Calibrated Noise Measurements with Induced Receiver Gain Fluctuations

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The lack of well-developed techniques for modeling changing statistical moments in our observations has stymied the application of stochastic process theory in science and engineering. These limitations were encountered when modeling the performance of radiometer calibration architectures and algorithms in the presence of non stationary receiver fluctuations. Analyses of measured signals have traditionally been limited to a single measurement series. Whereas in a radiometer that samples a set of noise references, the data collection can be treated as an ensemble set of measurements of the receiver state. Noise Assisted Data Analysis is a growing field of study with significant potential for aiding the understanding and modeling of non stationary processes. Typically, NADA entails adding noise to a signal to produce an ensemble set on which statistical analysis is performed. Alternatively as in radiometric measurements, mixing a signal with calibrated noise provides, through the calibration process, the means to detect deviations from the stationary assumption and thereby a measurement tool to characterize the signal's non stationary properties.

Data sets comprised of calibrated noise measurements have been limited to those collected with naturally occurring fluctuations in the radiometer receiver. To examine the application of NADA using calibrated noise, a Receiver Gain Modulation Circuit (RGMC) was designed and built to modulate the gain of a radiometer receiver using an external signal. In 2010, an RGMC was installed and operated at the National Institute of Standards and Techniques (NIST) using their Noise Figure Radiometer (NFRad) and national standard noise references. The data collected is the first known set of calibrated noise measurements from a receiver with an externally modulated gain. As an initial step, sinusoidal and step-function signals were used to modulate the receiver gain, to evaluate the circuit characteristics and to study the performance of a variety of calibration algorithms. The receiver noise temperature and time-bandwidth product of the NFRad are calculated from the data. Statistical analysis using temporal-dependent calibration algorithms reveals that the natural occurring fluctuations in the receiver are stationary over long intervals (100s of seconds); however the receiver exhibits local non stationarity over the interval over which one set of reference measurements are collected. A variety of calibration algorithms have been applied to the data to assess algorithms' performance with the gain fluctuation signals. This presentation will describe the RGMC, experiment design and a comparative analysis of calibration algorithms.