Regional Reference Frames for North America: Current Status and Future Plans

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ABSTRACT
In collaboration with the IAG community, its service organizations and the national geodetic organizations of North America, the IAG Regional Sub-commission SC1.3c (Regional Reference Frames for North America) provides international focus, cooperation and coordination for issues involving the geodetic reference frames and control networks of North America. These issues include the establishment, maintenance, future evolution and inter-relation of reference frames throughout the continent, and the specification of consistent standards and guidelines. In order to realize these objectives the Sub-commission has been organized into three working groups dealing with the densification of the ITRF and IGS reference frames in North America (NAREF), the definition of a new geocentric, plate-fixed North American reference frame to replace the existing non-geocentric NAD83, and the maintenance of the relationship between NAD83 and global reference frames. Future efforts include the solution with velocities will be estimated based on these reprocessed from a combination of several regional contributions and submitted to the IGS. Presently, work is underway by most contributors to reprocess the ITRF and IGS reference frames in North America (NAREF), the organized into three working groups dealing with the densification of the ITRF and IGS reference frames in North America (NAREF), the definition of a new geocentric, plate-fixed North American reference frame to replace the existing non-geocentric NAD83, and the maintenance of the relationship between NAD83 and global reference frames. Over the past few years there has been much preparation for major activities that have just recently begun. We report on these activities and the future plans of the working groups. In particular, the NAREF network has evolved from a few hundred permanent GPS stations to over 2000. Weekly NAREF solutions are produced in ITRF from a combination of several regional contributions and submitted to the IGS. Presently, work is underway by most contributors to reprocess the ITRF and IGS reference frames in North America (NAREF). Presented are the results of these reprocessed solutions and the ongoing discussions with the IAG community about how to define a new geocentric, plate-fixed ITRF-based North American reference frame to eventually replace NAD83 and ITRF in the next decade.

SUB-COMMISSION 1.3c FOR NORTH AMERICA

Co-Chairs
Dr. Michael Craymer (NRCan, Canada) – July 2013
Dr. Neil Weston (NGS, USA) – after July 2013

Objectives
Provide international focus and cooperation for issues involving the horizontal, vertical, and three-dimensional geodetic control networks of North America, including Central America, the Caribbean and Greenland (Denmark) e.g.,
- Densification of the ITRF reference frame in North America and promotion of its use
- Promotion of collocation of different measurement techniques such as VLBI, SLR, DORIS, GPS, etc.
- Effects of crustal motion, including tectonic motions along e.g., the western coast of N.A. and in the Caribbean, and post-glacial rebound
- Standards for the accuracy of geodetic positions
- Outreach to the general public through focused symposia, articles, workshops and lectures and technology transfer to other groups, particularly in N.A.

Working Groups
SC1.3c-WG1 North American Reference Frame (NAREF)
SC1.3c-WG2 Plate-Fixed North American Reference Frame
SC1.3c-WG3 Reference Frame Transformations

WG1 – NORTH AMERICAN REFERENCE FRAME (NAREF) – Con’t

Regional Contributions

<table>
<thead>
<tr>
<th>Contributor</th>
<th>Since</th>
<th>Software</th>
<th>Region</th>
<th># stations</th>
<th>wk 163/10 used</th>
</tr>
</thead>
<tbody>
<tr>
<td>INEGI</td>
<td>2010</td>
<td>GAMIT</td>
<td>Mexico</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>MIT/PRO</td>
<td>2004</td>
<td>Combi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NGS</td>
<td>2000</td>
<td>PAGES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRCan/GSD</td>
<td>2000</td>
<td>Bernese</td>
<td>Northern N.A.</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>NRCan/GPSY</td>
<td>2001</td>
<td>GIPSY</td>
<td>Canada (43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRCan/PGC</td>
<td>2001</td>
<td>Bernese</td>
<td>Pacific Northwest (55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIO/OSOPAC</td>
<td>2000</td>
<td>GAMIT</td>
<td>North/Central America (700/140)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Combination of GIPSY & GAMIT
2 Not contributing since GPS week 1631

NAREF Network Growth

<table>
<thead>
<tr>
<th>Type</th>
<th>Solutions</th>
<th>2500+ in 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAREF Sites</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>IGS/NAREF Sites</td>
<td>783</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>838</td>
<td></td>
</tr>
</tbody>
</table>

Future Plans
- Enhancing combination software to handle large networks using:
  - Dynamic memory allocation
  - Highly efficient matrix routines (LAPACK)
  - Expect to be ready to resume weekly combinations in early 2014

WG2 – PLATE-FIXED NORTH AMERICAN REFERENCE FRAME

Objectives
- Topology of the ITRF and NAD83 reference frames in North America
- Integration of the ITRF via the IGS global network
- Combine 6 regional networks into a continental one
- Include continuous GPS sites in North America (2500+)
- Follow IGS processing guidelines
- IGS final orbits and EOP’s
- Absolute antenna phase center models

Products
- Weekly coordinate solutions
- Multi-year cumulative (velocity) solutions, updated weekly

Weekly Combination Procedure

For each regional solution

- Apply weighted coordinates
- For multi-year solutions
- Use regional solutions
- Scale of solution
- Apply GPS to solution

Future Plans
- Use weekly combinations of repro1 solutions
- Produce weekly updated cumulative solutions
- Implement discontinuity detection software in order to handle thousands of stations
- Most contributors plan to reprocess all data with IGS repro2-compatible products and recombine

WG3 – REFERENCE FRAME TRANSFORMATIONS

Objectives
- To determine consistent relationships between international, regional and national reference frames/datums in North America
- Maintain and update these relationships
- Provide tools for implementing the transformations
- Primarily involves maintaining the adopted relationship between ITRF and NAD83 in Canada and the USA

Status & Future Plans
- NAD38 is now defined by a transformation from ITRF96
- The transformation is incrementally updated to new ITRF using the adopted IERS transformations between ITRF realizations
- The last update was for ITRF2008 and the next is expected to be for ITRF2013 in 2014
- NNR-NVUEL-1A is used to keep the frame fixed to North America (now known to be biased by about 2 mm/yr)

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