Evolving Beyond NAD 83

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
National Ocean Service
National Geodetic Survey

Positioning America for the Future

Natural Resources Canada

Ressources naturelles Canada

North American Datum of 1983 (NAD 83)

* NAD 83 is the legal reference system in the United States, Canada, Greenland, and in several Caribbean and Central American countries. (Mexico uses the ITRS.)

* National Geodetic Survey is responsible agency in the U.S.

* Natural Resources Canada is responsible agency in Canada.

NAD 83

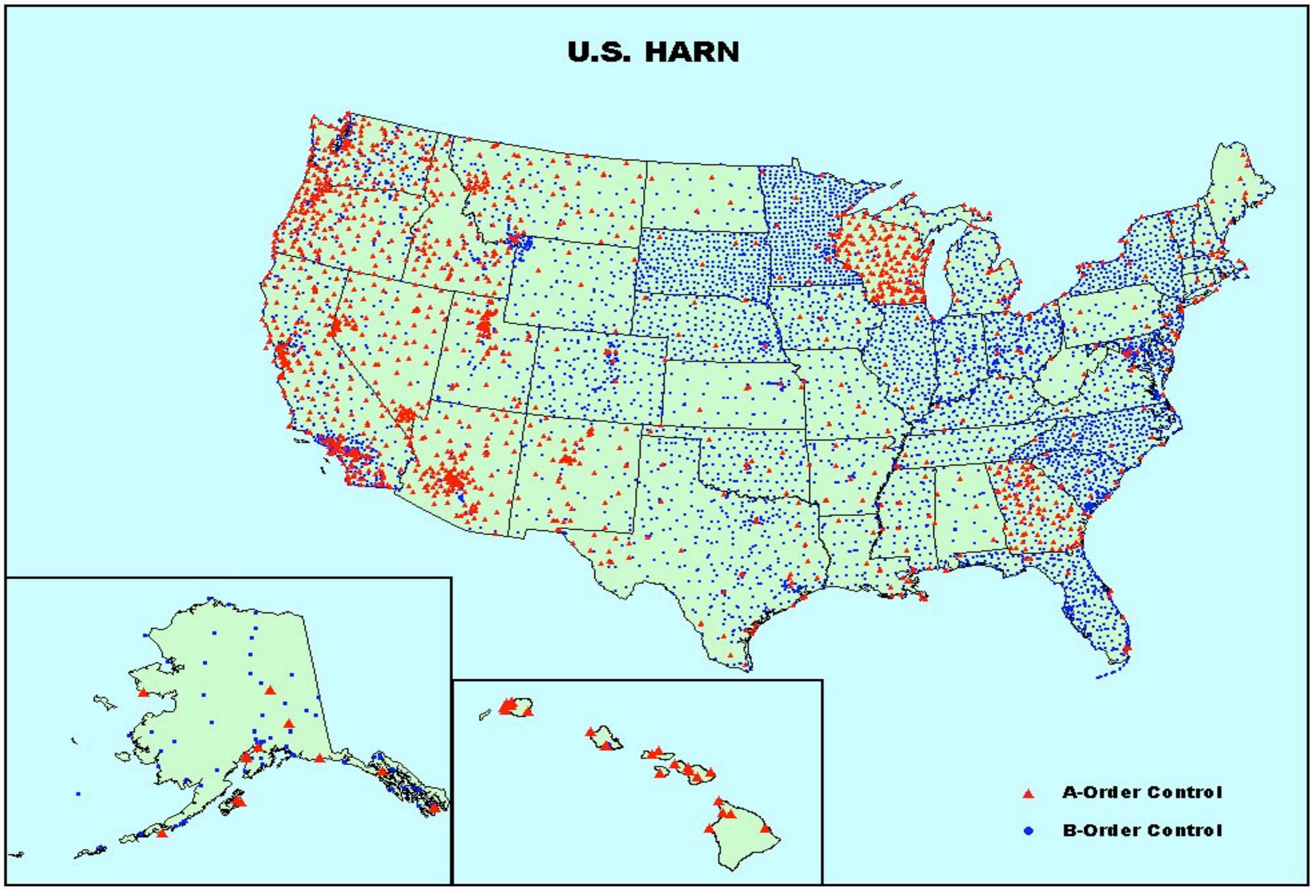
- Originally, NAD 83 was mostly a horizontal reference system as defined by the latitudes and longitudes of reference stations positioned by triangulation and/or trilateration. (The U.S. contains over 250,000 horizontal reference stations.)

- NAD 83 has evolved to a 3-D reference system, thanks to GPS. (The U.S. contains over 60,000 reference stations positioned by GPS.)

IMPROVING POSITIONAL ACCURACY

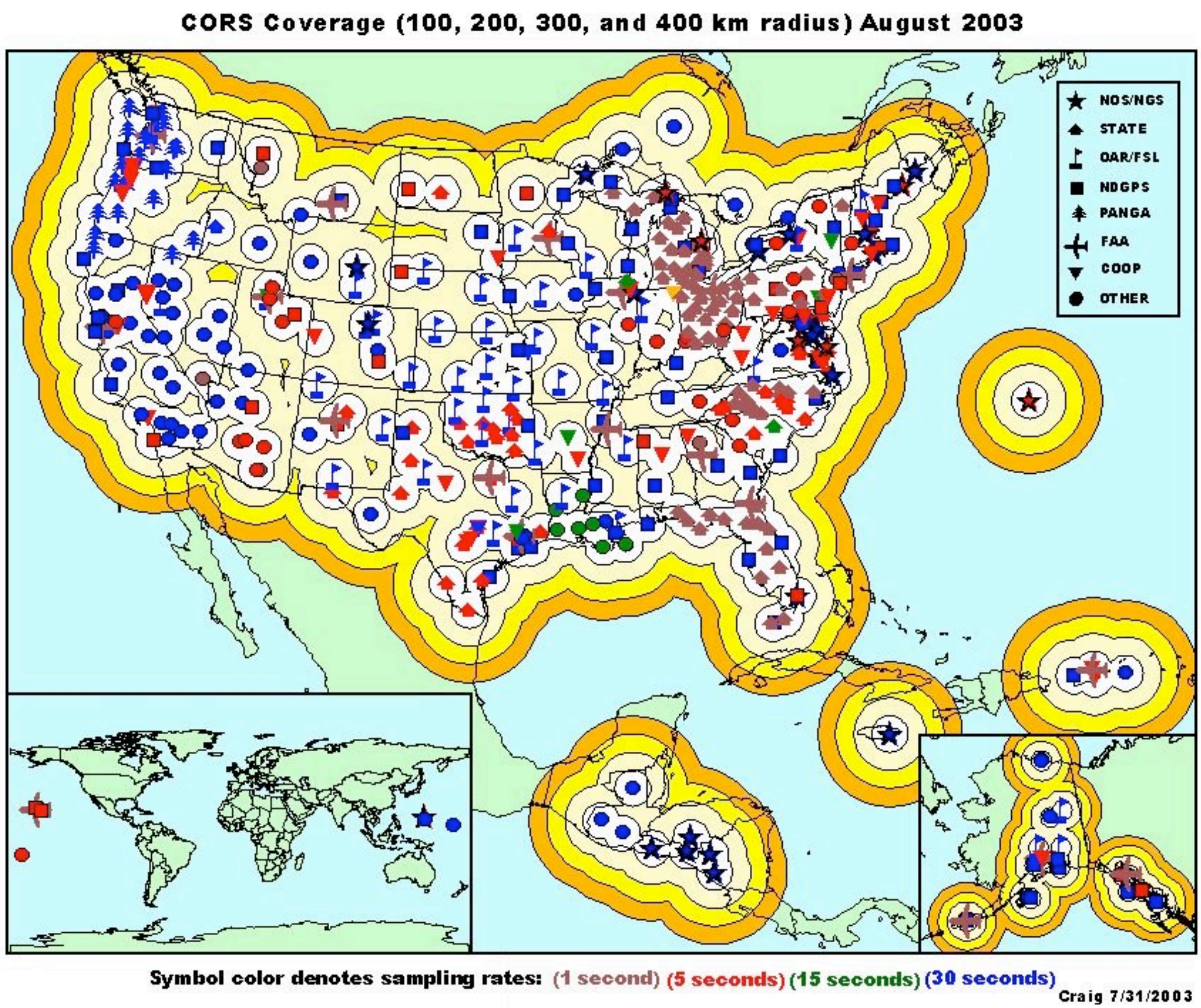
REFERENCE FRAME	TIME SPAN	NETWORK ACCURACY	LOCAL ACCURACY
NAD 27	1927-1986	10 Meters	First-Order (1 part in 0.1 million)
NAD 83(1986) NAD 83(Original)	1986-1990	1 Meter	First-Order (1 part in 0.1 million)
NAD 83(HARN)	1987-1997	0.1 Meter	B-Order (1 part in 1 million) A-Order (1 part in 10 million)
NAD 83(CORS) NAD 83(CSRS)	1994 -	< 0.01 Meter - Horizontal < 0.02 Meter - Ellipsoid Height	

HIGH ACCURACY REFERENCE NETWORKS (HARN)

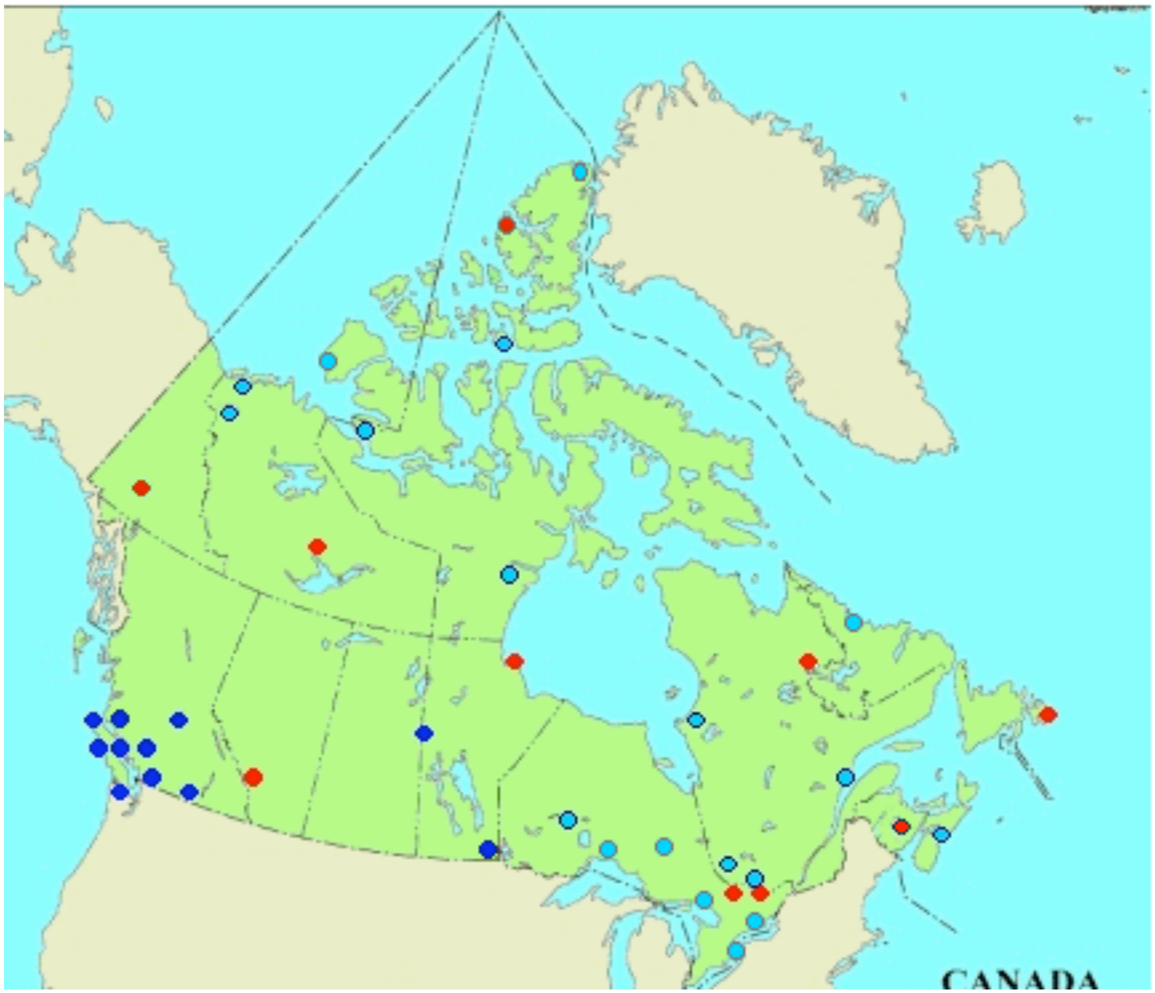


Canadian Base Network (CBN)

Continuously Operating Reference Stations



Canadian Active Control Network (CACS)



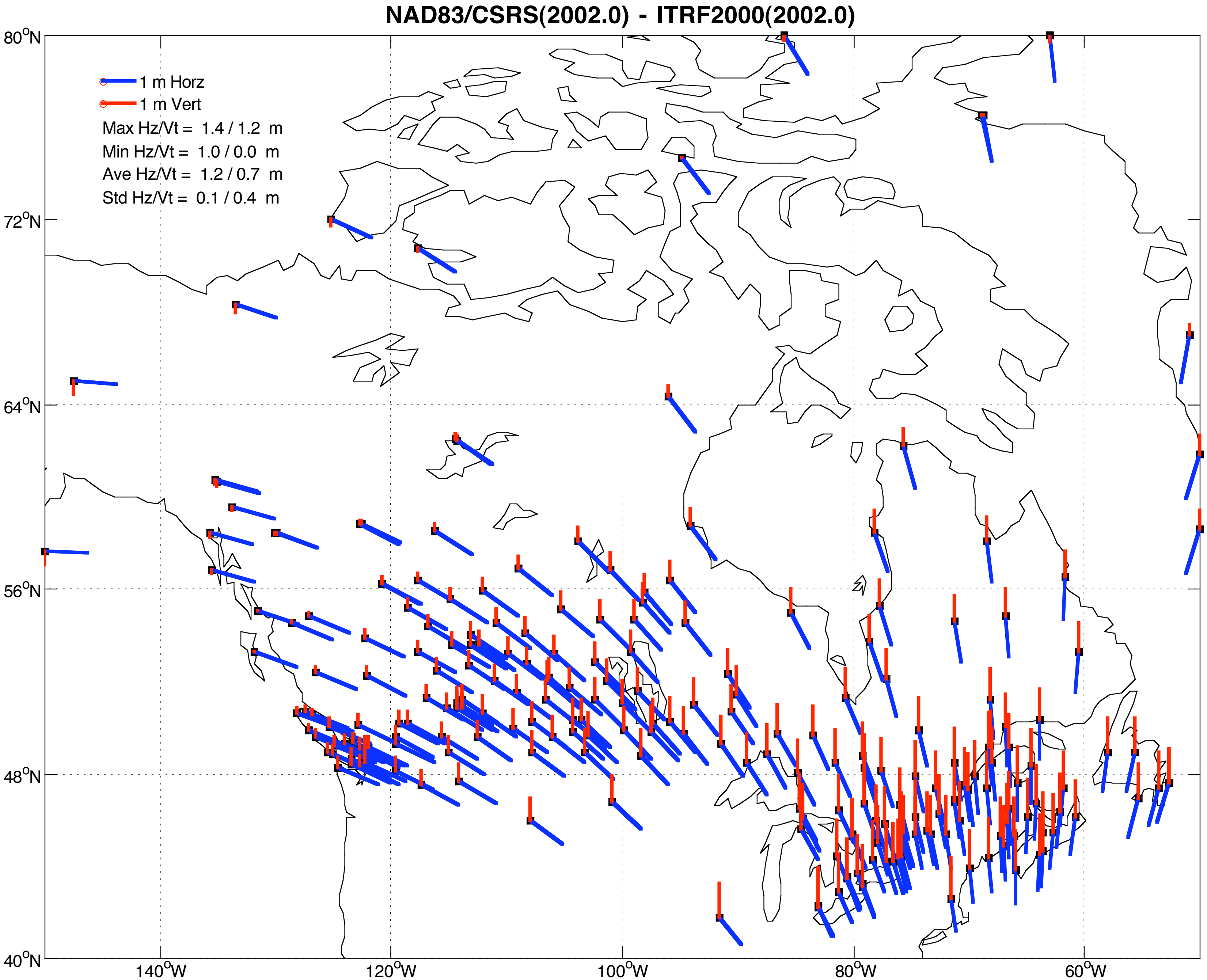
◆ GSD tracking sites ◆ GSC tracking sites ◆ Regional tracking sites

North American Datum of 1983

* Origin is located about 2 meters from Earth's center.

* Orientation of axes differs from current international standard.

* Scale has been changed to agree with current international standard.


NAD83/CSRS(2002.0) - ITRF2000(2002.0)
1 m Horz
1 m Vert
Max Hz/Vt = 1.4 / 1.2 m
Min Hz/Vt = 1.0 / 0.0 m
Ave Hz/Vt = 1.2 / 0.7 m
Std Hz/Vt = 0.1 / 0.4 m
80°N
72°N
64°N
56°N
48°N
40°N
140°W
120°W
100°W
80°W
60°W

Current definition of NAD 83

- The current realization of NAD 83 is called NAD 83 (CORS96) in the U.S. and NAD 83 (CSRS) in Canada.

- This realization is defined in terms of a 14-parameter Helmert transformation from ITRF00.

- This transformation is a composite of three separate transformation:

  ITRF00→ITRF97→ITRF96→NAD 83 (CORS96)

Reference Frame Transformation

$$x_{NAD} = T_x + (1+S)Xx_{ITRF} + R_zXy_{ITRF} - R_yXz_{ITRF}$$

$$y_{NAD} = T_y - R_zXx_{ITRF} + (1 + S)Xy_{ITRF} + R_xXz_{ITRF}$$

$$z_{NAD} = T_z + R_yXx_{ITRF} - R_xXy_{ITRF} + (1 + S)Xz_{ITRF}$$

The ITRF96→NAD 83 (CORS96) transformation was defined so that:

- ITRF96 coordinates of 12 VLBI stations located in North America map onto their corresponding NAD 83 coordinates.
- Scale of NAD 83 = Scale of ITRF96 at epoch 1997.0.
- The mapping of horizontal velocities from ITRF96 to NAD 83 is consistent with the NUVEL1A-NNR model.
- The origin of NAD 83 does not drift relative to the origin of ITRF96.
- The scale of NAD 83 does not change in time relative to the scale of ITRF96.

Transformation Parameters
ITRF96 --> NAD_83

Translations: $T_x = 0.9910$ meters
$T_y = -1.9072$ meters
$T_z = -0.5129$ meters

Rotations: $R_x = [25.79 + 0.0532X(t - 1997.0)]Xk$ radians
$R_y = [9.65 - 0.7423X(t - 1997.0)]Xk$ radians
$R_z = [11.66 - 0.0316X(t - 1997.0)]Xk$ radians

Scale change: $S = 0.0$ (unitless)

Transformation Parameters ITRF00 --> NAD_83

Translations: $T_x = 0.9956 + 0.0007 \cdot (t - 1997.0)$ meters

$T_y = -1.9013 - 0.0007 \cdot (t - 1997.0)$ meters

$T_z = -0.5215 + 0.0005 \cdot (t - 1997.0)$ meters

Rotations: $R_x = [25.915 + 0.067 X (t - 1997.0)] X k$ radians

$R_y = [9.426 - 0.757 X (t - 1997.0)] X k$ radians

$R_z = [11.599 - 0.051 X (t - 1997.0)] X k$ radians

Scale change: $S = 0.62 - 0.18 \cdot (t - 1997.0)$ ppb

Transforming Positions

• Use HTDP (US) or TRNOBS (CA) software to
  transform positions between reference frames
  and from one epoch to another

* HTDP = Horizontal Time-Dependent Positioning
  Available at http://www.ngs.noaa.gov
  Click on "Geodetic Tool Kit", then on "HTDP"
* TRNOBS = Transformation of Obervations & Coords
  Available at http://www.geod.nrcan.gc.ca

* HTDP can also be used to predict horizontal velocities

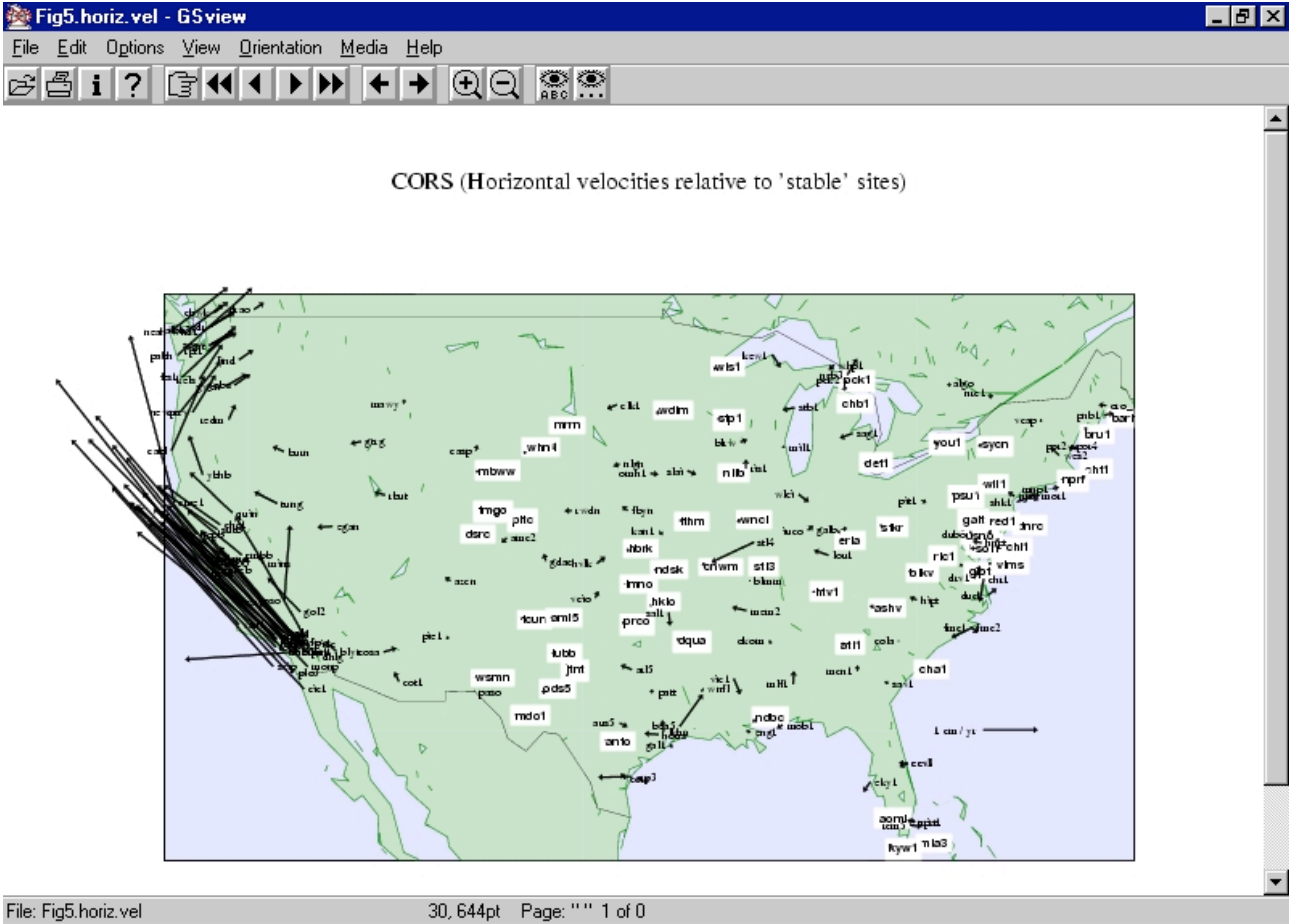


Fig5.horiz.vel - GSview
File Edit Options View Orientation Media Help
CORS (Horizontal velocities relative to 'stable' sites)
1 cm / yr
File: Fig5.horiz.vel
30, 644pt Page: "" 1 of 0

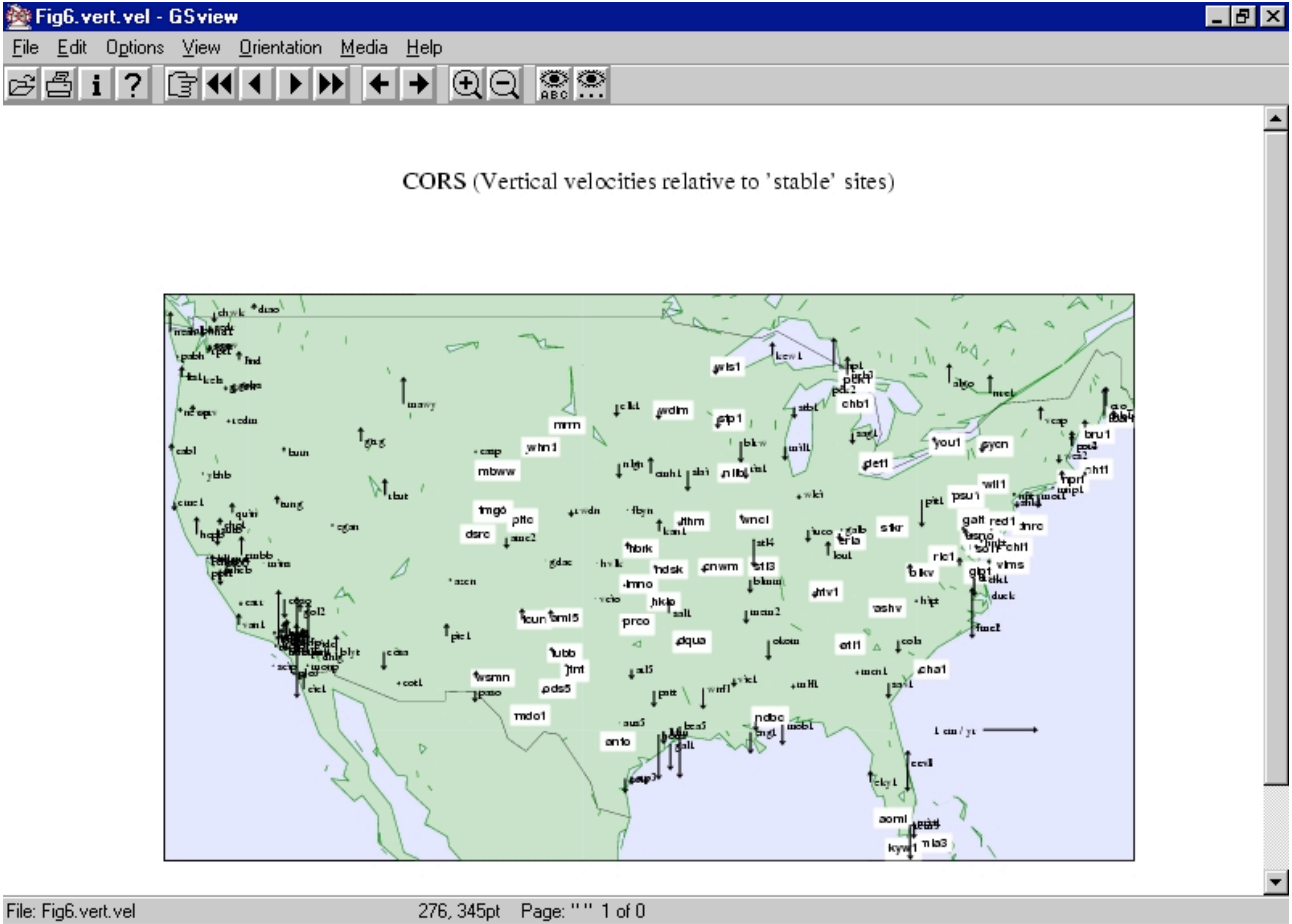


Fig6.vert.vel - GSview
File Edit Options View Orientation Media Help
CORS (Vertical velocities relative to 'stable' sites)
1 cm / yr
File: Fig6.vert.vel
276, 345pt Page: "" 1 of 0

Towards a Stable Reference System for Expressing 3-D motion

- We defined this stable reference frame by constraining our solution to maximize the number of stations whose horizontal velocities are less than 1 mm/yr and whose vertical velocities are less than 2 mm/yr in magnitude.

Towards a Stable Reference System for Expressing 3-D motion

- Our approach provides a mathematical-statistical basis for defining stability.

- The results of our approach depend upon the sample of reference stations. A sample of reference stations located exclusively in Canada or Mexico would likely yield a different concept for stable North America.

How do we define a stable reference system for North America?

- Is there a geophysical basis for defining stability? (plate tectonics for horizontal motion; what if anything for vertical motion?)

- Are current plate motion models biased by the horizontal motion associated with glacial isostatic adjustment (a.k.a., postglacial rebound)?

- What about fluid withdrawal, seismic deformation, magmatic processes, sediment compaction, crustal loading/unloading, erosion, hydrological effects, seasonal effects, geocenter motion, etc.?