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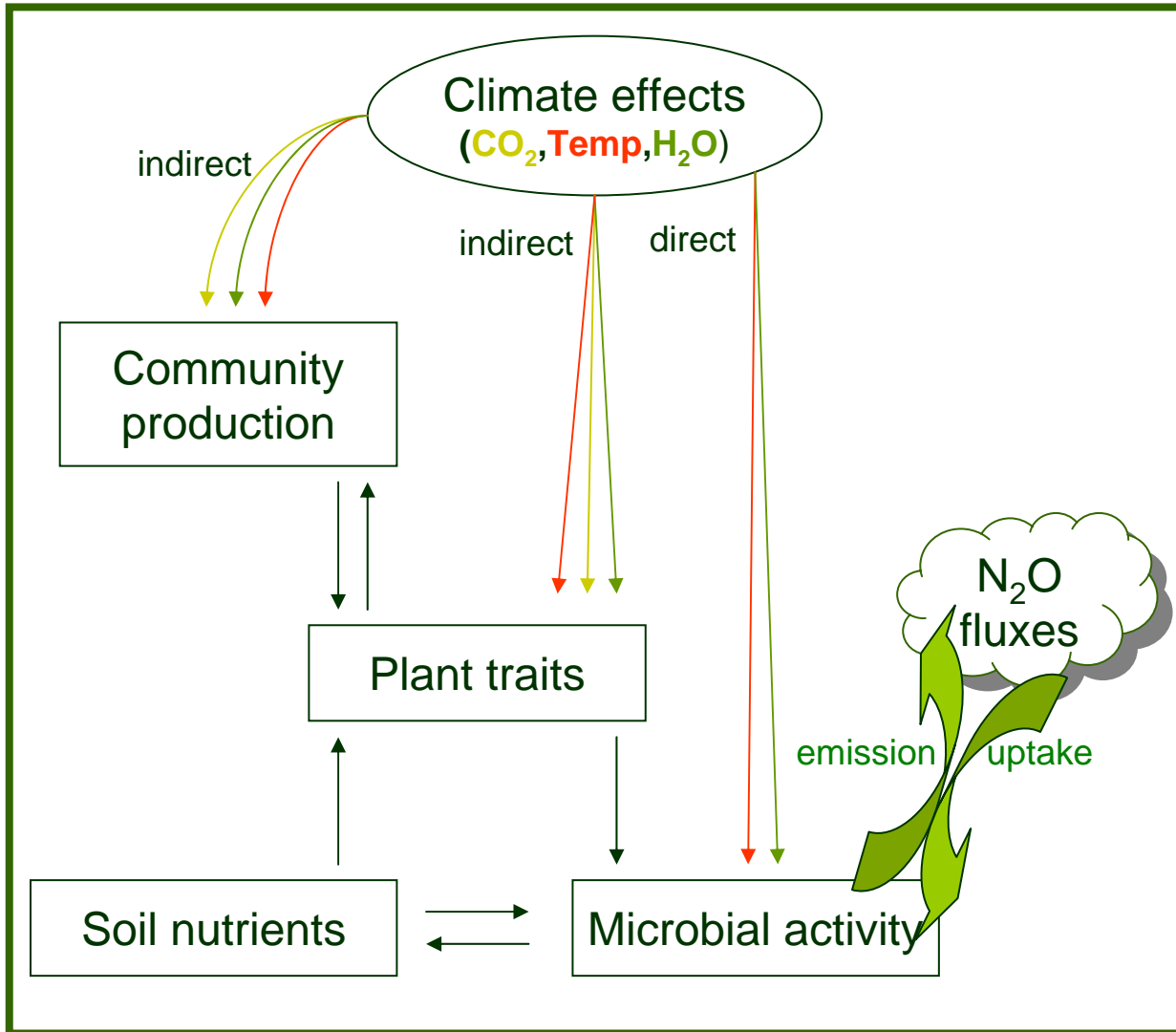
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Effects of temperature, drought and elevated CO₂ on N₂O fluxes in an upland grassland ecosystem : interactions with plant and microbial community structure

***Cantarel A., *Bloor J.M.G., #Poly F. & *Soussana J.F.**

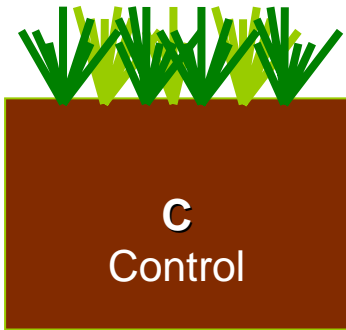
*Grassland Ecosystem Research Group, INRA Clermont-Theix, France; #LEM, CNRS-Université Lyon 1, France



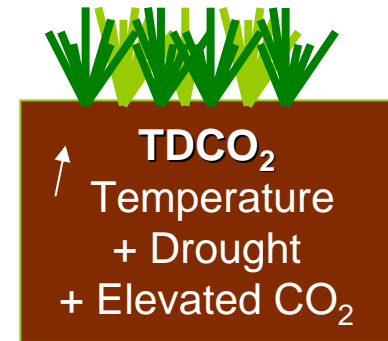
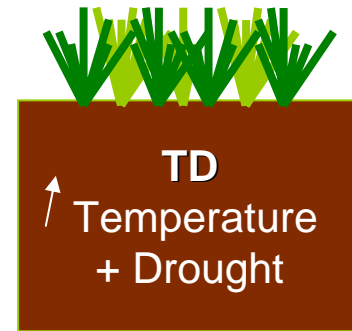
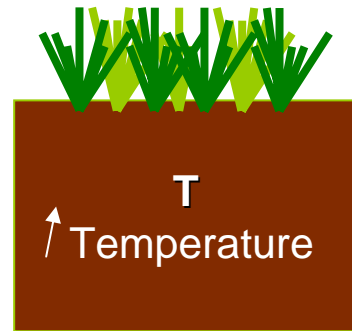


- To determine the direct and indirect effects of climate change drivers on N₂O fluxes
- To assess whether climate change modifies the influence of abiotic and biotic factors on N₂O fluxes

THEIX (850m)



CLERMONT-FERRAND (350m)



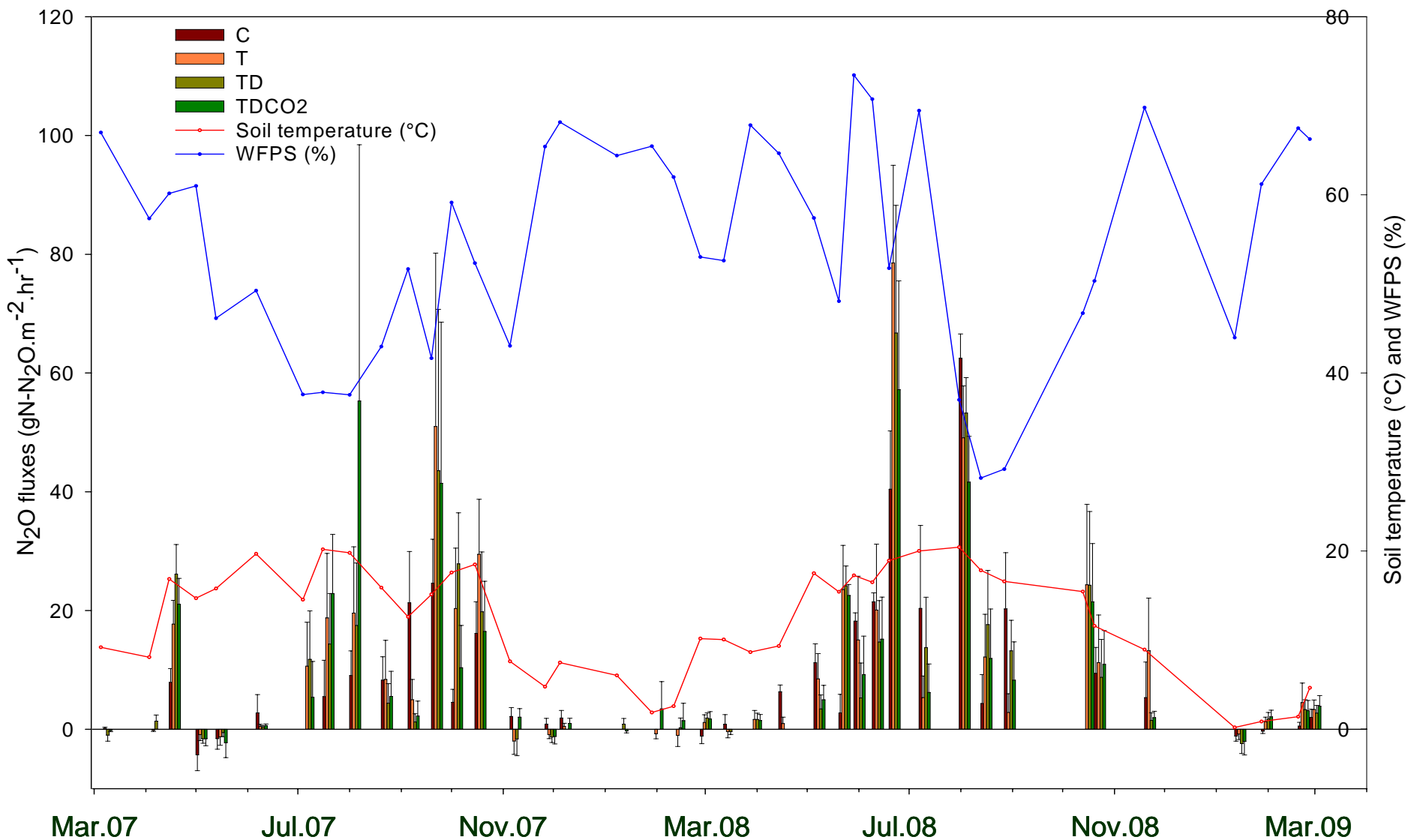
Temperature + 3.5 °C

Summer drought -20% CO₂ increase + 200ppm ([CO₂] = 600ppm)

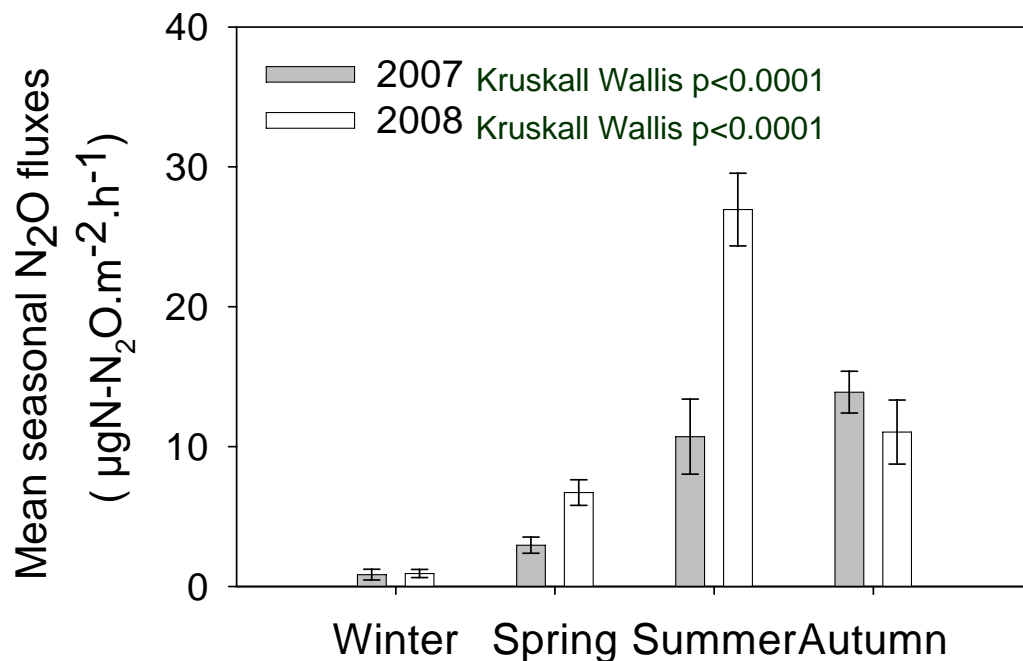
A2 scenario predicted for Massif-Central in 2070 (IPCC)



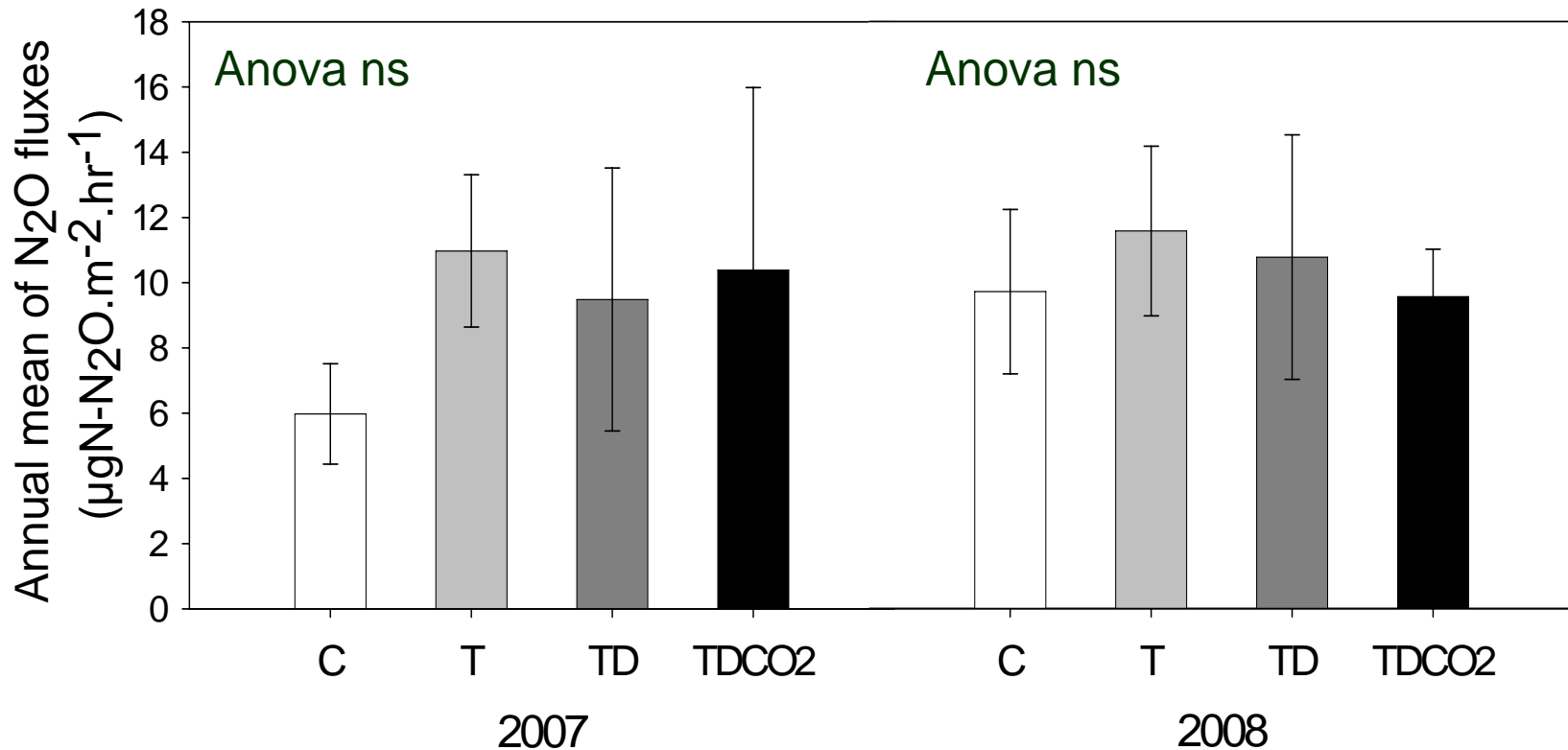
- Ecosystem: Acid grassland, light sheep grazing, no fertilizers
- 5 replicated experimental units per climate treatment
- N₂O measurements using closed static chambers and a photoacoustic gas analyzer (INNOVA)



Effect of season on N₂O fluxes (pooled across treatments)



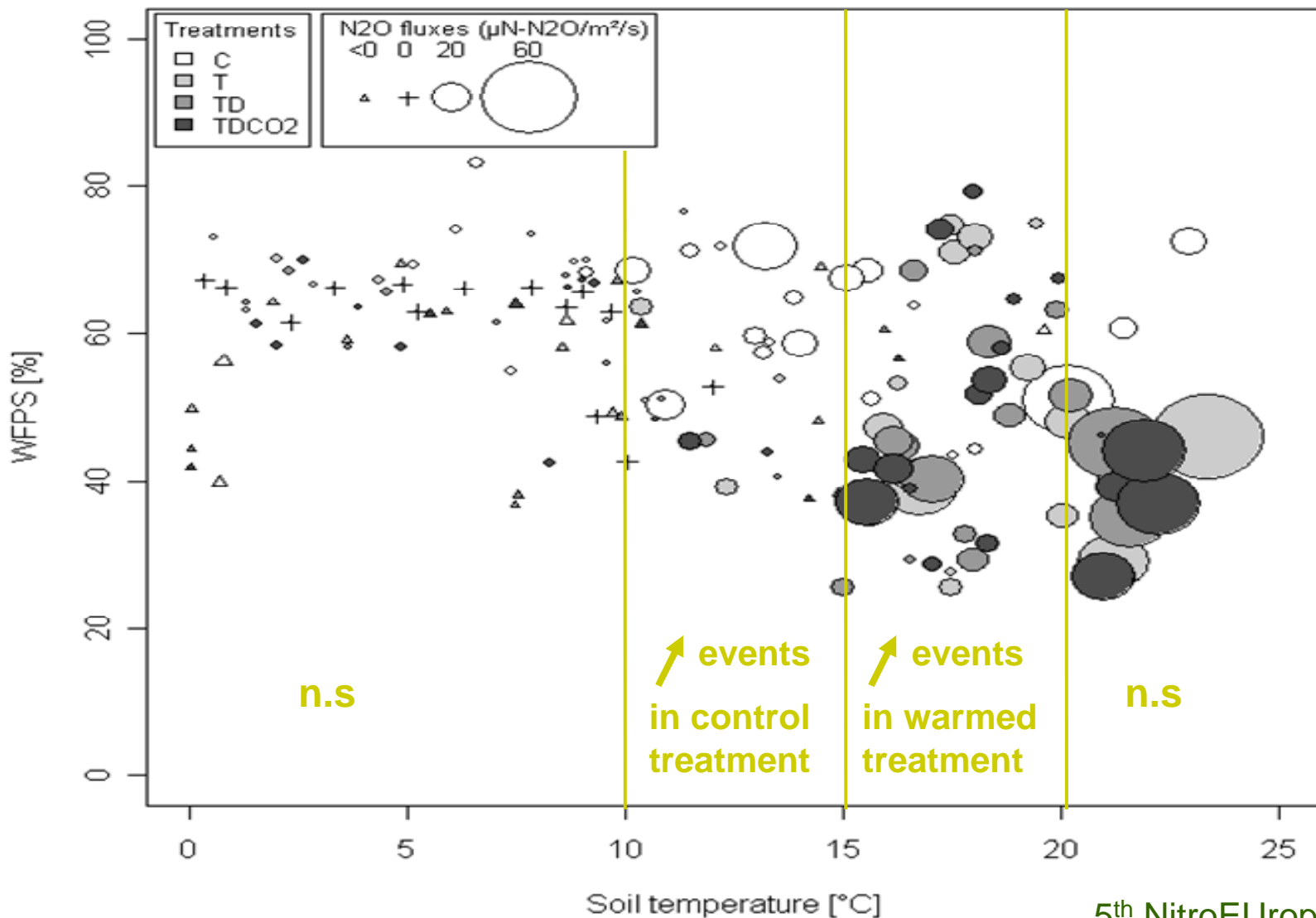
- N₂O fluxes showed significant seasonal variation :
 - In 2007 and 2008, N₂O fluxes were higher both in spring compared to winter and in summer compared to spring
 - In 2008 N₂O fluxes were lower in autumn compared with summer



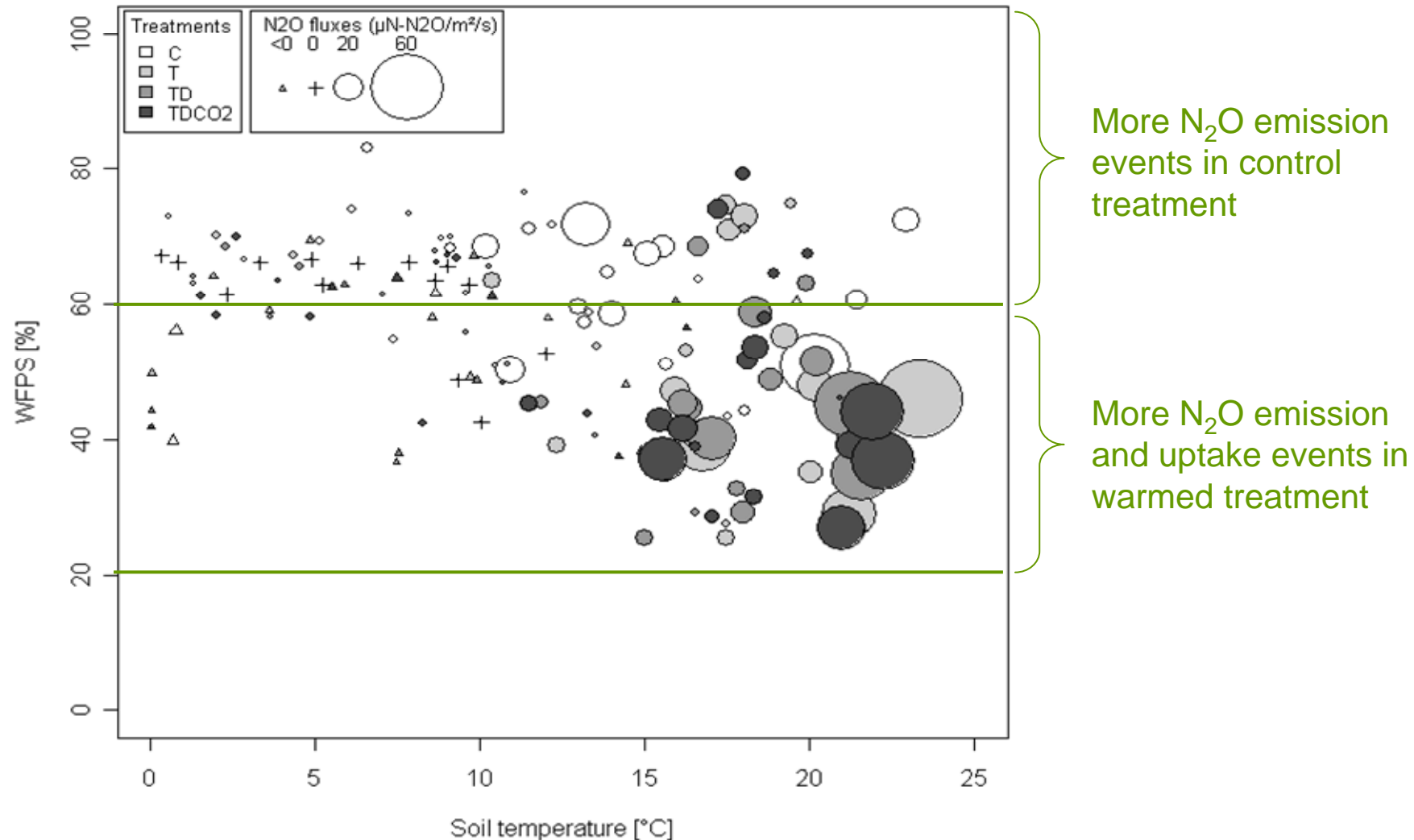
- Climate change treatments did not have a significant effect on annual N₂O fluxes in 2007 or in 2008
- No significant climate treatments effects were detected on seasonal N₂O fluxes.

Significant differences in magnitude of N₂O fluxes by emission events by soil temperature class

Temperature soil class (0-10, 10-15, 15-20, 20-25 °C, 0 Ch₂Ne dis) differences for uptake events



Significant treatment differences in magnitude of N₂O fluxes by events by WFPS class (20-60, 60-100%, Chi = ns)



- Positive effect of soil temperature (*Spearman R*: 0.643) and rainfall (*Spearman R*: 0.643) on N₂O fluxes
- Negative correlation between WFPS and N₂O fluxes (*R*: -0.250)

- Climatic treatments seem to modify relations between N₂O fluxes and abiotic factors.

□ Multiple regression analysis:

$$\text{Ln}(\text{N}_2\text{O}) = a + b \cdot \text{Ln}(\text{Soil temperature}) + c \cdot \text{Ln}(\text{WFPS}) + d \cdot \text{Ln}(\text{Rainfall})$$

Treatments	R ²	Soil temperature	WFPS	Rainfall
C	18.65**	**	ns	ns
T	45.55**	ns	**	***
TD	37.77**	*	*	*
TDCO2	30.30**	***	*	ns

- Coupled plant and flux measurements in April 2007/08
 - Mean N₂O fluxes calculated for the month prior to biomass harvest (cut at 5cm)
 - Measures of biomass, community structure and species traits

	N ₂ O fluxes in April 2007		N ₂ O fluxes in April 2008	
	p-value	R	p-value	R
Biomass	***	0.599	ns	-
Abundance of <i>Festuca arundinacea</i>	*	0.500	ns	-
Leaf Nitrogen Content (LNC)	*	-0.481	**	0.606

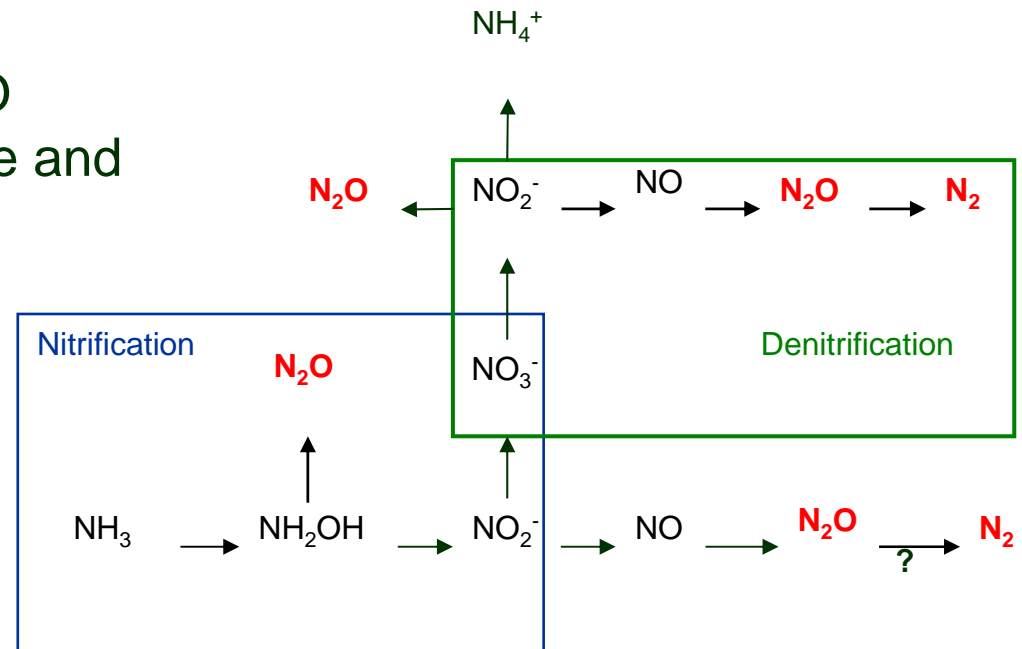
- Interannual variation in the importance of vegetation on N₂O fluxes may be linked to plant community dynamics

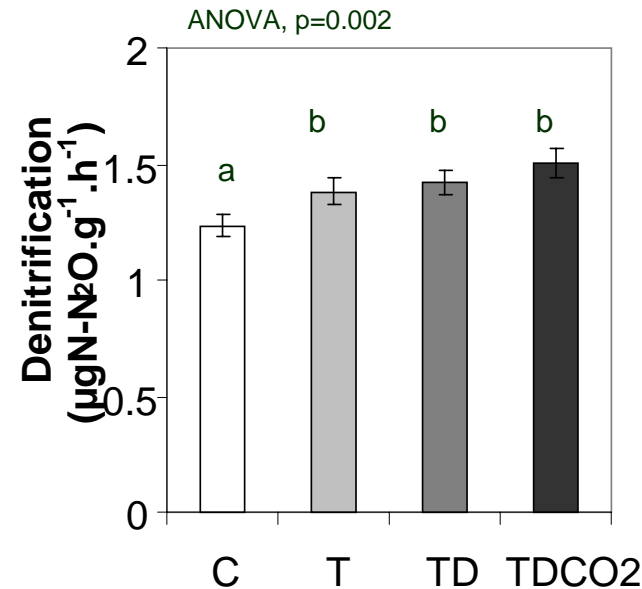
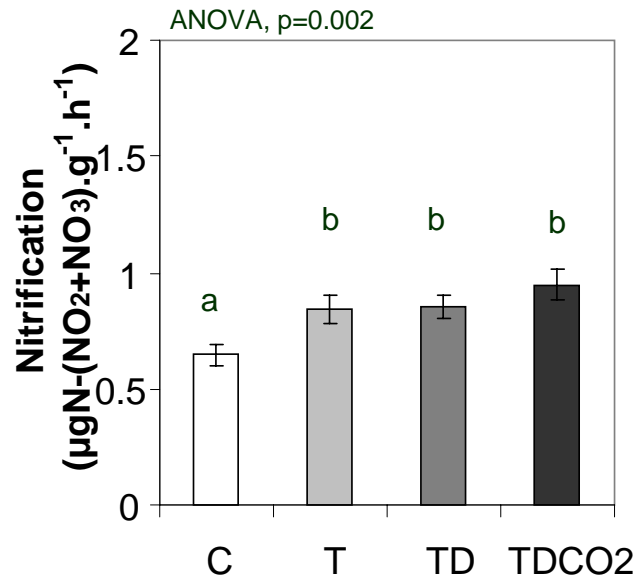
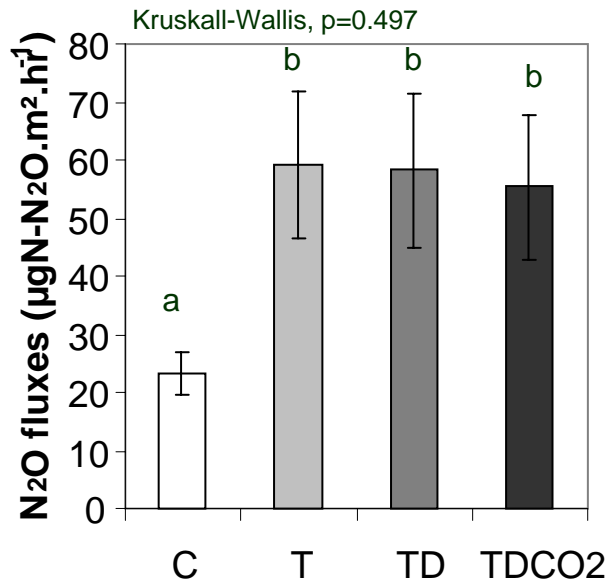
- Coupled microbial and flux measurements in 2009

- Targeted measurements in conditions favorable for N₂O emissions (high temperature and soil moisture)
- Soil sampling following flux measurements
- 4 replications in time

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

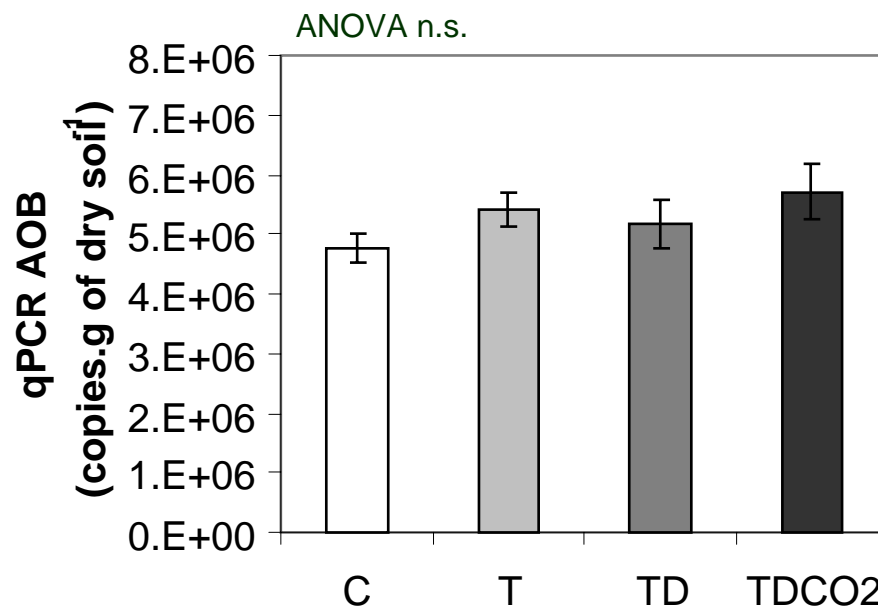
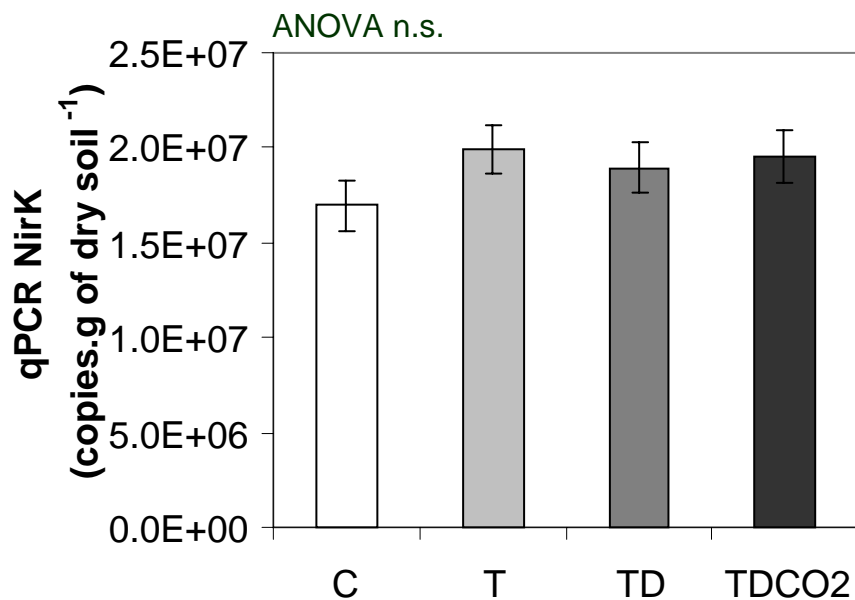
- Nitrification
- Denitrification





- Significant climate effects on N₂O 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...

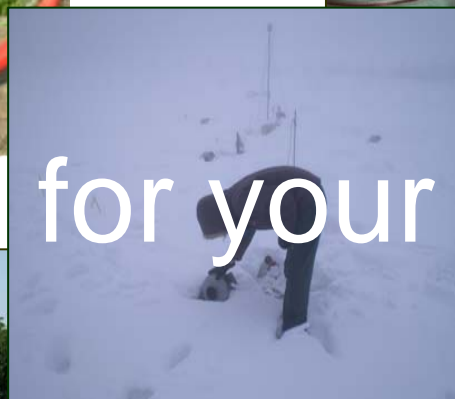
- No significant effects on size of denitrifying bacterial populations (NirK gene) or on nitrifying bacterial populations (AOB gene)



- Changes in microbial community? (work in progress)

- N₂O fluxes showed limited responses to climate change drivers in our study system.
 - Greater responses might be expected in more productive grasslands.
- N₂O fluxes were correlated with soil temperature, WFPS and rainfall
 - Climate treatments appear to modify the relationship between N₂O fluxes and abiotic factors
- Relative contribution of different biotic factors in N₂O flux variations remains to be determined.

Thank you for your attention!



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