MILLER INSTITUTE NEWSLETTER

Fall 2005

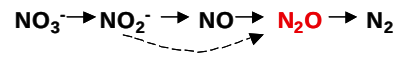
Miller Fellow Focus: Alex Thompson

Second year Miller Fellow Alex Thompson is an atmospheric chemist working with Prof. Ronald Amundson in the Department of Environmental Science, Policy and Management.

How do human activities impact the chemistry of the atmosphere? What are the interactions between the Earth's surface and the atmosphere? How do these interactions impact the climate and vice versa? These questions are the motivation behind Alex's research. More specifically, Alex is interested in using isotopes to probe the interface between the lower atmosphere and the oceans, cryosphere, and biosphere. Isotopes of an element have only very small differences in their chemical and physical properties. Their relative sensitivity or insensitivity to various processes allow isotope ratios to be powerful tracers in many areas of natural science research, including earth and atmospheric science. Alex uses stable (i.e. non-radioactive) isotopes of ubiquitous elements on Earth, e.g. C, N, and O, to investigate the production and processing of atmospheric trace gases.

Alex's doctoral research involved developing techniques of measuring compound specific $^{13}C/^{12}C$ ratios of atmospheric non-methane hydrocarbons and halocarbons. She applied this analysis to very clean air (from the Arctic and the Southern Ocean), and polluted air (from Toronto and Auckland) in order to understand emission patterns and atmospheric processing, i.e. mixing and photochemistry. After her doctorate, Alex recognised that the future of global environmental change research involves understanding earth system interfaces, often requiring a multidisciplinary approach. So she came to UC Berkeley to work with soil scientist and isotope geochemist Prof. Ronald Amundson (ESPM). They chose to investigate nitrous oxide.

Nitrous oxide lasts in the atmosphere for a long time (~120 years) and has 300 times the global warming potential of CO_2 making it an extremely influential greenhouse gas. Ice core records and contemporary measurements show that nitrous oxide levels have increased significantly since pre-industrial times and are continuing to rise. This is due to growing emissions, probably brought about by the extensive fertilization of soils in agriculture. The major sources of nitrous oxide are nitrification (oxidation of ammonium to nitrate) and denitrification (reduction of nitrate to dinitrogen), processes carried out by microorganisms in soils and oceans. Because nitrous oxide is a byproduct of these processes, a better understanding of their biochemical mechanisms is needed to mitigate emissions of nitrous oxide. There has been a large effort to



address the contribution of each production pathway using the total $^{15}N/^{14}N$ and $^{18}O/^{16}O$ content of nitrous oxide or its precursors as a diagnostic. The problem is that bulk isotope signatures are not sufficiently distinct or well enough defined to differentiate between production pathways. Fortunately, Prof. Kristie Boering (Chemistry Department) recently pioneered a new analytical method that allows for measurement of the position specific $^{15}N/^{14}N$ content of the linear nitrous oxide molecule (NNO). Since production of nitrous oxide involves making or breaking of N-N and N-O bonds, each step with

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Deadlines To Note:

Thursday, September 15
Miller Fellowship nominations due
Note new deadline date!

Thursday, September 22
Miller Professor applications due

Monday, September 26
Visiting Miller Professor nominations due

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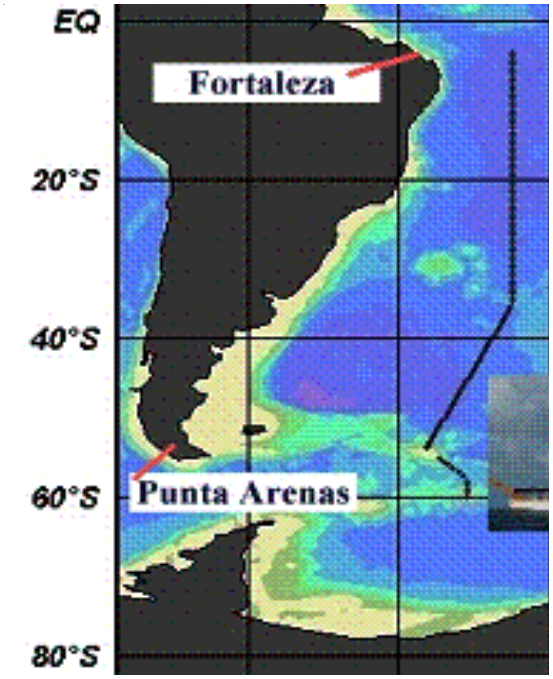
associated isotopic fractionation, the $^{15}N/^{14}N$ of each N position is a powerful probe of production mechanism.

To understand nitrous oxide emissions it is useful to isolate and study distinct production pathways. Alex worked with microbial ecologist Prof. Mary Firestone (ESPM) using denitrifying cell cultures to produce nitrous oxide under controlled conditions. The resulting nitrous oxide was then analysed for position specific $^{15}N/^{14}N$ content in the Boering lab. The results were unexpected and striking. They found not only did the total $^{15}N/^{14}N$ content of nitrous oxide change significantly with substrate concentration, but the difference between the position specific $^{15}N/^{14}N$ content of nitrous oxide did also. These observations have important implications on both global and molecular scales. First, since substrate (in this case nitrate) concentrations vary significantly in the Earth system, from pristine landscapes to polluted waters and agricultural soils, the isotopic signature of global nitrous oxide emissions can be expected to vary. Thus, this must be considered with regard to the global nitrous oxide isotope budget and in the interpretation of isotopic signals of nitrous oxide over time, for example in ice cores or firn air. Second, the position specific isotope dependence helps to constrain the chemistry of nitrous oxide production and its enzyme catalysis mechanism, which is currently very poorly understood.

In the second year of her Miller fellowship, Alex had the opportunity to delve into oceanography with a study of the effect of increased atmospheric CO_2 on ocean biogeochemistry with Dr. Jim Bishop (LBNL). The role of the oceans with regard to atmospheric CO_2 is enormous: the oceans absorb ~92 PgC/yr and emit ~90 PgC/yr, each flux representing approximately 12% of the entire carbon content of the atmosphere. Physical and biological processes control oceanic CO_2 uptake or emission. Where there is significant biological activity the ocean has a net uptake of CO_2. This is due to photosynthesis by phytoplankton, which converts

Alex sampling water in the South Atlantic (55°S)



Ship Track: January 11-February 28, 2005

dissolved inorganic carbon into particulate organic carbon (POC, i.e. cell bodies) and particulate inorganic carbon (PIC, i.e. $CaCO_3$). POC and PIC then sink, either to remineralize and be cycled back to the surface as dissolved inorganic carbon, or to become ocean sediment, essentially a carbon sink. Thus, ocean depth profiles of POC and PIC can tell us a lot about oceanic carbon cycling and the fate of CO_2. This study involved a five week oceanography cruise, from Punta Arenas, Chile to Fortaleza, Brazil going from a stormy area of high biological activity (Southern Ocean) to one of virtually no biological activity (tropics). At every half-degree latitude, Alex determined ocean depth profiles of POC and PIC, using traditional water filtration methods, optics (light attenuation and scattering), and continuing the development of a novel method using polarized light to detect $CaCO_3$. Sampling was achieved by lowering a "rosette" of sample bottles and the optical instruments to the bottom – at times up to 6000m deep – tripping the sample bottles on the way up, and then filtering the water once onboard. The filter samples are to be analysed for POC and PIC, and also a suite of elements including P, B, Fe, further illuminating nutrient cycling and biological activity. As this goes to press, sample and data analysis is underway.

In the future, Alex hopes to continue to reconcile her love of exploring the oceans, polar areas, and mountains with pertinent research into critical questions related to the Earth system and the changing atmosphere.

Next Steps

The Miller Institute congratulates outgoing Miller Fellows on their next endeavors.

YI CUI
Assistant Professor
Department of Chemistry
Stanford University

CARLOS D'ANDREA
Resident Fellow
Department of Mathematics
University of Barcelona, Spain

SAURABH JHA
Postdoctoral Fellow
Department of Astronomy
UC Berkeley

YOUNJOON JUNG
Postdoctoral Fellow
Department of Chemistry
Lawrence Berkeley National Laboratory

ELENA MANTOVAN
Assistant Professor
Department of Mathematics
California Institute of Technology

ELCHANAN MOSSEL
Assistant Professor
Department of Statistics
UC Berkeley

STÉPHANE BODIN
Postdoctoral Fellow
Department of Molecular and Cell Biology
UC Berkeley

RAGHUVEER PARTHASARATHY
Assistant Professor
Department of Chemistry
University of Oregon
(following one year of postdoctoral research at the UC Berkeley Department of Chemistry)

ALICE SHAPLEY
Assistant Professor
Department of Astronomy
Princeton University

HUAN TRAN
Postdoctoral Fellow
Space Sciences Laboratory
UC Berkeley

Awards & Honors

The following Miller Institute members were awarded the Alfred Sloan Fellowship in 2005:
Venkatesan Guruswami, Miller Fellow 2001-02
Tamas Hausel, Miller Fellow 1999-2002
Elchanan Mossel, Miller Fellow 2002-05
Yasunori Nomura, Miller Fellow 2000-02
Gregory Voth, Visiting Miller Professor Fall 2003

Jonathan Feng, Miller Fellow 1995-97, was awarded the Alfred Sloan Fellowship in 2004.

Jeffrey Townsend, Miller Fellow 2002-05, was awarded the Young Investigators' Prize by the American Society of Naturalists.

Giovanna Ferro-Luzzi Ames, Miller Professor Fall 1992, was elected to the American Academy of Arts and Sciences.

Calvin Moore, Miller Professor 1978-79, was was presented with the Berkeley Faculty Service Award by the Academic Senate.

The following Miller Institute members were named to the National Academy of Sciences:
Steven Louie, Miller Professor 1986-87, Fall 1995
Aziz Sancar, Visiting Miller Professor Spring 2002
Wallace Sargent, Visiting Miller Professor Spring 1993

Yasunori Nomura, Miller Fellow 2000-02, was presented with the Hellman Family Faculty fund award.

Karl Pister, Miller Professor 1962-63, was awarded an honorary Doctor of Science degree by the Board of Regents of the University of Colorado.

Jiaxing Huang, Miller Fellow 2004-07, was awarded the IUPAC Prize for Young Chemists by The International Union of Pure and Applied Chemistry.

Eugene Haller, Miller Professor Fall 1990, Fall 2001, has been named the Liao-Cho Innovation Endowed Chair in the College of Engineering. He is also this year's winner of the David Turnbull Lectureship Award, presented by the Materials Research Society.

The Miller Institute's
Ninth Annual Interdisciplinary Symposium
June 2005

Marcis Auzinsh, Alison Galvani, Dmitry Budker, Jeffrey Townsend, and Lord Robert May

Jiaxing Huang and YounJoon Jung

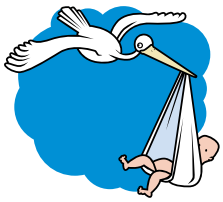
Olafur Magnusson, Mark Hauber, and Jonathan Arons

David McLaughlin and Alice Shapley

Jonas Peters, Barbara Levi, Don Tilley, and David Chandler

Ovidiu Savin and Carlos D'Andrea

Birth Announcements



Congratulations to Miller Fellow Josh Shaevitz and his wife Sarita on the birth of their daughter, Maina Tsipora Shaevitz. Maina was born on May 30, 2005.

Congratulations to Miller Fellow Raghuveer Parthasarathy and his wife Julie Mueller on the birth of their son, Kiran Mueller Parthasarathy. Kiran was born on July 20, 2005.

The Miller Institute for Basic Research in Science invites you to celebrate 50 years of science!

December 9-10, 2005

Friday, December 9 - Alumni Gathering
Saturday, December 10 - Lunch & Dinner

Talks will be held on the following topics:

New Science at the Scale of Nanometers
Speakers: Paul Alivisatos, Matthew Francis, Hong Kun Park
Voices in Biology
Speakers: John Hulsenbeck, David Jablonski, Erin O'Shea
The Cosmology-Fundamental Physics Connection
Speakers: John Barrow, Hitoshi Murayama

To register for this event, please click on the "Register Here" link on the Miller Institute's website: http://millerinstitute.berkeley.edu

Obituaries

Bruce Bolt, Miller Professor 1967-68, Fall 1989, Emeritus Professor of Earth & Planetary Science, and one of California's most visible experts on earthquakes and seismic hazards, passed away on July 21, 2005. He was 75.

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Fall 2005
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Publications

The following Miller Institute members have recently published works resulting from research during their Miller Institute terms. For more information about these publications, please visit the Miller Institute's website at: http://millerinstitute.berkeley.edu/publications.htm

Marcis Auzinsh
Visiting Miller Professor
Spring 2005

Stéphane Bodin
Miller Fellow 2002-05

Olivier Coussy
Visiting Miller Professor
Fall 2004

Yi Cui
Miller Fellow 2003-05

Carlos D'Andrea
Miller Fellow 2002-05

Sandra Faber
Visiting Miller Professor
Spring 2005

YounJoon Jung
Miller Fellow 2002-05

Russell Lande
Miller Professor 2004-05

Olafur Magnusson
Miller Fellow 2002-05

Elena Mantovan
Miller Fellow 2002-05

Elchanan Mossel
Miller Fellow 2002-05

Philip Myers
Visiting Miller Professor
Spring 2004

Raghuveer Parthasarathy
Miller Fellow 2002-05

Kenneth Raymond
Miller Professor Fall 2004

Alice Shapley
Miller Fellow 2003-05

T. Don Tilley
Miller Professor 2004-05

Taizan Watari
Miller Fellow 2003-06

Rory Waterman
Miller Fellow 2004-07

Patricia Zambryski
Miller Professor 2004-05

The Miller Institute is "dedicated to the encouragement of creative thought and the conduct of research and investigation in the field of pure science and investigation in the field of applied science in so far as such research and investigation are deemed by the Advisory Board to offer a promising approach to fundamental problems."