Analysis of the Temperature Dependent Coefficient as a Function of Wavelength

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Introduction

A study was initiated recently to determine the change in temperature coefficients as a function of wavelength and how they will be applied to IUE data during the Final Archive reprocessing effort. This work was done on images processed with current IUESIPS, however, eventually the analysis will be repeated with NEWSIPS data.

The problem of changes in camera sensitivity can be divided into several parts, each of which describes a different aspect of camera response:

a) a "constant term" or THDA (Camera Head Amplifier Temperature) coefficient, which is not a function of time. It is assumed that this term is the temperature dependence, since there are no other time-independent sources of variability.

b) a "camera term", or degradation coefficient which is the same for all stars and represents a percent change in camera sensitivity as a function of time.

c) terms representing the residual changes for the different stars.

The solution is derived mathematically by constructing a matrix of simultaneous equations, which when solved, provides one with a camera coefficient for each selected wavelength bin and an overall temperature coefficient for the camera. The term "overall" is used to describe the temperature dependent coefficient as it corresponds to the range of wavelengths that are specified in the analysis. The standard quick-look low-dispersion sensitivity monitoring (Garhart 1990) uses the following set of wavelengths:

LWP: 2075-2975Å LWR: 2250-3050Å SWP: 1225-1925Å.

The average THDA has been more or less constant (see Figure 1) since approximately 1981 (1983 for LWP), so the temperature coefficients are clearly decoupled from the average sensitivity degradation.

IUE flux values can be corrected for variations in camera sensitivity as a function of THDA using the temperature dependent coefficients as derived from the sensitivity monitoring analysis. The equation used to make this correction is:

$$Corrected\ Flux = \frac{Flux}{(1 + C(THDA - ref.\ THDA))}$$

where C is the temperature coefficient and *ref. THDA* is the reference THDA. The current values, as used in this equation, are listed in Table 1.

Table 1.

Temperature Coefficients and Reference THDA's

	LWP	LWR	SWP
Temp. Coef. (%/°C)	-0.19±0.03	-0.88±0.04	-0.46±0.03
Ref. THDA (°C)	9.5	14.5	9.5
Avg. ITF THDA	8.4	14.5	9.3
ITF epoch	1984.5	1984.0	1985.0
Avg. Sens. Mon. THDA	9.5	14.0	9.4

The reference THDA was calculated by taking an average of the camera temperatures for all science images. It must be decided whether to continue using these values or possibly using an average of the camera temperatures of observations used for the ITF or an average of the THDA's for the sensitivity monitoring data which are used to derive the temperature coefficients (see Table 1). The values of these coefficients have remained quite stable for the LWP and SWP cameras (within one sigma) over the past five years so there is clearly no time dependency involved (see Figure 2). There is some evidence of variability for the LWR, although this occured after the camera was decomissioned. Even though the correction due to the temperature dependent term is small, it should be included in the IUE Final Archive.

Analysis

The temperature coefficients assume that the response of the camera to THDA is independent of wavelength. A test of this assumption was performed by deriving temperature coefficients for several wavelength bins and analyzing the results. The software used to solve the camera response matrix is a multiple-linear regression routine created by Holm and Schiffer (1980) and is based on an algorithm developed by Bevington (1969). The method of analysis is similar to the one used for the standard quick-look sensitivity monitoring. The database consists of several hundred observations of five standard stars. The flux data for each observation were separated into relatively narrow wavelength bins (50Å), as compared with the broad-band regions used in standard sensitivity monitoring (150Å and 300Å), and ratioed to a reference spectrum. The binned flux ratios are then fitted using the above mentioned multiple-linear regression to find the temperature dependent coefficient for each region and its corresponding standard deviation. The coefficients are then plotted as a function of wavelength in Figure 3. A linear fit to each set of data points along with a line indicating the overall temperature dependent coefficient, as derived from the sensitivity monitoring analysis, are provided for each camera. A fourth order polynomial fit of the data is also included with the SWP plot.

Summary/Recommendations

The plotted data seem to indicate that there is little or no dependence of the temperature coefficients on wavelength for the LWP and LWR cameras, whereas the SWP shows a slight dependence. It is not clear what caused the three discrepant points in the LWR data, although the one at 2800Å corresponds to a region near the Mg II line. The coefficients for these three bins were determined for the past seven years and found to be consistent with the current value (i.e. abnormally low as compared with the other bins). We recommend using, at least, a constant correction for the LWP and LWR cameras, while the SWP temperature coefficients could be represented by some sort of fit (linear, polynomial, *etc.*).

The estimated errors from applying no THDA correction at all can be determined from the value of the temperature dependent coefficient:

$$\%error = C(THDA - ref.\ THDA).$$

Assuming a "worst case" scenario, where the camera temperature differs from the reference THDA by five degrees, the LWP fluxes would be in error by approximately one percent, the LWR by almost four and one-half percent, and the SWP by about two and one-half percent. The error between using an average temperature correction versus a fourth order wavelength fit for the SWP is one and one-half percent and the LWR coefficient at 2800Å, when compared with the standard value, results in a difference of almost three and one-half percent, assuming the same five degree temperature difference. As a result it may be necessary to include the three discrepant values as valid points using a nearest neighbor interpolation scheme. We would like to generate fluxes with an internal accuracy of one to two percent for the IUE Final Archive. The corrections made by the temperature dependent coefficients are of the same order, so their inclusion is worthwhile.

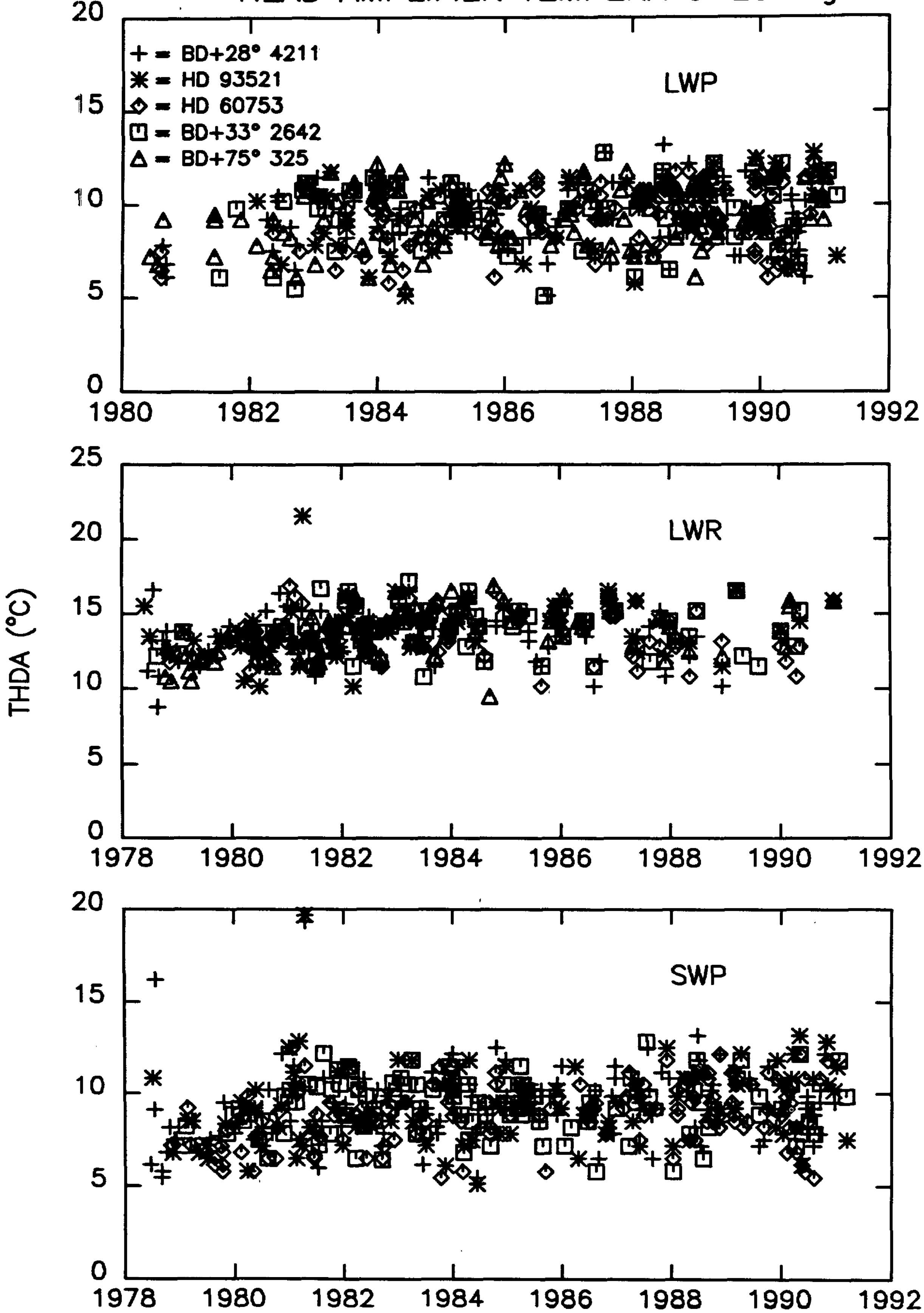
References

Bevington, P.R. 1969, *Data Reduction and Error Analysis for the Physical Sciences*, McGraw-Hill, New York.

Garhart, M.P. 1990, *NASA IUE Newsletter*, **41**, 213.

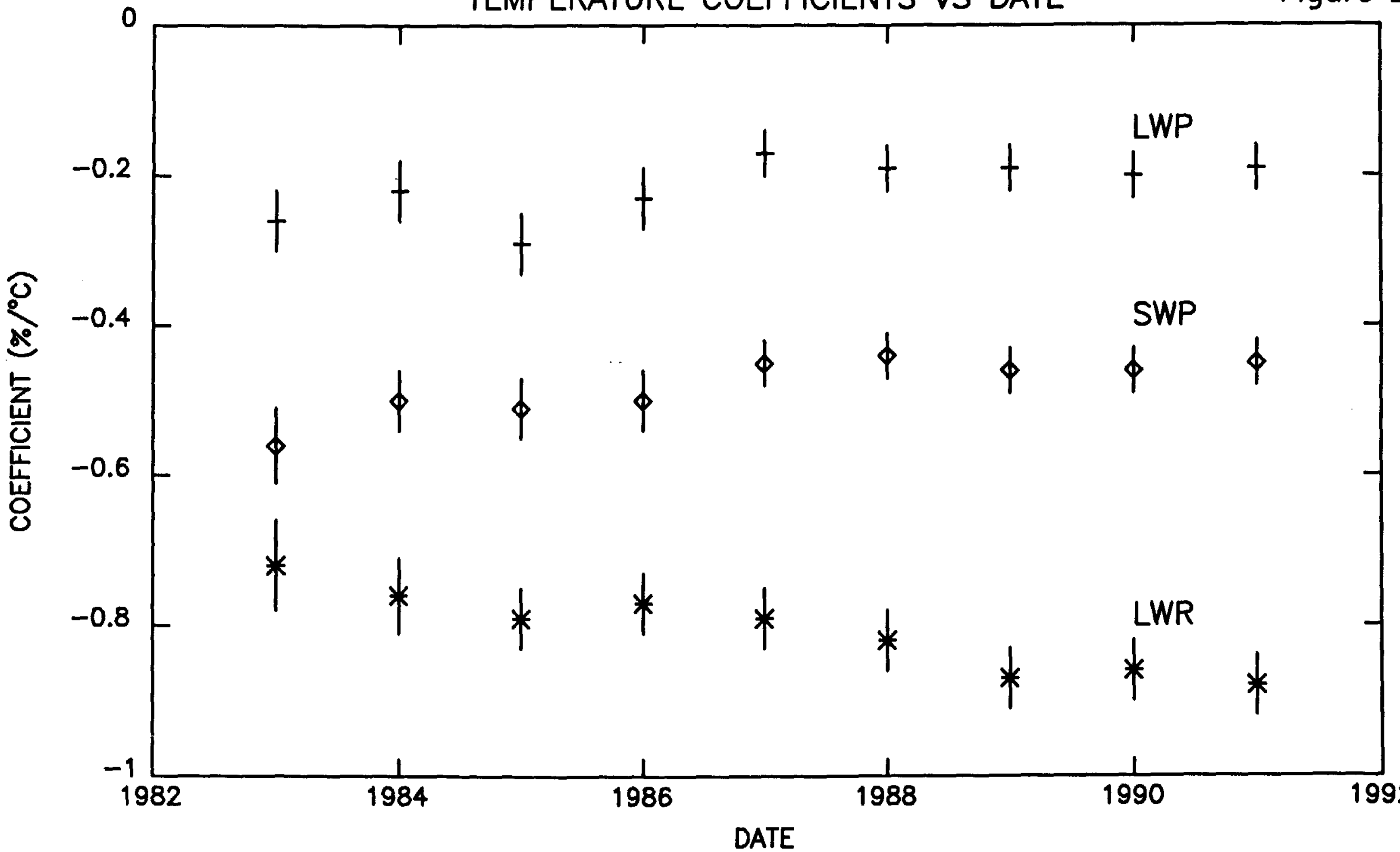
Holm, A.V. and Schiffer, F.H. 1980, *NASA IUE Newsletter*, **9**, 8.

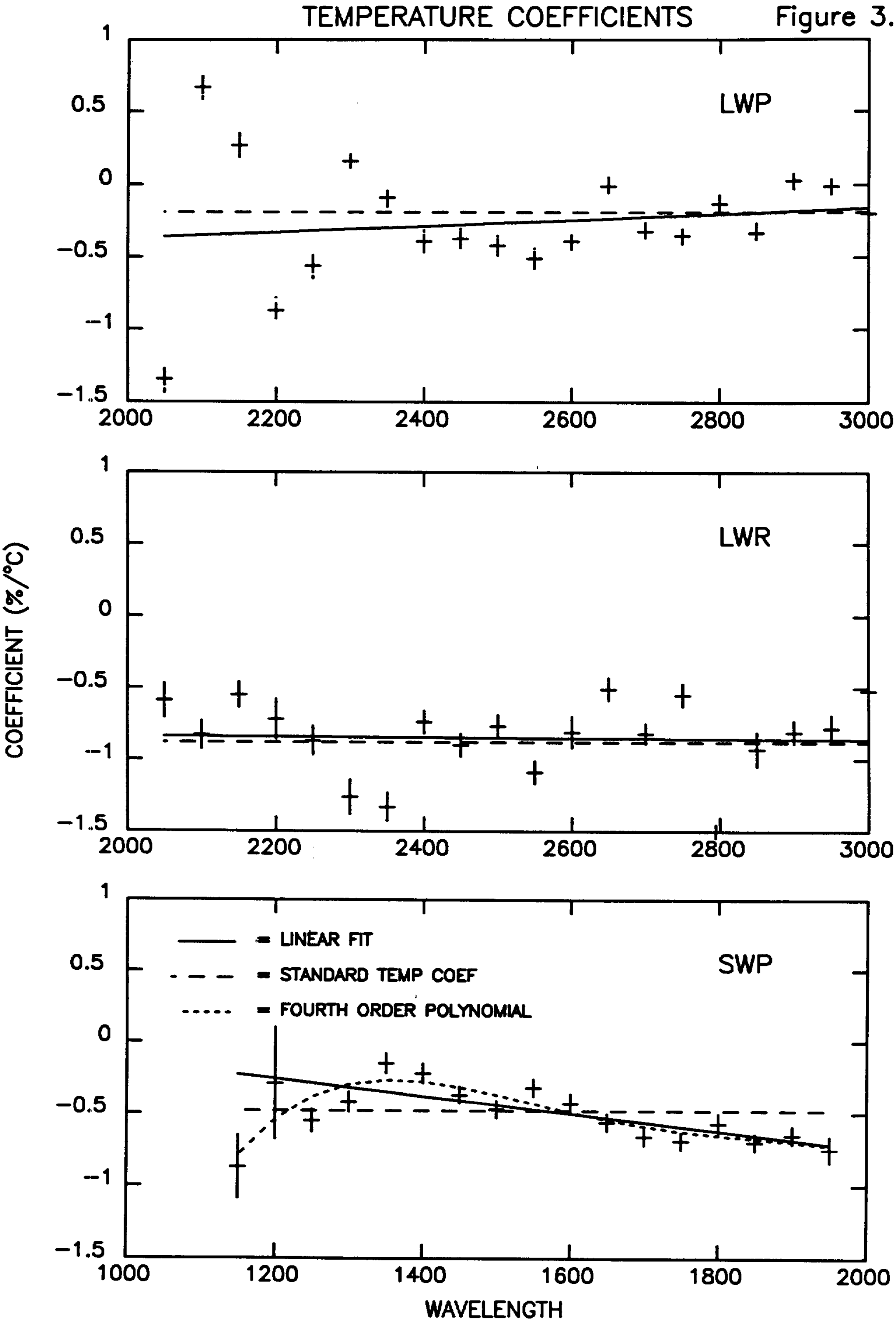
HEAD AMPLIFIER TEMPERATURES Figure 1.



TEMPERATURE COEFFICIENTS VS DATE

Figure 2.





TEMPERATURE COEFFICIENTS
Figure 3.
COEFFICIENT (%/°C)
LWP
LWR
SWP
= LINEAR FIT
= STANDARD TEMP COEF
= FOURTH ORDER POLYNOMIAL
WAVELENGTH
1
0.5
0
−0.5
−1
−1.5
2000
2200
2400
2600
2800
3000
1000
1200
1400
1600
1800