



# Airborne Measurements of Fluxes of CO<sub>2</sub> and Water Vapour over Sparse Vegetation in a Semi-Arid Region of Western Australia

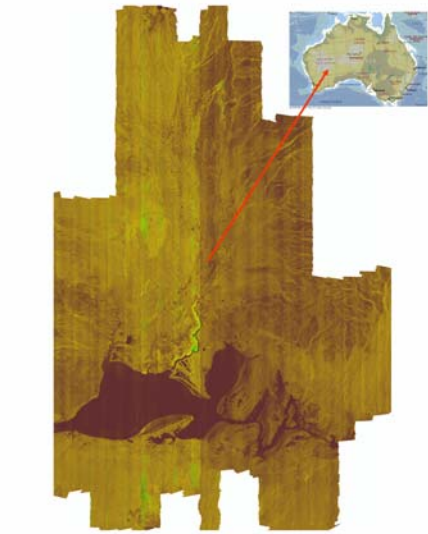


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NDVI image of central part of Sturt Meadows Station as composite from scans with the AWI/ARA Tri-spectral scanner flown on the Grob G109B aircraft. The dark area at the bottom of the image is Lake Raeside, a dry salt lake. The distance from the top to the bottom of the image is approximately 50km.

## The Project

Estimating the uptake of CO<sub>2</sub> by vegetation is one of the hottest topics in land-surface research. Budgets of CO<sub>2</sub> emissions and uptake are a very important factor in all Global Change considerations and many countries are conducting large scale comprehensive studies and monitoring programs to establish such budgets. A special aspect is the issue of 'Carbon Credits', which form an important part of the Kyoto Protocol, or in other words the question, what is the net amount of CO<sub>2</sub> that a nation emits and how is this balanced by the CO<sub>2</sub> uptake in this country, or by activities within the country. Many human activities emit CO<sub>2</sub>, but there are only a limited number of processes which remove CO<sub>2</sub> from the atmosphere.

One option for considerable CO<sub>2</sub> uptake would be planting of trees on a large scale. Australia has vast areas which could potentially be used for such plantations. Yet, as most of these areas are either arid or semi-arid landscapes, it might be difficult to maintain such plantations.

To study the options for planting trees in semi-arid regions, a large-scale and long-term research project field observation program is being undertaken (funded nearly exclusively by the Japan Science and Technology Agency) on Sturt Meadows Station near Leonora/WA. The project studies all aspects of tree planting using engineering, hydrological, soil science, plant physiological and atmospheric sciences methods. A number of dedicated plots of trees were established and are being monitored, as well as plots of native trees.

One of the crucial parameters to be measured in the project obviously is the uptake of CO<sub>2</sub> by these plots of trees under the various conditions. This is a major challenge and a number of different approaches are being assessed, such as flux towers and airborne methods. ARA and Flinders University with their capabilities of airborne flux measurements were the obvious partners for the airborne measurements. In 2002 and 2003, three measurement campaigns were carried out using the ARA Grob G109B research aircraft equipped with a comprehensive suite of in-situ sensors and remote sensing systems.

The project has mainly been funded by the Japan Science and Technology Corporation and a small contribution from the Australian Research Council.



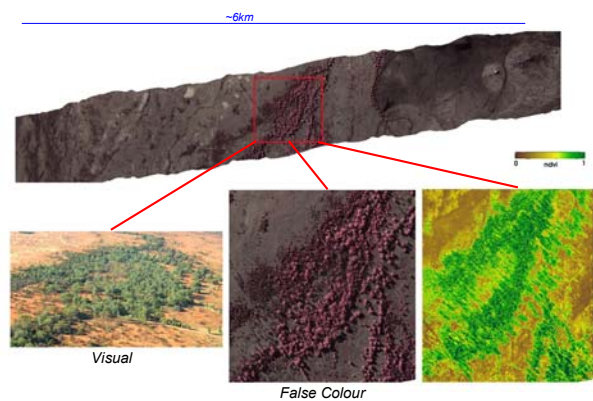
The airborne flux measurements focused on two areas:

- (1) A stand of tall Eucalyptus trees along a creek bed; and
- (2) One of the plantations, called "Site C".

Series of 6km-long transects were flown at ~15-20m above the surface.

## Doyle Creek – Tall Eucalyptus

## Site C - Plantation

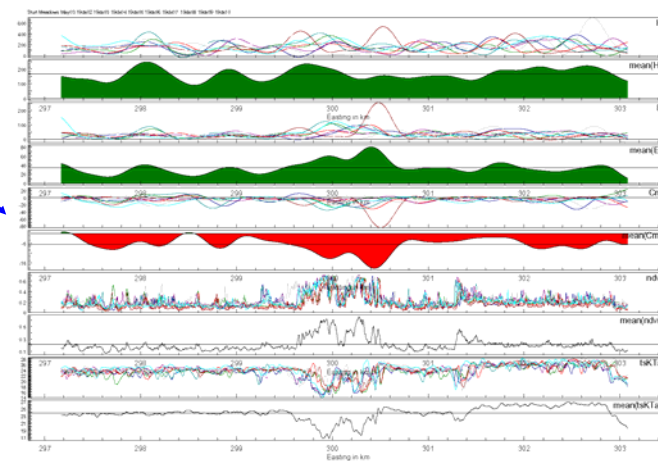
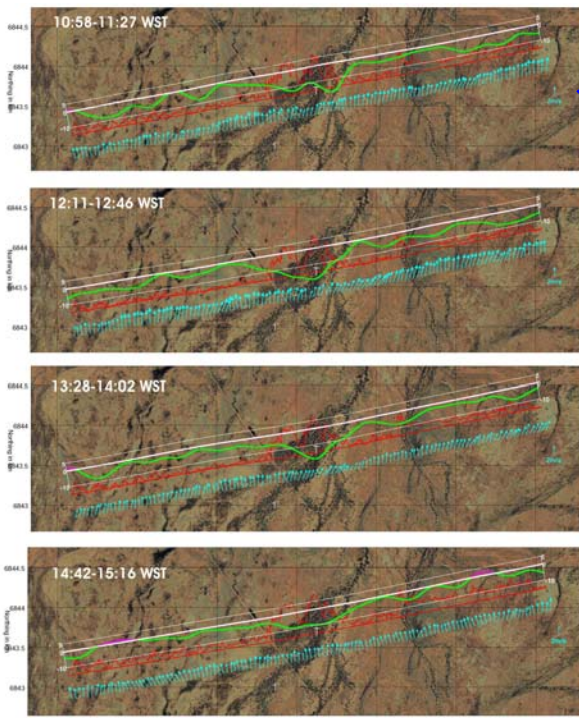
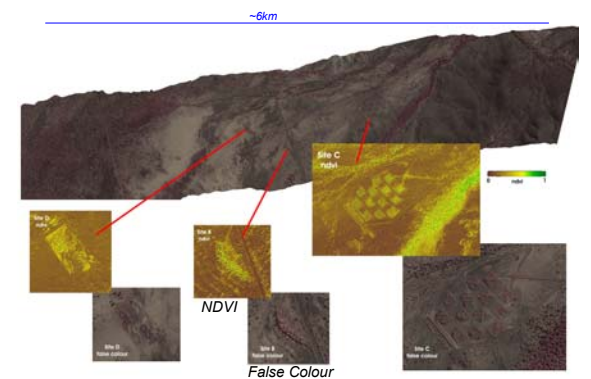


| Time (WST)    | H (W/m <sup>2</sup> ) | E (W/m <sup>2</sup> ) | C <sub>co2</sub> (μmol/m <sup>2</sup> /s) | T <sub>sp</sub> (°C) |
|---------------|-----------------------|-----------------------|---|----------------------|
| 10:58 – 11:27 | 169                   | 36                    | -6.0                                      | 23.7                 |
| 12:11 – 12:46 | 190                   | 51                    | -6.1                                      | 26.2                 |
| 13:28 – 14:02 | 148                   | 51                    | -5.5                                      | 25.9                 |
| 14:42 – 15:16 | 98                    | 26                    | -3.2                                      | 22.9                 |

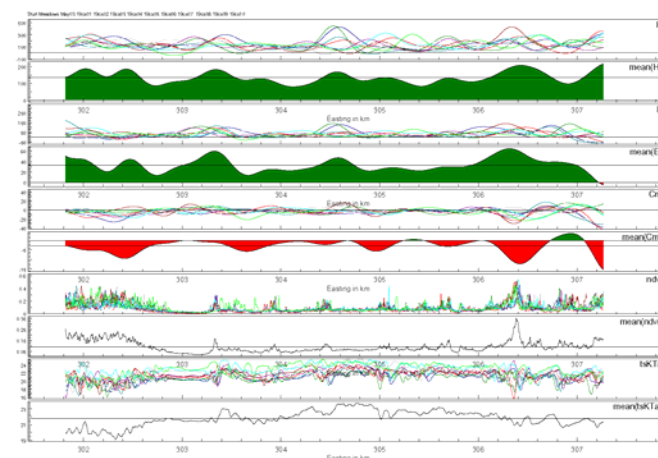
| Time (WST)    | H (W/m <sup>2</sup> ) | E (W/m <sup>2</sup> ) | C <sub>co2</sub> (μmol/m <sup>2</sup> /s) | T <sub>sp</sub> (°C) |
|---------------|-----------------------|-----------------------|---|----------------------|
| 10:13 – 10:44 | 133                   | 33                    | -3.1                                      | 22.0                 |
| 11:35 – 12:07 | 170                   | 41                    | -3.6                                      | 26.6                 |
| 12:50 – 13:23 | 159                   | 45                    | -3.3                                      | 28.2                 |
| 14:06 – 14:38 | 132                   | 30                    | -3.0                                      | 26.5                 |

| Time (WST)    | H (W/m <sup>2</sup> ) | E (W/m <sup>2</sup> ) | C <sub>co2</sub> (μmol/m <sup>2</sup> /s) | T <sub>sp</sub> (°C) |
|---------------|-----------------------|-----------------------|---|----------------------|
| 10:58 – 11:27 | 144                   | 64                    | -13.7                                     | 22.1                 |
| 12:11 – 12:46 | 186                   | 127                   | -13.7                                     | 24.1                 |
| 13:28 – 14:02 | 116                   | 94                    | -14.1                                     | 23.2                 |
| 14:42 – 15:16 | 64                    | 34                    | -8.9                                      | 20.6                 |

Averages of sensible (H) and latent (E) heat fluxes and CO<sub>2</sub> fluxes; and surface temperature (T<sub>sp</sub>). Top left: Doyle Creek transect; Bottom left: area of tall Eucalyptus trees at Doyle Creek transect only; Above: Site C transect.

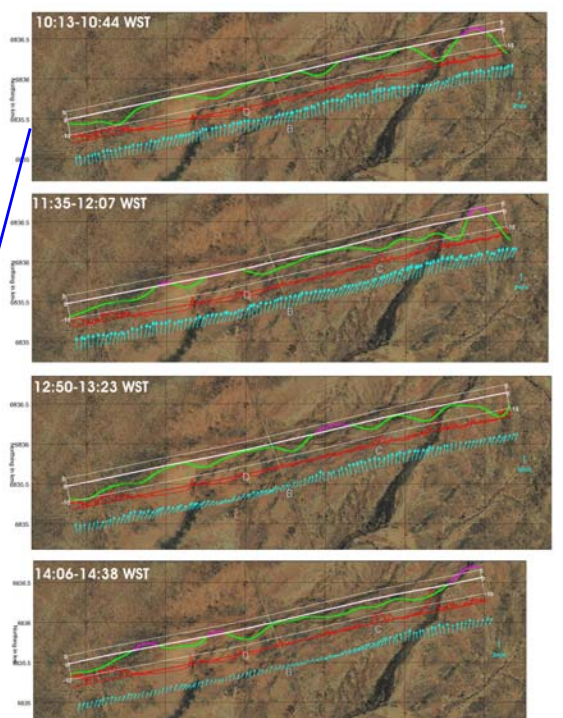


Space series of various parameters for single traverses (top: Doyle Creek; bottom: Site C transect). Parameters shown (top to bottom): sensible heat flux H; ensemble-averaged H; latent heat flux E; ensemble-averaged E; CO<sub>2</sub> flux; 500m ensemble-averaged CO<sub>2</sub> flux; ndvi; ensemble-averaged ndvi; surface temperature T<sub>sp</sub>; ensemble-averaged T<sub>sp</sub>. All fluxes are averages over 500m. Note the high variability of the fluxes.



CO<sub>2</sub> fluxes in μmol/m<sup>2</sup>/s and related parameters along Doyle Creek transect for four time periods on 19 May 2003. Data are averages over approximately 10 individual runs. Fluxes are averages over 500m. Negative (downward) fluxes are shown in green, positive (upward) fluxes in purple. Flight track is shown in red, ndvi is shown in red on an arbitrary scale. Horizontal wind vectors are shown in light blue; the scaling arrow on the right shows a 2m/s southerly wind. Scale for the CO<sub>2</sub> fluxes are indicated by the grid shown in white.

Note the marked downward fluxes over the tall trees along Doyle Creek and the slightly enhanced downward fluxes over the areas of denser vegetation.



CO<sub>2</sub> fluxes in μmol/m<sup>2</sup>/s and related parameters along Site C transect for four time periods on 19 May 2003. Data are displayed as for Doyle Creek transect. Note that there is only a very "loose" relationship between ndvi and the fluxes. The signature from the trees at Site C is nearly totally masked by the vegetation along the small creek to the south of the Site. Enhanced downward fluxes are visible over the denser vegetation at the western end of the transect.



Sturt Meadows Station



Some members of the team



Sometimes it was cold



And it even rained



But we also rested



And what would life be without a BBQ...



...at the end of the day