06

E7.6-10160
CR-146364

STUDY OF MESOSCALE EXCHANGE PROCESSES UTILIZING LANDSAT AIR MASS CLOUD IMAGERY

Earl S. Merritt (Principal Investigator)
Romeo R. Sabatini (Co-Investigator)
Earth Satellite Corporation
7222 47th St.
Washington, D. C. 20015

(E76-10160) STUDY OF MESOSCALE EXCHANGE PROCESSES UTILIZING LANDSAT AIR MASS CLOUD IMAGERY Interim Report, Dec. 1975 - Feb. 1976 (Earth Satellite Corp.) 8 p HC $3.50 CSCL 04B G3/43

N76-18581

Unclas
00160

February 1976
Interim Report for Period December 1975 - February 1976
Contract No. NAS5-20944

21540

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 20771

PREFACE AND SUMMARY

Small scale cumulus associated with both tropical and polar air masses over the central United States as observed in LANDSAT images are being analyzed. The objective of the analyses is to define relationships between the spacing and density of the cumuliform cloudiness and major terms of the surface energy and water budgets.

A visual analysis of cloud cover and albedo on two of the three LANDSAT images selected yielded a weak relationship between high albedo and high cumulus concentration.

LANDSAT CCT's have been received for the selected cases. Climatological data from cooperative climatological stations have been collected and punched on computer cards.

Computer algorithms necessary to read and printout selected portions of CCT's have been developed and tested. Albedo maps for 15X15 n.m. areas surrounding selected test sites have been prepared. Heat and moisture budgets are being calculated at the test sites. These calculations will be extended to the 15X15 n.m. area albedo matrix for comparison with cloud element size and density in the next study period.

1. WORK ACCOMPLISHED DURING THIS PERIOD

1.1 Case Studies

The five potential case studies have been selected (Table 1) and analyses are underway. Surface heat and moisture budgets are being calculated for the Argonne National Laboratory, Illinois and the Manhattan, Kansas areas. Calculations are being performed for 15X15 n.m. areas surrounding the primary test sites and existing first order reporting stations in the area. A search of possible LANDSAT 2 data is now underway.

TABLE 1

Selected Occurrences of Cumuliform Clouds in LANDSAT Images

Scene ID	Area	Date	Air Mass
173615555	Illinois	29 July '74	CP
170416243	Texas	27 July '74	CP
170116024	Illinois	24 June '74	CP
131715363	Ohio	5 June '73	Modified CP
167016331	Kansas	24 May ' 74	MP & CP

1.2 First Order and Climatological Weather Data

Climatological data necessary for calculating surface heat and moisture budgets have been extracted from NOAA publications for the five cases, and punched on cards.

The data from cooperative climatological stations and first order stations in the areas of interest include maximum and minimum temperatures, daily precipitation, dew point, wind, and cloud cover. The primary calculations will be prepared at the first order (airport) locations and as possible at the lysimeter sites. The cooperative station data is being used in the extrapolation process.

1.3 Computer Software for Calculating Heat and Moisture Budgets

The software to calculate the surface heat and moisture budget terms from daily weather data is fully assembled and tested. The overall description was included in the December 1975 Interim Report. We repeat it here for easy reference. The principal subroutines employed are, 1) ETP which calculates the radiation terms of the heat budget, and the potential evaporation (ETP) by the Penman (1948) method, and, 2) SMBGT which calculates soil moisture contents of three soil layers and the actual evaporation, ET, by a method called the "Versatile Budget, VB." developed by Baier and Robertson (1966) and slightly modified by EarthSat.

1.4 Software for Calculating Surface Albedo from MSS CCT's

The software to estimate surface albedo according to the equation given on page 20 of the work proposal has been completed and tested. The description of the routines was included in the December Interim. It is repeated here for easy reference. The estimation of the albedo consists

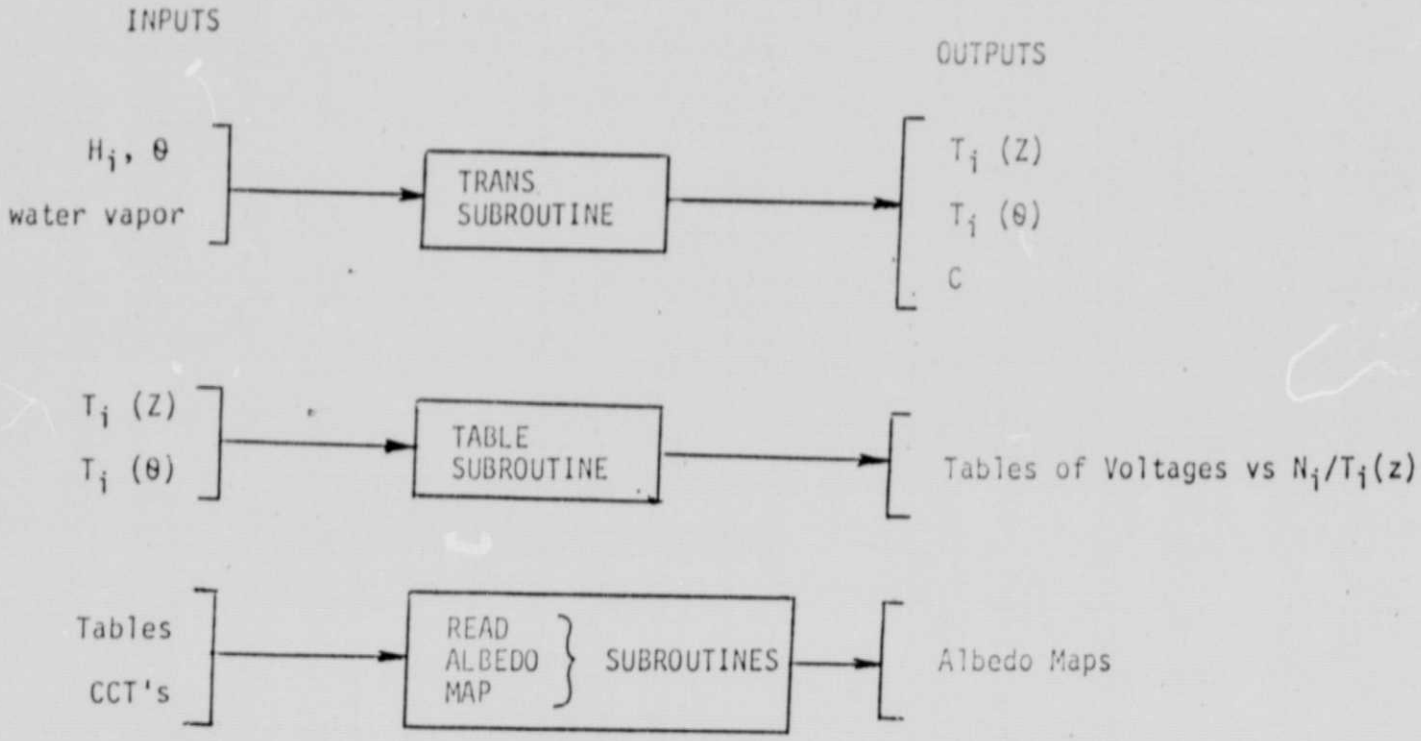

Figure 1

Input - Output of Software for Albedo Calculations

of three parts:

1) Calculation of verical and slant-path transmissivities, $T_i(z)$ and $T_i(\theta)$, for the LANDSAT case in question.
2) Construction of a look-up table of MSS channel voltage count V_i versus channel radiance divided by zenith transmissivity $(N_i/T(z)_i)$.
3) Reading of CCT's and translation of voltage counts to albedoes, A, by

$$A = C \cdot \sum_{i}^{4} \left(N_i / T_i(z) \right)$$

where

$$C = \pi / \cos\theta \left(\sum_{i}^{4} H_i T_i(\theta) \right)^{-1}$$

C is a constant for the specific case in question and is calculated in part (1). θ is solar elevation angle. H_i is solar radiance at top of atmosphere for MSS channels i = 1,2,3,4. The sequence of calculations is schematically illustrated in Figure 1.

The first part of the albedo estimation is accomplished by the TRANS SUBROUTINE, and requires as input solar elevation angle θ, solar radiances at top of atmosphere, H_i, and atmospheric water vapor.

The construction of the tables of Voltage counts vs. $N_i/T_i(z)$ greatly speeds up the albedo calculations. Additionally in the READ SUBROUTINE the MSS Voltage counts are sampled at specified intervals and values above certain threshold typical of clouds are eliminated so that the data are representative of surface albedo. The sampling scheme keeps down computer time and assures and adequate sample number. A recent change in the procedure outlined in the December Report improves the spatial resolution to approximately .25 n.m. rather than the 5 n.m.

specified in the report. This change was introduced to assure that our albedo calculations were representative of the potential effects on significant cloud formation. Cloud size per element might be reasonably assumed to average at .25 n.m.

1.6 Albedo Map Preparation

We have completed albedo maps for 15X15 n.m. areas centered on the lysimeter sites near Manhattan, Kansas and Weslaco, Texas for 6 May 1974 and 4 May 1974, and Argonne National Laboratory in Illinois on 29 July 1974. The maps are geographically referenced through identification of landmarks. Additional calculations are currently under way for other 15X15 n.m. areas withing the LANDSAT scenes.

1.7 Heat Budget Calculations

Heat and moisture budget calculations are now underway for the specific areas identified in Section 1.6. These calculations are being performed at points using the techniques referred to in Section 1.3. Matrices of heat and moisture budget values will be computed for the overall 15X15 n.m. area at a, to be selected, scale by varying albedo and, if possible, soil moisture and temperature in the point calculations. These matrix calculations will be used in correlation with cloud element size and density.

1.8 Cloud Analyses

1:250,000 scale enlargements of the LANDSAT scenes over the five selected areas have been ordered from NOAA EDS. As soon as those images are received we will evaluate cloud element size and cloud density at one (1) square mile intervals over the 15X15 n.m. albedo areas. These values will be derived visually rather than by computer. The resulting values will be correlated with the heat and moisture budget matrix calculations.

2. PROGRAM FOR NEXT REPORTING PERIOD

During the next three month reporting period we will accomplish the following activities:

(1) Extend the point calculations of heat and moisture budgets to a matrix encompassing the full 15X15 n.m. area.

(2) Perform additional albedo and heat budget computations for areas other than those listed in this report.

(3) Evaluate cloud density and element size on the 1:250,000 images where they have been received.

(4) Initiate correlation analyses of heat and moisture budget and cloud fields.

3. DATA USE

In the investigation to date we have the following data use:

1. Value of Data Allowed

Bulk	768
CCT	9600

2. Value Ordered

Bulk	350
CCT	2400

3. Value Received

Bulk	200
CCT	2400