Crustal Deformation Velocities From Episodic Regional Measurements at Canadian Base Network Sites

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Canadian Base Network (CBN) pillar at La Grande-1 (James Bay Region, Quebec).

Initiated in 1994, the Canadian Base Network (CBN) is a network of pillar monuments with forced-centering mounts for Global Positioning System (GPS) receiver antennae. Accurately positioned three-dimensionally with GPS, the CBN can serve as a monitoring network for deformation studies of the Canadian landmass. By combining nearly ten years of repeated multi-epoch (episodic) GPS measurements, we estimate velocities at the CBN sites to provide an increased spatial sampling of crustal deformation throughout Canada.

To determine individual station velocities, we systematically combine regional CBN solutions for each measurement epoch into a single Canada-wide, multi-epoch cumulative solution. In order to generate time series of consistent, high-accuracy coordinates for velocity estimation, it is necessary to ensure consistency in the realization of the reference frame. We accomplish this by aligning each of the individual CBN solutions to the IGS realization of ITRF using a subset of stations from a recent IGS cumulative solution for the IGS global network. Fortunately, there are many IGS stations in Canada and most were included in each regional CBN solution to strengthen the realization of the reference frame and ensure consistency between epochs. We also ensure consistent and realistic weighting of the individual CBN solutions though the estimation of variance components relative to the IGS global solution. After the individual CBN solutions are aligned and weighted, they are combined together in a simultaneous cumulative solution for velocities at each site.

CBN GPS PROCESSING

- Bernese GPS Software Version 4.x
- Double-differenced observations
- ≥2-5 days site occupations
- 30 second data sampling
- ≤10° elevation cut off
- Fixed precise orbits & ERPs (EMR/NRCan & IGS)
- Tropospheric zenith delays (every 2 hours)
- Niell mapping function (dry)
- No tropospheric gradients
- QIF ambiguity resolution
- No ocean loading model
- 1 IGS reference frame station constrained (fixed) (*e.g.* ALGO, DRAO, YELL)

CBN COMBINATIONS

Combining 28 individual CBN solutions (campaigns) from 1994 to 2003

Using two independent SINEX combination software:

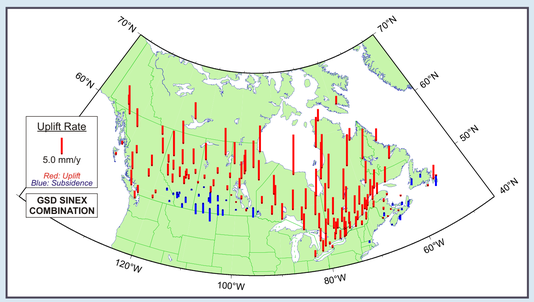
- GSD SINEX Software (*v1.0*) by R. Ferland (used for official IGS global combinations)
- CATREF (*2004ver*) by Zuheir Altamimi (used for official ITRF global combinations)

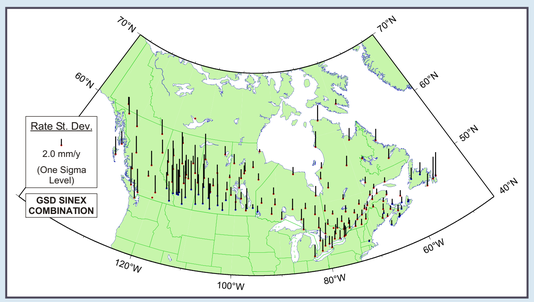
Each CBN solution aligned to recent IGS cumulative solution (*IGS04P44.snx*) at epoch of solution:

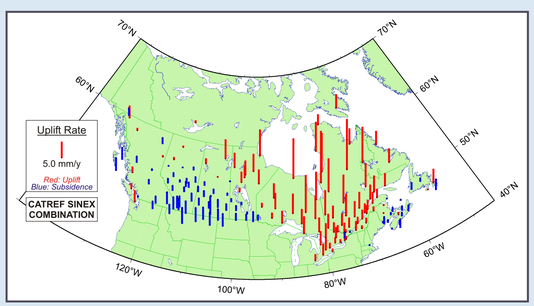
- "larger" networks (20 solutions): 3 translations, 3 rotations & scale change
- "smaller" networks (8 solutions): 3 translations

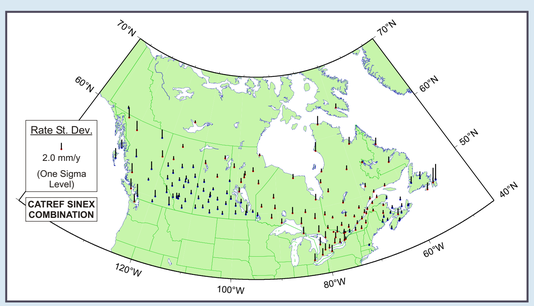
Covariance matrix of each CBN solution scaled by WRMS of residuals from alignment

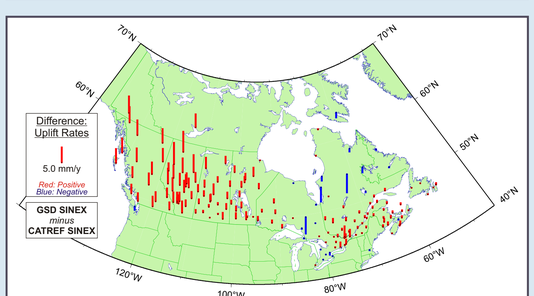
All (scaled) CBN solutions combined together with the IGS cumulative solution (summation of normals) and velocities estimated











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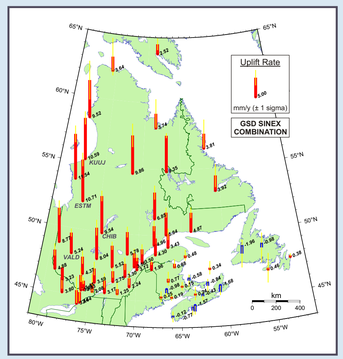
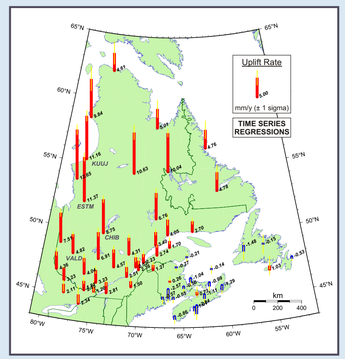
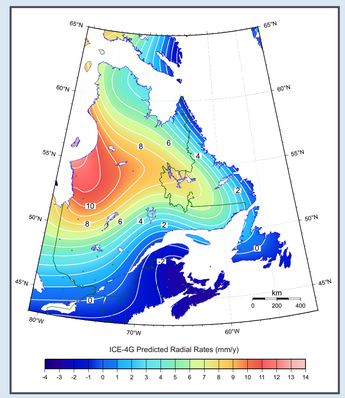
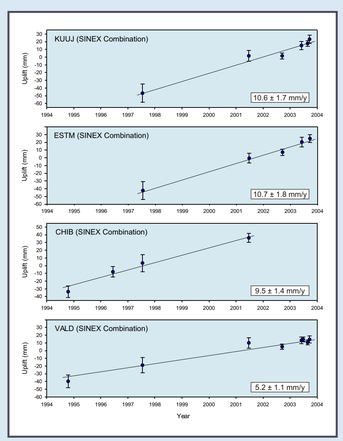
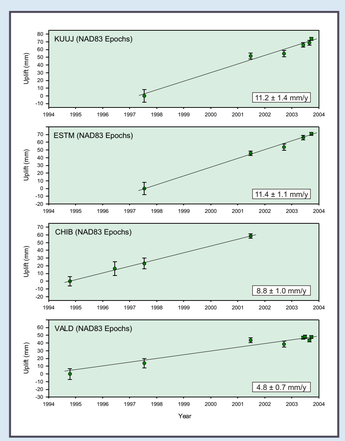






Regional map of model-predicted uplift rates. The present-day predicted uplift rates shown are from the glacial isostatic adjustment model ICE-4G (VM1) [*Peltier*, 1994].





The Nouveau Quebec-Labrador region was the site of one of the major ice domes of the Laurentide Ice Sheet and is currently experiencing postglacial rebound. High-precision geodetic observations are providing a useful and accurate method of measuring the pattern and rates of contemporary uplift in this area.

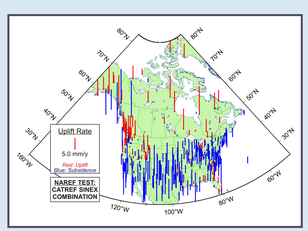
Preliminary results from the analysis of CBN time series in eastern Canada exhibit a spatially coherent pattern of uplift consistent with the expected post-glacial rebound (PGR) signal. For this region the highest observed uplift rates are in the vicinity of James Bay through to southwestern Labrador; the rates then decrease to the south and towards the coastal Atlantic margins.

Maps of observed regional CBN vertical velocities. Uplift rates (with 1-sigma error bars) determined from the GSD SINEX analysis software are compared to rates determined by a "site-by-site" time series approach. For the site-by-site approach, the trends are determined from weighted linear regression. Additionally, as ALGO (Algonquin Park) is held fixed during processing for the solutions, the time series of the CBN radial rates are adjusted by the vertical rate at ALGO.

Velocity trends and solution residuals for select CBN sites. Residuals (with 1-sigma error bars) determined from the GSD SINEX analysis software are compared to time-series of the"site-by-site" approach. The station IDs are labelled on the maps above.

Continuing & Future Work

- Continue to use different software (and techniques). The resulting solutions will continue to be useful for validating results.
- Add more CBN solution epochs (from smaller networks and/or from shorter (*i.e.* <1-2 day) site occupations).
- Develop more automated procedures for reliably identifying outlier stations and epochs.
- To yield more reliable solutions, use regional continuous GPS data (*i.e.* NAREF - *see below*) to include other available ("non-IGS") stations during the SINEX combination procedure.



In order to densify the velocity field in the Arctic and Great Lakes regions, future investigations will include additional, recent continuous and episodic GPS measurements in these areas of interest as well as continuous GPS measurements at selected CORS sites in the northern U.S. states.

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