Analyzing Non Stationary Processes in Radiometers

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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 for many scientific and engineering applications. Non linear effects of the observation methodology is one of the most perplexing aspects to modeling non stationary processes. This perplexing problem was encountered when modeling the effect of non stationary receiver fluctuations on the performance of radiometer calibration architectures. Existing modeling approaches were found not applicable; particularly problematic is modeling processes across scales over which they begin to exhibit non stationary behavior within the time interval of the calibration algorithm. Alternatively, the radiometer output is modeled as samples from a sequence random variables; the random variables are treated using a conditional probability distribution function conditioned on the use of the variable in the calibration algorithm. This approach of treating a process as a sequence of random variables with non stationary stochastic moments produce sensible predictions of temporal effects of calibration algorithms.

To test these model predictions, an experiment using the Millimeter wave Imaging Radiometer (MIR) was conducted. The MIR with its two black body calibration references was configured in a laboratory setting to observe a third ultra-stable reference (CryoTarget). The MIR was programmed to sequentially sample each of the three references in approximately a 1 second cycle. Data were collected over a six-hour interval. The sequence of reference measurements form an ensemble sample set comprised of a series of three reference measurements. Two references are required to estimate the receiver response. A third reference is used to estimate the uncertainty in the estimate. Typically, calibration algorithms are designed to suppress the non stationary effects of receiver fluctuations. By treating the data sequence as an ensemble collection, it is possible to apply temporal algorithms which exacerbate the non stationary effects. By varying the algorithm, information about the properties of the non stationary receiver fluctuations is obtained. Comparisons of analytical calculations and statistical analysis of data demonstrate impressive agreement.