**Table 1** Literature overview on published protocols and recommendations for soil-atmosphere GHG measurements with emphasis on the static chamber methodology. (*recommended reading)

| Topic | Specialization | Methods | Highlight | Reference |
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| *General overviews on methodology* | | | | |
| Measuring biosphere-atmosphere exchange of $CH_4$ and $N_2O$ | Overview on measuring techniques | Theoretical and practical information on measurements | Very good overview on measuring techniques | Denmead 2008* |
| Rice paddies/ wetlands/uplands | $CH_4$ flux measurement methods | Overview of techniques | Overview on $CH_4$ measuring techniques (micromet, chambers) | Schütz and Seiler 1992 |
| $CH_4$ and $N_2O$ fluxes from livestock systems | Review | Description of approaches and underlying mechanisms | Review, incl. processes, methodology | Kebreab et al. 2006 |
| Overview on measuring techniques with focus on static chambers flux measurements | Overview on techniques | Provides practical guidance on measuring soil GHG fluxes | Overview on methodologies and short-comes | Butterbach-Bahl et al. 2011 |
| Quality assurance for static chamber measurements | Quality assurance | Minimum set of criteria for static chamber design and deployment methodology | Confidence in the absolute flux values reported in about 60% of the studies was estimated to be very low due to poor methodologies or incomplete reporting | Rochette and Eriksen-Hamel 2007* |
| Micrometeorological measurements of $N_2O$, $CO_2$, $CH_4$ | Micro-meteorology | Description of procedures | Theory and application of micrometeorological measurements of GHG fluxes from agricultural fields | Pattey et al. 2006 |
| *Chamber measurement protocols* | | | | |
| Protocol for soil $N_2O$ flux measurements | Detailed description of all steps for soil gas flux measurements | Static chamber, focus on $N_2O$ | Detailed step by step description of procedures | De Klein and Harvey 2012* |
| Protocol for measurements of $N_2O$ and $CH_4$ fluxes from agricultural | Wide range of different techniques | Good overview about micro-meteorological and chamber techniques, incl. techniques to measure CH4 emissions | Standard text book on method to measure agricultural GHG fluxes for reference | IAEA 1992 |

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| sources | | from ruminants | | |
| Protocol for chamber measurements | Focus on chamber based flux measurements of $N_2O$, $CH_4$, $CO_2$ | Provides overview on calculations and practical recommendations for measurements | Standard protocol for the USDA-ARS GRACEnet project | Parkin and Venterea 2010* |
| Protocol for chamber measurements in rice paddies | $CH_4$ fluxes from rice paddies | Sampling times and dates across the rice growing season | Simplified measuring protocol for $CH_4$ fluxes from rice paddies to minimize number of measurements | Buendia et al. 1998 |
| Protocol for soil $N_2O$ flux measurements | Description of protocols for $N_2O$ measurements | Overview on static chamber methodology with focus on $N_2O$ | Discusses potential errors when installing static chambers and provides minimum requirements for using these chambers | Rochette 2011 |
| Common practices for manual GHG sampling | Literature review on protocols as being practised | Static closed chamber | Most widely used methodological features of manual GHG sampling identified | Sander et al. 2014b |
| Protocol for gas pooling technique for static chamber measurements | Gas pooling technique | Overcoming spatial heterogeneity with static chambers | Pooling of gas samples across individual chambers is an acceptable approach to integrate spatial heterogeneity | Arias-Navarro et al. 2013 |
| *Flux calculation for static chamber technique* | | | | |
| Flux calculation | Non-linear versus linear calculation methods for soil $N_2O$ fluxes | Static chamber | Linear calculation schemes are likely more robust to relative differences in fluxes | Venterea et al. 2009* |
| Flux calculation | Diffusion model | Static chamber | Common measurement practices and flux calculations underestimate emission rates by 15-25% under most circumstances. Error dependent on chamber height, soil air porosity and flux calculation method | Livingston et al. 2005* |
| Flux calculation | Flux correction for static chamber measurements of $N_2O$ and $CO_2$ fluxes | Static chambers | Correction scheme for estimating the magnitude of flux underestimation arising from chamber deployment | Venterea et al. 2010 |
| Flux calculation | Flux correction | Static chambers | The systematic error due to linear regression is of the same order as the estimated uncertainty due to temporal variation | Kroon et al. 2008 |
| Flux calculation | Flux correction | Static chamber | Linear versus non-linear, provides link to free R software download for flux calculation | Pedersen et al. 2010* |
| Flux calculation | Flux correction | Static chambers | Significant underestimation of soil $CO_2$ flux strength if linear regression is applied | Kutzbach et al. 2007 |

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| Flux calculation | Theoretical evaluation | Static chamber | Measurement and simulation of measuring errors | Hutchinson and Rochette 2003 |
| Static chamber $N_2O$ fluxes | Headspace $N_2O$ increase | Changes in soil gas concentrations upon chamber closure | Increased headspace concentration of $N_2O$ reduced effective efflux of $N_2O$ from the soil | Conen and Smith 2000 |
| *Chamber design and comparison of methods* | | | | |
| Comparison of chamber designs and flux calculation | Linear versus non-linear flux calculation | Static chamber comparison | Increasing chamber height, area and volume significantly reduces flux underestimation | Pihlatie et al. 2012 |
| Chamber measurements of $N_2O$ fluxes from soils | Focus on soil $N_2O$ fluxes | Closed and dynamic chambers | Comparison of different chamber types (sizes) with eddy covariance fluxes | Smith et al. 1996 |
| Static chamber design | Soil $N_2O$ fluxes | Recommendations for chamber and vent design and flux calculation method | Vent dimension effects N2O fluxes. One of the first papers on chamber design, flux calculations and venting | Hutchinson and Mosier 1981 |
| *Venting of static chambers* | | | | |
| Venting of closed chambers | Comparison of vented versus non-vented chambers | Closed chamber $N_2O$ fluxes | Venting can create larger errors than the ones it is supposed to overcome | Conen and Smith 1998 |
| Venting of closed chambers | Comparison of vented versus non-vented chambers | Closed chamber $CO_2$ fluxes for forest soils | Increases of $CO_2$ fluxes exceeding a factor of 2 in response to wind events for vented chambers | Bain et al. 2005 |
| Venting of closed chambers | Vent design | Closed chambers | Presenting a new vent design to avoid overestimation of $CO_2$ fluxes under windy conditions due to the Venturi effect | Xu et al. 2006 |
| Venting of closed chambers | Vent design and seals | Closed chambers | Discussion on the necessity of vents and of appropriate flux calculation | Hutchinson and Livingston 2001 |
| *Chambers and small scale variability of fluxes* | | | | |
| Chambers and small scale heterogeneity of soil properties | Effect of soil physical characteristics on fluxes | Flux calculation methods in dependence of soil properties | Re-iterates effects of non-steady soil conditions on errors while measuring fluxes with chambers | Venterea and Baker 2008 |
| Static chamber measurements of soil $CO_2$ fluxes | Spatial heterogeneity, flux calculation | Frequency of sampling and number of chambers for overcoming spatial heterogeneity | Means of eight randomly chosen flux measurements from a population of 36 measurements made with 300 cm2 diameter chamber were within 25% of full population mean 98% of the time and were within 10% of the full population mean 70% of the time | Davidson et al. 2002 |
| Protocol for gas | Gas pooling | Overcoming spatial | Pooling of gas samples across individual | Arias-Navarro et al. 2013 |

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| pooling technique for static chamber measurements | technique | heterogeneity with static chambers | chambers is an acceptable approach to integrate spatial heterogeneity | |
| *Timing of measurements, sampling frequency and cumulative fluxes* | | | | |
| Sampling frequency and $N_2O$ flux estimates | Comparison of auto-chambers with replicated manual chambers | Evaluating the importance of sampling time | Auto-chambers are useful if significant diurnal fluctuations in temperature are expected and for better quantifying fertilization emission pulses | Smith and Dobbie 2001 |
| Sampling frequency and $N_2O$ flux estimates | Automated measuring system | Effect of sampling frequency on estimates of cumulative fluxes | Sampling once every 21d yielded estimates within -40% to +60% of the actual cumulative flux | Parkin 2008 |
| Sampling frequency and $N_2O$ flux estimates | Automated measuring system | Evaluation of effects of sampling frequency on flux estimates | Low frequency measurements might lead to annual estimates which differ widely from continuous, automated flux measurements (e.g. 1 week = -5 - +20%) | Liu et al. 2010 |
| Static chamber measurements | Comparison of flux estimates by automated and manual chambers | Chamber effects on soil environmental conditions | Seasonal cumulative $N_2O$ and $CH_4$ fluxes as measured by manual chambers on daily basis were overestimated 18% and 31%, since diurnal variation in fluxes were not accounted for. On the other side, automated chambers reduced soil moisture. To avoid this, change of chamber positions is recommended | Yao et al. 2009 |
| $CH_4$ and $N_2O$ flux measurements from manure slurry storage system | Comparison of continuous and non-continuous flux measurements | Recommendations of sampling intervals and timing of measurements | For $CH_4$, sampling between 1800 and 0800h at intervals <7d yielded ±10% deviation for $N_2O$ was 50% when sampling at 2000h | Wood et al. 2013 |