Ensemble Detection Analysis for Characterizing Non-Stationary Processes
USNC-URSI National Radio Science Meeting

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There are many types of random processes and ways with which to describe them. A random process is stationary in the strict sense if its statistics are invariant to a shift in time/origin. A process is called wide-sense stationary if its first and second moment statistics are invariant to a shift in time/origin. A non-stationary process, however, has statistics that change with a translation of time/origin. A process may be non-stationary in its first, second, or n^{th} moment statistics. One of the most confounding properties of non-stationary processes is that the statistics obtained from observations depend on the sampling and processing algorithm used for analysis. Several methods such as spectrograms, Allan variances, wavelet-based approaches, and the Hilbert-Huang Transform have been used to model and analyze non-stationary processes.

Ensemble detection is a novel noise-assisted data analysis technique. The theoretical basis was derived by applying stochastic process theory to develop a generalized approach to examine uncertainty in radiometric measurements due to time varying receiver response and calibration algorithms. The approach treats the time series of samples from a radiometer's calibration references as an ensemble set of realizations of the underlying receiver response, i.e. gain. This analytical approach was verified by experiment and lead to the invention of the ensemble detector. An ensemble detector produces a set of realizations of a random process by mixing observations from it with wide sense stationary noise signals. The realizations comprise an ensemble set, which is admissible to statistical analysis and filtering algorithms that is otherwise not possible to implement using a single realization. Strict-sense and wide-sense stationary processes yield a-priori statistical relationships within ensemble sets. Non-stationarity is, thus quantified by deviations from the stationary assumption by applying functional algorithms with temporal dependency.

This presentation will describe the ensemble detection technique and its application to characterize the stationarity of random processes. Ensemble detection will be mathematically introduced and simulation results, which test and validate the mathematical description, will be described. Then the ensemble detector will be compared with other methods used to analyze non-stationary processes. Finally, statistical properties of several non-stationary atmospheric temperature measurements will be discussed using the Ensemble Detector and other techniques.