DOWNSLOPE WINDS
-and their consequences-

- Jason Sharples, UNSW Canberra
- Rick McRae, ACTESA

2013 Fire Weather & Risk Workshop

Sequential intense downslope runs. Kilmore, 2 Feb 2009. [Alder, NAFC]

OUTLINE:

- Part 1: Fire and wind regimes
  - Prevailing vs actual winds - the role of relief
  - Vectoring
  - Probabilistic winds
- Part 2: Leeward slope effects
  - Lee-slope wind regime
  - Wind reversals
  - Consequences
- Part 3: Consequences of downslope wind effects
  - Fire channelling
  - Deep flaming
  - Violent pyroconvection

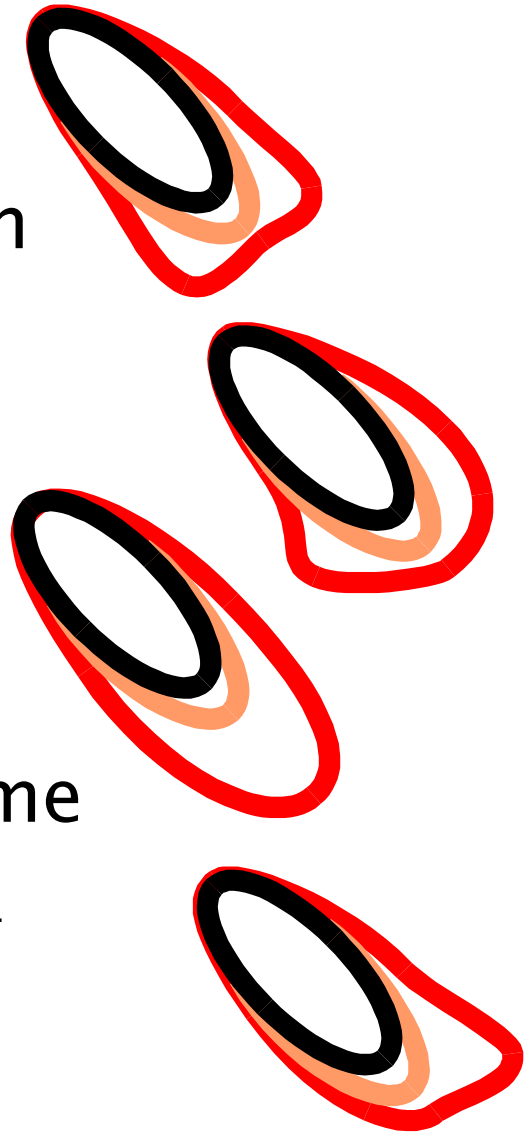
PART 1: Fire and wind regimes

Rapid crowning in strong winds. Kilmore, 2 Feb 2009. [Alder, NAFC]

- A fire will evolve within an envelope defined by the movement of the fluid within which it is embedded.

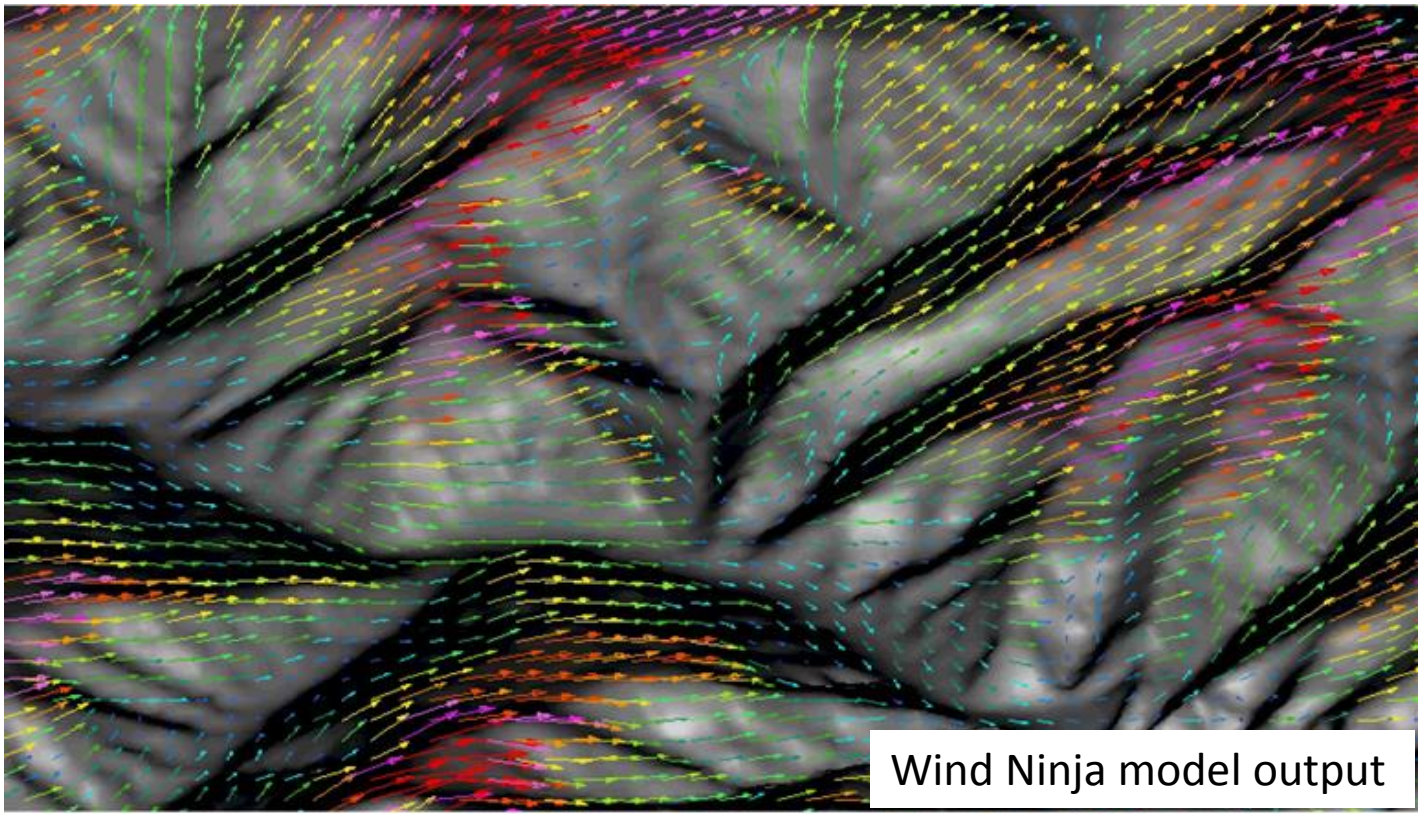
- Fluid flow is often complex.

- Most firefighters working in undulating or rugged terrain assume that their opportunities for control are best found on the downslope run. This may not be true...



Fire isochrone sets with varying goemetries.

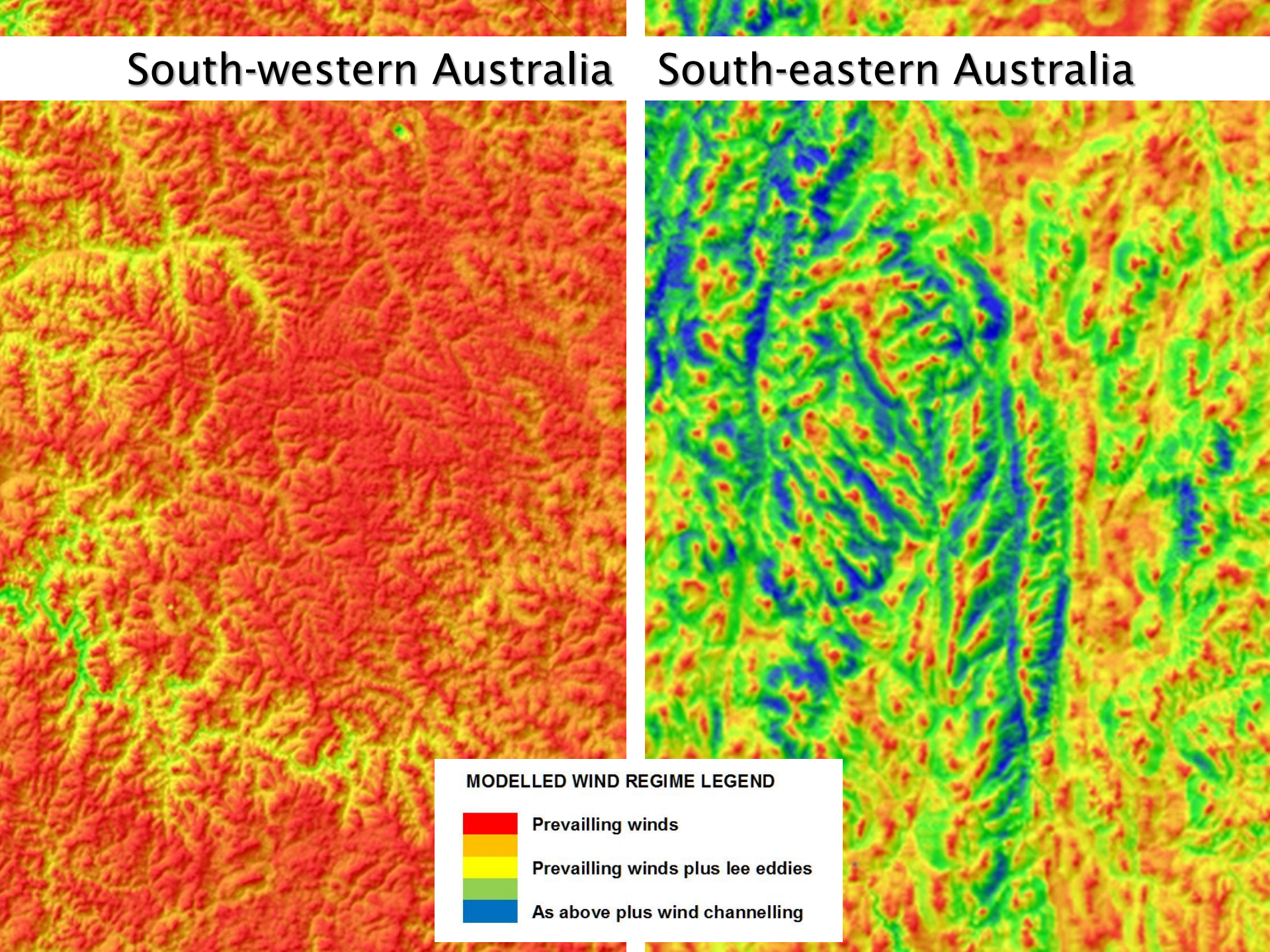
- The terrain geometry alters the prevailing winds and gives rise to local effects.



- Terrain types vary around Australia...

South-western Australia

South-eastern Australia



- The overall direction of fire spread is determined by the *vector sum* of the various local effects

- This will vary over the course of the day and depending on the particular location

10:00

Prevailing

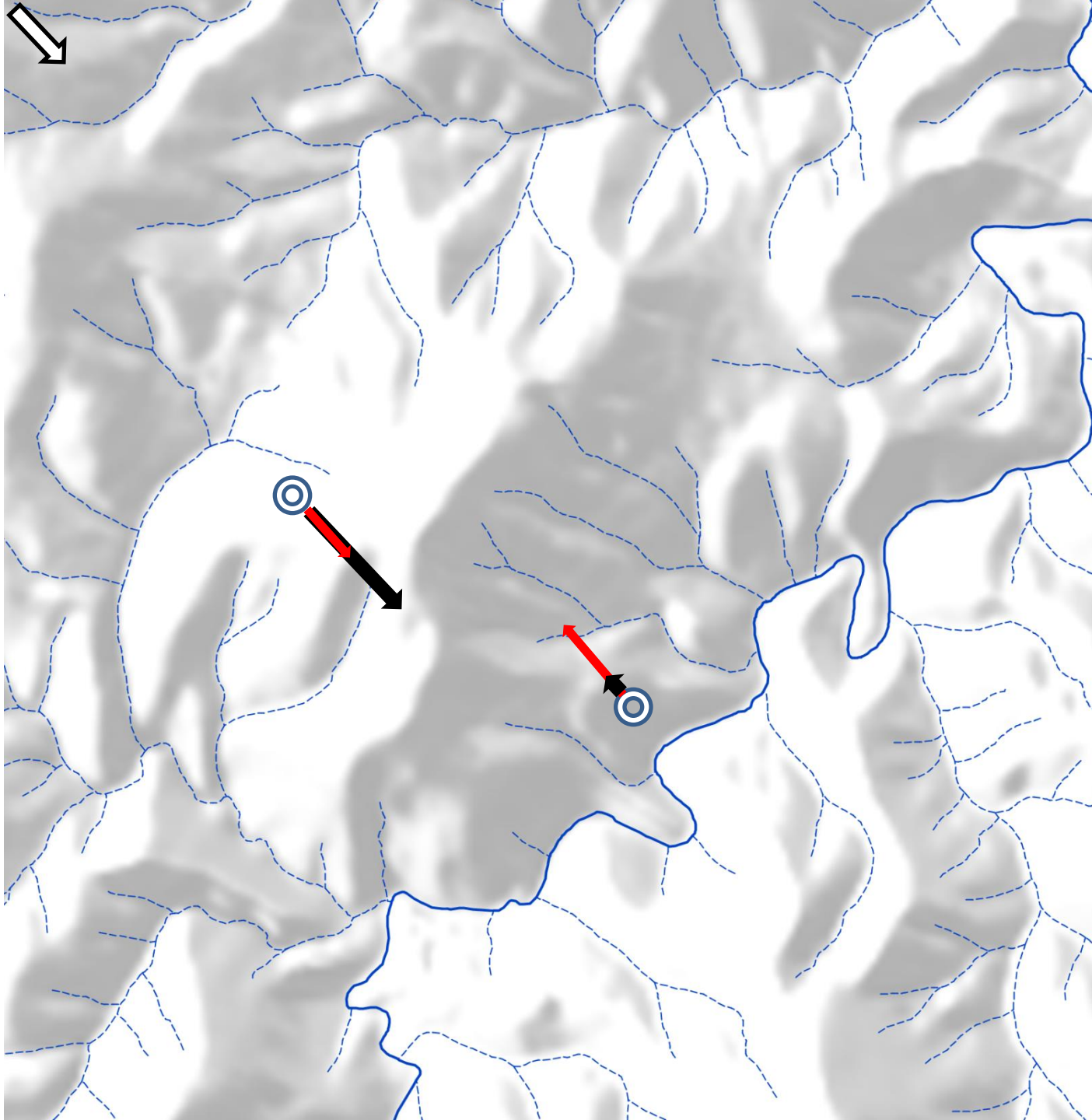
Thermal

Eddy

Channelling

Resultant

10 km/hr



12:00

Prevailing

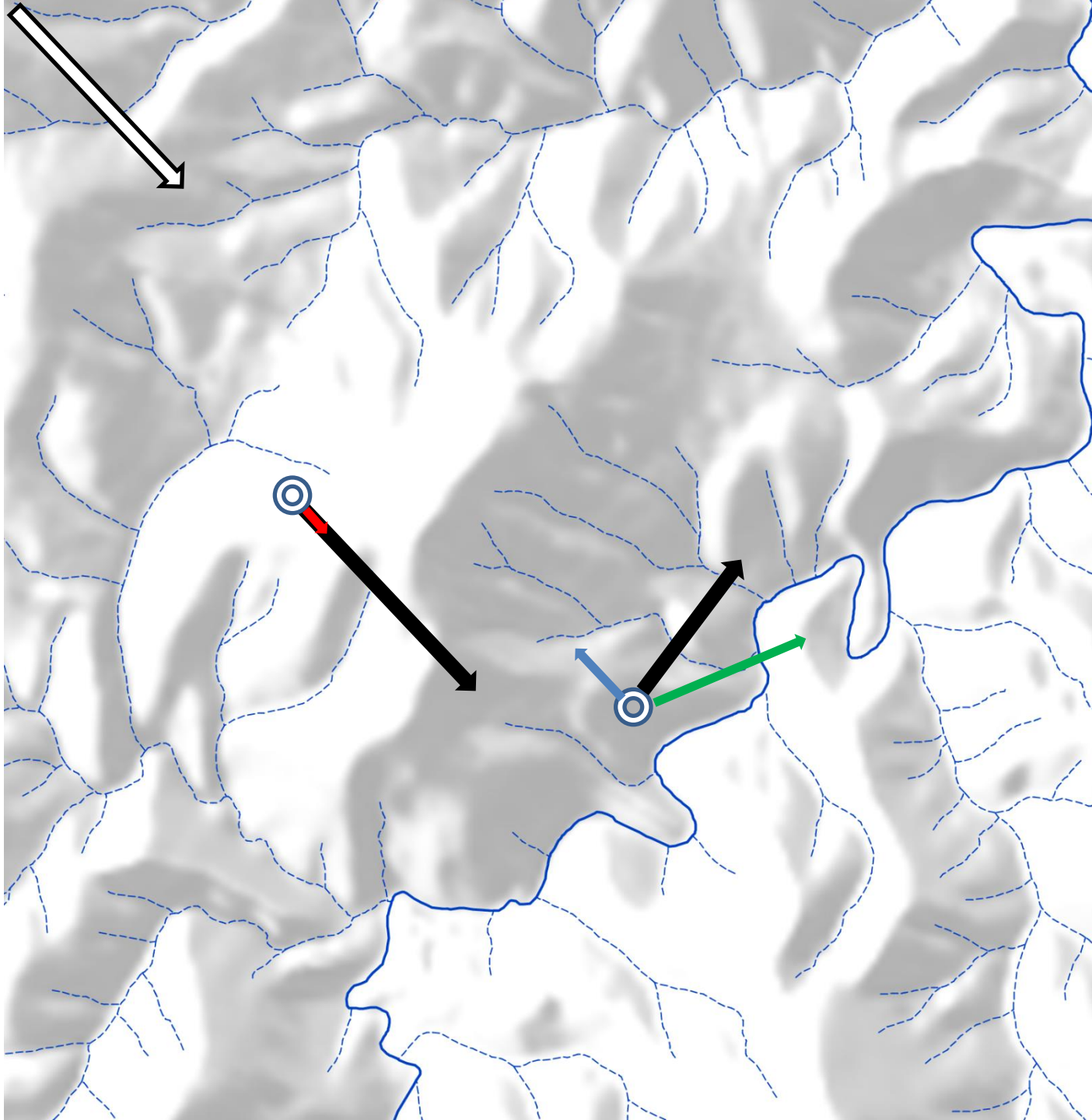
Thermal

Eddy

Channelling

Resultant

10 km/hr



15:00

Prevailing

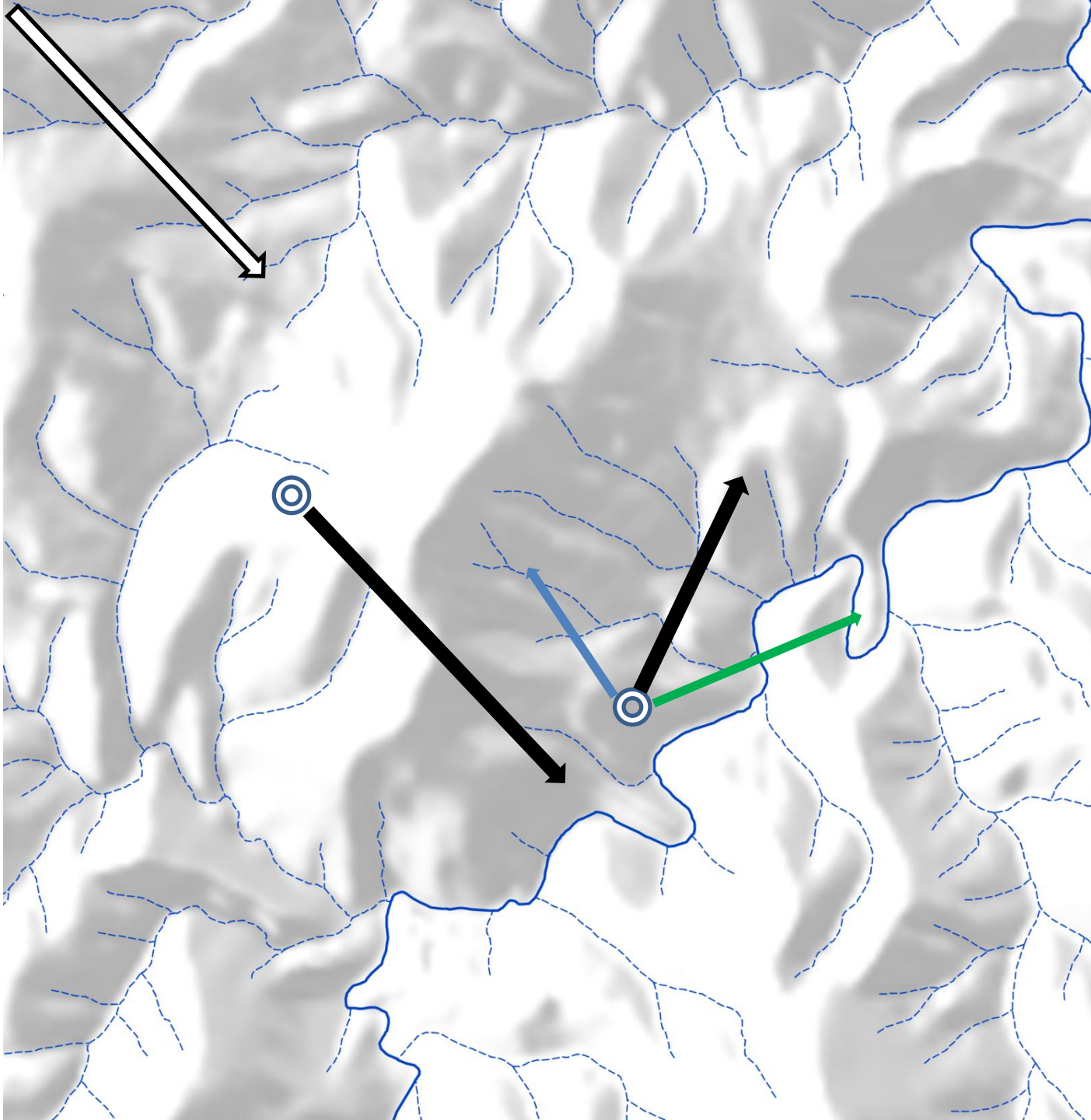
Thermal

Eddy

Channelling

Resultant

10 km/hr



20:00

Prevailing

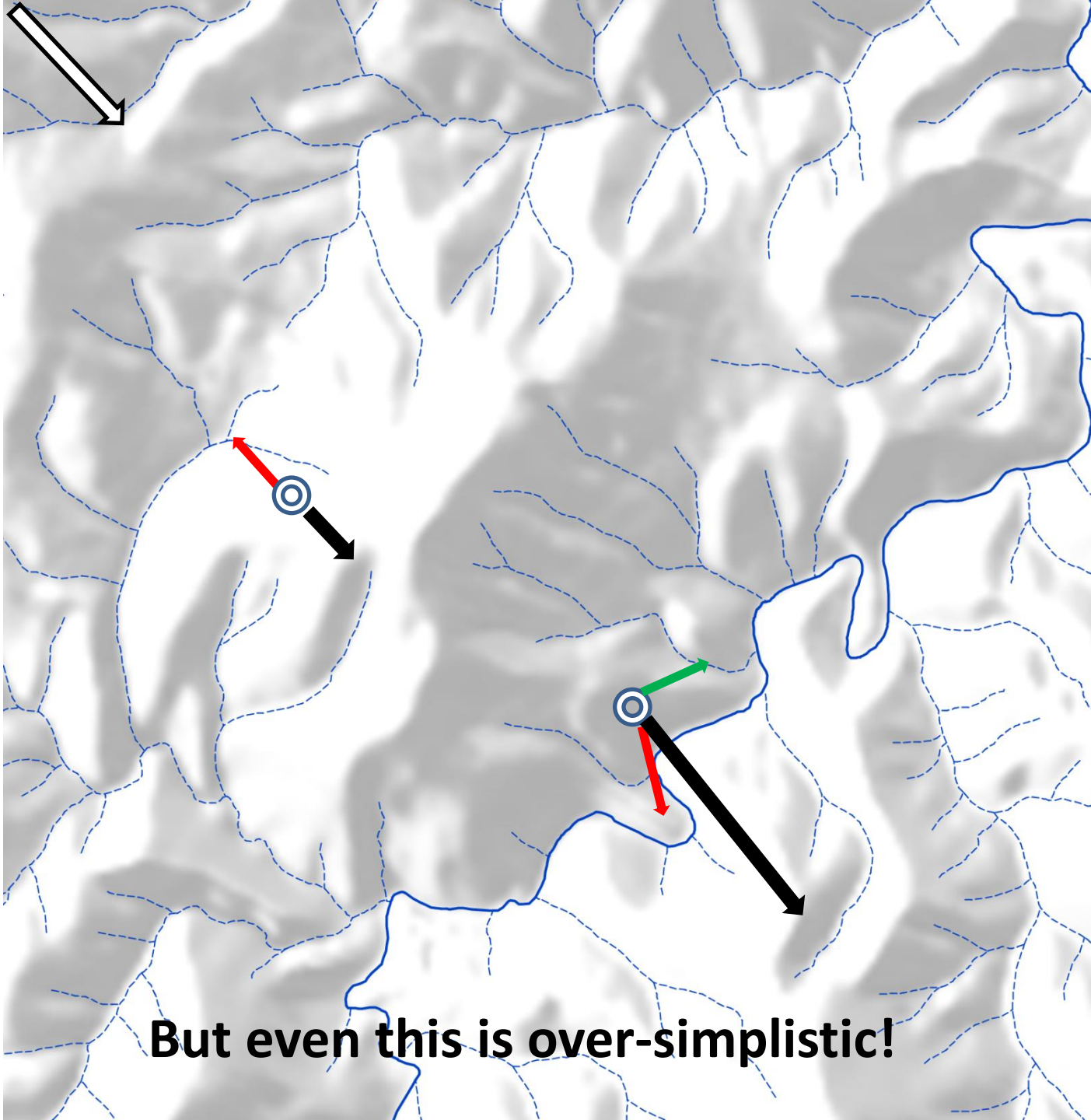
Thermal

Eddy

Channelling

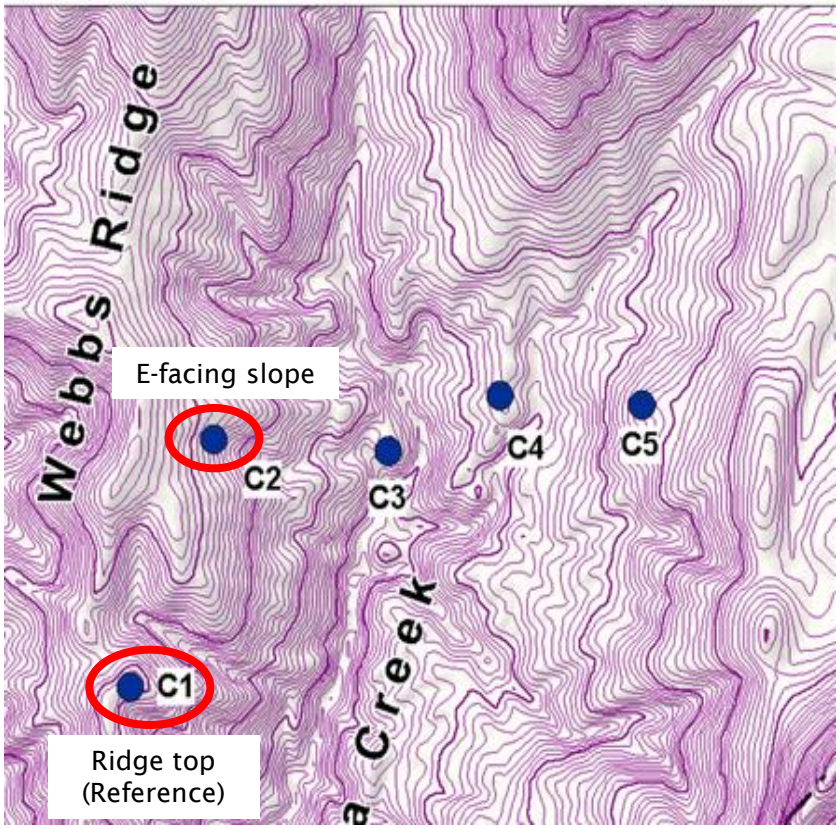
Resultant

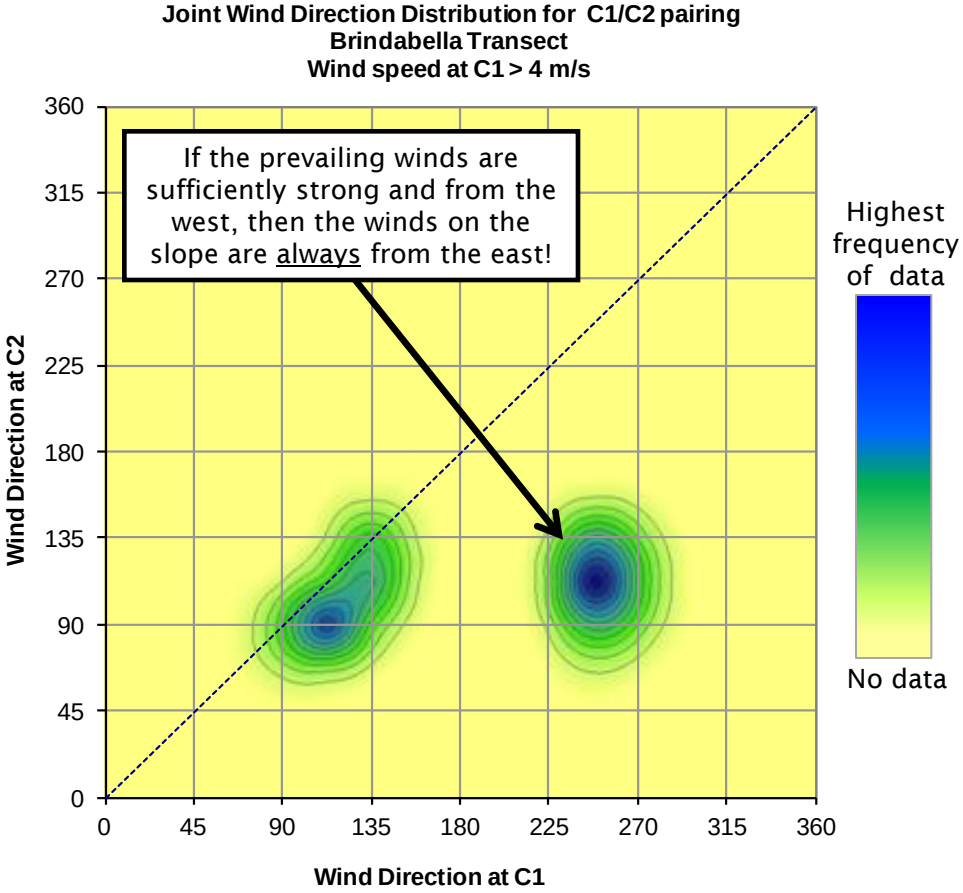
10 km/hr



But even this is over-simplistic!

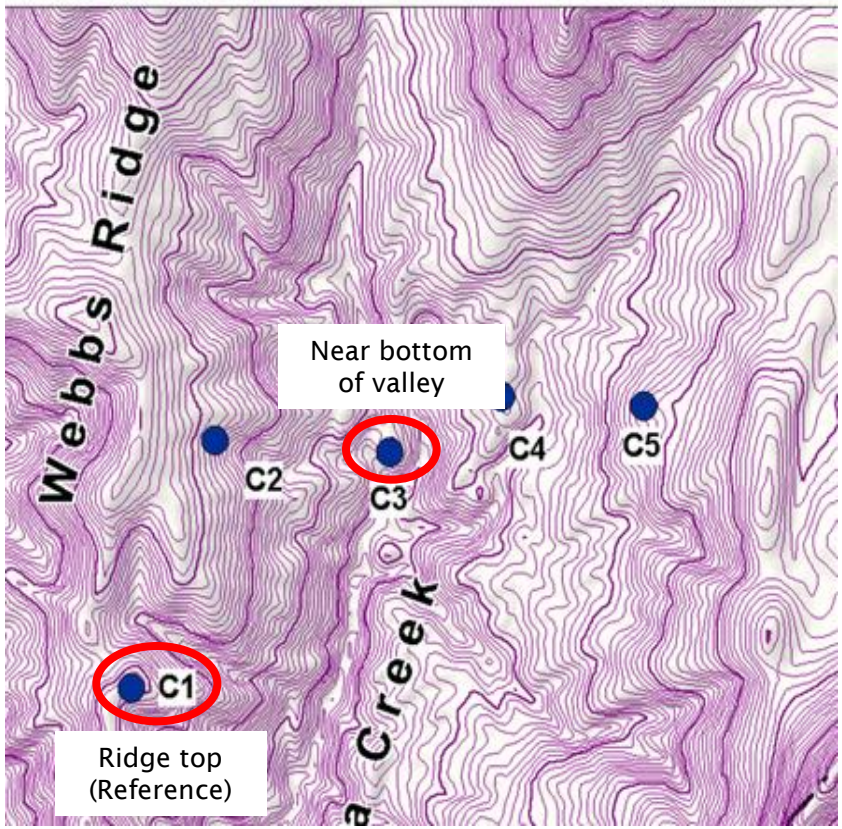
Wind reversal due to the presence of lee eddies and high wind speeds...

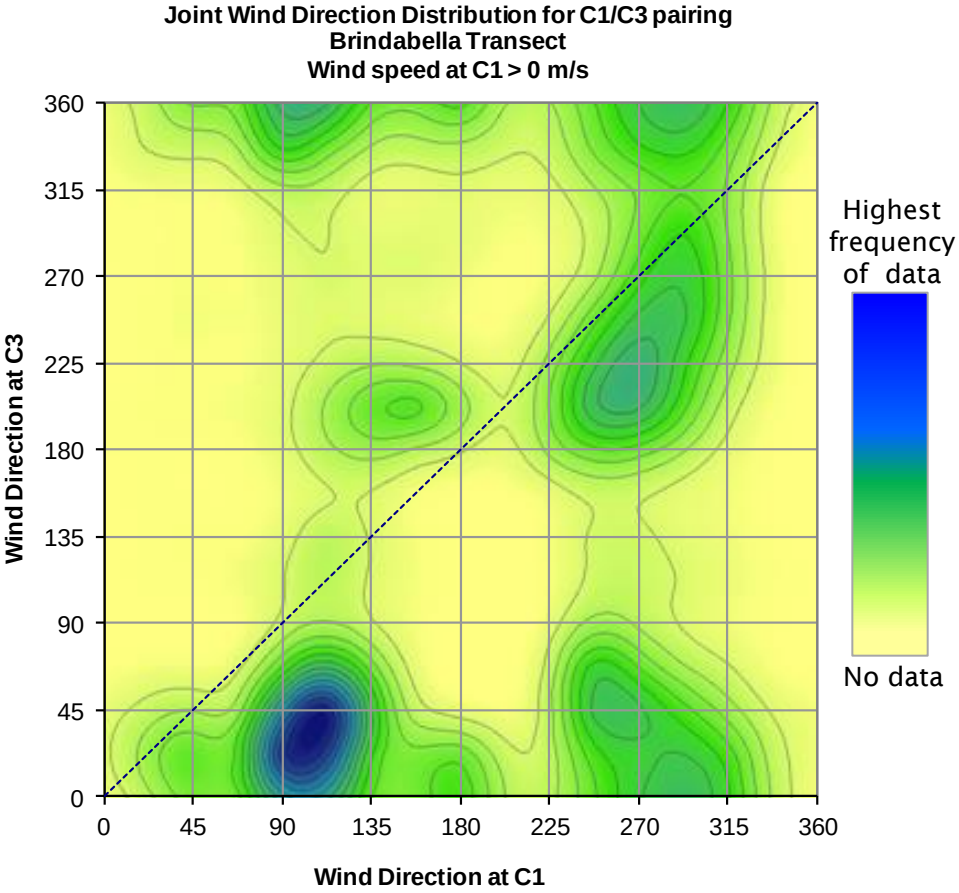




Lee eddies are prevalent!

- The local wind response (30 min average) is best characterised in probabilistic terms…





- That is, any deterministic model, regardless of how sophisticated it is, will not reflect the true nature of the system.

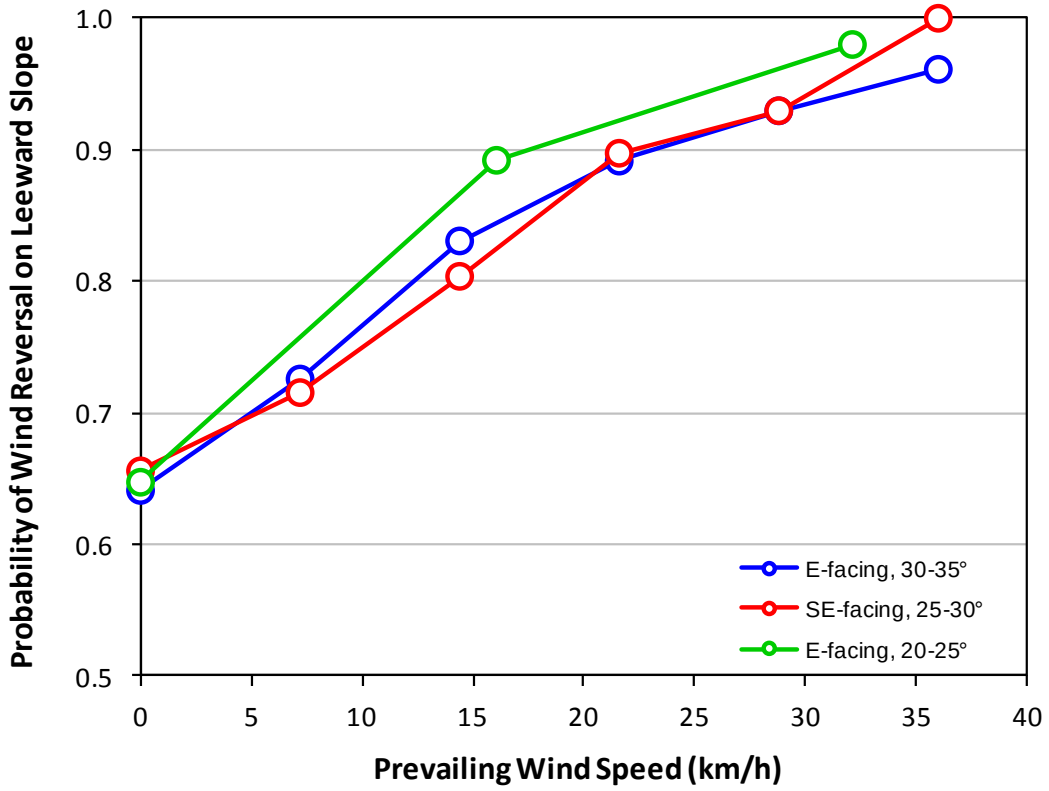
- There may be a role for ensemble forecasting?

PART 2: Leeward slope effects

Fire channelling, Tinderry Ranges, 17 Dec 2009 [Forbes]

- “Downslope” is only defined through identification of a “direction of spread”
- For wind-driven fires, downslope will typically mean leeward slope
- Lee slopes are prone to a number of effects:
  - Foehn winds
  - Dynamic channelling
  - Lee eddies

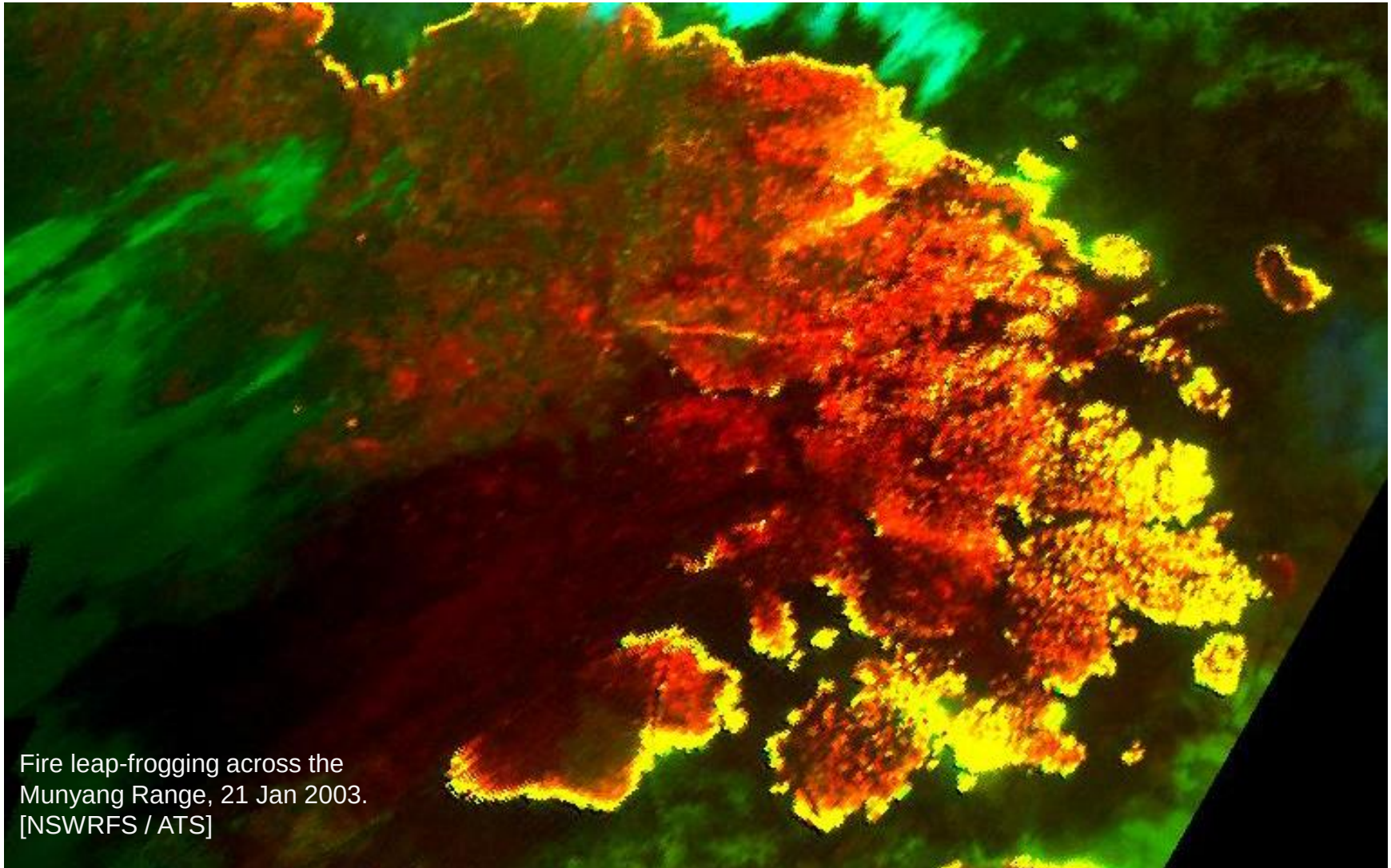
How strong is sufficiently strong...?



When winds are from the west and are stronger than about 20 km h^{-1}, there is a greater than 90% chance of a wind reversal on easterly aspects with slopes over 20°.

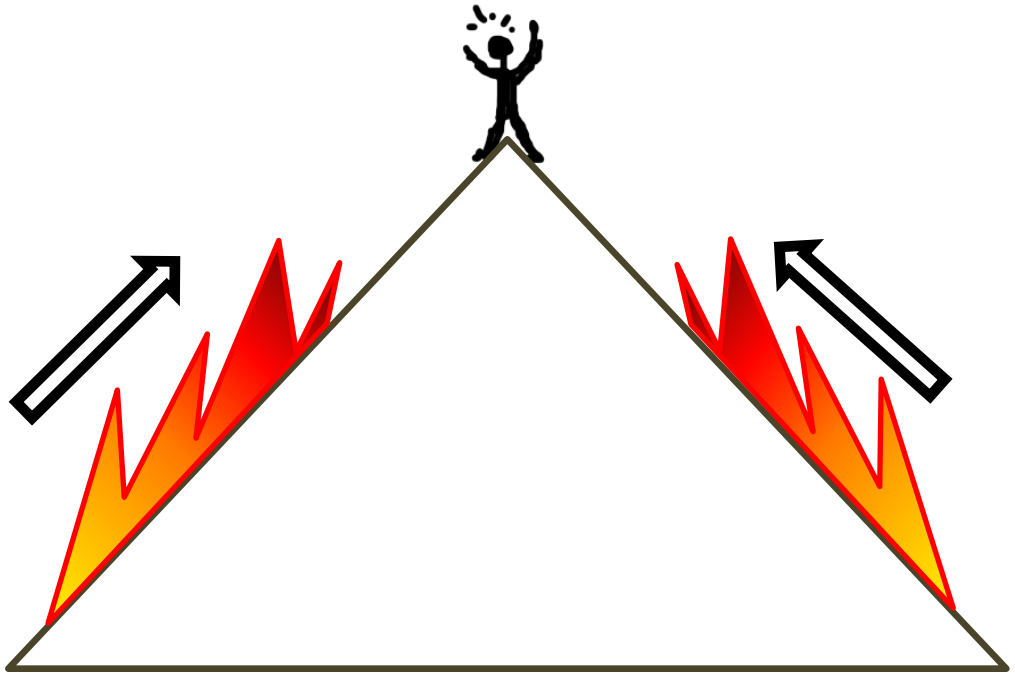
* Data are from east-facing slopes in the Brindabella Ranges (west of Canberra)

- Consequences of wind reversal
  - Fire intensity determines ember production and hence spot fire occurrence



Fire leap-frogging across the Munyang Range, 21 Jan 2003. [NSWRFS / ATS]

- Consequences of wind reversal
  - Both windward and leeward slopes have wind and slope effects in alignment and thus both contribute to fire intensity in a similar way (i.e. No respite on downslope!)



- Consequences of wind reversal
  - Dynamic interactions between wind, terrain and fire can lead to atypical fire spread…

PART 3: Consequences

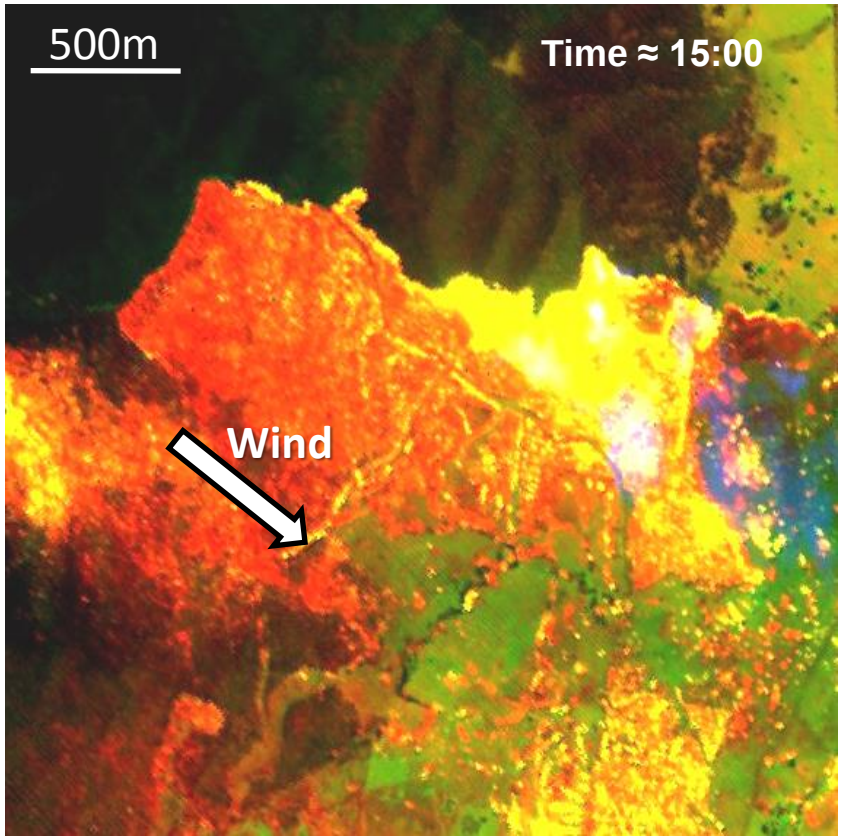
- Video

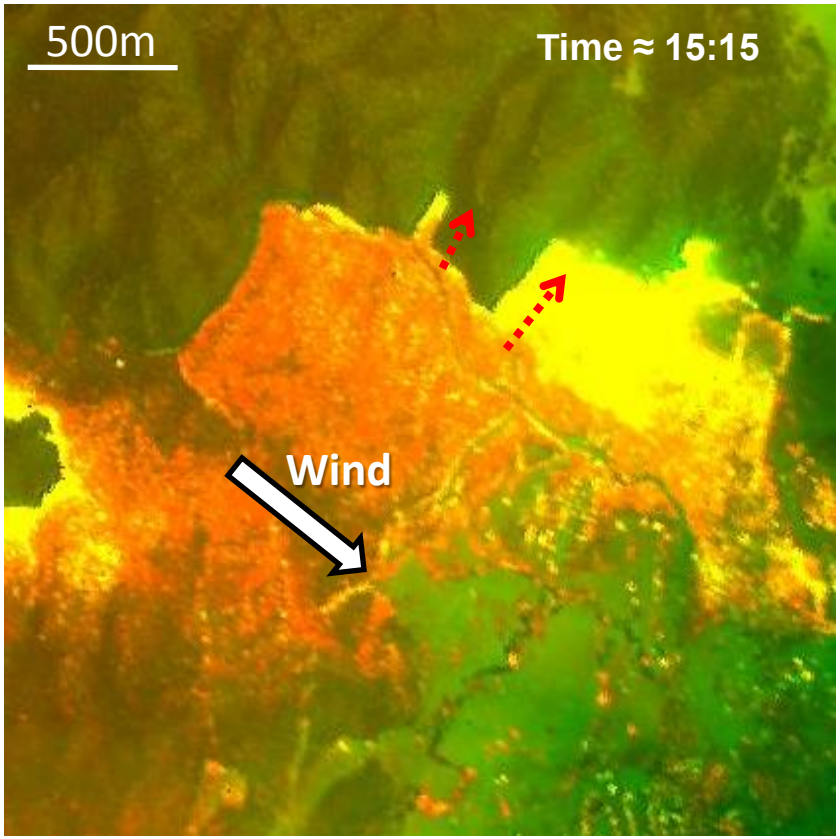
Fontenelle Fire, Wyoming. June 2012.

- Fire channelling
  - Fire channelling refers to rapid, bidirectional fire development across and downwind of a leeward slope.

- Recent research has indicated that fire channelling is vorticity-driven.

- McIntyre's Hut fire, west of Canberra 18 January 2003

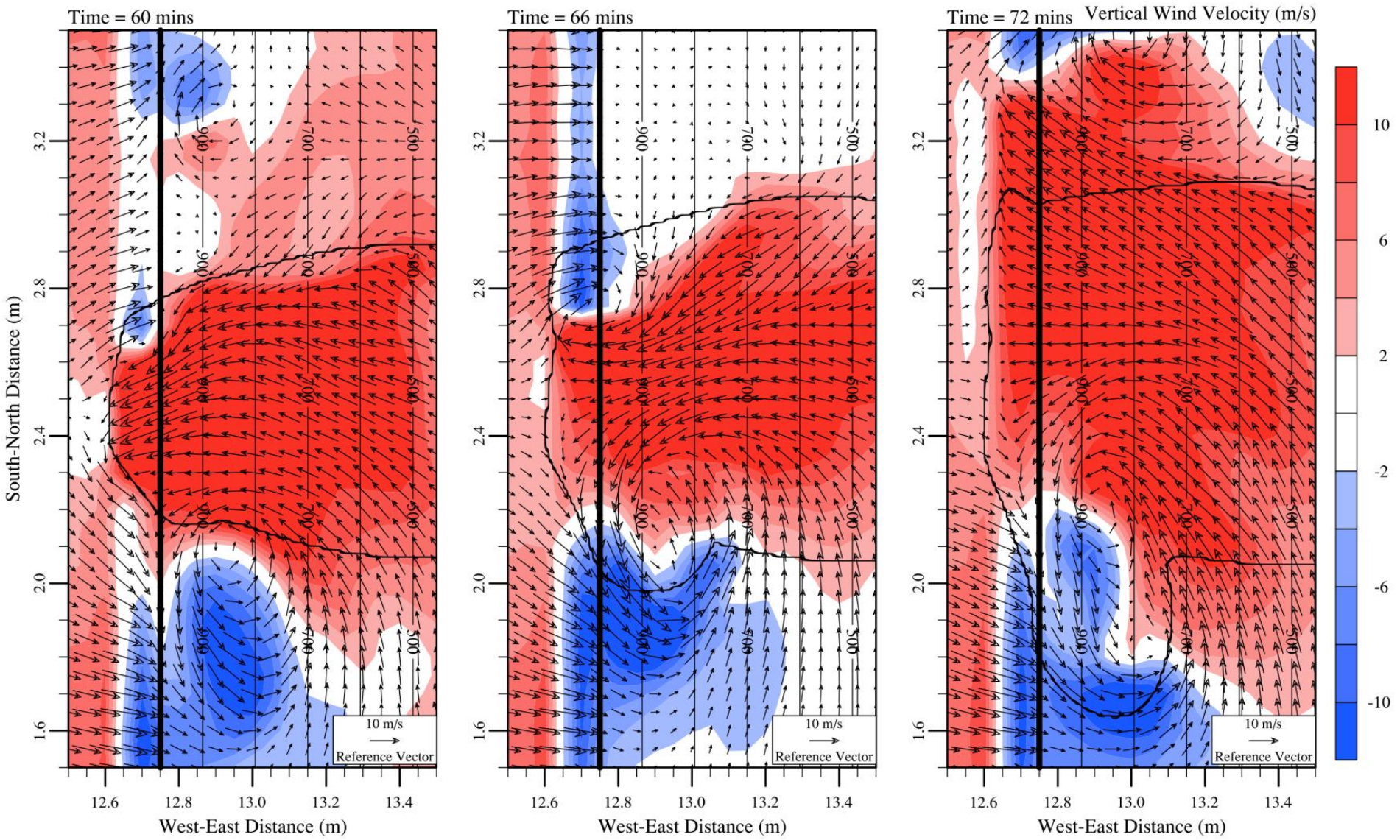




Lateral rates of spread (across the wind) of about 0.5 – 1.0 km/h

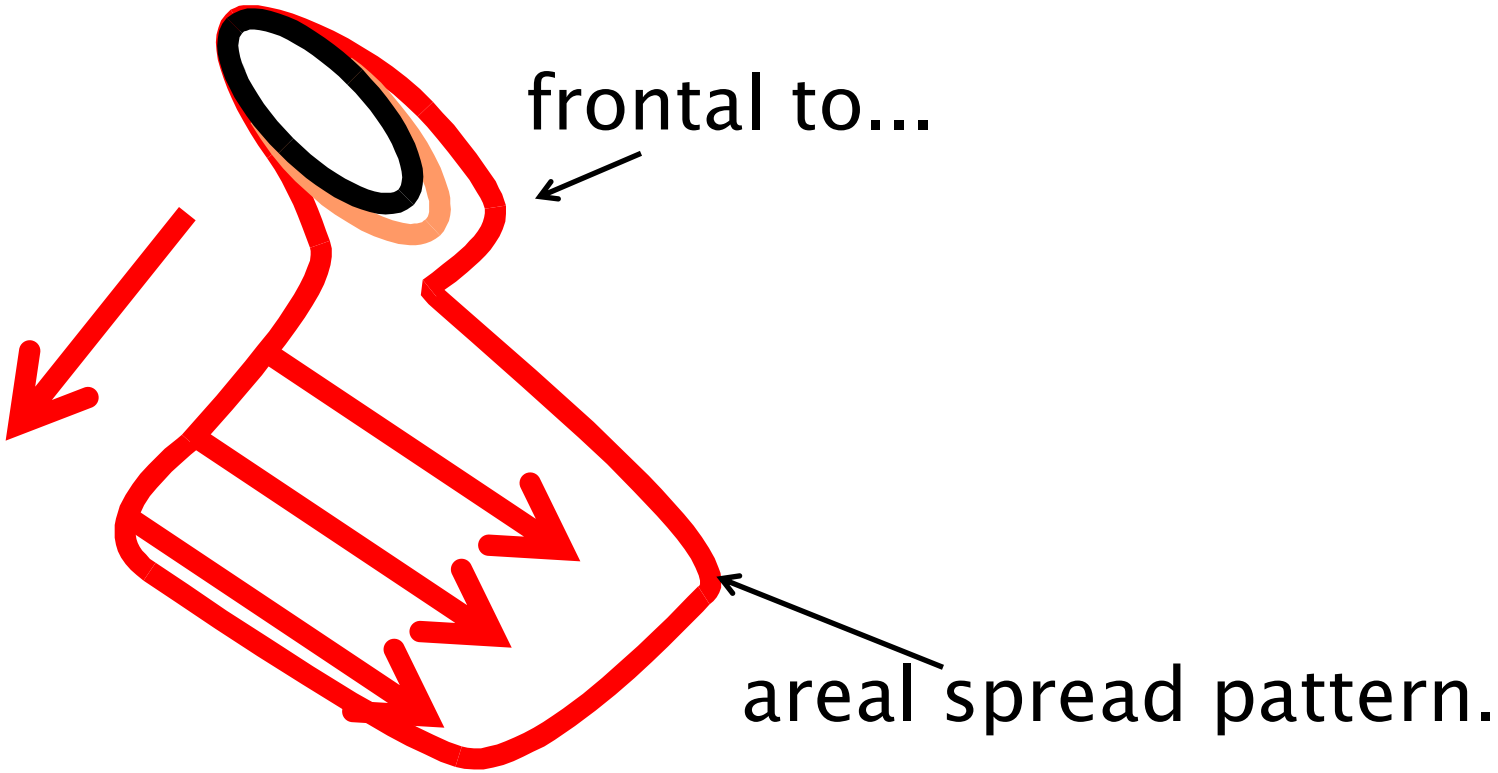
Fire channelling, Pig Hill.
18 Jan 2003. [NSWRFS / ATS]

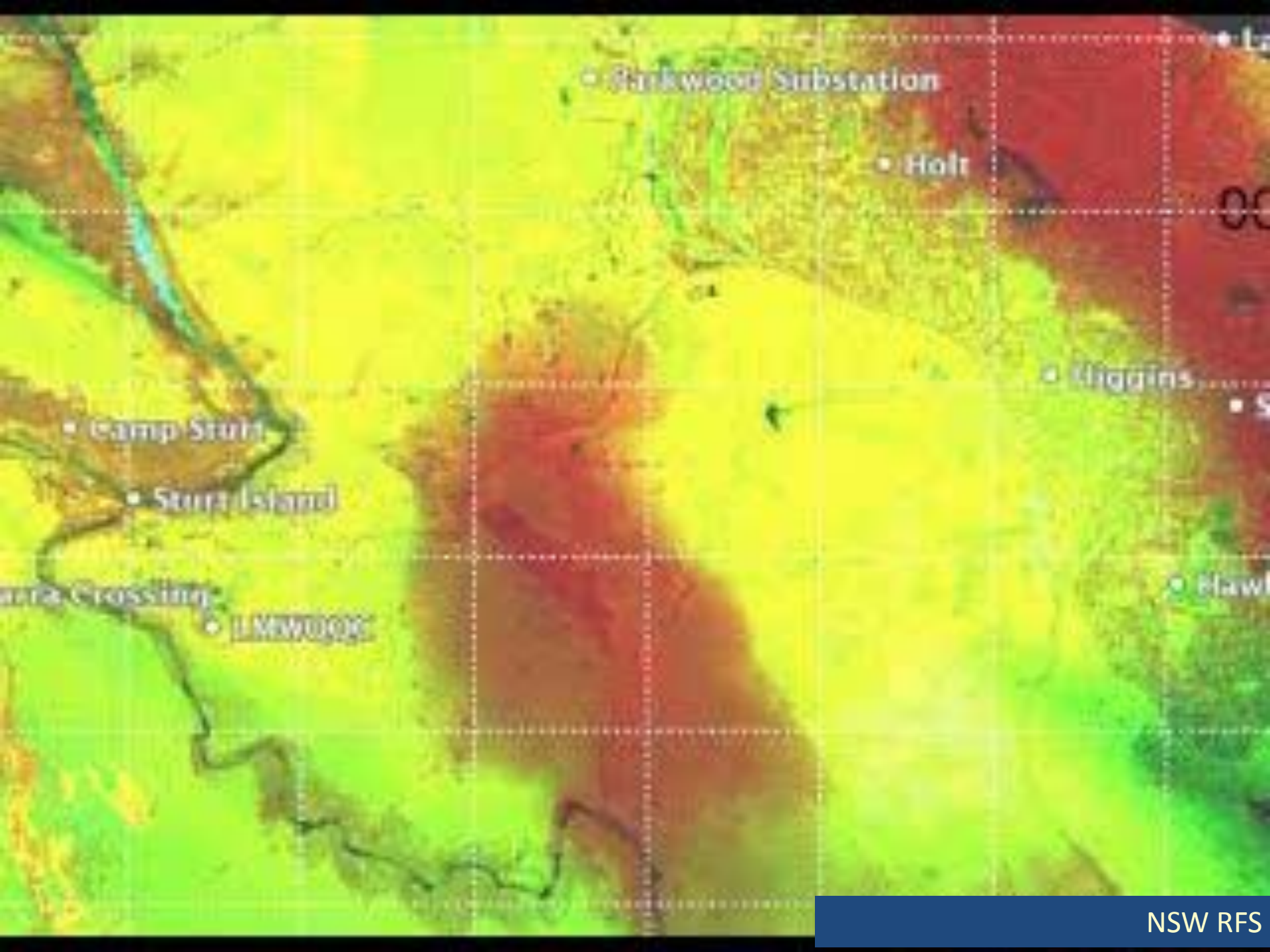
Vorticity-Driven Lateral Spread



- Impacts of fire channelling on fire spread

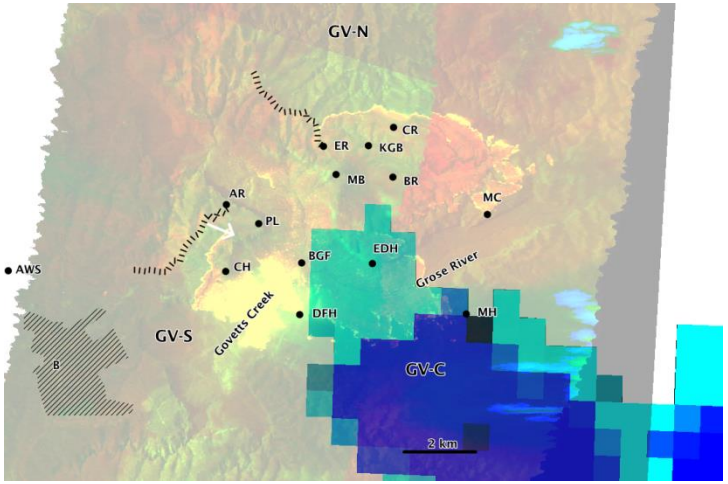
Bi-directional spread = change from...

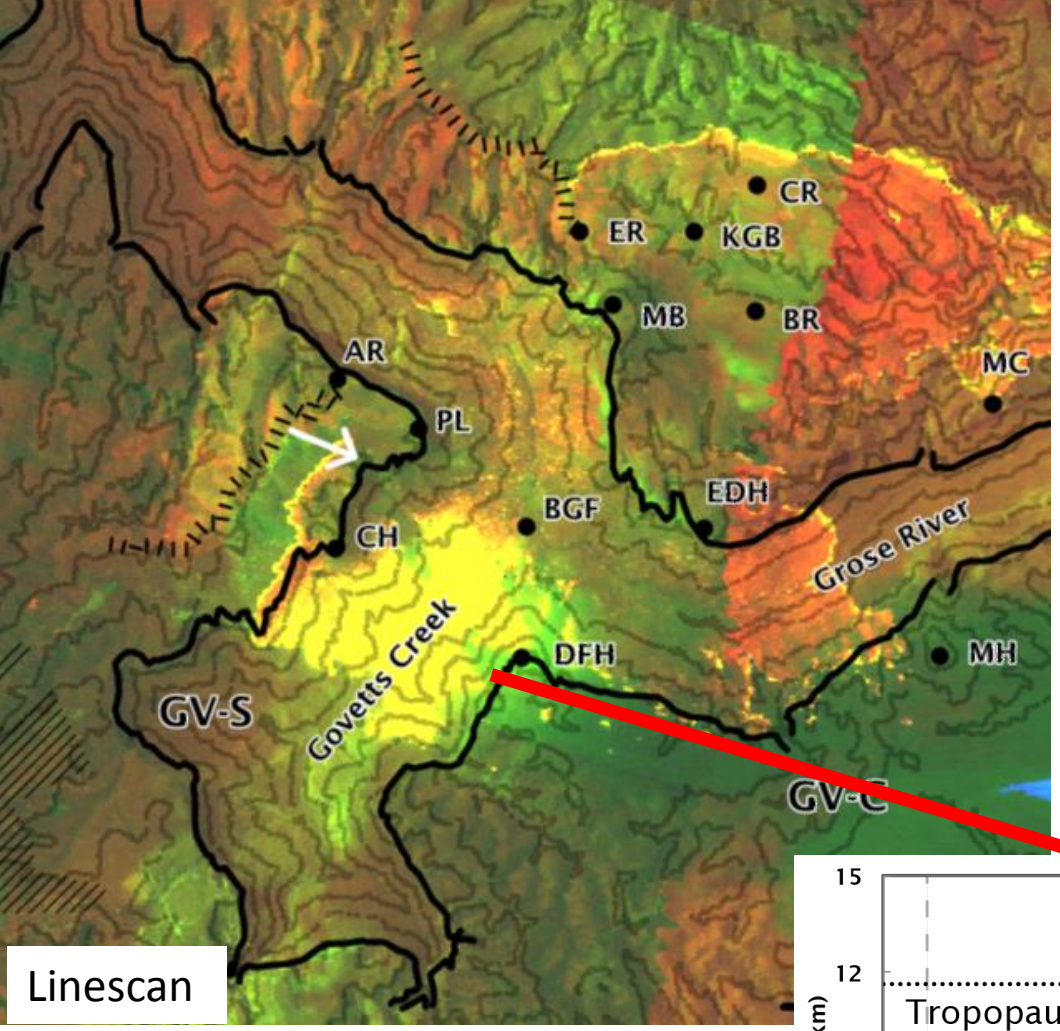



Parkwood Substation
Holt
Higgins
Camp Stuart
Stuart Island

NSW RFS

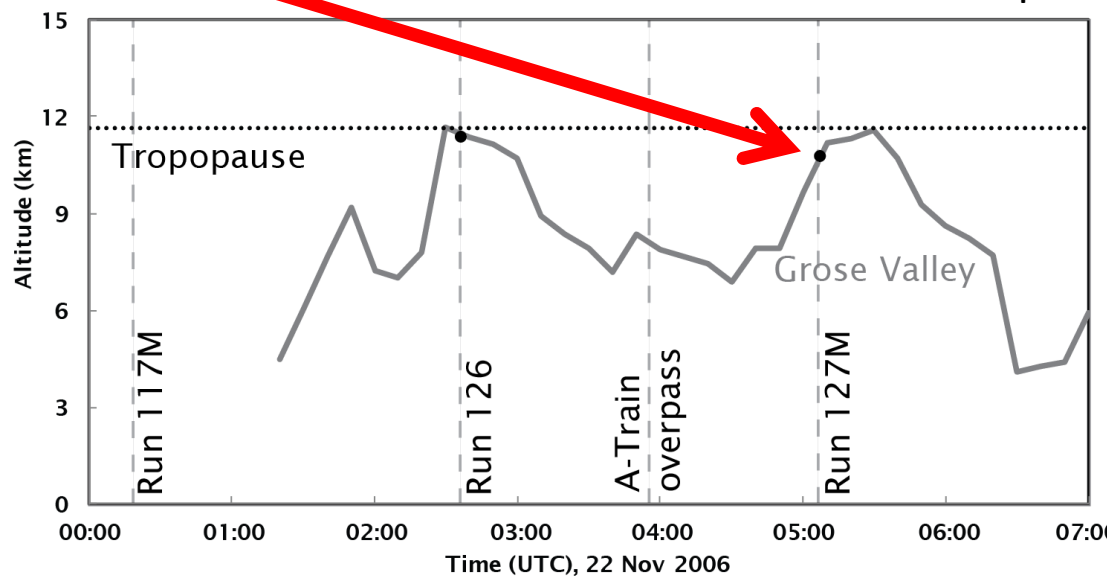
Linescan overlaid with radar reflectivity





Linescan

Radar echotops



Grose Valley, 2006

- A precursor to this blow-up fire event was an overnight foehn wind. This also produced escalation earlier in the day than may otherwise have been expected.

Bottom Line

- Beyond common perceptions, downslope winds can complicate the prediction of fire spread, and can result in conditions conducive to fire blow-up.

- There is a clear need for tools to forecast blow-up fire events. See our poster for a first-cut at this.

Questions?

(Quietly now!
Let the other easterners sleep!)