

Regional Reference Frames for North America Current Status and Future Plans



Michael Craymer, Geodetic Survey Division, Natural Resources Canada
Jake Griffiths & Neil Weston, U.S. National Geodetic Survey

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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. 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 all NAREF data in concert with the IGS "repro2" effort. A cumulative solution with velocities will be estimated based on these reprocessed results, and updated on an on-going basis with new weekly NAREF combinations as they are produced. Other important efforts include the updating of the transformation between NAD83 and ITRF, and discussions on how to define a new geocentric, plate-fixed ITRF-based North American reference frame to eventually replace NAD83 early in the next decade

SUB-COMMISSION 1.3c FOR NORTH AMERICA

Co-Chairs

- Dr. Michael Craymer (NRCAN, Canada)
- Dr. Jake Griffiths (NGS, USA) – to 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 network 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)

Objectives

Densify the ITRF and IGS reference frames in North America

- Integrate into the ITRF via the IGS global network
- Combine 6 regional networks into a continental one
- Include most continuous GPS sites in North America (2500+)

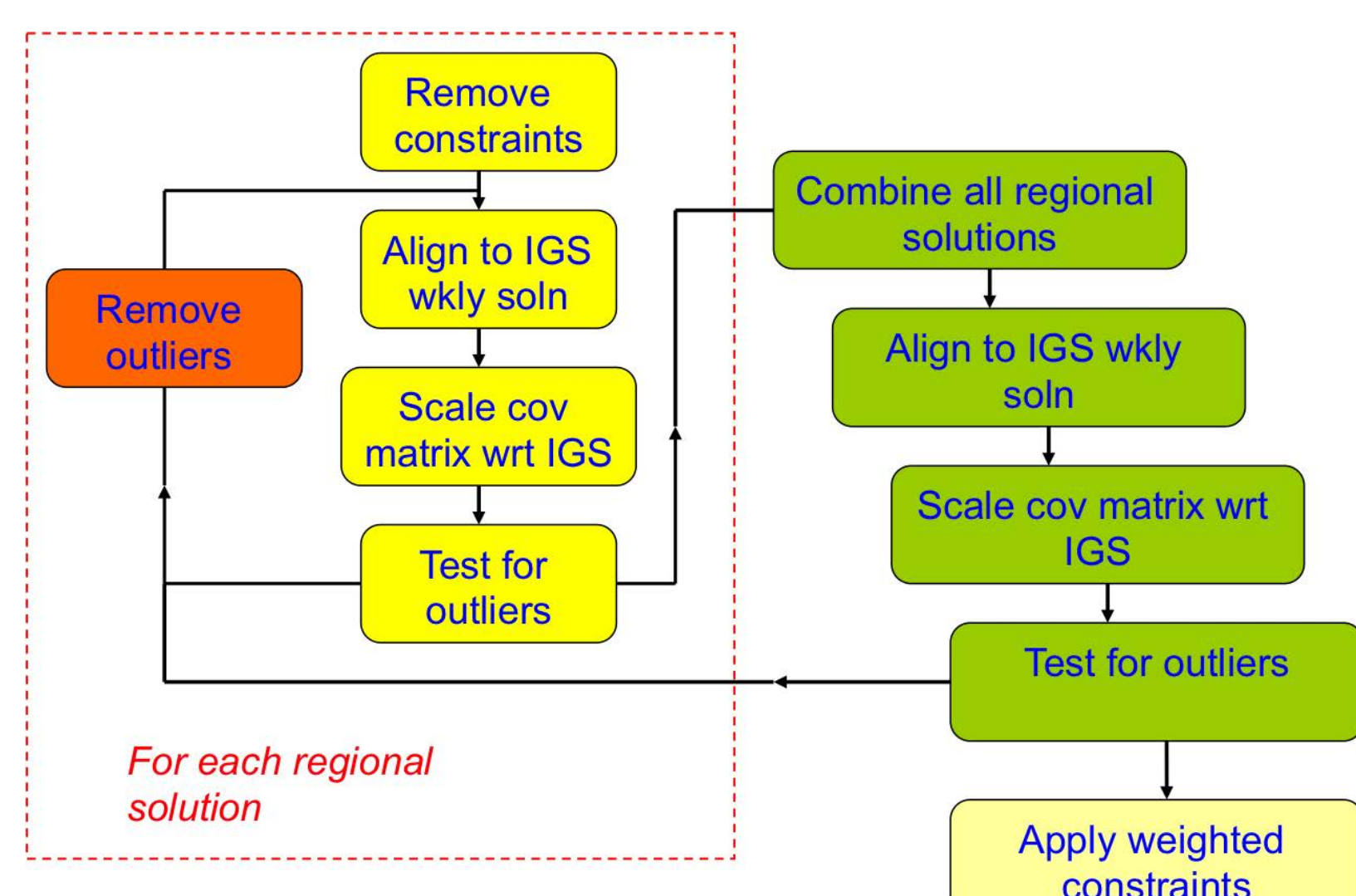
Follow IGS processing guidelines

- IGS final orbits and EOP's
- Absolute antenna phase centre models

Products

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

Weekly Combination Procedure



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

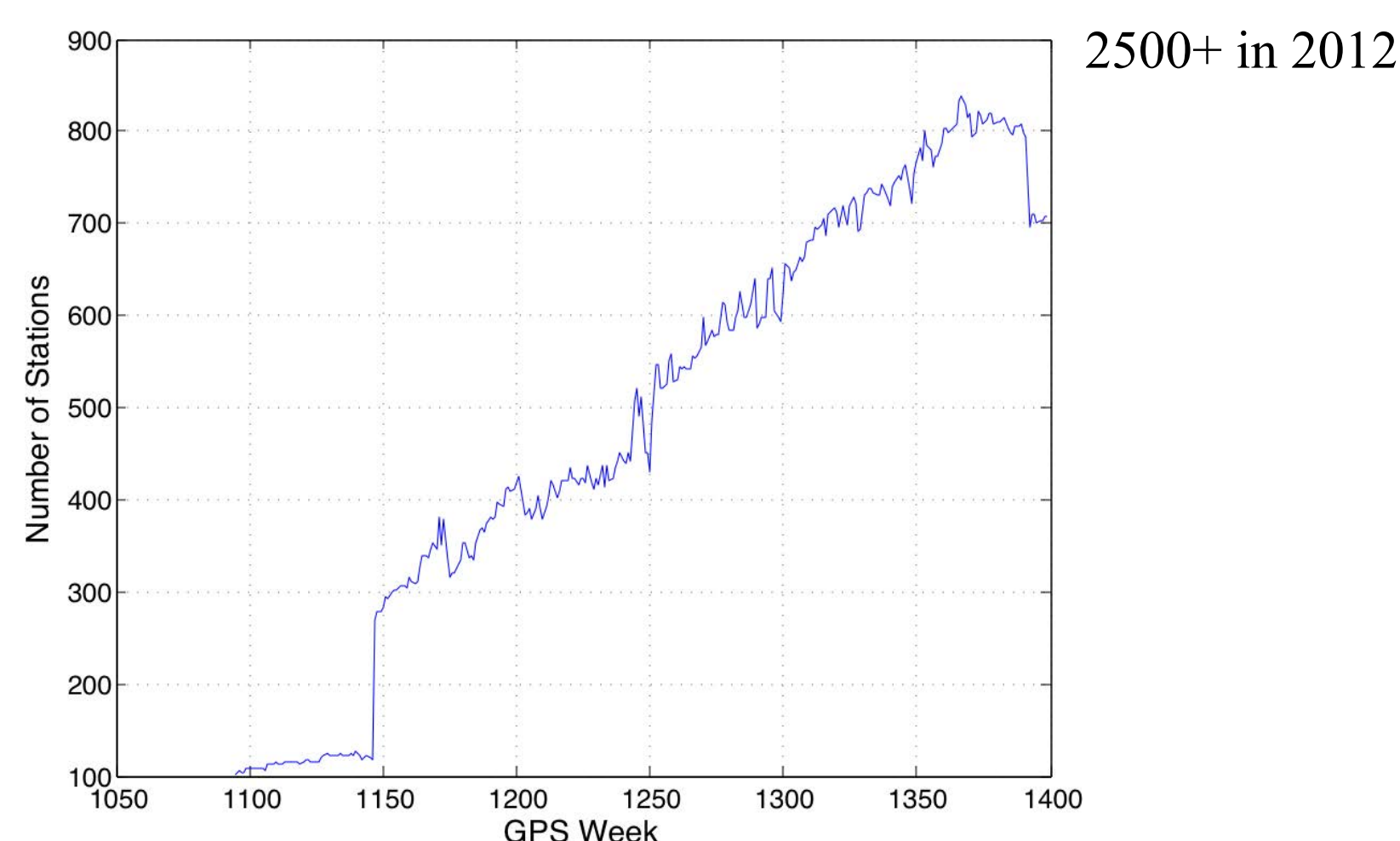
Regional Contributions

Contributor	Since	Software	Region (# stations wk 1631/used)
INEGI	2010	GAMIT	Mexico (44)
MIT PBO	2004	Combo ¹	Plate Boundary Observatory (670/183)
NGS	2000	PAGES	North+Central America (820/762)
NRCAN/GSD	2000	Bernese	Northern N.A. (112)
NRCAN/GSD ²	2001	GIPSY	Canada (43)
NRCAN/PGC ²	2001	Bernese	Pacific Northwest (55)
SIO/SOPAC	2000	GAMIT	North+Central America (700/140)

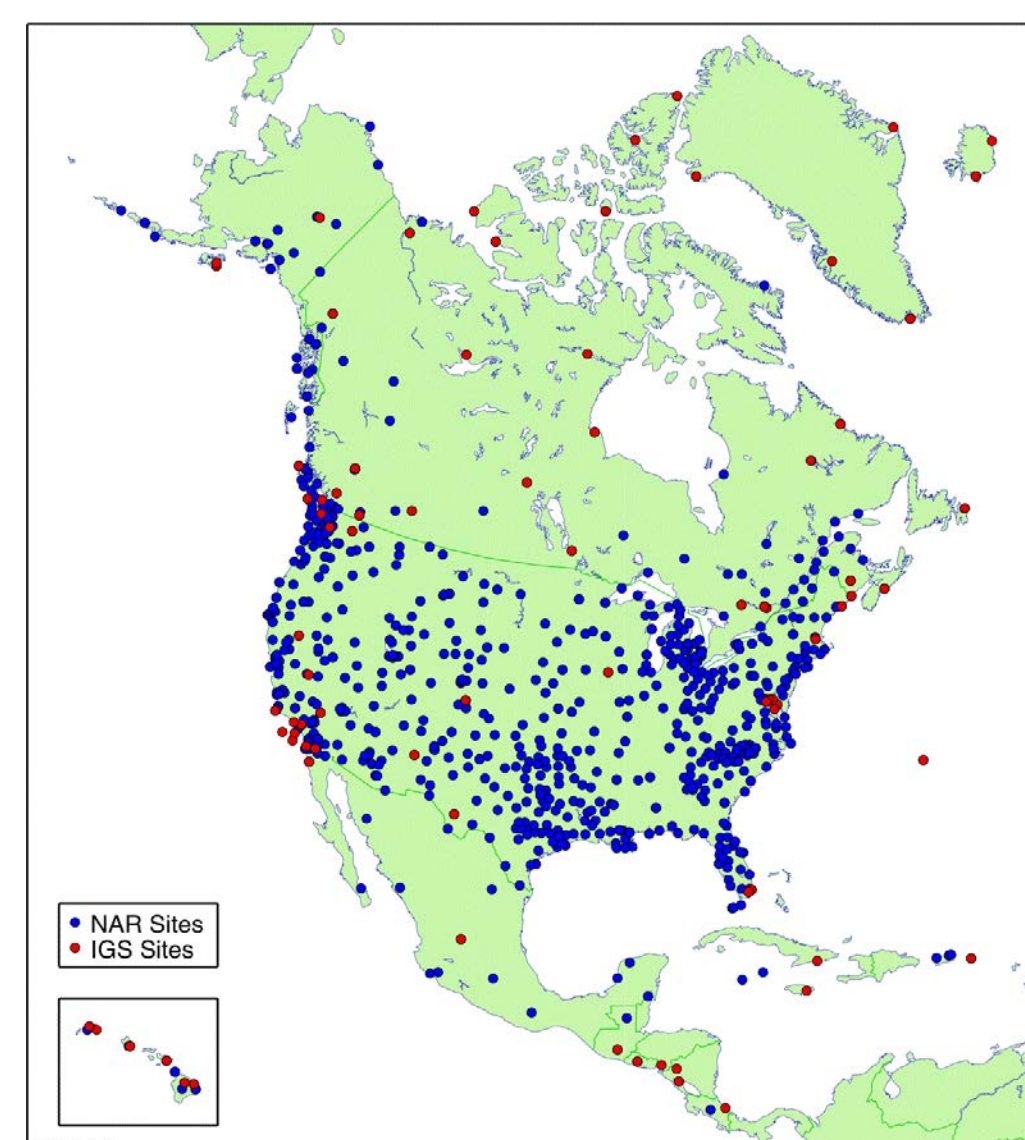
¹ Combination of GIPSY & GAMIT

² Not contributing since GPS week 1631

NAREF Network Growth

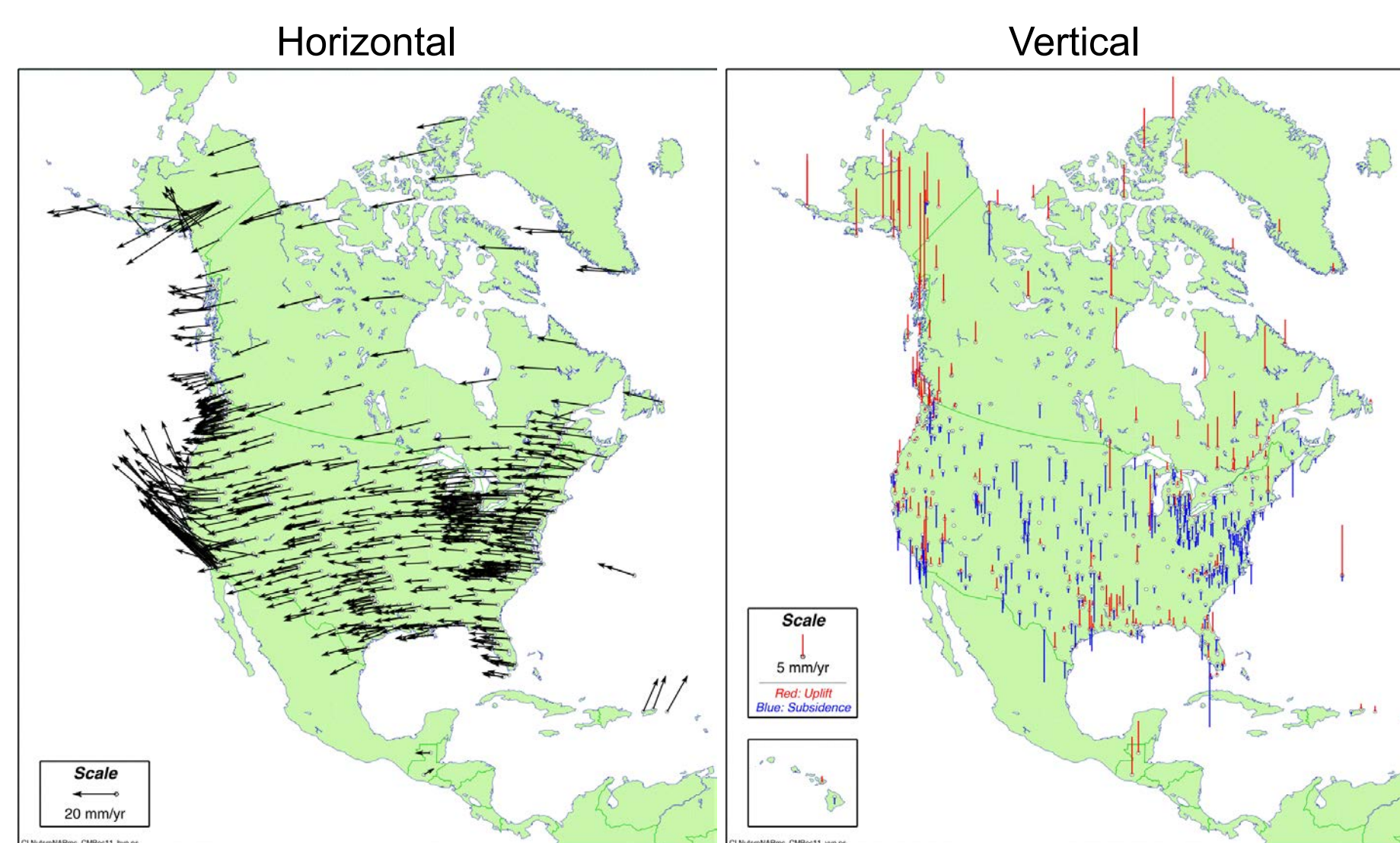


NAREF Network – Week 1399



ITRF/IGS Sites	55
NAREF Sites	783
Total	838
Number of Stations in	
1 solution	607 (72%)
2 solutions	105 (13%)
3 solutions	101 (12%)
4 solutions	20 (2%)
5 solutions	3 (0.4%)
6 solutions	2 (0.2%)

NAREF Network – Week 1399



Current Status

Weekly coordinate combinations

- The following continue to produce regional solutions for NAREF:

INEGI	NGS	SIO
MIT	NRCAN/GSD	
- All data reprocessed with IGS repro1-compatible products by contributors
- Combinations available only until GPS week 1512 (May 2010)
- Too many stations for combination software (2500+)
- Plan to resume combinations in early 2014

Multi-year cumulative solutions

- Only one cumulative solution available up to GPS week 1399
- Plan to eventually update weekly

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

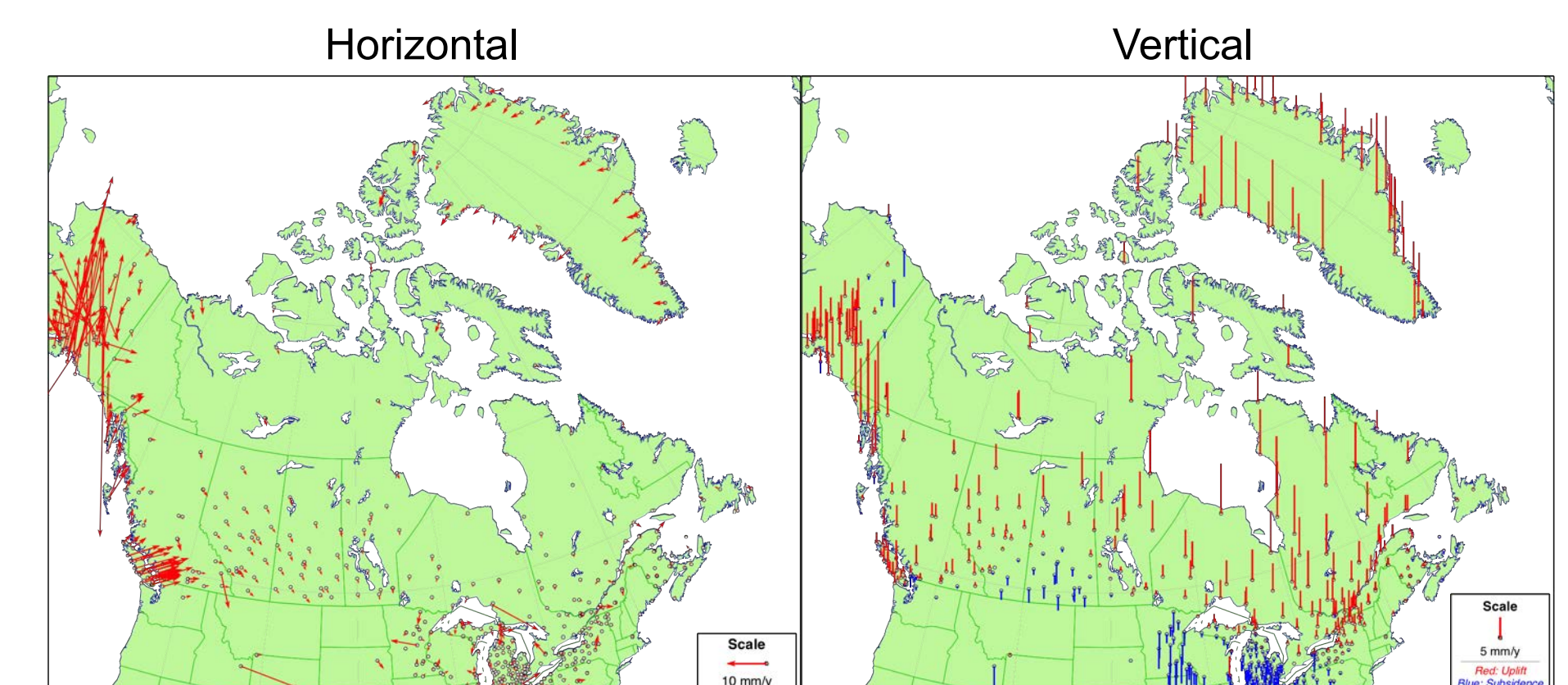
Future Plans

- Produce 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

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

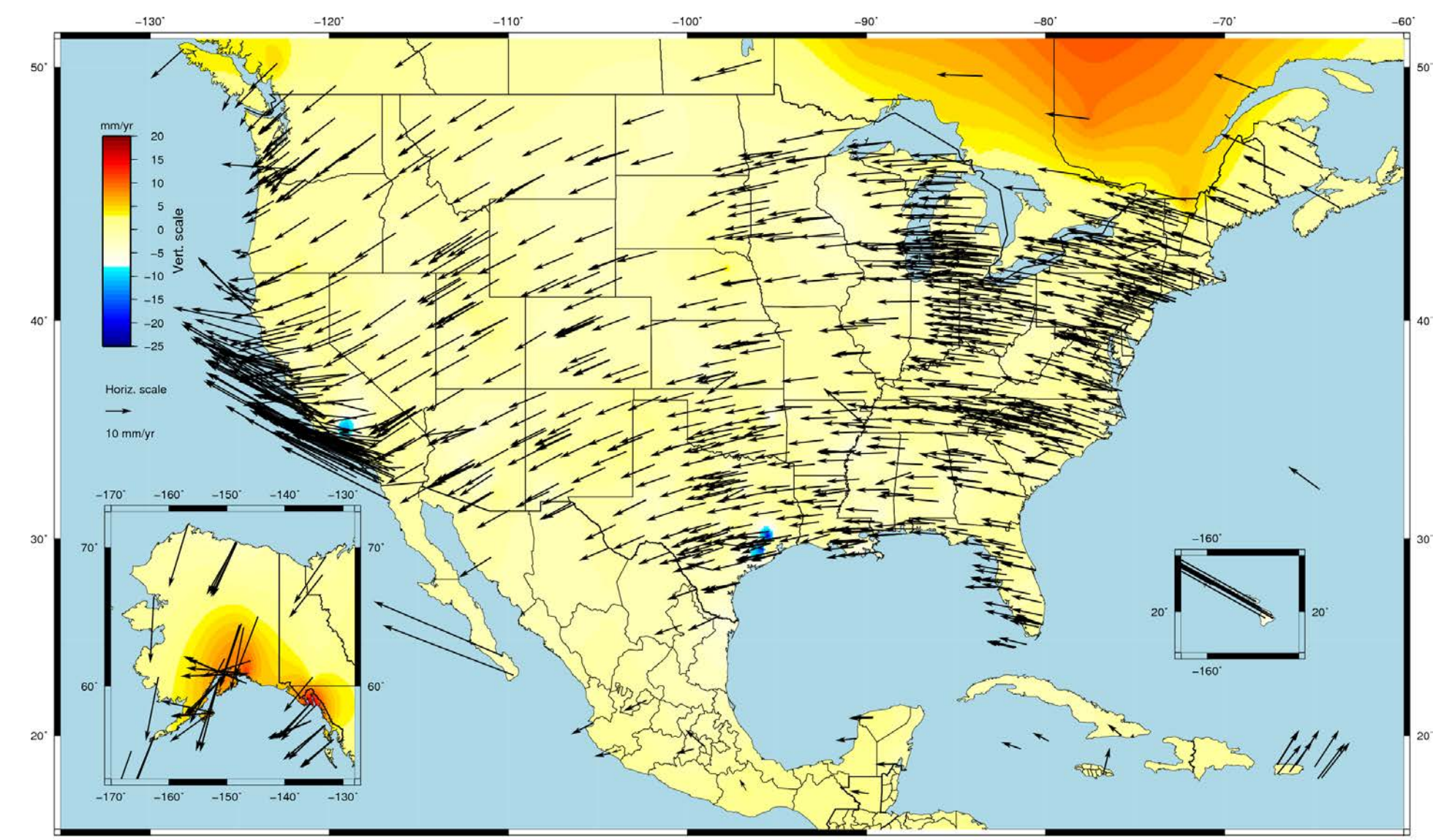
NRCAN/GSD Multi-Year Cumulative Solution

- Covers Canada, northern US (Great Lakes), Alaska and Greenland (685 stations)
- Based on weekly Bernese 5.0 solutions up to week 1631 (2011.3)
- Used repro1 products and igs05.atx antenna calibrations
- Densified coverage using high accuracy repeat occupations (at least 4) on the Canadian Base Network (another 160 stations)
- Corrected continuous solutions to igs08.atx using IGS model
- Aligned to IGS08 reference frame using 117 global sites
- ITRF2008 plate motion removed in following horizontal plot



NGS Multi-Year Cumulative Solution

- Covers primarily US, including Alaska (2264 stations)
- Based on weekly PAGES solutions up to week 1631 (2011.3)
- Used repro1 products and igs05.atx antenna calibrations
- Corrected continuous solutions to igs08.atx using IGS model
- Plate motion not removed in following plot



WG2 – PLATE-FIXED NORTH AMERICAN REFERENCE FRAME

Objectives

To establish a high-accuracy, geocentric reference frame, including velocity models, procedures and transformations, tied to the stable part of the North American tectonic plate

- NAD83 offset ~2 m from geocenter and ITRF frames
- Expect to replace both NAD83 and the US vertical datum by 2022
- New frame will provide a consistent, mm-accuracy, stable reference frame with which scientific and geomatics results can be produced and compared.

Status & Future Plans

- Initial discussions with the public held at the 2010 Federal Geospatial Summit
- It is currently thought the new system will be aligned exactly with the ITRF realization in 2022 at some adopted epoch and then rotated to fix the frame to the North American plate
- Future discussions will address the best method of fixing the frame to the stable part of the North American tectonic plate

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

- NAD83 is now defined by a transformation from ITRF96
- The transformation is incrementally updated to new ITRF's 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-NUVEL-1A is used to keep the frame fixed to North America (now known to be biased by about 2 mm/yr)