GPS·H v3.3

Submit you comments about ***GPS·H v3.3*** and this help file to:

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1- Introduction

GPS·H v3.3 is a user-friendly interface allowing the transformation of geodetic heights (***h***, ellipsoidal height) to orthometric heights (***H***, height above the geoid) and conversion between two vertical datums (e.g., CGVD28(HT2_0) to CGVD2013(CGG2013) or GSD95 to CGG2013). It also allows the inverse transformation from orthometric heights (***H***) to ellipsoidal heights (***h***). The transformations are possible through the use of a geoid model (***N***):

$$H = h - N$$

or

$$h = H + N.$$

The conversions correspond to:

$$H_2 = H_1 + \Delta H = H_1 + N_1 - N_2.$$

Generally, the inverse transformation (***h* -> *H***) is not recommended because the ellipsoidal heights will not be accurate with respect to the geometric reference frame (NAD83(CSRS) or ITRF) unless the orthometric heights are derived from a geoid model.

The **geoid** is the equipotential surface (W_0) that represents best in a least-squares sense, the global mean sea level. The geoid does not coincide with the mean sea level as the mean ocean surface has permanent hills and valleys (sea surface topography).

The orthometric heights will be in the same vertical reference frame as the geoid model unless the model is constrained to control stations (see Computation Method group box). In this case, they will be in the same vertical reference frame as the control stations.

CGVD2013: The recently release vertical datum for Canada (November 2013). It replaces CGVD28. The ellipsoidal heights can be directly tied to CGVD2013 using gravimetric geoid model CGG2013 (or a later version). The superseded gravimetric geoid models do not provide orthometric heights in CGVD2013.

CGVD28 (former height system): The ellipsoidal height can be directly tied to CGVD28 using a Height Transformation, e.g., ***HT v2.0***. A Height Transformation is a hybrid geoid model, i.e., a geoid model that was distorted to represent the levelling-realized vertical datum. This distortion is measured by observing geodetic (ellipsoidal) heights on benchmarks which have known height in CGVD28. The accuracy of a hybrid model depends on the geographical distribution and accuracy of the ellipsoidal heights, distortion of the vertical datum and the stability of the observed benchmarks. ***HT v2.0*** can provide accuracy generally better than 2-5 cm (95% confidence) with respect to CGVD28 along the federal first-order levelling network, but its accuracy will degrade where levelling lines are sparse or simply inexistent as it is the case for northern Canada.

You can create your own hybrid model by conducting GNSS observations on vertical control markers and making use of the ***Advanced mode*** options in ***GPS·H v3.3***.

NOTE: A Height Transformation (HT) is not valid for the United States of America and over the oceans. For the USA, NOAA's National Geodetic Survey (NGS) provides hybrid geoid models (e.g., Geoid12A), which allows the conversion of ellipsoidal heights to NAVD 88 heights. NAVD 88 is not an adopted datum in Canada

Recent geoid models (e.g., CGG2013) provide more precise (relative) and accurate (absolute) orthometric heights than a Height Transformation, but the orthometric heights are not compatible with published CGVD28 elevations (former height system). The orthometric height from different geoid models may differ as the models contains realisation errors (random and systematic) and they do not refer necessarily to the same equipotential surface. The reference surface of a geoid model is available through the ***Model Information*** window in ***GPS·H v3.3***.

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2- Main Window

The ***Main Window*** is divided into a series of group boxes and each group box has a name. Information about each group box is available in this help file. You can go directly to that information by clicking the name of the group box in the above Table of Contents.

You will find below general information about the ***Main Window***.

a. **Closing the main window**: The software is terminated by clicking the ***X*** icon in the top right corner of the window. When closing the window, the last set of parameters is safeguarded in a registry. It will bring back the latest parameters saved when starting the software again.

b. **Help**: This help file is accessible by clicking the ***Question mark*** icon located at the bottom left of the window. Furthermore, help is provided in a bubble form when placing the cursor above most group boxes, buttons and icons.

c. **Language**: The language can be switched to French by clicking ***Français*** located next to the ***Question mark*** icon. It can be switched back to English by clicking ***English***.

d. **Batch processing**: When the ***Batch processing*** check box is selected, the data sheet disappears and the software processes data in a batch mode. A file containing coordinates is opened by clicking the ***Input…*** button. The input format must be selected prior to activate the ***Input …*** button. After selecting an input file, it opens automatically a second window to save the results in an output file. The format of the output file is the default format associated with the input format. The batch mode is practical when processing a very large number of coordinates.

e. **h = H + N**: When the **h = H + N** check box is activated, ***GPS·H v3.3*** converts orthometric heights (H) into ellipsoidal heights (h). In addition, it changes the data sheet by switching the fields of the orthometric height (H) and ellipsoidal height (h) and adds a box above the name of the input file indicating that you are in the inverse conversion mode for heights (H -> h). When the selected model is a conversion, the text is changed for the names of the vertical datums or geoid models. By activating this check box, the software calculate the inverse conversion.

f. The **size** of the Main window can be changed by dragging one of the four corners or one of the four edges.

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3- Geoid Model

The ***Geoid Model*** group box is to load gravimetric and hybrid geoid models, to select the geoid model and to view the parameters of the active geoid model. In addition, it allows building conversions between two geoid models. This is done by selecting the last item in the table list (Create new conversion…). By selecting this option, a pop-up window will appear prompting you to select a *From* model and a *To* model. Click the blue disk, to save the conversion. This new conversion is added to the model drop list.

GPS·H v3.3 comes with three default model:

1) CGG2013an83.byn (CGVD2013),
2) HT2_0.byn (CGVD28), which is formally valid for epoch 1997.0, and
3) HT2_0_CGG2013a (Conversion between CGVD28 and CGVD2013 via models HT2_0 and CGG2013an83)

The ***Search*** icon opens a window to load a model in one of the three following formats: ***BYN*** (GSD format), ***BIN*** (US NGS format) and ***SLV*** (former GSD format; new models are not available in that format). The default format for the window is ***BYN***, but the other formats can be viewed by clicking the ***Files of Type*** button at the bottom of the active window.

The ***Information*** icon opens the ***Model Information*** window, which shows the area (*boundaries and spacing of grid*), parameters (*reference ellipsoid, geometric reference frame of the geoid model, potential of the equipotential surface* (W_0)*, tidal system, reference epoch of the geoid heights, and geocentric gravitational constant (GM)*) and seven-transformation parameters (three *translations, three rotations and one scale*) between the geometric reference frame of the geoid heights and geometric reference frame of the ellipsoidal heights.

In the ***Model Information*** window, undefined parameters are shown as empty boxes, unless they are the transformation parameters. In this case, it indicates that the geoid heights and ellipsoidal heights are in the same geometric reference frame. Thus, no transformations are applied to the geoid heights.

A geoid model can be removed from the list by clicking the ***X*** icon in the box showing the name of the model.

In addition, the ***Model Information*** window allows extraction of a subset of a ***BYN*** grid. The subset grid is saved in either the ***BYN*** or ***ASCII*** format. The boundary boxes are activated when the check box is checked. The boundaries can be entered as DMS.S, DM.M or D.D format. The boundaries will be automatically rounded to the proper values and viewed in the same geographical format used last in the data sheet. The subset option does not allow a region that overlaps the change of date line (e.g., W190 to W170).

Description of the ***BYN*** format is available by contacting Natural Resources Canada.

The ***BIN*** format from US NGS contains only the boundaries and spacing of the model in its header. Thus, it is assumed that all hybrid models are in NAD83(NSRS) and gravimetric geoid models are in ITRF. Details of the US NGS format are available at http://www.ngs.noaa.gov/GEOID/. The hybrid models allow only NAD83(NSRS) input coordinates while the gravimetric geoid models allow only ITRF input coordinates.

3.a- Error Estimates

GPS·H v3.3 can provide accuracy (absolute) of the geoid heights if the **.byn** file comes with an error file that has the **.err** extension. The two files must have the same name, but different extensions (**.byn** and **.err**). Even though the accuracy could reach the decimeter for geoid heights in certain regions, the precision (relative) can still be in the order of a few cm (1-3 cm) for baselines as long as 100 km. **The published accuracy must be considered as experimental**.

List of geoid models currently available from Natural Resources Canada:

Vertical datum: CGVD2013
Current version: CGG2013a
Superseded version: CGG2013
Vertical datum: Scientific

Current version: Current version of geoid model for CGVD2013
Superseded versions: CGG2010, CGG2005, CGG2000, GSD95, GSD91

Vertical datum: Global
Current version: EGM08
Superseded version: EGM96 (WW15MGH)

List of Height Transformations for Canada:

Vertical datum: CGVD28
Current version: HT v2.0 (based on CGG2000 and geodetic height for epoch 1997.0)
Superseded versions: HT v1.01 (based on GSD95), HT97 (based on GSD95)

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4- Reference Frame

The ***Reference Frame*** group box is to select the geometric reference frame of the input coordinates that are entered either manually through the user-friendly interface or a file. The coordinates can be either in NAD83(CSRS) or one of the ITRF realizations. The ITRF realization can be changed by clicking the arrow or right-clicking the ***ITRF*** name. The transformation parameters that will be used by the software can be visualized by clicking the ***Information*** icon within the ***Geoid Model*** group box.

The difference between the two reference systems (NAD83(CSRS) and ITRF) for the vertical component corresponds to a long wavelength ranging from -0.2 to 2.0 metres across Canada. The differences between each ITRF realization are within a few cm.

Example 1: If the input coordinates are in NAD83(CSRS) and the geoid model is in ITRF97, the geoid heights will be automatically transformed from ITRF97 to NAD83(CSRS) using a seven-parameter transformation (three translations, three rotations and one scale factor) based on the Epoch of geoid model (epoch of the model can be viewed using the information icon).

Example 2: If the input coordinates are in ITRF2008 and the geometric reference frame of the geoid model is ITRF97, the geoid heights will be automatically transformed from ITRF97 to ITRF2008 using a seven-parameter transformation (three translations, three rotations and one scale factor) based on the Epoch of data.

If the geoid model is in ITRF and the Canadian format .byn, the epoch of data is deactivated and set to the conventional epoch of the geoid model when the input coordinates are NAD83(SCRS).

If the geoid model is in the US binary format (.bin), the reference frame of input coordinates is set to the same reference frame as the geoid model. The software does not allow transformation between reference frames when using a geoid model in the US format.

If the user is working in a local reference frame, it is preferable to select an ITRF realization and use control stations.

NOTE: Users have to be careful when working with the WGS84 system. The original WGS84 was compatible with the NAD83 reference system; however, WGS84 has been redefined and it is now compatible with the ITRF reference system. As of 2016, WGS84 is aligned with ITRF2008 with the reference epoch of 2005.0.

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5- Epoch of data

The ***Epoch of data*** group box is to select the epoch representing the input coordinates. The option is deactivated when the geoid model is in the same geometric reference system as the input coordinates because the geoid is considered static. However, the ***Epoch*** plays a role when geoid heights must be transformed between ITRF realisations.

The seven-transformation parameters are slightly different for different epochs.

Example: ITRF2005 <-> NAD83(CSRS)

Epoch	TX (m)	TY (m)	TZ (m)	RX (mas)	RY (mas)	RZ (mas)	Scale (ppb)
1997.0	0.9963	-1.9024	-0.5219	-25.915	-9.426	-11.599	0.775
2002.0	0.9988	-1.9054	-0.5285	-26.248	-5.639	-11.343	0.265
2010.0	1.0027	-1.9102	-0.5393	-26.781	0.420	-10.932	-0.551

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6- Ellipsoid

The ***Ellipsoid*** group box is to select the reference ellipsoid of the input coordinates. The selection of the ellipsoid is done by clicking the arrow in the box. The software has four defined reference ellipsoids:

Ellipsoid	***a (m)***	***1/f***
GRS80	6378137.0	298.257222101
WGS84	6378137.0	298.257223563
Alt1	6378136.3	298.256415099
Alt2	6378136.3	298.257

NAD83(CSRS) works only with the **GRS80** ellipsoid.

The maximum geometric difference between **GRS80** and **WGS84** is 0.105 mm. ***Alt1*** and ***Alt2*** are reference ellipsoids for satellite altimetry data. The semi-major axis (***a***) of these two ellipsoids is 0.7 m shorter than those of **GRS80** and **WGS84**.

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7- Data

The ***Data*** group box is to load and show input coordinates, show results (geoid heights, orthometric heights, and deflections of the vertical) and activate control stations.

Any errors in the data sheet are indicated by an exclamation mark in a red circle on the left-end side of the record. If the result is non-defined, '**ND**' will appear in the cell. The ***Summary*** group box shows the total number of records in the data sheet and the number of non-defined records.

7.a- Coordinates

The ***Coordinates*** group box is for the selection on how to visualise the coordinates in the data sheet. The coordinates can be visualised as ***Geographic*** (latitude, longitude and height), ***Cartesian*** (x, y and z) or ***UTM/MTM*** (easting, northing and height). The view of the geographical coordinates can be changed between decimal degrees (D.D), degrees and decimal minutes (DM.M) and degrees, minutes and decimal seconds (DMS.S) by right clicking the ***Latitude*** or ***Longitude*** header above the data sheet.

The ***UTM*** coordinates can be viewed in standard UTM (zones of 6 degrees), provincial MTM or in a Mercator projection defined by the user. The Mercator projections can be selected and edited by right-clicking the ***UTM/MTM*** text in the ***Coordinates*** group box.

The ***MTM*** window, which opens when selecting ***Edit…*** from the drop-down list box, allows the user to define and save his/her own Mercator projections. The user requires defining the central meridian, false easting, false northing and scale factor. These parameters are saved by entering a name in the drop-down list box and clicking the ***Disk*** icon. The name of a projection should neither be 1 to 60 as they are reserved for the standard UTM projections nor a pre-defined provincial MTM name. You can view/edit the defined projections by selecting a name through the drop-down list box. You can delete a projection by clicking the ***X*** icon.

For example, if you name your projection "MTM2", "MTM2" would be the name to enter in the ***Zone*** field of the data sheet to properly project your Mercator coordinates to geographical coordinates.

You can overwrite the highlighted cells in the ***Zone*** field of the data sheet by right-clicking the ***Zone*** header and by selecting the correct projection. It is also possible to edit each ***Zone*** cell individually.

NOTE: Options in the ***Coordinates*** group box do not affect the reading of coordinates from an input file. For example, the coordinates option can be UTM and the file can contain geographical coordinates. However, the geographical coordinates will be shown as UTM coordinates in the data sheet. The format for an input file is selected using the drop-down list box on the right side of the ***Input…*** button (see also ***Input…***).

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7.b- Longitude Code

The ***Longitude Code*** indicates the **positive direction** of the longitudes. However, the ***Longitude Code*** is omitted when the longitudes have one of those characters to indicate the direction: “O”, “o”, “W”, “w”, “E” or “e”. If the character is a negative sign (“-“), the longitude is going in the opposite direction of the ***Longitude Code***.

NOTE: The ***Longitude Code*** affects only data entered manually in the data sheet.

Longitudes shown in the data sheet are always values between 0 and 180 degrees (positive or negative). Therefore, an absolute longitude larger than 180 degrees will be converted according to the ***Longitude Code*** or the character representing the direction of the longitude.

NOTE: The proper ***Longitude Code*** must be selected prior to enter the coordinates of the stations.

Examples:

If the ***Longitude Code*** is West (commonly used in Canada):

Longitude		Longitude shown
E 23 0 0.000	->	E 23 0 0.00000 (not affected by code)
W 23 0 0.000	->	W 23 0 0.00000 (not affected by code)
E 250 0 0.000	->	W110 0 0.00000 (not affected by code)
23 0 0.000	->	W 23 0 0.00000
250 0 0.000	->	E110 0 0.00000
-110 0 0.000	->	E110 0 0.00000
-250 0 0.000	->	W110 0 0.00000

If the ***Longitude Code*** is East:

Longitude		Longitude shown
E 23 0 0.000	->	E 23 0 0.00000 (not affected by code)
W 23 0 0.000	->	W 23 0 0.00000 (not affected by code)
E 250 0 0.000	->	W110 0 0.00000 (not affected by code)
23 0 0.000	->	E 23 0 0.00000
250 0 0.000	->	W110 0 0.00000
-110 0 0.000	->	W110 0 0.00000

-250 0 0.000	->	E110 0 0.00000

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7.c- Input… button

The ***Input…*** button opens a window to select a file containing coordinates. The name of the selected file will be shown in the text box to the right of the button. The input is automatically processed by the software according to the selected parameters (Geoid model, Reference frame, Epoch of data and Ellipsoid).

The format of the file is selected from the drop-down list box to the right side of the ***Input…*** button. The list includes already three pre-defined formats: **GHOST**, **GeoLab** and **UNICSV**. These formats are described in **Appendix A**. In addition, the user can create and save his/her own free or fixed formats using the ***Edit…*** option in the drop-down list box. This option opens ***My Format*** window where the user can enter and save his/her own parameters. There is more information about creating and saving your own formats in **Appendix D**.

A file containing coordinates can also be loaded into ***GPS·H v3.3*** by dragging its icon in the data sheet (**drag and drop**). The format of the coordinates must be selected prior to drag and drop the icon.

Coordinates can also be loaded into ***GPS·H v3.3*** by **copying and pasting** fields from a spreadsheet.

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7.d- Data Sheet

The ***Data Sheet*** is to enter coordinates manually, view coordinates from an input file and show resulting geoid heights (N) and orthometric heights (H) or deflections of the vertical (ξ and η). The type of coordinates to enter manually is determined from the option selected in the ***Coordinates*** group box.

NOTE: A station name or coordinates are registered in the data sheet only after hitting ‘Tab’, ‘Return’ or another cell of the datasheet

NOTE: The station name is case sensitive. For example, station ‘92A001’ is not the same station as ‘92a001’.

Geographic coordinates can be entered as DMS.S, DM.M or D.D format. It does not have to match the geographical format shown in the header. For example, you can enter a geographical coordinates in decimal degrees even if the header is in DMS. However, they will be shown in DMS once the coordinate is registered in the data sheet. The geographical viewing format can be changed by right-clicking the ***Latitude*** or ***Longitude*** header of the data sheet.

For the standard ***UTM*** coordinates, the zone can be between 1 and 60. It is also possible to edit the zone for each cell or overwrite all cells by right-clicking the header ***Zone*** and entering the zone number under the UTM option.

For the ***MTM*** coordinates, the user must use either the pre-defined provincial MTM projections or define and save his/her own zone parameters by right-clicking the ***UTM/MTM*** text in the ***Coordinates*** group box and selecting ***Edit...*** This function can also be called by right-clicking the ***Zone*** header in the data sheet. When selecting a user-defined zone through the ***Zone*** header, it replaces all highlighted zones in the data sheet. It is possible to enter individually user-defined zones for each cell by double clicking it.

NOTE: As the geoid models are in a geographical format, it is important that the zone of the Mercator coordinates be well defined for each record. You can verify if the zone is correct by switching the data sheet viewing to ***Geographic*** to see if the geographical coordinates make sense.

The station name is optional. A sequential number will be provided if nothing is entered in the cell.

The inverse conversion inverse (H to h) is activated by right-clicking the “h” header of the datasheet. When the option is activated, a frame box containing h = H + N appears above the filename box. This frame box remains visible until the inversion conversion is turned off by either right-clicking the H header of the datasheet or the h = H + N frame box.

You can ***copy and paste*** the highlighted data from the data sheet into a spreadsheet (e.g., Excel) for one or several fields at a time. Similarly, it is possible to copy and paste data from a spreadsheet to the ***GPS·H v3.3*** data sheet as long as the field of the spreadsheet are in the same order as the data sheet. You can copy one field or several fields at a time. ***Ctrl-C*** and ***Ctrl-V*** can be used for copy and paste, respectively. The copy, paste and select all can be called by right-clicking the data sheet or header. Copy and paste cannot be activated from the ***Latitude***, ***Longitude, h*** and ***Zone*** headers.

You can **delete highlighted rows** in the datasheet by using the “cut” option when right clicking the left margin of the datasheet. The rows must be highlighted from the margin.

You can **search station** names by using the ***Ctrl-F*** command. It will find all stations ***starting with*** the string entered.

Even if you load a set of coordinates from a file, you can add extra records manually or by loading other files. Each file can also be in a different format. Make sure to select the correct format for each file before loading the data.

After selecting the format of an input file, this file can be loaded by simply using the **drag and drop** of the file icon into the data sheet.

The data sheet will add the ***Control*** field when ***Advanced mode*** is activated. This field contains check boxes, which can be checked to indicate the control stations (stations with known orthometric heights). When a control is checked, the orthometric height can be edited after double-clicking the cell. The new orthometric height is only registered after you hit ‘Tab’, ‘Return’ or another cell of the data sheet.

The maximum number of coordinates that can be loaded in the data sheet depends on the memory size of your computer. You may be able to load more than one million stations if you a have a recent computer.

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7.e- Reset button

The ***Reset*** button empties completely the data sheet and clear all data from memory.

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7.f- Show deflections of the Vertical (check box)

The data sheet is modified to show the deflections of the vertical (ξ and η) when the box is checked. The deflections of the vertical are interpolated from the active geoid model and determined on the geoid surface. The deflections of the vertical are defined positive east.

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7.g- The Save… button

The ***Save…*** button opens a window to save your results. The format of the output file is determined from the active format in the drop-down list box (right to the **Save…** button). The selection includes already three pre-defined formats: **GHOST**, **GeoLab** and **UNICSV**. These formats are described in **Appendix C**. In addition, the user can create and save his/her own output formats by selecting ***Edit…*** from the drop-down list box. There is more information about creating and saving your own formats in **Appendix D**.

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8- Computation Method

The default approach is the direct conversion. The orthometric height (***H***) is determined by subtracting the interpolated geoid height (***N***) to the ellipsoidal height (***h***):

$$H = h - N.$$

NOTE: The orthometric heights determined using this approach are tied directly to CGVD2013 when using geoid model CGG2013. The direct tie to CGVD28 (former height system) is done using a Height Transformation (HT) such as ***HT v2.0***.

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8.a- Advanced mode button

The ***Advanced mode*** button expends the ***Computation Method*** group box and allows users to make use of control stations to apply a bias or planar correction to a geoid model, which would provide orthometric heights compatible with a national, regional or local datum (e.g., CGVD28, NAVD 88).

When the ***Advanced mode*** is active, the data sheet adds an extra field containing check boxes to select control stations manually. It becomes possible to edit the orthometric height cell when the control check box is checked. The control stations can also be loaded through a file by using the ***Control file…*** button. The format of the Control file is described in **Appendix B**. The number of control stations is indicated in the ***Summary*** box.

The ***Compute*** button starts the computation of the transformation (after selecting the bias or planar radio button). When the computation is completed, the ***Compute*** button becomes a ***Reset*** button. At this time, the data sheet is frozen until you click the ***Reset*** button. The ***Reset*** button brings back the data sheet as it was before the ***Compute…*** button was activated.

Thus, the results from a transformation must be saved before hitting the ***Reset*** button of the ***Computation Method*** group box.

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8.b- Bias Transformation (radio button)

The ***Bias Transformation*** is activated when there is at least one control station available. This transformation ties the orthometric heights to the vertical datum of the control stations (e.g., CGVD28, NAVD 88 or local datum). The determination of the bias can be expressed as:

$$Bias = 1/n\ Sum[\ H_i - (h_i\ - N_i)]\ for\ i = 1\ ,\ n$$

where n is the number of control stations. It is recommended to use at least three control stations to assure that the observed benchmarks are locally or regionally stable. The discrepancies can be viewed by dragging the cursor over the cell of the controlled orthometric height. The discrepancies can also be viewed in a pdf file that is created when saving the results. The discrepancies are shown after applying the bias.

The determination of orthometric heights from the ***Bias Transformation*** can be expressed as:

$$H = h - (\ N + Bias\ ).$$

The statistics of the bias transformation are shown in red in the ***Summary*** group box.

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8.c- Planar Transformation (radio button)

The ***Planar Transformation*** is activated when three or more control stations are available. This transformation removes a bias and tilt between the geoid model and the vertical datum, and ties the orthometric heights to the vertical datum (e.g., CGVD28, NAVD 88 or local datum). The correction can be expressed as:

$$\textbf{Correction} = \boldsymbol{A}\mathbf{x} + \boldsymbol{B}\mathbf{y} + \boldsymbol{C}$$

where *A*, *B* and *C* are the plane parameters, which are determined by least-squares adjustment, and x and y are the coordinates of the control stations. The discrepancies can be viewed by dragging the cursor over the cell of the controlled orthometric height. The discrepancies can also be viewed in a pdf file that is created when saving the results. The discrepancies are shown after applying the correction.

The determination of orthometric heights from the ***Planar Transformation*** can be expressed as:

$$\boldsymbol{H = h - (N + Correction).}$$

NOTE: In order to use the Planar Transformation, it is important to have a good distribution of the control stations across the project. A bad distribution could deteriorate the results. ***GPS·H v3.3*** does not verify if the distribution of the control stations is valid.

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9- Summary Box

The ***Summary*** group box shows the number of processed stations and the number of non-defined stations in the data sheet. If applicable, it will also show the number of control stations and statistics for the bias or planar transformation.

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10- GPS·H Versions

GPS·H v3.3: Version 3.3 now allows the conversion between two vertical datums (official and scientific datums such as CGVD28, CGVD2013, GSD95, CGG2005 and CGG2010). The user can either work from an existing file containing the separation between the two datums or create a new conversion between two geoid models. In addition, CGS applied new restrictions in terms of transforming geoid models in compatibility with input coordinates. For example, if the geoid model is in NAD83(CSRS), only NAD83(CSRS) coordinates are accepted. For ITRF coordinates, the geoid model must in an IRTF realization. If the geoid model is ITRF, coordinates can be either NAD83(CSRS) or ITRF. (**January 2017**).

GPS·H v3.2: Change the activation and deactivation of boxes **Epoch of data** and **Reference Frame** depending on the reference frame and grid format of the geoid model. This change is required as NRCan is now publishing geoid models in ITRF and NAD83(CSRS) reference frames.

Normally, there should be as many NAD83(CSRS) version as epochs because of the drift between the ITRF realizations. However, NRCan is **publishing only one version** of NAD83(CSRS) which is the one based on the conventional epoch of the model. **(November 2013)**

GPS·H v3.1.1: Minor modifications.

GPS·H v3.1: Version 3.1 is a complete overall of the user-friendly interface. It allows more flexibility in terms of input and output formats. Users can create and saves their own formats. In addition, version 3.1 allows input in Cartesian (x, y, and z) and Mercator (easting, northing, heights) coordinates. The Mercator coordinates can be in standard UTM, provincial MTM or in a projection defined by the user. Geographical coordinates are accepted in decimal degrees (D.D), degrees and decimal minutes (DM.M) and degrees, minutes and decimal seconds (DMS.S). Finally, version 3.1 can also be run in a batch mode for very large files. **(March 2011)**

GPS·H v2.1: The NS deflection, which was always equal to zero in the previous version (v2.0), is now operational. This version accepts the new GSD binary format .byn and the US NGS binary format .bin. The previous version accepted only specific types of .byn format (e.g., data had to be short integer); therefore, it is not recommended to use the .byn format with v2.0. The users have a larger selection of input and output formats. The default format has changed by adding comma between each column of results for the purpose of quick loading within spreadsheet and GIS software. The program saves the last directory selected for the Browse, Input, Control and Output buttons, even when exiting the program. The planar transformation replaces the four-parameter transformation. Finally, the geoid heights are expressed at the mm level.

GPS·H v2.0: This version is developed for Windows 95. It is not compatible with Windows 3.1. Version 2.0 includes a new set of transformation parameters (ITRF96 <-> NAD83 (CSRS98)). In addition, the transformation parameters are shown on the dialogue box "Model Information." Finally, the input coordinates at the stations can be entered from a file in a free format.

GPS·H v1.2: Minor modification brought to the summary file (GPSH.sum). In the previous version, if a station was entered as a control station and the user removed its control status subsequently, the software was printing in the summary file the difference between the height of the station (given as a control) and the estimated height instead of leaving a blank space. This minor modification did not affect the final results.

GPS·H v1.1: Original version to be distributed nationally and internationally.

GPS·H v1.0: Beta version, distributed to a few users for testing.

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11- Contact us

For further information, you can contact the Canadian Geodetic Survey:

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Appendix A: Pre-defined formats for input files

If a name of a station appears more than once in a file, only the latest coordinates will be loaded into the data sheet.

Input file format: GHOST

The **GHOST** format is defined positive west if no character defined the longitude.

Columns	Format	Description	
1	Character	*Must be blank if not it represents a comment line*	(1)
7-15	Characters	Unique name of the station	
40	Character	Code of latitude (N, S, - or blank for north)	(2)
41-42	Integer	Latitude (degrees)	
43-45	Integer	Latitude (minutes)	
46-54	Real	Latitude (seconds)	
55	Character	Code of longitude (E, W, O, - or blank for west)	(2)
56-58	Integer	Longitude (degrees)	
59-61	Integer	Longitude (minutes)	
62-70	Real	Longitude (seconds)	
71-80	Real	Ellipsoidal height (metres)	

(1) If there is a character in the first column, the record is skipped by the software
(2) Lower cases are also accepted.

Input file format: GeoLab

GeoLab comes into two valid formats. The software can identify the two formats by only selecting ***GeoLab*** from the drop-down list box. The ***GeoLab*** format is defined positive east if no character defined the longitude.

GeoLab (version 1)

Columns	Format	Description
1	Character	*Must be blank if not it represents a comment line*
11-22	Characters	Unique name of the station
24	Character	Code of latitude (N, S, - or blank for north)
26-27	Integer	Latitude (degrees)
29-30	Integer	Latitude (minutes)
32-40	Real	Latitude (seconds)
42	Character	Code of longitude (E, W, O, - or blank for east)
43-45	Integer	Longitude (degrees)
47-48	Integer	Longitude (minutes)
50-58	Real	Longitude (seconds)
60-71	Real	Ellipsoidal height (metres)

(1) If there is a character in the first column, the record is skipped by the software
(2) Lower cases are also accepted.

GeoLab (version 2)

Columns	Format	Description
1	Character	*Must be blank if not it represents a comment line*
10	Character	* (Asterisk)
11-41	Characters	Unique name of the station (Can include blank spaces)
43	Character	Code of latitude (N, S, - or blank for N)
45-46	Integer	Latitude (degrees)
48-49	Integer	Latitude (minutes)
51-59	Real	Latitude (seconds)
61	Character	Code of longitude (E, W, O, - or blank for east)
62-64	Integer	Longitude (degrees)
66-67	Integer	Longitude (minutes)
69-77	Real	Longitude (seconds)
79-90	Real	Ellipsoidal height (metres)

(1) If there is a character in the first column, the record is skipped by the software
(2) Lower cases are also accepted.

Input file format: UNICSV (Universal Comma Separated Values)

Each data field must be separated by a tab or comma. The first record is the header. The following records are the data, which must be in the same order as the key words in the header.

The table below indicates the valid key words for the header.

Geographic	**name, lat, lon, height**
Cartesian	**name, car_x, car_y, car_z**
UTM/MTM	**name, utm_e, utm_n, height, utm_z**

The header is not case sensitive and the software will recognize any words that start with one of the key word. For example, the following words are all equivalent: lat, LAT, Lat, Latitude, LATITUDE.

The latitude and longitude must be in decimal degrees. The default is positive east longitude.

utm_z is optional. If the zone is not indicated, ***GPS·H v3.3*** will prompt you for a zone number. The same zone will be applied for all records. If the zone is not a standard 6-degree UTM or provincial MTM, you must define your zone before loading the data.

The header can have other key words for other fields in the data file, but they will not be read by ***GPS·H v3.3***. These other fields can be located before, after or between the fields recognized by ***GPS·H v3.3***. The order is not important as long as the key words and the data are in the same order.

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Appendix B: Format for control files

The control stations (if available) are loaded using the ***Control file…*** button in the ***Computation Method*** box after clicking the ***Advanced mode*** button. The station names must match those of the data sheet. The control file must be in one of the two following formats:

1- The station name and the orthometric height of the station must be separated by at least a space, single tab, comma (,), semi-colon (;), exclamation mark (!), or vertical bar (|).
2- If the station name includes one or more empty spaces (blanks), the two fields must be separated by a comma and the name of the file must end with the extension ".csv". The ".csv" file does not have a header record.

The number of control stations found is indicated in the ***Summary*** box.

NOTE: The control stations can also be edited manually through the data sheet.

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Appendix C: Pre-defined formats for output files

1- GHOST

Columns	Format	Description
3	Character	Code = 4
7-15	Characters	Unique name of the station
40	Character	Code of latitude (N or S)
41-42	Integer	Latitude (degrees)
43-45	Integer	Latitude (minutes)
46-54	Real	Latitude (seconds)
55	Character	Code of longitude (E or W)
56-58	Integer	Longitude (degrees)
59-61	Integer	Longitude (minutes)
62-70	Real	Longitude (seconds)
71-80	Real	Orthometric height (metres)

2a- GeoLab (PLO) short Format

Columns	Format	Description
2-4	Characters	Code = PLO
11-22	Characters	Unique name of the station
24	Character	Code of latitude (N or S)
26-27	Integer	Latitude (degrees)
29-30	Integer	Latitude (minutes)
32-40	Real	Latitude (seconds)
42	Character	Code of longitude (E or W)
43-45	Integer	Longitude (degrees)
47-48	Integer	Longitude (minutes)
50-58	Real	Longitude (seconds)
60-71	Real	Orthometric height (metres)

2b- GeoLab (PLO) long format

Columns	**Format**	**Description**
2-4	Characters	Code = PLO
10	Character	* (Asterisk)
11-41	Characters	Unique name of the station
43	Character	Code of latitude (N or S)
45-46	Integer	Latitude (degrees)
48-49	Integer	Latitude (minutes)
51-59	Real	Latitude (seconds)
61	Character	Code of longitude (E or W)
62-64	Integer	Longitude (degrees)
66-67	Integer	Longitude (minutes)
69-77	Real	Longitude (seconds)
79-90	Real	Orthometric height (metres)

3- UNICSV (Universal Comma Separated Values)

The UNICSV will produce an output file in the same coordinates viewed last in the datasheet. The first record is one of the following headers:

Geographic:	**name,lat,lon,height,N,elev**
Cartesian:	**name,car_x,car_y,car_z,N,elev**
UTM/MTM:	**name,utm_e,utm_n,height,utm_z,N,elev**

The following records are the results for each station. Each value is separated by a comma. The order of the values on the record is one of the following:

Geographic	***Cartesian***	***UTM***
Station Name	Station Name	Station Name
Latitude (D.d)	X (m)	Easting (m)
Longitude (D.d)	Y (m)	Northing (m)
Ellipsoidal height (m)	Z (m)	Ellipsoidal height (m)
Geoid height (m)	Geoid height (m)	Zone
Orthometric height (m)	Orthometric height (m)	Geoid height (m)
		Orthometric height (m)

4-GHOST (Deflections of the vertical)

The deflections of the vertical are:

$\xi = \Phi - \phi$ North-South component

$\eta = (\Lambda - \lambda) \cos \phi$ East-West component

where Φ and ϕ are the astronomical and geodetic latitudes, and Λ and λ are the astronomical and geodetic longitudes, respectively

NOTE: The E-W component (η) of the deflection of the vertical is positive to the east.

Columns	**Format**	**Description**
3	Character	Code = 9
7-15	Characters	Unique name of the station
46-54	Real	N-S component (ξ) of the deflection of the vertical (arcsec.)
62-70	Real	E-W component (η) of the deflection of the vertical (arcsec.)
71-80	Real	Geoid height (metres)

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Appendix D: Creating and saving your own formats

Your can create your own input and output formats. The formats are created through ***My Format*** window. This window can be activated by selecting ***Edit…*** from the drop-down list box of the input or output format. ***My Format*** saves an input format and an output format under the same name. Even if the user-defined format name contains an input format and an output format, you can still read from one format and write from a second format. However, ***in batch mode***, the output format will be the format associated with the input format.

You can create two types of format: ***Free*** or ***Fixed***.

Free format: Each value is separated by a delimiter.

Fixed format: The values are defined in specific columns.

For the two types of formats, you must determine your type of coordinates (geographic, Cartesian or MTM). If the coordinates are geographic, the Longitude code must be selected for cases where the longitude does not have a code to indicate its direction. The latitude is always associated to the northern hemisphere unless the latitude has one of the following code: 'S', 's', or '-'.

For the ***Free*** format, you must select

4) a ***separator*** which will be applied to the input and output formats;
5) the ***values*** which are part of the input file and their ***columns***;
6) the number of ***lines in header*** for the input file; and
7) the ***values*** to write to the output file and their ***columns*** (order).

The ***Free Format*** is saved by naming the format and clicking the blue disk.

The geographical coordinates must be in decimal degrees.

NOTE: The software does not verify if the fields are defined properly.

For the ***Fixed*** format, you must

1) select the values that are part of the input file;
2) write the columns defining the fields (start-end);
3) write the number of lines of header in the input file;
4) select the values to write to the output file; and
5) write the columns defining the fields (start-end)

The ***Fixed Format*** is saved by naming the format and clicking the blue disk.

NOTE: The software does not verify if the fields are defined properly.

For the geographical coordinates, the latitude and longitude can be in formats D.D, DM.M or DMS.S as long as each element is separated by at least one blank. The latitude code ('N','s', '-', …) and longitude code ('E', 'w', '-', …) can be attached to the degrees. If there are no spaces between each element, you must activate the DMS fixed format check box and define the DMS format for the latitude and longitude. The format is:

a**C*****b*****D*****c*****M*****d*****S**

where *a*, *b*, *c* and *d* are the number of characters for the longitude code (C), degree (D), minutes (M) and seconds (S), respectively *a* cannot be less than one. *b* cannot be less than two for the latitude and less than three for the longitude. *c* and *d* cannot be less than 2. The sum of *a*, *b*, *c* and *d* should be equal or less than the length of the field. The DMS fixed format is applied to the input and output files.

If the DMS fixed format check box is not active, the geographical coordinates will be written to the output file in the same geographical format as view last in the data sheet.

Example (input)

```
Latitude:  20-36

                2               3
Columns:        01234567890123456
                N 345412.876

DMS fixed format: 1C3D2M10S
```

Example (output)

```
Latitude:  20-36

DMS fixed format: 1C3D2M10S

                 2               3
Columns:         01234567890123456
                 N 3454 12.876000
```

For the latitude and longitude, the integer values are right justified while the real values are left justified. All other values (e.g., height, geoid) are right justified.

A user-defined format can be edited by selecting its name from the drop-down list box of the ***My Format*** window. A user-defined format can also be deleted from the drop-down list by clicking the ***X*** icon.

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Appendix E

Allowed transformations from ellipsoidal height to orthometric height:

VERTICAL DATUM			
Geoid Models		Coordinates	
Ref. Frame	Format	NAD83(CSRS)	ITRFyyyy
NAD83(CSRS)	BYN	Direct	
NAD83(CSRS)	BIN	Direct	
ITRF	BYN	Epoch of Model	Epoch of data
ITRF	BIN		Direct

Allowed conversions between two geoid models:

VERTICAL DATUM TRANSFORMATION						

No	GEOID MODELS				Coordinates	
	FROM		TO			
	Ref. Frame	Format	Ref. Frame	Format	NAD83(CSRS)	ITRFyyyy
1	NAD83(CSRS)	BYN	NAD83(CSRS)	BYN	Direct/Direct	Direct/Direct
2	NAD83(CSRS)	BYN	NAD83(CSRS)	BIN	Direct/Direct	Direct/Direct
3	NAD83(CSRS)	BIN	NAD83(CSRS)	BYN	Direct/Direct	Direct/Direct
4	NAD83(CSRS)	BIN	NAD83(CSRS)	BIN	Direct/Direct	Direct/Direct
5	NAD83(CSRS)	BYN	ITRF	BYN	Direct/Ep. of Model	
6	NAD83(CSRS)	BYN	ITRF	BIN		
7	NAD83(CSRS)	BIN	ITRF	BYN	Direct/Ep. of Model	
8	NAD83(CSRS)	BIN	ITRF	BIN		
9	ITRF	BYN	NAD83(CSRS)	BYN	Ep. of Model/Direct	
10	ITRF	BYN	NAD83(CSRS)	BIN	Ep. of Model/Direct	
11	ITRF	BIN	NAD83(CSRS)	BYN		
12	ITRF	BIN	NAD83(CSRS)	BIN		
13	ITRF	BYN	ITRF	BYN	Ep. of Model/Ep. of Model	Ep. of data/Ep. of data
14	ITRF	BYN	ITRF	BIN		Epoch of data/Direct
15	ITRF	BIN	ITRF	BYN		Direct/Epoch of data
16	ITRF	BIN	ITRF	BIN		Direct/Direct

* First transformation/second transformation

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Version 3.3