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TEXTURE-BASED CLOUD CLASSIFICATION

by

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I. INTRODUCTION

Clouds have a large impact upon the earth's radiative budget. Accurate monitoring of climate change, as well as improved modeling of general circulation and climate, requires more complete understanding of cloud-radiative interactions. For instance, recent studies have shown that GCM calculations are sensitive to the way that clouds are parameterized indicating that more accurate parameterization of cloud types is required, as well as more accurate treatment of the cloud-radiative interaction. GCM and climate models do not yet consider the important effect of fractional cloud cover and spatial inhomogeneities. However, numerous studies have shown that the radiative properties of broken cloudiness are much different from their plane-parallel counterparts. Therefore, not only is cloud type important in classification studies, but also the subspecies (e.g., cirrus, cirrocumulus, and cirrostratus).

Standard cloud classification algorithms rely on multispectral signatures to identify high, medium and low clouds. However, single-channel, high spatial resolution satellite imagery is found sufficient to classify cloud types wit accuracies of about 85% using texture-based features. It is significant that this method is capable of distinguishing high cirrus clouds from low clouds strictly on the basis of spatial brightness patterns.

The purpose of the 1988 ASEE Summer Program has been 1) to broaden the application of texture-based cloud classification approaches to lower spatial resolution goes imagery, and 2) to design texture-based approaches for determining cloud cover over high albedo surfaces.

II. GOES IMAGERY.

A large number of 256 x 256 pixel regions in the visible spectrum have been selected from goes imagery, along with coincident 64 x 64 pixel regions in the infrared spectrum. Each of these subregions have been identified according to cloud and surface type. For each subregion, the spectral and textural features have been determined. Textural features have been computed using the gray level difference vector method and the gray level sum/difference methods. These approaches provide classification accuracy equivalent to that obtained using the gray level co-occurrence matrix method, but with significant savings in both computer storage requirements and runtime. The main effort has been focused upon accumulation of a database sufficient to insure statistical reliability in the classifier. Stepwise discriminant analysis has been used for classification. This is a sequence of analysis steps which adds or deletes a feature variable at each step of the classification process. The variable which provides the greatest separation between classes is added to (or the variable which adds the least separation is sometimes deleted from) the discriminant function.

The procedure is as follows:

1) The gray levels of the visible image are divided by the cosine of the solar zenith angle to produce uniform brightness ranges;
2) Thresholds in the visible and infrared spectrums are determined which separate cloud from surface;
3) Difference vectors and sum/difference vectors are computed as a function of pixel separation;
4) Textural measures are computed - angular second moment, contrast, entropy, local homogeneity, correlation, asymmetry, kurtosis, etc;
5) Discriminant analysis is applied to classify each could and surface type; and
6) Monte Carlo analysis is used to determine theoretical accuracy of the classification procedure.

II. HIGH ALBEDO SURFACES.

Over high albedo surfaces, such as ice and snow, complex terrain, and deserts, the brightness of the surface may be equal to or even greater than cloud brightness (measure radiance). Standard brightness thresholding techniques are inadequate to distinguish and recognize cloud regions in such environments.

A number of high surface albedo images were digitized using the digital image processing facility, stored on mag tape, and textural processed. The purpose of these studies was to determine potential class separability for these surface types. The results show that detection of clouds over snow-covered mountainous terrain, over deserts, and over relatively smooth ice- and show-covered arctic regions can be attained with high accuracy. However, one problem area was identified. Cloud detection over regions of broken and severely cracked ice is more difficult, requiring further study. The goal of this program is the development of region growing and morphological filter algorithms capable of mapping cloud cover over these regions.