Trillium 40/240 Response Issue

****CASCADIA?**

4/17/2013 Don Forsyth discovered some problems with the instrument responses of SIO Trillium 40 s OBS s and one of the 240 s OBS. When the vertical is slightly tilted, there is a strong correlation between horizontal and vertical noise, because the current generated noise on the horizontals is two to three orders of magnitude larger than the vertical noise. The apparent tilt angle should be constant, independent of frequency, and the phase shift between horizontal (in the tilt direction) and vertical should be zero. The T 40's have an obvious phase shift between horizontal and vertical components of the noise when filtered to long periods

4/19/2013 Gabi Laske asked about the source of the T-40 responses. A preliminary wrong version (determined for the Vernon/Levander Venezuela deployment) was circulated. PLUME also has two versions one in a DATALESS for PLUME and one for OBSIP in general

5/13/2013 Jeff Babcock responded that the RESP files at the DMC are (to the best of his knowledge) consistent and correct. He commented that Don is seeing upwards of .6 degree tilt which seems unlikely.

5/16/2013 Don mentions following: RESP files are identical for vertical and horizontals so making a correction would make no difference to the relative response. There are large phase shifts on the instruments. (6-10s). Suggests investigating the same instruments in other deployments to see if the tilt sensor is accurately aligned to the vertical component.

7/2/2013 Forwarding issue to Management Council. There is a DPG calibration chamber at SIO that they have been using to calibrate the instruments.

Problem with instrument responses – SIO Trillium 40s

In attempting to remove the effects of small tilt from the vertical channel, I have discovered problems with the instrument responses of the SIO Trillium 40 s OBSs in our western Pacific PLATE experiment. When the vertical is slightly tilted, there is a strong correlation between horizontal and vertical noise, because the current generated noise on the horizontals is two to three orders of magnitude larger than the vertical noise. Correlation coefficients between horizontal and vertical at long periods during quiet times when there are no earthquakes are often higher than 0.99.

By searching for the maximum correlation, you can find the azimuthal direction of tilt and the apparent tilt angle from vertical. In principle, the apparent tilt angle should be constant, independent of frequency, and the phase shift between horizontal (in the tilt direction) and vertical should be zero. For the Trillium 240 s OBSs, this is approximately true (see later comment for exception to this). However, the T 40's have an obvious phase shift between horizontal and vertical components of the noise when filtered to long periods, even though the noise levels through the course of a day are clearly highly correlated.

To deal with this phase shift, I have derived complex transfer functions between horizontal and vertical, rotating the horizontals to find the direction of maximum coherence between rotated horizontal and vertical, which gives the tilt direction. The transfer function between rotated horizontal and vertical gives you both amplitude and phase shift. If instrument responses for vertical and horizontal were identical, the phase shift should be zero and the amplitude of the transfer function can be translated into apparent tilt.

Figures 1 and 2 compare the amplitude and phase shifts for the transfer functions from horizontal to vertical (based on 21 2000 s noise samples) for the two T40s (OBSs 4 and 15) with the transfer function for one of the T240s (OBS 1). It is clear that the T240 behaves as expected, but amplitudes and phases of the transfer functions for the T40s do not. The phase shifts are quite large and frequency dependent. The poles and zeros supplied are the same for the horizontals as for the vertical, but it is clear that the responses of the horizontal components are different from the vertical. Although not as well constrained (and not illustrated in these figures), it looks like the two horizontal components are approximately equal in response. From this analysis, I can't tell whether the vertical is off or the horizontals, but if I remember right, in our ambient noise analysis, it looked like the vertical on OBS 15 was compatible with the verticals on the T240 at periods approaching 20 s. When we do the long-period Rayleigh wave phase velocity analysis, I will be able to test whether there is a phase shift on the vertical. Bottom line is that it is clear there is both an amplitude and phase shift between horizontal and vertical components on the T40s.

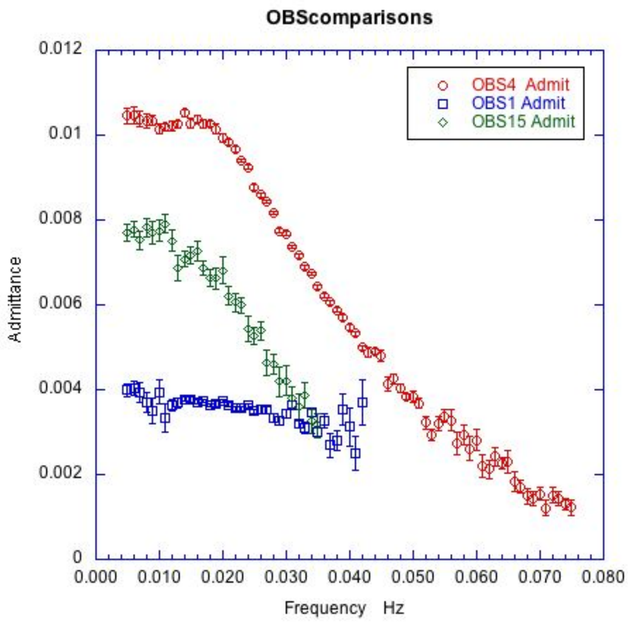


Figure 1. Admittance (amplitude of transfer function) as function of frequency. Absolute amplitude depends on tilt of vertical. Frequency range shown covers the range for each OBS where coherence is > 0.5, but where error bars are small, coherence is > 0.98.

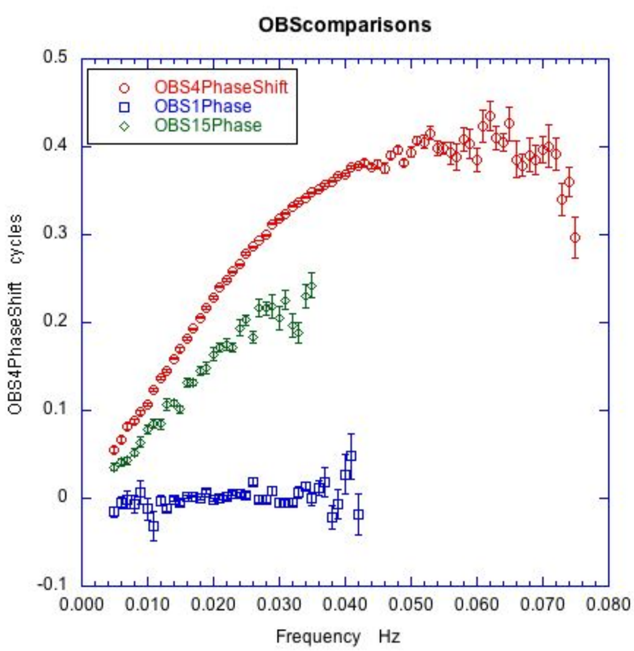
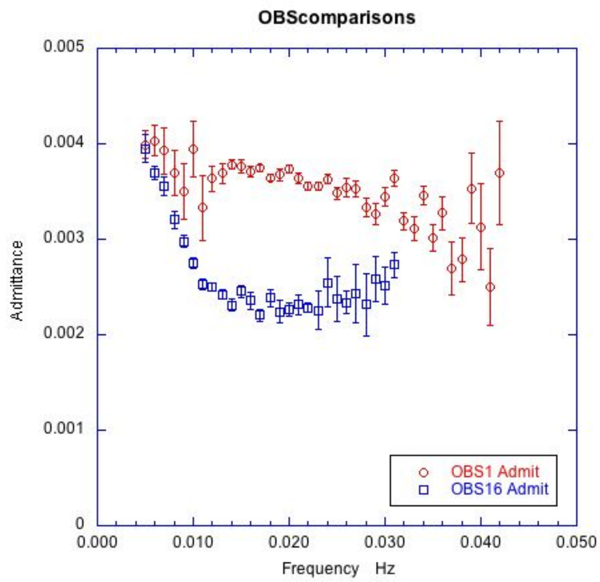
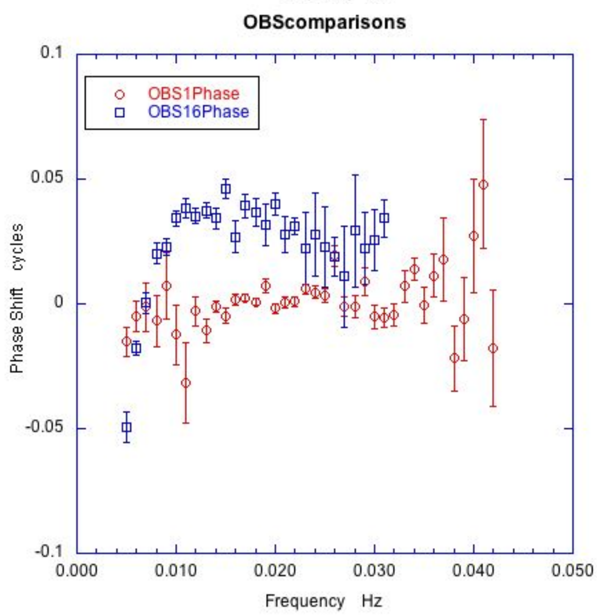


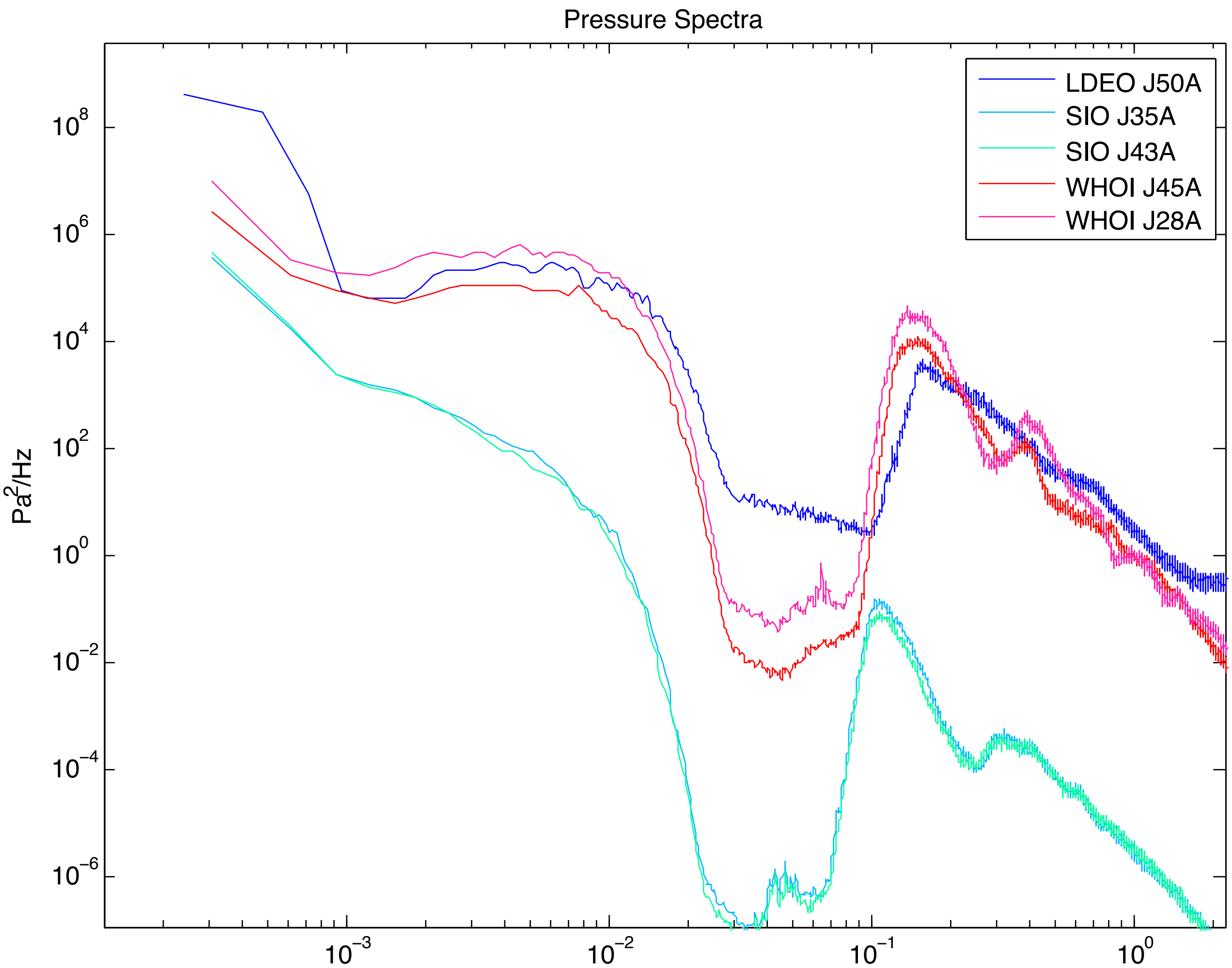
Figure 2. Phase shift in cycles (0.5 = π) between horizontal and vertical in transfer function. + means horizontal leads vertical.

Slight problem with SIO Trillium 240s response.

There were 4 working Trillium 240s in our experiment. OBS11 was essentially perfectly vertical, so we couldn't assess the transfer function between horizontal and vertical as there was no significant horizontal noise on the vertical. The phase shift between horizontals and verticals on OBSs 1 and 7 were indistinguishable from zero. However, there was a phase shift on OBS16, indicating a mismatch between horizontals and vertical, and the amplitude response or apparent tilt was also frequency dependent at periods > ~ 100 s.






Pressure Spectra
LDEO J50A
SIO J35A
SIO J43A
WHOI J45A
WHOI J28A
Pa^2/Hz
10^8
10^6
10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
10^{-3}
10^{-2}
10^{-1}
10^0