

## Supplementary Material - Laske: Normal Modes on OBSs

## 1 SUPPLEMENTARY TABLES AND FIGURES



**Figure S1.** Noise curves for selected stations as published in the FDSN station book. In the free oscillation band, stations KIP and PPT are some of the quietest ocean island sites for the vertical components and compare well with two of the quietest sites on land, IRIS-IDA station TLY (Talaya, Russia) and GEOSCOPE station TAM (Tamanrasset, Algeria). The horizontal components, are sensitive to tilt motion and are generally much noisier. Note though that the KIP horizontal components are quite comparable to those observed on land.

Table S1. Earthquakes with Scalar Seismic Moment  $M_0 \ge 2.0 \times 10^{20}$  Nm.

Source Region	Year. Julian Day	Month/ Day	Time	Lat.[N]	Long.[E]	Depth	$M_0 \times 10^{20}$	$M_S$	this study
PLUME Phase 1 (Jan 05 - Jan 06) Sumatra-Andaman Tarapaqa, N. Chile New Ireland N. Peru Pakistan	2005.087 2005.164 2005.252 2005.269 2005.281	03/28 06/13 09/09 09/26 10/08	16:09:37 22:44:33 07:26:44 01:55:34 03:50:38	2.09 -19.90 -4.57 -5.66 34.43	97.02 -69.13 153.40 -76.37 73.54	30 110 95 85 10	111.00 5.14 3.62 2.15 2.94	8.2 7.9 7.3 7.5 7.6	X X - -
PLUME Phase 2 (Apr 06 - Jun 07) NE of Kamchatka Tonga S. of Java Kuril Islands Kuril Islands Solomon Islands	2006.110 2006.123 2006.198 2006.319 2007.013 2007.091	04/20 05/03 07/17 11/15 01/13 04/01	23:25:02 15:26:40 08:19:29 11:14:18 04:23:21 20:39:56	60.95 -20.19 -9.25 46.57 46.24 -8.46	167.09 -174.12 107.41 153.29 154.52 157.04	22 55 34 38 10 10	2.99 11.18 4.61 35.08 17.77 15.66	7.6 7.9 7.7 8.3 8.2 8.1	- - X -
NoMelt (Dec 11 - Jan 13) Indian Ocean Indian Ocean Sea of Okhotsk E of Philippines Costa Rica. Queen Charlotte Isl. SE Alaska	2012.102 2012.102 2012.227 2012.244 2012.249 2012.302 2013.005	04/11 04/11 08/14 08/31 09/05 10/28 01/05	08:38:37 10:43:11 02:59:39 12:47:33 14:42:08 03:04:09 08:58:19	2.33 0.80 49.80 10.81 10.10 52.79 55.39	93.06 92.46 145.06 126.64 -85.31 -132.10 -134.65	20 25 583 28 35 14 10	91.40 28.93 4.84 3.37 3.42 5.68 2.47	8.6 8.2 7.7 7.6 7.7 7.8 7.7	X - - - -
ALBACORE (Aug 10 - Sep 11) Mentawai, Sumatra Izu Bonin Tohoku, Japan Tohoku, Japan Tohoku, Japan Kermadec	2010.298 2010.355 2011.070 2011.070 2011.070 2011.187	10/25 12/21 03/11 03/11 03/11 07/06	14:42:23 17:19:41 05:46:23 06:15:45 06:25:50 19:03:18	-3.49 26.90 38.32 36.13 38.11 -29.54	100.08 143.70 142.37 140.23 144.55 -176.34	20 14 24 30 19 17	6.77 1.76 531.2 8.48 3.10 2.99	7.8 7.5 7.9 6.8 7.1 7.8	x x - - x
ADDOSS/ADS3 (Dec 13 - Mar 14) none									
ADDOSS/follow-up (Sep 15) Chile	2015.259	09/16	22:54: 33	-31.57	71.67	22	32.29	8.3	X

Table S2. Quality Grades for Low-Frequency Spectra of the 15 November 2006 Kuril Islands event, for each of the temporary PLUME instrument types.

Instrument Type	# A	В	С	D	Ε	F	total
WHOI OBS	2	4	3	2	7	4	22
SIO OBS	7	-	-	-	-	1	8
CIW-land	2	1	1	-	1	-	5



**Figure S2.** Normalized vertical-component spectra at PLUME SIO OBS PL40 for the 15 November 2006 Kuril Islands earthquake of 50-hour long segments, starting 1.5 h after the event time. The time series was highpass-filtered with a -20 dB convolution filter between 0 and 0.5 mHz. a) raw time series; b) time series after correcting for 365-sample repeat segments that contain the average transient (see main text for details). Green mode identifiers mark identifiable modes, while orange identifiers mark unobserved modes. Red crosses and blue labels mark harmonics related to long-period transients in the time series. Red mode identifiers mark modes that are affected by the transients and therefore cannot be analyzed. A correction greatly reduces the harmonic noise but does not completely remove it.



## Periodograms for 3-hour long segments on 4/11/12

**Figure S3.** Raw-count periodograms for 3-hour long time series starting two hours after the 11 April 2012 Indian Ocean earthquake. The time series were tapered with a Hanning window. The sensor at site B17 was reportedly a Nanonmetrics Trillium T-40 wideband sensor which is confirmed by the steeper low-frequency rolloff of the corresponding periodogram.



**Figure S4.** Average of signal-to-noise ratios for the 15 NoMelt broadband stations that had useful seismic data. Seven grade-E or F stations were discarded and not included. Green: Average over 11 records at 7 GSN stations (shown in Figure 10). The results are slightly offset in frequency between instrument types or better display. Red stars mark the SNR measured at station MOBB (Monterey Bay broadband ocean bottom seismic observatory).



**Figure S5.** Normalized raw vertical-component spectra for the 11 March 2011 Tohoku, Japan earthquake of 60-hour long segments, starting 2 h after the event time. a) Eight OBSs with water depths less than 3800 m; b) Eight OBSs with water depths greater than 3800 m. Site OS21 featured a Nanometrics Trillium T-40 wideband sensor.



Tohoku Event (03/11/11) day 070 2/60

**Figure S6.** Low-frequency zoom-in of Figure 14. Normalized raw vertical-component spectra for the 11 March 2011 Tohoku, Japan earthquake of 60-hour long segments, starting 2 h after the event time. The bottom six spectra are from permanent land stations (see Figure 15), while the top six spectra are for ALBACORE OBS sites. Site OS21 featured a Nanometrics Trillium T-40 wideband sensor.