# A Survey of Surveys: the Canadian Spatial Reference System Precise Point Positioning Service

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## Introduction

Natural Resources Canada (NRCan) provides a service known as Canadian Spatial Reference System Precise Point Positioning (CSRS-PPP) that delivers improved positioning using Global Navigation Satellite Systems (GNSS). NRCan has processed more than 2.05 million GNSS datasets from around the globe with CSRS-PPP since it was inaugurated in late 2003, maintaining usage records that serve as the source for the analysis in this study. This report assesses the nature and scale of usage, including regional differences and trends over time.

The surveys processed are for professional (surveying, mapping, engineering) and scientific activities (glaciology, plate tectonics, education) from locations across the planet.

This study illustrates one Canadian contribution to the international community in light of the recent United Nations General Assembly resolution related to geodesy [*United Nations General Assembly* 2015] that calls for improved international access to the Global Geodetic Reference Frame. Maps of CSRS-PPP usage graphically illustrate national and international economic activity in a novel fashion. Some usage maps are inspiring illustrations of the extent of geoscience activities on this planet.

If you were wondering how many users have benefited from CSRS-PPP and how they were using the service, read on.

## 1. Preliminaries: What is CSRS-PPP?

CSRS-PPP is an online application for GNSS data that allows users to achieve significant improvements in position accuracy (metres to centimetres) [*NRCan* 2017a]. The application is a post-processing tool that uses precise GNSS information (satellite ephemerides: orbit and clock information) to process client data. CSRS-PPP does not use local references for differential positioning as other systems do.

The precise GNSS data used by the service is made available by the International GNSS Service (IGS) [*Dow et al.* 2009] and its contributing agencies. This precise satellite information relies on open access to GNSS tracking data from stations spanning the globe. NRCan, as a contributing organization in IGS, provides data from GNSS receivers operated in Canada to this collective effort, and benefits very significantly from data collected by organizations around the world. Without this global partnership and sharing of data, CSRS-PPP could not function.

NRCan also processes GNSS data from the global IGS network to determine information regarding the clocks on each GNSS satellite, as well as information on the satellites' locations (i.e. orbits). Armed with this information in near real-time, user data from anywhere on earth can be processed to obtain accurate position information.

Users have the option of accessing the service via a link to a Government of Canada website or through a desktop application, preferred by frequent users. With both options, the process for submitting data is brief and straightforward. Users upload the raw GNSS data they have collected, and select the mode (static or kinematic), the desired reference frame and epoch.

CSRS-PPP will use the best available satellite ephemeris information available for the time period at which the user data was collected. The service provides three levels of accuracy for these ephemerides: Ultra Rapid, Rapid and Final, with wait times of 90 minutes, 24 hours, and two weeks, respectively. The Rapid and Final solutions benefit from more data and better quality, but for most applications the Ultra Rapid solutions are of acceptable quality (the choice of ephemerides is a minor consideration for nearly all users) [*Donahue* 2017].

Users may choose to obtain positions in the International Terrestrial Reference Frame (ITRF) [*Altamimi et al.* 2011] or in the NAD83 Canadian Spatial Reference System (NAD83(CSRS)) [*Craymer* 2006a,b]. NAD83(CSRS) users can choose an epoch other than that of observation to align the data with other data or with the adopted epoch in the province of their work. Epoch transformations use a velocity grid [*Robin et al.* 2016] that accounts for crustal motion in Canada. Users may also obtain orthometric heights by selecting a geoid model, such as the