Global Warming Potential (GWP) of GHG fluxes in Terrestrial Ecosystems

Paul Leahy, Matthias Peichl, Matteo Sottocornola, Ann-Kristin Koehler, Mikhail Mishurov, Ger Kiely

HYDROMET, Civil Engineering, University College Cork

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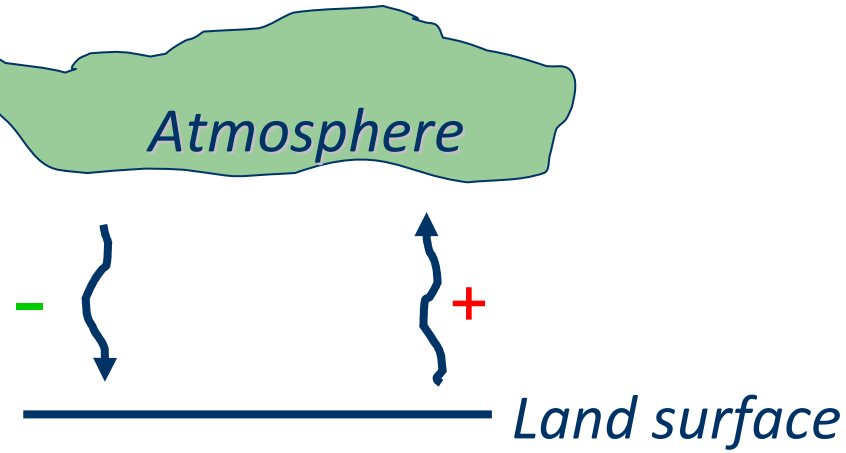
Terrestrial Ecosystems

- **Grasslands**
- **Peatlands**
- **Forestry**

GHG Fluxes: CO_2; N_2O; CH_4

Sign convention



Sink or Source

- SINK – means the ecosystem (soils + vegetation) removes carbon (as CO_2 or small amounts of N_2O or CH_4) from the atmosphere
  – computed over a timescale from 10Hz to years

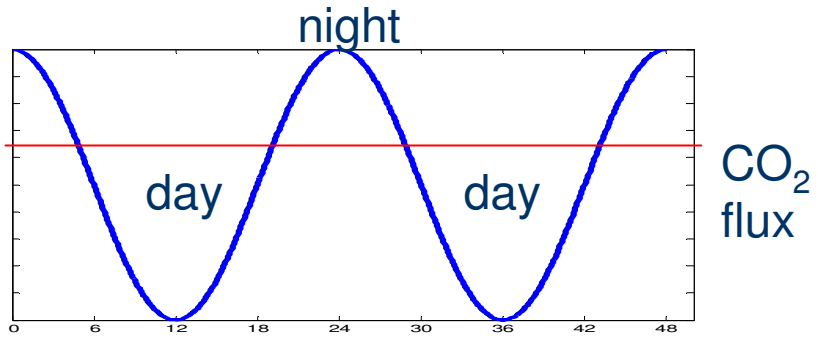
- SOURCE – means the ecosystem returns carbon (and/or N_2O or CH_4 to the atmosphere

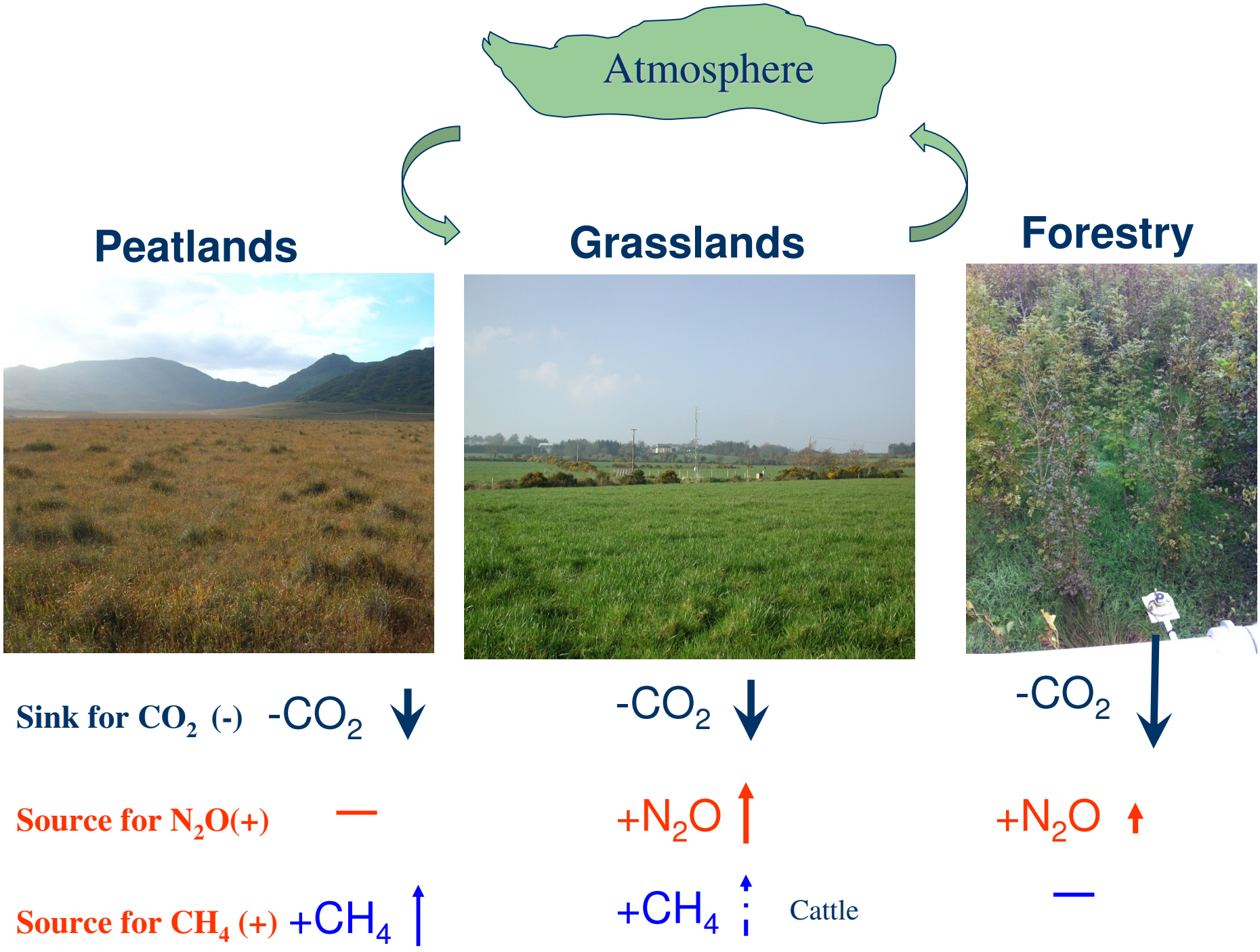
Annual NEE = Net Ecosystem Exchange = CO_2 Uptake (mostly but not always)

NEE = P_G – Rtot

P_G = Gross Photosynthesis

Rtot = Total Respiration (soil + plant)




Atmosphere
Peatlands
Grasslands
Forestry
Sink for CO_2 (-) $-CO_2$
Source for N_2O(+)
Source for CH_4 (+) $+CH_4$
$-CO_2$
$+N_2O$
$+CH_4$
Cattle
$-CO_2$
$+N_2O$

Global Warming Potential

Global Warming Potential (GWP) is a measure to compare the global warming effect of a unit mass of a greenhouse gas (GHG), *x*, to that of a reference GHG, *r*, over a given horizon, *TH*.

$$GWP(x) = \frac{\int_0^{TH} a_x \cdot [x(t)]dt}{\int_0^{TH} a_r \cdot [r(t)]dt}$$

CO_2 is normally chosen as the reference gas.

Global Warming Potential (GWP)

$$GHG's = -\ ?\ CO_2 \ + \ ?\ CH_4 \ + \ ?N_2O$$

- CO_2: **1.0** (reference GHG)
- CH_4 **25**
- N_2O **298**

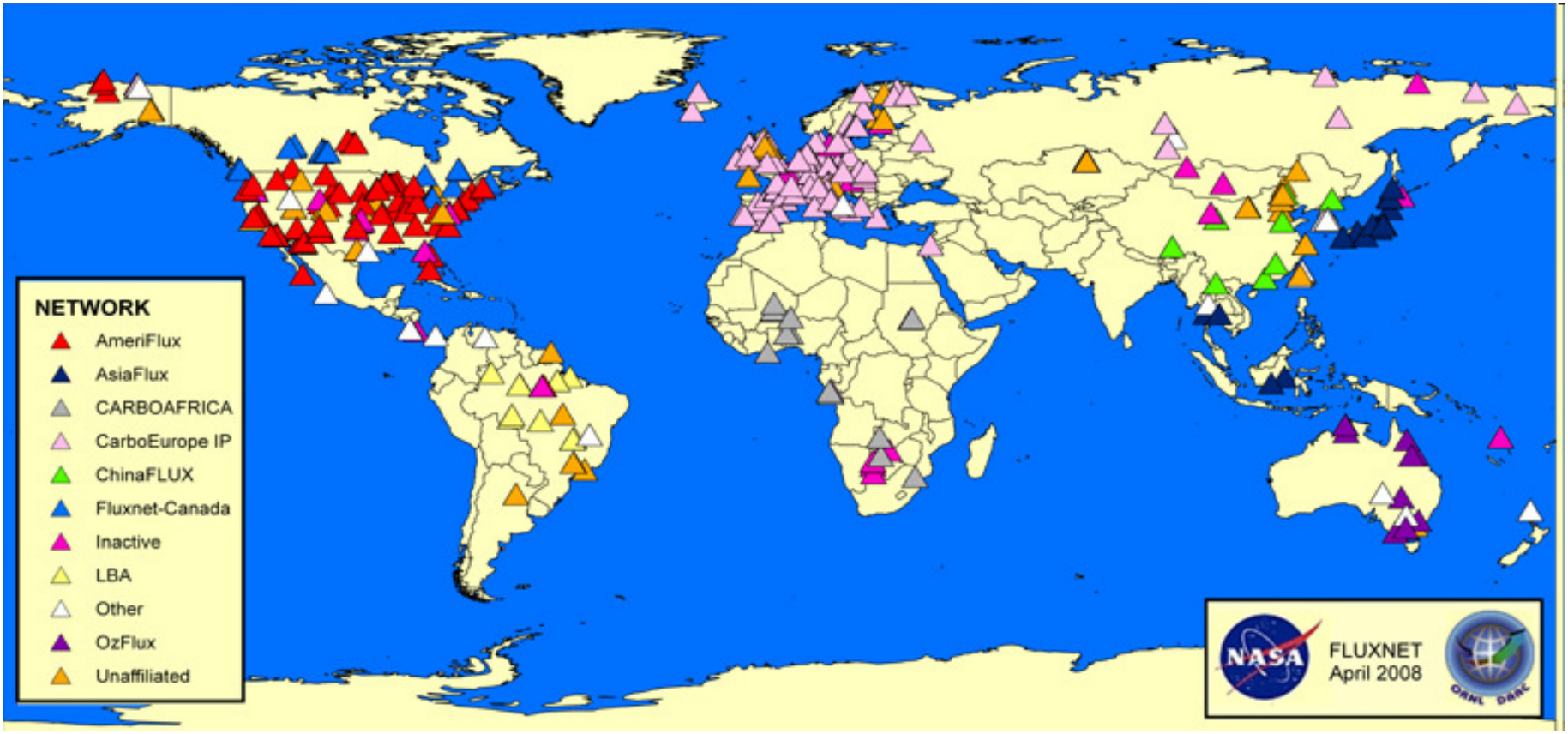
(time horizon: 100 years)

Source: IPCC 2007

GHG Flux studies

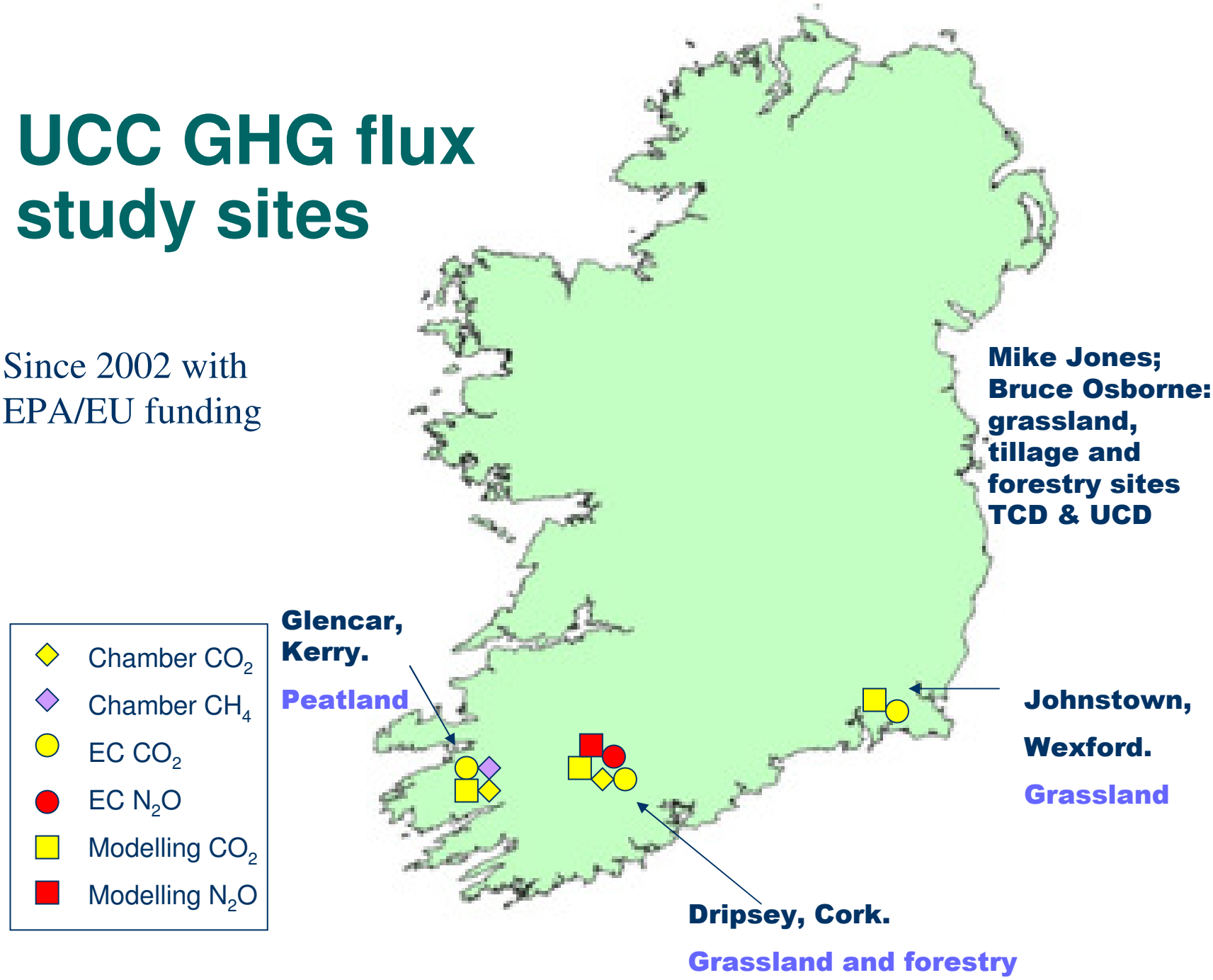
- **Eddy Covariance** measurements
  - Continuous, year-round
  - Provides annual flux sums at the ecosystem scale ~ km^2
- Chamber measurements
  - Plot scale
  - Highly defined small areas ~ m^2
- Flux modelling
  - Isolate controlling environmental factors
  - Investigate scenarios e.g. climate change
  - Upscale to regional, national levels

Global FLUXNET sites

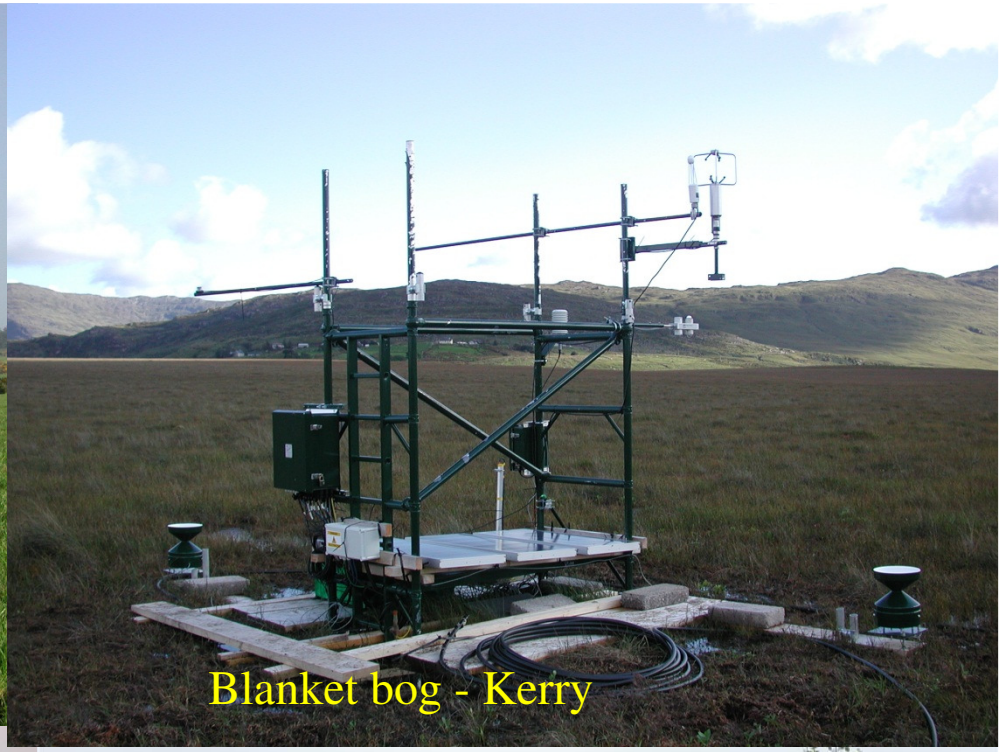


UCC GHG flux study sites

Since 2002 with EPA/EU funding



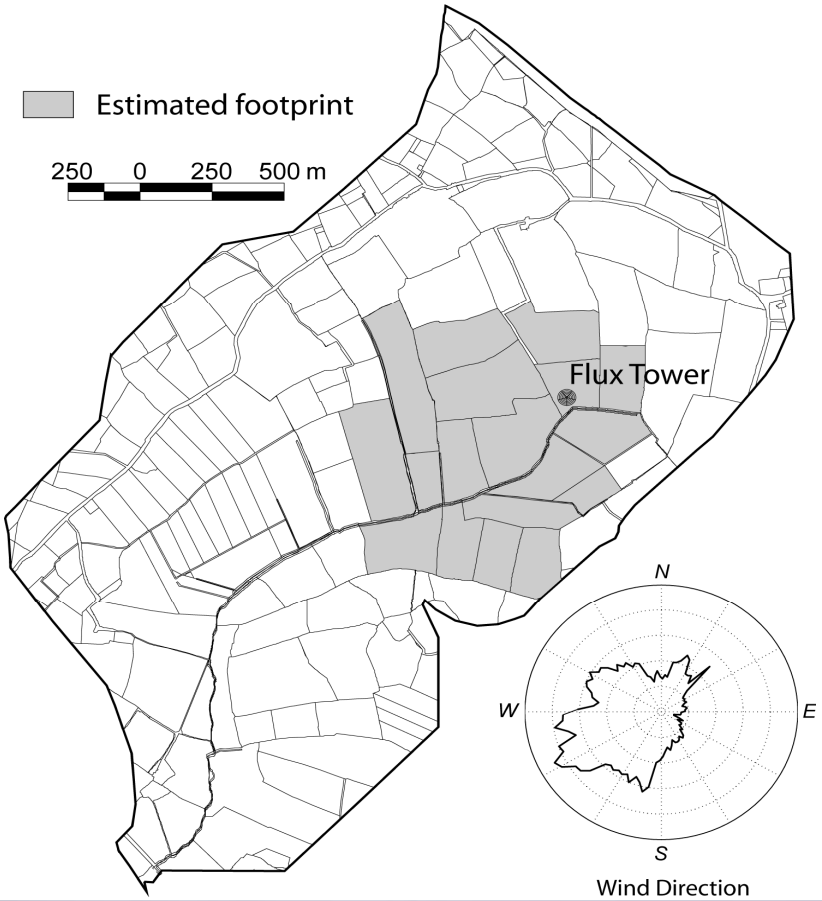
Grassland – Dripsey, Cork

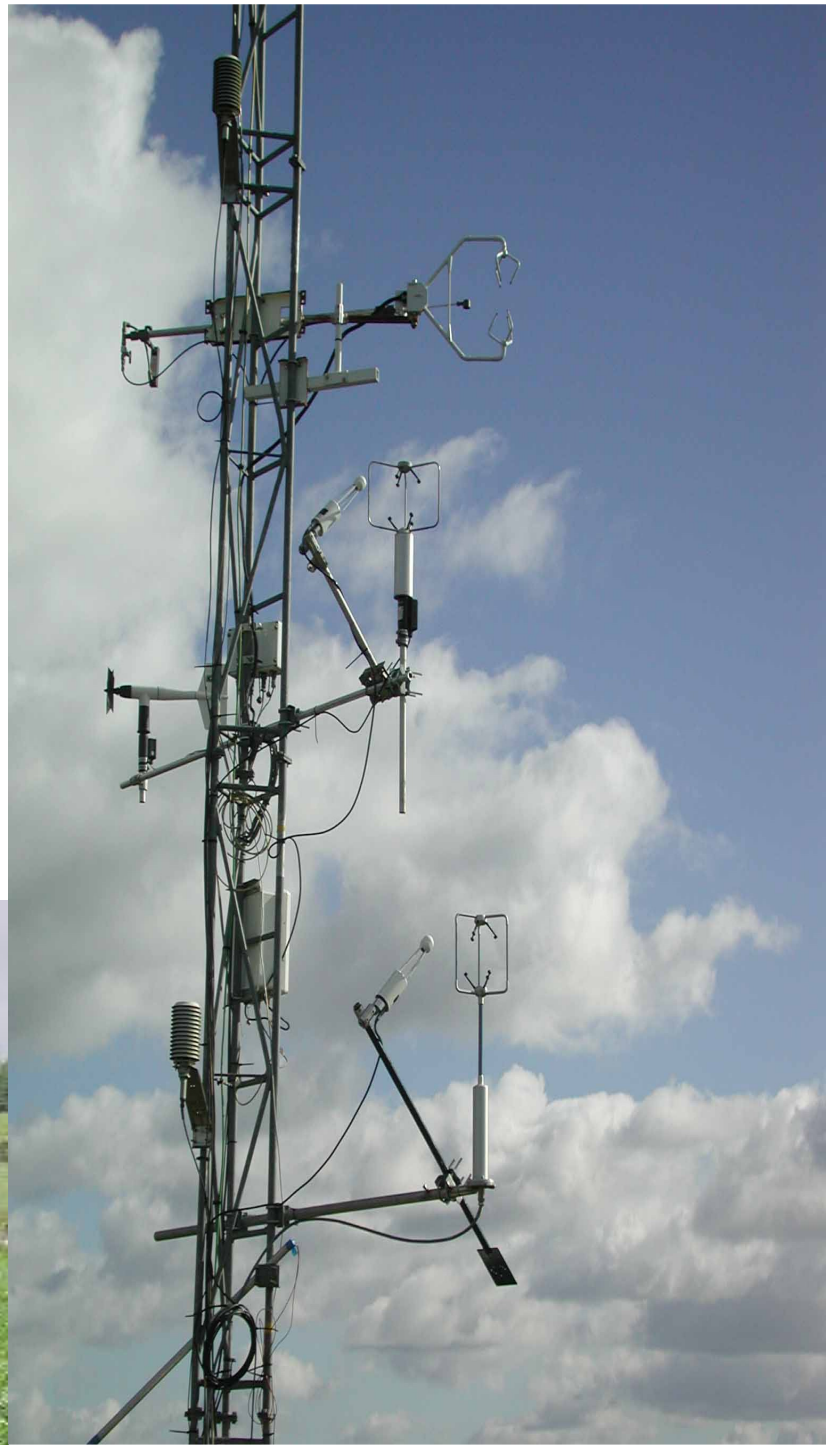


Blanket bog - Kerry

Grassland – Wexford

Broadleaf Forestry - Cork


Estimated footprint
250 0 250 500 m
Flux Tower
N
W
E
S
Wind Direction



Eddy Covariance CO_2 Flux measurements

LI-7500 Open Path CO_2/H_2O gas analyser

3D-Sonic anemometer

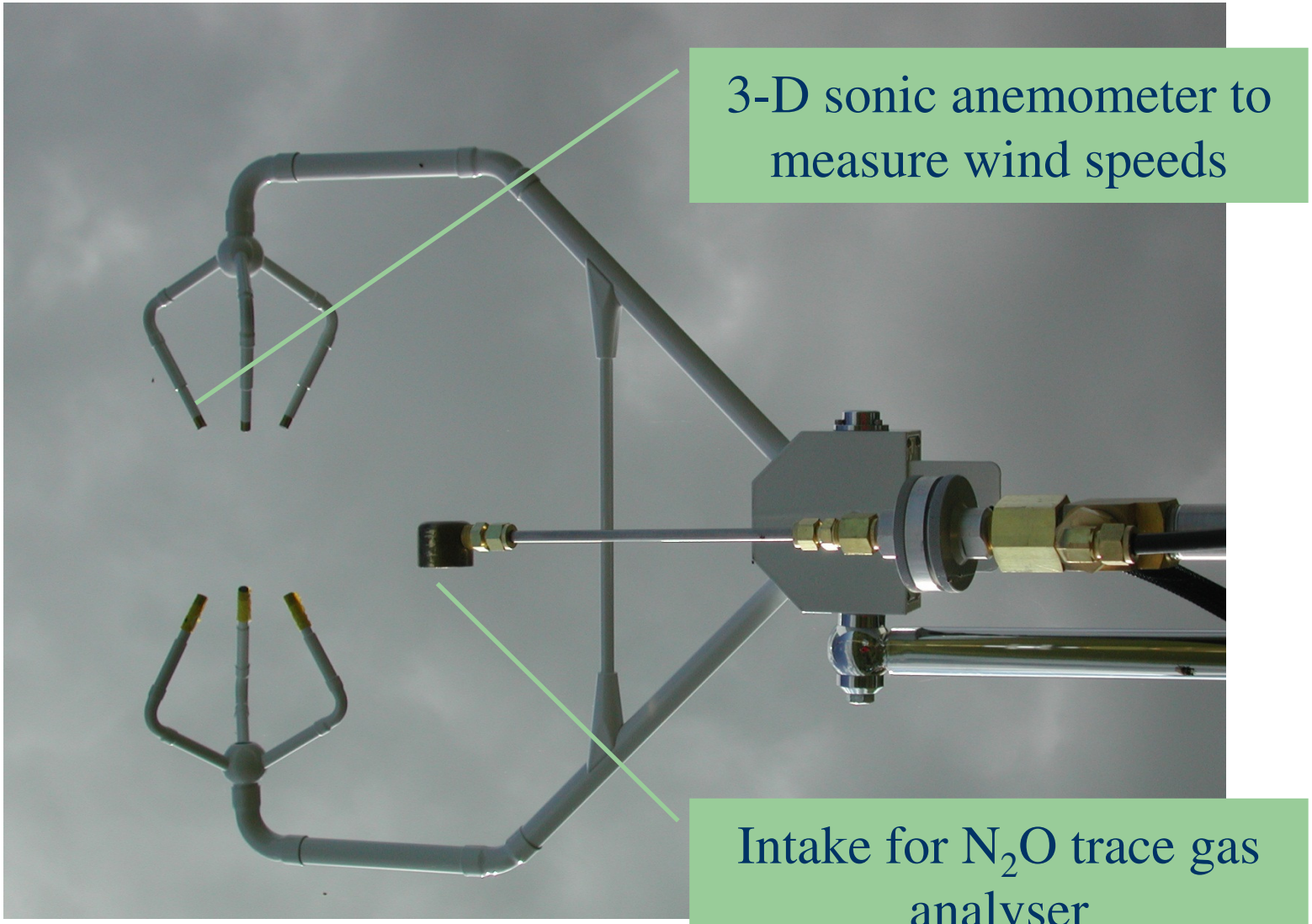
We sample the turbulent motion between the biosphere and the atmosphere to determine the net difference of moving material (CO_2, N_2O, CH_4). We sample the 3D wind speed and GHG concentrations at 10Hz and then average over 30 min

$$F_c \cong -\overline{w'\,\rho_c'}$$

w' = fluctuation of the vertical wind speed @ 10 Hz

ρ_c' = density fluctuation of CO_2 @ 10 Hz

Eddy Covariance N_2O Flux measurements



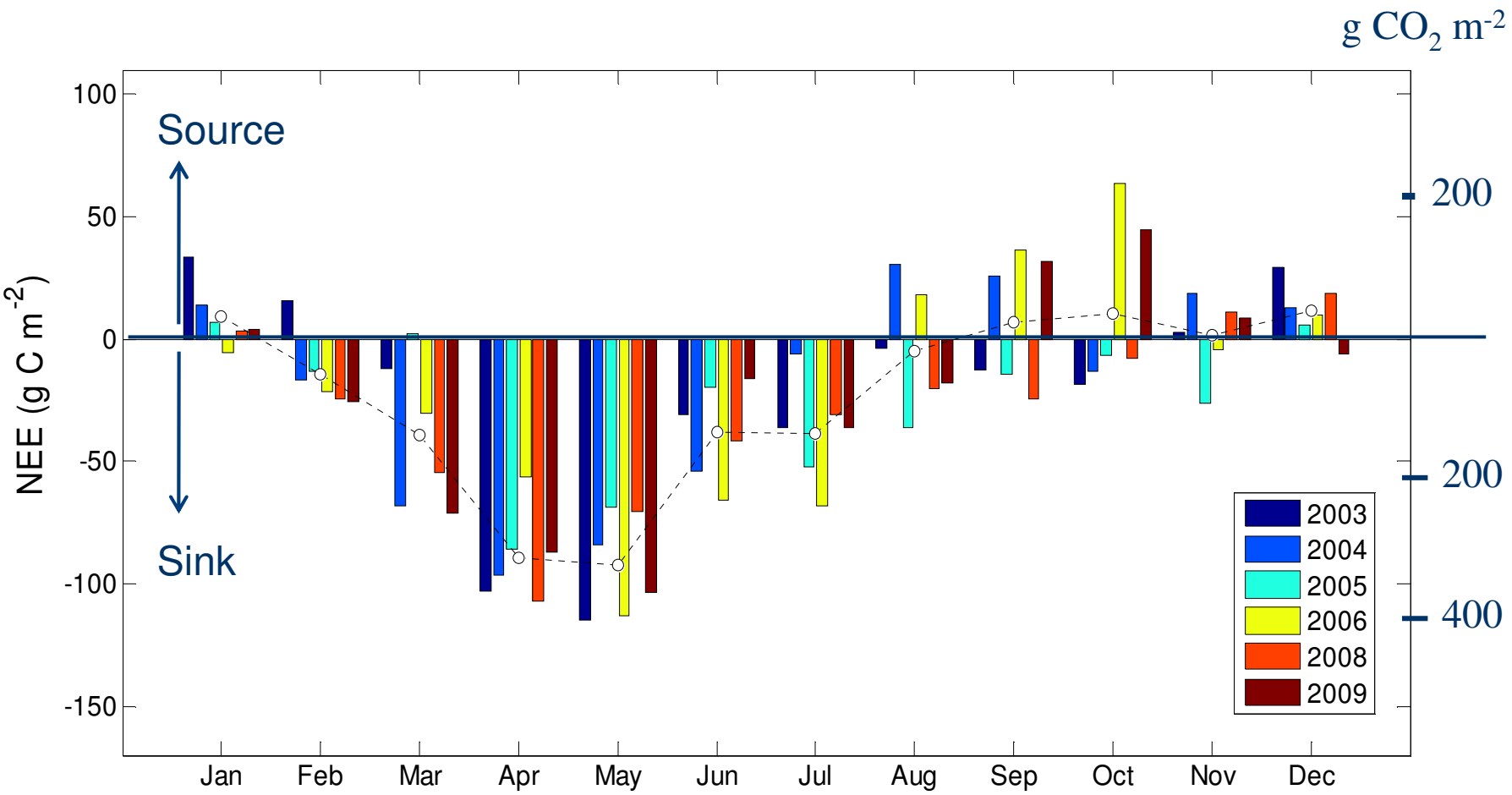
N_2O - Tuneable Diode Laser Absorption Spectrometer

TGA100
Trace Gas
Analyser

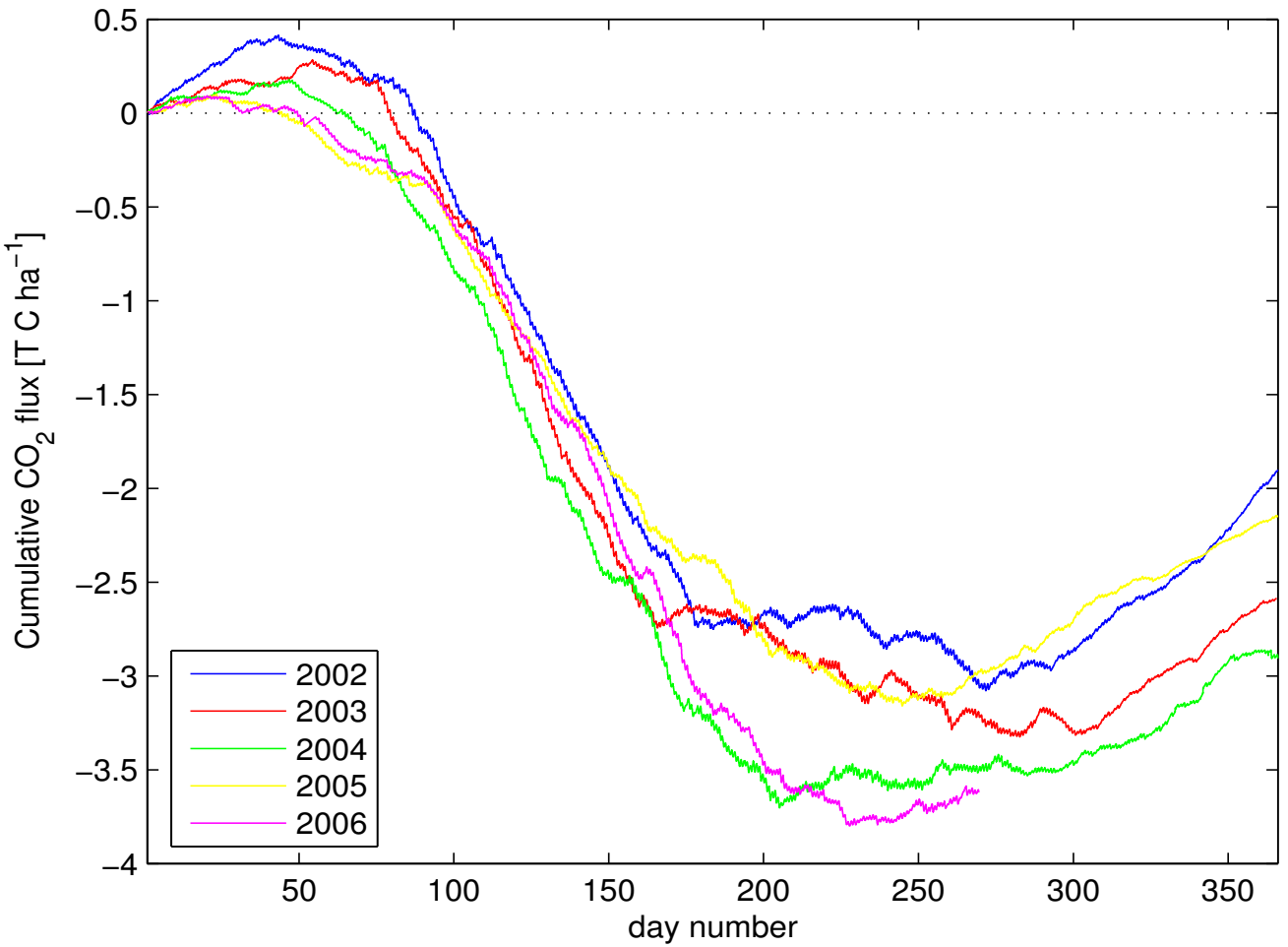
N_2O
concentrations
at 10 Hz in
ppb

Dripsey – Monthly Uptake – (NEE – Net Ecosystem Exchange)

Managed grassland - 3 farms – mix of grazing + silage fields



Dripsey Grassland CO_2 fluxes 2002-2006



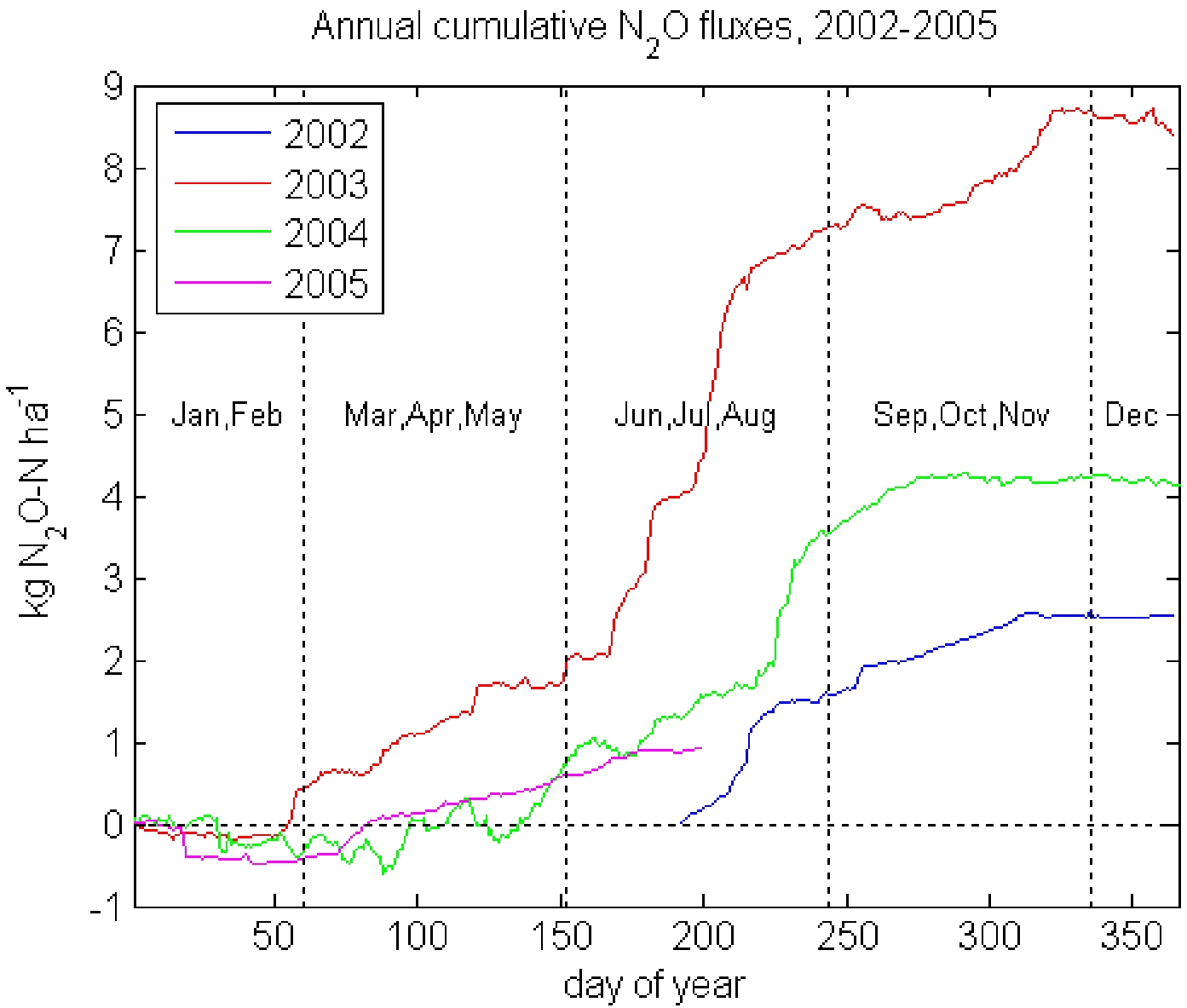
Range or interannual variability

2 to 3 T C/ha.yr

or

7 to 11 T CO_2/ha.yr

Dripsey Grassland N_2O fluxes 2002-2005



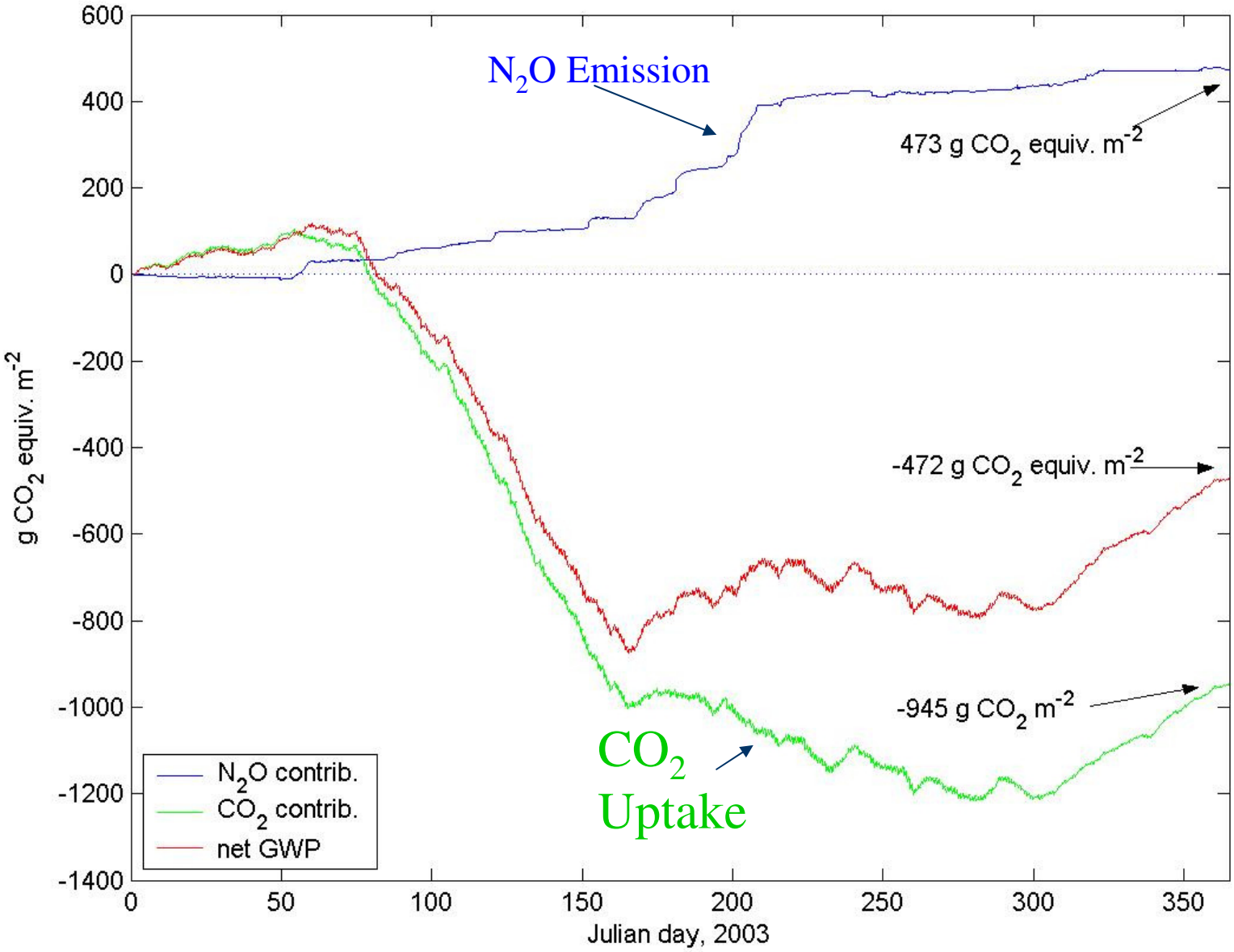
Range or interannual variability

3 to 10 kg N-N_20/ha.yr

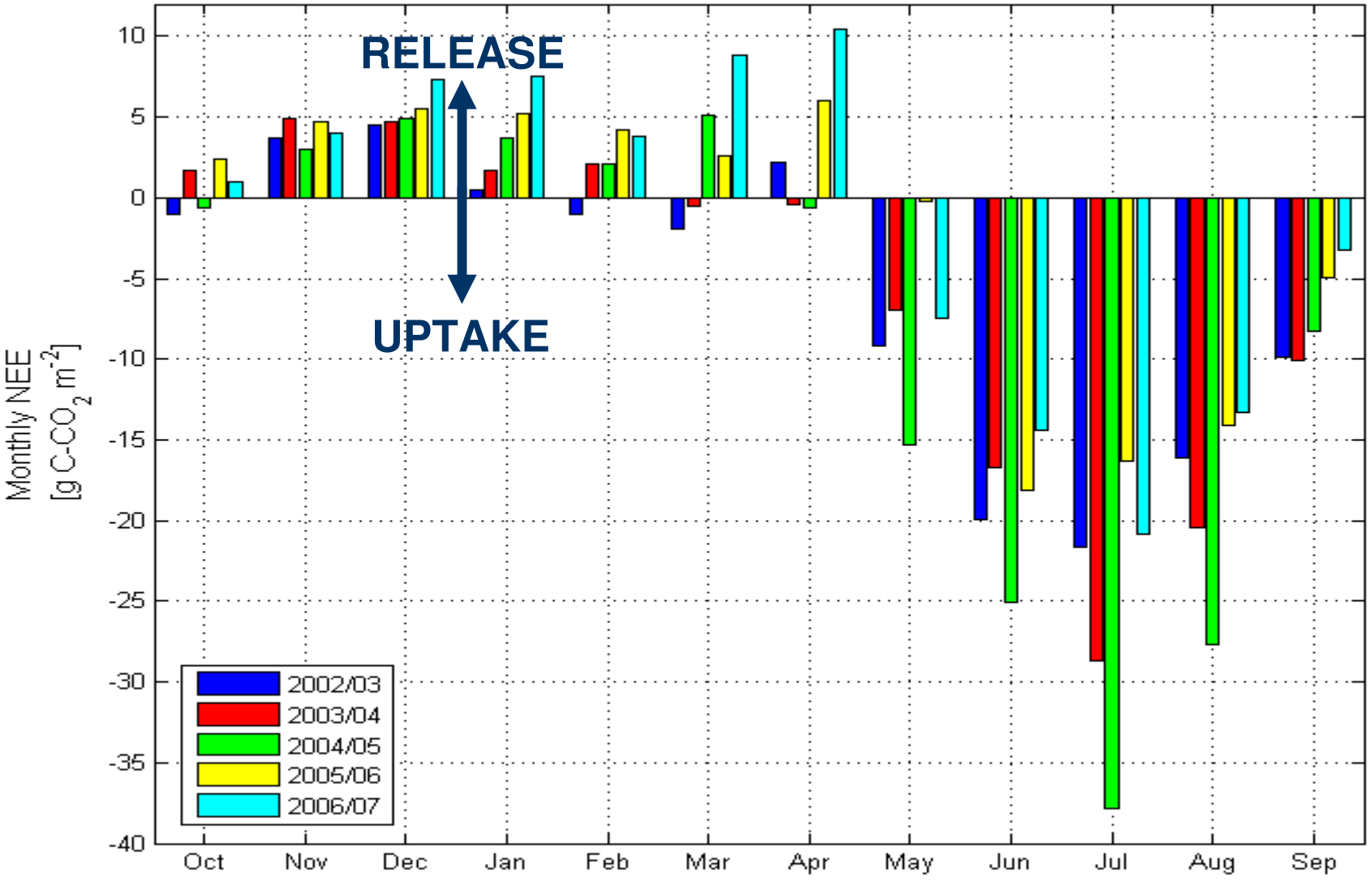
or

1.4 to 4.5 T.CO_2 eq/ha. yr

Dripsey Grassland - GWP 2003

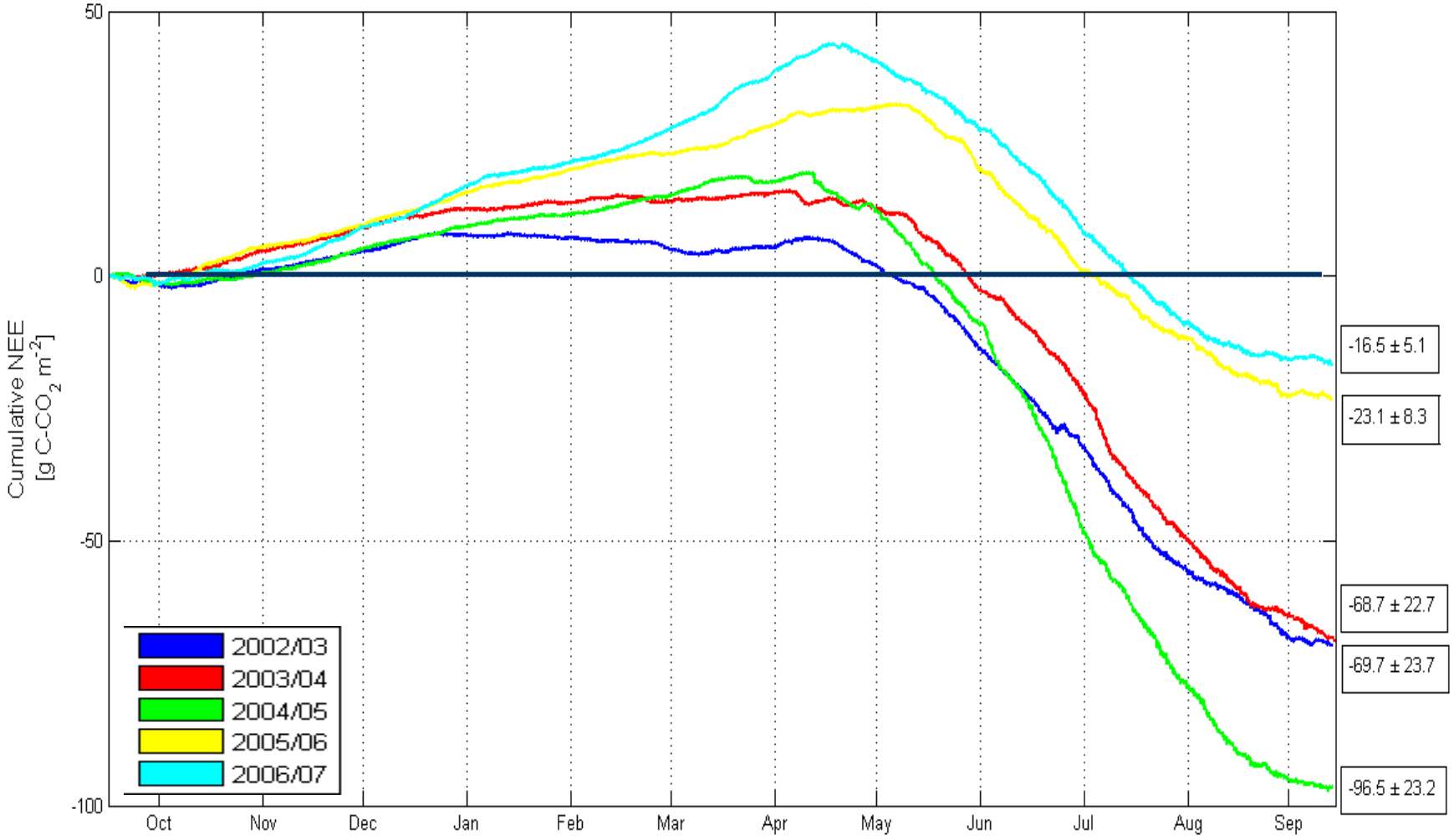


PEATLAND: monthly CO_2 flux

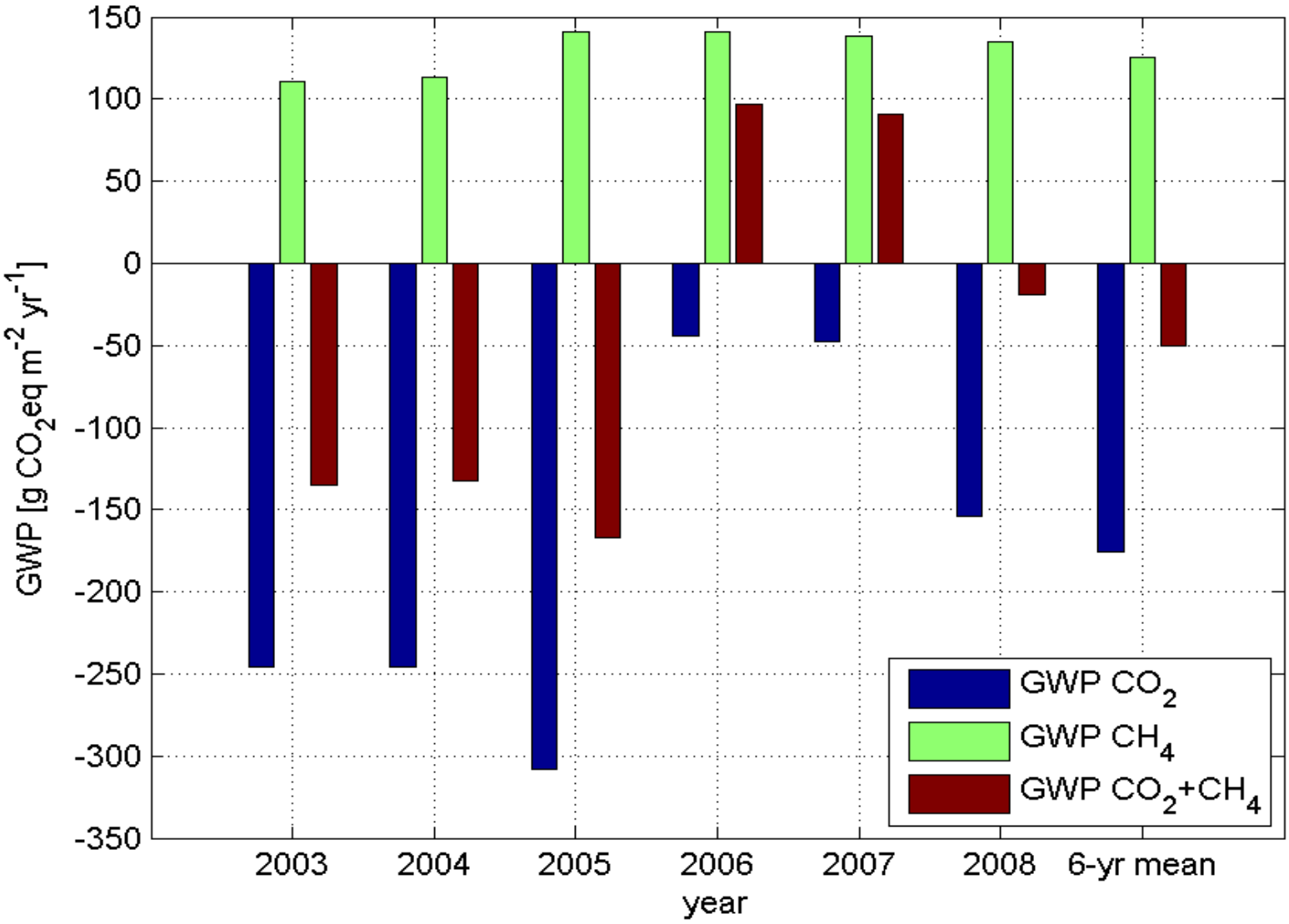


Sottocornola & Kiely, 2010. Agricultural and Forest Meteotology

PEATLAND: cumulative CO_2 flux



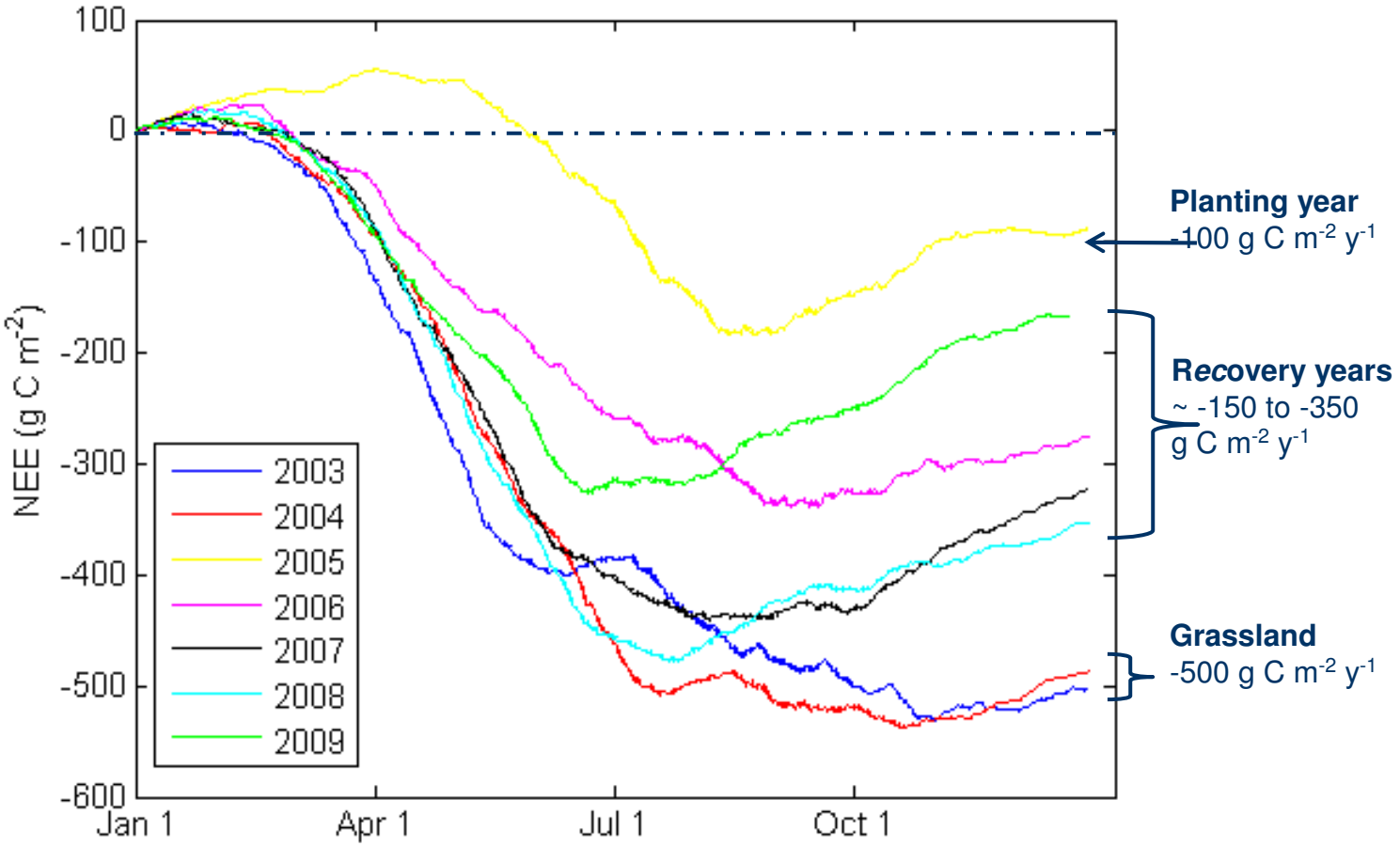
GWP - PEATLAND



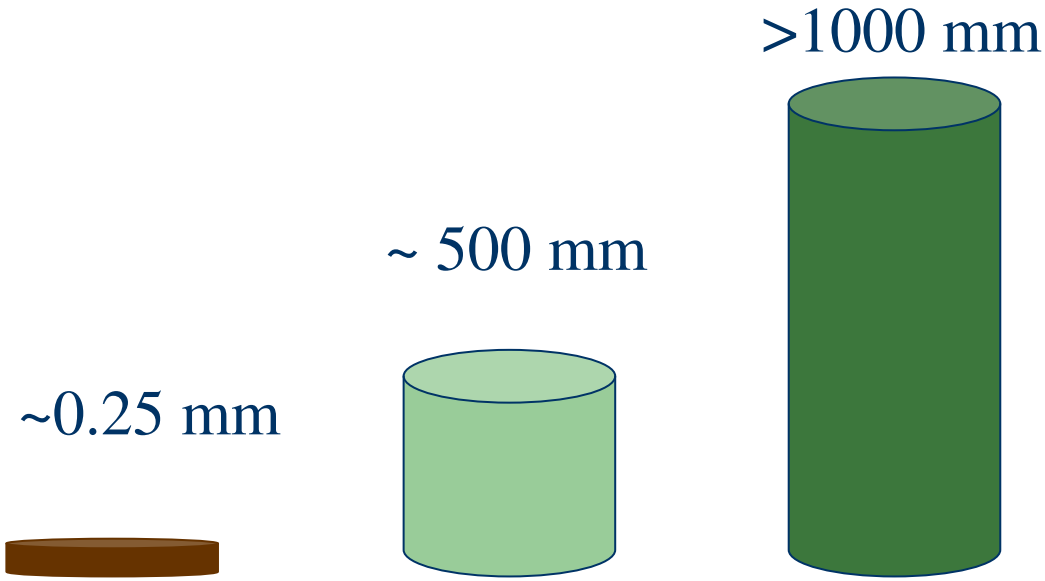
Land Use Change (LUC)

Grassland to Broadleaf Forest – CO_2 Exchange

Grassland tower – forest sector, 2003 - 2009



Indicative annual biomass growth



CONCLUSIONS - GRASSLAND

- *CO_2 sink range from -7 to -11 T.CO_2/ha. yr*
- *N_2O source range from +1.4 to +4.5 T.CO_2 eq/ha. yr*
- *CH_4 source range of +1.7 to +3.4 T.CO_2 eq/ha. yr*

(cattle 1-2 LU ha^{-1})

in GWP terms, the "cooling" due to the CO_2 sink is reduced by ~2/3^{rds} by the "warming" emissions of N_2O & CH_4

CONCLUSIONS - PEATLAND

- *CO_2 sink range from -0.4 to -3.3 $T.CO_2$/ha. yr*
- *CH_4 emission range from +1 to +1.5 $T.CO_2$ eq/ha. yr*

in GWP terms, the "cooling" due to CO_2 uptake is in some years cancelled by the "warming" emissions of CH_4

- this highlights the sensitivity of this ecosystem

CONCLUSIONS – New Broadleaf Forest

From 0 to 5 years (After planting)

CO_2 sink range from -3.5 to -11.0 T.CO_2/ha. yr

N_2O emission range of +2.1 to +1.1 T.CO_2 eq/ha. yr

in year 1, the "cooling" GWP ~ -1.4 T.CO_2/ha. yr

in year 5, the "cooling" GWP ~ -9.9 T.CO_2/ha. yr

Position

- Today, we have the technology to continuously measure and quantify the GHG fluxes from the different ecosystems
- Globally, there are ~ 300 research EC sites with 4/5 Irish sites
- ICOS – International Carbon Observation System aims to put GHG fluxes on a similar footing to meteorological synoptic stations with real time publicly accessible data

Acknowledgements

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