Fire Case Studies

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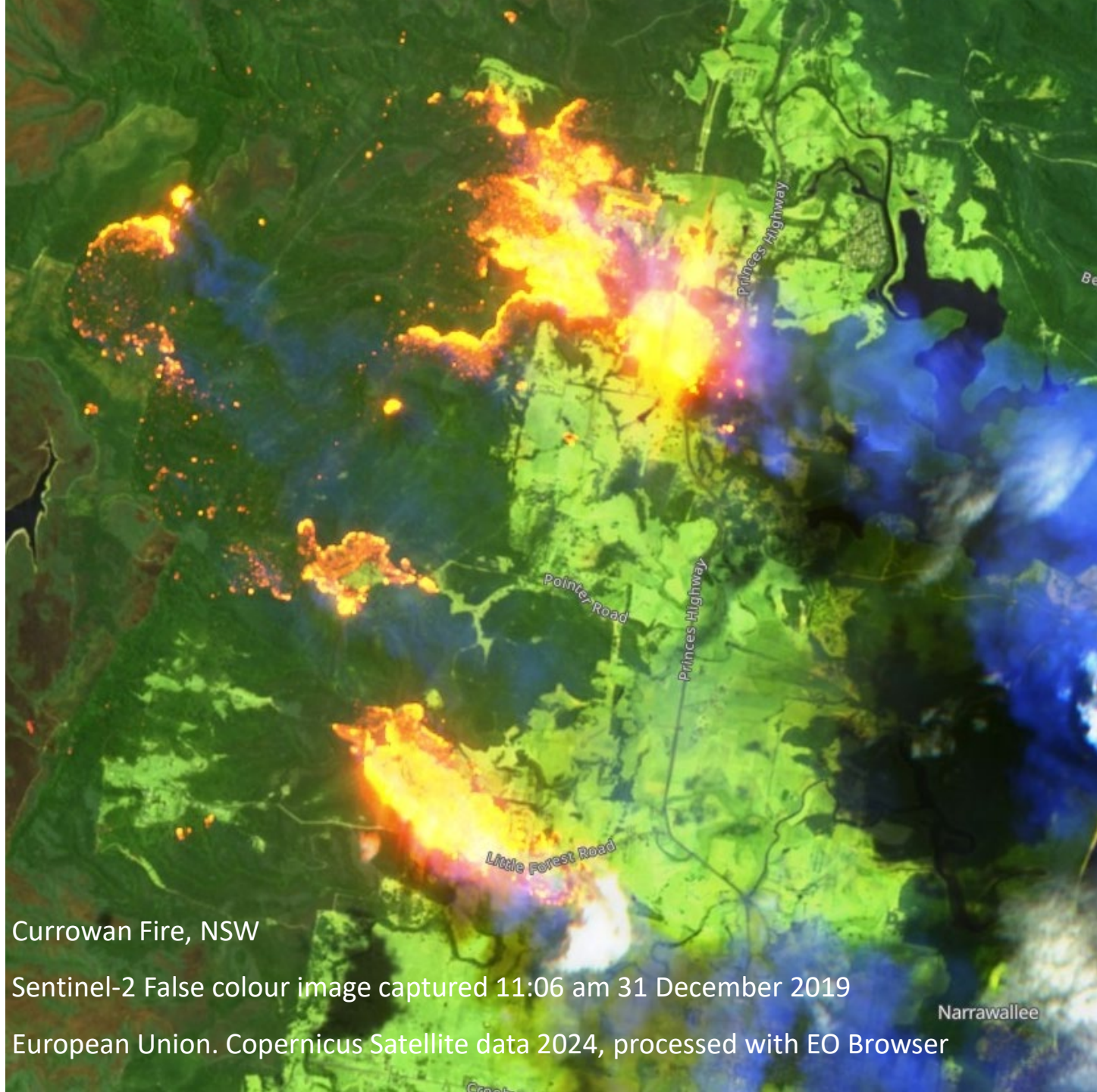
Thanks to:
NHRA (Natural Hazards Research Australia)
DFES (Dept. of Fire and Emergency Services, WA)
RFS (Rural Fire Service, NSW)
CFA (Country Fire Authority, Victoria)
Satellite and Radar research teams (Bureau of Met)



Currowan Fire, NSW

Sentinel-2 False colour image captured 11:06 am 31 December 2019

European Union. Copernicus Satellite data 2024, processed with EO Browser

ACCESS-Fire

Australia's operational and research ACCESS model coupled to a set of fire spread models

Fire spread models the same operational (AFDRS) for a range of vegetation types

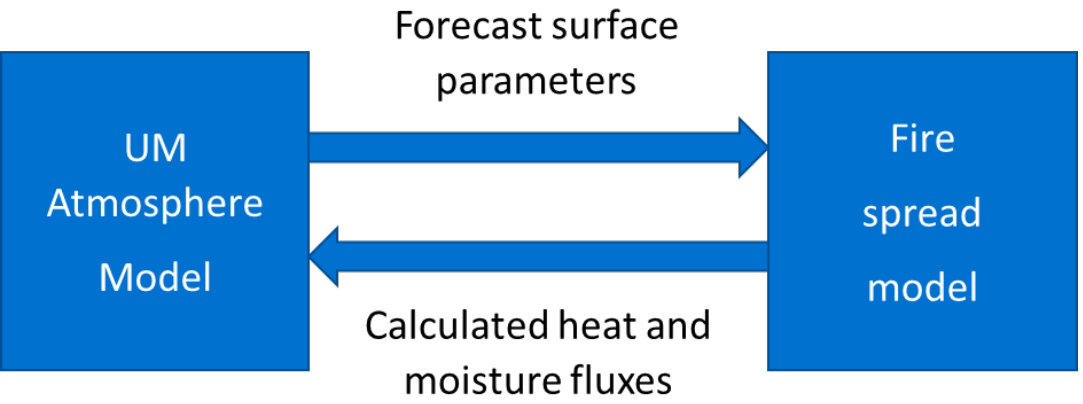
100 m or 300 m horizontal resolution

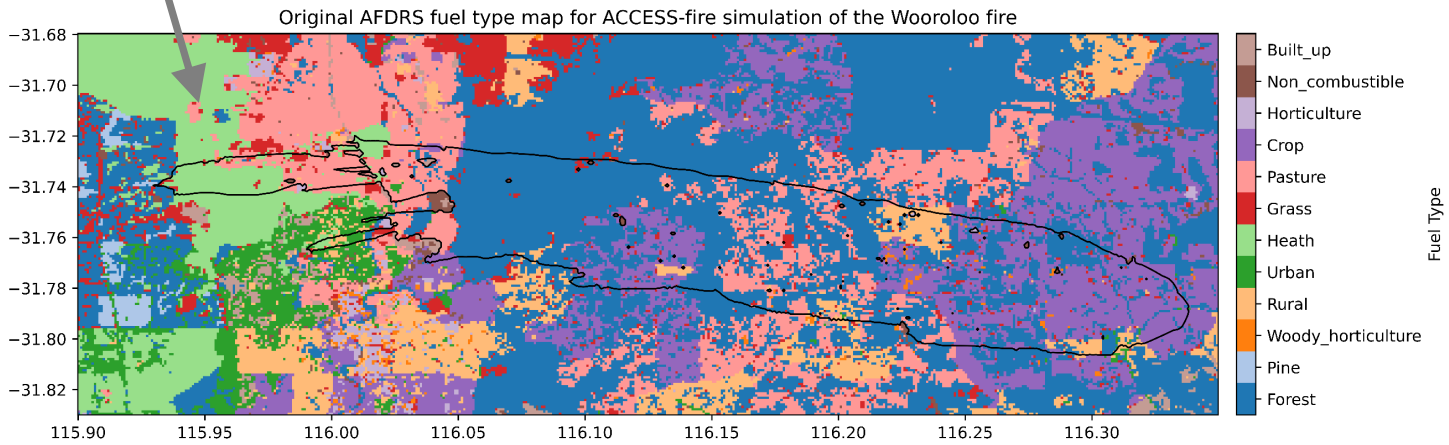
140 vertical levels

10-minute or 1-minute output

Currently research only

ACCESS model framework used for Australia's operational weather prediction and for climate simulations = familiar.





Wooroloo fire

50 km northeast of Perth.

Rural-urban interface with a mosaic of fuels

1-6 February 2021

10,900 ha burned, 86 properties lost

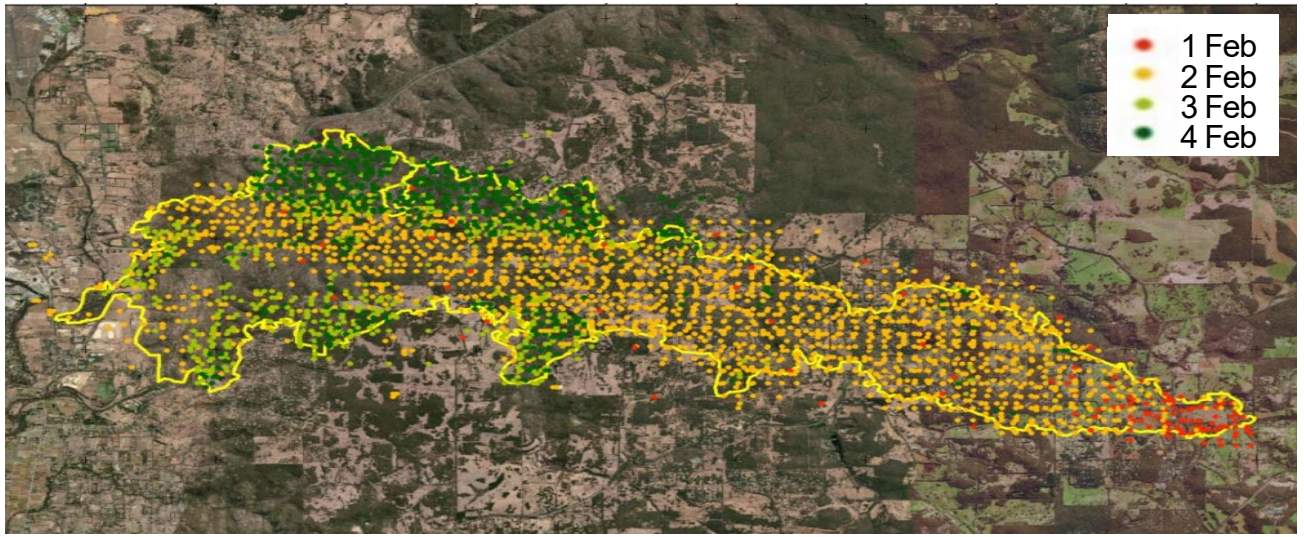
Extended period of persistent easterly winds

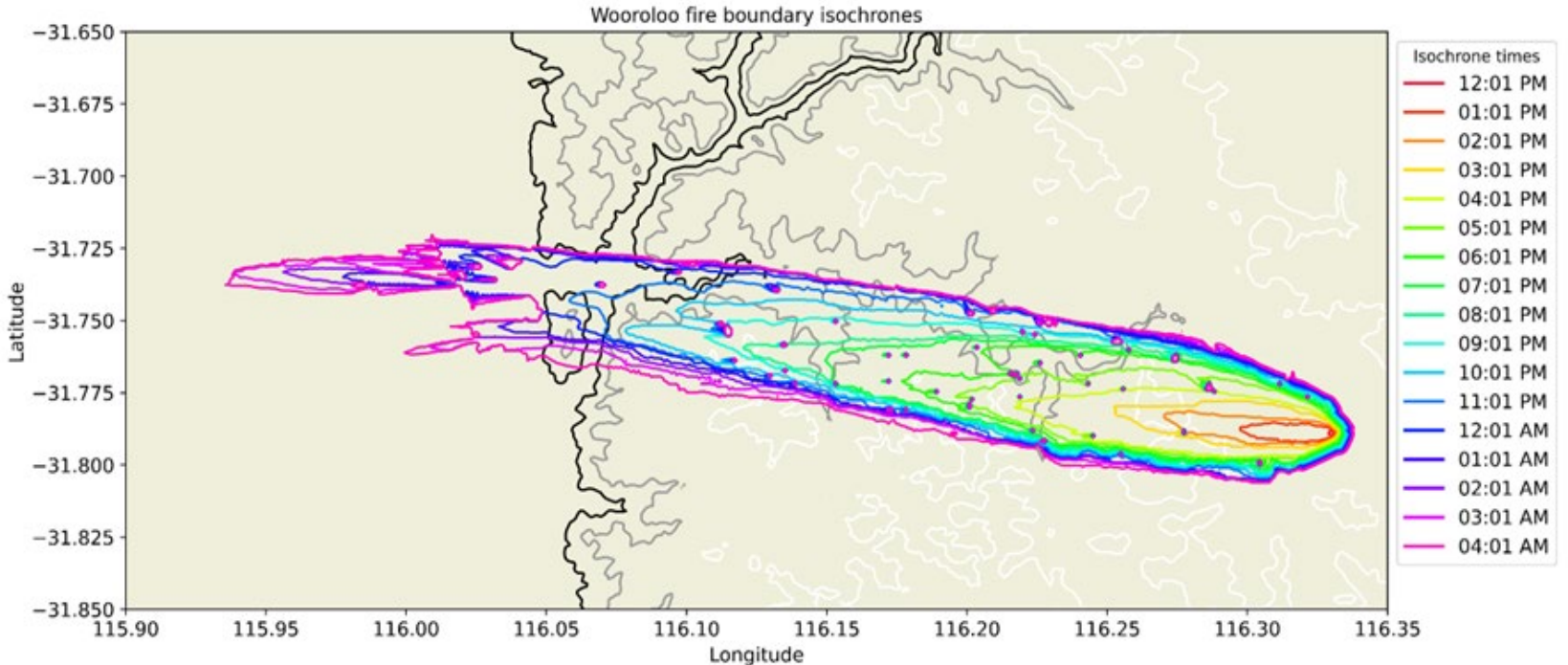
Focus on first 24 hours when the fire tripled in size overnight

Red and yellow dots on satellite image show the first two days of the fire

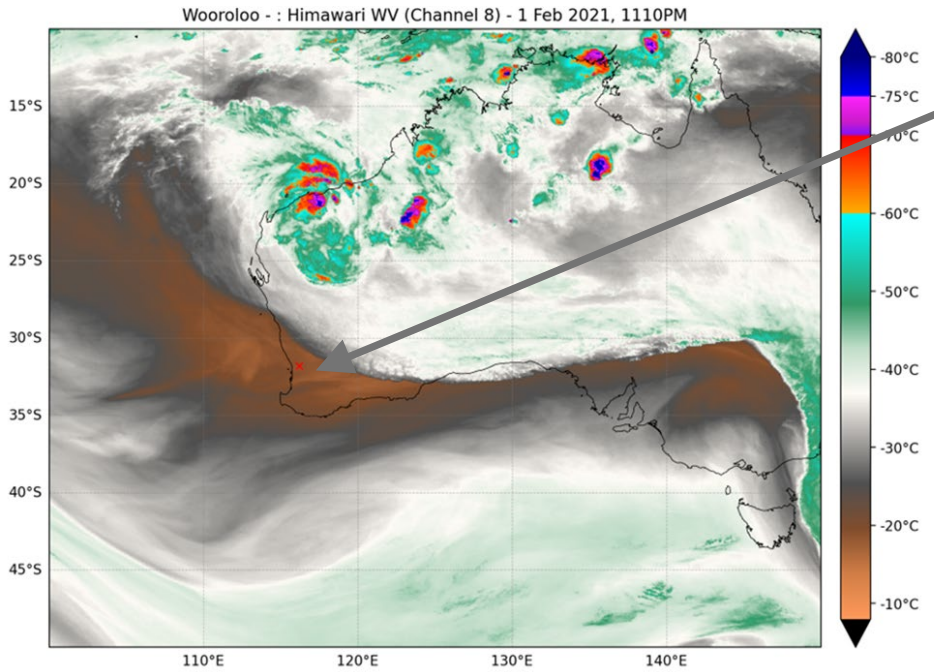
Coloured isochrones show hourly firespread and grey and black show topography

Satellite hot spots and fire perimeter



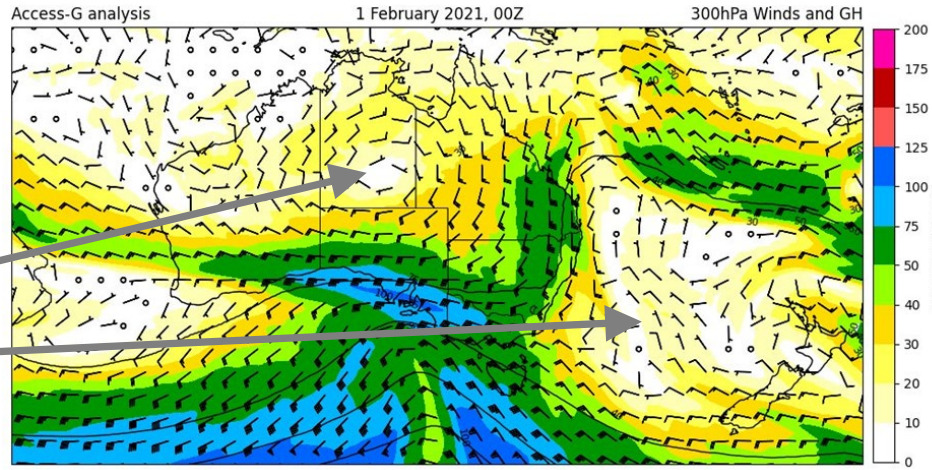


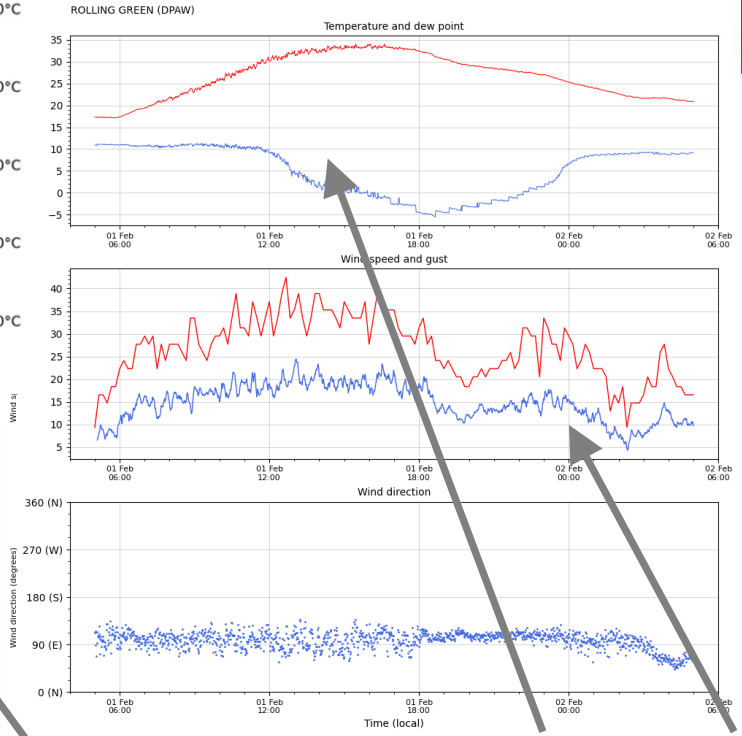
Wooroloo fire meteorology



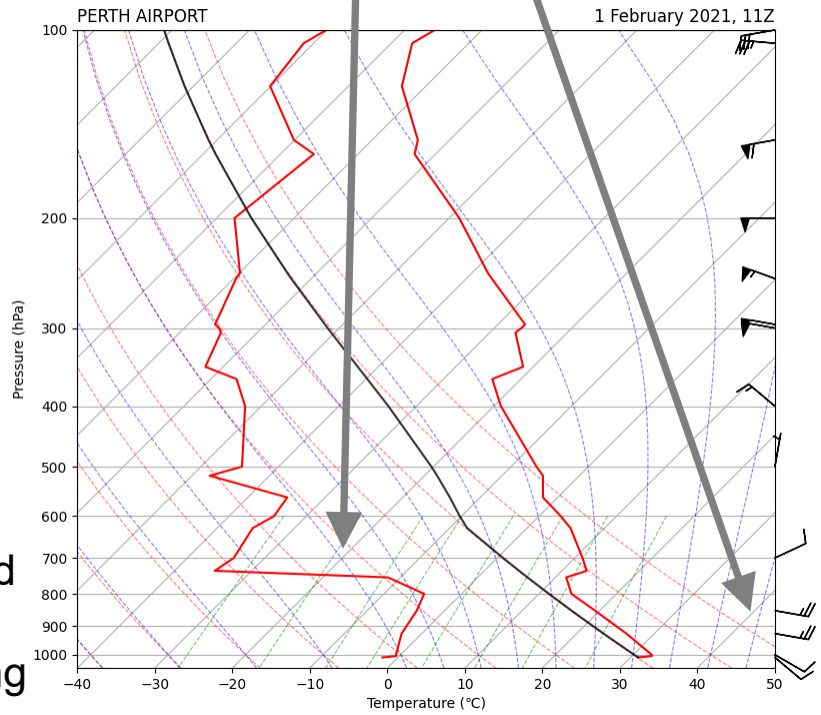
Very dry slot over Wooroloo in Himawari WV

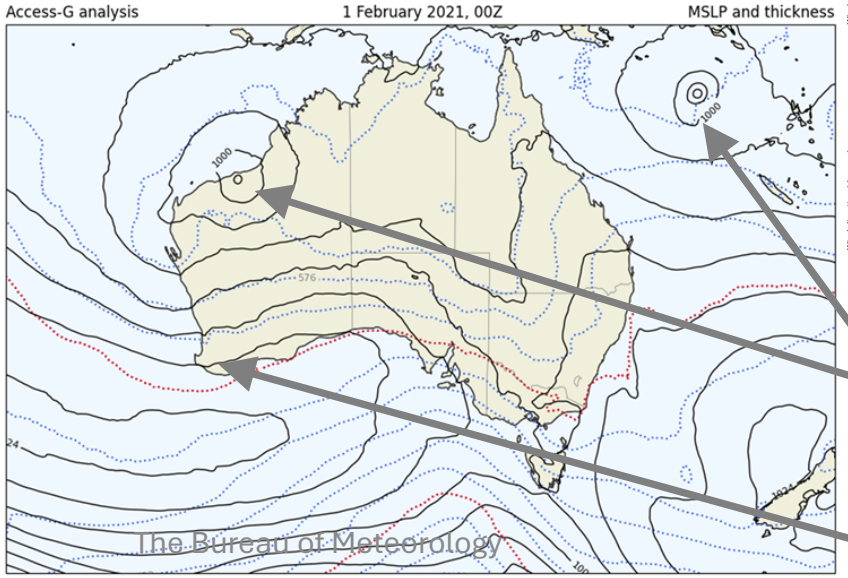
Upper ridge over central Australia and split flow over Tasman





Extremely dry air and low-level wind maximum

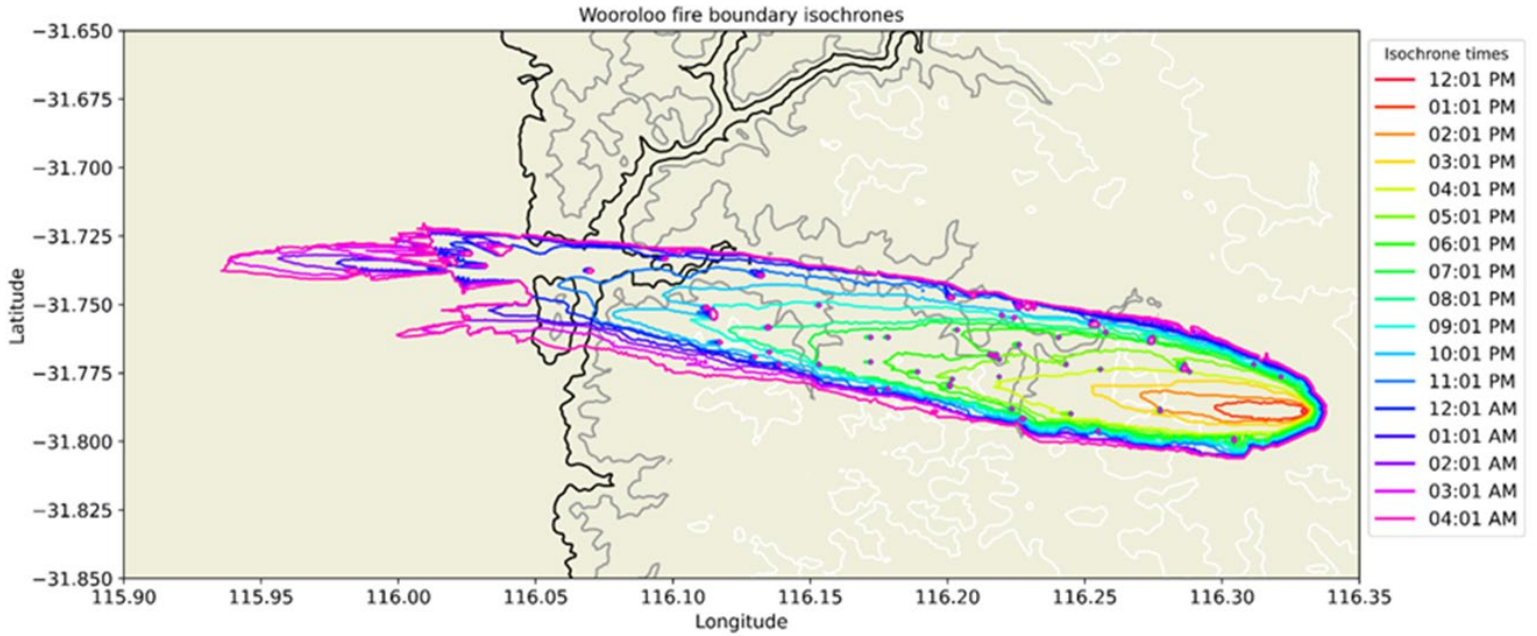




TC to the north. Pilbara low and Southern Ocean ridge producing a tight coastal trough pressure gradient.

Hot, dry air and gusty offshore winds persisting overnight.

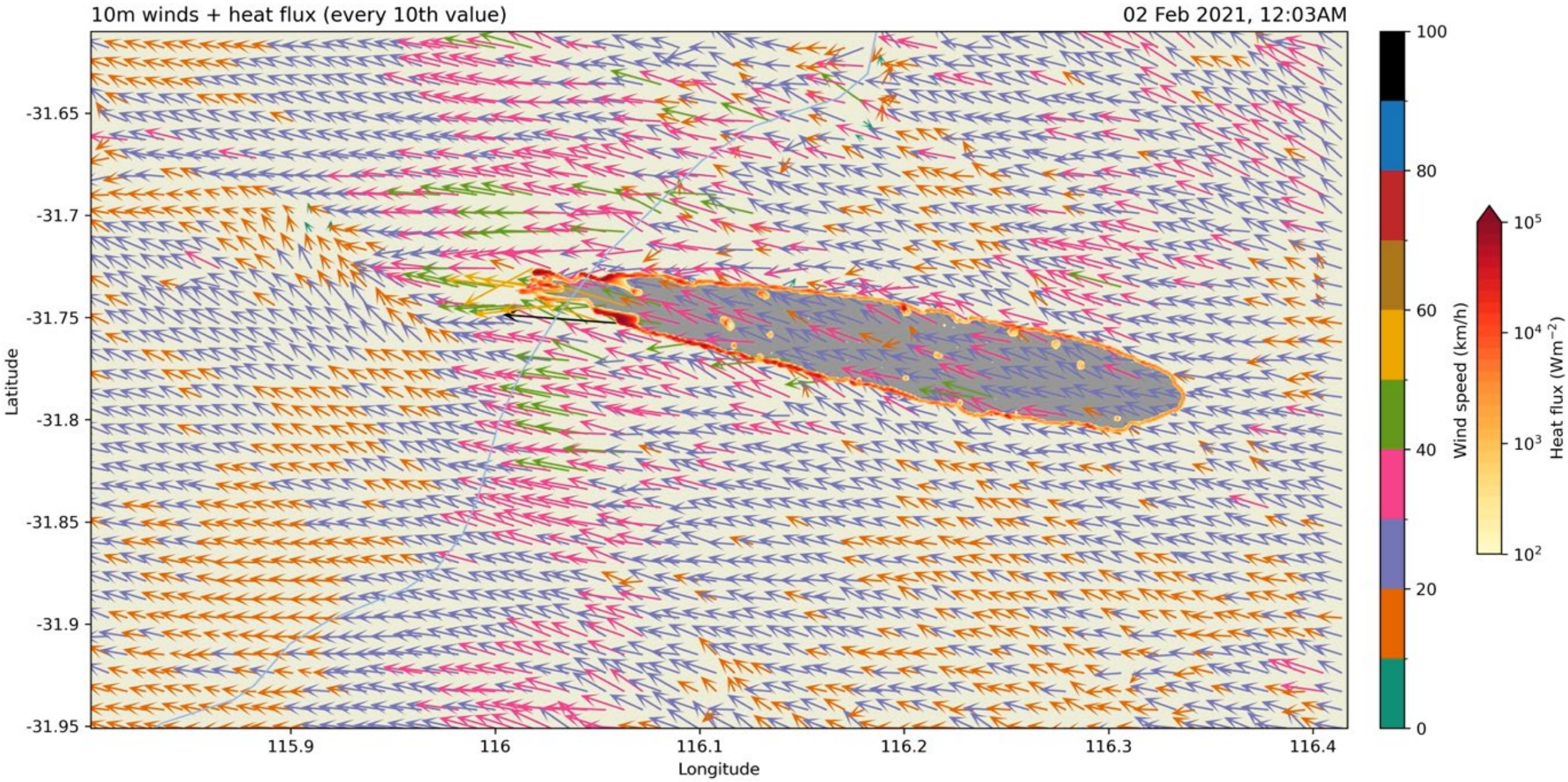
Wooroloo ACCESS-Fire simulations



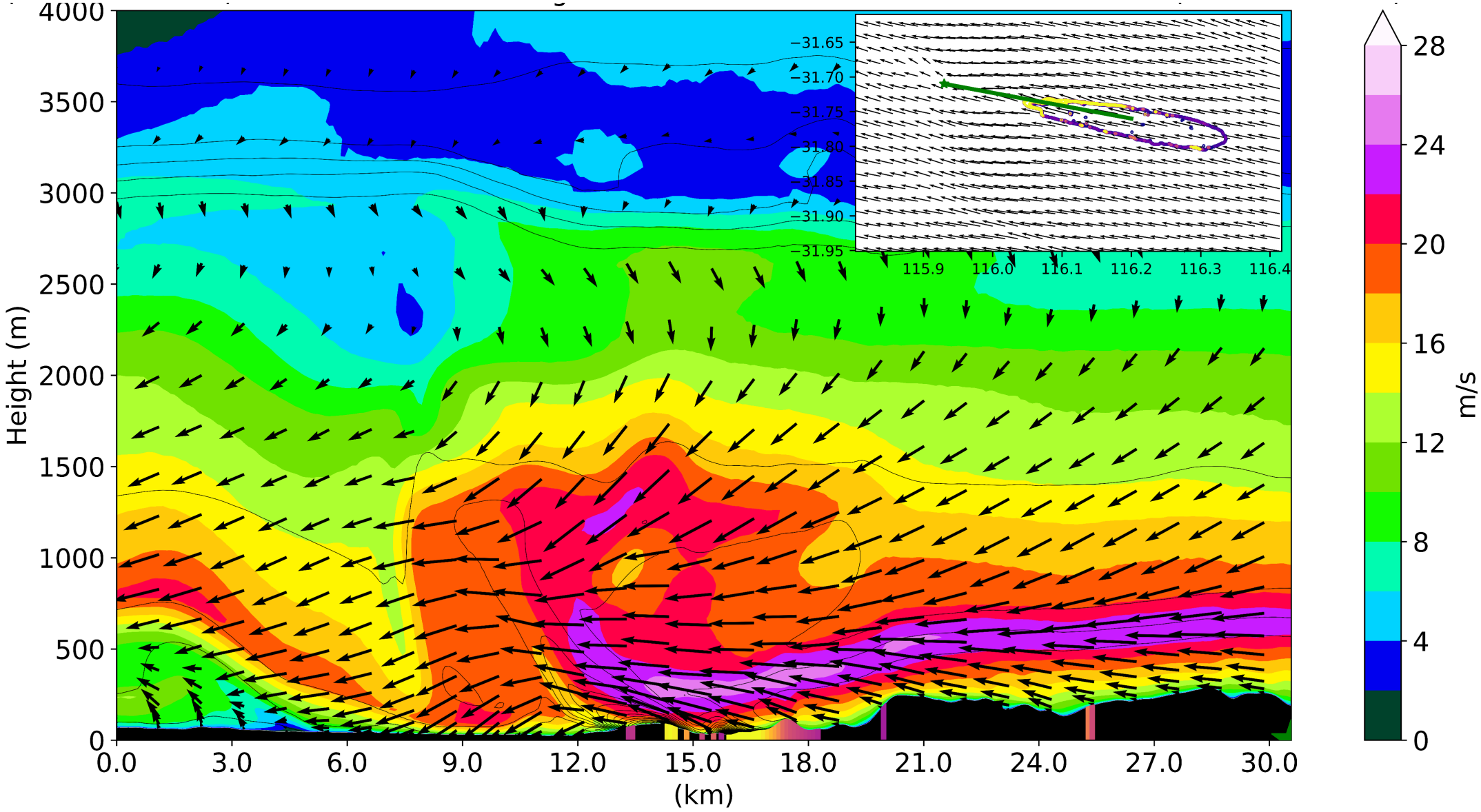
Topography contours
White= 100 m
Grey = 150 m
Black = 200m

Isochrones of hourly fire spread show :

- Elongated fire perimeter in response to persistent easterly winds
- Fast fire spread occurs overnight (blue and pink contours) when the expectation is that fires will 'lie down'
- Fingering of fire spread in response to more urban fuels on coastal plain


10m winds + heat flux (every 10th value)
02 Feb 2021, 12:03AM
-31.65
-31.7
-31.75
-31.8
-31.85
-31.9
-31.95
Latitude
115.9
116
116.1
116.2
116.3
116.4
Longitude
100
80
60
40
20
0
Wind speed (km/h)
10^5
10^4
10^3
10^2
Heat flux (Wm^{-2})

Overnight low-level jet (11:20 pm)

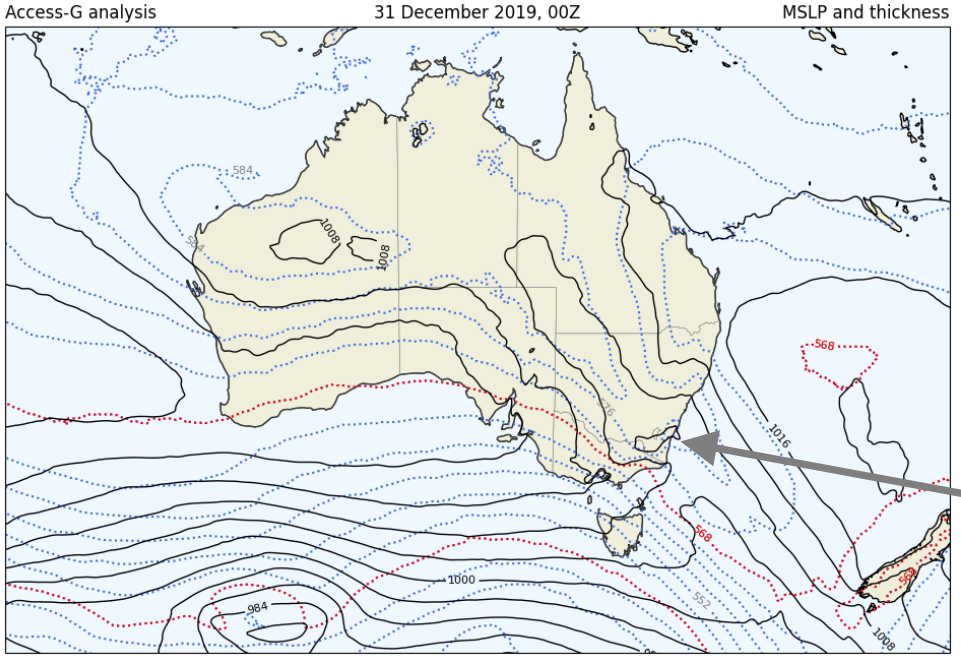


Currowan fire

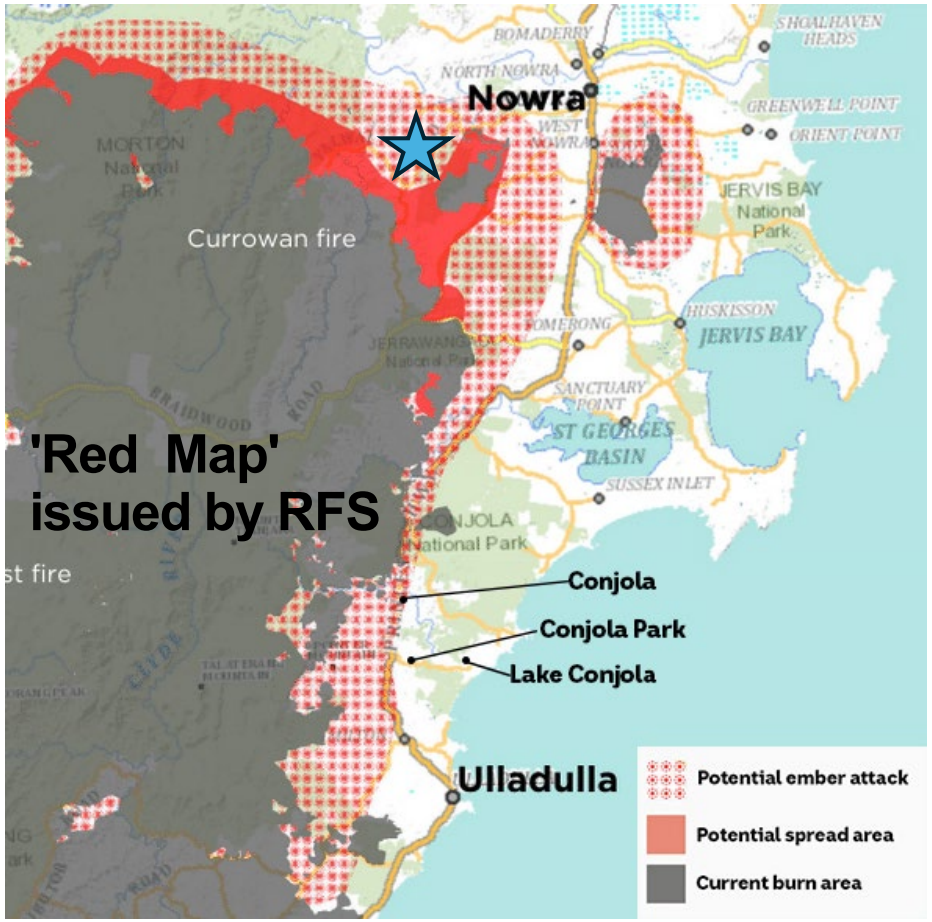
More than 200,000 ha total burned area

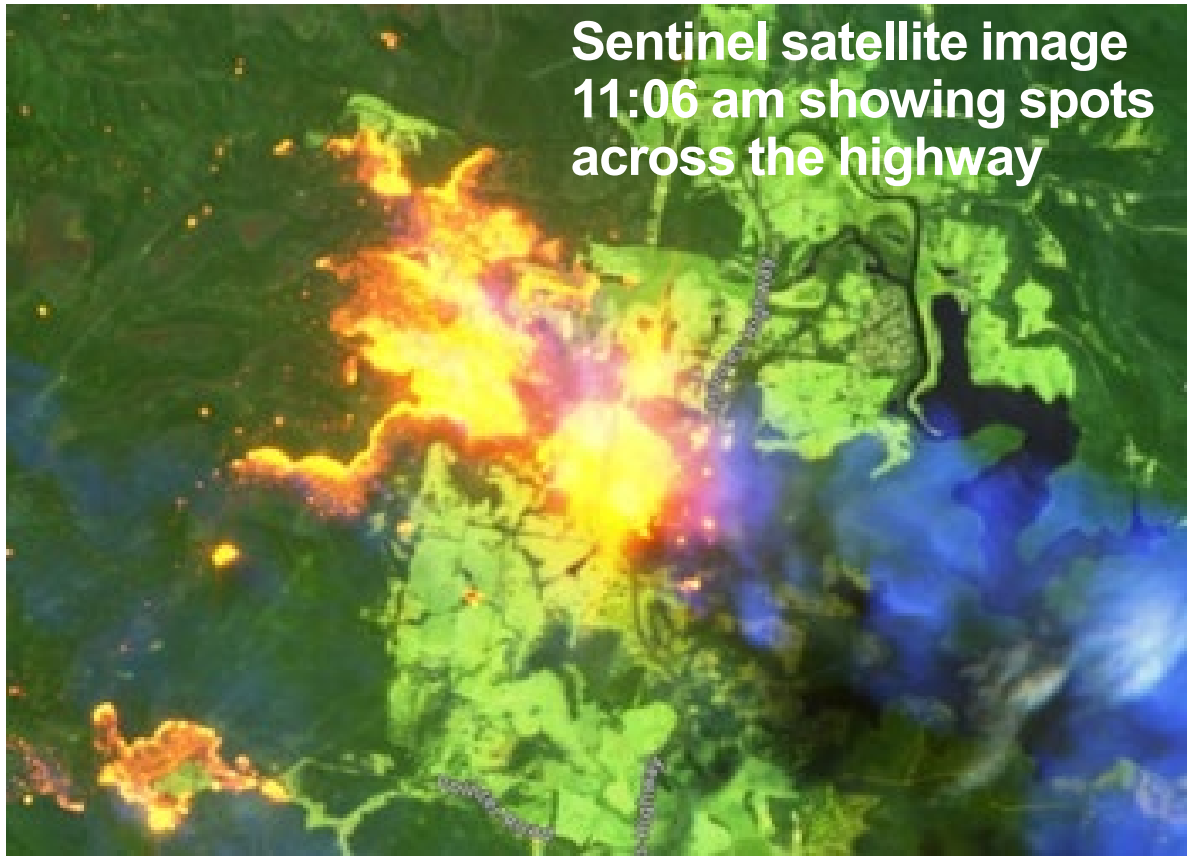
Currowan fire spotted across Princes Highway near Conjola

89 homes destroyed. 3 fatalities
On NYE 2019 there were multiple active fires over southeast Australia



Currowan Fire





Currowan fire

RFS 'Red Map' shows the fire was expected to stay west of the Princes Highway

Sentinel satellite image shows fire activity at 11:06 am

The fire crossed the six-lane highway and impacted Lake Conjola and Conjola Park

Winds at the fireground did not match forecasts or AWS observations

The Bureau's 'Incident Weather Forecast' ★ was located 40 km north of Conjola

Fire isochrones

Half hourly isochrones of simulated fire spread

Domain ~ 15 x 15 km

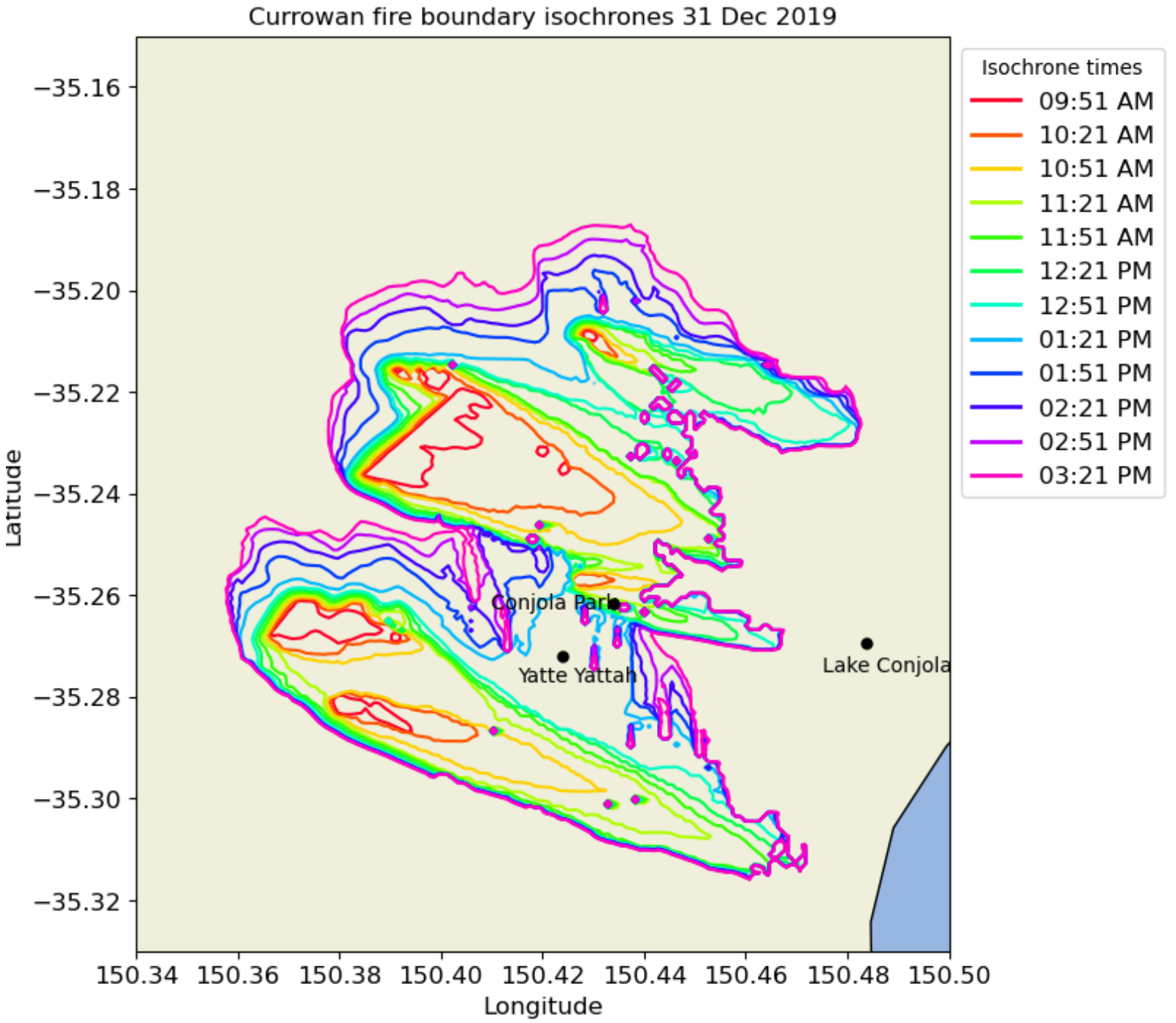
Red initial fireline(s) taken from line scan image at 9:51 am

Feature of interest:

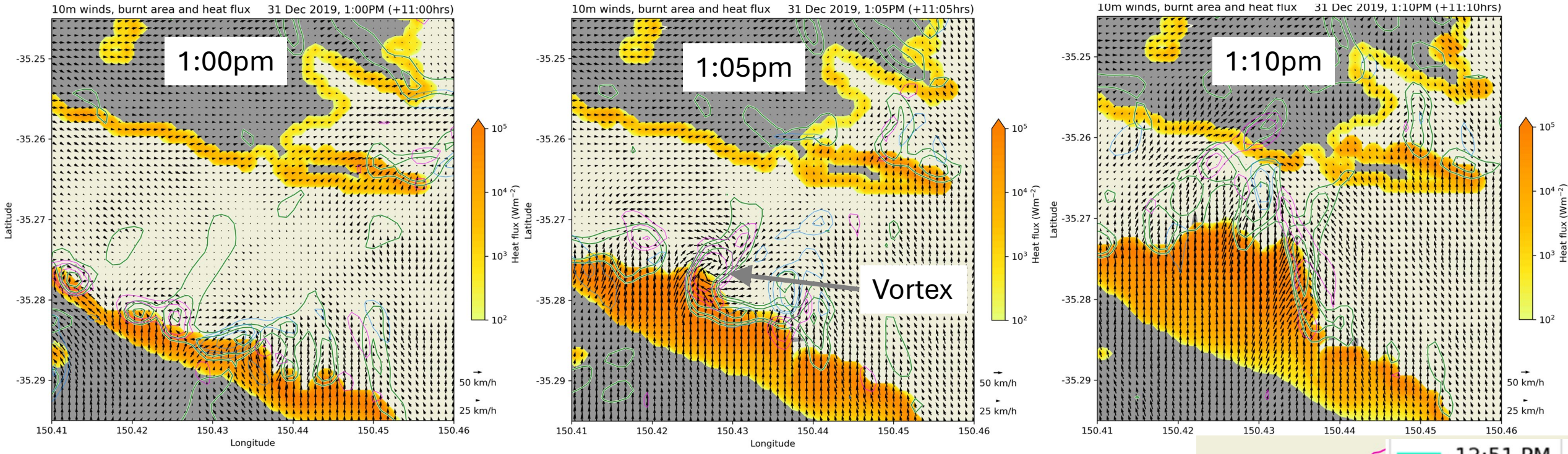
Individual fires took fast runs in different time periods

Coalesence between individual fires

Rapid spread at southern fire (Yatte Yattah) when the southerly change moved across



Wind change surge



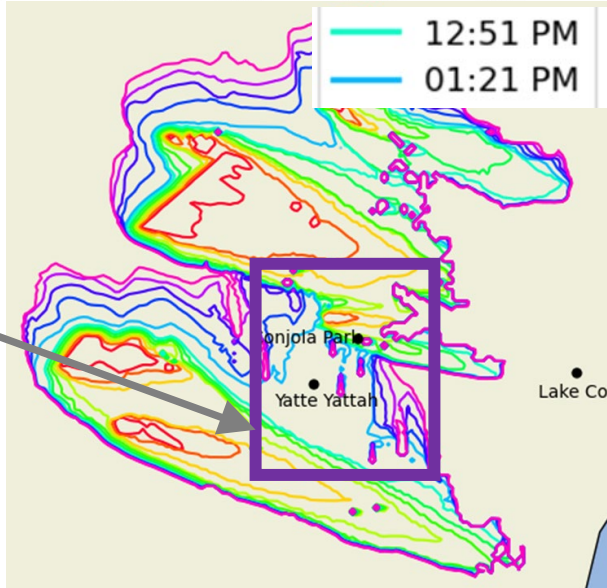
Rapid spread on the southern fire from ~1:00 pm when the shallow (< ~500m) density current southerly change moved across Yatte Yattah. (Inset box)

Simulated fire spread ~ 12 km/h for a short period

Near-surface simulated wind speed 22-24 m/s

Vortices develop ahead of the leading edge of the fire front

'Dead Man Zone' on fire flank where wind change moved across



Fire plume cross section

Green line inset = cross-section location

Just ahead of wind change

Red shading = updraft

Blue shading = downdraft

Green shading = cloud liquid water

Yellow shading = cloud ice water

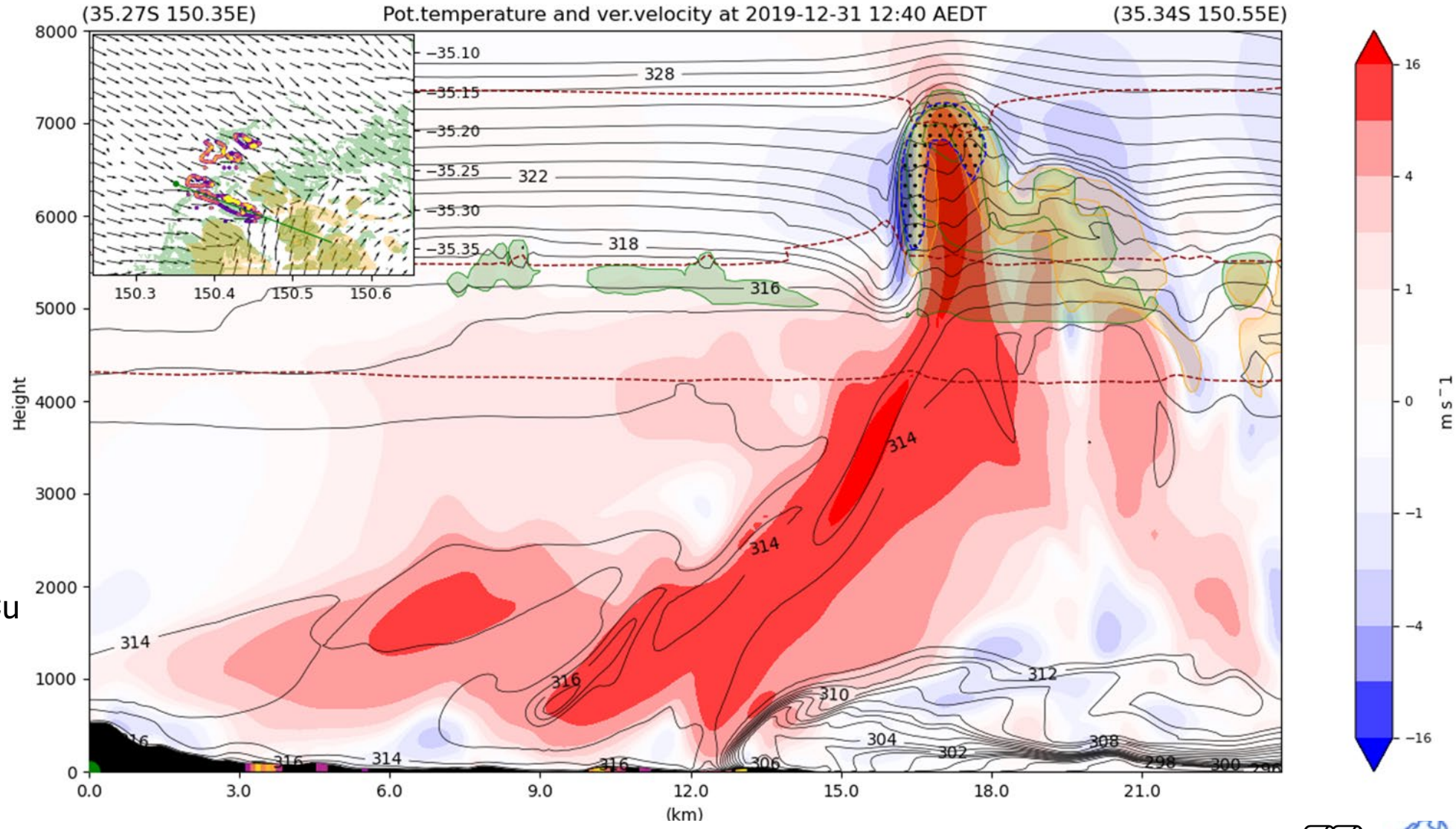
Black lines = potential temperature

Features to note:

Updraft speeds >16 m/s with strongly tilted plume

Cloud above 6000 m is pyroCu (<20°C isotherm), consistent with satellite imagery

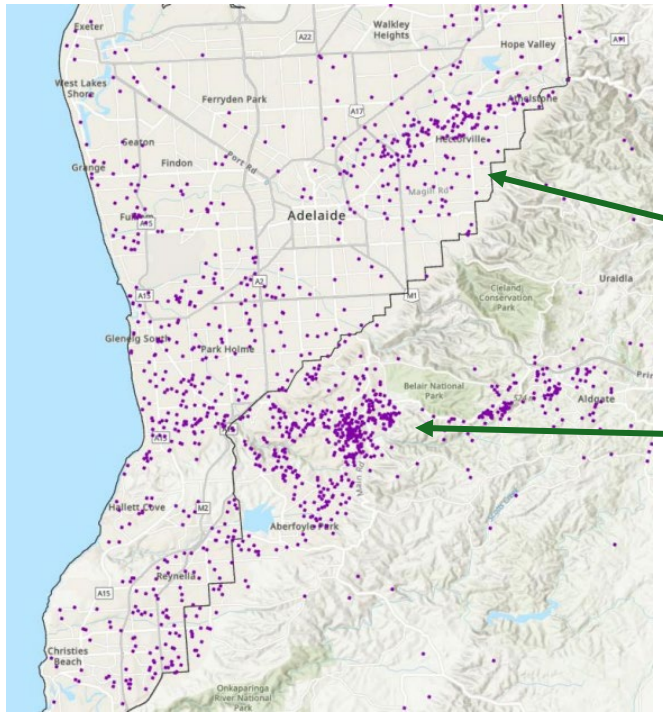
Shallow (colder) density current in isotherms



Thunderstorm Mesovortices I

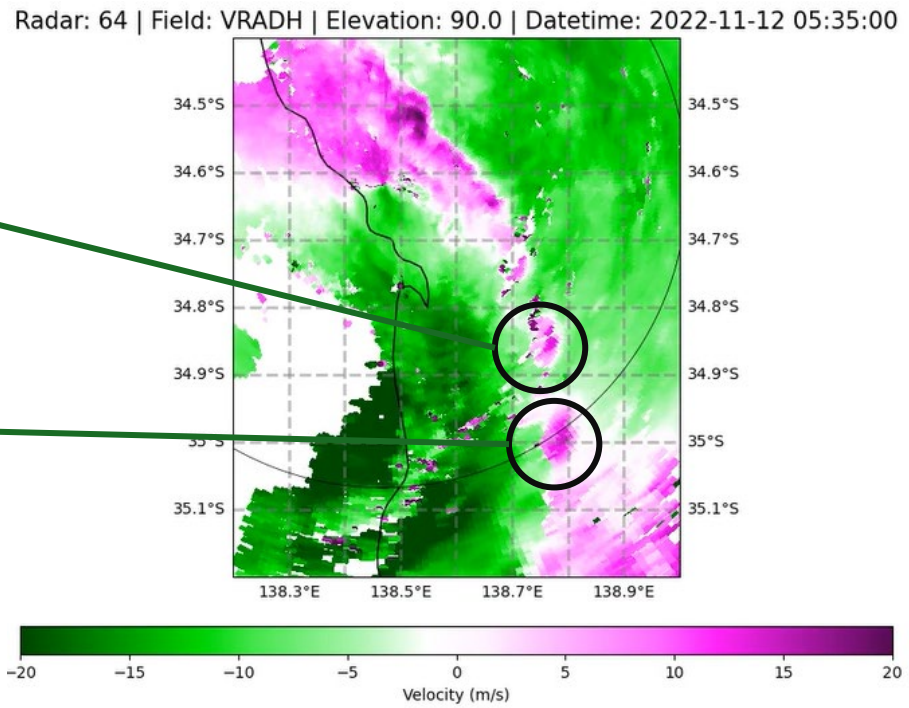
Adelaide 'Pageant Day' severe thunderstorm and squall line mesovortices 12 November 2022

Motivation: demonstrate the 'Fire Case Study' ACCESS model configuration and analysis tools are hazard agnostic



SES damage reports

~ 800 calls to SES.



Radar radial velocity at 0535 UTC.
Mesovortices (ellipses) in the squall line match the purple damage reports clusters.

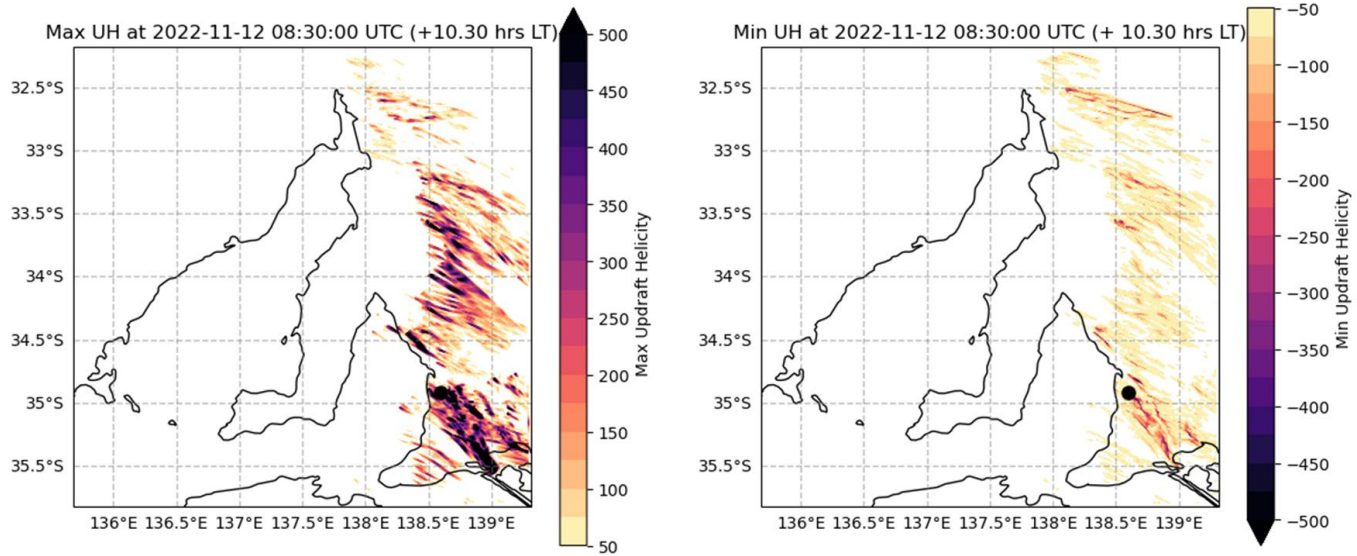
Significant tree and powerline damage.

Thunderstorm Mesovortices II

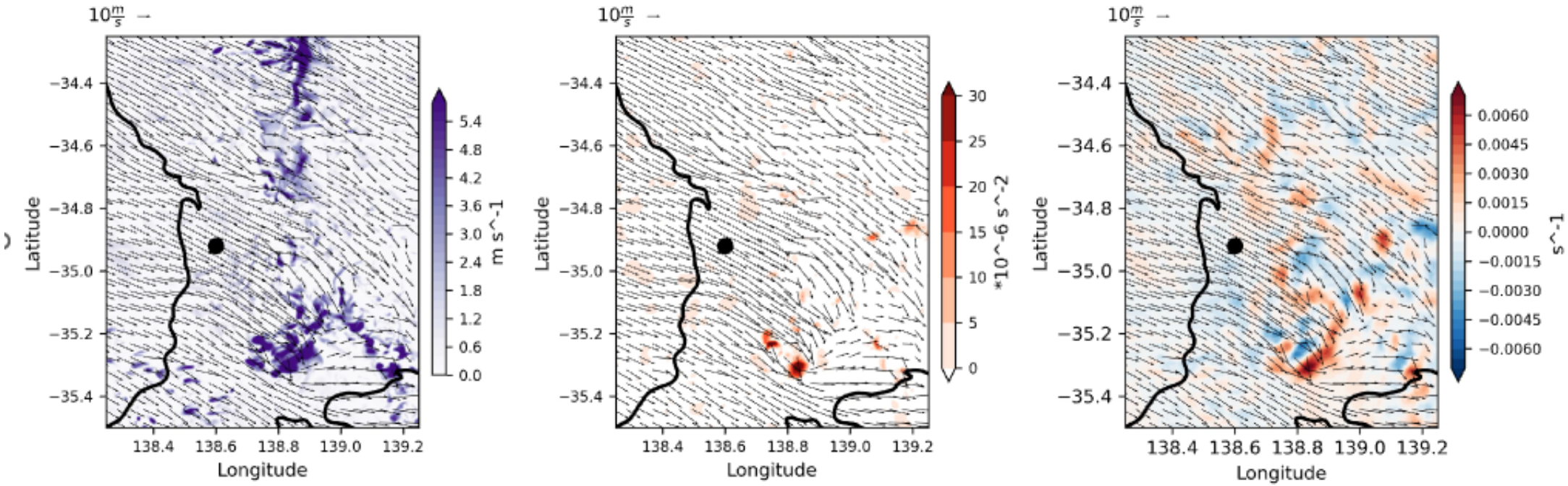
Updraft helicity – where conditions are favourable for intense rotating thunderstorm updrafts

Okubo–Weiss (OW) parameter – identifies areas of strong vorticity

Fire Case study project outcomes can be applied to other hazards and weather events



300 m max and min updraft helicity at 22/12/2022 0830 UTC



300 m vertical velocity, Okubo-Weiss parameter and vorticity at 3 km 22/12/2022 0830 UTC

Utilisation 1 – fire specific learnings.

'How can fire agencies use this stuff?'

Knowledge that can improve situational awareness and safety at fire grounds.

- Simulations at 100 m show local variability in wind speed and direction temporally and spatially
- Different parts of the fireline can experience different wind regimes
- Small shifts in wind direction can change the active fire flank
- Wind change dynamics → density currents can accelerate local fire spread and cut off the plume
- Nocturnal low-level jets, downslope winds and plume interactions → overnight fire activity
- Fire coalescence of adjacent fires enhanced by fire modified winds
- Pyroconvective cloud. Plume structure. Cloud processes. Winds and updrafts. Heat flux thresholds
- Future fire predictions .. shift from data source of 6 km, hourly grids > 100 m, 1 minute meteorological inputs

Utilisation 2 – case studies of extreme events

- Why are (fire) case studies valuable? Learning from impactful events will improve knowledge and operational decisions next time
- High resolution simulations give fascinating insights into local scale processes. How is the value realised? Years to decades of collaboration in operations and research between Bureau and Australian fire agencies. Fire agencies providing the funding and support for high-res modelling.
- Are the simulations 'right'? All models are wrong, but some models are useful (see #1 and #2 above)
- Can the framework be run on non-fire weather events? Turn 'off' the fire component and run 300 m or 100 m simulations anywhere in Australia
- Cost of compute for a high-resolution ACCESS-Fire or non-fire run? ~<$1000 compute for a 24 hr simulation. (Investment in Australia in climate simulations order of $10,000,000's)
- Time and cost to collect data and analyse simulations? Historically slow, but faster with analysis tools developed during the project
- How close to real time can we produce a case study and with what turnaround time? We will get faster with practice

Conclusions

NHRA project has developed a framework for rapid turnaround case studies with high resolution coupled fire-atmosphere simulations and observational data.

- Detailed case studies of the Wooroloo and Currowan fires.
  - Reports drafted. Papers in preparation.

- Online extended seminars to be hosted by NHRA in coming months. One on each fire, Currowan and Wooroloo.

- Many thanks to NHRA and Fire Agencies (RFS, DFES & CFA) for supporting the project.

- Question: Future utilisation of the case study framework?