

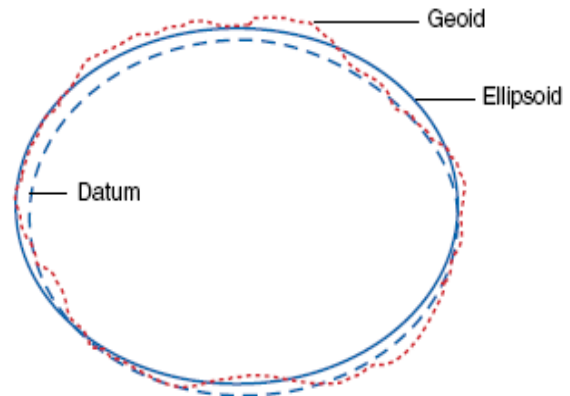
GPS and Mean Sea Level in ESRI® ArcPad®

October 30, 2014

Summary

In order to record elevation values as accurately as possible with ArcPad, it is necessary to understand how ArcPad records elevation. Rather than storing elevation values relative to Mean Sea Level (MSL), ArcPad records z values as Height Above Ellipsoid (HAE) meters. HAE values can differ by up to hundreds of feet from MSL, and in coastal areas, HAE values can even be negative.

GPS satellites use an ellipsoid as the basis for their height measurement. An ellipsoid is a three-dimensional mathematical model of the earth's shape. GPS uses the WGS 1984 ellipsoid, which has as its origin the center of the earth's mass. Since GPS satellite orbits also originate with the center of the earth's mass, it is easy for GPS to calculate a height relative to this surface.



Note: Trimble® GPS Analyst™ Extension for ArcGIS® and the Trimble Positions Desktop Add-in always rebuild the z values from the underlying GPS data, which is always stored as Height Above Ellipsoid in meters. Therefore, neither of the workarounds suggested in this Support Bulletin will have any effect for GPS Analyst and Trimble Positions users, who must wait until ArcGIS support vertical datum transformations. Geoid calculations can be done after the data is processed in ArcGIS Desktop.

Since sea level is a function of gravity, and is therefore an irregular shape, HAE values must be converted to MSL values using a geoid model. A geoid is defined as the surface of gravitational equipotential - basically what sea level would be if projected through land masses.

A geoid model applies geoid separation values for a particular location. Geoid separation values are not constant, but vary with location. Many GPS receivers store a lookup table of geoid separation values, but due to storage constraints on the GPS receiver, these values may not be very accurate. For example, many GPS receivers use a DMA10x10 geoid model, which stores geoid separation values for a 10° x 10° area. In such a large area, geoid separation values would actually vary a great deal, meaning that MSL values calculated with such a 'rough' geoid model could tend to be very inaccurate. Accurate geoid separation values are available from national geodetic agencies. The following will show 2 ways to change the height reference with ArcPad to MSL without sacrificing accuracy.



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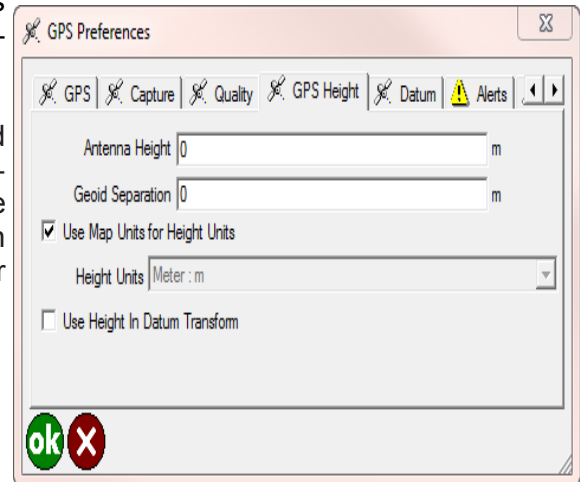
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Setting Geoid Separation in ArcPad GPS Preferences

To obtain accurate MSL values in the field with ArcPad, it is necessary to enter both the antenna height and a geoid separation on the GPS Height tab in GPS Preferences.

Make sure to enter the geoid separation in the specified height units. Geoid separation values for the US can be obtained from the [National Geodetic Survey](#). These values are supplied in meters. ArcPad subtracts the geoid separation from the ellipsoidal height (HAE) to determine the height for the z-value. The resultant height is MSL.

Be aware that geoid separation values can vary with location. Therefore this method may be best when working in a relatively small geographic area, or if you have determined that the geoid separation is the same wherever you work. If an incorrect geoid separation is entered in ArcPad, resulting z-values will be incorrect.

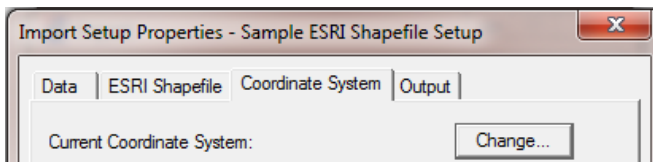
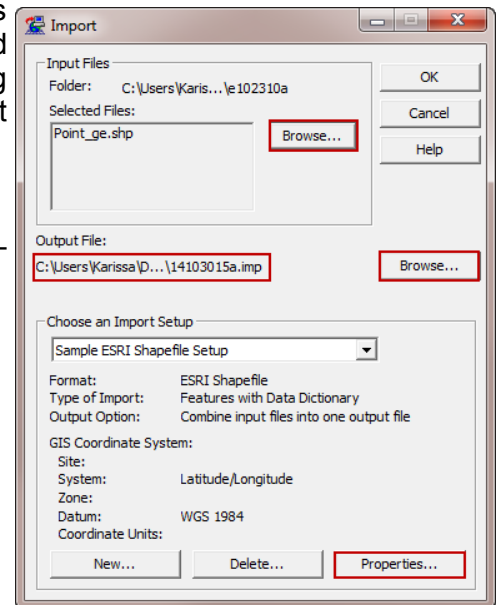


Using Trimble GPS Pathfinder® Office to Change Height Reference

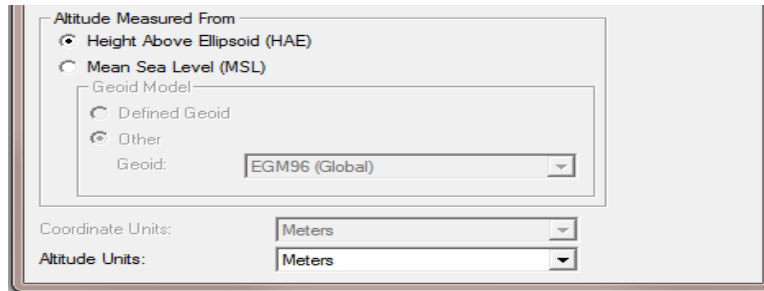
An alternative to entering a geoid separation in ArcPad involves using Pathfinder Office to convert HAE to MSL. An accurate and up-to-date geoid model is available in this software. If employing this method, leave the geoid separation set to 0 in ArcPad, so that HAE values are recorded in the field.

To perform the conversion, do the following:

1. Use the Import utility in Pathfinder Office to transform shapefiles that are HAE meters into Trimble IMP files.
- Press the top Browse button to select shapefiles to convert.
 - Press the Browse button next to 'Output File' to change the name of the Trimble IMP file.
 - Beneath 'Choose an Import Setup,' select the Sample ESRI Shapefile Setup from the drop-down list.
 - Press the Properties... button in the lower right.
 - Click on the Coordinate System tab, then press the Change... button.



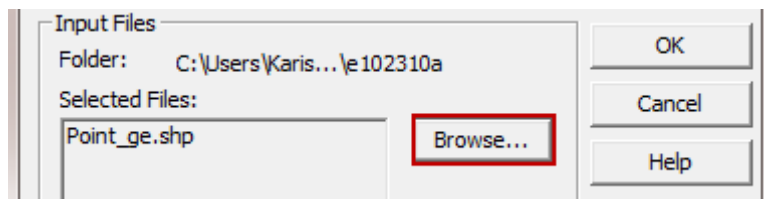
- Specify the coordinate system, zone, datum, and coordinate units that the shapefiles are currently in.



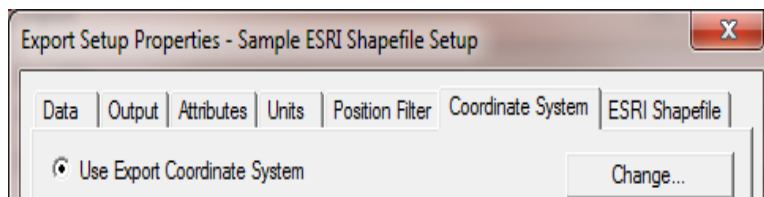
- Most importantly, specify HAE meters for the current height reference.
- Press OK to save settings changes until you are at the main Import screen. Press OK to run Import.

2. Use the Export utility to transform Trimble IMP files into shapefiles that are referenced to MSL.

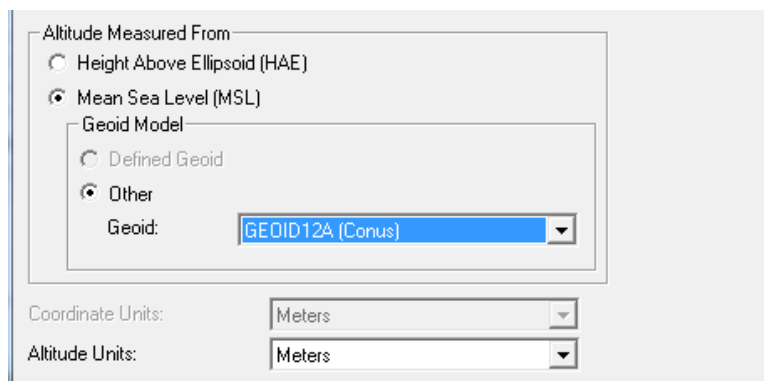
- If not already listed, press the top Browse button to choose the IMP file created in the last step.



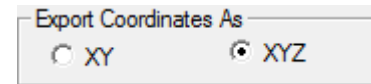
- Press the center Browse button to set the output folder to the original ArcPad shapefile location.
- Beneath 'Choose an Export Setup,' select 'Sample ESRI Shapefile Setup' and press the Properties... button.
- Click on the Coordinate System tab, choose 'Use Export Coordinate System' and click the Change... button



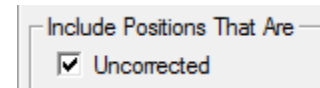
- Set the output coordinate system, zone, datum, and coordinate units to match the original shapefiles.
- Most importantly, change the 'Altitude Measured From' to MSL and specify the GEOID12A (Conus) geoid model. This is the most up-to-date geoid model available in Pathfinder Office.



- Tap OK.
- At the bottom of the dialog, select the 'Export Coordinates as XYZ' to ensure a 3D shapefile is created by the Export utility.
- Click on the Position Filter tab.



- Check the box to 'Include Positions That Are Uncorrected.'
- Click OK to return to the main Export dialog.
- Click OK to complete Export. When warned that files will be overwritten, click Yes.



Conclusion

Using a geoid separation value in ArcPad GPS Preferences results in MSL values being stored while data is collected in the field. However, care must be taken that the geoid separation value entered is correct as location varies.

Using Pathfinder Office to convert from HAE to MSL allows the use of the most up-to-date geoid model from the NGS but involves several extra steps. In addition, it only works with shapefiles, not with ArcPad AXF data.

Either method will result in the most accurate MSL value possible. Absolute accuracy will vary, as vertical accuracy (HAE) is 1-3 times worse than horizontal to begin with, and conversion from HAE to MSL also introduces some error.