



Canadian Geodetic Reference System Committee

Reference Frame Modernization in Canada

C. Robin¹; G. Banham²; R. Berg³; M. Craymer^{1*}; G. Cross⁴; B. Donahue¹; J. Harrietha¹; J. Huang¹; R. Messier Paquin⁵; R. Tardif¹; Y. Thériault⁵

¹Natural Resources Canada; ²Ministry of Environment and Parks, Alberta; ³Ministry of Transportation, Ontario; ⁴Service New Brunswick; ⁵Ministère de l'Énergie et des Ressources naturelles, Québec

ABSTRACT

The United States National Geodetic Survey (NGS) is planning to adopt a new geometric reference frame for the U.S. in 2025 (NATRF2022), which will be based on ITRF2020 and separated from NAD83, the currently adopted frame in both Canada and the U.S., by up to 1.5 metres at the Canada-U.S. border (Figure 1). The Canadian Geodetic Survey (CGS) will also adopt NATRF2022 as a new national standard in 2025, and is collaborating with NGS to define and realise NATRF2022 to ensure reference frame compatibility across both countries. In parallel, CGS is leading an effort to adopt NATRF2022 as a unified reference frame across provincial and other jurisdictions, which have the authority to adopt reference systems used within their own jurisdictions. In this paper, we describe Canadian considerations for the definition and realisation of NATRF2022, and outline efforts and challenges in migrating to NATRF2022 as a unified reference system throughout all jurisdictions in Canada, and maintaining such unification in the future. We will also discuss a

new geoid-based height system (NAPGD2022) to be adopted by the U.S. together with NATRF2022, and its implications for Canada, where a geoid-based height system (CGVD2013) has been in place since 2013.

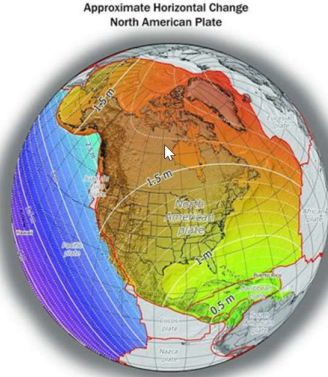


Figure 1: The approximate change in horizontal position between NAD83 and NATRF2022 will be up to 1.5 metres over Canada (NGS-1).

MODERNIZATION

NATRF2022: an improved geometric reference system

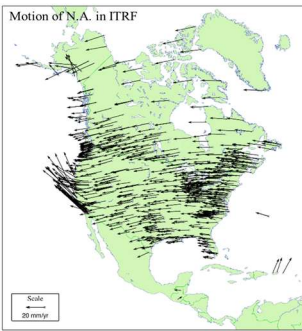


Figure 2: The motion of GNSS stations in north American showing the rotation of the plate around an Euler pole off the west coast of Southern America.

- The currently adopted geometric reference frame in Canada is NAD83(CSRs) v.7*.
- NAD83 is a plate-fixed reference system. However it is offset from the center of mass of the earth by 2.2 metres, and its plate motion has a residual of approximately 2 mm/year in Canada.
- NATRF2022 will be tied and equivalent to ITRF2020 at epoch 2020.0, and therefore will be a truly geocentric reference system, more compatible with GNSS, modern applications such as automated transport, and mass market positioning.
- NATRF2022 will separate from ITRF through a rotation around an Euler pole to follow the motion of the North American Plate (Figure 2), defined with an improved set of rotation parameters (NGS-2).
- There will be differences of up to 1.5 metres between NAD83 and NATRF2020 (Figure 1).

- NATRF2022 will be a fully dynamic datum, like NAD83(CSRs).
- A deformation model based on GNSS ground station observations will allow epoch changes by taking into account intra-plate crustal motion.
- CGS and NGS are collaborating to ensure that compatible velocities are used for common stations used in each countries' deformation model.

* North American Datum of 1983 (Canadian Spatial Reference System), version 7

CGVD2013 / NAPGD2022: For Canada, only an update

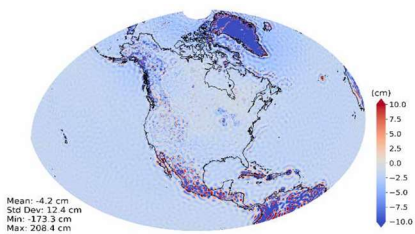


Figure 4: Geoid height differences between NGS and CGS models (CGSA – Bouga), performed as part of Experimental GEOID 2020 (Wang et al.)

- The current federally adopted height system for Canada is CGVD2013*, which is realized by a geoid model.
- With NAPGD2022, the US will move to a geoid-based datum for the first time.
- NAPGD2022 will define mean sea level using the same geopotential as CGVD2013 ($W_0 = 62,636,856.0 \text{ m}^2\text{s}^{-2}$)
- Canada will retain CGVD2013 but adopt a new realization in 2025, using an improved geoid model compatible with the one which will realize NAPGD2022.
- CGS and NGS are collaborating to develop a common geoid model (Figure 4).

* Canadian Geodetic Vertical Datum of 2013

UNIFIED REFERENCE FRAMES

- In Canada, reference frame adoption is under the jurisdiction of individual provinces.
- Currently, many versions of NAD83(CSRs) are adopted provincially (Figure 5), and were adopted a different times (Figure 6).
- Even more versions are in use and made available by provincial agencies (Figure 7).
- Differences between these frames are on the order of 10-20 cm; a scattered approach to the adoption of NATRF2022 will give rise to 1.5 meter differences at jurisdictional boundaries.

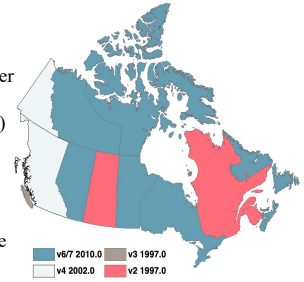


Figure 5: Versions and epochs of NAD83(CSRs) currently adopted in the provinces (updated from Erickson et al.).

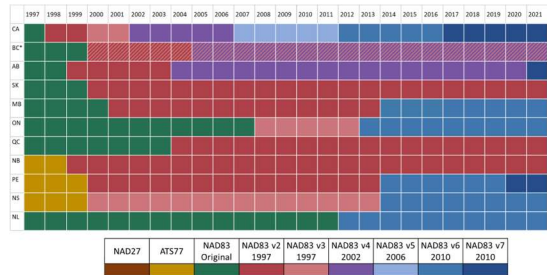


Figure 6: History of NAD83(CSRs) version adoptions by Canadian provinces since its release.

- Provinces, through the Canadian Geodetic Reference System Committee (CGRSC), have developed a roadmap towards a nationally coordinated adoption of NATRF2022.
- Strategies for migrating official/published coordinates and data layers to this new datum are being developed by most provinces.
- Similarly, some provinces have not yet adopted CGVD2013, and are defining strategies to adopt the new version being realized in 2025.
- CGS and NGS are holding summits for geospatial software developers to ensure their products will support migration to and operation in both NATRF2022 and CGVD2013/NAPGD2022.

Province	Adopted	Published online	Available upon request	Used**
BC	v4 2002.0	v4 2002.0	v4 2002.0	v4 2002.0
AB	v7 2010.0	v7 2010.0	v4 2002.0	original
SK	v4 2002.0	v4 2002.0	v4 2002.0	original
MB	v4 2002.0	v4 2002.0	v4 2002.0	original
ON	v4 2002.0	v4 2002.0	v4 2002.0	original
QC	v4 2002.0	v4 2002.0	v4 2002.0	original
NS	v4 2002.0	v4 2002.0	v4 2002.0	original
PE	v4 2002.0	v4 2002.0	v4 2002.0	original
NL	v4 2002.0	v4 2002.0	v4 2002.0	original

Figure 7: Versions and epochs of NAD83(CSRs) currently in use in the provinces.

Summary

- Canada will adopt NATRF2022 at the federal level in 2025 in parallel with the US.
- NATRF2022 will be a fully dynamic datum, as NAD83(CSRs) has been since 2006 (Figure 8).
- The Canadian Geodetic Survey will issue a new realization of CGVD2013 in 2025, using an improved geoid model compatible with the one which will realize NAPGD2022.
- Provinces are building strategies to adopt NATRF2022 and a new version of CGVD2013 with the aim of unifying mandated reference frame usage across the country.
- CGS and NGS are collaborating to define the new datums, and ensure that users have the tools needed to migrate to new or updated reference systems.

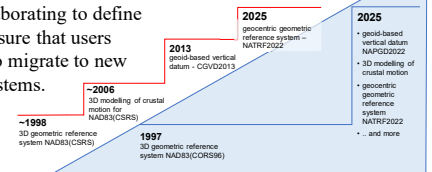


Figure 8: Canada has been modernizing in steps, whereas the US is modernizing all at once. (Diagram for illustration and is not comprehensive)

References

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