



[DRI Home](#) / [DRI Personnel Directory](#) / [Directory](#) / [David Mitchell](#)

Dr. David L. Mitchell

Title: Associate Research Professor Physics
Affiliation: [Division of Atmospheric Sciences](#)
Location: [Reno Campus](#)
Email: David.Mitchell@dri.edu
Phone: 775-674-7039
Full Resume / CV: [Download](#)



Keywords:

cloud microphysics, cirrus clouds, cloud optical properties, remote sensing, climate engineering, global climate modeling, climate change, North American monsoon

Professional Interests

Dr. Mitchell's research has focused on the following areas: (1) theoretical understanding and modeling of the microphysical evolution within cirrus and frontal clouds, especially with regard to particle size spectra and crystal concentrations; (2) understanding and modeling the radiative properties of ice clouds; (3) remote sensing of cloud properties; (4) understanding and predicting the onset, strength and extent of the North American monsoon; (5) modification of cirrus clouds to reduce global warming.

Accomplishments regarding (1) include the development of two models successfully predicting the evolution of ice particle size spectra. The input for one model consists of the ice water content and temperature profiles, while the other is driven by changes in super-saturation. These models are computationally efficient, utilizing analytical solutions for ice particle growth by vapor diffusion and aggregation, and can be easily used to improve radar estimates of precipitation at ground level.

Regarding (2), the optical properties of ice clouds have been successfully described by parameterizing the absorption and scattering processes and rigorously treating their dependence on

cloud microphysics. This treatment, the Modified Anomalous Diffraction Approximation (MADA), was formulated in terms of the size distribution and ice particle shape, and agrees with explicit electrodynamic solutions of ice crystal single scattering properties within 15%. These developments, along with parameterizing the asymmetry parameter for various crystal shapes, have lead to a new treatment of ice cloud radiative properties which is used in (i) the GCM and operational forecast model at the Hadley Centre/U.K. Meteorological Office, (ii) in the new NCAR GCM (CCSM4), (iii) in the Colorado State University GCM, (iv) in the Regional Atmospheric Modeling System (RAMS) at CIRES and (v) in the Rapid Radiation Transfer Model (RRTM) and the Paleoclimate version of RRTM at Atmospheric and Environmental Research (AER), Inc.

Regarding (3), a new method for estimating the amount of ice contained in clouds (i.e. the ice water path, or IWP) from satellite- or ground-based platforms has been developed, based on the heat emitted by the earth at discrete wavelengths in the infrared “window” region. The method considers the details of the size distribution and ice particle shape. In addition, two new satellite retrieval algorithms have been developed that estimate (1) the ice particle size distribution including the number concentration of small ($D < 60 \mu\text{m}$) ice crystals and (2) the percentage of liquid water relative to the total (ice + liquid) condensate in cold clouds. Method (1) is of value due to the difficulty in measuring small ice crystal concentrations from aircraft (which help determine cirrus cloud optical properties) and method (2) is important since ice cloud optical properties strongly depend on the fraction of liquid water when present. Both methods were the first to retrieve the indicated cloud properties.

Regarding (4), a new approach to understanding the Mexican monsoon has been pursued in terms of sea surface temperatures (SSTs) in the eastern tropical Pacific and the Gulf of California. Results from six monsoon seasons show that relatively heavy rainfall in Arizona commences once the SST in the northern Gulf of California exceeds 29 °C. Moreover, ten years of satellite altimeter observations of sea surface height in the eastern tropical Pacific indicate this threshold SST can be predicted 1-2 months in advance. Together these relationships provide a potential means of predicting the Arizona onset of the North American monsoon 1-2 months in advance.

Regarding (5), it is generally accepted that the mean increase in global surface temperatures (relative to pre-industrial times) should not exceed 2 °C if mankind is to avoid “unacceptable” consequences of climate change. Recent research has led some scientists to conclude that this threshold may be unavoidable unless some type of climate engineering is invoked to remove CO₂ from the atmosphere and/or temporarily cool the planet (e.g. by reflecting more sunlight) while simultaneously very rapidly converting to non-carbon based energy systems. A new type of climate engineering has been proposed, based on the aircraft seeding of the coldest cirrus clouds to reduce their global coverage, resulting in a global cooling effect. This has some potential advantages over the most studied climate engineering approach; the injection of sulfur compounds into the stratosphere to reflect more sunlight.

Research Areas

Cloud Microphysics

Cloud Radiative Properties (especially ice clouds)

Remote Sensing of Cloud Physical Properties

Climate Dynamics

Large-Scale and Mesoscale Dynamic Meteorology

Precipitation Scavenging

Education

Scroll horizontally to view the whole table

DEGREE	YEAR	INSTITUTION	AREA
Ph.D..	1995	University of Nevada, Reno	Atmospheric Science
M.S.	1986	University of Nevada, Reno	Atmospheric Science
B.Sc.	1981	California Polytechnical State, University, San Luis Obispo	Chemistry

Selected Publications

Liu, X., Easter, R. C., Ghan, S. J., Zaveri, R., Rasch, P., Shi, X., Lamarque, J.-F., Gettelman, A., Morrison, H., Vitt, F., Conley, A., Park, S., Neale, R., Hannay, C., Ekman, A. M. L., Hess, P., Mahowald, N., Collins, W., Iacono, M. J., Bretherton, C. S., Flanner, M. G., and Mitchell, D., 2012: Toward a minimal representation of aerosols in climate models: description and evaluation in the Community Climate Model CAM5. *Geosci. Model Development*, 5, 709-739, doi:10.5194/gmd-5-709-2012.

Mitchell, D. L., S. Mishra, and R. P. Lawson, 2011: Representing the ice fall speed in climate models: Results from Tropical Composition, Cloud and Climate Coupling (TC4) and the Indirect and Semi-Direct Aerosol Campaign (ISDAC), *J. Geophys. Res.*, 116, D00T03, doi:10.1029/2010JD015433.

Mitchell, D.L., R.P. Lawson, and B. Baker, 2011: Understanding effective diameter and its application to terrestrial radiation in ice clouds. *Atmos. Chem. Phys.*, 11, 3417-3429, doi:10.5194/acp-11-3417-2011.

Mitchell, D. L., and R. P. d'Entremont, 2011: Satellite retrieval of the liquid water fraction in tropical clouds between -20° and -38°C. *Atmos. Meas. Tech. Discuss.*, 4, 1-42, doi:10.5194/amtd-4-1-2011.

Morrison, H., Vitt, F., Conley, A., Park, S., Neale, R., Hannay, C., Ekman, A. M. L., Hess, P., Mahowald, N., Collins, W., Iacono, M. J., Bretherton, C. S., Flanner, M. G., and Mitchell, D., 2011: Toward a

minimal representation of aerosol direct and indirect effects: model description and evaluation, *Geosci. Model Dev. Discuss.*, 4, 3485-3598, doi:10.5194/gmdd-4-3485-2011.

Gettelman, A., X. Liu, S.J. Ghan, H. Morrison, S. Park, A.J. Conley, S.A. Klein, J. Boyle, D.L. Mitchell, and J.-L.F. Li, 2010: Global simulations of ice nucleation and ice supersaturation with an improved cloud scheme in the Community Atmosphere Model. *J. Geophys. Res.*, 115, D18216, doi:10.1029/2009JD013797.

Lawson, R.P., E. Jensen, D.L. Mitchell, B. Baker, Q. Mo and B. Pilon, 2010: Microphysical and Radiative Properties of Tropical Clouds Investigated in TC4 and NAMMA. *J. Geophys. Res.*, 115, D00J08, doi:10.1029/2009JD013017.

Mitchell, D.L., R.P. D'Entremont, and R.P. Lawson, 2010: Inferring Cirrus Size Distributions through Satellite Remote Sensing and Microphysical Databases. *J. Atmos. Sci.*, 67, 1106-1125, doi:10.1175/2009JAS3150.1.

Mitchell, D.L. and W. Finnegan, 2009: Modification of cirrus clouds to reduce global warming. *Environ. Res. Lett.*, 4, 045102 (8 pp), doi:10.1088/1748-9326/4/4/045102.

Mitchell, D.L., R.P. d'Entremont, and R.P. Lawson, 2009: Inferring cirrus size distributions through satellite remote sensing and microphysical databases. *J. Atmos. Sci.*, 67, 1106-1125. doi:10.1175/2009JAS3150.1.

Mitchell, D.L., P.J. Rasch, D. Ivanova, G.M. McFarquhar, T. Nousiainen, 2008: Impact of small ice crystal assumptions on ice sedimentation rates in cirrus clouds and GCM simulations. *Geophys. Res. Lett.*, 35, doi:10.1029/2008GL033552.

Mishra, S., D.L. Mitchell, and D. DeSlover, 2008: Ground based retrievals of small ice crystals and water phase in Arctic cirrus. American Institute of Physics (AIP), Proceedings of the International Radiation Symposium, Foz do Iguassu, Brazil, 3-8 August 2008.

Mitchell, D.L., and R.P. d'Entremont, 2008: Satellite remote sensing of small ice crystal concentrations in cirrus clouds. American Institute of Physics (AIP), Proceedings of the International Radiation Symposium, Foz do Iguassu, Brazil, 3-8 August 2008.

Mitchell, D.L., A.J. Brown, W.P. Arnott, and C. Schmitt, 2006: Testing and comparing the modified anomalous diffraction approximation. Accepted for publication

in J. Atmos. Sci., 63, 2948-2962.

Mitchell, D.L., A. Huggins and V. Grubisic, 2006:

A new snow growth model with application to radar precipitation estimates. Atmos. Res., 82, 2-18.

Mitchell, D.L. and A.J. Heymsfield, 2005:

Refinements in the treatment of ice particle terminal velocities, highlighting aggregates. J. Atmos. Sci., 62, 1637-1644.

Mitchell, D.L., R.P. d'Entremont, D.H. DeSlover, and W.P. Arnott, 2003:

Multispectral thermal retrievals of size distribution shape, effective size, ice water path, optical depth and photon tunneling contribution. 12th Conf. on Satellite Meteorology and Oceanography, AMS Annual Meeting, Long Beach, California, 9-13 Feb. 2003.

Mitchell, D.L., 2002:

Effective diameter in radiation transfer: General definition, applications and limitations. J. Atmos. Sci., 59, 2330-2346.

Mitchell, D.L., D. Ivanova, R. Rabin, K. Redmond, and T.J. Brown, 2002:

Gulf of California sea surface temperatures and the North American monsoon: Mechanistic implications from observations. J. Climate, 15, 2261-2281.

Ivanova, D.C., D.L. Mitchell, W. Patrick Arnott and M. Poellot, 2001:

A GCM parameterization for bimodal size spectra and ice mass removal rates in mid-latitude cirrus clouds. Atmos. Res., 59, 89-113.

Mitchell, D.L., 2000:

Parameterization of the Mie extinction and absorption coefficients for water clouds. J. Atmos. Sci., 57, 1311-1326.

Mitchell, D.L., 1996:

Use of mass- and area-dimensional power laws for determining precipitation particle terminal velocities. J. Atmos. Sci., 53, 1710-1723.

Mitchell, D.L., A. Macke, and Y. Liu, 1996:

Modeling cirrus clouds. Part II: Treatment of radiative properties. J. Atmos. Sci., 53, 2967-2988.

Mitchell, D.L., 1994:

A model predicting the evolution of ice particle size spectra and the radiative properties of cirrus clouds. Part I: Microphysics. J. Atmos. Sci., 51, 797-816.

Mitchell, D.L. and W.P. Arnott, 1994:

A model predicting the evolution of ice particle size spectra and the radiative properties of cirrus clouds. Part II: Dependence of absorption and extinction on ice crystal morphology. J. Atmos. Sci., 51, 817-832.

Book Reviews and Book Chapters

Mitchell, D. L., 2011: Book review of “Geo-engineering Climate Change: Environmental Necessity or Pandora’s Box?”, Brian Launder and J. Michael T. Thompson (Eds.), 2010, 332 pp., Cambridge Univ. Press, ISBN 978-0-521-19803-5. Bull. Amer. Meteorol. Soc., 92, 1503-1504.

Mitchell, D. L., S. Mishra and R. P. Lawson, 2011: **Cirrus clouds and climate engineering: New findings on ice nucleation and theoretical basis**. In: Planet Earth 2011 - Global Warming Challenges and Opportunities for Policy and Practice, Prof. Elias Carayannis (Ed.), ISBN 978-953-307-733-8, InTech, Available from

Conference papers, proceedings, and presentations

Mitchell, D.L., S. Mishra and R.P. Lawson, 2011: Modification of cirrus clouds to reduce global warming: New findings. American Geophysical Union, Fall Meeting, San Francisco, California, 5-9 December 2011.

Mitchell, D., 2011: Invited talk: Engineering of Cirrus Clouds to Reduce Global Warming. International Union of Geophysics and Geodesy (IUGG), Union session on climate engineering, 27 June - 8 July 2011, Melbourne, AU.

Publications

2015

Erfani, E., Mitchell, D. L. (2015). **Evolution of Snow-sized Spectra by the Growth Processes of vapor Deposition, Aggregation and Riming**, Paper, 95th AMS Annual Meeting: Phoenix, AZ, January 5, 2015

Ivanova, D., Mitchell, D. L. (2015). **WRF and MM5 Modeling of the 1999 North American Monsoon Onset and the Las Vegas Flood**, Paper, 95th AMS Annual Meeting: Phoenix, AZ, January 7, 2015

Mitchell, D. L. (2015). **On the ethics of climate engineering: An overlooked question?**, Joint session on Human Alteration of Climate: Engineering, Ethics, and Politics, 95th AMS Annual Meeting, 20th

Conference on Planned and Inadvertent Weather Modification, and the Seventh Symposium on Aerosol: Phoenix, AZ, January 5, 2015

Mitchell, D. L., Avery, M. A., Garnier, A. (2015). [Inferred Differences in Ice Crystal Nucleation Rates between Continental and Maritime Deep Convective Clouds.](#), Joint session on Human Alteration of Climate: Engineering, Ethics, and Politics, 95th AMS Annual Meeting and Seventh Symposium on Aerosol, Cloud, Climate Interactions: Phoenix, AZ, January 7, 2015

Mitchell, D. L., Garnier, A., Avery, M. (2015). [Evidence of More Frequent Homogeneous Ice Nucleation During Arctic Winter](#), ASR Annual Meeting: Vienna, VA, March 16, 2015

Mitchell, D. L., Garnier, A., Avery, M. (2015). [New Physical Understanding of Satellite Retrieved Effective Absorption Optical Depth Ratios](#), ASR Annual Meeting: Vienna, VA, March 16, 2015

2014

Erfani, E., Mitchell, D. L. (2014). [Mechanisms for the onset and evolution of North American monsoon](#), Proceedings, Climate Prediction S&T Digest, (February 2014), pp. 13-15, 38th NOAA Climate Diagnostics and Prediction Workshop Special Issue, Climate Prediction S & T Digest, NWS Science & Technology Infusion Climate Bulletin Supplement: College Park, MD, October 21, 2013

Erfani, E., Mitchell, D. L. (2014). [A Partial Mechanistic Understanding of the North American Monsoon](#), *J. Geophys. Res.*, 119, 13096, 13115, Accepted

Erfani, E., Mitchell, D. L. (2014). [Improving a Snow Growth Model with Application to Radar Quantitative Precipitation Estimates](#), AMS Conference on Cloud Physics: Boston, MA, July 6, 2014

Mishra, S., Mitchell, D. L., Turner, D. D., Lawson, R. P. (2014). [Parameterization of ice fall speeds in mid-latitude cirrus: Results from SPARTICUS](#), *J. Geophys. Res.*, 119, 3857-3876, doi:10.1002/2013JD020602

Mitchell, D. L. (2014). [Globally mapping regions of homo- and heterogenous nucleation as a function of latitude and season: A potential strategy using CALIPSO](#), ASR Annual Meeting: Potomac, MD, March 10, 2014

Mitchell, D. L. (2014). [An overview of cirrus cloud thinning and determining its scientific feasibility](#), Invited talk. Climate Engineering Conference 2014, Critical Global Discussions: Berlin, Germany, August 18, 2014

Mitchell, D. L. (2014). [Evolution of the North American monsoon: Potential large- and small-scale mechanism](#), Invited talk, Pennsylvania State University, Dept. of Meteorology seminar series: University Park, PA, December 10, 2014

Mitchell, D. L., Avery, M. A., Garnier, A. (2014). [Inferred Differences in Ice Crystal Nucleation Rates between Continental and Maritime Deep Convective Clouds](#), Presentation, 2014 AGU Fall Meeting: San Francisco, CA, December 15, 2014

Mitchell, D. L., Erfani, E. (2014). [Parameterizing Ice Particle Mass and Area in Ice Clouds: Towards a](#)

[Self-consistent Treatment of Ice Microphysics and Radiation](#), Atmospheric Model Working Group, NCAR: Boulder, CO, February 10, 2014

Mitchell, D. L., Erfani, E., Mishra, S. (2014). [Developing and bounding ice particle mass- and area-dimensional expressions for use in atmospheric models and remote sensing](#), ASR Annual Meeting: Potomac, MD, March 10, 2014

2013

Erfani, E., Mitchell, D. L. (2013). [Mechanisms for the onset and evolution of North American monsoon](#), 38th NOAA Climate Diagnostics and Prediction Workshop Special Issue, Climate Prediction S & T Digest, NWS Science & Technology Infusion Climate Bulletin Suppleme: College Park, MD, October 21, 2013

Erfani, E., Mitchell, D. L. (2013). [Air-sea interaction in the Gulf of California and its effect on the North American Monsoon](#), Oral presentation, Atmospheric System Research (ASR) 2013 Fall Meeting: Rockville, MD, November 4, 2013

Erfani, E., Mitchell, D. L., Ivanova, D. (2013). [A Mechanism for the Impact of Gulf of California Sea Surface Temperature on North American Monsoon](#), Poster presentation, Atmospheric System Research (ASR) 2013 Science Team Meeting: Potomac, MD, March 18, 2013

Erfani, E., Mitchell, D. L., Ivanova, D. (2013). [North American Monsoon: Progress Toward a Mechanistic Understanding](#), Poster presentation, 18th Annual CESM Workshop: Breckenridge, CO, June 17, 2013

Erfani, E., Mitchell, D. L., Ivanova, D. (2013). [Mechanisms Governing the Onset, Extent and Strength of the North American Monsoon](#), Poster presentation, 14th Annual WRF Workshop: Boulder, CO, June 24, 2013

Erfani, E., Mitchell, D. L., Ivanova, D. (2013). [Toward a Mechanistic Understanding of the Onset and Extent of the North American Monsoon](#), Poster presentation, Gordon Research Conference and Gordon Research Seminar on Radiation and Climat: New London, NH, July 6, 2013

Erfani, E., Mitchell, D. L., Ivanova, D., Lavin, M. (2013). [Partial validation of the onset mechanism for the North American monsoon](#), Poster presentation, AGU Fall Meeting: San Francisco, CA, December 9, 2013

Mitchell, D. L., Erfani, E., Mishra, S. (2013). [Convergence on ice particle mass- and area-dimensional expressions for ice clouds](#), Poster presentation, AGU Fall Meeting: San Francisco, CA, December 9, 2013

Mitchell, D. L., Lance, S., Lawson, R. P. (2013). [Improving the Ice Optics in CAM5: Treatment of the Asymmetry Parameter](#), Oral presentation, Atmosphere Model Working Group, NCAR: Boulder, CO, February 10, 2013

Mitchell, D. L., Mejia, J. F., Kuebbeler, M., Lohmann, U., Mishra, S., Comstock, J. (2013).

[Constraining the Negative Twomey Effect for Cirrus Clouds](#), Poster presentation, Gordon Research Conference: Radiation and Climate: New London, NH, July 6, 2013

Mitchell, D. L., Mejia, J. F., Kuebbeler, M., Lohmann, U., Xiao, M. (2013). [Seeding of Cirrus Clouds to Reduce Global Warming, Applications of Numerical Models to Weather and Climate Modification](#), 19th Conference on Planned and Inadvertent Weather Modification, 93rd American Meteorological Society Annual Meeting: Austin, TX, January 6, 2013

Mitchell, D. L., Mejia, J. F., Kuebbeler, M., Xiao, M., Rasch, P. (2013). [Cirrus Cloud Climate Engineering](#), Oral presentation at the AMS Annual Meeting: Austin, TX, January 6, 2013

Mitchell, D. L., Mejia, J. F., Lohmann, U., Kuebbeler, M., Mishra, S., Comstock, J., Rasch, P. (2013). [Microphysical and radiative impacts of the cirrus cloud negative Twomey effect in two GCMs based on SPARTICUS data](#), Oral presentation, Atmospheric System Research (ASR) 2013 Fall Working Groups, Washington, D.C., November 4, 2013

Mitchell, D. L., Mishra, S., Comstock, J., Mejia, J. F., Kuebbeler, M., Lohmann, U. (2013). [Relevance of the negative Twomey effect for ice clouds](#), Poster presentation, Gordon Research Conference: Radiation and Climate: New London, NH, July 6, 2013

Zhang, K., Liu, X., Wang, M., Comstock, J. M., Mitchell, D. L., Mishra, S., Mace, G. (2013). [Evaluating and constraining ice cloud parameterization in CAM5 using aircraft measurements from the SPARTICUS campaign](#), *Atmos. Chem. Phys. Discuss.*, 13, 1201-1246

2012

Erfani, E., Mitchell, D. L., Ivanova, D. C., Lavin, M. (2012). [Dependence of the North American monsoon on Pacific Ocean eastern boundary currents](#), Paper presented: AGU 2012 Fall Meeting: San Francisco, CA, December 3, 2012

Liu, X., Easter, C., Ghan, S. J., Zaveri, R., Rasch, P., Shi, X., Lamarque, J. F., Gettelman, A., Morrison, H., Vitt, F., Conley, A., Park, S., Neale, R., Hannay, C., Ekman, A., Hess, P., Mahowald, N., Collins, W., Iacono, M. J., Bretherton, C. S., Flanner, M. G., Mitchell, D. L. (2012). [Toward a minimal representation of aerosols in climate models: Description and evaluation in the Community Atmospheric Model CAM5](#), *Geosci. Model Develop.*, 5, (3), 709-739

Mitchell, D. L., d'Entremont, R. P. (2012). [Satellite retrieval of the liquid water fraction in tropical clouds between -20 and -38 C](#), *Atmos. Meas. Tech.*, 5, (7), 1683-1698

Mitchell, D. L., Mejia, J. F., Xiao, M., Rasch, P. J., Kuebbeler, M. (2012). [Cirrus Cloud Climate Engineering](#), International Conference on Clouds and Precipitation (ICCP): Leipzig, Germany, July 30, 2012-August 3, 2012

DRI Personnel Directory

[Administrative Personnel](#)

[Atmospheric Science Personnel](#)

[Earth & Ecosystem Science Personnel](#)

[Hydrological Science Personnel](#)

[Graduate Students](#)

[Featured Researchers](#)

[Featured GRAD Students](#)

[Personal Page Index](#)

ABOUT DRI

[Mission & Vision](#)

[History](#)

[President's Office](#)

[Administration](#)

[Newsroom](#)

[Our Campuses](#)

[Careers](#)

[DRI Foundation](#)

[Contact DRI](#)

ACADEMICS

[Graduate Programs](#)

[Graduate Association](#)

[Graduate Research](#)

[Courses by DRI faculty](#)

[GreenPower Program](#)

EnergySmart Education

RESEARCH & SERVICES

DRI Research

Programs

Projects

Publications

Labs & Facilities

Libraries

Research Support at DRI

Sponsored Projects Office

Technology Transfer Office

FOR INDUSTRY

Working with DRI

Scientific Services

Innovation at DRI

Labs & Facilities

Become a DRI Vendor

Contact DRI

FOR THE PUBLIC

Newsroom

Media Resources

Connect with DRI

DRI Video Gallery

DRI Photo Gallery

Annual Reports

Public Records

Contact DRI

[Privacy Policy](#) | [Public and Personal Safety](#) | [DRI Research Park](#) | [NSHE](#) | [Tech Transfer Office](#)
| [National Atomic Testing Museum](#)

Desert Research Institute | Nevada's Global Laboratory with campuses in Reno and Las Vegas