Natural Resources Canada
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The NAREF Initiative to Densify the ITRF in North America

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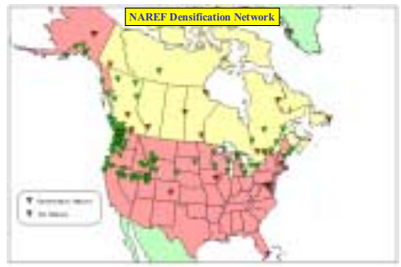
ABSTRACT

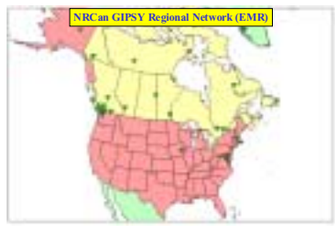
Since the beginning of 2000, the Geodetic Survey Division of Natural Resources Canada (NRCan) has been involved in the North American Reference Frame (NAREF) Working Group of IAG Commission X (Subcommission for North America), in support of the International GPS Service (IGS) initiative to densify the International Terrestrial Reference Frame (ITRF) in North America. Following the IGS distributed processing approach, NRCan has been computing weekly regional solutions following IGS guidelines, using both GIPSY-OASIS II and the Bernese GPS Software for quality control. Included in these solutions are all IGS stations in the northern half of North America, as wells as all stations of the Canadian Active Control System, the Western Canada Deformation Array, and subsets of the US Continuously Operating Reference Station (CORS) network, the Alaska Deformation Array, the Pacific Northwest Geodetic Array, the Eastern Basin Range Yellowstone Array, the British Columbia Active Control System and the Quebec Permanent GPS Network. In addition to the two NRCan solutions, we have also collected some from other agencies for a number of regional networks throughout North America. These different solutions have been combined into a single NAREF weekly combination for all of North America beginning with the first week of 2001. Some stations are included in more than one solution thereby providing redundancy checks and allowing for correct weighting of the different solutions relative to each other. All solutions show relatively good agreement. By the end of June we hope to begin submitting weekly NAREF combinations to the IGS for eventual incorporation into the official IGS densification network.



REGIONAL SOLUTIONS

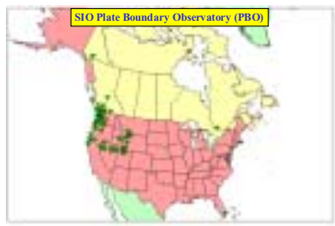
- FromGeodetic Survey Division, NRCan
- Bernese GPS Software Version 4.2
- Doubledifferenced observations
- 3 minutes data sampling
- 10deg elevation cut off
- Fixed IGS precise orbits & ERP
- Tropospheric zenith delay (every 2 hours)
- Niellmapping function (dry)
- Tropospheric gradient (1/day)
- QIF ambiguity resolution with regional ionosphere model
- No ocean bading model
- 1 IGS reference frame station (DRAO) constrained to ITRF97

	Horizontal	Vertical
Maximum	2 mm	10 mm
Average	1 mm	3 mm
Std.	1 mm	3 mm

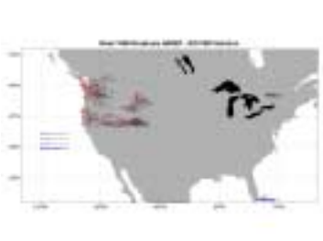


- FromGeodetic Survey Division, NRCan
- GIPSY-OASISII software
- Undifferenced observations
- 7.5 minutes data sampling
- 15deg elevation cut off
- Fixed IGS precise orbits & ERP
- Tropospheric zenith delay (random walk)
- Niellmapping function (wet)
- Tropospheric gradient (random walk)
- No ambiguity resolution
- IERS96 ocean loading model
- 1 IGS reference frame station (DRAO) constrained to ITRF97

	Horizontal	Vertical
Maximum	3 mm	7 mm
Average	1 mm	2 mm
Std.	1 mm	2 mm



- FromScripps Institution of Oceanography (SIO)
- GAMIT v9.72 software
- Doubledifferenced observations
- 2 minute data sampling for final solution
- 10deg elevation cut off
- Fixed SIO precise orbits & ERP
- Tropospheric zenith delay (random walk)
- Niellmapping function (dry & wet)
- Tropospheric gradient (1/day)
- Ambiguities resolved for lines < 500 km
- IERS 96 ocean loading model
- IGS reference frame stations loosely constrained to IGS97



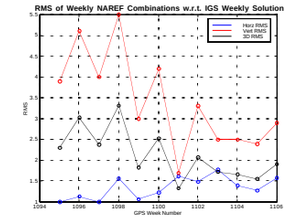
	Horizontal	Vertical
Maximum	8 mm	5 mm
Average	1 mm	1 mm
Std.	2 mm	1 mm

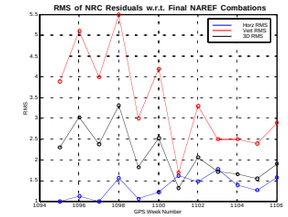
- FromHerb Dragert, Pacific Geoscience Centre (PGC), NRCan
- Bernese GPS Software Version 4.2
- Doubledifferenced observations
- 30 second data sampling
- 10deg elevation cut off
- Fixed IGS precise orbits & ERP
- Tropospheric zenith delay (every 2 hours)
- Niellmapping function (dry)
- Tropospheric gradient (4/day)
- QIF ambiguity resolution
- LOADSDP v5.02 ocean loading model
- 1 IGS reference frame station (DRAO) constrained to ITRF97

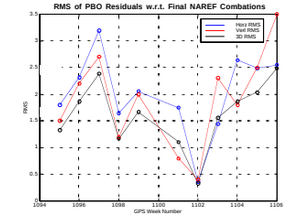
	Horizontal	Vertical
Maximum	2 mm	4 mm
Average	2 mm	3 mm
Std.	0 mm	1 mm

REGIONAL COMBINATION PROCEDURE

- Using SINEX Software v1.0 by R. Ferland (used for official IGS global combinations)
- A priori datum constraints removed from each regional solution
- Each regional solution aligned to IGS weekly solution (3 translations, 3 rotations & scale change)
- Residuals tested for outliers (removed)
- Covariance matrix of each regional solution scaled by RMS of residuals
- All (scaled) regional solutions combined (summation of normals)
- Combined solution aligned to IGS weekly solution (3 translations, 3 rotations & scale change)
- Covariance matrix for combined solution scaled by RMS of residuals
- Residuals tested for outliers (removed)
- 1 IGS reference frame station (DRAO) constrained to ITRF97 (min constraint)
- Generated SINEX file for combined solution (NAREF solution)



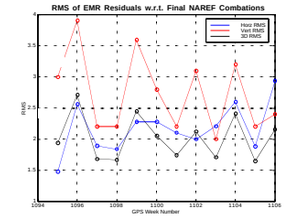


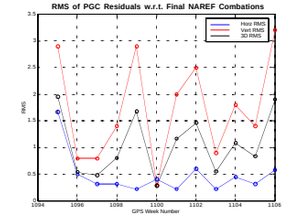


	Horizontal	Vertical
Maximum	8 mm	7 mm
Average	2 mm	3 mm
Std.	2 mm	2 mm

NAREF COMBINATION RESULTS

- Week 1095 used as an example
- Differences between the NAREF combination & IGS weekly solution at IGS stations show good agreement: 2 – 2 mm horizontally & 3 – 2 mm vertically
- Residual discrepancies between individual solutions (transformed) and final NAREF combination show good agreement to better than 3 mm on average (see plots at bottom left of poster)
- Timeseries of RMS fits for several weeks show agreement better than 3.5 mm horizontally and 5.5 mm vertically





FUTURE WORK

- Incoporate other regional solutions:
  - NGS CORS stations (>150 stations across entire US)
  - New Western Arctic Deformation Network (3 permanent stations)
  - New PostGlacial Uplift Monitoring Network (6 permanent stations)
- Begin submitting combined weekly solutions to IGS for incorporation in IGS densification network
- Perform regular cumulative solutions after collecting a year of weekly solutions (estimate velocities)

ACKNOWLEDGMENTS

- Herb Dragert, Pacific Geoscience Centre, for contributing WCDA solutions
- Brian Donahue, Geodetic Survey Division (GSD), for contributing NRCan GIPSY Solutions
- Mathijs van Domselaar, Scripps Institution of Oceanography, for contributing PBO solutions
- Remi Ferland and Jan Kouba, GSD, for general advice