LADCP deployment on P16S, NBP-1403, March to May 2014

Steven Howell

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1 Introduction

On March 20, 2014, the *RVIB Nathaniel B. Palmer* set sail on the third occupation of the CLIVAR/GOSHIP P16 line. It was *Palmer* cruise nbp1403. The LADCP operator was Steven Howell, from the University of Hawai'i Mānoa. The opposite watch stander was Veronica Tamsitt, a grad student from Scripps Institute of Oceanography. The chief scientist for the cruise was Lynne Talley, also of Scripps. Brendan Carter of Princeton was the co-chief scientist. The PI for the LADCP effort was Eric Firing of UH, assisted by François Ascani and Julia Hummon.

1.1 Cruise plan

The CLIVAR/GO-SHIP P16S line runs along 150°W from near Antarctica to Tahiti. It repeats elements of cruises on the *Revelle* in 2005 and the *Knorr* in 1992. The original plan was to have stations every 0.5 degree of latitude. Principally because of weather delays, we managed to do 90 stations, 86 of which were along 150°W, from 67°to 15°S.

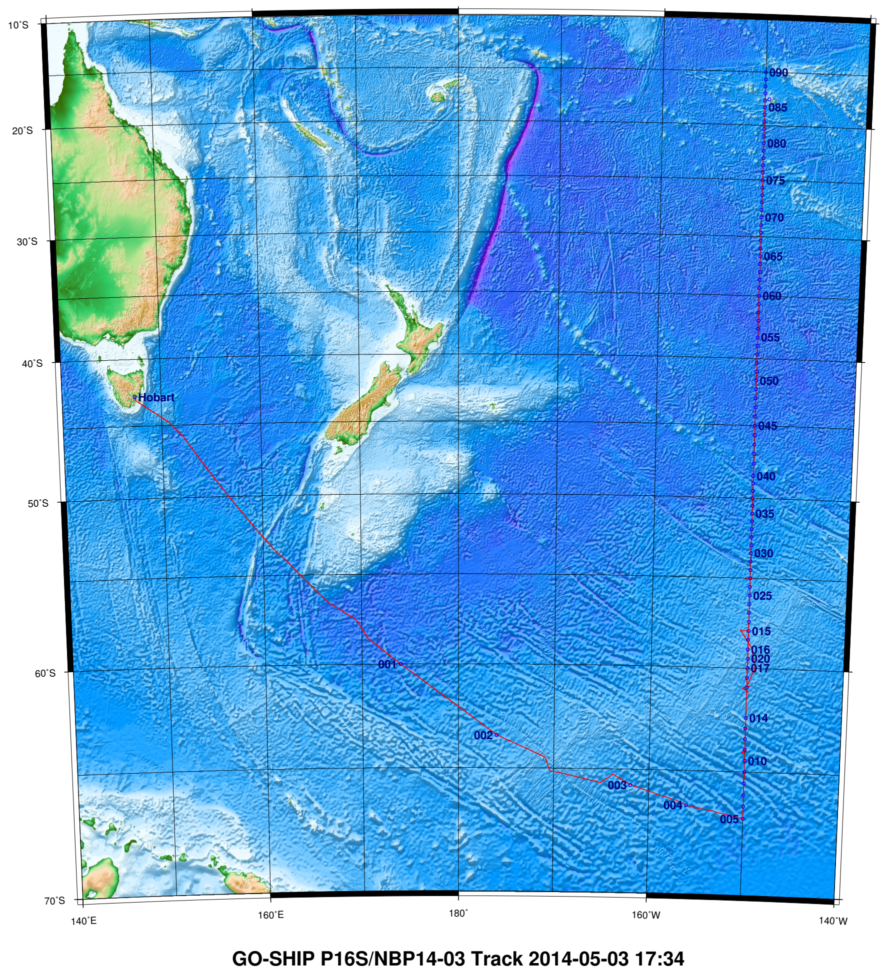


Figure 1: The P16 cruise track

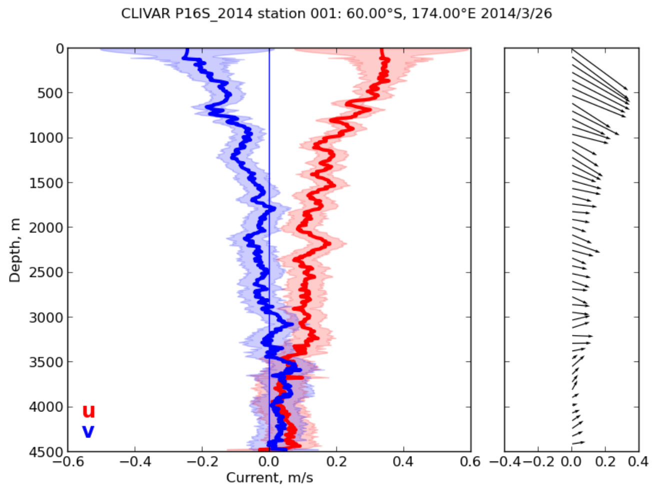
2 Stations

2.1 Station 1: 03/26 60°00´S 174°00´E

Errors and Warnings: None

Depths: MB=4534, CTD=4484, DAB = n/a
`check_ladcp:  zmax=4456, zend=-72`
LDEO max depth=4475 bottom=4489

Notes: This cast was not on the P16 line, but was an Argo float launching station. There was also a NASA optical cast (used for dark currents; it was night). Originally referred to as cast 1, this was retroactively renamed cast 2, as the optical cast came first and it was decided that all over the side operations should be given a cast number in the order that they occurred.



Comments:

The first cast went well for the LADCP. It kept pinging, the beams were all strong, and the shear and inverse solutions agreed well enough. Seems like a good profile! The IMP pressure vessel was on the rosette with the spare end cap and the new Impulse male bulkhead connector in place. Following a suggestion from Bruce Huber, we did not actually put any electronics in the pressure vessel. This was strictly a leak check. It passed that test; there was no water inside after the cast. However, when disassembling the pressure vessel, we discovered that the plastic band clamp that

Figure 2: The broken band clamp from the first station.

holds the end cap on was cracked (Figure 2). I stuck it back together with cyanoacrylate cement (Super Glue, but a different brand) and held it clamped until shortly before the next cast.

There were some problems with the CTD system. The altimeter failed to work, so they just used the depth from the multibeam and were conservative about nearing the bottom. The 10 meter bottom contact switch was never triggered. The primary conductivity cell went out partway through the cast. John Calderwood guessed that it was a loose connection in a cable.

2.2 Station 2: 03/28 63°30´S 176°00´W

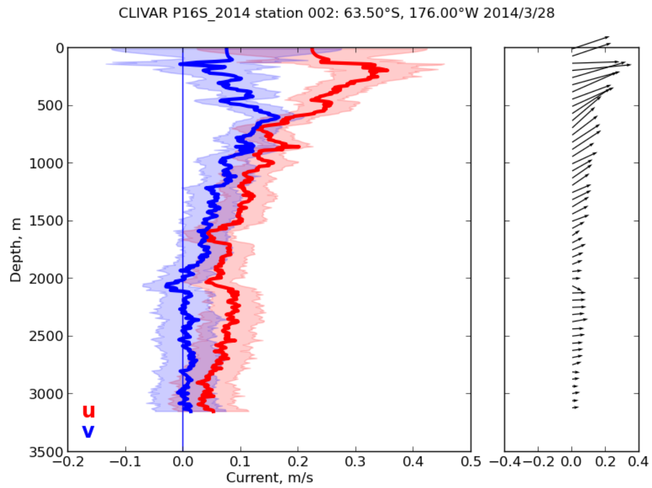
Errors and Warnings: None

Depths: MB=3171, CTD=3156, DAB = 9.4

`check_ladcp: zmax=3163, zend=0`

LDEO max depth=3155 bottom=3158

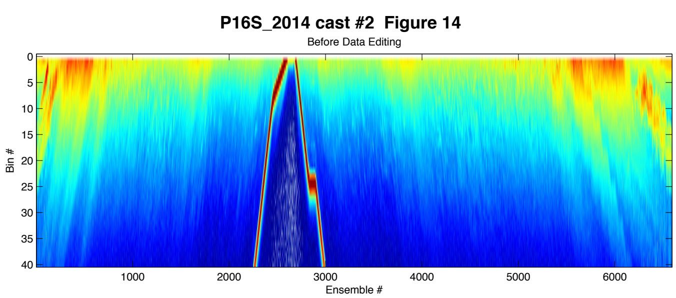
Notes: This cast was not on the P16 line, but was an Argo float launching station. This time the NASA cast came after the CTD.



Comments:

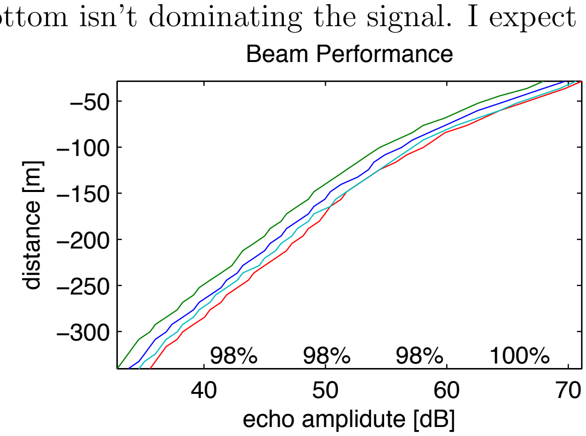
Another good cast for the LADCP itself. No significant problems. The CTD system worked better too, with the conductivity cell and and altimeter working. The bottom contact switch was a bit annoying, as it was seen by the altimeter quite frequently as it swung back and forth, and appeared as an 11 m depth, more or less alternating with more reasonable depth measurements.

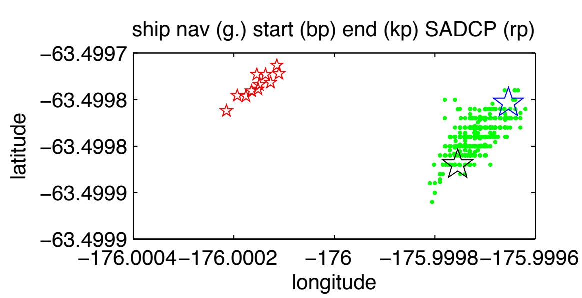
The IMP pressure case was a different story. As I installed it on the rosette, I noticed that the other PVC band clamp was broken in a similar way to the one just glued together. I sent it down anyway. When it came back up, the repaired band clamp was still intact, but the hose clamp around it was loose. When I opened it up, there was perhaps 30 mL of water in the pressure vessel. It is conceivable that it came in via the bulkhead connector or the blank end cap with the broken clamp, but it is most likely that it came in through the flange held by the loose clamp. I had not worked to tighten that clamp very hard for fear of splitting it again.



After the cast, John Calderwood and I glued the other band clamp back together, this time using PVC cement and primer. (We hadn't been aware the marine techs had that when we did the first repair.) Following advice from Andreas and Bruce, we tightened the hose clamps more, but also tapped the clamp as we were tightening to try to get stresses to distribute evenly.

In contrast to P02, there is enough scattering at depth that previous ping interference (PPI) is not noticeable in either the LDEO figure 3 or 14 plots. That may mean that the data at 880 m and 1170 m above the bottom is okay, because the bottom isn't dominating the signal. I expect it should be filtered out anyway.





At least at the beginning of this cruise, all of the beams look okay. They are performing similarly, and the noise seen in P02 is not obvious. If I recall correctly how this plot works, the best beam is defined as 100%, and the other beams are compared to it.

An oddity I just noticed, but haven't tried to address is shown in the plot on the right above. I have no idea why the shipboard ADCP points are all separated from the ship's GPS. It seems really odd. Probably doesn't have any real effect, since currents aren't likely to be different 20 meters away. Is it possible that the ADCP positions are adjusted for the relative positions of the ADCP and GPS.

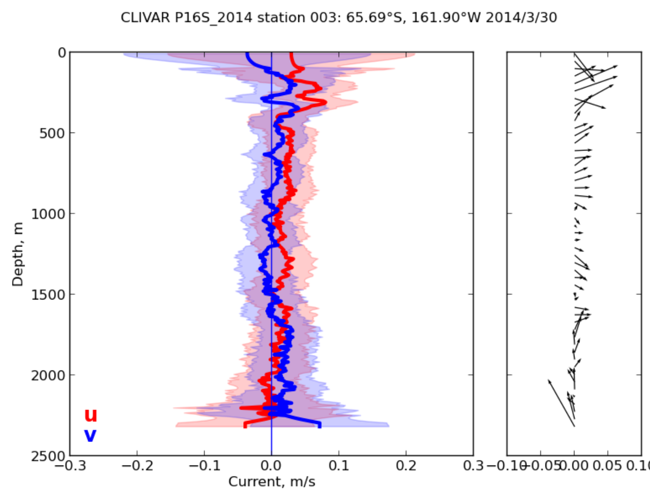
Update: It turns out the CTD data files use `$GPGGA` from Seapath 1, while the SADCP positions are from the Trimble GPS. I don't know the actual distance between those devices.

2.3 Station 3: 03/30 65°42´S 161°54´W

Errors and Warnings: Warning: removed 68 pressure spikes during: 3 scans

Depths: MB=4077, CTD=1993, DAB = n/a
`check_ladcp: zmax=2020, zend=0`
LDEO max depth=1992 bottom=n/a

Notes: This cast was not on the P16 line, but was an Argo float launching station. Due to fairly high seas, the cast was just to 2000 m rather than the bottom. The NASA cast came after the CTD.



Comments:

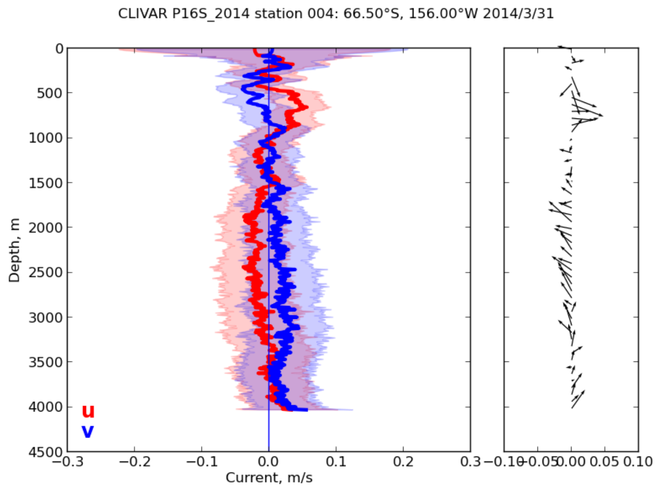
Aside from significant heave (up to 6 m), the cast was uneventful. Very small currents.

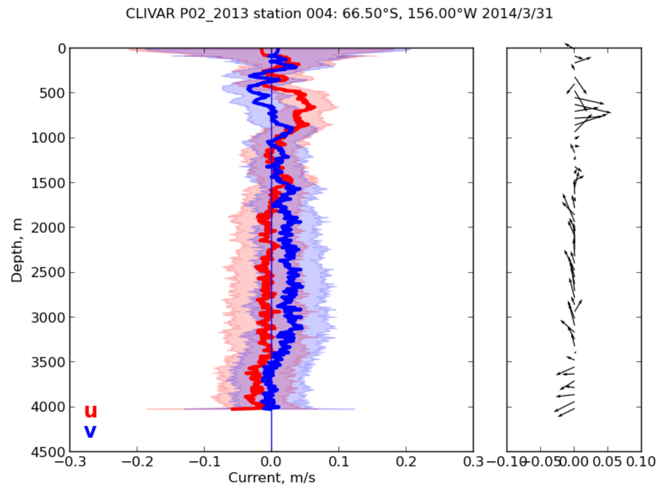
The IMP pressure vessel interior was dry this time. I decided to do the full IMP installation. I stuck the Raspberry Pi above the sensor board and shoved that to the rear of the pressure vessel, with the bare WiFi antenna toward the bulkhead connector end. I carved a hole for the DC-DC converter in a piece of foam, connected wire 3 from the bulkhead connector to V_{in}^{+} and wire 7 to V_{in}^{-}. I set the output voltage to 8 V, then connected the precision voltage regulator to the output, stuffed everything into the pressure vessel, and sealed it up.

Seemed to work. As was Bruce's experience, I had to get my computer very close to the pressure vessel to avoid `Cannot connect: timeout error`. After that, I could retreat to the catwalk and communicate just fine.

2.4 Station 4: 03/31 66°30´S 156°00´W

Errors and Warnings: None





Depths: MB=4053, CTD=4034, DAB = 10.1
`check_ladcp: zmax=4046, zend=-12`
LDEO max depth=4033 bottom=4035

Notes: This cast was not on the P16 line, but was an Argo float launching station. NASA casts came before the CTD, so this was cast 3 at the station.

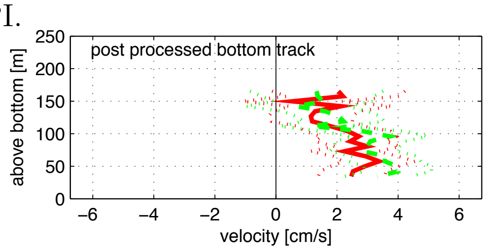
Comments:

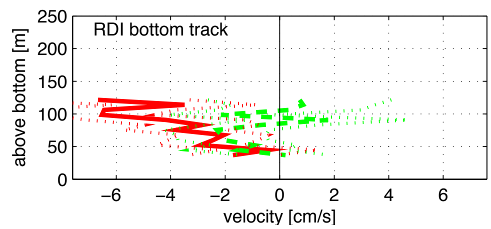
This was the first cast with the IMP operational. It was a bit of a pain to start, as my iPad had to be within a few inches to make the wireless connection. Once that was done I stepped back and used ssh to send `sudo reboot`. I reconnected a few minutes later to ensure that a new file was being written.

One thing I noticed is that the IMP is a significant drain on the SOB. About 10 minutes before the deployment, I decided to top off the battery, and it took considerably longer than I'm used to. By the time I had to disconnect, the SOB was not fully charged, still drawing 0.8 A. I'll have to check whether battery voltage drops significantly more during the cast.

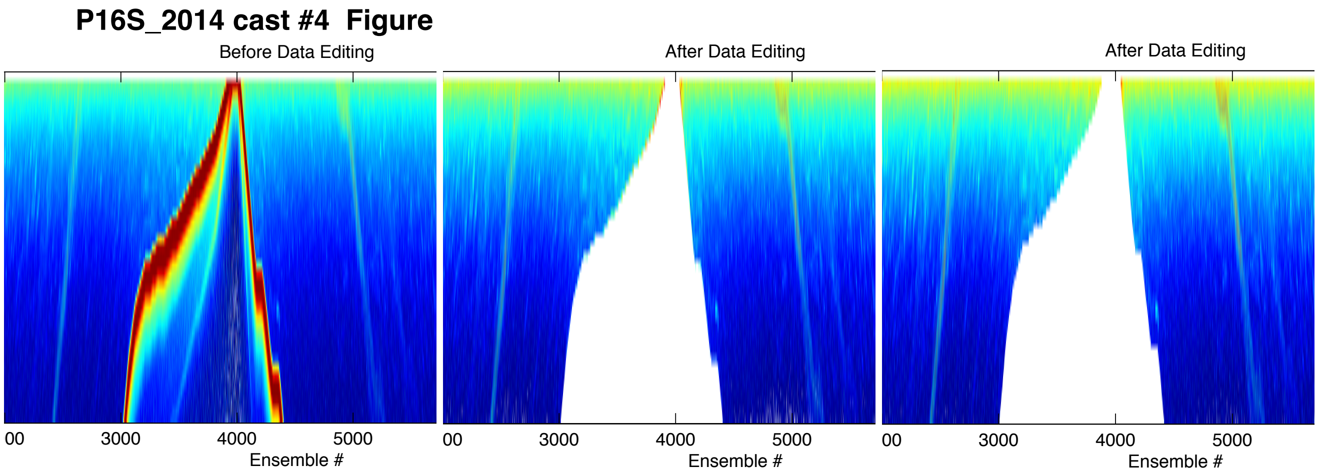
The end of the cast was uneventful. I encased the iPad in a ziploc bag to protect it, and had less trouble connecting. I ran `IMP_test` for a short period then `^C` to kill acquisition. After bottle sampling was done, I took my computer into the Baltic Room and synced the file over. It took perhaps 15 minutes, as the file was 200 MB! Maybe I should try the `-z` option.

One bit of drama during the cast was a pronounced false bottom seen by the altimeter at about 200 m above the real bottom. It caused considerable confusion. Turns out that there was previous ping interference. The altimeter pings at about 4 Hz, and apparently the bottom is relatively reflective. (The Knutsen shows an unusually sharp reflection.) The LADCP does show pronounced PPI.





I played around with bottom track on this station. The RDI bottom track seemed unrealistic, with strong shear in the bottom 100 m that the inversion was unable to follow. The LDEO bottom track looked much better, but I'm suspicious that it didn't fully filter out the bottom reflection. Careful examination of the plot below shows some enhancement right above the filtered-out zone, which I'd guess is insufficient filtering. Alternatively, there could be critters near the bottom. Another thing to note is the regular patterns of acoustic interference. I'm not sure whether there's actually more interference in this cruise than usual. The net effect of the different bottom track velocity is pretty clear in the profile plots above: the bottom flow is completely reversed and the northward transport through most of the ocean depth with the RDI bottom track turns eastward. However, all of these currents are pretty small; one could argue that it's all within error limits, so I shouldn't be making too much of the differences.

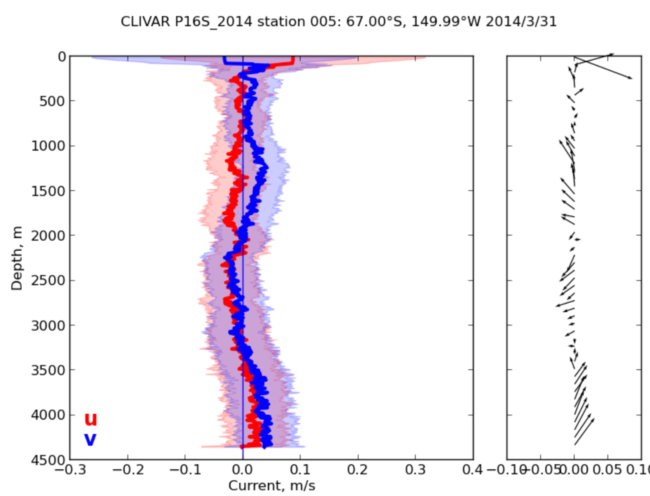


2.5 Station 5: 03/31 67°00´S 150°00´W

Errors and Warnings: None given, but see below. *Update: fixed by reprocessing with corrected CTD time series. No error or warnings.*

Depths: MB=4383, CTD=4366, DAB=8
`check_ladcp: zmax=4381, zend=0`
LDEO max depth=4365 bottom=4366

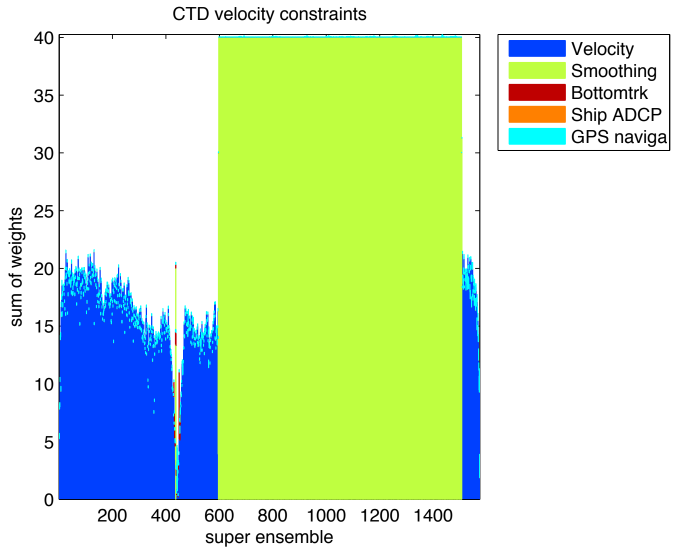
Notes: This was the first cast on the P16 line. NASA casts came before the CTD, so this was cast 3 at the station. An Argo float was launched.

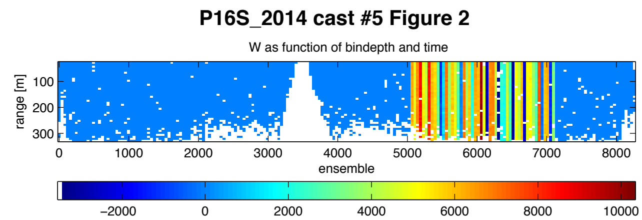


Comments:

Water was much calmer than previous casts. Icebergs all around, though none closer than 2 km or so. Everything seemed pretty routine until I analyzed the data. `check_ladcp wh005_03.dat` was a bit odd, I suppose, since it had `zmin=-8` and `zend=0`. The IMP was no particular problem. I can put the iPad in its plastic bag directly on the IMP pressure vessel, where it rapidly acquires the wireless channel. This was only a 160 MB file.

The first sign of trouble was that the inversion took preposterously long. No errors were given in figure 11. Then I noticed in LDEO figure 12 that there was a big region with only smoothing constraints. Then I saw preposterous velocities in figure 2 and an odd jump in figure 1.





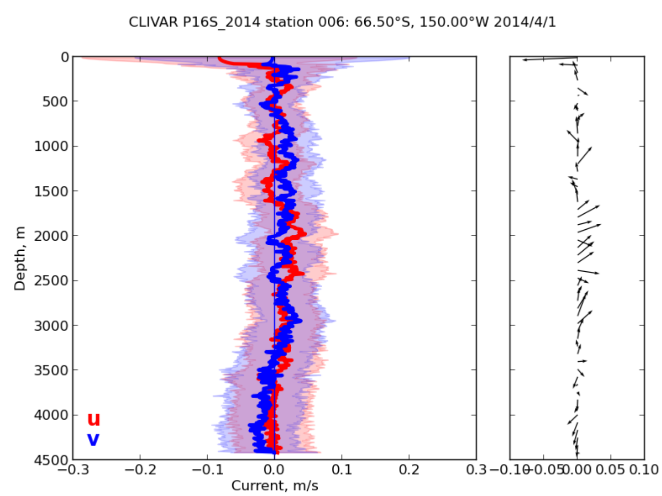
After much fussing with the raw data, including sending it to Hawaii, it turned out that the problem was in the 0.5 s CTD timeseries. The primary temperature sensor failed during the upcast, giving nonsense results for temperature, salinity, oxygen, and perhaps depth and speed of sound. The automatic CTD processing filled those fields with -999, which apparently screwed up the LDEO processing. When Courtney reprocessed the CTD files with the backup thermistor, all went normally.

2.6 Station 6: 04/01 66°30´S 150°00´W

Errors and Warnings: None.

Depths: MB=4458, CTD=4433, DAB = 5.5
`check_ladcp: zmax=4460, zend=11`
LDEO max depth=4431 bottom=4430

Notes: Uneventful. No NASA casts or floats. Getting into full CLIVAR production mode.



Comments:

Not much in the way of currents either. Lynee says to expect that while we're south of the front. Using `rsync -auxvz imp@169.254.219.1:/Data/ ~/projects/p16s/data/imp/` does appear to speed up transfers from the IMP.

2.7 Station 7: 04/01 66°00´S 150°00´W

Errors and Warnings: None.

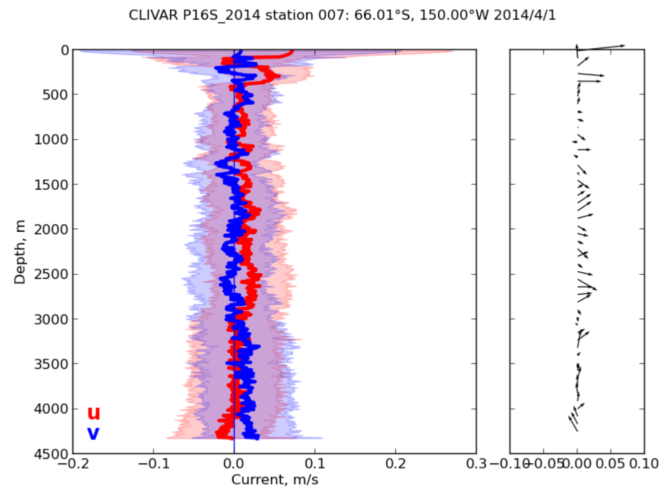
Depths: MB=4343, CTD=4334, DAB = 9.3
`check_ladcp: zmax=4354, zend=-16`
LDEO max depth=4332 bottom=4336

Notes: Time was getting short, so Veronica power cycled the IMP rather then take the time to connect with the iPad and issue a reboot command. That wears out the plug, but I had encouraged her to do that rather than hold up the cast.

Comments:

A touch of drama when Veronica tried to download the data and got no response from the LADCP. She had me roused from bed. I discovered that the lab cable wasn't actually plugged in to the rosette. Easiest troubleshooting ever. Veronica was trying to be sample cop at the same time, so was rather distracted. She was sufficiently embarrassed that it's not likely to happen again!

Cast was uneventful. Again, a lot of shear in the RDI bottom track.



2.8 Station 8: 04/01 65°30´S 150°00´W

Errors and Warnings: None.

Depths: MB=3927, CTD=3507, DAB = 10.5

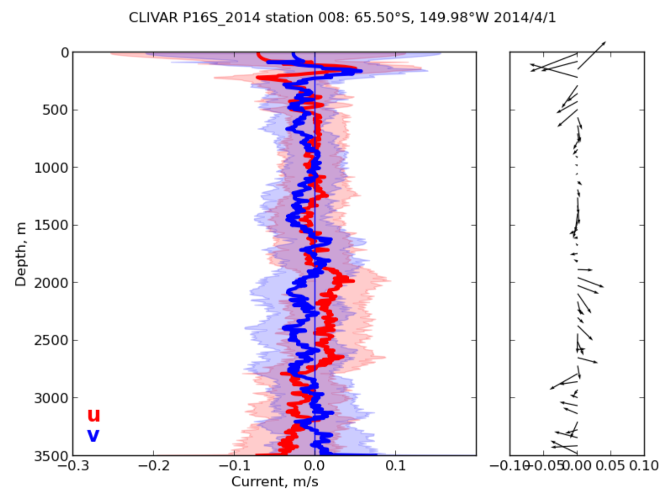
`check_ladcp: zmax=3541, zend=-3`

LDEO max depth=3506 bottom=3510

Notes: NASA casts afterward.

Comments:

Uneventful. Still not much current, RDI bottom track has large shear.



2.9 Station 9: 04/02 65°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=3908, CTD=4102, DAB = 8.3

`check_ladcp: zmax=4148, zend=6`

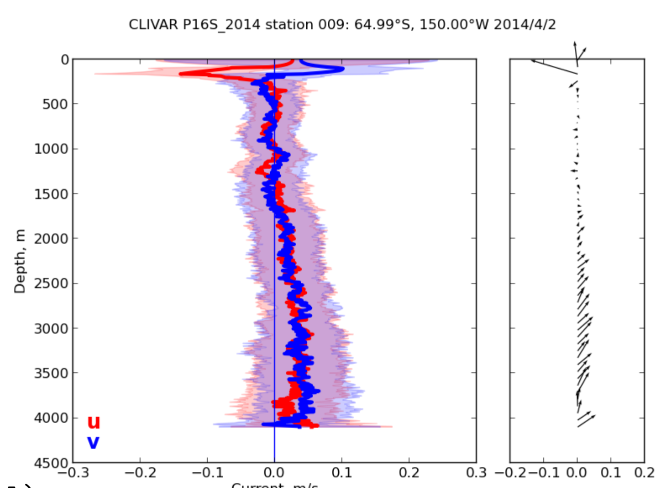
LDEO max depth=4100 bottom=4113

Notes: Had to move the station a bit because an iceberg was sitting on the spot. LDEO bottom track.

Comments:

Processing with RDI bottom track failed to find the bottom. Kind of odd, since the processing reported finding plenty of bottom track data and discarding only a fraction of it. Processing figure 4 suggests that it found the bottom 200 m below the actual bottom, which it had detected but evidently threw out.

```
DETECTED BEAM bottom track coordinates!
0 3-beam solutions calculated (0% of total)
```



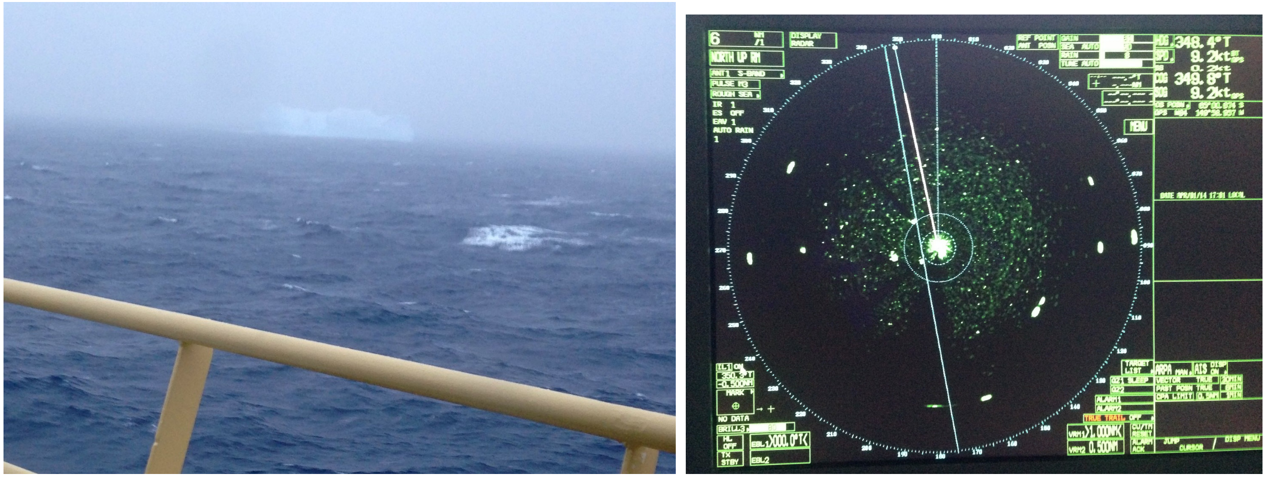


Figure 3: Hey! We wanted that spot! Left: Iceberg occupying Station 9. Right: Radar display at about the same time. Bright spots (except at the center) are all small icebergs. Only the closest were visible due to snow. The iceberg in the left picture was the one at about 320° on the radar.

```
found 495 finite RDI bottom velocities
removed 2 values because of error velocity > 0.5 m/s
removed 77 bottom-track velocities because of error velocity > 0.5 m/s
removed 3 values because of horizontal speed > 2.5 m/s
Outlier discarded 12632 bins down looking
Outlier discarded 56 bottom track
```

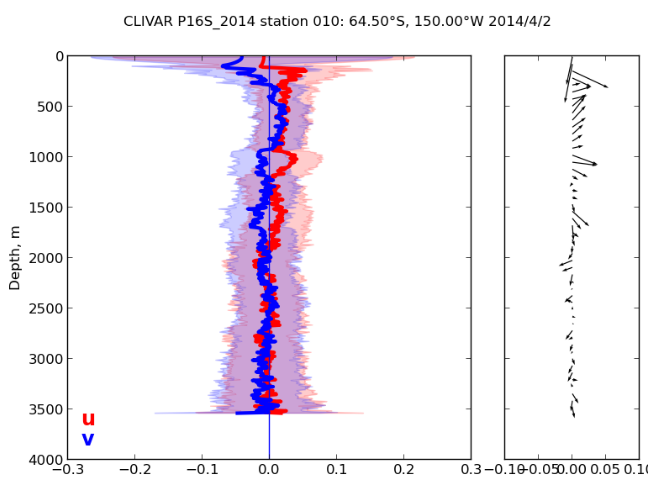
The LDEO bottom track looked reasonable, without excessive shear or strong currents, but processing figure 16 makes it look as though the bottom is not effectively rejected.

2.10 Station 10: 04/02 64°30´S 150°00´W

Errors and Warnings: None.

Depths: MB=4984*, CTD=3549, DAB = 8.4
check_ladcp: zmax=3570, zend=-35
LDEO max depth=3547 bottom=3550

Notes: * Multibeam depths unreliable–very scattered results.



Comments:

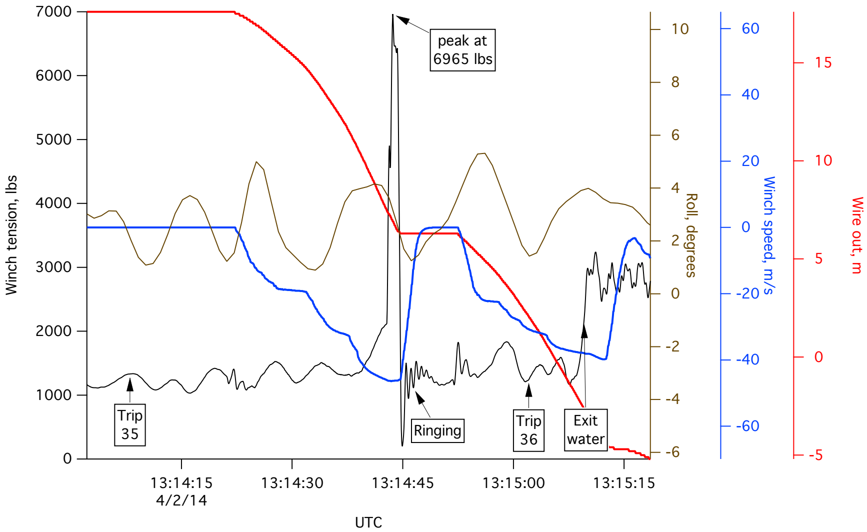
Rough recovery, as the weather was worsening. There was apparently a very large tension spike (6900 lbs) during recovery. Apparently no one noticed the moment it happened, so the cause isn't known.

Update on the tension spike (This update is on April 27, though the work was done by April 2nd).

I sent out an email, so rather than retype everything:

John Calderwood mentioned to me that there was a big spike in tension at the end of the last cast, and no one noticed exactly when it happened or had any good guesses why.

I've done a cursory examination of the data, but haven't concluded much beyond a few things that were not causes. I've attached a plot of winch parameters plus roll from the Seapath.



The spike occurred when the package was about 10 m below the surface, after bottle 35 was tripped at 20 m, and before bottle 36 was tripped on the fly at 5 m (conditions were too rough for stopping at the surface).

The tension peak lasted about 2.1 seconds, with a 3/4 second rise to a sharp peak, about a second at about 6400 lbs, then a rapid drop followed by some ringing. As the tension peaked, the winch wire out stopped. Curiously, the winch speed took a couple of seconds before stopping. The winch remained stopped for 7 seconds before resuming the upcast.

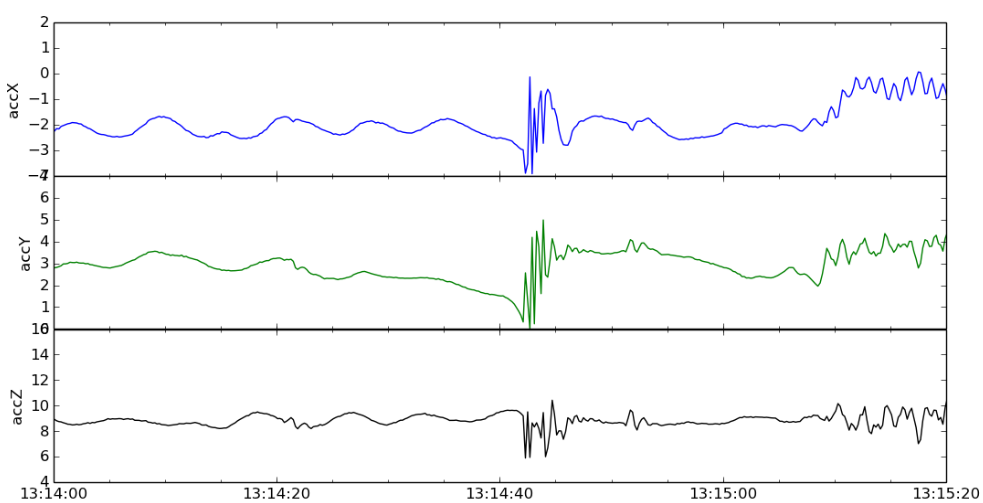
This is not a case of a swell lifting the package, then dropping it. The package was still 10 m down. In addition, the lift would have reduced tension before the spike, rather than after.

It doesn't look like an electrical glitch. The peak lasted too long, and the ringing after the peak looks mechanical to me.

This isn't a sudden swell increasing tension. No unusual rolling or heaving was going on, and those motions are smoother and take longer.

It looks like something got snagged. I don't know what, though. None of the suggestions I've heard seem likely. They include hitting the bottom of the ship, hitting a growler (mini-iceberg), a whale(!), or debris in the sheave.

I sent a plot to Andreas, too, or meant to, with IMP accelerations for the moment of the spike. In retrospect, it appears that I forgot to actually attach the plot. Here it is:



Further information arrived on 27 April, when Tyler Hennon mentioned that one of the thermisters from the χ-pod system had been crushed at the end of that cast. It had suddenly stopped sending data near the end of the cast. Not knowing about the voltage spike, he assumed it had hit the Baltic Room door during recovery.

The other bit of information is that the rosette was discovered to be a bit bent. No one actually knows when it happened, but April 2 seems as good a guess as any. I think at this point it is clear that the rosette actually hit the ship just before recovery.

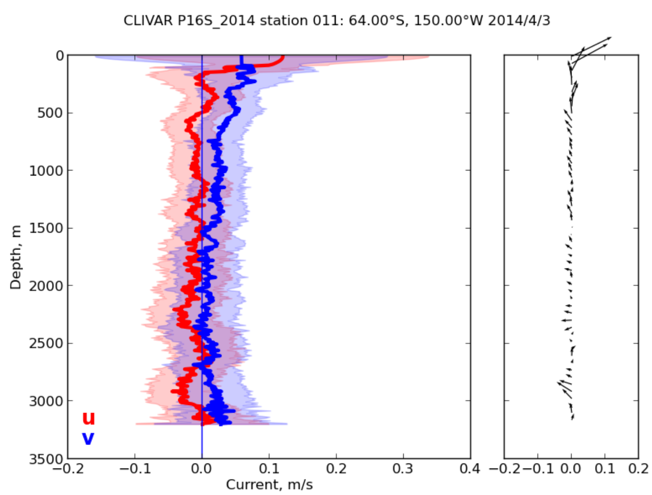
John Calderwood and the MTs did examine the last 20 m of the cable, looking for any damage. They found none. Indeed, John marveled at how nice and supple the cable was. The decision was made to keep using the cable without retermination.

2.11 Station 11: 04/03 64°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=3212, CTD=3204, DAB = 6.9
`check_ladcp: zmax=3267, zend=2`
LDEO max depth=3203 bottom=3212

Notes: Uneventful.



Comments:

The RDI bottom track processing identified the bottom as about 200 m below the real bottom. No clue why. Oddly, those depths below the bottom had non-zero velocities. The profile here is from the LDEO bottom track data, which got the bottom about right, but as usual, failed to reject all of the bottom.

I'm not sure why, but the depth calculation in `check_ladcp` (really an alias for `ladcp_rawplot.py --plotnames scalars --showfigs`) seems to work better than the LDEO processing.

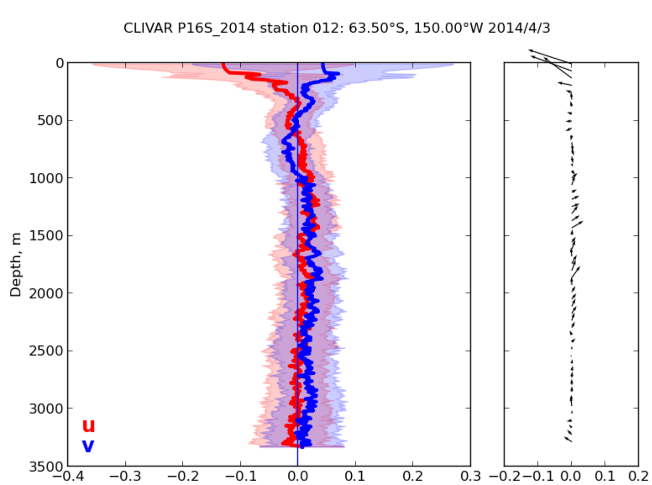
Update April 21: The reason the depth calculation was off is because the cast events file had maximum pressure, not depth. Courtney added a Max Z column, and I've gone through and entered those. The LDEO processing appears much better now.

2.12 Station 12: 04/03 63°30´S 150°00´W

Errors and Warnings: None.

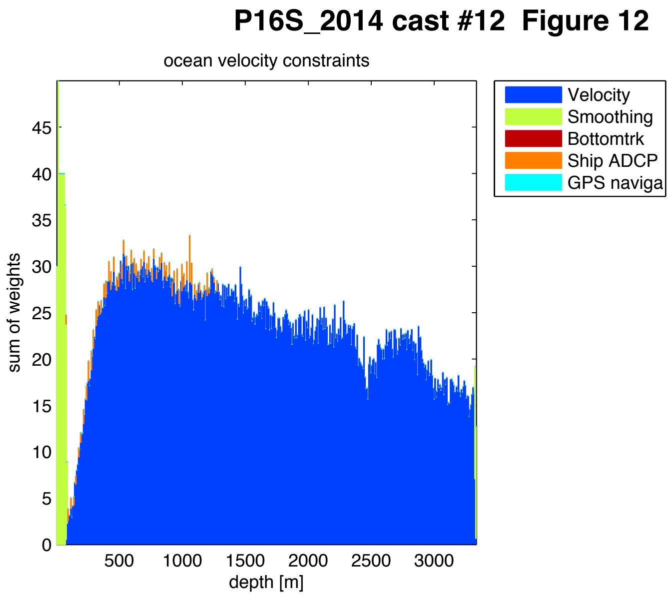
Depths: MB=3358, CTD=3342, DAB = 8.5
`check_ladcp: zmax=3374, zend=-38`
LDEO max depth=3547 bottom=3550

Notes: Uneventful.



Comments:

Remarkably weak currents through the water column. Once again, it seems to me that the weighting for the inversion is peculiar. It appears that there is essentially no data below about 200 m, even though there are a lot of SADCP pings, each of which has as much information as a WH150 ping.



It looks as though the inversion weights one 5 minute average from the OS38 the same as a single ping from the LADCP. It ought to treat each ping from each SADCP as equivalent to a WH150 ping. There would still need to be smoothing near the top, as the SADCP installations are at 7 m and have blanking intervals of 8 m and 24 m. Another possible improvement could be to discount LADCP orientation near the surface. From Andreas:

> the magnetometer data that I have looked at from the top few 10s of meters tend to be severely contaminated and I am wondering whether those data should be removed from processing. Perhaps this is related to the observation that solutions from different LADCP processing methods do not agree particularly well in the uppermost ocean.

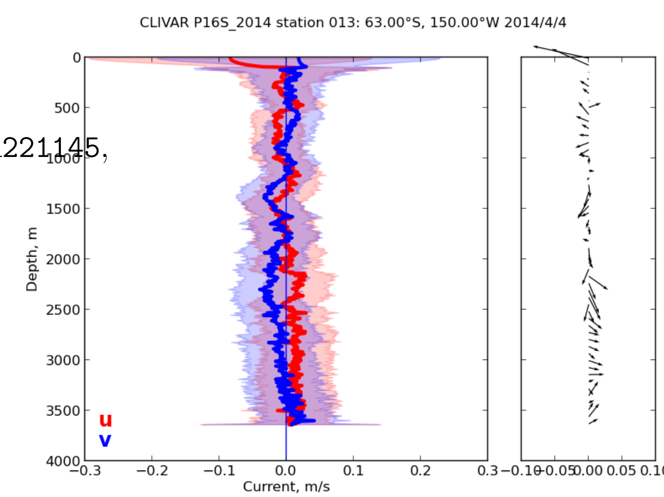
It seems to me that the SADCPs are not subject to this and it might make sense to rotate the LADCP data to best match the SADCPs.

2.13 Station 13: 04/04 63°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=3668, CTD=3647, DAB = 7.6
`check_ladcp: zmax=3668, zend=-3`
LDEO max depth=3646 bottom=3655

Notes: There is a spurious IMP file, 20140403_221145, because the seas were initially too rough to do a cast. Everything was started up, then nothing happened, and eventually the cast was delayed an hour or so, so I shut everything down and deleted the LADCP file, but didn't bother with the IMP.

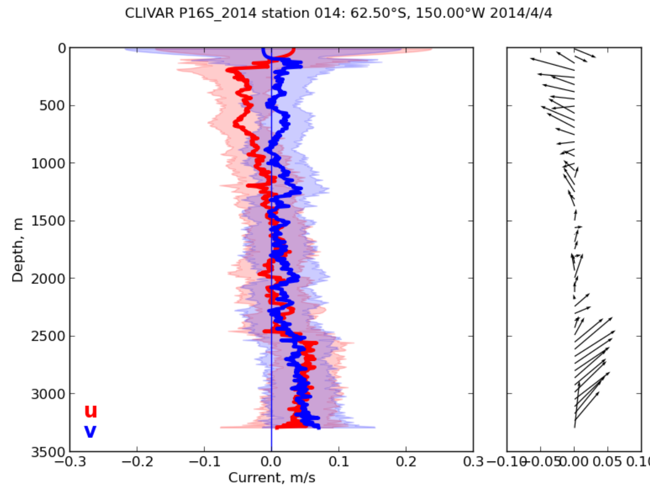


Comments:

RDI bottom track worked, but extended a pitifully short distance above the bottom. LDEO bottom track was much deeper, though U was a bit jagged.

2.14 Station 14: 04/04 62°30´S 150°00´W

Errors and Warnings: None.

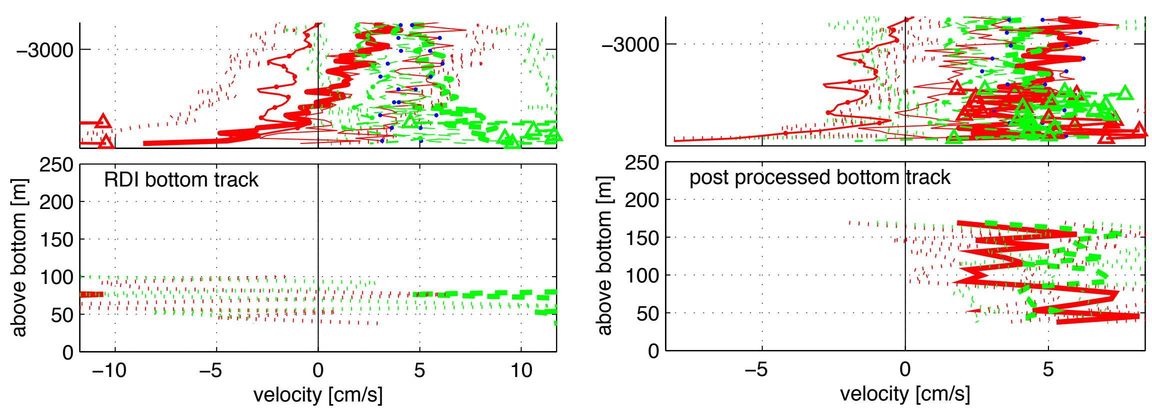


Depths: MB=3298, CTD=3298, DAB = 5.9
`check_ladcp: zmax=3339, zend=-8`
LDEO max depth=3296 bottom=3306

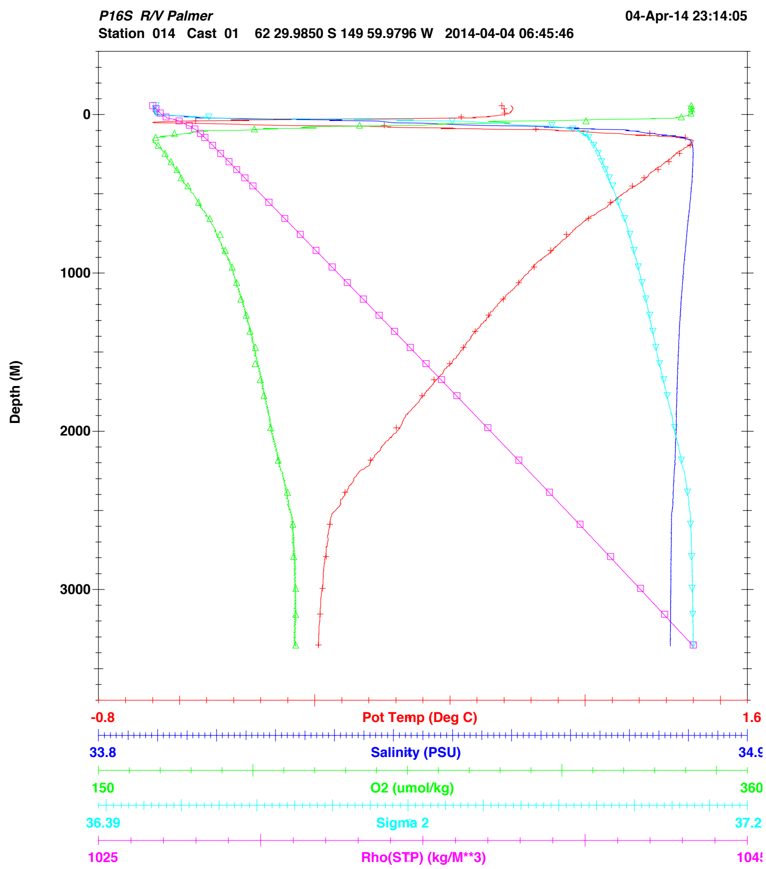
Notes: Uneventful cast.

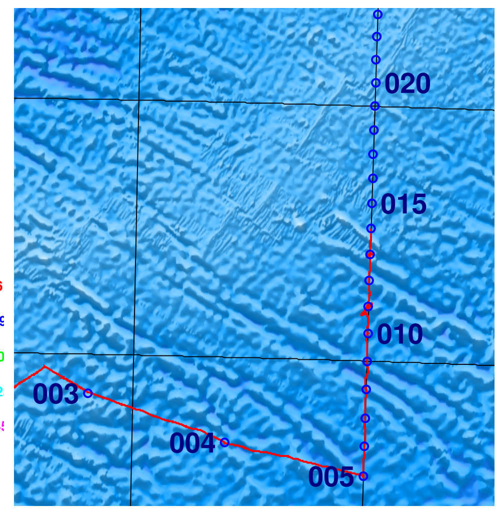
Comments:

RDI bottom track worked to detect the bottom, but had absurdly large velocities near bottom. It looks like there was actually a bottom current here below 2500 m. Lynne tells me that there has been a bottom layer about 1000 m thick through the last several stations, but I sure haven't noticed a bottom current. Perhaps its because we are nearing a ridge.



After the end of the cast, we fled north to try to avoid the worst of a storm.

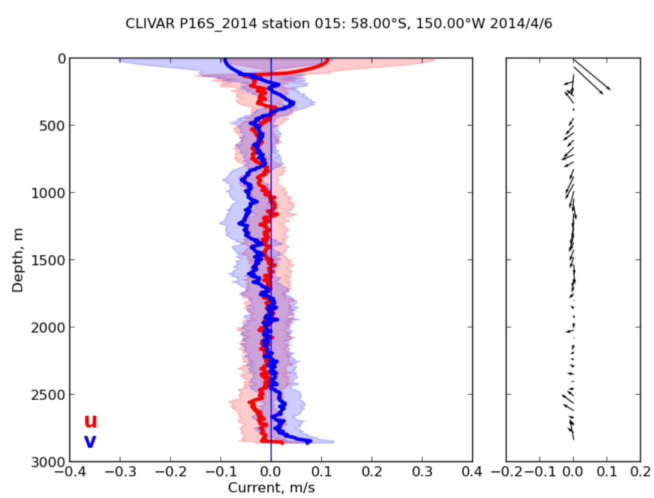




2.15 Station 15: 04/06 58°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=2875, CTD=2864, DAB = 7.7
`check_ladcp: zmax=2881, zend=-7`
LDEO max depth=2863 bottom=2872

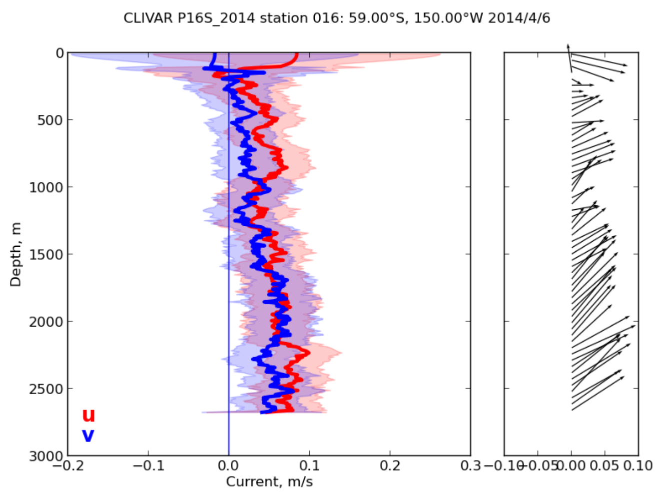


Notes: First cast after a weather delay and running 3°30´N seeking weather we could work in. Deployment turned out to be a bit chaotic. Short notice, since we had planned to go to 57°. and then luau seemed to be hung. Not really hung, but extremely busy, running the hard drive a lot and responding very slowly to user input. It was taking too long to even do a `top` command to see what was going on, so I hit the power button. On reboot, it wanted to do an `fsck` (not necessarily because of the ungraceful shutdown; my ssh connections had said it was overdue). Fortunately, the screen gave the option of hitting C to stop the disk check, so I did that and got the LADCP going. In the process, I forgot to set the station and cast, so the log went to `wh000_01.log`. Then I rebooted luau to give it the chance to `fsck`, which it did not do. When I restarted `ladcp_wh150.py` I entered the right station and cast number. When Veronica downloaded the data, she got an error message about the log directory or file not existing. The data download went fine.

Comments:

RDI bottom track failed to detect the bottom. LDEO bottom track seemed to work fine. I was a little surprised not to see the bottom current from station 14. This station is just north of the Pacific-Antarctic Ridge though, so as we return south to the stations we skipped, maybe it will reappear.

2.16 Station 16: 04/06 59°00´S 150°00´W



Errors and Warnings: None with LDEO bottom track. With RDI bottom track there was a message about large U and V bottom track biases.

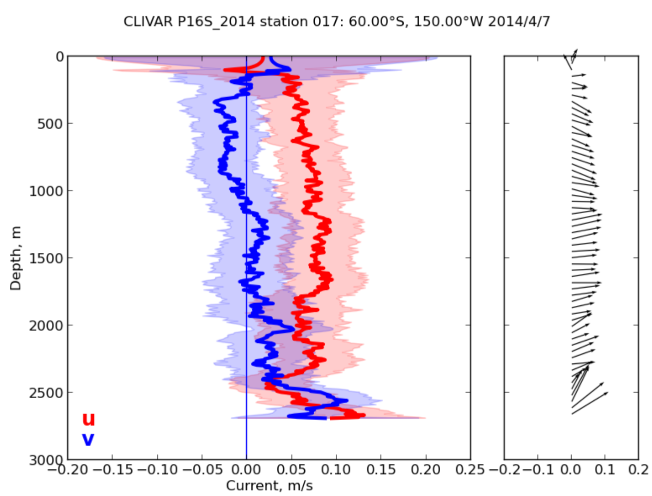
Depths: MB=2838*, CTD=2686, DAB = 7.1
`check_ladcp: zmax=2712, zend=13`
LDEO max depth=2684 bottom=2692

Notes: * Multibeam showed lots of variation. Either steep topography or poor data due to rough seas.

Comments:

Had to use LDEO bottom track again. RDI bottom track had the bottom well below the actual bottom again. The bottom current is back. We are very near the crest of the Pacific-Antarctic Ridge.

2.17 Station 17: 04/07 60°00´S 150°00´W



Errors and Warnings: Warning: removed 12 pressure spikes during: 2 scans

Depths: MB=2713, CTD=2697, DAB = 9.4
`check_ladcp: zmax=2752, zend=16`
LDEO max depth=2684 bottom=2692

Notes: Uneventful cast. NASA cast went first, so this was officially cast 2, though I screwed it up in the datafile name. At the moment, it appears that the CTD files share the mistake.

Comments:

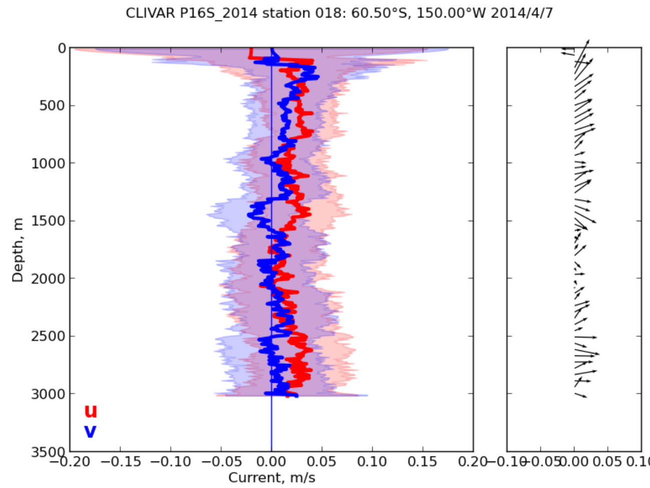
Had to use LDEO bottom track again. RDI bottom track had the bottom well below the actual bottom again. the bottom current is back. Doesn't look like LDEO bottom track eliminated bottom contamination. Around 800 m there is an odd spike in the SADCP V current. Seems unlikely to be real.

2.18 Station 18: 04/07 60°30´S 150°00´W

Errors and Warnings: None with LDEO bottom track. With RDI bottom track there was a message about large U and V bottom track biases.

Depths: MB=2997*, CTD=3024, DAB = 8.7
`check_ladcp: zmax=3054, zend=-28`
LDEO max depth=3023 bottom=3025

Notes: * Multibeam depths for the rest of the cast were about 3030 m. Probably bad data, but possibly an uneven bottom.



Comments:

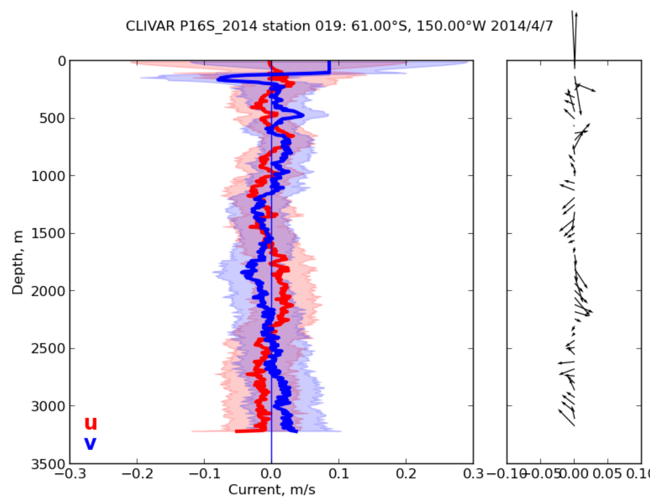
RDI bottom track worked okay this time. Spiky, as usual. General eastward flow through the column.

2.19 Station 19: 04/07 61°00´S 150°00´W

Errors and Warnings: None with LDEO bottom track. With RDI bottom track there was a message about large U and V bottom track biases.

Depths: MB=2688*, CTD=3226, DAB = 9.8
`check_ladcp: zmax=3248, zend=-9`
LDEO max depth=3224 bottom=3236

Notes: * Multibeam depth scattered again, all shallower than max CTD depth. Clearly bad.



Comments:

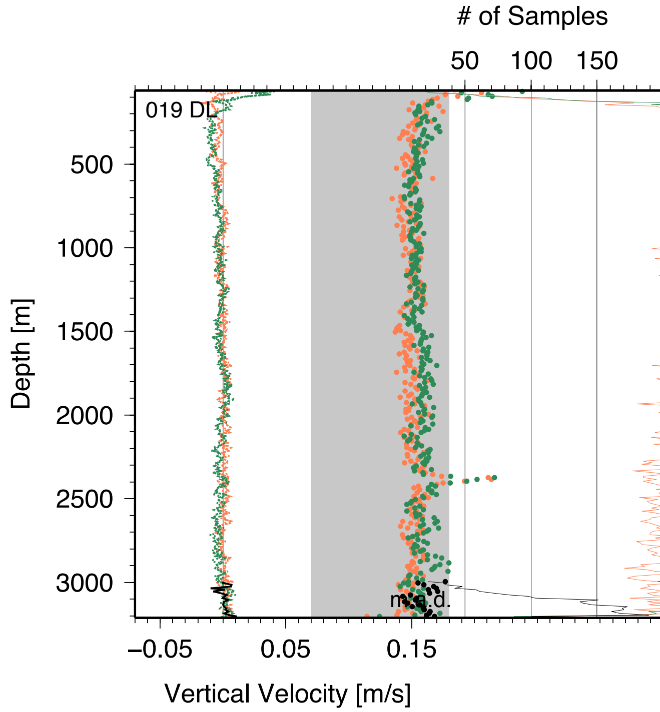
Use LDEO bottom track again. RDI bottom track was usable but spiky. There are some odd spikes at the bottom of the SADCP profile (1300 m)again.

Update 04/18:

The region over the Antarctic-Pacific Ridge shows substantial net upwelling in the Southern Ocean State Estimate (SOSE), at least when averaged over a 3 year period. Therefore, it seems like a natural spot to try out Andreas' scheme for extracting w using the difference between CTD-derived vertical rosette speed and LADCP w relative to the package. My enthusiasm was dampened a bit when I realized that the while the upwelling was a striking feature in the SOSE plot, it was really averaging only $3 \times 10^{-5}\,\mathrm{m\,s^{-1}}$, or $30\,\mu\mathrm{m\,s^{-1}}$. Try measuring that with a Doppler instrument!

Nevertheless, Lynne wanted to try, and after all, if this is a turbulent region, that small w is probably an average of much larger positive and negative values, so maybe we'd see something. I sent Andreas the 24 Hz CTD data and the LADCP file for this station, and he sent back this figure, saying that the vertical currents were very small, but he believed they were real:

I have processed the LADCP data for w and attached the most relevant plot. The data appear to be of high quality. In terms of w, the profile is about as quiescent as any I have seen, consistent with more than 100 LADCP profiles collected in the Pacific sector of the Southern Ocean (including over the PAR) during DIMES US2.



In the plot, 3 quantities are shown: 5 different vertical velocity profiles on the left, sampling statistics (per-bin mean absolute deviations from the median) with dots in the middle and number of samples on the right. Because of the excellent range of the WH150, the number of samples is beyond my default axis range. The 5 vertical-velocity profiles are as follows:

1) black: bottom-tracked w; I have evidence suggesting that this is accurate to 1mm/s 2&3) orange: 2 separate down-cast w profiles (dotted and solid), each calculated from one of the two beam pairs (1&3, 2&4). 4&5) green :2 separate up-cast w profiles (dotted and solid), each calculated from one of the two beam pairs (1&3, 2&4).

I believe that the fluctuations with apparent vertical wavelengths between 100 and a few 100s of meters are real (rather than measurement errors) because finescale spectra are consistent with internal waves (not shown). The apparent downwelling above 1000m or so may also be real but I am less certain about that. I do not trust the strong apparent upwelling above 100m measured during the upcast, as the number of samples is small and the mean absolute deviation high.

I immediately noticed the nice PPI signal at 2400 m. The deviations go up there because half of the points are at 0 (the bottom) and half are water data. It's encouraging to see w tending to zero there as well.

2.20 Station 20: 04/08 59°30´S 150°00´W

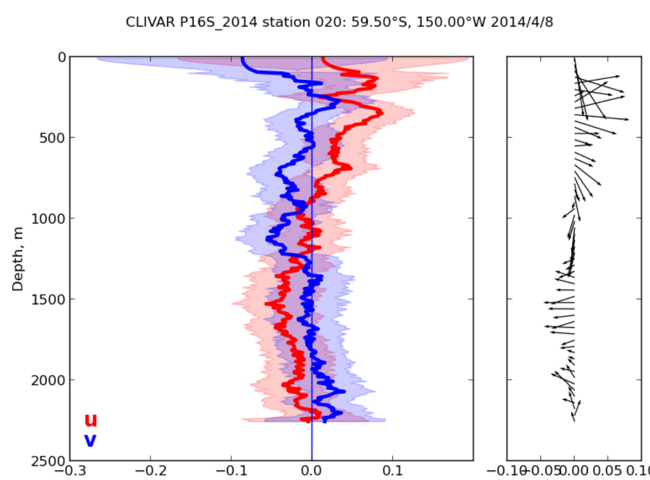
Errors and Warnings: None with LDEO bottom track.

Depths: MB=2259, CTD=2254, DAB = 9.8

`check_ladcp:  zmax=2281, zend=-13`

LDEO max depth=2254 bottom=2274

Notes: Uneventful cast.



Comments:

Use LDEO bottom track again. RDI bottom track was bad. LDEO bottom track did not reject the bottom well at all.

2.21 Station 21: 04/08 58°30´S 150°00´W

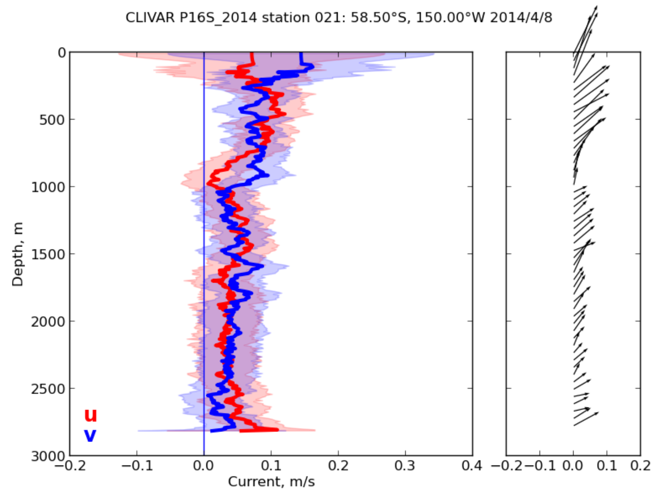
Errors and Warnings: None with LDEO bottom track.

Depths: MB=2841, CTD=2820, DAB = 8.4

`check_ladcp: zmax=2826, zend=-36`

LDEO max depth=2819 bottom=2829

Notes: Uneventful cast.



Comments:

Use LDEO bottom track again. This time it did a good job rejecting the bottom.

2.22 Station 22: 04/09 57°30´S 150°00´W

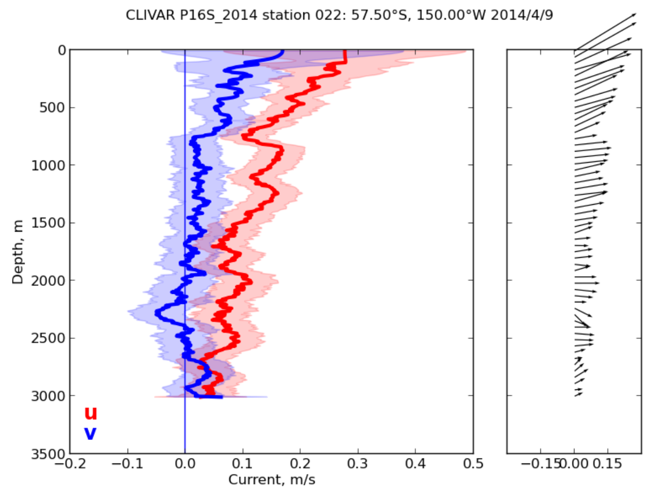
Errors and Warnings: None with LDEO bottom track. With RDI bottom track there was a message about large U and V bottom track biases.

Depths: MB=2998*, CTD=3019, DAB = 2.7

`check_ladcp: zmax=3248, zend=-9`

LDEO max depth=3224 bottom=3236

Notes: The start of the cast was a bit of a panic. The NASA cast was supposed to go first, but that decision was reversed and no one thought to tell me until the marine techs were already there. Deployment seemed to go okay, but rather than wait for the WiFi connection with the IMP, I power-cycled it.



* Multibeam depths varied from 2998 m to 3042 m. May be good.

Comments:

Use LDEO bottom track again. Once again, the bottom was rejected nicely. We seem to be in the Antarctic Circumpolar Current (ACC) again, with transport to the east through the entire water column and surface currents >30 cm s^{-1}.

2.23 Station 23: 04/09 57°00´S 150°00´W

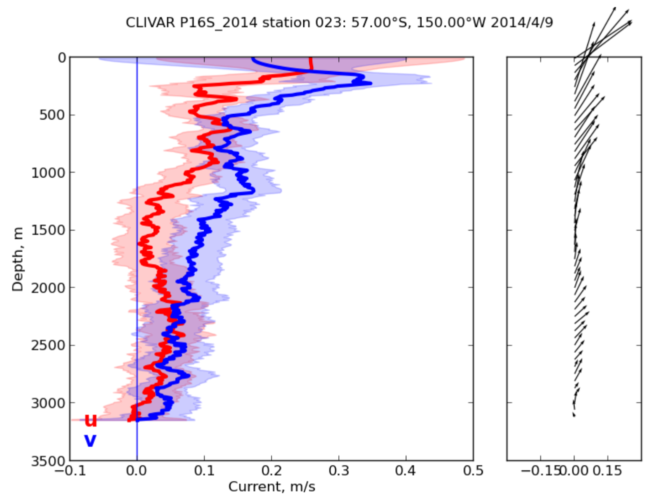
Errors and Warnings: None with LDEO bottom track.

Depths: MB=3273, CTD=3155, DAB = 8.4
`check_ladcp: zmax=3194, zend=-18`
LDEO max depth=3154 bottom=3165

Notes: Uneventful.

Comments:

Used LDEO bottom track again. The bottom was rejected poorly this time, particularly on the way down. Once again, current towards the northeast through the entire water column.



2.24 Station 24: 04/09 56°30´S 150°00´W

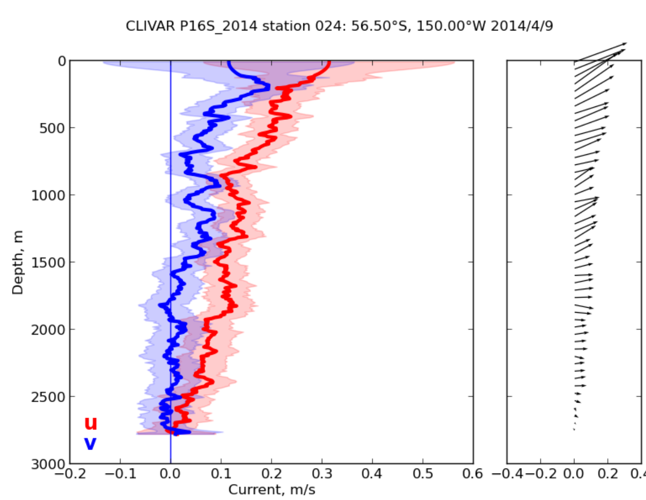
Errors and Warnings: None with LDEO bottom track.

Depths: MB=3064*, CTD=2782, DAB = 8.6
`check_ladcp: zmax=2789, zend=-51`
LDEO max depth=2781 bottom=2795

Notes: * Multibeam depths varied from 2768 m to 3064 m. May be good.

Comments:

Used LDEO bottom track again. The bottom was rejected poorly. Current towards the east through the entire water column.



2.25 Station 25: 04/10 56°00´S 150°00´W

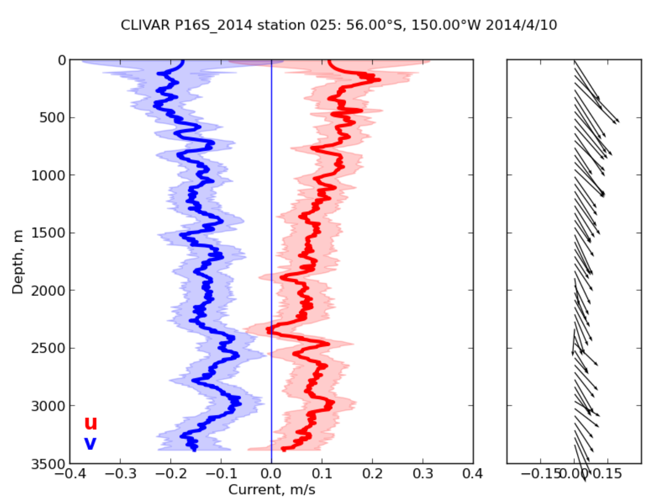
Errors and Warnings: None with LDEO bottom track.

Depths: MB=3405, CTD=3387, DAB = 7
`check_ladcp: zmax=3406, zend=18`
LDEO max depth=3385 bottom=3394

Notes: Uneventful.

Comments:

Had a bit of a shock when I went to process the data and the Matlab code abruptly quit with an error message about bad axis range. Since `check_ladcp` had gone without a hitch, I figured it probably wasn't the LADCP data. Looked more carefully and found that the CTD



had gone down 85 km! Turned out that Courtney had changed the CTD datafile to include the fluorometer. That addition messed up the GPS location columns. Put the correct columns into `set_cast_params.m` and ran without a hitch. Courtney tells me she has updated all of the CTD files with the additional column, so reprocessing older stations won't require a different `set_cast_params.m`.

RDI bottom track processing again failed to find the bottom. Used LDEO bottom track again. Bottom rejection was better, but still not perfect. Still flow towards the east through the entire water column, but a substantial southward component has been added.

2.26 Station 26: 04/10 55°30´S 150°00´W

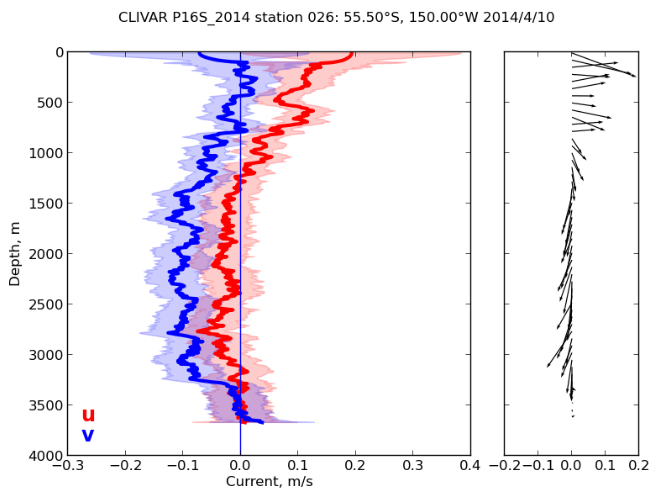
Errors and Warnings: None

Depths: MB=3680, CTD=3682, DAB = 9.1

`check_ladcp: zmax=3698, zend=-5`

LDEO max depth=3680 bottom=3684

Notes: Uneventful.



Comments:

RDI bottom track worked okay for a change.

2.27 Station 27: 04/11 55°00´S 150°00´W

Errors and Warnings: Warning: removed 14 pressure spikes during: 2 scans.

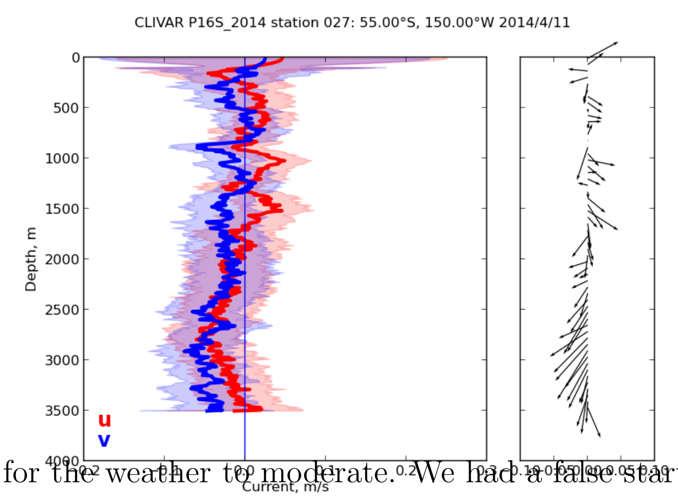
Depths: MB=n/a*, CTD=3514, DAB = 8.7

`check_ladcp: zmax=3512, zend=-9`

LDEO max depth=3511 bottom=3522

Notes: Used LDEO bottom track. Error message from `ladcp_wh150.py` saying there was no such directory, so could not make the backup data file.

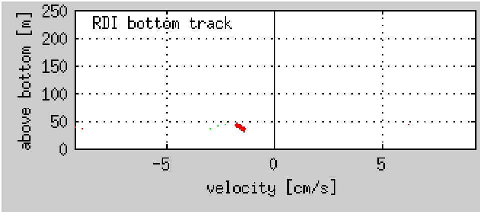
* Multibeam data bad from start to bottom. When CTD exited water, was at 3834 and 2 minutes later was 3529 m. Those vary fast enough that they are likely bad. Rough seas probably the culprit.



Comments:

We had strong winds and pretty big seas all day. Heave was often 6 m peak to peak. The cast was delayed over 12 yours while we waited for the weather to moderate. We had a false start about an hour before the real cast. I never started the LADCP, but did get the IMP going, so there's a spurious IMP file.

There was some problem with winch tension at the start of this cast. Right near the launch, the tension apparently zeroed. I guess it didn't put much, if any, slack in the system because there wan't a huge tension spike. Then the downcast was pretty slow because tension regularly went quite low.



RDI bottom track did okay seeing the bottom, but as often happens, had trouble getting much data above the bottom. This case was particularly pitiful.

2.28 Station 28: 04/11 54°30´S 150°00´W

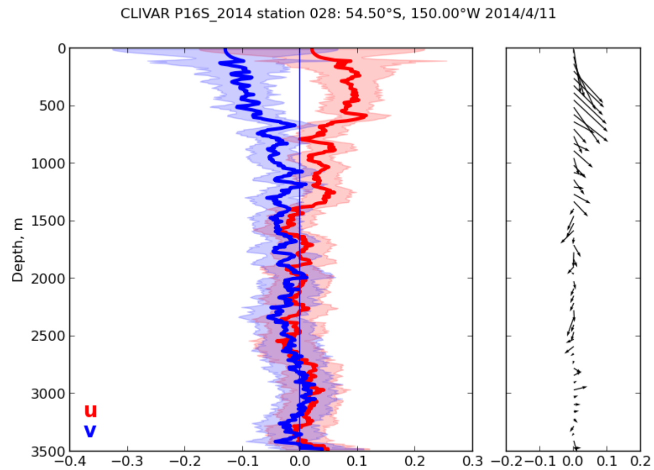
Errors and Warnings: None with LDEO bottom track.

Depths: MB=3502, CTD=3490, DAB = 9.4

`check_ladcp: zmax=3489, zend=-16`

LDEO max depth=3488 bottom=3498

Notes: Uneventful. Had to use LDEO bottom track, which did reject the bottom nicely.



Comments:

2.29 Station 29: 04/11 54°00´S 150°00´W

Errors and Warnings: None with LDEO bottom track.

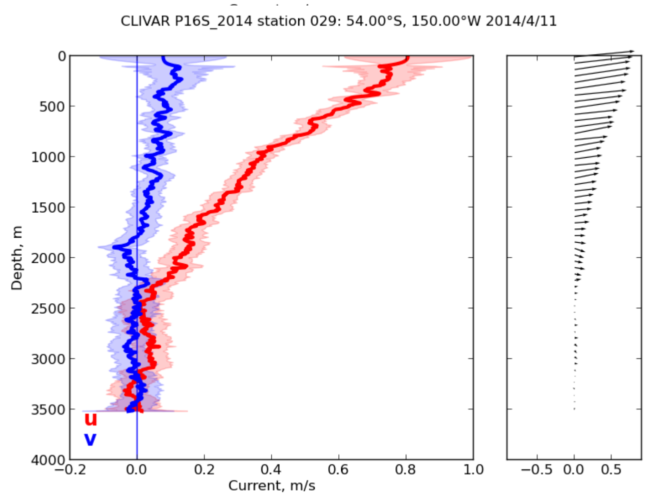
Depths: MB=3513*, CTD=3529, DAB = 10.1

`check_ladcp: zmax=3406, zend=18`

LDEO max depth=3385 bottom=3394

Notes: Had to use LDEO bottom track, which did reject the bottom nicely. IMP file fouled up by a full disk.

* Multibeam depths range 3100 m to 3598 m. May be real.



Comments:

Whee! We're in a significant current, at about 2 knots, a product of the sub-Antarctic Front. This caused a bit of drama near the bottom, as there was a big wire angle extending under the ship, which was forced to drift with the current. There was some fear that the ship's motion could allow the wire to straighten, lowering the package to the bottom without any winch action. Time at the bottom was minimized to reduce the chances of that. Seemed like everything worked out.

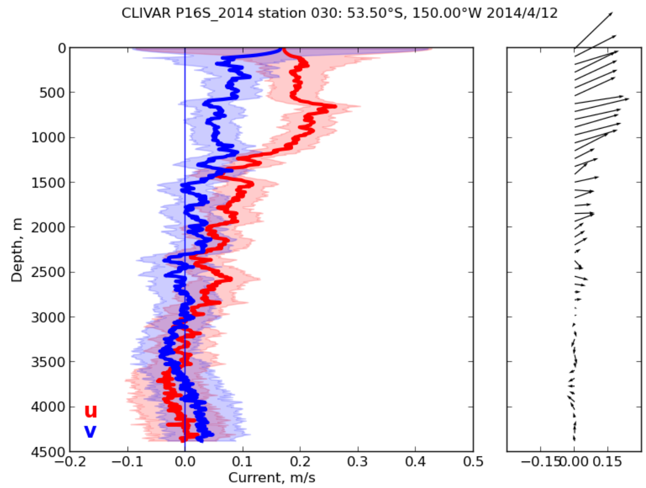
The IMP file for this cast is very small, and the `df` command revealed 0% free space. I transferred all data to the Mac and deleted it. Lesson: 6 casts is the limit.

2.30 Station 30: 04/12 53°30´S 150°00´W

Errors and Warnings: None with LDEO bottom track.

Depths: MB=4410, CTD=4389, DAB = 6.8
`check_ladcp: zmax=4386, zend=-50`
LDEO max depth=4385 bottom=4404

Notes: Had to use LDEO bottom track. Bottom rejected very poorly, but better than the RDI bottom track.



Comments:

Eastward current still present, but very much weaker. Past the front? LADCP range in deep water has deteriorated significantly; it's now about 200 m rather than 300. I expect it will get worse through the rest of the cruise. Not nearly as bad as P02 yet, when I was lucky to get 100 m.

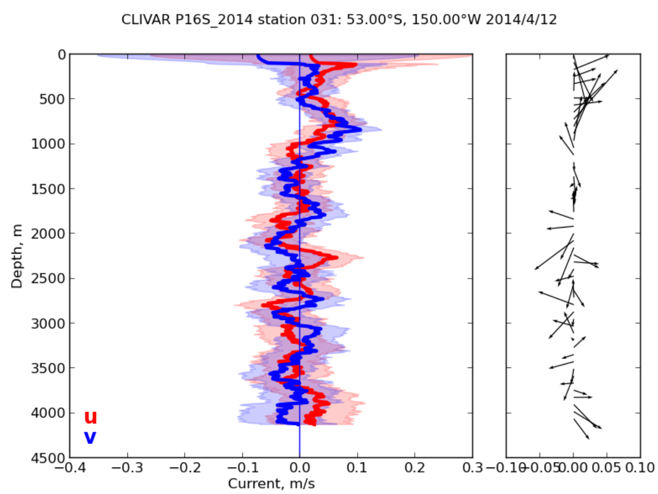
Meghan (the marine tech on duty for the cast) noticed a stretch of cable near 4100 m with a loose strand of the outer armor.

2.31 Station 31: 04/12 53°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=4578, CTD=4133, DAB = 9.9
`check_ladcp: zmax=4103, zend=-52`
LDEO max depth=4130 bottom=4137

Notes: RDI bottom track looked okay, though short this time.



Comments:

Currents are gone! Very weak through the entire cast.

The bottom of this cast was very slow as the cable was examined by the marine techs, the MPC, and John Calderwood. They found a stretch of wire with at least two broken strands of outer armor, and declared the cable beyond 4100 m unusable. It appears to be an embrittlement problem, as the cable snapped cleanly across without the thinning typical of breaks due to excessive tension. There is a backup drum and winch (the "upper waterfall winch") with 0.322" cable a bit farther aft, serving the side A-frame. Lynne Talley conferred with techs and came up with the following:

- Is the backup cable actually in good shape? (After all, the /em Brown lost its rosette after going to a backup cable that turned out to be deceptively good-looking on the outside, but in very bad shape.) This can be tested by hanging a weight on the cable and examining it as 4 km is paid out. That won't tell us about the cable farther along.

- The best option is to spool the backup cable on to the Baltic Room winch, so we can continue to sample in a sheltered space. Can that be accomplished? It requires spooling out the bad cable (and discarding it or hanging it off the side of the ship) then respooling the backup cable to the Baltic winch, then spooling the bad cable onto the waterfall winch. Not easy, particularly if seas are not calm.
- If we have to use the upper waterfall winch, we have to get the rosette outside. Can we do a transfer out the big Baltic Room door then pulling the rosette around to the A-frame, or must we disassemble the rosette enough to get it through the aft door? Deploying from the A-frame would mean that water sampling would take place outside, which would be unpleasant in inclement weather and slow, because the ship would have to remain on station until the sampling is done. I'd have a hard time downloading IMP data.
- It is also possible to use the aft A-frame, which has a 0.681" cable with a conductor that should work. That would mean sampling on the fantail, an even wetter option than the side A-frame. Doesn't sound like fun.

2.32 Station 32: 04/12 52°30´S 150°00´W

Errors and Warnings: None with LDEO bottom track.

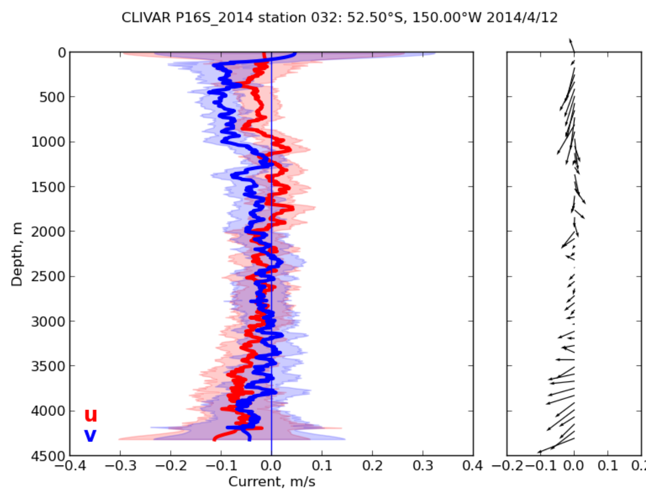
Depths: MB=4671*, CTD=4030, DAB = 56.8

`check_ladcp: zmax=4037, zend=-8`

LDEO max depth=4027 bottom=3394

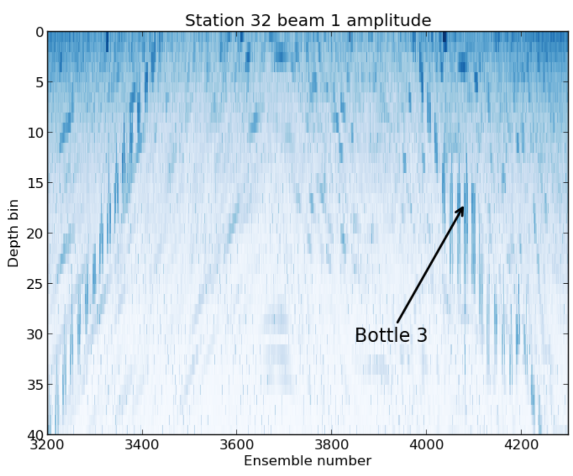
Notes: No close bottom approach since we were limited by usable wire length.

* Multibeam data scattered; a bit hard to believe.



Comments:

After the cast, the first 3700 m of backup cable was examined by lowering a weight. The cable looks really nice. The weather is too bad to transfer the cable between winches or to move the rosette outside without disassembling it, so for the next 8 casts, we will simply limit casts to 4000 m, which won't quite reach the bottom. Beyond that, the ocean is deeper, so we'd be losing too much science. At that point we hope the weather will be better.



While the bottom was not directly visible in the data, PPI was pretty obvious in Figure 14. Using that, I ought to be able to estimate the depth. Unfortunately, it wasn't obvious in figure 3. Maybe 3800 m. In any event, the formula for PPI is

$$\Delta z = \frac{1}{2} c \Delta t \cos\theta \qquad (1)$$

The speed of sound, c, was $1522\,\mathrm{m\,s^{-1}}$ at the bottom of the cast.It undoubtedly rose with pressure, but I'll ignore that. Δt is 1.2 s, and the beam angle θ is 20°, yielding 860 m under the artifact. I read in the raw data and plotted amplitude from beam 1, much as in Figure 14, but with the raw data I could identify times. I noticed a level spot that must have been a bottle stop, looked at the time, and found that bottle 3 was tripped then, at a depth of 3829 m. Bin 17 seems to have had the strongest signal, and that was $860 + 17 \times 8 - 4 + 16 = 1008$ m under the LADCP, for a bottom depth of about 4840 m. That is within the range of multibeam depths for the cast, although those are scattered enough that they don't seem very trustworthy.

I wonder whether it's practical to get bottom velocities from PPI-dominated bins. If so, it would provide CTD velocity, and thus water velocity within range of the LADCP.

2.33 Station 33: 04/13 52°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=4767, CTD=4031, DAB = n/a

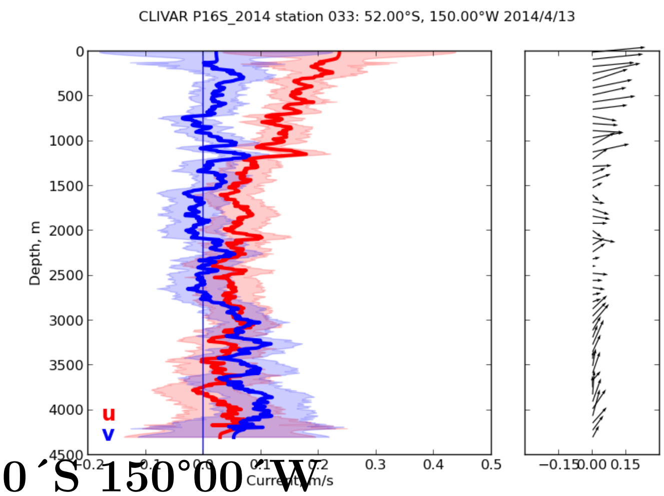
`check_ladcp: zmax=4021, zend=-55`

LDEO max depth=4028 bottom=n/a

Notes: No close bottom approach since we were limited by usable wire length.

Comments:

Again, bottom is visible in PPI. Could estimate the depth again. Offhand, it looks a bit farther from the rosette than it was in station 32.



2.34 Station 34: 04/13 51°30´S 150°00´W

Errors and Warnings: None.

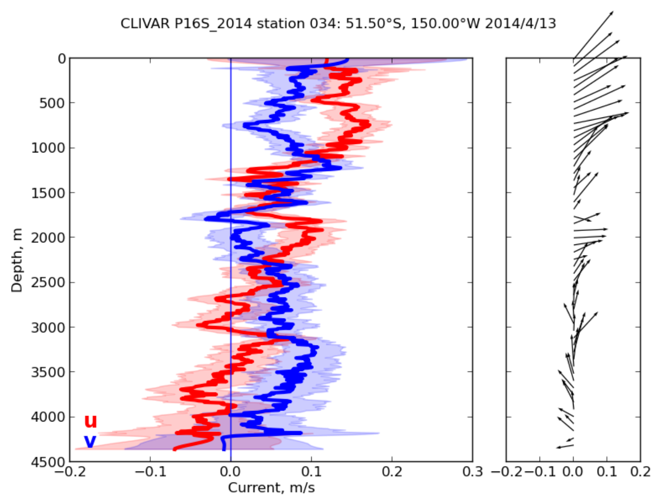
Depths: MB=4374, CTD=4032, DAB = n/a

`check_ladcp: zmax=4014, zend=-38`

LDEO max depth=4014 bottom=n/a

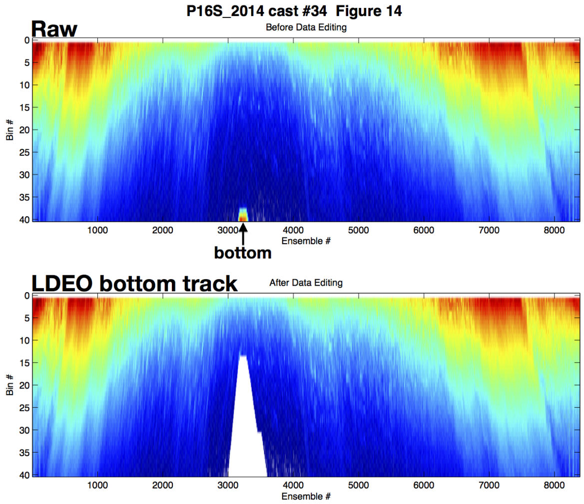
Notes: No close bottom approach since we were limited by usable wire length.

Comments:



The bottom was actually visible this time. It was in bins 38 to 40 at the very deepst part of the cast. 40 was stronger than 38 and 39, which may have been side lobe reflections. That means the bottom was $40 \times 8 - 4 + 16 = 332$ m or perhaps a bit more below the rosette, for 4362 m estimated depth, perfectly reasonable considering the multibeam depth.

This clearly presented a challenge for the bottom detection and rejection algorithms in the LDEO processing. There were 134 RDI bottom track points, but they were apparently all rejected, because none of them were edited out in figure 14. The bottom plot looked exactly like the top plot.



The LDEO bottom track was worse: it detected bottom when there was none. It edited out points 200 m above the real bottom for no reason that was obvious. The max bottom track depth (`btrk_range`) for the LDEO algorithm is 300 m, so it should not have found any at all. Instead, it found `7503 valid values`,

2.35 Station 35: 04/13 51°00´S 150°00´W

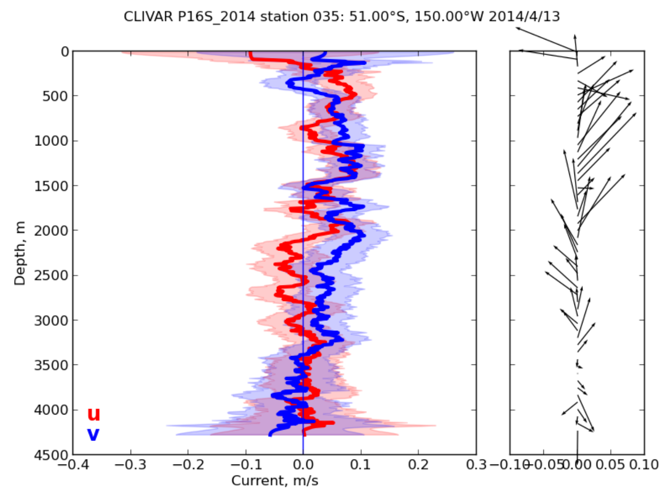
Errors and Warnings: None.

Depths: MB=4949, CTD=4031, DAB = 56.8
`check_ladcp: zmax=4044, zend=5`
LDEO max depth=4028 bottom=n/a

Notes: No close bottom approach since we were limited by usable wire length.

Comments:

PPI suggests the rosette came to about 880 m from the bottom. The multibeam agrees, with a depth exceeding wire out by 900 m. I suppose it's no surprise that the shear and inverted profiles are very similar when there is no bottom track.



2.36 Station 36: 04/14 50°30´S 150°00´W

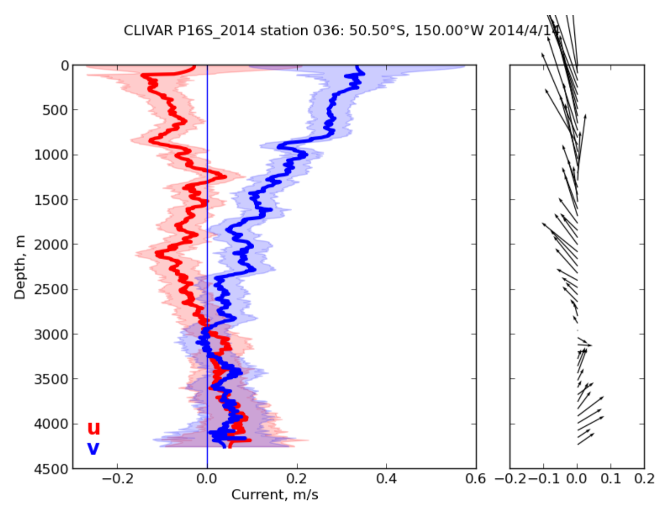
Errors and Warnings: None.

Depths: MB=4442, CTD=4031, DAB = n/a
`check_ladcp: zmax=4048, zend=-24`
LDEO max depth=4028 bottom=n/a

Notes: No close bottom approach since we were limited by usable wire length.

Comments:

Relatively strong northward current at this point. PPI signature makes it look like we were closer to the bottom this time, though not quite enough to see the bottom directly.



2.37 Station 37: 04/14 50°00´S 150°00´W

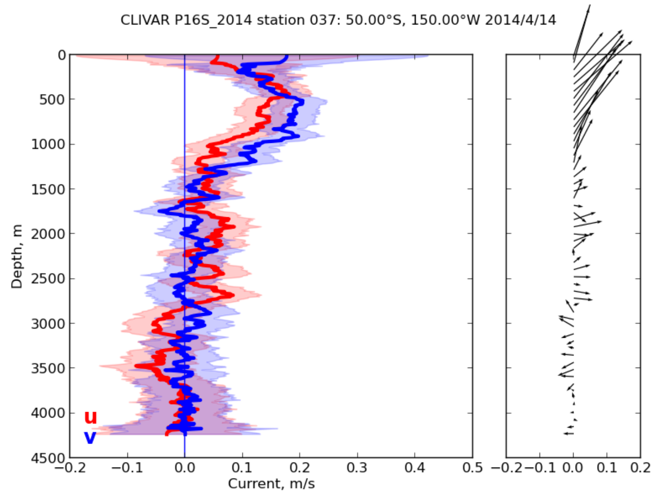
Errors and Warnings: None.

Depths: MB=4257, CTD=4033, DAB = n/a
`check_ladcp: zmax=4019, zend=-40`
LDEO max depth=4029 bottom=4255

Notes: No close bottom approach since we were limited by usable wire length. CTD was cast 2 since NASA went first.

Comments:

While there was no close bottom approach, the bottom was clearly visible in the data, roughly 200 m below the cast bottom. The RDI bottom tracking did not edit out bottom data, while the LDEO processing did a good job.



2.38 Station 38: 04/14 49°30´S 150°00´W

Errors and Warnings: None.

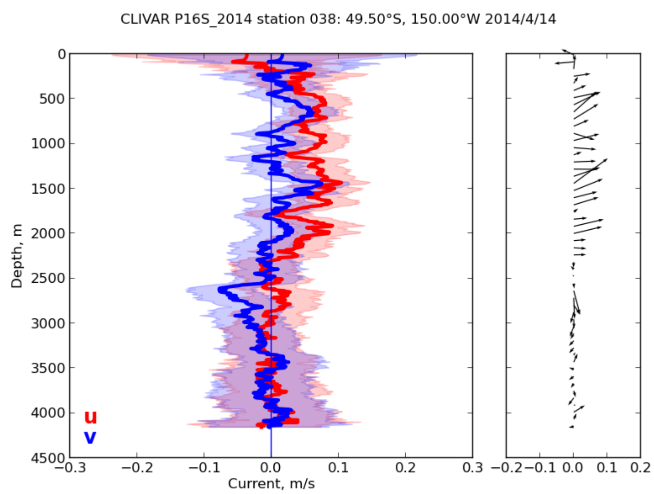
Depths: MB=4178, CTD=4031, DAB = n/a
`check_ladcp: zmax=4021, zend=-40`
LDEO max depth=4027 bottom=4177

Notes: No close bottom approach since we were limited by usable wire length.

Comments:

This time the RDI bottom track edited out too much data. The LDEO bottom track seemed okay. No idea why. Since we got to within 150 m of the bottom, the CFCs apparently rose just a bit at the bottom station. Just a tiny bit.

After this station, we transferred the rosette to the starboard A-frame, which is directly aft of the Baltic room, where we had been operating. I transferred the acquisition computer, luau, to the aft control room, and shifted the lab cable.

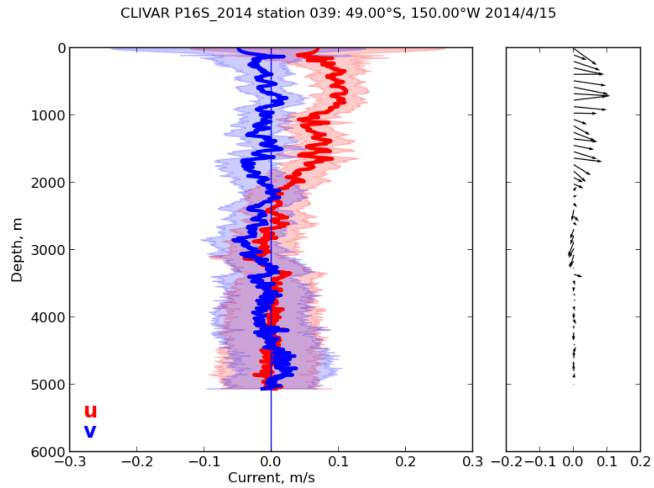


2.39 Station 39: 04/15 49°00´S 150°00´W

Errors and Warnings: Warning: removed 90 pressure spikes during: 3 scans. Also, bad data in CTD screws up the processing.

Depths: MB=5043, CTD=5074, DAB = 10.4
check_ladcp: zmax=283, zend=-29 (cast 1)
check_ladcp: zmax=349, zend=-20 (cast 2)
check_ladcp: zmax=5029, zend=-89 (cast 3)
LDEO max depth=5070 bottom=5077

Notes: First station with backup cable. First two casts aborted due to communications problems with CTD.



Comments:

There have been some teething pains associated with the new winch and wire. After transferring the rosette to the upper waterfall winch, mechanical and electrical terminations needed to be done. The mechanical termination was fine and tested at 3000 lbs without incident. The electrical termination also seemed fine on deck. When in the water, however, there were a lot of dropped frames, to use the CTD parlance, where a "frame" is a data message. There were far too many, so the cast was aborted. Barry redid the electrical termination, but the second cast had the same symptoms. At that point, I suggested that if one one end (the termination at the rosette) was okay, the next place to look is the other end (the slip rings). I'm still not sure whether that was helpful or a wild goose chase. My idea was given some credence when it was realized that the noise quit when the winch was stopped. Barry checked the slip ring on the waterfall winch; it seemed flaky, so he replaced it with one that had a label

> looks like it was hit with an ugly club, but checks out okay

There was no evident improvement in tests on deck, so Barry replaced the slip rings with the ones from the Baltic room winch, which had been working fine. That seemed to help, so the cast went ahead.

The third cast revealed that the problems were not completely fixed. The noise problems continued, but at a reduced level as long as the package was moved relatively slowly. This had us in mind of the problems in P02_2013, which were ultimately caused by a grounding problem. We decided to let the cast continue and let the next shift take over the troubleshooting.

During the cast, another problem arose. Tensions were too high, peaking at about 5400 lbs and maintaining 4500 lbs even without moving the winch even though the depth was insufficient to explain it. It turned out that the metering wheel had come loose from the fair lead. It was put back into place with C-clamps, but the thought is that it was calibrated while loose, so the values are incorrect now that it is back in place.

After the cast, George Aukon and John Calderwood discovered that the resistance between conductor and ground in the cable was 10 MΩ, when it should have been >1 GΩ. In addition, the resistance between signal and ground of a pigtail was 100 MΩ. They redid the termination again, achieving 2 GΩ in the cable and replaced the pigtail. That seemed to fix the communication problem, as station 40 has not suffered any dropped frames as yet.

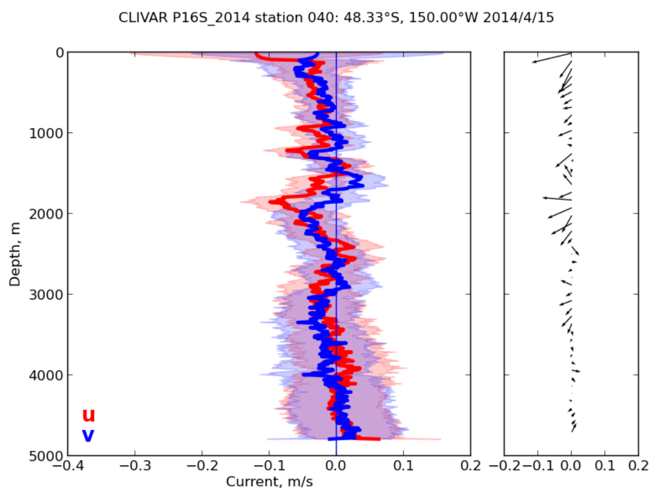
The LDEO processing of this cast has problems. The glitches in the CTD 0.5 s timeseries are bad enough that the synchronizing routines had trouble. There were also odd glitches in the beam performance and data range plots. I don't think it's worth commenting until a cleaner CTD dataset is produced. Courtney plans to get that done sometime soon.

One more odd thing is that the winch operator claimed that the LADCP computer beeped whenever he talked on the radio. I actually heard this 3rd hand, so in a telephone-like situation, I understood that the computer beeped when the CTD was getting bad data. Either way, it seems preposterous. During cast 41, I went up to the winch control room, pushed the button on the battery charger, and asked whether that's the beep he heard. Yes. Still strange. The charger beeps when charging starts and when it switches from constant current to constant voltage mode. The only thing I can think of is that the radio is somehow triggering the battery charger to come on.

A striking feature of the `check_ladcp` plots was how much the package spun during the cast. Counting by hand yielded 92 spins clockwise with 15 counterclockwise spins at the end. Evidence that this is a wire not exposed to high tensions before.

2.40 Station 40: 04/15–16 48°20´S 150°00´W

Errors and Warnings: None.



Depths: MB=5207, CTD=4805, DAB = 11.1
`check_ladcp: zmax=4763, zend=-9`
LDEO max depth=4801 bottom=4804

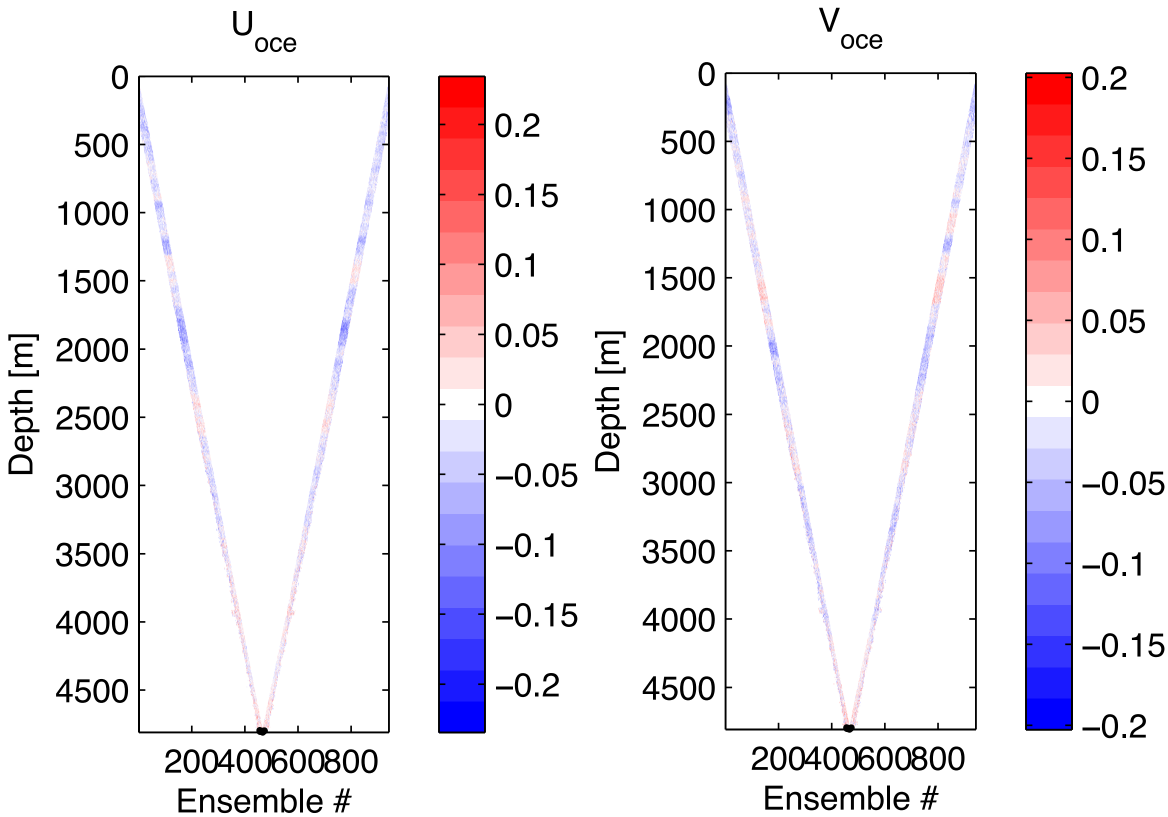
Notes: Much better cast than the last one. This is cast #2 because a NASA deployment went first while the retermination after the last station was being done.

Comments:

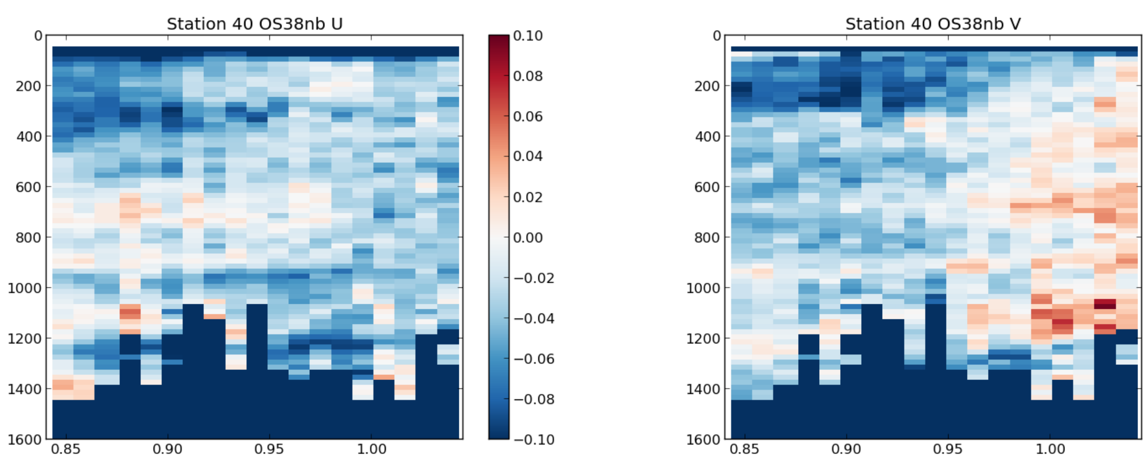
Where did the currents go? We seem to be past the eddy field associated with the sub-Antarctic front.

An odd thing happened when I went up to the aft control room to end the cast and charge the battery. The charger was on, and beeping frantically as each ping drew the voltage down and triggered constant current mode. My thought was that Veronica had forgotten to turn off the charger at the start of the cast, but then I thought of the beeping described in station 39. So maybe she did turn it off and the radio turned it back on.

While looking through the LDEO diagnostics plot, I ran across an odd thing in figure 3. One of the things I look for is that the upcast should look like the downcast–features on one side of the v should be repeated on the other. That was true of the u plot, but there were bands at 900 m and 1200 m in the v on the upcast that wasn't there on the way down.



This had me wondering whether currents really change that fast. Was this a current that changed from S to SW over the three hours between down- and up-casts, or just vagaries in the data? After some struggle, I pulled out some data from the shipboard OS 38 contour.mat files to see whether it showed changes over that period of time.



I'm not really sure how to interpret the results. Features in the u WH150 and OS38 plots seem to agree really well, with a northward current at 700 m and southward at 400 m, 950 m and 1250 m, and the entire column a more southward on the upcast. v is not so clear-cut.

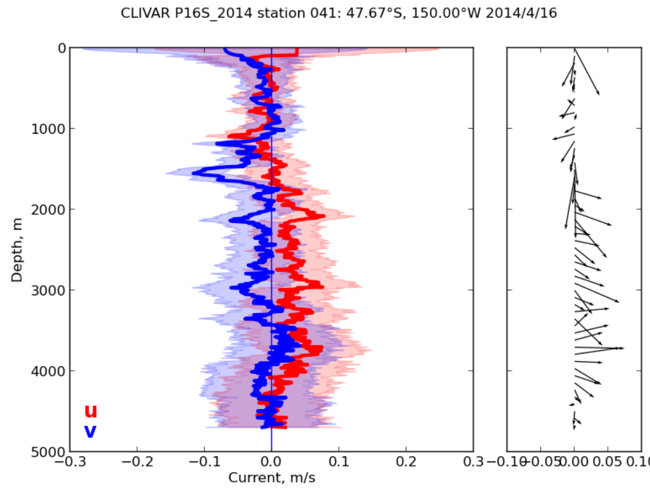
2.41 Station 41: 04/16 47°40´S 150°00´W

Errors and Warnings: None.

Depths: MB=4720, CTD=4711, DAB = 7.4
`check_ladcp: zmax=4658, zend=-61`
LDEO max depth=4707 bottom=4710

Notes:

Comments:



It occurs to me that if the PPI signal is strong enough compared to the water signal, it could be used to establish package velocity up to about a kilometer from the seafloor. Not sure what the criterion should be. PPI amplitude twice that of the water return? This looks like a good cast to explore this on, because the PPI bulges in figure 3 seem to be colored a bit differently then their surroundings.

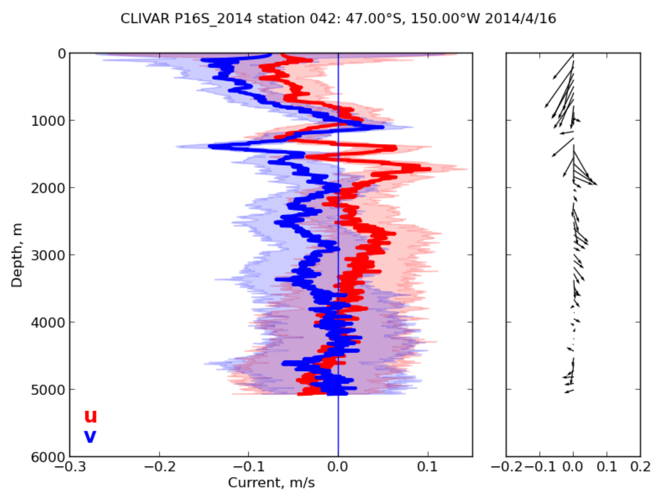
Odd peak in CTD upward velocity, at $>2\,\mathrm{m\,s^{-1}}$.

2.42 Station 42: 04/16 47°00´S 150°00´W

Errors and Warnings: None.

Depths: MB=5104, CTD=5084, DAB = 8.5
`check_ladcp: zmax=5024, zend=-55`
LDEO max depth=4801 bottom=4804

Notes: Much better cast than the last one. This is cast #2 because a NASA deployment went first while the retermination after the last station was being done.



Comments:

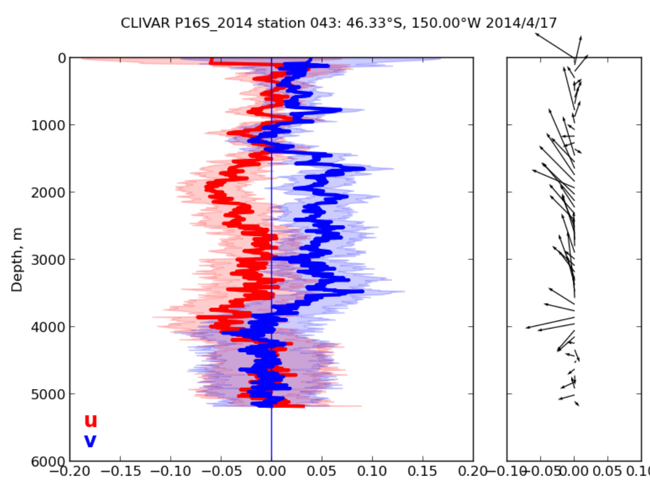
A lot of structure between 1000 m to 2000 m.

2.43 Station 43: 04/17 46°20´S 150°00´W

Errors and Warnings: None.

Depths: MB=5246, CTD=5188, DAB = 10.6
`check_ladcp: zmax=5141, zend=-51`
LDEO max depth=4801 bottom=4804

Notes: Cast 3 since NASA cage and javelin went first.



Comments:

Used this as an example for John Calderwood of how sensitive the map of CTD motion is to the bottom track choice. The RDI-based bottom track analysis had the CTD going well northwest and southeast of the ship. The LDEO bottom track had the CTD stay pretty much northwest of the ship. That seems more consistent with the currents, which were to the northwest through

2.44 Station 44: 04/17 45°40´S 150°00´W

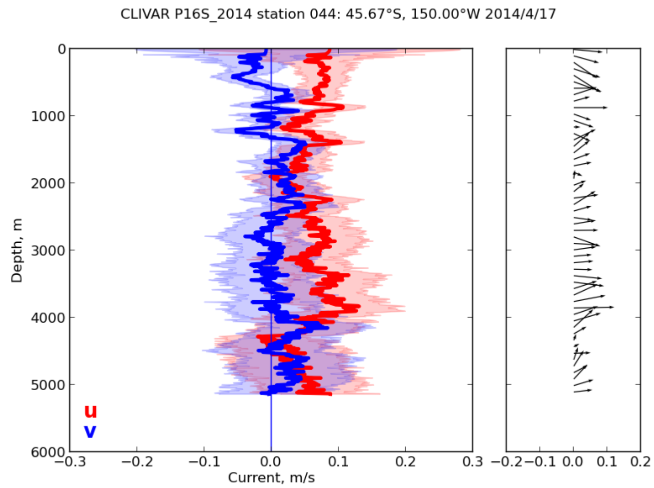
Errors and Warnings: None.

Depths: MB=5162, CTD=5151, DAB = 8.6

`check_ladcp: zmax=5141, zend=-51`

LDEO max depth=4801 bottom=4804

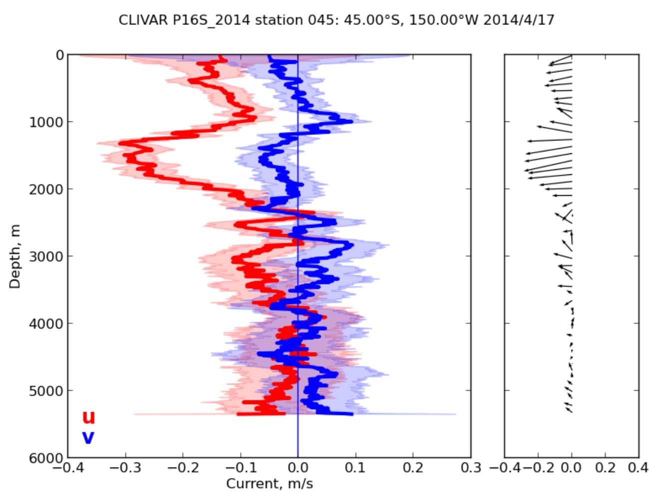
Notes: Much better cast than the last one. This is cast #2 because a NASA deployment went first while the retermination after the last station was being done.

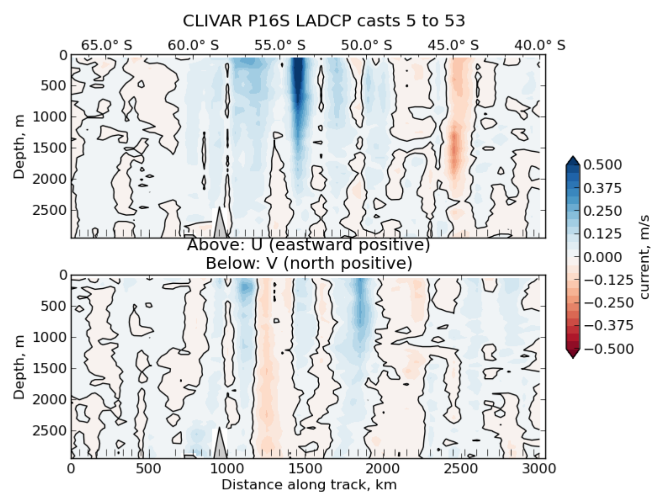


Comments:

It took 10 minutes to set up for the cast. That is, 25 minutes after the bridge gave us a 15 minute warning, the rosette was hoisted on the crane. Not sure whether the MTs waited until bridge reported we were on station before unstrapping the rosette. If so, and not against policy, could save a couple of minutes by unstrapping after ship slows & before fully in position.

2.45 Station 45: 04/17 45°40´S 150°00´W





Errors and Warnings: None.

Depths: MB=5350, CTD=5354, DAB = 9.1

`check_ladcp: zmax=5324, zend=-26`

LDEO max depth=4801 bottom=4804

Notes: Used LDEO bottom track. Just seemed a bit cleaner than the RDI. Both dealt with the bottom okay.

Comments:

Nice westward current centered at about 1500 m. SADCP barely reached it, but agrees. Also little regions of shear from 2000 m to 3000 m seem to be real. Figure 3 in the Matlab processing is a bit deceptive because the u colorscale is so much larger than the v. Shear solution diverges from inversion by roughly $10\,\mathrm{cm\,s^{-1}}$ below 4000 m.

Update 20 April Some excitement about this station. That westward current was the strongest we've seen aside from the ACC (see contour plot above) and in a depth range that also had numerous CTD anomalies. It appears that above 1400 m, water at a given depth had been a bit deeper during station 45, while water below 1400 m came from shallower depths. Essentially, the water layers appeared to have thickened. Notice on the first plot of Figure 4 that all of the lines cross at the same depth, 1420 m. This happened at $\sigma_2 = 36.57\,\mathrm{kg\,m^{-3}}$. When water properties are plotted against σ_2 in the second graph, differences between the casts are very small (except for depth). That indicates that the changes are not due to the introduction of another water mass, but rather the redistribution of water masses already present. There are at least 3 possibilities under consideration as causes:

1. A subsurface eddy, much like the "Meddies" that glurp out of the Straits of Gibralter. These are occasionally found all through the oceans and can give ADCP profiles like that. It is quite possible to fit such an eddy in the 148 km between stations 44 and 46, leaving no indications except at 45. The feature is near the depth of the top of the Antarctic-Pacific Ridge, and there are gaps through which water could flow, perhaps generating eddies. There are a couple of factors that make this seem a bit unlikely. First, eddies like that transport water from one place to another, so we'd expect to find anomalous water masses like Roger Lukas found in an eddy at Station Aloha. Second, eddies have turning flows, so transects through them show striking changes in flow direction. The OS38 sees only the very top of the current, but shows no obvious signs of turning flow. There is a weaker flow near the surface, so Lynne is looking at altimeter data to determine whether there is a surface geostrophic flow.

2. An internal wave generated by flow over the Antarctic-Pacific Ridge. This would be consistent with water masses thickening rather than advecting in. It's also consistent with diagonal features in the SADCP contour plots that are much more visible if you squint a bit. I have no idea whether such a feature would be confined to just a single station, or whether we should see evidence of it in more than one station.

3. It turns out there was a magnitude 5.5 earthquake 5 hours in one of the transverse faults of the Antarctic-Pacific Ridge. If it emitted internal waves of some sort, perhaps we spotted a single feature moving past the P16 line.

Update 28 April I sent the LADCP and CTD data to Andreas Thurnherr to do a vertical velocity calculation. It turns out that there were significant vertical velocities associated with the feature around 1500 m. I'll just quote the email and copy the plots he sent:

> Hi Lynne,
>
> Thanks so much for the plots and discussion. I have calculated vertical velocities for profile #45, again excellent quality — two plots are attached. The first one is the "standard" profile plot, as before. There is clearly much more of a w signal here than in profile #19 throughout the water column. The vertical-velocity levels are not extraordinary by any means. In terms of the feature you are interested in, the layer of strong horizontal velocities coincides with a layer of weak vertical velocities. Above and below the horizontal-velocity core, there are two layers where w is particularly large.
>
> On the scales I can resolve, Instantaneous vertical-velocity profiles in the ocean are mostly dominated by high-frequency (near-N) internal waves. The second attached figure shows

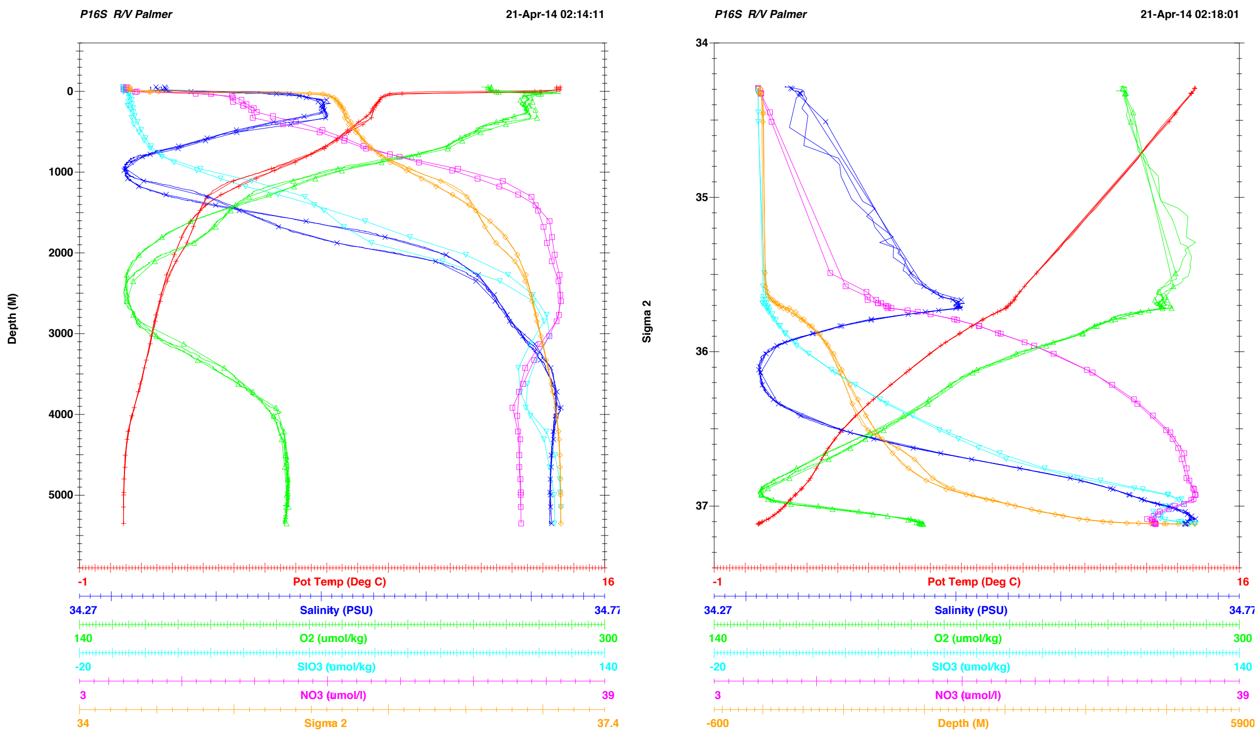


Figure 4: Profiles of bottle data from stations 44 and 45

profiles of rms(w) in 100m bins and buoyancy frequency profiles smoothed over the same scale. The covariation between N and rms(w) is quite striking. I think that the elevation of w above and below the horizontal-velocity core may be related to trapping of high-frequency internal-wave energy in the stratification maximum. As this energy cannot escape, I expect elevated turbulence levels there, and maybe quite low levels in the core of the "feature". To me, the apparent effect on high-frequency internal waves by the "feature" suggests that it has a time scale much longer than the buoyancy time scale, i.e. I suspect that it is subinertial.

Of course, all this is quite speculative.

Cheers

- Andreas

PS: Of course, I'll be happy to process data from additional stations. A great reason not to work on what I should be working on :)

On Apr 25, 2014, at 10:35 PM, Talley, Lynne (Guest) wrote:

Hi Andreas!

(Hi Jonathan, Jen and Jim - copying you on this "interesting" feature. Looking forward to seeing what the chipod shows compared with more "normal" stations.)

Steve has just sent you email about sta 45 with plots from the LADCP - here's another message and a few other plots to accompany it.

We're wondering if you might be willing to squeeze in a few more w profiles? We had a very anomalous event at one station 45 at 45S (coincidental station number and latitude), with isopycnal displacements of 200 to 300 m well down in the thermocline, and an LADCP velocity of > 30 cm/sec at 1200-1800 m. We've been corresponding some with Eric Firing about it. We haven't ruled out either a subthermocline eddy or an internal wave. Now that we have more information beyond the station, it appears that there is a slight property anomaly on the displaced isopycnals so it might not be as pure an internal wave type thing as I initially thought. There is a weak, stationary anticylonic eddy at this location in altimetry. Shipboard ADCP confirms the LADCP structure to the extent that it can (down to 1300 dbar with the os38).

Anyhow, this and its surrounding stations would be an second excellent group to calculate w from - higher excitement value than the basic question of structure of the circulation over the ridge and near the Polar Front although that is still very high on the list.

I'm attaching one pdf with these pages:

Station map with Orsi fronts (sorry, couldn't figure out how to put the station numbers in my gmt script yet, and Orsi fronts are a little odd, but give good general impression of where the SAF and PF are). The red dot at 45S, 150W is station 45. Numbers increase northward, so 44 is just to the south of 45, 46 is to the north. Pink dot on the Pacific-Antarctic Ridge is coincidentally both the location where the Subantarctic Front passes over the ridge crest, and where there was a magnitude 5.5 earthquake early on the same day as station 45. Later on I'll pick off all the fronts I can see from water properties and put on a section. There is a deep salinity front just south of station 44

BV frequency and potential density sections so you can see the displacement

CTD profiles at stations 44-48 - they aren't labeled, but the one that is different in theta, S, oxygen, sigma0 is sta. 45.

LADCP profiles for stations 44,45, 46, 47, 48

SADCP os38 for this region (pay more attention to the time series plot as the contouring on the latitude plot mushes the feature - just included so it's possible to see the latitude range of the westward flow band)

Altimetry for April 17 showing the weak eddy. Downloaded altimetry SSH anomalies from CCAR site for about 4 days before and 2 days after, and this particular eddy barely changes, just weakens a little by April 17, no propagation. I can't access aviso altimetry which would have a mean field added in, so don't have a version of the total flow, guess the mean is small here since we were north of the ACC band. Also small based on SADCP, and surface flows in SADCP are consistent with the eddy in the CCAR SSH anomaly field.

Tonia Capuano has calculated the LADCP/CTD shear-strain diffusivity for all stations (not included), and it is elevated around this feature, and doesn't look like a fluke.

The cruise is going really smoothly now (currently at 31S) - hard to believe how much weather we were battling just 2 weeks ago. Just a little more than a week to go.

A striking thing about the plot is that on the downcast had downward motion through the region, whole the upcast had upward velocities. I had naïvely expected to see $w > 0$ above 1500 m and $w < 0$ below. Lynne said this behavior strongly suggests a wave, with a period comparable to the time of the cast. The second plot bears that out, as a buoyancy frequency of $0.003\,\mathrm{rad\,s^{-1}}$ works out to 35 minutes. She did caution me that an eddy could possibly do the same sort of thing.

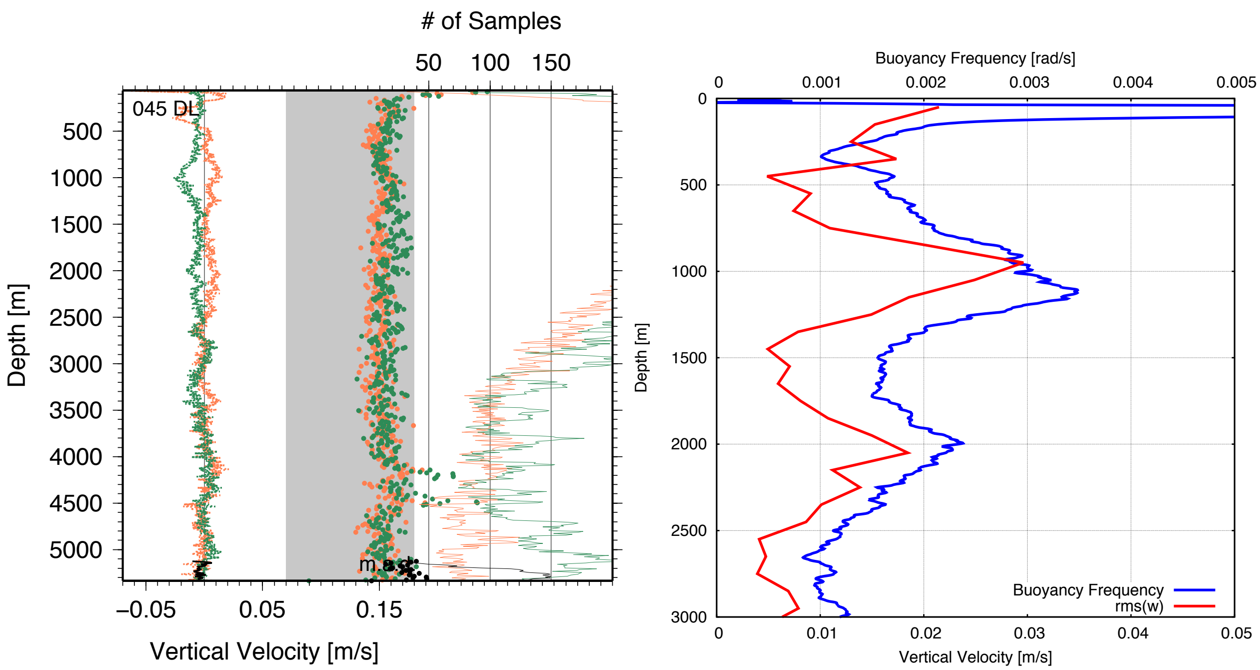


Figure 5: The plots of station 45 w data sent by Andreas Thurnherr. Left plot left panel: w from bottom track (black), down cast (orange), and up cast (green). Center panel: per-bin mean absolute deviations from the median. Right panel: number of samples. Right plot: described in text.

2.46 Station 46: 04/18 44°20´S 150°00´W

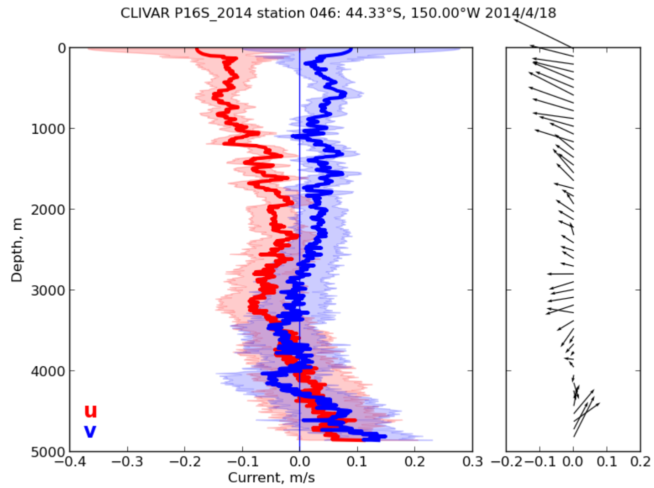
Errors and Warnings: Warning: removed 24 pressure spikes during: 2 scans

Depths: MB=4863, CTD=4864, DAB = 7.8

`check_ladcp: zmax=5141, zend=-51`

LDEO max depth=4801 bottom=4804

Notes: In a hurry, so power cycled the IMP to start it sampling for the cast.



Comments:

Instrument range now well under 200 m below 3 km or so. Below that, shear and inversion start to diverge. If LDEO bottom track can be believed, there is a 15 cm current in the lowest 200 m or so.

2.47 Station 47: 04/18 43°40´S 150°00´W

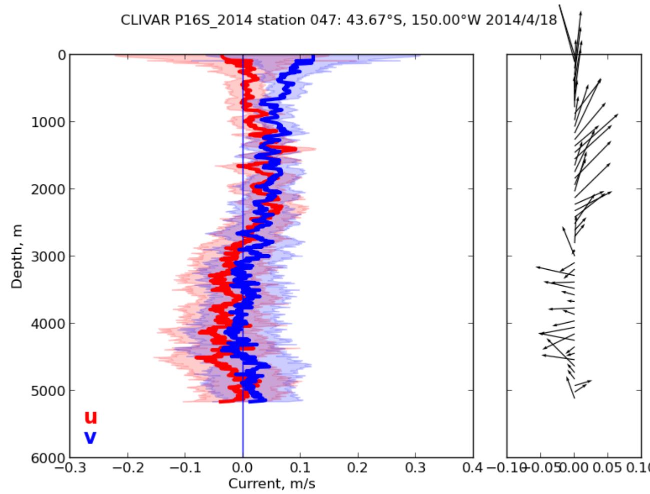
Errors and Warnings: None.

Depths: MB=∼ 5190*, CTD=5181, DAB = 9.3

`check_ladcp: zmax=5125, zend=-11`

LDEO max depth=5177 bottom=5179

Notes: * Bad multibeam depth at time of deepest descent, but about 5190 m over the rest of the cast.



Comments:

Veronica had a hard time connecting to the IMP to kill `IMP_acquire` at the end of the cast. She wound up pulling the plug to cycle power, after which she had no problem connecting. She then killed the new acquisition process. When I downloaded the data, the cast file `20140418_132843` was pretty long, at over 6 hours, but seemed intact. There is also a small file, `20140418_194056` generated after the power cycle before Veronica could kill acquisition.

2.48 Station 48: 04/18–19 43°00´S 150°00´W

Errors and Warnings: Warning: removed 14 pressure spikes during: 2 scans

Depths: MB=5165, CTD=5154, DAB = 8.7

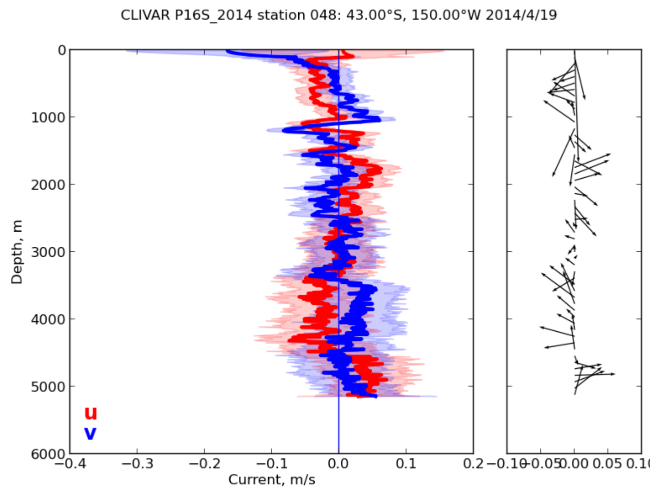
`check_ladcp: zmax=5127, zend=-9`

LDEO max depth=5150 bottom=5163

Notes: This should have been cast 3 as NASA javelin and cage deployments came first. It is cast 3 in the CTD files, but cast 1 in the LADCP file. Not much difference between RDI and LDEO bottom track. Due to a miscommunication, I was the time-limiting factor, so I rebooted the IMP by power cycling.

Comments:

Signal amplitudes are getting smaller. both the 1.2 s and 1.6 s PPI are pretty obvious now, and there is a sprinkling of bins without any data at all. That said, the shear features between 1000 m to 2500 m appear in up and down casts. I wonder about the shear at 4500 m though; it's striking in the inversion u profile but missing from the shear profile. Makes me think its an artifact of the inversion trying to match the bottom track. I tried running without bottom track to check that supposition, with mildly interesting results.



Since Veronica had trouble connecting to the IMP when ending station 47, I followed Andreas' advice from April 13 in the hopes that connecting might become easier. But, I am a bit concerned that it will use more SOB power during transits.

> I am frantically writing Firmware beta2.0, which allows different sensor combinations and has other improvements. One of the things I noticed is that the IMP likes to suspend itself when the WiFi is inactive, which makes it a pain to log in and reboot. If you add the line `options 8192cu rtw_power_mgnt=0` to the file `/etc/modprobe.d/8192cu.conf` the Pi won't fall asleep anymore.
>
> and
>
> What I particularly like about the modified setup is that it allows me to use the symbolic name `Mk3.local` to connect to the IMP, rather than the static IP address. (This also works sometimes with the original setup but the name Mk3.local seems to disappear every time the IMP falls asleep.)

Aside from a few minutes trying to remember elementary vi commands, it went smoothly. I didn't reboot before the cast to test it though. It seems unlikely to help with connecting after a cast though. After all, the Pi isn't asleep; it's sampling at 100 Hz.

2.49 Station 49: 04/19 42°20´S 150°00´W

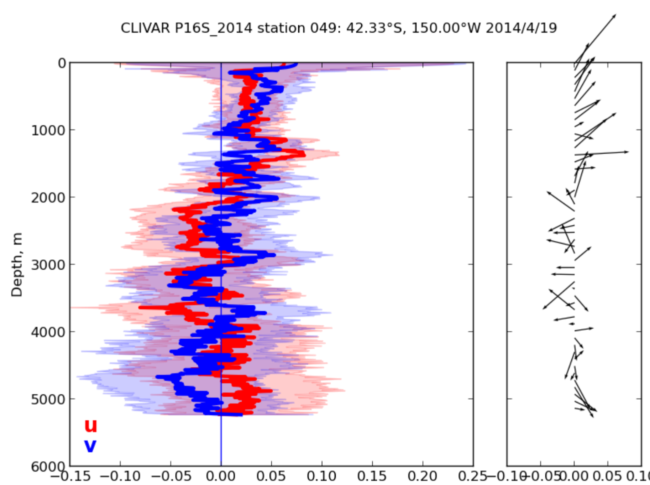
Errors and Warnings: none

Depths: MB=5254, CTD=5249, DAB = 7.2

`check_ladcp: zmax=5197, zend=-28`

LDEO max depth=5245 bottom=5246

Notes: Veronica could not connect to the IMP to shut down sampling. As feared, the anti-sleep modification to the Pi did not help.



Comments:

Very small currents throughout the column. Error range below 3000 m dwarfs the currents.

2.50 Station 50: 04/19 41°40´S 150°00´W

Errors and Warnings: None.

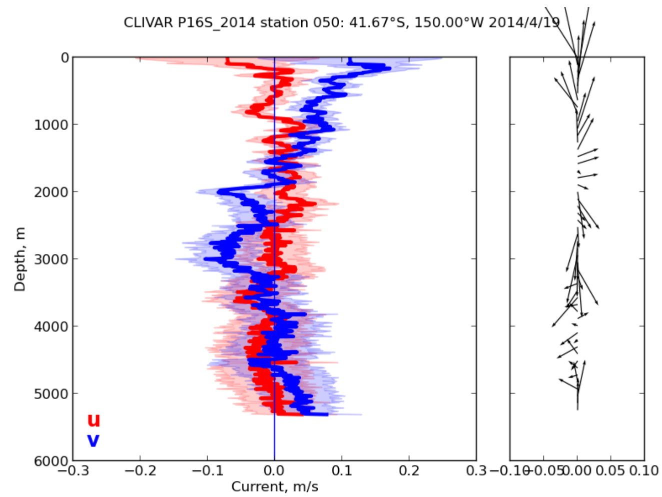
Depths: MB=∼ 5320*, CTD=5320, DAB = 9

`check_ladcp: zmax=5255, zend=-13`

LDEO max depth=5315 bottom=5328

Notes: Lots of divergence between shear and inverse solutions below 3500 m.

* Again, bad multibeam at time of deepest CTD, but ran around 5320 m during cast.



Comments:

Used LDEO bottom track, for no particularly good reason. Currents not quite as small as the last cast, but still minimal. Shear solution diverges from inversion through much of the column.

After Veronica downloaded the data file, `check_ladcp wh050_01.dat` failed. The first few diagnostic lines came out, culminating with

```
    No magnetic declination available; using 0
  Killed
```

before the plot showed up. I had done an rsync while the file was downloading, so though it possible (though unlikely) that the download had fouled up somehow, so I renamed the data file to `wh050_01_bad.dat` and downloaded again. No better. No surprise, since both files on disk and the file on the WH150 were the same size. I rebooted luau and everything was fine. I suspect the problem was with the plotting procedures, but I have no good idea what happened.

Data are getting sparse, with range down to 150 m by 2000 m to 3000 m. By 4500 m, the sum of weights for ocean velocity gets down to 11 (from a peak of 40), and for CTD velocity is 7 (from 28).

2.51 Station 51: 04/20 41°00´S 150°00´W

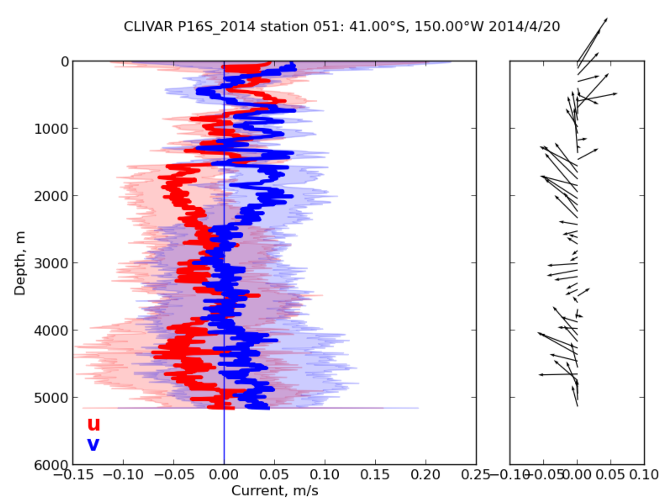
Errors and Warnings: None.

Depths: MB=5162, CTD=5161, DAB = 9.9

`check_ladcp: zmax=5141, zend=-27`

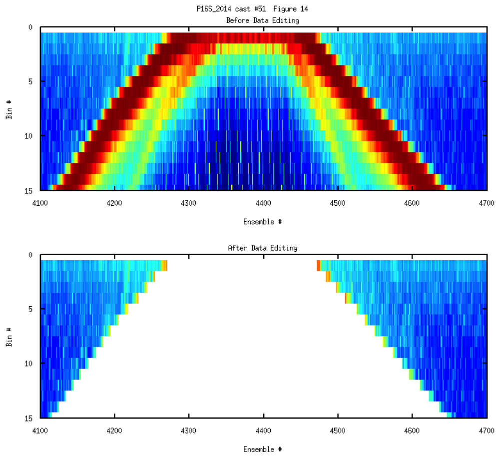
LDEO max depth=5157 bottom=5171

Notes: This was cast 3 as NASA javelin and cage deployments came first. Used the LDEO bottom track, but there appeared to be a little bottom contamination near the top of figure 14.



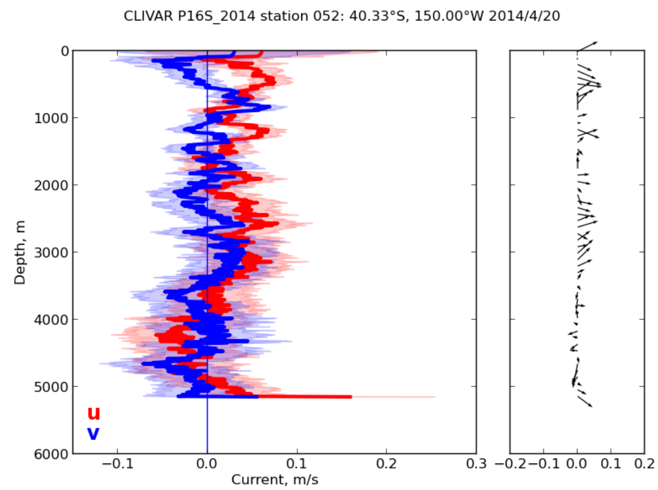
Comments:

Used the LDEO bottom track because it is deeper and less spiky. But, as often occurs, there was a bit of apparent bottom contamination. It's a bit subtle in this case, until you zoom in. Part of the problem may be that the ocean bottom isn't flat.



2.52 Station 52: 04/20 40°20´S 150°00´W

Errors and Warnings: None.



Depths: MB=5173, CTD=5160, DAB = 9.6
`check_ladcp: zmax=5126, zend=-9`
LDEO max depth=5156 bottom=5159

Notes: Uneventful. Used the RDI bottom track for no particular reason. Seems okay.

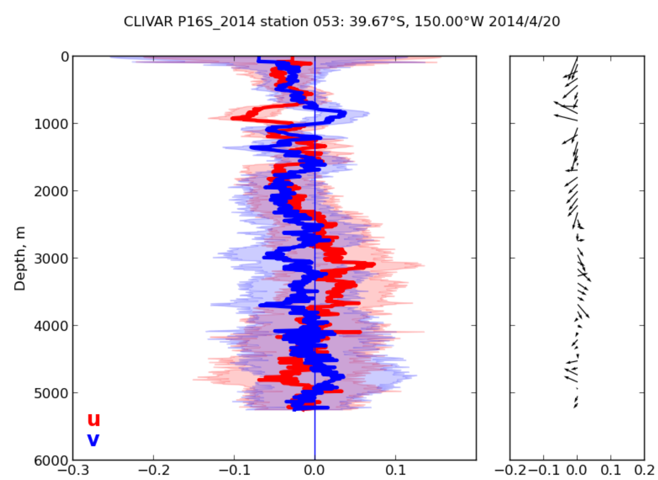
Comments:

Shear profile for u slants from 10 cm/s shallow to −12 cm/s deep, in contrast to the inversion profile, which never exceeds ±5cm/s. I don't think it's my imagination that the PPI artifacts show up at about 4000 m and 4300 m.

Odd strong spike to the ENE at the very bottom of the profile. Not reflected in bottom track. Must be an artifact, but I don't know what caused it.

2.53 Station 53: 04/20 39°40´S 150°00´W

Errors and Warnings: None.



Depths: MB=∼ 5266*, CTD=5259, DAB = 10.1
`check_ladcp: zmax=5201, zend=-40`
LDEO max depth=5255 bottom=5258

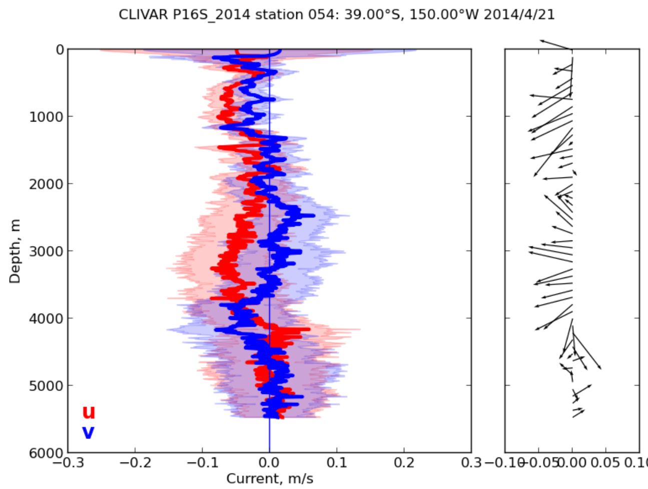
Notes: Winds and seas are up, so launch and recovery were a bit wet.
* Multibeam data messed up by rough seas. 5266 m seems representative of the little decent data.

Comments:

Lots of divergence between shear and inversion, and between up and down casts. Currents are small though.

2.54 Station 54: 04/21 39°00´S 150°00´W

Errors and Warnings: None.



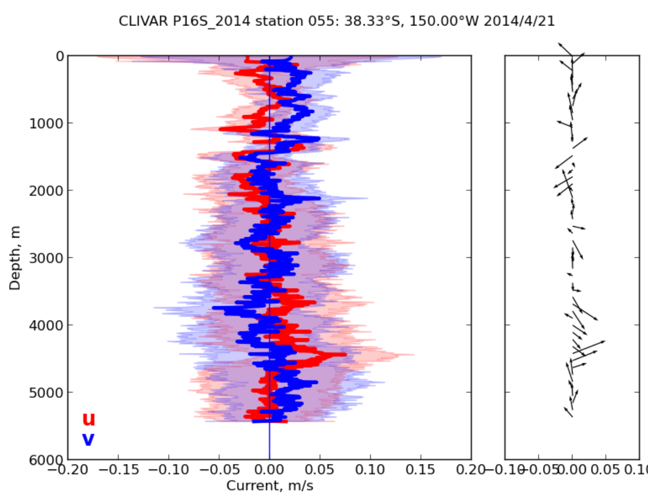
Depths: MB=∼ 5490*, CTD=5482, DAB = 6.9
`check_ladcp: zmax=5425, zend=-24`
LDEO max depth=5157 bottom=5171

Notes: Winds and seas are up, so launch was a bit wet. Could not get out to prepare rosette before getting on station, so I rushed to get ADCP and IMP ready. Power cycled IMP.
* Multibeam data messed up by rough seas. 5490 m seems representative of the little decent data.

Comments:

2.55 Station 55: 04/21 38°20´S 150°00´W

Errors and Warnings: None.



Depths: MB=5456, CTD=5445, DAB = 9.1
`check_ladcp: zmax=5381, zend=-56`
LDEO max depth=5157 bottom=5171

Notes: Fairly uneventful cast.

Comments:

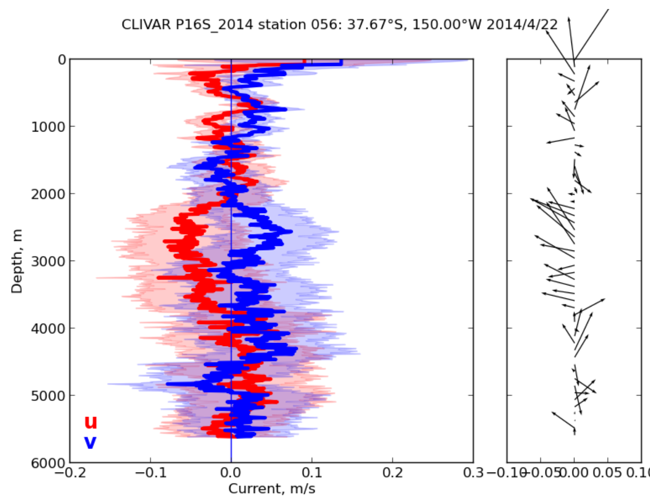
Weak currents, with inversion never getting over 5 mm s^{-1}. Shear solution diverges below 38 900 m.

There was one storm in the S. Pacific north of 40°and it had to be right on top of us. We had to sample station 54 on station rather than steam towards station 55, then had to sample on station during 55 as well. It proved to be a pretty good idea, too. The wind and waves were coming from the east, which is a bit unusual, and deck, which gets wet under normal circumstances, was repeatedly inundated during the transit. Sampling would have been really dangerous.

2.56 Station 56: 04/22 37°40´S 150°00´W

Errors and Warnings: None.

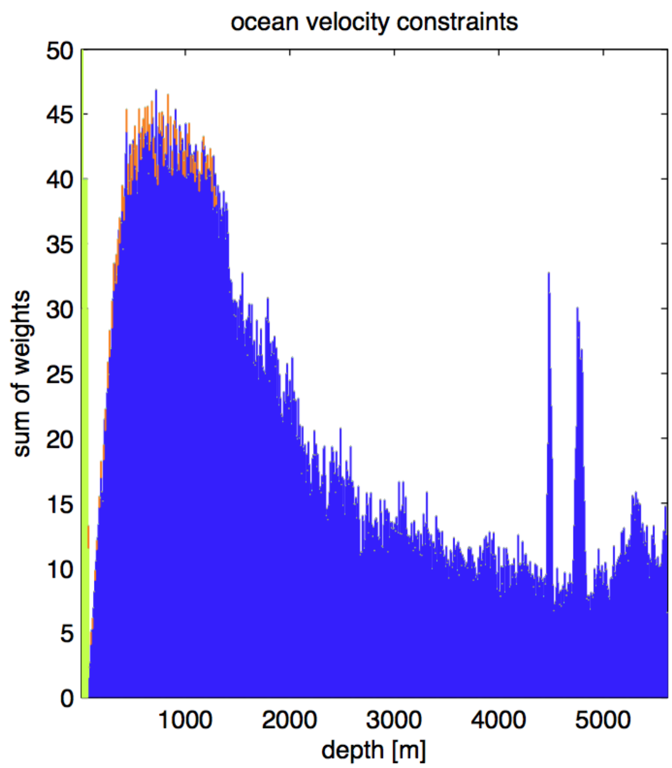


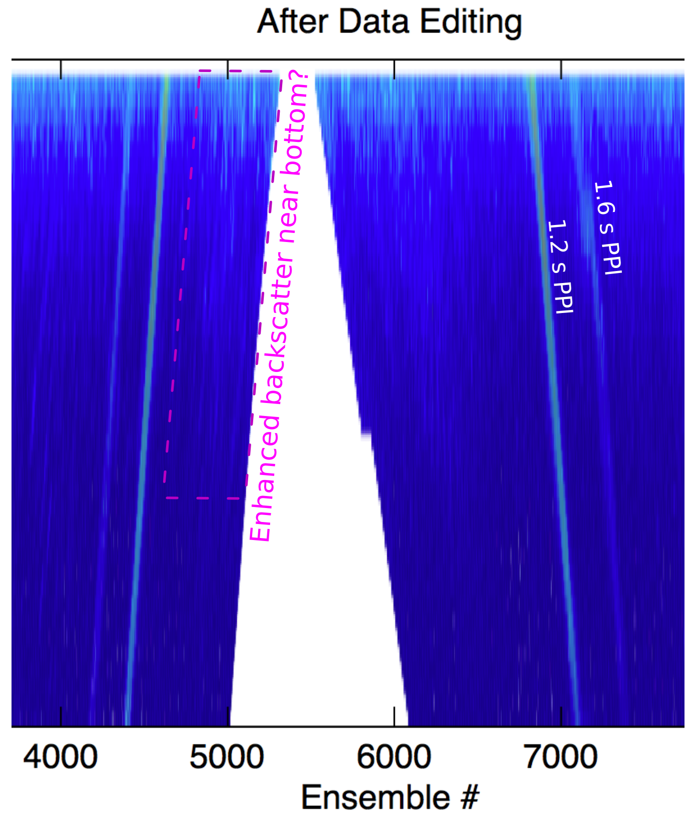
Depths: MB=5636, CTD=5627, DAB = 8.1
`check_ladcp: zmax=5543, zend=-63`
LDEO max depth=5157 bottom=5171

Notes: Winds and seas are up, so launch was a bit wet. Could not get out to prepare rosette before getting on station, so I rushed to get ADCP and IMP ready. Power cycled IMP.
* Multibeam data messed up by rough seas. 5268 m seems representative of the little decent data.

Comments:

As we get to regions with less backscatter,
I'm trying to pay attention to how much decent data there is as a function of depth. Figure 3 is a good indicator; it's getting alarmingly thin at depth. Another is Figure 12, which shows how much data is going into the inversion. I was surprised to see a bilge near the bottom of this cast. Is it real? Just bottom contamination? Looking at the figure 14 plot of signal strength, I see no sign of bottom contamination and it looks like maybe there is a real bulge in scattering down deep.





2.57 Station 57: 04/22 37°00´S 150°00´W

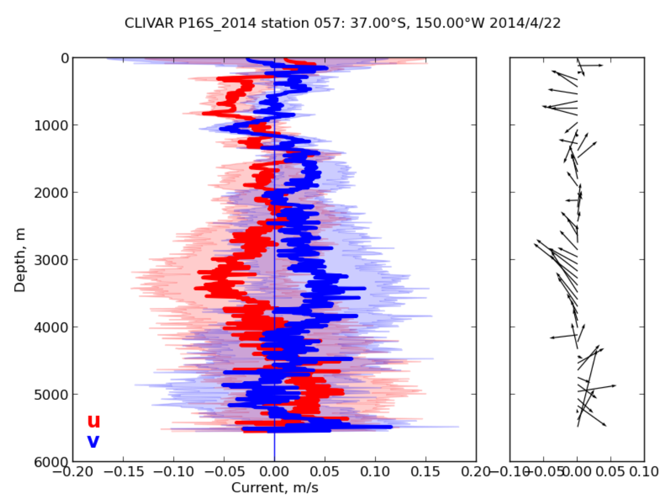
Errors and Warnings: None.

Depths: MB=5929, CTD=5555, DAB = 8.8
`check_ladcp: zmax=5495, zend=-35`
LDEO max depth=5550 bottom=5562

Notes: LDEO bottom track used, because RDI was spiky. LDEO isn't really much better, really spiky, particularly in v.

Comments:

Range while deep still shrinking. Now about 100 m at depth. The figure 12 sum of weights drops to 7 or so at 4600 m. The slightly enhanced signal near the bottom is similar to, but smaller than the last station.

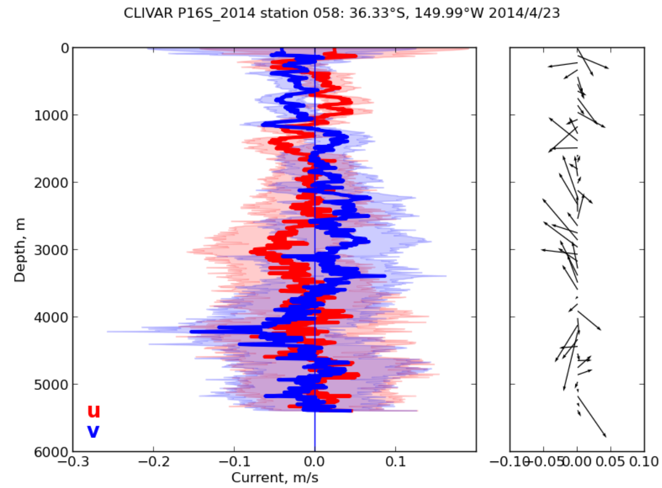


2.58 Station 58: 04/23 36°20´S 150°00´W

Errors and Warnings: None.

Depths: MB=5416*, CTD=5403, DAB = 7.8
`check_ladcp: zmax=5358, zend=-35`
LDEO max depth=5399 bottom=5401

Notes: Nice day! Let the default RDI bottom track remain, although it's short.
* Multibeam data messed up. 5416 m seems representative of the little decent data.



Comments:

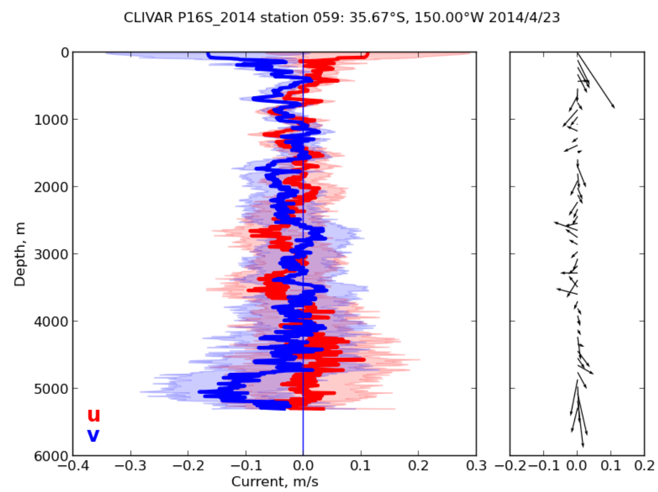
I'm not sure whether the start disbelieving this profile starting at 2000 m or at 3000 m. The quiver profile looks almost random, and there are some spikes in v around 4200 m that seem plainly bad. They are around the 1.6 s PPI depth, so proper editing might help.

2.59 Station 59: 04/23 35°40´S 150°00´W

Errors and Warnings: None.

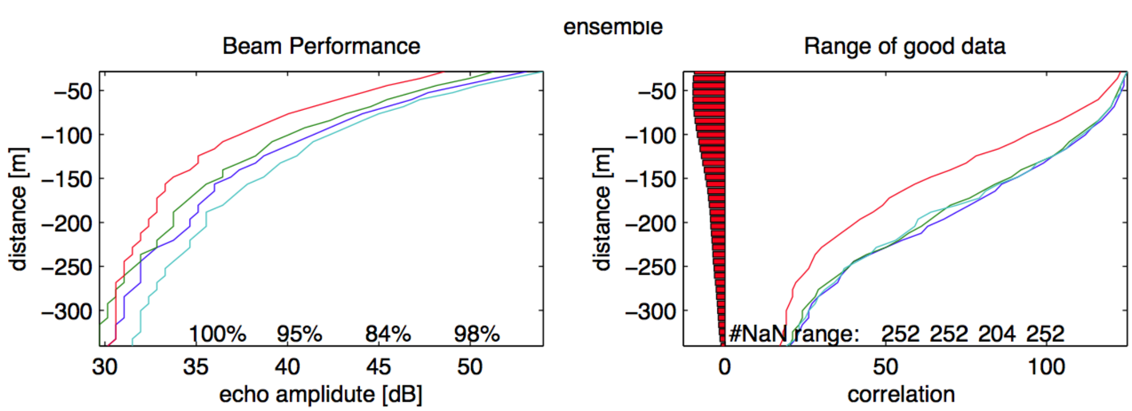
Depths: MB=5317, CTD=5312, DAB = 8.7
`check_ladcp: zmax=5241, zend=-35`
LDEO max depth=5307 bottom=5310

Notes: Nice day!



Comments:

Over the last several casts, I've noticed a pattern of beam 3 being weaker than the others. It's pretty obvious in the bottom plot of figure 2 of the LDEO processing:

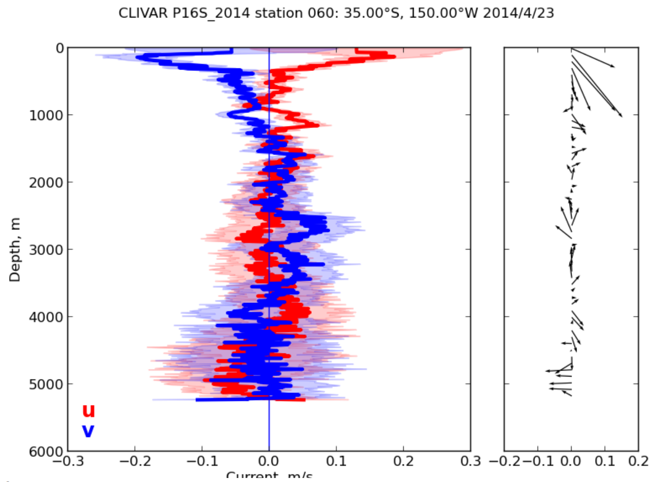


2.60 Station 60: 04/23 35°00´S 150°00´W

Errors and Warnings: None.

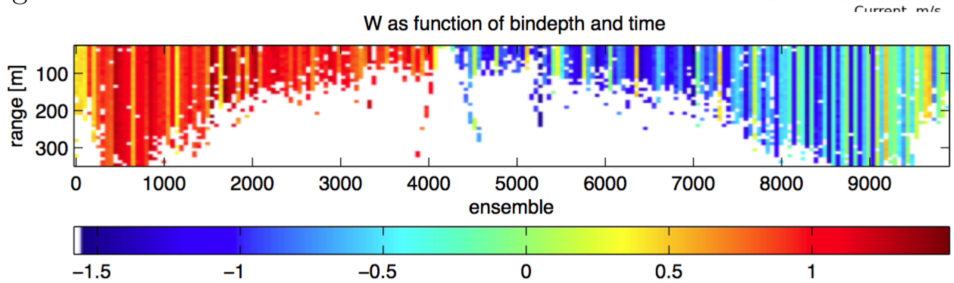
Depths: MB=n/a, CTD=5247, DAB = 9.8
`check_ladcp: zmax=5189, zend=-30`
LDEO max depth=5242 bottom=5346

Notes: Nice day!



Comments:

I think the measurements are now pretty much useless down deep. The range of the instrument is below 100 m. The up and down casts and the shear solutions bear little resemblance to each other below 2500 and don't look too great between 1000 m and 1800 m.

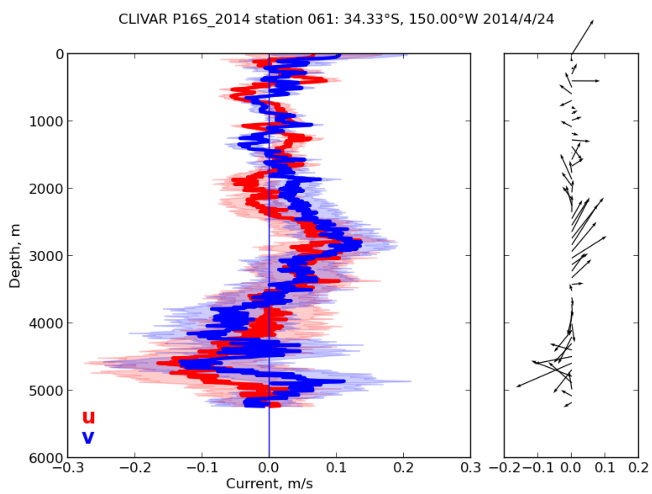


2.61 Station 61: 04/24 34°20´S 150°00´W

Errors and Warnings: None.

Depths: MB=5720*, CTD=5249, DAB = 9.2
`check_ladcp: zmax=5235, zend=4`
LDEO max depth=5245 bottom=5249

Notes: The RDI bottom track worked surprisingly well. Extended up to 150 m from bottom.
* The multibeam depths varied 460 m over the course of the cast, even though the dynamic positioning of the ship held position to within about 10 m. I have a hard time believing that's real.

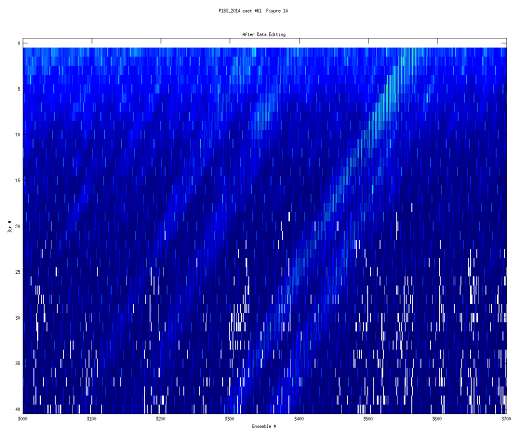


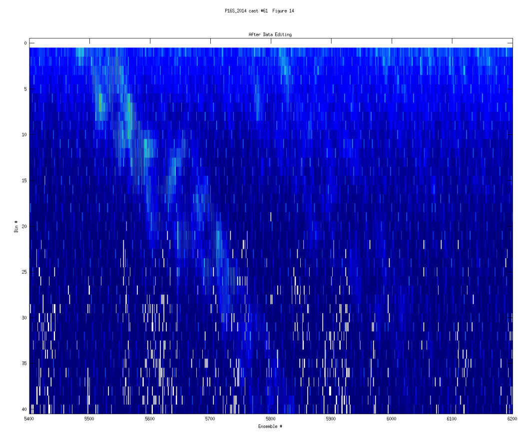
Comments:

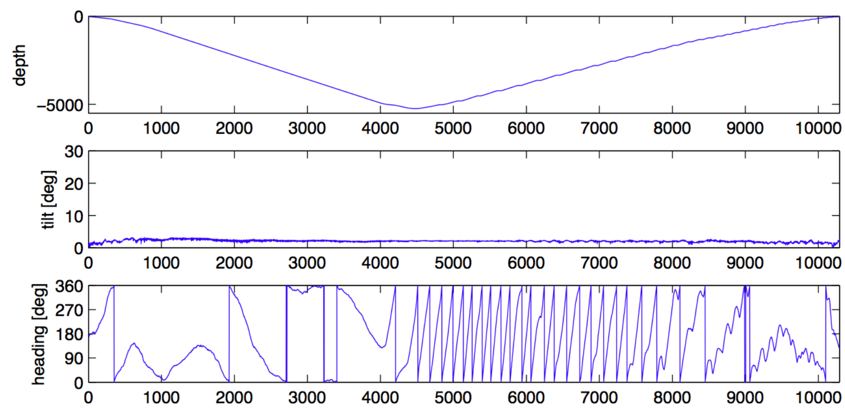
While this cast was down, I dragged out the WH300, the spare battery, the battery charger, a long lab cable, and a Y-cable. I tested the system and everything seemed okay. Plan is to install it tomorrow morning. I'll remove the IMP.

Again, I'm not at all sure the profile means anything below 2500 m, where the various solutions start to diverge a lot.

I was looking at the PPI in figure 14, and noticed that the stripes on the downcast were doubled and narrowed as the instrument descended, while in the upcast the 1.2 s PPI was broad and irregular and the 1.6 s PPI was hard to discern.







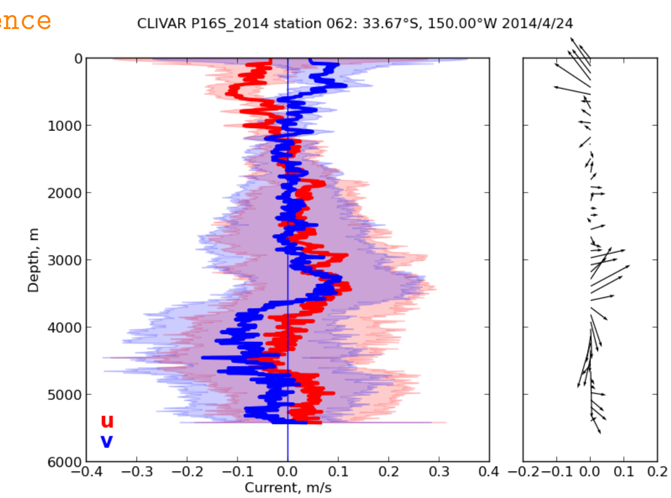
I think the story here is that the bottom is pretty steeply sloped, so individual beams show the bottom at different depths. During the downcast, the LADCP stayed in a pretty constant orientation with respect to the slope. Two of the beams saw one distance, the other two a slightly deeper bottom. On the way up, the package was spinning, mushing the different bottom distances together.

2.62 Station 62: 04/24 33°40´S 150°00´W

Errors and Warnings: `Warning: Increased error because of shear - inverse difference`

Depths: MB=5596, CTD=5425, DAB = 9.2
`check_ladcp: zmax=5338, zend=-82`
LDEO max depth=5420 bottom=5424

Notes: The RDI bottom track wasn't so great this time extending up 125 m from bottom.



Comments:

I've been watching the shear solution diverge from the inversion over the last week or so and was a bit surprised that the warning didn't show up until now. The profile is pretty ugly, with up and down casts and shear solutions completely dissimilar all the way down. It's kind of amusing seeing the inversion solution taking advantage of the 40 m distance from the bottom to the start of the bottom track data to put a giant spike in u right near the bottom. Oddly, that feature doesn't show up in my profile plot though it's plainly visible in LDEO figure 1.

2.63 Station 63: 04/24–25 33°00´S 150°00´W

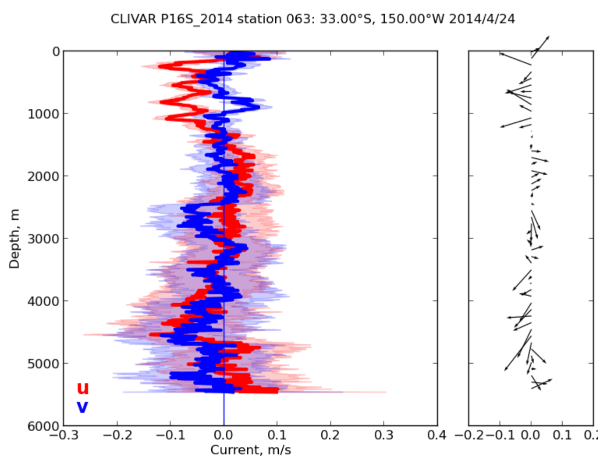
Errors and Warnings: A veritable cascade of warnings. From Figure 11:

```
  warning mean ping rate not equal between both instruments
warning instruments have no fixed ping rate
```

From the log file:

```
WARNING WARNING WARNING WARNING WARNING WARNING WARNING WARNING
warning ping rate not equal in down instrument
 min down ping rate :1.2  max down ping rate :1.6
warning mean ping rate not equal between both instruments
 mean down ping rate :1.4  mean up ping rate :0.58711
warning instruments have no fixed ping rate
 down dt for common ping number:4.5516  up dt :1.91 hours
find best time match of up-looking ADCP to down looking ADCP
up instrument is different by 16199 ensembles
WARNING WARNING WARNING WARNING WARNING WARNING WARNING WARNING
...
**  found  25  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
...
CHECKINV all values are given in [m/s]
Velocity profile error:  0.070  should be about noise:  0.054
```

Depths: MB=5371*, CTD=5461, DAB = 9.3
`check_ladcp: zmax=5305/5220, zend=40/-25`
LDEO max depth=5456 bottom=5470



Notes: First cast with up looking WH300 in addition to down looking WH150. RDI bottom track is really ugly, but LDEO bottom track has obvious bottom contamination.

About all those warnings: The LDEO How-to for LADCP processing states that the two-instrument solution assumes constant ping frequency and that both instruments ping at the same rate. Andreas said that I should expect those warnings, but that as far as he can tell, it causes no particular problems. I don't know whether it actually treats the data properly. It is interesting to see that the WH300 ping period is 0.587 11 s rather than the 5.3 s I programmed. Wonder whether that's a fundamental ping rate limitation or whether processing limits it and I could speed it up by recording fewer bins. It seems not to get useful data beyond 15 bins near the surface and down deep only reaches 1 or 2 bins. I could reduce the number of bins to 10 or 15 to see whether that gets faster pinging.

The warnings about matching times are a bit disturbing. It seems to be trying to match ensembles, which would be reasonable if both instruments were pinging at the same rate. However, all of the figures seem to show timing agreement between the instruments.

* Multibeam data ranged from 5371 m to 5735 m. Probably bogus.

Comments:

Mounted the WH300 in the rosette before this cast. The star cable wasn't long enough to reach the WH300, so I had to use the only 1 m extension cable I have to connect it. That isn't really a problem, except it means that every time I connect and disconnect the lab cables, I'm wearing out the star cable.

Aside from that, installation went fine, except for the rain and my struggles to fit inside and then work within the confines of the rosette while John Calderwood and Veronica Tamsitt helped from the outside. In addition to installing and cabling the WH300, we had to lower a couple of bottles so the caps won't hit the WH300 as they are triggered.

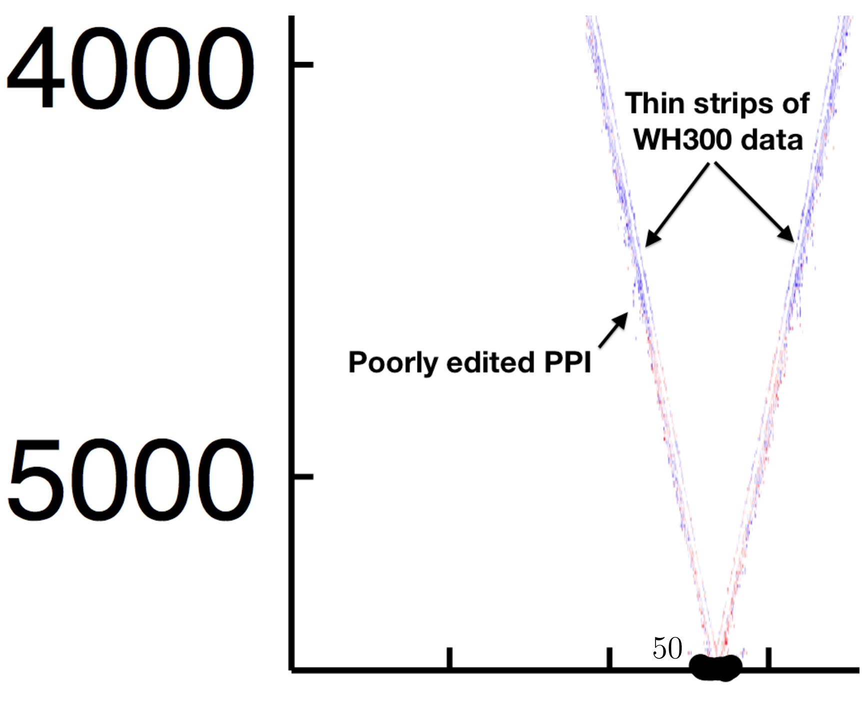
In the lab, I set up the 2-port USB↔RS232 adapter. It worked fine for deployment. I tested the WH300 on its own using staggered pinging at 1.2/1.6 s between pings, then at 0.61 s. Veronica is tall enough to put her ear to the WH300 and hear its pinging and confirmed that it was going. I then tried the master/slave configuration with the WH300 as master, triggering the WH150. Both pinged, but not in the staggered timing I intended. I should explore the actual timing, which is in the files `up999_44.dat` for the WH300 and `dn999_44.dat` for the WH150. I then went to a free-running scheme with the WH300 at 0.61 s and the WH150 in the same configuration as all the casts to this point. That test is in `up999_45.dat` and `dn999_45.dat`.

For the actual deployment, I sped the WH300 to 0.53 s since I wanted a prime number and two 0.61 s cycles comes very close to the 1.2 s period in the WH150. (I have to admit that three 0.53 s cycles comes very close to the 1.6 s WH150 period, but oh, well.)

At the end of the cast, the WH300 had recorded 17.9 MB while the WH150 file was 12.2 MB. Downloading proved to be something of an issue. When I started downloading and the baud rate jumped to 115200, the other simply stopped and I got timeout errors. I downloaded the files one at a time, but that was a bit frustrating. After the downloads finally succeeded, I connected a USB hub to luau and connected the clivar_backup disk and the single port USB↔RS232 adapter I'd been using with the WH150. It came up as `/dev/ttyUSB2` so I modified `wh_dnup.py` to put the WH300 on that port. Then a simultaneous download worked fine.

The results were interesting. Rather than rewriting everything, I'll past in the email I sent to the Firing lab:

I had a long talk with Lynne this afternoon about how trustworthy LADCP data is in this region. It was inspired by the plots I showed her after looking at station 63, the first with the WH300.



In one sense, the WH300 adds pitifully little data. Down deep, it usually gets 1 bin, and sometimes manages 2. The first attached plot shows the extremely narrow addition of the WH300 to the total data at each depth. On the other hand, down deep, even 1 bin is a significant addition to the total. I'm not sure whether the processing actually takes the almost 3X higher ping rate of the WH300 into account.

That little addition of data to the actually changes the profiles quite a bit. The second and third plots show the profile with only the

WH150 and both instruments, respectively. The effect is particularly striking in u, where the biggest excursions are suppressed, but both u and v have much smaller excursions over 100 m vertical scales. I don't think I can conclude that adding the WH300 actually makes the profile useful, but it sure looks better.

While poking around, I also looked at the effect of changing bottom track analyses. The fourth plot is just like the third, but using the LDEO bottom track. There are visible changes up to 1500 m, but most of the difference is in u in the lowest 700 m or so.

One more step: I applied the spike editing in an effort to remove PPI and any effects of one instrument on the other. The only really obvious change is at about 4600 m, the level of the 1.2 s PPI. The filtered version has stronger southwestward currents at that depth and much higher shear immediately below. I'm not sure whether that change is a) real, and became visible as the effects of the stationary bottom were removed or b) are an artifact of the extremely little data left at that depth to constrain the inversion.

So I think Lynne has a better appreciation for how uncertain LADCP data is at those depths, with that tenuous strip of WH300 data making that much difference. We talked some about how to make that more visible to others who want to use the data. She was thinking along the lines of a data flag describing high confidence, medium confidence, and probably worthless data. What can be used as an indicator for that? The two things that have occurred to me are 1) agreement between different profiles calculated from the same data, e.g. the shear solution and up and down casts; and 2) the amount of information available to the solution, whether it be the sum of valid data points at a depth from figure 3 (the first one attached) or the sum of weights on the data, either as an absolute number like 10 or 20, or a ratio to the best depths (if the sum of weights is normalized–I'm not sure exactly how the weights are calculated).

I've included the plot of weights used in constraining the profiles in station 63 and, for contrast, the same plot from station 5 (the southernmost). I don't know how the inversion works, but it sure looks like in station 63, the tolerance for errors in the about 6X as high at 5000 m as it is at 1000 m, while all depths are nearly equally important at station 5.

As mentioned in the caption for Figure 6, I hadn't noticed that the LDEO bottom track is pretty badly contaminated by the bottom. A pity, because the RDI bottom track is really ugly, with dramatic spikes that are completely ridiculous. The LDEO bottom track isn't pretty , but is much better.

2.64 Station 64: 04/25 32°20´S 150°00´W

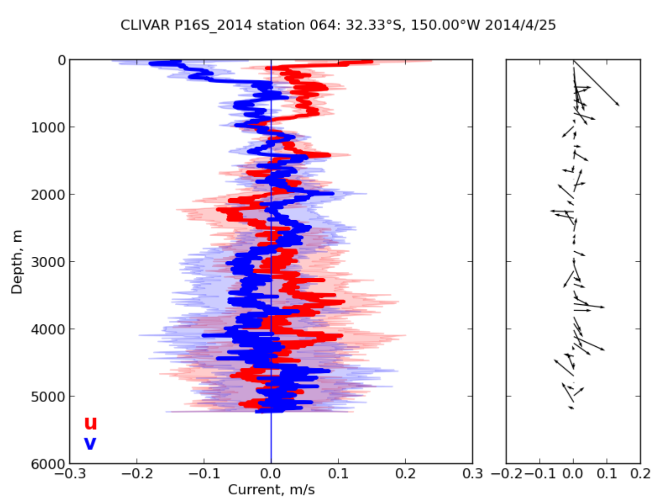
Errors and Warnings: The usual array about ping timing.

Depths: MB=5244, CTD=5237, DAB = 8.0
`check_ladcp: zmax=5099/4996, zend=17/-74`
LDEO max depth=5233 bottom=5234

Notes: RDI bottom track not as hideous as last station. Used it.

Comments:

Pretty similar to the last station, though I didn't test all of the processing combinations. Again, WH300 is pretty tenuous down deep.



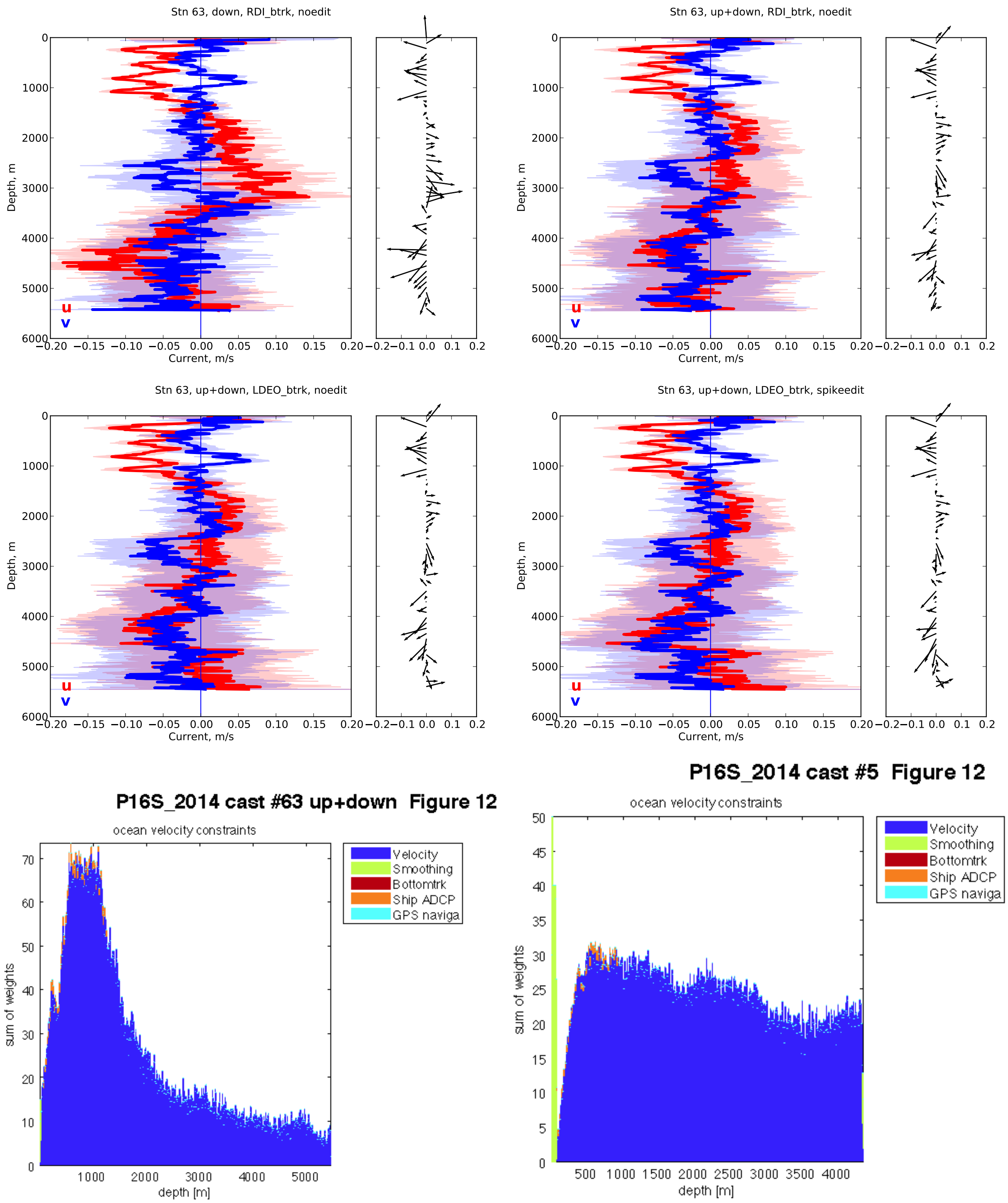


Figure 6: Top left: Profile using WH150 (down looking) only. Top right: add the up-looking WH300 and the profile changes dramatically. Middle left: Switch to LDEO bottom track. Unfortunately, it is pretty badly contaminated by the bottom, which I hadn't noticed earlier. Middle right: effect of adding spike filtering to the LDEO bottom track analysis profile. The chief effect is near the 1.2 s PPI period. The bottom figures are the weights going into the velocity calculations for this station, and, for contrast, station 5.

2.65 Station 65: 04/25 31°40´S 150°00´W

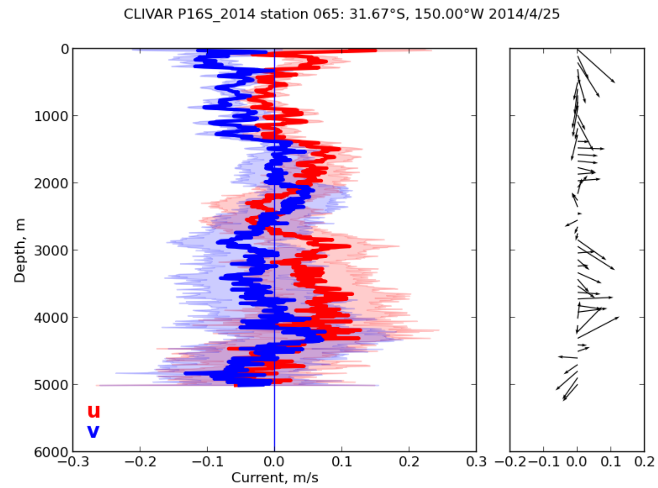
Errors and Warnings: The usual array about ping timing.

Depths: MB=5034, CTD=5019, DAB = 9.7

`check_ladcp: zmax=4902/4795, zend=63/-50`

LDEO max depth=5015 bottom=5018

Notes: RDI bottom track pretty bad. Used it.



Comments:

Figure 14 shows far more acoustic noise in the WH300 signal down deep. I wonder what changed. Possibly in line with the multibeam?

Overall, not too crazy looking.

2.66 Station 66: 04/26 31°00´S 150°00´W

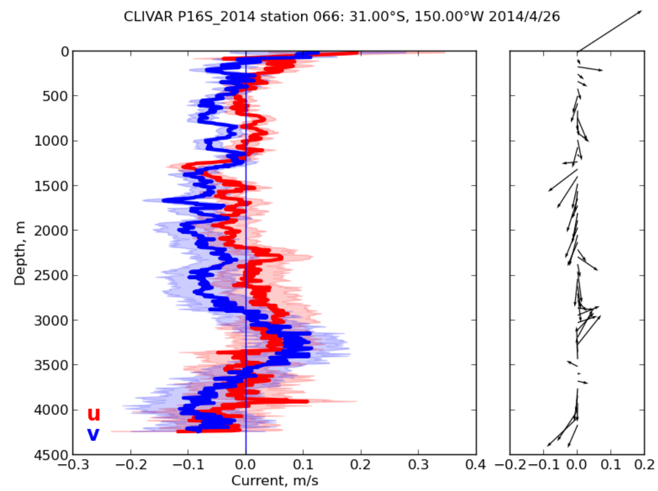
Errors and Warnings: The usual array about ping timing.

Depths: MB=4246, CTD=4250, DAB = 8.6

`check_ladcp: zmax=4162/4127, zend=52/-5`

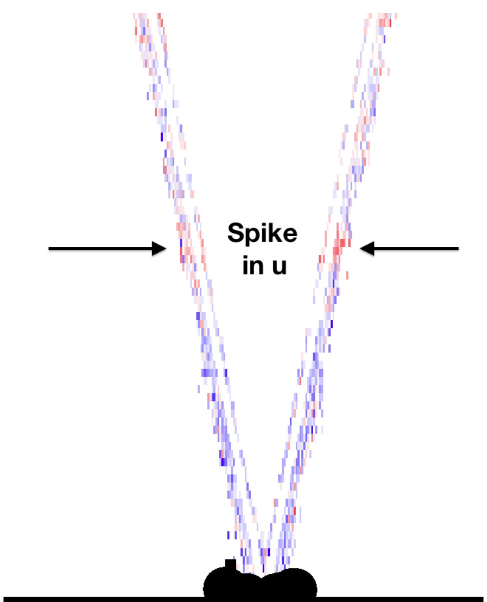
LDEO max depth=4246 bottom=4250

Notes: RDI bottom track not good, but better. Used it. This time WH300 ping period was 0.589 44 s. Not sure what causes the changes.



Comments:

Acoustic noise in WH300 isn't present this time. Strange. Could it be that the package was under the multibeam during cast 65 but not 63, 64, or 66? Seems unlikely.



The really puzzling thing about this cast is that it looks so good. The error range is very small compared with previous stations, and except for an odd spike in u at 3900 m, there aren't very many odd jumps. It's not that there's more scattering or more total weight near the bottom. This is a relatively shallow cast compared to other recent ones. Maybe 4200 m or so is shallow enough that the inversion doesn't can't escape very far from reality. Yeah, right.

Equally oddly, that spike at 3900 m is plainly visible in both instruments on the downcast and upcast. Not many data points, but in unison. Actually, it's stronger in the upcast than the down. Maybe I'll ask whether the χ-pods saw anything interesting there.

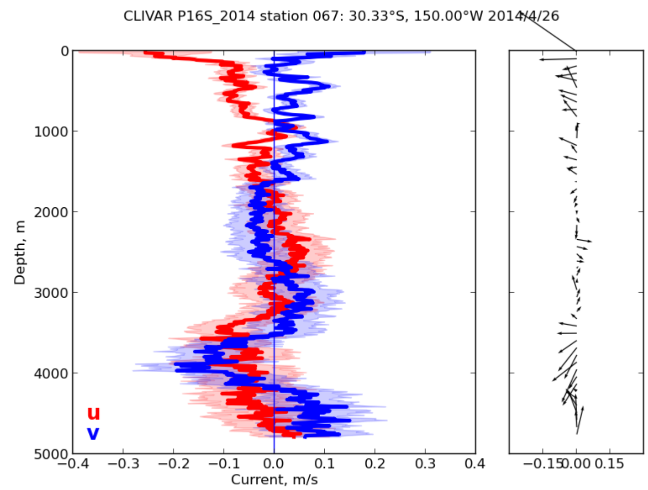
Update 04/27 I mentioned the spike to Lynne, who took it far more seriously than I expected. It turns out that the CTD trace for this cast was interesting, with a stair-step structure in O_2, θ, and salinity (Figure 7). As mentioned above, this was a pretty shallow cast since there was a ridge nearby. Perhaps the topography is preventing circulation or enhancing mixing.

2.67 Station 67: 04/26 30°20´S 150°00´W

Errors and Warnings: Warning: beam 3 weak
Warning: large up/down bias (u=?0.07m/s; v=0.04m/s) ??? GPS problems?
usual array about ping timing.

Depths: MB=4825, CTD=4804, DAB = 9.3
`check_ladcp: zmax=4634/4589, zend=84/-52`
LDEO max depth=4799 bottom=4798

Notes: RDI bottom track pretty good. Used it. This time WH300 ping period was 0.588 82 s. The noise in the WH300 is back.



Comments:

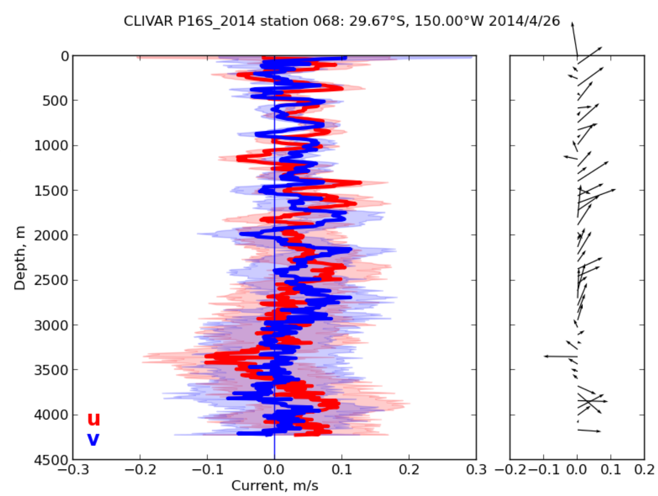
Another remarkably clean cast despite being deeper than the last cast. As Eric predicted, beam 3 continues to deteriorate. Disappointing. The warning about large up/down biases is new to me. Really seems inconsistent with the small error bands. However, there really do seem to be consistent differences in the upcast and downcast solutions. I can't offhand imagine how the GPS can be causing problems. We did not drift far.

2.68 Station 68: 04/26 29°40´S 150°00´W

Errors and Warnings: usual array about ping timing.

Depths: MB=4240, CTD=4235, DAB = 9.3
`check_ladcp: zmax=4146/4088, zend=-14/-8`
LDEO max depth=4231 bottom=4235

Notes: RDI bottom track noisy, not hideous. Used it. I modified the WH300 command file to only look at 10 bins. Reducing it to 5 probably would not compromise the data. This time WH300 ping period was 0.53 s, the value I set. It appears that I'm pinging about as fast as the WH300 can handle. The noise disappeared again.



It was rough enough that no one was allowed out to prepare the rosette before arriving on station. Therefore preparation was rushed and Veronica forgot to erase the previous data files. No harm done, but she was concerned that the data would overfill the memory capacity. I really should alter the checklist to indicate that the total is 256 MB, not 20!

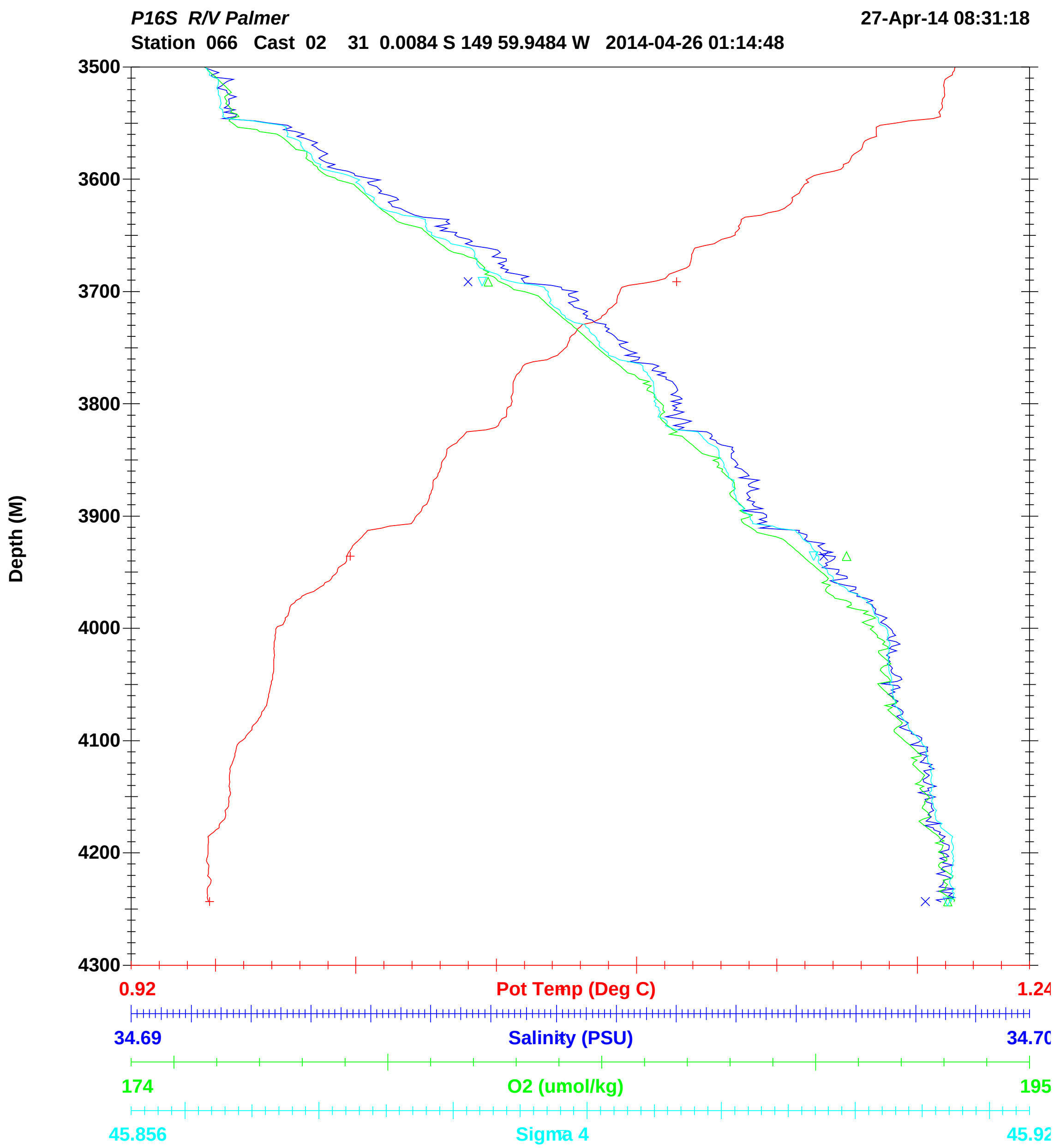
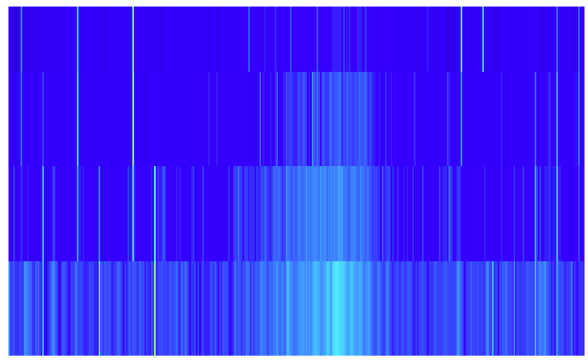


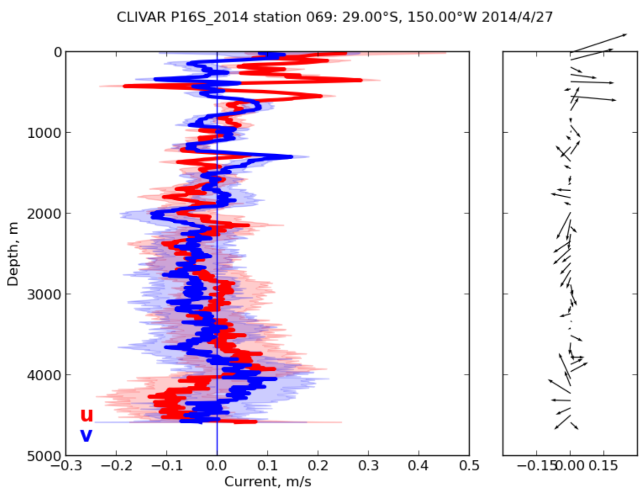
Figure 7: CTD profile at the bottom of cast 66. The odd spike in u seen by the LADCP was at 3900 m.

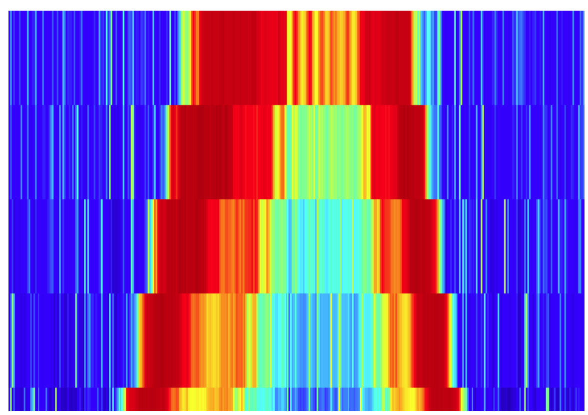
Comments:

Complex current structure through the first 2000 m that seems reasonable. Then amount of data decreases, errors increase, the inversion becomes jittery, and there are features like the westward spike at 3500 m that seem unlikely to be real. Perhaps though, what I should be suspicious of is the spike towards zero in the middle. The overall westerly flow around that depth seems secure, present in figure 3 of the processing in both instruments and both up- and down-casts. The spikes may be from imperfectly filtered PPI, as they seem to be little pink pixels out at the ends of the WH150 range.

2.69 Station 69: 04/27 29°00´S 150°00´W







Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.

```
 removed 84 values because of horizontal speed > 2.5 m/s
**  found  13  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
```

Depths: MB=4602, CTD=4600, DAB = 7.4
`check_ladcp: zmax=4499/4431, zend=51/-14`
LDEO max depth=4231 bottom=4235

Notes: The noise in the WH300 is absent again.

Comments:

The figure on the right is a zoom in of figure 14 (signal strength) near the bottom. The WH300 clearly shows enhanced backscatter between 16 m to 40 m above the bottom, and presumably closer (8 m package elevation + 8 m blanking). That should be visible to the WH150 as well, though I suppose side lobe reflections could spoil it. In any case, I see no sign of the enhancement in the edited data using the RDI bottom track. Looking at the unedited WH300 data in the plot, it does look like the enhanced scattering is there, but it would be pretty difficult to edit out the bottom without eliminating the enhanced scattering in the water. There are never two enhanced bins above the bottom and often there are none. The one enhanced bin may or may not be contaminated by the surface.

I was wondering whether those WH300 points could be anchored by the bottom tracking, but it would be a bit tricky, since the rosette is well within the 16 m blanking interval of the WH150.

2.70 Station 70: 04/27 28°20´S 150°00´W

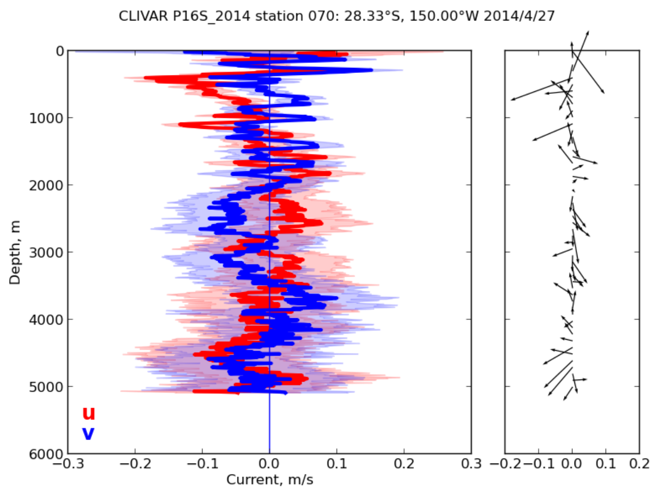
Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.

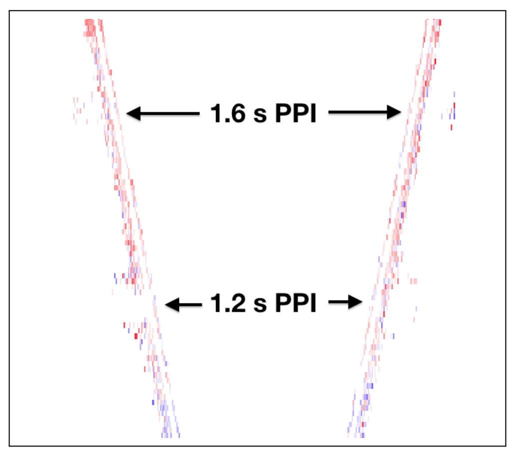
```
 removed 98 values because of horizontal speed > 2.5 m/s
**  found  57  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
```

Depths: MB=5124, CTD=5106, DAB = 8.8

`check_ladcp:  zmax=4904/4821, zend=-28/-24`

LDEO max depth=5101 bottom=5102





Notes: The noise in the WH300 is present.

Comments:

As I found on P02, the spike editing does not handle spikes within PPI regions at all well. This cast seems worse than other recent ones. The plot from processing figure 3 above shows gaps where it appears that decent data (from the other ping delay) has been edited out and points that are clearly PPI that were left in.

2.71 Station 71: 04/27 27°40´S 150°00´W

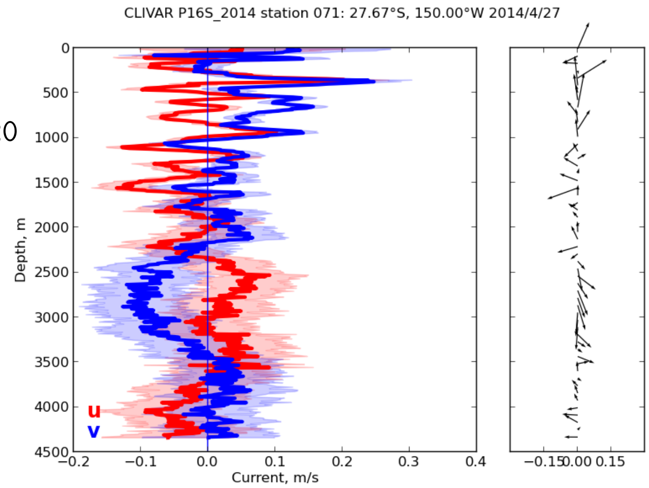
Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.

Depths: MB=4391, CTD=4367, DAB = 9.7

`check_ladcp: zmax=4258/4213, zend=-35/-20`

LDEO max depth=4363 bottom=4350

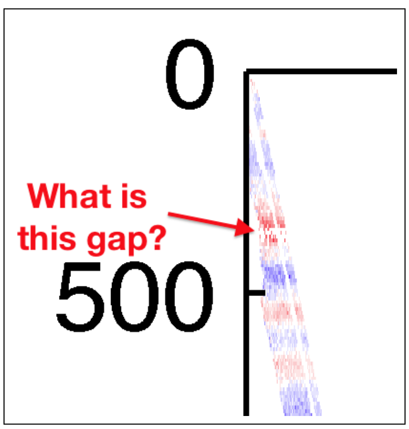
Notes: The noise in the WH300 is absent.

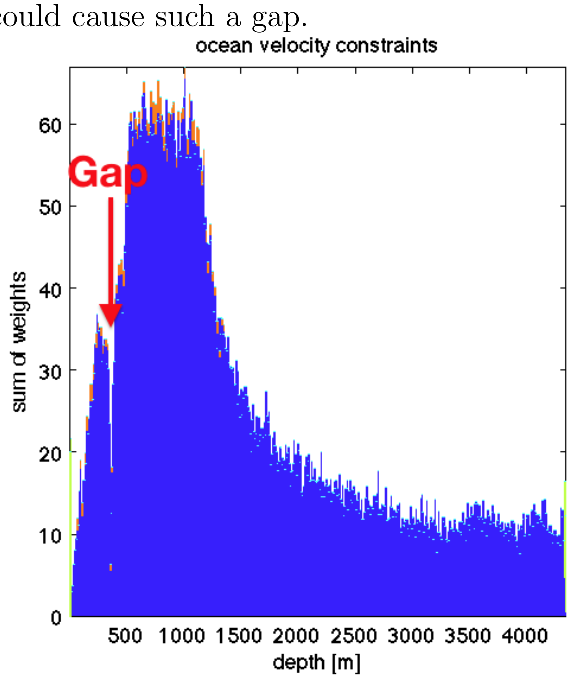


Comments:

Bad editing for this cast. I don't have time to play with it at the moment. The spike filter removed all of the first WH300 bins when close to the bottom. Why? There is also pretty obvious bottom contamination in the edited data. The PPI appears to be poorly filtered. Perhaps it is a very sloped bottom.

But the strangest thing is a data gap at about 350 meters. It shows up both in processing figures 3 and 12. In a sense, it doesn't matter, because the OS38 has that covered. (Though I haven't actually checked for gaps in the OS38 data, the contour plots don't show anything alarming.) I just have trouble imagining what could cause such a gap.





2.72 Station 72: 04/28 27°00´S 150°00´W

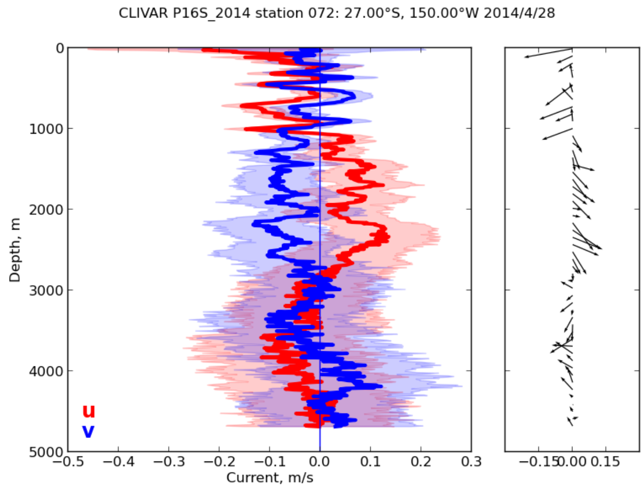
Errors and Warnings: Warning: increased error because of shear—inverse difference. Usual array about ping timing.

Depths: MB=4727, CTD=4704, DAB = 8.8

`check_ladcp: zmax=4627/4497, zend=23/-33`

LDEO max depth=4699 bottom=4702

Notes: The noise in the WH300 started partway through the cast. First cast since adding the WH300 that I've gotten the warning about the divergence between shear and inversion.



Comments:

The editing seems somewhat better this cast, with the fewer PPI point left in and the WH300 near the bottom not removed. The figure 3 colors are so faint though, that it's hard to tell.

The inversion don't become seriously jagged until about 2800 m, but the shear solution in u differs the whole way down; more to the west from the surface to 2800 m, then to the west to the bottom, wandering up to almost 0.3 m s^{-1}. I can't read the plot well enough to tell whether v is much different. Really abominable plot in figure 1! The up and down casts align pretty well though, and the inversion solution never has big currents or shears, so looks plausible. Given the shear solution though, probably can't trust the inversion either.

2.73 Station 73: 04/28 26°20´S 150°00´W

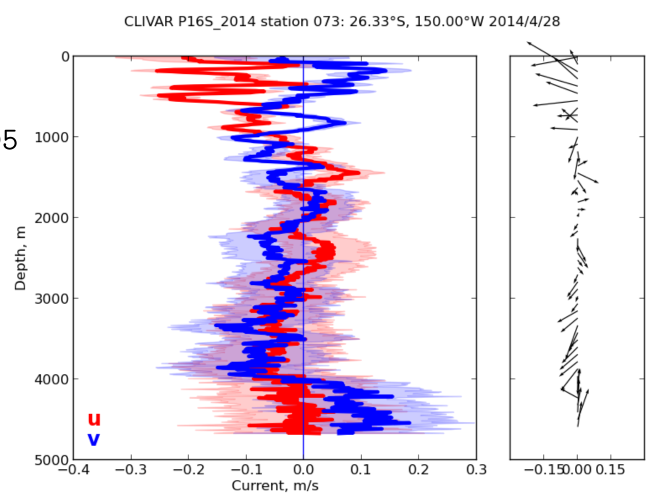
Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.

Depths: MB=4735, CTD=4701, DAB = 9.2

`check_ladcp: zmax=4583/4407, zend=49/-105`

LDEO max depth=4699 bottom=4702

Notes: This time the noise in the WH300 was present at the beginning of the cast then gradually disappeared.



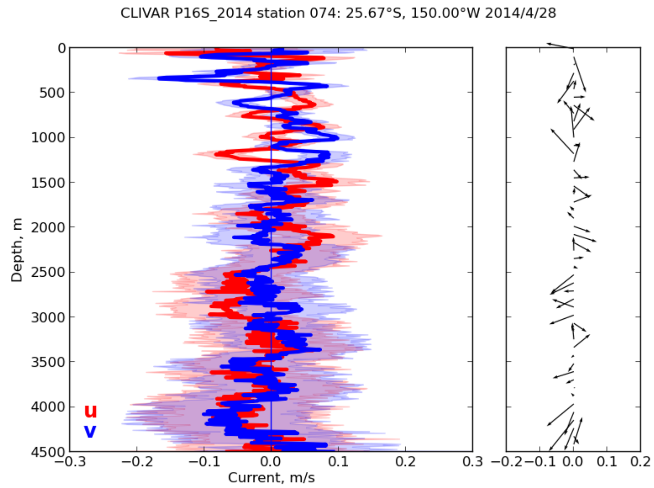
Comments:

Bottom editing not particularly good this time, even with the RDI bottom track. Filtered out some of the enhanced scattering the WH300 saw near the bottom. PPI poorly filtered.

Profile looks reasonable, though I'm not sure whether to believe the northward current below 4000 m. Looks driven by the bottom track, which is pretty noisy. The LDEO bottom track is much smoother, though shows about the same offset and had pretty bad bottom contamination.

2.74 Station 74: 04/28 25°40´S 150°00´W

Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.



Depths: MB=4526*, CTD=4513, DAB = 8.7
`check_ladcp: zmax=4365/4287, zend=16/-13`
LDEO max depth=4510 bottom=4512

Notes: Came after a NASA cage deployment, so cast 2. This time the noise in the WH300 disappeared during latter part of the cast.

* Multibeam depth bad at bottom approach, but was 4526 at launch and recovery.

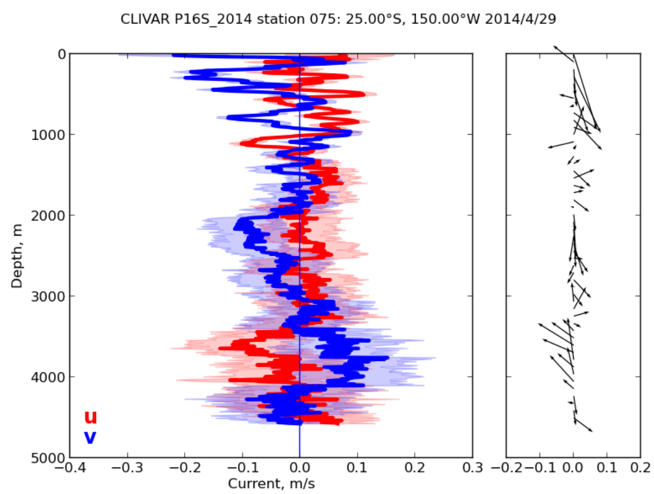
Comments:

Bottom editing better, but PPI editing still weak.

Big errors down deep but plausibly small currents until one gets to the bottom track area, which is a mess with the RDI bottom track.

2.75 Station 75: 04/29 25°00´S 150°00´W

Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.



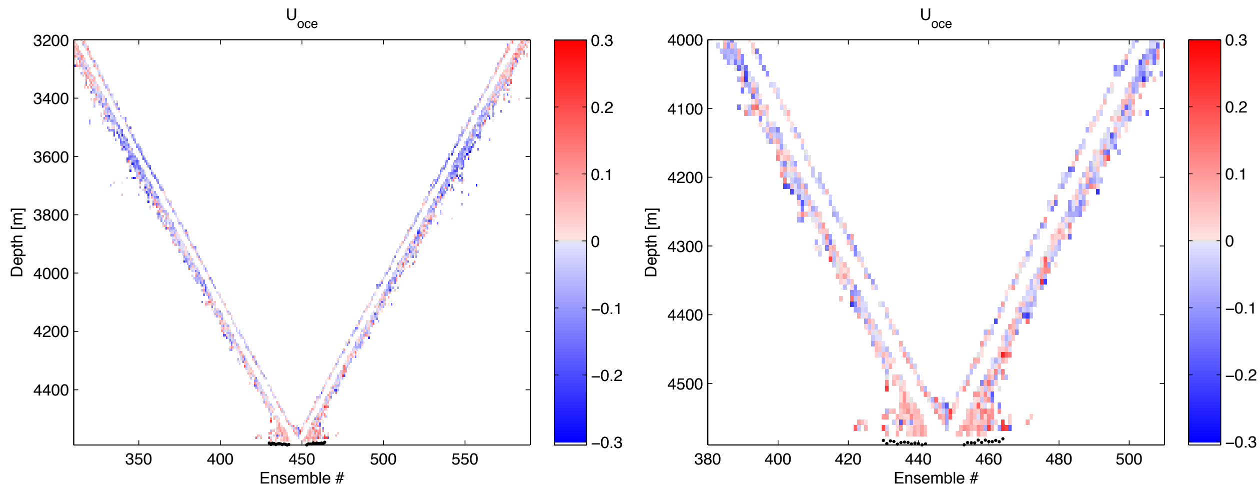
Depths: MB=4599, CTD=4592, DAB = 8.3
`check_ladcp: zmax=4344/4314, zend=23/-24`
LDEO max depth=4587 bottom=4590

Notes: WH mean ping period was 0.531 44 s. Wonder why it was higher than 5.3. Beam 3 is down to 70%. This time the noise in the WH300 disappeared during latter part of the cast.

Comments:

Below around 3300 m the profile gets seriously jinky. Looking at figure 3 of the processing reveals that not only is there not much data, it's noisy. No surprise the inversion looks bad.

The RDI bottom track is jagged, as is pretty common. This time, the enhanced scattering near the bottom was quite visible in figure 14. Nicely done. Below, I've included two zooms on the bottom of the cast from figure 3. The enhanced scattering near the bottom is visible, as is inadequately edited PPI. In addition, the plots are simply more colorful then they ought to be; the colors look almost randomly distributed. Maybe the overall shape can be believed, but I wouldn't count on it.



2.76 Station 76: 04/29 24°20´S 150°00´W

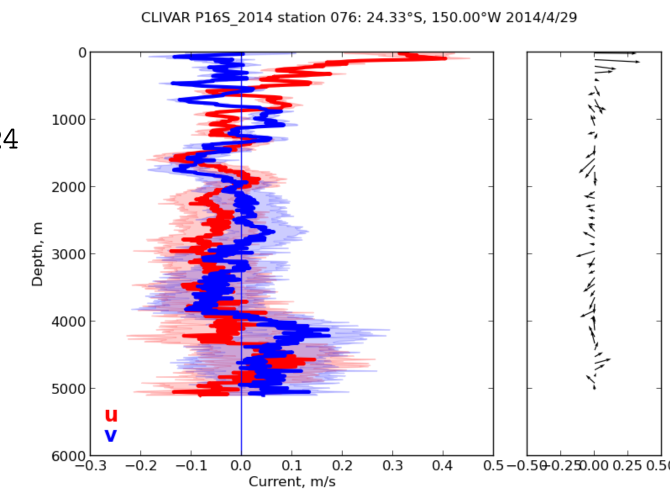
Errors and Warnings: Warning: beam 3 weak. Usual array about ping timing.

Depths: MB=5118, CTD=5110, DAB = 9

`check_ladcp: zmax=4840/4618, zend=23/-24`

LDEO max depth=4840 bottom=4590

Notes: WH300 mean ping period back to 0.53 s. Beam 3 is down to 65%. WH300 noise appears near the end.



Comments:

Deep data really tenuous. Sum of weights down to 5. Nevertheless, the solutions are all pretty close down to 4300 m or so. Not sure how much of the cast can be trusted.

2.77 Station 77: 04/29 23°40´S 150°00´W

Errors and Warnings: Warning: beam 3 weak.

Warning: increased error because of shear - inverse difference

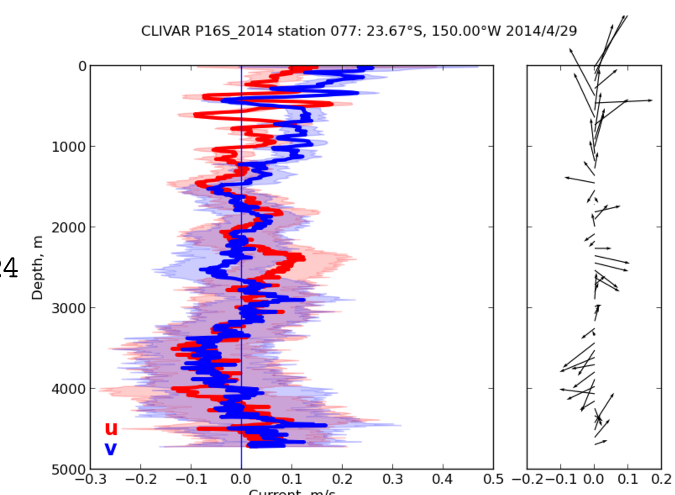
Usual array about ping timing.

Depths: MB=4717*, CTD=4728, DAB = 8.7

`check_ladcp: zmax=4840/4618, zend=23/-24`

LDEO max depth=4840 bottom=4590

Notes: WH300 mean ping period 0.53 s. Beam 3 is at 67%. WH300 noise appears near the end.

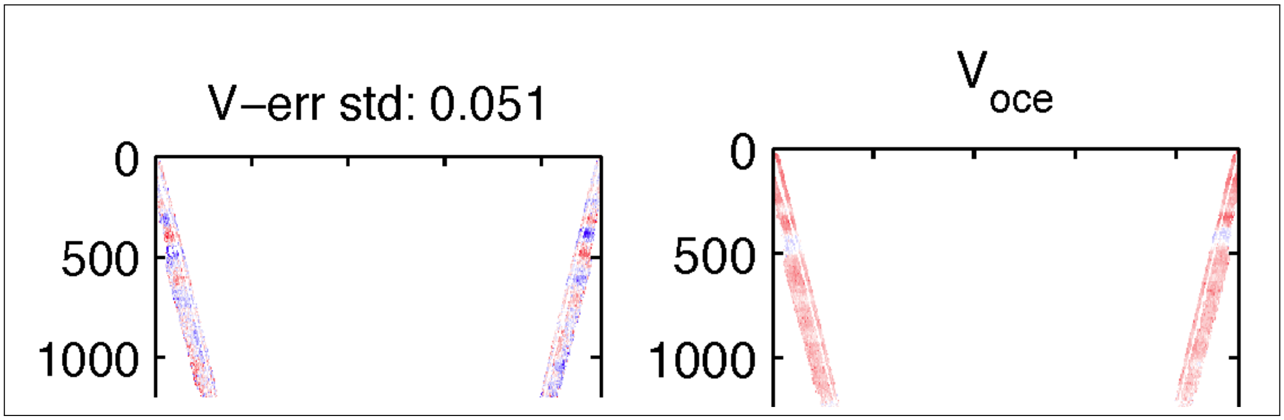


* Multibeam depths at launch and recovery were 4735 m and 4673 m, so either bad data or an uneven bottom.

Comments:

u shear actually not too far from inversion. v disagrees pretty badly though. I rather doubt that means the u can be trusted more. PPI not well edited. (So what else is new?)

After all these stations, it finally occurred to me to think a little about the error plots in processing figure 3. The Howto states that there shouldn't be any really obvious patterns, but that's not what I was seeing. I didn't worry much about it, because the patterns were most noticeable shallow, where the data are good and are backed up by the SADCP. In this case, the error is caused because currents in the upper km change from the beginning to the end of the cast, so the patterns in the error are essentially color-reversed mirror images. That suggests that the superensembles are averages of the the two cast directions, which is what should happen in these circumstances.

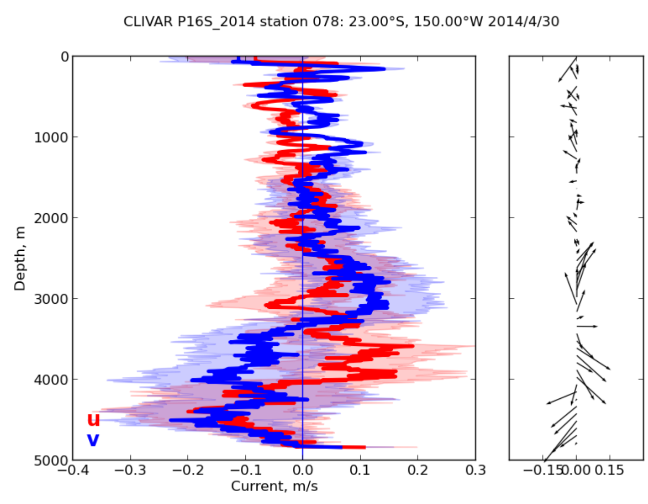


2.78 Station 78: 04/30 23°00´S 150°00´W

Errors and Warnings: Warning: beam 3 weak.
Warning: increased error because of shear - inverse difference

Depths: MB=4854*, CTD=4848, DAB = 8.5
`check_ladcp: zmax=4784, zend=-60`
LDEO max depth=4844 bottom=4847

Notes: WH150 only (downlooking). Beam 3 is at 71%.
* Multibeam depths at range from 4852 m to 5742 m, so probably bad data. 4852 m when rosette exited water.



Comments:

`check_ladcp` for cast 77 failed as it had earlier, just saying "Killed" after spitting out the first 3 lines and grinding a bit. As before, it worked fine after rebooting. As it turned out, I was insufficiently paranoid after the reboot, and did not check communications with the ADCPs. When it was time to start the LADCPs for the cast, the WH150 was fine, but I got nothing but timeout errors when trying to start the WH300. I tried plugging and unplugging RS232 and USB cables, tracking ports with `ls -ltr /dev/tty* | tail`, and using the port tab in `wh_dnup.py`, all to no avail. What I did not do at that point was reboot, as I thought it'd take too long. I ran `ladcp_wh150.py` and sent the package down with only the WH150.

After downloading the data at the end of the cast, I powered down luau, unplugged all USB devices, rebooted, plugged in the 2-port RS232↔USB adapter (`/dev/ttyUSB0` and `/dev/ttyUSB1`), and then plugged in the USB hub with the single-port RS232↔USB adapter and the backup drive. Communications were fine.

The cast was pretty bad, as one would expect, with little agreement between down- and up-cast, shear solution, and inverse. Jagged, improbably large values in the inversion below 2500 m

2.79 Station 79: 04/30 22°20´S 150°00´W

Errors and Warnings: Warning: beam 3 weak.

```
 removed 90 values because of horizontal speed > 2.5 m/s
**  found  46  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
```

Usual array about ping timing.

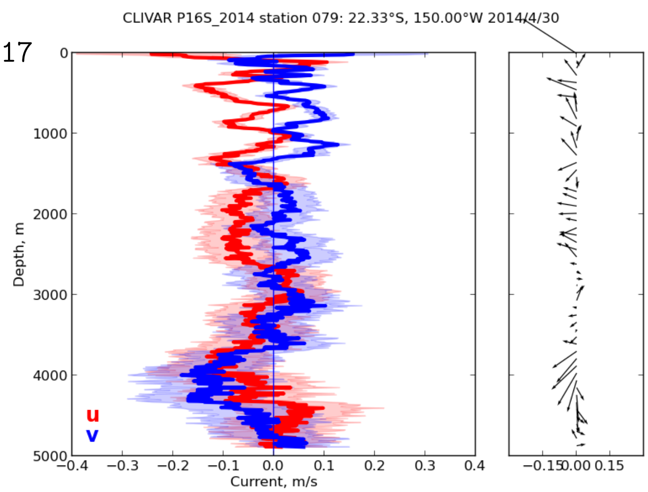
Depths: MB=n/a*, CTD=4904, DAB = 8.5

`check_ladcp: zmax=4657/4570, zend=-56/-117`

LDEO max depth=4899 bottom=4912

Notes: WH300 mean ping period 0.53 s. Beam 3 is at 71%. WH300 noise absent. RDI bottom track failed to edit the bottom out at all.

* Multibeam depths bad at CTD bottom time, and ranged from 4864 m to 5411 m, so not useful.



Comments:

This cast looks much better than the previous one, with all of the solutions pretty close and relatively small reported errors. Still not sure whether deep currents exceeding 15 cm s^{-1} are reasonable. There's also a big shear at 4350 m that looks fishy.

That's a lot of excessively high velocities in the error messages! Probably ought to check out where they are occurring to see whether there are likely to be ambiguity wrap errors in pints that are not edited out.

As mentioned above, the default LDEO analysis using the RDI bottom track pings failed to edit out the bottom at all. I switched to the LDEO bottom track, which did better, but left a fair among of bottom contamination in place. It should have removed 2 or 3 more bins above the bottom.

2.80 Station 80: 04/30 to 05/01 21°40´S 150°00´W

Errors and Warnings: Warning: beam 3 weak (79%)

Usual array about ping timing.

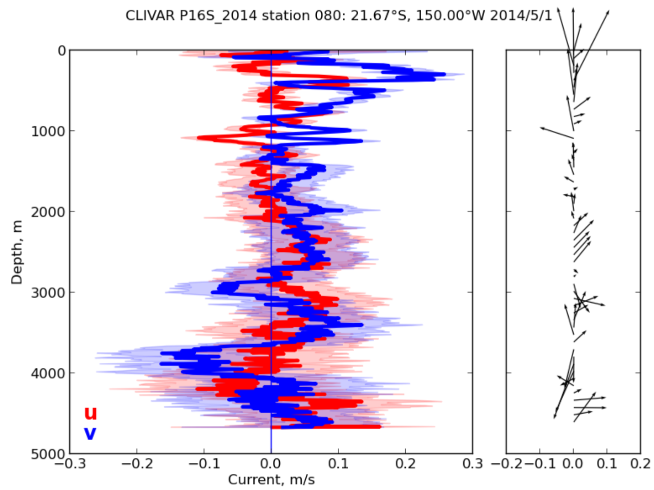
Depths: MB=4691*, CTD=4684, DAB = 10.4

`check_ladcp: zmax=4577/4423, zend=70/-6`

LDEO max depth=4679 bottom=4682

Notes: WH300 noise appears throughout.

* Multibeam depths variable again, but in this case the value at time of CTD max depth was reasonable.



Comments:

Kind of ugly again, with large, jagged currents starting about 2900 m and getting worse below. u shear solution departs markedly from the inversion, particularly near the bottom. The median u error in the upper middle plot of processing figure 3 shows a big kick at the bottom. Sum of weights is down to 5 for many bins (processing figure 12). How much less scattering can there be?

2.81 Station 81: 05/01 21°00´S 150°00´W

Errors and Warnings: Warning: beam 3 weak (77%)

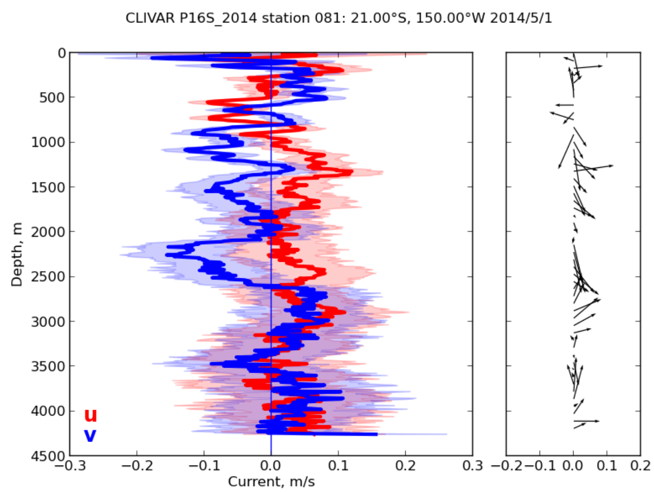
Usual array about ping timing.

Depths: MB=4286, CTD=4271, DAB = 8.0

`check_ladcp: zmax=4198/4091, zend=42/-21`

LDEO max depth=4267 bottom=4270

Notes: WH300 noise absent.



Comments:

The big southward current at 2200 m to 2500 m seems real, though there are some spikes on it that are probably not. I looked through the CTD data to see whether there were anomalies accompanying the current. Subtle, if anything at all. Potential temperature has a slightly steadier gradient than in the surrounding casts. Grasping at straws, I think. Profile pretty jagged below 3500 m, but the different solutions keep together pretty well. There actually seems to be a little better signal this cast. No idea why.

2.82 Station 82: 05/01 20°20´S 150°00´W

Errors and Warnings: Warning: beam 3 weak (78%)

```
 removed 71 values because of horizontal speed > 2.5 m/s
**  found  41  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
```

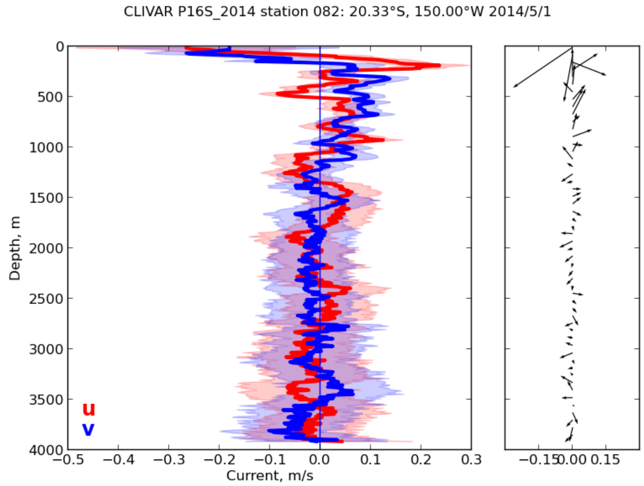
Usual array about ping timing.

Depths: MB=3931, CTD=3935, DAB = 9.2

`check_ladcp: zmax=3902/3807, zend=-5/-56`

LDEO max depth=3931 bottom=3928

Notes: WH300 noise absent.



Comments:

Kind of amusing seeing the CTD deeper than the bottom and the LADCP below the bottom in the LDEO analysis.

Again, the profile looks better, with small currents and pretty good agreement between solutions all the way down. Bottom track is spiky and a bit of a mess. The inversion can put a bit more weight now in the deep water; it's up to about 10 in the deep water. Part of the reason, I suppose, is that the cast is a little shallower than recent ones, but I'm wondering whether the waters are a bit more productive than farther south. Lynne said the lows productivity might be associated with the subtropical front, which is usually around 30°S, so higher productivity here is plausible. There's also an upwelling associated with the ITCZ branch in the SH, but that's usually much farther west, causing the South Equatorial current and the South Equatorial countercurrent, both of which are weaker than their NH counterparts.

2.83 Station 83: 05/01 19°40´S 150°00´W

Errors and Warnings:

```
 removed 53 values because of horizontal speed > 2.5 m/s
**  found  12  horizontal velocities > 3m/s in middle hour of cast
** WARNING  check maximum velocity setting on CMD-file   **
```

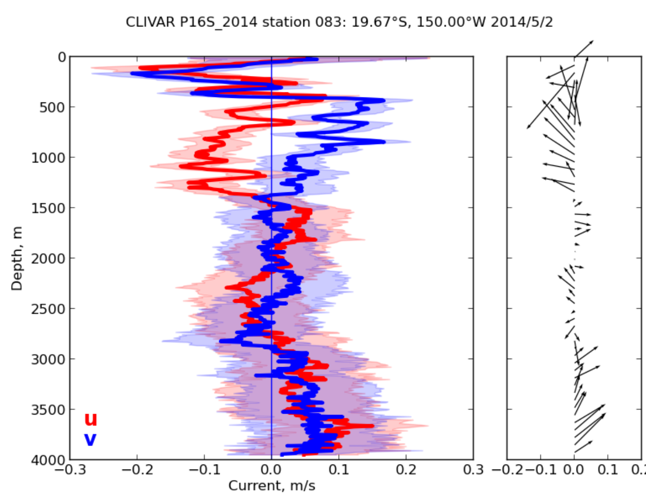
Usual array about ping timing.

Depths: MB=3982, CTD=3950, DAB = 7.7

`check_ladcp: zmax=3903/3847, zend=52/46`

LDEO max depth=3946 bottom=3964

Notes: Big surprise: WH150 beam 3 was at 93%. WH300 noise absent. Used LDEO bottom track, since RDI was spiky.



Comments:

As usual, the LDEO bottom track analysis did not fully eliminate the bottom, but this time only a 1 bin thick set of points should have been edited out.

Again, a pretty nice looking cast, with most of the solutions sticking together. The exception is the u shear solution, which was $5\,\mathrm{cm\,s^{-1}}$ faster between 1500 m and 2500 m, then wandered farther negative below 3500 m.

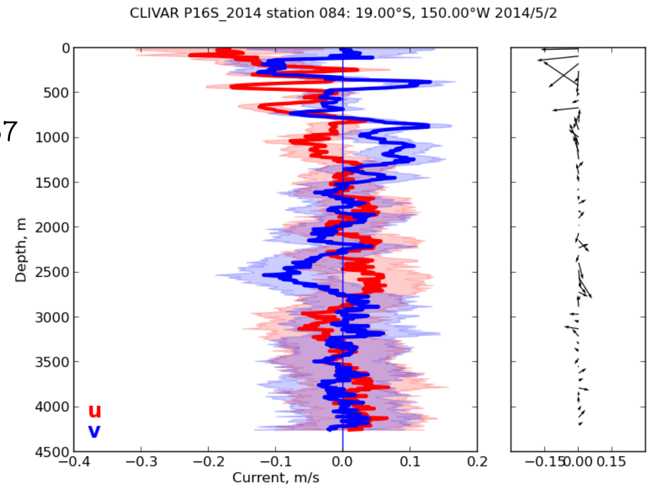
2.84 Station 84: 05/02 19°00´S 150°00´W

Errors and Warnings: Usual array about ping timing.

Depths: MB=4285, CTD=4269, DAB = 7.1

`check_ladcp: zmax=4227/4140, zend=-51/-57`
LDEO max depth=4264 bottom=4279

Notes: WH300 noise present through the cast. Used LDEO bottom track. Beam 3 performance was 87%.



Comments:

Surprisingly ugly cast. Both ADCPs had stronger signals than usual, with more bins at each depth. But processing figure 3 looks more speckled than usual, and the u downcast and shear solutions deviate from the overall inversion below 3200 m, while the v deviate away at about 2900 m. This may be somewhat illusory; more data makes it easier to see speckled red and blue; currents near zero cross from positive to negative more often, enhancing the speckles, and the entire column has pretty small currents, so the autoscaling zooms in a bit, making the deviations look larger.

As usual, the LDEO bottom track left in one too many bins at the bottom. I don't know whether editing those out would help. The RDI bottom track failed to edit out the bottom at all.

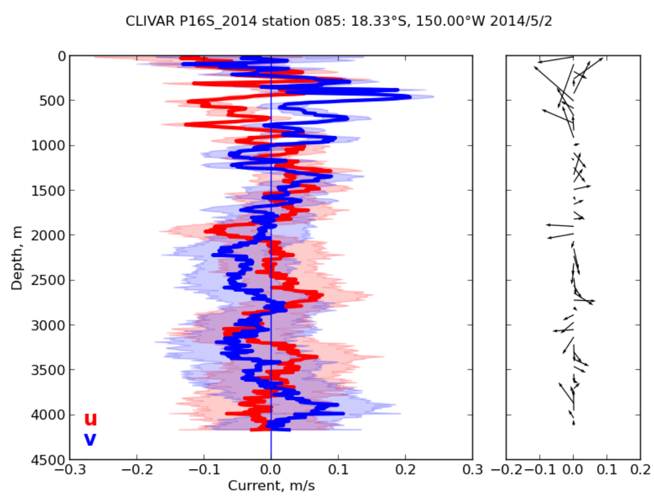
2.85 Station 85: 05/02 18°20´S 150°00´W

Errors and Warnings: Usual array about ping timing.

Depths: MB=4187, CTD=4174, DAB = 10.9

`check_ladcp: zmax=4138/4042, zend=16/-11`
LDEO max depth=4170 bottom=4175

Notes: WH300 noise absent. RDI bottom track worked okay. Beam 3 performance was 85%.



Comments:

Better looking than the last cast. Solutions deviate less from each other. Bottom track a bit ugly, but it doesn't have bottom contamination. Editing could be better, as usual; there are lots of example in the processing figure 3 where an anomalously deep return is a different color than the same depth when the LADCP is closer.

2.86 Station 86: 05/02–3 17°40´S 150°00´W

Errors and Warnings: Usual array about ping timing.

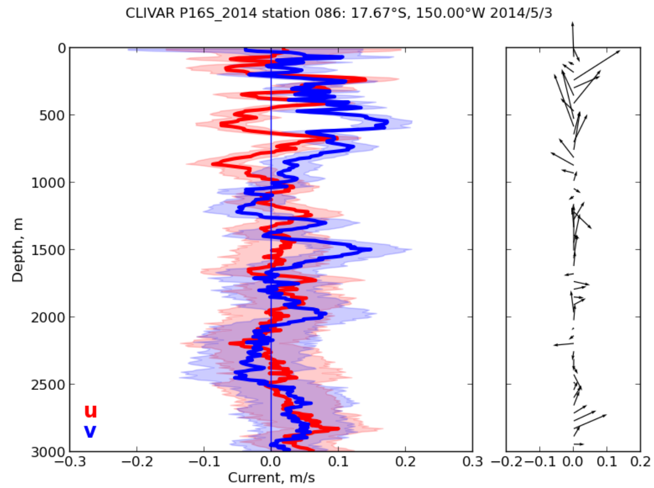
Depths: MB=5632*, CTD=3004, DAB = 9.2

`check_ladcp: zmax=3006/2927, zend=3/-17`

LDEO max depth=3001 bottom=3011

Notes: WH300 noise in first half of cast. RDI bottom track failed, so used LDEO version. Beam 3 performance was 85%.

*The real depth is 3015 m or so, but the multibeam data ranged from 4427 m to 5778 m. It appears entirely absurd.



Comments:

We're very close (10 miles) to Moorea. This is the shallowest cast we'll have in this region.

The profile looks pretty good, except for the u shear solution below 2500 m. It looks like a noisy bottom track is pulling the inversion away.

Scattering is quite enhanced near the bottom, but it does not appear that the LDEO bottom track analysis is actually contaminated by the bottom.

2.87 Station 87: 05/3 17°00´S 150°00´W

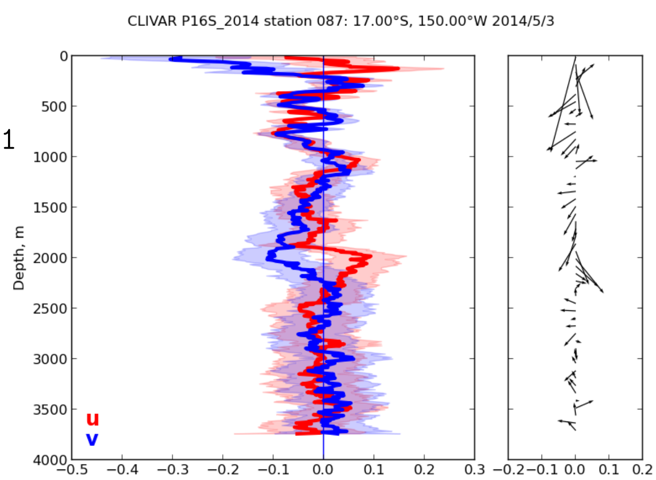
Errors and Warnings: Usual array about ping timing.

Depths: MB=3759, CTD=3749, DAB = 8.8

`check_ladcp: zmax=3738/3627, zend=-45/-41`

LDEO max depth=3745 bottom=3754

Notes: WH300 noise absent. RDI bottom track failed, so used LDEO version. Beam 3 performance was 89%.



Comments:

Wow. Minimal currents. Decent-looking profile though, all solutions agreeing all the way down.

2.88 Station 88: 05/03 16°20´S 150°00´W

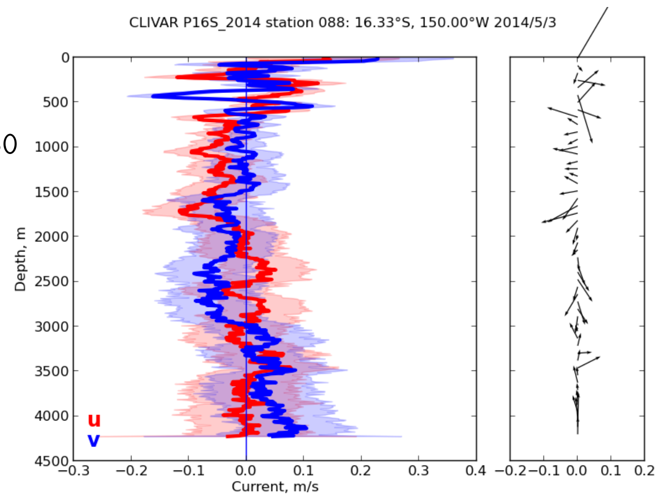
Errors and Warnings: Warning: beam 3 weak (78%)Usual array about ping timing.

Depths: MB=4251, CTD=4239, DAB = 9.0

`check_ladcp: zmax=4158/4087, zend=-77/-50`

LDEO max depth=3001 bottom=3011

Notes: WH300 noise in first half of cast. RDI bottom track okay. Bottom contact switch removed before this cast. Shouldn't actually make any difference.



Comments:

Another pretty good-looking profile, though with exceedingly small currents. A bit of deviation between solutions below 3500 m.

2.89 Station 89: 05/03–4 15°40´S 150°00´W

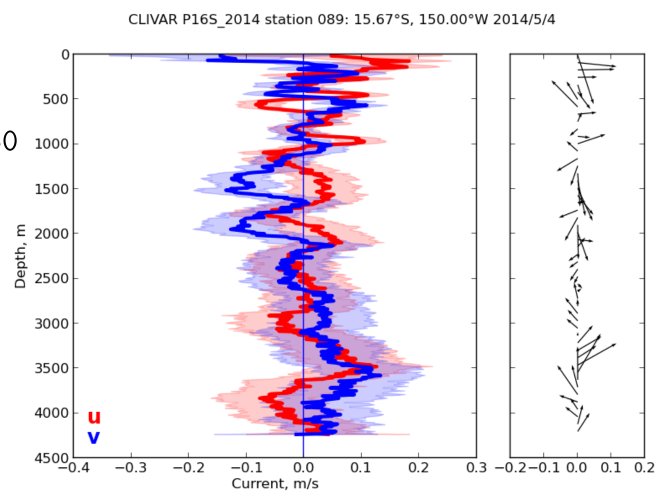
Errors and Warnings: Usual array about ping timing.

Depths: MB=4261, CTD=4246, DAB = 8.9

`check_ladcp: zmax=4158/4087, zend=-77/-50`

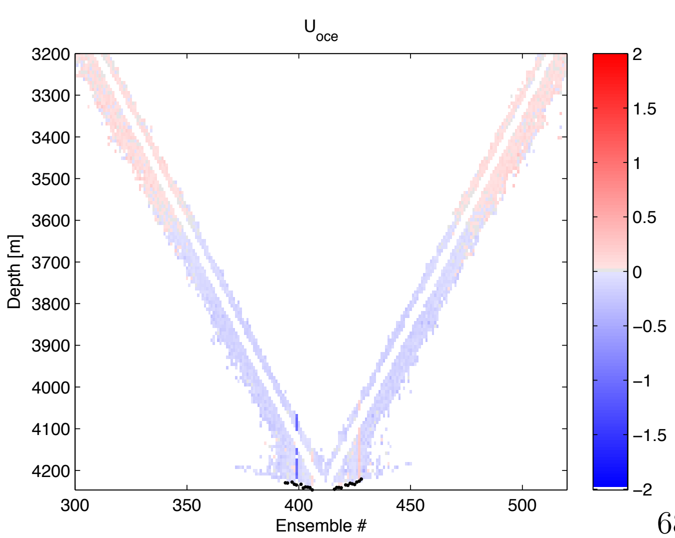
LDEO max depth=3001 bottom=3011

Notes: WH300 noise in first half of cast. Beam 3 at 83%. RDI bottom track very jagged and had artifacts; used LDEO.



Comments:

Fairly nice cast, until the chaos at the bottom caused by the bottom track. Currents are quite small, but a red flag is raised because the maximum current is below 3800 m.



At the bottom of processing figure 3, there was a very clear example of something I've seen, but never so dramatically. There was a very striking vertical line near the bottom at a nearly constant, large velocity. In this case, there are two, and they each include both instruments. The blue one has the preposterous velocity of −2 m/s. The pink one isn't so crazy, at 0.3 m/s, but is still an artifact. I have no good idea what could cause it.

Note also the evidence of bottom contamination. This plot was from the RDI bottom track, but it had considerable contamination. Not at the peak, but from pretty far away.

Switching to the LDEO bottom track improved things considerably. It was a lot less jagged and the bottom retrievals were flatter. Those artifacts disappeared. Bottom contamination was still pretty bad, though. The bottom current dropped from 15 cm s^{-1} to about 7. Don't know whether it's correct, but it's probably less wrong.

Playing with the moire patterns in figure 14 makes it look very much like the WH300 noise is also present in the WH150—the patterns line up pretty well. Hard to confirm though. And why would the WH300 sometimes not see it?

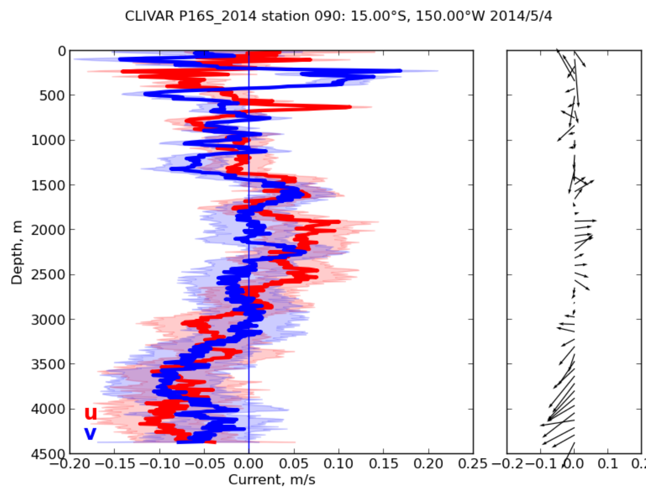
2.90 Station 90: 05/04 15°00´S 150°00´W

Errors and Warnings: Usual array about ping timing.

Depths: MB=4388, CTD=4377, DAB = ???

`check_ladcp: zmax=4360/4257, zend=55/35`
LDEO max depth=4373 bottom=4383

Notes: WH300 noise in first half of cast. Beam 3 at 86%. RDI bottom track did not edit out below-bottom region, used LDEO.



Comments:

Fairly nice cast, until the u shear diverged below 3700 m. It's not clear to me whether the southwestward current below 300 m is real. It looks fine, and the instruments agree, but it is suspiciously strong.

3 Distractions

3.1 Wire tension

As with P02, wire tension during deep casts are an issue. The first cast went to 4566 m and had tensions of up to 4300 lbs. Unlike P02, it appears that the *Palmer* folks do not like tensions > 4500 lbs. That leaves a pretty small margin for deep casts with our heavy rosette.

I decided to see if I could quantify what's affecting winch tension, so we might be able to reduce the problem some or at least forecast the tensions likely to occur. Obviously wire out is the biggest effect, since the mass of the wire is considerable. That is shown in Figure 8. The linear fit suggests that the package weighs 1187 lbs in the water (it weighs about 1800 lbs in the air) and each meter of cable adds 0.45 lbs. John Calderwood thought these values seemed reasonable. However, my calculated weight in seawater is 3.6% below that in the specifications (Table 1). I'm not sure how to account for the difference. The seawater here is somewhat denser than the 1028 kg m^{-3}, but not by anywhere near enough to add that much buoyancy. It's possible the winch calibration isn't perfect, that I have a biased sample of tensions, or that it's a mistake to separate out influences one at a time, as I'm doing here. Perhaps a multivariate model would give better results.

It appears that the wire out accounted for 70% of the variation in tension. Removing the influence of wire out and looking at winch payout speed yields the plot on the right of Figure 8. Winch speed clearly has an influence, but is not the major factor. One unexpected indication from the plot is that the drag of pulling the rosette through the water dominates over the skin friction of pulling kilometers of wire. There is no evident change in the tension vs winch speed with amount of wire out.

The last easy thing to look at was the acceleration of the winch. I was surprised by the lousy correlation shown in Figure 8c. I suppose it's comforting that the intercept is near zero and the slope is the right direction, but $r^2 = 0.0003$ means that winch acceleration is a trivial fraction of the variability.

The next obvious place to look for influences on winch tension is the motion of the ship. I used heave and roll data from the Kongsberg Seapath #1. It reports at 1 hertz, so I had to decimate the winch data to fit the datasets together. The proper way to do this would be to use the roll, pitch, and heave data and translate from the Seapath IMU reference location to the sheave position. I don't know exactly where the reference position is, though I'm told it's in the engine compartment, near amidships. I figure the Baltic Room (from which the rosette is launched) is near enough to midships that I could neglect pitch. As it turned out, heave was far more important than roll, even though roll was magnified by the 40 ft the boom extends from the centerline. That's probably because the ship faces the wind and waves, minimizing roll, whereas heave is difficult to minimize. A cursory look at sheave position and tension showed a very strong apparent correlation between the two, but with a phase difference. Going to sheave vertical speed resolved much of the phase (Figure 8e). Looking at the correlation between sheave speed and tension was a bit disappointing, with r^2 only 0.67 and elliptical patterns that suggest I don't have the phase quite right. Perhaps acceleration is playing a more important role than I anticipated. Or there could be a wire angle issue. It is strange that the best fit line doesn't appear to fit the trend well. There must be a lot of data points hidden underneath.

Table 1: A few 0.322" cable specifications from Tyco Electronics

	Metric	English	Mixed
Physical			
Weight in air	257 kg km^{-1}	173 lb kft^{-1}	0.567 lb m^{-1}
Weight in water	212 kg km^{-1}	143 lb kft^{-1}	0.467 lb m^{-1}
Specific gravity	5.7	5.7	
Mechanical			
Working load at 0.4% strain	11 kN	2500 lbf	
Maximum working load	22 kN	5000 lbf	
Rotation at 2500 lbf	49 °/m	15 °ft^{-1}	

I expect the proper way to do this is to start from an analytical perspective. The force on the cable at the sheave is

$$F_s = \overbrace{[M_r - B_r + (m_c - b_c)w]\, g}^{\text{weight}} + \overbrace{(D_r + d_c w)(\dot{w} + \dot{s})}^{\text{drag}} + \overbrace{(M_r + M_b N_b + m_c w)(\ddot{w} + \ddot{s})}^{\text{acceleration}} \qquad (2)$$

where the constants are given in Equation 2. Variables are w, the length of cable out, and s, the vertical position of the sheave, determined as $s = H + L \cos R$, where H and R are heave and roll from the Seapath and L is the length of the boom from the centerline of the ship, about 40 ft/12.2 m. Overdots are time derivatives, so velocity and acceleration. This is a dramatic oversimplification, of course; I'm not including changes in rosette drag with tripped bottle, the thinning of the cable as it stretches, and lots of other details that I expect are small.

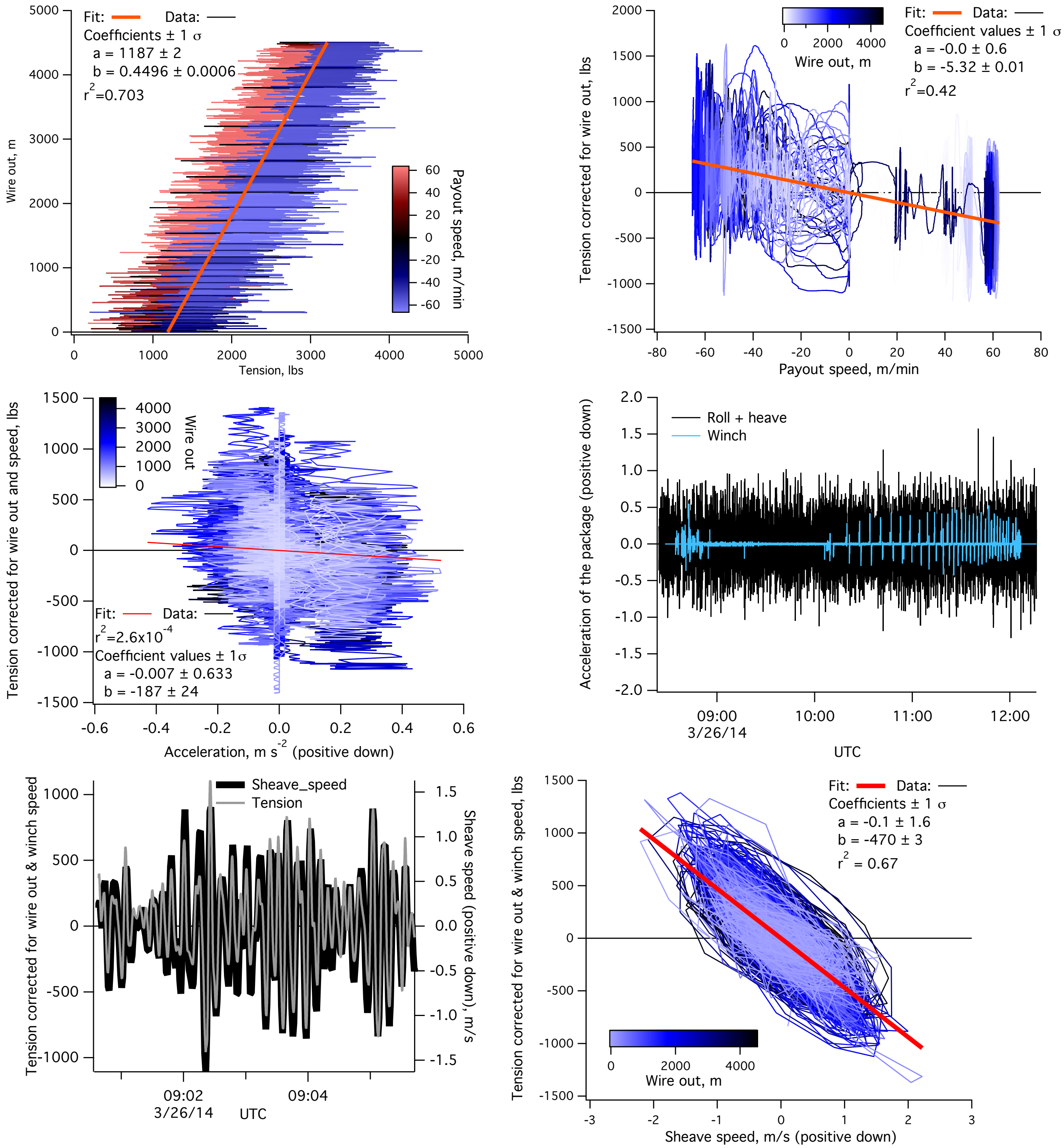


Figure 8: Analysis of winch tension from station 1. Winch tension and wire out (upper left) and tension versus winch speed after subtracting the fitted tension versus wire out function (upper right). Center left: Winch acceleration is very poorly related to tension, even after correction for wire out and speed. Center right: Accelerations due to motion of the sheave were up to 4 times larger than those from winch operation. Lower left: After correction for wire out and winch speed, there appears to be an excellent correlation between vertical motion of the sheave and tension. Lower right: the correlation isn't actually as good as I expected from the timeseries, but does explain most of the variation. Figures from `winch_85.pxp`

.

Table 2: Constants in Equation 2

Variable	description	estimate	est. in SI	fit
M_r	Mass of rosette (empty)	1907 lb *	860 kg	
B_r	Mass of water displaced by rosette	720 lb †	327 kg	
M_b	Mass of water in tripped bottle	22.7 lb ‡	10.3 kg	
m_c	Mass of cable	$0.257\,\mathrm{kg\ m^{-1}}$§		
b_c	Mass of water displaced by cable	0.042	$0.053\,\mathrm{kg\ m^{-1}}$	
D_r	Drag of rosette	$5.32\,\mathrm{lb\ s\ m^{-1}}$	$23.7\,\mathrm{N\ s\ m^{-1}}$	
d_c	Drag of cable	$3\,\mathrm{lb\ km^{-1}}$ @ $60\,\mathrm{m\ min^{-1}}$	$0.0002\,\mathrm{n\ s\ m^{-2}}$	0

One thing I thought might be significant but appears not to be is the skin friction of the cable through the water. According to the Nbpedia, a 2011 dump of Wikipedia, the drag equation is

$$F_D = \frac{1}{2}\rho u^2 C_D A \tag{3}$$

The choice of C_D isn't quite obvious, as there's no entry for a rod. Most appropriate seems to be a flat plate parallel to the fluid motion, with $A = \pi dw = \pi 0.322\text{''} w = 0.026\,\mathrm{m^2\ m^{-1}}$ being surface area. C_D for such a plate is 0.001 in laminar flow to 0.005 in turbulent flow. I don't know whether the flow is turbulent or how to deal with the roughness of the cable. $\rho = 1030\,\mathrm{kg\ m^{-3}}$. Assuming winch speed $u = 60\,\mathrm{m\ min^{-1}} = 1\,\mathrm{m\ s^{-1}}$ and $C_D = 0.001$, Equation 3 yields $0.013\,\mathrm{n\ m^{-1}}$, or $3\,\mathrm{lb\ km^{-1}}$. If I haven't made a major mistake, this isn't significant even if C_D is a factor of 5 too low and there are 5 km of wire out.

As shown in Figure 8d, accelerating the mass of cable and rosette is a fairly small part of the tension. Typical winch acceleration upward was $0.2\,\mathrm{m\ s^{-2}}$, though it was occasionally double that. Given the mass of the rosette and $F = ma$, $F = 860\,\mathrm{kg} \times 0.2\,\mathrm{m\ s^{-2}} = 172\,\mathrm{n} = 39\,\mathrm{lb}$. Each kilometer of cable adds $F = 257\,\mathrm{kg} \times 0.2\,\mathrm{m\ s^{-2}} = 51\,\mathrm{n} = 12\,\mathrm{lb}$. The rosette alone is pretty close to the 39 lb from the fit in Figure 8d, despite the terrible correlation. I'm surprised the order of magnitude is right!

3.2 Instrument positions

The *Palmer* used Dynamic Positioning (DP) to maintain position while on station. I don't really understand why; the important thing isn't to maintain position, it's to keep the wire angle acceptable. It also takes time to set up DP. I mentioned that I thought DP was a wast of time to Lynne a couple of times and she either thought it wasn't important enough to bother the bridge with it or she did but failed to convince them. Or maybe on the Palmer, DP really is the best way to go. I expect it's easiest for the bridge.

Anyhow, this excessively precise station-keeping made a trivial distinction look big. I noticed that the position of the ship as included in the GPS was persistently separated from the positions in the SADCP data. This was initially alarming, until I noticed how small the scale was. See Figure 9 for an example.

*From tension during launch

†From Figure 8

‡From difference between launch and recovery tensions

§From Table 1

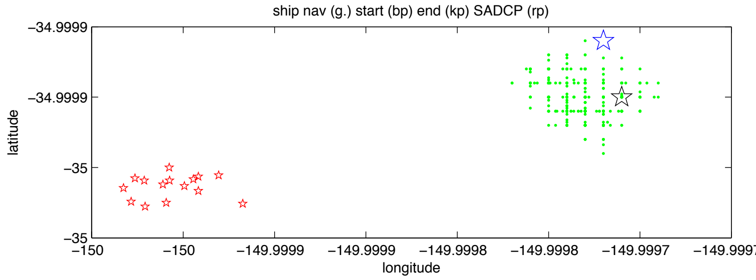


Figure 9: An example of the offset between GPS positions reported for the SADCP and the ship (in the CTD files). This is from station 60, on 24 April. By-eye averaging of the ship position was 34.99994°S, 149.99978°W, while the SADCP was 35.00002°S, 150.00001°W, which is 23 m away.

The 23 m difference turns out be a pretty reasonable value. I asked about the data sources. The SADCPs use the Trimble GPS, while the CTD datafiles use the Kongsberg Seapath #1. Both instruments use GPS antennae on the science mast, but the Seapath deck box (the Motion Reference Unit, or MRU) is located well forward (Figure 10).

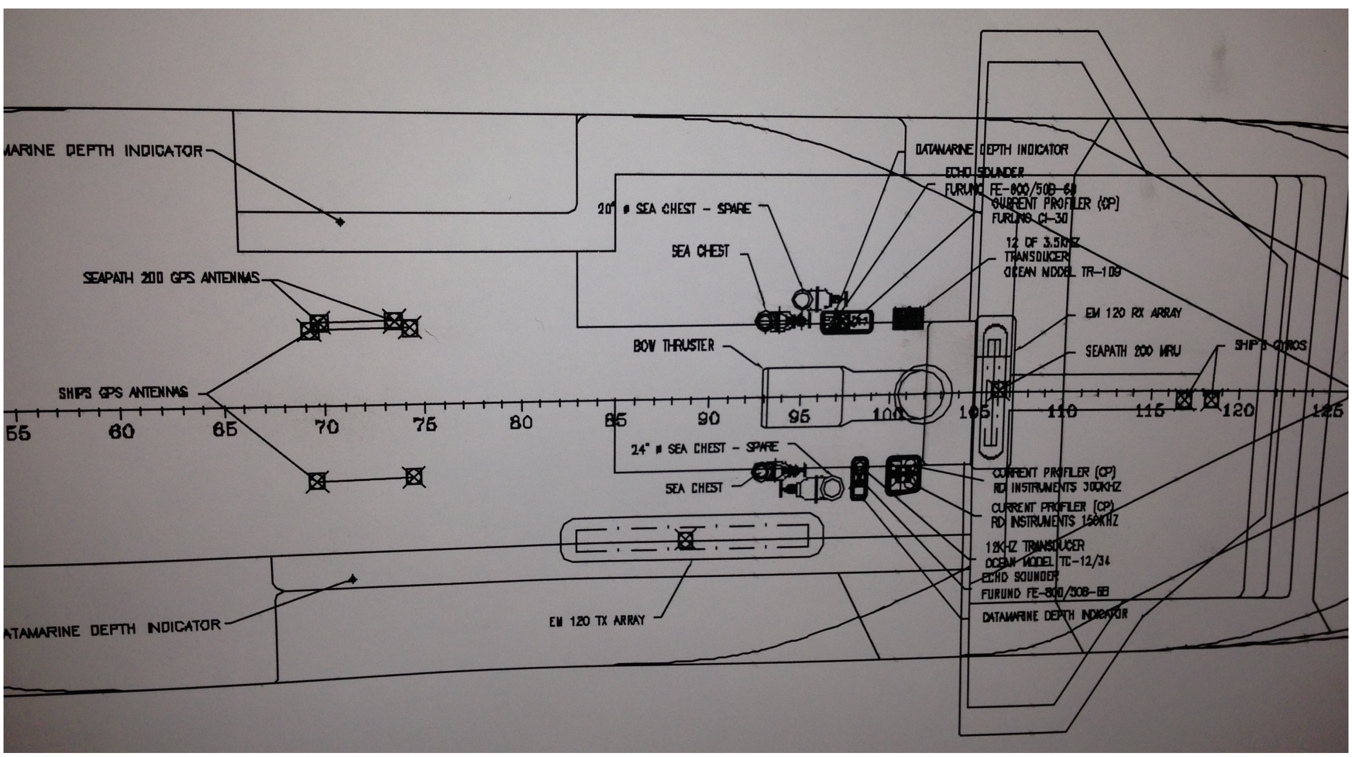


Figure 10: A plan view of instrument locations I noticed on the wall of the main lab, dated 2002. The length scale is 2 foot units. I'm not sure which antenna is for the Trimble (used by the SADCP), but I assume it's at location 70 or so. The Seapath MRU is at location 107, roughly 22.5 m forward. The Baltic Room squirt boom and the starboard A-frame are at locations 58 and 45, respectively.

The net result is that the Seapath, only 3.7 m away, would be an excellent position reference for the SADCP. Instead, the Trimble, 19 m away, is being used. In contrast, the Trimble is 23 mcloser to the CTD positions in the Baltic Room and at the starboard A-frame. (Though one could use the heading from the Seapath to calculate true position of the CTD sheave.

Of course, all of this is trivial. These distances have no oceanographic significance, and of course the rosette wanders around below the ship in a manner only poorly constrained by the LDEO analysis, but probably over larger distances than these.

Less trivially, Figure 10 makes it obvious why the bow thruster trashes the SADCP, multibeam, and Knudsen depth finder data. They are all neatly arranged around the thruster! If I had realized this early in the cruise, I might have suggested that the bridge try to minimize bow thruster use.

A LADCP installation

The LADCP was a Teledyne/RDI Workhorse 150, serial number 16283. Power was supplied by a Deep Sea Power & Light SB-48V/18A marine battery ("Safe Orange Battery", or SOB, serial number 01527). They were mounted at the bottom of a 36-place rosette along with the CTD and related sensors (Figure 11). The LADCP was held in place by an anodized aluminum ring bolted to 3 struts connected to mounting tabs on the frame (Figure 12). It differs a bit from the P02_2013 installation. John Calderwood, who designed the mounting system in the first place, specified that the ring should have a diameter $\frac{1}{4}$" larger than the WH150 pressure vessel, leaving a clearance of $\frac{1}{8}$" around the LADCP. Strips of $\frac{1}{4}$" rubber line the rings. The rubber is thus squeezed 50%. It's actually pretty hard to do that, and the instrument feels very tightly held. Thus the lack of the strap Rob Palomares had on P02 is not a big concern. Another safety factor is that the rosette sits on a pair of rails; even if the LADCP slips, it is unlikely to contact the rails.

Update at end of experiment The LADCP did not slip at all as far as I can tell. This scheme seems more secure than Rob's, though it would have been much harder to twist in place, which was useful on P02.

The WH150 operated in a staggered pinging mode, where the delay between pings alternated between 1.2 s and 1.6 s. This was done to reduce the effect of previous ping interference (PPI), where a strong echo from the bottom from a previous ping appears as an artifact in a later ping. With constant ping rates, the artifact hits a single depth, essentially invalidating all data at that depth. By alternating delays, we destroy half the data at two depths, but have some data through the entire column. The artifact should appear at a distance $\Delta z = \frac{1}{2} c \Delta t \cos\theta$ where Δt is the period between pings, c is the speed of sound (typically around $1500\,\mathrm{m\,s^{-1}}$), and θ is the beam angle from vertical (20° for the WH150). At 1.2 s and 1.6 s, PPI should appear at 900 m and 1200 m.

A.1 LADCP command file

```
# Candidate for 2013 UH WH150:
# test to see if it gives more consistent ping timing.
# Note that actual ping timing can change throughout the cast.
CR1    # factory defaults
PS0    # Print system serial number and other info.
WM15   # sets LADCP mode; WB -> 1, WP -> 001, TP -> 000100, TE -> 00000100
TC2    # 2 ensembles per burst
TB 00:00:02.80     ### also try old BB settings, 2.6 and 1.0
TE 00:00:01.20
TP 00:00.00
WN40    # 40 cells, so blank + 320 m with 8-m cells
```

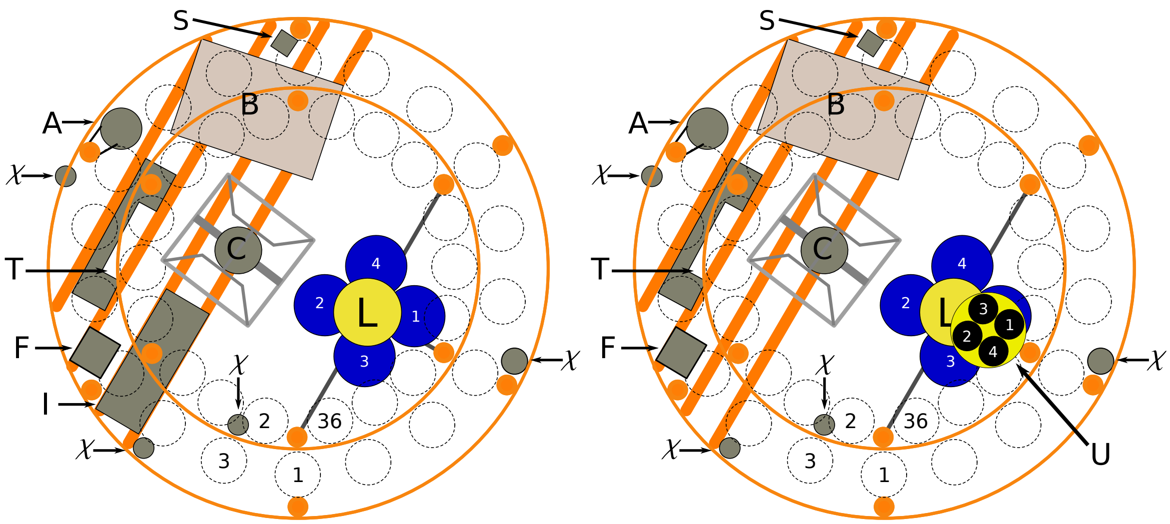


Figure 11: Schematic plan view of instrument and bottle locations on the rosette before (left) and after the upward-looking WH300 was mounted. Orange elements are parts of the rosette frame. Bottle locations are indicated by dashed circles and numbers. Instruments are identified by letters: L, LADCP (WH150); U, Up-looking LADCP (WH300); B, Battery for LADCP/IMP power; I, IMP; S, bottom contact Switch; C, CTD;A, Altimeter (120 kHz Benthos echosounder); T, transmissometer; F, Fluorometer for chlorophyll-A; and χ, elements of the χ-pod fast temperature system. White numerals show ADCP beam positions.

```
WS0800  # 8-m cells
WT1600  # 16-m pulse
WF1600  # Blank, 16-m
WV330      # 330 is max effective ambiguity velocity for WB1
EZ0011101  # Soundspeed from EC (default, 1500)
EX00100    # No transformation (middle 1 means tilts would be used otherwise)
CF11101    # automatic binary, no serial
LZ30,230   # for LADCP mode BT; slightly increased 220->230 from Dan Torres
# For Master/slave use, uncomment the following 3 lines (from Dan Torres)
#SM1        # Master (for dual setup)
#SA011      # send pulse before ensemble, before water ping
#SW05000    # wait 5000 x 0.1 msec (1/2 second) after pulse before pinging
CL0        # don't sleep between pings (CL0 required for software break)
```

A.2 WH300

Beginning at station 63, a 300 kHz instrument (WH300, model WHS-I-UG300, serial no. 12734, firmware 50.40) was mounted in a collar at the top of the rosette with beams facing upward (Figure 13). It collected data on every subsequent station, except during station 78, when I screwed up the serial connection. It was mounted nearly directly above the WH150 in a clamp made of two half circles. The initial idea was to put a ring of rubber around the WH300 as with the WH150, but we couldn't manage to squeeze it in, so we put two smaller pieces in on opposite sides.

The WH300 used 8 m pings, blanking intervals, and receive ranges. For stations 63 to 67, the instrument was set to listen through 20 depth bins of 8 m each, for a total range of 168 m. My

Figure 12: The WH150 mounted in the rosette. Upper left: along the left from bottom to top are the IMP, the CTD, and (barely visible) the SOB. Upper right: view from above. The IMP, CTD, and SOB are visible along the top. Lower left: view of the clamp. Note the mark showing beam 3. Lower right: the rosette at launch shows vertical positions more clearly. The spar on the left has a χ-pod thermistor at the top and a χ-pod data acquisition module hose-clamped to it.

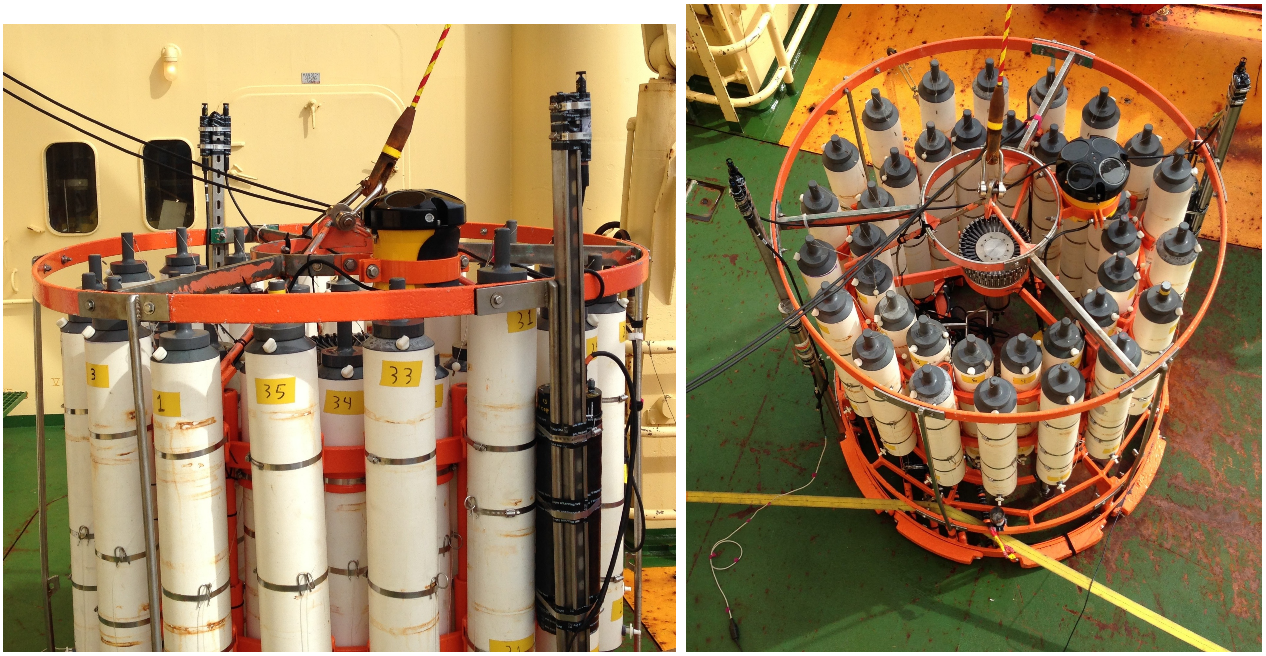


Figure 13: The WH300 mounted in the rosette. Left: side view. The χ-pod thermistors are on the spars to either side and the two LADCP lab cables go off to the upper left. Right: from above. The structure of the clamp is more visible from this perspective.

thought was to have the WH300 ping as often as possible, but out of sync with the WH150, so there wouldn't be a short-period regular interference pattern. 0.53 s seemed like a reasonable choice.

As it turned out, the WH300 could not ping that fast when sampling 20 bins. Starting at station 68, I chose to reduce the number of bins to 10, limiting range to 88 m. My justification was that bins beyond the 10th rarely had significant data, and that only occurred near the surface, where there was plenty of other data from the WH150 and the SADCPs. This did enable the WH300 to ping every 0.53 s, except for one cast (I think), where the average was fractionally longer. I must have been very near the limit.

A.3 The WH300 command file (stations 68 and higher)

```
CR1     # Factory defaults
PS0     # Print system serial number and configuration
WM15    # Sets LADCP mode WP->1; WB->1; TE->00:00:01; TP->00:01
TC1     # 1 ensemble per burst
TB 00:00:00.53  # Time between bursts
TE 00:00:00.00  # Minimum time between ensembles
TP 00:00.00     # Minimum time between pings
WP 1        # 1 ping per ensemble
WN10        # 10 cells. That's beyond the useful range for most of the cast.
WS0800      # 8 m cells (No WT command means transmit length also 8 m)
WF0800      # 8 m blank
WV330       # Ambiguity velocity
EZ0011101   # Manual sound speed, depth, salinity; others from ADCP sensors
EX00100     # No transformation (middle 1 means tilts would be used otherwise)
```

```
CF11101
```

From station 63 to 67, the command file was identical except that line 8 had WN20.

A.4 Using the WH300 as master

I did briefly try out my scheme to use the WH300 as a master and the WH150 as a slave to get coordinated staggered pinging. It was a bit awkward, since the computer was up in the aft control room and the rosette was a level down. In addition, it was hard to hear the WH300 pinging. Fortunately, the grad students had good ears. The upshot was that the WH300 did successfully trigger the WH150, but the WH150 pings were clearly not staggered. I was in kind of a hurry at that point and never did look at the data files to get the actual ping rates.

Here is the WH300 command file I used

```
# Try using upward-facing WH300 as a master to a downward facing WH150
CR1     # Factory defaults
PS0     # Print system serial number and configuration
WM15    # Sets LADCP mode WP->1; WB->1; TE->00:00:01; TP->00:01
TC2     # 2 ensembles per burst
TB 00:00:02.80  # Time between bursts = 2.8 s, minus 1.2 s gives 1.6 s delay
TE 00:00:01.20  # Min time between ensembles = 1.2 s
TP 00:00.00     # Could be used instead of TE
WP 1       # 1 ping per ensemble
WN20       # 20 cells
WS0800     # 8 m cells (No WT command means transmit length also 8 m)
WF0800     # 8 m blank
WV330      # Ambiguity velocity
EZ0011101  # Manual sound speed, depth, salinity; others from ADCP sensors
EX00100    # No transformation (middle 1 means tilts would be used otherwise)
CF11101
SM1        # Master
SA011      # Trigger slave first, then delay before ping
SW08000    # Wait 0.8 s for WH150 before pinging
```

The WH150 command file for the test:

```
# Try using downward-pointing WH150 as a slave to an upward-pointing WH300:
# test to see if it gives more consistent ping timing.
# Note that actual ping timing can change throughout the cast.
CR1    # factory defaults
PS0    # Print system serial number and other info.
WM15   # sets LADCP mode; WB -> 1, WP -> 001, TP -> 000100, TE -> 00000100
TC2    # 2 ensembles per burst
TB 00:00:02.80     ### also try old BB settings, 2.6 and 1.0
TE 00:00:01.20
TP 00:00.00
WN40   # 40 cells, so blank + 320 m with 8-m cells
WS0800  # 8-m cells
WT1600  # 16-m pulse
```

```
WF1600  # Blank, 16-m
WV330      # 330 is max effective ambiguity velocity for WB1
EZ0011101  # Soundspeed from EC (default, 1500)
EX00100    # No transformation (middle 1 means tilts would be used otherwise)
CF11101    # automatic binary, no serial
LZ30,230   # for LADCP mode BT; slightly increased 220->230 from Dan Torres
# For Master/slave use, uncomment the following 3 lines (from Dan Torres)
SM2        # Slave (for dual setup)
SA001      # wait for pulse from master before water ping
ST0        # wait indefinitely for pulse from master
CL0        # don't sleep between pings (CL0 required for software break)
```

A.5 Computers and software

The acquisition computer was the palmtop named "luau" and the processing computer was "nini". The processing software was the Visbeck/Thurnherr LDEO LADCP software version IX_8. The setup was as described in the online LADCP documentation, so I won't repeat it here.

I had only two real problems with the hardware setup. They are detailed in the cast descriptions, but I'll summarize. The 2-port USB↔RS232 converter was unable to handle two simultaneous downloads, so could not handle the 2 LADCP setup. Since luau had only 2 USB ports, I used a 4-port USB hub to connect the backup USB disk and a single-channel USB↔RS232 converter to one of luau's ports and left the 2-channel USB↔RS232 converter on the other port connected just to the WH150. The other issue was that `check_ladcp` failed twice on perfectly valid files. A reboot fixed the problem (but caused me to screw up serial communication on one station).

B IMP

The Incidental Measurement Package (IMP, but formerly the Inertial Measurement Package) is a combination accelerometer/magnetic flux gate compass that Andreas Thurnherr of LDEO developed for augmenting the tilt and heading sensors on LADCPs. This is a new technology, deployed for the first time during the *Palmer* cruise immediately before P16S. This was its most extensive deployment by far, both in terms of number of stations and depth of casts.

The IMP hardware (Figure 14) consists of

- a sensor board with 3-axis accelerometers for tilt and 3-axis magnetometers for heading. There are actually two complete sets of sensors on the board; I'm not quite sure why. Two different measurement chips are used, an LSM303DLHC and a newer LSM303D. If only there were rotation sensors as well, it would be a complete motion package. Unfortunately, the gyroscope packages in the same series of sensors sensitivity is $0.008\,75\,^{\circ}\,\mathrm{s}^{-1}$ or 31 rotations per hour!

- a Raspberry Pi model A computer running ArchLinux with a ChronoDot clock board. It communicates with the outside world through a WiFi interface it sets up using SSID `IMP_MK3` and no password.

- a DC/DC power supply to transform the SOB nominal 48 V to the well-controlled 5 V required by the Pi. There were actually 2 DC/DC converters; one that dropped the SOB voltage to 8 V and a precision 5 V regulator.

- an aluminum pressure case rated to 6000 m. This was a curious device, built to be cheap, with PVC band clamps holding on the end caps. The band clamps were secured by hose clamps. There were 2 o-rings in each end cap, one a face seal and the other a curious triangular crush scheme. There was some corrosion in the caps, but none actually at the seals. It worked okay, but seemed tenuous.

I had some problems with the band clamps. Bruce Huber suggested that I send the pressure vessel down empty at first, as it had not been demonstrated at depths below 2 km. I did that on station 1, and the interior was dry after a cast to 4.3 km. However, the PVC clamp split. John Calderwood and I glued it back together with cyanoacrylate cement, seeing no other obvious choice. I tightened it much less. The next cast, it took on about 30 mL of seawater, and I found that the clamp was a bit loose. I also found that the other band clamp was cracked in much the same way. This time we glued it with 2-part PVC cement (cleaner and solvent). On assembly, we tightened the hose clamps more, but following a suggestion from Bruce Huber, tapped the PVC clamps while tightening to give a better chance of clamping evenly. It came up dry from station 3, so I added the electronics for station 4. It survived that cast, so I just left it in place through cast 62.

The IMP was mounted to the floor of the rosette, as shown in Figure 15. We used thick rubber sheet taped to the pressure vessel to keep the delicate PVC band clamps from contacting the bars of the rosette floor.

Before the first IMP cast, I set the clock on the Raspberry Pi. I did not reset it through the entire project.

During the cruise, I did not really check the IMP data much, except to ascertain that it was being collected. I did plot a few things as sanity checks, but the files were too big to work with easily. Andreas looked at the data afterward and seemed satisfied. He didn't mention the lack of data from station 29 though; I suspect his quick scan through the data didn't catch it.

Figure 14: The IMP, disassembled. The Raspberry Pi is on the right, with the USB WiFi dongle at the bottom. The sensor board is in the styrofoam box rubber-banded to the Pi. That was shoved to the far end of the pressure vessel (top), followed by the foam pad and then the DC/DC converter encased in foam. Note the precision voltage regulator between the DC/DC converter and the Pi. The DC/DC converter was powered through pins 3 (+) and 7 (-) of the male Impulse bulkhead connector in the end cap.

Figure 15: The IMP in the rosette. The photo on the left also shows the transmissometer, fluorometer, and CTD cage. Behind the CTD is the WH150 and behind the IMP is the down-facing χ-pod thermistor and (mostly hidden,) a χ-pod acquisition module. At far lower left, the clamps holding the altimeter are visible. In the right photo, the χ-pod components are more visible, as are the altimeter and WH150.

C Thoughts about final processing of LADCP data

The absolute minimal thing to do would be to just process the SADCP data, then use stock processing on all of the stations, presumably using the spike filtering and LDEO bottom track. That would leave several issues unexplored:

- Bottom tracking isn't good:
  - RDI bottom track doesn't always eliminate bottom, is really jagged
  - LDEO bottom track better, but usually contaminated by the bottom LDEO ought to be better; it isn't ping-by-ping. Probably possible to tweak it to eliminate the bottom better. Might even be some parameter that I've missed.
- PPI editing isn't really good.
  - Best stock version is with the spike filter parameter. Doesn't edit out spikes that occur within PPI region for other ping delay.
  - Does spike editing operate on individual beams or after velocities calculated?
  - Could modify the PPI filter to handle staggered pinging. Need either manual editing or pretty paranoid settings to cover it.
- Can we use PPI to extend bottom track up to about 1000 m above the bottom? Seems kind of tricky: need to gauge when bottom signal is enough to dwarf water return. Need PPI from at least 3 beams simultaneously, so can't have a strongly sloped bottom.
- Is the acoustic interference regular enough that we can eliminate it some way other than the spike filter? Is there actually a strong need to?
- Is there any possibility that the processing doesn't actually handle the multiple WH300 pings per WH150 ping? Should average WH300 pings together, and I suspect that's what happens, but it is possible that it could just take the nearest single WH300 ping. Requires combing through the code.
- We need to develop some way to communicate errors. Possibilities include error estimates, error flags (good, questionable, bad?) and NaNing out untrustworthy data. Part of the difficulty with this is that people will have different uses for the data, so "untrustworthy" will be tough to define well.
  - Based on amount of valid data. Set up some criterion for how much valid data there is in a depth bin and calculate error from there. Can't easily do this as part of the LDEO processing, because the amount of data isn't obviously available anywhere except for figure 12.
  - Based on agreement between solutions. If shear and inversion are in agreement and upcasts differ little from downcasts then we have high confidence. Easy to describe but hard to quantify.
  - Based on error estimates from inversion. Easy, but a copout, since it's not clear just what the error estimates mean. Pretty much useless for people interested in shear.

  - In the documentation, Martin (or Andreas) has a parameter to skip pings according to a user-defined pattern, and suggests that one could get some idea about errors by seeing how well two inversions of the same cast using different data agree. Is this worth following up, at least in the early stations where there is plenty of data all the way down?

- What do we do with the IMP data?
  - Nothing.
  - Use Andreas's `.imped` files for stations 5–62.
  - Use IMP corrections for the rest of the casts too.

- What about the compass data from the WH300? The LDEO analysis by default ignores the uplooker compass. Should it be looked at?

D Weekly reports from the chief and co-chief scientists

Lynne Talley and Brendan Carter sent out weekly reports on the progress of the cruise. They are included in full on the following pages.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #1. 24 March 2014.

Lynne Talley (SIO) and Brendan Carter (Princeton)

On 20 March, 2014, we sailed from Hobart, Tasmania on the U.S. Antarctic Program's Nathaniel B. Palmer, passing under the Tasman Bridge and on out to sea. We are underway to our first bio-Argo float deployment far south of New Zealand, which is on the way to GO-SHIP section P16S, commencing at 67°S, 150°W. The transit to the first float deployment is taking about 6 days. By the end of the cruise in Tahiti on May 5 we will have deployed 12 profiling biogeochemical floats, 30 surface drifters, made daily biogeochemical observations for NASA ocean color satellite cal/val, and completed more than 105 stations with physical and chemical measurements from surface to bottom. We are sampling or deploying instruments for approximately 18 different principal investigators, from NSF funding, NOAA and NASA. Our science party of 29 includes 9 grad students from all over the U.S. and the world.

The 12 floats that we will be deploying will be part of the global Argo float array, profiling every 10 days to 2000 m depth. They include the first set of fully-equipped Southern Ocean biogeochemical profiling floats, measuring oxygen, nitrate, fluorescence and backscatter, and—the newest addition—pH sensors, with the southernmost group having the capability to sense and avoid coming up to the sea surface under sea ice. We hope that these will be the "tip of the iceberg" for the growing Southern Ocean Observing System. The goal is to observe the Southern Ocean's important uptake of excess CO_2 from the atmosphere, and directly observe its acidification resulting from global change.

The stations that we will occupy along 150°W are repeats of two earlier transects. This set of stations was occupied in 1991 as part of that decades' global observing program WOCE, and then again in 2005 as part of the international repeat hydrography program, now called GO-SHIP, which criss-crosses all of the oceans. We are analyzing about 19 different properties in the water collected from the rosette water sampler, and collecting vertical profiles of conductivity, temperature, oxygen (2 sensors), and pressure (on the CTD), velocity from a Lowered Acoustic Doppler Current Profiler (LADCP), transmittance, fluorescence, and temperature microstructure from a new program ("chi-pod") for U.S. GO-SHIP. The goal is to observe changes over the decades in the ocean's heat, salt, nutrient, oxygen, and carbon content. In this part of the world ocean, many of the changes observed thus far have been linked to global change.

We're currently steaming southeast just along the Australian/New Zealand EEZ boundary. We passed north of Macquarie Island earlier today, getting a push from the northernmost branch of the Antarctic Circumpolar Current, which roughly parallels the Campbell Plateau. Underway measurements commenced close to Hobart: velocity profiling with the ship's two ADCP systems; meteorological and bathymetric measurements; surface seawater sampling for temperature, salinity, pCO2; and continuous surface sampling of optical properties (backscatter, chlorophyll, CDOM fluorometry).

We estimate that we'll be in position for the first station/float deployment —on a P14S waypoint measured in 2012 by a Japanese research expedition, and in 1996 as part of WOCE—in the afternoon on the 26th of March local time.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #2. March 25-31, 2014.

Lynne Talley (SIO) and Brendan Carter (Princeton)

During our second week on the Nathaniel B. Palmer, we completed an 11-day transit from Hobart, Tasmania to the southernmost station of our GO-SHIP hydrographic section, at 67°S, 150°W. We are arriving on station 5 to commence that section today, which will go northward with stations every 30 nm (55 km) to 15°S.

During the second half of our transit, beginning south of New Zealand, we deployed 4 biogeochemical profiling floats, spaced roughly 1 days' steam apart. Each float has a CTD (temperature/salinity), and sensors for oxygen, nitrate and fluorescence/backscatter. At each float location we made a CTD/36-place rosette/LADCP/transmissometer/fluorometer station to depth, and a profile of Inherent optical properties (IOP) to 200 m (nicknamed the "NASA Cage"). Three of the four CTD stations were to the ocean bottom. The first was at the location of a station on WOCE/GO-SHIP P14S, south of Chatham Rise, so it will be possible to not only use our water sample data (nutrients, oxygen, pH, alkalinity, HPLC pigments) to calibrate the float profile, but also to compare our water properties with those collected in 1996 in WOCE and in 2012 in GO-SHIP. Station and float deployment 2 was on the northern flank of the Pacific-Antarctic Ridge and that profile was also taken to the ocean bottom, given the minimal additional time required and the nearly unmeasured hydrographic nature of this region.

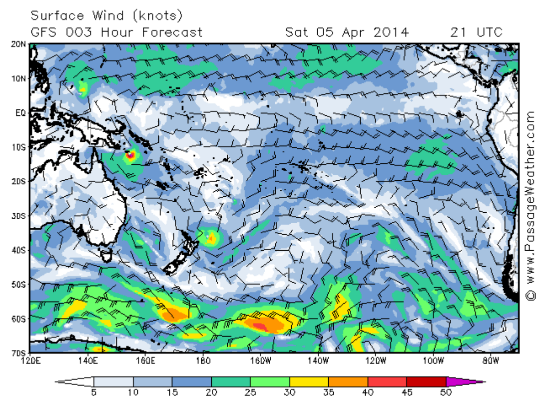
Station and float deployment 3, located south of the Pacific-Antarctic Ridge and within the Ross Sea gyre south of the Antarctic Circumpolar Current, were shifted farther east along the transit than originally planned because of sustained high winds and seas. During a break in the weather, the station was occupied to the minimum necessary depth of 2000 m, a bio-optics cast was carried out, and the third float was deployed. As a result of the weather and constant waves on the main deck, which has often been secured, the DIC analysis group moved operations from their van into the main lab.

Station and float deployment 4 were then also shifted eastward to lie between station 3 and the anchor station for the P16S repeat at 67°S, 150°W. Weather and seas calmed considerably prior to Station 4, and we began seeing tabular icebergs and smaller floating ice. The mid-day conditions were sufficiently calm that the NASA bio-optics group deployed their apparent optical properties (AOP) profiler (nicknamed the "Javelin" by popular acclaim), the farthest south such profile at the time. The subsequent "Javelin" profile at Station 5 broke that record, as it was slightly farther south at our southernmost station overall.

During the long transit we have been collecting underway data: ADCP velocities to 1200 m, surface water properties with sampling every four hours, meteorology, and bathymetry.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #3. April 7, 2014.Lynne Talley (SIO) and Brendan Carter (Princeton)

Our third week at sea of hydrography, float and surface drifter deployments, and bio-topical measurements began smoothly, with 10 stations, and 2 floats deployed in the relatively calm Ross Sea. By mid-week, we were sitting in a very wide tunnel of sustained westerly winds with gusts to more than 45 knots and very high seas centered at 60°S, right over our station plan. Most of the rest of the week was consumed with frequent consultations with Captain Souza, working with the Spawar and OTSR weather forecasters, who proved to be quite accurate. Because of the persistently bad conditions, we decided to sail northward out of the weather, from 62°S to 58°S. We then proceeded back to the south, making stations every 1 degree latitude, following the forecast of a developing lull between two low pressure systems, and were able to return to 61°S. Given the total cruise time, we then had to turn back northward, and began filling in our ½ degree stations. We had to abandon 2 stations and will be sampling for the next few days at station separations dictated by weather. Overall for the week we completed 15 stations, and deployed 3 floats and 4 surface drifters.



On the positive front, the data collection and quality are excellent, and the entire team from science to ASC to ECO dealt well with the protracted poor weather. The floats that we've deployed are returning their first profiles, and our first float has just reported its second profile. The two floats with the cutting edge pH sensors are reporting good pH profiles. Our first surface drifters for NOAA's Global Velocity Program were deployed at 60°S. The NASA team been able to complete bio-optical profiling each day when we have been able to work, and their work was featured on the NASA outreach website, Image of the Day for April 5 (Cruising for Ocean Data) http://earthobservatory.nasa.gov/IOTD/

An initial science result: The Ross Sea bottom waters continue to warm, with a monotonic increase over the 4 WOCE/CLIVAR surveys thus far: 1992, 2005, 2011, and now 2014. The bottom 1000 m thick layer is nearly adiabatic (well mixed with lower temperature variance than the abyssal thermocline above it), and can be easily compared from one survey to the next. Additionally, we note that the entire deep temperature structure has shifted from cooler to warmer, and hence it appears that the warming of the bottom layer is partly a function of warming of the abyssal layer, from 2500 to 4500 m.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #4. April 14, 2014.
Lynne Talley (SIO) and Brendan Carter (Princeton)

In our fourth week at sea, we completed 16 stations, deployed 3 additional biogeochemical Argo-equivalent floats, and 18 surface drifters for the NOAA Global Surface Velocity Program. All of our biogeochemical floats have thus far reported their first profiles, and the earliest floats have successfully completed their first 10 day cycles. We have been able to send our coincident lab analyses back to the float PIs for comparison with the float results, which are giving good profile shapes but with offsets, confirming the usefulness of chemistry at the time of biogeochemical float deployments.

Our station completion rate continued at the slow rate of the previous week, again due to weather restrictions as we continued to battle the broad wind tunnel centered at 60S and extending over our full station track to 55S, just beyond the top of the Pacific-Antarctic Ridge and in the center of the Antarctic Circumpolar Current. Beyond this point, the weather began to clear and we began more routine operations at a rate of about 3 stations per day.

Our station 29 was directly north of the Subantarctic Front based on the high surface velocities registered by the shipboard ADCP, and the abrupt change to subantarctic type waters. Water samplers appreciated the vanishing of negative temperature waters.

As we proceeded northward across the ridge, at the first station deeper than 4100 m, we uncovered multiple breaks in the outer layer of the CTD wire. The breaks looked to be worse farther down in the spool. We continued safely sampling to 4100 m for the next 8 stations over the next two days while considering options for sampling to the > 5000 m depths that are arriving at 49S. After determining that the spare wire appears to be in good shape, the viable option was to transfer operations from the Baltic room to the main deck even though the sheave is not the best for this wire. With excellent weather today, the transfer was accomplished successfully (picture). Because the deck has been nearly continuously awash for most of the cruise, the water sampling will likely not be done underway, which will add approximately 60 hours of station time to the cruise. This and the time required for the transfer of operations means cancelling a large number of stations, and will be accommodated by increasing the station spacing, potentially from the stipulated ½ degree to 1 degree.

As said last week, on the positive side, it is a pleasure to work with this team of professionals and dedicated students, each contributing their thorough expertise and the ability to adapt to circumstances.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #5. April 21, 2014.
Lynne Talley (SIO) and Brendan Carter (Princeton)

The CLIVAR/GO-SHIP P16S cruise passed north of 50°S at the start of this week, sailed on past 40°S, and we are now working towards the mid 30°s. The weather improved dramatically just past 50°S and gave us a long stretch of much-needed routine work. Because of major weather delays in the previous weeks, we increased our station spacing to 40 nm, and are now working at a steady pace of 2 to 3 stations per day. We are mostly able to sample while underway, and stations are being occupied at a good pace. An extratropical storm yesterday pushed us back into memories of last week's poor weather, and necessitated sampling on station.

The switch to the backup CTD wire at the end of week 4 was completely successful after a days' very hard work on the part of the ETs and MTs who got the setup rigged and the winch in top working order. The switch to outside coincided with conditions that make sampling more comfortable every day.

Milestones this week: We completed 18 more stations, moving clearly into the subtropical gyre and our deepest stations, in the Southwest Pacific Basin. We completed all of the biogeochemical float deployments. All 12 floats are reporting and the data are being posted. We continue to make nearly real-time comparisons with the shipboard lab analyses. We also completed the last of our 30 surface drifter deployments and are receiving data from those that were deployed.

Some fun around the last couple of floats when we were cleared to have "float signings" (left). An Easter wombat visited the Palmer on Sunday leaving 68 tiny origami candy boxes hidden all over the labs.

Some science highlights: excellent quality data from all groups! Compared with 2005, oxygen continues to increase in the ventilated subtropical thermocline. The pioneering nitrous oxide is looking great. Speculations rife about the energetic subthermocline eddy or internal wave at a station outside the ACC's eddy field with westward flow > 30 cm/sec at 1200-1800m, and 300 m isopycnal deflections.

NBP14-03 GO-SHIP P16S Chief Scientists' Weekly Report #6. April 28, 2014.
Lynne Talley (SIO) and Brendan Carter (Princeton)

In our fifth week of the CLIVAR/GO-SHIP P16S cruise, all has been quiet and pleasantly routine with regular stations every day, and increasingly warming weather and calmer sea states, clear subtropical waters, scattered rainshowers. Our station spacing must remain at 40 nm for the remainder of the cruise due to the beating we took from storms and high seas south of 50°S, but the spacing is appearing adequate for resolving the principal oceanographic features and changes from the two previous occupations of this section, in 2005 and 1991.

Milestones this week: Moving steadily northward along 150°W, we completed another 20 stations, and are now moving from the deep Southwest Pacific Basin up the rise to Polynesia. All 12 biogeochemical floats continue to report, the earliest now with 4 good profiles, and the data continue to be posted. We have smooth/excellent communications between all groups operating during stations – bridge, deck, winch, CTD console operations, NASA casts, and continued excellent data from all groups due to very high levels of diligence and immediate troubleshooting. We are preparing final cruise reports, getting ready to put together the final data sets, recognizing that there will be just one day between the end of the last station and the dock.

Out next and final weekly report will be from near port in Papeete, Tahiti.

E Cast events from the CTD data processing

SIO Shipboard Technical Support

Welcome, CTD Deepthought | 2 Members Online | Your Account | Logout

Shipboard Technical Support : cruise : CLIVAR-P16S : Hydro-P16S : Cast Events

CLIVAR/GO-SHIP P16S -- Cast Events Sun May 4 19:49:45 UTC 2014

Cast	Event	When	Where	Speed	Course	MBcntr Depth	DAB	Max Wire Out	Max Z	Duration
NASA SS/C 1/1 IOP CAGE START	Start	2014-03-26 07:42:55	60 0.0912 S 174 0.1068 E	0.6	30.1	4528				
NASA SS/C 1/1 IOP CAGE END	Start	2014-03-26 08:18:29	60 0.0900 S 174 0.1056 E	0.6	357.4	4719				
	Start	2014-03-26 08:26:28	60 0.0792 S 174 0.1068 E	0.2	184.3	4539				
	Submerge	2014-03-26 08:40:36	60 0.0498 S 174 0.1050 E	0.2	214.3	4492				
1/2	Bottom	2014-03-26 10:11:08	60 0.0120 S 174 0.1050 E	0.4	160.6	4534	-999	-999	4484.1	03:38:24
	Emerge	2014-03-26 12:03:32	59 59.9658 S 174 0.1194 E	0.3	15.3	4541				
	End	2014-03-26 12:04:52	59 59.9760 S 174 0.1254 E	0.9	311.9	4540				
Float S/N 6091 Argo (IONF)	Start	2014-03-26 13:52:00	60 6.2412 S 174 16.8606 E	10.9	124.1	5443				
	Start	2014-03-28 00:53:37	63 29.9892 S 175 59.9796 W	1.5	47.4	3187				
	Submerge	2014-03-28 00:56:11	63 29.9880 S 175 59.9790 W	0.8	339.1	3176				
2/1	Bottom	2014-03-28 02:00:23	63 29.9898 S 175 59.9844 W	1.5	197.5	3171	9.4	3176.2	3156.4	02:40:54
	Emerge	2014-03-28 03:33:10	63 29.9922 S 175 59.9850 W	0	290	3073				
	End	2014-03-28 03:34:31	63 29.9922 S 175 59.9832 W	1.7	239.1	3172				
NASA SS/C 2/2 IOP CAGE START	Start	2014-03-28 03:52:14	63 29.9922 S 175 59.9856 W	0.4	232	3173				
NASA SS/C 2/2 IOP CAGE END	Start	2014-03-28 04:24:03	63 29.9934 S 175 59.9898 W	0.2	339.5	3507				
Float S/N 7557 Argo (IONF)	Start	2014-03-28 04:45:00	63 29.2656 S 176 0.6996 W	1.7	354.3	3200				
3/1	Start	2014-03-30 04:00:59	65 41.4474 S 161 53.7480 W	1.7	91.2	3885				
	Submerge	2014-03-30 04:05:00	65 41.4492 S 161 53.7348 W	1.2	134.7	4087				
	Bottom	2014-03-30 05:01:54	65 41.4306 S 161 53.7330 W	0.3	184.3	4077	-999	2003.7	1993	02:23:43
	Emerge	2014-03-30 06:22:44	65 41.5038 S 161 53.6628 W	1	200.9	3737				
	End	2014-03-30 06:24:42	65 41.5068 S 161 53.6604 W	0.7	276.7	3910				
NASA SS/C 3/2 IOP CAGE START	Start	2014-03-30 06:53:04	65 41.5020 S 161 53.6538 W	0.8	67.8	4064				
NASA SS/C 3/2 IOP CAGE END	Start	2014-03-30 07:27:20	65 41.4516 S 161 53.6784 W	0.7	188.3	4092				
Float S/N 7567 Argo (IONF)	Start	2014-03-30 07:54:19	65 41.1798 S 161 55.2378 W	1.5	280.8	3284				
NASA SS/C 4/1 IOP CAGE START	Start	2014-03-31 00:31:30	66 29.9550 S 156 0.0156 W	0.2	78.8	4045				
NASA SS/C 4/1 IOP CAGE END	Start	2014-03-31 01:04:37	66 29.9562 S 156 0.0132 W	1	126.5	4049				
NASA SS/C 4/2 HYPERPRO START	Start	2014-03-31 01:12:33	66 29.9550 S 156 0.0138 W	0.4	281.9	4047				
NASA SS/C 4/2 HYPERPRO END	Start	2014-03-31 01:26:30	66 29.9568 S 156 0.0162 W	0.2	306.8	4050				
	Start	2014-03-31 01:38:24	66 29.9562 S 156 0.0174 W	1.6	268.5	4049				
	Submerge	2014-03-31 01:44:55	66 29.9562 S 156 0.0156 W	0.4	177.3	4050				
4/3	Bottom	2014-03-31 03:21:21	66 29.9550 S 156 0.0180 W	0.4	228.6	4053	10.1	4061.3	4034.5	03:43:47
	Emerge	2014-03-31 05:20:36	66 29.9550 S 156 0.0114 W	1.2	80.4	4051				
	End	2014-03-31 05:22:11	66 29.9550 S 156 0.0108 W	0.6	102.7	4049				
Float S/N 7613 Argo (IONF)	Start	2014-03-31 05:46:50	66 30.6042 S 155 59.5230 W	3.1	157.9	3955				
NASA SS/C 5/1 IOP CAGE START	Start	2014-03-31 20:52:11	67 0.0048 S 149 59.9160 W	0.2	132.4	3928				
NASA SS/C 5/1 IOP CAGE END	Start	2014-03-31 21:25:10	67 0.0066 S 149 59.8896 W	0.8	245.1	3089				
NASA SS/C 5/2 HYPERPRO START	Start	2014-03-31 21:49:37	66 59.9946 S 149 59.7888 W	0.4	89.1	4284				
NASA SS/C 5/2 HYPERPRO END	Start	2014-03-31 22:02:07	66 59.9634 S 149 59.5836 W	1	41	4379				

	Start	2014-03-31 22:15:55	66 59.9262 S 149 59.3598 W	0.2	153.2	4386				
	Submerge	2014-03-31 22:19:07	66 59.9262 S 149 59.3592 W	0.6	292.1	4366				
5/3	Bottom	2014-03-31 23:45:53	66 59.9274 S 149 59.3538 W	0.2	82.5	4383	8	4394.5	4366.5	03:22:39
	Emerge	2014-04-01 01:37:12	66 59.9268 S 149 59.3598 W	0.4	283.3	4386				
	End	2014-04-01 01:38:34	66 59.9268 S 149 59.3592 W	0.7	291.9	4793				
Float S/N 7614 Argo (IONF)	Start	2014-04-01 02:02:28	67 0.7614 S 149 59.9298 W	2.8	201.2	5069				
	Start	2014-04-01 05:24:00	66 29.9880 S 149 59.9904 W	0.5	318.1	4937				
	Submerge	2014-04-01 05:28:09	66 29.9874 S 149 59.9880 W	0.7	159.9	4446				
6/1	Bottom	2014-04-01 06:52:17	66 29.9898 S 149 59.9922 W	0.7	150.6	4458	5.5	4463.5	4432.7	03:26:55
	Emerge	2014-04-01 08:49:36	66 29.9988 S 149 59.9874 W	0.4	254.5	4436				
	End	2014-04-01 08:50:55	66 29.9988 S 149 59.9862 W	0.4	326.4	4440				
	Start	2014-04-01 12:16:39	66 0.5976 S 149 59.9700 W	0.3	76.4	-999				
	Submerge	2014-04-01 12:21:30	66 0.5976 S 149 59.9694 W	0.2	172.4	4342				
7/1	Bottom	2014-04-01 13:45:58	66 0.6030 S 149 59.9700 W	0.6	219	4343	9.3	4359.7	4333.7	03:28:29
	Emerge	2014-04-01 15:43:04	66 0.6048 S 149 59.9736 W	0.3	322.8	4342				
	End	2014-04-01 15:45:08	66 0.6048 S 149 59.9730 W	0.5	233.8	4345				
	Start	2014-04-01 19:11:36	65 29.7852 S 149 59.1012 W	0.5	66.2	3471				
	Submerge	2014-04-01 19:16:57	65 29.7798 S 149 59.0964 W	0.2	358	3901				
8/1	Bottom	2014-04-01 20:30:02	65 29.7066 S 149 58.9368 W	0.4	68.1	3927	10.5	3530.8	3507.4	02:56:55
	Emerge	2014-04-01 22:07:03	65 29.8788 S 149 59.2764 W	1	217.1	3465				
	End	2014-04-01 22:08:31	65 29.8788 S 149 59.2770 W	0.5	258.3	3468				
NASA SS/C 8/1 HYPERPRO START	Start	2014-04-01 22:39:16	65 29.2542 S 150 1.8234 W	1.3	112.4	3269				

NASA SS/C 8/1 HYPERPRO END	Start	2014-04-01 22:51:52	65 29.3670 S 150 1.5462 W	2.8	73.8	3272				
NASA SS/C 8/2 IOP CAGE START	Start	2014-04-01 23:06:19	65 29.3448 S 150 1.1610 W	0.4	257.9	3724				
NASA SS/C 8/2 IOP CAGE END	Start	2014-04-01 23:39:09	65 29.3436 S 150 1.1634 W	0.5	326.4	4153				
	Start	2014-04-02 03:21:08	64 59.4750 S 150 0.0168 W	0.6	314.9	4080				
	Submerge	2014-04-02 03:25:16	64 59.4750 S 150 0.0174 W	0.3	145.9	4635				
9/1	Bottom	2014-04-02 04:49:36	64 59.4090 S 149 59.8140 W	0.9	183.2	3908	8.3	4131.4	4101.6	03:22:21
	Emerge	2014-04-02 06:41:28	64 59.4090 S 149 59.8104 W	0.2	239.1	4140				
	End	2014-04-02 06:43:29	64 59.4036 S 149 59.8008 W	0.3	42.9	4120				
	Start	2014-04-02 10:06:06	64 30.0138 S 149 59.7198 W	1.5	352.7	15				
	Submerge	2014-04-02 10:25:47	64 30.0102 S 149 59.7084 W	1	32.8	3913				
10/1	Bottom	2014-04-02 11:41:00	64 30.0204 S 149 59.7264 W	0.9	188.3	4984	8.4	3570.6	3548.6	03:12:07
	Emerge	2014-04-02 13:15:11	64 30.0018 S 149 59.6010 W	2.3	40.6	15				
	End	2014-04-02 13:18:13	64 29.8824 S 149 59.5272 W	2.6	335.4	5686				
	Start	2014-04-03 04:20:30	64 0.0036 S 149 59.9412 W	0.6	275.9	4128				
	Submerge	2014-04-03 04:27:06	64 0.0030 S 149 59.9436 W	0.4	36	4277				
11/1	Bottom	2014-04-03 05:43:32	63 59.9946 S 149 59.9424 W	0.3	188.4	3212	6.9	3226.5	3204.4	03:02:55
	Emerge	2014-04-03 07:21:22	63 59.9514 S 149 59.9622 W	0.4	250.2	3197				
	End	2014-04-03 07:23:25	63 59.9286 S 149 59.9700 W	0.8	290.9	3737				
NASA SS/C 11/2 IOP CAGE START	Start	2014-04-03 07:43:44	63 59.8884 S 149 59.9964 W	0.7	344.6	3216				
NASA SS/C 11/2 IOP CAGE END	Start	2014-04-03 08:13:41	63 59.8986 S 149 59.9892 W	0.7	194.5	3223				
Float S/N 9091 Argo (IONFp)	Start	2014-04-03 08:34:03	63 59.5812 S 150 1.2060 W	2.8	334.1	3452				
12/1	Start	2014-04-03 11:47:54	63 30.0522 S 149 59.9178 W	0.7	325.7	3411				

	Submerge	2014-04-03 11:59:37	63 30.0480 S 149 59.9106 W	0.3	151.4	3360				
	Bottom	2014-04-03 13:11:30	63 29.9886 S 149 59.8836 W	0.8	136.7	3358	8.5	3363.1	3341.8	03:07:57
	Emerge	2014-04-03 14:54:11	63 30.0114 S 149 59.8890 W	1	27.9	3350				
	End	2014-04-03 14:55:51	63 30.0012 S 149 59.8896 W	0.6	53.5	3350				
	Start	2014-04-04 00:13:42	62 59.9862 S 150 0.0468 W	1.1	262.1	3664				
	Submerge	2014-04-04 00:18:37	62 59.9886 S 149 59.9910 W	0.3	273.3	3665				
13/1	Bottom	2014-04-04 01:39:31	63 0.0018 S 149 59.9538 W	0.9	58.7	3668	7.6	3667.2	3647	03:11:15
	Emerge	2014-04-04 03:23:25	62 59.9952 S 149 59.9496 W	0.5	201	3687				
	End	2014-04-04 03:24:57	62 59.9982 S 149 59.9388 W	0.5	50.4	3659				
	Start	2014-04-04 06:45:46	62 29.9850 S 149 59.9796 W	0.9	187.3	3486				
	Submerge	2014-04-04 06:50:53	62 29.9808 S 149 59.9718 W	0.6	48.2	5178				
14/1	Bottom	2014-04-04 07:58:41	62 29.9820 S 149 59.9898 W	1.3	63.6	3298	5.9	3316.2	3297.6	02:53:57
	Emerge	2014-04-04 09:38:29	62 29.9724 S 149 59.9580 W	0.4	303	3297				
	End	2014-04-04 09:39:43	62 29.9724 S 149 59.9568 W	0.4	126.3	3301				
Drifter S/N 114536 AOML Drifter	Start	2014-04-05 06:57:15	60 55.2372 S 149 54.3642 W	7.6	322.3	5784				
Drifter S/N 114533 AOML Drifter	Start	2014-04-05 06:57:45	60 55.1904 S 149 54.4206 W	6.8	320.9	5761				
	Start	2014-04-06 07:54:10	58 0.0306 S 149 59.9376 W	0.7	5.5	2871				
	Submerge	2014-04-06 08:00:03	57 59.9946 S 149 59.9418 W	0.8	9.8	2765				
15/1	Bottom	2014-04-06 09:09:11	57 59.9784 S 149 59.9646 W	0.8	140.2	2875	7.7	2874.4	2863.7	02:43:04
	Emerge	2014-04-06 10:35:43	57 59.9994 S 149 59.9700 W	0	54.4	2870				
	End	2014-04-06 10:37:14	57 59.9868 S 149 59.9742 W	0.5	267.9	2868				
16/1	Start	2014-04-06 17:30:28	59 0.0006 S 149 59.9748 W	0.3	149.2	2692				

	Submerge	2014-04-06 17:36:27	59 0.0036 S 149 59.9742 W	0.4	212	2693				
	Bottom	2014-04-06 18:38:11	59 0.0018 S 149 59.9796 W	0.9	193.6	2838	7.1	2703.6	2685.5	02:32:16
	Emerge	2014-04-06 20:00:32	58 59.9610 S 149 59.9736 W	1.6	267.6	2705				
	End	2014-04-06 20:02:44	58 59.9556 S 149 59.9736 W	0.8	65.1	2704				
NASA SS/C 16/2 IOP CAGE START	Start	2014-04-06 20:14:59	58 59.8818 S 149 59.9538 W	1.1	0.9	2690				
NASA SS/C 16/2 IOP CAGE END	Start	2014-04-06 20:46:14	58 59.8236 S 149 59.9184 W	2.1	30.2	2677				
Drifter S/N 1114665 AOML Drifter	Start	2014-04-06 20:54:00	58 59.6736 S 149 59.9100 W	3.8	335.6	2671				
NASA SS/C 17/1 IOP CAGE START	Start	2014-04-07 03:46:26	60 0.0006 S 149 59.9502 W	1.7	251.5	2723				
NASA SS/C 17/1 IOP CAGE END	Start	2014-04-07 04:18:33	60 0.0036 S 149 59.9520 W	0.3	32.5	2733				
	Start	2014-04-07 04:30:05	60 0.0054 S 149 59.9520 W	0.2	21.2	2739				
	Submerge	2014-04-07 04:35:58	60 0.0030 S 149 59.9526 W	0.6	132.9	2702				
17/2	Bottom	2014-04-07 05:44:57	59 59.9982 S 149 59.9466 W	1	250	2713	9.4	2715.6	2696.9	02:37:45
	Emerge	2014-04-07 07:06:37	59 59.9940 S 149 59.9754 W	0.5	148.6	2706				
	End	2014-04-07 07:07:50	59 59.9928 S 149 59.9718 W	0.7	304	2708				
Float S/N 9092 Argo (IONFp)	Start	2014-04-07 07:33:00	59 59.5980 S 150 0.9864 W	0.9	0.8	2940				
Drifter S/N 114645 AOML Drifter	Start	2014-04-07 07:40:00	59 59.4360 S 150 1.4514 W	3.9	326.5	2929				
	Start	2014-04-07 12:45:36	60 29.9304 S 149 59.8218 W	0.1	125.6	3033				
	Submerge	2014-04-07 12:58:19	60 30.0000 S 149 59.9586 W	1.4	319.1	3036				
18/1	Bottom	2014-04-07 14:03:48	60 29.9640 S 150 0.0120 W	0.2	83.3	2997	8.7	3044.8	3023.8	02:59:18
	Emerge	2014-04-07 15:43:25	60 30.0396 S 149 59.9082 W	0.5	229.3	3026				
	End	2014-04-07 15:44:54	60 30.0456 S 149 59.9022 W	0.4	311.4	3030				

	Start	2014-04-07 19:02:53	60 59.9730 S 149 59.9328 W	2.3	222.2	2733			
	Submerge	2014-04-07 19:09:13	60 59.9874 S 149 59.9718 W	1	159.8	3003			
19/1	Bottom	2014-04-07 20:15:34	60 59.9916 S 149 59.9760 W	0.6	144.7	2688	9.8	3247	3225.5 02:44:17
	Emerge	2014-04-07 21:45:21	61 0.0030 S 149 59.9796 W	0.3	283.6	2833			
	End	2014-04-07 21:47:10	61 0.0030 S 149 59.9802 W	0.9	198.9	2298			
NASA SS/C 19/2 IOP CAGE START	Start	2014-04-07 22:00:18	61 0.0036 S 149 59.9832 W	0.3	72.1	3140			
NASA SS/C 19/2 IOP CAGE END	Start	2014-04-07 22:33:25	61 0.0078 S 149 59.9832 W	1.4	70.8	3150			
	Start	2014-04-08 07:36:14	59 29.9766 S 149 59.8836 W	1.8	305.3	2588			
	Submerge	2014-04-08 07:47:13	59 29.9868 S 149 59.9418 W	0.4	341.7	2282			
20/1	Bottom	2014-04-08 08:37:42	59 29.9874 S 149 59.9550 W	0.6	271.8	2259	9.8	2268.7	2254.3 02:03:48
	Emerge	2014-04-08 09:38:36	59 29.9712 S 149 59.9784 W	0.4	277.5	2287			
	End	2014-04-08 09:40:02	59 29.9688 S 149 59.9796 W	0.6	251.2	2290			
	Start	2014-04-08 15:58:14	58 29.9526 S 149 59.8584 W	0.5	66.9	2832			
	Submerge	2014-04-08 16:06:51	58 29.9430 S 149 59.8620 W	0.2	209.8	2832			
21/1	Bottom	2014-04-08 17:08:18	58 29.9850 S 149 59.9826 W	0.5	281	2841	8.4	2840.6	2820.1 02:26:53
	Emerge	2014-04-08 18:23:53	58 30.0114 S 149 59.9862 W	0.6	307.1	3158			
	End	2014-04-08 18:25:07	58 30.0090 S 149 59.9868 W	0.4	213.9	2845			
	Start	2014-04-09 01:09:35	57 29.8278 S 149 59.8200 W	0.1	244	3001			
	Submerge	2014-04-09 01:15:51	57 29.8500 S 149 59.8212 W	1.4	26.9	3004			
22/1	Bottom	2014-04-09 02:22:41	57 29.9250 S 149 59.9094 W	1.1	192	2998	2.7	3038.5	3019.3 02:57:55
	Emerge	2014-04-09 04:06:07	57 29.9808 S 149 59.8992 W	0.6	24.1	3034			
	End	2014-04-09 04:07:30	57 29.9844 S 149 59.8986 W	0.5	143.8	3042			
NASA SS/C 22/2 IOP CAGE START	Start	2014-04-09 04:24:22	57 30.0108 S 149 59.9010 W	0.8	159.3	3042			

NASA SS/C 22/2 IOP CAGE END	Start	2014-04-09 04:44:14	57 30.0078 S 149 59.8998 W	1	187.2	3035			
	Start	2014-04-09 08:00:42	56 59.9724 S 149 59.9268 W	0.8	55.9	3164			
	Submerge	2014-04-09 08:06:30	56 59.9682 S 149 59.9178 W	0.4	246.2	3166			
23/1	Bottom	2014-04-09 09:12:04	57 0.0192 S 149 59.9904 W	0.4	327.3	3273	8.4	3176.9	3155.3 02:44:30
	Emerge	2014-04-09 10:43:43	57 0.0078 S 149 59.9862 W	1.7	223.5	3695			
	End	2014-04-09 10:45:12	57 0.0102 S 149 59.9880 W	1.3	207.2	3162			
Drifter S/N 116269 AOML Drifter	Start	2014-04-09 10:53:00	57 0.0108 S 150 0.0642 W	2	302.1	3601			
Drifter S/N 114661 AOML Drifter	Start	2014-04-09 10:54:00	56 59.9952 S 150 0.1254 W	3.1	283.2	3168			
Drifter S/N 114680 AOML Drifter	Start	2014-04-09 10:54:01	56 59.9952 S 150 0.1272 W	2.9	284.8	3168			
	Start	2014-04-09 14:25:48	56 30.0000 S 149 59.8992 W	0.2	28.7	3198			
	Submerge	2014-04-09 14:31:57	56 30.0000 S 149 59.8992 W	0.6	44.5	3030			
24/1	Bottom	2014-04-09 15:34:18	56 29.9994 S 149 59.9046 W	1.3	231.9	3064	8.6	2804.5	2782.4 02:43:52
	Emerge	2014-04-09 17:08:04	56 30.0042 S 149 59.9082 W	0.6	162.7	2772			
	End	2014-04-09 17:09:40	56 30.0042 S 149 59.9076 W	0.6	241.2	2768			
	Start	2014-04-10 00:30:50	56 0.0030 S 149 59.9358 W	0.3	100.2	3517			
	Submerge	2014-04-10 00:36:07	55 59.9814 S 149 59.9316 W	0.8	255.9	3408			
25/1	Bottom	2014-04-10 01:53:10	55 59.9928 S 149 59.9340 W	0.2	248.2	3405	7	3414.6	3387.1 03:11:51
	Emerge	2014-04-10 03:41:18	55 59.9610 S 149 59.9370 W	0.5	20.2	3731			
	End	2014-04-10 03:42:41	55 59.9700 S 149 59.9364 W	1.7	177.4	3408			
NASA SS/C 25/2 IOP CAGE START	Start	2014-04-10 03:54:17	55 59.9898 S 149 59.9406 W	0.7	309.3	3466			
NASA SS/C 25/2 IOP CAGE END	Start	2014-04-10 04:25:23	55 59.9838 S 149 59.9322 W	0.5	34.4	3404			

Drifter S/N 116263 AOML Drifter	Start	2014-04-10 04:33:00	55 59.9526 S 150 0.0954 W	1.8	318.5	3402				
Drifter S/N 114644 AOML Drifter	Start	2014-04-10 04:34:00	55 59.9346 S 150 0.1782 W	3	328	3404				
Drifter S/N 114540 AOML Drifter	Start	2014-04-10 04:34:01	55 59.9340 S 150 0.1788 W	3.5	348.8	3404				
	Start	2014-04-10 08:03:40	55 30.0234 S 149 59.9550 W	1.8	54.7	3694				
	Submerge	2014-04-10 08:10:36	55 30.0174 S 149 59.9556 W	0.4	59.9	3692				
26/1	Bottom	2014-04-10 09:25:19	55 30.0108 S 150 0.0012 W	0.8	19.6	3680	9.1	3708.5	3682.4	03:05:44
	Emerge	2014-04-10 11:07:57	55 29.9946 S 149 59.9940 W	1.6	213	3689				
	End	2014-04-10 11:09:24	55 29.9946 S 149 59.9946 W	0.7	229.9	4003				
	Start	2014-04-11 04:25:19	55 0.0030 S 149 59.9490 W	1	35.6	-999				
	Submerge	2014-04-11 04:34:10	54 59.9682 S 149 59.9976 W	1.2	327.4	-999				
27/1	Bottom	2014-04-11 06:07:08	54 59.9832 S 149 59.9922 W	0.2	78.9	-999	8.7	3539.4	3513.8	03:19:08
	Emerge	2014-04-11 07:42:33	54 59.9886 S 149 59.9820 W	0.6	240.9	3834				
	End	2014-04-11 07:44:27	54 59.9736 S 150 0.0096 W	1.3	59.8	3529				
NASA SS/C 27/2 IOP CAGE START	Start	2014-04-11 07:56:28	54 59.9616 S 150 0.0528 W	1.3	233.6	4779				
NASA SS/C 27/2 IOP CAGE END	Start	2014-04-11 08:27:08	54 59.9808 S 150 0.0222 W	0.6	270.4	3521				
NASA SS/C 27/3 IOP CAGE START	Start	2014-04-11 08:40:07	54 59.9718 S 150 0.0444 W	0.4	66.4	3364				
NASA SS/C 27/3 IOP CAGE END	Start	2014-04-11 09:09:31	54 59.9994 S 149 59.9964 W	1	252.6	3518				
Float S/N 9031 Argo (ONFp)	Start	2014-04-11 09:30:00	55 0.2688 S 150 0.8694 W	0.7	234.4	3529				
Drifter S/N 114678 AOML Drifter	Start	2014-04-11 09:36:00	55 0.3732 S 150 1.1604 W	2.5	254.7	3878				

Drifter S/N 114673 AOML Drifter	Start	2014-04-11 09:36:01	55 0.3732 S 150 1.1616 W	3.1	241.1	3878				
Drifter S/N 114654 AOML Drifter	Start	2014-04-11 09:37:00	55 0.3900 S 150 1.2480 W	1.8	237.2	3484				
	Start	2014-04-11 13:01:49	54 30.0006 S 149 59.8932 W	0.5	306.2	3558				
	Submerge	2014-04-11 13:06:45	54 30.0006 S 149 59.9052 W	0.9	67.6	3505				
28/1	Bottom	2014-04-11 14:17:11	54 30.0156 S 149 59.9796 W	0.4	195.7	3502	9.4	3512.3	3490.1	03:08:05
	Emerge	2014-04-11 16:08:32	54 30.0204 S 149 59.9748 W	1.1	232.3	3502				
	End	2014-04-11 16:09:54	54 30.0204 S 149 59.9724 W	0.2	37.5	3904				
	Start	2014-04-11 19:25:22	54 0.0204 S 149 59.9784 W	0.6	244.9	3598				
	Submerge	2014-04-11 19:28:46	54 0.0144 S 149 59.9802 W	0.7	187.8	3576				
29/1	Bottom	2014-04-11 20:37:37	54 0.1584 S 149 58.9038 W	1.8	201.7	3513	10.1	3562.9	3528.9	02:48:44
	Emerge	2014-04-11 22:12:51	54 0.3840 S 149 57.1824 W	0.9	96.2	3250				
	End	2014-04-11 22:14:06	54 0.3888 S 149 57.1584 W	0.7	75.2	3100				
NASA SS/C 29/2 IOP CAGE START	Start	2014-04-11 22:26:07	54 0.4014 S 149 56.9136 W	1	61.5	3254				
NASA SS/C 29/2 IOP CAGE END	Start	2014-04-11 22:58:46	54 0.4194 S 149 55.2744 W	2.4	82.6	3438				
NASA SS/C 29/3 HYPERPRO START	Start	2014-04-11 23:07:33	54 0.4104 S 149 54.7734 W	1.7	92.6	3417				
NASA SS/C 29/3 HYPERPRO END	Start	2014-04-11 23:19:52	54 0.3810 S 149 54.6504 W	1.1	266.2	3401				
Drifter S/N 116454 AOML Drifter	Start	2014-04-11 23:25:00	54 0.3918 S 149 54.5772 W	2.4	260.3	3398				
Drifter S/N 114532 AOML Drifter	Start	2014-04-11 23:25:01	54 0.3918 S 149 54.5778 W	2.3	245.2	3398				
Drifter S/N 116456 AOML Drifter	Start	2014-04-11 23:26:00	54 0.3918 S 149 54.6282 W	2.5	276.1	3327				

	Start	2014-04-12 02:49:08	53 29.9238 S 149 59.9088 W	0.6	243.8	4406				
	Submerge	2014-04-12 03:02:34	53 29.9232 S 149 59.9112 W	1.5	21.6	4403				
30/1	Bottom	2014-04-12 04:31:21	53 29.9238 S 149 59.9154 W	0.6	73.9	4410	6.8	4416.7	4389	03:48:25
	Emerge	2014-04-12 06:36:22	53 29.9610 S 149 59.9712 W	1.2	227.2	4409				
	End	2014-04-12 06:37:33	53 29.9628 S 149 59.9730 W	0.9	217.8	4838				
	Start	2014-04-12 09:52:41	53 0.0270 S 150 0.0072 W	0.7	52	4167				
	Submerge	2014-04-12 09:57:12	53 0.0234 S 150 0.0018 W	0.3	316.6	3756				
31/1	Bottom	2014-04-12 11:25:24	53 0.0294 S 150 0.0054 W	0.4	71.7	4578	9.9	4155.5	4133.4	03:28:39
	Emerge	2014-04-12 13:20:08	53 0.0066 S 149 59.9856 W	1.1	80.8	4138				
	End	2014-04-12 13:21:20	53 0.0012 S 149 59.9766 W	1.2	71.7	4138				
Drifter S/N 114664 AOML Drifter	Start	2014-04-12 14:13:00	53 0.0000 S 150 0.0426 W	2.3	308.5	4481				
Drifter S/N 116264 AOML Drifter	Start	2014-04-12 14:13:01	52 59.9994 S 150 0.0432 W	2.5	323.5	4481				
Drifter S/N 114539 AOML Drifter	Start	2014-04-12 14:13:02	52 59.9988 S 150 0.0438 W	2.9	331.3	4481				
	Start	2014-04-12 17:46:44	52 29.9982 S 149 59.9574 W	1	158.6	4806				
	Submerge	2014-04-12 17:51:28	52 30.0102 S 149 59.9808 W	0.4	76.8	4920				
32/1	Bottom	2014-04-12 19:06:32	52 29.9838 S 149 59.9382 W	0.5	97.4	4671	-999	4061.8	4030.5	03:06:45
	Emerge	2014-04-12 20:52:18	52 29.9886 S 149 59.9388 W	0.1	117.1	4153				
	End	2014-04-12 20:53:29	52 29.9868 S 149 59.9340 W	0.7	84.6	4664				
NASA SS/C 32/2 IOP CAGE START	Start	2014-04-12 21:11:42	52 29.9736 S 149 59.9100 W	0.8	23.7	4658				
NASA SS/C 32/2 IOP CAGE END	Start	2014-04-12 21:45:46	52 29.9766 S 149 59.9028 W	0.5	34	4151				
Float S/N 9018 Argo (Op)	Start	2014-04-13 01:15:00	52 29.5014 S 150 0.3876 W	2.3	349.3	4754				

	Start	2014-04-13 05:10:54	52 0.0024 S 149 59.9550 W	0.1	232.5	4501				
	Submerge	2014-04-13 05:17:44	52 0.0012 S 149 59.9580 W	0.5	253.5	4495				
33/1	Bottom	2014-04-13 06:49:47	51 59.9952 S 149 59.9466 W	0.5	135	4767	-999	-999	4031.4	03:27:00
	Emerge	2014-04-13 08:36:36	51 59.9856 S 149 59.9412 W	0.4	285.3	4512				
	End	2014-04-13 08:37:54	51 59.9862 S 149 59.9406 W	0.4	326.2	4520				
	Start	2014-04-13 12:36:59	51 30.0198 S 149 59.9400 W	0.4	304.6	4445				
	Submerge	2014-04-13 12:42:04	51 30.0198 S 149 59.9394 W	0.7	217.2	4170				
34/1	Bottom	2014-04-13 14:00:37	51 30.0210 S 149 59.9418 W	0.5	207.4	4374	-999	4061.5	4032.2	03:25:57
	Emerge	2014-04-13 16:02:21	51 30.0162 S 149 59.9400 W	0.8	233	4379				
	End	2014-04-13 16:02:56	51 30.0162 S 149 59.9406 W	0.2	39.9	4132				
	Start	2014-04-13 19:11:30	51 0.0012 S 150 0.0648 W	0.2	232.1	4954				
	Submerge	2014-04-13 19:16:08	51 0.0066 S 150 0.0714 W	0.5	275.8	4963				
35/1	Bottom	2014-04-13 20:31:38	51 0.0186 S 150 0.0588 W	0.7	197.2	4949	-999	4059.8	4031	03:06:41
	Emerge	2014-04-13 22:17:13	51 0.0240 S 150 0.0420 W	1	305.2	4978				
	End	2014-04-13 22:18:11	51 0.0246 S 150 0.0444 W	0.9	216.1	4069				
NASA SS/C 35/2 IOP CAGE START	Start	2014-04-13 22:57:00	51 0.0336 S 150 0.0504 W	1.3	215.6	4958				
NASA SS/C 35/2 IOP CAGE END	Start	2014-04-13 23:30:11	51 0.0180 S 150 0.0390 W	0.1	323.8	4947				
Drifter S/N 114676 AOML Drifter	Start	2014-04-13 23:41:00	51 0.0534 S 149 59.9130 W	1.4	81.2	4932				
Drifter S/N 114677 AOML Drifter	Start	2014-04-13 23:41:01	51 0.0528 S 149 59.9118 W	2.2	55.5	4932				
Drifter S/N 114683 AOML Drifter	Start	2014-04-13 23:42:00	51 0.0552 S 149 59.8884 W	1.4	63.7	4947				
36/1	Start	2014-04-14 02:57:20	50 29.9838 S 149 59.9892 W	0.1	359.6	4437				

	Submerge	2014-04-14 03:02:06	50 29.9868 S 149 59.9922 W	0.8	287.1	4431				
	Bottom	2014-04-14 04:26:53	50 29.9994 S 150 0.0030 W	0.3	184.4	4442	-999	4059.6	4031.2	03:32:05
	Emerge	2014-04-14 06:28:13	50 29.9970 S 149 59.9964 W	0.9	352.2	4614				
	End	2014-04-14 06:29:25	50 29.9976 S 149 59.9952 W	0.4	221.9	4437				
NASA SS/C 37/1 IOP CAGE START	Start	2014-04-14 09:47:42	50 0.0810 S 150 0.0270 W	0.8	338.5	4712				
NASA SS/C 37/1 IOP CAGE END	Start	2014-04-14 10:20:42	50 0.0792 S 150 0.0228 W	0.6	16.9	4370				
	Start	2014-04-14 10:29:05	50 0.0798 S 150 0.0240 W	0.4	312.4	4752				
	Submerge	2014-04-14 10:32:39	50 0.0780 S 150 0.0234 W	0.5	138.6	4470				
37/2	Bottom	2014-04-14 11:50:17	50 0.0792 S 150 0.0216 W	0.8	339.4	4257	-999	4055.2	4032.7	03:08:29
	Emerge	2014-04-14 13:36:07	50 0.0798 S 150 0.0150 W	0.2	75.6	4257				
	End	2014-04-14 13:37:34	50 0.0798 S 150 0.0138 W	0.6	241.9	4292				
Float S/N 9095 Argo (ONFp)	Start	2014-04-14 14:00:00	49 59.6136 S 149 59.5788 W	1.3	26.5	4189				
	Start	2014-04-14 18:10:25	49 30.0306 S 150 0.0144 W	1	357.7	4179				
	Submerge	2014-04-14 18:15:24	49 30.0222 S 150 0.0168 W	0.3	114.3	4183				
38/1	Bottom	2014-04-14 19:28:46	49 30.0162 S 150 0.0150 W	0	158.9	4178	-999	4058.2	4031	03:03:25
	Emerge	2014-04-14 21:13:10	49 30.0168 S 150 0.0030 W	0.3	176.1	4178				
	End	2014-04-14 21:13:50	49 30.0156 S 150 0.0042 W	0.3	64.1	4177				
NASA SS/C 38/2 IOP CAGE START	Start	2014-04-14 21:25:05	49 30.0150 S 149 59.9982 W	0.4	243.1	4179				
NASA SS/C 38/2 IOP CAGE END	Start	2014-04-14 21:48:38	49 30.0156 S 149 59.9988 W	0.7	47.5	4170				
	Start	2014-04-15 08:47:44	49 0.0240 S 150 0.0096 W	0.8	55.2	5045				
39/3	Submerge	2014-04-15 08:51:14	49 0.0246 S 150 0.0096 W	1	46.7	4987				
	Bottom	2014-04-15 11:45:00	49 0.0210 S 150 0.0018 W	0.5	180.9	5043	10.4	5176.6	5074.3	06:28:43

	Emerge	2014-04-15 15:15:20	49 0.0216 S 150 0.0024 W	0.4	18.8	5131				
	End	2014-04-15 15:16:27	49 0.0210 S 150 0.0012 W	0.3	206	5148				
Drifter S/N 114588 AOML Drifter	Start	2014-04-15 15:31:00	48 59.9832 S 150 0.0138 W	1.9	357.1	5149				
Drifter S/N 116380 AOML Drifter	Start	2014-04-15 15:32:00	48 59.9430 S 150 0.0282 W	2.7	350.7	5144				
NASA SS/C 40/1 IOP CAGE START	Start	2014-04-15 20:18:22	48 20.0244 S 149 59.9814 W	0.4	88.4	4859				
NASA SS/C 40/1 IOP CAGE END	Start	2014-04-15 20:45:39	48 20.0166 S 149 59.9712 W	0.6	175.1	4865				
	Start	2014-04-15 21:05:23	48 20.0184 S 149 59.9778 W	0.3	66.1	5048				
	Submerge	2014-04-15 21:07:21	48 20.0196 S 149 59.9832 W	1	271.1	4868				
40/2	Bottom	2014-04-15 22:40:36	48 20.0304 S 150 0.0084 W	0.3	289.3	5207	11.1	4898.4	4805	03:56:19
	Emerge	2014-04-16 00:57:34	48 20.0292 S 150 0.0078 W	1.4	233	4863				
	End	2014-04-16 01:01:42	48 20.0304 S 150 0.0102 W	1.6	218.4	4858				
	Start	2014-04-16 06:09:39	47 40.0716 S 150 0.0540 W	0.9	8.6	4902				
	Submerge	2014-04-16 06:11:16	47 40.0776 S 150 0.0630 W	1.4	222.3	4775				
41/1	Bottom	2014-04-16 07:43:06	47 40.0230 S 149 59.9994 W	0.5	170.3	4720	7.4	4805.6	4711.3	03:47:02
	Emerge	2014-04-16 09:54:48	47 40.0128 S 149 59.9832 W	0.8	354.1	4724				
	End	2014-04-16 09:56:41	47 40.0092 S 149 59.9790 W	0.5	187.7	4845				
	Start	2014-04-16 14:26:44	47 0.0012 S 149 59.9820 W	0.3	315.6	5103				
	Submerge	2014-04-16 14:29:29	47 0.0018 S 149 59.9808 W	0.9	313.2	4663				
42/1	Bottom	2014-04-16 16:11:49	47 0.0030 S 149 59.9814 W	0.3	168.8	5104	8.5	5187.7	5084.2	04:16:49
	Emerge	2014-04-16 18:42:56	47 0.0132 S 149 59.9988 W	0.2	166.2	5088				
	End	2014-04-16 18:43:33	47 0.0108 S 149 59.9988 W	0.6	254.8	5135				

Drifter S/N 114534 AOML Drifter	Start	2014-04-16 18:50:00	46 59.9658 S 150 0.0762 W	4	347.3	5079				
Drifter S/N 116373 AOML Drifter	Start	2014-04-16 18:50:01	46 59.9646 S 150 0.0768 W	4	352.6	5079				
NASA SS/C 43/1 HYPERPRO START	Start	2014-04-16 23:24:54	46 20.1168 S 149 59.5722 W	1.1	120.1	5203				
NASA SS/C 43/1 HYPERPRO END	Start	2014-04-16 23:37:43	46 20.2116 S 149 59.3094 W	0.7	89.2	5224				
NASA SS/C 43/2 IOP CAGE START	Start	2014-04-16 23:55:33	46 20.3034 S 149 59.2098 W	0.1	111.8	5541				
NASA SS/C 43/2 IOP CAGE END	Start	2014-04-17 00:25:27	46 20.3022 S 149 59.2092 W	0.4	115.3	5199				
	Start	2014-04-17 00:46:54	46 20.0004 S 149 59.9478 W	0.4	13.8	5375				
	Submerge	2014-04-17 00:49:51	46 20.0040 S 149 59.9706 W	0.7	35.8	5233				
43/3	Bottom	2014-04-17 02:37:27	46 20.0004 S 149 59.9826 W	0.1	151.9	5246	10.6	5289	5188.2	04:24:01
	Emerge	2014-04-17 05:09:29	46 20.0022 S 149 59.9832 W	0.8	82.3	5364				
	End	2014-04-17 05:10:55	46 20.0034 S 149 59.9808 W	0.1	184.6	5195				
	Start	2014-04-17 09:28:55	45 40.0260 S 149 59.9922 W	1.4	200.4	5163				
	Submerge	2014-04-17 09:31:06	45 40.0290 S 149 59.9934 W	0.2	257.2	-999				
44/1	Bottom	2014-04-17 11:08:49	45 39.9822 S 149 59.9892 W	0.7	33.9	5162	8.6	5256.1	5151.2	04:06:31
	Emerge	2014-04-17 13:34:46	45 39.9882 S 149 59.9916 W	0.4	100.9	-999				
	End	2014-04-17 13:35:26	45 39.9900 S 149 59.9922 W	0.2	1.5	5162				
	Start	2014-04-17 17:54:29	44 59.9796 S 150 0.0222 W	0.2	146.8	5320				
	Submerge	2014-04-17 18:04:41	44 59.9832 S 150 0.0156 W	0.2	76.4	5379				
45/1	Bottom	2014-04-17 19:47:52	45 0.0102 S 149 59.9808 W	0.3	125	5350	9.1	5468.2	5354.2	04:25:28
	Emerge	2014-04-17 22:17:58	44 59.9982 S 149 59.9790 W	0.6	10.2	-999				
	End	2014-04-17 22:19:57	44 59.9964 S 149 59.9874 W	0.2	342.3	5358				

NASA SS/C 45/1 IOP CAGE START	Start	2014-04-17 22:34:12	44 59.9772 S 150 0.0552 W	0.6	111.4	5303				
NASA SS/C 45/1 IOP CAGE END	Start	2014-04-17 23:04:50	44 59.9658 S 150 0.0744 W	0.8	306.7	5364				
Float S/N 9101 Argo (Op)	Start	2014-04-18 01:00:00	44 58.8804 S 149 59.7498 W	4	12.4	6026				
Drifter S/N 114668 AOML Drifter	Start	2014-04-18 01:06:00	44 58.4202 S 149 59.5488 W	5.6	14	5248				
Drifter S/N 114541 AOML Drifter	Start	2014-04-18 01:07:00	44 58.3320 S 149 59.5140 W	5	9.7	5247				
	Start	2014-04-18 05:03:33	44 19.9698 S 150 0.0552 W	0.7	34.8	4869				
	Submerge	2014-04-18 05:14:48	44 19.9704 S 150 0.0534 W	1.2	44	4871				
46/1	Bottom	2014-04-18 06:58:35	44 19.9920 S 150 0.0156 W	0.4	356.9	4863	7.8	4966.1	4864.1	04:07:08
	Emerge	2014-04-18 09:08:50	44 19.9932 S 150 0.0378 W	0.6	66.6	4859				
	End	2014-04-18 09:10:41	44 19.9932 S 150 0.0414 W	0.3	262.2	4864				
	Start	2014-04-18 13:30:08	43 39.9780 S 149 59.9688 W	0.6	47.1	5195				
	Submerge	2014-04-18 13:33:05	43 39.9900 S 149 59.9436 W	1.5	38.8	5190				
47/1	Bottom	2014-04-18 15:22:52	43 39.9786 S 150 0.0012 W	0.8	327.7	-999	9.3	5282.6	5181.2	04:24:16
	Emerge	2014-04-18 17:53:21	43 39.9780 S 149 59.9934 W	0.4	9.9	5189				
	End	2014-04-18 17:54:24	43 39.9780 S 149 59.9934 W	0.5	87.6	5183				
NASA SS/C 48/1 HYPERPRO START	Start	2014-04-18 22:14:10	42 59.9580 S 149 59.9460 W	0.7	50.2	5184				
NASA SS/C 48/1 HYPERPRO END	Start	2014-04-18 22:26:34	42 59.8212 S 149 59.9208 W	0.4	356.1	5160				
NASA SS/C 48/2 IOP CAGE START	Start	2014-04-18 22:44:23	42 59.7306 S 149 59.8674 W	0.2	26.8	5716				
NASA SS/C 48/2 IOP CAGE END	Start	2014-04-18 23:13:46	42 59.7324 S 149 59.8698 W	0.4	264.7	5770				
48/3	Start	2014-04-18 23:24:01	42 59.7306 S 149 59.8668 W	0.5	22.5	5174				

	Submerge	2014-04-18 23:25:39	42 59.7306 S 149 59.8656 W	0.3	249.4	5152			
	Bottom	2014-04-19 01:21:38	42 59.7324 S 149 59.8686 W	0.5	123.6	5165	8.7	5250.7	5154.2 04:31:25
	Emerge	2014-04-19 03:53:33	42 59.7324 S 149 59.8674 W	0.8	243.5	5172			
	End	2014-04-19 03:55:26	42 59.7318 S 149 59.8662 W	0.2	312.5	5169			
Drifter S/N 114084 AOML Drifter	Start	2014-04-19 04:21:00	42 57.0444 S 150 0.0462 W	10.1	4.5	5186			
	Start	2014-04-19 08:06:48	42 19.9830 S 149 59.9898 W	0.3	241.8	5253			
	Submerge	2014-04-19 08:09:11	42 19.9878 S 149 59.9964 W	0.1	267.8	5260			
49/1	Bottom	2014-04-19 09:54:12	42 19.9908 S 150 0.0018 W	1.8	49.2	5254	7.2	5350.1	5249.2 04:16:56
	Emerge	2014-04-19 12:22:10	42 19.9908 S 150 0.0012 W	0.5	111.1	5253			
	End	2014-04-19 12:23:44	42 19.9920 S 150 0.0006 W	0.4	290.2	5384			
	Start	2014-04-19 16:26:06	41 39.9828 S 150 0.0006 W	0.2	61.5	5319			
	Submerge	2014-04-19 16:29:29	41 39.9858 S 149 59.9988 W	0.5	228.6	5327			
50/1	Bottom	2014-04-19 18:12:52	41 39.9888 S 150 0.0084 W	0.4	92.8	-999	9	5428.7	5319.6 04:07:57
	Emerge	2014-04-19 20:33:36	41 39.9918 S 150 0.0132 W	0.4	66.8	5325			
	End	2014-04-19 20:34:03	41 39.9912 S 150 0.0138 W	0.2	10	5319			
NASA SS/C 51/1 HYPERPRO START	Start	2014-04-20 01:01:14	41 0.1320 S 149 59.9910 W	0.5	161.7	2564			
NASA SS/C 51/1 HYPERPRO END	Start	2014-04-20 01:15:03	41 0.1626 S 150 0.0072 W	0.6	23.2	-999			
NASA SS/C 51/2 IOP CAGE START	Start	2014-04-20 01:25:16	41 0.1782 S 149 59.9682 W	0.5	348.8	-999			
NASA SS/C 51/2 IOP CAGE END	Start	2014-04-20 01:55:17	41 0.1746 S 149 59.9886 W	0.3	172.3	-999			
	Start	2014-04-20 02:02:50	41 0.1740 S 149 59.9880 W	0.5	219.6	5186			
51/3	Submerge	2014-04-20 02:06:33	41 0.1758 S 149 59.9886 W	0.1	81.2	5163			

	Bottom	2014-04-20 03:52:14	41 0.1884 S 149 59.9988 W	0.8	357	5162	9.9	5262.2	5161.1 04:18:03
	Emerge	2014-04-20 06:19:23	41 0.1632 S 149 59.9952 W	0.4	350	-999			
	End	2014-04-20 06:20:53	41 0.1626 S 149 59.9952 W	0.7	205.5	5433			
Drifter S/N 116377 AOML Drifter	Start	2014-04-20 06:40:00	40 58.1214 S 150 0.0192 W	10.4	357	5302			
	Start	2014-04-20 10:24:50	40 19.9752 S 150 0.0414 W	0.2	72.2	5482			
	Submerge	2014-04-20 10:26:28	40 19.9746 S 150 0.0438 W	0.5	341.6	5711			
52/1	Bottom	2014-04-20 12:10:35	40 19.9758 S 150 0.0420 W	0.6	4.1	5173	9.6	5257.2	5160.3 04:04:21
	Emerge	2014-04-20 14:28:31	40 19.9740 S 150 0.0438 W	0.1	200.5	5164			
	End	2014-04-20 14:29:11	40 19.9752 S 150 0.0432 W	1.4	182.1	5159			
	Start	2014-04-20 18:48:16	39 40.0320 S 150 0.0318 W	0.2	121.6	5268			
	Submerge	2014-04-20 18:50:59	39 40.0374 S 150 0.0246 W	0.6	21.3	-999			
53/1	Bottom	2014-04-20 20:33:35	39 40.0260 S 150 0.0174 W	1.3	0.7	-999	10.1	5366.4	5259.1 04:11:47
	Emerge	2014-04-20 22:58:20	39 40.0914 S 149 59.9742 W	0.4	346.5	5264			
	End	2014-04-20 23:00:03	39 40.0872 S 149 59.9754 W	0.5	308.8	-999			
NASA SS/C 53/2 IOP CAGE START	Start	2014-04-20 23:09:36	39 40.0362 S 150 0.0090 W	1	352.6	-999			
NASA SS/C 53/2 IOP CAGE END	Start	2014-04-20 23:37:35	39 40.0164 S 150 0.0168 W	0.4	199.5	-999			
Float S/N 9254 Argo (ONFp)	Start	2014-04-20 23:56:00	39 39.7842 S 149 59.2536 W	1.7	88.8	5287			
	Start	2014-04-21 04:54:51	39 0.0066 S 150 0.0150 W	0.5	54.2	5487			
	Submerge	2014-04-21 04:57:39	39 0.0078 S 150 0.0156 W	0.3	348.9	5879			
54/1	Bottom	2014-04-21 06:56:16	39 0.0126 S 150 0.0186 W	0.6	320.7	-999	6.9	5594.5	5482.3 04:32:58
	Emerge	2014-04-21 09:26:16	39 0.0288 S 150 0.0216 W	0.7	159	5491			
	End	2014-04-21 09:27:49	39 0.0372 S 150 0.0180 W	1.1	181.3	-999			

	Start	2014-04-21 16:21:17	38 20.0178 S 149 59.9868 W	1.3	358.3	5894				
	Submerge	2014-04-21 16:23:31	38 20.0190 S 149 59.9874 W	1.6	191	5597				
55/1	Bottom	2014-04-21 18:19:11	38 20.0112 S 149 59.9922 W	0.9	169.8	5456	9.9	5556.7	5445.3	04:28:22
	Emerge	2014-04-21 20:48:49	38 20.0748 S 150 0.0204 W	0.1	115.4	5457				
	End	2014-04-21 20:49:39	38 20.0796 S 150 0.0228 W	0.4	93.9	5457				
NASA SS/C 56/1 IOP CAGE START	Start	2014-04-22 05:04:07	37 40.0038 S 149 59.9796 W	0.5	97	5632				
NASA SS/C 56/1 IOP CAGE END	Start	2014-04-22 05:34:03	37 40.0056 S 149 59.9856 W	1	42.1	5952				
	Start	2014-04-22 05:41:57	37 40.0050 S 149 59.9850 W	0.9	37.2	-999				
	Submerge	2014-04-22 05:46:20	37 40.0056 S 149 59.9850 W	0.9	205.5	5639				
56/2	Bottom	2014-04-22 07:55:45	37 40.0080 S 149 59.9862 W	0.2	17.2	5636	8.1	5739.6	5627.5	04:48:12
	Emerge	2014-04-22 10:29:09	37 40.0062 S 149 59.9874 W	0.8	207.5	5539				
	End	2014-04-22 10:30:09	37 40.0062 S 149 59.9856 W	0.6	226.9	5634				
	Start	2014-04-22 15:32:56	37 0.0150 S 149 59.9898 W	1.3	221.5	5570				
	Submerge	2014-04-22 15:35:05	37 0.0150 S 149 59.9898 W	0.3	73.1	5559				
57/1	Bottom	2014-04-22 17:20:00	37 0.0048 S 149 59.9862 W	0.4	204.6	5929	8.8	5670.5	5554.9	04:18:36
	Emerge	2014-04-22 19:50:36	37 0.0054 S 149 59.9868 W	0.7	236.4	5782				
	End	2014-04-22 19:51:32	37 0.0060 S 149 59.9856 W	0.5	114.9	5813				
NASA SS/C 58/1 HYPERPRO START	Start	2014-04-23 00:46:18	36 19.9278 S 149 59.9058 W	0.4	68	-999				
NASA SS/C 58/1 HYPERPRO END	Start	2014-04-23 01:01:46	36 19.7994 S 149 59.6760 W	0.9	32.5	5725				
NASA SS/C 58/2 IOP CAGE START	Start	2014-04-23 01:16:55	36 19.7418 S 149 59.5458 W	0.2	229.9	5848				
NASA SS/C 58/2 IOP CAGE END	Start	2014-04-23 01:48:57	36 19.7418 S 149 59.5482 W	0.3	22.1	5408				
58/3	Start	2014-04-23 01:58:27	36 19.7412 S 149 59.5476 W	0.2	230.4	-999				

	Submerge	2014-04-23 02:00:40	36 19.7424 S 149 59.5482 W	0.1	22.6	5406				
	Bottom	2014-04-23 03:47:34	36 19.7418 S 149 59.5470 W	0.5	153.5	-999	7.8	5511	5403.4	04:22:55
	Emerge	2014-04-23 06:21:01	36 19.7466 S 149 59.5470 W	0.2	157.7	5425				
	End	2014-04-23 06:21:22	36 19.7460 S 149 59.5470 W	0.4	342.6	5426				
	Start	2014-04-23 10:33:06	35 40.0104 S 149 59.9736 W	0.3	313.2	5319				
	Submerge	2014-04-23 10:36:33	35 40.0110 S 149 59.9730 W	0.5	118.9	5324				
59/1	Bottom	2014-04-23 12:16:44	35 40.0098 S 149 59.9736 W	0.1	213.8	5317	8.7	5412.8	5312	04:05:35
	Emerge	2014-04-23 14:37:48	35 40.0374 S 149 59.9700 W	1.1	166.8	5323				
	End	2014-04-23 14:38:41	35 40.0470 S 149 59.9700 W	0.7	178.8	5319				
	Start	2014-04-23 18:52:19	34 59.9964 S 149 59.9832 W	0.3	26.6	5442				
	Submerge	2014-04-23 18:54:14	34 59.9940 S 149 59.9856 W	0.2	234.7	5253				
60/1	Bottom	2014-04-23 20:34:27	34 59.9976 S 149 59.9868 W	0.4	171.3	-999	9.8	5354.6	5246.7	03:57:44
	Emerge	2014-04-23 22:48:20	34 59.9970 S 149 59.9850 W	0.4	179.4	15				
	End	2014-04-23 22:50:03	34 59.9964 S 149 59.9844 W	0.1	137.7	5194				
NASA SS/C 60/1 IOP CAGE START	Start	2014-04-23 22:59:56	34 59.9976 S 149 59.9856 W	0.2	252.2	5774				
NASA SS/C 60/1 IOP CAGE END	Start	2014-04-23 23:27:24	34 59.9964 S 149 59.9856 W	0.3	194.1	-999				
NASA SS/C 60/2 HYPERPRO START	Start	2014-04-23 23:39:22	34 59.9724 S 149 59.9154 W	1.4	72.5	5249				
NASA SS/C 60/2 HYPERPRO END	Start	2014-04-23 23:54:47	34 59.9088 S 149 59.7048 W	0.7	58.1	5270				
	Start	2014-04-24 04:00:05	34 19.9938 S 149 59.9826 W	0.3	226.3	-999				
	Submerge	2014-04-24 04:02:49	34 19.9950 S 149 59.9832 W	0.6	33.9	5596				
61/1	Bottom	2014-04-24 05:49:22	34 19.9998 S 149 59.9874 W	0.3	241.3	5720	9.2	5359.3	5249.7	04:08:24
	Emerge	2014-04-24 08:06:46	34 20.0022 S 149 59.9856 W	0.5	161.3	5257				

	End	2014-04-24 08:08:29	34 20.0034 S 149 59.9862 W	0.1	83.3	5264				
	Start	2014-04-24 12:10:41	33 40.0140 S 149 59.9964 W	0.4	27	-999				
	Submerge	2014-04-24 12:11:59	33 40.0128 S 149 59.9970 W	0.2	208.2	5432				
62/1	Bottom	2014-04-24 13:52:58	33 40.0122 S 149 59.9970 W	0.4	237.5	5596	9.5	5536.5	5425	04:02:58
	Emerge	2014-04-24 16:13:09	33 40.0116 S 149 59.9970 W	0.3	356.9	5438				
	End	2014-04-24 16:13:39	33 40.0122 S 149 59.9970 W	0.1	301.9	5432				
NASA SS/C 63/1 IOP CAGE START	Start	2014-04-24 20:19:04	33 0.0354 S 149 59.9904 W	0.1	55.5	5502				
NASA SS/C 63/1 IOP CAGE END	Start	2014-04-24 20:44:46	33 0.0348 S 149 59.9904 W	0.1	34.5	-999				
NASA SS/C 63/2 HYPERPRO START	Start	2014-04-24 21:15:38	33 0.6498 S 149 59.9424 W	1.4	176.1	5537				
NASA SS/C 63/2 HYPERPRO END	Start	2014-04-24 21:24:44	33 0.8682 S 149 59.9502 W	1.4	196.2	5495				
	Start	2014-04-24 21:44:03	33 0.0216 S 150 0.0138 W	0.2	187.1	5735				
	Submerge	2014-04-24 21:45:12	33 0.0216 S 150 0.0144 W	0.3	85.1	5488				
63/3	Bottom	2014-04-24 23:32:19	33 0.0204 S 150 0.0150 W	0.1	313.2	5371	9.3	5547.9	5460.6	04:08:02
	Emerge	2014-04-25 01:50:26	33 0.0210 S 150 0.0144 W	0.5	353.6	5547				
	End	2014-04-25 01:52:05	33 0.0204 S 150 0.0144 W	0.1	101.7	5513				
	Start	2014-04-25 06:08:05	32 20.0328 S 150 0.0060 W	0.3	250.6	5267				
	Submerge	2014-04-25 06:11:11	32 20.0328 S 150 0.0072 W	0.1	126	5267				
64/1	Bottom	2014-04-25 07:52:43	32 20.0304 S 150 0.0108 W	0.3	208.6	5244	8	5340.6	5237.3	04:07:33
	Emerge	2014-04-25 10:14:18	32 20.0250 S 150 0.0144 W	0.1	139.8	5259				
	End	2014-04-25 10:15:38	32 20.0250 S 150 0.0144 W	0.4	304.2	-999				
	Start	2014-04-25 15:25:33	31 40.0140 S 149 59.9982 W	0.3	133.6	-999				
65/1	Submerge	2014-04-25 15:28:48	31 40.0140 S 149 59.9982 W	0.3	243	4980				

	Bottom	2014-04-25 17:03:09	31 40.0134 S 149 59.9988 W	0.1	226.3	5034	9.7	5124.6	5019.1	03:48:46
	Emerge	2014-04-25 19:13:08	31 40.0128 S 150 0.0006 W	0.1	28.9	-999				
	End	2014-04-25 19:14:19	31 40.0128 S 149 59.9994 W	0.6	268	4980				
NASA SS/C 66/1 IOP CAGE START	Start	2014-04-26 00:40:05	31 0.0084 S 149 59.9496 W	1.1	210.8	-999				
NASA SS/C 66/1 IOP CAGE END	Start	2014-04-26 01:07:45	31 0.0078 S 149 59.9490 W	0.2	139.7	4196				
	Start	2014-04-26 01:14:48	31 0.0084 S 149 59.9484 W	0.4	119.6	4272				
	Submerge	2014-04-26 01:17:59	31 0.0090 S 149 59.9496 W	0.5	9.3	4272				
66/2	Bottom	2014-04-26 02:43:47	31 0.0174 S 149 59.9760 W	0.9	197.7	4246	8.6	4334.4	4249.9	03:28:16
	Emerge	2014-04-26 04:41:21	31 0.0132 S 149 59.9742 W	0.3	62.8	-999				
	End	2014-04-26 04:43:04	31 0.0132 S 149 59.9736 W	0.2	98.1	-999				
	Start	2014-04-26 09:28:01	30 20.0016 S 149 59.9892 W	0.9	240.5	5339				
	Submerge	2014-04-26 09:29:25	30 19.9980 S 149 59.9904 W	0.5	338.5	4833				
67/1	Bottom	2014-04-26 11:06:46	30 19.9692 S 149 59.9952 W	0.9	127.2	4825	9.3	4902.9	4803.8	03:47:41
	Emerge	2014-04-26 13:14:39	30 19.9194 S 150 0.0102 W	0.3	256.3	4817				
	End	2014-04-26 13:15:42	30 19.9146 S 150 0.0012 W	0.8	358.6	-999				
	Start	2014-04-26 18:13:11	29 39.9804 S 149 59.9904 W	0.4	289.7	4235				
	Submerge	2014-04-26 18:16:00	29 39.9648 S 150 0.0090 W	0.4	15.5	4237				
68/1	Bottom	2014-04-26 19:45:49	29 39.9672 S 150 0.0204 W	0.7	148.9	4240	9.3	4323.4	4235	03:24:28
	Emerge	2014-04-26 21:36:53	29 39.9810 S 150 0.0084 W	0.3	58.3	4248				
	End	2014-04-26 21:37:39	29 39.9786 S 150 0.0138 W	0.2	48.3	4224				
NASA SS/C 68/2 IOP CAGE START	Start	2014-04-26 21:52:34	29 39.9600 S 150 0.0342 W	0.3	208.7	4225				
NASA SS/C 68/2 IOP CAGE END	Start	2014-04-26 22:20:15	29 39.9642 S 150 0.0294 W	0.3	115.9	4211				

	Start	2014-04-27 03:03:29	28 59.9742 S 149 59.9874 W	0.3	38.5	4610				
	Submerge	2014-04-27 03:04:55	28 59.9736 S 149 59.9874 W	0.6	80.8	4608				
69/1	Bottom	2014-04-27 04:38:48	28 59.9760 S 149 59.9832 W	1.6	41.1	4602	7.4	4695.6	4599.9	03:41:59
	Emerge	2014-04-27 06:43:56	28 59.9742 S 149 59.9802 W	0.2	48.5	4380				
	End	2014-04-27 06:45:28	28 59.9730 S 149 59.9838 W	1	41.6	4604				
	Start	2014-04-27 10:56:00	28 19.9998 S 149 59.9826 W	1.9	278.5	5112				
	Submerge	2014-04-27 11:01:32	28 19.9788 S 150 0.0024 W	0.4	107.2	15				
70/1	Bottom	2014-04-27 12:36:58	28 19.9824 S 150 0.0000 W	0.2	90.2	5124	8.8	5209.3	5106.1	04:03:38
	Emerge	2014-04-27 14:58:22	28 20.0046 S 149 59.9508 W	0.6	134	15				
	End	2014-04-27 14:59:38	28 20.0088 S 149 59.9400 W	0.6	127.9	-999				
	Start	2014-04-27 19:14:08	27 39.9894 S 149 59.9778 W	0.9	159.4	4390				
	Submerge	2014-04-27 19:15:26	27 39.9900 S 149 59.9766 W	0.4	292.6	4389				
71/1	Bottom	2014-04-27 20:41:25	27 39.9906 S 149 59.9976 W	0.4	283.8	4391	9.7	4457.6	4367.1	03:25:37
	Emerge	2014-04-27 22:37:57	27 39.9900 S 149 59.9946 W	0.3	297.4	4392				
	End	2014-04-27 22:39:45	27 39.9888 S 149 59.9862 W	0.4	166.7	4387				
NASA SS/C 71/2 IOP CAGE START	Start	2014-04-27 22:50:34	27 39.9936 S 149 59.9808 W	0.7	338.9	4385				
NASA SS/C 71/2 IOP CAGE END	Start	2014-04-27 23:18:08	27 39.9942 S 149 59.9682 W	0.4	248.6	4366				
NASA SS/C 71/3 HYPERPRO START	Start	2014-04-27 23:27:15	27 39.9642 S 149 59.9688 W	0.8	160.7	4382				
NASA SS/C 71/3 HYPERPRO END	Start	2014-04-27 23:40:16	27 39.9192 S 149 59.8746 W	0.7	169.4	4416				
NASA SS/C 71/4 HYPERPRO START	Start	2014-04-27 23:41:01	27 39.9186 S 149 59.8698 W	0.7	86.7	4453				
NASA SS/C 71/4 HYPERPRO END	Start	2014-04-27 23:49:47	27 39.8784 S 149 59.8362 W	0.4	55.3	4488				

	Start	2014-04-28 03:53:58	26 59.9862 S 150 0.0090 W	0.4	193.7	4713				
	Submerge	2014-04-28 03:55:47	26 59.9880 S 150 0.0078 W	0.1	40.7	4971				
72/1	Bottom	2014-04-28 05:36:26	26 59.9874 S 150 0.0060 W	0.7	48.9	4727	8.8	4802.9	4703.5	03:57:20
	Emerge	2014-04-28 07:50:40	26 59.9898 S 150 0.0108 W	0.6	19.3	4737				
	End	2014-04-28 07:51:18	26 59.9904 S 150 0.0114 W	0.3	196.4	4713				
	Start	2014-04-28 11:57:55	26 19.9974 S 150 0.0288 W	0.1	159.1	4893				
	Submerge	2014-04-28 11:59:21	26 19.9968 S 150 0.0282 W	0.1	242.6	4737				
73/1	Bottom	2014-04-28 13:28:12	26 19.9914 S 150 0.0282 W	0.3	241.1	4735	9.2	4796.7	4701	03:35:20
	Emerge	2014-04-28 15:32:22	26 19.9908 S 150 0.0282 W	0.2	23.6	4418				
	End	2014-04-28 15:33:15	26 19.9920 S 150 0.0282 W	0.2	220.1	4678				
NASA SS/C 74/1 IOP CAGE START	Start	2014-04-28 19:51:43	25 39.9954 S 150 0.0030 W	0.6	184.6	4519				
NASA SS/C 74/1 IOP CAGE END	Start	2014-04-28 20:15:37	25 39.9936 S 150 0.0108 W	0.6	153.3	4518				
	Start	2014-04-28 20:19:18	25 39.9924 S 150 0.0090 W	0.2	171.9	4530				
	Submerge	2014-04-28 20:21:18	25 39.9930 S 150 0.0096 W	0.5	98.7	4526				
74/2	Bottom	2014-04-28 21:44:04	25 39.9966 S 150 0.0168 W	0.6	0.5	-999	8.7	4606.4	4513.7	03:22:21
	Emerge	2014-04-28 23:40:04	25 39.9960 S 150 0.0150 W	0.2	308.7	4526				
	End	2014-04-28 23:41:39	25 39.9972 S 150 0.0156 W	0.4	340.7	4524				
NASA SS/C 74/3 HYPERPRO START	Start	2014-04-28 23:52:35	25 39.9960 S 150 0.0108 W	0.1	124.8	4505				
NASA SS/C 74/3 HYPERPRO END	Start	2014-04-28 23:57:21	25 40.0062 S 150 0.0096 W	1.2	185.8	4520				
	Start	2014-04-29 04:51:51	24 59.9886 S 150 0.0084 W	0.7	190.5	4596				
75/1	Submerge	2014-04-29 04:53:26	24 59.9898 S 150 0.0096 W	0.4	353.9	4582				
	Bottom	2014-04-29 06:29:08	24 59.9898 S 150 0.0072 W	0.4	8	4599	8.3	4687.9	4591.5	03:40:21

	Emerge	2014-04-29 08:30:55	24 59.9976 S 150 0.0216 W	0.5	291.6	4601				
	End	2014-04-29 08:32:12	24 59.9994 S 150 0.0252 W	0.4	232.5	5032				
	Start	2014-04-29 12:44:12	24 19.9932 S 149 59.9982 W	0.8	260.2	5322				
	Submerge	2014-04-29 12:50:40	24 19.9860 S 150 0.0132 W	0.2	334.4	5130				
76/1	Bottom	2014-04-29 14:26:23	24 19.9824 S 150 0.0048 W	0.4	36.4	5118	9	5213.6	5109.7	03:58:50
	Emerge	2014-04-29 16:42:01	24 19.9818 S 150 0.0042 W	0.4	62.2	5091				
	End	2014-04-29 16:43:02	24 19.9830 S 150 0.0042 W	0.1	117.3	5128				
	Start	2014-04-29 21:52:39	23 39.9486 S 150 0.0630 W	0.6	227.2	4759				
	Submerge	2014-04-29 21:57:20	23 39.9492 S 150 0.0618 W	0.3	92.7	4735				
77/3	Bottom	2014-04-29 23:32:26	23 39.9480 S 150 0.0624 W	0.3	325	4717	8.7	4819.4	4728	03:41:26
	Emerge	2014-04-30 01:32:31	23 39.9486 S 150 0.0636 W	0.3	171.8	4736				
	End	2014-04-30 01:34:05	23 39.9492 S 150 0.0624 W	0.2	8.2	5503				
	Start	2014-04-30 05:44:06	22 59.9898 S 150 0.0102 W	0.1	159.2	4852				
	Submerge	2014-04-30 05:46:13	22 59.9898 S 150 0.0096 W	0.6	179.8	5742				
78/1	Bottom	2014-04-30 07:24:28	22 59.9952 S 150 0.0150 W	0.1	123.3	-999	7.7	4950.7	4848.4	03:55:14
	Emerge	2014-04-30 09:38:48	22 59.9904 S 150 0.0126 W	0.5	274.7	4854				
	End	2014-04-30 09:39:20	22 59.9928 S 150 0.0162 W	0.8	253.1	-999				
	Start	2014-04-30 13:48:16	22 19.9758 S 150 0.0114 W	0.4	128.1	4864				
	Submerge	2014-04-30 13:50:11	22 19.9746 S 150 0.0108 W	0.5	12.5	5262				
79/1	Bottom	2014-04-30 15:24:30	22 19.9782 S 150 0.0138 W	0.5	309.2	-999	8.5	5004.1	4904	03:49:09
	Emerge	2014-04-30 17:36:39	22 19.9824 S 150 0.0228 W	0.2	246.2	5411				
	End	2014-04-30 17:37:25	22 19.9842 S 150 0.0276 W	0.8	269.8	5332				
NASA SS/C 80/1 IOP CAGE START	Start	2014-04-30 21:52:21	21 39.9930 S 150 0.0198 W	0.4	277.6	5372				

NASA SS/C 80/1 IOP CAGE END	Start	2014-04-30 22:20:43	21 39.9936 S 150 0.0192 W	0.4	181.6	4679				
NASA SS/C 80/2 HYPERPRO START	Start	2014-04-30 22:28:07	21 40.0038 S 150 0.0144 W	0.6	224.5	4683				
NASA SS/C 80/2 HYPERPRO END	Start	2014-04-30 22:40:16	21 39.9798 S 150 0.0486 W	0.8	332.5	-999				
	Start	2014-04-30 22:46:01	21 39.9768 S 150 0.0468 W	0.4	184.4	5161				
	Submerge	2014-04-30 22:48:30	21 39.9780 S 150 0.0480 W	0.9	201.6	4748				
80/3	Bottom	2014-05-01 00:26:07	21 39.9720 S 150 0.0384 W	1.6	13.6	4691	10.4	4774.2	4683.8	03:42:13
	Emerge	2014-05-01 02:27:36	21 39.9642 S 150 0.0186 W	0.1	312.1	-999				
	End	2014-05-01 02:28:14	21 39.9660 S 150 0.0210 W	0.6	202.9	4689				
	Start	2014-05-01 06:34:40	20 59.9904 S 149 59.9652 W	0.1	265.7	4672				
	Submerge	2014-05-01 06:38:14	20 59.9904 S 149 59.9658 W	0.4	269.9	4283				
81/1	Bottom	2014-05-01 08:03:53	21 0.0048 S 149 59.9946 W	0.7	35.6	4286	8	4359.3	4270.8	03:26:02
	Emerge	2014-05-01 09:59:06	21 0.0084 S 150 0.0030 W	0.4	40.5	4275				
	End	2014-05-01 10:00:42	21 0.0072 S 150 0.0030 W	0.2	56.1	4276				
	Start	2014-05-01 14:12:34	20 19.9908 S 150 0.0150 W	0.3	100.4	3926				
	Submerge	2014-05-01 14:14:08	20 19.9908 S 150 0.0108 W	0.2	266.3	3932				
82/1	Bottom	2014-05-01 15:32:18	20 19.9914 S 150 0.0090 W	0.7	2.7	3931	9.2	4018.8	3935.5	03:14:35
	Emerge	2014-05-01 17:26:02	20 19.9932 S 150 0.0108 W	0.3	88.9	3945				
	End	2014-05-01 17:27:09	20 19.9932 S 150 0.0114 W	0.2	65.2	3948				
NASA SS/C 83/1 IOP CAGE START	Start	2014-05-01 21:38:14	19 39.9918 S 150 0.0018 W	0.1	242.9	3908				
NASA SS/C 83/1 IOP CAGE END	Start	2014-05-01 22:03:40	19 39.9930 S 150 0.0030 W	0.5	18.3	3973				
NASA SS/C 83/2 C-Ops (Kite) END	Start	2014-05-01 22:08:14	19 39.9924 S 150 0.0036 W	0.6	132.1	4330				

NASA SS/C 83/2 C-Ops (Kite) START	Start	2014-05-01 22:41:33	19 39.9030 S 149 59.9802 W	1.1	342.8	4295				
	Start	2014-05-01 23:24:49	19 39.9912 S 150 0.0288 W	0.2	197.1	3971				
	Submerge	2014-05-01 23:27:39	19 39.9900 S 150 0.0288 W	0.7	116.5	3989				
83/3	Bottom	2014-05-02 00:47:07	19 39.9912 S 150 0.0282 W	0.2	3.7	3982	7.7	4030.3	3950	03:18:49
	Emerge	2014-05-02 02:43:24	19 39.9906 S 150 0.0282 W	1	13.1	4331				
	End	2014-05-02 02:43:38	19 39.9894 S 150 0.0276 W	0.5	7.3	3934				
	Start	2014-05-02 06:55:13	19 0.0096 S 150 0.0384 W	0.3	348.3	4286				
	Submerge	2014-05-02 06:57:07	19 0.0078 S 150 0.0390 W	0.8	178.5	4286				
84/1	Bottom	2014-05-02 08:23:49	19 0.0120 S 150 0.0330 W	0.9	358.5	4285	7.1	4354.4	4268.7	03:24:35
	Emerge	2014-05-02 10:18:34	19 0.0114 S 150 0.0246 W	0.9	185.8	4286				
	End	2014-05-02 10:19:48	19 0.0114 S 150 0.0252 W	0.2	345.9	5293				
	Start	2014-05-02 14:24:22	18 19.9992 S 150 0.0150 W	0.6	4.8	5347				
	Submerge	2014-05-02 14:27:17	18 19.9968 S 150 0.0132 W	1.2	339	4919				
85/1	Bottom	2014-05-02 15:49:23	18 19.9962 S 150 0.0126 W	0.6	321.1	4187	10.9	4261.4	4174.3	03:19:25
	Emerge	2014-05-02 17:42:19	18 20.0022 S 150 0.0144 W	0.3	103.3	4184				
	End	2014-05-02 17:43:47	18 19.9968 S 150 0.0132 W	0.2	7.8	4187				
	Start	2014-05-02 23:36:43	17 40.0062 S 150 0.0138 W	0.2	77.9	5604				
	Submerge	2014-05-02 23:37:58	17 40.0062 S 150 0.0144 W	0.2	96.7	4427				
86/2	Bottom	2014-05-03 00:41:07	17 40.0062 S 150 0.0144 W	0.5	335.2	5632	9.2	3062.4	3004	02:38:20
	Emerge	2014-05-03 02:13:04	17 40.0062 S 150 0.0144 W	0.4	175.1	5225				
	End	2014-05-03 02:15:03	17 40.0062 S 150 0.0132 W	0.1	96.2	5778				
	Start	2014-05-03 06:48:53	17 0.0030 S 150 0.0258 W	0.6	203.7	3754				
87/1	Submerge	2014-05-03 06:51:16	17 0.0054 S 150 0.0330 W	0.3	260.6	3756				

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	Bottom	2014-05-03 08:06:52	17 0.0132 S 150 0.0348 W	0.3	239.9	3759	8.8	3823.8	3749.2	03:14:09
	Emerge	2014-05-03 10:02:44	17 0.0114 S 150 0.0294 W	0.1	209.9	3761				
	End	2014-05-03 10:03:02	17 0.0114 S 150 0.0294 W	0.3	189.8	3761				
	Start	2014-05-03 14:11:31	16 19.9866 S 150 0.0012 W	0.4	242.2	4247				
	Submerge	2014-05-03 14:12:20	16 19.9878 S 150 0.0042 W	0.1	321.2	4250				
88/1	Bottom	2014-05-03 15:36:07	16 19.9992 S 150 0.0126 W	0.3	223.3	4251	9	4327.5	4238.8	03:22:44
	Emerge	2014-05-03 17:33:14	16 19.9944 S 150 0.0120 W	0.3	40.7	4251				
	End	2014-05-03 17:34:15	16 19.9950 S 150 0.0120 W	0.1	90.6	5561				
NASA SS/C 89/1 C-Ops (Kite) START	Start	2014-05-03 21:51:52	15 39.9708 S 150 0.0780 W	1.2	243.5	4211				
NASA SS/C 89/1 C-Ops (Kite) END	Start	2014-05-03 22:06:23	15 39.9522 S 150 0.3774 W	0.7	248.6	3921				
NASA SS/C 89/2 IOP CAGE START	Start	2014-05-03 22:20:13	15 39.9570 S 150 0.5046 W	0	39.6	4037				
NASA SS/C 89/2 IOP CAGE END	Start	2014-05-03 22:47:10	15 39.9558 S 150 0.5034 W	0.1	131.3	3990				
	Start	2014-05-03 23:03:01	15 39.9966 S 150 0.0360 W	0.4	330.2	4259				
	Submerge	2014-05-03 23:05:12	15 39.9960 S 150 0.0366 W	0.4	177.9	4274				
89/3	Bottom	2014-05-04 00:31:42	15 39.9972 S 150 0.0342 W	0.4	175.8	4261	8.9	4333.6	4246.3	03:22:41
	Emerge	2014-05-04 02:24:06	15 39.9996 S 150 0.0348 W	0.5	0.8	4276				
	End	2014-05-04 02:25:42	15 39.9990 S 150 0.0348 W	0.3	192.3	4266				
	Start	2014-05-04 06:35:30	15 0.0234 S 150 0.0192 W	0.5	108.5	4404				
	Submerge	2014-05-04 06:36:40	15 0.0228 S 150 0.0174 W	0.5	24.1	4391				
90/1	Bottom	2014-05-04 08:02:31	15 0.0168 S 150 0.0060 W	0.4	213.5	4388	198.9	4466.5	4377.2	03:23:01
	Emerge	2014-05-04 09:56:42	15 0.0144 S 150 0.0072 W	0.4	203.8	4389				
	End	2014-05-04 09:58:31	15 0.0156 S 150 0.0078 W	0.1	339.9	4390				

Cast	Event	When	Where	Speed	Course	Depth MBcntr	DAB	Max Wire Out	Max Z	Duration