Precise Estimation of Passive Environmental Microwave Brightness Temperatures in the Presence of Weak Digital Interfering Signals

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Passive microwave remote sensing of naturally occurring thermal emissions is used to measure a wide variety of environmental parameters. For example, the ability to accurately estimate the power in such emissions directly impacts the reliability and precision of weather forecasts and data for environmental management. A leading contributor to the disability to accurately measure radiometric power for environmental applications is contamination of the signal by anthropogenic radio frequency interference.

A number of techniques for detecting and mitigating the presence of RFI in radiometric data have been proposed and tested by the by the passive remote sensing community. While several methods (e.g., threshold and subband detection) have good performance at high SNR - where the signature of the anthropogenic signal is strong - methods remain insensitive to very low levels of RFI, such as when the SNR of a continuous signal is below -10 dB. The use of the kurtosis metric improves upon these significantly, however, levels of RFI as low as -30 dB SNR can significantly bias model-based forecasts of weather, and levels as smal as -40 dB can impact the ability to estimate climatological records.

In an effort to extend the sensitivity of RFI mitigation to such low SNR levels a Bayesian estimation technique for the detection of the presence of a class of interfering signals in radiometer data resulting from common digital modulation methods is being developed. The technique exploits the ability to sample and process the radiometric signal prior to power detection with a large number of bits using FPGA hardware along with the predictability of the amplitude distribution of the digitally modulated signal and the known amplitude distribution of the thermal environmental noise. The overall sum distribution is parameterized only by the SNR and is independent of both the specific data transmitted and (within a subset of modulation methods) the modulation scheme. The statistical limitations of this technique and its application to precision radiometry are discussed and illustrated.

By analyzing the behavior of a class of modulation schemes, specifically those modulations constrained to carrier variations in phase and/or frequency, it is shown that the presence of weak digitally modulated signals at very low SNRs are detectable at levels significantly lower than those of recently proposed methods relying on (e.g.) kurtosis. Furthermore, this method separates the contributions to the total power by the environment and interferer, thus providing a direct estimate of the environmental power.