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DRYLAND PASTURE AND CROP CONDITIONS AS SEEN BY HCMM

Progress Report for Period
January 1978 - April 1978

Prepared for

NASA - Goddard Space Flight Center
Greenbelt, Maryland 20771

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By

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1.0 BACKGROUND AND SUMMARY

1.1 Background

This 16-month project is an extension of several other projects which involve estimates of wheat yield (Harlan et al., 1978), green biomass (Deering et. al., 1977), and watershed runoff coefficient (Blanchard, 1978) using visible, near infrared and passive microwave data. In each estimate, soil moisture content is a major determining factor. The hypothesis of this study is that high resolution thermal infrared data, such as those received from HCMM, will enhance estimates of soil moisture content. Therefore, the three objectives of this project, as given in the statement of contract NAS 5-24383, are

1) to assess the capability for determining winter wheat and pasture canopy temperatures in a dryland farming region from HCMM data.

2) to assess the capability for determining soil moisture from HCMM data in dryland crops (winter wheat) from adjacent range lands.

3) to determine the relationship of HCMM-derived soil moisture and canopy temperature values with the condition of winter wheat and dryland farming areas during the principal growth stages.

To accomplish these objectives measurements will be obtained at three levels: ground truth, aircraft, and satellite. The sites selected for these measurements are on the Washita River watershed, near Chickasha, Oklahoma. The area has a dense USDA/ARS network of rain gauges, and rangeland and dryland winter wheat are often adjacent to each other. Ground truth data include canopy and lake surface temperatures, neutron probe and gravimetric soil moisture samples, and daily precipitation data. The aircraft will collect day/night thermal scanner data and aerial photos of commercial wheat and pasture fields; HCMM will collect day/night surface temperatures over the same sites. Data collected from each level will be correlated in three ways:

1) thermal (HCMM and aircraft) parameters of soil moisture and crop canopy temperatures will be derived,

2) a technique will be developed to calculate the antecedent precipitation indices from the thermal parameters of soil moisture and canopy temperatures, and

3) an input parameter for yield prediction models will be developed.

1.2 Summary

Accomplishments during the first quarter (January-

April 1978) were in developing a ground sampling procedure, organizing required equipment and locating sampling sites. The ground sampling procedure during the scheduled aircraft flight in May and on future HCMM overpass dates, can be divided into four different areas:

1) determining wheat and pasture grass canopy thermal emissivity,

2) obtaining soil moisture (neutron and gravimetric) samples,

3) obtaining general photos of the measurement site, and

4) determining lake surface temperature.

All of the equipment needed for sampling was purchased. A lack of personnel at the ARS office at Chickasha might limit the amount of data obtained during the aircraft flight, so personnel from the TAMU Remote Sensing Center (RSC) will assist.

In preparation for the aircraft flight in May, RSC personnel have selected sites in several commercial fields along the flight line for photographing, obtaining gravimetric soil moisture samples, and determining canopy emissivity. At permanent rain gauge sites, neutron probe tubes were placed to determine soil moisture content in lower layers of the root zone. After inventorying fields along each flight line, the west flight line was moved 10 miles to the southeast from its placement in the flight request to obtain an adequate representation of dryland winter wheat fields. Questionnaries were sent to the farmers asking for permission to sample on their property along the flight line. To increase ground coverage the flying altitude was increased from 1500 feet to 5000 feet.

2.0 ACCOMPLISHMENTS, PROBLEMS AND RECOMMENDATIONS

2.1 Accomplishments

During this first quarter, the major accomplishments were in developing a ground-truth data acquisition procedure and selecting measurement sites. During the next period, ground and aircraft data will be collected. Hopefully, HCMM will be launched into a proper orbit to begin providing day/night satellite thermal data over the Chickasha area.

Data Acquisition Procedure

To determine relative temperature difference between pasture grass and winter wheat, thermal emissivity measurements are needed. An error of .02 (2%) in ε could cause absolute temperature to be off by as much as 6° C. Emissivity is related to actual and radiative surface temperature by the following equation:

$$R = \varepsilon\sigma T^4 + (1-\varepsilon) B^*$$

where R is the emitted thermal radiation from the surface (ly min^{-1}), σ is the Stephan-Bolzman constant (8.14 ly min^{-1} °K), ε is the thermal emissivity which is considered constant (dimensionless), T is the surface temperature (°K), and B* is the background radiation emitted from the surroundings (ly min^{-1}). Therefore, the crop canopy radiative temperature will be higher than actual temperature, because of additional background radiation picked up by the radiation thermometer. B* is dependent on cloud cover--an increasing cloud cover percentage increases B*.

The instruments needed to estimate emissivity in the field, using the technique of Fuchs and Tanner (1966) as the basis, include a radiation thermometer, a large can with a hole in the bottom and lined on the inside with aluminum foil, and a reference panel (or plate) having a known emissivity. The emissivity of the plate is determined by measuring radiative temperatures (T_{pe}) of the plate over a large temperature range in a constant temperature room (to keep B* constnat). The actual temperatures of the plate (T_p) are monitored by thermistors. The slope of the curve T_{pe} versus T_p is equal to the emissivity of the plate. The large can will act as a blackbody reflecting thermal radiation on the inside of the can.

The emissivity of a canopy cover will be determined in four steps. First, the can will be placed over the plate and the temperature of the plate inside of the can will be measured. In this case, the emissivity of the target would be one (a perfect thermal emitter) and the radiative temperature would be the actual plate temperature. Second, the radiative temperature of the exposed panel would be measured. These two measurements will provide an estimate of background radiation, B*. Third, the can is placed upside down over the canopy and the canopy temperature within the can is determined. Since in this case the canopy emissivity would be one inside of the can, the radiative temperature is equal to actual canopy temperature. And finally, the can is removed from the crop and canopy temperatures are measured. Since we know B*, T and R we can easily calculate the canopy ε. Because of the dependence of B* on cloud cover, we will take these measurements under clear skies (less than 30% cover).

Because of atmospheric interference with thermal data obtained at different altitudes, the apparent surface temperature collected from aircraft or satellite platforms is determined in part by moisture and temperature profile of the atmosphere. To eliminate these effects on thermal data, the actual surface temperature of a reference surface will be correlated with reference surface radiative temperatures obtained from the sensor platform. We plan to use lake surface temperatures as the ground reference temperature during aircraft and satellite overpass times. Surface temperatures will be measured at Lake Burtchie, located southwest of Chickasha, and correlated to Fort Cobb reservoir temperatures. Fort Cobb can be detected from HCMM while Lake Burtchie will not, but manpower limitations restrict our obtaining the actual data at Fort Cobb reservoirs.

Soil moisture samples will be taken at rain gauge sites and at selected sites in commercial winter wheat field and rangeland pastures. Gravimetric samples will be taken in the commercial fields to a depth of 12 inches. About 20 feet from the edge of the road in each field, five samples will be taken at each site. The number of fields where measurements are taken is dependent on the number of farmers granting permission to take samples on their land. Neutron probe measurements down to 24 inches will be collected at the rain gauge sites along the flight lines (0-6 inch gravimetric samples will also be taken). In most cases, the roots will not penetrate below this depth in the soils of the area. Gravimetric samples will be taken back to the ARS office in Chickasha to be weighed and dried. The soil moisture content percentage by weight will be calculated by

$$\%(\mathrm{SMW}) = \frac{\text{wet weight of soil - dry weight of soil}}{\text{dry weight of soil}} \times 100$$

To compare crop conditions between fields, general color photos will be taken at each site.

Site Selection

In March, a group from the Remote Sensing Center and the ARS Watershed Lab at Chickasha constructed a field inventory of crops grown along the flight lines. Soil moisture and emissivity measurement sites were selected where wheat and pasture fields were adjacent to one another. Also, large pasture and wheat fields were selected as potential data sources after HCMM is launched. Many pasture/wheat sites were located along flight line #1 (near Pocasset, Oklahoma). Along flight line #2 (near Hinton, many irrigated wheat fields were noted because of the low water holding capacity of the sandy soil. This is not representative of the preferred dryland cropland. Therefore, we suggested that the flight line be moved 10 miles to the southeast (near Gracemont and Lookeba). Figure 1 shows where the flight lines will be now. All of the measurement sites will be mapped exactly and located on the aerial photography and aircraft thermal imagery. Ground truth data will then be correlated with aircraft thermal data.

Questionnaires were sent to the farmers who owned land where the sites were selected. It is hoped that with the cooperation of the ARS office in Chickasha, a large number of measurement sites can be used. Response so far has been favorable.

2.5 TEST SITE MAP	TEST SITE 184 Chickasha, OK	PROJECT NUMBER 0610-1

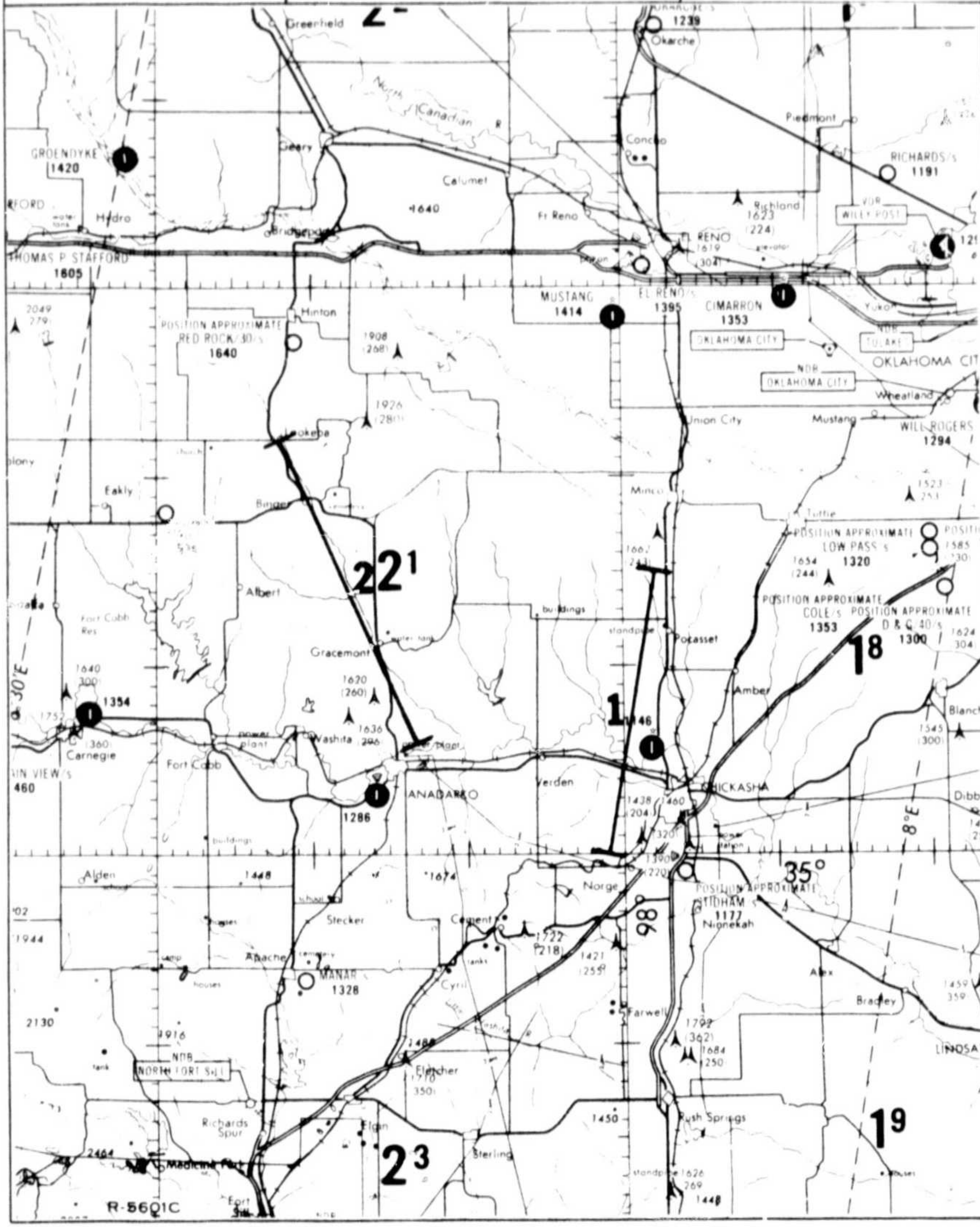

Figure 1. Proposed Flight Lines Over the Oklahoma Sites

2.2 Future Accomplishments

During the next quarter, the aircraft flight is scheduled and HCMM will be launched. We anticipate receiving and processing this data.

2.3 Problem Areas and Recommendations

Depending on the satellite o-bit, the measurement sites at Chickasha will be near the southern bounddary of day/night coverage of HCMM. If the satellite does not get into the proper orbit, Chickasha will not be covered and the aircraft flight over the area would be less significant. In spite of this potential problem, we feel enough preparation has been made at Chickasha that the aircraft flight should still be scheduled.

While inventorying the fields along the west flight line (near Hinton) it was noted that many of the fields are irrigated and the number of adjacent wheat/pasture combinations was limited. About 10 miles to the southeast, the soil changes from sand to a sandy loam, and as a result fewer fields are irrigated. This area also has several wheat/pasture combinations. Therefore, it is recommended that the flightline be moved to cover the area along Sugar Creek (Figure 1).

It was also noted that the flight request asked for a flying altitude of 1500 feet. At this altitude, the swath width on the ground would be about 1500 feet, which would cause difficulty in locating the measurement sites. A change was requested in flying altitude to 5000 feet AGL, thus increasing the swath width on the ground to 5000 feet.

3.0 SIGNIFICANT RESULTS, PRESENTATIONS AND PUBLICATIONS

No significant results have been obtained during this quarter because the NASA C-130 will not fly over Chickasha until May, and the satellite will not be launched until late April. Therefore, since no data has been collected, no publications have been published nor presentations given this quarter.

4.0 FUNDS EXPENDED

The majority of expenditures this quarter have been for salaries, travel to Oklahoma, and supplies. The amount spent is $5,105. This is smaller than the calculated average amount per quarter--$10,409. Table 1 classifies these expenditures. During the next three quarters, funds will also be expended on data acquisition and processing.

Table 1. Funds Expended for the First Quarter

Salaries & Wages	$ 3,439
Supplies	$ 1
Travel	$ 69
Other Costs	$ 33
Total Other Direct Costs	$ 103
Total Indirect Costs	$ 1,553
TOTAL FUNDS EXPENDED	$ 5,105

5.0 AIRCRAFT AND SATELLITE DATA USAGE

Because aircraft or satellite data acquisition was not scheduled during the first quarter, none was utilized.

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