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Fourier transform techniques
for the inference of cloud motion

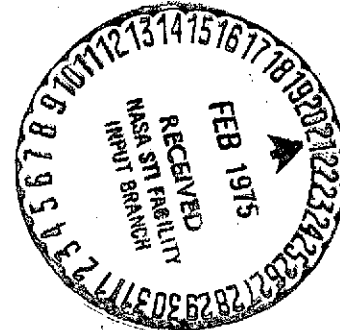
Final Technical Report
covering the period
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The main concern of this project was the development and evaluation of phase shift techniques based on the Fourier transform for the estimation of cloud motion from geosynchronous meteorological satellite photographs. An alternative approach to cloud motion estimation, involving thresholding, was also proposed and studied. Further details can be found in the following abstracts of the technical reports written on the project:

1. A study of the application of Fourier transforms to cloud movement estimation from satellite photographs

R. C. Lo and J. A. Parikh

(Computer Science Center Technical Report 242)

May, 1973

A preliminary study of the application of Fourier transforms to cloud motion estimation based on two successive satellite photographs is conducted. The primary techniques of cloud motion estimation developed are an analysis of the cross-covariance function and a Fourier phase-difference technique. Computer programs utilizing these techniques are developed.

Simulations of various changes of cloud features which are often observed in the real atmosphere are made. The cross-covariance and phase-difference techniques are applied to these cases. The results are analyzed and discussed. Since real cloud feature changes in the atmosphere can usually be regarded as one or a combination of these simulated situations, results from the present study are expected to be revealing and beneficial to the analysis of real data applications. Such applications and other further studies are planned.

2. Applications of Fourier transform methods of cloud movement estimation to simulated and satellite photographs

R. C. Lo, J. Mohr and J. A. Parikh

(Computer Science Center Technical Report 292)

January, 1974

Spectral filters of different types and sizes are applied to Fourier transforms of successive simulated and real pictures in an attempt to isolate clouds of certain types, and thus avoid the inaccuracy of Fourier transform method estimates of cloud movement, caused by the presence of a mixture of cloud motions in the pictures. The Fourier transform methods utilized are a cross-correlation technique and a phase shift technique. They are applied to the filtered transforms for the estimation of cloud motion. The simulations included in this report are designed to examine the abilities and limits of the filtering technique. The real cases chosen represent different typical cloud phenomena observed in the atmosphere. The results obtained in each case are analyzed and discussed.

3. Applications of enhancement and thresholding techniques to Fourier transform cloud motion estimation

R. C. Lo and J. Mohr

(Computer Science Center Technical Report 326)

September, 1974

Two approaches have been developed to process pairs of successive satellite photographs before they are utilized through Fourier transform techniques to derive cloud motion estimates. The purpose of this pre-processing is to obtain better cloud motion estimates than those obtained from direct methods. The first approach attempts to improve the definition of cloud features in the satellite photographs. It accomplishes its task by modifying the gray level histogram of the real picture into an artificial frequency distribution which is defined according to characteristics that are desired in the resultant modified pictures. The second approach attempts to isolate cloud motion by separating clouds of different types in the original photographs. A threshold technique is utilized to

accomplish this purpose. The Fourier transform techniques are then applied to pairs of pre-processed pictures for cloud motion estimation. The results are analyzed and discussed.

4. An evaluation of Fourier transform techniques for cloud motion estimation

A. A. Arking, R. C. Lo and A. Rosenfeld

(Computer Science Center Technical Report 351)

January, 1975

Two techniques based on the Fourier transform were developed for the estimation of cloud motion from pairs of pictures. They are the cross-correlation method and the phase shift method. They have been applied to simulated and real satellite data. Because of the restrictive assumptions involved in these techniques, the results were not very satisfactory. A frequency domain filtering technique and an enhancement technique were then developed for the improvement of the cloud motion estimates. The results of their application are discussed, and suggestions for future improvements are made.

5. The application of a thresholding technique in cloud motion estimation from satellite observations

Robert C. Lo

(Computer Science Center Technical Report 357)

February 1975

One of the greatest difficulties in cloud motion estimation from satellite photographs is the existence of mixtures of clouds. A thresholding technique based on brightness observations, using a non-linear least squares regression approach, is presented in this study. The application of this technique not only produces results consistent with those obtained from other independent techniques, but also provides information about the vertical wind profile. Further development of an automatic method of estimating parameters which are needed as input for the least squares regression approach is also suggested. A preliminary study of a two-dimensional

thresholding technique based on bivariate frequency distribution functions is also included in this report. Results from this study are promising. Further development of it should be pursued.