Comparing Geoid Height (Undulation differences)

By Derek Loo
Waypoint Consulting Inc
August 2002

Introduction

The purpose of this report is to compare three different Geoid height model (undulation) released by Geodetic Survey Division of Natural Resources Canada. The three geoid height models are GSD95, HTv1_01, and HTv2.0. Where GSD95 is the oldest and HTv2.0 is the newest. Each newer geoid model is supposed to be an improvement compared to its predecessors.

The Geodetic Survey Division (GSD) of Canada adopted the oldest model GSD95 in August of 1995. There are three key factors that make this model more precise than its predecessor. One is that it was computed using multi-band spherical fast Fourier transform (FFT). This method helped to improve the precision in the northern latitudes. The second key factor that enhanced the model is the addition of new gravity measurements in British Columbia and the Yukon Territory. Difference of 10 meters can be found compared to GSD95, especially in these two regions. The third key factor is the use of Digital Terrain Elevation Data (DTED) Level 1 in the southern part of Canada. Overall GSD95 increased accuracy in northern, southern, western, and the ocean as well. The accuracy of the model is quoted to be approximately 1 meter (1 sigma).

The next model that followed GSD95 was HTv1_01. It was developed based upon 1483 GPS survey stations positioned across Canada. HTv1_01 fixed some of the errors that were realized from CVGD28 and GSD95. HTv1_01 accuracy is estimated to be ± 5 cm (with 95% confidence), except for the northern region, which can be a few decimeters larger.

The latest model is HTv2.0. It combines the CGG2000 (Canadian Gravimetric Geoid 2000) geoid model and the errors in the realization of CGVD28. The model was developed based upon 1926 GPS survey stations. Just like HTv1_01, HTv2.0 has an accuracy of ± 5 cm (with 95% confidence) in the southern region, with decimeter accuracy in the northern region.

Methodology

In order to compare all three models, they had to be in the same format. Waypoint's own Waypoint-Geoid (.WPG) format were used as the common format, especially important since the geoid format changed from HTv1_01 to HTv2.0. A small program was made using MS Visual C++ to perform the comparison. The program steps through two WPG files simultaneous and differences the computed undulation values. A boundary was used so that only the area of interest was analyzed. The boundary was set at:

- North: 72.0°
- South: 41.0°
- East: -48.0°
- West: -140°

The program starts off at the northwest corner and navigates to the southeast at an interval of 0.1° (Δlatitude = 0.1°, Δlongitude = 0.1°). The differences are outputted into a text file. In order to visualize the differences a bitmap was created based on these values. Figure 1, 2, and 3 shows the bitmap.

Description

The difference in the three models ranges from –2.54m to 2.30m. The comparison between HTv2.0 and GSD95, ranges from –2.54m to 1.77m with a RMS of 0.65m. The next comparison, HTv2.0 and HTv1_01, ranges from –1.83m to 2.30m with a RMS of 0.29m. For GSD95 and HTv1_01 the difference ranges from –1.47m to 1.12m with a RMS of 0.59m. Looking at the Figures, the blue indicates the extreme difference in the negative and the red indicates the extreme difference in the positive and the black indicates no data were available. The green means that the difference is very small. Figure 1 and 2 seems to have share similar patterns. However Figure 1 shows more instances of non-green (extreme values) than Figure 2. Generally, the southern regions (especially in the west) show the best agreement, indicating very little adjustment between geoids.

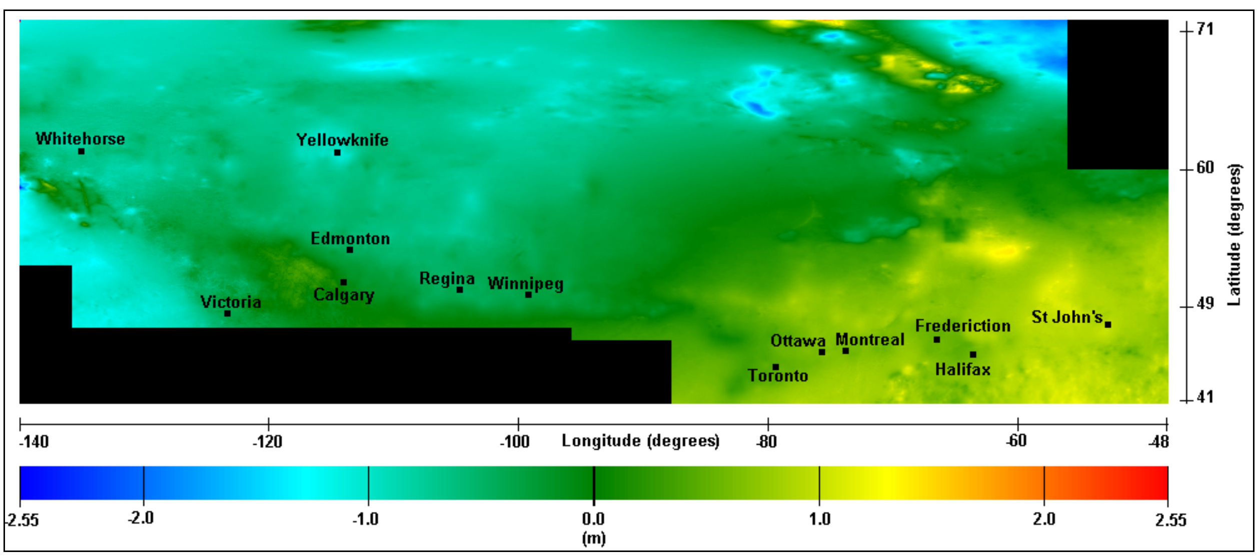

Figure 1. Difference between HTv2.0.wpg and Gsd95.wpg

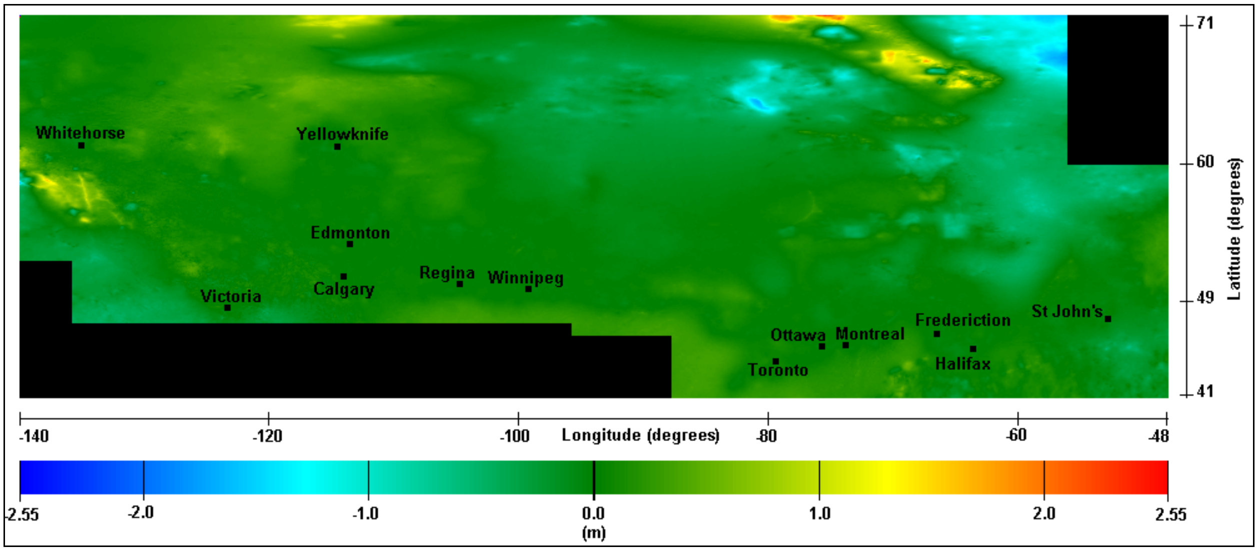

Figure 2. Difference between HTv2.0.wpg and HTv1_01.wpg

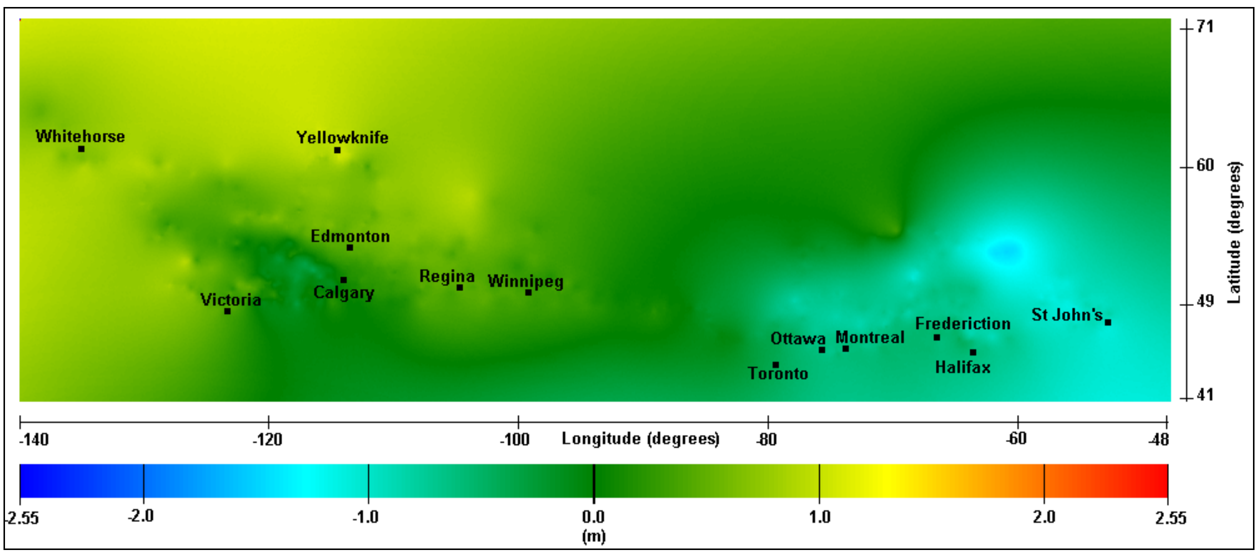

Figure 3. Difference between Gsd95.wpg and HTv1_01.wpg

Conclusion

As mention before each successor model is supposed to be better then its predecessors. The report mainly shows how all three models compares and where are some of the improvements. To following table will give more insight of the differences:

	GSD95	**CGG2000 (HTv2.0)**
Boundary	North: 72° South: 41° East: 142° West: 56°	North: 84° South: 20° East: 170° West: 10°
Equipotential surface	U_0 (GRS80)	W_0 (Bursa et al., 1997)
Number of gravity observations	1.5 millions	2.8 millions
Altimetry	Sandwell and Smith (1994)	Sandwell and Smith (v9.2), CLS/SHOM (1998), KMS (1999), and GSFC (2000)
DEM	ETOPO5	Provincials DEM for BC, Alberta and NB, and CDED 1:250 000
Stokes kernel	Standard	Modified Spheroidal
Computation	Multi-Band 2D-FFT	1D-FFT

Reference

CGEOID2000 Package. (n.d.). Retrieved July 29, 2002, from the World Wide Web: http://www2.geod.nrcan.gc.ca/~marc/Html/Y2000/Html/index_e.html

Fact Sheet: HTv1_01. (n.d.). GPS-HT: GPS Height Transformation Package. Retrieved July 29, 2002, from the World Wide Web: http://www2.geod.nrcan.gc.ca/~marc/Html/Y1995/GPSH_Fact_E.html

GSD95. (n.d.). The Canadian Geoid Package 1995. Retrieved July 29, 2002, from the World Wide Web: http://www2.geod.nrcan.gc.ca/~marc/Html/Y1995/GSD95.html