

# Land use change suppresses precipitation

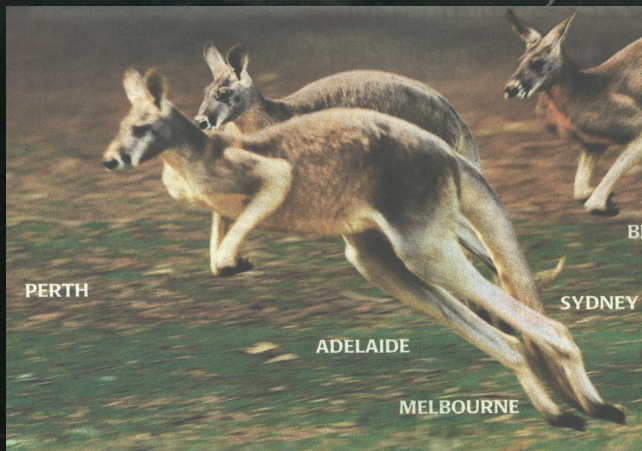
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Airborne Research Australia, Flinders University, Adelaide, Australia<sup>2</sup>

Murdoch University, Perth, Australia<sup>3</sup>

National Space Science Technology Center, Huntsville, Alabama, USA<sup>4</sup>



# Outline

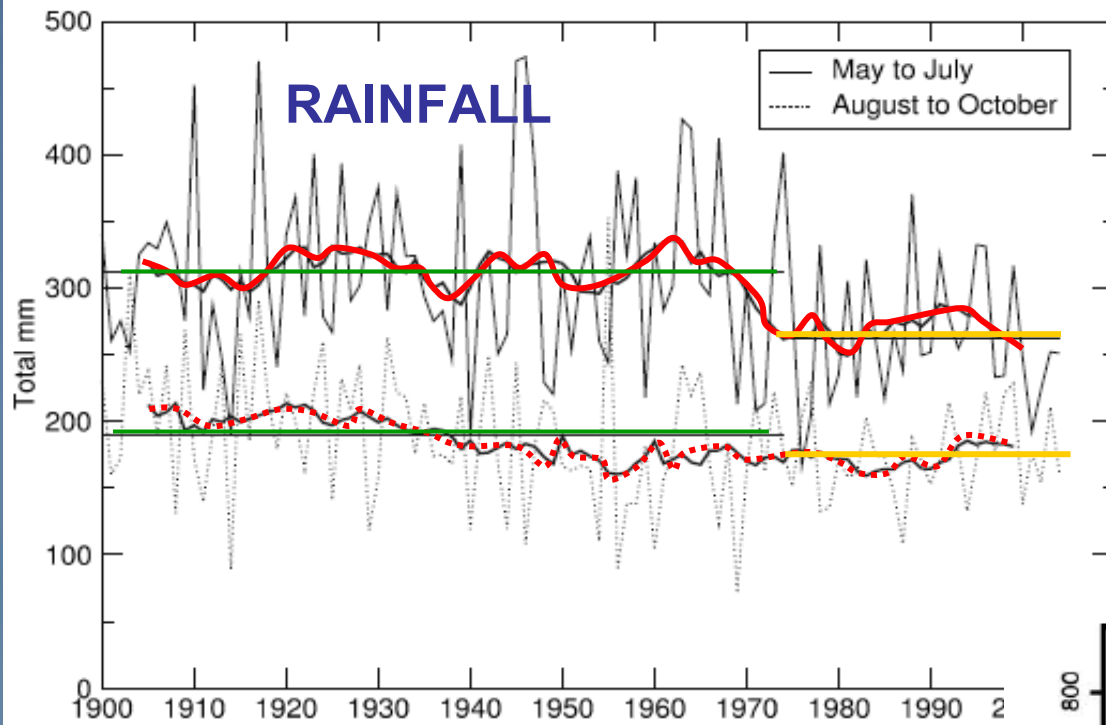
## Background

## Experimental setup

## Results

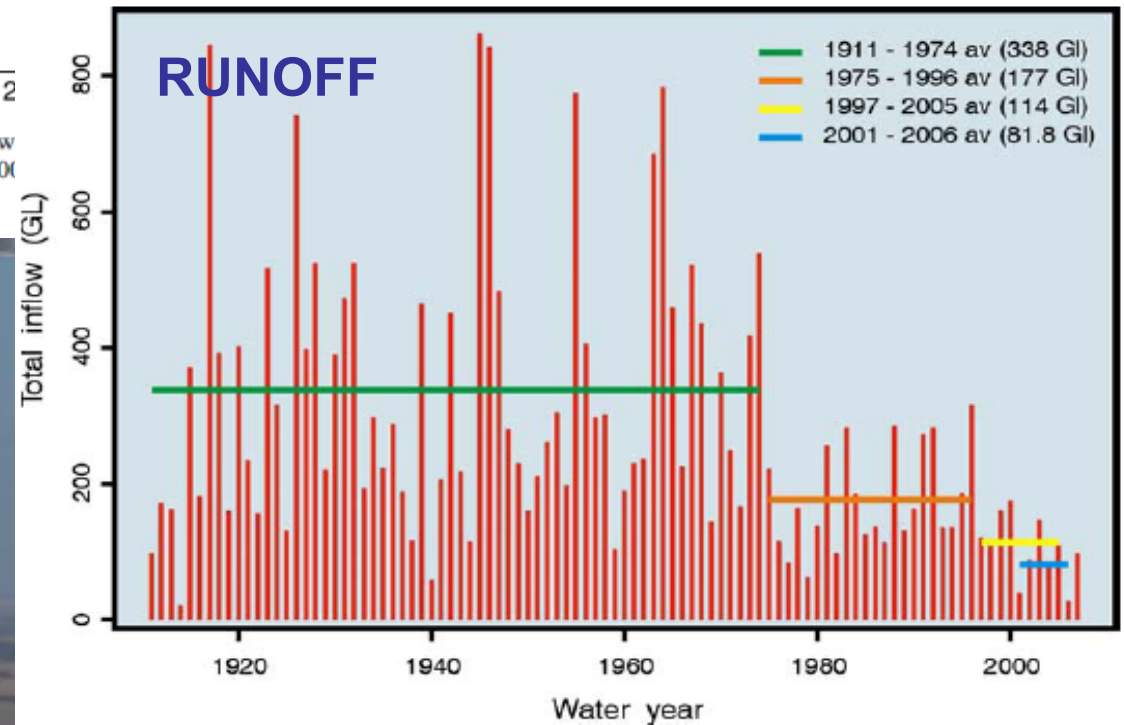
## Summary





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

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

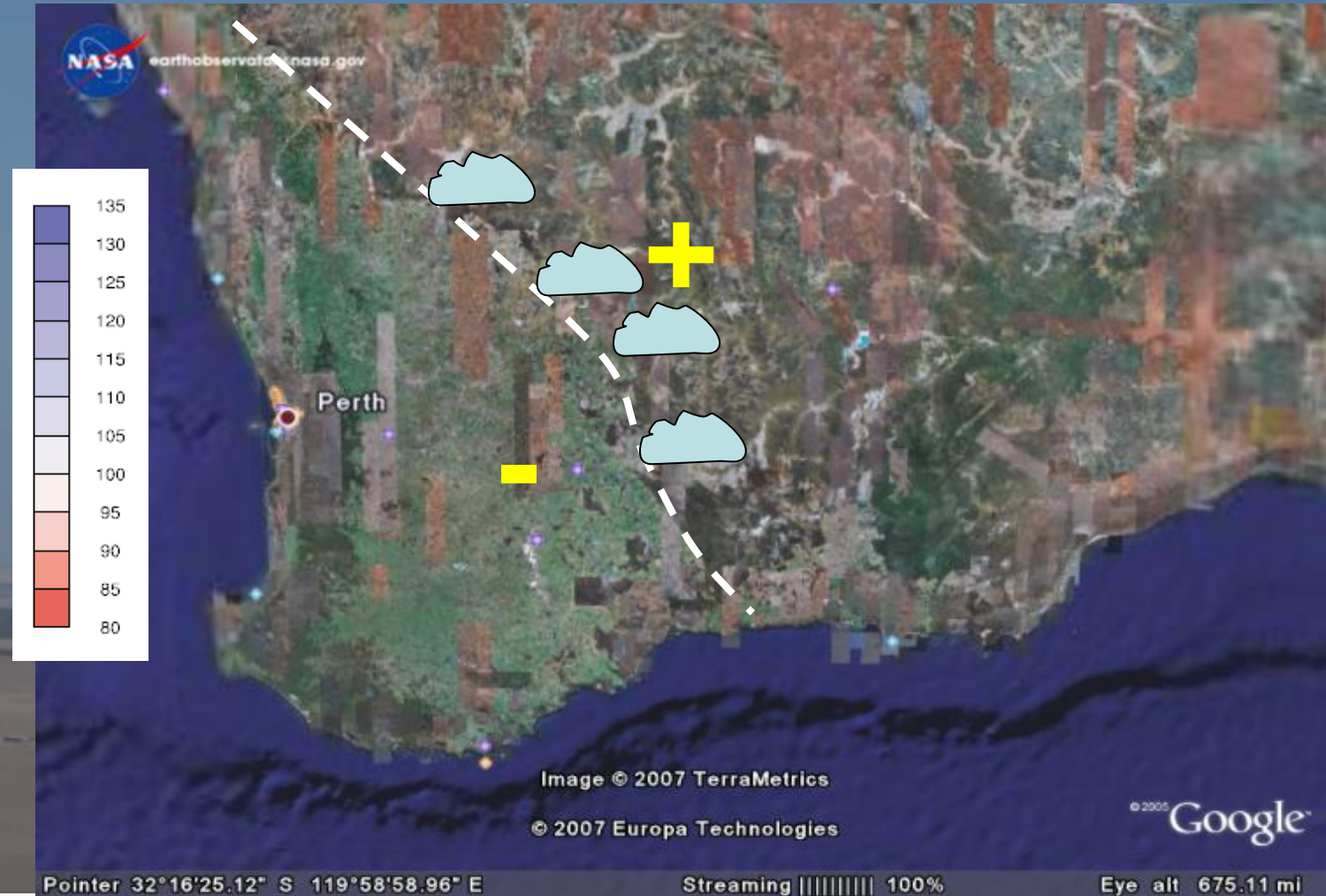
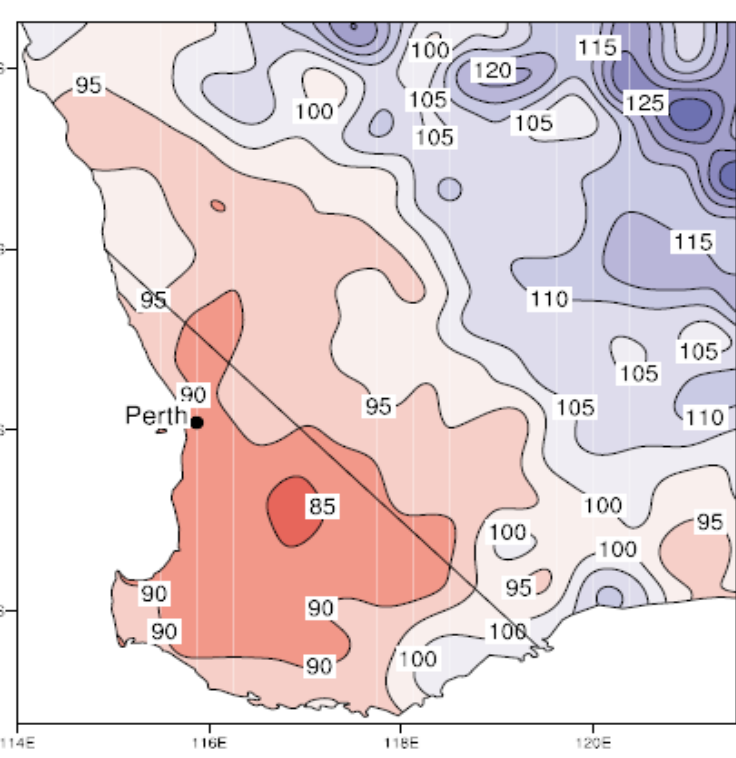


**Fig. 5** Annual (May to April) inflow series (GL) for the Integrated Water Supply System. Source: <http://www.watercorporation.com.au>

# DROUGHT IN WESTERN AUSTRALIAN WHEAT BELT

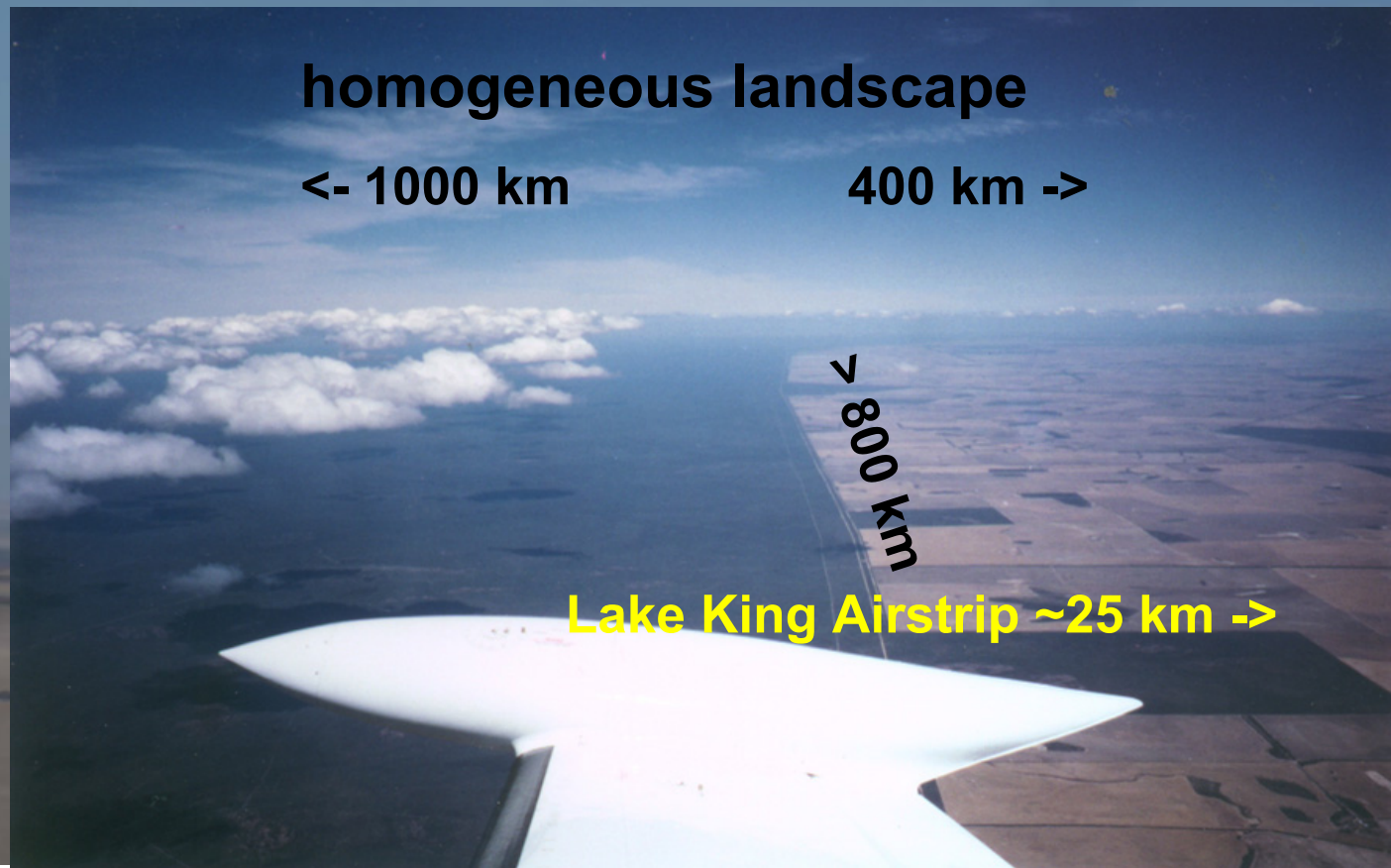
# Precipitation change distribution

## -clouds over natural vegetation



# The **BUFEX** experiment 12/2006, 08/2007

airborne investigations  
in a natural laboratory  
comparing meteorology  
and aerosols  
2 seasons



homogeneous landscape

<- 1000 km

400 km ->

> 800 km

Lake King Airstrip ~25 km ->

**Background**

**Experimental setup**

**Results**

**Summary**



## Lake King Airstrip

Flux & Remote Sensing  
Dimona

Aerosol Dimona



## Lake King Airstrip

Flux & Remote Sensing  
Dimona

Aerosol Dimona

GRIMM SMPS, 5.5 – 350 nm	2 min
GRIMM 1.108, 300 nm – 15 $\mu$ m	6 sec
TSI 3010 > 10 nm	2 sec
FSSP 100 0.5 – 47 $\mu$ m	1 sec

Meteorology (temp, dewpoint) and radiation parameters (radiation balance, albedo)





**Background**

**Experimental setup**

**Results**

**Summary**

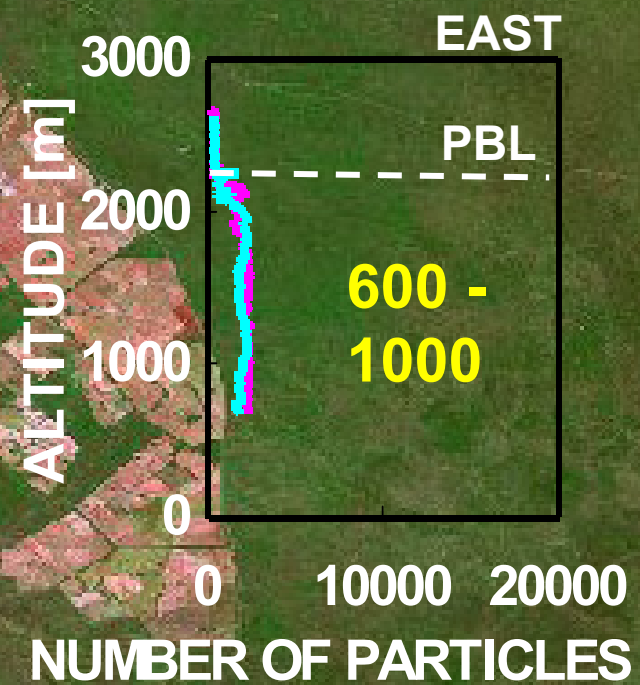
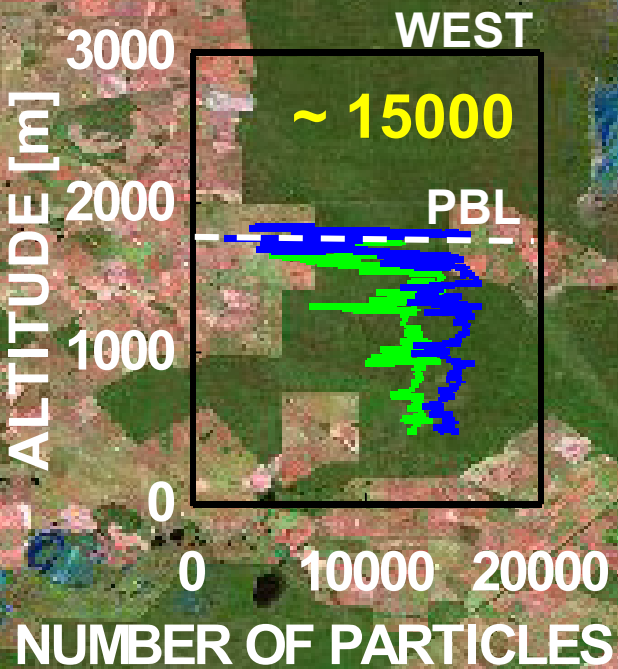


# TSI CPC COUNTS

40 km

PARTICLES > 10 nm (red)

**NO nm-SIZE PARTICLES OVER THE FOREST !!!**  
**VERTICAL MIXED UP TO PBL**

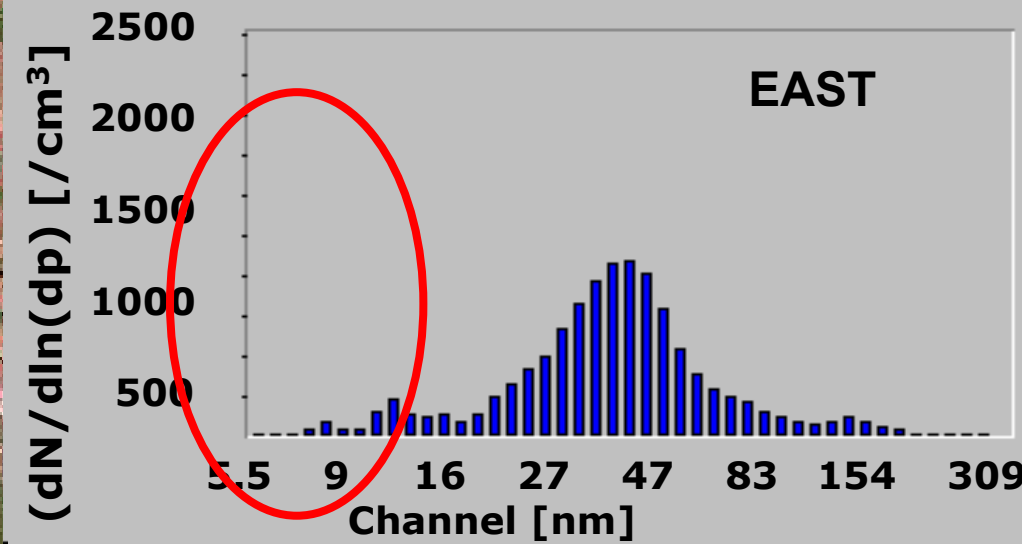
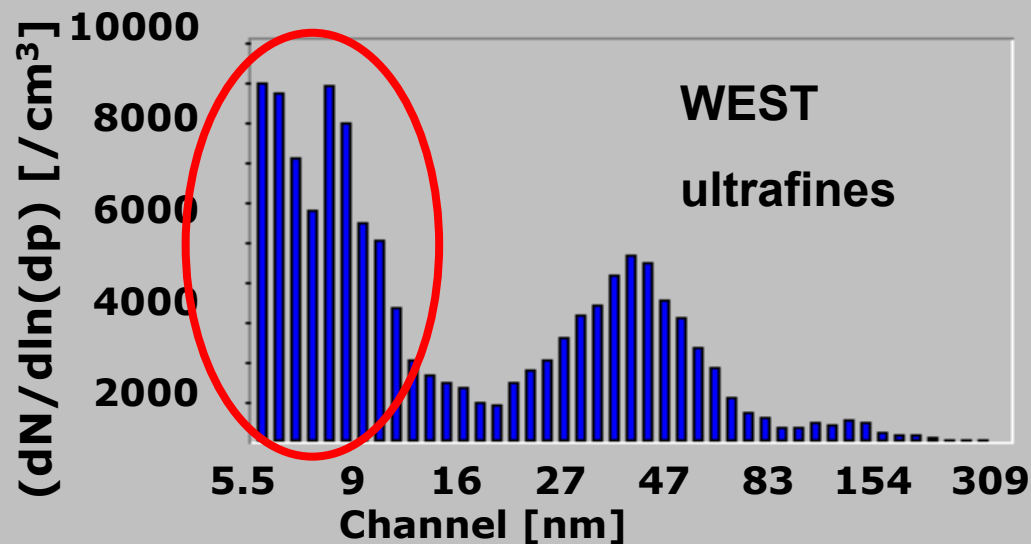


PARTICLES > 10 nm (red)

40 km

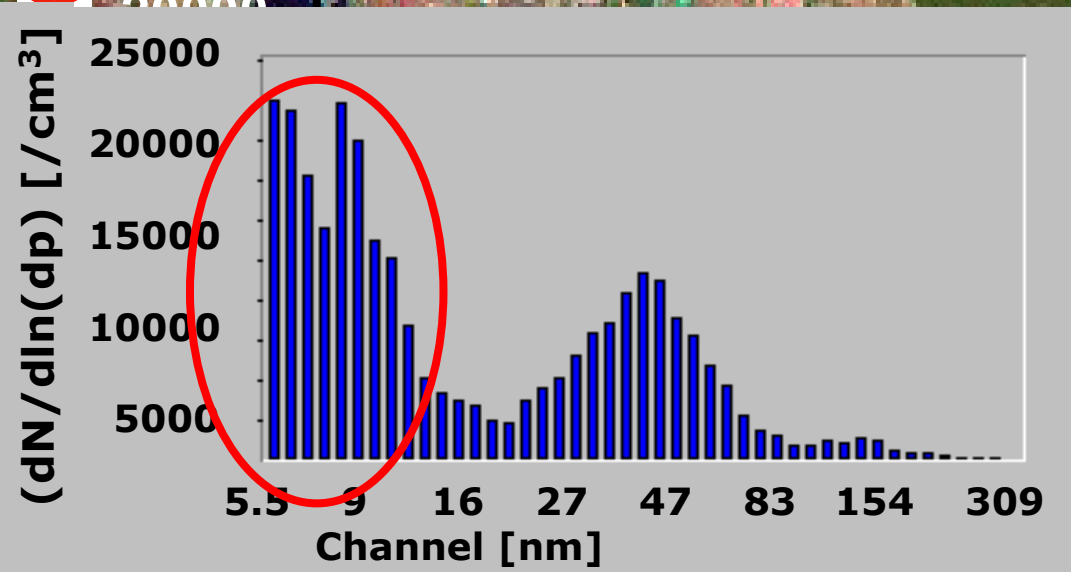
**NO nm SIZE PARTICLES OVER THE FOREST !!!**  
**SIZE DISTRIBUTIONS**

20000  
10000  
0

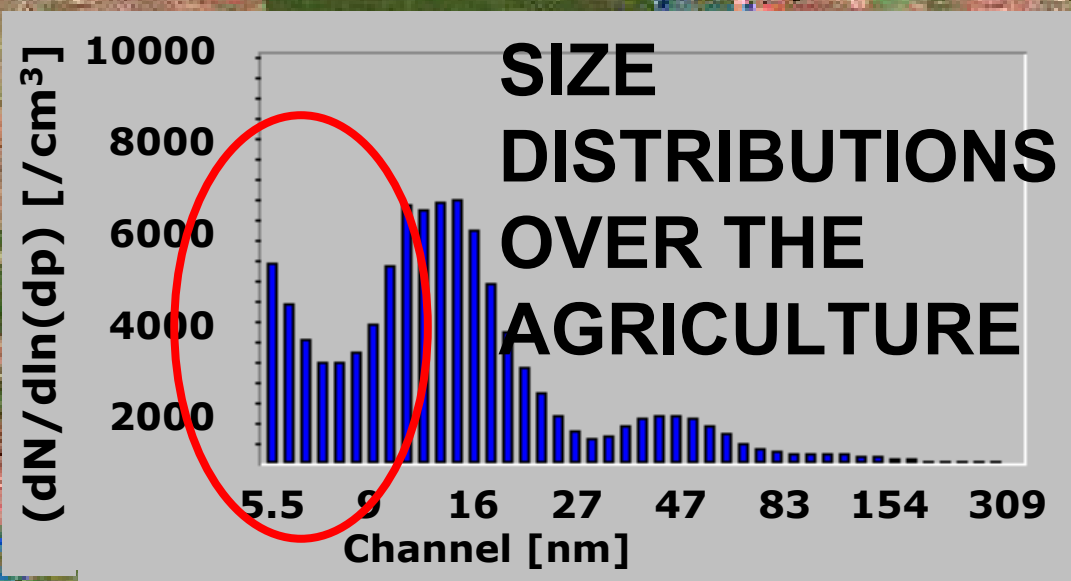


40 km

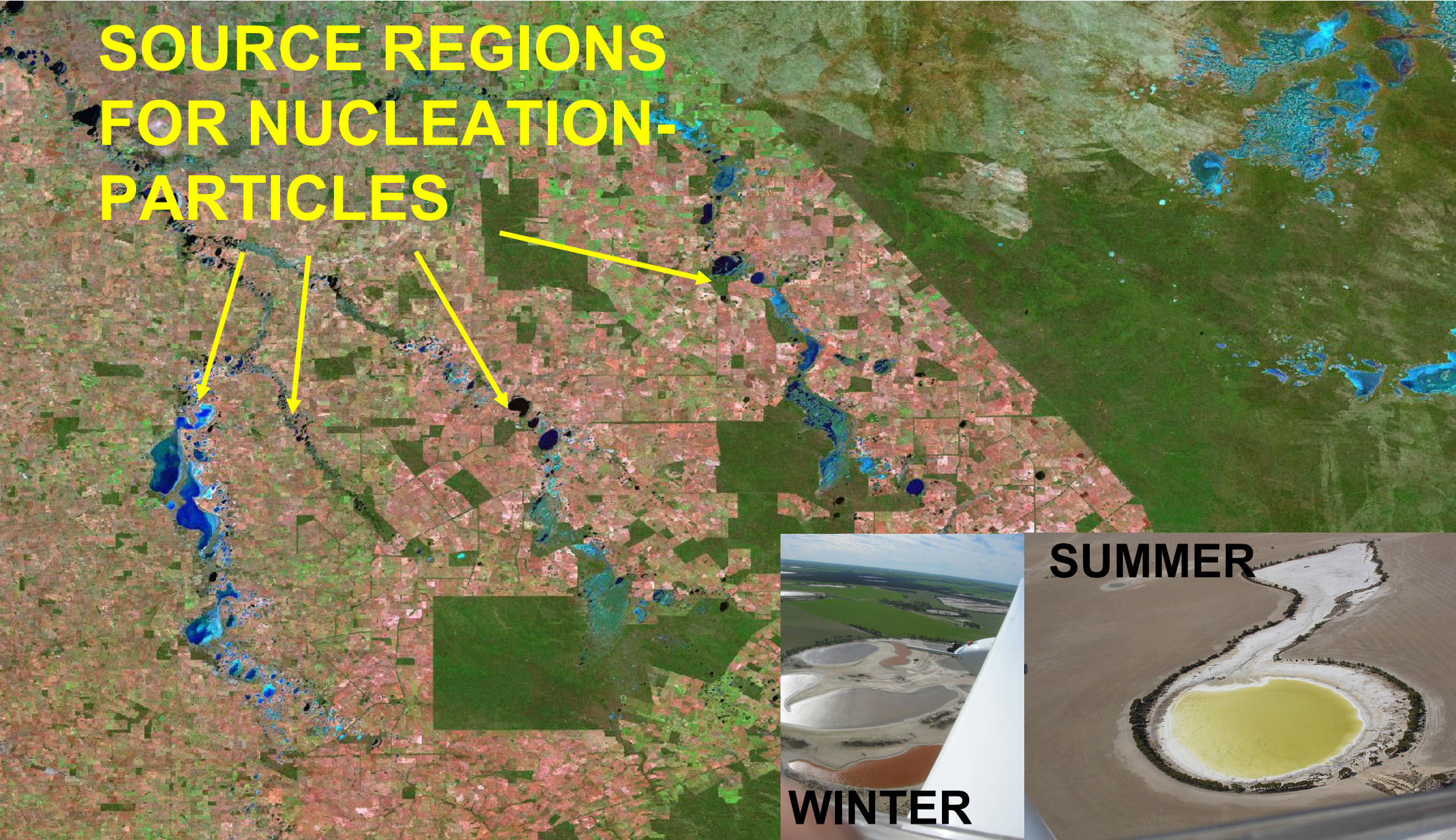
(red)

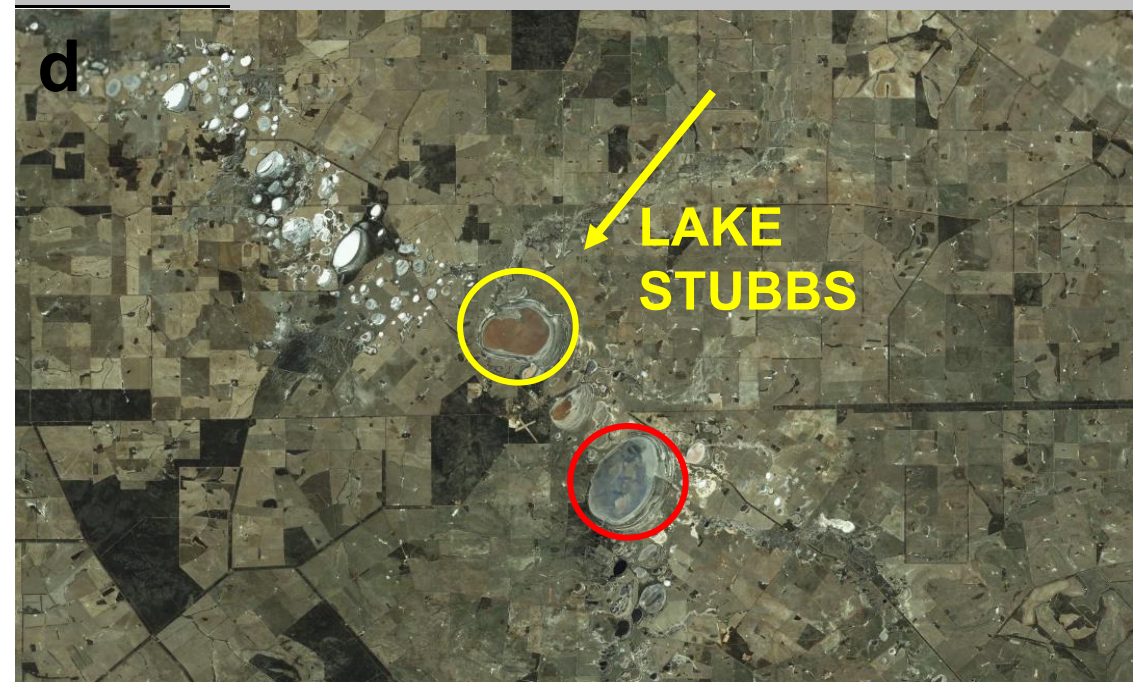
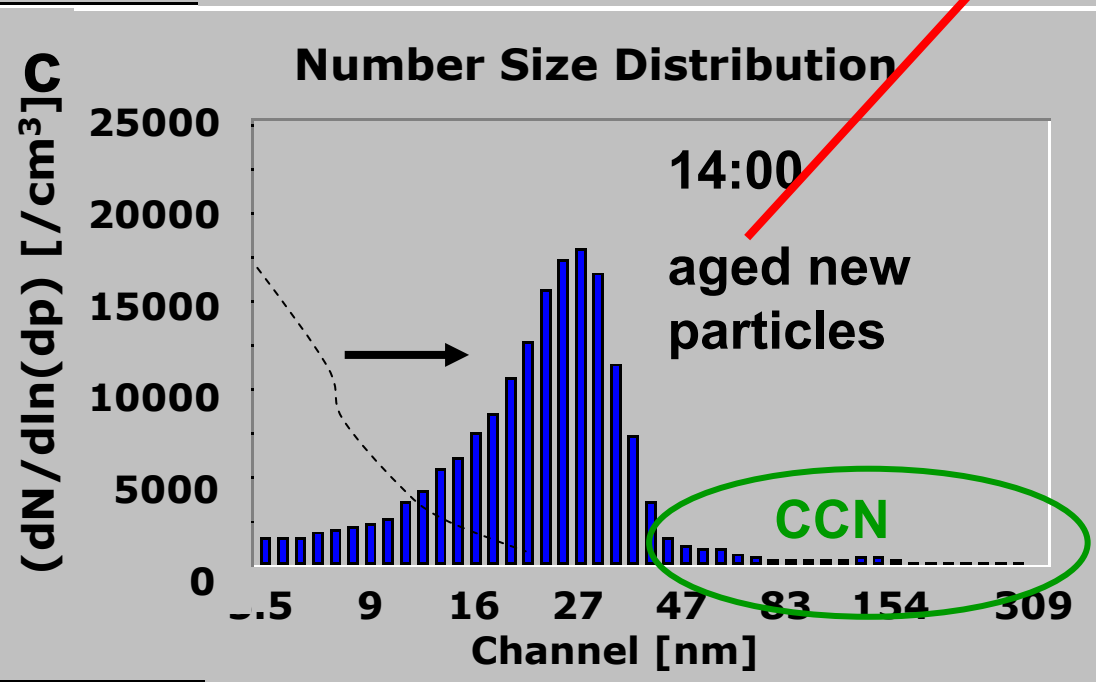
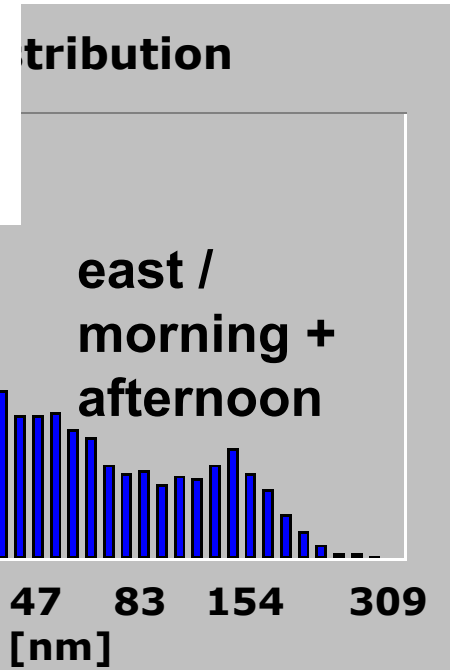
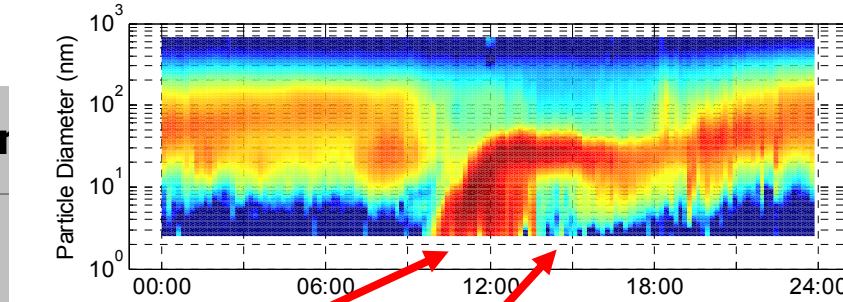
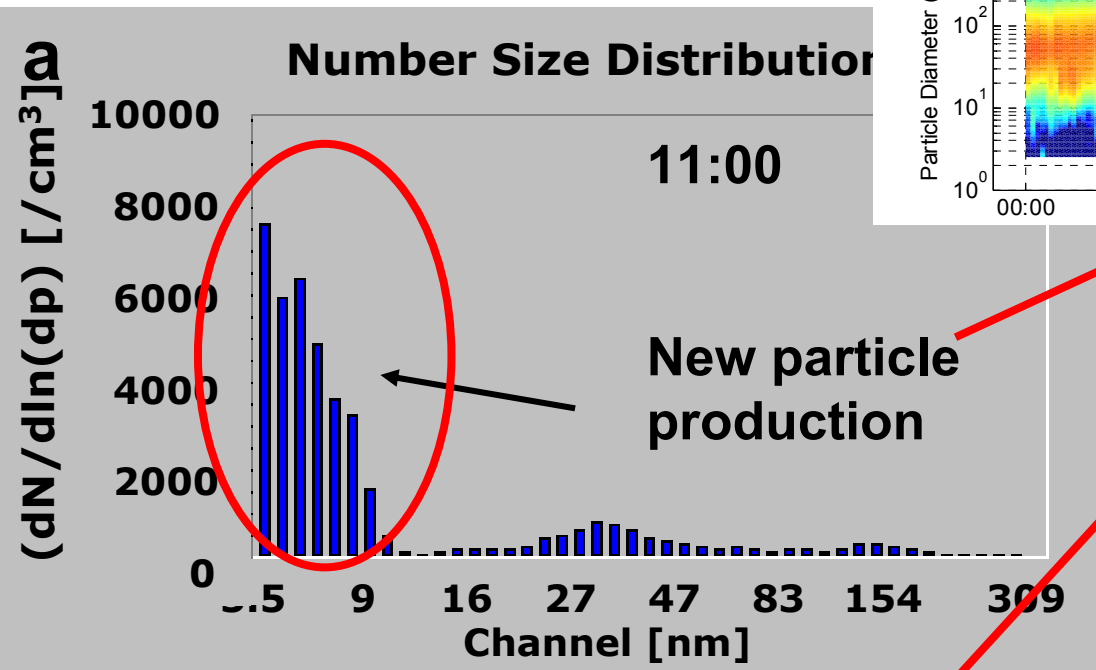


**- INDEPENDENT FROM SEASON**  
**- NO DEPENDENCE ON VEGETATION**  
**ON AGRICULTURE**

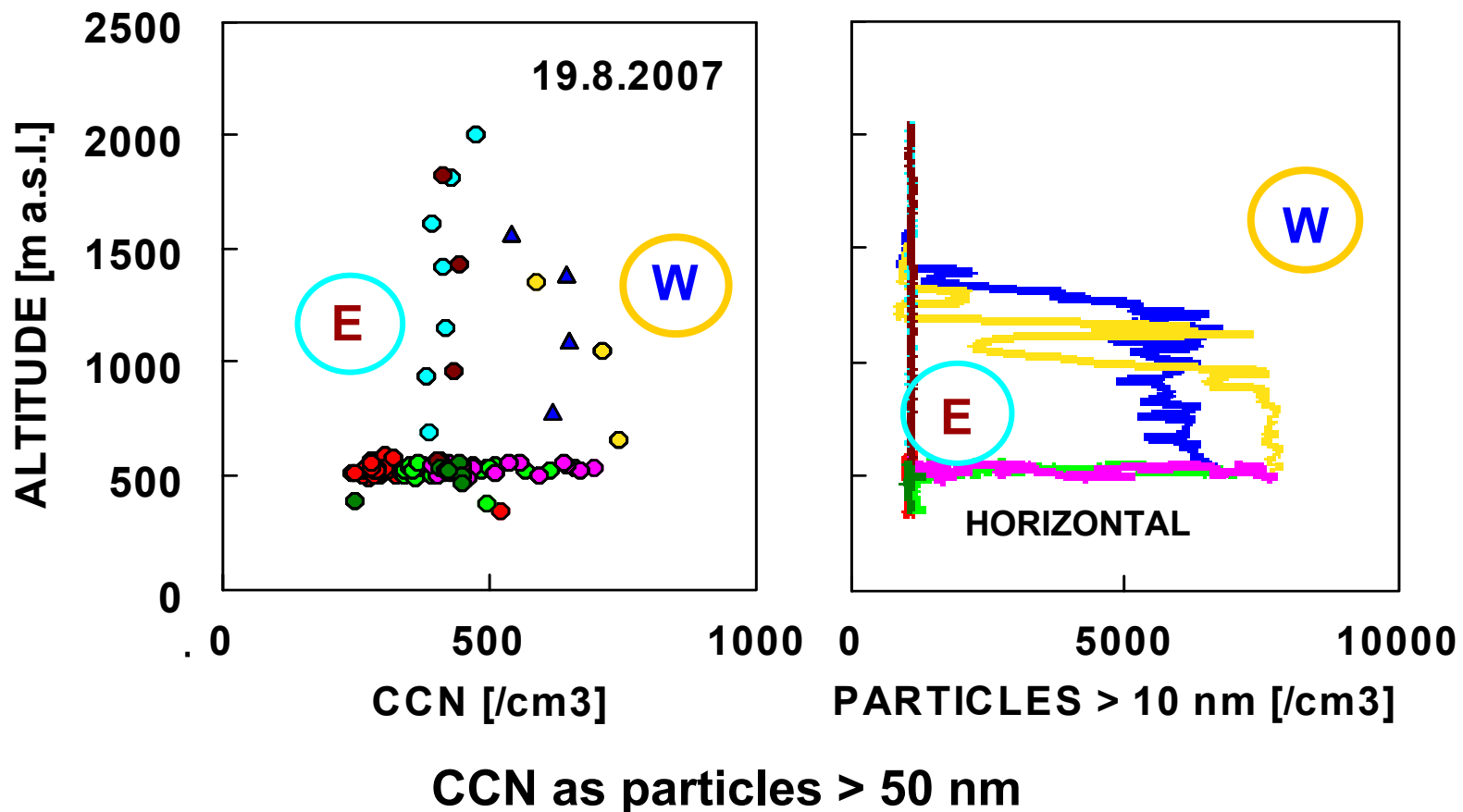


# SOURCE REGIONS FOR NUCLEATION- PARTICLES





# NUCLEATION AEROSOL EFFECT ON PRECIPITATION -> HIGHER DROPLET NUMBER AND REDUCTION OF DROPLET SIZES DUE TO ENHANCED CCN (FLETCHER, 1962, Lohmann and Feichter, 2005....)



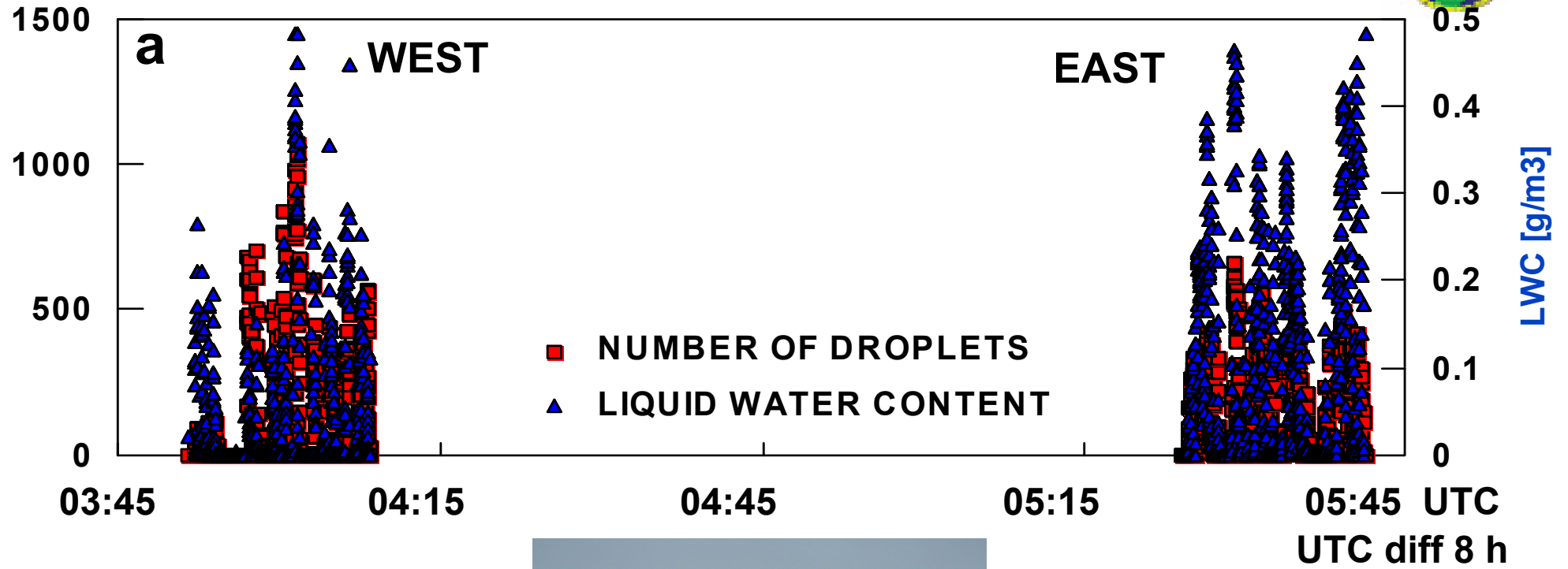
# CLOUDS OVER BOTH AREAS, 21.8.2007



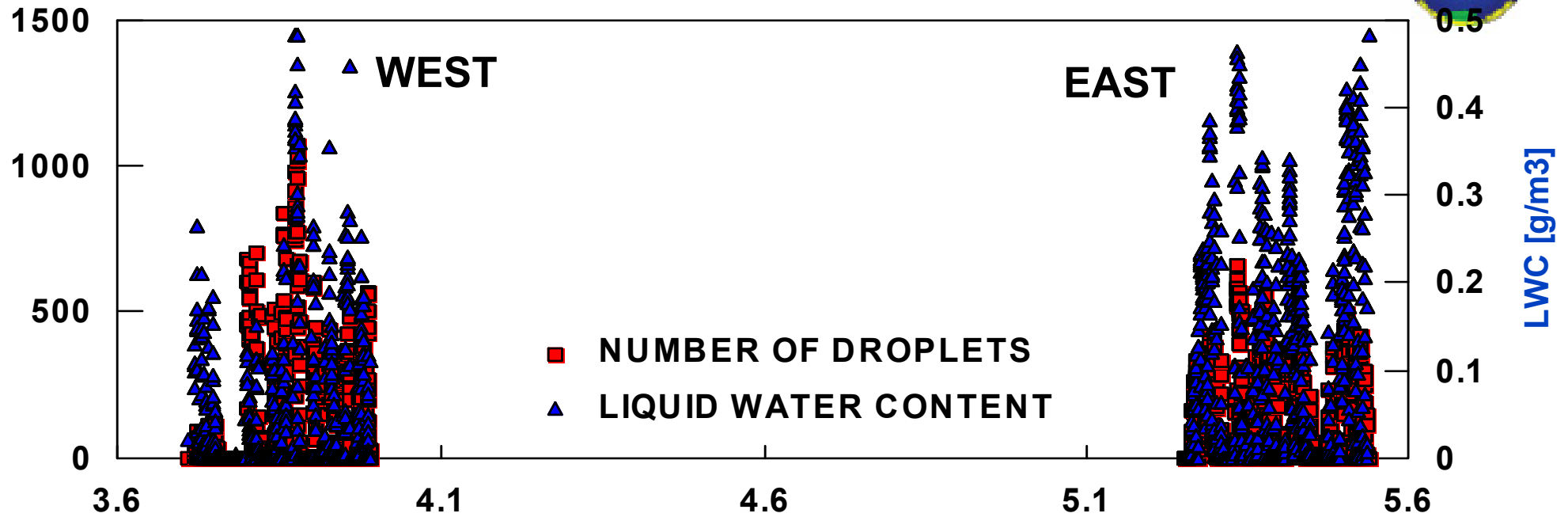
**Experimental proof**



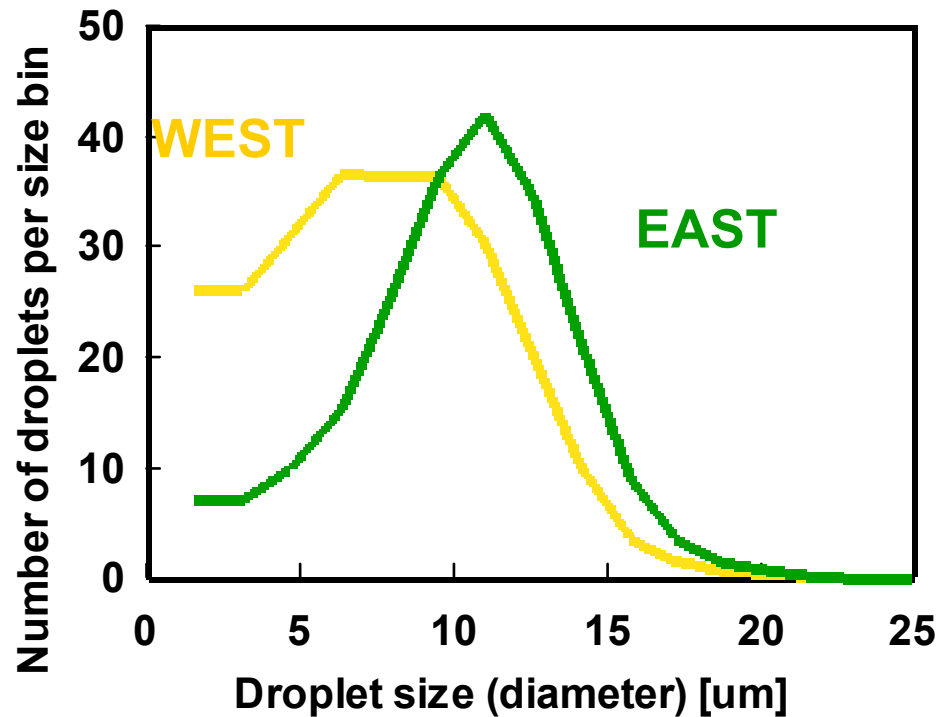
NUMBER OF DROPLETS [cm<sup>3</sup>]



NUMBER OF DROPLETS [cm<sup>3</sup>]



CCN 400/cm<sup>3</sup>



CCN 280/cm<sup>3</sup>

Parameter	West (agriculture)		East (natural vegetation)	
	ground	cloud base	ground	cloud base
Temperature (air) [°C ]	16	10	20	6
Pressure [hPa]	975	900	975	800
Dewpoint [°C ]	11	9	6	3.5
Water [g/m <sup>3</sup> ]	9.9	8.8	6.9	6.1
<b>CCN</b>		~ 400		~ 280
Cloud droplets [/cm <sup>3</sup> ]		247		198
Average diameter [um]		8.3		9.5
Liquid water content [g/m <sup>3</sup> ]		0.10		0.15

Note the difference of water vapor converted into LWC

**Background**

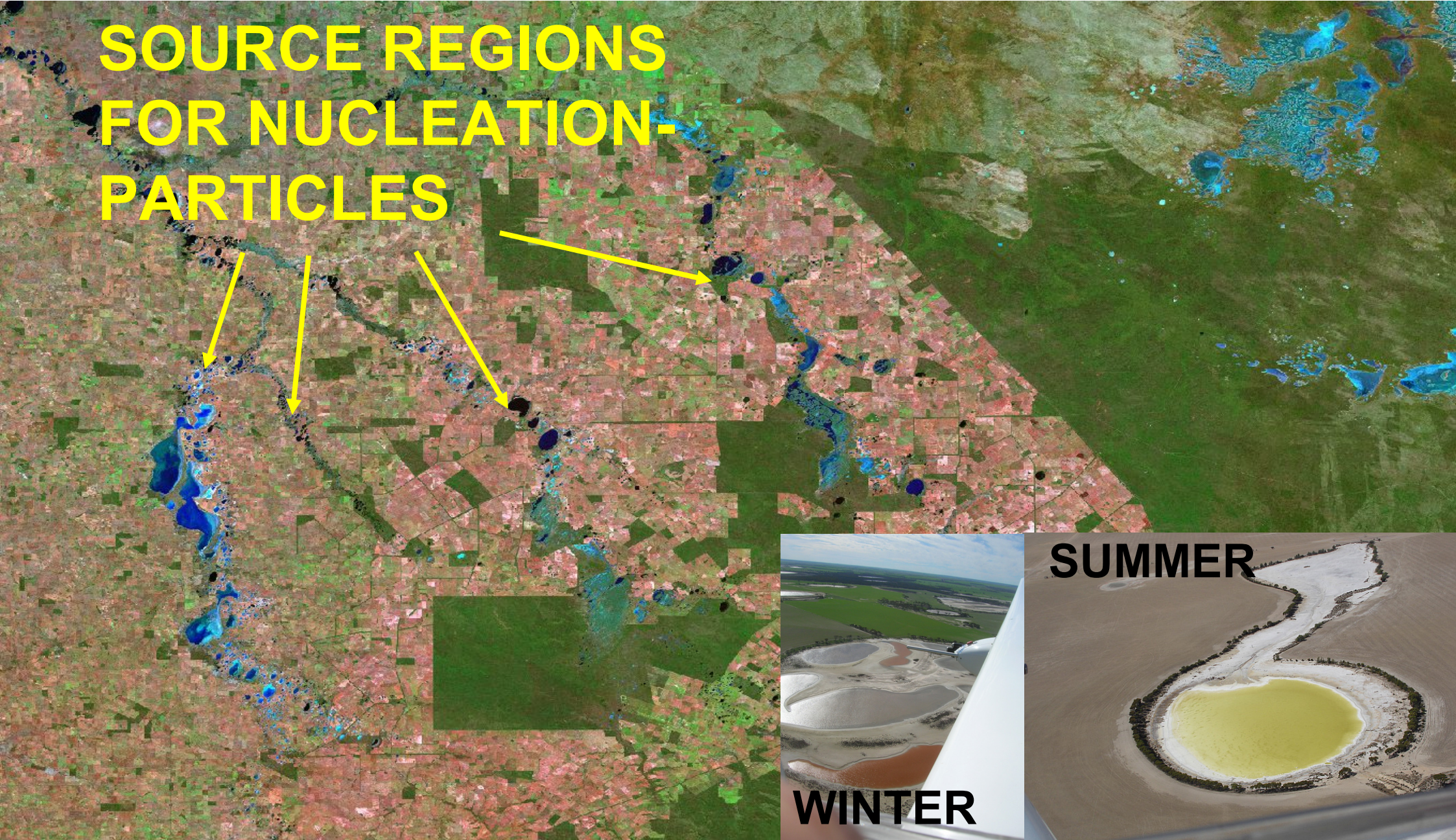
**Experimental setup**

**Results > Landuse change**

**Summary**



# SOURCE REGIONS FOR NUCLEATION- PARTICLES



# DIFFERENCES BETWEEN THE LAKES?

**MOIST**

**DRY**

High \_\_\_\_\_ **GROUNDWATER TABLE** low \_\_\_\_\_  
~ 2 m > 20 m



# DIFFERENCES BETWEEN THE LAKES?

**MOIST**

**DRY**

High ——— GROUNDWATER TABLE low ———

~ 2 m

**DEFORESTATION**

> 20 m



## SUMMARY

Enhanced ultrafine particle numbers over agriculture

Nucleation source not related to vegetation

Salt lake chemistry / emissions, most probably  
halogen (iodine?) chemistry

Enhanced CCN numbers affect cloud microphysics

Modification of cloud microphysics can explain the  
observed precipitation patterns

Link to land use change →



## Long term experiment, natural laboratory

### Deforestation 1829-1960

- >rising ground water table (GWT)
- >GWT close to surface ~ 1970
- >wet chemistry in salt lakes
- >increased number of CCN ->
- >reduction of precipitation

# Acknowledgement

**Admiral James Stirling**



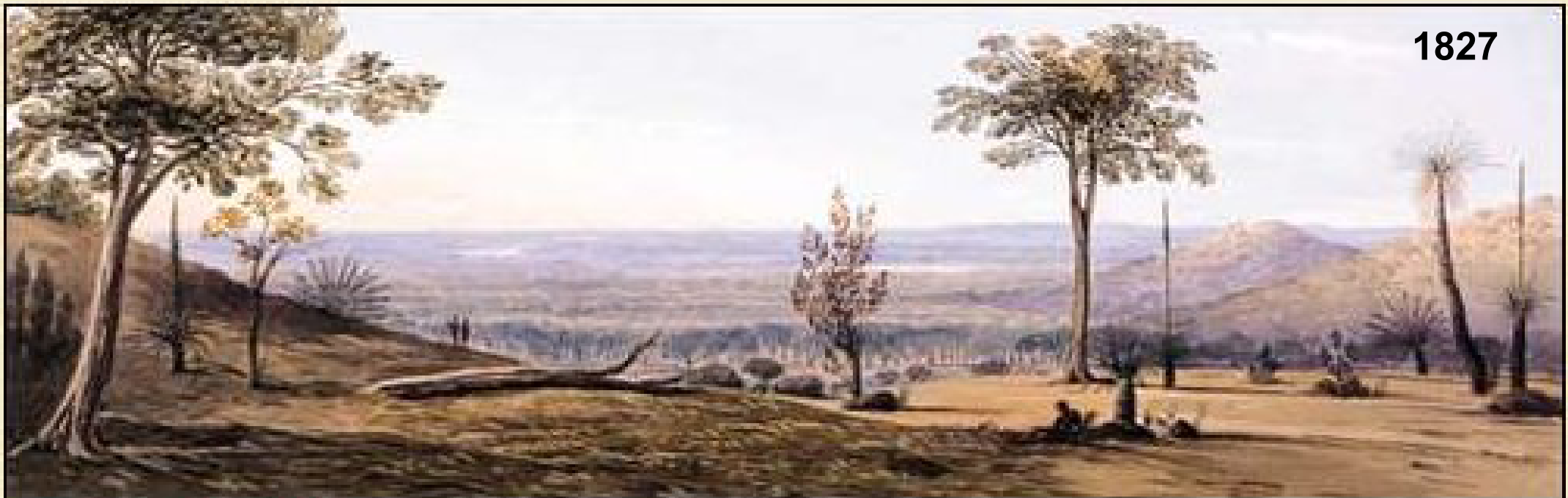
**Settlers who helped clearing the forest**



**National Science Foundation grant ATM-0523583 and  
Australian Research Council's Discovery funding scheme  
(project DP0664515)**

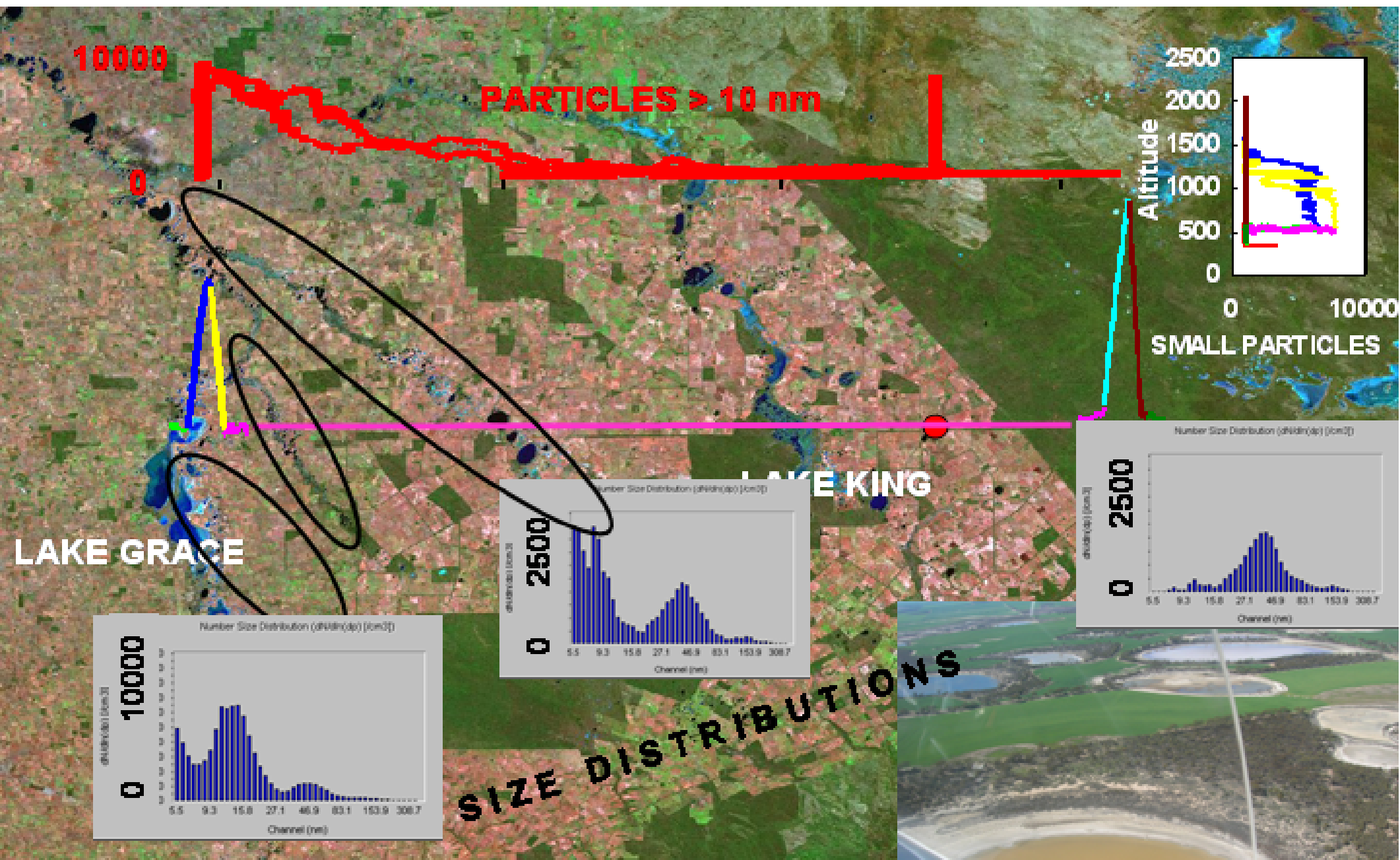
**One of the aircraft was donated by the late Ms. Joyce  
Schultz**

# Thank you for your attention



Swan Coastal Plain, 1827

# HIGH WIND CONDITIONS AUGUST 2007, NW WIND 20-30 kts



**MAIN SOURCE AREAS: CHAINS OF SMALL SALT LAKES**

NUMBER OF DROPLETS [ /cm<sup>3</sup> ]

