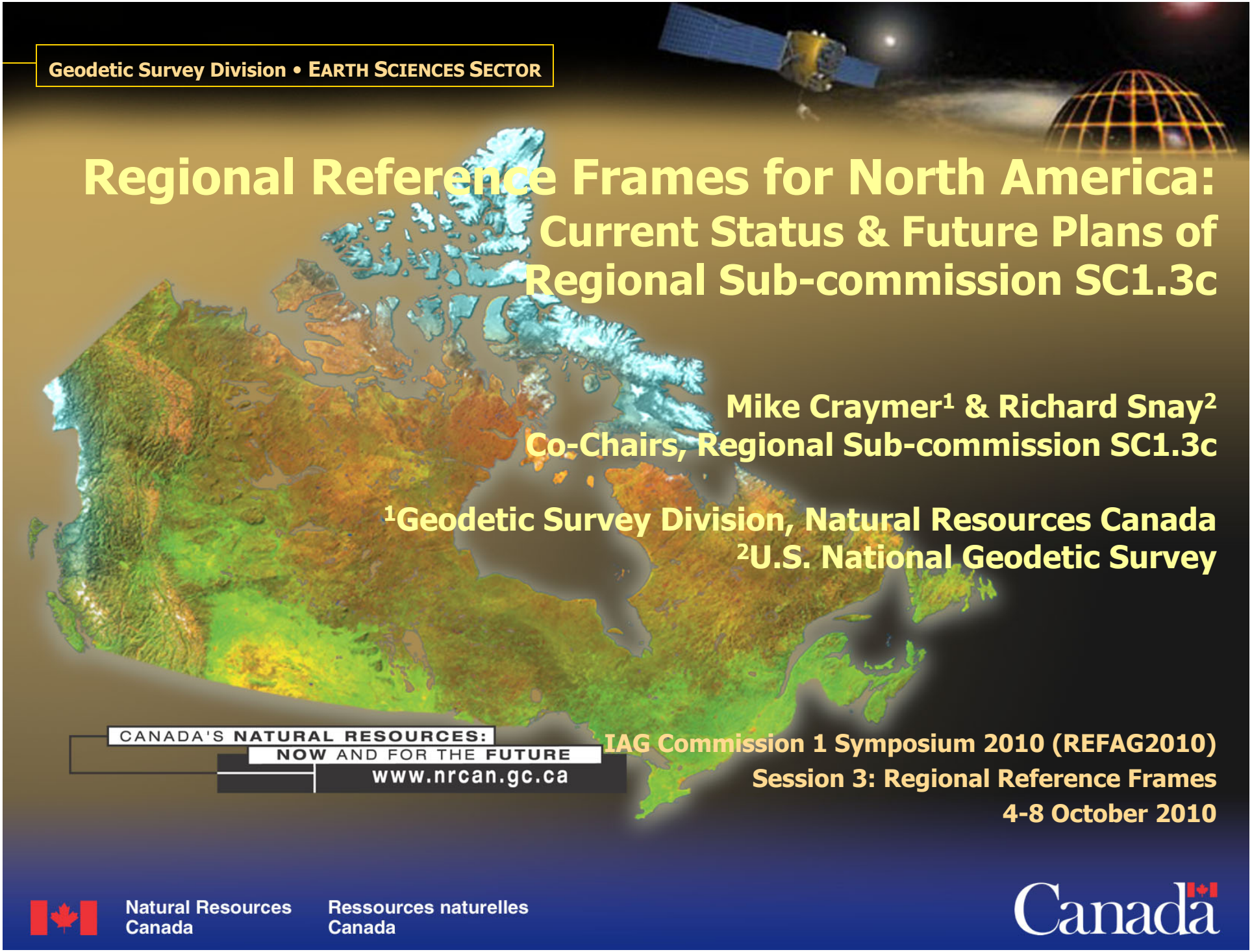

Geodetic Survey Division • EARTH SCIENCES SECTOR

Regional Reference Frames for North America:
Current Status & Future Plans of Regional Sub-commission SC1.3c

Mike Craymer[1] & Richard Snay[2]
Co-Chairs, Regional Sub-commission SC1.3c

[1]Geodetic Survey Division, Natural Resources Canada
[2]U.S. National Geodetic Survey

CANADA'S NATURAL RESOURCES:
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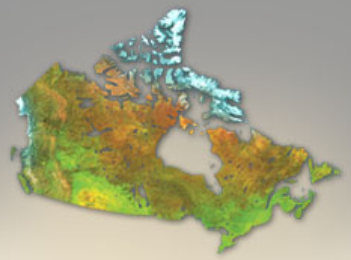
IAG Commission 1 Symposium 2010 (REFAG2010)
Session 3: Regional Reference Frames
4-8 October 2010

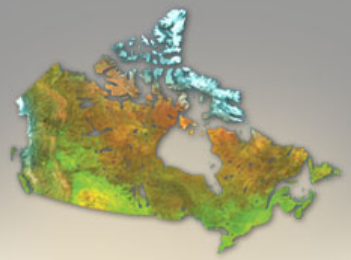
Natural Resources Canada | Ressources naturelles Canada

Canada



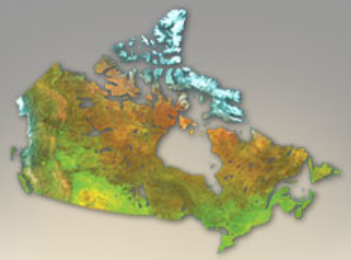
Working Groups

- **WG1 – Reference Frame Densification (NAREF)**
- **WG2 – Stable North American Reference Frame (SNARF)**
- **WG3 – Refernence Frame Transformations (NAD83)**
- **New WG for 2011 – ITRF-Based NAD20xx**



WG1 – NAREF
Reference Frame Densification

- **Objectives**
  - Densify the ITRF/IGS global reference frame in North America
    - Integrating into ITRF via the IGS global network
    - *Combining 6 regional networks into a continental one*
    - Includes most continuous GPS sites in N.A. (2000+ stations)
  - Following IGS processing guidelines
    - IGS orbits and EOPs
    - Absolute antenna phase center offsets used since GPS week 1400
- **Products**
  - Weekly coordinate solutions (combinations)
    - *Currently only available to GPS wk 1519 (end of Jan 2009)*
    - Too may stations for combination software
  - Periodic cumulative (velocity) solutions
    - *Last one only available to GPS wk 1399 (Nov 2006)*

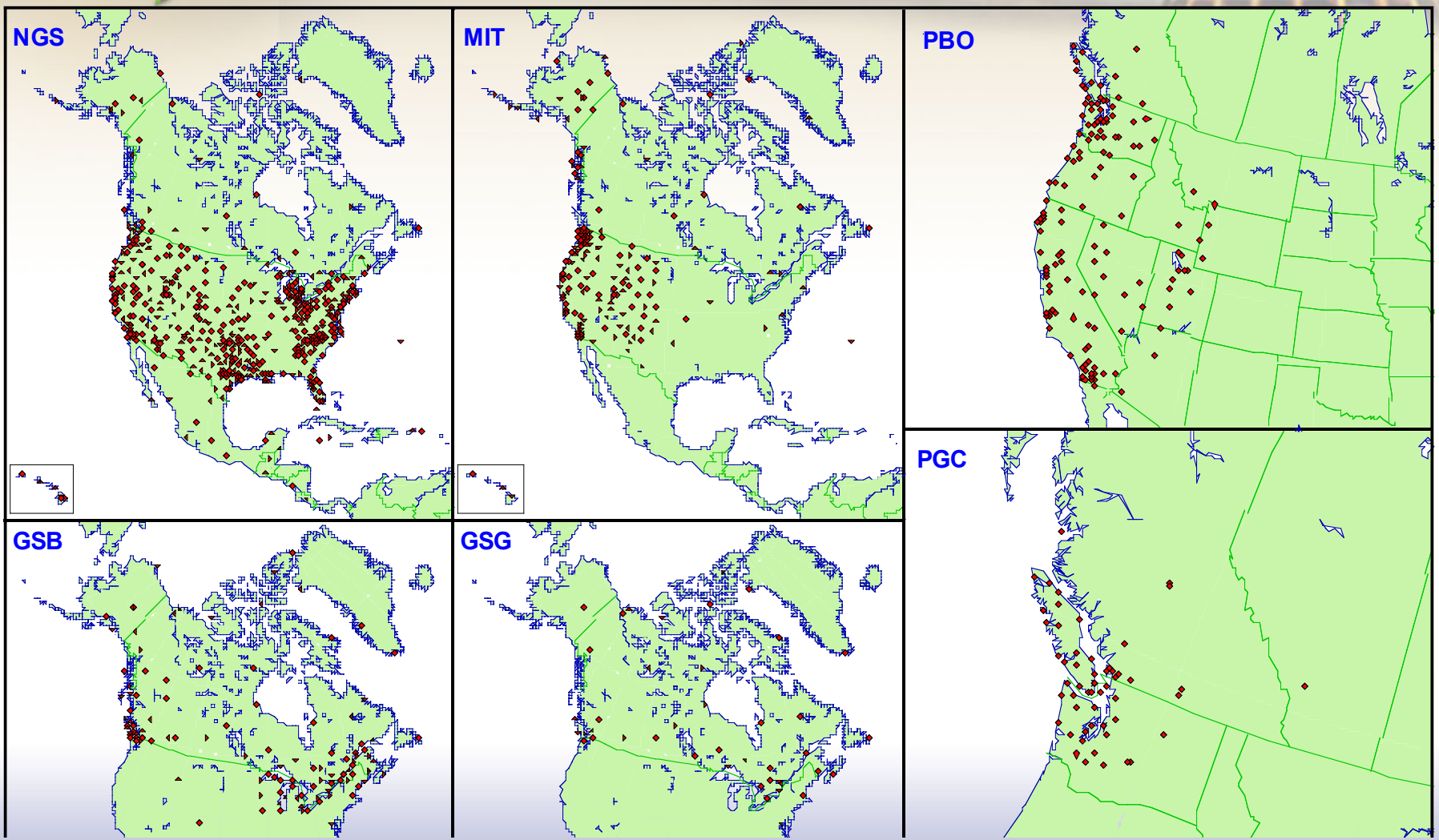


NAREF Contributions

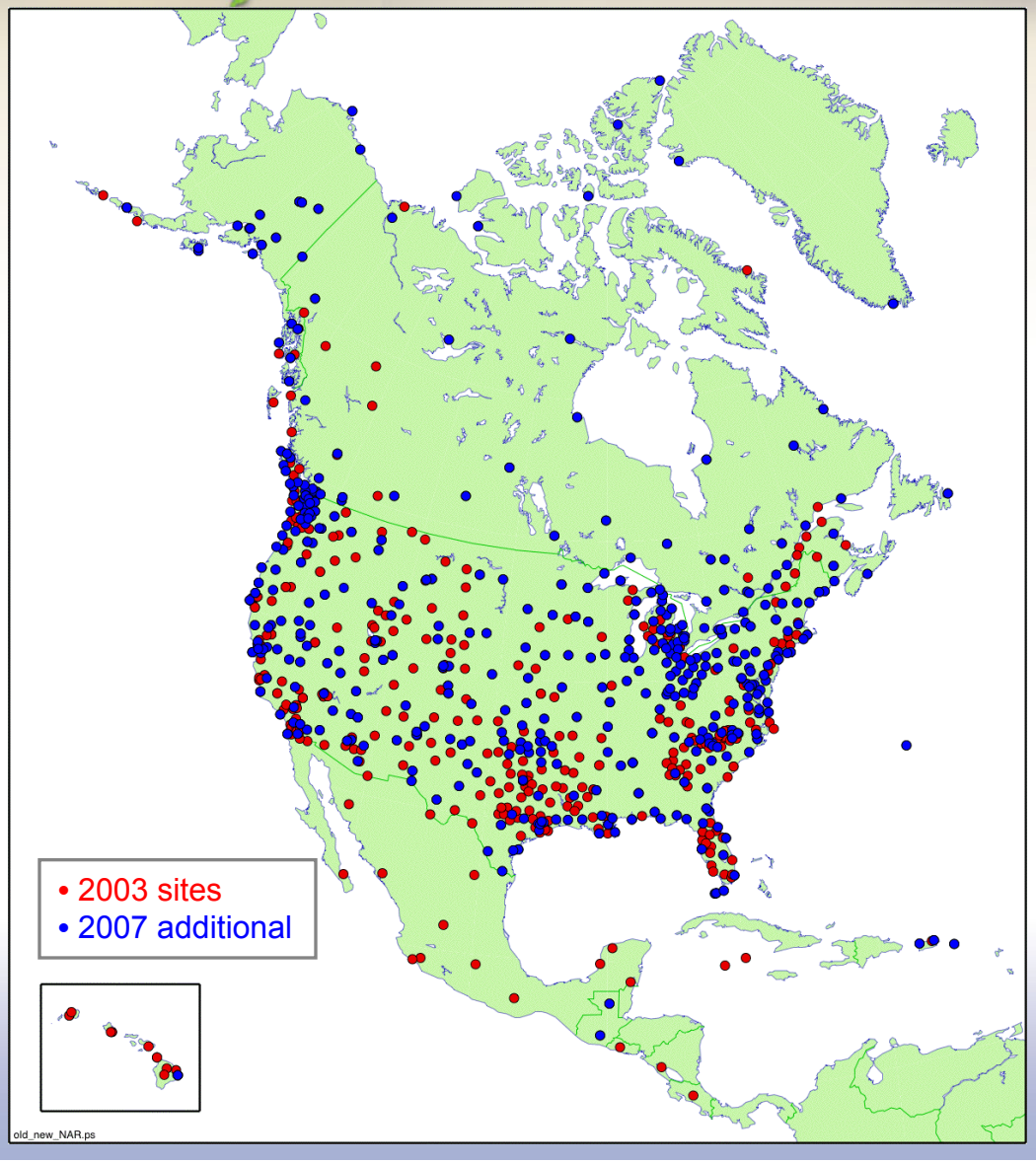
Contributor	Since	Software	Region (# stations wk 1399)
GSD/NRCan	2001	Bernese	Northern N.A. (112)
GSD/NRCan	2001	GIPSY	Canada (43)
PGC/NRCan	2001	Bernese	Pacific Northwest (55)
NGS	2002	PAGES	North/Central America (820/762)
SIO/SOPAC*	2001	GAMIT	North/Central America (700/140)
MIT*	2004	Combination (GIPSY+GAMIT)	PBO – Western US (670/183)

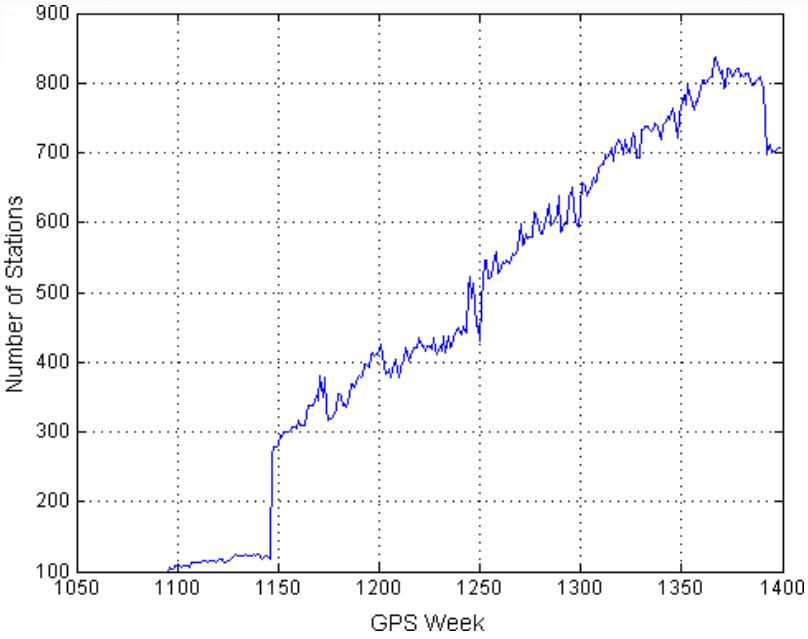
* Daily solutions – need to combine into weekly solutions for NAREF

Regional Networks (Wk 1399)



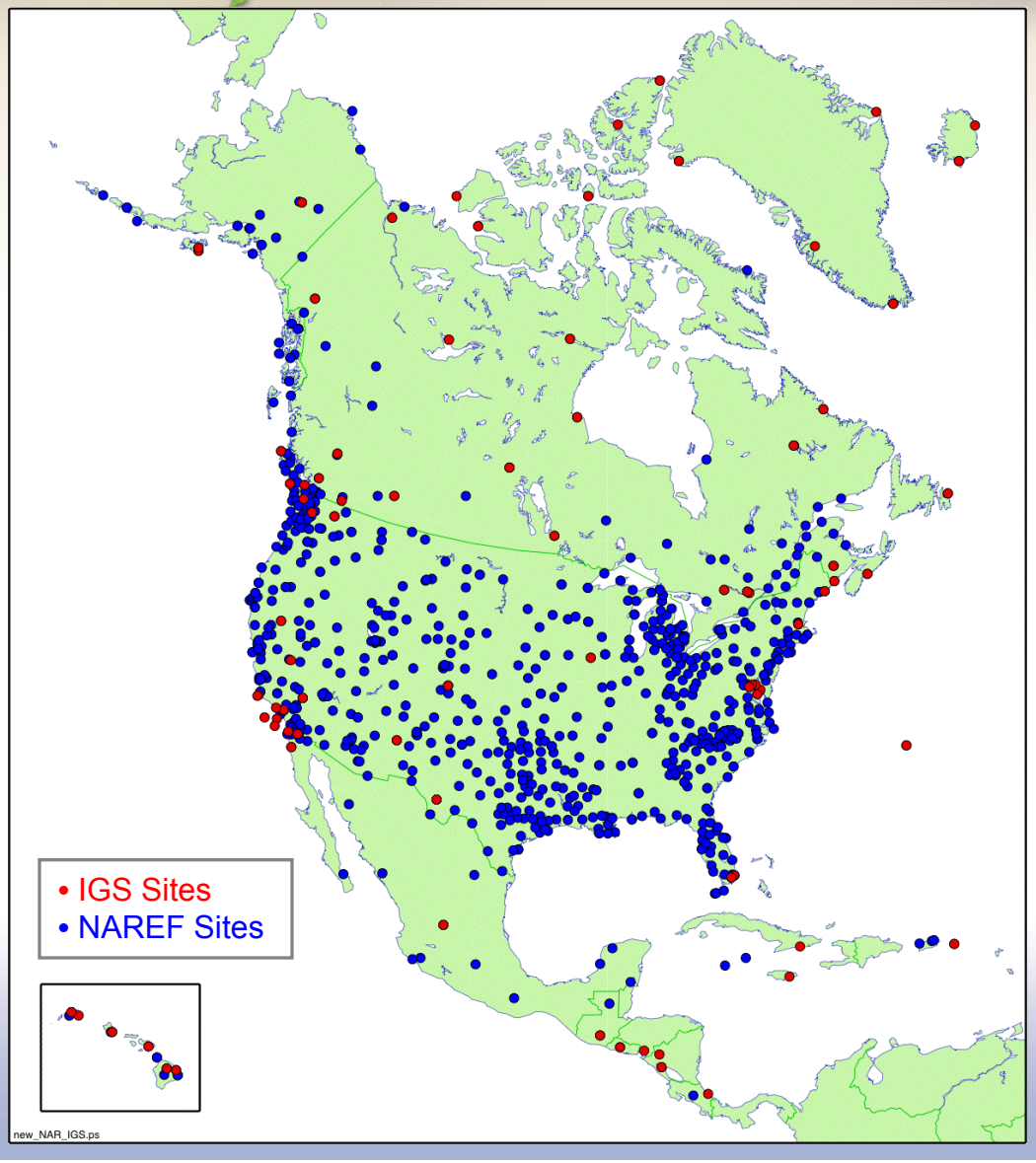
NAREF Network Growth





Canada

NAREF Network (Wk 1399)



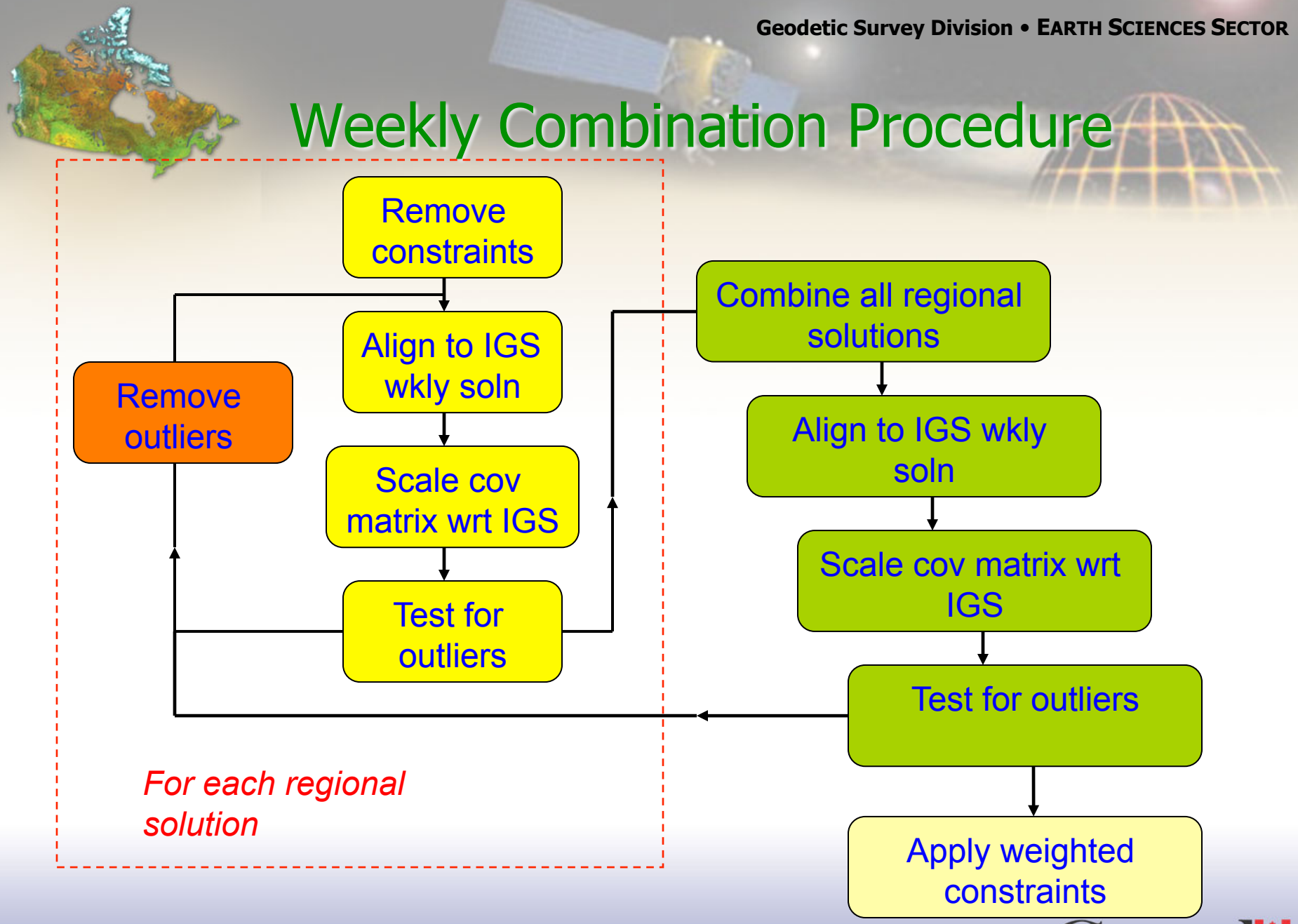
ITRF/IGS Frame Sites	55
NAREF Densification	783
Total	838

Number of Stations in

1 solutions	607 (72%)
2 solutions	105 (13%)
3 solutions	101 (12%)
4 solutions	20 (2%)
5 solutions	3 (0.4%)
6 solutions	2 (0.2%)

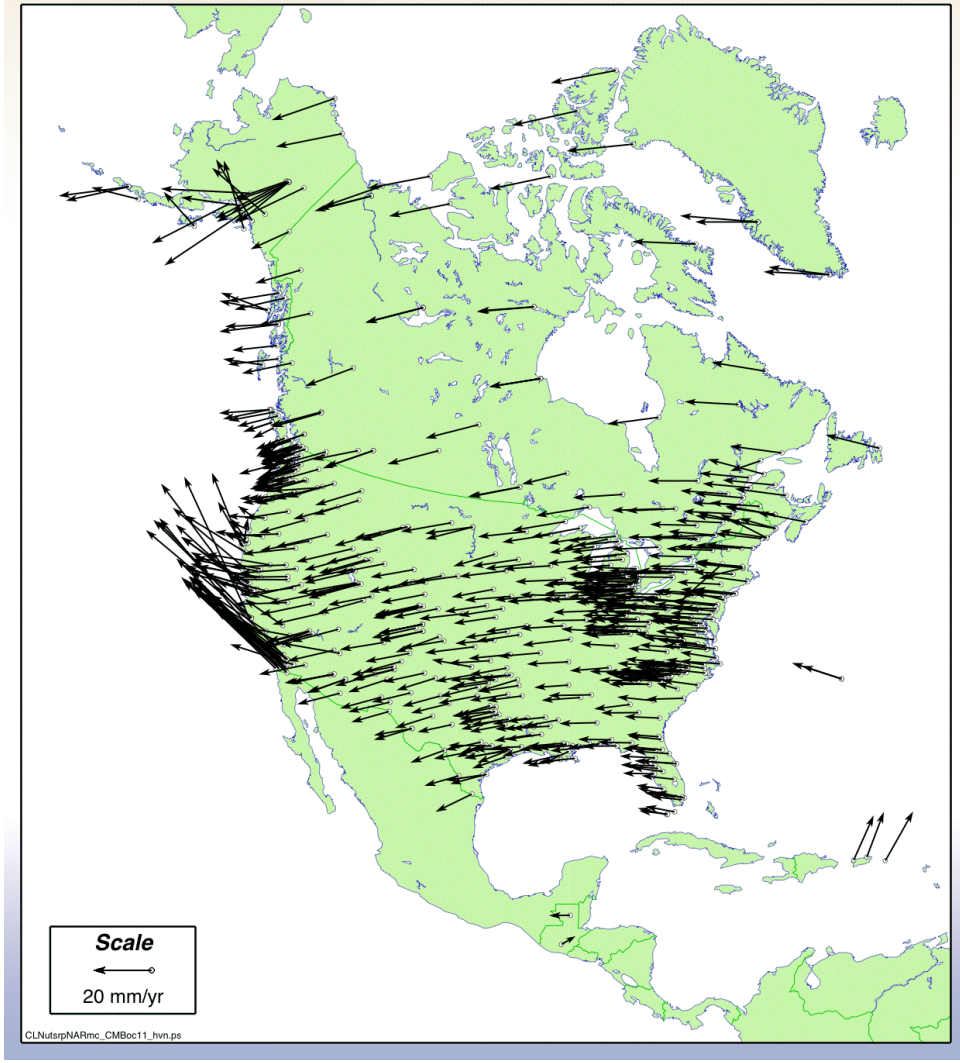
Canada

Weekly Combination Procedure

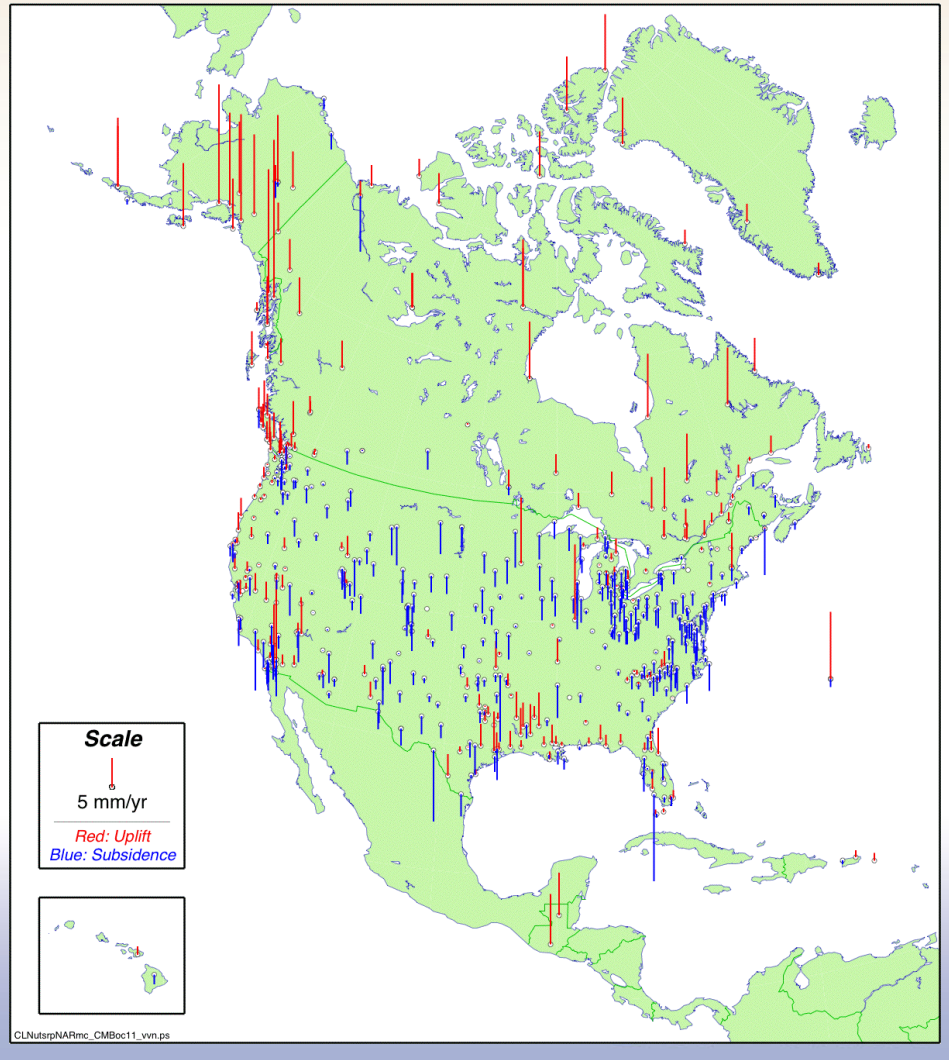


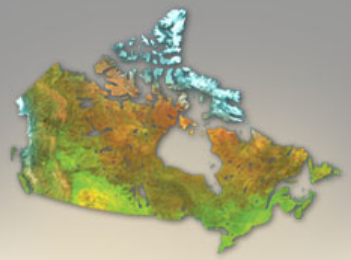
NAREF Velocity Field (Wk 1399)

Horizontal



Vertical

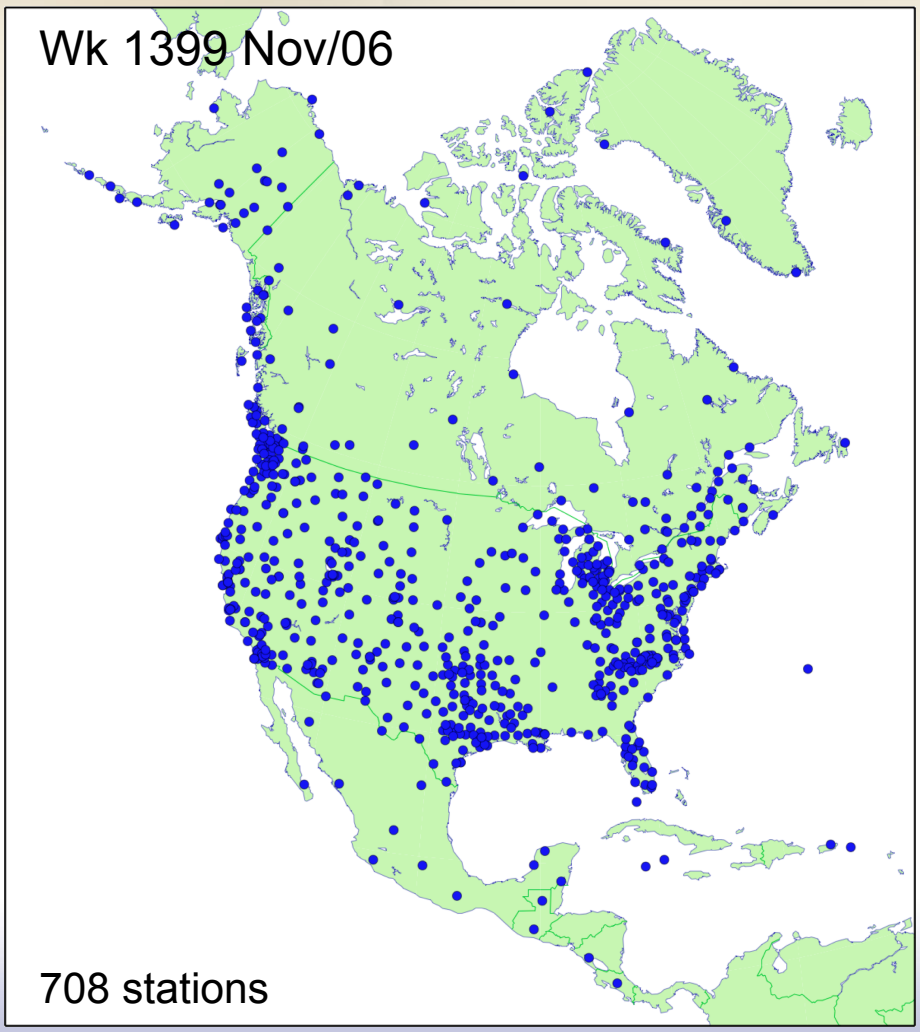


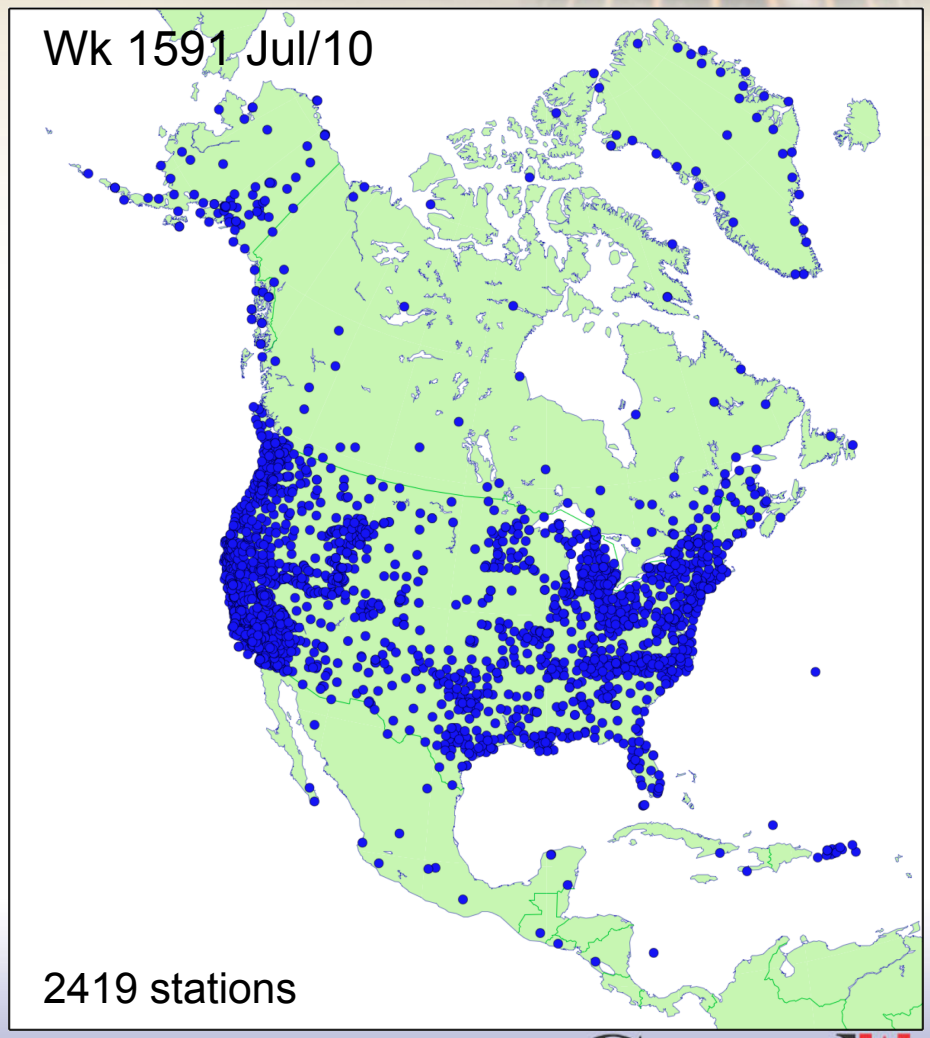


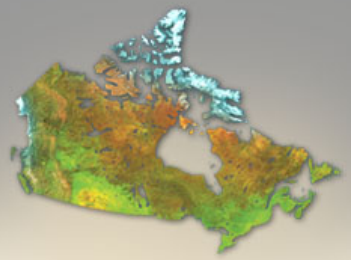
Current NAREF Status & Plans

- **Solutions since GPS week 1400**
  - Many more stations included (>2400 for wk 1591 Jul/10 – see plot)
    - *More stations with redundant solutions*
    - SOPAC solution expanded to cover all N.A.
  - Included more global sites for improved reference frame realization
  - Using absolute antenna phase center offsets (APCO's)
- **Combinations of regional solutions on hold since wk 1513**
  - Too many stations (2000+) for combination software to handle
  - Remi Ferland currently enhancing SINEX combination software
    - Dynamic memory allocation
    - Faster LAPACK matrix library
- **Will resume combinations in early 2011**

Current NAREF Network

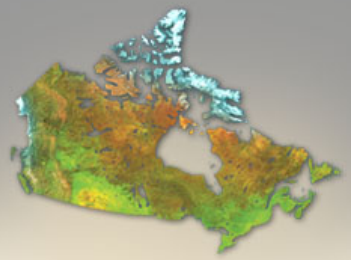






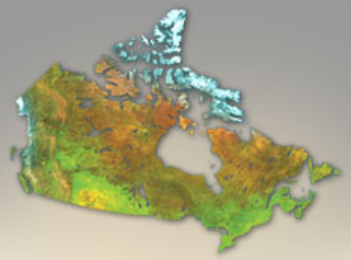
Current Status & Plans (con't)

- **Reprocessing all data before GPS week 1400**
  - Using IGS repro1 orbits and APCO's
  - Including data back to ~1996 for US CORS sites
  - Added more global sites to improve reference frame realization
- **NGS & SOPAC completed regional reprocessing during global Repro1 solutions for IGS**
  - NGS also computed a velocity field based on their solutions
  - See Griffiths et al. (this session)
- **Other contributors still reprocessing – using fixed IGS orbits**
  - NRCan/GSD (Bernese; GIPSY being replaced by PPP solutions)
  - NRCan/PGC
  - MIT (PBO Analysis Centers)



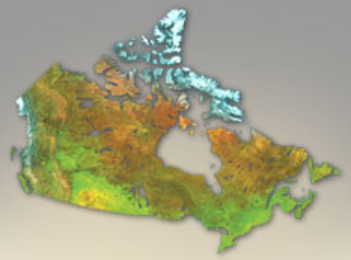
Current Status & Plans (con't)

- **Automated detection of time series discontinuities**
  - Too many stations to visually inspect each time series for offsets
  - NGS investigated different approaches for automated detection
  - Results reported in Griffiths et al. (this session)



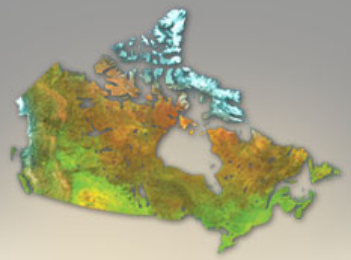
WG2 – SNARF
Stable North American Ref. Frame

- **Objective**
  - Define a reference frame that represents the stable interior of North America (plate-fixed)
  - To facilitate inter-comparison & geophysical interpretation of intra-plate motions for EarthScope/PBO studies in U.S.
- **SNARF v1.0 – released 2006 –** ***still used for PBO***
  - Aligned to IGb00 reference frame
  - Fixed to stable part of N.A. using Euler rotation
  - SNARF positions and velocities at PBO sites
  - Also generated a GIA model with estimated velocities at PBO sites
- **SNARF v2.0 –** ***never materialized***
  - Updated solutions using data to week 1399
  - Was supposed to be aligned to IGS05



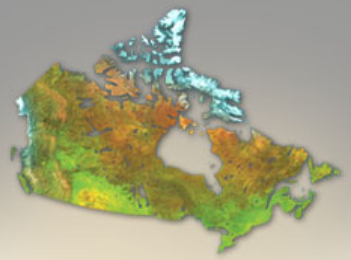
WG3
Reference Frame Transformations

- **Objective**
  - To determine consistent relationships between international, regional and national reference frames, and to update these relationships as needed
- **NAD83-ITRF relationship**
  - NAD83 still the official geometric reference frame for Can & US
  - Defined by 14-parameter transformation from ITRF (since 1998)
    - 7-parameter transformation w.r.t. ITRF96
    - Updated to other ITRF's using published IERS transformations with respect to ITRF96
    - NNR NUVEL-1A used to align frame with N.A. (biased ~ 2 mm/y)
  - *Transformation recently updated to ITRF2008*



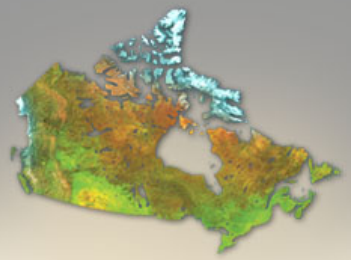
New WG for 2011 ITRF-Based NAD20xx

- **Objective**
  - Define and implementation an ITRF-based geocentric reference frame to replace NAD83
  - NAD83 is non-geocentric (offset ~2 m from ITRF)
- **Definition of Frame**
  - Considering either a global and plate-fixed frame – haven't decided yet
  - Must consider impact on general user community, esp. mapping & GIS
- **Implementation**
  - US NGS 10 year plan to modernize its spatial reference system
    - Discussions began May 2010 – US Federal Geospatial Summit
    - Planning to implement new frame around 2020+
  - Canada has no official plans yet to replace NAD83 but will enable users to use new system if they wish



For More Information

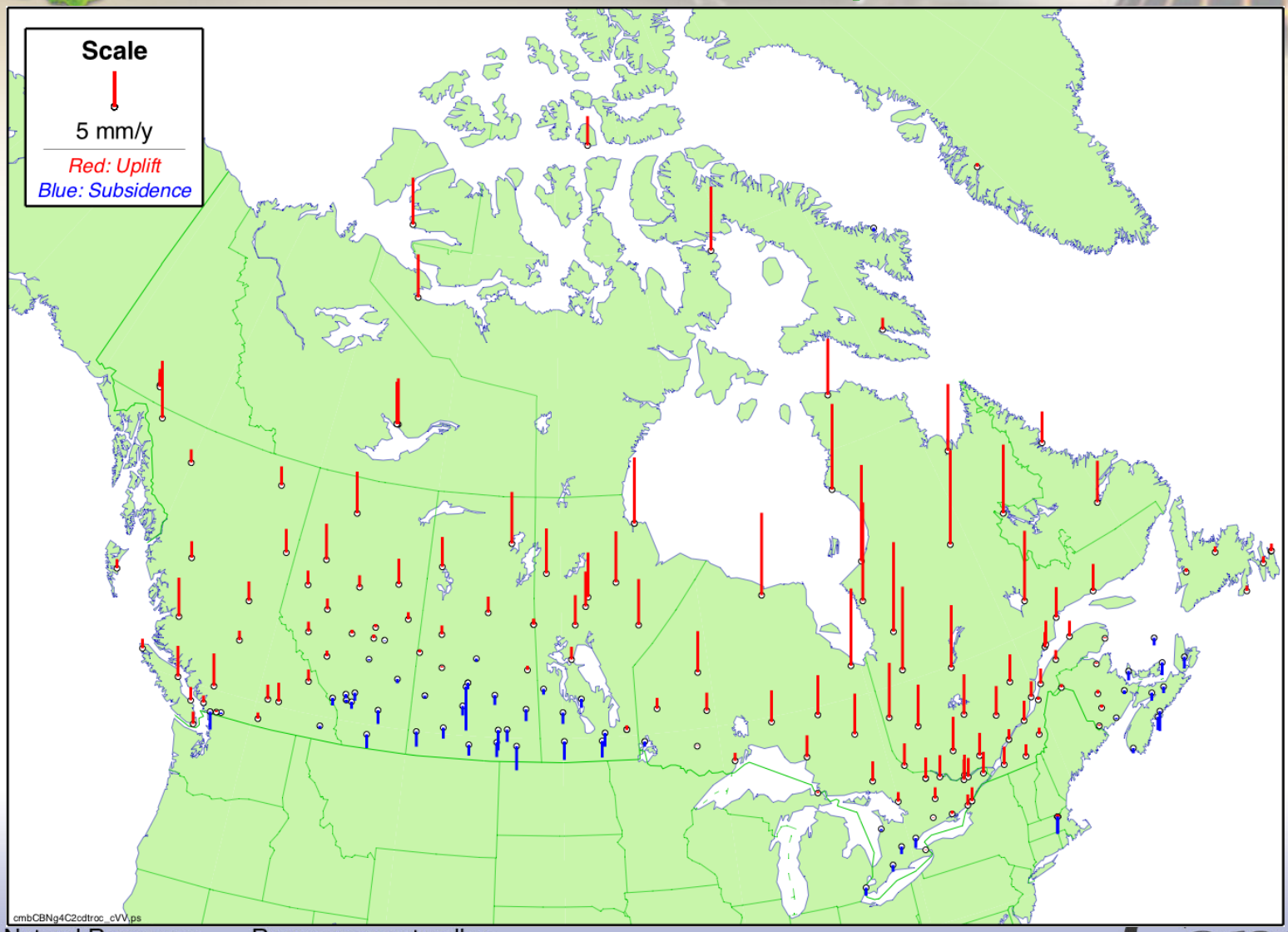
www.naref.org



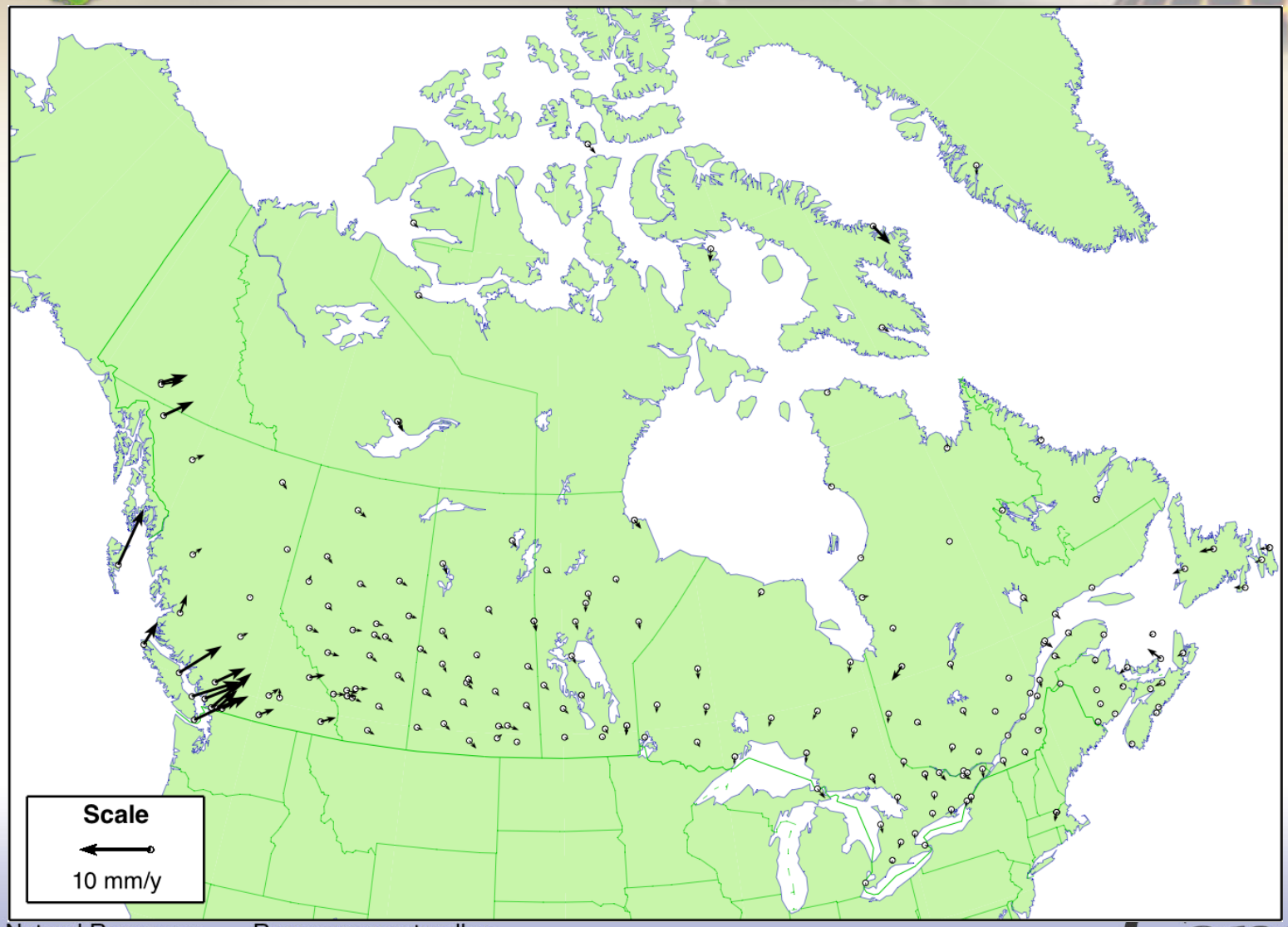
Canadian Base Network

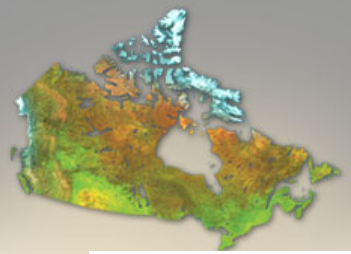
- **Canadian Base Network (CBN)**
  - Network of stable pillars across Canada
  - Occupied with GPS every 4-5 years since 1994-99
  - 4-th campaign 2010/11
- **Velocity field**
  - Primarily based on main campaign surveys:
    1994-1999
    2001-2002
    2005-2006
  - Some other smaller campaigns also included (27 total)
- **Combined with NAREF velocity field**
  - Used to densify the NAREF network in Canada

NAREF+CBN Velocity Field - Vert

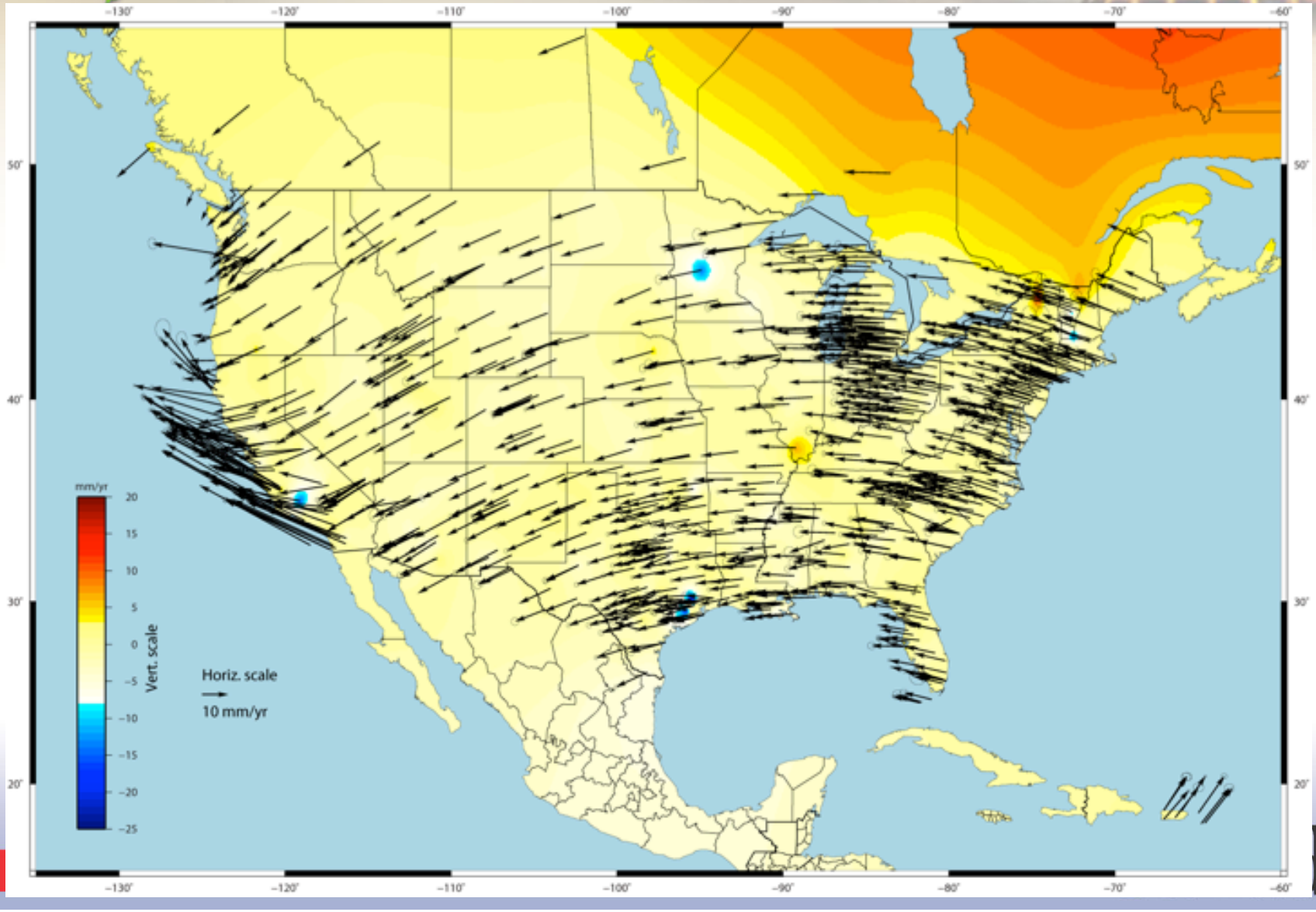


NAREF+CBN Velocity Field - Horz





NGS Velocity Field (Griffiths et al.)



SNARF v1.0 GIA Model