# DEGRADATION OF THE SENSITIVITY OF THE LWP CAMERA WITH TIME

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We have examined the degradation with time of the sensitivity of the LWP camera, as applied to low dispersion images. The object of this study was to develop a procedure, within the Regional Data Analysis Facility (RDAF) software environment, to compensate for this change in sensitivity. A similar procedure for correcting low dispersion LWR camera data has been available as an option in the IUE RDAF reduction software for some time. The numerical tables used in the RDAF routines are based on studies by Clavel, Gilmozzi, and Prieto (1985; 1986) and Imhoff (1986; 1987).

For the present study we examined the LWP images of the five low dispersion sensitivity standards, viz., HD 60753, HD 93521, BD +28° 4211, BD +75° 325, and BD +33° 2642. This included data from 1980 through the present. The photowrites of these images were examined for radiation hits or other defects, and corrupted spectra were discarded from the data set. In addition, comparisons were made between spectra of the same star, and a few discrepant ones were discarded, though the cause of their variation was not necessarily obvious. The final data base consisted of 400 images. All of the data were reprocessed by the IUE Project so that the details of their processing were uniform and used the current LWP Intensity Transfer Function (ITF2) and absolute calibrations. The analysis was done on the extracted net spectrum, before application of the absolute calibration (i.e. in flux numbers). The spectra were corrected for camera temperature variations using the THDA, and a temperature dependence rate of 0.18 %/° C (Garhart and Teays 1989). Portions of the spectra affected by camera reseaux, were corrected by linear interpolation from immediately adjacent good data points.

In the initial phase of the analysis the data sets for each star were treated separately. The spectra were segregated into nineteen bins, based on the time of observation. Each bin contained all of the spectra taken during a six month interval. The spectra within a six month bin were resampled to a uniform wavelength and averaged. Table 1 lists the number of spectra in each date bin. The average fluxes corresponding to the time interval centered on 1984.5, the time during which the current ITF data were acquired, was used as a baseline, to which the other values were compared. For these comparisons the spectra were binned into 25 Å segments, using the standard RDAF routine BINS. The ratios [Bbetween the mean flux for each wavelength/time bin and the reference values at 1984.5 were then calculated.

We will refer to these ratios as "degradation ratios" in what follows.

The choice of a 25 Å bin size was originally chosen since it represents the wavelength resolution of the inverse sensitivity function. This is also the resolution of the current LWR degradation correction. We performed some experiments in using smaller bins, viz., ten and five Å, but found that the results appeared rather noisy. These considerations led us to choose the 25 Å binning. (Bohlin and Grillmair (1988) came to a different conclusion in their study of SWP camera degradation; they preferred five Å binning.)

The results for the individual calibration standards were in good agreement, so we averaged the results. The degradation ratios for these average spectra were calculated and are given in Table 2, where the data are tabulated with respect to the mid-points of the intervals used. The second entry in each column gives the standard deviation of the mean for all of the spectra in that wavelength/date bin. Figure 1 shows the numbers in this table in the form of a pseudo-three dimensional plot of wavelength vs. time. The ridge line which is apparent in Figure 1 corresponds to the time after which the LWP came into use as the default camera. (The LWP began being routinely used in October of 1983, and a rise in camera sensitivity was noted as it came to be used regularly.) The numbers in Table 2 are consistent with the results from the routine camera sensitivity monitoring (Garhart and Teays 1989), which uses a much broader bandwidth (150 Å). Also apparent in Figure 1 is that the ratios are quite noisy prior to 1984, due largely to the small number of spectra in each bin. This is not a major problem, given the few spectra, other than those taken for calibration purposes, that were acquired before this time. The data at the wavelength extremes of the LWP camera are also rather noisy, simply reflecting the high noise level of the camera in those regions.

Figure 2 gives a few examples of the variation of degradation ratio with time, at a fixed wavelength. The error bars shown in Figure 2 represent the standard deviations listed in Table 2. The general trend for all wavelengths is a somewhat irregular variation prior to the end of 1983, followed by a slight increase, as the camera became used regularly, and a steady decline beginning with the fiducial date of 1984.5.

We tested these degradation ratios by applying them to mean spectra of each of the calibration targets, taken at two different epochs. An average was formed of the fluxes of several images of the same object that were acquired in the six month interval centered on 1984.0, and a second mean was calculated for the same target, using images taken in the interval centered on 1989.0. The degradation correction in these tests was applied by simply dividing all of the wavelengths in the spectrum which fell within the boundaries of the 25 Å bins by the degradation ratio for that bin. While this is a rather crude procedure, and would be replaced by a more rigorous technique in actual implementation, it served to test the overall correctness of the degradation ratios. The results of two of these tests are shown in Figures 3 and 4, where the upper panel in each figure shows the percentage difference between the mean fluxes of the 1984 and 1989 spectra, while the lower panel displays the same percentage difference after correcting them both, using the degradation ratios in each wavelength bin of Table 2. Figure 3 is based on a comparison of ten spectra of HD 60753 taken between 1983.79 and 1984.17, with eight spectra taken between 1988.77 and 1989.18. Figure 4 shows the same comparison between seven "old" spectra of HD 93521 and four

"new" spectra. The corrections appear to be generally correct. The residual scatter is comparable to that found by Clavel, Gilmozzi, and Prieto (1985;1986) for the LWR camera. (In fact the format of Figures 3 and 4 was chosen to emulate theirs.)

We performed various experiments with polynomial fitting, but it is clear that for the period of time after 1984.25, the decline can be reliably represented by a linear fit. Some samples of linear fits to this truncated data set are shown in Figure 5. Table 3 lists the numerical values that were determined from the linear fits and Figure 6 summarizes these slopes by representing them as another pseudo three-dimensional plot, similar to Figure 1.

## DISCUSSION

It appears that the LWP camera degradation in low dispersion can be adequately represented by linear relationships, between the dates of 1984.5 and 1989.5. Prior to 1983.5 the number of calbration spectra is small, and so the determination of degradation ratios is quite uncertain.

The linear fitting in the post-1984 era is very attractive, due to its simplicity. More importantly, a linear relation can be extrapolated to cover future LWP low dispersion images in a straightforward fashion, and so can be used on a continuing basis, until the present study is updated. (Of course, the routine monitoring of the camera sensitivity will be used to verify that the realtionship continues to be linear.) Figure 7 shows the results of a test which was similar to the one done to generate Figure 4, but making use of the linear relations to correct the spectra. The results are essentially the same as for the discrete case.

The individual grid points can be used in a nearest neighbor interpolation scheme for correction of pre-1984 data. Of course, the fluxes of corrected pre-1984 data will be less accurate than the fluxes of corrected post-1984 data due to the higher uncertainty in the degradation ratio's for the early data.

## REFERENCES


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Table 1. Number of Spectra Included in Each Date Bin

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1980.5 | 9 | 1983.0 | 22 | 1985.5 | 23 | 1988.0 | 21 |
| 1981.0 | 1 | 1983.5 | 21 | 1986.0 | 26 | 1988.5 | 36 |
| 1981.5 | 4 | 1984.0 | 37 | 1986.5 | 22 | 1989.0 | 43 |
| 1982.0 | 4 | 1984.5 | 24 | 1987.0 | 23 | 1989.5 | 16 |
| 1982.5 | 19 | 1985.0 | 22 | 1987.5 | 27 | | |

# Table 2

LWP DEGRADATION RATIOS

| WAVELENGTH REGION | 1980.5 | | 1981.0 | | 1981.5 | | 1982.0 | | 1982.5 | | 1983.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.97 | 0.02 | 0.97 | 0.02 | 0.92 | 0.09 | 0.96 | 0.03 | 0.99 | 0.06 | 0.95 | 0.06 |
| 1975 | 0.96 | 0.04 | 0.94 | 0.06 | 0.88 | 0.04 | 0.91 | 0.06 | 0.93 | 0.06 | 0.93 | 0.04 |
| 2000 | 1.04 | 0.04 | 1.01 | 0.01 | 1.04 | 0.03 | 1.00 | 0.04 | 1.02 | 0.05 | 0.98 | 0.06 |
| 2025 | 0.98 | 0.03 | 1.00 | 0.02 | 0.96 | 0.04 | 0.95 | 0.04 | 0.96 | 0.03 | 0.96 | 0.04 |
| 2050 | 1.03 | 0.03 | 1.04 | 0.04 | 0.95 | 0.05 | 0.96 | 0.05 | 0.95 | 0.05 | 0.96 | 0.05 |
| 2075 | 1.00 | 0.04 | 1.03 | 0.00 | 0.95 | 0.08 | 0.97 | 0.04 | 0.98 | 0.03 | 0.99 | 0.06 |
| 2100 | 0.95 | 0.02 | 0.95 | 0.01 | 0.94 | 0.03 | 0.93 | 0.03 | 0.93 | 0.03 | 0.96 | 0.05 |
| 2125 | 0.95 | 0.03 | 0.95 | 0.04 | 0.87 | 0.06 | 0.95 | 0.03 | 0.93 | 0.04 | 0.99 | 0.04 |
| 2150 | 1.01 | 0.02 | 0.99 | 0.02 | 0.99 | 0.03 | 0.97 | 0.01 | 0.97 | 0.04 | 0.95 | 0.04 |
| 2175 | 0.96 | 0.04 | 0.98 | 0.04 | 0.89 | 0.04 | 0.94 | 0.03 | 0.92 | 0.05 | 0.96 | 0.04 |
| 2200 | 1.09 | 0.03 | 1.06 | 0.01 | 1.02 | 0.04 | 1.08 | 0.03 | 1.06 | 0.05 | 0.97 | 0.04 |
| 2225 | 0.99 | 0.03 | 1.02 | 0.02 | 0.94 | 0.07 | 0.99 | 0.05 | 1.01 | 0.03 | 0.98 | 0.05 |
| 2250 | 1.02 | 0.03 | 1.01 | 0.04 | 0.98 | 0.03 | 0.98 | 0.01 | 0.99 | 0.03 | 0.99 | 0.04 |
| 2275 | 1.03 | 0.03 | 0.99 | 0.05 | 0.93 | 0.05 | 0.98 | 0.03 | 0.96 | 0.03 | 0.98 | 0.04 |
| 2300 | 1.07 | 0.02 | 1.07 | 0.06 | 0.97 | 0.02 | 1.00 | 0.02 | 0.99 | 0.03 | 0.96 | 0.03 |
| 2325 | 1.02 | 0.03 | 1.02 | 0.01 | 0.96 | 0.04 | 0.95 | 0.02 | 0.97 | 0.03 | 0.98 | 0.04 |
| 2350 | 1.08 | 0.02 | 1.05 | 0.03 | 1.00 | 0.03 | 0.97 | 0.03 | 0.97 | 0.04 | 0.97 | 0.04 |
| 2375 | 1.02 | 0.03 | 0.97 | 0.03 | 0.95 | 0.04 | 0.95 | 0.03 | 0.97 | 0.02 | 0.96 | 0.04 |
| 2400 | 1.03 | 0.02 | 1.03 | 0.01 | 0.98 | 0.05 | 0.97 | 0.01 | 0.98 | 0.03 | 0.96 | 0.04 |
| 2425 | 1.01 | 0.03 | 1.03 | 0.03 | 0.99 | 0.01 | 0.99 | 0.01 | 0.98 | 0.03 | 0.95 | 0.03 |
| 2450 | 1.01 | 0.03 | 1.02 | 0.00 | 0.99 | 0.04 | 1.02 | 0.02 | 0.99 | 0.03 | 0.98 | 0.03 |
| 2475 | 1.01 | 0.02 | 1.01 | 0.02 | 0.97 | 0.03 | 0.97 | 0.02 | 0.97 | 0.03 | 0.96 | 0.03 |
| 2500 | 1.03 | 0.03 | 1.03 | 0.03 | 1.01 | 0.04 | 0.98 | 0.02 | 0.97 | 0.03 | 0.97 | 0.03 |
| 2525 | 1.01 | 0.01 | 1.00 | 0.02 | 1.00 | 0.03 | 0.99 | 0.01 | 1.00 | 0.02 | 0.97 | 0.03 |
| 2550 | 1.01 | 0.04 | 1.06 | 0.02 | 1.00 | 0.04 | 1.00 | 0.02 | 0.99 | 0.04 | 0.98 | 0.03 |
| 2575 | 0.99 | 0.02 | 1.00 | 0.03 | 1.01 | 0.04 | 1.01 | 0.02 | 0.99 | 0.03 | 1.00 | 0.02 |
| 2600 | 0.99 | 0.04 | 1.02 | 0.01 | 1.02 | 0.04 | 0.98 | 0.02 | 0.98 | 0.03 | 0.99 | 0.03 |
| 2625 | 1.01 | 0.02 | 1.02 | 0.01 | 0.98 | 0.04 | 1.00 | 0.02 | 0.99 | 0.02 | 0.99 | 0.02 |
| 2650 | 0.98 | 0.03 | 1.00 | 0.00 | 0.98 | 0.02 | 0.98 | 0.02 | 0.99 | 0.02 | 0.99 | 0.03 |
| 2675 | 0.97 | 0.02 | 0.98 | 0.01 | 0.97 | 0.03 | 1.00 | 0.03 | 0.98 | 0.02 | 0.97 | 0.02 |
| 2700 | 1.01 | 0.03 | 1.02 | 0.01 | 1.02 | 0.02 | 1.02 | 0.03 | 1.02 | 0.02 | 0.99 | 0.03 |
| 2725 | 1.01 | 0.02 | 1.04 | 0.02 | 1.00 | 0.02 | 1.00 | 0.02 | 1.01 | 0.03 | 0.97 | 0.02 |
| 2750 | 1.01 | 0.02 | 1.02 | 0.02 | 1.01 | 0.01 | 1.01 | 0.02 | 1.01 | 0.02 | 0.98 | 0.02 |
| 2775 | 1.01 | 0.03 | 1.03 | 0.01 | 1.01 | 0.01 | 1.01 | 0.01 | 1.01 | 0.01 | 0.98 | 0.03 |
| 2800 | 1.00 | 0.02 | 1.00 | 0.01 | 0.99 | 0.04 | 1.01 | 0.02 | 1.00 | 0.02 | 1.00 | 0.02 |
| 2825 | 0.99 | 0.04 | 1.01 | 0.00 | 1.00 | 0.02 | 1.01 | 0.02 | 1.00 | 0.02 | 0.99 | 0.02 |
| 2850 | 0.98 | 0.03 | 1.01 | 0.01 | 0.98 | 0.03 | 0.99 | 0.02 | 1.00 | 0.03 | 0.98 | 0.02 |
| 2875 | 1.03 | 0.02 | 1.04 | 0.01 | 0.98 | 0.04 | 0.99 | 0.02 | 1.00 | 0.03 | 0.98 | 0.03 |
| 2900 | 0.98 | 0.03 | 0.98 | 0.01 | 0.96 | 0.02 | 0.98 | 0.01 | 0.98 | 0.02 | 0.98 | 0.02 |
| 2925 | 0.98 | 0.03 | 1.01 | 0.03 | 1.00 | 0.04 | 1.01 | 0.04 | 1.00 | 0.03 | 0.98 | 0.03 |
| 2950 | 1.00 | 0.02 | 0.99 | 0.02 | 0.97 | 0.01 | 1.01 | 0.02 | 1.00 | 0.03 | 0.99 | 0.02 |
| 2975 | 1.02 | 0.03 | 0.99 | 0.01 | 0.99 | 0.02 | 1.00 | 0.02 | 1.01 | 0.02 | 1.00 | 0.03 |
| 3000 | 0.98 | 0.03 | 1.00 | 0.01 | 0.98 | 0.01 | 1.01 | 0.03 | 1.01 | 0.03 | 0.98 | 0.03 |
| 3025 | 0.98 | 0.02 | 1.00 | 0.02 | 1.00 | 0.03 | 1.00 | 0.02 | 1.01 | 0.02 | 0.98 | 0.03 |
| 3050 | 1.03 | 0.03 | 1.05 | 0.05 | 1.04 | 0.05 | 1.00 | 0.07 | 1.03 | 0.05 | 0.98 | 0.05 |
| 3075 | 1.02 | 0.04 | 1.02 | 0.03 | 1.02 | 0.04 | 1.03 | 0.05 | 1.06 | 0.05 | 1.00 | 0.05 |
| 3100 | 1.03 | 0.02 | 1.05 | 0.02 | 1.02 | 0.10 | 1.03 | 0.03 | 1.04 | 0.05 | 1.00 | 0.04 |
| 3125 | 1.05 | 0.04 | 1.14 | 0.00 | 1.02 | 0.11 | 1.02 | 0.06 | 1.04 | 0.08 | 0.99 | 0.05 |
| 3150 | 1.03 | 0.05 | 1.04 | 0.07 | 1.10 | 0.04 | 1.03 | 0.07 | 1.06 | 0.06 | 0.99 | 0.05 |
| 3175 | 1.08 | 0.09 | 1.06 | 0.04 | 1.03 | 0.07 | 1.08 | 0.08 | 1.05 | 0.11 | 1.01 | 0.11 |
| 3200 | 1.05 | 0.06 | 1.09 | 0.06 | 1.05 | 0.11 | 1.03 | 0.09 | 1.06 | 0.11 | 1.01 | 0.06 |
| 3225 | 0.97 | 0.09 | 1.00 | 0.14 | 1.13 | 0.11 | 1.03 | 0.11 | 1.03 | 0.10 | 1.01 | 0.09 |
| 3250 | 1.05 | 0.11 | 1.03 | 0.03 | 0.93 | 0.14 | 1.04 | 0.14 | 1.05 | 0.16 | 0.99 | 0.16 |
| 3275 | 1.22 | 0.12 | 1.28 | 0.09 | 1.05 | 0.15 | 1.22 | 0.20 | 1.19 | 0.21 | 0.95 | 0.10 |
| 3300 | 1.11 | 0.17 | 1.24 | 0.11 | 1.19 | 0.28 | 1.18 | 0.29 | 1.20 | 0.26 | 1.07 | 0.14 |
| 3325 | 0.84 | 0.13 | 0.77 | 0.05 | 1.05 | 0.27 | 1.07 | 0.55 | 1.13 | 0.47 | 0.96 | 0.19 |
| 3350 | 1.08 | 0.16 | 0.93 | 0.01 | 1.24 | 0.29 | 1.31 | 0.27 | 1.28 | 0.30 | 1.07 | 0.19 |

# Table 2 (Continued)

LWP DEGRADATION RATIOS

| WAVELENGTH REGION | 1983.5 | | 1984.0 | | 1984.5 | | 1985.0 | | 1985.5 | | 1986.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.92 | 0.08 | 0.96 | 0.05 | 1.02 | 0.06 | 0.96 | 0.04 | 0.97 | 0.04 | 0.95 | 0.07 |
| 1975 | 0.93 | 0.05 | 0.98 | 0.07 | 1.01 | 0.06 | 0.99 | 0.07 | 0.98 | 0.06 | 0.97 | 0.04 |
| 2000 | 0.96 | 0.07 | 1.00 | 0.05 | 0.99 | 0.05 | 1.00 | 0.04 | 0.96 | 0.05 | 0.97 | 0.05 |
| 2025 | 0.95 | 0.04 | 0.95 | 0.05 | 1.01 | 0.03 | 1.01 | 0.03 | 0.99 | 0.04 | 0.99 | 0.05 |
| 2050 | 0.95 | 0.04 | 0.97 | 0.04 | 1.00 | 0.03 | 0.98 | 0.03 | 1.00 | 0.05 | 0.97 | 0.06 |
| 2075 | 0.97 | 0.04 | 0.98 | 0.05 | 1.00 | 0.05 | 0.99 | 0.04 | 0.98 | 0.03 | 0.99 | 0.04 |
| 2100 | 0.95 | 0.06 | 0.97 | 0.05 | 1.01 | 0.05 | 1.01 | 0.05 | 1.02 | 0.05 | 0.99 | 0.06 |
| 2125 | 0.95 | 0.06 | 0.99 | 0.05 | 1.00 | 0.04 | 1.04 | 0.04 | 1.02 | 0.03 | 0.99 | 0.07 |
| 2150 | 0.98 | 0.05 | 1.00 | 0.05 | 1.00 | 0.04 | 0.99 | 0.05 | 0.98 | 0.03 | 0.99 | 0.05 |
| 2175 | 0.96 | 0.04 | 0.97 | 0.04 | 1.00 | 0.04 | 0.99 | 0.05 | 1.01 | 0.04 | 0.97 | 0.10 |
| 2200 | 0.97 | 0.07 | 0.98 | 0.06 | 1.00 | 0.04 | 0.98 | 0.04 | 0.96 | 0.05 | 0.97 | 0.07 |
| 2225 | 0.97 | 0.04 | 0.96 | 0.05 | 1.01 | 0.03 | 0.98 | 0.04 | 0.96 | 0.04 | 0.94 | 0.05 |
| 2250 | 0.97 | 0.03 | 0.96 | 0.03 | 0.99 | 0.03 | 0.98 | 0.05 | 0.99 | 0.04 | 0.98 | 0.04 |
| 2275 | 0.97 | 0.03 | 0.97 | 0.04 | 1.01 | 0.03 | 0.97 | 0.04 | 0.97 | 0.04 | 0.96 | 0.05 |
| 2300 | 0.96 | 0.03 | 0.98 | 0.03 | 0.99 | 0.04 | 1.01 | 0.05 | 0.98 | 0.04 | 0.99 | 0.05 |
| 2325 | 0.97 | 0.02 | 0.99 | 0.04 | 1.00 | 0.04 | 0.99 | 0.04 | 0.99 | 0.03 | 0.97 | 0.04 |
| 2350 | 0.98 | 0.04 | 0.98 | 0.03 | 1.00 | 0.04 | 0.99 | 0.04 | 0.96 | 0.03 | 0.93 | 0.04 |
| 2375 | 0.96 | 0.03 | 0.98 | 0.04 | 1.00 | 0.04 | 1.00 | 0.04 | 0.98 | 0.04 | 0.99 | 0.03 |
| 2400 | 0.97 | 0.04 | 0.98 | 0.04 | 1.00 | 0.03 | 0.98 | 0.04 | 0.98 | 0.04 | 0.98 | 0.03 |
| 2425 | 0.97 | 0.04 | 0.98 | 0.04 | 1.00 | 0.03 | 0.97 | 0.03 | 0.97 | 0.04 | 0.95 | 0.03 |
| 2450 | 0.98 | 0.03 | 0.99 | 0.03 | 1.00 | 0.03 | 1.00 | 0.03 | 0.99 | 0.03 | 0.98 | 0.03 |
| 2475 | 0.96 | 0.03 | 0.98 | 0.03 | 1.00 | 0.03 | 0.99 | 0.03 | 0.98 | 0.02 | 0.96 | 0.03 |
| 2500 | 0.97 | 0.02 | 0.99 | 0.03 | 1.00 | 0.02 | 0.99 | 0.03 | 0.99 | 0.03 | 0.97 | 0.03 |
| 2525 | 0.98 | 0.03 | 0.98 | 0.05 | 1.00 | 0.03 | 0.99 | 0.03 | 0.98 | 0.03 | 0.96 | 0.03 |
| 2550 | 0.97 | 0.04 | 0.97 | 0.05 | 1.00 | 0.02 | 0.99 | 0.04 | 0.98 | 0.04 | 0.96 | 0.03 |
| 2575 | 0.97 | 0.03 | 0.99 | 0.03 | 1.00 | 0.03 | 1.00 | 0.02 | 0.98 | 0.05 | 0.96 | 0.03 |
| 2600 | 0.97 | 0.03 | 0.99 | 0.02 | 1.00 | 0.02 | 0.99 | 0.02 | 0.99 | 0.02 | 0.97 | 0.03 |
| 2625 | 0.97 | 0.03 | 0.99 | 0.03 | 0.99 | 0.03 | 0.99 | 0.03 | 0.98 | 0.02 | 0.97 | 0.03 |
| 2650 | 0.98 | 0.02 | 1.00 | 0.02 | 1.01 | 0.03 | 1.00 | 0.02 | 0.98 | 0.02 | 0.97 | 0.03 |
| 2675 | 0.97 | 0.02 | 0.99 | 0.03 | 1.00 | 0.03 | 0.99 | 0.03 | 0.97 | 0.02 | 0.96 | 0.03 |
| 2700 | 0.98 | 0.03 | 0.99 | 0.03 | 1.00 | 0.02 | 1.00 | 0.02 | 0.99 | 0.03 | 0.98 | 0.03 |
| 2725 | 0.97 | 0.03 | 0.98 | 0.02 | 1.01 | 0.03 | 0.99 | 0.02 | 0.97 | 0.03 | 0.97 | 0.03 |
| 2750 | 0.97 | 0.03 | 0.99 | 0.02 | 1.00 | 0.03 | 0.99 | 0.02 | 0.99 | 0.03 | 0.96 | 0.02 |
| 2775 | 0.98 | 0.03 | 1.00 | 0.03 | 0.99 | 0.05 | 1.00 | 0.03 | 1.00 | 0.03 | 0.97 | 0.02 |
| 2800 | 0.99 | 0.02 | 1.01 | 0.02 | 0.99 | 0.04 | 1.01 | 0.02 | 1.00 | 0.03 | 0.99 | 0.03 |
| 2825 | 0.98 | 0.02 | 1.00 | 0.03 | 1.00 | 0.04 | 0.99 | 0.02 | 0.98 | 0.02 | 0.98 | 0.03 |
| 2850 | 0.97 | 0.03 | 0.99 | 0.03 | 1.00 | 0.03 | 0.99 | 0.03 | 0.99 | 0.03 | 0.98 | 0.04 |
| 2875 | 0.98 | 0.03 | 0.99 | 0.03 | 1.00 | 0.03 | 0.98 | 0.03 | 0.99 | 0.03 | 0.98 | 0.03 |
| 2900 | 0.98 | 0.02 | 0.99 | 0.02 | 1.00 | 0.03 | 1.00 | 0.02 | 0.98 | 0.02 | 0.97 | 0.03 |
| 2925 | 0.98 | 0.03 | 0.99 | 0.03 | 1.00 | 0.02 | 0.98 | 0.03 | 0.98 | 0.03 | 0.96 | 0.03 |
| 2950 | 0.99 | 0.02 | 1.00 | 0.03 | 1.00 | 0.02 | 0.99 | 0.03 | 1.01 | 0.03 | 1.00 | 0.03 |
| 2975 | 0.99 | 0.03 | 1.00 | 0.04 | 1.00 | 0.03 | 1.00 | 0.02 | 0.99 | 0.03 | 0.99 | 0.03 |
| 3000 | 0.97 | 0.03 | 0.99 | 0.03 | 1.01 | 0.04 | 0.98 | 0.04 | 0.97 | 0.04 | 0.97 | 0.04 |
| 3025 | 0.98 | 0.02 | 1.00 | 0.03 | 1.00 | 0.03 | 1.00 | 0.03 | 0.99 | 0.03 | 0.98 | 0.03 |
| 3050 | 0.98 | 0.04 | 1.00 | 0.03 | 1.01 | 0.04 | 0.97 | 0.03 | 0.94 | 0.04 | 0.94 | 0.05 |
| 3075 | 0.98 | 0.05 | 1.02 | 0.04 | 1.00 | 0.05 | 0.98 | 0.05 | 0.97 | 0.04 | 0.99 | 0.05 |
| 3100 | 1.01 | 0.03 | 1.03 | 0.05 | 1.00 | 0.06 | 1.02 | 0.06 | 0.99 | 0.06 | 0.98 | 0.04 |
| 3125 | 1.01 | 0.05 | 1.01 | 0.05 | 1.01 | 0.08 | 0.99 | 0.04 | 0.98 | 0.05 | 0.99 | 0.05 |
| 3150 | 1.02 | 0.07 | 1.01 | 0.06 | 1.00 | 0.08 | 0.99 | 0.06 | 0.96 | 0.05 | 0.96 | 0.06 |
| 3175 | 0.99 | 0.07 | 1.01 | 0.06 | 1.01 | 0.09 | 1.00 | 0.07 | 0.95 | 0.07 | 0.92 | 0.11 |
| 3200 | 1.02 | 0.07 | 1.02 | 0.08 | 1.01 | 0.10 | 0.95 | 0.08 | 0.97 | 0.08 | 0.99 | 0.08 |
| 3225 | 0.99 | 0.09 | 1.05 | 0.09 | 0.99 | 0.17 | 0.96 | 0.08 | 0.95 | 0.09 | 0.93 | 0.09 |
| 3250 | 0.94 | 0.14 | 1.05 | 0.10 | 0.99 | 0.14 | 0.93 | 0.13 | 0.98 | 0.10 | 0.98 | 0.17 |
| 3275 | 1.04 | 0.12 | 1.12 | 0.21 | 1.00 | 0.17 | 0.91 | 0.11 | 0.95 | 0.16 | 0.99 | 0.16 |
| 3300 | 1.09 | 0.12 | 1.05 | 0.09 | 1.00 | 0.16 | 0.95 | 0.12 | 1.03 | 0.15 | 0.96 | 0.11 |
| 3325 | 0.94 | 0.22 | 1.01 | 0.18 | 1.00 | 0.26 | 1.03 | 0.31 | 0.83 | 0.19 | 1.04 | 0.52 |
| 3350 | 0.99 | 0.28 | 1.11 | 0.27 | 0.96 | 0.22 | 0.92 | 0.28 | 0.89 | 0.15 | 0.88 | 0.16 |

# Table 2 (Continued)

LWP DEGRADATION RATIOS

| WAVELENGTH REGION | 1986.5 | | 1987.0 | | 1987.5 | | 1988.0 | | 1988.5 | | 1989.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.97 | 0.07 | 0.97 | 0.04 | 0.96 | 0.05 | 0.97 | 0.04 | 0.95 | 0.06 | 0.94 | 0.05 |
| 1975 | 1.02 | 0.06 | 0.96 | 0.06 | 1.02 | 0.06 | 0.99 | 0.08 | 1.01 | 0.08 | 0.94 | 0.05 |
| 2000 | 0.99 | 0.04 | 0.95 | 0.04 | 0.97 | 0.05 | 0.97 | 0.05 | 0.95 | 0.04 | 0.95 | 0.04 |
| 2025 | 0.98 | 0.03 | 0.98 | 0.02 | 0.98 | 0.05 | 1.00 | 0.04 | 0.97 | 0.05 | 0.98 | 0.05 |
| 2050 | 0.95 | 0.05 | 0.97 | 0.03 | 0.93 | 0.07 | 0.95 | 0.05 | 0.90 | 0.06 | 0.95 | 0.04 |
| 2075 | 0.96 | 0.04 | 0.97 | 0.03 | 0.96 | 0.04 | 0.95 | 0.04 | 0.94 | 0.04 | 0.93 | 0.03 |
| 2100 | 0.97 | 0.05 | 1.00 | 0.05 | 0.97 | 0.06 | 0.98 | 0.04 | 0.95 | 0.03 | 0.95 | 0.05 |
| 2125 | 0.98 | 0.03 | 1.01 | 0.05 | 0.99 | 0.04 | 1.02 | 0.04 | 0.99 | 0.04 | 1.00 | 0.04 |
| 2150 | 1.01 | 0.04 | 0.99 | 0.05 | 1.02 | 0.05 | 0.99 | 0.03 | 0.99 | 0.04 | 0.97 | 0.03 |
| 2175 | 0.99 | 0.04 | 0.99 | 0.06 | 0.96 | 0.04 | 0.95 | 0.04 | 0.94 | 0.04 | 0.92 | 0.05 |
| 2200 | 0.95 | 0.04 | 0.91 | 0.05 | 0.93 | 0.04 | 0.93 | 0.04 | 0.90 | 0.04 | 0.92 | 0.03 |
| 2225 | 0.94 | 0.04 | 0.94 | 0.04 | 0.93 | 0.04 | 0.95 | 0.05 | 0.92 | 0.04 | 0.91 | 0.03 |
| 2250 | 0.98 | 0.04 | 0.96 | 0.03 | 0.94 | 0.03 | 0.93 | 0.03 | 0.92 | 0.03 | 0.92 | 0.03 |
| 2275 | 0.97 | 0.04 | 0.94 | 0.03 | 0.95 | 0.03 | 0.94 | 0.03 | 0.93 | 0.04 | 0.90 | 0.03 |
| 2300 | 0.99 | 0.05 | 0.97 | 0.03 | 0.99 | 0.04 | 0.95 | 0.04 | 0.97 | 0.04 | 0.92 | 0.04 |
| 2325 | 0.98 | 0.03 | 0.94 | 0.04 | 0.96 | 0.04 | 0.95 | 0.03 | 0.95 | 0.03 | 0.91 | 0.04 |
| 2350 | 0.95 | 0.04 | 0.92 | 0.03 | 0.92 | 0.03 | 0.92 | 0.02 | 0.90 | 0.04 | 0.89 | 0.04 |
| 2375 | 0.96 | 0.03 | 0.97 | 0.04 | 0.94 | 0.04 | 0.94 | 0.03 | 0.92 | 0.03 | 0.92 | 0.03 |
| 2400 | 0.98 | 0.04 | 0.96 | 0.03 | 0.95 | 0.03 | 0.96 | 0.02 | 0.94 | 0.04 | 0.92 | 0.03 |
| 2425 | 0.97 | 0.04 | 0.94 | 0.03 | 0.93 | 0.03 | 0.92 | 0.03 | 0.92 | 0.03 | 0.90 | 0.03 |
| 2450 | 0.98 | 0.03 | 0.96 | 0.02 | 0.95 | 0.03 | 0.96 | 0.02 | 0.93 | 0.04 | 0.94 | 0.03 |
| 2475 | 0.96 | 0.04 | 0.95 | 0.03 | 0.94 | 0.03 | 0.93 | 0.03 | 0.92 | 0.02 | 0.90 | 0.03 |
| 2500 | 0.97 | 0.03 | 0.96 | 0.01 | 0.96 | 0.03 | 0.95 | 0.03 | 0.94 | 0.03 | 0.92 | 0.03 |
| 2525 | 0.98 | 0.03 | 0.95 | 0.03 | 0.94 | 0.04 | 0.94 | 0.03 | 0.90 | 0.04 | 0.92 | 0.03 |
| 2550 | 0.97 | 0.05 | 0.95 | 0.03 | 0.92 | 0.04 | 0.94 | 0.03 | 0.91 | 0.04 | 0.91 | 0.03 |
| 2575 | 0.97 | 0.03 | 0.95 | 0.03 | 0.94 | 0.03 | 0.94 | 0.02 | 0.91 | 0.03 | 0.92 | 0.02 |
| 2600 | 0.98 | 0.02 | 0.96 | 0.03 | 0.95 | 0.03 | 0.95 | 0.03 | 0.93 | 0.03 | 0.92 | 0.03 |
| 2625 | 0.96 | 0.03 | 0.95 | 0.03 | 0.96 | 0.03 | 0.95 | 0.03 | 0.94 | 0.03 | 0.94 | 0.02 |
| 2650 | 0.97 | 0.02 | 0.96 | 0.03 | 0.96 | 0.02 | 0.95 | 0.03 | 0.95 | 0.02 | 0.94 | 0.02 |
| 2675 | 0.96 | 0.02 | 0.94 | 0.02 | 0.94 | 0.03 | 0.94 | 0.02 | 0.93 | 0.02 | 0.93 | 0.02 |
| 2700 | 0.97 | 0.02 | 0.97 | 0.03 | 0.95 | 0.03 | 0.96 | 0.02 | 0.93 | 0.03 | 0.94 | 0.02 |
| 2725 | 0.96 | 0.02 | 0.95 | 0.03 | 0.95 | 0.03 | 0.93 | 0.03 | 0.91 | 0.02 | 0.91 | 0.02 |
| 2750 | 0.97 | 0.03 | 0.96 | 0.02 | 0.96 | 0.04 | 0.96 | 0.03 | 0.93 | 0.03 | 0.94 | 0.03 |
| 2775 | 0.98 | 0.01 | 0.97 | 0.03 | 0.97 | 0.03 | 0.95 | 0.02 | 0.94 | 0.03 | 0.94 | 0.02 |
| 2800 | 0.98 | 0.02 | 0.98 | 0.03 | 0.97 | 0.03 | 0.96 | 0.03 | 0.95 | 0.02 | 0.95 | 0.02 |
| 2825 | 0.96 | 0.02 | 0.96 | 0.02 | 0.96 | 0.02 | 0.96 | 0.03 | 0.94 | 0.02 | 0.95 | 0.02 |
| 2850 | 0.96 | 0.03 | 0.96 | 0.02 | 0.95 | 0.02 | 0.97 | 0.03 | 0.93 | 0.03 | 0.94 | 0.02 |
| 2875 | 0.98 | 0.03 | 0.97 | 0.03 | 0.96 | 0.03 | 0.95 | 0.02 | 0.95 | 0.03 | 0.95 | 0.03 |
| 2900 | 0.98 | 0.02 | 0.97 | 0.03 | 0.96 | 0.02 | 0.97 | 0.04 | 0.95 | 0.03 | 0.95 | 0.02 |
| 2925 | 0.97 | 0.02 | 0.96 | 0.03 | 0.96 | 0.03 | 0.96 | 0.03 | 0.94 | 0.02 | 0.94 | 0.03 |
| 2950 | 0.98 | 0.03 | 0.98 | 0.04 | 0.97 | 0.02 | 0.96 | 0.04 | 0.95 | 0.03 | 0.96 | 0.02 |
| 2975 | 0.97 | 0.03 | 0.98 | 0.03 | 0.97 | 0.03 | 0.96 | 0.03 | 0.95 | 0.03 | 0.95 | 0.03 |
| 3000 | 0.97 | 0.02 | 0.96 | 0.04 | 0.96 | 0.03 | 0.96 | 0.03 | 0.95 | 0.03 | 0.93 | 0.03 |
| 3025 | 0.97 | 0.02 | 0.95 | 0.04 | 0.95 | 0.03 | 0.96 | 0.03 | 0.95 | 0.03 | 0.96 | 0.03 |
| 3050 | 0.96 | 0.04 | 0.95 | 0.04 | 0.96 | 0.05 | 0.95 | 0.03 | 0.94 | 0.05 | 0.93 | 0.05 |
| 3075 | 0.97 | 0.05 | 0.98 | 0.05 | 0.95 | 0.04 | 0.97 | 0.04 | 0.96 | 0.02 | 0.96 | 0.04 |
| 3100 | 0.98 | 0.05 | 1.01 | 0.06 | 0.96 | 0.04 | 0.96 | 0.04 | 0.95 | 0.05 | 0.97 | 0.04 |
| 3125 | 0.97 | 0.04 | 0.99 | 0.05 | 0.96 | 0.07 | 0.95 | 0.04 | 0.92 | 0.06 | 0.96 | 0.06 |
| 3150 | 0.94 | 0.04 | 0.97 | 0.06 | 0.95 | 0.04 | 0.96 | 0.04 | 0.93 | 0.07 | 0.93 | 0.05 |
| 3175 | 0.94 | 0.07 | 0.98 | 0.07 | 0.92 | 0.06 | 0.96 | 0.07 | 0.92 | 0.07 | 0.95 | 0.08 |
| 3200 | 0.94 | 0.09 | 0.99 | 0.09 | 0.93 | 0.06 | 0.97 | 0.07 | 0.94 | 0.06 | 0.95 | 0.08 |
| 3225 | 0.95 | 0.09 | 0.93 | 0.10 | 0.91 | 0.08 | 0.93 | 0.05 | 0.92 | 0.06 | 0.94 | 0.07 |
| 3250 | 0.94 | 0.12 | 1.01 | 0.23 | 0.93 | 0.11 | 0.95 | 0.10 | 0.91 | 0.12 | 0.97 | 0.13 |
| 3275 | 1.02 | 0.18 | 0.94 | 0.11 | 0.92 | 0.11 | 0.95 | 0.12 | 0.85 | 0.10 | 0.92 | 0.11 |
| 3300 | 0.85 | 0.16 | 0.90 | 0.17 | 0.91 | 0.14 | 0.85 | 0.16 | 0.92 | 0.15 | 0.85 | 0.11 |
| 3325 | 0.84 | 0.22 | 0.92 | 0.23 | 0.81 | 0.19 | 0.85 | 0.23 | 0.90 | 0.15 | 0.85 | 0.22 |
| 3350 | 0.85 | 0.17 | 0.87 | 0.20 | 0.87 | 0.21 | 0.90 | 0.16 | 0.89 | 0.14 | 0.92 | 0.24 |

# Table 2 (Continued)

LWP DEGRADATION RATIOS

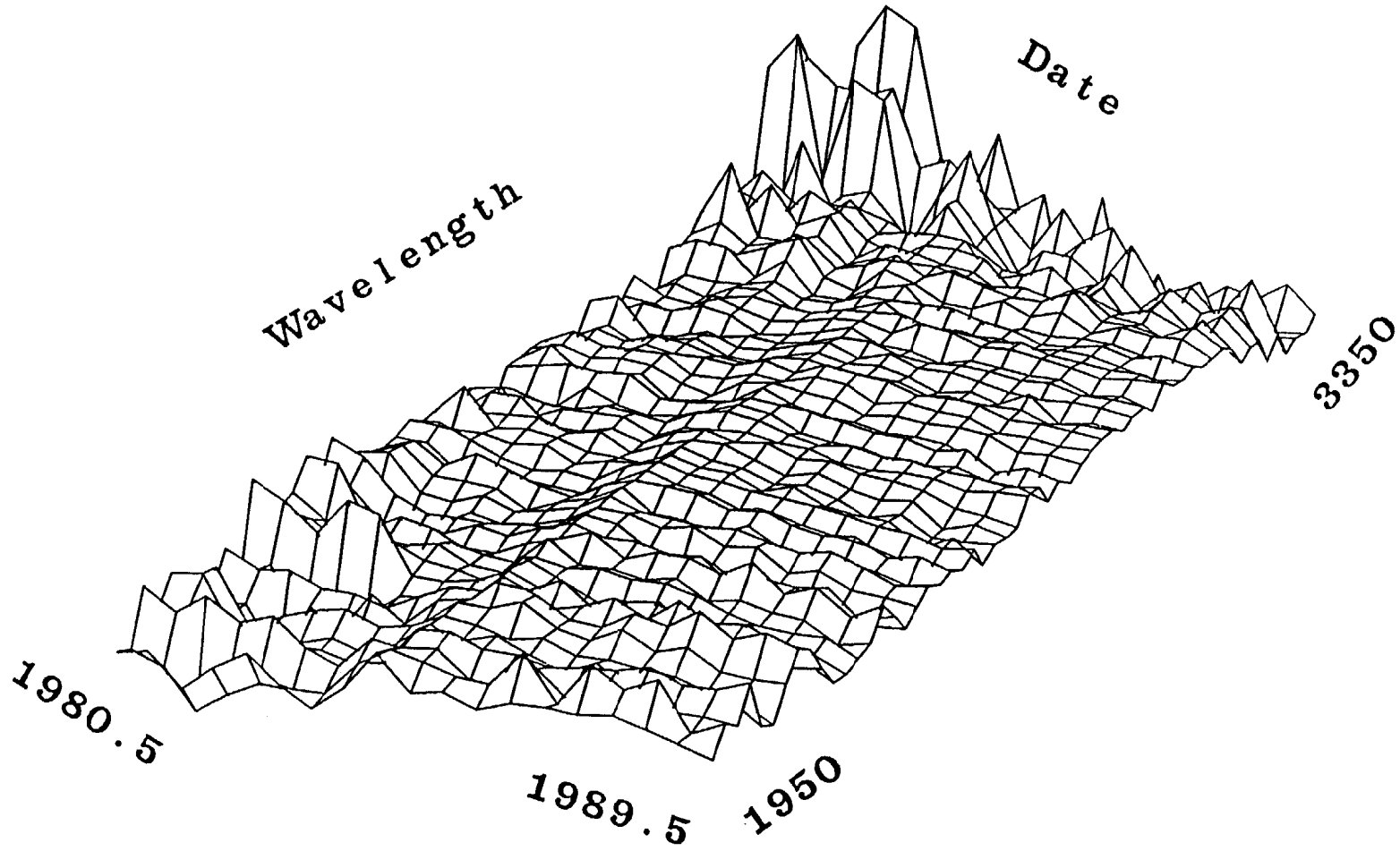
| WAVELENGTH REGION | 1989.5 | |
|---|---|---|
| 1950 | 0.92 | 0.04 |
| 1975 | 0.96 | 0.06 |
| 2000 | 0.94 | 0.05 |
| 2025 | 0.99 | 0.04 |
| 2050 | 0.91 | 0.05 |
| 2075 | 0.90 | 0.04 |
| 2100 | 0.95 | 0.06 |
| 2125 | 0.98 | 0.03 |
| 2150 | 0.97 | 0.03 |
| 2175 | 0.92 | 0.04 |
| 2200 | 0.89 | 0.03 |
| 2225 | 0.89 | 0.04 |
| 2250 | 0.90 | 0.03 |
| 2275 | 0.91 | 0.02 |
| 2300 | 0.95 | 0.05 |
| 2325 | 0.92 | 0.06 |
| 2350 | 0.89 | 0.03 |
| 2375 | 0.91 | 0.03 |
| 2400 | 0.93 | 0.03 |
| 2425 | 0.91 | 0.04 |
| 2450 | 0.92 | 0.04 |
| 2475 | 0.91 | 0.02 |
| 2500 | 0.93 | 0.03 |
| 2525 | 0.89 | 0.04 |
| 2550 | 0.91 | 0.04 |
| 2575 | 0.90 | 0.03 |
| 2600 | 0.91 | 0.02 |
| 2625 | 0.94 | 0.02 |
| 2650 | 0.94 | 0.02 |
| 2675 | 0.91 | 0.02 |
| 2700 | 0.92 | 0.03 |
| 2725 | 0.91 | 0.02 |
| 2750 | 0.93 | 0.03 |
| 2775 | 0.94 | 0.02 |
| 2800 | 0.94 | 0.02 |
| 2825 | 0.94 | 0.03 |
| 2850 | 0.93 | 0.03 |
| 2875 | 0.94 | 0.02 |
| 2900 | 0.94 | 0.03 |
| 2925 | 0.92 | 0.04 |
| 2950 | 0.96 | 0.02 |
| 2975 | 0.94 | 0.03 |
| 3000 | 0.94 | 0.03 |
| 3025 | 0.94 | 0.04 |
| 3050 | 0.93 | 0.04 |
| 3075 | 0.93 | 0.04 |
| 3100 | 0.94 | 0.03 |
| 3125 | 0.93 | 0.05 |
| 3150 | 0.89 | 0.04 |
| 3175 | 0.90 | 0.06 |
| 3200 | 0.90 | 0.05 |
| 3225 | 0.85 | 0.08 |
| 3250 | 0.89 | 0.09 |
| 3275 | 0.84 | 0.07 |
| 3300 | 0.86 | 0.16 |
| 3325 | 0.85 | 0.20 |
| 3350 | 0.87 | 0.19 |

Table 3

COEFFICIENTS OF LINEAR FITS TO LWP DEGRADATION RATIOS

| WAVELENGTH | SLOPE | INTERCEPT | WAVELENGTH | SLOPE | INTERCEPT |
|---|---|---|---|---|---|
| 1950 | -1.06824E-02 | 22.187 | 2650 | -1.27366E-02 | 26.274 |
| 1975 | -6.02747E-03 | 12.964 | 2675 | -1.70485E-02 | 34.827 |
| 2000 | -9.46993E-03 | 19.784 | 2700 | -1.56378E-02 | 32.037 |
| 2025 | -4.83712E-03 | 10.600 | 2725 | -1.89184E-02 | 38.541 |
| 2050 | -1.68702E-02 | 34.478 | 2750 | -1.37498E-02 | 28.283 |
| 2075 | -1.73052E-02 | 35.345 | 2775 | -1.38530E-02 | 28.493 |
| 2100 | -1.37503E-02 | 28.302 | 2800 | -1.30238E-02 | 26.853 |
| 2125 | -4.29682E-03 | 9.5387 | 2825 | -1.18540E-02 | 24.520 |
| 2150 | -3.50920E-03 | 7.9629 | 2850 | -1.37983E-02 | 28.380 |
| 2175 | -1.65377E-02 | 33.829 | 2875 | -1.24291E-02 | 25.665 |
| 2200 | -1.88855E-02 | 38.465 | 2900 | -1.07954E-02 | 22.420 |
| 2225 | -1.82976E-02 | 37.299 | 2925 | -1.26175E-02 | 26.032 |
| 2250 | -1.84947E-02 | 37.702 | 2950 | -1.11301E-02 | 23.094 |
| 2275 | -1.84362E-02 | 37.582 | 2975 | -1.27317E-02 | 26.271 |
| 2300 | -1.18656E-02 | 24.550 | 3000 | -1.19428E-02 | 24.693 |
| 2325 | -1.68160E-02 | 34.372 | 3025 | -1.12692E-02 | 23.360 |
| 2350 | -2.25062E-02 | 45.655 | 3050 | -9.43198E-03 | 19.695 |
| 2375 | -2.00479E-02 | 40.792 | 3075 | -8.85840E-03 | 18.571 |
| 2400 | -1.49379E-02 | 30.644 | 3100 | -1.33991E-02 | 27.602 |
| 2425 | -1.67850E-02 | 34.297 | 3125 | -1.42296E-02 | 29.242 |
| 2450 | -1.64566E-02 | 33.664 | 3150 | -1.53915E-02 | 31.536 |
| 2475 | -1.96593E-02 | 40.012 | 3175 | -1.40167E-02 | 28.800 |
| 2500 | -1.57201E-02 | 32.198 | 3200 | -1.27455E-02 | 26.283 |
| 2525 | -2.09640E-02 | 42.606 | 3225 | -1.64753E-02 | 33.668 |
| 2550 | -1.97379E-02 | 40.167 | 3250 | -1.20731E-02 | 24.942 |
| 2575 | -1.96115E-02 | 39.920 | 3275 | -2.21409E-02 | 44.930 |
| 2600 | -1.90353E-02 | 38.782 | 3300 | -2.97623E-02 | 60.054 |
| 2625 | -1.08158E-02 | 22.453 | 3325 | -3.09156E-02 | 62.333 |
| | | | 3350 | -6.42652E-03 | 13.661 |

# Figure 1




L W P Degradation Ratios

Figure 2a

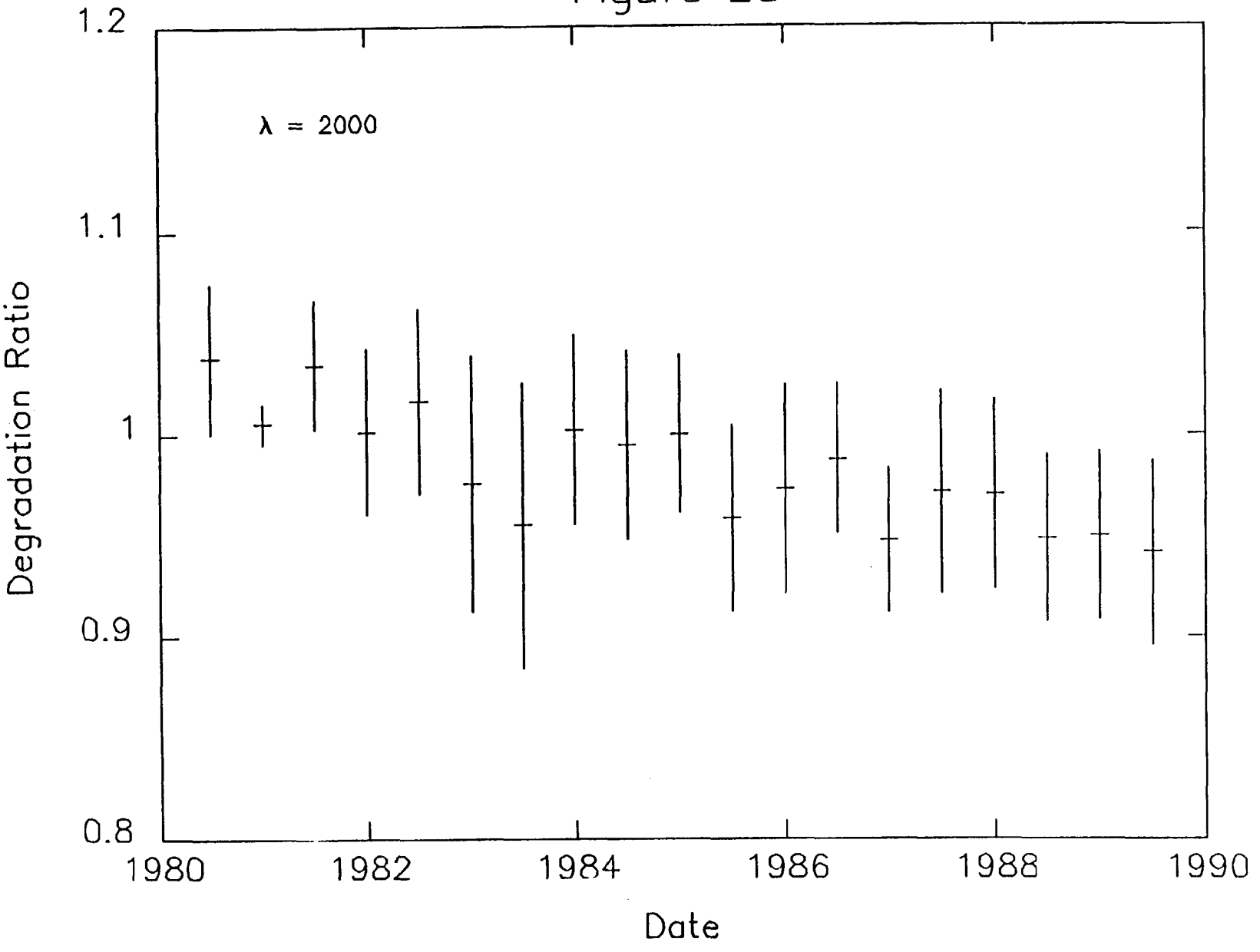

λ = 2000
1.2
1.1
1
0.9
0.8
1980
1982
1984
1986
1988
1990
Date
Degradation Ratio
104

Figure 2b

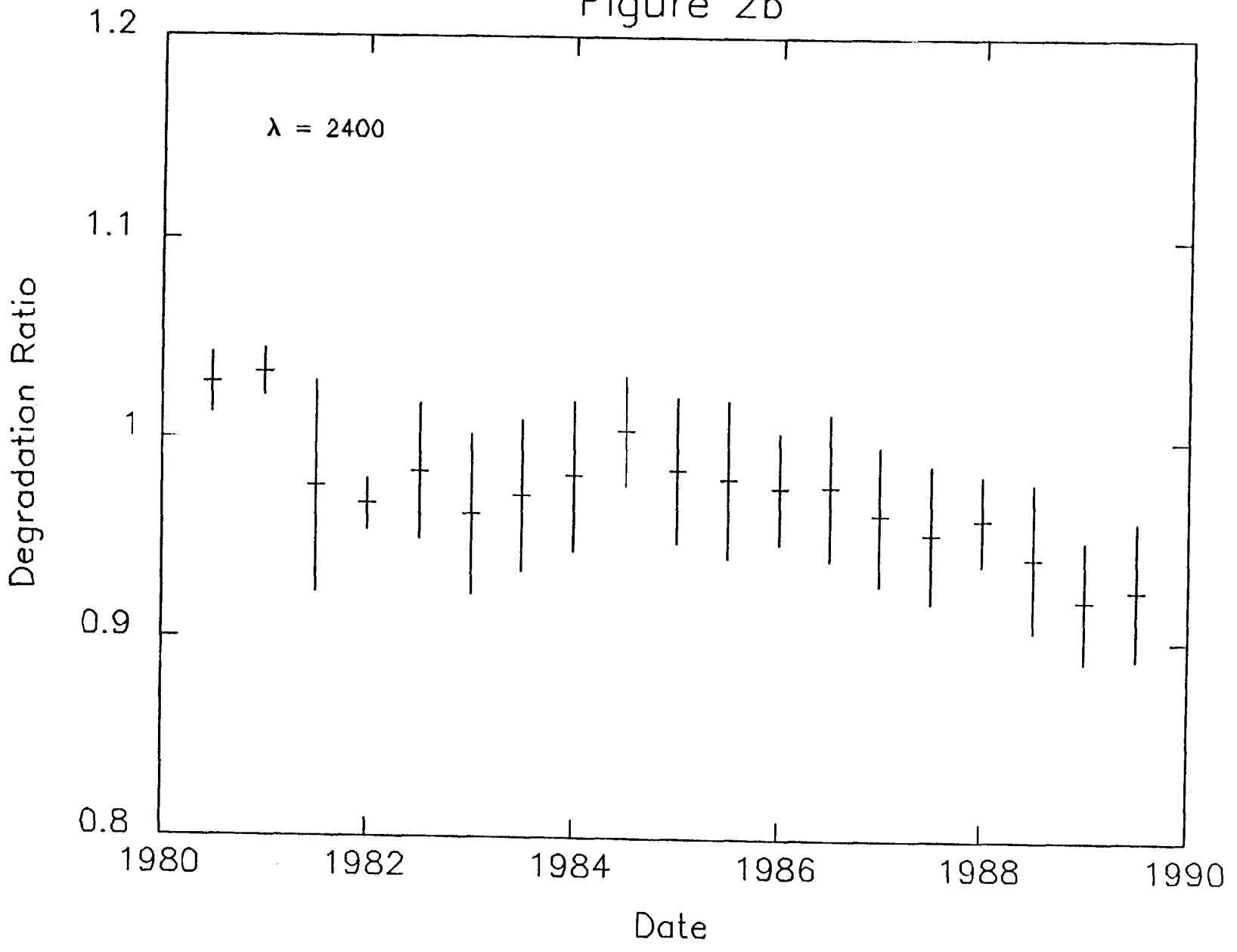

λ = 2400
Degradation Ratio
105
1.2
1.1
1
0.9
0.8
1980
1982
1984
1986
1988
1990
Date

Figure 2c

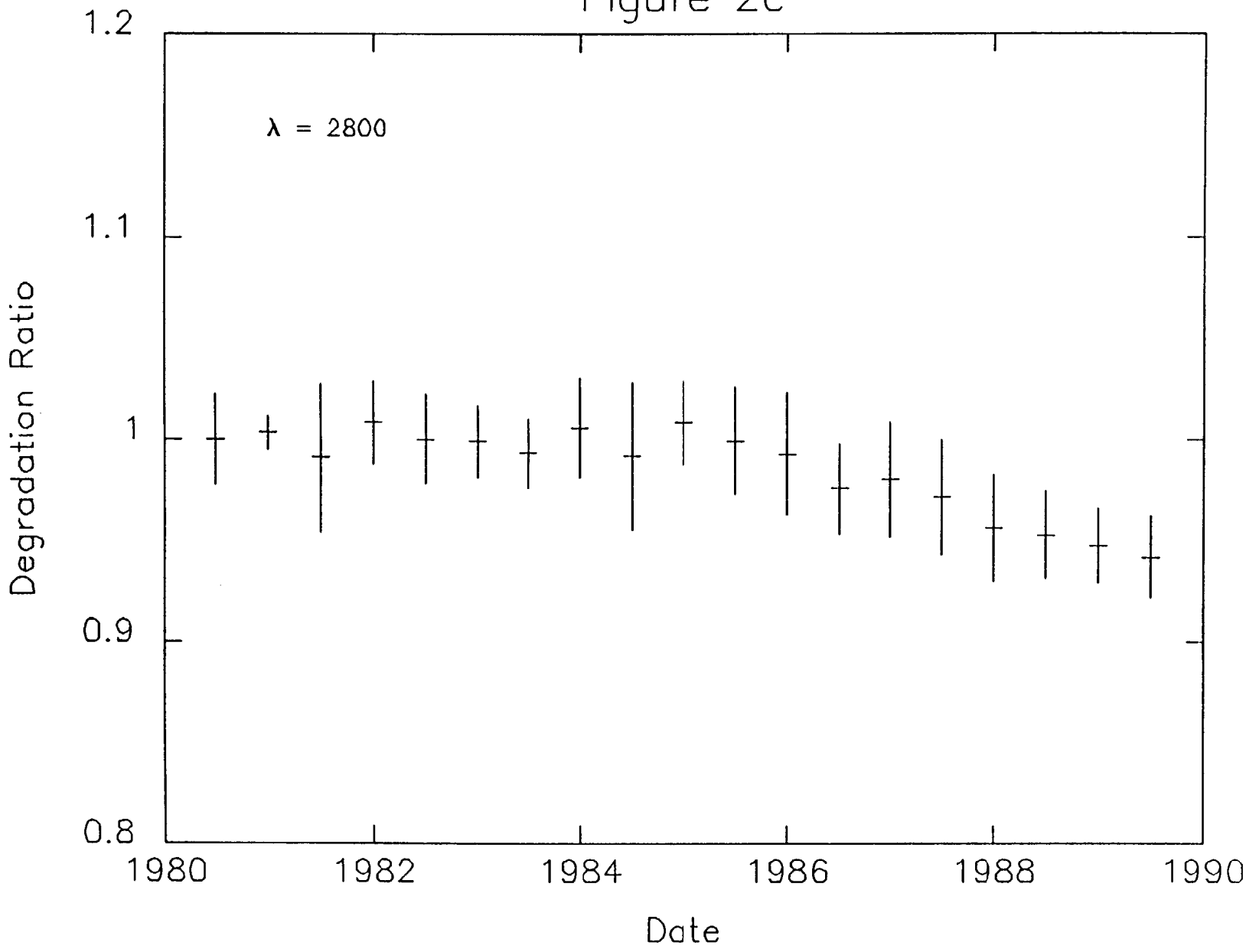
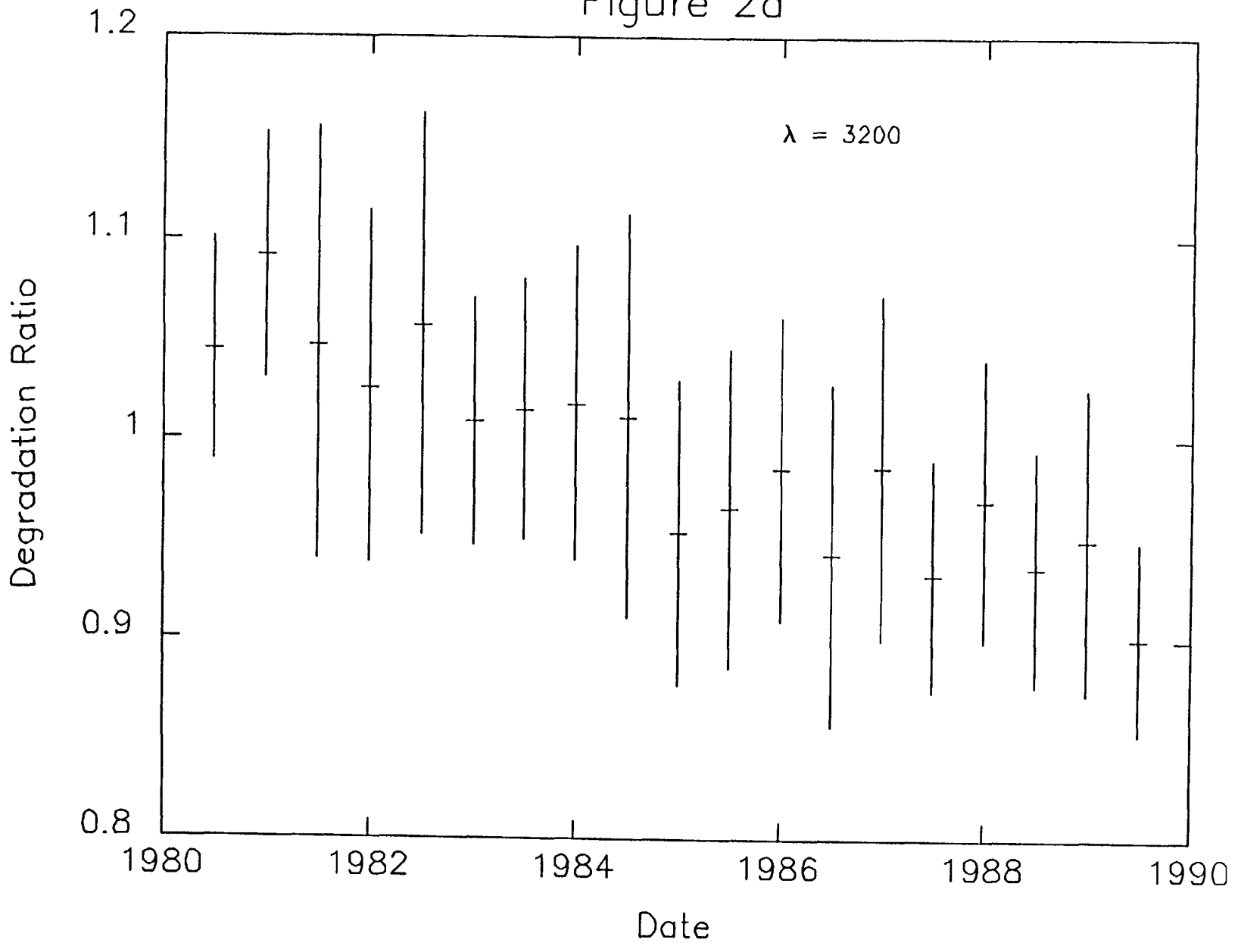

λ = 2800
1.2
1.1
1
0.9
0.8
1980
1982
1984
1986
1988
1990
Date
Degradation Ratio
90I

Figure 2d


1.2
1.1
1
0.9
0.8
λ = 3200
Degradation Ratio
107
1980
1982
1984
1986
1988
1990
Date

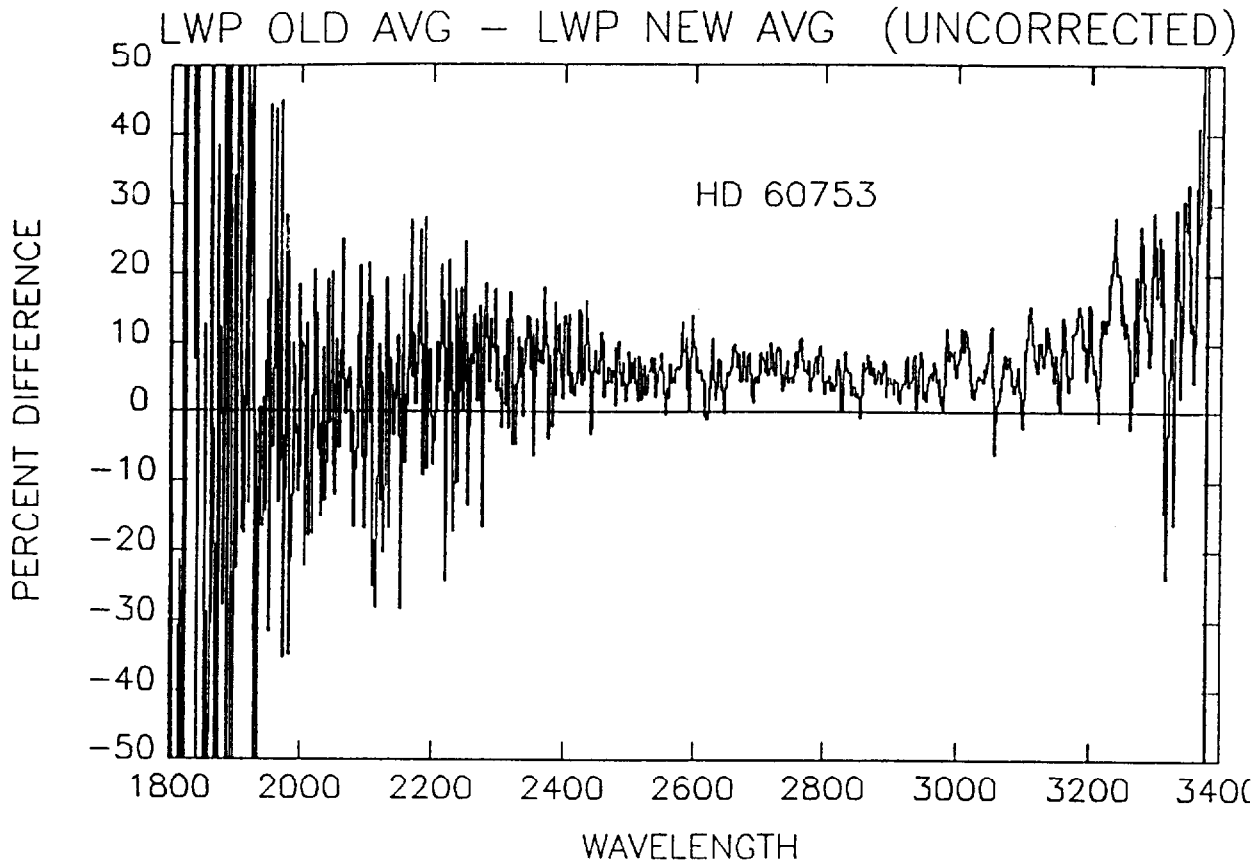
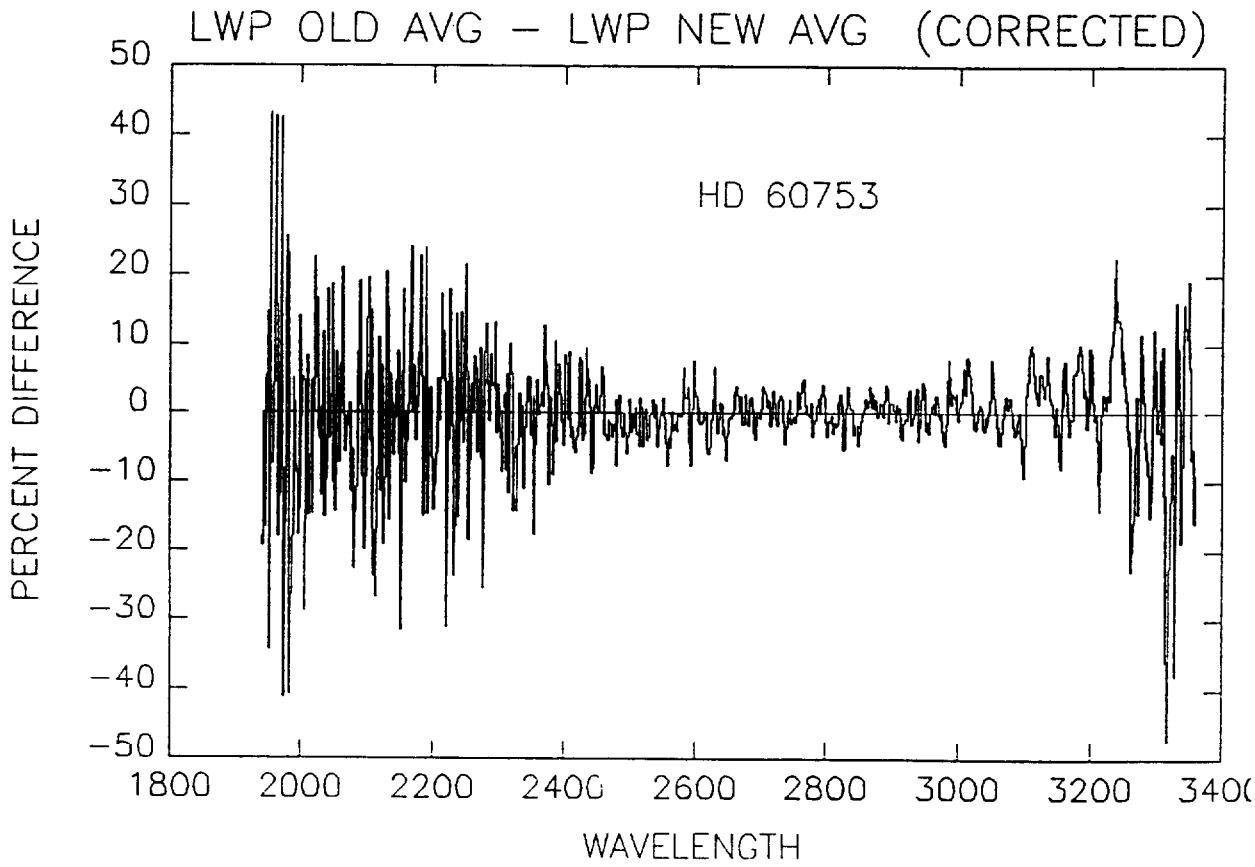

LWP OLD AVG – LWP NEW AVG (UNCORRECTED)
HD 60753
PERCENT DIFFERENCE
WAVELENGTH
50
40
30
20
10
0
−10
−20
−30
−40
−50
1800
2000
2200
2400
2600
2800
3000
3200

**Figure 3**


LWP OLD AVG – LWP NEW AVG (CORRECTED)
HD 60753
PERCENT DIFFERENCE
WAVELENGTH
50
40
30
20
10
0
−10
−20
−30
−40
−50
1800
2000
2200
2400
2600
2800
3000
3200

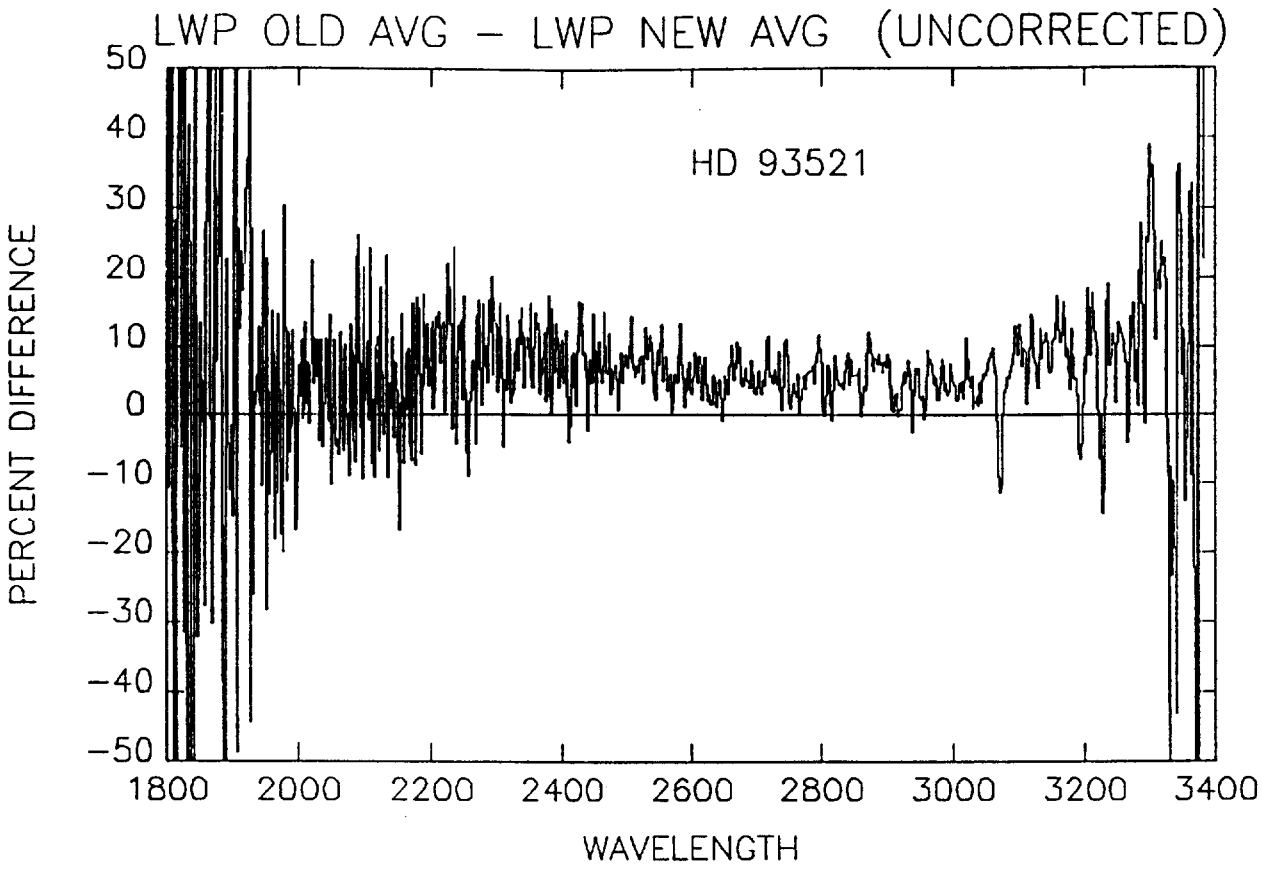

LWP OLD AVG – LWP NEW AVG (UNCORRECTED)
HD 93521
PERCENT DIFFERENCE
50
40
30
20
10
0
−10
−20
−30
−40
−50
1800
2000
2200
2400
2600
2800
3000
3200
3400
WAVELENGTH

**Figure 4**

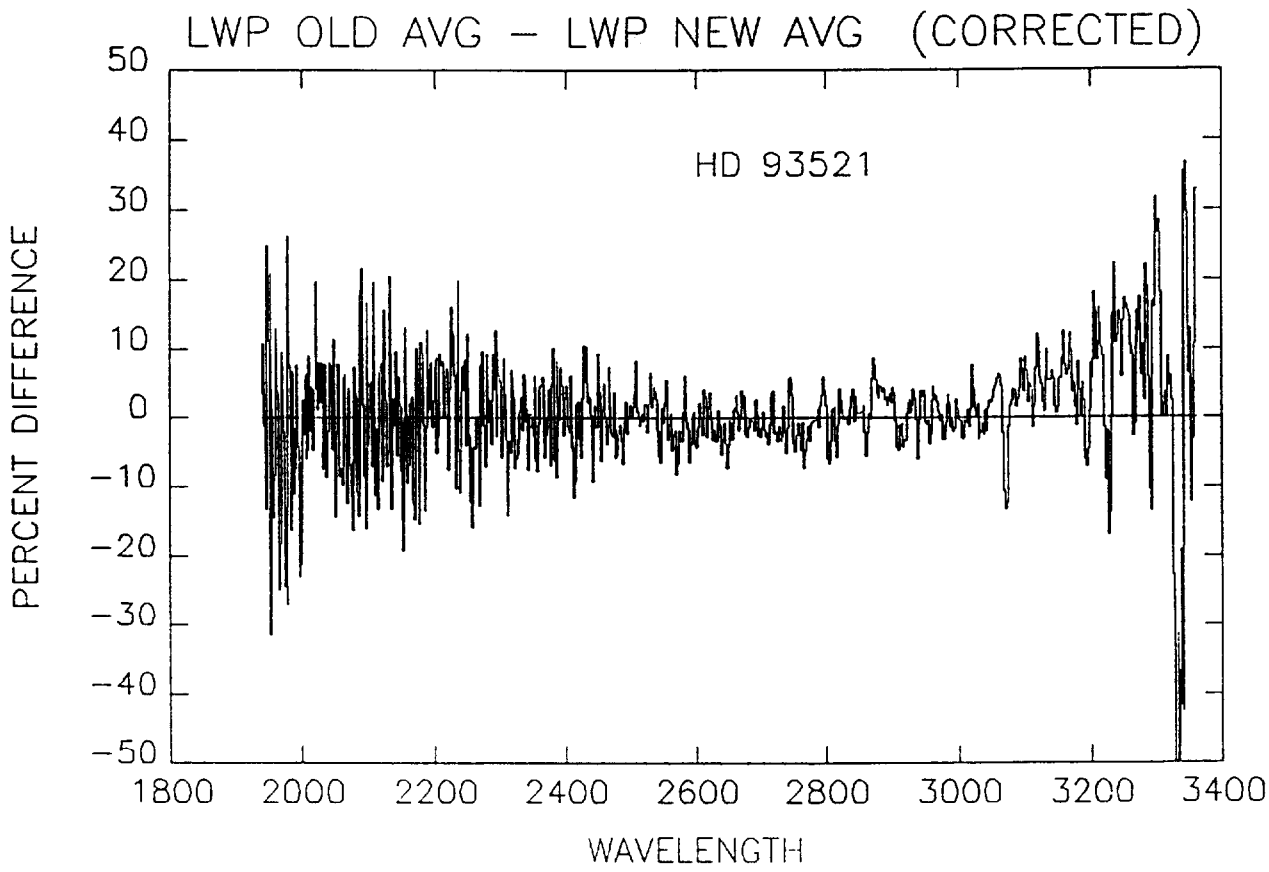

LWP OLD AVG – LWP NEW AVG (CORRECTED)
HD 93521
PERCENT DIFFERENCE
50
40
30
20
10
0
−10
−20
−30
−40
−50
1800
2000
2200
2400
2600
2800
3000
3200
3400
WAVELENGTH

Figure 5a

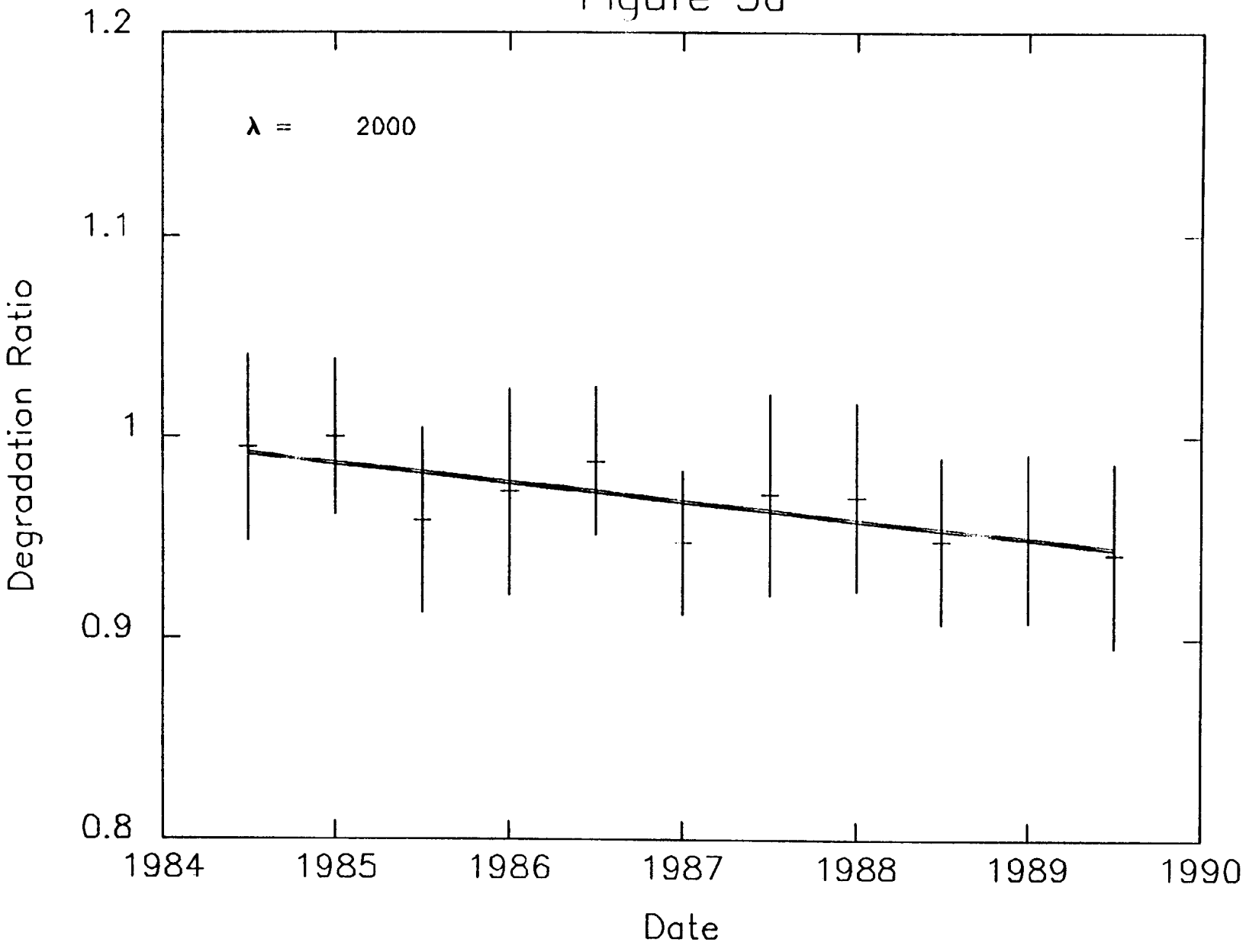

λ = 2000
Degradation Ratio
1.2
1.1
1
0.9
0.8
1984
1985
1986
1987
1988
1989
1990
Date

Figure 5b

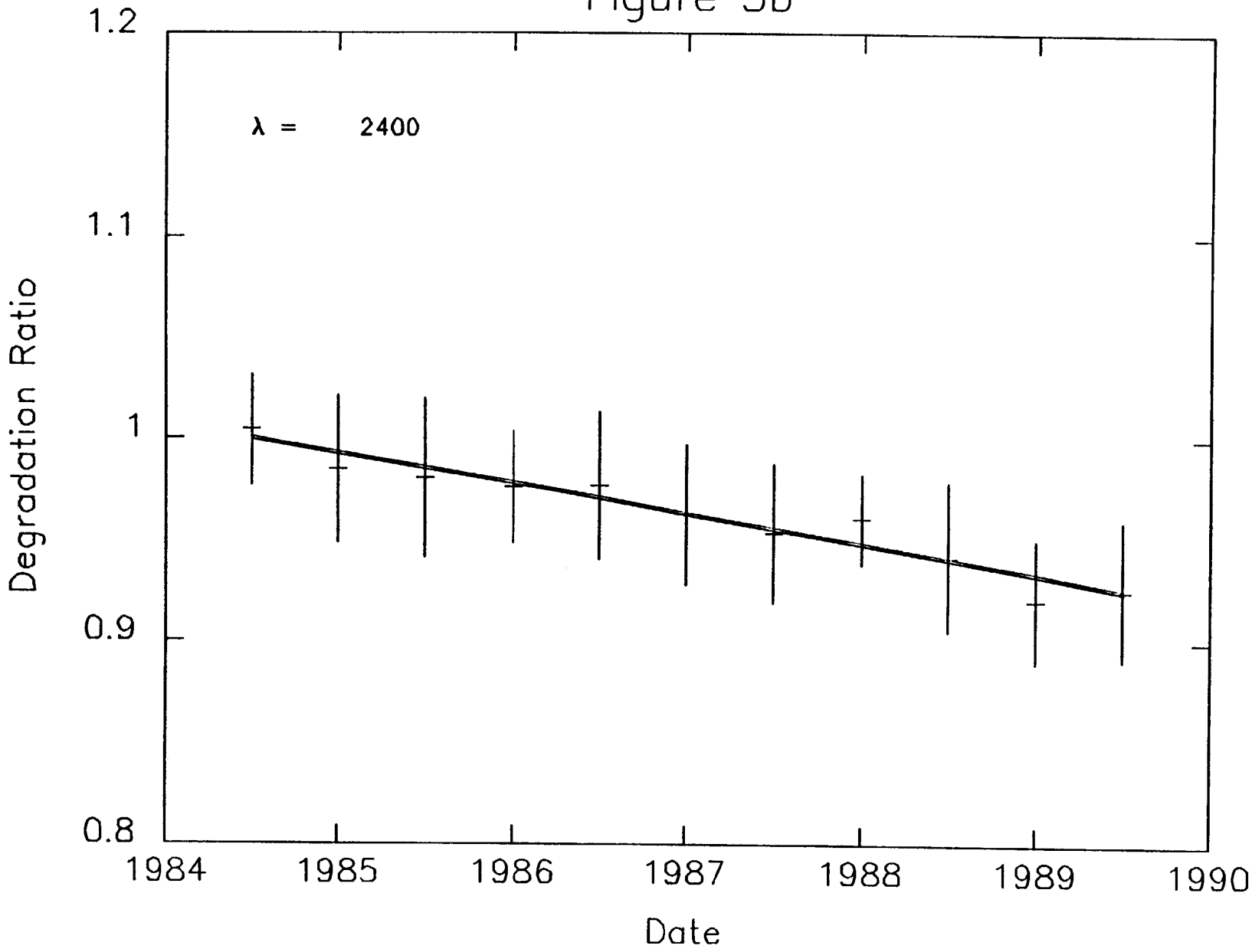

λ = 2400
Degradation Ratio
1.2
1.1
1
0.9
0.8
1984
1985
1986
1987
1988
1989
1990
Date

Figure 5c

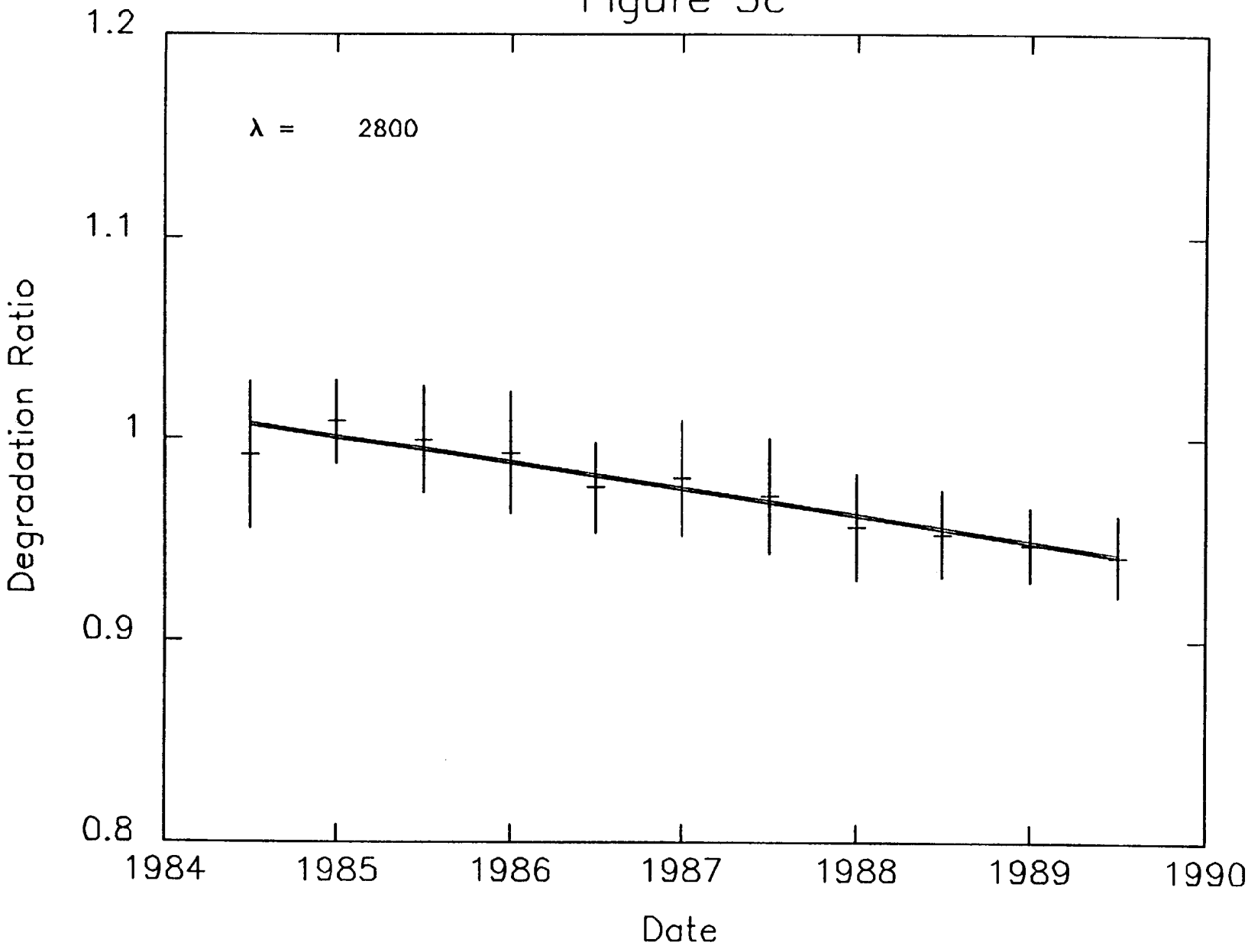
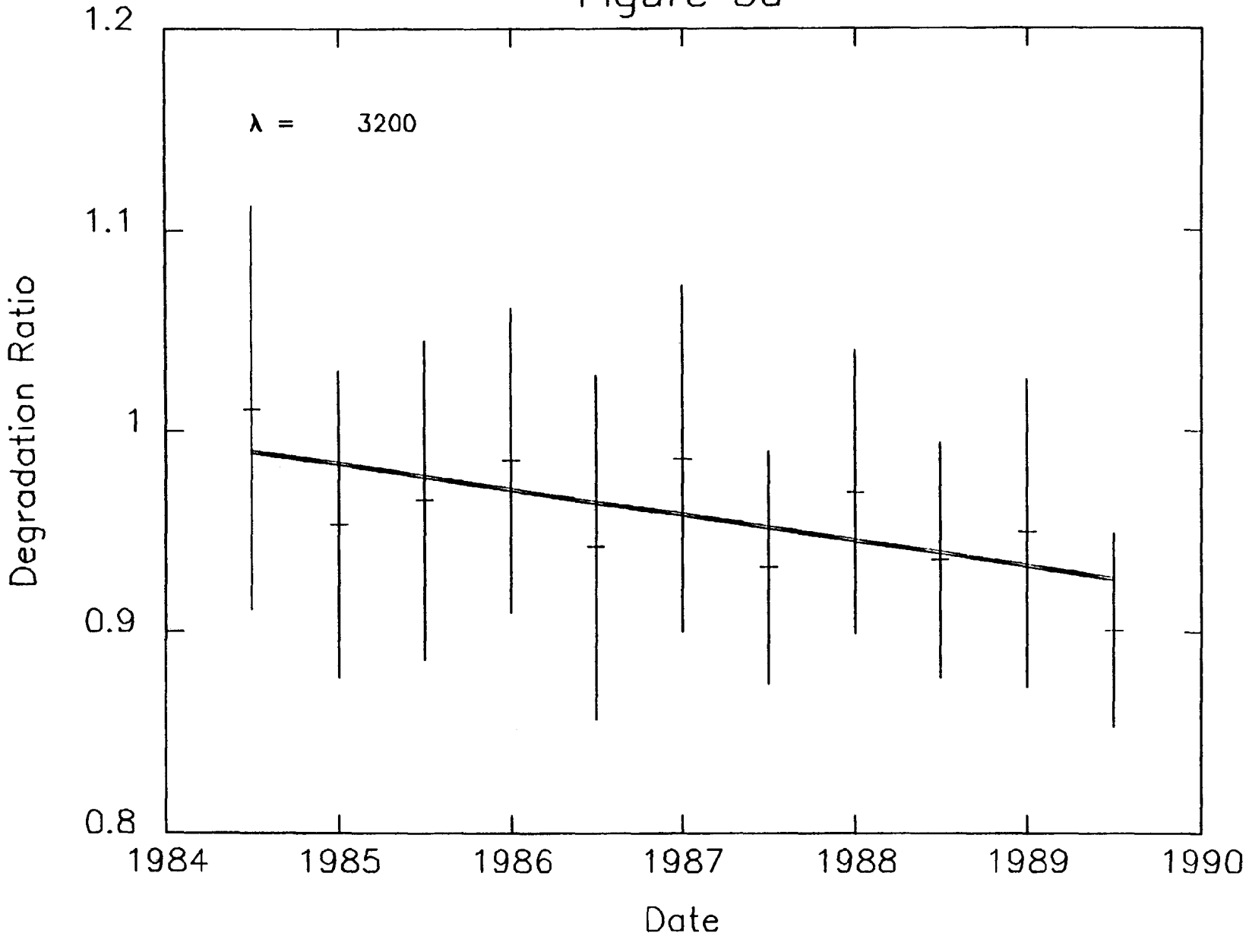

λ = 2800
Degradation Ratio
1.2
1.1
1
0.9
0.8
1984
1985
1986
1987
1988
1989
1990
Date

Figure 5d


λ = 3200
Degradation Ratio
1.2
1.1
1
0.9
0.8
1984
1985
1986
1987
1988
1989
1990
Date

# Figure 6

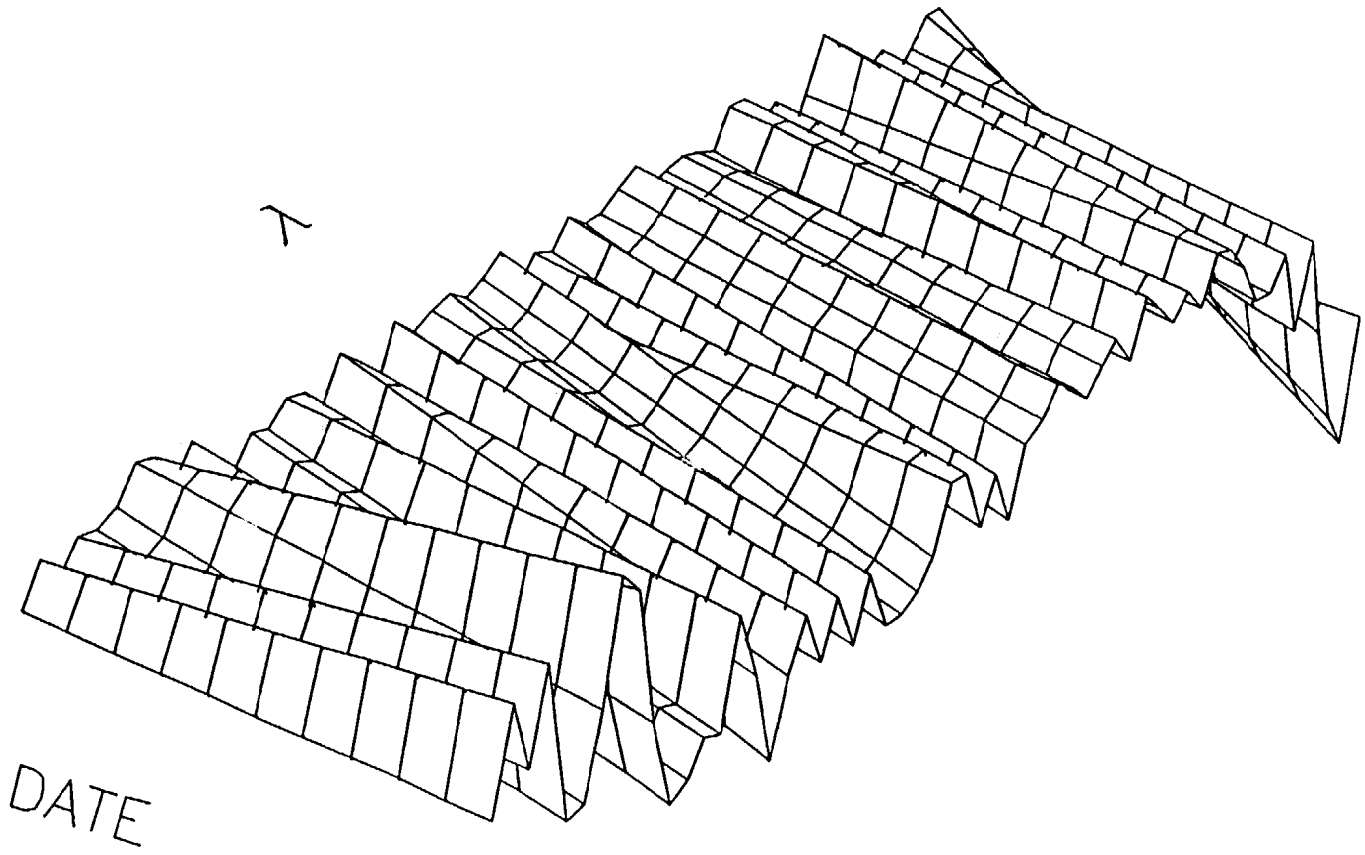
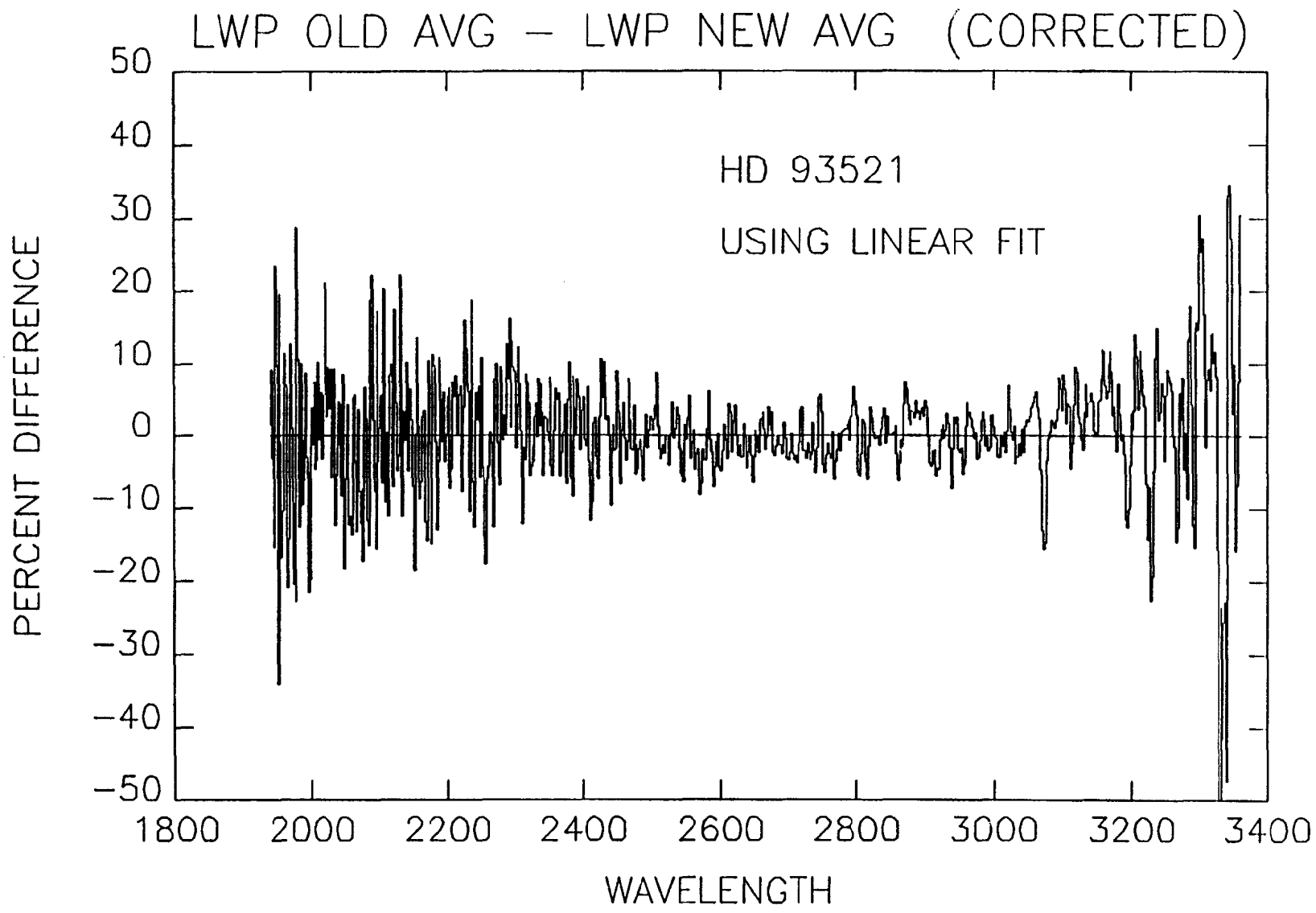


**Figure 7**


LWP OLD AVG – LWP NEW AVG (CORRECTED)
HD 93521
USING LINEAR FIT
PERCENT DIFFERENCE
50
40
30
20
10
0
−10
−20
−30
−40
−50
1800
2000
2200
2400
2600
2800
3000
3200
3400
WAVELENGTH