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USE OF THERMAL INERTIA DETERMINED BY HCMM TO PREDICT NOCTURNAL COLD PRONE AREAS IN FLORIDA

HCMM Data Investigation HFO-002
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TABLE OF CONTENTS

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INTRODUCTION

This report covers the problems and progress of this HCMM data investigation for the period June 16, 1982, to November 15, 1982. Because of numerous problems with CCT's and with CCT processing, this HCMM Data Investigation contract was extended (no-cost) from November 15, 1982, to March 15, 1982.

Much progress has been made on processing HCMM CCT's during this reporting period. We have successfully processed a daytime and nighttime surface temperature image pair from two periods that represent two different segments of the Florida peninsula. Because the 1978-79 winter season over Florida was very frequently cloudy, few day-night images were available for comparison. For the south Florida latitude band between Lake Okeechobee and Florida Bay, we compared daytime IR images obtained on January 29, 1979, with nighttime IR images obtained on February 1, 1979. For the north Florida latitude band around the Gainesville area, we used daytime IR images from February 3, 1979, and nighttime IR images from February 1, 1979. Because climatological temperatures were so nearly the same during much of this period, very little adjustment in temperatures was required to achieve realistic day-night pairs of temperature comparisons although the image pairs were separated by more than one half day.

SUMMARY OF PROGRESS

During this reporting period, we worked with Dr. Toby N. Carlson, former HCMM contractor at the Pennsylvania State University, in adapting his boundary-layer model for use under Florida winter conditions (Carlson et al., 1981). This dynamic, complex energy balance model of the boundary layer permits estimation of surface thermal inertia and moisture availability, as well as energy balance components of sensible heat flux and latent heat flux (evapotranspiration). The computer program was quickly adapted to the Amdahl system at the University of Florida. We developed local inputs for Carlson's model as follows: local latitude and longitude for computing incominb solar radiation; atmospheric soundings from Ruskin, Florida (Tampa Bay area), to supply wind speed and direction profiles, and air temperature and dewpoint depression profiles in the troposphere. From these soundings we estimated precipitable water to be 1.0 cm. Albedo was estimated to be 0.24. The lowest level air temperature for program initialization at 0600 local time (EST) was selected from the National Climatic Centers' average of the minimum observations for the area for February 1, 1979. A soil temperature at one-meter depth of 292°K was used.

Initial runs of the model predicted values of surface temperature were outside the range of the satellite observed values. (HCMM surface temperatures were already corrected by adding 5.5°K back to the values extracted from CCT data.) The model-predicted temperatures were too high compared to the HCMM values, especially with respect to the daytime HCMM surface temperatures over north Florida wetlands.

Since cloudiness was prevalent in surrounding areas (but not over areas that were analyzed), and since atmospheric soundings over the period January 28, 1979, to February 4, 1979, frequently showed one or more layers of near-saturated air, we suspected that some cloud and reflected radiation may have actually occurred during parts of the daytime periods. We decided to increase the combination of surface and atmospheric albedo to 0.32 to account for this suspected effect. We also decreased precipitable water to 0.5 cm based on weighted estimates. We presumed that no water vapor corrections were necessary to apply to HCMM under the low water vapor contents in the winter continental polar air masses, because the data agreed well with both climatological observations and with other sources of GOES data.

One set of the HCMM day-night IR data were registered to the other set by data processing at Goddard Space Flight Center to produce a ΔT data set. This process allowed us to use HCMM data directly, without going through the data registration procedures outlined by Carlson et al. (1981).

The Carlson et al. (1981) model uses a range of fixed thermal inertias and moisture availabilities to sequentially produce a set of energy balances and to predict the surface temperatures at 20-minute intervals. Also, surface temperatures are predicted at specific satellite day-night overpass times. Carlson et al. (1981) used multiple regression analysis techniques to produce Thermal Inertia and Moisture Availability maps as a function of satellite-produced surface daytime and nighttime temperatures. We developed a slightly different procedure whereby the multiple regression equation that predicted thermal inertia had moisture availability as one of the components, and whereby the multiple regression equation that predicted moisture availability had thermal inertia as one of the components. Given satellite-observed surface temperatures at the daytime and nighttime overpass, moisture availability and thermal inertia were predicted by simultaneous solution of the best-fit regression equations.

In summary, we have good surface temperature and temperature difference digital maps for two areas and two periods in Florida (one in north Florida, and one in south Florida). We have adapted the Carlson model to predict moisture availability and thermal inertia for these scenes. We have predicted subsets of scenes from wetland areas and upland well-drained areas. These results show clearly that the wetlands areas have high moisture availabilities (near 1.0) and high thermal inertias (over $0.05\ cal/cm^3/sec^{\frac{1}{2}}/°K^{\frac{1}{2}}$), whereas the upland well-drained soil areas have low moisture availability (less than 0.4) and low thermal inertias (less than $0.05\ cal/cm^3/sec^{\frac{1}{2}}/°K^{\frac{1}{2}}$). We are consulting with Dr. Carlson to improve the relevant sensitive model input parameter measurements or estimates to improve our HCMM satellite-derived estimates of moisture availability and thermal inertia.

Specific points to be reported are covered below:

1. Problems:

During this reporting period, few problems have been encountered. We have been working with Dr. Toby Carlson, previous HCMM contractor at the Pennsylvania State University, in adapting his detailed boundary layer model to predict Thermal Inertia and Moisture Availability of two selected periods for two selected areas in Florida. The Carlson model was easily entered onto the Amdahl system at the University of Florida.

We found that it was not necessary to develop registered day-night data sets, because our day-night ΔT data supplied by NASA-Goddard Space Flight Center was in registration with either the day IR or night IR, depending upon which scenes were being compared. One problem in use of these data is that the CCT's were not clearly identified in all cases.

One other type of problem with the CCT's was that scenes were sometimes split from tape to tape without header information. This required extra programmer and computer time to verify information that was contained on tapes before we could proceed.

The main problem in using the Carlson model appears to be in obtaining adequate region-wide meteorological input information.

2. Accomplishments:

   A. We have developed quantitative temperature and ΔT maps of a band across north Florida and across south Florida, using registered data sets, for use with Carlson's boundary layer energy balance model.

   B. We have Carlson's model working, and have Thermal Inertia and Moisture Availability computations for north Florida that are being used to investigate model sensitivity and to evaluate input parameters.

   C. We adapted a new curve-fitting procedure for determining moisture availability and thermal inertia.

3. Significant results:

Temperature differences of day-night HCMM overpasses clearly differentiate wetlands and upland areas. Carlson's boundary layer energy balance model has helped quantify these temperature differences in terms of moisture availability and thermal inertia of the surfaces.

4. Publications: none yet from this sutdy because it is not yet complete.

5. Recommendations: see previous progress reports.

6. Funds expended.

7. Data utility:

The HCMM data used in this report have been useful in helping to determine thermal inertia and moisture availability of wetlands and upland areas in Florida. Topographic interference is minimal in the Florida peninsula.

8. Program for next reporting interval:

   A. Complete the quantitative comparison of thermal inertia and moisture availability on two latitude bands in peninsular Florida.

   B. Develop a thermal inertia map of Florida from these data and from apparent thermal inertia images.

   C. Refine patterns of nocturnal cold-prone and warm-prone areas from nighttime and daytime overflights.

   D. Compare wet front and dry front thermal inertia patterns.

   E. Fulfill the statement of work, prepare the final report, and submit for approval.

REFERENCES

Carlson, T.N., J.K. Dodd, S.G. Benjamin, and J.N. Cooper. 1981. Satellite estimation of the surface energy balance, moisture availability, and thermal inertia. J. Appl. Meteorol. 20:67-87.