International Workshop on N_2O Emissions in Various Ecosystems

Site-Based Research and Global Synthesis

Workshop summary report

Date | November 28th – December 1st, 2017

Venue | Taiwan Agricultural Research Institute (TARI)

Organizing Committee | Chiling Chen (TERN, TARI, Taiwan | Chair), Jianwu Tang (US-LTER, the Ecosystem Center, Marine Biological Laboratory, USA), Yi-Ching Lin (TERN, Tunghai University, Taiwan), Hideaki Shibata (JaLTER, Hokkaido University, Japan)

Co-organizers | TERN (Taiwan LTER), JaLTER (Japan LTER), ILTER (International Long-Term Ecological Research Network), Towards INMS (International Nitrogen Management System)

Participants | 9 Keynote speakers, 10 Oral presenters, 34 Poster presenters, and >50 other participants from 10 countries

Plenary and poster sessions | Many of outstanding research findings, current synthesis and suggestions for future works were presented on various N_2O emission studies in wide range of regions (i.e., Temperate, Sub-tropical, Mediterranean, Arid, and High Arctic) and ecosystems (i.e., Cropland, Paddy field, Forest, Dryland, Wetland and others). They include various research approaches such as site-based N_2O flux monitoring (i.e. chamber measurements, eddy covariance etc.), in situ manipulation (i.e., N fertilization, warming, CO_2 enrichments etc.), laboratory incubations (incl. isotope tracer experiments), literature meta-analysis (i.e. emission factors, charcoal impact) and global modeling studies with various temporal and spatial scales. New insights of N_2O emission processes (e.g., Feammox) and analytical tools (e.g., laser sensors, site preference of N isotopes) were also presented. Thera were number of interactive discussions among participants during the keynotes, plenary and poster session. See the attached programs for details (Appendix A).

Field discussions | Participants visited two research stations of Taiwan Agricultural Research Institute (TARI), the Chia-Yi and Chi-Ko Branches. These sites are assigned as agricultural sites of Taiwan Ecosystem Research Networks (TERN). Chiling Chen overviewed the TERN activities with special attention to nitrogen cycle studies which has been contributing to the ILTER-Nitrogen Initiative. Instruction of representative

chamber measurements of N_2O emission with the current method in TARI was presented by Ping-Yu Wu and his colleagues both indoor and on-site in the research sites. Participants including younger scholars and students discussed those chamber methods from various technical points of views such as issues of physical disturbances during the chamber installation, duration and frequency to measure N_2O concentration in chambers etc. Participant also visited various research sites and field facilities in those research stations.

Topical discussions | Participants discussed following three topics in breakout groups that moderated by Jianwu Tang (Topic 1), William McDowell (Topic 2) and Luis Lassaletta (Topic 3).

Topics 1. Protocol of N_2O emission measurement

- What are current technical problems to measure the N_2O emission?
- What are possible/expected new methods to improve the accuracy of N_2O emission?
- How can we develop common methodology to measure N_2O emission?

Topics 2. Fostering the collaborative research across the ILTER sites

- What is an exciting new research project on N_2O emission using the ILTER strength?
- How can we implement the above research project?

Topics 3. Indicators, drivers and assessment methodology of the N-threats relating to N_2O emissions (Towards INMS)

- What are threats relating to N_2O emission for human and ecosystems?
- How can we assess those N-threats on N_2O emission regionally and/or globally?

See the Appendix B for outcomes in each discussion. The following action items were agreed among participants.

Topics 1

- Create working team to develop the review paper on updated methodology of N_2O emission for the ILTER site-based monitoring for global comparative study and synthesis. Need to find the updated techniques, experiences and knowledges (e.g., laser) by referring the similar text books and previous papers.
- Jianwu Tang and colleagues will initiate to develop the draft structure of the above paper, authors' team and expected schedule in next weeks.

Topics 2

- Collect information of exiting N_2O emission studies with simple metadata in ILTER sites. William McDowell, Luis Lassaletta will develop initial template for the questionnaire and send it out to the ILTER researchers. Need to explore this survey for non-LTER sites through the LTER researchers too.
- Global inter-laboratory incubation project would be feasible to develop powerful dataset representing global potential N_2O emission from soils using common methodology with sound quality check at various ecosystems and environment setting. Whendee Silver, Hideaki Shibata and colleagues will develop the initial draft proposal in next weeks.

Topics 3

- Develop the summary document analyzing the driving factors of N_2O emission with their characteristics, interactions, uncertainties and knowledge gaps which would be helpful and valuable for the activities of the Towards INMS projects.
- Luis Lassaletta and Hideaki Shibata will develop the above short summary and circulate it to the participants to review it in next weeks.

In the end of the workshop, Chiling Chen announced that the ILTER annual meeting will be held in Taichung, Taipei in October 2018, and encourage their participations. All of the workshop participants appreciated Chilling Chen and staff of the TARI for their great organization and hospitalities during the workshop.

Group photo at the venue of the workshop | Taiwan Agricultural Research Institute (TARI)

Field discussion about N_2O emission measurements

Breakout discussion about specific research topics

Appendix A | Workshop program

Workshop Agenda / Date: Nov. 28th-Dec. 01st, 2017

Day 1 / Nov. 28th, 2017

Venue: International Conference Hall, Taiwan Agricultural Research Institute (TARI)

09:00-09:30 Opening Ceremony | Junne-Jih Chen

09:30-10:10 Keynote talk I | Challenges of global synthesis of N cycles under changing environments: ILTER N-Initiative and the contribution to the Towards INMS | Hideaki Shibata (Japan)

10:10-10:30 Coffee Break

10:30-11:10 Keynote talk II | The importance of establishing regional N_2O emission factors: lessons learned from the Mediterranean-type cropping systems | Luis Lassaletta (Netherlands)

11:10-11:50 Keynote talk III | Global comparison and synthesis of N_2O emissions from agriculture ecosystems | Jianwu Tang (USA)

11:50-12:10 Discussion I

12:10-14:00 Lunch time / Poster session

14:00-14:40 Keynote talk IV | N cycle in a subtropical high-standing island, Taiwan | Teng-Chiu Lin (Taiwan)

14:40-15:10 Keynote talk V | N_2O emission from agriculture ecosystem in Taiwan | Chi-Ling Chen (Taiwan)

15:10-15:30 Coffee Break

15:30-16:10 Keynote talk VI (on-line) | Biochar and soil N_2O emissions: where do we stand? |Maria Luz Cayuela (Spain)

16:10-16:30 Use of $^{15}N_2O$ laser for the evaluation of nitrogen cycle in a contaminated soil | Yoshitaka Uchida (Japan)

16:30-17:00 Discussion II

Day 2 / Nov. 29th, 2017

Venue: Taiwan Soil Exhibition Hall, Taiwan Agricultural Research Institute (TARI)

09:00-09:30 Keynote talk VII (on-line) | GCP-INI Joint Activity on the Global N_2O budget: Synthesis through Top-Down and Bottom-Up Approaches | Hanqin Tian (USA)

09:30-10:00 Keynote talk VIII | Upscaling cropland N_2O emissions from site-based observations to global synthesis | Feng Zhou (China)

10:00-10:20 Coffee Break

10:20-10:50 Keynote talk IX | Denitrification and anaerobic ammonium oxidation in a subtropical constructed wetland | Hsing-Juh Lin (Taiwan)

10:50-11:20 Drivers of N2O flux from streams and rivers: searching for a better predictive model of N_2O concentrations in inland waters | William H. McDowell (USA)

11:20-11:40 Beyond denitrification: Exploring alternative pathways in the nitrogen cycle and implications for N_2O emissions | Whendee Silver (USA)

11:40-12:10 Discussion III

12:30-14:00 Lunch time / Visit Taiwan Soil Exhibition Hall (13:15-14:00)

14:00-14:20 nirK-possessing denitrifying bacteria contributes to nitrous oxide with unknown isotopic signature from dairy manure compost | Koki

MAEDA (Japan)

14:20-14:40 Evaluation of field based quantum cascade lasers for measuring N_2O fluxes from static chambers and eddy covariance towers | Ilya Gelfand (USA)

14:40-15:00 Rainfall gradient induce high gaseous nitrogen loss in soils of desert ecosystem | Eli Zaady (Israel)

15:00-15:20 Estimations of N_2O emissions from natural and managed ecosystems in the LTER-Austria Network | Eugenio Diaz-Pines (Austria)

15:40-16:00 Conceptualizing Floodplains as a Social- Ecological System | Prakash Jha (India)

16:00-16:20 Bird rookeries: A hotspot of N_2O emissions in the High Arctic | Kentaro Hayashi (Japan)

16:20-16:40 Emissions of carbon dioxide and nitrous oxide from agriculturally fertilized rice fields | Mao-Chang Liang (Taiwan)

16:40-17:20 Discussion IV

Day 3 / Nov. 30th, 2017

Field Trip & Hands-on training | 08:00-17:00

1. Field visit on the agricultural LTER site: Rice-peanut field, Lychee Orchard
2. Hands-on training on N_2O measurement

Day 4 / Dec. 01st, 2017

Group discussion & Conclusion

Venue: Taiwan Soil Exhibition Hall, Taiwan Agricultural Research Institute (TARI)

08:30-12:00 Theme I: Protocol of N_2O emission measurement
Theme II: Fostering the collaborative research cross ILTER sites (incl.

	new research agenda) Theme III: Indicators, drivers and assessment methodology of the N_2O threats for the environment (Towards INMS)
12:00-13:30	Lunch time
13:30-14:15	Report of the group discussion (with Q & A) | Hideaki Shibata (Japan) & Chiling Chen (Taiwan)
14:15-15:15	General discussions (incl. next step to foster the N_2O project) | Hideaki Shibata (Japan) & Chiling Chen (Taiwan)
15:30	Conclusions and workshop close

Appendix B | Discussion notes in the breakout group

Topics 1

We cannot have common methodology for all because the method is highly site and objective specific.

Attention to be paid:

- Data format.
- CO2 interference on N2O measurement: Remove CO2 by soda lime? –need to calibrate/validate using standard gases (CO2=0 vs. CO2 = 400 PPM)
- Chamber locations: with or without roots.
- Chamber measurement time: under rainy dates?
- Chamber cutting should be not too deep, to disturb the belowground profile. (5 cm?) (10-15 cm into soils). Not too shallow: if shallow, leaking problem happens.
- The height of base issue? The water flooding issue inside the chamber/collar.
- Terminology: Anchor = collar = base; Monitor = analyzer
- Air inlet and outlet: height and take.
- Higher accuracy and precision of the analyzer, shorter time needed for the closed chamber. Frequency of the analyzers. Range. Calibration.
- Needle/pigtail design: influenced by turbulence
- How about wind speed and pressure effect?
- How to use curve to fit? Linear or non-linear: related to soil profile. Use some type of programming to do calculation and share with the community.
- Separate the standard approach vs. optional approaches which are site specific.
- About the machine: Laser ones are better.
- Residue air: how long it takes to flush the air. Flow rate, the length of tubing.

Topics 2

Collaboration – possible types of collaboration

1. Synthesis of existing information
2. Coordination among existing projects
    a. Shipping samples among sites
    b. developing new expertise among participants
    c. developing new experiments

3. New initiative with new proposal, objectives, funding

Exciting research topics/projects

1. **"Ecosystem Cataloging"** What is depth of knowledge on ecosystem-level N_2O fluxes and drivers across a range of different sites/land use types/management regimes/ecosystem types/biomes? How can we improve estimates for global models? Are there regional sub-models, or are they worth developing? What are the scalable components? How do they vary across the range of "natural" to heavily managed systems?
2. What is the role of N_2O in the overall N budget of different sites/ecosystem types/biomes (deposition inputs, stream N outputs (NO_3, NH_4, DON, and N_2O), soil N_2O outputs, across a mosaic of site complexity/heterogeneity? headwater forests to working landscapes?)

3. **"Driver cataloging"** Role of episodic drivers on soil N_2O flux {temporal variability}. Wet/dry, Freezing/thawing cycles, snow cover/no snow cover too. For example, how do wetting and drying cycles (short, episodic versus seasonal) affect the overall N_2O flux from a site? What role does soil texture play in this? Lab vs field measurement? Eugenio's previous work highly relevant? Similarly, how do large, episodic disturbances affect N_2O fluxes (e.g. how does frequency of typhoon/hurricane events, fires, others?) affect soil/stream coupling?
4. What can we infer about N cycling processes using natural isotopic abundance of inputs, outputs, and N2O outputs?
5. N_2O production at microbial/enzymatic level, versus what is produced at ecosystem level? Quantifying the inherent variability in molar ratio; importance of both production and reduction of N_2O; very high leverage in terms of total N_2O production; maybe address with 6) above

6. **BOTH Ecosystem cataloging and driver cataloging**: Global potential N_2O fluxes: a laboratory incubation experiment (a few labs running various assays, with sites and collaborators all over; tracking pathways with ^{15}N enrichments) Strong enthusiasm for this among multiple labs, with a real proposal to get it funded. Emphasis on building response surfaces for global models
7. Campaign measurement of N_2O in fresh waters, along with physical and biogeochemical parameters that are known drivers of concentration and efflux

Standardized protocols are needed for soil GHG flux for any collaborative research; but also troubleshooting forum or other collaborative approaches

Topics 3

Threats: Climate change + Ozone depletion

Drivers:

- **Those we cannot control**: e.g. temperature, geology, rainwater
- **Those we can control**: water input, N input, tillage, organic amendments…

Mitigation strategies, therefore policy relevant!!!

Uncertainties and knowledge gaps

- **Gaps on the current active research**
  - **Technical problems** in measurements and modelling
  - More knowledge on **drivers** at the crop & farm scale and their interaction
  - **Enzyme** compositions
  - **Short** vs. **long-term** assessments
- **Very unknowns**
  - **Underrepresented crops** (soybeans, alfalfa…)
  - **Underrepresented regions** (Africa, Latin America, SE Asia)
  - **Underrepresented sectors** (energy, natural emissions, WWTP, water bodies, urbanization)
  - Underrepresented processes (Feammox, DNRA, annamox, soil mining?)
  - **Other interaction with global change components** : N deposition, acid rain (NOx), other pollutants (e.g. lead), biodiversity, invasive species (fixers or not), microbiological biodiversity
  - **Upstream downstream emissions** (life cycle assessment approaches)
  - **N2O sinks**
  - **Trade & leakages**
- **Feedbacks and interactions**
  - **Climatic feedbacks** (Temperature, water regime, CO_2 fertilization)
  - **Other interaction with global change components** : N deposition, acid rain (NOx), other pollutants (e.g. lead), biodiversity, invasive species (fixers or not)
- **Policy implications**
  - **Policy priorities**
  - **Benefit for farmers**
  - **Scenarios construction**

The relevant role of ILTER as a network to unify, harmonize and teaming up!!!