Endeavor Spatial Dual Heading Performance

Introduction

Endeavor has two Ashtechs, an ADU2 and an ADU5. The ADU2 is much older than the ADU5, and neither is really robust. The ADU5 seems to drop out more frequently and with larger gaps than the ADU2. They do not agree as well as they should but it seems that although the ADU2 is much older, it is still the better instrument.

Endeavor recently purchased a unit made by SBG Systems. It has been integrated into the UHDAS data acquisition system under the name "Dual Ref". Among other fields, this device puts out roll, pitch, heave and heading. The quality of the heading is the primary concern for the ADCP data. High quality ADCP data requires headings accurate to 0.1deg, to keep errors due to heading smaller than other factors. Endeavor techs have kindly created a fake **`$PASHR`** message and seeded the "heading accuracy" field with something they thought might serve as a quality indicator. The value is a DualRef product related to the standard deviation of its heading solution. It is referred to in this report as the "QC candidate".

This report assesses

- the usefulness of the DualRef QC candidate in flagging DualRef heading errors
- the quality of the heading, i.e. what kind of errors does it have in comparison to the ADU2 and ADU5
- the accuracy of the heading after the bad parts are removed.

For convenience, the summary is repeated here:

Summary

When the DualRef headings are good, i.e. no drifts and no glitches, the headings do seem to be sufficiently accurate for shipboard ADCP work. Unfortunately the QC candidate is essentially useless as a parameter for editing out the heading deviations. We may be able to throw out the glitches using statistics -- we have the advantage of looking at chunks of 120-300sec at a time, and the glitches seem to be shorter than that -- but we cannot get rid of the subtle drifts by any kind of programming trickery. The only way to identify the subtle drifts is by comparing the DualRef to another accurate heading device. The number of glitches and drifts give the DualRef headings the quality as a POSMV that is not working well, but without the presence of a QC field to work with. We will continue to log it, but cannot recommend it for shipboard ADCP use unless the glitches and drifts go away.

The figures look terrible in this report, so links are provided to higher-resolution versions.

Values in the `$PASHR` message

A true **`$PASHR`** message provides timestamped roll, pitch, heading, heave, and error estimates for those four values. As a matter of general interest, we plotted heading, roll, and pitch for the Dualref, ADU2 and ADU5. Plotted over the same time range is the DualRef heading QC candidate. (link to Figure 1) It looks like the ship encountered rougher seas during the last day, because roll, pitch, and heave were all greater than earlier in the cruise.

Points of interest:

- DualRef pitch is about 4deg greater then ADU2 or ADU5 pitch
- The DualRef QC candidate was higher (worse) during the earlier part of the cruise, and had fewer excursions during the second half of the cruise (including the rougher period). Perhaps the antennas were changed (at about 2016/05/21 12:00:00 UTC)
- When the DualRef QC candiate was at its lowest consistent values, most values were under 0.2. In this report, 0.2 is used as a cutoff for the QC candidate.

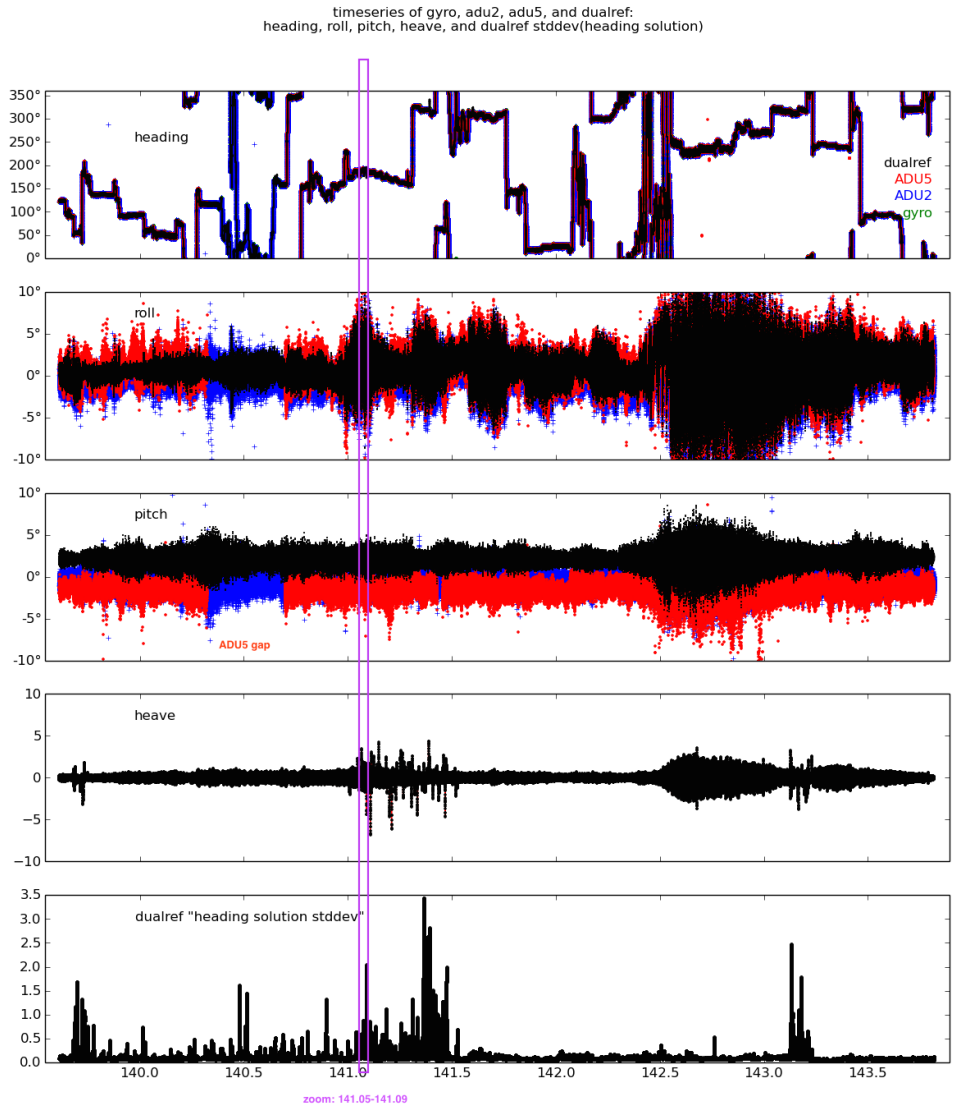

Figure 1: Panel plots of heading, roll, pitch, heave, and candidate DualRef QC indicator

The second figure shows a zoom in of about an hour of data. (link to Figure 2) Of note here:

- Several brief heading deviations of a few degrees each are visible in the DualRef at the beginning of the zoomed plot. There is no obvious manifestation in the QC candidate (bottom panel). A third instance occurs about 60% through the zoomed plot -- again there is no indication in the QC candidate.
- In the middle of the zoomed plot, are four spikes in the QC candidate (bottom panel) but no associated deviations in heading.
- Near the end of the zoomed plot, a very large heading deviation takes place (15deg) and that is associated with a large excursion in the QC candidate

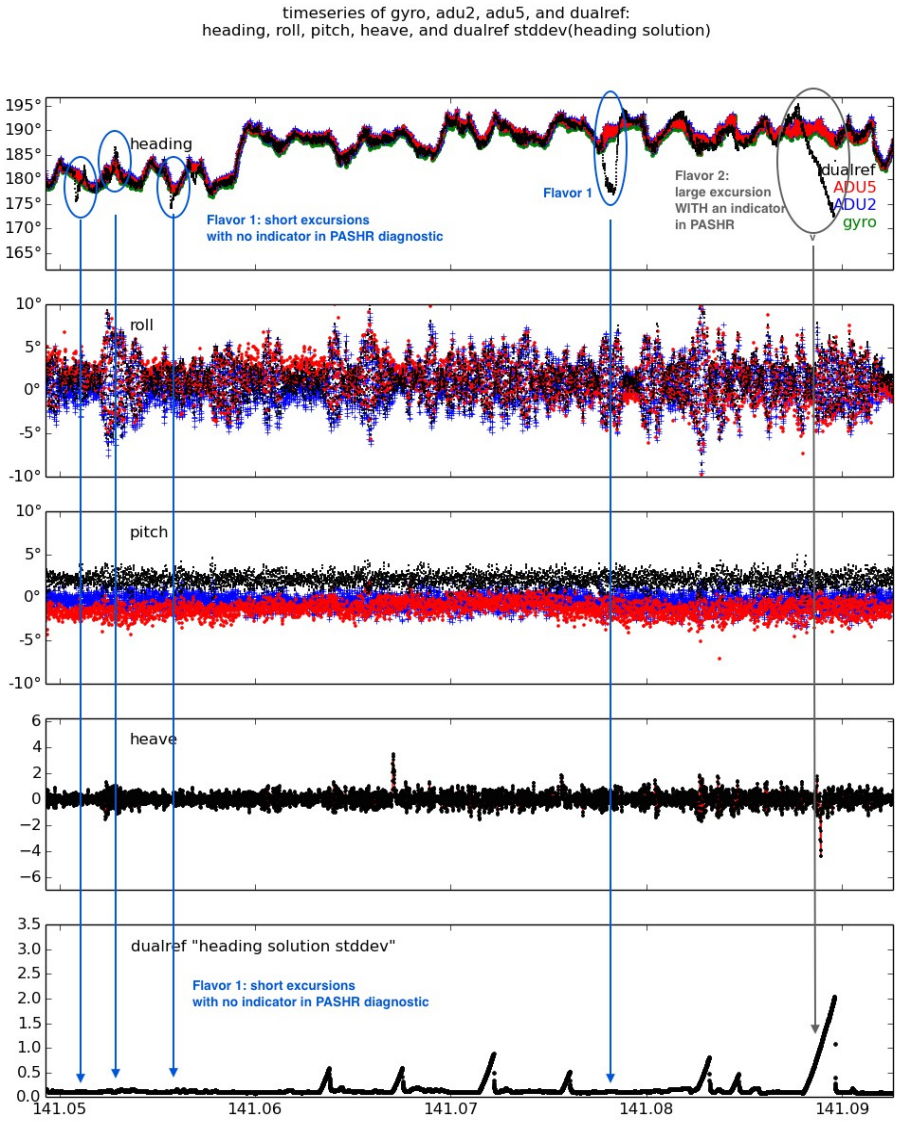

Figure 2: Zoom in of panel plot: heading, roll, pitch, heave, candidate QC indicator

The heading glitch at decimal day 141.09 is only one of two where the QC candidate was clearly flagging a heading deviation correctly.

Comparisons between heading devices

Comparisons were made between all four heading devices: gyro, ADU2, ADU5, DualRef. The next 4 plots have 6 panels each. The first plot is an overview, the next 3 are zooms, highlighting three specific areas. In all four plots, the top panel shows the headings of all four instruments (gyro, ADU2, ADU5, DualRef). The QC candidate is plotted in the second panel, with values greater than 0.2 in pink and values 0.2 or below in black. The desired behavior of this QC parameter is that large deviations in the DualRef heading are flagged by large excursions in the QC parameter. If this is true, then heading deviations should be in pink and there should not be much other pink. The remaining 4 panels show heading differences: ADU5-ADU2 (third panel, all black, because there is no Dualref QC candidate involved) followed by the differences between DualRef and (in sequence, in panels 4,5,6) ADU2, ADU5, and gyro. (link to Figure 3)

In the last 3 panels, a pink spike that exists in all three panels indicates a heading deviation in the DualRef that was associated with a high value of the QC candidate in the DualRef. All the rest of the spikes are black, and indicate a DualRef heading error that was not flagged by the QC candidate (at least not at the 0.2 level)

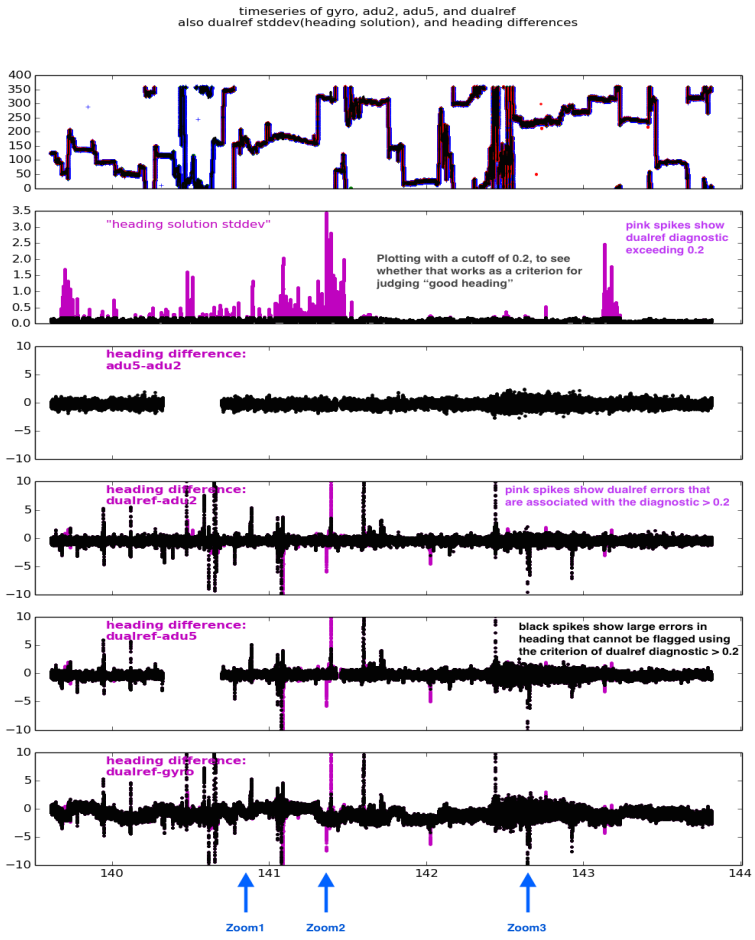

Figure 3: Panel plot of heading, candidate QC indicator, and heading comparisons between ADU2, ADU5, DualRef, and Gyro

Zoom 1

There are two flavors of error here:

- Flavor 1: deviations of 2-3 degrees that are **not** associated with high QC indicator. These could probably be edited out by comparing the DualRef with some other heading device -- any of the other three would work if these glitches are short and isolated
- Flavor 3: These are insidious smaller (0.5deg) but longer drifts of the DualRef. They cannot be caught at all, except by comparing the DualRef to an accurate heading device. If that accurate heading device exists, we don't need the DualRef. If it does not exist, these are a major problem.

(link to Figure 4)

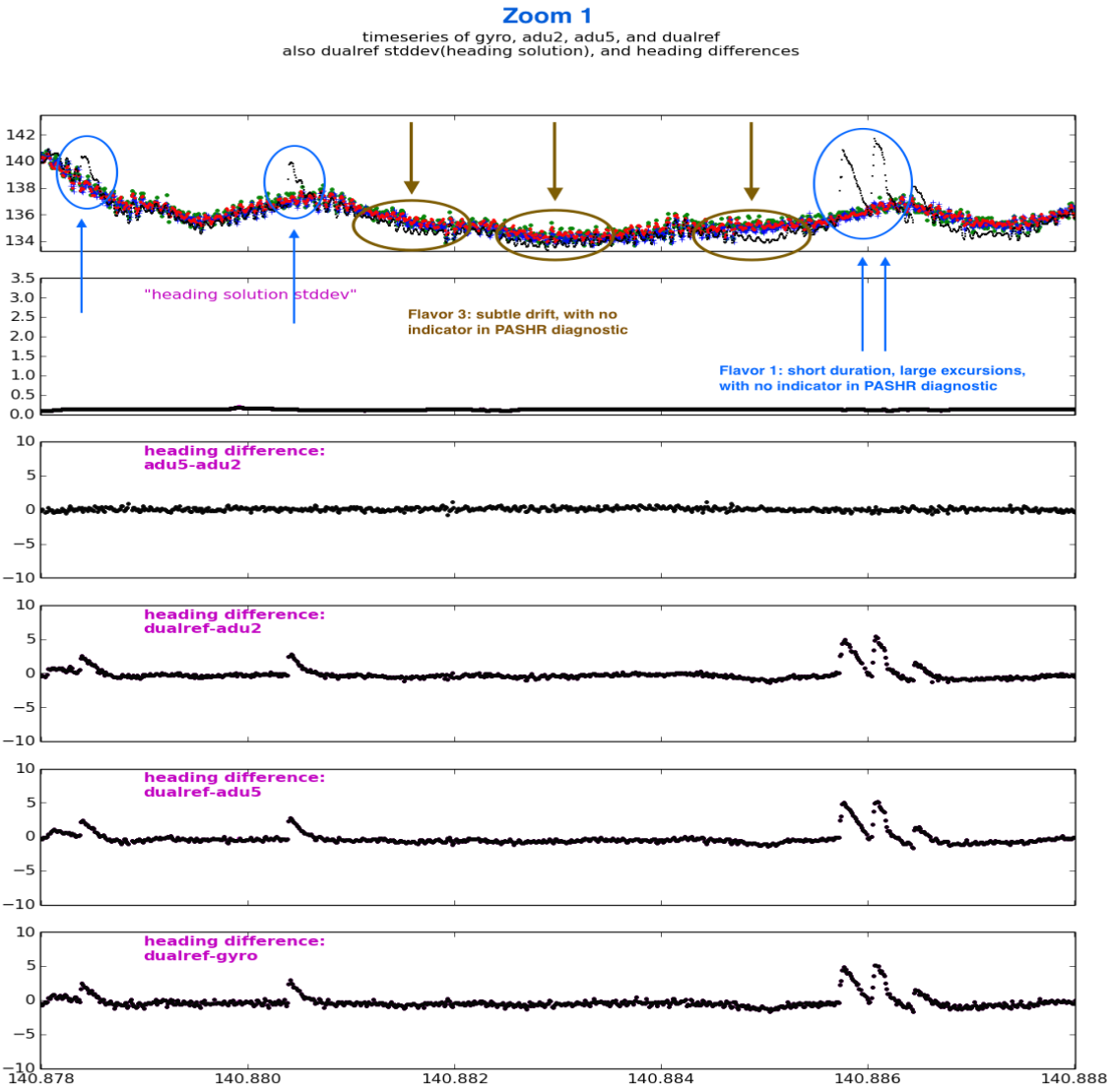

Figure 4: Zoom: Panel plot of heading, candidate QC indicator, and heading comparisons between ADU2, ADU5, DualRef, and Gyro

Zoom 2

This figure shows two heading errors in the DualRef (beginning and end), both of which are identified by the QC indicator. However there are many other little glitches in the QC indicator, only perhaps half of which caught the smaller drifts in DualRef heading.

(link to Figure 5)

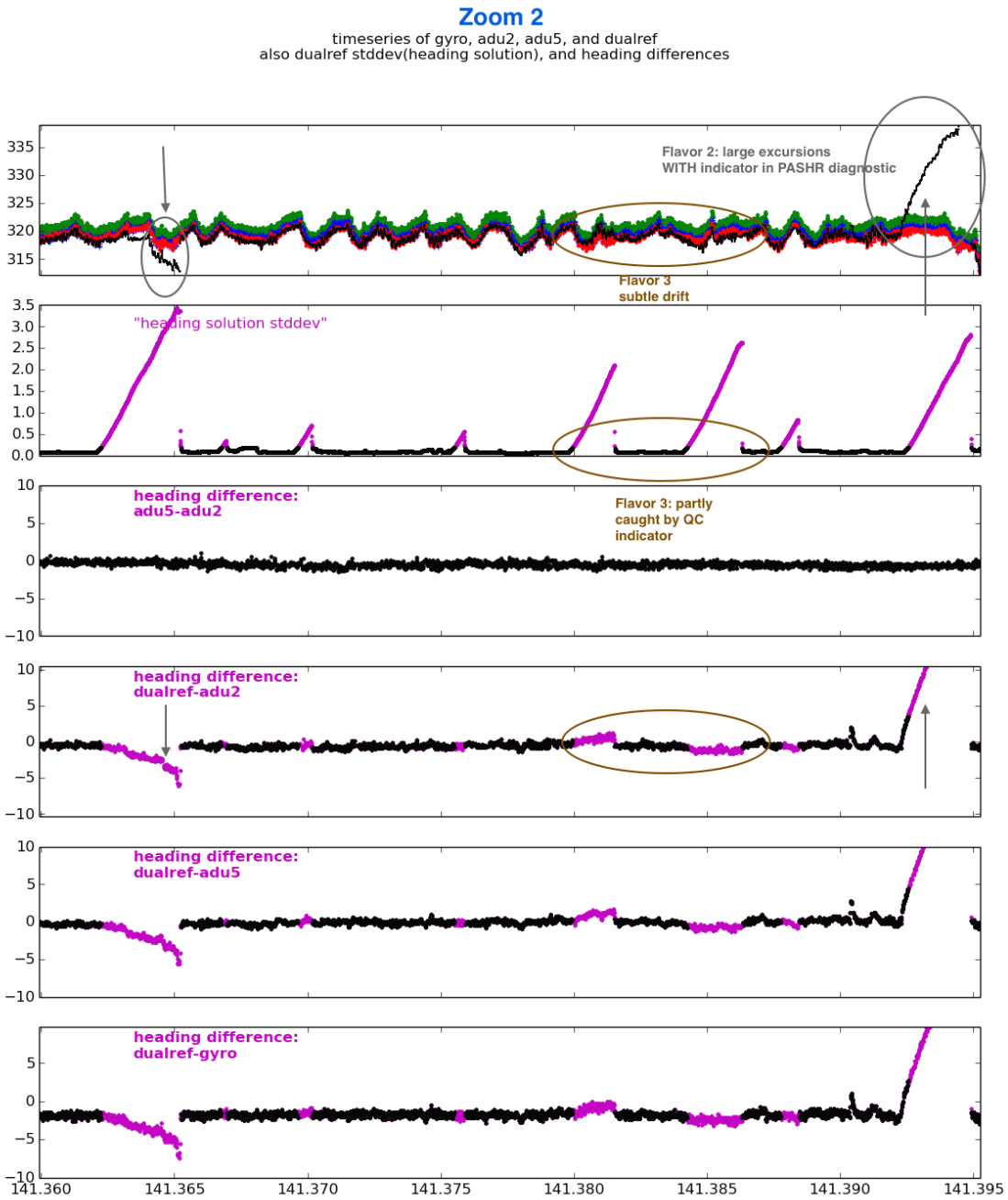

Figure 5: Zoom: Panel plot of heading, candidate QC indicator, and heading comparisons between ADU2, ADU5, DualRef, and Gyro

Zoom 3

One drift (Flavor 3), which is partially flagged, is circled in brown. Three DualRef heading errors which are not caught by the QC indicator, are circled in blue. (link to Figure 6)

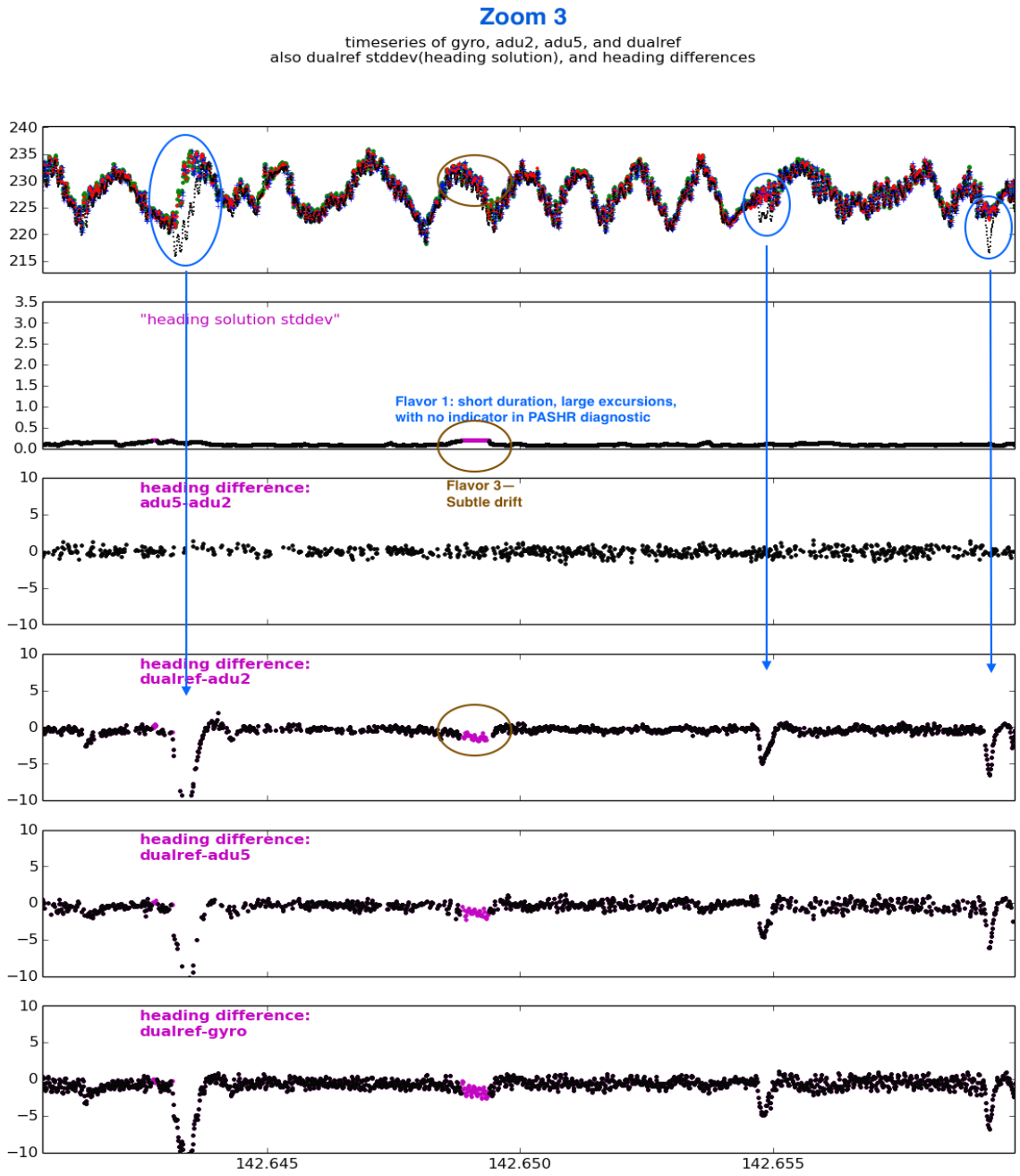

Figure 6: Zoom: Panel plot of heading, candidate QC indicator, and heading comparisons between ADU2, ADU5, DualRef, and Gyro

Comparison of DualRef heading error and QC indicator

The value in the "heading accuracy" field of the PASHR message is pretty much useless. Unless there is a more useful quantity to substite for this purpose, we might as well use **`$PRDID`** because it has roll, pitch, heading, and does not pretend to have any QC.

Figure 7 shows all the Dualref QC indicators (vertical axis) plotted with heading error (comparison with ADU2) on the horizontal axis. This lets us draw a horizontal line at 0.2 and keeps the QC indicator in black or pink just as it has been in the earlier plots. Now we can see that there are many large heading errors even below the 0.2 cutoff. Only two large heading errors are caught by the QC indicator. They look like outliers or anomalies, but they are actually what we want to see: large deviation in heading correlated with large value for QC indicator. (link to Figure 7)

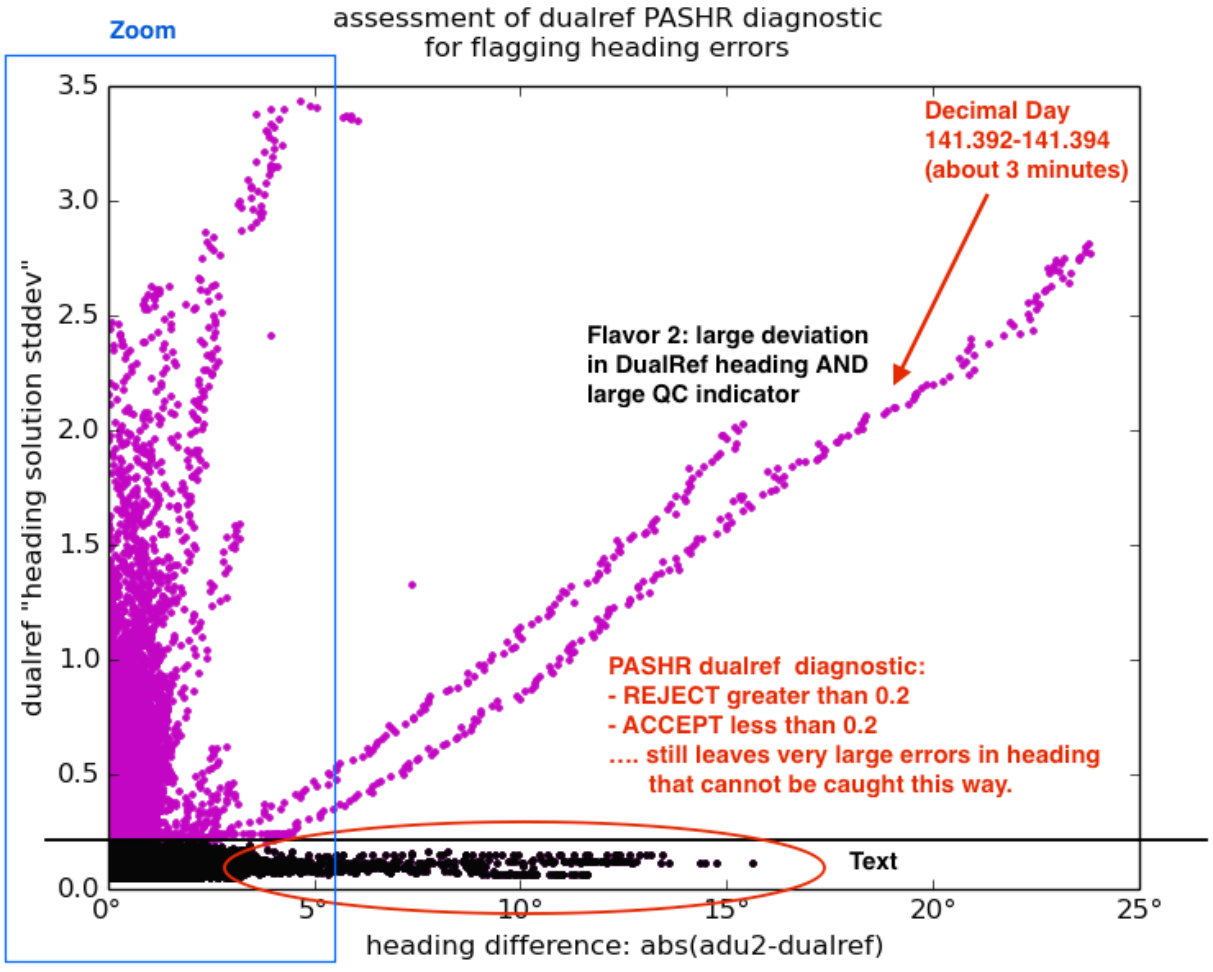

Figure 7: Comparison between DualRef QC candidate and actual heading error

Figure 8 shows a zoom in on the left of the plot. There is still no obvious threshold that can be used to effectively throw out bad headings and keep good headings. (link to Figure 8)

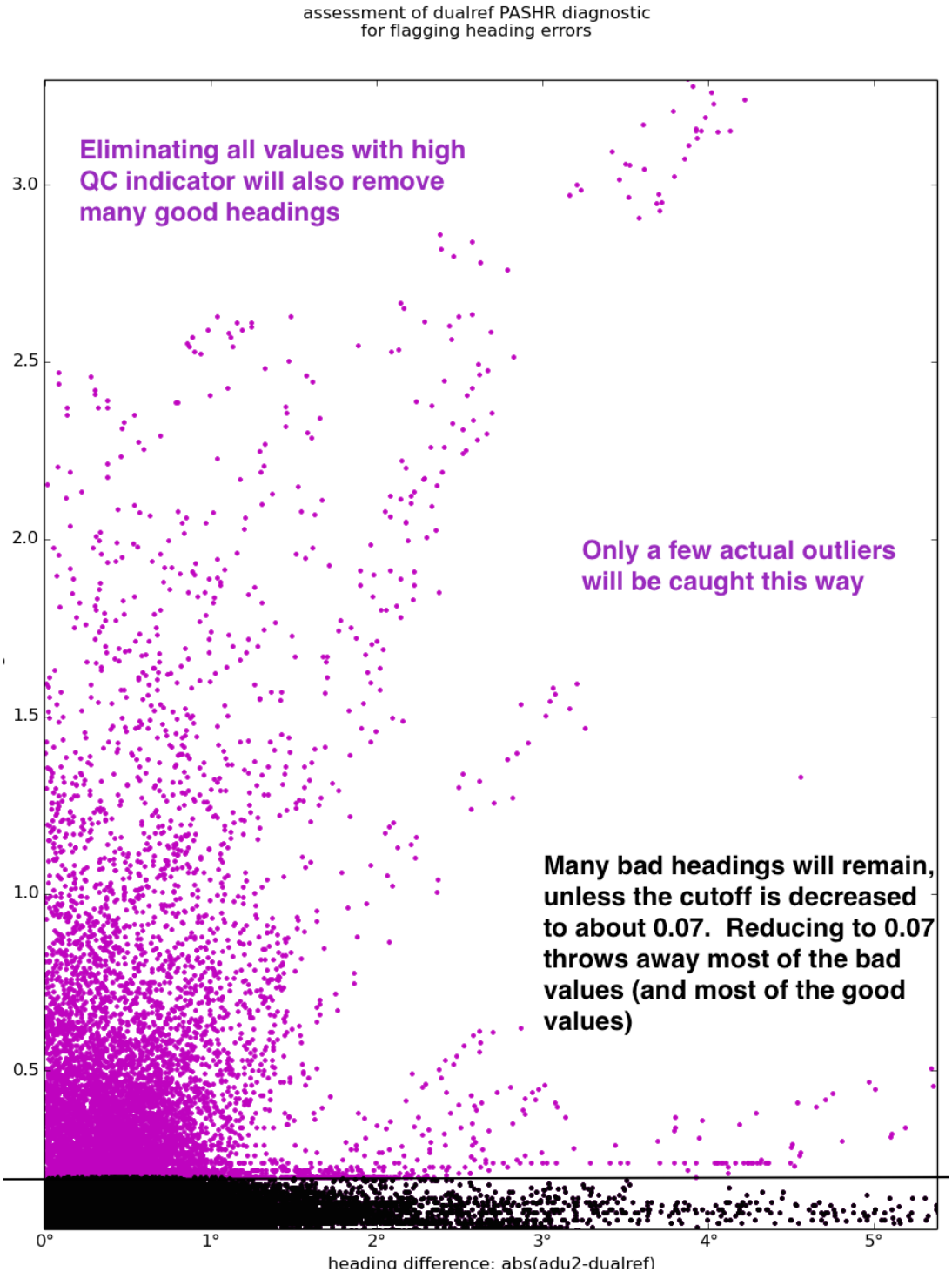

Figure 8: zoom: Comparison between DualRef QC candidate and actual heading error

Heading quality

If the heading errors could be removed by additional algorithms and comparison with other heading devices, it looks like the remainder of the data compare well to the ADU2. The ADU2 and ADU5 agree less well than expected -- Ashtechs should have errors around 0.1-0.2deg over these time scales, not 0.3-0.4 deg. But the DualRef is surprisingly close to the ADU2. Unfortunately, to get rid of the subtle drifts (Flavor #3), the editing requires comparison with an accurate heading device. Obviously if we have one of those, we don't need the DualRef. (link to Figure 9)

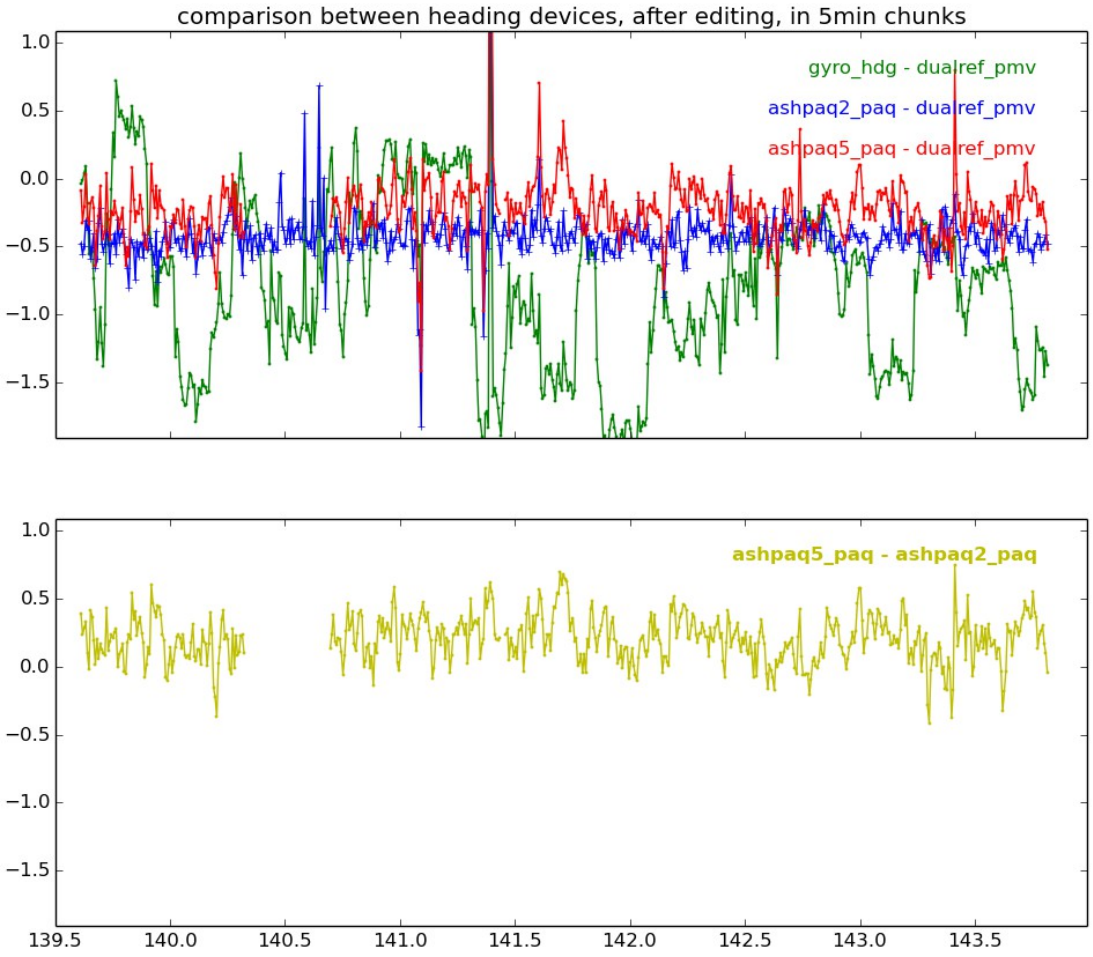

Figure 9: Heading comparison between instruments

Summary

When the DualRef headings are good, i.e. no drifts and no glitches, the headings do seem to be sufficiently accurate for shipboard ADCP work. Unfortunately the QC candidate is essentially useless as a parameter for editing out the heading deviations. We may be able to throw out the glitches using statistics – we have the advantage of looking at chunks of 120-300sec at a time, and the glitches seem to be shorter than that – but we cannot get rid of the subtle drifts by any kind of programming trickery. The only way to identify the subtle drifts is by comparing the DualRef to another accurate heading device. The number of glitches and drifts give the DualRef headings the quality as a POSMV that is not working well, but without the presence of a QC field to work with. We will continue to log it, but cannot recommend it for shipboard ADCP use unless the glitches and drifts go away.