

KATHRYN MCKAIN

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EDUCATION

Ph.D. Harvard University, Environmental Science and Engineering, 2015
M.A. Harvard University, Earth and Planetary Sciences, 2013
B.A. Mount Holyoke College, Biology and Chemistry, *summa cum laude*, 2005

RESEARCH AND PROFESSIONAL EXPERIENCE

Research Scientist, Cooperative Institute for Research in Environmental Sciences, University of Colorado, and NOAA Global Monitoring Laboratory, Boulder, CO

2019-present

- PI of the Aircraft Network within the NOAA Global Greenhouse Gas Reference Network

2015-present

- Atmospheric greenhouse gas measurements and modeling, with a focus on airborne observational platforms, in support of a long-term monitoring and shorter-term intensive projects

Graduate Research Assistant, Harvard University, Cambridge, MA, 2010-2015

- Atmospheric measurements and a modeling to investigate urban greenhouse gas fluxes and trends

Intern, Environmental Protection Agency, Climate Change Division, Washington DC, 2015

- Led weekly reading group of recent scientific publications on methane emissions from oil and gas to improve internal familiarity with methods and results, and attended all meetings related to greenhouse gas emissions quantification and potential regulations

Research and Development, Feed Resource Recovery, Boston, MA, 2008-2009

- Start-up company focused on anaerobic digestion of supermarket food waste where I conducted technology and industry research, and helped to design and operate a pilot-scale system

Research Assistant, Harvard Forest, Petersham, MA, 2005-2008

- Oversaw the ecological research activities at the Harvard Forest Environmental Monitoring Site, including the collection, analysis, and archiving of multiple long-term datasets on forest carbon cycling

GRANTS AWARDED AND PENDING

Accelerometer-based turbulence profile sensors for low-cost determination of boundary layer height from small aircraft, CIRES Innovative Research Program, PI: K. McKain, 2019-2020

Toward disentangling causes for the substantial increase of CO₂ seasonal amplitude in the Arctic, NASA Terrestrial Ecology Program, PI: L. Hu, 2019-2022

Collaborative Research: Southern Ocean carbon gas observatory (SCARGO), NSF Office of Polar Programs, PI: B. Stephens, 2019-2021

Establishing WMO Traceability for XCO₂ from OCO-2 using AirCore and Aircraft vertical profiles, NASA Science Team for the OCO Missions, PI: B. Baier, 2018-2021

Airborne seasonal survey of CO₂ and CH₄ across the ABoVE domain, NASA Arctic-Boreal Vulnerability Experiment, PI: C. Sweeney, 2017-2019

Measurements of CH₄ and CO₂ on the Atmospheric Tomography Mission, NASA Earth Venture Suborbital sub-award, PI: K. McKain, 2016-2020

NASA Earth and Space Science Graduate Fellowship, 2014 – 2015

FIELD CAMPAIGNS

- East Coast Outflow, impact of COVID shutdown on greenhouse gas emissions (ECO-COVID), Scientific Aviation Mooney, April-May, 2020
- Arctic-Boreal Vulnerability Experiment (ABoVE), Airborne Seasonal Survey of CO₂ and CH₄, Scientific Aviation Mooney, Alaska, 2017
- Atmospheric Tomography Mission (ATom), NASA DC8, 2016-2018 [NASA Group Achievement Award]
- North Slope and Prudhoe Bay Oil Field, NOAA Twin Otter, Deadhorse, Alaska, 2016
- O₂/N₂ Ratio and CO₂ Airborne Southern Ocean (ORCAS) Study, NSF Gulfstream-V, Punta Arenas, Chile, 2016
- Study of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC⁴RS), NASA ER2, 2013

PUBLICATIONS

- Kulawik SS, Worden JR, Payne VH, Fu D, Wofsy SC, **McKain K**, Sweeney C, Daube BC, Lipton A, Polonsky I, He Y, Cady-Pereira KE, Dlugokencky EJ, Jacob DJ, Yin Y (2021) Evaluation of single-footprint AIRS CH₄ profile retrieval uncertainties using aircraft profile measurements, *Atmospheric Measurement Techniques*, 14(1): 335-354, doi: 10.5194/amt-2020-145.
- Liu J, Baskaran L, Bowman K, Schimel D, Bloom AA, Parazoo NC, Oda T, Carroll D, Menemenlis D, Joiner J, Commane R, Daube B, Gatti LV, **McKain K**, Miller JB, Stephens BB, Sweeney C, Wofsy S (2021) Carbon monitoring system flux net biosphere exchange 2020 (CMS-Flux NBE 2020), *Earth System Science Data* 13 (2): 299-330, doi: 10.5194/essd-13-299-2021.
- Yu X, Millet DB, Wells KC, Henze DK, Cao H, Griffis TJ, Kort EA, Plant G, Deventer MJ, Kolka RK, Roman DT, Davis KJ, Desai AR, Baier BC, **McKain K**, Czarnetzki AC, Bloom AA (2021) Aircraft-based inversions quantify the importance of wetlands and livestock for Upper Midwest methane emissions, *Atmospheric Chemistry and Physics*, 21(2): 951-971, doi: 10.5194/acp-21-951-2021.
- Bourgeois I, Peischl J, Thompson CR, Aikin KC, Campos T, Clark H, Commane R, Daube B, Diskin GW, Elkins JW, Gao R, Gaudel A, Hintsa EJ, Johnson BJ, Kivi R, **McKain K**, Moore FL, Parrish DD, Querel R, Ray E, Sanchez R, Sweeney C, Tarasick DW, Thompson AM, Thouret V, Witte JC, Wofsy SC, Ryerson TB (2020) Global-scale distribution of ozone in the remote troposphere from the ATom and HIPPO airborne field missions, *Atmospheric Chemistry and Physics* 20 (17): 10611-10635, doi: 10.5194/acp-20-10611-2020.
- Brune WH, Miller DO, Thams AB, Allen HM, Apel EC, Blake DR, Bui TP, Commane R, Crouse JD, Daube BC, Diskin GS, DiGangi JP, Elkins JW, Hall SR, Hanisco TF, Hannun RA, Hintsa EJ, Hornbrook RS, Kim MJ, **McKain K**, Moore FL, Neuman JA, Nicely JM, Peischl J, Ryerson TB, St Clair JM, Sweeney C, Teng AP, Thomsson C, Ullmann K, Veres PR, Wennber PO, Wolfe G (2020) *Journal of Geophysical Research: Atmospheres* 125 (1), doi: 10.1029/2019JD031685.
- Kupc A, Williamson CJ, Hodshire AL, Kazil J, Ray E, Bui TP, Dollner M, Froyd KD, **McKain K**, Rollins A, Schill GP, Thames A, Weinzierl BB, Pierce JR, Brock CA (2020) The potential role of organics in new particle formation and initial growth in the remote tropical troposphere, *Atmospheric Chemistry and Physics*, 20 (23): 15037-15060, doi: 10.5194/acp-20-15037-2020.
- Martinez-Alonso S, Deeter M, Worder H, Borsdorff T, Aben I, Commane R, Daube B, Francis G, George M, Landgraf J, Mao D, **McKain K**, Wofsy S (2020) 1.5 years of TROPOMI CO measurements: comparisons to MOPITT and ATom, *Atmospheric Measurement Techniques*, 13 (9): 4841-4864, doi: 10.5194/amt-13-4841-2020.
- Nalli NR, Tan C, Warner J, Divakarla M, Gambocorta A, Wilson M, Zhu T, Wang T, Wei Z, Pryor K, Kalluri S, Zhou L, Sweeney C, Baier BC, **McKain K**, Wunch D, Deutscher NM, Hase F, Iraci LT, Kivi R, Morino I, Notholt J, Ohyama H, Pollard DF, Te Y, Velasco V, Warneke T, Sussmann R, Rettinger M (2020) Validation of carbon trace gas profile retrievals from the NOAA-unique combined atmospheric processing system for the cross-track infrared sounder, *Remote Sensing* 12 (19): 3245, doi: 10.3390/rs12193245.

- Thames AB, Brune WH, Miller DO, Allen HM, Apel EC, Blake DR, Bui TP, Commane R, Crouse JD, Daube BC, Diskin GS, DiGangi JP, Elkins JW, Hall SR, Hanisco TF, Hannun RA, Hintsä E, Hornbrook RS, Kim MJ, **McKain K**, Moore FL, Nicely JM, Peischl J, Ryerson TB, St Clair JM, Sweeney C, Teng A, Thompson CR, Ullmann K, Wennberg PO, Wolfe GM (2020) Atmospheric Chemistry and Physics, 20 (6), doi: 10.5194/acp-20-4013-2020.
- Travis KR, Heald CL, Allen HM, Apel EC, Arnold SR, Blake DR, Brune WH, Chen X, Commane R, Crouse JD, Daube BC, Diskin GS, Elkins JW, Evans MJ, Hall SR, Hintsä EJ, Hornbrook RS, Kasibhatla PS, Kim MJ, Luo G, **McKain K**, Millet DB, Moore FL, Peischl J, Ryerson TB, Sherwen T, Thames AB, Ullmann K, Wang X, Wennber PO, Wolfe GM, Yu F (2020) Constraining remote oxidation capacity with ATom observations, Atmospheric Chemistry and Physics, 20 (13): 7753-7781, doi: 10.5194/acp-20-7753-2020.
- Wang S, Apel EC, Schwantes RH, Bates KH, Jacob DJ, Fischer EV, Hornbrook RS, Hills AJ, Emmons LK, Pan LL, Honomichi S, Tilmes S, Lamarque JF, Yang M, Marandino CA, Saltzman ES, Bruyn W, Kameyama S, Tanimoto H, Omori Y, Hall SR, Ullmann K, Ryerson TB, Thompson CR, Peischl J, Daube BC, Commane R, **McKain K**, Sweeney C, Thames AB, Miller DO, Brune WH, Diskin GS, DiGangi JP, Wofsy SC (2020) Global atmospheric budget of acetone: air-sea exchange and the contribution of hydroxyl radicals, Journal of Geophysical Research: Atmospheres 125 (15), doi: 10.1029/2020JD032553.
- Asher E, Hornbrook RS, Stephens BB, Kinnison D, Morgan EJ, Keeling RF, Atlas EL, Schauffler SM, Tilmes S, Kort EA, Hoecker-Martinez MS, Long MC, Lamarque JF, Saiz-Lopez A, **McKain K**, Sweeney C, Hills AJ, Apel EC (2019) Novel approaches to improve estimates of short-lived halocarbon emissions during summer from the Southern Ocean using airborne observations, Atmospheric Chemistry and Physics, 19 (22): 14071-14090, doi: 10.5194/acp-19-14071-2019.
- Crowell S, Baker S, Schuh A, Basu S, Jacobson AR, Chevallier F, Liu J, Deng F, Feng L, **McKain K**, Chatterjee A, Miller JB, Stephens BB, Eldering A, Crisp D, Schmel D, Nassar R, O'Dell CW, Oda T, Sweeney C, Palmer PI, Jones D (2019) The 2015-2016 carbon cycle as seen from OCO-2 and the global in situ network, Atmospheric Chemistry and Physics, 19 (15): 9797-9831, doi: 10.5194/acp-19-9797-2019.
- Floerchinger C, **McKain K**, Bonin T, Peischl J, Biraud SC, Miller C, Ryerson TB, Wofsy SC, Sweeney C (2019) Methane emissions from oil and gas production on the North Slope of Alaska, Atmospheric Environment 218: 116985, doi: 10.1016/j.atmosenv.2019.116985.
- Hu L, Andrews A, Thoning K, Sweeney C, Miller JB, Michalak A, Dlugokencky E, Tans P, Shiga Y, Mountain M, Nehrkorn T, Montzka S, **McKain K**, Kofler J, Trudeau M, Michel S, Biraud SC, Fischer ML, Worthy DEJ, Vaughn BH, White JWC, Yadav V, Basu S, van der Velde ER (2019) Enhanced North American carbon uptake associated with El Niño, Science Advances, 5 (6), doi: 10.1126/sciadv.aaw0076.
- Kulawik SS, Crowel S, Baker D, Liu J, **McKain K**, Sweeney C, Biraud SC, Wofsy S, O'Dell CW, Wennberg PO, Wunch D, Roehl CM, Deutscher NM, Kiel M, Griffith DWT, Velasco VA, Notholt J, Warneke T, Petri C, Maziere M, Sha MK, Sussman R, Rettinger M, Pollard DF, Morino I, Uchino O, Hase F, Feist DG, Roche S, Strong K, Kivi R, Iraci L, Shiomi K, Dube MK, Sepulveda E, Rodriguez OEG, Te Y, Jeseck P, Heikkinen P, Dlugokencky EJ, Gunson MR, Eldering A, Crisp D, Fisher B, Osterman GB (2019) Characterization of OCO-2 and ACOS-GOSAT biases and errors for CO₂ flux estimates, Atmospheric Measurement Techniques Discussions, 10.5194/amt-2019-257.
- Lan X, Tans P, Sweeney C, Andrews A, Dlugokencky E, Schwietzke S, Kofler J, **McKain K**, Thoning K, Crotwell M, Montzka S, Miller BR, Biraud SC (2019) Long-term measurements show little evidence for large increases in total US methane emissions over the past decade, Geophysical Research Letters, 46 (9): 4991-4999, doi: 10.1029/2018GL081731.
- Morgan EJ, Stephens BB, Long MC, Keeling RF, Bent JD, **McKain K**, Sweeney C, Hoecker-Martinez MS, Kort EA (2019) Summertime atmospheric boundary layer gradients of O₂ and CO₂ over the Southern Ocean, Journal of Geophysical Research: Atmospheres 124 (23): 13439-13456, doi: 10.1029/2019JD031479.

- Wolfe G, Nicely J, St. Clair J, Hanisco T, Liao J, Oman L, Brune W, Miller D, Thames A, Abad G, Ryerson T, Thompson C, Peischl J, **McKain K**, Sweeney C, Wennberg P, Kim J, Crouse J, Hall S, Ullmann K, Diskin G, Bui P, Chang C, Dean-Day J (2019) Mapping hydroxyl variability throughout the global remote troposphere via synthesis of airborne and satellite formaldehyde observations, *Proceedings of the National Academy of Sciences*, doi: 10.1073/pnas.1821661116.
- Miles NL, Martins DK, Richardson SJ, Rella CW, Arata C, Lauvaux T, Davis KJ, Barkley ZR, **McKain K**, Sweeney C (2018) Calibration and field testing of cavity ring-down laser spectrometers measuring CH₄, CO₂, and δ₁₃CH₄ deployed on towers in the Marcellus Shale region, *Atmospheric Measurement Techniques* 11 (3): 1273-1295, doi: 10.5194/amt-11-1273-2018.
- Sargent M, Barrera Y, Nehr Korn T, Hutyra LR, Gately CK, Jones T, **McKain K**, Sweeney C, Hegarty J, Hardiman B, Wofsy SC (2018) Anthropogenic and biogenic CO₂ fluxes in the Boston urban region, *Proceedings of the National Academy of Sciences*, 115 (29): 7491-7496, doi: 10.1073/pnas.1803715115.
- Stephens BB, Long MC, Keeling RF, Kort EA, Sweeney C, Apel EC, Atlas EL, Beaton S, Bent JD, Blake NJ, Bresch JF, Casey J, Daube BC, Diao M, Diaz E, Dierssen H, Donets V, Gao BC, Fierach M, Green R, Haag J, Hayman M, Hills AJ, Hoecher-Martinez MS, Honomichi SB, Hornbrook RS, Jensen JB, Li RR, McCubbin I, **McKain K**, Morgan EJ, Nolte S, Powers JG, Rainwater B, Randolph K, Reeves M, Schauffler SM, Smith K, Smith M, Stith J, Stossmeister G, Toohey DW, Watt AS (2018) The O₂/N₂ Ratio and CO₂ Airborne Southern Ocean Study, *Bulletin of the American Meteorological Society* 99 (2): 381-402, doi: 10.1175/BAMS-D-16-0206.1.
- Turnbull, JC, Karion A, Davis KJ, Lauvaux T, Miles NL, Richardson SJ, Sweeney C, **McKain K**, Lehman SJ, Gurney KR, Patarasuk R, Liang JM, Shepson PB, Heimburger A, Harvey R, Whetstone J (2019) Synthesis of Urban CO₂ Emission estimates from multiple methods from the Indianapolis Flux Project (INFLUX), *Environmental Science and Technology*, 53 (1): 287-295, doi: 10.1021/acs.est.8b05552.
- Richardson SJ, Miles NL, Davis KJ, Lauvaux T, Martins DK, Turnbull JC, **McKain K**, Sweeney C, Cambaliza MOL (2017) Tower measurements of in-situ CO₂, CH₄, and CO in support of the Indianapolis flux (INFLUX) experiment, *Elementa* 5: 59, doi: 10.1525/elementa.140.
- Sweeney C, Dlugokencky E, Miller CE, Wofsy S, Karion A, Dinardo S, Chang RYW, Miller JB, Bruhwiler L, Crotwell AM, Newberger T, **McKain K**, Stone RS, Wolter SE, Lang PE, Tans P (2016) No significant increase in long-term CH₄ emissions on North Slope of Alaska despite significant increase in air temperature, *Geophysical Research Letters*, 43 (12): 6604-6611, doi: 10.1002/2016GL069292.
- McKain K** (2015) Atmospheric observations and models of greenhouse gas emissions in urban environments, Ph.D. Dissertation, Harvard University.
- McKain K**, Down A, Raciti SM, Budney J, Hutyra LR, Floerchinger C, Herndon SC, Nehr Korn T, Zahniser M, Jackson RB, Phillips N, Wofsy SC (2015) Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts. *Proceedings of the National Academy of Sciences*, 112 (7): 1941-1946, doi: 10.1073/pnas.1416261112. (*Selected media coverage: Science I & II, Boston Globe, Reuters, CBS News, Christian Science Monitor, Inside Climate News*)
- Nehr Korn T, Henderson M, Leidner M, Mountain M, Eluszkiewicz J, **McKain K**, Wofsy S (2013) WRF simulations of the urban circulation in the Salt Lake City area for CO₂ modeling, *Journal of Applied Meteorology and Climatology*, 52: 323-340, <http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-12-061.1>.
- McKain K**, Wofsy SC, Nehr Korn T, Eluszkiewicz J, Ehleringer J, Stephens B (2012) Assessment of ground-based atmospheric observations for verification of greenhouse gas emissions from an urban region, *Proceedings of the National Academy of Sciences* 109 (22): 8423-8428, doi: 10.1073/pnas.1116645109, www.pnas.org/content/109/22/8423. (*Selected media coverage: Scientific American, Science*)

Urbanski S, Barford C, Wofsy S, Kucharik C, Pyle E, Budney J, **McKain K**, Fitzjarrald D, Czikowsky M, Munger JW (2007) Factors controlling CO₂ exchange on timescales from hourly to decadal at Harvard Forest, *Journal of Geophysical Research – Biogeosciences* 112: G0202, doi: 10.1029/2006JG000293.

McKain K (2005) Methods for measuring carbon accumulation in tree biomass in Northeastern forests, Undergraduate Thesis, Mount Holyoke College.

DATASETS PUBLISHED

Sweeney C, McKain K (2019) ABoVE: Atmospheric Profiles of CO, CO₂ and CH₄ Concentrations from Arctic-CAP, 2017. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1658>.

Sweeney C, McKain K, Higgs J, Wolter S, Crotwell A, Neff D, Dlugokencky E, Lang P, Novelli P, Mund J, Moglia E, Crotwell M (2018) NOAA Carbon Cycle and Greenhouse Gases Group aircraft-based measurements of CO₂, CH₄, CO, N₂O, H₂ & SF₆ in flask-air samples taken since 1992, NOAA Earth System Research Laboratory, Global Monitoring Division. <http://dx.doi.org/10.7289/V5N58JMF>.

Wofsy SC, Afshar S, Allen HM, Apel E, Asher EC, Barletta B, Bent J, Bian H, Biggs B, Blake DR, Blake N, Bourgeois I, Brock CA, Brune WH, Budney JW, Bui TP, Butler A, Campuzano-Jost P, Chang CS, Chin M, Commane R, Correa G, Crounse JD, Cullis PD, Daube BC, Day DA, Dean-Day JM, Dibb JE, DiGangi JP, Diskin GS, Dollner M, Elkins JW, Erdesz F, Fiore AM, Flynn CM, Froyd K, Gesler DW, Hall SR, Hanisco TF, Hannun RA, Hills AJ, Hintsä E, Hoffman A, Hornbrook RS, Huey LG, Hughes S, Jimenez JL, Johnson BJ, Katich JM, Keeling R, Kim MJ, Kupc A, Lait LR, Lamarque JF, Liu J, McKain K, Mclaughlin RJ, Meinardi S, Miller DO, Montzka SA, Moore FL, Morgan EJ, Murphy DM, Murray LT, Nault BA, Neuman JA, Newman PA, Nicely JM, Pan X, Paplawsky W, Peischl J, Prather MJ, Price DJ, Ray E, Reeves JM, Richardson M, Rollins AW, Rosenlof KH, Ryerson TB, Scheuer E, Schill GP, Schroder JC, Schwarz JP, St.Clair JM, Steenrod SD, Stephens BB, Strode SA, Sweeney C, Tanner D, Teng AP, Thames AB, Thompson CR, Ullmann K, Veres PR, Vieznor N, Wagner NL, Watt A, Weber R, Weinzierl B, Wennberg P, Williamson CJ, Wilson JC, Wolfe GM, Woods CT, Zeng LH (2018) ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1581>.

Sweeney C, McKain, K, Newberger T (2017) ORCAS Picarro Data. Version 1.1. UCAR/NCAR - Earth Observing Laboratory. <https://doi.org/10.5065/D69W0CWW>.

SELECTED PRESENTATIONS

Development efforts toward increasing density and coverage of aircraft vertical profile measurements of greenhouse gases through ride-along and commercial flight opportunities, Global Monitoring Annual Conference, Boulder, CO, July 2020.

Southern Ocean CO₂ fluxes and seasonality from atmospheric vertical gradients observed on multiple airborne campaigns, oral presentation, American Meteorological Society Annual Meeting, Austin, TX, January 2018.

Adaptation of a Picarro greenhouse gas analyzer for airborne measurements with expanded altitude range and performance on large-scale aircraft campaigns, oral presentation, 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT-2017), Dubendorf, Switzerland, August 2017.

An Atmospheric Measurement Network and Modeling Framework to Quantify Methane Emissions from Natural Gas Losses in the Boston Urban Region, MIT, Department of Civil and Environmental Engineering, Environmental Sciences Seminar Series, April 2015.

An Atmosphere-based Method for Detection and Quantification of Methane Emissions from Natural Gas Infrastructure in an Urban Environment, invited oral presentation, AGU Fall Meeting, December 2015.

Characterization of urban methane emissions in Boston, Massachusetts using an observational network and inverse modeling framework, oral presentation, AGU Fall Meeting, December 2012.

SERVICE

NOAA Global Monitoring Laboratory Seminar Series co-organizer, 2019-present

Peer Review: Geophysical Research Letters, Journal of Geophysical Research – Atmospheres, Proceedings of the National Academy of Sciences, Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques, Atmospheric Environment, Elementa, Urban Ecosystems, Carbon Management

Proposal Review: Small Business Innovation Research (SBIR, 2016-2017); NOAA Atmospheric Chemistry, Carbon Cycle and Climate (AC4, 2015, 2020)

OUTREACH

To improve understanding and encourage discourse about our results on methane emissions in Boston, I made public presentations and participated in meetings at: National Grid (Nov 2013), Boston City Hall (Jan 2015), the Environmental Defense Fund (Jan, Feb 2015), a Department of Energy project workshop (Feb 2015), the Boston Bar Association (May 2015), New England Conference of Public Utility Commissioners (June 2015), a Harvard Law School seminar on oil and gas law (Nov 2015), and submitted testimony to the Massachusetts State Legislature (Nov 2015).

TEACHING

Head Teaching Fellow “The Fluid Earth”, an undergraduate introductory course on the atmosphere, oceans, and climate system, Harvard College, Spring 2012

Supervised multiple undergraduate thesis projects, 2005-2008, 2011