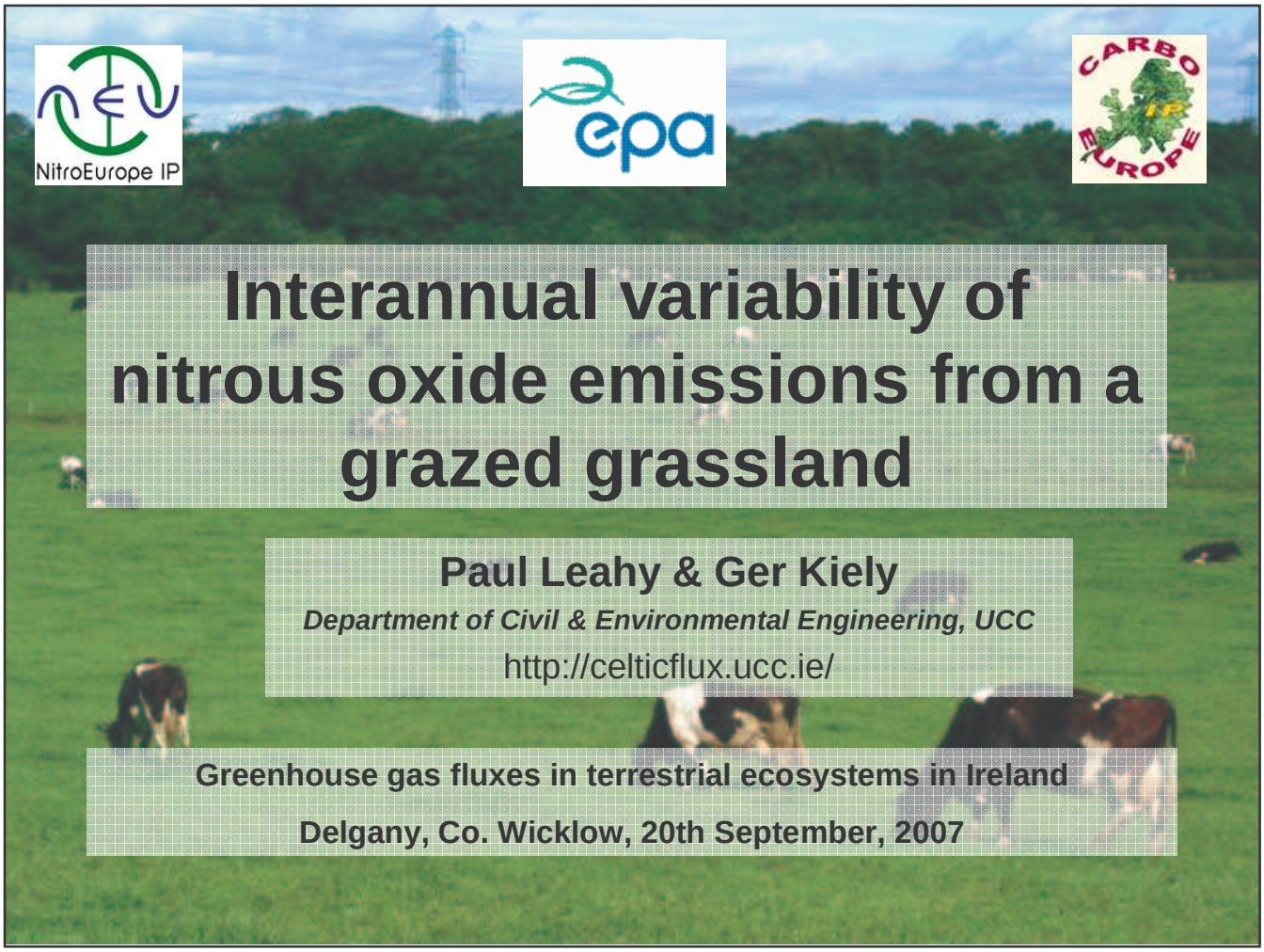

Interannual variability of nitrous oxide emissions from a grazed grassland

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http://celticflux.ucc.ie/

Greenhouse gas fluxes in terrestrial ecosystems in Ireland

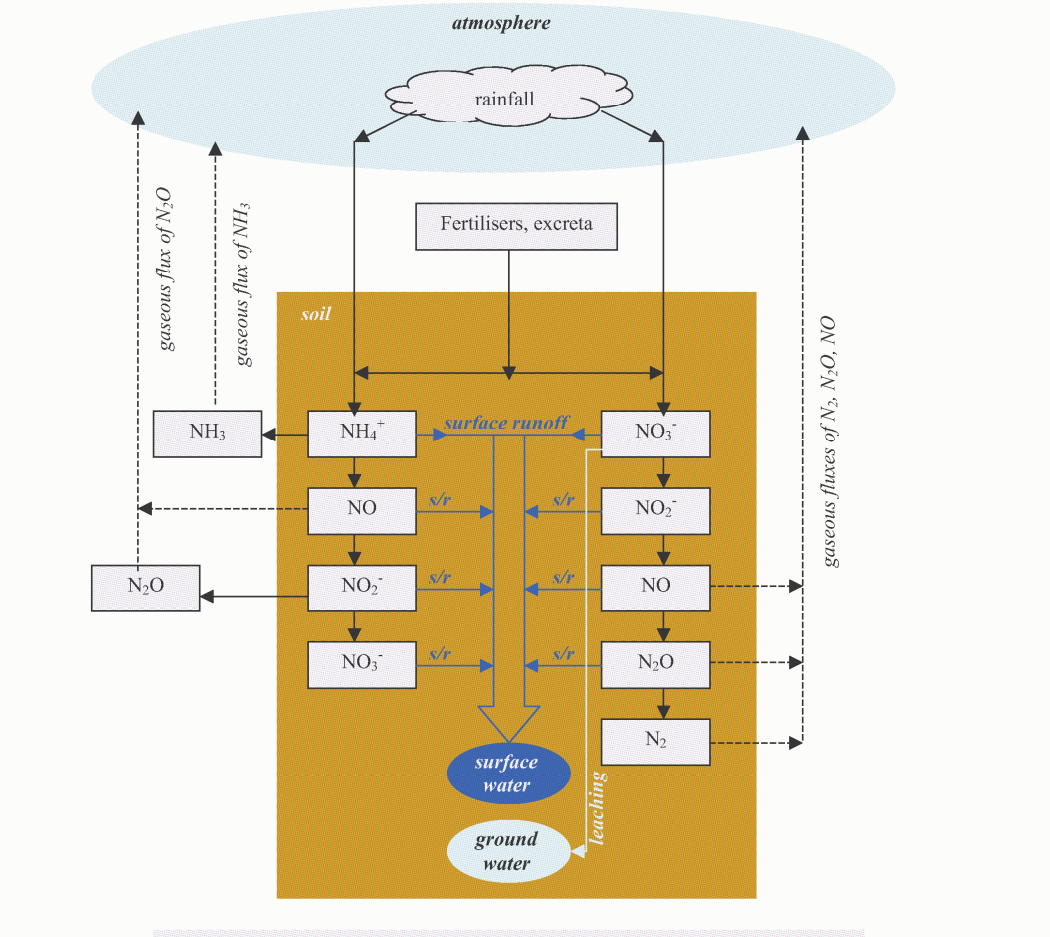
Delgany, Co. Wicklow, 20th September, 2007

Why measure N_2O fluxes?

- Potent greenhouse gas
  - 296 times atmospheric warming effect of CO_2
- 14 % of *total* Irish GHG emission is N_2O from agriculture
- Grassland is the dominant land use type in Ireland
- Management and climate control N_2O emissions

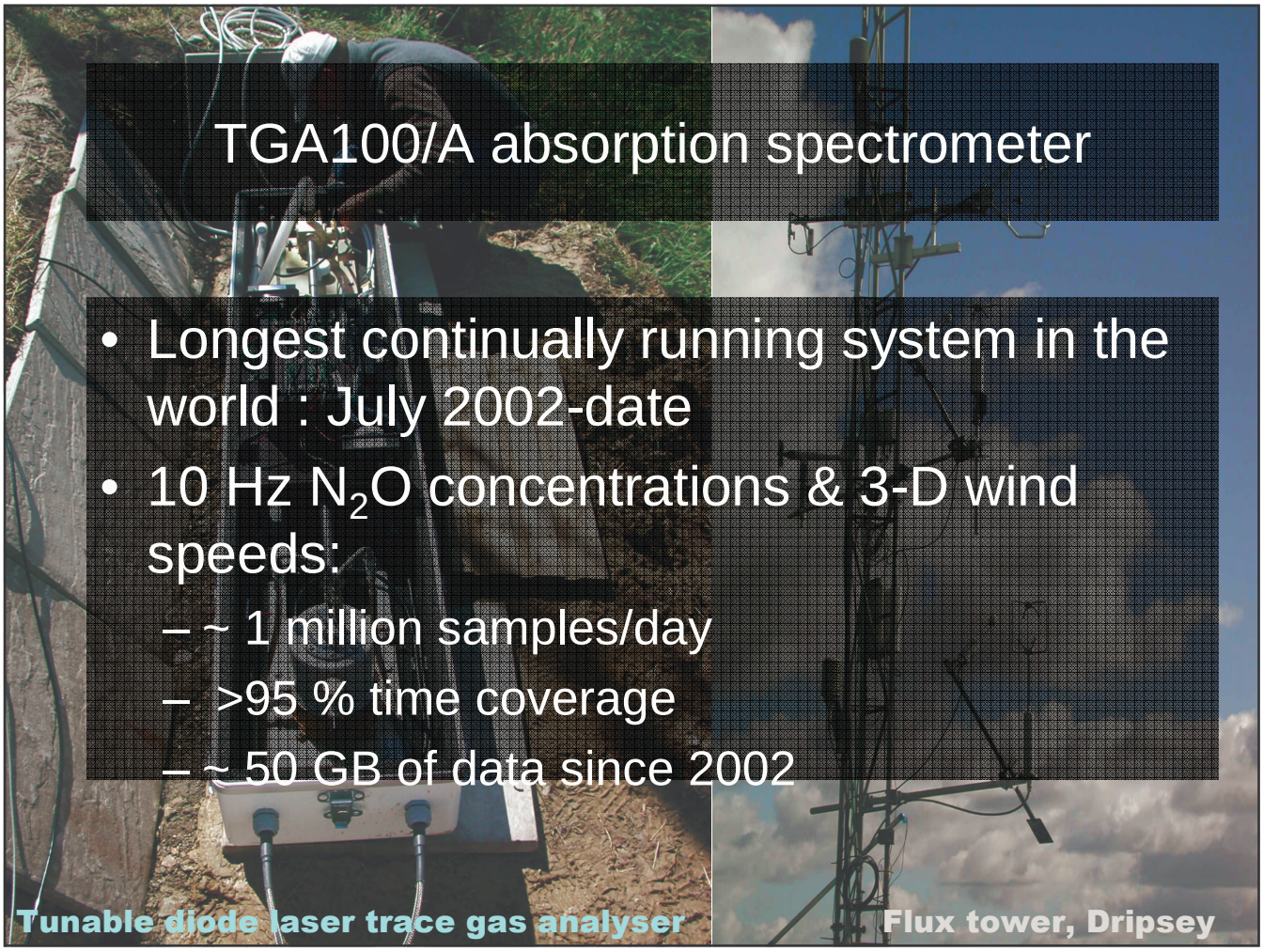
In situ measurement techniques

- Closed chambers: < 1 m^2
  - Spatial variability (if multiple chambers)
  - Limited coverage of temporal variability unless automatic
- Eddy covariance: > 1 ha
  - Can cover temporal variability
  - Integrates over space
  - How to eliminate spatial variability?

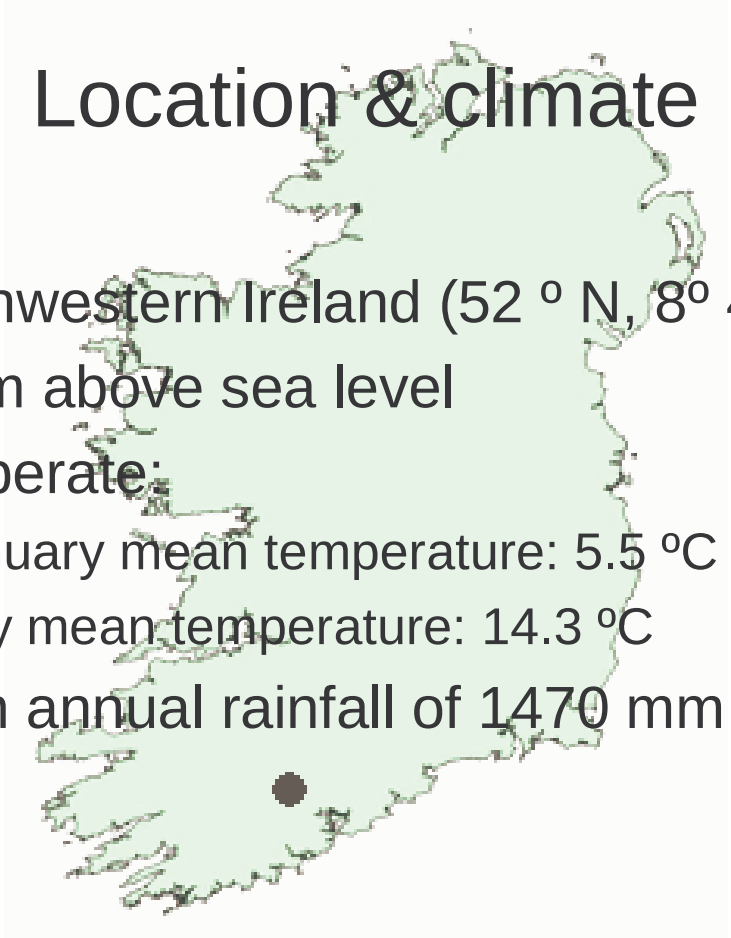

atmosphere
rainfall
Fertilisers, excreta
soil
gaseous flux of N_2O
gaseous flux of NH_3
gaseous fluxes of N_2, N_2O, NO
NH_3
NH_4^+
surface runoff
NO_3^-
NO
s/r
NO_2^-
N_2O
NO_2^-
NO
NO_3^-
N_2O
N_2
surface water
ground water
leaching

Variability of N_2O fluxes

- Spatial : CV ~ 120 %
  - Soil heterogeneity
  - Management / history
- Temporal: 10^2 within 1 week
  - Short term (“pulses”) <= 1 week
  - Background (seasonal)
  - Longer term (interannual)


TGA100/A absorption spectrometer
• Longest continually running system in the world : July 2002-date
• 10 Hz N_2O concentrations & 3-D wind speeds:
– ~ 1 million samples/day
– >95 % time coverage
– ~ 50 GB of data since 2002
Tunable diode laser trace gas analyser
Flux tower, Dripsey

Location & climate



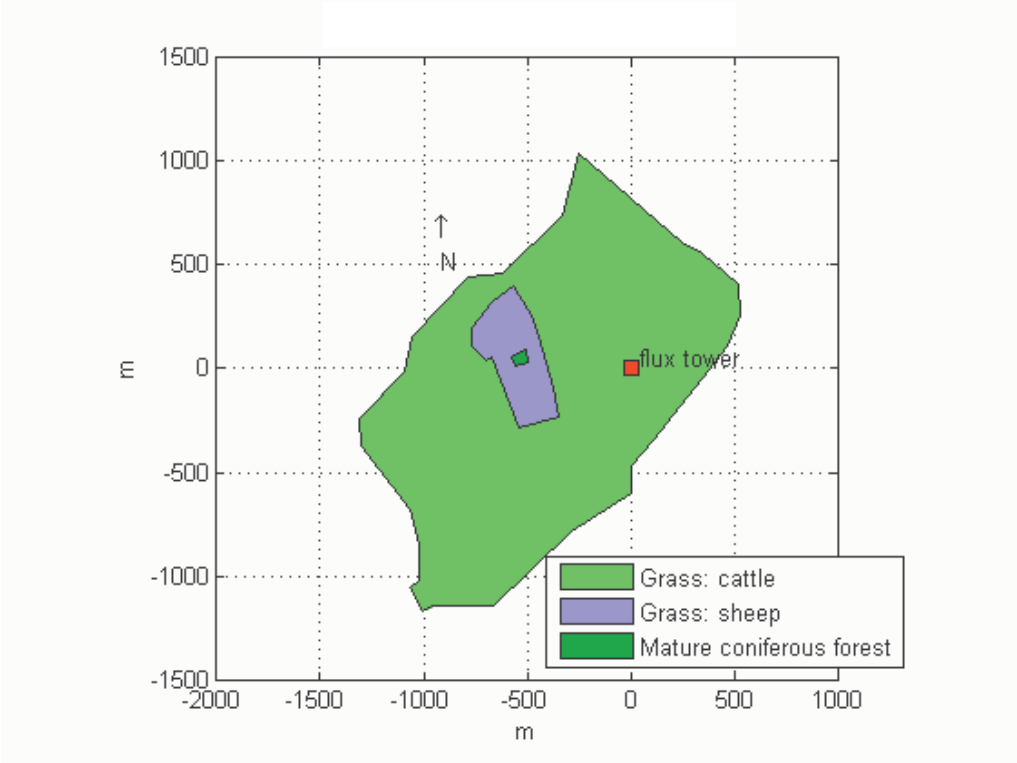
- Southwestern Ireland (52 º N, 8º 45` W)
- 180 m above sea level
- Temperate:
  - January mean temperature: 5.5 ºC
  - July mean temperature: 14.3 ºC
- Mean annual rainfall of 1470 mm

Soils

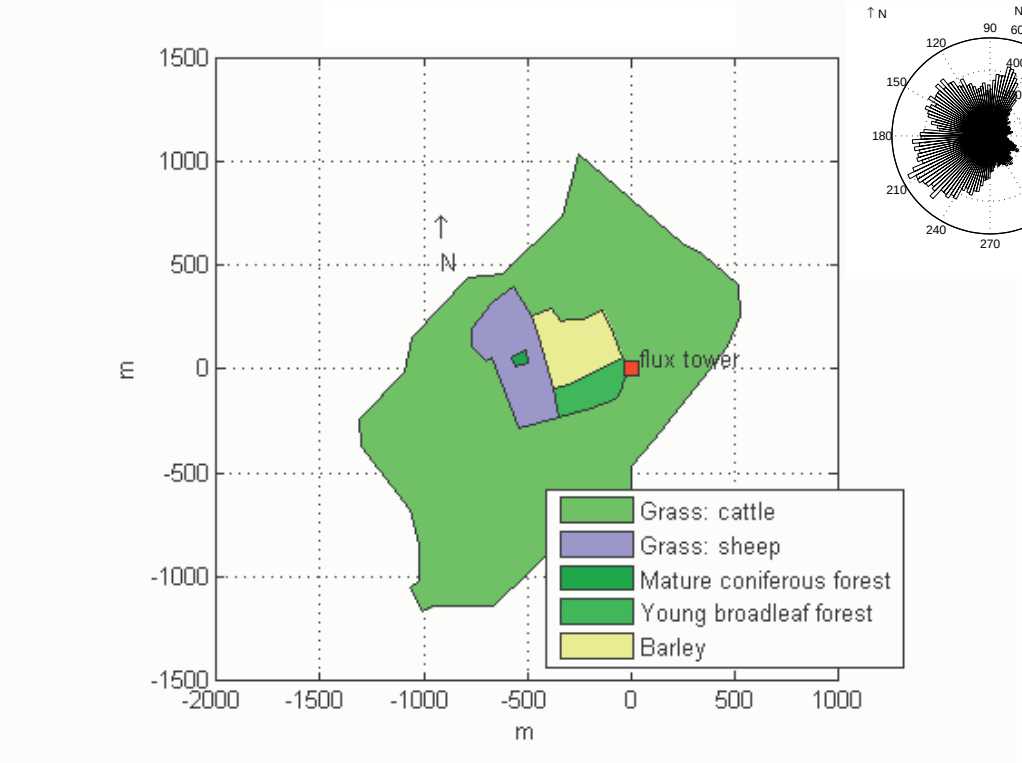
- Surface water gley[1]
- Top 20 cm is a loam
  - Subsoil (20-30 cm) is sandy clay loam / loam
- pH in top layer: 5.4 – 5.9

1 *Gardiner & Radford Irish soils map*

Land use (to Feb 2005)



Land use (after Feb 2005)

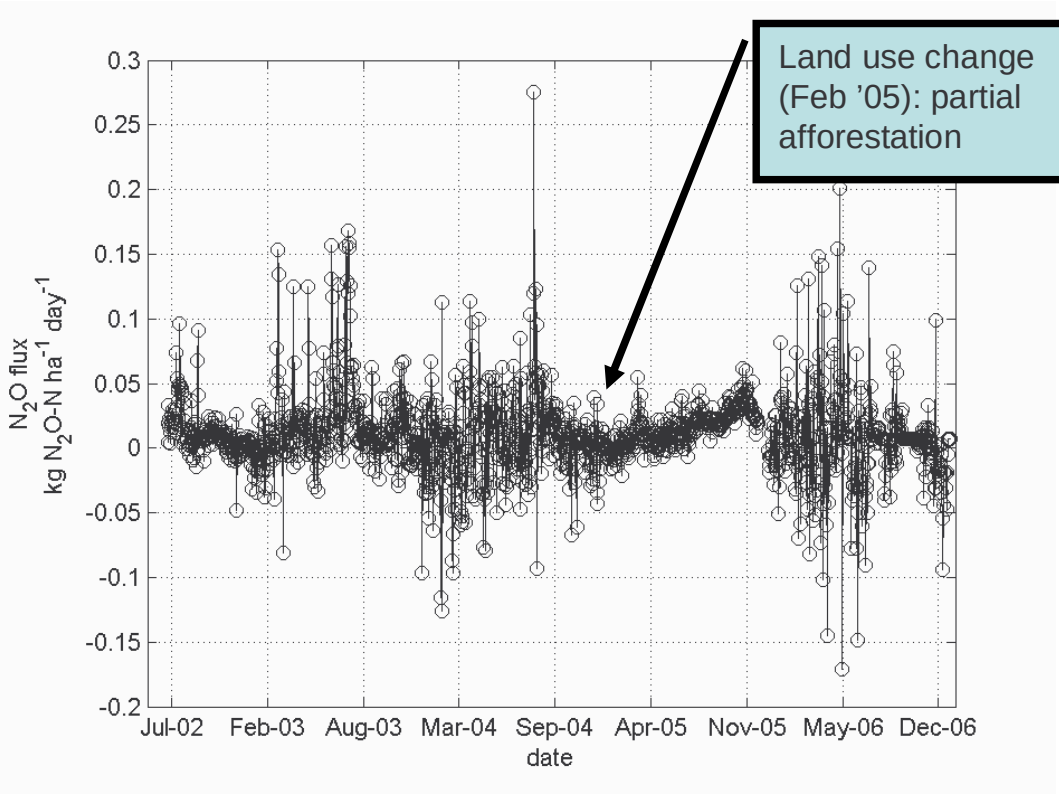


Management

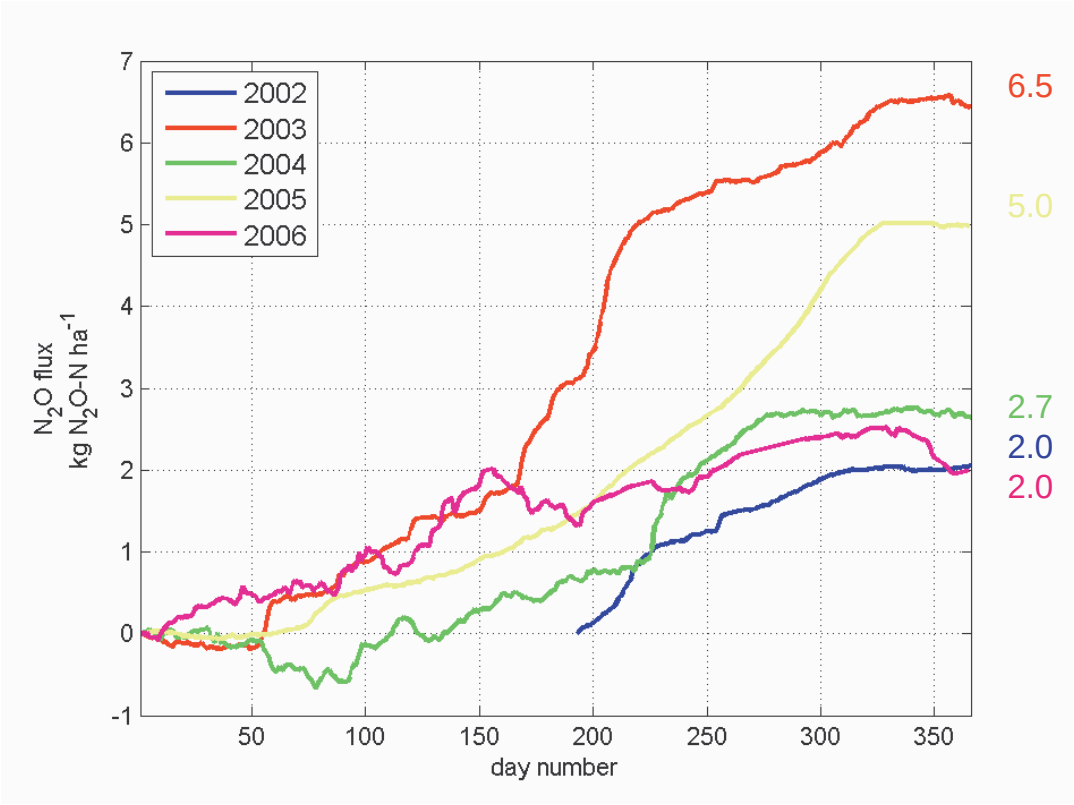
- Mixed grazing / grass cutting
- N inputs :
  - 2002* : 110 kg N ha^{-1}
  - 2003 : 340 kg N ha^{-1}
  - 2004 : 208 kg N ha^{-1}
  - 2005/2006 : <150 kg N ha^{-1}
- General reduction in management intensivity over measurement area since 2002

** July-December only*

Daily fluxes 2002-2006



Annual fluxes 2002-2006



Grassland sites comparison

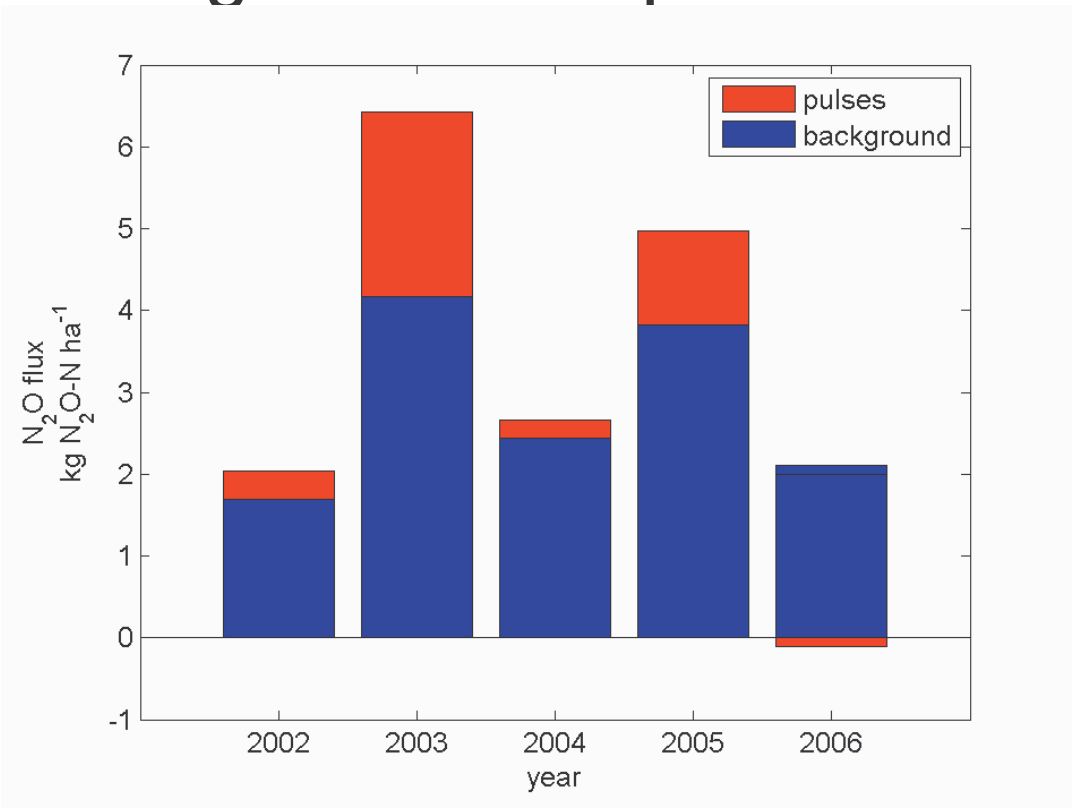
	Application kg N ha^{-1}	Emission kg N_2O-N ha^{-1}
• Dripsey [Ireland]	120 - 340	2.0 – 6.5
• Various [UK][1]	130 - 427	1.7 – 27.6
• Johnstown [Ireland][2]	303 - 493	2.2 – 24.3
• Oensingen [Switz.][3]	200	4.7
• Oensingen [Switz.] [3]	0	-0.4
• Carranza [Spain][4]	140 - 536	5.9 - 7.9

1 Dobbie & Smith. Global Change Biology (2003) 9:204-218.
2 Hyde et al. Teagasc Project Report RMIS 4974 (2005).
3 Flechard et al. Global Change Biology (2005) 11:12.
4 Merino et al. Soil Use & Management (2001) 17:121-127.

Background and pulse fluxes

- Much of the annually observed totals are due to relatively short pulses
- Therefore, a large amount of interannual variability is due to the occurrence of flux pulses
- However, background pulses also vary seasonally (and interannually)

Background and pulse fluxes



Interannual flux variability

- Annual total **background** fluxes vary from 2.1 to 4.2 kg N_2O-N ha^{-1}
- Annual total **event** fluxes vary from -0.1 to 2.25 kg N_2O-N ha^{-1}
- A large proportion of the interannual variability is controlled by the amount and magnitude of pulses

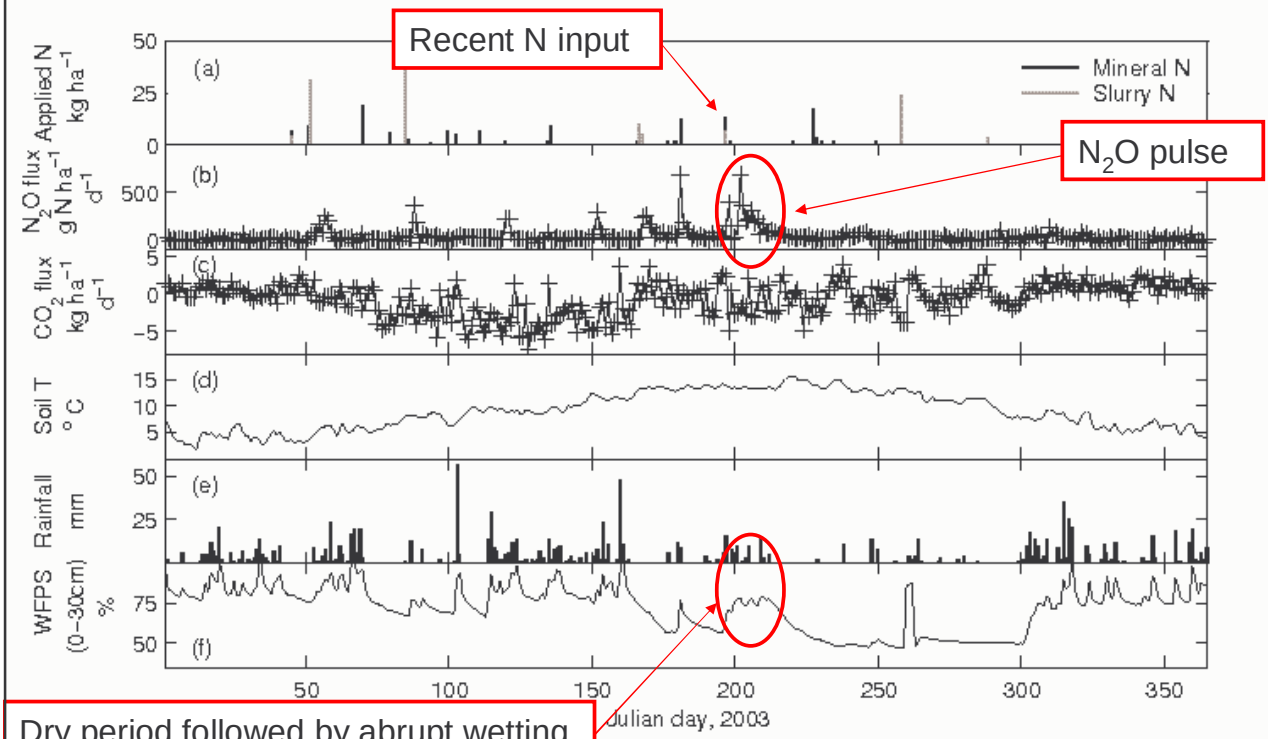
2003: several large pulses

- 16 % of total 2003 flux was emitted in a single pulse of 20 days' duration in July.
- 9 % of total emitted over 10 days in Feb.
- 7 % over 6 days in June.

What controls N_2O pulses?

- The key to much of interannual variability
- Ideal pulse conditions:
  - High N availability
  - High soil temperature
  - Sudden wetting after long, dry period
    - Anaerobic “switch”
- 2003 example

Flux pulse example

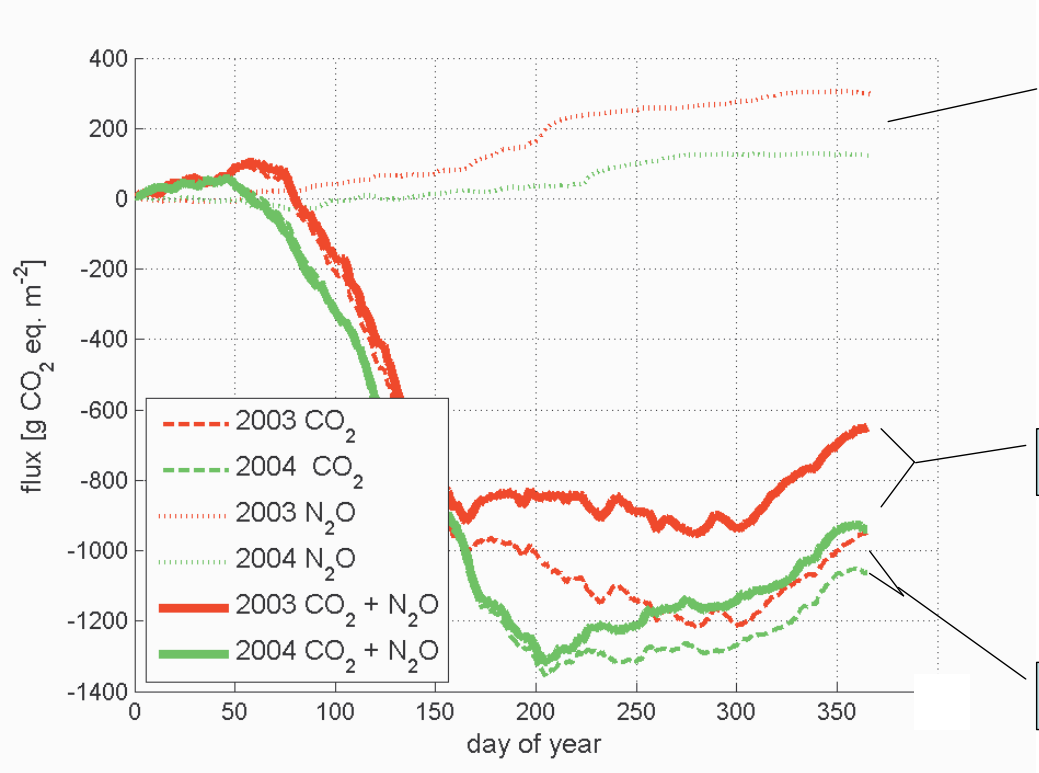


Net greenhouse exchange

- *Net greenhouse exchange* is used to combine the effects of several GHGs on the atmosphere's radiative budget
- Relative effect of each GHG expressed by its *global warming potential*
- $GWP_{CO2} = 1$; $GWP_{N2O} = 296$

- $NGE_{CO2 + N2O} = F_{CO2} + 296\ F_{N2O}$

Net greenhouse exchange



Key findings

- N_2O emissions of 2.0 to 6.5 kg N ha^{-1} $year^{-1}$
  - Significant interannual variation
  - Large pulses under intensive management
  - Most of the emission in spring & summer (high T_{soil}, frequent wetting)
- Emission factors of 1.2 to 3.3 %
- Emissions decreasing with less intensive management
- NGE close to zero (N_2O + CO_2 + est. CH_4)
- N_2O uptake frequently observed
  - ~30% of days in 2006

Further information

- Poster 1. Chamber and flux-tower measurement of N_2O flux from Irish grassland. Mishurov, M., Leahy P. and G. Kiely.
- Poster 6. Nitrous Oxide Flux studies at multiple grassland sites Jimmy Casey .
- Poster 8. Field Instrumentation for CO_2 flux and related measurements Murphy, K., Leahy P. and Kiely G.

http://aeon.ucc.ie/ http://www.hydromet.org/

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  - EPA PRTLI (Celticflux)
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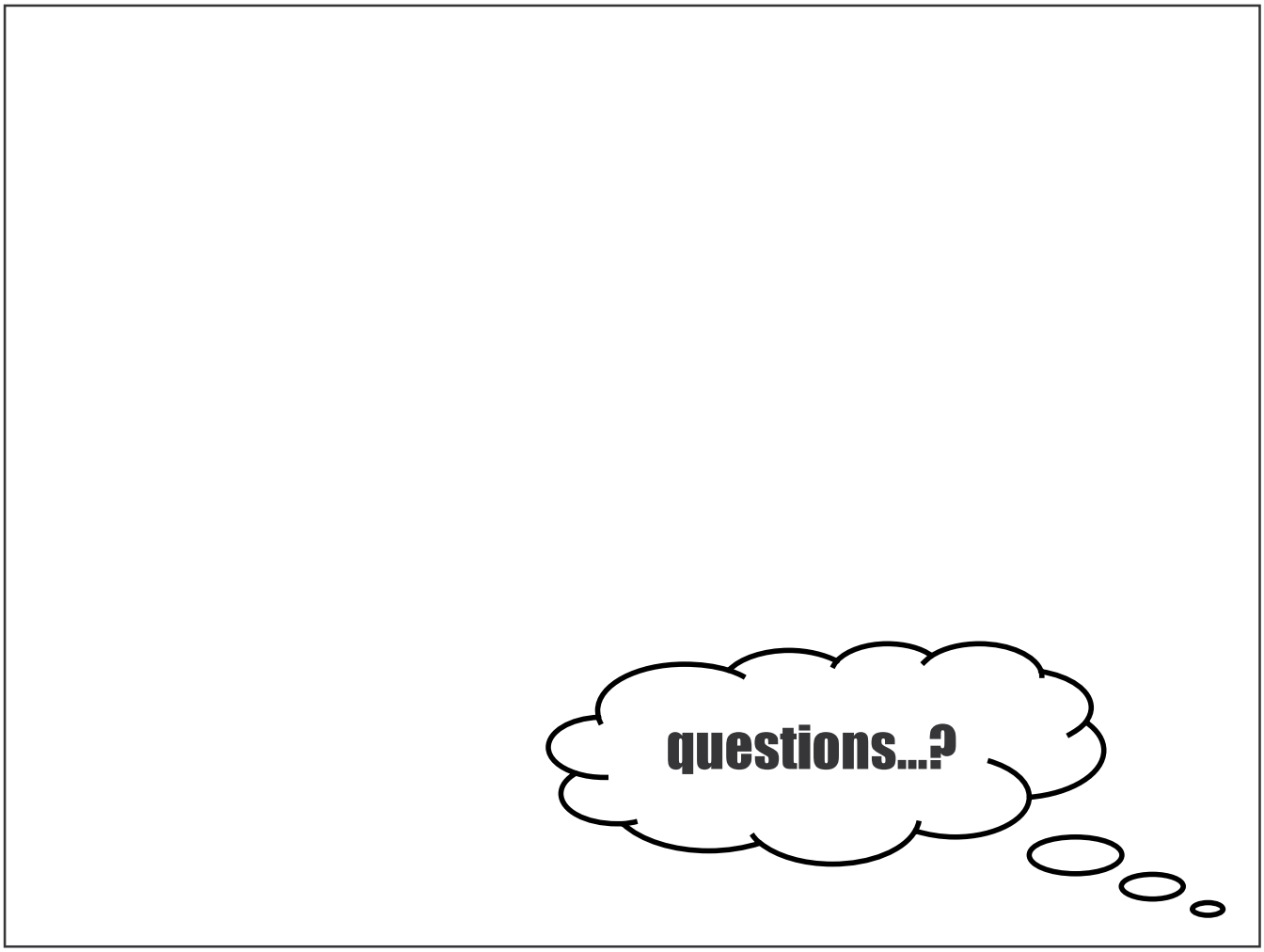
questions...?