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Eddy Covariance Measurements of CO_2 and CH_4 with a view to Optimizing Carbon Capture in Wetland Restoration

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Goals and Motivations

- The artificial isolation of floodplain wetlands from inundation has been one of the most widespread causes of ecological decline across the globe.

- Wetlands are biodiversity hotspots in the landscape, and their isolation from floodwaters and, on the coast, flood tide inundation has led to the degradation of ecological services including reductions in fisheries production, waterbird habitat, and habitat refugia.

- Scientific and policy interest has recently turned to the value of coastal wetlands for carbon sequestration ("Blue Carbon").

- Coastal mangrove and saltmarsh restorations are now at the forefront of developments for ecosystem-based climate change mitigation and adaptation.

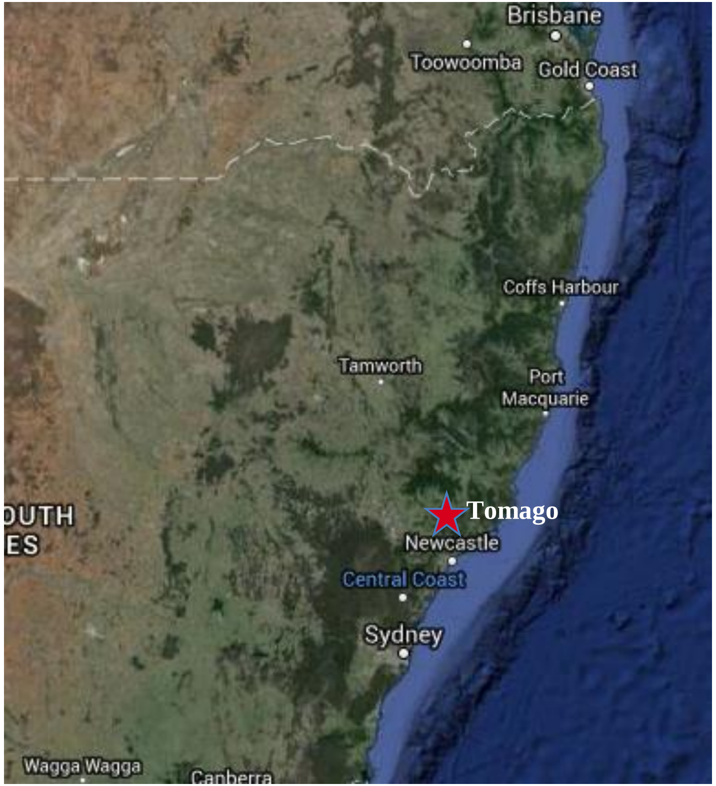
- The 2013 (Wetlands Supplement) to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provides a framework for the incorporation of wetland carbon sequestration in national carbon accounts.

Goals and Motivations

- Tomago wetland located near Newcastle, NSW, Australia is undergoing rehabilitation restoring tidal inundation to a previously leveed floodplain

- It is hypothesised that the restoration of tidal inundation would convert a methane source into a sink as a consequence of soil salinization.

- A Before-After-Control-Impact experimental design has been applied to measure the impact of tidal reinstatement on wetland floodplain accretion and gas flux.



Methodology

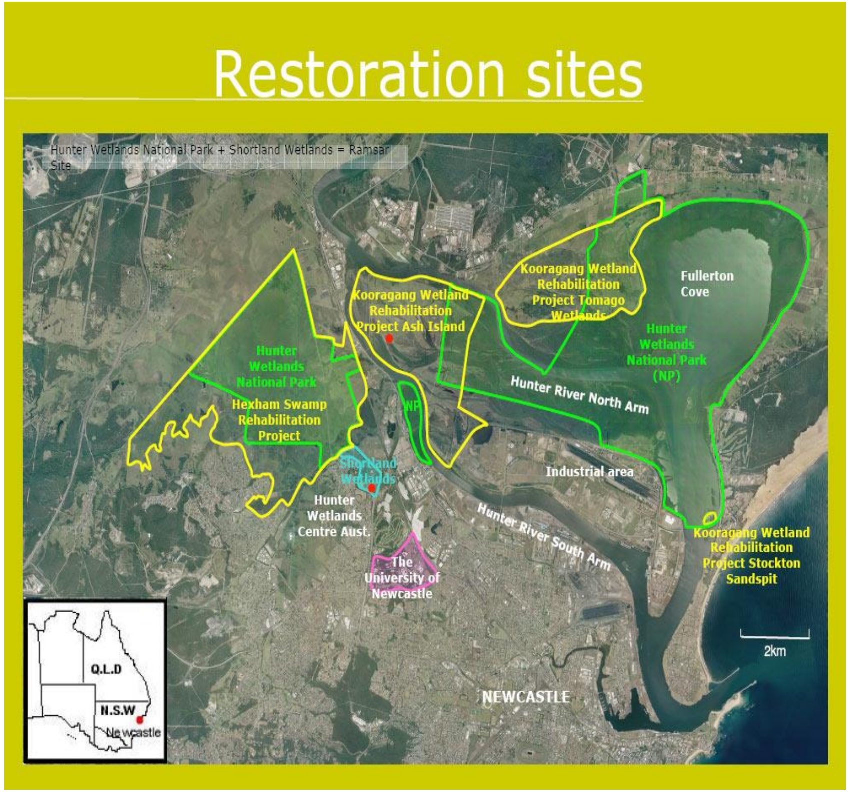
- 4 months prior to tidal reinstatement, we have installed an extensive set of environmental measurements at impacted and control sites.

- Hydrodynamic modelling identified the sites within the wetland predicted to remain disconnected from tidal flow.

- Eddy covariance tower at disturbed site, Gill Windmaster, LICOR 7500,7700 open path (CO_2, CH_4, H_2O).

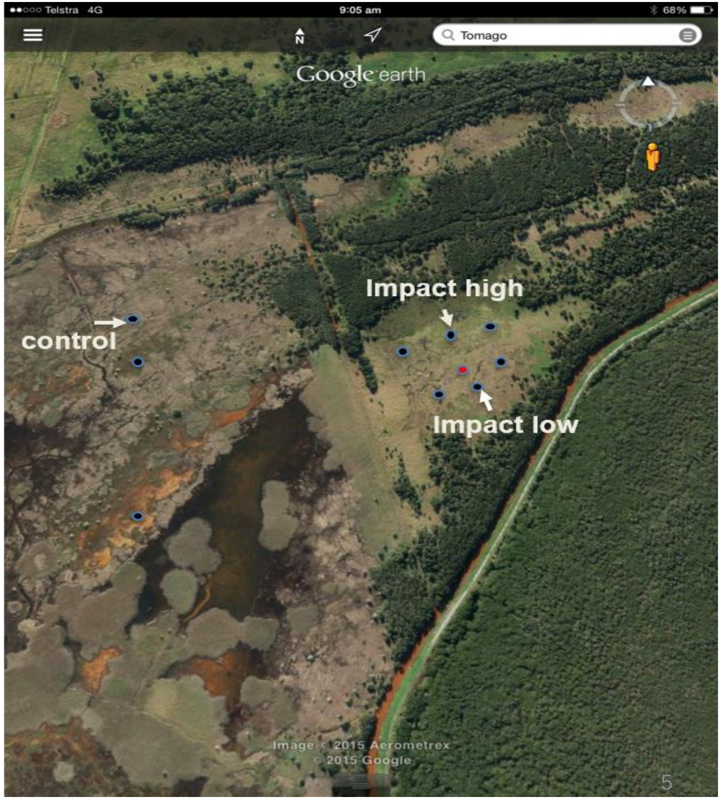
- LICOR smart flux system, eddypro software, QA/QC procedures, telemetry

- 4 component radiation (Kipp and Zonen cnr1), soil surface temperature (thermocouple).

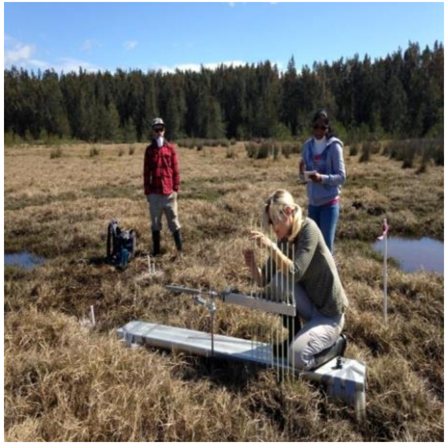


Methodology

- Electron conductivity and water temperature (HOBO® U24)
- RSET-MH: Surface elevation, surface accretion, and continuous water level (HOBO U20L) inundation regime.
- Soil microbial community sampling and analysis (16S rRNA gene milliseq).
- Local Air samples for carbon isotopes of CO_2 and CH_4 including hydrogen isotopes for methane.
- Meteorological data from nearby (10 Km) Williams Town air base including precipitation
- Soil sampling, vegetation surveys



Methodology



Methodology

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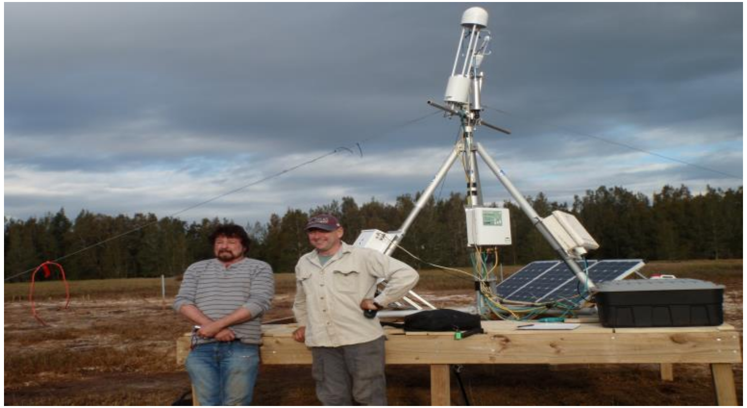
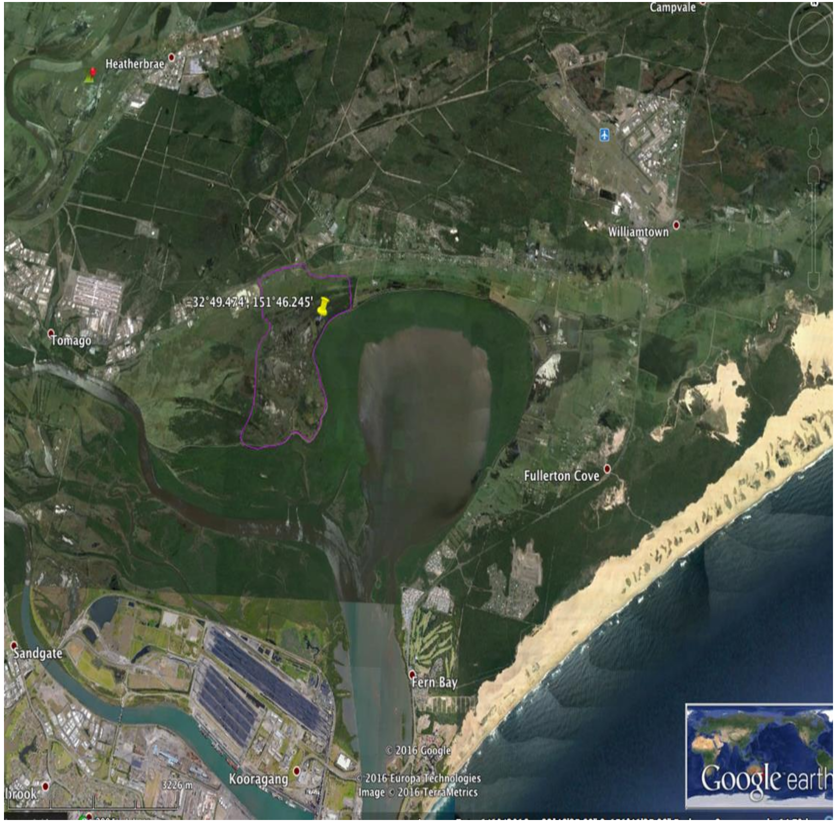
Results

- Eddy covariance measurements began August 4, 2015 and is ongoing.

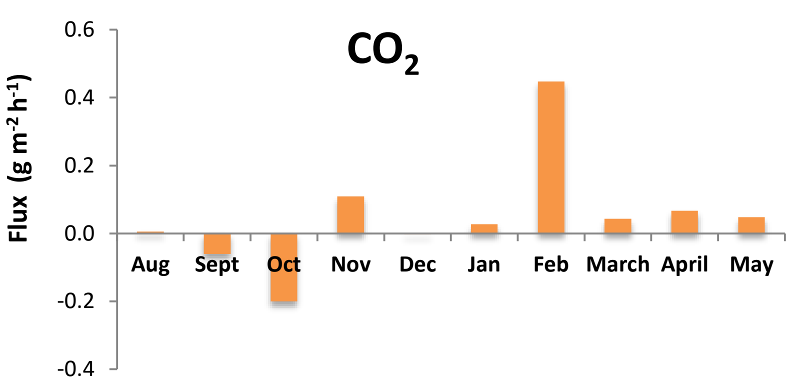
- Tidal re-instatement was mid November 2015.

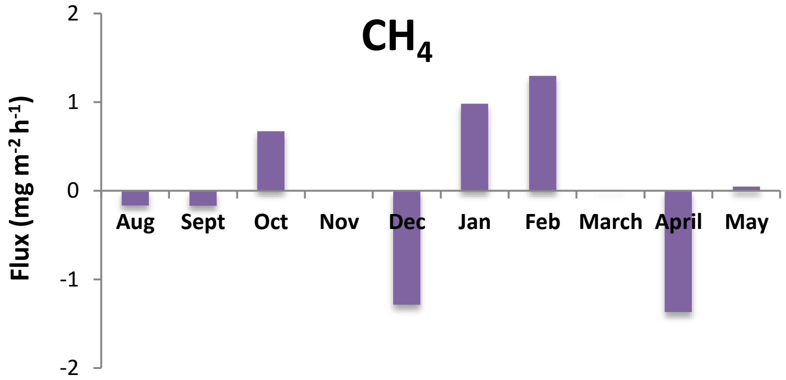
- Presented are preliminary results from August 2015 to May 2016.

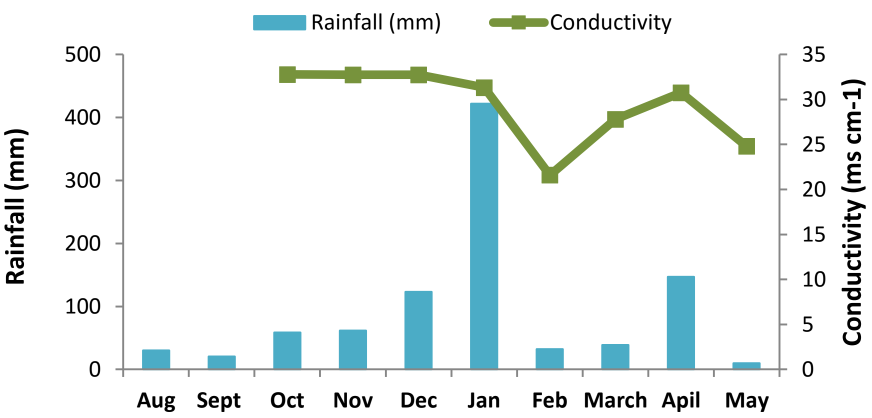


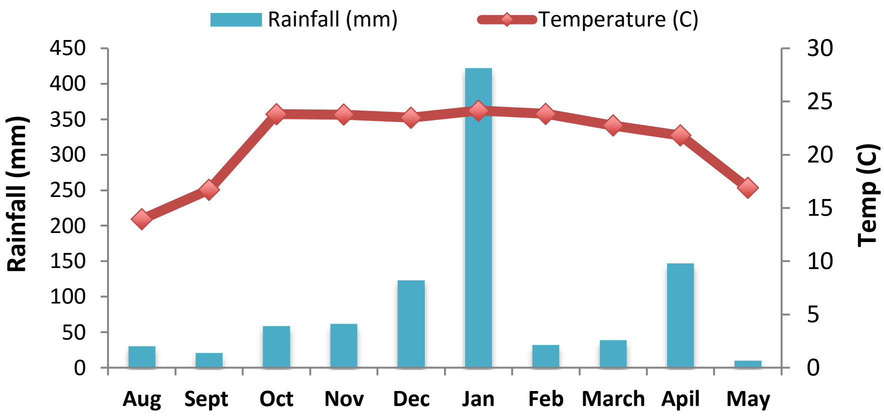


Results


CO2
Flux (g m-2 h-1)
0.6
0.4
0.2
0.0
-0.2
-0.4
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
April
May

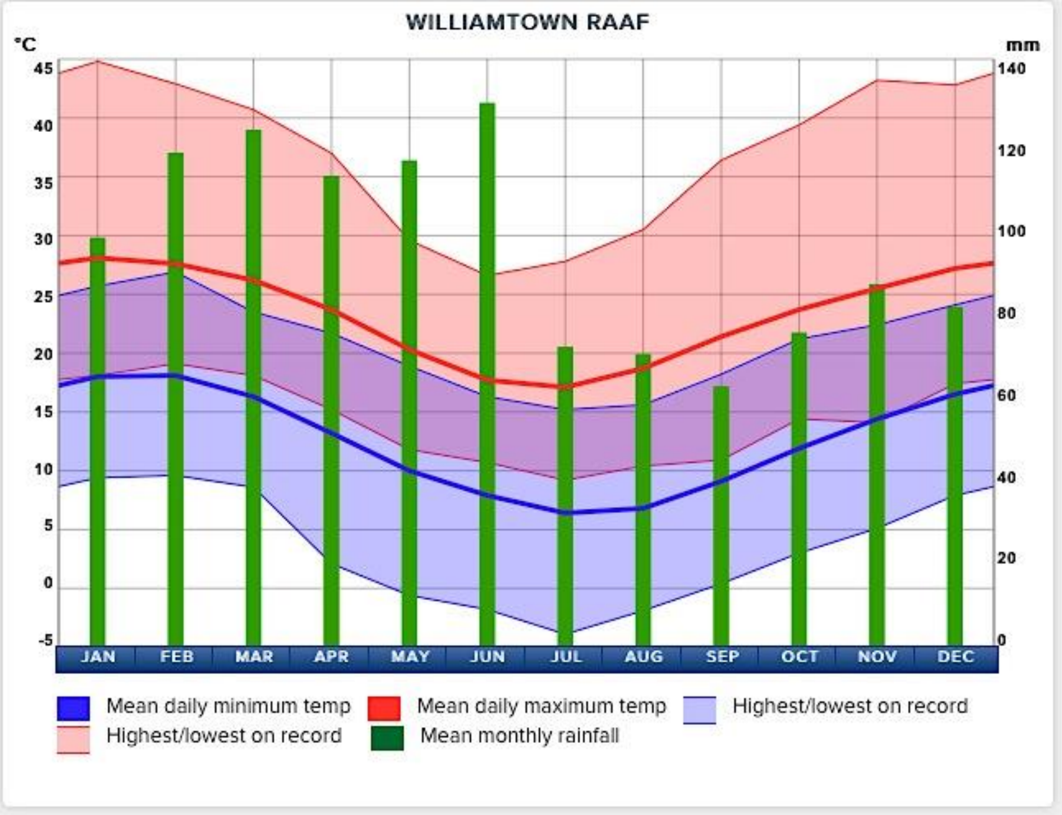

CH4
Flux (mg m-2 h-1)
2
1
0
-1
-2
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
April
May


Rainfall (mm)
Conductivity
Rainfall (mm)
Conductivity (ms cm-1)
500
400
300
200
100
0
35
30
25
20
15
10
5
0
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
Apil
May

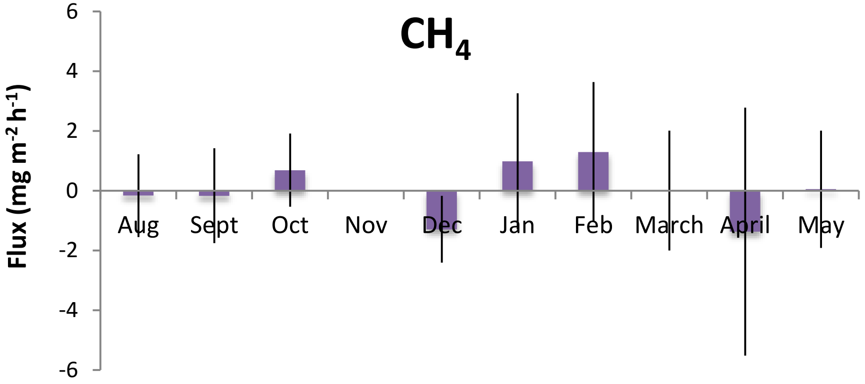

Rainfall (mm)
Temperature (C)
Rainfall (mm)
Temp (C)
450
400
350
300
250
200
150
100
50
0
30
25
20
15
10
5
0
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
Apil
May

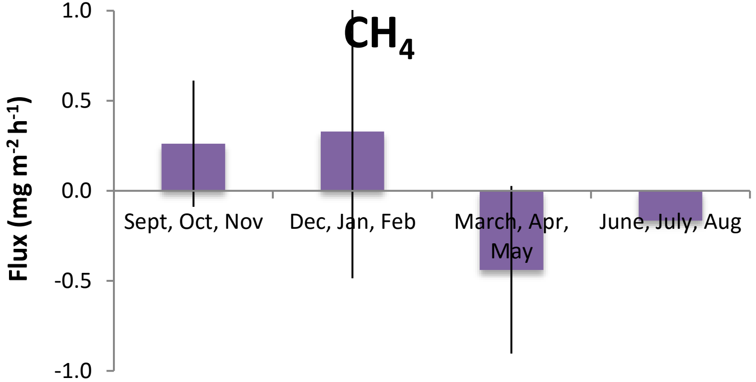
Results

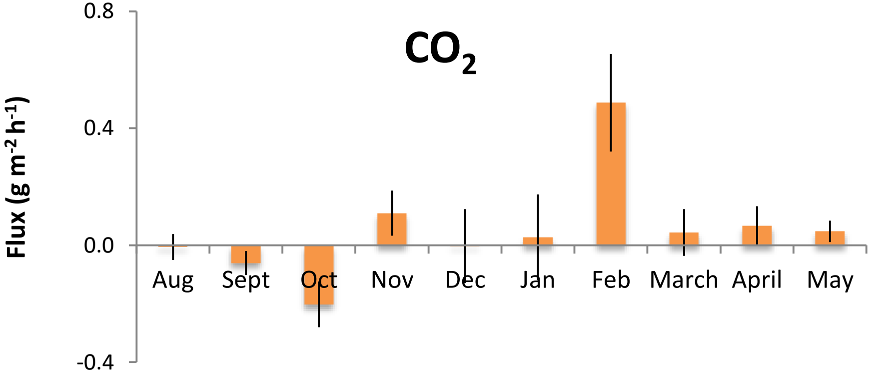
- William Town climatology: 60 yr. record of rainfall and temperature1942 to 2002
- Study period to date anomalous with respect to precipitation input

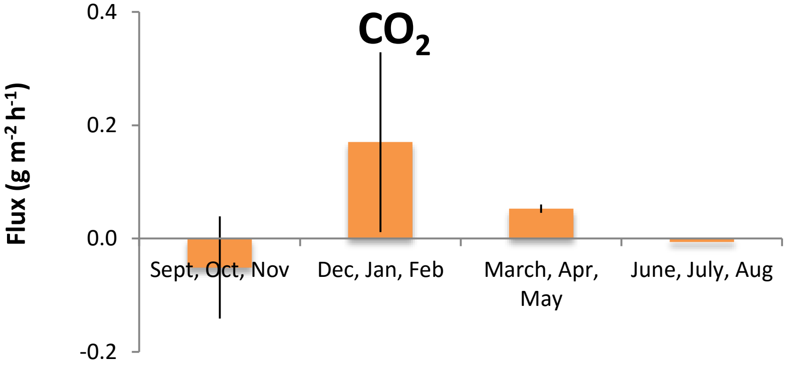


Results: monthly and seasonal

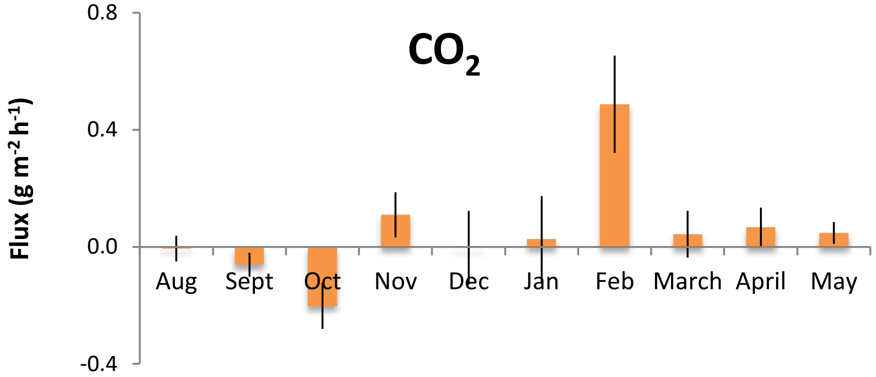


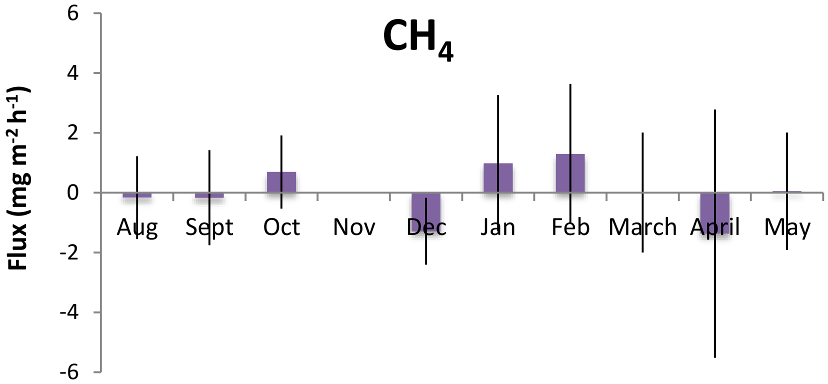


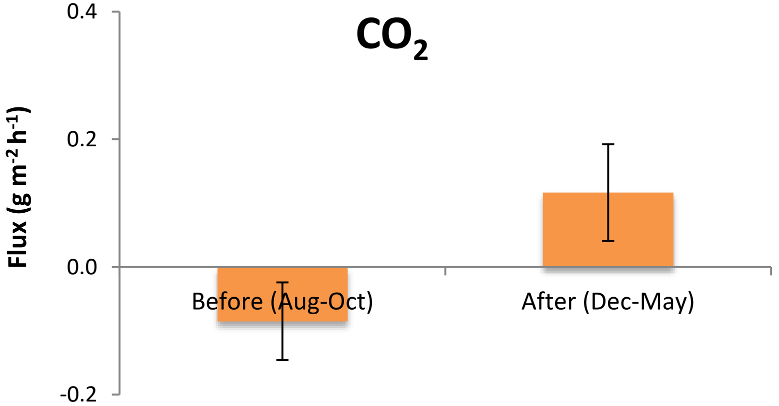


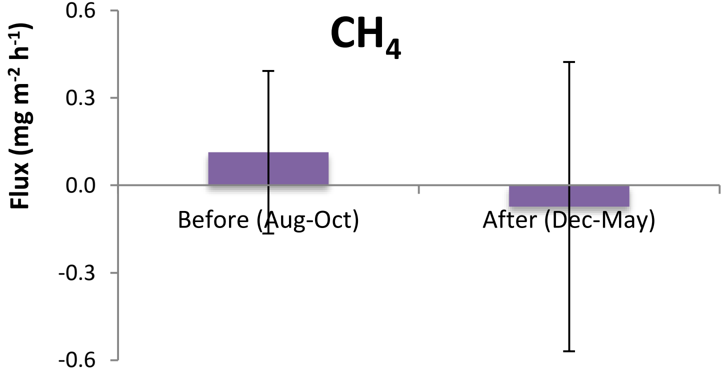


Results: Before and After Flooding









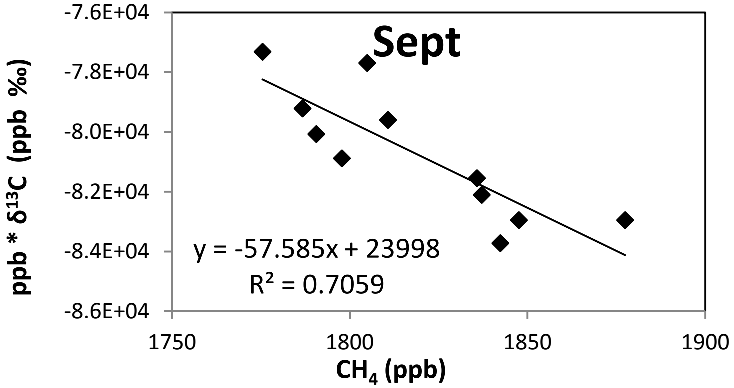
Results: Comparison

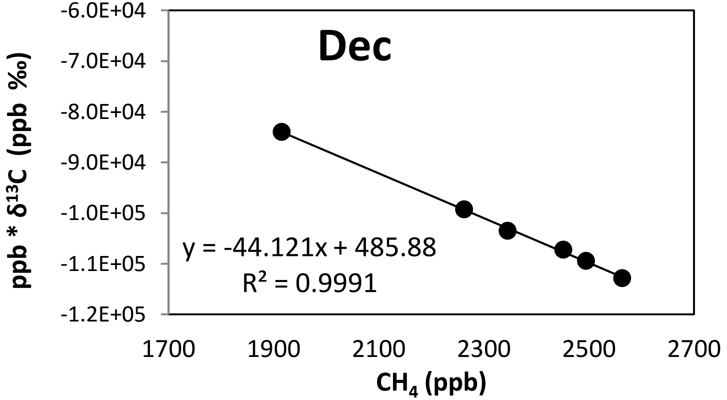
- To date we are not seeing a clear signal from tidal re-enstatement, especially for methane.
- Averaging CO_2 before and after tidal re-instatement does show, coincidently, a change from a sink to a source.
- Over the ten months of measurements methane is a small source to the atmosphere.
- CO_2 is the dominate source of carbon to the atmosphere.

	CO_2 ($g\ m^{-2}\ h^{-1}$)	CH_4 ($g\ m^{-2}\ h^{-1}$)
Before	-0.0850	0.000113
After	0.116	-0.0000734
Sum (NOT including Nov when flooding occurred and we have no CH_4 data)	**0.374**	**-0.0000221**

Wetlands GWP after flooding (after Nov)	CO_2 ($g\ m^{-2}\ h^{-1}$)	CH_4 expressed as CO_2 ($g\ m^{-2}\ h^{-1}$)	SUM
100 yr GWP (CH_4 x 21)	0.1163	-0.00154	0.1148
20 yr GWP (CH_4 x 31)	0.1163	-0.00227	0.1140

Results: Air sampling CH_4 stable isotope signatures



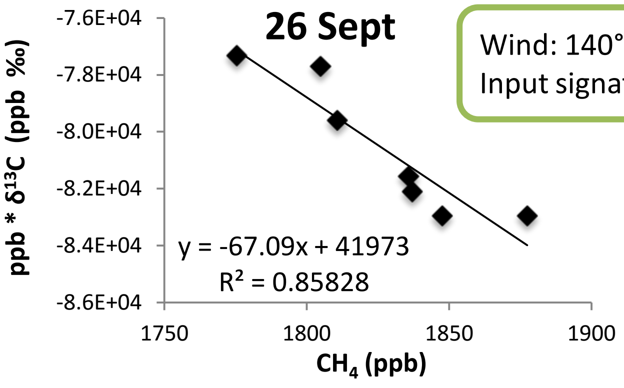


- $\delta^{13}C$ signatures of CH_4 indicate carbon source (Whiticar 1999)
  - Biogenic $\delta^{13}C < -50$
  - Thermogenic/fossil fuel $\delta^{13}C > -50$

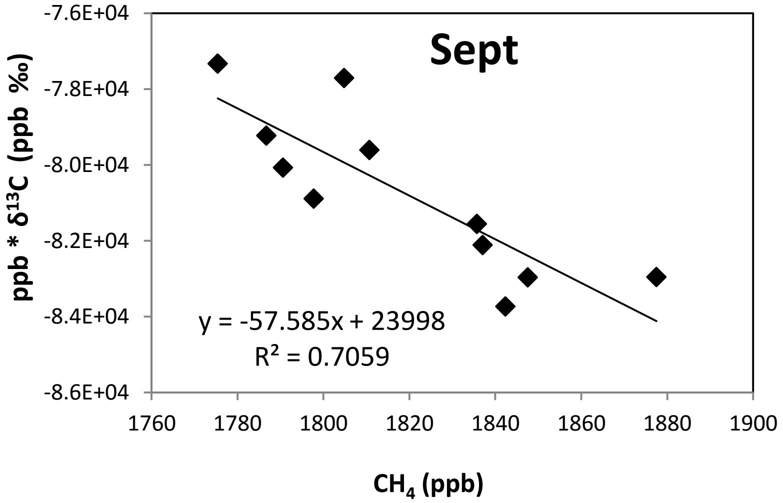
- September
  - Wind direction: 140° to 204°
  - Input signature: -57.6
    - Biogenic input signature

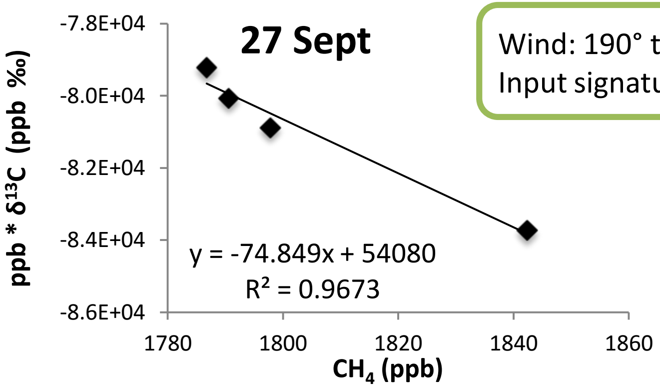
- December
  - Wind direction: 68° to 85°
  - Input signature: -44.1
    - Thermogenic/fossil fuel

Results: atmospheric isotopic sampling



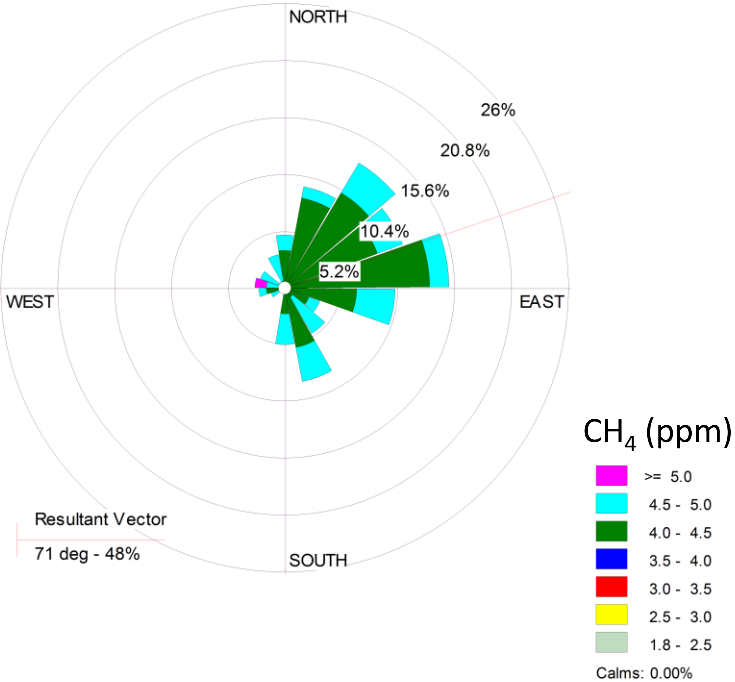
Wind: 140° to 170°
Input signature: -67.1

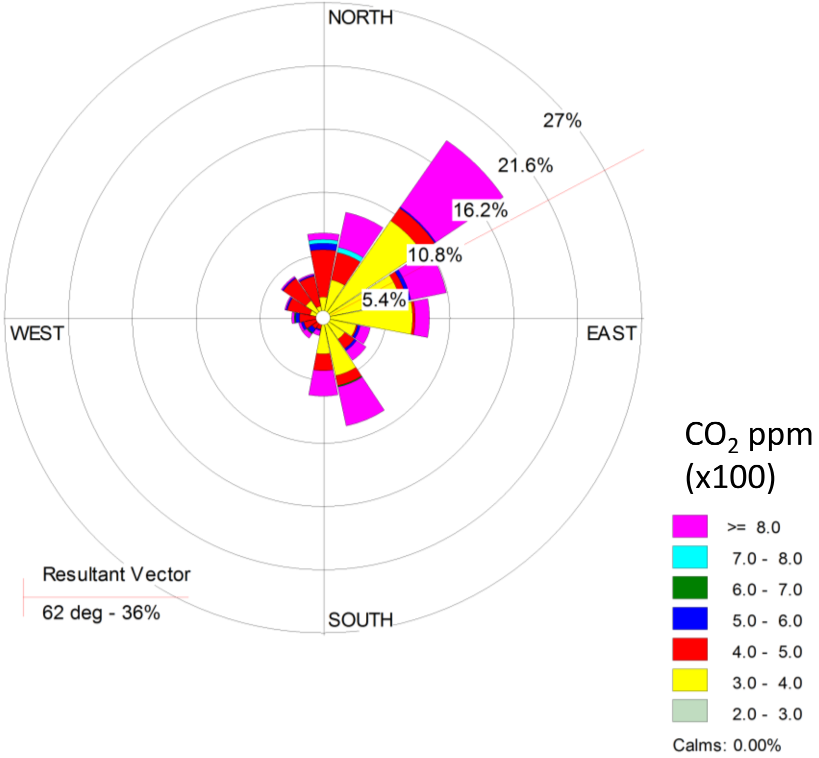




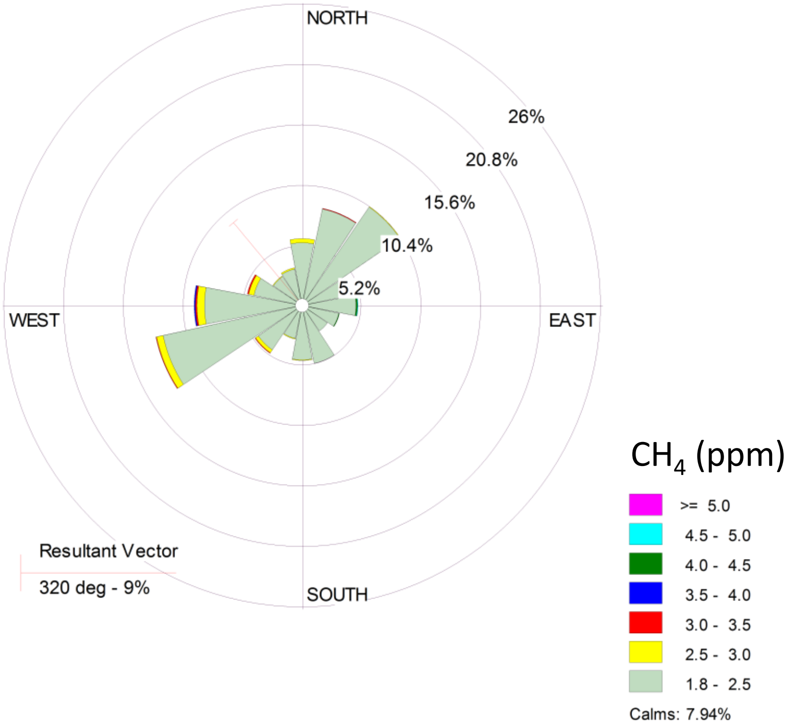
Wind: 190° to 204°
Input signature: -74.9

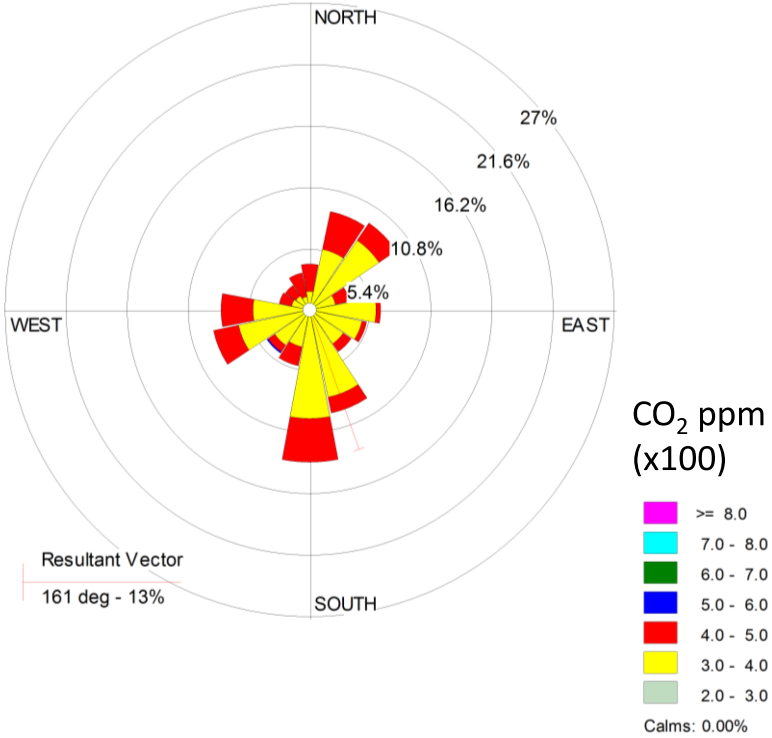
Results: December





Results: September





Conclusions

- Tidal re-instatement in impounded wetlands potentially represents and important “blue carbon” opportunity in Australia
- Tidal re-instatement does not prevent periodic freshening and associated greenhouse gas production.
- In the first 10 months carbon budget dominated by freshwater inputs as opposed to signal from tidal re-instatement
- Site may be influenced by anthropogenic atmospheric input to background air (military base)
- As complete data set is collected/analysed and integrated to describe the carbon budget at this site the full impact of restoration is unknown.

Acknowledgements

- NSW Office of Environment and Heritage (funding, field support)
- Professor Martin Kennedy (loan of EC tower, postdoc)
- KerryLee Rogers and Chris Owers, University of Wollongong
- Will Glamore, Water Research Laboratory