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SNARF 2.0: A Regional Reference Frame for North America

Current Status

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Abstract G21B-01

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Overview

- Rationale for a "SNARF"
- SNARF GIA model
- Contributing GPS solutions to SNARF 2.0
- Analysis of contributions
- Motions in the SNARF realization
- Iteration needed to generate GIA model for use in final alignment

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Rationale for SNARF

- Define a reference frame fixed to stable interior of North America
  - ITRF velocities dominated by tectonic plate motion
  - Plate-fixed frame better for studying intra-plate deformations
  - Need to account for effects of GIA
- Provide a standard plate-fixed frame to facilitate…
  - Geophysical interpretations
  - Inter-comparison of solutions
  - Primarily for Earthscope/PBO studies

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SNARF GIA Model

- Velocity Model

$$\vec{V}_{\mathrm{GPS}}(\lambda,\phi) = \vec{V}_{\mathrm{GIA}}(\lambda,\phi) + \delta\vec{\Omega} \times \hat{r}(\lambda,\phi) + \delta\vec{T}$$

V_{GIA} = GIA velocities (a priori values from stochastic model)
dΩ = Rotation rates (plate motion)
dT = Translation rates (satellite phase center issues)

- GPS velocities – focus of this talk
  - Combination of several solutions (SNARF 1.0 used only 3)
- A priori stochastic GIA model
  - Based on ICE-5G loading model (SNARF 1.0 used ICE-1)
  - Using ensemble of reasonable Earth/ice models

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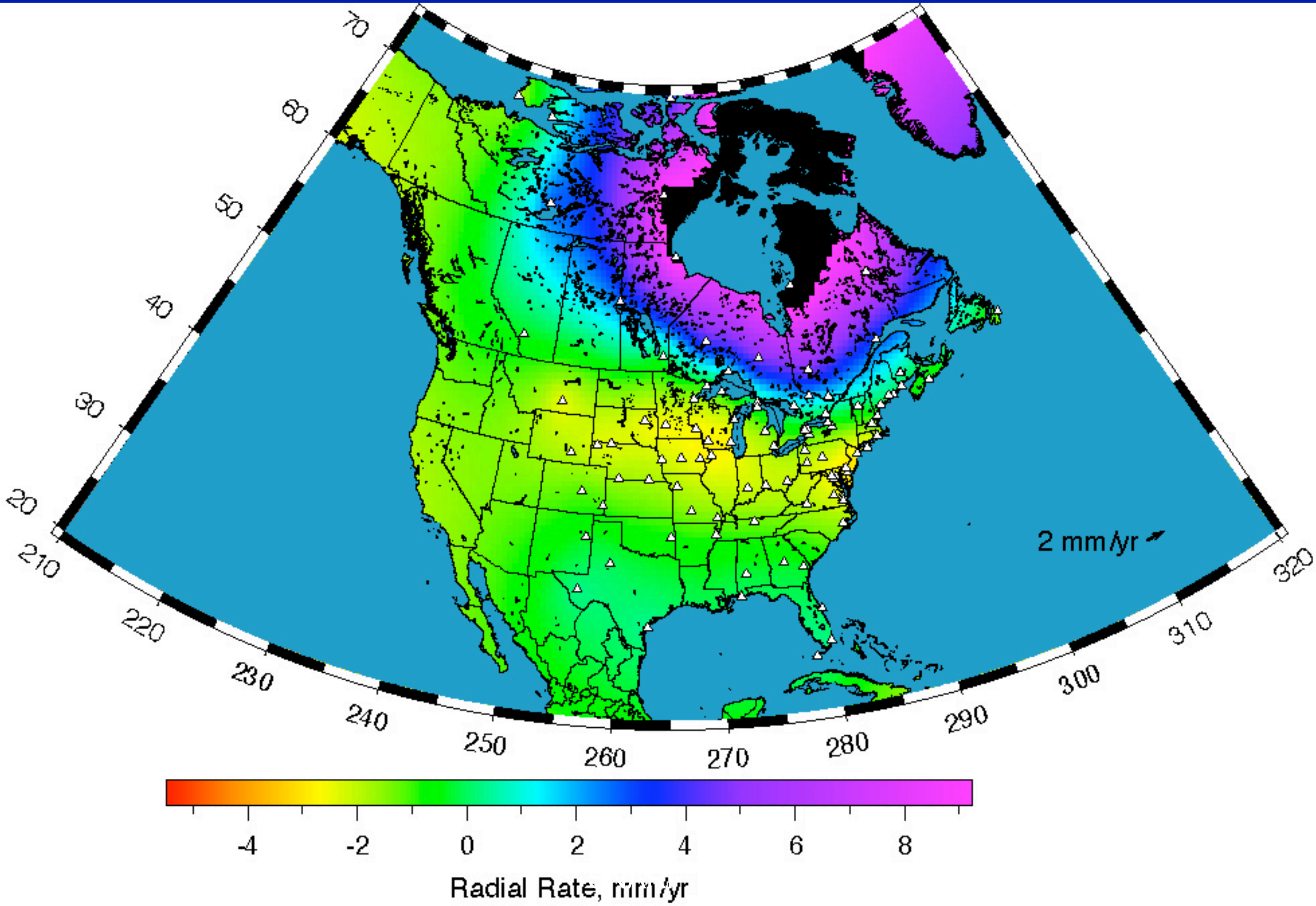
SNARF 1.0 GIA Model



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Contributions to SNARF 2.0 (1/2)

- Five contributing velocity solutions
  - NAREF – combination of 7 regional solutions (4 different s/w)
  - Purdue – combination of GIPSY & GAMIT
  - Univ. of Alaska Fairbanks – GIPSY
  - Univ. of Nevada Reno – GIPSY
  - Canadian Base Network – 27 campaign surveys – Bernese
- All solutions based on relative antenna phase centers
  - Using data up to GPS week 1399 (Nov/06)
  - Need to re-do with absolute phase centers after IGS re-proc.
- Using sites in at least two contributions
  - 283 unique sites (many more than SNARF 1.0)
  - 465 velocity estimates (many breaks in station time series)

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Contributions to SNARF 2.0 (2/2)

Code	AC	File	Stat	UStat	Rew
CBN	CBN/NRCAN	CBN06P30v4uc.snx	200	190	8.8
NAR	NAREF/NRCAN	NAR06P44v6uc.snx	724	578	621
PUR	EC/Purdue	calais_nov06.snx	677	675	3.6
UAF	JF/UAF	UAF_SNARF.stacov	132	132	7236
UNR	GB/UNR	UNR_SNARF_0208.stacv	45	45	2653

Stat - Number of stations in solution. Multple entries for stations with breaks
Ustat - Number of unique stations
Rew - Covariance matrix re-weighting factor to make velocity sigmas realistic & consistent

- Re-weighting factors determined from the normalized root mean square (NRMS) of differences with IGS05 velocities in North America

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Analysis Method

- Added ±10 mas and ±1 m rotation & translation uncertainties to contributions with constraints
- Covariance matrices re-scaled by NRMS fit of velocities to IGS05
- Rotation/translation/scale values & rates estimated for each contribution during combination
- Reference frame of combination realized by alignment to desired reference system (eg, SNARF 1.0 GIA, ITRF2005 NA plate)
- UAF contribution not presently used due to numerical stability problems – being investigated
- Final version of SNARF 2.0 will use GIA model derived from preliminary version – iterative scheme
- Velocities at collocated sites are equated

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RMS of Velocity Differences Between Contributions and Preliminary SNARF 2.0

Code	#	WRMS (mm/yr)			NRMS		
		N	E	U	N	E	U
CBN	73	0.23	0.55	0.61	0.29	0.51	0.13
NAR	311	0.55	0.58	1.51	0.34	0.37	0.25
PUR	204	0.17	0.15	0.44	0.33	0.34	0.41
UAF	96	0.78	0.75	2.59	0.18	0.24	0.29
UNR	36	0.29	0.33	1.96	0.56	0.66	1.09

- Preliminary SNARF 2.0 aligned to SNARF 1.0 GIA
- NRMS < 1 for most contributions, suggesting over-weighting

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RMS of Position Differences Between Contributions and Preliminary SNARF 2.0

Code	#	WRMS (mm)			NRMS		
		N	E	U	N	E	U
CBN	77	0.48	0.95	2.12	0.23	0.34	0.17
NAR	228	0.88	1.24	4.00	0.44	0.61	0.51
PUR	199	1.12	1.36	2.62	0.43	0.73	0.77
UAF	83	1.28	1.66	3.89	0.07	0.12	0.10
UNR	36	1.11	1.84	5.69	0.94	1.60	1.38

- Horizontal positions agree fairly well
- Vertical variability possibly due to remaining antenna height discrepancies among contributions – needed to rename 76 sites and equate velocities

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Preliminary SNARF 2.0

- Aligned to SNARF 1.0 GIA
- Figures that follow show vertical and horizontal motions for SNARF 2.0 and the contributing solutions
- Sites with vertical velocity sigmas < 6.5 mm/yr are shown with white triangles
- Vertical velocity contours use sigmas as weights
- Sites with horizontal velocity sigmas < 1.0 mm/yr are shown with 95% confidence ellipses

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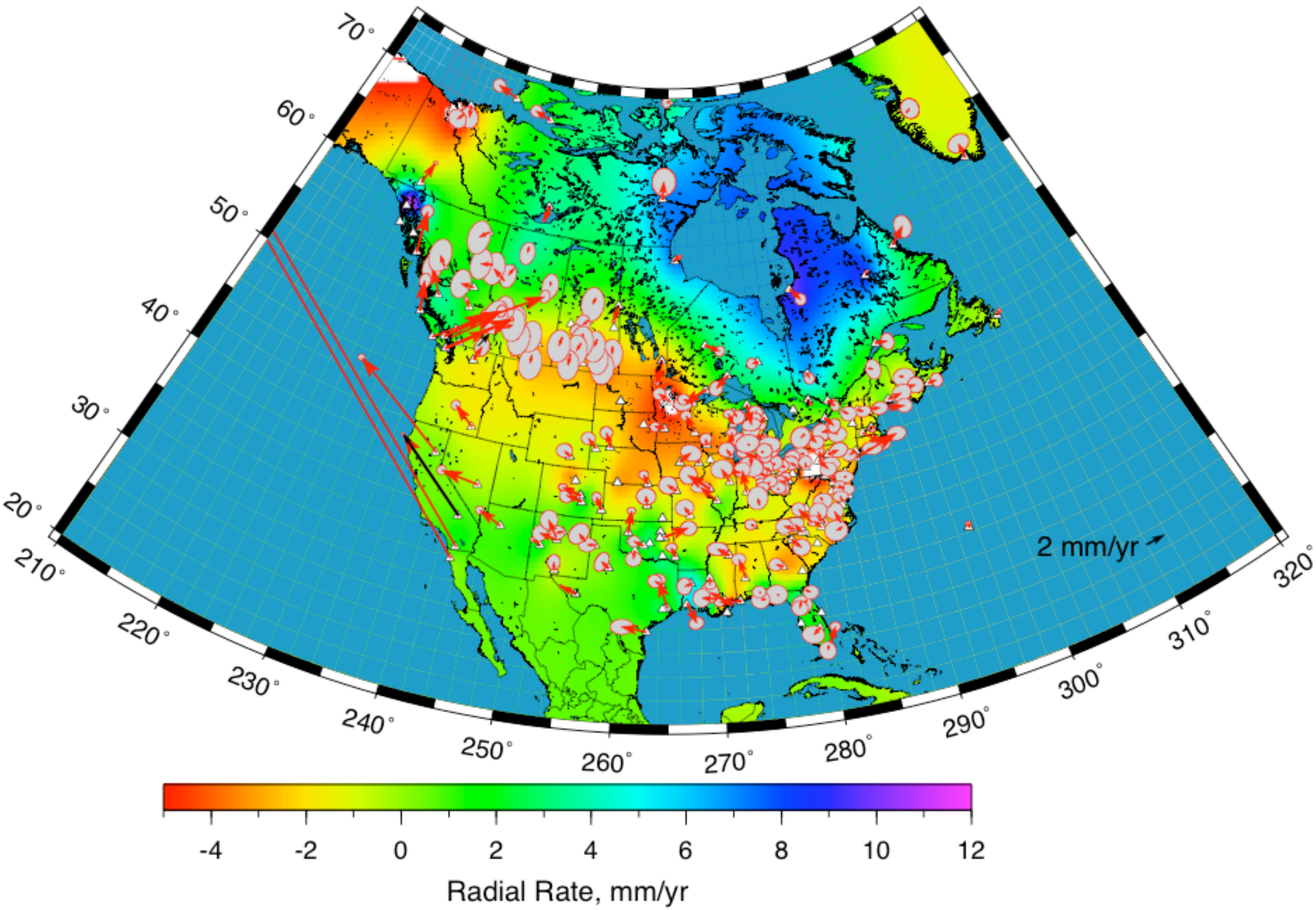
Preliminary SNARF 2.0 (aligned with SNARF 1.0)



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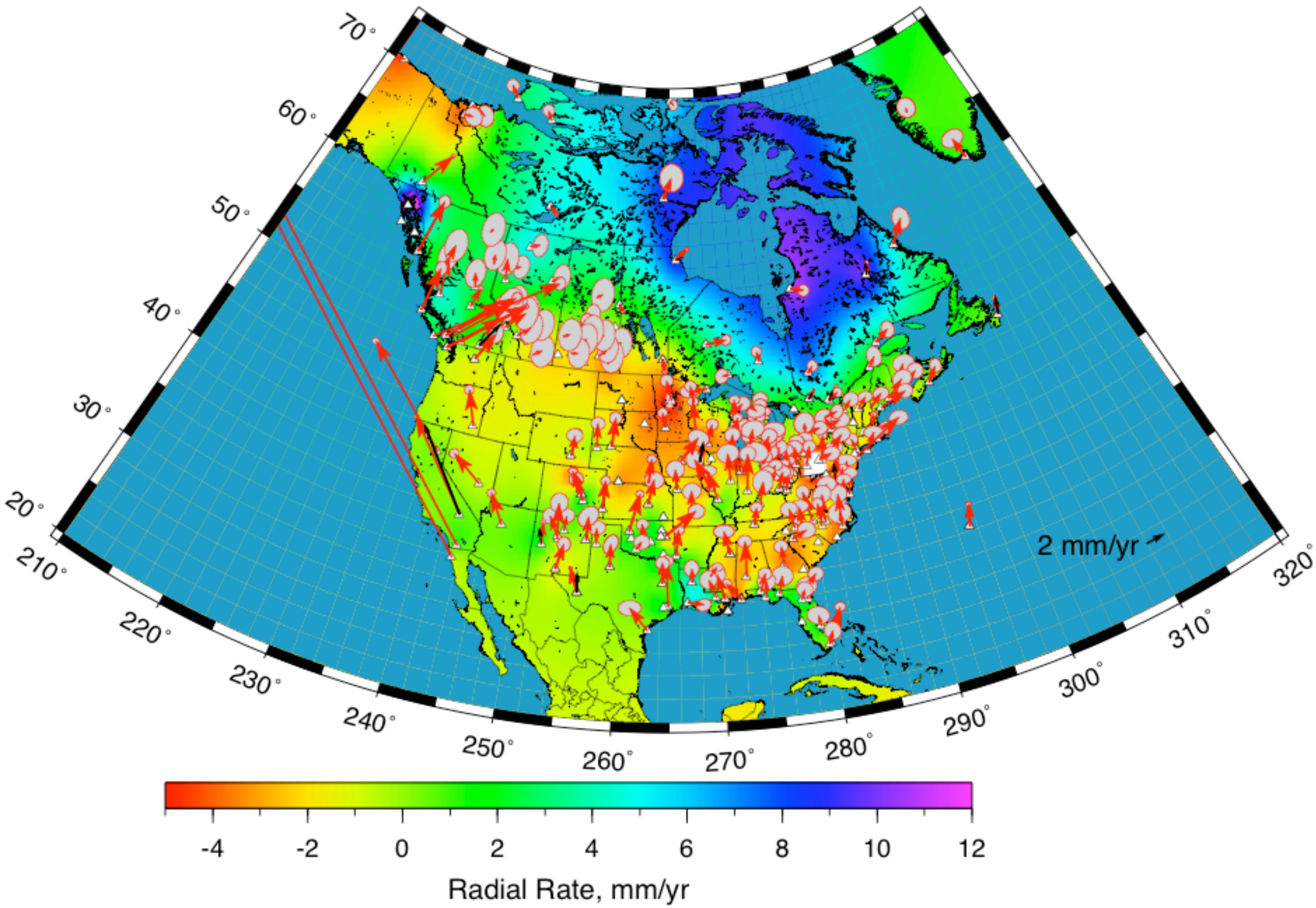
SNARF combination aligned with ITRF2005 N.A. plate



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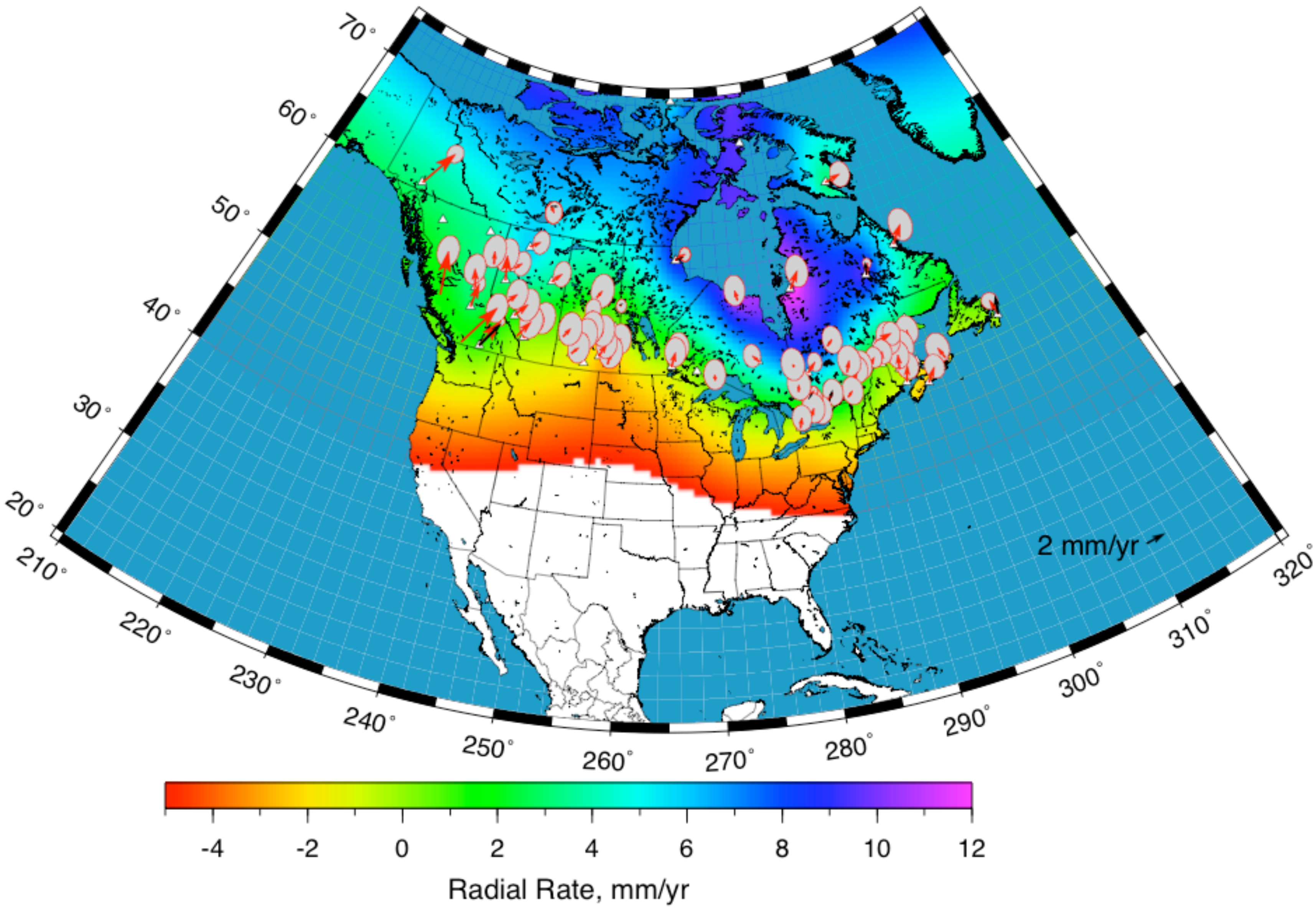
CBN Contribution



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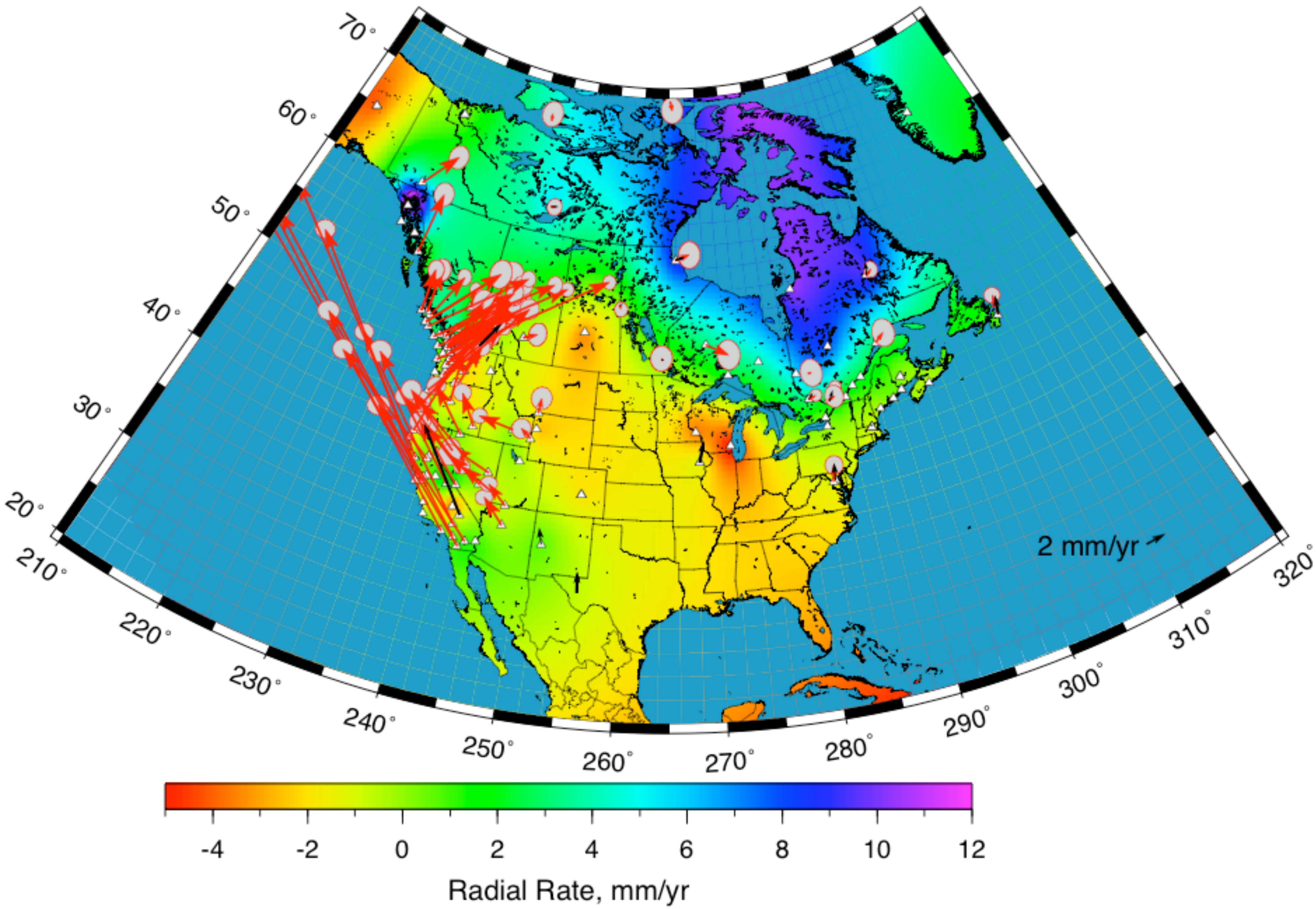
NAR Contribution



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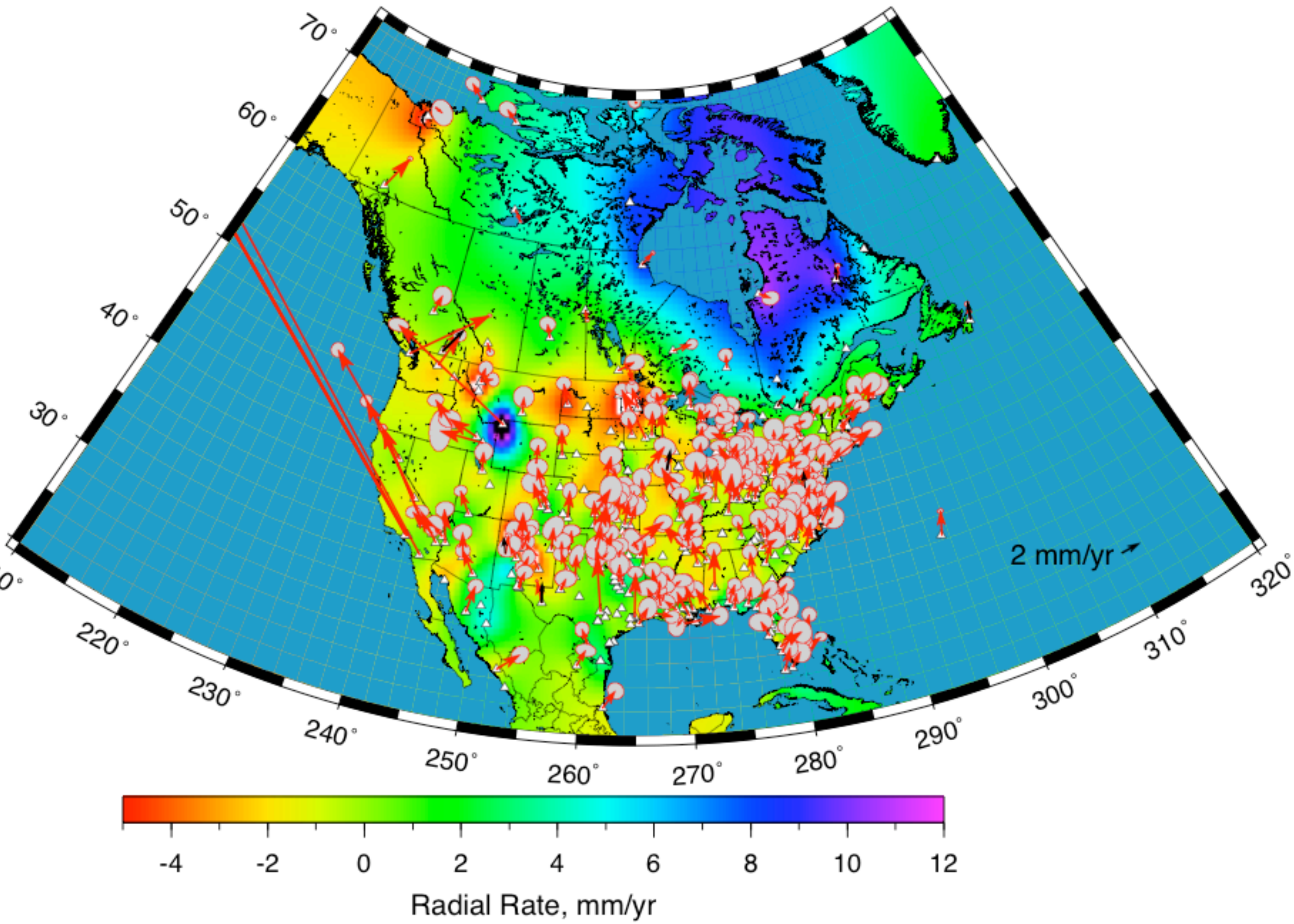
PUR Contribution



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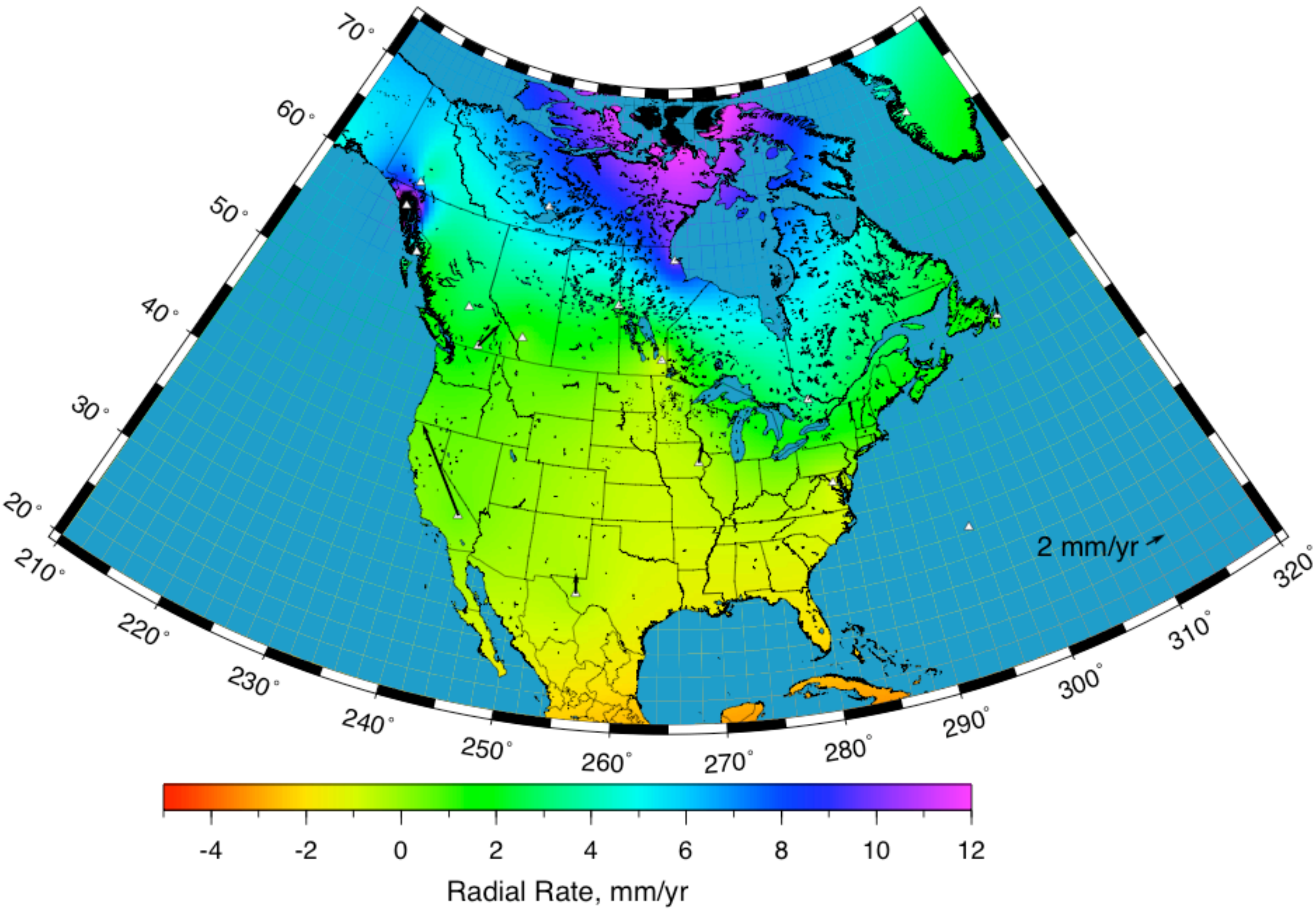
UAF Contribution



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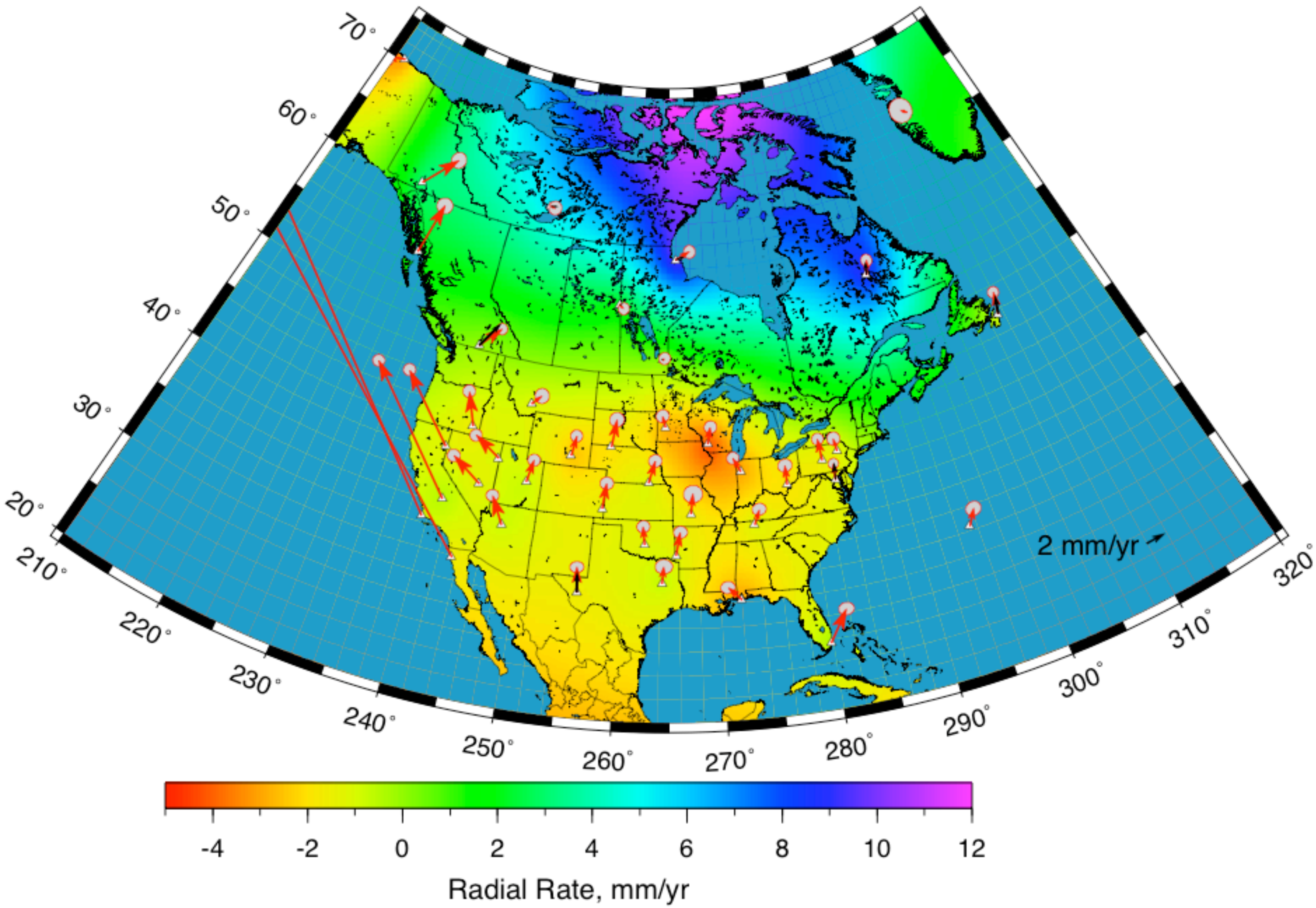
UNR Contribution



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Summary

- Rigorous combination of analyses is possible with antenna height discrepancies accounted for (except UAF) – 47 sites have significant discrepancies and there could be problems at other sites
- Noise models could be improved. There are large variance re-scaling factors likely due to correlated noise at stations and re-use of IGS sites in NAREF combination. Development of site specific noise models would improve the overall reliability of the final solution.
- Preliminary combination needs to be incorporated into the GIA ensemble model for the final frame alignment. Consistency of horizontal and vertical motions could be a problem.
- Numerical stability problems when UAF combination is included which needs to be resolved.
- Some small remaining editing of sites needed.
- Results are all pre-absolute antenna phase center and so…
  Frame will need to re-done when IGS re-processing is complete