Cool and wet or coal and dry, how coal fired power generation modifies regional climate

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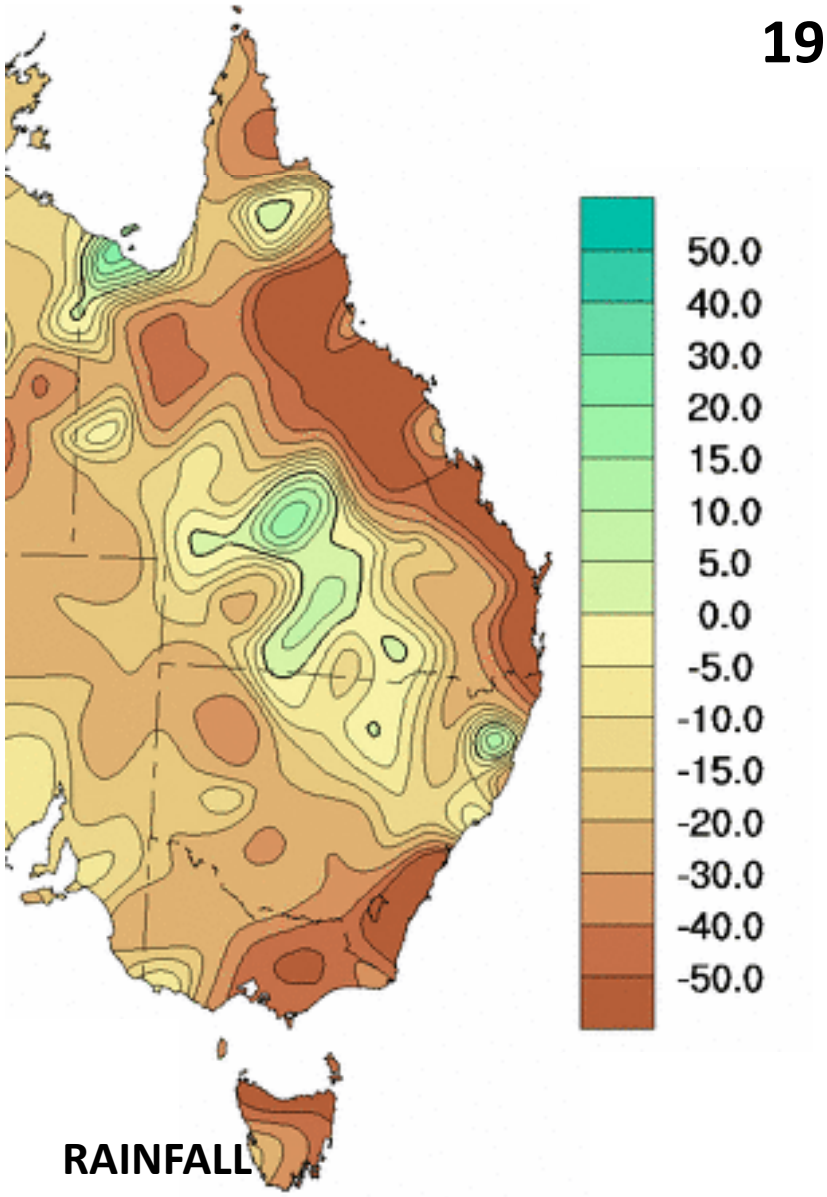
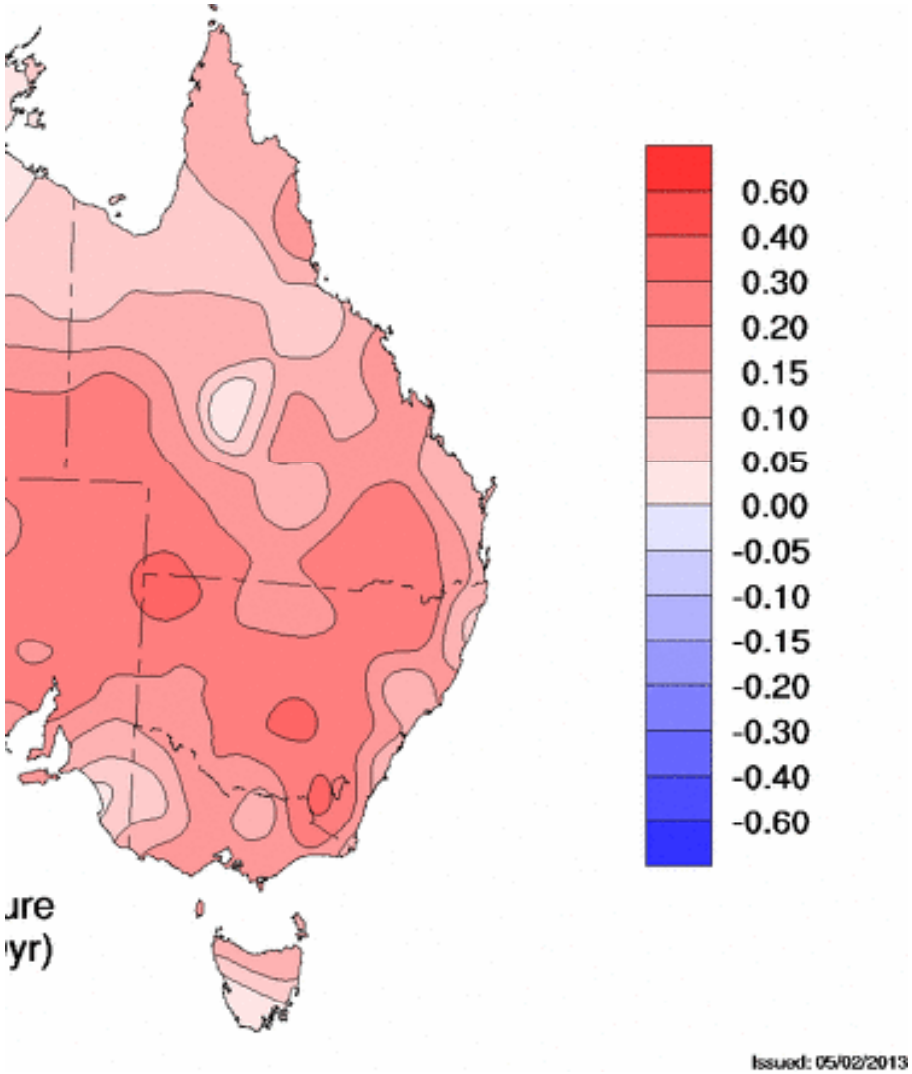
Can regional drought be homemade?

REGIONAL CLIMATE CHANGE
1970 – 2010

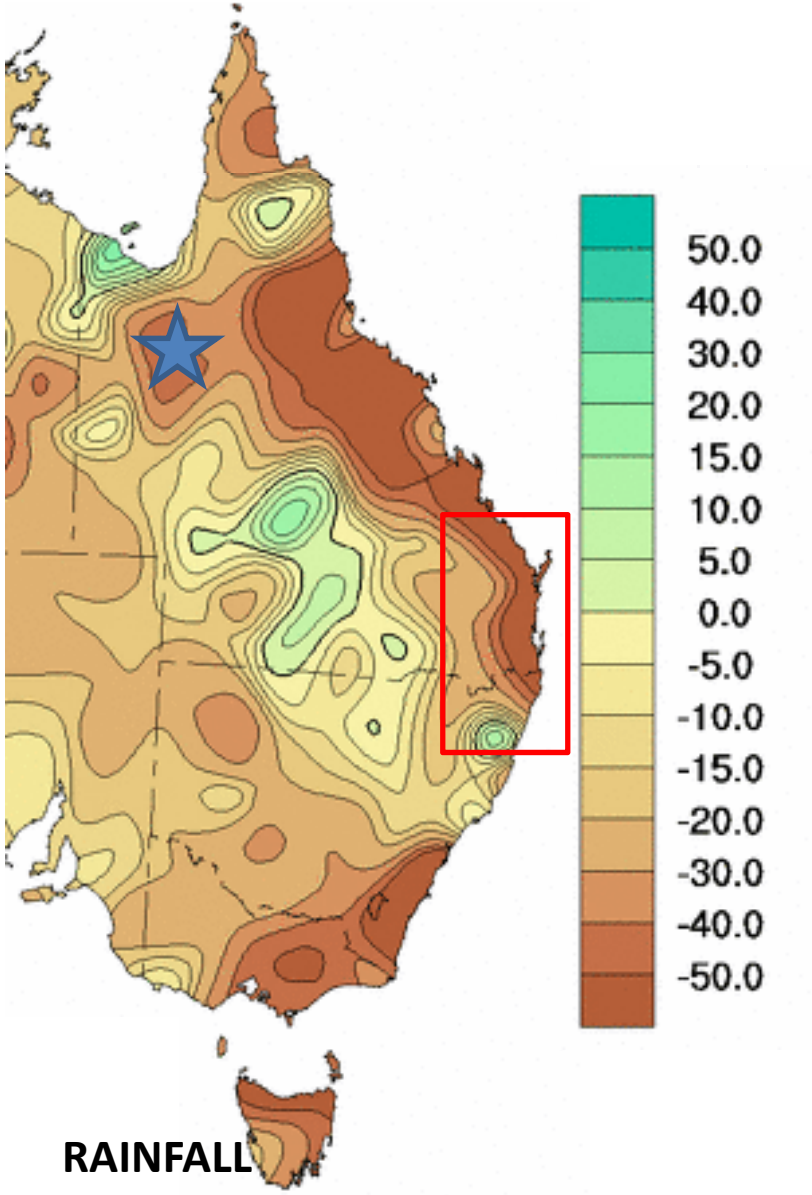


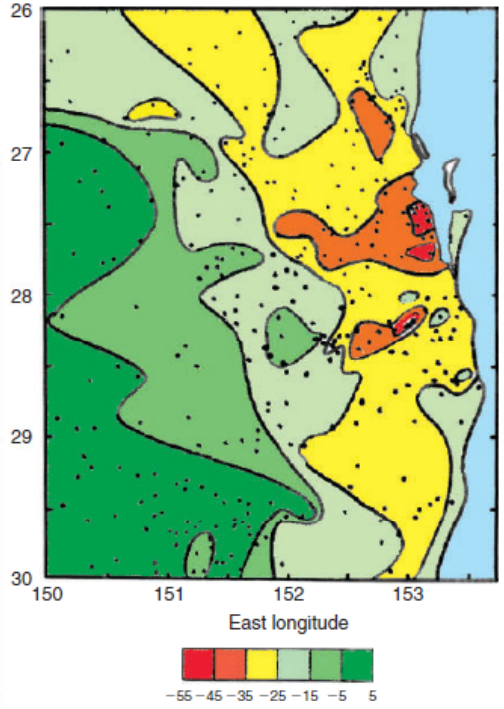


RAINFALL
BOM, AUSTRALIA, 2010/2011

Trends in rainfall associated with sources of air pollution

Bigg, *Environ. Chem.* 2008, 5, 184–193.





Contours of the change in rainfall in 35 years (1970–2004)
ed as a percentage of the mean daily rainfall for that period at each
e sites are listed in the appendix and are shown as dots on this diagram.

RAINFALL
BOM, AUSTRALIA, 2010/2011

LARGE SCALE CIRCULATION?
CCN? Mt.ISA 2* 10^{18}/sec
SCALE?

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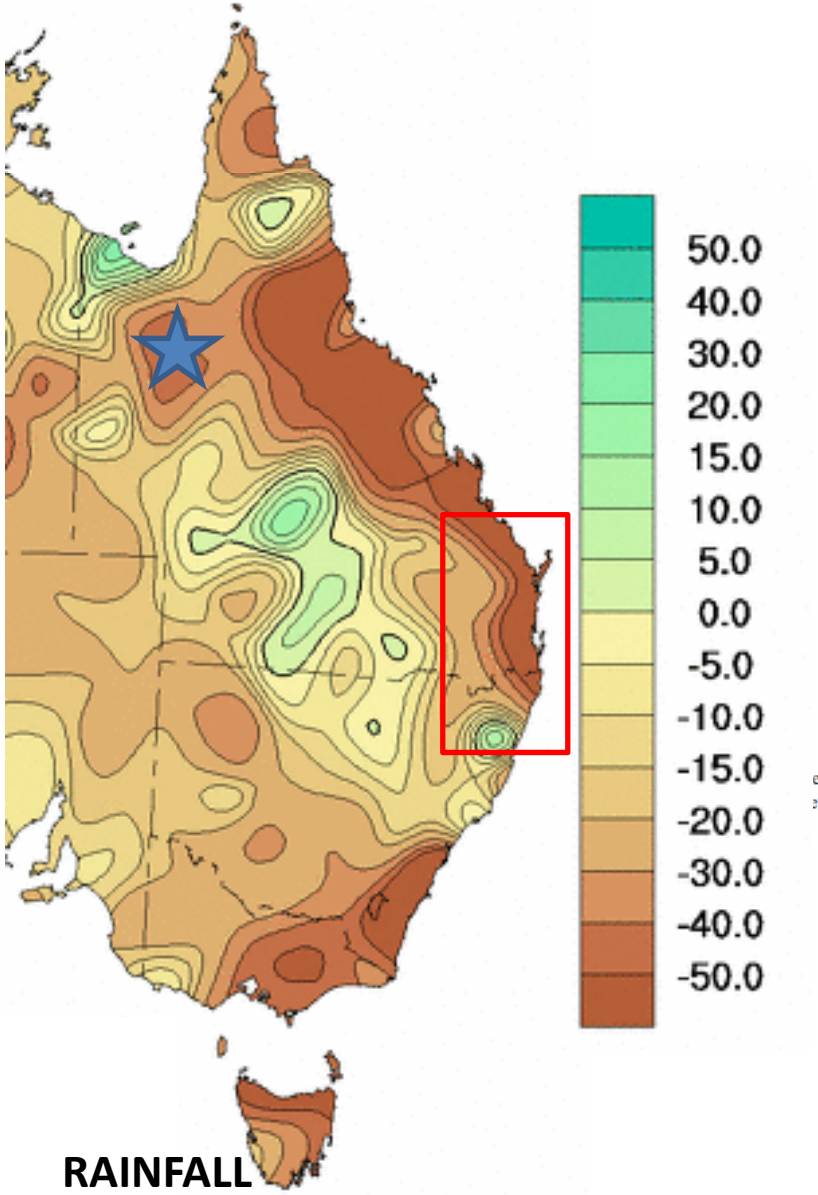
ARA

Trends in rainfall associated with sources of air pollution

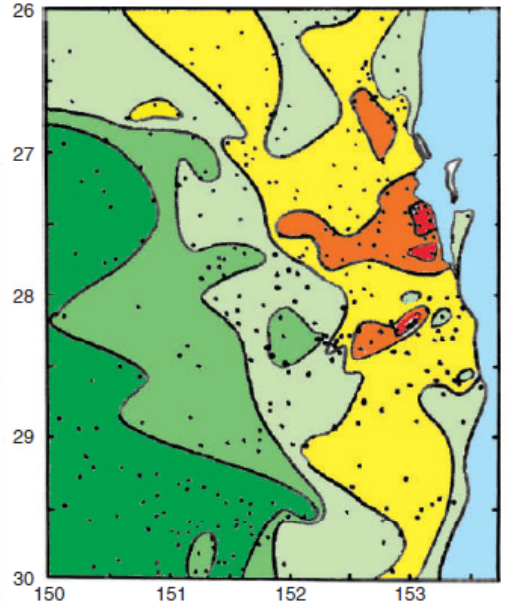
Bigg, *Environ. Chem.* 2008, 5, 184–193.

KIT Karlsruhe Institute of Technology



RAINFALL

BOM, AUSTRALIA, 2010/2011



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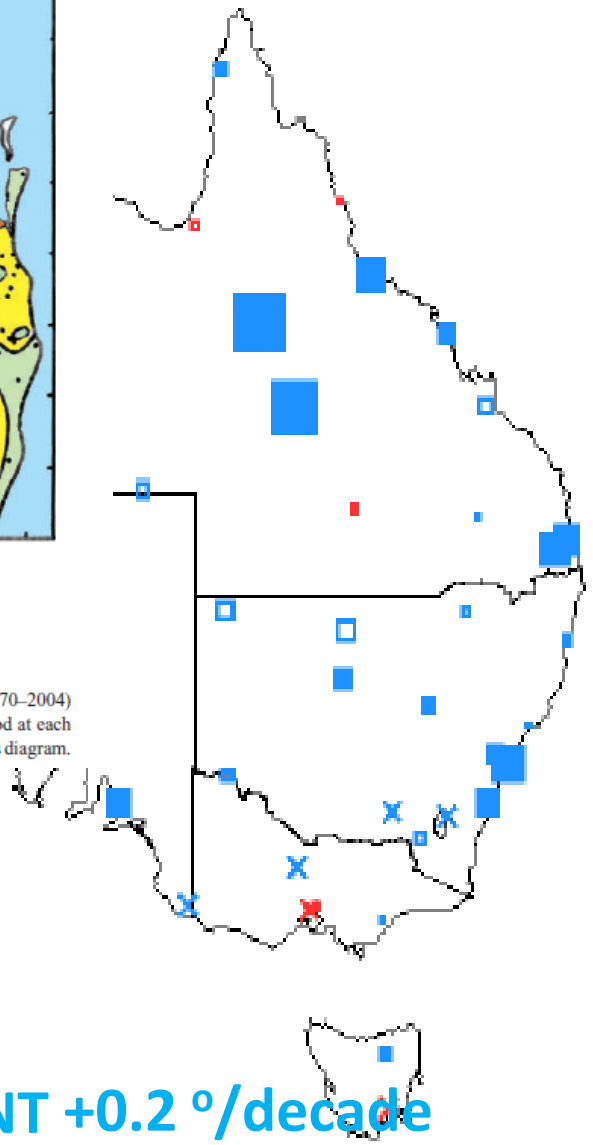
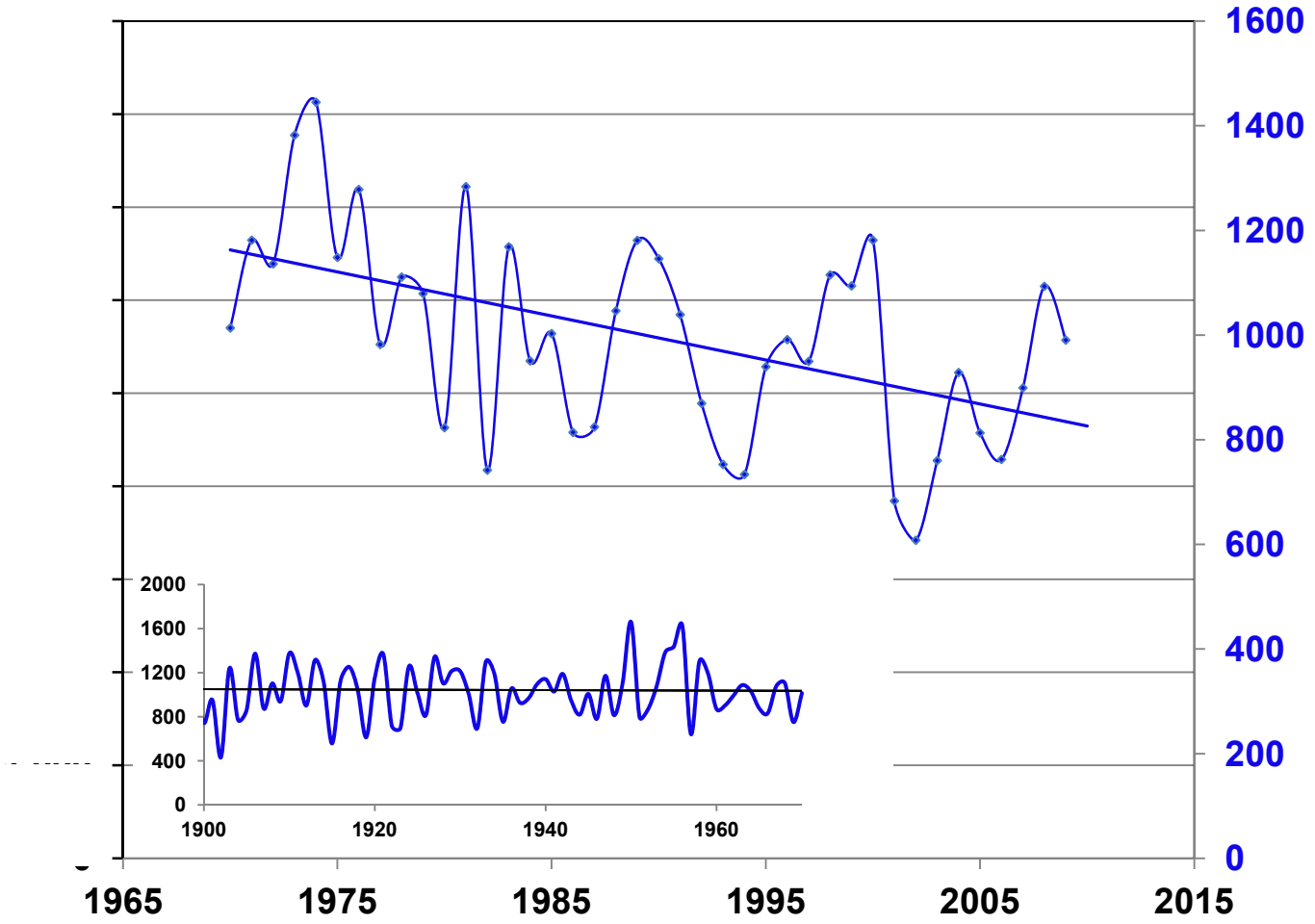


DEWPOINT +0.2 °/decade

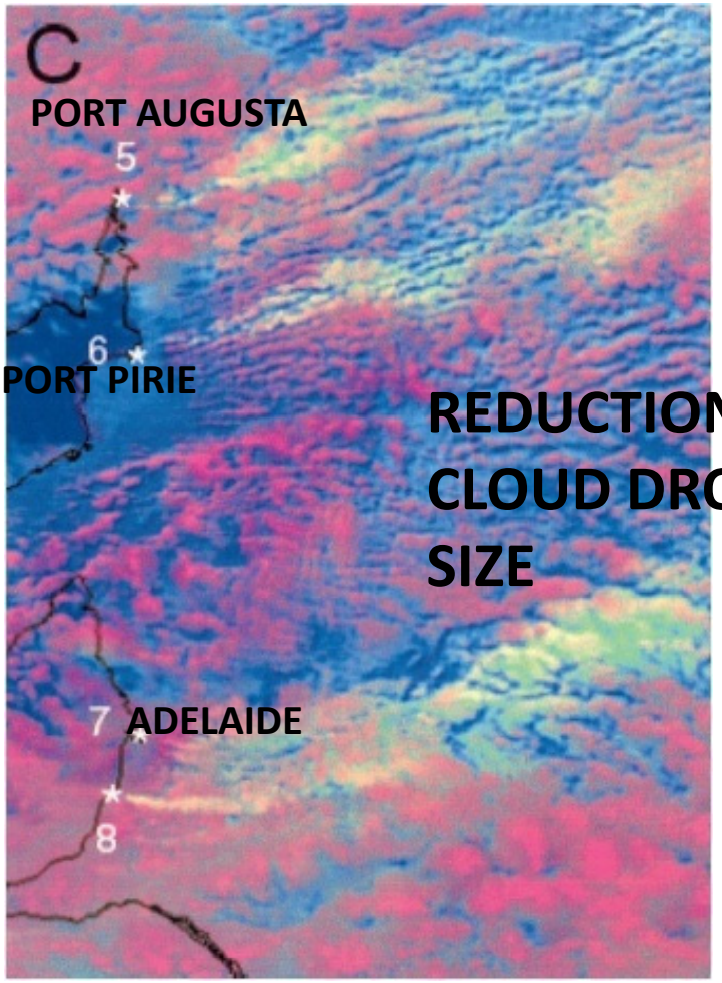
Lucas, 2010, CSIRO/BOM

ANNUAL PRECIPITATION [mm/a], 1970 - 2010



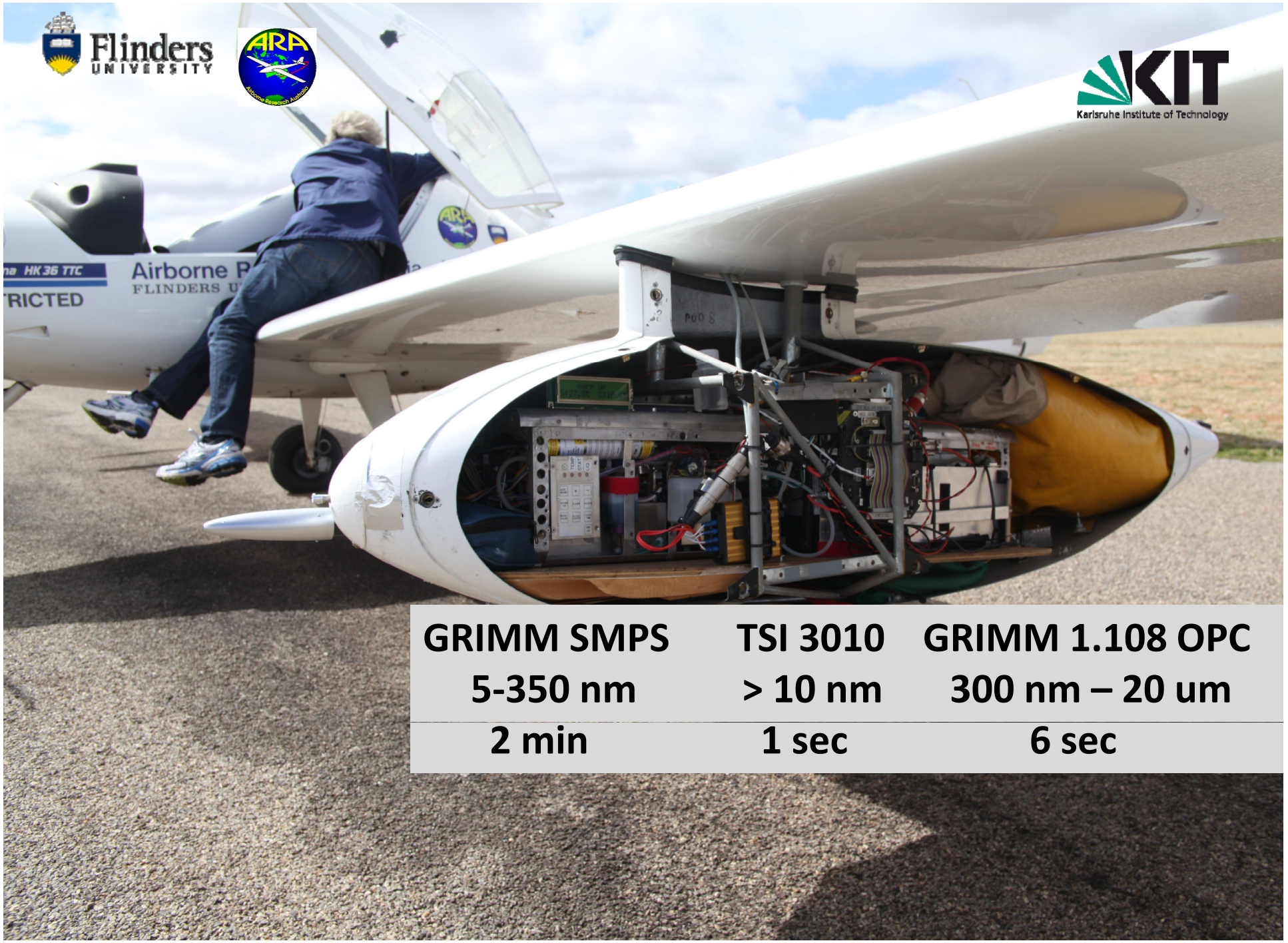
PORT AUGUSTA , SA, April 2011 / Sept. 2012

Daniel Rosenfeld
Science **287**, 1793 (2000);

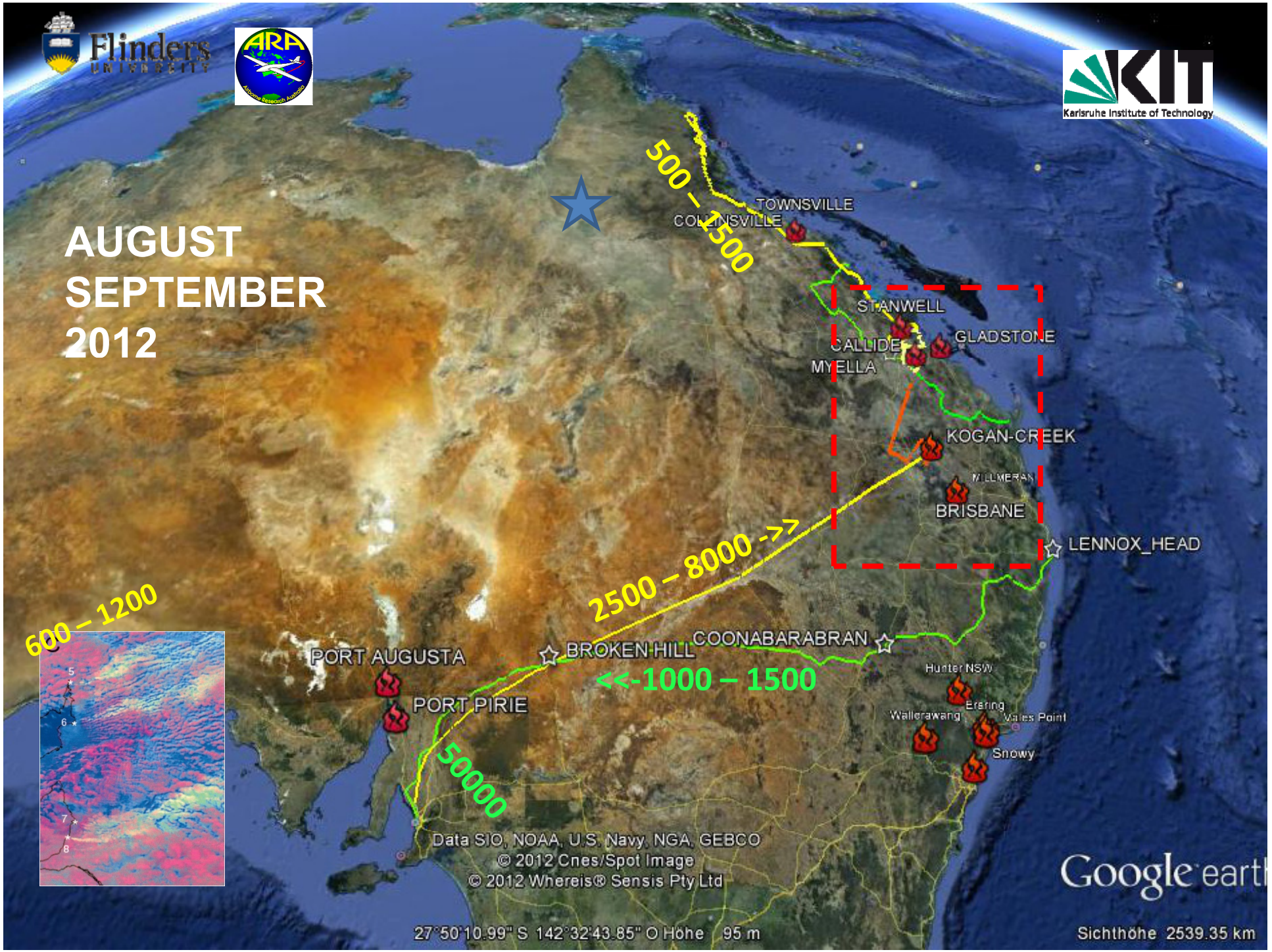


REDUCTION OF CLOUD DROPLET SIZE

Visible cloud effects after about 30 km ~ 2 h (HYSPLIT)



GRIMM SMPS	TSI 3010	GRIMM 1.108 OPC
5-350 nm	> 10 nm	300 nm – 20 um
2 min	1 sec	6 sec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Australian Research Aviation
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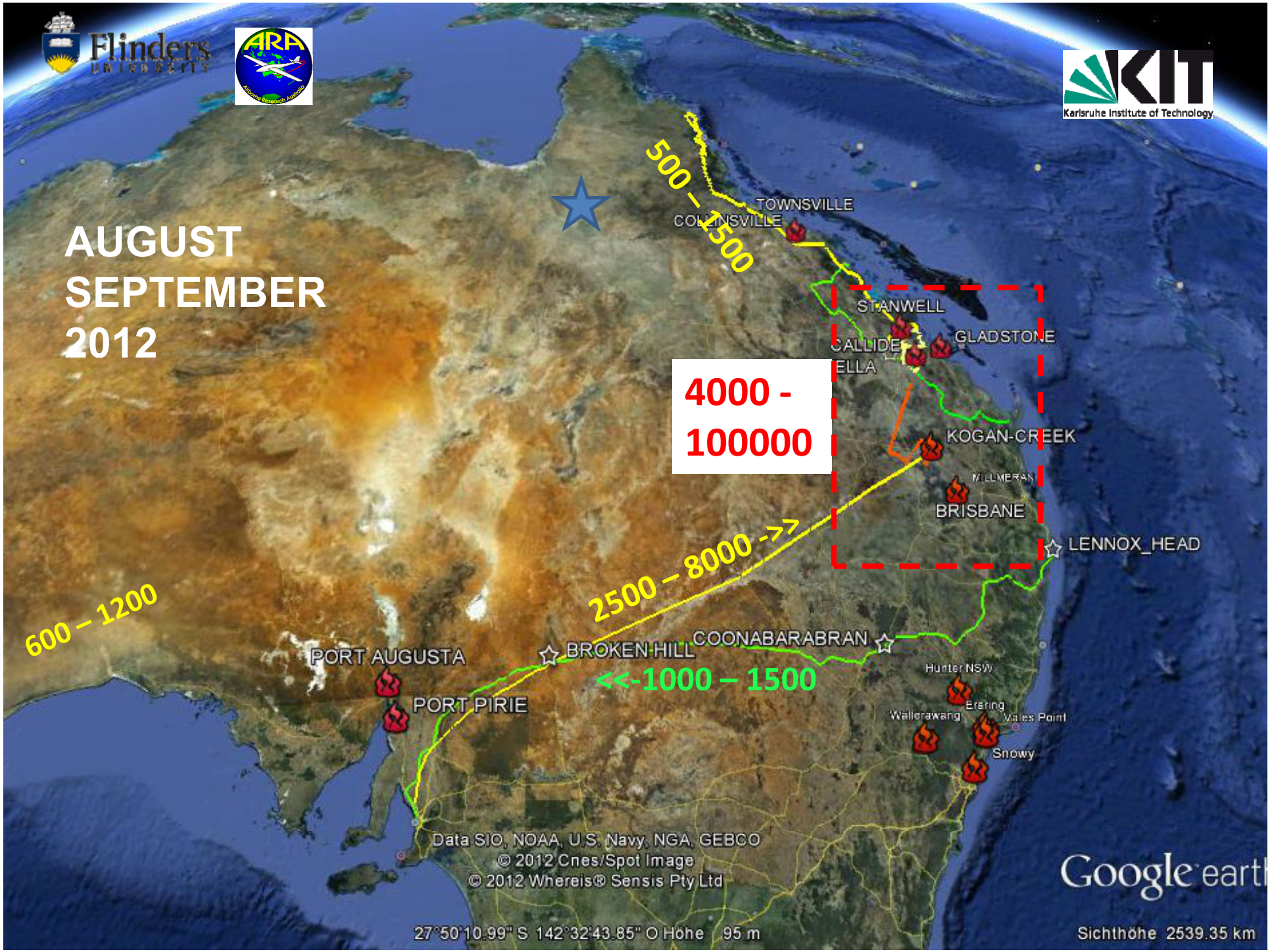
Karlsruhe Institute of Technology
AUGUST
SEPTEMBER
2012
500 – 1500
TOWNSVILLE
COLLINSVILLE
STANWELL
CALLIDE
GLADSTONE
MYELLA
KOGAN-CREEK
MILLMERAN
BRISBANE
LENNOX_HEAD
2500 – 8000 ->>
600 – 1200
COONABARABRAN
BROKEN HILL
<<-1000 – 1500
PORT AUGUSTA
PORT PIRIE
Hunter NSW
Erering
Wallerawang
Vales Point
Snowy
50000
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
© 2012 Whereis® Sensis Pty Ltd
27°50'10.99" S 142°32'43.85" O Höhe 95 m
Google earth
Sichthöhe 2539.35 km


Flinders UNIVERSITY
ARA
KIT
Karlsruhe Institute of Technology
AUGUST
SEPTEMBER
2012
500 – 1500
TOWNSVILLE
COLLINSVILLE
STANWELL
CALLIDE
ELLA
GLADSTONE
4000 -
100000
KOGAN-CREEK
MILLMERAN
BRISBANE
LENNOX_HEAD
2500 – 8000 ->>
600 – 1200
COONABARABRAN
BROKEN HILL
<<-1000 – 1500
PORT AUGUSTA
PORT PIRIE
Hunter NSW
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
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27°50'10.99" S 142°32'43.85" O Höhe 95 m
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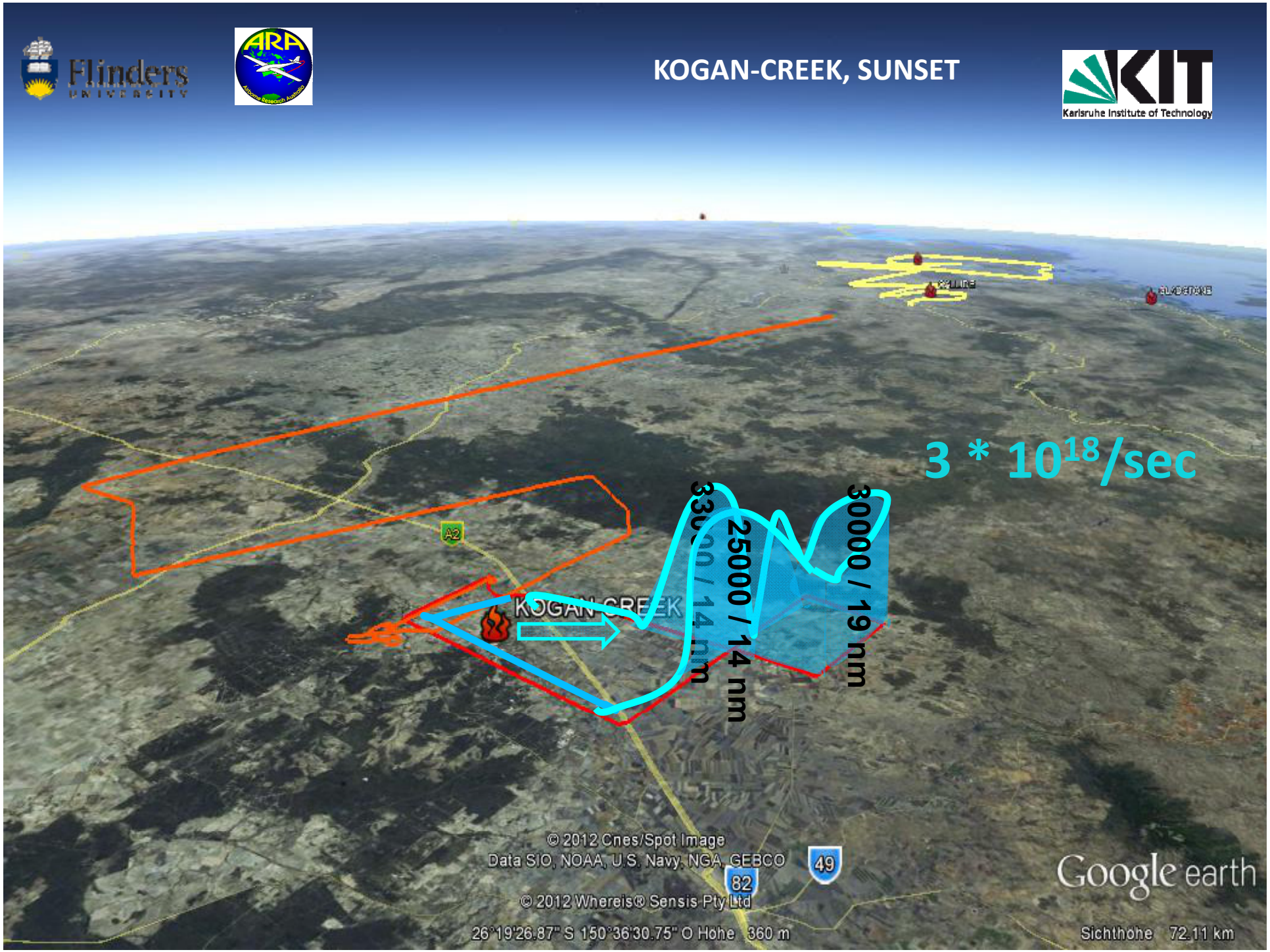
KOGAN-CREEK, SUNSET
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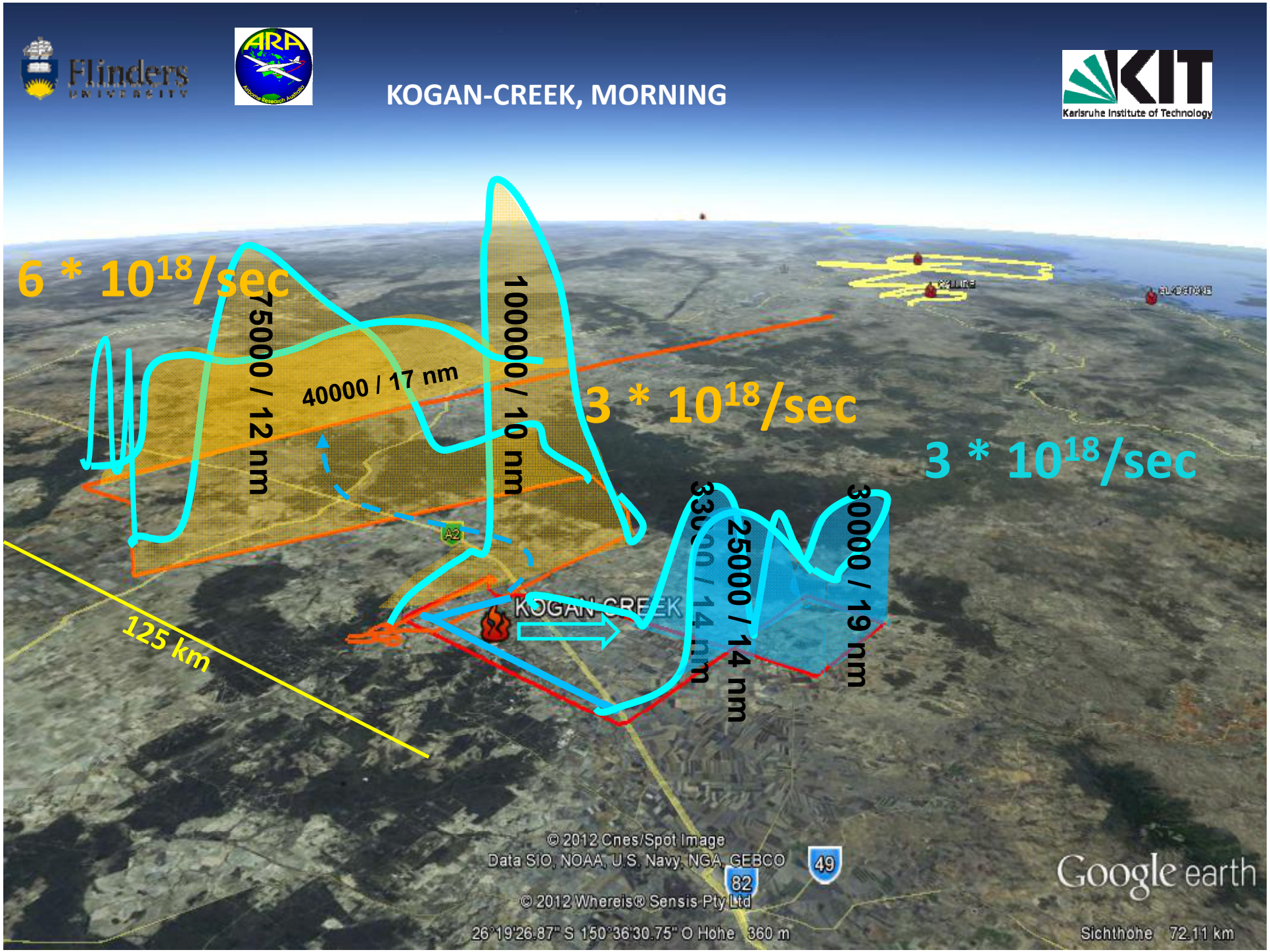
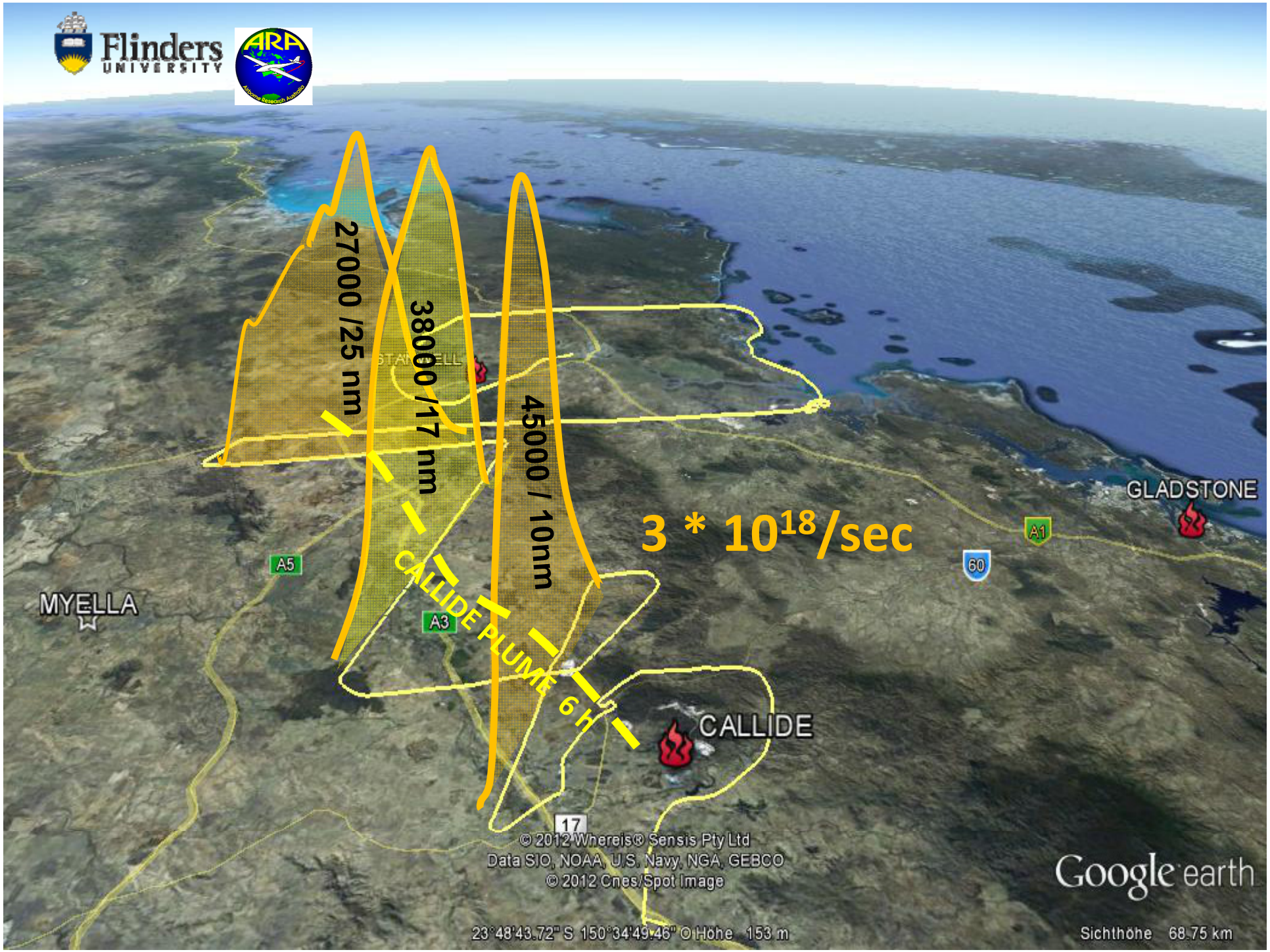
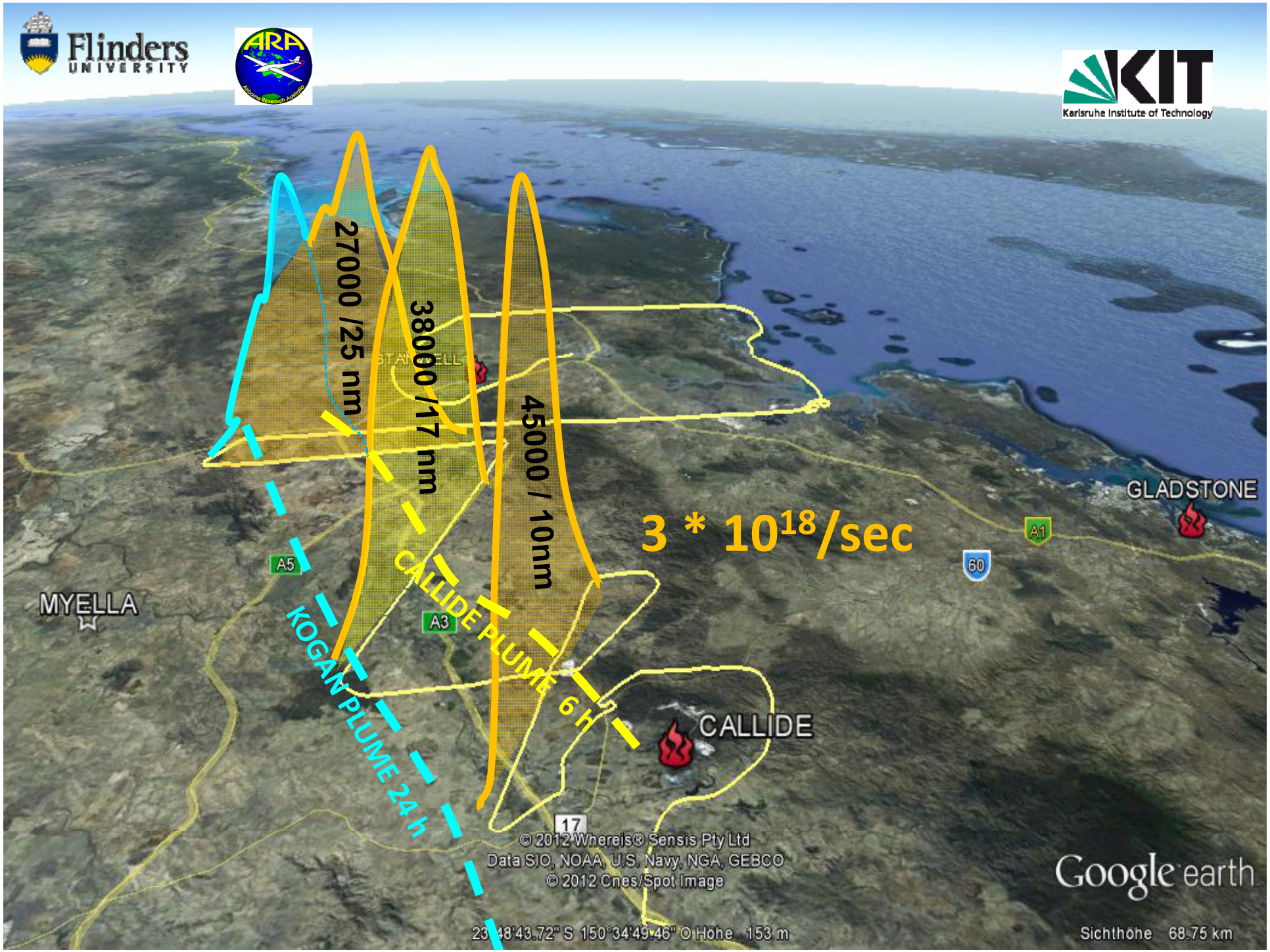
3 * 10^18/sec
25000 / 14 nm
30000 / 19 nm
KOGAN CREEK
A2
49
82
© 2012 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Whereis® Sensis Pty Ltd
26°19'26.87" S 150°36'30.75" O Höhe 360 m
Google earth
Sichthöhe 72.11 km


KOGAN-CREEK, MORNING
6 * 10^18/sec
75000 / 12 nm
40000 / 17 nm
100000 / 10 nm
3 * 10^18/sec
3 * 10^18/sec
33000 / 14 nm
25000 / 14 nm
30000 / 19 nm
125 km
KOGAN CREEK
A2
49
82
© 2012 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Whereis® Sensis Pty Ltd
26°19'26.87" S 150°36'30.75" O Hohe 360 m
Google earth
Sichthohe 72.11 km


Flinders UNIVERSITY
ARA
27000 /25 nm
38000 /17 nm
45000 / 10nm
3 * 10^18/sec
CALLIDE PLUME 6 H
CALLIDE
GLADSTONE
MYELLA
A5
A3
A1
60
17
© 2012 Whereis® Sensis Pty Ltd
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
Google earth
23°48'43.72" S 150°34'49.46" O Höhe 153 m
Sichthöhe 68.75 km


Flinders UNIVERSITY
ARA
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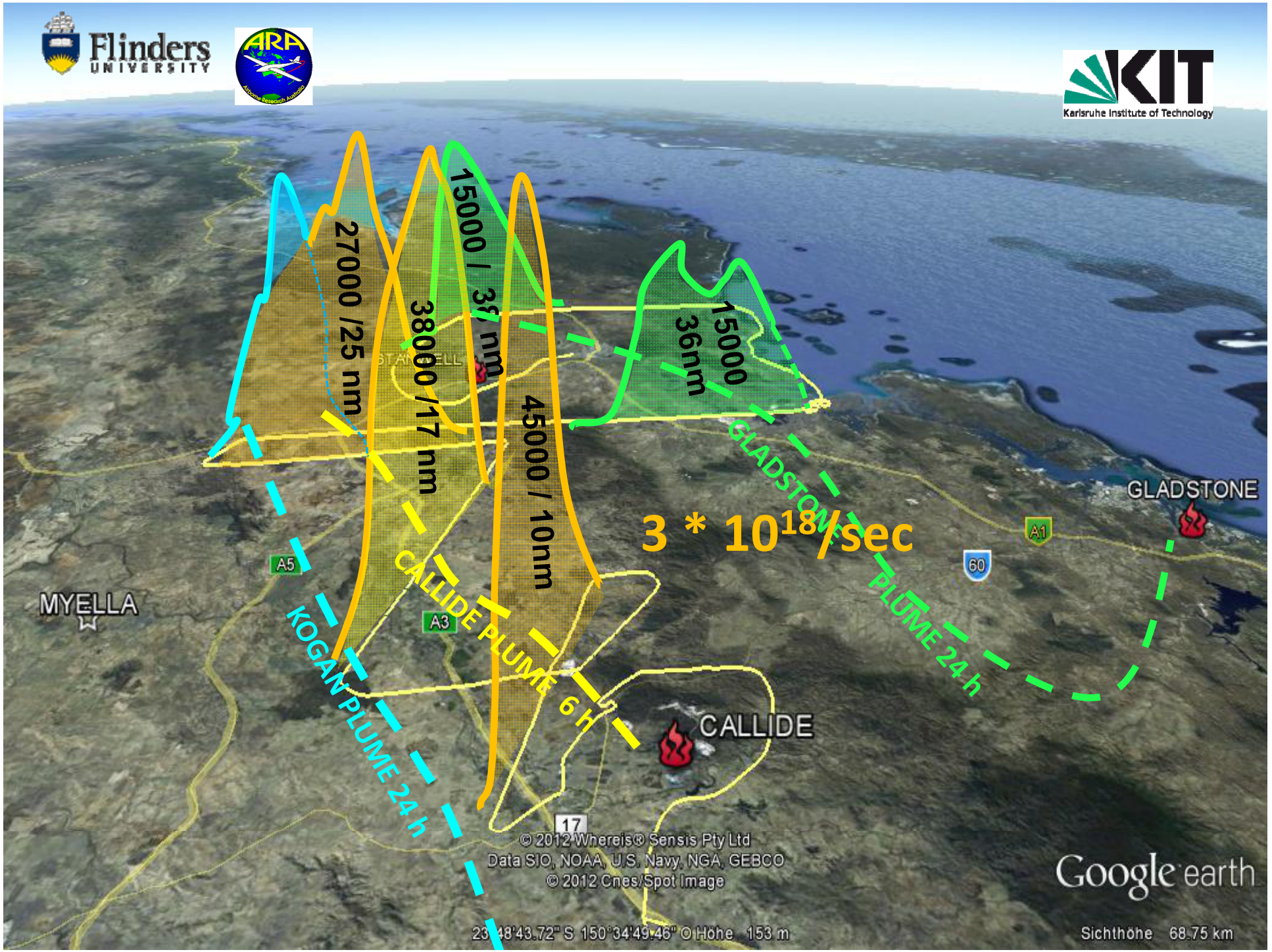
27000 /25 nm
38000 /17 nm
45000 / 10nm
3 * 10^18/sec
CALLIDE PLUME 6 h
KOGAN PLUME 24 h
GLADSTONE
MYELLA
CALLIDE
A1
A3
A5
60
17
© 2012 Whereis® Sensis Pty Ltd
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
Google earth
Sichthöhe 68.75 km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ARA
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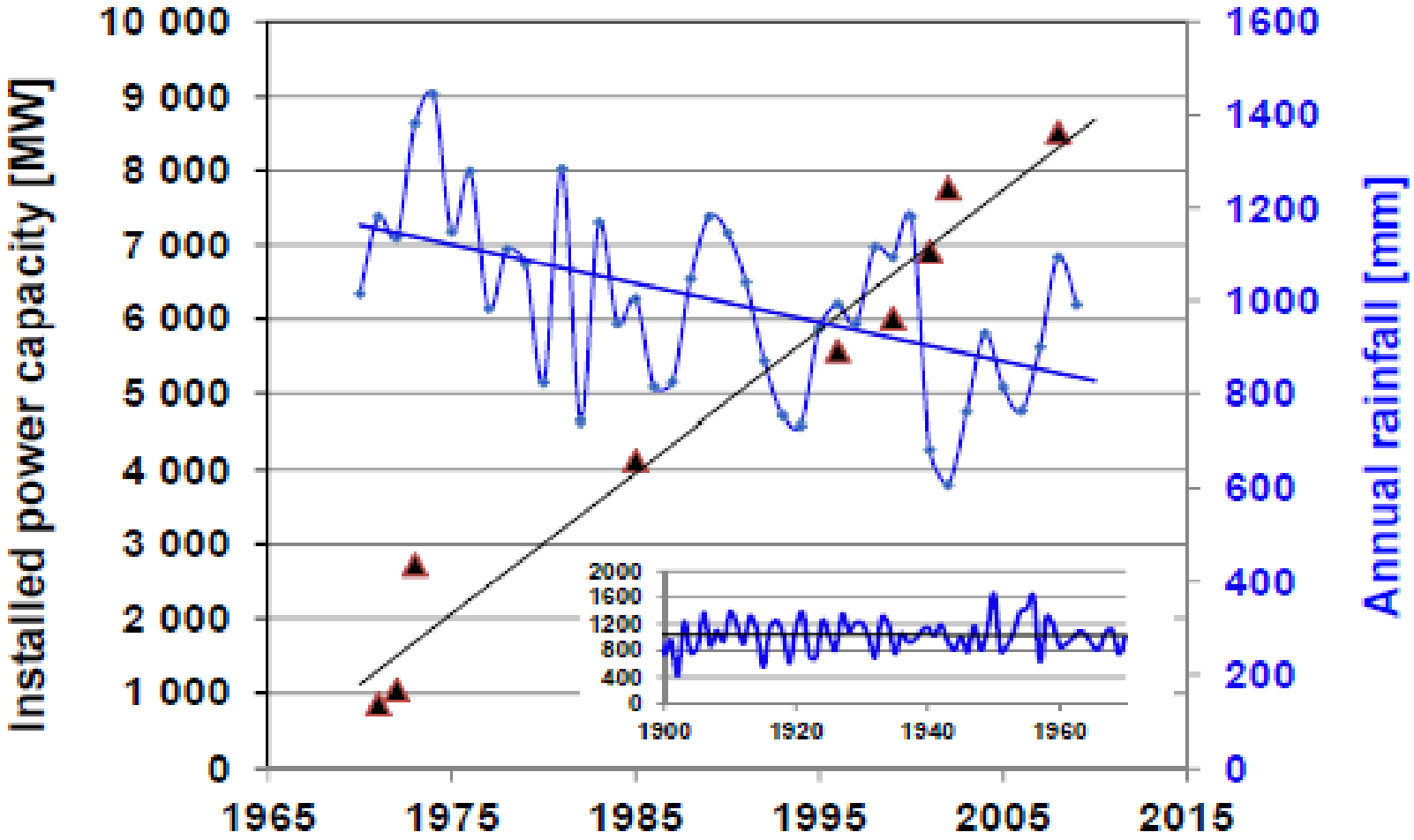
27000 /25 nm
38000 /17 nm
15000 / 38 nm
45000 / 10nm
15000
36nm
3 * 10^18 /sec
GLADSTONE
MYELLA
CALLIDE
A5
A3
A1
60
17
KOGAN PLUME 24 h
CALLIDE PLUME 6 h
GLADSTONE PLUME 24 h
© 2012 Whereis® Sensis Pty Ltd
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
Google earth
Sichthöhe 68.75 km


Installed power capacity [MW]
10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
1965
1975
1985
1995
2005
2015
Annual rainfall [mm]
1600
1400
1200
1000
800
600
400
200
0
2000
1600
1200
800
400
0
1900
1920
1940
1960

ANTHROPOGENIC CCN BUDGET FOR QLD

PARTICLE PRODUCTION / 600 MW based on KA and QLD measurements	2* 10^{18} /s
PARTICLE PRODUCTION / 8000 MW	2.7*10^{24} /d
QUEENSLAND PBL VOLUME (1.2 km)	2.1*10^{21} cm^3
RES.TIME 5d >>>>	+ 3500 / cm^3
5 fold enhancement of CCN in QLD	

1966)

EFFECTS OF ENHANCED CCN

MORE AND SMALLER CLOUD DROPLETS (LESS LIQUID WATER?)

TEMPORAL, SPATIAL AND INTENSITY REDISTRIBUTION OF RAINFALL

REDUCTION OF NUMBER OF RAINFALL DAYS, INCREASED RAINFALL/DAY

POSSIBLE LOSS OF WATER TO THE OCEAN (FOR COASTAL REGIONS) >> ANNUAL PRECIP.LOSS

1966)

SUMMARY

ENHANCED NUMBERS OF ULTRAFINE PARTICLES (CCN / CCN PRECURSORS) IN REMOTE, DROUGHT AFFECTED REGIONS OF AUSTRALIA FROM COAL FIRED POWER STATIONS

NO OTHER COMPARABLE SOURCES IDENTIFIED -> HISTORY

SUMMARY

TRANSPORT > 1500 km AND REGIONAL SCALE ENHANCEMENT

ANTHROP. CCN > 5 times NATURAL BACKGROUND

SUFFICIENT FOR THE OBSERVED RAINFALL MODIFICATION

THANK YOU FOR YOUR ATTENTION

What‘s the climate effect of increased nucleation mode particles?

Western Australia
regional scale production of ultrafine aerosol following drastic land cover change

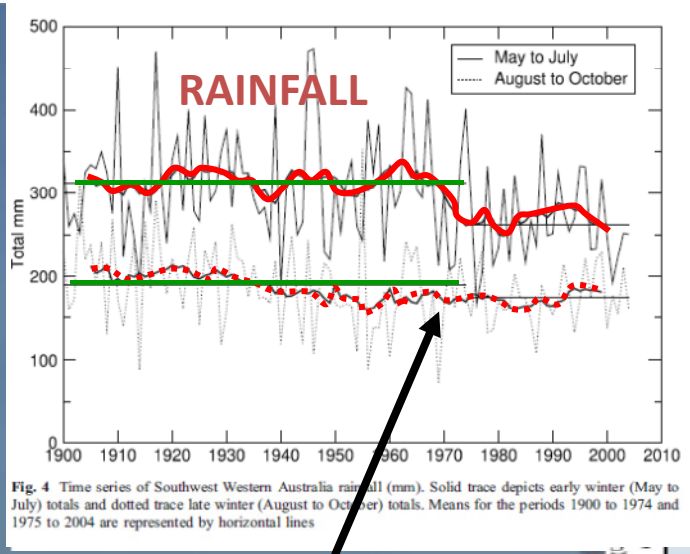


Fig. 4 Time series of Southwest Western Australia rainfall (mm). Solid trace depicts early winter (May to July) totals and dotted trace late winter (August to October) totals. Means for the periods 1900 to 1974 and 1975 to 2004 are represented by horizontal lines

Bates et al.
Climatic Change, 89,
2008, 339-354

SURFACE RUNOFF

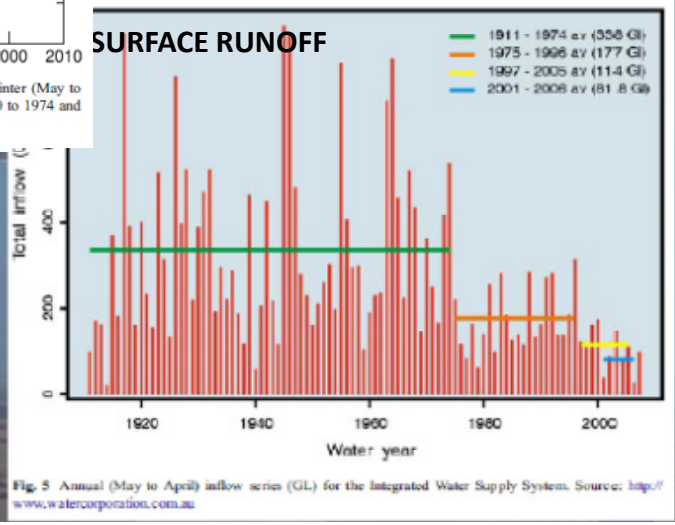
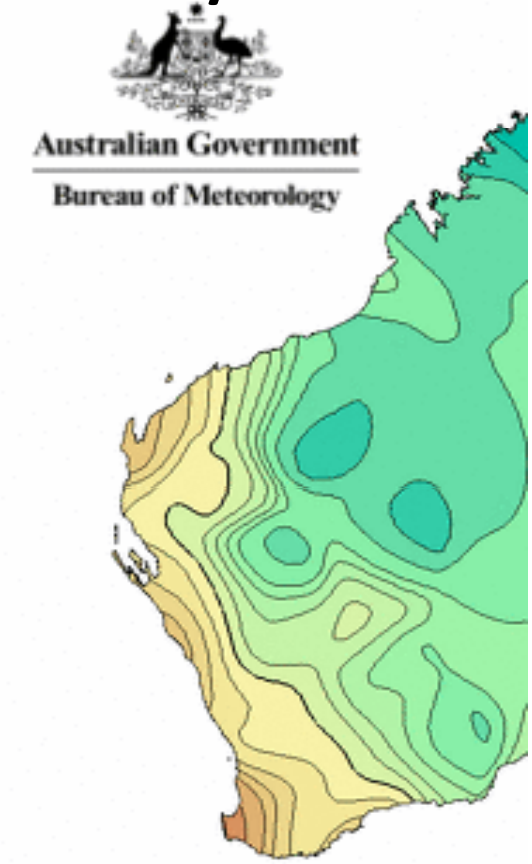


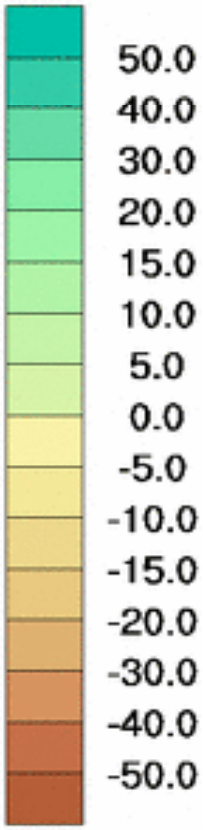
Fig. 5 Annual (May to April) inflow series (GL) for the Integrated Water Supply System. Source: http://www.watercorporation.com.au

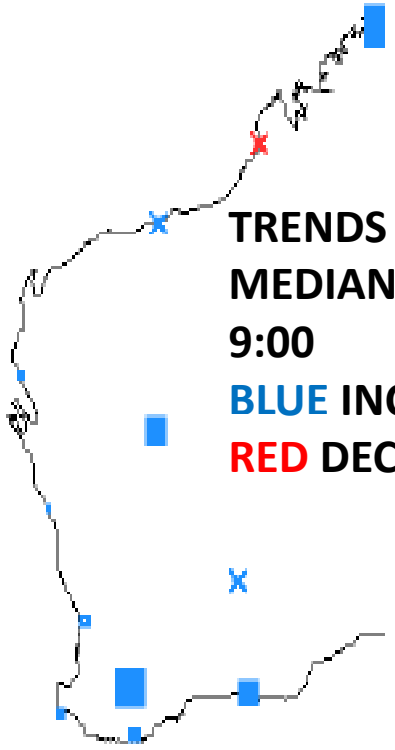
BEGIN OF UF-PARTICLE PRODUCTION ?

CLIMATE/PRECIPITATION H_2O TRENDS



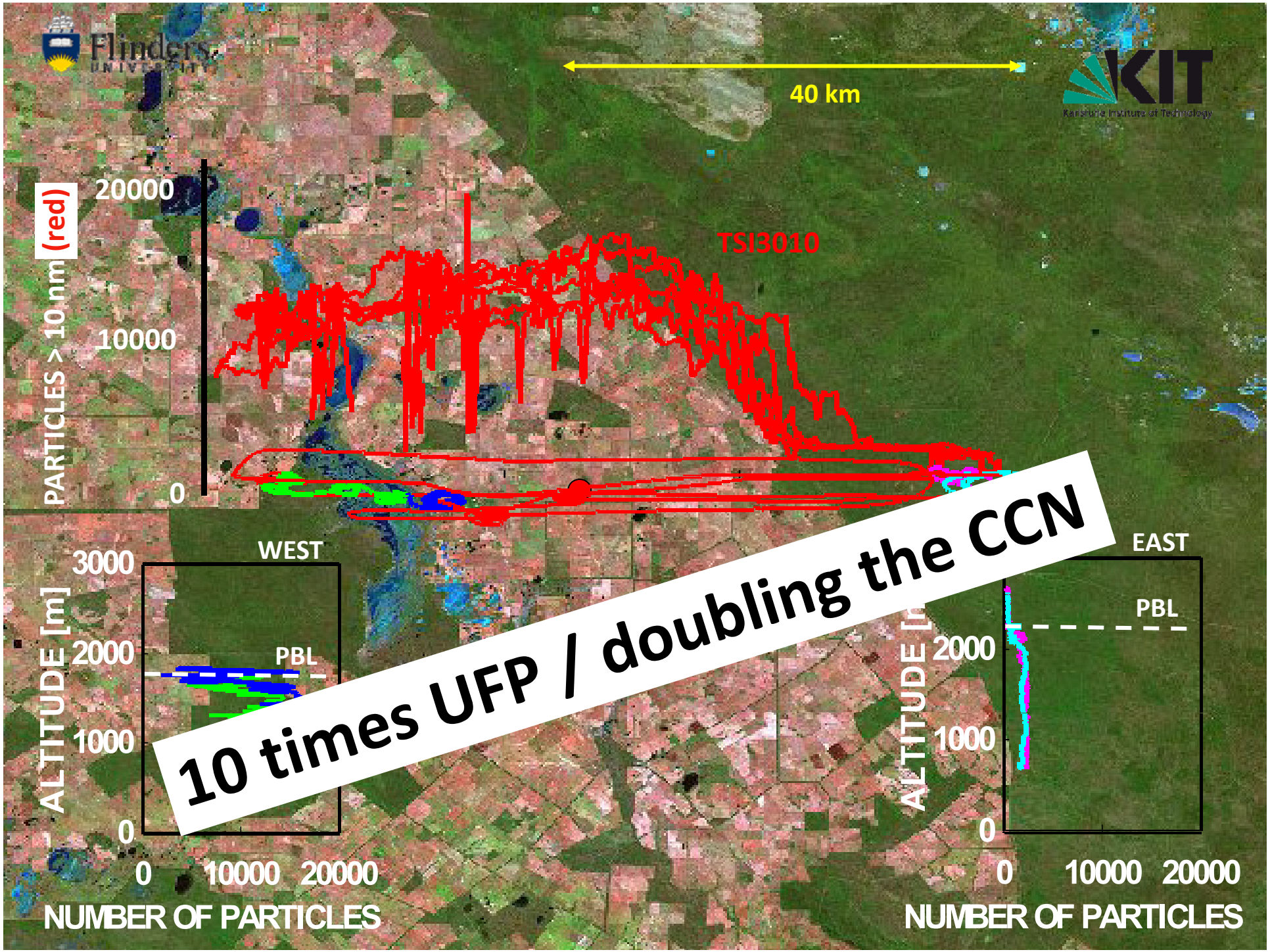
Trend in Annual Total Rainfall
1970-2010 (mm/10yrs)



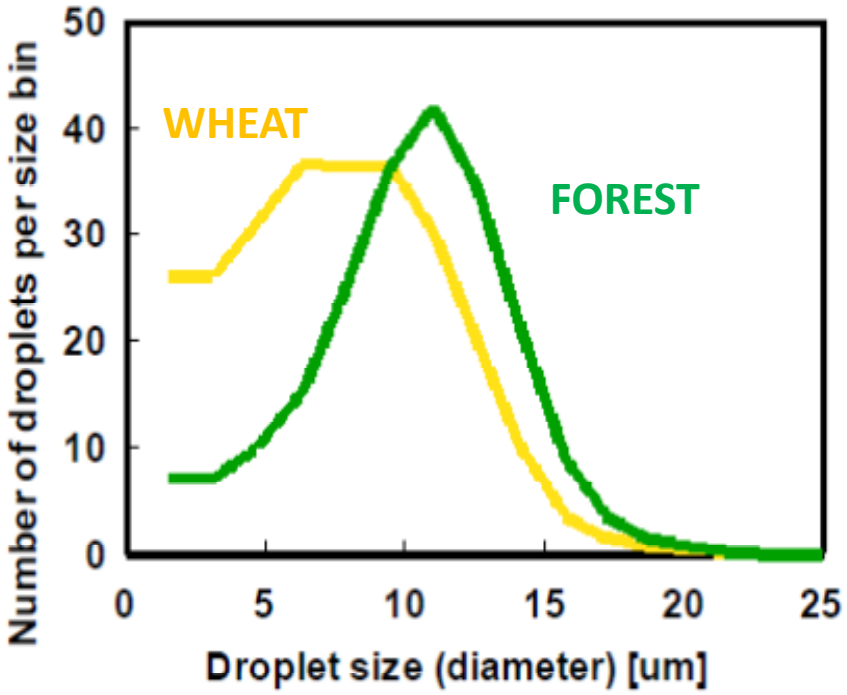


TRENDS IN MONTHLY MEDIAN DEWPOINT AT 9:00
BLUE INCREASING
RED DECREASING

+0.25 C / DECADE


Flinders UNIVERSITY
40 km
KIT
Karlsruhe Institute of Technology
PARTICLES > 10 nm (red)
20000
10000
0
TSI3010
10 times UFP / doubling the CCN
WEST
EAST
ALTITUDE [m]
3000
2000
1000
0
PBL
0
10000
20000
NUMBER OF PARTICLES

EFFECT OF INCREASED CCN NUMBERS ON CLOUDS



Junkermann et al, ACP, 2009, Australia

	H2O(g)	LWC	%
NAT (198)	**6.1**	**0.15**	**2.4**
AGR (247)	**8.8**	**0.10**	**1.1**
	g/m3		

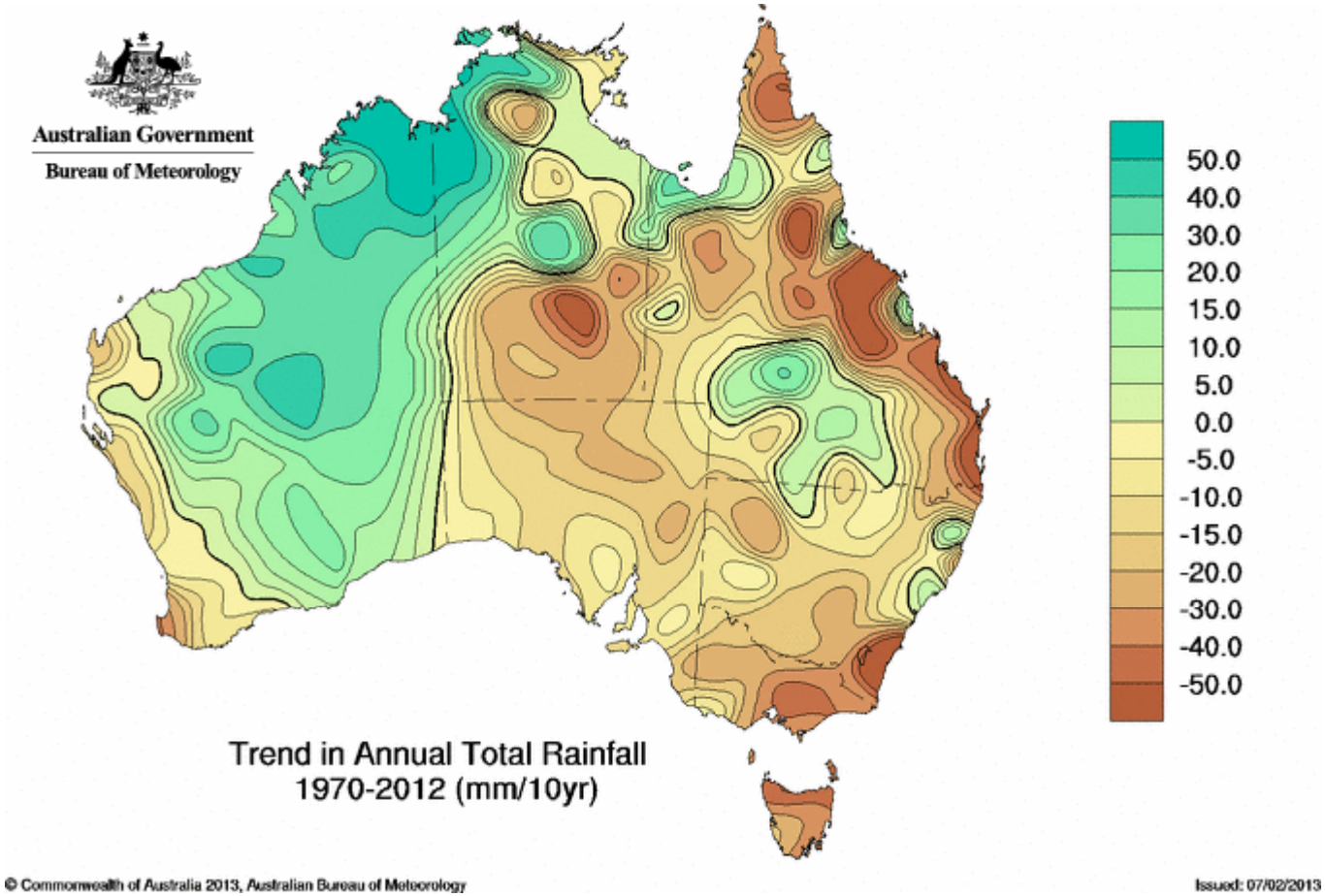
F= 2.0

$$R \sim LWP^{\alpha} N_d^{-\beta}$$

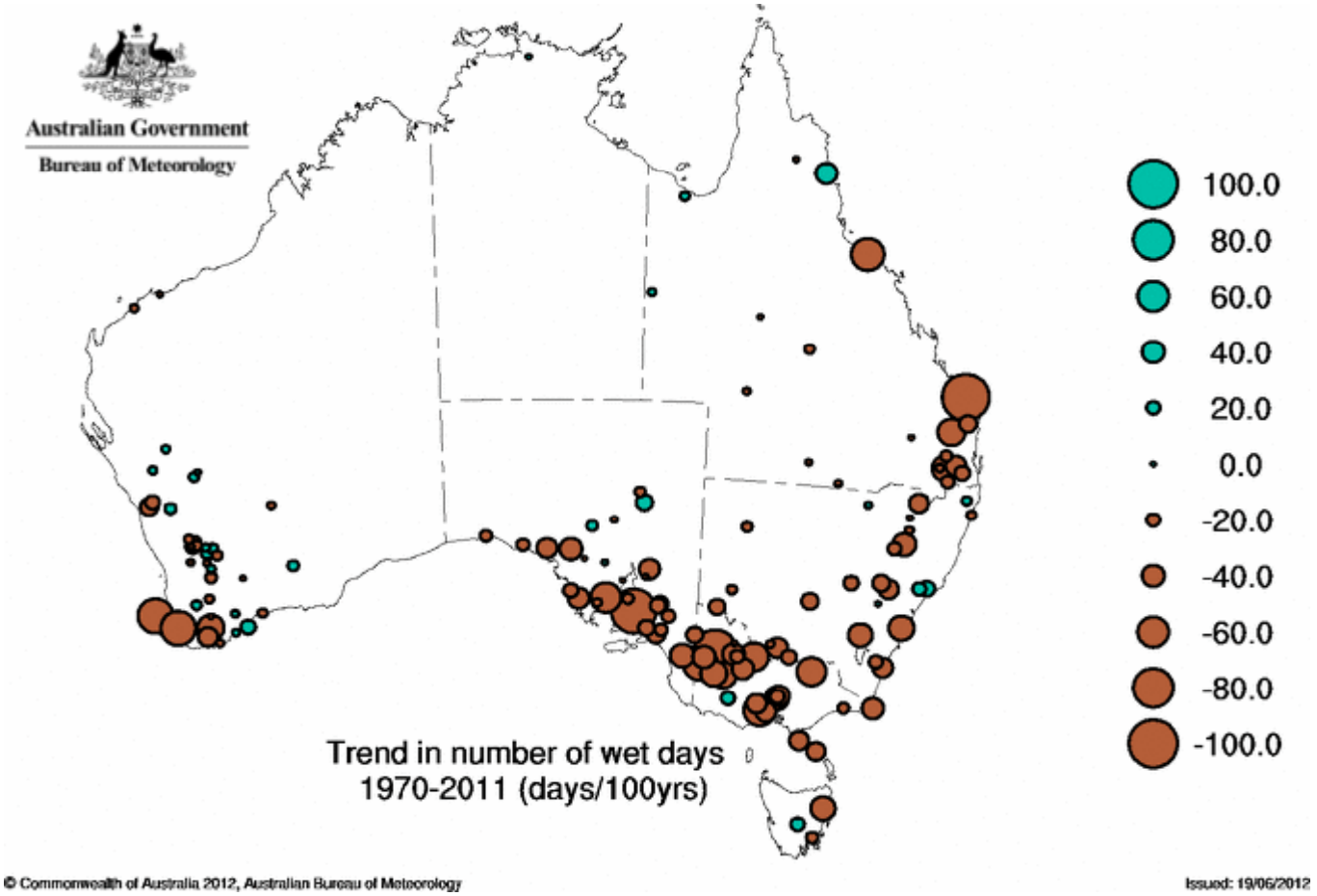
R = rain rate (cloud base)
LWP = liquid water path (macro)
N_d *= drop conc (microphysical)*

$\alpha \sim 1.50$
$\beta \sim 0.67$

Wang and Feingold, 2009a



Issued: 07/02/2013


Australian Government
Bureau of Meteorology
Trend in number of wet days
1970-2011 (days/100yrs)
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
© Commonwealth of Australia 2012, Australian Bureau of Meteorology
Issued: 19/06/2012