

# Reference Frames National

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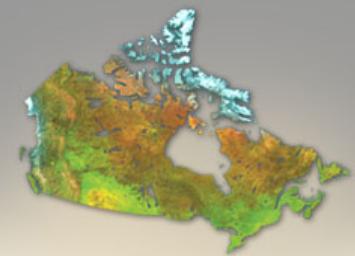
Canadian Geodetic Reference  
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Natural Resources  
Canada

Ressources naturelles  
Canada

Canada



# Outline

- National
  - NAD83(CSRS) realizations
  - New NAD83 v6
- Velocity Model
  - Velocity grid generation
  - Version numbering
  - Future improvements
  - Issues



## NAD83 Realizations

- Details provided in comments of CACS coordinate files on CGRSC FTP site

Version (epoch)	Frame	Adopted	Description
v0	Original	1986-1993	Horizontal adjustments
v1 (1988.0)	CSRS96	1996	Transformed from ITRF??, limited use
v2 (1997.0)	CSRS98*	1998	Transformed from ITRF96
v3 (1997.0)		2000	Transformed from ITRF97
v4 (2002.0)		2002	Transformed from ITRF2000
v5 (2006.0)		2009	Transformed from ITRF2005

\* Adopted ITRF-NAD83 transformation (CSRS98=CSRS)



## NAD83 v6

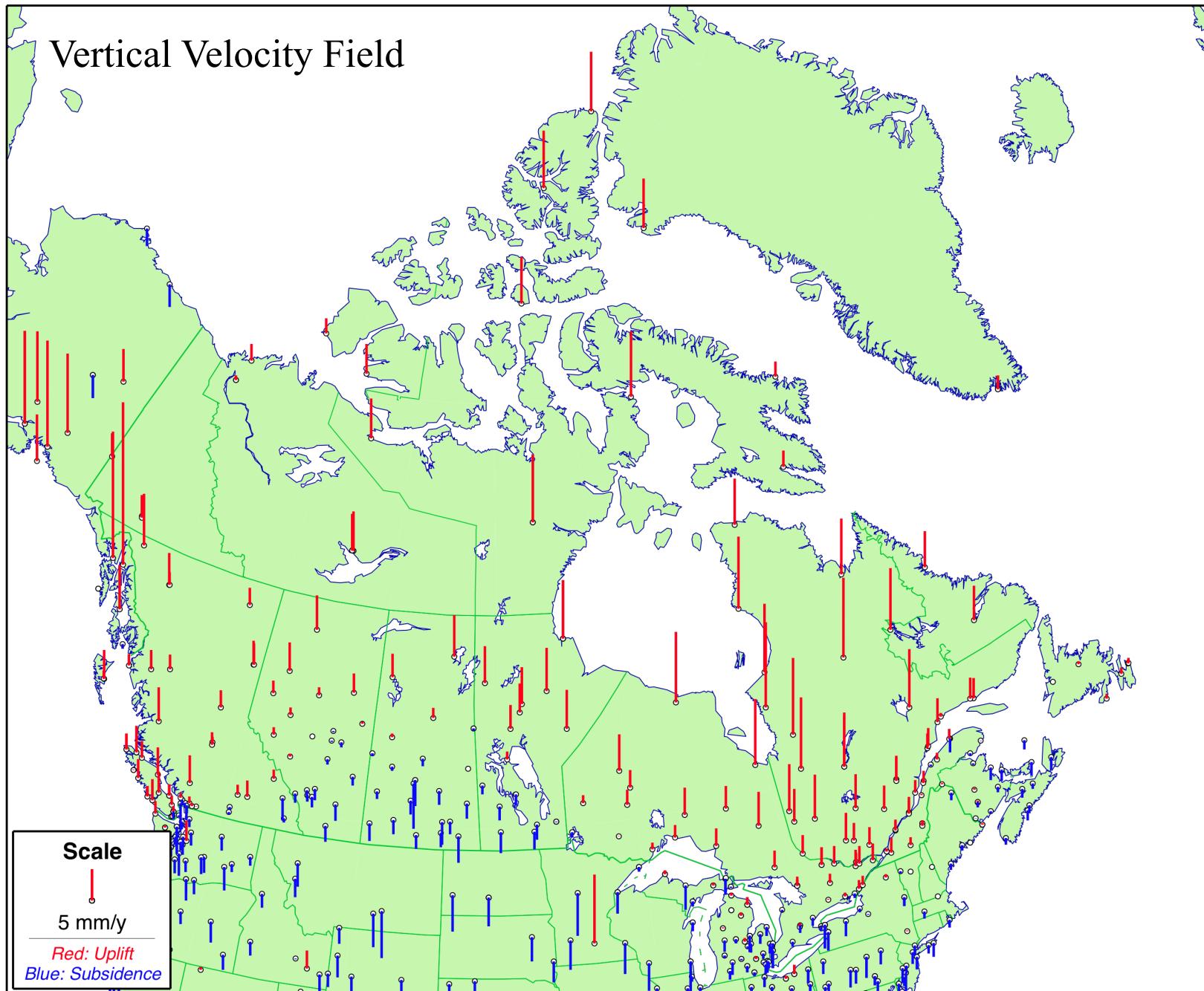
- Based on ITRF2008
  - Transform ITRF2008 coordinates of CACS to NAD83
  - 9 more CACS sites in ITRF2008 than ITRF2005  
BAIE, ESCU, KUUJ, PICL, QIKI, SASK, TUKT, VALD, WSLR
- ITRF2008-NAD83 transformation
  - Updated using ITRF2008-ITRF2005 transformation parameters adopted by IERS (in collaboration with U.S.)
  - Update TRNOBS and add epoch transformation
- Update epoch to 2010.0
  - Will provide up-to-date coordinates, especially in GIA areas
  - U.S. will adopt 2010.0 epoch for all CORS coordinates
  - Propagate ITRF2008 coordinates to 2010.0 epoch and transform to NAD83



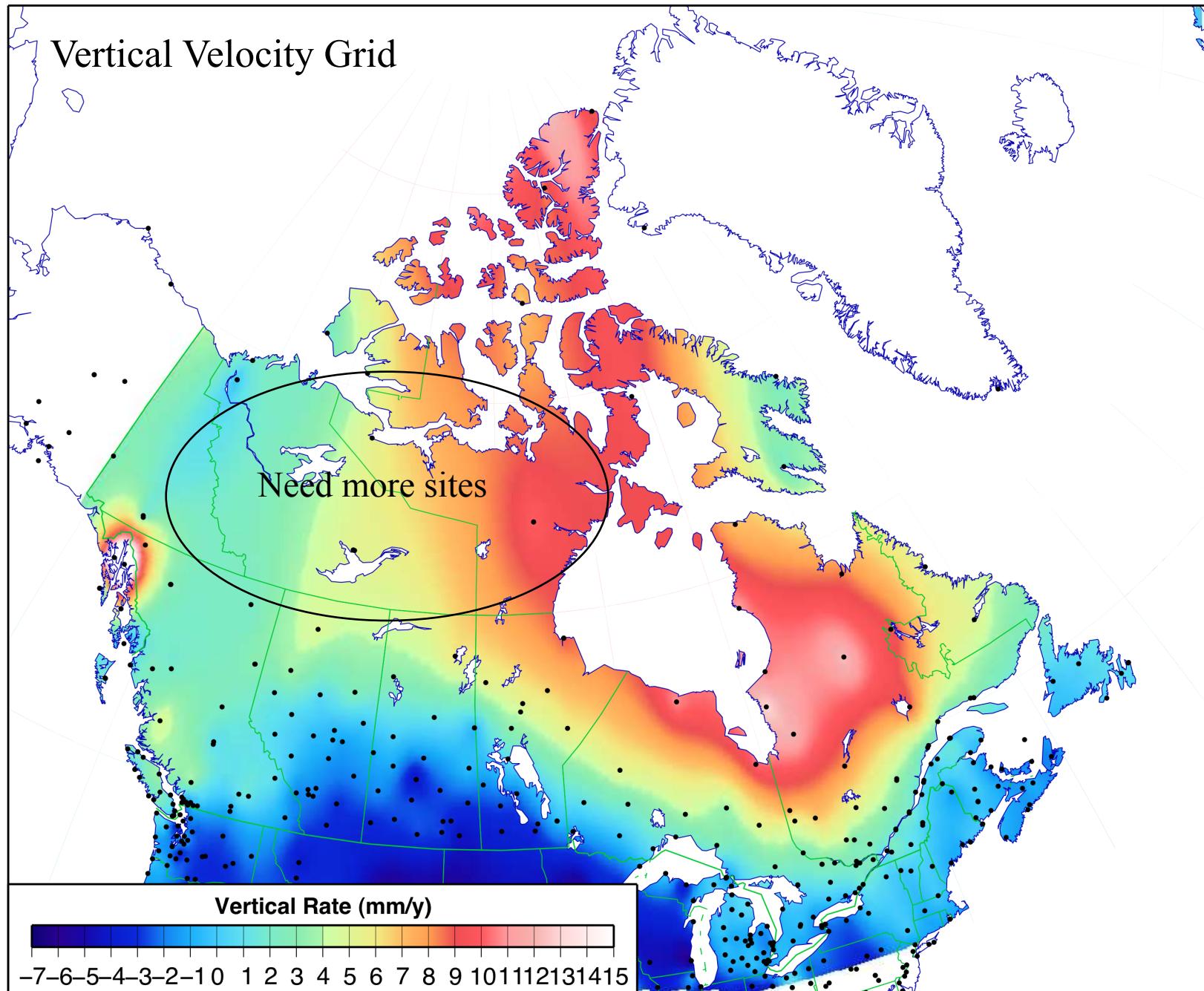
# Velocity Model

- Current version
  - Based on NAREF+CBN velocity solution using data up to Nov/06
  - Sparse coverage in north
  - See last year's CGRSC presentation for info on development and comparisons among CACS & CBN adjustments
- Next version
  - Will be based on reprocessed NAREF+CBN data up to 2011.0
    - Including 4<sup>th</sup> CBN epoch
  - Velocities will be more accurate & consistent
  - Will attempt to improve accuracy in spare areas with a GIA model
    - Collaborative research with Tom James (GSC)

## Vertical Velocity Field



## Vertical Velocity Grid





## Velocity Grid

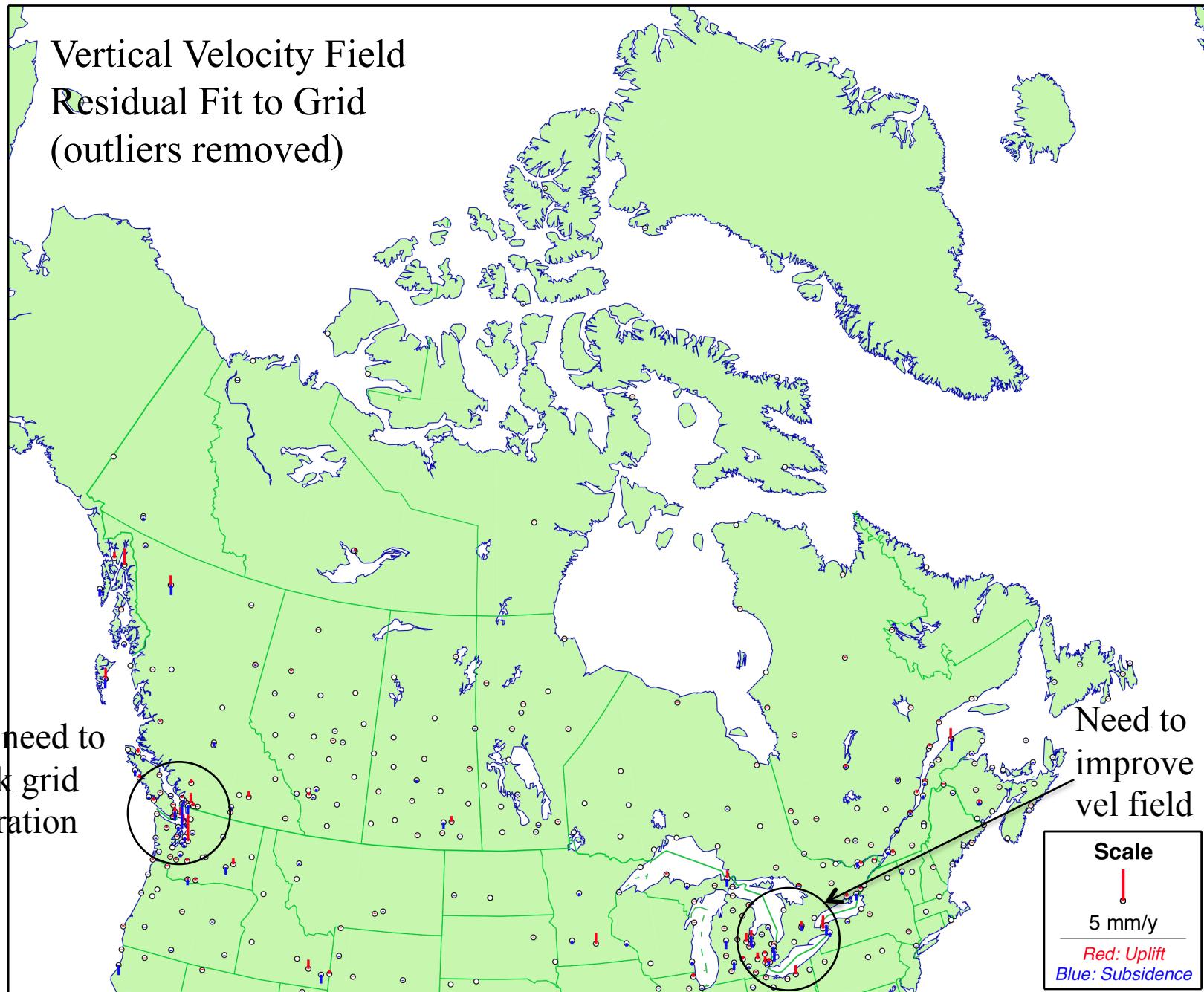
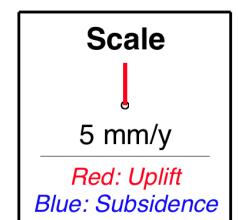
- Generated with GMT (Generic Mapping Tools)
  - Adjustable tension continuous curvature surface gridding algorithm
  - Separate grids for north, east and vertical velocities
  - Std. deviations not generated by GMT
- Grid interpolated with NTv2 bi-linear interpolator
  - Extended grid format to 3D
  - No std. deviations included in grid file
- Residual fit of velocity field to grid (mm/y)

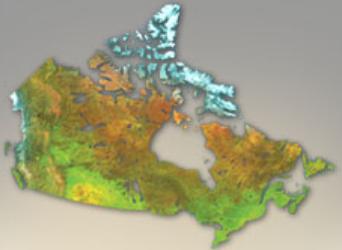
	North	East	Vertical
Mean	0.0	0.0	0.0
StDev	0.4	0.4	0.6
Max	2.7	1.9	4.3
Min	-1.9	-1.6	-4.0

Vertical Velocity Field  
Residual Fit to Grid  
(outliers removed)

May need to  
tweak grid  
generation

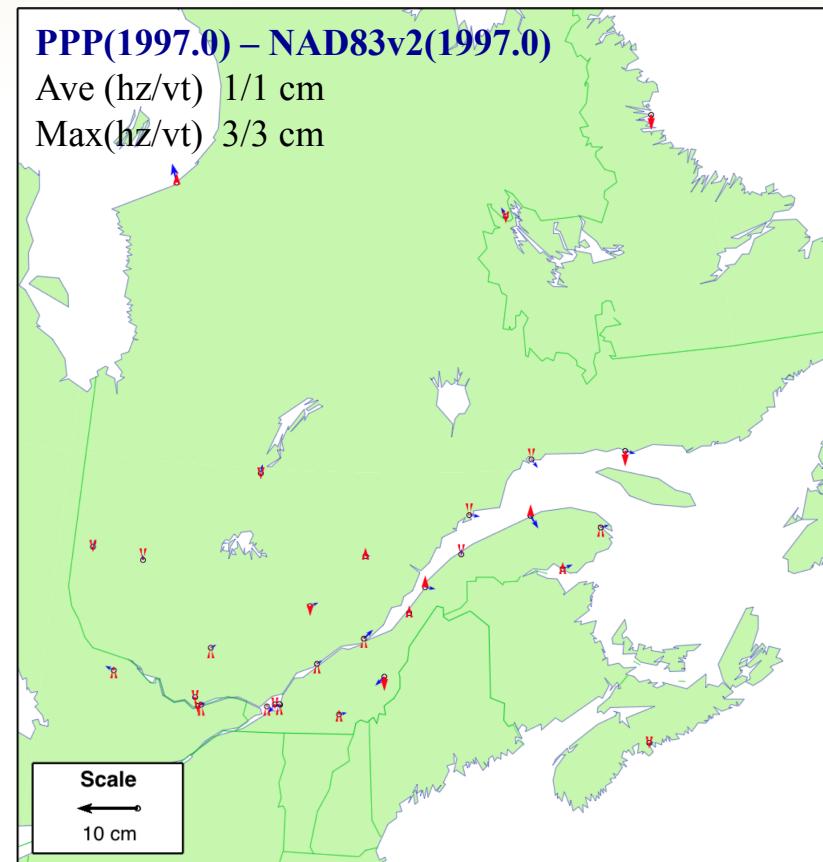
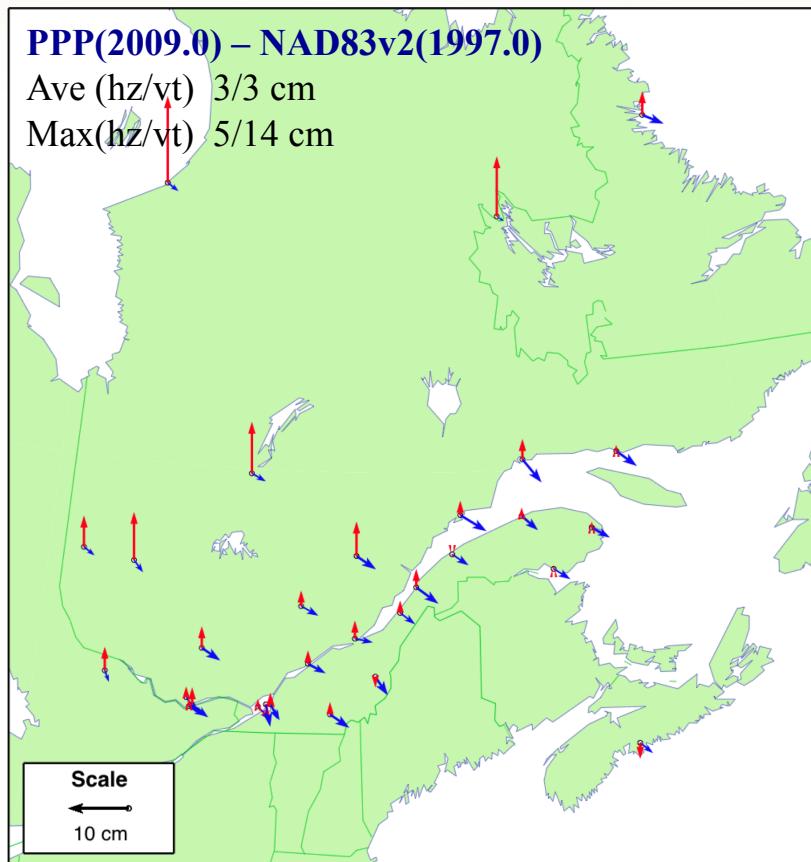
Need to  
improve  
vel field

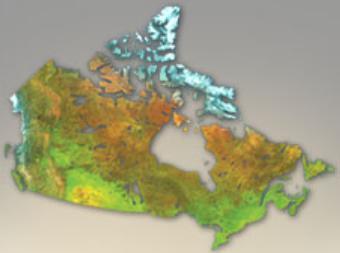




# Quebec PPP Tests

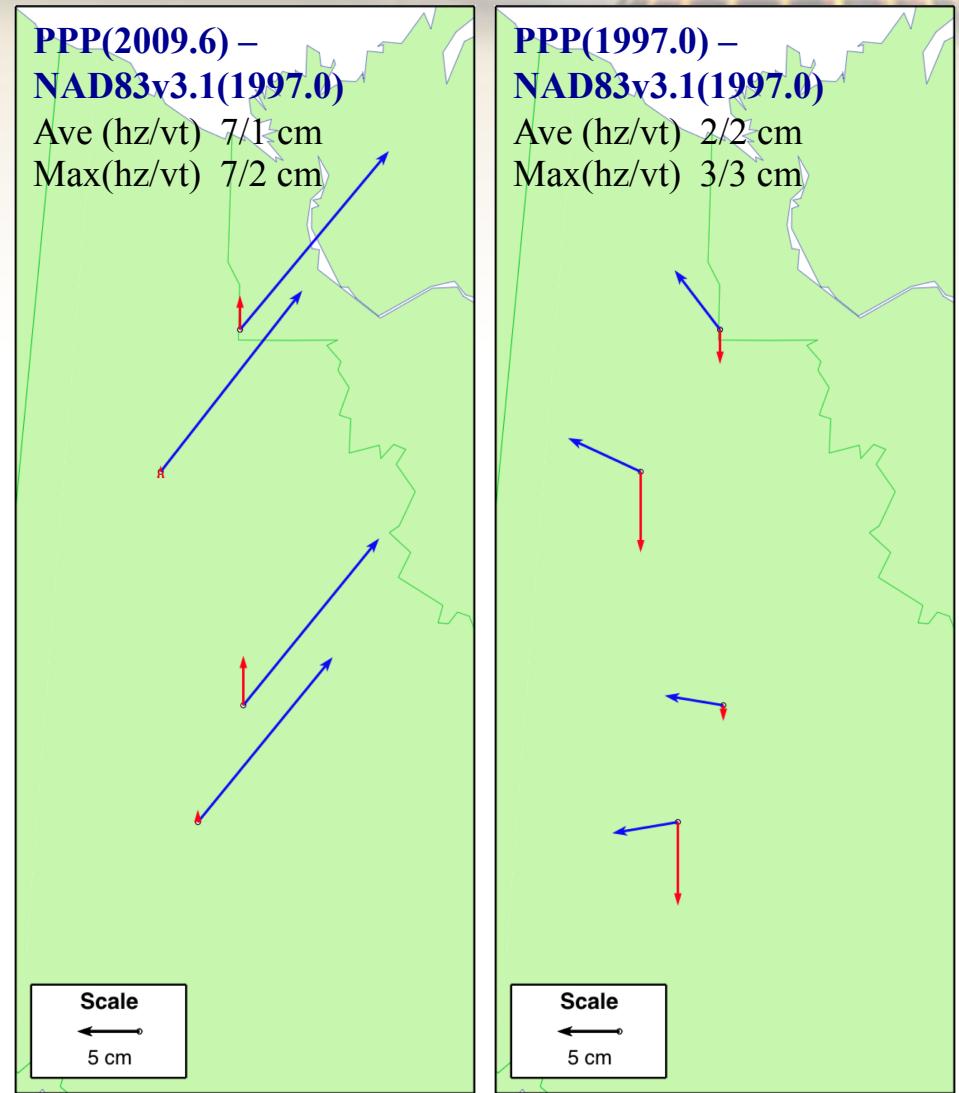
- PPP results for GPS data at CACS & CBN sites in 2009.0
  - Only a test of velocity field, not grid interpolation
  - PPP results in NAD83 v5 at 2009.0 and propagated to 1997.0

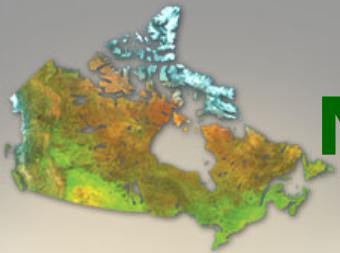




# Yukon PPP Tests

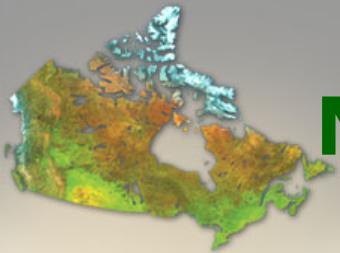
- PPP results for GPS data along Dempster Highway in 2009.6
  - PPP results in NAD83 v4 at 2009.6 and propagated to 1997.0
  - Illustrates limitations of velocity grid in north





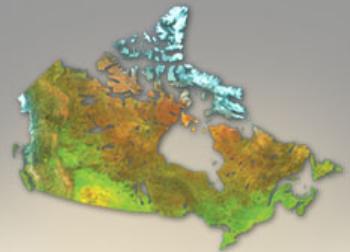
# National Epoch Transformation Software

- NET software
  - Propagates coordinates to different epochs using velocity grid
  - Fortran program based on NTv2 interpolation and grid format
  - Will also be implemented in TRNOBS (when updated to ITRF2008)
- NETv1 – available now
  - Used in on-line PPP service
  - Command-line (Unix) program with no user prompts
  - Only reads GHOST code 4 records
  - Does not output GHOST/GeoLab-compatible records



# National Epoch Transformation Software

- NETv2 – to be completed end of this week
  - Simple Unix/DOS-style program with user prompts (similar to TRNOBS)
  - Will read/output standard GHOST/GeoLab records
  - UTM not currently supported
    - Is it needed?
    - Horizontal coordinates not affected much by epoch transformation
  - Main computational part isolated to one subroutine call for easier implementation in other software (same with new TRNOBS)
  - May take some time to add to GSD web site
- Windows & Web GUI
  - Will allow for input and output of other formats (e.g., csv records)
  - Software library in development
  - Plan to use for NET, TRNOBS and other GSD software



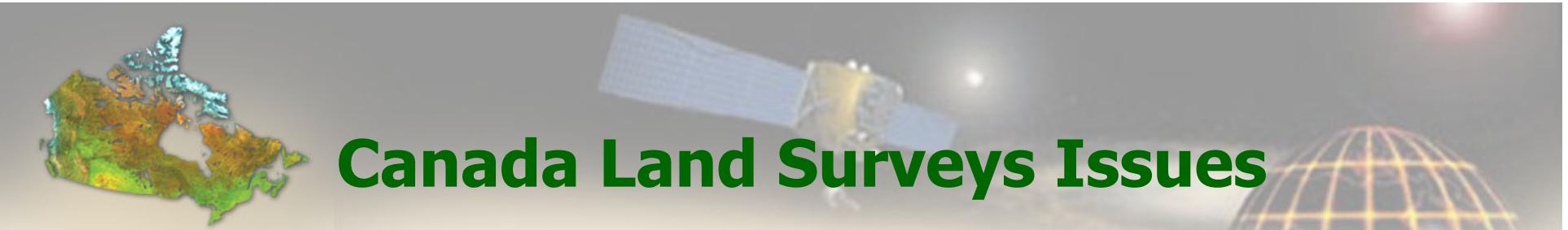
# Velocity Grid Version Numbering

- Use same scheme as coordinate numbering
  - Velocities come from same solution as coordinates
  - Numbering scheme really represents version of solution/adjustment
- Coordinate/velocity numbering scheme
  - NAD83 va.b.c.X.d...
    - a = version of realization of NAD83
    - b = version of CACS coordinates (0 for ITRF soln)
    - c = version of CBN or primary horizontal control network
    - X = sub-network/agency ID (Canada Post codes); can be multiple characters
    - d = province/agency version numbering scheme; e.g., a new field can be added for each hierarchy of the network
- Current version: v5.0.0 (based on NAREF+CBN solution)



## Future Improvements

- Update velocity solution
  - Reprocessing all NAREF+CBN data with IGS Repro1 orbits
  - Will provide more consistent velocities
- Densify velocity field for future solutions
  - Need at least 3 years to get a reliable velocity estimate
  - Will try to obtain more GPS measurements west of Hudson Bay
  - Continuous and semi-continuous sites
- Provide std. deviations for interpolated velocities
  - Based on residual misfit of velocity field to grid
  - Or use more sophisticated gridding algorithm that provides st. dev.
- Incorporate GPS velocity field with GIA model
  - Constrain GIA model to GPS velocities
  - Evaluate new ICE-6G GIA model (constrained to CACS+CBN velocities)



# Canada Land Surveys Issues

- Coordinate epoch for Territories?
  - Published coordinates in a variety of NAD83 versions and epochs
  - Most coordinates in NAD83(Original) => no epoch defined
  - CACS/CBN/GPSonBM in NAD83(CSRS) at different epochs
  - Significant horizontal crustal motions in Yukon
  - Velocity field/grid inadequate in north – too sparse
- Coordinate epoch for off-shore?
  - Positions are relative to shore-based control => use epoch of control
  - Epoch of shore control varies with province
  - PPP coordinates
    - Coordinates propagated to desired epoch using velocity grid
    - Will need to evaluate extrapolation of velocity grid to off-shore