

## What are boundary-layer rolls and how might they contribute to fire spread?

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Will Thurston  
High Impact Weather Research  
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Thanks to Robert Fawcett, Jeff Keper, Kevin Tory, Susan Rennie



## Introduction

*"Understanding Complex Fire Behaviour: Modelling investigation of lofting phenomena and wind direction variability"*

- (i) Updraft phenomena
- (ii) Wind direction variability

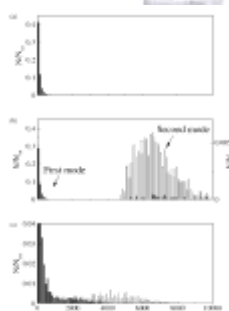


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## Updraft phenomena

- Spot fires lead to unpredictable and accelerated fire spread
- Spotting is caused by the lofting of firebrands into strong ambient wind
- Anecdotal evidence of spotting tens of kilometres ahead of fire (e.g. Kilmore East)
- *Theoretical* modelling results support possibility of long range spotting (Sardoy et al., 2008)



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## Updraft sources

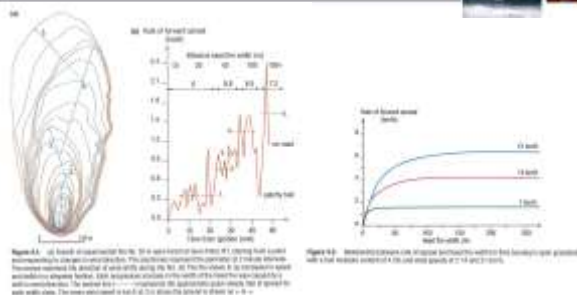
- Two broad classes of updraft phenomena:
- **Meteorological updraft phenomena:**
  - Mountain waves, rotors and terrain-induced circulations
  - Sea breezes
  - Frontal passage
  - Convergence lines
  - Boundary-layer rolls and other organised convective circulations
- **Fire updraft phenomena:**
  - Conventional smoke plumes
  - Pyro-cumulonimbus
  - Pyro-tornadogenesis
- Interaction between the two is important



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## Wind direction variability



(Cheney & Sullivan, 2008)



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## Wind direction variability sources

- Small scale (cms), high frequency (s)
- Large scale (synoptic), low frequency (h)

These are well understood, but what about sources of variability that fall between these scales?

- Boundary-layer rolls
- Convective clouds
- Topographically-induced flows



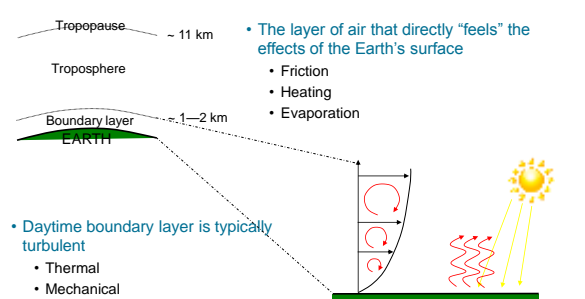
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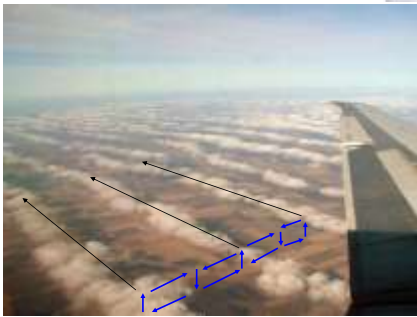
Boundary-layer rolls

- Boundary-layer rolls are a source of both:
  - Updrafts
  - Wind direction variability
- What are boundary-layer rolls?
- Evidence of boundary-layer rolls was observed on Black Saturday
- Are we able to simulate boundary layer rolls with high resolution numerical weather prediction?

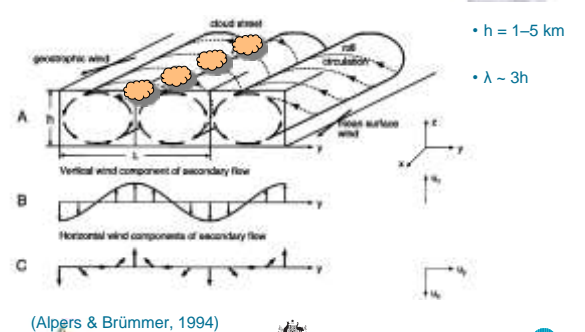
What is the atmospheric boundary layer?



What are boundary-layer rolls?



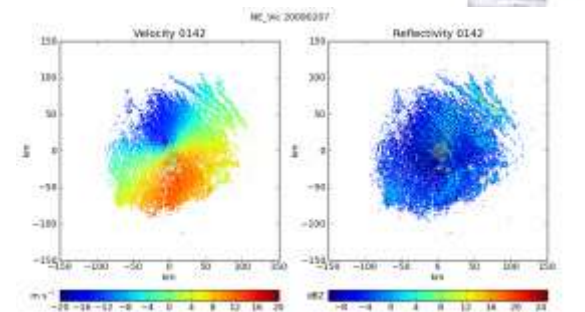
Boundary-layer rolls: Schematic diagram

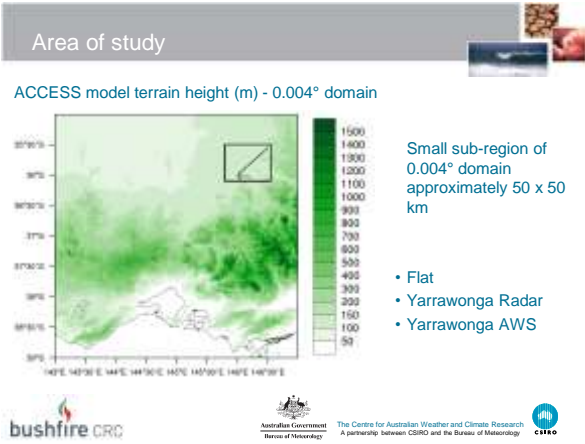
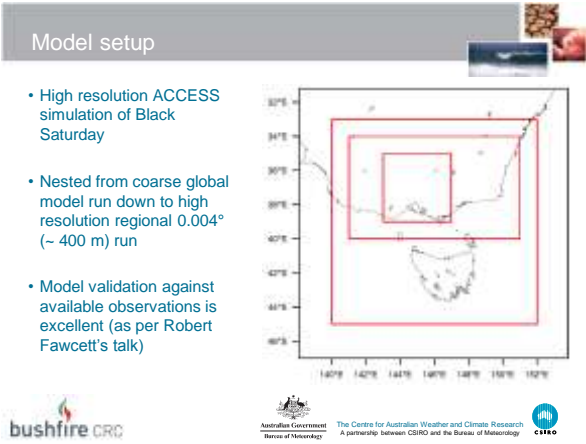
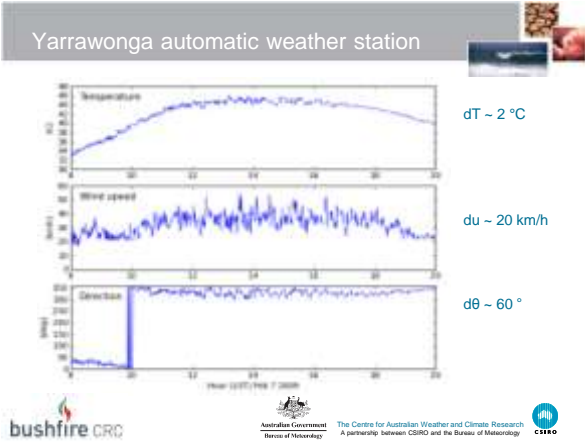
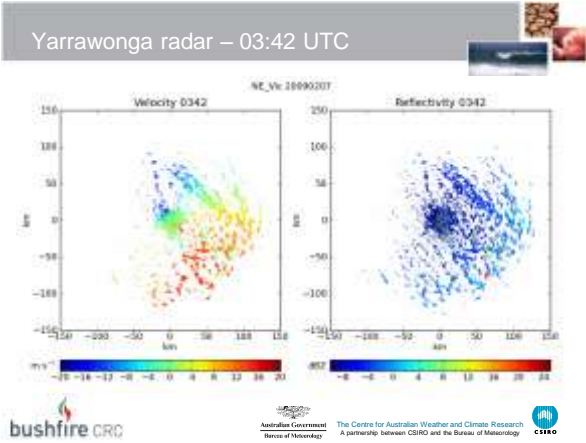
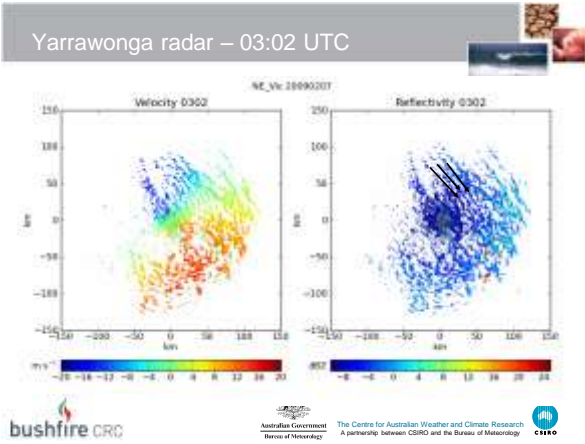
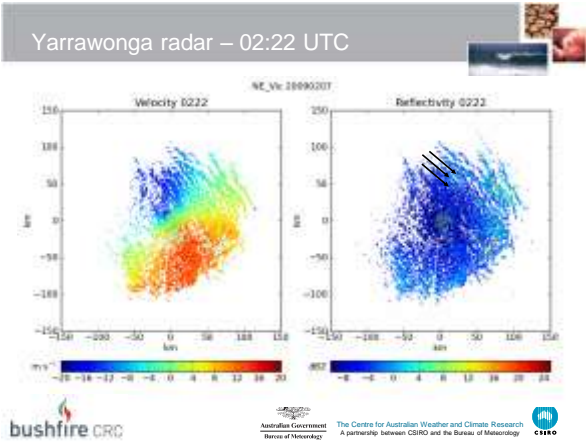


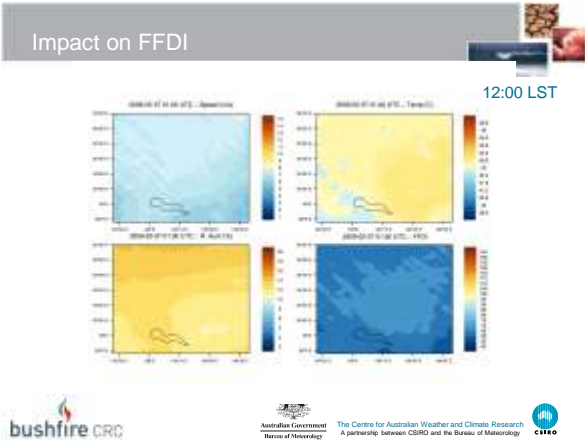
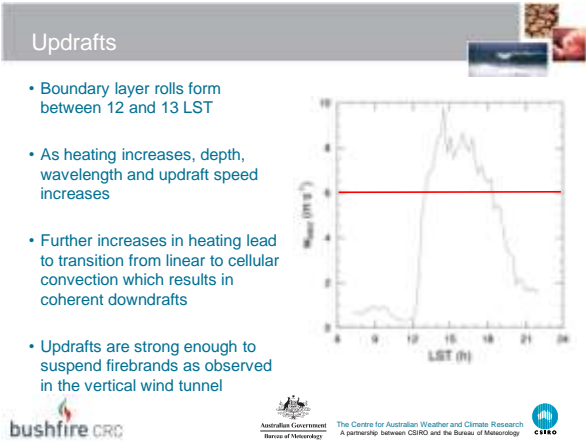
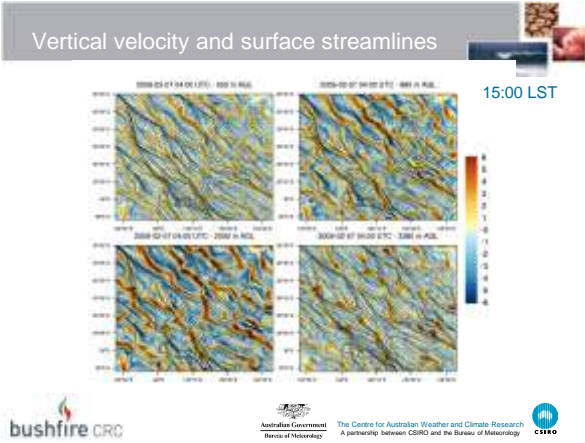
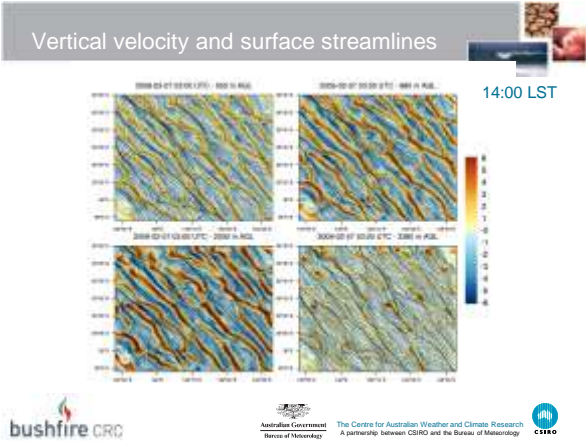
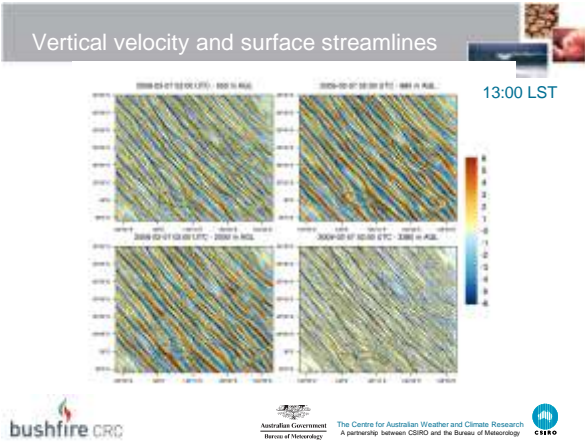
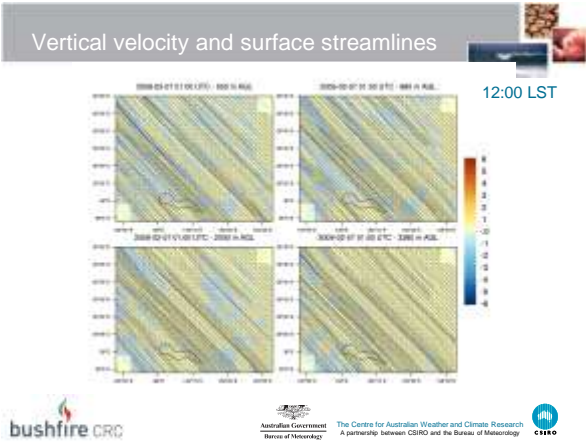
Black Saturday - MODIS Aqua 04:50 UTC



Yarrowonga radar – 01:42 UTC

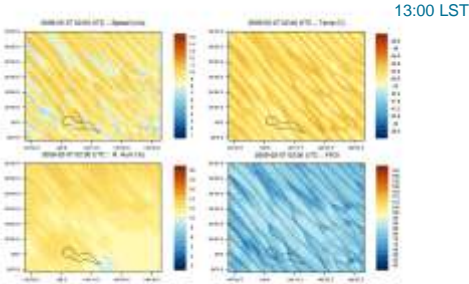




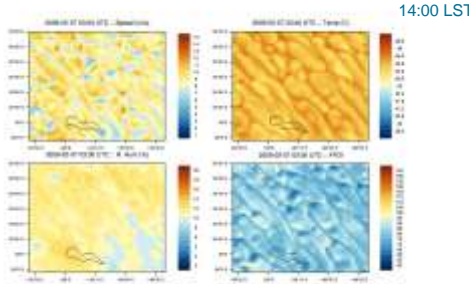




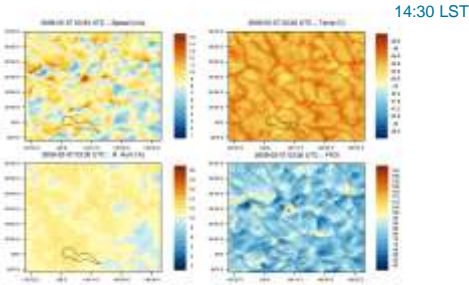
Impact on FFDI



Impact on FFDI



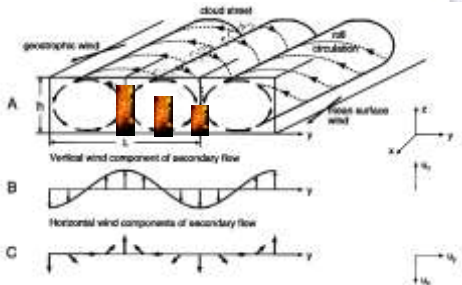
Impact on FFDI



Future work

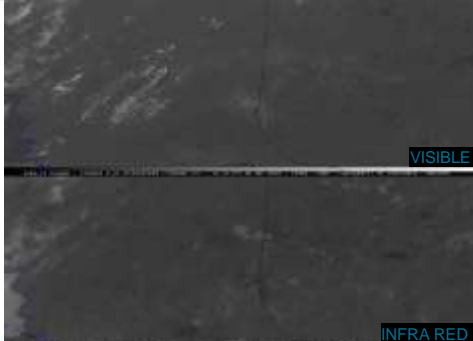
- Modelling work to date has focussed purely on meteorological aspects of boundary-layer rolls
- The characteristics of rolls alone result in significant surface fluctuations and convergence, in addition to sustained updrafts
- Our next aim is to understand the interaction between boundary layer rolls and a fire column
- Add an intense heat/moisture soil at the model surface to simulate a fire

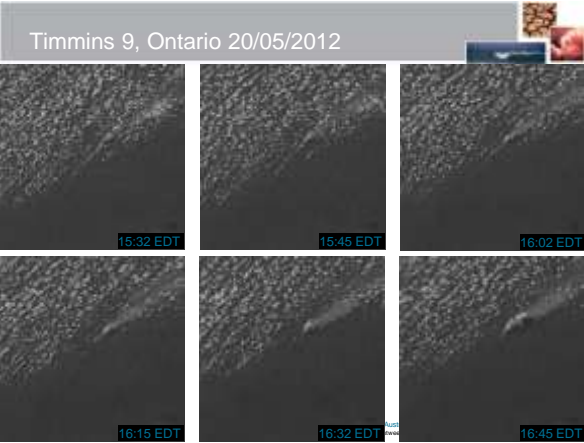
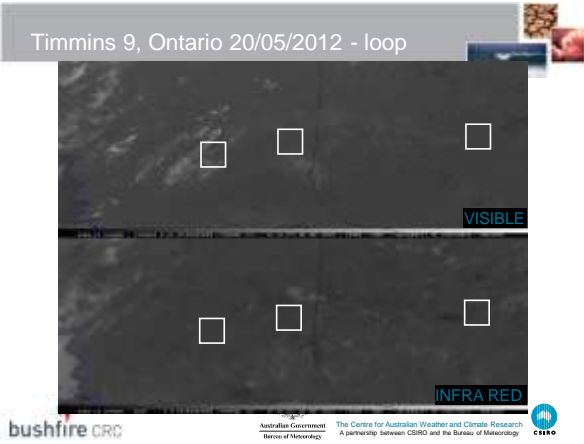
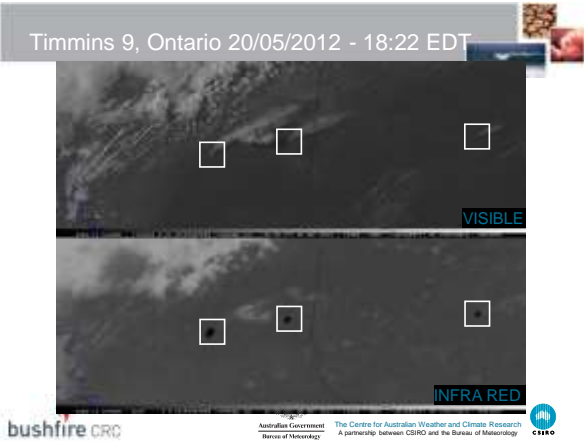
Future work



- Timmins fire, Ontario, Canada.

Timmins 9, Ontario 20/05/2012 - 12:15 EDT





Summary

- Boundary layer rolls are linear convective circulations
- They contribute to temperature, wind speed and direction fluctuations at the surface
- They contain updraft velocities in excess of the fall velocities of common firebrands
- Numerical weather prediction models run in high resolution 'research' mode are capable of reproducing these features

bushfire CRC

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