



NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

A National Crustal Velocity Model For Canada

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US NGS, Silver Spring, MD, June 9, 2016



Natural Resources
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Terminology

- CACS (Canadian Active Control System) = CORS
- RACS (Regional Active Control System) = CORS
- CBN (Canadian Base Network) = “Passive” stations/pillars (FBN?)
- Velocity Field
 - Point velocities at individual stations
 - Determined together with coordinates at a reference epoch
 - Usually just at the CACS/RACS/CBN stations
 - Part of reference frame realization
- Velocity Model/Grid
 - A model (grid) of velocities derived from the velocity field
 - Predicts velocities anywhere within velocity field
 - Also considered part of the reference frame
- NAD83(CSRS) – NAD83 realizations/versions based on ITRF
 - Same as NAD83(CORS96) & NAD83(2011)



The Need for a Velocity Model

- To propagate coordinates to different epochs
 - Significant cm/yr crustal motions throughout Canada
 - Vertical GIA in most of Canada \sim 1-2 cm max
 - Horizontal & vertical tectonic deformation on west coast \sim 1 cm
 - Error in NUVEL-1A plate motion model defining NAD83(CSRS)
 - Different reference epochs adopted by provinces
 - Precise Point Positioning (PPP) gives coordinates at epoch of observations/orbits)
 - Need to propagate coordinates to adopted epochs
- For scientific studies
 - Velocity field can be used to improving GIA models – ICE-6G used our GPS to “tune” the model (ice load) in Canada
 - Velocity model needed to estimate crustal motions when predicting relative sea level changes for assessing coastal flooding hazards
 - GPS strain used as additional input to maps of seismic hazards

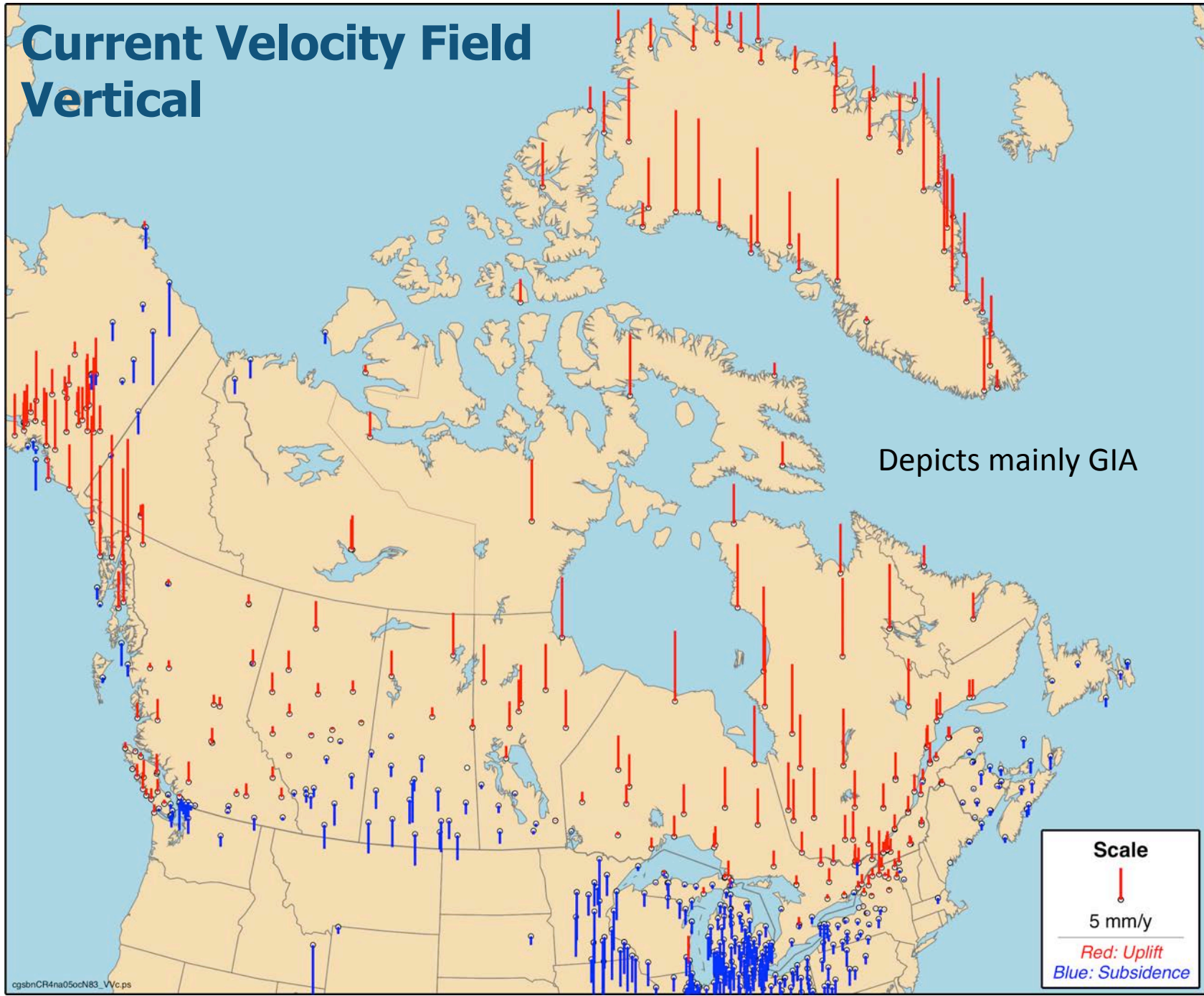


Current Velocity Field

- Based on CACS/RACS/CORS/CBN in northern half of N.A.
- Data used
 - CACS/RACS/CORS: 2000 – 2011.3 (switch to IGS08)
 - CBN: 1994 – 2011 (4 primary campaigns + “occupations of opportunity”)
- Produced velocity field using repro1 multi-year densification solution
 - Bernese GNSS Software 5.0 to estimate coordinates & velocities
 - IGS05 (repro1) orbits & antenna calibrations
 - Aligned to IGS08 using a global set of 117 ref. frame stations
 - Corrected for IGS08 antenna calibrations using IGS correction model
- Transformed to NAD83(CSRS)



Current Velocity Field Vertical



Depicts mainly GIA

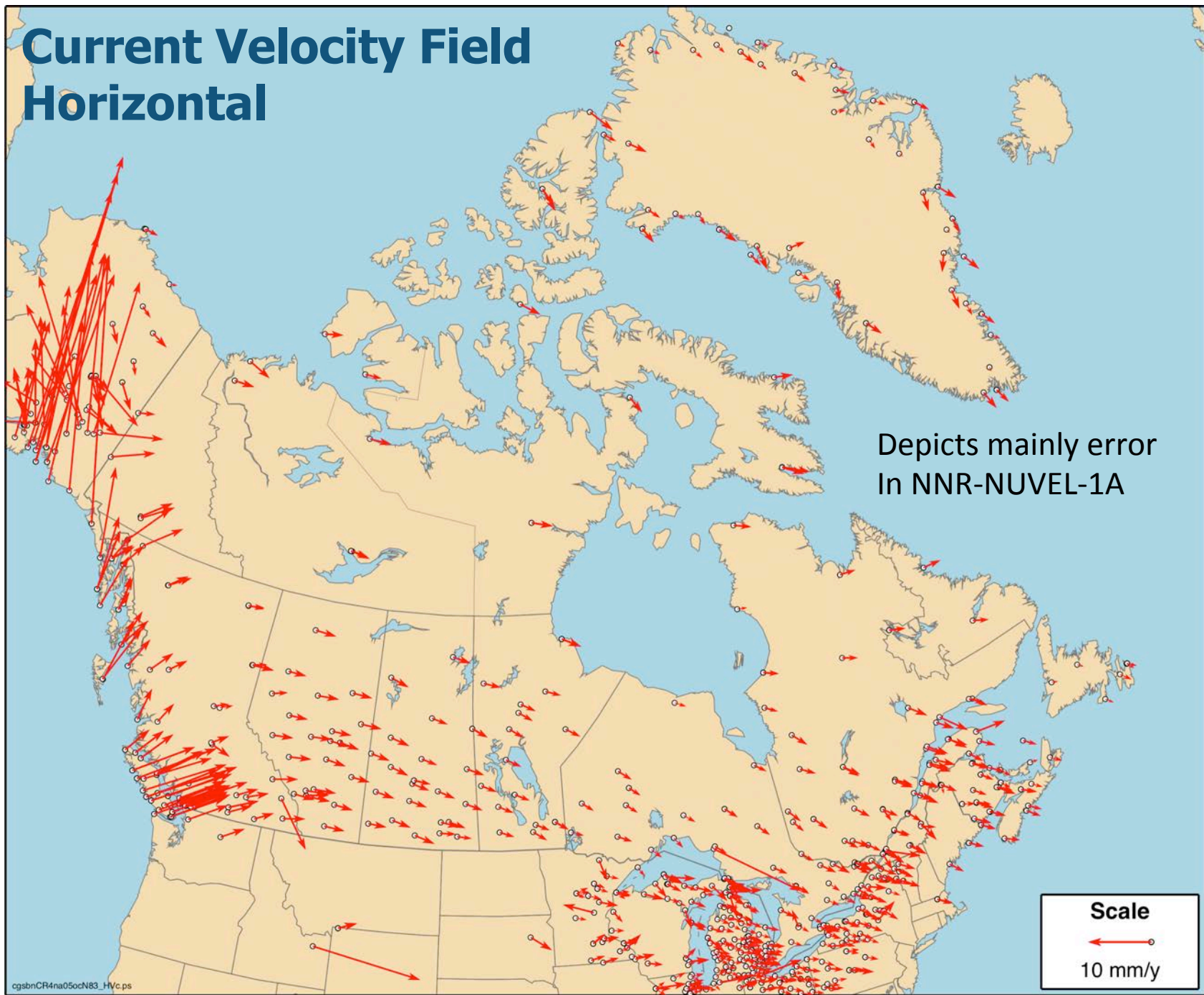
Scale



5 mm/y

Red: Uplift
Blue: Subsidence

Current Velocity Field Horizontal



Current Velocity Model

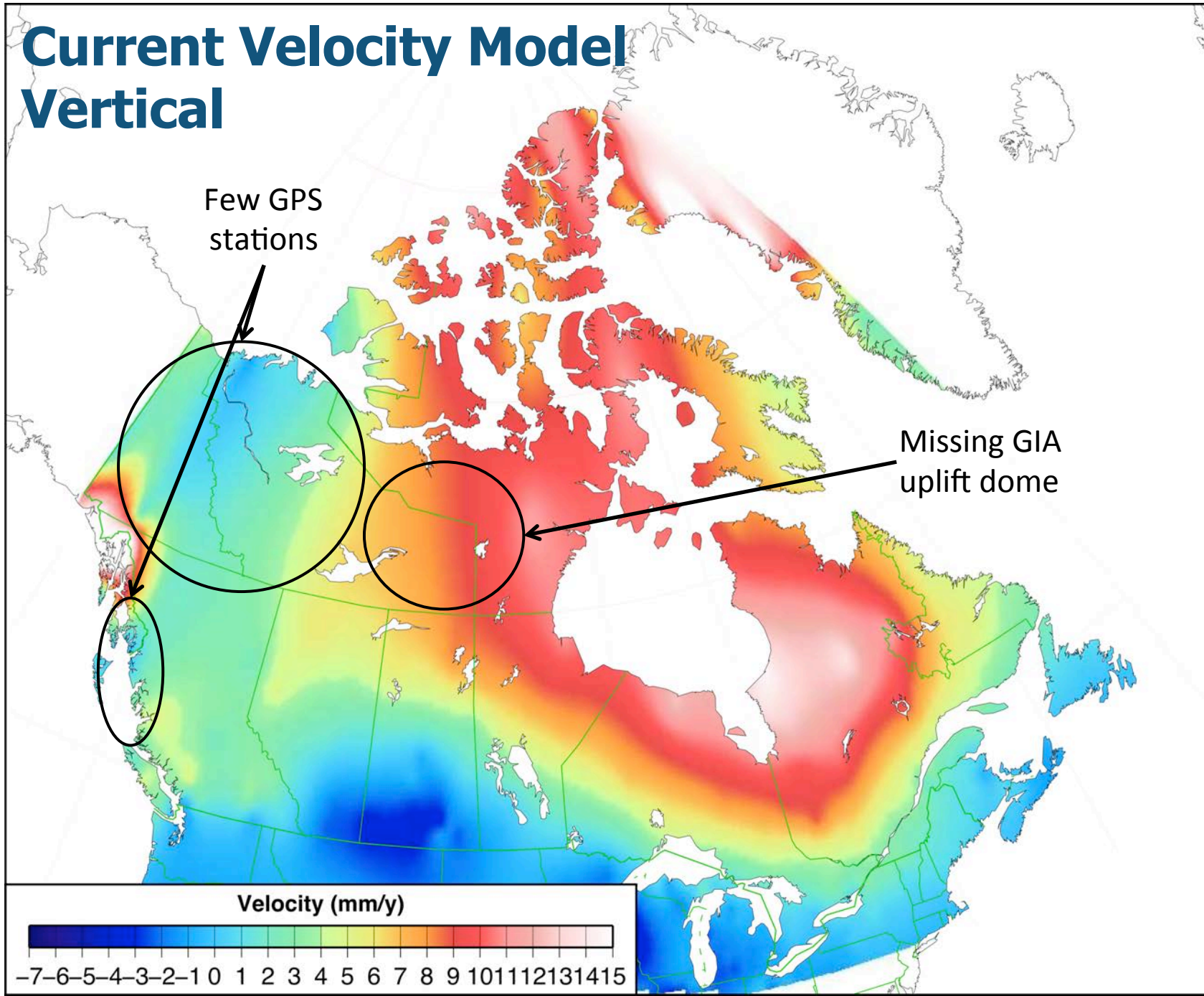
- Based on only GPS velocity field in NAD83(CSRS)
- Used GMT interpolation to produce a velocity grid (model)
- Removed outlier velocities in an iterative manner
- Separate grid for each coordinate component (lat,lon,h)

- Considered part of NAD83(CSRS) v6 realization
- Used in current CSRS-PPP software to propagate solutions to adopted provincial epochs
- Used in current TRX transformation software

- Good modelling in south where many GPS sites
- Poor modelling in north & west coast where few GPS sites

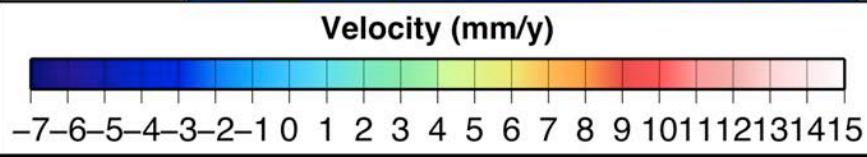


Current Velocity Model Vertical



Few GPS stations

Missing GIA uplift dome

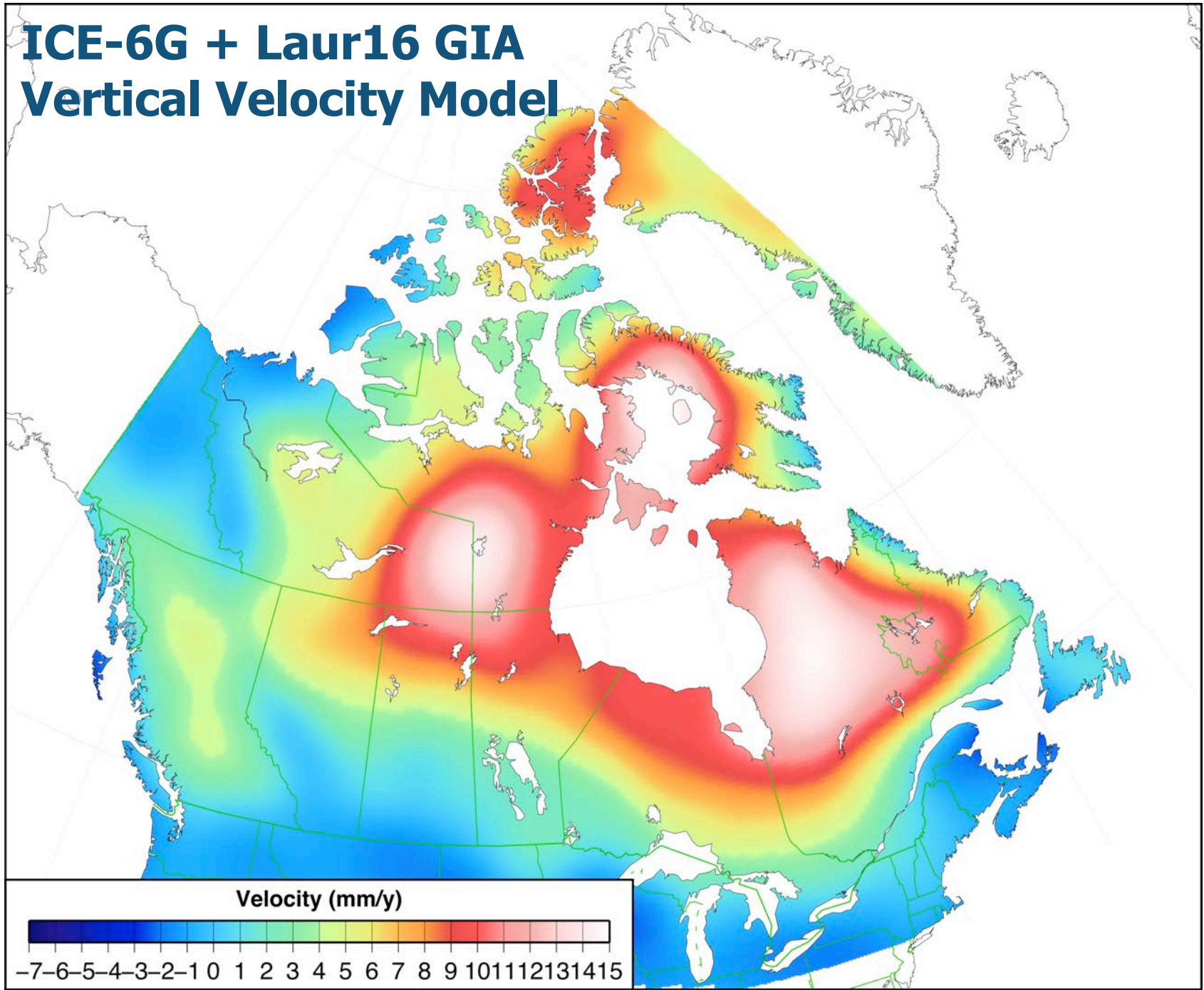


New Vertical Velocity Model

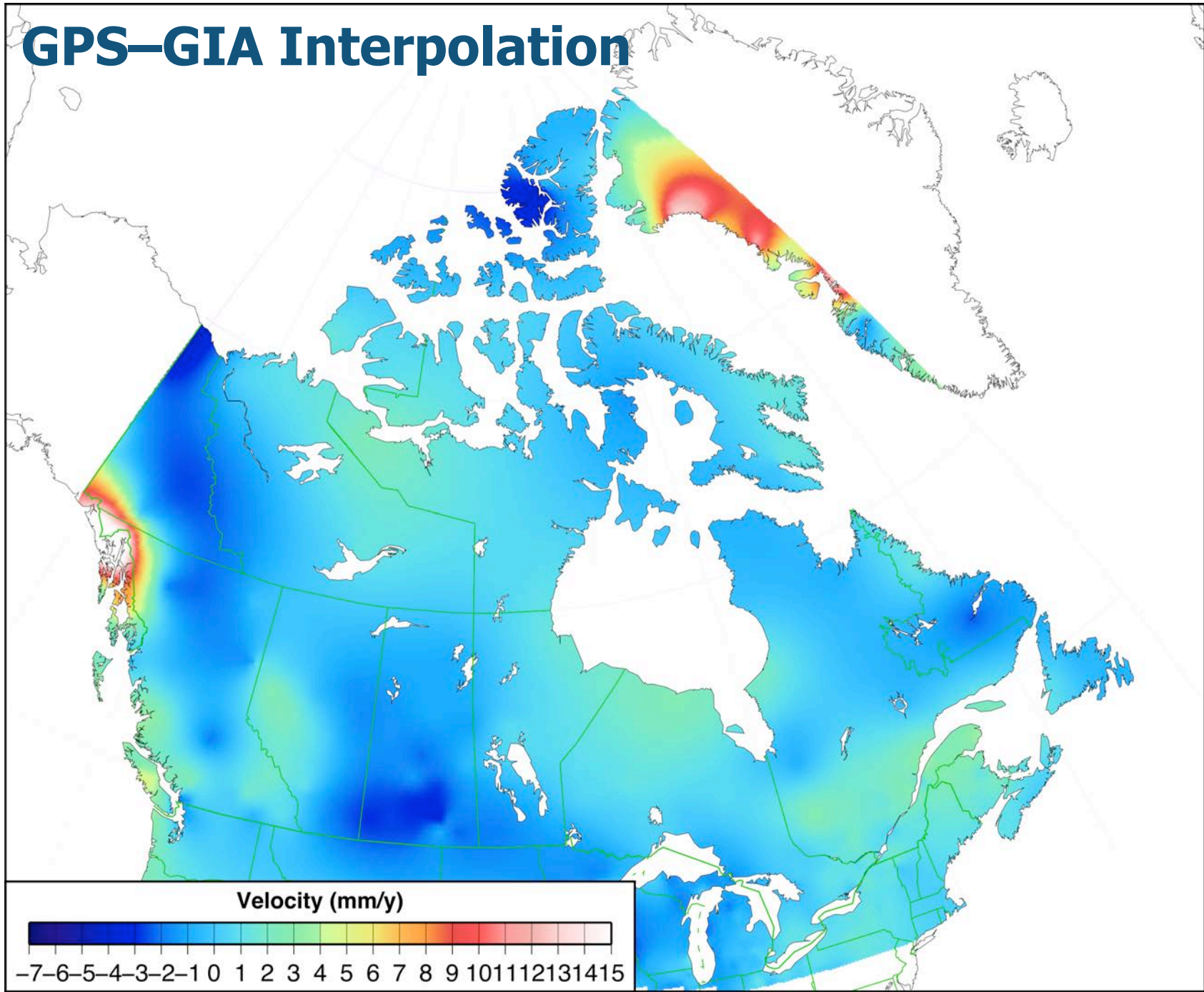
- Incorporated a GIA model
 - To improve vertical velocity model where few GPS sites
 - Effectively used as a more intelligent interpolation
- GIA models used
 - ICE-6G as “base” model
 - Added Laur16 elastic model in Ellesmere Island area (more recent deglaciation)
- Method
 - Estimated ICE-6G velocities at GPS sites in velocity field
 - Determined misfit between ICE-6G and GPS velocities
 - Interpolated misfit to a grid = correction to ICE-6G to agree with GPS
 - Added misfit grid to ICE-6G grid to obtain “hybrid grid” constrained to GPS – effectively a GIA interpolation between GPS points
 - *Same as distorting geoids to fit levelling datum (“hybrid geoids”)*



ICE-6G + Laur16 GIA Vertical Velocity Model

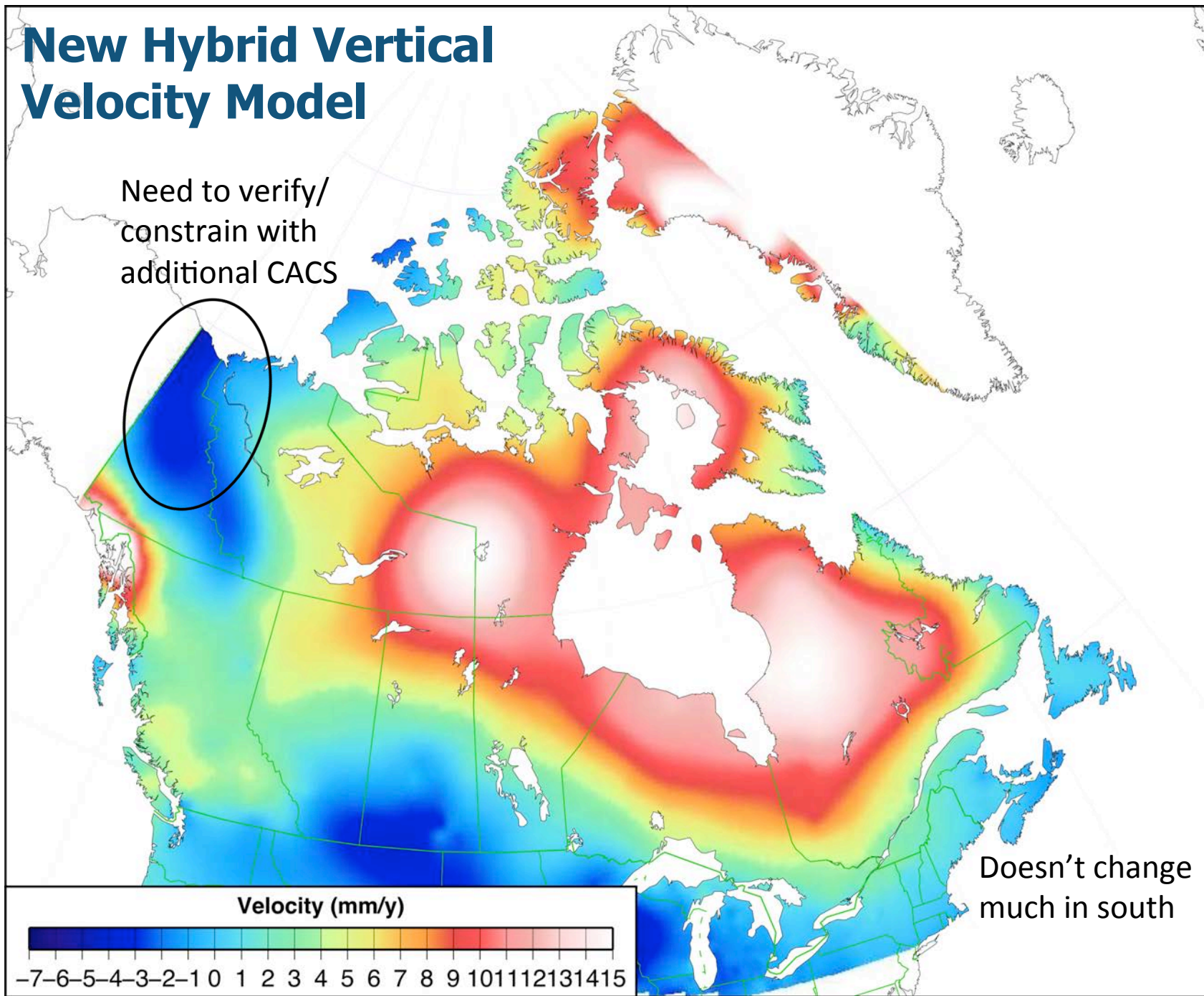


GPS-GIA Interpolation

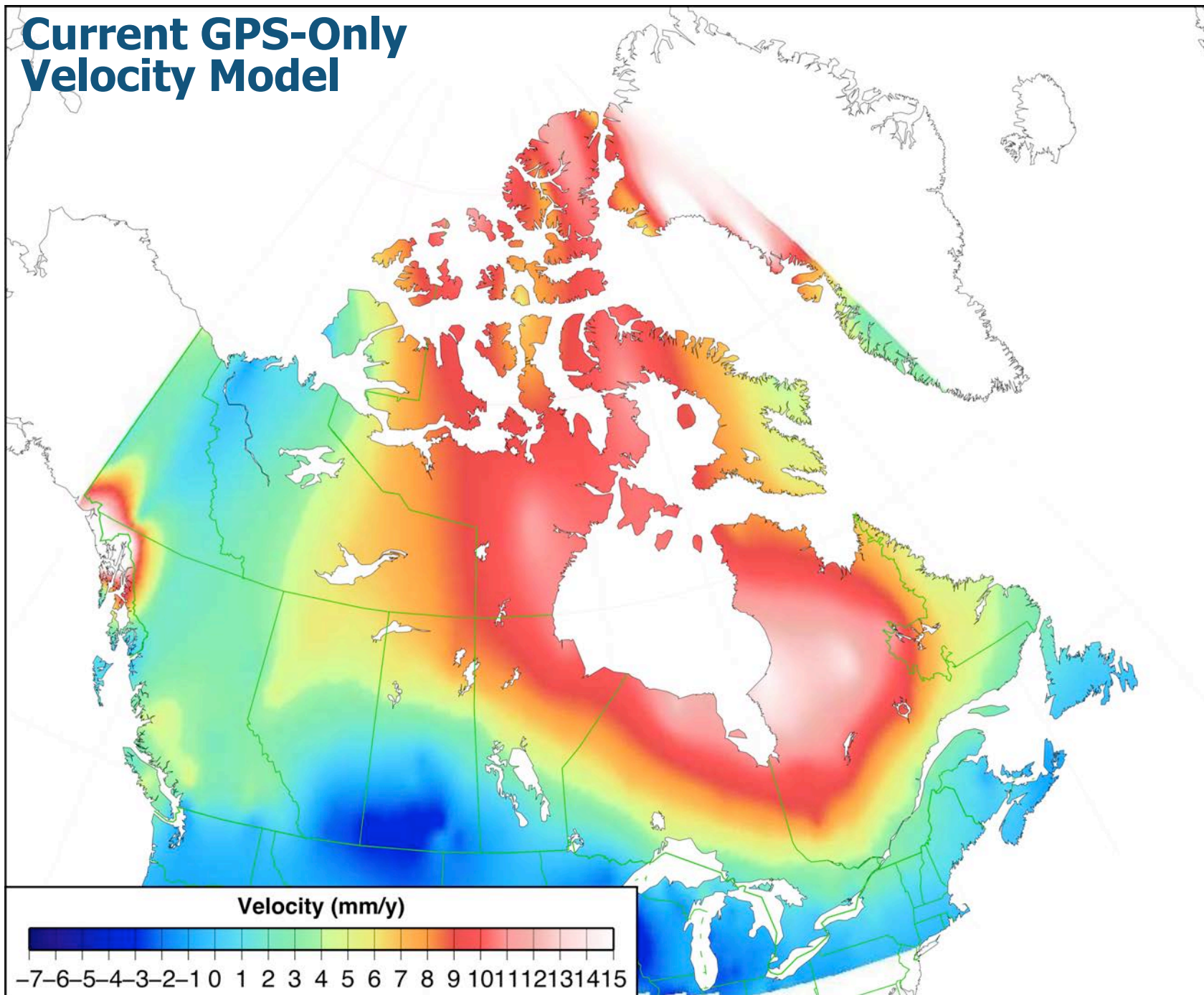


New Hybrid Vertical Velocity Model

Need to verify/
constrain with
additional CACS



Current GPS-Only Velocity Model

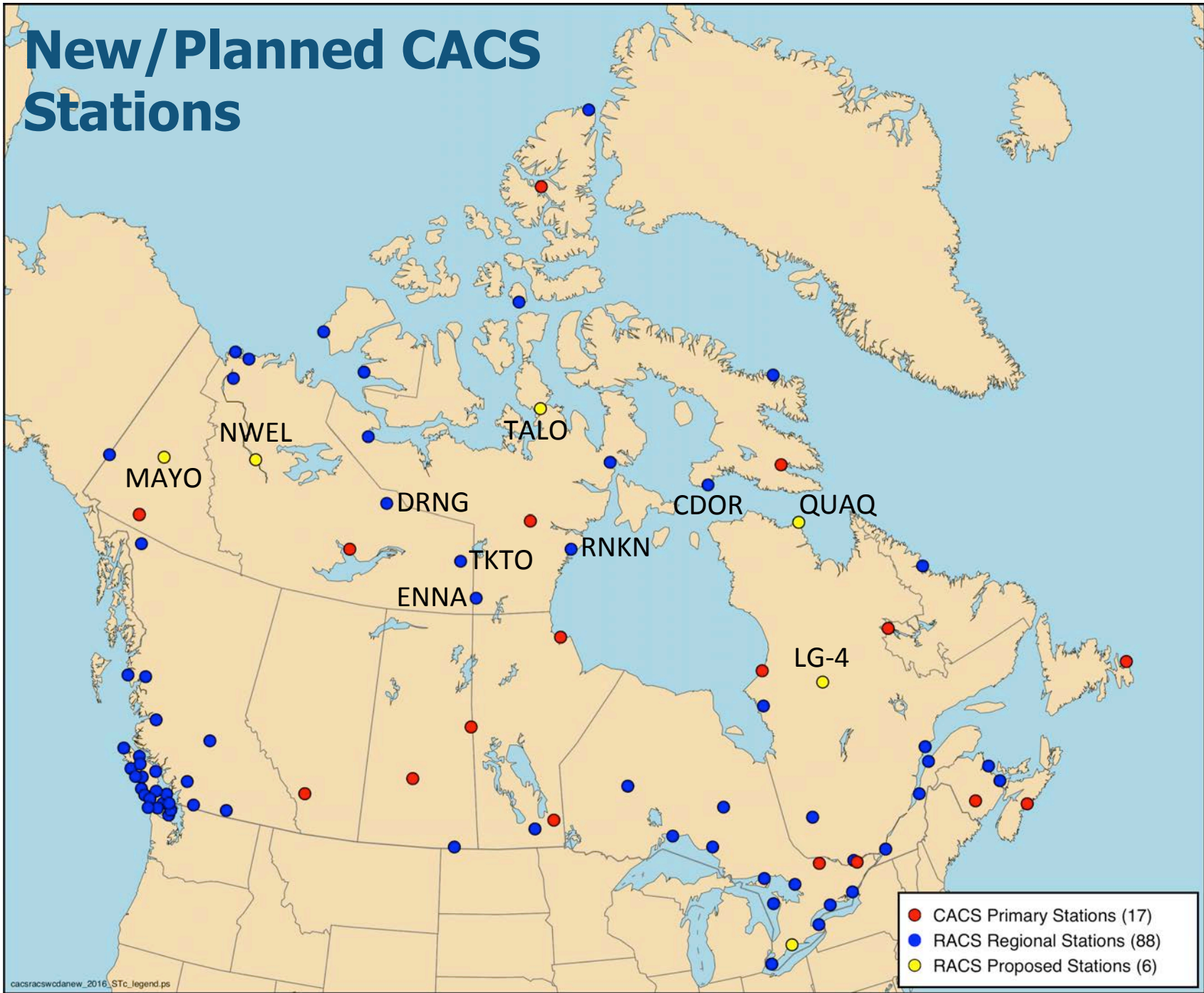


Future Improvements – Velocity Field

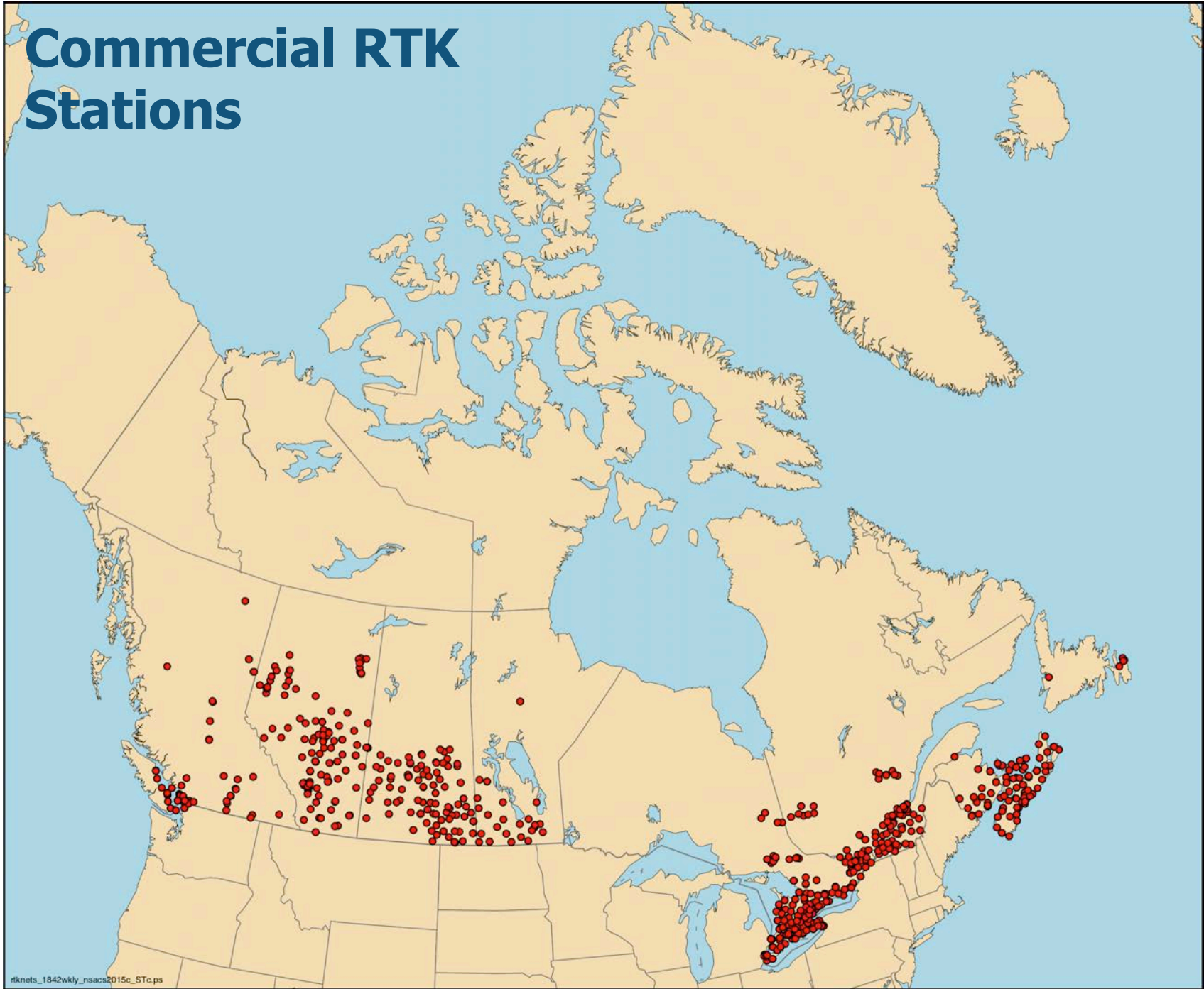
- Install new CACS in targeted areas to better constrain GIA model – see map
 - 5 new stations in last few years (not in 2011 solution)
DRNG ENNA **TKTO (max uplift point)**
RNKN CDOR
 - 5 new stations planned for installation 2016/17
MAYO NORW TALO
QUAQ **LG-4 (max uplift point)**
- Incorporate selected sites from commercial RTK networks in targeted areas
- Reprocess all data for consistency with current solutions
 - Using Bernese 5.2 and repro2 orbits
 - Aligning to ITRF2014/IGS14
 - 80% done



New/Planned CACS Stations



Commercial RTK Stations



Future Improvements – Velocity Model

- Investigate more GPS-compatible GIA models
 - LAUR15 (James/Simon) – based on ICE-6G with more GPS information
 - Laur16 elastic rebound model for high Arctic (Ellesmere Island)
 - Little Ice Age velocity model (Freymueller et al.) – Glacier Bay, AK
- Incorporate “block” models of tectonic deformation on west coast
- Improve interpolation method
 - Investigate NTV2-type interpolation
 - Include estimation of uncertainties



Questions?



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