

## Curriculum Vitae

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### Work Experience

- 2010-present Appointed as a team member on NASA Langley Research Center's CLARREO Infrared Instrument Integrated Product Team. CLARREO is NASA's climate benchmark spaceflight mission that has just entered Phase-A. This effort includes providing expertise to formulate instrument requirements and conduct instrument design, including detailed design and development of the on-board calibration and validation system. This will include specifying all associated temperature metrology and calibration techniques, and will include prototype fabrication and testing.
- 2008-present Co-investigator on a NASA Instrument Incubator Program grant that is focused on developing enabling technologies for NASA's CLARREO Mission. Key technology developments are related to providing on-orbit absolute radiometric calibration traceable to SI standards, and include absolute temperature calibration using multiple phase change materials, and emissivity measurement using the heated halo technique. These efforts build directly upon pioneering work conducted under the internal SSEC program described below. This work is critical to NASA's upcoming climate satellite mission, and will most certainly be integral to any future infrared measurement satellite instrument that strives for state-of-the-art absolute radiometric precision.
- 2005-2008 Lead Researcher on SSEC's internally funded On-Orbit Absolute Temperature Calibration program and inventor of a novel scheme that uses transient temperature signatures of small quantities of phase transition material to provide on-orbit absolute temperature calibration. 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. This effort was intended to provide a proof of concept of the idea, and to put SSEC in a position to propose for external funding to bring the technology to a higher level of technical readiness. A key foundation for this research was the SSEC-developed GIFTS Blackbody spaceflight design.
- 2003-present Co-investigator on NASA and NOAA projects related to risk reduction, calibration, and verification of the operational polar orbiting high spectral resolution 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.

1999-present Technical Director of the UW Space Science and Engineering Center. This role involves overseeing the technical aspects of the Center's hardware development programs and technical computing group, including quality assurance and safety. This responsibility includes cultivating and maintaining a world-class team of 50 engineers and technicians to work on a wide variety of instrument hardware and software developments for ground-based, aircraft-based, and spaceflight applications.

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 and lead mechanical systems engineer for all UW-SSEC 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 a 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-both 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 (Engineering Mechanics), University of Wisconsin-Madison, 1978.

### **Awards**

- 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:

- Gero, J.; Taylor, J.; Best, F.; Revercomb, H.; Knuteson, R.; Tobin, D.; Adler, D.P.; Ciganovich, N.; Dutcher, S. and Garcia, R. On-orbit absolute blackbody emissivity determination using the heated halo method. *Metrologica* (accepted for publication),
- Best, F. A., Adler, D. P., Pettersen, C., Revercomb, H. E., Perepezko, J. H.; *On-orbit absolute temperature calibration using multiple phase change materials*. *J. Atmos. Oceanic Technol.*, in preparation. (2011).
- Holz, R.; Tobin, D.C.; Nagle, F.; Knuteson, R.O.; Best, F.A. and Revercomb, H.E. Impact of spatial and temporal sampling differences when using CLARREO to calibrate operational sounders. *EOS Transactions*, Volume 89, Issue 53, 2008, Abstract GC23A-0752.
- 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).
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- Knuteson, R. O., Revercomb, H. E., Best, F. A., Ciganovich, N. C., Dedecker, R. G., Dirkx, 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., Ellingson, 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).
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## Conference Papers and Reports

- Best, F.A.; Adler, Douglas P.; Pettersen, Claire; Revercomb, Henry E.; Gero, Jonathan; Taylor, Joseph K.; Knuteson, Robert O. and Perepezko, John H. *On-orbit absolute radiance standard for future IR remote sensing instruments*. Earth Science Technology Forum 2011 (ESTF2011). NASA, Jet Propulsion Laboratory, 2011.
- Gero, P. Jonathan, Adler, Doug P., Best, Fred A., Knuteson, Robert O., Pettersen Claire, Revercomb Henry, E., Taylor, Joseph K., Tobin, David C.; *A new Infrared radiance standard for on-orbit absolute calibration*. ABB Bomem Workshop on Infrared Remote Sensing Applications (WIRSA) (2010).
- Revercomb, Henry E., Smith, William L., Best, Fred A., Knuteson, Robert O., Tobin, David C., Taylor, Joseph K., Feltz, Wayne, Turner, David, LaPorte, Daniel D., Ellington, Scott D., Dirkx, Timothy P., Dedecker, Ralph G., Garcia, Ray K., Ciganovich, Nick N., Dutcher, Stephen, Howell, H. Benjamin, Hackel, Denny, Adler Douglas P., and Pettersen, Claire; *The path to accurately calibrated FTIR: Progress from the University of Wisconsin HIS aircraft instruments, to the ground-based AERI, to spaceborne atmospheric sounding instruments (AIRS, IASI, CrIS), and onward to the NASA CLARREO climate benchmark mission*. ABB Bomem Workshop on Infrared Remote Sensing Applications (WIRSA) (2010).
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- Best, F. A., Adler, D. P., Pettersen, C., et al.; *On-orbit absolute temperature calibration using multiple phase change materials: overview of recent technology advancements*. *Proceedings of SPIE* Vol. 7857, 78570J (2010).
- Taylor, J. K., Revercomb, H. E., Buijs, H., Best, F. A., et al.; *The University of Wisconsin Space Science and Engineering Center Absolute Radiance Interferometer (ARI)*. *Proceedings of SPIE* Vol. 7857, 78570K (2010).
- Gero, P. J., Taylor, J. K., Best, F. A., et al.; *On-orbit absolute blackbody emissivity determination using the heated halo method*. *Proceedings of SPIE* Vol. 7857, 78570L (2010).
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- Best, F A, et al.; *On-Orbit Absolute Radiance Standard (OARS) for future IR remote sensing instruments*. *Eos Trans. AGU*, 90(52), Fall Meet., A43B-0203 (2010)
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- Taylor, J. K., Tobin, D. C., Revercomb, H. E., Knuteson, R. O., Borg, L. and Best, F. A.; *Analysis of the CrIS Flight Model 1 radiometric linearity*. in Fourier Transform Spectroscopy, OSA Technical Digest Optical Society of America, paper FMA4 (2009).
- Revercomb, H. E., Best, F. A., Dykema, J. A., Taylor, J. K., Tobin, D. C., Knuteson, R. O., Adler, D. P., and M. Mulligan; *High spectral resolution IR instrument developments for CLARREO*. in Fourier Transform Spectroscopy, OSA Technical Digest Optical Society of America, paper JMA4 (2009).
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- Best, Fred A., Knuteson, Robert O., Revercomb, Henry E., Tobin, David C., Gero, P. Jonathan, Taylor, Joseph K., Rice, J., Hanssen, L., Mekhontsev, S.; *Measurements of the Atmospheric Emitted Radiance Interferometer (AERI) blackbody emissivity and radiance using multiple techniques*. Conference on Characterization and Radiometric Calibration for Remote Sensing (CALCON) (2009.)
- Revercomb, H. E., Best, F. A., et al.; *CLARREO IR spectra: achieving 0.1 K 3-sigma*. Eos Trans. AGU, 90(52), Fall Meet., GC52A-06 (2009).
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- Best, F. A., Adler, D. P., Ellington, S. D., et al.; *On-orbit absolute calibration of temperature with application to the CLARREO mission.* Proceedings of SPIE Vol. 7081, 708100 (2008).
- Revercomb, H. E., Smith, W. L., Tobin, D. C., Knuteson, R. O., Best, F. A., Taylor, J. K., Turner, D. D., Zhou, D. K., Reisse, R. A., Cantwell, G. W., and Tansock, J.; *GIFTS radiance validation from ground-based sky-viewing comparisons to AERI.* in Fourier Transform Spectroscopy/ Hyperspectral Imaging and Sounding of the Environment, OSA Technical Digest Series Optical Society of America, paper FTuA5 (2007).
- Tobin, D. C., Revercomb, H. E., Taylor, J. K., Best, J. K., Knuteson, R. O., Smith, W. L., Elwell, J., Cantwell, G. W., Bingham, G., Tansock, J., Reisse, R. A., and Zhou, D. K.; *Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) thermal vacuum testing: aspects of spectral characterization.* in Fourier Transform Spectroscopy/ Hyperspectral Imaging and Sounding of the Environment, OSA Technical Digest Series Optical Society of America, paper FTuA6 (2007).
- Smith Sr., W. L., Revercomb, H. E., Best, F. A., Huang, A., Knuteson, R. O., Larar, A., Liu, X., Mango, S., and Zhou, D. K.; *Hyperspectral infrared imaging and sounding -- measurement concept, technology, and processing approach.* in Fourier Transform Spectroscopy/ Hyperspectral Imaging and Sounding of the Environment, OSA Technical Digest Series Optical Society of America, paper JMA1 (2007).
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