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 CO_2, N_2O, and NO fluxes form 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 (CO_2) and methane (CH_4), 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 (CO_2 and CH_4) fluxes from seven sites of four land use types. They found that pine forest has significant lower CO_2 emission and higher CH_4 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 CH_4 uptake over time primarily depended on changes in soil moisture in the upper five centimeters of the mineral soil. They further reported that the CH_4 flux linearly responded to soil moisture content. They also observed that low CH_4 uptake activity during winter was further reduced when the soil was covered with snow. Nitrous oxide is another important GHG.

In a two year study Kitzler et al. (2006) measured nitrogen oxides (N_2O and NO_x), and carbon dioxide (CO_2) 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.

2. Description of the work carried out during the visit

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 CO_2, N_2O 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.

CO_2 = CO_2 measured↔Temp (1divK) ↔ Ln CO_2 ↔ Slope CO_2 ↔ R_2 ↔ Activation Energy CO_2 (kj mol l)$^{-1}$

NO = NO measured↔Temp (1divK) ↔ Ln NO ↔ Slope NO ↔ R_2 ↔ Activation Energy NO (kj mol l)$^{-1}$

N_2O = N_2O measured↔Temp (1divK) ↔ Ln N_2O ↔ Slope N_2O ↔ R_2 ↔ Activation Energy N_2O (kj mol l)$^{-1}$

Note: For site HU-Bug CO_2 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 CO_2, NO and N_2O were different between land-use types. The highest temperature sensitivity of soil CO_2 fluxes were recorded from SE-Nor (forest) along with FR-Lq_2 (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 N_2O and CO_2 emissions.

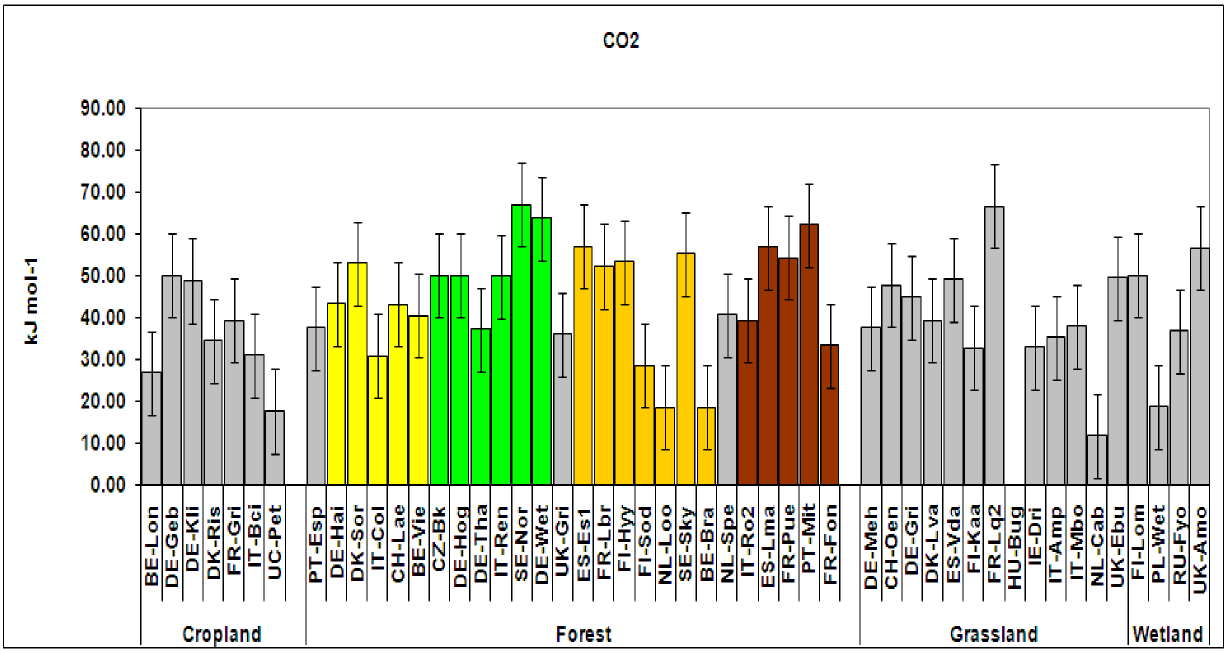

Figure 1: CO_2 fluxes of different countries are classified according to their landuses.

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 temperture sensitivities were calculated from IE-Dri & IT-Amp while the lowest was ES-Vda. Overall the lowest activation energies were recorded in wetland landuse.

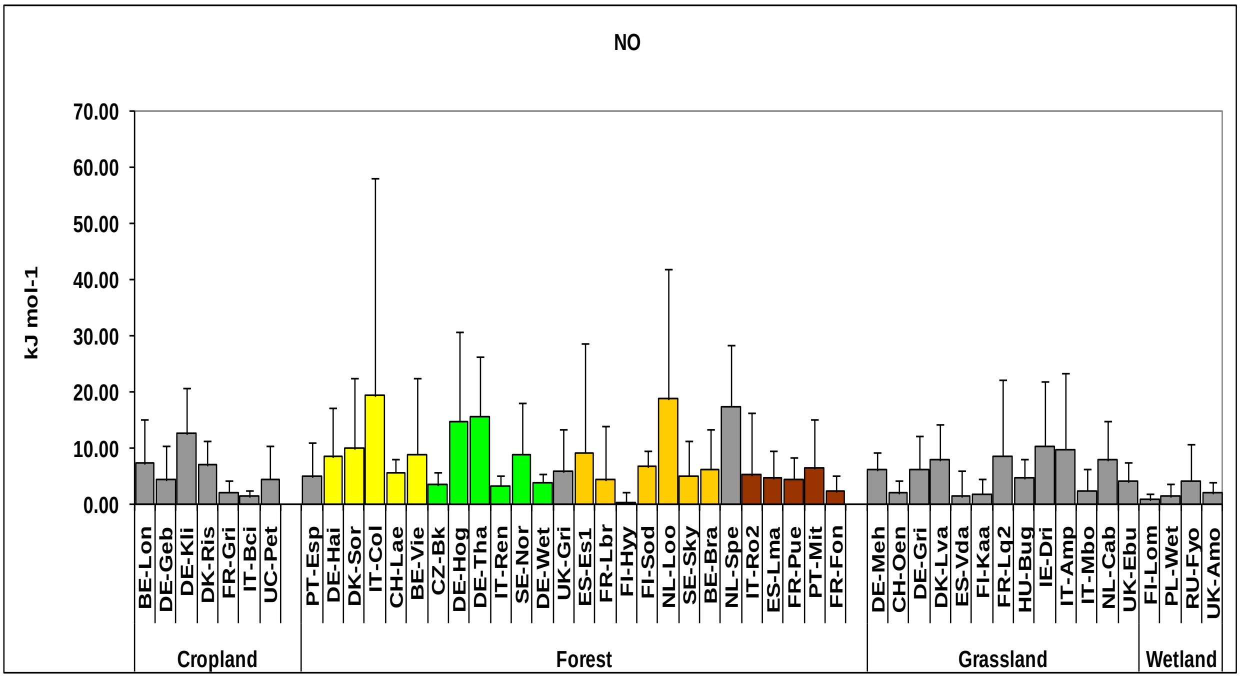

Figure 2: Activation energies of NO of different countries are classified according to their landuses.

Temperature sensitivities of N_2O 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 N_2O emissions were quite low i.e. PT-Esp, CZ-Bk, DE-Tha, SE-Nor, UK-Gri, FI-Hyy, SE-Sky and ES-Lma.

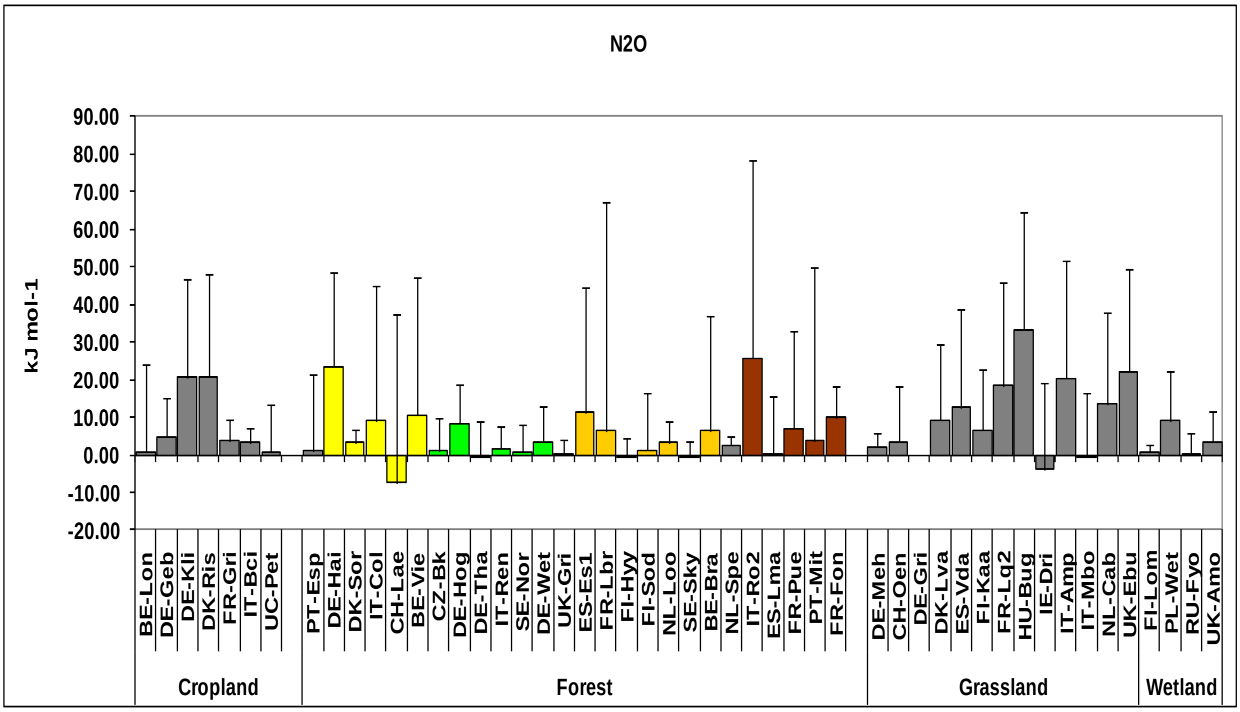

Figure 3: Activation energies of N_2O of different countries are classified according to their landuses.

In further steps we aim to interpret the calculated activation energies and relate them to various climatic and soil parameters. 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 extremly 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 CO_2, N_2O and NO fluxes under different landuse types.

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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