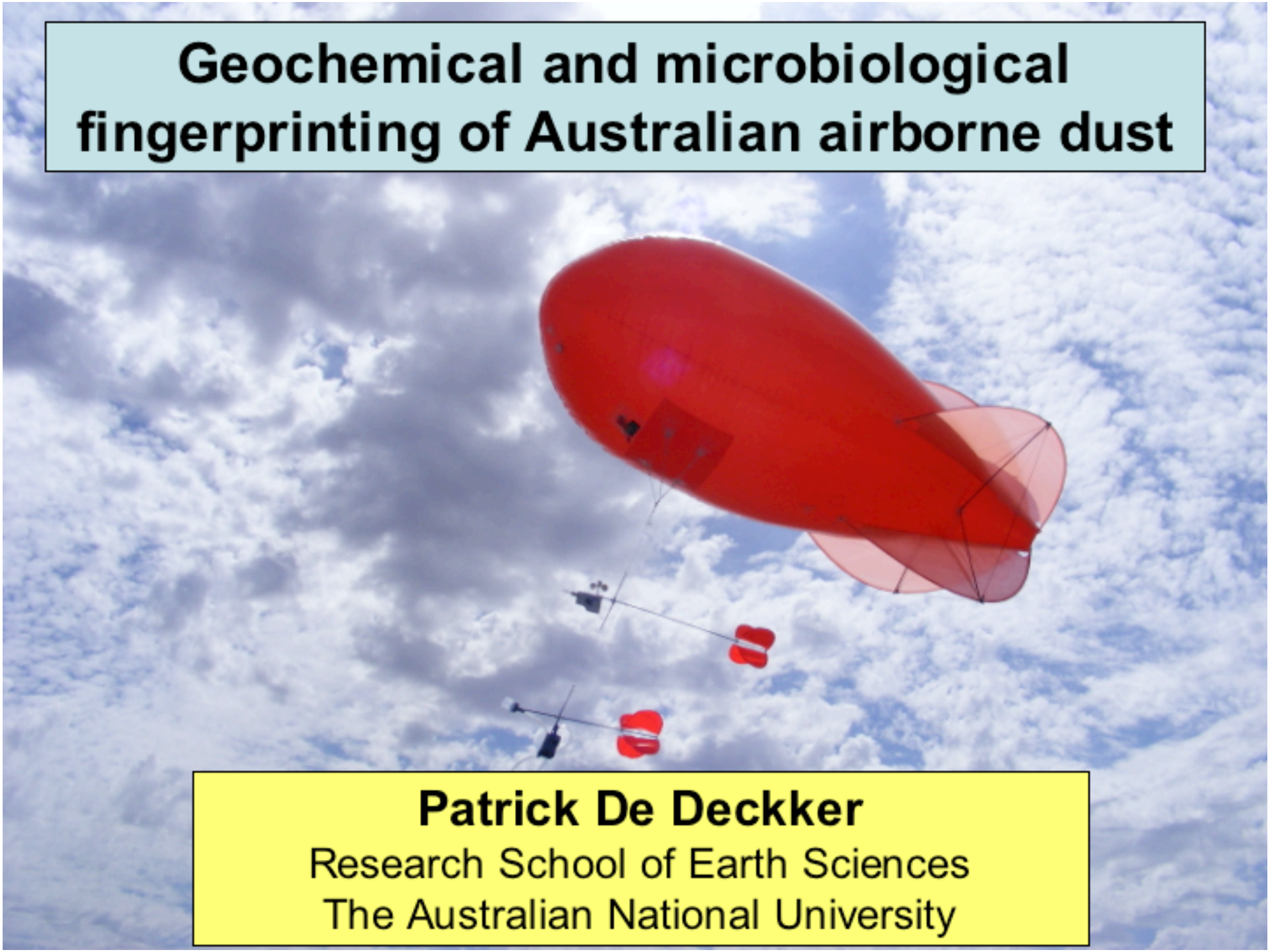
Geochemical and microbiological fingerprinting of Australian airborne dust



Patrick De Deckker
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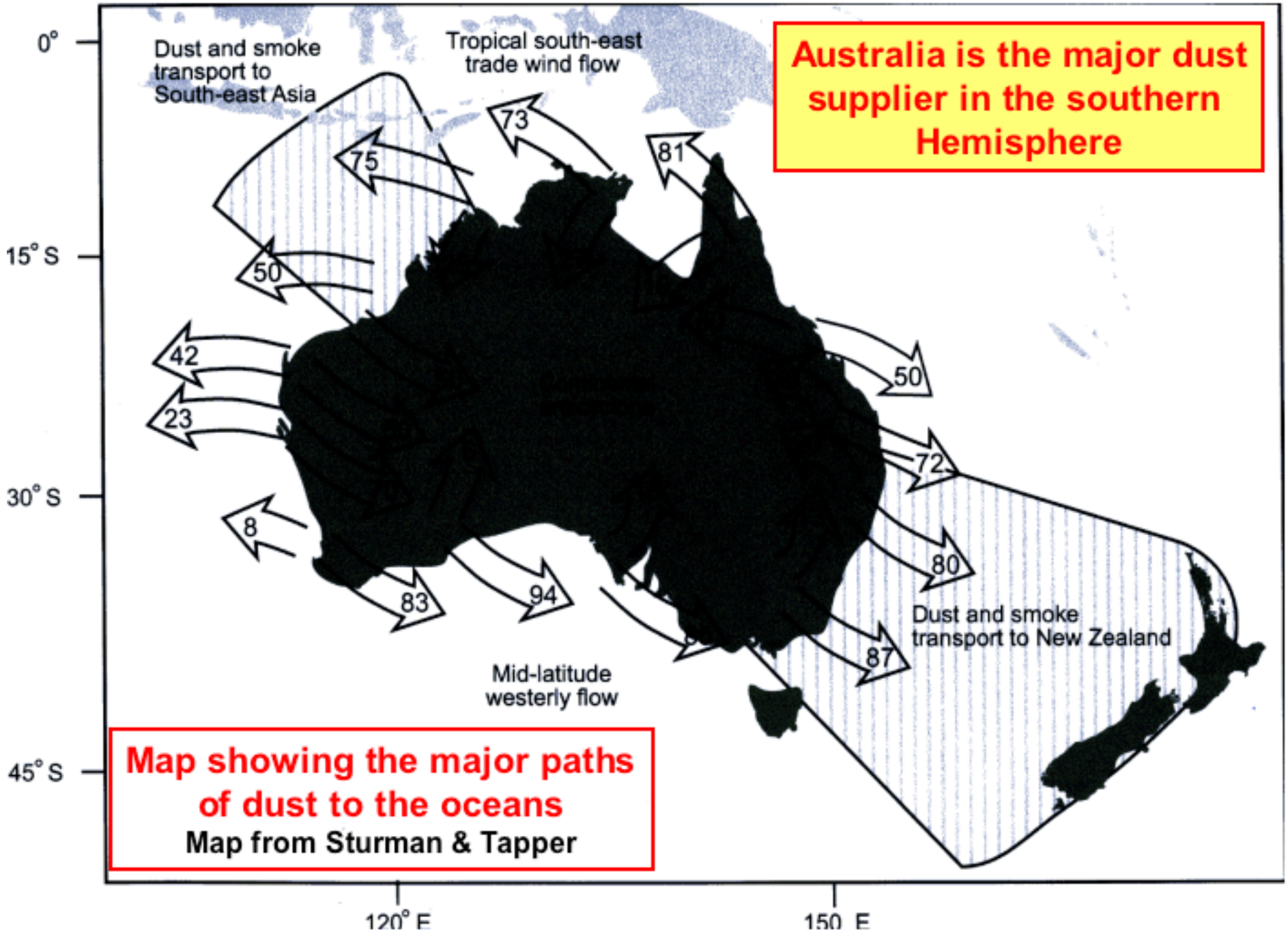
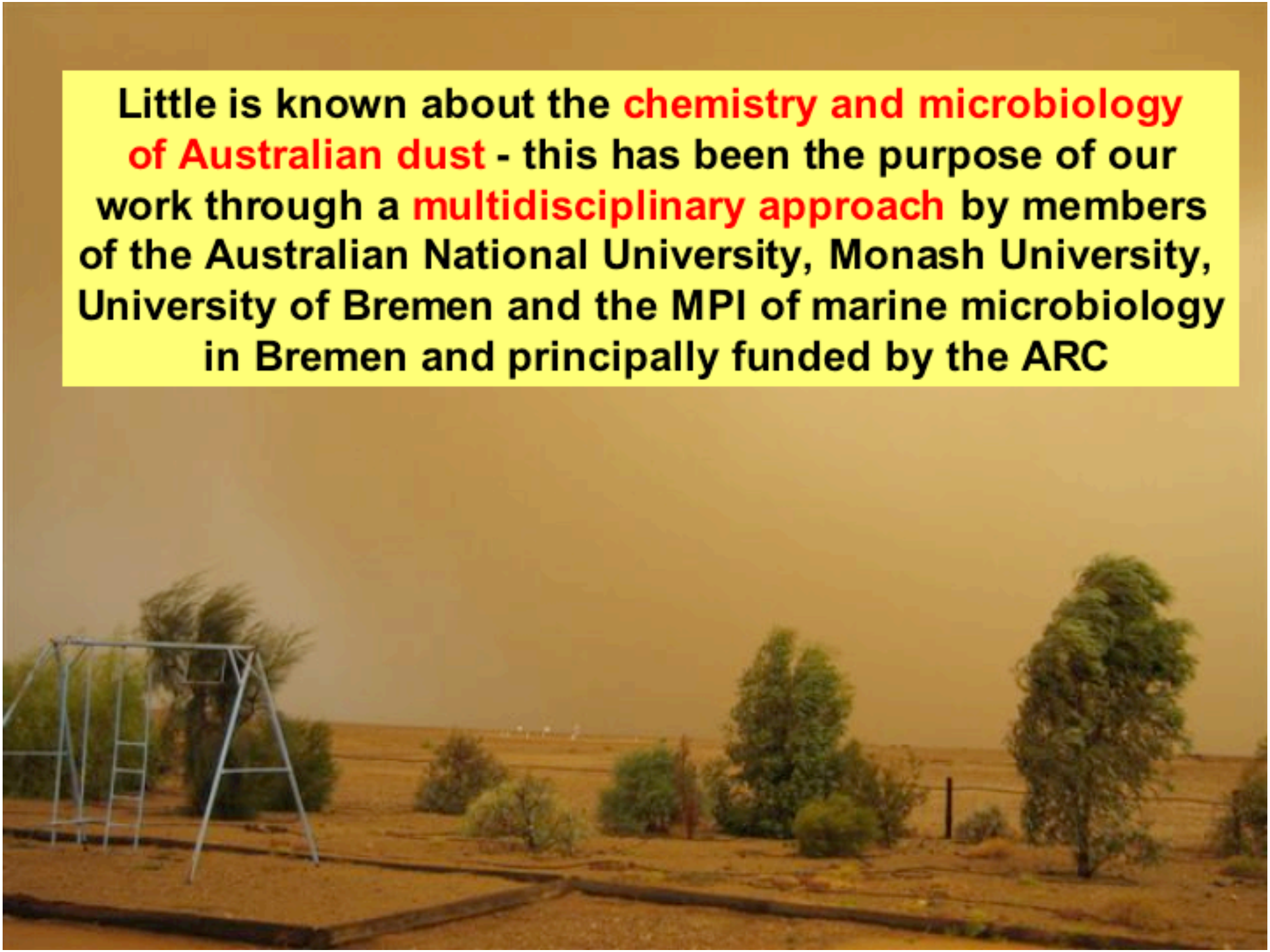

0°
15° S
30° S
45° S
120° E
150 E
Dust and smoke transport to South-east Asia
Tropical south-east trade wind flow
Australia is the major dust supplier in the southern Hemisphere
73
81
75
50
42
23
8
83
94
50
72
80
87
Dust and smoke transport to New Zealand
Mid-latitude westerly flow
Map showing the major paths of dust to the oceans
Map from Sturman & Tapper

Salt lakes, with groundwater just below the surface, and flood plains are the prime source of dust in Australia

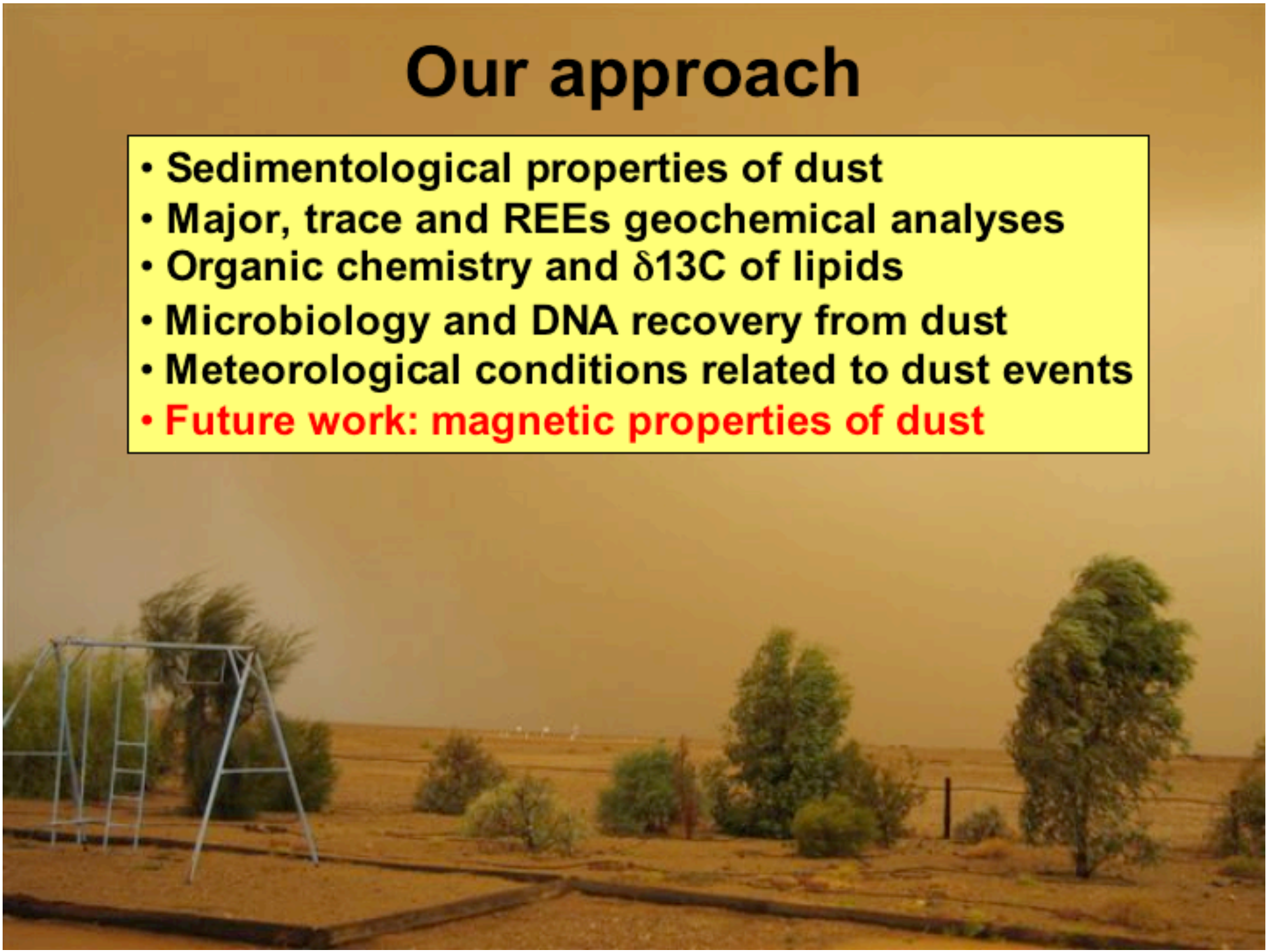
Dust storms are often generated during significant meteorological re-organisation of wind regimes & fronts that create significant shear zones at ground level

eg principally in early Spring and Autumn

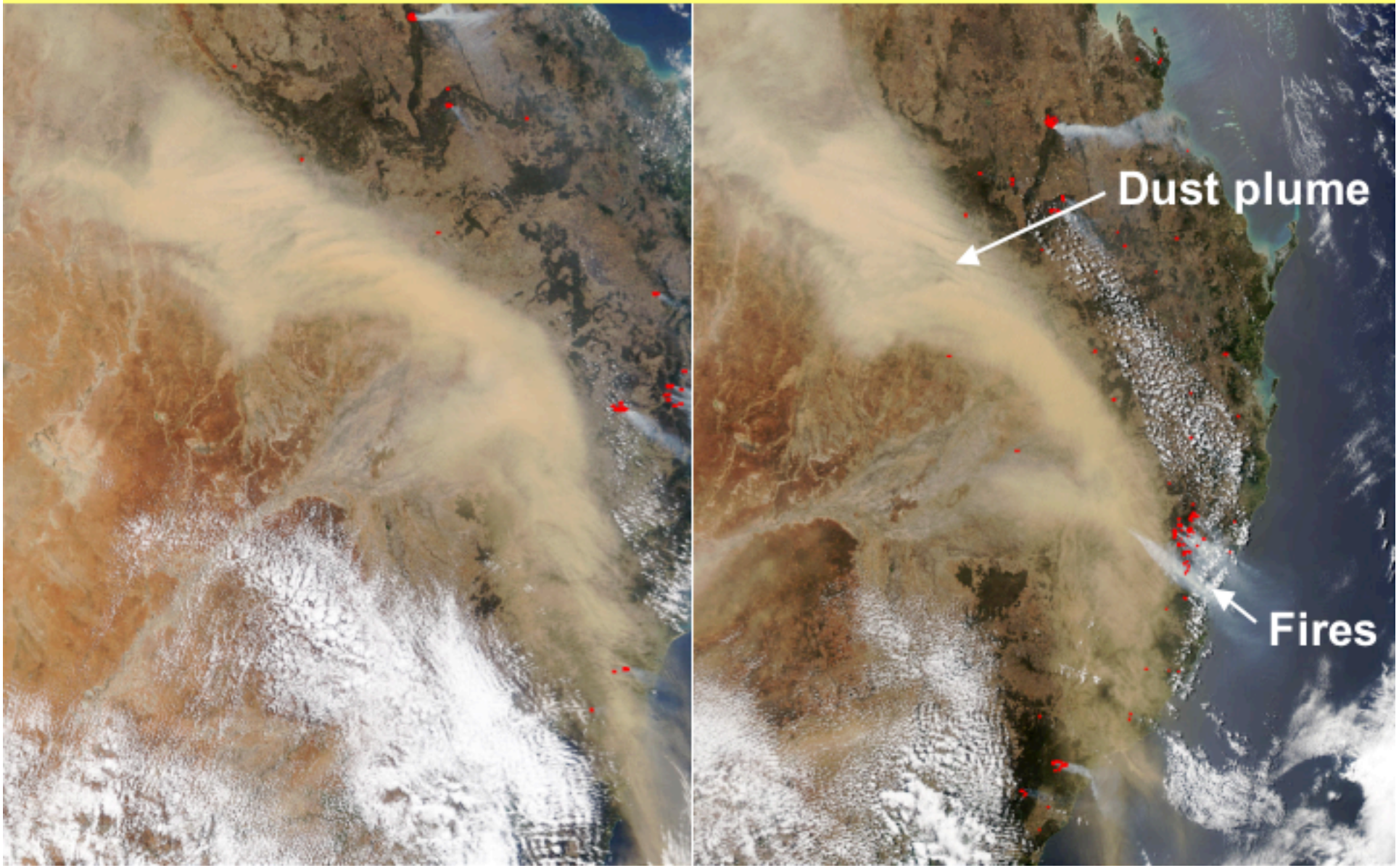

Little is known about the chemistry and microbiology of Australian dust - this has been the purpose of our work through a multidisciplinary approach by members of the Australian National University, Monash University, University of Bremen and the MPI of marine microbiology in Bremen and principally funded by the ARC

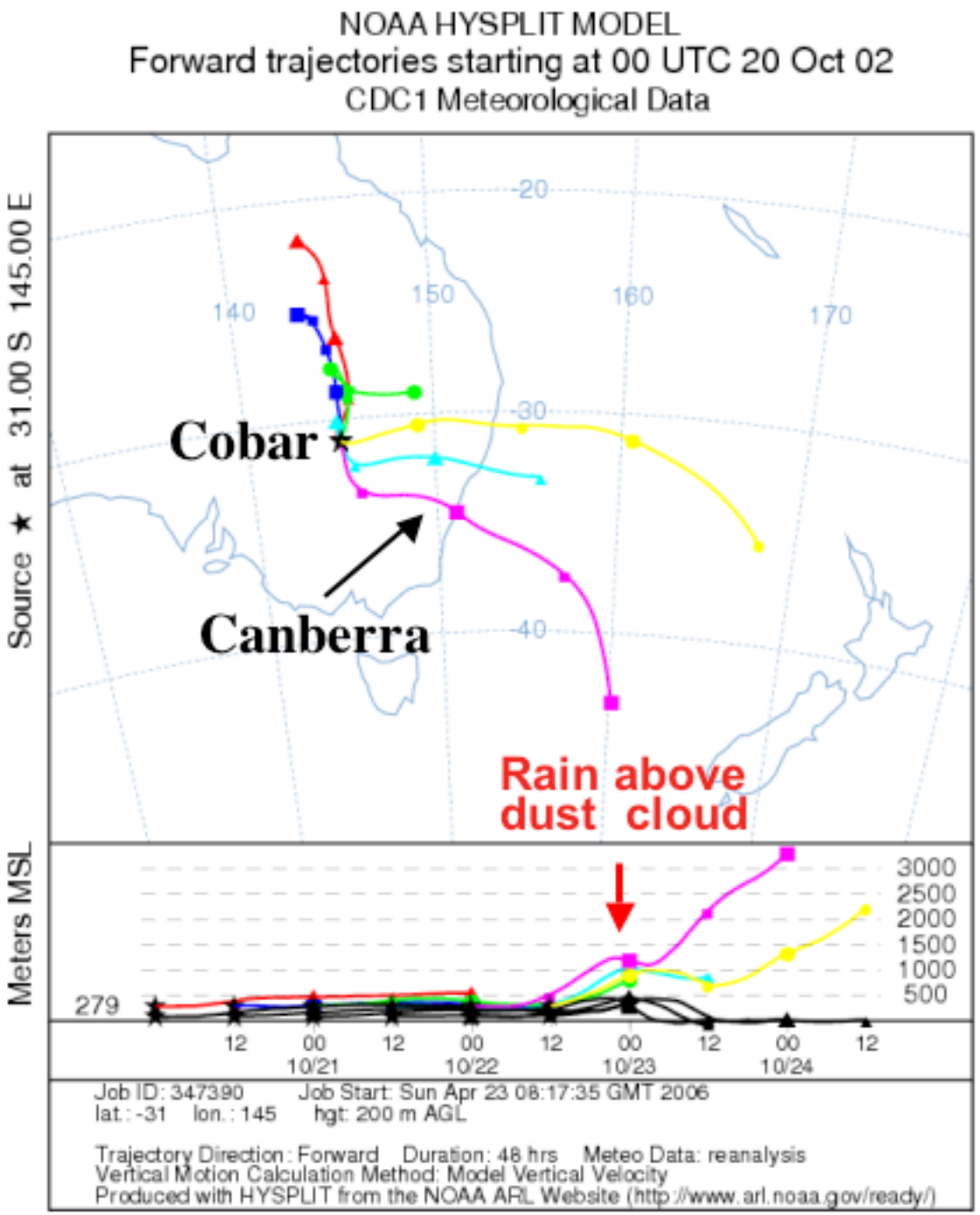
Our approach

- Sedimentological properties of dust
- Major, trace and REEs geochemical analyses
- Organic chemistry and δ13C of lipids
- Microbiology and DNA recovery from dust
- Meteorological conditions related to dust events
- Future work: magnetic properties of dust



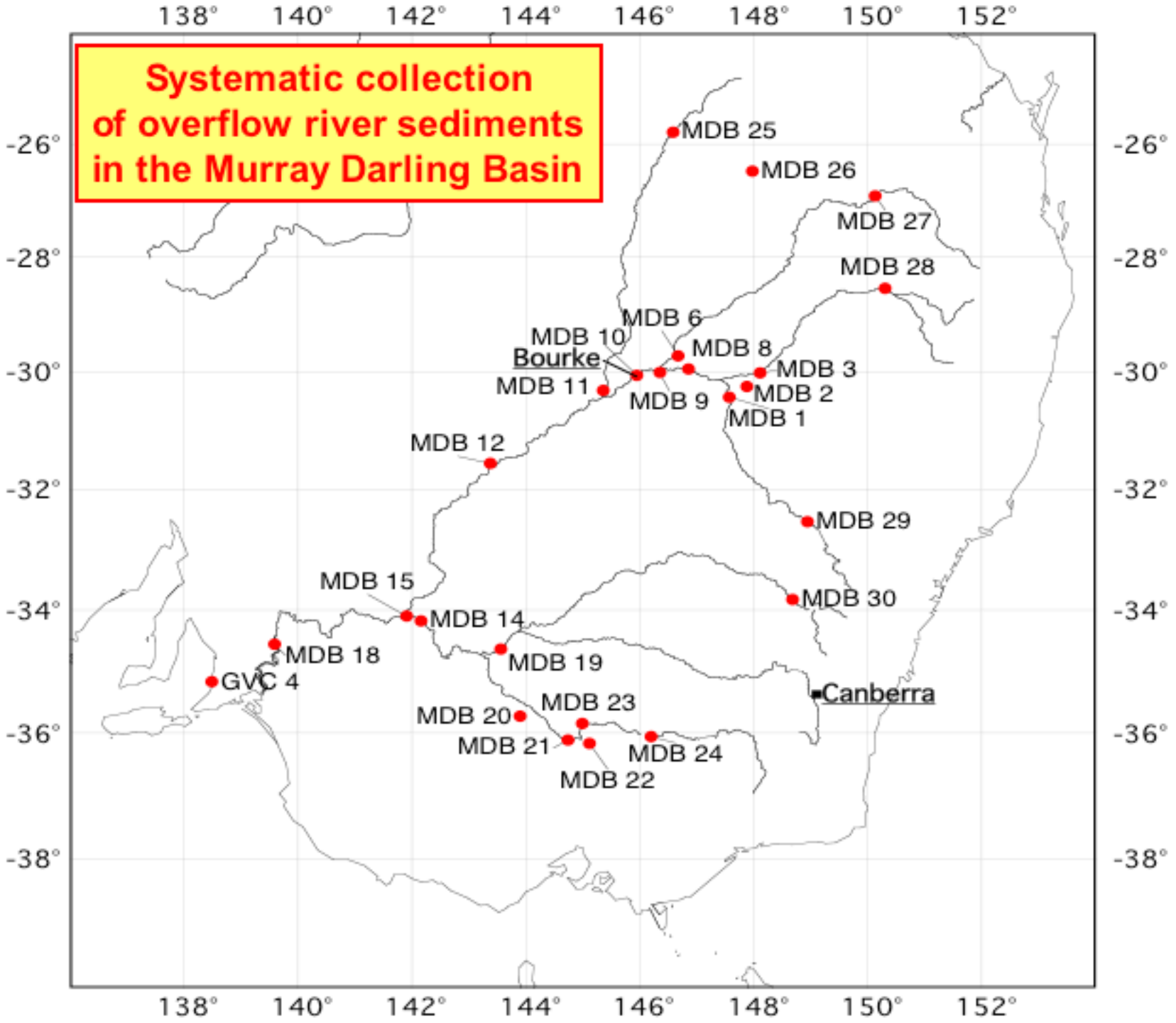
Example: the dust storm of 22/23 October 2002 which transgressed a large portion of eastern Australia, some of which rained down over Canberra

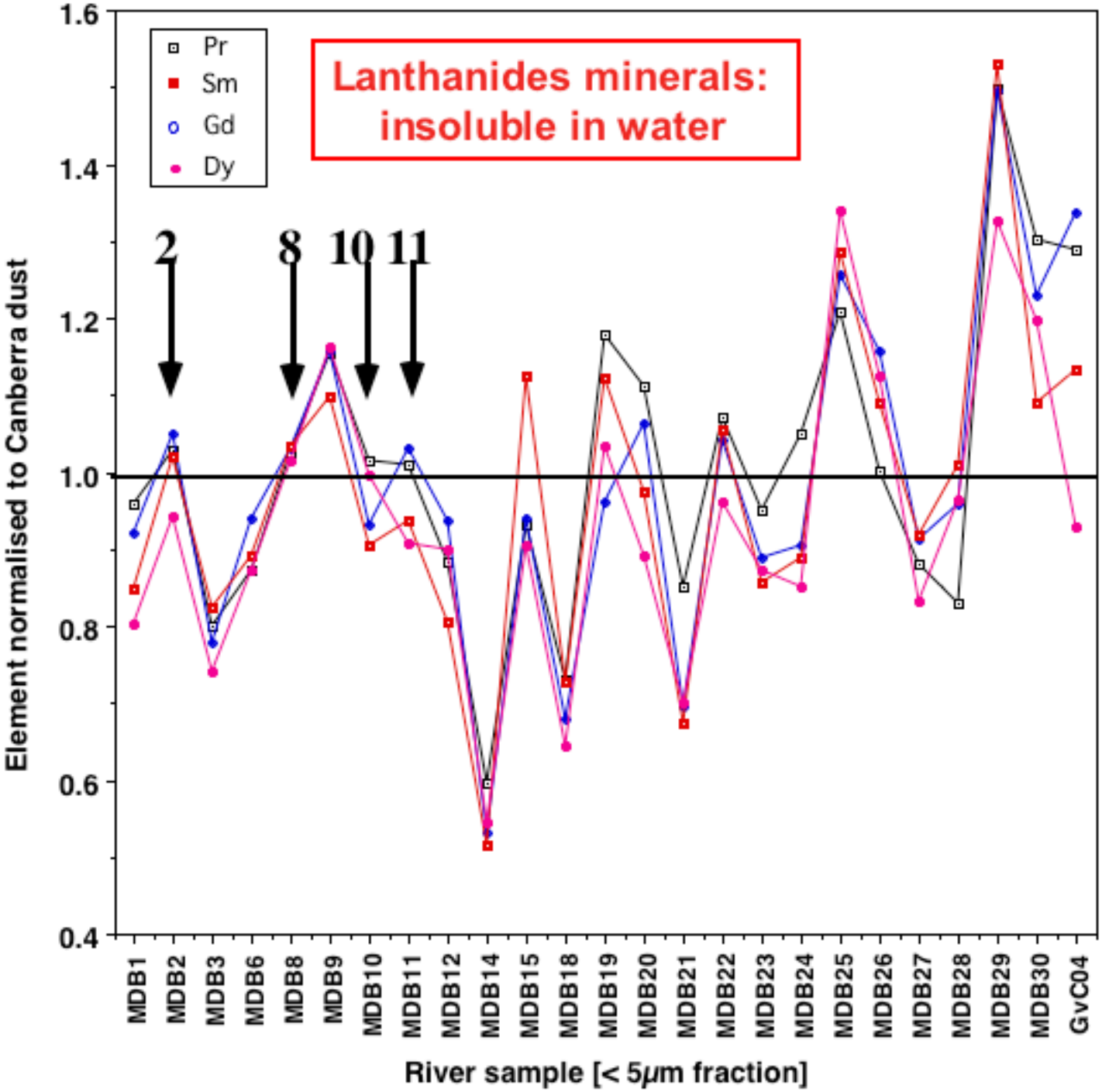


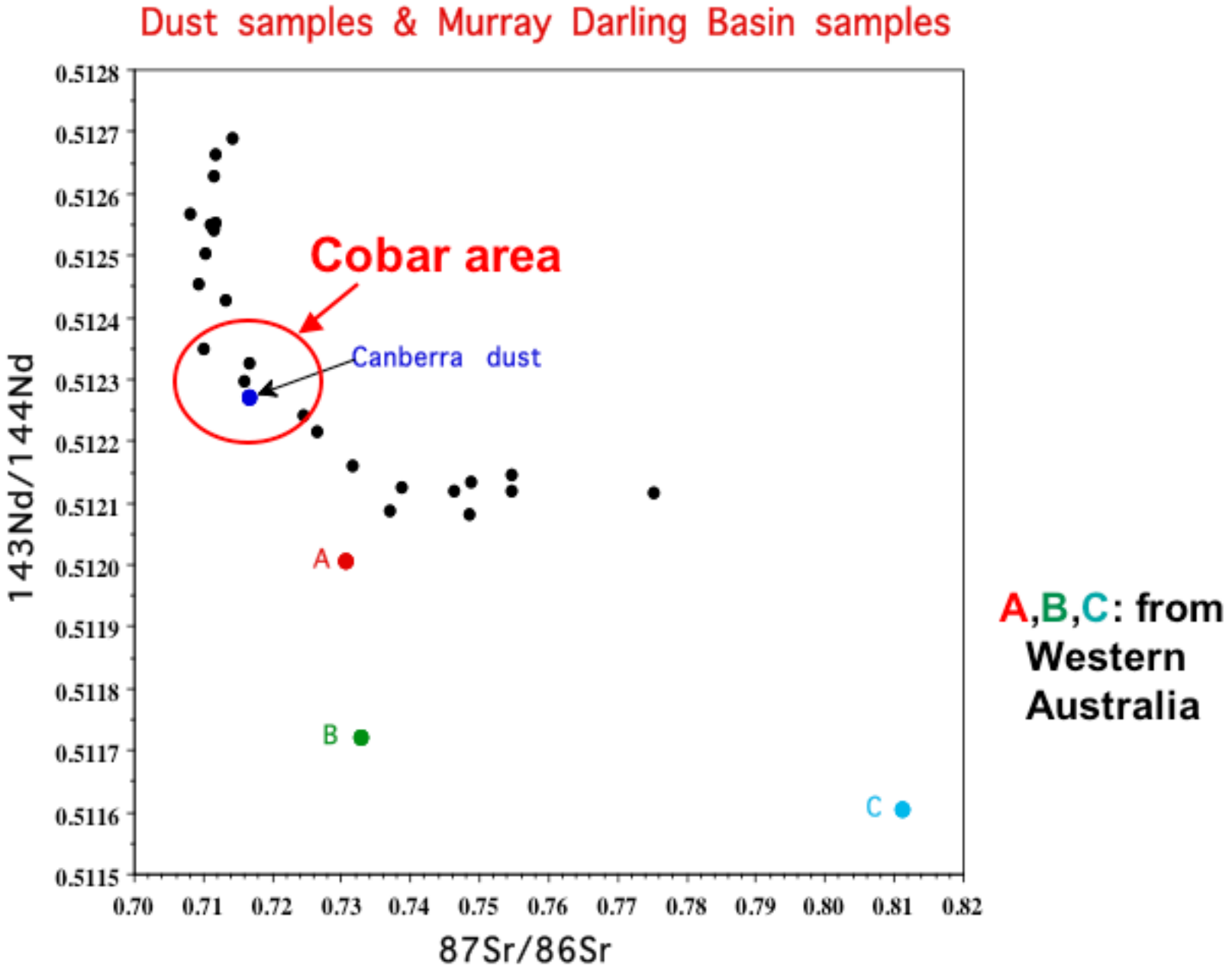


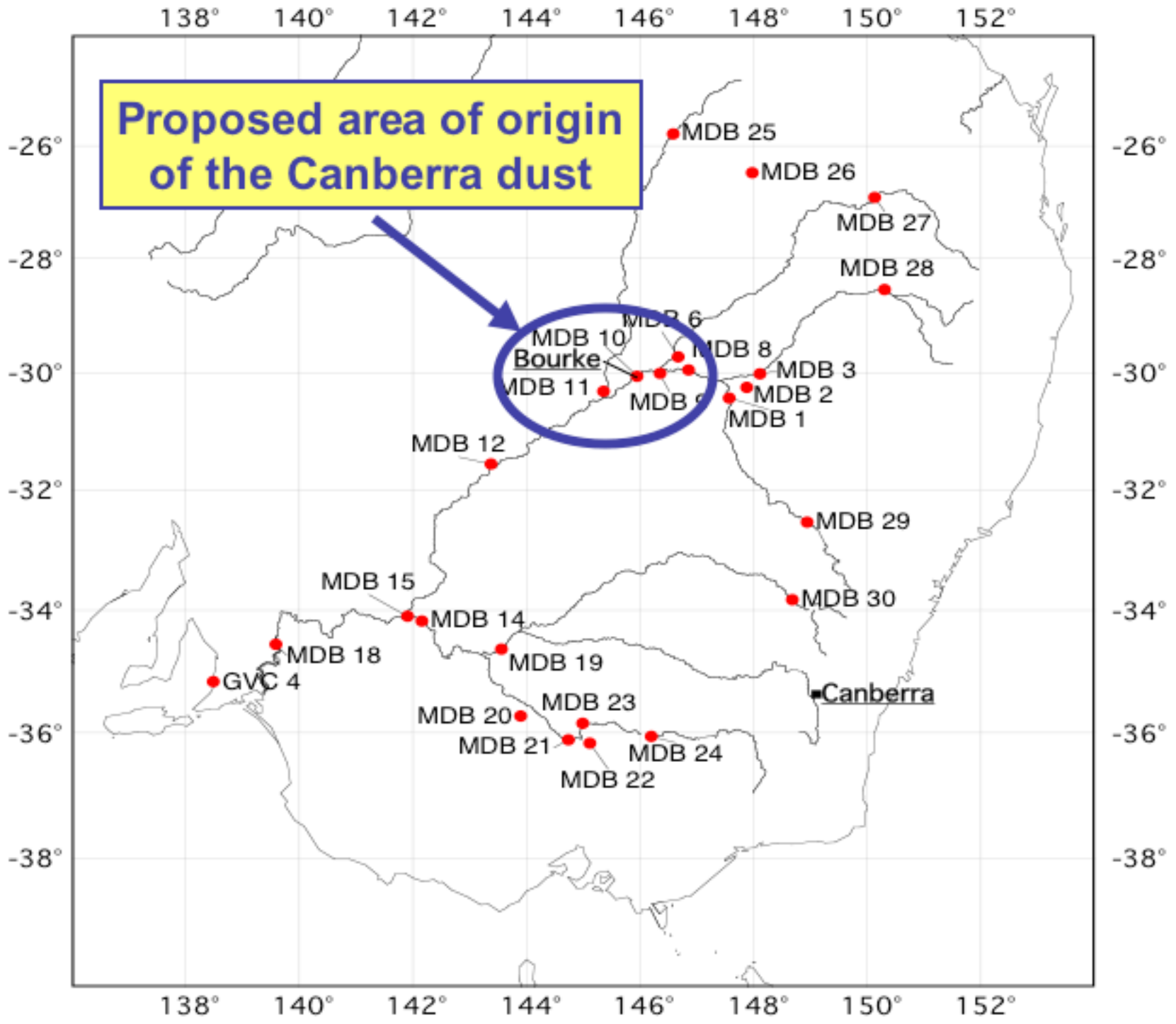
Forward trajectories starting on Oct. 20, 2002 confirm that the dust plume originated from the NW of NSW (Cobar)

and it was 1.5km high over Canberra and dew point was reached there, so it rained mud


Systematic collection
of overflow river sediments
in the Murray Darling Basin
138°
140°
142°
144°
146°
148°
150°
152°
-26°
-28°
-30°
-32°
-34°
-36°
-38°
MDB 25
MDB 26
MDB 27
MDB 28
MDB 6
MDB 10
MDB 8
Bourke
MDB 3
MDB 11
MDB 9
MDB 2
MDB 1
MDB 12
MDB 29
MDB 15
MDB 30
MDB 14
MDB 18
MDB 19
GVC 4
Canberra
MDB 23
MDB 20
MDB 21
MDB 24
MDB 22

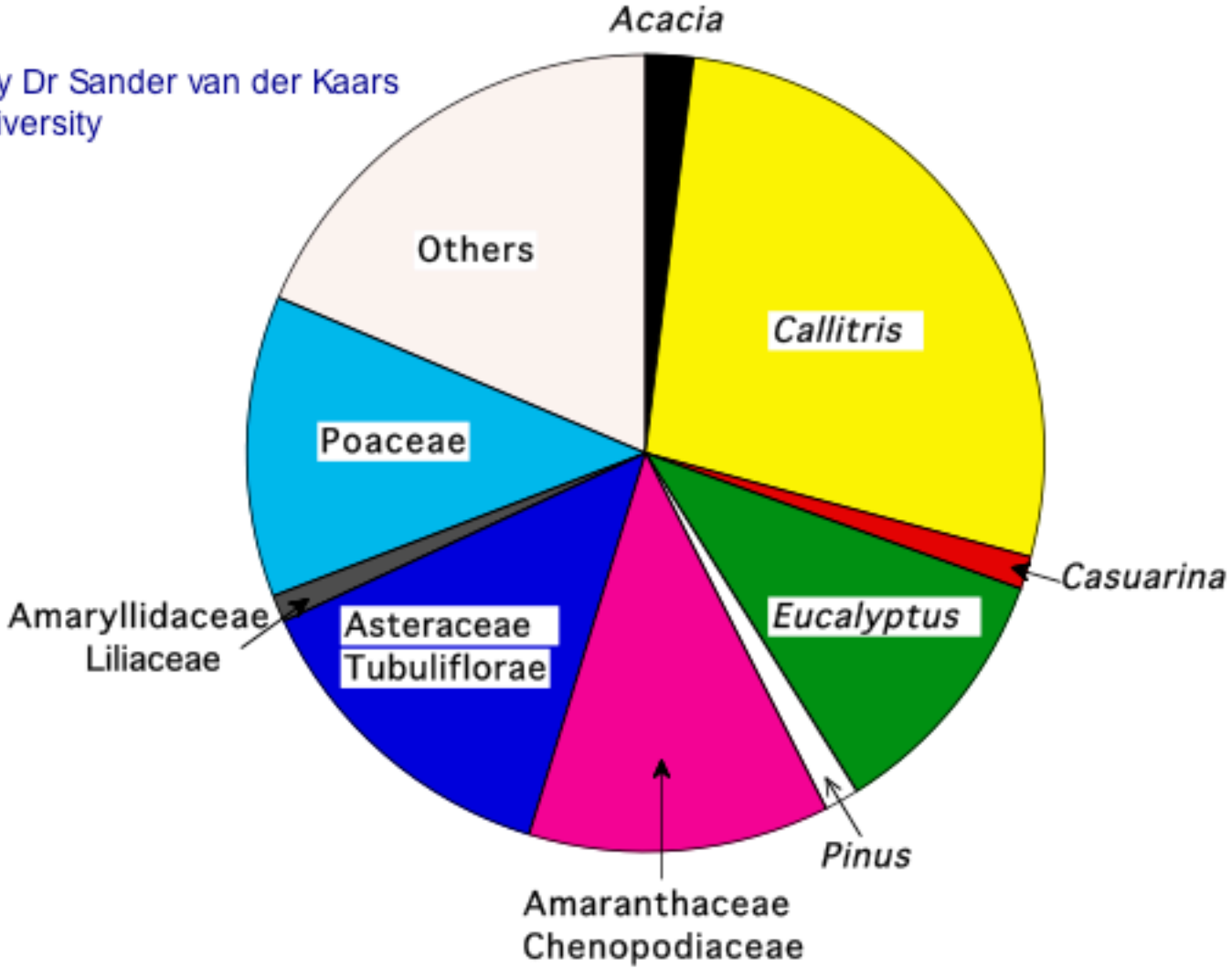

Pr
Sm
Gd
Dy
Lanthanides minerals:
insoluble in water
2
8
10
11
Element normalised to Canberra dust
1.6
1.4
1.2
1.0
0.8
0.6
0.4
MDB1
MDB2
MDB3
MDB6
MDB8
MDB9
MDB10
MDB11
MDB12
MDB14
MDB15
MDB18
MDB19
MDB20
MDB21
MDB22
MDB23
MDB24
MDB25
MDB26
MDB27
MDB28
MDB29
MDB30
GvC04
River sample [< 5μm fraction]


Dust samples & Murray Darling Basin samples
Cobar area
Canberra dust
A
B
C
143Nd/144Nd
87Sr/86Sr
0.5128
0.5127
0.5126
0.5125
0.5124
0.5123
0.5122
0.5121
0.5120
0.5119
0.5118
0.5117
0.5116
0.5115
0.70
0.71
0.72
0.73
0.74
0.75
0.76
0.77
0.78
0.79
0.80
0.81
0.82
A,B,C: from Western Australia

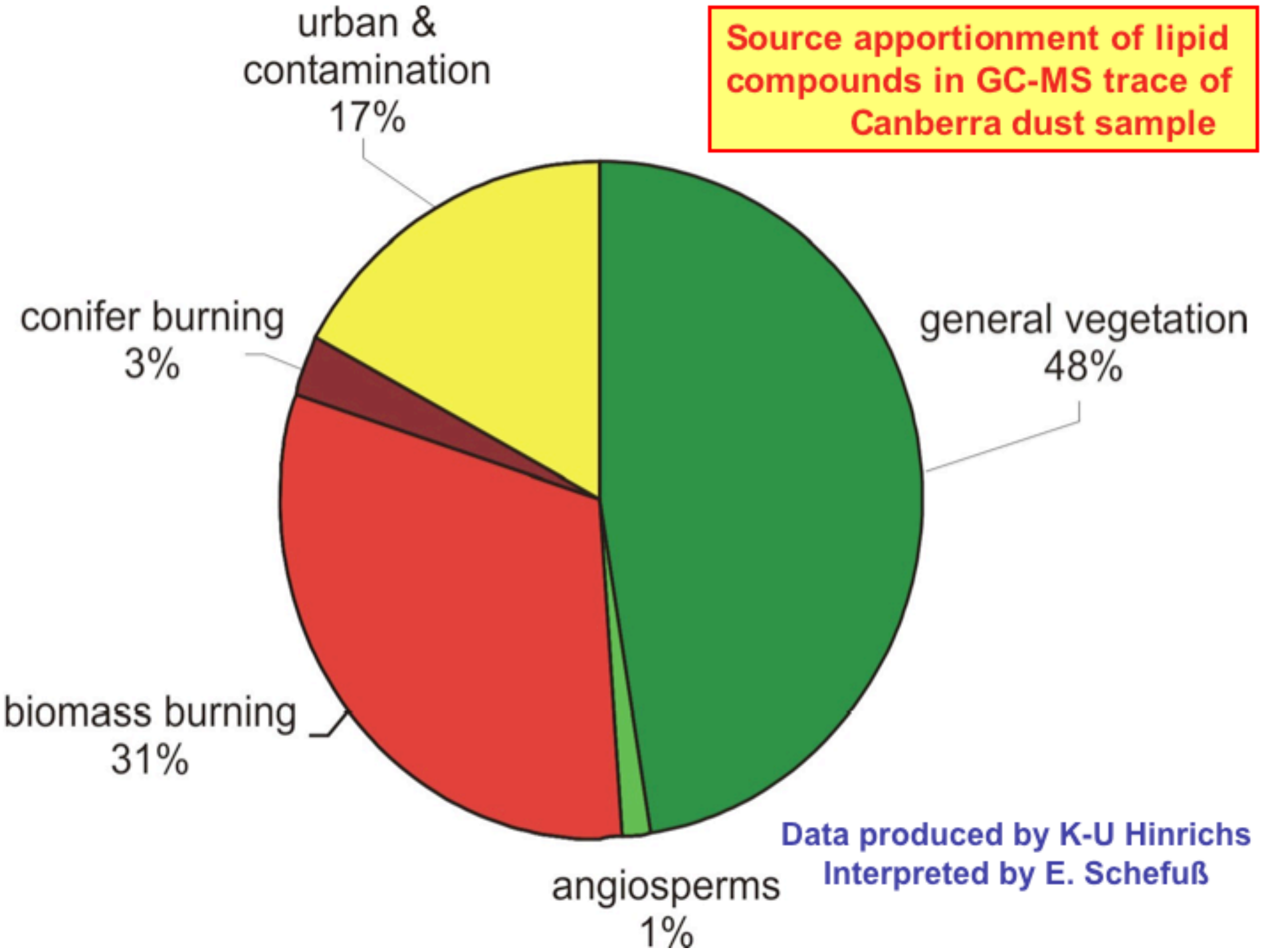

Proposed area of origin of the Canberra dust
138°
140°
142°
144°
146°
148°
150°
152°
-26°
-28°
-30°
-32°
-34°
-36°
-38°
MDB 25
MDB 26
MDB 27
MDB 28
MDB 10
Bourke
MDB 8
MDB 3
MDB 11
MDB 2
MDB 1
MDB 12
MDB 29
MDB 15
MDB 30
MDB 14
MDB 18
MDB 19
GVC 4
Canberra
MDB 23
MDB 20
MDB 21
MDB 24
MDB 22

Pollen counts for the Canbera dust

Produced by Dr Sander van der Kaars
Monash University



Potential pollen source area: **around BOURKE** with the following main vegetation types: open *Eucalyptus* woodland with a lower stratum of *Acacia* & *Callitris*; open mixed *Eucalyptus* & *Callitris* woodland +grasses


Source apportionment of lipid compounds in GC-MS trace of Canberra dust sample
urban & contamination 17%
conifer burning 3%
general vegetation 48%
biomass burning 31%
angiosperms 1%
Data produced by K-U Hinrichs
Interpreted by E. Schefuß

Dr Enno Schefuß' findings

The organic geochemical signature is predominantly determined by molecular markers for lipid contributions from **fresh plant biomass and biomass burning**.

The vegetation source of the directly emitted plant lipids as well as their thermal combustion products was likely **dominated by conifer trees (C_3 plants) with some angiosperms (flowering plants)** in low abundance.

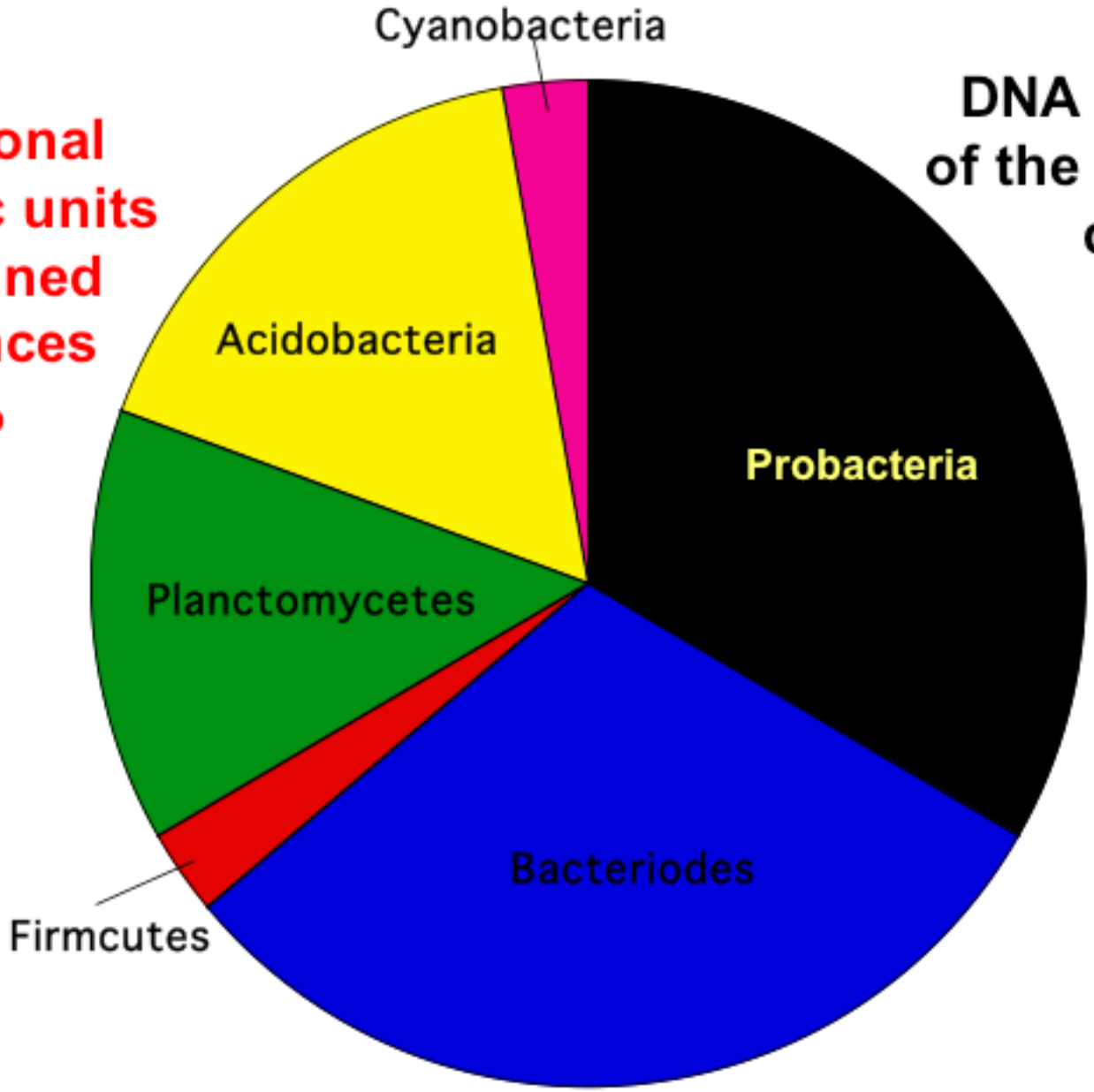
Professor K-U. Hinrichs' findings

Bacteria and fungi have also been detected.

In the unlikely event that the lipids are exclusively bacterial, the concentrations would correspond to **~2 * 10^{10} cells g $^{-1}$ dry dust.**

DNA analysis of the Canberra dust

39 operational taxonomic units were obtained by sequences with >97% similarity



Clones obtained by Raeid Abed

Many of the affiliates to cultured species recovered in the Canberra dust originate from soils and desert crusts, usually first isolated from areas far away from Australia

The Cyanobacteria clone is related to a bacterium known to be associated with corals [eg.black band disease]

Brain coral infected with black-band disease

bacterial slime

Taken from USGS web site

Another major dust event affected Sydney in Sept. 2009 as well as a large part of SE Australia,

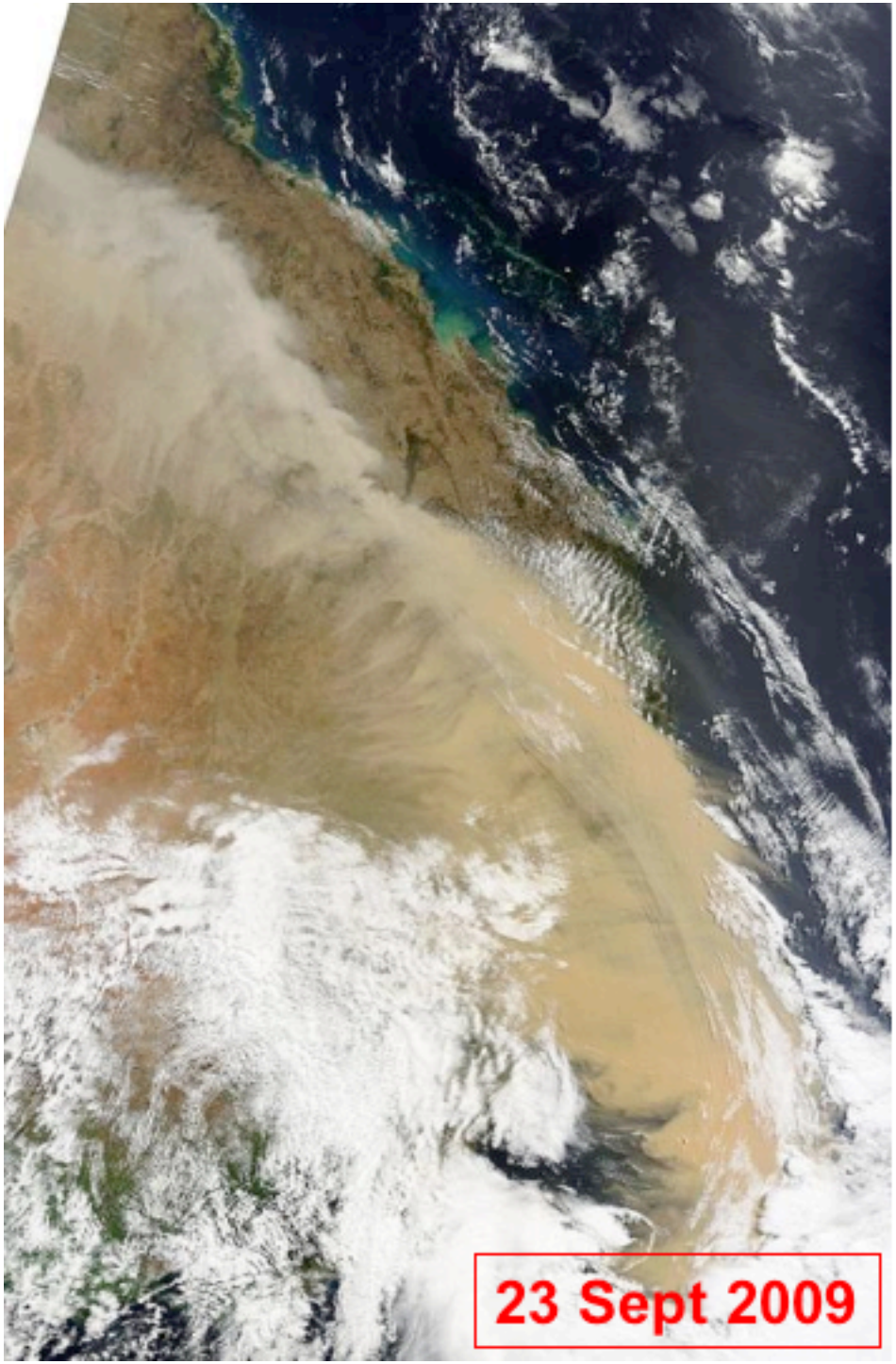
including Canberra during the night.

Our meteorological colleagues at Monash predicted the event, and that enabled us to sample the dust fallout efficiently

One example of our investigations relates to the microbial fingerprinting of the dust for comparison with dust from the Oct 2002 event

Also, geochemical analyses carried out by Dr M. Norman (ANU) showed that throughout the night, the chemical composition of the dust changed as the plume picked up new material along its course

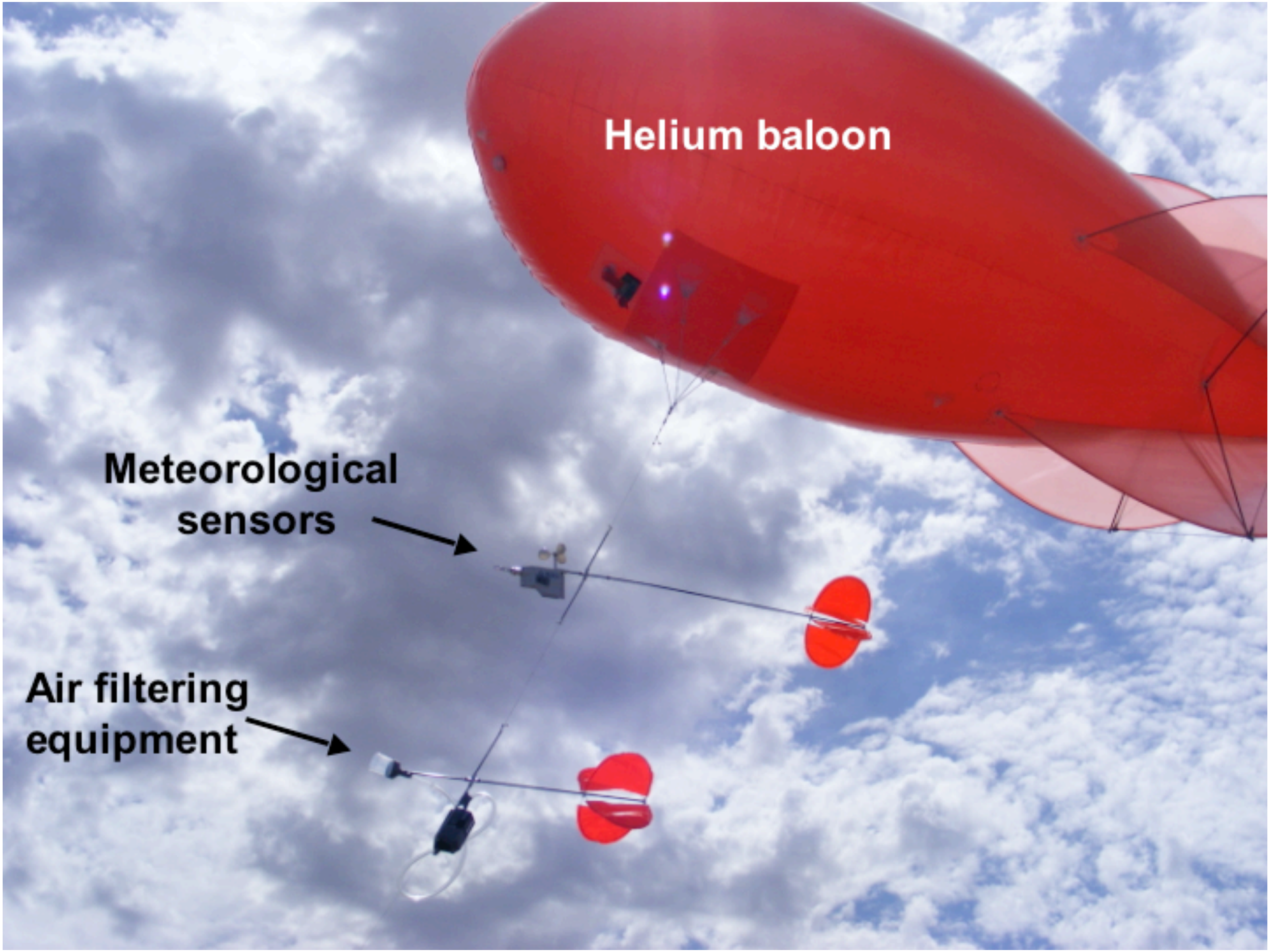
Red haze envelopes Sydney Harbour Bridge.
Amber Hooper available ABC web site

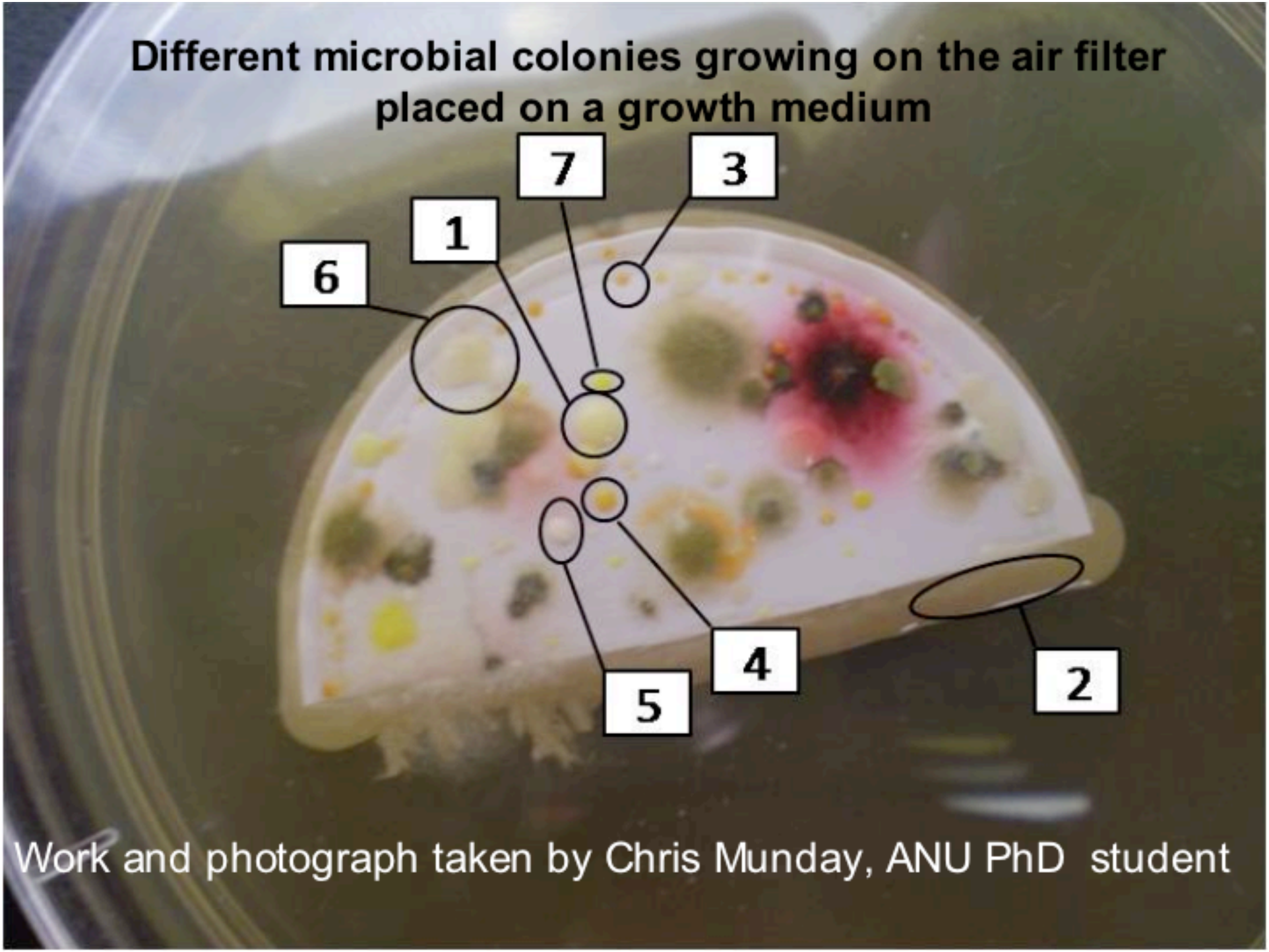


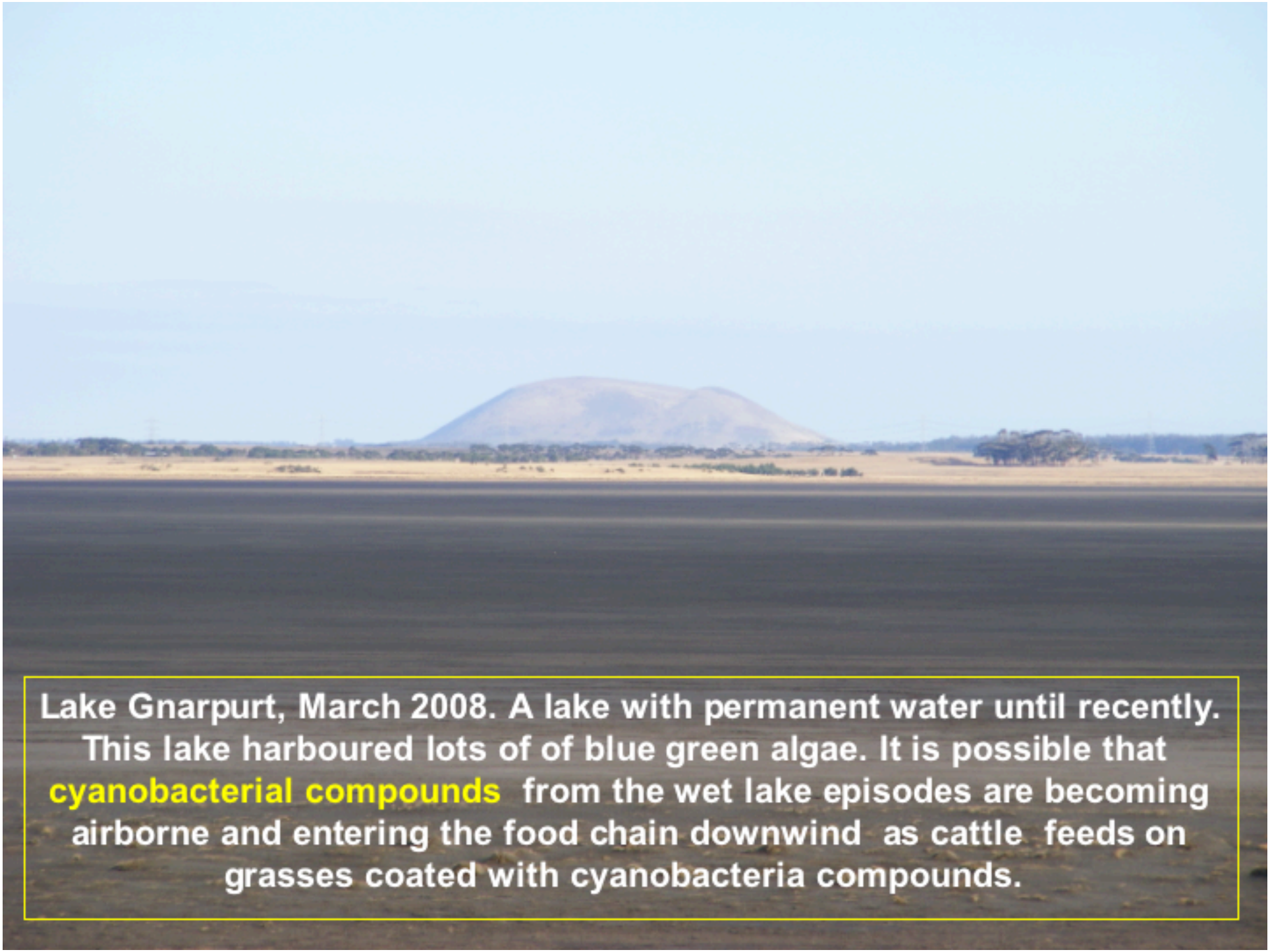
Courtyard of the Menindee motel, 4.15pm

Dishes placed at 2 hours interval

Current work with colleagues from Monash [meteorology] and ANU [microbiology]

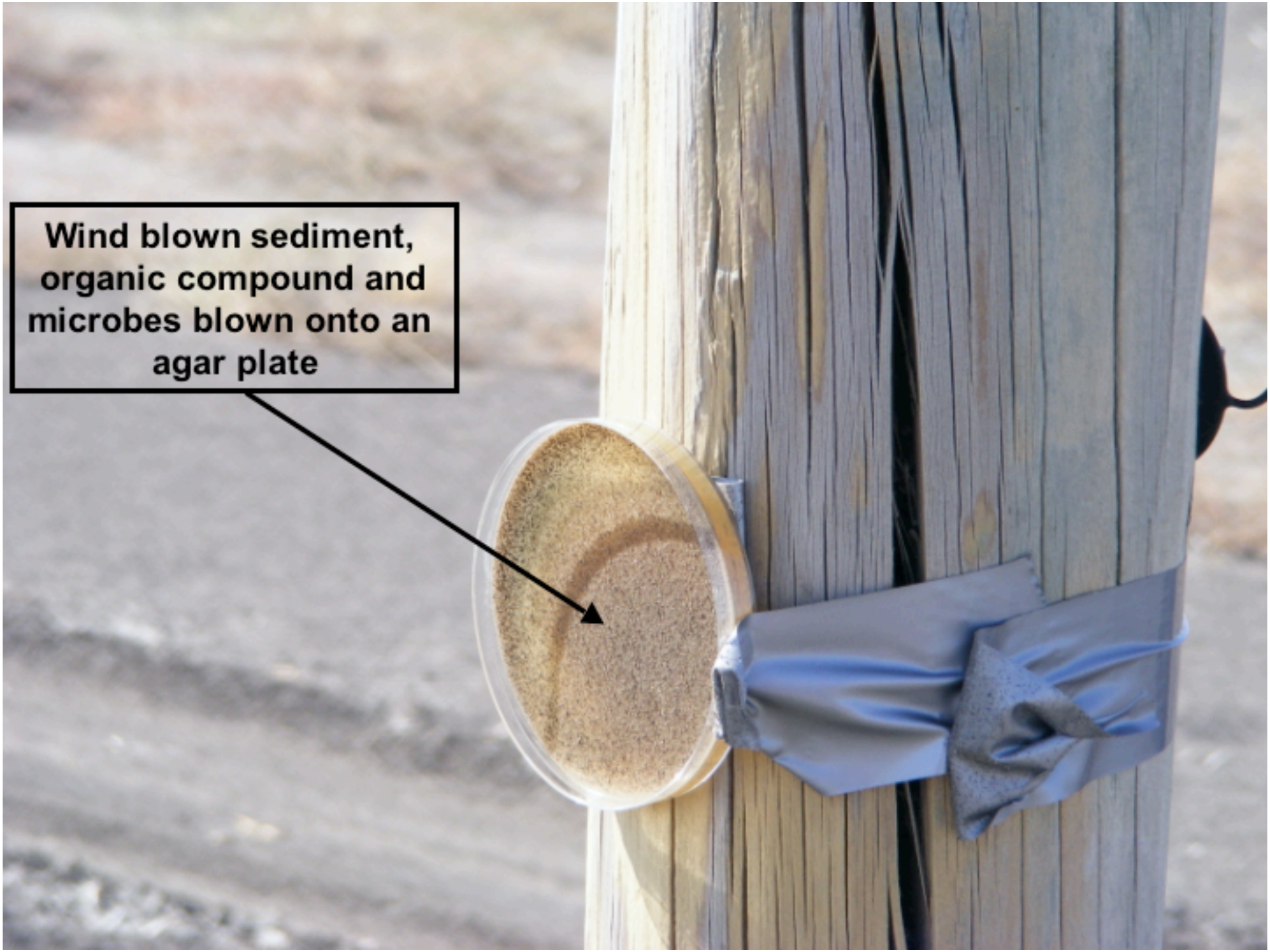

Helium baloon
Meteorological sensors
Air filtering equipment


Different microbial colonies growing on the air filter placed on a growth medium
7
3
1
6
4
5
2
Work and photograph taken by Chris Munday, ANU PhD student

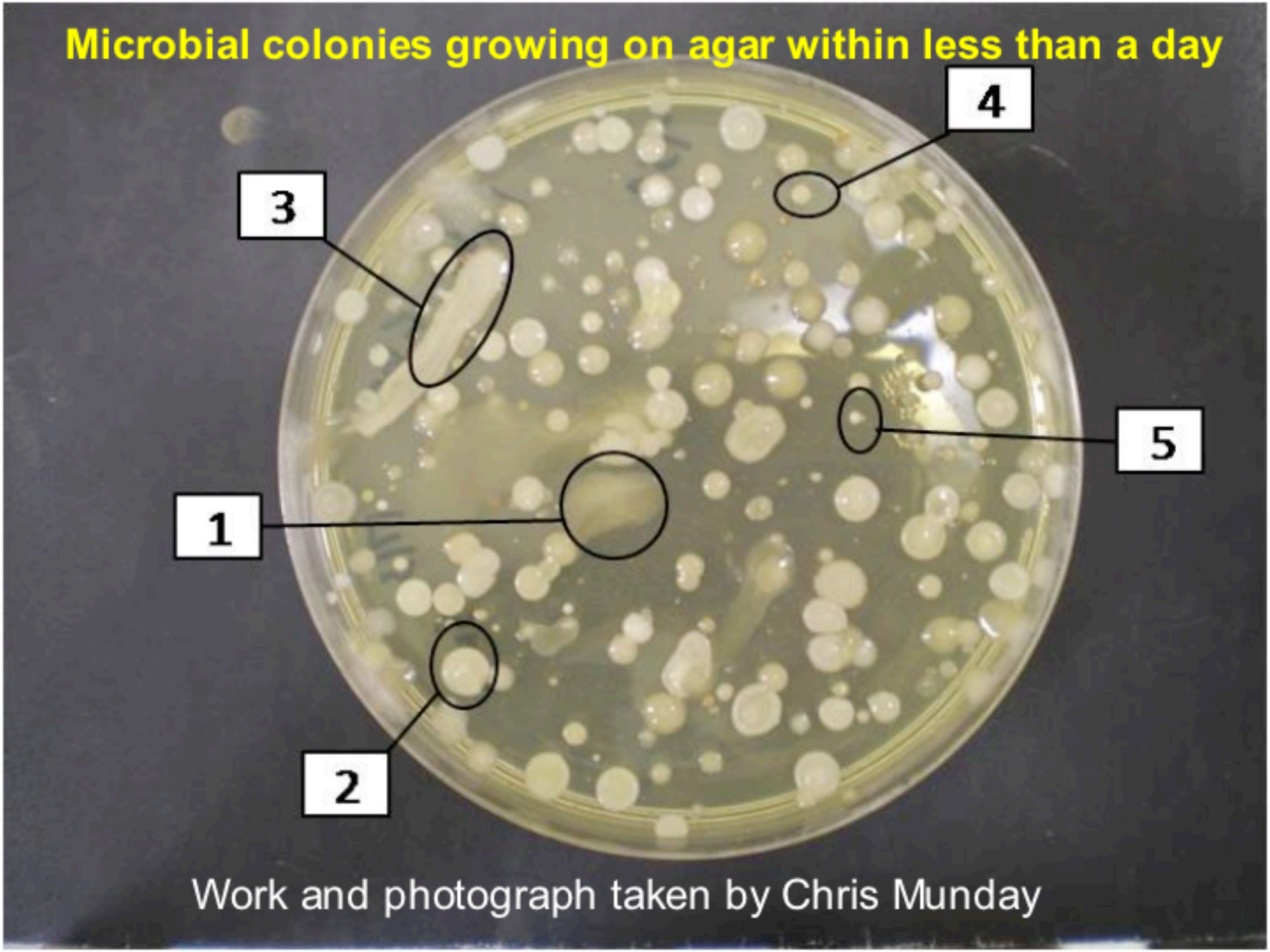

Lake Gnarpurt, March 2008. A lake with permanent water until recently. This lake harboured lots of of blue green algae. It is possible that cyanobacterial compounds from the wet lake episodes are becoming airborne and entering the food chain downwind as cattle feeds on grasses coated with cyanobacteria compounds.

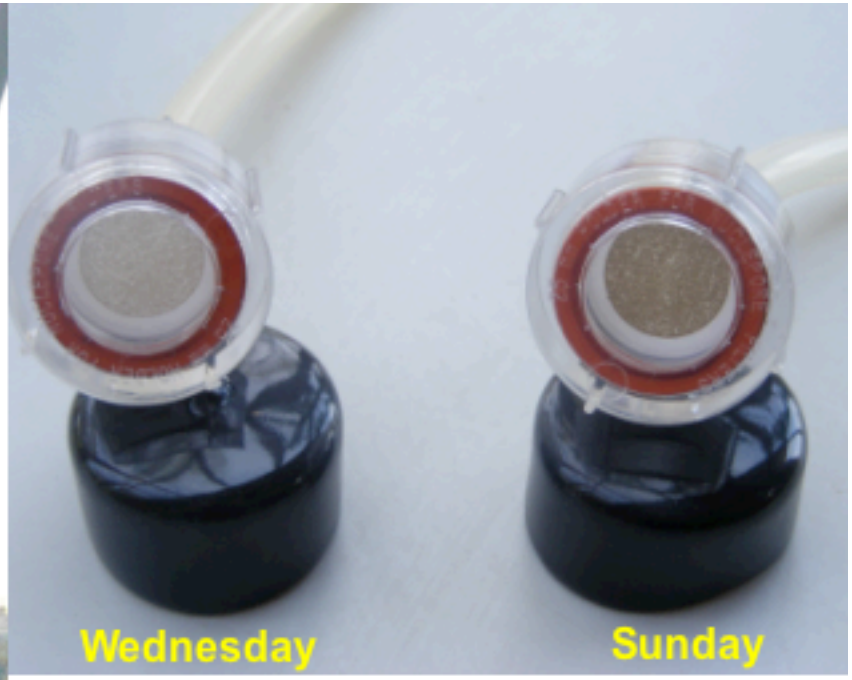
A few hours later on St Patrick's Day…. March 17th

Attempt at placing sampling equipment during the dust storm


Wind blown sediment, organic compound and microbes blown onto an agar plate

Sampling during the dust/deflation event


Microbial colonies growing on agar within less than a day
4
3
5
1
2
Work and photograph taken by Chris Munday



Twice-weekly, 24h

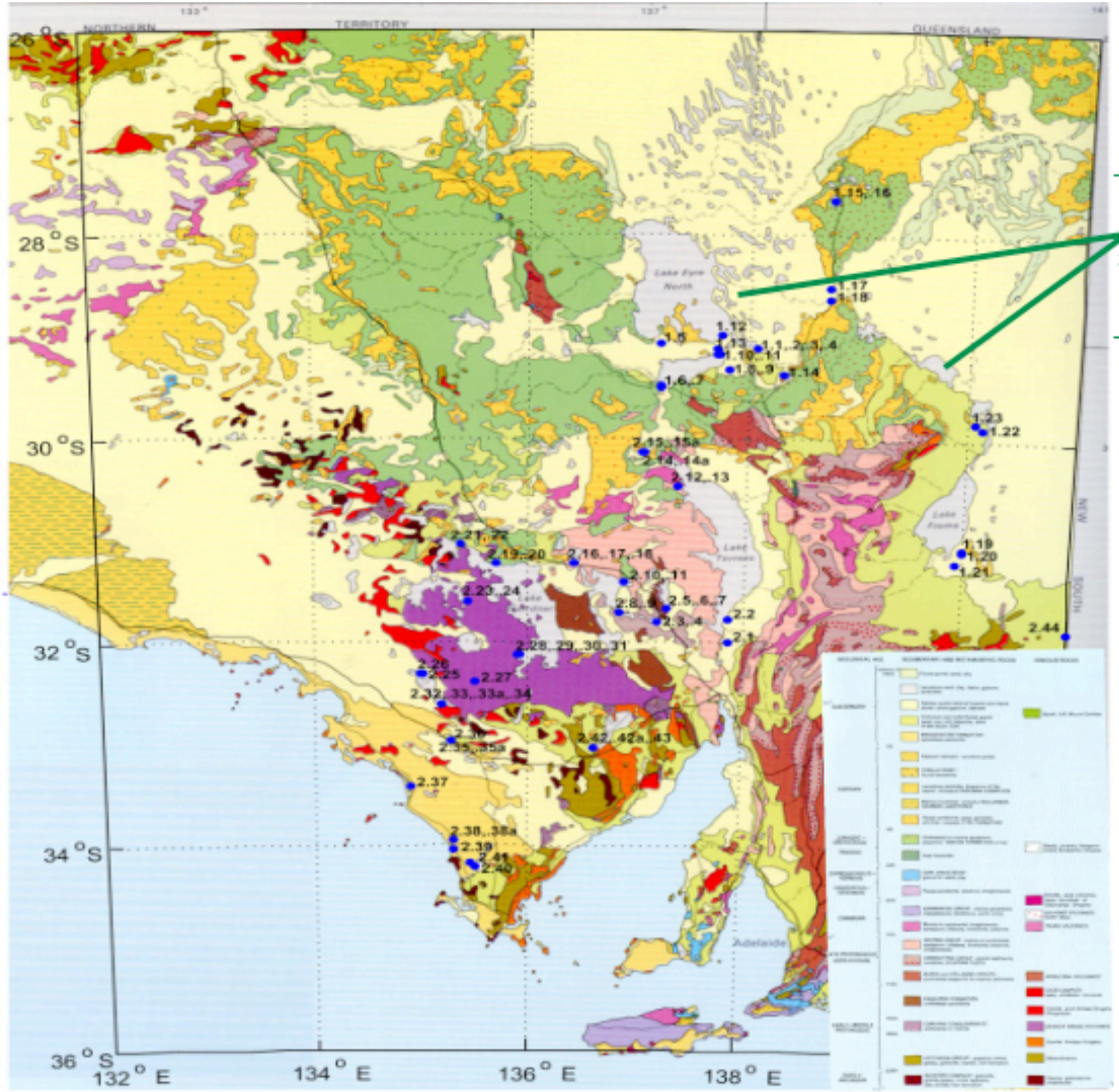
Air filtering at several locations in Australia

We are targeting:

- what is in the atmosphere,
- also dust sources, such as desert [microbial] desert crust,
- organic compounds in lake floors, mats and soils,
- geologies of different ages and geochemistries.

The eventual aim is to reconstruct what ends up in the ocean & determine the possible effects due to dust fall in the marine realm.

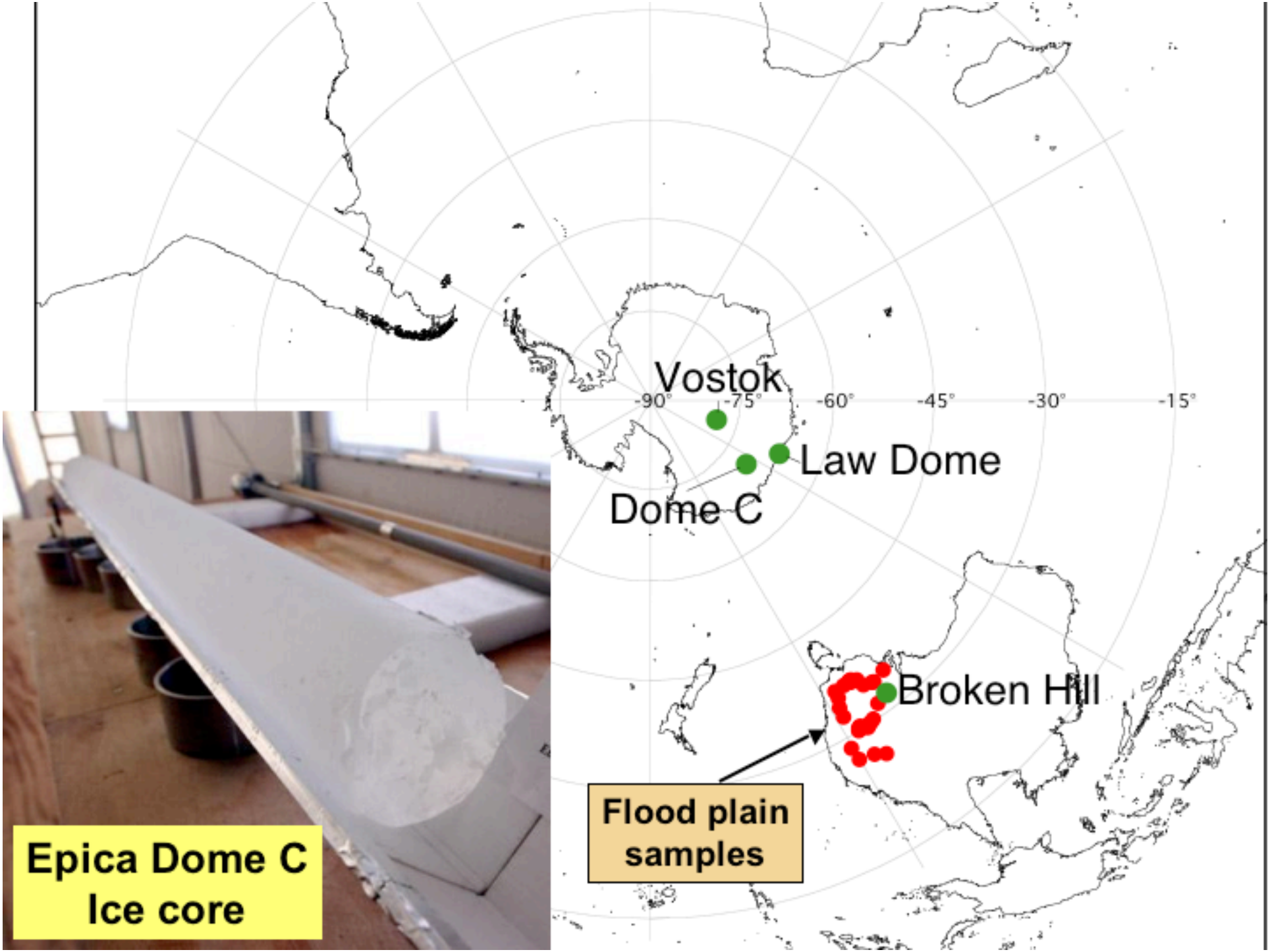
July 2009
Western
Australia
Lake Eyre
Basin
Darling R.
Central & W.
South Aust.
Murray R.

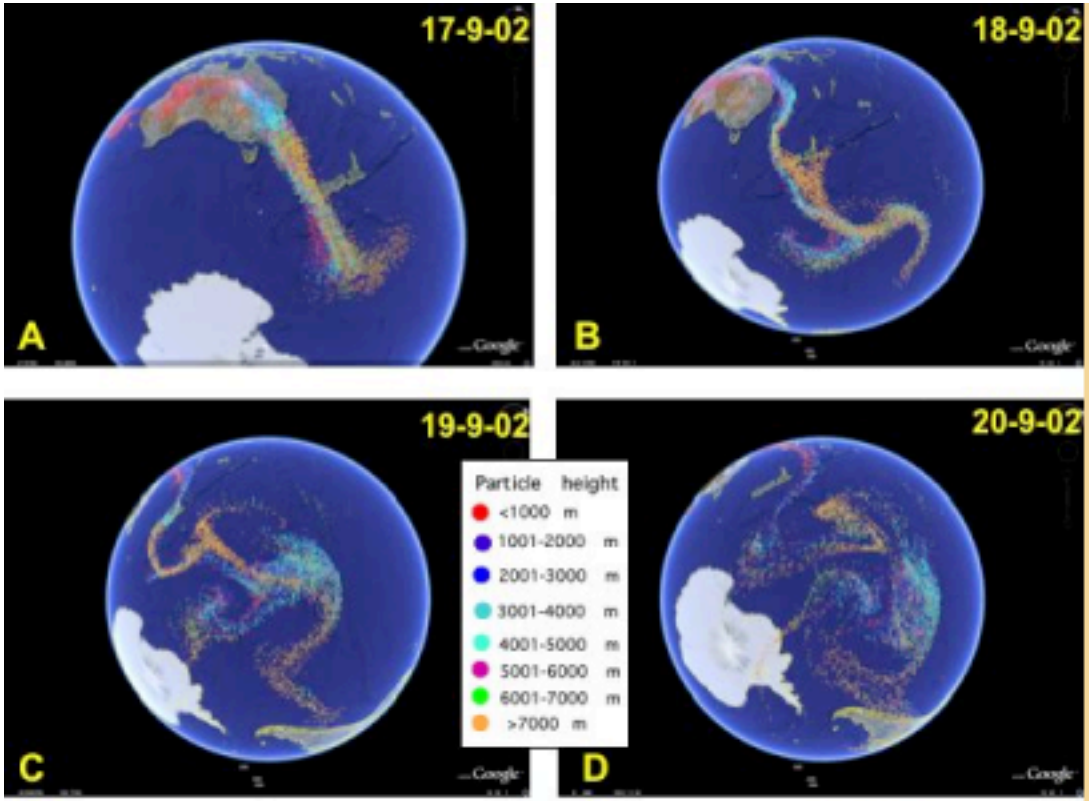


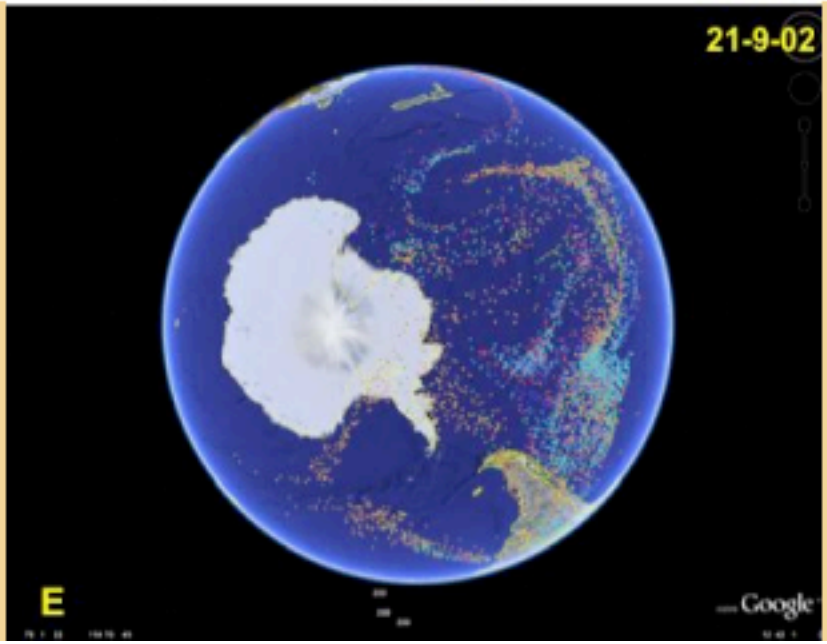
Tether balloon sampling planned for Sept. 2010

2007-8 sampling Stations.
In 2009, we sampled the NW coast of WA

Map prepared by M.Bausch


Vostok
-90°
-75°
-60°
-45°
-30°
-15°
Law Dome
Dome C
Broken Hill
Flood plain samples
Epica Dome C Ice core





Trajectory of an airmass at different altitudes showing an (and dust particles) can travel from Australia as far as Antarctica

Images prepared by A. Wain, BOM

Thank you