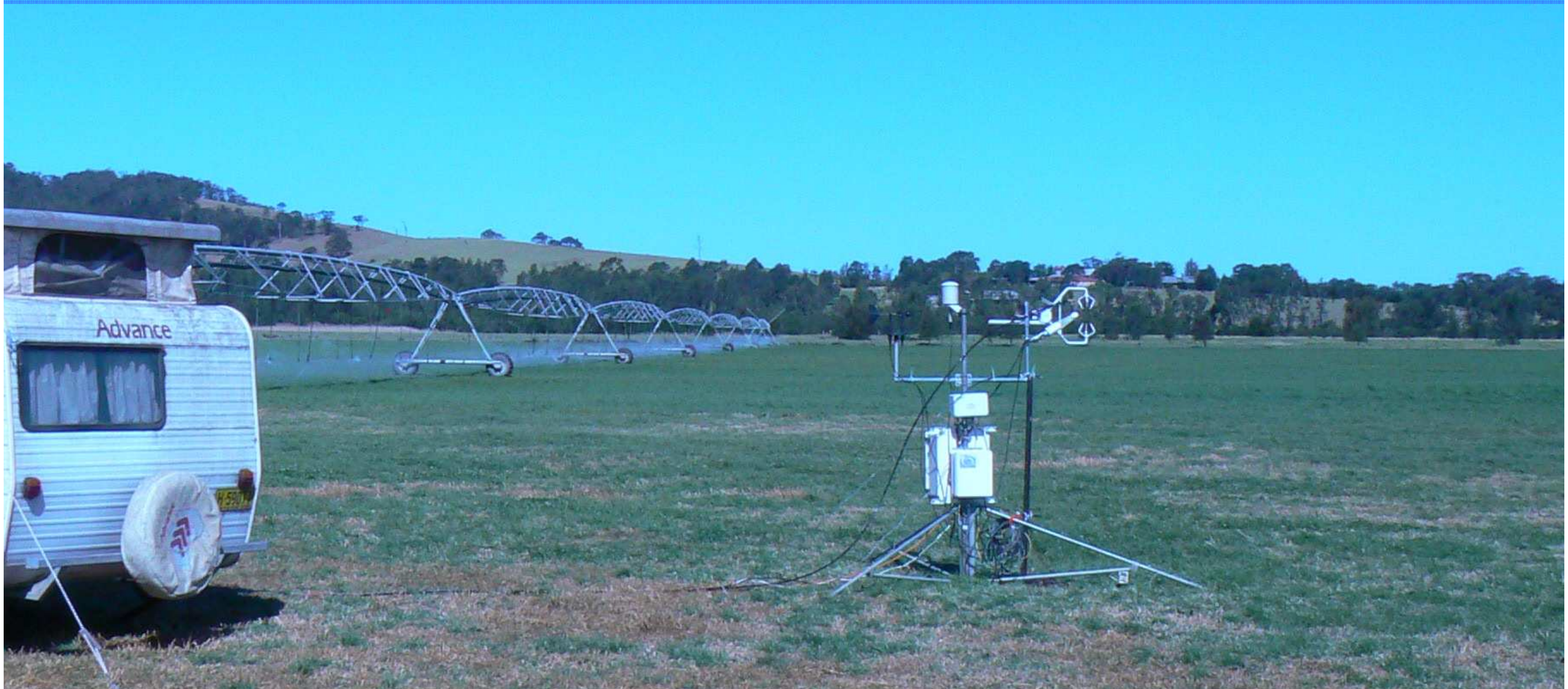
The development of a disjunct eddy accumulation system for the determination of ecosystem level fluxes of CO_2, CH_4 and N_2O



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Bachelor of Science (Chemistry)
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Outline of Honours Project

Two Phases:

1. Development of a Disjunct Eddy Accumulation (DEA) system for the measurement of greenhouse gas fluxes.

2. Deployment in the field for evaluation of:
   - The DEA system
   - Greenhouse gas fluxes

Outline of Presentation

1. Greenhouse Gas Fluxes

   Note on the importance of CO_2, CH_4 & N_2O fluxes.

2. Flux Measurement Techniques

   Micrometeorological techniques, Disjunct Eddy Accumulation (DEA), development of DEA system, implementation of technique.

3. Results

   Measured fluxes, verification of the DEA technique

4. Conclusions and Future Directions

1. Greenhouse Gas Flux Estimation

- Currently there are large uncertainties in the source and sink estimates for greenhouse gases

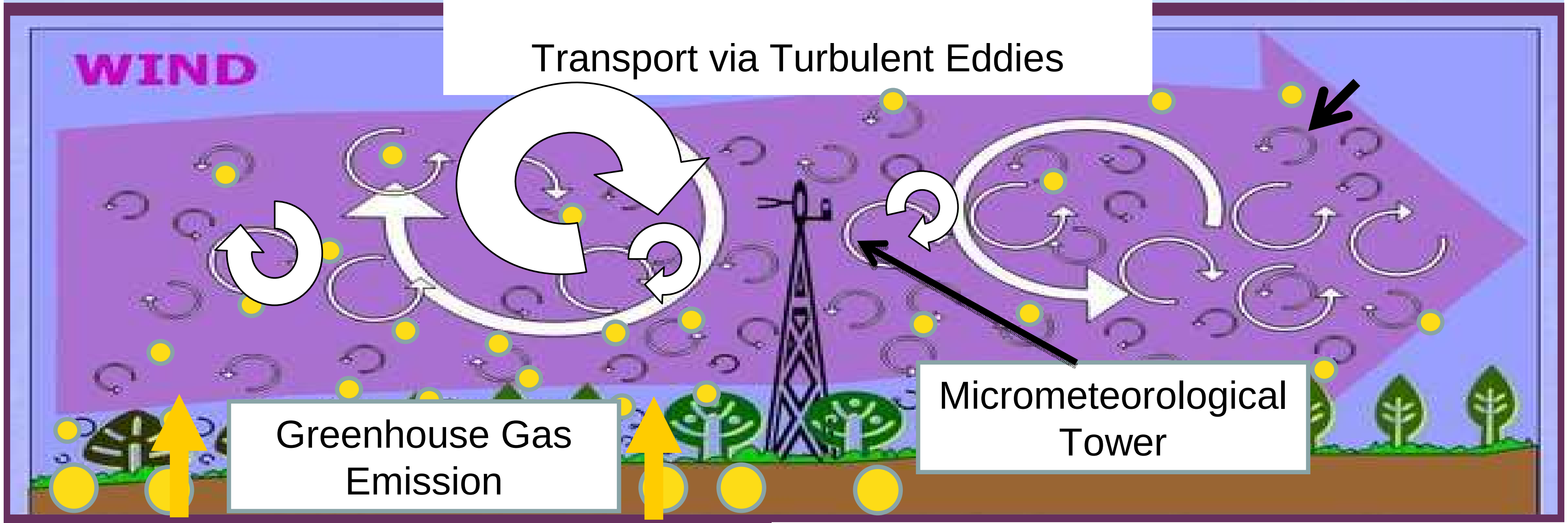
Table: Sources, Sinks and Atmospheric Budgets of CH_4 ($Tg(CH_4)yr^{-1}$)

References	Wuebbles and Hayhoe, 2002	J. Wang et al., 2004	Mikaloff Fletcher et al., 2004a
Natural Sources	145	200	260
Anthropogenic Sources	358	307	350
Total Sources	503	507	610
Total Sinks	515	492	577
Imbalance	-12	+15	+33

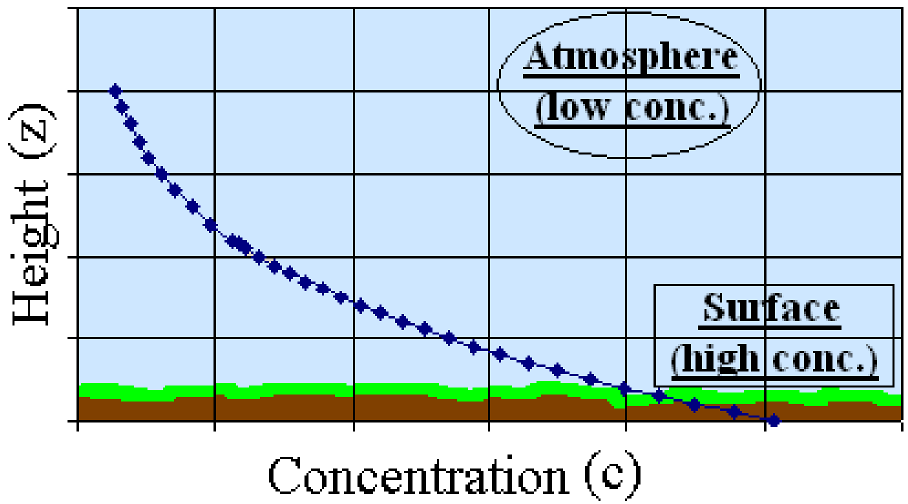
- Compared to measured 0.6 Tg (CH_4) yr-1 average annual increase, 2000-2005 (IPCC, 2007).
- Desirable to obtain more accurate greenhouse gas flux estimates in order to:
  - provide better data for modelling
  - decrease the uncertainty in source sink estimates
  - allow for more effective mitigation strategies.

IPCC, 2007

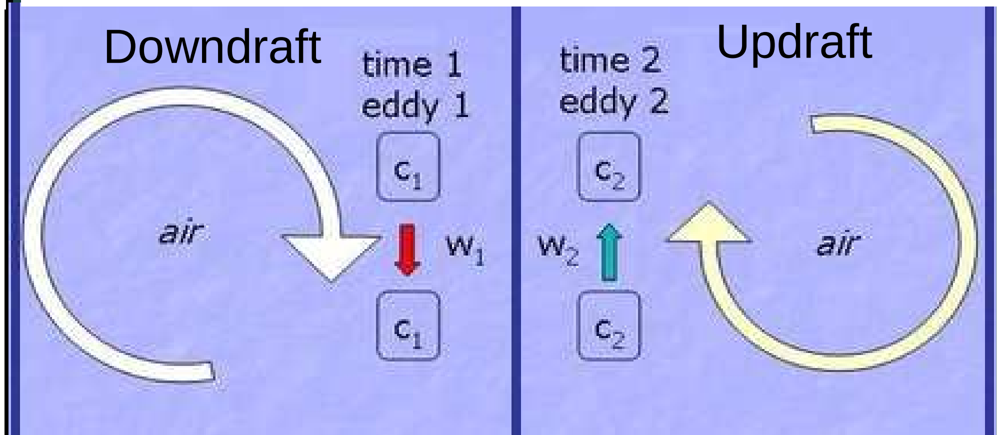
2. Principles of Micrometeorological Flux Measurement Techniques



Concentration Profile (Emission)



Concentration in Eddies (Emission)



Note: Updraft conc. > Downdraft conc.

2. Disjunct Eddy Accumulation (DEA)

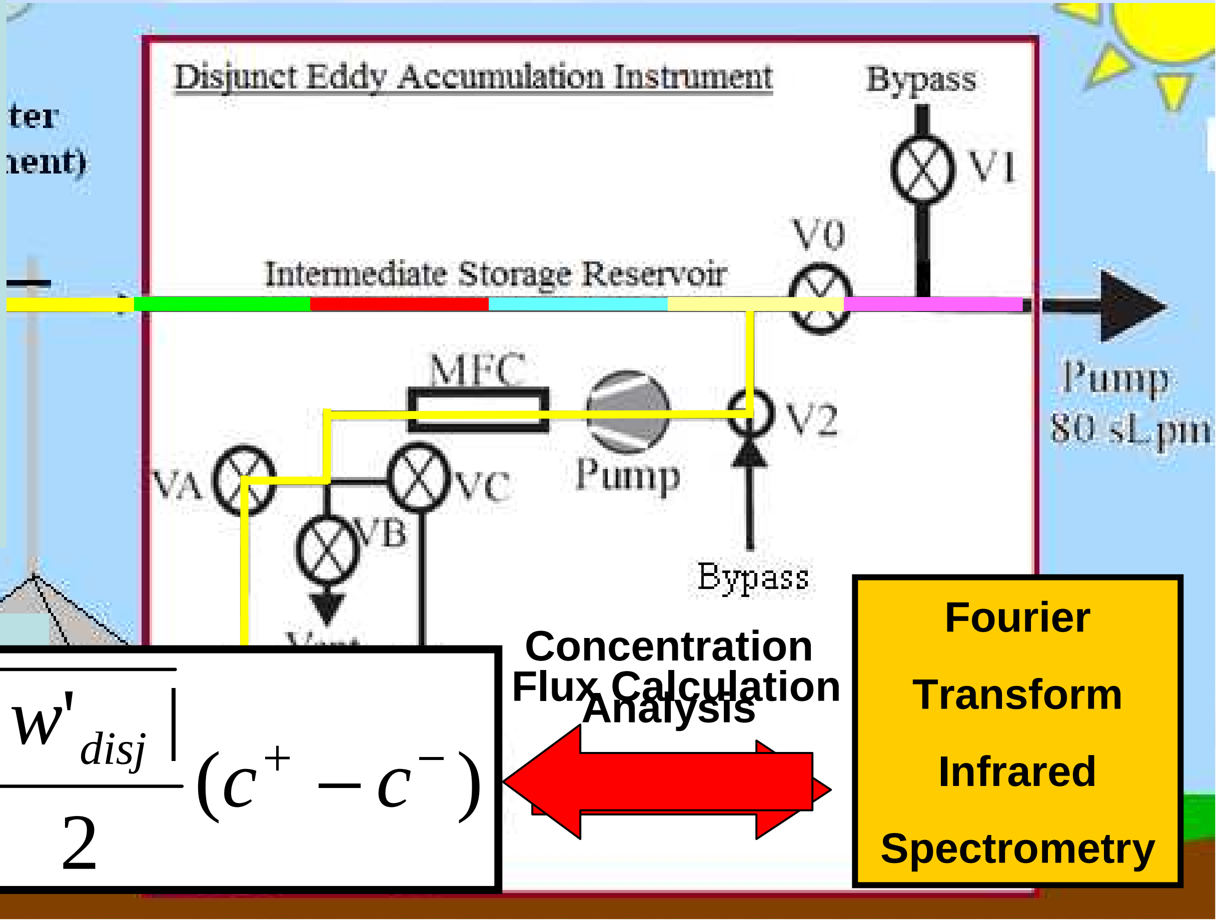
- DEA - innovative technique with potential to provide simultaneous measurement of CO_2, CH_4 and N_2O fluxes.
- ‘Disjunct sampling’ – samples are taken periodically from a continuous data series; expect a similar result but larger statistical uncertainty.
- Further experimental verification of the technique is required (Turnipseed et al., 2009)

Benefits of Disjunct Eddy Accumulation

- **Non-intrusive** technique
- **Slow response analytical sensor capability** – allows for analysis of **CO_2, CH_4 & N_2O**
- **Long-term** measurement capabilities e.g. full growing or seasonal cycle
- **Large spatial resolution** e.g. paddock/ecosystem scale

Principles of The DEA Technique

1. Measure the instantaneous vertical wind velocity (w') of air sample (~0.1s) to be captured.
2. Quickly capture the sample of air
3. Quantitatively transfer a volume of the sample into an updraft or downdraft reservoir, (volume proportional to the measured w').
4. Disjunct s… every 12s, Acc… over 30mi…



$$Flux = \frac{\overline{|w'_{disj}|}}{2}(c^{+} - c^{-})$$

Development of DEA system

1. DEA manifold

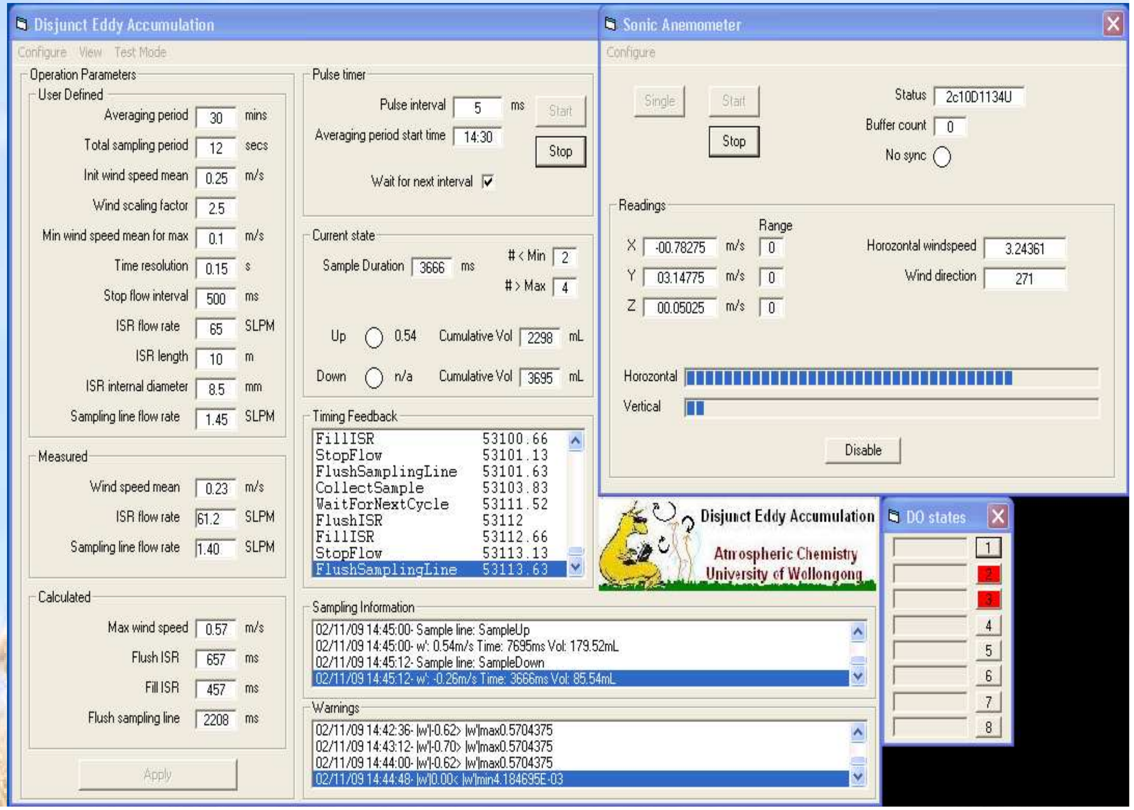
- Hardware: valves, flow meters, main line and sampling line, bypasses

Technical Assistance: Martin Riggenbach

Development of DEA system

2. DEA program

- Controlled valve timing to carry out sampling based on the instantaneous vertical wind velocity (w')
- Retrieved w' measurements from sonic anemometer (20Hz)
- Logged data e.g. $\overline{|w'_{disj}|}$
- Technical assistance by Graham Kettlewell

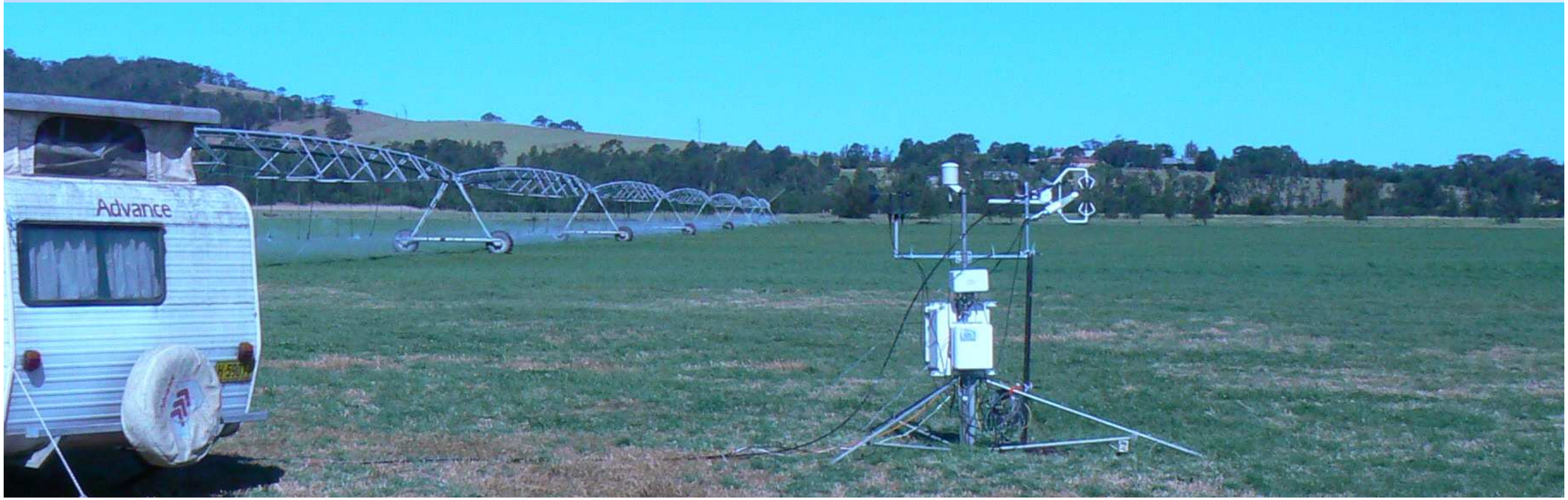


Field Setup

- Circular grass paddock 1km in diameter
- Location: Shoalhaven Starches Environmental Farm, near Nowra
- Measurement Period – 28th August onwards

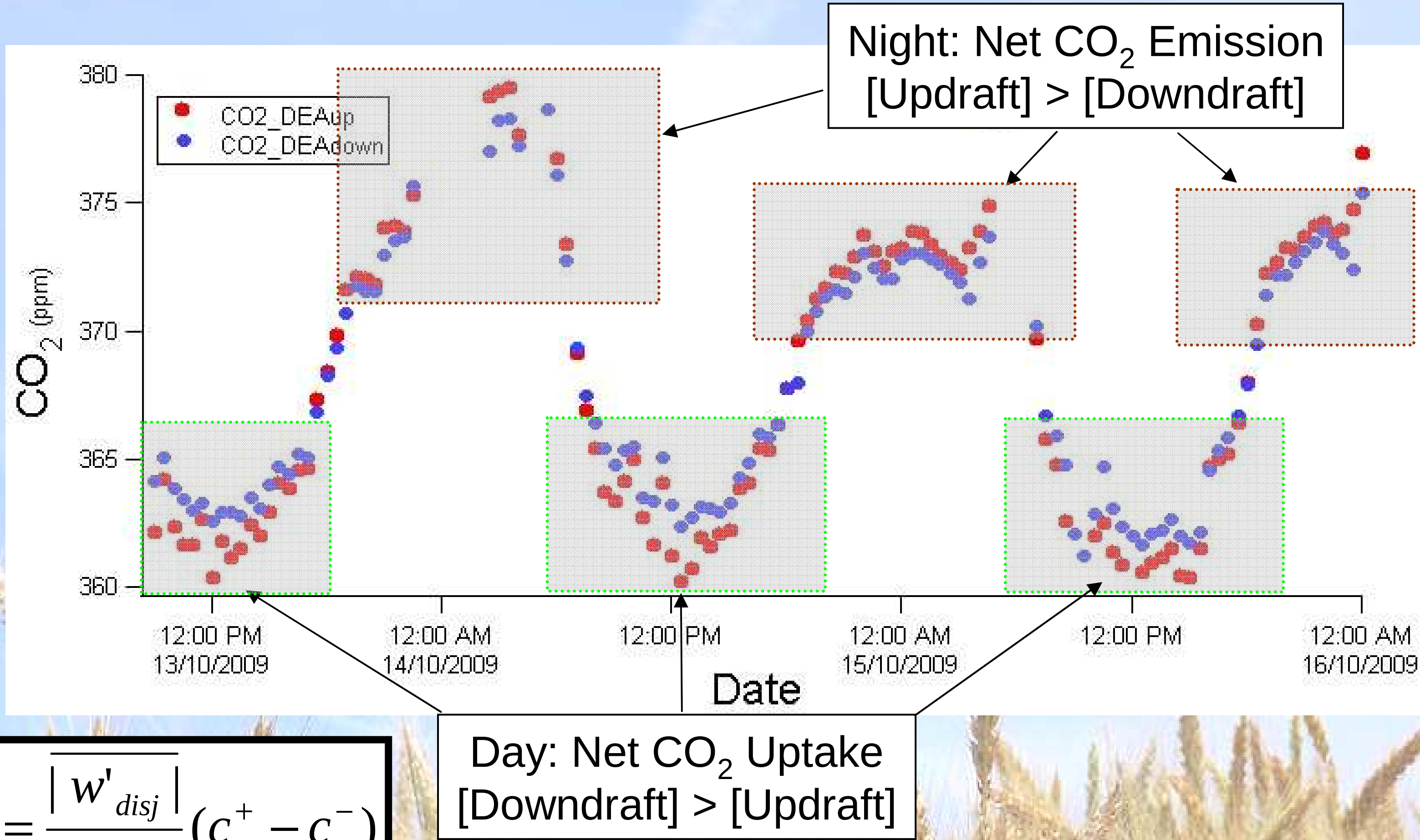
<u>Two flux measurement techniques:</u>

1. Eddy Covariance – Used for experimental verification DEA
2. Disjunct Eddy Accumulation



3. Results – Raw CO_2 Data

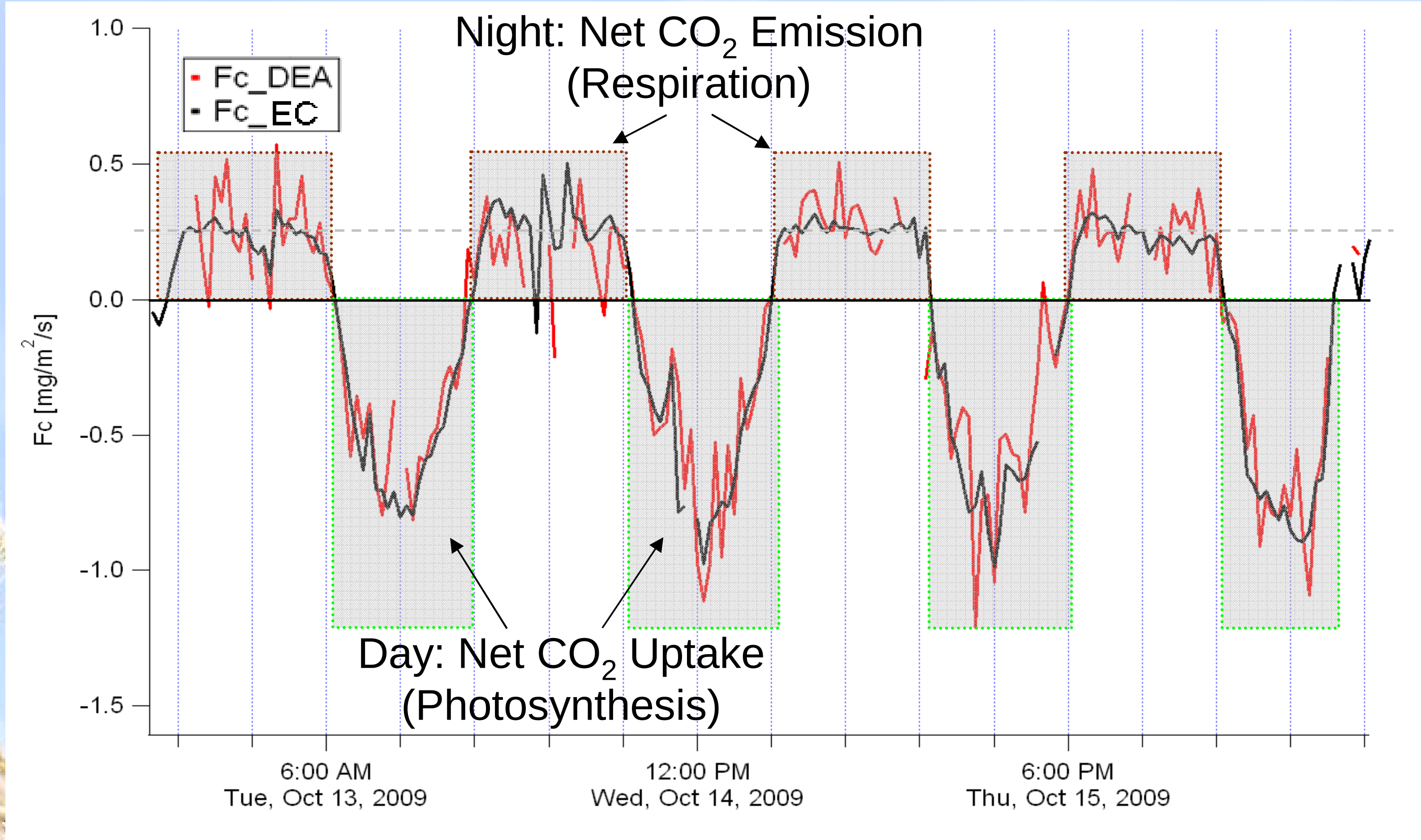
- Reservoir CO_2 concentrations measured by the DEA technique (13th – 16th of October).



$$Flux = \frac{\overline{|w'_{disj}|}}{2}(c^{+} - c^{-})$$

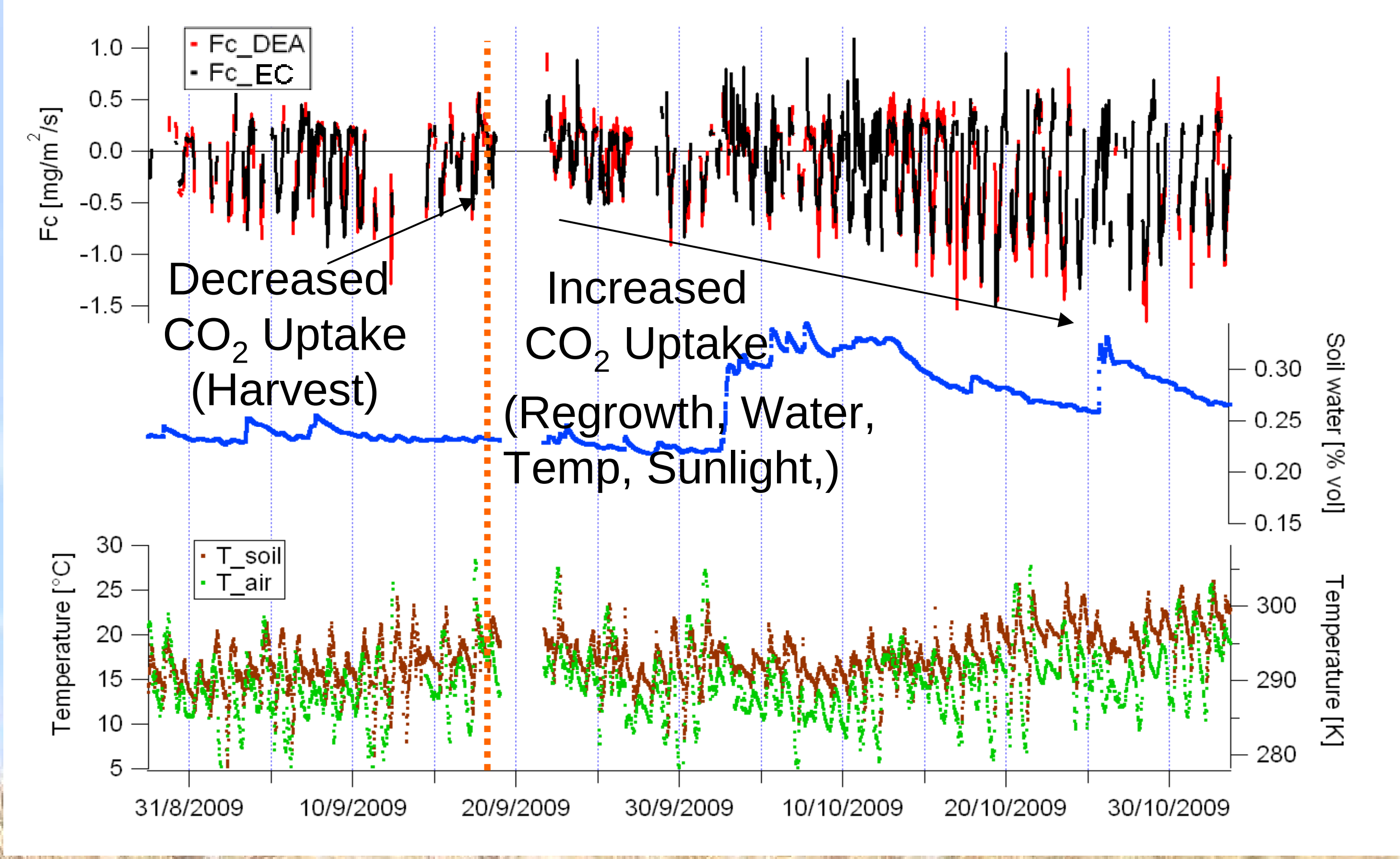
Results – CO_2 Flux

- CO_2 fluxes measured by the DEA and EC techniques (12th – 16th of October).



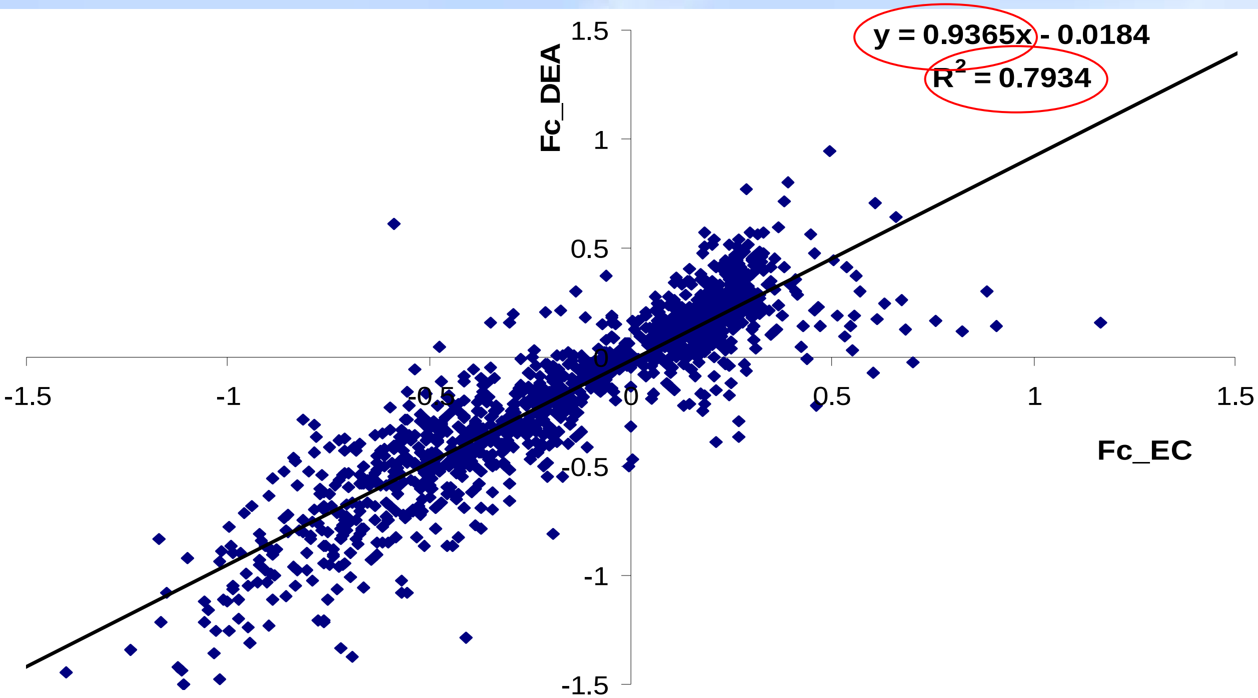
Results – CO_2 Flux

- CO_2 fluxes measured by the DEA and EC techniques over entire record (28/8 to 5/11)



Results – CO_2 Flux (DEA vs EC)

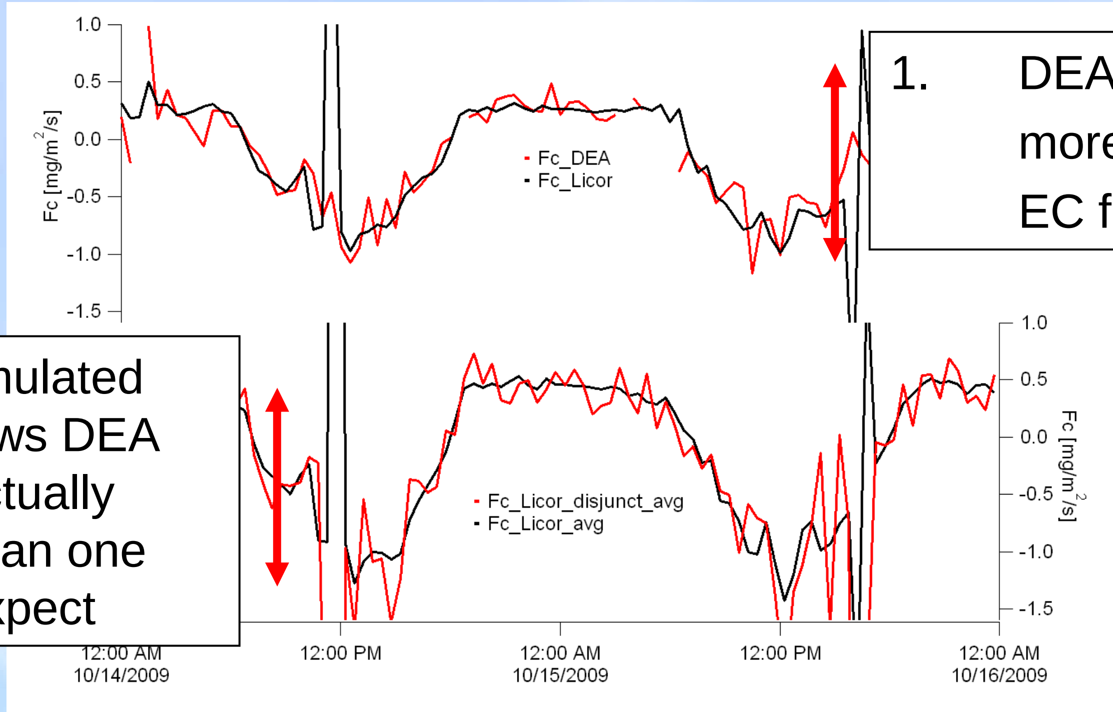
- Linear regression plot of DEA vs EC-measured CO_2 fluxes (28/8 to 5/11)



- DEA generally underestimated EC flux by ~6%
- Better agreement than other literature results

Results – DEA Simulation

- Top Graph: CO_2 fluxes measured by the DEA and EC techniques (2 days).



1. DEA flux appears more noisy than EC flux (statistics)

2. DEA-simulated flux shows DEA noise actually better than one might expect

- Bottom Graph: DEA-simulated flux – provided by ‘disjunct’ sampling of10Hz EC flux measurements every 12s i.e. 1 in every 120 EC data points was sampled.
- Simulation provided by Thorsten Warneke.

4. Conclusions

- Good agreement between DEA and EC measurement techniques; Slope=0.94, R^2=0.79.
- Long term measurements provided insight regarding seasonal and climatic drivers of the flux (e.g. sunlight, temp.).
- DEA has the ability to provide reasonably accurate measurements of CO_2, CH_4 and N_2O fluxes over complete seasonal or growing cycles (months, years).

Future Directions

- Long-term deployment where detectable and significant fluxes of CO_2, CH_4 and N_2O occur e.g. Australian wheat belt and sugar cane growing regions (heavily fertilised), rice fields (high CH_4 emission)
- Develop greenhouse gas budget estimates for agricultural systems and ecosystems.
- Refine the DEA system and optimise its measurement capabilities
- Determine the minimum detectable fluxes of CO_2, CH_4 and N_2O using DEA.

Acknowledgements

- Centre for Atmospheric Chemistry (CAC), in particular: D. Griffith (supervisor), M. Riggenbach, G. Kettlewell and T. Warneke.
- Glenys Lugg and those working at the Manidra Group Shoalhaven Starches Environmental Farm
- Thankyou for listening…. are we wasting our time?

Farmers win in ETS backdown by Labor

STEPHANIE PEATLING POLITICAL CORRESPONDENT
November 15, 2009 - 12:02AM

FARMERS would be exempt from the emissions trading scheme in the first concessions the Federal Government has made to the Opposition to gain its support

Coalition changes offer protection for big polluters

TOM ARUP ENVIRONMENT CORRESPONDENT

o the proposed emissions trading
polluting industry from the short-
e.

Farmer ploughs ahead in greenhouse gas war

CARMEL EGAN
November 1, 2009

A BATTLE is raging beneath the bobbing heads of Ian Linklater's wheat crop in the red loamy soils of Gol Gol.

Government querie
negotiations

November 10, 2009

The Rudd Government has questioned whether there is any point to negotiating on emissions trading when the Coalition remains unmoved on the science behind man-made global warming.

who fight
\- scientists

PAYING farmers and investors to preserve native forests, plant vast areas of trees, stop land clearing and improve soil could help Australia make big cuts to its greenhouse gas emissions and boost the chances of threatened native animals and plants, a group of leading Australian scientists argues.