PRISim vs pyuvsim 1.2 reference simulation comparison

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ABSTRACT

This memo presents the third out of three comparisons between PRISim and pyuvsim reference simulations. This reference simulation has very few sources but a very long time axis. We compare the reference simulation amplitudes and phases over time and fringe rate transforms of the visibilities. We discovered that amplitudes agree but phases differ very slightly. An analysis of the uvw coordinates of one baseline also shows slight differences. The most likely explanation is a difference in phasing of the data.

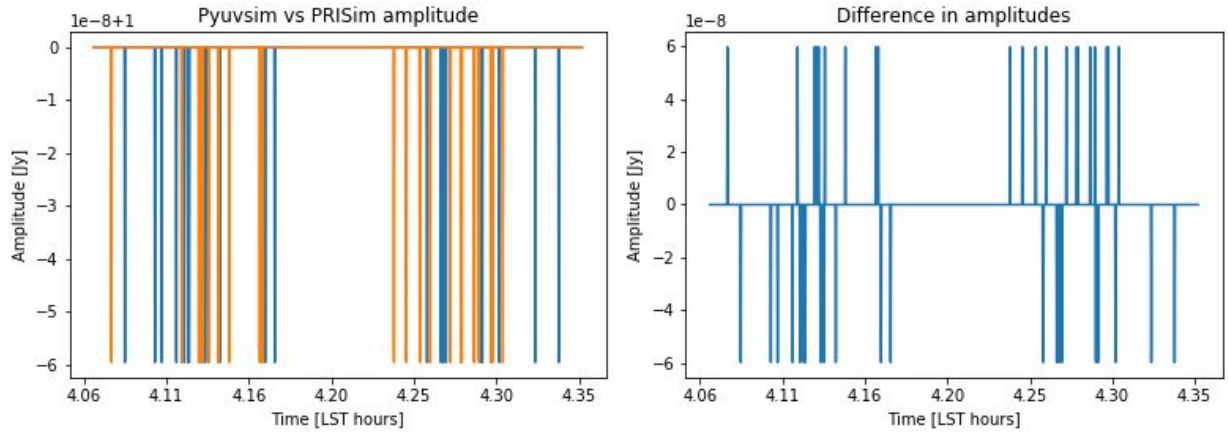
1. Introduction

Pyuvsim reference simulation contains 86400 times, 1 frequency, 4 polarizations and 10 baselines. It's simulating one sources and then 2 sources going over the horizon over 24 hours. However, PRISim could not reproduce such a long simulation so instead 2 PRISim reference simulations were created. One starting at the same time but much shorter (about 17 minutes) with 1 second cadence, and another one which spans the length of pyuvsim reference simulation (almost 23 hours) with 80 seconds cadence. Each PRISim reference simulation contains 1024 times, 2 frequencies, 1 polarization and 6 baselines. In both cases, we selected the best matching 1024 times, 1 frequency, 1 polarization and 1 baseline. We chose baseline 2_0 which is oriented exactly North and is 50 m long.

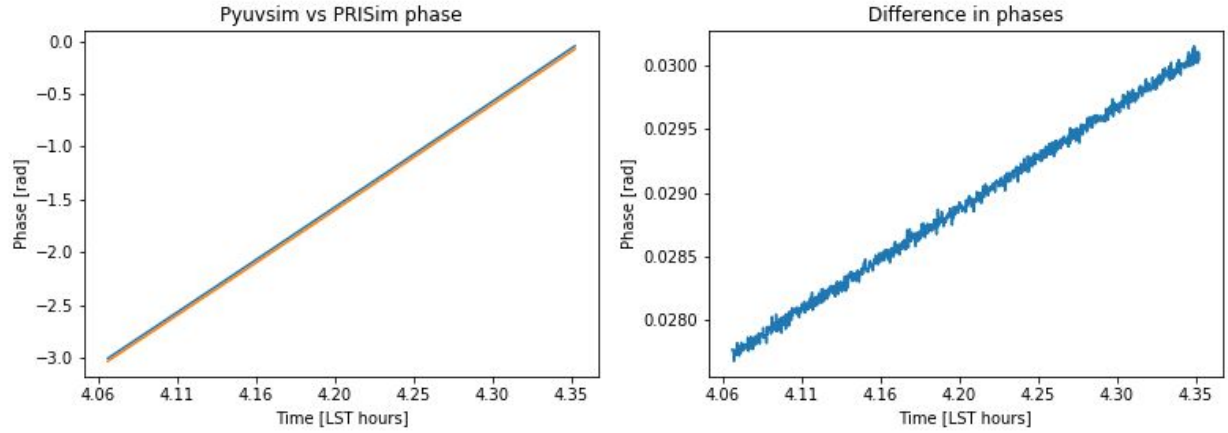
2. Discussion

2.1 Short simulations with high time resolution comparison

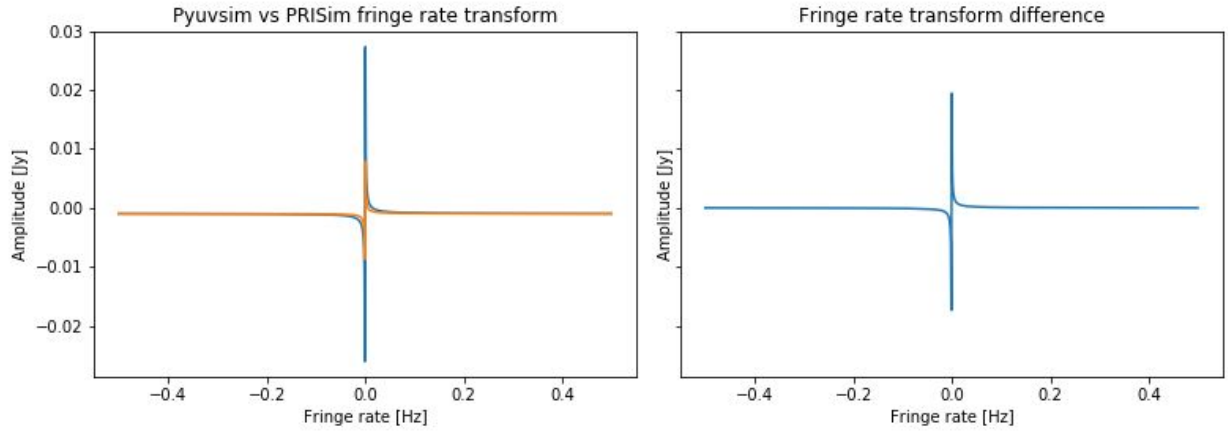
We are first going to compare short 1s cadence simulations that observe only one source in the sky. We are now going to plot amplitude and phase over time, and the fringe rate transform.



These simulations only have one source with amplitude of 1 Jy above the horizon and no beam. Hence, the correct answer is 1 Jy and the simulations agree on that and the differences are 7 orders of magnitude smaller than the signal and highly quantized, suggesting machine precision level errors.



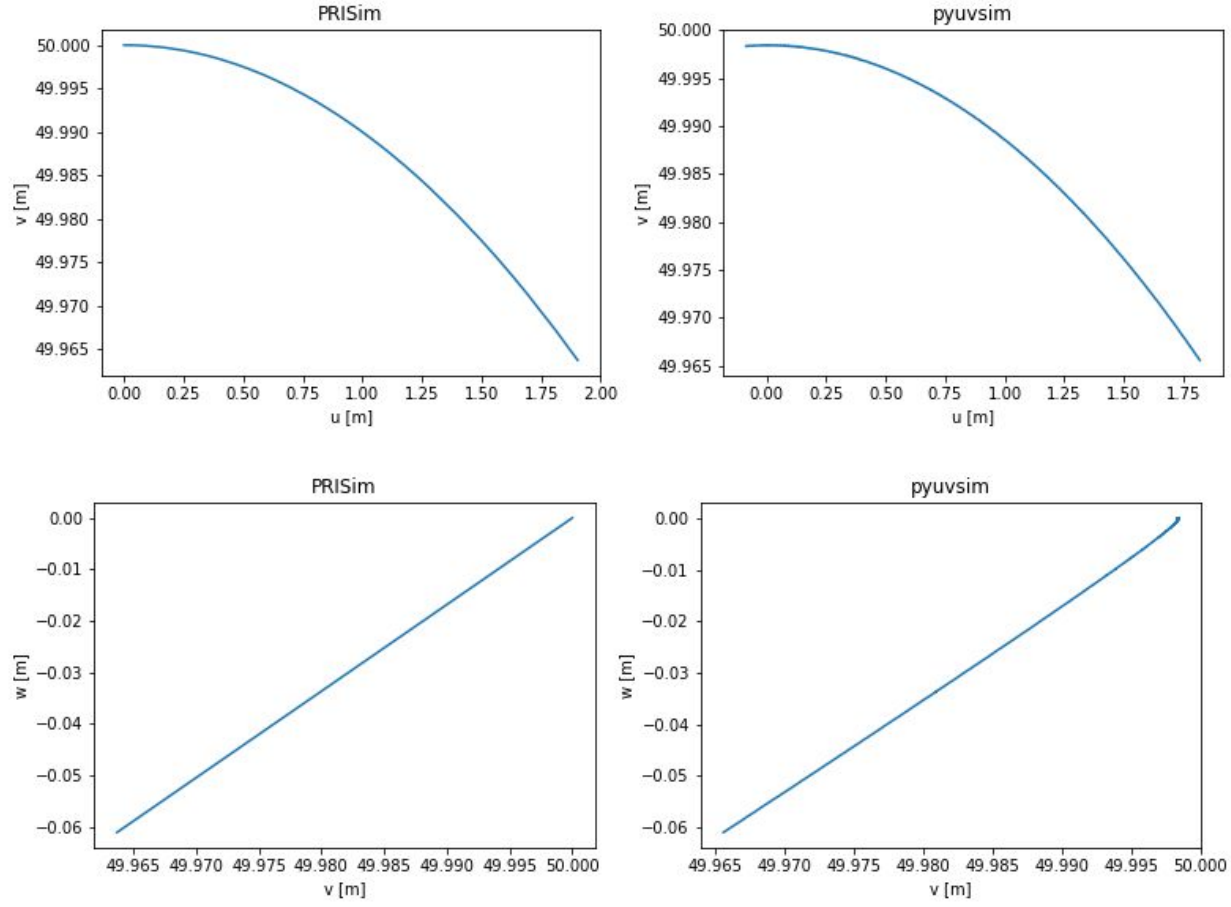
We can see that the phases of PRISim and pyuvsim disagree only slightly. There is an overall phase slope difference and the difference is also noisy. By eye, the difference is about 10^-4 radians or about 20 arcseconds.

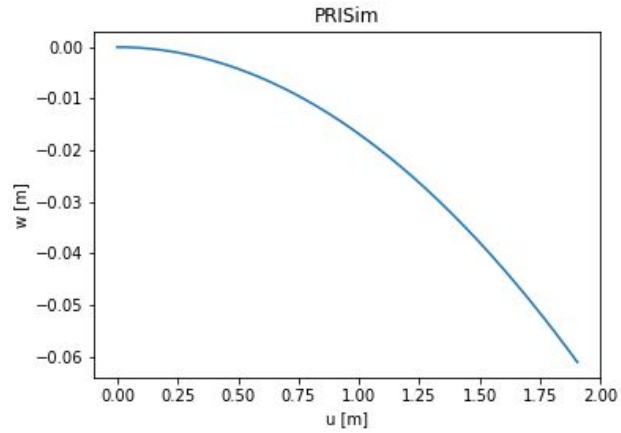


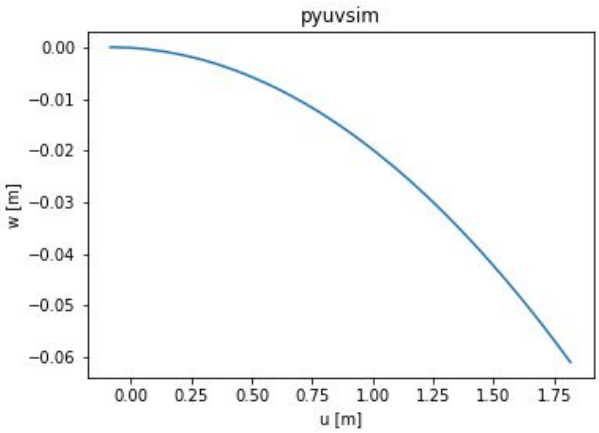
We can see that the fringe rate transform plots don't exactly agree but since it's a North-South baseline, we expect to have zero fringe rate so qualitatively these plots are correct. We looked at other baselines, with other orientations, and qualitatively nothing has changed. However, we are going to investigate it further by looking at the uvw coordinates of the baseline.

2.2 UVW comparison

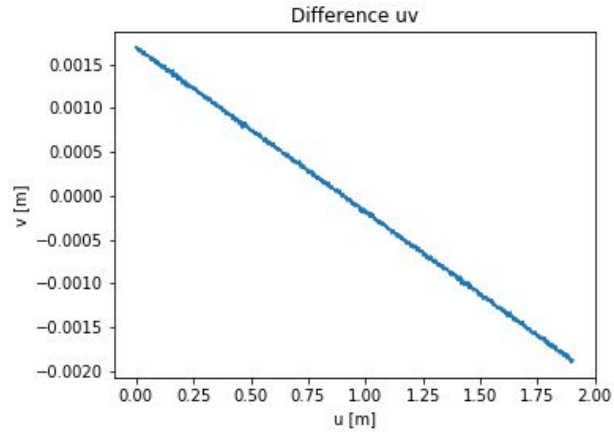
To check that the difference is in phasing, we decided to compare pyuvsim and PRISim uvw positions. These are phased (u, v, w) coordinates for one baseline for all times, so they form a line because they are from a number of different times.

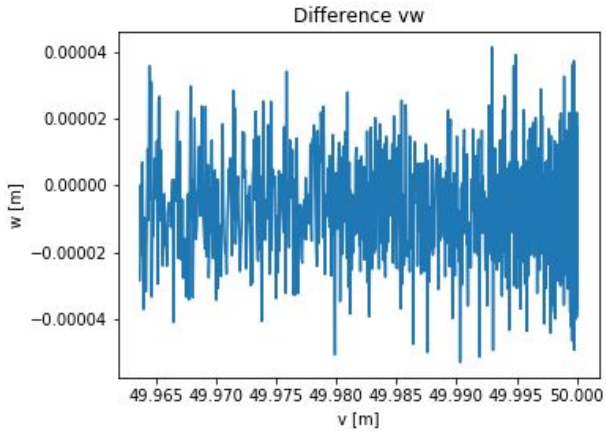


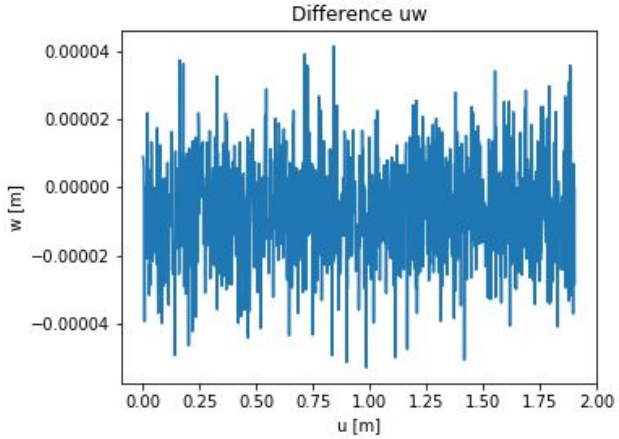




We then plotted the difference of (u, v, w) positions [pyuvsim - PRISim] and we can see that they differ slightly:

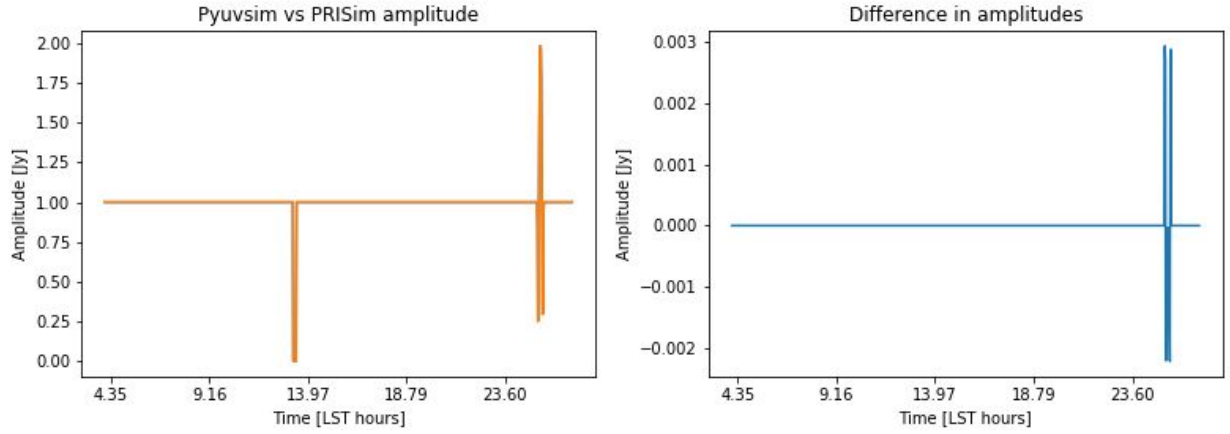




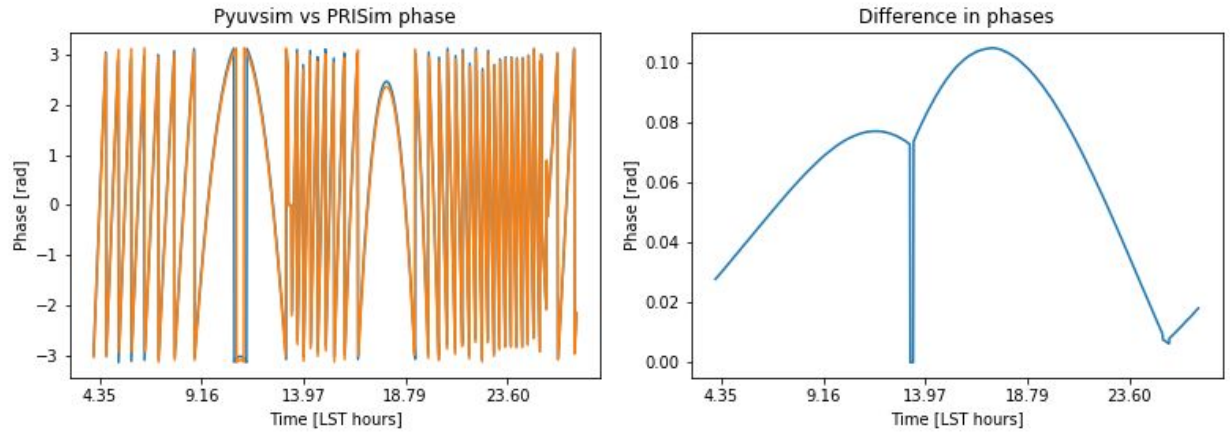


2.3 Long simulations with low time resolution comparison

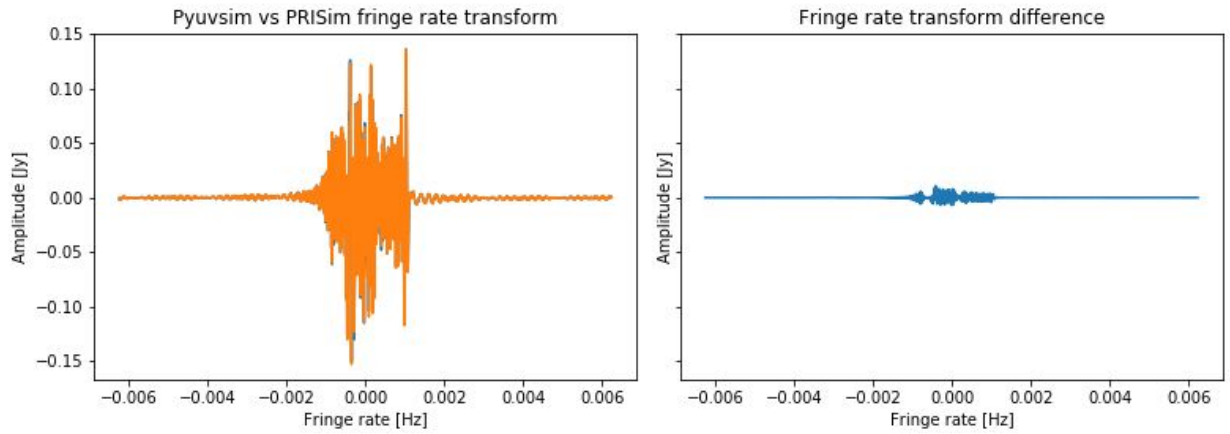
We are now going to compare 23 hours long 80s cadence simulations that observe either no source, one source or two sources in the sky depending on the LST. We are again going to plot amplitude and phase over time, and the fringe rate transform. This is a phased comparison so the phase center goes under the horizon for about 12 hours of the observation.



Both simulations start with one source (1 Jy), then no source (0 Jy right before 13.97 hrs LST), one source again and then two sources (2 Jy after 23.60 hrs LST). We can see that both simulations agree perfectly when there are one and no sources in the sky. However, we can see that they disagree when two sources are in the sky, but they only disagree to 0.2%



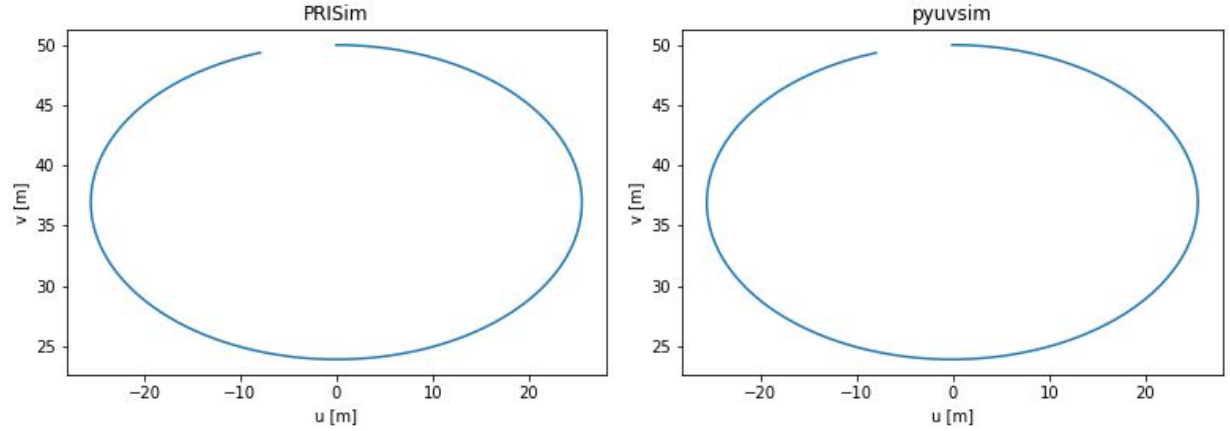
We can see that phases mostly agree, but the difference between them is under 2%. This might be due to the difference in phasing. PRISim and pyuvsim do the conversion from (right ascension, declination) coordinates to (local altitude, local azimuth) coordinates differently. PRISim calculation is known to be slightly wrong.

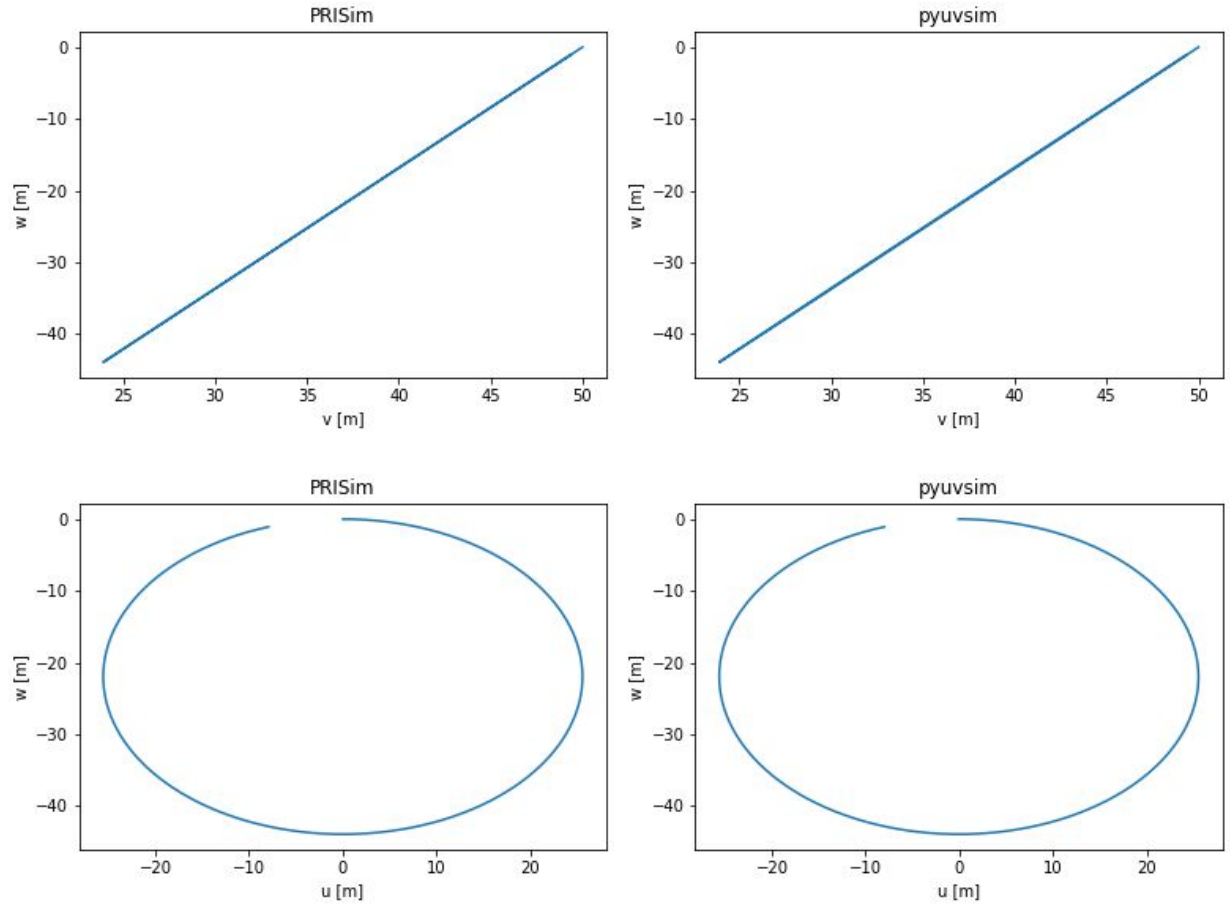


We can see that fringe rate transforms mostly agree but they differ by about 5%. This could be due to the difference in phasing.

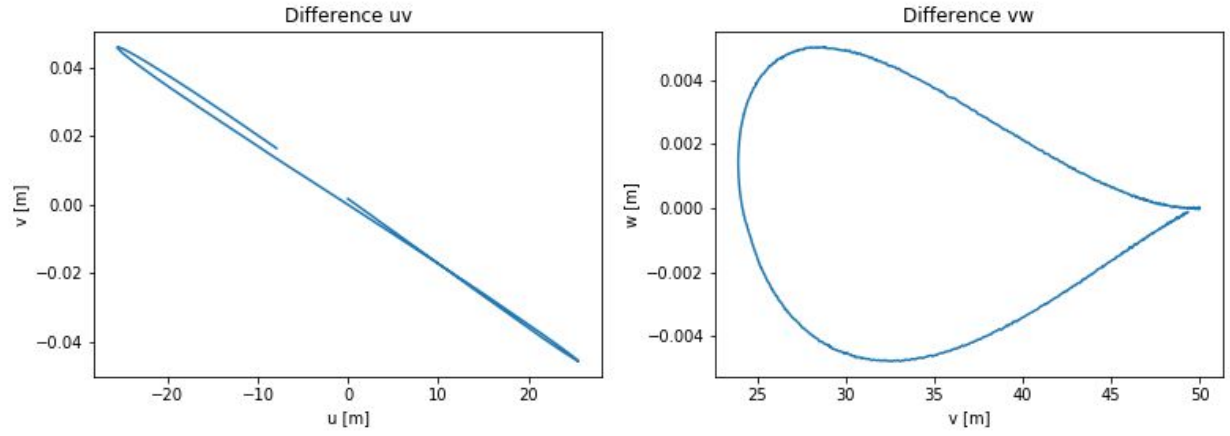
2.4 UVW comparison

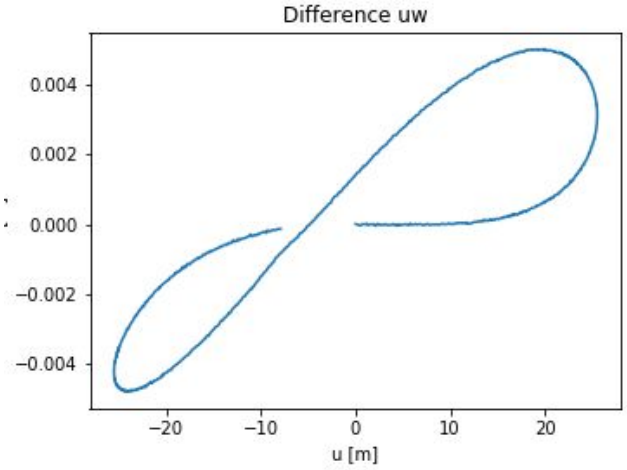
Similarly, we are going to compare pyuvsim and PRISim uvw positions. These are also phased (u, v, w) coordinates for one baseline for all times.





Similarly, we can see that they differ slightly when we plotted the difference between them.





We see an overall drift in the differences, but a close inspection also reveals a small noisy component to the differences.

3. Conclusion

In conclusion, the amplitudes of pyuvsim and PRISim do not differ significantly. However, their phases and fringe rate transform plots are slightly different. Similarly, uvw positions are also slightly different, which is likely due to the difference in phasing between pyuvsim and PRISim. The level of error is consistent with the level of error in the first comparison between PRISim and pyuvsim 1.1 reference simulations, which further suggests that the difference is likely due to the difference in phasing.