

Scientific report

1. Background and Purpose of the visit

The researcher has successfully completed an exchange visit under European Science Foundation (ESF) CLIMMANI activity entitled, **“Temperature sensitivity of soil GHG fluxes from different land use types and the project “LYSTRAT” (Consequences of climate change on ecosystem functions, water balance, productivity and biodiversity of agricultural soil in the Pannonian area)**, at the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW), Vienna, Austria, for 7 weeks. The two main research foci of the visit were to 1) analyse causal relationships between GHG emissions, land use, temperature, soil parameters and N deposition across a range of 50 European sites, and 2) calculate the temperature sensitivities of soil CO₂, N₂O, and NO fluxes from different land use types under different moisture conditions. The project collates variables from 50 European sites investigated within the NitroEurope IP (land use, temperature, N deposition, GHG fluxes, soil parameters etc.) as a base for dynamic modelling. Another purpose of the visit was to get soil and gas samples from a national funded project called “LYSTRAT” and analyze soil GHGs on the GC. The final results will explore GHG emissions and climatic parameters from European sites to determine impacts of these relationships.

Increased human activities lead to higher emissions of GHGs resulting in climatic changes, like higher air temperature and changing precipitation patterns (e.g. flooding, drought), which have a huge impact on the ecosystems including agriculture production, forest, range management, biodiversity, quantity and quality of ground water etc. Global climate change and its effects on our future environment require a better understanding. Forster et al. (2007) reported that the carbon dioxide (CO₂) and methane (CH₄), the two most important greenhouse gases besides water vapor, play an important role in the balance of the earth's atmosphere. Iqbal et al. (2009) conducted a four years study to determine the GHG (CO₂ and CH₄) fluxes from seven sites of four land use types. They found that pine forest has significant lower CO₂ emission and higher CH₄ uptake than agriculture land uses. They concluded that soil C fluxes from different land uses are controlled by different climatic parameters and nutrient availability of soil. In an investigation of a deciduous mixed forest in Germany Guckland et al. (2009) revealed that the variation of CH₄ uptake over time primarily depended on changes in soil moisture in the upper five centimeters of the mineral soil. They further reported that the CH₄ flux linearly responded to soil moisture content. They also observed that low CH₄ uptake activity during winter was further reduced when the soil was covered with snow. Nitrous oxide is another important GHG.

2. Description of the work carried out during the visit

Justification: In a two year study, Kitzler et al. (2006) measured nitrogen oxides (N₂O and NO_x), and carbon dioxide (CO₂) emissions from a spruce-fir-beech forest soil in Austria and found that soil temperature, soil moisture and bulk N-deposition followed by air temperature and precipitation were the most important parameters affecting N-emissions. Some key factors including land use, temperature and precipitation, N input and soil properties, e.g. soil texture, pH and C/N ratio are vital during exchange of these different gases between soil and atmosphere (Schaufler et al., 2010). Soil temperature and moisture have vital impact on emission and uptake of gases through their effects on microorganisms and root activity (Smith et al., 2003). In order to know the degree and extent of soil temperature sensitivity of CO₂, N₂O and NO fluxes influence soil respiration under different landuse. What are the governing factors and can we classify them according to different landuses? Are there any similar characteristics, if temperature is constant for CO₂, N₂O and NO fluxes?

a) NitroEurope data set analysis and activation energy modeling

NitroEurope datasets from eighteen countries having 50 sites with different landuses (grassland, forest, wetland and cropland) and different plant species were used to calculate the temperature sensitivities of soil CO₂, N₂O and NO fluxes. Many scientists used mathematical formulations of dependence for different analysis for their own research variables (e.g. Jenkinson, 1990; Lloyd and Taylor, 1994; Fang and Moncrieff, 2001). There are several models for defining the role of temperature for soil respiration. Mikko et al. (2008) have given an important comparison of different models with their limitations and parameters for temperature dependence. There is no specific perfect model which has no limitations taking account of temperature dependence of soil organic matter decomposition.

The data sets were organised in the following order.

- Country = 18
- Site = 50
- Landuse = 4
- Cylinder = 18
- Temperature = 5, 10, 15, 20
- Water filled pore space [%] = WFPS

The following parameters were measured for activation energy modeling.

CO₂ = CO₂ measured ↔ Temp (1divK) ↔ Ln CO₂ ↔ Slope CO₂ ↔ R₂ ↔ Activation Energy CO₂ (kJ mol l)⁻¹

NO = NO measured ↔ Temp (1divK) ↔ Ln NO ↔ Slope NO ↔ R₂ ↔ Activation Energy NO (kJ mol l)⁻¹

N₂O = N₂O measured ↔ Temp (1divK) ↔ Ln N₂O ↔ Slope N₂O ↔ R₂ ↔ Activation Energy N₂O (kJ mol l)⁻¹

Note: For site HU-Bug CO₂ data is missing...

Table 1: Site and land use from respective countries used are as follows.

Country	Site	Landuse
BE	BE-Bra, Be-Lon, BE-Vie,	Forest, Cropland, Forest
CH	CH-Lae, CH-Oen	Forest, Grassland
CZ	CZ-Bk	Forest
DE	DE-Geb, DE-Gril, DE-Hay, DE-Hog, DE-Kli, DE-Meh, DE-Tha, DE-Wet.	Cropland, Grassland, Forest, Forest, Cropland, Forest, Forest, Forest
DK	DK-Lva,DK-Ris,DK-Sor	Grassland, Cropland, Forest
ES	ES-Esi, ES-Lma, ES-Vda	Forest, Forest, Grassland
FI	FI-Hyy, FI-Kaa, FI-Lom, FI-Sod.	Forest, Grassland, Wetland, Forest
FR	FR-Fon, FR-Gri, FR-Lbr, FR-Lq2, FR-Pue.	Forest, Cropland, Forest, Grassland, Forest
HU	Hu-Bug	Grassland
IE	IE-Dri	Grassland
IT	IT-Amp, IT-Bci, IT-Col, IT-Mbo, IT-Ren, IT-RO2	Grassland, Cropland, Forest, Grassland, Forest, Forest
NL	NL-Cab, NL-Loo, NL-Spe	Grassland, Forest, Forest
PL	PL-Wet	Wetland
PT	PT-Esp,PT-Mit	Forest, Forest
RU	RU-Fyo	Wetland
SE	Se-Nor,SE-Sky	Forest, Forest
UC	UC-Pet	Cropland
UK	UK-Amo, UK-Ebu, UK-Gri.	Wetland, Grassland, Forest

3. Description of the main results

The activation energies of CO₂, NO and N₂O were different between land-use types. In forest landuse, we took 26 different sites while for cropland we have 7 sites. In grassland 13 sites and for wetland four sites were used. The highest temperature sensitivity of soil CO₂ fluxes were recorded from SE-Nor (forest) along with FR-Lq₂ (grassland) while the lowest was NL-Cab (grassland). Schaufler et al. (2010) reported that in grassland system, maximum soil microbial activity is stimulated by high carbon (C) and nitrogen (N) activities, dense root systems and high C input were the most likely causes for high N₂O and CO₂ emissions. In summer CO₂ emissions are highest due to mineralization of organic matter while in winter they are very low. During mineralization, soil temperature and soil moisture have been considered the most important abiotic parameters determining soil respiration and its underlying processes at a global scale (Kutsch et al., 2009). The feedback of different landuse with varying temperatures having biodiverse environment on soil respiration will be quite interesting for better understanding for formulation of models. The critical assessment of these factors will provide best estimates of potential green house gas exchange from 50 soils of Europe. Response of different types of vegetative species under various landuse is also one of the factors for this agreement. Different colors show different species.

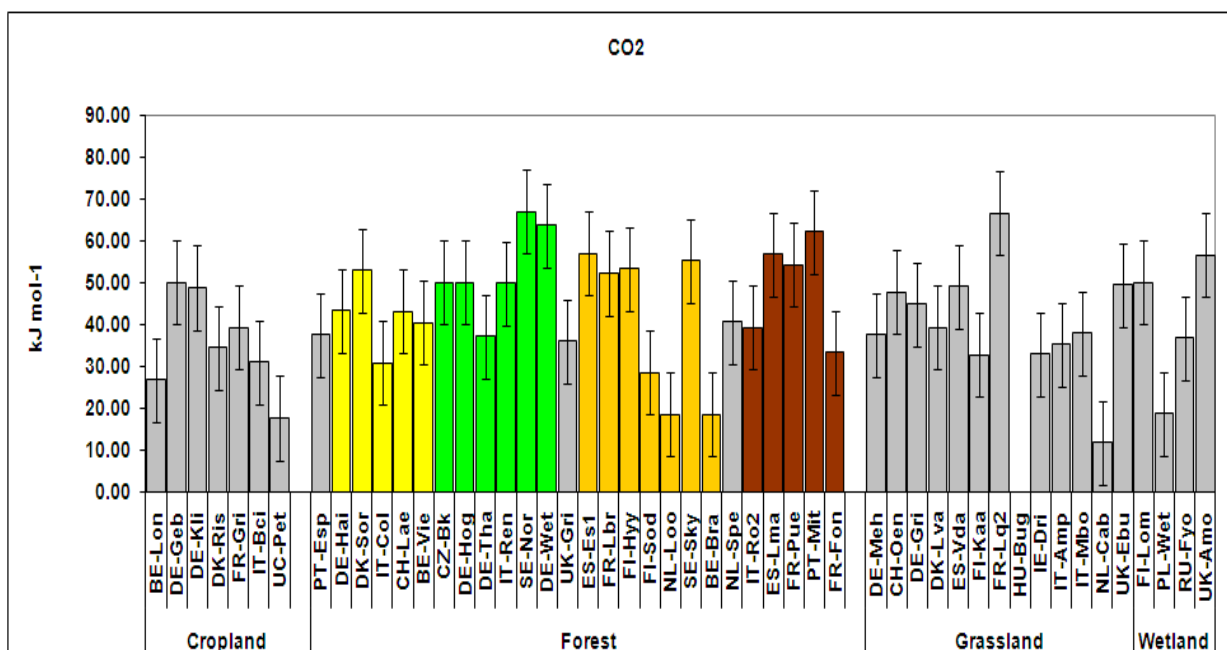


Figure 1: CO₂ fluxes of different countries are classified according to their landuses.

For NO, highest temperature sensitivities were measured from forests. One of the reasons for high NO emissions from forest soils are the low pH and high soil porosity. At grassland sites, high temperature sensitivities were calculated from IE-Dri & IT-Amp while the lowest was ES-Vda. Overall the lowest activation energies were recorded in wetland landuse. The lowest activation energy for NO fluxes in cropland is IT-Bci while in forest the lowest FI-Hyy, in grassland ES-Vda and in wetland FL-Lom. The temperature sensitivities are low as compared to CO₂ results. The highest temperature sensitivity of soil CO₂ fluxes were recorded from SE-Nor (forest) along with FR-Lq₂ (grassland) while for NO same sites were low but showing almost same trend.

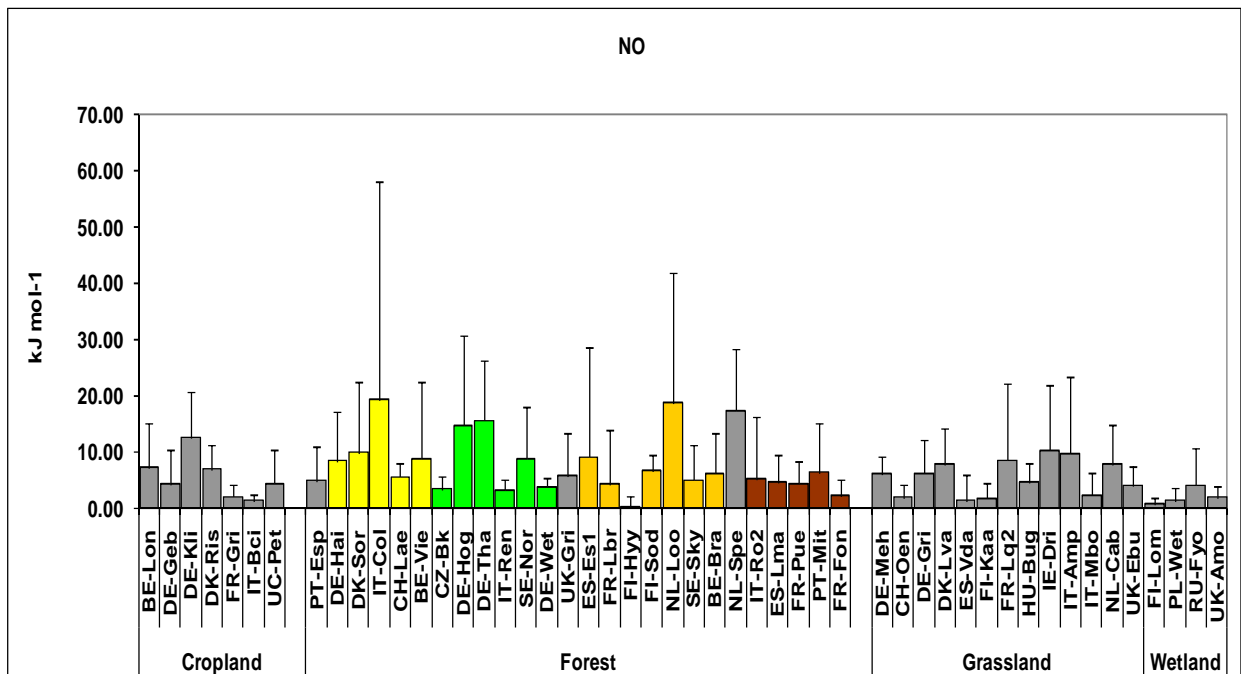


Figure 2: Activation energies of NO of different countries are classified according to their landuses.

Temperature sensitivities of N₂O fluxes were high in grassland followed by forest land use. The highest rate was calculated from HG-Bug site a grassland site. The majority of grassland sites show high activation energies except DE-Meh, CH-Oen, DE-Gri and IT-Mbo. In forests, IT-Ro2 was the highest then followed by DE-Hai. In some of the forest sites temperature sensitivities of N₂O emissions were quite low i.e. PT-Esp, CZ-Bk, DE-Tha, SE-Nor, UK-Gri, FI-Hyy, SE-Sky and ES-Lma. In N₂O some of the data set is missing while some are recorded for short time.

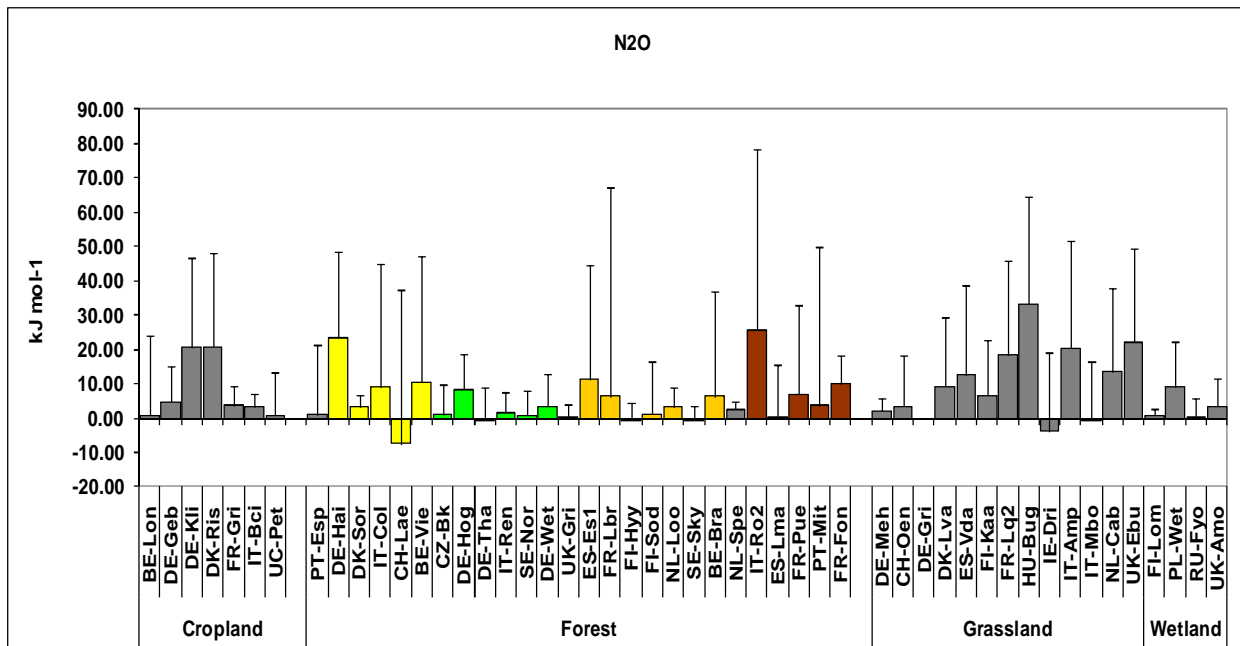


Figure 3: Activation energies of N₂O of different countries are classified according to their landuses.

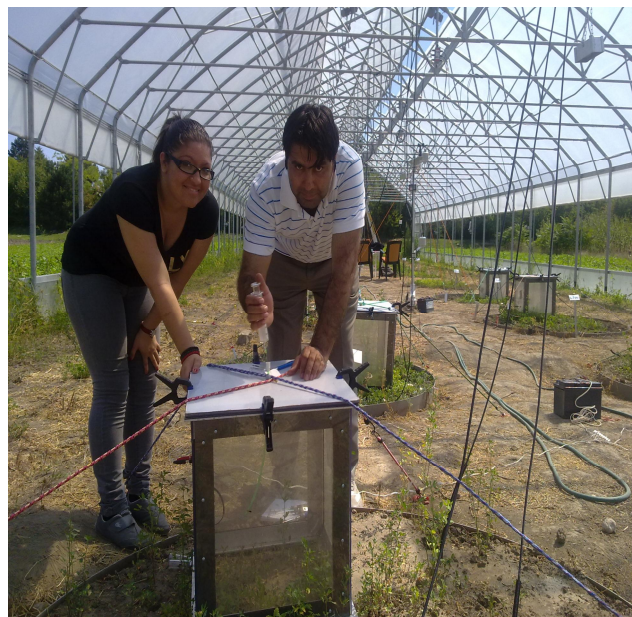
Conclusions

In agreement with our hypothesis, we found distinct and specific land-use effects on different gas fluxes in spite of the variety of origins of soils. In further steps we aim to interpret the calculated activation energies and relate them to various climatic and soil parameters. In order to check various models of activation energies, this data set needs to be set according to different models as mentioned by Tuomi et al., 2008. This will give us key answers to see the extent of temperature sensitivity for fluxes under different landuses. Vanhala et al. 2007 reported that different soil carbon fractions response to temperature sensitivity is an important source of uncertainty in the current models describing the climate–soil–carbon interactions. Furthermore, Fraction-specific measurements on temperature sensitivity are scarce and thus the

models assume that old and young soil carbon is equally sensitive to temperature (Jones et al., 2005). However, some contradicts (e.g., Reichstein et al. 2005; Davidson and Janssens, 2006).

b) “LYSTRAT” Consequences of climate change on ecosystem functions, water balance, productivity and biodiversity of agricultural soil in the Pannonian area:

In addition to the previously described work using already existing NitroEurope data, soil GHG fluxes from 3 different soil types at the AGES lysimeters were sampled and analysed later on at the GC in the laboratory of the BFW.



The procedure was as follows.

1. Soil samples were taken from all the lysimeters from 0-5cm.
2. Soil temperature was measured.
3. Eighteen chambers were installed in the respective lysimeters for gas sampling. The chambers were kept airtight with clamps and ropes.

4. All the chambers were sampled at time 0, 5, 15 and 60 min for GHG emissions on hourly basis.
5. The gas samples were analysed by gas chromatography (Agilent 6890N, Agilent, Santa Clara, CA, USA), connected to an automatic sample-injection system. See also (Schaufler et al. 2010).

4. Future collaboration with host institution

Professor Malcolm S. Cresser at University of York and Dr. Barbara Kitzler (BFW- Austria), Professor Sophie Zechmeister at University of Vienna, Austria and Professor M. Afzal at (KPK Agricultural University Peshawar, Pakistan) have shown great interest in the way project activities were accomplished. Our proposed research linkage will be crucial for future collaborative research. This project will help building new relationships for research students and staff members. We are aiming to sustain the relationships primarily via inter-departmental joint projects both for research and teaching, and through visiting scholarships based at KPK, AUP. Considerable intellectual activity is expected to be generated through this project as groups of scientists would be engaged in publishing quality and challenging research work as collegiate partners. Furthermore, we are developing an international project which we will submit to Marie Curie fellowship involving UK, Austria and Pakistan with common goals. Joint publications arising will cement a longer-term relationship. This project will allow scholars to advance their knowledge-base, establish new contacts and mentors through the experience gained in studying in other research cultures.

5. Projected publication/articles resulting or to result from your grant

The preliminary results of the huge NitroEurope datasets are extremely encouraging. They will be published in a research articles in a peer reviewed journal of high impact factor with the working title:

Activation energies of soil CO₂, N₂O and NO fluxes under different landuse types.

In order to achieve the target of quality publication, The MS will be submitted jointly and the following plan will be followed.

Annual Time Frame for publications

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					Year							
	1	2	3	4	5	6	7	8	9	10	11	12
Organising NitroEurope Data set												
Choosing different models												
Applying data to said models												
Results												
Removing missing data												
Applying Statistics												
Writing Manuscript												
1st Draft												
2nd Draft												
Final MS to be submitted												
Reviewer comments response												
Seminars/Workshops/Forum/Conference												

6. Acknowledgements

The proposed research project and associated professional training has a broad impact on shaping my research and teaching career in the University. Currently I am working as Assistant Professor in the Department of Soil & Environmental Sciences at KPK AUP, Peshawar Pakistan. I have studied biogeochemical C and N cycling in acid grassland ecosystem, how N deposition makes modification and how stream water quality is adversely affected by N leaching. I believe this study has enabled me to gain new insights and broaden my intellectual horizons in the soil biogeochemistry. I am very thankful to ESF for all the financial support and BFW-Austria for hosting my research.

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