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GPS Pathfinder Office Software or GPS Analyst Extension for ESRI ArcGIS Software: Resolving the NAD 83 Datum Transformation Issue

Summary

The current realizations of the North American Datum of 1983 (NAD 83) and the World Geodetic System 1984 datum (WGS-84) differ by a meter or more. An error can be introduced by assuming that they are the same. This support note explains how to avoid such “datum shift” errors in Trimble postprocessing software (the Trimble® GPS Pathfinder® Office software or the Trimble GPS Analyst™ extension for Esri ArcGIS software).

Background

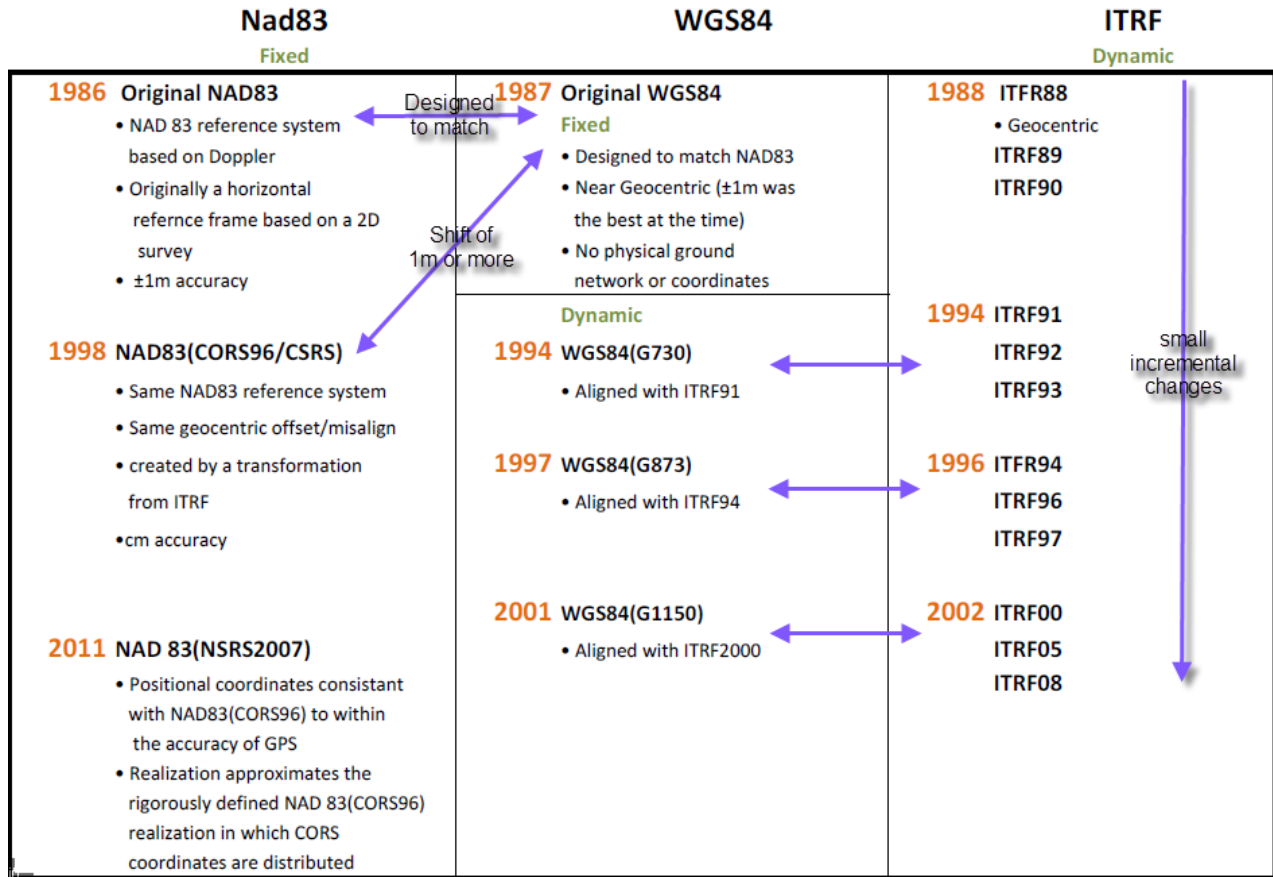
The original WGS-84 datum definition was essentially the same as the original NAD 83 datum definition (called NAD 83 (1986)). Over time, both datums have been redefined several times, and they can differ by a meter or more.

The WGS-84 definition has been aligned with the global International Terrestrial Reference Frame (ITRF) definition, to the point where ITRF00 and the current realization of WGS-84 differ by only a centimeter worldwide. Therefore, wherever a WGS-84 reference position or datum transformation is required, an ITRF00 reference position or datum transformation can be substituted.

The NAD 83 datum is relevant only to North America, and is used to define the coordinate systems for Canada and the US State Plane systems. The most widely used realization is called NAD 1983 (CORS 96).

Note: For detailed information on NAD 83 realizations and the differences between them, refer to the article titled “Modern Terrestrial Reference Systems Part 2: The Evolution of NAD 83”. This article is available on the National Geodetic Survey (NGS) website at www.ngs.noaa.gov/CORS/Articles.

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Issues

Reference Frame

By default, differentially corrected GNSS positions are in terms of the correction source's reference frame. For example, if you correct against a Continuously Operating Reference Station (CORS) base station using a NAD 83 reference position, then your corrected data is in terms of the NAD 83 datum. Similarly, US Coast Guard beacons provide corrections in terms of the NAD 83 datum, so real-time beacon-corrected positions are in terms of NAD 83.

In the base station list, provided and published by Trimble, ITRF00, Epoch(1997.0) reference positions are provided for all CORS, Cooperative CORS, and Scripps Orbit and Permanent Array Center (SOPAC) stations. Other stations' reference positions may be in terms of the NAD 83 datum or other reference frames. Knowing the reference frame of the base station that you are using is the first step towards eliminating datum shift errors. To check a base station's reference position, go to the base provider's website.

Trimble postprocessing software assumes that all GNSS data is in terms of the current WGS-84 datum. If you have differentially corrected against a correction source whose reference position is not in terms of WGS-84 or ITRF00, then this assumption is false and a datum shift may be introduced. For example, if your correction source is in terms of NAD 83 (CORS 96), this datum shift may be a meter or more.

If your data is real-time corrected, the Trimble TerraSync™ software version 3.20 (and later) allows you to configure the datum of your real-time source. Correctly configuring the real-time datum means corrected positions are automatically shifted to WGS-84 and no datum shift error is introduced in the field. If you have not configured the real-time datum to match the reference system of your real-time source, or you use an earlier version of the TerraSync software, or you use the Trimble GPSCorrect™ extension or GPS Analyst extension to collect your data, your real-time corrected positions will be in terms of the reference system of your real-time source and a datum shift error may be introduced. If your real-time correction source is in terms of NAD 83 (CORS 96), this error may be a meter or more.

Zero Datum Transformation from WGS-84 to NAD 83

Because WGS-84 and NAD 83 (1986) were previously treated as the same, the coordinate system database (CSD) in the GPS Pathfinder Office software contains a “zero” NAD 83 datum transformation definition, which does not transform coordinates between WGS-84 and NAD 83.

When you export WGS-84 GNSS data from the GPS Pathfinder Office software to a GIS that uses a coordinate system based on the “zero” NAD83 datum transformation, no transformation is performed, as you are assuming the original NAD 83 realization (1986). If you were looking for a current realization of NAD 83, such as CORS 96, a datum shift of a meter or greater will occur. It is therefore important to be aware of what realization of NAD83 you are using as this is what will introduce the data shift.

Solutions

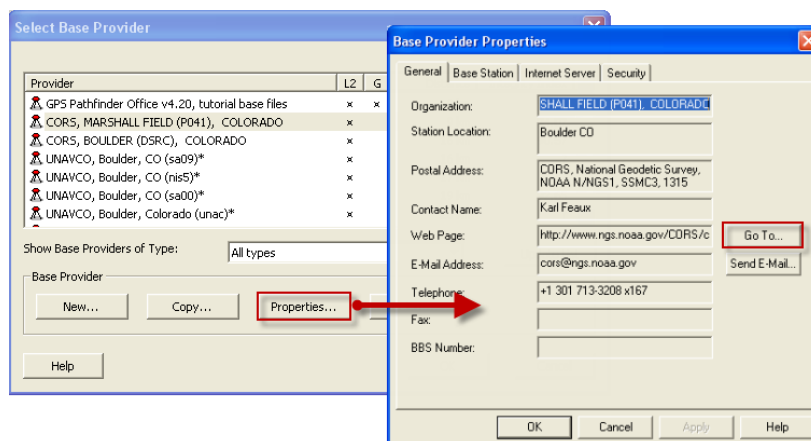
To ensure that you do not introduce datum shift errors into your data, it is important that you do the following:

- **Determine your desired reference frame for your exported data.**

In many cases this is driven by the data already in the GIS. For example, your GIS may already have cadastral and other layers in terms of NAD83(CORS 96).

- **Verify the reference frame of any differential correction source that you use.**

This includes real-time correction sources, base providers from the Trimble base station list, and any other base data that you use. To check a base provider’s reference position, go to the base provider’s website. The base provider’s website URL can be found under base properties in the Differential Correction Wizard by selecting properties/Go To... (see image below).



- **Apply the correct real-time datum transformation in your field software.**

The correct real-time datum transformation depends on the reference frame of the real-time correction source, and on the datum used by the coordinate system in your GIS. If the datums of the real-time correction source and your GIS match (for example, both are in NAD 83(CORS 96), the best solution is usually to work entirely within the same datum, and to apply no real-time datum transformations in your field software.

- **Apply the correct datum transformation between your GNSS data and your GIS.**

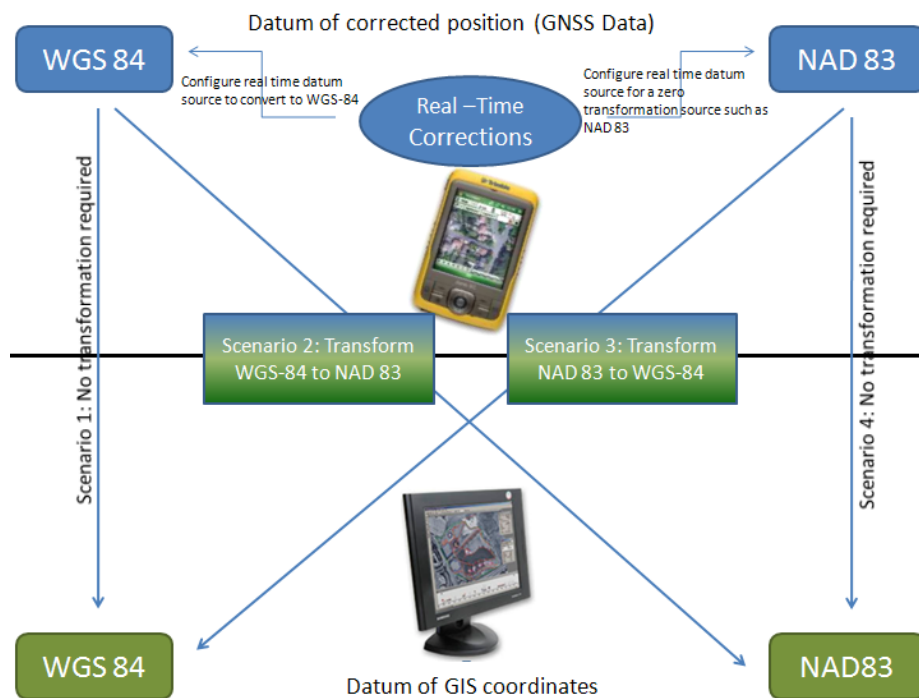
The correct datum transformation depends on the reference frame of the correction source, and on the datum used by the coordinate system in your GIS. If the datums and realizations of the correction source and your GIS match (for example, both are NAD 83 (CORS 96), or both are ITRF00), the best solution is usually to work entirely within the same datum, and to perform no datum transformations in your postprocessing software.

If necessary, update the reference position for the base provider in your Trimble postprocessing software, so that it is in the required reference frame. Remember, every time you apply a correction you assume the geodetics of that base.

Trimble also recommends that you postprocess GNSS data that has been corrected in real time. Re-correcting real-time positions not only gives you more accurate data, but also eliminates datum shift errors that may have been introduced by real-time correction sources.

Scenarios

This section describes common user scenarios, lists the problems that can occur, and the suggested solutions. These are the four basic scenarios:



Scenario 1: Corrected positions in terms of WGS-84, WGS-84 in GIS

GNSS data is corrected against sources that use WGS-84 or ITRF00 as their reference frame. Examples include real-time Wide Area Augmentation System (WAAS), or a base station with an ITRF reference position.

The GIS uses a coordinate system that is based on the WGS-84 datum.

GPS Pathfinder Office software

When you export your GNSS data from the GPS Pathfinder Office software, the required transformation between WGS-84 and the datum of the export coordinate system is performed. No datum shift error is introduced.

GPS Analyst extension

When you GPS-enable your geodatabase, the GPS Analyst extension prompts you to select a datum transformation. Select the NAD_1983_WGS_1984_1 (This transformation treats the NAD 83 and WGS-84 datums as though they are equivalent). Using the correct transformation ensures that no datum shift error is introduced when GNSS data is build into GIS feature geometry. Both GNSS data and GIS reference data are both in WGS-84, therefore there will be no transformation.

Scenario 2: Corrected positions in terms of WGS-84, but GIS is in terms of NAD 83

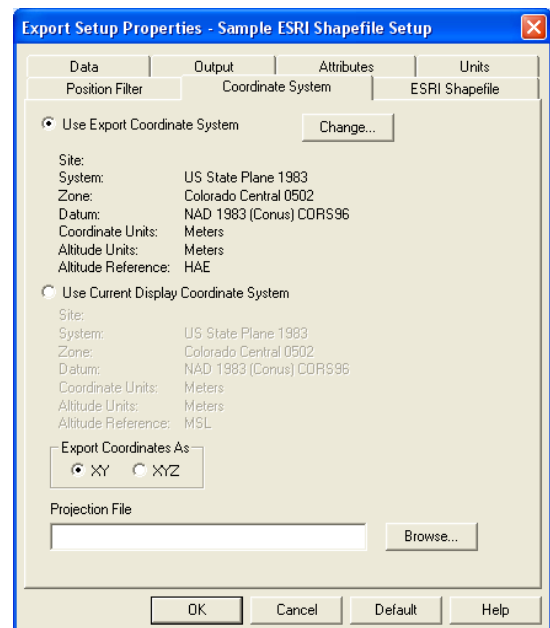
GNSS data is corrected against sources that use WGS-84 or ITRF00 as their reference frame. Examples include real-time WAAS, or a base station with an ITRF reference position.

The GIS uses a coordinate system based on a realization of the NAD 83 datum.

GPS Pathfinder Office software

When you export your GNSS data from the GPS Pathfinder Office software, the zero WGS-84 to NAD 83 (1986) transformation is performed, and a datum shift error of a meter or more is introduced. In order to remove this datum shift use the NAD 83 (CORS 96) datum in the export.

For the export, select *Utilities / Export / Properties*, and then select the *Coordinate Systems* tab. You can edit the export coordinate system, as shown:



GPS Analyst extension

When you GPS-enable your geodatabase, the GPS Analyst extension prompts you to select a datum transformation. Select a transformation—NAD_1983_To_WGS_1984_5 is the current one for the U.S. National Geodetic Survey (NGS) using CORS96. Using this transformation ensures that no datum shift error is introduced when GNSS data is built into GIS feature geometry.

For more information on other transformations (Canada and Hawaii) and determining which transformation to use, see the ESRI Support website at:

<http://resources.arcgis.com/content/kbase?fa=articleShow&d=24159>

Scenario 3: Corrected positions in terms of NAD 83, non-NAD 83 in GIS

GNSS data is corrected against sources that use a NAD 83 realization as their reference frame, such as CORS 96. Examples include US Coast Guard beacons, or a base station with a NAD 83 (CORS 96) reference position.

The GIS uses a coordinate system that is based on the WGS-84 datum.

GPS Pathfinder Office software

When you export your GNSS data, a datum shift error of a meter or more is introduced because the corrected data is in term of NAD 83, but the software treats it as a WGS-84 data. To remove the datum shift error, a reverse transformation (from NAD 83 to WGS-84) is required.

To avoid introducing this error, do one of the following:

- To remove the NAD 83 (CORS 96) datum transformation, the data can be differentially corrected using the *From Base Provider* option in the Differential Correction Wizard (Reference Position = ITRF00 [Epoch 1997.0]).
- Configure the real-time datum in the TerraSync software (3.20 and later) to convert real-time corrected positions on-the-fly to WGS-84. If you do this, refer to scenario 1.

If you are unable to differentially correct your real time data using one of the techniques listed above, you can remove the datum shift error by applying a reverse transformation (from NAD 83 to WGS-84) when you export the data. Define a NAD83 to WGS-84 transformation in the Coordinate System Manager utility that matches the time that you collected the transformation epochs for the GPS Pathfinder office software.

GPS Analyst extension

When GNSS data is built into GIS feature geometry, a datum shift of a meter or more will be because the corrected data is in terms of NAD 83 (CORS 96), but the GPS Analyst extension treats it as WGS-84 data. One way to eliminate this data shift is to differentially correct the data using the *From Base Provider* option (WGS-84 = IRFT00 [Epoch 1997.0]).

Scenario 4: Corrected positions in terms of NAD 83, NAD 83 in GIS

GNSS data is corrected against sources that use NAD 83 as their reference frame. Examples include US Coast Guard beacons, or a base station with a NAD 83 reference position.

The GIS uses a coordinate system that is based on the same realization of the NAD 83 datum (for example, CORS 96).

Note: *If the NAD 83 realizations used by the correction source and the GIS are different, some errors are introduced. The amount of error depends on the realizations used. For example, NAD 83 (HARN) and NAD 83 (CORS 96) differ by only a few centimeters in most US states. However, the original NAD 83 (1986 or conus) realization is significantly different from these later realizations.*

GPS Pathfinder Office software

When you export your GNSS data from the GPS Pathfinder Office software, the zero WGS-84 to NAD 83 transformation is performed. Because the data is already in terms of the required datum, NAD 83 (Conus), no datum shift error is introduced. No change to your current workflow is required to avoid introducing errors.

GPS Analyst extension

If you select a null transformation when you GPS-enable (either the <null> option, or the transformation named NAD_1983_To_WGS_1984_1), then no transformation is performed between the GNSS data and GIS feature geometry. Because the data is already in terms of the required datum (NAD 83), no datum shift error is introduced.

If you select a non-zero WGS-84 to NAD 83 datum transformation, such as CORS 96, when you GPS-enabled your geodatabase, then a datum shift error may be introduced when GNSS data is built into GIS feature geometry. The corrected data is in terms of NAD 83 but the GPS Analyst extension treats it as WGS-84 data and applies an additional transformation, which may introduce an error of a meter or more.