WHOTS GPS Derived Buoy Velocity Calculations

Craig Nosse, Ethan Roth and Roger Lukas

March 12, 2013

Summary: Velocity calculations for the WHOTS buoy were performed for WHOTS -3, 5, 6 and 7. GPS failures for WHOTS-1, 2 and 4 resulted in very small datasets that presently are not making calculations worthwhile. The velocity calculations are intended to allow corrections in WHOTS ADCP and VMCM velocity data for buoy motion.

Sample Interval: GPS logging for WHOTS-5, 6 and 7 was set in a "burst sample" mode where multiple GPS position fixes were recorded at a preselected interval (see Table 1 for details). WHOTS-3 only returned single fixes at a 10 minute sample interval.

Deployment	Burst Interval	# of Samples per Burst	Sample Interval
WHOTS-5	30 minutes	30	10 seconds
WHOTS-6	30 minutes	15	20 seconds
WHOTS-7	30 minutes	15	20 seconds

Table 1 GPS Burst sampling parameters for WHOTS-5, 6 and 7

The number of samples in a burst was not always consistent, nor was the burst/sample interval consistent. This can be seen in histograms of the time intervals between samples (top panel, Figure 1 through Figure 4). The two separate distributions shown in those histograms are1) the time between samples within one burst and 2) the time between the sample at the end of one burst and the sample at the beginning of the following burst. After averaging data within a burst to the midpoint time of the burst, an ensemble can be created. The distributions of time intervals between these ensembles are shown in the bottom panel of Figure 1 through Figure 4. WHOTS-7 ensemble time distributions (lower panel, Figure 4) differ from other deployments as there were frequent occasions where the GPS on this deployment would power cycle and then establish a different sample interval until it could be manually reset from WHOI.

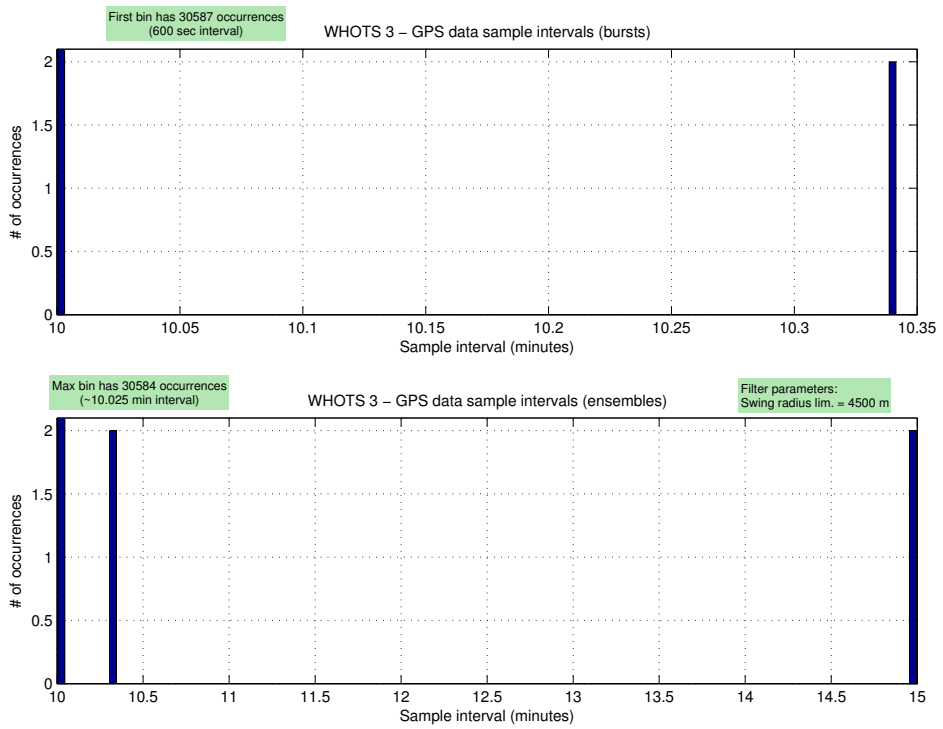

Figure 1 Distribution of time intervals between GPS samples (top panel) and time interval between GPS ensembles (bottom panel) for WHOTS-3.

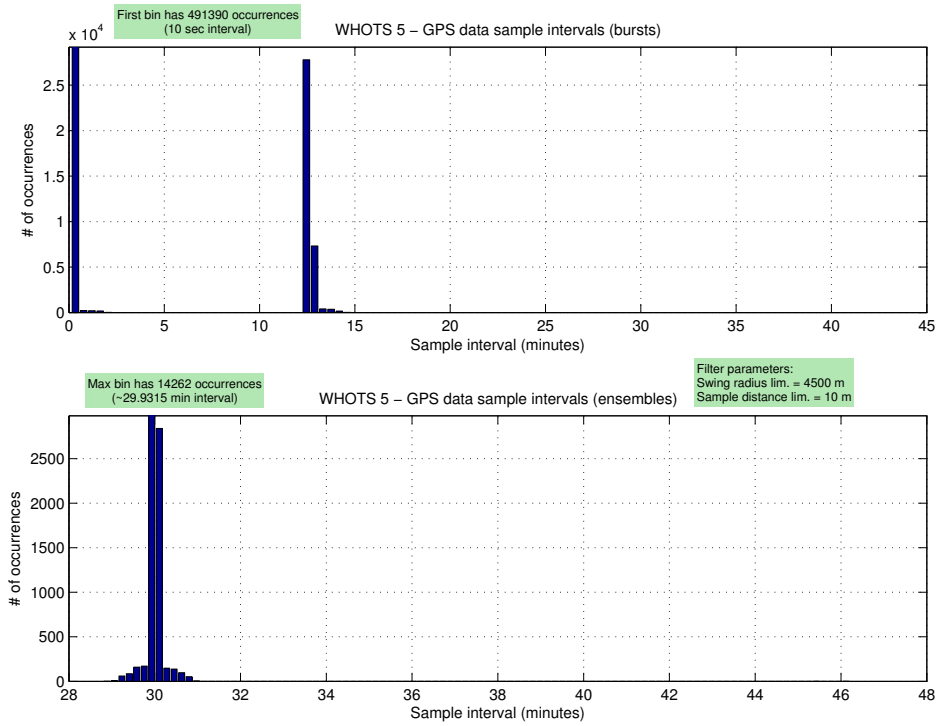

Figure 2 Same as for Figure 1 but for WHOTS-5.

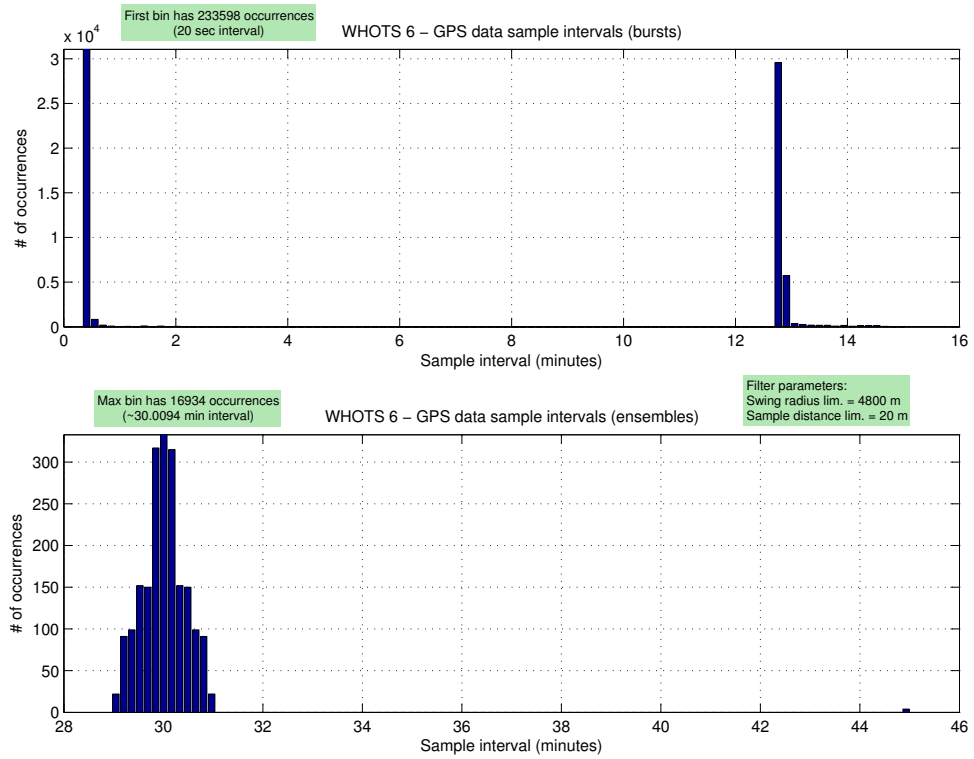

Figure 3 Same as Figure 1 but for WHOTS-6.

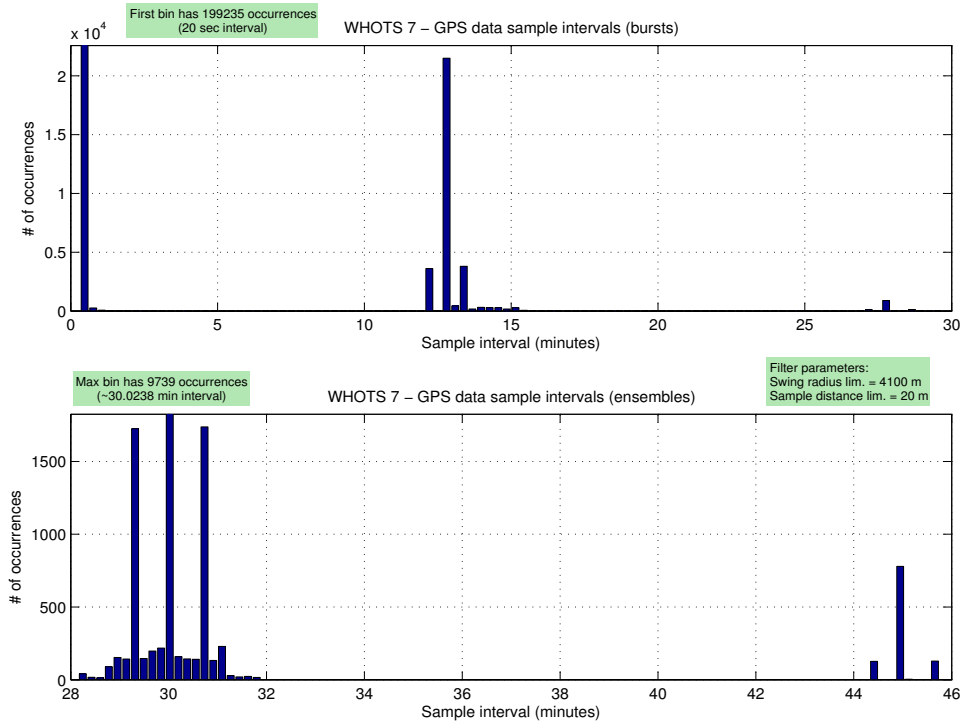

Figure 4 Same as for Figure 1 but for WHOTS-7.

Screen for Bad Fixes: Efforts were made to quality control the GPS data by eliminating gross error fixes as well as fixes that were not consistent within an ensemble. Gross errors were determined by identifying points that were well outside the watch circle of the buoy during deployment. The deployment period was defined as starting one hour after the anchor was dropped to one hour before the anchor was released upon recovery. All GPS fixes for each deployment were plotted (left panel, Figure 5 through Figure 8) to determine approximate buoy watch circles. These estimated watch circles were then applied to screen out fixes outside of this radius and to average each good GPS fix in a burst to an ensemble value (right panel, Figure 5 through Figure 8).

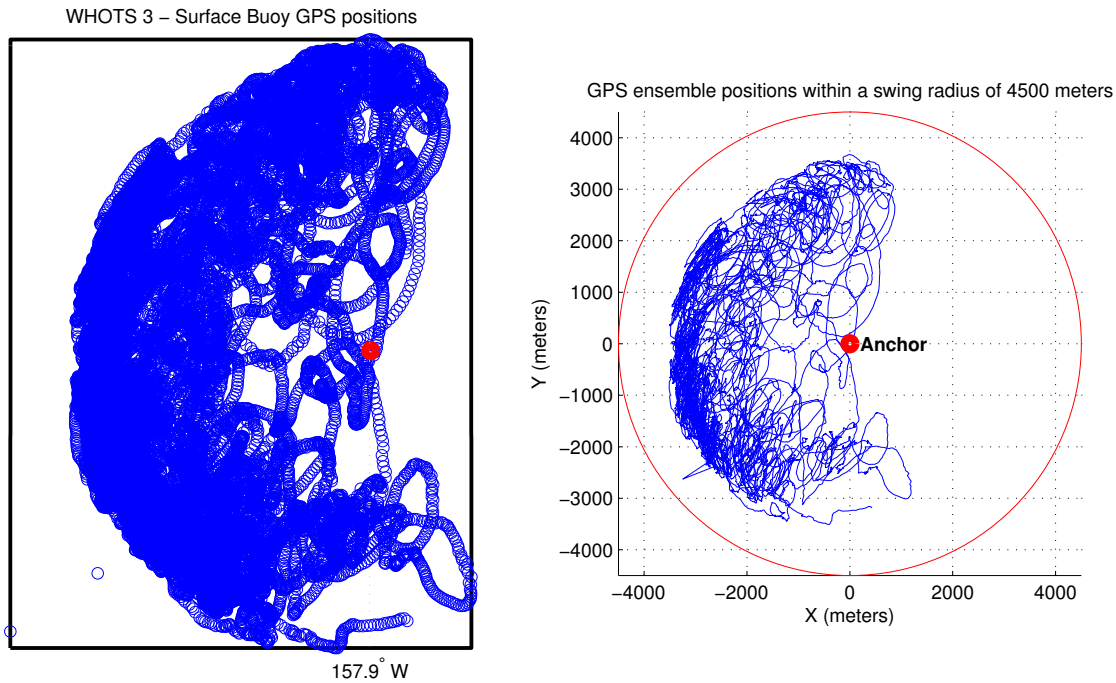

Figure 5 Raw GPS fixes (left panel) and quality screened GPS ensembles (right panel) for WHOTS-3.

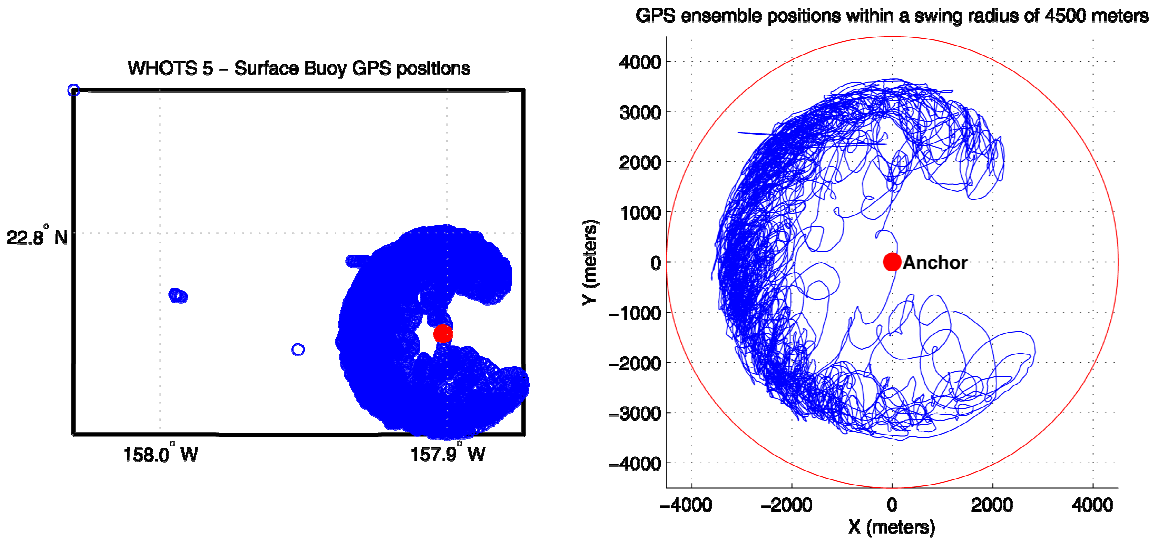

Figure 6 Same as for Figure 5 but for WHOTS-5.

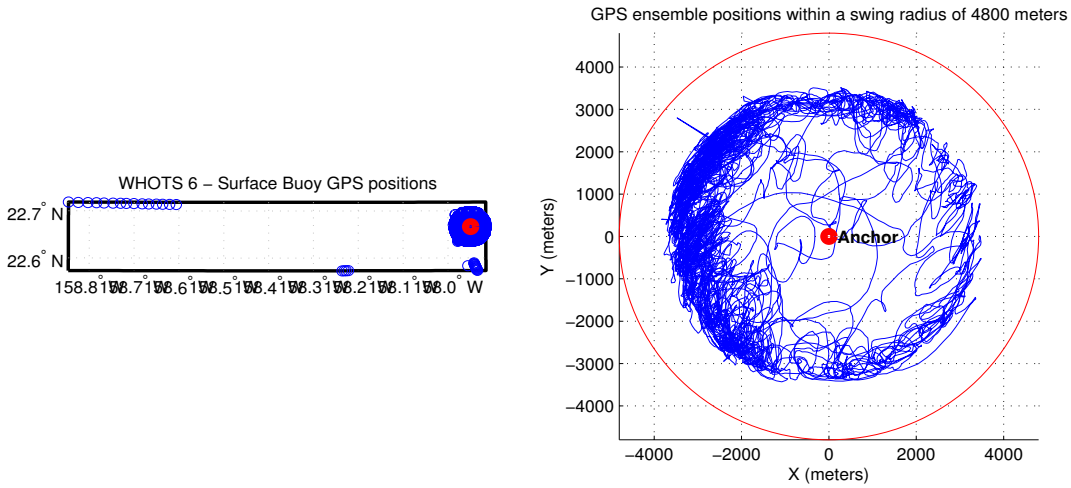

Figure 7 Same as for Figure 5 but for WHOTS-6.

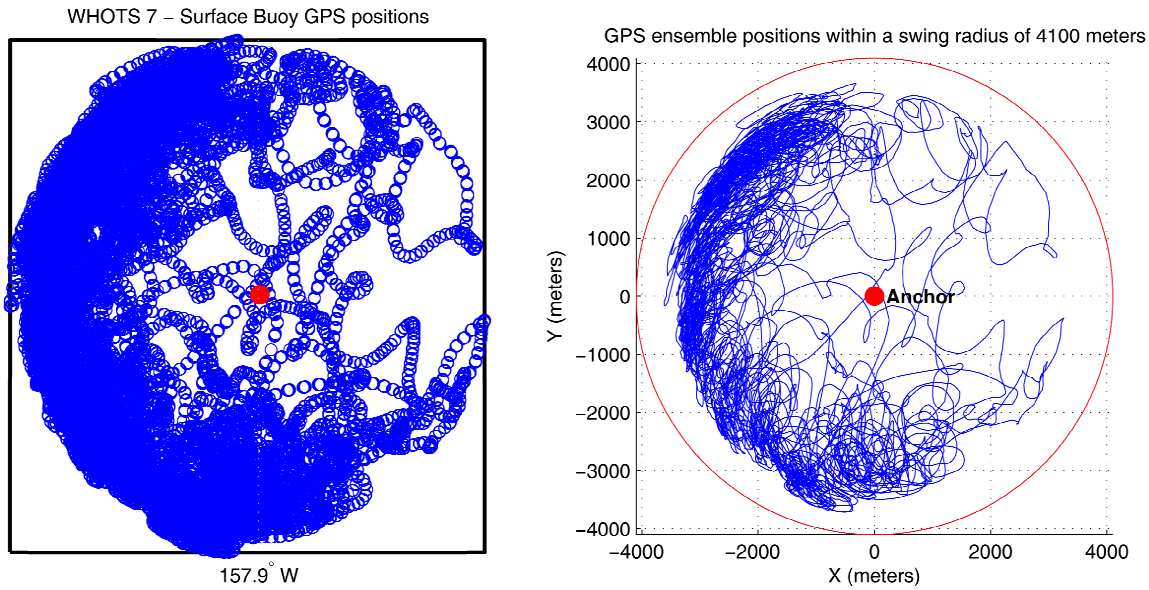

Figure 8 Same as for Figure 5 but for WHOTS-7.

Upon close examination of some these gross error GPS fixes, it can be seen on occasion that all the individual samples within a burst are bad (for example, Figure 9).

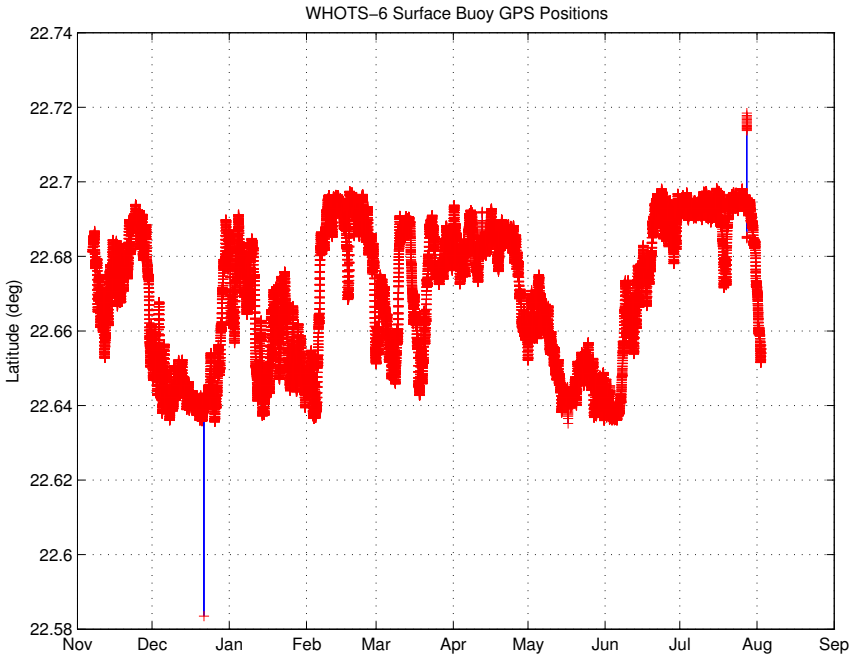

Figure 9 An examination of gross errors GPS fixes from WHOTS-6. All gross error points in July are within one burst.

However, some excursions of the buoy outside the watch circle can be real. For example, looking at WHOTS-6, an ensemble can be seen outside of the northwest quadrant of the watch circle (right panel, Figure 7). Close examination shows that the buoy quickly and systematically

transited outside the watch circle and then returned (Figure 10). We believe incidents similar to this one occur when fishermen tie up to the buoy and then drag it away to catch fish underneath it. Once the buoy is released, it “slingshots” back towards the anchor position. Speed and direction of this event is captured in Figure 11.

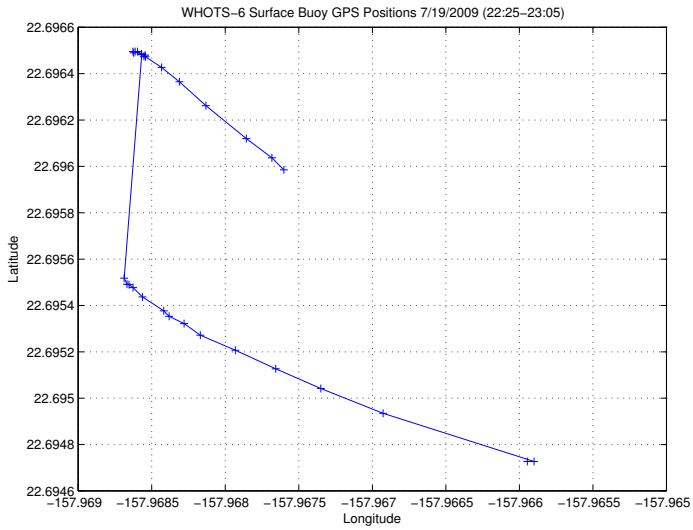

Figure 10 Raw GPS fixes from the WHOTS-6 buoy during a "slingshot" event.

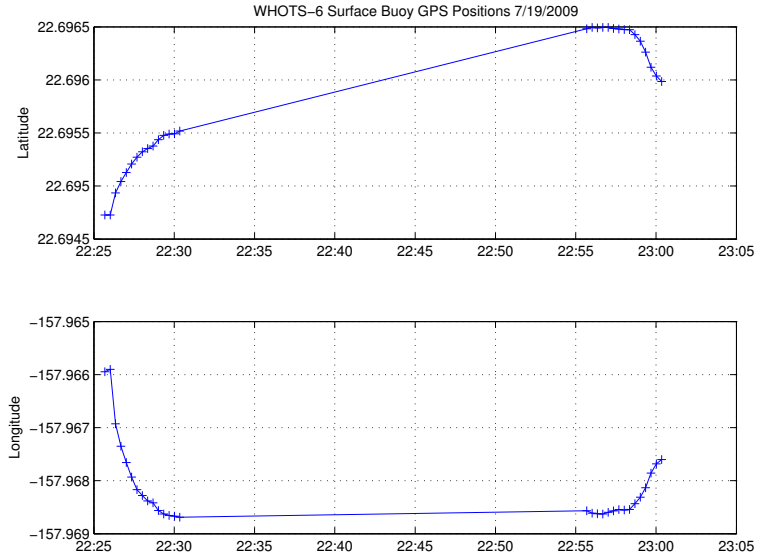

Figure 11 WHOTS-6 Buoy latitude GPS fixes versus time (upper panel) and longitude GPS fixes versus time (lower panel) during a "slingshot" event.

These “slingshot” events are going to have to be removed from the ADCP and VMCM velocity time-series. We will most likely use standard deviation within an ensemble to help determine these events.

Compute Standard Deviation Within an Ensemble: Computing the standard deviation of fixes within an ensemble can be an indicator for when there are either poor fixes or “slingshot” events. Time-series of standard deviation within GPS ensembles were plotted to help assess this measure for the different deployments (Figure 12throughFigure 14).

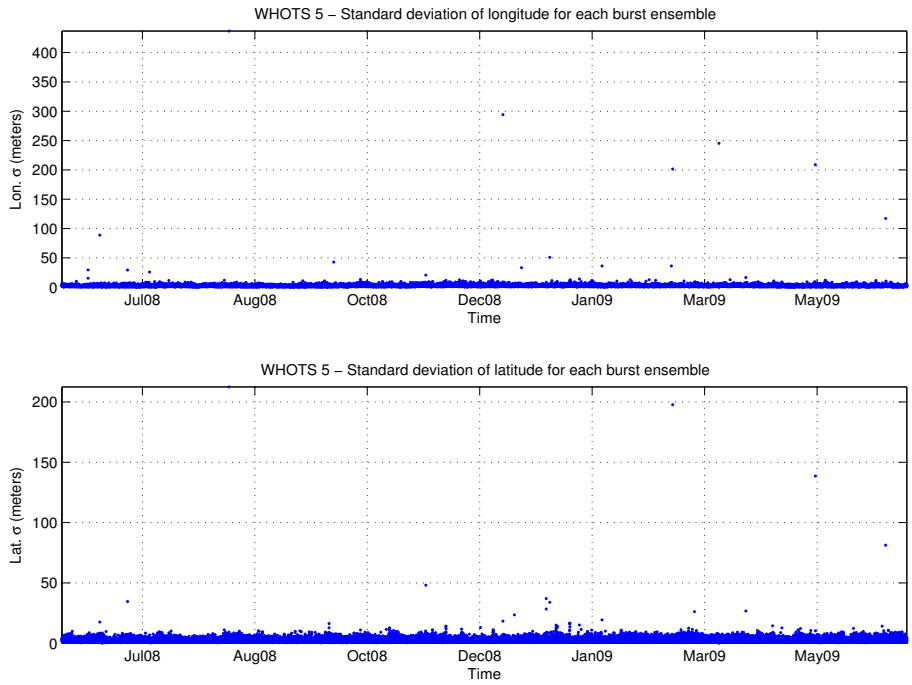

Figure 12 Time-series of standard deviation of GPS fixes within an ensemble during WHOTS-5.

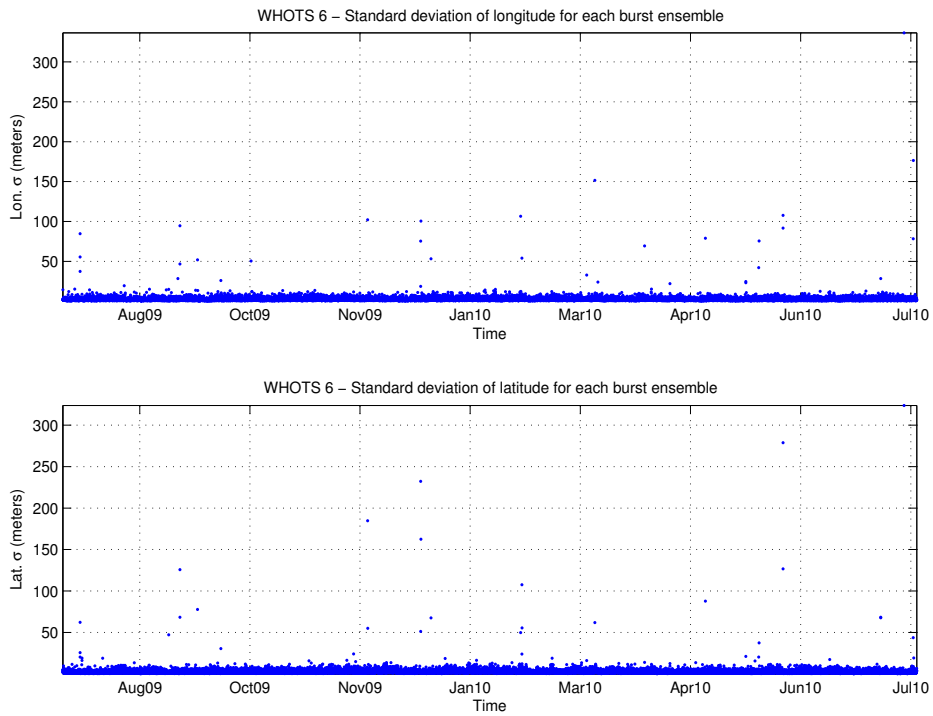

Figure 13 Same as for Figure 12 but for WHOTS-6.

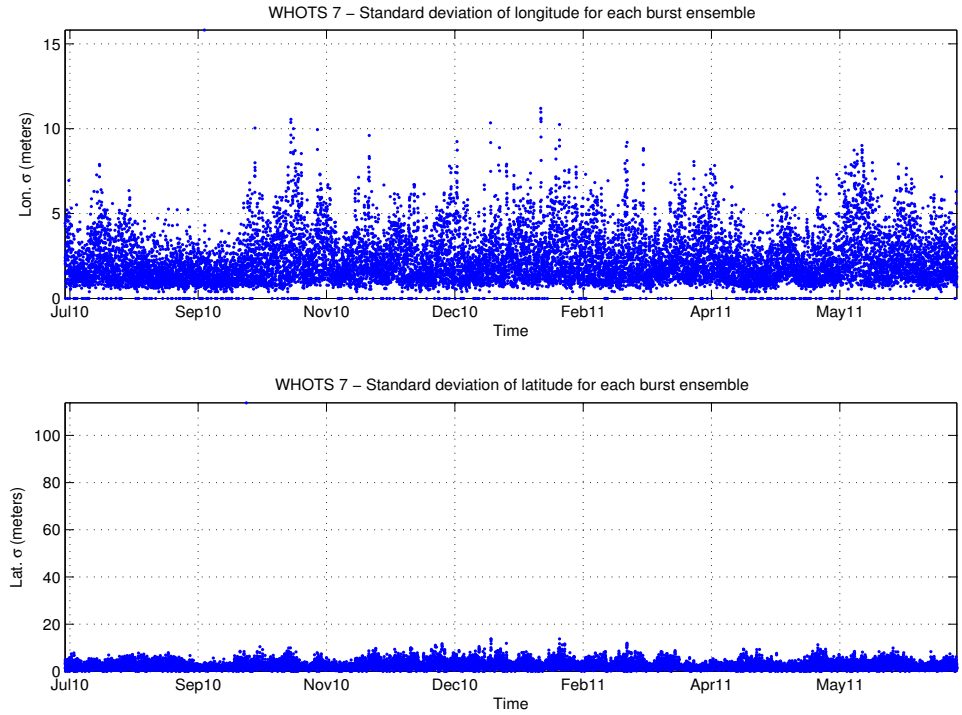

Figure 14 Same as for Figure 12 but for WHOTS-7.

Velocity Computations: To assess the level of corrections needing to be applied to ADCP and VMCM velocity data, buoy speed was computed. These computations were made between ensembles and only used GPS fixes within preselected radii from Figure 5 through Figure 8. Time-series of buoy velocity are shown in Figure 15 through Figure 18.

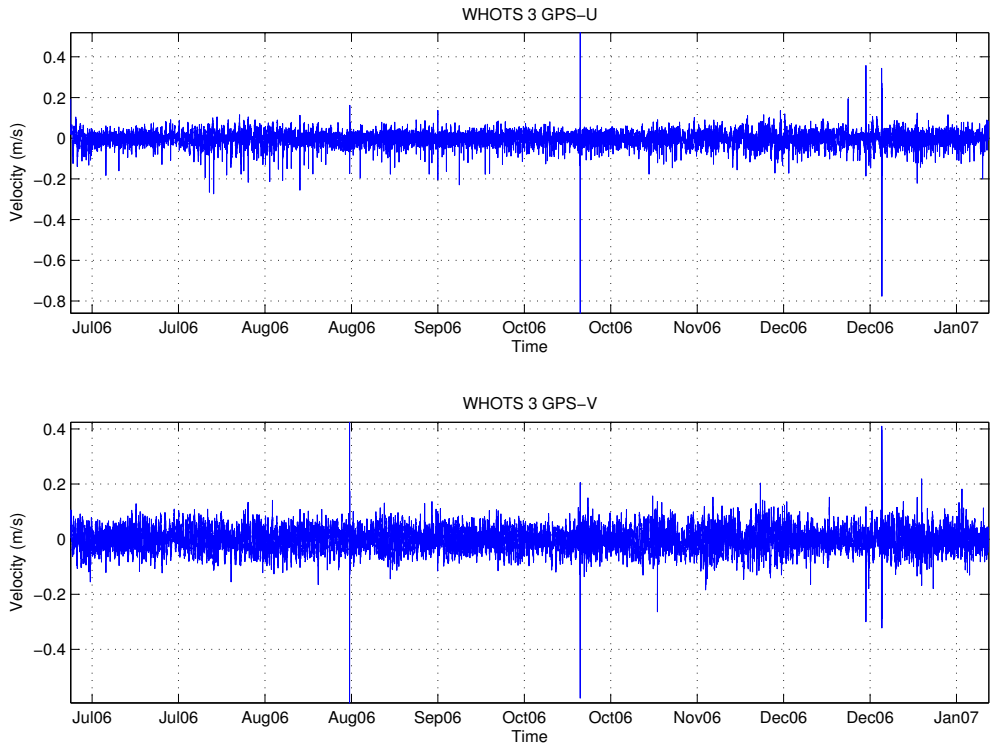

Figure 15 Time-series of buoy velocity computed from adjacent ensembles for WHOTS-3.

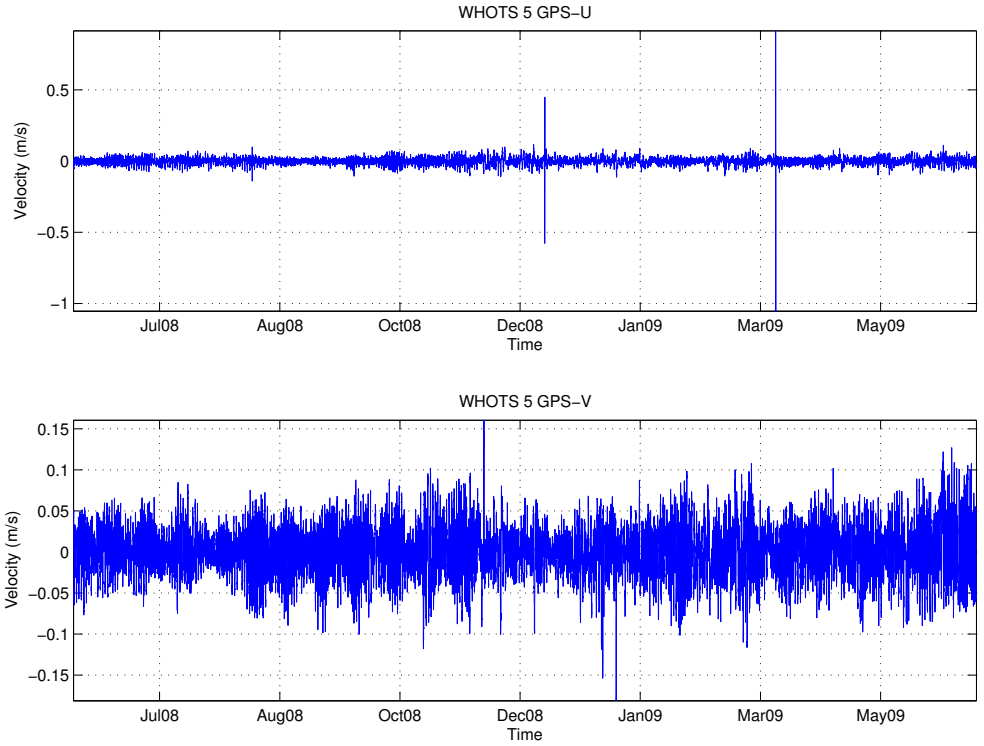

Figure 16 Same as for Figure 15 but for WHOTS-5.

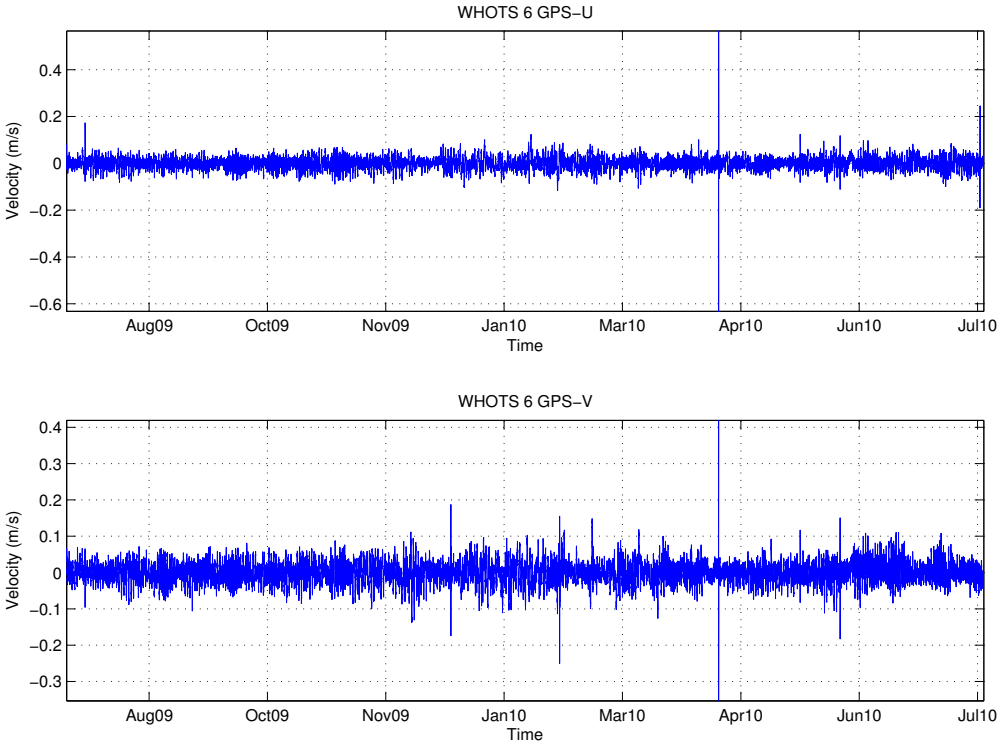

Figure 17 Same as for Figure 15 but for WHOTS-6.

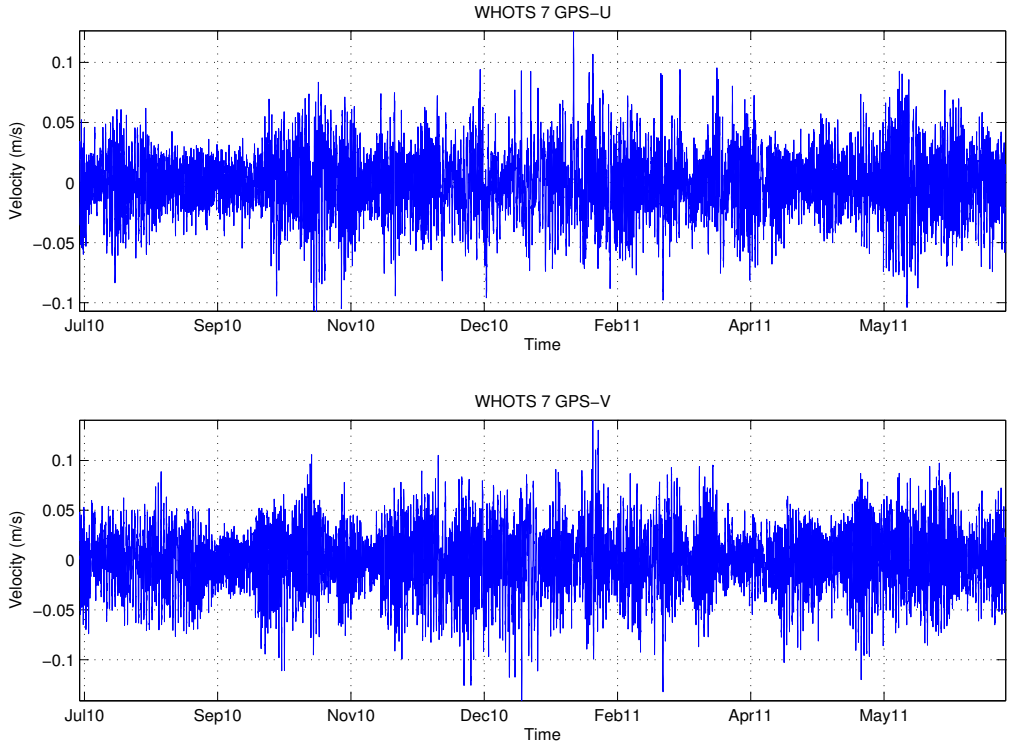

Figure 18 Same as for Figure 15 but for WHOTS-7.