CO_2, N_2O and CH_4 exchange of a high intensity dairy pasture system in NZ

Landcare Research
Manaaki Whenua

Ozflux meeting | Palm Cove, Australia | July 2013

Ecosystems and Global Change Team
Measuring and Mitigating GHG Emissions

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THE IMPORTANCE OF DAIRY PRODUCTION IN NZ

Local importance

16 billion litres of milk pa (6,400 OSP)

95% of dairy produce is exported

Export revenue $12.1 billion pa, 25% of export earnings

10 fold increase in cows in last 20 years

International importance

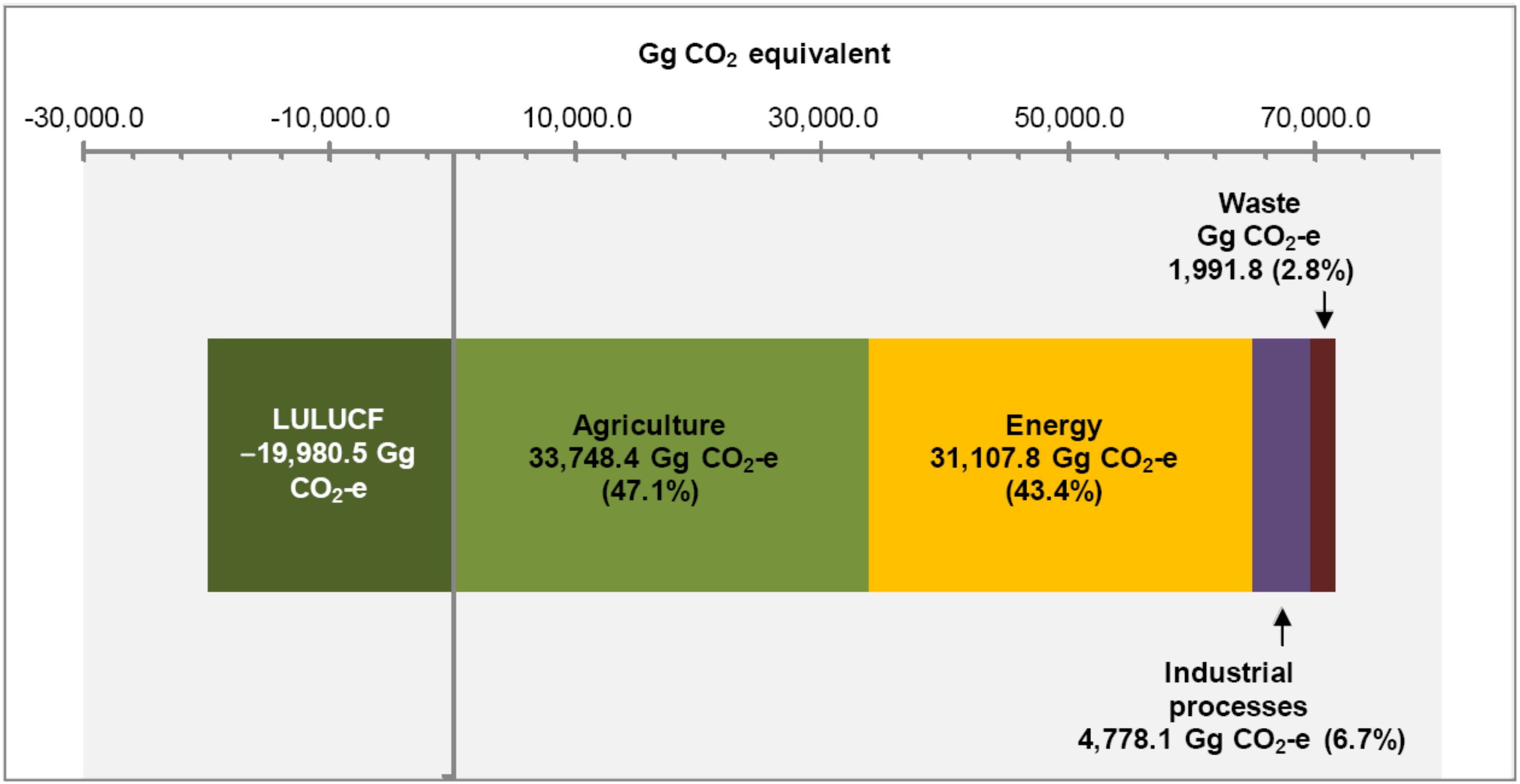
2% of total world production of milk

44% of all traded butter

30% of all traded milk powder

HOW MUCH DOES FARMING CONTRIBUTE TO GHG EMISSIONS?

New Zealand's emissions by sector in 2010



Source: New Zealand's Greenhouse Gas Inventory 1990-2010, Ministry for the Environment, 2012

OBJECTIVES

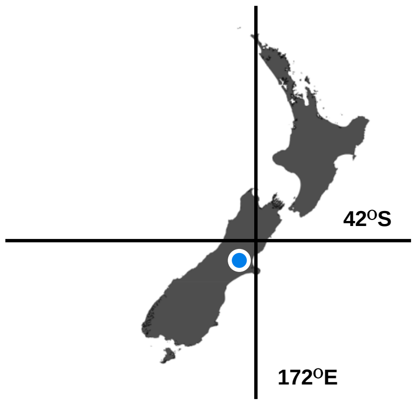
Investigate the impact of the **conversion of dry-land grazing to irrigated dairy** on **GHG emissions** and **soil carbon storage**

in particular

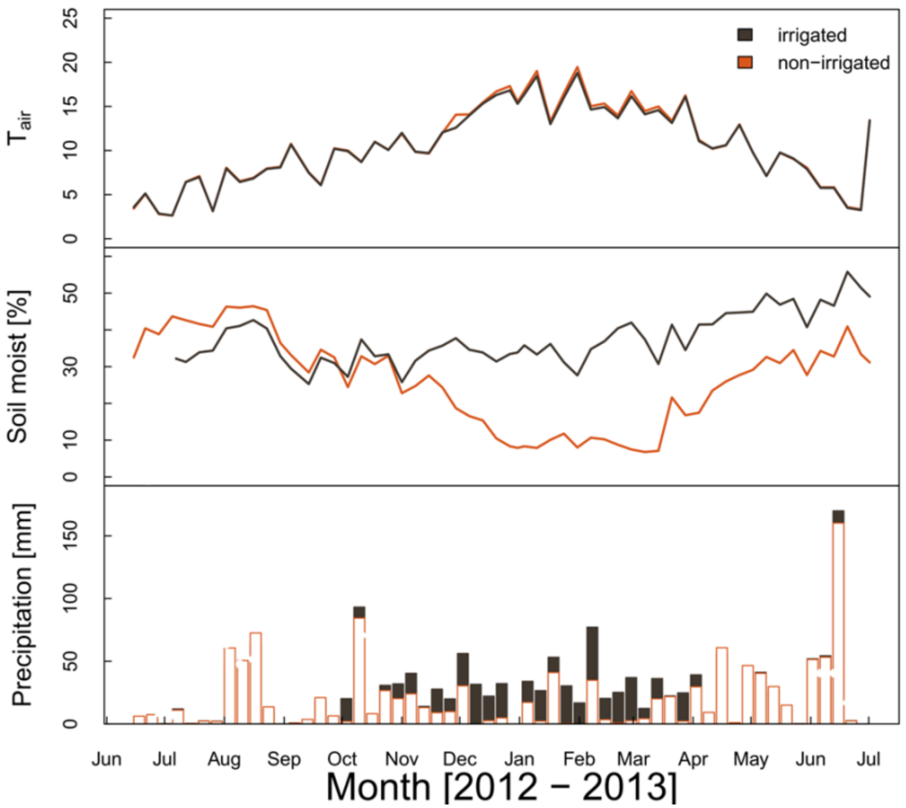
- Seasonal variation
- Environmental drivers
- Annual budgets

- Water-use and nitrogen-use efficiency
- The impact of irrigation and fertiliser application on nitrate leaching.

SITE INFORMATION



- Mean annual temperature 11oC
- Mean annual precipitation 900 mm



- South Island, New Zealand
- Mid-Canterbury Plains, 210 m asl
- Large scale dairy farm (Synlait™)
- Conversion 2008
- Irrigated and fertiliser applied
- 850 cows, 284 ha
- Lismore soil (stony, well drained)

Deans Rd
Otira Hwy
77
73
Darfield
Kirwee
Johns Rd
74
Fendalton Rd
Yaldhurst Rd
73A
Hororata
Rolleston
1
Rakaia Hwy
Lincoln
Dunsandel
75
Bankside
Rakaia
Leeston
Lake Ellesmere
Chertsey
14.9 km
© 2012 Cnes/Spot Image
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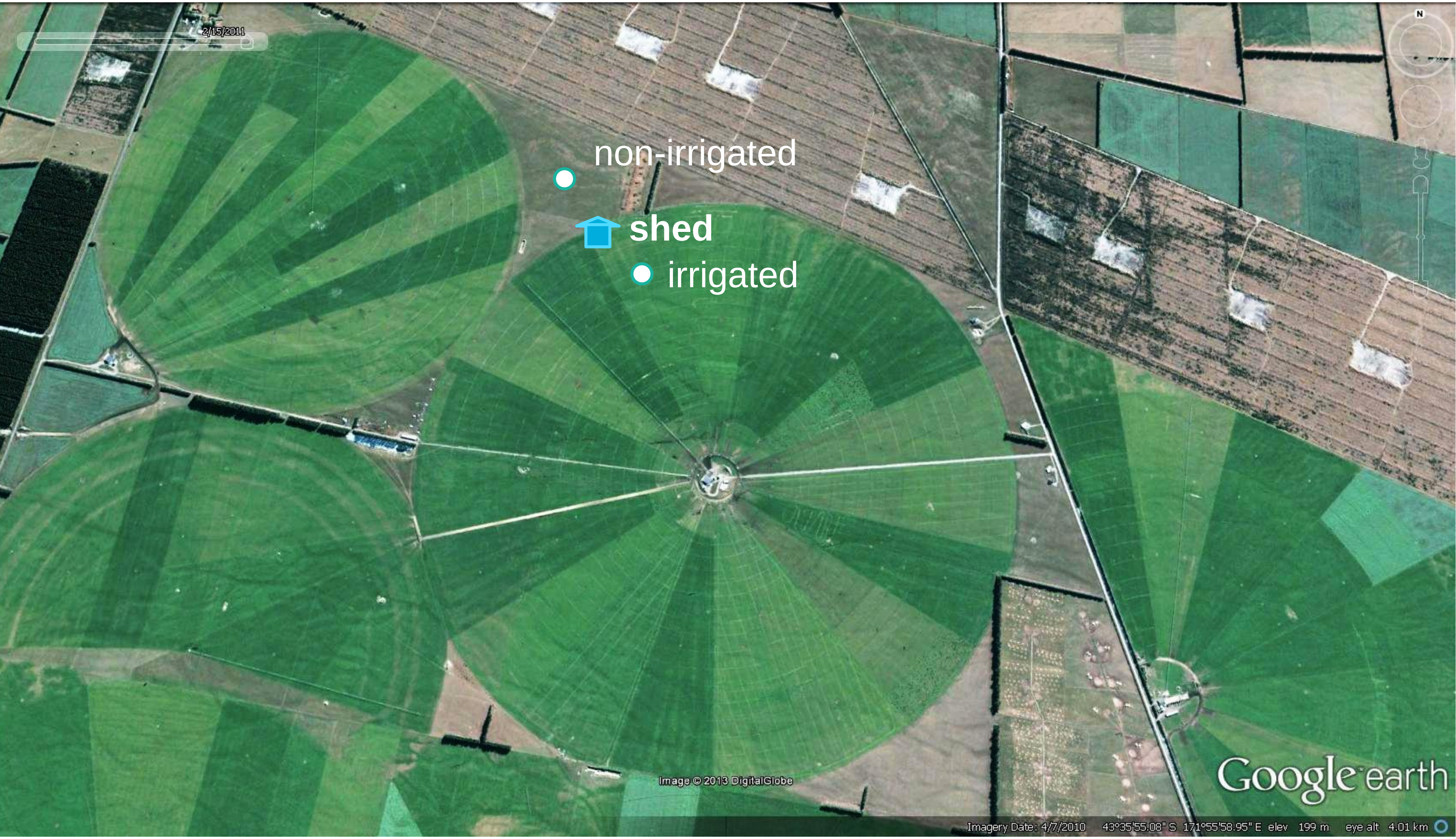
Google earth

LAND USE 2004

LAND USE 2007

LAND USE 2010



INSTRUMENTS

Gas analyser

LI-7200 enclosed path CO_2/H_2O analyser
FTIR – CH_4, N_2O, CO_2, $\delta^{13}C$ analyser

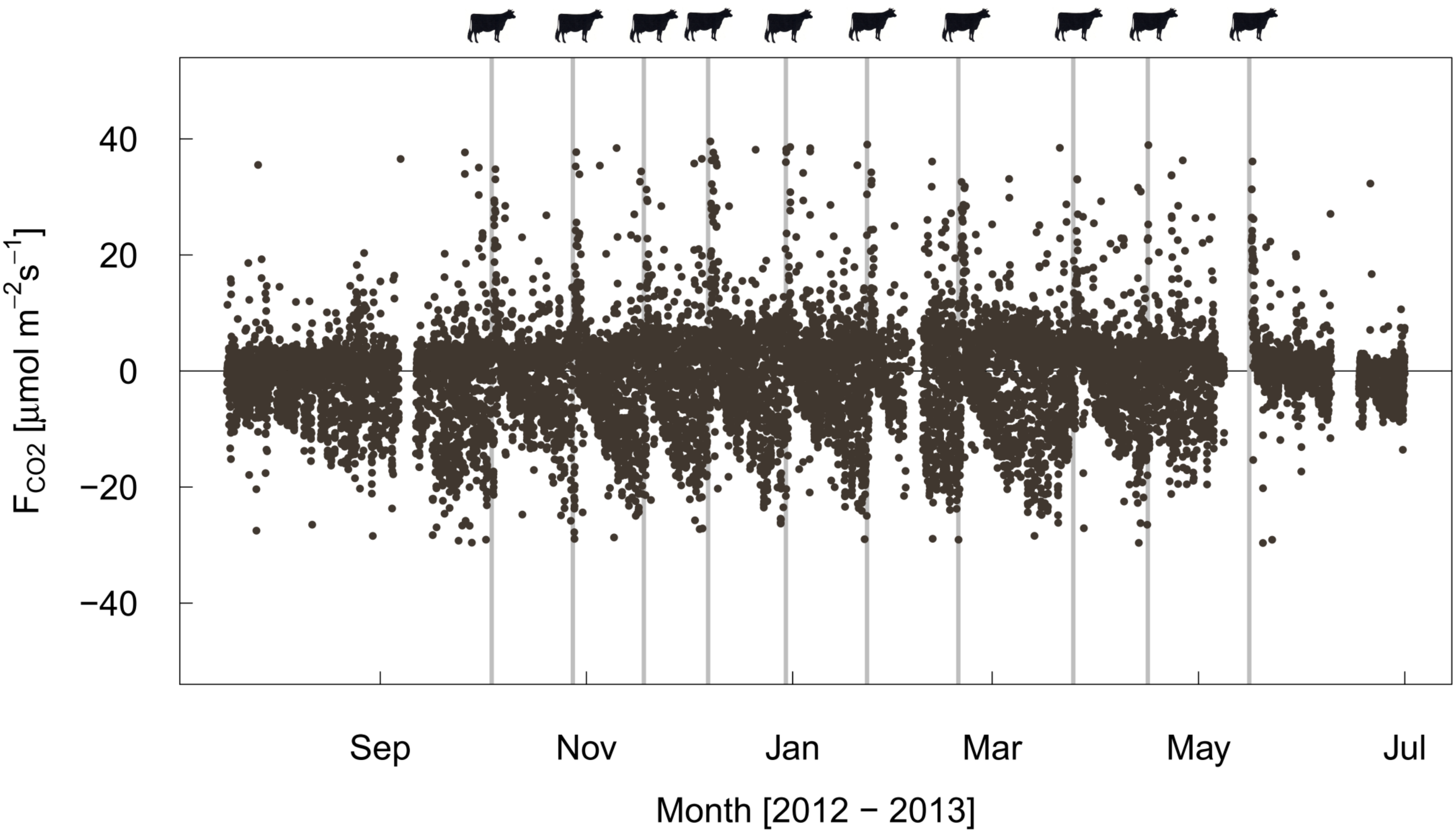
Sensors

sonic anemometer (Gill)
soil moisture profiles (-5, -10, -25, -50 cm)
soil temperature profiles (-2, -5, -10, -25, -50 cm)
PAR (diffuse and direct radiation)
NDVI
rain gauge
anemometer + wind vane
air temperature/RH
heat flux plate (-4 cm)
net radiation, SW albedo, $T_{surface}$
leaf wetness

Irrigated

Non-irrigated

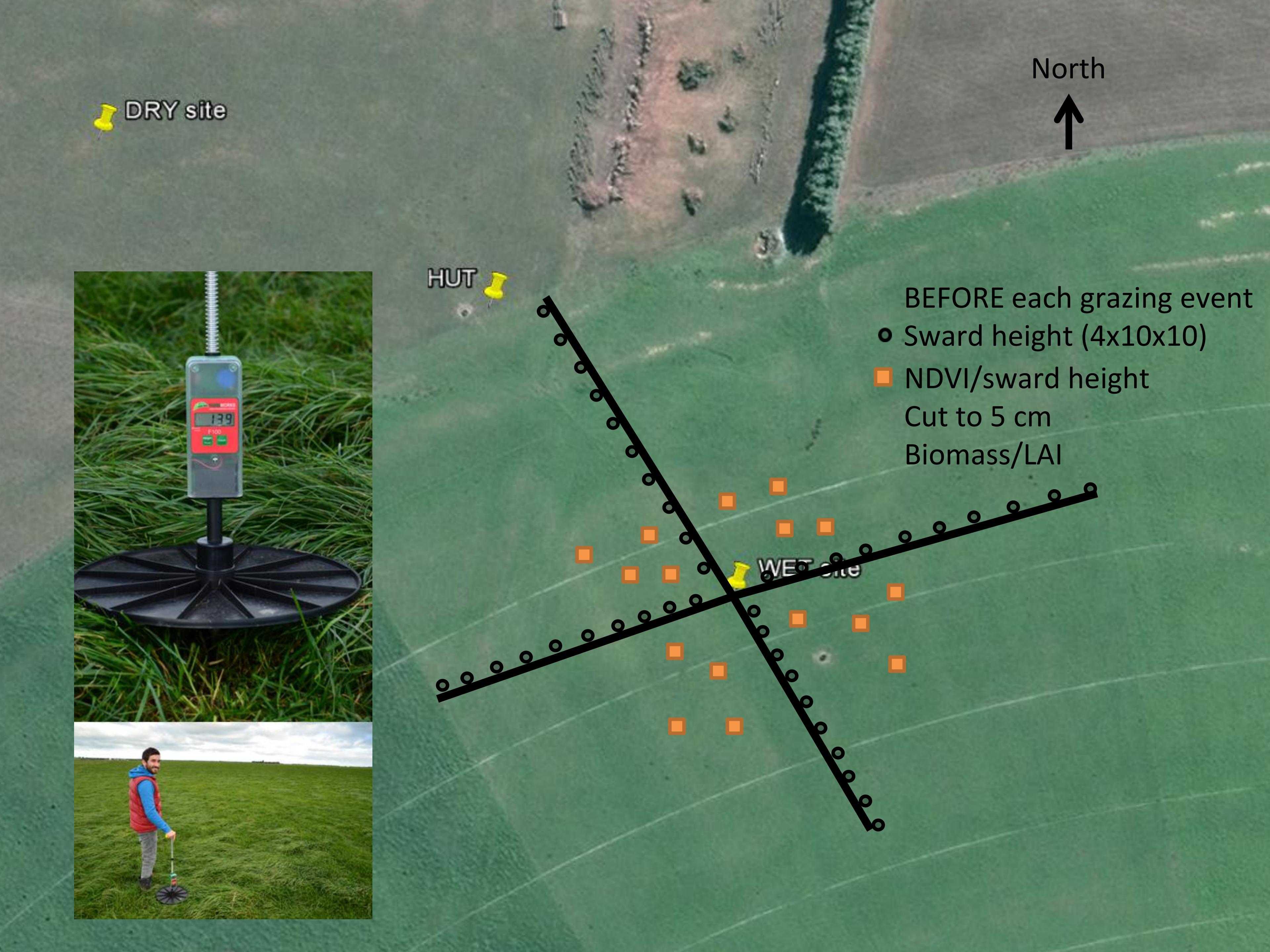
CO_2 FLUXES



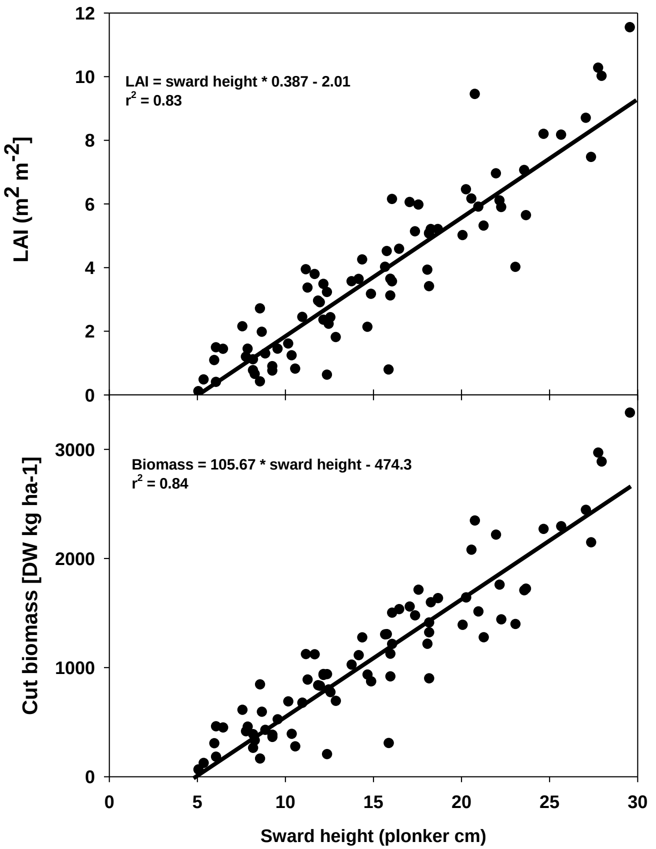
40
20
0
−20
−40
F_{CO2} [µmol m^{-2}s^{-1}]
Sep
Nov
Jan
Mar
May
Jul
Month [2012 − 2013]

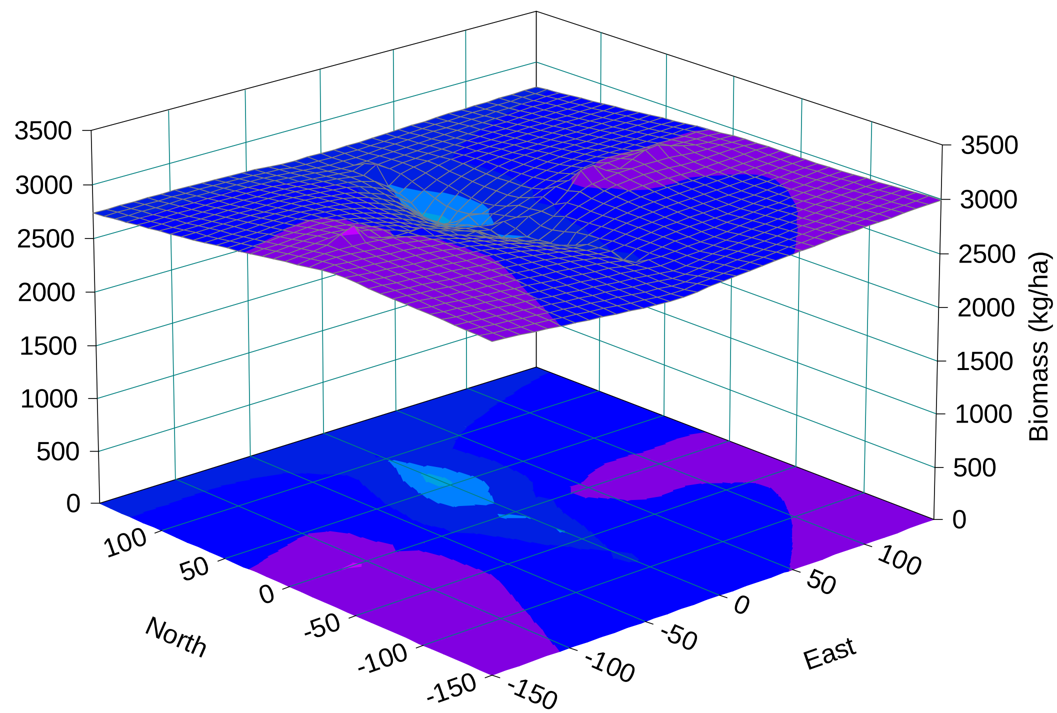
What regulates pasture CO_2 flux?

- F_{CO_2} f (Q, Temp, H_2O, nutrients, LAI)
- Pasture characteristics
  - Shifting mosaic in space and time
  - Uniform over larger space scales
  - Measure sward height along 4 cardinal points using a plonker (n = 400, 5x)
- Daily LAI and biomass
  - Using 16 cut plots, 5x, pre grazing, construct functions between NDVI and (LAI and biomass)
  - Apply these functions to continuous NDVI data at eddy site

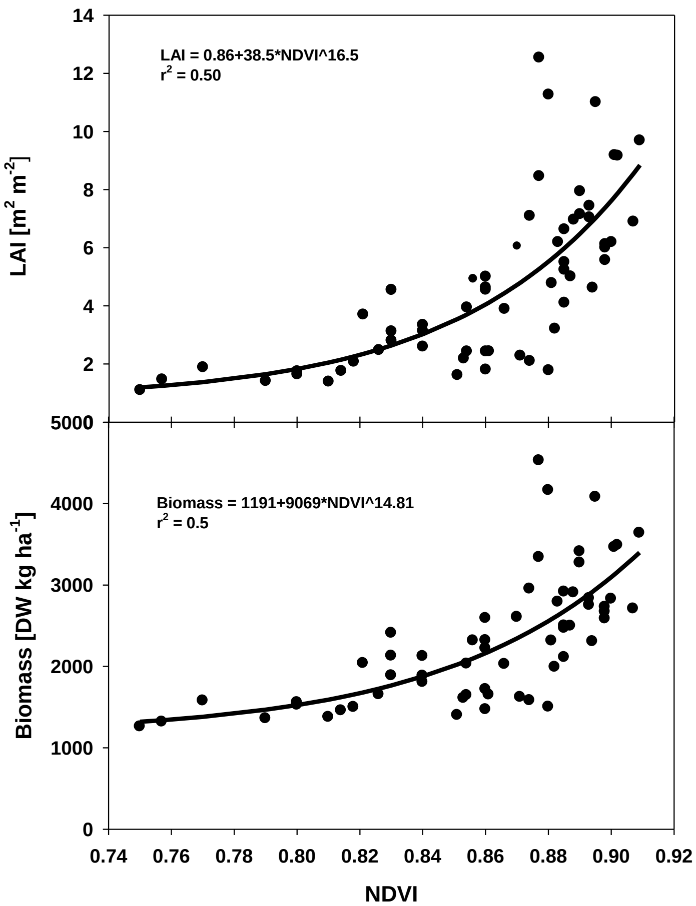

North
DRY site
HUT
BEFORE each grazing event
Sward height (4x10x10)
NDVI/sward height
Cut to 5 cm
Biomass/LAI

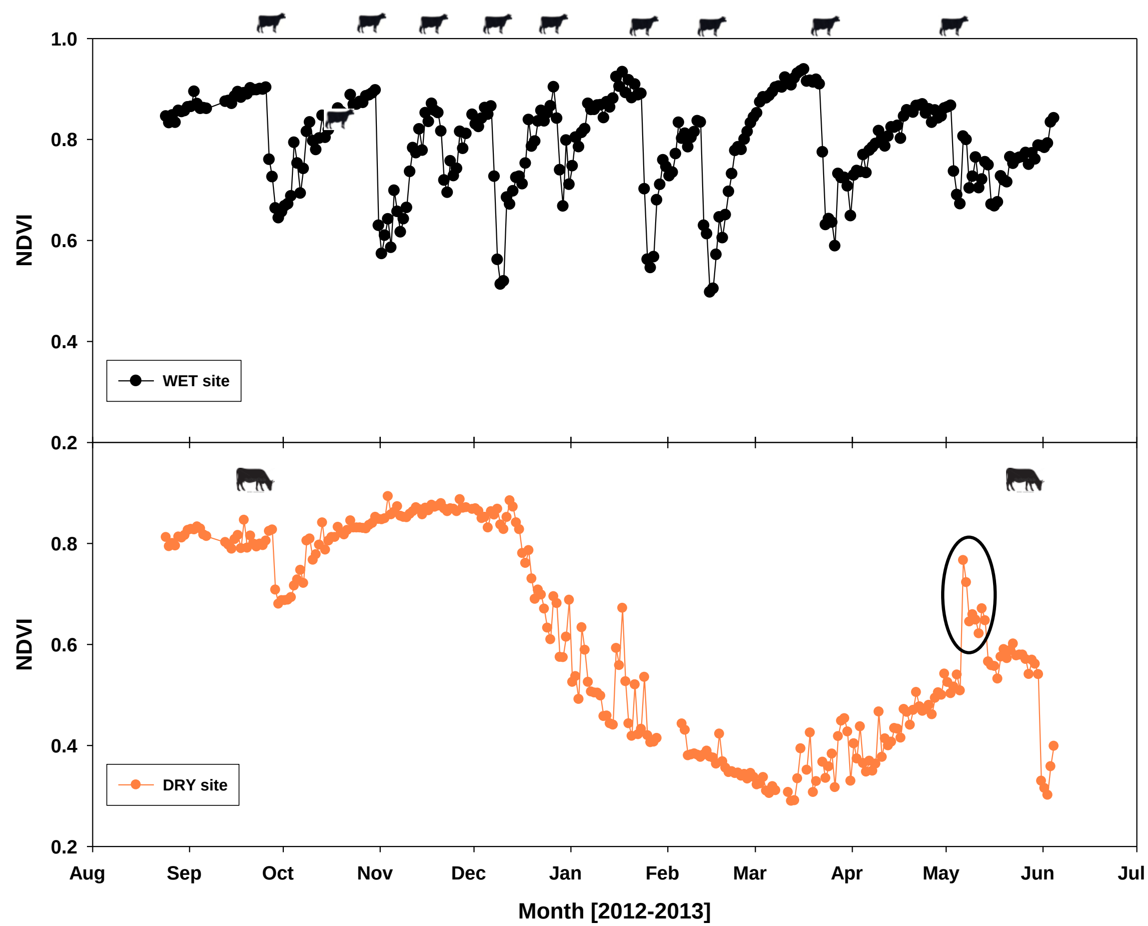
Pasture distribution, pre-grazing



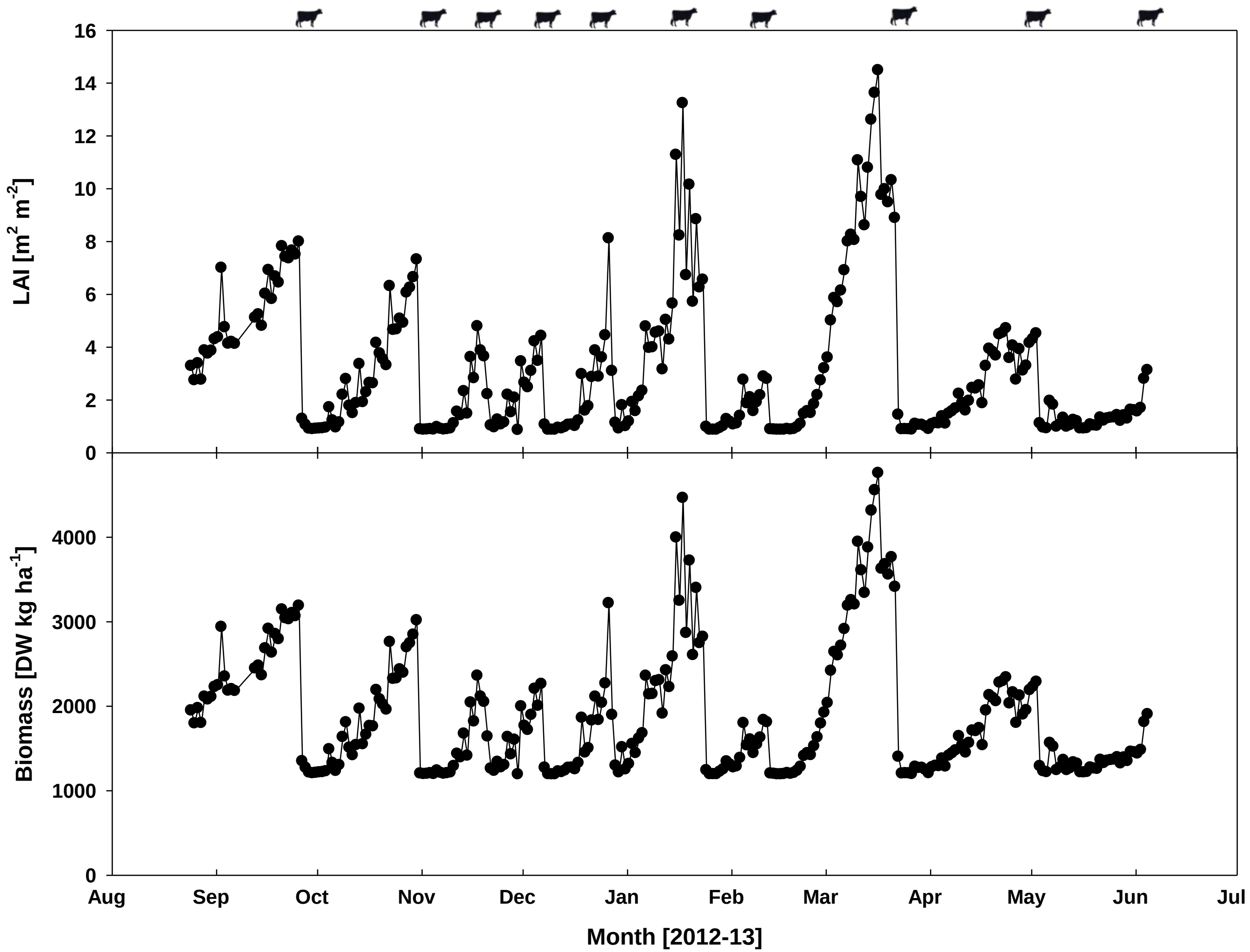


Measured NDVI and functions

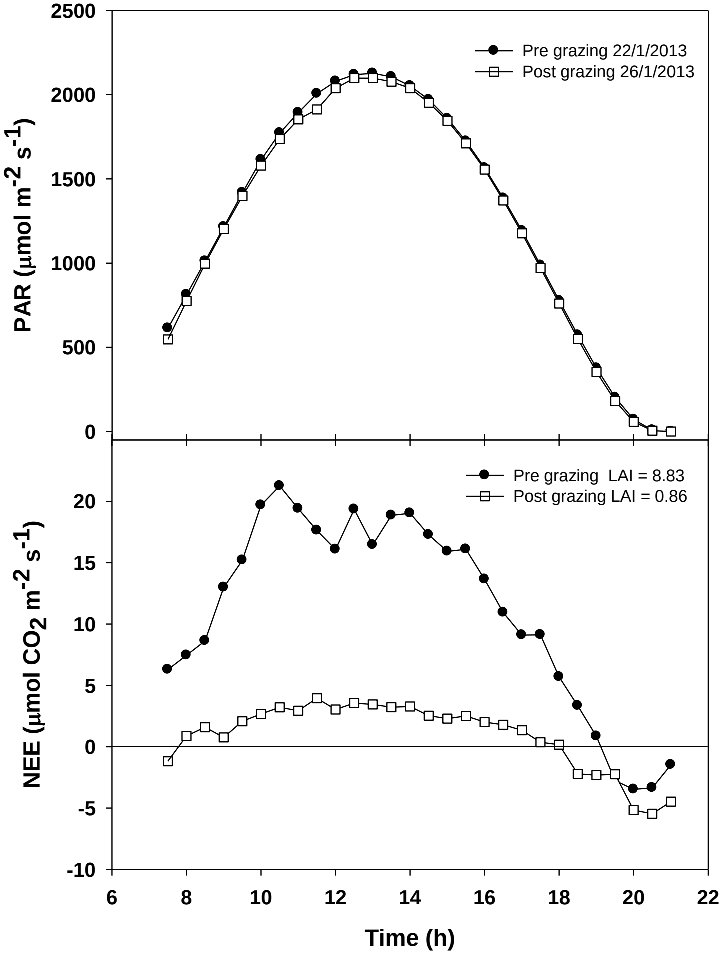


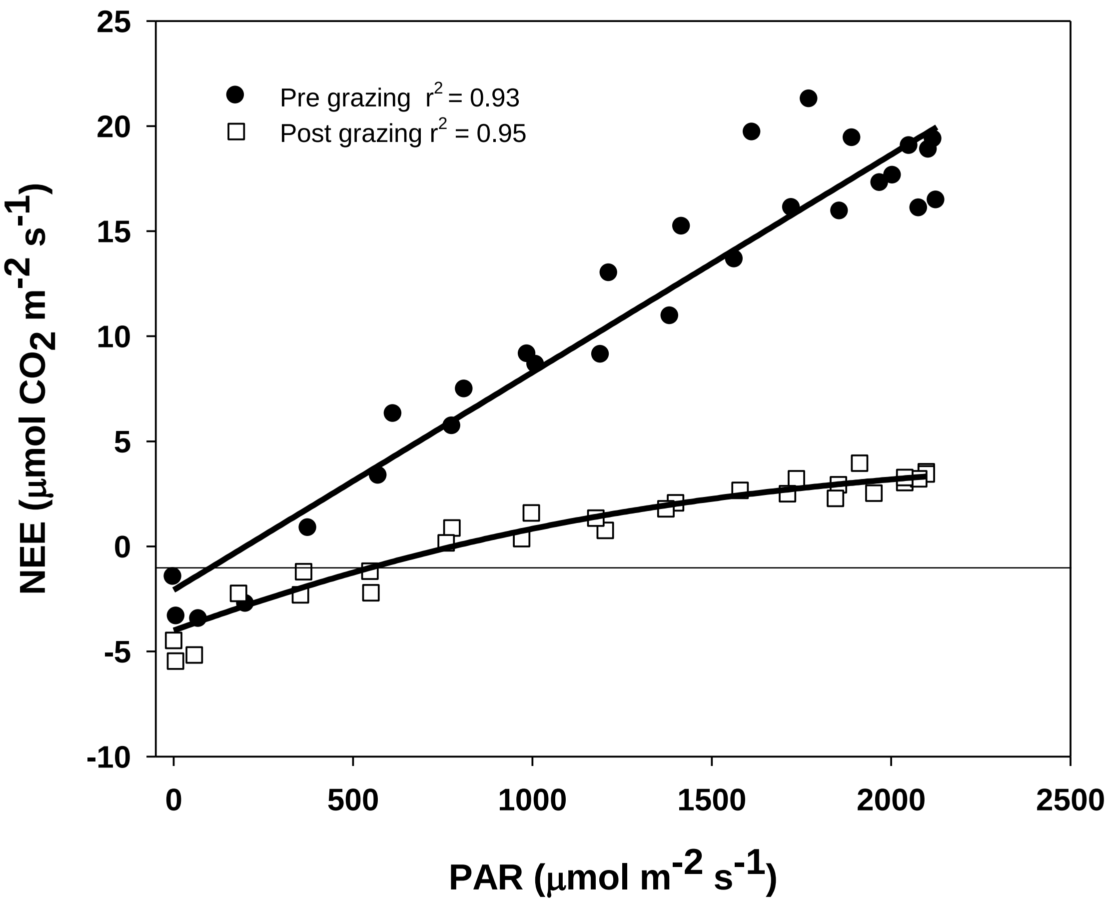


Derived daily LAI and biomass

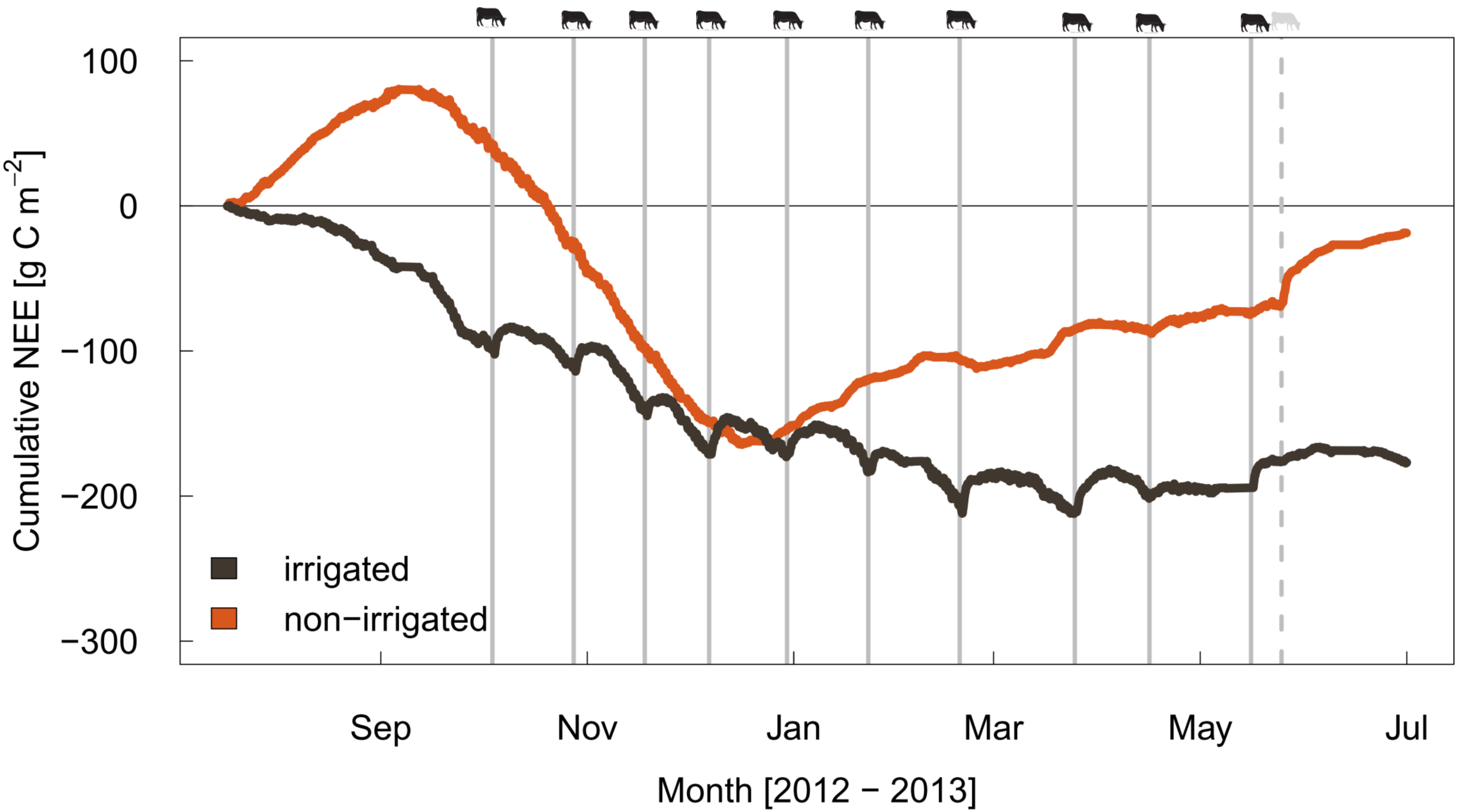


GRAZING EFFECTS ON LIGHT RESPONSE





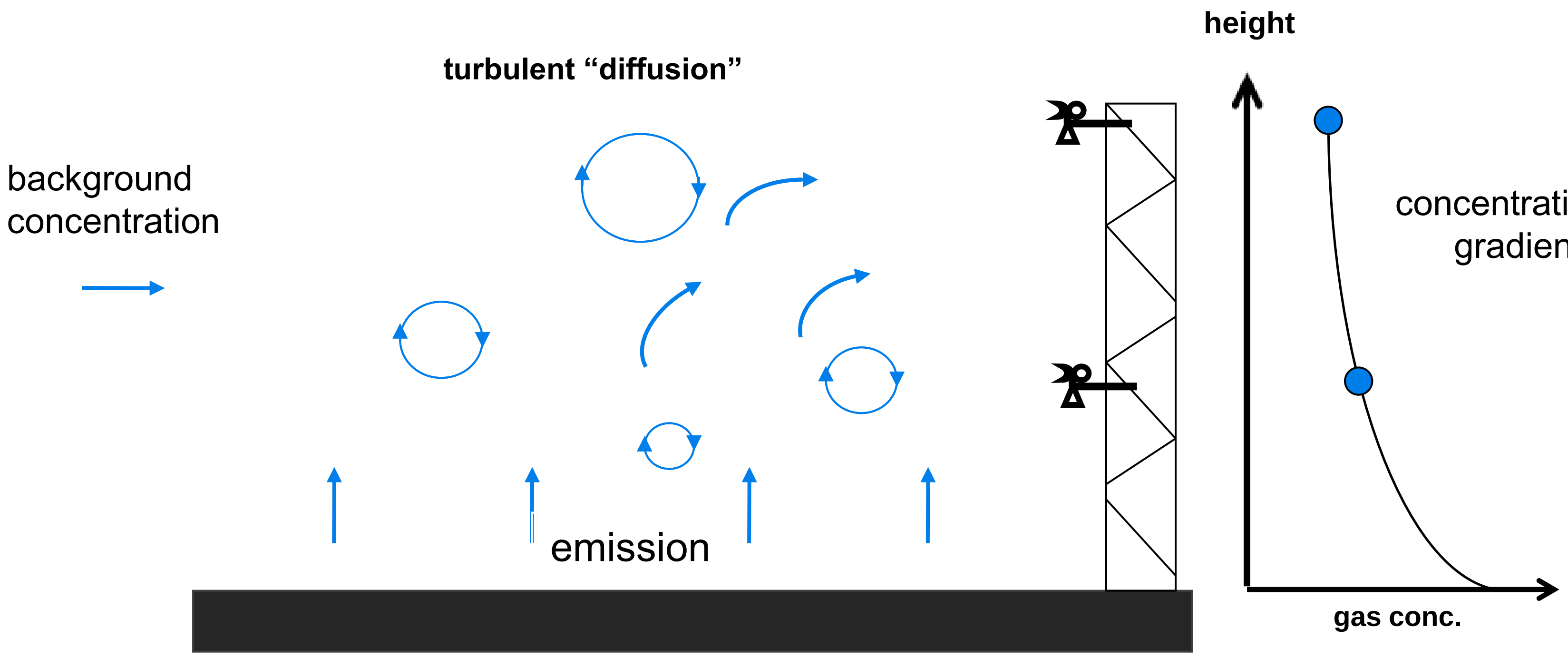
CO_2 FLUXES



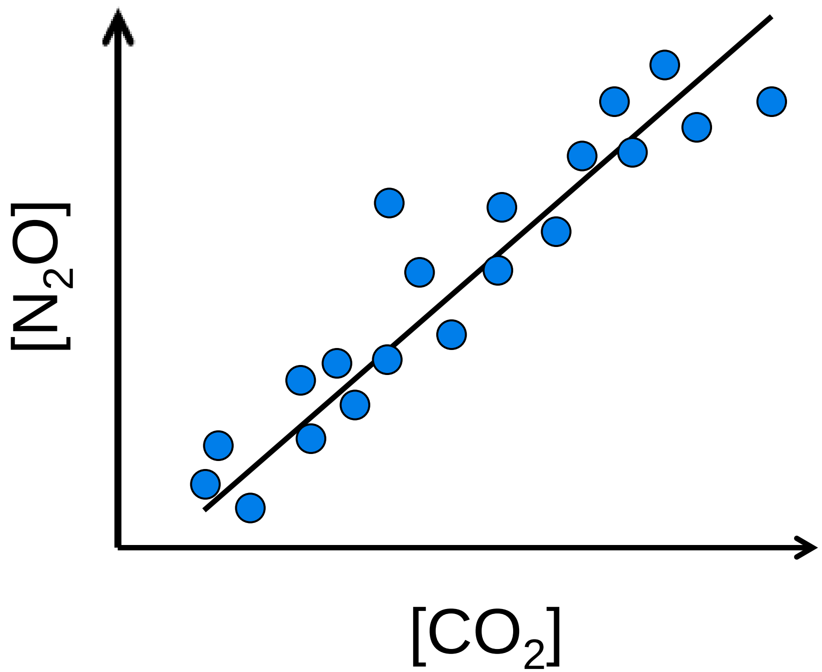
100
0
−100
−200
−300
Cumulative NEE [g C m−2]
irrigated
non−irrigated
Sep
Nov
Jan
Mar
May
Jul
Month [2012 − 2013]

CH_4 AND N_2O – FLUX GRADIENT METHOD

$$F_{CH4} = F_{CO2} \frac{\Delta C_{CH4}}{\Delta C_{CO2}}$$



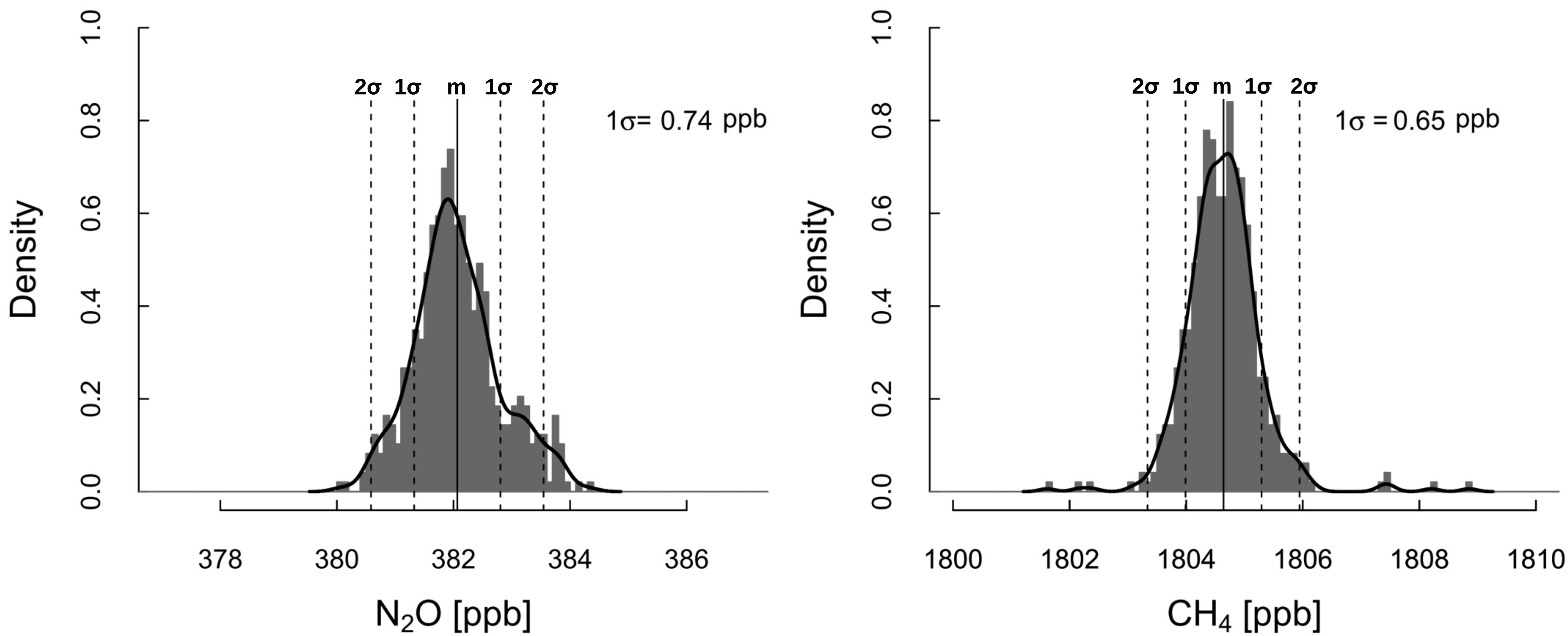
CH_4 AND N_2O – NOCTURNAL BOUNDARY LAYER METHOD



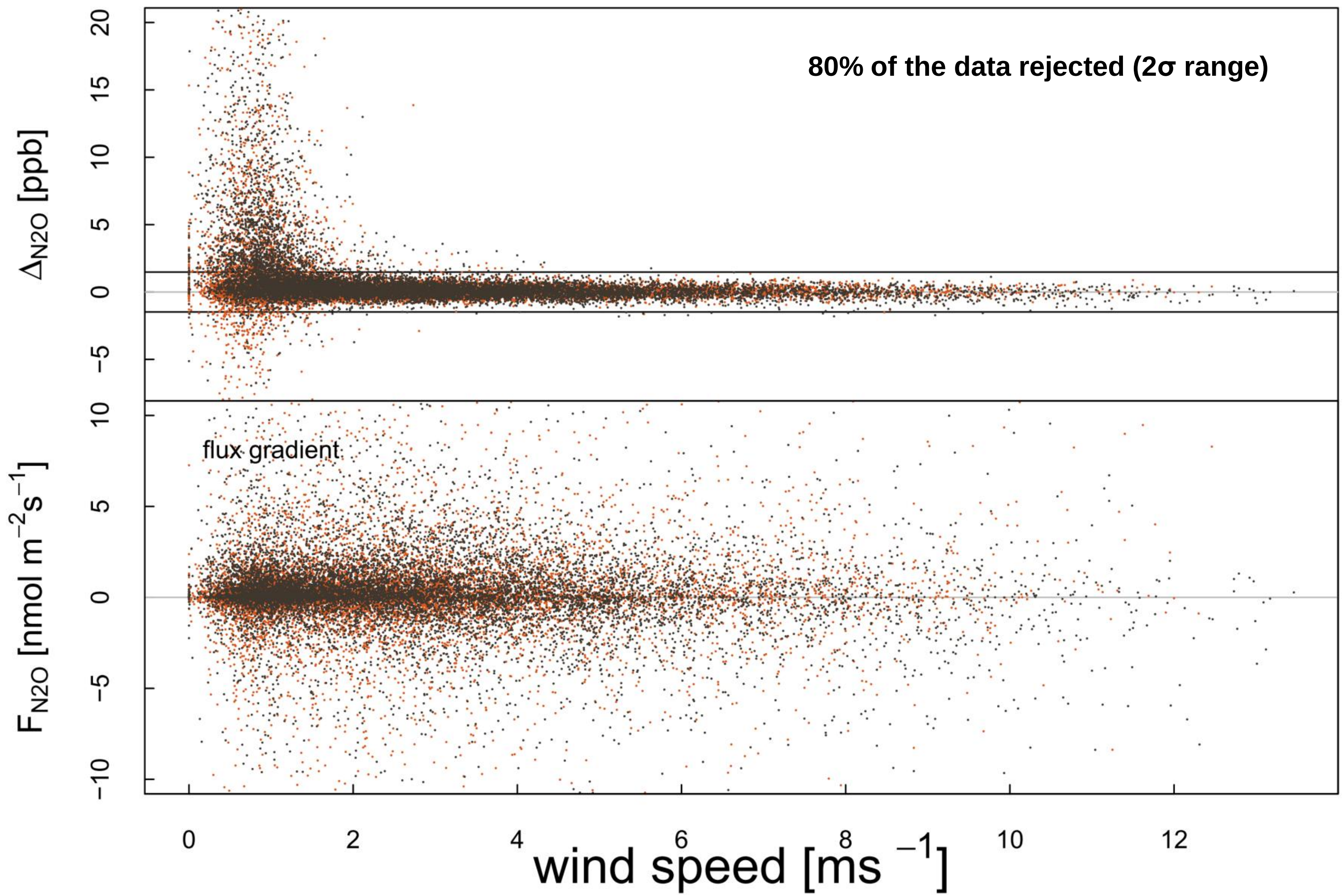
y = mx + c

$$F_{N2O} = mF_{CO2}$$

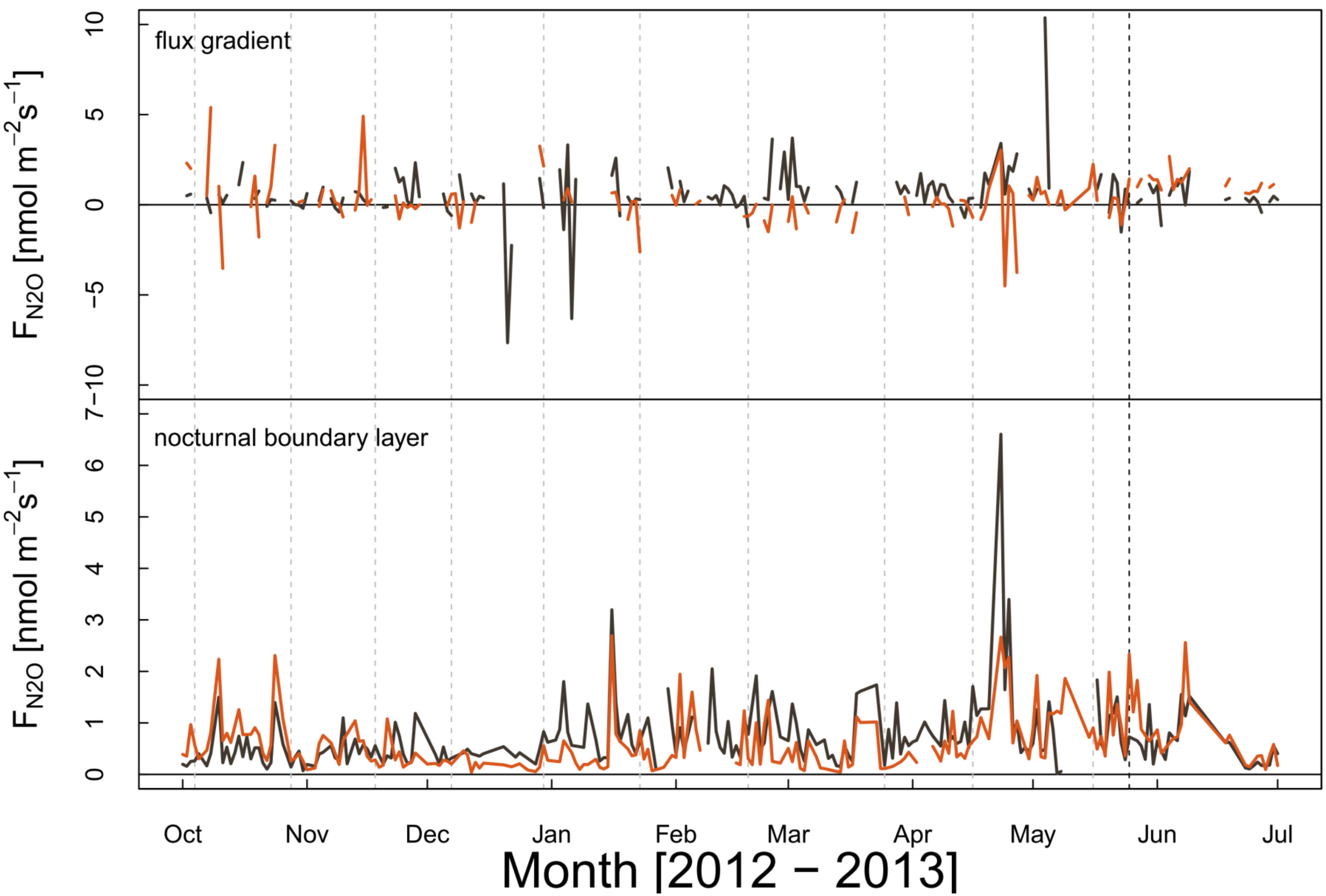
FTIR – LONG TERM STABILITY



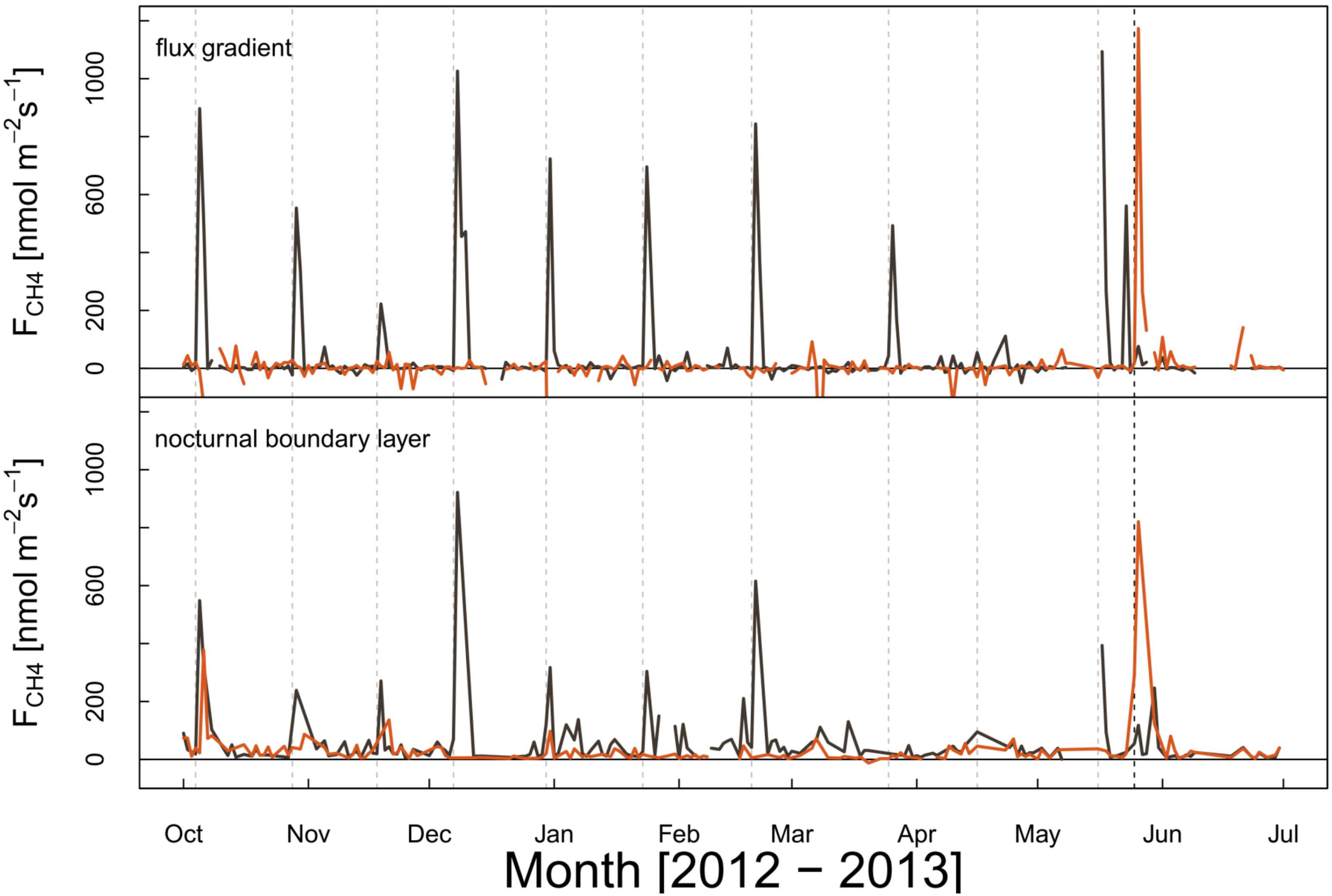
N_2O Fluxes


80% of the data rejected (2σ range)
flux gradient
Δ_{N2O} [ppb]
F_{N2O} [nmol m^{-2}s^{-1}]
wind speed [ms $^{-1}$]
20
15
10
5
0
−5
10
5
0
−5
−10
0
2
4
6
8
10
12

N_2O FLUXES


flux gradient
nocturnal boundary layer
F_{N2O} [nmol m^{-2}s^{-1}]
F_{N2O} [nmol m^{-2}s^{-1}]
10
5
0
−5
−10
7
6
5
4
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Month [2012 − 2013]

CH_4 FLUXES



flux gradient
nocturnal boundary layer
F_{CH4} [nmol m^{-2}s^{-1}]
0
200
600
1000
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Month [2012 − 2013]

SUMMARY

Continuously measure CO_2, N_2O and CH_4

CO_2

- Pre-grazing standing biomass is reasonably homogeneous
- Daily LAI derived from continuous NDVI measurements
- Each grazing changes NEE abruptly from sink to source
- Non-irrigated site is carbon neutral

N_2O & CH_4

- FG more suitable for CH_4 fluxes
- Methane is only detected when cows are in paddock
- NBL technique can detect N_2O fluxes
- N_2O differences between intakes are within the detection limit of the instrument in 80% of the cases → usage of FG challenging

✉ Contacts

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Funding and collaboration

Core Funding from Ministry of Science and Innovation

• Ministry of Agriculture & Forestry, Ministry for the Environment
• New Zealand Agricultural Greenhouse Gas Research Centre.
• Synlait Farms™

Collaborative research with NIWA, Plant and Food Research, AgResearch, Lincoln University, University of Waikato, Massey University and University of Canterbury and in partnership with the dairy farming industry.