

Curriculum Vitae

Jeffrey R. Key

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PROFESSIONAL POSITIONS

Supervisory Physical Scientist and Branch Chief, Advanced Satellite Products Branch, National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS), Madison, WI, 2003-present. Perform satellite meteorology and climatology research focusing on the polar regions. Manage a seven-member NOAA team involved in the algorithm development, the specification of future satellite systems, calibration, and the use of satellite products in weather prediction systems. Support 5-7 university scientists and manage multiple projects with funding over \$1M/year. Oversee funding to the Cooperative Institute for Meteorological Satellite Studies (CIMSS) on the order of \$12M/year.

Acting Division Chief, Cooperative Research Program (CoRP) division, Center for Satellite Applications and Research (STAR), NOAA/NESDIS, Madison, WI, 02/2018-present. Supervise STAR federal employees in three branches stationed at cooperative institutes (CI) in Madison, WI, Fort Collins, CO, and College Park, MD; oversee processing of more than 130 grants per year. Work with the NOAA Research Council Cooperative Institute Committee on CI matters.

Adjunct Professor, Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, 2007-present. Adjunct Associate Professor, 1999-2006.

Past Positions

Physical Scientist, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Madison, WI, 1999-2002. Perform satellite meteorology research with applications in numerical weather prediction. **Acting Team Leader**, Advanced Satellite Products Team, 4/2001-12/2002.

Associate Professor (tenured), Department of Geography, Boston University, 1995-1999. Taught courses in meteorology, climatology, and remote sensing; conducted research in climatology and satellite remote sensing. **Director of Graduate Studies**, 1996-1998.

Research Associate, Cooperative Institute for Research in Environmental Sciences (CIRES), 1989-1995, University of Colorado, Boulder. Performed climatology research, with an emphasis on remote sensing of the polar radiation budget. Supervised and supported 2-4 research assistants and graduate students/yr. **Assistant Professor Attendant Rank**, Department of Geography, 1994-1995; **Fellow**, Program in Atmospheric and Oceanic Sciences (PAOS), 1994-1995; **Lecturer**, Astrophysical, Planetary and Atmospheric Sciences Department, 1990-1995 (taught courses in meteorology).

Instructor, Department of Mathematical Sciences, University of Alaska, Anchorage, 1984-1987. Taught courses in applied statistics and computer science.

Other

Research Assistant (1983-1984, 1987-1988), CIRES, University of Colorado; **Graduate Part-time Instructor**; **Teaching Assistant** (1982-1984), Dept. of Geography, University of Colorado; (1981-1982), Dept of Geography, Northern Michigan University.

EDUCATION

- Ph.D., University of Colorado, Boulder, Dept. of Geography (Climatology), 1988.
Thesis: "Cloud analysis in the Arctic from combined AVHRR and SMMR data"
- M.A., Northern Michigan University, Marquette, Dept. of Geography (Resource Analysis), 1982.
Thesis: "SHORELINE: a model for the prediction of shoreline changes"
- B.S., Northern Michigan University, Marquette, Dept. of Geography (Environmental Conservation), 1979. Summa Cum Laude. Academic scholarships all years. National Dean's List.
- Other: Wayne State University, Detroit, MI, Dept. of Music (performance major, classical guitar, 1971-1975). Academic scholarships all years.

AWARDS

- NASA Agency Honor Awards, Group Achievement Award for "For excellence resulting in the successful GOES-R satellite launch, providing the nation's foundation for the world's highest quality weather monitoring and forecasting", 2017 (with 500+ others).
- U.S. Department of Commerce Bronze Medal "For the timely creation and leadership of the team to increase the scientific value of the Suomi satellite environmental data products to meet NOAA users' needs", 2014 (with 12 others).
- NASA Group Achievement Award to Suomi NPP Mission Development Team "For extraordinary dedication, skill, teamwork, and perseverance in developing and delivering the Suomi NPP Mission for the Nation", 2012.
- NOAA Administrator's Award for scientific leadership and excellence in support of domestic and international polar observing activities during the International Polar Year (with Pablo Clemente-Colón), 2009.
- U.S. Department of Commerce Bronze Medal, 2008, for "innovative uses of operational weather satellites to understand climate change and to quantify trends in the global climate system" (with A. Heidinger, R. Ferraro, T. Smith, M. Eakin, and K. Gallo).
- U.S. Department of Commerce Silver Medal for Scientific and Engineering Achievement, 2005 - improving global weather forecasts through better utilization of satellite observations over the polar regions (with J. Daniels).
- Other (minor) recognition: DOC Gold Medal Organizational Award (not individual) to NESDIS for the success of the NOAA-20 and GOES-17 missions, 2018; JPSS Program Office Certificate of Recognition for contributing to key milestones, 2013; JPSS Program Office Certificate of Recognition for contributing to the successful launch and commissioning of S-NPP, 2012; NOAA/NESDIS Certificate of Achievement for property management, 2013; NOAA cash award for outstanding leadership in planning the first Global Cryosphere Watch (GCW) Implementation Meeting at WMO headquarters in Geneva, 2012; NOAA cash award for a successful GOES-R Algorithm Working Group Cryosphere Team critical design review, 2009; NOAA cash award for leading the Integrated Global Observing Strategy (IGOS) Cryosphere Theme, 2007.

PROFESSIONAL ACTIVITIES

Advisory Groups and Committees

Current

- World Meteorological Organization (WMO) Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services (EC-PHORS), U.S. representative (one of three), 2009-present.
- WMO Global Cryosphere Watch (GCW), co-lead on implementation, 2008-2011; Science Advisor,

2014-2016; representative to EC-PHORS, 2008-present; lead/co-lead on multiple teams, 2008-present. (<http://globalcryospherewatch.org>)
WMO Polar Space Task Group (formerly the International Polar Year STG), 2007-present; Vice Chair, 2011-present.
NOAA: NOAA Research Council's Cooperative Institute Committee (2018-present); Arctic Core Team/Arctic Task Force (2010-present); Tiksi Atmospheric Observatory Science Team (2008-present); GOES-R AWG Cryosphere Algorithm Team lead (2006-present); JPSS Cryosphere Algorithm Team lead (2010-present); GCOM-W1 Cryosphere Algorithm Team lead (2011-present).
University of Wisconsin: Cooperative Institute for Meteorological Satellite Studies (U. Wisconsin) Board of Directors, 2001-present.

Past

NOAA: NOAA-Canada Polar Communications and Weather mission Coordination Group (2010~2013); International Affairs Council Polar Committee (2006~2014); GIMPAP Technical Advisory Committee (2008~2013).
Polar Communications and Weather (PCW) Mission User and Science Team, 2009~2013.
Inter-Commission Coordination Group for WMO Integrated Global Observing System (ICG-WIGOS) Task Team on WIGOS Regulatory Material, 2012-2013.
WCRP Observations and Assimilation Panel (WOAP; CliC representative), 2004-2011.
Associate Editor (radiation), *Journal of the Atmospheric Sciences*, 2004~2011.
Space Science and Engineering Center (U. Wisconsin) Science Council, 2001-2013.
Arctic Council's Snow, Water, Ice, and Permafrost of the Arctic (SWIPA) Integration Team, 2009-2011.
Chair, Observation Products Panel, WCRP Climate and Cryosphere (CliC) project, 2004-2011.
Chair, Integrated Global Observing Strategy (IGOS) Cryosphere Theme, 2004-2009.
Polar DAAC Advisory Group (PoDAG), 2001-2008.
NOAA: NOAA SEARCH science team; GOES-R Technical Advisory Committee (2007-2008).
Member, MODIS Science Team (NASA EOS), (2004-2007; Adjunct Member 1992-2003).
Advisory committee for MODIS Snow and Ice products, 1996-2004.
AMS Committee on Polar Meteorology & Oceanography, 1998-2001.
DOE ARM North Slope of Alaska CART Site Advisory Panel, 1994-1998.
NASA EOS Cyrospheric Working Group, 1997-1999.
RADARSAT Geophysical Processing System Science Working Group, 1994-1996.
ATSR (ERS-1 Along Track Scanning Radiometer) Validation Team, 1992-1994.

Invited Speaker

JPSS Short Course, Seattle, January 2017 | EUMETSAT, July 2016 | WIGOS Vision 2040, Geneva, November 2015 | 2nd International Satellite Snow Products Intercomparison Workshop, Boulder, Colorado, September 2015 | Foreign Press Centers, (DC), May 2015 | NOAA Science Days, March 2015 | The Climate Symposium 2014, Darmstadt, Germany, October 2014 | IPY2012: From Knowledge to Action, Montreal, Quebec, April 2012 | EUMETSAT Meteorological Conference, Oslo, Norway, September 2011 | Second Workshop on Satellite Imaging of the Arctic, Montreal, September 2009 | First Workshop on Satellite Imaging of the Arctic, University of Copenhagen, August 2008 | NOAA/NESDIS Cooperative Research Program Symposium on Satellite Climatology, University of Maryland, June 2007 | EUMETSAT Meteorological Satellite Conference, Helsinki, Finland, June 2006 | First Asia CliC Symposium, Yokohama, Japan, April 2006 | National Satellite Meteorology Center, Beijing, July 2004 | Workshop on Numerical Weather Prediction in the Polar Regions, Fairbanks, Alaska, October 2003 | AMS Polar Meteorology and Oceanography Conference, Hyannis, Massachusetts, May 2003 | Goddard Institute for Space Studies, March 2002 | National Ice Center, May 2000 | SHEBA annual meeting, April 2000 | IGARSS'99 session on sea ice, June 1999 | Goddard Institute for Space Studies, September 1996 | RADARSAT Geophysical Processing System Science Group meeting, Seattle, April 1994 and Boulder, September 1994 | Goddard Institute for

Space Studies, February 1991 | National Center for Atmospheric Research, Advanced Studies Program, March 1989.

Invited Participant

Global Climate Observing System (GCOS) Terrestrial Observation Panel for Climate (TOPC) meeting, Boulder, Colorado, 2016 | WCRP Climate and Cryosphere (CliC) Science Steering Group meeting, Boulder, Colorado, 2015 | Tiksi Science Meeting, Saint Petersburg, 2012 | NOAA Sea Ice Forecasting Workshop, Anchorage, 2011 | Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) Executive Panel meeting, Darmstadt, 2010 | International Polar Year workshop on Sustaining Arctic Observing Networks (SAON), Edmonton, June 2008 | International Polar Year workshop on Sustaining Arctic Observing Networks (SAON), Stockholm, 2007 | International Polar Year workshop on Sustaining Arctic Observing Networks (SAON), 2007 | GEWEX Cloud Climatology Workshop, Madison, Wisconsin, 2006 | GEWEX Cloud Climatology Workshop, Madison, Wisconsin, 2005 | Sino-U.S. Joint Arctic Climate Workshop, Beijing, 2004 | Arctic climate change workshop, Lamont Doherty Earth Observatory, NY, 2004 | ARCSS Arctic Synthesis workshop, Big Sky, Montana, 2003 | ACSYS/CliC meeting, Beijing, China, October 2002 | ARCMIP meeting, Norrkoping, Sweden, 2002 | ISCCP Workshop, New York (GISS), 1996 | MODIS Snow and Ice Products Workshop, Greenbelt, MD (GSFC), 1995 | NASA Workshop on Polar Data Sets, Seattle, 1993 | NSF ARCSS Workshop on Arctic Surface Energy Balance (SHEBA), Orlando, February 1993 | NSF Arctic System Science (ARCSS OAI) Modeling Workshop, Monterey, 1992 | NASA Workshop on Sea Ice Thickness, Greenbelt, MD, 1991 | WMO Workshop on Polar Radiation Fluxes and Sea Ice Modeling, Bremerhaven, Germany (Alfred Wegner Institute), 1990.

Current Memberships

American Meteorological Society (AMS)
American Geophysical Union (AGU)
International Association of Cryospheric Sciences (IACS)

Other

Co-organized major WMO Global Cryosphere Watch meetings in Arusha, Tanzania (2017), Salekhard, Russia (2016), Santiago, Chile (2014), Beijing (2014), Geneva (2010).
Co-organized the US-Canada Group on Earth Observations (GEO) workshop, Arlington, VA, October 2008.
Co-organized IGOS Cryosphere Theme Workshops in Kananaskis, Alberta (2005), Noordwijk, The Netherlands (2006), Yokohama, Japan (2006).
Co-organized the NOAA Cooperative Research Program Annual Science Symposium on Calibration and Validation, Madison, WI, July 2005.
Conference program committees: AMS January 1999, AAG Spring 1998.
Reviewer for many major scientific journals; NASA, NSF, NOAA, and DOE proposals.

RESEARCH

Interests

Polar climatology; cloud radiative effects; satellite remote sensing of the atmosphere, snow and ice; surface energy budget.

Grants

Summary: PI, Co-PI, or Co-I on 69 grants totaling over \$31M since 1990.

(In the listing below, UWisc is University of Wisconsin-Madison, BU is Boston University, CU is University of Colorado-Boulder, UWash is University of Washington, UMD is University of Maryland-College Park, GMAO is the NASA Global Modeling and Assimilation Office)

Current

1. Development and Impact of Global Winds from Tandem S-NPP and NOAA-20 VIIRS, JPSS Proving Ground and Risk Reduction, \$250K, PI, NOAA/NESDIS with UWisc, 2018-2019.
2. Ice Motion from VIIRS, AMSR2, and SAR –Development and Operational Applications, JPSS Proving Ground and Risk Reduction, ~\$400K, Co-I, NOAA/NESDIS with UWisc, 2018-2020.
3. Polar Winds from Metop-C, NOAA Office of Projects, Planning, and Analysis (PSDI), PI, \$40K, NOAA/NESDIS with UWisc, 2018.
4. Enterprise Snow Algorithm Evaluation, NOAA Office of Projects, Planning, and Analysis (PSDI), PI, \$75K, NOAA/NESDIS with UWisc, 2018.
5. NOAT Top-5 Ice Product Checkout, NOAA Office of Projects, Planning, and Analysis (PSDI), PI, \$50K, NOAA/NESDIS with UWisc, 2018.
6. Diagnosis and Analysis of Arctic Sea-ice Leads, NASA ROSES-2017, Co-I (PI: S. Ackerman), \$440K, 2018-2020.
7. JPSS VIIRS Derived Winds Validation and Science, JPSS Program Office, PI, \$260K, NOAA/NESDIS with UWisc, 2016-2018.
8. Snow and Ice Products from GOES-R ABI, GOES-R Program Office, PI, \$3.32M, NOAA/NESDIS and UWisc (with NWS/NOHRSC, UMD, and CUNY), 2007-2017.
9. Science and Management Support for NPP VIIRS Snow and Ice EDRs, JPSS Program Office, PI, \$3.387M, NOAA/NESDIS (with UWisc, CU, and CUNY/CREST), 2011-2018.
10. Implementation of GCOM-W1 AMSR2 Cryosphere Products, JPSS Program Office, PI, \$1.26M, NOAA/NESDIS (with UWisc, CU, and UMD/CICS), 2012-2018.
11. Transition of Polar AVHRR Fundamental and Thematic Climate Data Records to NCDC, NOAA/NCEI, PI/Co-I, \$241.5K, NESDIS and UWisc, 2013-2018.

Past

12. Updates for JPSS-1 VIIRS Derived Motion Winds, NOAA Office of Projects, Planning, and Analysis (PSDI), PI, \$100K, NOAA/NESDIS with UWisc, 2016-2017.
13. An Algorithm to Determine the Spatial and Temporal Distributions of Sea-ice Leads in the Arctic, NASA, Co-I (PI: S. Ackerman), \$330K, 2014-2017.
14. Development of S-NPP Cryosphere EDRs to Extend the EOS Data Record for Earth System Science, NASA, Co-I (PI: D. Hall), \$699K, 2014-2017.
15. Transition of MODIS and AVHRR Winds to GOES-R/VIIRS Algorithm, NOAA Office of Systems Development, PI, \$214K, NOAA/NESDIS and UWisc, 2014-2016.
16. Assimilation and forecast impact of high temporal resolution Leo/Geo AMVs in the high-latitude data-gap corridor, GOES-R Risk Reduction Program, Co-I (PI: B. Hoover); \$211K, UWisc and NOAA/NESDIS, 2014-2016.
17. Implementing the GOES-R Future Capability Ice Products into the GOES-R Processing System, GOES-R Program Office, PI, \$342K, NOAA/NESDIS and UWisc, 2015-2016.
18. Collaborative Research: Impact of Storm Activity on Recent Changes in Arctic Sea Ice Mass Balance, NSF, Co-PI (PI: X. Zhang, U. Alaska-Fairbanks; UWisc PI: X. Wang), \$306K (UWisc), 2010-2015.
19. Cryosphere Products from Himawari-8 for the High-Latitude Proving Ground, GOES-R Program

- Office, PI, \$30K, NOAA/NESDIS and UWisc, 2014-2015.
20. JPSS Risk Reduction: Uniform Multi-Sensor Algorithms for Consistent Products, NOAA Office of Systems Development, Co-PI (PI: W. Wolf), \$346K, NESDIS and UWisc, 2012-2014.
 21. Development, Generation, and Demonstration of New JPSS Ice Products in Support of a National Ice Center JPSS Proving Ground and Risk Reduction Activity, JPSS Program Office, Co-I (PI: Y. Liu, UWisc), \$152K, NESDIS and UWisc, 2013-2014.
 22. VIIRS Polar Winds, NOAA Office of Systems Development, PI, \$366K, NOAA/NESDIS and UWisc, 2009-2014.
 23. Sea Ice Thickness from Aqua and Terra Data: Generation, Evaluation and Application, NASA, Co-I (PI: J. Maslanik, CU), \$754K, NESDIS and UWisc, 2011-2013.
 24. A Blended Polar Winds Product using Atmospheric Motion Vectors from MODIS Imager and AIRS Moisture Retrieval Data, NASA, Co-I (PI: D. Santek, UWisc), \$229K, 2011-2012.
 25. Combined Geo/Leo High Latitude Atmospheric Motion Vectors, NOAA, Co-I (PI: M. Lazzara, UWisc), \$140K, UWisc, 2009-2011.
 26. A Product Development Team for Snow and Ice Climate Data Records, NOAA (NCDC), PI, \$957K, NOAA/NESDIS and UWisc (\$325K), UColorado, 2009-2012.
 27. Sea Ice Thickness from Aqua and Terra Data: Generation, Evaluation and Application, NASA, Co-I (PI: J. Maslanik, CU), \$754K, NESDIS and UWisc (\$292K), 2011-2013.
 28. NPP Science Team Participation in Support of Cryosphere Products, NASA, Co-I (PI: M. Tschudi, CU), \$355K, NESDIS and UWisc (\$140K), 2011-2013.
 29. Generation and Initial Evaluation of a 27-Year Satellite-Derived Wind Data Set for the Polar Regions, NASA, Co-I (PI: D. Santek), \$210K, UWisc, 2009-2011.
 30. NPP/NPOESS Cryospheric Products Calibration and Validation Activities, NPOESS Integrated Program Office, PI, \$500K, NOAA/NESDIS and UWisc (with UColorado), 2008-2009.
 31. Cloud-drift and Water Vapor Winds in the Polar Regions from Polar-orbiting Imagers, NOAA Office of Systems Development, PI (NOAA; PI at CIMSS: C. Velden), \$1.17M, NOAA/NESDIS and UWisc, 2001-2009.
 32. Improving ice thickness and age estimate with GOES-R ABI, NOAA GOES-R Program Office, Co-I, \$80K, UWisc, 2008-2009.
 33. Assessment of Satellite-derived Cloud Motion Vectors height assignments utilizing active remote sensing measurements from CALIPSO, Joint Center for Satellite Data Assimilation (NOAA), Co-I, \$50K, UWisc, 2007-2008.
 34. Satellite Products for the International Polar Year, NESDIS, PI, \$120K, NOAA/NESDIS and UWisc, 2008.
 35. Generating and Validating NPOESS Products at Direct Broadcast Sites in the Arctic and Antarctic, Integrated Program Office, PI, \$403K, NOAA/NESDIS and UWisc, 2004-2008.
 36. A Land Surface Model Hind-Cast for the Terrestrial Arctic Drainage System, NSF, Co-PI (PI: M. Serreze, CU, Co-PIs: M. Clark, CU, A. Slater, CU, D. Lettenmaier, UWash), \$199K, UWisc, 2003-2007.
 37. Polar Winds from Satellite Imagers and Sounders, NASA, PI, \$979K, NOAA/NESDIS, UWisc, Rutgers Univ., NASA GMAO, 2004-2007.
 38. Development and Application of a 20-Year Satellite-Derived Wind Data Set for the Polar Regions, NOAA/NESDIS/ORA, PI, \$60K, NOAA/NESDIS, UWisc, 2003 and 2006.
 39. Retrospective Analysis of Arctic Clouds and Radiation from Surface and Satellite Measurements, NOAA Arctic Research Office, PI, \$176K, NOAA/NESDIS and UWisc, 2003-2006.
 40. Interactions Among Observations of Laterally Advected Heat and Moisture, Cloud Properties,

- Surface Temperature, Surface Radiation Fluxes, and Net Precipitation in the Arctic, NSF, Co-PI (PI: J. Francis, Rutgers Univ.; Co-PI: S. Ackerman), \$170K, UWisc, 2003-2006.
41. Polar winds data assimilation experiments, NOAA/NASA Joint Center for Satellite Data Assimilation, PI (Co-PI: C. Velden), \$172K, NOAA/NESDIS, UWisc, and NASA Data Assimilation Office, 2003-2005.
 42. VIIRS Snow and Ice Product Risk Reduction, Integrated Program Office, PI (Co-PI: P. Romanov, CIRIA), \$130K, NOAA/NESDIS and UWisc, 2003-2004.
 43. VIIRS Risk Reduction Activities, Integrated Program Office, Co-PI (NOAA; NOAA PI: W.P. Menzel, Co-PI: A. Heidinger; CIMSS PI: S. Ackerman), \$477K, NOAA/NESDIS and UWisc, 2001-2002.
 44. Interactions of Laterally Advected Heat and Moisture with Arctic Cloud Properties, NOAA, Co-PI (PI: J. Francis, Rutgers Univ.; Co-PI: S. Ackerman), \$77K, UWisc, 2001-2003.
 45. Cloud-Drift Winds in the Polar Regions from MODIS, NOAA/GIMPAP, Co-I and Program Manager (PI: C. Velden), \$40K, UWisc/NOAA, 2000-2001.
 46. Development and Summary of Arctic Basin-Scale to Local-Scale Gridded Products in Support of Modeling Investigations During the SHEBA Period, NSF, Co-I (PI: J. Maslanik, CU, Co-Is: C. Fowler, A. Lynch, T. Arbetter), \$430K, CU, 2000-2003.
 47. Antarctic Cloud Properties and Their Effect on the Surface Energy Budget, NSF, PI, \$225K, BU, UWisc, 1999-2001.
 48. NPOESS Algorithm Development, AER and ITT, Co-PI (PI: C. Schaaf, Co-PIs: A. Strahler, C. Woodcock, M. Friedl), \$609K, BU, 1998-2000.
 49. Center for Excellence in Remote Sensing at Boston University, NASA, Co-I (PI: C. Woodcock, Co-Is: El-Baz, Cleveland, Friedl, Gopal, Kaufmann, Dye, Myneni, Salvucci, Strahler), \$444K, BU, 1998-1999.
 50. AVHRR-Based Polar Pathfinder Products - Evaluation, Enhancement, and Transition to MODIS, NASA, Co-I, (PI: C. Fowler; Co-PI: J. Maslanik), \$293K, CU, 1998-2000.
 51. Documenting, Understanding, and Predicting the Aggregate Surface Radiation Fluxes for SHEBA, NASA and NSF. PI at BU (PI: J. Curry, Co-PIs: F. Evans, J. Maslanik, K. Steffen), \$800K, CU, BU, 1997-2000.
 52. Polar Exchange at the Sea Surface (Poles), NASA EOS Interdisciplinary Program, PI at BU (PI at UWash: D. Rothrock), \$1.7M, UWash, BU, 1991-2000.
 53. Polar-wide Geophysical Products Derived from AVHRR Data, NASA, PI at BU (PI at CU: J. Maslanik, Co-PIs: T. Scambos, C. Fowler), \$700K, CU, BU, 1995-1998.
 54. Sea Ice and Atmospheric Characteristics of the SHEBA Field Area, NSF, PI at BU (PI at CU: M. Serreze, Co-PI: J. Maslanik), \$89K, CU, BU, 1995-1996.
 55. Analysis of Existing Aircraft Datasets of Arctic Clouds, Radiation, and Surface Characteristics: Applications to SHEBA Planning, NSF, Co-PI (PI: J. Curry, CoPIs: G. Liu, J. Tilley, J. Maslanik), \$340K, CU, 1995-1997.
 56. Arctic System Science Data Coordination Center at NSIDC, NSF, Co-PI (PI: C. Hanson, Co-PIs: R. Barry, R. Armstrong), \$490K, CU, 1995-1998.
 57. The Arctic Radiation Balance, NSF, PI (Co-PIs: M. Serreze, R. Stone, R. Barry, K. Steffen), \$350K, CU, BU, 1994-1997.
 58. RADNET: A Neural Network-based Estimation of the Surface Radiation Budget in the Arctic from TOVS and AVHRR Data, NASA, Co-PI (PI: A. Schweiger), \$90K, CU, BU, 1994-1995.
 59. Evolution of Sea Ice Characteristics, Cloud Properties and Radiation Fluxes During the Autumnal Freezing of the Beaufort Sea Coastal Waters, NSF, Co-PI (PI: J. Curry, Co-PI: G. Liu), \$342K, CU,

1994-1995.

60. Ice Surface Temperature Retrieval from AVHRR, ATSR, and Passive Microwave Satellite Data: Algorithm Development and Application, NASA, PI (Co-PIs: J. Maslanik, K. Steffen), \$237K, CU, BU, 1993-1996.
61. Assessment of Climate Variability of the Greenland Ice Sheet: Integration of In Situ and Satellite Data, NASA, Co-PI (PI: K. Steffen), \$479K, CU, 1993-1996.
62. Modeled and Observed Sea Ice Variability in the Arctic: Sensitivity to Atmospheric Conditions and the Surface Energy Budget, NASA, Co-PI (PI: J. Maslanik), \$151K, CU, 1991-1993.
63. Characterization of Sea Ice and Clouds in the Arctic, NASDA (National Space Development Agency of Japan), Co-I (PI: J. Maslanik), data request only (no \$), CU, 1992-1993.
64. Lead Detection and Mapping with Reference to Relationships Between Scale, Sensor Characteristics, Surface Conditions, and Atmospheric Properties, ONR, PI (Co-PI: J. Maslanik), \$182K, CU, 1990-1993.
65. Sea Ice-Atmosphere Interaction: Application of Multispectral Satellite Data in Polar Surface Energy Flux Estimates, NASA, Co-PI (PI: K. Steffen, Co-PIs: J. Maslanik, R. Barry), \$358K, CU, 1990-1993.
66. Artificial Intelligence Applications for Sea Ice Classification and Processes NASA, Co-PI (PI: J. Maslanik), \$254K, CU, 1990-1993.
67. Observations in Support of Remote Sensing and Modeling of Arctic Sea Ice and Atmospheric Conditions, NSF, Co-PI (PI: M. Serreze, Co-PI: J. Maslanik), \$94K, CU, 1991-1992.
68. Development and Trend Analyses of an Arctic TOVS Temperature Sounding Record, NOAA, Co-I, PI last 6 months (PI: S. Khalsa, Co-PIs: J. Kahl, R. Schnell, M. Serreze), \$273K, CU, 1991-1993.
69. Parameterization and Scaling of Arctic Ice Conditions in the Context of Ice-Atmosphere Processes, NASA, Co-PI (PI: R. Barry, Co-PIs: K. Steffen, J. Maslanik), \$290K, CU, 1991-1994.

TEACHING

Summary: Taught 15 different courses (total of 33 sections) in remote sensing, meteorology, statistics, geography, and computer science at four universities. Evaluation average, all universities, all courses: 87% (with 75%= "average").

Courses Taught

Boston University (1995-99)

Natural Environments: The Atmosphere (GG 101)

Physical Climatology (GG 504)

Remote Sensing of the Lower Atmosphere (GG 646/446)

Directed Studies: Problems in Climatology (GG 925)

University of Colorado, Boulder (1982-84, 1990-95)

Environmental Systems 1: Climate and Vegetation (GEOG 100)

Environmental Systems 2: Soils and Landforms (GEOG 101)

Atmospheric Science I: Severe Storms (APAS 115)

Dynamic Earth III (meteorology) (GEOG/APAS 319)

Remote Sensing (labs) (GEOG 409/509)

Nominated for Teaching Excellence Award, 1983.

University of Alaska, Anchorage (1984-87)

Elementary Statistics (AS 300)

Probability and Statistics (AS 307)

Intermediate Statistics (AS 308)
Fortran Programming (CS 105)
Software and Hardware Concepts (CS 201)
Programming Language Structures (CS 331)
Artificial Intelligence (CS 405)
Directed Studies: Scientific Sampling (AS 402)

Northern Michigan University (1980-82)

Physical Geography, GC 100
Map Interpretation (labs), GC 225
Cartography (labs), GC 230

Advising

Supported and/or supervised 2-4 graduate students annually, 1990-2008. **Theses supervised** (research or academic advisor, 1st or 2nd Reader; other committee participation is not listed):

- Letterly, Aaron D., 2015, The Influence of Winter Cloud on Summer Sea Ice in the Arctic, 1982-2013, M.S. thesis, University of Wisconsin-Madison (Research advisor).
- Nelson, Kyle, 2014, The Role of Optically Thin Liquid Clouds in the 2012 Greenland Ice Sheet Surface Melt Event, M.S. thesis, University of Wisconsin-Madison (Research advisor).
- Santek, David, 2007, The Global Impact of Satellite-Derived Polar Winds on Model Forecasts, *Ph.D. thesis*, University of Wisconsin-Madison (Research advisor).
- Dworak, Richard, 2007, Historical AVHRR Satellite-Derived Winds Archive (1982-2002), Validation and Comparison to the ERA-40, *M.S. thesis*, University of Wisconsin-Madison (Research advisor).
- Liu, Yinghui, 2006, Possible Causes of Recent Changes in the Arctic Cloud Cover, Surface Temperature, and Temperature Inversions, *Ph.D. thesis*, University of Wisconsin-Madison (Research advisor).
- Wang, Xuanji, 2003, Arctic Climate Characteristics and Recent Trends from Space, *Ph.D. thesis*, University of Wisconsin-Madison (Research advisor).
- Pavolonis, Michael J., 2002, Antarctic cloud radiative forcing at the surface estimated from the ISCCP D1 and AVHRR Polar Pathfinder data sets, 1985-1993. *M.S. thesis*, University of Wisconsin-Madison (Research advisor).
- Wong, Adeline, 2000, Estimating the Cloudy Sky Surface Temperature of Sea Ice from Space, *M.A. thesis*, Boston University (1st Reader).
- Chan, Alan C.K., 1998, A Global Climatology of 500 mb Cyclones, *Independent Work for Distinction (BA)*, Boston University (Advisor).
- Fan, Shaohua, 1998, EIFOV as a Function of View Geometry for MODIS, *M.A. paper*, Boston University (2nd Reader).
- Klein, Rachael, 1997, The Whole Thing Could Be Chaos, *Boston University Academy undergraduate thesis* (1st Reader).
- Box, Jason E., 1997, Polar Day Effective Cloud Opacity in the Arctic from Measured and Modeled Solar Radiation Fluxes, *M.A. thesis*, University of Colorado (2nd Reader).
- Silcox, Robert A., 1994, Downwelling Radiation Fluxes at the Arctic Surface Based on Parameterizations, *M.A. thesis*, University of Colorado (Research advisor, 2nd Reader).
- Schweiger, Axel J., 1992, Arctic Radiative Fluxes Modeled from the ISCCP-C2 Data Set, 1983-1986, *Ph.D. dissertation*, University of Colorado (Research advisor, 2nd Reader).

Additional thesis committee participation (3rd, 4th, or 5th Reader):

Cuzzone, Joshua, 2010, The Relationship between Arctic Sea Ice and Cloud-related Variables in ERA Interim Reanalysis and Climate Model Data, *M.S. thesis*, University of Wisconsin-Madison (3rd Reader).

Lazzara, Matthew A., 2008, A Diagnostic Study of Antarctic Fog, *Ph.D. thesis*, University of Wisconsin-Madison (Ad hoc committee member).

Ali, Ali Hamid A., 1997, Statistical Analysis of Meteorological Events in the Arabian Peninsula and the Gulf Region, *Ph.D. dissertation*, Boston University (5th Reader).

Stroeve, Julienne C., 1996, Radiation Climatology of the Greenland Ice Sheet, *Ph.D. dissertation*, University of Colorado (3rd Reader).

Haefliger, Marcel P.S., 1995, Radiation Balance Over the Greenland Ice Sheet Derived by NOAA AVHRR Satellite Data and In Situ Observations, *Ph.D. dissertation*, Swiss Federal Institute of Technology, Zurich (3rd Reader).

FIELD WORK

Atmospheric and Cryospheric Sciences

GLAWEX, Green Bay, Wisconsin, February 2017

Measurements of ice thickness, snow properties, and surface meteorology on Green Bay for the validation of satellite products. Part of the Great Lakes Winter Experiment (GLAWEX). The Coast Guard icebreaker Mobile Bay also participated.

McMurdo, Antarctica, October-November 2004

Developed and implemented a system to produce real-time MODIS polar winds from direct broadcast data at McMurdo. Worked with Space and Naval Systems Center (SPAWAR) forecasters regarding the use of satellite data in an operational forecasting environment. Serviced automatic weather stations.

SHEBA, July 1998

Measurements of radiation and cloud microphysical properties on-board the NCAR C-130 aircraft for process studies and remote sensing validation. Done in conjunction with the Surface Heat Budget of the Arctic Ocean (SHEBA) surface campaign, Beaufort Sea.

Greenland, May-June 1995

Part of a multi-year study of the surface energy balance of the Greenland Ice Sheet, at the equilibrium snow line. Measurements of surface radiation fluxes, atmospheric temperature and humidity, aerosols, and clouds for process studies.

BASE, September-October 1994

Measurements of radiation and cloud microphysical properties on-board the NCAR C-130 aircraft. Done in conjunction with the Canadian Beaufort and Arctic Seas Experiment (BASE), Beaufort Sea.

SIMMS'93, May 1993

Aerosol optical depth (sun photometer), cloud base height and atmospheric extinction (laser ceilometer), radiation and energy budget measurements (temperature, reflectance, snow depth, radiative fluxes, etc.) at the sea ice surface; done in conjunction with the Canadian SIMMS (The Seasonal Sea Ice Monitoring and Modeling Site) program; Baffin Strait/Lancaster Sound.

SIMMS'92, May-June 1992

Radiation and energy budget measurements (temperature, reflectance, snow depth, radiative fluxes, etc.) at the sea ice surface primarily for the validation of satellite retrieval algorithms; done in conjunction with the Canadian SIMMS (The Seasonal Sea Ice Monitoring and Modeling Site) program; Baffin Strait/Lancaster Sound/Wellington Channel near Resolute, N.W.T.

LEADEX, April 1992

Sun photometer measurements on-board the NOAA P-3 for studies of tropospheric and stratospheric Arctic aerosols in support of LEADEX (ONR and NOAA-sponsored) and AGASP-IV (Arctic Gas and Aerosol Sampling Program); Beaufort Sea.

Biological Sciences

U.S. Fish and Wildlife Service, 1981, 1982 (summers)

Sea lamprey adult population studies by trapping, tagging, and radio tracking; Lake Superior and Michigan's Upper Peninsula rivers.

U.S. Fish and Wildlife Service, 1979, 1980 (summers)

Stream survey for sea lamprey larvae assessment by electro-shocking methods; Michigan, Wisconsin, and Minnesota rivers.

MAJOR/OPERATIONAL SATELLITE PRODUCTS AND SOFTWARE TOOLS

AVHRR Polar Pathfinder (APP-x) – More than 30-year satellite fundamental climate data record the Arctic and Antarctic. Citation: Key, Jeffrey; Liu, Yinghui; Wang, Xuanji; and NOAA CDR Program (2015). NOAA Climate Data Record (CDR) of AVHRR Polar Pathfinder (APP) Cryosphere, Version 1.0. NOAA National Centers for Environmental Information (NCEI). doi:10.7289/V5BC3WHM.

Extended AVHRR Polar Pathfinder (APP-x) – More than 30-year satellite thematic climate data record for cloud, surface, and radiation properties over the Arctic and Antarctic. Citation: Key, Jeffrey; Wang, Xuanji; Liu, Yinghui; NOAA CDR Program (2014). NOAA Climate Data Record of AVHRR Polar Pathfinder Extended (APP-X), Version 1.0. Revision 1. NOAA National Climatic Data Center. doi:10.7289/V5MK69W6.

Real-time polar winds – Tropospheric winds in the polar regions from MODIS, AVHRR (all NOAA POES satellites plus Metop-A and -B), and VIIRS, tropospheric winds used by 13 operational numerical weather prediction centers in nine countries. Winds are also generated on-site at three direct broadcast stations in the Arctic and two in the Antarctic. With D. Santek, J. Daniels, and H. Qi. (Operational)

GCOM-W1 AMSR2 snow and ice products: snow cover, depth, and snow water equivalent. With Y.-K. Lee, C. Kongoli, and W. Meier. (Operational)

S-NPP VIIRS ice products: ice concentration, temperature, and thickness. With Y. Liu and X. Wang. (Operational).

GOES-R ABI ice and snow products: ice concentration, temperature, motion, and thickness; fractional snow cover. With Y. Liu, X. Wang, and T. Painter. (Operational in 2019).

Historical polar winds from AVHRR – A 30-year satellite climate data record for reanalysis use. With R. Dworak.

Streamer, a radiative transfer model (<http://stratus.ssec.wisc.edu/streamer>), for research and education.

FluxNet, a neural network for surface and top-of-atmosphere radiative fluxes (<http://stratus.ssec.wisc.edu/fluxnet>).

CASPR, the Cloud and Surface Parameter Retrieval system (no longer available).

PUBLICATIONS

Summary: Author/co-author on 120+ journal papers and other peer-reviewed publications, 6 book chapters, 16 technical and data reports (some peer-reviewed), numerous workshop reports, and 83 conference proceedings papers and newsletter articles. h-index: 51, i10-index: 96 (January 2019, Google Scholar). PDFs of the papers below are available at <https://stratus.ssec.wisc.edu/jk-papers/>.

Peer-Reviewed Journal Papers

1. Hoffman, J.P., S.A. Ackerman, Y. Liu, and J. Key, 2019, The detection and characterization of Arctic sea ice leads with satellite imagers, *Remote. Sens.* (submitted, December 2018).
2. Liu, Y., R. Dworak, and J. Key, 2018, Ice Surface Temperature Retrieval from a Single Satellite Imager Band, *Remote Sens.*, 10, 1909, doi:10.3390/rs10121909.
3. Liu, Y., J. Key, S. Vavrus, and C. Woods, 2018, Time evolution of cloud response to moisture intrusions into the Arctic during winter, *J. Climate*, 31(22), 9389-9405, doi: 10.1175/JCLI-D-17-0896.1.
4. Letterly, A., J. Key, and Y. Liu, 2018, Arctic Climate: Changes in Sea Ice Extent Outweigh Changes in Snow Cover, *The Cryosphere*, 12, 3373–3382, <https://doi.org/10.5194/tc-12-3373-2018>.
5. Riihelä, A., T. Manninen, J. Key, Q. Sun, M. Sütterlin, A. Lattanzio, and C. Schaaf, 2018, A multisensor approach to global retrievals of land surface albedo, *Remote Sens.*, 10(6), 848, <https://doi.org/10.3390/rs10060848>.
6. Manninen, T., A. Riihelä, A. Heidinger, C. Schaaf, A. Lattanzio, J. Key, 2018, Intercalibration of polar-orbiting spectral radiometers without simultaneous nadir observations, *IEEE Trans. Geosci. Remote Sens.*, 56(3), 1507-1519, doi: 10.1109/TGRS.2017.2764627.
7. Katlein, C., S. Hendricks, and J. Key, 2017, Brief communication: Increasing shortwave absorption over the Arctic Ocean is not balanced by trends in the Antarctic, *The Cryosphere*, 11, 2111-2116, <https://doi.org/10.5194/tc-11-2111-2017>.
8. Riihelä, A., J. R. Key, J. F. Meirink, P. Kuipers Munneke, T. Palo, and K.-G. Karlsson, 2017, An intercomparison and validation of satellite-based surface radiative energy flux estimates over the Arctic, *J. Geophys. Res. Atmos.*, 122, 4829–4848, doi:10.1002/2016JD026443.
9. Meier, W.N., J.S. Stewart, Y. Liu, J. Key, and J. Miller, 2017, Operational implementation of sea ice concentration estimates from the AMSR2 sensor, *IEEE J. Selected Topics Appl. Earth Obs. Remote Sens.* (J-STARS), 10(9), 3904-3911, doi: 10.1109/JSTARS.2017.2693120.
10. Dorofy, P., R. Nazari, P. Romanov, and J. Key, 2016, Development of a mid-infrared sea and lake ice index (MISI) using the GOES Imager, *Remote Sens.*, 8, 1015, doi:10.3390/rs8121015.
11. Wang, X., J. Key, R. Kwok, and J. Zhang, 2016, Comparison of sea ice thickness from satellites, aircraft, and PIOMAS data, *Remote. Sens.*, 8, 713, doi:10.3390/rs8090713.
12. Liu, Y. and J. Key, 2016, Assessment of Arctic cloud cover anomalies in atmospheric reanalysis products using satellite data, *J. Climate*, 29, 6065-6083, doi: <http://dx.doi.org/10.1175/JCLI-D-15-0861.1>.
13. Liu, Y., J. Key, and R. Mahoney, 2016, Sea and Freshwater Ice Concentration from VIIRS on Suomi NPP and the Future JPSS Satellites, *Remote. Sensing*, 8(6), 523; doi:10.3390/rs8060523.
14. Letterly, A., J. Key, and Y. Liu (2016), The influence of winter cloud on summer sea ice in the Arctic, 1983–2013, *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2015JD024316.
15. Key, J., X. Wang, Y. Liu, R. Dworak, A. Letterly, 2016, The AVHRR Polar Pathfinder Climate Data Records, *Remote Sens.*, 8(3), 167, doi:10.3390/rs8030167.

16. Lee, K.-L., C. Kongoli, and J. Key, 2015, An in-depth evaluation of heritage algorithms for snow cover and snow depth using AMSR-E and AMSR2 measurements, *J. Atmos. Oceanic Tech.*, 32, 2319-2336, doi: 10.1175/JTECH-D-15-0100.1.
17. Liu, Y., J. Key, M. Tschudi, R. Dworak, R. Mahoney, and D. Baldwin, 2015, Validation of the Suomi NPP VIIRS Ice Surface Temperature Environmental Data Record, *Remote Sens.*, 7, 17258–17271, doi:10.3390/rs71215880.
18. Key, J., B. Goodison, W. Schöner, Ø. Godøy, M. Ondráš, and Á. Snorrason, 2015, A Global Cryosphere Watch, *Arctic*, 68 (Suppl. 1), 48-58, doi: <http://dx.doi.org/10.14430/arctic4476>.
19. Meier, W., G. Hovelsrud, B. van Oort, J. Key, K. Kovacs, C. Michel, C. Haas, M. Granskog, S. Gerland, D. Perovich, A. Makshtas, and J. Reist, 2014, Arctic sea ice in transformation: A review of recent observed changes and impacts on biology and human activity, *Rev. Geophys.*, 51, doi: 10.1002/2013RG000431.
20. Overland, J., J. Key, E. Hanna, I. Hanssen-Bauer, B.-M. Kim, S.-J. Kim, J. Walsh, M. Wang, U. Bhatt, Y. Liu, R. Stone, C. Cox, V. Walden, 2014, The Lower Atmosphere: Air Temperature, Clouds and Surface Radiation [in “State of the Climate in 2013”], *Bull. Amer. Meteor. Soc.*, 95(7), S115-S120, doi: <http://dx.doi.org/10.1175/2014BAMSStateoftheClimate.1>.
21. Liu, Y. and J. Key, 2014, Less Winter Cloud Aids Summer 2013 Arctic Sea Ice Return from 2012 Minimum, *Environ. Res. Lett.* 9 044002, doi:10.1088/1748-9326/9/4/044002.
22. Lazzara, M., R. Dworak, D. Santek, B. Hoover, C. Velden, and J. Key, 2013, High-latitude Atmospheric Motion Vectors from Composite Satellite Data, *J. Appl. Meteorol. Climatol.*, 53, 534–547. doi: <http://dx.doi.org/10.1175/JAMC-D-13-0160.1>.
23. Key, J. R., R. Mahoney, Y. Liu, P. Romanov, M. Tschudi, I. Appel, J. Maslanik, D. Baldwin, X. Wang, and P. Meade, 2013, Snow and ice products from Suomi NPP VIIRS, *J. Geophys. Res. Atmos.*, 118, doi:10.1002/2013JD020459.
24. Overland, J., J. Key, B.-M. Kim, S.-J. Kim, Y. Liu, J. Walsh, M. Wang, U. Bhatt, and R. Thoman, 2013, Air temperature, atmospheric circulation, and clouds [in “State of the Climate in 2012”], *Bull. Amer. Meteor. Soc.*, 94(8), S121–S123, doi: <http://dx.doi.org/10.1175/2013BAMSStateoftheClimate.1>.
25. Wang, X., J. Key, Y. Liu, C. Fowler, J. Maslanik, and M. Tschudi, 2012, Arctic climate variability and trends from satellite observations, *Adv. Meteorol.*, v2012, 22 pp, doi:10.1155/2012/505613.
26. Overland, J., U. Bhatt, J. Key, Y. Liu, J. Walsh, and M. Wang, 2012, Air Temperature, Atmospheric Circulation and Clouds, [in “State of the Climate in 2011”], *Bull. Amer. Meteorol. Soc.*, 93, S1-S264, doi: 10.1175/2012BAMSStateoftheClimate.1.
27. Hall, D., J. Comiso, N. DiGirolamo, C. Shuman, J. Key, and L. Koenig, 2012, A Satellite-Derived Climate-Quality Data Record of the Clear-Sky Surface Temperature of the Greenland Ice Sheet, *J. Climate*, 25, 4785-4798, doi:10.1175/JCLI-D-11-00365.1.
28. Liu, Y., J. Key, S. Ackerman, G. Mace, and Q. Zhang, 2012, Arctic cloud macrophysical characteristics from CloudSat and CALIPSO, *Remote Sens. Environ.*, 124, 159-173, doi:10.1016/j.rse.2012.05.006.
29. Liu, Y., J. R. Key, Z. Liu, X. Wang, and S. J. Vavrus, 2012, A cloudier Arctic expected with diminishing sea ice, *Geophys. Res. Lett.*, 39, L05705, doi:10.1029/2012GL051251.
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31. Callaghan, T., M. Johansson, J. Key, T. Prowse, M. Ananicheva, and A. Klepikov, 2011, Feedbacks and interactions: From the Arctic cryosphere to the climate system, *Ambio*, 40, 75-86, doi 10.1007/s13280-011-0215-8.

32. Wang, X., J. Key, and Y. Liu, 2010, A thermodynamic model for estimating sea and lake ice thickness with optical satellite data, *J. Geophys. Res.-Oceans*, 115, C12035, doi:10.1029/2009JC005857.
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36. Dworak, R. and J. Key, 2009, 20 Years of Polar Winds from AVHRR: Validation and Comparison to the ERA-40, *J. Appl. Meteorol. Clim.*, 48(1), 24-40.
37. Frey, R., S. Ackerman, Y. Liu, K. Strabala, H. Zhang, J. Key, and X. Wang, 2008, Cloud Detection with MODIS, Part I: Improvements in the MODIS Cloud Mask for Collection 5, *J. Atmos. Ocean. Tech.*, 25, 1057-1072, DOI: 10.1175/2008JTECHA1052.1.
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42. Liu, Y., J. Key, J. Francis, and X. Wang, 2007, Possible causes of decreasing cloud cover in the Arctic winter, 1982-2000, *Geophys. Res. Letters*, 34, L14705, doi:10.1029/2007GL030042.
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45. Chapin, F.S., M. Sturm, M.C. Serreze, J.P. McFadden, J.R. Key, A.H. Lloyd, A.D. McGuire, T.S. Rupp, A.H. Lynch, J.P. Schimel, J. Beringer, H.E. Epstein, L.D. Hinzman, G. Jia, C.-L. Ping, K. Tape, W.L. Chapman, E. Euskirchen, C.D.C. Thompson, J.M. Welker, and D.A. Walker, 2005, Role of land surface changes in Arctic summer warming, *Science*, vol. 310, doi: 10.1126/science.1117368, October 28.
46. Overpeck, J.T., M. Sturm, J.A. Francis, D.K. Perovich, M.C. Serreze, R. Benner, E.C. Carmack, F.S. Chapin III, S.C. Gerlach, L.C. Hamilton, L.D. Hinzman, M. Holland, H.P. Huntington, J.R. Key, A.H. Lloyd, G.M. MacDonald, J. McFadden, D. Noone, T.D. Prowse, P. Schlosser, and C. Vörösmarty, 2005, Arctic system on trajectory to new, Seasonally ice-free state, *EOS*, 86(34), 309-314.
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- Polar Pathfinder data set. Part II: Recent trends, *J. Climate*, 18(14), 2575-2593.
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