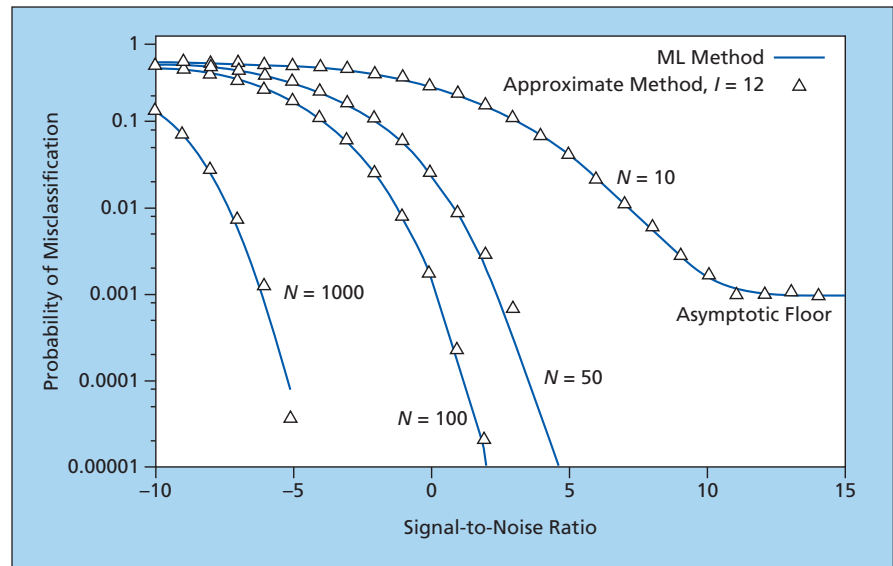ent signal types and configure themselves accordingly.

The concept of modulation classification as outlined in the preceding paragraph is quite general. However, at the present early stage of development, and for the purpose of describing the present alternative method, the term "modulation classification" or simply "classification" signifies, more specifically, a distinction between M-ary and M'-ary PSK, where M and M' represent two different integer multiples of 2.

Both the prior optimal method and the present alternative method require the acquisition of magnitude and phase values of a number (N) of consecutive baseband samples of the incoming signal + noise. The prior optimal method is based on a maximum-likelihood (ML) classification rule that requires a calculation of likelihood functions for the M and M' hypotheses: Each likelihood function is an integral, over a full cycle of carrier phase, of a complicated sum of functions of the baseband sample values, the carrier phase, the carrier-signal and noise magnitudes, and M or M'. Then the likelihood ratio, defined as the ratio between the likelihood functions, is computed, leading to the choice of whichever hypothesis — M or M' — is more likely.

In the alternative method, the integral in each likelihood function is approximated by a sum over values of the inte-grand sampled at a number, I, of equally spaced values of carrier phase. Used in this way, I is a parameter that can be adjusted to trade computational complexity against the probability of misclassification. In the limit as $I \rightarrow \infty$, one obtains the integral form of the likelihood function and thus recovers the ML classification.

The present approximate method has been tested in comparison with the ML method by means of computational simulations. The results of the simulations have shown that the performance (as quantified by probability of misclassification) of the approximate method is nearly indistinguishable from that of the ML method (see figure).

This work was done by Jon Hamkins of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-40965*

Performances of the ML and Approximate Methods were computed in simulations for a case of non-coherent reception of signals that had equal probability of being binary PSK or quaternary PSK.

Improvement in Recursive Hierarchical Segmentation of Data

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A further modification has been made in the algorithm and implementing software reported in "Modified Recursive Hierarchical Segmentation of Data" (GSC-14681-1), *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 51. That software performs recursive hierarchical segmentation of data having spatial characteristics (e.g., spectral-image data). The output of a prior version of the software contained artifacts, including spurious segmentation-image regions bounded by processing-window edges. The modification for suppressing the artifacts, mentioned in the cited article, was addition of a subroutine that analyzes data in the vicinities of seams to find pairs of regions that tend to lie adjacent to each other on opposite sides of the seams. Within each such pair, pixels in one region that are more similar to pixels in the other region are reassigned to the other region. The present modification provides for a parameter ranging from 0 to 1 for controlling the relative priority of merges between spatially adjacent and spatially non-adjacent regions. At 1, spatially-adjacent-/spatially-non-adjacent-region merges have equal priority. At 0, only spatially-adjacent-region merges (no spectral clustering) are allowed. Between 0 and 1, spatially-adjacent-region merges have priority over spatially-non-adjacent ones.

This program was written by James C. Tilton of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1). GSC-14994-1*
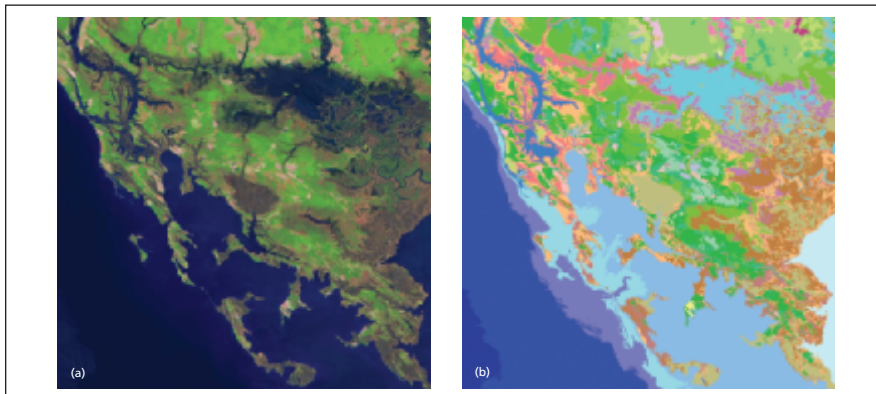
A Segmentation of the Landsat ETM+ Image displayed on the left is shown on the right. The new approach eliminates processing artifacts.