

Vita for Owen B. Toon

ADDRESS:

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EDUCATION:

University of California, Berkeley, A.B., Physics 1969
Cornell University, Ph.D., Physics, 1975. Thesis title "Climatic Change on Mars and Earth"

POSITIONS HELD:

Research Assistant, University of California, Berkeley, 1969.
Physicist, Environmental Research Division, Naval Coastal Systems Center, Panama City, Florida, 1969-1970.
Teaching Assistant, Physics Department, Cornell University, 1970-1972.
Research Assistant, Astronomy Department, Cornell University, 1972-1975.
Visiting Scientist, NASA, Ames Research Center, 1973.
National Academy of Sciences Resident Research Associate, NASA, Ames Research Associate, 1975 to 1977.
Research Associate, Cornell University, 1977-1978.
Visiting Scientist, NASA, Ames Research Center, 1977-1978.
Research Scientist, NASA, Ames Research Center, 1978-1989.
Group Leader for Theoretical Atmospheric Sciences, NASA Ames Research Center, 1984 to 1989.
Associate Fellow, NASA, Ames Research Center, 1987-1989.
Senior Scientific and Technical Staff, NASA Ames, 1989-1997.
Professor, Program in Atmospheric and Oceanic Sciences and Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder Aug. 1997-2005
Professor, Environmental Studies Program, University of Colorado, Boulder, 1999-2005.
Director, Program in Atmospheric and Oceanic Science, University of Colorado, Boulder, Oct 2000-Dec 2005.
Chair (founding), Department of Atmospheric and Oceanic Sciences, University of Colorado, Dec 2005-2012.
Professor, Department of Atmospheric and Oceanic Sciences and Research Scientist, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder Aug. 2005-present

FIELD PROJECT MANAGEMENT POSITIONS:

Deputy Project Scientist, NASA, Airborne Antarctic Ozone Expedition, 1986-1988.
DC-8 Flight Scientist, NASA, Airborne Arctic Stratospheric Expedition, 1988-1989.
DC-8 Flight Scientist, NASA, Airborne Arctic Stratospheric Expedition II, 1991-1992.
Co-Project Scientist, NASA, Vortex Ozone Transport Experiment /Tropical Ozone Transport Experiment, 1994-1996.

- Project Scientist, NASA, Subsonic Aircraft Contrail and Cloud Effects Special Study 1994-1998.
- Co-Project Scientist, NASA, SAGE III ozone loss and validation experiment, 1998-2002.
- Co-Project Scientist, NASA Crystal field project to understand the role of deep convection in Earth's climate. 2001-2003.
- Co-Mission Scientist, NASA Tropical composition, clouds and climate coupling experiment, 2006-2007.
- Platform Scientist, NASA, ATTREX field missions to investigate the properties of tropical high-altitude clouds and the transport of water into the stratosphere, 2011-2015
- Campaign Leader, NASA, SEAC4RS field mission to understand the vertical transport of pollutants into the stratosphere and chemistry of the Southeastern U.S., 2011-2014.

HONORS AND AWARDS:

- 1979 NASA Special Achievement Award
- 1981 NASA Group Achievement Award-Shuttle Environmental Effects Team
- 1983 NASA Certificate of Appreciation-For important scientific and managerial contributions to NASA-sponsored studies of the climatic effects of the massive El Chichon volcanic cloud.
- 1983 H. Julian Allen Award - Given for the outstanding scientific or engineering paper of 1983 at Ames Research Center. "Evolution of an Impact Generated Dust Cloud and its Effects on the Atmosphere" O.B. Toon et al.
- 1983 NASA Medal for Exceptional Scientific Achievement - "In recognition of his outstanding contributions to the understanding of the causes of climate variations on the Earth and the relations between atmospheric processes on the Earth and those on other planetary bodies".
- 1984 Co-recipient International Peace Garden Award from University of N. Dakota - For work on Nuclear Winter.
- 1985 37th Annual Arthur Flemming Award from Washington D.C. JCees - "For outstanding individual performance in the Federal Government".
- 1986 NASA Sustained Superior Performance Award
- 1986 Co-recipient Leo Szilard Award for Physics in the Public Interest from the American Physical Society - "For the investigation of the effects on the global atmosphere and climate from smoke and dust resulting from a nuclear war".
- 1987 Distinguished Lectureship - Phi Beta Kappa Society of University of Louisville.
- 1987 Associate Fellow at NASA Ames Research Center - "For sustained innovative and creative contributions to research".
- 1988 H Julien Allen Award-Given for the outstanding scientific or engineering paper of 1988 at Ames Research Center. "Condensation of HNO₃ and HCl in the Winter Polar Stratospheres". O.B. Toon et al.
- 1988 Elected Fellow of the California Academy of Sciences.
- 1989 NASA Medal for Exceptional Scientific Achievement-"in recognition of exceptional scientific achievement in identifying the condensation of acid vapors as critical in the chemistry responsible for the formation of the Antarctic Ozone Hole and in recognition of outstanding scientific leadership in the international missions to investigate the depletion of polar ozone".

- 1989 Group Achievement Award to Airborne Antarctic Ozone Experiment Team
- 1991 Elected Fellow of the American Meteorological Society.
- 1991 Group Achievement Award to Airborne Arctic Ozone Expedition Team
- 1991 Editor's Citation for Excellence in Refereeing, Geophysical Research Letters.
- 1992 Elected Fellow of the American Geophysical Union "for important discoveries about the atmospheres of Earth and other planets, including the role of stratospheric clouds in polar ozone depletion, the effects of volcanic and nuclear-war clouds on climate, and the extinction of the dinosaurs by meteor-generated dust clouds".
- 1995 Doctorate of Science Honoris Causa-University of Southern Utah
- 2001 NASA Group Achievement Award for SAGE-3 Ozone Loss and Validation Experiment Science Team
- 2002 Highly Cited Researchers Award, ISI Thomson Scientific for being "one of the most highly cited, influential researchers in Geosciences."
- 2003 NASA Group Achievement Award, for "outstanding accomplishments and contributions to the extremely successful Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment".
- 2005 NASA Group Achievement Award "in recognition of your significant contribution to the design, development and launch of the Aura satellite, which is producing astounding data for the atmospheric science community".
- 2006 NASA Group Achievement Award to TOMS Team "In recognition of creating 25-year long TOMS data sets of unprecedented accuracy, significantly advancing the study of global ozone and aerosols.
- 2006 NASA and Dept. of the Interior William T. Pecora Award to The Total Ozone Mapping Spectrometer (TOMS) Team "for developing innovative techniques for providing unique atmospheric ozone, sulfur dioxide, and aerosol data for more than 25 years".
- 2007 Recognized by UNEP as contributor to the IPCC Nobel Peace Prize (shared with possibly thousands of people and Al Gore)
- 2008 Jule Charney Lecturer -Spring AGU meeting- Another Inconvenient Truth—Even a Small Nuclear War Could Be Much Worse Than You Think
- 2008 NASA Group Achievement Award "For outstanding achievements in atmospheric science during the Tropical Composition, Cloud and Climate Coupling (TC4) Mission in Costa Rica and Panama in 2007".
- 2009 Robert L. Stearns Award from the University of Colorado Alumni Association for exceptional service to society.
- 2011 W.M. Keck Institute for Space Studies Distinguished Visiting Scholar
- 2011 Roger Revelle Medal-American Geophysical Union "for outstanding contributions in atmospheric sciences, atmosphere-ocean coupling, atmosphere-land coupling, biogeochemical cycles, climate, or related aspects of the Earth system"
- 2012 Peter Hobbs Memorial Lecturer, University of Washington, February 2012.
- 2013 University of Colorado, 2013 Distinguished Research Lecturer
- 2014 American Meteorological Society Carl-Gustaf Rossby Research Medal "For fundamental contributions toward understanding the role of clouds and aerosols in the climates of Earth and other planets."
- 2015 NASA Group Achievement Award "For outstanding accomplishments, Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional

- Surveys (SEAC4RS) in 2013”
- 2016 NASA Group Achievement Award to Airborne Tropical Tropopause Experiment
“For outstanding achievements for advancing the understanding of the physical processes of the tropical tropopause layer and its role in the Earth’s climate.”
- 2016 Distinguished Lecturer, International Lecture Course in Atmospheric Aerosols, Beijing, China.
- 2020 University of Colorado Graduate School, Outstanding Faculty Mentor Award, Honorable Mention.

MEMBERSHIP ON COMMITTEES AND EDITORIAL ACTIVITIES:

- Science Advisory Committee for NASA's climate research plan- drafted NASA's long-range climate research plan (1977).
- Proposal Peer Review Panel Member for NASA's weather and climate program (1978).
- Science Steering Group for NASA's program of aircraft measurements of the Earth's atmosphere (1977-1980).
- Proposal Peer Review Panel Member for NASA's Mars Data Analysis Program (1983).
- NASA Management Operations Working Group for Planetary Atmospheres (1980-1983).
- National Academy of Sciences Committee on the Atmospheric Effects of Nuclear Explosions (1983).
- Committee on Evolution of Complex and Higher Organisms - NASA (1983)
- Panel on Polar Stratospheric Clouds, NASA (1983).
- AGU Guest Editor of Geophys Res. Lett. special issue on the El Chichon Volcanic Eruption (with J. Pollack), 1983
- Presidential Science Advisor's Committee on National Program to study nuclear winter (1984).
- Chairman, Atmospheric Sciences Peer Review Panel for the Mars Orbiter Mission, (1985).
- Defense Nuclear Agency Advisory Committee on Field Program for the Global Effects Program (1985 to 1989).
- Executive Committee for NASA's ozone-hole projects (1986 to 1992).
- Aerosol subpanel of NASA's ozone trends review panel (1987).
- Earth Observing System Interdisciplinary Proposal Review Panel member (1988).
- AGU Guest Editor of J. Geophys. Res. special issue on the Airborne Antarctic Ozone Experiment (with B. Watson, and A. Tuck), 1989.
- NASA Upper Atmosphere Research Program Field Experiments Steering Committee (1990).
- DOE Atmospheric Radiation Experiment Science Advisory Group (1990).
- NASA High Speed Research Program Stratospheric Field Measurements Advisory Group (1991).
- NASA High Speed Research Program Models and Measurements Committee (1991).
- DOE Committee on the Use of Aircraft in the ARM program (1990-1992).
- AGU 1992 Chapman Conference on Volcanoes and Climate Steering Committee (1991-1992).
- NASA Venus Atmospheric Probe Discovery Mission- workshop participant (1991-1992).
- AGU 1992-1995. Atmospheric Sciences Section Committee on Honors and Awards, member.

DOE 1992 Atmospheric Radiation Measurements Program Interim Science Team for Unmanned Aerospace Vehicles, member.
 AGU- Guest Editor of Geophysical Research Letters for Airborne Arctic Stratospheric Expedition II (with J. Anderson).
 Co-chairperson 1993 Gordon conference on volcanoes and climate (with L. Walter).
 Organizer, 1994 Workshop on Effects of Subsonic Aircraft on Clouds and Climate, NASA Ames.
 Environmental Research Aircraft and Sensor Technology Leadership Team member, NASA, 1994-present.
 Co-Chairperson, 1994 Fall AGU meeting session Earth and Planetary Sciences Unified: In memory of James B. Pollack, 1994.
 NASA FIRE peer review panel member, Jan.1995.
 NASA Committee to draft a Science Policy Guide for NASA, 1995.
 Vice President Gore's Space Science Symposium Member, 1996.
 Associate Editor, Journal of Geophysical Research (Atmospheric Chemistry) 1996-2001.
 Associate Editor, Journal of Geophysical Research (Planets) 1997-9.
 Guest Editor, Geophysical Research Letters, Special Issues on SUCCESS, 1998.
 Lead Author, 1998 Intergovernmental Panel on Climate Change Special Report on Aviation and the Global Atmosphere.
 Member, NASA's Astrobiology Roadmap Committee, 1998.
 Member, DOE's Atmospheric Sciences Program Reconfiguration Panel, 2003
 Member, DOE's Committee of Visitors review panel, 2004
 Member, NOAA ESRL committee of visitors to review Chemical Sciences Division, 2007
 Chair, Visiting committee Georgia Tech School of Geosciences, 2009.
 Presentation to NRC committee on Geoengineering, June 2009.
 Presentation to NRC committee on NASA's suborbital program, Aug. 2009.
 Member, Government Accountability Office Review panel for Geoengineering report, Oct. 2010
 Member, Pontifical Academy of Sciences Working Group on the Fate of Mountain Glaciers in the Anthropocene, April 2011.
 Associate Editor for Special Issue for SEACRS J. Geophys. Res. Atmos. 2014-2016.
 Member, NASA panel to plan response to large volcanic eruptions, June 2016.

MEMBERSHIP IN PROFESSIONAL SOCIETIES:

American Meteorological Society (Fellow, 1991)
 American Geophysical Union (Fellow 1992)
 Division of Planetary Sciences of American Astronomical Society, Affiliate.
 Planetary Society
 American Association for the Advancement of Science

STUDENTS SUPERVISED¹ :

MASTERS:

¹ Supervision varies from providing numerical models for thesis research to supervision of thesis work

- Gail Fondahl - U.C. Berkeley, Dept. of Geography (1984) "The demise of the Norse Greenland colonies". (O. Granger, Committee Chair).
- Tim Haddix - San Jose State University, Dept. of Meteorology. Thesis on mesoscale simulations of cirrus clouds (1996).
- Annette Walker - San Jose State University, Dept. of Meteorology. Thesis on developing parameterizations of cirrus cloud radiative properties for use in large scale models (1996).
- Chris Kuhn- University of Colorado, Atmospheric and Oceanic Sciences Department.
- Ana Lia Quijano- University of Colorado, Atmospheric and Oceanic Sciences Department.
- Vidal Salazar-University of Colorado, Atmospheric and Oceanic Sciences Department.
- Olga Kalashnikova- University of Colorado, Atmospheric and Oceanic Sciences Department, Now at JPL.
- Matt Trebella- University of Colorado, Atmospheric and Oceanic Sciences Department
- Kari Klein- University of Colorado, Atmospheric and Oceanic Sciences Department.
- Elinor Newman- University of Colorado, Astronomy and Planetary Sciences Department.
- Holly Marcus (2014), University of Colorado, Department of Atmospheric and Oceanic Sciences. Now at Niwot High School
- Alexander Lanzano (2019) University of Colorado, Department of Atmospheric and Oceanic Sciences.

DOCTORATE:

- Douglas Westphal - Pennsylvania State University, Department of Meteorology (1986) - "A numerical investigation of the dynamics of Saharan dust storms" - (Toby Carlson, Committee Chair).
- Eric Jensen - University of Colorado, Department of Astrophysical, Planetary and Atmospheric Sciences (1989) - "A numerical model of polar mesospheric cloud formation and evolution"- (Gary Thomas, Committee Chair).
- James Murphy - University of Washington, Department of Atmospheric Science (1991) - "A dimensional hierarchy of numerical simulations of Martian global dust storms"- (Conway Leovy, Committee Chair).
- Jingxia Zhao - UCLA, Atmospheric Sciences Dept. (1993) - "Numerical studies of the stratospheric aerosol layer under background and perturbed conditions" - (Richard Turco, Committee Chair).
- Andrew Ackerman- University of Washington, Department of Atmospheric Science (1994) - "A numerical study of the effects of variations in aerosol concentrations on stratiform clouds in the marine boundary layer" - (Peter Hobbs, Committee Chair).
- William Hutzell - Georgia Tech, School of Earth and Atmospheric Sciences (1994) - "Variations in the Geometric Albedo of Titan"- (William Chameides, Committee Chair), now at EPA.
- Mark Jacobson - UCLA, Atmospheric Sciences Dept. (1994) - "Developing, coupling, and applying a gas, aerosol, transport, and radiation model to study urban and regional air pollution - (Richard Turco, Committee Chair), now Professor Stanford University.

- Kelly Snook - Stanford University, Department of Aerospace Engineering - The optical constants of Martian dust. (1997).
- Anthony Colaprete- University of Colorado, Astronomy and Planetary Sciences Department (2000). Climate change on Mars-now at NASA Ames Research Center
- Peter Colarco-University of Colorado, (2002) Program in Atmospheric and Oceanic Sciences Terrestrial dust storms, Now at Goddard Space Flight Center.
- Jennifer Heldmann (2003)-University of Colorado, Geology Department, Water on Mars- Now at NASA Ames Research Center
- Erika Barth- University of Colorado, Astronomy and Planetary Sciences Department (2004) Clouds on Titan, now at SWRI.
- Teresa Segura- (2005)University of Colorado, Program in Atmospheric and Oceanic Sciences. Climate changes due to impacts on Mars. Now Vice president of Business Development and Strategy, ACCION Systems.
- Tian Feng (2005)- University of Colorado, Astronomy and Planetary Sciences Department. Escape from planetary Atmospheres. now a professor at Tsinghua University in China.
- Brandy Gamblin (2005)-University of Colorado, Chemistry Department. Nitric Acid Condensation on Ice Clouds, now at Air Sciences, Golden Co.
- Kevin McGouldrick-(2007) University of Colorado, Astronomy and Planetary Sciences Department. Now at University of Colorado
- Rebecca Matichuk (2007) University of Colorado, Program in Atmospheric and Oceanic Sciences, Now at EPA.
- Kaj Williams (2008)- University of Colorado, Department of Atmospheric and Oceanic Sciences, now USGS Flagstaff.
- Charles Bardeen (2008), University of Colorado, Department of Atmospheric and Oceanic Sciences, Now at NCAR.
- Attila Elteto (2010)- University of Colorado, Astronomy and Planetary Sciences Department, now at Canada college.
- Lansing Madry (2010)- University of Colorado, Department of Atmospheric and Oceanic Sciences, Now at NCAR
- Jason English (2011) University of Colorado, Department of Atmospheric and Oceanic Sciences, now at NOAA ESRL.
- Ryan Neely (2012) University of Colorado, Department of Atmospheric and Oceanic Sciences. Now at Leeds University in Britain.
- Tianyi Fan(2012) University of Colorado, Department of Atmospheric and Oceanic Sciences, now a professor at Beijing Normal University.
- Lin Su (2012) University of Colorado, Department of Atmospheric and Oceanic Sciences, Now at NCAR.
- Richard Urata, (2012) University of Colorado, Astronomy and Planetary Sciences Department, Now at NASA Ames.
- Eric Wolf, (2014) University of Colorado, Department of Atmospheric and Oceanic Sciences, now at U. Colorado..
- Erik Larson (2014), University of Colorado, Department of Atmospheric and Oceanic Sciences, now at NOAA ESRL
- Pengfei Yu (2015), University of Colorado, Department of Atmospheric and Oceanic Sciences, Now at NOAA ESRL.

Yunqian Zhu (2015), University of Colorado, Department of Atmospheric and Oceanic Sciences, Now at University of Colorado.

Megan Bela (2016), University of Colorado, Department of Atmospheric and Oceanic Sciences. Now at NOAA ESRL.

Victoria Hartwick (2019), University of Colorado, Department of Atmospheric and Oceanic Sciences, Thesis “Clouds, dust and climate on Mars”, now at NASA Ames Research Center.

Chris Maloney (2019), University of Colorado, Department of Atmospheric and Oceanic Sciences, Thesis “Improved ice cloud representation in the Community Aerosol and Radiation Model for Atmospheres (CARMA) cirrus cloud model in CESM1. Now at NOAA ESRL.

Lu Wang, University of Colorado, Department of Atmospheric and Oceanic Sciences.

Margot Clyne, University of Colorado, Department of Atmospheric and Oceanic Sciences.

Parker Case, University of Colorado, Department of Atmospheric and Oceanic Sciences.

POST DOCTORAL:

Douglas Westphal- from Penn. State University-studied Saharan dust storms 1986-1988, now at Naval Research Laboratory, Monterey.

Bernhard Lindner- from Colorado State University-studied Martian ice clouds.

Joseph Pinto- from New York University-studied volcanic clouds 1988, now at EPA.

Stefan Kinne-from University of Utah-studied radiative transfer in ice clouds 1987-1990, now at University of Hamburg.

Diane Michaelangeli- from California Institute of Technology - studied microphysics of Martian ice clouds 1990-1991, deceased.

Eric Jensen- from University of Colorado- studied microphysics of cirrus clouds 1990-1993, now at NASA Ames Research Center.

Andy Ackerman- from University of Washington- studying microphysics of marine stratus, now at NASA GISS Research Center.

Azadeh Tabazadeh- from UCLA- studying microphysics of polar stratospheric clouds, 1994-1997. Recipient of NASA Presidential Young Investigator Award, 1999, AGU McElwayne Award, AMS Houghton Award. Now retired

Irina Sokolik- from Russian Academy of Sciences -studying radiative transfer in the Earth's atmosphere, 1995-1997. Now Professor Georgia Tech.

Michael Mills-from University of Colorado-studying volcanic clouds in the Earth's atmosphere, 1997-2010, now at NCAR.

Mark Bullock-from University of Colorado-studying the clouds of Venus, 1998-1999. Now at SWRI inc. Boulder Co.

Jamison Smith-University of Colorado-studying cumulus on Earth. 2000-2008. Assistant Professor Humbolt State University.

Alex Pavlov-Pennsylvania State-studying atmosphere of early Earth. Now at Goddard Space Flight Center. 2002-2005.

Melissa Trainer, University of Colorado -studying methane on Mars. 2005—2008, Now at Goddard Space Flight Center.

Feng Tian- University of Colorado,-Titan and early Earth 2010-2011, now a professor at Tsinghua University in China.

Jamison Smith-University of Colorado, studying carbon aerosols, 2010-2013.

Eric Wolf-University of Colorado-Astrobiology-2014-present

Jason English-University of Colorado-Volcanic clouds and Geoengineering-2014-2015,
Now at NOAA Earth System Research Lab.

Yunqian Zhu-University of Colorado, PSCs and volcanic clouds, 2015-present

Jamison Smith-University of Colorado, studying clouds, 2019-present.

STUDENT AWARDS:

Peter Colarco-Outstanding Student Paper in Atmospheric Science-Fall 1998 AGU meeting-Modeling dust emission and transport from the Western Sahara"

Peter Colarco-NASA Graduate Student Researcher Program-1998-2001.

Olga Kalashnikova-Best student paper-CEDAR_99 (Coupling Energetics and Dynamics of Atmospheric Regions) Fourteenth Summer NSF Workshop, June 13-18, Boulder, CO.

Kari Klein- NASA Graduate Student Researcher Program-2000-2001.

Brandy Gamblin- NASA Graduate Student Researcher Program-2001-2002.

Jennifer Heldmann- NASA Graduate Student Researcher Program-2002-2004.

Teresa Segura-- NASA Graduate Student Researcher Program-2003-2005.

Kaj Williams- NASA Graduate Student Researcher Program-2004-2007.

Attila Elteto NASA Graduate Student Researcher Program-2004-2007.

Rebecca Matichuk-NASA Graduate Student Researcher Program-2005-2008.

Chuck Bardeen- NASA Graduate Student Researcher Program-2005-2008.

Adrienne Dove- NASA Graduate Student Researcher Program-2008-2011.

Richard Urata- NASA Graduate Student Researcher Program-2008-2011.

Lin Su- NASA Graduate Student Researcher Program-2010-2011.

Erik Wolf- NASA Graduate Student Researcher Program-2010-2013.

Ryan Neely-NOAA Fellowship -2010-2015.

Jason English- NASA Graduate Student Researcher Program-2009-2012.

Eric Wolf- Outstanding Student Paper in Planetary Science Award, Fall 2010 AGU meeting.

Ryan Neely- Outstanding Student Paper in Atmospheric Science Award, Fall 2010 AGU meeting.

Ryan Neely- 2010 OAR Outstanding Scientific Paper Award, for: David J. Hofmann, John E. Barnes, Michael O'Neill, Michael Trudeau and Ryan Neely, On the Increase in background stratospheric aerosol observed with lidar at Mauna Loa Observatory and Boulder, Colorado, Geophys. Res. Lett., 36, doi: 10.1029/2009GL039008, 2009.

Victoria Hartwick-NSF graduate Fellowship, 2014-2017

Parker Case-NASA Earth System Science Fellowship, 2019-2022.

BIBLIOGRAPHY:

Peer reviewed papers

1. "Optical Properties of some Terrestrial Rocks and Glasses" (J. B. Pollack, O.B. Toon, and B.N. Khare), *Icarus*, 19, 372 (1973).
2. "Physical Properties of the Stratospheric Aerosols" (O.B. Toon, J.B. Pollack), *J. Geophys. Res.*, 78, 7051 (1973).
3. "Atmospheric Pressure Variation and the Climate of Mars" (P.J. Gierasch, O.B. Toon), *J. Atmos. Sci.*, 30, 1502 (1973).
4. "Climatic Change on Mars" (C. Sagan, O.B. Toon, and P.J. Gierasch), *Science*, 181, 1045-1049 (1973).
5. "Solar Luminosity Variations and the Climate of Mars" (O.B. Toon, C. Sagan, P.J. Gierasch), in *Possible Relationships Between Solar Activity and Meteorological Phenomena*, ed. W. Bandeen and S. Maran, NASA SP-366, pp. 179, (1975).
6. "Volcanic Explosions and Climatic Change: A Theoretical Assessment" (J.B. Pollack, O.B. Toon, C. Sagan, A. Summers, B. Baldwin, W. Van Camp), *J. Geophys. Res.*, 81, 1071 (1976).
7. "A Global Average Model of Atmospheric Aerosols for Radiative Transfer Calculations" (O.B. Toon, J.B. Pollack), *J. Appl. Meteor.*, 15, 225 (1976).
8. "Estimates of the Climatic Impact of Aerosols Produced by Space Shuttles, SST's and Other High-Flying Aircraft" (J.B. Pollack, O.B. Toon, A. Summers, W. Van Camp, and B. Baldwin), *J. Appl. Meteor.*, 15, 247 (1976).
9. "Stratospheric Aerosols and Climatic Change" (J.B. Pollack, O.B. Toon, C. Sagan, B. Baldwin, A. Summers, W. Van Camp), *Nature*, 236, 551 (1976).
10. "The Optical Constants of Several Atmospheric Aerosol Species: Ammonium Sulfate, Aluminum Oxide and Sodium Chloride," (O.B. Toon, J.B. Pollack, B.N. Khare), *J. Geophys. Res.* 81, 5733 (1976).
11. "Physical Properties of the Particles Composing the Martian Dust Storm of 1971-2" (O.B. Toon, J.B. Pollack, C. Sagan), *Icarus*, 30, 663 (1977).
12. "Physical Mechanisms Affecting the Stratospheric Aerosol Particles" (P. Hamill, O.B. Toon, C.S. Kiang), *J. Atmos. Sci.*, 34, 1104 (1977).
13. "Past Obliquity Oscillations of Mars: The Role of the Tharsis Uplift" (W. Ward, J. Burns, O.B. Toon), *J. Geophys. Res.*, 84, 243 (1979).
14. "A One-Dimensional Model Describing Aerosol Formation and Evolution in the Stratosphere. I. Physical Processes and Numerical Analogs" (R. Turco, P. Hamill, O.B. Toon, R. Whitten, C. S. Kiang), *J. Atmos. Sci.*, 36, 699 (1979).
15. "A One-Dimensional Model Describing Aerosol Formation and Evolution in the Stratosphere. II. Sensitivity Studies and Comparison with Observations" (O.B. Toon, R. Turco, P. Hamill, R. Whitten, and C. S. Kiang), *J. Atmos.*, 36, 718 (1979).
16. "Lidar Return from Stratospheric Aerosols as Calculated from a One-Dimensional Aerosol Model" (P. Hamill, T.J. Swissler, R. P. Turco, O.B. Toon), *Nature*, 278, 149 (1979).
17. "Anthropogenic Albedo Changes and the Earth's Climate." (C. Sagan, O.B. Toon, J.B. Pollack), *Science*, 206, 1363 (1979).
18. "Solar Spectral Variations: A Drive for Climatic Change?" (J.B. Pollack, W.J. Borucki, O.B. Toon) *Nature*, 282, 600 (1979).

19. "Stratospheric Aerosol Modification by Supersonic Transport and Space Shuttle Operations with Climate Implications" (R. Turco, O.B. Toon, J.B. Pollack, R.C. Whitten, I.G. Poppoff, P. Hamill), *J. Appl. Meteor*, 19, 78 (1980).
20. "OCS, Stratospheric Aerosols and Climate" (R. Turco, R.C. Whitten, O.B. Toon, J.B. Pollack, P. Hamill), *Nature*, 283, 283 (1980).
21. "Carbonyl Sulfide, Stratospheric Aerosols and Terrestrial Climate" (R.P. Turco, R.C. Whitten, O.B. Toon, J.B. Pollack and P. Hamill), in *Environmental and Climatic Impact of Coal Utilization*, A. Deepak and J. Singh, Eds., Academic Press, pp. 331-356 (1980).
22. "The Stratospheric Sulfate Aerosol Layer: Processes, Models, Observations, and Simulations" (R. Whitten, O.B. Toon, R.P. Turco), *Pure and Appl. Geophys.*, 118, 86 (1980).
23. "Smoke and Dust Particles of Meteoric Origin in the Mesosphere and Stratosphere" (D. Hunten, R. Turco, O.B. Toon), *J. Atmos. Sci.*, 37, 1342 (1980).
24. "Atmospheric Aerosols and Climate" (O.B. Toon, J.B. Pollack), *Amer. Scientist*, 68, 268 (1980).
25. "Greenhouse Models of Venus' High Surface Temperature, as Constrained by Pioneer Venus Measurements" (J.B. Pollack, O.B. Toon, R. Boese), *J. Geophys. Res.*, 85, 8233 (1980).
26. "Distribution and Source of the U.V. Absorption in Venus' Atmosphere" (J.B. Pollack, O.B. Toon, et al.), *J. Geophys. Res.*, 85, 8141 (1980).
27. "The Astronomical Theory of Climate Change on Mars" (O.B. Toon, J.B. Pollack, W. Ward, J. Burns, K. Bilski), *Icarus*, 44, 552 (1980).
28. "A Physical Model of Titan's Clouds" (O.B. Toon, R.P. Turco, J.B. Pollack), *Icarus*, 43, 260 (1980).
29. "On the Possible Relationship Between Secular Brightness Changes on Titan and Solar Variability" (J.B. Pollack, K. Rages, O.B. Toon, Y.L. Yung), *Geophys. Res. Lett.*, 7, 829 (1980).
30. "A Brief Review of the Evidence for Solar Variability on the Planets" (O.B. Toon, J.B. Pollack, K. Rages), *The Ancient Sun* ed. Pepin R., Eddy, J. and Merrill, R.P. Pergammon Press, p. 523 (1980).
31. "The Influence of Solar U.V. Variations on Climate" (W. Borucki, J. Pollack, O.B. Toon, H.T. Woodward, and D.R. Wiedman), *The Ancient Sun*, ed. Pepin, R. Eddy J. and Merrill, R.P. Pergammon Press, 513 (1980).
32. "Effect of Meteoric Debris on Stratospheric Aerosols and Gases" (R.P. Turco, O.B. Toon, P. Hamill, R.C. Whitten), *J. Geophys. Res.*, 86, 1113 (1981).
33. "Large Ozone Perturbations Caused by the 1908 Tunguska Meteor Fall: Were There Related Weather Effects?" (R.P. Turco, O.B. Toon, C. Park, R.C. Whitten, and P. Noerdlinger), *Proc. Quadrennial Int. Ozone Symposium*, S. Rutenberg, Ed. Vol II, pp 1067-1073 (1981).
34. "Reduced Stratospheric OH Concentrations Suggested by Sulfur Gas and Particle Measurements, and Revised Ozone Perturbations Due to Man's Activities" (R.P. Turco, O.B. Toon, E.C.Y. Inn and P. Hamill), *Proc. Quadrennial Int. Ozone Symposium*, S. Rutenberg, Ed. Vol II, pp . 968-975 (1981).

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AREAS of ACTIVE RESEARCH:

I have taught courses in two departments. I developed “Planetary Atmospheres”, which is a core graduate level course in the Astrophysical and Planetary Sciences Department, and is also an elective course in the Department of Atmospheric and Oceanic Sciences (ATOC). I also developed “Physics and Chemistry of Clouds and Aerosols”, which is a core graduate level course in ATOC, and has recently become an undergraduate class as well. I have also taught “Reading the IPCC report” a course I developed to understand the IPCC reports, as well as “Numerical Methods in Cloud Modeling”.

My 2021 research group consists of 3 graduate students at the University of Colorado and three postdoctoral workers. Presently research is active in the following areas.

Aerosols and Clouds above the Tropopause: This work has two facets - investigations of stratospheric aerosols and studies of polar stratospheric and mesospheric clouds. We have constructed a numerical model of stratospheric volcanic aerosols over the past two decades. The model was initially one-dimensional, approximating Earth as a vertical column of air. As computational tools have improved we expanded, and now have developed a fully three-dimensional global model by combining our microphysical model with the NCAR WACCM/CESM climate models so that detailed predictions can be made. These calculations aid in the analysis of remote sensing information, as well as being useful to studies of stratospheric ozone loss and to studies of climate change. Research Associate Yunqian Zhu, who graduated in 2015, built a model for polar stratospheric clouds, to improve our ability to simulate stratospheric ozone. Charles Bardeen now at NCAR coupled our aerosol code, CARMA, with the NCAR Community Earth System Model and has used the code to simulate noctilucent clouds, micrometeorites, and cirrus clouds. Peter Colarco, now at Goddard has linked CARMA to the GEOS-5 model and uses it for volcanic clouds. Presently, Parker Case is working with the Goddard version of the model, and Margot Clyne is collaborating with Yunqian Zhu on the NCAR version of the code to study volcanic clouds. Professor Toon is also working on stratospheric aerosols generated by nuclear conflicts. As one of the discoverers of Nuclear Winter in the 1980s, he continues to investigate the dangers of nuclear weapons.

Tropospheric Clouds, Aerosols and Radiative Transfer: Numerical simulations of the interactions between tropospheric aerosols and clouds are being conducted. One goal is to determine if the indirect effects of aerosols on clouds is a significant feature of Earth's climate system. Another goal is to simulate the life cycle of tropospheric aerosols and clouds in detail. The eventual goal is to be able to model tropospheric aerosols, marine boundary layer clouds and cirrus clouds including three-dimensional dynamics, atmospheric chemistry, and detailed microphysics. Pengfei Yu, who graduated in 2015, constructed a complete model for aerosols in the troposphere and stratosphere. He has applied the model to understand the origins of the Asian Tropopause Aerosol Layer, smoke in the RIM fire, and organic aerosols. This code is currently being placed into NCAR's CESM2 model to provide an alternative to the modal aerosol model. Student Lu Wang, and Researcher Jamison Smith are working to improve the aerosol/cloud interaction in the NCAR CESM model by adding a CARMA based liquid cloud model to provide an alternative to the current cloud model in CESM.

Experimental Investigations of Stratospheric and Tropospheric Phenomena: For many years I have been involved in using NASA aircraft to address various issues in stratospheric and tropospheric science. In the past, these studies have dealt with volcanic clouds, stratospheric ozone loss, stratospheric transport processes, searching for evidence of heterogeneous chemistry in the troposphere, as well as investigating the formation and radiative properties of cirrus clouds and the sensitivity of cirrus clouds to emissions from aircraft. I was the Deputy Project Scientist for the Airborne Antarctic Expedition in 1986, which resolved the causes of the ozone hole, and showed that polar stratospheric clouds are composed of nitric acid as I proposed. My group is still investigating the physics and chemistry of polar stratospheric clouds. I helped lead numerous other ozone related missions. I was the Co-project scientist for CRYSTAL/FACE in 2002. This project was aimed at understanding the role of deep convection in forming high altitude cirrus, and their role in influencing the energy budget of Earth. Six research aircraft made numerous flights from Key West, Fla. I was the Co-Mission Scientist for NASA's Tropical Composition, Clouds and Climate Coupling Experiment which took place in Costa Rica in July and Aug. 2007 to help validate Aura and the A-Train satellites, and to learn more about tropical clouds and stratosphere-troposphere exchange. I was Co-Project Scientist for the ATTREX field missions using the NASA Global Hawk to investigate water vapor in the upper troposphere and how it enters the stratosphere. I was the Campaign Leader for SEAC⁴RS, a mission to investigate how air pollution over Southeast U.S. may be lofted by deep convective clouds and then enter the stratosphere. This mission used the NASA DC-8, ER-2 and a SPEC Inc. Learjet for 2 months in 2013. Currently I am working with NASA and NSF on a WB57 and NCAR GV mission to investigate outflow from the Asian Monsoon.

Theoretical Investigations of Planetary Atmospheres and Exobiology: The focus of this work is to understand the clouds and climates of the terrestrial planets. Over time, my students and I have simulated clouds and aerosols on nearly every solar system object, and on exoplanets. We have developed a climate model for Mars based on the NCAR terrestrial climate models. Most recently, former student Victoria Hartwick showed high altitude clouds on Mars form on micrometeorites, and also for the first time created a model in which episodic dust storms occur as they do on Mars. Eric Wolf, a LASP research associate, is running a climate model for ancient Earth to better understand the faint young sun problem, and for various exo-planets. We have explored the ancient climates of Earth, and showed that the faint young sun problem could be resolved within current geologic constraints, and we explored the ultimate fate of Earth as the solar luminosity increases. With former graduate student Richard Urata we showed that the early climate of Mars, with rivers and rain, could be explained by a cloudy greenhouse. This theory remains under debate.