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INVESTIGATION OF THE APPLICATION OF
HCMM THERMAL DATA TO SNOW HYDROLOGY

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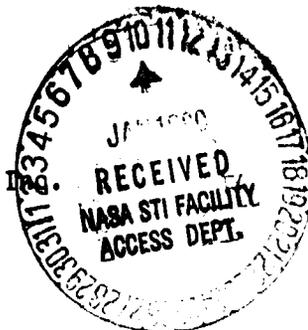
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1. INTRODUCTION

1.1 Objectives of Investigation

The objectives of the investigation of the application of HCMM thermal data to snow hydrology (HCMM Investigation No. 036) are as follows:

- (1) determine practical utility of HCMM thermal IR data to establish distribution of snow cover and determine accuracy of temperature measurements;
 - a. determine accuracy of surface temperatures acquired through use of HCMM thermal IR measurements,
 - b. determine relative resolution utility between VHRR and HCMM for thermal IR measurements, and
 - c. specifically delineate and quantify the problems involved with measuring snow temperature from space and relate them to present and planned earth observing satellite systems. This objective will take into consideration and utilize the capability of HCMM for day and night thermal measurements over appropriate sites and the satellite's eight-day repeat cycle;
- (2) determine if and how HCMM measurements can be factored in with Landsat data into an overall snow hydrology program related directly to snowmelt runoff prediction; and
- (3) develop an approach to automated data processing of combined visible and thermal infrared satellite acquired data to provide information of interest and use to the snow hydrologist.

1.2 Anticipated Results

The primary anticipated result of the proposed investigation is the development of improved techniques for the mapping and analysis of snow cover using spacecraft-acquired data. The results will provide an evaluation of the usefulness of high resolution thermal infrared data for snow mapping and for input to snowmelt prediction programs; and will provide a better understanding of the relationships between the measured

temperature values and such factors as type of snow, snow depth, type of terrain, and vegetation. The mapping and analysis techniques can then be applied to the automatic processing of data from future spacecraft systems, and will eventually enable snow survey, which is a vital part of water resources management, to be accomplished on a more cost-effective basis.

2. ACCOMPLISHMENTS DURING REPORTING PERIOD

2.1 Sierra Nevada Test Site

During this reporting period, several additional HCMM images have been received. Early in the period, the data sample for the Sierra Nevada test site was reviewed, and a number of CCT's were ordered. By the end of the period, CCT's for the following dates had been received:

- (1) 14 May 1978 - night IR
- (2) 30 May 1978 - night IR
- (3) 31 May 1978 - day IR
- (4) 17 July 1978 - day IR
- (5) 31 March 1979 - day IR
- (6) 3 April 1979 - night IR
- (7) 4 April 1979 - night IR
- (8) 27 April 1979 - day IR

The analysis of the Sierras test site has been concentrated on the 30-31 May 1978 case, for which the CCT's had been received earlier. As mentioned in the previous report, this is an excellent case because of the day/night sequential HCMM coverage as well as HCMR data from U-2 flights on 31 May and 1 June. Recently, a HCMM image for 29 May has also been received. The day/night registered data product has been requested for this case; the preliminary analysis has indicated day/night temperature differences of about 6°C for snowcovered areas and as much as 20°C for non-snowcovered terrain.

2.2 Arizona Test Site

During this reporting period, five CCT's containing digitized infrared data for the Arizona test site during the late winter and early spring of 1979 were received. These data are for the daytime passes of 9 and 15 February, 24 March, and 4 and 15 April. No nighttime data were available for these dates. A CCT for a nighttime pass on 7 February has also been received but has not yet been processed because of apparent considerable cloud cover over the test site.

The processing of the tapes (infrared data) for each of the above dates has been completed, and analyses of the data is in progress. The initial analysis indicates a rather broad range of temperature across the snowpack in each instance. These variations, of as much as 8° to 10°C, appear to correlate with changes in elevation of the terrain. The location of the lowest temperatures within the snowpack correspond to maximum elevations within the Salt-Verde watershed. Also, there appears to be a steady increase in the temperature of the snow surface throughout the period from early February to mid April.

For the most part, differences in grey scale are not detectable across the snowpack in the infrared images. On the infrared image of 15 April, however, there does appear to be a subtle grey scale variation detectable across the rather limited remaining snow extent. The positive transparencies of each of the infrared images have been received and are being examined to determine if grey scale variations corresponding to locations of temperature variation can be detected.

Considerable ground truth information has recently been received from the Soil Conservation Service (Phoenix office), and from the Watershed Division of the Salt River Project. These data include snow-course measurements, aerial survey maps, snow-extent maps derived from GOES satellite images, SNOTEL data, and miscellaneous ground observations for the winter and spring of 1979. Plots of the snowcourse data show rapid snowmelt conditions existing over most of the test site during late March and early April.

2.3 Contract Schedule

A request for a six-month extension in time for the investigation has been approved. With the revised schedule, the draft final report is now due 23 April 1980 and the final report 23 June.

3. PROBLEMS

We have recently received U-2 High Altitude Multispectral Scanner data for a day/night mission on 4 April 1979 over two of our HCMM test sites (Sierras and Central Arizona). The U-2 data are needed in the investigation to correlate with the corresponding HCMM satellite data in the analysis of snowpack surface temperatures. Earlier U-2 data for the Sierras test site in May and July 1978 were collected using the Heat Capacity Mapping Radiometer (HCMR).

Computer programs to process the U-2 HCMR data were written early in the contract period. We have now found that a considerable amount of effort will be required to handle the data from the new Multispectral Scanner, and we are currently involved in writing the necessary programs. Moreover, because of the high data rate of the Multispectral Scanner, a significantly greater amount of computer time will be required to process useable segments of the flight lines (even for only one or two spectral bands).

The new U-2 data appear to be of excellent quality, and we believe that it is essential that these data be used in the investigation. However, it will not be possible to work with any significant amount of the U-2 data under the existing resources of the contract. A request for additional funds, therefore, has been submitted.

4. PLANS FOR THE NEXT REPORTING PERIOD

An adequate sample of HCMM data has now been received, or is on order, to undertake the analyses needed to meet the original objectives of the investigation. The only data not yet on hand that will be needed are some additional CCT's (ordered but not yet received) and the day/night registered data (temperature differences). Because of the substantial

number of cloud-free HCMM passes and good supporting data, the remaining effort will be concentrated on the Sierras and Arizona test sites.

For the Sierras test site, the analysis will be carried out primarily for the cases with day/night sequential HCMM coverage. In addition to the 30-31 May 1978 case, day/night CCT's are on order for the case in July 1978, which also has HCMR data from corresponding U-2 flights. Another excellent case is expected to be in early April 1979, where another daytime pass may be available to go along with the nighttime passes of 3 and 4 April and the daytime pass of 31 March. The improved data from the U-2 High Altitude Radiometer are also available for day/night flights on 4 April; we anticipate that the requested additional funds will be provided, so that these U-2 data can also be processed and included in the analysis.

For these cases, the IR temperatures from the HCMM passes and U-2 flights will be compared for selected areas, and the day/night temperature differences will be determined. The temperature thresholds associated with snow cover will be examined, and relationships between the observed IR temperatures and snowmelt conditions will be investigated. Atmospheric corrections will be applied to the cases analyzed.

Because of the lack of nighttime passes over Arizona, the analysis for that test site will be concentrated on the behavior of the observed temperatures as the snowpack depletes during the melt season. As discussed in Section 2, several cloud-free passes were taken between mid-February and mid-April, and good correlative snow data for the Salt-Verde Watershed have been received for this period.

5. TRAVEL

No travel related to the project occurred during this reporting period.

6. PUBLICATIONS

No material related to this investigation was published during this reporting period.

7. SIGNIFICANT RESULTS

No significant results have been obtained through the ninth reporting period of the investigation.

8. FUNDS EXPENDED

Approximately 60 percent of the available funds have been expended to date. As stated in Section 3, additional funds have been requested for the analysis of the U-2 High Altitude Multispectral Scanner data. Early in this next reporting period, we will examine carefully the overall financial status of our contract to determine whether other additional funds will be needed to insure that the investigation can be completed meeting all originally proposed objectives.