ANALYSIS OF THE GOES 6.7 μm CHANNEL OBSERVATIONS DURING FIRE II

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INTRODUCTION

Clouds form in moist environments. FIRE Phase II Cirrus Implementation Plan (August, 1990) noted the need for mesoscale measurements of upper tropospheric water vapor content. These measurements are needed for initializing and verifying numerical weather prediction models and for describing the environment in which cirrus clouds develop and dissipate. Various instruments where deployed to measure the water vapor amounts of the upper troposphere during FIRE II (e.g. Raman lidar, CLASS sonds and new cryogenic frost hygrometer on-board aircraft)

The formation, maintenance and dissipation of cirrus clouds involve the time variation of the water budget of the upper troposphere. The GOES 6.7 μm radiance observations are sensitive to the upper tropospheric relative humidity, and therefore proved extremely valuable in planning aircraft missions during the field phase of FIRE II. Warm 6.7 μm equivalent blackbody temperatures indicate a relatively dry upper troposphere and were associated with regions generally free of cirrus clouds. Regions that were colder, implying more moisture was available may or may not have had cirrus clouds present. Animation of a time sequence of 6.7 μm images was particularly useful in planning various FIRE missions. The 6.7 μm observations can also be very valuable in the verification of model simulations and describing the upper tropospheric synoptic conditions. A quantitative analysis of the 6.7 μm measurement is required to successfully incorporate these satellite observations into describing the upper tropospheric water vapor budget. Recently, Soden and Bretherton (1993) have proposed a method of deriving an upper tropospheric humidity based on observations from the GOES 6.7 μm observations. The method is summarized in the next section. In their paper they compare their retrieval method to radiance simulations. Observations were also compared to ECMWF model output to assess the model performance.

The FIRE experiment provides a unique opportunity to further verify the GOES upper tropospheric relative humidity retrieval scheme by providing

1. aircraft observations to cross-validate the calibration of the GOES 6.7 μm channel and
2. accurate upper tropospheric water vapor concentrations for verification,
3. veritical variablitity of upper tropospheric water vapor

DATA ANALYSIS

Several studies have used employed satellite observations in the 6.7 μm regime to estimate the relative humidity of the upper troposphere (Hayden *et al* 1981; Schmetz and Turpeinen, 1988; Van de Berg *et al* 1991; Soden and Bretherton 1993). This paper makes use of 6.7 μm spectral measurements made by the Visible Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS) onboard the GOES-7 satellite. The nadir resolution is approximately 16 km. Calibration of the VAS is described by Menzel *et al* (1982) and is based on comparison between satellite pre-launch tests and simulated radiance based on co-located radiosondes. These studies suggest possible biases of 1.9 °K and random noise of an individual observations of ±0.75°K.

Using the Goody random band model, assuming strongly absorbing pressure broadened lines, Soden and Bretherton (1993) demonstrated that for an atmospheric profile corresponding to a constant relative humidity and lapse rate, the 6.7 μm brightness temperature ($T_{6.7}$) varied logarithmically with the ratio of relative humidity and cosine of the viewing zenith angle. Detailed calculations of the 6. 7 m radiance using the CIMSS transmittance model suppor the presence of this relationship between T and r. Comparisons of the forward calculated $T_{6.7}$, versus

thecorresponding value of log of the normalized upper tropospheric relative indicated an rms error in using a simple retrieval of roughly 1°K or roughly 8% in terms of relative humidity.

$$\log(\tilde{r} / \cos\theta) = a + bT_{6.7}$$

where, θ is the viewing zenith angle, and $\tilde{r}$ is the mean upper tropospheric relative humidity. Recently we have derived a similar relationship for the HIRS/2 6.7 μm channel flown on the NOAA polar orbiting satellites (a=34.30, b=-0.125K^{-1}). The similarity in the between the HIRS/2 and GOES formulations gives us additional confidence in the theoretical foundations for this simple retrieval algorithm.

Using the above expression, the upper tropospheric relative humidity was derived over the FIRE central site for the entire field phase at 1/2 hourly time intervals. To faciliate comparison of pixel measuremnte over the FIRE site, cloud screening was performed by simply removing all estimates of $\tilde{r}$ >100%.. Figure 1 is a time series plot of the $\tilde{r}$. A histogram of the occurances of a given value for the entire period is shown in figure 2. Comparisons of these parameters, with observations made with the CLASS sondes and RAMAN lidar will be presented at the meeting.

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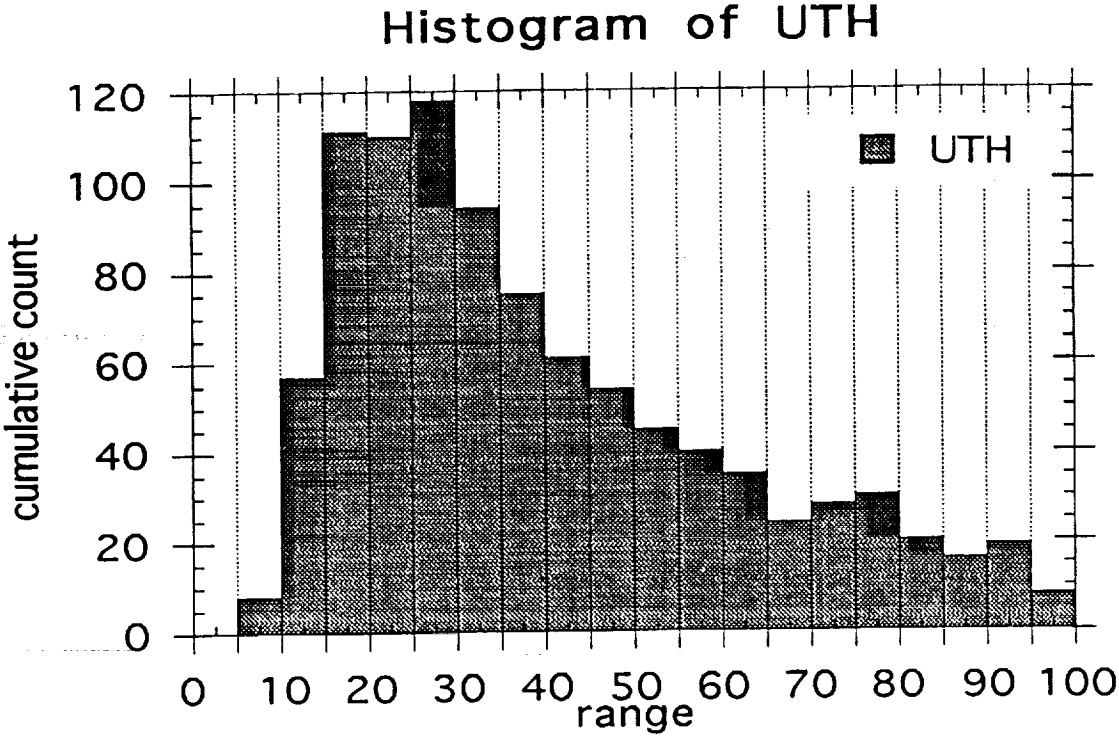
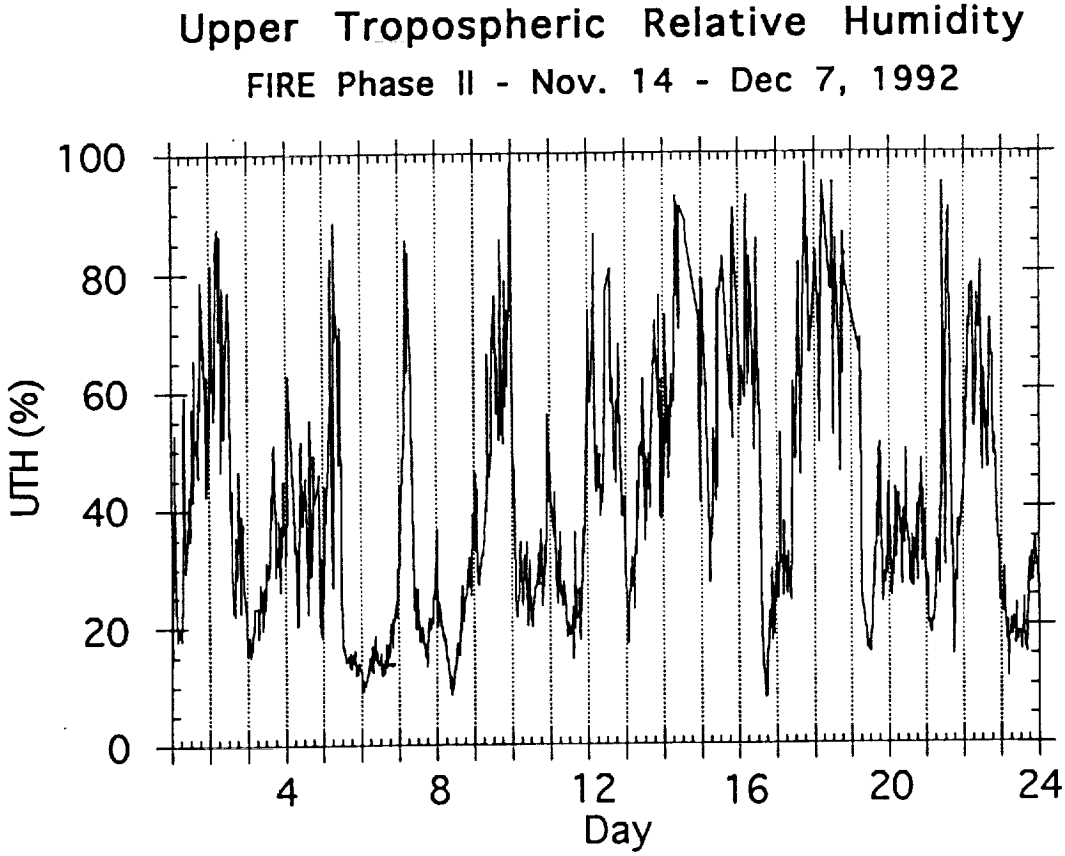

Histogram of UTH
UTH
cumulative count
range
0
20
40
60
80
100
120
0
10
20
30
40
50
60
70
80
90
100


Upper Tropospheric Relative Humidity
FIRE Phase II - Nov. 14 - Dec 7, 1992
UTH (%)
Day
0
20
40
60
80
100
4
8
12
16
20
24