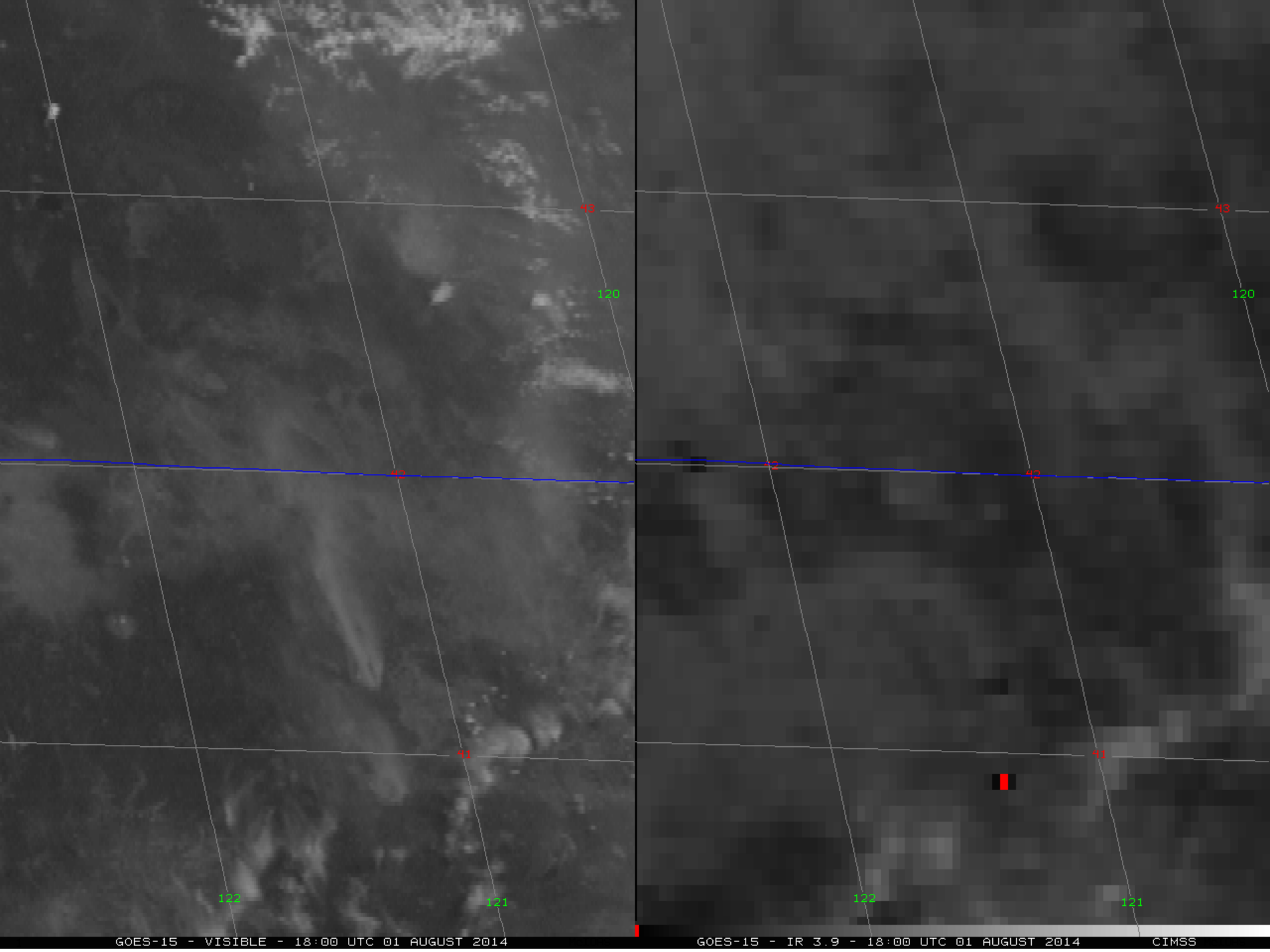
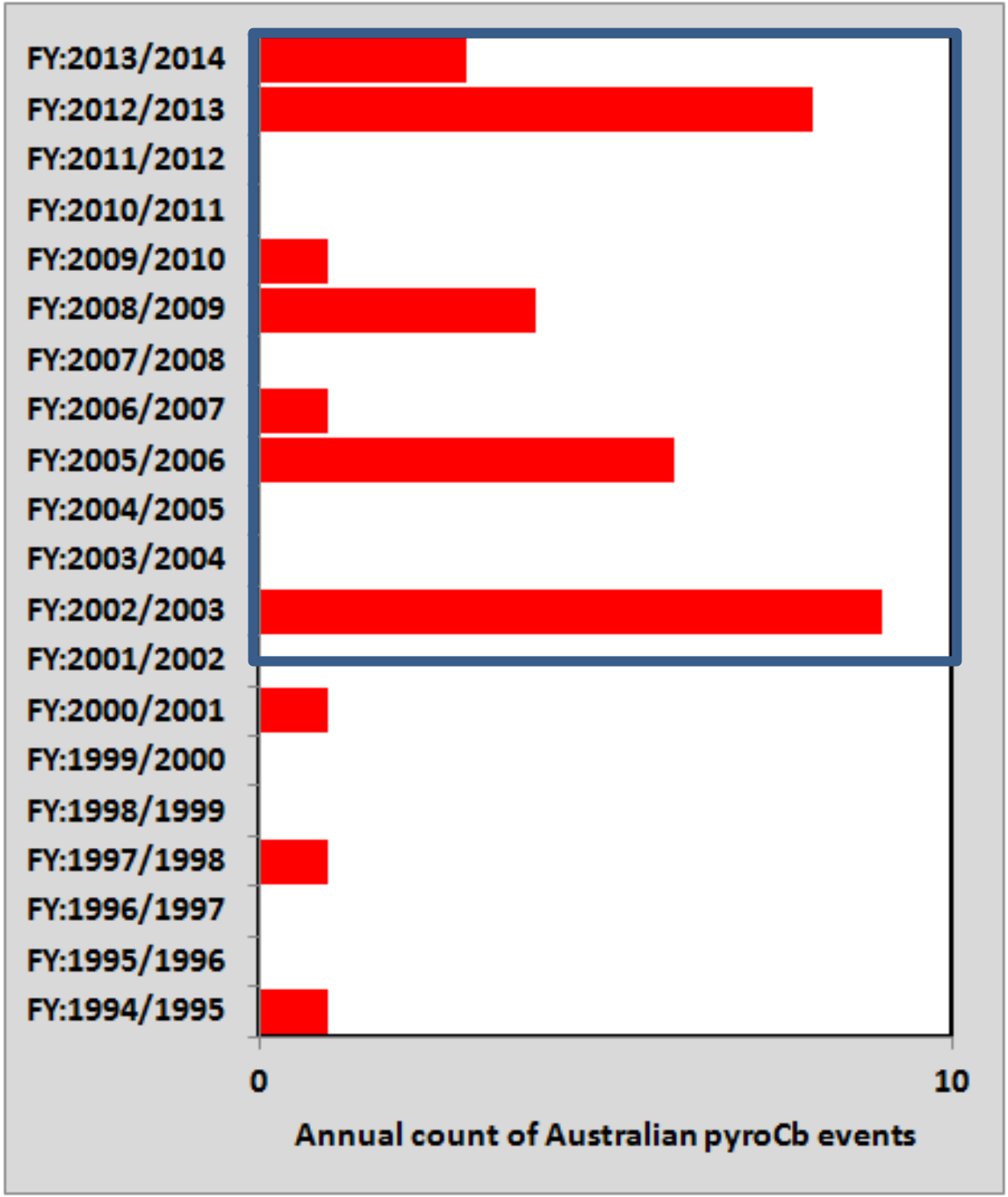
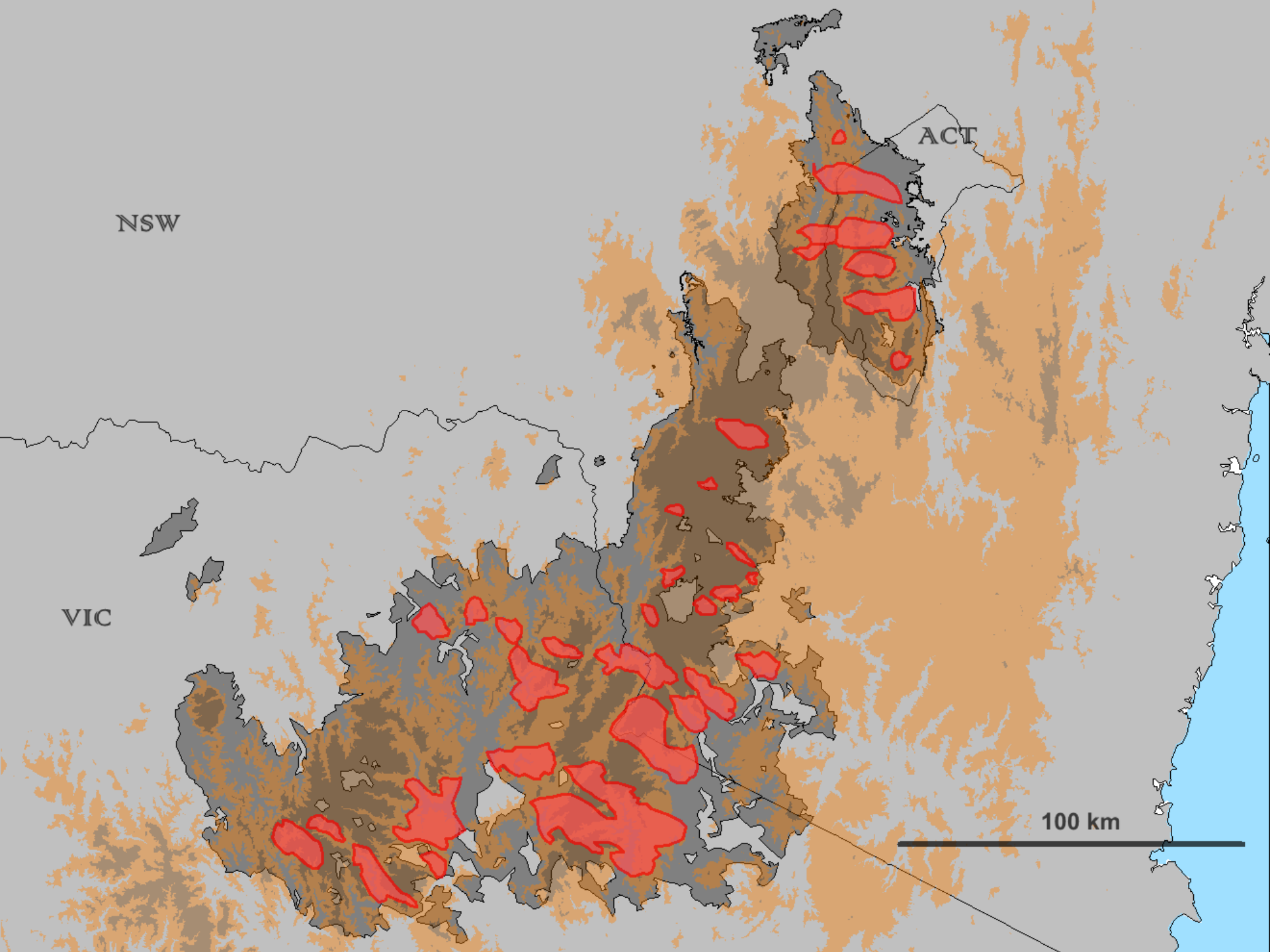
LINKING LOCAL WILDFIRE DYNAMICS TO PYROCB DEVELOPMENT

Rick McRae, ACT Emergency Services Agency, Canberra,
Jason Sharples, University of NSW, Canberra,
Mike Fromm &
Pat Kablick, Naval Research Laboratory, Washington.


43
120
42
41
122
121
GOES-15 - VISIBLE - 18:00 UTC 01 AUGUST 2014
43
120
42
41
122
121
GOES-15 - IR 3.9 - 18:00 UTC 01 AUGUST 2014
CIMSS

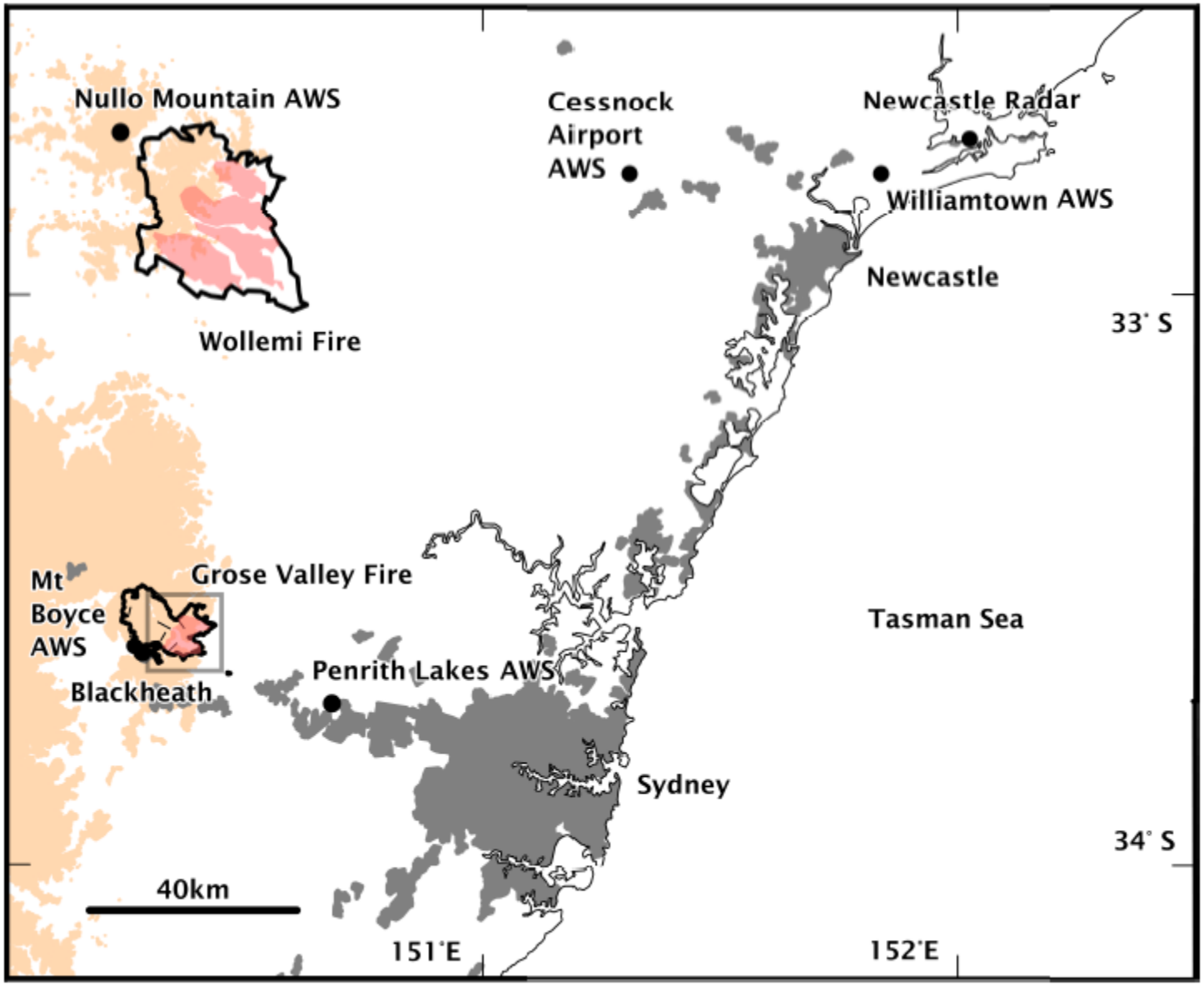

FY:2013/2014
FY:2012/2013
FY:2011/2012
FY:2010/2011
FY:2009/2010
FY:2008/2009
FY:2007/2008
FY:2006/2007
FY:2005/2006
FY:2004/2005
FY:2003/2004
FY:2002/2003
FY:2001/2002
FY:2000/2001
FY:1999/2000
FY:1998/1999
FY:1997/1998
FY:1996/1997
FY:1995/1996
FY:1994/1995
0
10
Annual count of Australian pyroCb events

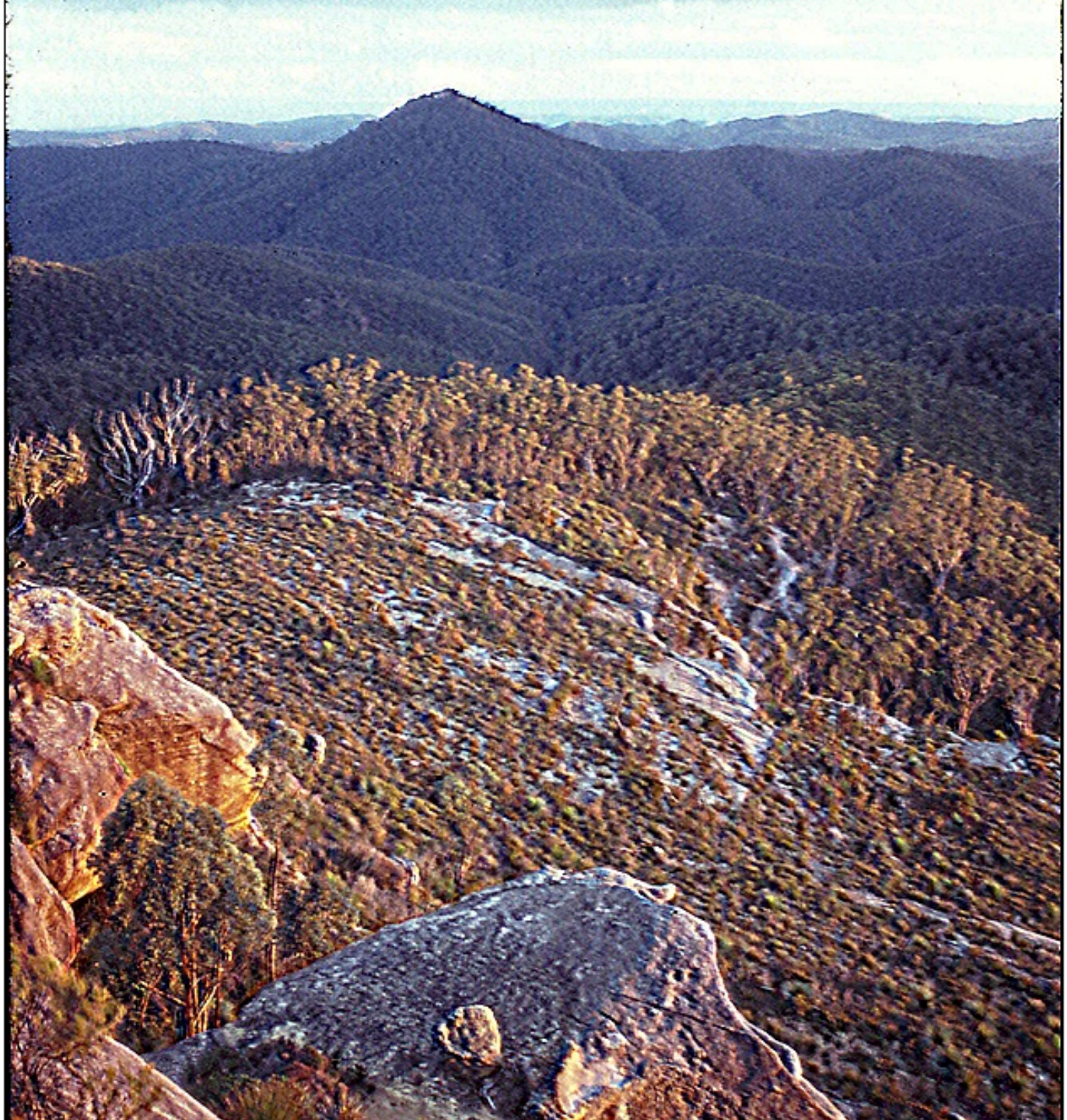

ACT
NSW
VIC
100 km

The pyroCbs in the 2003 ACT Fires validated the Nuclear Winter Hypothesis.

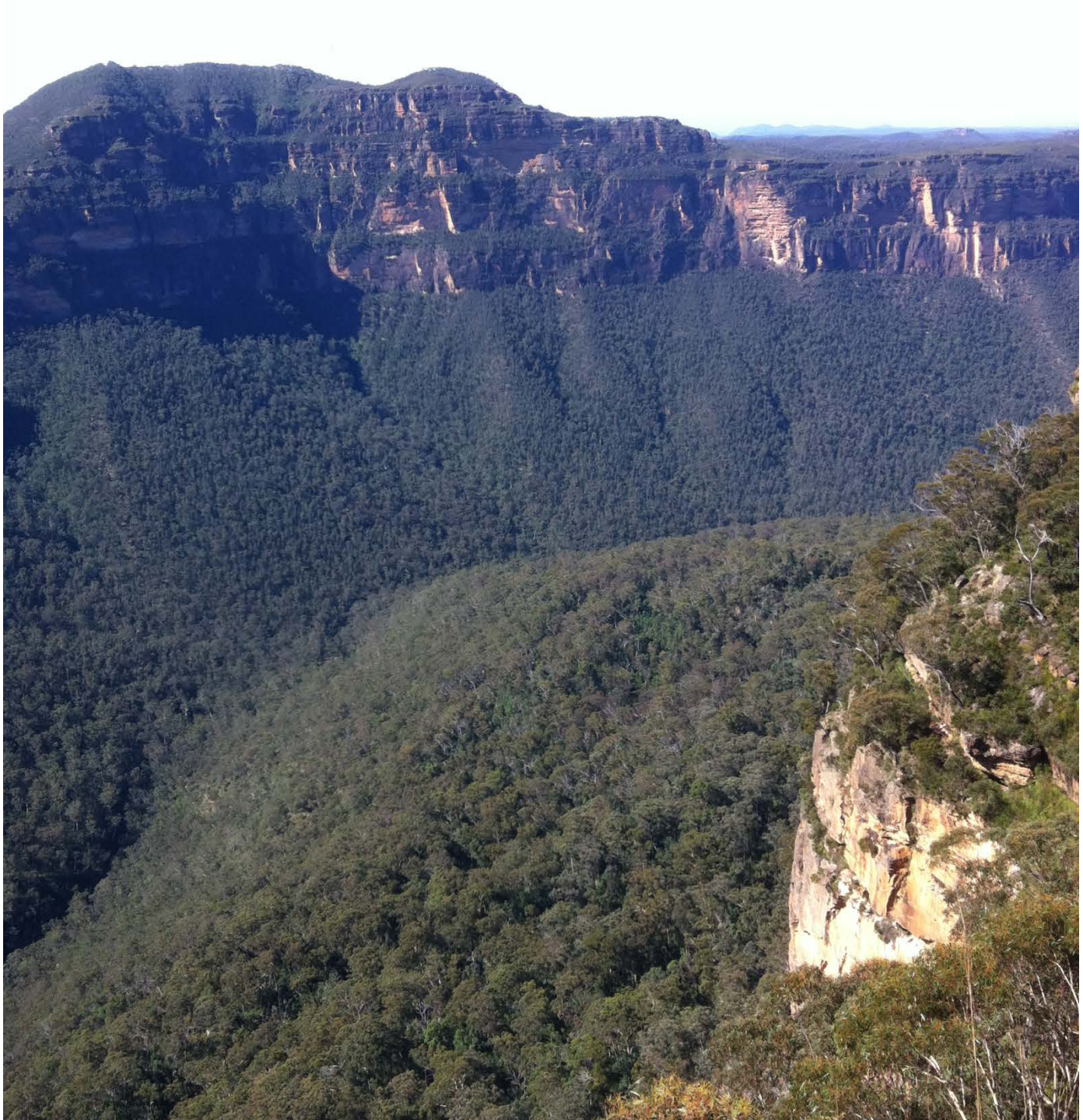
PAPER 1

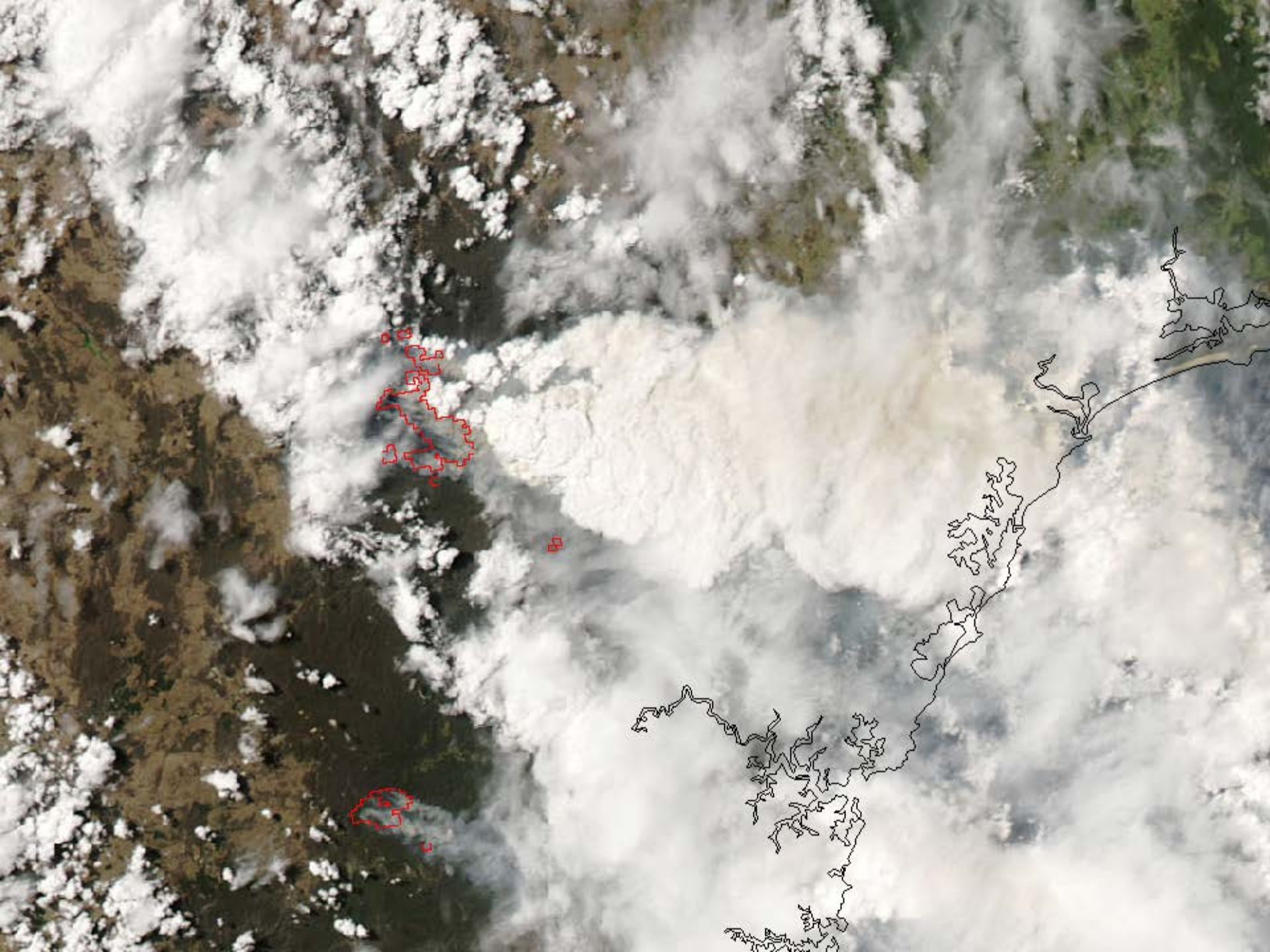
- Fromm, M.D., McRae, R.H.D., Sharples, J.J. & Kablick, G.P. (2012). Pyrocumulonimbus pair in Wollemi and Blue Mountains National Parks, 22 November 2006. *Australian Meteorological and Oceanographic Journal,* **62,** 117–126.

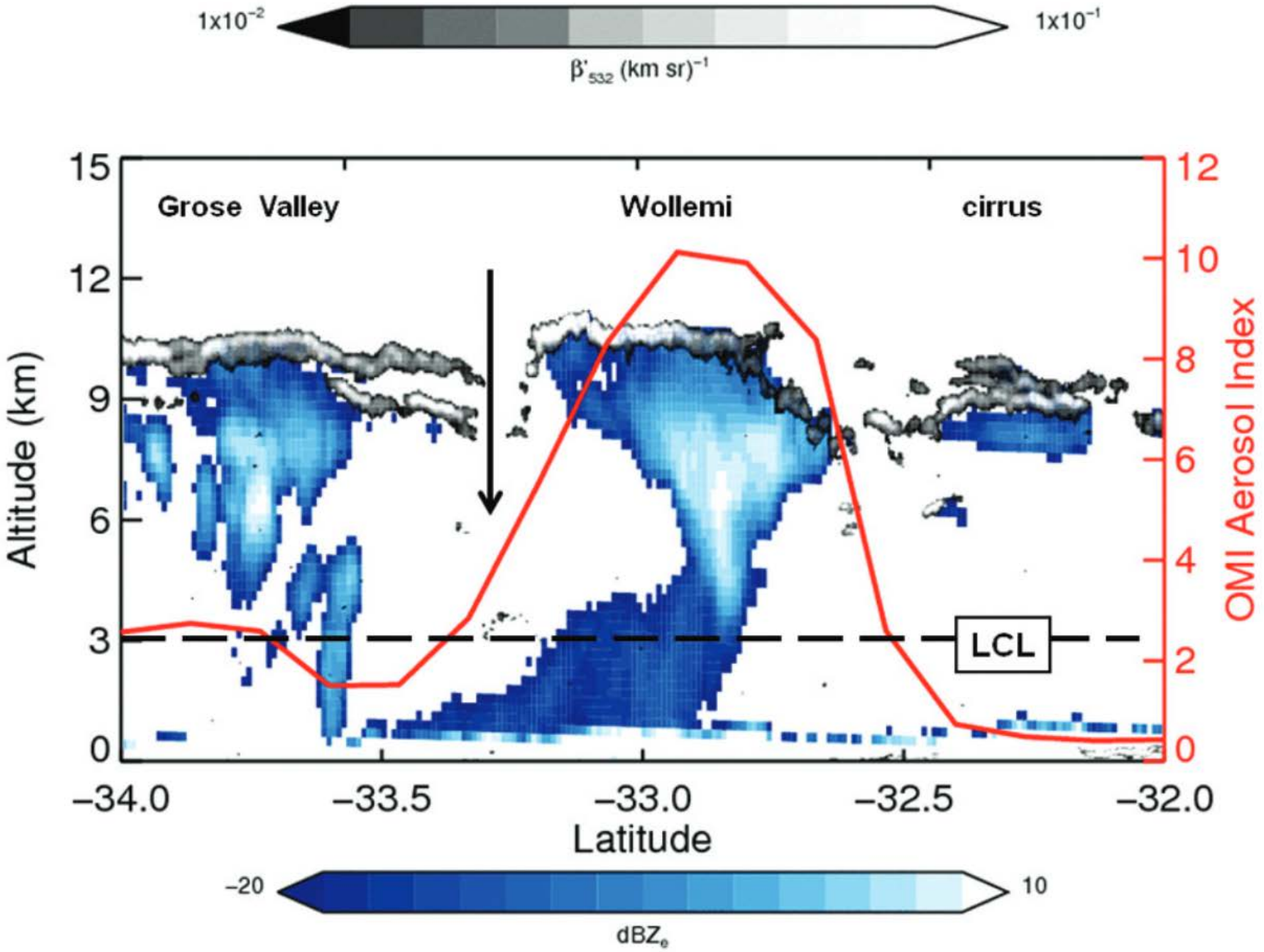

Nullo Mountain AWS
Cessnock
Airport
AWS
Newcastle Radar
Williamtown AWS
Newcastle
Wollemi Fire
33° S
Mt
Boyce
AWS
Grose Valley Fire
Tasman Sea
Penrith Lakes AWS
Blackheath
Sydney
34° S
40km
151°E
152°E

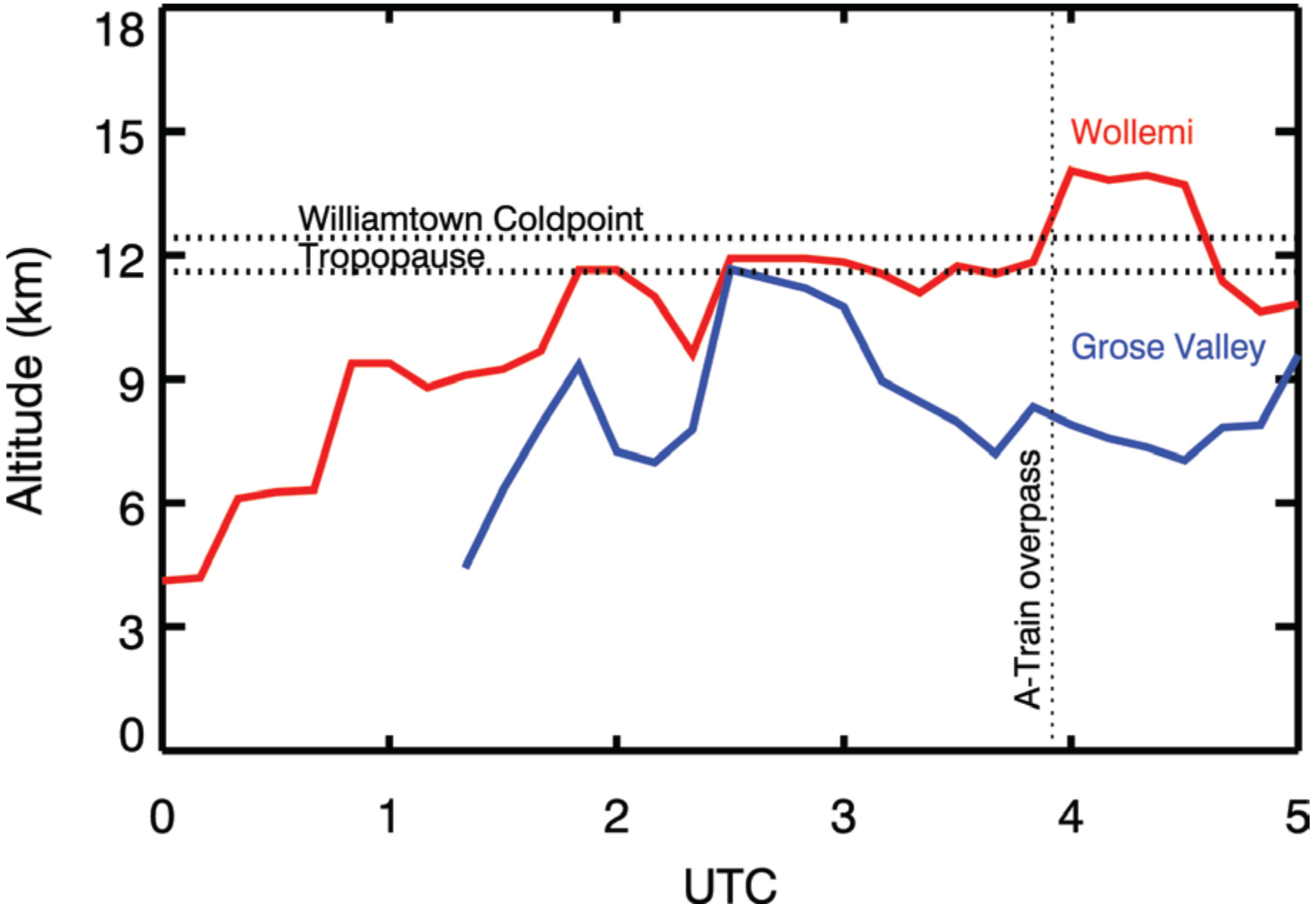



VH-PWS



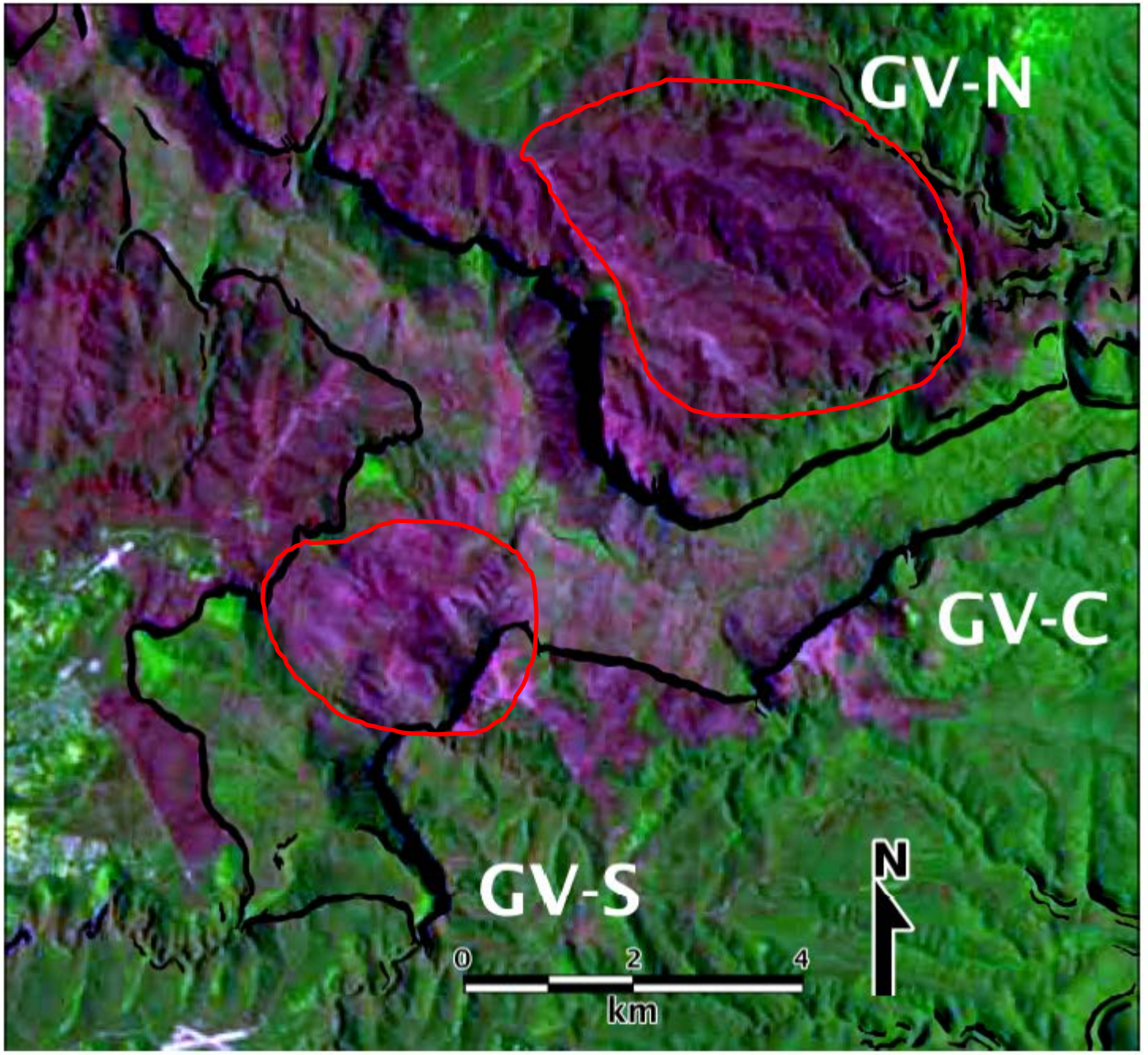


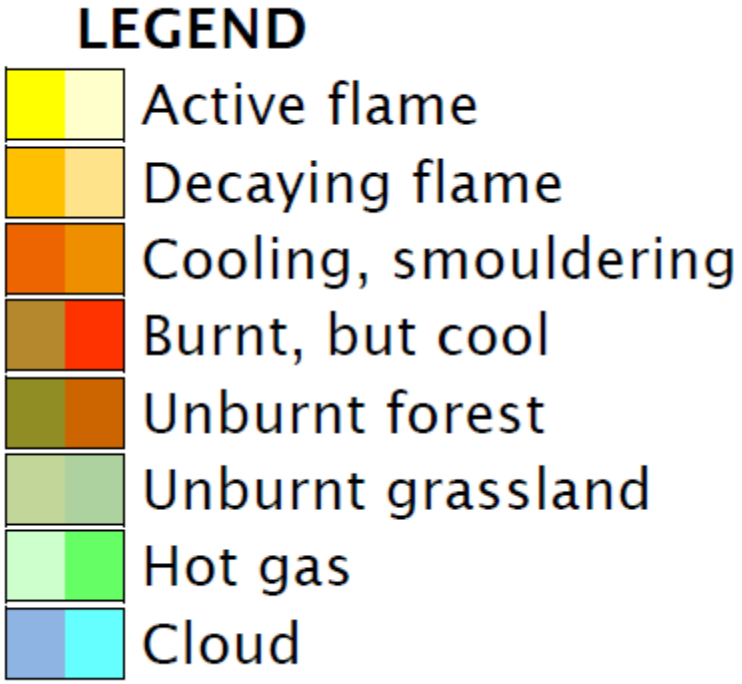

1x10⁻²
1x10⁻¹
β'532 (km sr)⁻¹
Grose Valley
Wollemi
cirrus
LCL
Altitude (km)
OMI Aerosol Index
Latitude
−34.0
−33.5
−33.0
−32.5
−32.0
0
3
6
9
12
15
0
2
4
6
8
10
12
−20
10
dBZe

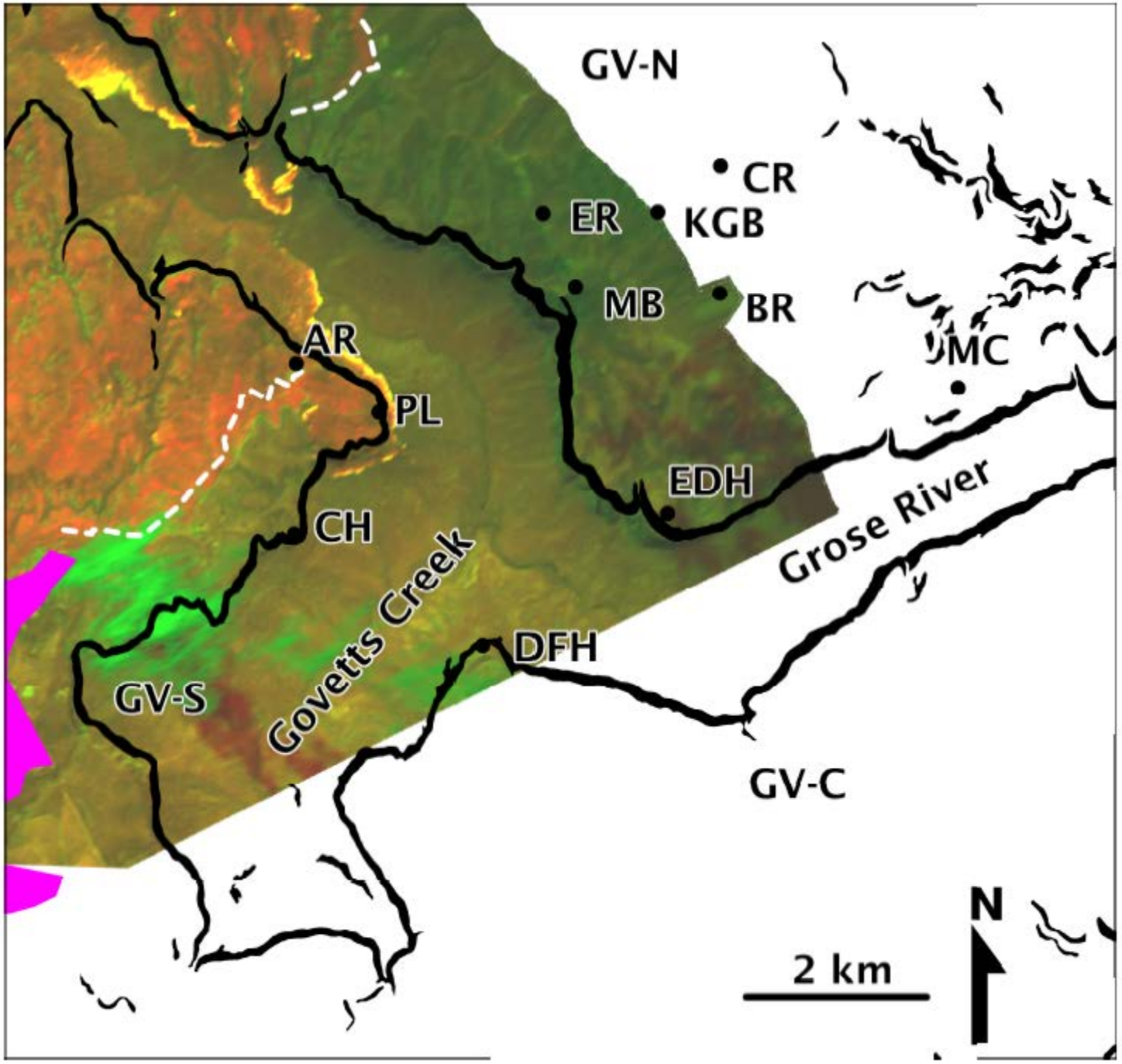

Altitude (km)
18
15
12
9
6
3
0
Williamtown Coldpoint
Tropopause
Wollemi
Grose Valley
A-Train overpass
0
1
2
3
4
5
UTC

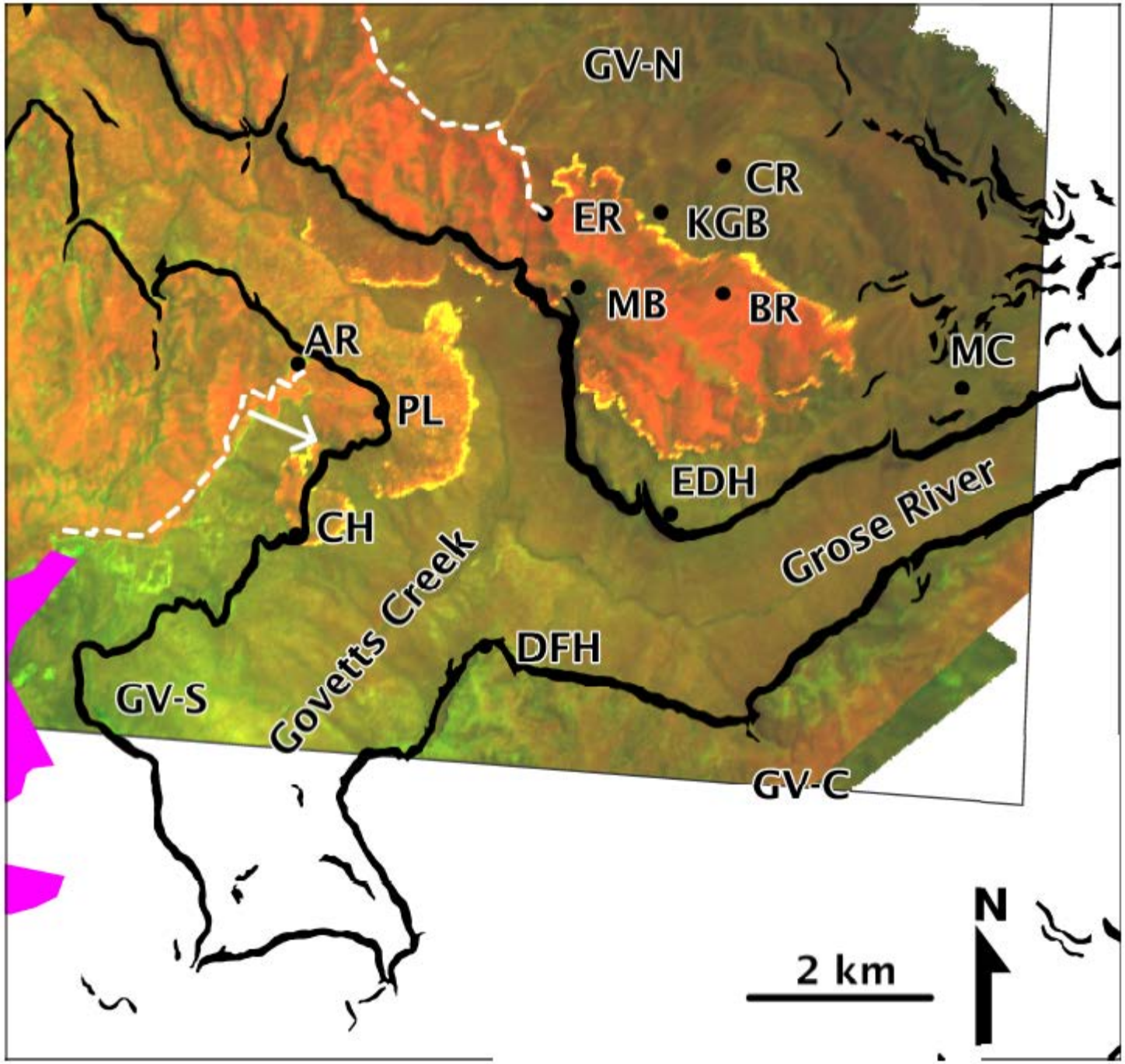
PAPER 2

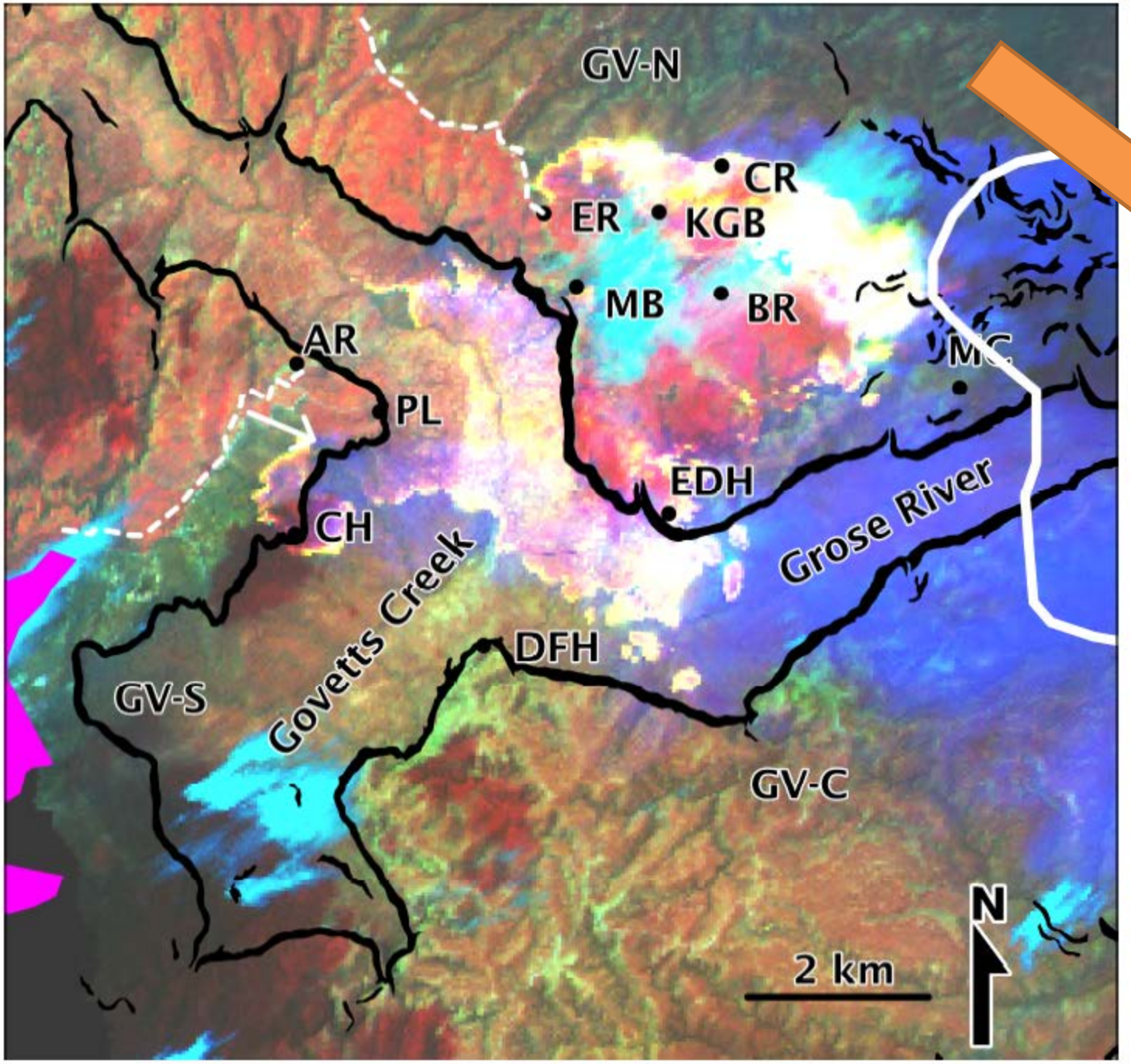
- R. H. D. McRae, J. J. Sharples and M. Fromm (2015). Linking local wildfire dynamics to pyroCb development. *Nat. Hazards Earth Syst. Sci.*, **15**, 417-428.

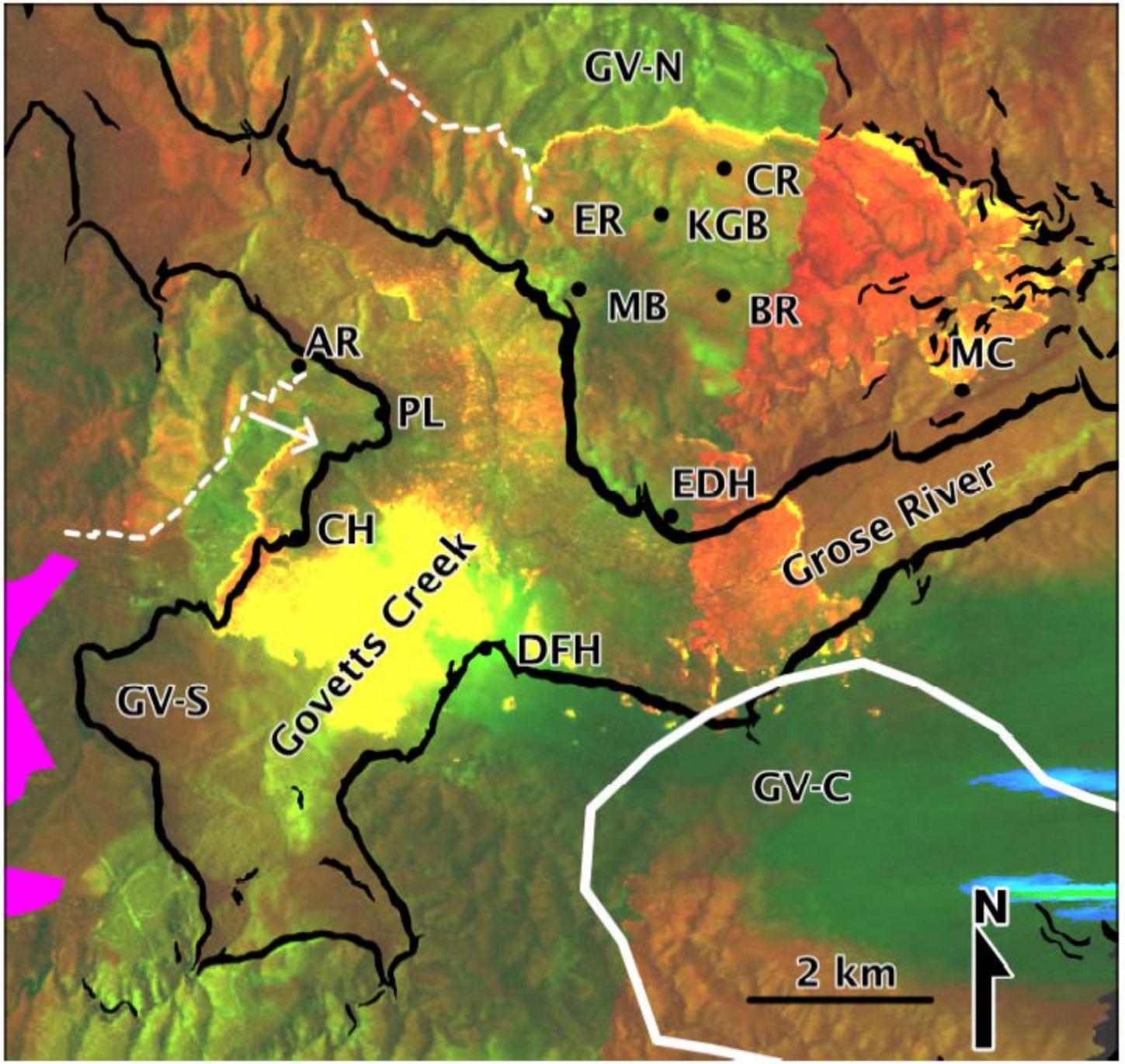

GV-N
GV-C
GV-S
0
2
4
km
N

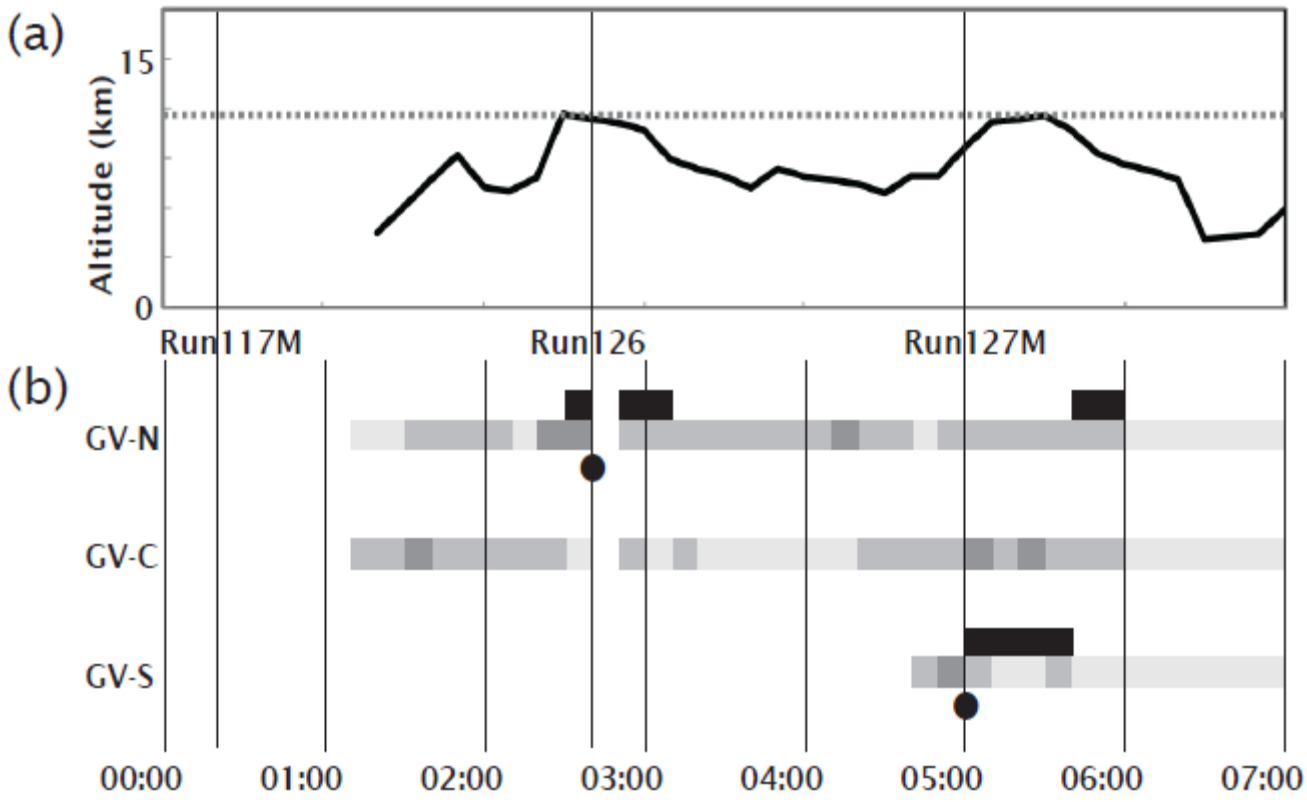

LEGEND
Active flame
Decaying flame
Cooling, smouldering
Burnt, but cool
Unburnt forest
Unburnt grassland
Hot gas
Cloud


GV-N
CR
ER
KGB
MB
BR
MC
AR
PL
EDH
CH
Govetts Creek
Grose River
DFH
GV-S
GV-C
N
2 km


GV-N
CR
ER
KGB
MB
BR
MC
AR
PL
EDH
CH
Grose River
Govetts Creek
DFH
GV-S
GV-C
2 km
N

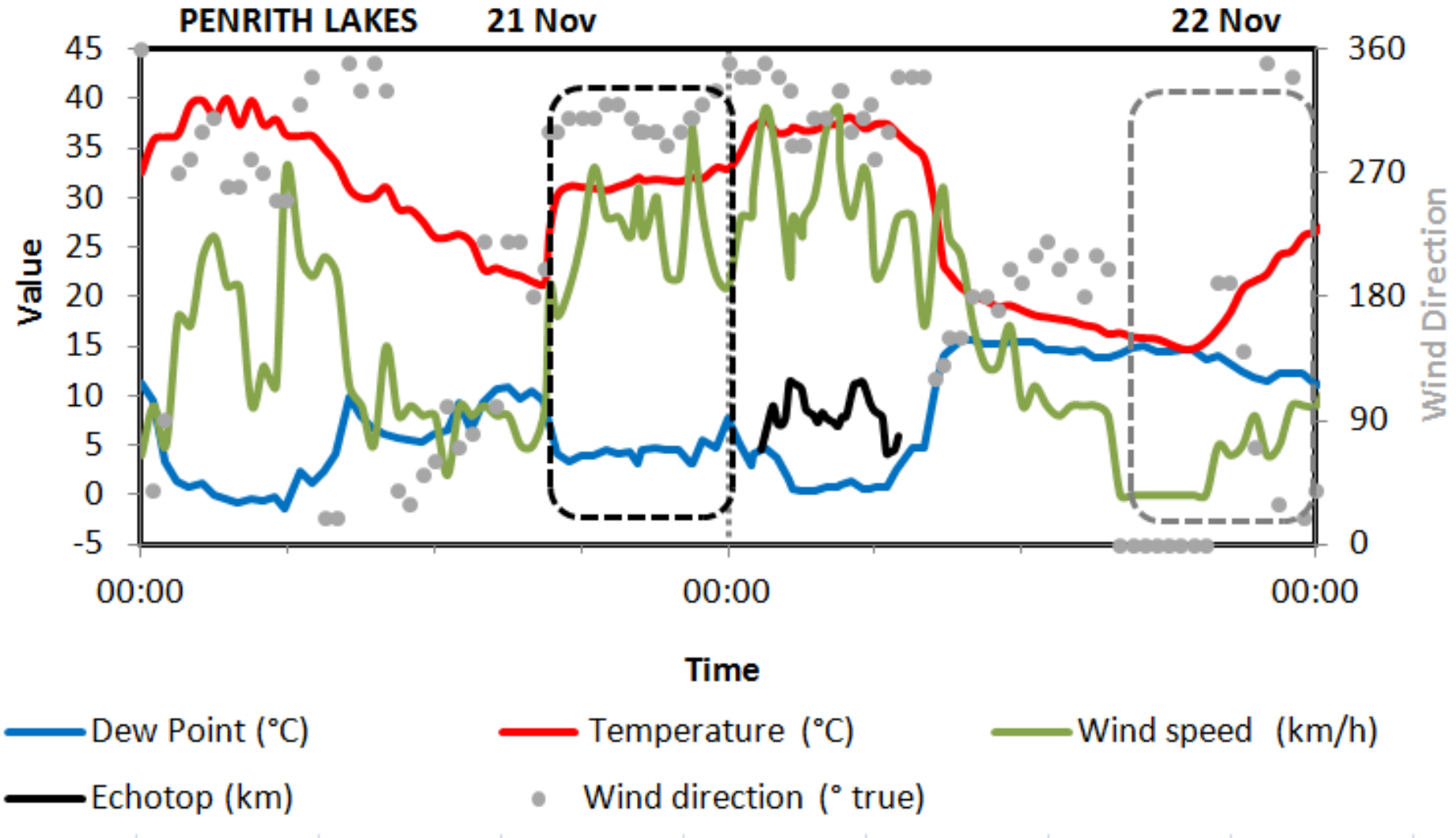

GV-N
CR
ER
KGB
MB
BR
AR
MC
PL
EDH
CH
Grose River
Govetts Creek
DFH
GV-S
GV-C
2 km
N

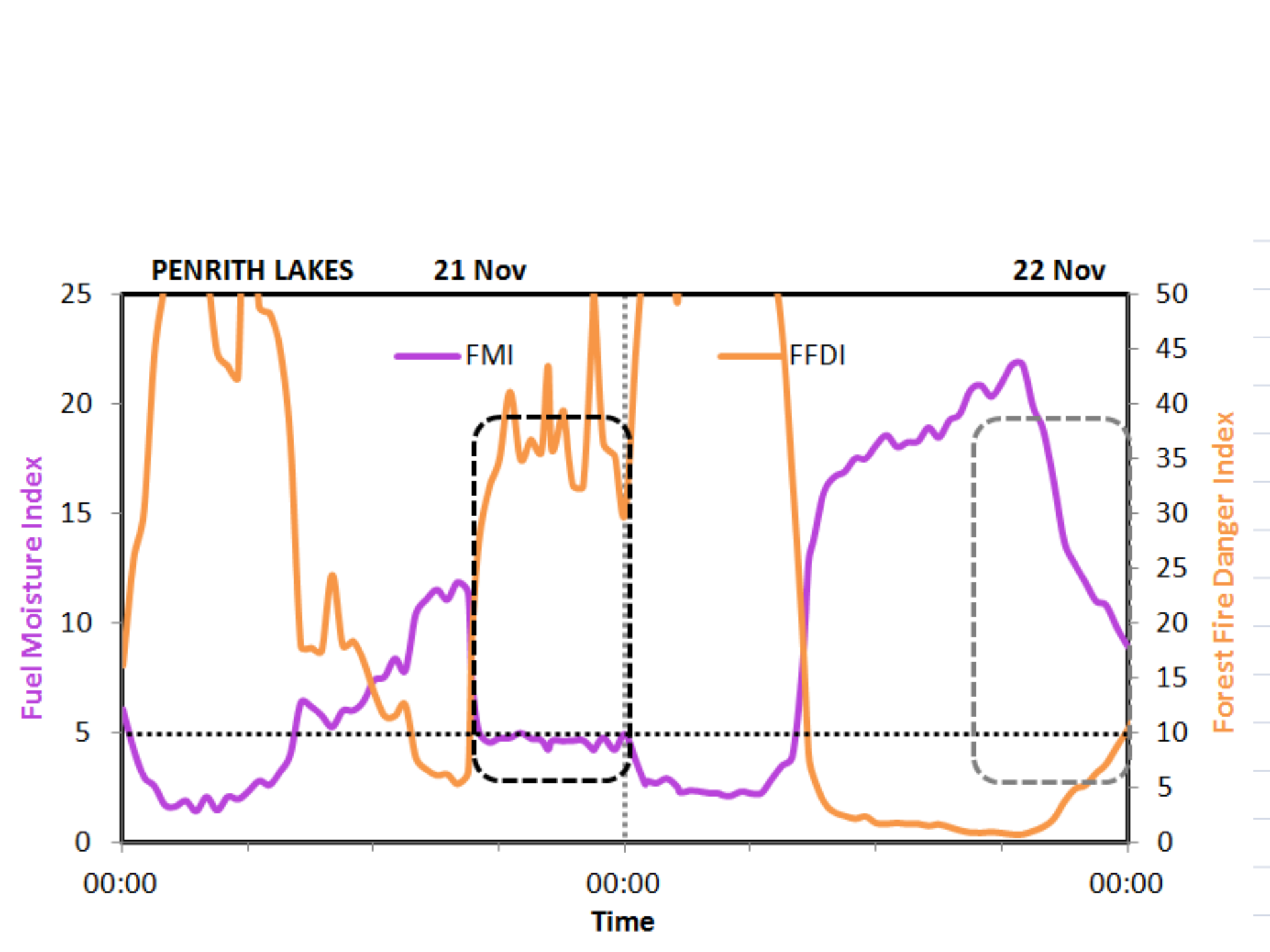

GV-N
CR
ER
KGB
MB
BR
MC
AR
PL
EDH
CH
Grose River
Goveтts Creek
DFH
GV-S
GV-C
N
2 km

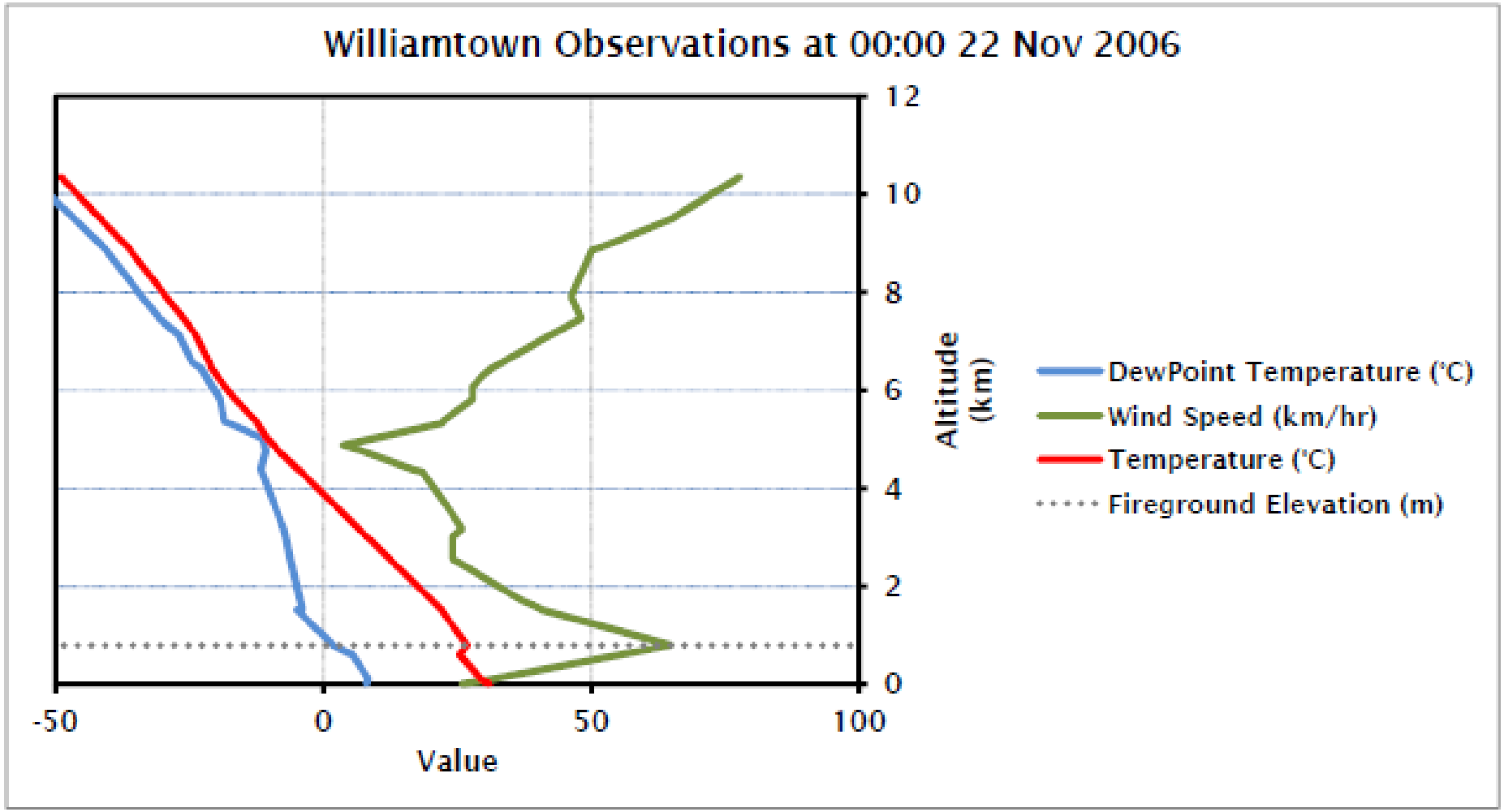

(a)
15
Altitude (km)
0
Run117M
Run126
Run127M
(b)
GV-N
GV-C
GV-S
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00

TO PREDICT THIS...

- McRae, R.H.D. & Sharples, J.J. (2013). A process model for forecasting conditions conducive to blow-up fire events. Proceedings, 2013 MODSIM Conference, Adelaide.
- McRae, R.H.D. & Sharples, J.J. (2014). Forecasting conditions conducive to blow-up fire events. CAWCR Research Letters, 11, 14-19.


PENRITH LAKES
21 Nov
22 Nov
45
40
35
30
25
20
15
10
5
0
-5
Value
360
270
180
90
0
Wind Direction
00:00
00:00
00:00
Time
Dew Point (°C)
Temperature (°C)
Wind speed (km/h)
Echotop (km)
Wind direction (° true)


PENRITH LAKES
21 Nov
22 Nov
FMI
FFDI
Fuel Moisture Index
Forest Fire Danger Index
25
20
15
10
5
0
50
45
40
35
30
25
20
15
10
5
0
00:00
00:00
00:00
Time


Williamtown Observations at 00:00 22 Nov 2006
12
10
8
6
4
2
0
Altitude (km)
-50
0
50
100
Value
DewPoint Temperature (°C)
Wind Speed (km/hr)
Temperature (°C)
Fireground Elevation (m)


2 km


BACK-BURN + WILDFIRE = CONVERGENCE ZONE = SPOTFIRE

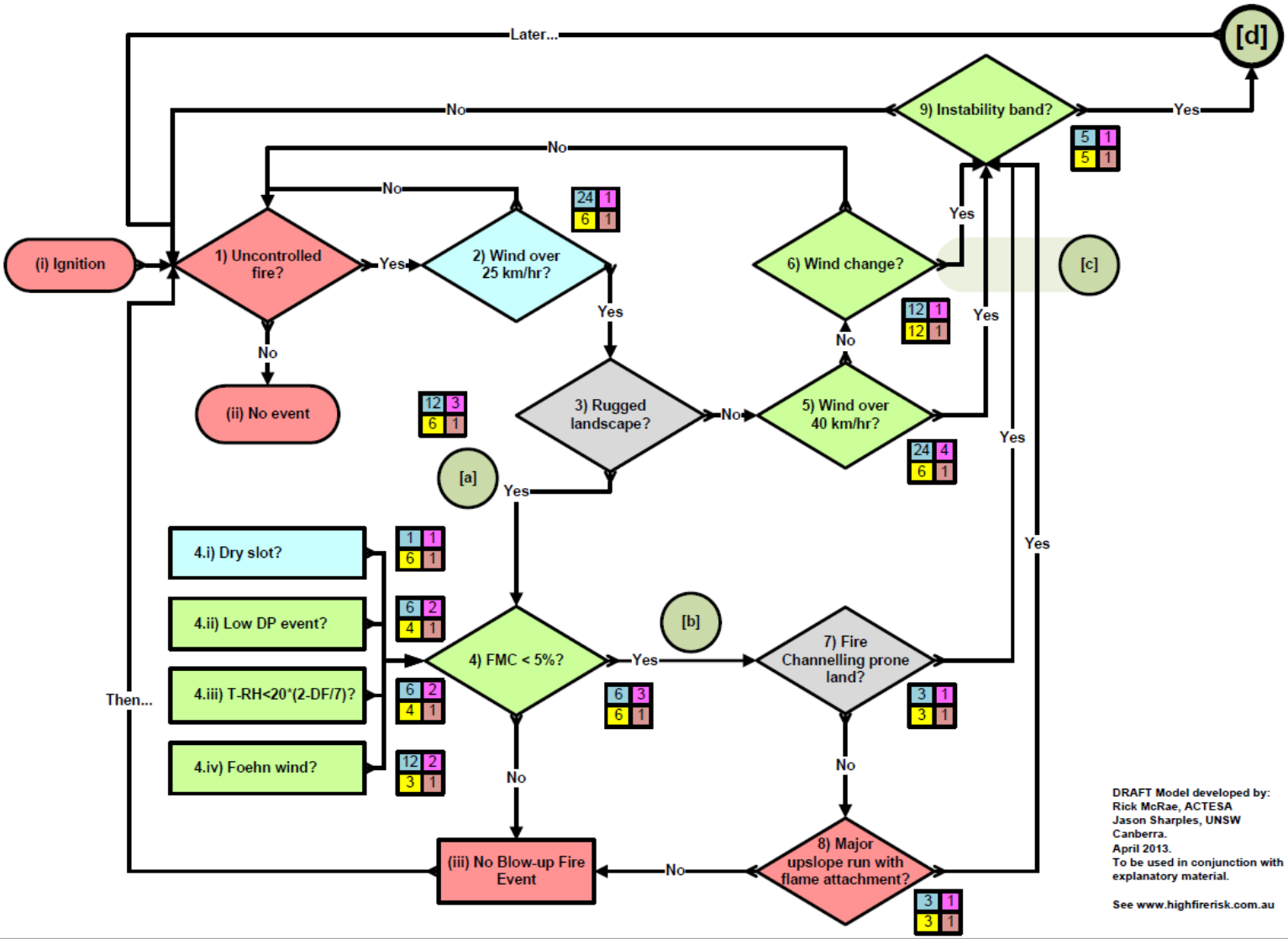

Tamworth
Kempsey
Nundle
Mt Seaview
Port Macquarie
Blackville
Quirindi
Murrurundi
Taree
Crowdy Head
Dunedoo
Stone
Gloucester
Merriwa
Lostock Dam
Gulgong
Jerrys Plains
Dungog
Singleton
Seal Rocks
Mudgee
Nullo Mt
Lemon Tree Passage
Nelson Bay
200 km
Williamtown Ap
Cessnock
Hill End
Newcastle
Lake Macquarie
Wyong
Wisemans Ferry
Norah Head
Bathurst
Lithgow
Gosford
Broken Bay
Oberon
Richmond Ap
Katoomba
Penrith
Sydney
Bankstown Ap
Port Hacking
Taralga
Wollongong
Port Kembla
Kiama
Goulburn
LemnTre 22/11/06 05:30UTC 000.5el 256km -1
Rain Rate
Light
Moderate
Heavy

FORECASTING RESULTS

May need to consider some **combinations** of:

- the absence of a fine fuel moistening phase;
- the typical diurnal cycle;
- a jet point in the wind profile;
- the terrain on which the fire is burning (ruggedness);
- the arrival time of fire in critical parts of the landscape; and
- the passage of pressure troughs

PROCESS MODEL FOR FORECASTING CONDITIONS CONDUCIVE TO BLOW-UP FIRE EVENTS ON A DAY OF ELEVATED FIRE DANGER RATING



LEGEND:

Inferred field occurences: [a] Flow separation; [b] High flammability; [c] Deep Flaming; [d] Blow-up fire event

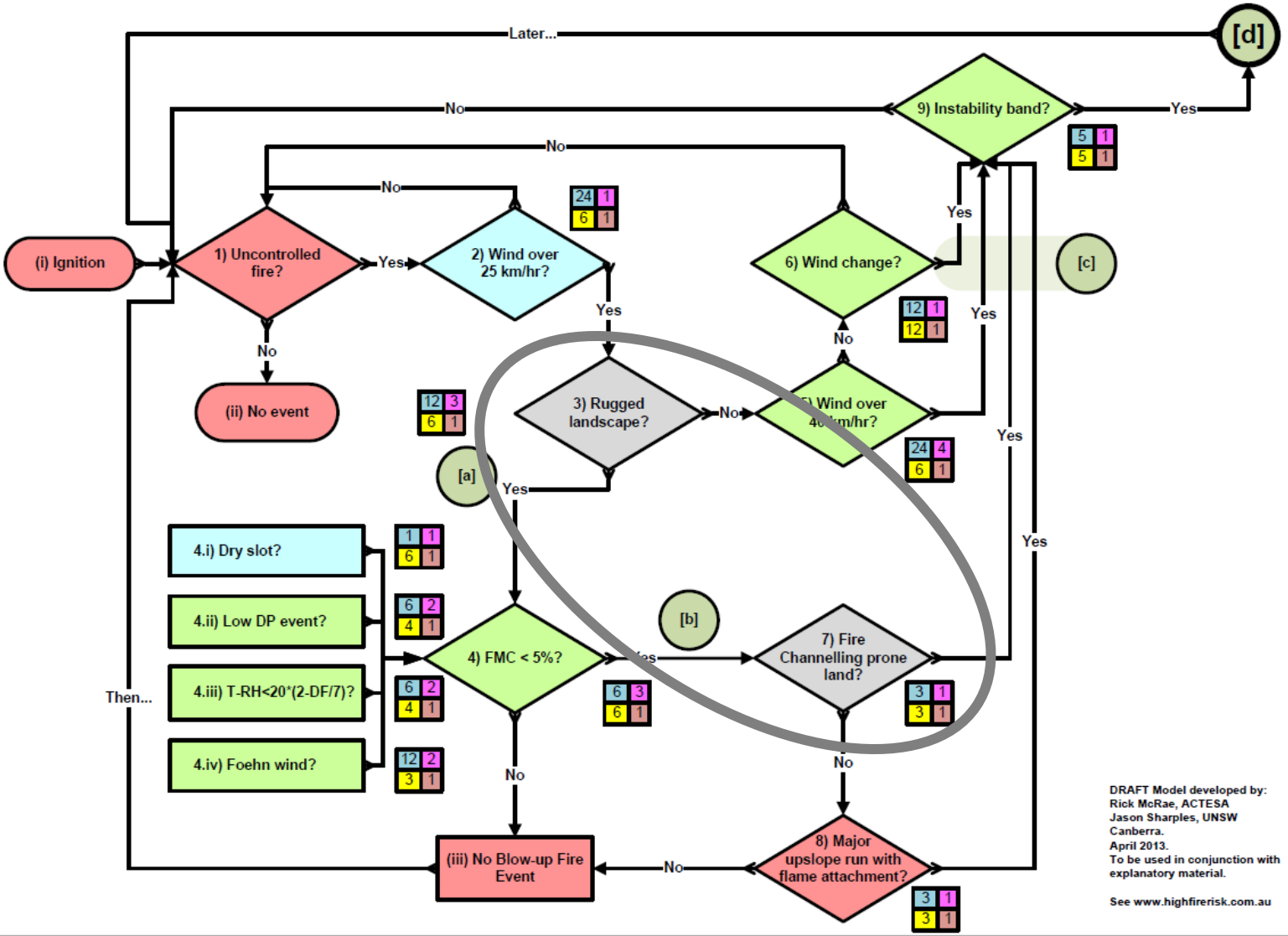
Data ownership: BoM | Fire agency | BoM & agency | HighFire Risk

Timing: (hrs)

F O
T V

[F]orecast of onset
[T]racking approach
[O]nset until effect
[V]erification after onset

PROCESS MODEL FOR FORECASTING CONDITIONS CONDUCIVE TO BLOW-UP FIRE EVENTS ON A DAY OF ELEVATED FIRE DANGER RATING



LEGEND:

Inferred field occurences: [a] Flow separation; [b] High flammability; [c] Deep Flaming; [d] Blow-up fire event

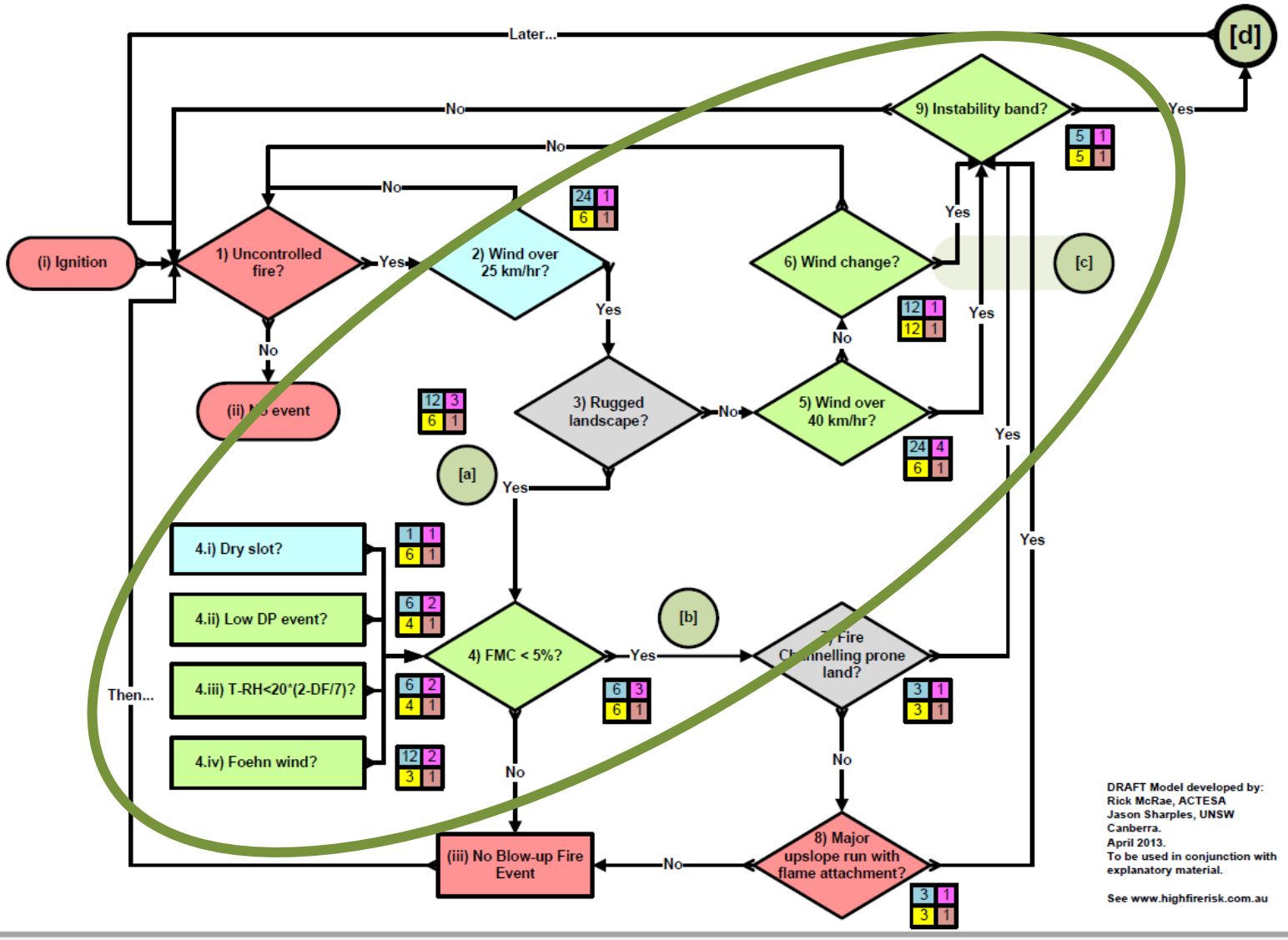
Data ownership: BoM | Fire agency | BoM & agency | HighFire Risk

Timing: (hrs)

F O
T V

[F]orecast of onset
[T]racking approach
[O]nset until effect
[V]erification after onset

PROCESS MODEL FOR FORECASTING CONDITIONS CONDUCIVE TO BLOW-UP FIRE EVENTS ON A DAY OF ELEVATED FIRE DANGER RATING



LEGEND:

Inferred field occurences: [a] Flow separation; [b] High flammability; [c] Deep Flaming; [d] Blow-up fire event

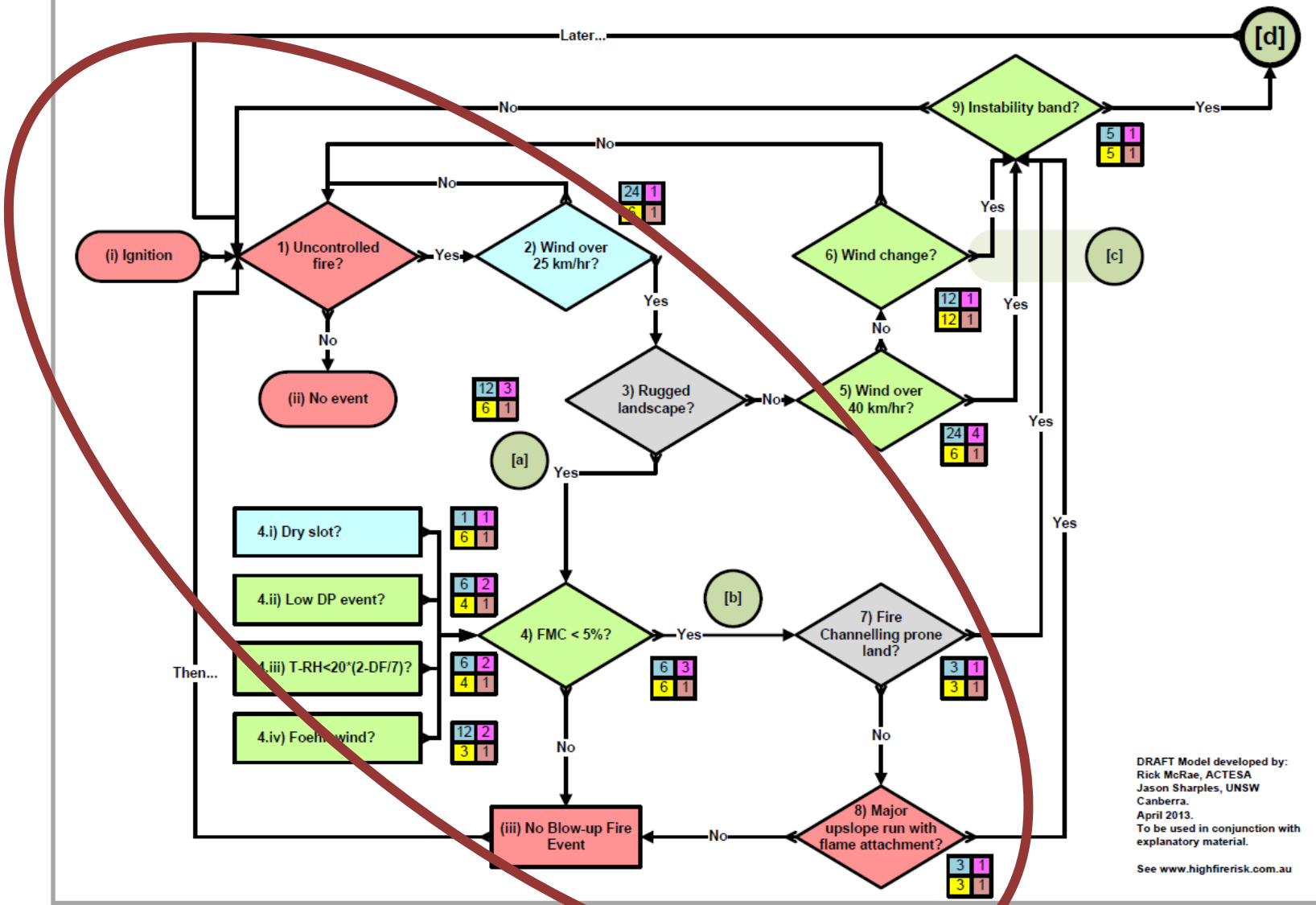
Data ownership: BoM | Fire agency | BoM & agency | HighFire Risk

Timing: (hrs)

F O
T V

[F]orecast of onset
[T]racking approach
[O]nset until effect
[V]erification after onset

PROCESS MODEL FOR FORECASTING CONDITIONS CONDUCIVE TO BLOW-UP FIRE EVENTS ON A DAY OF ELEVATED FIRE DANGER RATING



TAKE HOME MESSAGES

- The most extreme and damaging forms of wildfire develop pyroCbs.

- PyroCbs form after occurrence of a combination of instability and deep flaming events.

- Deep flaming can result from at least 5 processes.

- Fire channelling (VLS) is very efficient at causing deep flaming.

- This is an interaction of fire, weather and terrain.

- Prior foehn effects are a common facilitator of deep flaming events.

- Elevated fire danger is only a precursor.

Acknowledgements

People involved in this work include:

- NSW RFS for use of the linescans: Laurence McCoy.
- BoM for access to the radar and AWS data: Tony Bannister.
- The linescan operator: Robert Norman.
- Fire personnel: David Crust, NSW NPWS & Mal Cronstedt (IC).
- Naval Research Laboratory staff: Bo Cai Gao.

Time: 00:00 UTC - 11:00 am

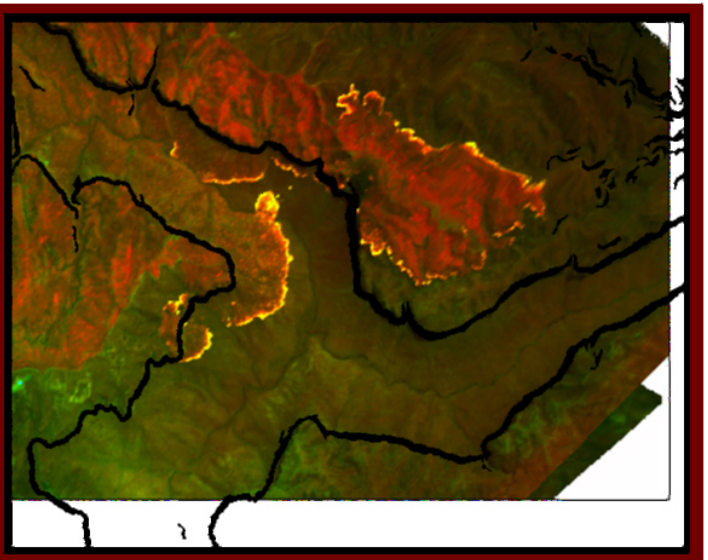
MSLP: 1011 hPa

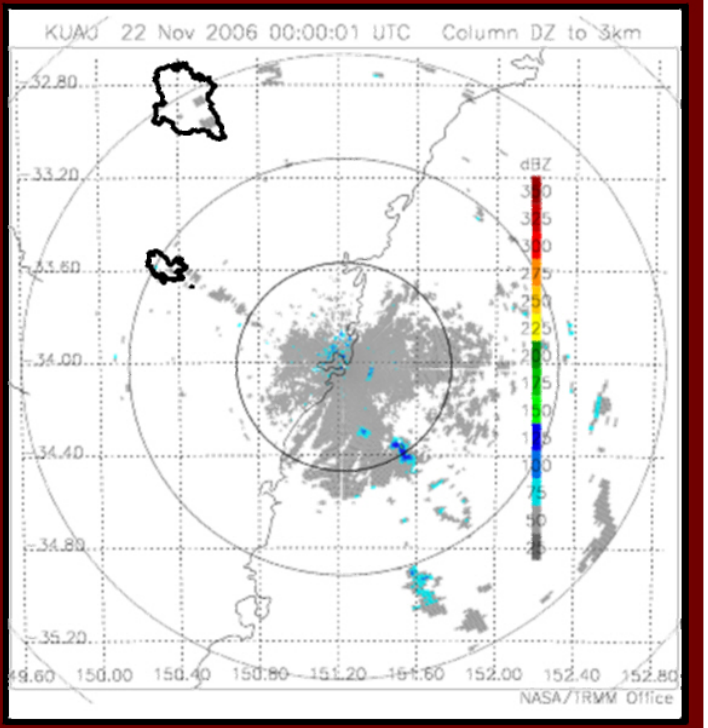
EchoTop:

FFDI: 35.6

FMI: 5.2

Events: Foehn





Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0

Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa

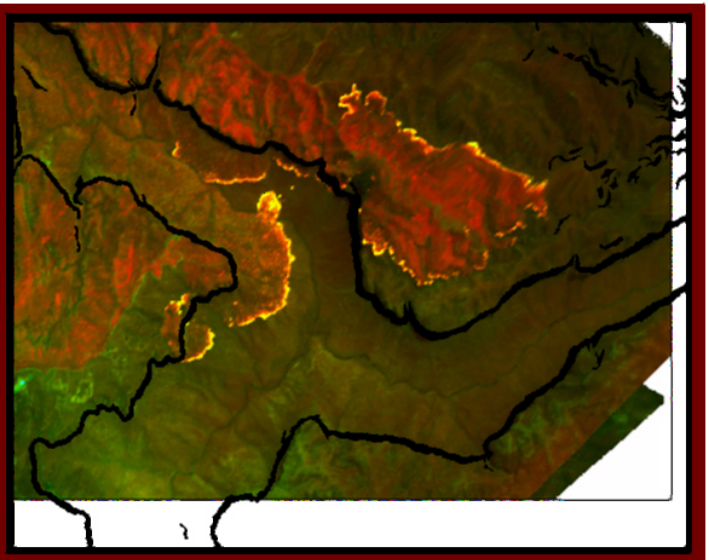
Events: Foehn

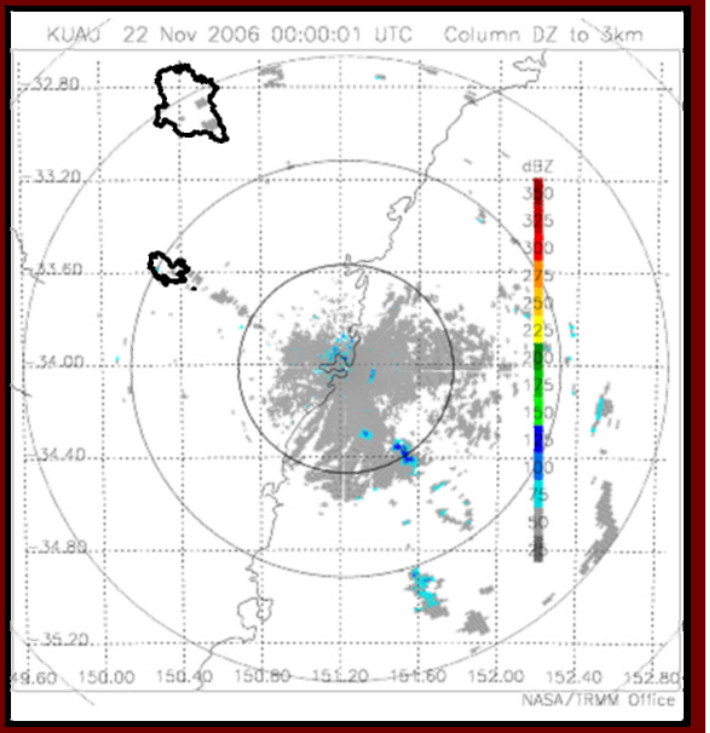
EchoTop:

FFDI: 35.6

FMI: 5.2

Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0





Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa

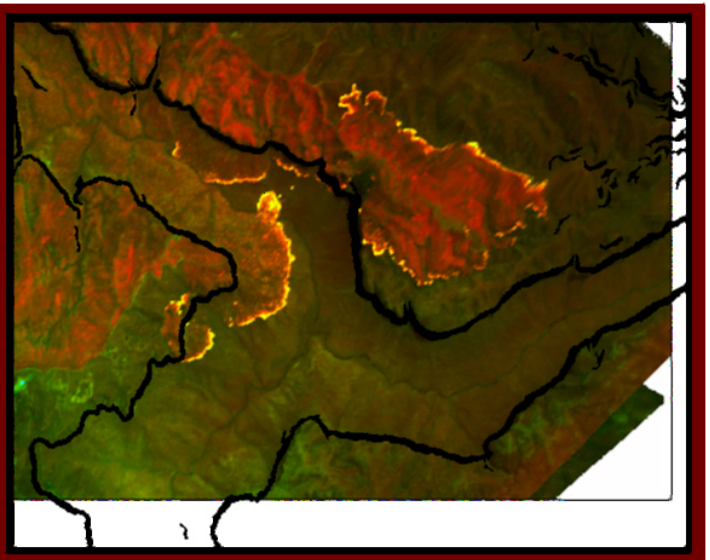
EchoTop:

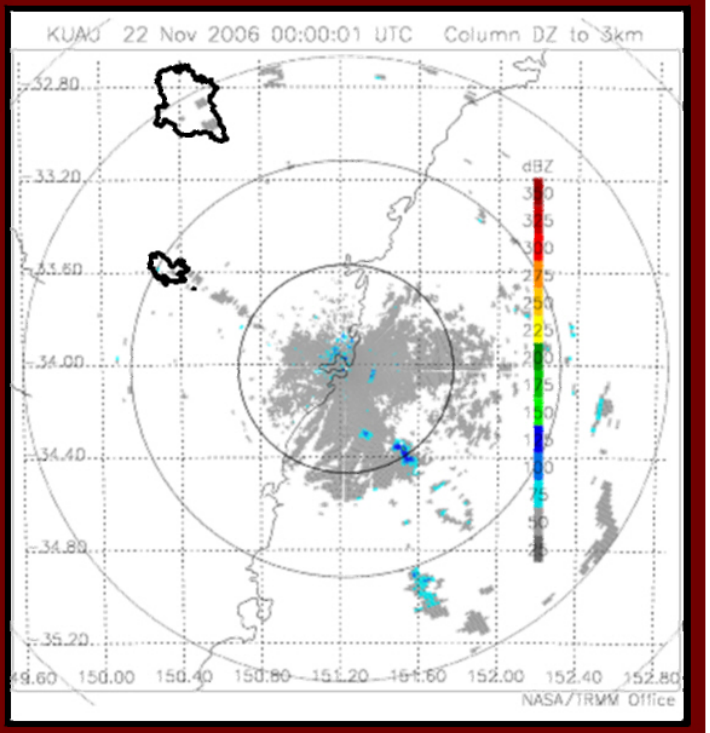
FFDI: 35.6

FMI: 5.2

Events: Foehn

Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0





Time: 00:00 UTC - 11:00 am

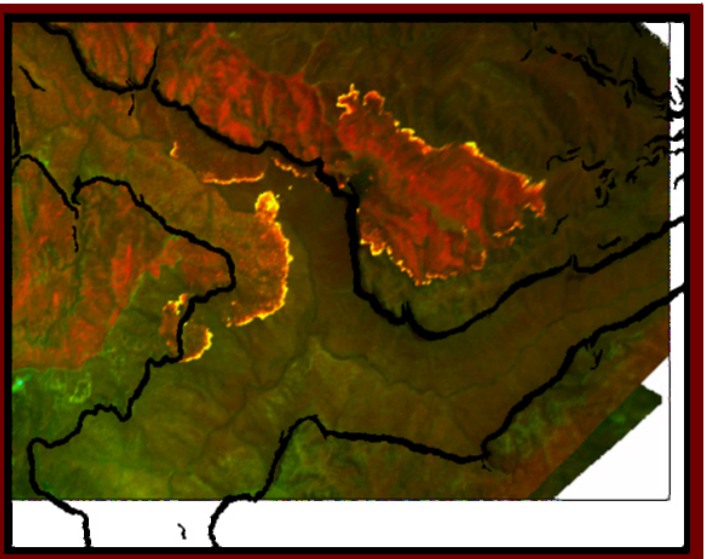
MSLP: 1011 hPa

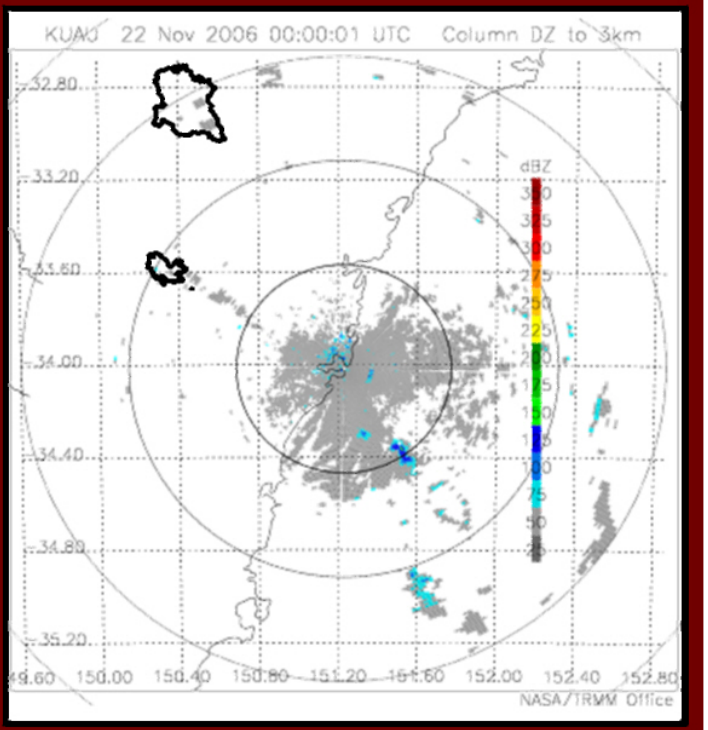
EchoTop:

FFDI: 35.6

FMI: 5.2

Events: Foehn





Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0

Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa

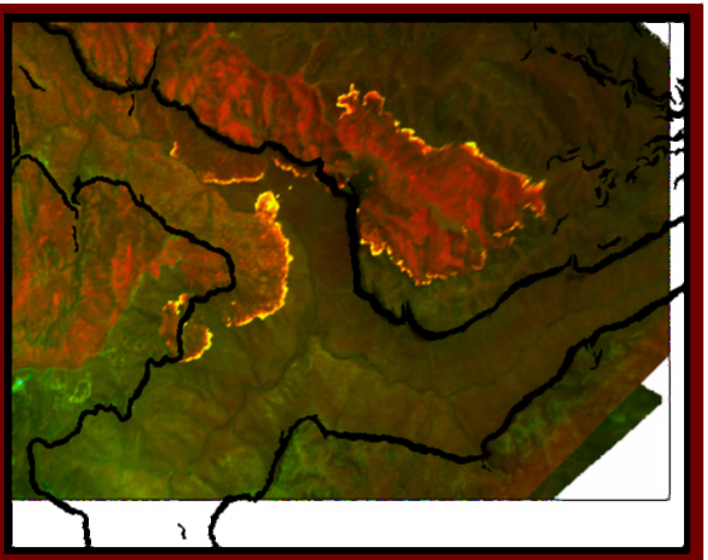
EchoTop:

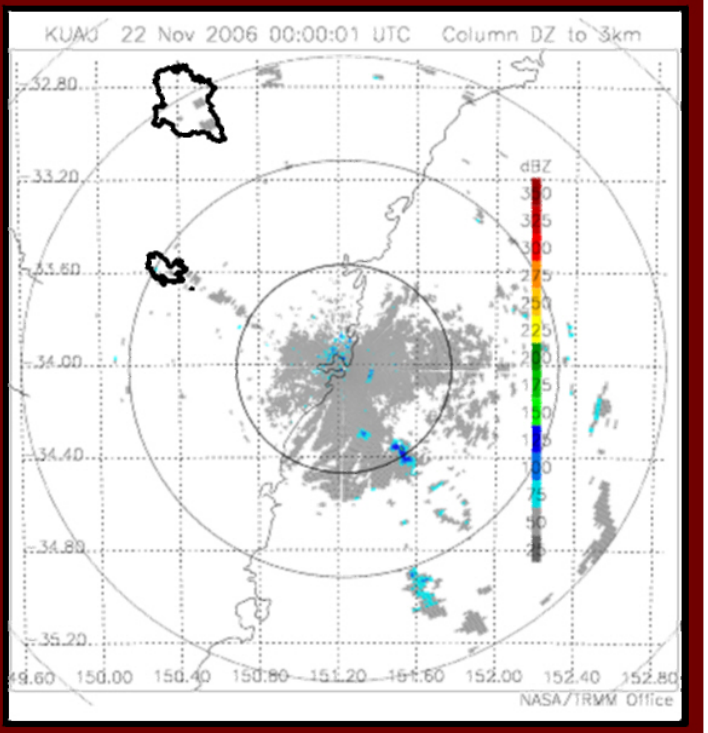
FFDI: 35.6

FMI: 5.2

Events:

Foehn



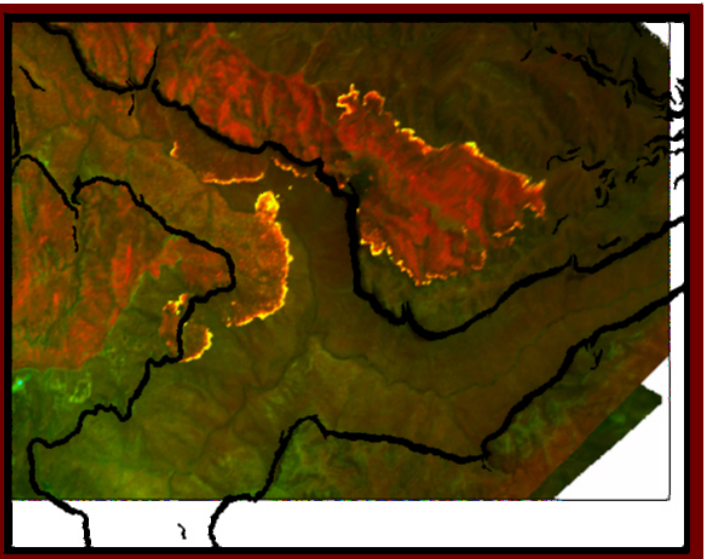


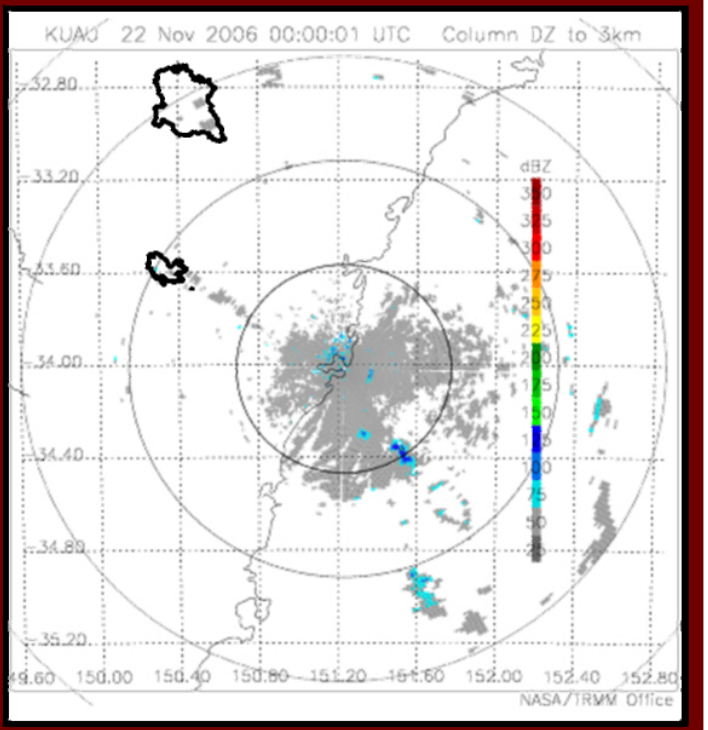
Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0

Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa
EchoTop:
FFDI: 35.6
FMI: 5.2

Events:
Foehn





Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0

Time: 00:00 UTC - 11:00 am

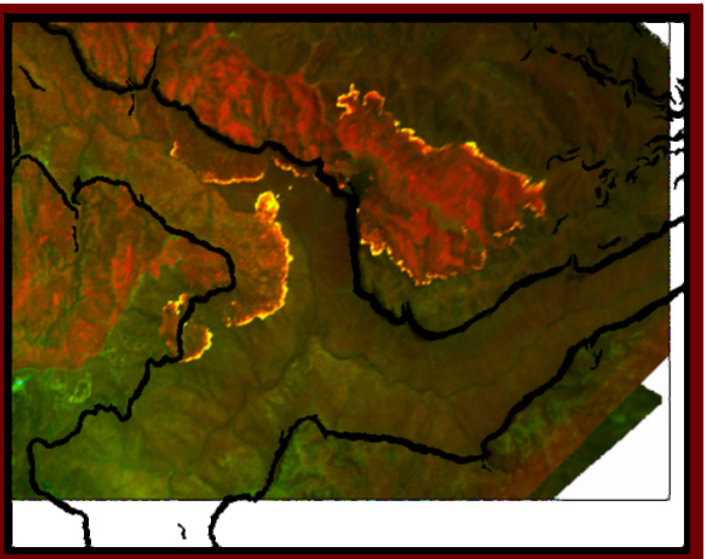
MSLP: 1011 hPa

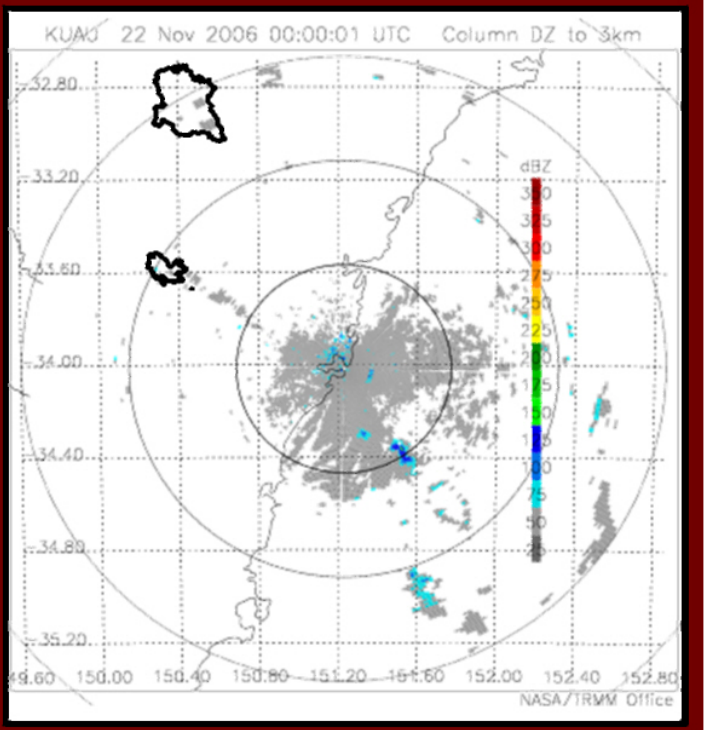
EchoTop:

FFDI: 35.6

FMI: 5.2

Events: Foehn





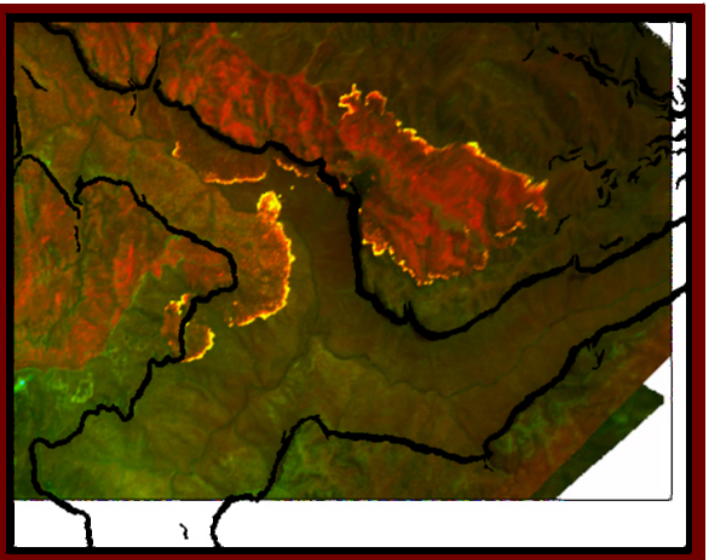
Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0

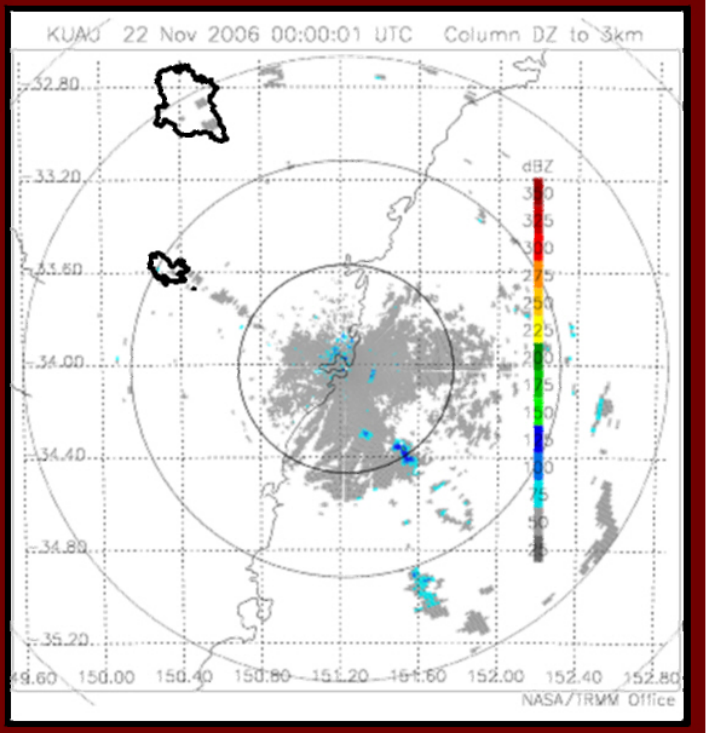
Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa
EchoTop:
FFDI: 35.6
FMI: 5.2

Events:
Foehn

Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0





Time: 00:00 UTC - 11:00 am

MSLP: 1011 hPa

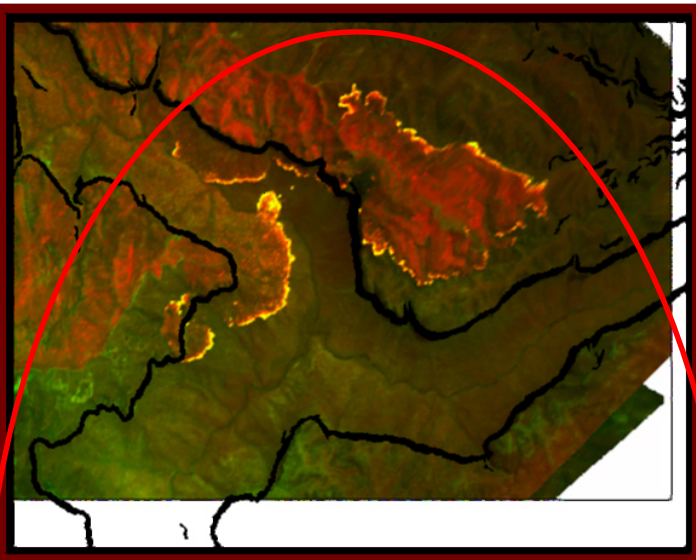
EchoTop:

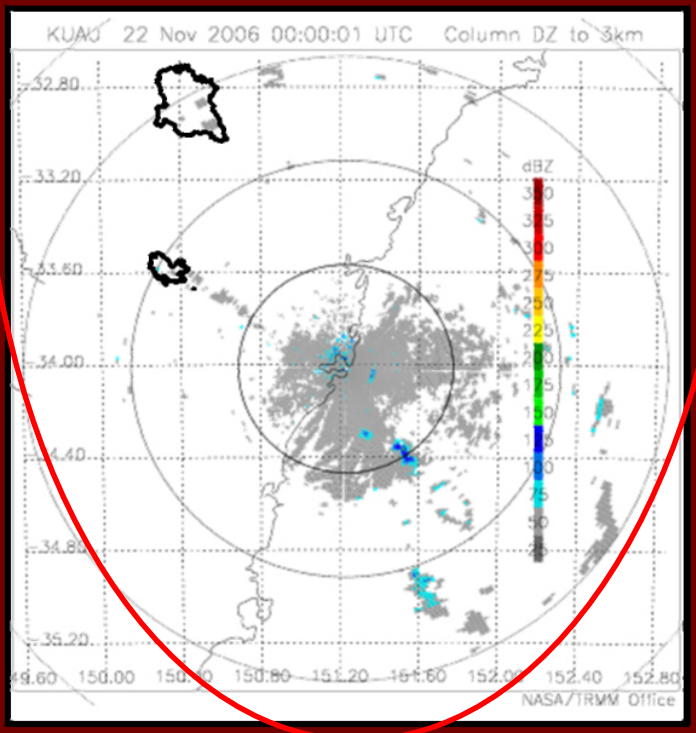
FFDI: 35.6

FMI: 5.2

Events: Foehn

Fire area:	Flaming:	Conv. Int.:
GV-N	Normal	0
GV-C	B'away	0
GV-S	Normal	0





Time: 01:00 UTC - noon

MSLP: 1011 hPa

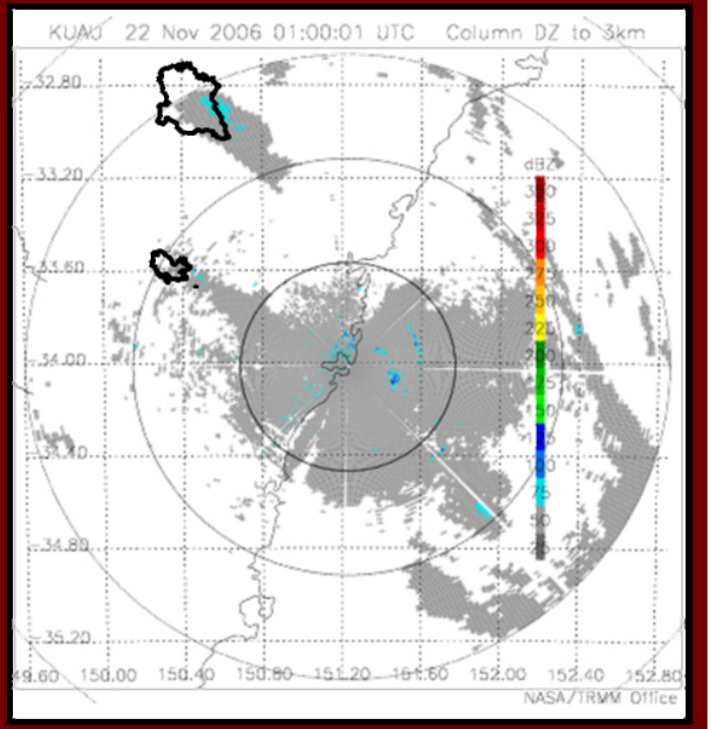
EchoTop:

FFDI: 39.2

FMI: 5.0

Events:

Fire area:	Flaming:	Conv. Int.:
GV-N	---	0
GV-C	---	0
GV-S	---	0

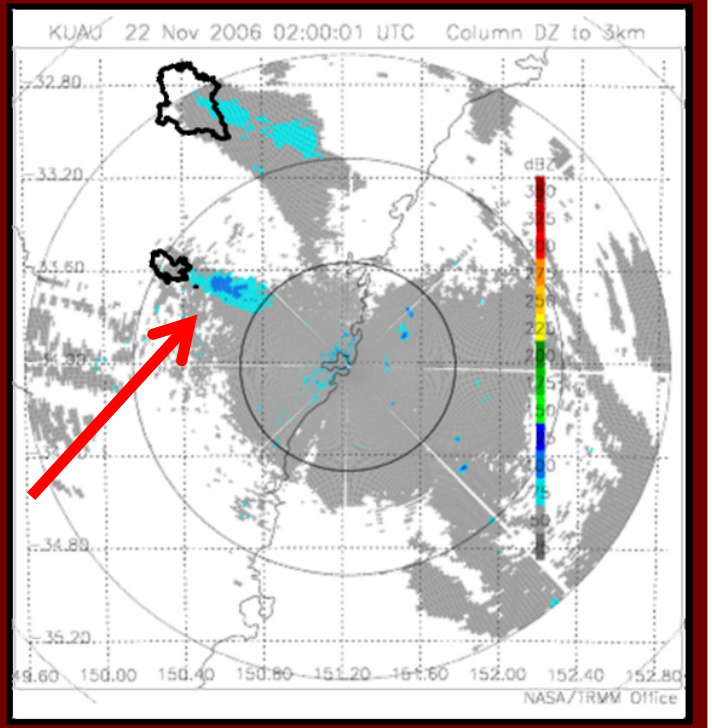


Time: 02:00 UTC - 1:00pm

MSLP: 1011 hPa
EchoTop: 7.2 km
FFDI: 40.1
FMI: 5.3

Events:

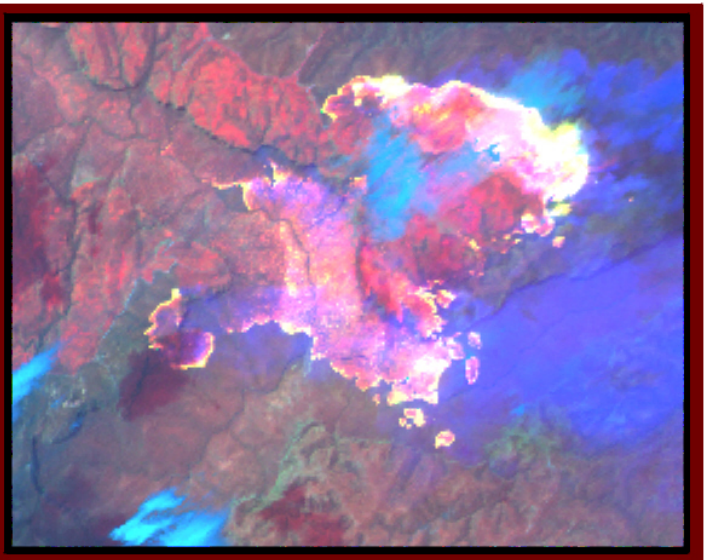
Fire area:	Flaming:	Conv. Int.:
GV-N	VDLS?	2
GV-C	VDLS?	2
GV-S	Normal	0

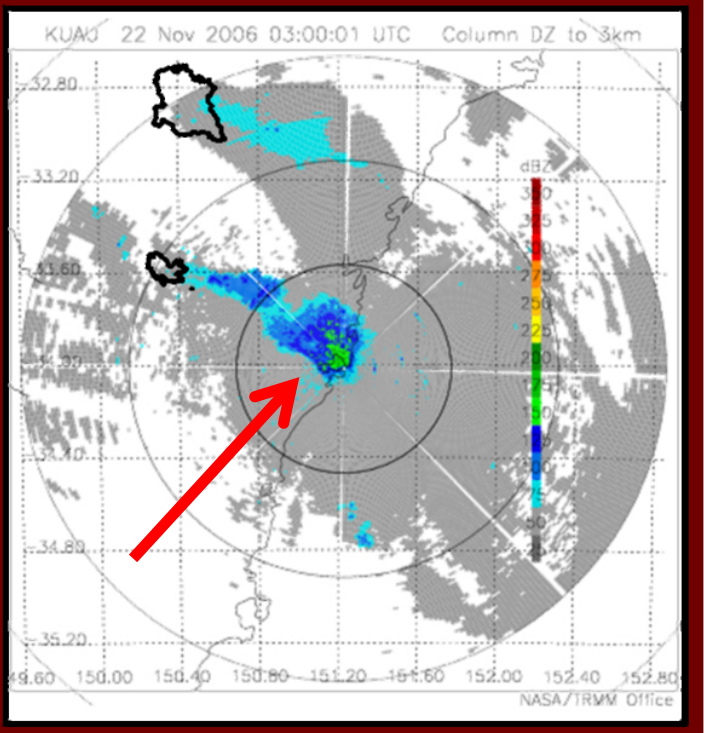


Time: 03:00 UTC - 2:00pm

MSLP: 1011 hPa
EchoTop: 11.5 km
FFDI: 44.8
FMI: 4.8

Events:
VDLS
PyroCb





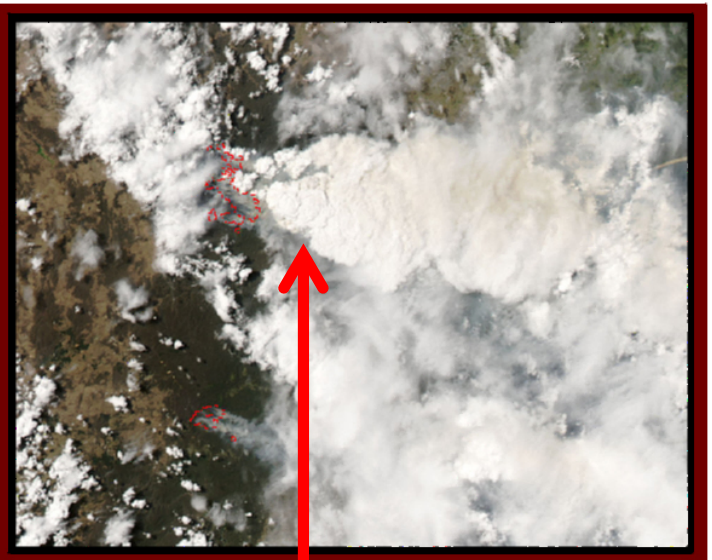
Fire area:	Flaming:	Conv. Int.:
GV-N	VDLS	2
GV-C	VDLS?	2
GV-S	Normal	0

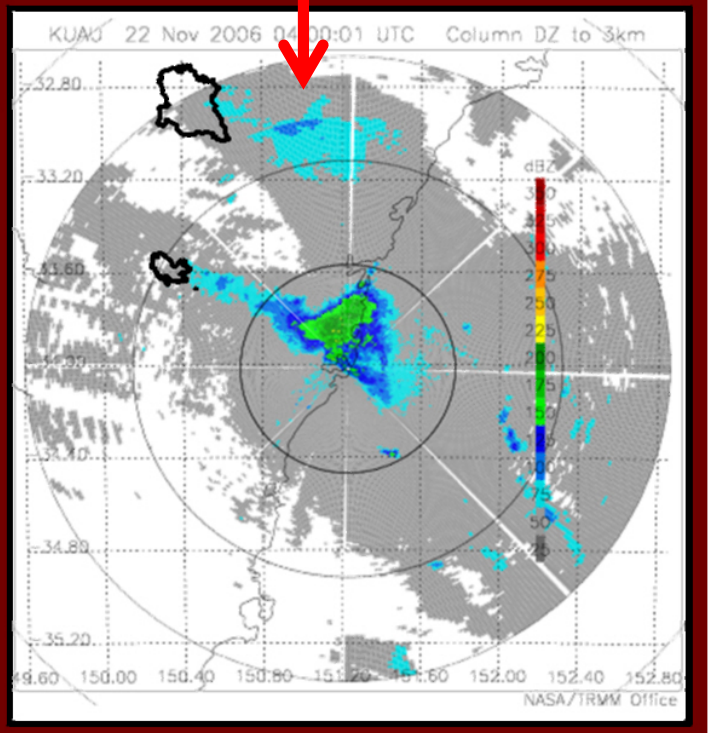
Time: 04:00 UTC - 3:00pm

MSLP: 1011 hPa
EchoTop: 8.7 km
FFDI: 43.0
FMI: 5.0

Events:

Fire area:	Flaming:	Conv. Int.:
GV-N	Consol.	2
GV-C	Consol.	1
GV-S	Changing	0

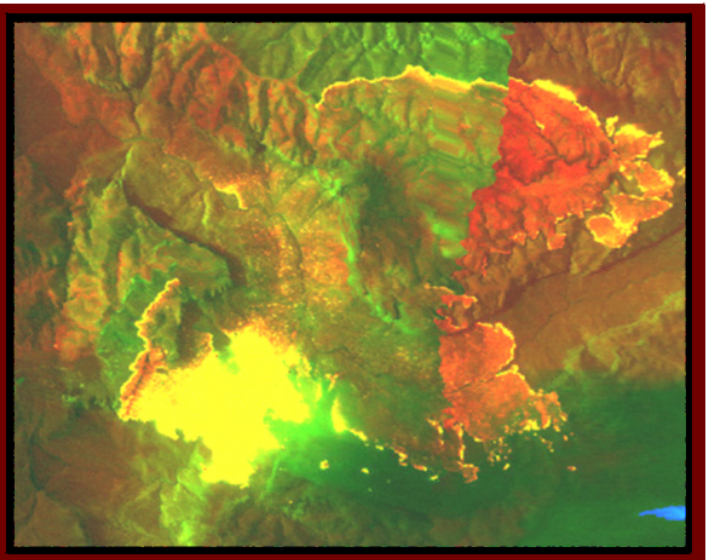


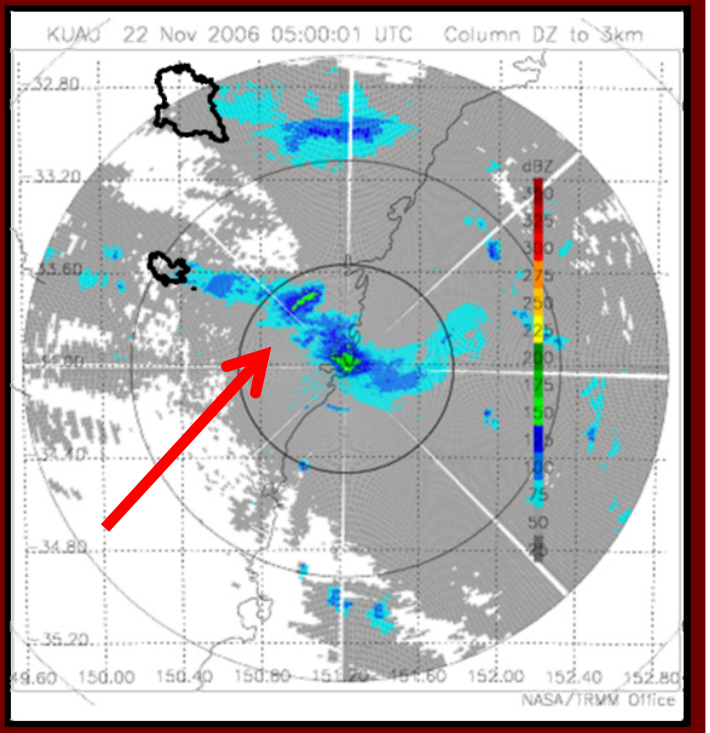


Time: 05:00 UTC - 4:00pm

MSLP: 1010 hPa
EchoTop: 9.6 km
FFDI: 27.9
FMI: 5.4

Events:
VDLS
PyroCb





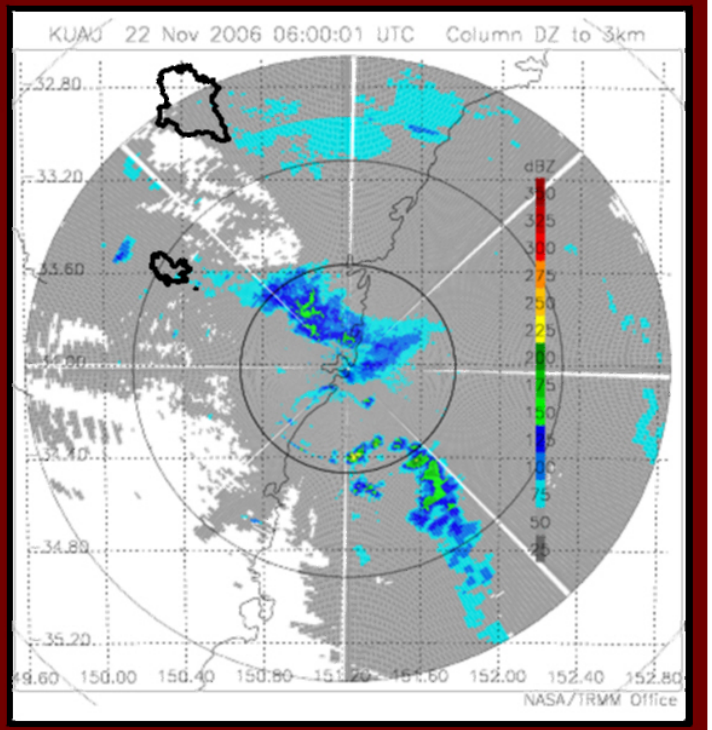
Fire area:	Flaming:	Conv. Int.:
GV-N	Consol.	2
GV-C	Consol.	1
GV-S	5 sq km	3

Time: 06:00 UTC - 5:00pm

MSLP: 1010 hPa
EchoTop: 11.5 km
FFDI: 26.0
FMI: 5.6

Events:

Fire area:	Flaming:	Conv. Int.:
GV-N	---	2
GV-C	---	2
GV-S	Consol.	1



Time: 07:00 UTC - 6:00pm

MSLP: 1010 hPa
EchoTop: 8.2 km
FFDI: 36.3
FMI: 5.4

Events: Trough-line

Fire area:	Flaming:	Conv. Int.:
GV-N	---	1
GV-C	---	1
GV-S	---	1