Differences were largest in the upper stratosphere and lower mesosphere (LIMS) temperatures. They used LIMS ozone and temperature data sets with those from Limb Infrared Monitor of the Stratosphere (LIMS) National Meteorological Center (NMC) data. They also carried out sensitivity studies by changing the temperature and ozone data sets and found that the RMCs were particularly sensitive to the temperature. Callis et al., [1987] (hereafter C87) derived RMCs using LIMS Kalman filtered temperature and ozone data. Remsberg et al., [1990] (hereafter G90) compared RMCs from a 4-year (1978-1982) climatology. The LIMS data set used by G90 and C87 are from measurements made in 1978-79. The NMC temperatures used by G90 and the BC temperatures used by C87 are multiyear climatologies. Temperature differences in the two data sets can arise from interannual variability, measurement errors or the objective analysis technique.

In this study we compare LIMS/NMC monthly zonal mean temperatures for the same time period and address the issue of temperature accuracy. Since NMC analyses in the upper stratosphere are derived from nadir-viewing sounder data, we compare LIMS/NMC temperatures with time series of high vertical resolution rocketsonde and radiosonde (RAOB) data. We also compare LIMS temperatures with the BC climatology and with the SAMS temps.

The constituent retrieval from a mid-infrared limb emission measurement is particularly sensitive to error in the black body source function and thus the input atmospheric profile. For example, a 2°K bias error in the temperature at 10 hPa can introduce a 20% error in retrieved water vapor mixing ratio (Russell et al., [1984]). Thus, the independent comparisons of correlative and satellite retrieved constituent mixing ratios are an indirect measure of the accuracy of the temperature profiles. We verify our estimates of temperature bias by referring to the quality of LIMS ozone and water vapor and SAMS N2O and CH4.

3 THE QUALITY OF STRATOSPHERIC TEMPERATURES

Temperature differences for April 1979 for LIMS minus NMC are shown in Fig. 1. (Note that the difference plot [Figure 3-f] in G90 is for NMC minus LIMS. Also their NMC is from the 4-year climatology). Both the LIMS and NMC temperatures are analyses at 12 UTC. The NMC fields used here have been modified for easier use in the analysis of stratospheric temperature fields. That is, the originally gridded NMC data are represented as coefficients of a harmonic series. Then the monthly zonal mean plots are created using the first coefficient. The NMC analyses
from 70 to 0.4 hPa in the southern hemisphere are based on satellite soundings. In the northern hemisphere the NMC analyses are based on satellite soundings and rocketsonde data from 5 to 0.4 hPa. Prior to 1984 the northern hemisphere NMC stratospheric analyses rely on RAOB data from 70 to 10 hPa. In addition, the results equatorward of 20° N are extrapolated from that latitude (Randel, [1987]). Differences near 100 hPa in Figure 1 at low latitudes are because LIMS retrievals do not follow the sharp tropical tropopause and are too warm. Differences at 10 hPa are primarily due to the NMC extrapolation of N. H. RAOB data to the Equator; thus, the effects of tropical waves are masked there.

LIMS temperatures have a vertical resolution of about 2.5 km. The information content in NMC data between 5 and 0.4 hPa comes from nadir-viewing Vertical Temperature Profile Radiometer (VTPR) and Stratospheric Sounding Unit (SSU) (after 2/25/79) instruments. The effective vertical halfwidth for VTPR and SSU channels in the upper stratosphere (Peckham [1974]) is of the order of 15 to 17 km. NMC uses a vertical regression procedure which improves the resolution of its retrieved profiles to about 10 km. Such a coarse resolution affects the accuracy of NMC temperatures at a given pressure-altitude. The temperature error patterns for nadir-sounders oscillate with a wavelength equivalent to the vertical resolution of the measurement (Jackson et al., [1990]). This characteristic is particularly evident in the upper stratosphere at low latitudes. Similar error patterns will apply to the low resolution nadir-sounder BC temperatures and the medium resolution limb viewing SAMS temperatures. Temperature accuracy during disturbed atmospheric conditions is also affected if the NMC climatological profile shape used for regression is not representative. This aspect of the NMC retrievals may also degrade their accuracy at high latitudes near the stratopause.

Fig. 1 Zonally-averaged, monthly-mean temperature differences for LIMS minus NMC for April 1979.

Fig. 2 Temperature-time series at Poker Flat, Alaska (65N, 212E) at a) 0.4 hPa, b) 1 hPa and c) 5 hPa. Solids are LIMS, dotted are NMC and diamonds are rocketsondes.

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RESULTS

Previous comparisons of LIMS temperatures with correlative datasonde values (Gille et al., 1984) showed agreement to better than 3°K from 50 to 0.5 hPa over the 7-month LIMS period. However, significant differences may have occurred within a subset of that period. To check this, we show time series comparisons (Fig 2) at Poker Flat (65N 212E) at three pressure levels (5, 1 and 0.4 hPa). LIMS reflects the day-to-day variations in temperature recorded by high resolution datasondes. NMC also follows the datasonde values, although the variations are much smoother. This behavior for NMC is expected given its lower vertical resolution. There are also clear biases for NMC for some periods. For example, Fig. 1 shows LIMS to be 5 K warmer than NMC at 1 hPa and 65N. Figure 2 also verify that there is little information in the NMC result at 0.4 hPa. Large-scale variations at low latitudes such as semi-annual oscillations, are underestimated by NMC, which will lead to significant biases in a derived RMC at those heights.

Because the effects of planetary wave activity are weak for both hemispheres during April, the vertical temperature distribution is fairly uniform in latitude and hence it becomes easier to identify and interpret small differences between different climatologies. We show the LIMS minus BC zonal mean for April in Figure 3. The BC climatology relies on radiosonde data between 100 hPa and 30 hPa and nadir sounder satellite data (SCR and PMR) above 30 hPa. There are marked differences in the patterns for Figures 1 and 3 in the upper stratosphere and mesosphere, part of which may be due to the different years of the BC climatology. However, there is a curious horizontally-banded structure in the patterns of Figure 3. We relate this feature to the error patterns that occur between temperature profiles of differing vertical resolution (Jackson et al., 1990). LIMS is about 2.5 km, BC ranges from 12 km in the stratosphere to 20 km in the mesosphere.

Figure 4 is the LIMS minus SAMS temperature difference for April 1979. Again a banded structure is present in the difference pattern, but the vertical wavelength for that pattern is shorter than in Figure 3. This change is expected because vertical resolution for SAMS is between 8 to 12 km. Although the difference pattern is most uniform with latitude for April, the results are similar for other months.

5 DISCUSSION

The retrievals of ozone, water vapor, NO₂ and HNO₃ from the LIMS instrument are based on temperatures retrieved as a function of pressure. As noted earlier, the errors in temperature can introduce noticeable errors in retrieved species. Suppose that the differences of order +5°K at 10 hPa in Fig. 1 are due to LIMS temperature errors. This would cause LIMS to underestimate ozone by nearly 50% (Remsberg et al., 1984) and water vapor by 40%. Remsberg and Wu (1989) reported LIMS ozone comparisons with the Solar Backscatter Ultraviolet (SBUV) version 5 data for the period 1978-79. The SBUV diffuser plate degradation is believed to have been minimal during this period. Those comparisons for Umkehr layer 6 (centered at 11 hPa) are better than 8% for April at all latitudes. The comparison for layer 5 (22 hPa) shows that LIMS calculates more ozone compared to SBUV for layer 5 in the tropics by about 30%. If LIMS temperatures are too warm based on Fig. 1, then the corrected LIMS temperatures would lead to even larger differences between LIMS and SBUV ozone in layer 5. Remsberg and Wu (1989) also show that LIMS and SAGE I ozone agrees at 10 hPa. Collectively, these comparisons indicate that the LIMS temperatures are accurate to better than +2°K.
Similarly, the retrieved LIMS water vapor is very sensitive to the input temperature profile. Bhatt et al. (1990) have shown that LIMS agrees with ATMOS and SAGE II water vapor for May at 30N to better than 20 percent.

Jones and Pyle (1984) report significant differences between SAMS profiles and correlative balloon measurements of N$_2$O and CH$_4$ at 26 to 32 km-an altitude region where the SAMS retrievals are particularly sensitive to temperature bias (see their table 2). If we assume that the LIMS temperatures at 10 hPa are correct, then Figure 4 indicates that SAMS temperatures are too cold by 4 K which could easily explain the observed bias between the SAMS species and the correlative measurements. On the other hand, temperature differences at 7 to 2 hPa are less than 2 K; the SAMS species results should be relatively free of temperature bias there.

6 CONCLUSIONS

Comparisons of satellite-derived temperatures with correlative temperatures indicate that the LIMS temperatures are accurate and contain more of the needed vertical resolution for calculating a residual mean circulation for transporting tracer-like species. Generally, the LIMS temperatures are accurate to at least 2 K. Other satellite data sets are comprised of temperatures with coarser vertical resolution, leading to biases that occur with an error pattern that is characteristic of their resolution. Their biases exceed 2 K at some altitudes.

Retrievals of species using an infrared limb emission technique are sensitive to any temperature bias. Generally, the LIMS comparisons with other data sets for ozone and water vapor are good to better than 20%; this represents an independent confirmation of the quality of LIMS temperatures. Zonal mean comparisons between LIMS and SAMS temperatures also indicate agreement to better than 2 K from about 7 to 2 hPa. Therefore, we are confident that SAMS N$_2$O and CH$_4$ are relatively free of temperature bias in that region. These factors support the generally good agreement in G90 between model NaO transported using a scheme that is characteristic of their resolution. Their biases could easily explain the observed bias between the SAMS species and the correlative measurements. On the other hand, temperature differences at 7 to 2 hPa are less than 2°K. These factors support the generally good agreement in G90 between model NaO transported using a scheme that is characteristic of their resolution. Their biases could easily explain the observed bias between the SAMS species and the correlative measurements.

REFERENCES


