

The fine-scale meteorology of Black Saturday

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High Impact Weather Research
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Acknowledgements

- Co-authors
 - Will Thurston, Jeff Keper and Kevin Tory
The Centre for Australian Weather and Climate Research
Docklands, Victoria
- Similar work
 - Engel, Lane, Reeder and Rezny (2012)
The meteorology of Black Saturday
Quarterly Journal of the Royal Meteorological Society (to appear)
 - Reeder (2012)
Modelling Black Saturday
Coupled Atmosphere-Bushfire Modelling Workshop
The University of Melbourne, 16-18 May 2012



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What are we trying to accomplish?

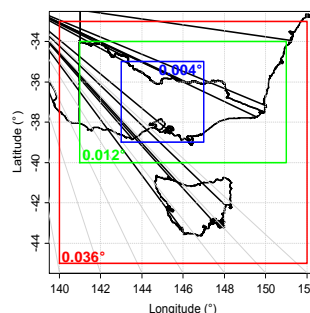
- to model the meteorology of Black Saturday (2009-02-07) across central Victoria
 - using the Australian Community Climate and Earth System Simulator (ACCESS), including the UK Met Office atmospheric model
 - at high resolution (0.012° latitude/longitude spacing = 1.2 km approx.)
 - at very high resolution (0.004° latitude/longitude spacing = 400 metres approx.)
- we will also perform analogous modelling of some other recent fires
- to see which aspects of the modelled meteorology might be important for fire behaviour and to see if aspects of the observed fire behaviour can be "explained" by the meteorology
- to see which aspects of the very-high-resolution meteorology are also seen in the lower-resolution simulations
 - lower resolution simulations are cheaper and faster to run, and therefore closer to operational implementation



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Nesting details



- The modelling begins with a global model run. The second level is at 0.11° resolution covering all of Australia and surrounding waters. Further levels of nesting increasingly focus on the area of interest.
- Boundaries of the **third (red)**, **fourth (green)** and **fifth (blue)** nesting levels for the Black Saturday model runs.
- Model boundaries are chosen, as far as is possible, to avoid areas of elevated topography.
- Comparison test runs also done at 0.008° and 0.006° (fifth level).



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How do we validate the simulations?

- Comparisons against surface observations
 - one-minute and thirty-minute automatic weather station (AWS) observations across Victoria
- Comparisons against upper-air observations
 - radiosonde balloon flight observations at Melbourne Airport
- Comparisons against radar data from the Yarrowonga Doppler radar
- Comparisons against satellite observations
 - visual, infra-red imagery
- None of these observational data are assimilated into the model simulation, so the simulation can be validated against completely independent data.



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What aspects of the modelling can we verify?

- timing of the main wind change on Black Saturday
- forecast maximum temperature
- forecast maximum wind speeds
- upper-level temperature and moisture
- features observed in the radar and satellite imagery



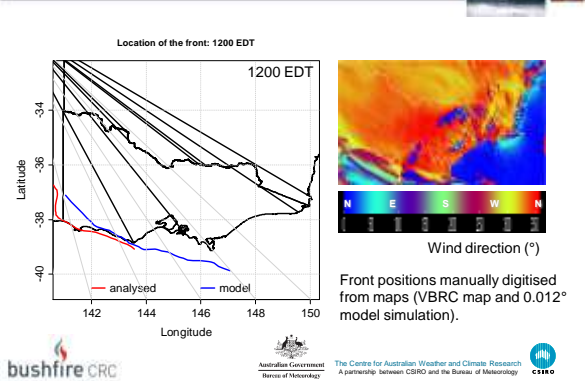
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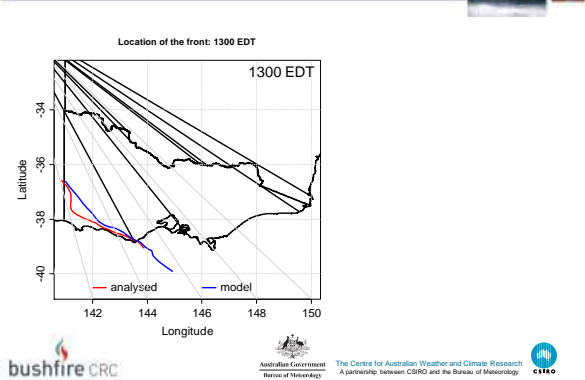
Primary wind change on Black Saturday



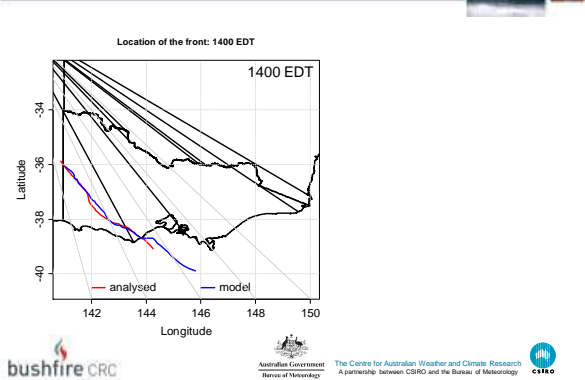
Hour-by-hour comparison



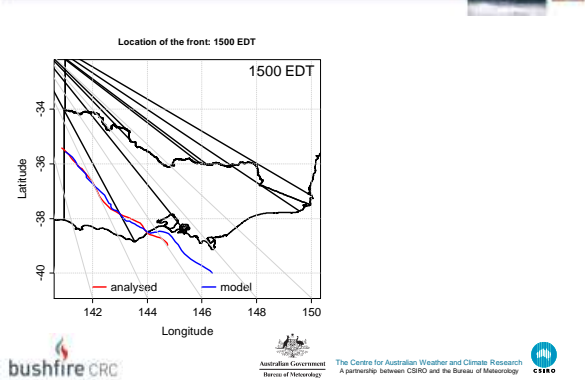
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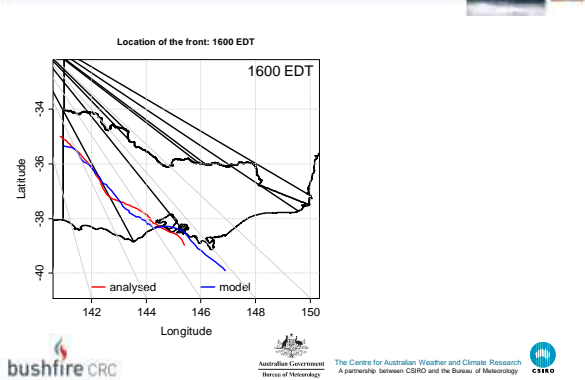
Hour-by-hour comparison



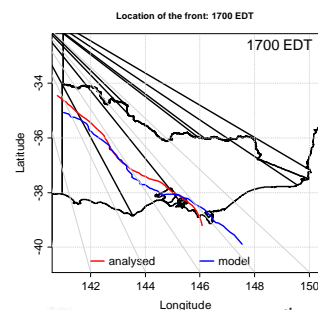
Hour-by-hour comparison



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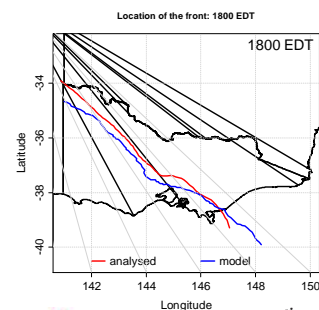
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Hour-by-hour comparison



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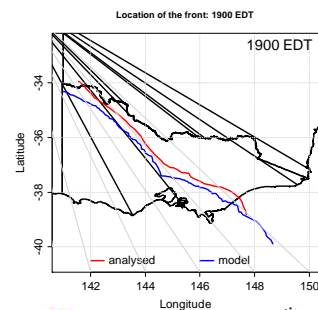
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Across central Victoria, the model front is slightly behind the observed front.

Hour-by-hour comparison



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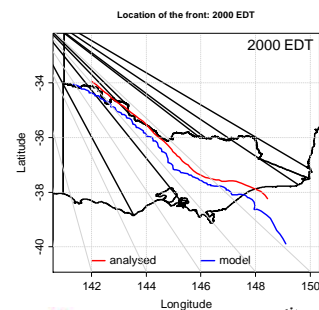
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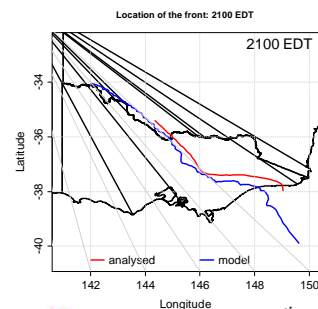
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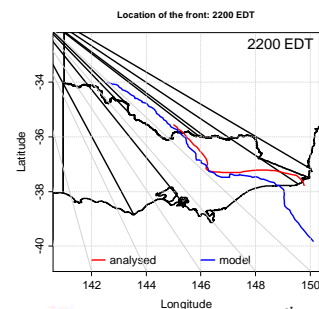
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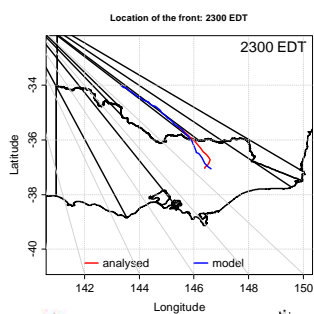
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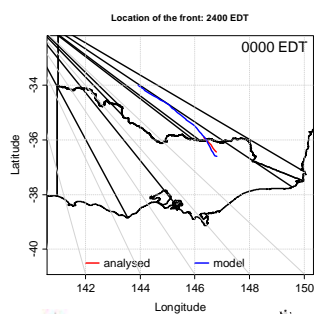
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Hour-by-hour comparison



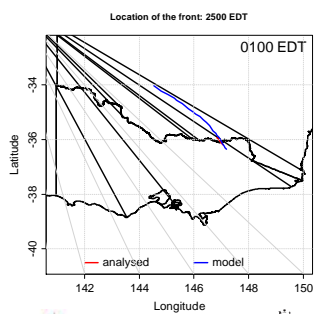
In both the observations and the model, it becomes very difficult to diagnose the precise location of the front across the mountains of the southeast.

Hour-by-hour comparison



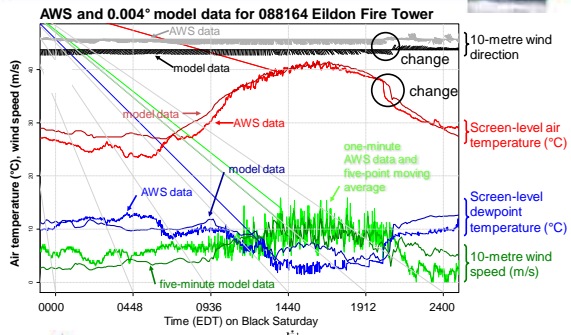
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Hour-by-hour comparison

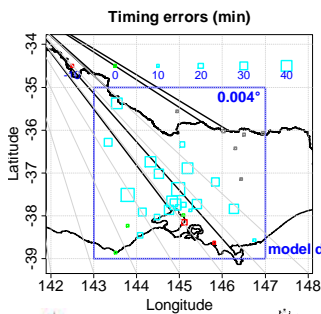


In both the observations and the model, it becomes very difficult to diagnose the precise location of the front across the mountains of the southeast.

Determining the timing and max. temp. errors

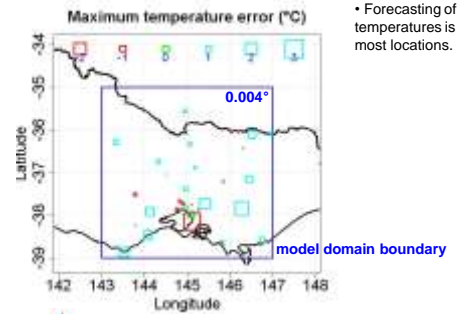


Wind-change timing error



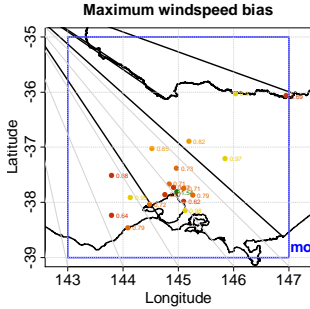
- Over much of central Victoria, the model wind change is around 20 to 50 minutes late.
- Timing errors are quite small along the southern coastline.
- Timing of the wind change is harder to determine in the northwest of the model domain, so errors are not given.

Maximum temperature error



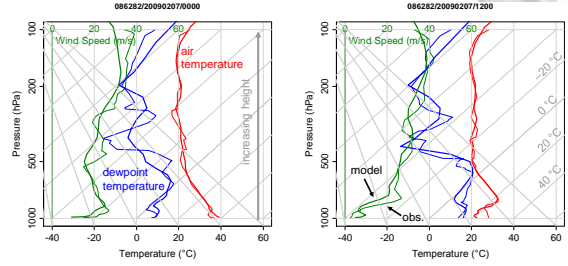
- Forecasting of maximum temperatures is very good at most locations.

Maximum hourly wind speed bias



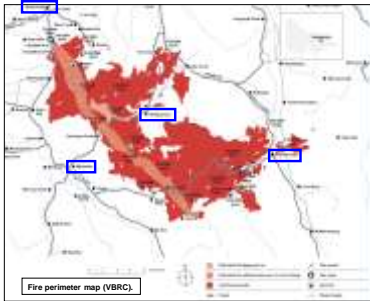
- Comparison of the windiest hour in the model data to the windiest hour in the observational data – 10-metre wind speeds
- Peak model wind speeds are typically less than observed peak wind speeds, by about 20 to 30%.

Upper-level data



Vertical temperature traces for Melbourne Airport (086282) at 0000 UTC (left) and 1200 UTC (right) on Black Saturday, from the 800-metre resolution model runs. Temperatures are skewed.

A well-observed aspect of the meteorology

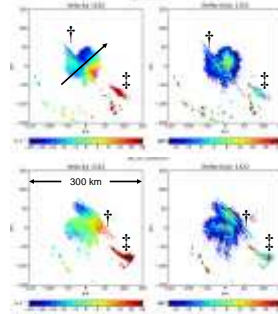


- At 2334 EDT (1234 UTC) on Black Saturday (2009-02-07), extreme fire behaviour and significant spotting were reported including up to 1 km from the town of Myrtleford in northeast Victoria.

[VBRC report on the Beechworth-Mudgegonga fire]

- What happened meteorologically speaking and how well was it modelled?

In the Yarrowonga Doppler radar ...

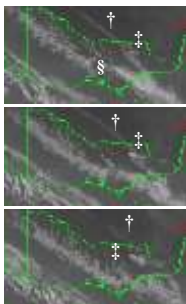


1202 UTC
2302 EDT

1322 UTC
0022 EDT

- Yarrowonga radar is northwest of the Beechworth-Mudgegonga fire (†).
- A disturbance (†) passes across the radar view at around midnight, travelling from the southwest towards the northeast.
- As it passes across the B-M fire, the fire is seen in the radar data to intensify considerably.
- Radar images available at 20-minute intervals.

In the satellite images ...



1230 UTC
2330 EDT

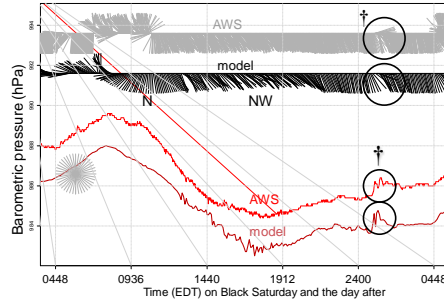
1330 UTC
0030 EDT

1430 UTC
0130 EDT

- The disturbance (†) is also visible in the infra-red satellite imagery, available at hourly intervals.
- As it passes across the Beechworth-Mudgegonga fire (†), the smoke plume grows and remains larger for at least one hour.
- A much larger smoke plume (§) is also visible in these images.

On the ground ...

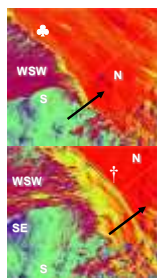
AWS and 0.004° model data for 072160 Albury Airport AWS



10-metre
wind direction

- The disturbance (†) is visible in the wind direction and the barometric pressure data.
- AWS wdtr < 280° from 0101 EDT to 0108 EDT.
- Disturbance also seen in the Yarrowonga AWS.

What does the model say is happening ...



1100 UTC
2200 EDT

1300 UTC
0000 EDT

- The disturbance (♣) is initially just the leading edge of the wind change, but the wind change stalls, leaving an undular bore (†) to run on ahead towards the northeast.
- The undular bore is characterised at the surface by a temporary change in wind direction and speed.
- It is harder to see its progress across the mountainous areas of the southeast.

Wind direction (°)



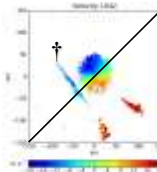
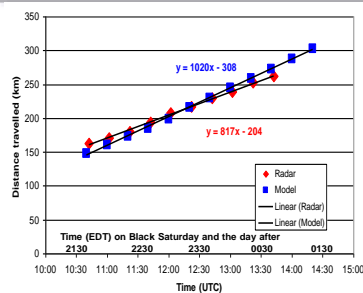
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Verification



- Positions along the SW-NE radar transect were estimated from the radar and model output images
- Model speed (1020 km/day) along transect about 25% faster than observed speed.

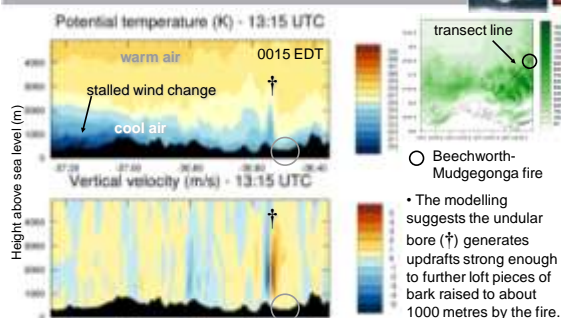
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Implications for the fire ...



- The modelling suggests the undular bore (†) generates updrafts strong enough to further loft pieces of bark raised to about 1000 metres by the fire.

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Concluding remarks ...

- The weather on Black Saturday has been modelled at very high resolution (0.004°) using ACCESS
- Modelling of maximum temperatures is very good
- The wind change is modelled well, with timing errors of only 20 to 50 minutes.
- Peak surface wind speeds are typically underestimated
- Some of the fire behaviour in the north east can be explained by an undular bore running ahead of a stalled wind change, a meteorological feature well supported by the available observational evidence
- The simulation shows lots of interesting small-scale detail ... to be further illustrated in Will Thurston's presentation
- Not all fire weather cases will be as well modelled as this one ...

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Thank you

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