10.3: Background Removal

Another form of noise is a systematic background signal on which the analytical signal of interest is overlaid. For example, the following figure shows a Gaussian signal with a maximum value of 50 centered at $x = 125$ superimposed on an exponential background. The dotted line is the Gaussian signal, which has a maximum value of 50 at $x = 125$, and the solid line is the signal as measured, which has a maximum value of 57 at $x = 125$.

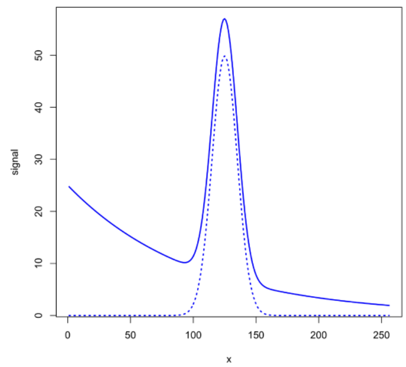

Figure 10.3.1: A Gaussian signal (dotted line) superimposed on an exponential background, which gives rise to the measured signal (solid line).

If the background signal is consistent across all samples, then we can analyze the data without first removing its contribution. For example, the following figure shows a set of calibration standards and their resulting calibration curve, for which the *y*-intercept of 7 gives the offset introduced by the background.

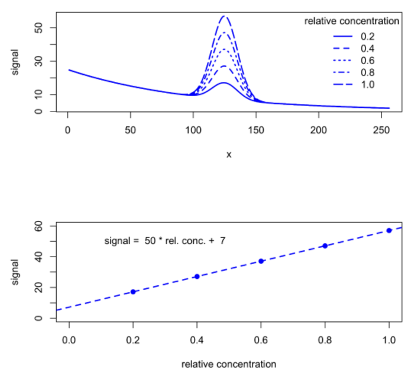

Figure 10.3.2: When the background is the same for all calibration standards and samples, then we can construct a calibration curve without taking into account the presence of the background.

But background signals often are not consistent across samples, particularly when the source of the background is a property of the samples we collect (natural water samples, for example, may have variations in color due to differences in the concentration of dissolved organic matter) or a property of the instrument we are using (such as a variation in source intensity over time). When true, our data may look more like what we see in the following figure, which leads to a calibration curve with a greater uncertainty.

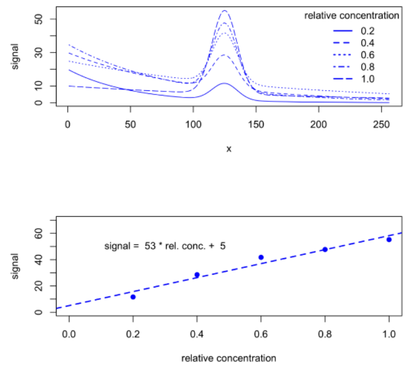

Figure 10.3.3: When the background is not the same for all calibration standards, the quality of the calibration curves suffers, making it less useful for the analysis of samples.

Because the background changes gradually with the values for *x* while the analyte's signal changes quickly, we can use a derivative to the distinguish between the two. One approach is to use a Savitzky-Golay derivative filter using the same approach described in the last section. For example, applying a 7-point first-derivative Savitzky-Golay filter with weights of

$$-3/28 \qquad -2/28 \qquad -1/28 \qquad 0/28 \qquad 1/28 \qquad 2/28 \qquad 3/28$$

to the data in Figure $10.3.3$ gives the results shown below. The calibration signal in this case is the difference between the maximum signal and the minimum signal, which are shown by the dotted red lines in the top part of the figure. The fit of the calibration curve to the data and the calibration curve's *y*-intercept of zero shows that we have successfully compensated for the background signals.

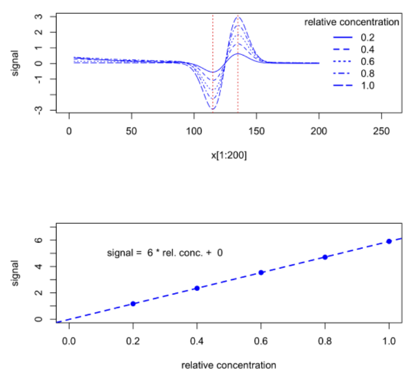

Figure 10.3.4: Applying a Savitzky-Golay derivative filter to the calibration curve data in Figure $10.3.3$ corrects for the differences in the background signals, yielding an improved calibration curve.

For other Savitzky-Golay derivative filters, including second-derivative filters, see Savitzky, A.; Golay, M. J. E. *Anal Chem*, **1964**, *36*, 1627-1639.