# The Translation of the Tropospheric Zenith Range Effect From a Radiosonde Balloon Site to a Tracking Station

K. L. Thuleen and V. J. Ondrasik
Tracking and Orbit Determination Section

*The temporal behavior of the wet tropospheric zenith range effect, $\Delta\rho_z(w)$, over the radiosonde balloon sites at Edwards AFB and Yucca Flats, Nevada, was compared. The $\Delta\rho_z(w)$ over the balloon site may be translated to a nearby tracking station for use in performing tropospheric navigational error analysis studies and for developing models, incorporating seasonal variations, to be used for the tropospheric calibration of radio metric data. The daily variations in $\Delta\rho_z(w)$ appear to prohibit the use of radiosonde balloon data for the daily calibration of radio metric data.*

## I. Introduction

One of the error sources which corrupts range and doppler data, and thereby degrades navigational capabilities, is the troposphere. To determine the amount of this tropospheric-induced degradation, and also to improve the tropospheric model used for calibrations, it is very valuable to examine the temporal behavior of the tropospheric zenith range effect, $\Delta\rho_z$. References 1 and 2 examined the variability of $\Delta\rho_z$ throughout 1967 and 1968 by using radiosonde balloon data obtained from the radiosonde balloon site closest to each tracking station complex. Implicit in these studies was the assumption that the behavior of $\Delta\rho_z$ over the radiosonde balloon site is representative of the $\Delta\rho_z$ behavior over the tracking station. This article attempts to evaluate this assumption by comparing the behavior of $\Delta\rho_z$ over Yucca Flats, Nevada, and over Edwards AFB, California, during 1967. These two radiosonde balloon sites were chosen because the Goldstone tracking complex lies between them, as shown in Fig. 1. The comparison of the Yucca Flats- and Edwards AFB-generated values of $\Delta\rho_z$ shows that the gross features of the time behavior of $\Delta\rho_z$ may be translated from one station to the other for use in accuracy analysis studies or in the development of a tropospheric model involving seasonal variations as described in Ref. 2. Unfortunately the comparison also seems to show that the behavior of $\Delta\rho_z$ over the two sites is different enough to prevent use of the data gathered at a radiosonde balloon site to make daily calibrations of the radio metric data.

## II. Zenith Range Effect

Using the methods described in Ref. 1, the tropospheric zenith range effect can be computed from atmospheric pressure, temperature, and humidity data obtained from radiosonde balloon measurements. The total tropospheric range effect $\Delta\rho_z$ is the sum of a dry portion, $\Delta\rho_z(d)$, and

a wet portion, $\Delta\rho_z(w)$. Since the dry portion can be computed very accurately (1%) from surface pressure measurements, only the results involving $\Delta\rho_z(w)$ will be considered.

The radiosonde balloon data used in this study was obtained with the help of Mr. Richard Davis and Mr. Larry Snelson of the National Climatic Center in Asheville, North Carolina, and Capt. George Frederick, USAF.

Figure 2 shows the behavior of $\Delta\rho_z(w)$ over Edwards AFB during 1967 and over Yucca Flats for the first nine months of 1967 computed from radiosonde balloon data which went up to 24,384 m (80,000 ft). The last three months of the Yucca Flats' $\Delta\rho_z(w)$ in Fig. 2 was computed from radiosonde balloon data which went up to 6096 m (20,000 ft) and the wet model described in Ref. 2. To ease the comparison of the gross features of the time behavior of $\Delta\rho_z(w)$ over Edwards AFB and Yucca Flats, the monthly averages and standard deviations, $\sigma$, were computed and are shown in Fig. 3. For convenience the Edwards AFB and Yucca Flats monthly averages are overlaid in Fig. 4. An examination of Figs. 2, 3, and 4 shows that the gross time behavior of $\Delta\rho_z(w)$ computed from the Edwards AFB data is very similar to the same quantity computed from the Yucca Flats data. For example, the standard deviation of the difference between the Edwards AFB and Yucca Flats monthly averages of $\Delta\rho_z$ is only 1½ cm. Using the procedure described in Ref. 1, this number can be shown to give an equivalent error in the distance of the tracking station off the spin axis of 8 cm.

Because the time behavior of $\Delta\rho_z(w)$ is grossly the same for the two stations, it appears that radiosonde data taken from a nearby balloon site may be successfully used to perform the following two tasks:

(1) Determine spacecraft navigational errors generated by variations in the tropospheric zenith range effect and refractivity profile (see Ref. 3).

(2) Develop tropospheric models, which incorporate seasonal trends, to calibrate radio metric data.

In an attempt to determine the fine structure similarity of the temporal behavior of $\Delta\rho_z$, the Edwards AFB and Yucca Flats values are overlaid for the months of July and August in Fig. 5. It is difficult to obtain a measure of how much the daily variations in $\Delta\rho_z(w)$ at Yucca Flats reflect the daily variations in $\Delta\rho_z(w)$ at Edwards AFB, and vice versa, because the measurements were generally not made at the same time of day. However, at first glance, it appears that the differences between the Edwards AFB and Yucca Flats values of $\Delta\rho_z(w)$, at nearly the same time, appear to be approximately the same size as the variation of $\Delta\rho_z(w)$ about its monthly average. If this is generally true, it will not be advantageous to use data taken from radiosonde balloon sites to make daily tropospheric calibrations of the radio metric data.

## III. Summary and Conclusions

The temporal behavior of the wet zenith range effect, $\Delta\rho_z(w)$, over the radiosonde balloon sites at Edwards AFB and Yucca Flats, Nevada, were compared during 1967. The gross behavior of $\Delta\rho_z(w)$ over the two sites is very similar. This similarity enables the radiosonde balloon data to be used effectively in performing tropospheric navigational error analysis studies and developing models, incorporating seasonal variations, to be used to make tropospheric calibrations of radio data. Unfortunately, it appears that the daily variations in $\Delta\rho_z(w)$ are such that they cannot be translated from the balloon site to the tracking station for the daily calibration of radio metric data.

This study suffers from the fact that only 1967 data for Edwards AFB and Yucca Flats have been examined. It is doubtful that an examination of data obtained during different years or from different stations would modify the conclusions which have been stated regarding the gross features of the temporal behavior of $\Delta\rho_z(w)$. However, if the question of using radiosonde balloon data to make daily calibrations of radio metric data is being addressed, it will be necessary to make use of data taken from other balloon sites, and for different years.

## References


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2. Thuleen, K. L., and Ondrasik, V. J., "The Repetition of Seasonal Variations in the Tropospheric Zenith Range Effect," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VI, pp. 83–98. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1971.

3. Miller, L. F., Ondrasik, V. J., and Chao, C. C., "A Cursory Examination of the Sensitivity of the Tropospheric Range and Doppler Effects to the Shape of the Refractivity Profile," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. I, pp. 22–30. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1971.

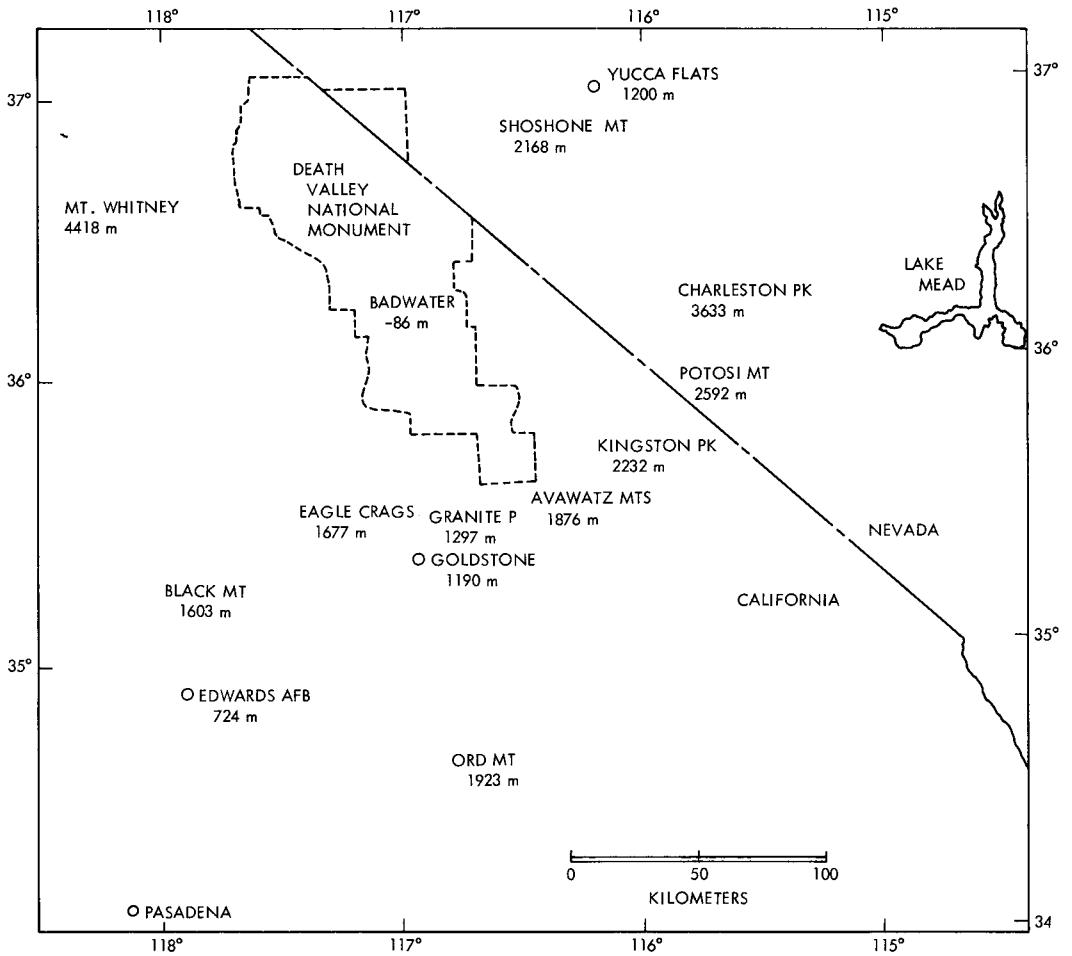


**Fig. 1. Relative locations of Edwards AFB, Goldstone, and Yucca Flats**

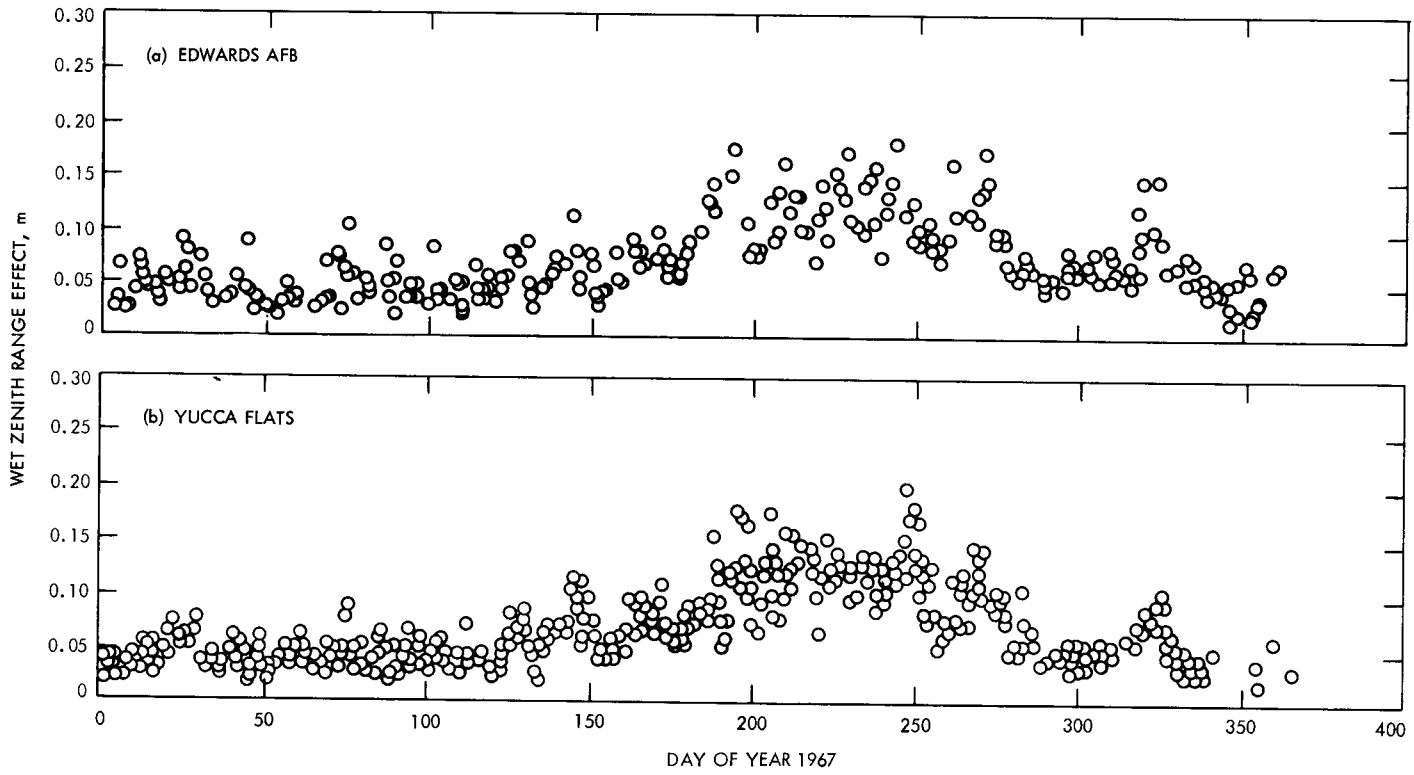


**Fig. 2. Wet zenith range effect over Edwards AFB and Yucca Flats during 1967**

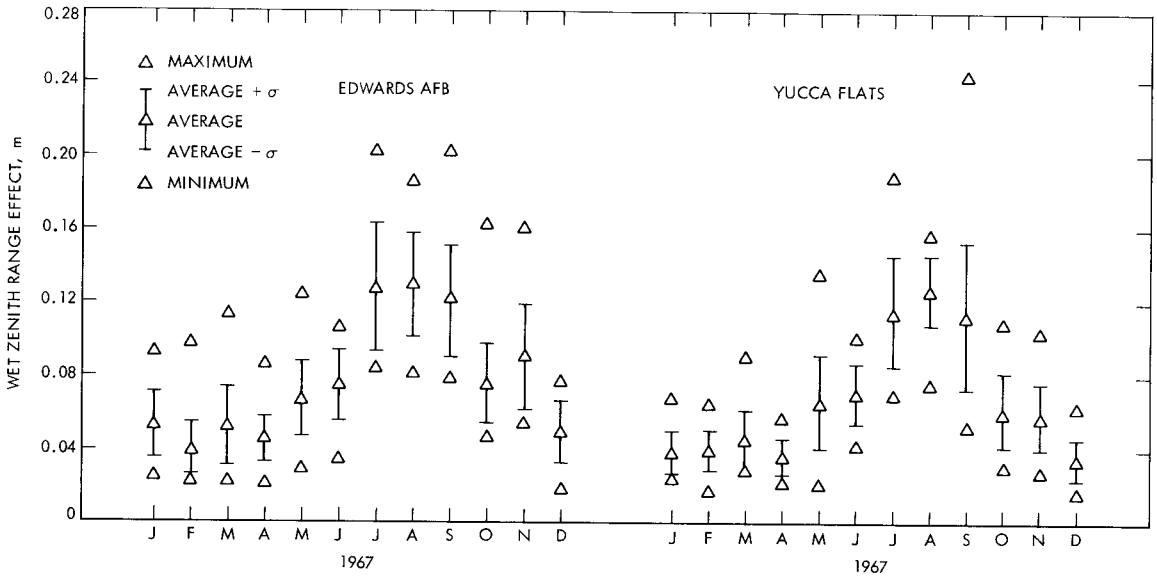


**Fig. 3. Monthly averages and standard deviations of wet zenith range effects over Edwards AFB and Yucca Flats during 1967**

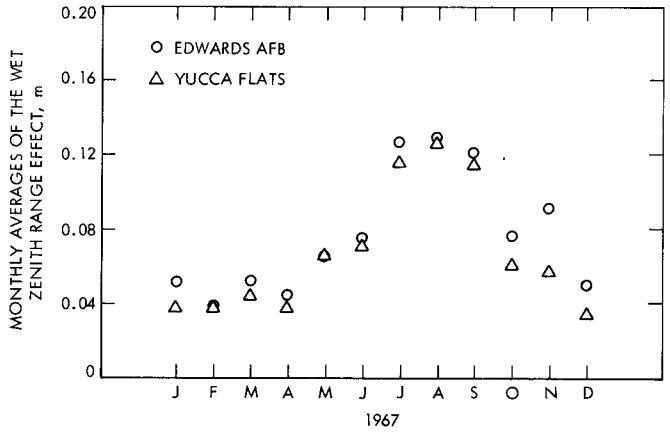


**Fig. 4. Comparison of the Edwards AFB and Yucca Flats monthly averages of the wet zenith range effect during 1967**

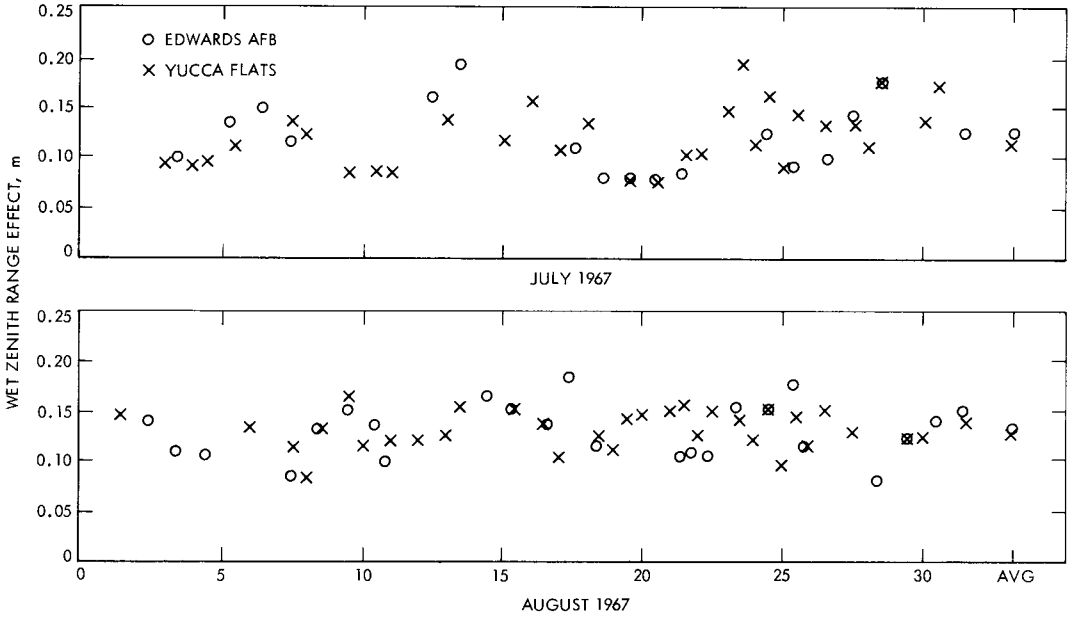


**Fig. 5. Wet zenith range effect over Edwards AFB and Yucca Flats during July and August 1967**