with the change.

Fire run for the 20th and 21st of December 2019

Figure 51 shows the fire progression from 1505hrs on the 19th to 1029hrs on the 21st of December 2019.

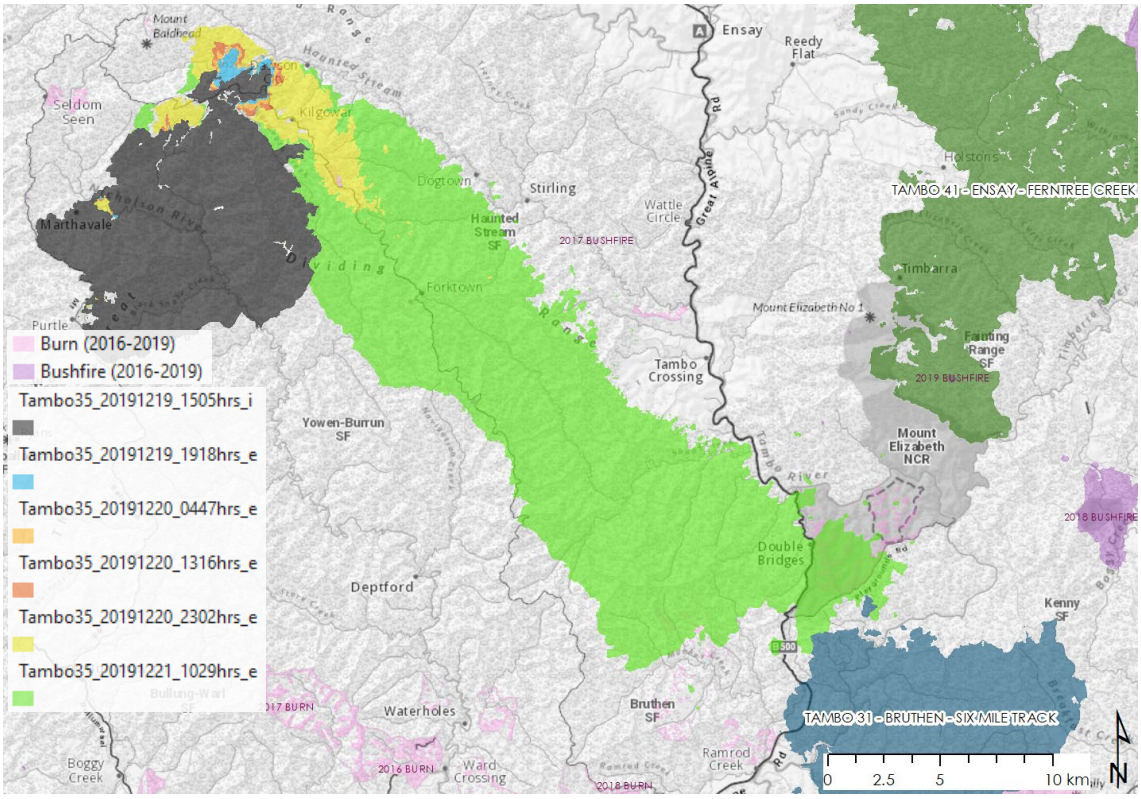


FIGURE 51: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 19TH OF DECEMBER TO 21ST OF DECEMBER 2019

Figure 52 and Figure 53 show a 3d representation of the initial breakout.

FIGURE 52: LINE SCAN AT 1316 HRS 20TH OF DECEMBER 2019

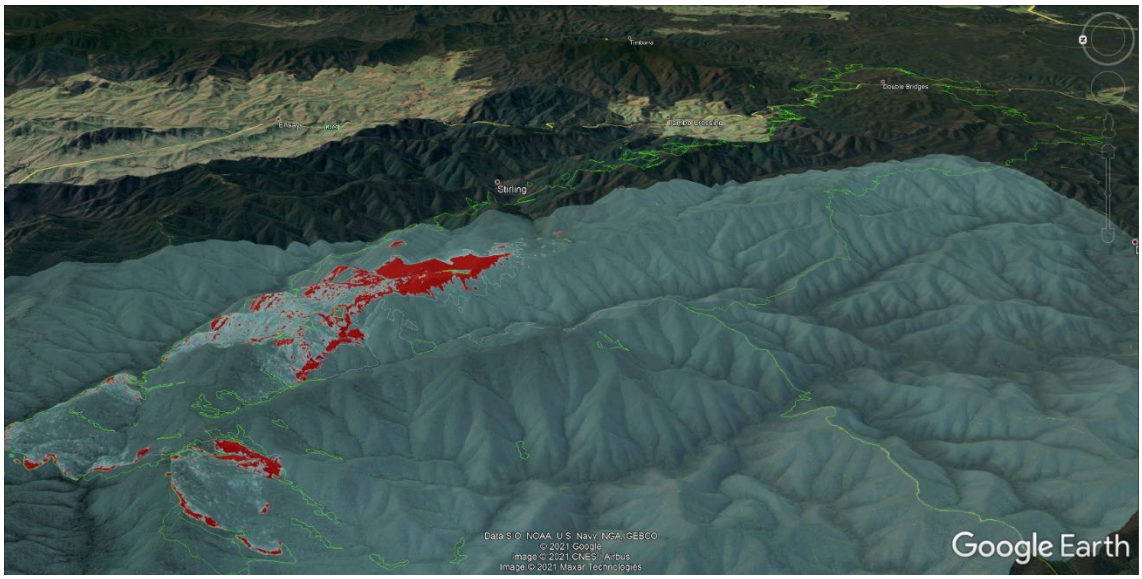


FIGURE 53: LINE SCAN AT 2237HRS 20TH DECEMBER 2019.

The green line is the boundary after the fire run toward Double Bridges (1016hr 21st of December). The 1316hrs line scan shows the fire is beginning to become active, however it did not fully breakout until around 1700hrs. Air attack may have limited the spread. The fire then progressed quickly and by 2237hrs had travelled 7km with spot fires a further 2km ahead.

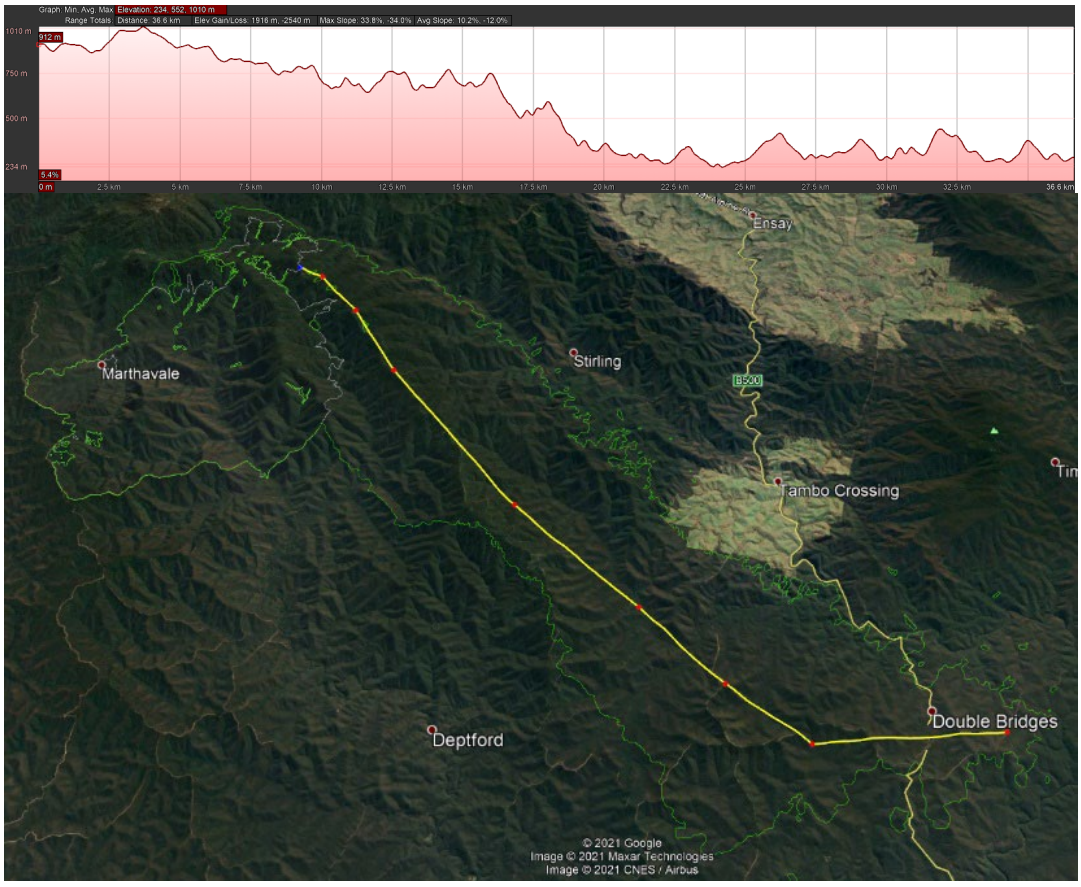


FIGURE 54: ELEVATION PROFILE FOR THE FIRE RUN OF THE 20TH INTO THE 21ST OF DECEMBER 2019

The elevation profile and fire path are shown in Figure 54. The fire started at 912m, then rose to the highest point at 1010m, and the lowest 234m. The length of the run was 33-36km. The topography was ideal for medium and long-distance spotting. The weather at PAWS J provides a good insight to the warm dry and windy conditions at high elevations.

The southwest wind change arrived on the fireground at around 0250-0320hrs. At this point the fires had already run 33km. The change drove fire to the northeast until 0600hrs with activity abating but still some activity observable at 0800hrs.

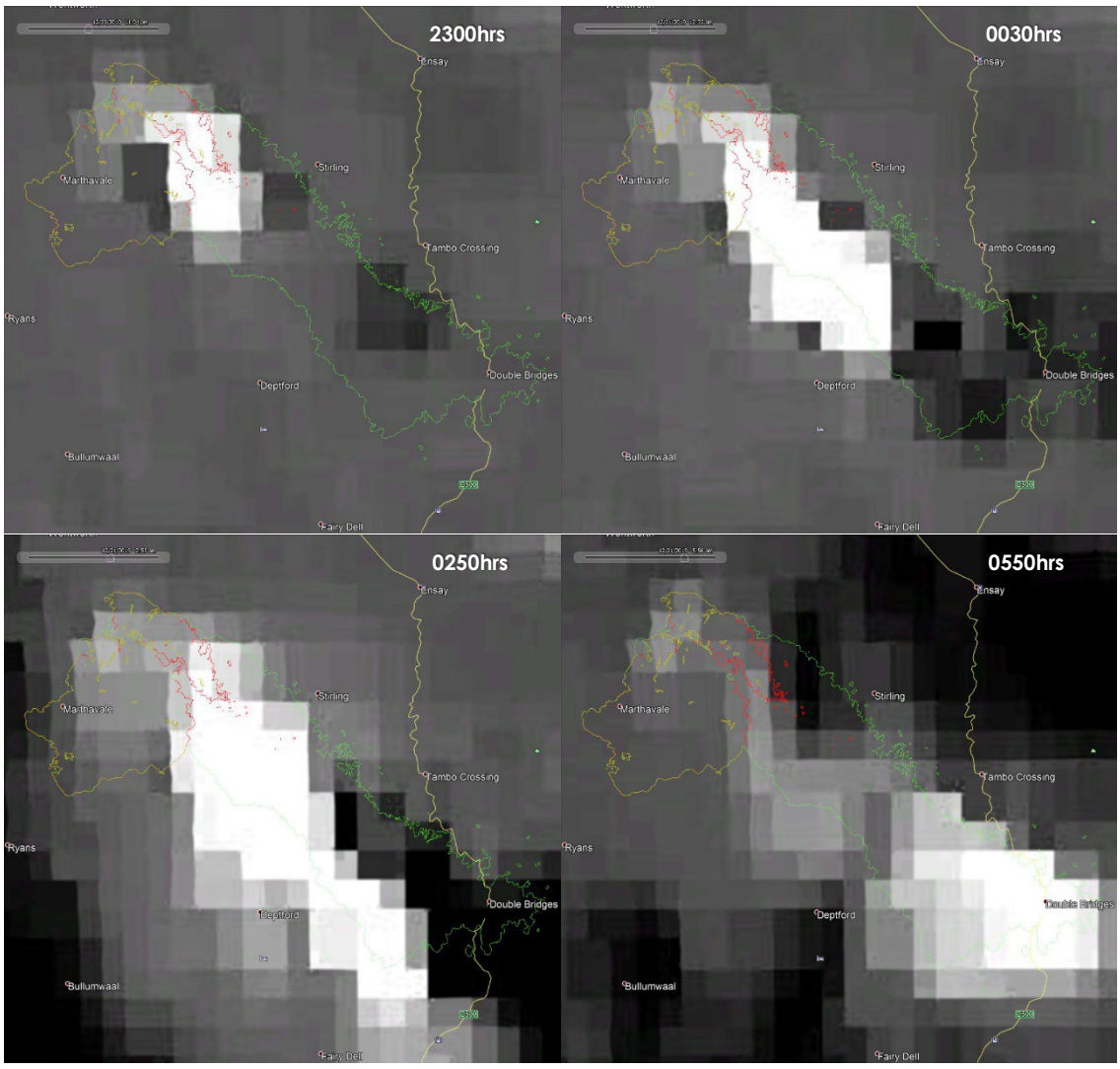


FIGURE 55: HIMAWARI SWIR SEQUENCE SHOWING FIRE POSITION AT 2300, 0030, 0250 AND 0550HRS

The sequence in Figure 55 is taken from a 3d Google Earth Himawari animation with 10-minute time steps prepared for this fire run. While there are some offset effects created by heat from the column it is possible to see when the fire was most active, the forward progress, the arrival of the wind change, and the density and direction of the convection column.

Further work could investigate this fire run. An untapped resource for this and many of the fires is the BOM Bairnsdale radar.

Fire Progression 21st December to 30th of December 2019

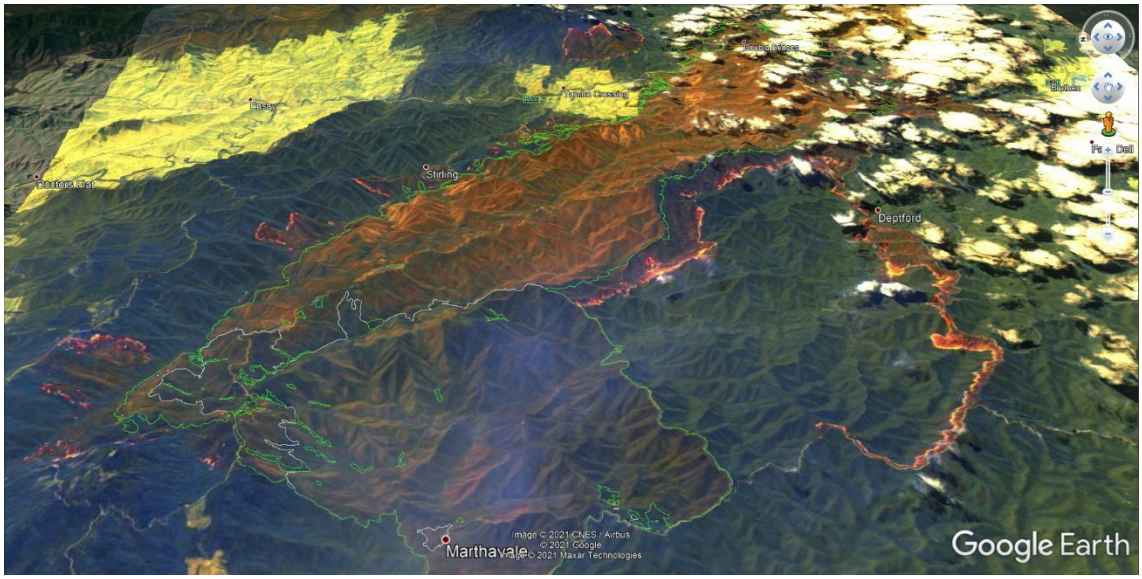


FIGURE 56: LOOKING EAST - 3D OVERLAY OF 24TH 1117HRS NOVEMBER SENTINEL 2 SWIR NIR COMPOSITE (SOURCE: EO BROWSER/GOOGLE EARTH)

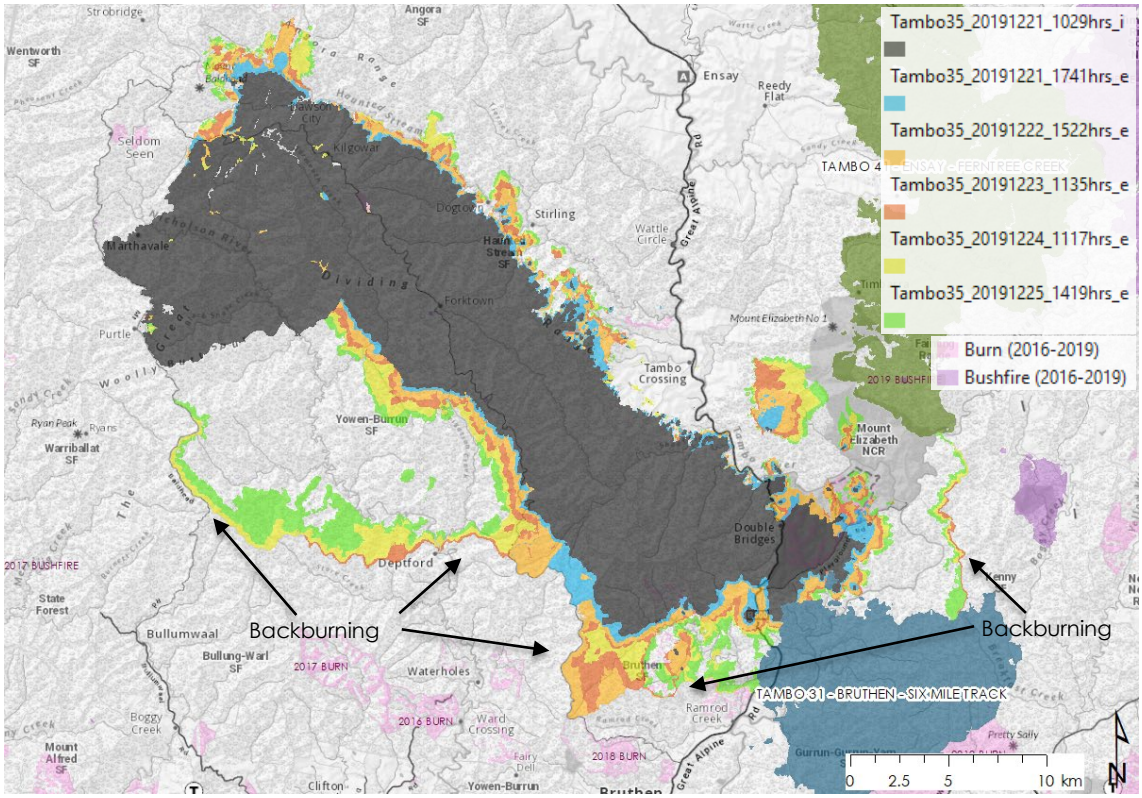


FIGURE 57: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 21ST OF DECEMBER TO 25TH OF DECEMBER 2019

From the 21st to 30th of December, large backburns were implemented. The first was from Woolybutt Spur via Deptford and Ramrod Creek to the Great Alpine Road and the Bruthen - Six Mile bushfire. The second was from the Bruthen - Six Mile bushfire to the Ensay - Ferntree bushfire via Kenny Road. Figure 57 to Figure 59 show the progression of the backburn and areas around the Angora Range, Haunted Stream and Mt Elizabeth continuing to expand. In this phase, the fire grew from 35,000 to 83,000 hectares.

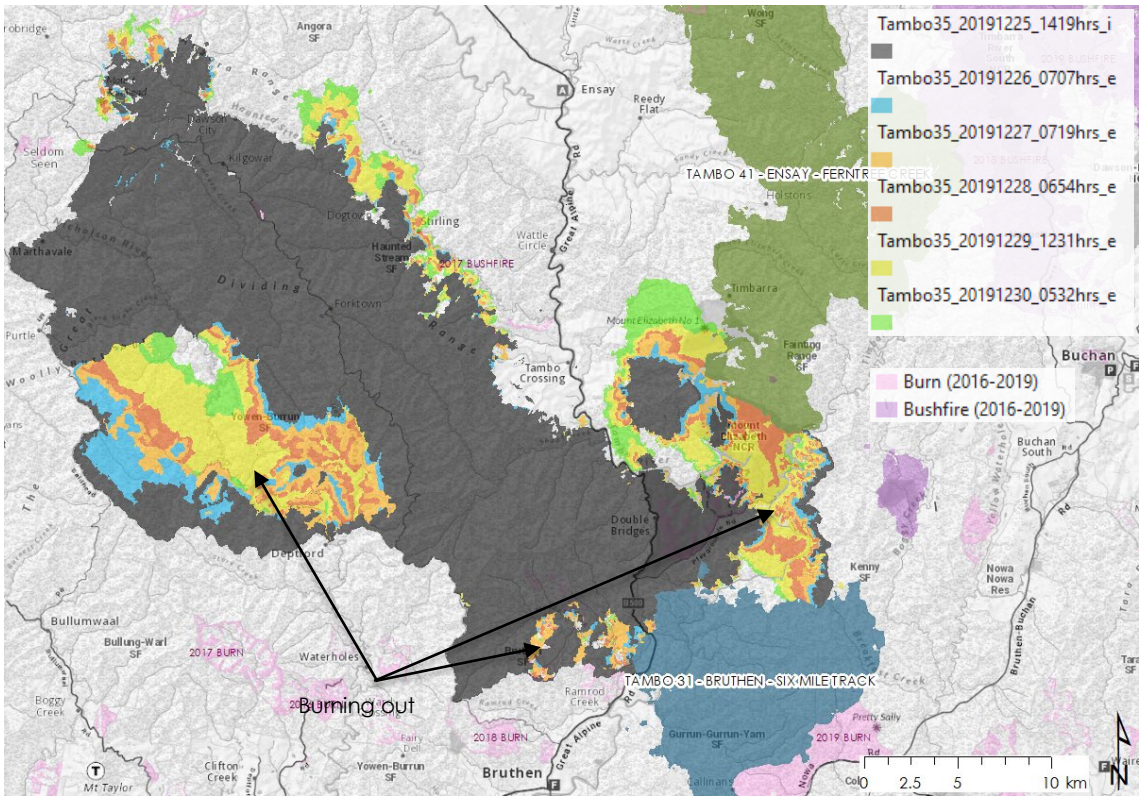


FIGURE 58: FIRE PROGRESSION BARMOUTH SPUR – MARTHAVALE BUSHFIRE 25TH OF DECEMBER TO 30TH DECEMBER 2019

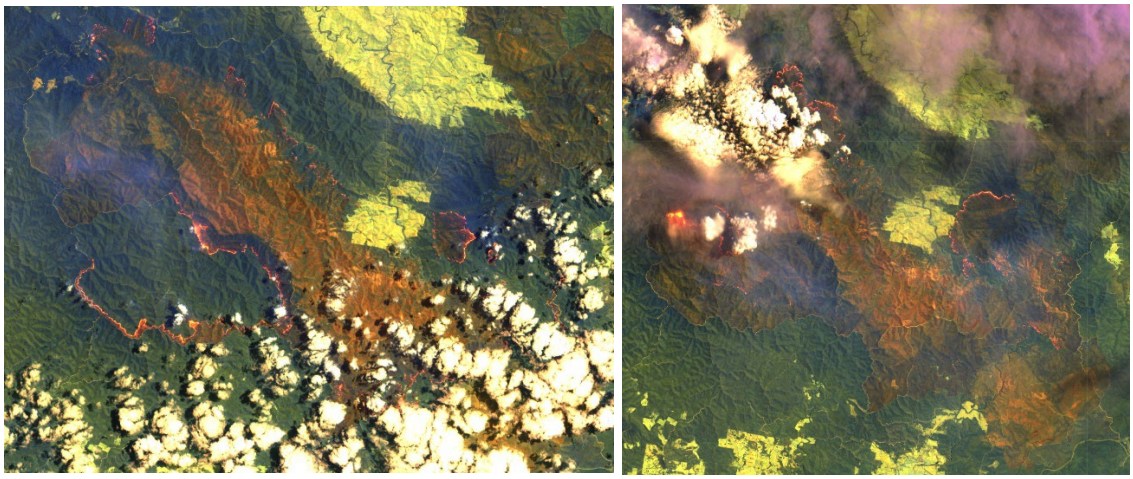


FIGURE 59: SENTINEL 2 NIR/SWIR COMPOSITE 1117HRS ON THE 24TH OF DECEMBER AND AT 1107HRS ON THE 29TH OF DECEMBER

Despite all the backburning and consolidation, major fire runs occurred on the 30th of December and many of these are detailed in *Tambo 35: Tambo Complex - 30th and 31st of December 2019* on page 125

TAMBO 39 – W TREE – YALMY: 22ND NOVEMBER TO 30TH DECEMBER 2019

This section of the report examines the W Tree Yalmy fire from the first report on the 22nd of November, through the continued expansion despite suppression efforts until the 30th of December. An initial investigation into the blow-up day on the 25th of November has been included in this section. Figure 60 shows this rapid growth on the 25th followed by a slow but steady increase.

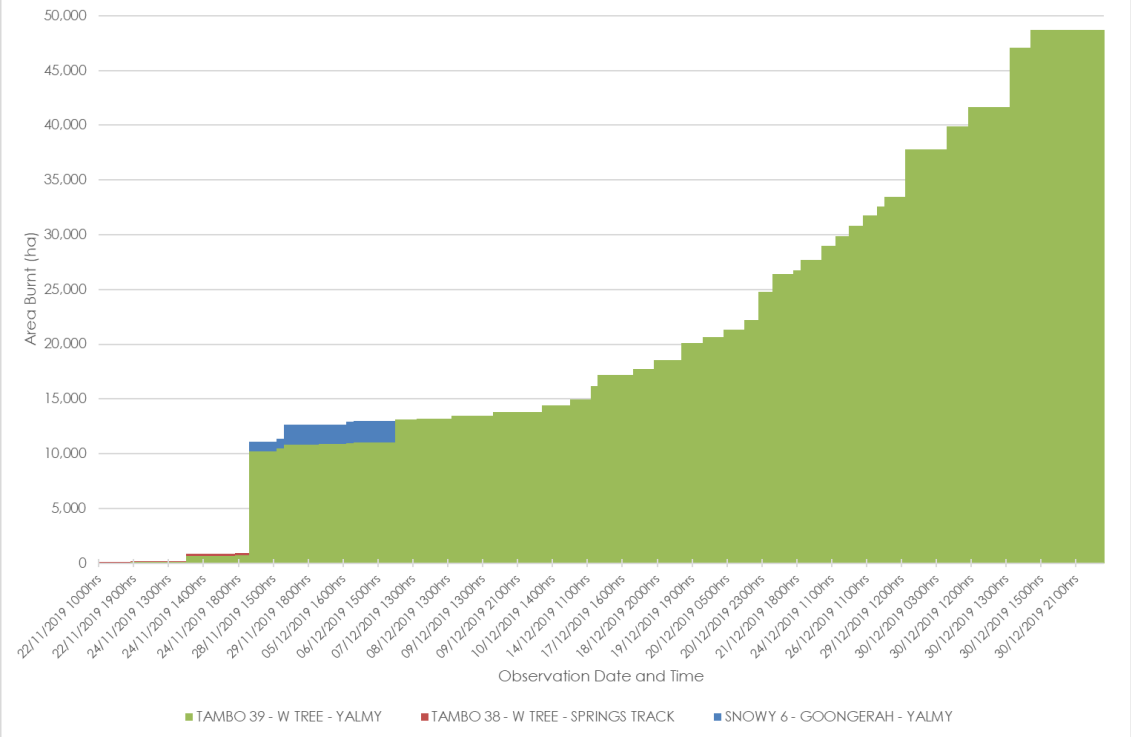


FIGURE 60: GROWTH OF THE W TREE – YALMY FIRE

Initial Weather

The weather details for the initial ignition on the 21st and the blow-up day on the 25th of November 2019 are examined. The following sections contain a preliminary study. A more detailed study by meteorologists is recommended.

Weather for the 21st and 22nd of November 2019

The broad synoptic pattern has been described on page 32. Figure 61 shows data for the Gelantipy AWS. Winds at this site appear more northerly than at coastal areas with the change arriving at 2130hrs on the 21st of November. The temperature peaked at 34.5 °C and was above 30°C for 10 hours. Conditions on the 22nd of November were much milder. Records show the calculated KBDI for this site was 13 which again does not appear to reflect the true condition of the fuels.

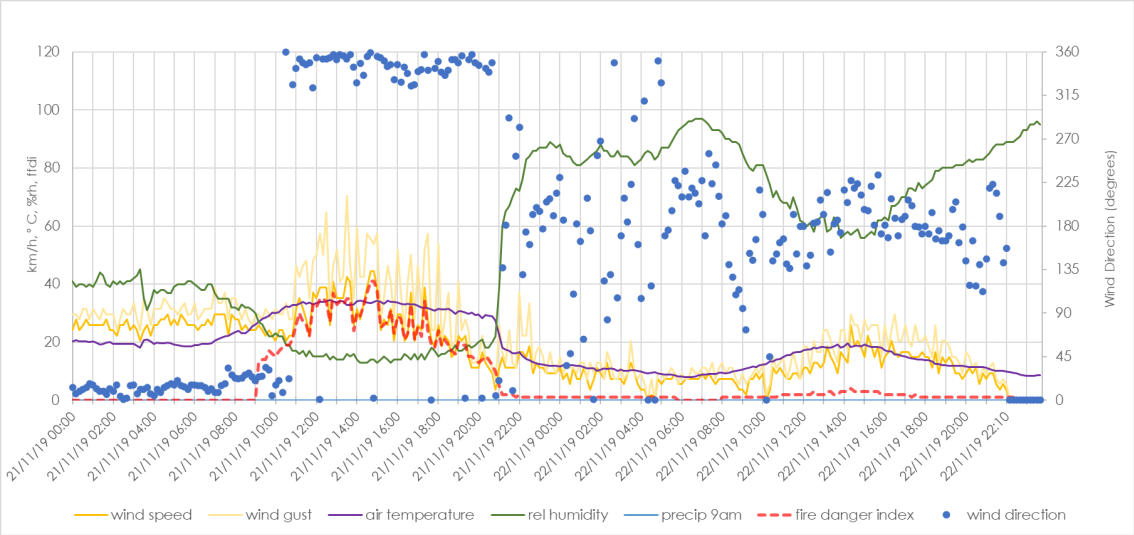


FIGURE 61: GELANTIPY AWS DATA FOR 0000HRS ON THE 21ST TO 0000HRS ON THE 23RD OF NOVEMBER 2019

Weather for the 25th of November 2019

The precise weather parameters that occurred on the 25th of November and the reasons for them remain unclear. This has been identified for further investigation.

The Gelantipy AWS was not working (24th - 29th of November), and a PAWS unit had not been installed. Observations were available from a personal weather station which showed a deep dew point depression lasting overnight and strong gusty winds. The wind direction is inconclusive and may be influenced by station location. It does show that 12mm of rain fell on the fire on the 26th of November.

Weather parameters for the days between the 18th of November to the 2nd of December are shown in Figure 62 and the proximity of the fire to the personal weather station in Figure 63.

Further input from the BOM is being sought, but a likely scenario is that where the fire was at 760m elevation, it was initially experiencing strong dry northerly winds. At some point in the afternoon, a shallow, but strong southerly to pushed up, causing the fire to run north. A shift to the SW pushed the fire across the Snowy River and the final shift to the SE caused the fire to throw embers to the NW and cause impacts on private property.

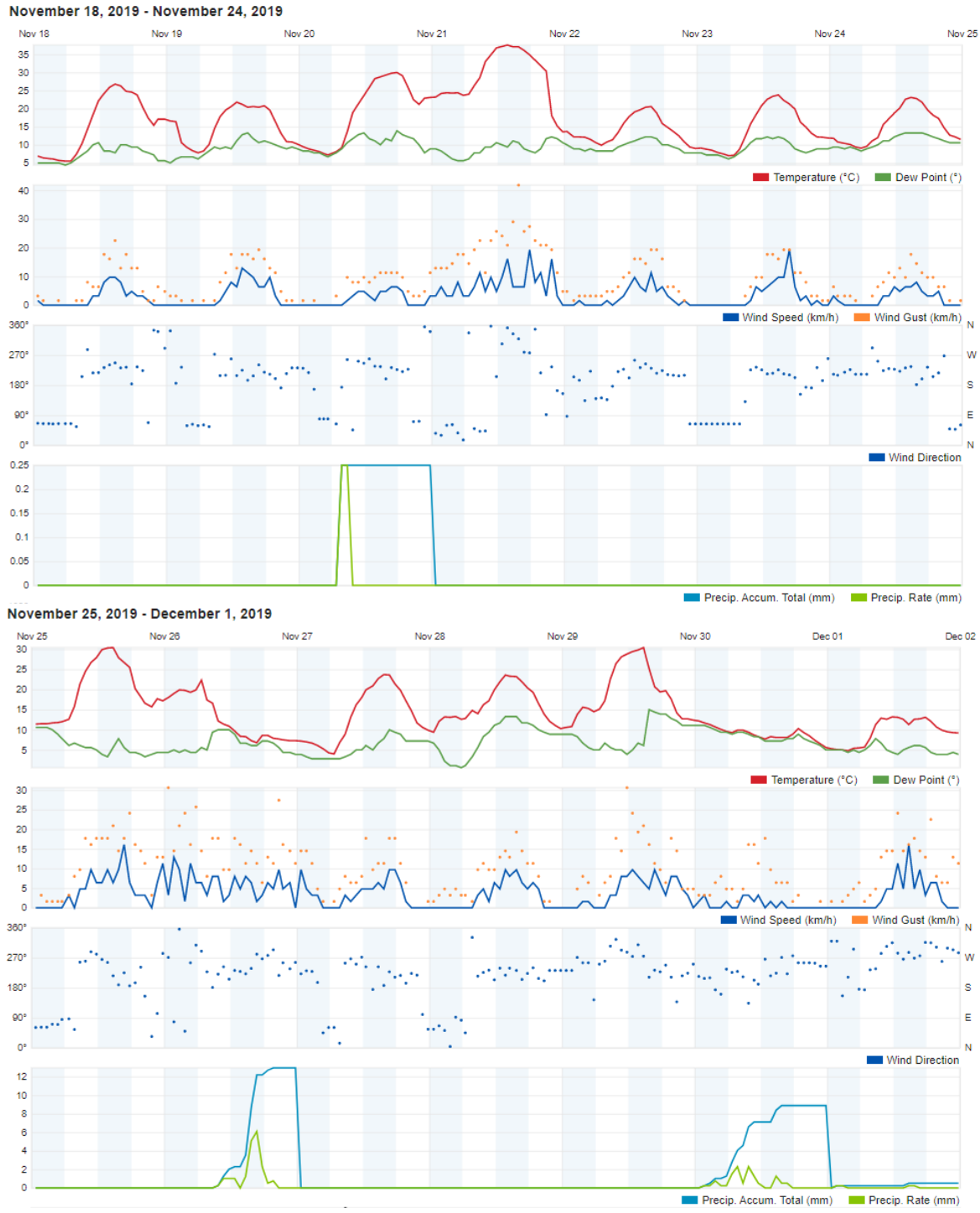


FIGURE 62: WEATHER UNDERGROUND W-TREE STATION IVICTORI1949

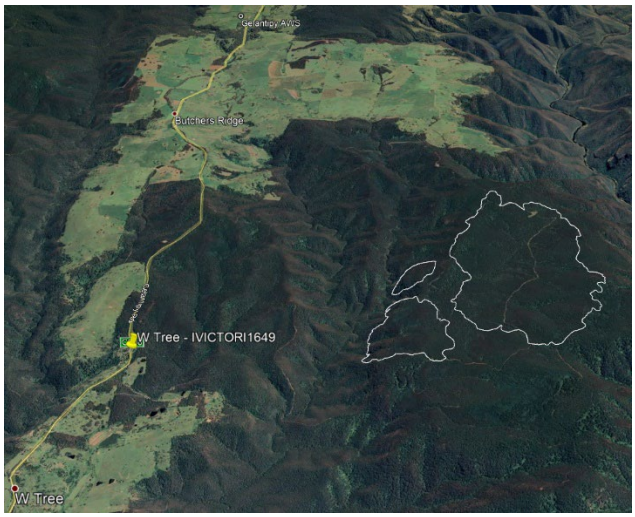


FIGURE 63: WEATHER UNDERGROUND WEATHER STATION LOCATION AND FIRE BOUNDARY AS AT 1812HRS 24TH NOVEMBER 2019

Calculations of FFDI were made using the Personal Weather Station (PWS) data and can be seen in Figure 64. This used the gridded weather drought factor of 6.8. It is recognized that the drought factor may have been an underprediction but even if it was 10, then the maximum FFDI would have been 24. Calculations for FFDI for nearby AWS were examined. Omeo peaked at 21and Mt Nowa Nowa at 23 on the 25th of November.

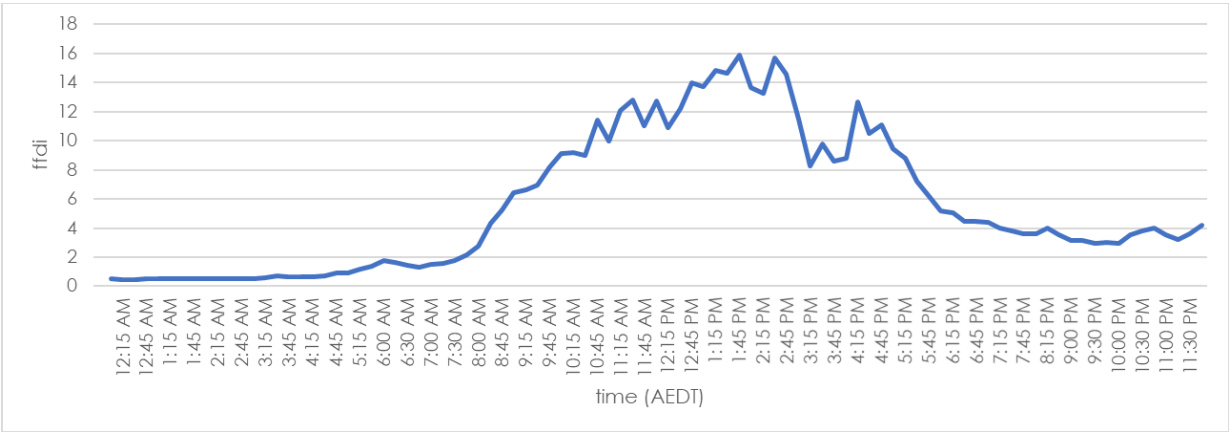


FIGURE 64: CALCULATED FFDI FOR WEATHER UNDERGROUND W TREE STATION FOR 25TH NOVEMBER 2019

There is more investigation required as to what caused the fire to behave the way it did. The wind changes and sea breeze interactions are often complex and do not behave the way they do in western Victoria (pers comm Graham Mills) and although the atmosphere was slightly unstable no significant PyroCu or PyroCb developed or was predicted by the PFT (Pyrocumulous Fire Threshold), (pers comm Kevin Tory). The gridded weather forecast for the morning and afternoon did point to the weather conditions that occurred. Further to this, FBAN predictions did show the directions and extent of what occurred.

Figure 65 shows upper level (950hPa) winds and the smoke columns at 1100hrs on the 25th of November. Figure 66 shows the four active fires in the Tambo District at 1850hrs and SSE surface winds forecast by Access C. The fire on the east of the Snowy River can be seen. At the time of the

image(1850hrs) spotting was occurring to the west of the Gelantipy Rd. There were report that this was caused by the column losing energy and "collapsing", thus releasing embers.

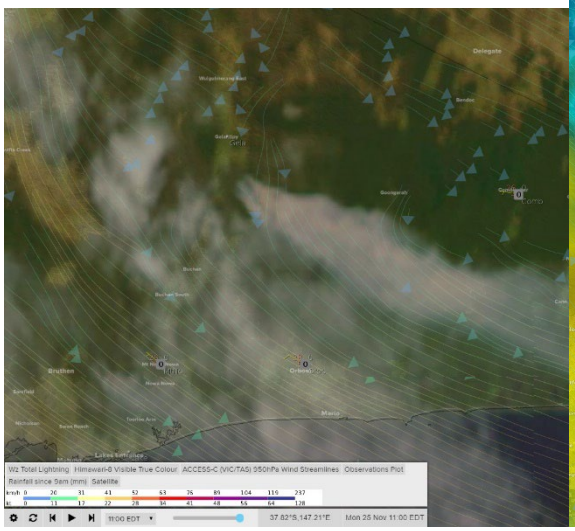


FIGURE 65: WEATHERZONE LAYERS SHOWING THE UPPER-LEVEL WINDS (ACCESS-C) AND SMOKE COLUMN AT 1100HRS

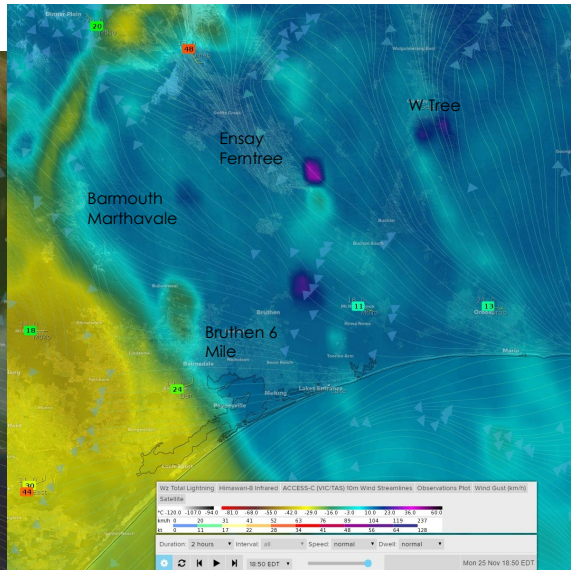


FIGURE 66: WEATHERZONE LAYERS FOR 1850HRS 25TH NOVEMBER 2019 - 10M WINDS, ENHANCED IR SHOWING THE 4 ACTIVE FIRES AND THE W TREE YALMY FIRE HAVING CROSSED THE RIVER. A WELL DEVELOPED COUMN HAS FORMED TO THE SOUTH OF THE ENSAY FERNTREE FIRE HIGHLIGHTING THE SHALLOWNESS OF THE CHANGE.

Initial Fire Progression

Matt Long from Tambo District provided this summary:

> *Tambo fires 38 and 39 were first reported on the 22nd of November 2019 at 1208hrs. These fires were only able to be resourced on the 22nd with 3 crew members who were tasked to monitor fire spread and help develop control strategies. A line scan overnight of the 22nd put the fire at 90ha as at 0354hrs. By the afternoon of the 23rd the fire was becoming very active and a column was noted to be developing (See Figure 67). On the 24th of November at 1250hrs the fire size was listed as 636 hectares. Resources were shared between these two fires and consisted of 7 firefighters and 2 large dozers. The fire area was updated to 745ha at 0353hrs. No night crew were available for these fires.*
>
> *At 1237hrs on the 25th the fire had merged with Tambo 38 with a combined area of 2250 hectares. By 1527hrs it had grown to 3835 hectares under the influence of dry northerly winds. By 1643hrs the fire was travelling north and impacting on private property at Butchers Ridge. Minimal resources were available. Spot fires west of the Gelantipy Road were reported at 1847hrs with flame heights of two metres. Crews pulled back to safe locations and reverted to asset protection. The fire size had increased to 5200 hectares by 2014hrs. The fire continued to impact on private property through the night of the 25th with CFA and FFMV resources defending dwellings NE of W-Tree. By 0902hrs on the 26th, the fires size was estimated at 6851 hectares.*

On the afternoon of the 25th at 1334hrs the fire spotted across the Snowy River into inaccessible country. By 1538hrs fire quickly grew driven by a westerly wind and an uphill run. A further five spot fires were recorded. This fire was listed as Snowy 6 - Goongerah -Yalmy.

FIGURE 67: AERIAL VIEW OF TAMBO FIRES 38 AND 39 ON THE 1517HRS 23RD OF NOVEMBER 2019 (SOURCE DELWP AIR OBSERVER)

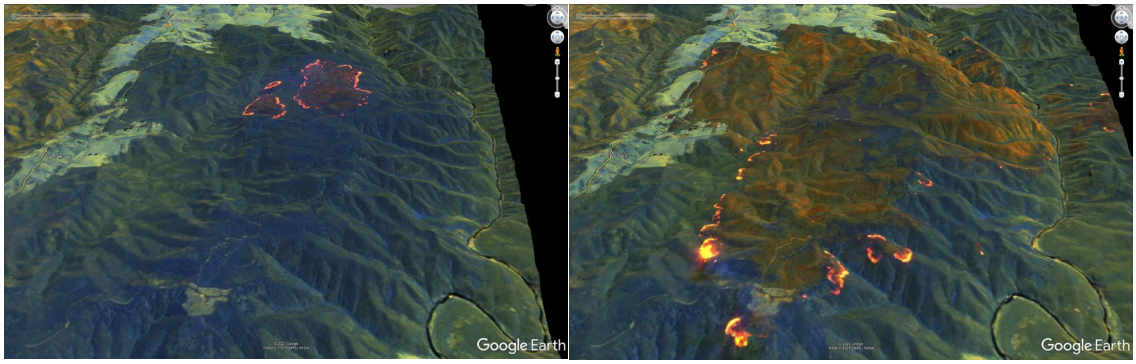


FIGURE 68: SENTINEL 2 SWIR NIR COMPOSITE IMAGES FOR 1117HRS 24TH OF NOVEMBER AND 1107HRS 29TH OF NOVEMBER 2019

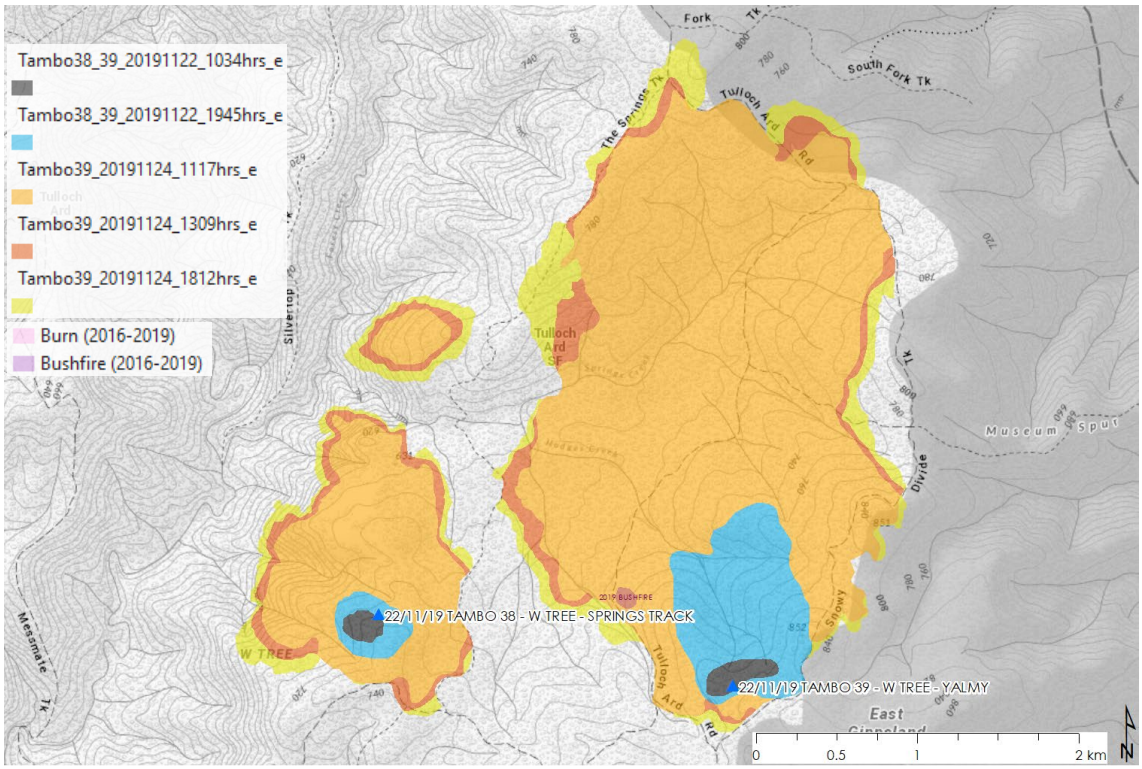


FIGURE 69: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 22ND NOVEMBER TO 24TH NOVEMBER 2019

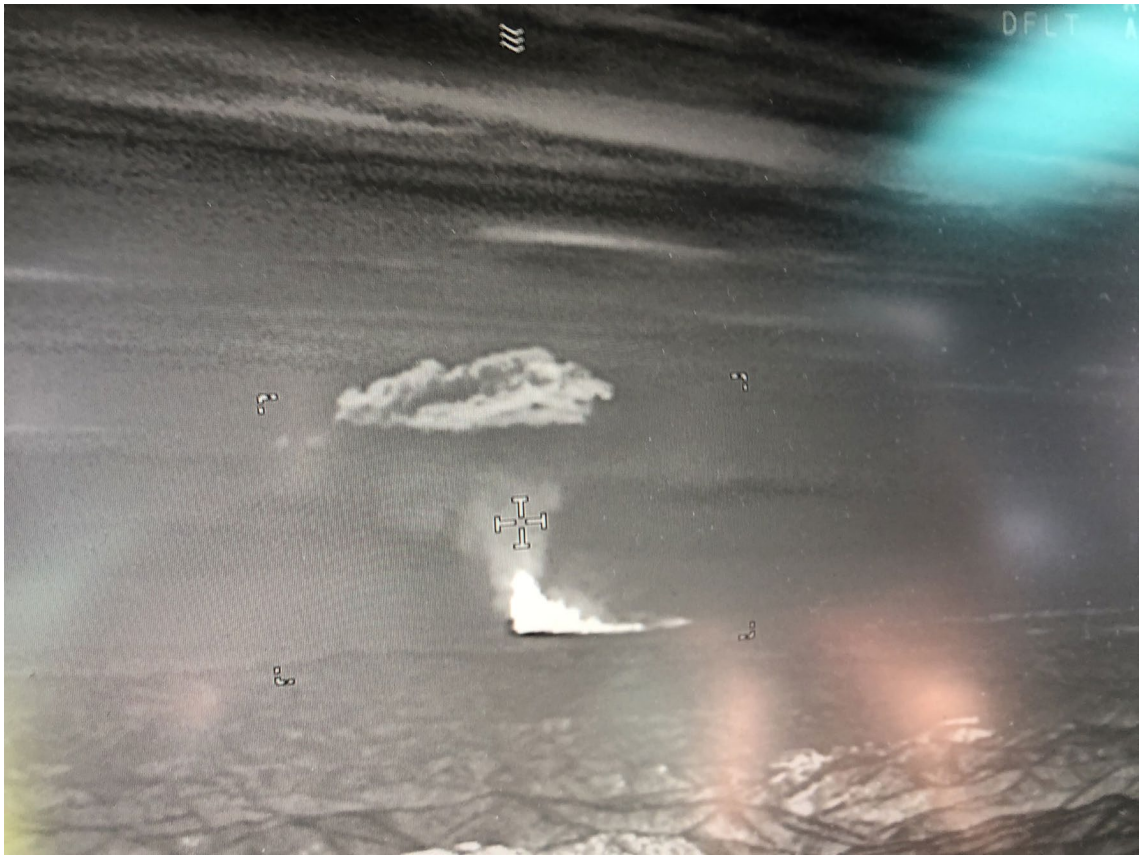


FIGURE 70: CONVECTION COLUMN OBSERVED BY THE AIG HELICOPTER FROM ABOVE DARGO (QUNTON PAKAN)

FIGURE 71: W TREE FIRE FROM THE CORNER OF BATES AND GELANTIPY ROAD - AFTERNOON 25TH OF NOVEMBER AND 22ND OF JANUARY (PHOTOS: SHANE MOYNAGH AND PETER CECIL)

Figure 70 shows the convection column through an unstable atmosphere. show the volatility of the fire and resulting severity. At ground level the fire behaviour was extreme as seen in Figure 71.

Figure 72 shows the extent of the fire run on the 25th into the 26th of November. The fire run was finally flown by line scan on the 28th. The blue area burnt almost certainly all occurred prior to the 12mm of rain which began mid-morning on the 26th of November.

Figure 73, Figure 74,and Figure 76 show the continual progression of the W Tree - Yalmy fire with back burning and consolidation occurring at the private property interface in the southwest. The fire continued to expand in rugged terrain to the north and east.

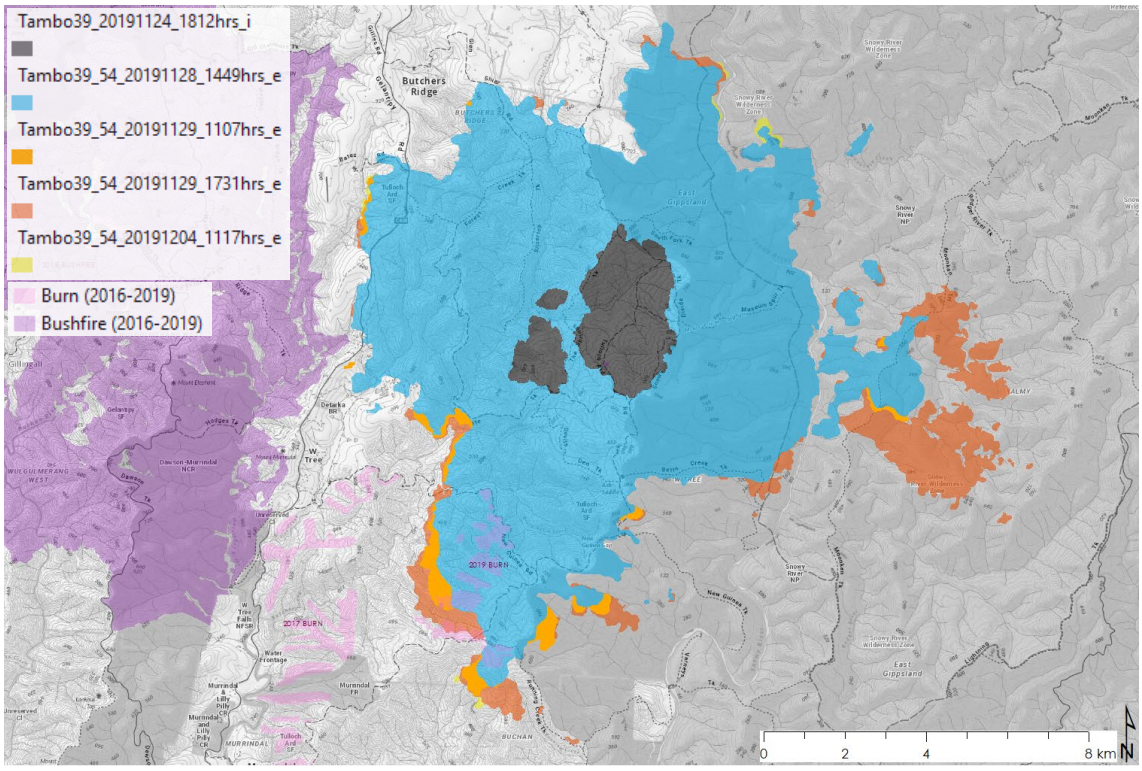


FIGURE 72: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 24TH NOVEMBER TO 4TH DECEMBER 2019

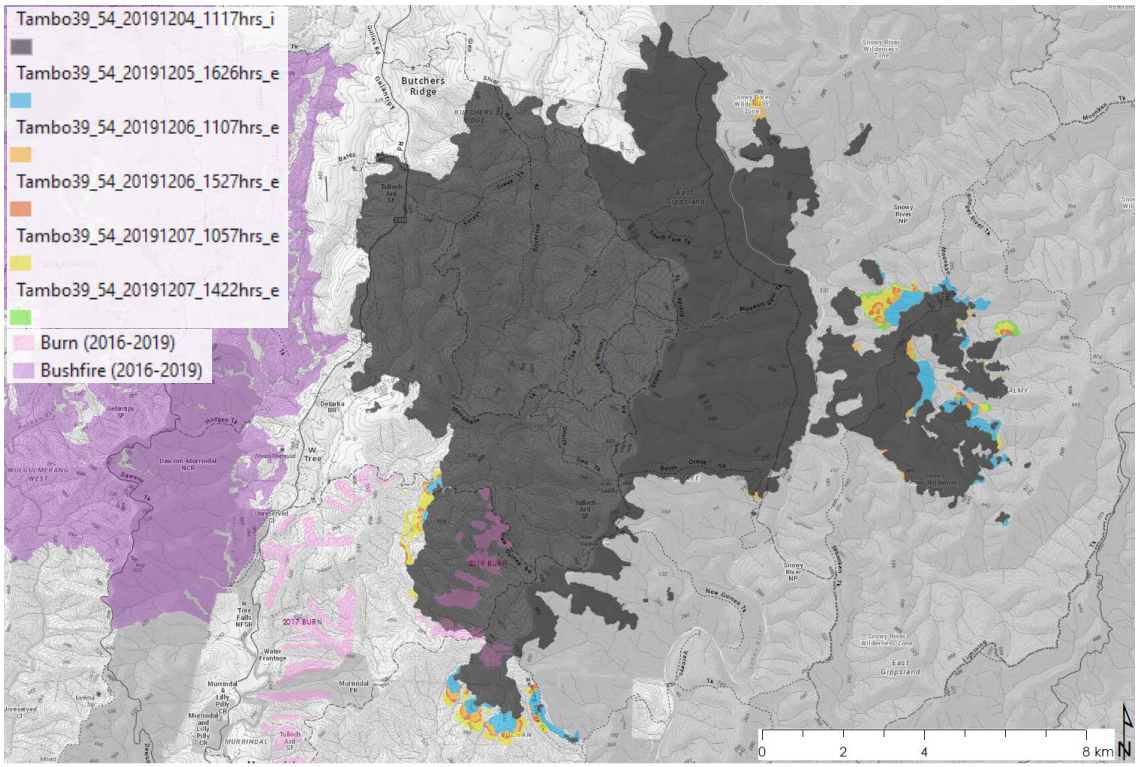


FIGURE 73: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 4TH DECEMBER TO 7TH OF DECEMBER 2019

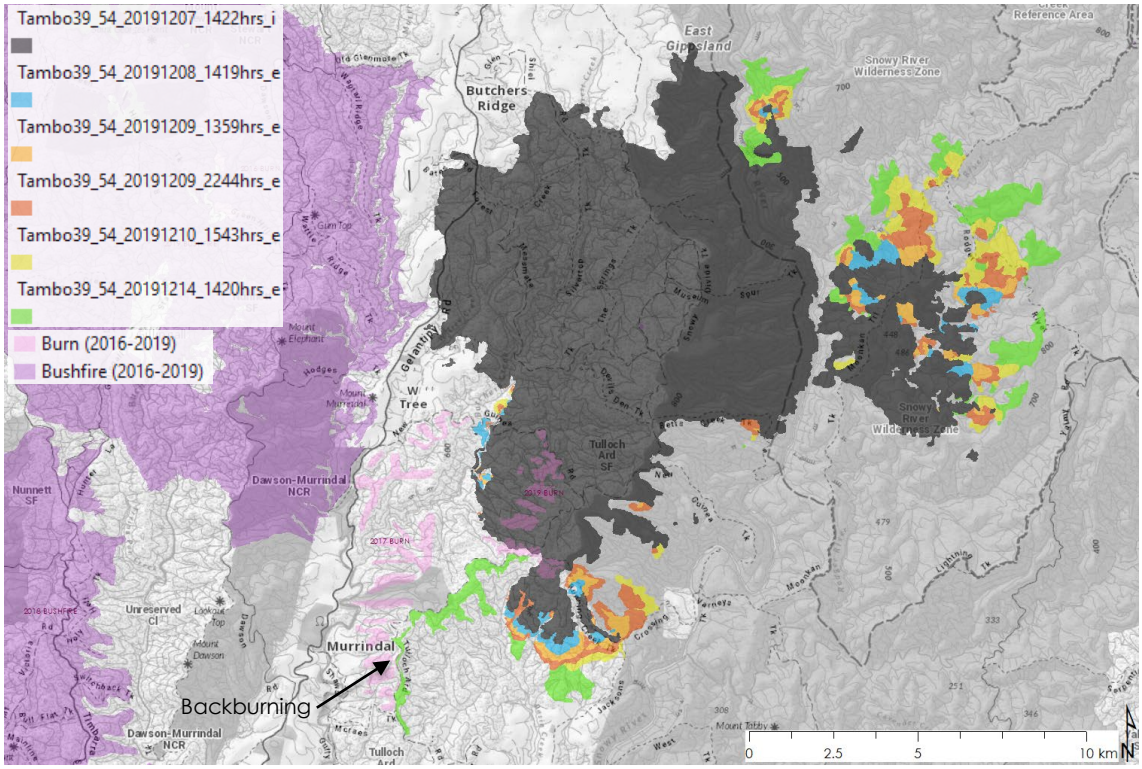


FIGURE 74: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 7TH DECEMBER TO 14TH OF DECEMBER 2019

FIGURE 75: W TREE YALMY FIRE LOOKING NORTH OVER THE SNOWY RIVER 8TH DECEMBER 2019 (DELWP EM DRIVE)

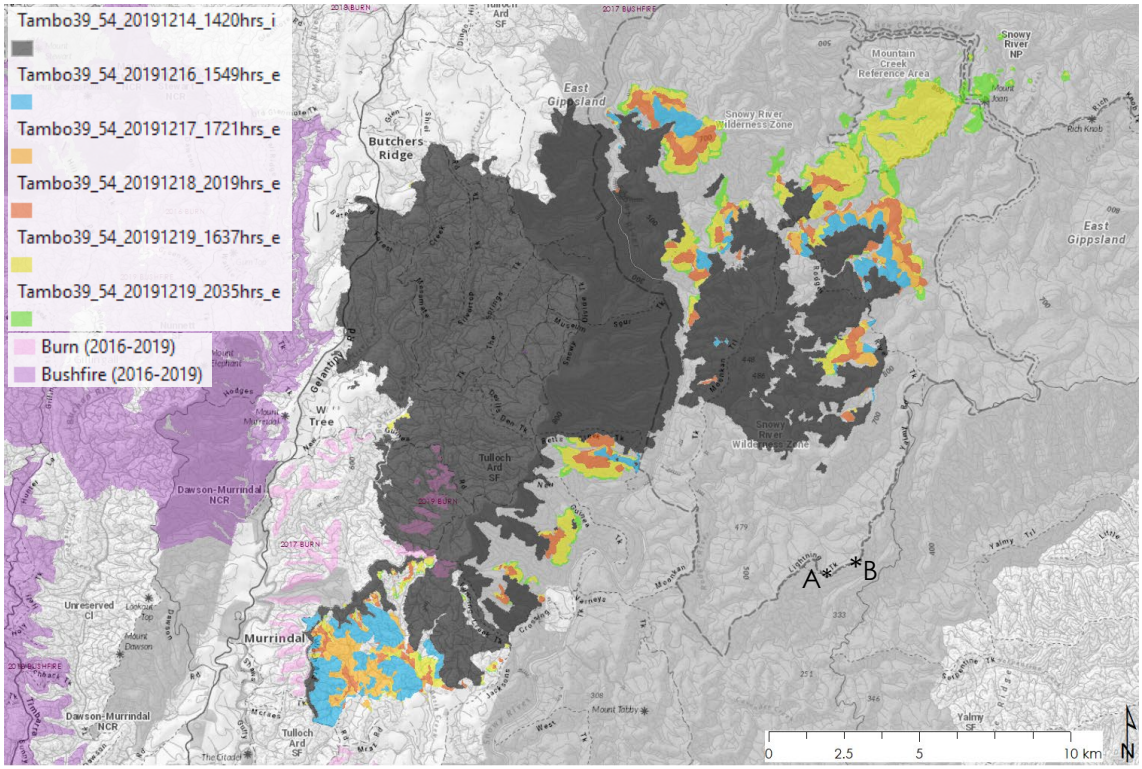


FIGURE 76: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 12TH OF DECEMBER TO 19TH OF DECEMBER 2019 (SHOWING SITE OF FUEL MOISTURE READING)

Readings of fuel moistures taken at sites A and B on Lightning Track (see Figure 76) on the 19th of December show fuel moistures in the range of 5-10 % (seeTable 2)

	Site A	Site B
elevated	9.8%, 6.7%	5.7%, 5.6%
exposed	7.7%, 6.6%	5.1%, 5.5%
contact	7.6%, 10.5%	6.3%, 9.7%

TABLE 2: FUEL MOISTURE CONTENT MEASUREMENTS TAKEN ON THE 19TH OF DECEMBER 2019(DELWP SITREP)

Figure 77 to Figure 80 show the continued progression of the fire from the 19th to the morning of the 30th of December. The fire had continued to

expand north and west and backburning along the Yalmy Rd appears to have been ineffective with the fire breaking out from that location.

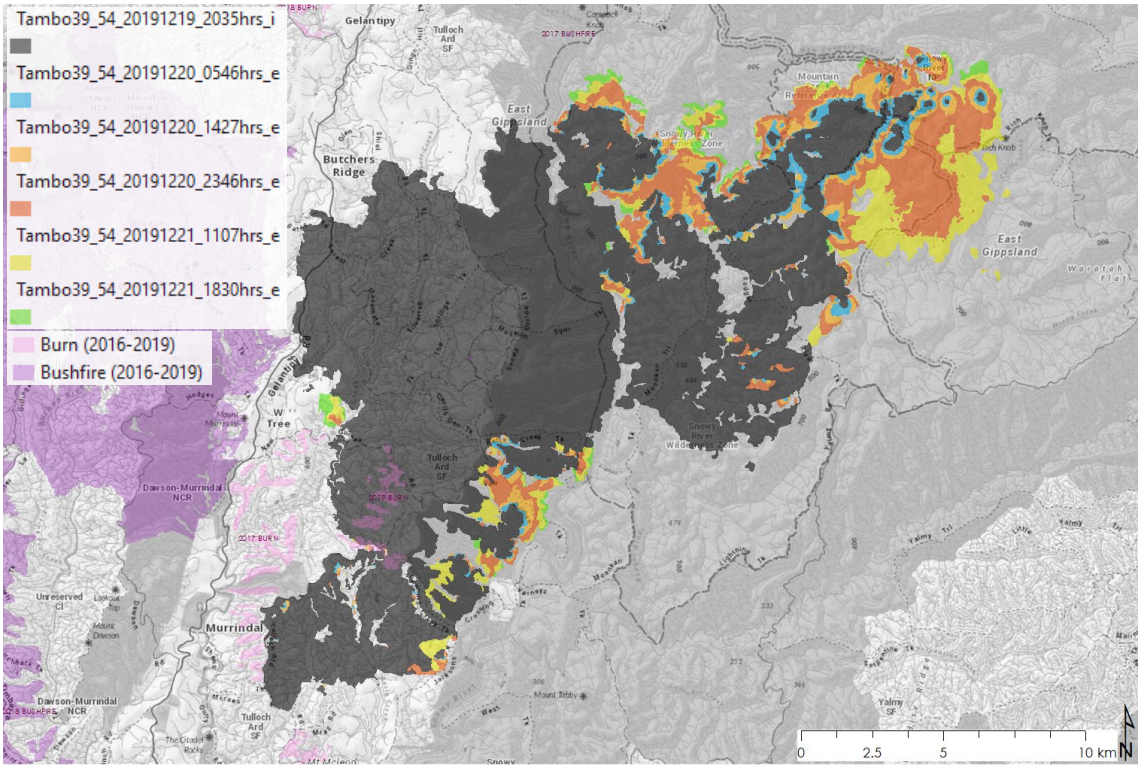


FIGURE 77: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 19TH OF DECEMBER TO 21ST OF DECEMBER 2019

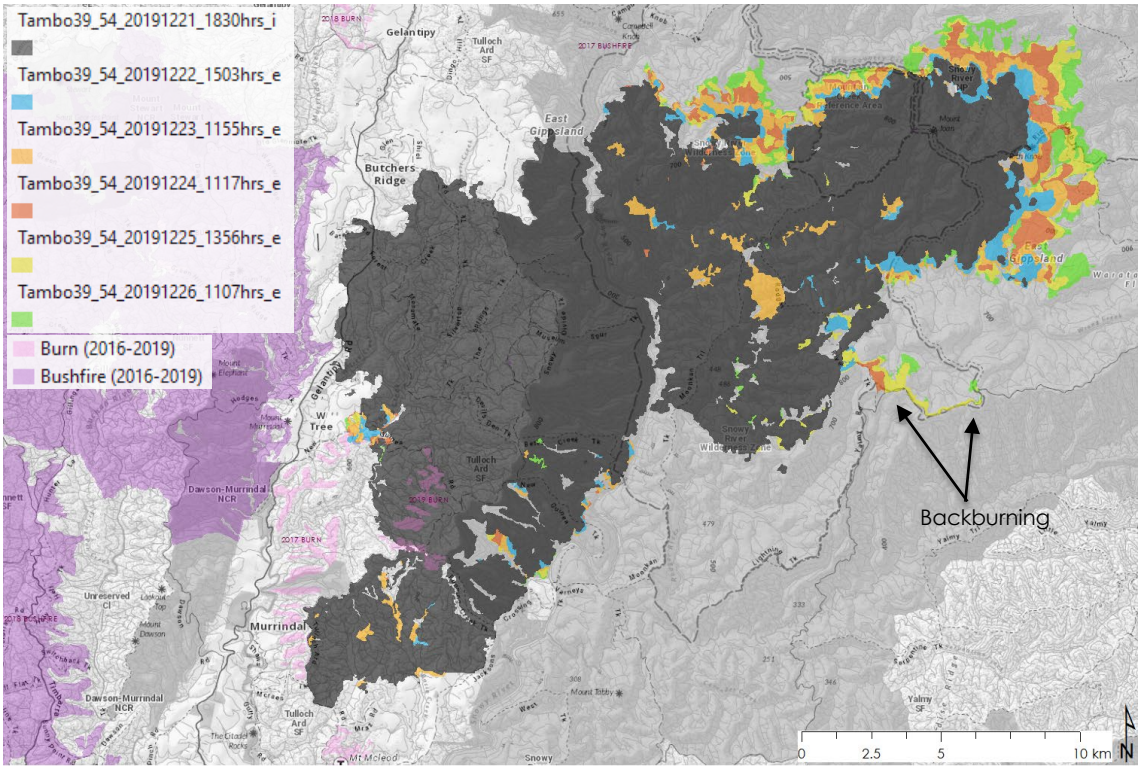


FIGURE 78: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 21ST OF DECEMBER TO 26TH OF DECEMBER 2019

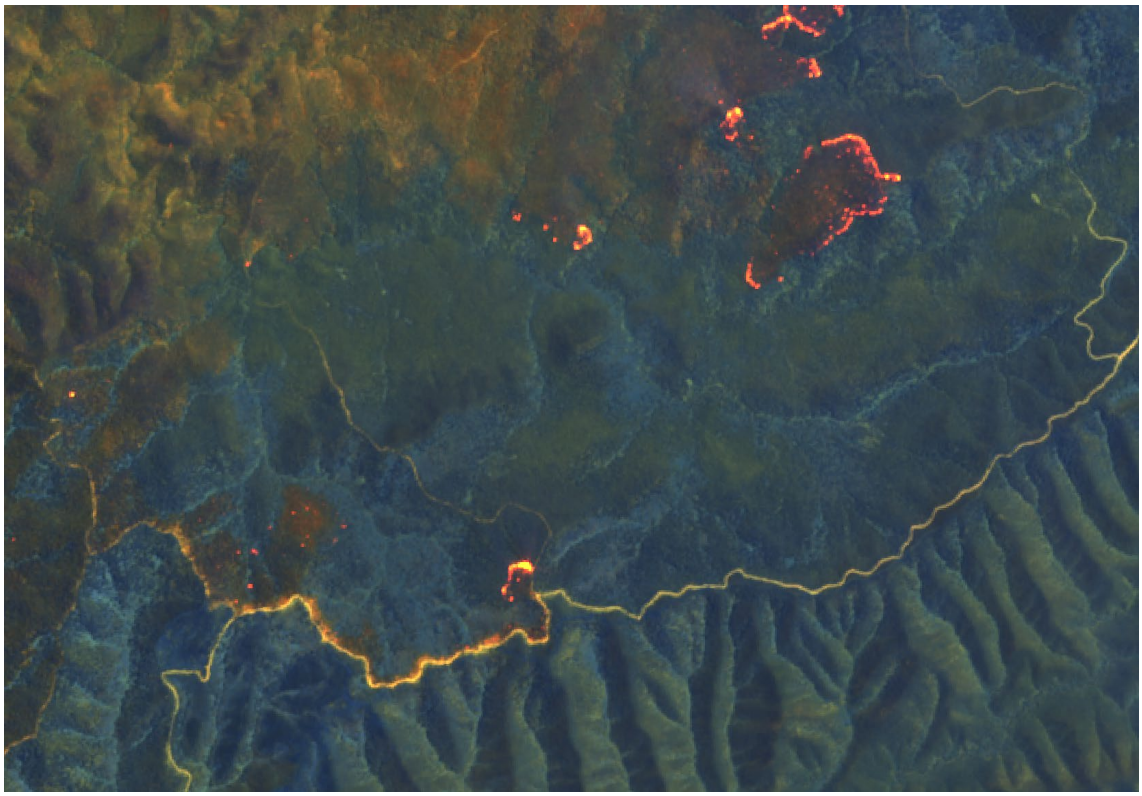


FIGURE 79: SENTINEL 2 IMAGE OF BACK BURNING ALONG THE RODGER RIVER TRACK AND YALMY ROAD 1107 HRS 26TH DECEMBER 2019

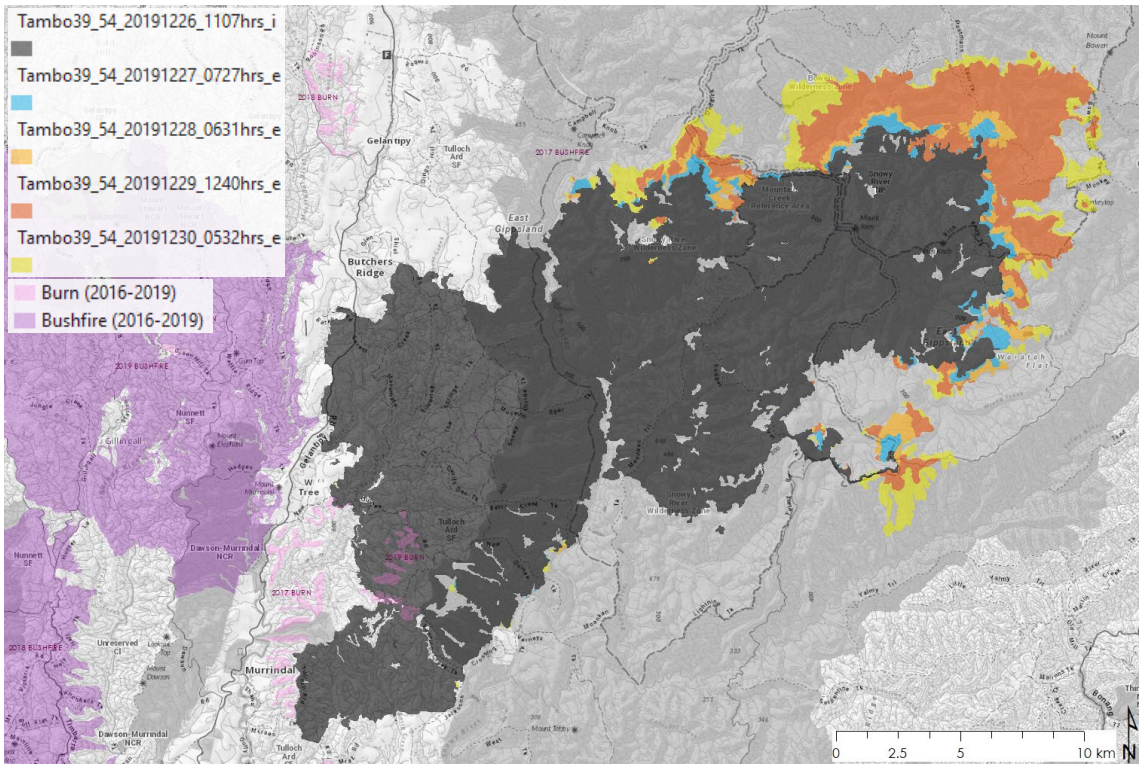


FIGURE 80: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 26TH OF DECEMBER TO 30TH OF DECEMBER 2019

By the early morning of the 30th of December, the fire had burnt 39,880 hectares. The further progression of the fire is continued in *Tambo 35: Tambo Complex - 30th and 31st of December 2019* on page 125.

TAMBO 41 & 44 – ENSAY – FERNTREE CREEK & BUCHAN SOUTH – MT ELIZABETH: 22ND NOVEMBER TO 30TH DECEMBER 2019

The Ensay Ferntree fire experienced significant fire activity before joining with other fires and becoming part of the Tambo Complex. The initial run on the 25th of November saw the fire expand to 2,500 hectares and further runs on the 10th of December and backburning and burning out had seen the fire increase to 10,000 hectares. By the 30th of December the fire was largely contained but not controlled at 20,000 hectares

The following sections focus on the initial blow-up day of the 25th of November. This was unexpected to a certain degree and relates to the wind change that arrived on site late in the day.

Later sections will examine the fire runs that impacted on Tambo Crossing (and potentially Waiwera) and Buchan that occurred on the 30th of December 2019 (see *Tambo 35: Tambo Complex - 30th and 31st of December 2019* on page 125.)

Weather for the 25th of November 2019

Hot dry northerlies had been forecast for the 25th of November, but there was uncertainty as to how the cool change would impact. In hindsight, the change on the 25th of November was shown by the AM gridded weather forecast. By the PM forecast, this was more defined, but was issued an hour before the change arrived on the fire ground. Further analysis of the fire weather on this day for this and the other three major fires burning on the day has been identified as further research project.

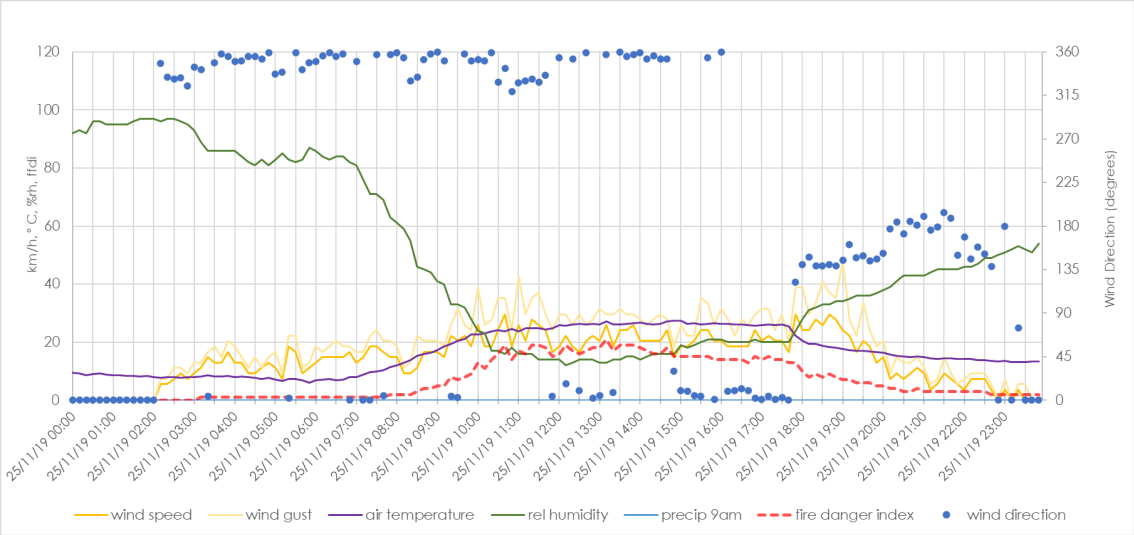


FIGURE 81: FIRE WEATHER PARAMETERS FOR OMEO AWS 25TH NOVEMBER

The KBDI for Omeo was 22.1 and the predicted drought factor was 6.3 and 7.4 on fireground. These may be an underprediction given the extended preceding drought, however if the grassland were used as a guide, it was not fully cured and did not burn at this stage of the fire. The AWS records for Omeo show the hot dry NNW winds, low RH and the

wind change arriving just prior to 1800hrs. At this time fuels would have been the driest and the 20-40km/h winds were aligned with the topography to significantly expand the fire. Upper winds were from the North and these carried long distance spots which caused two further ignitions.

Fire Progression

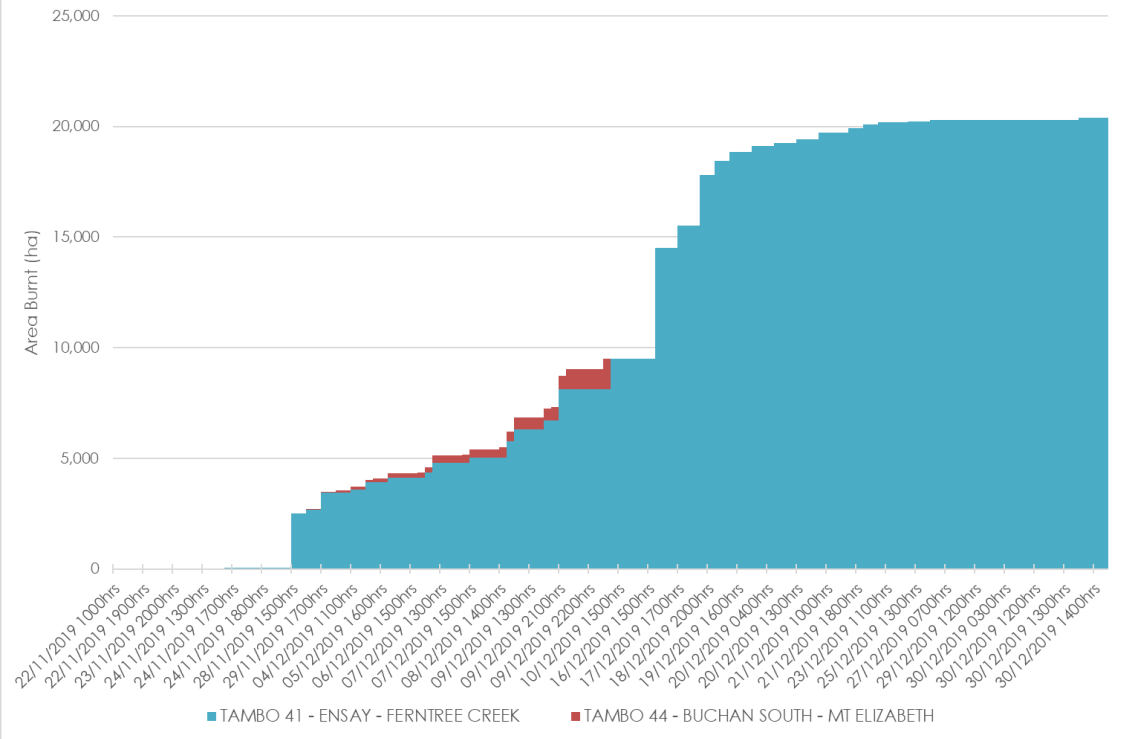


FIGURE 82: FIRE GROWTH OF THE ENSAY - FERNTREE AND BUCHAN SOUTH MT ELIZABETH FIRES, NOVEMBER TO DECEMBER 2019

Tambo 41 Ensay-Ferntree Creek was first reported on 22nd of November 2019 at1435hrs. The cause was lightning. The fire was initially small, and resources were limited to air attack and small ground crews. Difficulties with spotting were encountered from the early stages. On the morning of the 25th of November northerly winds caused the fire to spot over the containment line and creek to the south. Three dozers and ground crew were not able to contain the fire. By 1700 it was spotting 3-4km driven by south-easterly winds and topography.

Figure 84 and Figure 86 show the development of the fire as seen from Reedy Flat. Two spot fires appear to have been caused by this escalation (see Figure 83). An examination of the Himawari IR, observations and Access C model 10 m winds (see Figure 66) shows the shallowness of the change and the strong upper-level winds consistently from the north. Fireweb records the cause of Tambo44 as suspected lightning, but DELWP Regional staff point to spots being the cause (pers comm Matt Long). The closest weather station was at Omeo (see Figure 81) and this shows the strong northerly winds followed by the gusty shallow change at 1600hrs).

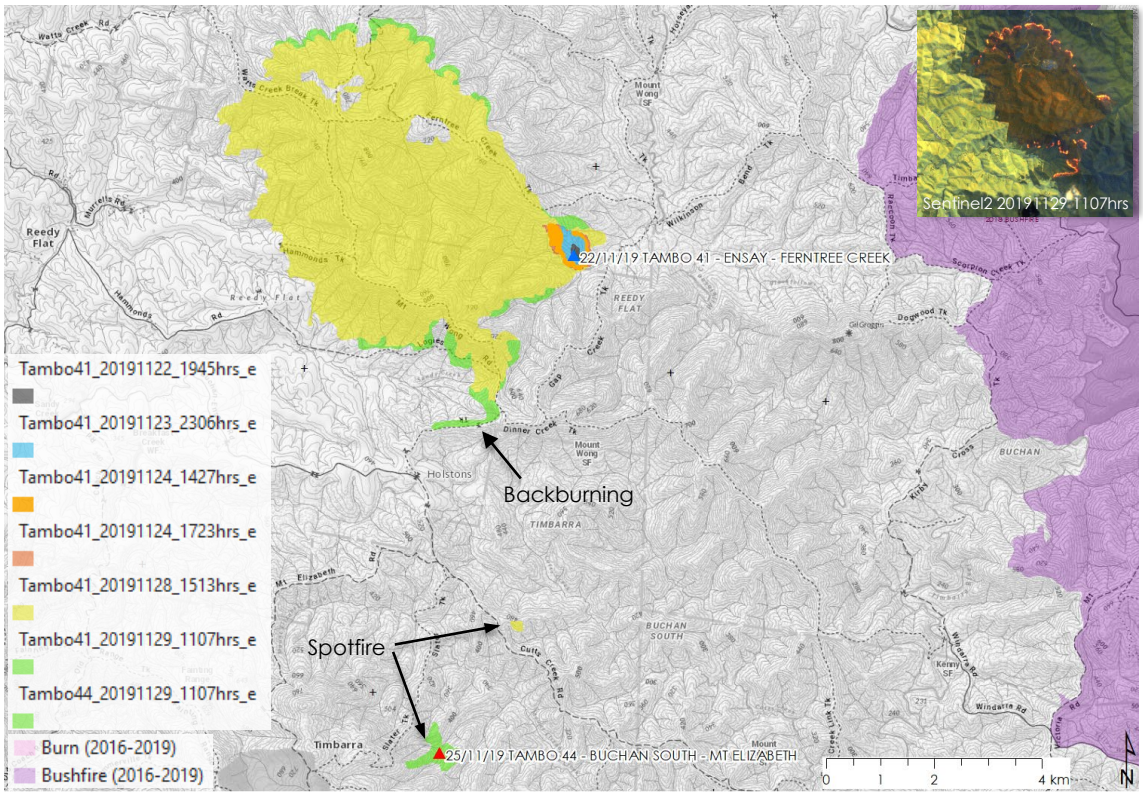


FIGURE 83: FIRE PROGRESSION ENSAY – FERNTREE CREEK BUSHFIRE 22ND TO 29TH NOVEMBER 2019

FIGURE 84: FIRE SEQUENCE FROM SCOTT RD, REEDY FLAT LOOKING EAST TOWARD MT WONG (PHOTOS: JULIE PURDEY)

FIGURE 85: MT WONG SPOTFIRES ~1900HRS 25TH NOVEMBER 2019 NEAR CNR TAYLOR AND HAMMONDS RD (PHOTO ALAN WATKINSON-DELWP)

FIGURE 86: MT WONG 1957HRS 25TH NOVEMBER 2019 NEAR CNR TAYLOR AND HAMMONDS RD (PHOTO ALAN WATKINSON-DELWP)

Figure 87 to Figure 92 show the ongoing progression of the fire. There were small but significant fire runs, a reliance on indirect attack due to the terrain and significant fire behaviour related to short and medium distance spotting and high flame height and intensities. As November progressed into December grassland fuels fully cured, forest fuels dried further, and once moist gullies dried and burned.

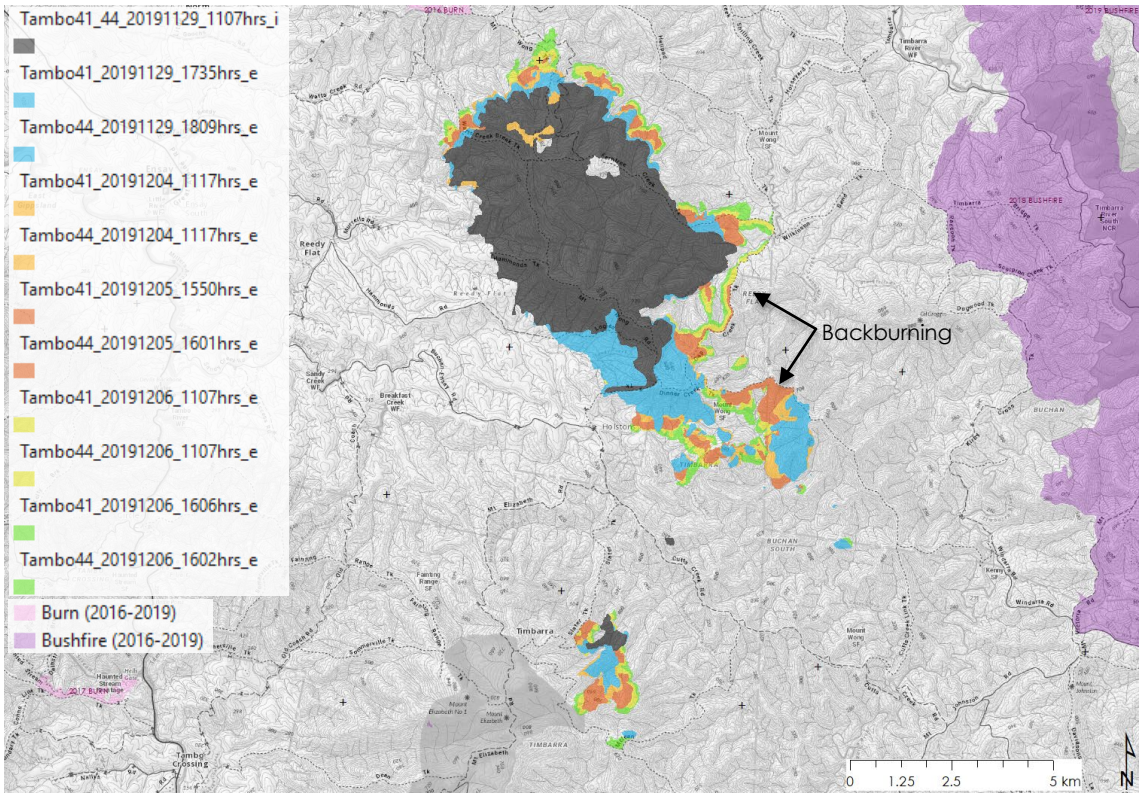


FIGURE 87: FIRE PROGRESSION ENSAY – FERNTREE CREEK AND MT ELIZABETH BUSHFIRES 22ND OF NOVEMBER TO 6TH OF DECEMBER 2019

Figure 87 highlights the difficulty experienced in both direct and indirect attack. On the 29th of November the backburnt control line was breached and the fire expanded and spotted to the SSE. Attempts at direct attack failed and a longer term indirect strategy was adopted.

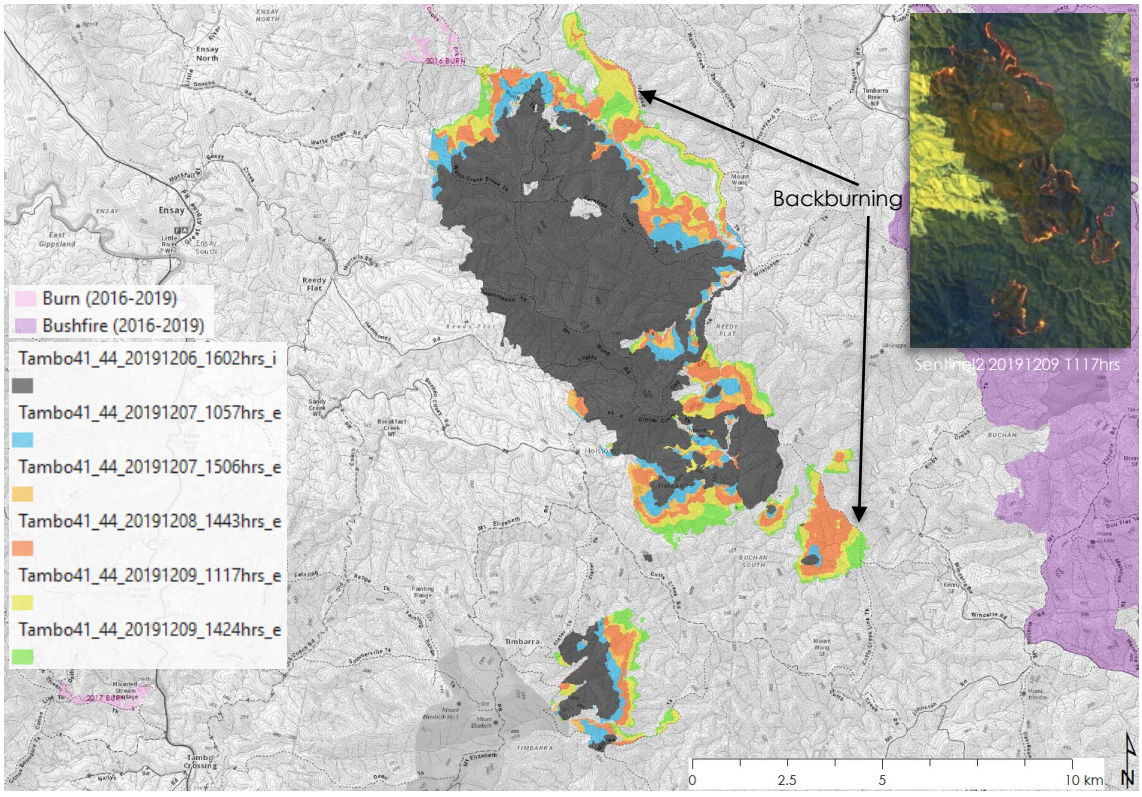


FIGURE 88: FIRE PROGRESSION ENSAY – FERNTREE CREEK AND MT ELIZABETH BUSHFIRES 6TH TO 9TH OF DECEMBER TO 2019

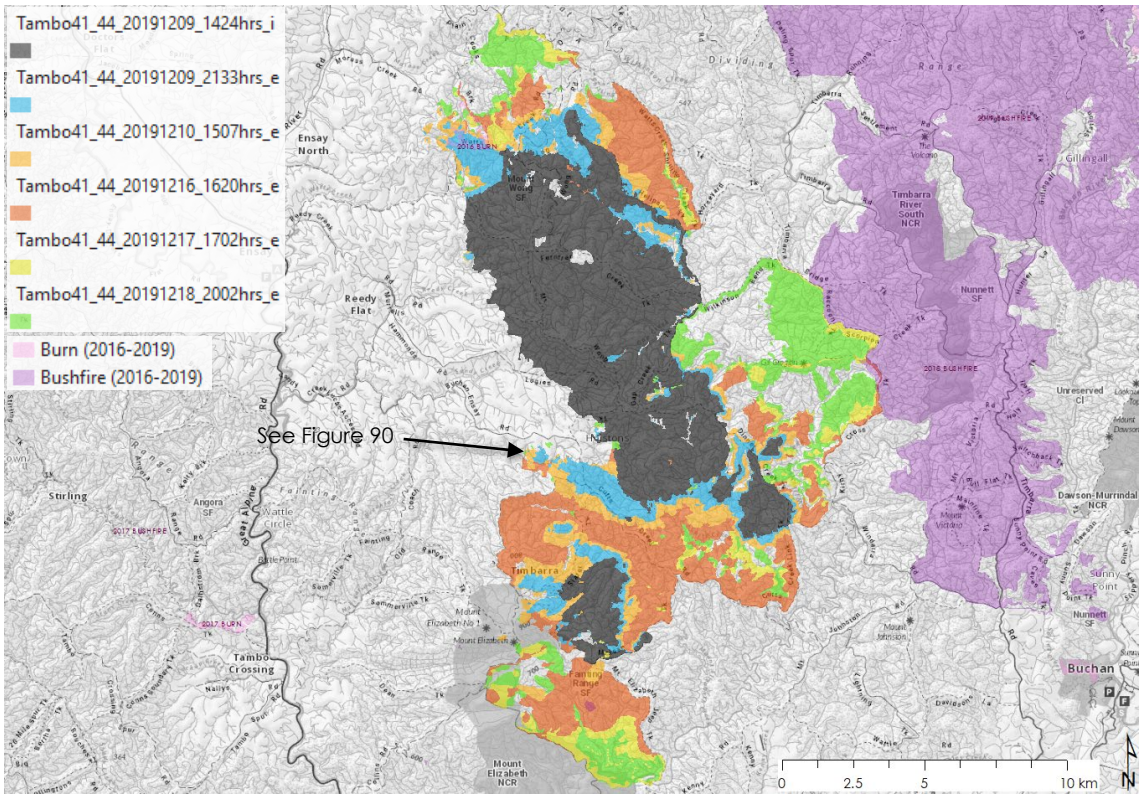


FIGURE 89: FIRE PROGRESSION ENSAY – FERNTREE CREEK AND MT ELIZABETH BUSHFIRES 9TH TO 18TH OF DECEMBER 2019

FIGURE 90: SPOTFIRES FROM SE WIND BUCHAN ENSAY RD 9TH DECEMBER 2019 1743HRS (37°25'33.18"S, 147°56'34.43"E) (MIKE IRVINE)

Figure 89 and Figure 90 highlight that prefrontal troughs, dry changes and sea breezes, (or mixtures thereof) pushed far inland and created additional challenges. On the 9th of December strong SE winds caused

the Ensay Ferntree and Mt Elizabeth fires to merge and take a run to the northwest.

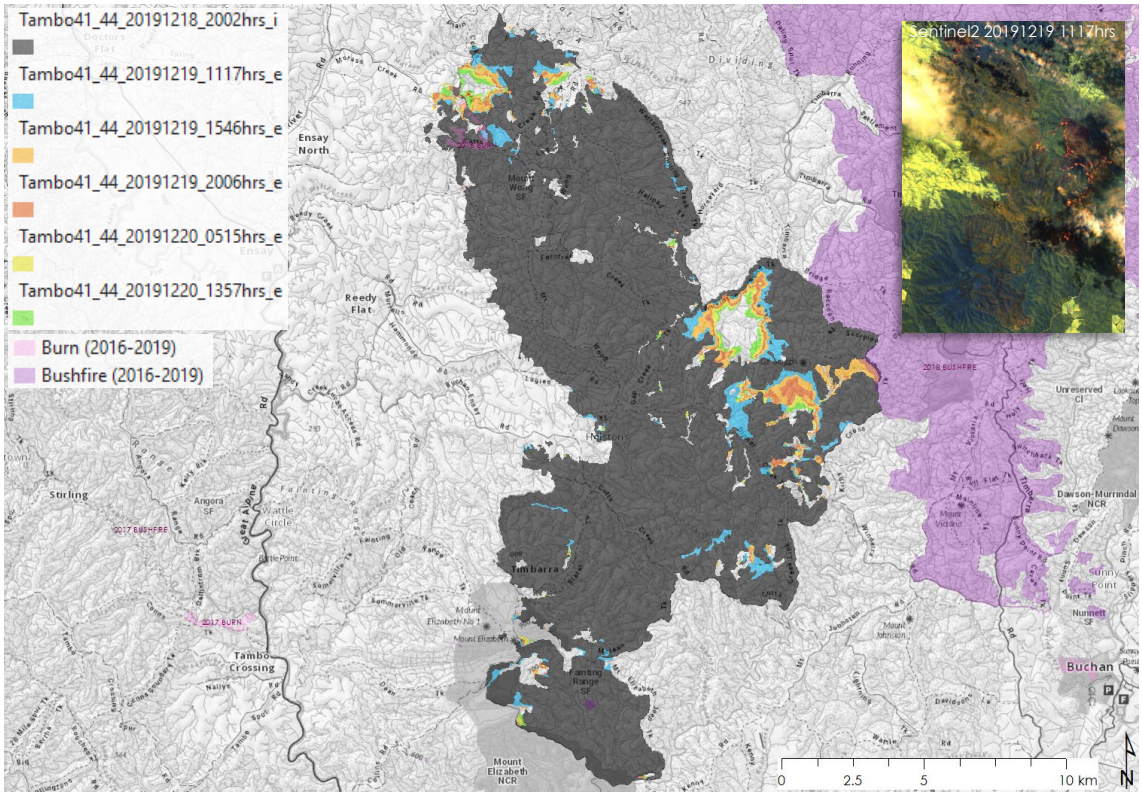


FIGURE 91: FIRE PROGRESSION ENSAY – FERNTREE CREEK AND MT ELIZABETH BUSHFIRES 18TH TO 20TH DECEMBER 2019

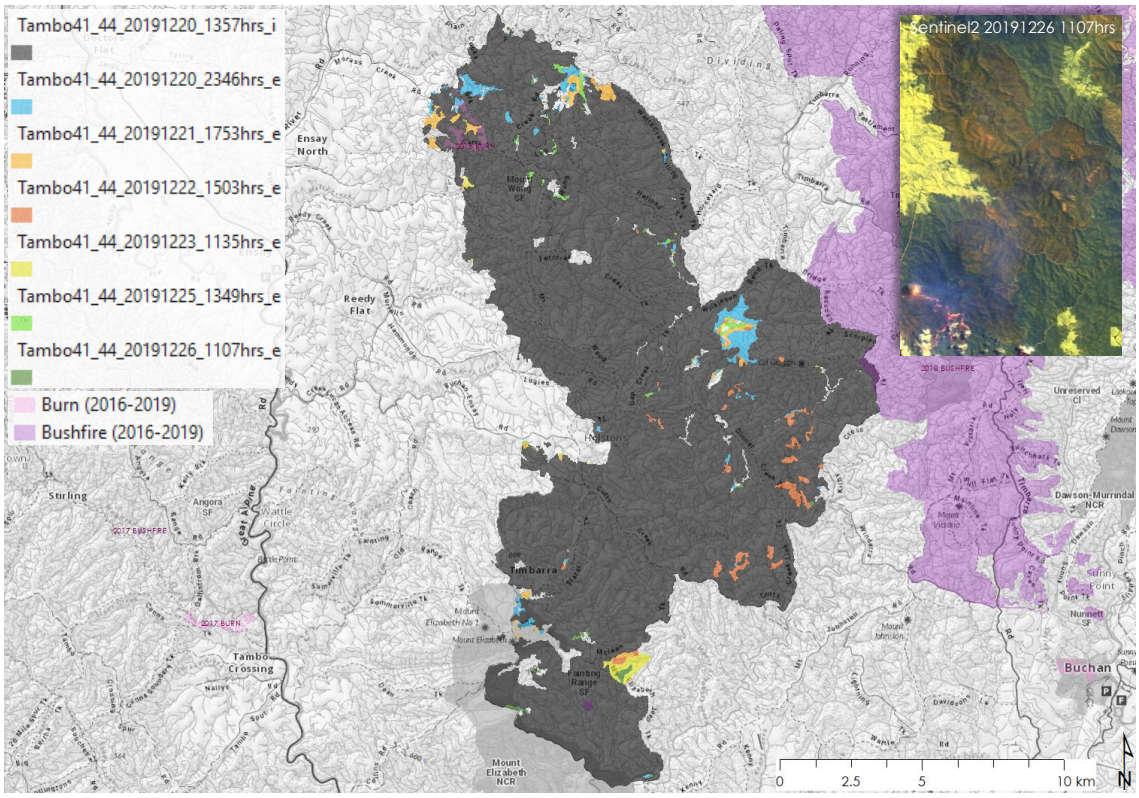


FIGURE 92: FIRE PROGRESSION ENSAY – FERNTREE CREEK AND MT ELIZABETH BUSHFIRES 20TH TO 26TH DECEMBER 2019

By the 26th of December the fire was largely contained and had burnt 20,295 hectares.

UPPER MURRAY 26 – UPPER MURRAY – WALWA

Antecedent weather conditions

Consecutive days and nights of heatwave conditions over southern NSW and northern Victoria at the end of December 2019 exacerbated the long-term severe drought conditions in the area, leading to very dry and flammable fuels and priming the landscape for intense fire activity. The KBDI for the Upper Murray region was in the range 100-150. Fuel moisture at Mount Elliott (50 km southeast of the ignition site) showed extremely low surface soil moisture readings of 4-7% and sub surface moisture levels of between 2.5 and 6%.

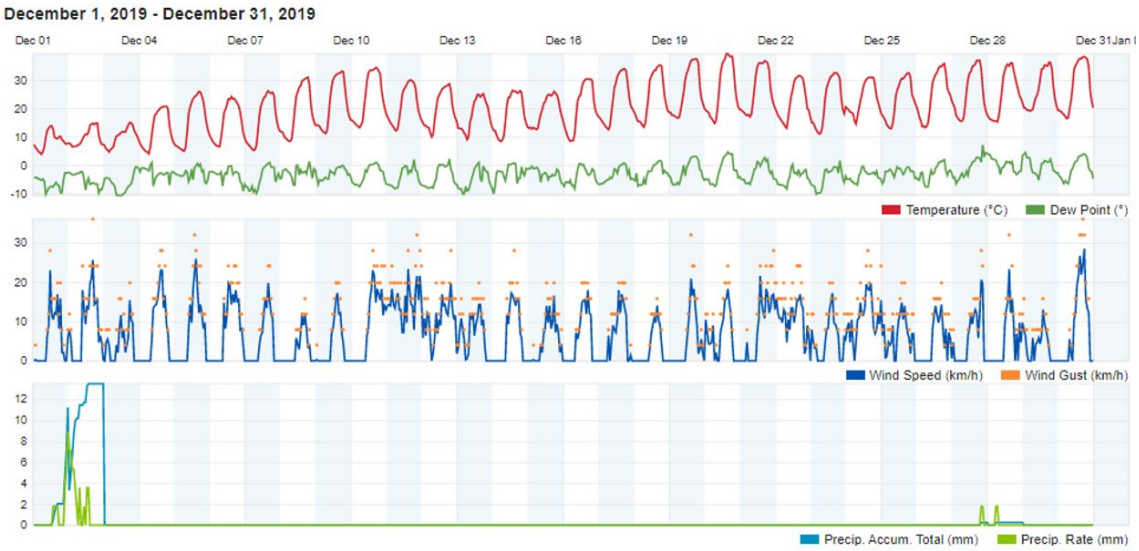


FIGURE 93: PERSONAL WEATHER STATION DATA FOR THE MONTH OF DECEMBER – NARIEL VALLEY (ELEV 457M, 36.44 °S, 147.84 °E) SHOWING CONDITIONS LEADING UP TO THE UM26 BUSHFIRE (HTTPS://WWW.WUNDERGROUND.COM/DASHBOARD/PWS/ITOWONGS2)

Weather for the 30th to 31st of December 2019

Weather conditions on the 30th of December 2019 were very hot and dry with north-westerly winds 15 to 40 km/h in the early afternoon. Maximum temperatures in the area were near 40°C and the relative humidity dropped below 10% in the late afternoon.

Synoptic weather charts from 0500hrs on the 30th to 1100hrs on the 31st of December (Figure 94) show a blocking high directing hot and dry air over the fire area. This is followed by the movement of a sharply defined trough of low pressure extending from a cold front. The trough marked the boundary between a very hot, dry airmass on its eastern side, and a milder, lighter, and more variable wind flow to its west.

Figure 95 and Figure 96 show weather records for the two nearest AWS. These show that here was considerable variation between the two sites that are 50km apart. Hunters Hill is at 970m and Khancoban at 340m. The fire began at around 500m, reached over 900m before dropping to the valley floor at 200m and then climbing to nearly 1200m at Mt Burrowa. Higher elevations remained under the influence of strong NNW winds and only swung westerly in the afternoon of the 31st of December.

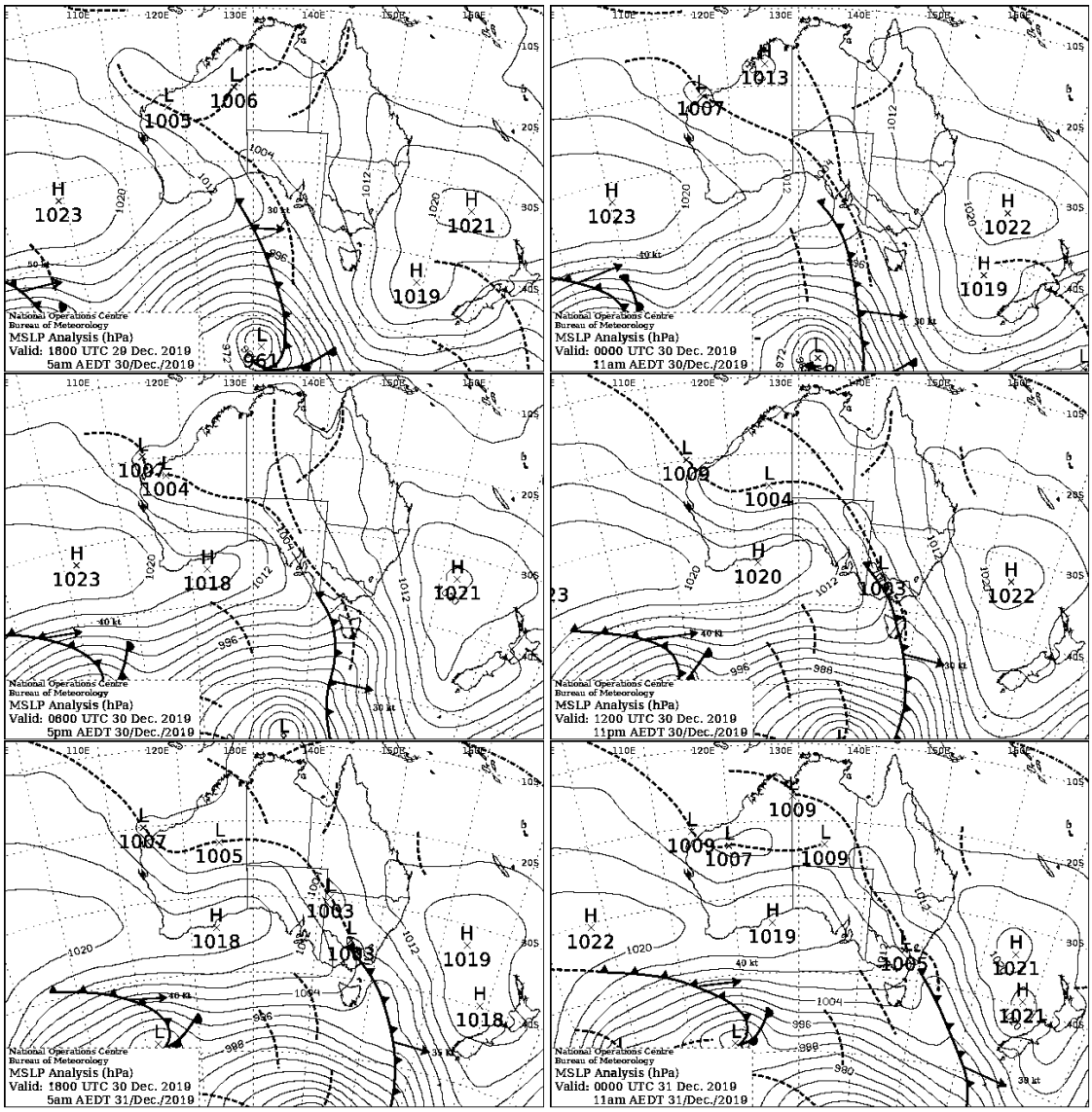


FIGURE 94: SYNOPTIC CHARTS 0500HRS 30TH DECEMBER 2019 TO 1100HRS 31ST OF DECEMBER

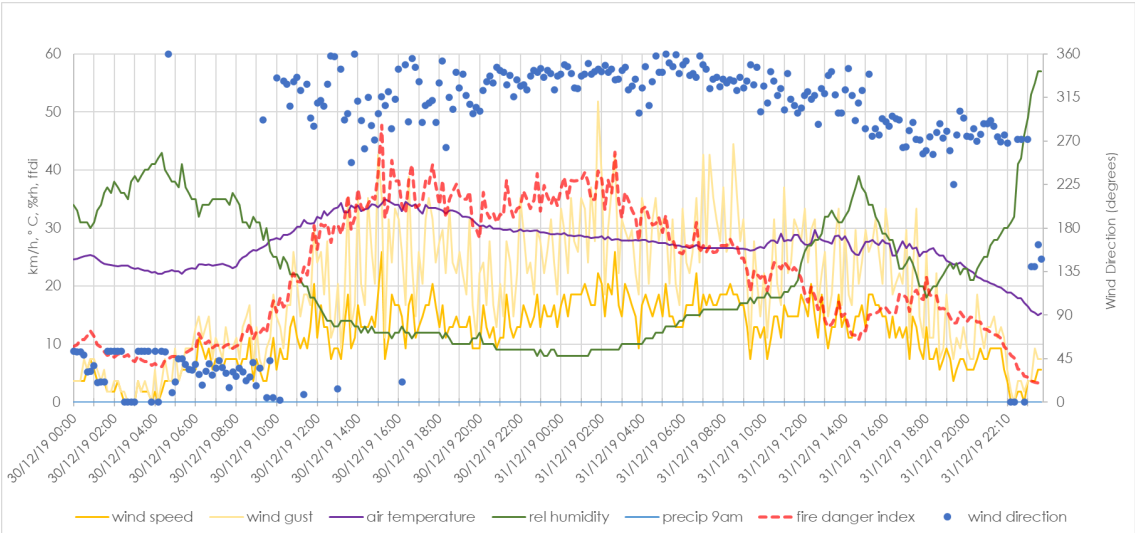


FIGURE 95: HUNTERS HILL AWS WEATHER PARAMETERS FOR 30TH AND 31ST OF DECEMBER 2019 (NOTE: FFDI CALCULATED WITH DF =10 FROM GRIDDED FORECAST)

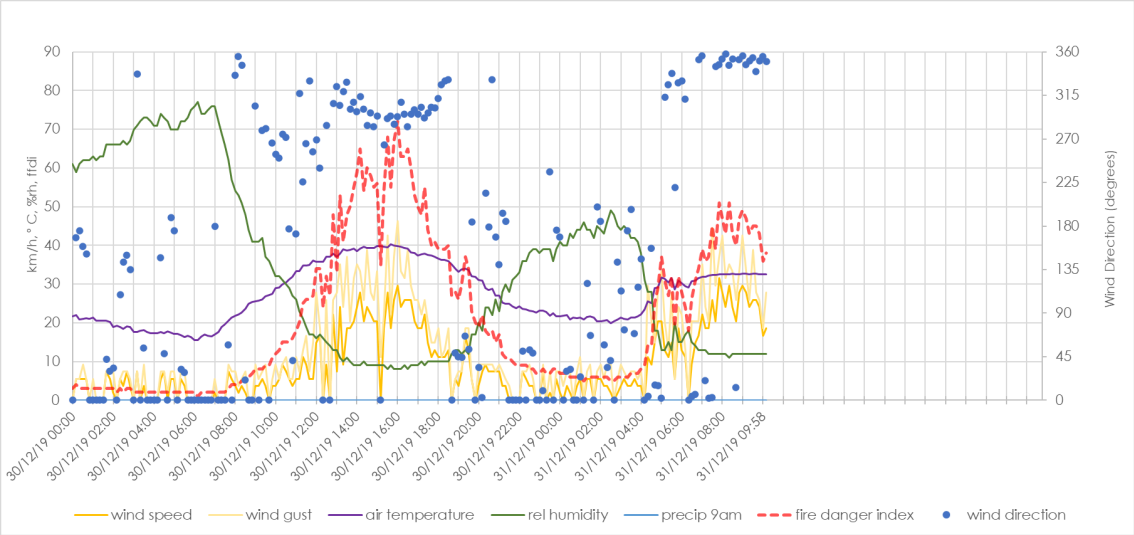


FIGURE 96: KHANCOBAN AWS WEATHER PARAMETERS FOR 30TH AND 31ST OF DECEMBER 2019 (UNTIL RECORDING CEASED)

Fire Progression 29th December 2019 – 4th January 2020

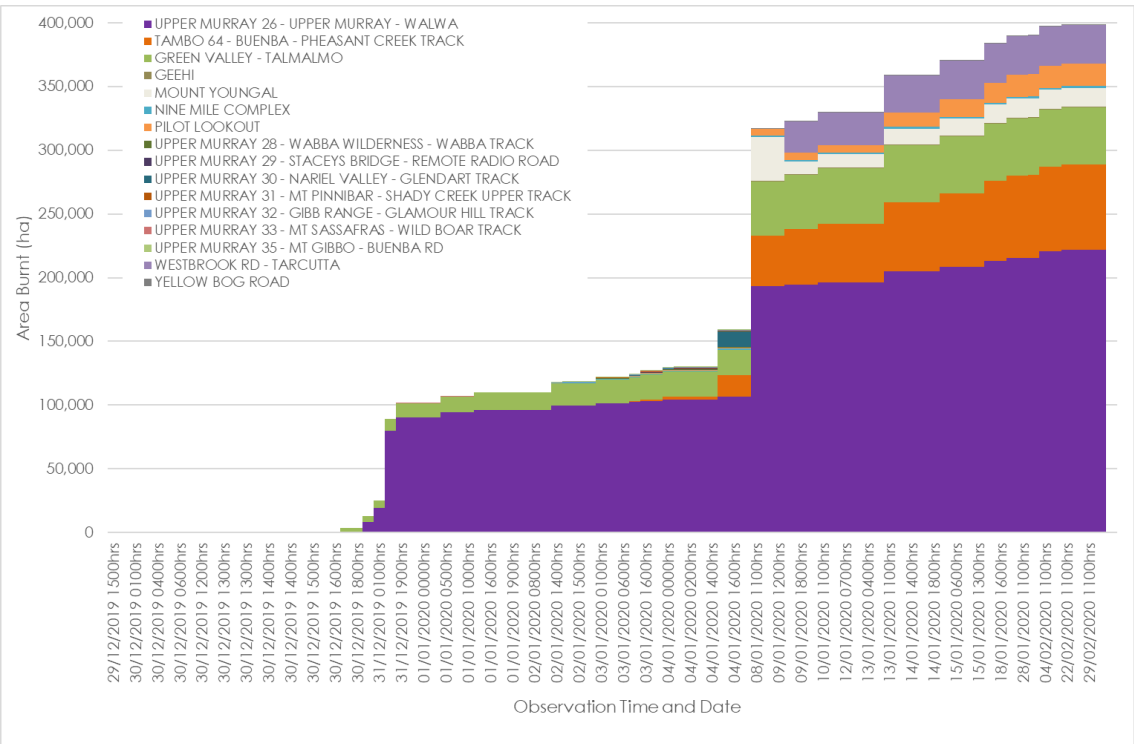


FIGURE 97: OBSERVATION DATES AND TIMES AND AREA BURNT OF EACH FIRE EXAMINED

The Upper Murray Walwa fire was ignited by a lightning strike in the Woomargama national Park in NSW on 29th of December 2019, where it was referred to as the Green Valley - Talmalmo fire. The fire burned through Green Valley near the township of Jingellic in southern NSW on 30th of December 2019. The fire gained momentum and spread rapidly from northwest to southeast across Green Valley.

FIGURE 98: INITIAL SIZE AND FIRE BEHAVIOUR OF THE GREEN VALLEY - TALMALMO BUSHFIRE (L) 1726HRS, (R)1814HRS 29TH OF DECEMBER 2019 (JOHN SILINS)

In the late afternoon, the fire crossed the Murray River into Victoria. During the period from early afternoon on 30 December to the early morning of the 1st of January almost 110,000 ha of forest and farming land was burnt, with the most dangerous fire behaviour and rate of spread being in the late afternoon of 30 December in southern NSW and continuing into the Upper Murray region of Victoria overnight through to the middle of the day on the 31st of December. The fire burnt from northwest to southeast on a path several kilometres wide and impacted Victorian communities at Walwa, Cudgewa, Corryong and Nariel Valley.

There were additional lightning strikes on the 31st of December, and the majority of these eventually joined with the UM26 fire. A portion of the fire was managed by Gippsland Region and was referred to as the Tambo 64 - Buenba - Pheasant Creek Track Fire

The following fires were mapped as part of the project and are shown in this section

- Green Valley, Talmalmo (NSW)
- Westbrook Rd, Tarcutta (NSW)
- Mount Yougal (NSW)
- Pilot Lookout (NSW)
- Geehi (NSW)
- Yellow Bog Road (NSW)
- Nine Mile Complex (NSW)
- Tambo 63 - Tom Groggin - Top Flat
- Tambo 64 - Buenba - Pheasant Creek Track
- Upper Murray 26 - Upper Murray - Walwa
- Upper Murray 28 - Wabba Wilderness - Wabba Track
- Upper Murray 29 - Staceys Bridge - Remote Radio Road

- Upper Murray 30 - Nariel Valley - Glendart Track
- Upper Murray 31 - Mt Pinnibar - Shady Creek Upper Track
- Upper Murray 32 - Gibb Range - Glamour Hill Track
- Upper Murray 33 - Mt Sassafras - Wild Boar Track
- Upper Murray 35 - Mt Gibbo - Buenba Rd

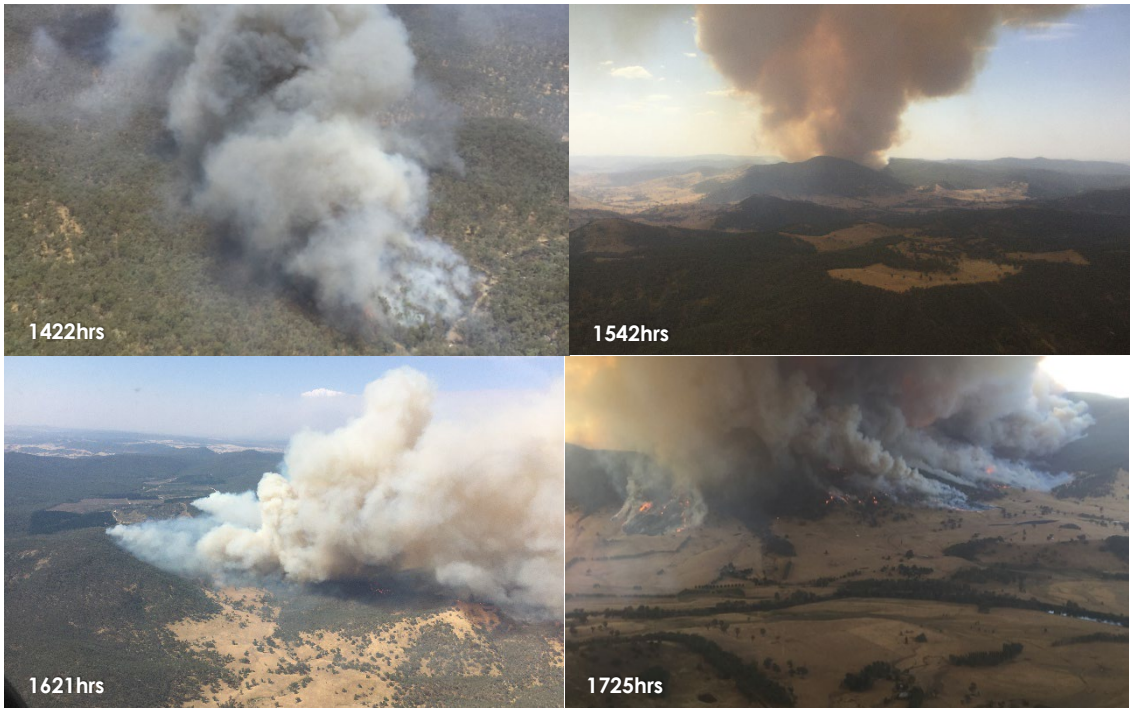


FIGURE 99: FIRE PROGRESSION OF THE GREEN VALLEY – TALMALMO FIRE FOR THE AFTERNOON OF THE 30TH OF DECEMBER 2019 (PHOTOS: J. HOPPER, K. GOYNE)

The generated vortex is shown developing at 1725hrs. This resulted in the generation of winds over 220km/h which overturned a fire tanker causing the death of RFS NSW fire fighter Samuel McPaul. The Bureau of Meteorology has investigated the incident and prepared a report for the RFS NSW - *Report on the meteorological conditions and fire-weather interaction processes that caused very destructive winds at the Green Valley, Talmalmo bushfire on 30 December 2019* (BOM, 2020)[1]. The report states that:

The environment surrounding Green Valley was broadly favourable for development of FGVs due to:

- a deep atmospheric boundary layer
- high intensity fire activity in very dry fuels
- moderate (not strong) winds above the surface
- ambient winds perpendicular to the ridgeline
- location of the fire in the lee of a ridgeline

The fire then spotted over the Murray River and ran rapidly through grassland and forest areas with spot fires contributing to the rate of

[1] The Green Valley Talmalmo/Corryong fire is described further in the report "Coupled fire-amosphere simulations of five Black Summer fires using the ACCESS-Fire model" available at: https://www.bnhcrc.com.au/publications/black-summer-fire-modelling

spread.Figure 101 and Figure 102 show the initial progression of the fire and elevation profile. The forested hills running perpendicular to the fire spread would have launched embers well ahead of the fire.

FIGURE 100: PHOTOGRAPHS TAKEN BY DELWP FIRE CREW AROUND 1730HRS 30TH DECEMBER 2019LOOKING NORTH FROM VICTORIA

FIGURE 101: ELEVATION PROFILE FOR THE FIRE RUN ON THE 30TH OF DECEMBER - ORANGE LINE IS THE BOUNDARY AT 0114 HRS MAPPED FROM LINE SCAN, THE RED ARROW IS THE HIGH POINT AT MT BURROWA.

An analysis of the data shows that by 0114 hrs on the 31st of December, thefire had travelled 32.5km in 9hrs. This equates to an average rate of spread (ROS) of 3.6km/h. By approximately 1200hrs that day the fire had travelled 67km with average ROS of 3.3km/h and by 1900hrs travelled a total of 77km by with average ROS 2.85km/h.

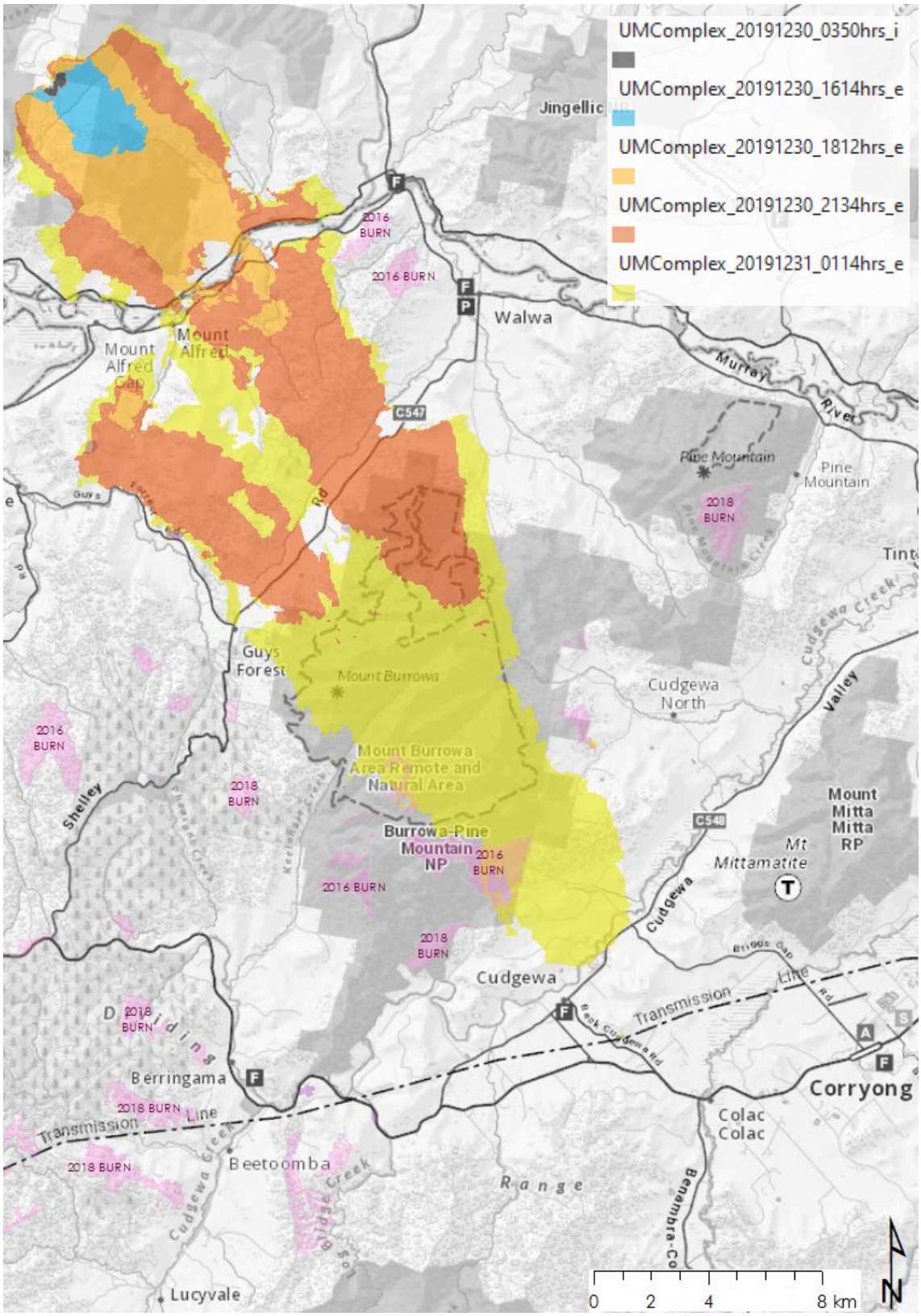


FIGURE 102: FIRE PROGRESSION UPPER MURRAY – WALWA BUSHFIRE 30TH TO 31ST OF DECEMBER 2019

Figure 103 shows the aftermath of the fire south of Corryong. Grassland areas were fully cured and totally consumed by the fire.

FIGURE 103 LOOKING SOUTH FROM CORRYONG TO SUGARLOAF RD (SHEPPARTON NEWS)

FIGURE 104: LOOKING SOUTH ON THE BENAMBRA CORRYONG RD MORNING OF THE 31ST OF DECEMBER, NARIEL VALLEY (-36.34, 147.80). THE MAIN FIRE IS TO THE LEFT OF THE RD AND SPOT FIRES CAN BE SEEN IN THE PADDOCKS (DELWP).

Figure 105 toFigure 107 show the fire spread as observed by the Himawari 8 satellite shortwave infrared (band 7). Although at a coarse scale it correlates well with line scans taken at similar times. There are some issues

with detected infrared in the plume occurring outside the boundary and the 'heat' being obscured by moisture in the plume of frontal cloud. The ten-minute interval and 10-20 minute latency makes this a very useful tool for analysis and real time monitoring. These images come from the FireWatch Landgate Pro website and have been assembled into a Google Earth animated time series with mapped fire isochrones.

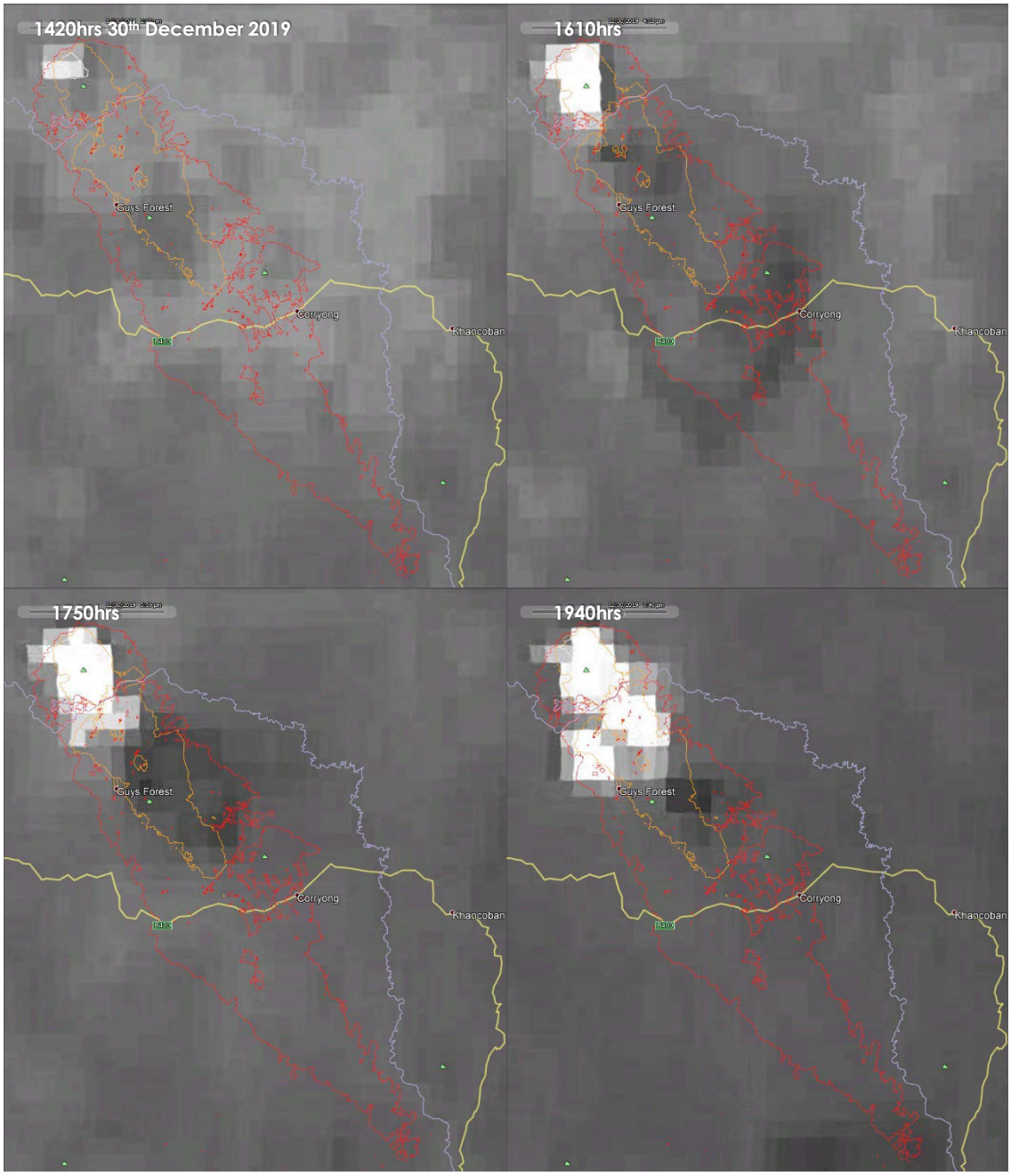


FIGURE 105: FIRE SPREAD ISOCHRONES (ORANGE-0114HRS, RED-1939HRS 31ST DECEMBER) AND 2KM GRID CELLS SHOWING HIMAWARI BAND 7 (3.9µM – SHORT WAVE INFRARED) FROM 1420HRS TO 1940HRS

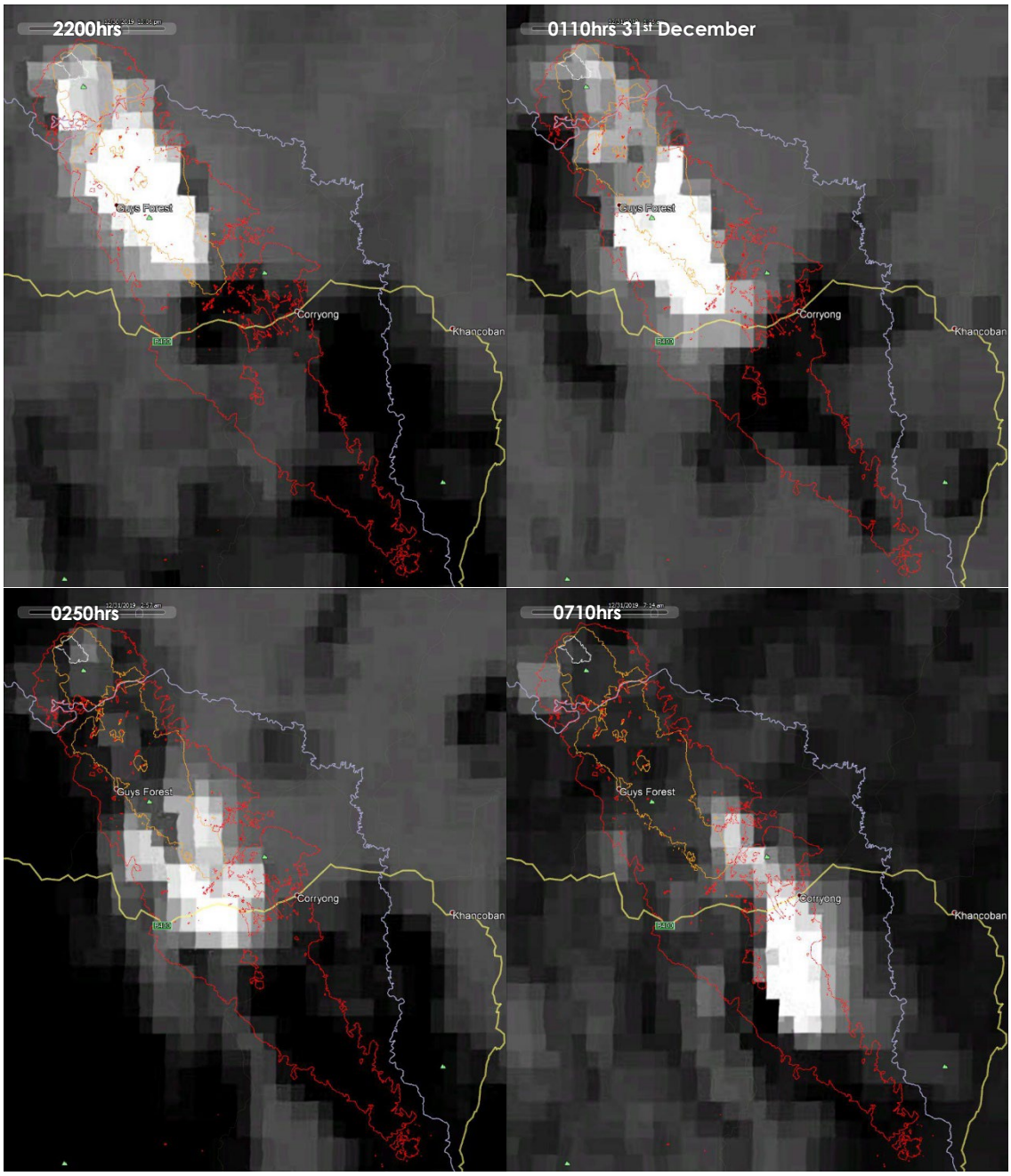


FIGURE 106: FIRE SPREAD ISOCHRONES (ORANGE-0114HRS, RED-1939HRS 31ST OF DECEMBER) AND 2KM GRID CELLS SHOWING HIMAWARI BAND 7 (3.9µM – SHORT WAVE INFRARED) FROM 2200HRS 30TH OF DECEMBER TO 0710HRS 31ST OF DECEMBER

Using the imagery has advantages over hotspot data. It is possible to see frontal cloud and convection columns and when combined with higher resolution natural colour images (during daylight hours) a very clear picture of what is occurring is often (but not always) possible. There is great potential in feeding this data into current systems such that imagery can be combined with known fire boundaries and predictions. The exact combination of bands and processing the data specifically for bushfire is an opportunity for future development. Himawari 9 has already been deployed and is due to replace Himawari 8 in 2022.

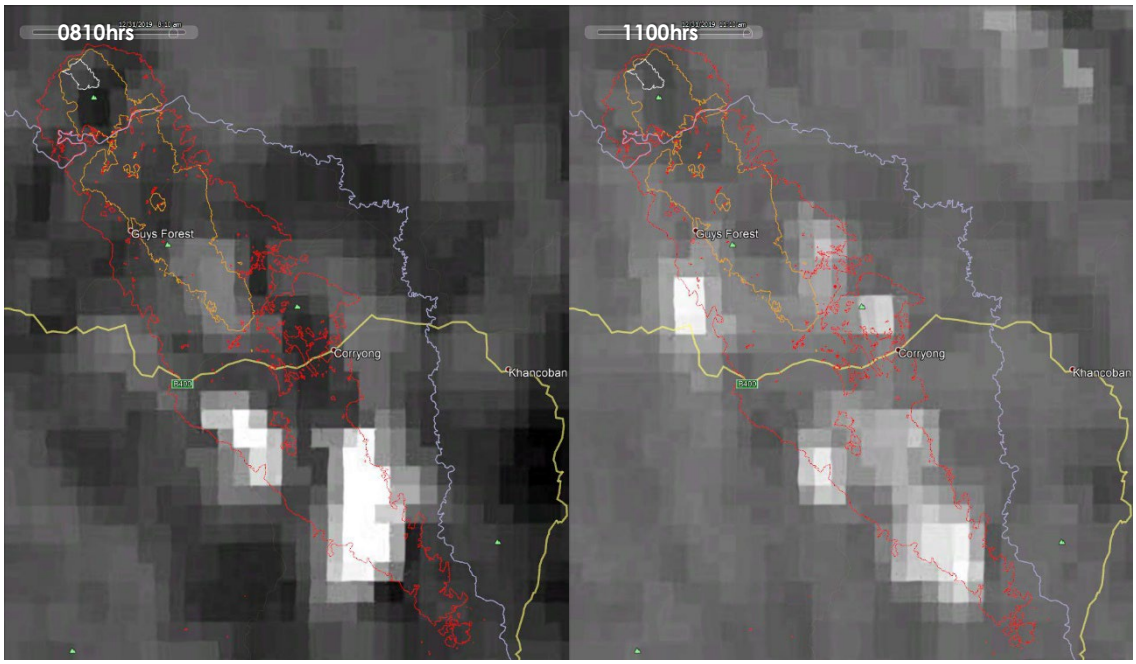


FIGURE 107: FIRE SPREAD ISOCHRONES (ORANGE-0114HRS, RED-1939HRS 31ST OF DECEMBER) AND 2KM GRID CELLS SHOWING HIMAWARI BAND 7 (3.9µM – SHORT WAVE INFRARED) FROM 0810HRS TO 1100 HRS 31ST OF DECEMBER

FIGURE 108: NARIEL VALLEY ON THE MORNING OF THE 31ST OF DECEMBER (DELWP)

FIGURE 109: WESTERN FLANK OF THE UM 26 FIRE NORTH OF BERINGAMA AT 2016HRS ON THE 31ST OF DECEMBER 2019

Imagery shows Cudgewa being impacted between 0000hr and 0100hrs and Corryong from 0300hrs onward. Also, at this time, the fire re-entered the forest and moved rapidly. The weak change did not reach higher elevations and the dry north westerlies continued to push the fire SSE. Spot fires were thrown well ahead of the fire and were burning well when the AIG helicopter arrived at 1000hrs. Several fires south of Tom Groggin were suspected to be spot fires from the Upper Murray 26 fire.

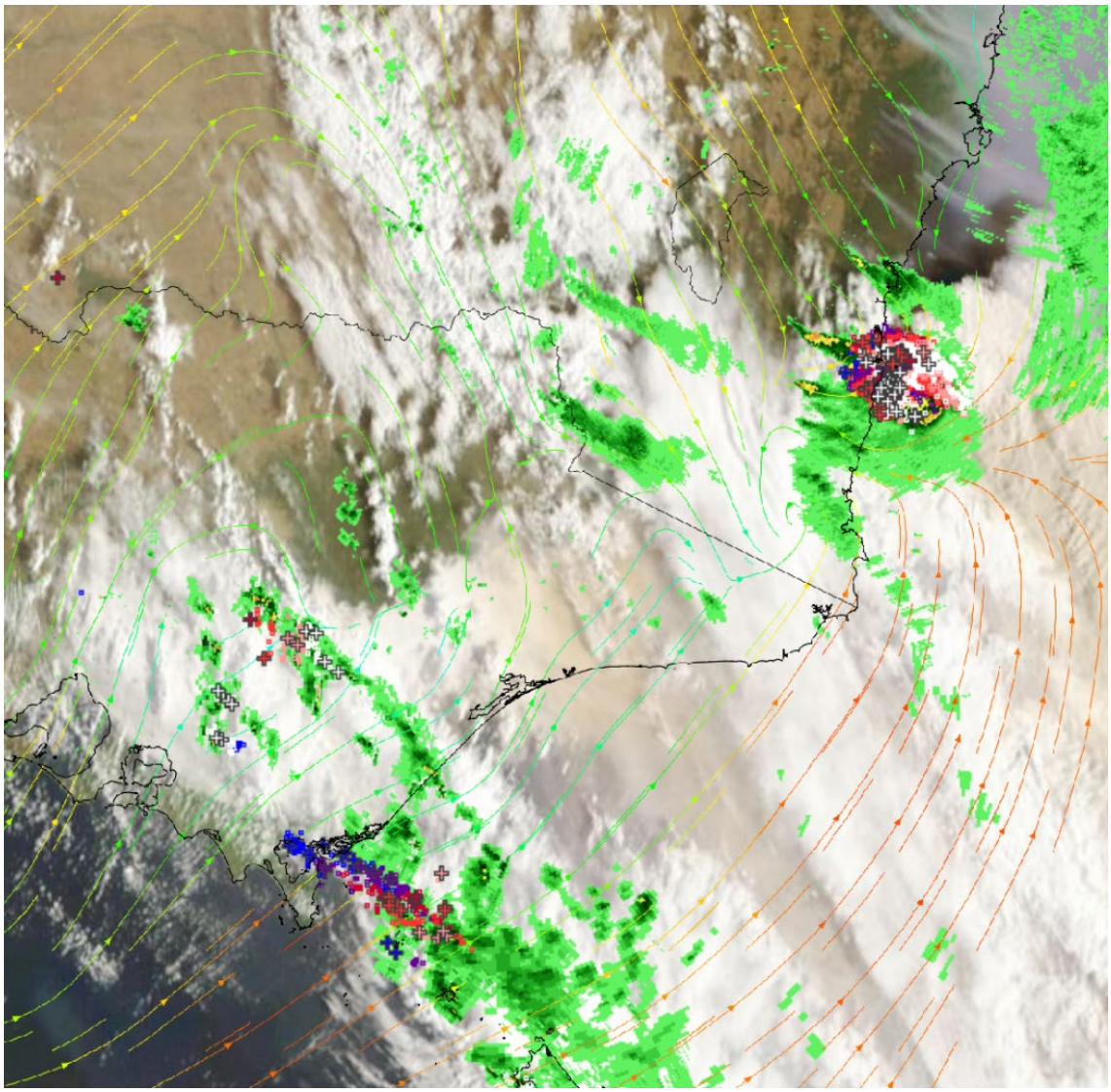


FIGURE 110 WEATHERZONE LAYERS 0900HRS 31ST OF DECEMBER 2019

Figure 110 shows the situation in the morning of December. Surface winds are shown as lines with green being weaker and red being stronger. The change has pushed further inland to the west but in the east has not passed the divide and a plume for the upper Murray fire is clearly visible on the radar at the southern end of what is still an active fire. Figure 111 shows this in greater detail and has the fire boundary (red) that was mapped by the AIG between 1000 and 1200hrs. Also, of interest in Figure 110 is the PyroCb in NSW and strong SSE winds near Mallacoota which was impacted one to two hours earlier. Not fully visible is the smoke which continues well past the south of New Zealand.

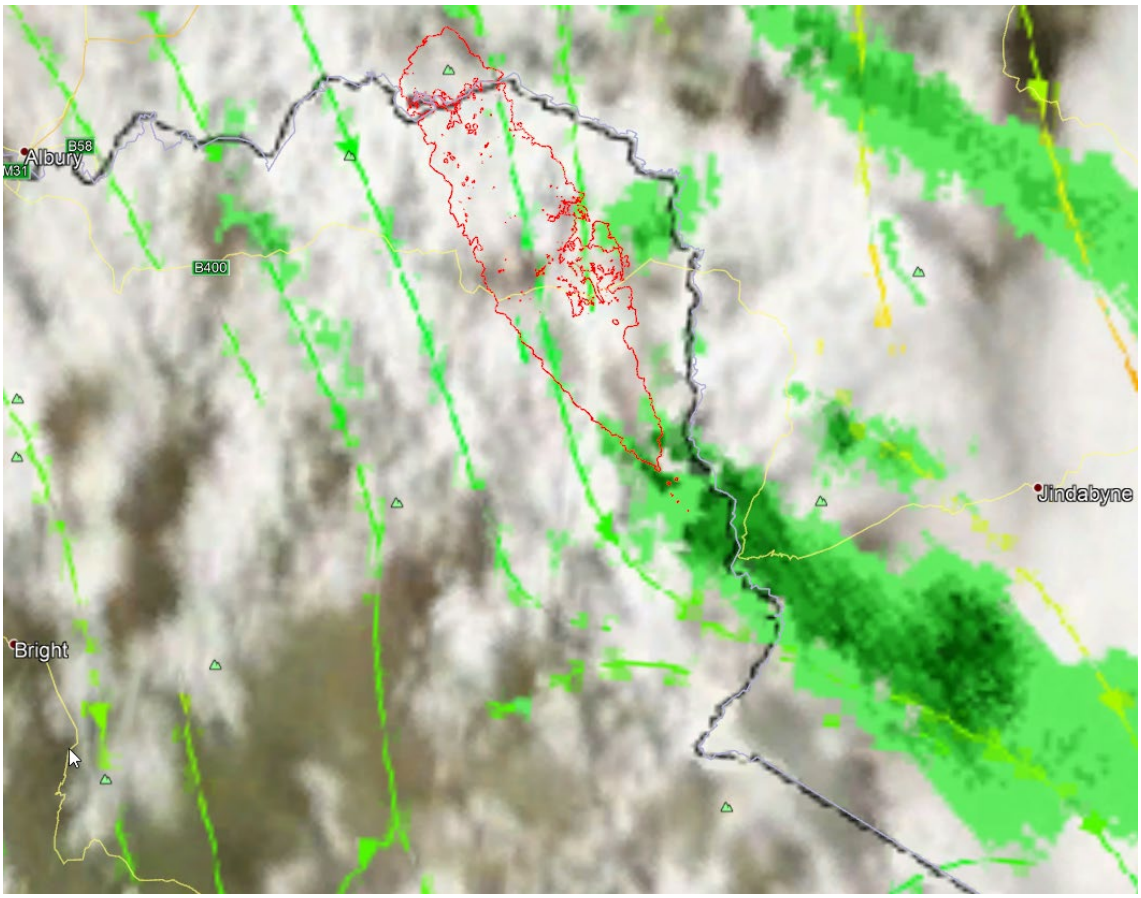


FIGURE 111: FIRE BOUNDARY 1200 OVERLAID OVER RADAR AT 0900 SHOWING FIRE STILL ACTIVE UNDER NNW WINDFLOW

Figure 112 shows the fire progression for the 31st of December to the 2nd of January 2020. In the afternoon of the 31st of December, further dry lightning storms occurred igniting at least 9 more fires in the Upper Murray District and numerous more in Tambo and Ovens Districts. The lightning and ignitions can be seen in Figure 23.

Figure 113 shows the fire progression from the 2nd to the mid-afternoon of the 4th of January. The 4th was a fire spike day and is subject of greater detail in this report. All the lightning strikes had started spreading in the early morning and had become well developed by the afternoon. The fire runs of the 4th are detailed in Figure 117 on page 89.

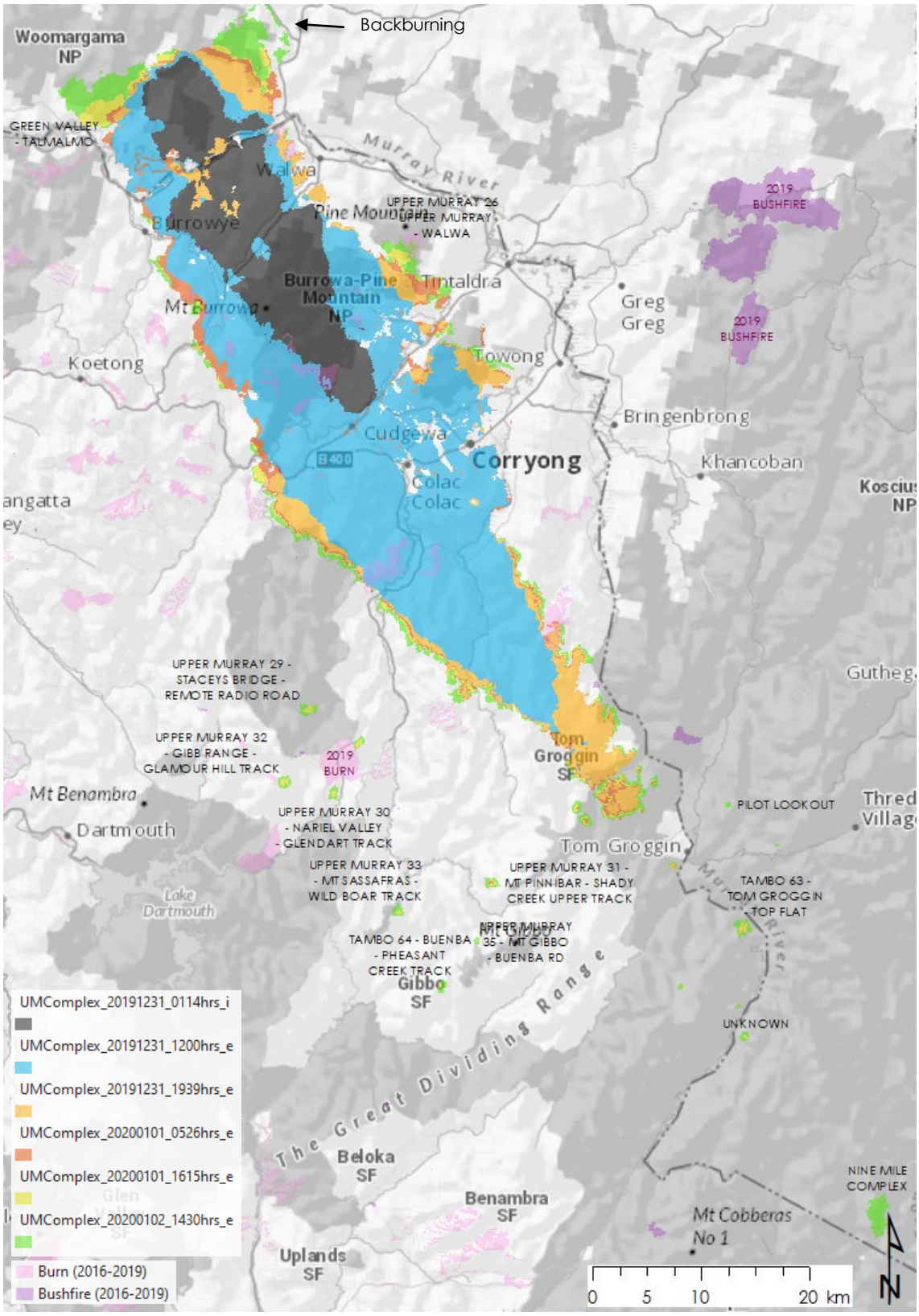


FIGURE 112: FIRE PROGRESSION UPPER MURRAY – WALWA BUSHFIRE 31ST DECEMBER 2019 TO 2ND JANUARY 2020

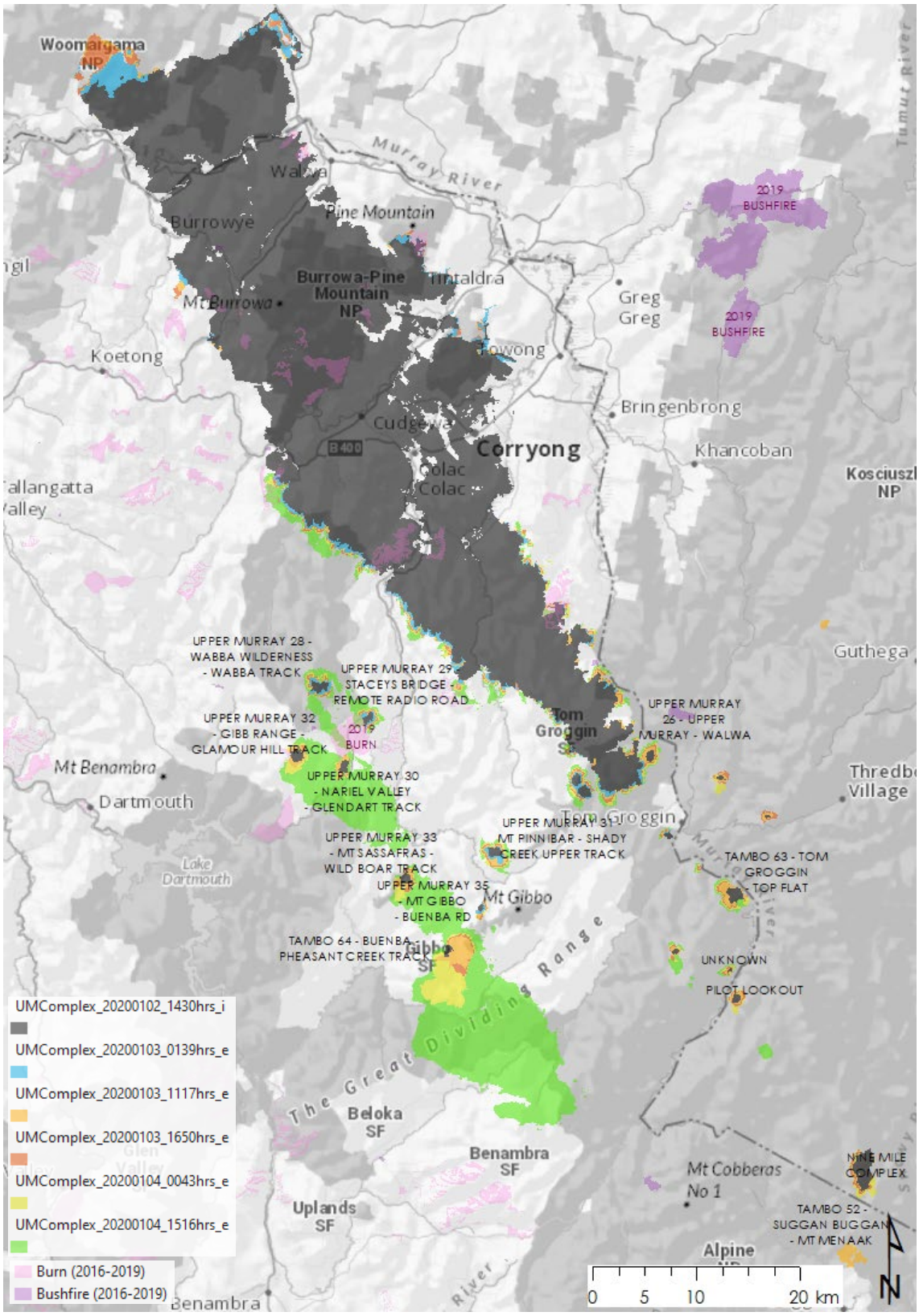


FIGURE 113: FIRE PROGRESSION UPPER MURRAY – WALWA BUSHFIRE 2ND TO 4TH OF JANUARY 2020

Weather for the 4th of January 2020

Figure 114 and Figure 115 show fire weather parameters for the nearest working stations on Cabramurra and Hunters Hill. The Khancoban AWS was not working at this time. Both stations are at elevation and provide good guidance for parts of the fire at similar elevations (800-1400m). The Thredbo (1957m) and Perisher(1735m) AWS records were also examined. Temperatures peaked at 26 and 29 degrees respectively. The FFDI at Thredbo peaked at 27 and at Perisher was estimated at 26 using a drought factor of 10.

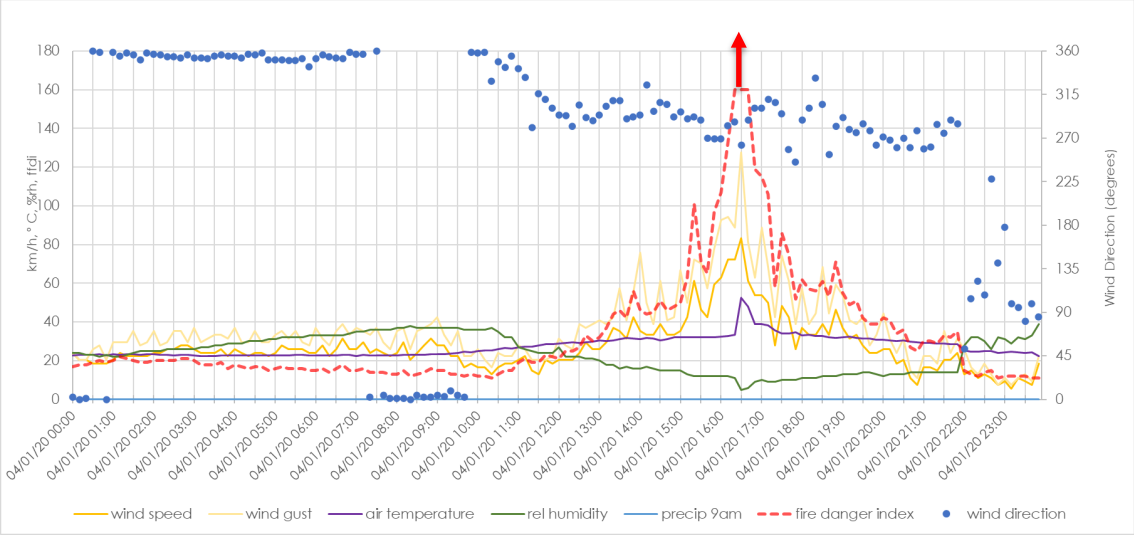


FIGURE 114: CABRAMURRA AWS – NOTE 1640HRS AND 1650HRS FFDI CALCULATED AT 429 AND 213 RESPECTIVELY DUE TO THE DUNNS ROAD FIRE IMPACTING ON THE TOWN

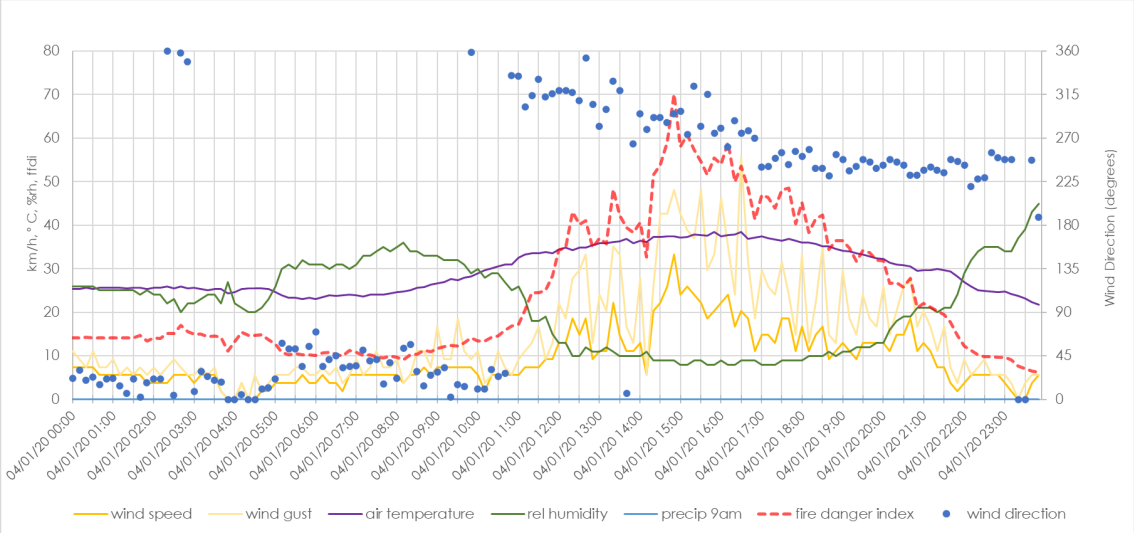


FIGURE 115: HUNTERS HILL AWS (WITH DF OF 10 APPLIED)

Synoptic charts can be found at Figure 126 on page 98.

Fire Progression of the 4th of January to 2nd of February 2020

Figure 116 shows the progression from 1516hrs on the 4th to 15th of January 2020. Fire activity had reduced significantly by 2300hrs, and it was not until the 8th of January that the cloud cleared, and imagery was able to capture the extent of the fire runs. In the days that followed the

fires slowly expanded in forested areas, direct attack and blacking out continued in the north and large backburning operations were commenced to the west.

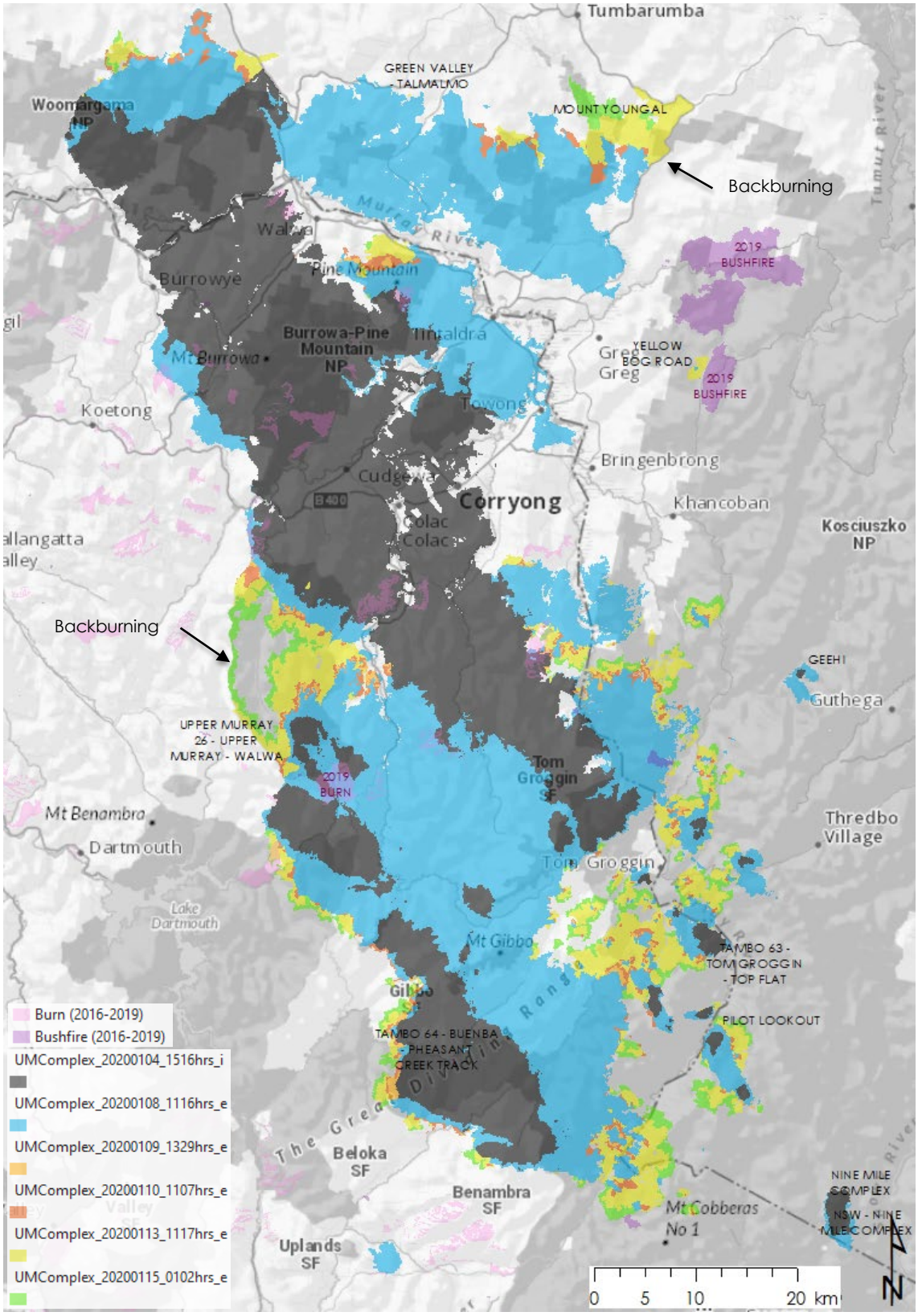


FIGURE 116: FIRE PROGRESSION UPPER MURRAY – WALWA BUSHFIRE 4TH TO 15TH OF JANUARY 2020

Figure 117 shows the times the fire runs began on the 4th.The area of fire in the Upper Murray district increased from 106,700ha on the 3rd of January to 236,300ha on the 8th of January. The section of the fires in the Tambo District increased from 1,255ha to 42,750ha for the same period

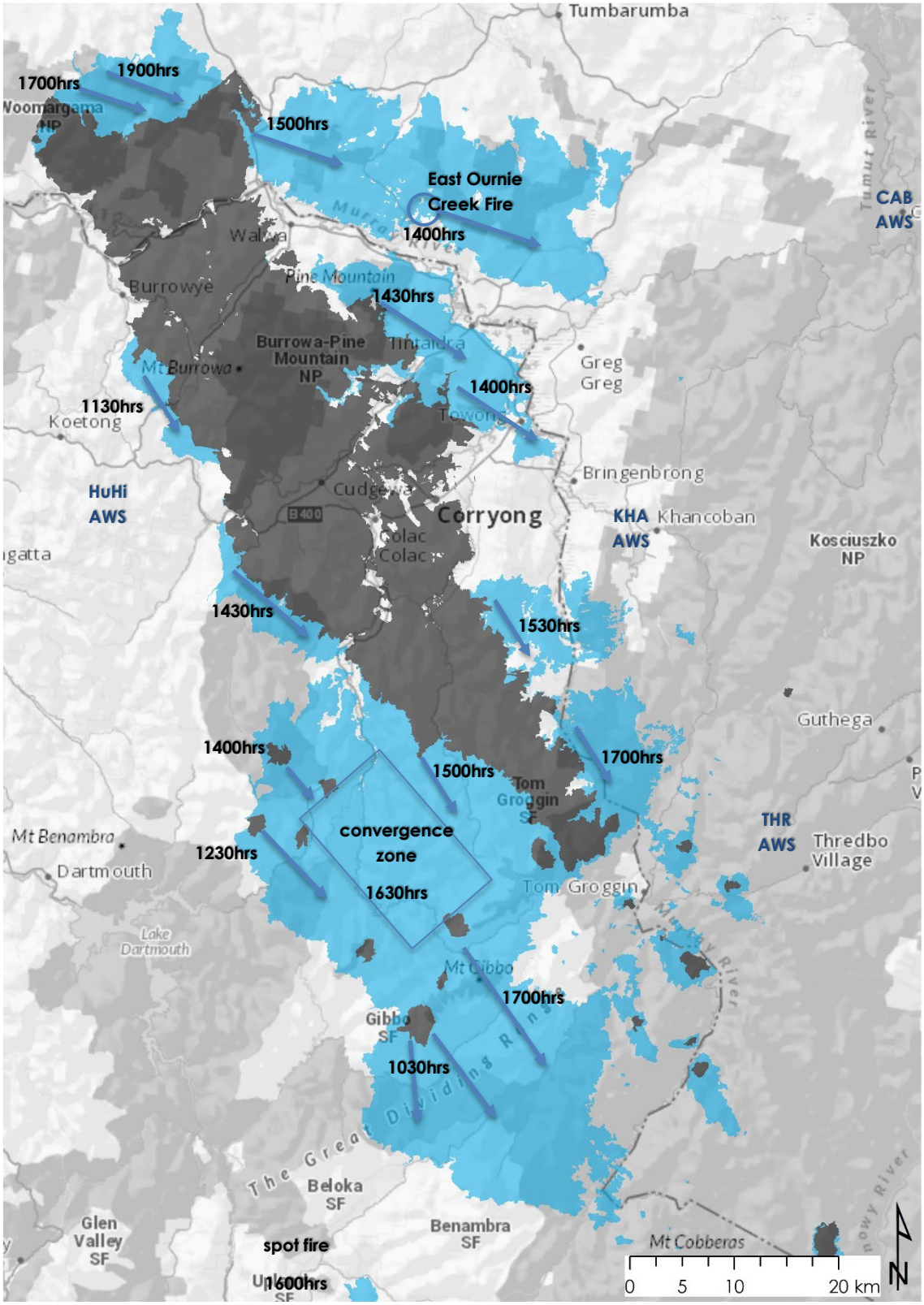


FIGURE 117: MAIN FIRE RUNS OF THE 4TH OF JANUARY 2020 AND AWS LOCATIONS

Figure 118 shows a time sequence from a 3d animation prepared for the project. It clearly shows the convergence zone and the development of the PyroCb. It also shows a similar development of PyroCb associated with the Dunns Road fire in NSW.

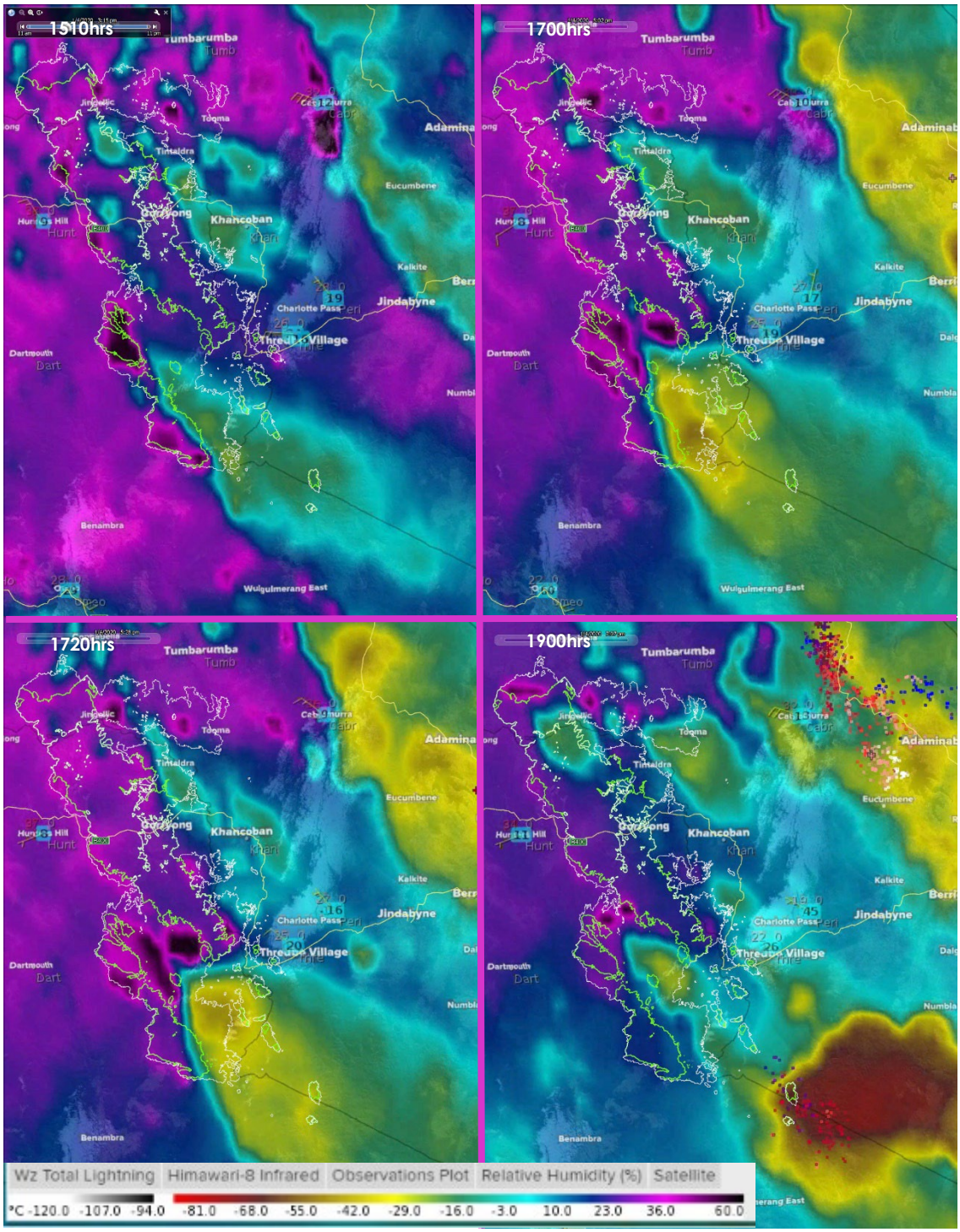


FIGURE 118: UPPER MURRAY 26 AND ADJACENT FIRES (GREEN LINE-START OF 4TH, WHITE LINE 8TH JAN)- SHOWING CONVERGENCE ZONE, PYROCB AND OTHER FIRE RUNS USING WEATHERZONE LAYER HIMAWARI IR

Figure 119 shows aerial photographs taken at around 1800hrs and the same view on the Himawari enhanced infrared satellite image.

FIGURE 119: PYROCB CLOUD ABOVE THE UPPER MURRAY 26 FIRE AROUND 1800 HRS AND WEATHERZONE LAYERS ENHANCED INFRA RED OVERLAID ON GOOGLE EARTH (CREDITS: TOP LEFT BRAD WOODS – EM DRIVE, BOTTOM BLAKE JOHNSON TWITTER)

Figure 120 shows the final days of the fire progression from 15th of January to the 4th of February 2020

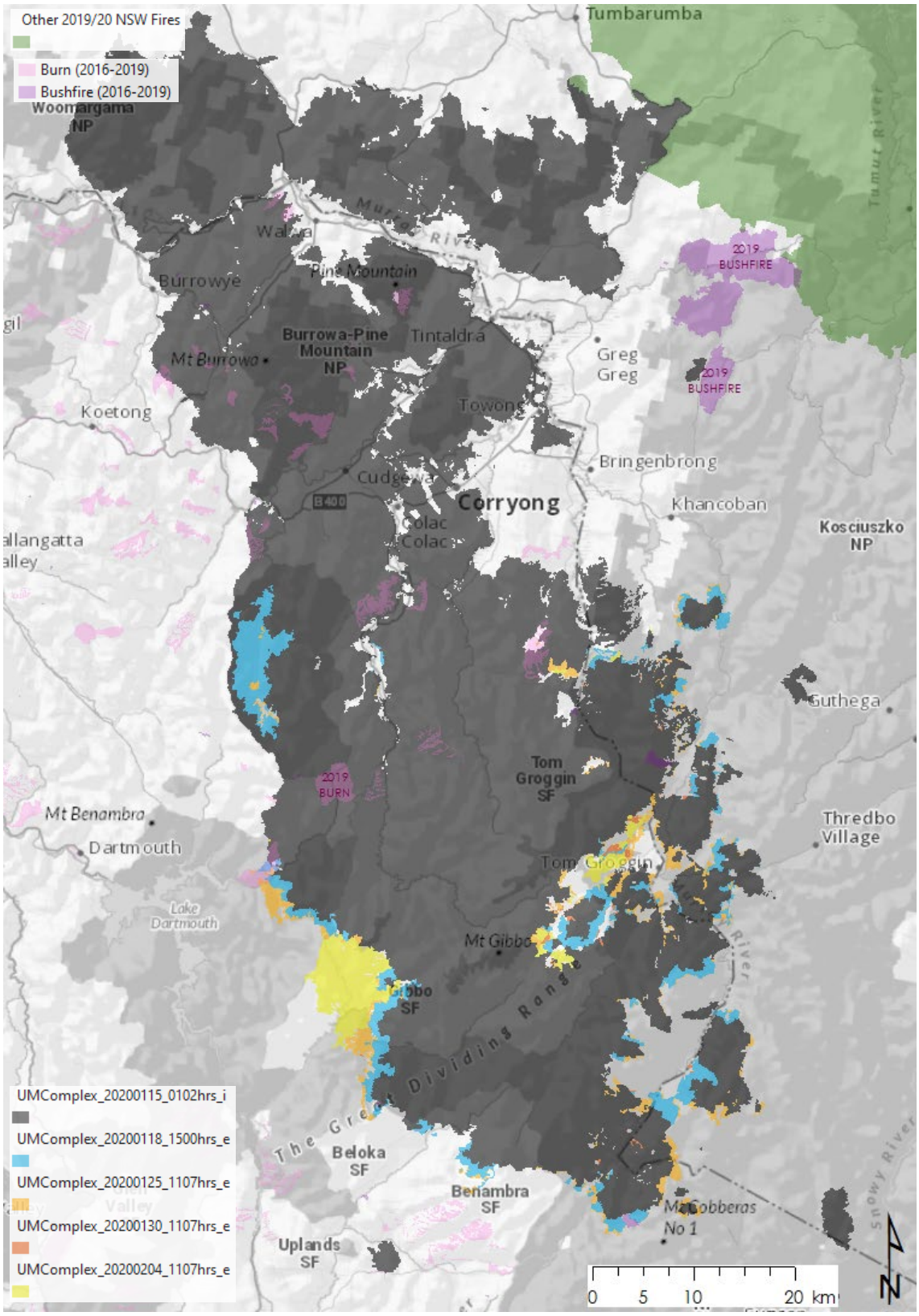


FIGURE 120: FIRE PROGRESSION UPPER MURRAY – WALWA BUSHFIRE 15TH OFJANUARY TO 4TH OF FEBRUARY 2020

TAMBO 49, 51 & 55: GELANTIPY AND SUGGAN BUGGAN

These fires were all lightning strikes on the 29th of December and developed rapidly. Matt Long (DELWP Tambo) provided a summary of the Tambo 49 bushfire as follows:

> *This was a remote lightning strike west of Seldom Seen fire tower and given all the other fire events it was not resourced. By 0600hrs on the 30th of December, the fire was estimated to be 35ha and highly active with spotting. By 1031hrs the fire was listed at 100ha and growing. The fire had moved to the SE and crossed the Buchan River leading to a significant uphill run towards the Seldom Seen Track. Weather was noted at this time to be 35°C, 13% RH and 25-35 km/hr winds from the NNW. By 1303hrs the fire had reached private property at Baldhills Road area and Gelantipy. By 1324hrs the fire size was estimated at around 3,200ha and continuing to spread. The fires continued spread overnight and joined up with other fires in the area.*

A map of the initial stages of the fire can be seen in Figure 121. The two Gelantipy fires expanded rapidly and merged. Spot fires can be seen south of Baldhills Rd. The column from this fire interacted with the Yalmy fire and may have caused spot fires near Bonang. This could be further investigated.

Figure 122 shows the initial stages of the fire in the late morning of the 30th near the Seldom Seen tower (marked on map). Figure 123 shows the developing convection column from Bindi some 33 kilometres away.

The Suggan Buggan – Mt Stradbroke fire ran rapidly and by 1600hrs was around 130ha and spotting to the SSE. By then end of the 31st of December it was 1,600ha and had impacted on large areas of farmland. Further expansion occurred in the forest on the 4th of January and the fire was close to 3,900ha before being overrun by the Tambo Complex on the 20th of January.

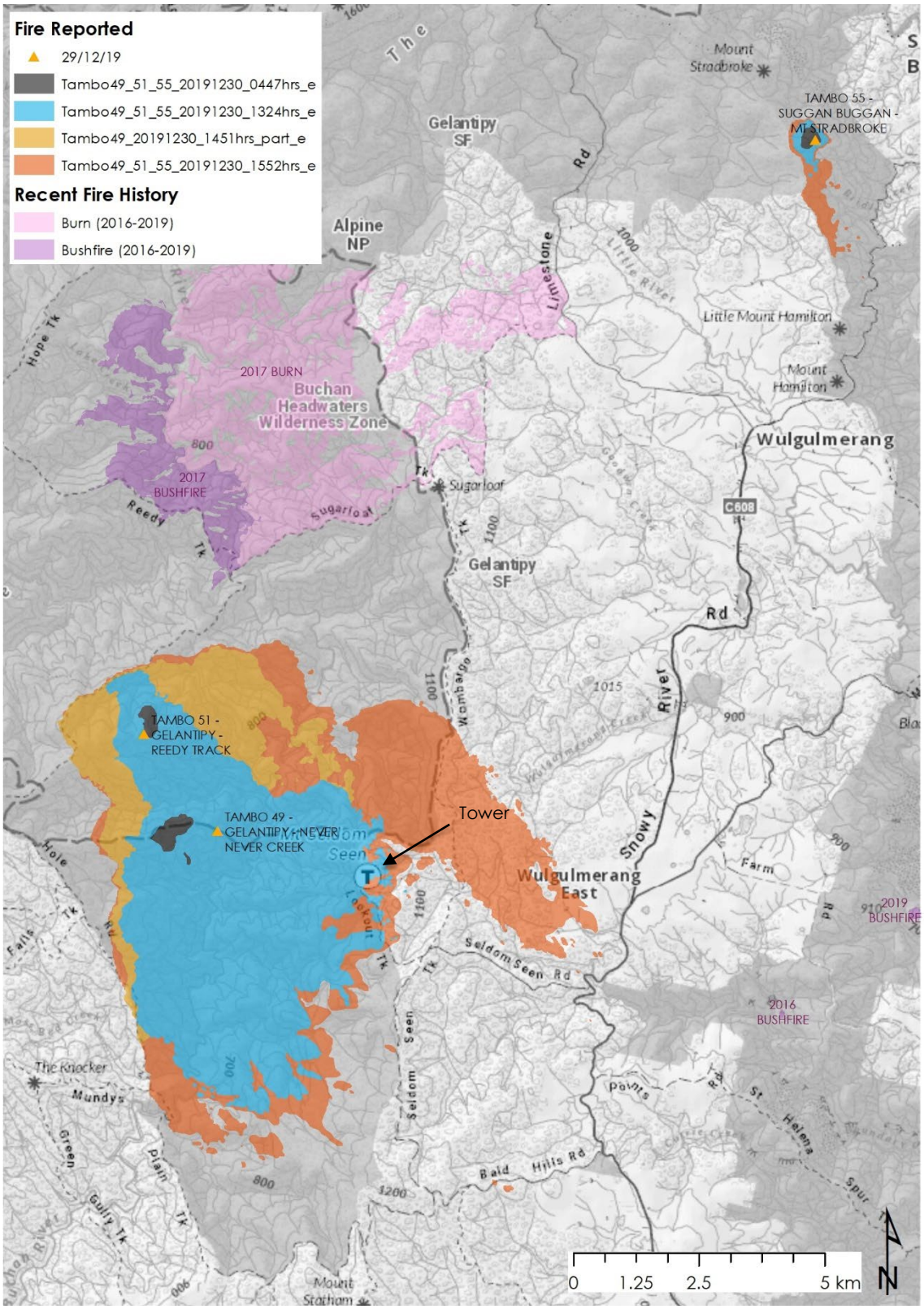


FIGURE 121: FIRE PROGRESSION OF THE TAMBO 49, 51 AND 55 FIRES

FIGURE 122: LOOKING WEST FROM THE SELDOM SEEN TOWER AROUND 1000HRS ON THE 30TH OF DECEMBER 2019 (DELWP)

FIGURE 123: 1516HRS 30TH DECEMBER FROM BINDI 33KM AWAY (DELWP EM DRIVE)

JANUARY 2020 ALPINE FIRES

This group of fires began from lightning strikes on 31st of December 2019. These lightning strikes are documented in Figure 23 on page 29. The fires occurred in the Macalister, Ovens and Tambo Districts and slowly grew until major runs occurred on the 3rd and 4th January 2020. This section of the report will examine the growth of the fires and examine the major runs on the 4th into the 5th of January 2020.

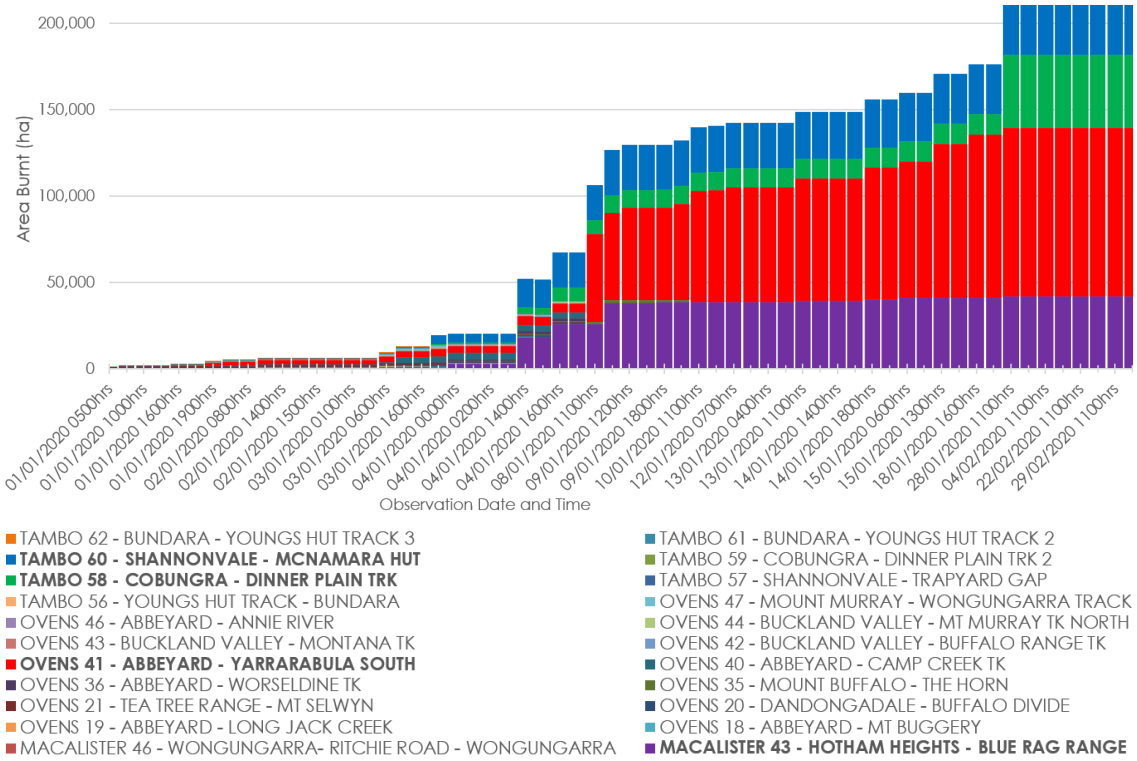


FIGURE 124: AREA GROWTH OF THE ALPINE FIRES FROM 1ST OF JANUARY TO 29TH OF FEBRUARY 2020 (NOTE THE X AXIS IS NOT LINEAR AND SHOWS THE TIME OF SCAN OR SATELLITE IMAGE)

Figure 124 shows the overall growth of the alpine fires for the months of January and February. The major fire runs occurred on the 4th into the 5th of January. The Ovens fires merged on the 10th of January with a smaller run. After this date most of the growth was from backburning and burning out.

The following sections look at the weather, the Ovens District fires, the Macalister and Tambo District fires, and finally some of the characteristics of the fire runs.

Weather for the Alpine Fires

Weather from the 31st of December 2019 to the 3rd of January 2020

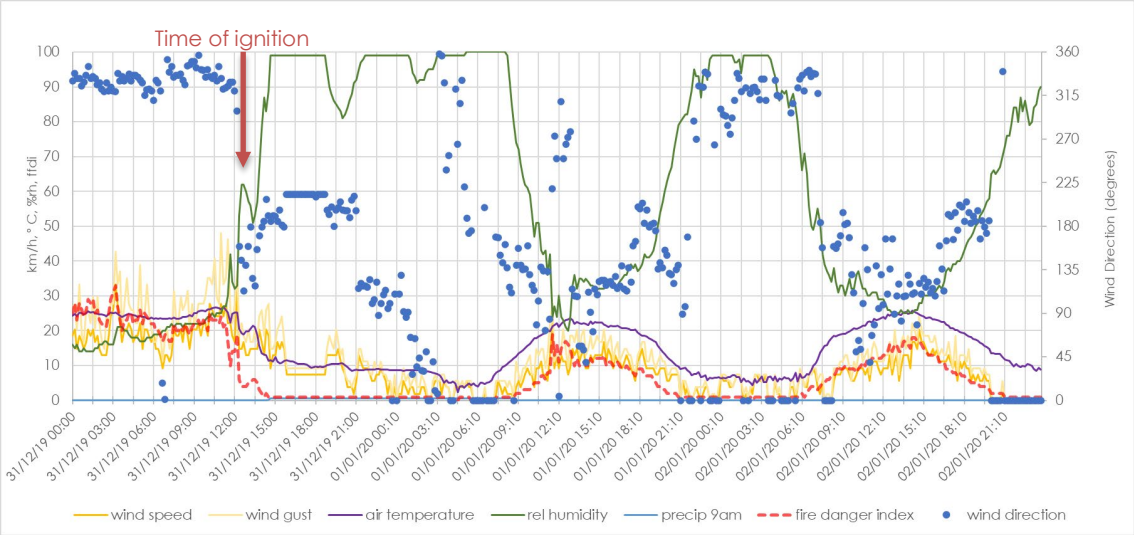


FIGURE 125: 3-DAY WEATHER OBSERVATIONS FOR MT HOTHAM AIRPORT - 31ST OF DECEMBER TO 2ND OF JANUARY 2020

Following the hot weather and the Very High fire danger of the 29th of December, conditions in the Alpine area for the 31st of December began with NNW winds, temperatures in the mid-20s, and FFDIs between 20 and 35. At around 1300 a predominantly dry change (0.6mm rain at Mt Hotham AP) with lightning came through the area igniting many fires. Conditions in the following days (see Figure 125). Conditions remained mild with winds under 10km/h, temperatures in the low 20s and high humidity overnight. The KBDI at Mt Hotham was 97 and the underlying dryness of fuels allowed the fires to steadily expand.

Weather for 4th and 5th of January 2020

Strong hot dry north westerlies ran for much of the 4th of January followed by a cold front south of the divide. The NW winds prior to the cold front were 30-55km/h and caused the FFDIs to spike to 75-85 in some areas of the fire ground. The arrival of the cold front caused a rapid end to the fire runs south of the divide, but to the north this was not the case.

The late run to the north by the Abbeyard - Yarrarabula fire was significant and difficult to predict. The weather pattern was conducive to downslope southerly winds given the height of the inversion and building high pressure ridge south of Victoria, while an inland trough only adds to the increasing pressure gradient. Downslope winds can be quite fierce in strength, especially if channelled in a similar orientated valley (pers comm Kevin Parkyn, BOM).

Synoptic charts from 0500hrs on the 4th to 0000hrs on the 5th of January can be seen in Figure 126. They show a large blocking high present until a cold front and south westerly change arrives in the late afternoon

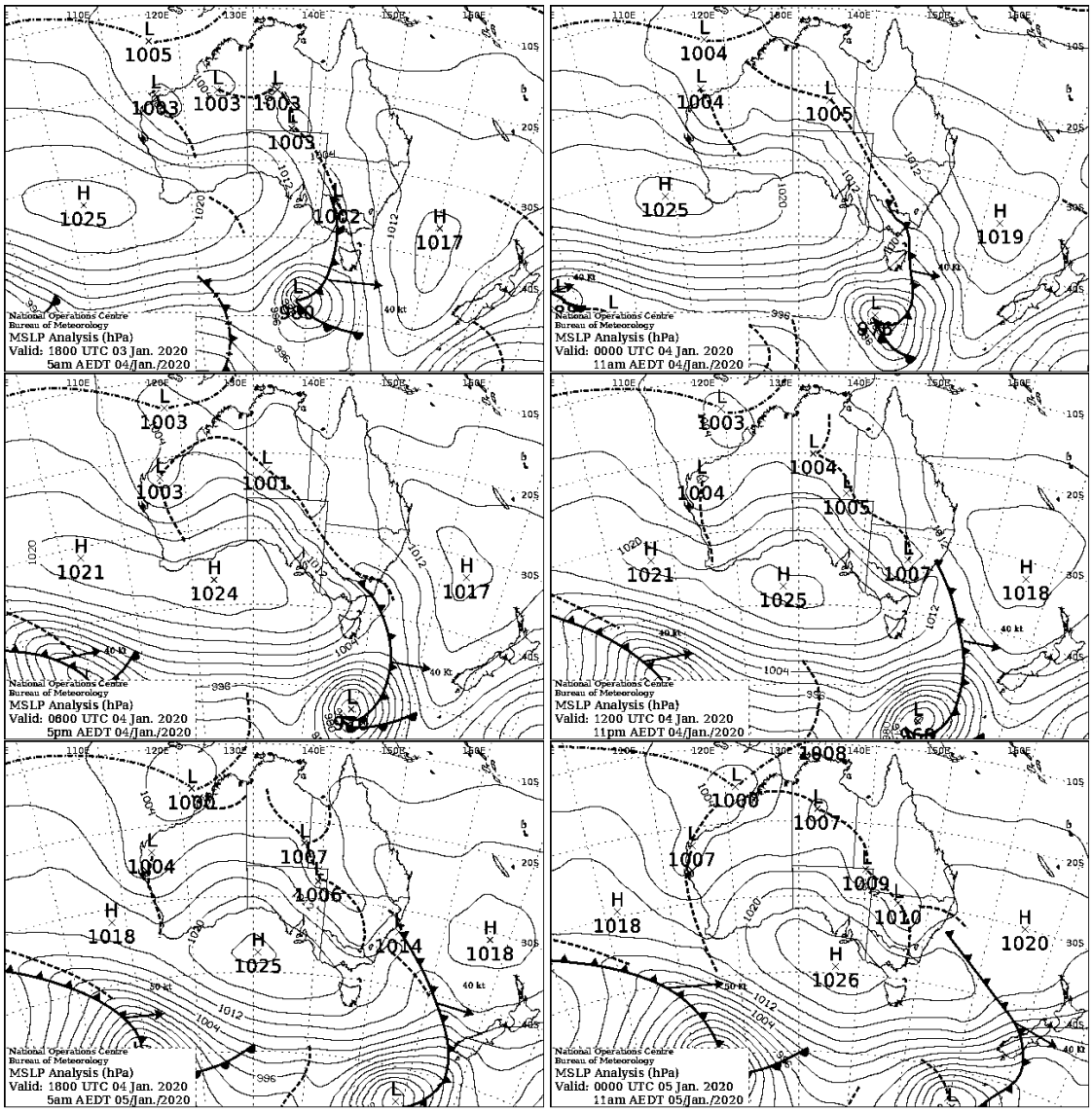


FIGURE 126: SYNOPTIC CHARTS 0500HRS 4TH OF JANUARY TO 1100HRS 5TH OF JANUARY 2020.

Weather records for adjacent stations can be seen in Figure 127 to Figure 131. There is significant variation in the timing and strength of the change. Data has been included for a Weather Underground personal weather station in Myrtleford in Figure 132. Its shows much drier air and warmer temperatures at lower elevations for the morning of the 5th. This may help explain the significant and ongoing spread. The study of the weather conditions for this day has been identified as an opportunity for further investigation.

The cool change was rapid and dropped the fire danger index to close to zero on arrival. This was responsible for stopping the spread of the many active fronts and spot fires at higher altitudes and south of the divide.

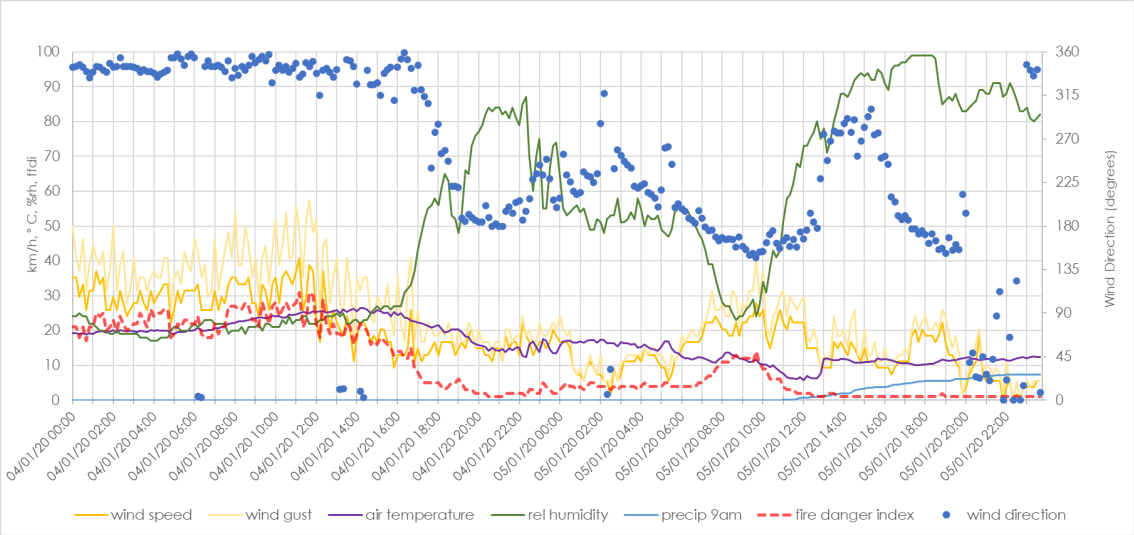


FIGURE 127: MT BULLER AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

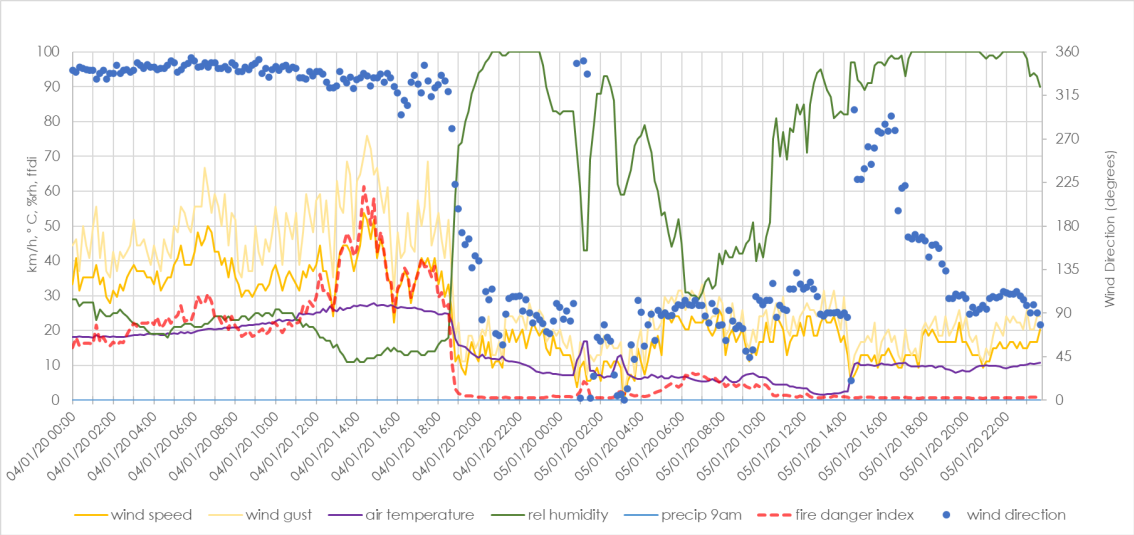


FIGURE 128: MT HOTHAM AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020 (USING DF OF 8.2)

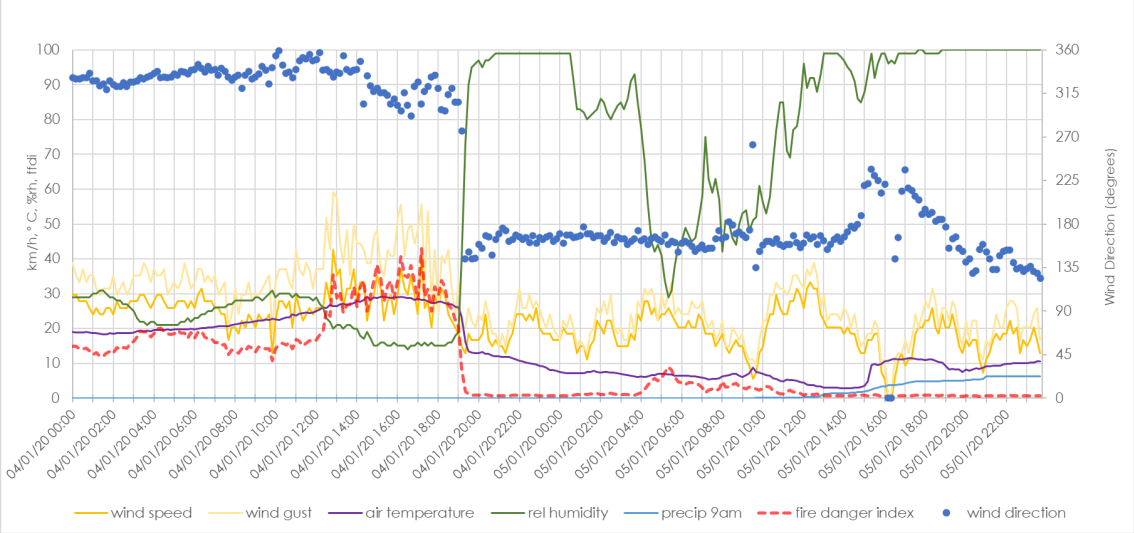


FIGURE 129: FALLS CREEK AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020 (USING A DF OF 8.6)

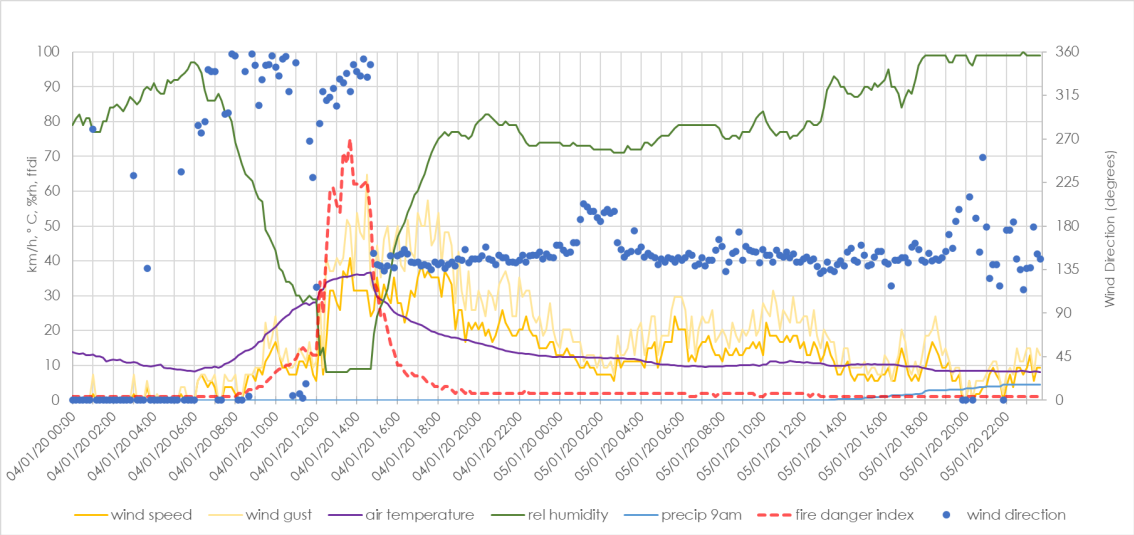


FIGURE 130: OMEO AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

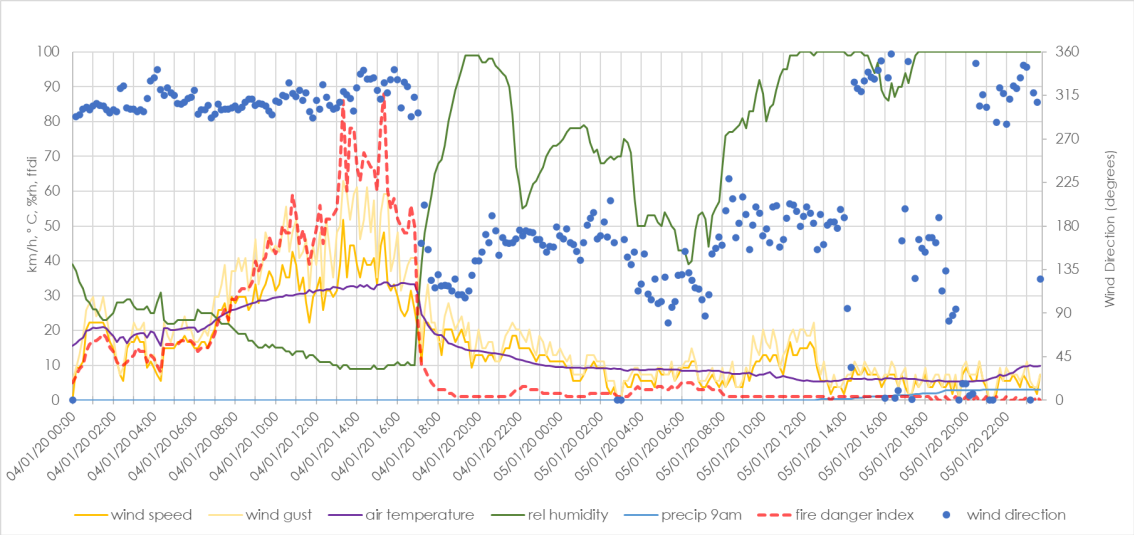


FIGURE 131: MT HOTHAM AP AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

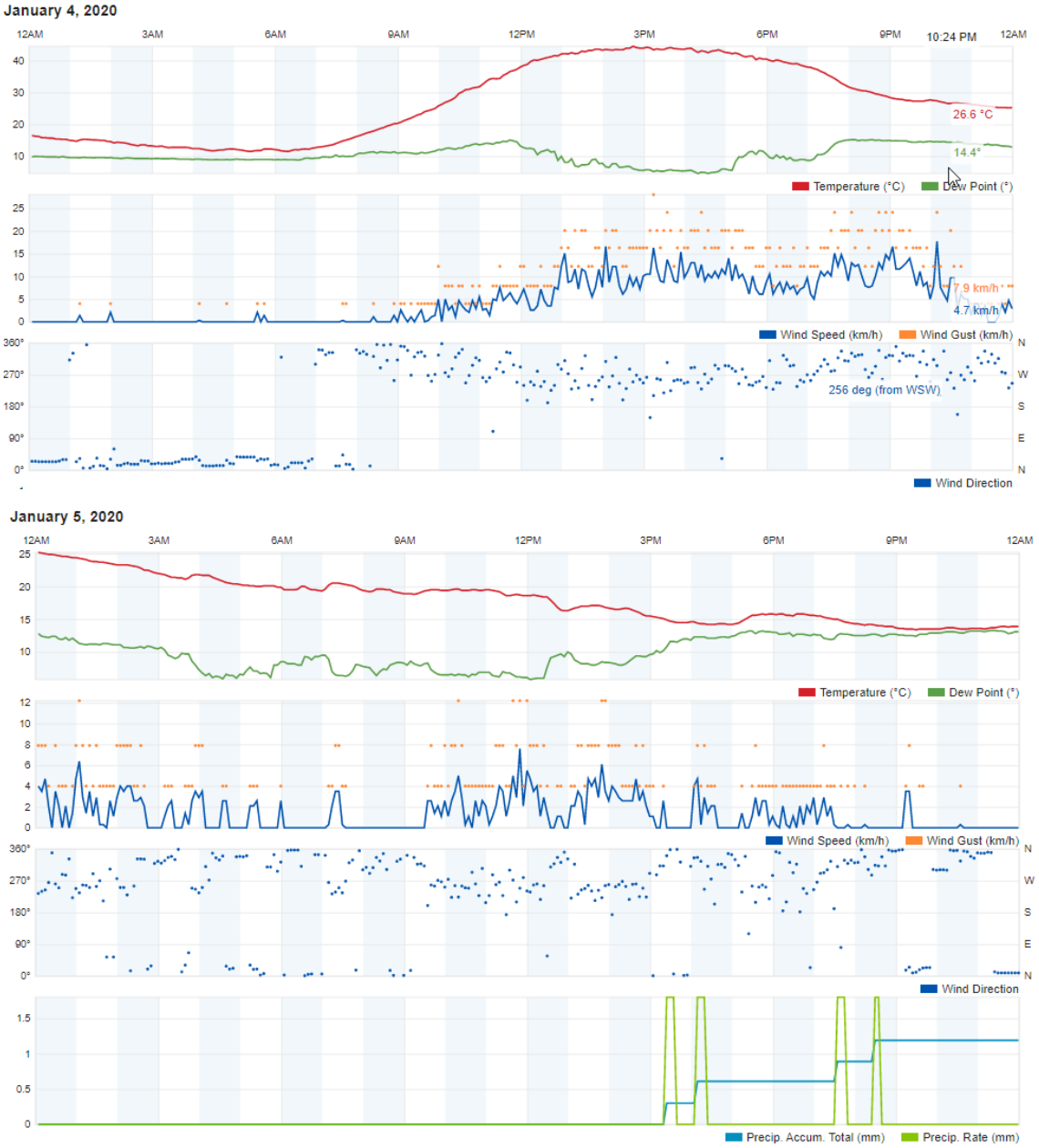


FIGURE 132: MYRTLEFORD PERSONAL WEATHER STATION DATA FOR THE 4TH AND 5TH OF JANUARY 2020 (36.547° S, 146.729° E, 225M ASL)

https://www.wunderground.com/dashboard/pws/IMYRTL1/graph/2020-01-5/2020-01-5/daily

Ovens District Fires

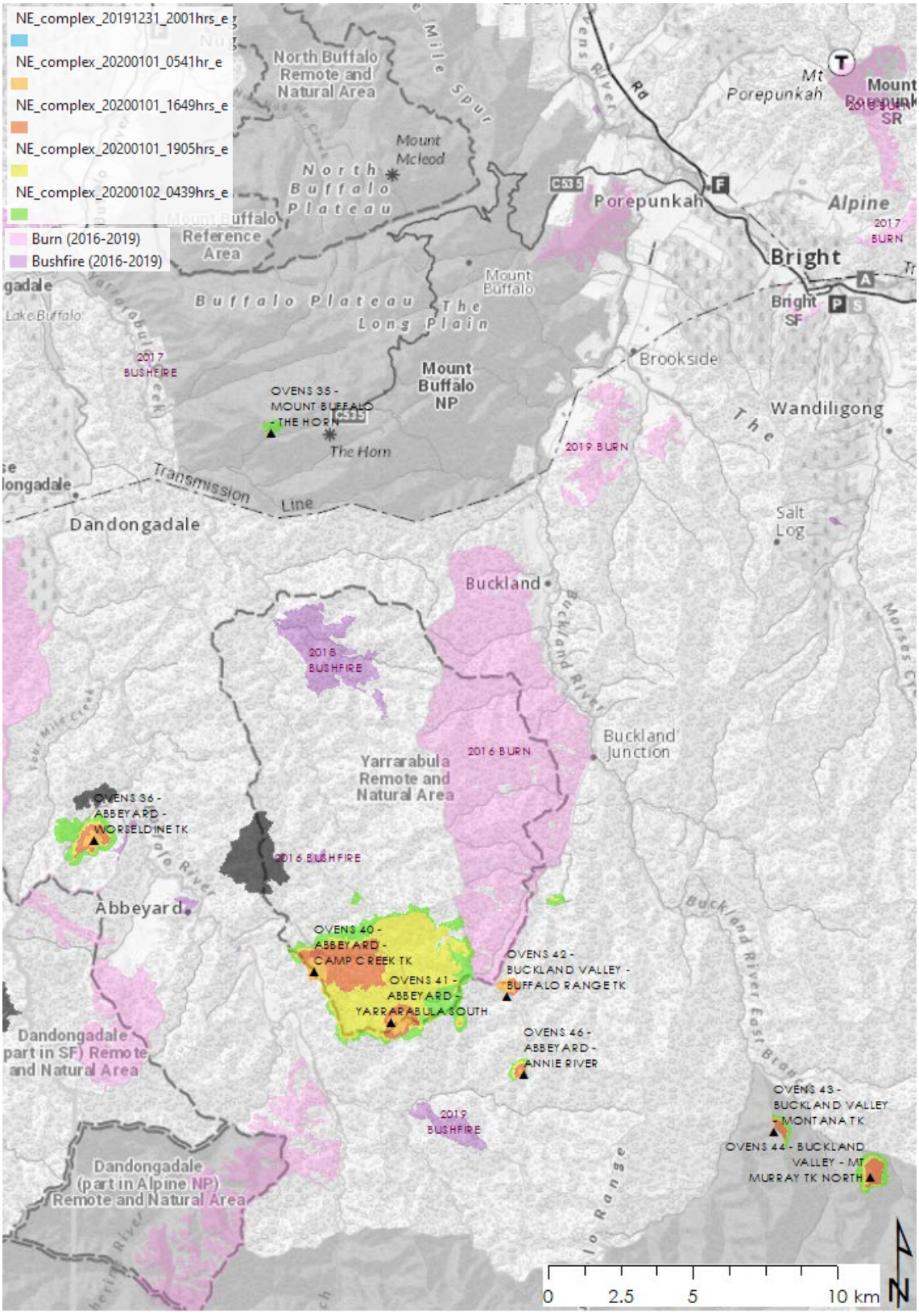


FIGURE 133: OVENS DISTRICT FIRES 31ST OF DECEMBER 2019 TO 2ND OF JANUARY 2020

Multiple lightning strikes on the afternoon of the 31st of December caused eight individual fires. Figure 133shows the initial development of the fires from the 31st of December to the 2nd of January. Although the

fire danger rating remained low, the underlying fuel dryness caused the fires to move during the daytime and exhibit short distance spotting.

FIGURE 134: ABBEYARED CAMP CREEK TRACK MERGING WITH ABBEYARD- YARRARABULA SOUTH AND BUCKLAND VALLEY - BUFFALO RANGE TK UNDERNEATH THE COLUMN 1821 HRS 1ST JANUARY 2020 (PHOTO QINTON PAKAN-36.867, 146.822)

Figure 134 shows the significant expansion of the fires under mild conditions.

Prior to the spike day on the 4th of January, all but one of the fires in the Ovens district continued to increase in size despite suppression efforts. Figure 135 shows the fire expansion to 0006hrs on the 4th of January. Figure 136 shows the growth of the fires that occurred on the 4th and into the 5th of January.

Note: The map legend shows time of imagery – The area denoted 20200108-1117hrs was the first available image that showed the fire run from 1430hrs on the 4th of January to the early morning of the 5th of January.

Figure 148 on page 113 shows the time that runs commenced and ended. This information has been derived from line scans and Himawari IR imagery. The major run down the Buffalo River valley overnight was not expected and is a good candidate for further study of weather, fuels and fire behaviour.

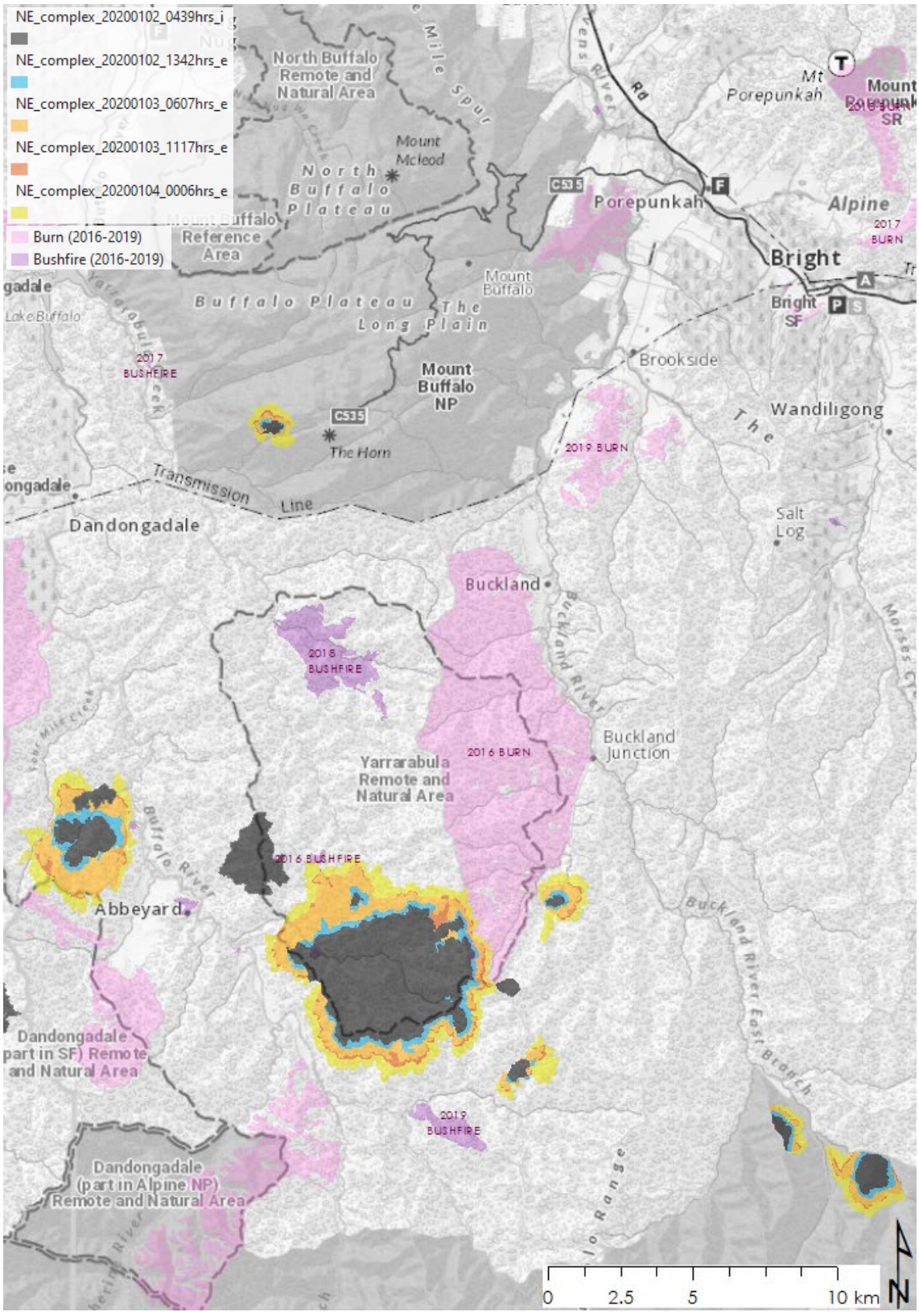


FIGURE 135: OVENS DISTRICT FIRES 2ND TO 4TH OF JANUARY 2020

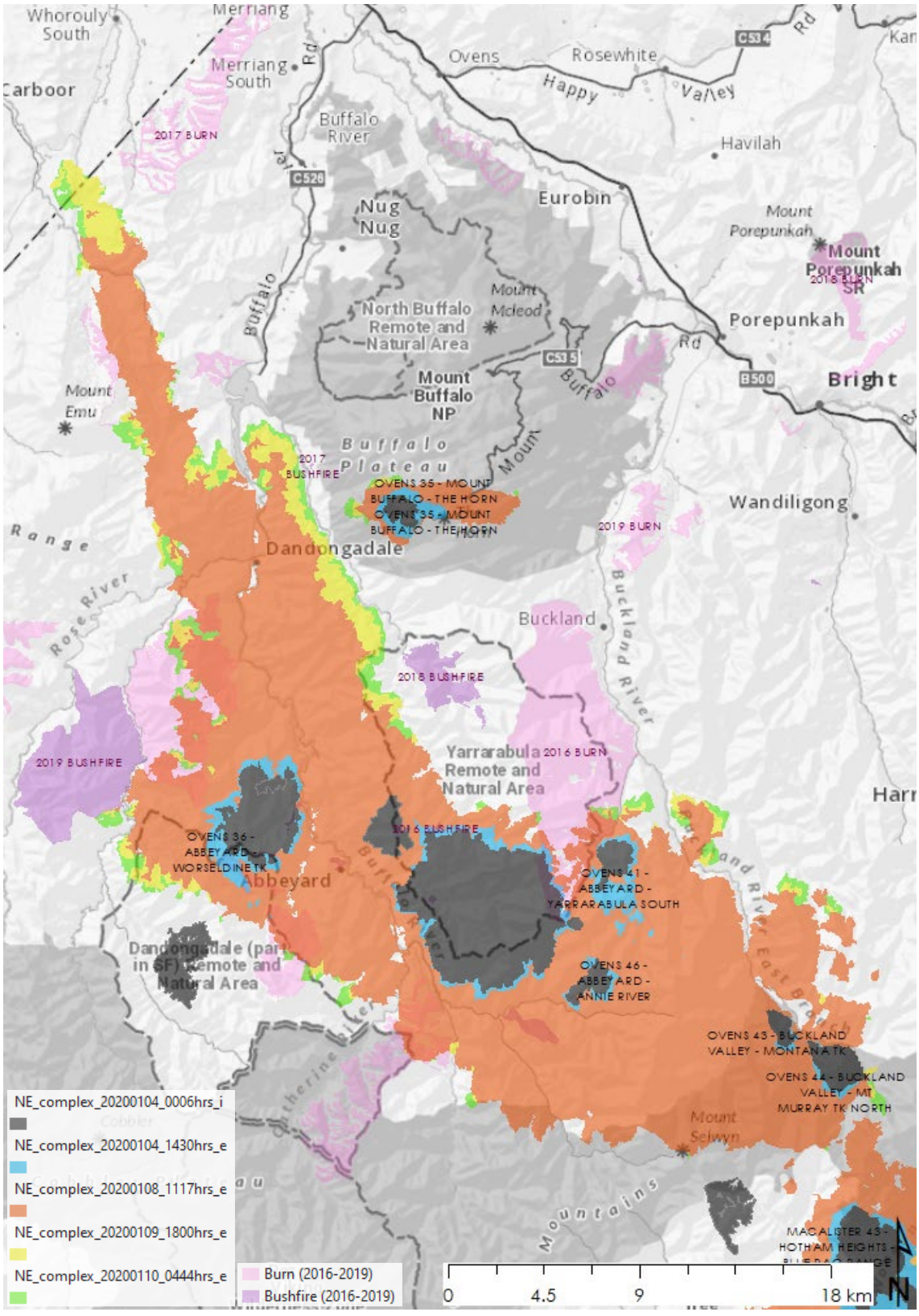


FIGURE 136: OVENS DISTRICT FIRES 4TH TO 10TH OF JANUARY 2020

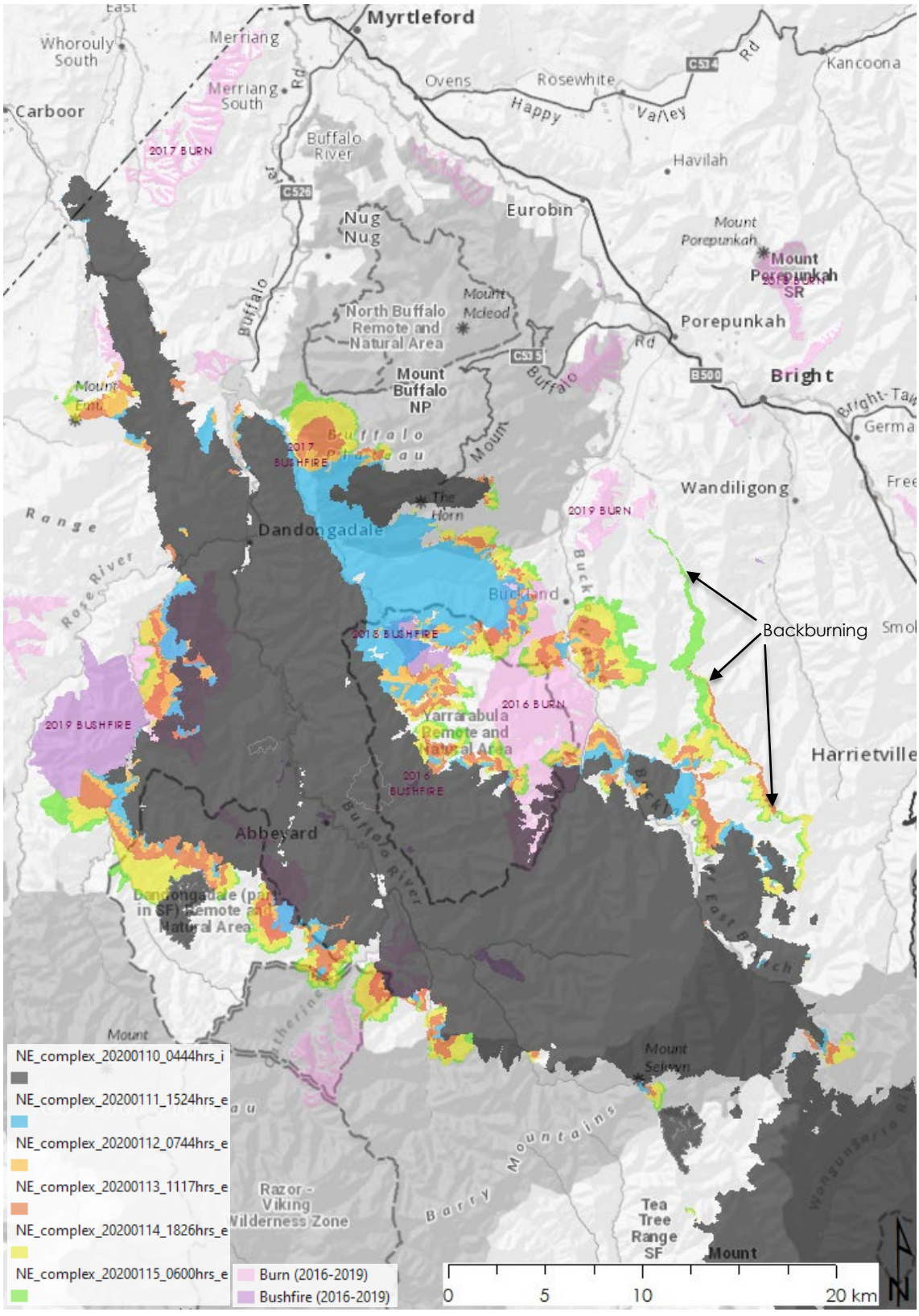


FIGURE 137: OVENS DISTRICT FIRES 10TH TO 15TH OF JANUARY 2020

Figure 137 and Figure 138 show the fire spread of the Ovens District fires and the start of the Demon Ridge Backburn (see https://www.facebook.com/watch/?v=672074510291606). Elsewhere the relatively benign conditions saw the fire spread slowly. Toward the west the fire was slowed by previous burning and bushfires from 2018/19 and 2019/20.

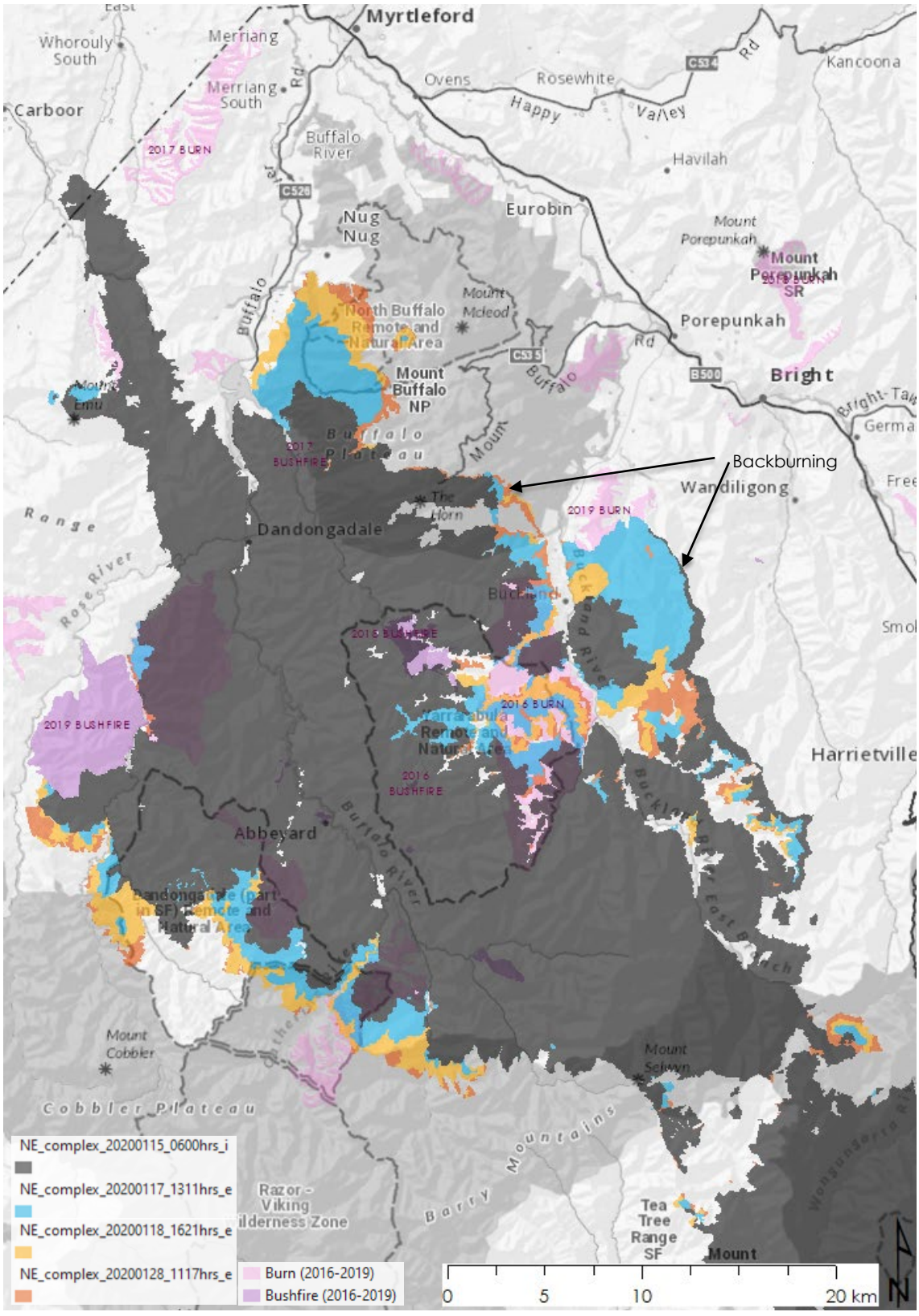


FIGURE 138: OVENS DISTRICT FIRES 15TH TO 28TH OF JANUARY 2020

Figure 138 shows the final spread of the fire with the Demon Ridge backburn almost fully burnt out and the northward expansion of the fire on the east of the Buffalo Plateau. Conditions moderated with rainfall eventually and suppression stopping all fire spread.

Macalister and Tambo Fires

This section describes the fires that began from lightning on the 31st of December 2019 south of the Great Dividing Range. Figure 139 and Figure 140 show the increase in size and activity to 0006hrs on the 4th of January.

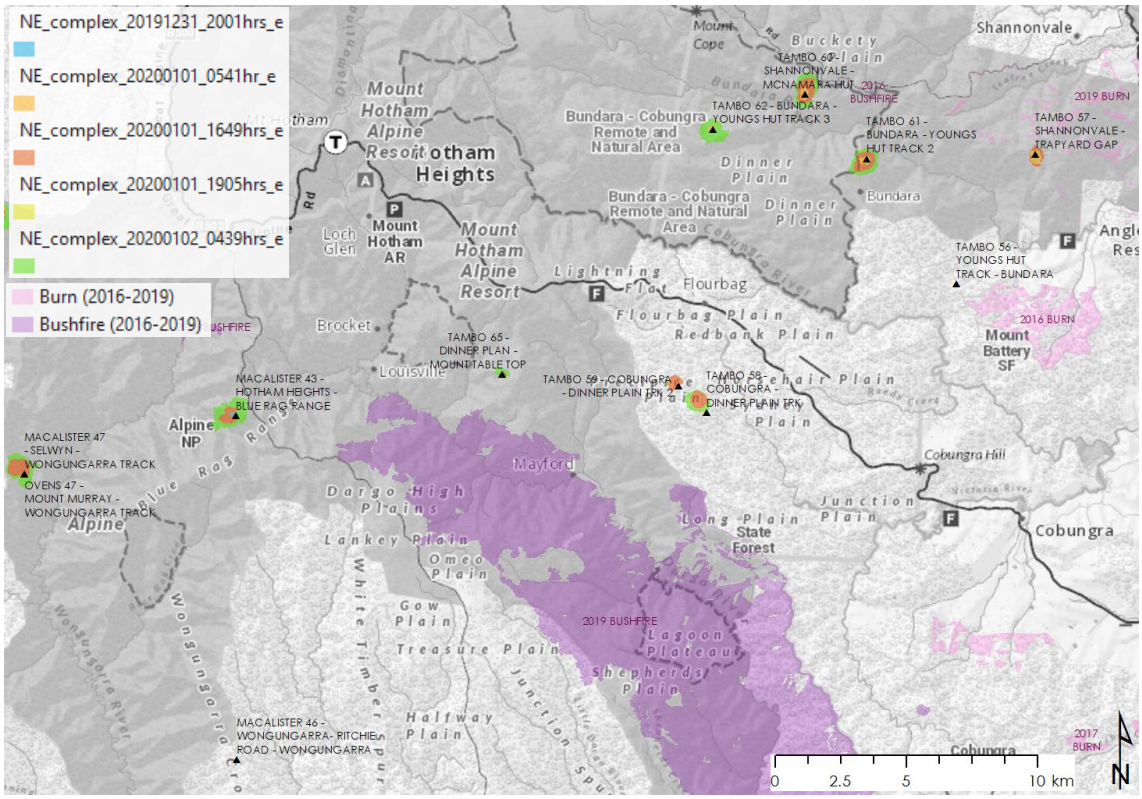


FIGURE 139: MACALISTER AND TAMBO DISTRICT FIRES 31ST DECEMBER 2019 TO 2ND OF JANUARY 2020

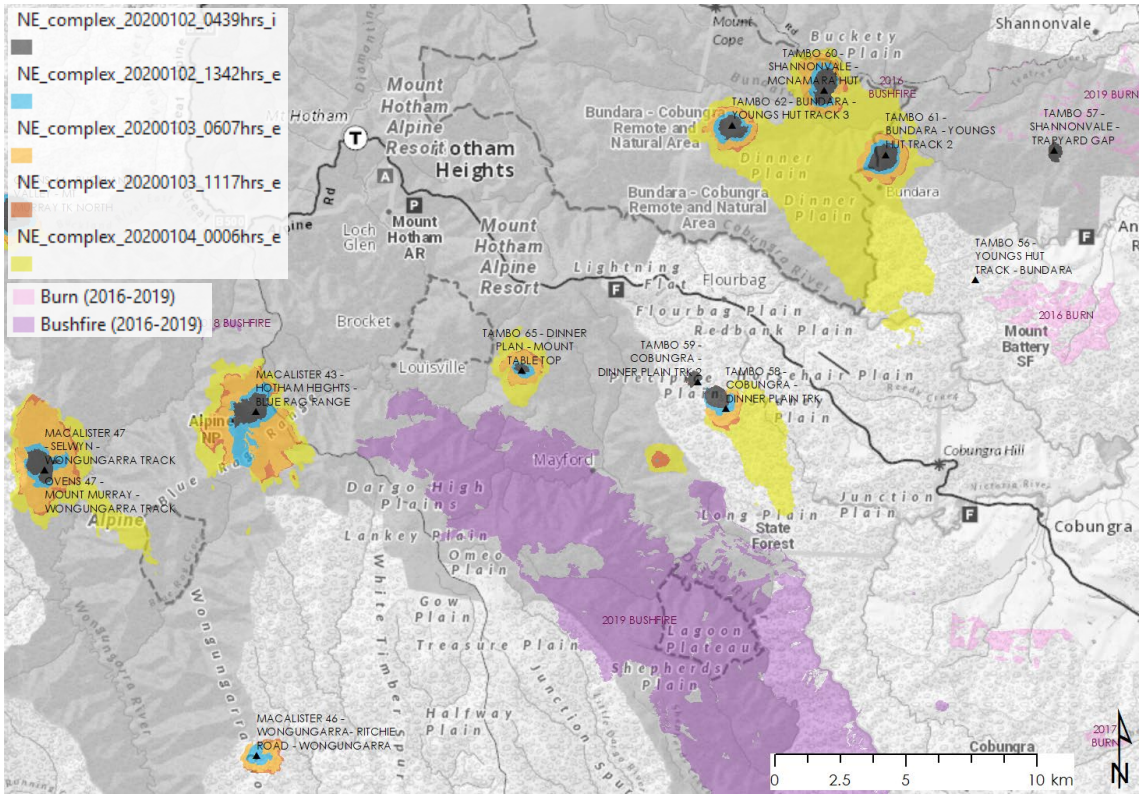


FIGURE 140: MACALISTER AND TAMBO DISTRICT FIRES 2ND TO 4TH OF JANUARY 2020

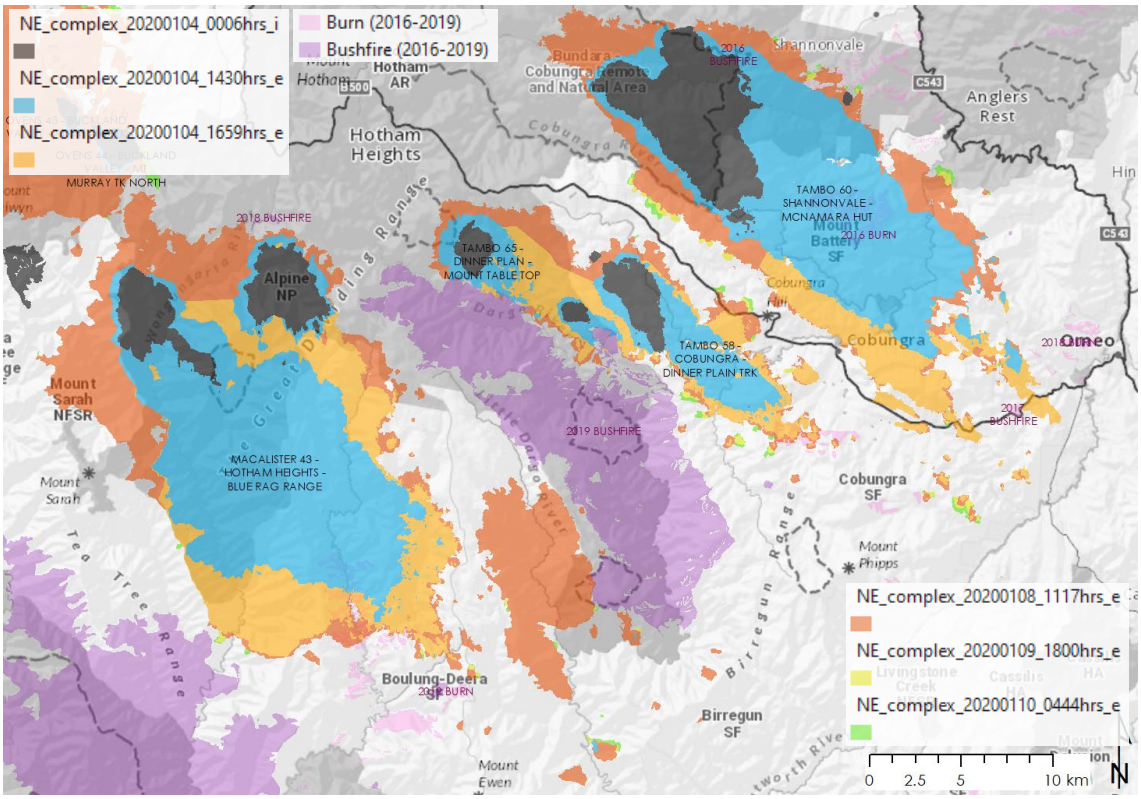


FIGURE 141: MACALISTER AND TAMBO DISTRICT FIRES 4TH TO 10TH OF JANUARY 2020 (NOTE 20201008 1117 FIRE BOUNDARY OCCURRED PREDOMINANTLY ON THE 4TH OF JANUARY PRIOR TO THE COLD CHANGE)

The fires south of the divide in the Tambo and Macalister Districts became very active in the late morning and early afternoon (whereas the Ovens District fires hardly moved prior to 1430hrs). The expansion of Macalister 43, and Tambo 58, 60 and 65 was rapid and intense with significant short medium and long-distance spotting. Figure 141 shows the numerous spot fires SE of the fire runs. It should be noted that the fire area as at 1659hrs on the 4th of January around the Little Dargo River and Lower Birregun Range was obscured by cloud and smoke column.

FIGURE 142: 1501HRS 4TH JANUARY 2020 AIG IMAGE LOOKING NORTH TOWARD SPOT FIRES EAST OF THE DARGO HIGH PLAINS RD (TAMBO 65 IS IN THE DISTANCE)

Examination of the Himawari IR imagery shows spot fires commencing to the east of the Dargo High Plains Road in the Little Dargo River Valley at around 1440hrs. These spot fires were mapped by the AIG and an image taken at 1501hrs can be seen in Figure 142. These spot fires developed rapidly and continued in a SE direction prior to the wind change driving the fire to the NE, where finally the fire activity subsided around 1800hrs. The next available image was on the 8th of January via the Sentinel 2 satellite.

Figure 143 shows the development of the Tambo 65 - Dinner Plan - Mount Table Top fire at 1200hrs on the 4th of January. The temperature at Mt Hotham was 25°C and the RH 20%. The temperature peaked at 27°C and the RH dropped to 11% by 1400hrs. Figure 145 shows a 3d representation of the 1336hrs line scan. Of note is the largely wind driven fire and considerable medium distance spotting created by the ribbony barked snow gums. Figure 144 shows a view at a similar time with the fire south of the Dinner Plain village.

FIGURE 143 LOOKING SW MT HOTHAM WEBCAM AT 1200HRS ON THE 4TH OF JANUARY LOOKING AT TAMBO 65 - DINNER PLAN - MOUNT TABLE TOP FIRE IN THE CENTRE OF THE IMAGE(HTTPS://MTHOTHAM.ROUNDSHOT.COM/)

There was relatively little fire activity after the 4th of January as can be seen in Figure 146 and Figure 147. There were minor runs near Cobungra, Shannonvale and out of the little Dargo River towards the Birregun Road. Backburning and strategic break construction was undertaken off the Birregun Road. The mild conditions meant that this was not required, and the main fire did not reach the backburn.

FIGURE 144: DINNER PLAIN 4TH JANUARY (DELWP EM DRIVE) – MOST LIKELY AT A SHORT TIME AFTER THE 1336HRS LINE SCAN

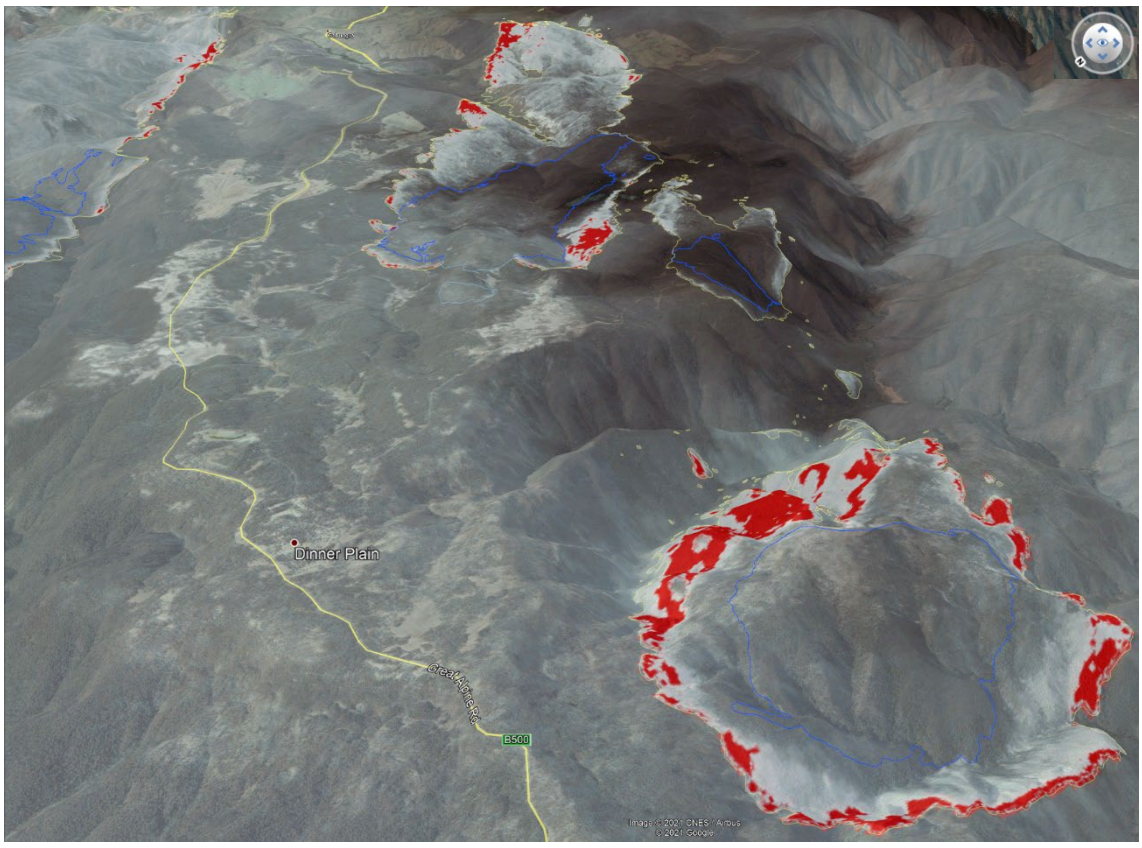


FIGURE 145: THE MORNING FIRE RUN SOUTH OF DINNER PLAIN 4TH JANUARY 2020 BLUE 0006HR BOUNDARY VS 1336HRS LINE SCAN (LOOKING DOWN THE GREAT ALPINE RD FROM MY HOTHAM, PAST DINNER PLAIN TOWARD COBUNGRA)

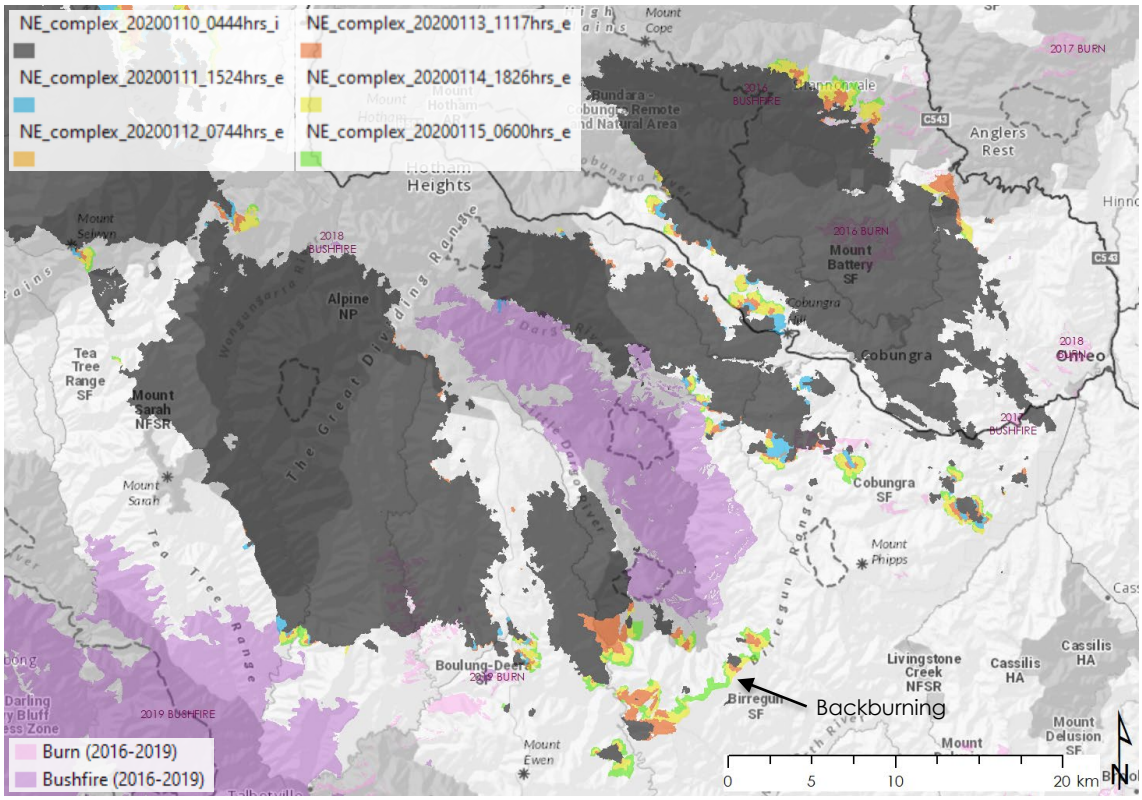


FIGURE 146: MACALISTER AND TAMBO ALPINE FIRES 10TH TO 15TH JANUARY 2020

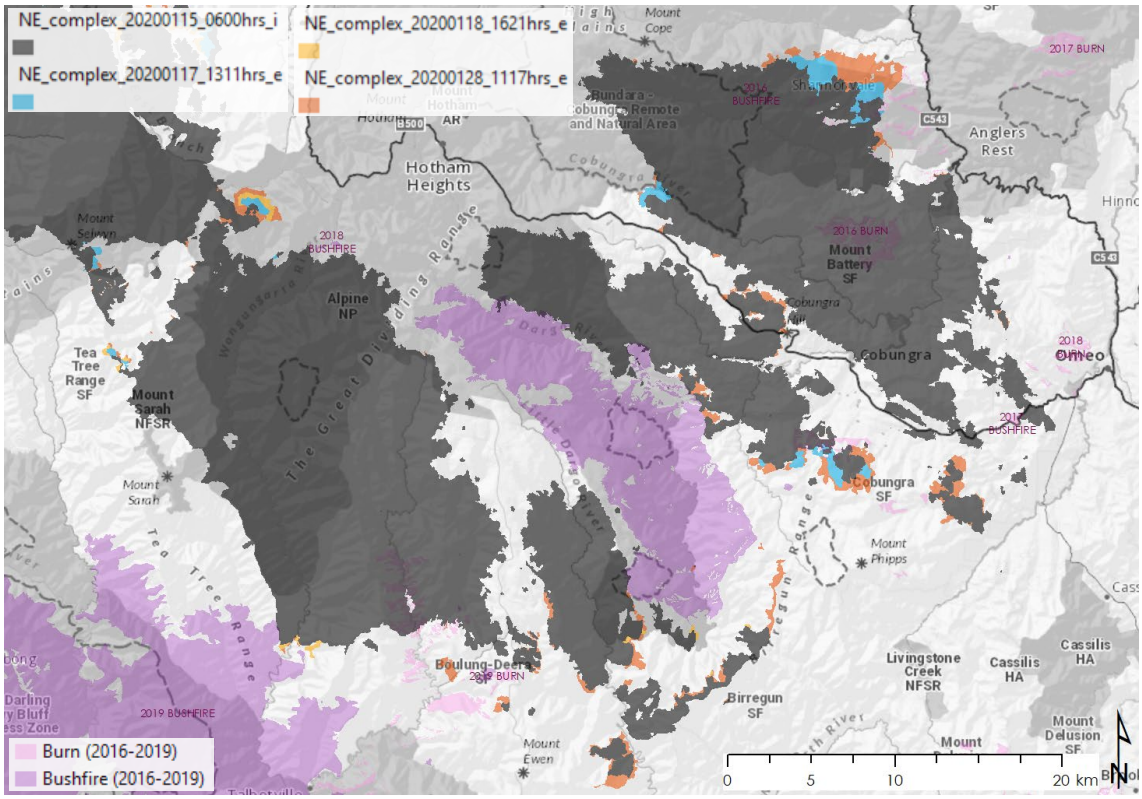


FIGURE 147: MACALISTER AND TAMBO ALPINE FIRES 15TH TO 28TH JANUARY 2020

Alpine Fire runs of the 4th and 5th of January 2020

A preliminary investigation of the fire runs was undertaken using line scans and a Google Earth 3d visualisation using the Himawari IR imagery.

The location, start time and end time for the fire runs can be seen in Figure 148. As previously stated, there is the potential for further study of the fire behaviour and weather for these fires.

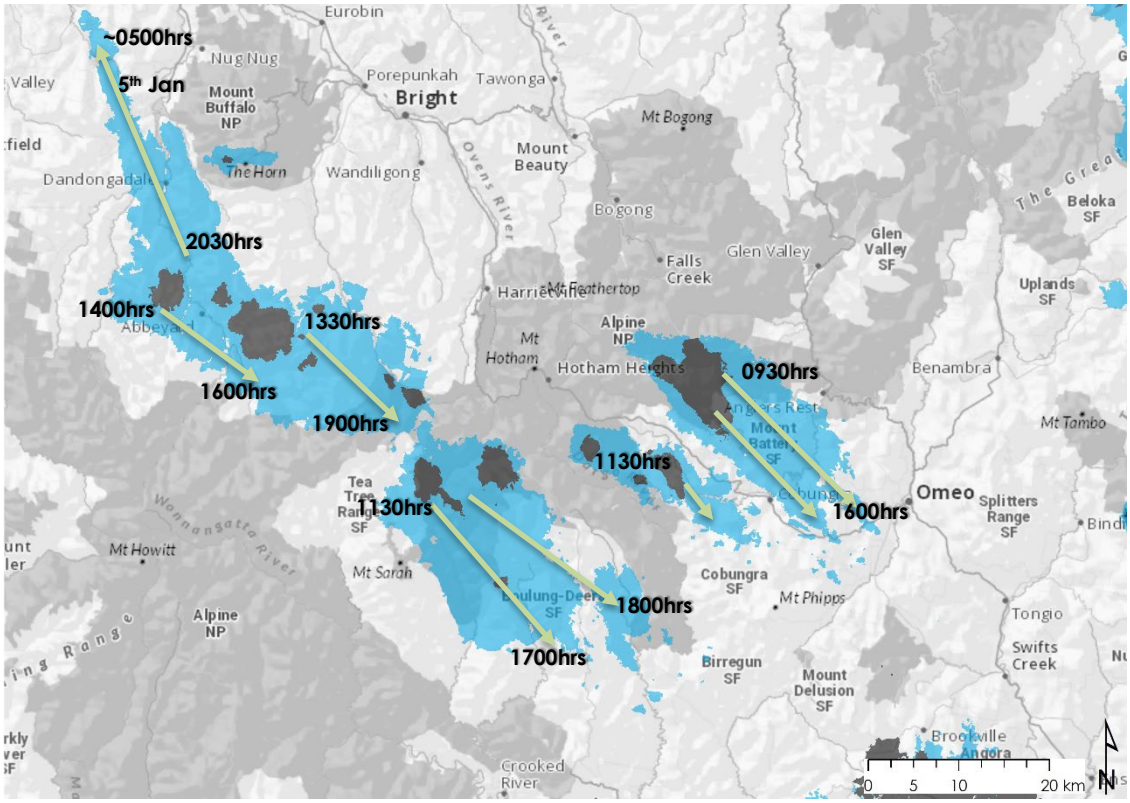


FIGURE 148: FIRE RUNS AND TIMINGS FOR THE ALPINE FIRES 4TH T TO 5TH OF JANUARY 2020

Long-distance Spotting

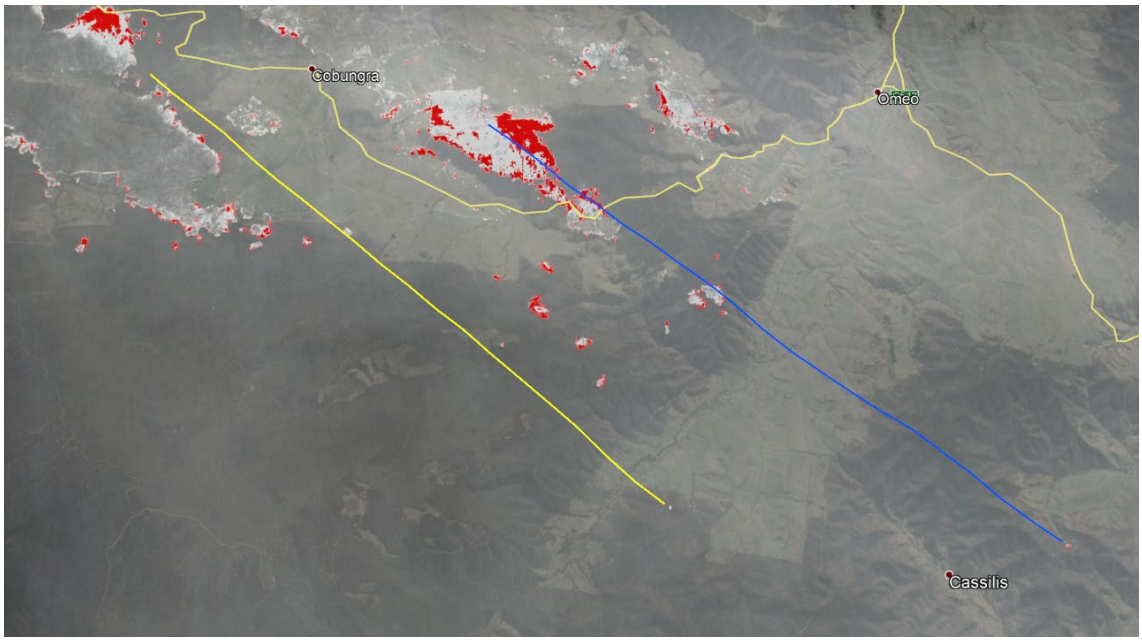


FIGURE 149: LONG DISTANCE SPOTTING FROM TAMBO 58 AND TAMBO 60 (1659HRS LINE SCAN 4TH JANUARY 2020)

Figure 149 shows two locations of long-distance spotting that occurred between 1600 and 1700hrs on the 4th of January. The distance is estimated to be 18km from either fire.

Himawari Satellite Imagery for the 4th of January 2020

Figure 150 to Figure 155 show Himawari imagery that was prepared as Google Earth animation for the project. It uses the Weatherzone Himawari enhanced infrared observations from the AWS and pre and post run fire boundaries. The colours represent temperature. The images show the spread of the fire, development of convection columns and the weather observations for each station (wind speed and direction, temperature rainfall and relative humidity).

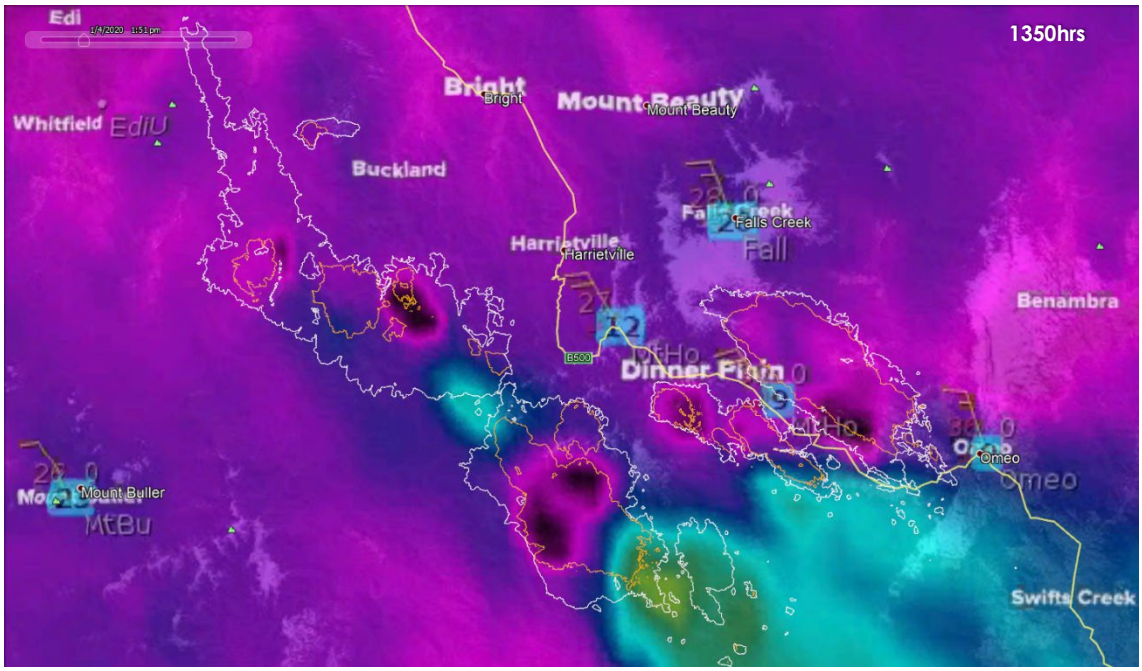


FIGURE 150: HIMAWARI WEATHERZONE IMAGE AT 1350HRS 4TH JANUARY 2020

The 1350hrs image in Figure 150 shows all winds are from the NNW and the fires are south of the divide very active and developing PyroCu.

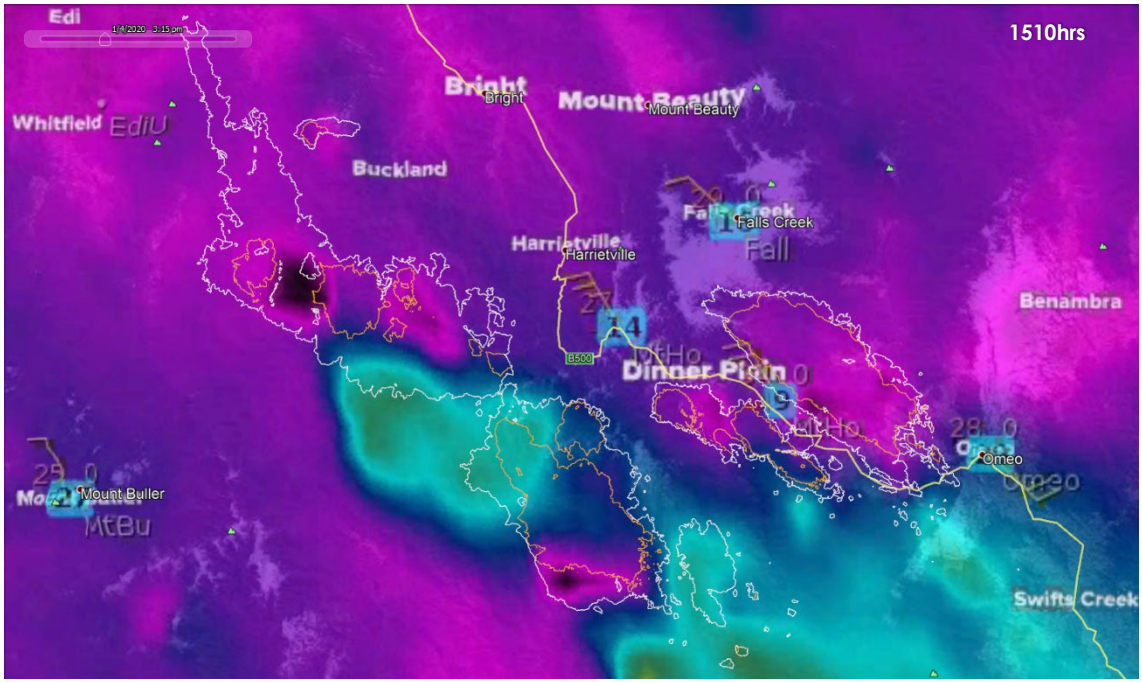


FIGURE 151: HIMAWARI WEATHERZONE IMAGE AT 1510HRS 4TH OF JANUARY 2020

Figure 151 shows that at 1510hrs the wind direction at Omeo had shifted to the SE and temperatures had fallen rapidly from 36 to 28°C. All other stations remained under the influence of the northerlies.

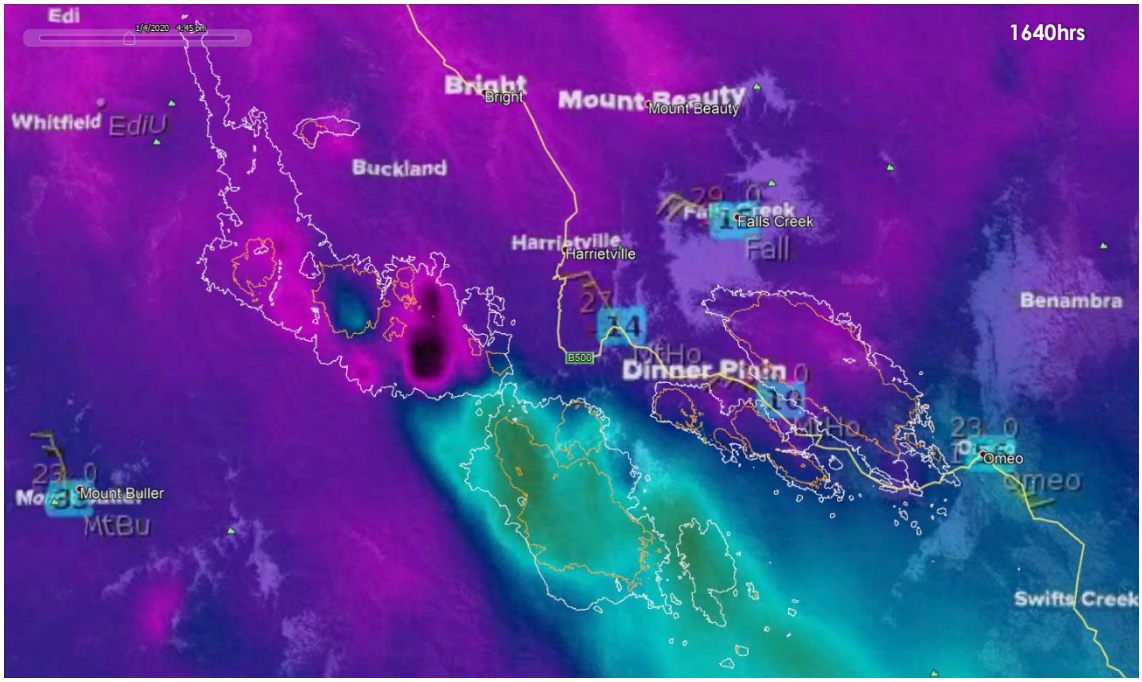


FIGURE 152: HIMAWARI WEATHERZONE IMAGE AT 1640HRS

Figure 152 shows that at 1640hrs the wind was still NNW north of the divide, and the Abbeyard - Yarrarbula fire was very active and producing PyroCu. The temperature at Omeo had fallen to 23°C.

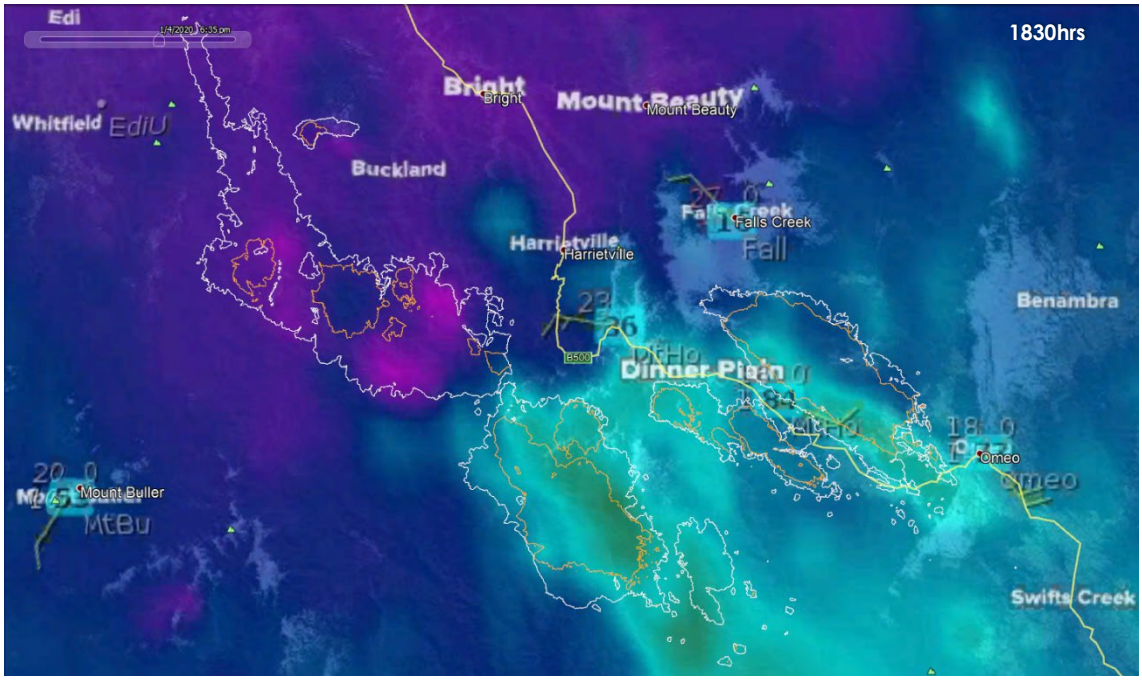


FIGURE 153: HIMAWARI WEATHERZONE IMAGE AT 1830HRS 4TH OF JANUARY 2020

Figure 153 shows that by 1830hrs the wind change had arrived at Mt Hotham AP and Mt Buller (See also AWS plots - Figure 127, Figure 128 and

Figure 131). The cooler air is shown as blue compared to the warmer purple air north of the divide.

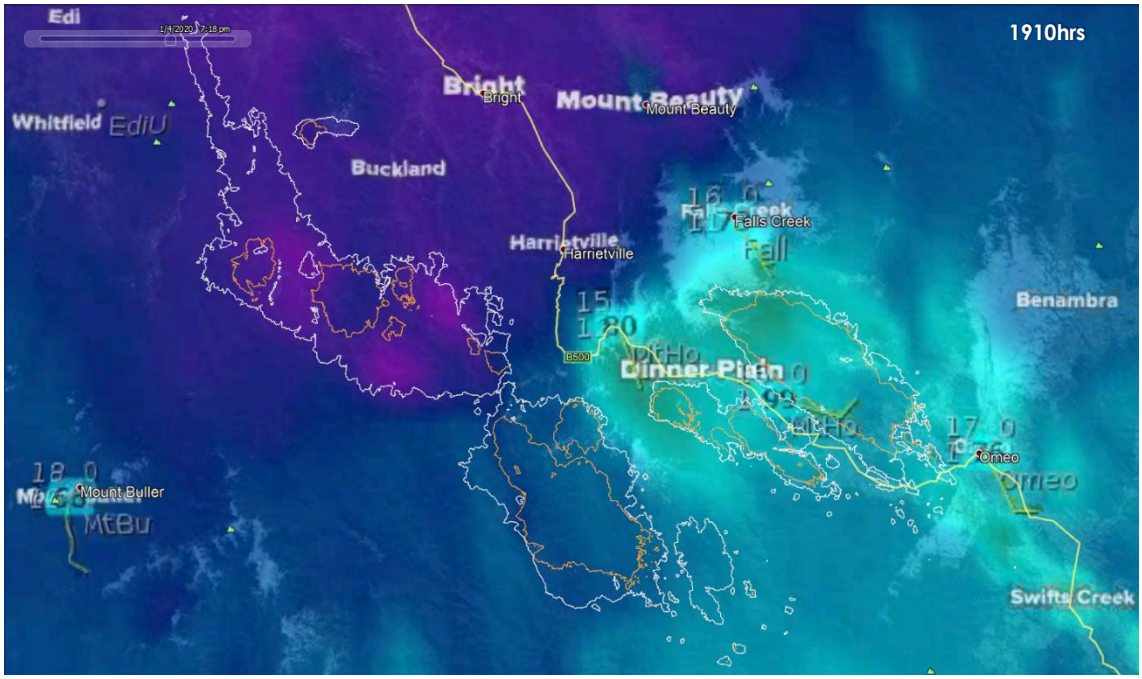


FIGURE 154: HIMAWARI WEATHERZONE IMAGE AT 1910 HRS

Figure 154 shows that at 1910hrs the temperatures south and on the divide had all dropped below 20°C. The conditions at Falls Creek saw the wind swing to the SE at 1910hrs and temperature drops from 26 to 16°C. It is at that time that the Abbeyard – Yarrarabula fire began to move north.

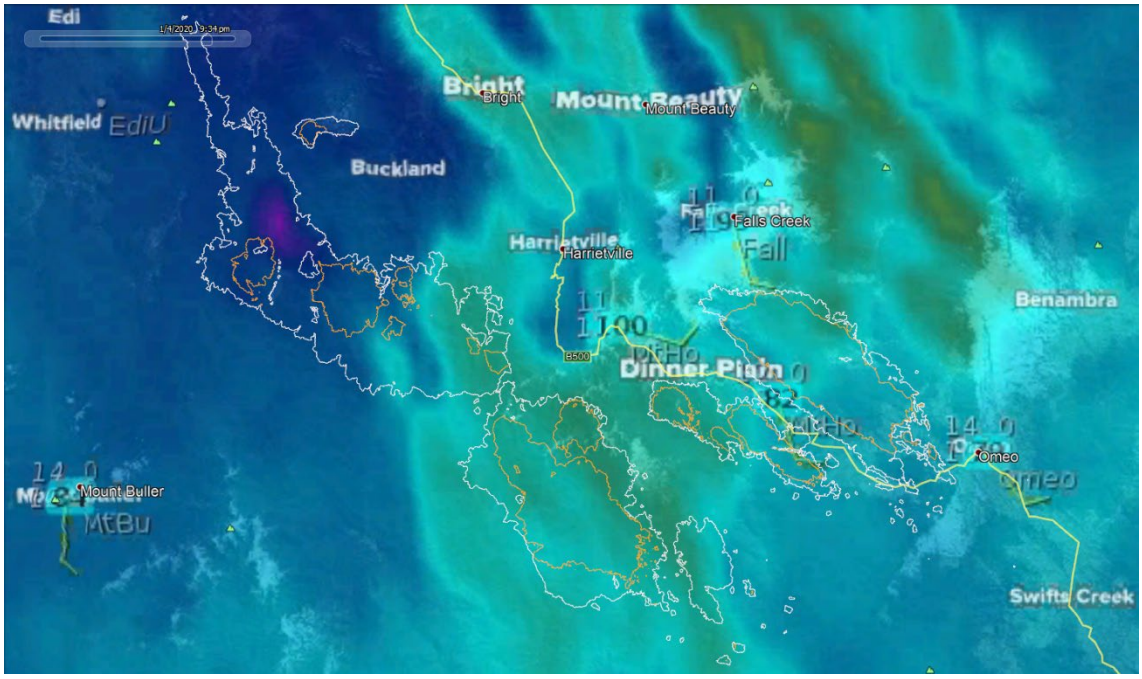


FIGURE 155: HIMAWARI WEATHERZONE IMAGE AT 2130HRS 4TH OF JANAURY

Figure 155 shows that by 2130hrs there is no observable fire activity except the Abbeyard - Yarrarabula fire which is progressing down the valley toward Myrtleford. At higher elevations like Mt Hotham the humidity had risen to 100% and temperature dropped to 11°C.

SNOWY 09: BANANA TRACK: 29TH OF DECEMBER 2019 TO 4TH JANUARY 2020

Weather for the 29th to 31st of December 2019

The weather in this region of Victoria is complex and further analysis is recommended. On the 29th an easterly wind flow was present caused by a trough behind a large high in the Tasman Sea. The winds swung to the NNE with the progression of the trough and strengthened, driving the fire toward the coast. By the morning of the 30th there was a slight push inland and then a strong hot NNW set in for the 30th. A strong gust cool SW change hit the fireground around 0400hrs on the 31st. Synoptic charts for the period prior to the front can be seen in Figure 156.

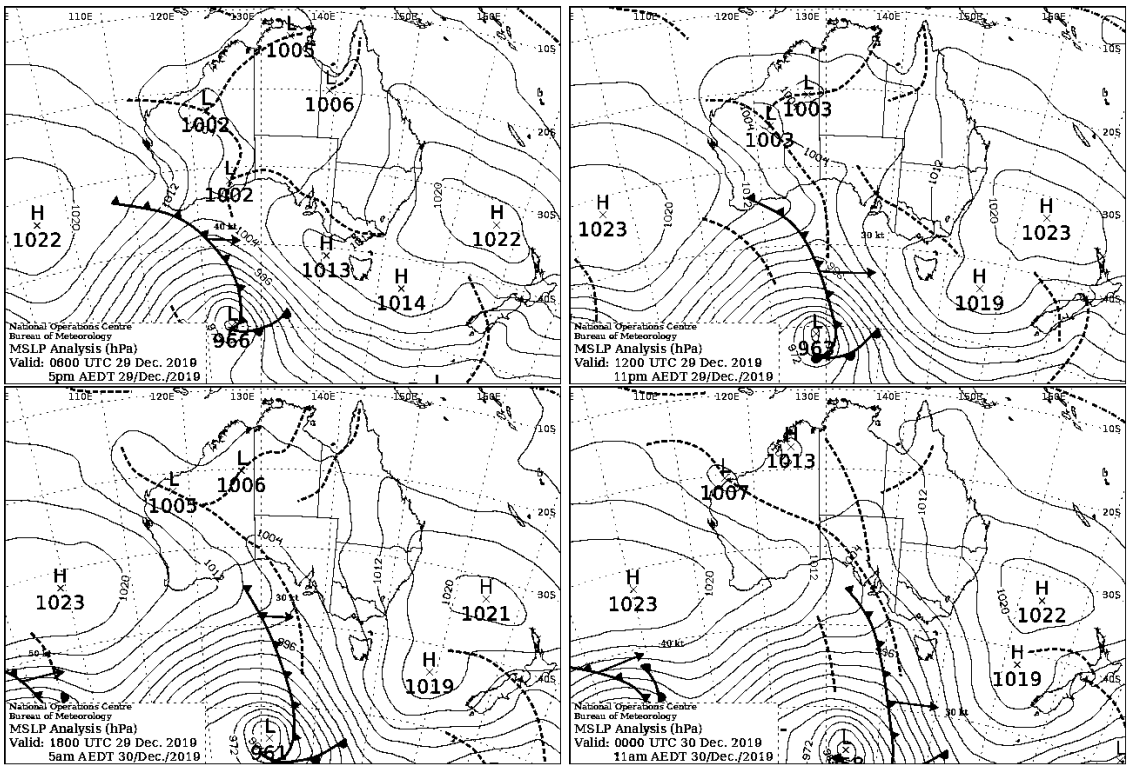


FIGURE 156: SYNOPTIC CHARTS FROM 0500HRS 29TH OF DECEMBER TO 1100HRS 30TH OF DECEMBER 2019

AWS charts for Mallacoota, Combienbar, and Orbost. for 1400hrs on the 29th to 1400hrs on the 31st of December can be seen in Figure 157 to Figure 159. Mallacoota provides the best idea as to what drove the fire toward the coast on the evening of the 29th and morning of the 30th. Gusty winds of 20-30km/h from the north were experienced from 2200hrs to 0600hrs.

Humidity at all three stations remained high although Orbost experienced a dip to 30% and the wind to swing more north easterly between 2200hr and 0000hrs. There were also no signs of hot drier air at higher elevations like Combienbar (641m elevation) at that time.

The rapid fire run to the coast and subsequent eastward run into Mallacoota have been identified for further analysis.

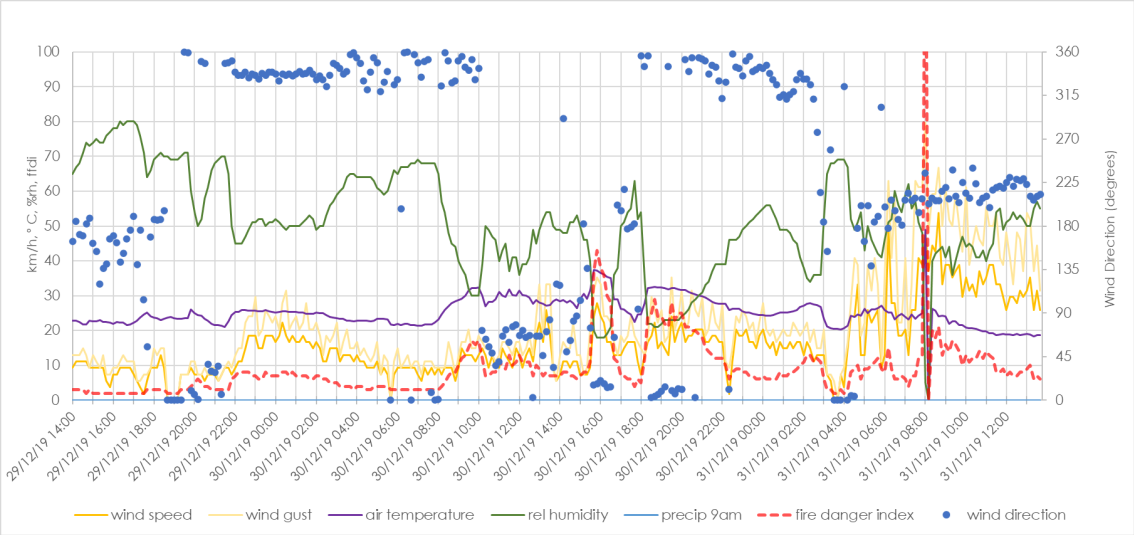


FIGURE 157: MALLACOOTA AWS DATA FOR THE 29TH AND 31ST OF DECEMBER (FFDI AT 0800 WAS 160 – (TEMP RECORDED WAS 49 DEGREES_AND RH 5)

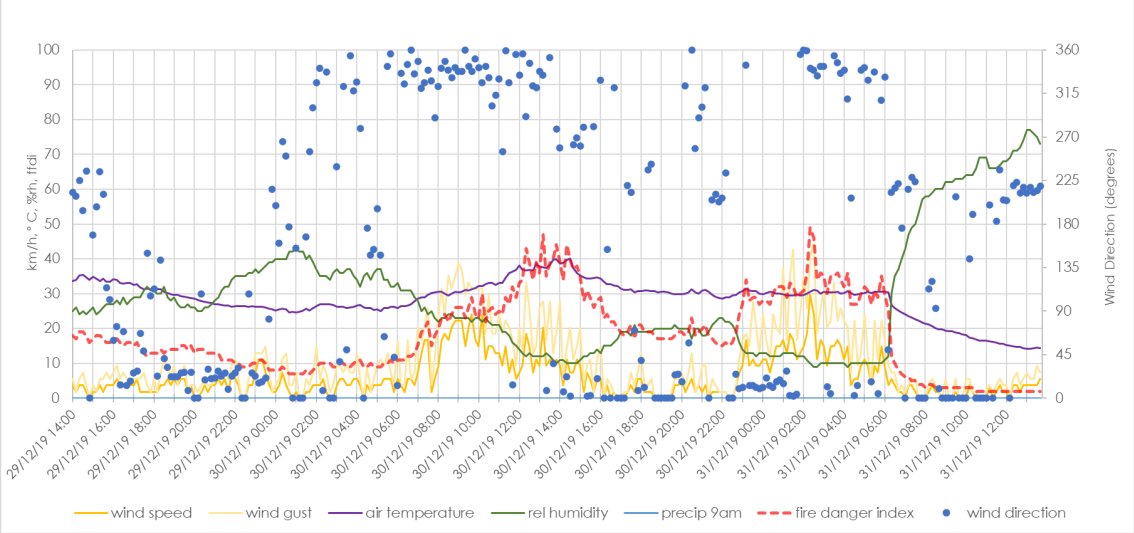


FIGURE 158: COMBIENBAR AWS DATA FOR THE 29TH AND 31ST OF DECEMBER 2019

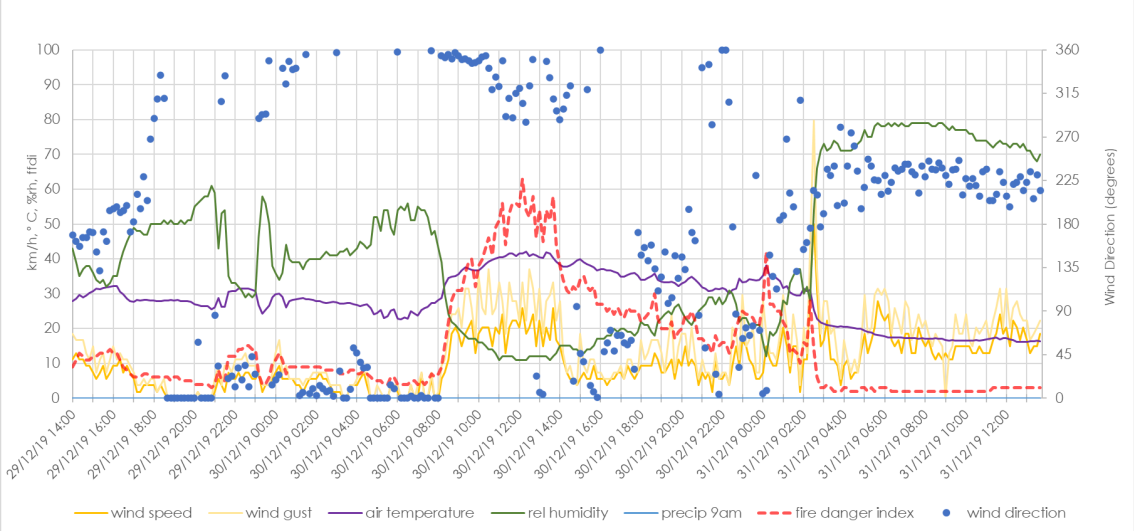
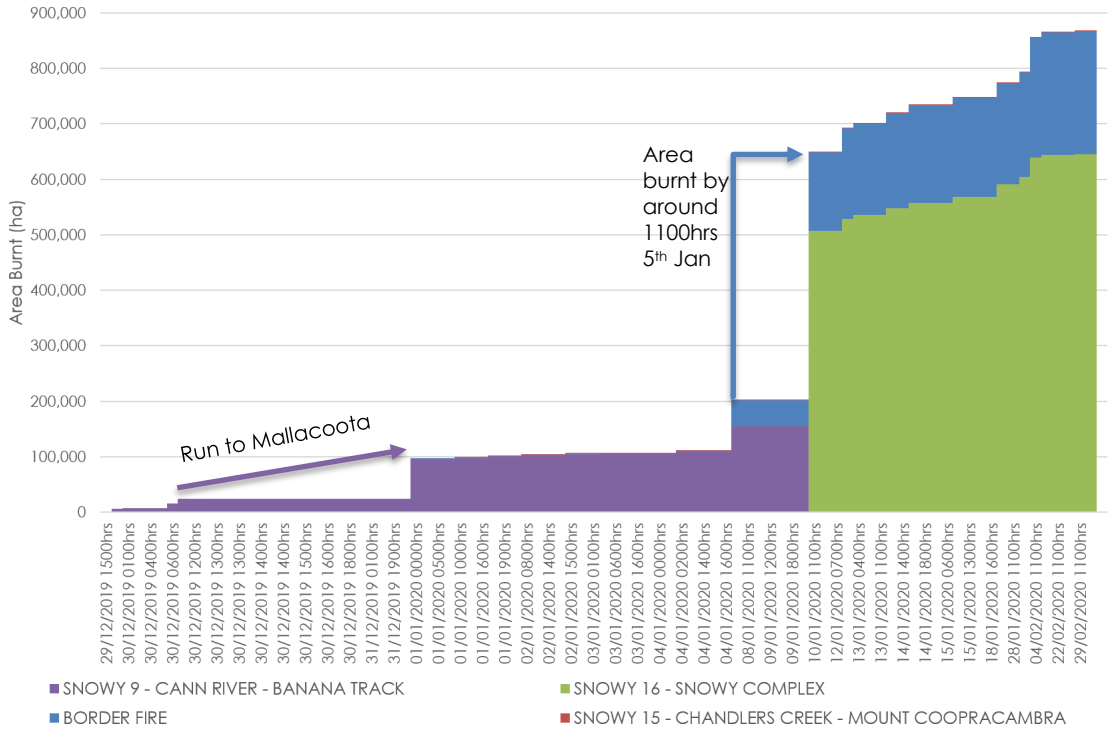


FIGURE 159: ORBOST AWS DATA FOR THE 29TH AND 31ST OF DECEMBER 2019

Fire Progression 29th of December 2019 to 4th of January 2020



The Banana Track (Snowy 09) fire was first reported at 1448hrs on the 29th of December 2019 and rapidly escalated. By 1525 hrs it was reported to have 3-4 km of running edge, 3-4 m flame heights with crowning fire and spotting 500m ahead of itself. Figure 160 and Figure 161 show the initial stages of the fire with multiple spotting in dry sclerophyll forest and heathland.

A NNE wind pushed the fire steadily toward the coast running around 20km from 1900hrs to 0200hrs (Average ROS 2.8km/h). The fire generated its own lightning from 2100hrs to 0000hrs.From 0200hrs to 0400hrs on the morning of the 30th of December the fire was driven by a northwest wind and again generated its own lightning. These stages of the fire can be seen in Figure 162. The top left image shows the model prediction for surface winds to come down the coast of NSW and across the coastal plain to the fireground. The top right image shows the AIG infrared image of the fire reaching the coast at 0149hrs.

It then expanded to the coast in the southeast and had progressed to the Wingan River (and spotted over it) in the east by 1200hrs. For the remainder of the 30th strong NNW winds caused the eastern flank to move to the east. By 1140hrs the fire was generating PyroCu, then PyroCb and creating its own lightning. This continued for the day and into the night. There appears to be an ENE wind on the fire prior to the change. Adding to the complexity much of the area was completely enveloped in dense smoke from the other Gippsland fires.

FIGURE 160: 1525HRS 29TH OF DECEMBER AERIAL OBSERVATION LOOKING EAST FROM THE HEAD FIRE UP THE NORTHERN FLANK

FIGURE 161: 1902 HRS 29TH OF DECEMBER AERIAL OBSERVATION SHOWING FIRE MOVING SOUTH 3-4KM FROM NORTHERN MOST BOUNDARY

The SW wind change arrived on the fireground between 0400hrs and 0500hrs and drove the fire toward Genoa and Mallacoota. The fire arrived at Genoa by 0800hrs and at Mallacoota township at 0900hrs. It appears that the southern end of town and the airport where the AWS is located were impacted at 0800hrs. The AWS recorded 49°C and an RH of 5 resulting in an FFDI of 160. The first reports of house losses also came from this area.

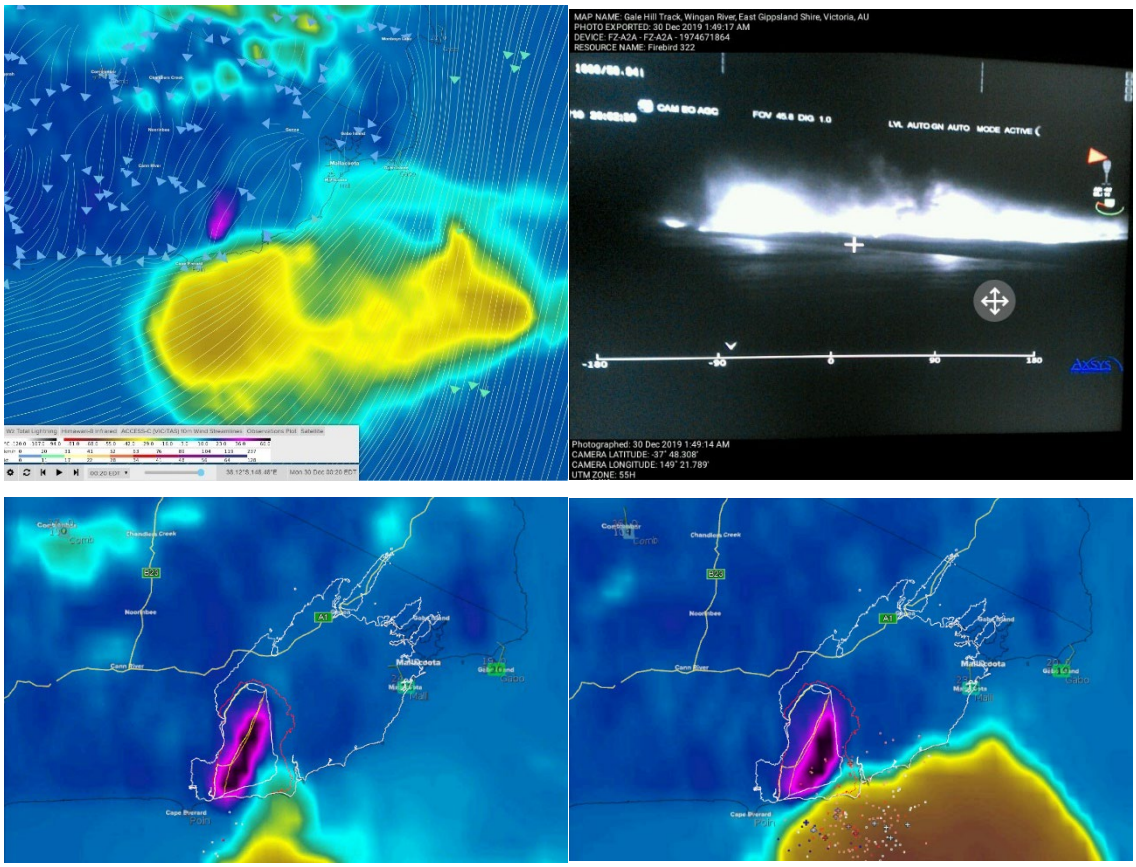


FIGURE 162: TOP: WEATHERZONE ENHANCED IR AT 0020HRS AND AIG IMAGE OF FIRE REACHING THE COAST AT 0149HRS ON THE 30TH OF DECEMBER. BOTTOM: WEATHERZONE ENHANCED IR 0240HRS AND 0330HRS ON THE 30TH OF DECEMBER 2019

FIGURE 163: 1121 HRS 30TH OF DECEMBER AERIAL OBSERVATION SHOWING FIRE MOVING EAST. THE VIEW IS LOOKING SOUTH OVER THE WINGAN RIVER

The progression of the fire can be seen in Figure 164. Analysis of the Himawari IR data in Figure 165 shows the most likely progression of the fire This has been correlated with situation reports where possible.

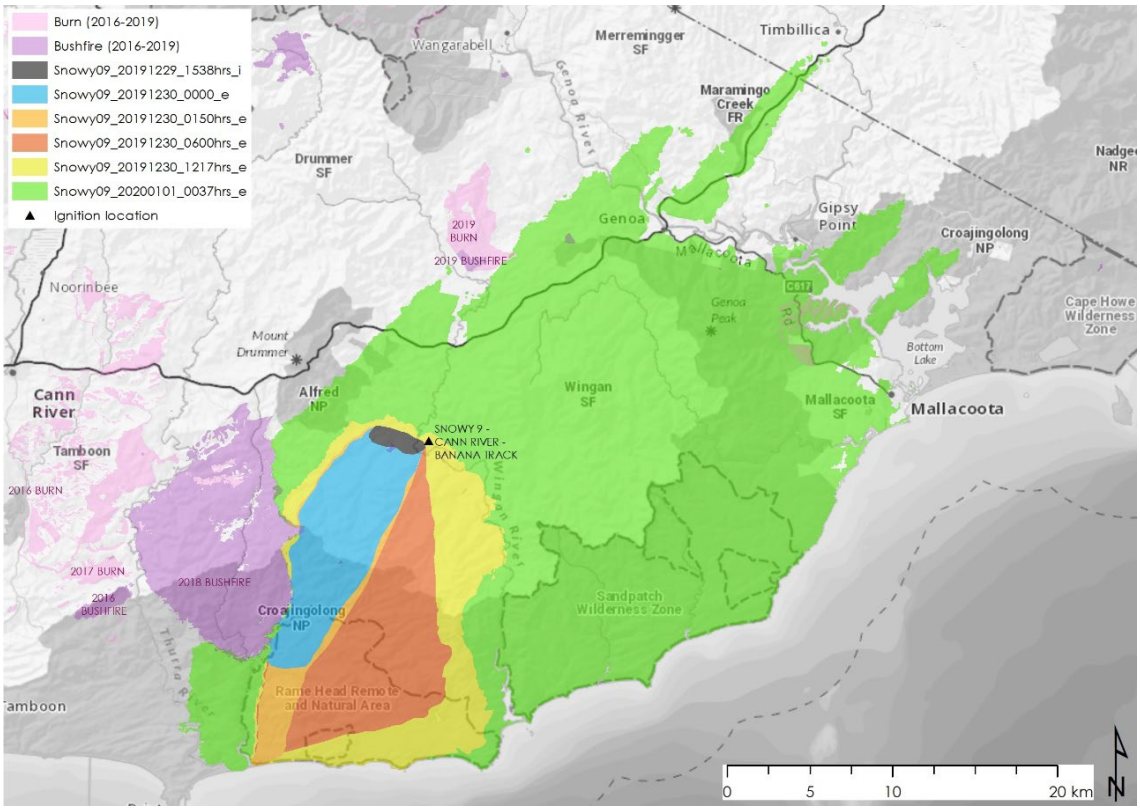


FIGURE 164: FIRE PROGRESSION FOR THE BANANA TRACK FIRE 29TH OF DECEMBER 2019 TO 1ST OF JANUARY 2020

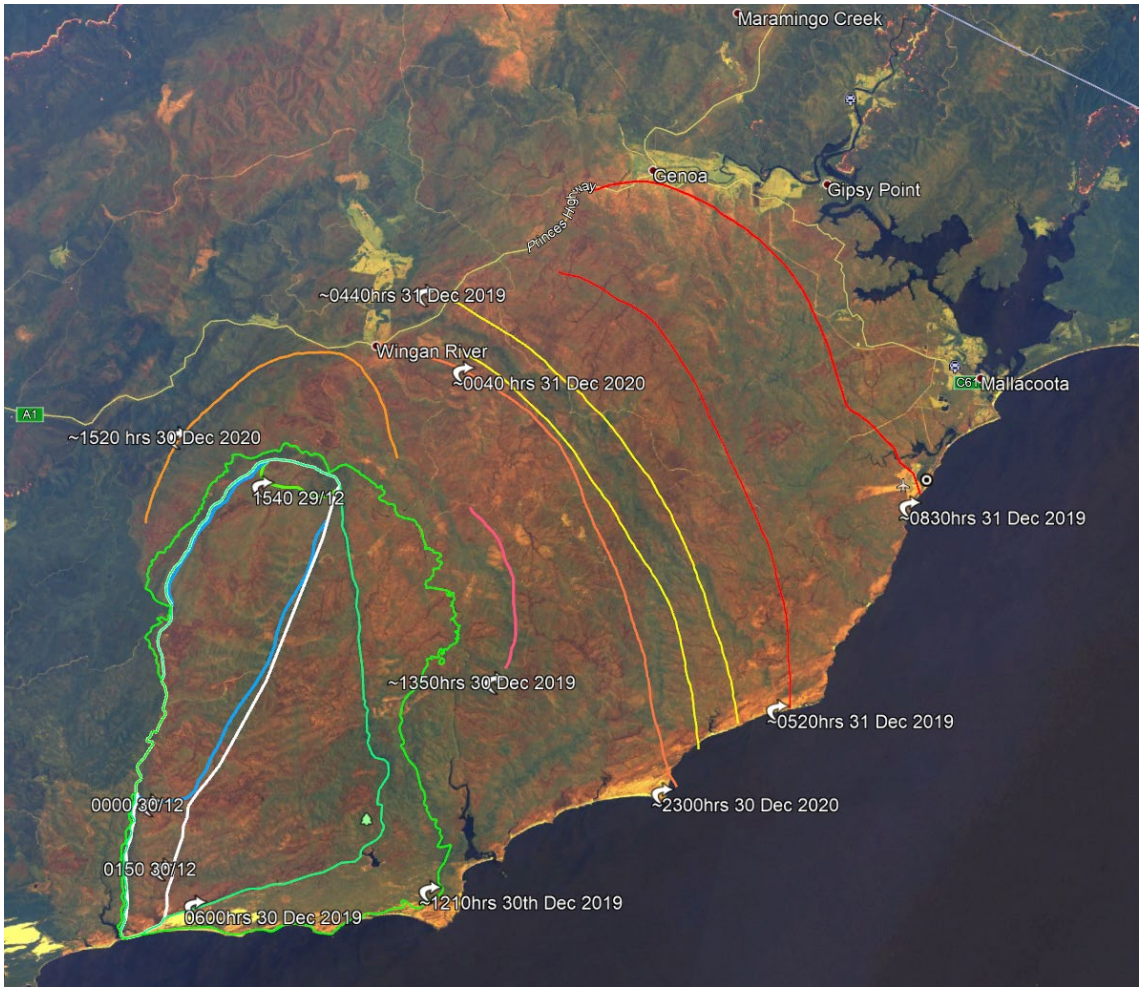


FIGURE 165: MOST LIKEY PROGRESSION OF THE BANANA TRACK FIRE ON THE 30TH AND INTO THE 31ST OF DECEMBER

FIGURE 166: 1153HRS 30TH DECEMBER 2019 LOOKING NW UNDER THE EASTERN FLANK (DALE APPLETON)

FIGURE 167: SPOTFIRE EAST OF THE WINGAN RIVER 1154HRS ON THE 30TH OF DECEMBER (DALE APPLETON)

Figure 163, Figure 166, Figure 167and Figure 168 show the progression of the flank fire where it quickly developed into a pyroCb. The reasons why this flank fire was so intense may be explained by its length (22km) and the dryness and flammability of fuels.

Figure 169 shows Weatherzone layers images as colour and enhanced IR for the 30th of December at the time of PyroCb development.

FIGURE 168: 1243HRS 30TH DECEMBER 2019 LOOKING SOUTH ALONG THE EASTERN FLANK (MIKE IRVINE)

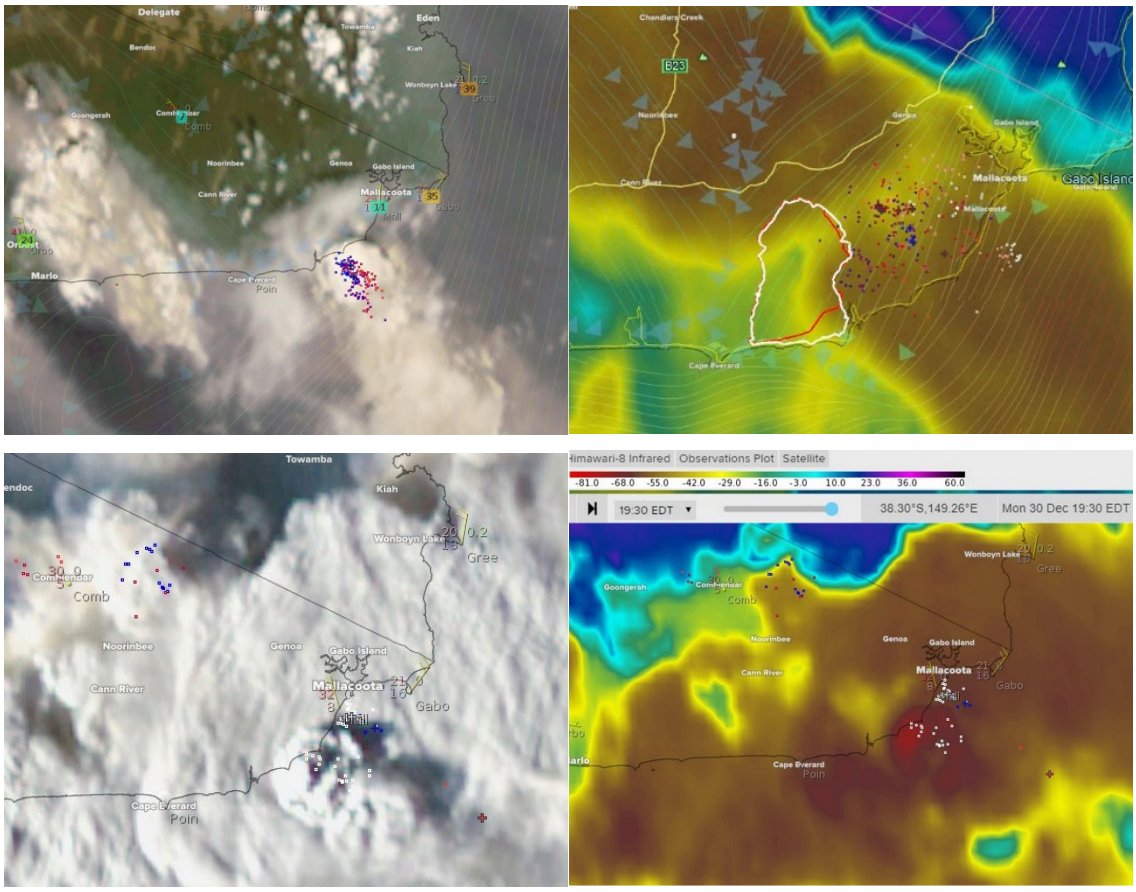


FIGURE 169: WEATHERZONE LAYERS CLOCKWISE FROM TOP LEFT -1240HRS TRUE COLOUR,1840 ENHANCED IR, 1930HRS ENHANCED IR AND 1930HRS TRUE COLOUR.

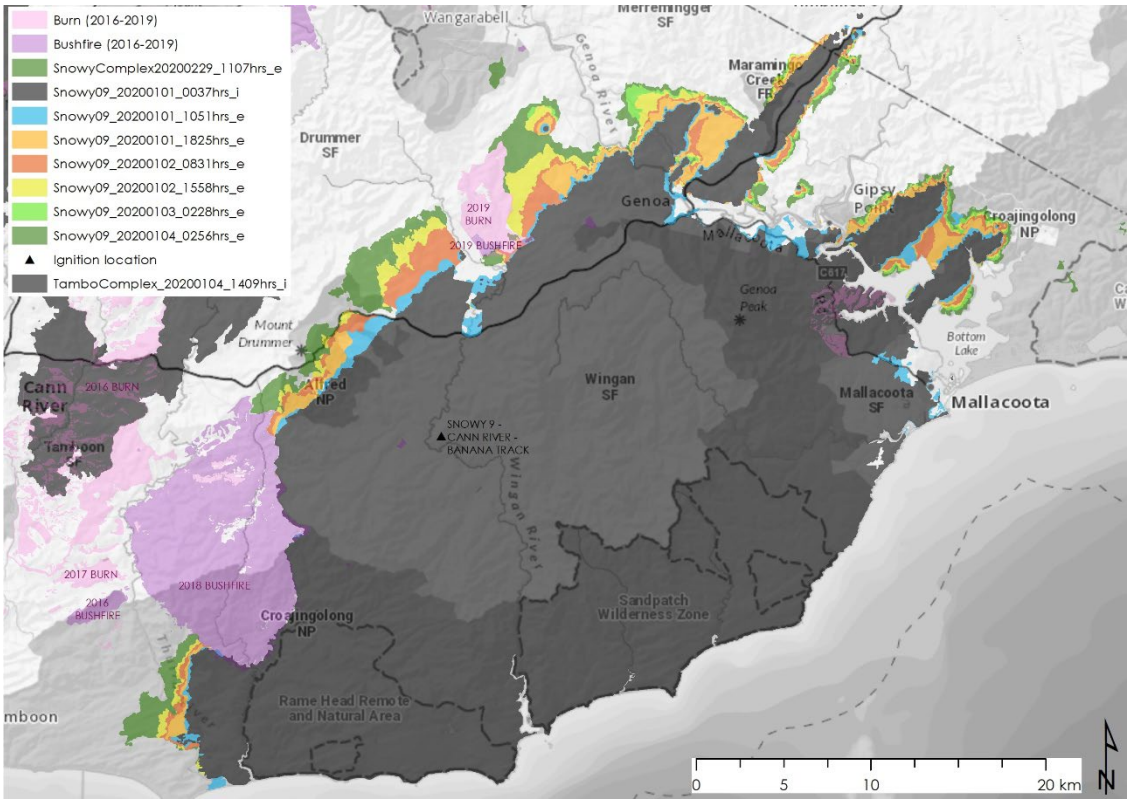


FIGURE 170: FIRE PROGRESSION FOR THE BANANA TRACK FIRE 1ST TO 4TH OF JANUARY 2020

Figure 170 shows the fire progression from the 1st to 4th of January. At this time the fire had burnt 106,000ha. After this time, the fire merged with the W Tree – Yalmy Fire/Tambo Complex and was renamed Snowy 16: Snowy Complex and in NSW was referred to as the Border Fire. A description of this along with progression maps can be found on page 174.

TAMBO 35: TAMBO COMPLEX - 30TH AND 31ST OF DECEMBER 2019

Naming of fires

Prior to the 31st of December the Marthavale – Barmouth Spur fire included the footprint of the Bruthen Six Mile fire (overrun 21st of December). The Ensay - Fern Tree and W Tree - Yalmy fires were still managed as separate entities. On the 31st of December, all fires were merged into the Tambo Complex. When this fire in turn merged with the Banana Track fire on the 4th of January, then all fires in the Snowy District became the Snowy Complex on the 7th of January 2020.

For the purposes of this report the following section describes the merging of the Tambo fires from the 30th of December.

Weather for the 30th and 31st of December 2019

This section shows AWS reading from stations within and adjacent to the fireground for this and other eastern Victorian fires occurring on the 30th and 31st of December. Figure 171 to Figure 178 show the variation across

such a large fireground which was 160km by 90km and ranged from sea level to 1200 metres. The fire area had grown from 130,000 to 600,000 hectares by the 1st of January 2020

The conditions that drove this involved long and unrelenting periods of very high, severe and extreme fire danger. Hot, dry and gusty NNW winds, temperatures in the high thirties, and relative humidity's in the teens or below were common over much of the fireground.

A SW wind change reached lower elevations between 1700hrs on the 30th and 0400hrs on the 31st of December. At higher elevations the wind change did not arrive, and strong NNW winds continued into the early morning of the 31st.

There remains a significant project for meteorologists to analyse the weather conditions for this period and other blow-up days for this fire season.

AWS records

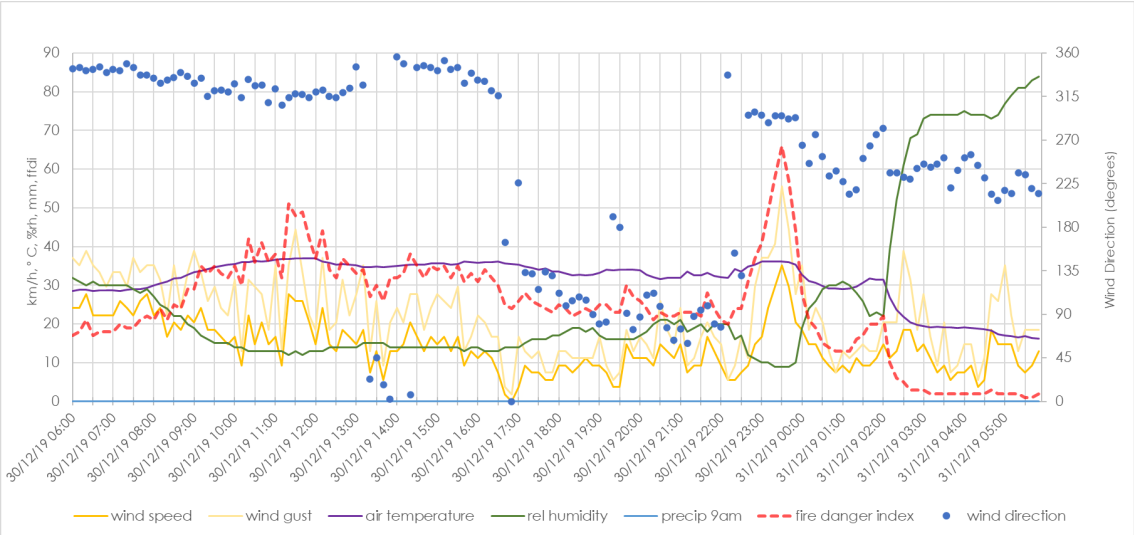


FIGURE 171: MT NOWA NOWA AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

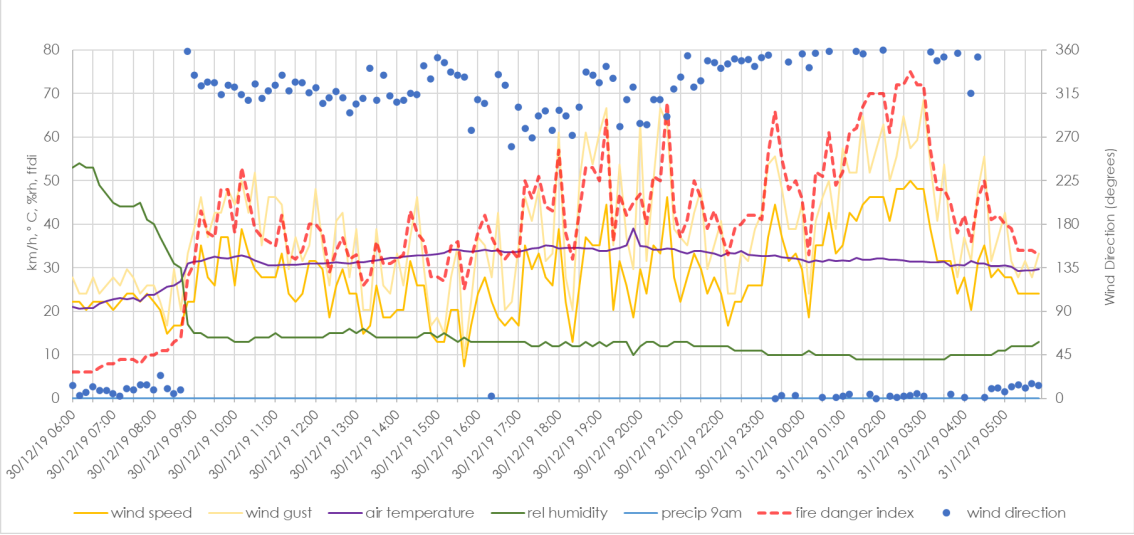


FIGURE 172: GELANTIPY AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

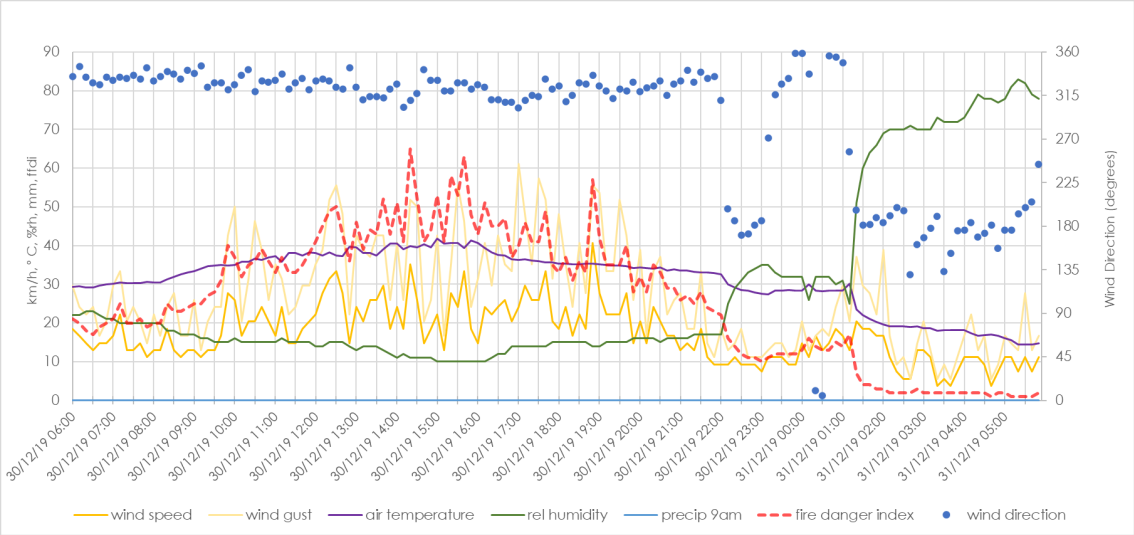


FIGURE 173: MT MOORNAPA AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

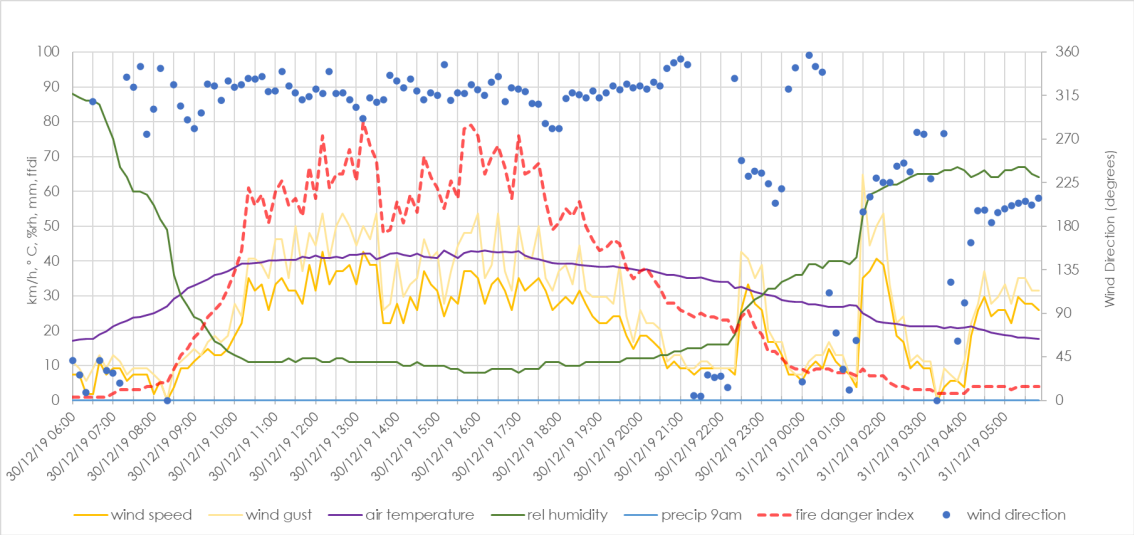


FIGURE 174: BAIRNSDALE AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

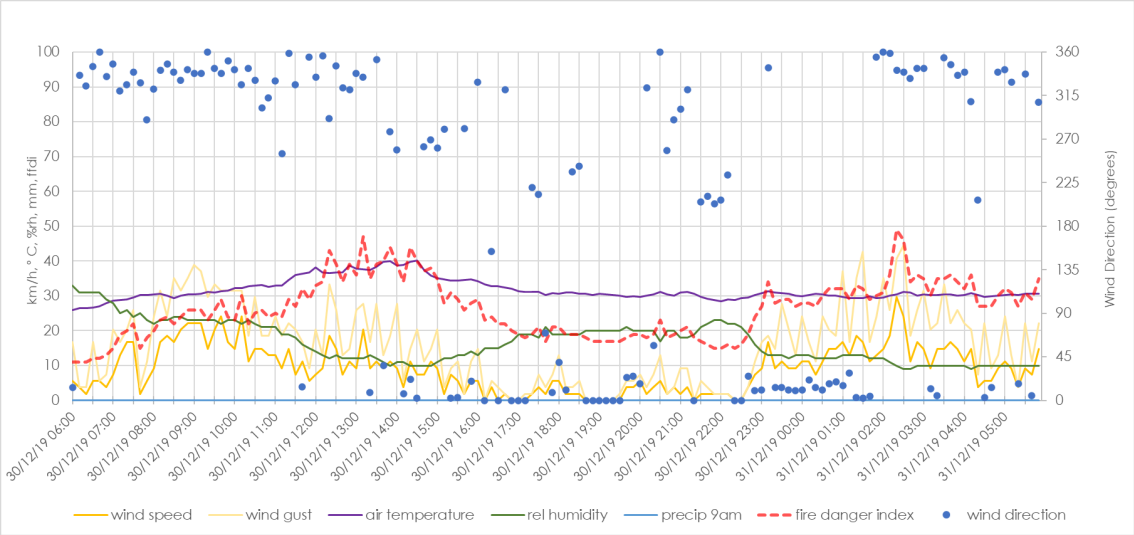


FIGURE 175: COMBIENBAR AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

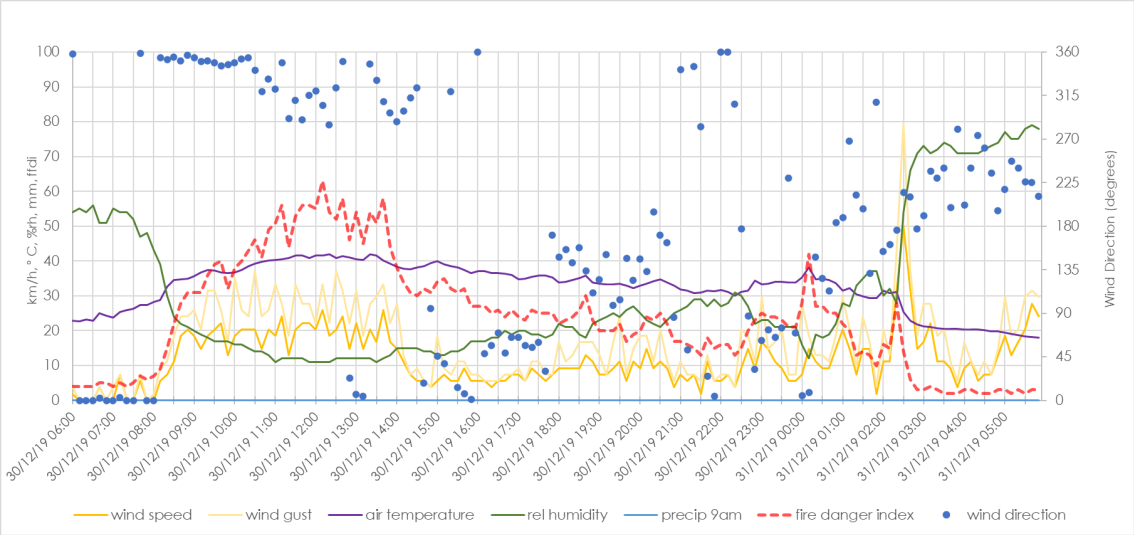


FIGURE 176: ORBOST AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

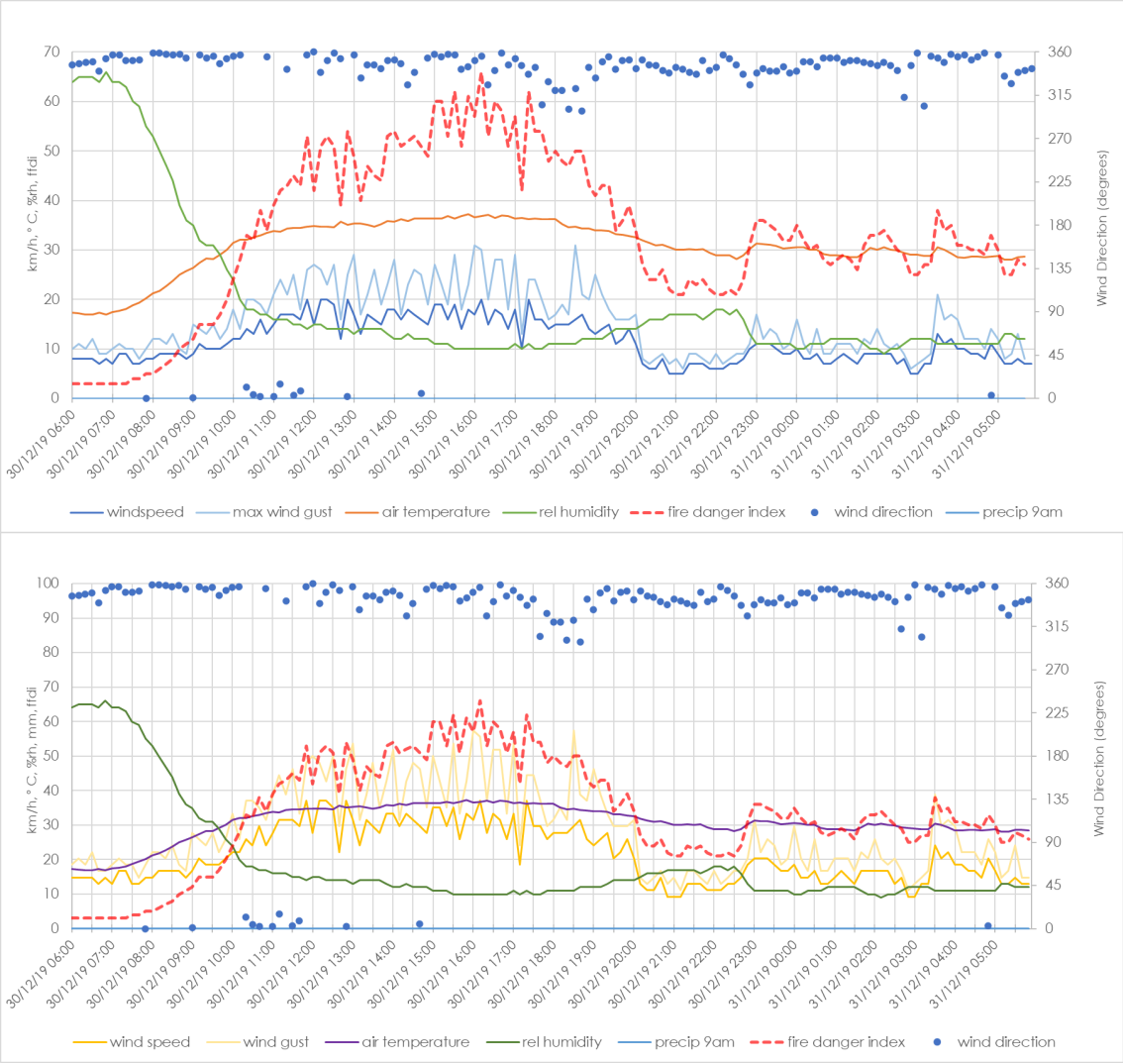


FIGURE 177: OMEO AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

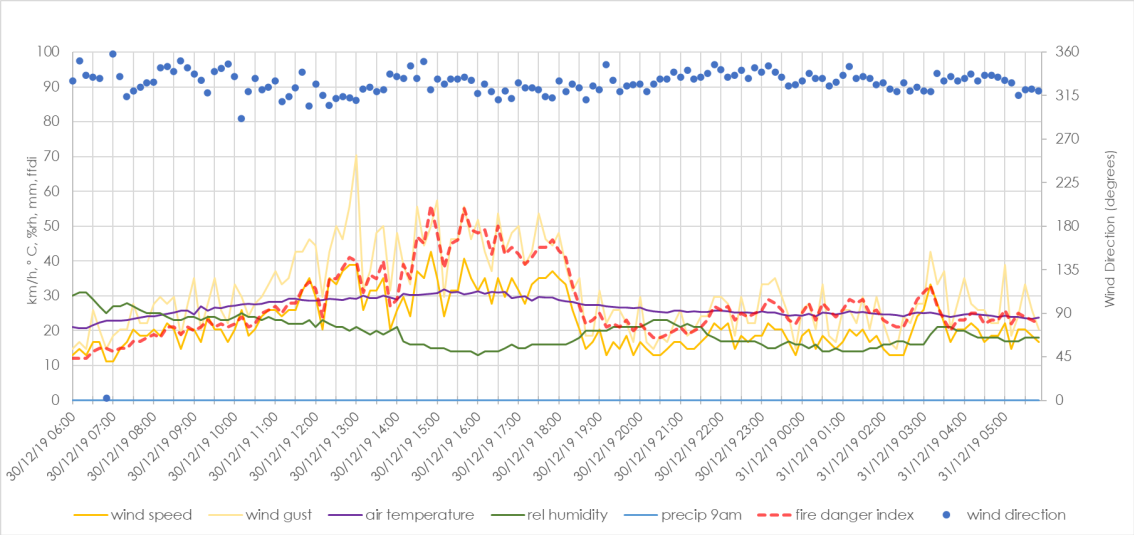


FIGURE 178: MT HOTHAM AIRPORT AWS DATA FOR THE 30TH AND 31ST OF DECEMBER

Wind Change

The wind change timing has been compiled from BOM issued wind change charts and station observations and can be seen in Figure 179. Further analysis of this change and other key weather events has been identified as an area for further work involving the BOM.

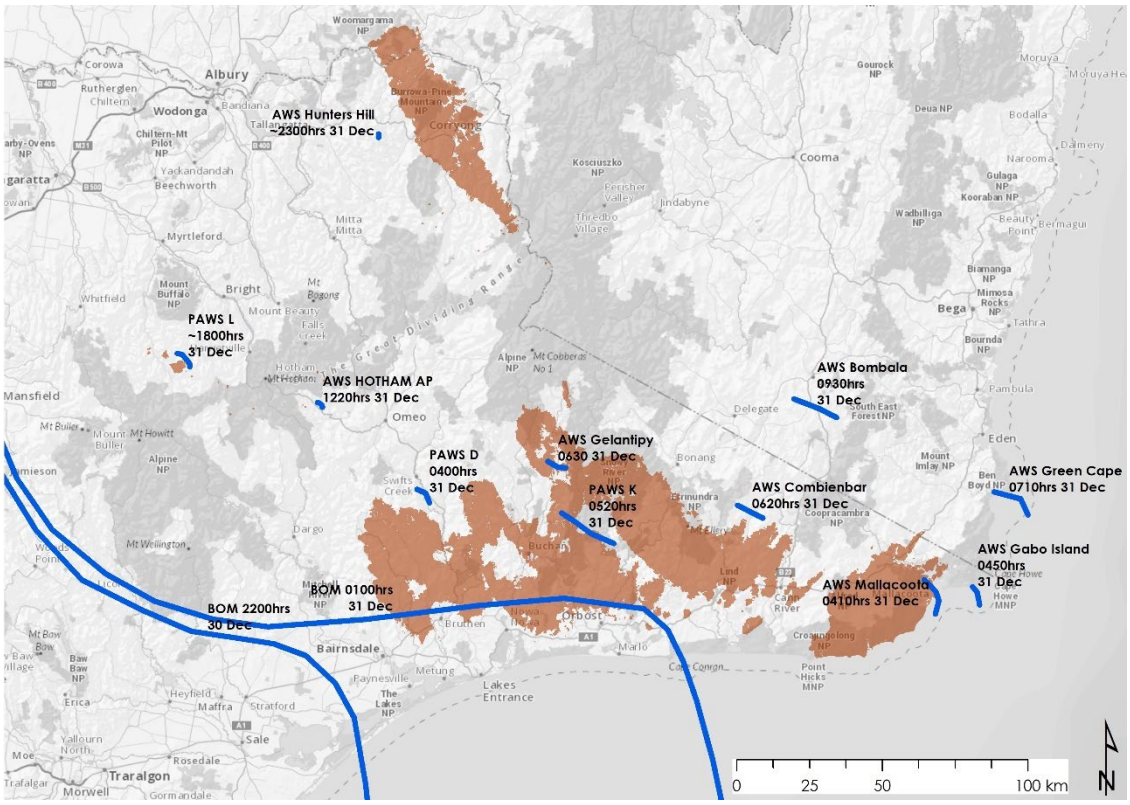


FIGURE 179: WIND CHANGE OBSERVATIONS 30TH TO 31ST DECEMBER 2019

Fire Runs of the 30th and 31st of December 2019

There were significant fire runs in multiple places on the 30th and 31st of December. There is good information on the initial stages with many

photographs and line scans. For the night of the 30th into the 31st there was less information and much of it comes from situation reports, stories from individuals, weather records and the Himawari satellite (see *Appendix Three: Snowy and Tambo Himawari IR progression* for a series of images that were taken from a Google Earth animation prepared for the project). This section presents a preliminary overview of the major runs. These were driven by NNW winds until the arrival of a SW change. This change slowly reached elevated inland areas as the morning progressed.

Figure 180 shows the major following section fire runs on the 30th of December and Table 3 provides a summary of fire behaviour parameters. The following sub-sections examine a number of these events. These summaries are partially complete and were compiled from available information. They utilise imagery, photographs videos, social media, AIG and line scan data sources.

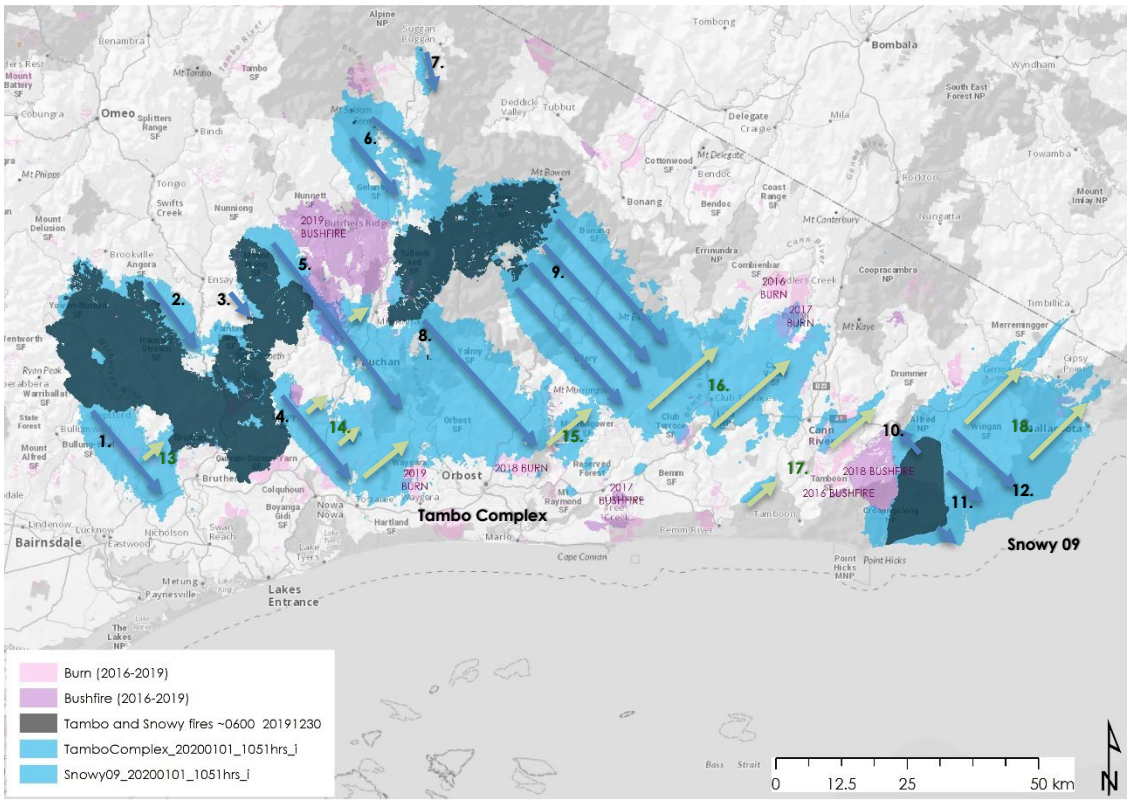


FIGURE 180: MAJOR FIRE RUNS ON THE 30TH INTO THE 31ST OF DECEMBER 2019

No	Name	Fire run Length (km)	Time of Run	Average ROS (km/h)	Max Spotting Distance (km)	Comment
1&13	Sarsfield/Clifton Creek	22	6hrs	3.6	8+km	
2	Angora Range				24?	2 stages
3	Reedy Flat/Holstons	7.5	2.3hrs	3.2	0	Predominantly grass fire
4&14	Buchan Sth to Wairewa	17	9hrs	1.9	?	Fire impacted Wairewa at ~2300hrs
5	Buchan	25	6hrs	4.2	?	
6	Seldom Seen	25	12hrs	2.1	5-6	
7	Mt Stradbroke	9	?	?	?	
8	Snowy River to Orbost	28	10hrs	2.8	5+	
9	Yalmy to Cann River	50	18hrs	2.7	15+	ROS calculated from Yalmy Rd to Princes Highway
11,12&18	Wingan to Mallacoota	25	20hrs	1.2	?	Was a flanking fire before wind change

TABLE 3: FIRE BEHAVIOUR PARAMETERS FOR SLECTED FIRE RUNS ON THE 30TH INTO THE 31ST OF DECEMBER 2019

Buchan

At some time around 1430hrs on the 30th of December 2019 the fire breached control lines on Watts Creek Track and began its progression SSE adjacent to the recently burnt Ensay - Ferntree Creek fire. It began at about 980m elevation and ran on a downslope trajectory with many undulating spurs and ridges in its path, to Buchan at 130m elevation. The fire path and elevation profile can be seen in Figure 181. The profile and forest types are such that it would have facilitated both long and medium distance spotting. The fire passed through the large Timbarra-Sunny Point bushfire that had occurred in September 2017. Snapshots of the progression can be seen in Figure 182. The fire impacted on Buchan and surrounds from 1900hrs to 2000hrs in the form of spot fires and a coalesced front and flanks. Images all taken around the time of impact can be seen in Figure 183 to Figure 185.

The fire continued and by 2330hrs had merged with adjacent fire runs and was then impacted by the wind change at lower elevations. Not much is known of how the fire runs interacted when they converged, but one would have expected increased fire behaviour. These convergence zones were in remote country and were not visible on satellite.

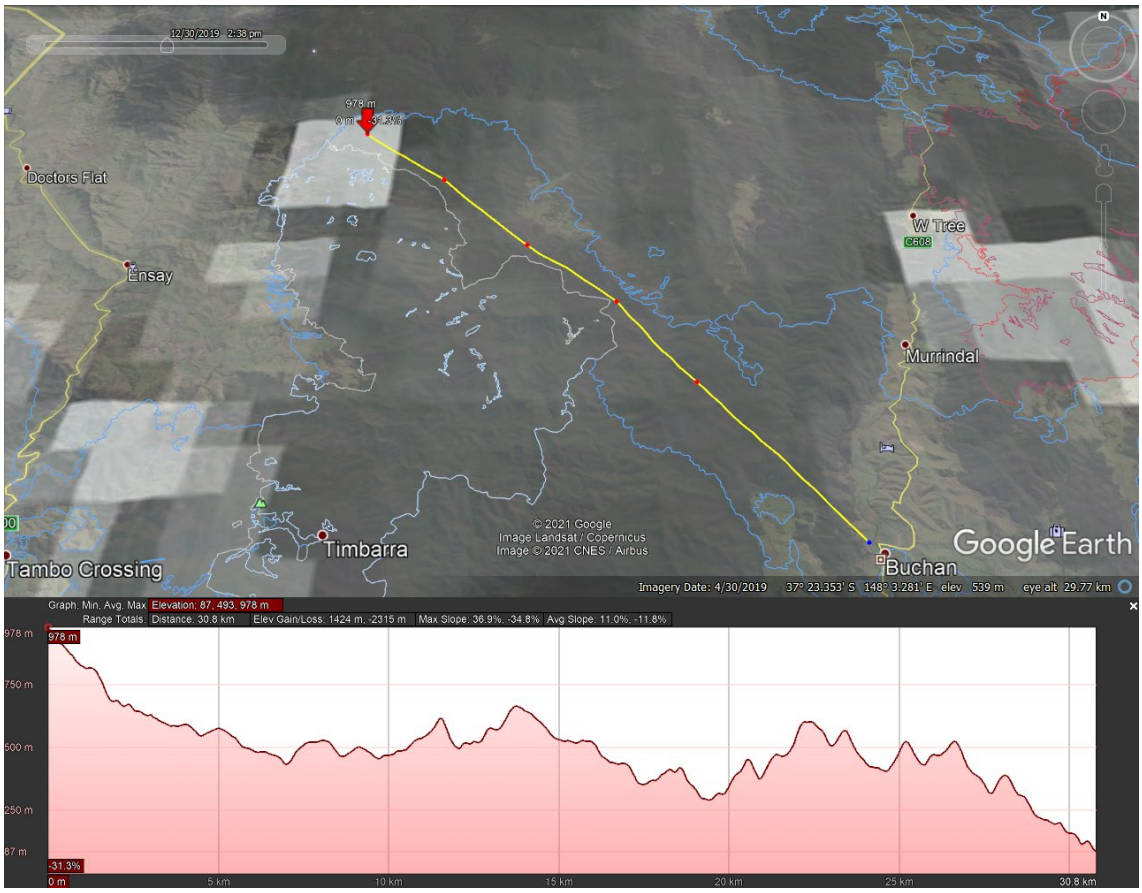


FIGURE 181: FIRE PATH AND ELEVATION PROFILE FOR THE BUCHAN FIRE RUN. THE WHITE LINE IS THE PRE-RUN BOUNDARY AND THE BLUE LINE THE POST-RUN BOUNDARY. THE RED ARROW IS THE APPROXIMATE POINT OF ORIGIN

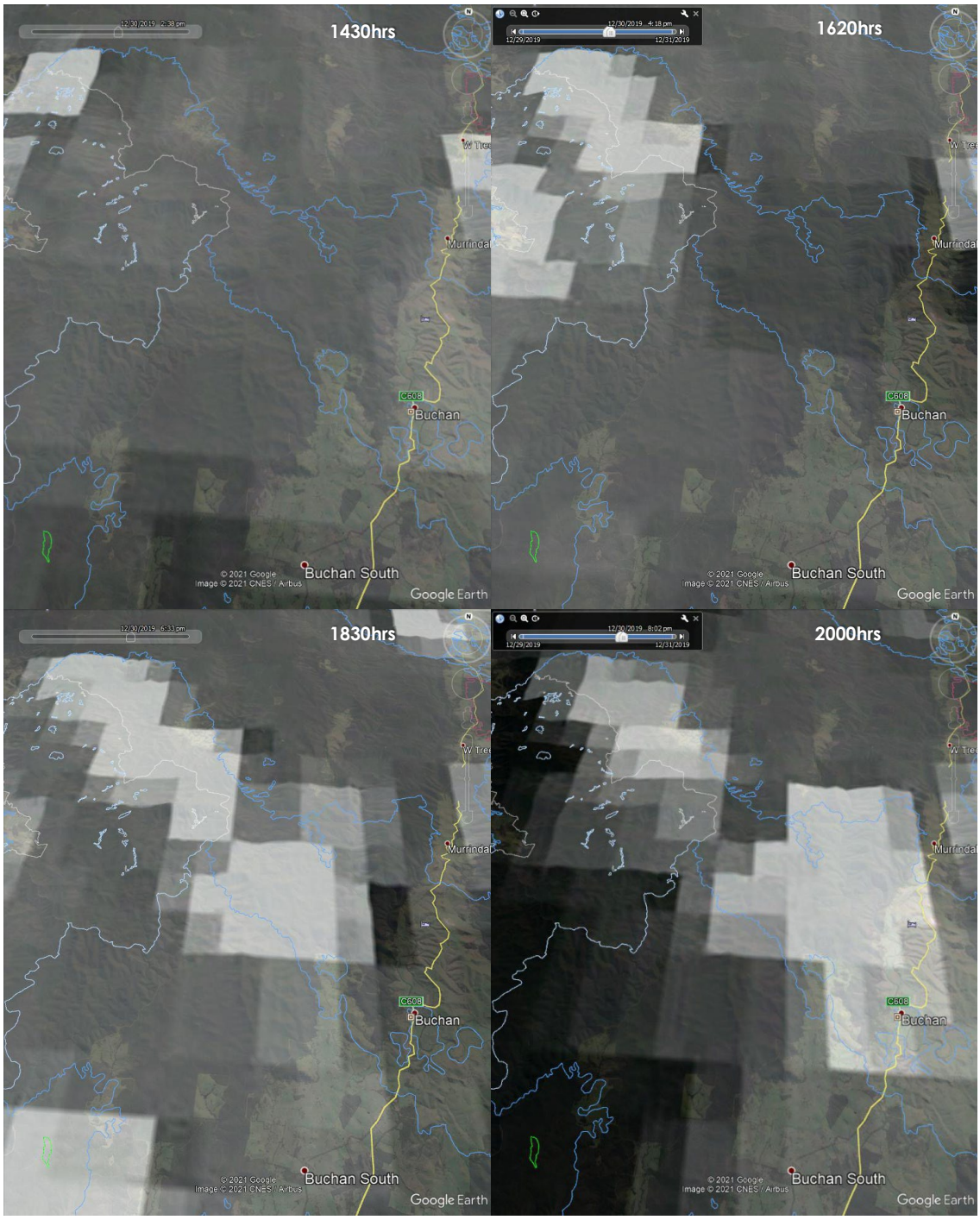


FIGURE 182: FIRE PROGRESSION SNAPSHOTS USING HIMAWARI 8 SWIR IMAGERY (THE WHITE LINE IS THE PRE-RUN BOUNDARY AND THE BLUE LINE THE POST-RUN BOUNDARY)

FIGURE 183: BUCHAN 1908HRS 30TH OF DECEMBER 2019 LOOKING NORTHEAST FROM BIRDDOG 393

FIGURE 184: LOOKING NORTH TOWARD BUCHAN FROM JUST EAST OF THE OLD BUCHAN RD-(37.509°, 148.168°) BUCHAN CAVES HOTEL FACEBOOK

FIGURE 185: SPOTFIRES IN BUCHAN (YOUTUBE VICPOL VIDEO)

Sarsfield Clifton Creek Breakout

This breakout is very well documented with line scans, photographs, AIG and suppression records. It has potential for further study. What follows is a preliminary analysis.

No fire crews were present at the site of the breakout. They had been taken offline and assigned to asset protection. The breakout most likely occurred from an ember to the north of Sisters Road crossing the road to the south near the corner of Howitt Spur Rd. Figure 186 shows heat signatures following the backburn and burning out and shows that there were very few areas of active fire. The centre top of the image shows the remaining unburnt area burning out. Figure 187 shows that there were faint hot spots (showing as white) within 150m of the breakout (red circle). The early stages of the breakout can be seen on the 1426hrs line scan, AIG and air observer photographs (see Figure 188, Figure 189 and Figure 193).

Figure 188 shows that the fire had travelled ~250m by the time of the scan (note positional accuracy and spread direction may be slightly incorrect) and was burning intensely.

Figure 192 provides on overview of the breakout showing the point of origin, and mapped line scans and AIG perimeters at different times. The initial boundary is shown as dark grey and the final boundary as light green.

FIGURE 186: LINE SCAN AT 1359HRS SHOWING REMAINING HOT AREAS 27 MINUTES BEFORE THE BREAKOUT

FIGURE 187: LINE SCAN AT 1359HRS SHOWING MOST LIKELY SOURCE

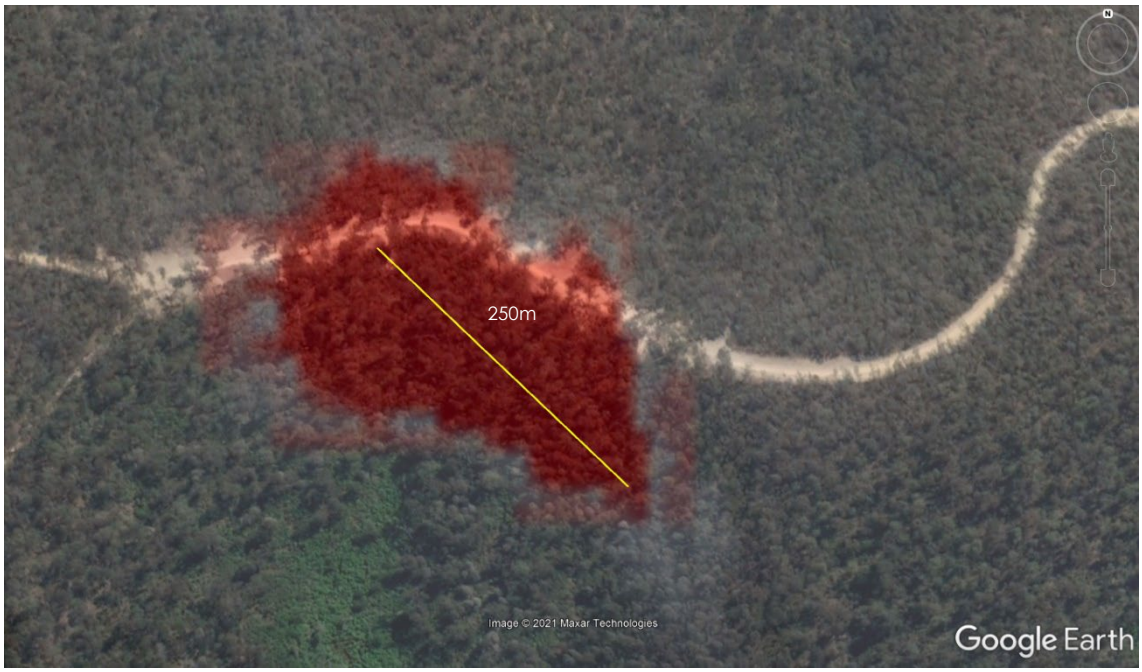


FIGURE 188: INITIAL ESCAPE CAPTURED BY 1426HRS LINE SCAN – YELLOW LINE SHOWS APPROXIMATE DIRECTION OF TRAVEL

The closest AWS to the fire were Bairnsdale and Mt Nowa Nowa. Graphs of the key parameters can be seen in Figure 171 and Figure 174. The wind change appears to have arrived at Mt Nowa Nowa at 1630hrs but was later at Bairnsdale and the fire ground. Further investigation into the weather is suggested.

Figure 189 compares the line scan with an AIG image which suggests the fire has travelled a further 660 metres in 8 minutes (roughly a 5km/h forward ROS). Figure 190 shows the rapidly developing spot fires in front of the head fire. This is around 20-30 minutes after ignition and at least 6 individual spots can be seen.

FIGURE 189: AIG IMAGE 1434HRS - TRAVELLED A FURTHER 660M IN 8 MINUTES (5KM/H) – FROM RED OF LINE SCAN TO YELLOW PIN (SAME AS CENTRE OF AIG IMAGE (CROSSHAIRS)

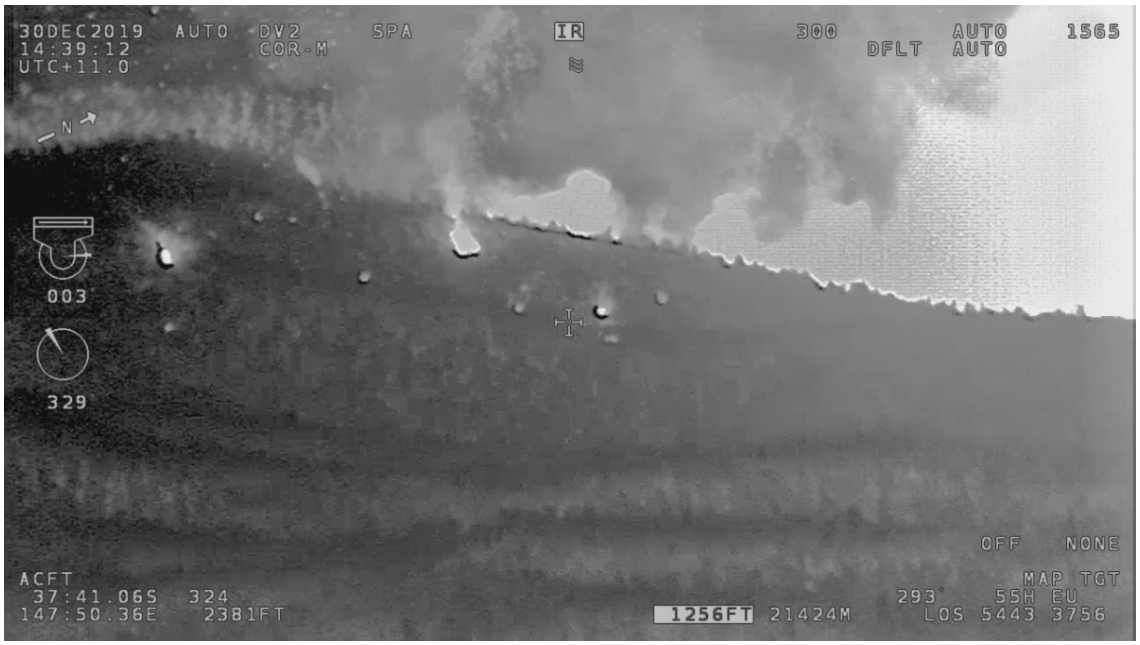


FIGURE 190: AIG IMAGE BY1439HRS SPOT FIRES 2.4KM FROM ORIGIN

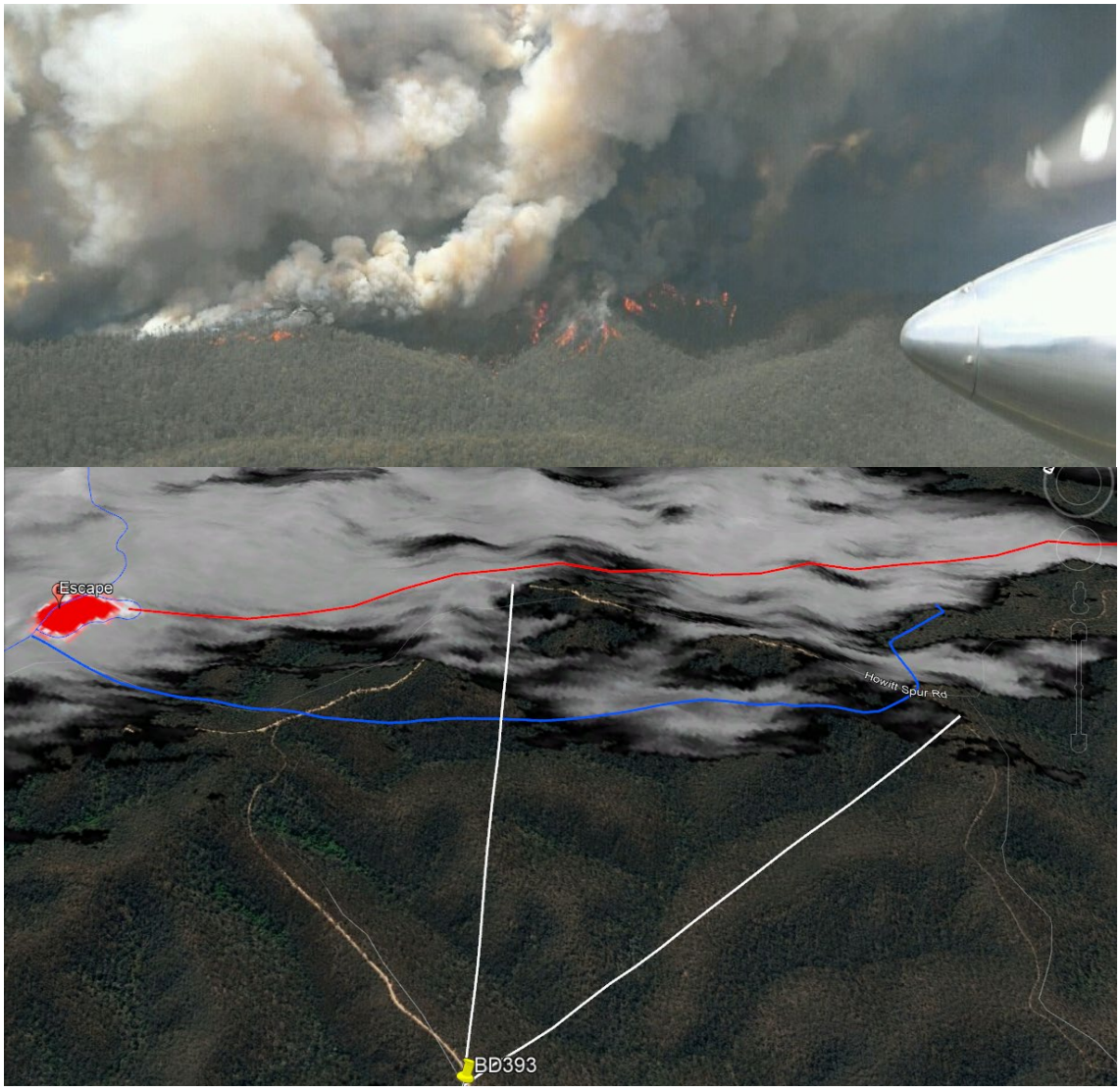


FIGURE 191: BIRDDOG 393 PHOTOGRAPH 1449HRS AND ANALYSIS _ WHITE LINES SHOW FIELD OF VIEW

Analysis (bottom) of the aerial observer photo (top) in Figure 191 shows the field of view (white), direction of run (red), and the approximate fire edge at 1449 (blue). The breakout was identified on the line scan at 1426hrs (red blob). Using this it is possible to estimate the rate of spread at 7.3km/h (2.8km in 23 minutes).

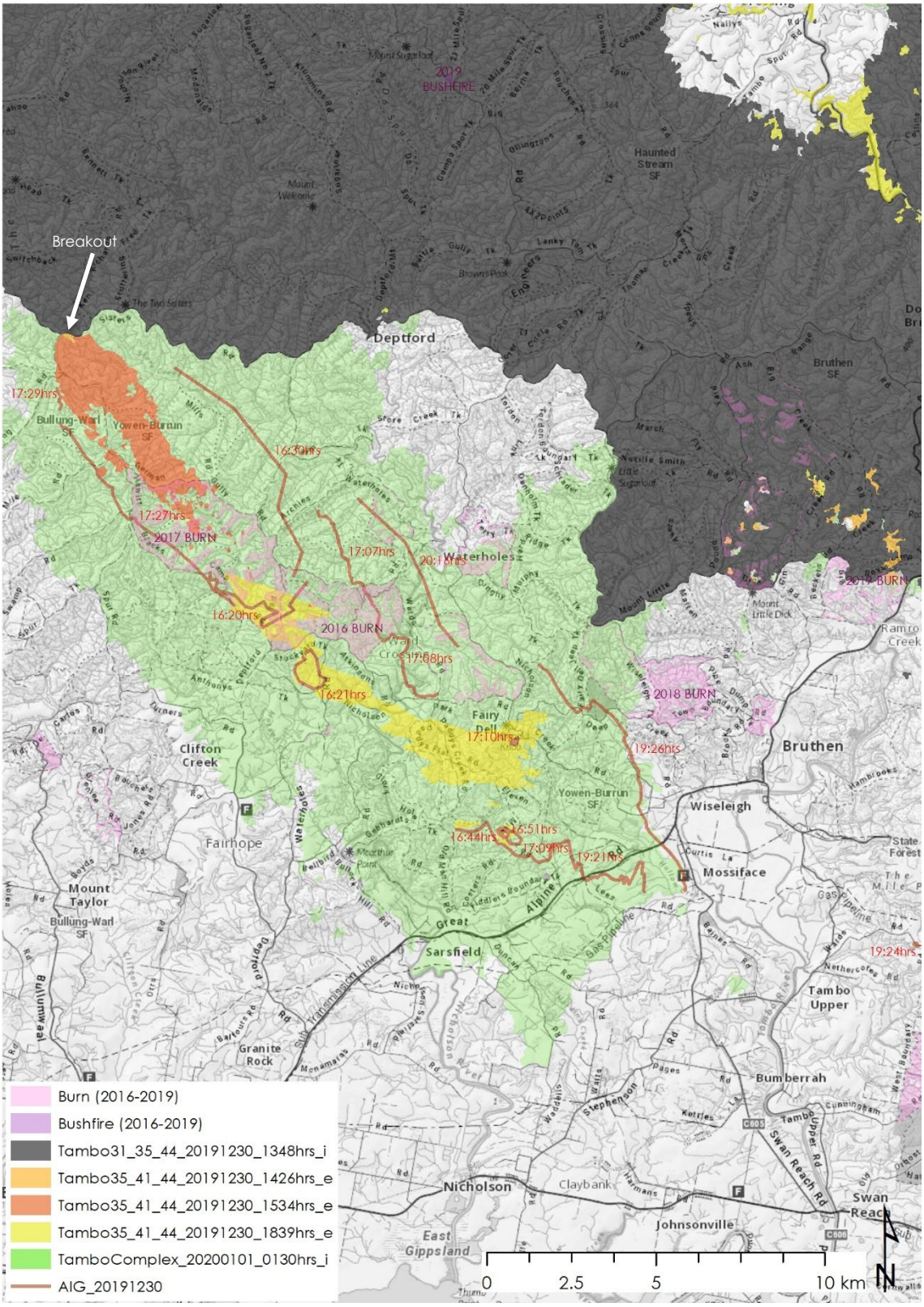


FIGURE 192: FIRE SPREAD FOR THE SARSFIELD - CLIFTON CREEK BREAKOUT 30TH DECEMBER 2019.

FIGURE 193: A VIEW FROM THE POINT OF ORIGIN AT 1522HRS 30TH OF DECEMBER 2019 (DALE APPLETON)

Figure 193 shows the breakout from near the source. The backburnt area is in the bottom left of the photograph.

FIGURE 194: TAMBO 35 BREAKOUT FROM BIRDDOG393 1539HRS 30TH OF DECEMBER 2019

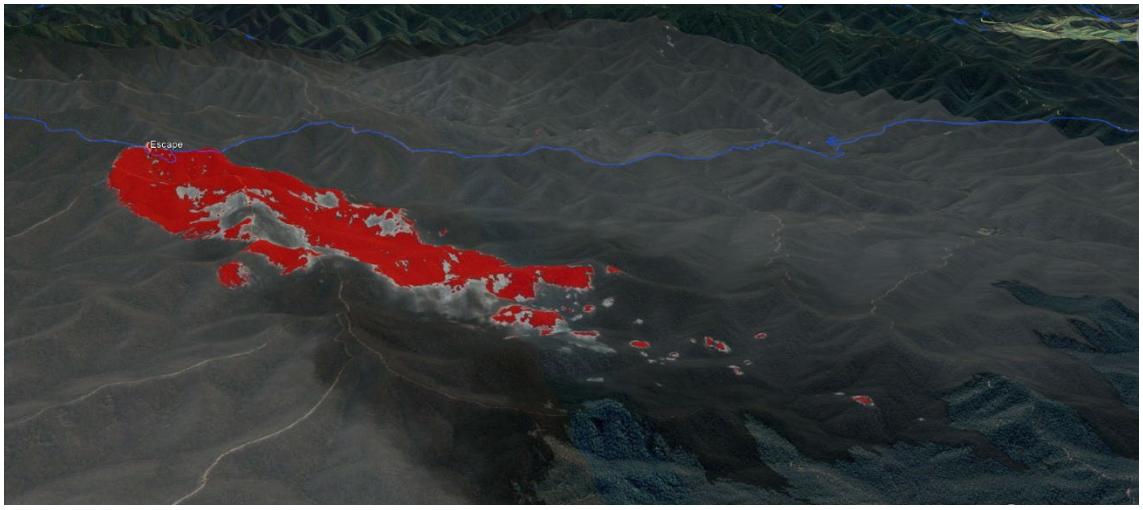


FIGURE 195: THE SAME SCENE AS A LINE SCAN 1534 HRS 30TH OF DECEMBER 2019

Figure 194 and Figure 195 show the same scene 5 minutes apart by aerial observer and infrared line scan. By 1535 the fire had a 6km line of continuous fire and numerous spot fires, the furthest being 12km from the origin.

Individual spot fires mapped by the AIG helicopter can be seen in Figure 196 (1434hrs to 1456hrs) and Figure 197 (1508 & 1519hrs).

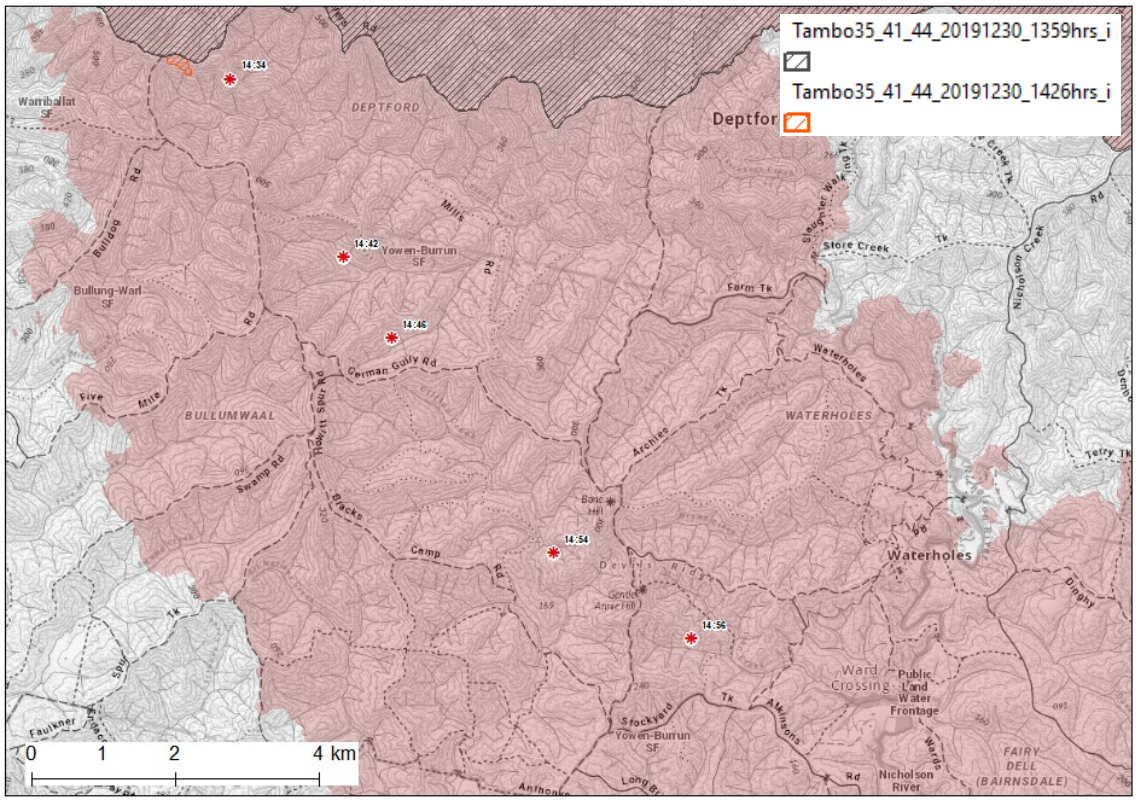


FIGURE 196: IN 30 MINUTES THE FIRE HAD SPOTTED A DISTANCE OF APPROXIMATELY 12KM

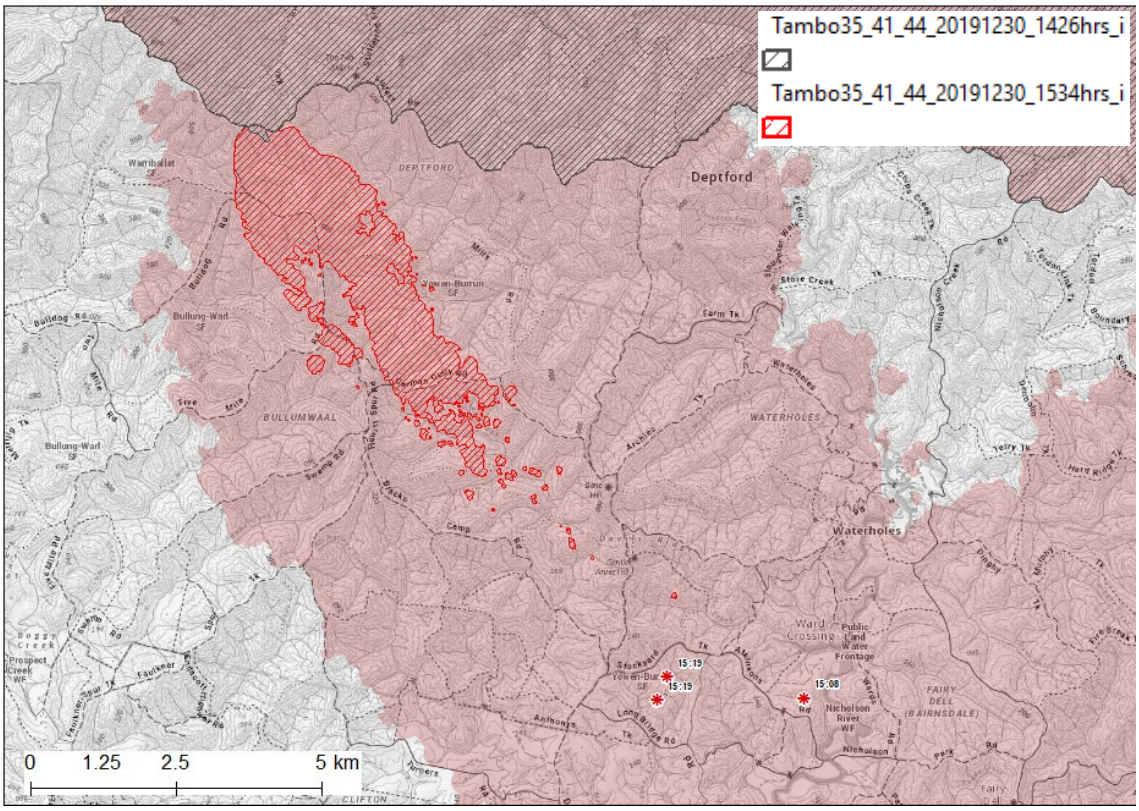


FIGURE 197 FURTHER SPOTTING WAS OCCURING AFTER 1500HRS – THESE WERE ESTIMATED TO BE IN EXCESS OF 8KM

FIGURE 198: THE NORTHEASTERN FLANK AT 1703HRS 30TH DECEMBER 2019 (DALE APPLETON)

Figure 198 shows the northeastern flank at 1703hrs. The length of run is around 20km and has travelled from around 550m elevation to around 120m.

Figure 199 has been widely seen and was taken by Dale Appleton in the AIG helicopter. It shows the head fire and column and the southwestern flank. It was taken at 1751 on the 30th of December. The Great Alpine Road (B500) runs along the forest/farmland boundary close to the smoke. Sarsfield is to the left and Wiseleigh to the right.

Additional photos can be found at

https://www.facebook.com/airattackmag/photos/a.2427951470754897/2427957007421010

There is also some video footage. See

https://www.facebook.com/watch/?v=2426570947583095

https://www.facebook.com/watch/?v=2629491907133416

FIGURE 199: THE WIDELY SEEN PHOTOGRAPH 1751HRS – LOOKING NORTHWEST, THE GREAT ALPINE ROAD(B500) RUNS ALONG THE FOREST/FARMLAND BOUNDARY CLOSE TO THE SMOKE. SARSFIELD IS TO THE LEFT AND WISELEIGH TO THE RIGHT. THE SMALL SPOT FIRE AT THE BOTTOM OF THE IMAGE IS ABOUT 1KM FROM THE GREAT ALPINE ROAD (DALE APPLETON)

FIGURE 200: TAMBO 35 BARMOUTH SPUR – MARTHAVALE BREAKOUT FLANK/HEAD 1758HRS 30TH DECEMBER 2019 (DALE APPLETON)

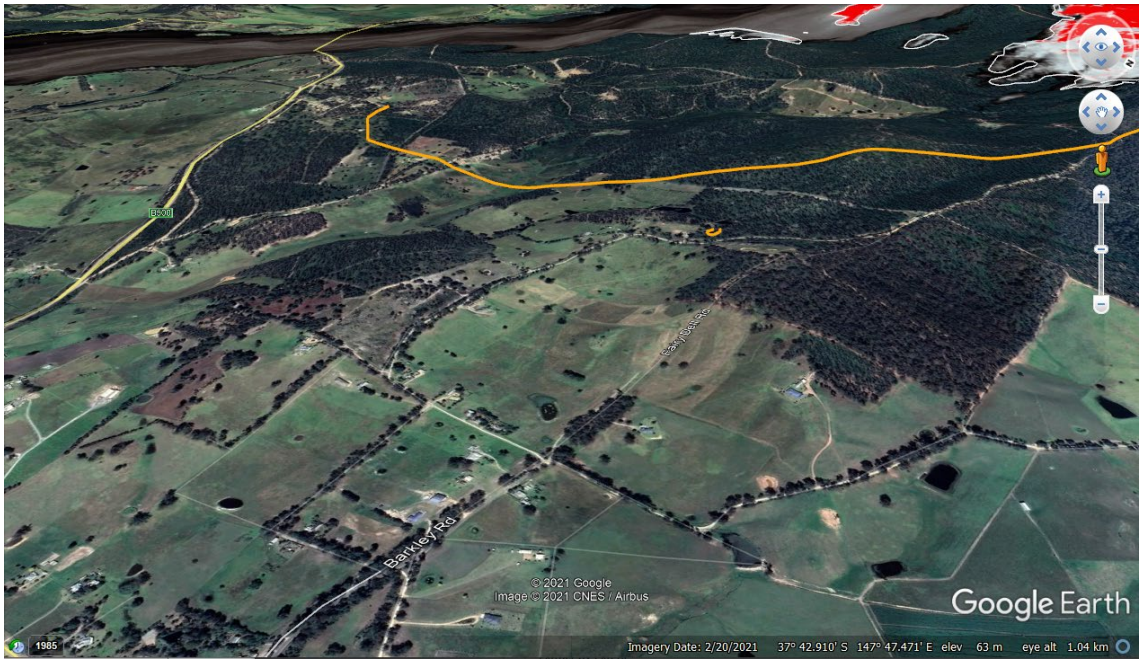


FIGURE 201: LOCATION OF FRONT/FLANK AND SPOT FIRE IN DALE APPLETON PHOTO (FIGURE 200)

Figure 200 shows the northeastern flank near the head fire. Figure 201 has mapped the fire edge from the photograph and shows the 1839 hrs line scan. This was captured 40 minutes after the photo however a combination of frontal cloud and intense plume obscured the fire in that area.

Figure 202 to Figure 208 show the fire progress and suppression effort. There is potential to undertake further study of suppression using these images, drop data, progression spatial data and records from ground crews.

FIGURE 202: FLANK FIRE AND SPOT FIRES IMPACTING ON PROPERTIES ON BELLBIRD RD AND LONG BRIDGE RD, CLIFTON CREEK ~1600-1700HRS

FIGURE 203 AIR ATTACK ON SPOT FIRES NEAR LONG BRIDGE RD AND WARDS RD, CLIFTON CREEK ~1600-1700HRS

FIGURE 204: SPOT FIRES UNDER MAIN PLUME - NICHOLSON CREEK RD, WISELEIGH ~1800-1900HRS

FIGURE 205: BETWEEN MOSSIFACE AND WISELEIGH -LOOKING WEST WITH AN EASTERLY WIND (THE EAST GIPPSLAND RAIL TRAIL IS DIRECTLY UNDERNEATH THE HELICOPTER)

FIGURE 206: BETWEEN MOSSIFACE AND WISELEIGH SHOWING SUPPRESSION OF MULTIPLE SPOT FIRES BY CFA AND LOCALS.

FIGURE 207: AN ISOLATED SPOT THREATENING A RESIDENCE AT MOSSIFACE

FIGURE 208: LOOKING WEST WHILE CFA AND LOCALS UNDERTAKE ASSET PROTECTION AND MONITOR SPOT FIRES AT FAIRY DELL RD ~1900HRS. THE EASTERLY WIND IS PRESENT.

Reedy Flat - Holstons

The Reedy Flat - Holstons run of the Ensay - Ferntree Fire run was predominantly a fast moving grass fire. It started at around 1400hrs from residual areas of unburnt forest that backed down towards private grazing land. (see Figure 209). By 1620hrs it had run a distance of 7.5km, parallel to the previously burnt forest.

FIGURE 209: LIKELY SOURCE AND INITIAL RUN OF REEDY FLAT HOLSTONS BREAKOUT

Prior to this run the grassland had been fully cured and spot fires emanating from the forest had not taken on previous blow-up days (25th of November and 9th of December). Air and ground suppression prevented further spread and eventually brought the fire under control. A 3d view of the fire run is shown in Figure 210.

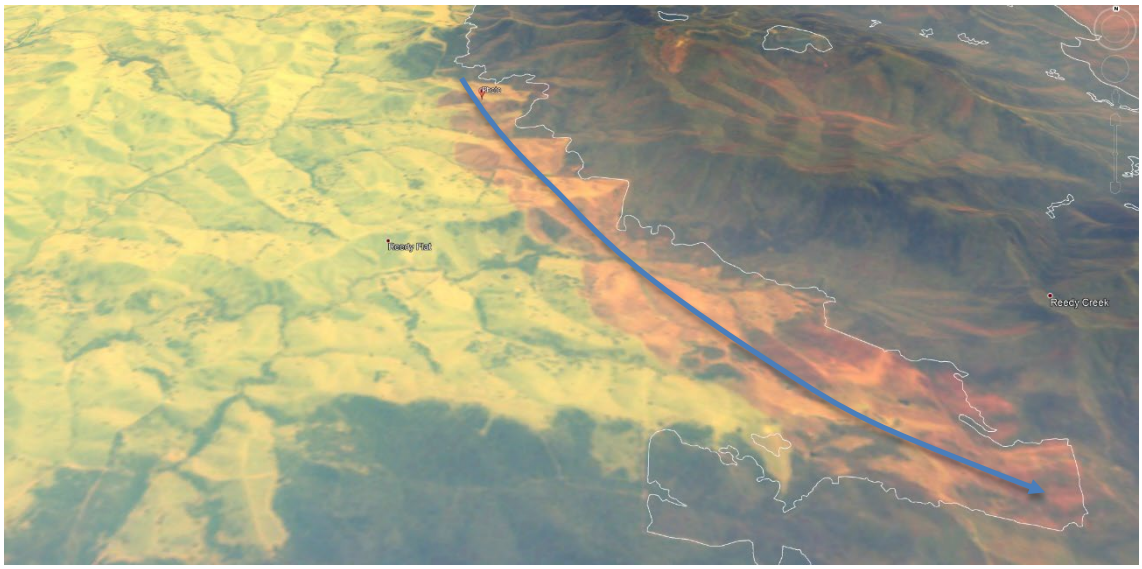


FIGURE 210: SENTINEL IMAGE FROM 3RD OF JANUARY SHOWING DIRECTION OF FIRE RUN ON THE 30TH OF DECEMBER.

FIGURE 211: AIR AND GROUND CREWS LIMITING THE SPREAD AND PROTECTING ASSETS EAST OF MURRELLS ROAD, REEDY FLAT 1430-1600HRS 30TH DECEMBER 2019

Figure 211 shows two views of the firefighting effort. Around five houses were saved, and the southwestern perimeter contained.

Tambo Crossing, Buchan South and Wairewa

This section examines the expansion of the fire in the Angora Range, the development of PyroCb, long distance spotting and the fire runs that impacted Tambo Crossing and Wairewa.

Suppression efforts leading up to the 30th of December had successfully linked the existing fires, and undertaken backburns and burning out operations. This resulted in an approximate fuel break of 6km between the active parts of the fire and the Buchan Valley. The analysis that follows shows how the fire impacted Tambo Crossing and spot fires started to the east that drove the fire to Wairewa

Figure 212 shows the mapping of line scan and AIG data that was available. The 0532hrs line scan shows that the fire had crossed the Haunted Stream and run to the top of the Angora Range (Point 1). By 1130hrs the fire expanded significantly with both topography and wind direction influencing the fire behaviour Sptt fires were first reported at this time in Tambo Crossing. By 1300 all of the east-southeast aspect was ablaze (seeFigure 215B). Figure 213 shows the situation at 1317hrs looking west. Figure 214 shows the fire at 1350hrs running along the top of the Angora Range toward Tambo Crossing. Also, at this time the Mt Elizabeth fire was also beginning to impact on Tambo Crossing. It appears that this continued with the peak fire behaviour at Tambo Crossing occurring at around 1500-1600hrs.

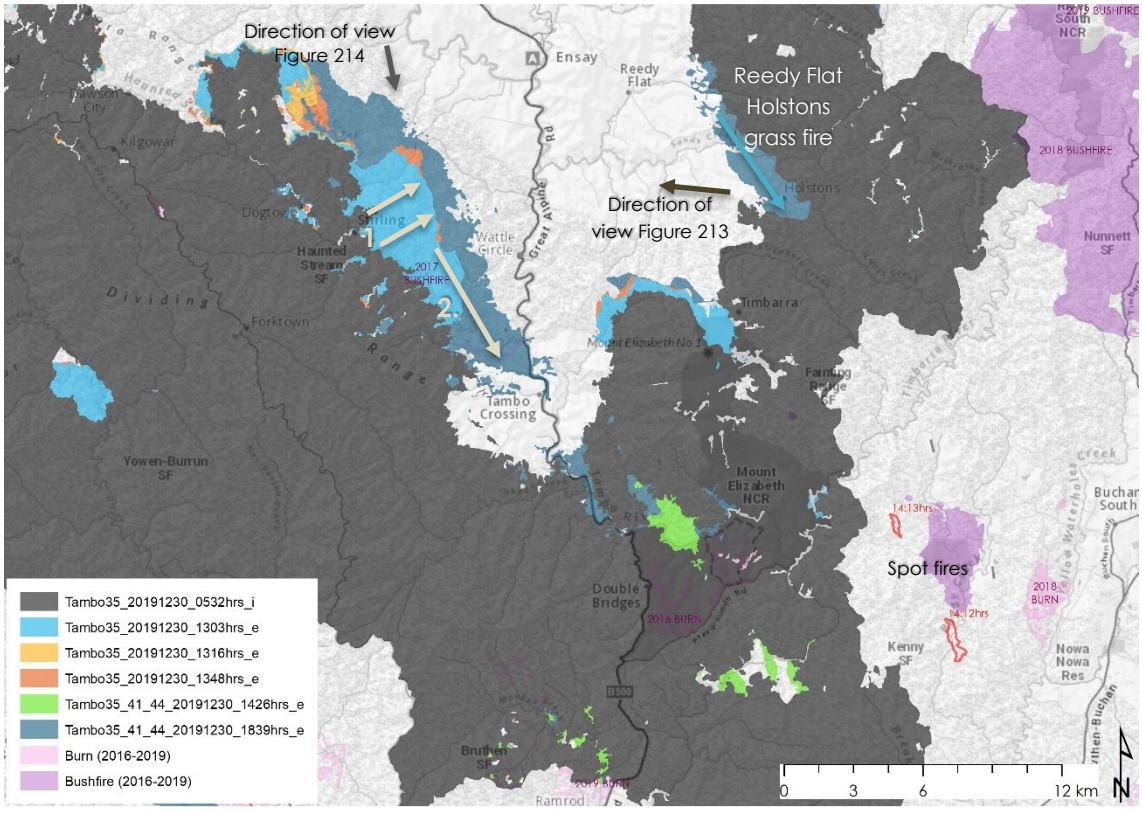


FIGURE 212: FIRE PROGRESSION ON THE 30TH OF DECEMBER TO 1839HRS. (NOTE IT IS INCOMPLETE IN SOME AREAS).

Figure 212 is not complete as the PyroCb obscured some of the line scans. It also shows the spot fires mapped by the AIG at 1412 and 1413hrs

FIGURE 213: VIEW TOWARD THE ANGORA RANGE LOOKING WEST OVER THE BUCHAN ENSAY ROAD 1317HRS (DELWP)

FIGURE 214: ANGORA RANGE 1350HRS 30TH DECEMBER LOOKING SOUTH TOWARD TAMBO CROSSING (ANGORA RANGE RD IN FOREGROUND)

Figure 215 shows the same scene of Tambo Crossing with line scans at 0532hrs, and 1303hrs on the 30th of December 2019 and a NIR SWIR Sentinel2 image from the 3rd of January 2020. The cleared land has been outlined for reference. At 0532hrs (A) the fire NE of Stirling is running up the Angora Range and the fire south of Reedy Creek is about to cross a drainage line just east of Mt Elizabeth

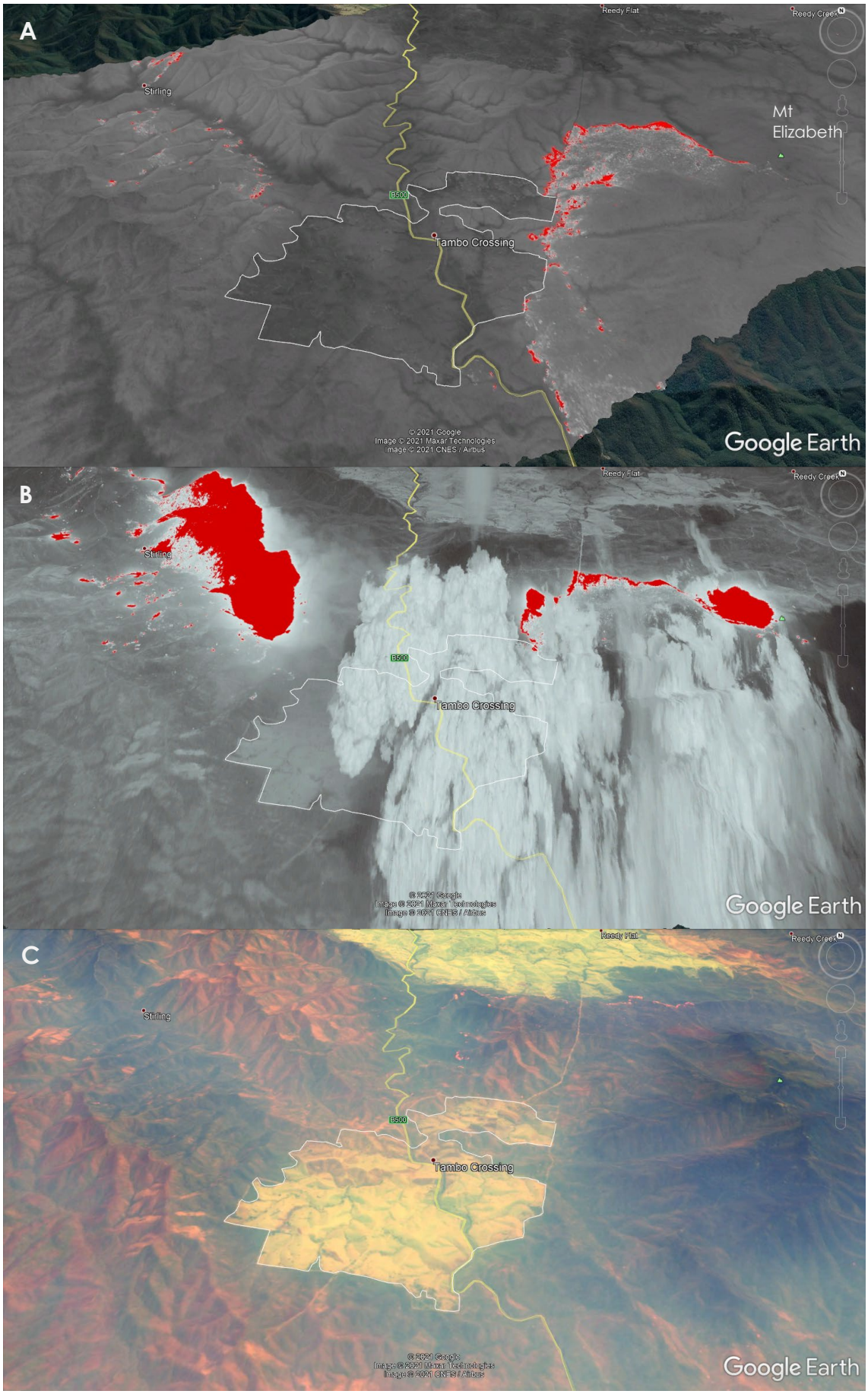


FIGURE 215: TAMBO CROSSING IMAGES (A)0532HRS 30TH DECEMBER, (B) 1303HRS 30TH DECEMBER 2019, (C)1107HRS 3RD JANUARY 2020

In Figure 215 (B) shows the Angora Range and Mt Elizabeth areas burning intensely and starting short distance spot fires. Much of Tambo Crossing is obscured under the PyroCb cloud. (C) shows the situation on the 3rd of January (which would be similar to that of early on the 31st of December). The previous fire run on the 20/21st December is in the bottom/far left and the run along the top of the Angora Range runs parallel to that northeast of Tambo Crossing. Figure 216 shows the situation in Tambo Crossing with all adjacent forest burning and numerous spot fires.

FIGURE 216: LOCALS CFA AND DELWP ALL WORKED TOGETHER TO PROTECT ASSETS AND FIGHT SPOT FIRES (DELWP)

The fire that impacted on Buchan South and Wairewa resulted from long distance spotting from either Mt Elizabeth or most likely the intense activity on the Angora Range. Figure 217 shows the 1303 hrs line scan, two spot fires mapped by the AIG (green outline), the perimeter at the start of the day (white outline) and the perimeter after the 31st of December (blue outline). The blue arrows show the possible direction of travel of embers from Mt Elizabeth, and the orange arrows the possible travel from the Angora Range. The distances involved are around 20 or 30km respectively.

Figure 218 shows the largest of these spot fires looking west over Molly Plains Rd at 1414 hrs. Examination of the Himawari true colour, enhanced IR and SWIR data (see Figure 219) shows the development of the large PyroCb and associated cloud to cloud lightning. The upper-level winds carry the plume from the Angora Range directly over the location of the spot fires. Thus it appears most likely that this was the source of the spot fires.

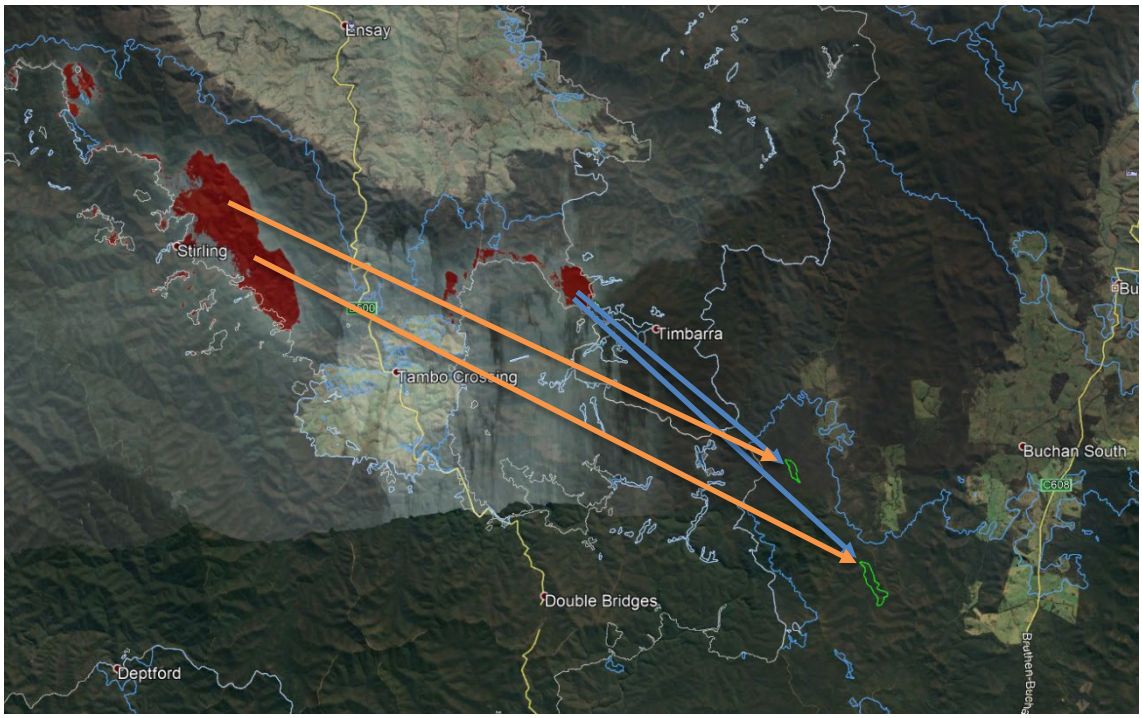


FIGURE 217: THE TWO POSSIBLE SOURCES OF SPOTTING MT ELIZABETH - 20KM OR ANGORA RANGE -30KM

FIGURE 218: THE SOUTHERN AND LARGEST (~1800M LONG) OF THE TWO SPOT FIRES THAT EVENTUALLY IMPACTED ON WAIREWA AND BUCHAN SOUTH - 1414HRS - LOOKING WEST OVER MOLLY PLAINS ROAD (DALE APPLETON)

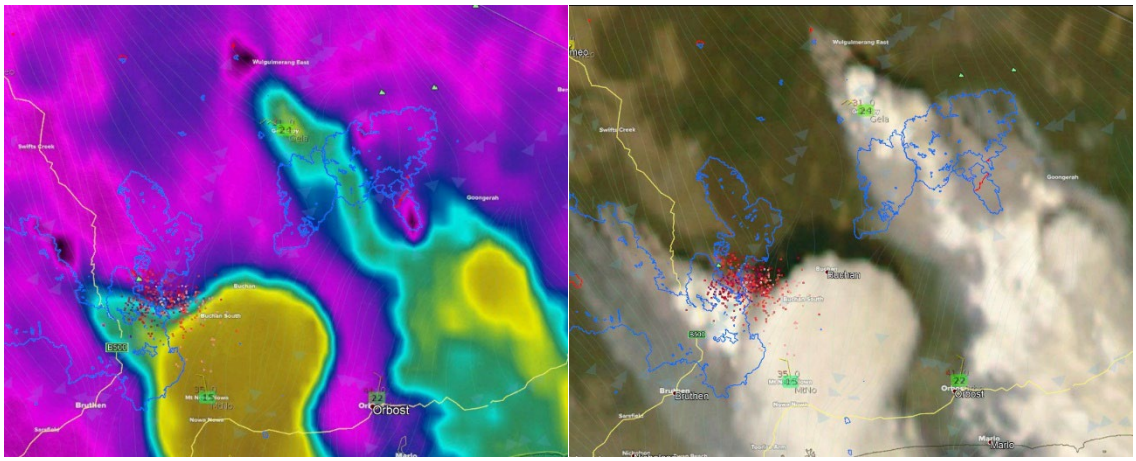


FIGURE 219: WEATHERZONE HIMAWARI ENHANCED IR AND TRU COLOUR IMAGES AT ~1320HRS SHOWING LARGE PYROCB GENERATING LIGHTNING

Following the establishment of these two spot fires, the fire continued to move southeast as shown in Figure 220. This schematic shows the pre-fire run boundary as a white outline and the post-fire run boundary as blue. The direction of view for Figure 221 taken at around 1700hrs is shown. Additional spot fires were mapped by the AIG at 1807hrs and are marked and shown in Figure 222.

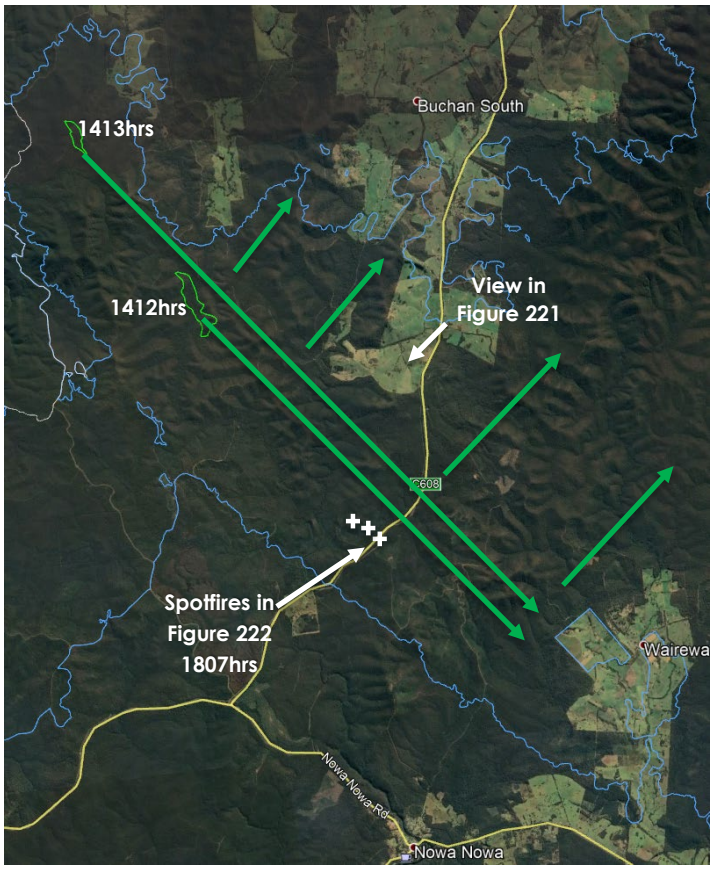


FIGURE 220: THE RUN OF SPOT FIRES EAST OF BUCHAN SOUTH TO WAIREWA AND THE SW WIND CHANGE

The situation report at 2230hrs suggests that Wairewa was being impacted and this appears consistent with Himawari imagery media reports that the fire entered the Wairewa Valley about an hour before midnight on December 30th 2019 (https://www.bairnsdaleadvertiser.com.au/news/local-news/523-the-night-wairewa-burnt).

FIGURE 221: VIEW OF ESCALATING SPOT FIRES SOUTH AND SOUTHWWEST OF BUCHAN SOUTH AT ~1700HRS (DELWP)

FIGURE 222: SPOTFIRES REACHING THE BUCHAN RD AT 1807HRS ON THE 30TH OF DECEMBER 2019 (LOOKING EAST)

Examination of the Mt Nowa Nowa AWS shows lessening of wind speed and change in direction, possibly associated with the prefrontal trough. Figure 171 shows that from 1630hrs the winds went westerly to south-westerly before strengthening and returning to the northwest before 2300hrs prior to the change proper. This change caused the north-eastern flank to push up to Buchan South in a series of tongues. North of Wairewa it joined with other fire runs (Buchan and Snowy River/Orbost)

Yalmy Road to Cann River

This breakout occurred in four initial SSE runs that eventually merged and ran NE with the wind change. The initial run was 50km long and 15km after the wind change.

There were many kilometres of uncontained edge. As the morning progressed, the fire edges developed in intensity and soon began spotting. The first breakout to show significant activity was the most southerly, close to the Yalmy Rd. Analysis shows this quickly expanding from 1000hrs. By 1400hrs it had travelled 11km and had merged with another breakout that had crossed Wrong Creek from the Waratah Flat area. Further to the northeast two more breakouts had occurred by 1200hrs. These produced many medium distance spots.

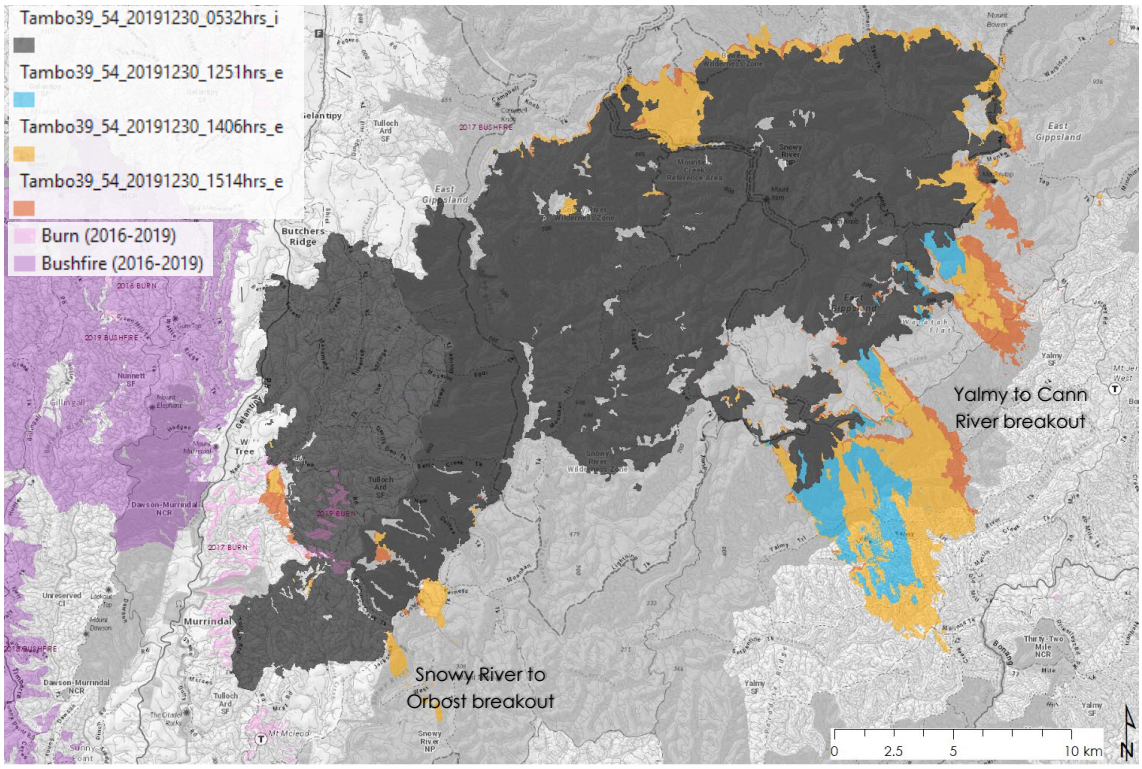


FIGURE 223: FIRE PROGRESSION W TREE - YALMY BUSHFIRE 0532HRS TO1514HRS 30TH OF DECEMBER 2019

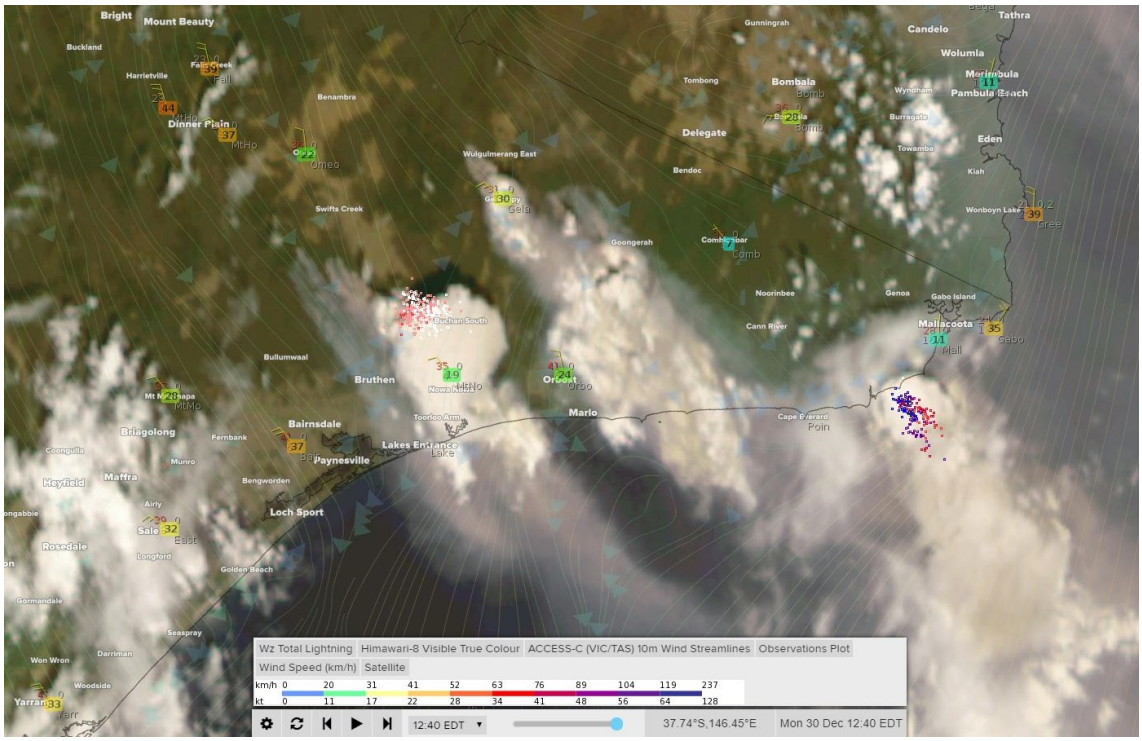


FIGURE 224: WEATHERZONE LAYERS HIMAWARI TRUE COLOUR IMAGE 1240HRS 30TH DECEMBER SHOWING THE SMOKE PLUMES FROM THE BARMOUTH SPUR – MARTHAVALE, GELANTIPY, W TREE – YALMY AND BANANA TRACK FIRES

The fire caused a pyroCb cloud to develop and this produced lightning after 1500hrs. A DELWP situation report at 1453hrs states that the fire had crossed the Bonang Highway and there were at least fifteen spots which were building rapidly. By around 1700hrs the individual runs had merged. Analysis shows that the fire ran 36km in 12 hours (1500hrs – 0300) which equates to an average forward rate of spread of 3km/h.

DELWP records state the fire reached the Goongerah Valley by 1800hrs on the 30th of December and a resident at Club Terrace stated the fire reached there by 0130hrs on the 31st of December.
(https://www.redcross.org.au/stories/emergency-services/it-sounded-like-a-hundred-jets)

Figure 225 to Figure 228 show 3d images for the 30th of December.

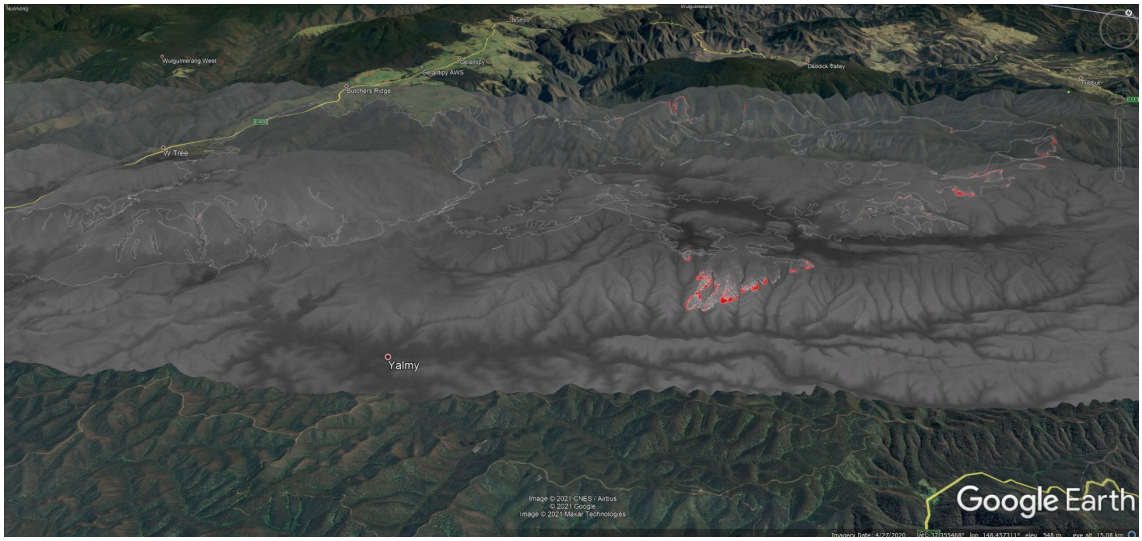


FIGURE 225: LINE SCAN SHOWING START OF W TREE – YALMY FIRE RUNS 0532HRS 30TH OF DECEMBER 2019

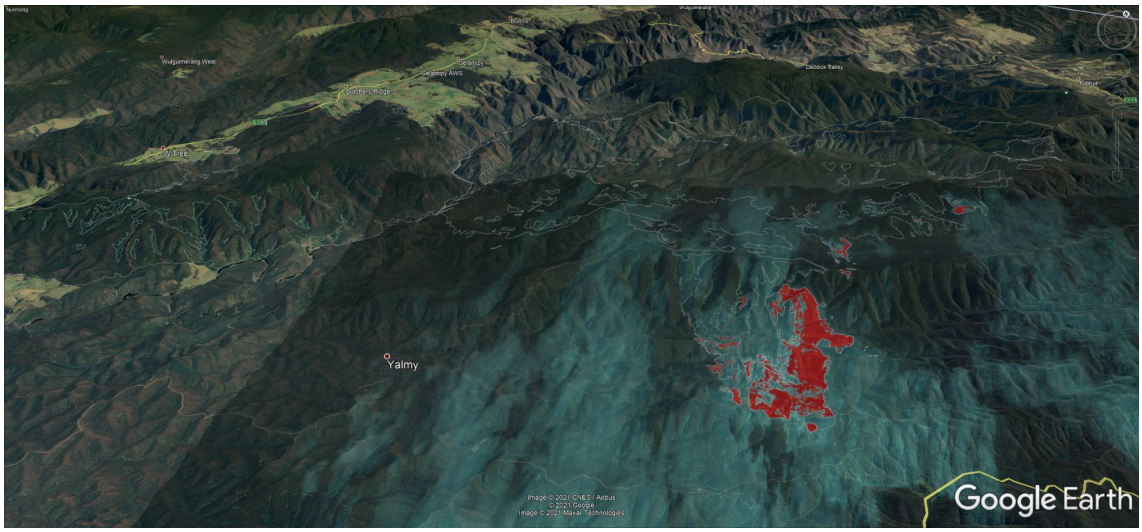


FIGURE 226: LINE SCAN SHOWING OF W TREE – YALMY FIRE RUNS 1251HRS 30TH OF DECEMBER 2019

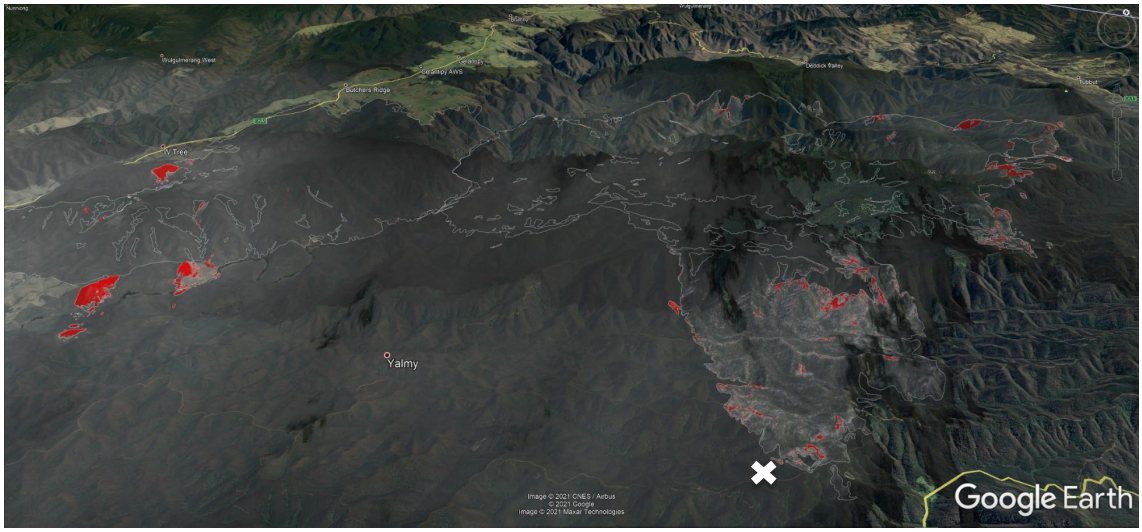


FIGURE 227: LINE SCAN SHOWING START OF W TREE – YALMY FIRE RUNS 1406&1418HRS 30TH OF DECEMBER 2019 (X IS THE LOCATION OF FIGURE 229)

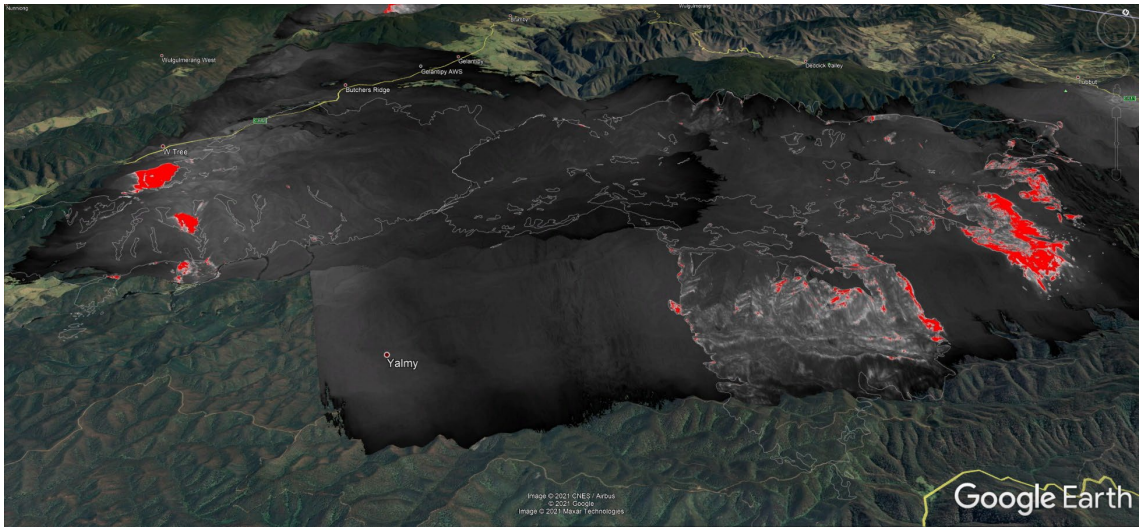


FIGURE 228: LINE SCAN SHOWING PROGRESSION OF W TREE – YALMY FIRE RUNS 1514HRS 30TH OF DECEMBER 2019

FIGURE 229: 1408HRS (MIKE IRVINE) DOWNHILL PROGRESSION OF W TREE YALMY FIRE NEAR MALINNS TRACK WITHIN 2KM OF THE BONANG HIGHWAY

Figure 229 shows an aerial image at 1408hrs. An "X" on Figure 227 shows the location of the photo.

Figure 230 to Figure 232 show Himawari SWIR images of the fire progression from 1900hrs to 0020hrs. The blue line shows the boundary as mapped at 0130hrs on the 1st of January.

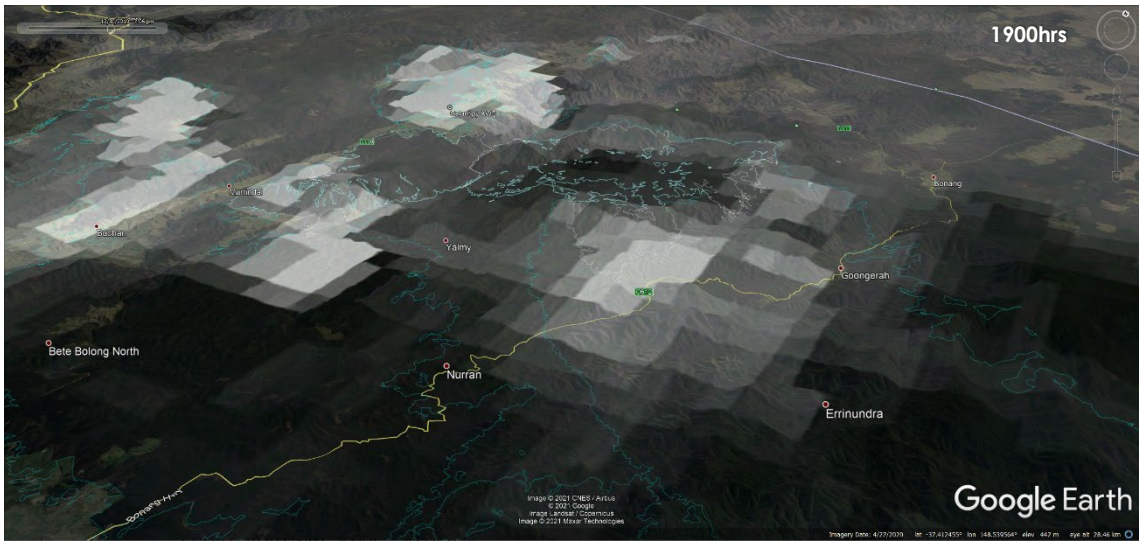


FIGURE 230: HIMAWARI 8 SWIR IMAGE SHOWING PROGRESSION OF W TREE – YALMY FIRE RUNS 1900HRS 30TH OF DECEMBER 2019

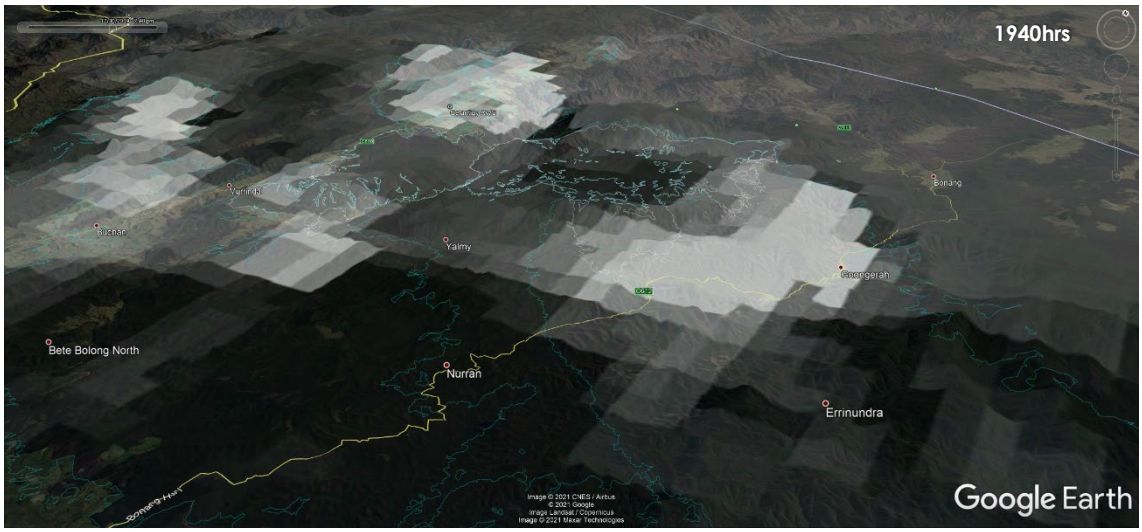


FIGURE 231: HIMAWARI 8 SWIR IMAGE SHOWING PROGRESSION OF W TREE – YALMY FIRE RUNS 1940HRS 30TH OF DECEMBER 2019

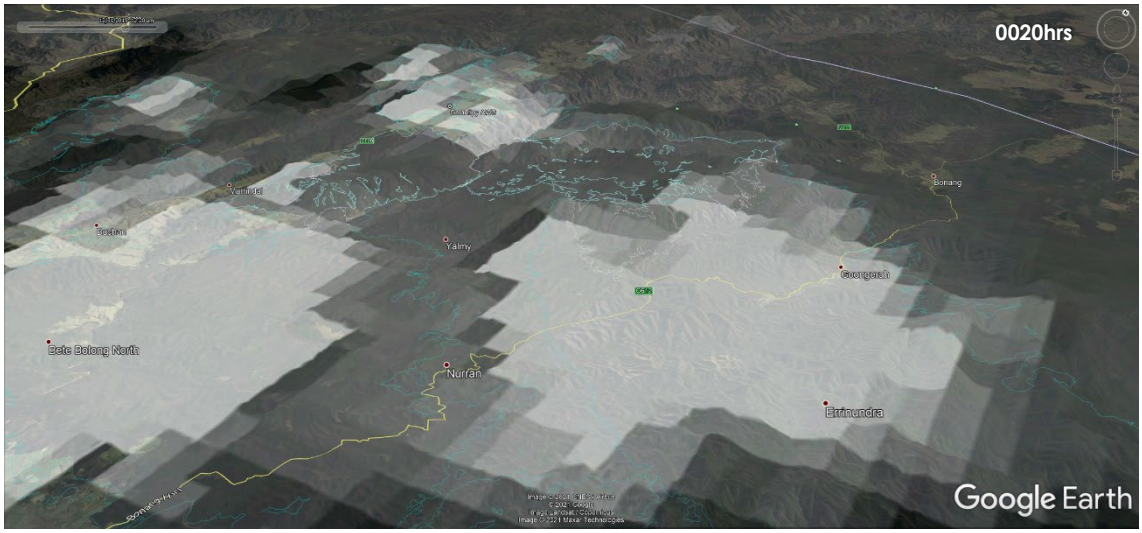


FIGURE 232: HIMAWARI 8 SWIR IMAGE SHOWING PROGRESSION OF W TREE – YALMY FIRE RUNS 0020HRS 31ST OF DECEMBER 2019

Further analysis could be undertaken to document the further fire spread past this point. Appendix Three: Snowy and Tambo Himawari IR progression contains a visual summary of the fire spread.

It is estimated that the fire reached the Princess highway somewhere near Bellbird Creek at around 0400hrs. This was approximately when the change arrived. The exact nature of the prefrontal trough and change requires further investigation but has been considered to some degree in *Weather for the 29th to 31st of December 2019* on page 117.

Spotting ahead of the fire appears to have been at least 15km with long distance spots occurring well south of the highway near Tamboon.

The main fire front did not reach Cann River although spot fires were recorded further east. There was active fire between Tonghi Creek and Cann River at around 0600-0700hrs. The wind change appears to have arrived at or just after this time pushing the fire away from the township.

Snowy River to Orbost

On the 30th of December at approximately 1300hrs, the W Tree - Yalmy fire broke containment lines on Basin Road and then spotted over the Snowy River at Jacksons Crossing. The spot fires started in in accessible terrain and quickly developed, leading to more spotting.

FIGURE 233: LOOKING SOUTH DOWN THE SNOWY RIVER1351HRS 30TH DECEMBER 2019(MIKE IRVINE)

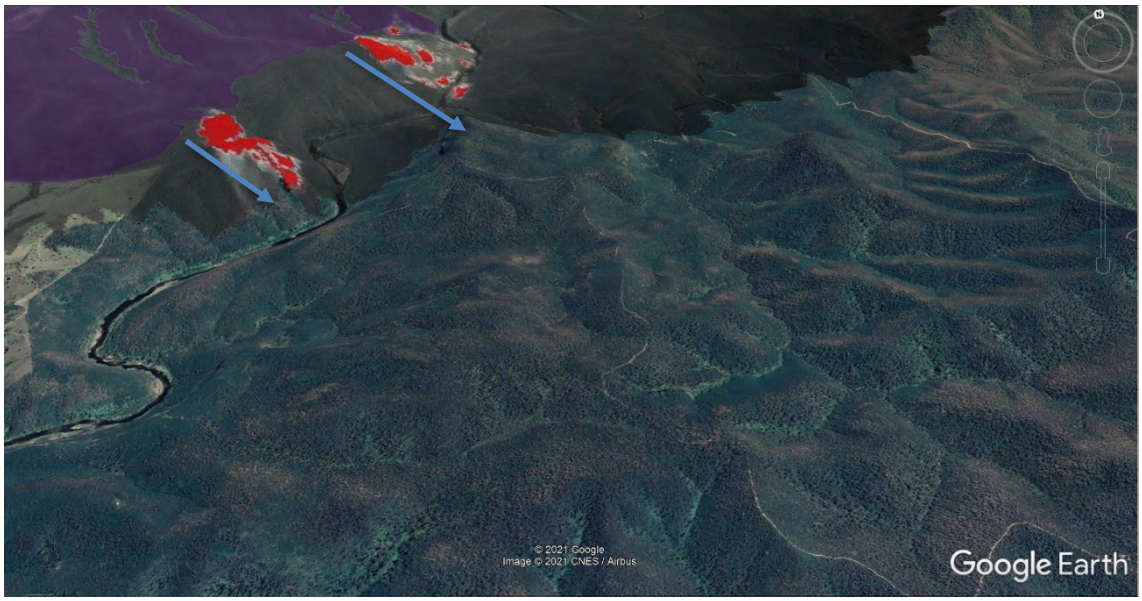


FIGURE 234: LINE SCAN FROM 1406HRS 30TH DECEMBER 2019. THE 1251HRS FIRE AREA IS SHOWN AS PURPLE. ARROWS SHOW DIRECTION OF FIRE MOVEMENT.

It is known that the fire impacted farmland adjacent to Orbost at around 0130hrs. By 0900hrs on the 31st of December there were reports of spot

fires south of Princess Highway east of Mt Raymond with 10 metre flame heights and a 100m fire front about to cross the highway near Cabbage Tree Creek.

FIGURE 235: LOOKING NORTH UP THE SNOWY RIVER 1355HRS 30TH DECEMBER 2019 WITH SPOT FIRES ESTABLISHING ON THE WEST SIDE OF THE RIVER AND SOON TO CROSS THE RIVER AND EVENTIUALLY RUN TO ORBOST (MIKE IRVINE).

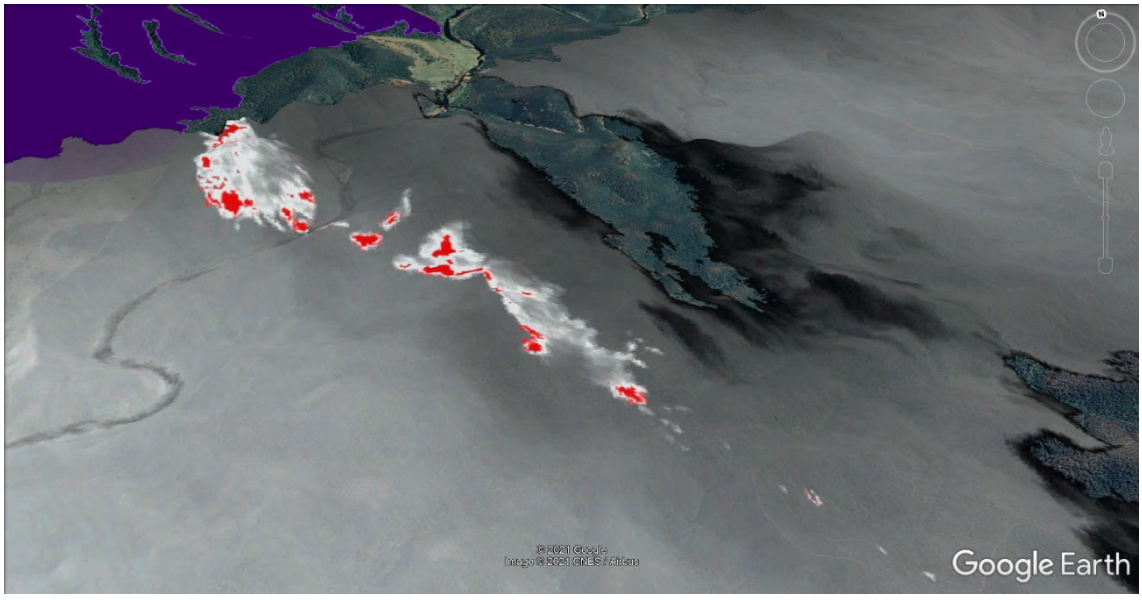


FIGURE 236: LINE SCAN 1440HRS 30TH DECEMBER 2019, THE SOUTHERN BREAK OUT HAD SPOTTED 5KM SE OF THE SNOWY RIVER BY THIS TIME (THE NORTHERN BREAKOUT IS OBSCURED BY A SMOKE DENSE PLUME)

It is noted that there were very many more fire runs, particularly after the change. There is more work that could be done to examine these. This would require meteorologist input and information from residents and firefighters.

TAMBO 35: TAMBO COMPLEX - 1ST JANUARY TO 20TH OF FEBRUARY 2020

The area of Tambo Complex increased from 487,000 to 565,000 hectares from the 1st of January to the early afternoon of the 4th of January. After the major fire runs in the east on the 4th and 5th of January, the fire was split into the Snowy and Tambo Complexes using the DELWP districts as the boundary.

Weather and Fire Danger for the 1st of January to the 20th of February 2020

There was little or no rain with the major change on the 31st of December. There were small amounts recorded on the 6th and 11th of January, but it was not until the 20th and 21st of January that significant falls influenced the drought index and availability of forest fuels. This was more apparent at lower elevations. Figure 237 shows the rainfall distribution for the 20th and 21st of January. The influence of this and earlier events is reflected in the KBDI and can be seen in Figure 238.

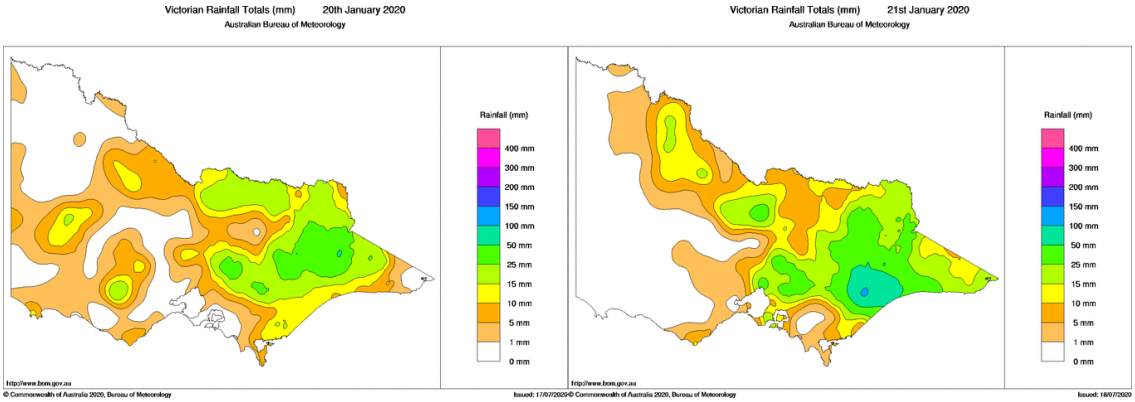


FIGURE 237: DAILY RAINFALL TOTALS FOR THE 20TH AND 21ST OF JANUARY 2021 (BOM)

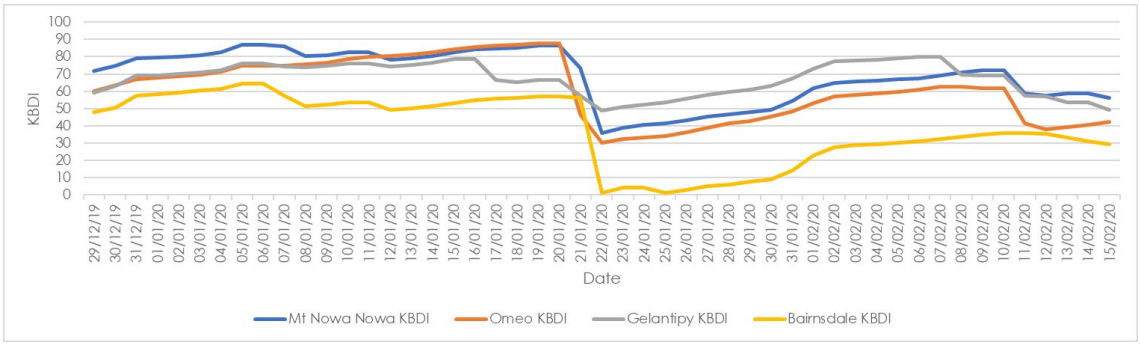


FIGURE 238: KBDI FOR SELECTED STATIONS WITHIN THE TAMBO COMPLEX 29TH OF DECEMBER 2019 TO 15TH OF FEBRUARY 2020

Figure 239 shows the peak FFDI values for four stations in the Tambo Complex from the 29th of December 2019 to the 15th of February 2020. Three more spike days Followed the extreme fire weather of the 30th of December. These occurred on the on the 4th, 10th and 31st of January. The 4th was more pronounced at higher elevations. In general, there were length periods of low to high fire danger which greatly assisted with burning out and protection of assets.

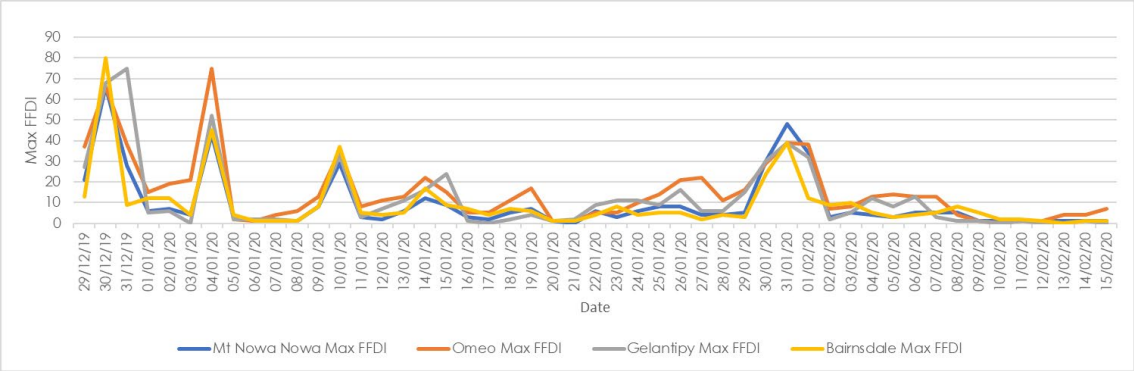


FIGURE 239: MAXIMUM FFDI FOR SELECTED STATIONS WITHIN THE TAMBO COMPLEX 29TH OF DECEMBER 2019 TO 15TH OF FEBRUARY 2020

Fire Progression from the 30th of December 2019 to 4th of January 2020

Figure 240 shows the fire progression from the 30th of December to the afternoon of the 4th of January. The area shown for the 30th is what was captured at the last line scan of that day and is incomplete. Mapping of the fire boundary as of the 1st of January has almost complete coverage.

Between the 1st and 4th of January the fire continued to expand in the west at Bullumwaal, and in the eats around Tamboon and Cann River. Significant consolidation and backburning was conducted between Nowa Nowa, Orbost and Cabbage Tree. Backburning was also undertaken at Bemm River.

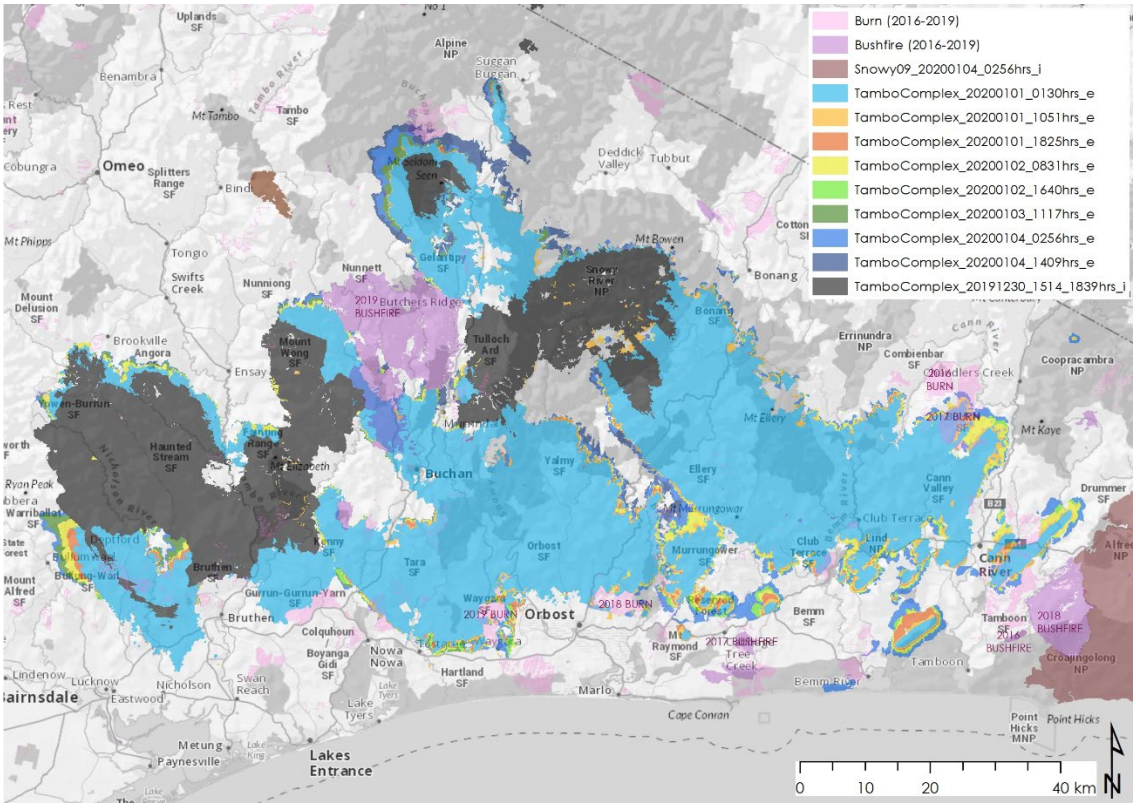


FIGURE 240: TAMBO COMPLEX FIRE PROGRESSION 30TH DECEMBER 2019 TO 4TH JANUARY 2020

The spike day of the 4th of January saw significant growth of the fire in the north near Mt Seldom Seen and Suggan Buggan, and in the east in what would become the Snowy Complex and Border Fire (NSW).

FIGURE 241: BEMM RIVER BACKBURN 2ND JANUARY 2020 (SOURCE ABC NEWS)

FIGURE 242: BEMM RIVER BACKBURN 1802HRS 2ND JANUARY 2020 (MIKE IRVINE)

The Bemm River backburn was first observed as IR on Himawari at 1540hrs January 2nd and developed rapidly. There was significant pressure from the local community to conduct the backburn. There has subsequently been concern that the backburn was unnecessary and went on to impact on Cape Conran. Issues like this may never be resolved but could be studied using fire simulations.

Fire progression from the 4th of January to 22nd of February 2020

Figure 243 toFigure 246 show the fire progression from the 4th to 22nd of January 2020. There were still significant fire runs to the north and east in the Tambo Complex and the size grew from 288000 to 324000hectares.

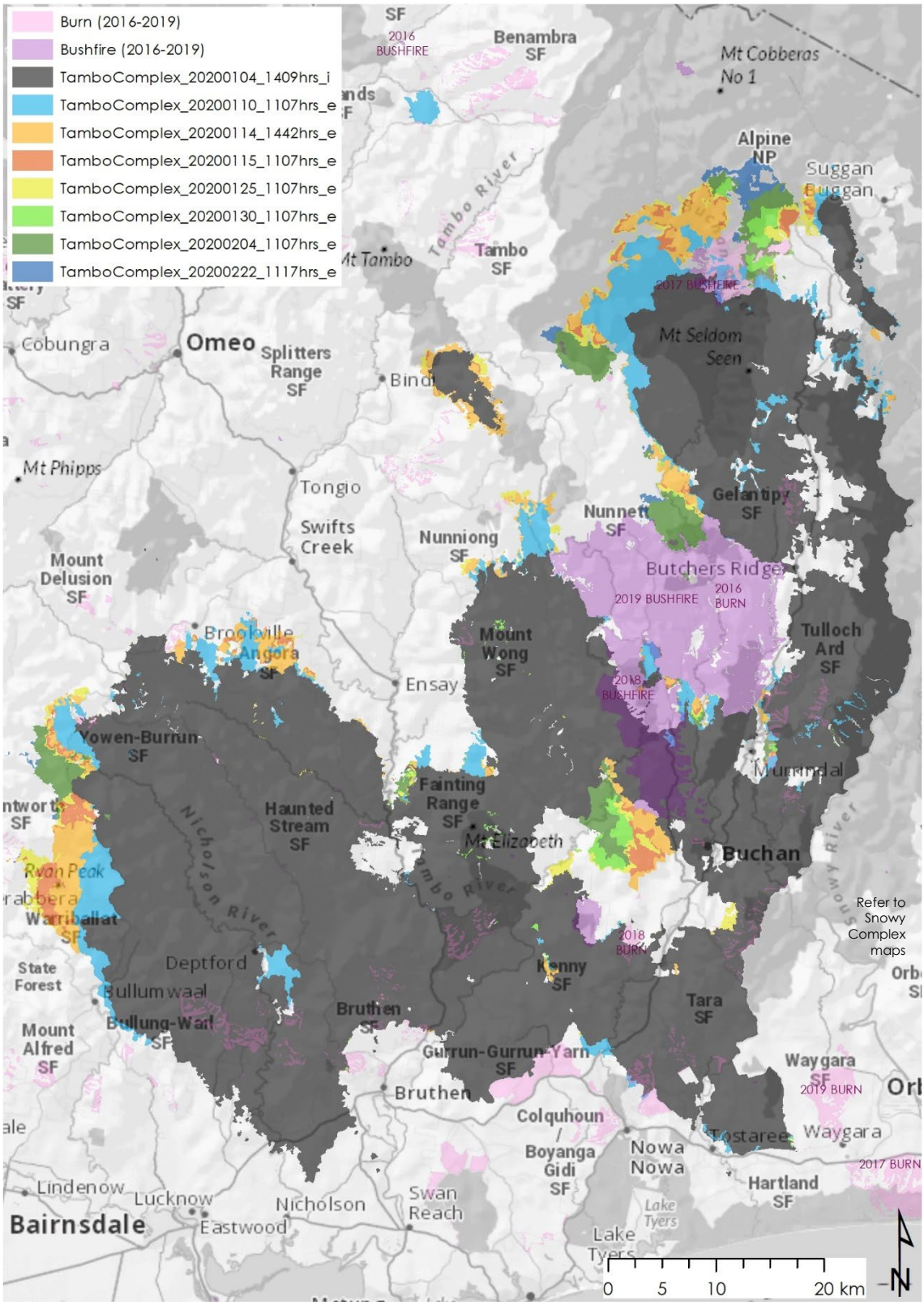


FIGURE 243: TAMBO COMPLEX FIRE PROGRESSION 4TH OF JANUARY TO 22ND OF FEBRUARY 2020

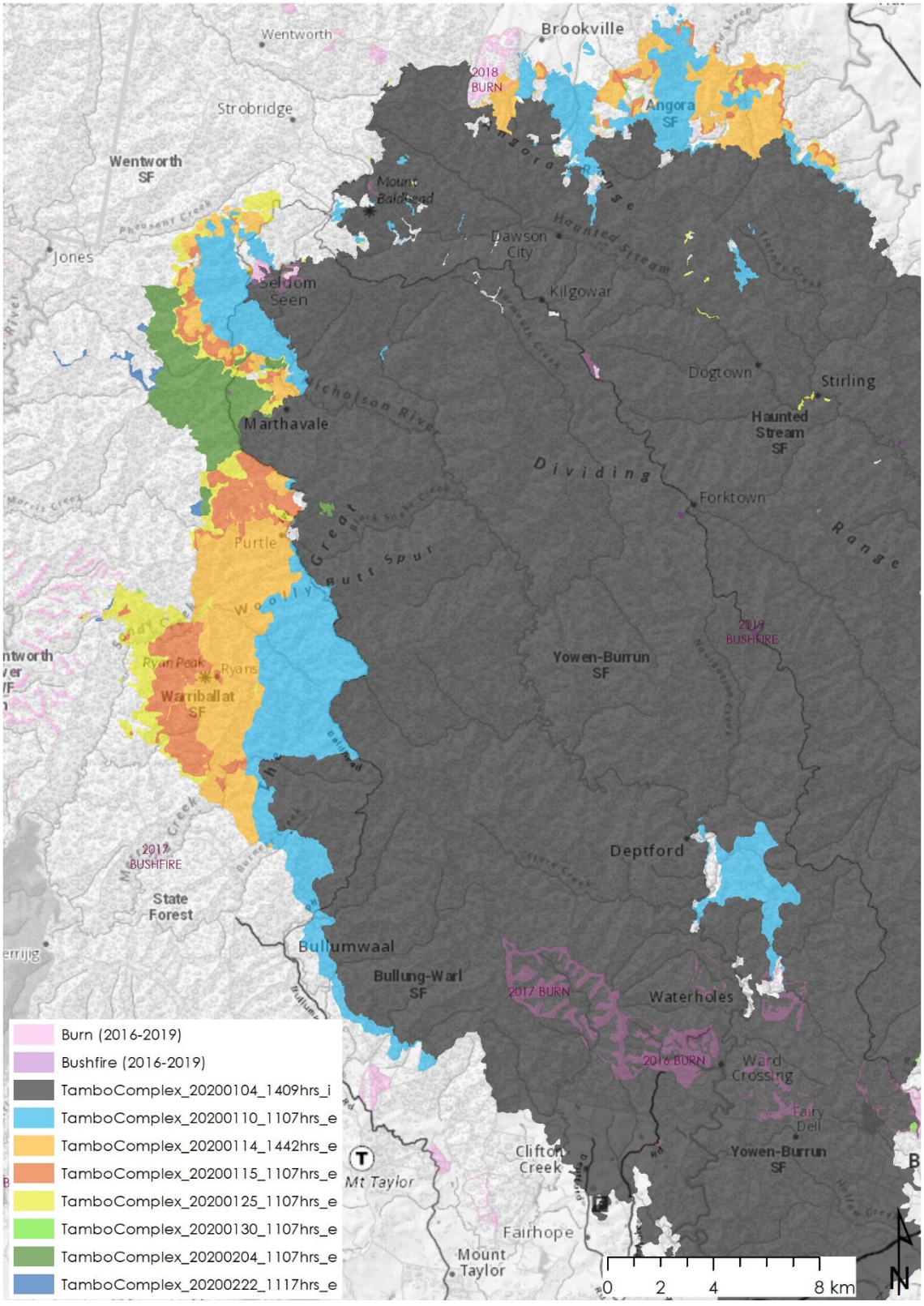


FIGURE 244: WESTERN SECTION TAMBO COMPLEX FIRE PROGRESSION 4TH JANUARY TO 22ND FEBRUARY 2020

Note: Areas shown as burnt on the 10th of January at 1107hrs were most likely burnt on the 4th and 5th of January and were only visible after the cloud cleared on the 10th.

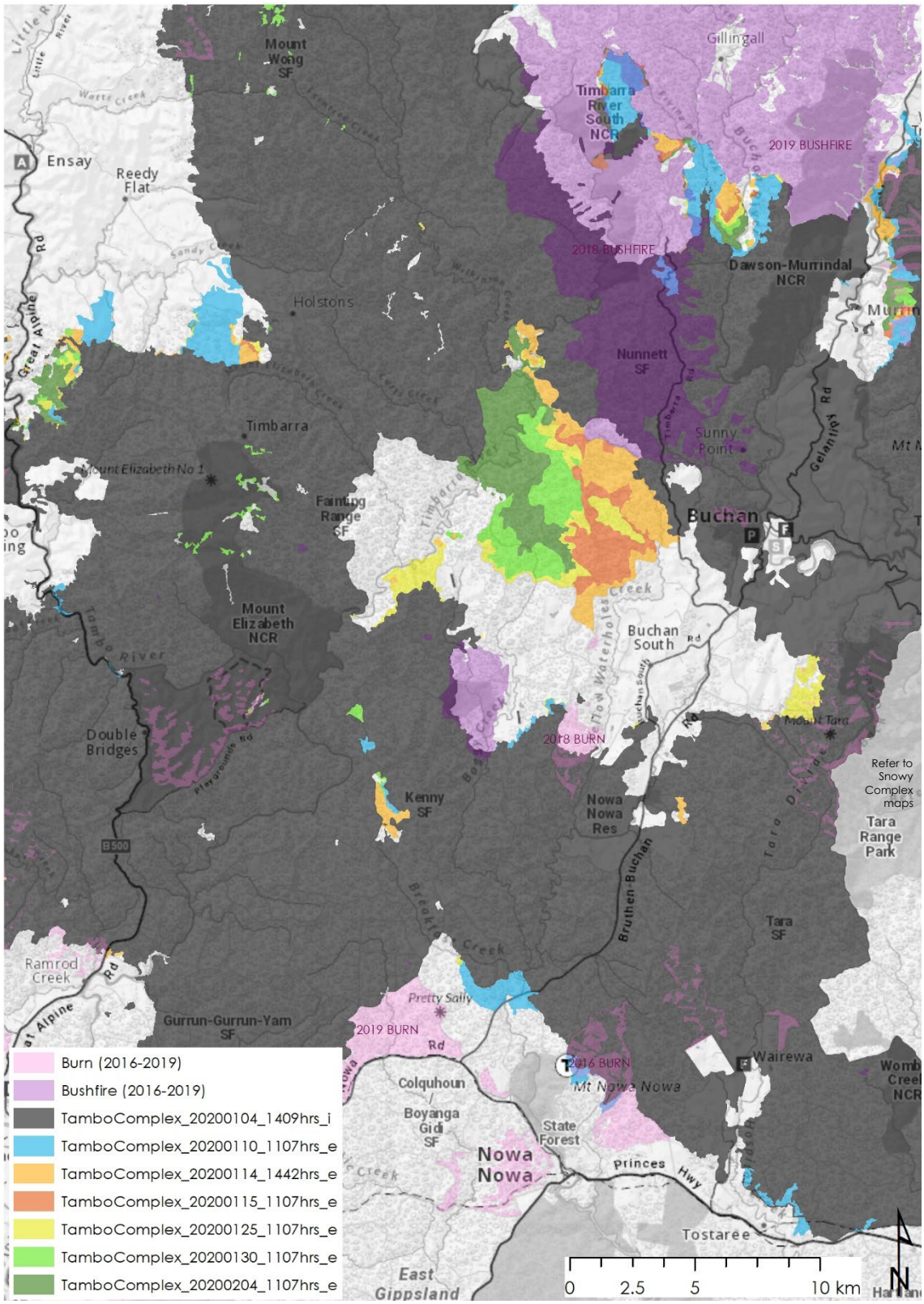


FIGURE 245: CENTRAL SECTION TAMBO COMPLEX FIRE PROGRESSION 4TH JANUARY TO 22ND FEBRUARY 2020

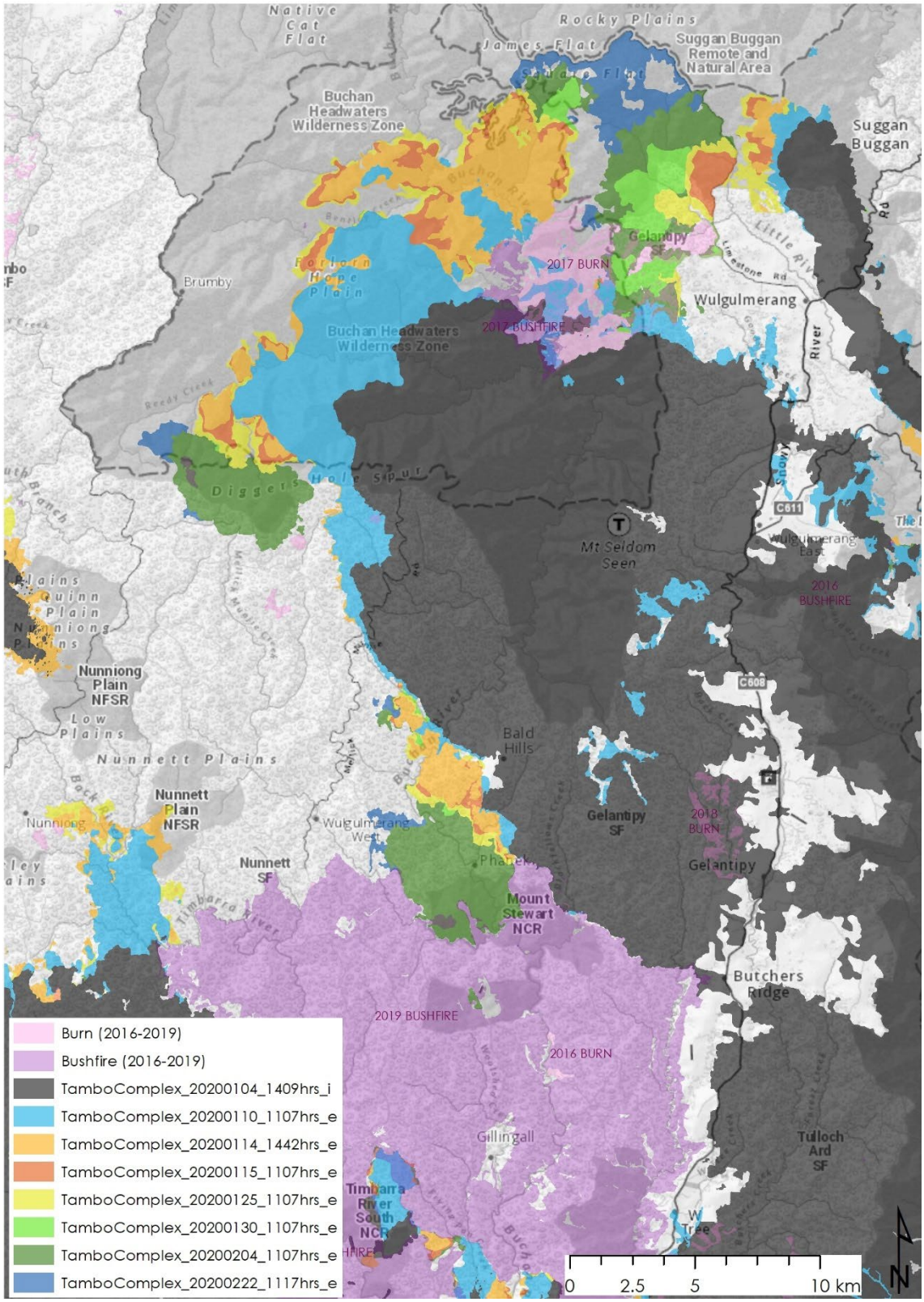


FIGURE 246: NORTH- EASTERN SECTION TAMBO COMPLEX FIRE PROGRESSION 4TH JANUARY TO 22ND FEBRUARY 2020

TAMBO 66: BINDI TIN POT CREEK

Prior to the Bindi Tin Pot Creek fire, there had already been a fire in the area. The first fire (Tambo 42 Bindi – Garron Track) was a lightning strike first recorded at 1120hrs on the 25th of November. The fire was initially detected by aerial reconnaissance and estimated to be 11 hectares in size. By 1044hrs on the 26th the fire had grown to 55ha. No crews were deployed to fire given the cool and wet conditions from overnight rain. Crews were able to access fire on the 27th of November and no active fire edge noted. On the 1st of December, the fire was listed as contained with an area of 121 hectares.

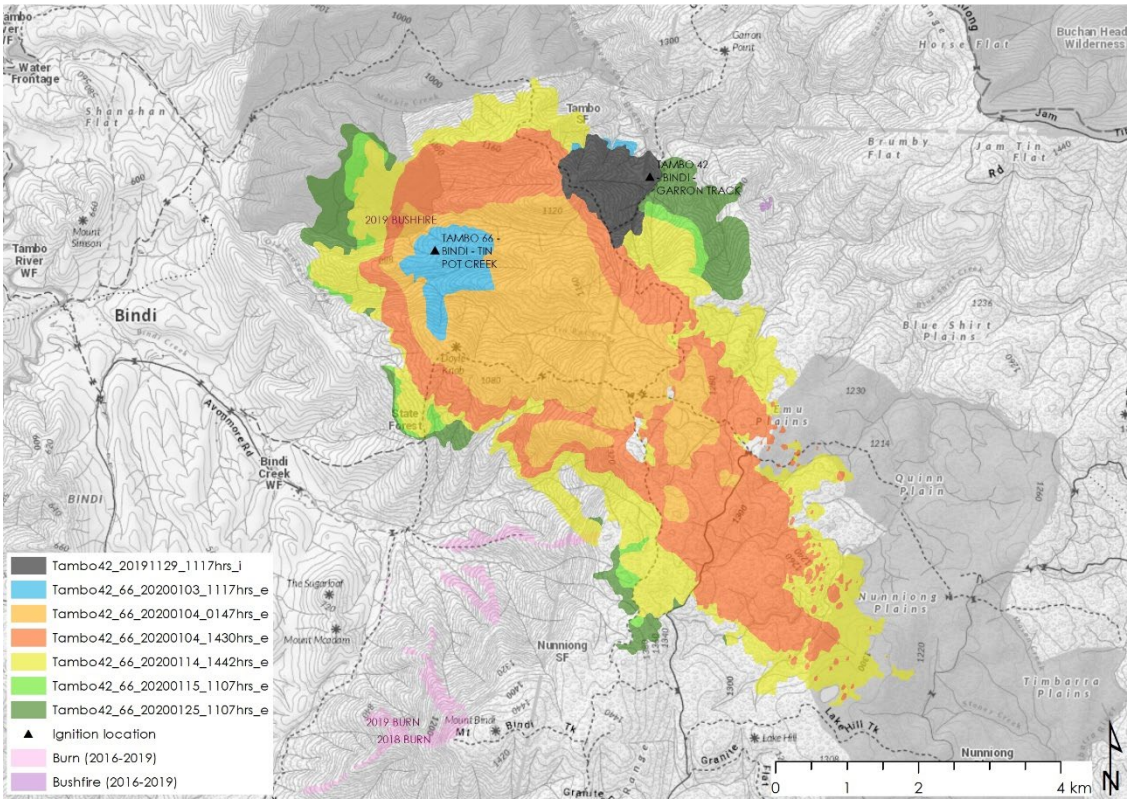


FIGURE 247: TAMBO 66 FIRE PROGRESSION 3RD TO 25TH JANUARY 2020

The second fire (Tambo66 Bindi – Tin Pot Creek) was first reported at 1001hrs on the 2nd of January 2020 and most likely started from Lightning on the 31st of December 2019. The fire was not resourced due to other priorities and by the 8th of January the fire had grown to 2670 hectares. After this time ground and air resources were allocated to limit spread and monitor fire movement. Eventually rain suppressed all fire activity, and the fire was declared contained on the 2nd of February 2020.

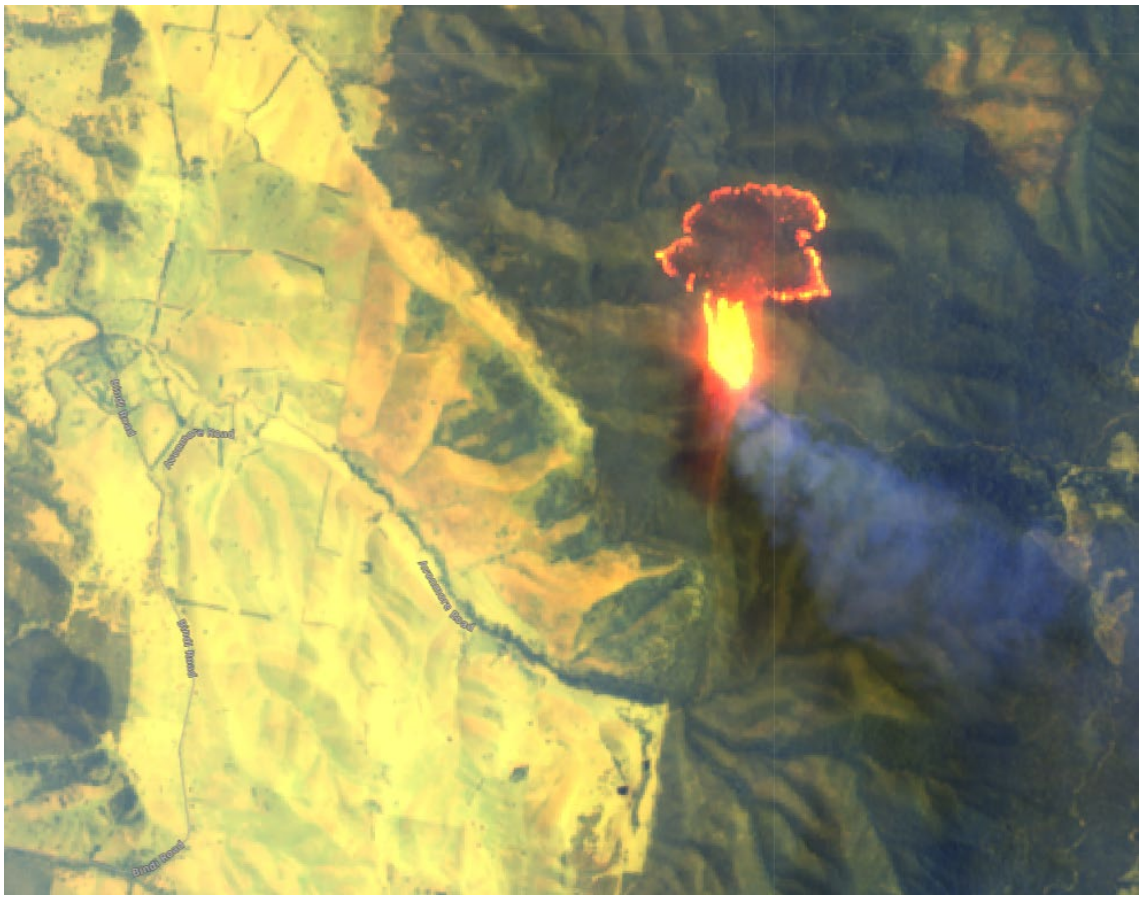


FIGURE 248: SENTINEL2 NIR SWIR IMAGE 3RD JANUARY 1117HRS SHOWING START OF FIRE AND PREVIOUS BURN SCAR FOR TAMBO 42

SNOWY 16: SNOWY COMPLEX & BORDER FIRE (NSW) JANUARY 4TH TO 6TH OF MARCH 2020

This section examines the fires in the Snowy District and spread into NSW from the 4th of January to containment on the 6th of March 2020. Much of the focus is on the major fire run on the 4th and into the 5th of January.

Naming of Fires

The Snowy Complex (Snowy 16) was a consolidation of the Chandlers Ck - Mt Coopracampra fire, Banana Track fire and the Tambo Complex that was in Snowy District. It was initiated on the 7th of January and an Incident Management Team was based at Orbost. All fires had merged by the end of the 4th of January.

Weather for the 4th and 5th of January 2020

The 4th of January was deemed as a spike day with the Northeast of Victoria categorised with a Code Red fire Danger Rating. East Gippsland as given a severe rating. The peak fire danger was expected with the wind change. This was forecast to be initially shallow and arrive in East Gippsland around 1200hrs (see Figure 249).

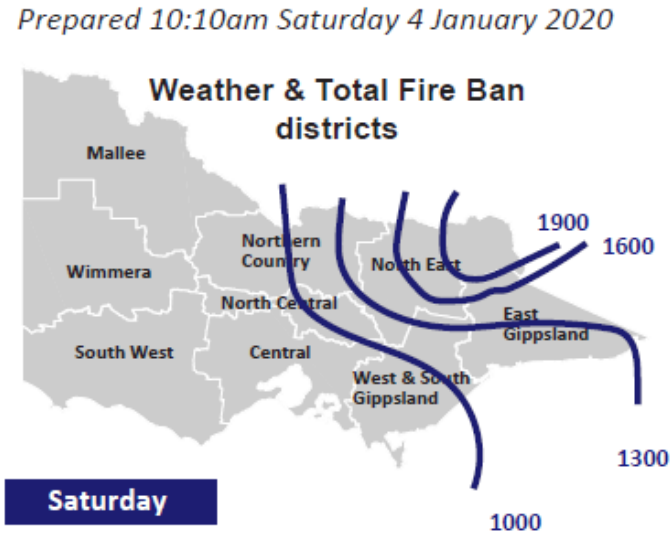


FIGURE 249: FORECAST WIND CHANGE (BUREAU OF METEOROLOGY – STATE CONTROL CENTRE)

The AWS at Mallacoota and Combienbar had been impacted by the fire and were not recording. Figure 250 to Figure 253 show the change arriving at Orbost at 1200hrs, Gabo Island 1400hrs, and Bombala and Green Cape at around 1500hrs. Significant sustained winds were recorded following the change at all these sites except Orbost. The FFDI peaked at 100 at Bombala and 55 at Orbost. Coastal areas such as Green Cape and Gabo Island did not experience the high temperatures of inland areas. In general temperatures were mild and relative humidity was high, and yet 400,000 hectares would burn in around 15 hours. Conditions across the fireground have been identified for further analysis.

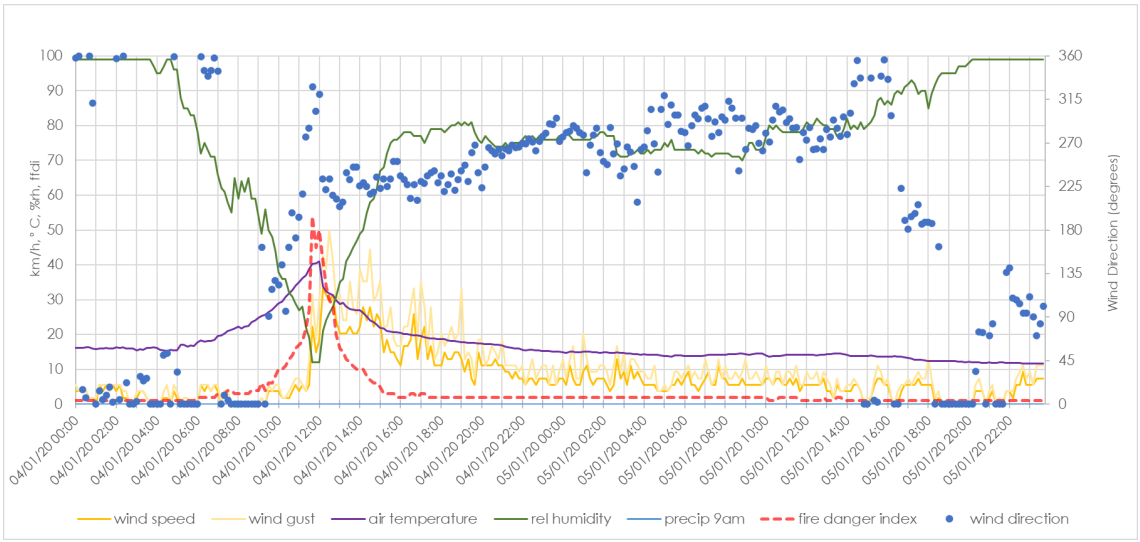


FIGURE 250: ORBOST AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

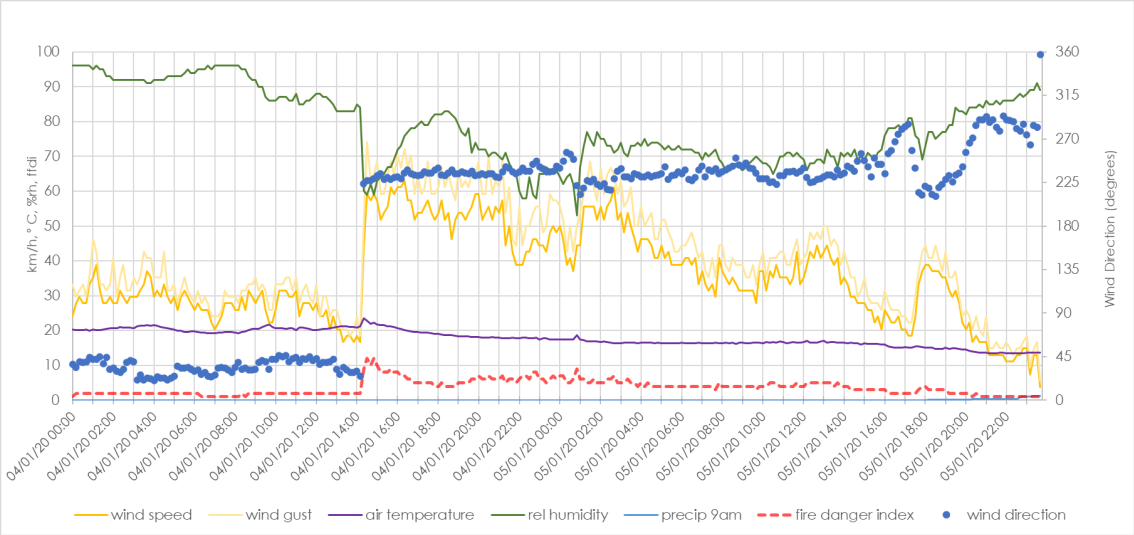


FIGURE 251: GABO ISLAND AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

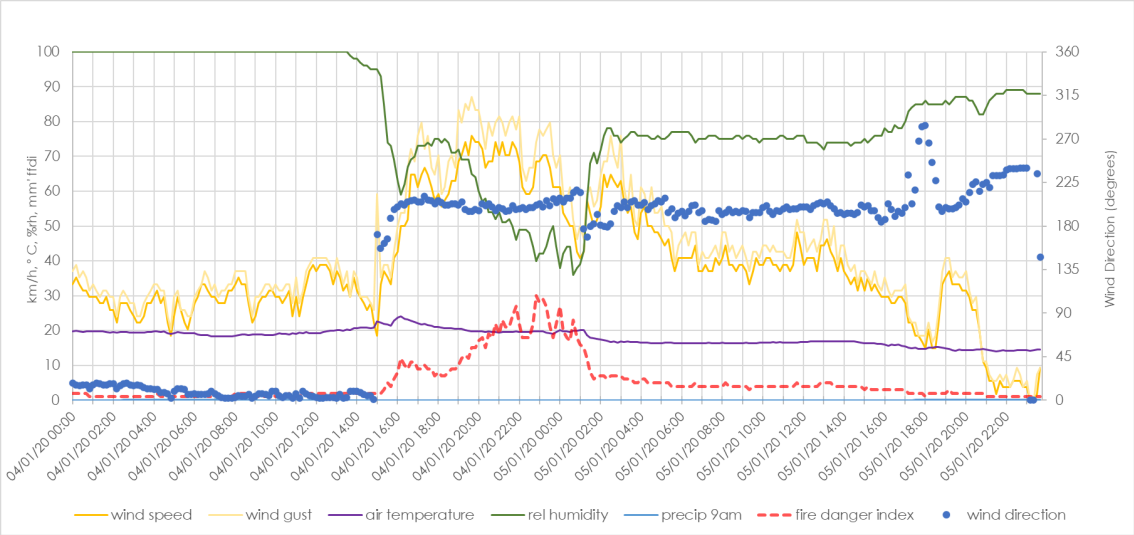


FIGURE 252: GREEN CAPE AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

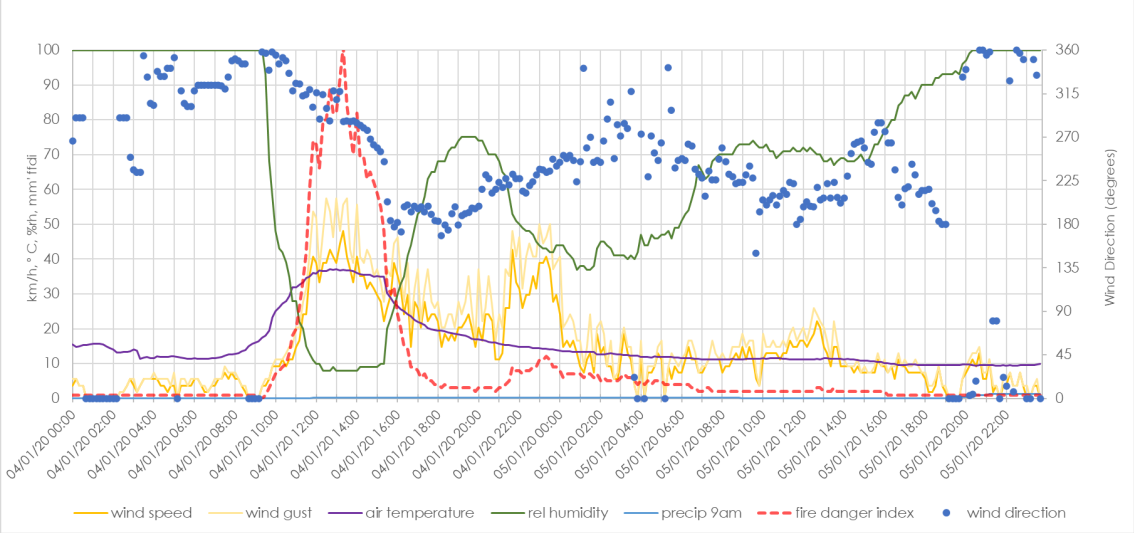


FIGURE 253: BOMBALA AWS DATA FOR THE 4TH AND 5TH OF JANUARY 2020

Fire Progression 4th and 5th of January 2020

The fire expansion of the Snowy Complex for the 4th and into the 5th of January was driven almost entirely by a wind change impacting on a large fireground with many kilometres of uncontained edge. High winds, very dry flammable fuels appear to be the main drivers. This was despite mild temperature and high humidity. Figure 254 shows the fire progression from the early morning of the 4th until the 15th of January 2020. After around 0500hrs on the 5th of January very little fire activity occurred until after the 10th of January when the clouds finally cleared. Figure 254 shows the fire run when it was able to be mapped on the 10th, however analysis has shown that this burnt on the 4th and 5th. This is further demonstrated in Figure 258 to Figure 260.

An examination of the Himawari SWIR data provides information on when the change arrived at the fireground. The change brought high winds to coastal areas– greater than 60km/h until around 0400hrs on January 5th then remained at around 40km/h until 1400hrs. The change quickly pushed into higher elevations. Inland areas also had high winds with Bombala having sustained 40km/h winds. It arrived at nearly all fire sites in the Snowy District between 1300hrs and 1400hr where all sections of the fire began to move steadily in a northeast direction. The fire travelled over a large coastal plain with a parallel run through low foothills as shown in Figure 11.

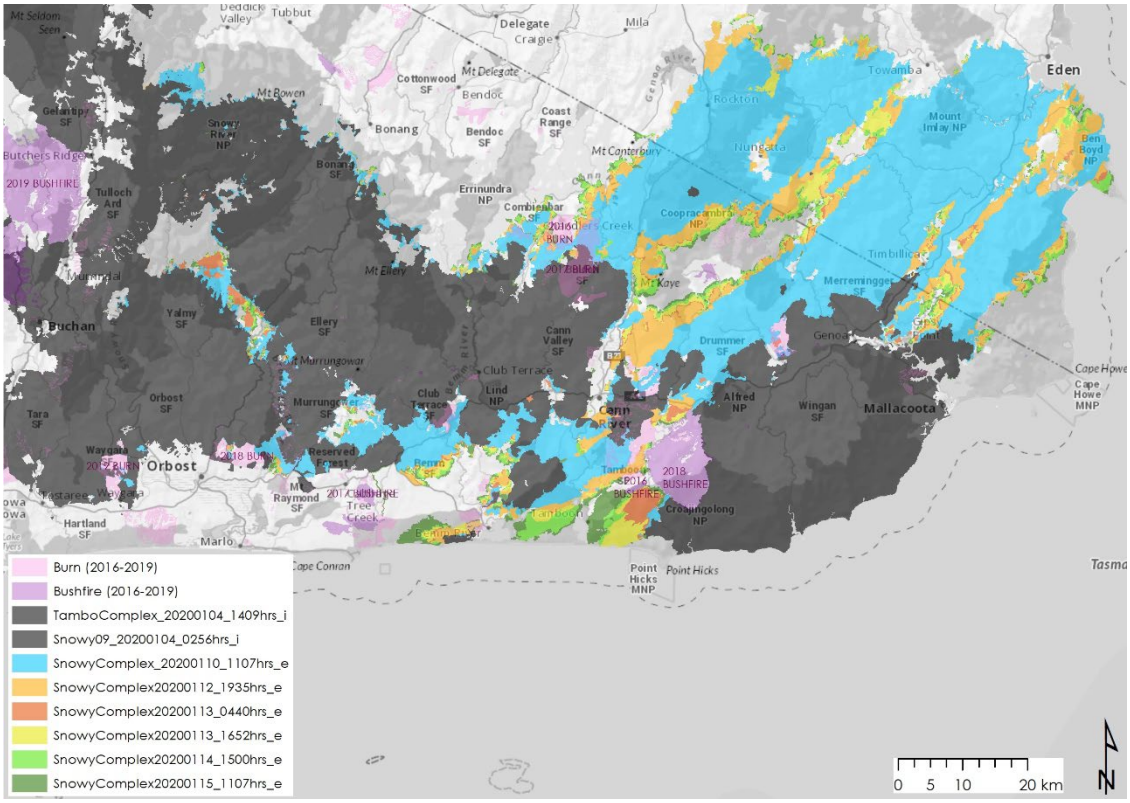


FIGURE 254: FIRE PROGRESSION FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

A summary map of the fire runs can be seen in Figure 255. This has been derived from the Himawari SWIR data that can be seen in Figure 258 and Figure 259.

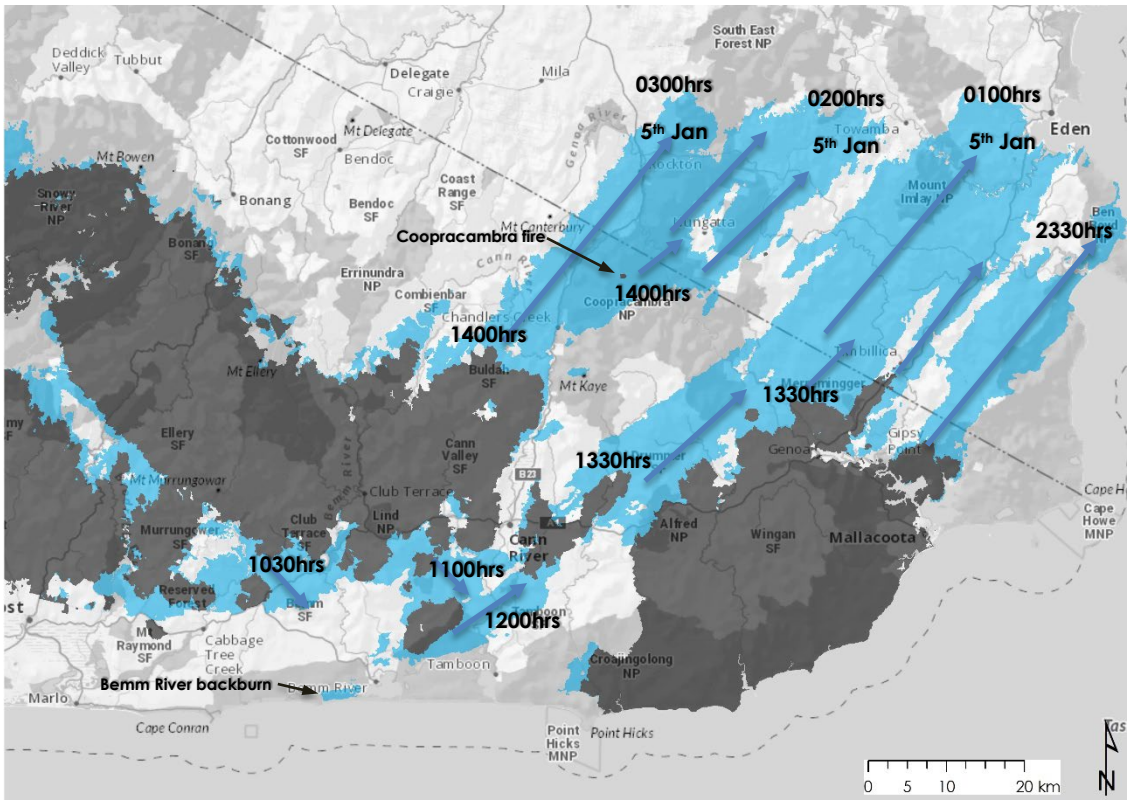


FIGURE 255: FIRE RUNS AND TIMINGS FOR FAR EAST GIPPSLAND FIRES ON THE 4TH AND 5TH OF JANUARY

The progress of the front and fire behaviour prior to its arrival can be seen in Figure 256. By 1130hrs the front was just about to reach Orbost and was pushing well inland north of Bruthen. To the north and east, strong north-westerly winds were pushing all the way to the coast. There were three areas of high fire intensity east of Orbost which had already produced recognisable columns.

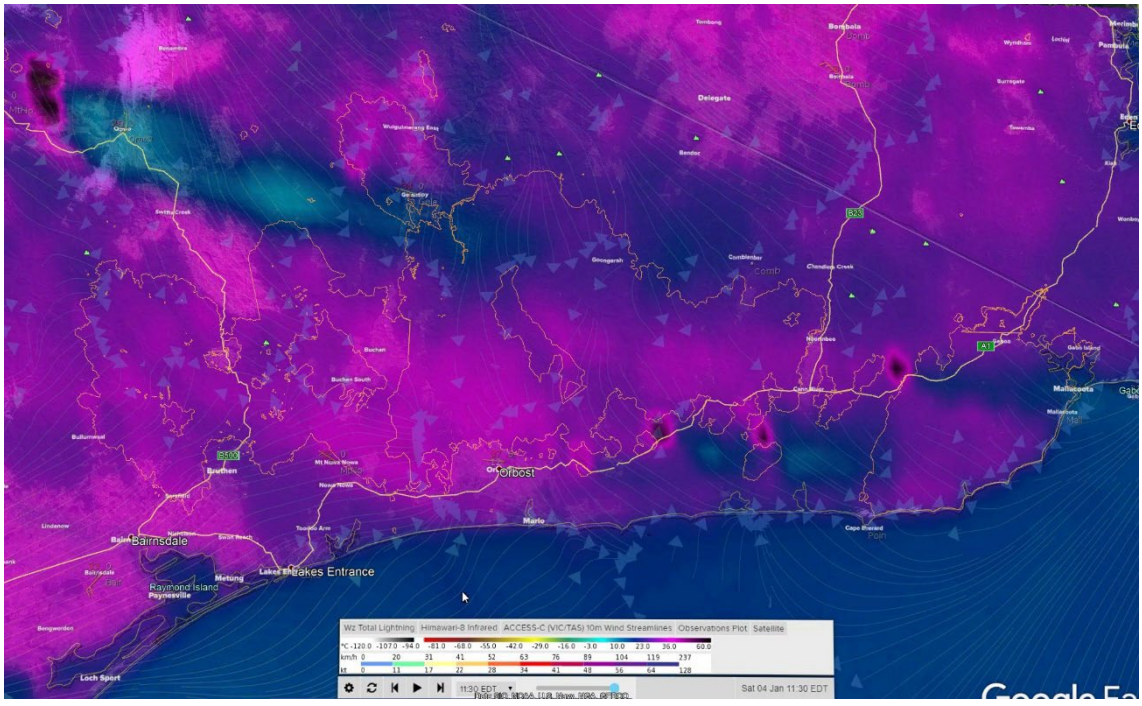


FIGURE 256: 1130HRS 4TH OF JANUARY 2020 WEATHERZONE LAYERS HIMAWARI ENHANCED IR COMBINED WITH EMAP FIRE SHAPES

Figure 257 shows the state of play at 1810hrs on the 4th of January. Both the Dunns Rd (NSW) and Upper Murray 26 fires were generating massive PyroCb columns, which were producing their own shade on the lower smoke layer. The cool change had pushed over the border south and east of the divide and was consistently blowing at 30-40km/h near the coast. The relative humidity had risen above 70% and temperatures had fallen to the 20's over much of the fireground and despite this the fire continued unabated. Upper-level winds were still from the north west and were driving a huge volume of smoke into the Tasman Sea and beyond. Despite this smoke the Himawari satellite IR bands could show the fire spread.

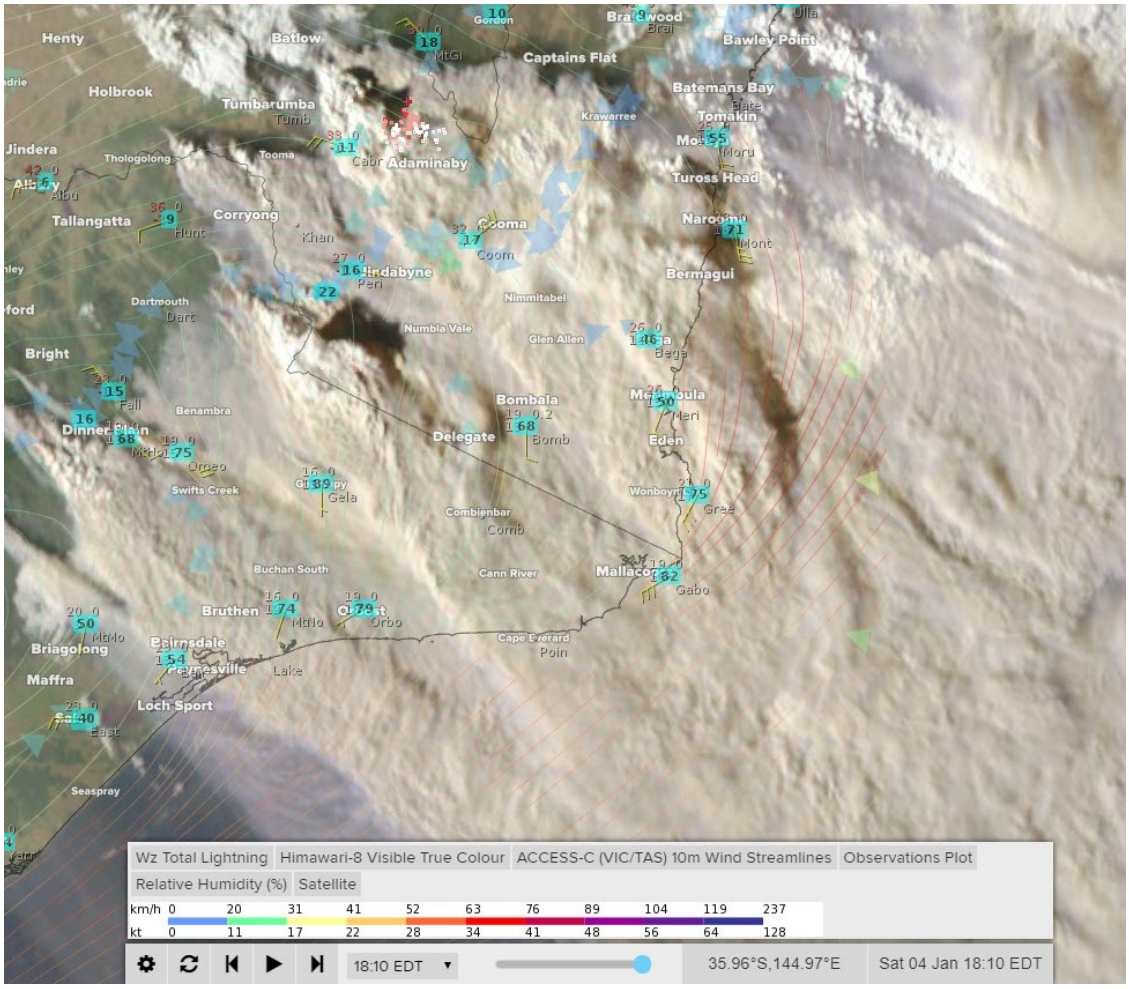


FIGURE 257: 1810HRS 4TH OF JANUARY 2020 WEATHERZONE LAYERS TRUE COLOUR

Figure 258 and Figure 259 show snapshots from a 3d Google Earth animation using Himawari SWIR band 7 from Landgate FireWatch Pro. The images also show the starting boundary of the fire for the 4th to 2300hrs and the final boundary for images 0000hrs and after. These provide a spatial reference and confirm that the fire run was complete by 0500hrs.

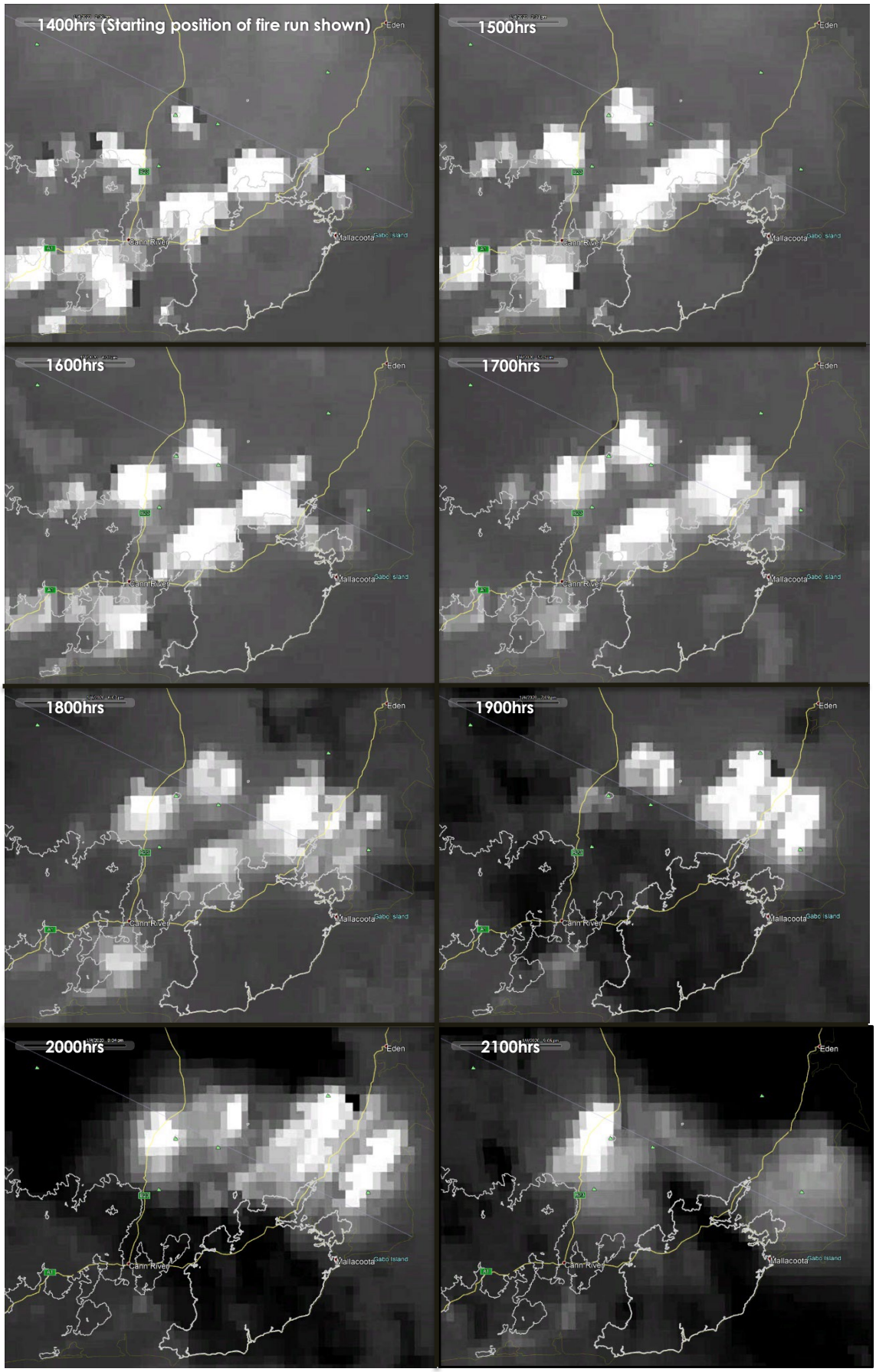


FIGURE 258: HIMAWARI BAND 7 FOR TAMBO COMPLEX AND SNOWY 9 INTO NSW (1400 2100HRS 4TH JANUARY 2020)

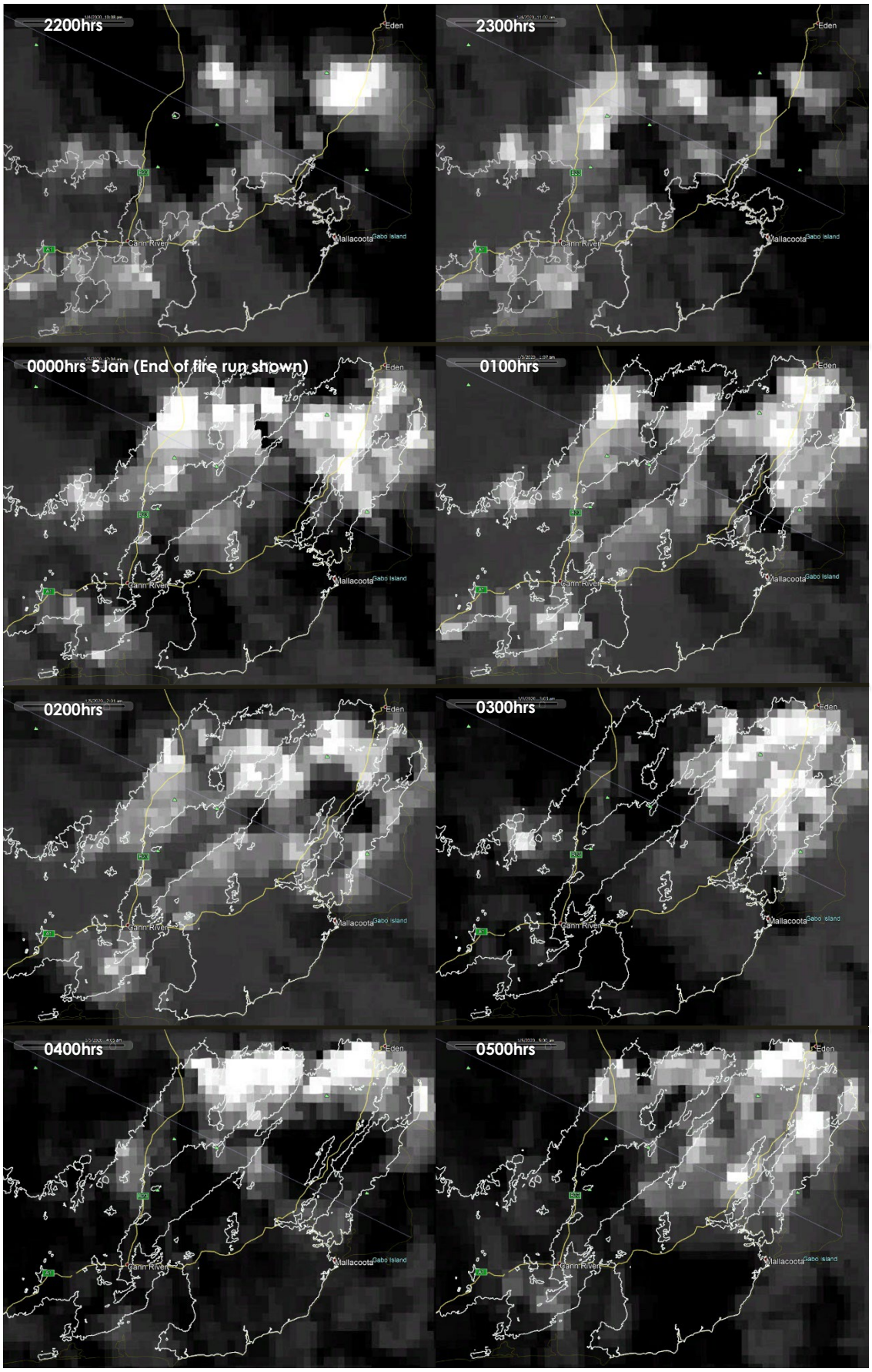


FIGURE 259: HIMAWARI BAND 7 FOR TAMBO COMPLEX AND SNOWY 9 INTO NSW (2200 0500HRS, 4TH – 5TH JANUARY 2020)

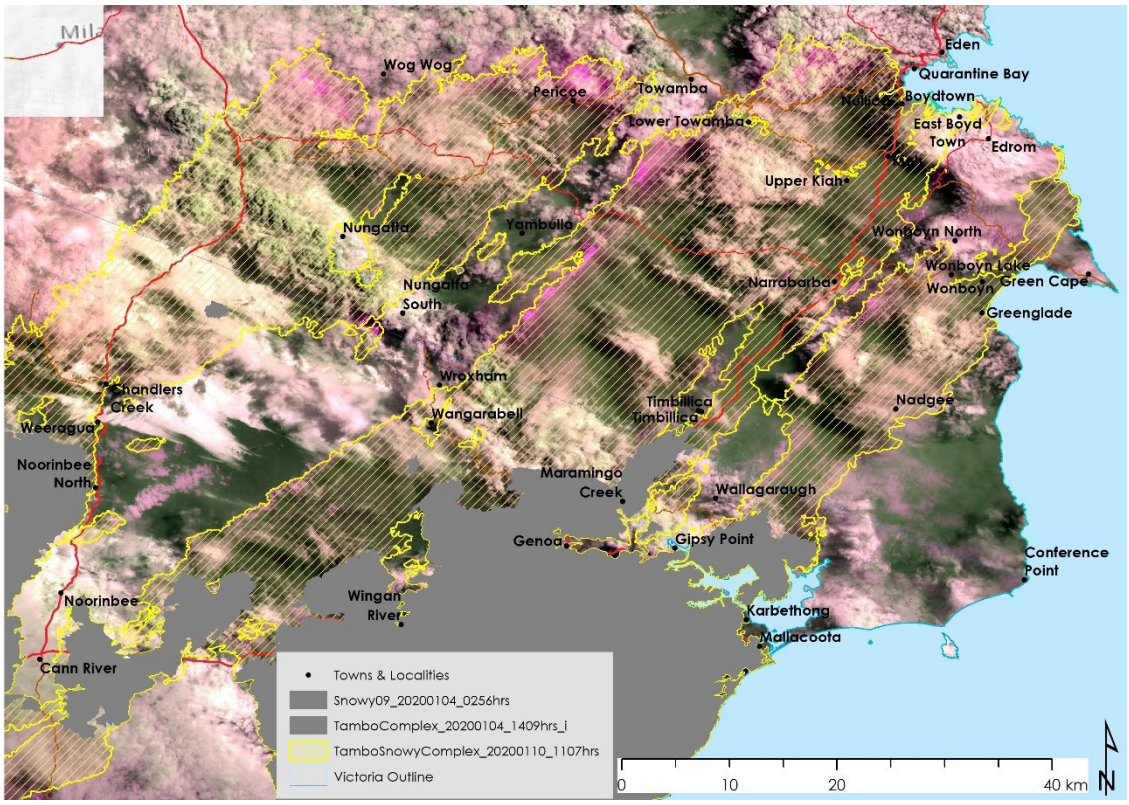


FIGURE 260 JANUARY 5TH 11AM SENTINEL SWIR COMPOSITE IMAGE SHOWING REMAINING HEAT SIGNATURES FOLLOWIN FIRE RUN

Figure 260 shows a Sentinel2 SWIR composite image. It illustrates that by 1100hrs on the 5th of January, the fire had ended its run and fire behaviour was limited to the bright pink areas. A large portion of fire area was covered by frontal cloud. The image can be compared to later mapping (yellow hatching) of the fire, five days later when relatively clear weather returned. Line scans and Himawari IR images also confirm that the fire activity did not continue much past 1100hrs on the 5th of January and that the northeast run was most likely at its full extent by 0500hrs.

Progression of the 4th to 15th of January 2020

Figure 254 provided an overview of this sequence of events. Finer resolution maps have been prepared and are shown in Figure 261 to Figure 266 These show the progression of the Snowy Complex from the 4th to the 15th of January 2020.

Much of the work by fire agencies was directed toward reopening of roads and communications, provision of basic services, protection of threatened infrastructure and communities. The fire continued to burn out areas between fire runs and expand slowly on the external perimeters.

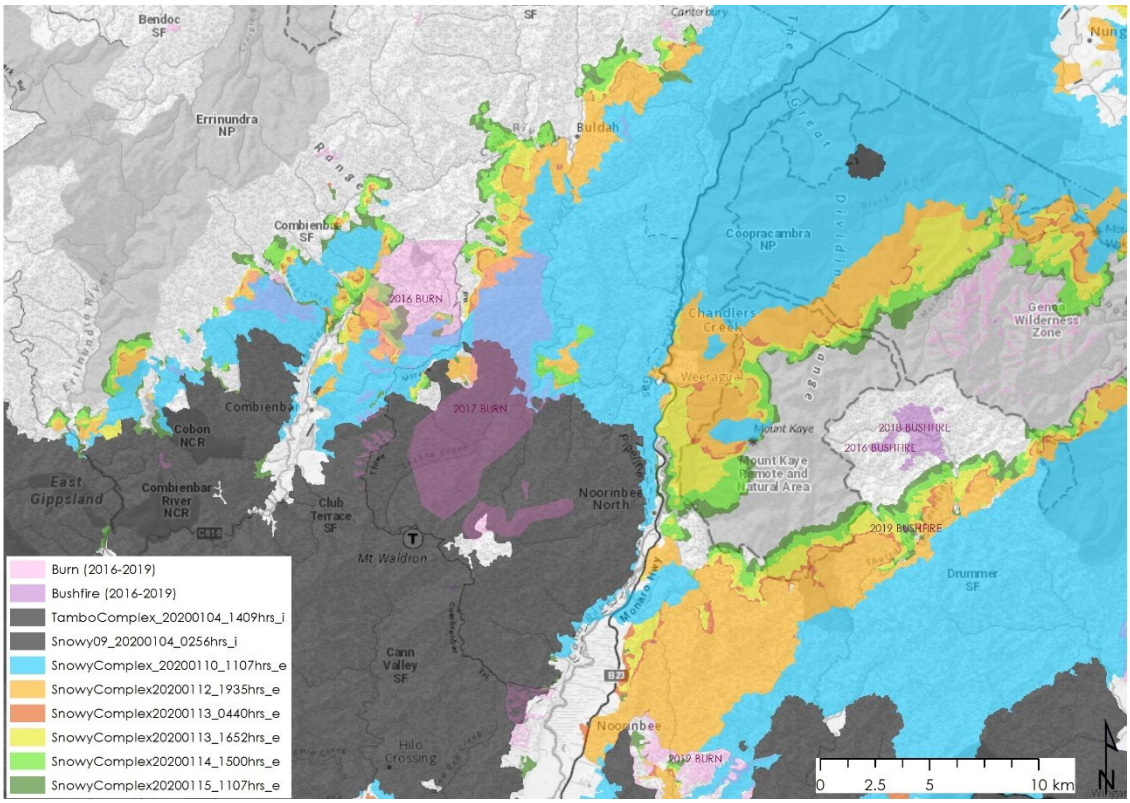


FIGURE 261: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

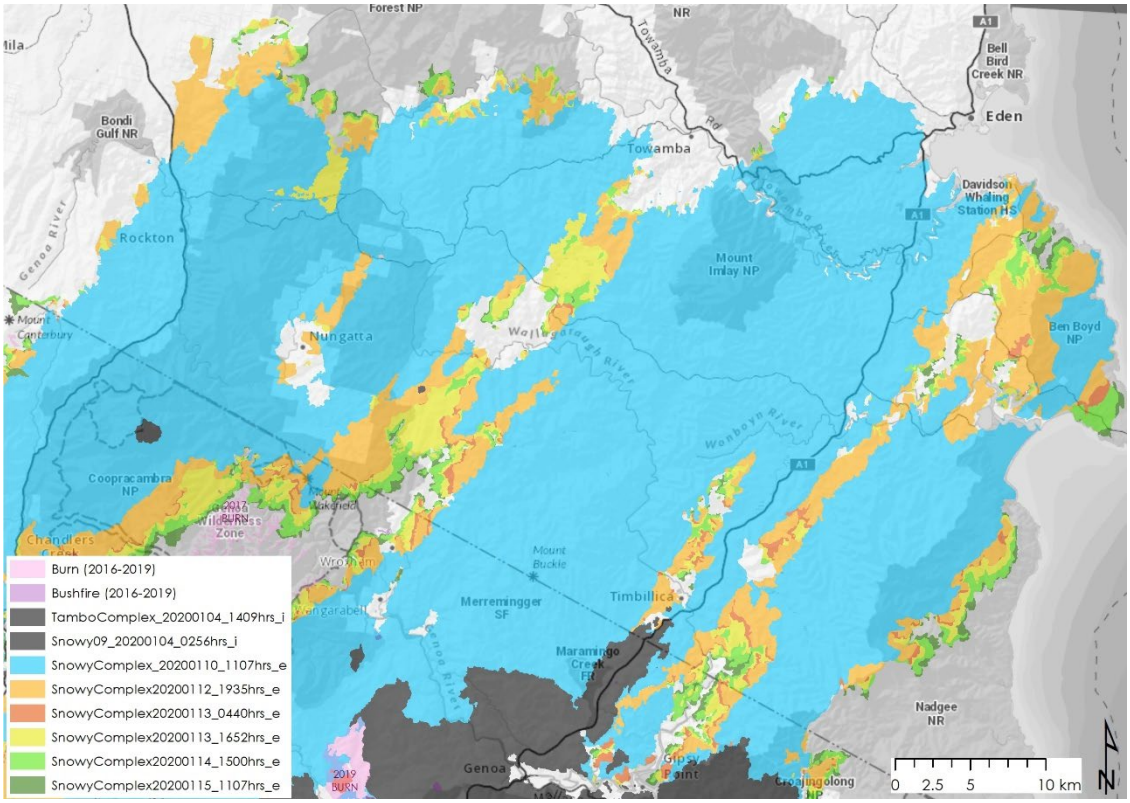


FIGURE 262: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

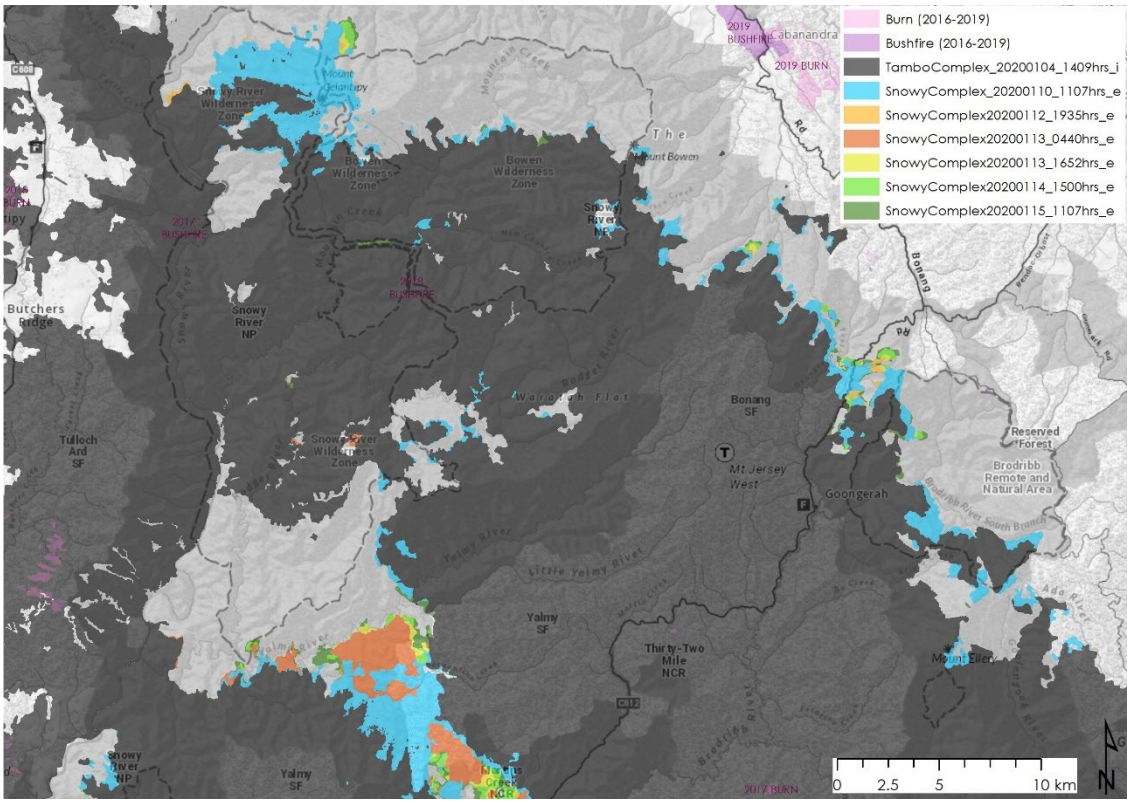


FIGURE 263: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

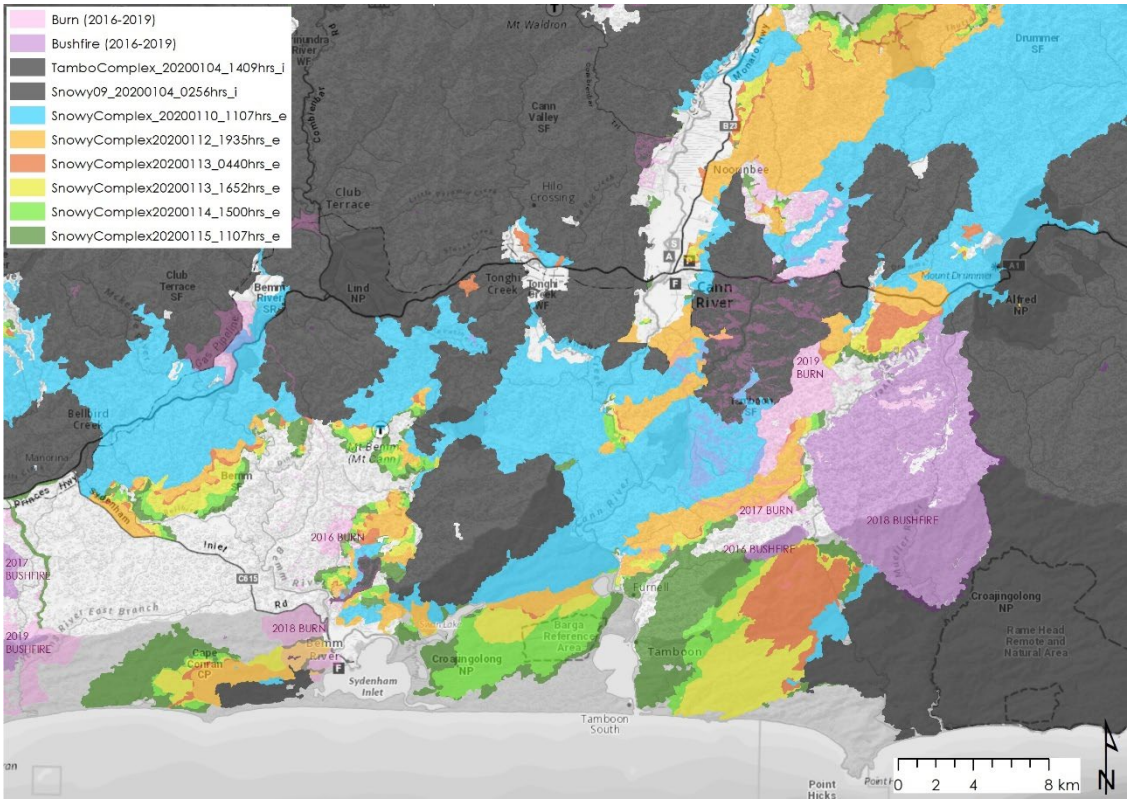


FIGURE 264: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

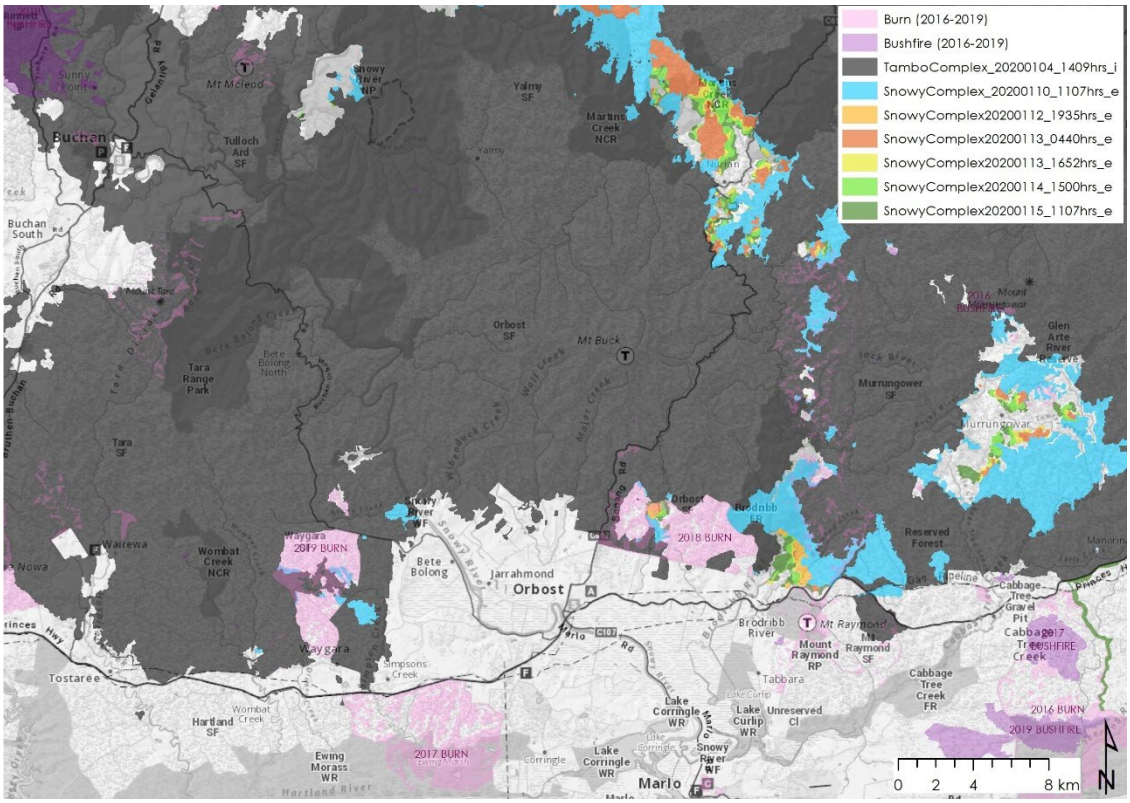


FIGURE 265: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 4TH TO 15TH OF JANUARY 2020

Progression15th of January to 6th of March 2020

The fires were finally contained on the 6th of March with major runs continuing into February with a further 136,000 hectares being burnt (88,000 in Victoria and 48,000 in NSW). The final section of the fire at Cape Howe continued to burn until late February when rain finally fell.

Project mapping of the fires for this period was undertaken at longer intervals than earlier stages. Figure 266 shows an overview map and finer detail can be seen in Figure 267 to Figure 270.

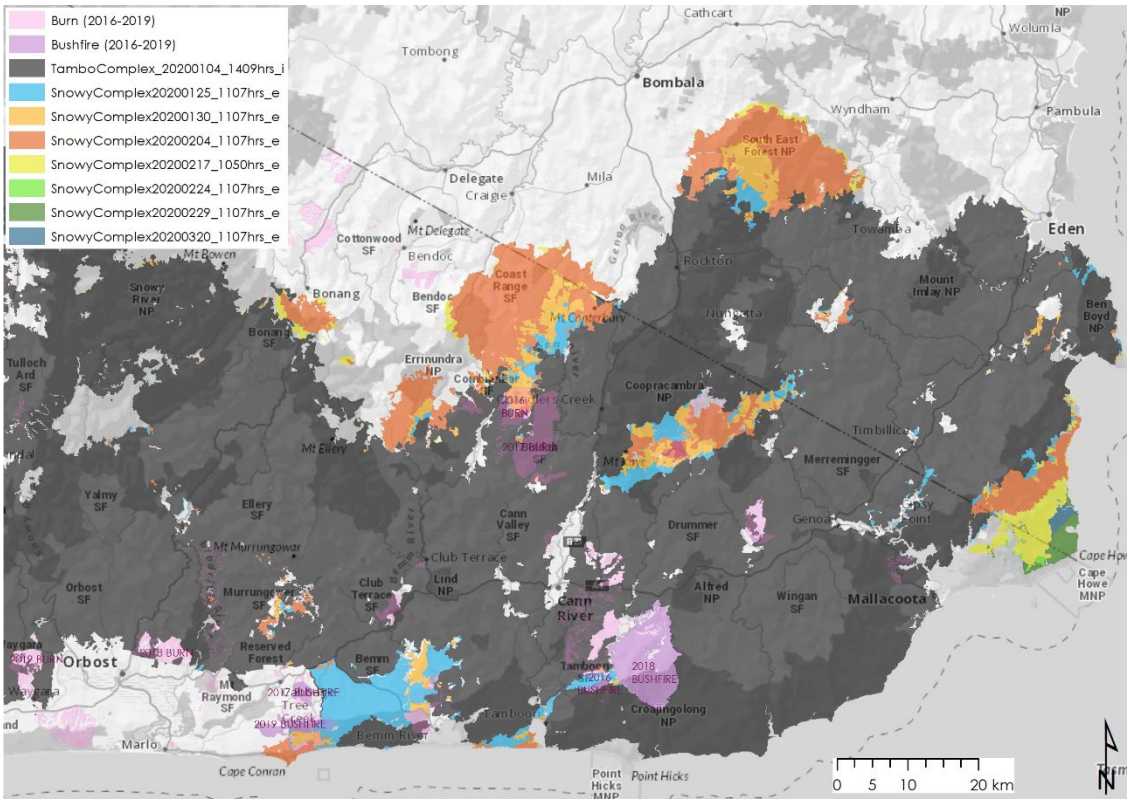


FIGURE 266: FIRE PROGRESSION OVERVIEW FOR THE SNOWY COMPLEX 15TH OF JANUARY TO 6TH MARCH 2020

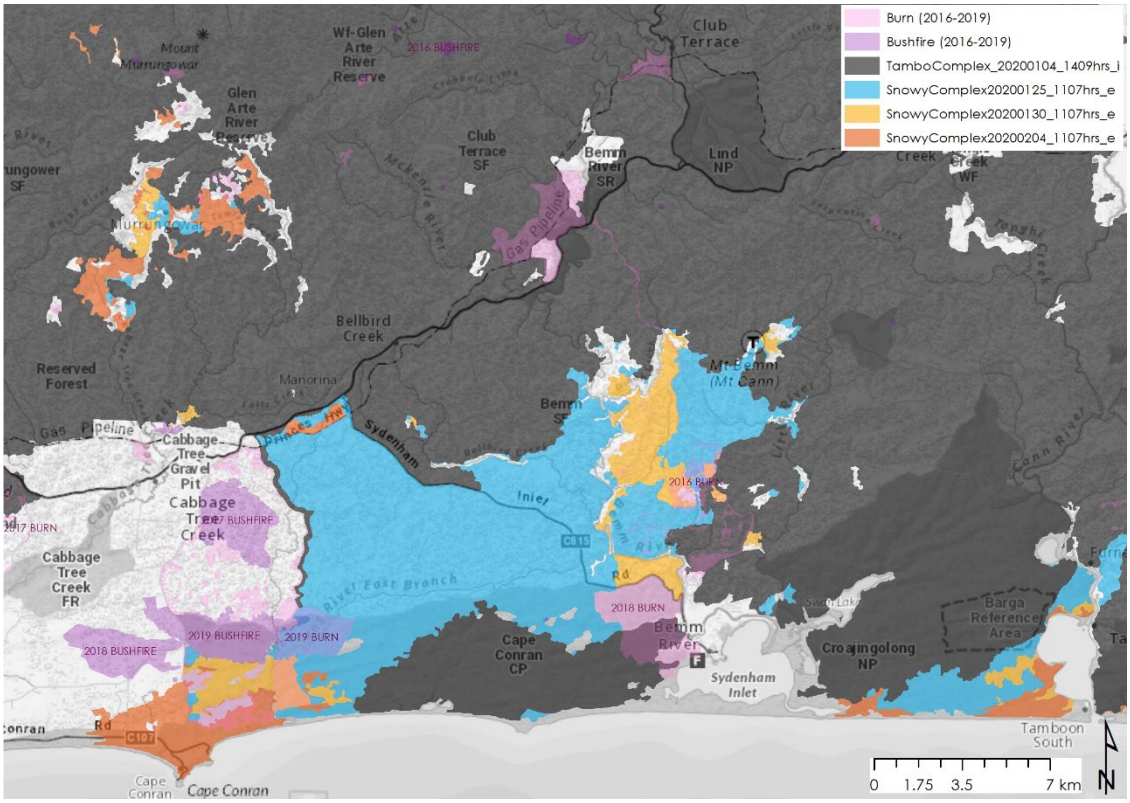


FIGURE 267: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 15TH OF JANUARY TO 6TH MARCH 2020

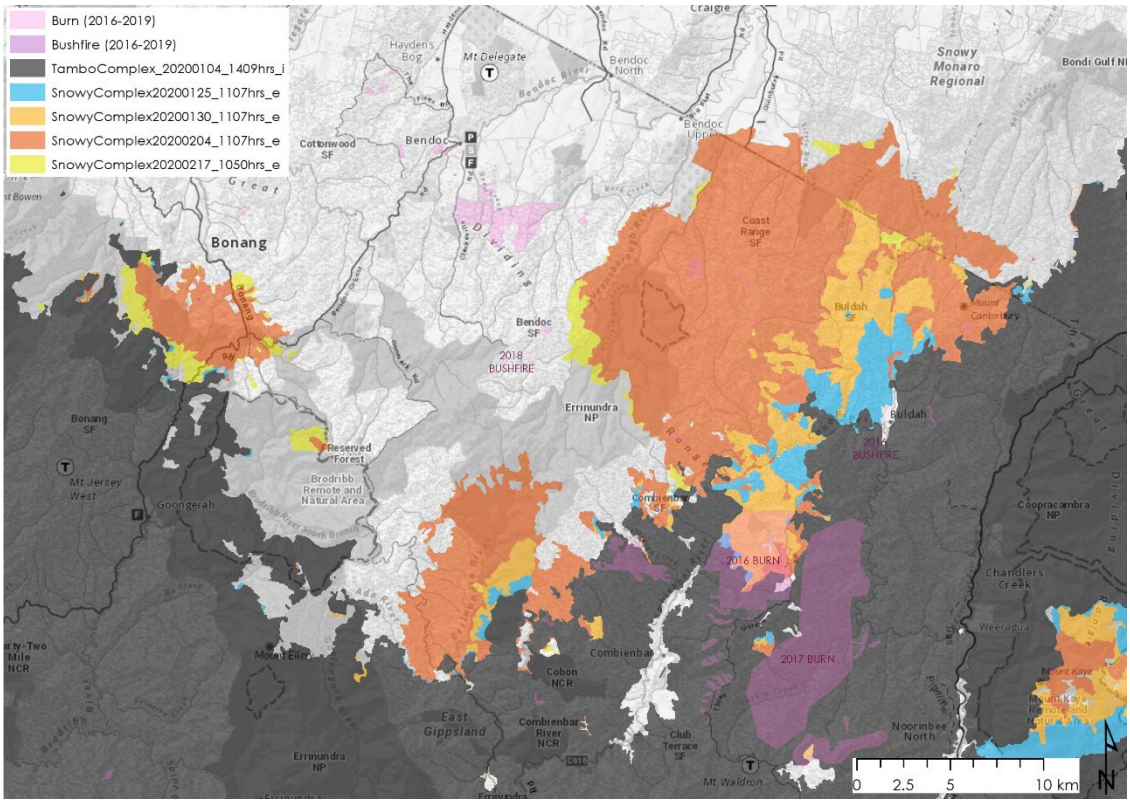


FIGURE 268: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 15TH OF JANUARY TO 6TH MARCH 2020

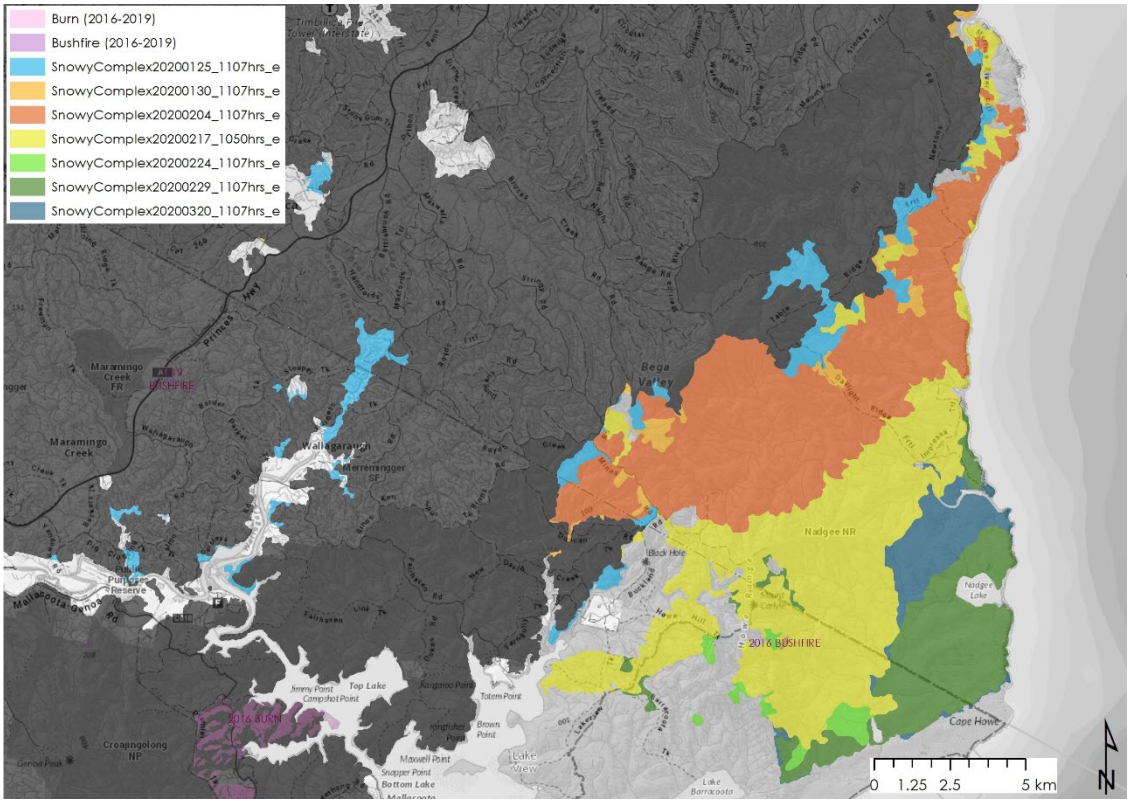


FIGURE 269: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 15TH OF JANUARY TO 6TH MARCH 2020

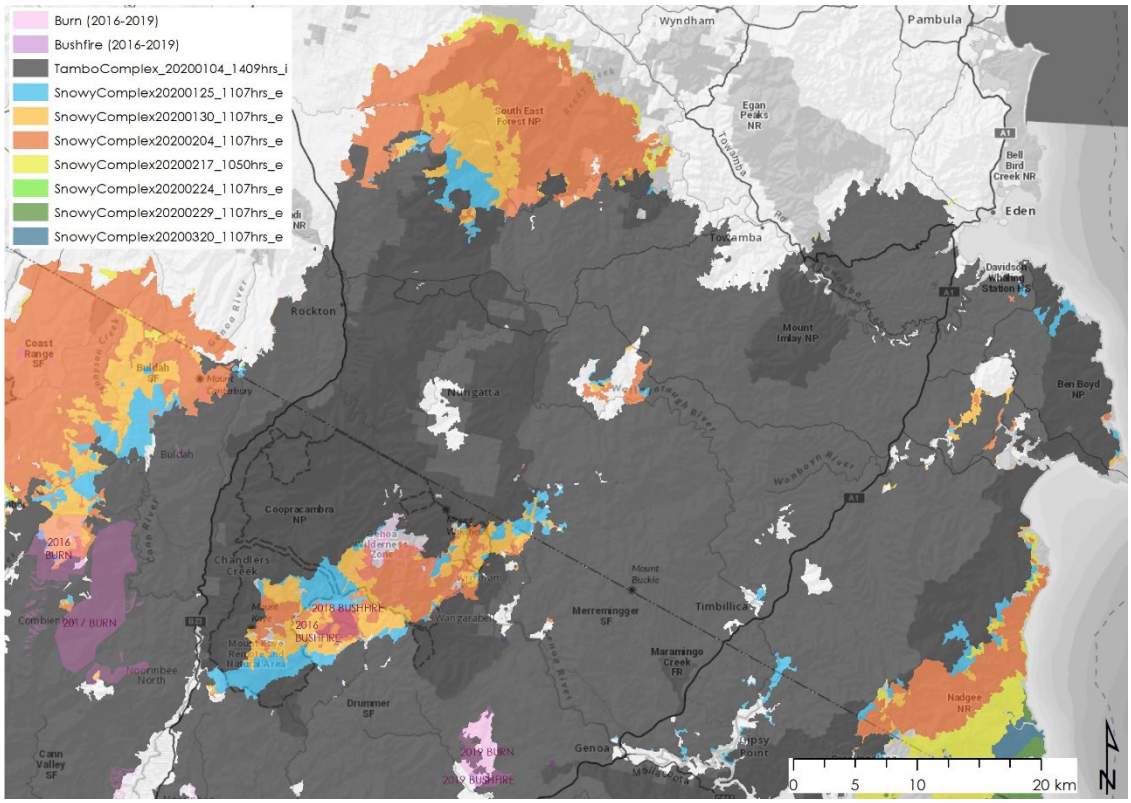


FIGURE 270: FIRE PROGRESSION DETAIL FOR THE SNOWY COMPLEX 15TH OF JANUARY TO 6TH MARCH 2020

INFLUENCE OF RECENT PLANNED AND UNPLANNED FIRE

There have been many studies of the influence of planned burning on the spread of bushfire. These range from anecdote, remote sensed severity mapping, to detailed case studies. The influence of previous planned burns or bushfire is related to the time since fire, burn coverage, severity and more importantly the context. Any determination of influence must also consider the weather, the topography and how the burn changed the fire behaviour or assisted suppression. Recent burns may be ineffective if the bushfire has an uphill run, is burning on a wide front, is spotting severely, or has become convective. This may also be true of a severe bushfire from two to three years past. Conversely, recent burning may assist suppression activities such as aerial foam/retardant drops and backburning as the fires are less intense and spotting activity is reduced.

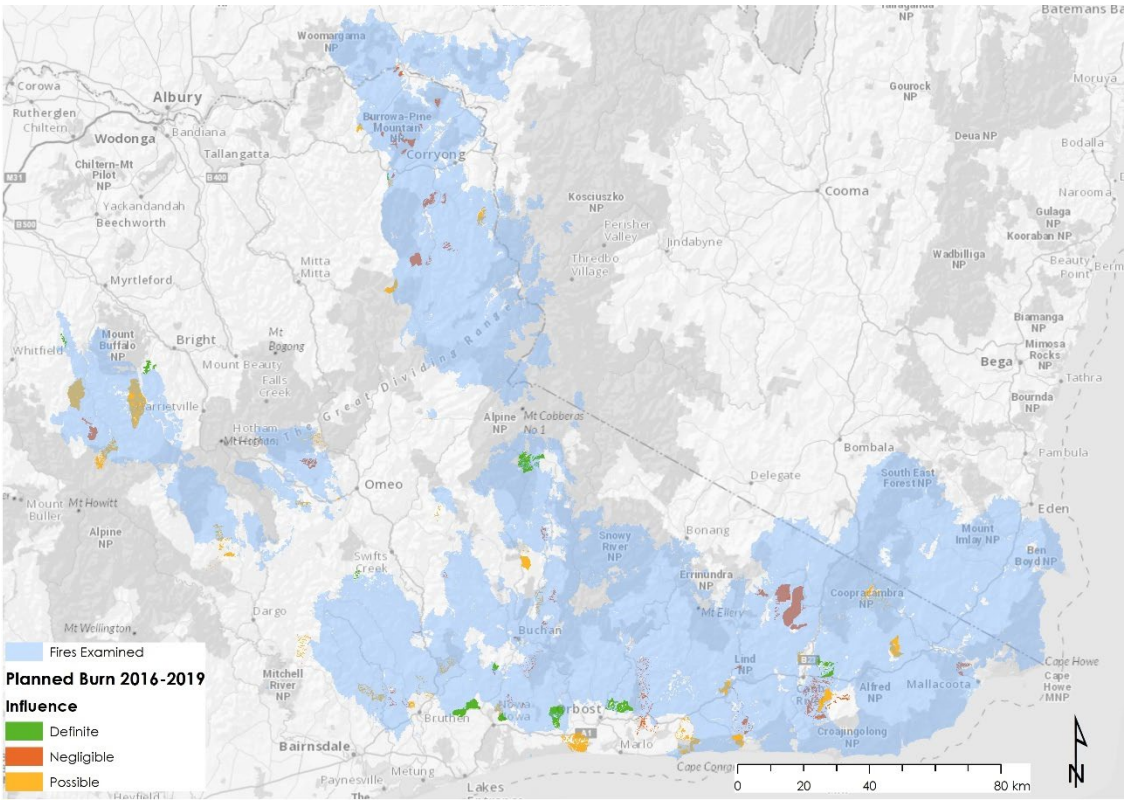


FIGURE 271: SUMMARY OF POSSIBLE INFLUENCE OF PLANNED BURNS ON THE SPREAD AND SUPPRESSION OF THE 2019/20 FIRES

It is sometimes difficult to show conclusively that burns and recent bushfire changed the fire behaviour or assisted with suppression. Figure 271 shows a desktop classification of the four years of planned burns that preceded the fires. The classification suggests that burns had a definite, possible, or negligible effect on the fire. This may provide a list for potential more detailed case studies. This will require detailed consultation with those who were operationally involved.

The method could be described as subjective expert opinion. It examined factors that included, fire and weather conditions when the

burn and fire interacted, suppression or response activities, burn coverage, resultant change to fire behaviour, burn coverage, and time since burn.

Figure 272 shows the recent bushfires and that nearly all large fires were not breached by the 2019/20 fires. The exception to this can be seen in detail in Figure 273. The fire that impacted on Buchan appears to have burnt easily through or spotted over the September 2017 Timbarra – Sunny Point bushfire.

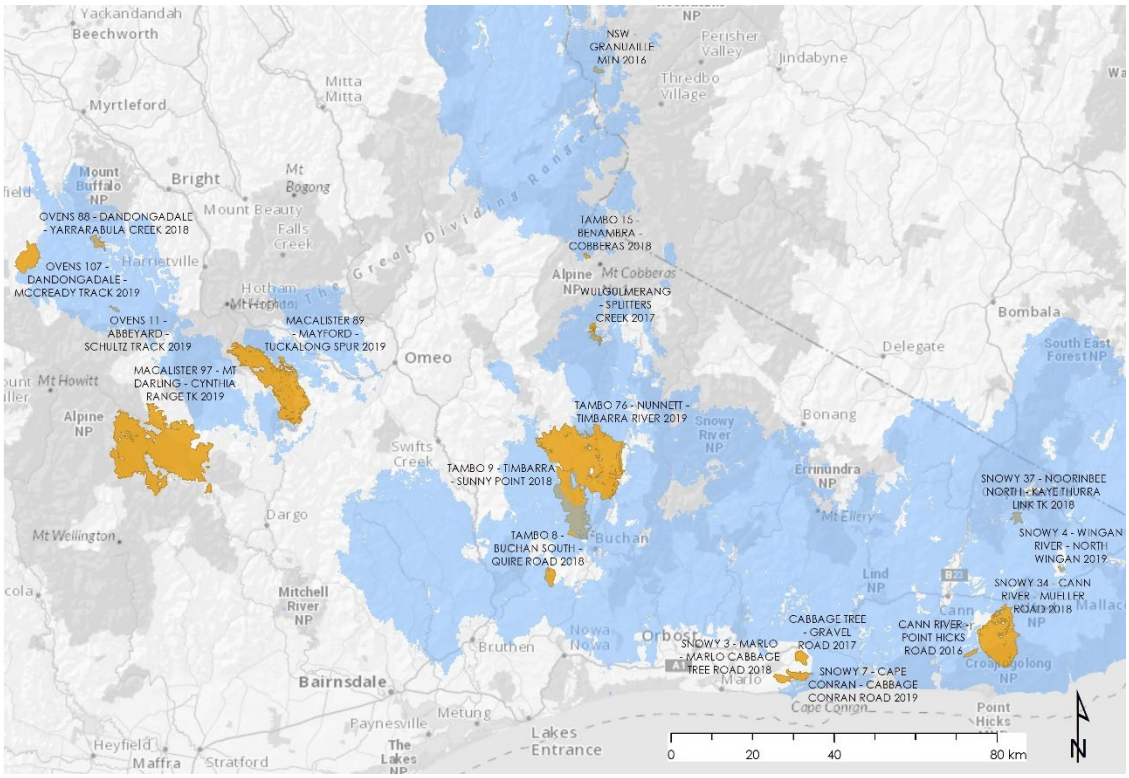


FIGURE 272: RECENT BUSHFIRE AND INFLUENCE ON FIRE SPREAD

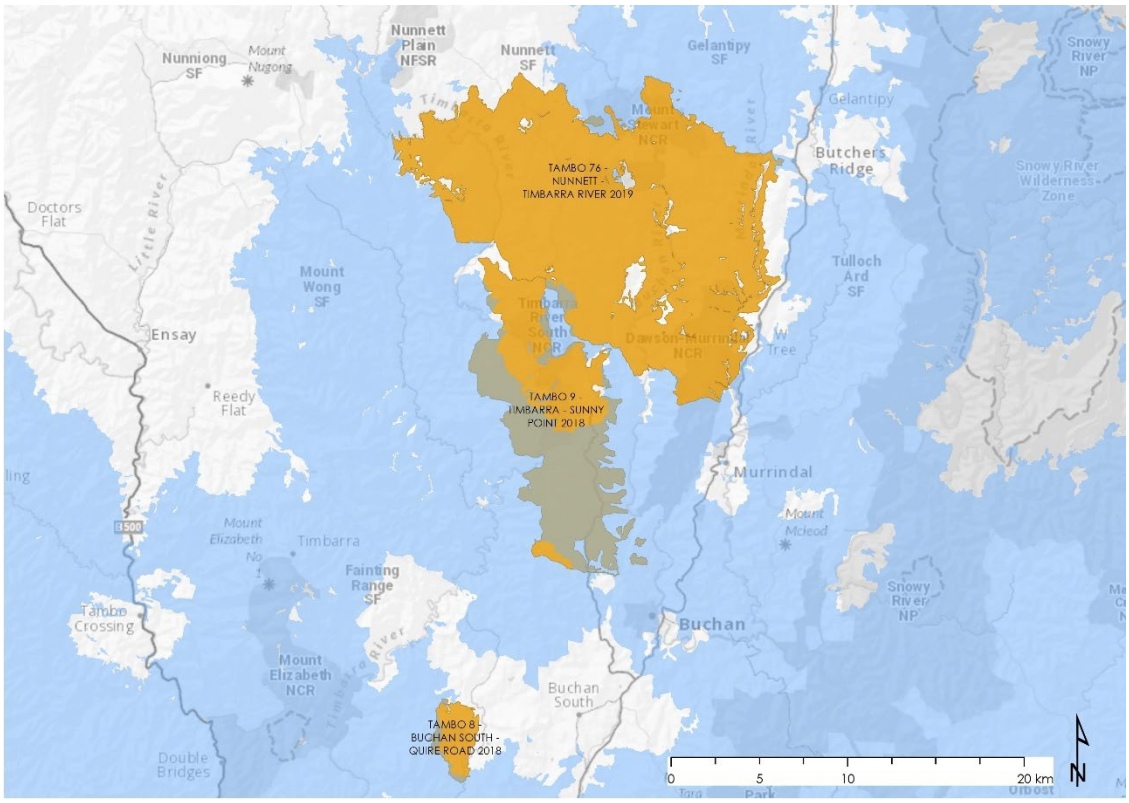


FIGURE 273: RECENT TIMBARRA BUSHFIRES AND INFLUENCE ON FIRE SPREAD

CONCLUSION

Documenting the spread of the Eastern Victoria Black summer fires has produced a record of what occurred and when. A reference document is now available that has a broad overview of the major fires, their spread and eventual containment. Preliminary analysis has documented the weather conditions and looked at how the fires made their major runs.

There will remain a multitude of questions and there will be many locations and events that were not examined. Further exploration of the events and management actions are now possible with this baseline study.

ONGOING IMPACTS

As a researcher there is a tendency to be distanced from the ongoing emotional and physical impacts of those who experienced the bushfires and continue to live with them. This report is dedicated to the family, friends, and colleagues of the firefighters and residents who lost their lives.

- David Moresi
- Mat Kavanagh (Forest Fire Management Victoria)
- Mick Roberts
- Bill Slade (Parks Victoria)
- Fred Becker
- Samuel McPaul (RFS NSW)

NEXT STEPS

The following are suggestions for possible next steps.

Weather review

A detailed weather review of the following days

- 25th of November for the four Gippsland fires.
- 20th/21st of December Marthavale - Barmouth Spur run
- 29th – 31st December including all Gippsland and North East fires
- 4th – 5th January including all Gippsland and North East fires

This might overlap with some southern NSW fires. These could be included if NSW authorities and BOM see the benefit.

As identified in discussion with CFA/BOM, the way changes and sea breezes move through Gippsland could be further investigated and guidance for fire agencies prepared.

More detailed case studies

These could look at further refining the detail of fire behaviour and local weather. Some candidates:

- Marthavale/Clifton Creek/Sarsfield 30th December 2019
- Abbeyard - Yarrarabula 4th of January 2020
- Ensay Ferntree and W-Tree Yalmy on the 25th of November 2019

These could look at the interaction between fuels, weather, suppression etc.

Other fires and days may be identified from the report, for example Banana Track to Mallacoota, Mallacoota to Eden fire run, backburning at Bemm River, Marthavale, Lightning Track, or Howe Range suppression tactics.

Effectiveness of planned burning

Modelling of residual risk shows that planned burning reduces the potential fire size and loss of assets. Finding actual examples in the 2019/20 fire season is more problematic. The scale of the fires on the 30th of December or the 4th of January was such that planned burning had little effect. None the less, there are examples on these and other days of where planned burning assisted with backburning, suppression or limited the spread of fires. The documentation of these events requires involvement of those present at the time. Such studies should be undertaken regionally.

Effectiveness of suppression: Direct attack – Land and Air

There are opportunities to examine many of the controlled fires that were not part of the study. Many studies focus on the fires that got away not the ones that were controlled. There were thousands of hours of air attack which knocked down spot fires, prepared control lines to protected infrastructure, limited spread, and supported firefighters.

Effectiveness of suppression: Indirect attack – Backburning

Large backburns were conducted which eventually contained the fires. There were some escapes. What worked? What didn't? What could be improved? Was the window available to conduct operations adequate? What level of resources were required? What preplanning helped? How did the escapes occur? (e.g. not blacked out, not patrolled, long distance spotting).

Tools for Fire Behaviour Analysts and other fire staff

This project has identified the use of different satellite data resources. The use of sentinel and Landsat through the EO browser can provide detailed NIR and SWIR data within 4 hours of data capture. This provides detailed broadscale coverage of fire areas and fire activity. A simple 'how to' guide and training could be prepared. SWIR/NIR composite images are the base product, but the ability to quickly produce severity mapping could also be documented.

The use of Himawari satellite feeds, provides a 10-minute frequency with a 10-20 minute latency. The current Weatherzone layers subscription can provide this data combined with Access-C and Access-R models, lightning tracker, field observations and radar data. This is invaluable to FBANs and situation staff.

The agencies should explore a purpose built Weatherzone layers application. It would combine all that is currently in this commercial platform with fire boundary and other operational data. Further to this, exploration of the infrared bands available from Himawari (e.g. Band 7) could be processed to provide fire specific outputs rather than the weather specific enhanced IR layer. This enhanced IR layer combined with lightning is a proven way of quickly identifying PyroCu/Cb events.

The BOM supply the base data to Weatherzone. A detailed proposal could be prepared for the development of this tool either via the BOM or Weatherzone to supply and maintain these specific tools.

The current true colour Himawari feed on fire web does not deliver. It does not have bands other than true colour, cannot be zoomed into and cannot be combined with other layers.

It is worth pointing out that there are limitations. Cloud or dense smoke will obscure the infrared signature and hence no data.

Review of fire models

The University of Melbourne are currently looking at the efficacy of fire spread models predicting fire spread. This is unlikely to delve into the detail as to why predicted spread did not match the actuals. Until there is a more detailed understanding of weather conditions, these studies will be limited to determination of error but not understanding its source.

Experiences Fire Behaviour Analysts have suggested we need to look at the weather in greater detail than just surface phenomena. The mixing down of hot dry winds, instability leading to PyroCu/Cb, upper-level winds causing spotting in the opposite direction to surface winds are just some examples of issues where current models are inadequate

How did the estimates of KBDI and DF perform? Do these accurately reflect the availability of fuel? Does long term drought mean that more than fine fuels (<6mm) should be considered. This is not a new issue and there have been many projects looking at this.

Data Archive

Finding the information required for reconstructing fire behaviour, undertaking case studies, and assessing suppression and prevention measures requires easily accessible and systematically stored data. There is the opportunity to build on projects that DELWP have been working on.

Both BOM and DELWP (not all) data tends to disappear into a deeply compressed inaccessible archive and there is a need to identify which days and sources that should be made more accessible. This may include AWS and PAWS, radar, AIG video, Weatherzone layers 10-minute data.

Digital images need to be kept with spatial and temporal data. Many firefighters and aircrew take photos and it would be good if there was a central archive available where public and agency staff could deposit photos with an understanding their use would require a credit to the image taker. Although a Pandora's box, it remains a worthwhile project.

Making reconstruction products

The preparation of 3d google earth Himawari true colour, EIR, SWIR, Weatherzone layers can easily be scripted to produce products for specific locations and time periods.

Further examination of PFT

After brief discussions with Kevin Tory, there is the opportunity to review events and determine if the PFT model adequately predicted the events that occurred. A review of the weather and access to 3d radar data from Bairnsdale may assist in confirming the PyroCu/Cb events and their timing. Reconstructed fire data can also provide information on the

timing of energy release and could be explored in finer detail using the Himawari IR bands

Understanding PyroCu/Cb

This could be in the form of a workshop with pre-prepared documentation. This would look at the conditions required, predicting it, confirming it, and understanding how it can affect fire behaviour.

Other Satellite sensors

Although not specifically mentioned in the report – Synthetic Aperture Radar (SAR) can see through cloud, and this could be evaluated. A good project for a postgrad. Is the data currently available? Does it work? Can it show severity? What is the turnaround time for data?

There has been work undertaken but this could be reviewed considering new sensors. See http://unsworks.unsw.edu.au/fapi/datastream/unsworks:10416/SOURCE02?view=true

Future weather conditions

What can we expect in the next 10 years? e.g. earlier fire seasons, fires behaviour being more difficult to predict. What implications for fuel management? How do we prepare? Are there learnings from these fires that we can use to adjust our thinking and management?

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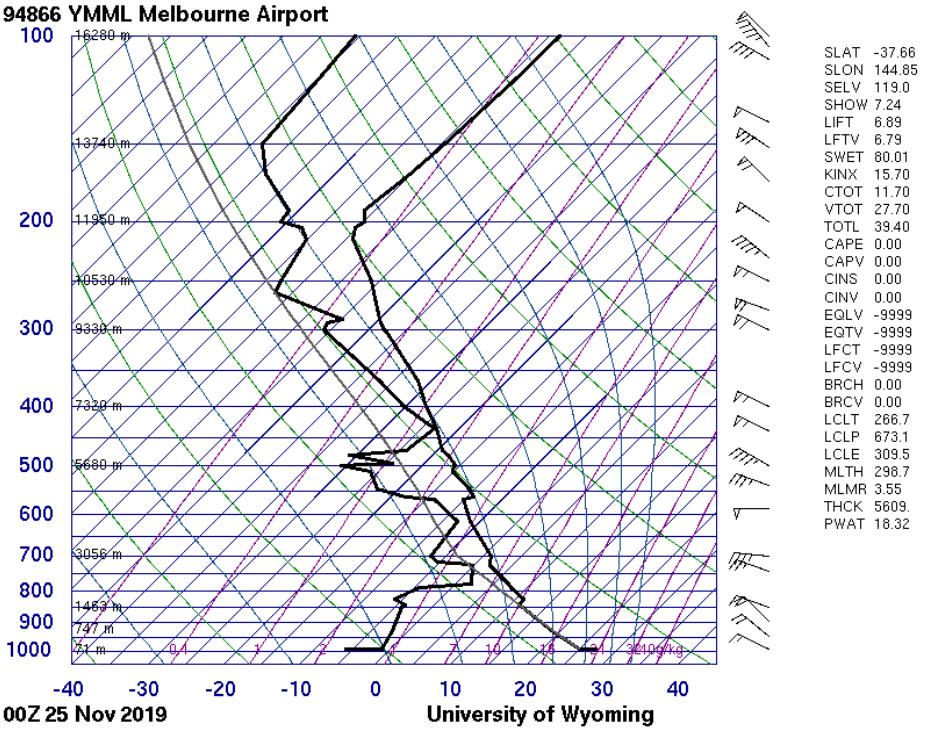
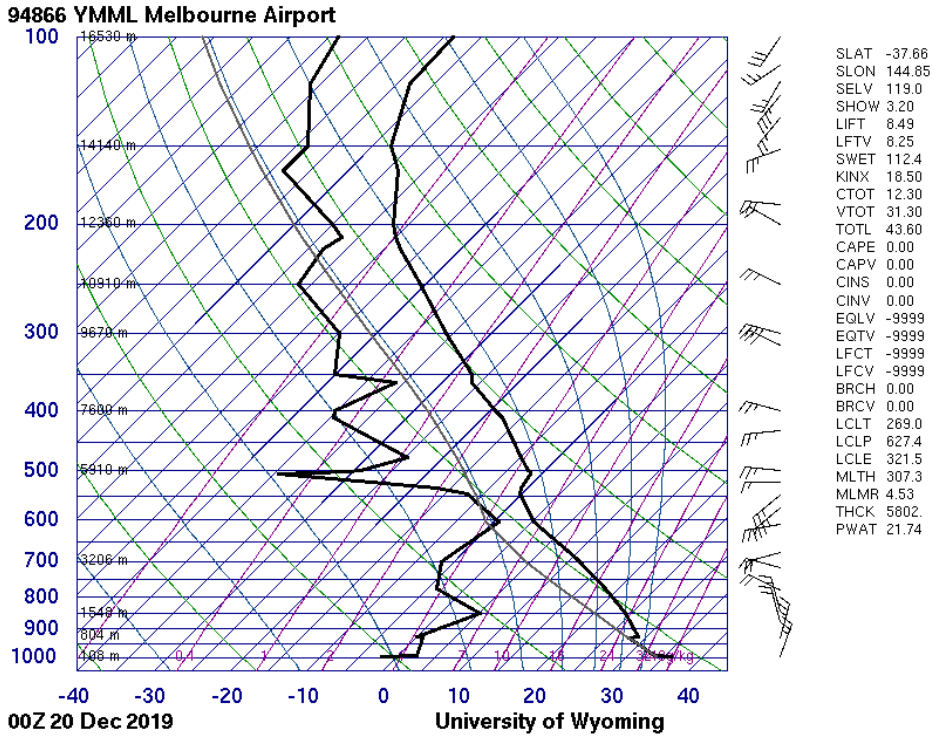
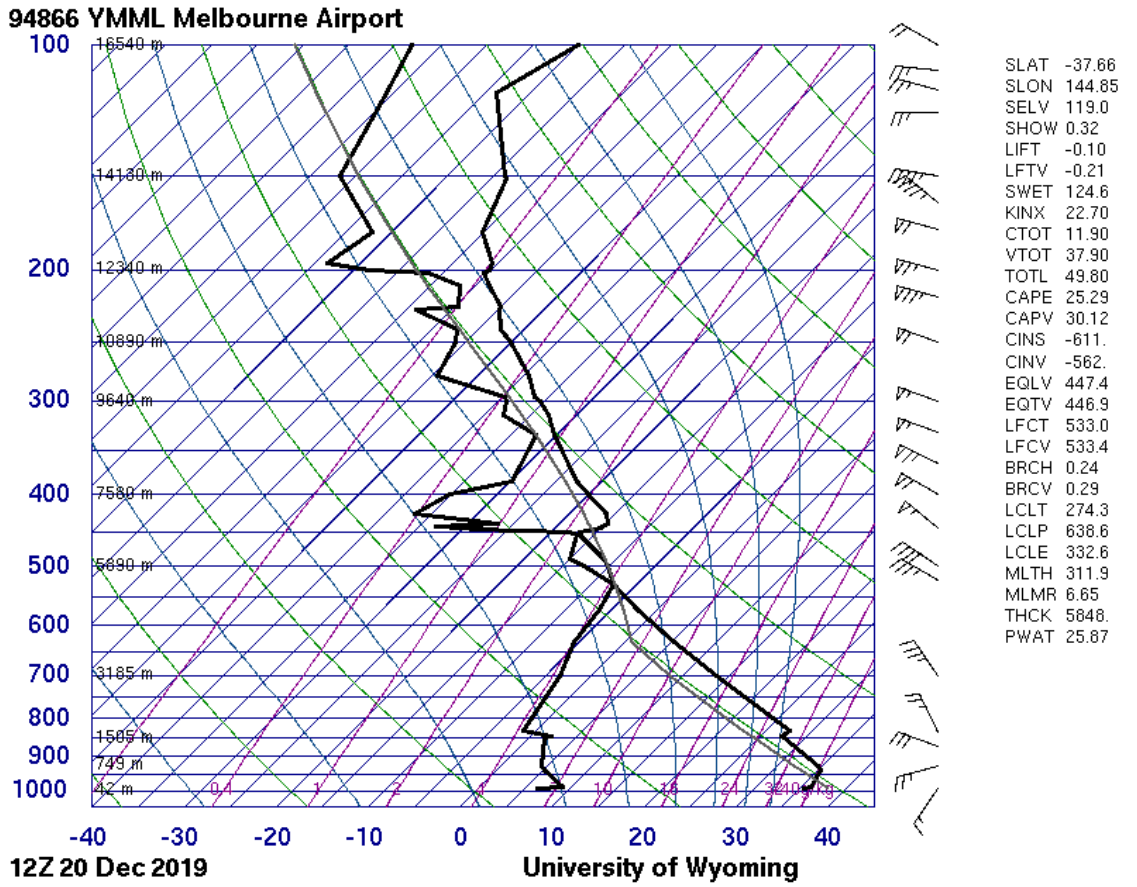
APPENDICES

APPENDIX ONE: AEROLOGICAL DIAGRAMS

See http://weather.uwyo.edu/upperair/sounding.html



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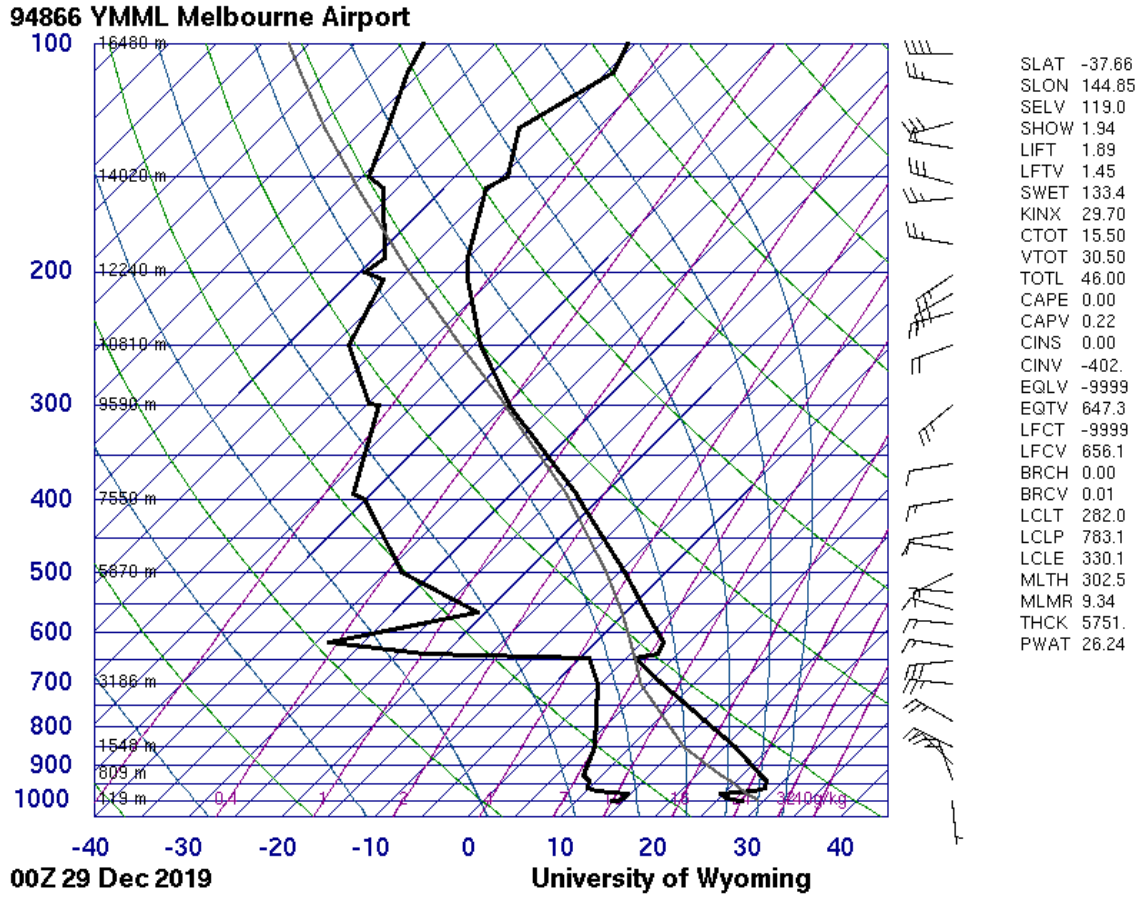
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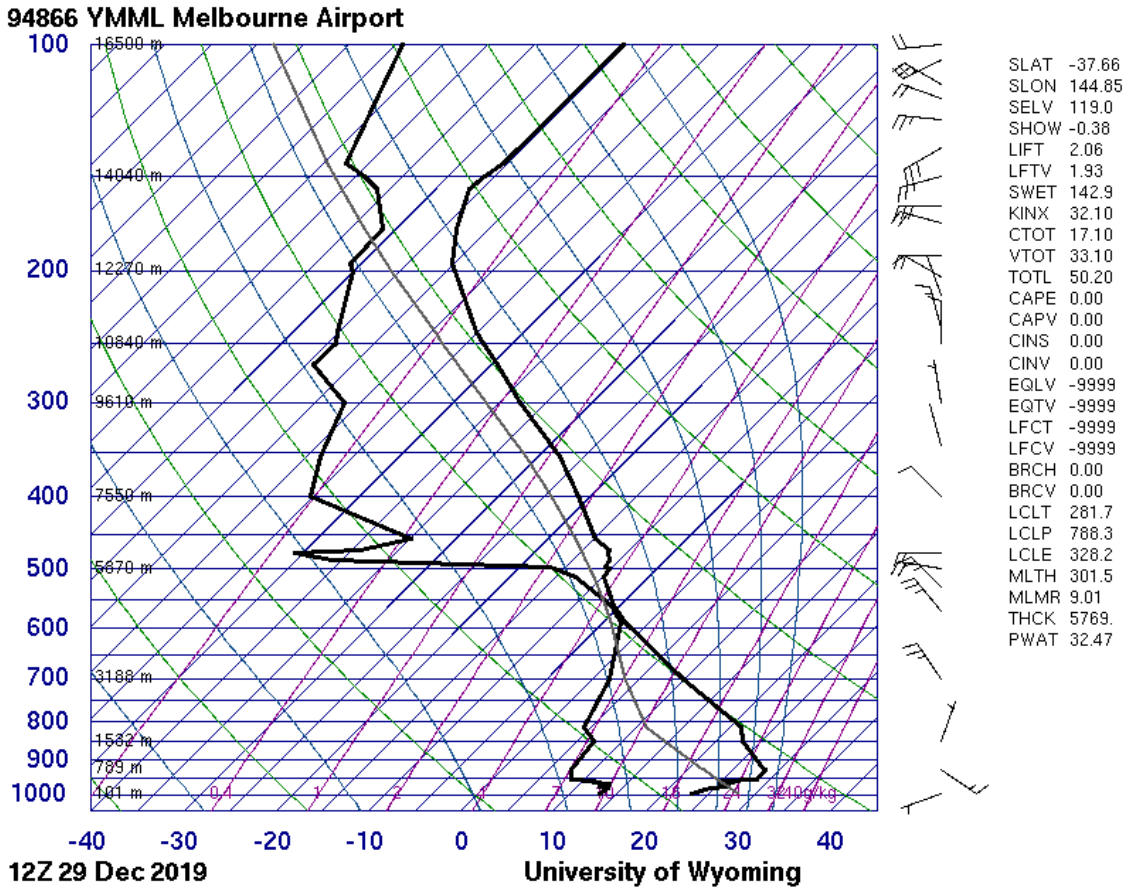
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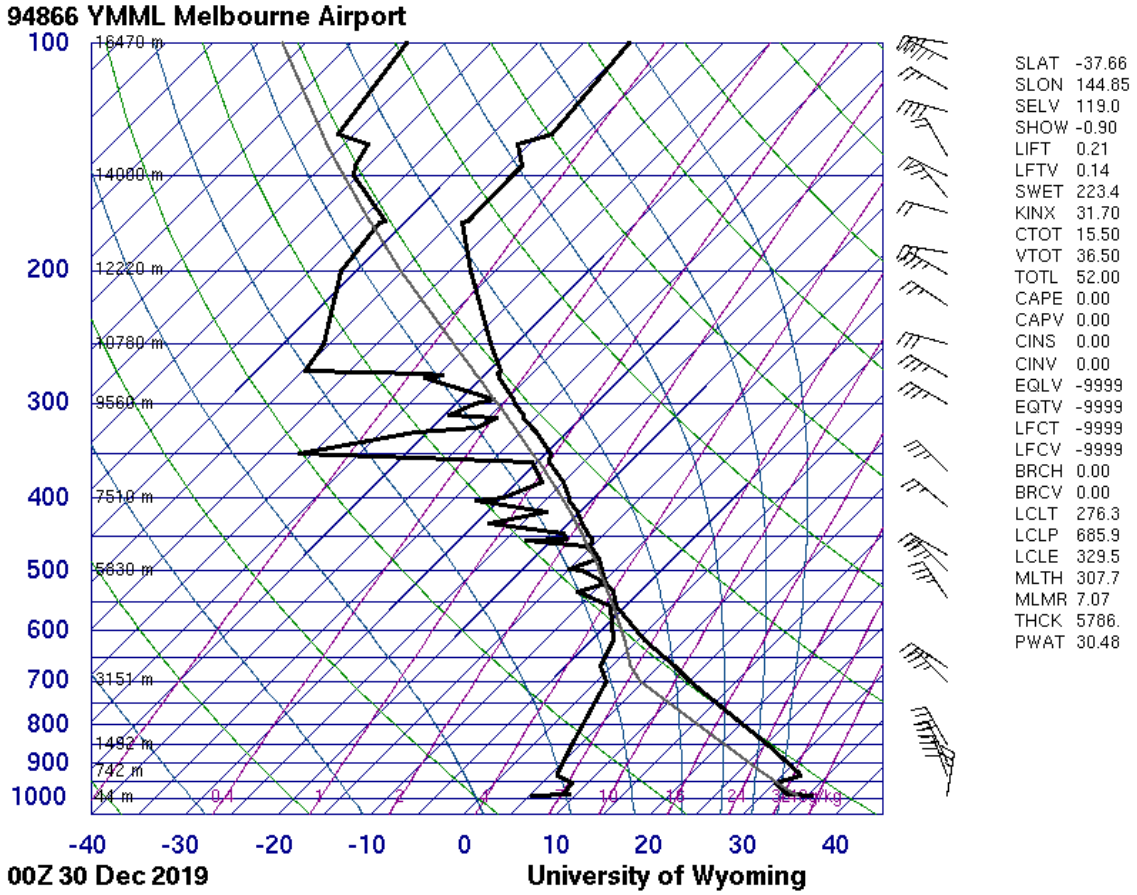
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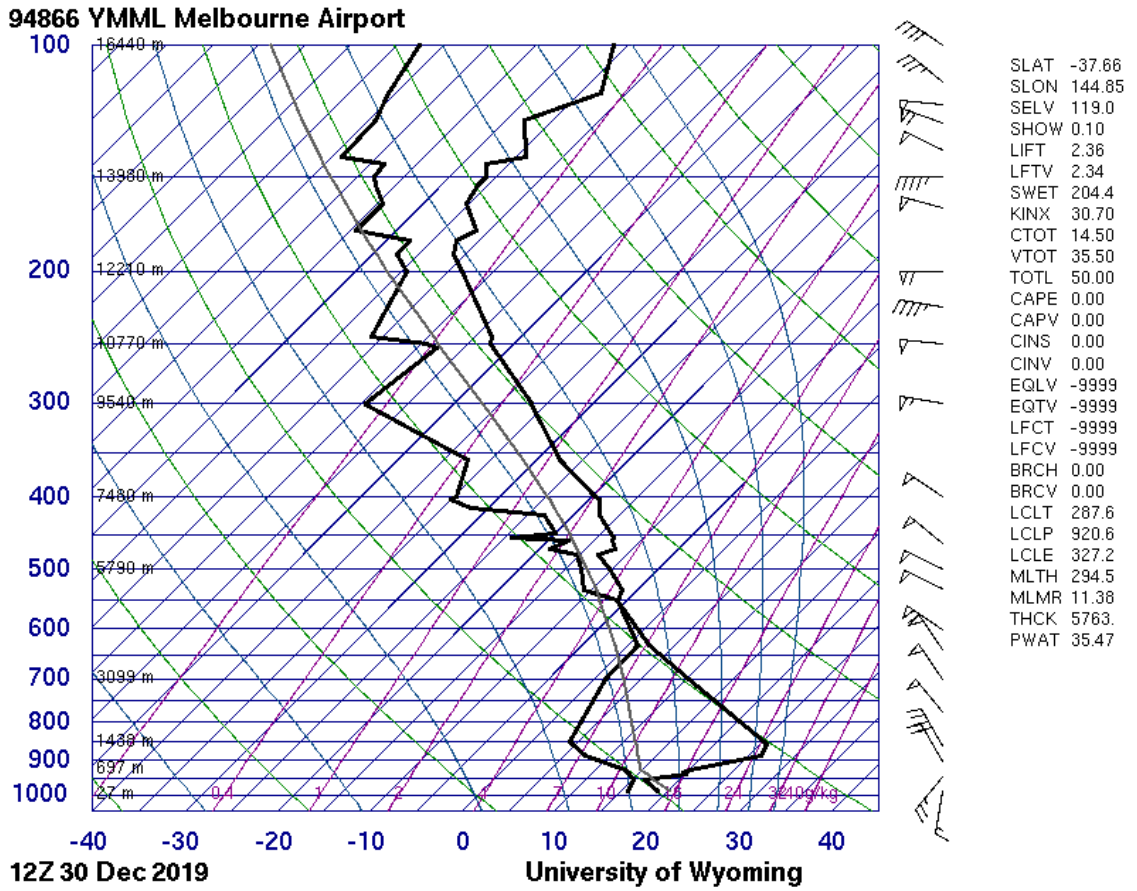
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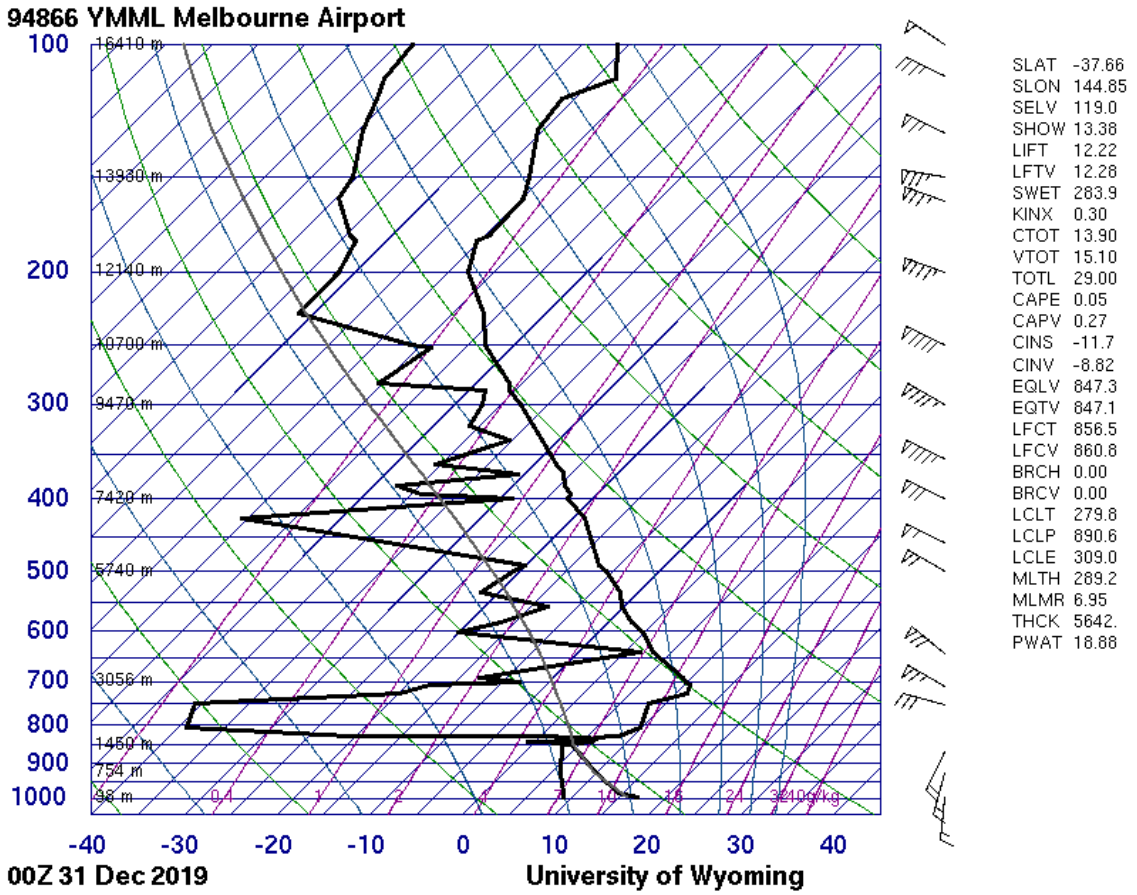
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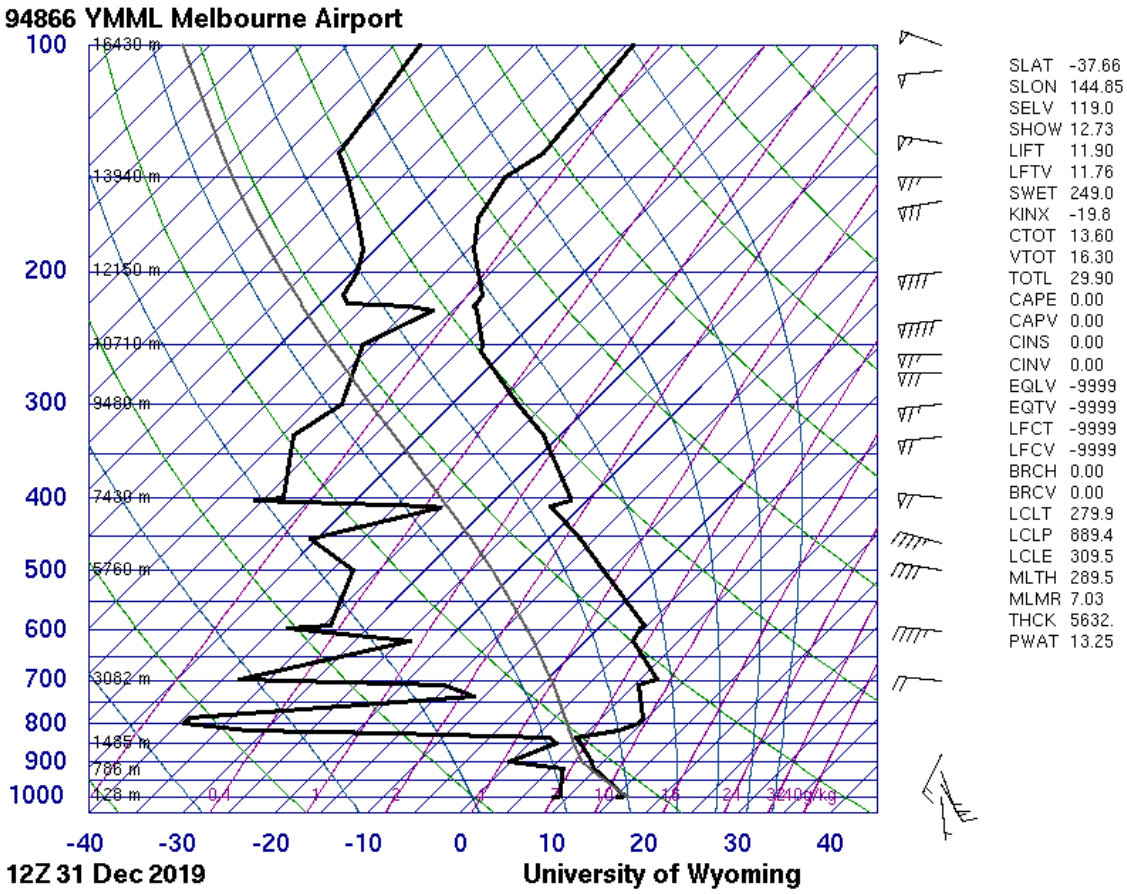
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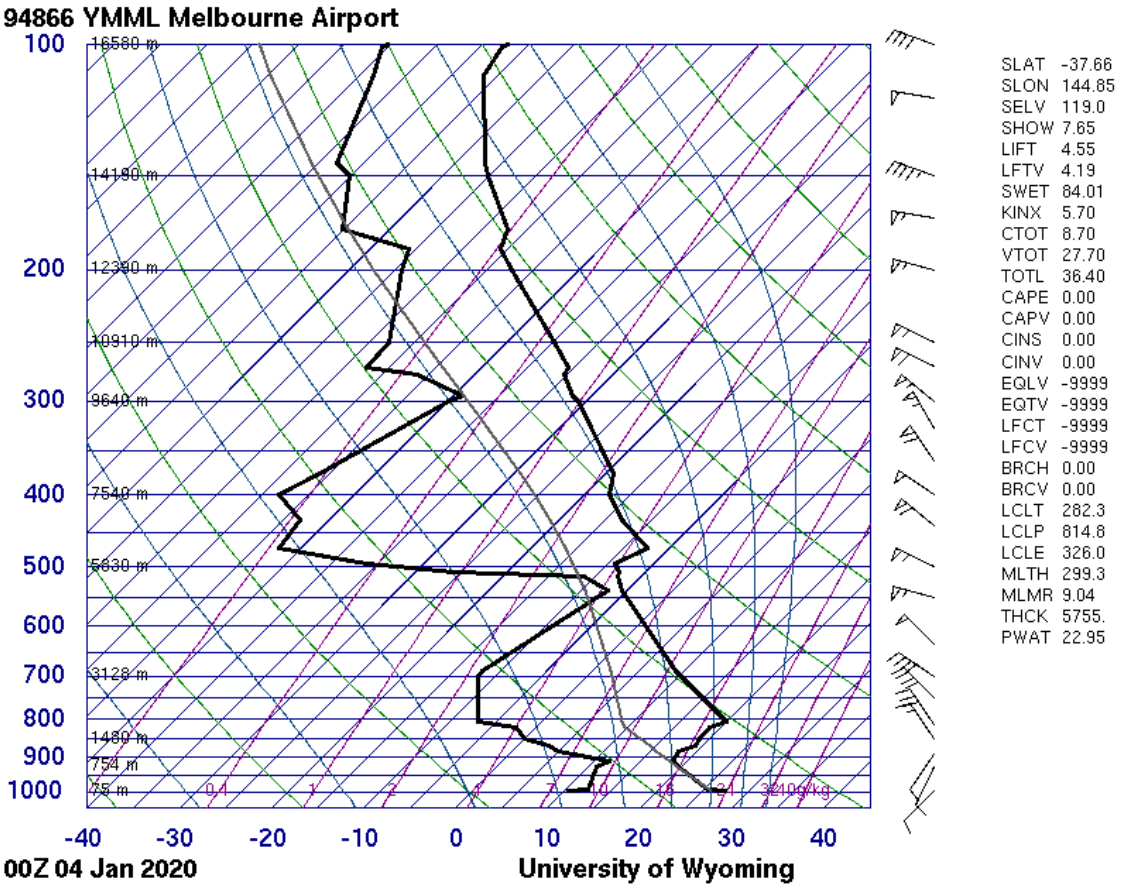
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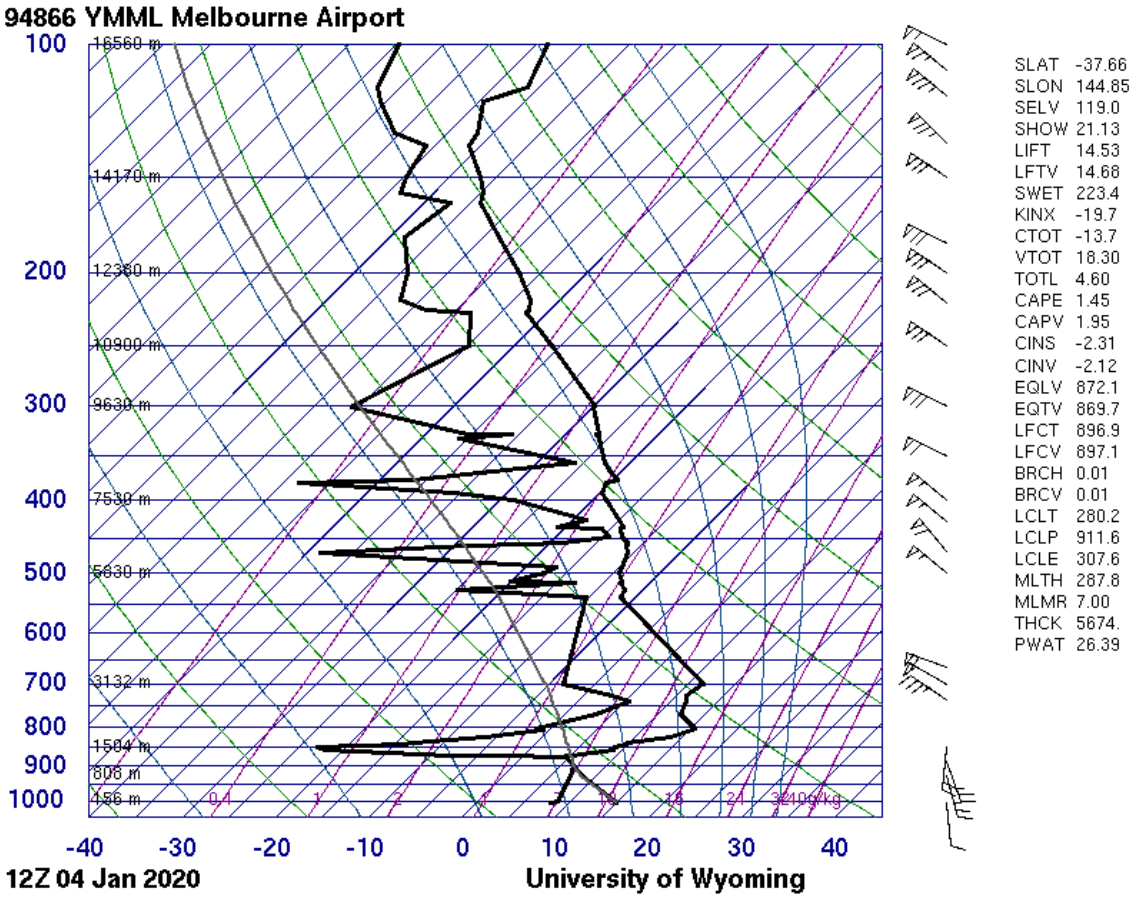
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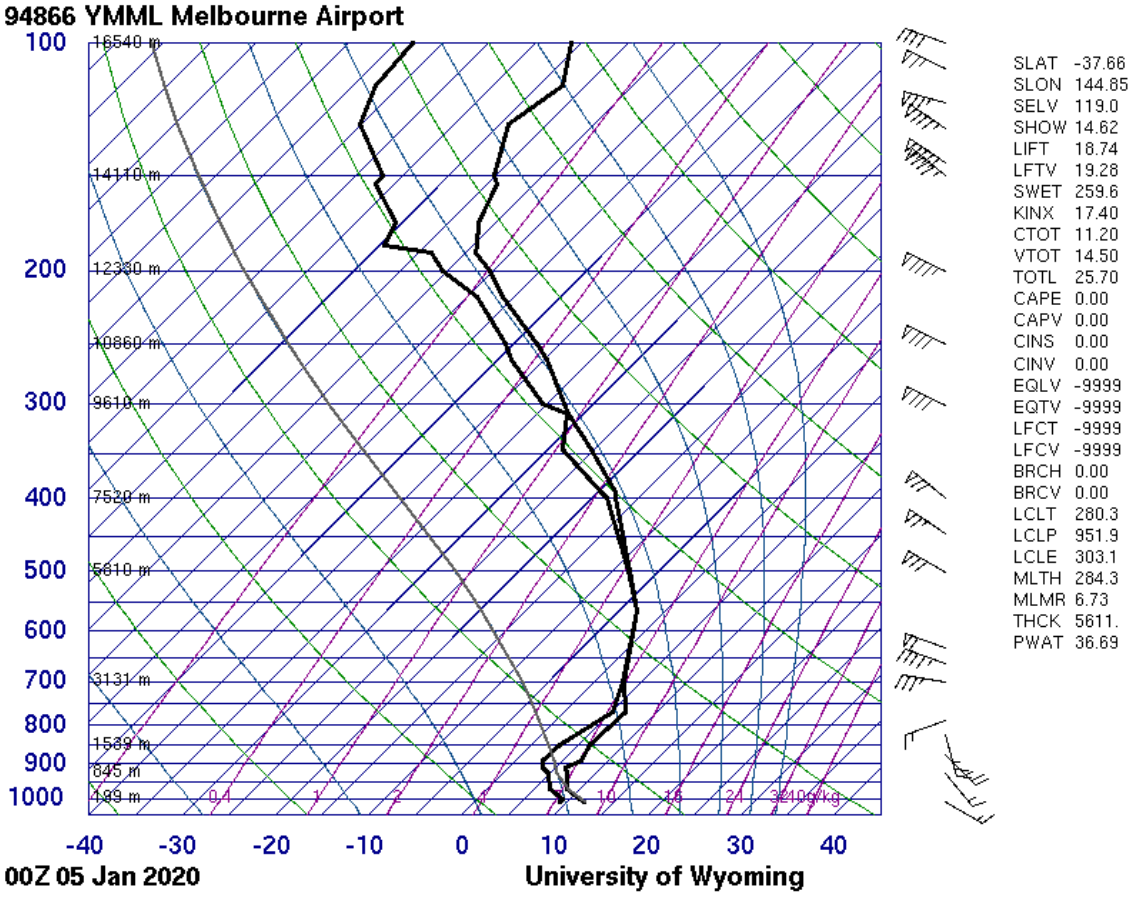
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APPENDIX TWO: LIST OF FIRES

This appendix contains the DELWP Fireweb summary for each fire that occurred in the area and time of interest.

It includes the date and time of first report, the final area recorded, the largest area the fire attained and on which day the fire status changed. The areas are from measurements taken at the time and are sometimes estimates.

Fire Name	Fireweb Final Area	Largest Area Recorded	Date Fire Started	Time Started	Status Change	Project Mapping Type	Cause
Macalister 43 - Hotham Heights - Blue Rag Range	35,560		31/12/19	14:37	C-06/02, UC1-13/02, S-08/05	Progression	Lightning
Macalister 46 - Wongungarra- Ritchie Road - Wongungarra	-	643	31/12/19	16:58	O-04/01 by MAC43	Progression	Lightning
Macalister 47 - Selwyn - Wongungarra Track	-	-	31/12/19	17:13	Is in Ovens - See OVE47 O-MAC43	Progression	Lightning
Ovens 18 - Abbeyard - Mt Buggery	-	384	22/11/19		C-17/12, UC1-17/12, UC2-20/12,O-04/01 by OVE41	Final Boundary	Lightning
Ovens 19 - Abbeyard - Long Jack Creek	-	74	22/11/19	09:18	C-26/12,UC1-03/12, UC2-07/12, O-04/01 by OVE41	Final Boundary	Lightning
Ovens 20 - Dandongadale - Buffalo Divide	-	619	22/11/19	09:26	C-10/12,UC1-17/12, UC2 20/12 S-07/01	Final Boundary	Lightning
Ovens 21 - Tea Tree Range - Mt Selwyn	-	438	22/11/19	09:42	C-01/12, UC1-07/12, UC-20/12, O-04/12 by OVE41	Final Boundary	Lightning
Ovens 25 - Selwyn - Mt Selwyn Road	-	6	16/12/19	16:14	C-17/12, UC1-17/12, UC-20/12, O-04/12 by OVE41	Not Mapped	Snigging, Hauling
Ovens 35 - Mount Buffalo - The Horn	-	1,562	31/12/19	13:51	O-10/12 by OVE41	Progression	Lightning
Ovens 36 - Abbeyard - Worseldine Tk	-	825	31/12/19	14:48	O-10/12 by OVE41	Progression	Lightning
Ovens 40 - Abbeyard - Camp Creek Tk	-	650	31/12/19	16:32	O-04/12 by OVE41	Progression	Lightning
Ovens 41 - Abbeyard - Yarrarabula South	105,910	105,910	31/12/19	16:32	C-05/22, UC1-10/03, UC-24/06, S-01/07/21	Progression	Lightning
Ovens 42 - Buckland Valley - Buffalo Range Tk	-	130	31/12/19	17:09	O-04/01 by OVE41	Progression	Lightning
Ovens 43 - Buckland Valley - Montana Tk	-	94	31/12/19	17:25	O-04/01 by OVE41	Progression	Lightning

Fire Name	Fireweb Final Area	Largest Area Recorded	Date Fire Started	Time Started	Status Change	Project Mapping Type	Cause
Ovens 44 - Buckland Valley - Mt Murray Tk North	-	177	31/12/19	17:32	O-04/01 by OVE41	Progression	Lightning
Ovens 46 - Abbeyard - Annie River	-	10	01/01/20	09:04	O-04/01 by OVE41	Progression	Lightning
Ovens 47 - Mount Murray - Wongungarra Track	-	135	31/12/19	17:13	O-04/01 by MAC43	Progression	Lightning
Snowy 12 - Bonang - Minchins Track	0	5	30/12/19	13:33	O-17/01 by SNO16	Initial Boundary	Lightning
Snowy 13 - Bonang - Swampy Creek	-	-	30/12/19	13:53	O-31/12 by TAM39	Not Mapped	Lightning
Snowy 14 - Noorinbee - Hunt Track	-	3	31/12/19	02:23	O-05/01 by TAM39	Not Mapped	Unknown
Snowy 15 - Chandlers Creek - Mount Coopracambra	-	5,056	02/01/20	10:05	O-07/01 by SNO16	Progression	Lightning
Snowy 16 - Snowy Complex -	662,252	662,252	06/01/20	N/A	C-06/03, UC1-31/03, UC2-08/05, S-30/06	Progression	Lightning
Snowy 5 - Wairewa - Wsm Mahogany Rd	1	1	22/11/19	16:02	C-22/11, UC1-23/11, UC2-26/11, S-01/12	Not Mapped	Lightning
Snowy 6 - Goongerah – Yalmy		2,256	25/11/19	13:34	O-07/12 by TAM31	Progression	Other (When fire crossed into District)
Snowy 7 - Wallagaraugh - Burgess Track	-	-	26/11/19	14:26	C-26/11, UC1-26/11, UC2-27/11, S-11/12	Not Mapped	Lightning
Snowy 8 - Wallagaraugh - Wallagaraugh Road	-	4	25/12/19	17:04	UC2-25/11,0-24/01	Not Mapped	Unknown
Snowy 9 - Cann River - Banana Track	-	147,460	29/12/19	14:48	O-07/01 by SNO16	Progression	Lightning
Tambo 26 - Nunnet - Rainbow Track	45	45	21/11/19	19:42	C-27/11, UC1-01/12, S-20/01	Final	Lightning
Tambo 27 - Buchan South - Canai Road	-	4	21/11/19	20:26	C-23/11, UC1-26/11, O-16/01 by TAM35	Not Mapped	Lightning
Tambo 28 - Buchan South - Rifle Range	-	0	21/11/19	21:19	UC1-21/11, O-16/01 by TAM35	Not Mapped	Lightning
Tambo 29 - Tosatree - Old Orbost Rd	84	84	22/11/19	08:18	C-22/11, UC1-26/11, UC2-01/12, S-06/12	FinalBoundary	Lightning
Tambo 31 - Bruthen - Six Mile Track	-	10,307	22/11/19	08:55	C-19/12, O-21/12 by TAM35	Progression	Lightning
Tambo 34 - Tostaree - Dawson Track	47	47	22/11/19	10:24	C-23/11, UC1-26/11, UC2-08/12, S-11/12	Progression	Lightning
Tambo 35 - Tambo Complex -	324,739	324,739	22/11/19	10:35	C-19/02, UC1-09/03, UC2-03/04, S-06/05	Progression	Lightning
Tambo 36 - Mitchell Riv NP - Billy Goat Bend	63	63	22/11/19	10:48	C-25/11, UC1-29/11, UC2-23/01, S-14/02	Progression	Lightning

Fire Name	Fireweb Final Area	Largest Area Recorded	Date Fire Started	Time Started	Status Change	Project Mapping Type	Cause
Tambo 37 - Nowa Nowa - Harris Creek	-	1	22/11/19	1111	C-22/11, UC1-26/11, O-16/01 by TAM35	Not Mapped	Lightning
Tambo 38 - W Tree - Springs Track	-	218	22/11/19	1221	O-25/11 by TAM39	Progression	Lightning
Tambo 39 - W Tree - Yalmy	-	387,461	22/11/19	1238	O-25/11 See SNO16	Progression	Lightning
Tambo 40 - Gelantipy - Glenmore Road	-	77	22/11/19	1336	C-27/11, UC1-28/11, O-16/01 by TAM35	Final Boundary	Lightning
Tambo 41 - Ensay - Ferntree Creek	-	20,315	22/11/19	1455	O-31/12 by TAM35	Progression	Lightning
Tambo 42 - Bindi - Garron Track	-	120	25/11/19	1120	C-01/12, UC1-14/12, O-05/01 by TAM66	Progression	Lightning
Tambo 43 - Ensay - Helipad Track	-	-	25/11/19	1637	Not Found, but overrun	N/A	Lightning
Tambo 44 - Buchan South - Mt Elizabeth	-	144	25/11/19	0941	O-02/12 by TAM41	Progression	Lightning
Tambo 45 - Sarsfield - Paddy`S Flat	-	-	03/12/19	1331	False Alarm But overrun	N/A	Other
Tambo 48 - Gelantipy - Robinsons Road	-	1	29/12/19	1629	O-06/01 by TAM35	Not Mapped	Lightning
Tambo 49 - Gelantipy - Never Never Creek	-	40,362	29/12/19	1642	O-06/01 by TAM35	Progression	Lightning
Tambo 50 - Wulgulmerrang - Forlon Hope Plain	-	1	29/12/19	1701	O-06/01 by TAM35	Not Mapped	Lightning
Tambo 51 - Gelantipy - Reedy Track	-	18	29/12/19	1740	O-30/12 by TAM49	Progression	Lightning
Tambo 52 - Suggan Buggan - Mt Menaak	363	363	29/12/19	1912	UC1-01/02,S-13/03	Progression	Lightning
Tambo 54 - Suggan Buggan - The Lighthouse 2	1	1	29/12/19	1917	S-01/02	Not Mapped	Lightning
Tambo 55 - Suggan Buggan - Mt Stradbroke	1	3740	29/12/19	1926	O-20/01	Final Boundary	Lightning
Tambo 56 - Youngs Hut Track - Bundara	-	12	31/12/19	1836	O-04/01 by TAM60	Final Boundary	Lightning
Tambo 57 - Shannonvale - Trapyard Gap	-	33	31/12/19	1843	O-04/01 by TAM60	Progression	Lightning
Tambo 58 - Cobungra - Dinner Plain Trk	-	11,530	31/12/19	2213	O-04/01 by TAM60	Progression	Lightning
Tambo 59 - Cobungra - Dinner Plain Trk 2		26	31/12/19	2228	O-13/01 by TAM58	Final Boundary	Lightning
Tambo 60 - Shannonvale - McNamara Hut	44,308	44,308	01/01/20	1136	C-04/02, UC1-10/03, UC2-31/03, S02/04	Progression	Lightning
Tambo 61 - Bundara - Youngs Hut Track 2	-	291	01/01/20	1151	O-04/01 by TAM60	Progression	Lightning
Tambo 62 - Bundara - Youngs Hut Track 3	-	267	01/01/20	1228	O-04/01 by TAM60	Progression	Lightning

Fire Name	Fireweb Final Area	Largest Area Recorded	Date Fire Started	Time Started	Status Change	Project Mapping Type	Cause
Tambo 63 - Tom Groggin - Top Flat	-	2,788	01/01/20	1847	O-15/01 by TAM64	Progression	Other
Tambo 64 - Buenba - Pheasant Creek Track	90,000	90,003	01/01/20	1850	C-11/02, UC1-10/03, UC2-31/03, S-02/04	Progression	Lightning
Tambo 65 - Dinner Plan - Mount Table Top	-	1,521	01/01/20	1925	O-15/01 by TAM58	Progression	Lightning
Tambo 66 - Bindi - Tin Pot Creek	3,484	3,484	02/01/20	1001	C-04/02, UC1-23/02, UC2-31/03, S-02/04	Progression	Lightning
Tambo 67 - Cassilis - Powers Gully Track	11	11	02/01/20	1003	C-06/01, UC1-13/01, UC2-26/01, S-11/02	Final Boundary l	Lightning
Tambo 68 - Cassilis - Powers Gully Track 2	5	5	02/01/20		C-06/01, UC1-13/01, UC2-26/01, S-11/02	Final Boundary	Lightning
Upper Murray 21 - Nariel Valley - Nariel Gap Track	0	0	26/11/19	1337	C-26/11, UC2-02/12, , S-25/12	Not Mapped	Lightning
Upper Murray 22 - Thowgla Upper - Stockwells Track	0	0	26/11/19	1737	C-26/11, UC1-26/11, UC2-02/12, S-04/12	Not Mapped	Lightning
Upper Murray 25 - Corryong - Wabba Wilderness		0	28/12/19	1002	C-28/12, UC1-29/12, UC2-09/11, O-26/01 by UM26	Not Mapped	Lightning
Upper Murray 26 - Upper Murray - Walwa	200,442	200,442	29/12/19	1834	C-24/01, UC1-27/03, UC2-01/07, S-06/07	Progression	Lightning in NSW
Upper Murray 28 - Wabba Wilderness - Wabba Track	-	48	31/12/19	1843	O-05/01 by UM30	Progression	Lightning
Upper Murray 29 - Staceys Bridge - Remote Radio Road	-	171	31/12/19	1845	O-05/01 by UM30	Progression	Lightning
Upper Murray 30 - Nariel Valley - Glendart Track	-	11,866	31/12/19	1846	O-08/01 by UM26	Progression	Lightning
Upper Murray 31 - Mt Pinnibar - Shady Creek Upper Track	-	35	31/12/19	1847	O-09/01 by UM26	Progression	Lightning
Upper Murray 32 - Gibb Range - Glamour Hill Track	-	41	31/12/19	1851	O-05/01 by UM30	Progression	Lightning

Fire Name	Fireweb Final Area	Largest Area Recorded	Date Fire Started	Time Started	Status Change	Project Mapping Type	Cause
Upper Murray 33 - Mt Sassafras - Wild Boar Track		14	31/12/19	1852	O-08/01 by UM26	Progression	Lightning
Upper Murray 35 - Mt Gibbo - Buenba Rd	-	3	01/01/20	2238	O-04/01 by TAM64/UM26	Progression	Lightning

APPENDIX THREE: SNOWY AND TAMBO HIMAWARI IR PROGRESSION

The following section has been created from a 3d Google Earth visualisation of the fire runs using Himawari 8 Band 7 SWIR imagery. There are still some issues where dense cloud cover or PyroCu/Cb will obscure the SWIR signal from the fire. Himawari images are every ten minutes and in general the whiter the pixel the more intense the fire. Smoke plumes will show up as grey to black and dense cloud shows as black and obscures the fire beneath. The snapshots have major roads and towns and the most recent line scan derived fire shape (brown) and final fire shape for the fire run as of the 1st of January at 0130hrs (green line).

Although the imagery is at coarse resolution, it is sensitive to capture small hot areas in the pixel. There are also some offset effects where heat outside of the fire area (hot air/smoke) may cause a false signal. None the less, many of the images correlate well with field observations and other imagery.

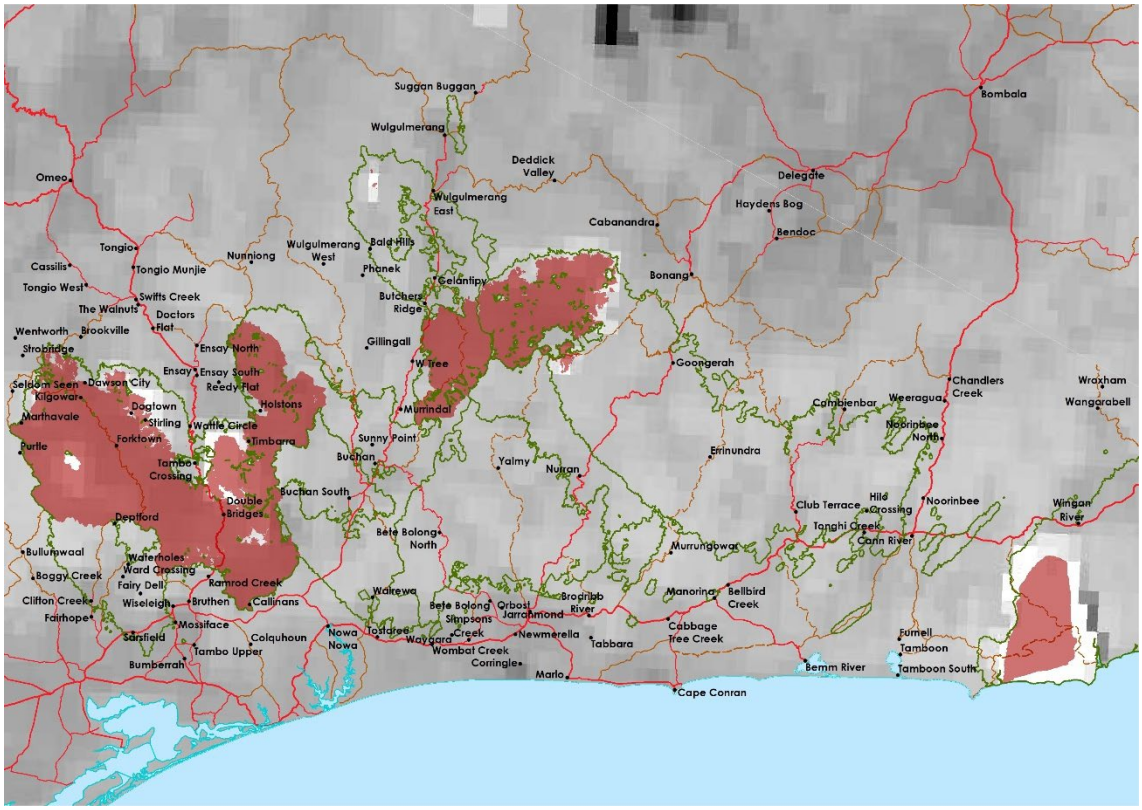

FIGURE 274: 0530HRS 30TH OF DECEMBER 2019

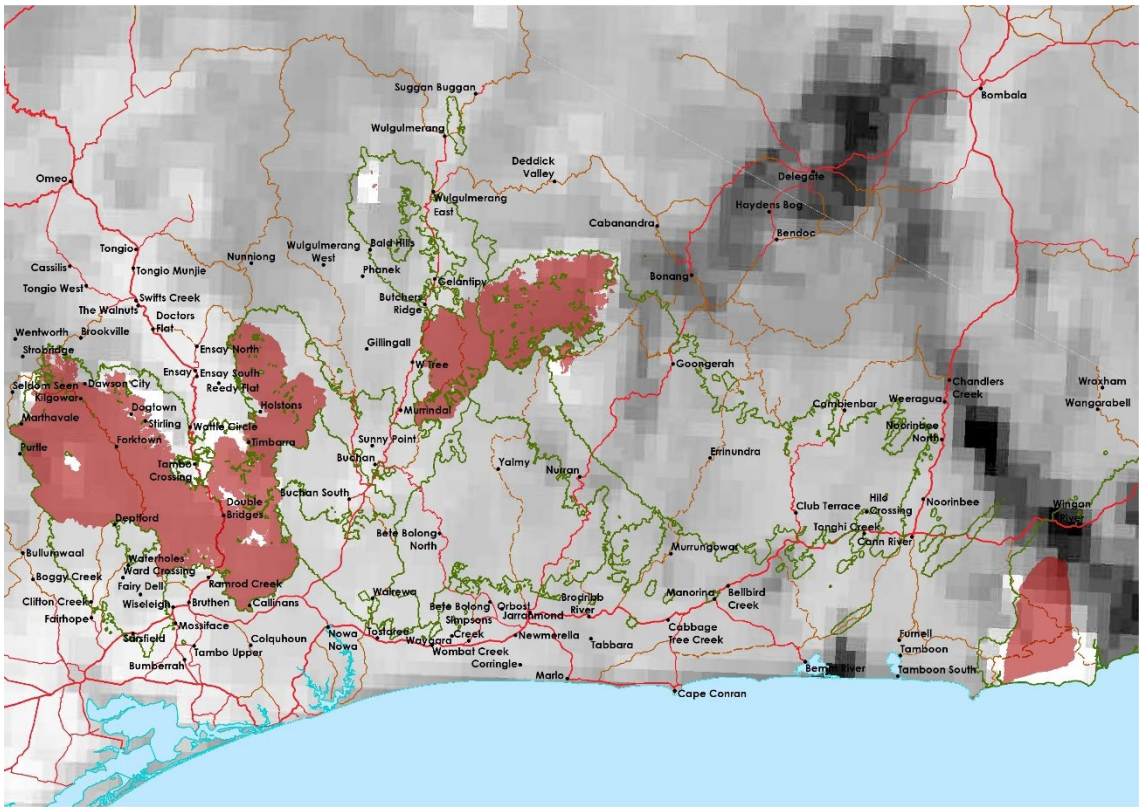

FIGURE 275: 0930HRS 30TH OF DECEMBER 2019

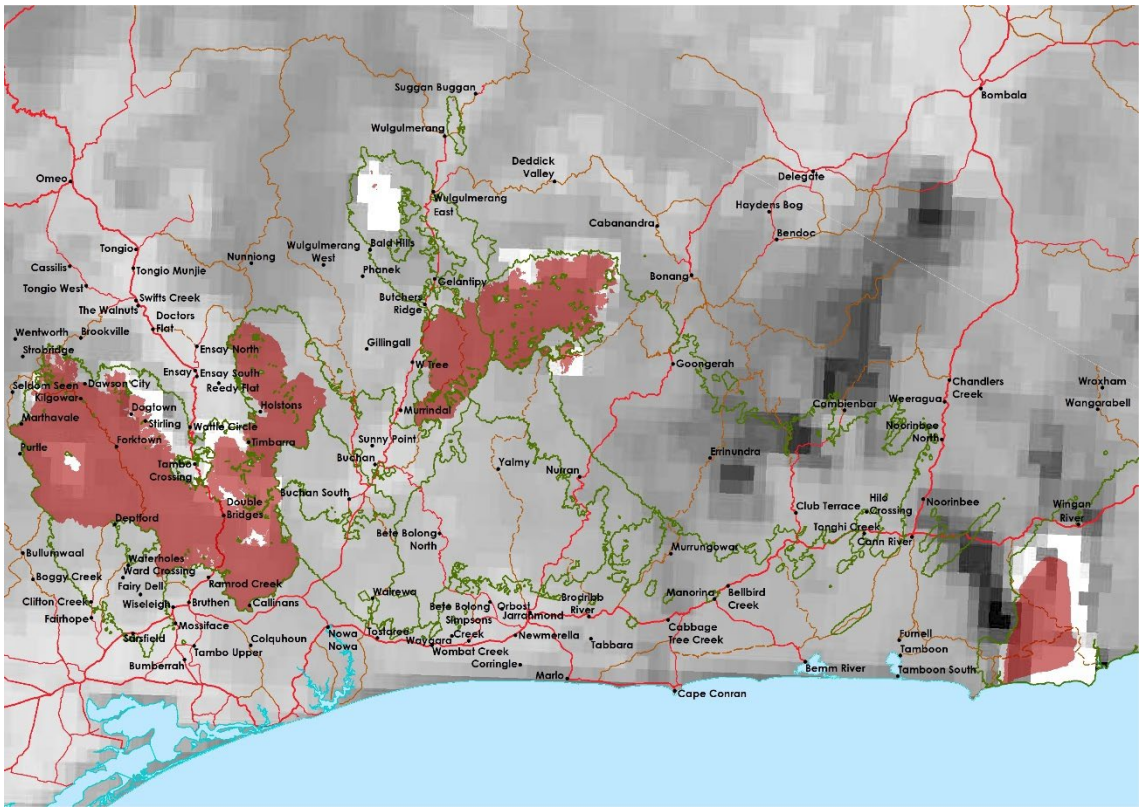

FIGURE 276: 1020HRS 30TH OF DECEMBER 2019

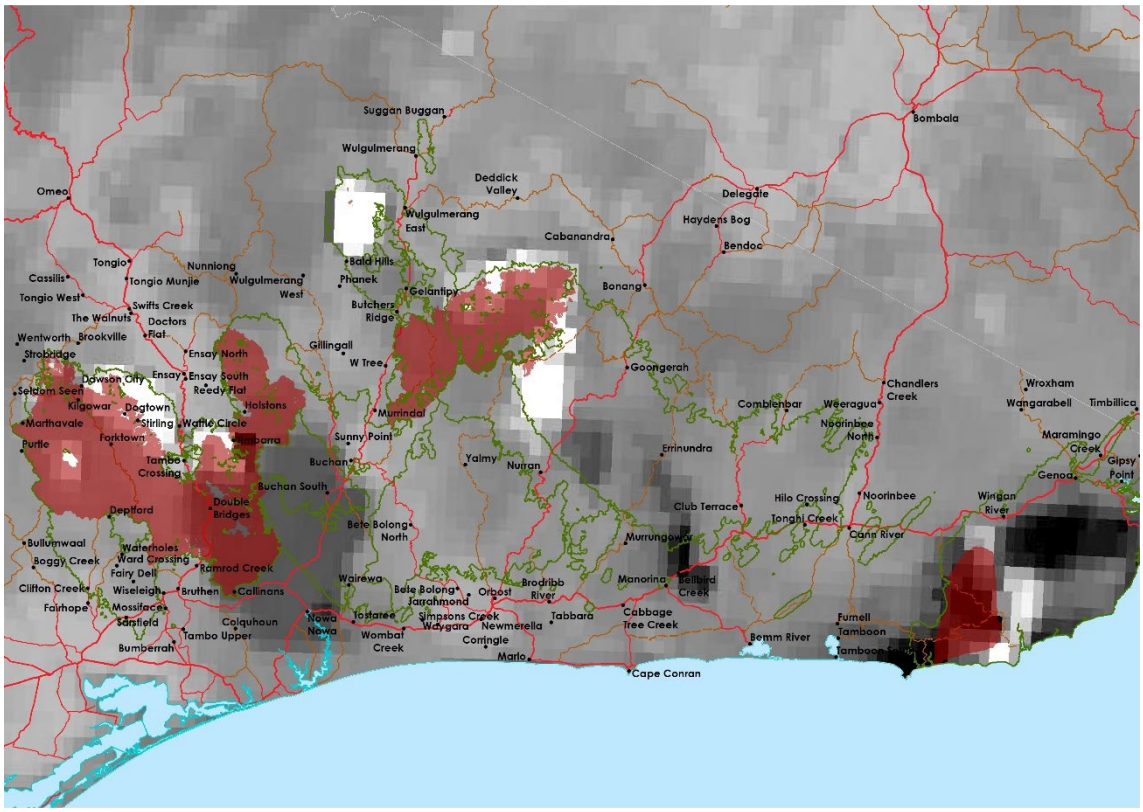

FIGURE 277: 1230HRS 30TH OF DECEMBER 2019

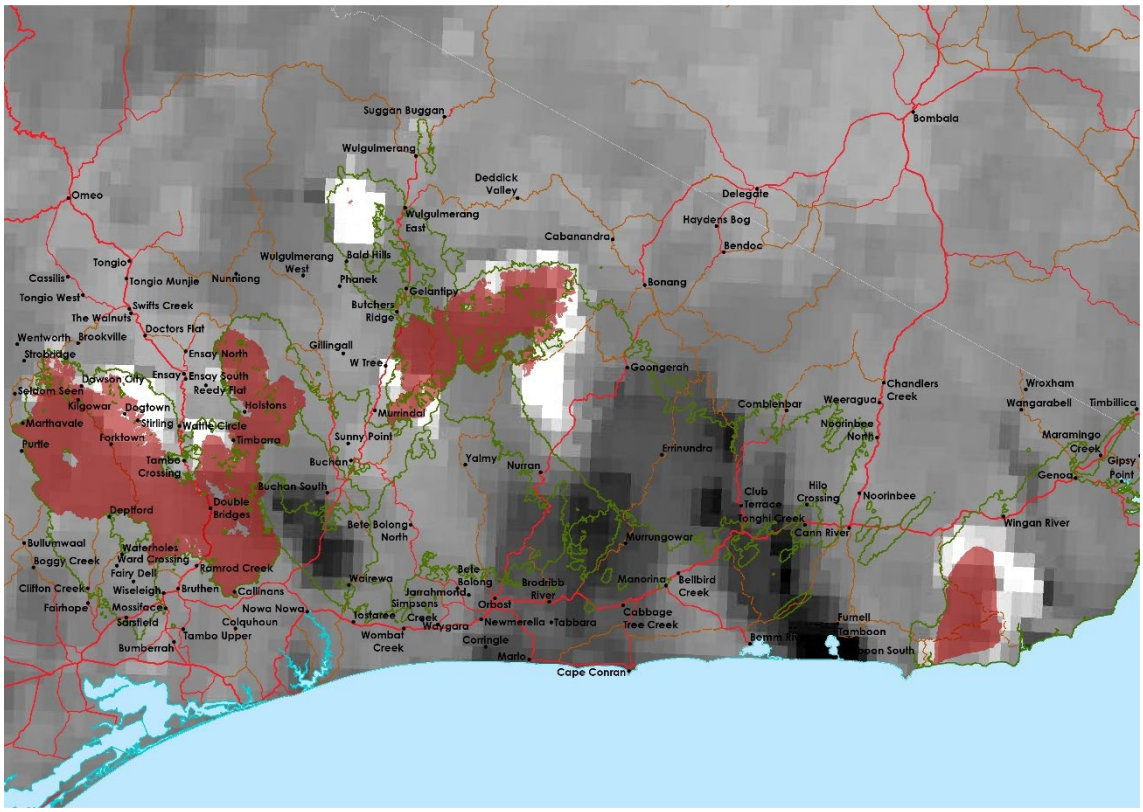

FIGURE 278: 1420HRS 30TH OF DECEMBER 2019

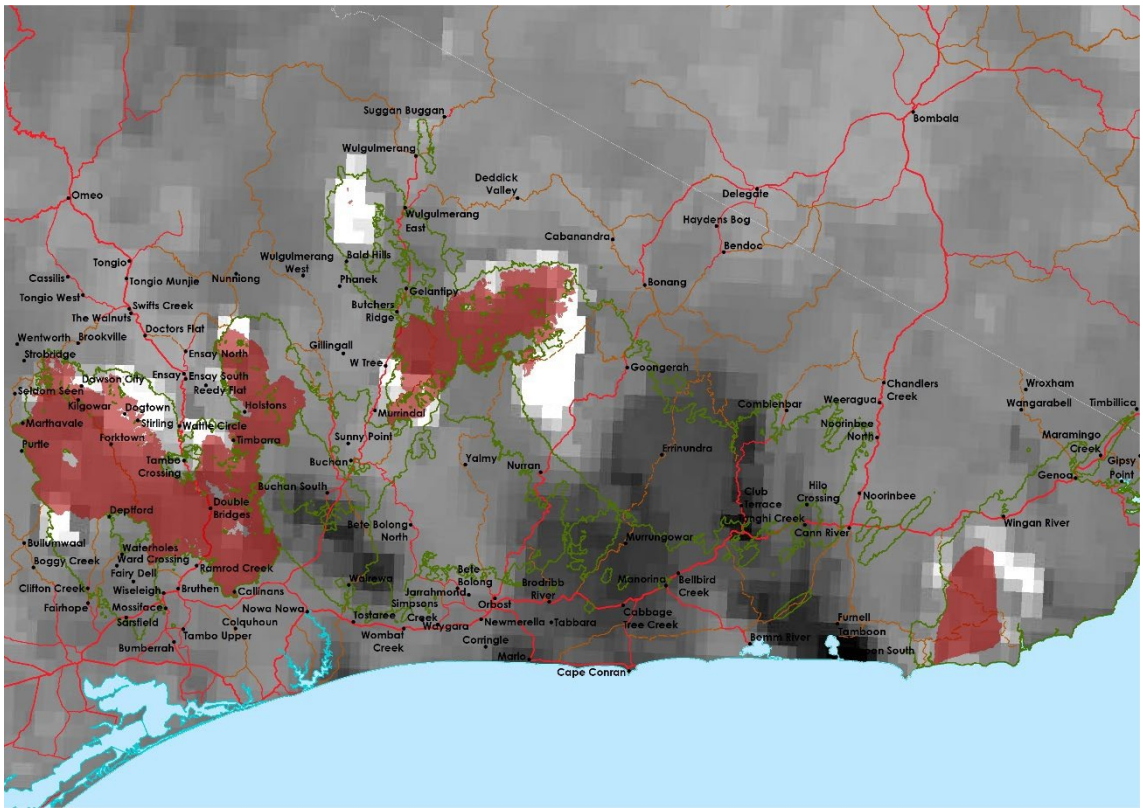

FIGURE 279: 1430HRS 30TH OF DECEMBER 2019

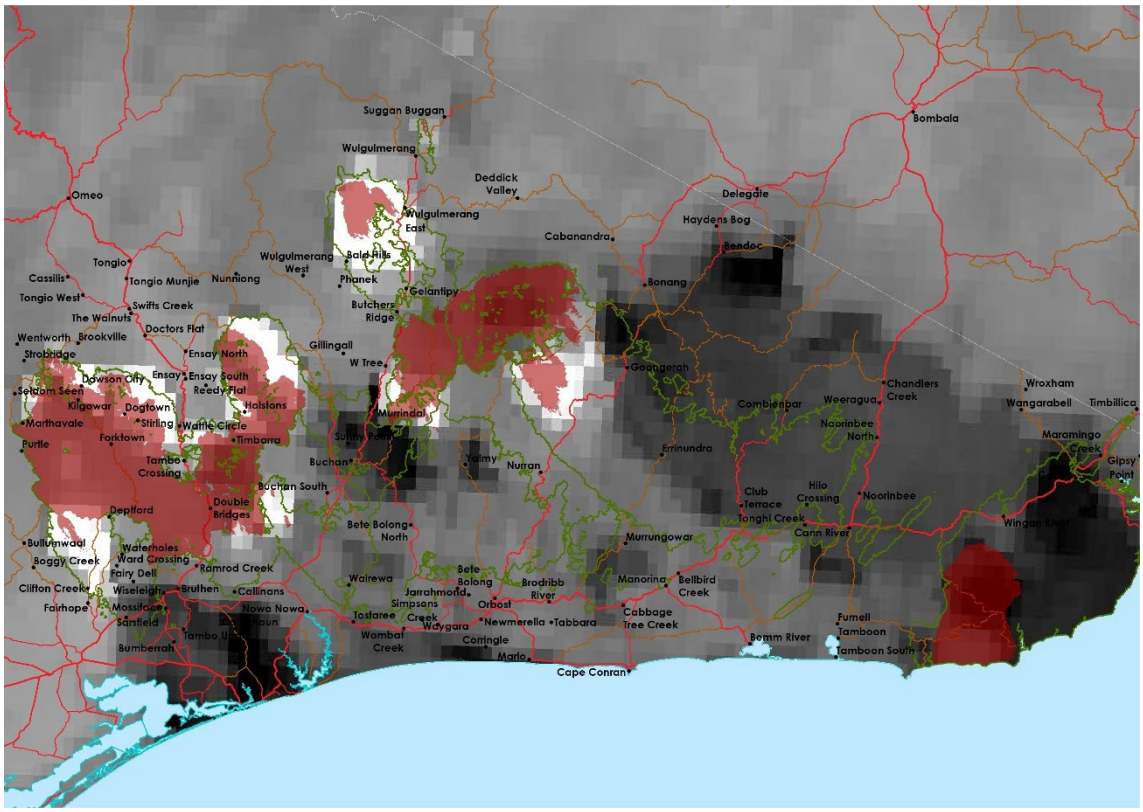

FIGURE 280: 1630HRS 30TH OF DECEMBER 2019

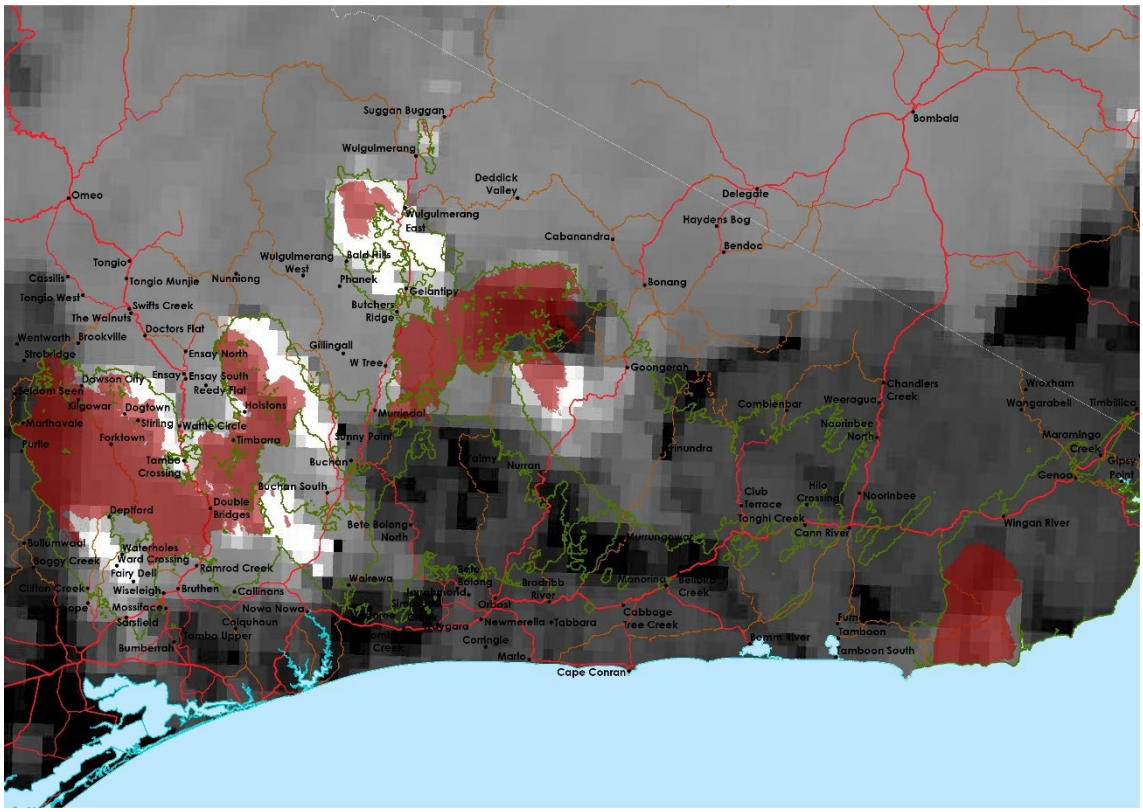

FIGURE 281: 1810HRS 30TH OF DECEMBER 2019

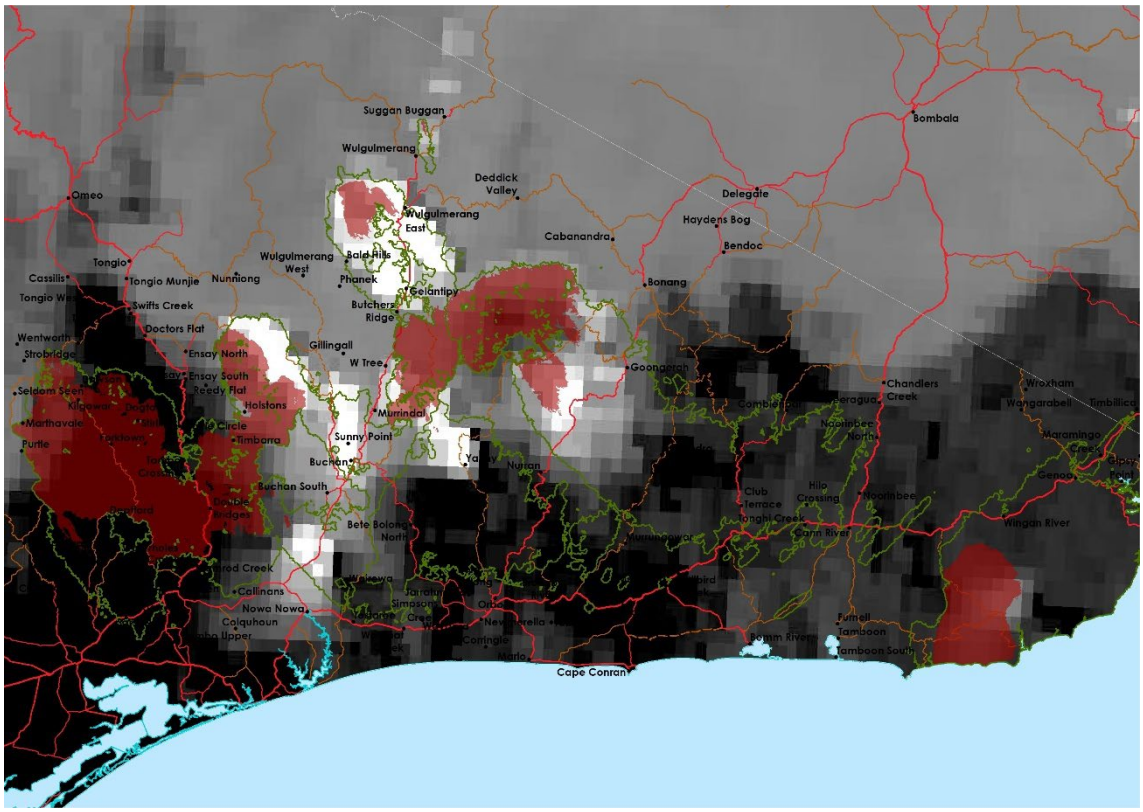

FIGURE 282: 1900HRS 30TH OF DECEMBER 2019

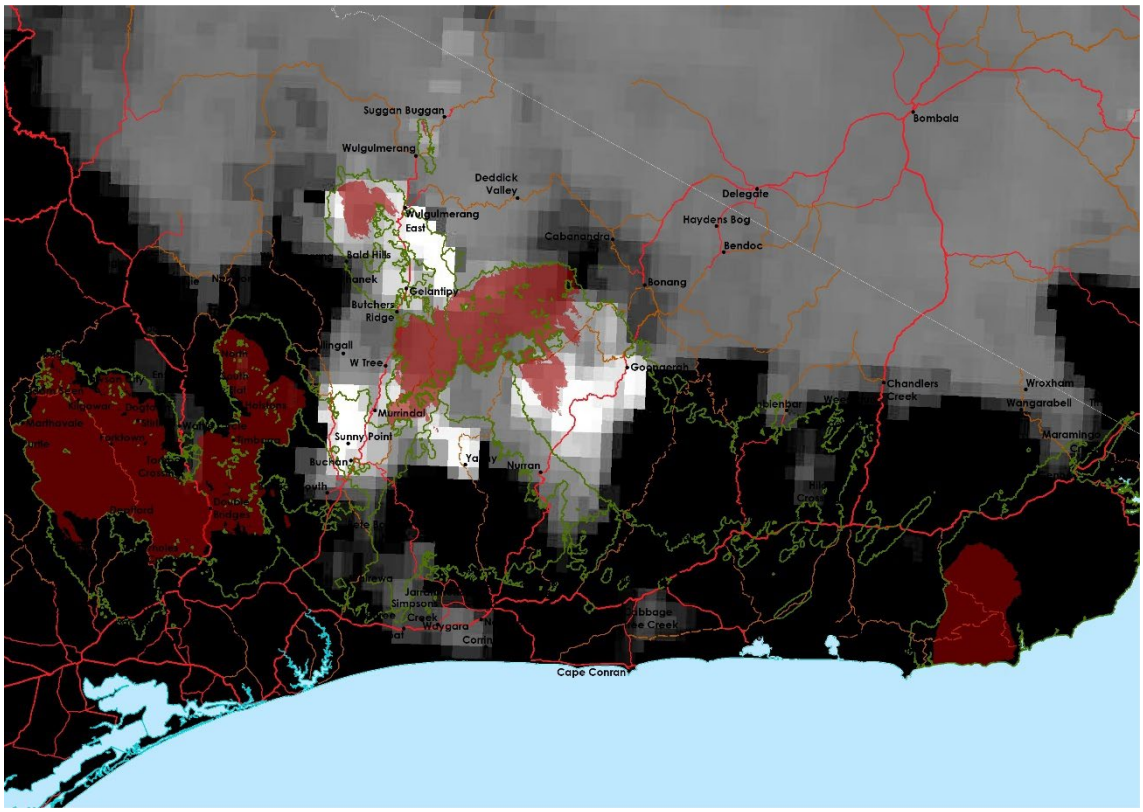

FIGURE 283: 2030HRS 30TH OF DECEMBER 2019

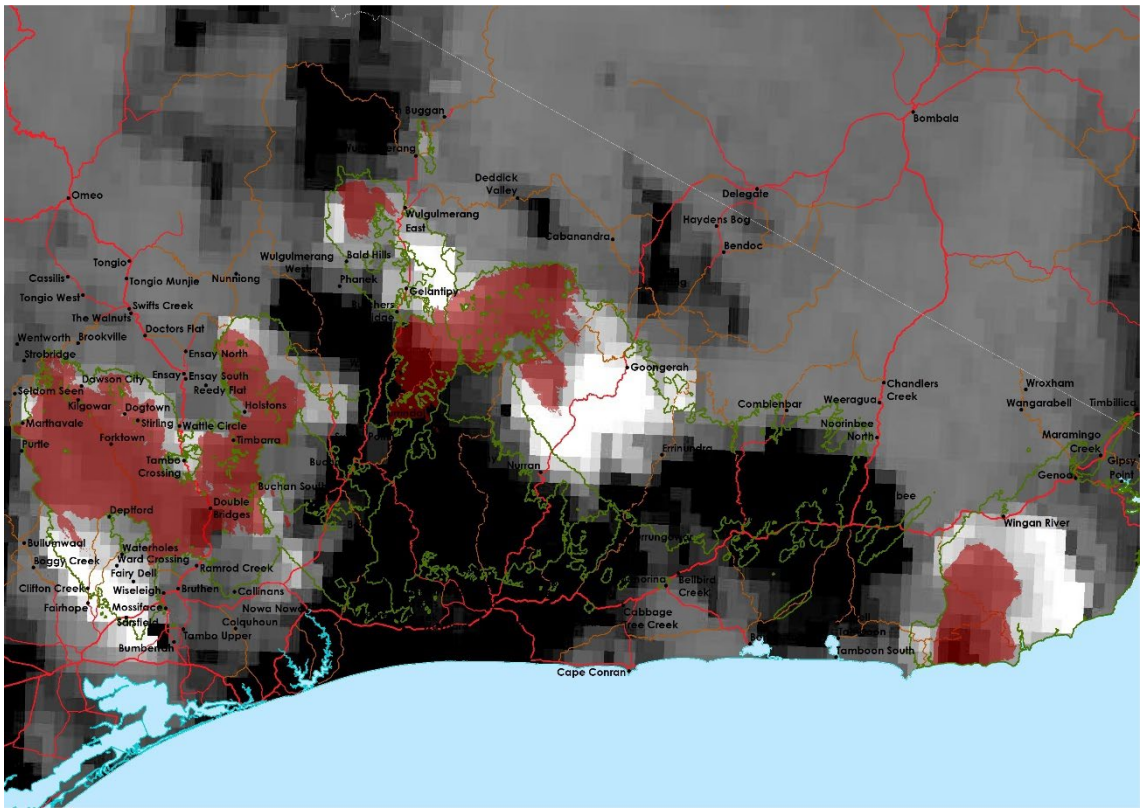

FIGURE 284: 2300HRS 30TH OF DECEMBER 2019

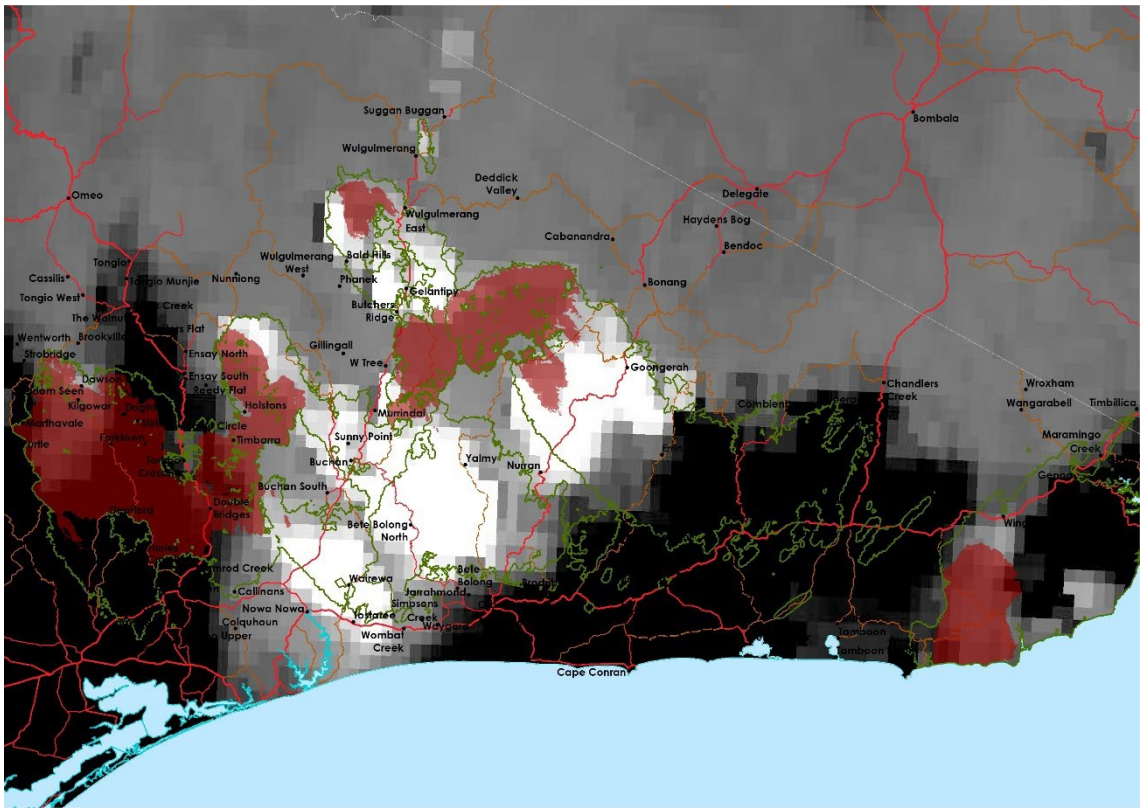

FIGURE 285: 0000HRS 31ST OF DECEMBER 2019

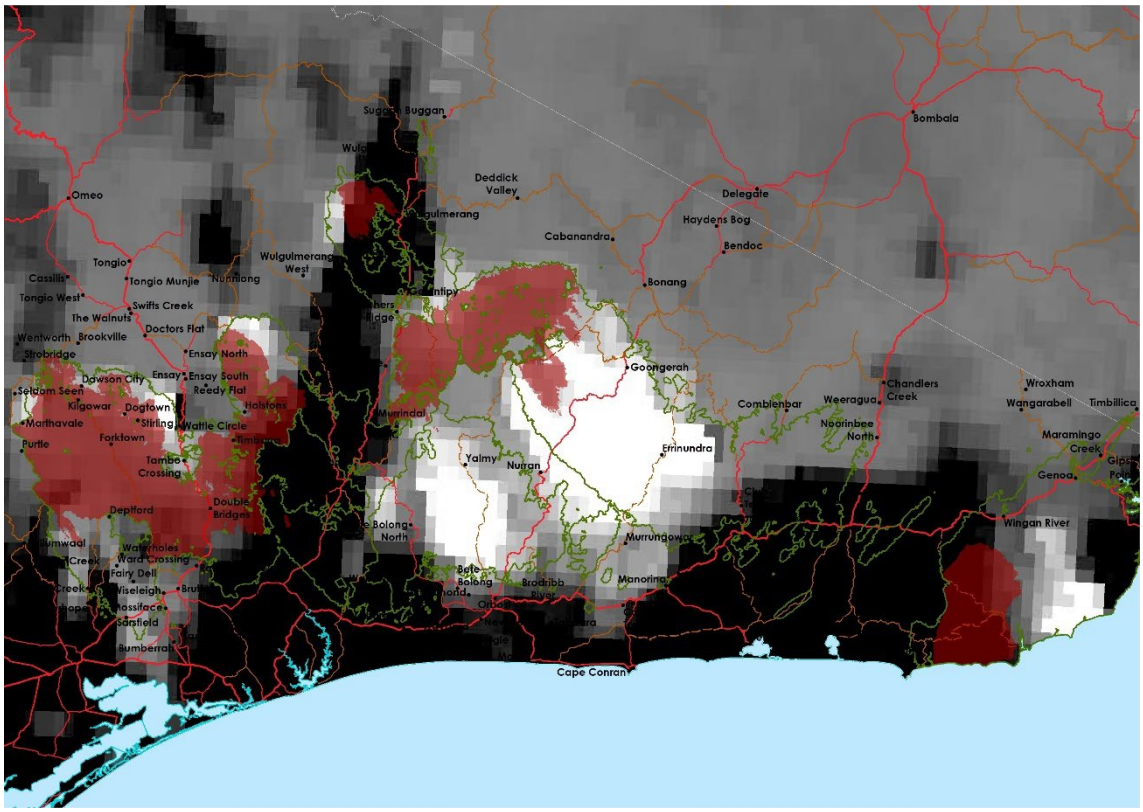

FIGURE 286: 0100HRS 31ST OF DECEMBER 2019

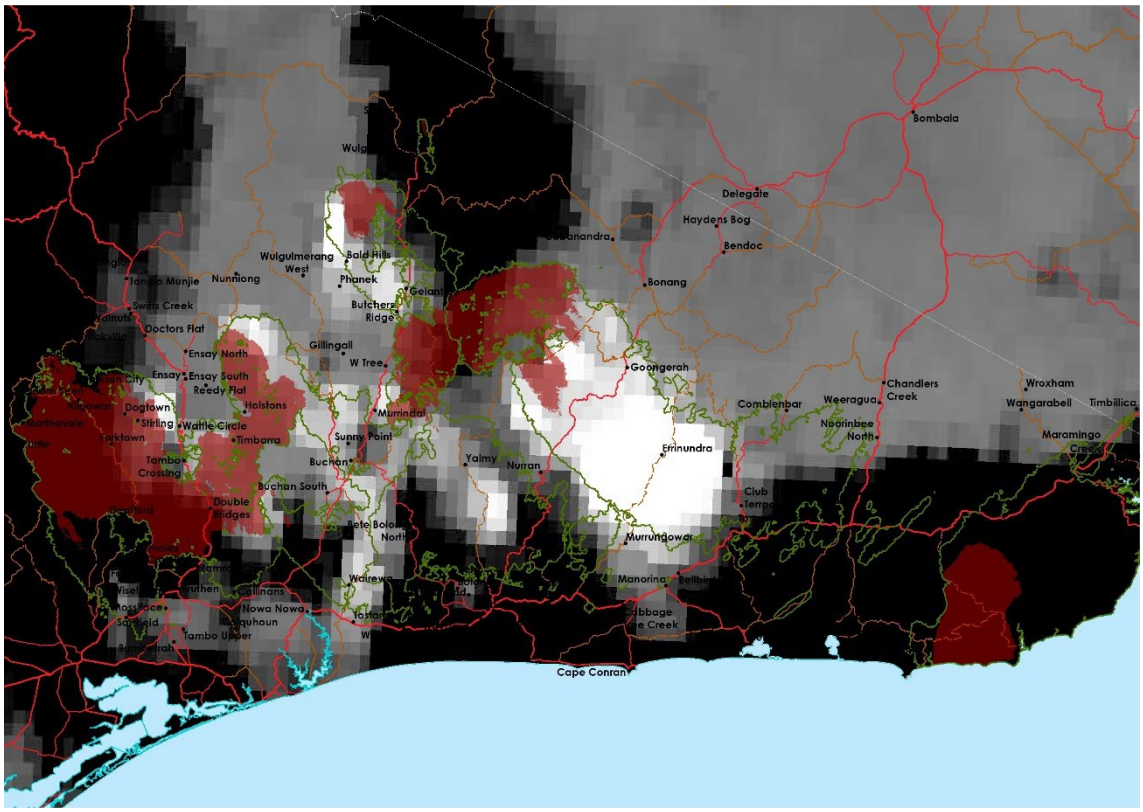

FIGURE 287: 0200HRS 31ST OF DECEMBER 20190200

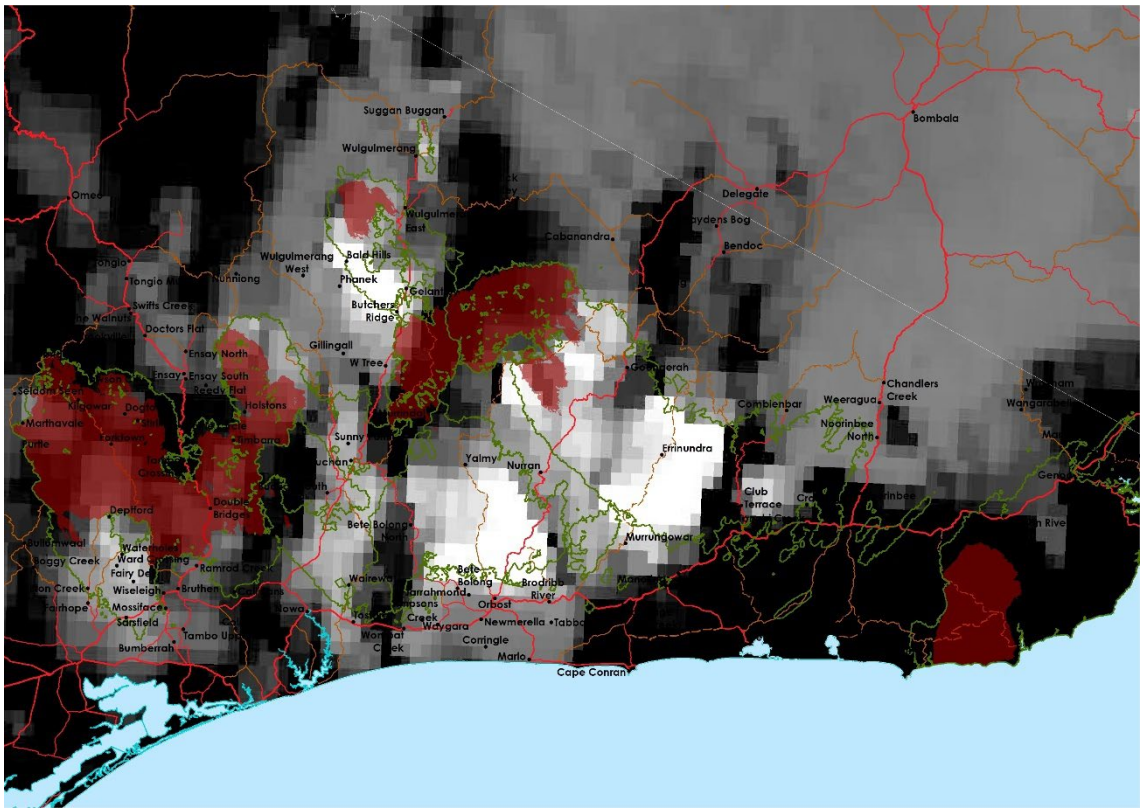

FIGURE 288: 0300HRS 31ST OF DECEMBER 2019

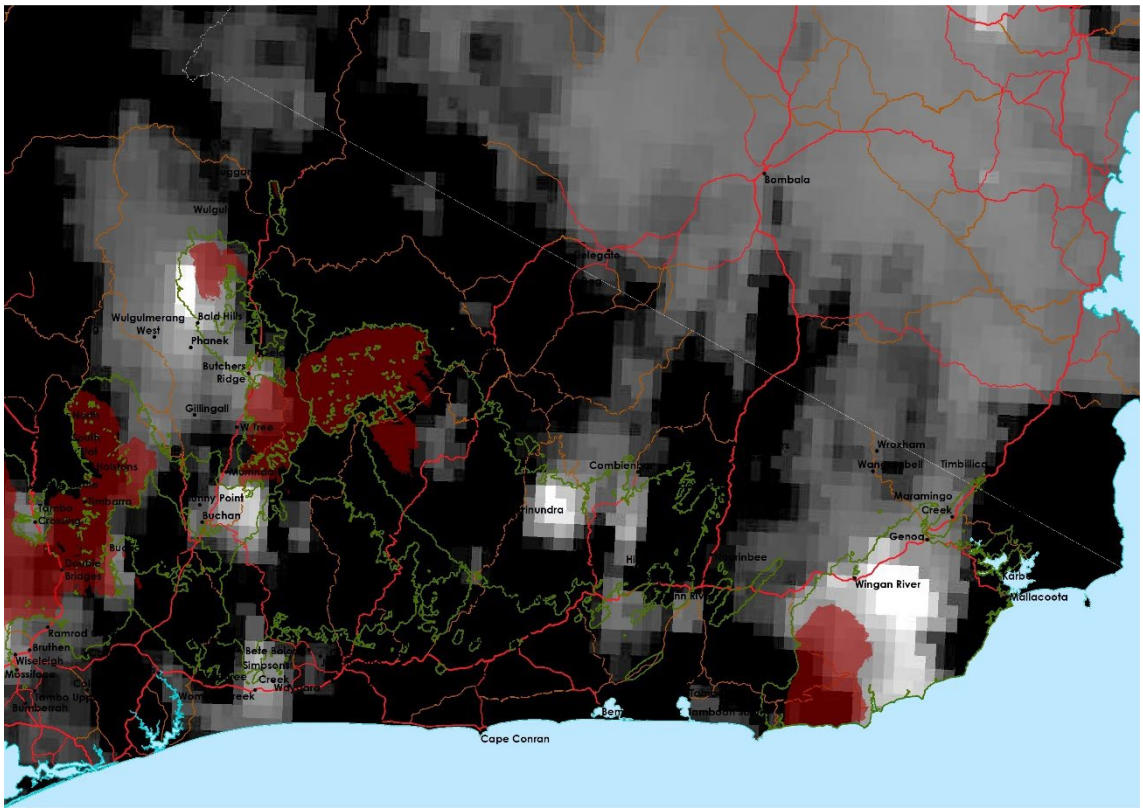

FIGURE 289: 0430HRS 31ST OF DECEMBER 2019

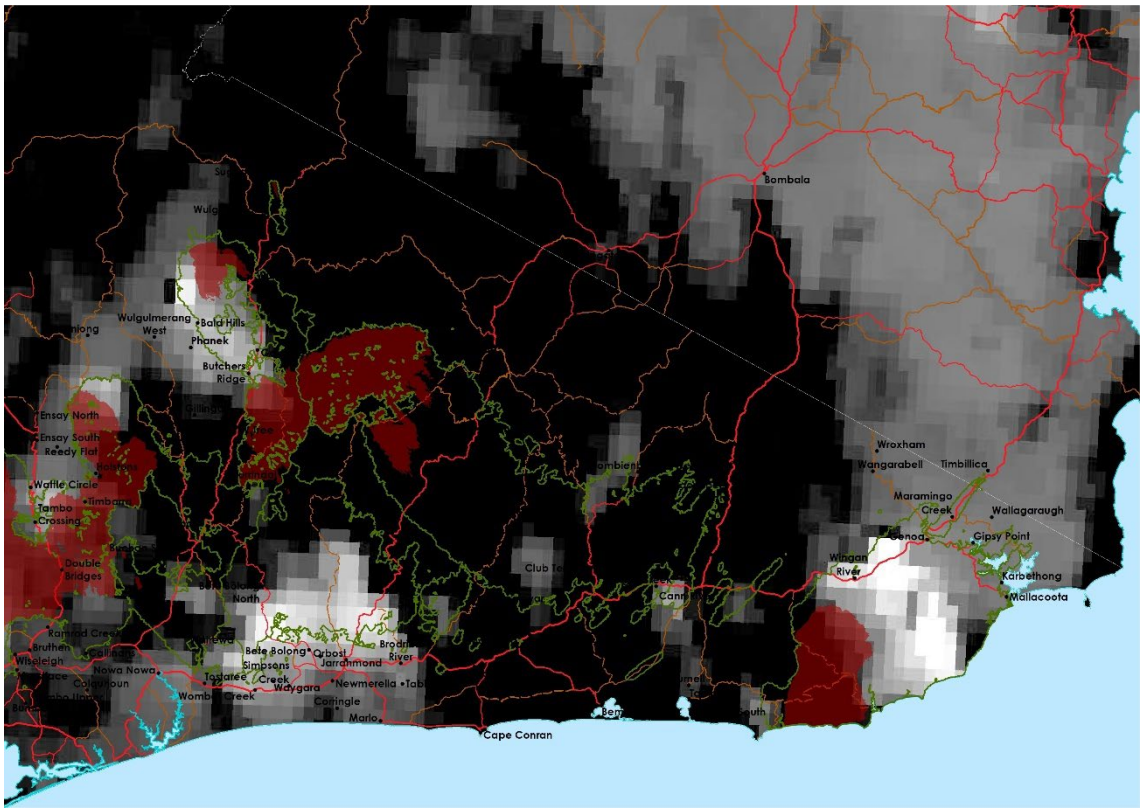

FIGURE 290: 0500HRS 31ST OF DECEMBER 2019

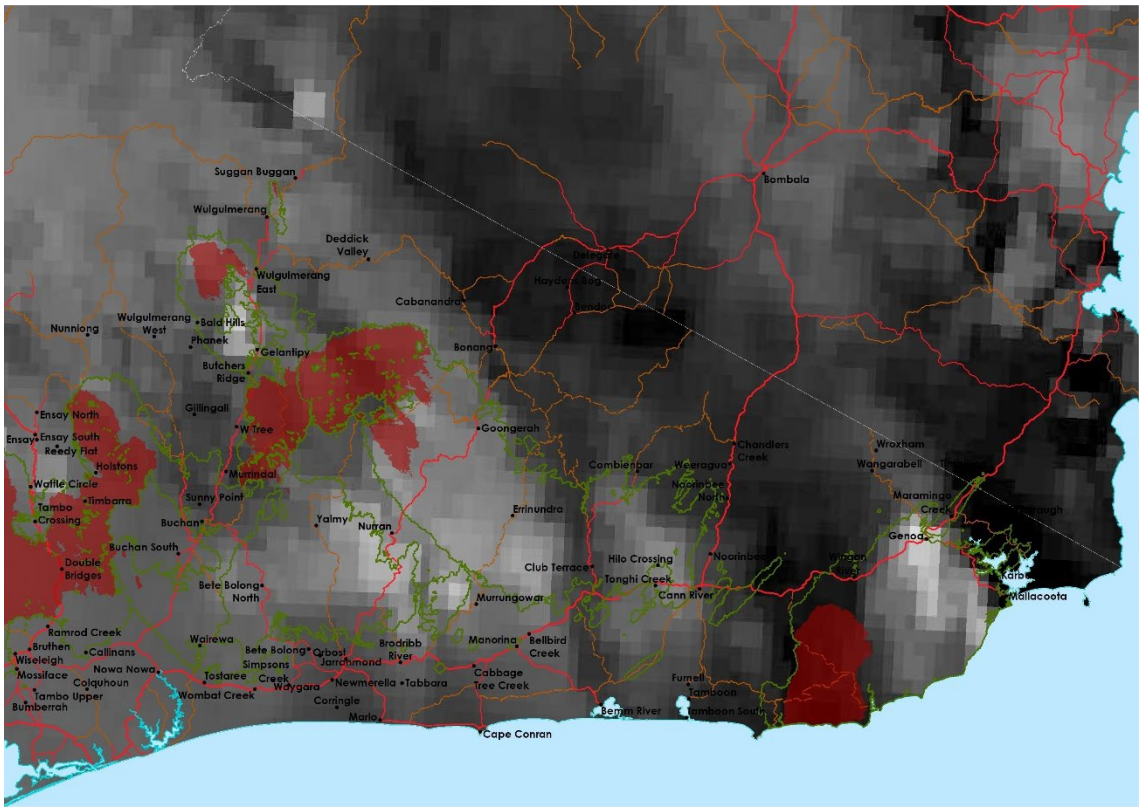

FIGURE 291: 0750HRS 31ST OF DECEMBER 2019

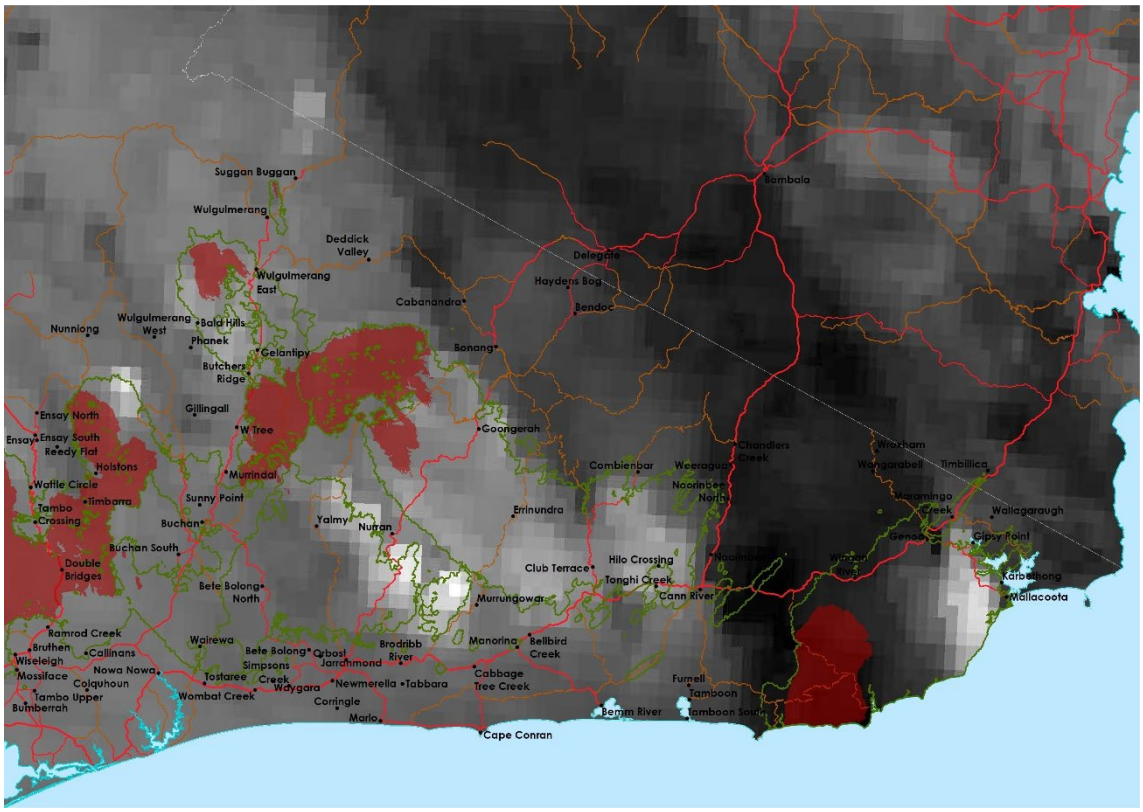

FIGURE 292: 0840 HRS 31ST DECEMBER 2019

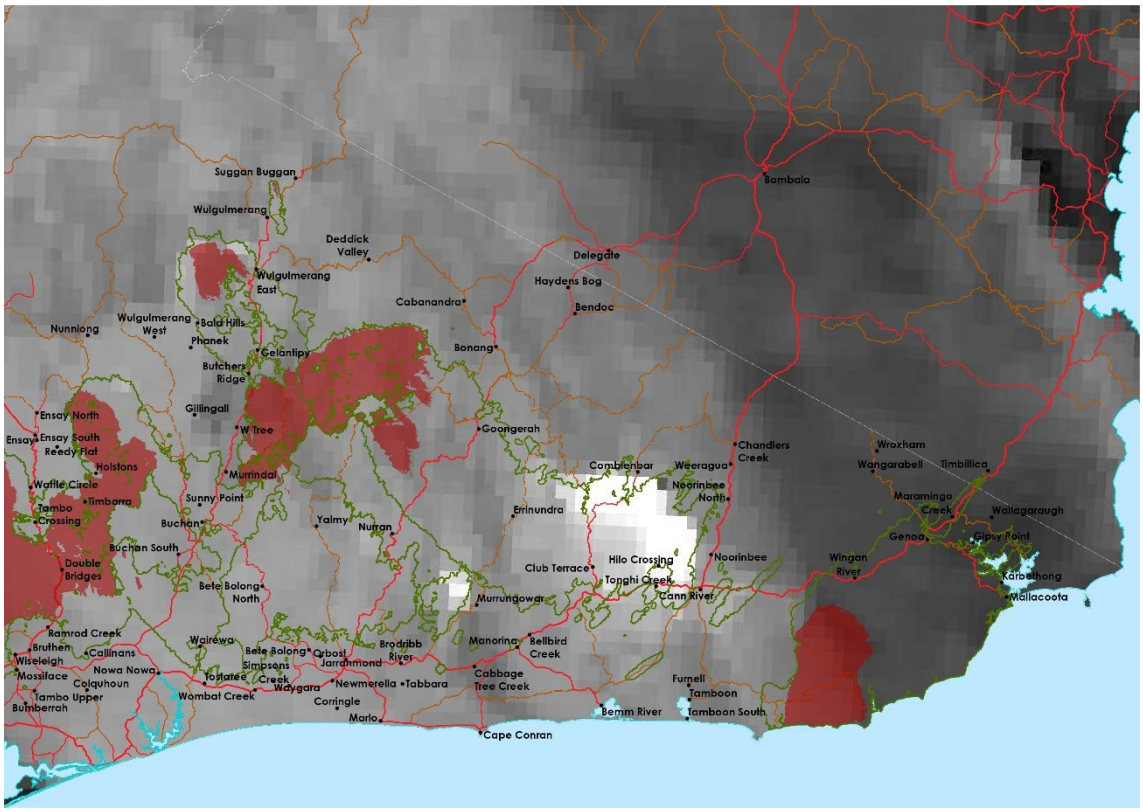

FIGURE 293: 1100HRS 31ST OF DECEMBER 2019

APPENDIX FOUR: SUMMARY OF PLANNED BURN INFLUENCE

FireWeb Fire #	Fire Name	Season	Influence	Hectares
2BBB0032	Waterholes - Dinghy Creek	2016	Negligible	106
2BBB0051	Waterholes - Stockyard Track	2016	Possible	432
2BBB0052	Wiseleigh - Wiseleigh Track	2016	Negligible	70
2BNN0020C	Buchan - Tara Range	2016	Negligible	406
2BNN0028	Nowa Nowa - Mt Nowa Nowa	2016	Possible	422
2BNN0057	Wairewa - Five Mile Road	2016	Negligible	15
2BNN0066	Buchan Caves - Northern Arm	2016	Negligible	46
2BNN0082	Wairewa - Lemon Hill North	2016	Negligible	141
2BNN0083	Buchan South - Holloways Road	2016	Negligible	42
2HDA220	Dargo - Basalt South	2016	Possible	1140
2OCR0011	Mallacoota - Premier Tk	2016	Negligible	118
2OCR0012	Mallacoota - Charlie Creek	2016	Negligible	236
2OCR0016C	LMB - Southern Burn - C	2016	Negligible	1651
2OCR0018C	Noorinbee - C	2016	Negligible	2169
2OCR0018D	Noorinbee D	2016	Negligible	157
2OCR0037A	Bemm River A	2016	Negligible	627
2OCR0142	Cann River - Noorinbee Tower Road	2016	Possible	216
2OOR0097	WFO - Cabbage Tree - Cabbage Tree Conran	2016	Possible	648
2OOR0134	Orbost - Rocky River Road	2016	Negligible	427

FireWeb Fire #	Fire Name	Season	Influence	Hectares
2SSC0044	Bundara - Grays Hill Tk	2016	Negligible	685
2SSC0047	Ensay - Cooks Brk	2016	Negligible	77
2SSC0068	Benambra - Limestone Road	2016	Possible	24
2SSC1408	Cobungra- West Hill Trk	2016	Possible	271
3OBW0044	Abbeyards - Dandongadale	2016	Negligible	1026
3OBW0080	Abbeyards - Razor Tk	2016	Possible	1668
3OOV0012	Lake Buffalo Dandongadale River	2016	Possible	3197
3OOV0082	Buckland - Yarrabuck North	2016	Possible	1221
3OOV0083	Buckland - Yarrabuck South	2016	Possible	3842
3UCOR002	Berringama - Black Mountain	2016	Negligible	176
3UCOR031	Walwa- Snake Gully	2016	Negligible	279
3UCOR041	Nariel Valley - Bonds Road	2016	Negligible	140
3UCOR053	Towong - Corryong Creek Ssr Heaps	2016	Negligible	0
3UCOR061	Scrubby Thowgla Creek Lmb	2016	Negligible	286
3UCOR079	Nariel Valley - Nariel Gap Rd	2016	Negligible	220
3UCOR099	Alberts - BNP	2016	Negligible	543
3UCOR105	Cudgewa Nth - Ex-School Block	2016	Negligible	0
3UTAL039	Koetong -Grants Track	2016	Possible	294
3UTAL071	Guys Forest - Andys Rd	2016	Negligible	40
GP-SNO-MAL-0004	Mallacoota - Double Creek	2016	Negligible	117
GP-TAM-BAI-0048	Waterholes - Archies Road	2016	Possible	545
GP-TAM-NOW-0035	Gelantipy - Glenmore	2016	Possible	995
2BBB0022	Bullumwaal - German Gully Road	2017	Possible	526
2BBB0045	Bruthen - Pound Yard	2017	Possible	209
2BBB0048	Fairy Dell - Wards Road	2017	Negligible	139
2BBB0111	Clifton Creek - Waterholes & Fishers	2017	Negligible	8
2BNN0030	Wulgulmerang - Splitters Creek	2017	Definite	2075
2BNN0071	Buchan - Mt Mcleod	2017	Negligible	119
2BNN0132	Nowa Nowa Running Ck Tulloch Ard	2017	Negligible	30
2OCR0016C	Southern Burn - C	2017	Negligible	321
2OCR0016F	Southern Burn - F	2017	Negligible	799
2OCR0018A	Noorinbee - A	2017	Negligible	492
2OCR0018D	Noorinbee - D	2017	Negligible	4013
2OCR0123	Wangarabell-Mealing Hill	2017	Possible	911
2OCR0173	Combienbar-Hensleigh Creek Road	2017	Negligible	401
2OOR0134	Orbost - Rocky River Road	2017	Negligible	730
2OOR0135	Orbost South Boundary Road	2017	Definite	659
2OOR0158	Orbost - Beach Road	2017	Possible	2387
2SSC1202	Anglers Rest - Emu Creek Track	2017	Possible	23
3UCOR082	Berringama - Leddin Trk	2017	Negligible	72
3UCOR100	Cudgewa North - Upper Dogman Track	2017	Negligible	80

FireWeb Fire #	Fire Name	Season	Influence	Hectares
3UTAL068	Guys Forest - Shelley Rd	2017	Negligible	4
3UTAL087	Guys Forest - Private Pines	2017	Negligible	23
GP-SNO-ORB-0019	Orbost - Mount Raymond	2017	Negligible	481
GP-TAM-BAI-0052	Tabberabbera - Morris Peak West	2017	Possible	442
GP-TAM-NOW-0036	Gelantipy - Butchers Creek	2017	Possible	525
GP-TBO-SCK-0002	Tambo Crossing - Dahlstrom Break	2017	Negligible	59
UPMCOR01	Berringama - Black Mountain North	2017	Negligible	84
UPMCOR04	Towong - Towong Hill Rd	2017	Possible	1
2OOR0002	Orbost - Boulder Creek	2018	Possible	762
2OOR0008	Bemm River - Swampy Ridges	2018	Possible	905
2OOR0025	Cape Conran - Residence	2018	Negligible	11
3UCOR060	Pine Mtn - Sandy Creek Rd	2018	Negligible	274
3UCOR082	Berringama - Leddin Trk	2018	Definite	88
3UCOR090	Berringama - Wild Goat Trk	2018	Negligible	133
3UCOR094	Cudgewa - Mcnamaras Trk	2018	Negligible	20
3UCOR104	Guys Forest - Ben Lomond	2018	Negligible	104
3UTAL085	Guys Forest - Edmondson Rd	2018	Negligible	51
GP-SNO-ORB-0012	Orbost Coulsons Road	2018	Definite	1019
GP-SNO-ORB-0017	Orbost South Boundary Road	2018	Definite	191
GP-TAM-BAI-0026	Bruthen - Rowley Creek	2018	Possible	245
GP-TAM-NOW-0034	Gelantipy - Robinson Road	2018	Negligible	257
GP-TAM-NOW-0037	Buchan South - Rankins Road North	2018	Definite	279
GP-TAM-SCK-0017	Brookville - Christmas Ridge	2018	Definite	181
GP-TAM-SCK-0024	Bindi - Escarpment Track	2018	Possible	131
2OCR0033	Cann River - Axemans	2019	Definite	1054
2OOR0204	Cape Conran - Old Coast Road	2019	Possible	1017
3UCOR038	Nariel Valley - Rawes Creek	2019	Negligible	765
3UCOR043	Bunroy- Mt Unicorn	2019	Possible	755
3UCOR075	Dartmouth - Raymond Crk	2019	Possible	739
3UCOR097	Lucyvale - Beetoomba Spur Trk	2019	Possible	170
GP-SNO-CAN-0012	Southern Burn - F	2019	Possible	1413
GP-SNO-CAN-0015	Club Terrace - Blackwatch	2019	Negligible	123
GP-SNO-CAN-0016	Genoa - Bens Track	2019	Possible	1429
GP-SNO-ORB-0018	Orbost - Partellis Crossing Road	2019	Definite	1779
GP-TAM-BAI-0040	Bruthen - Boys Camp Road	2019	Possible	126
GP-TAM-BAI-0052	Tabberabbera - Morris Peak West	2019	Negligible	28
GP-TAM-NOW-0003	Wairewa - North East Interface	2019	Negligible	73
GP-TAM-NOW-0029	Nowa Nowa - Radar Hill	2019	Definite	1733
GP-TAM-NOW-0030	Nowa Nowa - Old Buchan Road	2019	Definite	397
GP-TAM-NOW-0036	Gelantipy - Butchers Creek	2019	Negligible	179
GP-TAM-SCK-0003	Omeo - Kosciusko Lookout	2019	Possible	41

FireWeb Fire #	Fire Name	Season	Influence	Hectares
GP-TAM-SCK-0018	Glen Valley - Trapyard Gap Track	2019	Possible	344
HR-OVE-BRT-0006	Buckland Valley - Devils Creek	2019	Definite	581
HR-OVE-MYT-0013	Carboor East - Emu Quarry Road	2019	Definite	212
UPMCOR03	Nariel Valley - Dart River	2019	Negligible	1097