



Instructions for Detrending a GPS Time Series in Excel

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Introduction

Analyzing geodetic data sets often benefits by including consideration of plots of detrended data. This document outlines a simple method for accomplishing the calculations and creation of a plot of detrended data. Rather than just describing the general techniques, this document provides a step by step look at the components of a spread sheet where the vertical GPS time series is detrended. This instruction sheet can be passed on to students who do not have much experience with Excel to get them more comfortable with some of the functions and steps needed to apply this to a set of GPS stations. There are two variations presented which describe how to accurately calculate the residuals in data sets (especially where there may be time gaps in a dataset).

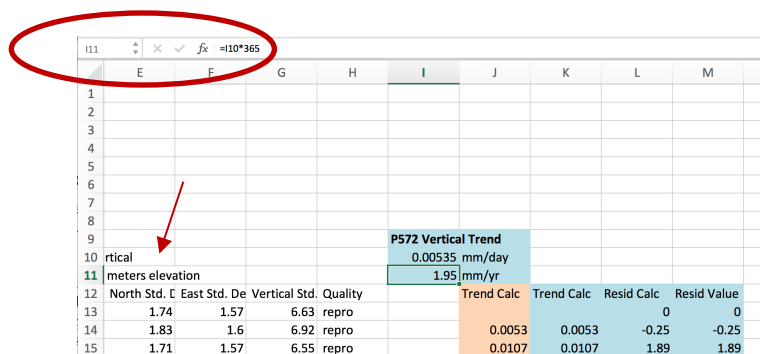
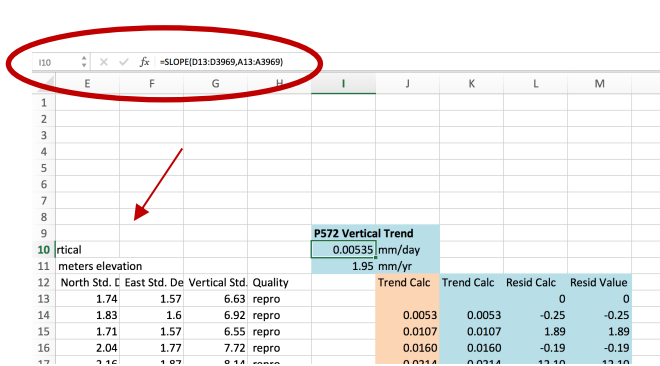
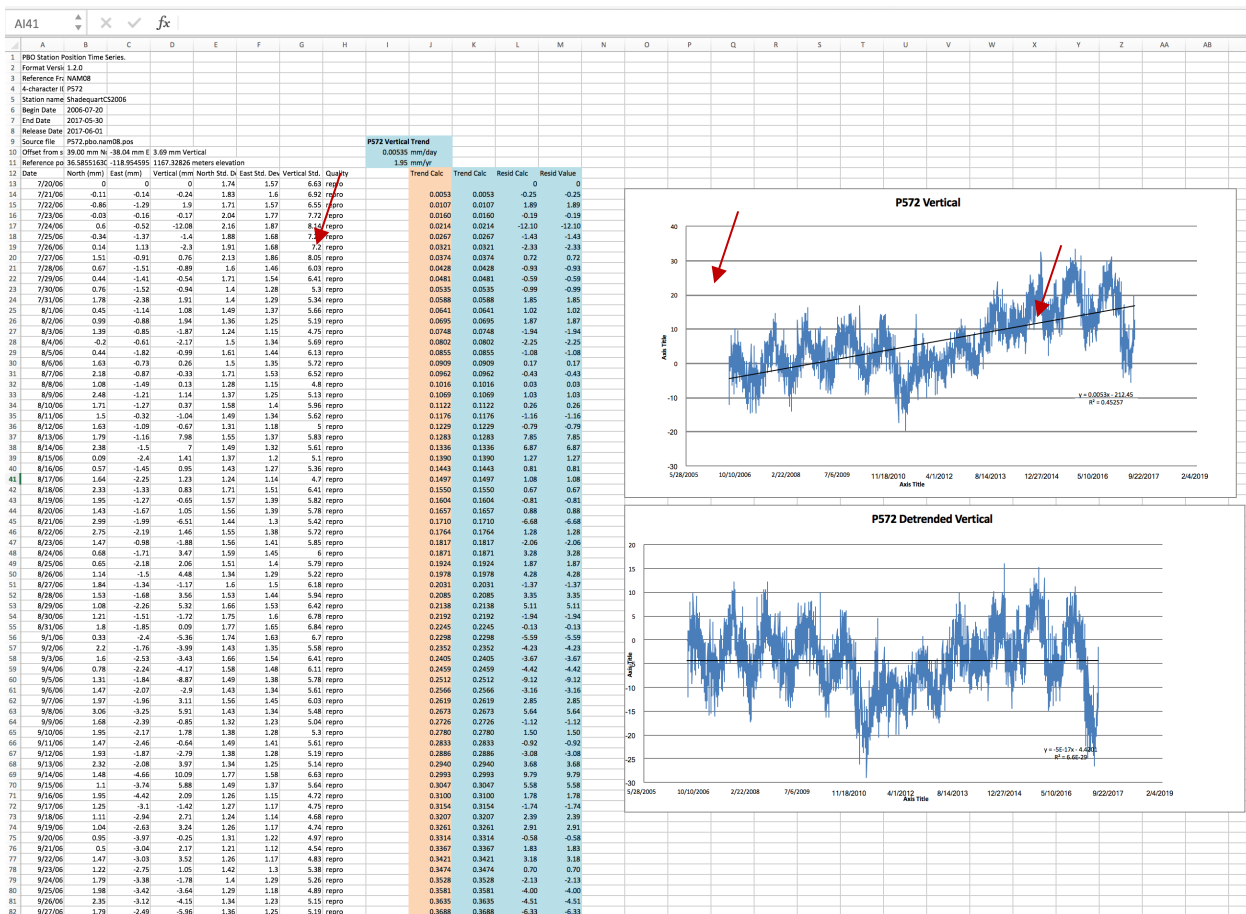
Figure 1 provides a view of the basic GPS data plotted, the general residual values resulting from the detrending calculations, and the resulting detrended plot. The rows and columns highlighted in color contain the calculations required to accomplish the detrending and calculated residuals. The column shown in tan contains the use of the Excel MIN(A:A) function to determine the starting date for the time series that is then used to calculate the value for the trend for each day of data. The blue columns contain a specified value to start the calculation using the `A13` designation for a specific column row that contains the starting date. It should be noted that in some cases within the spread sheets, the columns and rows have been specifically noted to include a tab designation as well as specific cells, but in other cases, the designations are not specifically fixed. It is **critical** to double check that items that are copied and pasted are not automatically adjusted to some new column designation (e.g. the Excel function that designates column A, which contains the date, is now shown as B in the function).

* Note: The Excel file associated with Unit 3 is provided with this tutorial ("Instructor Data File").

Detailed Steps

- 1.) The first step in creating a detrended time series is to calculate the **overall trend of the data**. This can be done on the plot by including a linear fit to the data or by using the Excel SLOPE function (Figure 2).
- 2.) The overall trend can then be **converted to the annual trend** as required (Figure 3). As mentioned above, there are two options for calculating the residuals for each day of the time series using either the Excel MIN (A:A) function used in the orange column or using a cell designation (`A13`) for the first date entry in the time series, as used in the blue columns. This is necessary to ensure that portions of the data that have missing days are properly filled in with the same overall trend; if this is not done then the calculated steps will not account for the missing days in the record. Depending on the size of the record searching for time gaps can be tedious.
- 3.) Once the data points that represent the time series trend are calculated (Figure 4), the difference between individual data points and the trend can be calculated to **produce residual values** (Figure 5). Another column can be added that contains the residual values (Figure 6) that uses the VALUE (L14) Excel function to facilitate plotting.
- 4.) **NOTE**: If the three new columns are created in the same location on additional GPS station data sets/tabs, it is efficient to copy and paste each of the appropriate cells to begin to create a detrended plot for another GPS time series.

Detrending GPS Time Series



Detrending GPS Time Series

$$K14 \quad \text{fx} \quad =\$I510*(A14-\$A\$13)$$

1													
2													
3													
4													
5													
6													
7													
8													
9													
10	Vertical												
11	meters elevation												
12	North Std. E. East Std. De	Vertical Std.	Quality										
13	1.74	1.57	6.63	repro									
14	1.83	1.6	6.92	repro									
15	1.71	1.57	6.55	repro									
16	2.04	1.77	7.72	repro									

Figure 4. Calculation of the daily values for daily increment of trend.

$$L13 \quad \text{fx} \quad =D13-K13$$

1	ies.												
2													
3													
4													
5	06												
6													
7													
8													
9	3.pos												
10	04 mm 3.69 mm Vertical												
11	3.95459 1167.32826 meters elevation												
12	(mm) Vertical (mm North Std. E. East Std. De	Vertical Std.	Quality										
13	0	0	1.74	1.57	6.63	repro							
14	-0.14	-0.24	1.83	1.6	6.92	repro							
15	-1.29	1.9	1.71	1.57	6.55	repro							
16	-0.16	-0.17	2.04	1.77	7.72	repro							

Figure 5. Calculation of the residual values for the time series.

$$M14 \quad \text{fx} \quad =\text{VALUE}(L14)$$

1	ies.												
2													
3													
4													
5	06												
6													
7													
8	3.pos												
9	04 mm 3.69 mm Vertical												
10	3.95459 1167.32826 meters elevation												
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14	-1.29	1.9	1.71	1.57	6.55	repro							
15	-0.16	-0.17	2.04	1.77	7.72	repro							

Figure 6. Conversion of the calculated residual values to a number for ease in plotting.

Additional Notes

- Unfortunately, there does not seem to be a convenient way in Excel to cut and paste the functions/formulas into the column other than dragging down to the bottom to indicate how many of the cells need to have the function/formula pasted.
- Once the last entry in the data set is known, this value can be used in constructing or modifying the plots to specify the end value for the data sets.
- Again, an efficient way to create a new plot is to copy the plot from one GPS station and paste it into another tab and then change the end values to those appropriate for the time series that you are now working on. The same is true for the plot of the detrended residual values.
- Another feature of Excel that can be problematic is how Excel handles dates. The hidden default for dates in Excel is that dates are given in number of days since 1900. If the dates appear to not be the same as those in the Date column (e.g. starting in 1900 rather than 2006) then once the plot is made, the x-axis can be selected and then the desired format can be specified in the pull-down format axis option menu (Figure 7).

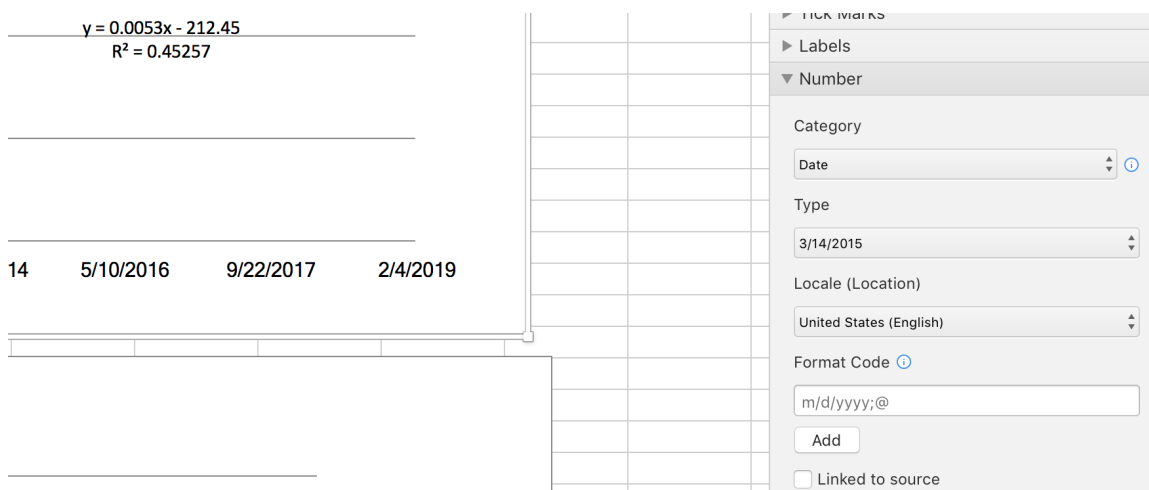


Figure 7. Pull down menus for formatting the x-axis to achieve the desired date label option.