NOTES AND CORRESPONDENCE

Day–Night Variation in Operationally Retrieved TOVS Temperature Biases

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1. Introduction

Several authors have reported that operationally retrieved TOVS (TIROS Operational Vertical Sounder) temperatures are biased with respect to rawinsonde temperatures or temperature analyses (Phillips et al., 1979; Schlatter, 1981; Gruber and Watkins, 1982). Not appearing in the literature, however, is an indication of how these biases may vary diurnally. This note documents a significant day–night variation in the biases over the United States during one time period.

2. Background

Under development at the Illinois State Water Survey is a sophisticated variational analysis model that offers a means for blending satellite and conventional soundings in a way which preserves the information content of both data sources. However, the model requires input data that are as bias-free as possible and about which the error characteristics are known. Because gridded data are required as input for the model, we needed to know the bias of TOVS temperatures with respect to objectively analyzed rawinsonde data. None of the previous studies of TOVS biases used precisely this standard of comparison. Phillips et al. (1979) and Gruber and Watkins (1982) used nearly colocated rawinsondes as a comparison, while Schlatter (1981) used NMC Final Analyses. We decided, therefore, to recalculate the biases.

3. Data and analysis

The case study on which the variational analysis model was first run is 10–11 April 1979. To do the calibration study, we acquired TIROS-N soundings and rawinsonde data for the period 26 March through 11 April 1979. This is the same period (plus three days) analyzed by Schlatter.

Operational TOVS soundings produced by the National Environmental Satellite, Data, and Information Service (NESDIS) are retrieved from satellite-measured radiances using statistical eigenvectors (Smith and Woolf, 1976; Smith et al., 1979). The soundings on the data tapes obtained from NESDIS are in the form of layer mean virtual temperatures (Kidwell, 1985). In addition, three types of retrievals are present on the tapes: 1) clear soundings, produced when there are enough holes in the clouds that some scan spots are completely cloud free; 2) partly cloudy soundings, produced using the N^* technique (Smith and Woolf, 1976) when too few cloud-free scan spots can be found; and 3) cloudy soundings, produced when the field is completely cloud covered and only the microwave channels can be used to sound the troposphere. Because these three types of soundings have different error characteristics, they are kept separate in this analysis.

To compare the satellite soundings with rawinsonde soundings, layer mean virtual temperatures, derived from rawinsonde thicknesses, every 12 hours for the period 0000 GMT 26 March through 1200 GMT 11 April 1979 were objectively analyzed on a 21 × 21 grid (260 km grid spacing at 45°N) covering most of North

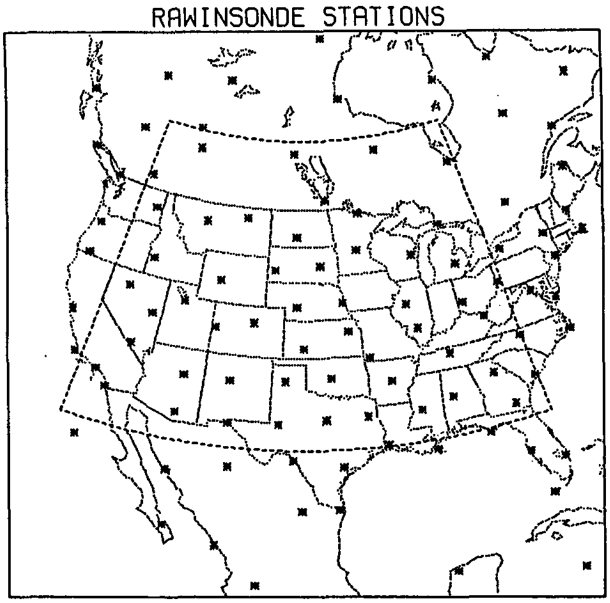
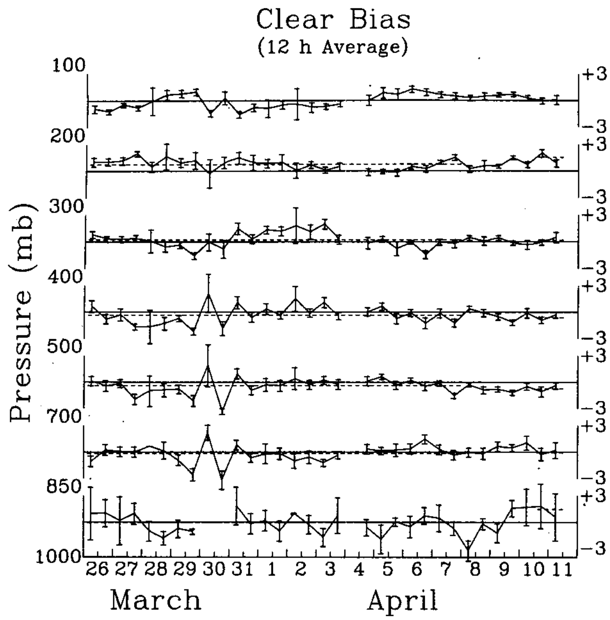
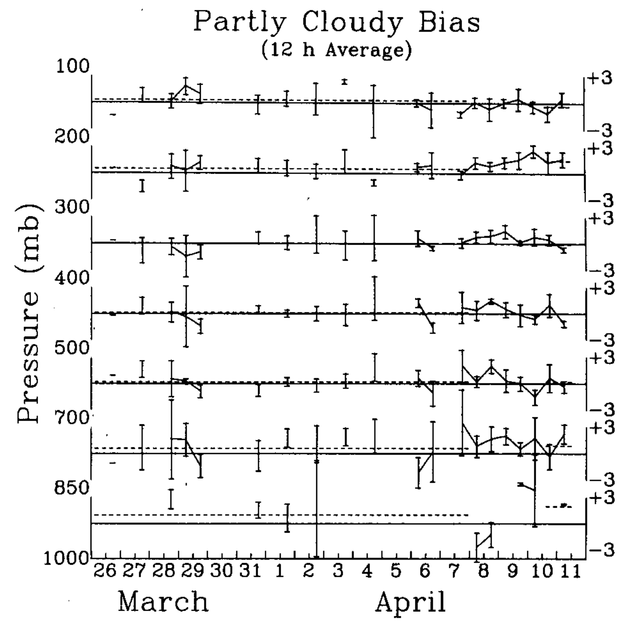


FIG. 1. Asterisks indicate the location of the 101 rawinsonde stations used to construct the objective analyses for comparison with satellite soundings. The dashed line encloses the satellite soundings. (This is the same area chosen by Schlatter, 1981.) Note that the satellite soundings are well within the boundaries of the rawinsonde objective analysis area; thus, edge effects should be minimal.





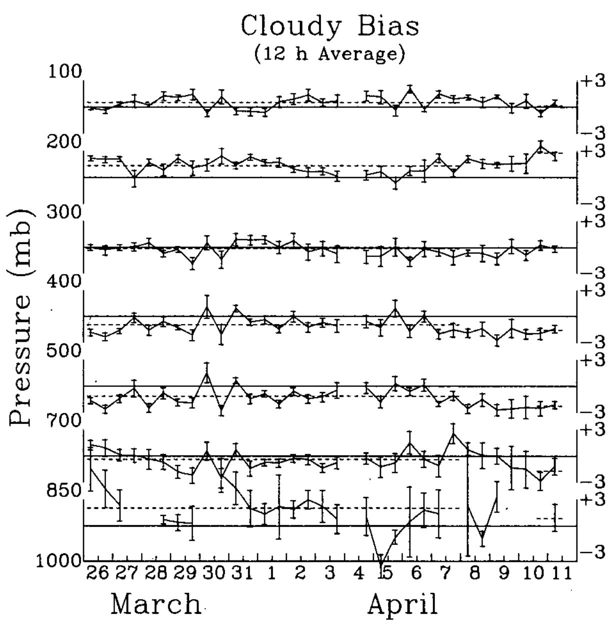
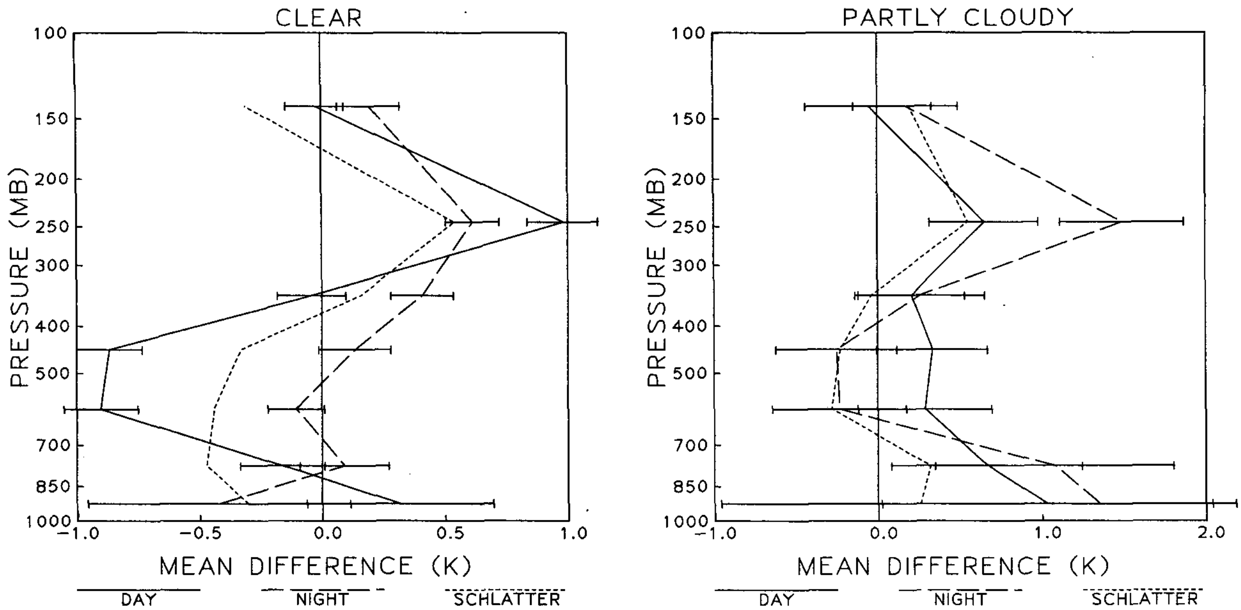


FIG. 2. Twelve-hour average biases of satellite soundings: (a) clear soundings, (b) partly cloudy soundings, (c) cloudy soundings. The error bars represent the 95% confidence interval. Dashed lines represent the average of the biases. The temperature scale on the right is in kelvin.

America (Fig. 1). Biases were estimated by calculating the difference between satellite-estimated mean virtual temperatures and rawinsonde values interpolated in both time and space from the analyses to the satellite data. Average biases were calculated for the 12-h periods centered on 0900 and 2100 GMT. Since TIROS-N had approximately 0330 and 1530 LST equator-crossing times, and since the analysis area, centered at 100°W, can be entirely observed by 2–3 satellite passes, nearly all of the satellite observations occurred within ±102 min (one orbital period) of 0900 or 2100 GMT. The 0900 GMT observations are called "night" observations, while the 2100 GMT observations are called "day" observations.

Figure 2 shows the 12-h average biases as a function of time for each layer. The dashed lines represent the mean biases for the periods 26 March through 8 April and 10–11 April. The three sounding types are plotted separately. The error bars represent 95% confidence intervals, assuming that the biases are normally distributed about the 12-h mean, which proved to be a good assumption upon examination. Two aspects are disturbing. 1) For a large number of points the error bars do not include the mean represented by the dashed line. Only one in 20 points should not include the mean if the long term average is representative. 2) There seems to be a 24-h oscillation, which indicates that day and night biases may be different. During the period



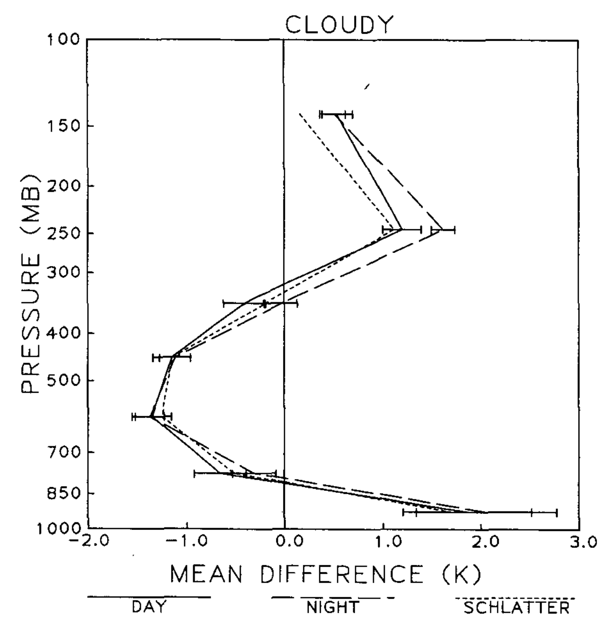


FIG. 3. Average biases for the period 26 March through 8 April 1979: (a) clear soundings, (b) partly cloudy soundings, (c) cloudy soundings. Day and night biases have been kept separate. The biases published by Schlatter (1981) are plotted for reference. The error bars represent the 95% confidence interval.

26 March through 8 April, no changes were made in the operational retrieval algorithm (Schlatter, 1981).

Day and night soundings were separated, and the mean biases for the period 26 March through 8 April were calculated. These results are plotted in Fig. 3 and tabulated in Table 1. Again, the error bars represent 95% confidence intervals. It is clear that biases for day and night soundings are statistically different (95% confidence) at most levels for clear and partly cloudy soundings, and at several levels for cloudy soundings. Day–night differences are particularly evident for clear soundings. In the midtroposphere, night soundings have little bias, while day soundings have a large cold bias. Schlatter's results are plotted for comparison. Because Schlatter did not separate day and night soundings, his biases tend to split the difference between the day and night biases. In the upper troposphere, Schlatter's biases tend to be colder than the biases calculated with respect to rawinsonde analyses.

4. Conclusions

It is concluded that at least for the time period 26 March through 8 April 1979 there was a significant day–night variation in TOVS mean layer virtual temperature biases with respect to objective analyses of rawinsonde data over the United States. Day–night variations may exist for other time periods and for other locations.

TABLE 1. Biases and standard deviations of operationally retrieved TIROS-N layer mean virtual temperatures (K).

Layer (mb)	Day			Night		
	Clear	Partly cloudy	Cloudy	Clear	Partly cloudy	Cloudy
			Biases			
200–100	−0.02	−0.05	0.54	0.19	0.18	0.51
300–200	0.98	0.65	1.20	0.61	1.49	1.62
400–300	−0.04	0.20	−0.41	0.41	0.26	−0.02
500–400	−0.87	0.33	−1.14	0.14	−0.25	−1.11
700–500	−0.90	0.29	−1.35	−0.10	−0.23	−1.37
850–700	−0.16	0.67	−0.65	0.09	1.08	−0.31
1000–850	0.32	1.03	1.87	−0.42	1.35	2.06
			Standard deviations			
200–100	1.29	1.63	1.48	1.38	1.12	1.47
300–200	1.57	1.40	1.74	1.18	1.34	1.45
400–300	1.50	1.37	1.83	1.38	1.40	1.99
500–400	1.43	1.43	1.70	1.59	1.30	1.89
700–500	1.62	1.72	1.77	1.25	1.44	1.77
850–700	1.84	2.42	2.31	1.84	2.28	2.60
1000–850	2.11	2.52	2.60	2.64	3.12	3.39

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