EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Exploratory Workshop Scheme

Standing Committee for Life, Earth and Environmental Sciences (LESC)

ESF Exploratory Workshop on

Towards A Global Synthesis Of Methane Fluxes From Land Ecosystems

Hamburg (Germany), 10-12 April 2012

Convened by:
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SCIENTIFIC REPORT

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1. Executive summary

The ESF Exploratory Workshop “Towards a Global Synthesis of Methane Fluxes from Land Ecosystems” was held from the 10th to 12th of April in Hamburg, Germany. The general goal of the workshop was to harmonize the steadily increasing number of methane (CH_4) measurements worldwide and to evaluate them jointly within a global synthesis activity. An important aim of this interdisciplinary workshop was to bring together scientists experienced in measuring CH_4 fluxes at different ecosystems and scientists that synthesize observations of land-atmosphere fluxes using remotely sensed information and models to generate an empirical picture of global CH_4 flux dynamics. Global constraints of this kind are needed for adequately incorporating CH_4 dynamics into global carbon cycle models. In total, 26 participants from 11 countries (10 European countries and the US) plus the ESF representative Prof. G. Scarascia-Mugnozza participated in the workshop.

CH_4 is the second most important non-condensing greenhouse gas in the atmosphere which is increasingly in the focus of climate research because it has a 25 times higher global warming potential per mass (100 year time horizon) compared to carbon dioxide (CO_2) and provides a significant contribution to radiative forcing. Given that CH_4 emissions from (mainly wetland) ecosystems are sensitive to temperature (besides of changing hydrological conditions), the role of CH_4 in the atmosphere is expected to increase as climate change progresses, especially in high latitude ecosystems. It has to be noted that – as human population increases – society can expect increasing CH_4 emissions resulting from agricultural activities, ruminants, waste, burning and fossil fuel production. In order to achieve a comprehensive global picture of sources and sinks of CH_4, it is of paramount importance to obtain a comprehensive spatio-temporal picture of CH_4 emissions from natural processes, i.e. from natural wetlands and rice paddies, and a better understanding of the responses of CH_4 fluxes to their controlling environmental factors.

Since the 1980s, many CH_4 flux studies have been conducted. However, unlike CO_2 flux observations, no comprehensive global synthesis of CH_4 flux observations has been achieved so far. The workshop aimed to scrutinize the possibilities and prerequisites for initiating a comprehensive global data repository for CH_4 flux observations. Ideally, this data collection should become an open-access repository and form a milestone for research on CH_4 fluxes. The idea was also to set the stage for global synthesis efforts on quantifying the main environmental controls of CH_4 emissions such as their dependencies on temperature, hydro-meteorological variations, and vegetation dynamics in the different climate zones of the Earth. Advanced analytical techniques have so far been applied mostly to CO_2 fluxes, and now offer great opportunities for a leap in understanding CH_4 cycle responses to climate and other factors.

The workshop was organized in topical sessions ranging from very fundamental questions to highly specific problems. We reviewed the current knowledge and uncertainties in the global CH_4 budget (i.e. contributions by talks from M. Heimann, A. Bloom, Ph. Bousquet) and then proceeded with specific ecosystem level reviews, i.e. on CH_4 fluxes from boreal land ecosystems (J. Rinne), from arctic land ecosystems (W. Oechel, D. Zona), and South-East Asia’s tropical peatlands (A. Schrier). In different instances the discussion turned to the fundamental prerequisites (e.g. upscaling efforts). In this context, surprisingly controversial issues emerged, most notably on the question “What are wetlands and where are they?” (E. Matthews) and the fact that fundamental properties such as “temperature sensitivities” are to be analyzed with caution in cases where we have system switches from anoxic to oxic conditions (D. Zona and also M. Mahecha). Yet another main focus of the presentations and

plenary discussions was on the question of representing CH_4 processes in climate-carbon cycle models (M. Heimann, J. v. Huissteden, T. Vesala), and important questions emerged on how a global network of CH_4 flux observations could be integrated into these modelling studies and constrain the relevant process descriptions (A. Bloom).

The workshop also put a strong emphasis on state-of-the art monitoring techniques of CH_4 fluxes, i.e. on chamber measurements (J. Riis Christiansen) and eddy covariance CH_4 flux measurements (W. Eugster), as well as on data processing schemes (S. Dengel). Ultimately, the workshop reviewed the state of the art in comparable efforts focusing on CO_2 such as FLUXNET (D. Papale) but also discussed related European projects that work on different aspects relevant to understanding CH_4 such as DEFROST (T. Vesala and T. Christensen), PERGAMON (T. Sachs) and PAGE21 (J. v. Huissteden).

Breakout discussion groups put a lot of effort on conceptually providing a basis for the initiation of a FLUXNET-CH_4 initiative on the one hand, and for elaborating best practice guidelines for different both chamber and eddy covariance flux studies in the context of CH_4 emissions from terrestrial ecosystems on the other hand (which are to a relevant degree different compared to the existing protocols on CO_2).

One important issue, however, needs to be explained to understand the internal dynamics and scientific preconditions of the workshop: During the evaluation period for the ESF workshop, a second parallel initiative emerged on a nearly identical topic. This second initiative was initiated in the wake of fully independent discussions at the mailing lists of the FP7 project GHG Europe (EU contract No. 244122). Given that this “competing” initiative is global in scope and follows the policy of an open call for participation, it was very positively received by the scientific community. It was clear from the beginning of the ESF workshop that working on competing scientific initiatives would limit the progress of both and efforts had to be joined. Hence, the unanimous feeling of the workshop participants was to use the time together in Hamburg to conceptually advance the scientific grounds to help the global efforts to be developed in the international meeting in Hyytiälä, Finland 2-7 September 2012 (for more information please see: http://www.ghg-europe.eu/uploads/tx_mininews/CH4_N2O_Workshop_announcement_Hyytiala_FI_01.pdf).

As a consequence, the general discussion on next steps to achieve the workshop deliverables, i.e. setting the stage, was put into perspective. Different tasks were distributed, e.g. on literature review, on elaborating scientific guidelines, on interacting with European projects like ICOS, Page21, ABBA and others to define best practices protocols and – most importantly – on prototyping case studies across ecosystems as a scientific basis for the global workshop to be held in in Hyytiälä, Finland 2-7 September 2012. We believe that the ESF workshop provided a unique and valuable contribution to kick off the global effort of synthesizing CH_4 flux observations and will certainly increase the visibility and help the leadership of the European scientific community in global studies of GHG fluxes.

Overall, the general atmosphere was very positive and highly interactive – with very enthusiastic individual presentations. The contributions covered a wide range of ecosystems and hence, participating scientists’ countries of origin. However, given that the topic was so far most intensively studied in the northern latitudes, Scandinavian, German, Dutch and UK participants dominated the composition of the audience. The equally distributed participation of young and experienced scientists made it also a very good place for knowledge transfer and fostered new inter-European and interdisciplinary collaborations.

2. Scientific content of the event

The workshop consisted of eight plenary sessions (six topical scientific sessions, two summarising discussion sessions) and of three time slots for three parallel break-out sessions in which subgroups focussed on advancing the specific deliverables of this workshop. Each scientific plenary session consisted of three to four talks (each 10-20 min) and ample time for general discussion (45 min). For the break-out sessions, a total of five hours were reserved for the subgroup work and 1.5 hours for the discussion of their outcomes in a plenary session. The following summary of the scientific workshop content is based on the protocols of the chairs and rapporteurs of the sessions and the convenors of the workshop. The slides of most of the presentations given during the plenary sessions can be found at the workshop website (http://www.klimacampus.de/esfworkshopch4.html).

10.04.2012

A. Plenary session: The need for a FLUXNET-CH_4; state of the art of land-atmosphere CH_4 flux research (Chair E.-M. Pfeiffer; Rapporteur E.-S. Tuittila)

The workshop was opened by a welcome address by the chair of the introductory session Eva-Maria Pfeiffer on behalf of the University of Hamburg and the KlimaCampus Hamburg. In the first talk, Lars Kutzbach and Miguel Mahecha welcomed the participants on behalf of the convenors and introduced the background, rationale, objectives and expected deliverables as well as the outline of the workshop. They stressed that a comprehensive understanding of the atmospheric growth rates of CH_4 is still limited which appears to be – at least partly – due to the currently incomplete global synthesis of CH_4 flux data. Therefore, the convenors of the ESF exploratory workshop proposed to use this workshop to initiate a global network of networks – a FLUXNET-CH_4 – as a necessary basis for a global CH_4 flux synthesis. Such a network should foster the joint work of field researchers and scientists who are experienced with remote sensing and/or empirical and/or deterministic modelling of CH_4 processes. The exploratory workshop was intended to kick-start the initiation of a global CH_4 synthesis effort by working on the following deliverables:

- the seed for an international and interdisciplinary CH_4-FLUXNET initiative which builds on and connects previous synthesis and networking activities;
- a strategy for the implementation of a new or the extension of an existing functional and consistent database collecting CH_4 flux measurements from the global land ecosystems applying different approaches, e.g. chamber and eddy covariance methods;
- recommendations on best practices in chamber and eddy covariance applications for CH_4 flux measurements and standardized protocols for data processing and quality control;
- the initialization of a series of synthesis papers on different aspects of CH_4 flux processes, for instance on the temperature sensitivity of production, oxidation and emission of CH_4;
- and strategies for the generation of scaled up CH_4 fields, a “quasi-observational” space-time explicit picture, at least for the northern temperate to arctic latitudes.

Afterwards, Giuseppe Scarascia-Mugnozza as ESF representative gave a presentation on the structure, objectives and activities of the ESF and the Standing Committee for Life, Earth and Environmental Sciences (LESC). It was made clear that the ESF is the natural partner for the European scientific community for advancing European high-level research and exploring new directions for research at the European level. Of particular interest for the

participants was the overview of scientific tools which are funded by the ESF. In the immediately following discussion, special opportunities for support of young scientists were enquired.

The introductory session was completed by a talk from Martin Heimann on current global perspectives of the CH_4 cycle of the Earth. He illustrated the still large uncertainties in our knowledge of the global CH_4 source strength of wetlands due to their large heterogeneity and unclear spatial distribution. An important recent development is the re-assessment of the geological CH_4 sources by several studies which estimate the global geological CH_4 sources to be three to five times higher than previously thought. Then, Heimann discussed different explanations for the atmospheric CH_4 growth rates observed over the last decades. The slow-down of the CH_4 growth rate over the last 20 years could be either explained by declining biogenic (wetlands + rice) sources in the northern hemisphere, declining fossil fuel emissions or increasing atmospheric CH_4 oxidation by OH radicals. All three explanations are partly supported by published scientific work, and it appears not possible to specify the relative importance of each mechanism with our current knowledge. Finally, Heimann discussed the potential of different CH_4 hydrate deposits to perturb the atmospheric CH_4 budget and stated that gas leaks from shallow circumarctic subsea permafrost would have the highest probability to significantly contribute to the global CH_4 source strength on relevant time scales (i.e. decades to centuries).

In the general discussion after the presentations, it was discussed if and how a better picture of global CH_4 emissions derived from bottom-up measurements in terrestrial ecosystems could help to constrain the different existing models explaining the observed evolution of atmospheric CH_4. There was agreement that reducing the uncertainties of both the spatial distribution as well as the temporal dynamics of of CH_4 fluxes from terrestrial ecosystems would be beneficial to significantly improve our understanding of the global CH_4 budget. This assessment would then also benefit understanding of the dynamics of other relevant CH_4 sources such as industrial emissions or geological seeps and of atmospheric CH_4 removal by oxidation processes.

B. Plenary session: CH_4 flux data availability from different land ecosystems (Chair A. Knohl; Rapporteur A.-K. Köhler)

In this session's first talk, Janne Rinne gave an overview of CH_4 flux studies from boreal land ecosystems. A large amount of chamber measurements of CH_4 fluxes is already available from this climatic zone – mostly from different types of peatlands – which were used to explore effects of temperature, water table level and vegetation composition on the CH_4 fluxes. However, published eddy covariance measurements of CH_4 fluxes are relatively few (i.e., < 10 publications) and often only conducted for short periods. Several new EC studies have recently been started but their results have not yet been published. First analyses show that seasonal variations of CH_4 fluxes from boreal fens appear to follow temperature in an exponential way. The influence of fluctuations in water table levels, however, is relatively unclear. It remains also largely unexplained why some sites show strong diurnal variability while others do not. The main contribution to annual CH_4 emissions (80-90%) happens during the snow-free period. Then, Rinne discussed two of the longest existing CH_4 EC flux time series from Finnish sites measured by the University of Helsinki and the Finnish Meteorological Institute, respectively, in more detail. The inter-annual variability observed in these CH_4 flux datasets was lower than has been described for CO_2 fluxes. Cumulative summer CH_4 fluxes appeared to increase with higher summer mean temperatures.

In the second talk, Walter Oechel presented an overview of CH_4 flux studies from arctic land ecosystems. Similar to work in the boreal ecosystems, many chamber studies but much fewer EC CH_4 flux studies have been published for the Arctic. Mainly presenting the work of his research group in Alaska, Oechel pointed out some of the major challenges and questions when working with arctic terrestrial CH_4 emissions. Importantly, a pronounced spatial heterogeneity of microrelief, hydrology and soil and vegetation conditions leads to a particularly high spatial variability of CH_4 fluxes on multiple scales. Oechel recommended combining high-resolution surface elevation and vegetation mapping with CH_4 flux measurements covering different scales of heterogeneity (chamber, tower-based and airborne EC) and deterministic process modelling. Further, Oechel stressed the value of experimental manipulation studies like artificial draining or flooding. Important driving variables of CH_4 fluxes from arctic tundra are thaw depth, soil temperature and water table. The productivity of the vegetation appears to be of minor importance since CH_4 emissions appear not to be limited by carbon supply.

In the third talk, Arina Schrier discussed the importance of tropical peatlands as carbon stores and potential greenhouse gas sources. Tropical peatlands have high biodiversity and store about 550 Gt of carbon; however, not much is known about greenhouse gas emissions from these warm and carbon-rich ecosystems. Degradation of these ecosystems due to drainage, deforestation and fires momentarily proceeds at extremely fast rates. Rough estimates indicate that the release of greenhouse gases from degraded peatlands is several times larger for South-East Asia than for Europe (1 Gt yr^{-1} compared to 174 Mt yr^{-1} CO_2 equivalents). However, the existing studies are by far not enough for robust GHG flux assessments from this important peatland region. Also, the methodology of flux measurements in tropical regions currently is often insufficient and needs to be significantly improved in the future.

In the general discussion, the following ecological topics were addressed: How can the diurnal patterns of CH_4 fluxes in some ecosystems be explained? How important is vegetation productivity as a control of CH_4 fluxes in different ecosystems? How does microbial CH_4 oxidation in aerobic soil horizons control CH_4 emissions? What is the importance of ebullition (gas release by gas bubbles) in different ecosystems and how can it be modelled? There was agreement that there is an urgent scientific need for more robust information on CH_4 fluxes and the underlying processes from tropical terrestrial ecosystems. On the other hand, the fear was expressed that socio-economically driven land use changes leading to loss of tropical peatlands might be so fast that they make any scientific knowledge improvements regarding these peculiar ecosystems obsolete. However, others expressed the opinion that increased scientific attention to tropical peatlands could help to increase public awareness and to initiate political actions against the continuation of peatland destruction at the current frightening speed.

11.04.2012

C. Plenary session: Towards standardized methodologies for CH_4 flux studies (Chair T. Vesala; Rapporteur D. Zona)

The first talk given by Jesper Riis Christiansen focussed on the results and conclusions from a chamber calibration campaign, in which 18 different static chamber designs for CH_4 and nitrous oxide (N_2O) flux measurements were compared. The tested chambers differed widely in their performance to replicate a reference flux suggesting that published estimates of trace-gas fluxes are often biased. Systematic errors derive from saturation of headspace,

lack of mixing and disturbance of the headspace. However, these biases can be minimised by applying non-linear regression flux calculation methods, increasing the chamber volume to basal area ratio, sufficient headspace mixing and minimising manual sampling volumes. Riis Christiansen concluded that there is definitely a need for the standardisation of chamber designs and experimental and data processing protocols.

In the second talk, Werner Eugster gave an overview of the state of the art of eddy covariance CH_4 flux measurements. After an introduction into the different optical-physical principles to measure CH_4 concentrations quickly and precisely enough for EC flux determination approaches, he presented the results of several CH_4 analyser comparison test campaigns in which newly developed and innovative instruments were tested. From these results and a literature review, Eugster draw the following conclusions: Newer instruments of the same type are better than old ones. Large fluxes can be measured with any of the currently available optical CH_4 analysers. Large fluxes can be measured also with weak pumps (even with high damping losses). Small fluxes are still a challenge making careful instrument selection important. Even with the preferred instrument for a measurement task, it is still necessary to continuously and critically check its performance. Data processing is still an issue as CH_4 analysers have different properties than CO_2 analysers, and additional or modified correction methods may be needed.

In the third talk, Sigrid Dengel discussed challenges of quality assurance and gap-filling for CH_4 flux datasets. Generally, quality assurance for CH_4 EC measurements should follow the principles which are already well established for energy, water and CO_2 flux EC measurements. Special care should be taken concerning the representativeness of the EC footprint, regular calibration and performance checks of the rather new instuments, the often necessary air density corrections, low-turbulence and storage effects, and appropriate communication of systematic and random error estimates. As flux measurements of CH_4 fluxes are technically more demanding than CO_2 flux measurements, a comparatively high percentage of gaps in CH_4 flux time series have to be expected, thus highlighting the need for appropriate gap-filling tools. Approaches developed for CO_2 flux gap-filling, like neural networks, need to be carefully tested for their suitability to fill gaps of CH_4 flux time series. Potential problems in this context could be the higher small-scale spatial heterogeneity of CH_4 fluxes compared to CO_2 fluxes and the importance of soil-atmosphere transport mechanisms which are not controlled by diffusion alone (e.g., ebullition, convective plant transport).

In the discussion, possibilities to use the outcome from chamber calibration campaigns to correct for biases in existing and future chamber CH_4 flux datasets were discussed. It was noted that strategies to develop such “post-calibration” procedures for chamber flux results would be valuable to make the best use of the large amount of chamber CH_4 flux data. Concerning EC flux methodologies, the problem of surface and flux heterogeneity in the fetches of the flux measurements was discussed; and it was agreed that the problem is highly dependent on the respective scales of heterogeneity in comparison to the measurement height. Therefore, the site’s heterogeneity should be carefully evaluated before the campaign. Another important topic was the applicability of atmospheric density fluctuation corrections for the different new open- and closed-path gas analysers used for EC CH_4 flux measurements.

D. Plenary session: Setting up a FLUXNET-CH_4 initiative (Chair M. Mahecha; Rapporteur P. Serrano Ortiz)

In this session's first contribution, Dario Papale described the current FLUXNET data base to explain the advantages and difficulties in such a big community effort. He illustrated how FLUXNET emerged and showed that it was designed and still works as a "self-organizing" system. FLUXNET currently forms the basis of more than 60 peer reviewed papers on CO_2, H_2O, and energy flux dynamics at ecosystem level. The talk explained how standardization routines guarantee the precision of the data base without loss of generality. Current efforts were highlighted, in particular on the challenges of deriving consistent data uncertainty estimates for model-data synthesis studies. An overview of data products (as they have been prototyped now, and those expected in the next generation of flux data) was given. Examples include, but are not limited to, long term meteorological downscaling data at the site level, separation of subsignals (filtering) at different frequency classes, or the inclusion of site level cutouts of remote sensing products. Then Papale gave an introduction to the European *Eddy Fluxes Databases Cluster* which is an initiative to improve standardization, integration and collaboration between databases that are part of European research projects. Finally, Papale explained the different open or data fair-use policies that should protect the intellectual contributions of both the site level experts (data providers) and environmental analysts (FLUXNET end-users).

After Papale's talk, several contributions followed that described other large European projects working on GHG dynamics.

Firstly, Timo Vesala gave an overview of the Nordic Center of Excellence DEFROST ("A changing cryosphere – *de*picting ecosystem-climate feedbacks as affected by perma*frost*, snow and ice", 2011-2015, six Scandinavian countries involved). The aims of DEFROST are to improve the understanding of Arctic terrestrial and shallow sub-sea permafrost interactions with climate, to provide improved data on energy exchange, carbon cycling and GHG emissions from terrestrial and near coastal cryospheric environments, and to improve climate model capabilities for simulating the feedback processes associated with observed changes in permafrost, snow and ice. Many investigators of DEFROST are also engaged in other European projects like PERGAMON and PAGE21. Within the DEFROST community, the new EC software EddyUH for calculating heat, water, CO_2, CH_4, N_2O, ozone and aerosol particle fluxes, which is developed by the University of Helsinki, is increasingly used, particularly for CH_4 fluxes.

Secondly, Torsten Sachs gave a short overview of the European COST action PERGAMON ("Permafrost and gas hydrate related methane release in the Arctic and impact on climate change: European cooperation for long-term monitoring", 2009-2013, 20 European countries involved). The objectives of PERGMAMON are to quantify the CH_4 input from marine and terrestrial sources into the atmosphere in the Arctic region and ultimately to evaluate the impact of Arctic CH_4 seepage on the global climate. Tasks of PERGAMON are to establish and refine the CH_4 inventory, e.g. in the sub-seafloor, investigate the biogeochemical processes in the sediments and the water column of the ocean that affect the ultimate release of CH_4 to the atmosphere, to evaluate the CH_4 fluxes from wetlands, tundra and Arctic-lakes, to monitor atmospheric CH_4 concentrations using land-based as well as airborne or satellite techniques, and to deliver its new empirical knowledge into deterministic models.

Thirdly, Ko van Huissteden gave an overview of the European collaborative project PAGE21 ("Changing Permafrost in the Arctic and its Global Effects in the 21st Century", 2011-2015, 11 European countries involved). The objectives of PAGE21 are to improve the

understanding of the processes affecting the size of the arctic permafrost carbon and nitrogen pools, to produce high-quality datasets to develop representations of permafrost and related processes in global models, and to use these models to reduce the uncertainties in feedbacks from arctic permafrost to global change. The project includes a strong field-based component to measure lateral fluxes of carbon and nitrogen and vertical land-atmosphere fluxes of CH_4, N_2O and CO_2.

In the following general discussion, several questions were asked about experiences with the fair-data-use policies previously applied in the FLUXNET community. Several participants stressed the importance of the appropriate consideration of data-ownership rights. Papale said that according to his experience with sharing data within the FLUXNET community, relatively few problems concerning the data use policy arose. On the other hand, the mutual benefits of sharing data between field researchers and specialists on new data analysis approaches became very clear, most evident by the long list of joint publications in high-impact scientific journals. Papale also stated that the existing databases in the *European Eddy Fluxes Databases Cluster* would be ready to be extended for CH_4 flux time series, both from EC and chamber measurements. For this, the CH_4 community has to specify the needed structure and the minimum information on measurement variables and metadata. Using the *European Eddy Fluxes Databases Cluster* would be probably the fastest and cheapest solution to create a central database needed for a global CH_4 flux synthesis.

Then, other important projects currently working on GHG dynamics were shortly discussed, e.g. GHG-Europe, ICOS, INGOS, ABBA and MethaneNet. MethaneNet is a UK-funded project which runs a well organised web platform. Kutzbach suggested to use this existing infrastructure as a communication tool for the CH_4 community and will discuss this in more detail with the principal organiser of MethaneNet Vincent Gauci. It was recognised that already quite many European research activities dealing with CH_4 emissions exist. It appears to be the right time to work on connecting these European projects and scientists in a most efficient and fruitful way. The next step must be the intensification of networking of these European projects with similar networks in other continents. Participants of the workshops reported that they know about existing large-scale CH_4 flux projects in the US, Japan and Brazil. However, it appeared that currently, the strongest concentration of CH_4-related projects is found in Europe. The discussion with the international community of CH_4 flux science about a truly international global synthesis effort has to be one focus of the Open Science Conference on “The importance of land-atmosphere fluxes of methane and nitrous oxide for the global greenhouse-gas balance – The need for a FLUXNET-GHG” in Hyytiälä, Finland, 2-7 September 2012.

G. Plenary session: Representation of CH_4 processes in climate-carbon cycle models

(Chair E. Matthews; Rapporteur Ph. Bousquet)

In this session’s first talk, Martin Heimann gave an introduction to deterministic modelling of wetland CH_4 fluxes and combinations of deterministic and empirical approaches. As an example, he presented work conducted using the so-called Walter-Heimann-model (Walter et al., 2001), whose principles are still the core of many currently applied deterministic CH_4 flux models. Heimann explained how several model modules have to be coupled to model CH_4 fluxes, i.e. a vegetation-soil module, a CH_4 biogeochemistry module, a gas transport module and a SVAT-like module including soil hydrology. The main drivers of the CH_4 flux in the Water-Heimann model are soil temperature, water table and vegetation productivity, the latter of which is used to estimate substrate availability to the methanogenic microorganisms.

Previous work could show that the model is able to capture inter-annual and seasonal variability of CH_4 fluxes at single wetland sites when the substrate availability was optimised as a tuning parameter for each site. Up-scaling CH_4 emissions can be done using empirical relationships between net primary productivity, average temperature and substrate availability and wetland distribution maps. Finally, Heimann discussed some major complications when modelling CH_4 fluxes from wetlands, e.g. how to scale from point to the model grid if microtopography of wetlands leads to pronounced small-scale variability of water tables, vegetation and CH_4 fluxes; how to address temporally inundated wetlands; how to better parameterize substrate availability; and how to consider microbial adaptation when looking at longer time scales.

In the second talk, Ko van Huissteden presented the PEATLAND-VU model. The PEATLAND-VU model uses the Walter-Heimann model to represent CH_4 biogeochemistry and transport. Importantly, it has special modules to model soil physics, organic matter production by plants and soil organic matter decomposition, respectively. The model was successfully applied to predict CH_4 emissions on the local, regional and global scale. Then, van Huissteden discussed the model sensitivity to parameter uncertainties and effects of parameter interdependencies and equifinality which can be analysed for example by Generalized Likelihood Uncertainty Analysis (GLUE) approaches. Van Huissteden concluded that to improve modelling of peatland CH_4 fluxes it is necessary to have better hydrology and vegetation input data, to better constrain parameters of the CH_4 biogeochemistry and transport modules (e.g. substrate availability, ebullition), and to adapt the CH_4 model to the higher temporal resolution offered by new flux technologies, e.g. by eddy covariance measurements. Further, model intercomparison studies as well as focussed analyses of the the effects of model complexity and parameter identifiability are needed.

In the third talk, Timo Vesala started with some general remarks on the challenges of introducing wetlands and CH_4 dynamics into global climate-carbon cycle models. Remaining fundamental tasks are to understand, model and predict CO_2 and CH_4 production in peat from decomposition, apportionment of dissolved and gaseous fractions of CH_4, diffusion and oxidation in peat, plant-mediated transport, and ebullition. Further, global models have to consider peat accumulation rates, nutrient supply, plant functional types, carbon availability for methanogens, hydrology, heat transport and phase transitions as well as disturbances and spatial heterogeneity of different types of wetlands. Vesala pointed out that it should not be forgotten that the complete model must in the end also be physically consistent. Afterwards, Vesala presented the approaches which are currently developed in a cooperation between Max-Planck-institute for Meteorology (MPI-M) Hamburg and the University of Helsinki to include a wetland module in the Earth System Model of MPI-M. The CH_4 processes represented in this model are in their main extent based on the model LPJ-WHyMe v1.3.1 by Wania et al. (2010) which itself is largely based on the Walter-Heimann model. However, a novel approach for estimating ebullition flux, which is based on nucleation physical theory, is under development and shall be implemented.

In the general discussion, the question was addressed of how much detail is needed and reasonable in large-scale deterministic CH_4 process models. It is known that many nonlinear processes are involved in controlling the CH_4 fluxes in terrestrial ecosystems; however, representing too many of them would introduce too many poorly constrained parameters and the need for too much, often unavailable input information. Thus, it was recommended that efforts for new combinations of deterministic and empirical approaches for modelling CH_4 fluxes should be further explored as it was felt that these would have a great potential for robust global assessments. Furthermore, the question was discussed how to cover the “hot

spots" and "hot moments" which are characteristic for CH_4 fluxes in terrestrial ecosystems. It was stated that it is particularly problematic to model CH_4 fluxes, which show a strongly nonlinear relation to water table levels, using grid cell averages of water tables as a driving variable if the covered land surfaces have heterogenous topography and hydrology. Some of the newer CH_4 flux models take this landscape heterogeneity into account by letting the model run for different model tiles for different contrasting landscape features (e.g. dry/wet sites).

12.04.2012

H. Plenary session: Global-scale analyses/synthesis of CH_4 processes and fluxes (Chair D. Papale; Rapporteur N. Shurpali)

The session was opened by Elaine Matthews, who is one of the pioneering scientists on wetland classification, with an seemingly simple question "What are wetlands and where are they?". Based on an extensive literature research she started with the issue that there is no global definition of wetlands (vague target and characteristics). Her proposal was to rely on some universal characteristics such as hydrological dynamics, vegetation characteristics, lack of non-adapted vegetation, and soil properties to develop a generic scheme to achieve such a classification. The talk then illustrated how uncertainties and wetland definitions (and hence, of the hydrological conditions) are propagated in modelling studies. As a consequence of these controversial base definitions, contradictory results on the global CH_4 modelling efforts are explainable. Finally, Metthews proposed ideas and concrete steps towards a methane-centric wetland classification.

In a short contribution, Anthony Bloom presented the latest results of his top-down parameter optimization approach which integrates a variety of satellite remote sensing data. With a specific emphasis on the Amazon basin, he explained the advantages and limitations of his approach. The talk nicely illustrated how to exploit this semi-empirical approach to derive a solid (but observationally well constrained) modelling framework for CH_4 fluxes.

In the second short contribution of the session, Miguel Mahecha et al. illustrated a general approach to estimate temperature sensitivities of biogeochemical processes by minimizing the effect of confounding factors. The approach was successfully applied in the context of CO_2 effluxes (ecosystem and soil respiration data from FLUXNET) and can now be extended to derive the temperature sensitivities of CH_4 fluxes. Clearly, some specific issues have to be considered such as abrupt system changes which can, however, be incorporated in the so called "scale-dependent parameter estimation".

The session was finalized by a presentation of Philippe Bousquet, Stefanie Kirschke et al. In an impressive meta-study, they compiled all available CH_4 budgeting approaches (such as those derived from inversions). In particular, they illustrated a novel synthesis budget for atmospheric CH_4 and global budget variations. The study also incorporated process-based modelling efforts and emission scenarios to derive regional budgets over the past three decades. The project was elaborated in the context of the Global Carbon Project and accurately describes important features such as the interannual variability in the global CH_4 budget.

In the discussion, it was pointed out that the arctic soils are the hardest to characterize for wetland classification and global upscaling. Also, in western Amazonia, there exist wetlands but the wetland species commonly identified elsewhere are not available here and ecosystems in the region are mostly treed environments. Risks associated with double

counting were identified as one of the problems in classifying global wetlands. As a result of discussions among the CH_4 scientists gathered at the exploratory workshop in Hamburg, it was decided to initiate a group activity to compile and to jointly analyse citations of research work involving CH_4 emissions from wetlands as a step towards a better wetland classification and a synthesised view of CH_4 fluxes from global wetlands.

Regarding the talk of Mahecha, the difficulty of assessing the temperature sensitivity of CH_4 emission was discussed as the CH_4 flux measured by chambers or EC is a net result of both CH_4 production and its oxidation. Therefore, discussions suggested that work on this topic should consider only the flooded sites so that the sensitivity analysis is not confounded by the effects of CH_4 oxidation. The discussions finally have led to the formation of a group of interested scientists to work together on the assessment of the temperature sensitivity of CH_4 emission using new time series analysis tools to explicitely account for confounding factors like CH_4 oxidation and vegetation phenology.

11.04. and 12.04.2012

E.a Break-out session: Next steps for the initiation of a FLUXNET-CH_4 initiative (Chair M Mahecha; Rapporteur A. Bloom)

This session discussed the practical prerequisites for setting up a FLUXNET CH_4 database. The possibilities of including eddy covariance and chamber CH_4 flux data to the *European Eddy Fluxes Databases Cluster* were discussed with Dario Papale who is one of the principal organisers of this database. He agreed to expand this database so that it fits to the needs of a CH_4 flux synthesis. Also, possible data use policies were intensively discussed. Some participants told about suboptimal experiences with overly open data use policies in the past. However, others strongly supported a rather open data use policy as it clearly fosters synthesis activities and collaborative scientific work. It was thought that for a large group of CH_4 scientists it will be interesting to voluntarily contribute data to a central database if similar data use policies would be established as have been applied in previous FLUXNET activities ("Who contributes data, can also use data"). Scientifically, the group discussed what the fundamental controlling variables of CH_4 fluxes. Mathematically speaking, it was asked what input space is required for formulating a comprehensive mapping to the output space (the CH_4 flux dynamics). At this point, the fundamental differences to the existing FLUXNET became clear: other than for CO_2 fluxes, we need to consider additional abiotic controls such as precise observations on variations in ground water table height and redox potential on high temporal resolutions, as well as accurate meta-information e.g. on micro-topography and soil organic carbon amongst others. As a consequence, this working group will prepare an extended version of the existing data collection sheets that are currently used in FLUXNET. The latter data collection is currently working with ancillary site data (that are relevant to understand the biological dynamics). This data spreadsheet must be extended to comprise all relevant information for understanding CH_4 fluxes. Along these lines, ICOS is currently making progress to also assemble meta-data on the site specific instrumentations. Again, this effort needs to be synchronized and updated such that all the specific issues on CH_4 fluxes can be included. Note that the workshop clearly revealed that focussing on eddy covariance data alone (as the current FLUXNET) will not be sufficient to support reasonable global synthesis. A FLUXNET-CH_4 can only be successful, then, if both eddy covariance and chamber measurements are equally considered. This is reasonable given that J. Riis Christiansen impressively showed how to calibrate chambers of different geometries and construction properties. As a consequence of this study, the instrument metadata will need to be adapted to allow the inclusion of chamber measurements and, in turn, requires a

prescription of flux data postprocessing methods to minimize systematic biases in the observations. These tasks have now been initiated and will be introduced at the Hyytiäla workshop to the wider community for further discussion.

E.b: Joint efforts on best practices for closed chamber CH_4 flux studies (Chair J. Riis Christiansen; Rapporteur S. Petersen)

This session focussed on two main tasks, namely (1) the evaluation of existing chamber-derived data and (2.) recommendations for future chamber measurements. There was agreement that the large amount of closed-chamber measurements – also from past measurement campaigns – are generally highly valuable for budget considerations and validation of modelling results. However, it is necessary to develop a strategy to correct or "post-calibrate" existing chamber data based on metadata information on the experimental set-up. At the very least, the uncertainty range due to different measurement designs has to be assigned to each chamber data set following a standardised approach. Chamber comparison campaigns under controlled environments can be useful in providing a basis for the development of such new developments. The group also discussed if it is possible to recommend "the perfect chamber" for future research programmes. Based on the already conducted comparison campaign, there are already good ideas about this optimal chamber set-up; however, it has to be kept in mind that different investigation sites and different scientific questions always require different designs, thus hampering standardisation. Further, the subgroup stated that recommendations for best practices should not only consider the specific chamber measurement but also to the representation of fluxes in time and space. In this regard, the number of gas sampling times during enclosure and the flux calculation method needs to be specified. To specify the number and distribution of chambers in the study area, a site's spatial variability should be screened before the start of an expensive project. Screening for temporal variability should reflect the temporal variability of drivers (soil hydrology, weather, temperature) and should include an assessment of the diurnal variation. The intense exchange within the group revealed that there is a clear demand for a joint article summarizing the state of the art and the still existing challenges of the closed chamber methodology for CH_4 measurements. Importantly, such a study should not be limited to a review of best practices but should develop tools for adequate comparison and uncertainty estimation of the various existing chamber measurement set-ups which would be urgently needed for global CH_4 flux synthesis.

E.c: Break-out session: Joint efforts on best practices for eddy covariance CH_4 flux studies (Chair W. Eugster; Rapporteur J. Rinne)

This session focussed on the state of the art of the EC technique which is being used as the most preferred method to assess the ecosystem scale GHG exchange from different ecosystems across the globe. With the advent of laser spectroscopic techniques, high resolution EC measurements of CH_4 and N_2O are also becoming ever more popular. The subgroup discussed several issues related to the current status of direct and continuous measurements of CH_4 exchange using the EC technique. Generally, most principles established for EC measurements of CO_2 are also valid for CH_4. Major methodological differences between EC measurements of CH_4 and CO_2 are related to lower flux magnitudes and less or no diurnal variability of CH_4 fluxes as well as to the differences in the instrumentation needed to detect CH_4 concentration quickly and and precisely enough for the EC approach. The CH_4 sensors currently available for this purpose include both closed-

and open-path sensors. As the current trend is to explore wetlands and peatlands in the arctic region where conditions are yet not conducive toward continuous measurement, open-path sensors were thought to be better suited since their main advantage is their lower power consumption. This is a great advantage in areas where electric mains power is not easily available. However, during the discussion, issues such as flow distortion, sensor heating (especially with the massive Li-Cor sensor in mind) came to the forefront. The group generally agreed that there is a need to better understand the impact of these instrument design constraints on the accuracy of the CH_4 flux measurements. Other topics included assessing the impact of advection and storage on the CH_4 fluxes. The group also pondered whether density corrections according to the Webb-Pearman-Leuning (WPL) theory on the CH_4 fluxes are of major concern in CH_4 flux measurements and if application of the WPL term on the fluxes or a point-by-point dilution calculation would be recommended. Standardization of the flux units and measurement techniques was also discussed. The initiation of a joint methodology paper on EC CH_4 flux measurements and the organisation of an intensive field course on CH_4 EC measurement were suggested and will be further evaluated in the next months.

3. Assessment of the results, contribution to the future direction of the field, outcome

A) The ESF exploratory workshop participants recognised the rising interest in the global CH_4 cycle and the need for a global initiative to synthesize existing and future CH_4 flux data. During the workshop, the following strategy to advance this global CH_4 flux synthesis with European CH_4 scientists being a central part of it was developed:

1) As there are already several big European projects dealing with CH_4 fluxes which are funded by the European Union (GHG-Europe, PAGE21, InGOS, ICOS, PERGAMON, ABBA) or national governments (e.g., DEFROST, MethaneNet), respectively, the workshop participants see the need for a “network of networks” for CH_4 research within Europe but preferably also on the global scale: a FLUXNET-CH_4.

2) This “network of networks” primarily needs a functional and consistent database and a well-maintained, functional and inspiring information exchange platform. The workshop participants suggested using existing infrastructure to efficiently build up these two basic prerequisites for a global CH_4 synthesis activity. As an information exchange platform, the group recommended using the existing internet platform www.MethaneNet.org (currently funded by the NERC, UK) which is already used by a relatively large proportion of the CH_4 science community. It was recommended to avoid redundant databases and to establish the new CH_4 flux database as a part of the already existing *European Eddy Fluxes Databases Cluster* (www.europe-fluxdata.eu). For long-term archiving, use of the open access library PANGAEA (http://www.pangaea.de) should be considered.

3) During the workshop, possibilities of including eddy covariance and chamber CH_4 flux data to the European *Eddy Fluxes Databases Cluster* were discussed with Dario Papale who is one of the principal organisers of this database. He agreed to expand this database so that it fits to the needs of a CH_4 flux synthesis. During the break-out sessions of the workshop, specialists of the respective fields already worked on recommendations for the database structure and the content of the metadata information which will be crucial for a useful CH_4 flux database. The different working groups developed lists of necessary site information as well as important technical documentation of applied eddy covariance and

chamber methodologies, respectively. This will be refined and further discussed among the workshop participants in the next months and then communicated to Dr. Papale who will implement it in the *European Eddy Fluxes Databases Cluster*.

4) The workshop participants plan to have the first version of a CH_4 flux database within the *European Eddy Fluxes Databases Cluster* in operation and filled with initial datasets from workshop participants by late summer 2012. In September 2012, the aim is to present this exploratory workshop's strategy for a CH_4-FLUXNET and the operational CH_4 flux database within the *European Eddy Fluxes Databases Cluster* to the larger international FLUXNET community which will meet in September 2012 in Hyytiälä, Finland, for the Open Science Conference on the topic "The importance of land-atmosphere fluxes of methane and nitrous oxide for the global greenhouse-gas balance – The need for a FLUXNET-GHG". The workshop participants think that the strategy developed during the ESF exploratory workshop will be useful to efficiently organise a real global CH_4 synthesis activity which can be kick-started in Hyytiälä. Further, the participants hope that they can convince the international community to use the then operational CH_4 flux database within the *European Eddy Fluxes Databases Cluster* as the central database of a future FLUXNET-CH_4.

B) The participants of the workshop agreed that the growing number of eddy covariance measurements of CH_4 fluxes is of great value especially for analysing the environmental controls of the temporal variability of CH_4 fluxes. On the other hand, it was stressed that there are plenty of published (and unpublished) CH_4 flux chamber studies that are also of great value, especially to analyse the spatial variability of CH_4 fluxes, but which are not yet incorporated for a global CH_4 synthesis. Two concrete CH_4 synthesis activities regarding these temporal and spatial scales, respectively, were initiated during the workshop and are now actively advanced:

1) Elaine Matthews has already established a large collection of publications of CH_4 fluxes. Following her initiative, several workshop participants agreed to extract the necessary information from a sub-set of Dr. Matthews' CH_4 literature collection for a comprehensive meta-data analysis of the existing CH_4 flux literature.

2) Miguel Mahecha proposed to apply new statistical time series analysis methods, which he previously applied to estimate the temperature sensitivity of ecosystem CO_2 respiration fluxes under explicit consideration of confounding factors, to available long-term CH_4 flux datasets. During the workshop, several participants who are responsible for some of the longest existing CH_4 flux measurement time series already agreed to contribute data to this cooperation study and have already send the data to Mahecha.

Furthermore, two subgroups worked intensively on the assessment of the state of the art and still existing challenges of CH_4 flux measurements of closed chamber and eddy covariance methodologies, respectively. During the group work, open methodological questions were identified, and several ideas for joint methodological papers on best-practices recommendation were developed and will be further evaluated in the next months by the participants.

C) At this time, the workshop participants have no direct plan to write a proposal for a new additional CH_4-focussed project. Momentarily, there are already various CH_4-related projects in operation in Europe. They rather would like to focus on networking between these different projects which will produce a wealth of new CH_4 flux measurements and on initiating scientific synthesis projects that use and expand the existing infrastructure, namely the *European Eddy Fluxes Databases Cluster* and www.MethaneNet.org.

4. Final programme

Tuesday, 10 April 2012

10.00-13.00 *Arrival, Reception*

13.00-14.30 *Lunch*

14.30-16:30 **A. Plenary session: The need for a FLUXNET-CH_4; state of the art of land-atmosphere CH_4 flux research**
(Chair **E.-M. Pfeiffer**; Rapporteur **E.-S. Tuittila**)

Welcome; Rationale, Goals and Outline of the Workshop
L. Kutzbach, Miguel Mahecha

Presentation of the European Science Foundation (ESF)
Giuseppe Scarascia-Mugnozza (Standing Committee for Life, Earth and Environmental Sciences (LESC)

Update on the global CH_4 budget – global perspectives
M. Heimann

Discussion

16.30-17:00 *Coffee Break*

17.00-18.45 **B. Plenary session: CH_4 flux data availability from different land ecosystems**
(Chair **A. Knohl**; Rapporteur **A.-K. Köhler**)

Methane fluxes from boreal land ecosystems
J. Rinne

Overview of CH_4 flux studies from arctic land ecosystems
W. Oechel, D. Zona

Greenhouse gases, carbon… and Tropical Peat
A. Schrier

Discussion

19.00-21.00 *Dinner*

Wednesday, 11 April 2012

08.30-10.15 **C. Plenary session: Towards standardized methodologies for CH_4 flux studies**
(Chair **T. Vesala**; Rapporteur **D. Zona**)

Comparison of static chambers to measure CH_4 and N_2O fluxes from soils – Conclusions from the CH_4 chamber calibration campaign
J. Riis Christiansen

State of the art of eddy covariance CH_4 flux measurements
W. Eugster

Quality assurance and gap-filling of CH_4 data
S. Dengel

Discussion

10.15-10.45 *Coffee Break*

10.45-12:30 **D. Plenary session: Setting up a FLUXNET-CH_4 initiative**
(Chair M. Mahecha; Rapporteur P. Serrano Ortiz)

Setting up a FLUXNET-CH_4 initiative –Experiences from FLUXNET
D. Papale

CH_4 research in DEFROST
T. Vesala, T. Christensen

CH_4 research in PERGAMON
T. Sachs

CH_4 research in PAGE21
J. v. Huissteden

Discussion

12.30-13.45 *Lunch*

13.45-15:30 **E. Break-out sessions**

a) **Next steps for the initiation of a FLUXNET-CH_4 initiative**
(Chair **M Mahecha**; Rapporteur **A. Bloom**)

b) **Joint efforts on best practices for closed chamber CH_4 flux studies**
(Chair **J. Riis Christiansen**; Rapporteur **S. Petersen**)

c) **Joint efforts on best practices for eddy covariance CH_4 flux studies**
(Chair **W. Eugster**; Rapporteur **J. Rinne**)

15.30-16.00 *Coffee Break*

16.00-17:45 **F. Break-out sessions - Continuation**

18.00-19.15 *Light evening meal*

19.30-21.15 **G. Plenary session: Representation of CH_4 processes in climate-carbon cycle models**
(Chair **E. Matthews**; Rapporteur **Ph. Bousquet**)

Modelling CH_4 emissions from wetlands: Empirical vs. process-based approaches
M. Heimann

CH_4 processes in the PEATLAND-VU model
J. v. Huissteden

Introducing wetlands and CH_4 dynamics in global climate-carbon cycle models
T. Vesala

Discussion

Thursday, 12 April 2012

08.30-10.15 **H. Plenary session: Global-scale analyses/synthesis of CH_4 processes and fluxes**
(Chair **D. Papale**; Rapporteur **N. Shurpali**)

What are wetlands and where are they?
E. Matthews

Cautionary note on the temperature sensitivity of biogeochemical fluxes
M. Mahecha

Estimating global wetland CH_4 emissions from satellite observations of CH_4 and gravity
A. Bloom

	Three decades of methane sources and sinks: budgets and variations **Ph. Bousquet**
	Discussion
10.15-10.45	*Coffee Break*
10.45-12.15	**I. Plenary session: Summary and general discussion of break-out sessions** (Chair **L. Kutzbach**; Rapporteur **M. Mahecha**)
12.15-13.15	*Lunch*
13.15-15.00	**J. Plenary session: General discussion on next steps to achieve the workshop deliverables, follow-up research activities and/or collaborative actions or other specific outputs** (Chair **L. Kutzbach**; Rapporteur **M. Mahecha**)
15.00-15.30	*Coffee Break*
15.30-17.00	**K. Break-out sessions - Continuation**
17:00	*End of the workshop and departure*

5. Final list of participants

Convenor:

1. Lars KUTZBACH
Institute of Soil Science, University of Hamburg, Germany

Co-Convenors:

2. Miguel MAHECHA
Max-Planck Institute for Biogeochemistry, Jena, Germany

3. Timo VESALA
Department of Physics, University of Helsinki, Finland

ESF Representative:

4. Giuseppe SCARASCIA-MUGNOZZA
Department of Agronomy, Forestry and Land Use, Agricultural Research Council of Italy, Italy

Participants:

5. Anthony BLOOM
School of GeoSciences, University of Edinburgh, United Kingdom

6. Philippe BOUSQUET
Laboratoire de Sciences du Climat y de l'Environnment, Institute Pierre Simon Laplace, France

7. Sigrid DENGEL
Department of Physics, University of Helsinki, Finland

8. Werner EUGSTER
Institute of Agricultural Sciences, ETH Zürich, Switzerland

9. Julia GEBERT

Institute of Soil Science, University of Hamburg, Germany

10. Martin HEIMANN
Max-Planck Institute for Biogeochemistry, Jena, Germany

11. Alexander KNOHL
Department for Bioclimatology, Georg-August University of Göttingen, Germany

12. Ann-Kristin KÖHLER
School of Earth and Environment, University of Leeds, United Kingdom

13. Annalea LOHILA
Finnish Meteorological Institute, Helsinki, Finland

14. Elaine MATTHEWS
NASA Goddard Institute for Space Studies, New York, United States

15. Walter OECHEL
Fondazione Edmund Mach, San Michele all'Adige, Italy

16. Dario PAPALE
Laboratorio di Ecologia Forestale, Università degli Studi della Tuscia, Italy

17. Søren PETERSEN
Department of Agroecology, Aarhus University, Denmark

18. Eva-Maria PFEIFFER
Institute of Soil Science, University of Hamburg, Germany

19. Jesper RIIS CHRISTIANSEN
Department of Biology, University of Copenhagen, Denmark

20. Janne RINNE
Department of Physics, University of Helsinki, Finland

21. Torsten SACHS
Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum GFZ, Potsdam, Germany

22. Arina SCHRIER
Wetlands International, Wageningen, The Netherlands

23. Penélope SERRANO ORTIZ
Department of Desertification and Geoecology, Estación Experimental de Zonas Áridas, Almería, Spain

24. Narasinha SHURPALI
Department of Environmental Science, University of Eastern Finland, Kuopio, Finland

25. Eeva-Stiina TUITTILA
School of Forest Sciences, University of Eastern Finland, Joensuu, Finland

26. Ko VAN HUISSTEDEN
Department of Earth Sciences, Vrije Universiteit Amsterdam, The Netherlands

27. Donatella ZONA
Department of Biology, University of Antwerp, Belgium

6. Statistical information on participants

In total, 26 participants from 11 countries (10 European countries and the US) plus the ESF representative Prof. G. Scarascia-Mugnozza participated in the workshop. The distribution of

participants by their country of origin is shown in Table 1. Two last-minute cancellations of non-German invitees (9.4.12 and 10.4.12) led to the unforeseen situation that the proportion of German workshop participants was higher than 25 % of the total number of participants. Due to the very late notice, it was not possible for the convenors to invite any replacement persons for re-adjusting the repartition of participants by their country of origin. Ten participants (38.5%) were female, and 16 participants (61.5%) were male. According to the ESF definition, 15 *young scientists* (57.7 %) and 11 *experienced scientists* (42.3 %) participated. No detailed information on age of the participants was collected.

Table 1. Distribution of participants by their country of origin

Country of origin	Number of participants	Percentage of total participant number
Belgium	1	3.8 %
Denmark	2	7.7 %
Finland	6	23.1 %
France	1	3.8 %
Germany	7	26.9 %
Italy	2	7.7 %
Spain	1	3.8 %
Switzerland	1	3.8 %
The Netherlands	2	7.7 %
United Kingdom	2	7.7 %
United States	1	3.8 %
Total	26	100 %