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Canadian Regional Solutions for NAREF Initial Investigations

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Abstract

Since the beginning of the year, the Geodetic Survey Division of Natural Resources Canada has been computing various Canadian regional GPS solutions in support of the International GPS Service (IGS) initiative to densify the ITRF following their distributed processing approach. These regional solutions will eventually be contributed to the NAREF Technical Working Group recently formed to coordinate this densification in North America. The regional solutions have been computed using both GIPSY-OASIS II and the Bernese GPS Software following IGS guidelines (e.g., minimum station constraints, fixed IGS orbits and EOPs, etc.). In addition to IGS stations in North America, the solutions include all stations from the Canadian Active Control System (CACS) and Western Canada Deformation Array (WCDA), as well as a selection of US Continuously Operating Receiver Stations (CORS) in Alaska and the northern conterminous states. Comparisons of solutions using different data sampling intervals, station selection, baseline selection, ambiguity resolution strategies, elevation weighting, cut-off angle, and ocean loading models were made in order to determine appropriate processing strategies. Other issues associated with the practical implementation of an automated data gathering and processing system are also discussed.

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Motivation

- *To integrate continuous GPS stations into ITRF*
- *Canadian Active Control System (CACS)*
  - Not all stations included in IGS weekly solutions
- *Western Canada Deformation Array (WCDA)*
  - PGC solutions no longer submitted to CDDIS
  - Not included in GNAAC polyhedron network
- *Provincial Active Control Stations*
  - BCACS
  - Ontario & Quebec provincial DGPS stations

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NRCan Regional Network

- *Current Network for Testing*
  - IGS stations – for reference frame connection (10)
  - CACS stations – some in IGS, some not (11)
  - WCDA stations – some in IGS, some not (8)
  - Northern CORS stations – for redundant processing (23)
- *Future Network*
  - Alaska Deformation Array (2 + CORS)
  - Only best CORS near borders
  - Possibly BC, Ontario & Quebec stations (about 13)

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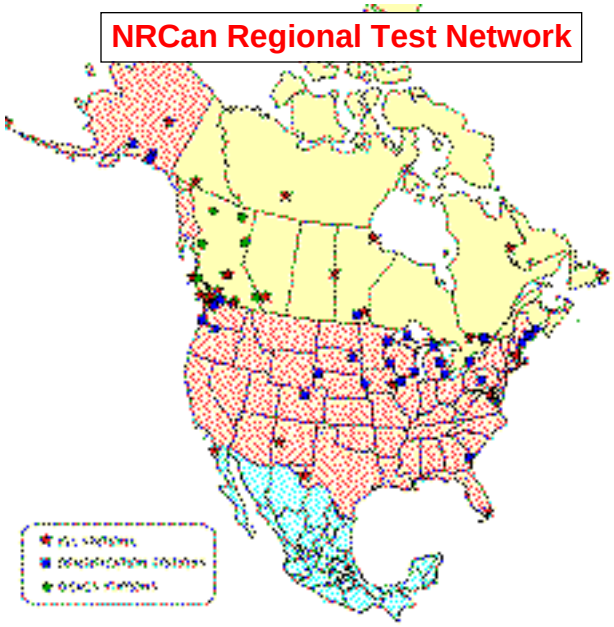
NRCan Regional Test Network



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Regional GPS Processing

- *Following IGS recommendations for regional densification*
  - Fixed IGS orbits & EOPs
  - Minimum of 3 IGS stations (using all in region)
- *Two independent GSD solutions*
  - For redundancy
  - Bernese GPS Software v4.2 (this presentation)
  - GIPSY-OASIS II (just starting)
- *Minimally constrained or "free" solutions*

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Bernese Processing

- *Following EUREF guidelines*
  - 3 minute data sampling
  - Double differencing
  - Tropospheric zenith delays (1 per 2hr instead of 1 per hr)
  - Niell mapping function (dry)
  - Elevation angle-dependent weighting
  - Tropospheric gradients
  - 10 deg. elevation cutoff angle (limited by CORS data)
  - QIF ambiguity resolution
  - Limited to about 65 stations for simultaneous processing

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Comparisons

- *Different processing options*
  - *Table 1 and Figures 1-5*
  - Data sampling rates – 7.5 vs. 3 minutes
  - Baseline selection – max. obs. vs. shortest baselines
  - Ambiguity resolution – fixed vs. free
  - Elevation mask & weighting – 10 deg. vs. 15 deg.
  - Ocean loading models – none vs. IERS
- *Need redundant processing*
  - To compare and assess solutions (QC)
  - May average out some “software noise” (hopefully)

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Table 1: Differences in Processing Options

Comparison	Horizontal Max	Horizontal RMS	Vertical Max	Vertical RMS
Sampling rate (7.5 vs 3 min)	0.1 cm	0.0 cm	0.5 cm	0.1 cm
Baseline selection (max. obs. vs shortest)	2.4	1.1	2.4	0.8
Ambiguity resolution (QIF vs float)	1.9	0.7	1.9	0.6
Elev. mask angle (10 vs 15 deg)	0.7	0.3	1.3	0.6
Ocean loading model (none vs IERS)	0.2	0.1	0.4	0.2

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Some Issues Encountered

- *Data Availability*
  - Some stations do not collect 24 hr data sets
  - Data also missing for several days at a time
  - Difficult to optimize baseline selection in Bernese
  - Removed stations with less than 18 hrs/day (75%) or large data gaps of several days – See Table 2
- *Automated Data Collection*
  - Needed to automate data collection
  - Some problems with antenna hts (site logs vs RINEX)

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Processing Results

- *Unconstrained results – Figure 6*
  - Compared to IGS weekly solution
  - Week 1043 (first week of 2000)
  - Large biases
    - Not sure why !
    - Initial GISPY results show similar bias
    - Due to fixing orbits in a network of continental extent? [Kouba, IGS 1996 Annual Report, p.110]
    - Allow for transformation in combination of results [Ibid.]
- *Transformed results – Figure 7*
  - Good agreement

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Future Plans

- *Station selection criteria*
  - Define and adopt more rigid criteria (esp. 24 hr data)
- Investigate bias in free solutions
- *Begin operational processing*
- *Begin combining solutions for NAREF effort*
  - GSD Bernese, GSD GIPSY, PGC Bernese to start
  - Variance component estimation (Bernese ADDNEQ2)
  - Eventually submit to GNAACs for integration in ITRF

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