Carbon Exchange Dynamics in Coastal and Marine Ecosystems

Summary

Project Leader(s)
Papakyriakou, Tim N.

Our overarching objective is to understand the effects of climate change on the air-sea exchange of climatically relevant gases (mainly CO2, but also dimethylsulfide), and to relate the air-sea gas exchange (and associated variability) to biogeochemical cycles within the polar marine ecosystem of the ArcticNet domain. Oceans exert considerable influence on climate through, among things, the cycling of climatic active gases. For instance, the absorption and release of carbon dioxide (CO2) by the global oceans is a primary factor controlling atmospheric CO2 concentration, taking in roughly 30% of anthropogenic CO2 emissions. Rates of CO2 uptake by the polar seas are thought to be much higher than the global ocean average. Often overlooked is the role that the oceans' production and emission of dimethyl sulfide (DMS) can have on climate. The largest source of sulfate in the remote marine environment is DMS, and once in the atmosphere the compound can trigger the formation of aerosols that serve as cloud condensation nuclei. An increased production of DMS may in fact provide a stabilizing effect on greenhouse gas induced warming by increasing back-scattered solar radiation associated with an increase in cloud coverage. Recent literature is divided as to how the thinning of sea ice, and its rapid transition from multi-year (MYI) to seasonal sea ice (SSI), will affect the atmosphere's role in the polar marine carbon cycle. Further, very little is known about the production and emission of DMS in polar waters, and the role that sea ice serves in this process. Despite recent increases in research activity in the Arctic Ocean and its peripheral seas, gas flux measurement are still sparse relative to observed variability, and attempts to use remote sensing for the estimation of gas exchange in the Arctic seas has so far been limited by sea ice, extensive cloud cover, seasonally high pelagic biomass accumulation, and the 'non-universality' of empirically-derived relationships for the surface fluxes, and surface water dissolved gas concentrations. If we are to understand the role of the Arctic Ocean in controlling contemporary and future concentrations of climate important gases, continued advancement in our process-level understanding of the air-sea flux needs to be combined with advancements in coupled sea ice and ocean models and scaling methodologies that will allow us to form the necessary conceptual links between atmospheric CO2 and DMS concentrations, and the polar marine ecosystem. A requirement of this project is to parameterize both those processes affecting the distribution of dissolved CO2 and DMS in Arctic surface water, and the mechanism by which the gases are exchanged with the atmosphere. Newly developed parameterizations are being implemented into a coupled atmosphere-sea ice-ocean biogeochemistry model to learn how the ocean's response (physical, biogeochemical and biological) to climate change and variability will affect the atmosphere-ocean cycling of CO2 and DMS within the ArcticNet domain..

People

Network Investigators
Flato, Gregory - University of Victoria
Levasseur, Maurice - Québec-Océan
Miller, Lisa - Fisheries and Oceans Canada - Institute of Ocean Sciences
Papakyriakou, Tim N. - University of Manitoba
Steiner, Nadja - Fisheries and Oceans Canada - Institute of Ocean Sciences
Vagle, Svein - University of Victoria

Collaborators & Research Associates
Barber, David G. - University of Manitoba
Bogucki, Darek - University of Miami - Rosenstiel School of Marine and Atmospheric Science
Drennan, Will - University of Miami - Rosenstiel School of Marine and Atmospheric Science
Gosselin, Michel - Université du Québec à Rimouski
Gratton, Yves - Institut national de la recherche scientifique - Eau, Terre et Environnement
Shadwick, Elizabeth - Dalhousie University

Snelgrove, Ken - University of Manitoba
Tenuta, Mario - University of Manitoba
Tremblay, Jean-Eric - Université Laval

Post-Doctoral Fellows
Godlovitch, Daniel - Fisheries and Oceans Canada - Institute of Ocean Sciences
Wurl, Oliver - Fisheries and Oceans Canada - Institute of Ocean Sciences

PhD Students
Brown, Christina - University of Victoria
Carnat, Gauthier - University of Manitoba
Else, Brent - University of Manitoba
Galindo, Virginie - Université Laval
Shadwick, Elizabeth - Dalhousie University
Skielka, Udo T. - University of Victoria

Masters Students
Stainton, Emmelia - University of Manitoba
Swystun, Kyle - University of Manitoba

Undergraduate Students
Pind, Meredith - University of Manitoba

Technical Staff
Johnson, Bruce - University of Manitoba
Lizotte, Martine - Université Laval

Project Staff
Steiner, Nadja - Fisheries and Oceans Canada - Institute of Ocean Sciences

Partners

Circumpolar Flaw Lead (CFL) System Study
Environment Canada - Canadian Centre for Climate Modelling and Analysis
Fisheries and Oceans Canada - Institute of Ocean Sciences
German Research Foundation
Indian and Northern Affairs Canada - Northern Scientific Training Program
IPY Federal Program Office
University of Manitoba
University of Victoria

Publications

Articles Published in Refereed Publications

Else, B.T.G., T.N. Papakyriakou, R.J. Galley, W.M. Drennan, L.A. Miller, and H. Thomas, 2010, Eddy covariance measurements of wintertime CO2 fluxes in an arctic polynya: Evidence for enhanced gas transfer during ice formation, Journal of Geophysical Research, , Submitted

Geilfus, N.-S., G. Carnat, G.S. Dieckmann, N. Halden, G. Nehrke, T. Papakyriakou, J.-L. Tison, and B. Delille, 2010, First estimates of the contribution of CaCO3 precipitation to the release of CO2 to the atmosphere during young sea ice growth, Journal of Geophysical Research, , Submitted

Luce M, M. Levasseur, M. Scarratt, S. Michaud, R. Kiene, C. Lovejoy, M. Gosselin, M. Poulin, and Y. Gratton, 2011, Fall distribution and microbial metabolism of dimethylsulfoniopropionate and dimethylsulfide during the 2007 Arctic ice minimum, Journal of Geophysical Research, , Submitted

Miller, L., T. Papakyriakou and 8 others, 2009, Carbon dynamics in sea ice: a winter flux time series, Journal of Geophysical Research, 1, Submitted

Miller, L.A., T. Papakyriakou, R. Collins, J. Demming, J. Ehn, R. Macdonald, A. Mucci, O. Owens, M. Raudsepp, and N. Sutherland, 2011, Carbon dynamics in sea ice: A winter flux time series., Journal of Geophysical Research, in press, Accepted

Mucci, A., B. Lansard, L.A. Miller and T.N. Papakyriakou, 2009, CO2 fluxes across the air-sea interface in the southeastern Beaufort Sea: the ice-free period, Journal of Geophysical Research (Oceans), 1, Accepted

Mucci, A., B. Lansard, L.A. Miller, and T.N. Papakyriakou, 2010, CO2 fluxes across the air-sea interface in the southeastern Beaufort Sea., Journal of Geophysical Research, C04003, doi: 10.1029/2009JC005330, Accepted

Papakyriakou, T., and Miller, L.A., 2011, Springtime CO2 exchange over seasonal ice in the Canadian Arctic Archipelago, Annals of Glaciology, in press, Accepted

Shadwick, E.H., H. Thomas, M. Chierici, B. Else, A. Franson, C. Michel, L.A. Miller, A. Mucci, A. Niemi, T. Papakyriakou, and J-E. Tremblay, 2011, Seasonal variability of the inorganic carbon system in the Amundsen Gulf region of the southeastern Beaufort Sea, Limnology and Oceanography, 303-322, Published

Shadwick, E.H., Papakyriakou, T., Prowe, A.E.F., Leong, D., Moore, S.A. and Thomas, H., 2009, Carbon cycling in the Arctic Archipelago: the export of Pacific carbon to the North Atlantic, Biogeosciences Discuss, v.6, 971-994, Published

Song, G., Xie, H., Aubry, C., Zhang, Y., Gosselin, M., Mundy, C.J., Benoit, P., and T. Papakyriakou, 2011, Spatiotemporal variations of dissovled organic carbon and carbon monoxide in first-year sea ice in the western Canadian Arctic, Journal of Geophysical Research, , Submitted

Stainton, E., T. Papakyriakou, R. Hesslein and D.G. Barber, 2010, River carbon transport and air-water CO2 exchange at the northernmost reach of the Churchill River, Ecohydrology, , Submitted

Vancoppenolle, M., R. Timmermann, S.F. Ackley, T. Fichefet, H. Goosse, P. Heil, J. Lieser, K.C. Leonard, M. Nicolaus, T. Papakyriakou, J-L., Tison, 2010, Assessent of radiation forcing data sets for large-scale sea ice models in the Sourthern Ocean, Deep Sea Research II, 1, Accepted

Wurl, O., Wurl, E., Miller, L., Johnson, K. and Vagle, S., 2011, Formation and global distribution of sea-surface microlayers, Biogeosciences, v.8, 121-135, Published

Non-Refereed Contributions

Geilfus, N.-X, Tison, J.-L., Carnat, G., Brabant, F., Borges, A.V. and Delille, B., 2009, Air-ice CO2 fluxes in the Arctic coastal area (Amundsen Gulf), 41st International Liege Colloquium on Ocean Dynamics, 1, Accepted

Papakyriakou, T., L. Miller, J-L Tison, and B. Delille, 2009, CO2 exchange between Arctic sea ice and the atmosphere: a second look, CMOS 2009 Congress, Halifax, Nova Scotia, June 3-5, 1, Accepted

Shadwick, E.H., Papakyriakou, T., Mucci, A., Prowe, A.E.F., Leong, D., Moore, S. and Thomas, H., 2009, Dissolved inorganic carbon in the Canadian Archipelago of the Arctic Ocean: The export of Pacific carbon to the North Atlantic via Baffin Bay, Arctic Frontiers Abstract Book: Arctic marine ecosystems in an era of rapid climate change, 2009, 73, Published

Shadwick, E.H., Papakyriakou, T., Mucci, A., Prowe, A.E.F., Leong, D., Moore, S. and Thomas, H., 2009, Dissolved inorganic carbon in the Canadian Archipelago of the Arctic Ocean: The export of Pacific carbon to the North Atlantic via Baffin Bay, EGU General Assembly, 1, Accepted

Shadwick, E.H., T. Papakyriakou, A.E.F. Prowe, D. Leong, S.A. Moore, and H. Thomas, 2009, Carbon cycling in the Arctic Archipelago: the export of Pacific carbon to the North Atlantic, CMOS 2009 Congress, Halifax, Nova Scotia, June 3-5, 1, Accepted

Skielka, U.T., and Steiner, N.S., 2009, Modeling Arctic Air-Sea-Ice exchange of CO2, 2009 ArcticNet Annual Conference Proceedings, 134, Published

Steiner, N. and Denman, K., 2010, Developing a 1-D model for gas exchange in ice-covered regions, Eos Trans. AGU, 91(26), Ocean Sci. Meet. Suppl, CO35C-02, Published

Wurl, O., S. Vagle, and L. Miller, 2010, Improved assessments of oceanic CO2 uptake in the Arctic, ArcticNet 2009 Annual Scientific Meeting, December 8-11, Victoria, BC, 1, Accepted