Epoch rectification of GPS on benchmarks in Canada

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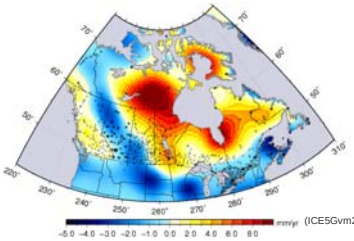
OVERVIEW

A national network of GPS on benchmarks is a valuable source for vertical datum studies and height transformations. In Canada, a subset of 1180 benchmarks of the first-order levelling network has been observed with high accuracy GPS, some co-located with Canadian Base Network (CBN) pillars and permanent GPS stations. Unfortunately, due to its shear size in both spatial coverage and number of points, it is impractical to survey the entire GPS on benchmark network over a short period of time. As a result, the network consists of many individual campaigns in patches across the country often done in conjunction with other surveys, such as the various campaigns of the first measurement of the Canadian Base Network. Consequently, the benchmarks have been occupied with GPS at different times over a period of about 15 years. Numerous temporal effects such as ongoing geophysical phenomena and in particular glacial-isostatic adjustment, anthropogenic or naturally induced land subsidence and land deformation introduce distortions in the adjusted heights. The goal of this new work is to compute a new GPS on benchmarks adjustment by taking these temporal effects into account in order to reference the heights to a common epoch. As a fist step, only post-glacial rebound is accounted for using a subset of 954 GPS stations. This will provide a temporally homogeneous reference network for future vertical datum investigations.

CANADIAN GPS NETWORK



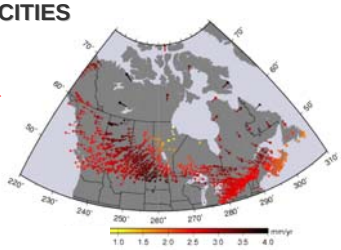
- 954 GPS sites (22 continuous GPS stns, 156 CBN, 776 other benchmarks)
- multi-epoch (episodic) GPS measurements from 1995 – 1999

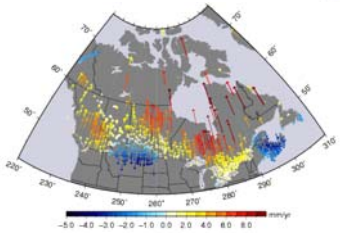
○ CBN SITE

Adjustment:
- incorporate vertical velocities for 5 stations (propagated heights from ITRF2000 vertical velocities)
- full data CV matrix
- common set of rotation & scale parameters assigned to all baseline sessions to align between projects and reference frame constraints

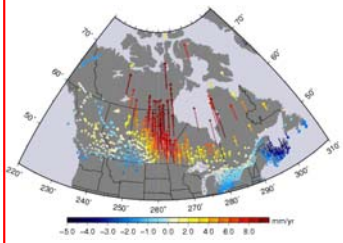
ESTIMATED SITE VELOCITIES

ICE5Gvm2 Horizontal Velocities



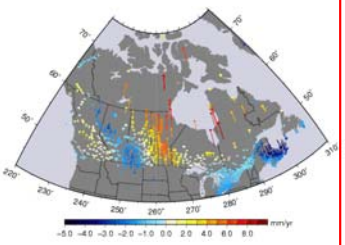


ICE3G_Spada Vertical Velocities



ICE5Gvm2 Vertical Velocities

ICE5Gvm4 Vertical Velocities



	V_{up} (mm/yr)			V_N (mm/yr)		V_E (mm/yr)	
	ICE5Gvm2	ICE5Gvm4	ICE3Gspa	ICE5Gvm2	ICE5Gvm4	ICE5Gvm2	ICE5Gvm4
min	-4.35	-4.26	-3.79	-3.34	-2.60	-3.87	-3.01
max	14.36	9.67	11.38	3.29	2.40	3.73	3.49
μ	1.45	2.45	3.17	-1.55	-1.30	-0.40	1.67
σ	3.75	0.18	1.87	1.20	0.88	1.98	-0.25

EPOCH ADJUSTED SITE NETWORK VALUES

Observation epoch ⟹ Reference epoch

$$\mathbf{dr}_{ij}^{t_{obs}} = \begin{bmatrix} \mathbf{dx}_{ij} \\ \mathbf{dy}_{ij} \\ \mathbf{dz}_{ij} \end{bmatrix}^{t_{obs}} = \begin{bmatrix} \mathbf{x}_j - \mathbf{x}_i \\ \mathbf{y}_j - \mathbf{y}_i \\ \mathbf{z}_j - \mathbf{z}_i \end{bmatrix}^{t_{obs}} \qquad \mathbf{dr}_{ij}^{t_{ref}} = \begin{bmatrix} \mathbf{dx}_{ij} \\ \mathbf{dy}_{ij} \\ \mathbf{dz}_{ij} \end{bmatrix}^{t_{ref}} = \begin{bmatrix} \mathbf{x}_j - \mathbf{x}_i \\ \mathbf{y}_j - \mathbf{y}_i \\ \mathbf{z}_j - \mathbf{z}_i \end{bmatrix}^{t_{ref}}$$

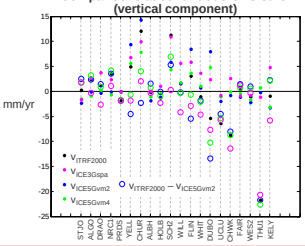
$$\mathbf{dr}_{ij}^{t_{ref}} = \mathbf{dr}_{ij}^{t_{obs}} + \mathbf{v}_{ij}^{k}(t_{ref} - t_{obs})$$

ij: baseline points
k: velocity model
t_{ref}: reference epoch (in this case,1997.0)
t_{obs}: observation epoch (varies from 1995 – 1999)

Velocity model	$\hat{\sigma}_o^{2\star}$	$\chi^2 - test$
No model	1.052	passed
ICE5Gvm2	1.038	failed
ICE5Gvm4	1.006	failed
ICE3Gspada	1.013	passed

Note: degrees of freedom = 5300

Comparisons at continuous GPS stns (vertical component)



DISCUSSION AND FUTURE WORK

- GPS data for constraining/improving PGR models **OR** PGR models for rectifying GPS site coordinates?
- Homogenization of GPS network comprised of episodic campaigns required for improved **outlier detection**
  - ICE5Gvm2 and vm4 models give the most reasonable outliers
  - ICE5Gvm4 model gives the fewest outliers and is consistent with those expected

➢ Future work: SNARF GIA model, Canada-wide Supernet GIA epoch rectification