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INTERCOMPARISON OF STANDARD RESOLUTION AND HIGH RESOLUTION TOVS SOUNDINGS WITH RADIOSONDE, LIDAR, AND SURFACE TEMPERATURE/HUMIDITY DATA

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INTRODUCTION - One objective of the FIRE Cirrus IFO is to characterize relationships between cloud properties inferred from satellite observations at various scales to those obtained directly or inferred from very high resolution measurements.[1] It is the purpose of this paper to compare satellite-derived NOAA-9 high and standard resolution TOVS soundings with directly measured lidar, surface temperature, humidity, and vertical radiosonde profiles associated with the Ft. McCoy site. The results of this intercomparison should be useful in planning future cloud experiments.

DATA - Satellite derived results were obtained by two methods. First, standard resolution (250 x 293 km subsatellite pixel size) TOVS sounding values were obtained from NOAA in the form of their standard product.[2] Second, a special high-resolution (18 x 18 km subsatellite pixel size) sounding product was created by the University of Wisconsin using only HIRS/2 instrument raw data.[3]

Radiosonde temperature and geopotential height data were extracted from the FIRE Cirrus radiosonde data set for Ft. McCoy in NASA's Climate Data System. Precipitable water amounts were calculated from raw radiosonde profiles using a method suggested by Charlock[4], integrating all possible 1.5 second reporting levels in each layer. A total of 9 cases were examined in this study. In 8 of the 9 cases radiosonde data from Ft. McCoy had launch times sufficiently close (within 3 hours of NOAA-9 overpass) as to permit a reasonable intercomparison.

Surface lidar measured cloud base altitudes for mid- and upper-altitude clouds. These data were averaged over time periods which were consistent with standard and high resolution TOVS-product pixel sizes. Additional surface observations in the form of thermograph and hydrograph data were taken on a continuous basis throughout the study period.

RESULTS - Figures 1 and 2 show that typical temperature soundings from both standard- and high-resolution TOVS compare reasonably well with the radiosonde trace. TOVS Surface temperatures displayed, in figure 3, are generally within 2 to 3^{o}K of radiosonde and/or thermograph results except on October 17th and 24th. This was also the case in the mid-tropospheric levels; however, temperatures at the 925 millibar level often displayed the greatest differences in the vertical profile.

In figures 4, 5, and 6; precipitable water amounts from both TOVS products under-estimate observed radiosonde values in the lower atmosphere while over-estimating in the 500 to 300 millibar layer. Estimates for the 700 to 500 millibar layer are split with high-resolution TOVS over-estimating and standard-resolution TOVS under-estimating precipitable water amounts.

Comparisons between lidar-measured cloud base altitudes and cloud top altitudes derived from the two TOVS products show considerable disagreement as is evident in figures 7 and 8. With the exception of October 22nd, TOVS cloud top heights were at or below measured cloud base altitudes. Of the two, the standard-resolution TOVS cloud tops display the greatest errors (approximately 5 km on average) compared to only 2.3 km for the high-resolution product.

Figure 9 compares cloud fractions from standard and high resolution products. Combining these data with cloud observation histories indicates that the cloud fraction comparisons are closest during periods approaching total overcast, while the greatest discrepancies exist with reported clear or scattered conditions. High resolution TOVS results are particularly poor on October 16th, 17th, and 18th.

CONCLUSIONS - Standard and high resolution TOVS temperatures compare reasonably well with both surface and radiosonde observations. The greatest differences occurred at the 925 millibar level. At no time are differences more than $6^{o}K$ and generally temperatures measured by TOVS were within 2 to $3^{o}K$ of the radiosonde observed values.

Precipitable water, cloud top altitudes, and cloud fractions do not compare well, or with any consistency, either with observed radiosonde values or between the TOVS products themselves. In the case of precipitable water, it appears that both TOVS products show wide scatter compared to radiosonde observed conditions. The high-resolution product appeared to give the better estimate of cloud top altitude even thought its cloud top value was less than lidar-observed cloud base for some days. For cloud fraction determination, high-resolution TOVS appears to be biased toward either clear or overcast cloud fractional amounts, while the standard-resolution TOVS fractions more closely reflect actual conditions.

REFERENCES

1. Starr, D. O'C., 1987: A Cirrus-Cloud Experiment:Intensive Field Observations Planned for FIRE. Bull. American Meteorological Society, Vol. 68, Number 2, 119 - 124.

2. Whitlock, C. H., S. R. LeCroy, and W. L. Darnell: Standard Resolution TOVS Observations for the FIRE/SRB Wisconsin Experiment Region from October 9 Through November 2, 1986. NASA TM 89151, May 1987.

3. Whitlock, C. H., D. P. Wylie, and S. R. LeCroy: High-Spatial-Resolution TOVS Observations for the FIRE/SRB Wisconsin Experiment Region from October 14 Through November 2, 1986. NASA TM 100522, January 1988.

4. T. P. Charlock, NASA Langley Research Center, Personal Communications, April 1989.

FIGURE 1. RADIOSONDE VERSUS STANDARD AND HIGH RESOLUTION TOVS TEMPERATURE SOUNDING OCTOBER 15, 1986 1957 GMT.

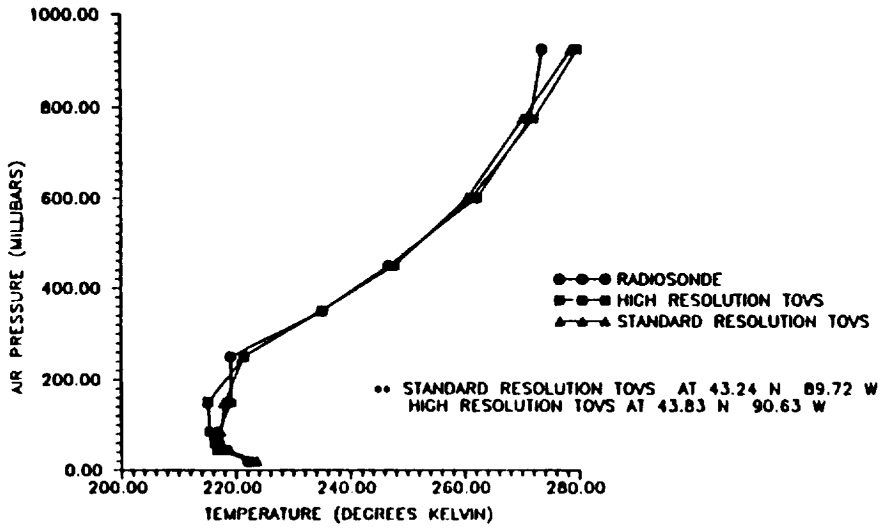

FIGURE 2. RADIOSONDE VERSUS STANDARD AND HIGH RESOLUTION TOVS TEMPERATURE SOUNDING OCTOBER 21, 1986 2033 GMT.

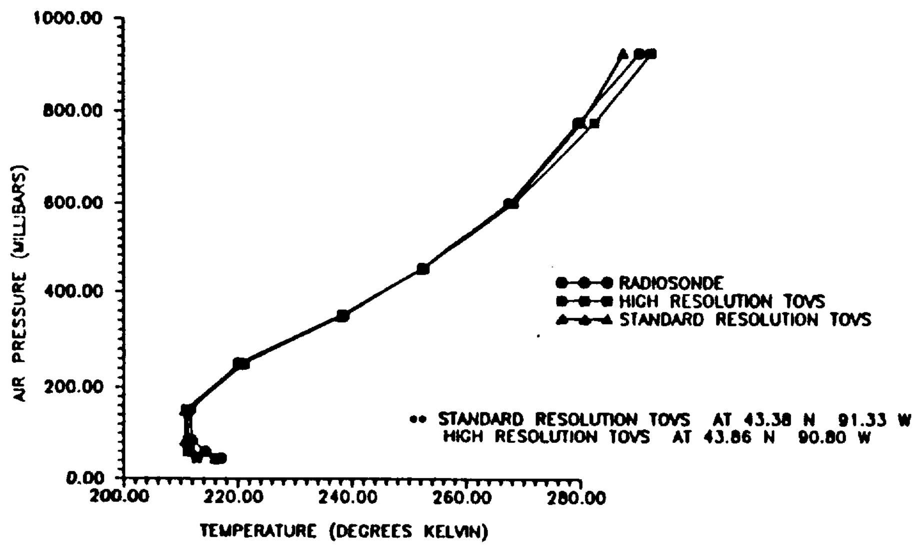

FIGURE 3. FORT McCOY SURFACE TEMPERATURES 14 OCTOBER - 2 NOVEMBER 1986.

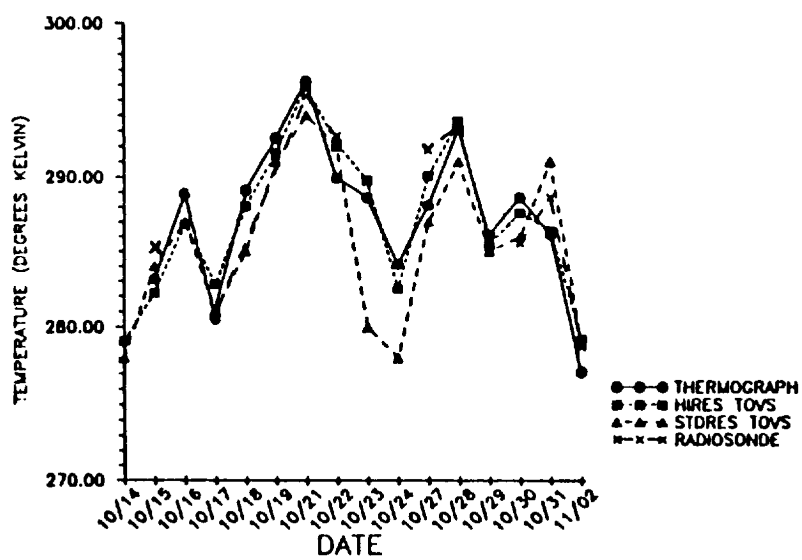

FIGURE 4. RADIOSONDE VERSUS STANDARD AND HIGH RESOLUTION TOVS SURFACE TO 700 MILLIBAR PRECIPITABLE WATER.

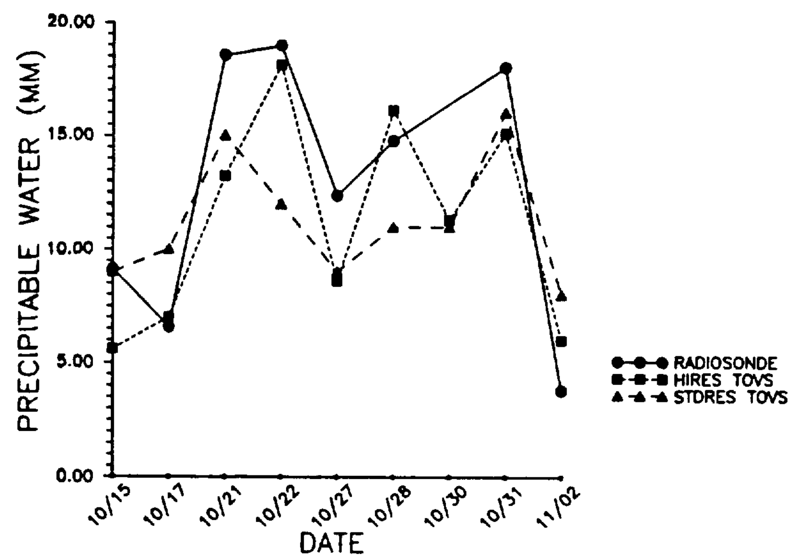

FIGURE 5. RADIOSONDE VERSUS STANDARD AND HIGH RESOLUTION TOVS 700 TO 500 MILLIBAR PRECIPITABLE WATER.

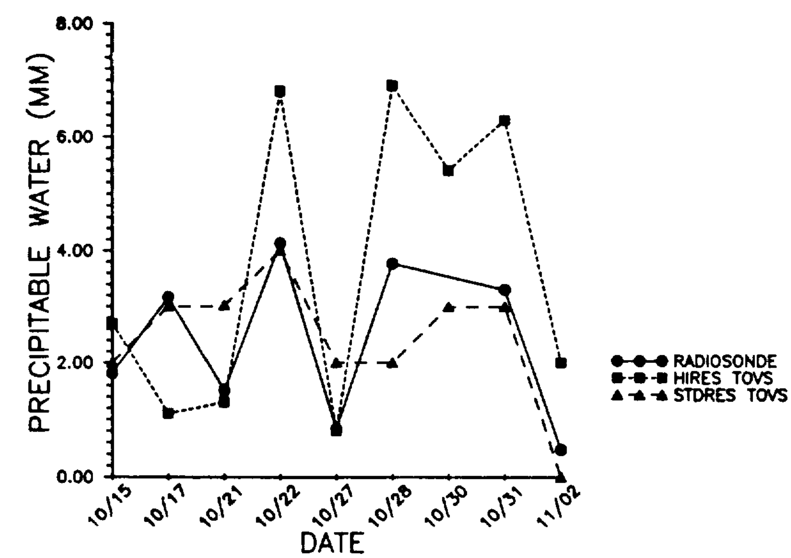

FIGURE 6. RADIOSONDE VERSUS STANDARD AND HIGH RESOLUTION TOVS 500 TO 300 MILLIBAR PRECIPITABLE WATER.

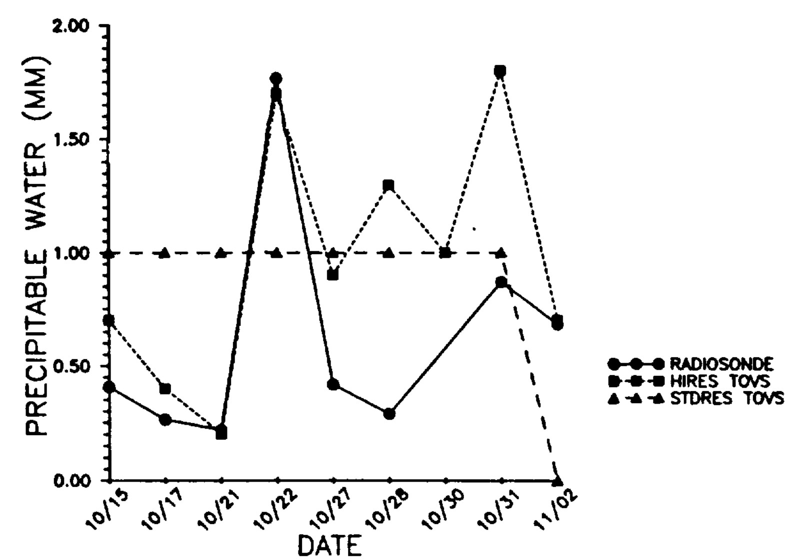

FIGURE 7. 5 HOUR AVERAGE LIDAR CLOUD BASE VERSUS STANDARD RESOLUTION TOVS CLOUD TOP ALTITUDES.

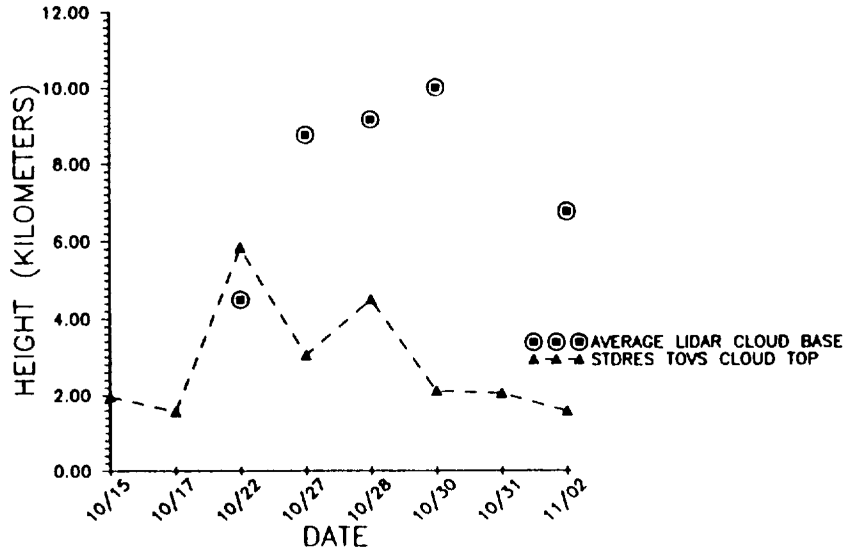

FIGURE 8. 30 MINUTE AVERAGE LIDAR CLOUD BASE VERSUS HIGH RESOLUTION TOVS CLOUD TOP ALTITUDES.

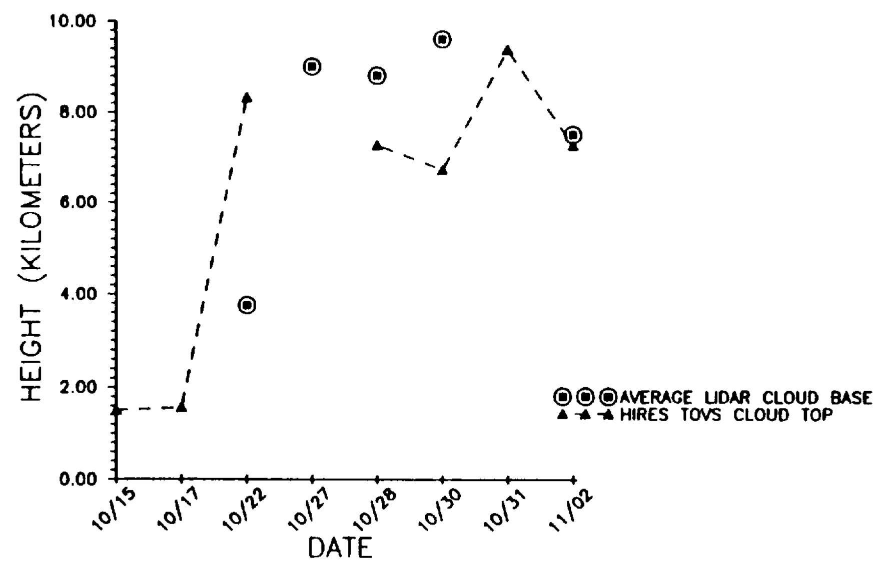

FIGURE 9. HIGH AND STANDARD RESOLUTION TOVS CLOUD FRACTIONS.