F-13 SSM/I INSTRUMENT FAILURE AVERTED BY REPOSITIONING SPACECRAFT SOLAR PANEL AND MITIGATING SENSOR OVERHEATING

Steve Swadley, Jeffrey Hawkins and Gene Poe
Naval Research Laboratory, Monterey CA

Dex Y. Landreth, Capt. USAF
Defense Meteorological Satellite Squadron
El Segundo CA

Eun-Sung Park and Donald J. Boucher
The Aerospace Corporation
El Segundo CA

Troy vonRentzell, Enzo Uliana and Beverly Gardiner
Interferometrics Inc.
Herndon VA

The F-13 Special Sensor Microwave/Imager (SSM/I), built by the United States Air Force Defense Meteorological Satellite Program (DMSP) System Program Office (SPO) and launched on 24 March 1995, is the longest performing US operational satellite passive microwave imager. The Naval Research Laboratory, appointed by joint Air Force/Navy Sponsors, conducted a comprehensive F-13 SSM/I calibration/validation program within the first 3 months after launch and the instrument was found to meet instrument specifications and continued to meet specification [1] until recently due to over-heating and aging of the 85GHz vertical and horizontal polarization high frequency receiver channels. For example, the minimum/maximum receiver gain of the 85H channel from 1 January 2002 to 20 June 2009, Figure 1, presents the long-term increase in sensitivity to the annual seasonal orbital heating extremes, 283 to over 313 K, experienced by the receiver. Near the middle of May 2009 the receiver gain of the 85H channel dropped precipitously from 4-5 to about 0.5 counts/K.

The degradation in the F-13 SSM/I receiver gain was first detected by NRL via anomalous noise and graininess within the 85H GHz tropical cyclone (TC) brightness temperature (T_B) imagery products hosted on the NRL Monterey TC web page: http://www.nrlmry.navy.mil/TC.html. Subsequent investigation by an NRL scientific team revealed a tremendous loss in receiver gain, pointing toward imminent sensor failure and potentially major negative impacts on critical Navy and Air Force Environmental Data Records (EDRs) of ocean surface windspeed, rainrate and total precipitable water as well as global tropical cyclone monitoring. DMSP F-8's SSM/I launch in the summer of 1987 began the effort to routinely monitor the atmosphere, ocean, and land surfaces for both near real-time as well as numerical weather prediction (NWP) applications [2]. F-13's SSM/I served as a reference point and calibration standard due to its longevity, high sensor performance, calibration stability, and temporal-spatial intersection with many other low earth orbiting operational and research microwave imagers.

The DMSP SPO coordinated the response by a team consisting of NRL, the Air Force Weather Agency (AFWA), the Fleet Numerical Meteorological and Oceanography Center (FNMOC), NOAA's Spacecraft Operation Command Center (SOCC), Aerospace Corporation, and Lockheed Martin in a period of less than 1 week that resulted in saving the F-13 SSM/I instrument from continued overheating and imminent instrument failure. The F-13 spacecraft's solar array was quickly repositioned to provide shadowing of the SSM/I instrument, significantly reducing the amount of solar radiation and instrument temperature. The SSM/I sensor responded immediately and returned to normal operating performance levels with all data products and imagery then back in sync. Due to the orbital characteristics of F-13 and the changing solar geometry, the solar array was adjusted again several months later to ensure sufficient battery charge powered the spacecraft, once again resulting in enhanced SSM/I electronics solar heating,, but at reduced levels than originally experienced. Finally, the solar array was stowed in the "nominal" position in September 2009 and SSM/I performance remained well within specification.

The F-13 SSM/I anomalous heating and degradation of sensor performance incident highlights the need for ongoing sensor health monitoring to appropriately identify potentially serious instrument issues. A team consisting of spacecraft, sensor, cal/val, and application experts is needed in order to swiftly outline the best action items while taking into consideration a myriad of end users.

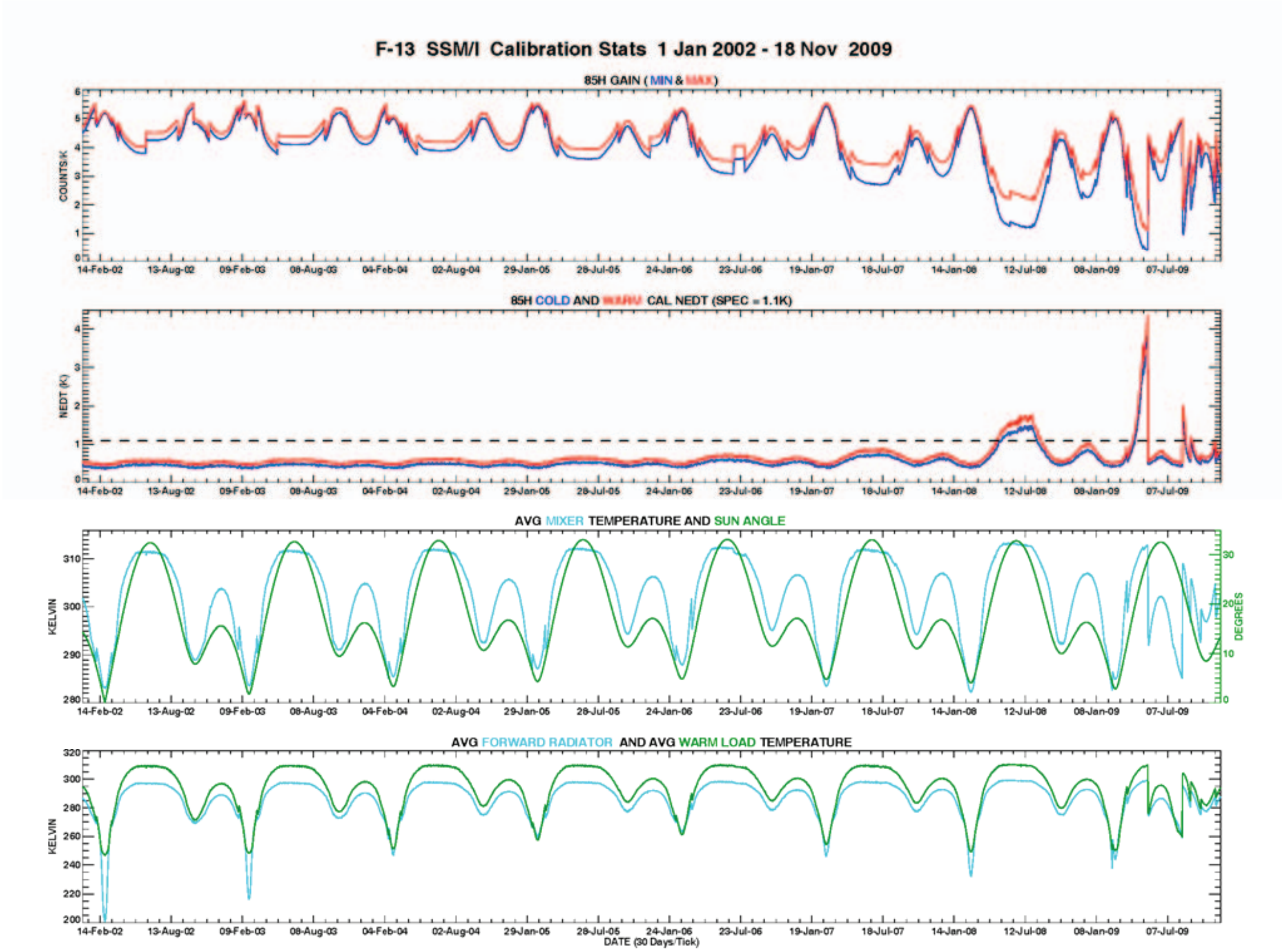

Figure 1. Time series depicting the increase in sensitivity to the annual seasonal orbital heating extremes, 283 to over 313 K, experienced by the SSMI receiver.

REFERENCES

[1] M.C. Colton and G.A. Poe, “Intersensor Calibration of DMSP SSM/I’s: F-8 to F-14, 1987-1997“, *IEEE Trans. Geosci. Remote Sens*., vol. 37, no. 1, pp. 418-439, Jan. 1999.

[2] J.P. Hollinger, J.L. Peirce and G.A. Poe, “SSM/I Instrument Evaluation”, *IEEE Trans. Geosci. Remote Sens.*, vol. 28, no. 5, pp. 781-790, Sept. 1990.