

## Curriculum Vitae

Fred A. Best

Distinguished Research Engineer

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### Work Experience

- 2018-present Distinguished Researcher and Principal Engineer for SSEC. Oversee the technical aspects of engineering efforts at SSEC and provide leadership support to the SSEC Director and Executive Director, including support for developing and executing strategic initiatives. Conduct research to advance technologies and techniques that enable new or enhance existing performance of next-generation of remote sensing instrumentation.
- 2011 Awarded "Distinguished" title by the University of Wisconsin--Madison
- 2010-2017 "Key member" of NASA's CLARREO Climate Benchmark Mission Team. Provided expertise to formulate the IR instrument requirements and conduct instrument design, including detailed design and development of the on-board calibration and verification system. This effort also included specifying the temperature metrology and calibration philosophy and techniques, and the development and implementation of enabling technologies to meet unprecedented Mission measurement goals.
- 1999-2018 Technical Director of the UW Space Science and Engineering Center. This role involved overseeing the Center's hardware development programs and technical computing group, including quality assurance and safety. This responsibility included cultivating and maintaining a world-class team of up to 50 engineers and technicians to work on a wide variety of instrument hardware and software developments for ground-based, aircraft-based, and spaceflight applications.
- 2008-2020 Co-investigator on a (\$4M) NASA Instrument Incubator Program project to develop enabling technologies for NASA's CLARREO Mission. This work culminated with the development of the CLARREO IR prototype instrument that demonstrated (under vacuum) the unprecedented 0.1 K performance required for the CLARREO climate benchmark instrument. This work also included instrument enhancements that reduced program risk.
- 2005-2008 Lead Researcher on SSEC's internally funded On-Orbit Absolute Temperature Calibration program and inventor of a novel scheme that uses the transient temperature signatures during melts of different phase transition materials to provide an absolute temperature scale. The technique is suitable for NASA's CLARREO Mission due to its extremely low mass and its ability to meet the

fundamental requirement that measurements on-orbit be tied to SI traceable absolute standards.

- 2003-present Co-investigator on NASA and NOAA projects related to risk reduction, calibration, and validation of the operational polar orbiting high spectral resolution infrared sounding instruments, including CrIS and AIRS.
- 2000-2005 Program Manager and technical lead for the On-board Blackbody Calibration Subsystem for the NASA New Millennium Program's Geostationary Fourier Transform Spectrometer (GIFTS) instrument. The demonstrated performance of this highly successful space flight subsystem significantly exceeded performance goals and set the stage for the next generation of technology developments, including absolute calibration techniques.
- 1994-1996 Program Manager and lead mechanical systems engineer for the development of the Skin-Layer Ocean Heat Flux Instrument (SOHFI), with Dr. Lawrence Sromovsky as PI. The scientific rationale and concept for this instrument came from Dr. Verner Suomi, founder of SSEC. SOHFI made untended in-situ measurements of the ocean surface heat flux. The salt-water environment provided significant engineering challenges throughout this project, but in the end successful measurements were obtained during several ocean field campaigns.
- 1989-present Program Manager (mostly transitioned to others in 2015) and lead mechanical systems engineer for all UW-SSEC infrared high-resolution spectroscopy hardware development programs, and related field campaigns. UW-SSEC is recognized as a world leader in developing state-of-the-art, radiometrically precise Fourier Transform Spectrometer based systems. Several hardware programs and major studies have resulted from our successful pioneering development of the High-resolution Interferometer Sounder (HIS) instrument (developed in 1985), with Dr. Henry Revercomb as PI, including: the Atmospheric Emitted Radiance Interferometer (AERI) funded by the Department of Energy (DOE) and its derivative the Marine-AERI, developed to make precise measurements of the sea surface; and the Scanning HIS (funded by DOE and NASA), which flies on the NASA ER-2 and WB-57 research aircraft. Key to all of these instrument developments is the internal blackbody calibration system and associated calibration techniques, for which Mr. Best had primary responsibility. Mr. Best is listed as a co-inventor for the technology behind the highly successful AERI instrument that has been licensed through WARF to ABB Bomem, Inc. of Quebec. UW still serves in a technical consulting role that includes instrument performance validation.
- 1986-1989 Program Manager and lead mechanical systems engineer for the refurbishment and calibration of the Net Flux Radiometer (NFR), that was one of the scientific instruments on-board the Galileo mission to Jupiter. This instrument was inherited at UW (with Dr. Lawrence Sromovsky as PI) after the untimely death of the original principal investigator at NASA Ames Research

Center. The efforts at UW included analysis, design, fabrication, and test of spaceflight instrumentation, as well as characterization and calibration testing of the NFR instrument. This role also included the management and development of the NFR Characterization and Calibration Facility. While serving in this role Mr. Best was key to uncovering the mechanism behind the mechanical failures of the NFR infrared detectors (observed before the instrument transfer to UW), and assembled an industry team of experts to successfully re-manufacture new detectors using more sophisticated techniques.

- 1984-1986      Lead mechanical engineer for the NASA funded Diffuse X-Ray Spectrometer (DXS) instrument (Professor William Kraushaar then Dr. Wilton Sanders, PI), which was successfully launched on Space Shuttle Mission STS-54 in 1993. Responsibilities included the mechanical design, stress and vibration analysis, and environmental testing of this instrument. Late in the program, while serving in this role, Mr. Best discovered the mechanism behind a particularly vexing pressure leak problem and designed an elegant solution that involved only minor modifications - allowing the DXS to meet its flight schedule on the Space Shuttle.
  
- 1984-1985      Lead mechanical engineer for the NASA and NOAA supported High-resolution Interferometer Sounder (HIS) instrument (Professor William Smith, PI) that flew on the NASA ER-2 high altitude aircraft. Engineering responsibilities similar to those listed above, and also included the opto-mechanical design of the cryogenic detector dewar system that operated at 4.2 kelvin. Major engineering challenges included isolation from structural borne random vibrations, and operation at the low temperature (-55 C) and low pressure (50 millibar) environment of the ER-2.
  
- 1978-1985      Joined UW Space Science and Engineering Center working as lead mechanical engineer for the NASA Hubble Space Telescope High Speed Photometer (HSP) instrument (Professor Robert Bless, PI). In this role Mr. Best was responsible for the instrument mechanical (and opto-mechanical) design, analysis, fabrication, and testing. The phone-booth sized HSP was one of the original scientific instruments on-board the Hubble and was built entirely at the UW. While extremely successful, the instrument was ultimately removed to make room for Hubble's corrective optics.

**Education**    B. S. Engineering Physics, University of Wisconsin-Madison, 1978.

#### **Awards**

- 2015    NASA Harry Reid Award for Outstanding Paper – lead author Bruce Wielecki, titled: "Achieving climate change absolute accuracy in orbit."
  
- 2015    Group Achievement Award for the Hurricane and Severe Storm Sentinel series of Sub-Orbital aircraft flights to investigate the factors influencing hurricane intensity change.

- 2012 NASA Group Achievement Award as part of the Suomi NPP Satellite Development team, for extraordinary dedication, skill, teamwork and perseverance in developing and delivering of the Suomi NPP Project Mission for the Nation.
- 2011 Awarded the “Distinguished” title by the University of Wisconsin--Madison
- 2012 NASA Group Achievement Award as part of the CLARREO Mission Concept Team for exceptional and innovative approaches to the mission design of CLARREO.
- 2007 NASA Group Achievement Award for TC4 Aircraft Cloud Study Mission in Costa Rica and Panama.
- 1996 Co-recipient of a NASA Group Achievement Award in recognition of the exceptional achievement of designing, constructing, implementing, and obtaining scientific data from Jupiter with the Net Flux Radiometer on-board the Galileo Probe.
- 1995 NASA Group Achievement Award in recognition of outstanding accomplishments and contributions to the highly successful Airborne Southern Hemisphere Ozone Experiment (ASHOE/MAESA).
- 1992 NASA Certificate of Recognition for significant contributions made in the development and successful operation of the Diffuse X-Ray Spectrometer (DXS) on the Space Shuttle Mission STS-54.
- 1991 NASA Certificate of Recognition for contributions to the Hubble Space Telescope Program.
- 1990 Co-recipient of a NASA Group Achievement Award for outstanding contributions to the successful completion of the Hubble Space Telescope High Speed Photometer.
- 1990 NASA Certificate of Appreciation for contributions to the Galileo project and its successful launch on the Space Shuttle.
- 1990 Co-recipient of a NASA Group Achievement Award in recognition of contributions to the development of the Galileo Probe spacecraft.

**Peer Reviewed Publications:**

- Taylor, Joseph K.; Revercomb, H.E.; Best, Fred A.; Tobin, Dave C; The Infrared Absolute Radiance Interferometer (ARI) for CLARREO; Remote Sensing (2020)—In preparation.
- Kasza, Ildiko; Adler, Doug; Nelson, David; Yen, Eric; Dumas, Sabrina; Ntambi, James; MacDougald, Ormond; Hernando, Diego; Porter, Warren; Best, Fred; Alexander, Caroline; *Evaporative Cooling Provides a Major Metabolic Energy Sink*. Molecular Metabolism, Volume 27, pp.47-61, (2019).
- Wielicki, Bruce A.; Young, D. F.; Mlynczak, M. G.; Thome, K. J.; Leroy, S.; Corliss, J.; Anderson, J. G.; Ao, C. O.; Bantges, R.; Best, F.; Bowman, K.; Brindley, H.; Butler, J. J.; Collins, W.; Dykema, J. A.; Doelling, D. R.; Feldman, D. R.; Fox, N.; Huang, X.; Holz, R.; Huang, Y.; Jin, Z.; Jennings, D.; Johnson, D. G.; Jucks, K.; Kato, S.; Kirk-Davidoff, D. B.; Knuteson, R.; Kopp, G.; Kratz, D. P.; Liu, X.; Lukashin, C.; Mannucci, A. J.; Phojanamongkolkij, N.; Pilewskie, P.; Ramaswamy, V.; Revercomb, H.; Rice, J.; Roberts, Y.; Roithmayr, C. M.;

- Rose, F.; Sandford, S.; Shirley, E. L.; Smith, W. L. Sr.; Soden, B.; Speth, P. W.; Sun, W.; Taylor, P. C.; Tobin, D. and Xiong, X.; *Achieving climate change absolute accuracy in orbit*. Bulletin of the American Meteorological Society, Volume: 94, Issue: 10, pp.1519-1539. Reprint # 7093, (2013).
- Tobin, David; Revercomb, Henry; Knuteson, Robert; Taylor, Joe; Best, Fred; Borg, Lori; DeSlover, Dan; Martin, Graeme; Buijs, Henry; Esplin, Mark; Glumb, Ronald; Han, Yong; Mooney, Daniel; Predina, Joe; Strow, Larrabee; Suwinski, Lawrence and Wang, Likun.; *Suomi-NPP CrIS radiometric calibration uncertainty*. Journal of Geophysical Research-Atmospheres, Volume: 118, Issue: 18, 2013, doi:10.1002/jgrd.50809. Reprint # 7079, (2013).
- Gero, P. Jonathan; Taylor, Joseph K.; Best, Fred A.; Garcia, Raymond K. and Revercomb, Henry E.; *On-orbit absolute blackbody emissivity determination using the heated halo method*. Metrologia, Volume: 49, Issue: 2, S1-S8. Reprint # 6631 (2012).
- Tobin, David C., Revercomb, Henry E., Knuteson, Robert O., Best, Fred A., Smith, William L., Ciganovich, Nick N., Dedecker, Ralph G., Dutcher, Steven; Ellington, Scott D.; Garcia, Raymond K.; Howell, H. Benjamin; LaPorte, Daniel D., Mango, Stephen A., Pagano, Thomas S., Taylor, Joe K., van Delst, Paul, Vinson, Kenneth H., and Werner, Mark W.; *Radiometric and spectral validation of Atmospheric Infrared Sounder observations with the aircraft-based Scanning High-Resolution Interferometer Sounder*. Journal of Geophysical Research, Volume 111, Doi:10.1029/2005JD006094. Call Number: Reprint # 5054 (2006).
- Knuteson, R. O., Best, F. A., DeSlover, D. H., Osborne, B. J., Revercomb, H. E., and Smith, W. L. Sr.; *Infrared land surface remote sensing using high spectral resolution aircraft observations*. Advances in Space Research, Volume 33, Issue 7, pp.1114-1119. Call Number: Reprint # 3720 (2004).
- Knuteson, R. O., Revercomb, H. E., Best, F. A., Ciganovich, N. C., Dedecker, R. G., Dirx, T. P., Ellington, S. C., Feltz, W. F., Garcia, R. K., Howell, H. B., Smith, W. L., Short, J. F., and Tobin, D. C.; *Atmospheric Emitted Radiance Interferometer, Part I: Instrument design*. Journal of Atmospheric and Oceanic Technology, Volume 21, Issue 12, 2004, pp.1763-1776. Call Number: Reprint # 4082 (2004).
- Knuteson, R. O., Revercomb, H. E., Best, F. A., Ciganovich, N. C., Dedecker, R. G., Dirx, T. P., Ellington, S. C., Feltz, W. F., Garcia, R. K., Howell, H. B., Smith, W. L., Short, J. F., and Tobin, D. C.; *Atmospheric Emitted Radiance Interferometer, Part II: Instrument performance*. Journal of Atmospheric and Oceanic Technology, Volume 21, Issue 12, 2004, pp.1777-1789. Call Number: Reprint # 4083 (2004).
- Minnett, P. J., Knuteson, R. O., Best, F. A., Osborne, B. J., Hanafin, J. A., and Brown, O. B.; *The Marine-Atmospheric Emitted Radiance Interferometer: A high-accuracy, seagoing infrared spectroradiometer*. Journal of Atmospheric and Oceanic Technology. Volume 18, Issue 6, 2001, pp.994-1013. Call Number: Reprint # 3060 (2001).
- Tobin, D. C., Best, F. A., Brown, P. D., Clough, S. A., Dedecker, R. G., Ellington, R. G., Garcia, R. K., Howell, H. B., Knuteson, R. O., Mlawer, E. J., Revercomb, H. E., Short, J. F., van

- Delst, P. F. W., and Walden, V. P.; *Downwelling spectral radiance observations at the SHEBA ice station: Water vapor continuum measurements from 17 to 26 microns*. Journal of Geophysical Research, Volume 104, pp.2081-2092. Call Number: Reprint # 2605 (1999).
- Sromovsky, L. A., Anderson, J. R., Best, F. A., Boyle, J. P., Sisko, C. A., and Suomi, V. E.; *The Skin-layer Ocean Heat Flux Instrument (SOHFI). Part I: Design and laboratory characterization*. Journal of Atmospheric and Oceanic Technology, Volume 16, Issue 9, pp.1224-1238. Call Number: Reprint # 2630 (1999).
- Sromovsky, L. A., Anderson, J. R., Best, F. A., Boyle, J. P., Sisko, C. A., and Suomi, V. E.; *The Skin-layer Ocean Heat Flux Instrument (SOHFI). Part II: Field measurements of surface heat flux and solar irradiance*. Journal of Atmospheric and Oceanic Technology, Volume 16, Issue 9, pp.1239-1254. Call Number: Reprint # 2631 (1999).
- Sromovsky, L. A., Best, F. A., Collard, A. D., Fry, P. M., Revercomb, H. E., Freedman, R. S., Orton, G. S., Hayden, J. L., Tomasko, M. G., and Lemmon, M. T.; *Solar and thermal radiation in Jupiter's atmosphere: Initial results of the Galileo probe Net Flux Radiometer*. Science, Volume 272, Issue 526, pp.851-854. Call Number: Reprint # 2268 (1996).
- Smith, W. L., Revercomb, H. E., Knuteson, R. O., Best, F. A., Dedecker, R., Howell, H. B., and Woolf, H. M.; *Cirrus cloud properties derived from High Spectral Resolution Infrared Spectrometry during FIRE II. Part I: The High Resolution Interferometer Sounder (HIS) systems*. Journal of the Atmospheric Sciences, Volume 52, Issue 23, pp.4238-4245. Call Number: Reprint # 2221 (1995).
- Sromovsky, L. A., Best, F. A., Revercomb, H. E., and Hayden, J.; *Galileo Net Flux Radiometer experiment*. Space Science Reviews, Volume 60, pp.233-262. Call Number: Reprint # 1289 (1992).

### **Conference Papers and Reports**

- Taylor, Joseph K.; Tobin, D. C.; Revercomb, H. E.; Best, F. A.; Garcia, R. K.; Knuteson, R. O.; Feltz, M.; Padula, F. P. and Goodman, S. J.; *Calibration Validation of GOES-16 Advanced Baseline Imager (ABI) with the Airborne Scanning High-Resolution Interferometer Sounder (S-HIS)*; American Meteorological Society, (2019).
- Taylor, Joseph K. et al.; *An On-orbit Infrared Inter-calibration Reference Standard for Decadal Climate Trending of the Earth*; Joe Taylor, et al.; SPIE, 2019
- Taylor, Joseph K.; Tobin, D. C.; Revercomb, H. E.; Best, F. A.; Garcia, R. K.; Knuteson, R. O.; Feltz, M.; Padula, F. P. and Goodman, S. J. *Calibration Validation of GOES-16 Advanced Baseline Imager (ABI) with the Airborne Scanning High-Resolution Interferometer Sounder (S-HIS)*; American Meteorological Society, 2019.
- Taylor, Joseph K.; Tobin, D. C.; Revercomb, H. E.; Best, F. A.; Garcia, R. K.; Merrelli, A. and Goldberg, M. D.. *Cold scene calibration validation of the Cross-track Infrared Sounder*

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- Revercomb, Henry E.; Knuteson, Robert O.; Tobin, David C.; Best, Fred A.; Taylor, Joe K.; Martin, Graeme; Gero, P. Jonathan; Adler, Douglas; Pettersen, Claire; Mulligan, Mark and Thielman, Don.; *Progress toward achieving an IR radiance records for decadal climate trending: Fundamental questions, challenges, and assessments*. Washington, DC, American Geophysical Union, Abstract A12B-03, (2017).
- Smith, William L. Sr.; Revercomb, H. E.; Glumb, R. J.; Best, F.; Gumley, L.; Knuteson, R.; Larar, A. M.; Petersen, R.; Taylor, J. K.; Toin, D. and Velden, C. S.; *Weather Alert Remote Nowcasting (WARN) satellite mission*. Boston, MA, American Meteorological Society, Abstract J6.2.A, (2017).
- Best, Fred A.; Revercomb, H. E.; Taylor, J. K.; Gero, P. J.; Adler, D.; Pettersen, C.; Knuteson, R. O.; Robin, D.; Wong, J.; Schwarz, M.; Thielman, D.; Mulligan, M. and Dykema, J. A.; *Absolute Radiance Interferometer (ARI) for the CLARREO Pathfinder: On-orbit verification and test (Part 2)*. Boston, MA, American Meteorological Society, Abstract 6.3 (2016).
- Revercomb, Hank; Best, Fred; Tobin, Dave; Knuteson, Bob; Smith, Nadia; Smith, William L. and Weisz, Elisabeth.; *Monitoring climate from space: A metrology perspective*. Bellingham, WA, SPIE-The International Society for Optical Engineering, , Paper 98810F. Reprint # 8146, (2016).
- Revercomb, Hank; Best, Fred; Taylor, Joe; Gero, Jon; Tobin, Dave; Knuteson, Bob; Adler, Doug; Pettersen, Claire; Mulligan, Mark; Wong, Jeff; Schwaraz, Mark and Thielman, Don.; *Climate benchmark quality IR measurement for CLARREO: Status of the Absolute Radiance Interferometer (ARI)*. Darmstadt, Germany, European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), (2016).
- Smith, William L. Sr.; Revercomb, H. E.; Best, F. A.; Glumb, R. J.; Klaes, K. D.; Knuteson, R. O.; Mango, S. A.; Robin, D. C. and Santek, D. A.; *CrIS - The evolution of the operational advanced sounder*. Boston, MA, American Meteorological Society, Abstract 1.4, (2016).
- Taylor, Joseph K.; Tobin, D. C.; Revercomb, H. E.; Best, F. A.; Garcia, R. K.; Merrelli, A. and Goldberg, M.; *Calibration validation of the Cross-track Infrared Sounder (CrIS) with the aircraft based Scanning High-resolution Interferometer Sounder (S-HIS)*. Boston, MA, American Meteorological Society, Abstract 380, (2016).
- Wagner, Timothy J.; Smith, N.; Best, F.; Eloranta, E.; Feltz, W. F. and Olson, E.. *SPARC: A mobile facility for a new generation of atmospheric research*. Boston, MA, American Meteorological Society, Abstract 390, (2016).
- Wielicki, Bruce A.; Cooke, Roger M.; Golub, Alexander A.; Baize, Rosemary R.; Thome, Kurtis J.; Shea, Yolanda; Kopp, Greg A.; Pilewskie, Peter; Revercomb, Henry E. and Best, Frederick A.; *Climate change observation accuracy: Requirements and economic value*. Bellingham, WA, SPIE-The International Society for Optical Engineering, Abstract 9881-10, (2016).



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- Gero, P. Jonathan; Knuteson, Robert O.; Shiomi, Kei; Kuze, Akihiko; Kataoka, Fumie; Revercomb, Henry E.; Tobin, David C.; Taylor, Joseph K. and Best, Fred A.; *GOSAT TANSO FTS TIR band calibration: A five year review*. Bellingham, WA, SPIE-The International Society for Optical Engineering, Paper 926316. Reprint # 8149 (2014).
- Revercomb, Hank; Best, F. A.; Knuteson, R. O.; Tobin, D. C.; Taylor, J. K.; Gero, P. J.; Adler, D.; Pettersen, C. and Mulligan, M.; *Establishing a high quality climate benchmark for the Earth: Utilizing a new on-orbit IR transfer standard to leverage next generational operational environmental satellite capabilities*. Boston, MA, American Meteorological Society, Abstract 6.1 (2014).
- Revercomb, Hank; Best, Fred; Knuteson, Bob; Tobin, Dave; Taylor, Joe; Gero, Jon; Adler, Doug; Pettersen, Claire and Mulligan, Mark.; *The Absolute Radiance Interferometer (ARI) for the UW/LASP/GSFC CLARREO tech demo/Pathfinder on ISS*. Hampton, VA, National Aeronautic and Space Administration (NASA), Langley Research Center, (2014).
- Taylor, Joseph K.; Revercomb, Henry E.; Best, Fred A.; Gero, P. Jonathan; Genest, Jerome E.; Buijs, Henry L.; Grandmont, Frederic J.; Tobin, David C. and Knuteson, Robert O.; *The University of Wisconsin Space Science and Engineering Center Absolute Radiance Interferometer (ARI): Instrument characterization and demonstrated radiometric performance*. Bellingham, WA, SPIE-The International Society for Optical Engineering, Paper 926313. Reprint # 8158, (2014).
- Revercomb, Henry E.; Tobin, Dave; Knuteson, Bob; Best, Fred; Taylor, Joe; DeSlover, Dan; Borg, Lori; Martin, Graeme; Quinn, Greg and Garcia, Ray.; *Suomi NPP/JPSS Cross-track*



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- Revercomb, H. E., Best, Fred; *NASA Instrument Incubator Program: A New Class of Advanced Accuracy Satellite Instrumentation (AASI) for the CLARREO Mission, Final Report.* University of Wisconsin, Space Science and Engineering Center, (2013).
- Revercomb, H. E., Best, Fred; *Vacuum Testing of the UW Absolute Radiance Interferometer (ARI) With End-to-End Verification Tests to Bring the Instrument to TRL 6, Final Report.* University of Wisconsin, Space Science and Engineering Center, (2013).
- Best, Fred A.; Adler, Douglas P.; Pettersen, Claire; Revercomb, Henry E.; Gero, P. Jonathan; Taylor, Joseph K.; Knuteson, Robert O. and Perepezko, John H.; *On-orbit absolute radiance standard for the next generation of IR remote sensing instruments.* Bellingham, WA, SPIE-International Society for Optical Engineering, Paper 85270N. Reprint # 7085, (2012)
- Mekhontsev, S.; Hanssen, L.M.; Rice, J.P.; Zeng, J.; Khromchenko, V.; Best, F.A. and Dykema, J.A.; *Comparative study of blackbody emissivity using reflectometry, modeling and radiance measurements.* [Washington, DC], Department of Commerce, National Institute of Standards and Technology, Session G-2, Paper 3 (2012).
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- Revercomb, Henry E.; Best, Fred A.; Knuteson, Robert O.; Tobin, David C.; Taylor, Joe K.; Gero, P. Jonathan; Adler, Douglas P.; Pettersen, Claire and Mulligan, Mark.; *Observing decadal trends in atmospheric feedbacks and climate change with Zeus and CLARREO.* Washington, DC, American Geophysical Union, Abstract A21E-0116, (2012).
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