Modelling Black Saturday

\[ M(\sqrt{-1}) \subset \mathfrak{h} \forall e^\ell \ \mathfrak{K} \ni \partial(e^r) \]

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and

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• UM version 7.5
• Nested: global/12 km/4 km/1 km/500 m  70 levels
• Staggered initialization (20090206): global 03Z, 12 km 03Z, 4 km 06Z, 1 km 09Z, 500 m 12Z.
• Updated high resolution topography (shown every 300 m from 100 m onwards).
• Modification to number of levels used for the boundary layer parameterization in 4 km/1 km/500 m.
ACCESS 12 km Simulation of Black Saturday

MSLP
1300 LST 7 February 2009
The flow is characterised by the classic hyperbolic deformation field.
ACCESS 12 km Simulation of Black Saturday

- The model develops a strong coastal front.
- Rossby wave breaking and PV stirring.
Time Series on Black Saturday

- Time series of pressure, temperature, wind speed and wind direction from Moorabbin Airport (grey) and from the ACCESS model (black).
- Four distinct mesoscale phenomena: undular bore(s); strong pre-frontal cross-isentropic mixing; coastal front; and synoptic front.
Undular Bores on Black Saturday

- Time series from Moorbbin Airport (grey) and from the ACCESS model (black).
What is a Bore?

- The hydraulic jump is the simplest kind of bore.
Undular Bores

- The **morning glory** is a series of low-level roll clouds that occur early in the morning at places around the southeastern part of the Gulf region.

- The morning glory is an undular bore.
Undular Bore over the Great Australian Bight Before Black Saturday

MODIS Satellite Image 6 February 2009

- On the day before Black Saturday, an undular bore developed on the marine stable layer ahead of the synoptic cold front.
- I believe bores commonly develop over the Bight ahead of cold fronts.

http://rapidfire.sci.gsfc.nasa.gov/gallery/
The bore arrives two and a half hours too early in the model (0300 LST).

The model bore is too weak.
Black Saturday Evening Prefrontal Bore

Yarrawonga Radar
2010 LST 7 February - 0130 LST 8 February 2009

Smoke plume from the Beechworth fire.
Black Saturday Evening Prefrontal Bore

- The bore arrives at Yarrawonga around 2220 LST, which is about 2 hours too early.
- The bore reinvigorated the Beechworth fires.
- The bore appears to be bound to the front.
- Flow splitting around the mountain range.
Prefrontal Mixed Layer on Black Saturday

- Time series from Moorabbin Airport (grey) and from the ACCESS model (black).
- The maximum model and observed temperature agree very well.
- Record temperature in Melbourne 46.4°C.
Prefrontal Mixed Layer on Black Saturday

- The model produces pronounced boundary layer rolls aligned with the shear.
- Horizontal wavelength around 8 - 10 km.
Prefrontal Mixed Layer on Black Saturday

MODIS Satellite Image 7 February 2009

http://rapidfire.sci.gsfc.nasa.gov/gallery/

- The observed cloud field is aligned along the shear also.
Black Saturday Cold Fronts

- Time series from Moorbbin Airport (grey) and from the ACCESS model (black).
- The coastal front is delayed in the model by about half an hour.
- Observations show two fronts (a coastal front and a synoptic front) whereas the model only captures the coastal front.
Black Saturday Cold Fronts

$\theta$ (K) at 500 m and wind vectors

16:00 LST 07/02/09

25 ms

36°S

37°S

38°S

39°S

144°E 145°E 146°E 147°E

291 294 297 300 303 306 309 312 315 318
Black Saturday Cold Fronts

- The leading edge of the coastal front is marked by a strong, but very narrow updraught.
Black Saturday Cold Fronts

- The coastal front has the structure of an unsteady gravity current.
- The boundary layer rolls are superimposed on the front.
Gravity Current Simulation

Phil Cunningham
Frontal Instabilities

Topography, Potential Temperature and Winds in the Cross-Section
Frontal Instabilities

Topographic Height, Potential Temperature and Horizontal Winds
Frontal Instabilities

• No strain

• Strained
Black Saturday FFDI

- The Forest Fire Danger Index is an empirical measure of the potential severity of a fire.

\[
FFDI = 2\exp\left(-0.45 + 0.987\ln(D) - 0.0345H + 0.0338T + 0.0234V\right)
\]
The Forest Fire Danger Index is an empirical measure of the potential severity of a fire.

It is the key measure of fire danger used in Australia.

The rating is scaled so that Black Friday 1939 is 100.

A total fire ban is triggered at 50.

Even so the FFDI has huge spatial and temporal variability.
Conclusions

• An undular bore formed ahead of the advancing cold front and propagated across southern Victoria in the early hours of Black Saturday.

• Deep boundary layer rolls developed during the day.

• A very strong cold front with the structure of a gravity current, develops at the coastline in the afternoon (in excellent agreement with Les Muir’s PhD thesis).

• As the turbulent mixing subsides in the late afternoon, the coastal front surges inland.

• In the evening, as a stable layer forms, the coastal front develops an undular bore at its leading edge (compare observations over central Australia, where every front produces a bore). As it passed this bore reinvigorated the Beechworth fires.