The Scanning High-resolution Interferometer Sounder (S-HIS)

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1 Short Description

The Scanning High-resolution Interferometer Sounder (S-HIS) measures emitted thermal radiation at high spectral resolution between 3.5 and 17.3 microns (580 – 2850 cm^{-1}) at 0.5 cm^{-1} spectral sampling resolution with 0.100 radians angular field of view (2 km footprint from 20 km observing altitude) and imaging accomplished via cross-track scanning. Since 1998, the S-HIS has participated in 35 field campaigns on the NASA ER-2, DC-8, Proteus, WB-57, and Global Hawk airborne platforms. The S-HIS has proven to be extremely dependable with high calibration accuracy and consistent performance on all platforms. The measurement applications have included radiances for evaluating radiative transfer models, temperature and water vapor retrievals, cloud radiative properties, cloud top retrievals, surface emissivity and temperature, trace gas retrievals, and satellite calibration validation.

2 Science Drivers

The S-HIS is well suited for the DOE AAF's newly acquired Bombardier Challenger 850 Aircraft because the S-HIS spectrally resolved infrared radiance measurements directly support many key ARM science objectives that are not fulfilled by current airborne facility instruments. Furthermore, the S-HIS is an existing state-of-the-art instrument with proven robust performance demonstrated on multiple aircraft. The S-HIS is a relatively simple instrument to support in the field, with a high calibration accuracy that is traceable to NIST standards. The operational data products are produced routinely and on a timely basis.

Thermodynamic profiles are required for the DOE ARM cloud and aerosol research objectives, and spectral infrared cloud properties have been identified as a priority measurement by DOE ARM researchers. As an example, a unique and timely airborne campaign that would be particularly applicable to ARM science objectives is a third installment of the Radiative Heating in Underexplored Bands Campaign (RHUBC) focusing on the study of ice cloud radiative properties in the infrared and far-infrared. With the S-HIS mounted in a wing pod of the DOE Challenger 850 Aircraft, the S-HIS would be capable of measuring both upwelling and downwelling radiances through a cross-track nadir viewport and zenith viewport, respectively. With the Challenger aircraft flying below a cirrus layer, the S-HIS would measure downwelling spectrally resolved radiances, which could be used to retrieve the temperature and cloud properties using observations in the 7-15 μm region. Radiative closure studies could then be examined at wavelengths beyond 15 μm. This would require the integration of the S-HIS 4-

detector dewar into the instrument to provide coverage beyond 20 µm, but would be a unique and valuable airborne measurement.

Past and current applications of the S-HIS measurements include radiances for evaluating radiative transfer models [1-3]; temperature and water vapor retrievals [4, 5]; cloud radiative properties [6, 7]; cloud top retrievals [4, 5, 8]; surface emissivity and temperature [9-11], trace gas retrievals [12]; the characterization of the thermodynamic environment around hurricanes and tropical storms [13-16]; the characterization of fire development, emission processes, plume evolution, and downwind impacts on air quality [17-19]; and satellite calibration validation [20-26]. Generally, S-HIS is highly valuable in field programs where this extensive range of properties (highly accurate radiance spectra, temperature and water vapor profile distributions, cloud and surface radiative properties, and trace gas amounts) is needed with higher spatial resolution and better temporal overlap than can be provided by satellite sounding instruments, and where more extensive coverage is needed than *in situ* observations can provide. This turns out to be a large fraction of field programs focused on climate and weather process studies.

3 Full Description

3.1 Instrument and Measurement Description

The Scanning High-resolution Interferometer Sounder (S-HIS) shown in Figure 1 is an advanced version of the HIS NASA ER-2 instrument. The S-HIS was initially designed to fly on an unmanned aircraft vehicle (UAV) with limited payload capacity. This drove it to be small, lightweight, and modular, with low power consumption. It was developed between 1996 and 1998, and refined beyond that, at the University of Wisconsin (UW) Space Science and Engineering Center (SSEC) with the combined support of the US DOE, NASA, and the NPOESS Integrated Program Office. Its design and calibration techniques have benefitted from experience with the HIS and with the ground based Atmospheric Emitted Radiance Interferometer (AERI) instruments developed for the DOE Atmospheric Radiation Measurement (ARM) program. The nadir-only spatial sampling of the original HIS was replaced by programmable cross-track coverage while maintaining similar sized footprints (100 mrad angular field of view). The programmable S-HIS scene mirror and front-end design also support a zenith view for compatible aircraft. The zenith view enables further calibration verification analysis and upper atmosphere studies.

The S-HIS is packaged in three enclosures each mounted to a structural frame, and the S-HIS structural frame mechanically mounts to the aircraft structure. This allows for simple mechanical integration, with a well-defined mechanical interface. The three enclosures are referred to as the Interferometer Module, Electronics Module, and the Data Storage Computer (data system). The Flight Calibration Assembly is directly mounted to the front of the Interferometer Module enclosure. The system is modular, and the three enclosures may be mounted on a different structural frame if required. Details of the instrument design, interface, and integration are available in the S-HIS Instrument Description Document [27].

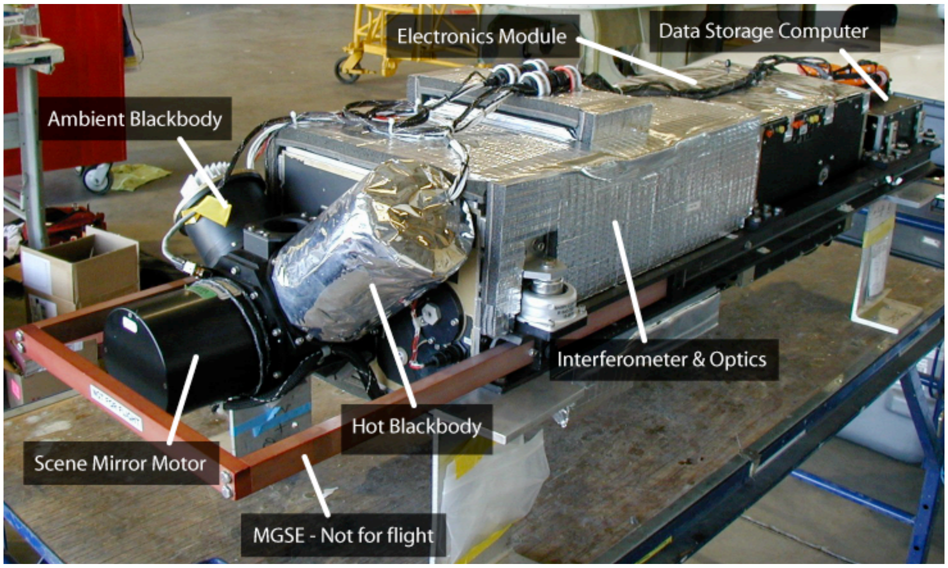

Figure 1: The Scanning High-resolution Interferometer Sounder (S-HIS); Proteus integration (with extra insulation on optical enclosure), Scaled Composites, July 2004.

The basic instrument and measurement characteristics are summarized in Table 1. The optical design is very efficient, providing useful signal-to-noise performance from a single 0.5 second dwell time. This allows imaging with 100 mrad resolution (2km at nadir from 20km altitude) to be accomplished by cross-track scanning. Onboard reference blackbodies are viewed via the rotating 45° scene mirror as part of each cross-track scan sequence, providing updated calibration information every 10-20 seconds.

The fundamental measurement consists of a numerically filtered interferogram for each of the three spectral bands, collected every 0.5 seconds. Scene and calibration view interferograms, along with calibration and engineering data are stored to an onboard solid-state hard drive. For platforms without a high bandwidth satellite downlink, the Level 0 data is downloaded from the instrument over an ethernet connection post-flight, and processed to geolocated calibrated radiances and temperature, water vapor, and trace gas retrievals. The Revercomb complex calibration method is used for radiometric calibration [28], and operational retrievals (temperature, water vapor, CO, CH_4, O_3, SO_2, N_2O profiles, total column CO_2, surface temperature and emissivity) use the Dual Regression Retrieval Algorithm [4, 5].

The continuous spectral coverage from 3.5 to 17.3 μm at 0.5 cm^{-1} resolution is illustrated in Figure 2 by a sample S-HIS measured upwelling infrared spectrum with some of the key spectral features labelled. The spectral coverage is divided into three bands with separate detectors (two photoconductive HgCdTe and one InSb) to achieve the required noise performance. The bands use a common field stop to ensure accurate spatial co-alignment. The longwave band provides the primary information for temperature sounding and for cloud phase and particle size. The midwave band provides the primary water vapor sounding information and additional cloud property information. The shortwave band provides information on cloud reflectance and augments sounding information. The detectors are cooled to 77K using a Litton 0.6W split-cycle Stirling cooler.

Table 1: S-HIS instrument and measurement characteristics.

Characteristic	Specification / Description	Note
Interferometer		
Interferometer type	Voice Coil Dynamically Aligned plane mirror (Custom Bomem DA-5)	
Fringe counting	¼ wave quadrature, continuous	
Optical Path Difference (OPD) sampling reference	HeNe laser w/ white light at startup	
Michelson mirror assembly	Linear bearing with voice coil	UW-SSEC design
Beamsplitter / Compensator	KBr; wedged; Antimony trisulphide and Ge coating	
Spectral resolution	$0.5\ cm^{-1}$	Unapodized
OPD scan speed	4 cm/s	
Maximum Optical Path Difference (OPD_{MAX})	±1.037 cm	unapodized resolution $= (2 * OPD_{MAX})^{-1}$
Angular FOV	±20 mrad	In interferometer
Scan time	0.5 s	
Beam diameter	4.5 cm (aperture stop)	In interferometer
Mirror tilt monitoring	0 – 2 kHz	
Spectral Coverage		
Longwave (LW) band	9-17.3 µm, $580\text{-}1200\ cm^{-1}$	HgCdTe
Midwave (MW) band	5.5-9 µm, $1030\text{-}1810\ cm^{-1}$	HgCdTe
Shortwave (SW) band	3.5-5.5 µm, $1760\text{-}2850\ cm^{-1}$	InSb
Cooler type / Detector temperature:	0.6 W Stirling Cooler (Litton), 78 K	
Spatial sampling		
Angular Field-of-view (FOV)	100 mrad	
Beam diameter	2.85 cm (at scene mirror)	
Cross-track scan step	0.15 rad	programmable
Number of IFOV per cross-track scan	15 earth views + 10 calibration views	Typical programmable
Mass	63 kg	Including ER-2 centerline pod frame
Dimensions		
Interferometer and Cal. Assembly	28.8 x 12 x 13 inches	73.2 x 30.5 x 33.0 cm
Electronics Module	15 x 11.5 x 11.3 inches	38.1 x 29.2 x 28.7 cm
Data Storage Computer	7.9 x 5.5 x 14.7 inches	20.1 x 14.0 x 37.3 cm
All, mounted on ER-2 frame	61.4 x 14.5 x 17.1 inches (envelope)	156.0 x 36.8 x 43.4 cm
Power	Two 28 VDC Busses Bus A: 15A fused (280W peak) Bus B: 15A fused (392W peak)	
Onboard data processing:	64-point FIR filter	
RMS noise (per spot):	< 0.25K at 260 K	
Radiometric Uncertainty (k=3):	< 0.3K absolute (at altitude) 233-300 K brightness temp equivalent scenes	

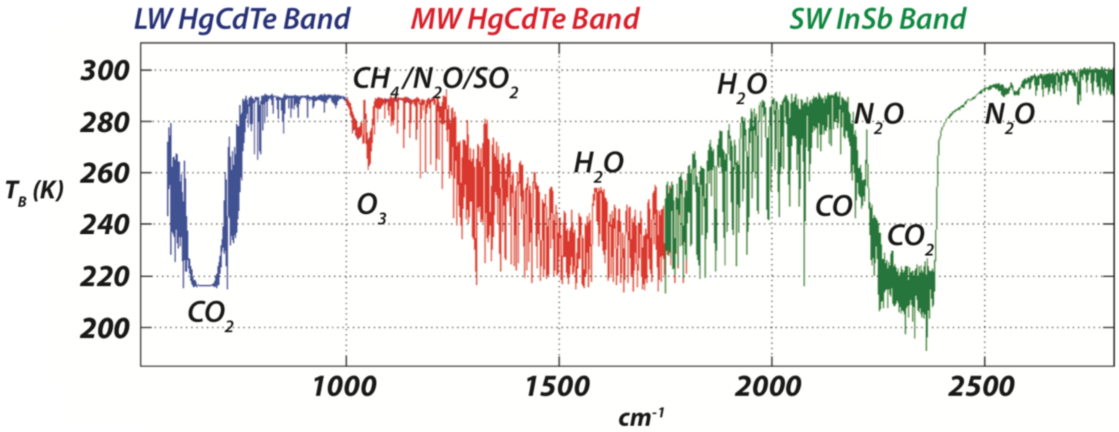

Figure 2: Typical S-HIS measured upwelling radiance spectrum (0.5 cm^{-1} sampling resolution)

The rapid sampling frequency of the S-HIS allows cross-track imaging at 2 km resolution with a swath width on the ground of 30 – 40 km from 20km altitude (ER-2 typical cruise altitude). An example of how this capability can be used to build up an image of a larger area by flying a mapping pattern with the aircraft is shown in Figure 3.

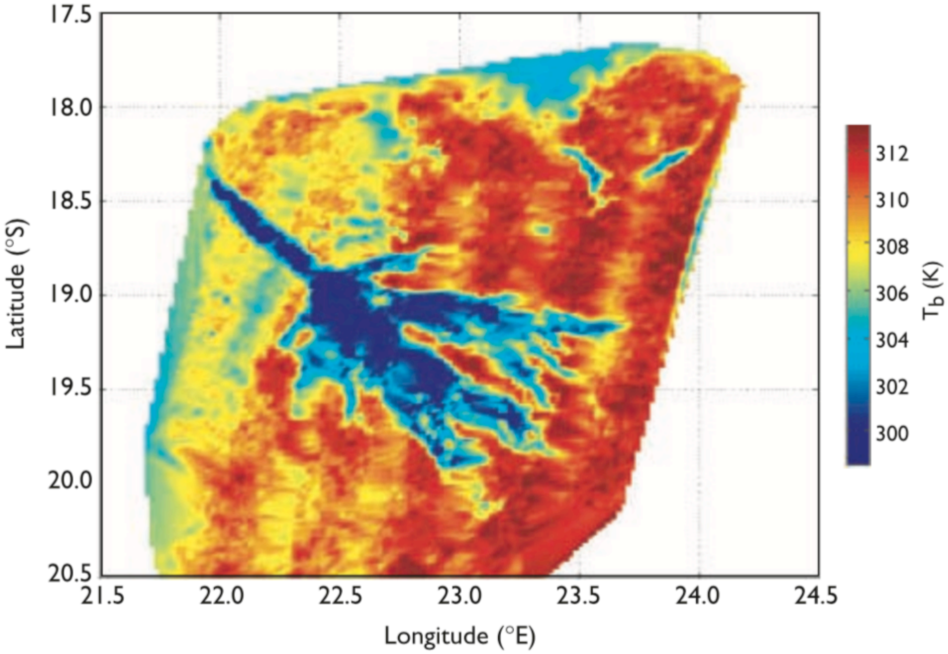

Figure 3: Brightness temperature of the Okavango Delta, Botswana at 10.2 micron, acquired by Scanning-HIS during six parallel flight lines over the Delta on 27 August 2000 [18]. Images can be made from any of the nearly 5000 spectral samples of the S-HIS. For clouds, linear combinations of clean window channels will be used to investigate the spatial distribution of cloud properties.

The S-HIS radiometric calibration, calibration verification, and traceability can be divided into four primary phases:

- Pre-integration calibration of on-board blackbody references at subsystem level;
- Pre- and post-deployment end-to-end calibration verification;
- Periodic end-to-end radiance evaluations under flight-like conditions with NIST transfer sensors;
- Instrument calibration during flight using two on-board calibration blackbody references.

Pre-integration calibration of the on-board blackbody references is typically completed on the order of every 5 years. The S-HIS thermistor readout electronics calibration is verified to within 5 mK using a series of 6 reference resistors, that are each calibrated to an accuracy of better than 0.5 mK (3-sigma) equivalent temperature, using a Fluke 8508A DMM. The S-HIS On-Board Calibration Blackbody thermistors are calibrated at 10 temperatures over the range from -60 °C to 60 °C. These tests are done in a controlled isothermal environment using a NIST traceable temperature probe that is calibrated at Hart Scientific to an accuracy of 5 mK (3-sigma). Following these tests, the On-Board Calibration Blackbodies and Readout Electronics are integrated to the S-HIS Instrument.

Prior to and after each field campaign, end-to-end calibration verification is performed. End-to-end calibration verification is conducted using a variable temperature blackbody at the zenith view and an ice bath blackbody at the nadir view. Radiances measured by the S-HIS instrument are compared to those calculated for the verification blackbodies, based on the measured cavity temperature, knowledge of the emissivity, and measurements of the background temperature. The variable temperature blackbody used for S-HIS calibration validation has its heritage rooted in the Atmospheric Emitted Radiance Interferometer (AERI) instrument [29, 30]. These blackbodies have had their emissivity verified at NIST to within 0.001 using three methods: the Complete Hemispherical Infrared Laser-based Reflectometer (CHILR); the Thermal Infrared Transfer Radiometer (TXR); and the Advanced Infrared Radiometry and Imaging Facility (AIRI). The ice bath blackbody is geometrically similar to the AERI Blackbody, and is coated with the same paint.

During flight, interferograms are collected for views of the onboard blackbody references (ambient blackbody and hot blackbody), along with every cross-track scan. These are used for calibration of the S-HIS Earth scene measurements. The S-HIS Ambient Blackbody (ABB) runs at the pod ambient temperature (between 218K and 245K, depending on the local ambient environment); and the Hot Blackbody (HBB) is typically heated to 305K.

UW-SSEC experience with the S-HIS has led to a more complete understanding of issues with absolute calibration. Tests with the NIST Thermal Infrared Transfer Radiometer (TXR) solidly confirm the calibration uncertainty estimates. To verify the S-HIS calibration accuracy and provide direct NIST traceability of the S-HIS radiance observations, laboratory tests of the S-HIS and the NIST TXR were conducted using a thermal chamber to simulate flight temperatures for the S-HIS instrument. Two basic tests were conducted: (1) comparison of radiances measured by the S-HIS to those from the TXR, and (2) measurement of the reflectivity of a UW-SSEC blackbody by using the TXR as a stable detector [31, 32].

The radiance comparison involved the S-HIS and the TXR each observing a highly stable (and accurate) Atmospheric Emitted Radiance Interferometer (AERI) blackbody over a wide range of temperatures (227 to 290 K). The test results showed mean agreement between (1) predicted AERI blackbody radiance and the S-HIS NIST TXR Channel 2 equivalent spectral band of 60 ± 90 mK, (2) predicted AERI blackbody radiance and NIST TXR channel 2 (10 µm) of -22 mK, (3) NIST TXR channel 2 and the S-HIS band equivalent of less than 40 mK, (4) predicted AERI BB radiance and the S-HIS NIST TXR channel 1 (5 µm) equivalent of 40±85 mK.

The radiometric uncertainty of a given measurement can be calculated via a differential analysis of the calibration equation and knowledge of the primary contributors to the uncertainty, as prescribed by the Guide to Uncertainty in Measurement [33]. For a wide range of scene temperatures, the calibration uncertainty (k=3 coverage factor) estimate for S-HIS is less than 0.2 K [34, 35]. An example of the S-HIS radiometric uncertainty (RU) contributions and total RU for a clear sky scene over ocean (2017-04-13) is shown in Figure 4.

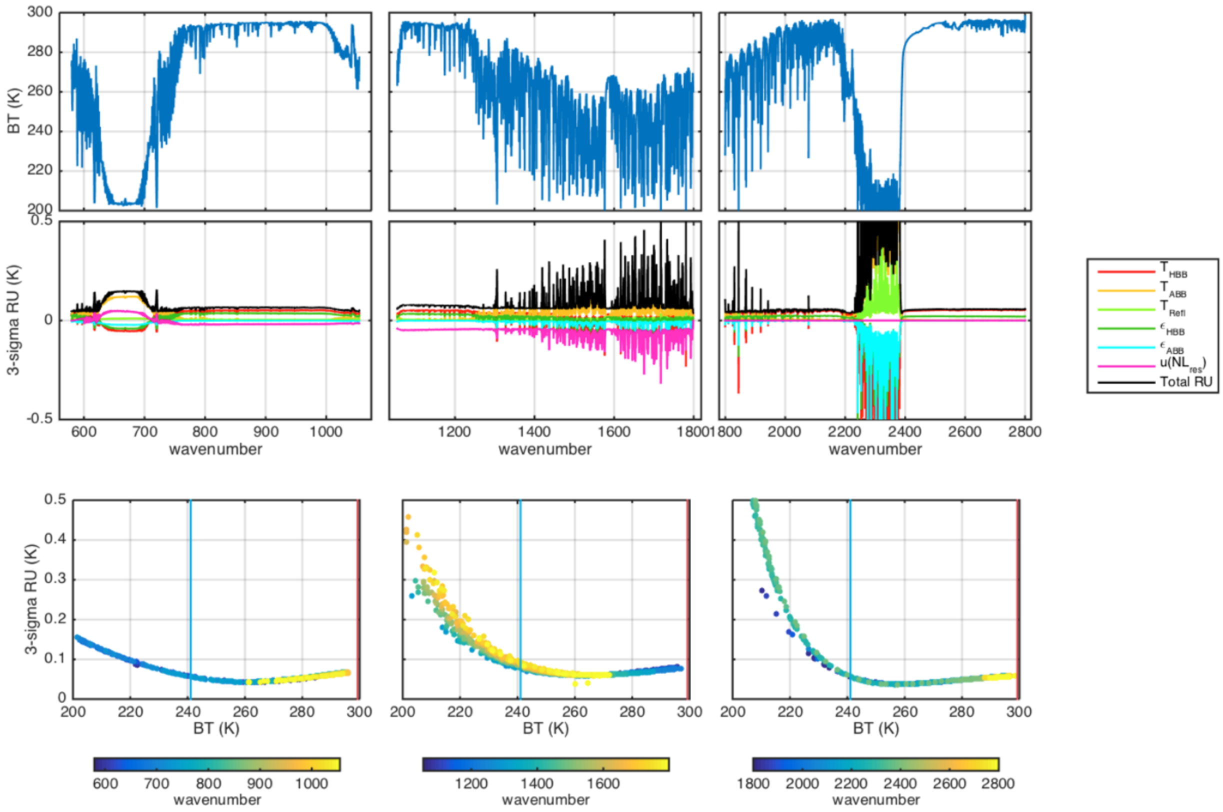

Figure 4: S-HIS brightness temperature spectra (top panels), and RU contributions and total RU (middle panels) for flight conditions encountered during the GOES-16 PLT ABI calibration validation on 2017-04-13 (with S-HIS on the ER-2). The bottom panels show scatter plots of the 3-sigma RU versus scene temperature, colored by wavenumber for the S-HIS longwave (left), midwave (middle), and shortwave (right) spectral bands. The light blue vertical line indicates the ambient blackbody temperature and the red vertical line (~300K) indicates the S-HIS hot blackbody temperature. For this case, the 3-sigma uncertainty is less than 0.2K for all bands for scene brightness temperatures greater than 220K.

The S-HIS absolute spectral calibration is determined by adjusting the effective metrology laser frequency to create optimal agreement with the positions of well-known spectral features present in clear sky calculated spectra. Analysis of ensembles of such cases [36] has determined the S-HIS spectral calibration with an uncertainty of ±0.5 ppm (3 sigma uncertainty in the mean) with no detectable changes with time.

3.2 Data Analyses

As noted in the preceding section, the fundamental measurement consists of one numerically filtered interferogram from each of the three spectral bands collected every 0.5 second. Scene and calibration view interferograms, along with calibration and engineering data are stored to an onboard solid-state hard drive. For platforms without a high bandwidth downlink, the Level 0 data is downloaded from the instrument over an ethernet connection post-flight, and processed to geolocated calibrated radiances (Level 1b) and temperature, water vapor, and trace gas retrievals (Level 2). Preliminary Level 1b and Level 2 products are typically available within a few hours of data download. This allows the data to be reviewed by the science team and initial conclusions to be made in a timely way for evaluating the success of experiment objectives as the field campaign progresses. Detailed instrument health and performance data is also processed each day to assure that a healthy instrument is ready for the next flight.

When a high bandwidth downlink is available for the aircraft, the Level 1 and Level 2 products are processed using a real-time ground data processing system that is capable of delivering atmospheric profiles, radiance data, and engineering status to mission support scientists in less than one minute from the time of observation. This capability was developed and utilized for the Hurricane and Severe Storm Sentinel (HS3) mission on the NASA Global Hawk [37, 38].

The Revercomb complex calibration method is used for radiometric calibration [28], and operational retrievals use the Dual Regression Retrieval Algorithm [4, 5]. While the processing is typically completed on a server at the UW-SSEC, the processing requirements are not significantly demanding and can be completed on a modern laptop computer in the field if required. The L1b and L2 processing are automated, with little manual effort required.

Other Level 2 (L2) data products that could be readily developed via published algorithms include infrared land surface emissivity, cloud properties, and trace gas retrievals that are not currently included in the S-HIS Dual Regression retrieval.

3.3 Operational Requirement and Experience

The S-HIS has flown on 35 field campaigns on the NASA ER-2, the NASA DC-8, the Scaled Composites Proteus, the NASA WB-57, and the NASA Global Hawk. The S-HIS has proven to be extremely dependable with high calibration accuracy and consistent performance on all platforms. Figure 5 illustrates the deployment history for the instrument.

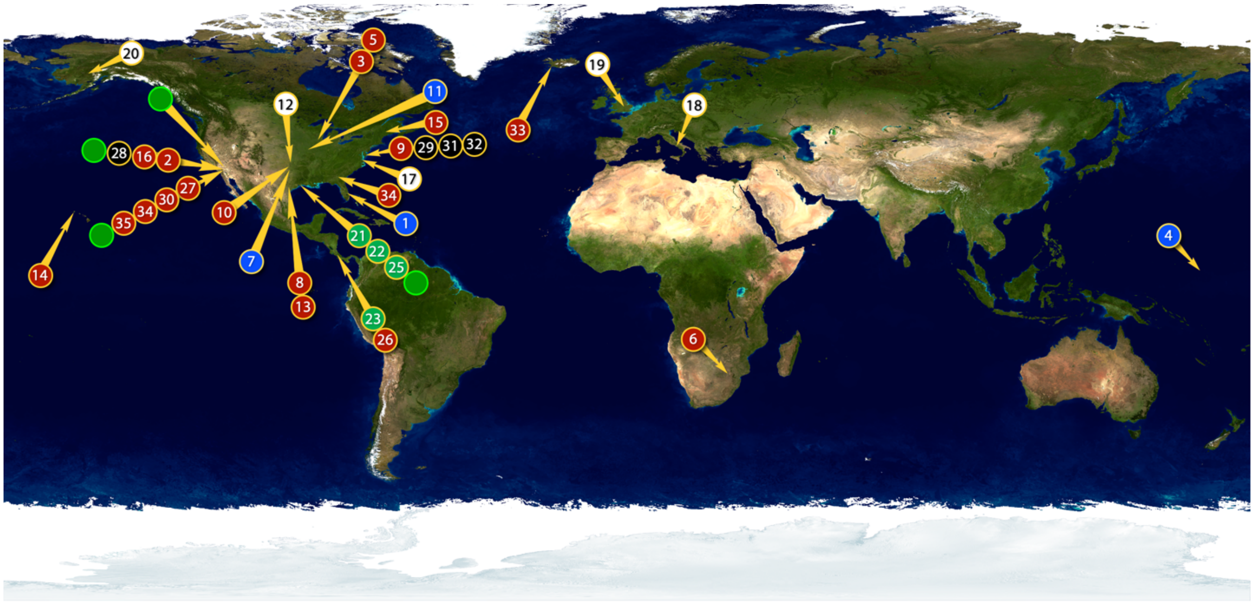

Figure 5: S-HIS field deployment map, 1998 to present. Green circles indicate aircraft integration locations. (1) CAMEX, DC-8, 1998; (2) AirMISR 98, ER-2, 1998; (3) WINTEX, ER-2, 1999; (4) KWAJEX, DC-8, 1999; (5) WISC-2000, ER-2, 2000; (6) SAFARI 2000, ER-2, 2000; (7) AFWEX, DC-8, 2000; (8) TX-2001, ER-2, 2001; (9) CLAMS, ER-2, 2001; (10) IHOP, ER-2, 2002; (11) SMEX 2002, DC-8, 2002; (12) ARM UAV-SGP, Proteus, 2002; (13) TX-2002, ER-2, 2002; (14) Pacific THORpex, ER-2, 2003; (15) Atlantic THORpex, ER-2, 2003; (16) Tahoe 2004, ER-2, 2004; (17) INTEX Proteus, Proteus, 2004; (18) ADRIEX Proteus, Proteus, 2004; (19) EAQUATE, Proteus, 2004; (20) M-PACE, Proteus, 2004; (21) AVE-OCT04, WB-57, 2004, (22) AVE-JUN05, WB-57, 2005; (23) CR-AVE, WB-57, 2006; (24) Tahoe 2006, ER-2, 2006; (25) JAVIEX, WB-57, 2007; (26) TC-4, ER-2, 2007; (27) Railroad Valley, ER-2, 2011; (28) HS3, Global Hawk, 2011; (29) HS3, Global Hawk, 2012; (30) SNAP2013, ER-2, 2013 (31) HS3, Global Hawk, 2013; (32) HS3, Global Hawk, 2014 (33) SNAP2015, ER-2, 2015; (34) GOES-16 PLT, ER-2, 2017; (35) FIREX-AQ, ER-2, 2019. Map imagery courtesy of NASA Visible Earth, http://visibleearth.nasa.gov.

Each aircraft provides both a unique interface set and operating environment. The optical, electrical, and mechanical interfaces are usually well-defined and can be accommodated with planned design modifications or additions. However, the operational environment is often less well defined, and depends not only on the airborne platform, but also on mount location within the payload, as well as the specifics of aircraft navigation during the flight (altitude, velocity, pitch, roll, flight profile, etc.).

The environmental elements with the largest potential for impact on instrument operation and which vary most from aircraft to aircraft are the pressure, vibration, and thermal environments. Accommodating such a wide variety of environments with a single instrument design presents significant challenges. However, the S-HIS has proven to be an extremely robust and effective instrument, and has provided hyperspectral infrared radiance measurements with high absolute accuracy and low noise, regardless of flight environment and independent of airborne platform. Taylor et al provide a detailed comparison of S-HIS instrument performance on various airborne platforms, and during ground characterization, with specific emphasis is placed on instrument improvements and some of the engineering lessons learned [39].

The S-HIS mass, power, and envelope are summarized in Table 1. Details of the instrument design, interface, and integration are included in the S-HIS Instrument Description Document [27], which is available via the URL listed in the reference section. The S-HIS Instrument Description Document has been previously provided to Jason Tomlinson (Director of Engineering, ARM Aerial Facility). Based on a preliminary review of the document, Dr. Tomlinson indicated that he was encouraged that the S-HIS could be supported on the new DOE Challenger 850 aircraft and that even wing pod integration may be possible. If the wing pod integration provided S-HIS access to a zenith view and is unpressurized, this would be the preferred integration location.

Operationally, the S-HIS typically requires 1-2 team members in the field for integration, mission support and de-integration, and 1 person at UW-SSEC for data processing support. A more significant team would likely be required for the initial integration effort and mission to deal with the nuances of a new airborne environment. A routine flight day typically includes of 15-30 minutes pre-flight and 30 minutes post-flight instrument access.

3.4 Potential Difficulties and Justification

As noted earlier, the pressure, vibration, and thermal environments have the largest potential for impact on instrument operation and typically vary the most from aircraft to aircraft. The S-HIS design and team have demonstrated the ability to provide robust instrument performance on five different airframes, each with significantly different environmental characteristics. In most cases, the S-HIS operates in an unpressurized environment with no thermal control (ambient temperature and pressure). Ideally, a similar integration environment would be available on the DOE Challenger 850. However, if this is not possible, there are feasible solutions. For example, in the DC-8 the S-HIS Interferometer, Electronics, and Data Storage Computer Modules are mounted in the pressurized cargo area. The Flight Calibration Assembly (scene select mirror assembly and blackbody references) are mounted in ambient pressure and temperature zone, and separated from the rest of the instrument via the S-HIS DC-8 Adapter Cap assembly which includes a ZnSe window. Photos of the S-HIS integrated on the DC-8 are shown in Figure 6. If an ambient pressure and temperature integration location was not available on the Challenger 850, a similar approach could be utilized, but integration into an ambient pressure and temperature area would be preferred, and likely more straightforward and less costly to integrate.

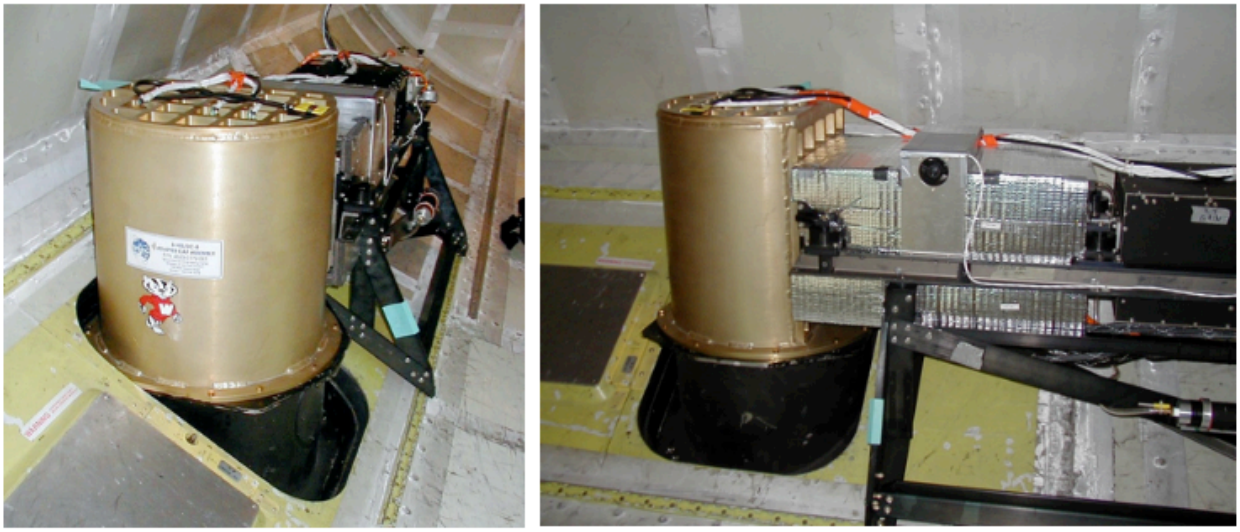

Figure 6: S-HIS installed into the DC-8. The S-HIS DC-8 Adapter Cap assembly includes a ZnSe window between the Flight Calibration Assembly and the Interferometer Module.

The S-HIS integration into Zone 25 on the Global Hawk provides a second example of overcoming a non-ideal thermal environment. While Zone 25 operates at ambient pressure, it is thermally regulated since it also contains temperature sensitive avionics electronics for the aircraft. The initial flights showed temperatures in this location were warmer than desired – close to the operational limit for some key S-HIS subsystems, and also non-optimal in terms of temperature separation between the ambient and hot calibration reference blackbodies. The S-HIS team worked with NASA engineers to a solution that would plumb outside air through Zone 25 through a 3” diameter tube. Five flexible heat straps were used to couple key areas on the S-HIS instrument to heat exchangers that were thermally coupled to the flow stream within the tube. Each of the unique thermal straps were designed and fabricated by UW SSEC. Figure 7 and Figure 8 illustrate the heat straps and their connection to the tube with internal heat exchangers. In the figures, the left (forward) end of the tube is connected to a new forward inlet port installed in the Global Hawk (zone 25), and the right (aft) end to a new outlet port. If the thermal environment on the Challenger 350 was such that the S-HIS required cooling, the cooling tube, heat exchangers, and flexible heat straps developed for the Global Hawk Zone 25 integration could be utilized to help moderate the integration costs and development.

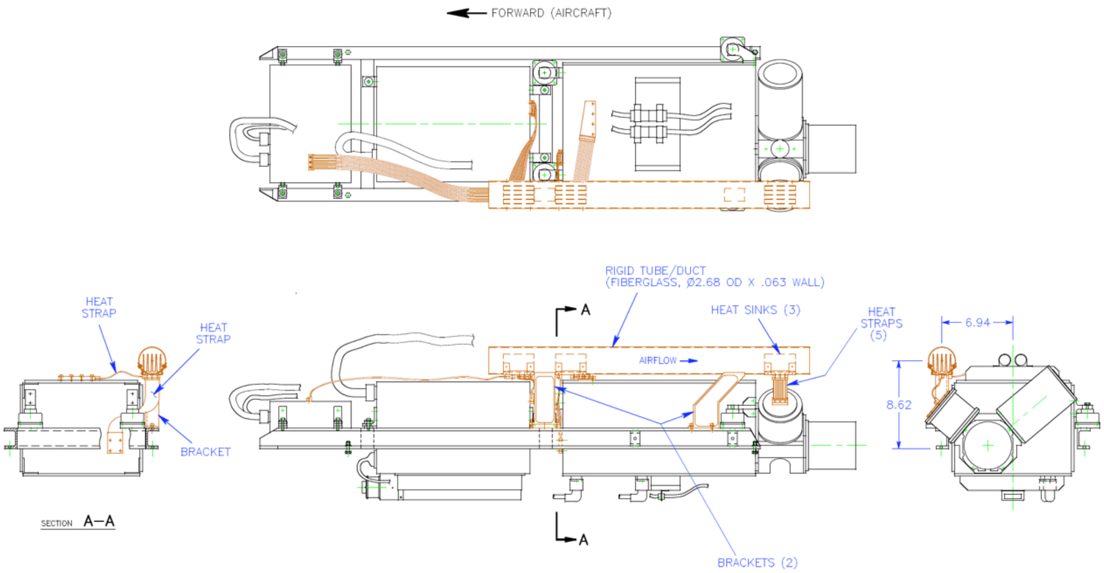

Figure 7: The flexible heat straps that are connected to heat exchangers within a tube where outside air is forced help reduce key temperatures in the S-HIS. The end-views at lower left and right show the heat exchangers mounted inside the flow tube.

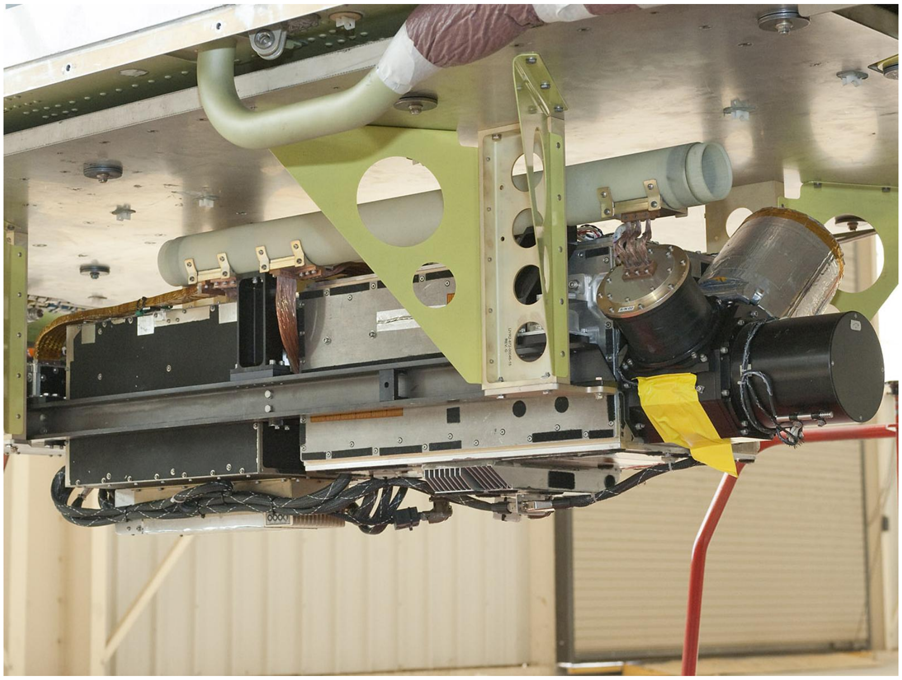

Figure 8: The S-HIS integrated to the Global Hawk with the heat straps (4 of 5 are visible) in place and connected to the rigid segment of the outside airflow tube.

4 Summary

The S-HIS measures emitted infrared radiation (580 – 2850 cm^{-1}) at high spectral resolution (0.5 cm^{-1}) with an angular field of view of 100 mrad (2 km footprint from 20 km observing altitude) and imaging accomplished via cross-track scanning. The S-HIS is well suited for the DOE AAF's newly acquired Bombardier Challenger 850 Aircraft because the S-HIS spectrally resolved infrared radiance measurements directly support many key ARM science objectives that are not fulfilled by current airborne facility instruments. Furthermore, the S-HIS is an existing state-of-the-art instrument that has demonstrated robust performance and high calibration accuracy on multiple aircraft over 35 field campaigns. The S-HIS a relatively simple instrument to support in the field, and preliminary Level 1b (geolocated radiances) and Level 2 (temperature, humidity, and trace gas profiles) products are typically available within a few hours of data download. This allows the data to be reviewed by the science team and initial conclusions to be made in a timely way for evaluating the success of experiment objectives as the field campaign progresses. When a high bandwidth downlink is available for the aircraft, the Level 1 and Level 2 products can also be processed using a real-time ground data processing system that is capable of delivering atmospheric profiles, radiance data, and engineering status to mission support scientists via a web browser in less than one minute from the time of observation. This capability was developed and utilized for flights on the NASA Global Hawk during the Hurricane and Severe Storm Sentinel (HS3) mission, and was used for near real-time changes to the flight plan.

We recommend the S-HIS initially be provided for usage on the ARM DOE Challenger 850 Aircraft as an investigator provided instrument (non-facility instrument), but would readily support the design and build of a new version of the S-HIS to serve as an ARM facility instrument in the future.

5 References

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