FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

How nucleation modifies precipitation: an experiment

W. Junkermann,[1] J. Hacker,[2] T. Lyons[3] and Udaysankar Nair[4]

FZK, IMK-IFU, Garmisch-Partenkirchen, Germany[1]

Airborne Research Australia, Flinders University, Adelaide, Australia [2]

Murdoch University, Perth, Australia [3]

National Space Science Technology Center, Huntsville, Alabama, USA [4]

Outline

Background

Experimental setup

Results

Summary

DROUGHT IN WESTERN AUSTRALIAN WHEAT BELT

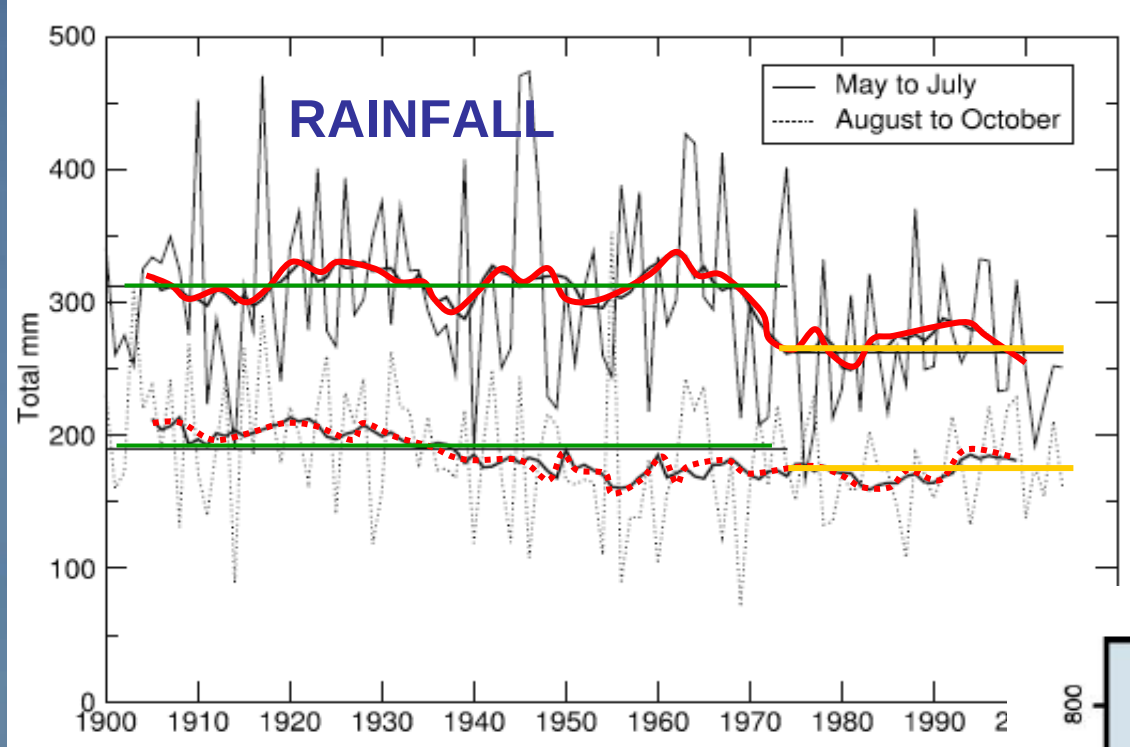


Fig. 4 Time series of Southwest Western Australia rainfall (mm). Solid trace depicts early w July) totals and dotted trace late winter (August to October) totals. Means for the periods 190 1975 to 2004 are represented by horizontal lines

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

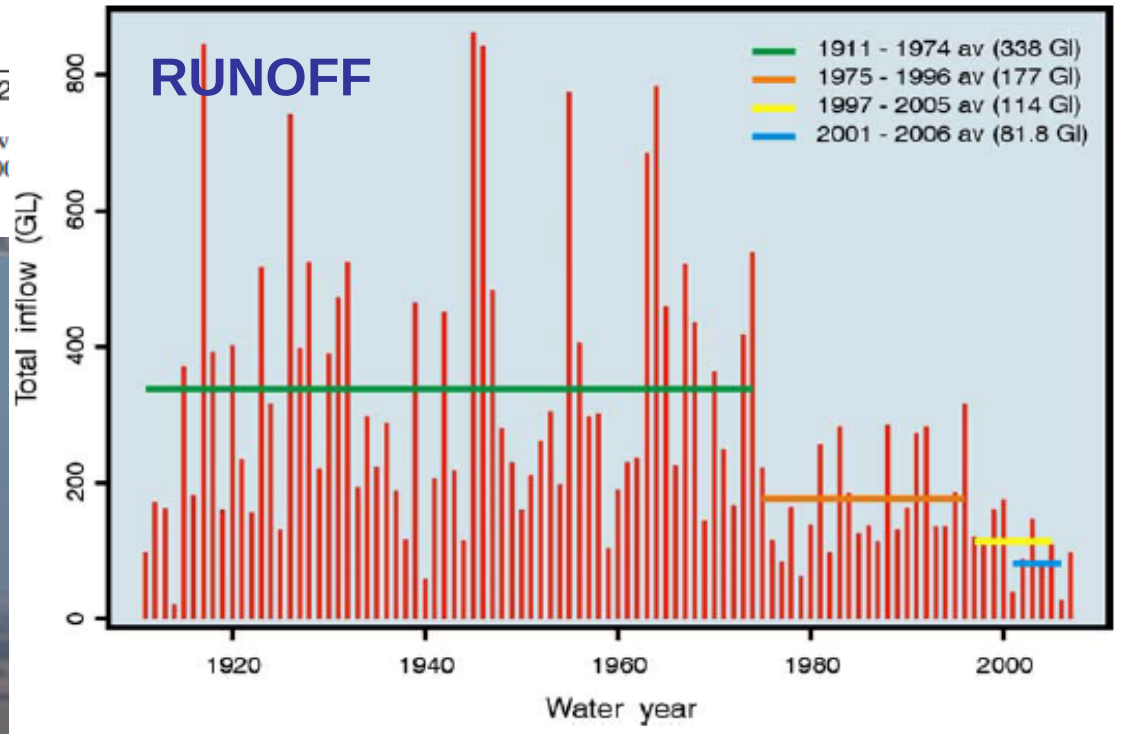
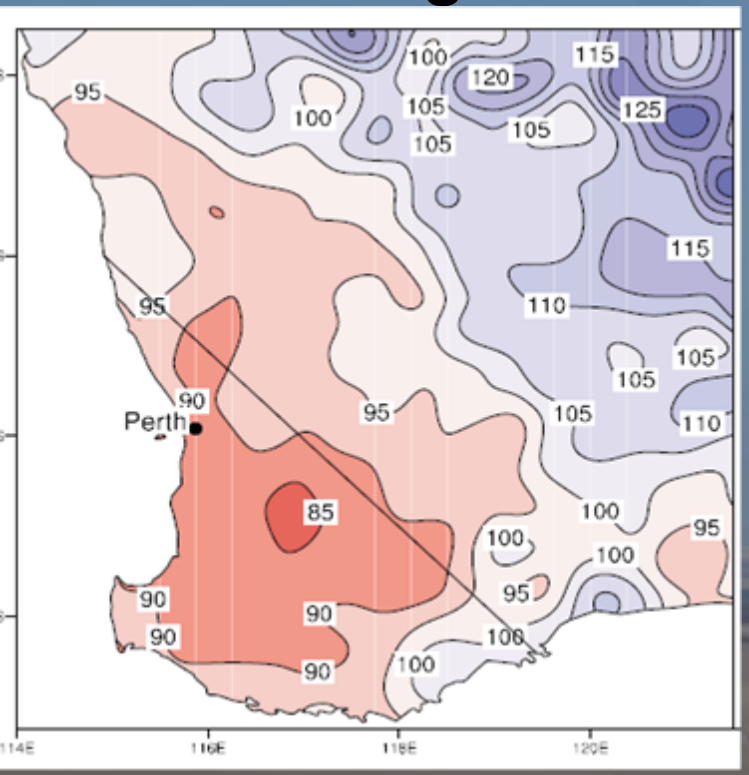


Fig. 5 Annual (May to April) inflow series (GL) for the Integrated Water Supply System. Source: http://www.watercorporation.com.au

Precipitation change distribution

-clouds over natural vegetation



IOCI, 2002

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

The BUFEX experiment 12/2006, 08/2007

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

Background

Experimental setup

Results

Summary


Lake King Airstrip
Flux & Remote Sensing Dimona
Aerosol Dimona


Flux Pod


Aerosol Pod 1


Remote Sensing Pod


Aerosol Pod 2

GRIMM SMPS, 5.5 – 350 nm	**2 min**
GRIMM 1.108, 300 nm – 15 um	**6 sec**
TSI 3010 > 10 nm	**2 sec**
FSSP 100 0.5 – 47 um	**1 sec**

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

Background

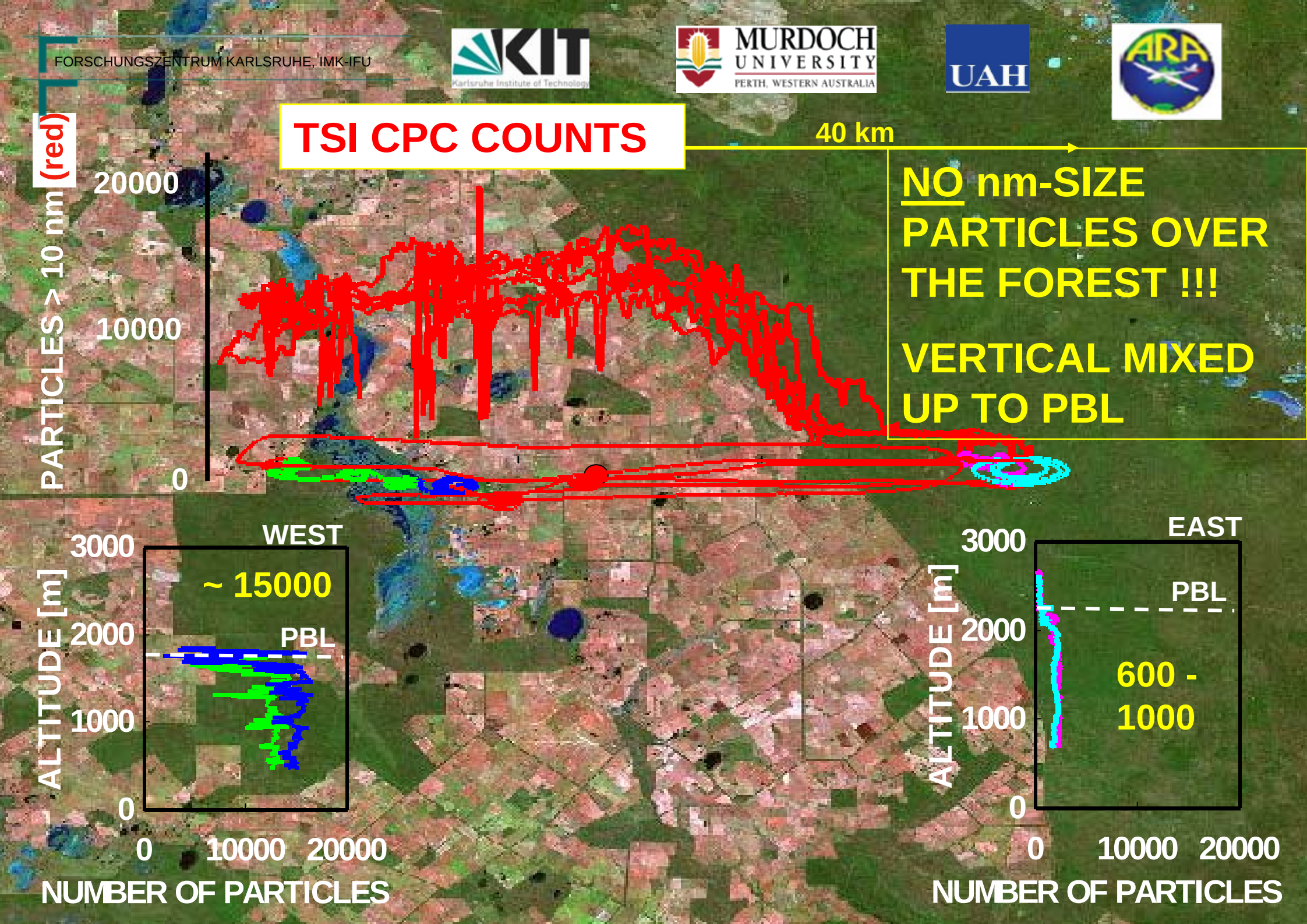
Experimental setup

Results

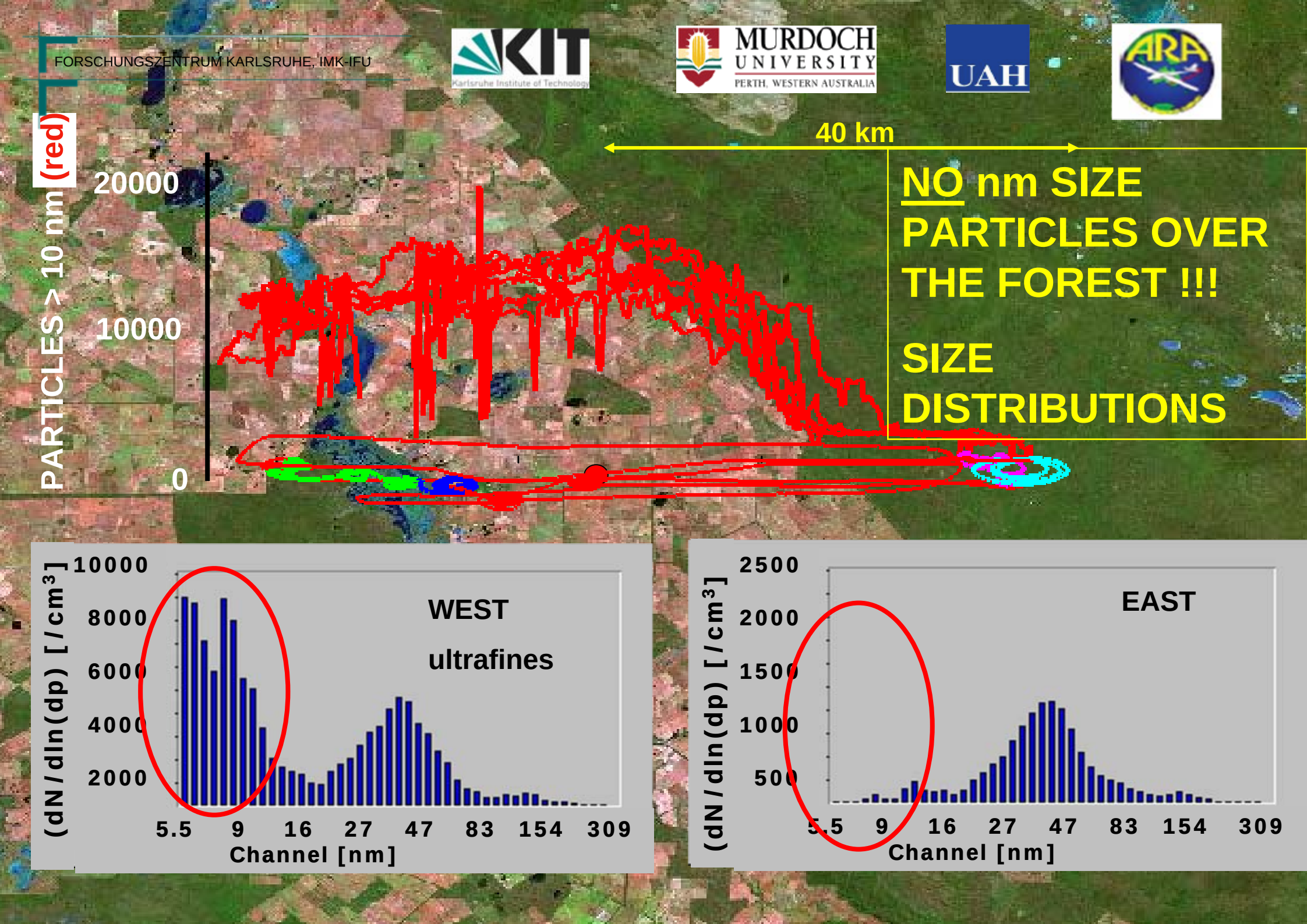
Summary

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

TSI CPC COUNTS



FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

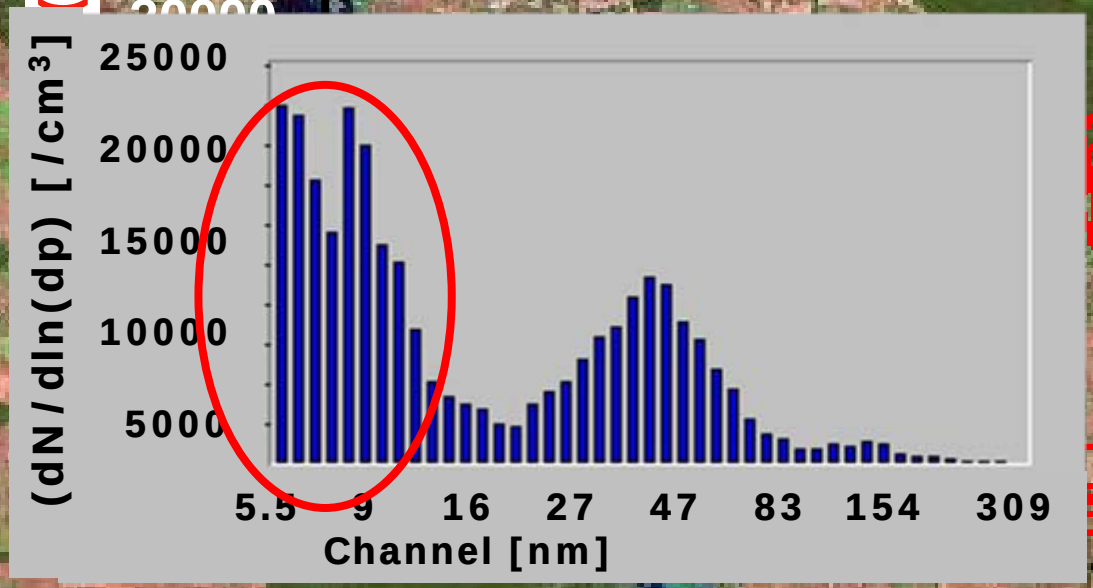


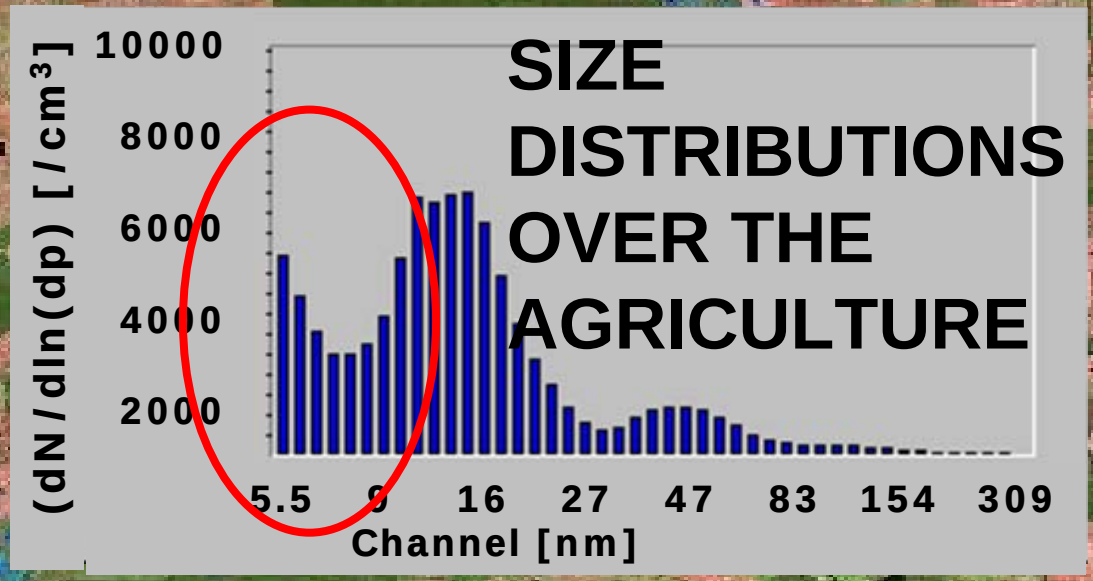
FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

40 km

- INDEPENDENT FROM SEASON

-NO DEPENDENCE ON VEGETATION ON AGRICULTURE



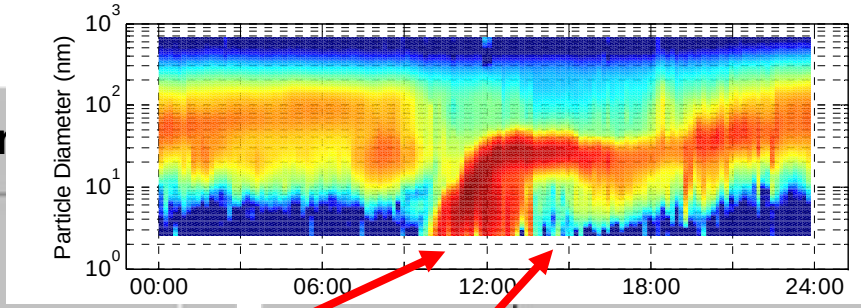


SIZE DISTRIBUTIONS OVER THE AGRICULTURE

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

SOURCE REGIONS FOR NUCLEATION-PARTICLES

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU



a

Number Size Distribution

(dN/dln(dp) [/cm³]

10000
8000
6000
4000
2000
0

11:00

New particle production

9 16 27 47 83 154 309

Channel [nm]

tribution

(dN/dln(dp) [/cm³]

600
400
200
0

east / morning + afternoon

5 9 16 27 47 83 154 309

Channel [nm]

c

Number Size Distribution

(dN/dln(dp) [/cm³]

25000
20000
15000
10000
5000
0

14:00

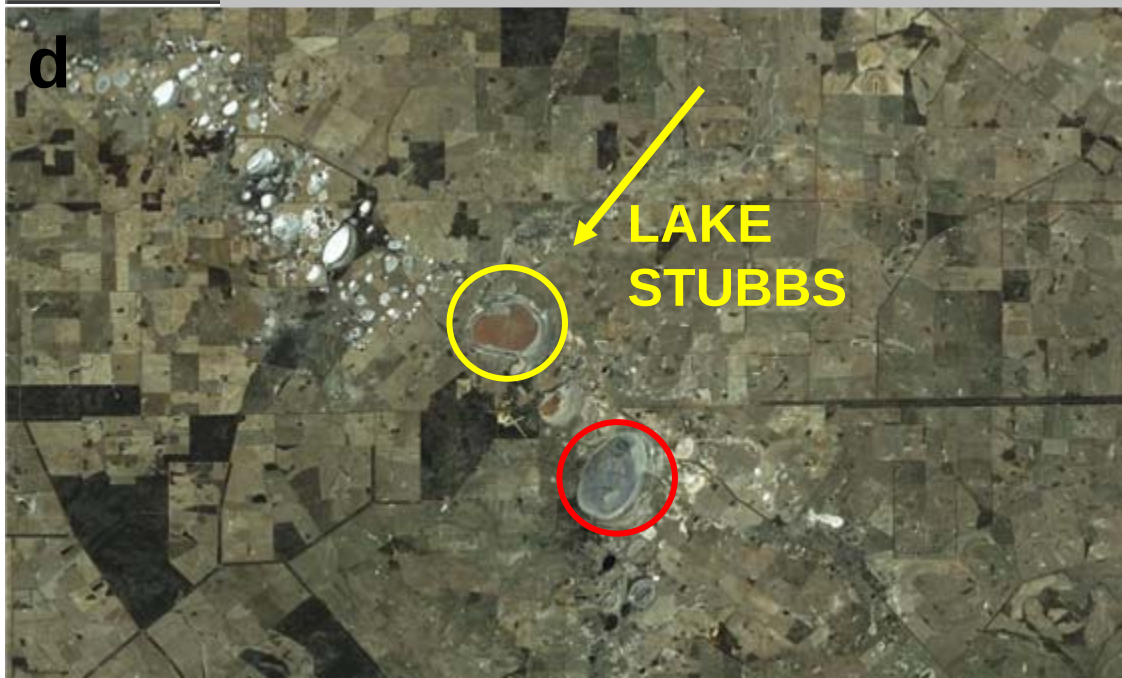
aged new particles

CCN

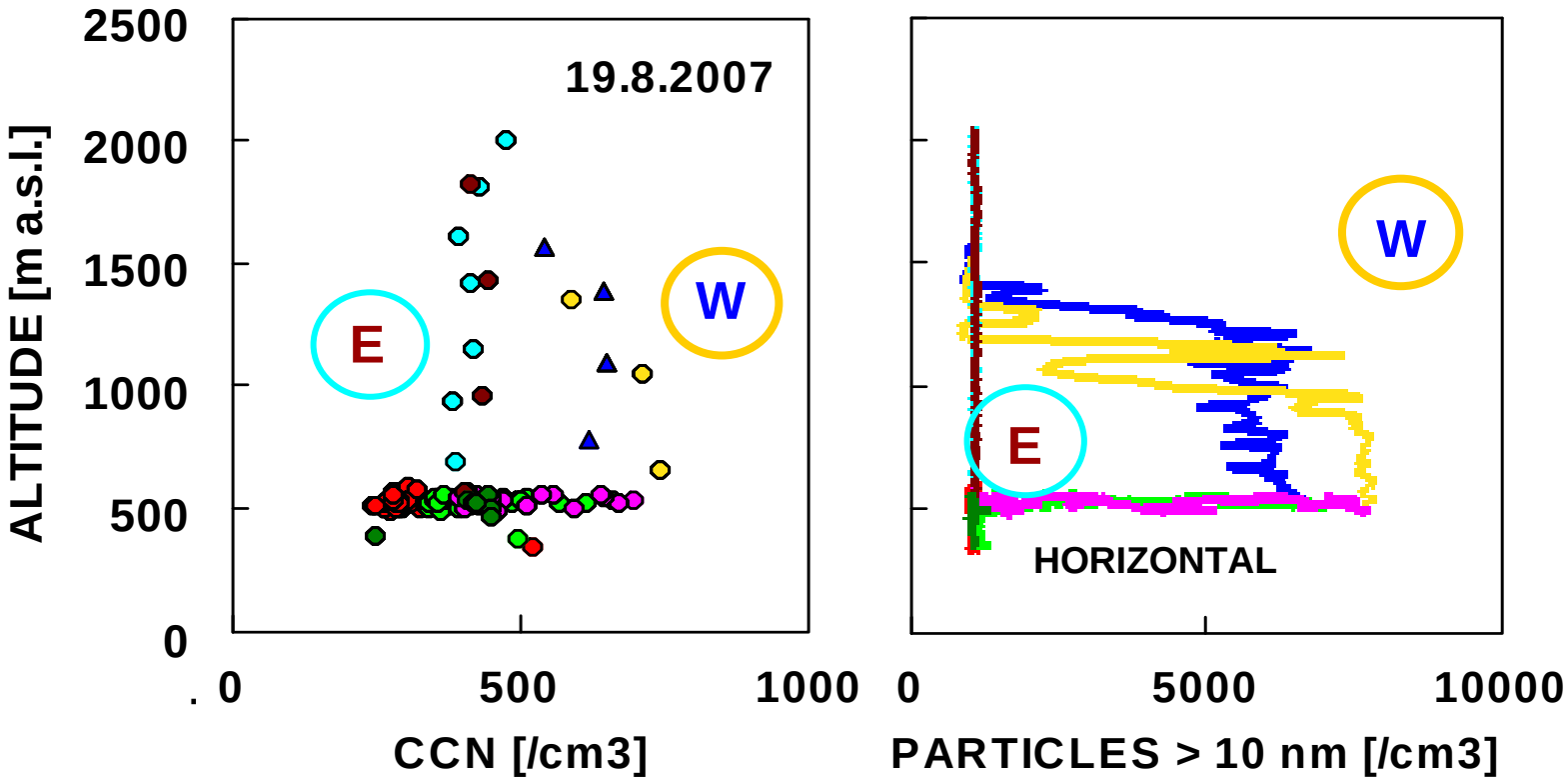
9 16 27 47 83 154 309

Channel [nm]

d



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

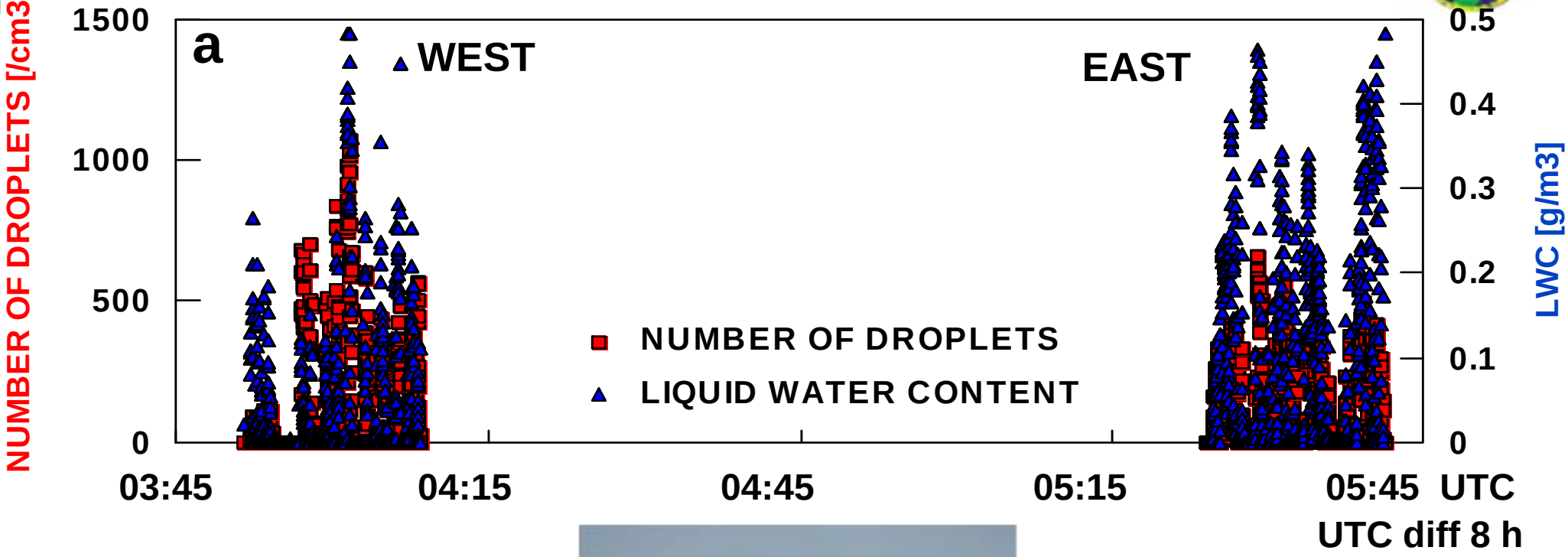


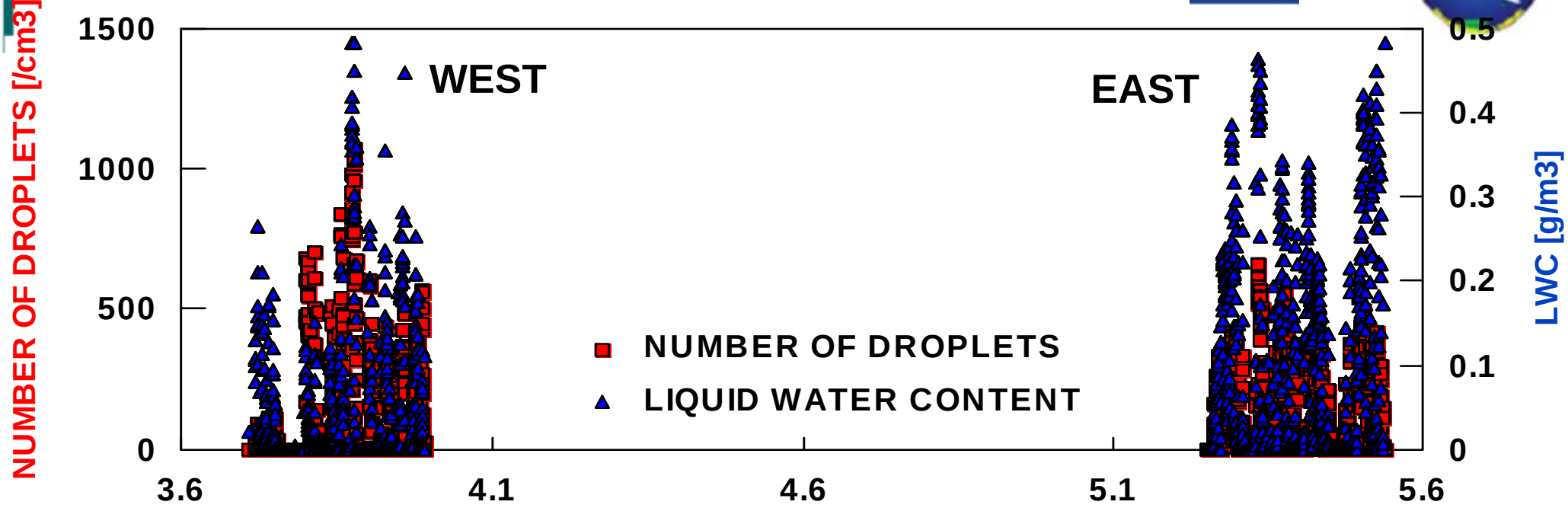
CCN as particles > 50 nm

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

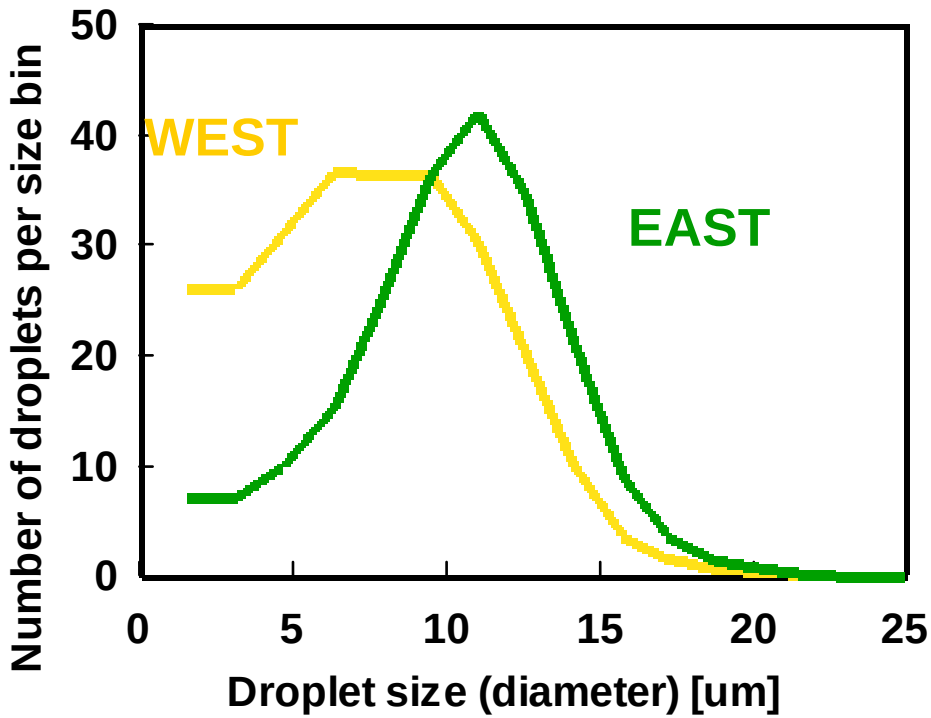
CLOUDS OVER BOTH AREAS, 21.8.2007

Experimental proof


a
WEST
EAST
NUMBER OF DROPLETS [/cm3]
LWC [g/m3]
1500
1000
500
0
0.5
0.4
0.3
0.2
0.1
0
NUMBER OF DROPLETS
LIQUID WATER CONTENT
03:45
04:15
04:45
05:15
05:45 UTC
UTC diff 8 h



CCN 400/cm3



CCN 280/cm3

Parameter	West (agriculture) ground	West (agriculture) cloud base	East (natural vegetation) ground	East (natural vegetation) cloud base
Temperature (air) [°C]	16	10	20	6
Pressure [hPa]	975	900	975	800
Dewpoint [°C]	11	9	6	3.5
Water [g/m3]	9.9	8.8	6.9	6.1
CCN		~ 400		~ 280
Cloud droplets [/cm3]		247		198
Average diameter [um]		8.3		9.5
Liquid water content [g/m3]		0.10		0.15

Note the difference of water vapor converted into LWC

Background

Experimental setup

Results > Landuse change

Summary

FORSCHUNGSZENTRUM KARLSRUHE, IMK-IFU

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

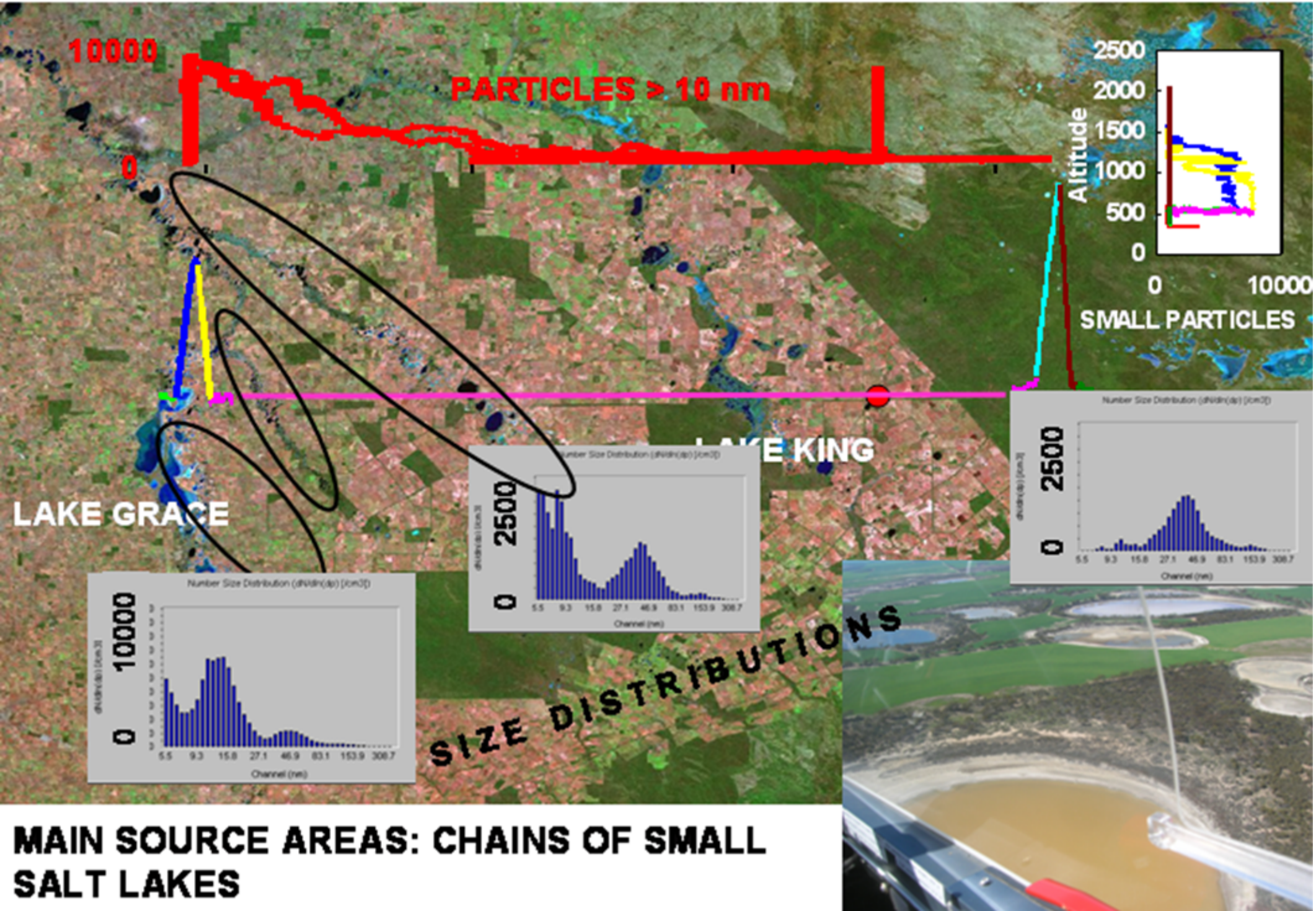
Australian Research Council's Discovery funding scheme (project DP0664515)

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

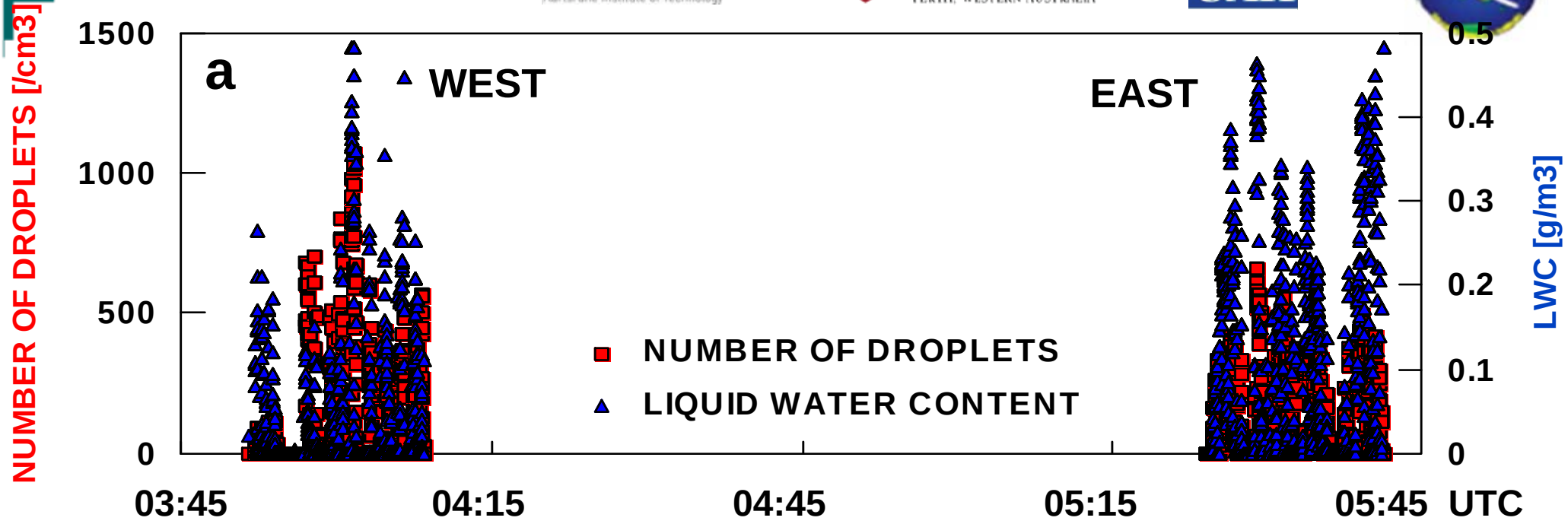
Thank you for your attention

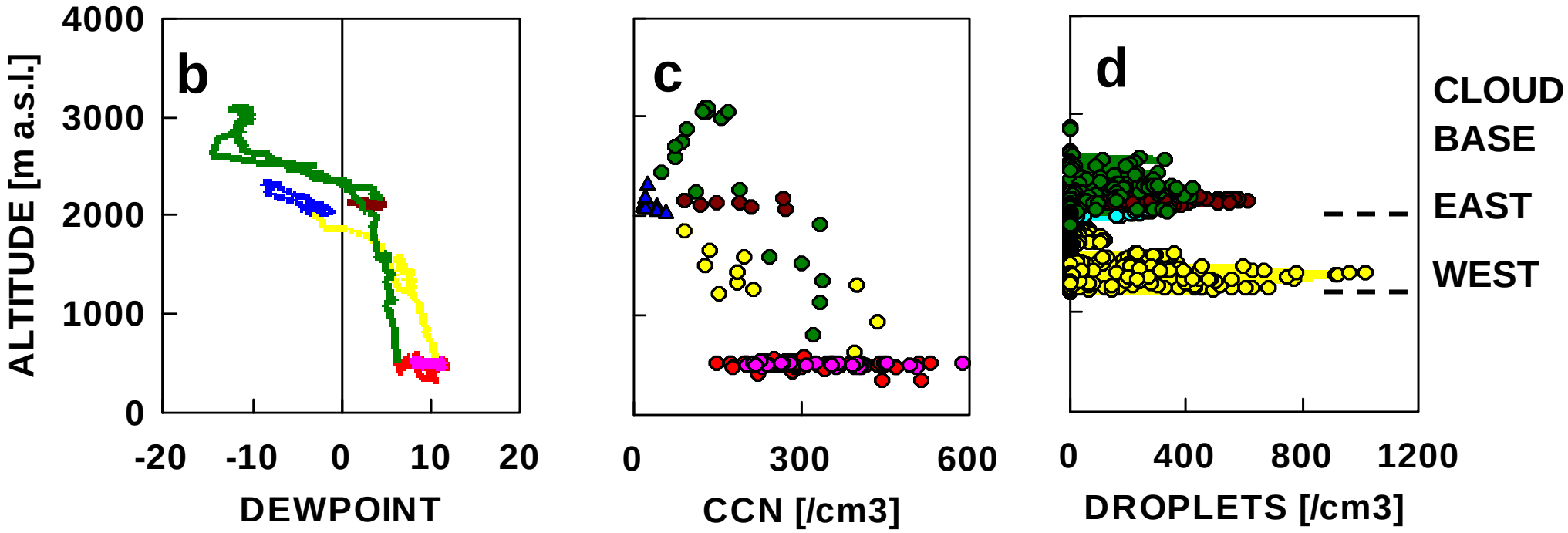
Swan Coastal Plain, 1827

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



MAIN SOURCE AREAS: CHAINS OF SMALL SALT LAKES


a
WEST
EAST
NUMBER OF DROPLETS [/cm3]
LWC [g/m3]
NUMBER OF DROPLETS
LIQUID WATER CONTENT
1500
1000
500
0
0.5
0.4
0.3
0.2
0.1
0
03:45
04:15
04:45
05:15
05:45 UTC
UTC diff 8 h


b
c
d
ALTITUDE [m a.s.l.]
4000
3000
2000
1000
0
-20
-10
0
10
20
DEWPOINT
0
300
600
CCN [/cm3]
0
400
800
1200
DROPLETS [/cm3]
CLOUD BASE
EAST
WEST