

# Timothy J. Garrett

## Education

*University of Washington*, Ph.D., Atmospheric Sciences, 2000

*University of Washington*, M.S. Atmospheric Sciences, 1995

*University of Waterloo*, B.Sc. Honours Physics, 1992

## Academic appointments

Professor with Tenure, Department of Atmospheric Sciences, *University of Utah*, 2014 - present

Associate Professor with Tenure, Department of Atmospheric Sciences, *University of Utah*, 2008 - present

Assistant Professor, Meteorology Department, *University of Utah*, 2002 - 2007

Huber Fellow, Princeton Environmental Institute, *Princeton University*, 2000 - 2002

## Other positions

Chief Scientific Advisor: *Particle Flux Analytics* 2018 - present

Academic advisory board: *The Curve Triangle & Rectangle Institute*, 2019 - present

Co-Founder and President: *Particle Flux Analytics* 2015 - 2018

Visiting Professor, *Université de Lille I*, Lille, France, 2016-2017

Academic advisor: *Belua*, 2014 - 2016

Co-Founder and President: *Fallgatter Technologies* 2012 - 2015

Visiting Scientist, *Centre de Météorologie Spatiale de Lannion*, June, 2015

Visiting Professor, *Université Blaise Pascal II*, Clermont-Ferrand, France, Summer, 2013

Visiting Professor, *Université de Lille I*, Lille, France, 2008-2009

Secondary School Science and Physics Teacher, *U.S. Peace Corps*, Kingdom of Tonga, 1995-1997

## Research interests

Clouds and precipitation play a key role in climate by removing pollutants from the atmosphere, shielding the Earth from sunlight, acting as pistons in the atmospheric heat engine, and serving as a lynchpin in the water cycle. They are dynamic over a vast range of interacting scales in time and space which makes them difficult to understand. My research aims to describe these phenomena using a combination of theory, measurements, and numerical modeling.

## Refereed Publications

(\* Garrett group)

1. Garrett, T. J. 2019, Steady-state analytical solutions for precipitation size distributions. *J. Atmos. Sci.* doi:10.1175/JAS-D-18-0309.1
2. Garrett, T. J., I. B. Glenn, S. K. Krueger, 2018: Thermodynamic Constraints on the Size Distributions of Tropical Clouds. *J. Geophys. Res.*, 123, 8832-8849, doi:10.1029/2018JD028803

3. Coopman, Q.\*, J. Riedi, D.P. Finch, and T. J. Garrett 2018: Evidence for Changes in Arctic Cloud Phase Due to Long-Range Pollution Transport, *Geophys. Res. Lett.*, 45, 10,709-10,718, doi:10.1029/2018GL079873
4. Patou, M.J.\*, Riedi, J. Vidot, G. Penide and T. J. Garrett, 2018: Prediction of the onset of heavy rain using SEVIRI cloud observations, *J. Appl. Met. Clim.* doi:10.1175/JAMC-D-17-0352.1
5. Q. Coopman\*, T. J. Garrett, D.P. Finch, and J. Riedi, 2018: High sensitivity of arctic liquid clouds to long-range anthropogenic aerosol transport, 45, 372-381, *Geophys. Res. Lett.* doi:10.1002/2017GL075795.
6. Gergely, M\*., S. J. Cooper, and T. J. Garrett, 2017: Using snowflake surface-area-to-volume ratio to model and interpret snowfall triple-frequency radar signatures, *Atmos. Chem. Phys.*, 17, 12011-12030, <https://doi.org/10.5194/acp-17-12011-2017>
7. Garrett, T. J., T. J. Reichler, P. Staten, 2017: High sensitivity to warming in an energetic model for Hadley cell width. *Nature Communications*. under review
8. Gergely M\* and T. J. Garrett, 2016: Impact of the natural variability in snowflake diameter, aspect ratio, and orientation on modeled snowfall radar reflectivity. *J. Geophys. Research*, doi: 10.1002/2016JD025192
9. Coopman, Q.\* , T. J. Garrett, J. Riedi, S. Eckhardt, and A. Stohl, 2016: Effect of long-range aerosol transport on the microphysical properties of low-level liquid clouds in the Arctic. *Atmos. Chem. Phys.* 16, 4661-4674, doi:10.5194/acp-16-4661-2016.
10. Minvielle, F., N. Ferlay, T. J. Garrett, and G. Penide,, 2015: Un mammatus à l'envers : par-delà le visible, des nuages inconnus! *La Météorologie*, 90, 50-52, doi:10.4267/2042/56838
11. Garrett, T. J., 2015: Long-run evolution of the global economy II: Hindcasts of innovation and growth. *Earth Syst. Dynam.* 6, 655–698
12. Garrett, T. J., 2015: Our capacity to discover and produce energy matters. *Retirement Management Journal*, 5, 47-48.
13. Garrett, T. J., Yuter, S.E., Fallgatter, C., Shkurko, K., Rhodes, S. R. and Endries, J. L., 2015: Orientations and aspect ratios of falling snow. *Geophys. Res. Lett.*, 42, 4617–4622, doi:10.1002/2015GL064040
14. Zhao, C.\* and T. J. Garrett, 2015: Effects of Arctic haze on surface cloud radiative forcing. *Geophysical Research Letters* 42, 557–564, doi: 10.1002/2014GL062015
15. Ferlay, N.; T. J. Garrett; Fanny Minvielle, 2014: Satellite observations of an unusual cloud formation near the tropopause. *J. Atmos. Sci.*, **71**, 3801–3815. doi:10.1175/JAS-D-13-0361.1
16. Garrett, T. J., S.E. Yuter 2014: Observed influence of riming, temperature, and turbulence on the fallspeed of solid precipitation. *Geophys. Res. Lett.* doi:10.1002/2014GL061016.
17. Garrett, T. J., 2014: Long-run evolution of the global economy Part I: Physical basis. *Earth's Future* **2**, 127–151, doi: 10.1002/2013EF000171
18. Garrett, T. J. and K. Hammonds, 2013: Crystallizing Opinion, *Meteorological Technology International*, April, pp. 32–36
19. Schmidt, C. T.\* and T. J. Garrett, 2013: A simple framework for the dynamic response of cirrus clouds to local diabatic radiative heating *J. Atmos. Sci.* **70**, 1409–1422.

20. Garrett, T. J., and C. Zhao, 2013\*: Ground based remote sensing of thin clouds in the Arctic. *Atmos. Meas. Tech.*, **6**, 1227-1243, 2013
21. van Diedenhoven, B., B. Cairns, A. M. Fridlind, A. S. Ackerman, and T. J. Garrett, 2013: Remote sensing of ice crystal asymmetry parameter using multi-directional polarization measurements – Part 2: Application to the Research Scanning Polarimeter *Atmos. Chem. Phys.* **13**, 3185-3203
22. *Airborne Measurements - Methods and Instruments*: co-author. M. Wendisch and J.-L. Brenguier, eds. 2013
23. Garrett, T. J., 2012: Can we predict long-run economic growth? *Retirement Management Journal* **2**, 53-61.
24. Garrett, T. J., C. Fallgatter, K. Shkurko, and D. Howlett, 2012: Fallspeed measurement and high-resolution multi-angle photography of hydrometeors in freefall. *Atmos. Meas. Tech.*, **5**, 2625-2633, doi:10.5194/amt-5-2625-2012
25. Garrett, T. J., M. Dubey, S. Schwartz, 2012. Diverse views on climate change: Third Santa Fe Conference on Global and Regional Climate Change. *EOS* **93**, 157, doi:10.1029/2012EO150007 .
26. Garrett, T. J., 2012: Modes of growth in dynamic systems *Proc. Roy. Soc. A*, **468**, 1471-2946, doi:10.1098/rspa.2012.0039
27. Garrett, T. J., 2012: No way out? The double-bind in seeking global prosperity alongside mitigated climate change, *Earth System Dynamics* **3**, 1-17, doi:10.5194/esd-3-1-2012
28. Garrett, T. J., S. Brattström, S. Sharma, D. E. J. Worthy, and P. Novelli, 2011: The role of scavenging in the seasonal transport of black carbon and sulfate to the Arctic, *Geophys. Res. Lett.*, **38**, L16805, doi:10.1029/2011GL048221.
29. Cooper, S. J.\* and T. J. Garrett, 2011: Application of infrared remote sensing to constrain in-situ estimates of ice crystal particle size during SPaTICus. *Atmos. Meas. Tech.*, **4**, 1593-1602
30. Baumgardner, D., et al., Airborne instruments to measure atmospheric aerosol particles, clouds and radiation: A cook's tour of mature and emerging technology, *Atmos. Res.* (2011), doi:10.1016/j.atmosres.2011.06.021
31. Garrett, T. J., 2011: How persistent is civilization growth? *arXiv:1101.5635v1*
32. Tietze, K.\*, Riedi, J., Stohl, A. and Garrett, T. J., 2011: Space-based evaluation of interactions between aerosols and low-level Arctic clouds during the Spring and Summer of 2008 *Atmos. Chem. Phys.*, **11**, 3359-3373, doi:10.5194/acp-11-3359-2011
33. Garrett, T. J. C. T. Schmidt\*, S. Kihlgren\* and Céline Cornet, 2010: Mammatus clouds as a response to cloud base radiative heating *J. Atmos. Sci.* **67**, 3891–3903
34. Leaitch, W. R., U. Lohmann, L. M. Russell, **T. Garrett**, N. C. Shantz, D. Toom-Sauntry, J. W. Strapp, K. L. Hayden, J. Marshall, D. Worsnop, and J. Jayne, 2010: Cloud albedo increase from carbonaceous aerosol. *Atmos. Chem. Phys.*, **10**, 7669-7684
35. Jourdan, O., G. Mioche, T. J. Garrett, A. Schwarzenböck, J. Vidot, Y. Xie, V. Shcherbakov, P. Yang, and J.-F. Gayet, 2010: Coupling of the microphysical and optical properties of arctic clouds during the ASTAR 2004 experiment: Implications for light scattering modelling. *J. Geophys. Res.* **115**, D23206

36. Cooper, S. J.\* and T. J. Garrett, 2010: Identification of small ice cloud particles using passive radiometric observations. *J. Appl. Meteorol. Clim.* **49**, 2334-2347
37. Garrett, T. J., C. Zhao, and P. Novelli, 2010: Assessing the relative contributions of transport efficiency and scavenging to seasonal variability in Arctic aerosol. *Tellus B*, **62**, 190-196.
38. Garrett, T. J., M. M. Maestas\*, S. K. Krueger, and C. T. Schmidt, 2009: Acceleration by aerosol of a radiative-thermodynamic cloud feedback influencing Arctic surface warming, *Geophys. Res. Lett.*, **36**, L19804, doi:10.1029/2009GL040195.
39. Zhao, C.\*, and T. J. Garrett, 2008: Ground-based remote sensing of precipitation in the Arctic, *J. Geophys. Res.*, **113**, D14204, doi:10.1029/2007JD009222
40. Menon, S., D. Unger, D. Koch, J. Francis, **T. Garrett**, I. Sednev, D. Shindell, and D. Streets, 2008: Aerosol climate effects and air quality impacts from 1980 to 2030 *Environ. Res. Lett.* **3**, 024004
41. P. K. Quinn, T. S. Bates, E. Baum, N. Doubleday, A. M. Fiore, M. Flanner, A. Fridlind, T. J. Garrett, D. Koch, S. Menon, D. Shindell, A. Stohl and S. G. Warren, 2008: Short-lived pollutants in the Arctic: their climate impact and possible mitigation strategies, *Atmos. Chem. Phys.*, **8**, 1723–1735
42. Garrett, T. J. and L. Verzella\*, 2008: An evolving history of Arctic aerosols. *Bull. Amer. Meteorol. Soc.*, **89** 299–302
43. Schultz, D.M., A.J. Durant, J.M. Straka, and T. J. Garrett, 2008: Reply. *J. Atmos. Sci.* **65**, 1095-1097
44. Garrett, T. J. Observational quantification of the optical properties of cirrus cloud. Chapter in *Light Scattering Reviews, Vol. 3*, Praxis, A. Kokhanovsky, ed., 2008
45. Liu, C., E. Zipser, T. J. Garrett, J. Jiang, and H. Su, 2007: How do the water vapor and carbon monoxide "tape recorders" start near the tropical tropopause? *Geophys. Res. Lett.*, **34**, L09804, doi:10.1029/2006GL029234, 2007
46. Garrett, T. J., M. B. Kimball\*, G. G. Mace, D. G. Baumgardner, 2007: Observing cirrus halos to constrain in-situ measurements of ice crystal size *Atmos. Chem. Phys. Discuss*, **7**, 1295-1325
47. Noel, V., D. M. Winker, T. J. Garrett, and M. McGill, 2007: Extinction coefficients retrieved in deep tropical ice clouds from lidar observations using a CALIPSO-like algorithm compared to in-situ measurements from the Cloud Integrated Nephelometer during CRYSTAL-FACE. *Atmos. Chem. Phys.* **7**, 1415-1422
48. T. J. Garrett, 2007: Comments on "Effective radius of ice cloud particle populations derived from aircraft probes" *J. Atmos. Oceanic. Technol.* **24**, 1492-1503.
49. Avey, L.\*, T. J. Garrett, A. Stohl, 2007: Evaluation of the aerosol indirect effect using satellite, tracer transport model, and aircraft data from ICARTT, *J. Geophys. Res.* **112**, D10S33, doi:10.1029/2006JD007581
50. Garrett, T. J., L. Avey\*, P. I. Palmer, A. Stohl, J. A. Neuman, C. A. Brock, T. B. Ryerson, and J. S. Holloway, 2006: Quantifying wet scavenging processes in aircraft observations of Nitric Acid and CCN. *J. Geophys. Res.* **111**, D23S51, doi:10.1029/2006JD007416
51. Garrett, T. J., M. A. Zulauf, and S. K. Krueger, 2006: Effects of cirrus near the tropopause on anvil cirrus dynamics, *Geophys. Res. Lett.*, **33**, L17804, doi:10.1029/2006GL027071

52. Garrett, T. J. and C. Zhao\*, 2006: Increased Arctic cloud longwave emissivity associated with pollution from mid-latitudes. *Nature*, 440, 10.1038/nature04636, 787-789
53. Garrett, T. J., J. Dean-Day, C. Liu, B. K. Barnett, G. G. Mace, D. B. Baumgardner, C. R. Webster, T. P. Bui, W. B. Read, and P. Minnis 2006: Convective formation of pileus cloud near the tropopause *Atmos. Chem. Phys.* **6**, 1185-1200
54. Schultz, D. M., K. M. Kanak, J. M. Straka, R. J. Trapp, B. A. Gordon, D. S. Zrnica, G. H. Bryan, A. J. Durant, T. J. Garrett, P. M. Klein, and D. K. Lilly, 2006: The mysteries of mammatus clouds: Observations and formation mechanisms. *J. Atmos. Sci.*, **63**, 2409-2435.
55. Garrett, T. J., B. C. Navarro\*, C. H. Twohy, E. J. Jensen, D. G. Baumgardner, T. P. Bui, H. Gerber, R. L. Herman, A. J. Heymsfield, P. Lawson, P. Minnis, L. Nguyen, M. Poellot, S. K. Pope, F. P. J. Valero, and E. Weinstock 2005: Evolution of a Florida cirrus anvil, *J. Atmos. Sci.*, **62**, 2352-2372.
56. Roskovensky, J. K., K.-N. Liou, T. J. Garrett, D. G., Baumgardner, 2004: Simultaneous Retrieval of Aerosol and Thin Cirrus Optical Depths using MODIS Airborne Simulator Data during CRYSTAL-FACE and CLAMS. *Geophys. Res. Lett.* Vol. **31**, No. 18, 10.1029/2004GL020457
57. **Garrett T. J.**, A. J. Heymsfield, B. A. Ridley, M. J. McGill, D. G. Baumgardner, T. P. Bui, and C. R. Webster, 2004: Convective generation of cirrus near the tropopause, *J. Geophys. Res.*, **109**, D21203, doi:10.1029/2004JD004952
58. Garrett, T. J., C. Zhao\*, X. Dong, G. G. Mace, P. V. Hobbs, 2004: Effects of Varying Aerosol Regimes on Low-Level Arctic Stratus. *Geophys. Res. Lett.* Vol. 31, No. 17, 10.1029/2004GL019928
59. P. J. Popp, R. S. Gao, T. P. Marcy, D. W. Fahey, P. K. Hudson, T. L. Thompson, B. Karcher, R. L. Herman, B. A. Ridley, A. J. Weinheimer, D. J. Knapp, D. D. Montzka, D. G. Baumgardner, T. J. Garrett, E. M. Weinstock, J. G. Smith, D. S. Sayres, J. V. Pittman, S. Dhaniyala, P. T. Bui, and M. J. Mahoney, 2004: Nitric acid uptake on subtropical cirrus cloud particles. *J. Geophys. Res.* **109**, D06302, doi: 10.1029/2003JD004255
60. Gao, R. S., P. J. Popp, D. W. Fahey, T. P. Marcy, R. L. Herman, E. M. Weinstock, D. G. Baumgardner, T. J. Garrett, K. H. Rosenlof, T. L. Thompson, P. T. Bui, B. A. Ridley, S. C. Wofsey, O. B. Toon, M. A. Tolbert, B. Karcher, Th. Peter, P. K. Hudson, A. J. Weinheimer, and A. J. Heymsfield, 2004: Evidence that Nitric Acid increases relative humidity in low-temperature cirrus clouds. *Science*, **303**, 516-520.
61. Garrett, T. J., H. Gerber, D. G. Baumgardner, D. G., C. H. Twohy, and E. M. Weinstock, 2003: Small, highly reflective ice crystals in low-latitude cirrus. *Geophys. Res. Lett.*, **30**, 2132, doi:10.1029/2003GL018153.
62. Garrett, T. J. L.M. Russell, V. Ramaswamy, S.M. Maria, and B. Huebert, 2003: Microphysical and radiative evolution of aerosol plumes over the tropical North Atlantic Ocean. *J. Geophys. Res.*, **108** (D1), 4022, doi:10.1029/2002JD002228.
63. Garrett, T. J., L.F. Radke, and P.V. Hobbs, 2002: Aerosol effects on cloud emissivity and surface longwave heating in the Arctic, *J. Atmos. Sci.*, **59**, 769-778.
64. Garrett, T. J., P.V. Hobbs, and L.R. Radke, 2002: High Aitken nucleus concentrations above cloud tops in the Arctic, *J. Atmos. Sci.*, **59**, 779-783.
65. Wendisch, M., T. J. Garrett, and W. Strapp, 2002: PVM-100A liquid water content probe response to large droplets. *J. Atmos. Ocean. Tech.*, **19**, 1577-1584.

66. Garrett, T. J., P.V. Hobbs, and H. Gerber, 2001: Shortwave, single-scattering properties of arctic ice clouds, *J. Geophys. Res.*, **106**, 15,155-15,172.
67. Curry, J. A, P. V. Hobbs, M. D. King, D. A. Randall, P. Minnis, G. A. Isaac, J. O. Pinto, T. Uttal, A. Bucholtz, D. G. Cripe, H. Gerber, C. W. Fairall, T. J. Garrett, J. Hudson, J. M., Intrieri, C. Jakob, T. Jensen, P. Lawson, D. Marcotte, L. Nguyen, P. Pilewskie, A. Rangno, D. C. Rogers, K. B Strawbridge, F. P. J. Valero, A. G. Williams, D. Wylie, 2000: FIRE Arctic Clouds Experiment. *Bull. Amer. Meteor. Soc.*, **81**, 5-29.
68. Durkee, P. and co authors, 2000: The impact of ship-produced aerosols on the microstructure and albedo of warm marine stratocumulus clouds: A test of MAST hypotheses 1i and 1ii. *J. Atmos. Sci.*, **57**, 2554-2569.
69. Ferek, R.J., T.J. Garrett and co-authors, 2000: Drizzle suppression in ship tracks. *J. Atmos. Sci.*, **57**, 2707-2728.
70. Hobbs, P.V., T.J. Garrett, and co-authors, 2000: Emissions from ships with respect to their effects on clouds, *J. Atmos. Sci.*, **57**, 2570-2590.
71. Hudson, J.G., T.J. Garrett, P.V. Hobbs, S.R. Strader, Y. Xie, and S.S. Yum, 2000: Cloud condensation nuclei and ship tracks. *J. Atmos. Sci.*, **57**, 2696-2706.
72. Noone K. J., D. W. Johnson, J. P. Taylor, R. J. Ferek, T. Garrett, P. V. Hobbs, P. A. Durkee, K. Nielsen, E. Öström, C. O'Dowd, M. H. Smith, L. M. Russell, R. C. Flagan, J. H. Seinfeld, L. De Bock, R. E. Van Grieken, J. G. Hudson, I. Brooks, R. F. Gasparovic, and R. A. Pockalny, 2000: A Case Study of Ship Track Formation in a Polluted Marine Boundary Layer. *J. Atmos. Sci.*, **57**, 2748-2764.
73. Noone, K. J., D. W. Johnson, J. P., Taylor, R. J. Ferek, T. Garrett, P. V. Hobbs, P. A. Durkee, K. Nielsen, E. Oestrom, C. O'Dowd, M. H. Smith, L. M. Russell, R. C. Flagan, J. H. Seinfeld, L. DeBock, R. E. Van Grieken, J. G. Hudson, I. Brooks, R. F. Gasparovic, I. Brooks, 2000: A case of ships forming and not forming tracks in moderately polluted clouds, *J. Atmos. Sci.*, **57**, 2729-2747.
74. Gerber, H., Y. Takano, T. J. Garrett, and P. V. Hobbs, 2000: Nephelometer measurements of the asymmetry parameter, volume extinction coefficient, and backscatter ratio in clouds. *J. Atmos. Sci.*, **57**, 3021-3034.
75. Garrett, T. J.: *Radiative Properties of Arctic Clouds*. Ph. D. Dissertation, University of Washington, 2000.
76. Garrett, T. J.: *Ship Tracks: An Example of Aerosol-Cloud Interactions*. Masters Thesis, University of Washington, 1995.
77. Garrett, T. J. and P.V. Hobbs, 1995: Long-range transport of continental aerosols over the Atlantic Ocean and their effects on cloud structures. *J. Atmos. Sci.*, **52**, 2977-2984.

### Conference proceedings, data products, and technical reports

78. Quentin Coopman\*, T. J. Garrett, and Jerome Riedi. 2017. Collaborative Research: Impacts of distant pollution sources on microphysical transitions in Arctic clouds. urn:node:ARCTIC. urn:uuid:bb14bf86-79eb-4a84-9734-4a1de99523d1.

79. Shkurko, K.I.\*, T. J. Garrett, 2016: *Getting started guide for the Multi-Angle Snowflake Camera*. Particle Flux Analytics, Inc.
80. Garrett, T. J., Bair, E.H., Fallgatter, C.J\*., Shkurko, K., Davis, R.E., and Howlett, D. 2012: *The Multi-angle snowflake camera*. Proceedings of the 2012 International Snow Science Workshop
81. Quinn, P.K., T.S. Bates, E. Baum, T. Bond, J.F. Burkhart, A.M. Fiore, M. Flanner, T.J. Garrett, D. Koch, J. McConnell, D. Shindell, A. Stohl, 2008. The Impact of Short-Lived Pollutants on Arctic Climate, AMAP Technical Report No. 2008-1, Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.
82. Kimball, M. B.\* and T. J. Garrett, *Constraining cirrus ice crystal size through observation of halos*. 12th Conference on Cloud Physics and Radiation, Madison, Wisconsin, 2006
83. Avey, L.\* , T. J. Garrett, and A. Stohl, *Evaluation of the aerosol indirect effect using satellite, chemical transport model, and aircraft data from ICARTT*, 12th Conference on Cloud Physics and Radiation, Madison, Wisconsin, 2006
84. Zhao, C.\* and T. J. Garrett, *Ground-based retrieval of seasonal cloud an precipitation properties in the Arctic*, 12th Conference on Cloud Physics and Radiation, Madison, Wisconsin, 2006
85. Garrett, T. J., H. Gerber, D. G. Baumgardner, M. Poellot, C. H. Twohy, and E. M. Weinstock, *Microphysical relationships in CRYSTAL-FACE anvil cirrus*. International Conference on Clouds and Precipitation, Bologna, Italy, 2004
86. Garrett, T. J., X. Dong, G. G. Mace, C. Zhao\*: *Effects of arctic haze on clouds and the surface radiation balance*. Seventh Conf. on Polar Meteorology and Oceanography and Joint Symposium on High Latitude Climate Variations, , Hyannis Mass., 16-23 May 2003.
87. Garrett, T. J. and P. V. Hobbs, 1999: *Calibration of liquid water probes from the University of Washington's CV-580 aircraft at the Canadian NRC wind tunnel*.

## Software products

88. Deshmukh, S.\* and T. J. Garrett, 2018: *Multi Angle Snowflake Camera: Snowflake Analysis and User Interface*
89. Shkurko, K.\* , T. J. Garrett, and K. Gaustad, 2016: *Multi-Angle Snowflake Camera Value-Added Product DOE/SC-ARM-TR-187*. Atmospheric Radiation Measurement (ARM) Climate Research Facility Data Archive: Oak Ridge, Tennessee, USA. doi:10.5439/1350635
90. Shkurko, K.S.\* and T. J. Garrett 2012: *Multi Angle Snowflake Camera: Simple Data Acquisition*

## Pending and issued patents

91. Fallgatter, C.\* and T. J. Garrett, 2013: Systems and methods for imaging of falling objects. *US Patent Number 8,891,895*
92. Fallgatter, C.\* , T. J. Garrett and K. I. Shkurko, 2016: Hydrometeor identification methods and systems. *US Patent Number US10026163B2*

93. Garrett, T. J., F. Solzbacher, K. I. Shkurko\*, 2016: Weather detecting devices and related methods  
*Patent Application No. US2018/055954*

### **Educational and outreach products**

94. Garrett, T. J., 2018 to present: *Nephologue*. A blog and twitter feed on applying thermodynamics to complex systems
95. Garrett, T. J., 2014: *Snowflake Formation: A series of lessons plans for 4th through 6th grade*.
96. Co-author on *Climate Change and Utah: The Scientific Consensus*, a report to the Governor of Utah's Blue Ribbon Advisory Committee on Climate Change.
97. Garrett, T. J. in collaboration with the Curriculum Development Unit of Tonga: *Form 3: Weather and the Sea*. Ministry of Education, Kingdom of Tonga, 1997.

### **Invited Presentations**

1. *Are the impacts of aerosols on convective cloud fields constrained by bulk tropospheric thermodynamics?* Short-Lived Climate Pollutants Workshops, Jeju-do, South Korea, November 2018
2. *New puzzles in precipitation microphysics revealed by the Multi Angle Snowflake Camera* Korean Meteorological Association Annual Meeting, Jeju-do, South Korea, October, 2018
3. *Impacts of Aerosols from Biomass Burning and Anthropogenic Pollution Sources on Low-Level Arctic Clouds*, American Meteorological Society Annual Meeting, Austin, Texas, January, 2018,
4. *Aerosols, clouds, and precipitation in the Arctic: Who's in charge?*, NETCARE Workshop, University of Toronto, Toronto, November, 2017
5. *Energy, Thermodynamics, and the Human Enterprise* Crans Meeting on Energy, Finance, Economy and Governance Risks, Crans, Switzerland, July, 2017
6. *The distinctive nature of aerosol-cloud-radiation feedbacks in the Arctic*. University of Leipzig, Leipzig, Germany, May, 2017.
7. *Impacts of long-range aerosol transport on phase transitions in Arctic clouds*, SLCP Meeting, Gangneung, South Korea, February 2017
8. *Power laws in tropical cloud fields and the relationship to atmospheric stability*, EECLAT Workshop, Baie de la Somme, January 2017
9. *Turbulence and temperature effects on hydrometeor fallspeed*. Université de Grenoble, France, January, 2017
10. *Turbulence and temperature effects on hydrometeor fallspeed*. Université Blaise-Pascal, Clermont-Ferrand, France, November, 2016
11. *Turbulence and temperature effects on hydrometeor fallspeed*. École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, September, 2016
12. *The distinctive nature of aerosol-cloud-radiation feedbacks in the Arctic*. Yonsei University, Seoul, Korea, February 20, 2016.

13. *The complexity of interactions between aerosols, clouds, precipitation and radiation in the Arctic.* Korean Meteorological Society workshop on Short-Lived Pollutants. Songdo, Korea, February 13, 2016
14. *The distinctive nature of aerosol-cloud-radiation feedbacks in the Arctic.* Seoul National University, Seoul, Korea, February 14, 2016.
15. *Market expectations in retirement planning: an evolutionary and thermodynamic perspective.* Retirement Income Industry Association Advisor Forum Week, Fort Lauderdale, March 11, 2015
16. *Aerosols, clouds, precipitation, radiation and climate: A problem of interactions across scales,* Korean Meteorological Society Annual Meeting, Jeju, Korea, Oct 13, 2014
17. *Aerosols, clouds, precipitation, radiation and climate: A problem of interactions across scales,* Gangneung University, Korea, Oct 16, 2014
18. *The Jevons Paradox: Why the increasing energy efficiency of the economy is accelerating global climate change* Duke University School of the Environment, Durham, NC, Sept 12, 2014
19. *Wealth is Power. What physics tells us about our financial future.* Chartered Financial Analyst Society of Indianapolis Annual Meeting. Carmel, IN, March 17, 2014.
20. *Why is the Arctic summer clean? Will the Arctic get cleaner? How wet scavenging controls the impacts of mid-latitude pollution in the Arctic.* AGU Fall Meeting, San Francisco, December 9-13, 2013
21. *Photographing snowflakes in freefall at Alta:* Université Blaise Pascal II, Clermont-Ferrand, France, May, 2013
22. *Thermodynamic constraints on economic innovation and growth:* Gruter Institute: Innovation, Economic Growth and Human Behavior, Squaw Valley, June 21-23, 2012
23. *Modes of growth in economic systems:* Gruter Institute: Economic Growth: Costs, Causes and Effects, Squaw Valley, June 23-25, 2012.
24. *Mountain meteorology: Precipitation and snow crystals in the atmosphere:* Avalanche science workshop, Mammoth, California, March 2012.
25. *Wealth is Power: Consequences and Implications for Retirees:* Keynote Talk for the Retirement Income Industry Association, Chicago, March, 2012
26. *A Simple Method for Diagnosing the Dynamic Response of Cloudy Air to Diabatic Heating and Cooling* University of Berkeley, California, February, 2012.
27. *Can we provide thermodynamic constraints for the long-term coupled evolution of the economy and the atmosphere?* Third Santa Fe Conference on Global and Regional Climate Change, October 2011.
28. *How will aerosol-cloud-precipitation-radiation interactions evolve in a warming Arctic?* Michigan Tech., September, 2011.
29. *How will aerosol-cloud-precipitation-radiation interactions evolve in a warming Arctic?* NASA Jet Propulsion Laboratory, August, 2011

30. *Application of simple (non-equilibrium) thermodynamics to constrain long-range economic growth and its coupling to atmospheric concentrations of CO<sub>2</sub>* Northwest Research Associates, July, 2011
31. *Is it physically possible to have our economic prosperity and stabilize atmospheric CO<sub>2</sub>?:* University of Edinburgh, June, 2011
32. *Will warming temperatures mediate the effects of short-lived aerosol pollutants on Arctic climate?:* University of Michigan, January, 2011
33. *Mammatus Clouds: A Window Into the Role of Radiation-Dynamic Feedbacks in Stratiform Cloud Evolution:* Texas A&M University, December, 2010
34. *Is it possible to de-couple economic wealth from carbon dioxide emission rates?:* Pacific Institute for Climate Solutions, University of Victoria, May, 2010
35. *Long-range pollution transport to the Arctic and its role in modulating regional aerosol-cloud-climate interactions:* Max-Planck Institute for Meteorology, Hamburg, Germany, June, 2009
36. *Remote sensing of clouds, precipitation and radiation in the Arctic and associated interactions with pollution from mid-latitudes:* Université de Blaise Pascal, Clermont-Ferrand, France, February, 2009
37. *A simple thermodynamic approach to the economic evolution of civilization and its carbon dioxide emissions:* Max Planck Institute for Biogeochemistry, Jena, Germany, January 2009
38. *What exactly is the difference between clear-sky and cloud?:* University of Bremen, December 2008
39. *All other things being equal: On the role of feedback in aerosol-cloud interactions.* University of Edinburgh, September, 2008
40. *Arctic climate forcing through aerosol-cloud interactions.* AMAP Workshop on Non-CO<sub>2</sub> Climate Forcers, Oslo, Norway, September 2008
41. *On the evolution of cloud systems:* Frontiers of Climate Conference, Kavli Institute of Theoretical Physics, Santa Barbara, California, May, 2008
42. *A look at the evolution of clouds:* University of Arizona, Tucson, April 2008
43. *Longwave and shortwave effects of aerosol interactions with clouds in the Arctic:* Norwegian Institute for Air Research, Kjeller, Norway, November 2007.
44. *Might anthropogenic aerosol be stimulating Arctic sea ice melting through their effects on clouds?* University of Toronto, September, 2007
45. *Is Arctic sea-ice melting stimulated by aerosol-cloud-radiative interactions?* Gordon Conference on Radiation and Climate, July, 2007.
46. *Is the Cloud System Homeostatic?* Dalhousie University, Canada, May, 2007
47. *Arctic Haze and Winter Warming* Arctic Climate Workshop sponsored by Clean Air Task Force, NASA GISS, January, 2007
48. *Pollution and the Arctic: 200 years of Man-Made Climate Change,* Wallace Stegner Center, University of Utah, October 2006

49. *Exploring Pollution-Cloud-Climate Interactions in the Arctic*, State University of New York, September 2006
50. *Exploring Pollution-Cloud-Climate Interactions in the Arctic*, Brookhaven National Laboratories, September 2006

## Teaching

**Undergraduate** *Atmos 5200: Cloud Physics*

*Atmos 5140: Atmospheric Radiation*

*Atmos 5130: Atmospheric Thermodynamics*

*Atmos 5210: Physical Meteorology*

Radiative Transfer and Climate, Thermodynamics, Cloud Physics

*Atmos 3410: Meteorological Analysis*

Using Matlab for time series analysis, fourier analysis, statistical analysis, and numerical modeling

**Graduate** *Atmos 6020: Physical Meteorology*

Radiative Transfer and Climate, Thermodynamics, Cloud Physics

*Atmos 6200: Radiative Transfer and Climate*

Physical principles and mathematical methods for approaching longwave and shortwave radiative transfer in the atmosphere

*Atmos 6300: Advanced Cloud Physics*

Cloud thermodynamics, microphysical and radiative processes, similarity theory, cloud dynamics, mixed-layer modeling

## Undergraduate Students Advised

1. Lisa Verzella 2008: Undergraduate Research Assistant
2. Miranda Oliver 2012: University of Utah UROP program
3. Karlie Rees 2016-2018: Atmospheric Sciences Capstone Project
4. Logan Hill: 2018 - present University of Utah UROP program

## Graduate Students Advised

1. Bradley Navarro. M. S. 2003 *Microphysical and Radiative Evolution of a Cirrus Anvil During CRYSTAL-FACE*
2. Nathaniel Mullins M. S. 2005 *Case Study of a Jet Contrail at the Tropopause: Properties, Evolution and Radiative Effects*
3. Margaret Kimball M. S. 2006 *Convectively Driven Formation of Thin Cirrus in the Tropopause Transition Layer*
4. Lance Avey M. S. 2006 *Evaluation of the aerosol indirect effect using satellite, tracer transport model, and aircraft data from ICARTT*

5. Chuanfeng Zhao Ph. D. 2007 *Effects of Arctic Haze on Low-Level Stratus Properties and the Surface Radiation Budget*
6. Stina Sjöström, M. S. Uppsala University, Sweden 2007 *Numerical Exploration of Radiative-Dynamic Interactions in Cirrus*
7. Kyle Tietze, 2007 - 2011, M. S., 2010 *Spaced Based Evaluation of the Aerosol Indirect Effect in the Arctic*
8. Clint Schmidt, 2007 - 2013, M. S. 2010 *A Simplified Model for Understanding the Evolution of Cirrus Clouds*
9. Melissa Maestas, 2008 - 2009
10. Sara Brattström, M. S. Stockholm University, Sweden, 2011 *The role of scavenging in the seasonal transport of black carbon and sulfate to the Arctic*
11. Zhiyu Wang, 2009 - 2015
12. Quentin Coopman, 2013 - 2016, Ph.D., 2016 *Impact of Aerosols on Arctic Clouds*
13. Shailesh Alva, 2014 - 2015
14. Maximilien Patou, 2015 - 2018, Ph.D. 2018 *Temporal analysis of the optical, microphysical and macrophysical properties of strongly precipitating cloud systems from SEVIRI/MSG*
15. Kyle Fitch, 2017 to present
16. Ahmad Talei, 2017 to present
17. Karlie Rees, 2018 to present

### **Graduate Student Committees**

1. Eric Vernon, M.S., 2002
2. Yuying Zhang M.S., 2002
3. Yaping Li, M.S. 2002
4. Haiyan Jiang, Ph.D. 2004
5. Kristen Dowd, M. S. 2004
6. Yuying Zhang, Ph. D. 2006
7. Ryan Riveland, M. S. 2006
8. Helena Schlueter, M. S. 2006
9. Daniel Hartsock, M.S. 2006
10. Jennifer Esker, M. S. 2006
11. Scott Robertson, M. S. 2007

12. Lis Cohen, M.S. 2008
13. Betsy Dupont, M.S. 2010
14. Peter Bogenschutz Ph.D. 2011
15. Michael Peterson, M. S. 2011
16. Samantha Balaich, M.S. 2012
17. Christy Wall, Ph.D. 2013
18. Kevin Hammonds, M.S. 2013
19. Chris Schwartz, Ph.D. 2013
20. Shan Zheng, Ph.D. *Université de Lille* 2014
21. Ian Glenn, M.S. 2013, Ph.D. 2017
22. Trevor Ferguson, M.S., 2014
23. Stephen Bannister, Ph.D. 2016
24. Arpa Hudait Ph. D. 2018
25. Quentin Coopman, Ph.D. 2016
26. Sarah Bang, Ph.D 2018
27. Jeanna Mascio, Ph.D. 2018

## **Service and Outreach**

1. University Promotion and Tenure Advisory Committee, 2018 to present
2. University Graduate Council, 2014 to 2016
3. University of Utah Senate, 2010 to 2013
4. University Personnel and Elections Committee 2010 to 2014
5. Editor, 2007-present, *Atmospheric Chemistry and Physics*
6. Associate Editor, 2003-2010, *Journal of Atmospheric Sciences*
7. Panel Review Committee for NASA NEWS, August, 2014
8. Panel Review Committee for DOE, May, 2012
9. Panel Review Committee for NASA CloudSat/Calipso July, 2010
10. Panel Review Committee for NOAA Office of Global Programs, October, 2004
11. Regular journal article reviewer for *Nature*, *Science* and *AMS*, AGU, EGU, Blackwell, and IEEE journals

12. Regular proposal reviewer for NASA, NSF, DOE, and NOAA
13. Research on snowflake photography, energy and economic growth, Arctic pollution and clouds, and cirrus clouds has been profiled in independent articles for *National Geographic*, *New Scientist*, *Science et Vie*, *Weather.com*, *CBC Television*, *Fox News*, *NBC*, *Yahoo*, *Gizmodo*, *Science*, *Le Monde*, *Figaro*, *Vice*, *Wired*, *EOS*, *Continuum*, *AdvisorOne Research magazine*, *International Innovation*, *Institutional Investor*, *Audubon*, *Slashdot*, *Helix*, *Photonics*, *Powder*, *Owl*, *The Avalanche Review*, *KOMO*, *BBC-5*, *NPR*, *KCLU*, *Radio EcoShock*, *KSL*, *Fox13*, *Salt Lake Tribune*, *Deseret Morning News*, *PhysicsWorld*, *Science News for Students*, *The Statesman*, *Utah Stories*, and *Christian Science Monitor*
14. Panelist for “Wildfires, Drought, Air Pollution: The Growing Climate Crisis”, Orem Public Library, November 28, 2018
15. Garrett, T. J., 2014: *Snowflake Formation: A series of lessons plans for 4th through 6th grade*. Presented in Salt Lake City and Bountiful 4th Grade classrooms.
16. Presenter for “Science Movie Night” at the Downtown Public Library, December 9, 2014
17. Snowflake research featured for a 2013 documentary for The WeatherChannel entitled *Secrets of the Earth: Blizzards*
18. Snowflake research featured for a 2014 documentary for the Canadian Broadcasting Corporation entitled *The Nature of Things: Chasing Snowflakes*
19. Provide real-time snowflake photographs for the “Snowflake Showcase” website hosted by Alta Ski Area
20. Invited panelist for “Focussing Cache: The Science of Climate”, Utah State University, January 31, 2008
21. Presenter for “Natural History Now!” at the Utah Museum of Natural History, February 1, 2008
22. Presenter for Hogle Zoo, June 28, 2008
23. Alta Historical Society “Fireside Chat” 2011, 2012.
24. Presenter for American Meteorological Society Salt Lake Chapter 2013

## **Awards**

1. *NASA New Investigator Program Award*, 2005 - 2008
2. *Huber Fellowship*, Princeton Environmental Institute, Princeton University, 2000 - 2002
3. *Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS)*, Invited participant, 2002
4. *Outstanding Student Paper Award*, AGU Fall Meeting, 1999

## Externally Awarded Research Funding to University of Utah (Total \$4,070,123)

1. **NASA** *Optical Properties of Tropical Cirrus Clouds*. P. I. T. J. Garrett, Co-P.I. H. Gerber. \$136,389. 01/2002 - 01/2004.
2. **NSF** *Aerosol-Cloud-Radiation Interactions in the Arctic*. P.I. T. Garrett, co-P.I. Xiquan Dong, Gerald G. Mace. \$339,503. 04/2003 - 04/2006.
3. **NSF** *New Approaches for the Measurement of Microphysics in Extratropical Hurricanes*. P.I. T. J. Garrett. \$19,946, 07/2003 - 07/2004.
4. **NOAA** 2003 *Aerosol-cloud-climate interactions downwind of North Eastern North America*. P.I. T. J. Garrett. \$351,234. 03/03 - 03/06.
5. **NASA** *Airborne Studies of Middle and Low-Latitude Cirrus*. P. I. T. J. Garrett. \$86,882. 01/04-01/05.
6. **NSF** *Formation and evolution of pileus cloud near the tropopause*. P. I. T. J. Garrett \$35,693. 1/1/06 - 12/31/06.
7. **NASA** (New Investigator Program Award) *Interaction between microphysics, radiation and dynamics in terrestrial cirrus*. P. I. T. J. Garrett \$339,976. 8/1/06 - 7/31/09.
8. **NSF** *Evaluation of Aerosol-Cloud-Radiation Processes and Feedbacks in the Alaskan Arctic*. P.I. T. J. Garrett \$324,121 6/1/07-5/30/10.
9. **Clean Air Task Force** *Quantifying the significance of mid-latitude pollution plumes to clouds and sea-ice melting in the Arctic*, \$100,000 6/1/07-10/30/09.
10. **NASA** *Evaluating tropical and mid-latitude cirrus properties using co-incident satellite and aircraft sensors*, P.I. T. J. Garrett, co-P.I. Jay Mace, \$240,000, 1/1/08-12/31/11
11. **Army** *Development of automated measurement techniques for improved parameterization of snowflakes in mesoscale weather models* \$49,620, 11/1/09-6/30/10
12. **Ewing Marion Kauffman Foundation** *How does energy govern innovation and global economic growth?* \$38,837, 4/1/2011 - 8/30/2012
13. **NASA** NASA Earth System Science Fellowship to Clinton Schmidt: *Application of CERES energy budget data to improve understanding of the dynamic role of clouds in the Earth's planetary albedo* \$90,000 9/1/2011 - 8/30/2014
14. **NSF Collaborative Research: The Wasatch Hydrometeor Aggregation and Riming Experiment** \$450,000 8/1/2011-7/31/2014
15. **Ewing Marion Kauffman Foundation** *Forecasting Civilization Expansion and Innovation as a Function of Energy Reserve Discovery* \$47,490, 4/1/2012 - 3/30/2013
16. **NASA** NASA Earth System Science Fellowship to Zhiyu Wang: *How will future Arctic sea ice decline impact atmospheric stability and cloudiness?* \$90,000 9/1/2012 - 8/30/2015
17. **NSF** *Impacts of distant pollution sources on microphysical transitions in Arctic clouds* \$459,658 9/1/2013 - 8/30/2016

18. **NASA** *A snowflake mass measurement device for the NASA Global Precipitation Measurement Mission* \$50,000 12/1/2013 - 6/30/2014
19. **NSF** Development of a Freefall Precipitation Camera for Weather Monitoring Systems. Sub-contract from Fallgatter Technologies: \$71,248, 5/1/2014 - 4/30/2015
20. **DOE** High temporal and spatial resolution measurement of hydrometeor mass for automated assessment of precipitation rate and type. Sub-contract from Particle Flux Analytics: \$102,032, 3/1/2017-12/31/2017
21. **DOE** Parameterization of arctic hydrometeor physics using new precipitation measurement technologies \$457,847, 9/1/2017 - 8/30/20
22. **DOE** High temporal and spatial resolution measurement of hydrometeor mass for automated assessment of precipitation rate and type. Sub-contract from Particle Flux Analytics: \$449,746, 5/1/2018-4/30/2020

### **Field Work**

1. **NASA CRYSTAL-FACE**, Summer 2002: Integrated Cloud Integrating Nephelometer (CIN) onto the NASA WB-57 aircraft for the study of Florida anvil cirrus.
2. **CNRC ETHEX**, Fall, 2003: Integrated CIN onto Canadian National Research Council CV-580 Airborne Facility for flight into mid-latitude Hurricane systems.
3. **NASA MidCiX**, Spring, 2004: Integrated CIN onto the the NASA WB-57 for the study of mid-latitude and sub-tropical anvil cirrus.
4. **NOAA ICARTT**, Summer, 2004: Integrated CIN, FSSP-100 and OAP 2D-C onto NOAA and CNRC aircraft for the study of the effects of North American pollution on cloud radiative properties.
5. **WASHARX**: 2012 to 2015: High resolution imaging of snowflakes at the High Altitude Research Laboratory for Diversity in Snow (HARoLDS) at 10,000' at the Alta Ski Area.
6. **Snowflake Settling Speed Experiment**: Winter 2017: Study of hydrometeor fallspeeds at Oliktok Point, Alaska.

### **Professional Memberships**

American Meteorological Society. 2000 - present

American Geophysical Union 1998 - present