Ontario

Ministry of
Natural Resources

Graphical Analysis of the Ontario NTv2 Conversion between NAD83-ORIG and NAD83-CSRS

prepared by
Don Junkins / NTv2 Consultant
for
Provincial Georeferencing
Geographic Information Ontario
Ministry of Natural Resources

Graphical Analysis User's Guide

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Introduction

Pictures tell better stories than words or lists of data. The data that is pictured here are the shifts and their accuracies from the grid shift file, and how they relate to the underlying network of geodetic control points on which they are based.

Several types of information are presented that allow users to analyze the nature of the transformation. Presenting map-based displays helps to place the data in a spatial context with respect to geographical locations and to the geodetic network. The separate maps depicting each different theme may be thought of as pages of an interactive atlas which guide the user through the various aspects of the transformation.

A basic statistical analysis has also been compiled to complement the graphics. Both tables and chart plots are presented for several aspects of the grid shift file.

The GIS application MapInfo was used to create the presentations. To enable others to browse such presentations, MapInfo provides a free application called ProViewer which can be downloaded from their website. It contains a high degree of functionality for interactively perusing the multi-layered workspaces, including zoom, pan, find and info tools.

For users who do not wish to delve into the MapInfo environment, a collection of images captured from various screen views has been compiled. They can be downloaded and browsed with commonly used picture viewers. Their formats and file directories are described in the beginning sections.

The images contained in this document are low resolution. They are presented for the sole purpose of providing context relating the descriptive content to the downloadable images and MapInfo workspaces.

For MapInfo & ProViewer Users

Throughout this document are supporting details that enable any user to peruse the various MapInfo presentations which have been made available. The segments containing this information are enclosed by a boxed border and headed with the note "***For MapInfo & ProViewer Users***", just as this one is. Readers who are not using MapInfo or ProViewer can skip these segments.

Proviewer is a **free** download provided by MapInfo. To obtain a copy, go to *www.mapinfo.com*, and navigate to > products & services > software > ProViewer , then click on the download link.

1: *Overview of Map Images*

From the MapInfo graphical analysis, there are eight distinct basic images grouped into four complementary pairs, as described later in four corresponding sections. They are:

Densified Areas with Labels
Densified Areas with Network

Network Residuals
Network Accuracies

Latitude Shift Contours
Longitude Shift Contours

Latitude Accuracy Contours
Longitude Accuracy Contours

The four contour images are presented twice – with and without the geodetic network showing. Including the network points helps to place the contour features in context, while omitting them allows the detail of the contoured regions to be examined without being obliterated by the symbols.

Each of these twelve images is then presented at three zoom widths, allowing different balances between coverage and detail. They are as follows:

Full **Window width 3200 km**

This view includes the entire province and the entire area covered by the *ON 5_min* base grid.

Network **Window width 1700 km**

This view includes the area covered by the entire geodetic network and includes all of the densified grid areas.

Regions **Window width 800 km**

This zoom level breaks the area covered by the geodetic network into three overlapping views.

The **Southern Ontario** view includes the *ONottawa*, *ONkinstn*, *ONtronto*, *ONsarnia*, and *ONWinsor* densified grid areas.

The **North Central Ontario** view includes the *ONsault*, *ONagawa*, and the eastern portion of the *ONnipign* densified grid areas.

The **North Western Ontario** view includes the western portion of the *ONnipign* densified grid area.

With each of the twelve images having five views and three formats, there are 180 possible image files altogether. However, the regional zooms do not include the two densified area images, since they would convey no more detail by zooming in. Thus, there are actually162 image files.

The files are organized into folders for image format at the highest level, followed by zoom width, then all of the basic images for each format/zoom combination. The generalized directory structure for the images folder is as follows:

Images

Images_JPEG
Zoom_Full
Zoom_Network
****Zoom_North_Central***
****Zoom_North_Western***
****Zoom_Southern***

Images_JPEG_640
Zoom_Full
Zoom_Network
****Zoom_North_Central***
****Zoom_North_Western***
****Zoom_Southern***

Images_PDF
Zoom_Full
Zoom_Network
****Zoom_North_Central***
****Zoom_North_Western***
****Zoom_Southern***

Each of the lowest-level directories contains the twelve image files in the specified format, with the exception of the regional zoom folders (as marked above by *) which do not include the two densified area images (as marked below by *). The files with an ***_x_net*** suffix are the contour plots without the geodetic network points showing.

****dense_areas_labels***
****dense_areas_network***
network_residuals
network_accuracies
latitude_shift
latitude_shift_x_net
latitude_accuracy
latitude_accuracy_x_net
longitude_shift
longitude_shift_x_net
longitude_accuracy
longitude_accuracy_x_net

2: *Image Types*

In total there are 54 images that have been created for graphical presentation. There are various groupings, which are described in the next section, and each of the images is presented in 3 different formats for various purposes.

Images in JPEG format have been captured using the Save Window feature of MapInfo. The default screen size for all images is 1281x899 pixels (13.3 x 9.4 inches), giving file sizes in the range of 166-685 KB. The corresponding bitmap images are all 3.3 MB in size, but the efficiency of the JPEG compression algorithms keeps the files much smaller.

These JPEG files are the same format used by digital cameras, and can be viewed with any of the applications normally used for that purpose, such as the ***Windows Picture and Fax Viewer***. Because they match a standard screen size, they are most suitable for casual viewing or in a slide show.

Although the JPEG file sizes are not individually very large, when they are all incorporated in a document such as this, the file size grows very quickly. The images must then be scaled down to fit the page size. For this purpose, corresponding half-size (640x450) images have been created. At one-quarter the image area, the file size is also quartered. They could also be more appropriate sized for email attachments or web page images.

The main drawback to the JPEG format is that they are raster images designed for screen resolution of 96 DPI, and quickly lose resolution when enlarged by zooming in. The pixels simply become fatter but no more detail emerges, which is a phenomenon known as pixelation.

Another familiar type of raster image can be created in the PDF format, which is commonly viewed using the ***Adobe Acrobat Reader*** application. The PDF acronym stands for Portable Document Format, and is essentially captured as a file intended for printer output. Depending on how the printer resolution is specified (usually between 300 and 1200 DPI), this allows several orders of zoom magnitude before pixelation occurs. File sizes are kept under control by the fact that only the printed portions are described, unlike JPEG which describes every pixel and then compresses the data.

Each of the distinct images has also been captured in PDF format. A resolution of 600 DPI was used, so even at the maximum Acrobat zoom factor of 32 (3200%), the detail remains acceptably intact. The main drawback that remains even with PDF format is that the symbols also increase in size and obscure the information layered under them. For this reason, alternate views of some of the images have also been captured that uncover some of the detail. Specifics of which images fall in this category are found in the next section.

Vector images provide the best format for viewing. They remain sharp when zooming in and do not pixelate, and symbols retain their nominal size without growing to obscure the underlying detail. Although the PDF format is also able to handle vector data, MapInfo has no option to output the images this way. To gain any more detail than available from either of the JPEG or PDF formats, the MapInfo GIS option should be pursued. MapInfo provides a free viewer call ***Proviewer*** (*www.mapinfo.com*) that can be used for perusing the MapInfo workspaces that these images were taken from.

3: *Overview of MapInfo Workspaces*

For MapInfo & ProViewer Users

MapInfo presentations are a composite of individual layers. Each layer has its own data file, plus other associated files such as table, map and index types. A workspace is a file containing a set of instructions indicating which files to open, and how to present them. To open the workspaces provided here, all of the files must be available in the same directory as the workspace. For this reason, the entire MapInfo directory must be preserved intact after downloading.

By selecting particular combinations of layers, different presentations have been created. These are the various map pages mentioned above. Each map page has it own workspace, all of which open the same 75 layers. Although all workspaces contain all of the layers, only the selected layers have been designated as viewable to display the appropriate information in each of the individual workspaces.

There are eight different workspaces, divided into four complementary pairs, that present the graphical analysis of the ON83CSv1 grid shift file. They are:

dense_areas_labels.WOR
dense_areas_network.WOR

network_residuals.WOR
network_accuracies.WOR

latitude_shift.WOR
longitude_shift.WOR

latitude_accuracy.WOR
longitude_accuracy.WOR

At the initial view of each workspace, only the key layers are visible. This allows the viewer to gain a general impression of the characteristics of the information being presented. Zooming in reveals the grid points, with the basegrid becoming visible at a 1000 km zoom, and the densified grids becoming visible at a 100 km zoom.

These zoomed layers that are common to all of the workspaces are:

Basegrid	***ONnipign***	***ONagawa***
ONsault	***ONwinsor***	***ONsarnia***
ONtronto	***ONkinstn***	***ONottawa***

Detailed information can be displayed for any of the visible layers by using the "info" tool. For example, by clicking on a grid point with the tool, and then selecting the grid from the list of tables, the info box will display the grid point ID, its latitude and longitude, and the shifts and accuracies from the grid shift file.

To simplify initial access, all eight views have been combined into a single workspace containing eight window panes. It is named:

ON83CSv1.WOR

Although each workspace view may be opened directly, it takes no more time or resources to open the composite workspace. But there is a lot of data to load either way, so patience is required while that takes place, even though it may seem like the application is hung up.

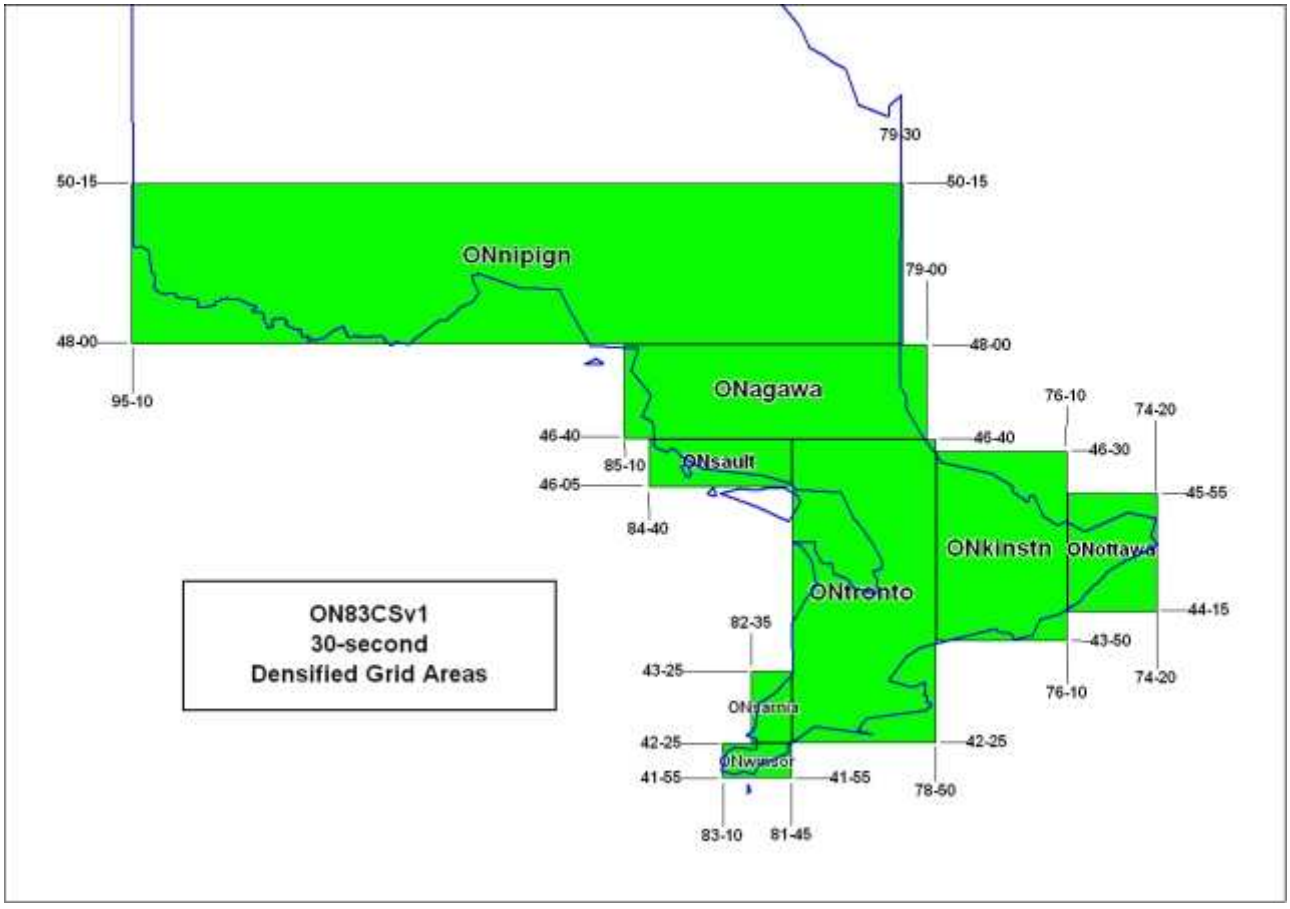
Once the composite workspace is open, using the Windows <maximize> button on the desired pane will bring it into full screen for perusing. When done exploring the information in this window, the Windows <restore down> button will return the pane to its original size and position, and another may be selected.

The maps in all of the windows are presented at the same window width of 3200 km., which allows the entire province to be included but does not provide much detail. Using the <View Entire Layer> item from the <Map> menu and selecting the ***CSRS*** layer will zoom to the views that are included in the following sections. This will produce a window width of 1700 km.

More tips for browsing the workspaces are found in a later section. A complete list of all the layers and in which workspaces they are visible is provided in a table at the end of this document. The next few sections will give some detail about what the workspace for each type of view contains.

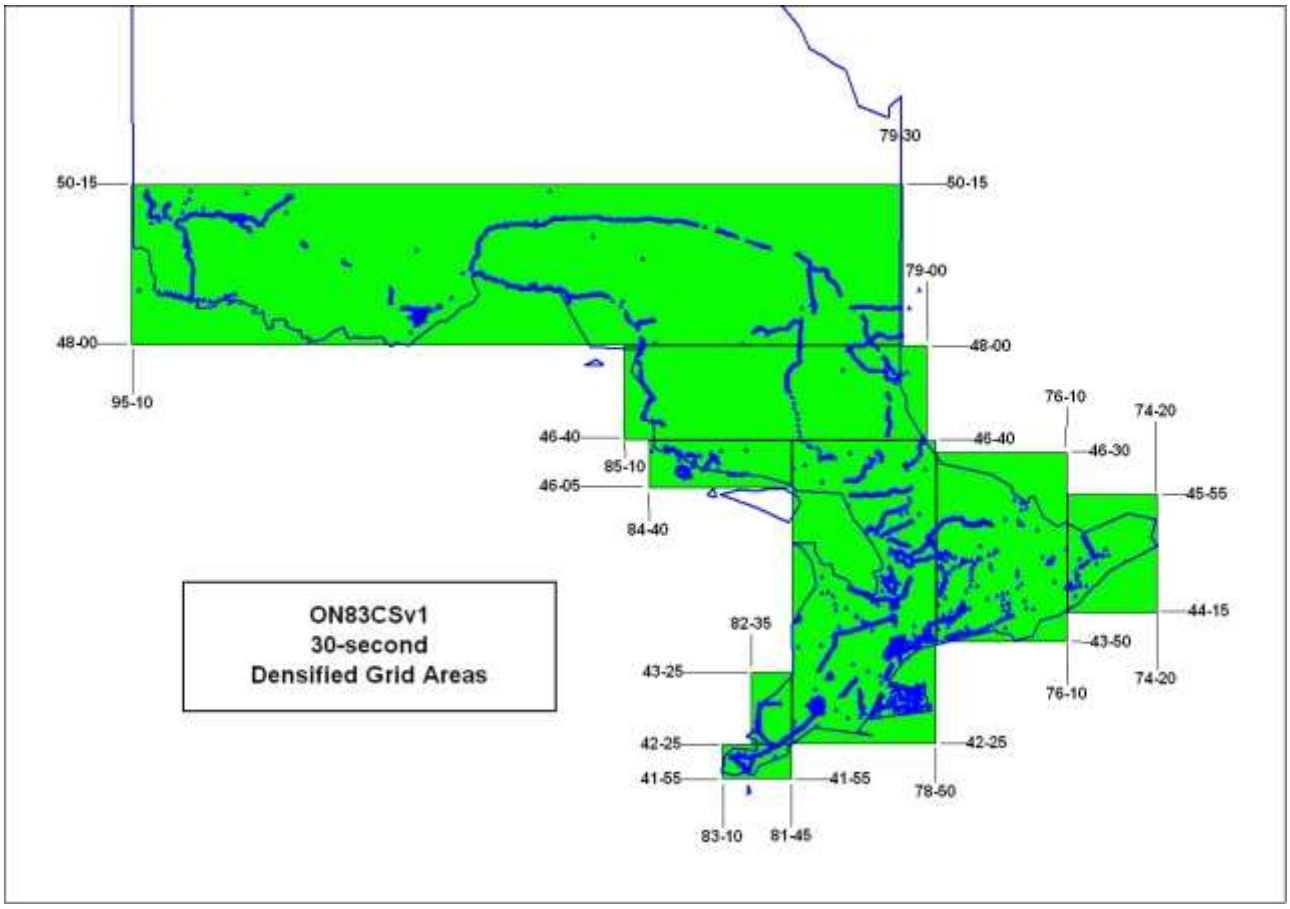
4: *Densified Area Workspaces*

The ***dense_areas_labels*** workspace shows the areas in which the grid has been densified so that it is more sensitive to local variations in the vicinity of the network points. The labels on each of the areas correspond to the names of the densified grids in the grid shift file ***ON83CS.gsb***.

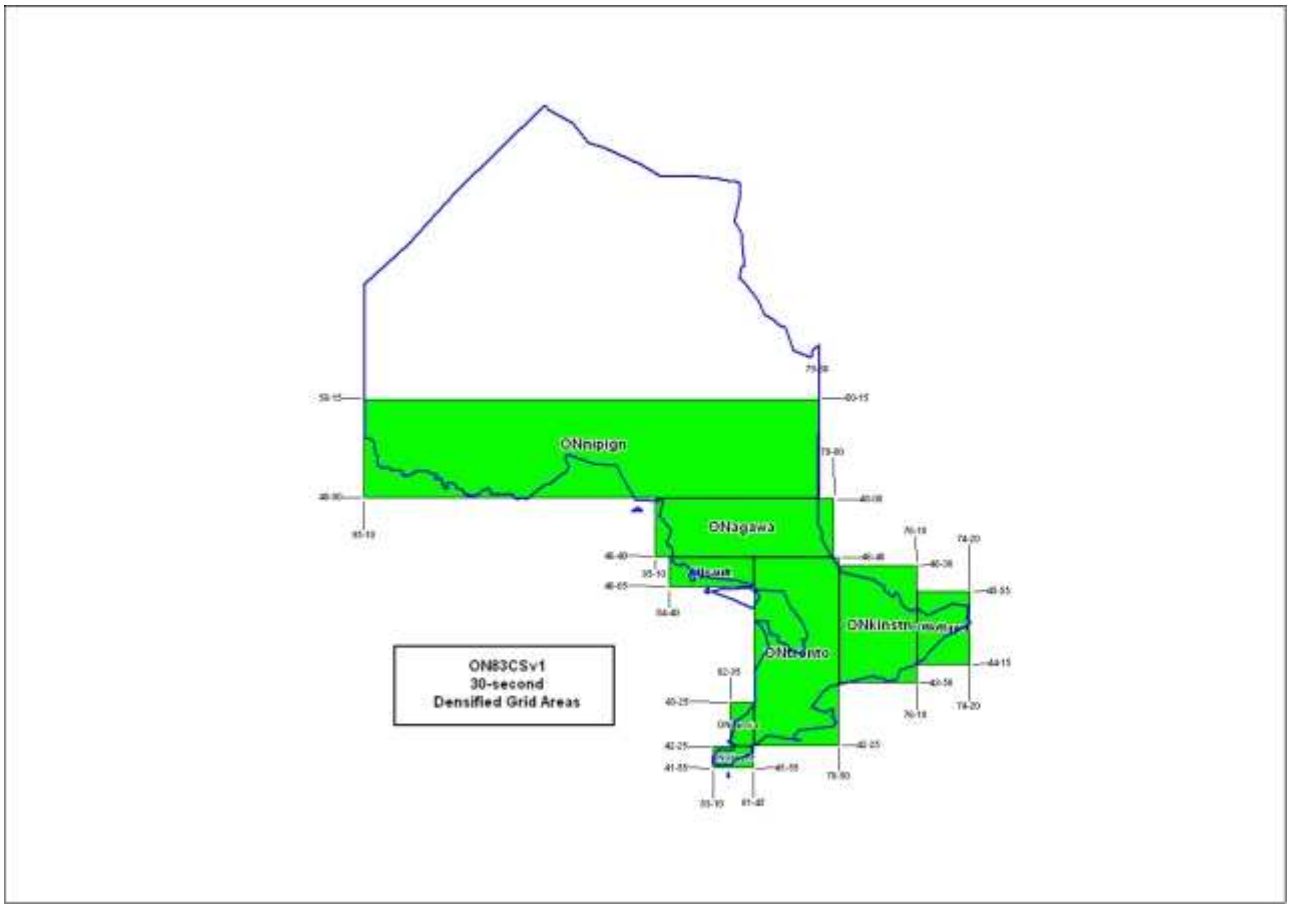


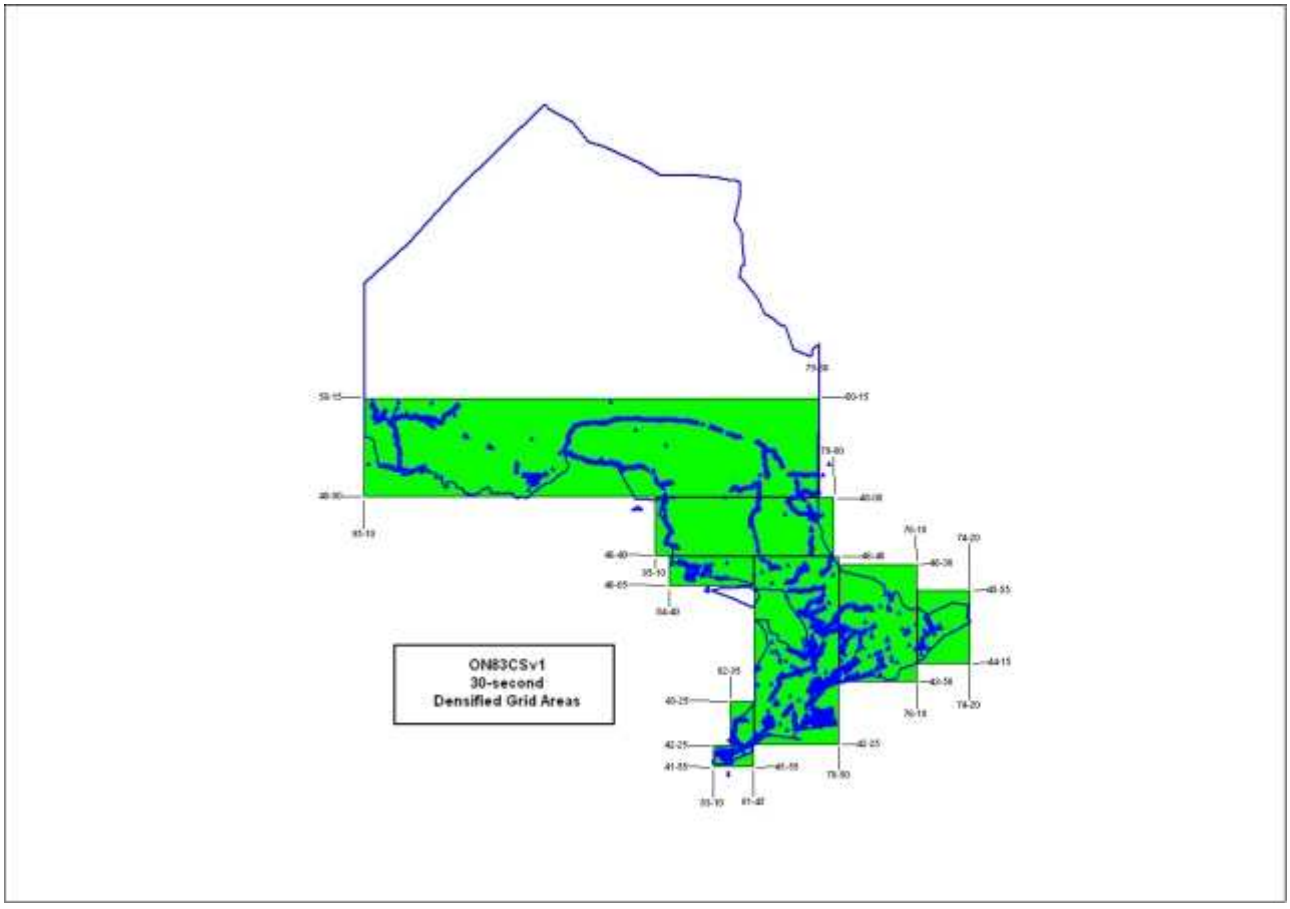
The ***dense_areas_network*** workspace shows essentially the same information, except the geodetic control network points are displayed instead of the names of the densified grids.

For both the ***dense_areas_labels*** and the ***dense_areas_network*** workspaces, the extent of each grid area is labelled with its latitude and longitude limits.



The preceding images have been zoomed to a window width of 1990 km so that the densified area labels fill the frame, allowing more detail to be seen. The next page shows the two images with a window width of 3200 km, covering the entire province.


ONnipign
ONsgawa
ONkinstn
ONtmmo
ON83CSv1
30-second
Densified Grid Areas


ON83CSv1
30-second
Densified Grid Areas

The base grid for the ***ON83CSv1*** grid shift file has a grid spacing of 5 minutes in both latitude and longitude. This is the same spacing as the base grid for the original NTv2.0 which transforms between NAD27 and NAD83-ORIG. The base grid is named:

ON 5_min

Six of the 30 second densified grid areas are the same as in the original NTv2.0 grid shift file. They cover the southern part of Ontario, and are named:

ONottawa
ONkinstn
ONtronto
ONsarnia
ONwinsor
ONsault

Two new 30 second densified grid areas have been created for this grid shift file. They enclose the areas in the northern part of Ontario that have geodetic control network coverage, and are named:

ONagawa
ONnipign

Details for each of these grid areas can also be seen with the <View> option in the NTv2 programs INTGRID, INTTAB, and READDA. A sample list from such a session is included at the end of this document.

For MapInfo & ProViewer Users

The layers included in the ***dense_areas_labels*** workspace are:

Ont_outline
dens_grid_area_labels
dens_grid_lat_labels
dens_grid_lon_labels
dens_grid_areas
dens_grid_title

The layers included in the ***dense_areas_network*** workspace are:

CSRS
Ont_outline
dens_grid_lat_labels
dens_grid_lon_labels
dens_grid_areas
dens_grid_title

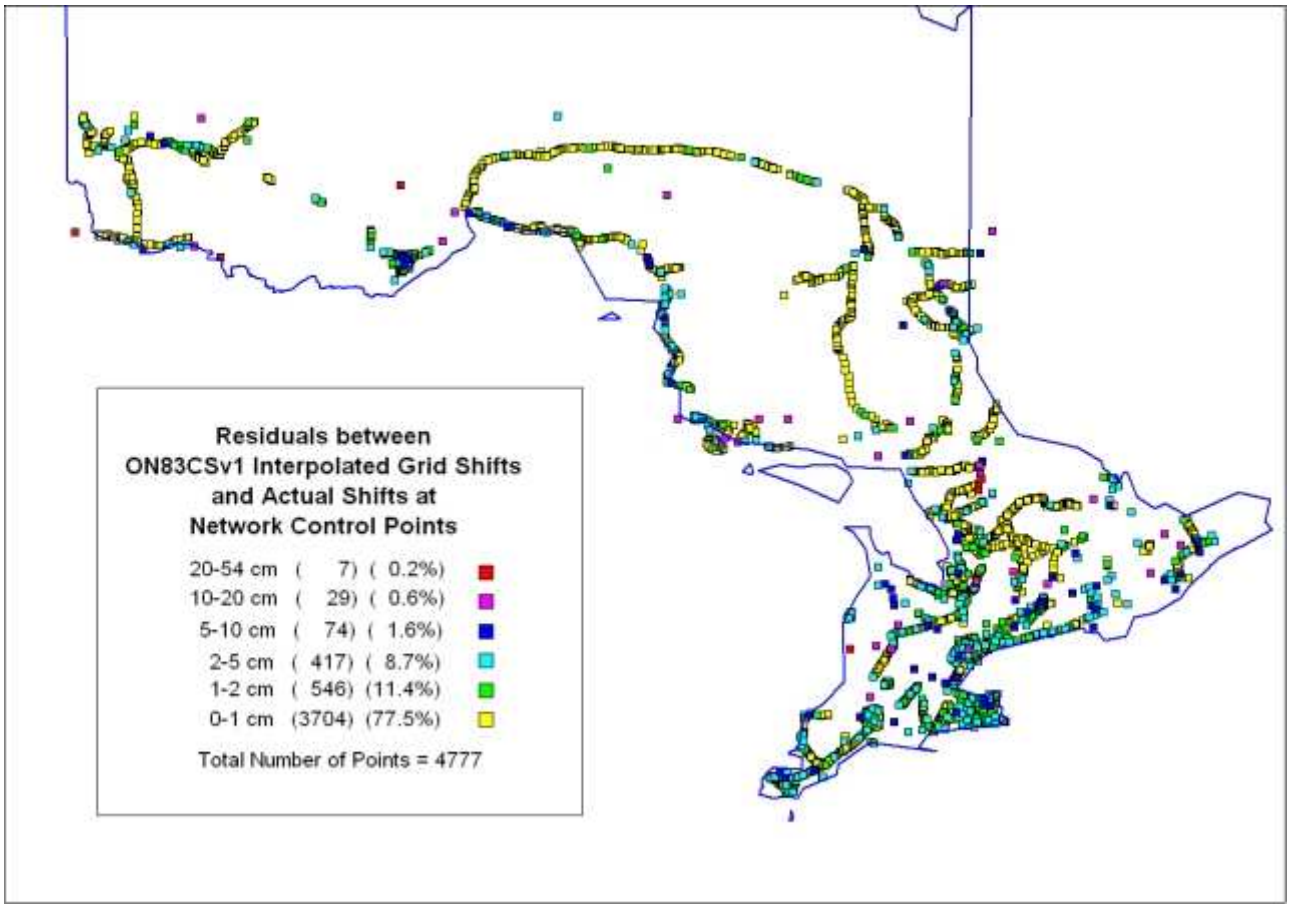
The window width of 1990 km is obtained by selecting the <View Entire Layer> item from the <Map> menu, then selecting the ***dens_grid_lon_labels*** layer. Selecting the ***CSRS*** layer for a window width of 1700 km, as used for all other workspaces, hides some of the limit labels.

5: *Geodetic Network Points Workspaces*

These two views show selected statistics for the geodetic network points on which the transformation is based.

The ***network_residuals*** workspace shows the differences between the actual NAD83-CSRS coordinates and those coordinates interpolated from the ***ON83CSv1*** grid shift file using the NAD83-ORIG coordinates for input. These differences are the sum (square root of the sum of the squares) of the latitude and longitude residuals to the least-squares surface fitting process that creates a distortion model for the area based on the actual shifts at the control network points.

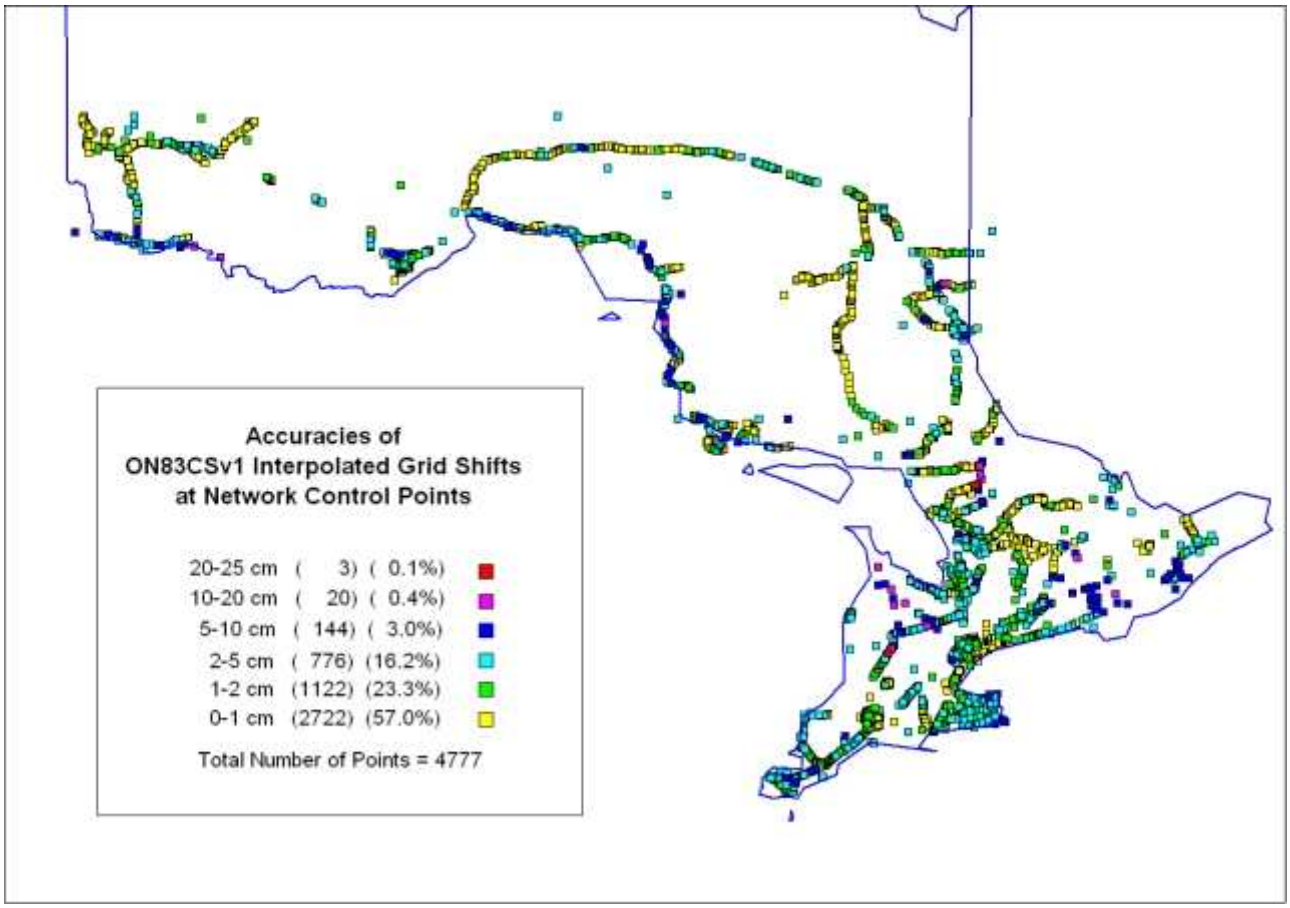
They are a gauge of how well the model fits the true values. By portraying them in a spatial graphic, the user can assess where the performance is good, and where the pockets of lower performance exist.



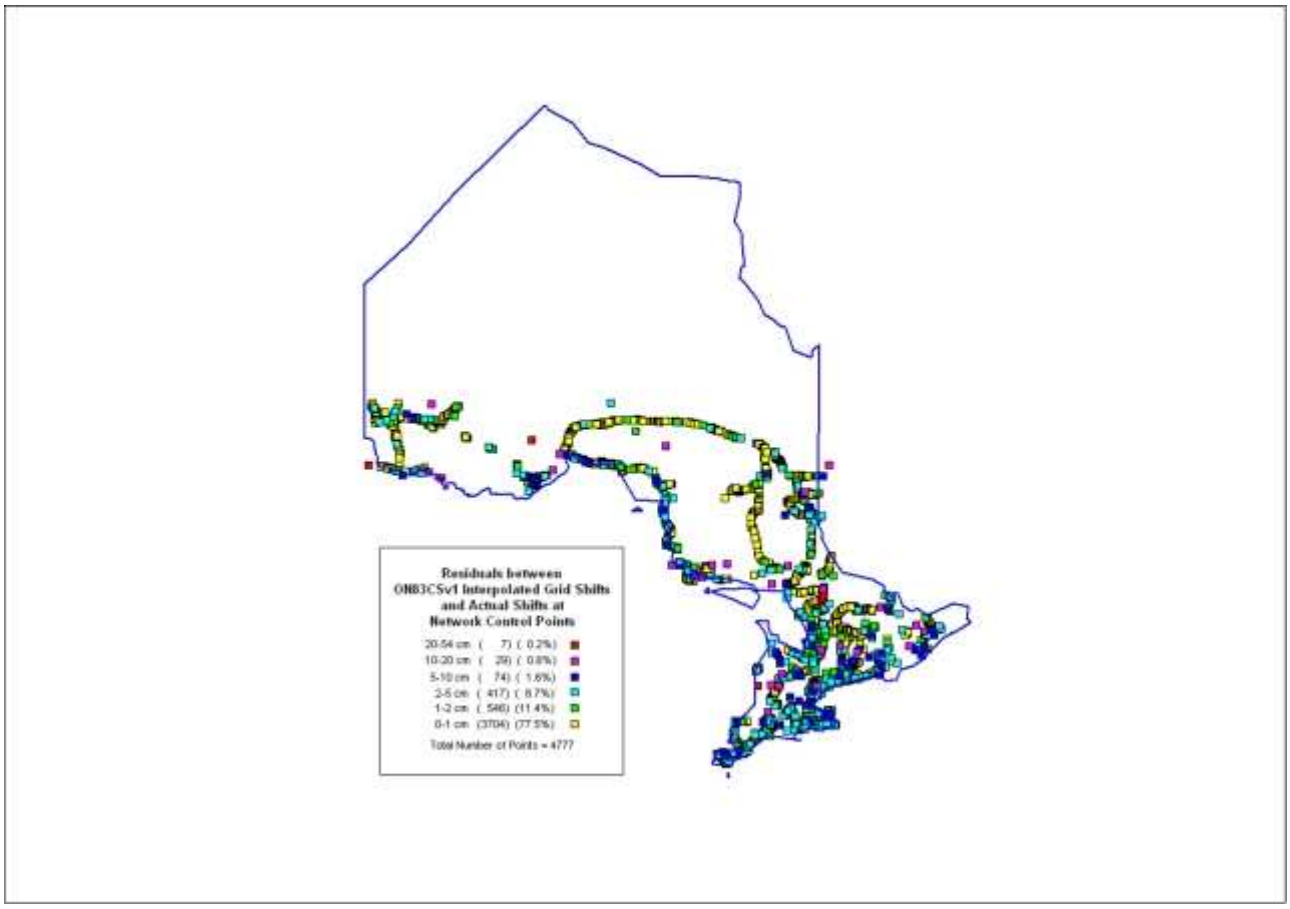
The ***network_accuracies*** workspace shows the accuracies of the shifts at the geodetic network points. The accuracies are interpolated at the points from the shifts at the grid points in the grid shift file, just as the shifts are interpolated. The sum (square root of the sum of the squares) of the latitude and longitude accuracies is used.

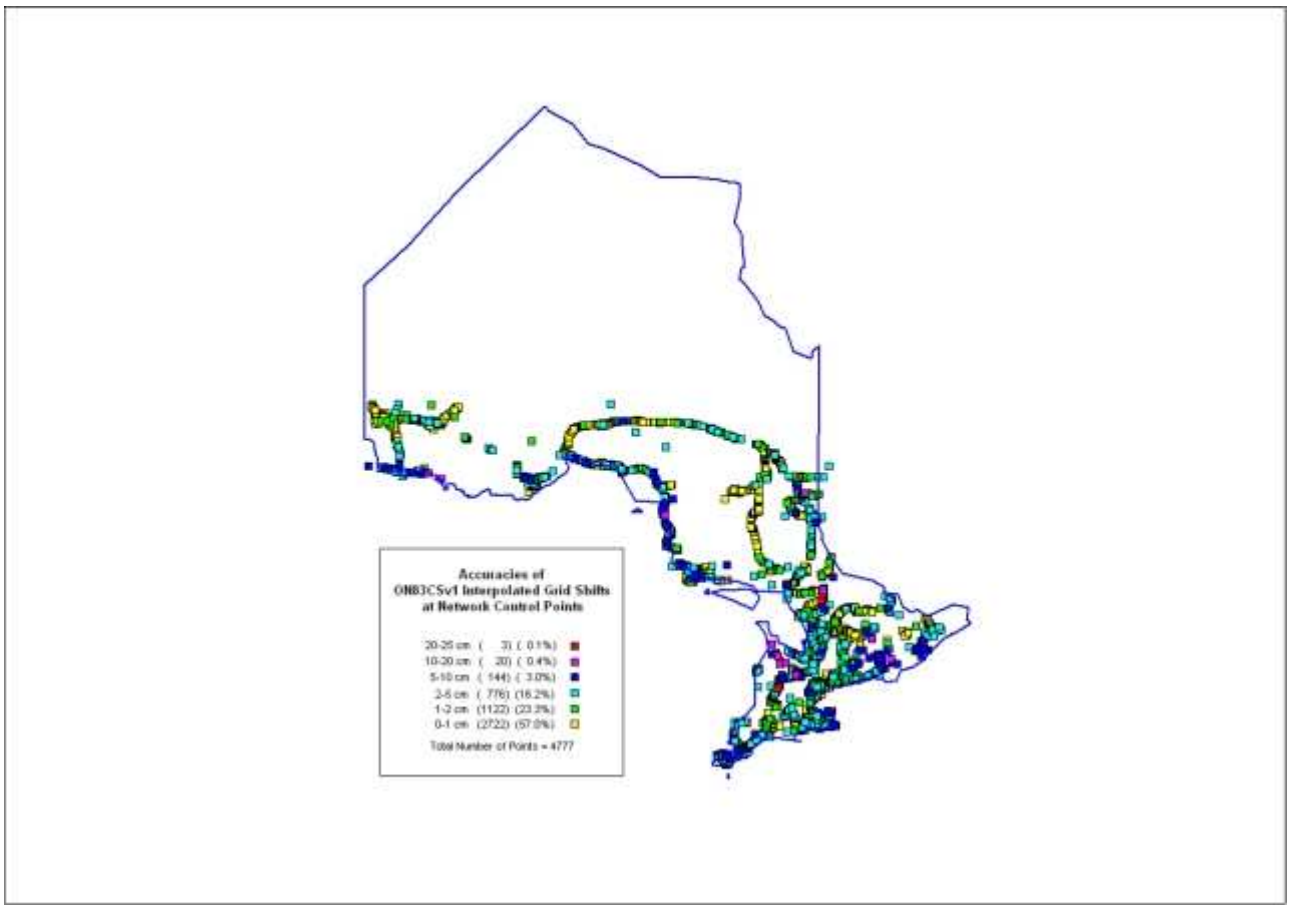
In the context of NTv2 methodology, accuracies are a measure of how well the actual shifts at the network points agree with the shifts at nearby network points. They are one sigma (1σ) standard deviations. The least-squares surface fitting process propagates these accuracies into the grid points.

Similar to the plot of the residuals, they are a gauge of how well the model fits the true values. By portraying them in a spatial graphic, the user can assess where the performance is good, and where the pockets of lower performance exist.



The preceding images have been zoomed to a window width of 1700 km so that the geodetic network fills the frame, allowing more detail to be seen. The next page shows the two images with a window width of 3200 km, covering the entire province.


Residuals between
ON83CSv1 Interpolated Grid Shifts
and Actual Shifts at
Network Control Points
20-54 cm (7) (0.2%)
10-20 cm (29) (0.6%)
5-10 cm (74) (1.6%)
2-5 cm (417) (8.7%)
1-2 cm (546) (11.4%)
0-1 cm (3704) (77.5%)
Total Number of Points = 4777


Accuracies of
ON83CSv1 Interpolated Grid Shifts
at Network Control Points
20-25 cm (3) (0.1%)
10-20 cm (20) (0.4%)
5-10 cm (144) (3.0%)
2-5 cm (776) (16.2%)
1-2 cm (1122) (23.5%)
0-1 cm (2722) (57.0%)
Total Number of Points = 4777

The residual and accuracy plots for the network points are both based on the same data file. This file is the layer named ***diff***, which is found in all of the four contour plot workspaces.

For the purpose of the plots described here, the ***diff*** file has been sorted into several classes. Each class appears as a separate layer, with a coloured symbol marking each point of each layer on the map. The legends also provide a tally of the number of points in each class , and the corresponding percentage of the total. This provides an additional impression of the performance of the grid shift file.

For MapInfo & ProViewer Users

The layers for the ***network_accuracies*** workspace are:

Ont_outline
acc_title
acc_20_25_cm
acc_10_20_cm
acc_5_10_cm
acc_2_5_cm
acc_1_2_cm
acc_0_1_cm
CSRS

The layers for the ***network_residuals*** workspace are:

Ont_outline
res_title
res_20_54_cm
res_10_20_cm
res_5_10_cm
res_2_5_cm
res_1_2_cm
res_0_1_cm
CSRS

When the info tool is used to view the data associated with these layers, the records are found to contain many fields.

The field that is plotted for the residuals is labelled ***Tot_resid***. It is the magnitude of the residual vector, which is the sum (square root of the sum of the squares) of the ***Lat_resid*** and ***Lon_resid*** vector components.

The field that is plotted for the accuracies is labelled ***Tot_acc***. It is the magnitude of the accuracy vector, which is the sum (square root of the sum of the squares) of the ***Lat_acc*** and ***Lon_acc*** vector components.

These fields are described in more detail in the Statistical Analysis section later this document.

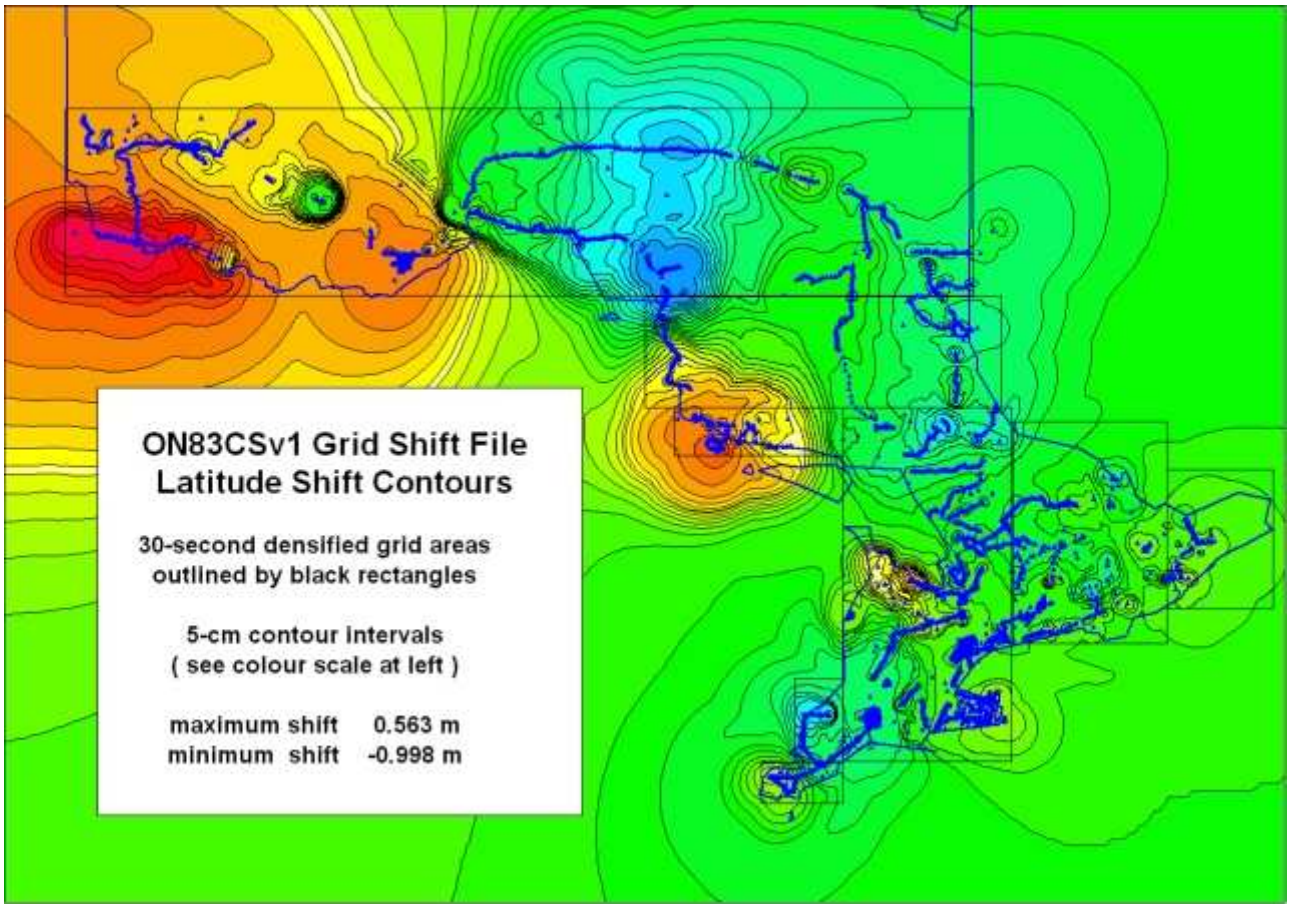
6: *Shift Contour Workspaces*

The grid points in the grid shift file each have a latitude shift and a longitude shift associated with them. By treating each component separately, contour plots can be used to visualize the magnitude and the spatial distribution of the shifts. Total shifts are not plotted because they would lack the azimuth component of the shift vector.

The ***latitude_shift*** contour plot shows that the general overall shift is approximately –0.3 metres. This value is represented by the expansive green areas far from the network. The median shift from the basegrid is –0.287 metres, while the median from the densified grids is -0.369 metres. The average of the actual latitude shifts at the geodetic network points is –0.295 metres. As indicated in the legend box, the maximum grid shift is +0.563 metres and the minimum shift is -.998 metres.

NOTE: Please see the comments about average values in the Statistics section.

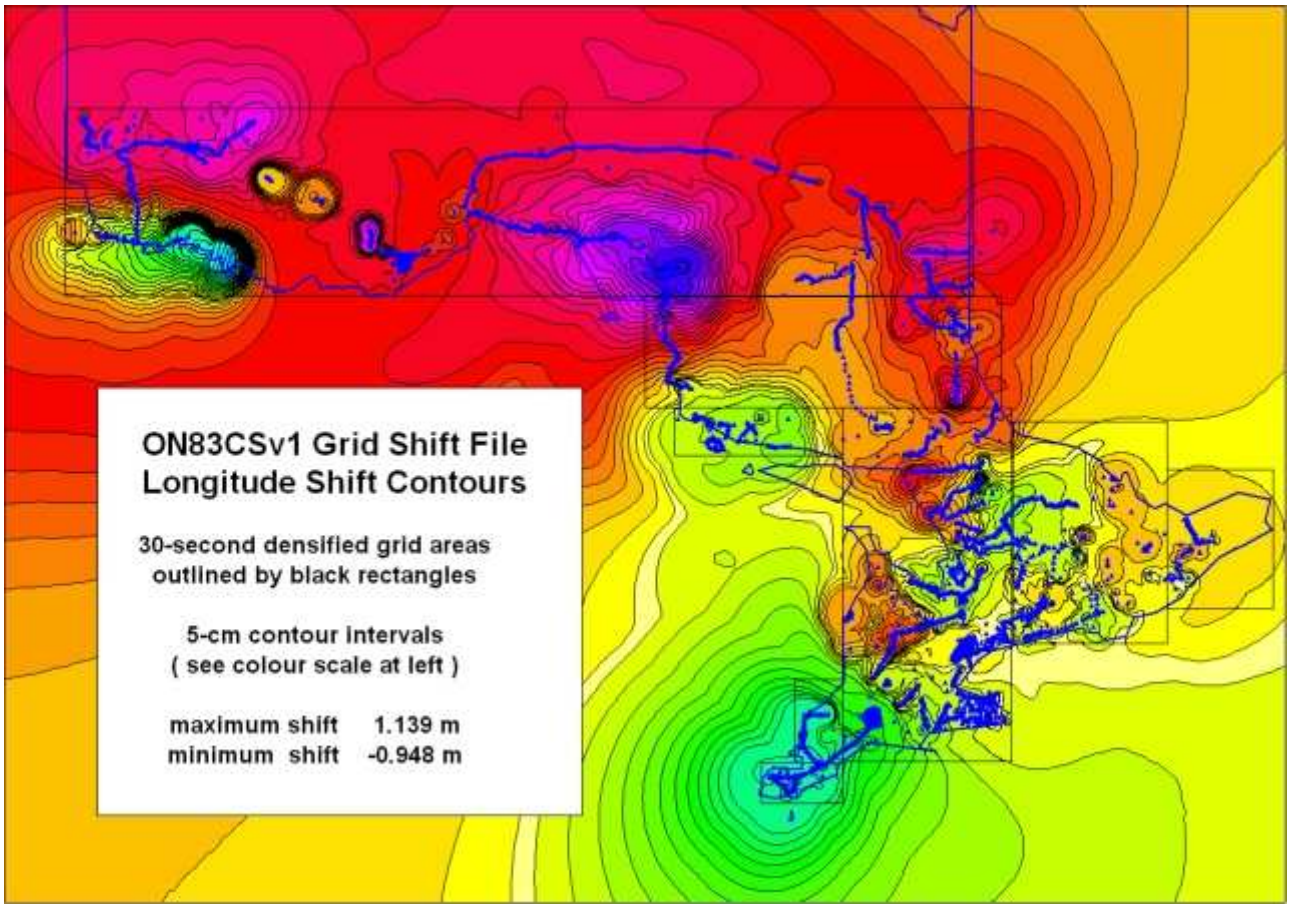
There are obvious pockets of local distortion in the vicinities of Owen Sound, Sault Ste. Marie, Wawa, Thunder Bay, and Rainy River.



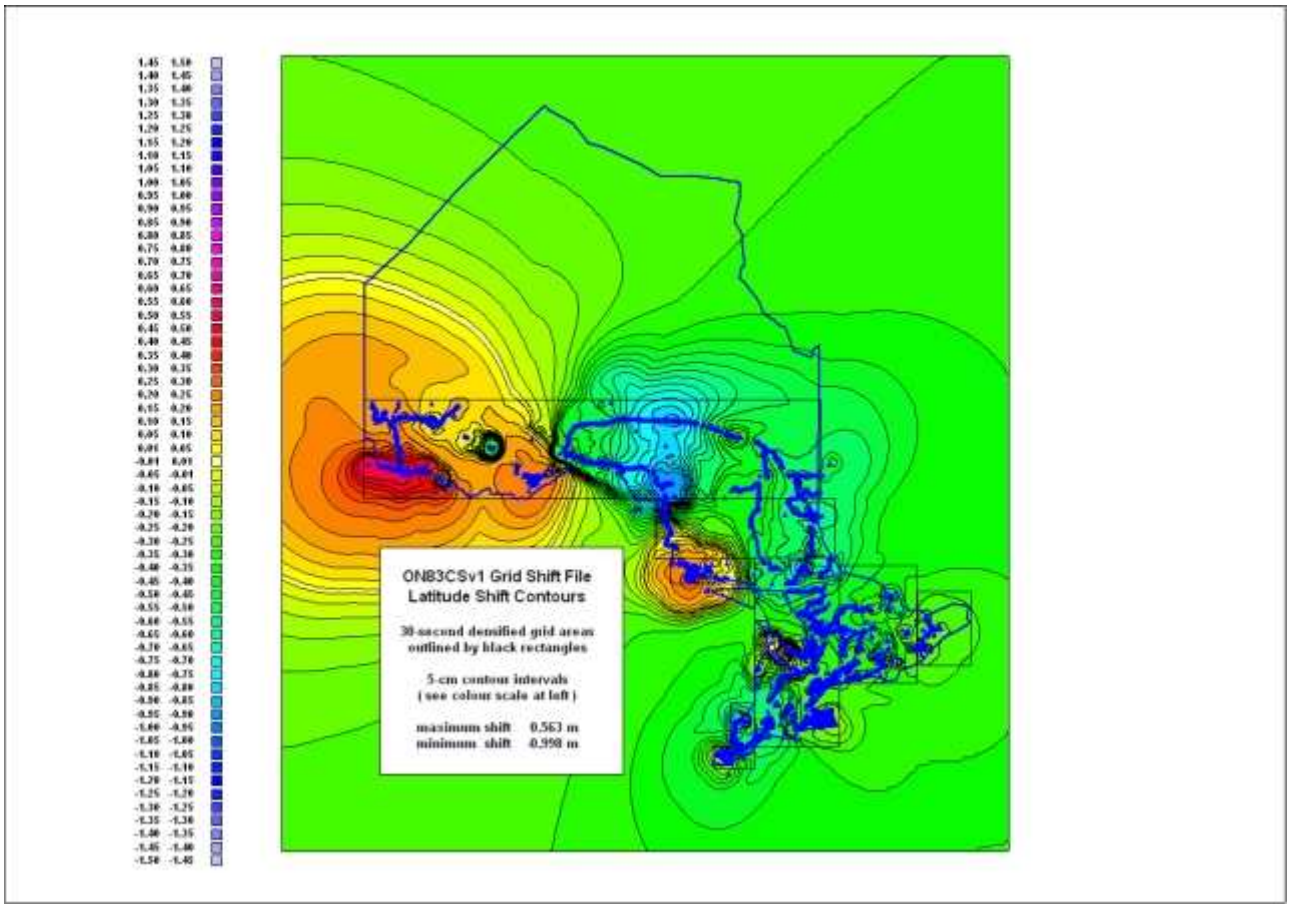
The ***longitude_shift*** contour plot shows a much greater variation in the trends of the areas away from the network. There is a significant positive trend in the northern part of the province, but a near zero trend through the central and eastern parts. The median shift from the basegrid is +0.182 metres, while the median from the densified grids is +0.297 metres. The average of the actual longitude shifts at the geodetic network points is +0.102 metres. As indicated in the legend box, the maximum grid shift is +1.139 metres and the minimum shift is –0.948 metres.

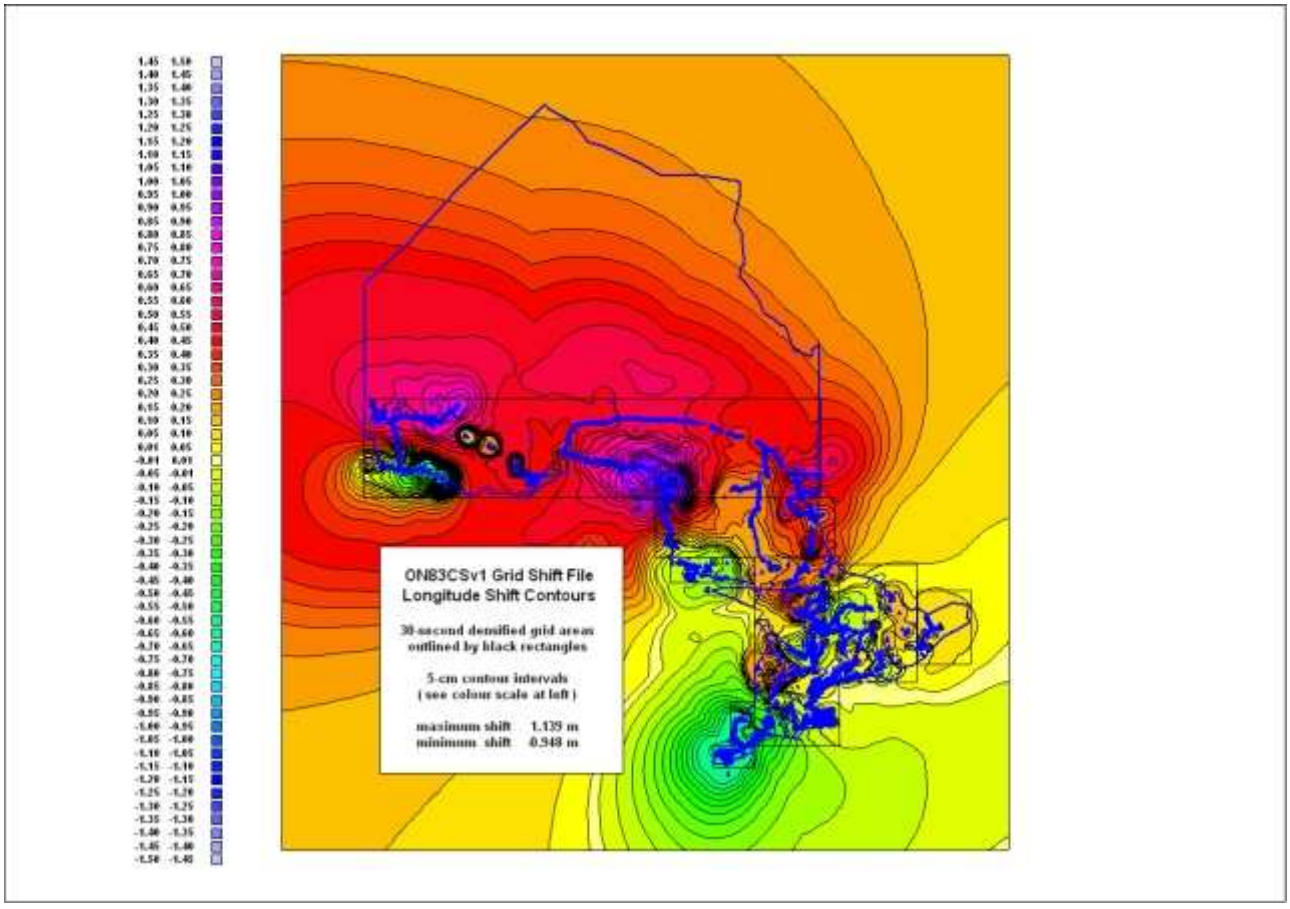
NOTE: Please see the comments about average values in the Statistics section.

Similar to the latitude shifts, there are obvious pockets of local distortion, but there are many more smaller pockets with greater local anomalies. One of the more interesting features is the reversal of trend creating a deep crater-like artefact in the Rainy River area.



The preceding images have been zoomed to a window width of 1700 km so that the geodetic network fills the frame, allowing more detail to be seen. The next page shows the two images with a window width of 3200 km, covering the entire province.


ON83CSv1 Grid Shift File
Latitude Shift Contours
30-second densified grid areas outlined by black rectangles
5-cm contour intervals
(see colour scale at left)
maximum shift 0.563 m
minimum shift -0.998 m


ON83CSv1 Grid Shift File
Longitude Shift Contours
30-second densified grid areas outlined by black rectangles
5-cm contour intervals
(see colour scale at left)
maximum shift 1.135 m
minimum shift -0.948 m

The contour plots for the 30 second densified regions overlay the one for the 5 minute base grid region. They have much finer detail since the densified grids have 100 times the number of grid points for the same area and can more closely follow the undulations of the distortion model. The outlines of the densified areas show up as rectangles outlined by fine black lines.

Both the ***latitude_shift*** and ***longitude_shift*** contour plots are based on the same contour interval of 5 cm and use the same colour palette. The legend to the left of the plot shows the detail of the colour gradations. Essentially, a zero shift shows as yellow, with positive shifts ranging through red and magenta to blue, while negative shifts range through green and cyan to blue.

The entire colour palette has been presented for completeness. As seen from the minimum and maximum values, neither of the plots has any contour regions that approach the limits of the palette. When blue shaded areas do appear, their sign (+ or -) can easily be determined by the colours to which they are adjacent.

For MapInfo & ProViewer Users

The layers in the ***latitude_shift*** workspace are:

CSRS
diff
Ont_outline
shift_contour_legend
lat_shift_title
legend_box
ONottawa_Lat_shift_contour
ONkinstn_Lat_shift_contour
ONtronto_Lat_shift_contour
ONsarnia_Lat_shift_contour
ONwinsor_Lat_shift_contour
ONsault_Lat_shift_contour
ONagawa_Lat_shift_contour
ONnipign_Lat_shift_contour
Basegrid_Lat_shift_contour

The layers in the ***longitude_shift*** workspace are:

CSRS
diff
Ont_outline
shift_contour_legend
lon_shift_title
legend_box
ONottawa_Lon_shift_contour
ONkinstn_Lon_shift_contour
ONtronto_Lon_shift_contour
ONsarnia_Lon_shift_contour
ONwinsor_Lon_shift_contour
ONsault_Lon_shift_contour
ONagawa_Lon_shift_contour
ONnipign_Lon_shift_contour
Basegrid_Lon_shift_contour

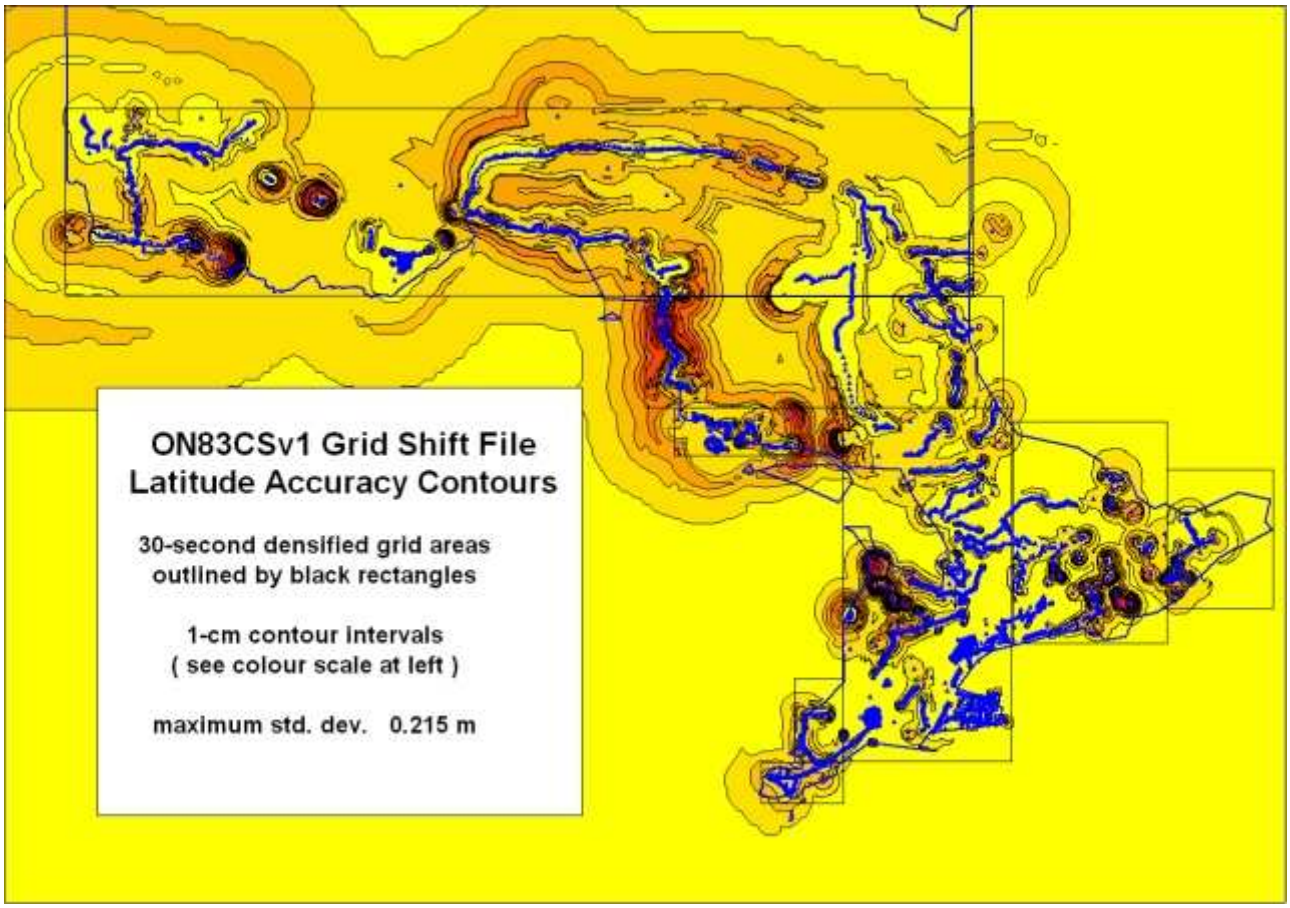
Placing the cursor over any contour region will cause a pop-up indicating the lower limit for that region. These can be placed as labels on the lower boundary of the region.

7: *Accuracy Contour Workspaces*

The grid points in the grid shift file each have a latitude accuracy and a longitude accuracy associated with them. By treating each component separately, contour plots can be used to visualize the magnitude and the spatial distribution of the accuracies. Total accuracies are not plotted because they would lack the azimuth component of the accuracy vector.

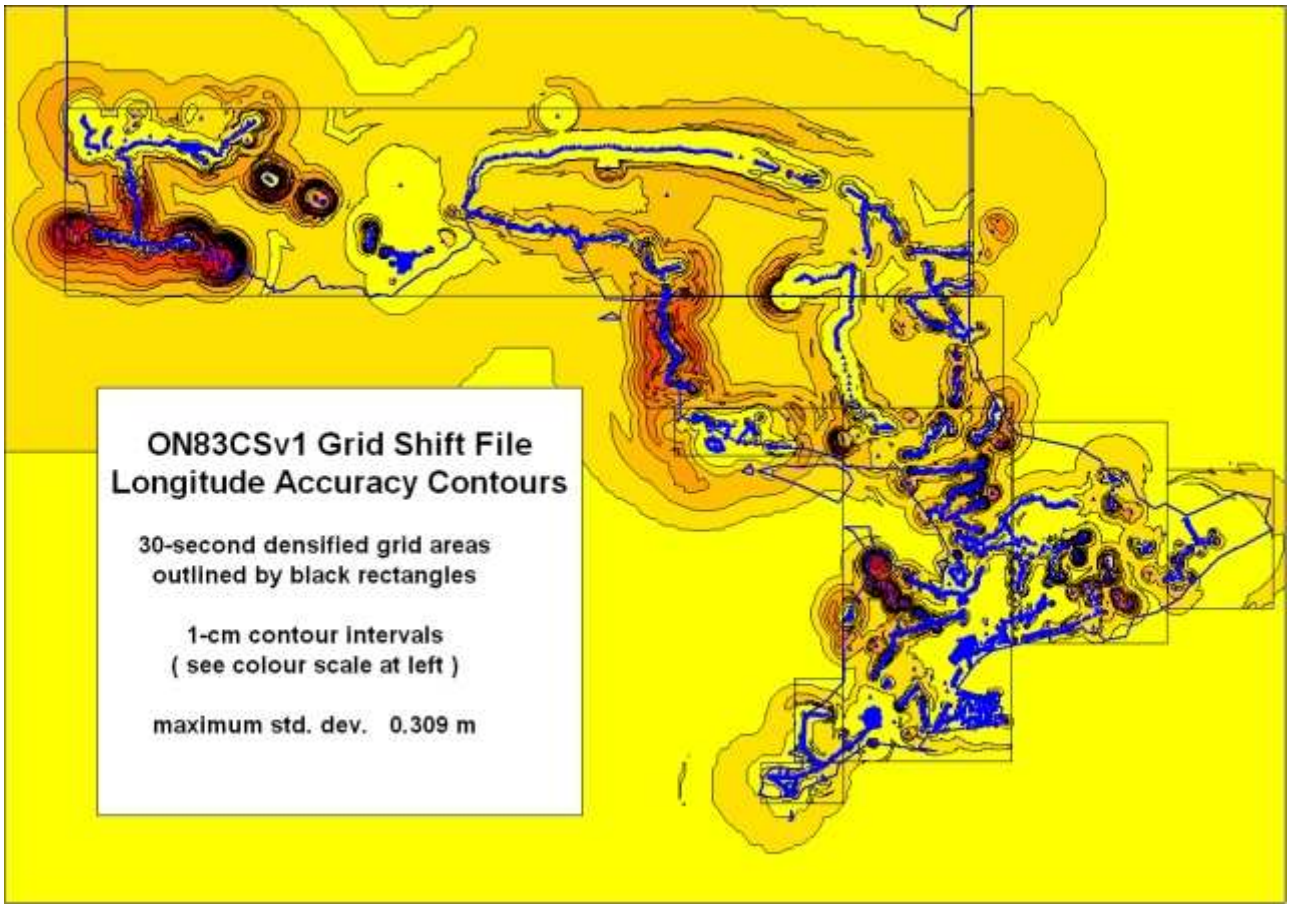
The accuracies are an indicator of the consistency of the shifts at the nearby geodetic control network points. Values near zero indicate that all of the nearby points have virtually identical shifts, while larger values indicate a greater range in shifts. In areas far from the network points, values tend to zero since the mean shifts do not vary much from one location to another. Thus the background is mostly yellow, with most contours clustered around the network. The worst cases usually correspond to the locations of greatest distortion seen in the shift contour plots.

The ***latitude_accuracy*** contour plot shows generally very good accuracy, but with several concentrated pockets of poorer accuracy. As indicated in the legend box, the maximum standard deviation (poorest accuracy) is 0.215 metres. The median from the basegrid is 0.005 metres, while the median from the densified grids is 0.015 metres.

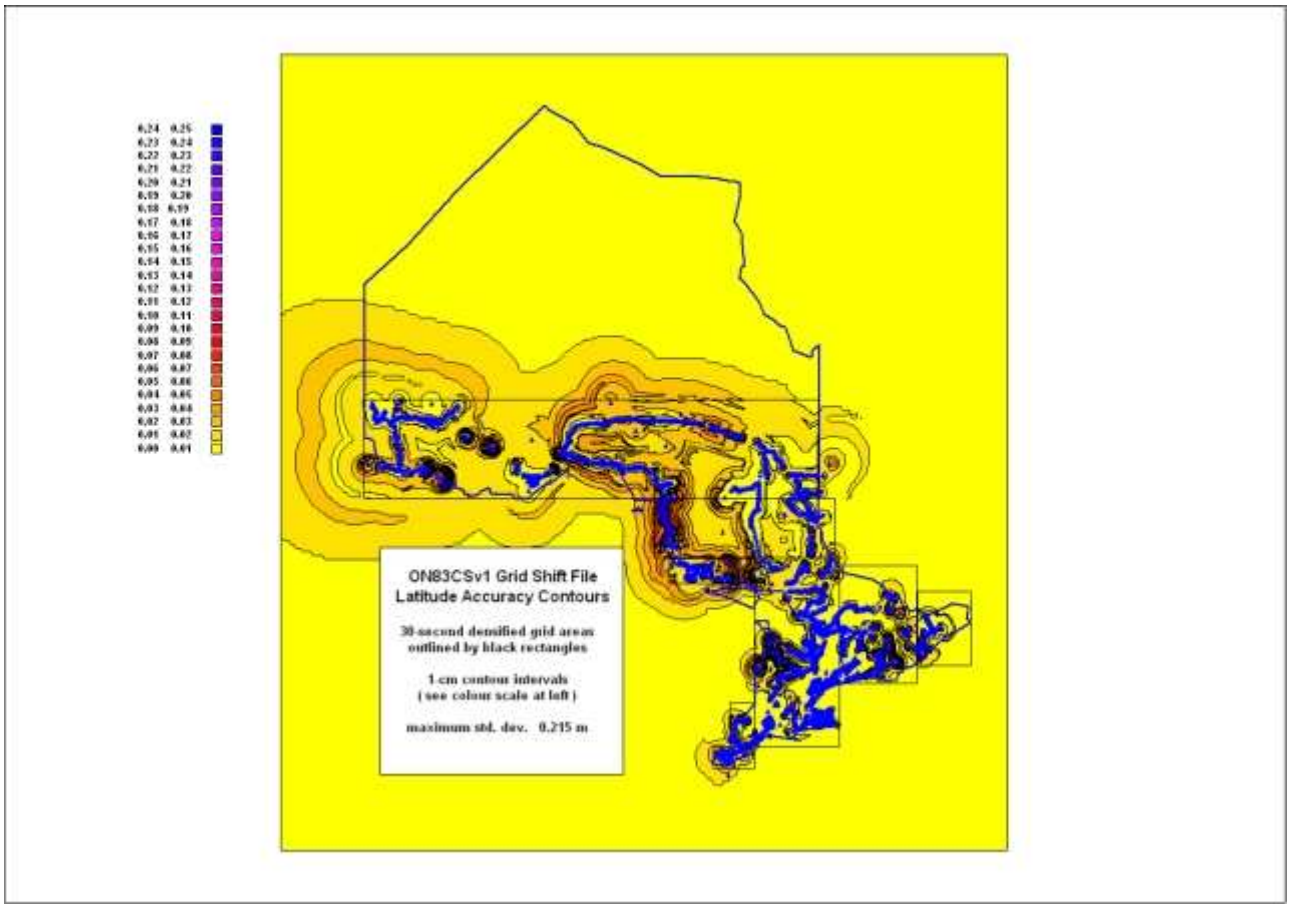


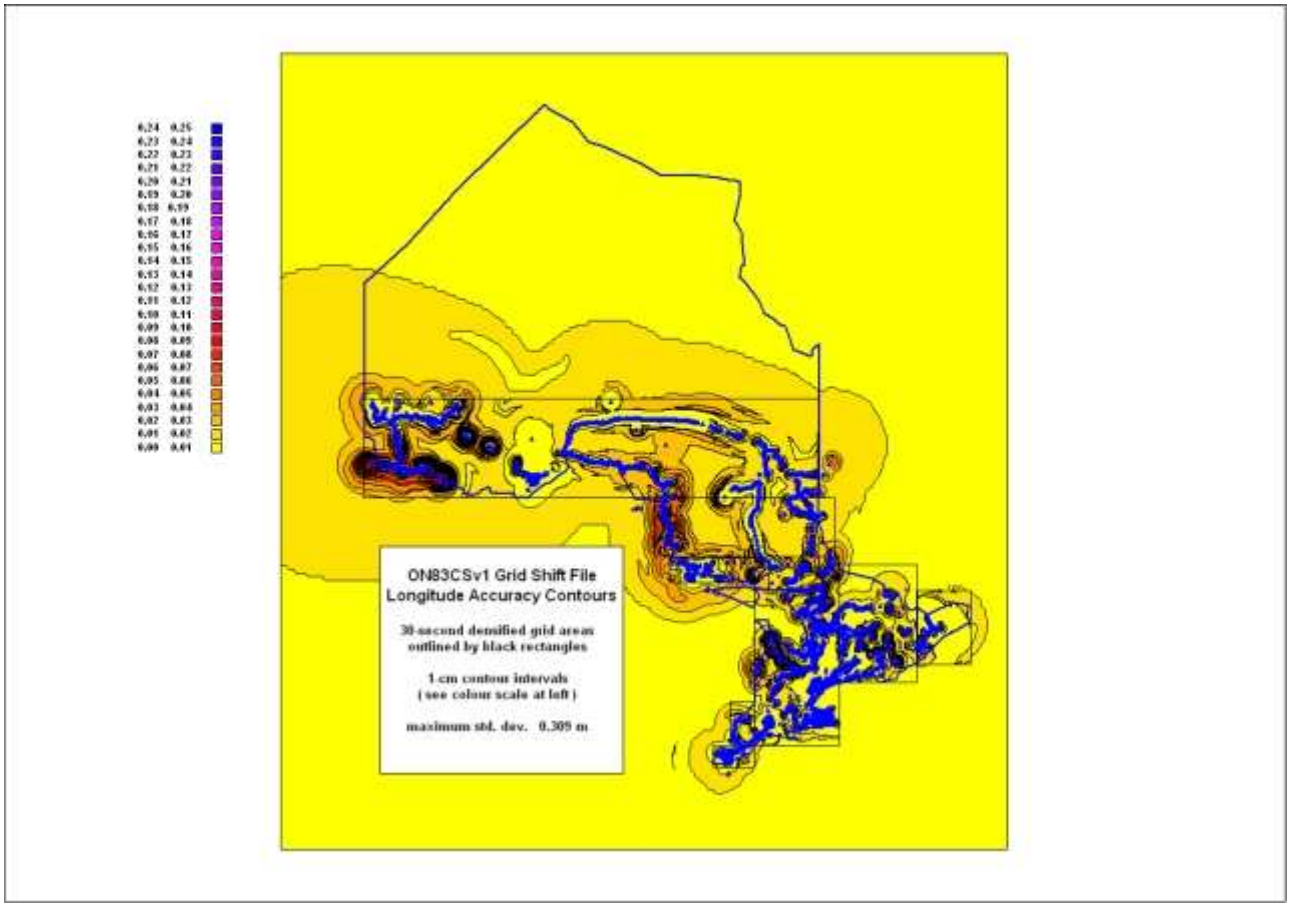
The ***longitude_accuracy*** contour plot also shows generally very good accuracy, but with several concentrated pockets of poorer accuracy. As indicated in the legend box, the maximum standard deviation (poorest accuracy) is 0.227 metres. The median from the basegrid is 0.006 metres, while the median from the densified grids is 0.014 metres.

NOTE: Please see the comments about average values in the Statistics section.



The preceding contour images have been zoomed so that the geodetic network fills the frame, allowing more detail to be seen in this document. The next page shows the two windows as they initially appear in the workspace, with the colour palette displayed.


ON83CSv1 Grid Shift File
Latitude Accuracy Contours
30-second densified grid areas outlined by black rectangles
1 cm contour intervals
(see colour scale at left)
maximum std. dev. 0.215 m


ON83CSv1 Grid Shift File
Longitude Accuracy Contours
30-second densified grid areas outlined by black rectangles
1 cm contour intervals
(see colour scale at left)
maximum std. dev. 0.309 m

As with the shift contour plots, the 30 second densified regions overlay the one for the 5 minute base grid region. They have much finer detail since the densified grids have 100 times the number of grid points for the same area and can more closely follow the undulations of the distortion model. The outlines of the densified areas show up as rectangles outlined by fine black lines.

Both the ***latitude_accuracy*** and ***longitude_accuracy*** contour plots are based on the same contour interval of 1 cm and use the same colour palette. The legend to the left of the plot shows the detail of the colour gradations. The range has only positive values. Essentially, a zero accuracy shows as yellow, with greater values ranging through red and magenta to blue.

The entire colour palette has been presented for completeness. As seen from the maximum values, neither of the plots has any contour regions that approach the upper limit of the palette.

For MapInfo & ProViewer Users

The layers in the ***latitude_accuracy*** workspace are:

CSRS
diff
Ont_outline
accuracy_contour_legend
lat_acc_title
legend_box
ONottawa_Lat_acc_contour
ONkinstn_Lat_acc_contour
ONtronto_Lat_acc_contour
ONsarnia_Lat_acc_contour
ONwinsor_Lat_acc_contour
ONsault_Lat_acc_contour
ONagawa_Lat_acc_contour
ONnipign_Lat_acc_contour
Basegrid_Lat_acc_contour

The layers in the ***longitude_accuracy*** workspace are:

CSRS
diff
Ont_outline
accuracy_contour_legend
lon_acc_title
legend_box
ONottawa_Lon_acc_contour
ONkinstn_Lon_acc_contour
ONtronto_Lon_acc_contour
ONsarnia_Lon_acc_contour
ONwinsor_Lon_acc_contour
ONsault_Lon_acc_contour
ONagawa_Lon_acc_contour
ONnipign_Lon_acc_contour
Basegrid_Lon_acc_contour

Placing the cursor over any contour region will cause a pop-up indicating the lower limit for that region. These can be placed as labels on the lower boundary of the region.

8: *Statistical Analysis*

The following table gives the minimum and maximum values for the shifts and accuracies in all of the grid areas of the ***ON83CSv1*** grid shift file.

Because the densified grids can more closely follow the undulations of the distortion model than the sparser base grid, there are cases where the min and max values are outside those of the base grid. In fact, the ***ONnipign*** densified grid area has the greatest extremes for all of the shift statistics, while ***ONtronto*** has the greatest values for the accuracy statistics.

The overall minimum and maximum values are those indicated in the contour plot legends.

Grid Area	Latitude Shifts		Longitude Shifts		Latitude Accuracies		Longitude Accuracies	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Basegrid	-.972	.556	-.929	1.121	.000	.145	.000	.226
ONottawa	-.422	-.073	-.035	.214	.000	.103	.000	.064
ONkinstn	-.581	-.123	-.211	.272	.000	.119	.000	.124
ONtronto	-.947	.194	-.555	.543	.000	.215	.000	.309
ONsarnia	-.820	-.357	-.637	-.263	.000	.056	.000	.044
ONwinsor	-.575	-.073	-.809	-.453	.002	.072	.001	.068
ONsault	-.448	.392	-.236	.176	.000	.156	.000	.117
ONagawa	-.977	.210	-.155	1.063	.000	.143	.000	.090
ONnipign	-.998	.563	-.948	1.139	.000	.130	.000	.227
Overall	**-.998**	**.563**	**-.948**	**1.139**	**.000**	**.215**	**.000**	**.309**

The next several tables and their corresponding plots give much more detail regarding the statistical distribution of the shifts and accuracies at the grid points, in contrast to the spatial distribution presented by the contour plots.

The percentile tabulations and plots for the grid points elaborate on the simple minimum and maximum values given above. Note the very significant differences between the values from the base grid compared to those from the cumulative densified grids. This is due to the fact that there is greater variability nearer to the geodetic network control points, while the distortion model becomes more smooth farther from them. A quick glance at the contour plots confirms that this is indeed the case. The densified grids have much less of their area far from the network points than does the base grid, hence the differences in statistics.

Thus it becomes apparent that any simple representative statistic computed from the grid points is very subject to the arbitrary selection of which grid points to include. The 50^{th} percentile values are those reported as medians in the descriptions of the contour plots.

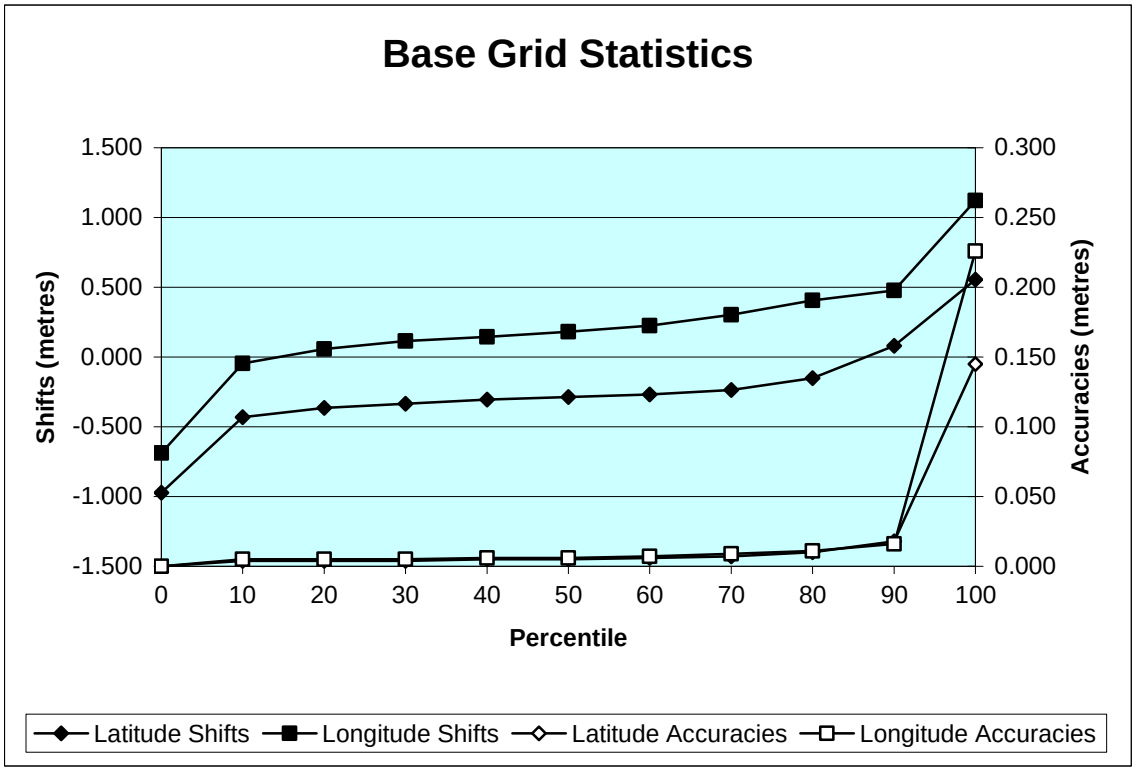
When the shifts at the grid points are compiled into population distribution plots (the corresponding tables are omitted for brevity), we also see some significant differences between the base grid and the densified grids. For both the latitude and longitude shifts, the base grid shows a strong central tendency, with only a slight secondary hump. By contrast, the densified grids show pronounced double peaks with no definitive central value.

When the actual shifts between the two sets of coordinates for the geodetic network points are plotted, this lack of a central tendency is even more pronounced. The distortion model is based on these known values. It attempts to fit these shifts while creating a smooth transition in the areas between the network points and off into the regions beyond them.

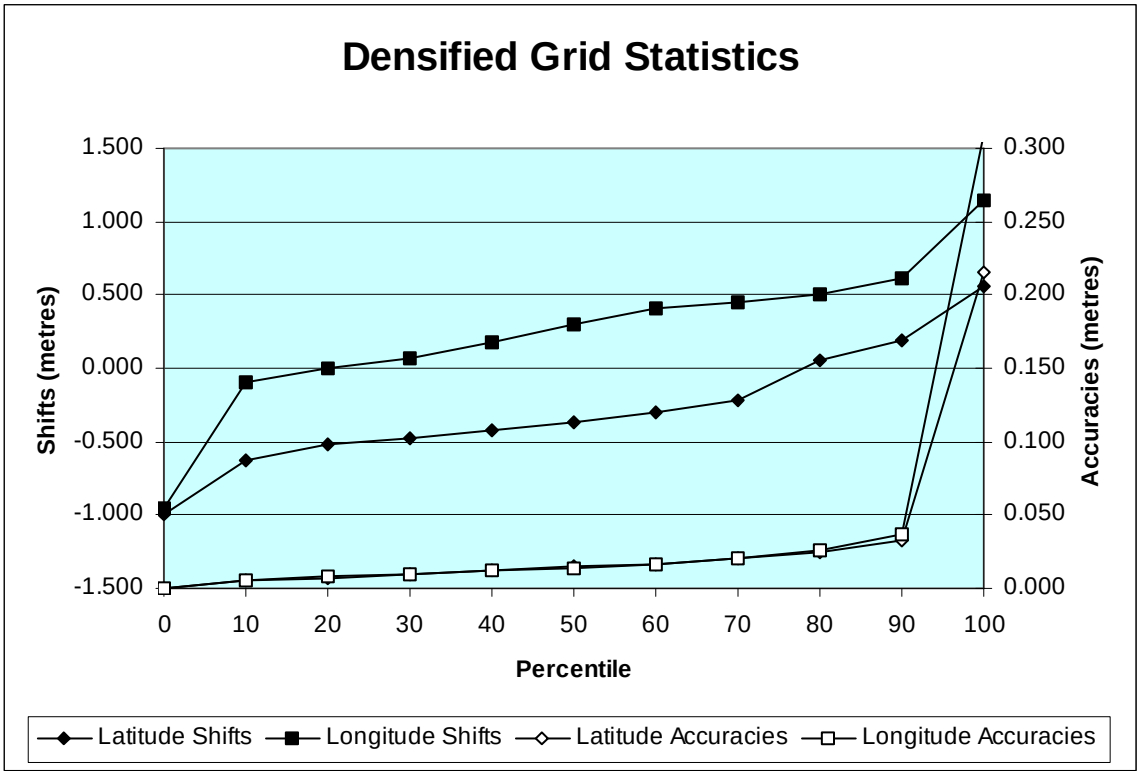
The variation in the shifts is a result of the respective adjustments of the networks, which are influenced by the network geometry and adjustment constraints. The pattern of the shifts varies according to the local and regional distortions between the two adjustments, which is why a distortion model has been created and delivered to the end user in the form of an NTv2 grid shift file.

WARNING: Generalized values, especially mean shifts, should NOT be applied for any purpose whatsoever!

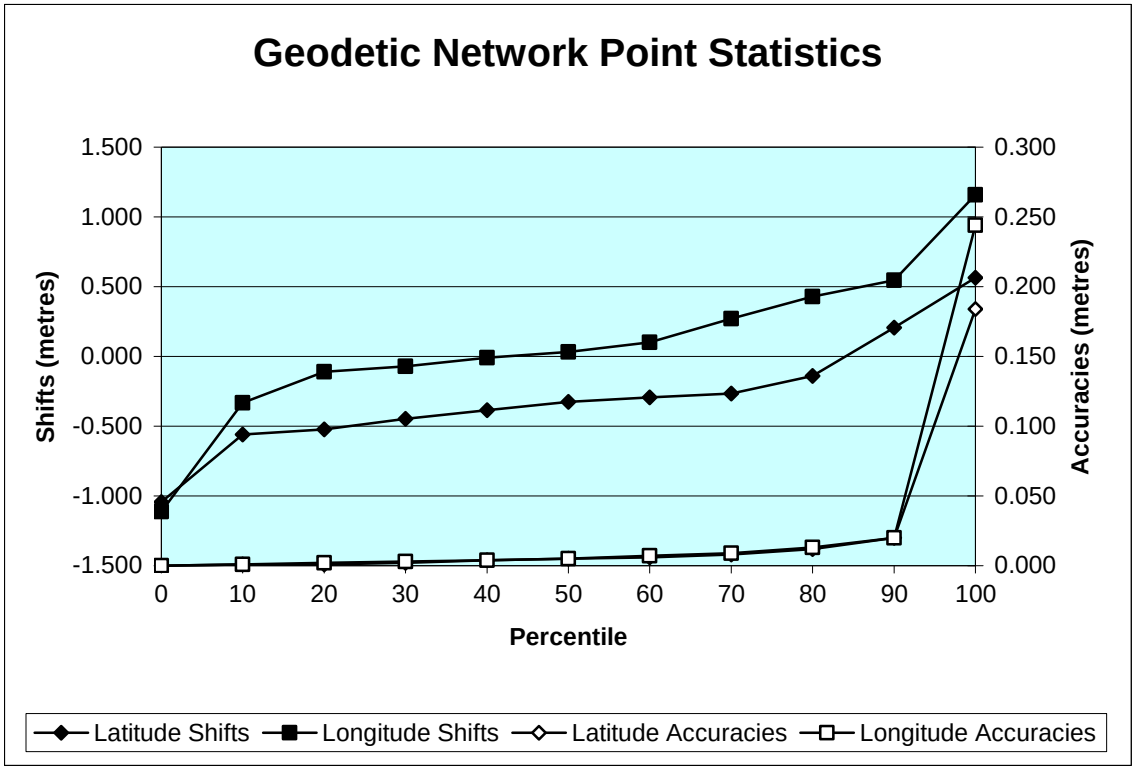
Percentile	Number of Grid Points	Latitude Shifts	Longitude Shifts	Latitude Accuracies	Longitude Accuracies
0	0	-0.972	-0.688	0.000	0.000
10	6532	-0.432	-0.045	0.004	0.005
20	13063	-0.364	0.058	0.004	0.005
30	19595	-0.336	0.114	0.004	0.005
40	26127	-0.306	0.145	0.005	0.006
50	32659	-0.287	0.182	0.005	0.006
60	39190	-0.268	0.225	0.006	0.007
70	45722	-0.236	0.302	0.007	0.009
80	52254	-0.152	0.406	0.010	0.011
90	58785	0.080	0.477	0.018	0.016
100	65317	0.556	1.121	0.145	0.226

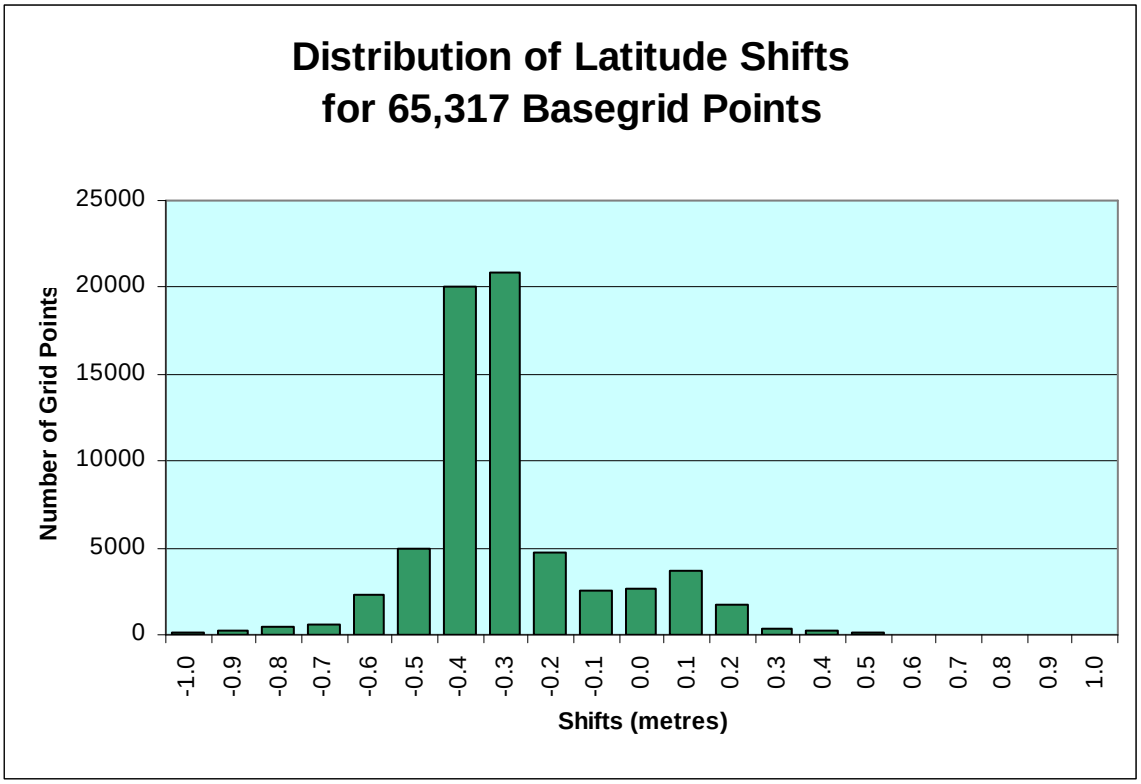


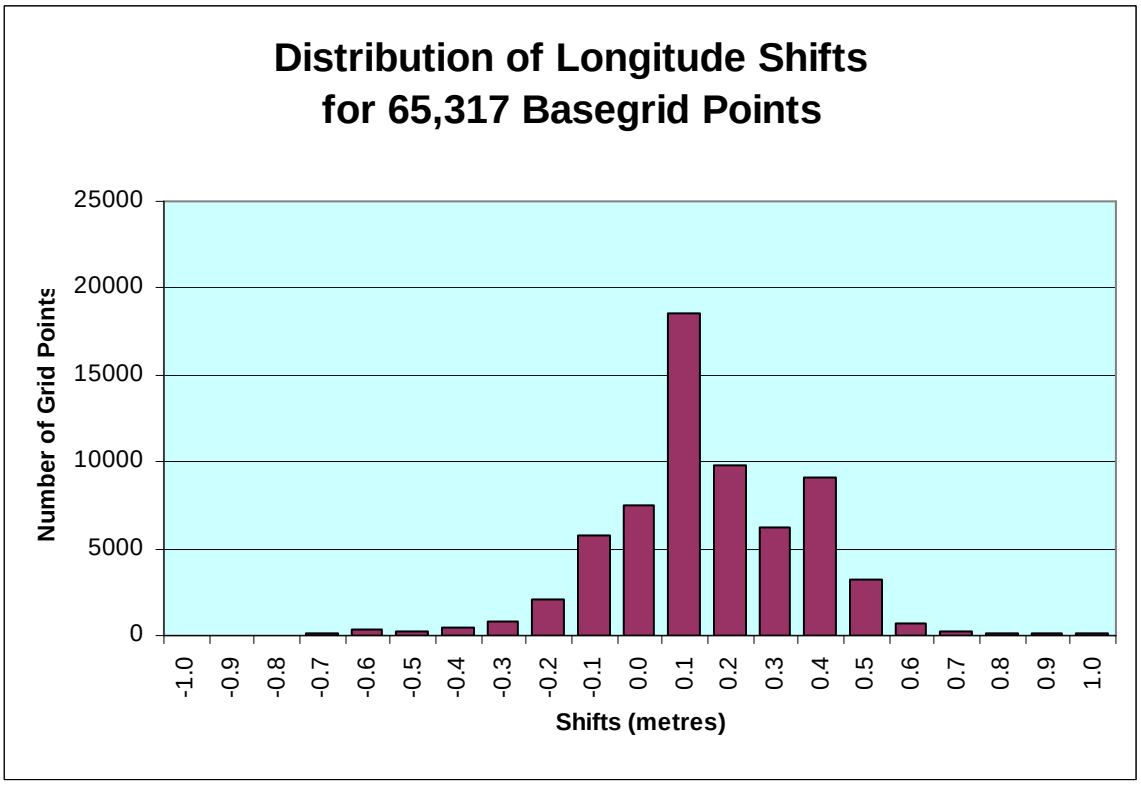
Percentile	Number of Grid Points	Latitude Shifts	Longitude Shifts	Latitude Accuracies	Longitude Accuracies
0	0	-0.998	-0.948	0.000	0.000
10	100345	-0.623	-0.100	0.005	0.006
20	200690	-0.523	0.001	0.007	0.008
30	301034	-0.475	0.069	0.010	0.010
40	401379	-0.421	0.182	0.012	0.012
50	501724	-0.369	0.297	0.015	0.014
60	602068	-0.297	0.413	0.017	0.017
70	702414	-0.213	0.454	0.020	0.021
80	802758	0.061	0.500	0.024	0.026
90	903103	0.191	0.607	0.033	0.037
100	1003448	0.563	1.139	0.215	0.309

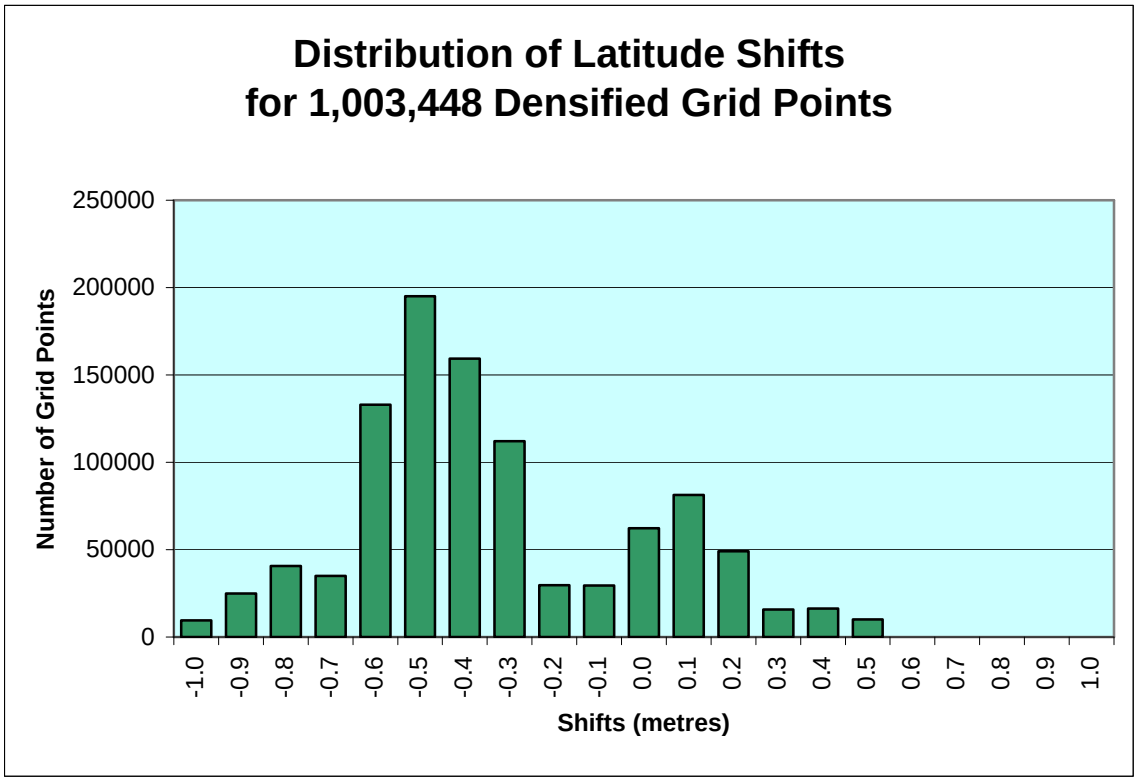


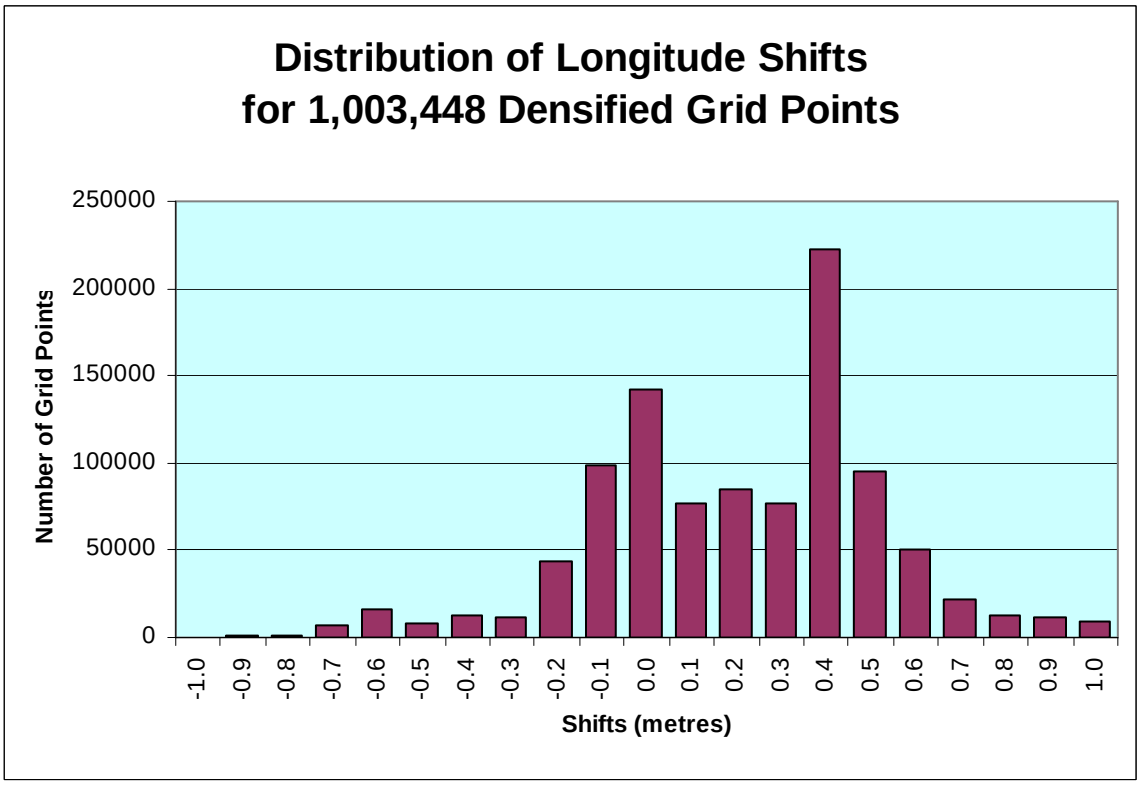
Percentile	Number of Network Points	Latitude Shifts	Longitude Shifts	Latitude Accuracies	Longitude Accuracies
0	0	-1.043	-1.112	0.000	0.000
10	478	-0.560	-0.333	0.001	0.001
20	955	-0.524	-0.110	0.001	0.002
30	1433	-0.448	-0.071	0.002	0.003
40	1911	-0.386	-0.009	0.004	0.004
50	2389	-0.325	0.033	0.005	0.005
60	2866	-0.293	0.102	0.006	0.007
70	3344	-0.265	0.270	0.008	0.009
80	3822	-0.139	0.429	0.012	0.013
90	4299	0.207	0.545	0.020	0.020
100	4777	0.564	1.159	0.184	0.244

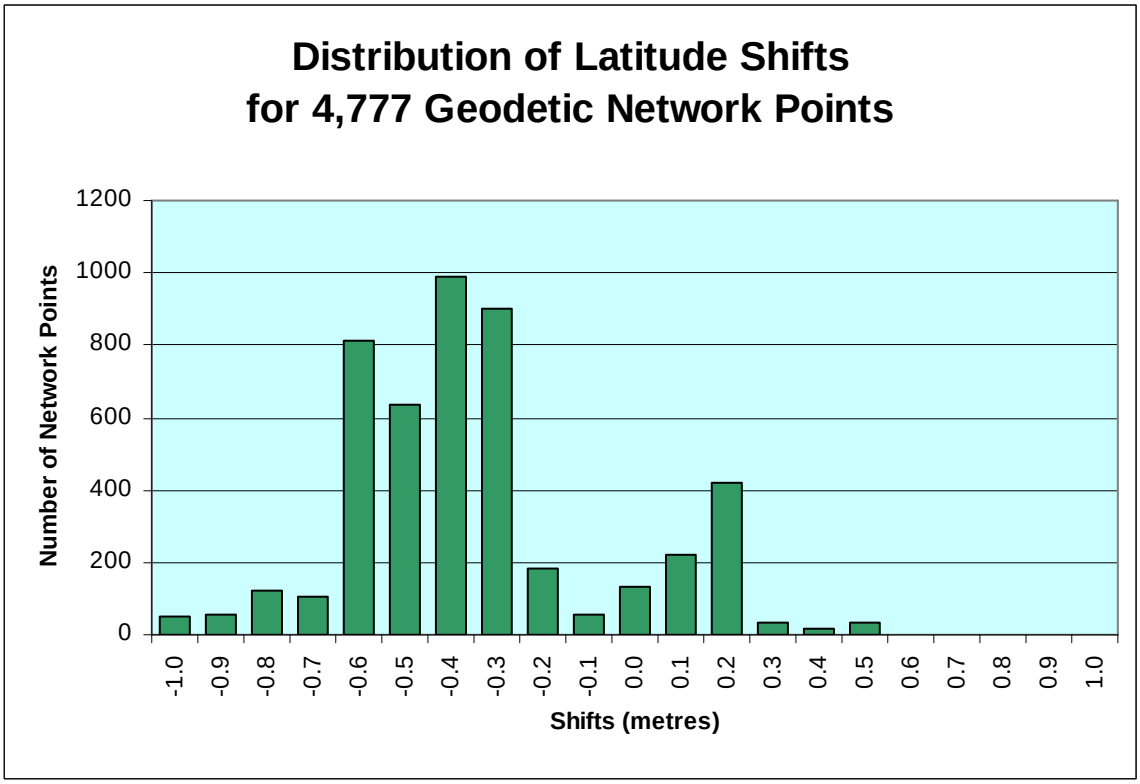


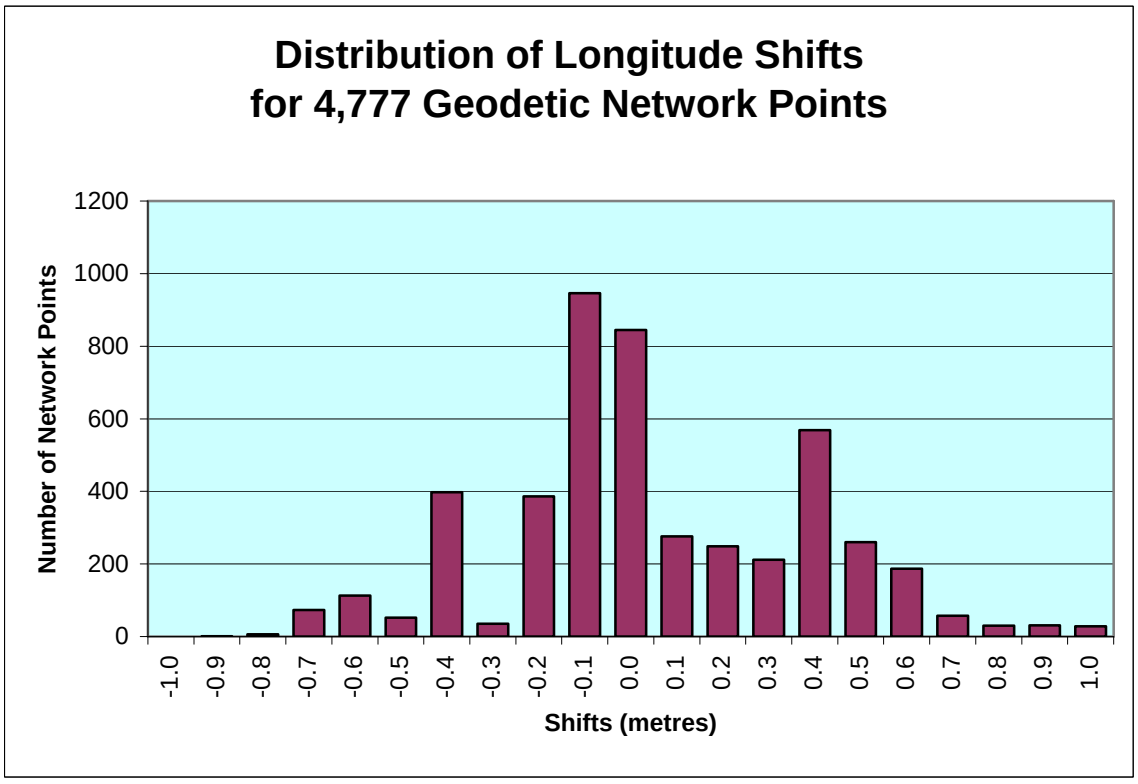

Distribution of Latitude Shifts
for 65,317 Basegrid Points
Number of Grid Points
25000
20000
15000
10000
5000
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)


Distribution of Longitude Shifts
for 65,317 Basegrid Points
Number of Grid Points
25000
20000
15000
10000
5000
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)


Distribution of Latitude Shifts
for 1,003,448 Densified Grid Points
Number of Grid Points
250000
200000
150000
100000
50000
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)


Distribution of Longitude Shifts
for 1,003,448 Densified Grid Points
Number of Grid Points
250000
200000
150000
100000
50000
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)


Distribution of Latitude Shifts
for 4,777 Geodetic Network Points
Number of Network Points
1200
1000
800
600
400
200
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)


Distribution of Longitude Shifts
for 4,777 Geodetic Network Points
Number of Network Points
1200
1000
800
600
400
200
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Shifts (metres)

For MapInfo & ProViewer Users

The ***diff*** layer that appears in all four of the contour plots provides a great deal of specific data regarding the ***ON83CSv1*** grid shift file. It is obtained by a comparison of the known shifts at the geodetic network points to the predicted shifts and their accuracies from the grid shift file.

The statistics produced are:

Difference	the difference between the known coordinates for NAD83-ORIG and NAD83-CSRS (actual shift)
Shift	the shift from the grid shift file (predicted shift)
Residual	the difference between the actual and predicted shifts
Accuracy	the accuracy of the shift from the grid shift file
Ratio	the residual divided by the accuracy (standardized residual)

Each of these five statistics is produced for the latitude, the longitude, and the total vector magnitude of these two components. This results in 15 columns of statistics. With the point ID, and the latitude and longitude values for both NAD83-ORIG (system 1 header) and NAD83-CSRS (system 2 header), there are 20 fields in each record.

The layers contained in the ***network_residuals*** and the ***network_accuracies*** workspaces are derived from the ***diff*** file. By sorting the file by the total residual field, and dividing it into separate files for each range, the layers in the ***network_residuals*** workspace are created. Similarly, the total accuracy field is used to create the layers of the ***network_accuracies*** workspace.

Having the ***diff*** layer available while browsing the contour plots is very useful for comparing the specific source of the data to the generalization imparted by the contoured regions. When using the info tool, the diff record for a network point will appear along with the ***CSRS*** record when the triangle symbol is clicked.

9: *Grid Details using NTv2 <View> Option*

The following data provides some of the details about the contents of the ***ON83CSv1*** grid shift file. It is copied from an on-screen session of the NTv2 program **INTGRID**, and the same output is also available from programs **INTTAB** and **READDA**.

This is only a sample, with details for the basegrid and two of the eight densified grids.

```
   NTV2 - Program INTGRID - Main Menu
  ----------------------------------
  Input  - Grid Shift File        [G] ON83CSv1.gsb
  Input  - Coordinate File        [C] Keyboard
  Output - Report Listing         [R]
  Output - Coordinate File        [N]
  Output - Coords Not Transformed [M]
  ----------------------------------
  Input  - Coordinate Type        [T] GEO
  Input  - from Keyboard          [K] YES
  Input  - Formatted/Delimited    [I] GHOST Records
  Output - Screen / File / Both   [S] Screen
  Output - Formatted/Delimited    [O] GHOST Records
  Direction of Transformation     [D] NAD83   -> CSRS
  ----------------------------------
  Go to Analysis Option Menu      [A]
  View Header Blocks              [V]
  Go to Information Screen        [H]
  Quit and exit from program      [Q]
  Proceed - Transform coordinates [X]
  ----------------------------------
  Select a menu item
V


   Overview Header Block

        1   NUM_OREC    11
        2   NUM_SREC    11
        3   NUM_FILE     9
        4   GS_TYPE    SECONDS
        5   VERSION    MTO 3a_0
        6   DATUM_F    NAD83
        7   DATUM_T    CSRS
        8   MAJOR_F     6378137.000
        9   MINOR_F     6356752.314
       10   MAJOR_T     6378137.000
       11   MINOR_T     6356752.314

  [CR] TO CONTINUE
  [Q]  TO EXIT

    1 ON 5_min     2 ONagawa      3 ONkinstn     4 ONnipign     5 ONottawa
    6 ONsarnia     7 ONsault      8 ONtronto     9 ONwinsor

   Quit      [0]
   Select Subfile Number
1
```

```
   Subfile   1  ON 5_min   Header Records

       12   SUB_NAME   ON 5_min
       13   PARENT     NONE
       14   CREATED    05-12-30
       15   UPDATED    06-03-22
       16   S_LAT       40  0   .000000
       17   N_LAT       58  0   .000000
       18   E_LONG      73  0   .000000
       19   W_LONG      98  0   .000000
       20   LAT_INC      0  5   .000000
       21   LONG_INC     0  5   .000000
       22   GS_COUNT          65317

  [CR] TO CONTINUE
  [Q]  TO EXIT

    1 ON 5_min     2 ONagawa      3 ONkinstn     4 ONnipign     5 ONottawa
    6 ONsarnia     7 ONsault      8 ONtronto     9 ONwinsor

   Quit      [0]
   Select Subfile Number
2


   Subfile   2  ONagawa    Header Records

    65340   SUB_NAME   ONagawa
    65341   PARENT     ON 5_min
    65342   CREATED    06-03-22
    65343   UPDATED    06-03-31
    65344   S_LAT       46 40   .000000
    65345   N_LAT       48  0   .000000
    65346   E_LONG      79  0   .000000
    65347   W_LONG      85 10   .000000
    65348   LAT_INC      0  0 30.000000
    65349   LONG_INC     0  0 30.000000
    65350   GS_COUNT         119301

  [CR] TO CONTINUE
  [Q]  TO EXIT

    1 ON 5_min     2 ONagawa      3 ONkinstn     4 ONnipign     5 ONottawa
    6 ONsarnia     7 ONsault      8 ONtronto     9 ONwinsor

   Quit      [0]
   Select Subfile Number
8


   Subfile   8  ONtronto   Header Records

   879062   SUB_NAME   ONtronto
   879063   PARENT     ON 5_min
   879064   CREATED    06-03-22
   879065   UPDATED    06-03-31
   879066   S_LAT       42 25   .000000
   879067   N_LAT       46 40   .000000
   879068   E_LONG      78 50   .000000
   879069   W_LONG      81 45   .000000
   879070   LAT_INC      0  0 30.000000
   879071   LONG_INC     0  0 30.000000
   879072   GS_COUNT         179361

  [CR] TO CONTINUE
  [Q]  TO EXIT
Q
```

10: *Tips for Viewing MapInfo Workspaces*

For MapInfo & ProViewer Users

This section presents a few hints for browsing effectively through the MapInfo workspaces for the ***ON83CSv1*** grid shift file. Most tips are applicable to MapInfo in general, while some are specific to these particular workspaces, and still others are for the ProViewer application.

The default tool ascribed to the pointer in the map window is the pointer arrow, or **<select>** tool. As expected, it can select any map item by clicking on it. Double clicking will bring up an info box some basic information about the item, which usually includes coordinates. Just holding the cursor over an item will cause a pop-up box to appear with a single bit of info about it, usually the first field of its table record.

Basic zooming and panning within the map window can be done with the tools on the MapInfo toolbar. The **<Zoom-in>** tool (magnifying glass with a plus sign) zooms in by a factor of two with the centre of the image at the click point. It can also be clicked and dragged to select an area to be expanded. The **<Zoom-out>** tool (magnifying glass with a minus sign) zooms out by a factor of two with the centre of the image at the click point. It can also be clicked and dragged to select the size of the area to which the window is to be reduced. The **<Grabber>** tool (open hand) moves the map image around (panning) by clicking and dragging.

Under the **<Map>** menu are three very useful tools, **<Change View>**, **<Previous View>**, and **<View Entire Layer>**. These items can also be accessed by right clicking anywhere in the map window.

The **<Change View>** tool allows the zoom to be set by specifying either the window width or the map scale, and the pan to be set by specifying the coordinates for the centre of the map window. This can be used to show or hide the base grid, which appears at a width of 1000 km or less, and the densified grids, which appear at a width of 100 km or less. It can also be used to get exactly the same view in two or more different windows for comparing the information displayed in each.

The **<View Entire Layer>** tool is useful for zooming and centring the map to a standard position after doing some exploring. All of the ***ON83CSv1*** workspaces are set to view the ***Basegrid*** layer so that the entire area covered by the transformation can be seen. A better view for most purposes would be to select the ***CSRS*** layer, which maximizes the geodetic network.

The **<Previous View>** tool allows the map to be redrawn to the view immediately preceding the current view. It is useful as a “back” or “oops” option to recover from an unintentional change in view, but only goes back by one step.

The **<Info>** button on the toolbar is useful for gaining specific detail about the data underlying the graphics. When it is selected, clicking on any item in the map window will cause an info box to pop up with a list of all the tables that correspond to the graphic item. Clicking on the name of any table in the list will bring up the record for that item with the names and values of each field in the record. The name of the table will appear to the right of the buttons at the bottom of the info box. The next or previous records can be viewed by clicking on the left or right arrow buttons, or the list button can be used to

For example, if the **<Info>** tool is used to select a geodetic network point in one of the contour plots, both the ***CSRS*** and ***diff*** tables will appear for the point, plus the underlying contour area for both the basegrid and densified grid areas.

The **<Label>** button on the toolbar allows a label to be placed on a selected map object. This is done by clicking on the object with the **<Label>** tool. The only layers that can be labelled are the geodetic network points in the ***CSRS*** table and the contour regions in all of the contour layers. When using ProViewer, the labels cannot be customized such as by selecting the field to be used or by moving them to eliminate overlaps. However, the contour region labels, which are the lower limit of the region, can be placed wherever the map is clicked.

In the ***CSRS*** table, there are two fields that serve to identify the geodetic network point. The ***Point_ID*** field is the main identifier for all NTv2 files and procedures. Because it is limited to 9 characters in length, it cannot accommodate the 12 character Ontario COSINE identifiers. Instead, it uses an abbreviation derived from them, which is also used in all other tables in the workspaces. The ***Station_Number*** field contains the COSINE identifiers, and these are used for labelling purposes. A cross-reference for the two identifiers can be obtained by looking into the ***CSRS*** table.

The most useful and informative graphics are the contour plots. It is sometimes effective to view these in pairs, such as latitude and longitude shifts, or latitude shift and accuracy. To view more than one map window at the same time, two techniques can be used. The first is to open only the two workspaces of interest, or to minimize all others. These two windows can then be tiled for side-by-side comparison, or maximized and switched between using the Window select menu item. For snappier switches between windows, multiple instances of MapInfo or ProViewer can be opened, one for each window of interest. With either technique, exactly the same view should be used in each window.

ProViewer can print the map window that is displayed on the screen, with its current view (zoom and pan) and any labels that have been selected. It cannot save this view as a workspace, nor can it save the window as a graphic file such as **jpeg**, as can MapInfo. To save a digital image of the window, a screen capture program such as HyperSnap (*www.hyperionics.com*) can be handy. Another option is a utility such as PDFCreator (*www.pdfforge.org/products/pdfcreator*) that captures the print file and converts it to ***pdf*** format for viewing with Acrobat Reader. *(Note: no endorsements implied)*

This table shows which layers are visible in each workspace The grid layers marked as ~ are zoom layered in all workspaces	dense_areas_labels	dense_areas_network	network_residuals	network_accuracies	latitude_shift	longitude_shift	latitude_accuracy	longitude_accuracy
CSRS		●			●	●	●	●
diff					●	●	●	●
Ont_outline	●	●	●	●	●	●	●	●
dens_grid_area_labels	●							
dens_grid_lat_labels	●	●						
dens_grid_lon_labels	●	●						
dens_grid_areas	●	●						
dens_grid_title	●	●						
Basegrid	~	~	~	~	~	~	~	~
ONnipign	~	~	~	~	~	~	~	~
ONagawa	~	~	~	~	~	~	~	~
ONsault	~	~	~	~	~	~	~	~
ONwinsor	~	~	~	~	~	~	~	~
ONsarnia	~	~	~	~	~	~	~	~
ONtronto	~	~	~	~	~	~	~	~
ONkinstn	~	~	~	~	~	~	~	~
ONottawa	~	~	~	~	~	~	~	~
res_title			●					
res_20_54_cm			●					
res_10_20_cm			●					
res_5_10_cm			●					
res_2_5_cm			●					
res_1_2_cm			●					
res_0_1_cm			●					
acc_title				●				
acc_20_25_cm				●				
acc_10_20_cm				●				
acc_5_10_cm				●				
acc_2_5_cm				●				
acc_1_2_cm				●				
acc_0_1_cm				●				
CSRS			●	●				

This table shows which layers are visible in each workspace The grid layers marked as ~ are zoom layered in all workspaces	dense_areas_labels	dense_areas_network	network_residuals	network_accuracies	latitude_shift	longitude_shift	latitude_accuracy	longitude_accuracy
shift_contour_legend					•	•		
lat_shift_title					•			
lon_shift_title						•		
accuracy_contour_legend							•	•
lat_acc_title							•	
lon_acc_title								•
legend_box			•	•	•	•	•	•
ONottawa_Lat_shift_contour					•			
ONottawa_Lon_shift_contour						•		
ONkinstn_Lat_shift_contour					•			
ONkinstn_Lon_shift_contour						•		
ONtronto_Lat_shift_contour					•			
ONtronto_Lon_shift_contour						•		
ONsarnia_Lat_shift_contour					•			
ONsarnia_Lon_shift_contour						•		
ONwinsor_Lat_shift_contour					•			
ONwinsor_Lon_shift_contour						•		
ONsault_Lat_shift_contour					•			
ONsault_Lon_shift_contour						•		
ONagawa_Lat_shift_contour					•			
ONagawa_Lon_shift_contour						•		
ONnipign_Lat_shift_contour					•			
ONnipign_Lon_shift_contour						•		
Basegrid_Lat_shift_contour					•			
Basegrid_Lon_shift_contour						•		

This table shows which layers are visible in each workspace The grid layers marked as ~ are zoom layered in all workspaces	dense_areas_labels	dense_areas_network	network_residuals	network_accuracies	latitude_shift	longitude_shift	latitude_accuracy	longitude_accuracy
ONottawa_lat_acc_contour							•	
ONottawa_lon_acc_contour								•
ONkinstn_lat_acc_contour							•	
ONkinstn_lon_acc_contour								•
ONtronto_lat_acc_contour							•	
ONtronto_lon_acc_contour								•
ONsarnia_lat_acc_contour							•	
ONsarnia_lon_acc_contour								•
ONwinsor_lat_acc_contour							•	
ONwinsor_lon_acc_contour								•
ONsault_lat_acc_contour							•	
ONsault_lon_acc_contour								•
ONagawa_lat_acc_contour							•	
ONagawa_lon_acc_contour								•
ONnipign_lat_acc_contour							•	
ONnipign_lon_acc_contour								•
Basegrid_lat_acc_contour							•	
Basegrid_lon_acc_contour								•