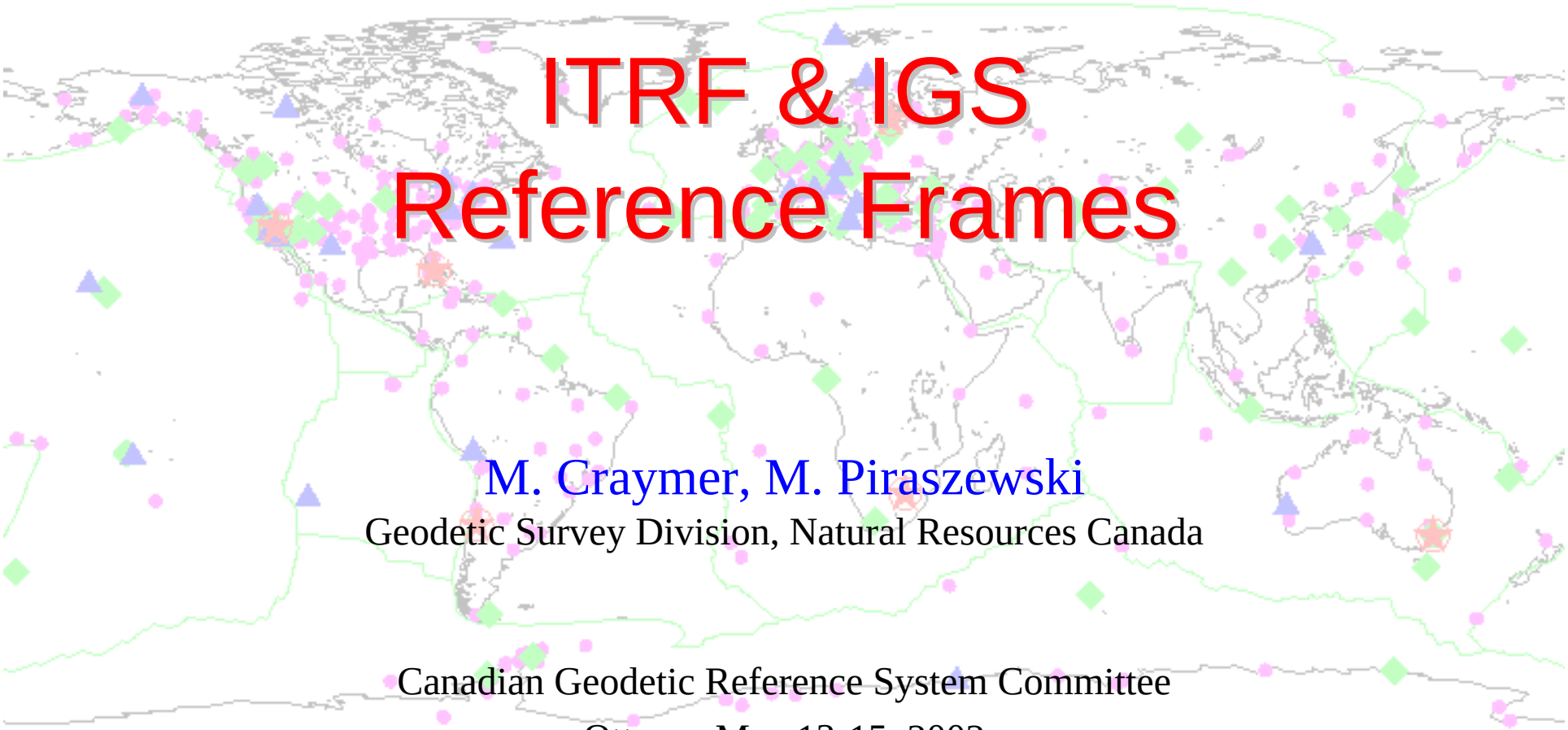


ITRF & IGS Reference Frames

M. Craymer, M. Piraszewski
Geodetic Survey Division, Natural Resources Canada

Canadian Geodetic Reference System Committee
Ottawa, May 13-15, 2002

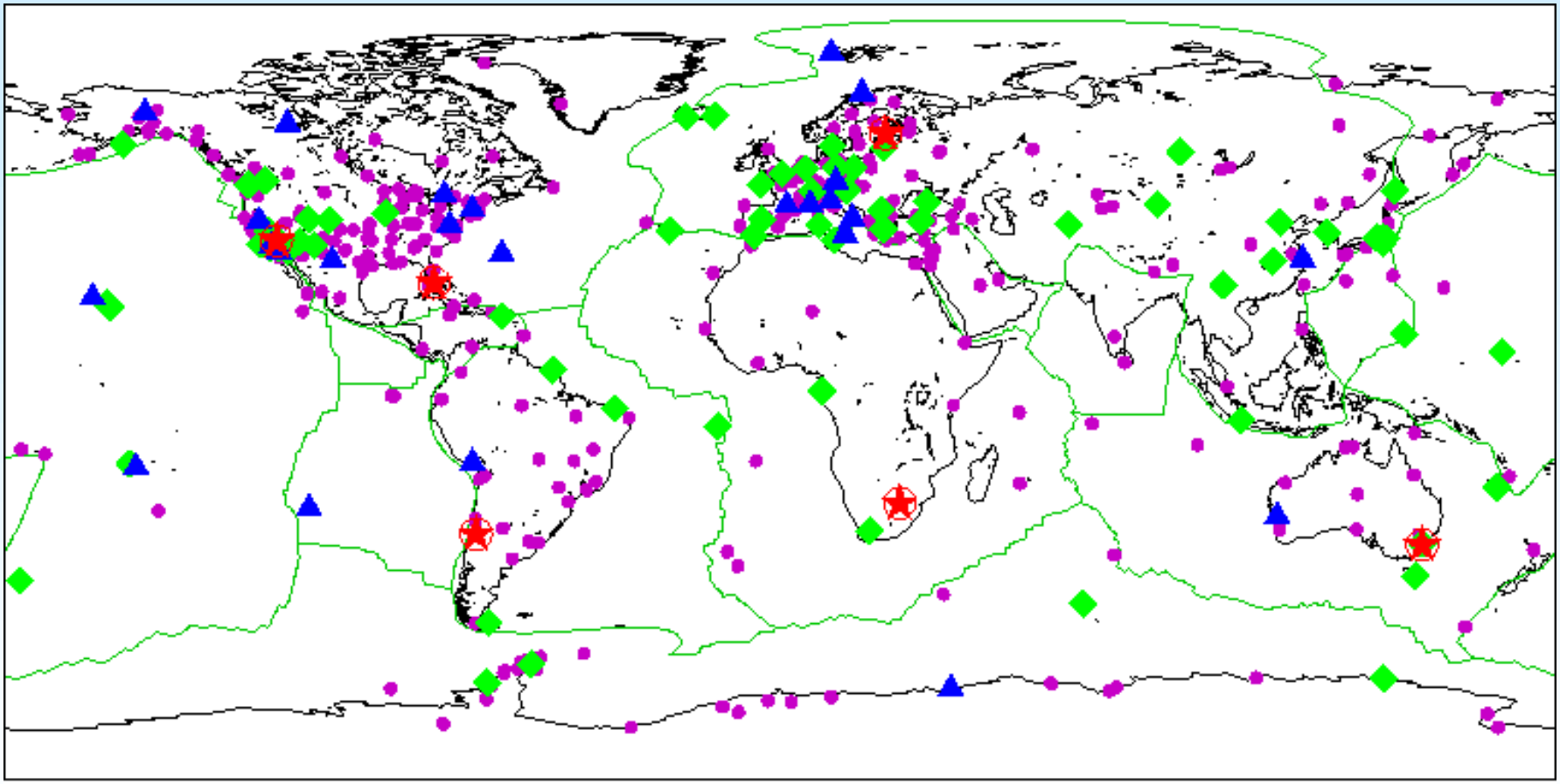
ITRF 2000

- Introduced in 2001
- Includes data up to November 2000
- Two parts
  - Primary combination (global)
  - Densification solutions integrated in a second step
- Incorporates solutions for different techniques
  - VLBI (3) LLR (2) SLR (10)
  - GPS (6) DORIS (3) SLR+DORIS (2)
  - Densification solutions (12): e.g., CORS, SIRGAS, EUREF, ...

ITRF 2000 (con't)

- Datum definition
  - Scale — Wtd average of VLBI & SLR
  - Origin — Wtd average of SLR
  - Orientation — ITRF97 at 1997.0
    No net rotation w.r.t. NNR-NUVEL1A
  - Based on "best" 54 sites
    - At least 3 yrs continuous observations
    - Located on rigid tectonic plates away from plate boundaries
    - Std deviation of velocity estimates < 3 mm/y
    - Residuals of velocity estimates < 3 mm/y

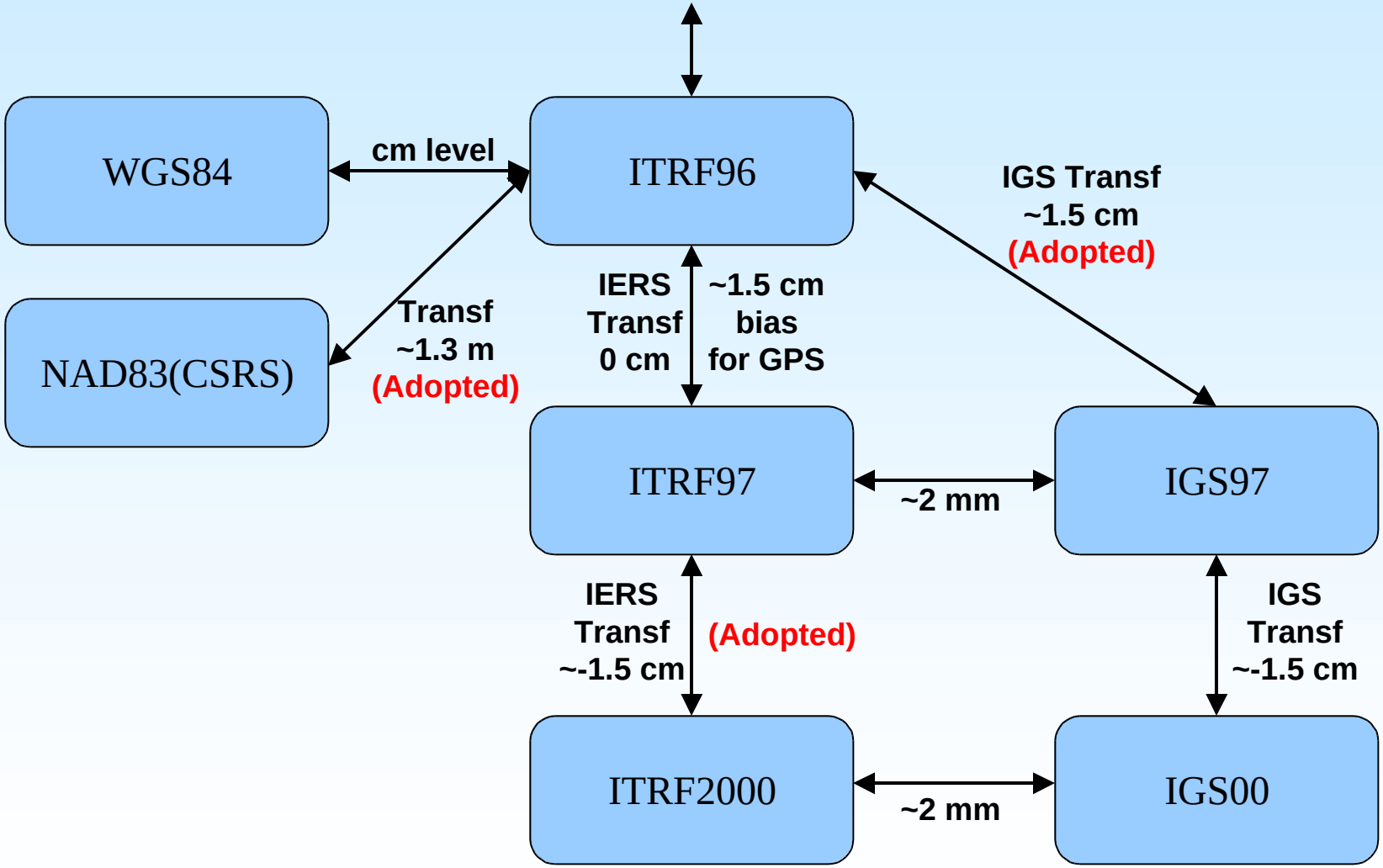
Primary ITRF Sites



IGS 00

- Adopted Dec 2, 2001
- All IGS products now in this system
- Continuation of IGS 97
  - Based cumulative solution IGS01P37 (2001 week 37)
  - Realigned to ITRF 2000 using 54 “best” stations
  - Ensures better internal consistency among time series of IGS products
- Consistent with ITRF 2000 at 2 mm level

Differences & Transformations



Transformations

ITRF97 to ITRF2000 **Epoch 01-JAN-1998**

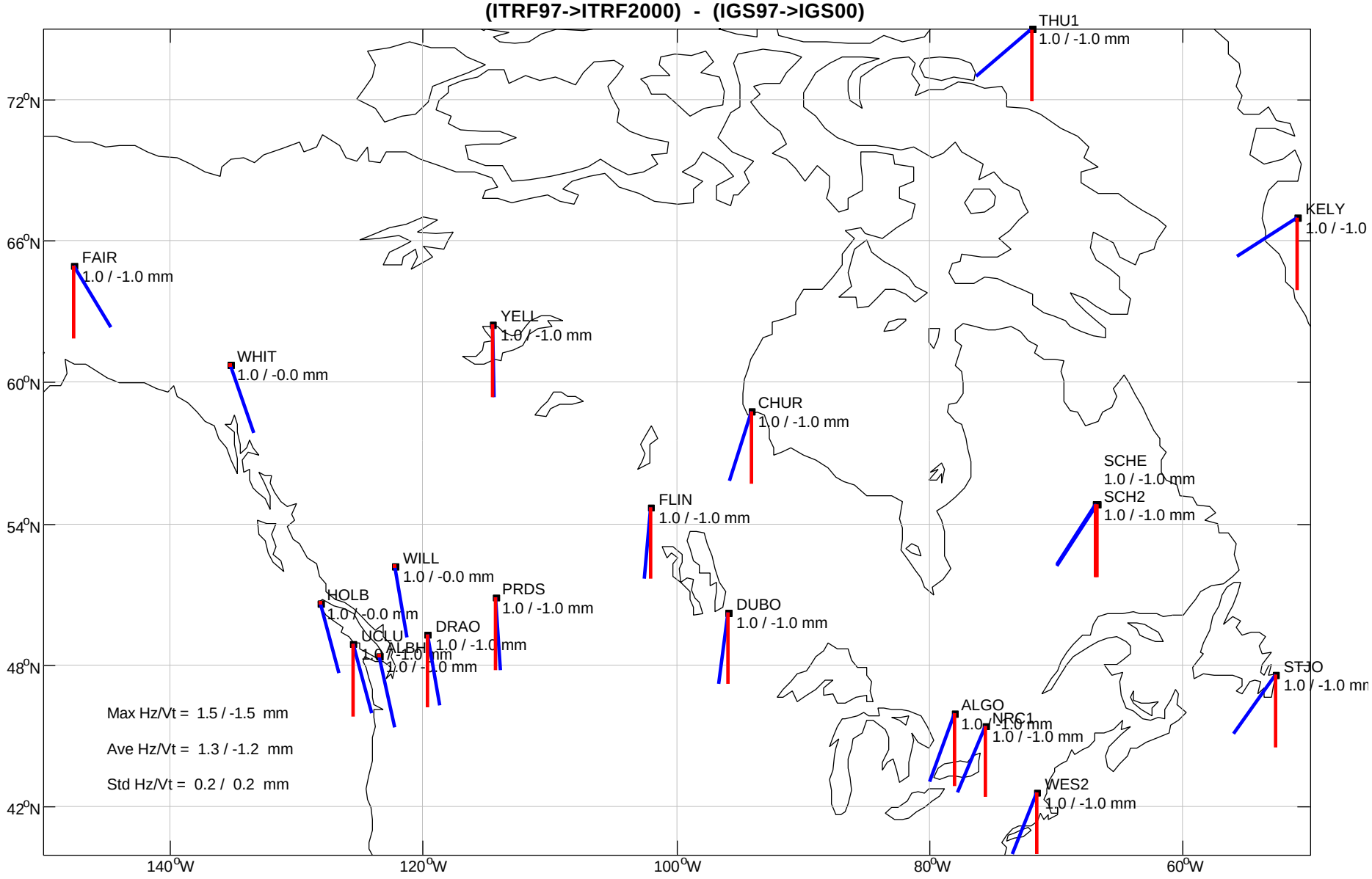
	TX mm	TY mm	TZ mm	RX mas	RY mas	RZ mas	D ppb
Offset	-6.7	-5.5	19.9	0.00	0.00	-0.02	-1.56

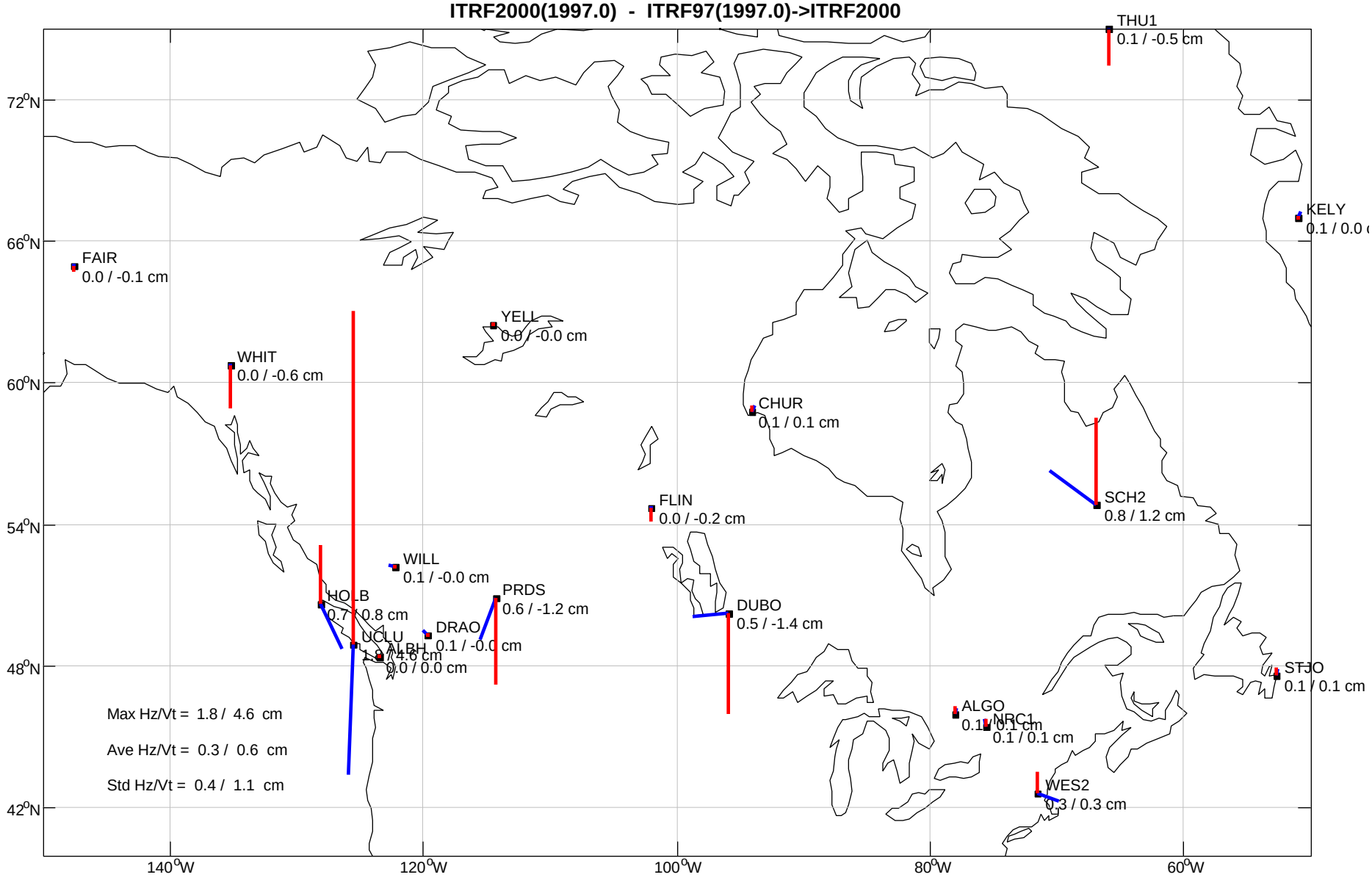
	dTX mm/y	dTY mm/y	dTZ mm/y	dRX mas/y	dRY mas/y	dRZ mas/y	dD ppb/y
Drift	0.0	0.6	1.4	0.00	0.00	-0.02	-0.01

IGS(ITRF97) to IGS(ITRF2000) **Epoch 01-JAN-1998**

	TX mm	TY mm	TZ mm	RX mas	RY mas	RZ mas	D ppb
Offset	-6.0	-5.6	20.1	-0.040	0.001	-0.043	-1.403
+/-	2.5	3.3	5.1	.053	.060	.036	.12

	dTX mm/y	dTY mm/y	dTZ mm/y	dRX mas/y	dRY mas/y	dRZ mas/y	dD ppb/y
Drift	0.4	0.8	1.5	0.004	-0.001	-0.030	-0.012
+/-	1.7	1.9	2.8	.038	.040	.034	.12


(ITRF97->ITRF2000) - (IGS97->IGS00)
THU1
1.0 / -1.0 mm
KELY
1.0 / -1.0
FAIR
1.0 / -1.0 mm
YELL
1.0 / -1.0 mm
WHIT
1.0 / -0.0 mm
CHUR
1.0 / -1.0 mm
SCHE
1.0 / -1.0 mm
SCH2
1.0 / -1.0 mm
FLIN
1.0 / -1.0 mm
WILL
1.0 / -0.0 mm
PRDS
1.0 / -1.0 mm
HOLB
1.0 / -0.0 mm
DUBO
1.0 / -1.0 mm
DRAO
1.0 / -1.0 mm
UCLU
1.0 / -1.0 mm
ALBH
1.0 / -1.0 mm
STJO
1.0 / -1.0 mm
ALGO
1.0 / -1.0 mm
NRC1
1.0 / -1.0 mm
WES2
1.0 / -1.0 mm
Max Hz/Vt = 1.5 / -1.5 mm
Ave Hz/Vt = 1.3 / -1.2 mm
Std Hz/Vt = 0.2 / 0.2 mm
72°N
66°N
60°N
54°N
48°N
42°N
140°W
120°W
100°W
80°W
60°W


ITRF2000(1997.0) - ITRF97(1997.0)->ITRF2000
THU1
0.1 / -0.5 cm
KELY
0.1 / 0.0
FAIR
0.0 / -0.1 cm
YELL
0.0 / -0.0 cm
WHIT
0.0 / -0.6 cm
CHUR
0.1 / 0.1 cm
SCH2
0.8 / 1.2 cm
FLIN
0.0 / -0.2 cm
WILL
0.1 / -0.0 cm
HOLB
0.7 / 0.8 cm
PRDS
0.6 / -1.2 cm
DUBO
0.5 / -1.4 cm
DRAO
0.1 / -0.0 cm
UCLU
1.8 / 4.6 cm
ALBH
0.0 / 0.0 cm
STJO
0.1 / 0.1 cm
ALGO
0.1
NRC1
0.1 cm
0.1 / 0.1 cm
WES2
0.3 / 0.3 cm
Max Hz/Vt = 1.8 / 4.6 cm
Ave Hz/Vt = 0.3 / 0.6 cm
Std Hz/Vt = 0.4 / 1.1 cm
72°N
66°N
60°N
54°N
48°N
42°N
140°W
120°W
100°W
80°W
60°W

ITRF/IGS Densification

- NAREF densification in North America
- Objectives
  - Combine regional solutions throughout North America
  - Generate weekly coordinate solutions
  - Generate cumulative solutions with velocities
- Standards
  - State-of-the-art methods (following IGS and EUREF example)
  - Fixed IGS precise orbits
  - Each solution tied to at least 3 IGS stations

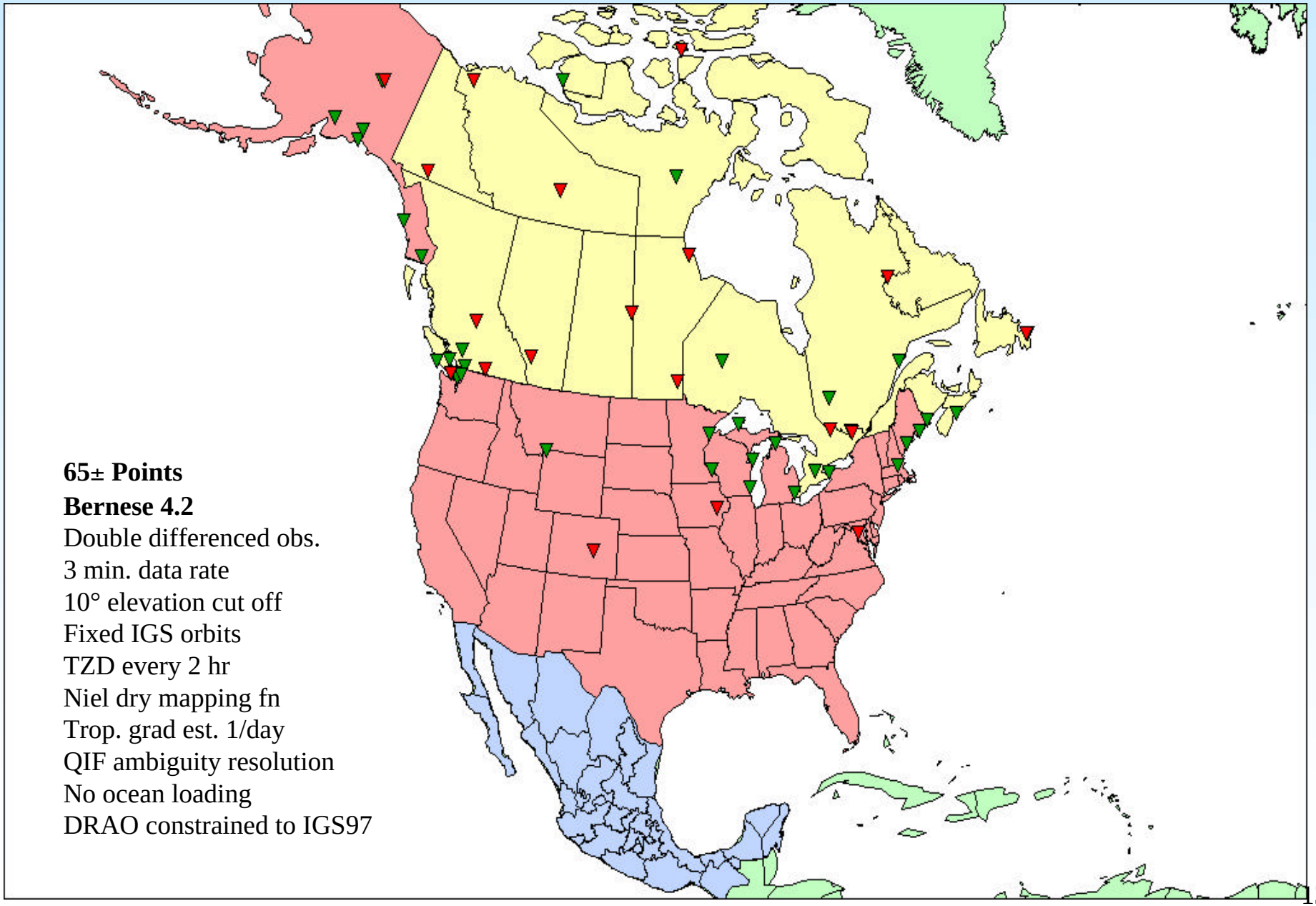
Problems

- Regional solutions
  - From independent organization
  - Limited resources
  - Objectives different from NAREF
  - Difficult to impose standards
- Uneven coverage & redundancy
  - Some stations in all solutions
  - Many stations in only one solution
  - Causes uneven weighting of stations in combinations

Contributors

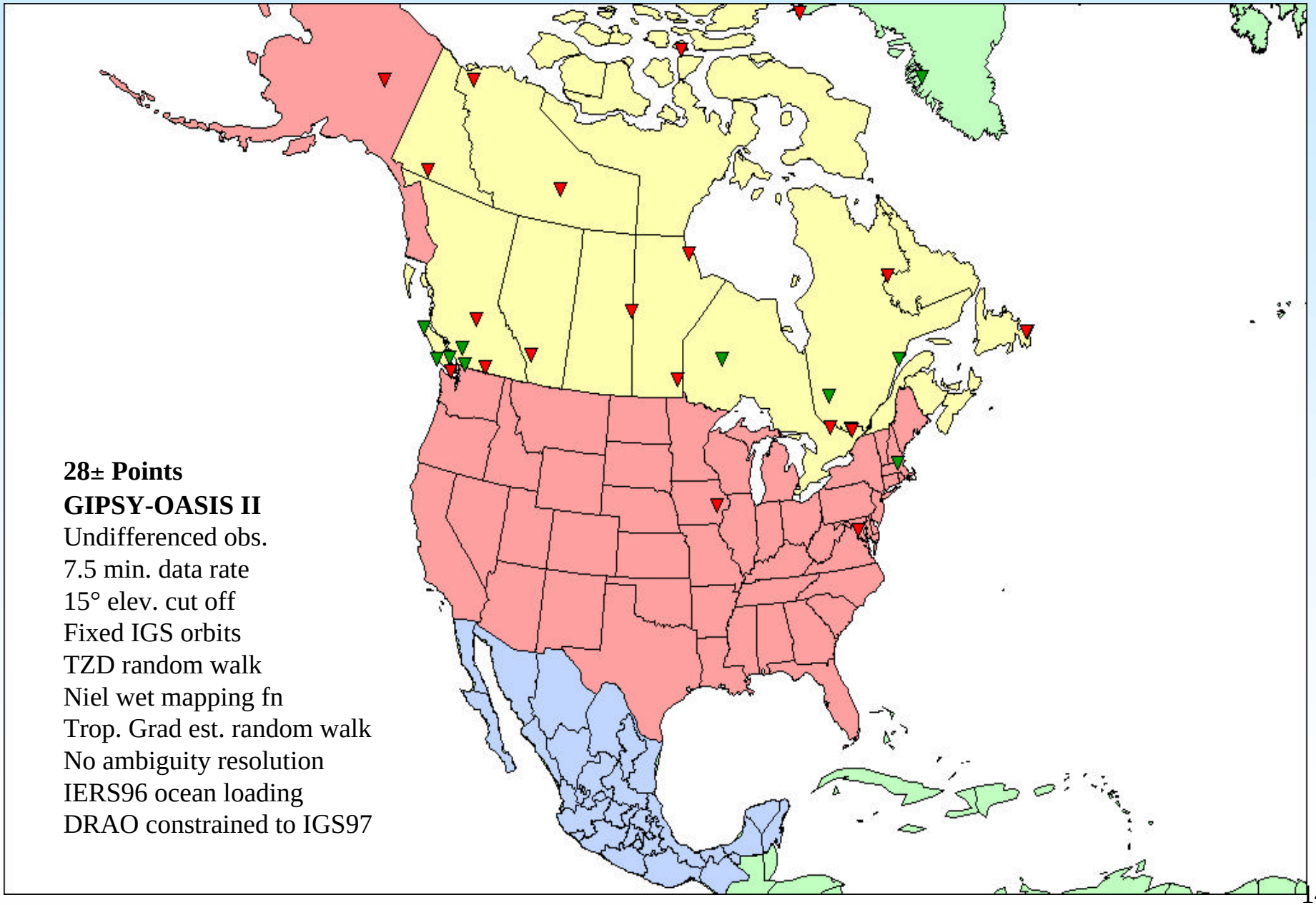
- Currently 4 solutions since beginning 2001
  - ✓ GSD Bernese regional network
  - ✓ GSD GIPSY regional network
  - ✓ PGC Western Canada Deformation Array
  - ✓ SIO Plate Boundary Observatory
  - ✘ Removed BC ACS and Quebec DGPS networks
- Need more for U.S. and Mexico
  - ➢ CORS network (over 200 points)
  - ➢ Mexican permanent network (about 10 points)

GSD Bernese Regional Network (GSB)



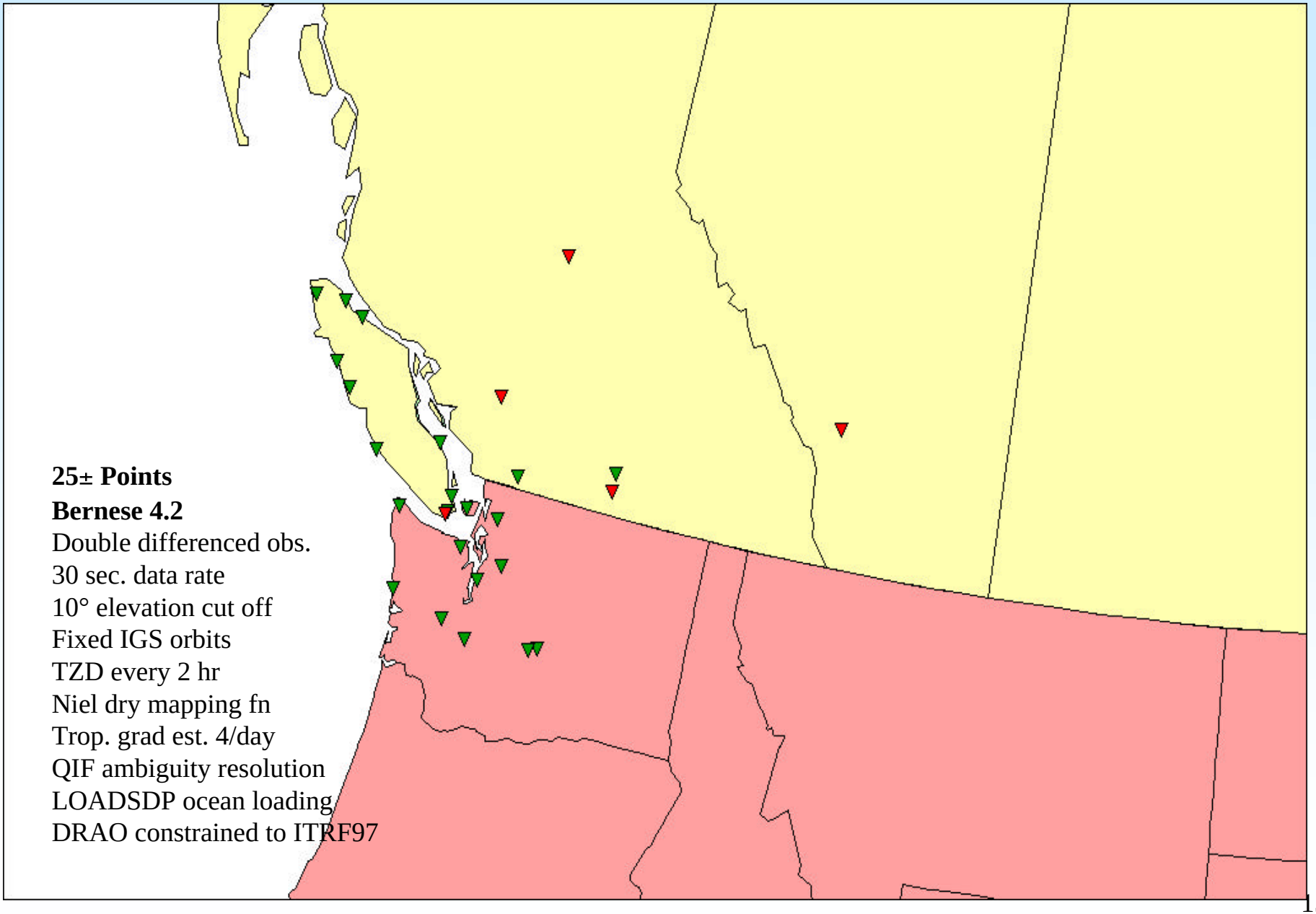
65± Points
Bernese 4.2
Double differenced obs.
3 min. data rate
10° elevation cut off
Fixed IGS orbits
TZD every 2 hr
Niel dry mapping fn
Trop. grad est. 1/day
QIF ambiguity resolution
No ocean loading
DRAO constrained to IGS97

GSD GIPSY Regional Network (GSG)

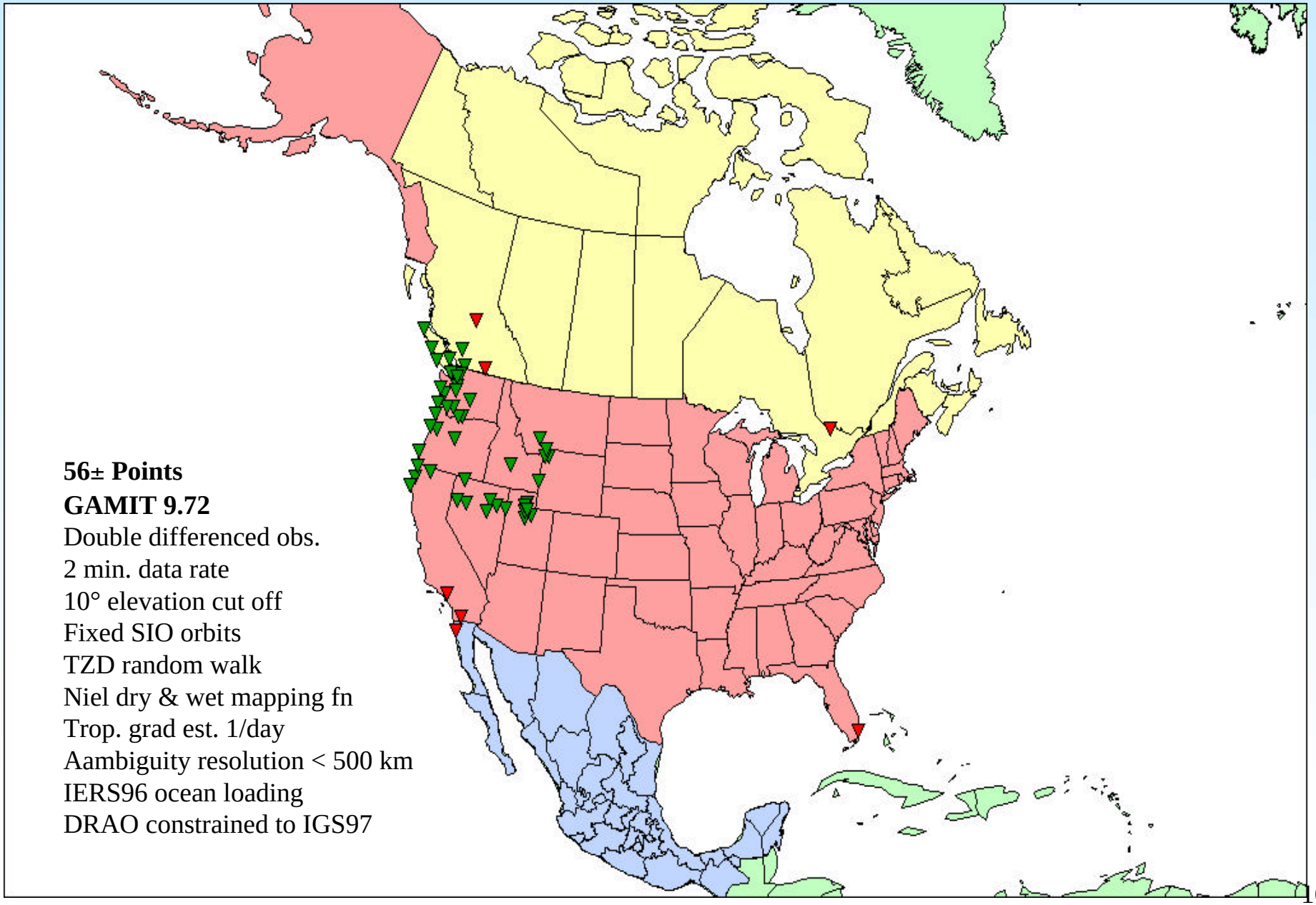


28± Points
GIPSY-OASIS II
Undifferenced obs.
7.5 min. data rate
15° elev. cut off
Fixed IGS orbits
TZD random walk
Niel wet mapping fn
Trop. Grad est. random walk
No ambiguity resolution
IERS96 ocean loading
DRAO constrained to IGS97

PGC Western Canada Deformation Array (WCDA)

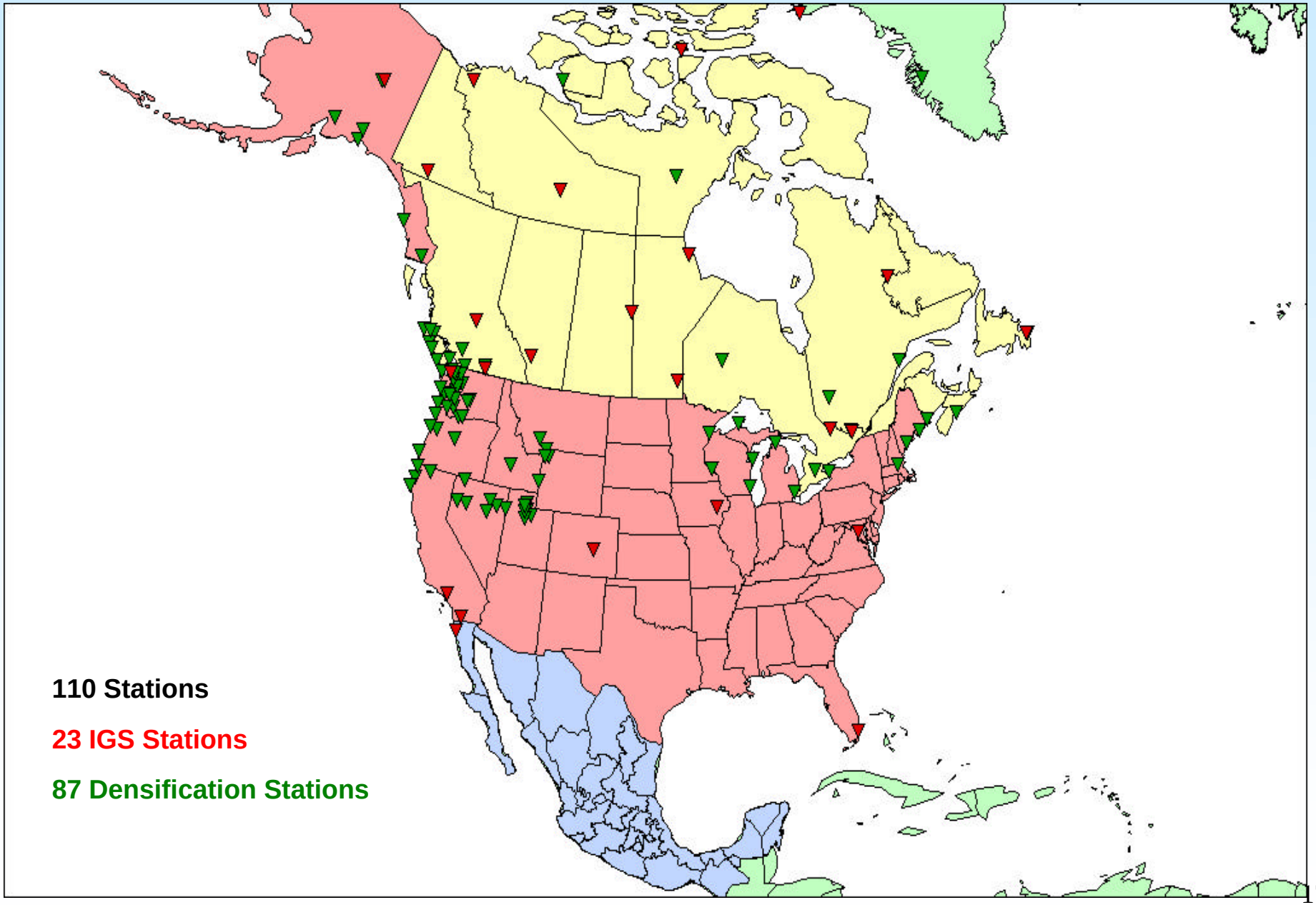


SIO Plate Boundary Observatory (PBO)



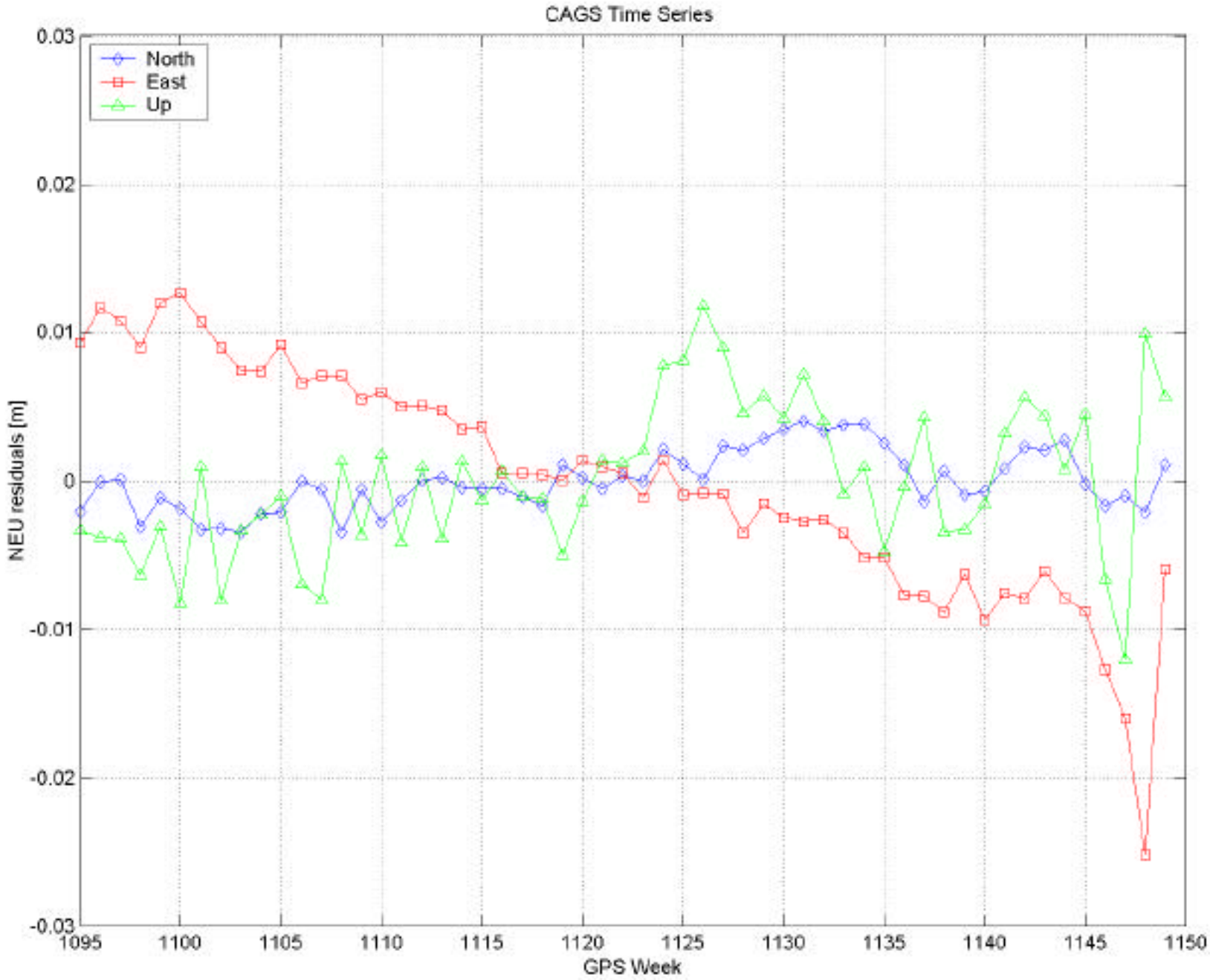
56± Points
GAMIT 9.72
Double differenced obs.
2 min. data rate
10° elevation cut off
Fixed SIO orbits
TZD random walk
Niel dry & wet mapping fn
Trop. grad est. 1/day
Aambiguity resolution < 500 km
IERS96 ocean loading
DRAO constrained to IGS97

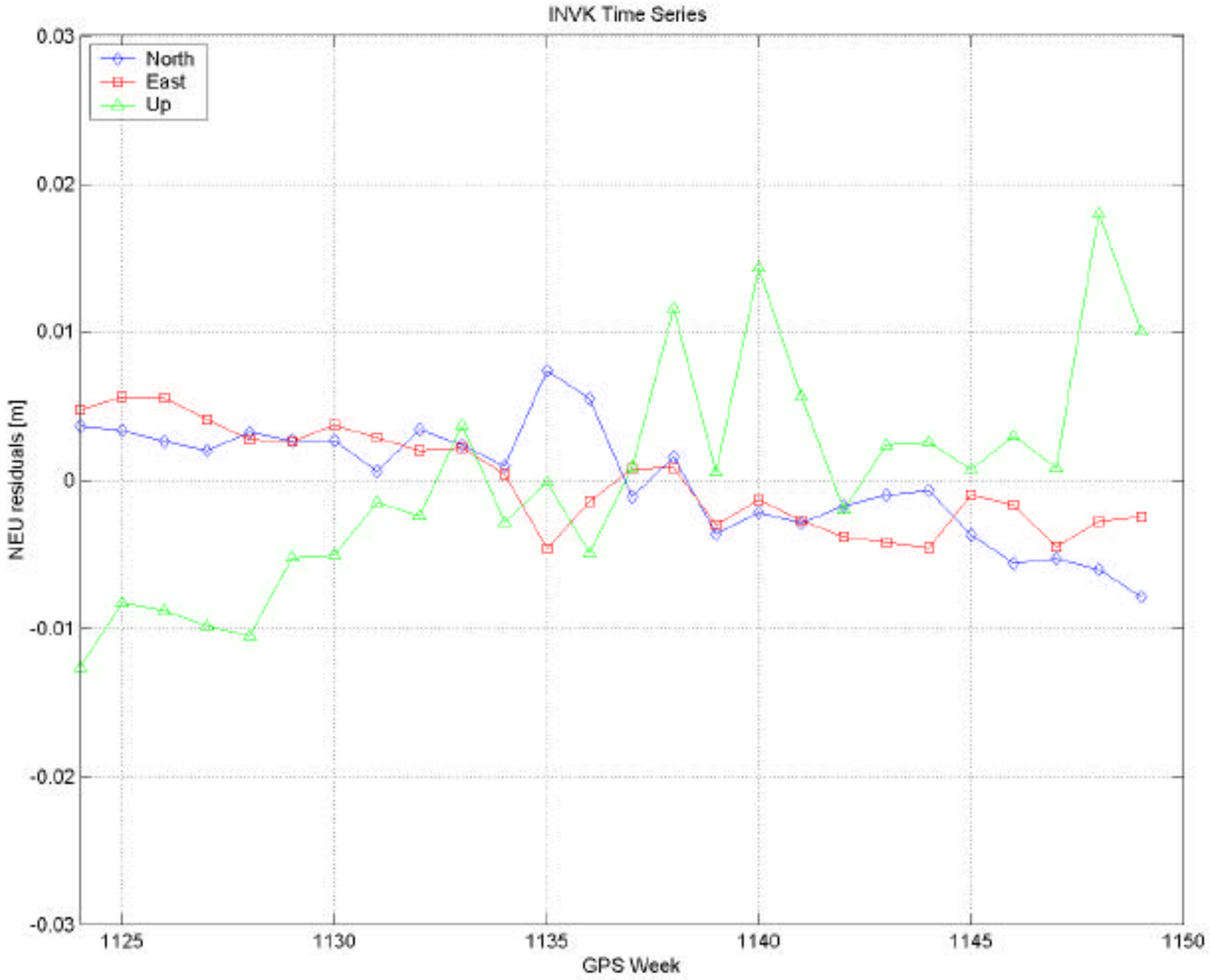
NAREF Combined Densification Network



Combination/Integration

- Combination
  - Align each regional solution with IGS weekly solution
  - Combine as weighted position observations (summation of normals)
- Integration into IGS network
  - Use IGS weekly solutions as weighted constraints
- Software
  - Using Remi Ferland's SINEX Software
  - Linux bug limits size of regional networks


CAGS Time Series
North
East
Up
NEU residuals [m]
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
1095
1100
1105
1110
1115
1120
1125
1130
1135
1140
1145
1150
GPS Week


INVK Time Series
North
East
Up
NEU residuals [m]
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
1125
1130
1135
1140
1145
1150
GPS Week

Future Work

- Incorporate other regional networks
  - OSU/NGS Great Lakes CORS (21 stations) – in progress
  - GPS at Arctic Tide Gauges (4 stations) – Summer 2002
  - ➤NGS National CORS network (hundreds) – soon??
  - Mexican national CORS (about 10 stations) – ??
- Software enhancements
- Cumulative solutions for velocity estimation

International Earth Rotation Service

- IERS Products
  - International Celestial Reference Frame (ICRF)
  - ➢International Terrestrial Reference Frame (ITRF)
  - Earth orientation information/data
- Components
  - Technique Centers
  - Product Centers
  - Combination Centers
  - Analysis Coordinator
  - Central Bureau
  - Directing Board

ITRS Combination Center

- Responsibilities
  - Provide ITRF products
  - Combine ITRF output from “Technique Centers”; e.g., IVS, IGS, IGEX, ILRS
- GSD invited to become a Combination Center
  - Remi Ferland, Project Leader
- Other Combination Centers
  - IGN
  - DGFI

Tasks

- Organization
  - Define the scope and organizational aspects with IERS
  - Define roles and responsibilities of GSD personnel
- Methodology & Software
  - Methodologies to be determined with CRC
  - Develop/enhance necessary software
  - Enhance current SINEX format for non-GPS techniques
- Implementation