Effects of temperature, drought and elevated CO2on N2O fluxes in an upland grassland ecosystem : interactions with plant and microbial community structure.

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Effects of temperature, drought and elevated CO_2 on N_2O fluxes in an upland grassland ecosystem : interactions with plant and microbial community structure

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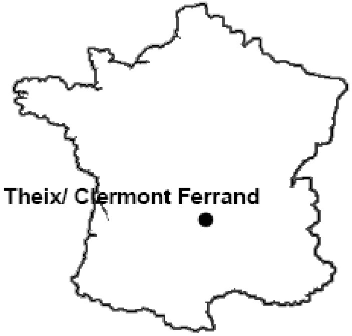
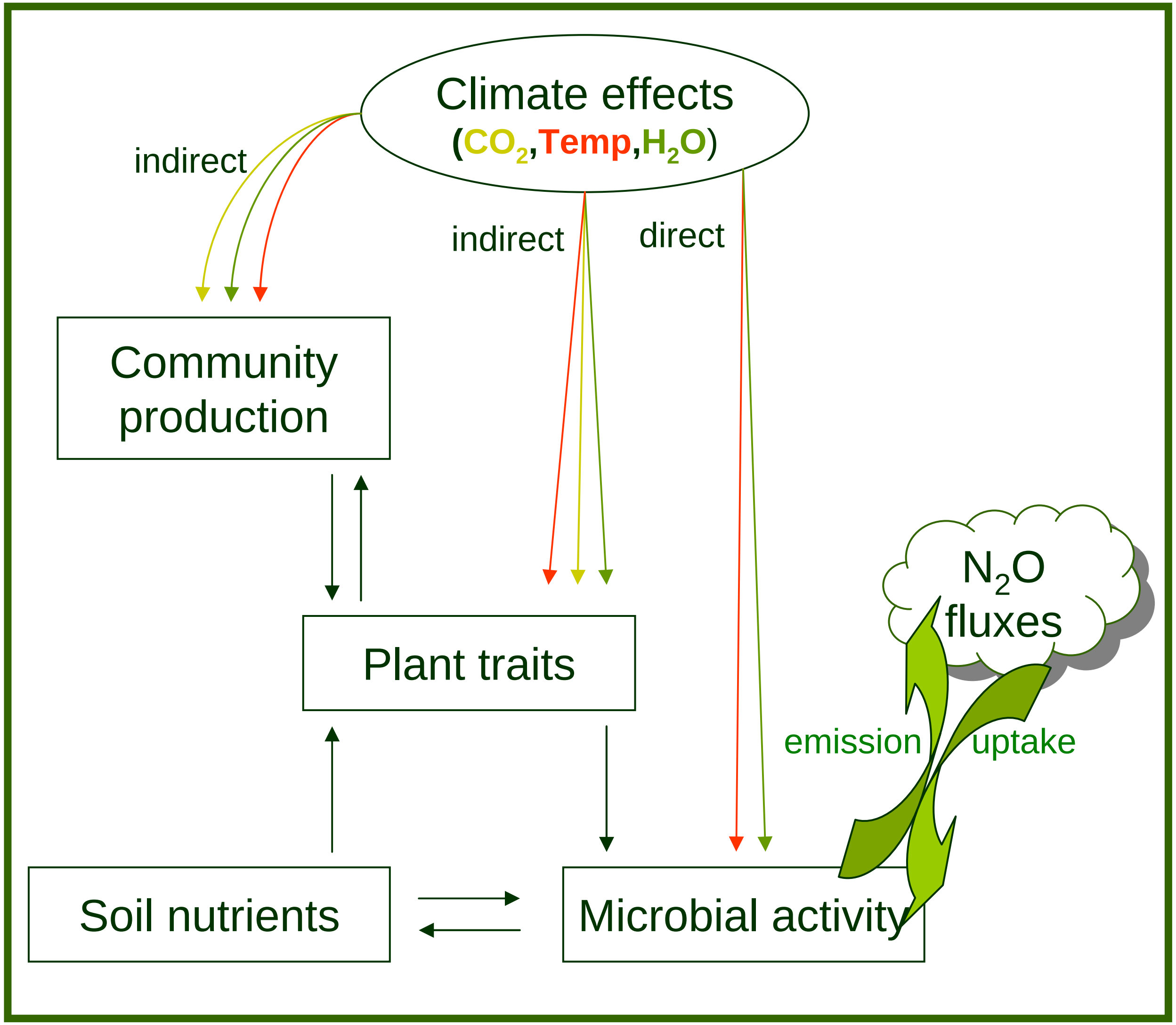


5th NitroEUrope GA 2010

Study aims



- To determine the direct and indirect effects of climate change drivers on N_2O fluxes
- To assess whether climate change modifies the influence of abiotic and biotic factors on N_2O fluxes

Experimental design

THEIX (850m)

CLERMONT-FERRAND (350m)

C
Control

T
↑ Temperature

TD
↑ Temperature
+ Drought

$TDCO_2$
↑ Temperature
+ Drought
+ Elevated CO_2

Temperature + 3.5 °C

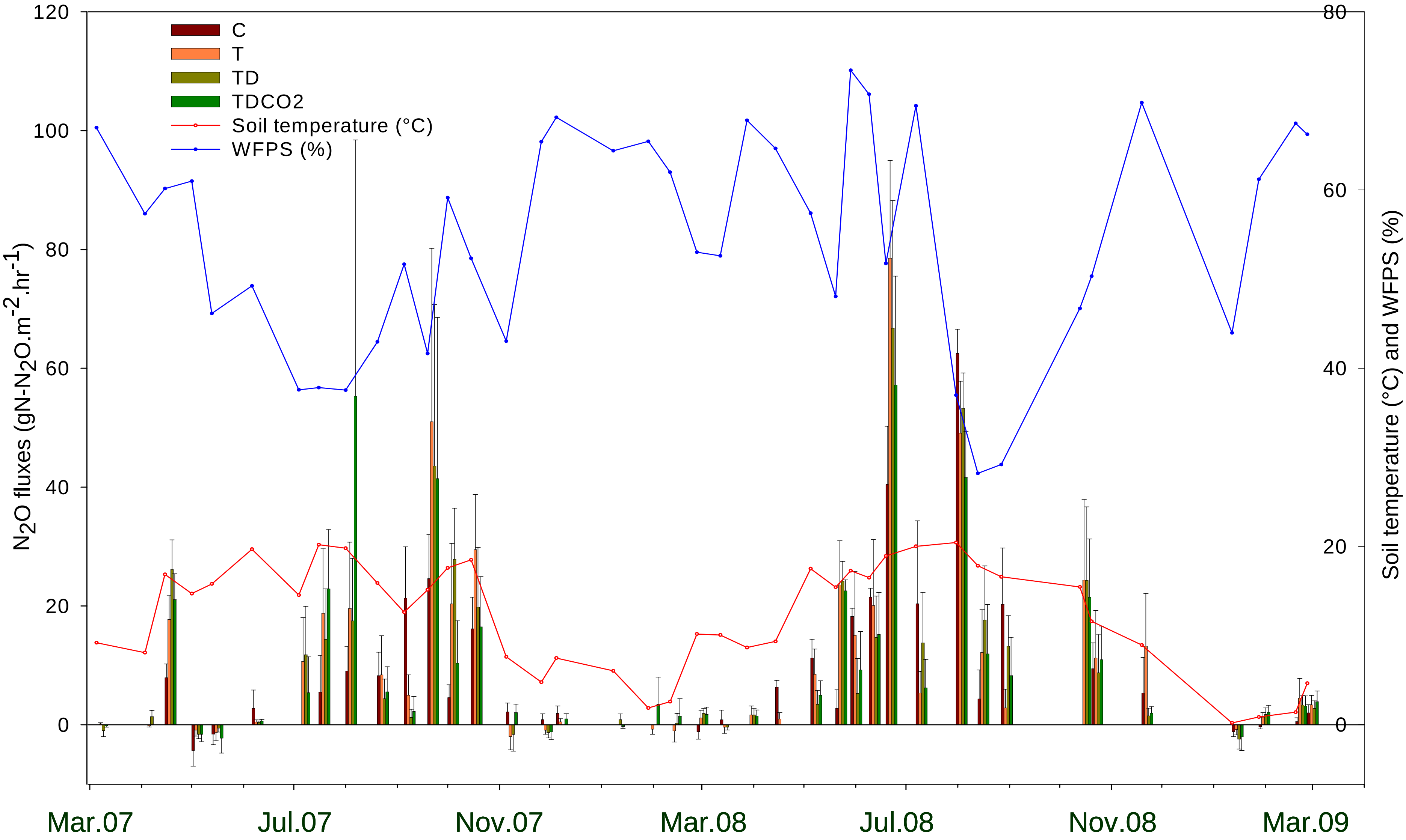
Summer drought -20%

CO_2 increase + 200ppm ([CO_2] = 600ppm)

A2 scenario predicted for Massif-Central in 2070 (IPCC)

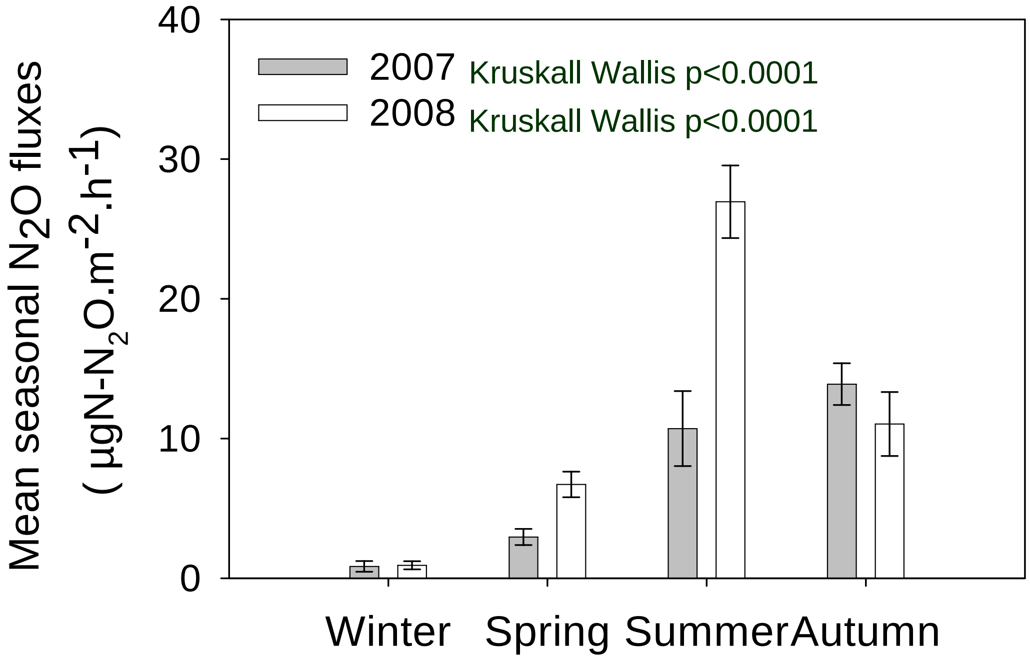
- Ecosystem: Acid grassland, light sheep grazing, no fertilizers
- 5 replicated experimental units per climate treatment
- N_2O measurements using closed static chambers and a photoacoustic gas analyzer (INNOVA)

Variation in N_2O fluxes



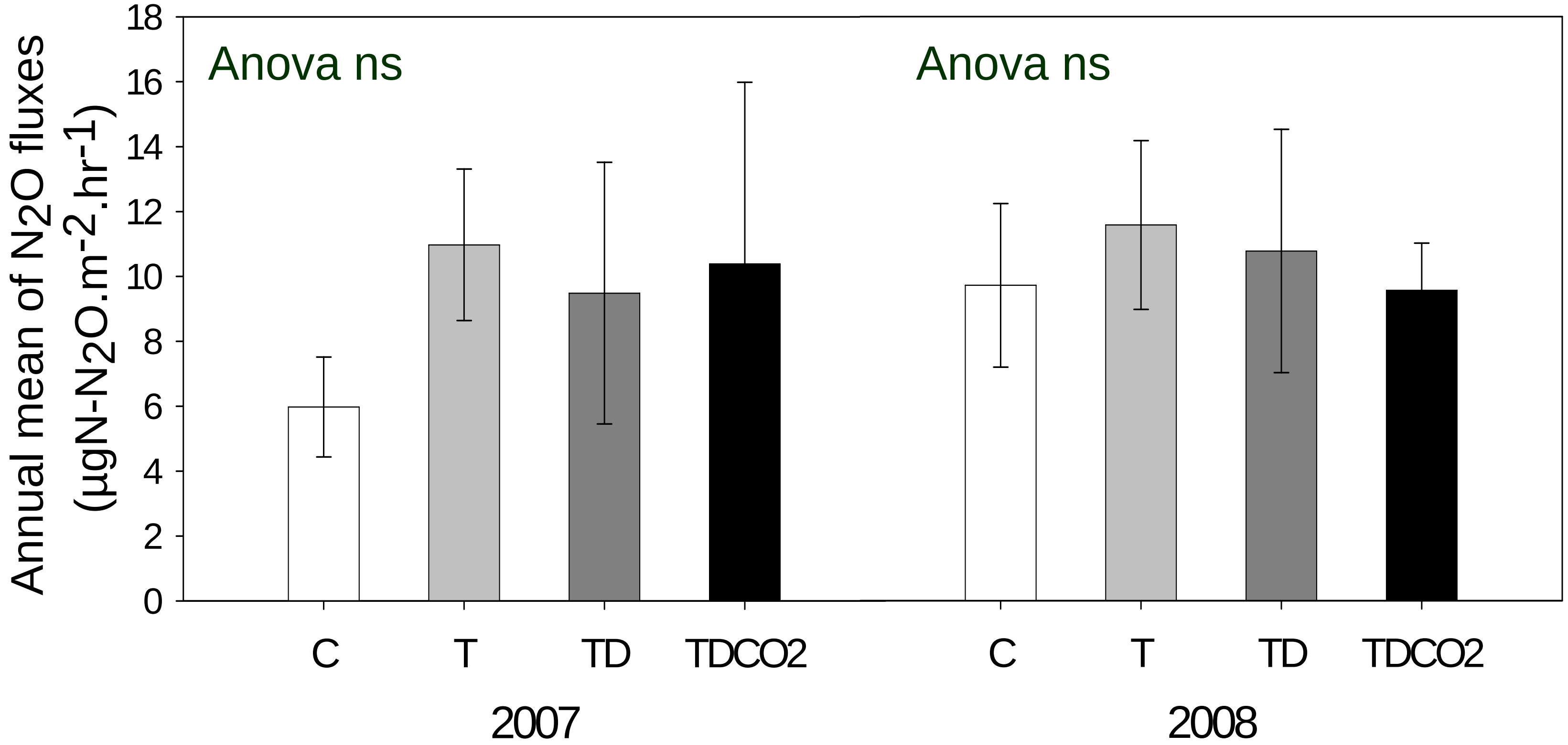
Effect of season on N_2O fluxes

(pooled across treatments)



- N_2O fluxes showed significant seasonal variation :
  - In 2007 and 2008, N_2O fluxes were higher both in spring compared to winter and in summer compared to spring
  - In 2008 N_2O fluxes were lower in autumn compared with summer

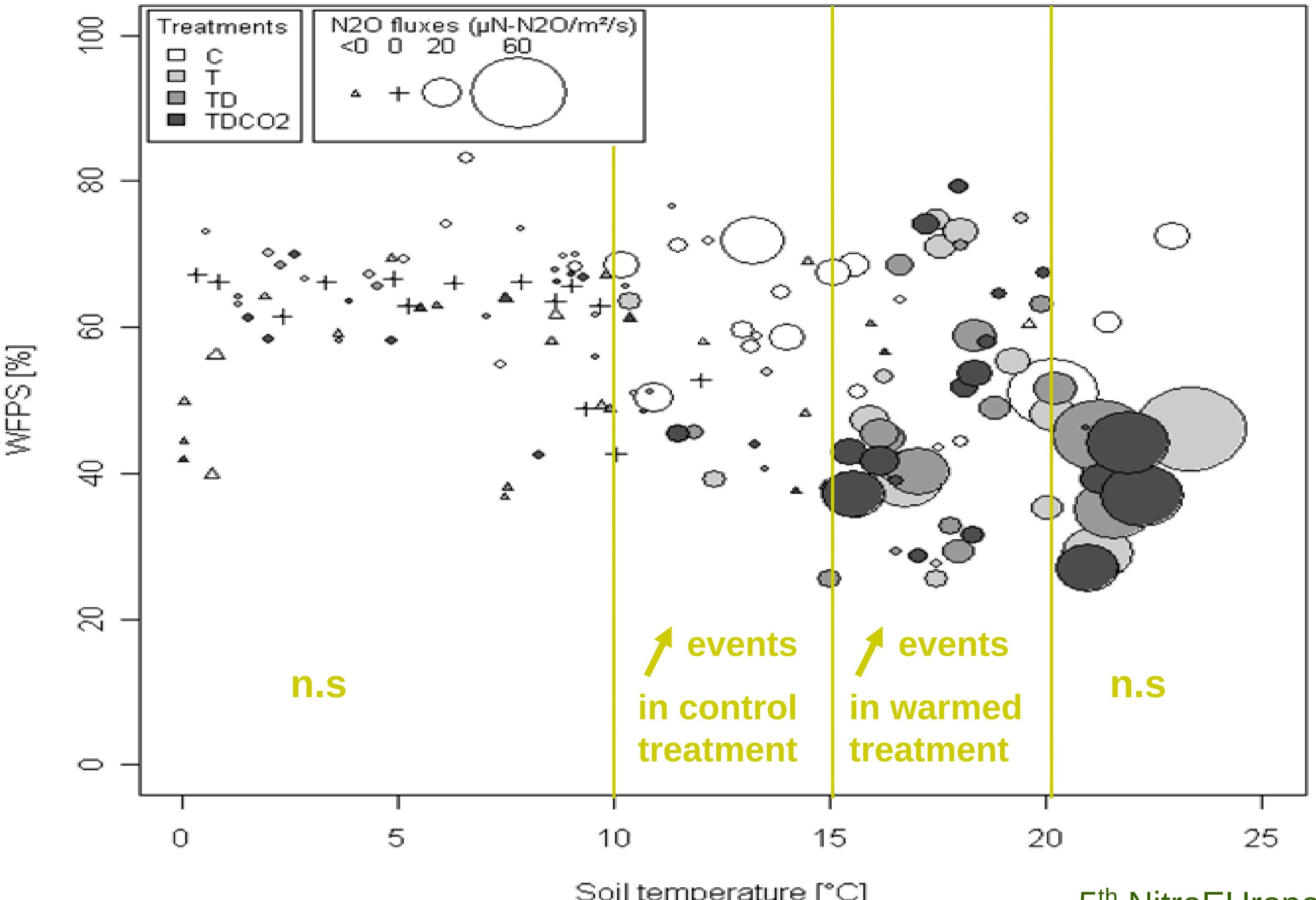
N_2O fluxes and climate change treatments



- Climate change treatments did not have a significant effect on annual N_2O fluxes in 2007 or in 2008
- No significant climate treatments effects were detected on seasonal N_2O fluxes.

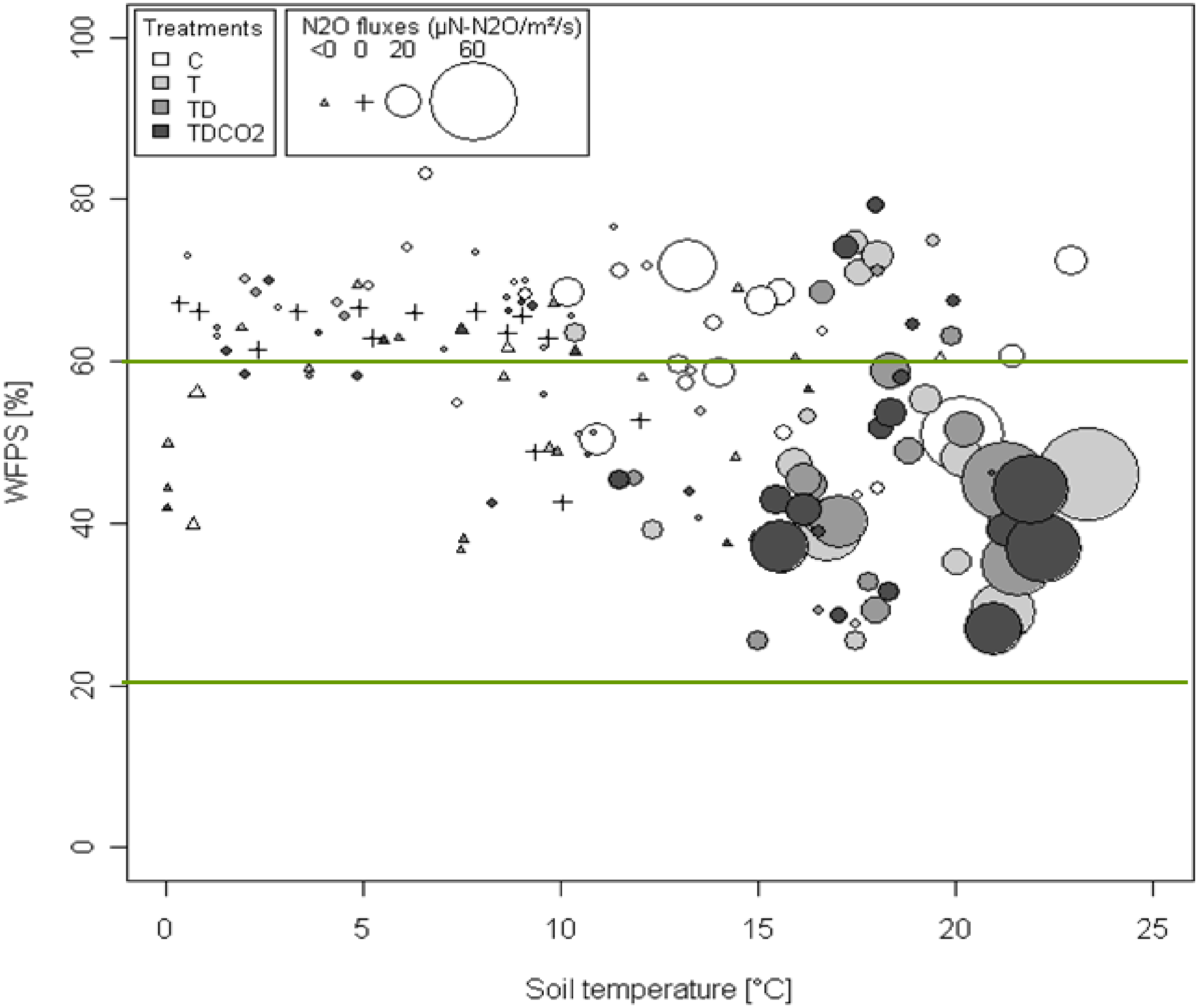
Abiotic factors and N_2O fluxes

- No treatment differences in magnitude of N_2O fluxes by soil temperature class (0-10, 10-15, 15-20, 20-25°C; Chi² = ns)
- Significant treatment differences in number of N_2O emission events by soil temperature class (Chi-test, p=0.03); No differences for uptake events



Abiotic factors and N_2O fluxes

- Significant treatment differences in number of N_2O flux events by WFPS class (Chi² test, p=0.04)
- No treatment differences in magnitude of N_2O fluxes by WFPS class (20-60, 60-100%, Chi = ns)



More N_2O emission events in control treatment

More N_2O emission and uptake events in warmed treatment

Abiotic factors and N_2O fluxes

- Positive effect of soil temperature (*Spearman R*: 0.643) and rainfall (*Spearman R*: 0.643) on N_2O fluxes
- Negative correlation between WFPS and N_2O fluxes (R: -0.250)

- Climatic treatments seem to modify relations between N_2O fluxes and abiotic factors.
  - Multiple regression analysis:

$$Ln(N_2O) = a + b*ln(Soil\ temperature) + c*ln(WFPS) + d*ln(Rainfall)$$

Treatments	R²	Soil temperature	WFPS	Rainfall
C	18.65**	**	ns	ns
T	45.55**	ns	**	***
TD	37.77**	*	*	*
TDCO2	30.30**	***	*	ns

Biotic factors and N_2O fluxes

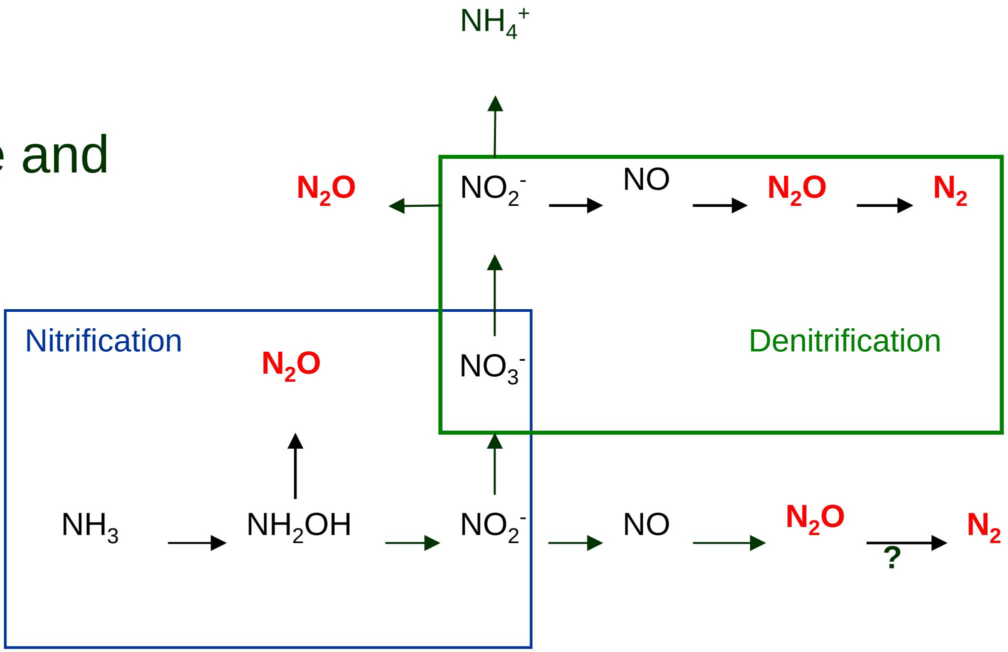
- Coupled plant and flux measurements in April 2007/08
  - Mean N_2O fluxes calculated for the month prior to biomass harvest (cut at 5cm)
  - Measures of biomass, community structure and species traits

	N_2O fluxes in April 2007		N_2O fluxes in April 2008	
	p-value	R	p-value	R
Biomass	***	0.599	ns	-
Abundance of *Festuca arundinacea*	*	0.500	ns	-
Leaf Nitrogen Content (LNC)	*	-0.481	**	0.606

- Interannual variation in the importance of vegetation on N_2O fluxes may be linked to plant community dynamics

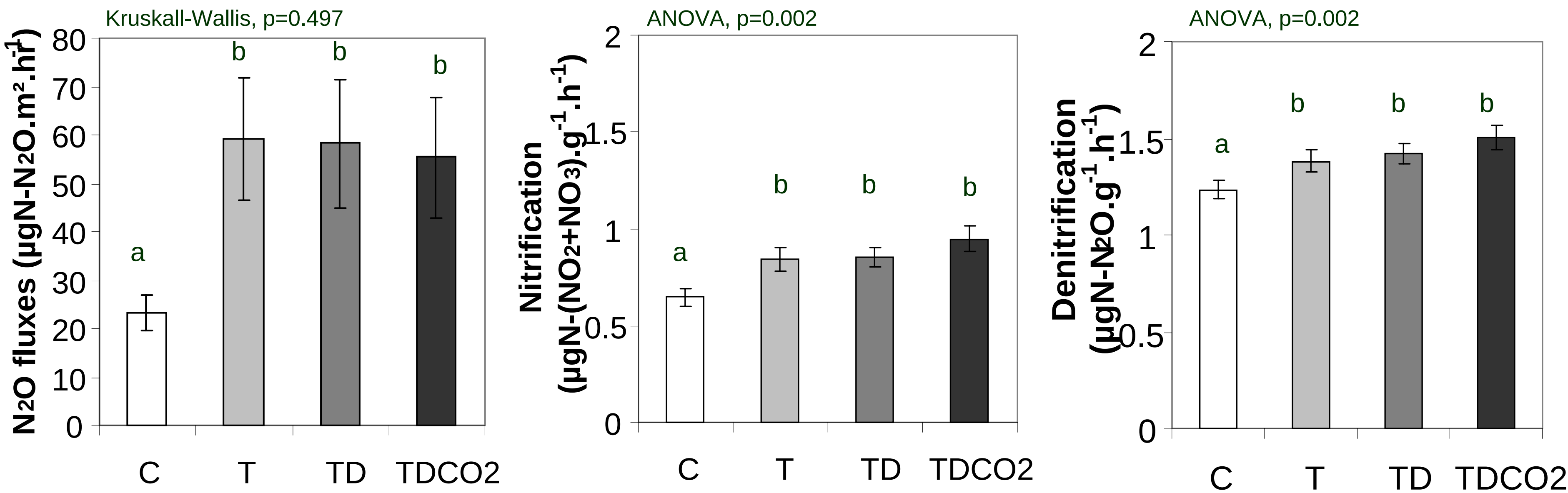
Biotic factors and N_2O fluxes

- Coupled microbial and flux measurements in 2009
  - Targeted measurements in conditions favorable for N_2O emissions (high temperature and soil moisture)
  - Soil sampling following flux measurements
  - 4 replications in time



- Analysis of microbial activity (collaboration with LEM, Lyon)
  - Nitrification
  - Denitrification

Biotic factors and N_2O fluxes

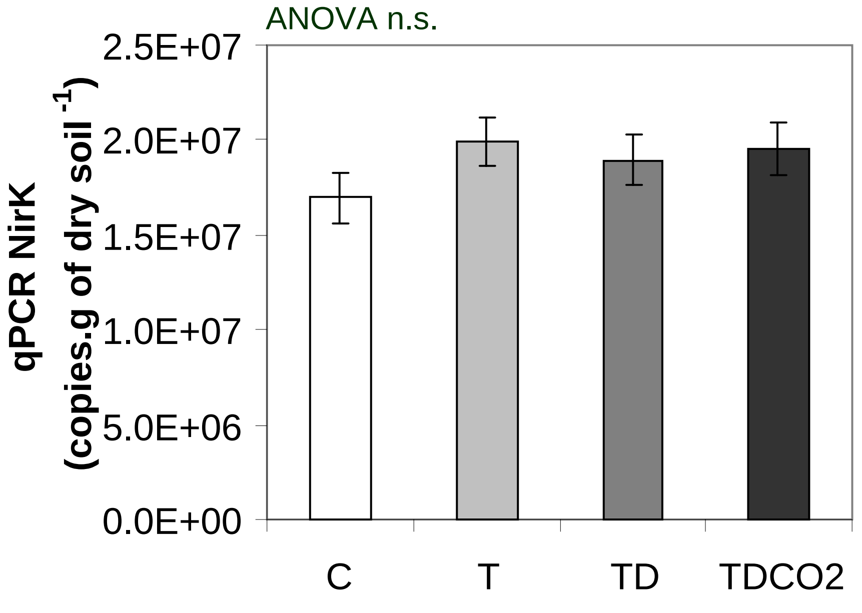


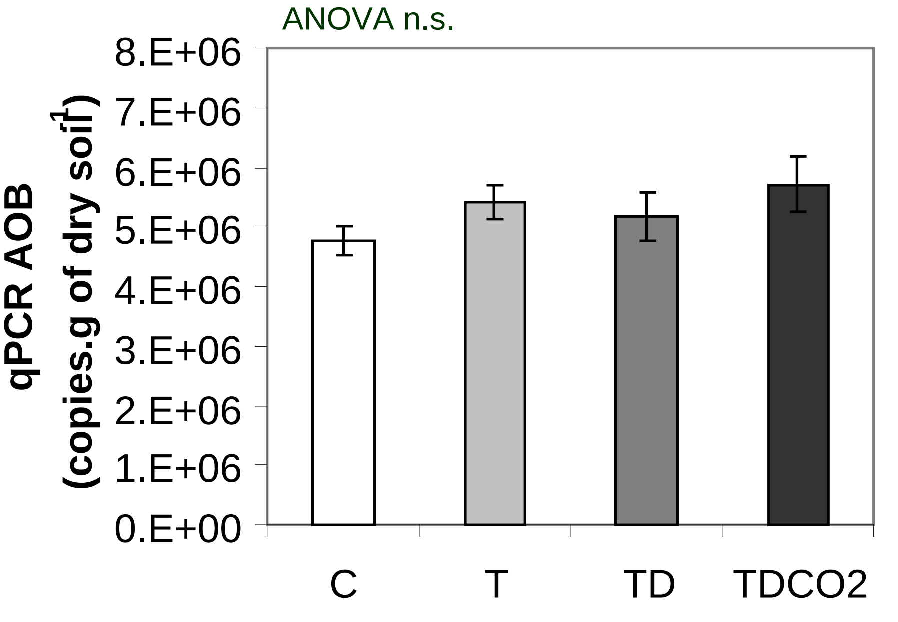
- Significant climate effects on N_2O fluxes mirrored by patterns in nitrification and denitrification

- Temperature effects on microbial activity may be related to microbial population size, community structure or upregulation in enzymatic activity...

Biotic factors and N_2O fluxes

- No significant effects on size of denitrifying bacterial populations (NirK gene) or on nitrifying bacterial populations (AOB gene)





- Changes in microbial community? (work in progress)

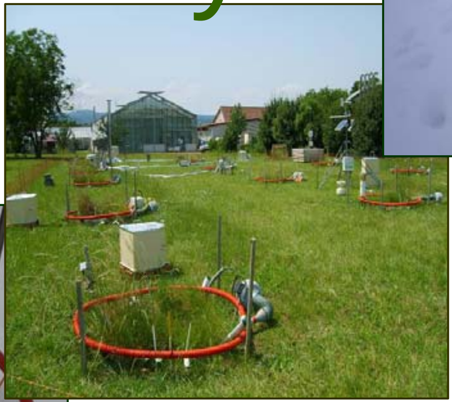
Conclusions

- N_2O fluxes showed limited responses to climate change drivers in our study system.
  - Greater responses might be expected in more productive grasslands.
- N_2O fluxes were correlated with soil temperature, WFPS and rainfall
  - Climate treatments appear to modify the relationship between N_2O fluxes and abiotic factors
- Relative contribution of different biotic factors in N_2O flux variations remains to be determined.





Thank you for your attention!

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