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TRAGNET analysis and synthesis of trace gas fluxes

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A critical synthesis of information on the biotic and abiotic controls of trace gas fluxes was needed in order to advance our ability to determine regional estimates of various trace gas compounds. In response to this need, the U.S. Trace Gas Network (TRAGNET), as part of an International Global Atmospheric Chemistry (IGAC) activity, developed an accessible database of multiyear trace gas flux (CH_4, NO_x, and N_2O) and ancillary data from a range of ecosystems (tropical to arctic) across North America, Europe, and Central America. These data have been collected by a number of independent research programs. Through the support of National Science Foundation (NSF), United States Department of Agriculture/Agriculture Research Service (USDA/ARS), Natural Resource Ecology Laboratory at Colorado State University, and National Center for Ecological Analysis and Synthesis (NCEAS), TRAGNET has assembled the data sets and has begun to analyze and synthesize these trace gas data on regional to global scales to (1) determine a generalized understanding of environmental factors controlling trace gas fluxes in order to develop methods for spatial and temporal interpolation and regional extrapolation, (2) test and validate trace gas models across different spatial, temporal, and process scales, and (3) determine regional trace gas fluxes from the measured set of fluxes in the database.

TRAGNET includes flux data from 29 sites which include grassland, forests, and cropland areas representing a gradient of climate and soil properties (Table 1). Within TRAGNET we organized the data into a standard format and incorporated the data into an integrated database of trace gas flux and ancillary data (e.g., data of meteorological conditions, soil properties, land use, and geographical characteristics). There is a basic set of data which includes flux data expressed in common units (e.g., g ha^{-1} d^{-1}), site characterization data, and specific environmental conditions associated with the fluxes (see TRAGNET homepage: http://www.nrel.colostate.edu/Programs/atmosphere/tragnet/tragnet.html).

Data collected within TRAGNET are multiyear and encompass a wide range of temporal and spatial variation that is helpful in understanding how fluxes will respond to climate and land management changes. The initial use of the data was in a model comparison study using the Denitrification and Decomposition Model [*Li et al.*, 1992], Century [*Parton et al.*, 1994, 1996], Carnegie Ames Stanford Approach [*Potter et al.*, 1996] and ExpertN [*Engel and Priesack*, 1993] conducted by *Frolking et al.* [1998]. These models represent a range of spatial and temporal detail of biogeochemical processes currently being implemented in trace gas modeling efforts. The data required for this study include detailed characterization of biogeochemical properties (e.g., seasonal N mineralization rates, microbial biomass estimates, C turnover estimates, soil moisture dynamics, etc.) and general information on site characteristics (e.g., climate, soil texture, bulk density, etc.). Comparison of model results with observed fluxes across the spatial and temporal range of process representation was a robust test of proposed relationships between factors controlling net trace gas flux.

In addition to using more process oriented models to study ecosystem and land use management controls on trace gas fluxes [*Frolking et al.*, 1998], we have utilized spreadsheet regression models to study simple relationships. These modeling studies have served three major functions: to test causal relationships of environmental factors affecting trace gas fluxes, to provide a basis to extrapolate site level findings across a regional database that geographically delineates the spatial pattern of the driving variables, and to identify gaps in our understanding of the controls on trace gas fluxes.

An essential component to linking data and models is the close interaction of the field measurement scientist and the modeler. The TRAGNET project has facilitated constant dialogue among modelers and field scientists. This interactive development of data collection, analysis, and modeling was a vital component of TRAGNET that will ensure further development of our understanding of the processes controlling trace gas fluxes and provide estimates of current fluxes of key trace gases.

The combined results of the database development and its use in modeling were first reported in a special session of the American Geophysical Union annual meeting in December, 1998. From some of these papers, a set of five manuscripts is presented in this issue: *Bogner et al.* [2000], *Davidson and Verchot* [2000], *Del Grosso et al.* [this issue(a)], *Del Grosso et al.* (this issue (b), and *Groffman et al.* [2000].

These papers represent various stages of synthesis of trace gas flux data from a variety of ecosystems. Using data from subarctic, temperate, and tropical study sites shows that the same control variables can be used across ecosystems to explain the main variability in trace gas fluxes. The papers represent data synthesis for a variety of spatial and temporal scales and are to be published in *Global Biogeochemical Cycles* to demonstrate the improved level of understanding that has evolved as a result of the TRAGNET data and model integration project. Our future efforts will focus on extending the database to many other regions of the world (e.g., East Asia). This will allow future syntheses to encompass a broader range of ecosystems and will facilitate modeling efforts to estimate

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Table 1. Location and Brief Description of Trace Gas Measurement Sites That Have Contributed Data to the TRAGNET Database[1]

Site Name/Location	Latitude	Longitude	Mean Annual Temperature °C	Mean Annual Precipitation mm	Vegetation Class/ Land Use	Contact Person
High Latitude						
Swedish Agriculture/Sweden	60.17° N	17.63° E	5.4°	520	agriculture	Klemedtsson
Alaska/Alaska, United States	68.6° N	149.6° W	-7.0°	300	tundra	Reeburgh
Temperate						
Central Plains Experimental Range/ Colorado, United States	40.84° N	104.75°W	9.2°	322	shortgrass steppe	Mosier
Sidney, Nebraska/United States	41.32° N	103.00°W	8.5°	411	wheat/fallow/grassland	Mosier
Barley/Colorado, United States	40.77° N	105.03°W	9.3°	360	irrigated agriculture	Mosier
Glacier Lake/Wyoming, United States	41.33° N	106.33°W	-1°	1000	spruce/wet meadow	Mosier
Fort Collins Drake Road/Colorado, United States	40.73° N	105.08°W	9.4°	380	irrigated agriculture	Mosier
Durham, New Hampshire/New Hampshire, United States	43.15° N	70.95° W	8.1°	924	deciduous woodland	Crill
Fam/Germany	48.83° N	11.35° E	7.4°	833	rain - fed agriculture	Flessa
Solling/Germany	51.52° N	9.57° E	6.4°	1090	spruce forest	Brumme
Höglwald/Germany	48.5° N	11.17° E	7.3°	800	spruce/beech forest	Papen
New York/New York, United States	40.9°-41.85°N	74.3°-74.75°W	8.5°-12.5°	1030-1080	urban-rural oak woodland	Groffman
Scottish Pasture/Scotland, United Kingdom	55.85° N	3.05° W	7.4°	895	grassland/pasture	Smith
Gullane/Scotland, United Kingdom	56.03° N	2.83° W	8.5°	675	woodland/agriculture/grass	Smith
Mallard Lake Landfill/ United States	41.95° N	88.12° W	9.4°	909	landfill	Bogner
Kellogg Biological Station/ Michigan, United States	42.4° N	85.4° W	9.7°	890	rain-fed agriculture	Robertson
Subtropical/Tropical						
Mayaguez, Puerto Rico	18.22° N	67.13° W	26°	1930	pasture	Mosier
Lajas, Puerto Rico	18.03° N	67.07° W	23°	1120	pasture	Mosier
Isabela, Puerto Rico	18.47° N	67.04° W	24°	1650	pasture	Mosier
Mexico/Sonora, Mexico	27° N	109° W			irrigated/agriculture	Matson
Banana/Costa Rica	10.43° N	84.0° W	25.8°	3962	agriculture	Keller
Core Experiment/Costa Rica	10.43° N	84.0° W	26°	3960	forest/pasture	Keller
Pasture/Costa Rica	10.03° N	84.92° W	25.8°	3962	grassland/pasture	Keller
Guapiles/Costa Rica	10.2° N	83.53° W	25.8°	3962	forest/pasture	Keller
Beaumont 1990/Texas, United States	30.08° N	94.22° W	19.6°	1465	agriculture/irrigated rice	Sass

TRAGNET homepage: (http://www.nrel.colostate.edu/programs/atmosphere/tragnet/tragnet.html

fluxes from larger regions of the world. The extended database will also include a broader range of management approaches and will promote the identification of ecosystem management practices that may mitigate trace gas emissions.

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