UNAVCO GAGE GNSS Data Product Notice to Users:
Notes on 2023 GAGE CWU NAM14 and ANT14 velocity fields
End GPS week 2241, 2022-12-24
2023-01-27

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These notes describe to development of the GAGE velocity fields using Central Washington University (CWU) analysis center results. The report from the fields generated up to the end of 2021 is available but not on the UNAVCO web. It is an update from the 2021 report in the same way this report is an update from that one. The notes here add supplemental information to:
"Notes on 2021 GAGE CWU NAM14 and ANT14 velocity fields, End GPS week 2136, 2021-12-18"
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_Velocity_Field_20201219.pdf
"Notes on 2020 GAGE CWU NAM14 and ANT14 velocity fields End GPS week 2083, 2019-12-14"
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_GNSS_Velocity_Field_Release_Notes_20191214.pdf
"Notes on the 2019 GAGE NAM14 Combined Velocity field to GPS Week 2018 2019-09-15"
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_Velocity_Field_20190612.pdf,
"Notes on the 2017 GAGE Velocity field to GPS Week 1977 2017-12-02";
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_GPS_Velocity_Release_Notes_20171202.pdf,
"Notes on the 2016 PBO Velocity field to Week 1925 2016-12-30",
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_GPS_Velocity_Release_Notes_20161230.pdf, and
"Notes on the 2015 PBO Velocity field to Week 1870 2015-11-14"
https://www.unavco.org/data/gps-gnss/derived-products/docs/GAGE_GPS_Velocity_Release_Notes_20151223.pdf
Associated with this PDF is a folder rel_221224 that contains the comparison velocity fields and other ancillary files used in generating the velocity fields. The contents of the folder are similar that associated with the Herring *et al.*, (2016) paper.

Two velocity fields are described here. One in the North America (NA) region expressed in a North America fixed frame and the other in the Antarctica (ANT) region in an Antarctica fixed frame. The 2022 NA GAGE full velocity solution includes GPS data from GPS week 0834 (Jan-01-1996) to week 2241 (Dec-24-2022) and contains all reprocessed and operational data from the Central Washington University (CWU) analysis center in the ITRF2014 system realization of the North America fixed reference frame. The 2020 ANT solution uses CWU solutions from GPS week 1304 (Feb-12-2005) to week 2241 (Dec-24-2022).

The two sets of velocity fields in the GAGE velocity file format have been queued to LDM as cwu.final_igs14.vel. 20230126114648, cwu.final_nam14.vel. 20230126114648 (NA) and cwu.fanet_ant14.vel. 20230126114648, cwu.fanet_igs14.vel. 20230126114648 (ANT)

The reference frames for this release are NAM14 and ANT14 based on the ITRF2014 system [*Altamimi et al.,* 2016] and the North America plate Euler pole in the ITRF2014 system [*Altamimi, et al.,* 2017].

The complete analysis of the full GAGE velocity field generated from CWU SINEX files (i.e., incorporating full variance covariance matrices and allowing re-alignment of the reference frame for the velocity field) is now released. The 2015 release documents the methods being used to generate these velocity fields using combinations of sub-networks. These methods remain unchanged except now they are based solely on CWU SINEX files. The ANT region has a small enough number stations to allow a simply direct generation of the velocity field.

The process noise models, in the form of random walk time-step variances or process noise (RWPN) are given in All_PBO.rw for the NA region and All_ANT.rw for the ANT region. These values are generated by analysis of the position residuals from fitting the time series for each station. Stations that have process noise values greater than 2.0 mm^2/yr are not included in this velocity solution so that they do not contaminate nearby stations. This criteria removed 501 stations from the full covariance matrix reference frame solution. These sites are included in the time series based velocity solutions. Most of these stations have a combination of large systematics and/or short durations of valid data. The final full combination for the NAM14 reference frame we also excluded sites with <3 yr data span and process noise values greater than 2 mm^2/yr. These limits were placed to keep the total number of elements in the Kalman filter state vector less than 40,000. The final number of NAM14 stations was 2200. For the ANT analysis, we restrict the full analysis stations to those RW process noise less than 10 mm^2/yr. The following stations are included in the times series analyses only: PECE, WWAY, TOMO. KHLR, UTWH and LTHW. We also impose a minimum random walk process noise (RWPN) of 0.05 mm^2/yr. 444 stations in the NA and 16 stations in the ANT analysis have computed RWPN values less than this value. The process noise statistics are generated from the time series using the GAMIT/GLOBK script sh_gen_stats based on tsfit fits to the time series with the realistic sigma algorithm used to account for correlated noise. [*Herring et al*., 2016; *Floyd and Herring*, 2019]. The tsfit solution also generates a list of station position estimates not to be used in the velocity solution because they are outliers (either due to bad analyses, antenna failures or snow on antennas). The current list of edited station position estimates is given in All_NOTA_edits.eq.

NA processing.

The NA processing divides the 2701 stations analyzed into 34 networks each with approximately 80 station locations. 2200 of these sites are included in the final combination. With breaks included, there are 6396 parameter names needed to represents the breaks in the time series. (The final number of estimated parameters for each network depends on the number of breaks needed at each station). The networks need from 113 to 391 individual station names to accommodate the discontinuities, with a median number of stations of 217. There is an average of 2.9 breaks per station in the 28 years. There is no overlap between the stations in the first 34 networks. A 35th network is created to tie all the other 34 networks into a single solution. To form the stations in the 35th network, three stations for each network are chosen so as to minimize the trace of the covariance matrix of the estimates of rotation and translation using these stations. Weights assigned to each station in accord with the expected variance of the velocity estimate for the station (i.e., combination of the RWPN and duration of data at the station). If equal weights are given to each station, this algorithm is the same as choosing the three stations that cover the largest area. The details of the stations in each network are given in All_NOTA_netsel.use. The analyses of the 34 networks can be run in parallel and takes a few hours to run. The combination of the 35 networks uses ~12 Gbytes of memory for the CWU combination, along the equating of velocities (with a constraint of ±0.01 mm/yr) at stations with discontinuities takes about three days of CPU time. The velocity combinations use loose constraints and we align the reference frame as we wish at the end of the combination. We generate four reference frame realizations: (1) A North America frame aligned to our current NAM14 frame using 1656 stations in our hierarchical list of reference frame stations; (2) A North America frame aligned to IGS14 rotated into the North America frame using the 86 stations original used in ITRF2014 to define the North America plate and (3) and (4) are the same as (1) and (2) except the reference velocities are in a NNR reference frame.

The full GLOBK SINEX velocity solution allows us to re-align the reference frames based on the combination of all of the data collected between 1996 for the NA analysis and current day (2022-12-24 GPS Week 2241 for this analysis). The time series analyses for velocities is much faster but the daily solutions need to be aligned the reference frame each day based on an earlier realization of the frames. Tables 1 and 2 compare the WRMS and NRMS scatters of the differences between the velocity estimates obtained using different analysis methods and from previous PBO combined NAM14 and NAM08 velocity solutions released at earlier times. Table 1's caption explains the naming scheme used to describe the solutions. The velocity estimates are generated with three different methods (1) GLOBK SINEX combinations, GK (2) time series analyses using weighted least squares (LS) and (3) time series analyses using a Kalman filter of the time series (KF). The time series LS analysis is the one that generates the monthly GAGE SNAPSHOT fields. The GK analysis can be aligned to the current NAM14 frame (NA)

or be realigned to the IGS14 frame (IG). In all analyses, the same process noise models, discontinuities and post-seismic non-linear models (based on time series analyses) are used. Two set of comparison are shown. The first do not re-align the velocity fields in any way. The RMS values are based on the simple differences between the estimates. The second part of the tables shows results with rotation and translation rates between the reference frames estimated. The numbers of stations do not match between the analyses because the GK analyses exclude stations with large process noise values. Tables 3 and 4 show the same type of comparison when we restrict the stations to the best 772 stations in the solution. (These stations have velocity standards less than the median standard deviations in north, east and up in all three components, 0.13, 0.13 and 0.55 mm/yr, respectively). The number of stations is less than half the number of stations because the standard deviation condition must be met in all components). The NRMS values are very consistent with those in Tables 1 and 2, and in many cases smaller, suggesting that even the stations with the smallest sigma match in accordance with their sigmas.

Table 1: Comparison of North and East velocities between different velocity field determination methods for the NA analysis. No transformation parameters between the fields have been estimated. The codes for the solutions are: CCC_TTYY where CCC is the center CWU or the combined PBO analysis; TT is the type of analysis:
GK – GLOBK Kalman filter; TS – time series fit; and YY is combination of method and reference frame: LS – least squares, KF – Kalman filter; NA – NAM14, IG – IGS14 rotated to NA. The final entries CWU_2021, CWU_2020, CWU_2019 and PBO_2018 are the earlier 2021, 2020 and 2019 CWU only solution (2021 highlighted in yellow) and the 2018 PBO full solutions The PBO field is in the NAM08 reference frame, # is the number of common stations in the solutions.

Soln1 - Soln2	#	N mean (mm/yr)	N WRMS (mm/yr)	N NRMS	E mean (mm/yr)	E WRMS (mm/yr)	E NRMS
CWU_GKNA- CWU_TSLS	2200	-0.00	0.17	1.306	0.01	0.21	1.589
CWU_GKNA- CWU_TSKF	2200	-0.01	0.21	1.331	0.01	0.25	1.608
CWU_GKNA- CWU_GKIG	2200	0.04	0.06	0.318	0.03	0.07	0.370
CWU_TSLS- CWU_TSKF	2699	-0.00	0.13	1.111	0.00	0.13	1.096
CWU_TSLS- CWU_GKIG	2200	0.04	0.19	1.336	0.02	0.23	1.634
CWU_GKNA- CWU_2021	2175	0.01	0.08	0.438	-0.01	0.07	0.412
CWU_GKNA- CWU_2020	2173	-0.02	0.10	0.573	0.00	0.11	0.627
CWU_GKNA- CWU_2019	2187	-0.05	0.15	0.812	0.03	0.15	0.804
CWU_GKNA- PBO_2018	2183	-0.05	0.20	1.085	0.03	0.22	1.156

Comparison with rotation and translation alignment

CWU_GKNA- CWU_TSLS	2200	0.00	0.17	1.307	-0.00	0.21	1.587
CWU_GKNA- CWU_TSKF	2200	-0.00	0.21	1.327	-0.00	0.25	1.606
CWU_GKNA- CWU_GKIG	2200	0.00	0.00	0.022	0.00	0.00	0.023
CWU_TSLS- CWU_TSKF	2699	-0.00	0.13	1.114	-0.00	0.13	1.098
CWU_TSLS- CWU_GKIG	2200	-0.00	0.18	1.298	0.00	0.22	1.581
CWU_GKNA- CWU_2021	2175	0.00	0.08	0.437	0.00	0.07	0.408
CWU_GKNA- CWU_2020	2173	0.00	0.10	0.554	0.00	0.11	0.632
CWU_GKNA- CWU_2019	2187	0.00	0.14	0.747	0.00	0.15	0.789
CWU_GKNA- PBO_2018	2183	-0.00	0.20	1.058	0.00	0.21	1.134

Table 2: Similar to Table 1 except here the mean horizontal velocity (HzMean, HzWRMS, HzNRMS) and vertical velocity (U columns) are compared.

Soln1 - Soln2	#	HzMean (mm/yr)	HzWRMS (mm/yr)	HzNRMS	U Mean (mm/yr)	U WRMS (mm/yr)	U NRMS
CWU_GKNA- CWU_TSLS	2200	0.00	0.19	1.454	-0.03	0.37	0.809
CWU_GKNA- CWU_TSKF	2200	0.00	0.23	1.476	0.10	0.47	0.959
CWU_GKNA- CWU_GKIG	2200	0.03	0.06	0.345	0.27	0.30	0.528
CWU_TSLS- CWU_TSKF	2699	0.00	0.13	1.104	0.10	0.40	1.164
CWU_TSLS- CWU_GKIG	2200	0.03	0.21	1.492	0.29	0.50	1.061
CWU_GKNA- CWU_2021	2175	0.00	0.08	0.425	-0.05	0.29	0.493
CWU_GKNA- CWU_2020	2173	-0.01	0.11	0.601	-0.11	0.37	0.605
CWU_GKNA- CWU_2019	2187	-0.01	0.15	0.808	-0.07	0.48	0.779
CWU_GKNA- PBO_2018	2183	-0.01	0.21	1.121	0.12	0.66	1.052

Comparison with rotation and translation alignment

CWU_GKNA- CWU_TSLS	2200	0.00	0.19	1.454	-0.03	0.37	0.808
CWU_GKNA- CWU_TSKF	2200	-0.00	0.23	1.473	0.02	0.45	0.932
CWU_GKNA- CWU_GKIG	2200	0.00	0.00	0.023	-0.00	0.00	0.008
CWU_TSLS- CWU_TSKF	2699	-0.00	0.13	1.106	0.03	0.39	1.127
CWU_TSLS- CWU_GKIG	2200	-0.00	0.20	1.447	0.03	0.38	0.803
CWU_GKNA- CWU_2021	2175	0.00	0.08	0.423	-0.02	0.28	0.484
CWU_GKNA- CWU_2020	2173	0.00	0.11	0.594	-0.05	0.35	0.582
CWU_GKNA- CWU_2019	2187	0.00	0.14	0.768	-0.05	0.48	0.773
CWU_GKNA- PBO_2018	2183	0.00	0.21	1.097	0.05	0.65	1.037

Table 3: Comparison of North and East velocities similar to Table 1 except we limit the stations to those that have horizontal and vertical velocities sigmas both less than the median horizontal and vertical velocity sigmas. (Reason there are less than 1100 stations is because both horizontal and vertical sigma conditions must be satisfied.) To be included in this table the north and east velocity sigmas must be less than 0.13 and 0.13 mm/yr and the height velocity sigma less than 0.49 mm/yr.

Soln1 - Soln2	#	N mean (mm/yr)	N WRMS (mm/yr)	N NRMS	E mean (mm/yr)	E WRMS (mm/yr)	E NRMS
CWU_GKNA- CWU_TSLS	757	-0.00	0.06	0.603	-0.00	0.07	0.650
CWU_GKNA- CWU_TSKF	757	-0.01	0.07	0.586	0.01	0.07	0.586
CWU_GKNA- CWU_GKIG	757	0.03	0.05	0.352	0.02	0.06	0.421
CWU_TSLS- CWU_TSKF	757	-0.01	0.07	0.878	0.01	0.07	0.890
CWU_TSLS- CWU_GKIG	757	0.04	0.08	0.707	0.02	0.09	0.807
CWU_GKNA- CWU_2021	756	0.01	0.04	0.274	-0.01	0.04	0.305
CWU_GKNA- CWU_2020	757	-0.02	0.06	0.410	0.00	0.06	0.428
CWU_GKNA- CWU_2019	757	-0.04	0.09	0.600	0.02	0.08	0.574
CWU_GKNA- PBO_2018	757	-0.05	0.13	0.860	0.01	0.13	0.890

Comparison with rotation and translation alignment

CWU_GKNA- CWU_TSLS	757	0.00	0.06	0.603	0.00	0.07	0.653
CWU_GKNA- CWU_TSKF	757	-0.00	0.07	0.575	-0.00	0.07	0.578
CWU_GKNA- CWU_GKIG	757	0.00	0.00	0.028	-0.00	0.00	0.029
CWU_TSLS- CWU_TSKF	757	-0.00	0.07	0.884	-0.00	0.07	0.889
CWU_TSLS- CWU_GKIG	757	-0.00	0.06	0.583	-0.00	0.07	0.632
CWU_GKNA- CWU_2021	756	0.00	0.04	0.274	0.00	0.04	0.299
CWU_GKNA- CWU_2020	757	0.00	0.05	0.371	-0.00	0.06	0.442
CWU_GKNA- CWU_2019	757	0.00	0.07	0.493	0.00	0.08	0.558
CWU_GKNA- PBO_2018	757	-0.00	0.12	0.781	0.00	0.13	0.881

Table 4: Same as Table 3 except for the combined horizontal and vertical comparison.

Soln1 - Soln2	#	HzMean (mm/yr)	HzWRMS (mm/yr)	HzNRMS	U Mean (mm/yr)	U WRMS (mm/yr)	U NRMS
CWU_GKNA- CWU_TSLS	757	-0.00	0.06	0.627	-0.04	0.24	0.712
CWU_GKNA- CWU_TSKF	757	-0.00	0.07	0.586	0.07	0.31	0.879
CWU_GKNA- CWU_GKIG	757	0.03	0.05	0.388	0.26	0.29	0.699
CWU_TSLS- CWU_TSKF	757	0.00	0.07	0.884	0.09	0.24	1.048
CWU_TSLS- CWU_GKIG	757	0.03	0.08	0.758	0.31	0.41	1.188
CWU_GKNA- CWU_2021	756	0.00	0.04	0.290	-0.05	0.17	0.381
CWU_GKNA- CWU_2020	757	-0.01	0.06	0.419	-0.11	0.23	0.497
CWU_GKNA- CWU_2019	757	-0.01	0.09	0.587	-0.07	0.32	0.683
CWU_GKNA- PBO_2018	757	-0.02	0.13	0.875	0.08	0.50	1.053

Comparison with rotation and translation alignment

CWU_GKNA- CWU_TSLS	757	0.00	0.06	0.628	-0.03	0.24	0.705
CWU_GKNA- CWU_TSKF	757	-0.00	0.07	0.576	0.01	0.30	0.858
CWU_GKNA- CWU_GKIG	757	0.00	0.00	0.029	-0.00	0.00	0.010
CWU_TSLS- CWU_TSKF	757	-0.00	0.07	0.886	0.03	0.23	0.983
CWU_TSLS- CWU_GKIG	757	-0.00	0.07	0.608	0.03	0.24	0.697
CWU_GKNA- CWU_2021	756	0.00	0.04	0.287	-0.02	0.15	0.355
CWU_GKNA- CWU_2020	757	0.00	0.06	0.408	-0.05	0.20	0.443
CWU_GKNA- CWU_2019	757	0.00	0.08	0.526	-0.04	0.31	0.670
CWU_GKNA- PBO_2018	757	-0.00	0.13	0.833	0.04	0.50	1.042

Over all the agreement between the different methods of estimating the velocities are very good with the WRMS difference in the NE components typically <0.23 mm/yr with the comparison to the PBO 2018 velocity all being about 0.2 mm/yr. The comparison to last year's CWU only solution has WMRS scatters of 0.08 mm/yr. The height WRMS differences are less than 0.5 mm/yr with the comparisons to the earlier solutions being less than 0.7 mm/yr with or without frame re-alignment. The NRMS scatter of the differences is typically less than 1.0 for the different analysis methods and less than 1.1 when compared to earlier solutions.

As noted above, stations have been removed from the GLOBK Kalman filter estimation if the Horizonal Random Walk (HRW) value with >2 mm^2/yr. Velocity estimates for these stations only appear in the time series based analyses.

To show most of the distribution of the stations in the velocity field estimates, we show in Figure 1, the vertical rates of the 2194 stations which have vertical rates with standard deviations less than 5 mm/yr. Due to the process noise limits in the solution, only 6 stations have standard deviations in the vertical rates larger than this value.

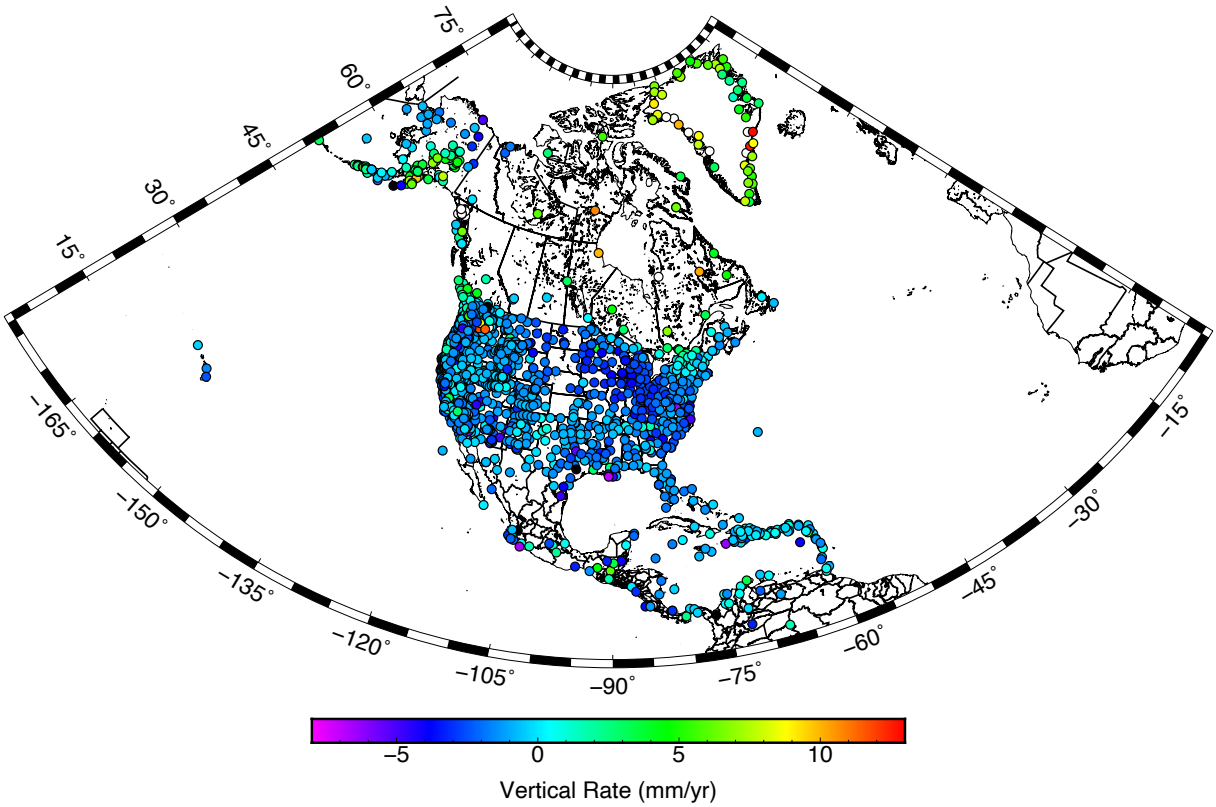

Figure 1: Vertical rate estimates for the 2194 stations in the CWU NAM14 solution with vertical velocity standard deviations of less than 5 mm/yr. (The whole solution contains 2200 stations).

ANT processing

The Antarctica processing is much simpler than the NA processing because of the much smaller number of stations and to a lesser degree the shorter duration of the data: GPS week 1304 (Feb-12-2005) to week 2241 (Dec-24-2022). In the time series analysis, 77 sites are included but in the GLOBK SINEX file combination of 71 stations are included. The 6 additional sites in the time series analysis have larger systematics that are likely to corrupt the combined analysis even with large process noise values assigned to the these stations. As with the NA analysis we compare the results of different analysis types (SINEX versus time series) and with the earlier 2019 combined PBO analysis results. The statistics of the comparison given in Tables 5-8 which are similar to Tables 1-4 for the NA analysis.

Table 5: Comparison of North and East velocities between different velocity field determination methods for the ANT analysis. No transformation parameters between the fields have been estimated. The codes for the solutions are: CCC_TTYY where CCC is the center CWU or the combined PBO analysis; TT is the type of analysis: GK – GLOBK Kalman filter; TS – time series fit; and YY is combination of method and reference frame: LS – least squares, KF – Kalman filter; NA – NAM14, IG – IGS14 rotated to NA. CWU_2020 is last year's solution and is highlighted in yellow. The final entry PBO_2019 is the PBO full solution generated in October 2019. # is the number of common stations in the solutions.

Soln1 - Soln2	#	N mean (mm/yr)	N WRMS (mm/yr)	N NRMS	E mean (mm/yr)	E WRMS (mm/yr)	E NRMS
CWU_GKAN- CWU_TSLS	71	0.02	0.17	1.173	-0.02	0.17	1.233
CWU_GKAN- CWU_TSKF	71	0.01	0.23	1.321	-0.04	0.19	1.157
CWU_GKAN- CWU_GKIG	71	0.04	0.37	1.921	0.09	0.15	0.839
CWU_TSLS- CWU_TSKF	77	-0.01	0.17	1.238	-0.01	0.16	1.209
CWU_TSLS- CWU_GKIG	71	-0.00	0.37	2.338	0.11	0.24	1.569
CWU_GKAN- CWU_2021	71	-0.01	0.09	0.450	0.01	0.09	0.493
CWU_GKAN- CWU_2020	71	0.02	0.11	0.601	-0.02	0.08	0.463
CWU_GKAN- CWU_2019	71	0.01	0.14	0.705	0.01	0.12	0.637
CWU_GKAN- PBO_2019	32	0.00	0.13	0.850	0.00	0.11	0.737

Comparison with rotation and translation alignment

CWU_GKAN- CWU_TSLS	71	-0.01	0.16	1.089	-0.00	0.16	1.185
CWU_GKAN- CWU_TSKF	71	-0.01	0.21	1.184	-0.02	0.18	1.091
CWU_GKAN- CWU_GKIG	71	0.00	0.00	0.020	-0.00	0.00	0.022
CWU_TSLS- CWU_TSKF	77	0.01	0.17	1.212	-0.02	0.16	1.206
CWU_TSLS- CWU_GKIG	71	0.02	0.17	1.090	0.00	0.18	1.154
CWU_GKAN- CWU_2021	71	-0.00	0.08	0.410	0.00	0.09	0.483
CWU_GKAN- CWU_2020	71	-0.01	0.10	0.526	0.00	0.07	0.387
CWU_GKAN- CWU_2019	71	0.01	0.12	0.600	0.01	0.10	0.567
CWU_GKAN- PBO_2019	32	0.02	0.13	0.845	-0.00	0.09	0.589

Table 6: Similar to Table 5 except here the mean horizontal velocity (HzMean, HzWRMS, HzNRMS) and vertical velocity (U columns) are compared.

Soln1 - Soln2	#	HzMean (mm/yr)	HzWRMS (mm/yr)	HzNRMS	U Mean (mm/yr)	U WRMS (mm/yr)	U NRMS
CWU_GKAN- CWU_TSLS	71	-0.00	0.17	1.203	-0.17	0.41	0.844
CWU_GKAN- CWU_TSKF	71	-0.02	0.21	1.242	-0.14	0.50	0.976
CWU_GKAN- CWU_GKIG	71	0.06	0.28	1.482	-0.43	0.90	1.570
CWU_TSLS- CWU_TSKF	77	-0.01	0.17	1.224	0.06	0.40	0.969
CWU_TSLS- CWU_GKIG	71	0.05	0.31	1.991	-0.27	0.80	1.622
CWU_GKAN- CWU_2021	71	0.00	0.09	0.472	-0.05	0.24	0.424
CWU_GKAN- CWU_2020	71	0.00	0.10	0.536	-0.22	0.52	0.875
CWU_GKAN- CWU_2019	71	0.01	0.13	0.672	-0.04	0.51	0.868
CWU_GKAN- PBO_2019	32	0.00	0.12	0.796	0.11	0.30	0.669

Comparison with rotation and translation alignment

CWU_GKAN- CWU_TSLS	71	-0.01	0.16	1.138	0.00	0.37	0.765
CWU_GKAN- CWU_TSKF	71	-0.02	0.19	1.138	0.04	0.49	0.962
CWU_GKAN- CWU_GKIG	71	0.00	0.00	0.021	0.00	0.01	0.009
CWU_TSLS- CWU_TSKF	77	-0.00	0.16	1.209	0.05	0.39	0.951
CWU_TSLS- CWU_GKIG	71	0.01	0.17	1.122	-0.00	0.38	0.765
CWU_GKAN- CWU_2021	71	0.00	0.08	0.448	-0.02	0.23	0.407
CWU_GKAN- CWU_2020	71	-0.00	0.09	0.462	-0.03	0.47	0.791
CWU_GKAN- CWU_2019	71	0.01	0.11	0.584	0.02	0.47	0.798
CWU_GKAN- PBO_2019	32	0.01	0.11	0.728	0.07	0.29	0.6491

Table 7: Comparison of North and East velocities similar to Table 1 except we limit the stations to those that have horizontal and vertical velocities sigmas both less than the median horizontal and vertical velocity sigmas. (Reason there are less than 35 stations is because both horizontal and vertical sigma conditions must be satisfied.) To be included in this table the north and east velocity sigmas must be less than 0.16 and 0.18 mm/yr and the height velocity sigma less than 0.51 mm/yr.

Soln1 - Soln2	#	N mean (mm/yr)	N WRMS (mm/yr)	N NRMS	E mean (mm/yr)	E WRMS (mm/yr)	E NRMS
CWU_GKAN- CWU_TSLS	25	-0.00	0.08	0.759	-0.02	0.10	1.045
CWU_GKAN- CWU_TSKF	25	-0.05	0.12	0.927	-0.03	0.13	1.050
CWU_GKAN- CWU_GKIG	25	-0.09	0.25	1.832	0.09	0.16	1.171
CWU_TSLS- CWU_TSKF	25	-0.03	0.08	0.901	0.00	0.09	1.011
CWU_TSLS- CWU_GKIG	25	-0.10	0.27	2.472	0.11	0.20	1.823
CWU_GKAN- CWU_2021	25	-0.01	0.06	0.410	0.00	0.05	0.403
CWU_GKAN- CWU_2020	25	0.01	0.05	0.381	-0.01	0.06	0.426
CWU_GKAN- CWU_2019	25	-0.01	0.07	0.512	0.01	0.06	0.438
CWU_GKAN- PBO_2019	20	0.00	0.06	0.460	-0.00	0.07	0.588

Comparison with rotation and translation alignment

CWU_GKAN- CWU_TSLS	25	-0.01	0.07	0.698	-0.01	0.10	1.002
CWU_GKAN- CWU_TSKF	25	-0.02	0.09	0.697	-0.02	0.11	0.927
CWU_GKAN- CWU_GKIG	25	0.00	0.00	0.029	-0.00	0.00	0.027
CWU_TSLS- CWU_TSKF	25	0.00	0.07	0.742	-0.01	0.09	0.962
CWU_TSLS- CWU_GKIG	25	0.01	0.08	0.690	0.01	0.10	0.935
CWU_GKAN- CWU_2021	25	-0.00	0.05	0.376	0.01	0.05	0.396
CWU_GKAN- CWU_2020	25	0.00	0.04	0.311	0.00	0.04	0.300
CWU_GKAN- CWU_2019	25	0.01	0.07	0.479	0.01	0.05	0.395
CWU_GKAN- PBO_2019	20	0.01	0.07	0.496	0.00	0.05	0.386

Table 8: Same as Table 7 except for the combined horizontal and vertical comparison.

Soln1 - Soln2	#	HzMean (mm/yr)	HzWRMS (mm/yr)	HzNRMS	U Mean (mm/yr)	U WRMS (mm/yr)	U NRMS
CWU_GKAN- CWU_TSLS	25	-0.01	0.09	0.913	-0.11	0.32	0.958
CWU_GKAN- CWU_TSKF	25	-0.04	0.12	0.991	-0.10	0.41	1.142
CWU_GKAN- CWU_GKIG	25	0.00	0.21	1.537	-0.21	0.63	1.549
CWU_TSLS- CWU_TSKF	25	-0.02	0.09	0.958	0.03	0.20	0.740
CWU_TSLS- CWU_GKIG	25	0.00	0.24	2.172	-0.14	0.60	1.725
CWU_GKAN- CWU_2021	25	-0.01	0.05	0.406	-0.02	0.06	0.143
CWU_GKAN- CWU_2020	25	0.00	0.05	0.404	-0.18	0.21	0.494
CWU_GKAN- CWU_2019	25	0.00	0.06	0.477	0.02	0.16	0.400
CWU_GKAN- PBO_2019	20	-0.00	0.07	0.528	0.12	0.26	0.675

Comparison with rotation and translation alignment

CWU_GKAN- CWU_TSLS	25	-0.01	0.09	0.863	-0.02	0.31	0.918
CWU_GKAN- CWU_TSKF	25	-0.02	0.10	0.820	-0.04	0.40	1.130
CWU_GKAN- CWU_GKIG	25	0.00	0.00	0.028	0.00	0.01	0.013
CWU_TSLS- CWU_TSKF	25	-0.00	0.08	0.859	-0.01	0.17	0.636
CWU_TSLS- CWU_GKIG	25	0.01	0.09	0.822	0.02	0.31	0.906
CWU_GKAN- CWU_2021	25	0.00	0.05	0.387	-0.03	0.06	0.153
CWU_GKAN- CWU_2020	25	0.00	0.04	0.306	-0.01	0.10	0.238
CWU_GKAN- CWU_2019	25	0.01	0.06	0.439	0.00	0.17	0.414
CWU_GKAN- PBO_2019	20	0.01	0.06	0.444	0.05	0.22	0.578

The agreement between the different analysis methods and earlier solutions is at the 0.2 mm/yr and 0.5 mm/yr levels in the horizontal and vertical components. The NRMS scatter of the sites with better than the median horizontal and vertical sigmas are similar to NRMS values of all stations suggesting the sigmas are scaled consistently. The Figures 2 and 3 we show the horizontal and vertical motions of the 71 sites included in the GLOBK SINEX analysis.

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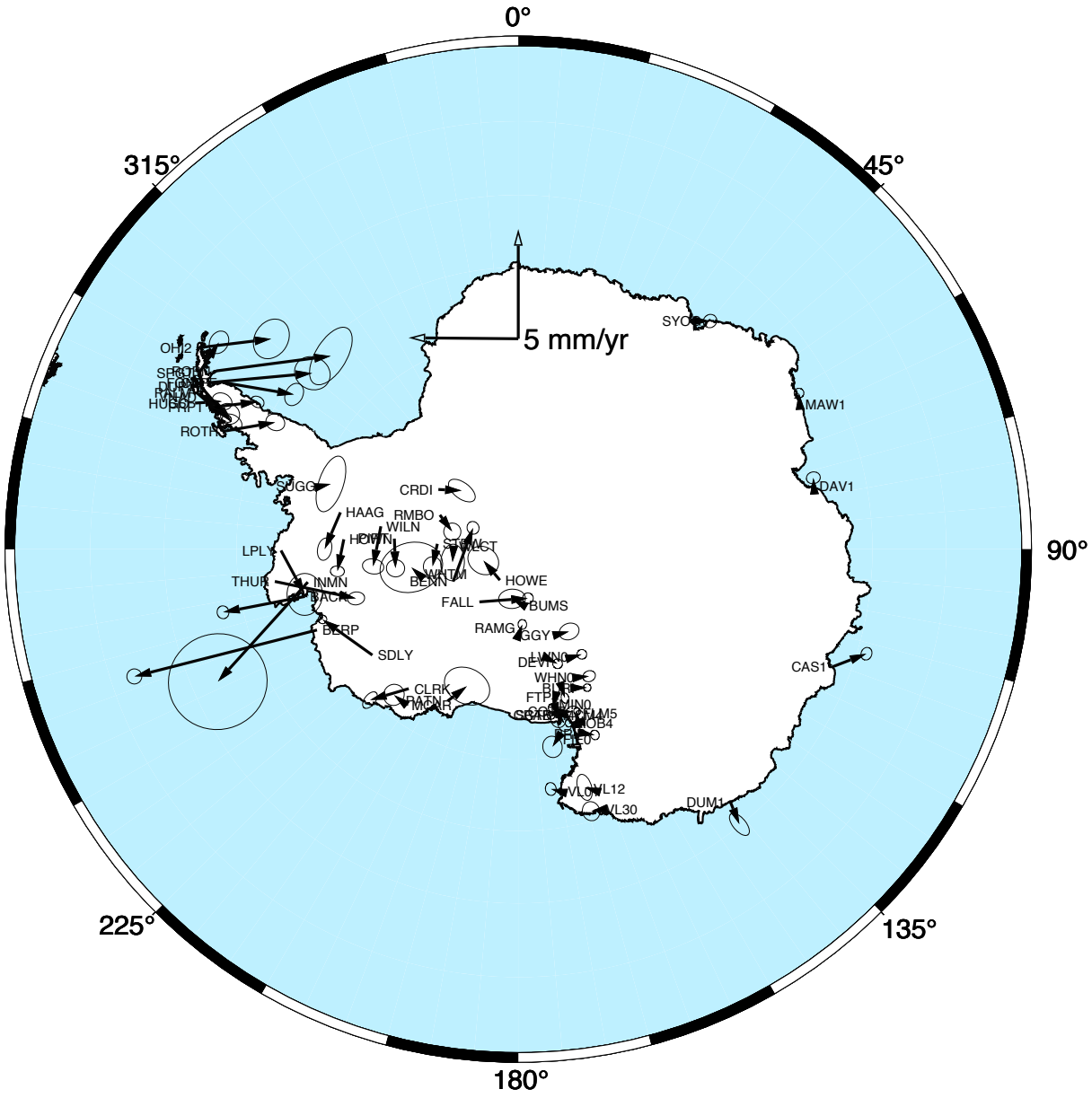

Relative to NONE Input file : CWU_ant_221224_ANT14.vel

Figure 2: Horizontal motions in the ITRF2014 Antarctica fixed reference frame from the GLOBK SINEX file analysis (GKAN).

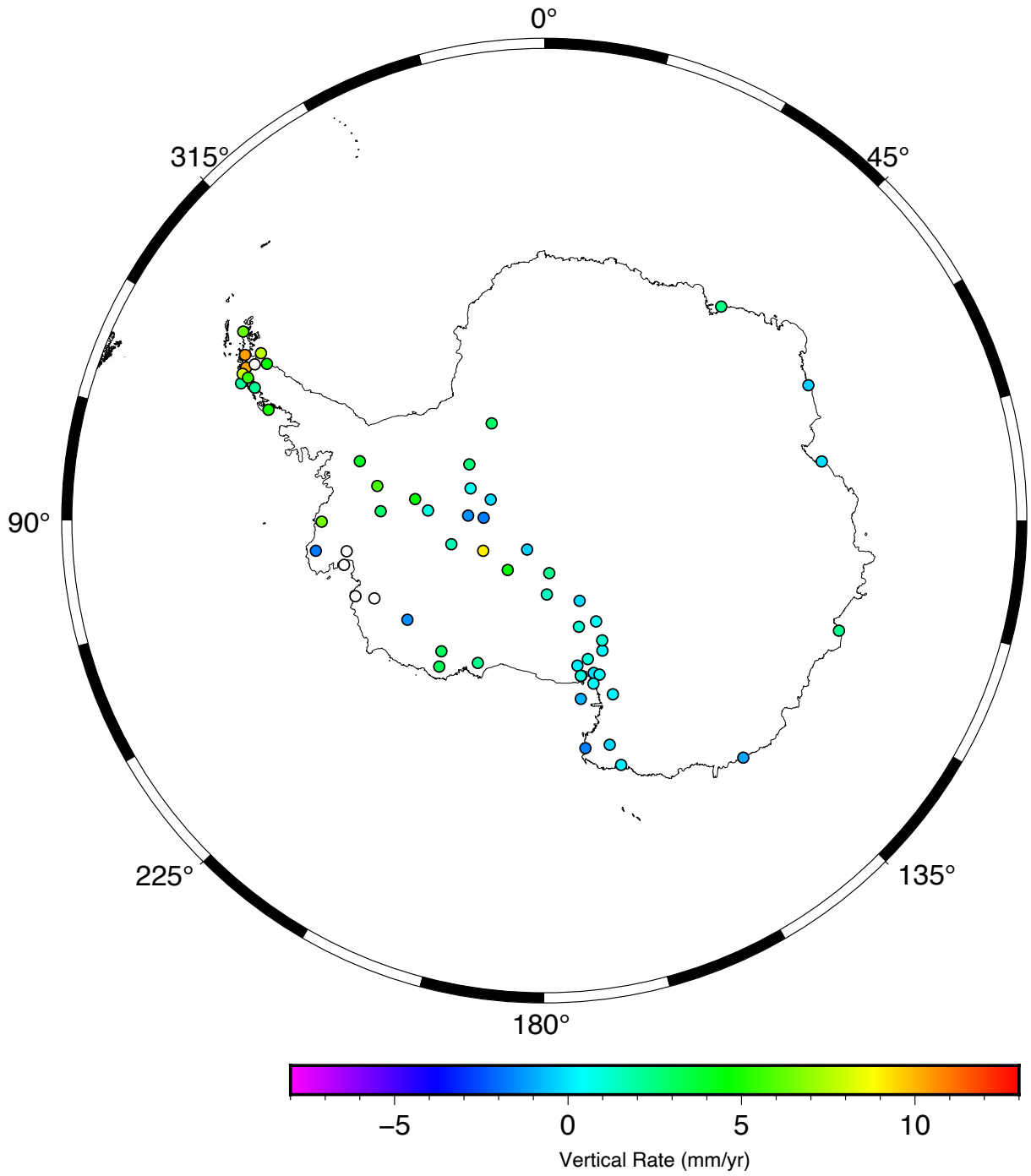

Figure 3: Vertical motions from the GLOBK SINEX file analysis (GKAN). The sites with white symbols are uplifting at rates >15 mm/yr.