



# Ultrafine particles and rainfall modification: experimental evidence from airborne studies?

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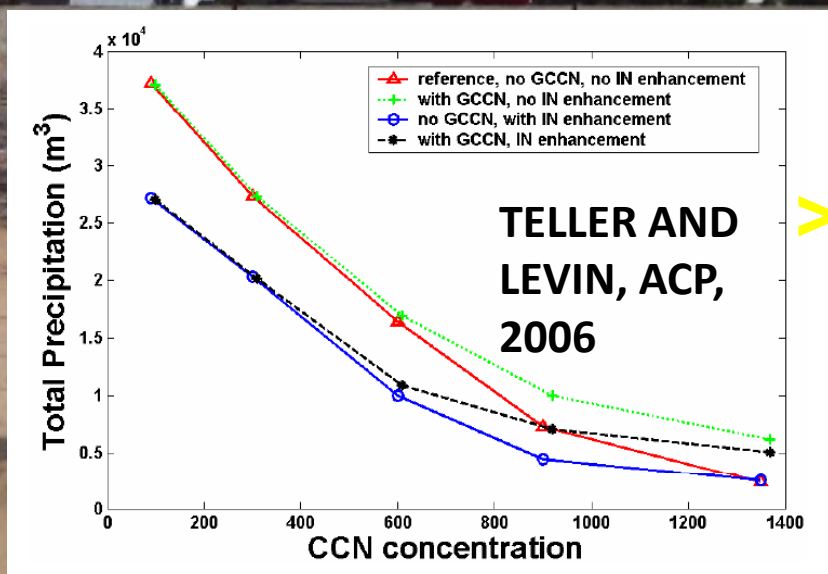




# What to expect?



addition of UFP -> CCN   
> smaller droplets  
> delay of raindrop formation  
> .....



> regional to continental scale

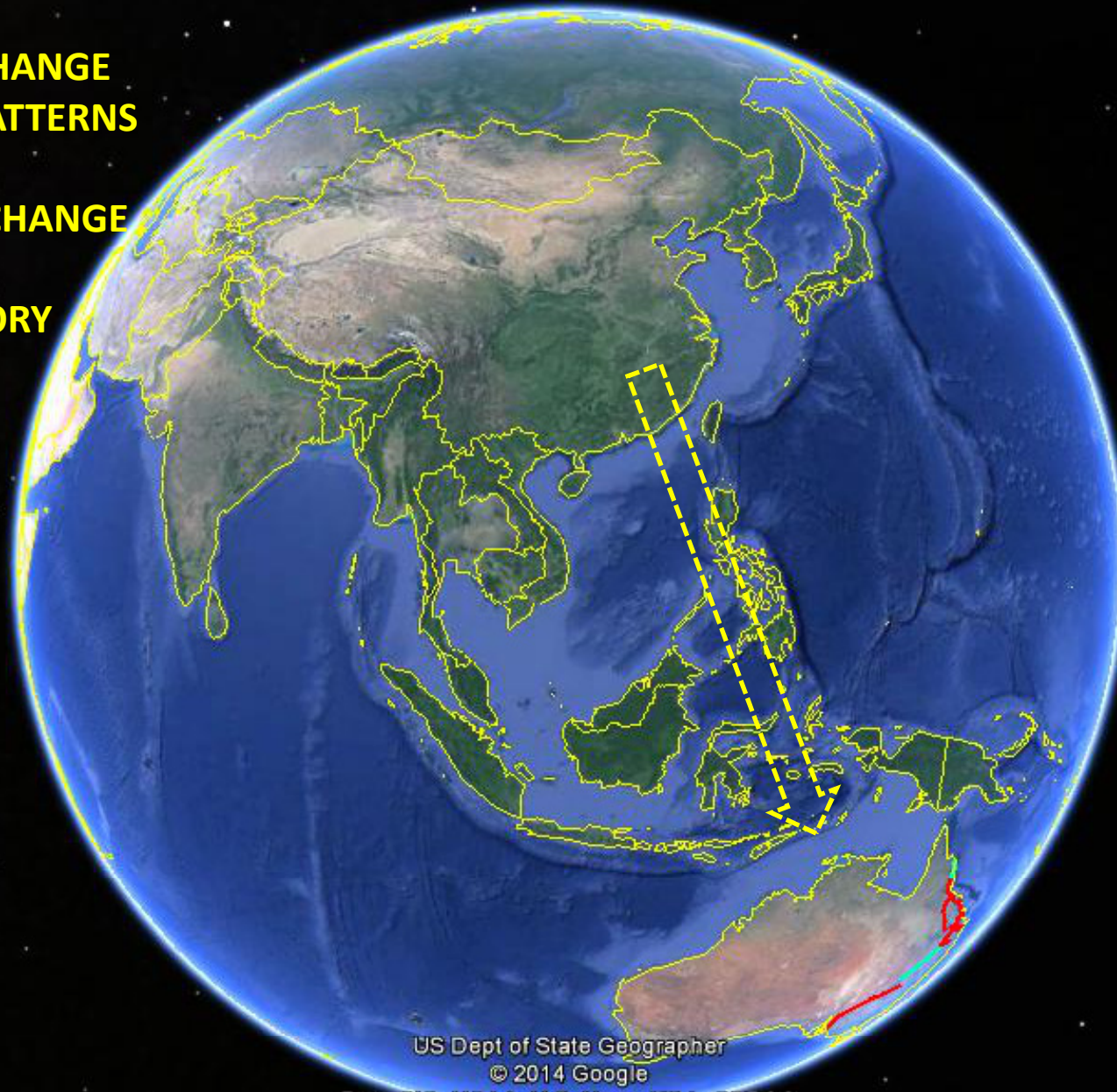


**FINDING A SUITABLE AREA:**

**SIGNIFICANT CHANGE  
OF RAINFALL PATTERNS**

**NO LAND USE CHANGE**

**AEROSOL HISTORY**

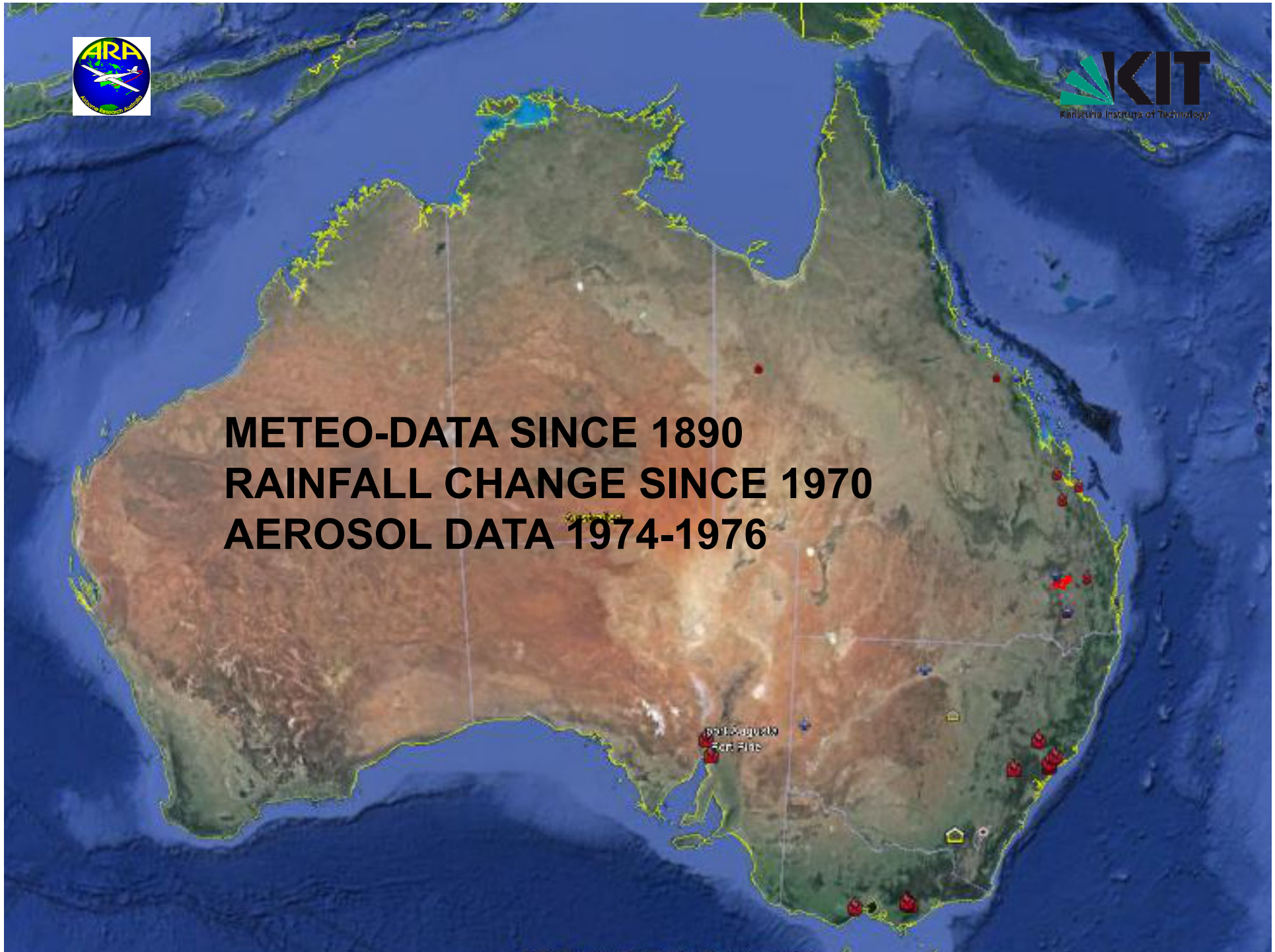


US Dept of State Geographer  
© 2014 Google  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
© 2009 GeoBasis-DE/BKG

Google earth



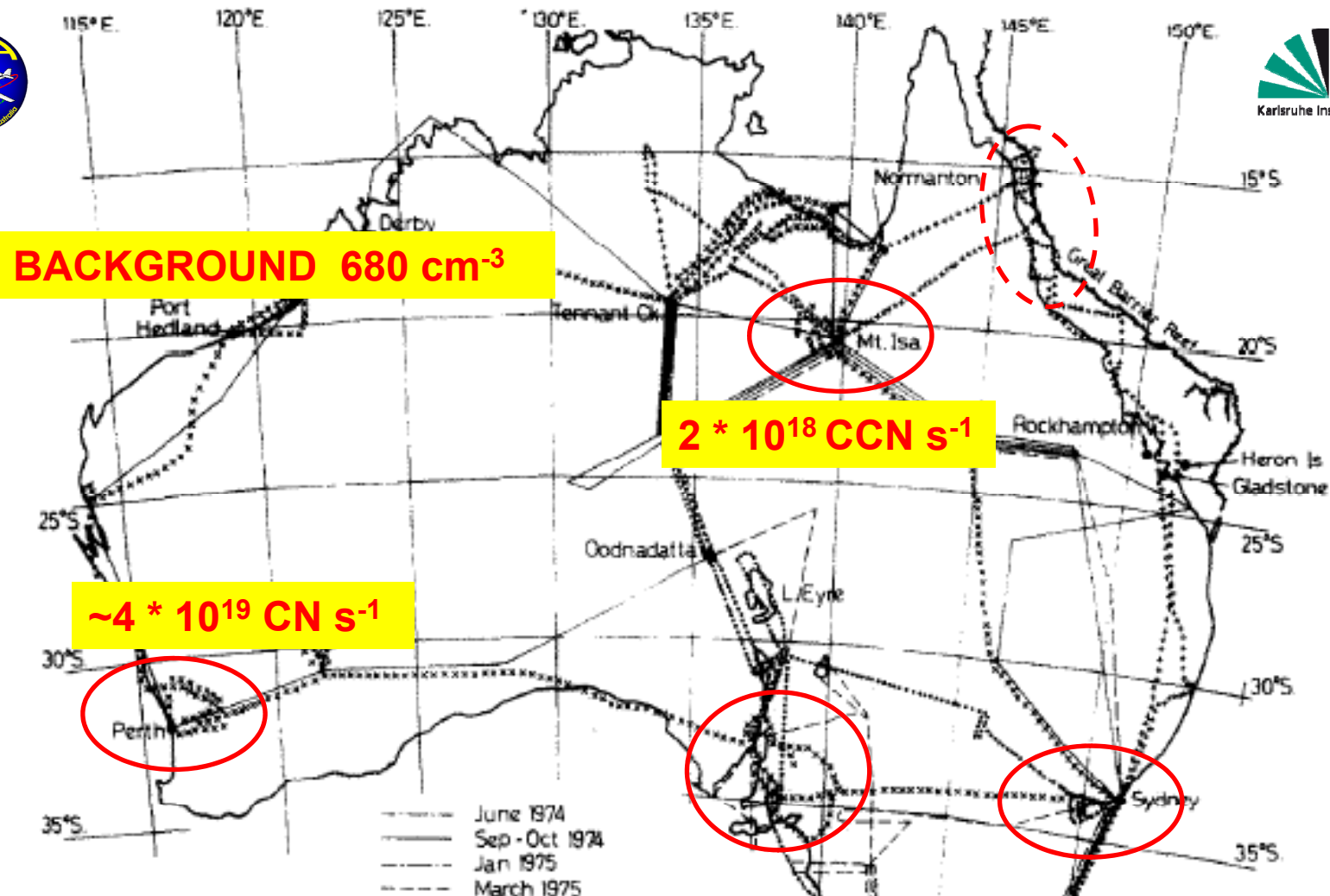
**METEO-DATA SINCE 1890**  
**RAINFALL CHANGE SINCE 1970**  
**AEROSOL DATA 1974-1976**



# SOURCES OF ATMOSPHERIC PARTICLES OVER AUSTRALIA

E. K. BIGG and D. E. TURVEY

Atmospheric Environment, 1978



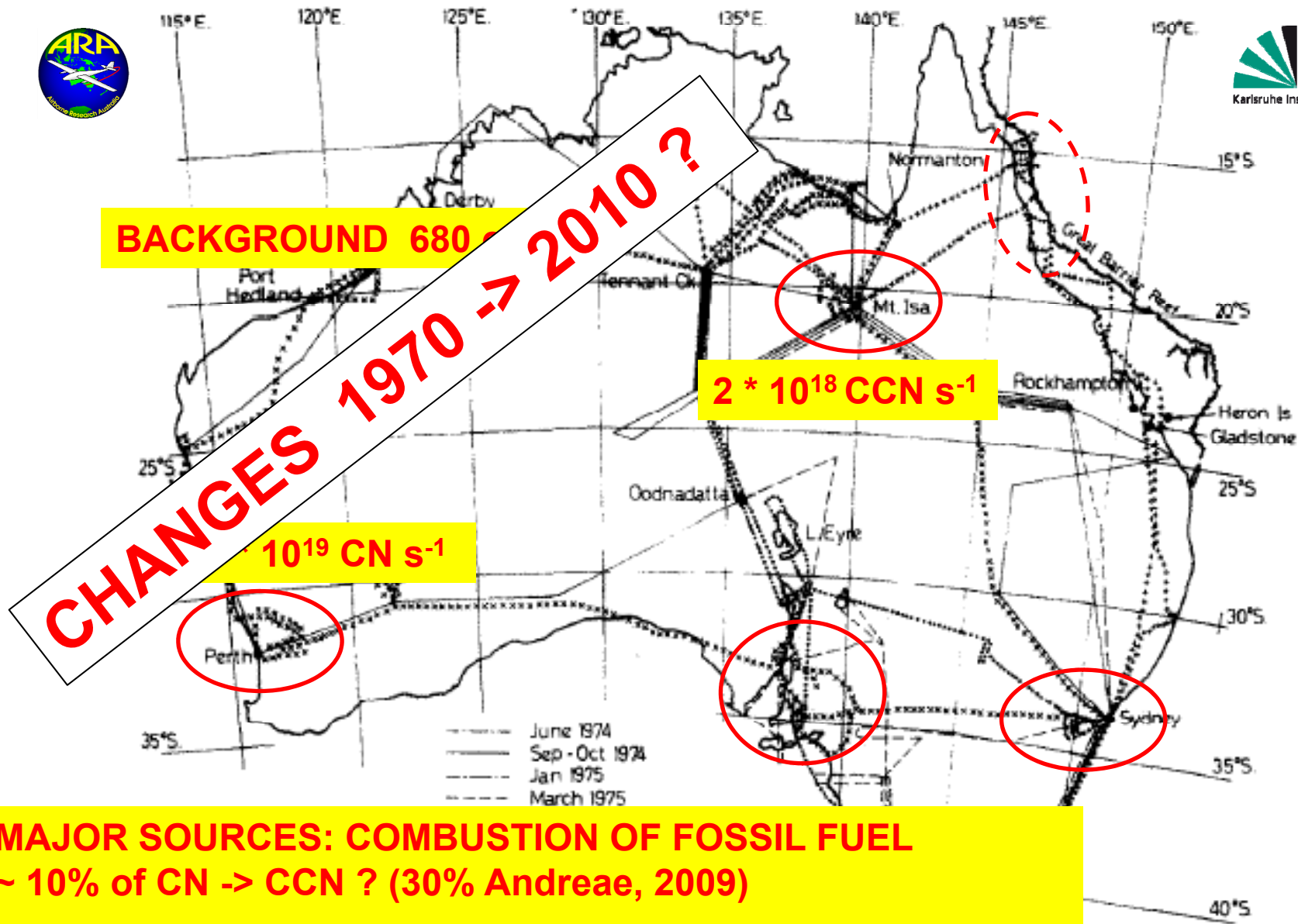
**MAJOR SOURCES: COMBUSTION OF FOSSIL FUEL  
~ 10% of CN -> CCN ?**

**TOTAL NATURAL CN PRODUCTION AUS  $\sim 1 * 10^{19} \text{ s}^{-1}$**

# SOURCES OF ATMOSPHERIC PARTICLES OVER AUSTRALIA

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**MAJOR SOURCES: COMBUSTION OF FOSSIL FUEL**  
**~ 10% of CN -> CCN ? (30% Andreae, 2009)**

**TOTAL NATURAL CN PRODUCTION AUS ~1 \* 10<sup>19</sup> s<sup>-1</sup>**



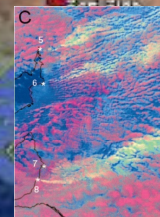
Australian Government  
Bureau of Meteorology

# AEROSOL RAINFALL STUDIES

WARNER, 1968



ROSENFELD, 2000



WJ and JMH, 2009





**GRIMM SMPS**

**5-350 nm**

**2 min**

**TSI 3010**

**> 10 nm**

**1 sec**

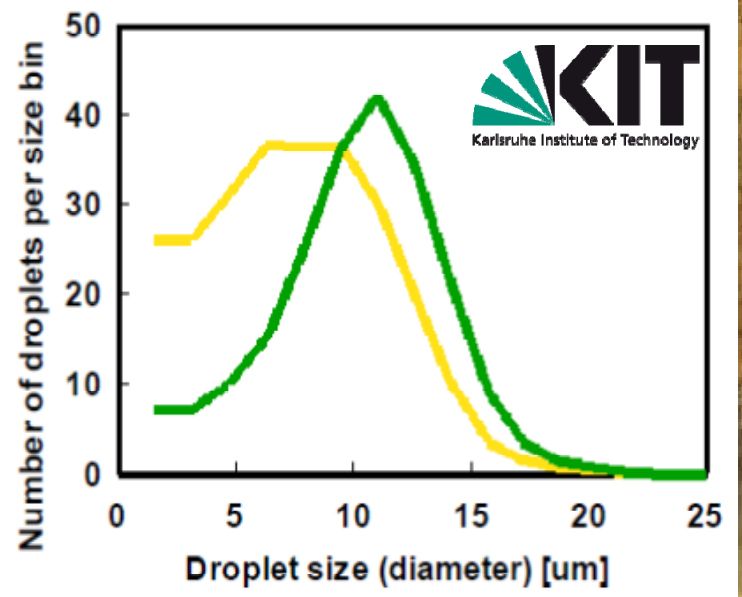
**GRIMM 1.108 OPC**

**300 nm – 20 um**

**6 sec**

**PLUS FSSP 100**



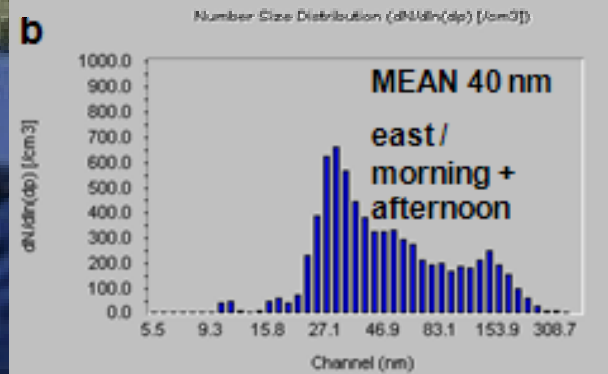
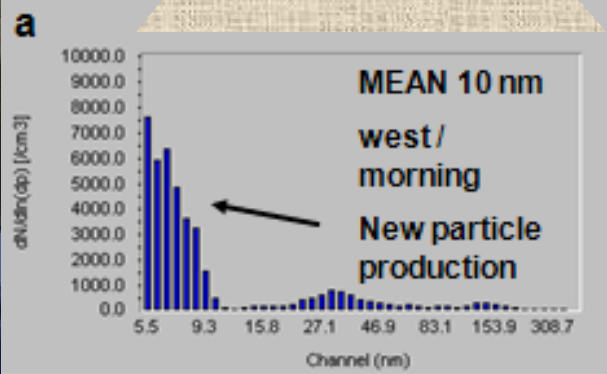


Perth WA, Australien

400 km

1000

NPP SOURCES



Trends in rainfall associated with sources of air pollution, *Environ. Chem.* 2008, 5, 184–193. 1970–2004

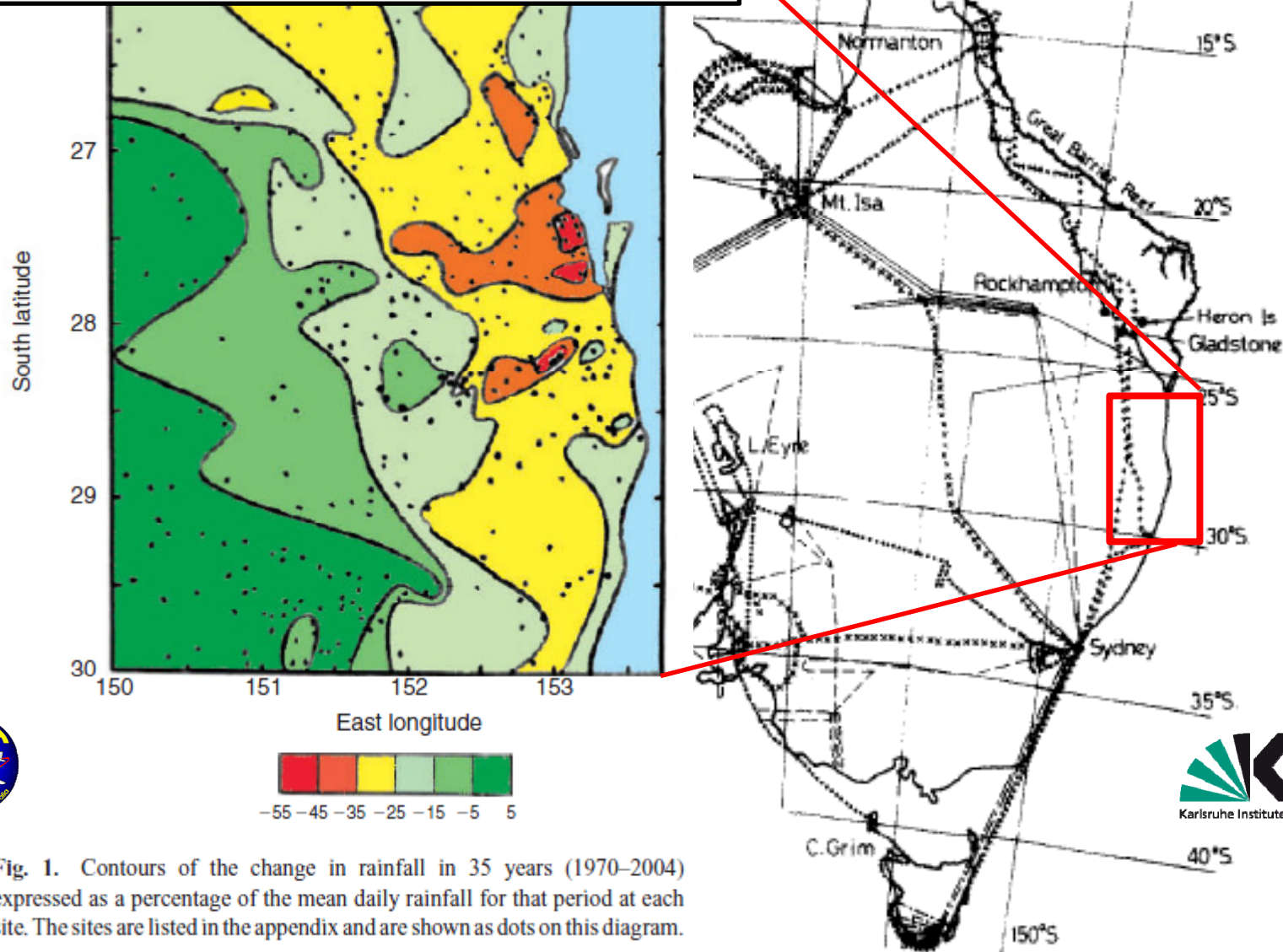
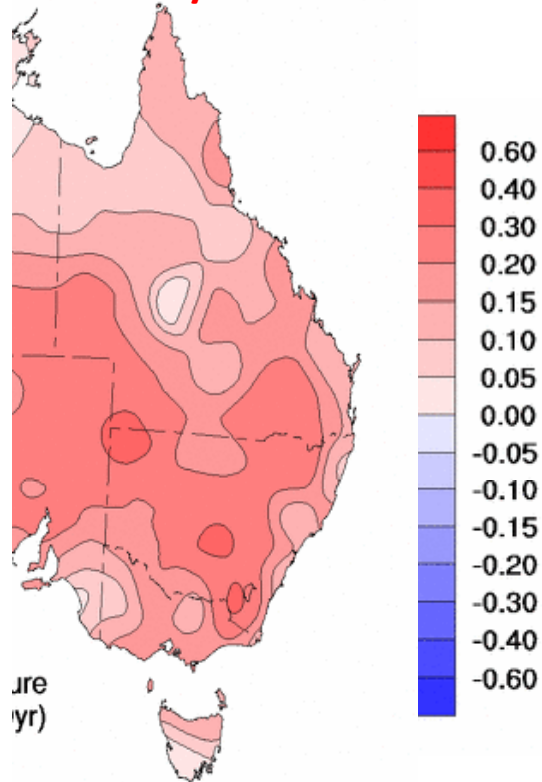


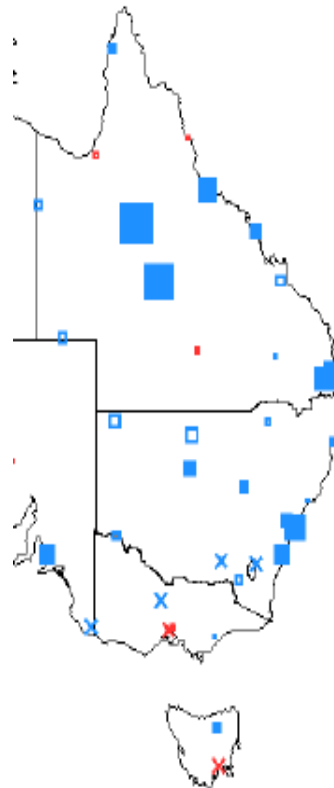
Fig. 1. Contours of the change in rainfall in 35 years (1970–2004) expressed as a percentage of the mean daily rainfall for that period at each site. The sites are listed in the appendix and are shown as dots on this diagram.

# CLIMATE CHANGE, EASTERN AUSTRALIA, 1970-2010

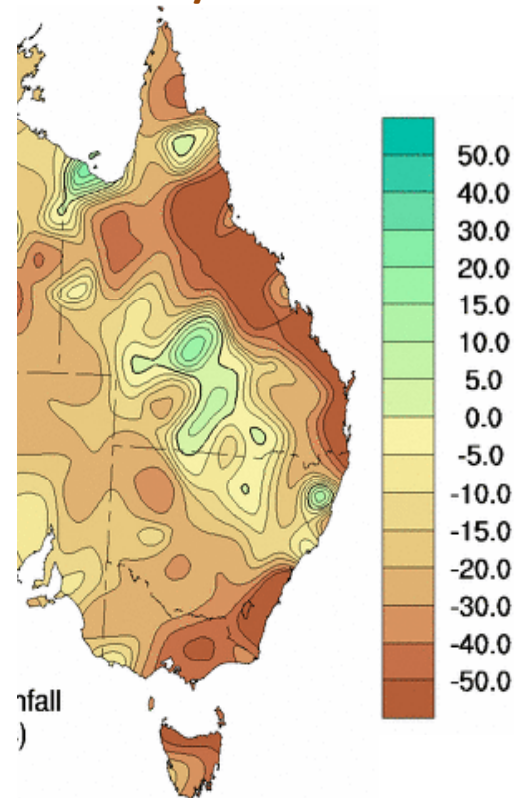
**TEMPERATURE**  
**+ 0.2° / dec**



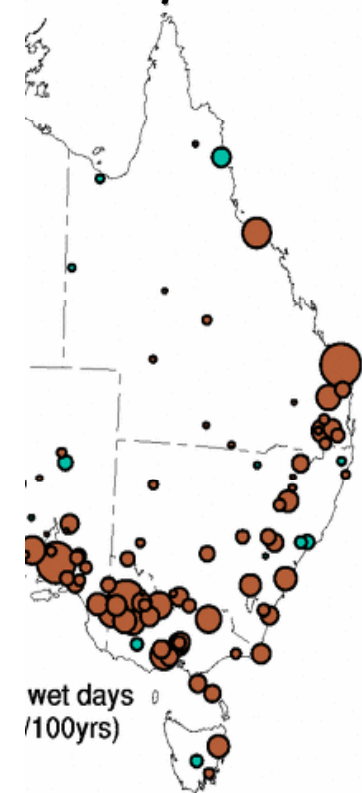
**DEWPOINT**  
**+0.25° / dec**



**RAINFALL**  
**- 40 mm / dec**



**# OF WET DAYS**  
**- 6-8 d / dec**

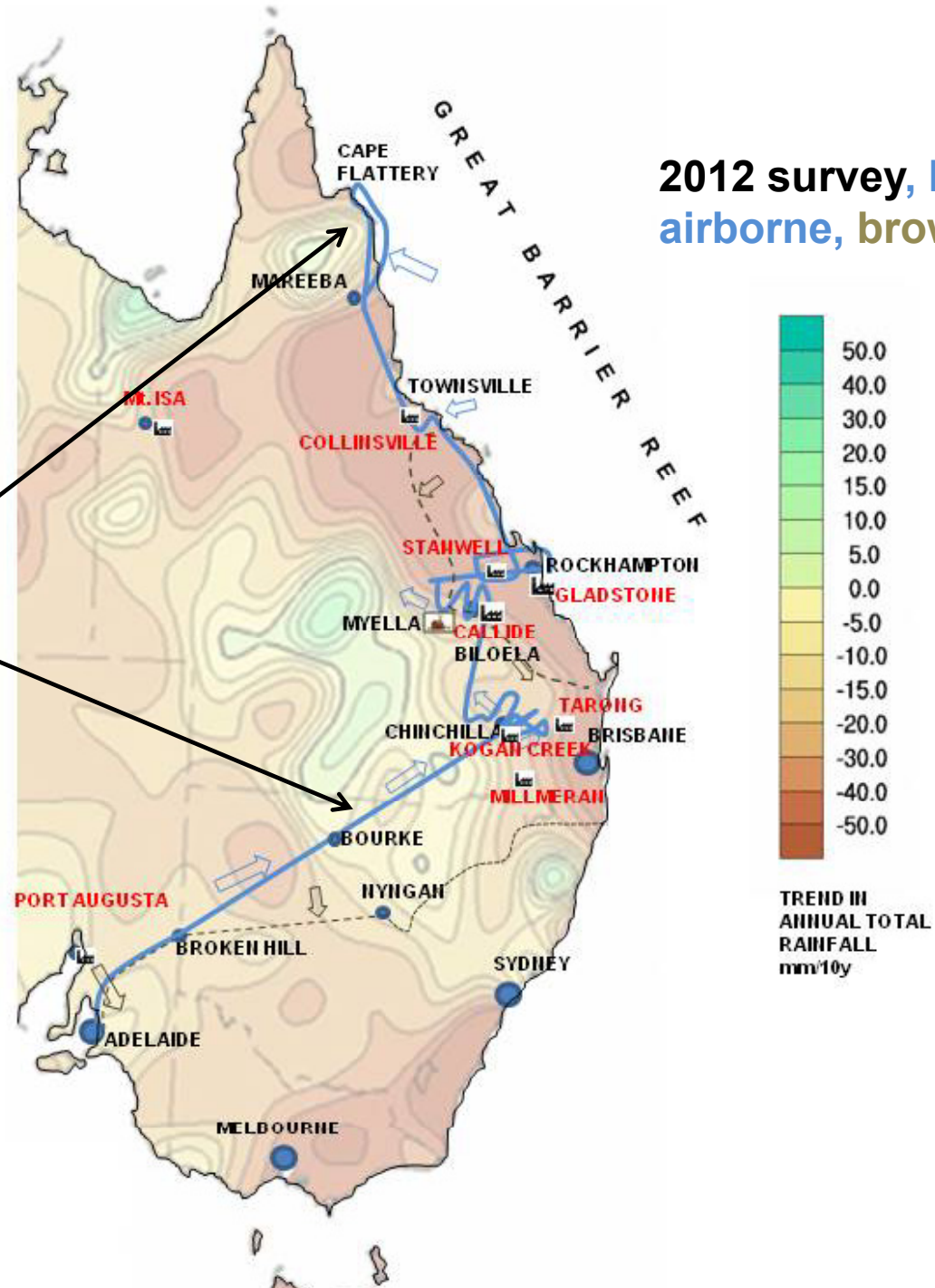




2012 survey, blue  
airborne, brown vehicle

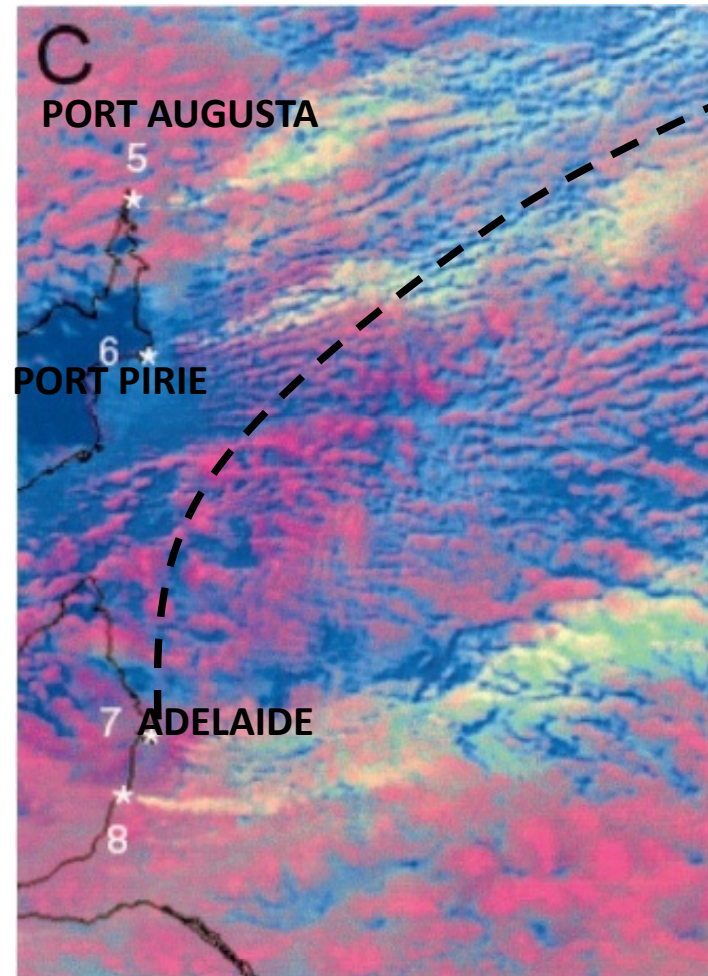
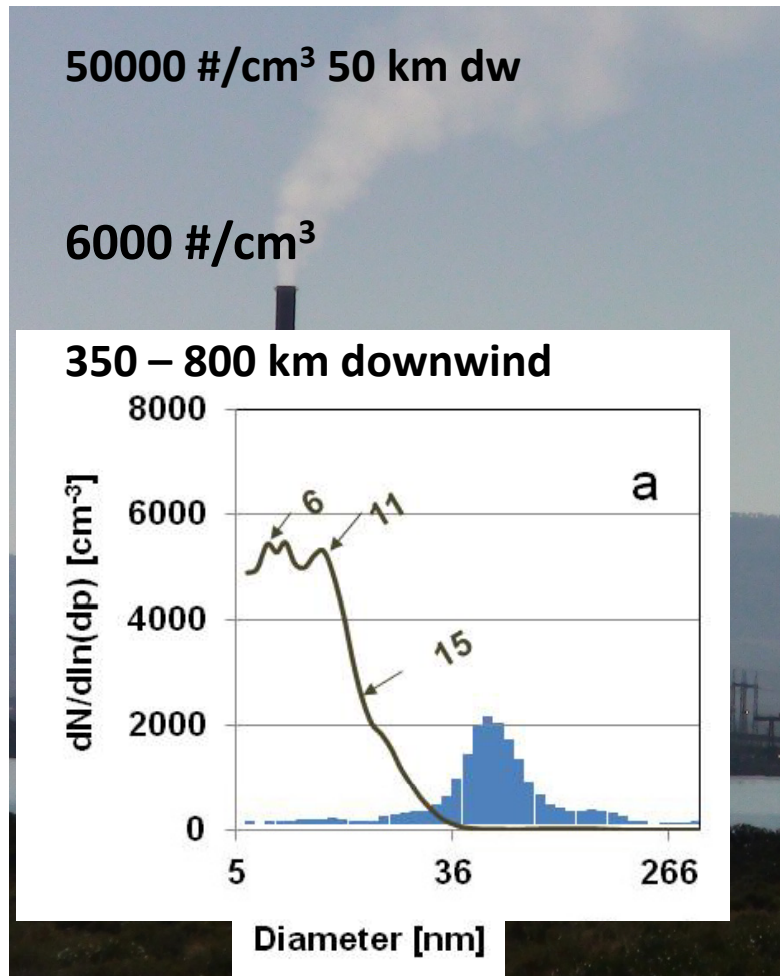
REGIONAL SCALE  
POLLUTION IN  
REMOTE AREAS?

BACKGROUND ?



PORT AUGUSTA , SA, April  
2011 / Sept. 2012

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



Visible cloud effects ~ 50 km (2 h) (HYSPLIT)

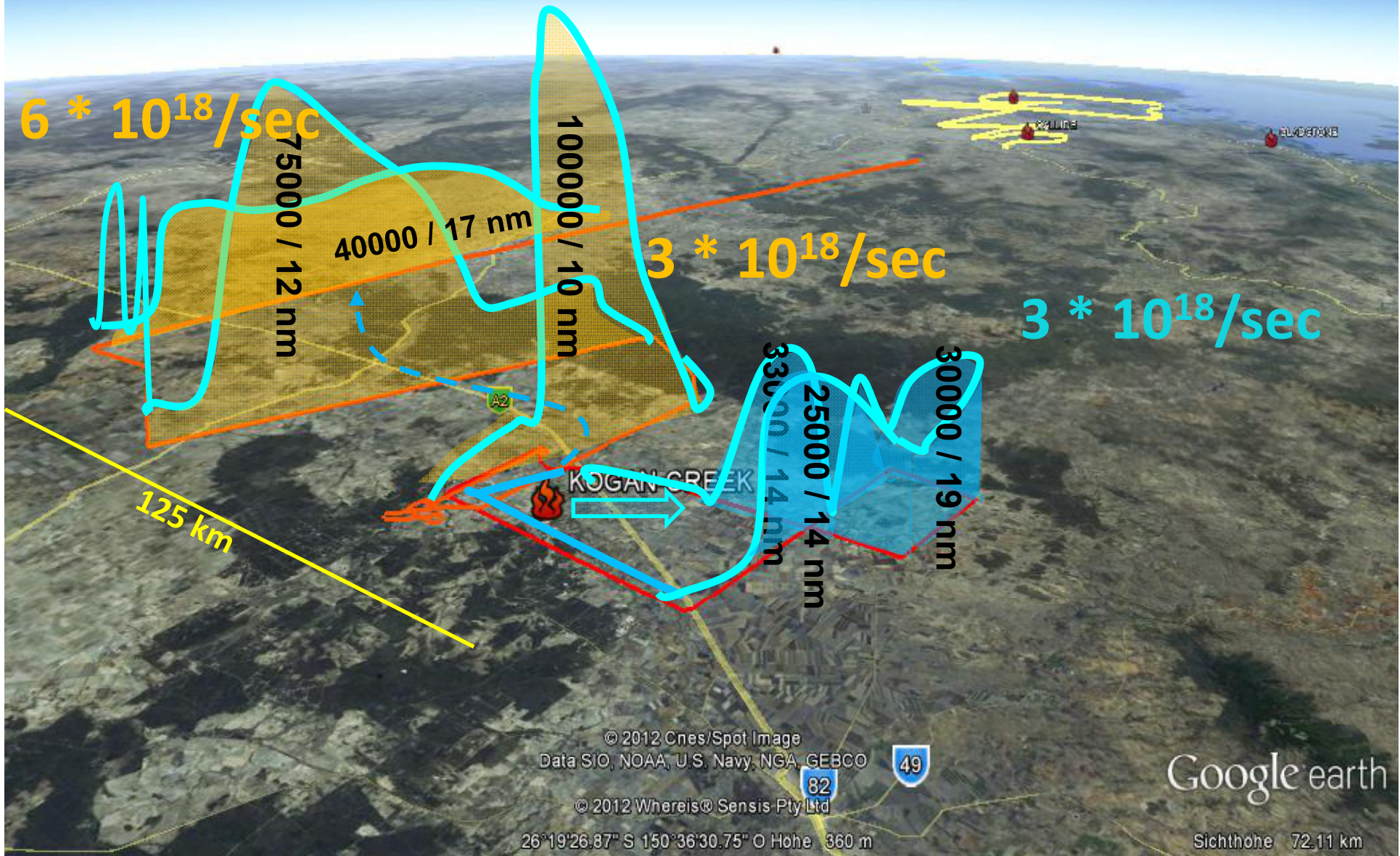


# KOGAN-CREEK, SUNSET

$3 * 10^{18}/\text{sec}$



# KOGAN-CREEK, LATE MORNING





$6 * 10^{18} / \text{sec}$

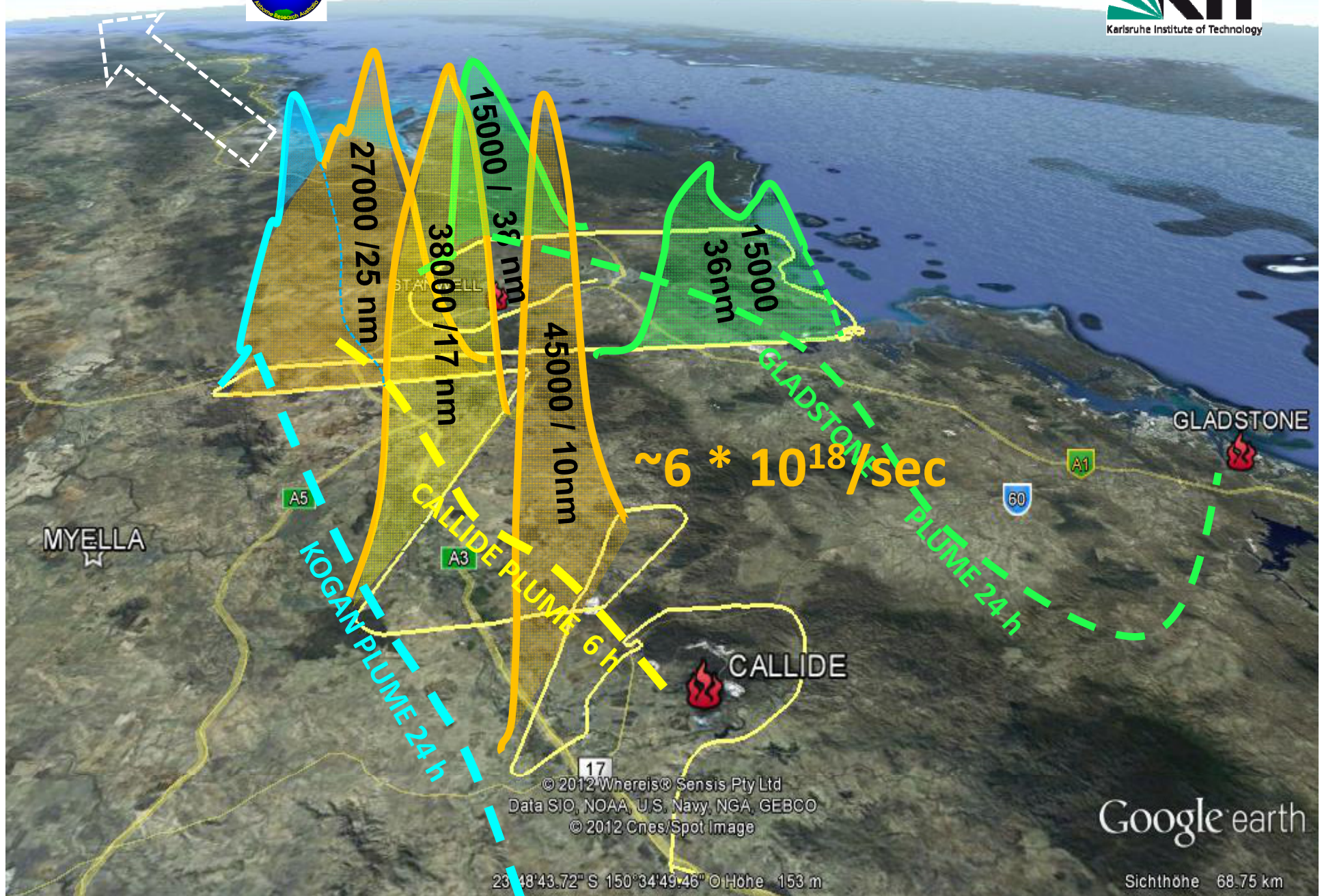
75 nm / 12 nm

**PRIMARY EMISSION  
INDEPENDENT ON  
OH - RADICAL CONCENTR.  
 $\sim 3 * 10^{18} \text{ s}^{-1}$   
FURTHER DOWNWIND  
OH - RELATED NPF**

$* 10^{18} / \text{sec}$

125 km

4 nm



**PRIMARY EMISSION  
~ PROPORTIONAL TO  
ENERGY PRODUCTION  
CCN SIZES AFTER ~ 10h**

MYELLA

> 5000 cm<sup>-3</sup>

A5

PLUME 6h

PLUME 24h

17

CALLIDE

60

A1

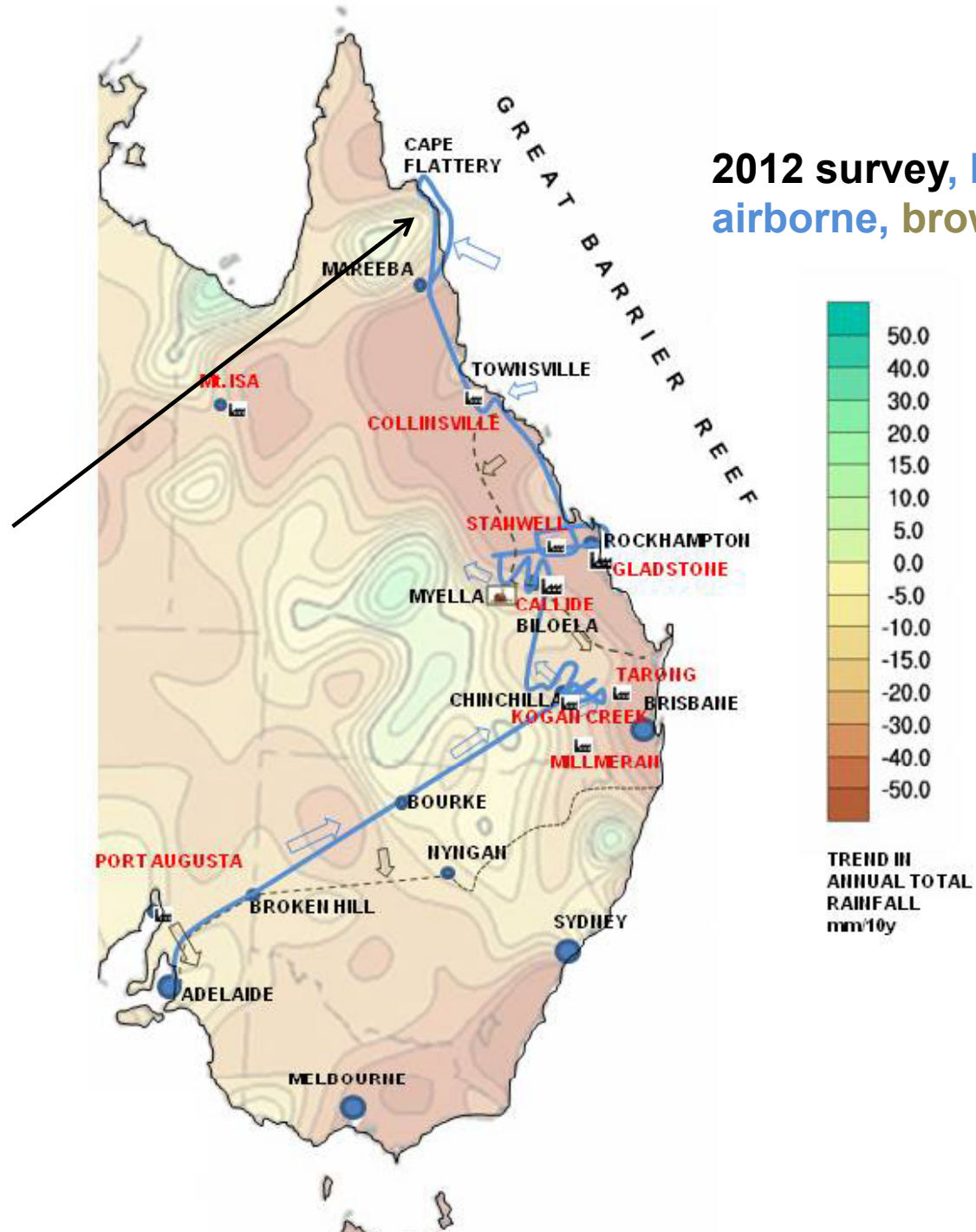
GLADSTONE

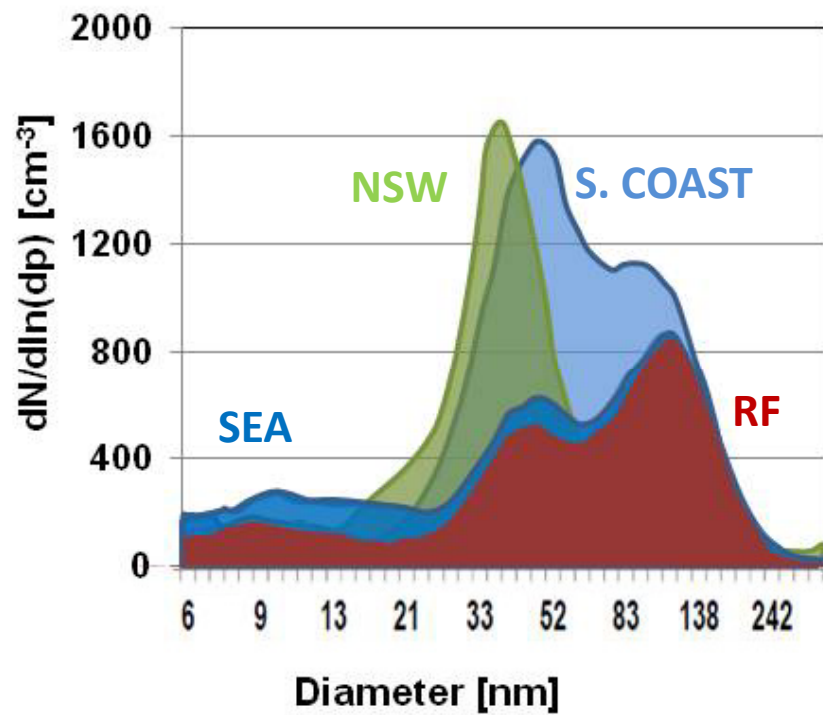
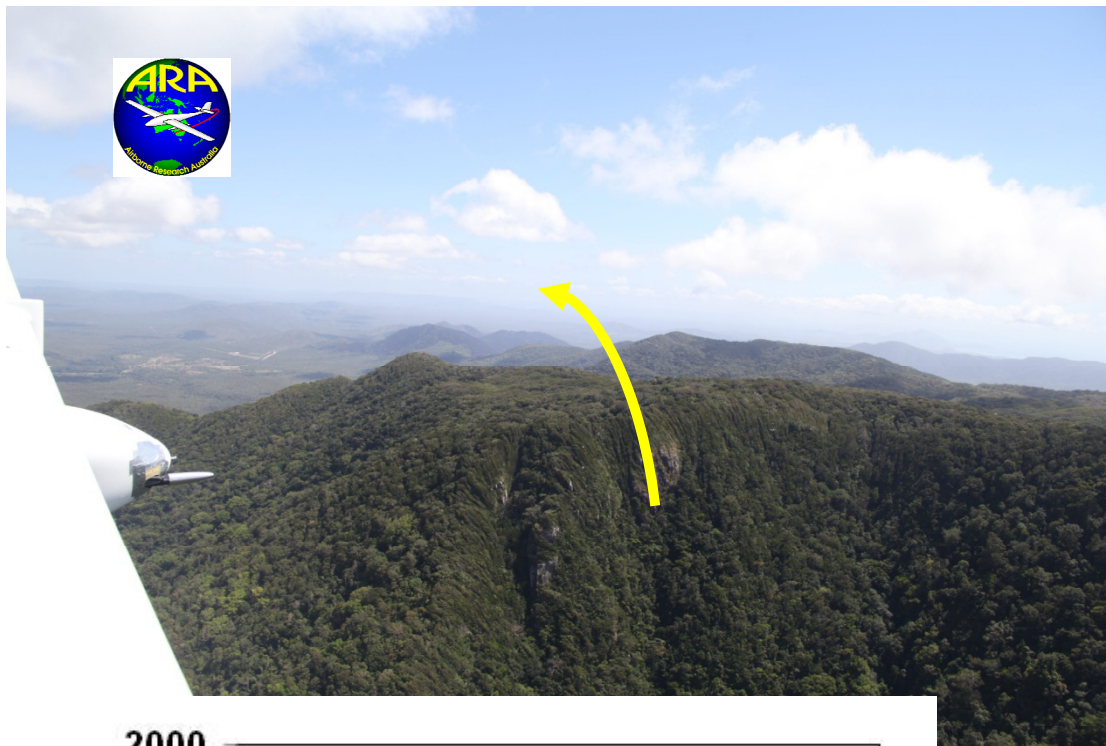
PLUME 24h



2012 survey, blue  
airborne, brown vehicle

BACKGROUND

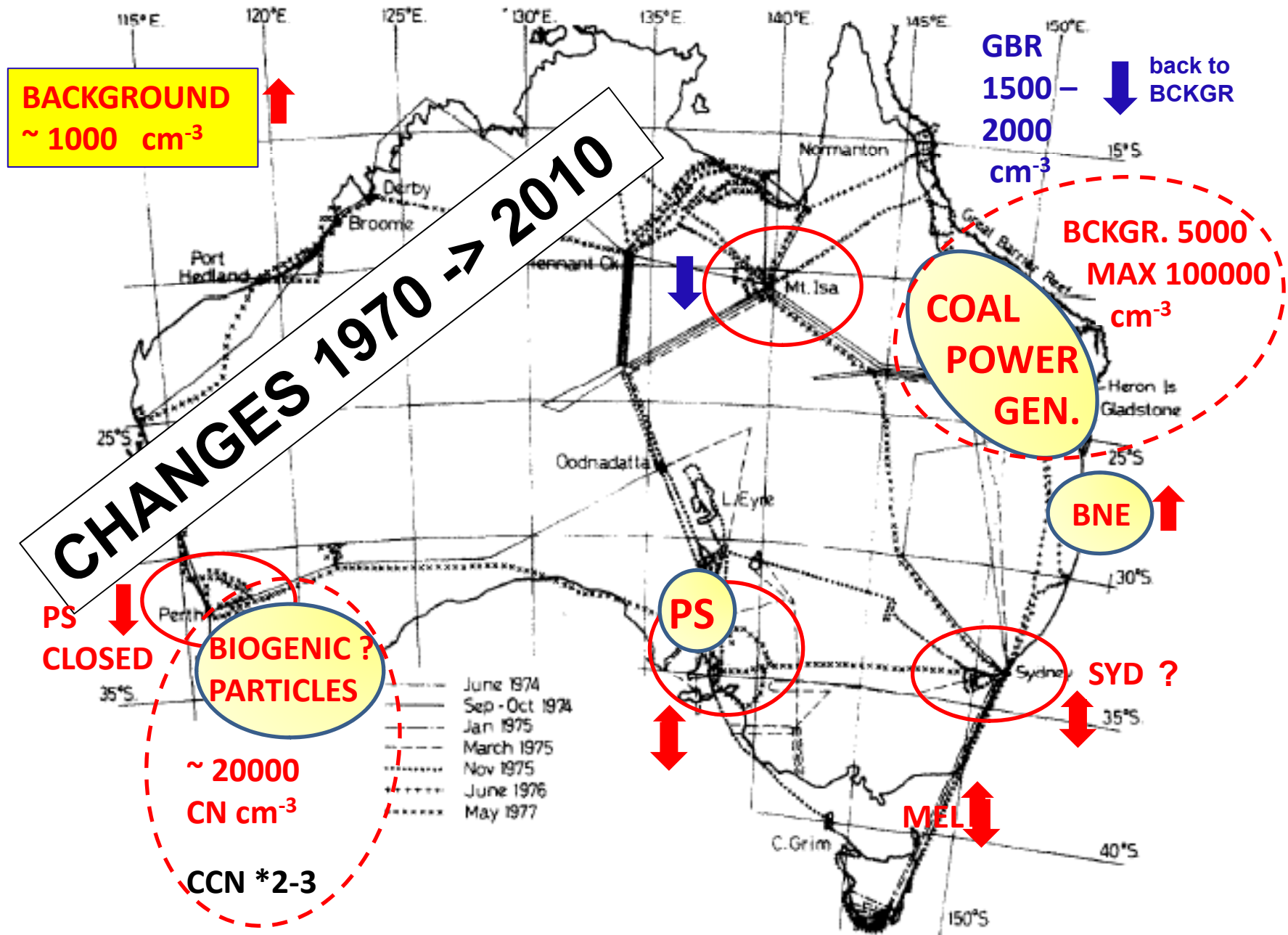




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# ***SUMMARY***



**Sources of UFP identified in remote areas with negative rainfall trends.**

**Emission into altitude most effective for transport and cloud impact (QLD)**

**Magnitude sufficient for CCN increase**

**Timeline in agreement with rainfall trends, no trends observed in reference years (QLD) or reference areas (WA)**

**Satellite images confirm cloud activity (~ 2 h after emission)**

**QLD land use change most probably not significant**





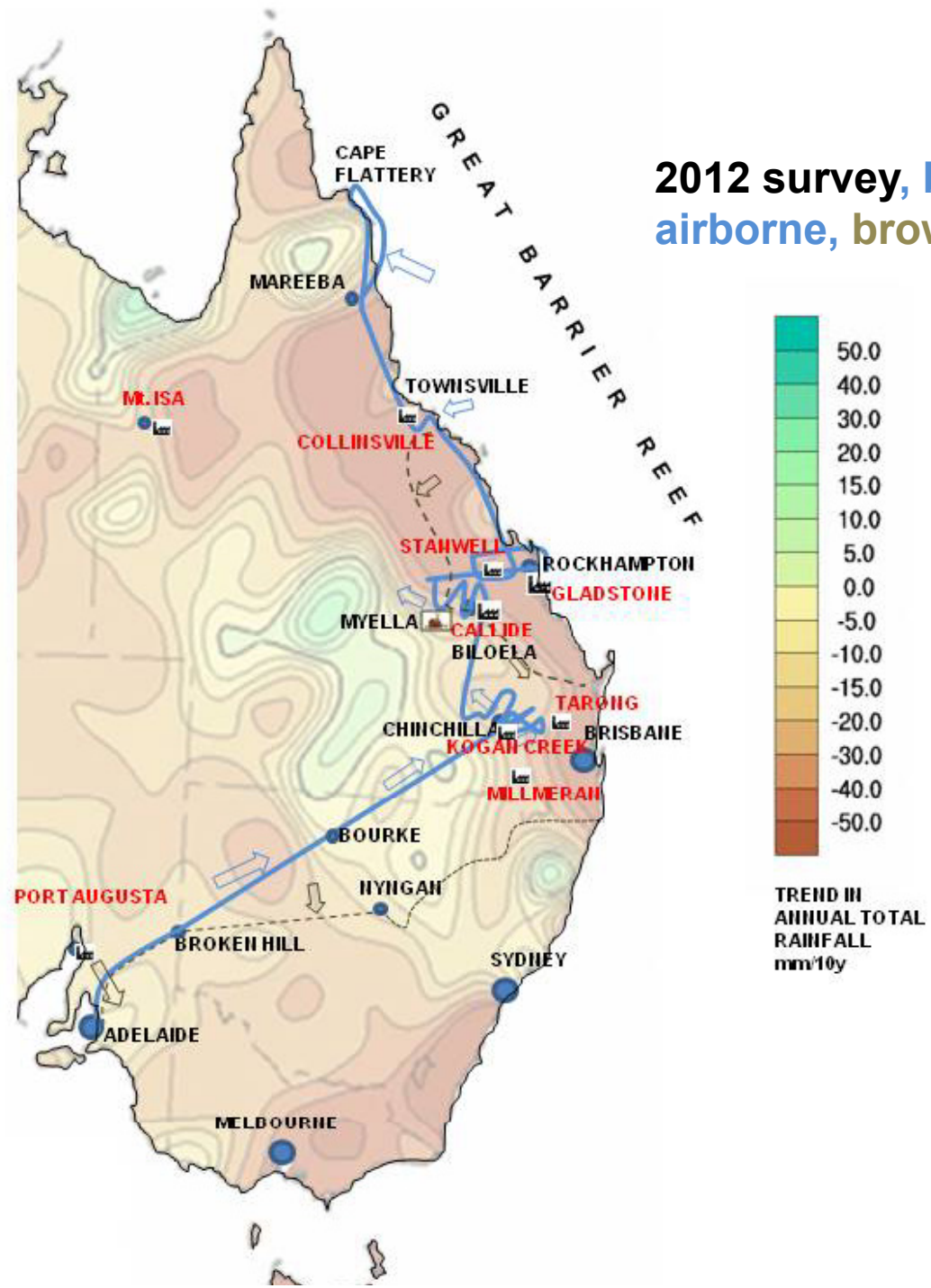
***THANK YOU FOR YOUR ATTENTION***



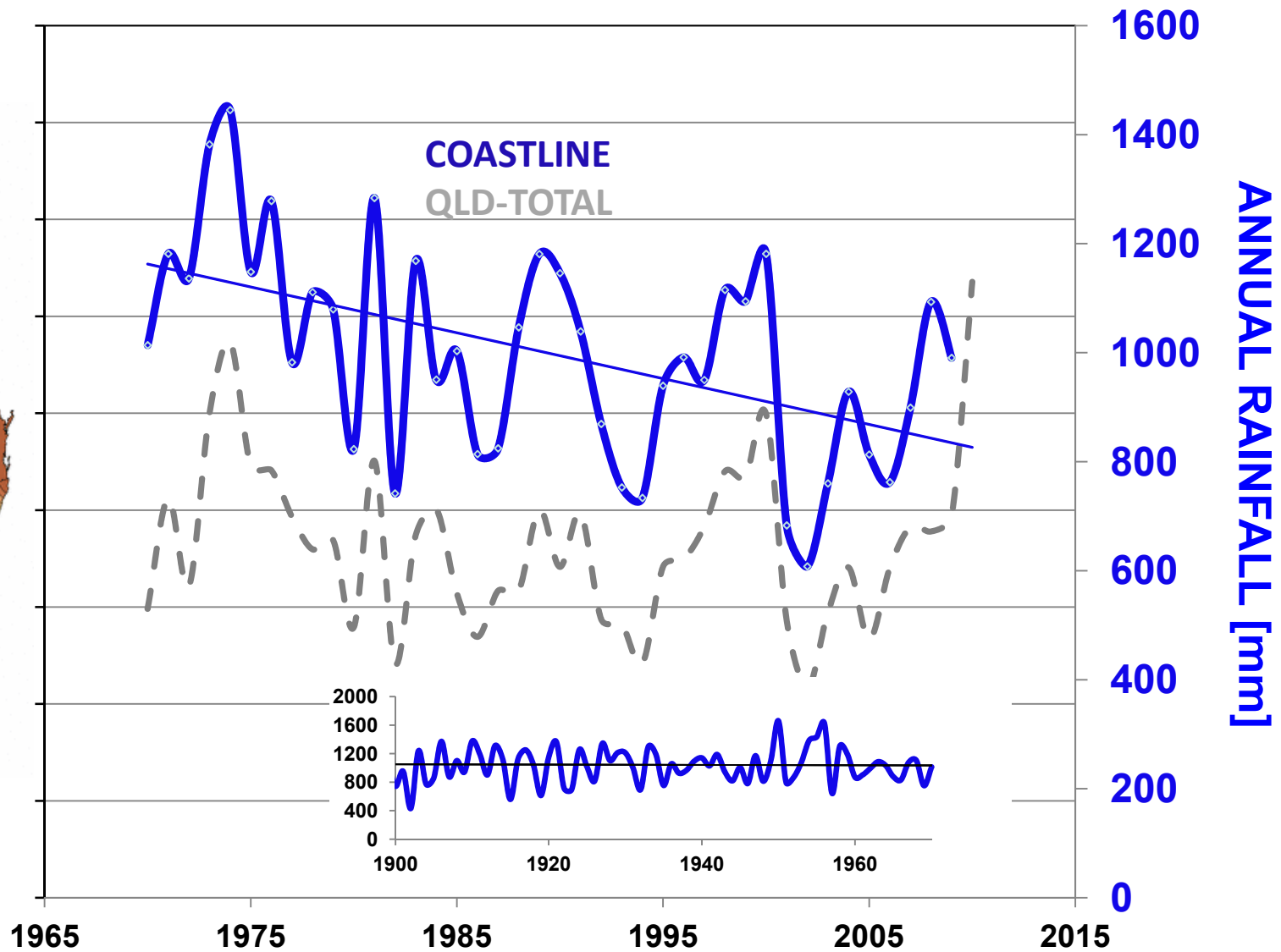
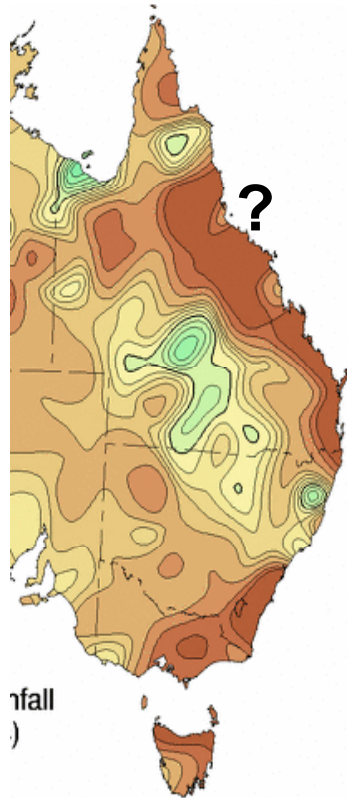


2012 survey, **blue**  
airborne, **brown** vehicle

# MEASUREMENTS IN THE COAL AREA



## LONG TERM DATA (RAINFALL)



# CLOUD DROPLET SIZE DISTRIBUTION

300 ft above cloud base

base  $\leftrightarrow$  top  $\sim$  1200 ft

DEWPOINT BELOW CLOUD 8 °C

AGRICULTURE

DEWPOINT BELOW CLOUD 6 °C

NATIVE VEG.

