Cruise Report: KM2401 - February, 2024

Determining the origin of Haxby lineaments using magnetotelluric and bathymetric data

Ship, Ports, and dates:

R/V Kilo Moana, Left Honolulu, HI January 6 embarked Papeete Hawaii February 12.

Funding National Science Foundation – OCE 2211895

Overview of Objectives and Results:

The objective of this study is to determine the origin of Haxby gravity lineaments, which are small, periodic undulations (150-250 km wavelength) in the gravity field. They are observed on the Pacific plate in areas with seafloor devoid of large volcanoes and other topographic structures. We deployed 40 ocean bottom broadband magnetotelluric instruments to measure variations in mantle conductivity in the lithosphere and asthenosphere, and mapped the seafloor topography and sonar backscatter, in a 130 km by 600 km area northeast of the Marquesas islands in the Pacific Ocean basin. By correlating the measured conductivity and bathymetry with the gravity anomalies, we will be able to distinguish between multiple competing models attempting to explain the Haxby lineaments.

During the cruise we deployed 40 instruments. One failed to be recovered and 39 were recovered and had good data. We planned to map an area 600 by 200 km but only had time for 600 X 130 km because ship speed was curtailed due to a need to conserve fuel so the mapping time and, thus area covered, was reduced by 5.8 days. Nevertheless this combined MT/bathymetry data recovery is excellent. Other data collected include magnetic field during mapping and gravity during the entire cruise. In addition, multiple instruments on the ship recorded ocean surface temperature, near surface currents, and other meteorological data.

Table 1 and Figure 1 show the main phases of the cruise, the time allocated to each phase, and the propeller rpm which governed the ship speed. The total cruise was 888 hours (37 days). The total transit time was 542 hours (22.8 days). The total science time was 515.5 hours (21.5 days). This was partitioned into 247 hours (10.3 days) for MT recovery and 268.5 hours (11.2 days) for mapping.

Table 1 Ship time allocations

phase	start (UTC)	hours	rpm/speed	notes
transit1	JAN 06 18:00	213-6	120/10.5	6 hours subtracted for Konter seamount survey
deployment/ mapping	JAN 15 15:00	72+6	120/10.5	mostly mapping time
mapping	JAN 18 15:00	168	85/8.5	
recovery	JAN 25 15:00	247	80/7.5	
mapping	FEB 04 22:00	22.5	85/8.5	
Transit2	FEB 05 18:30	167.5	80/7.5	
Papeete	FEB 12 18:00			
total		888		

In the proposal we requested 24 days of ship time. The actual ship time for science was 21.5 days so there was a 2.5-day deficit. This deficit can be attributed to a slower than anticipated ship speed during the first transit due to headwinds, combined with a curtailment of the ship speed for the second transit to save fuel. The captain noted that, during the first transit, we were using more fuel than anticipated to maintain a speed of 10.5 knots which was the speed planned for the entire cruise. Because it was typhoon season in the French Polynesia area, the captain allocated 20,000 gallons of fuel for reserve at the end of the cruise in case the ship needed to use an alternate route to reach Papeete. With some experimentation, we found we could finish the cruise at 80 rpm for recovery of instruments, 85 rpm (8.5 knots) for mapping, and 80 rpm (7.5 knots) on the transit back to Tahiti. The main negative impact of this speed reduction was that the instrument recovery plan was revised from 2 instruments every 8 hours to 2 instruments every 12 hours resulting in an increase of 80 hours or 3.3 days. This reduction, plus the 2.5 days increase in transit time, reduced the mapping time by about 5.8 days. Originally, we planned to survey an area 200 by 600 km (white box in Figure 2) but ended up with a complete survey of an area 130 km by 600 km. This reduction will have some impact on the science, and we are in discussions with the UH Marine Facility to allocate a few days of mapping during a future cruise to the area.

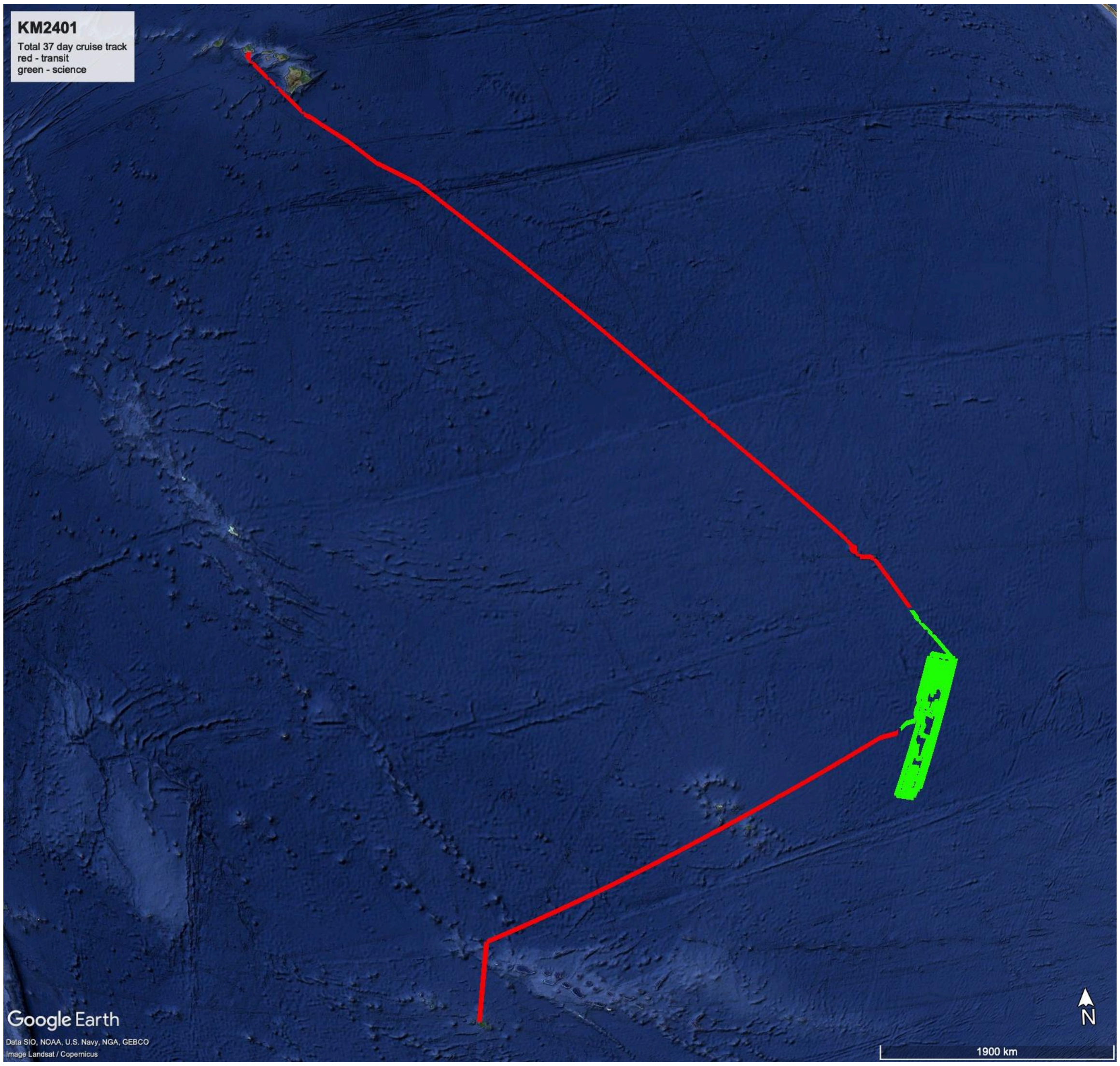


Figure 1. Trackline of KM2401 cruise. Red is the transit portion of the cruise and green is science.

It should be noted that there were no losses of ship time due to equipment problems or personnel issues. Moreover, the multibeam sonar worked better than anticipated with a constant swath width of 17 km in 4.6 deep ocean and no need for editing the data on the outer beams. The magnetometer did not always return valid data but that was not part of our experiment. The gravimeter seemed to work well although we have not completely processed the data yet. Figure 2 shows the details of the science part of the cruise with the locations of the 40 MT deployments.

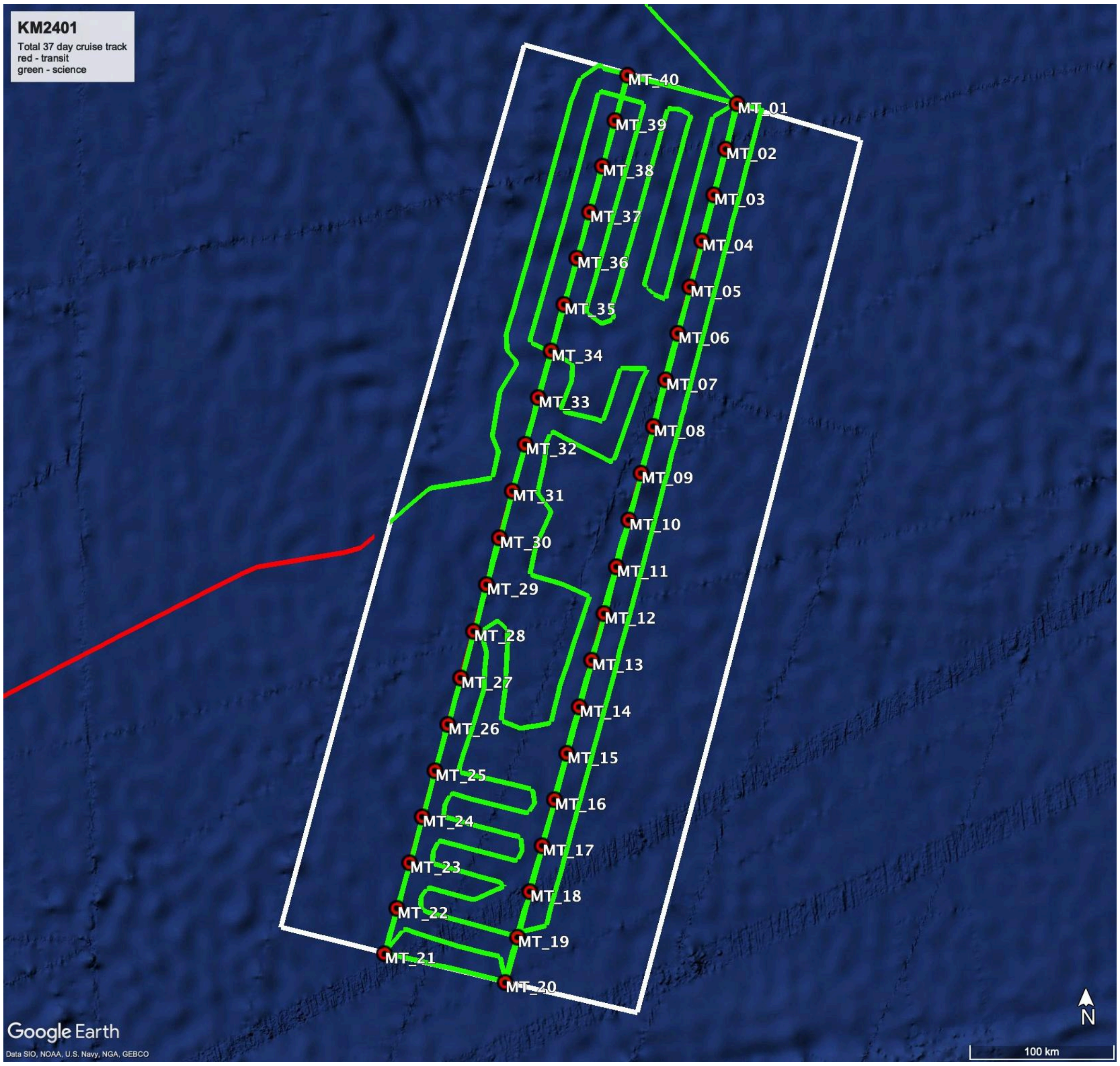


Figure 2 Science portion of the KM2401 trackline (green). The white box is 600 km by 200 km. The 40 MT instruments were deployed along two 600-km lines spaced by 75 km. Instrument spacing was 17 km.

Participants:
The participants included 18 crew and 12 scientists/technicians.
David Sandwell – M – dsandwell@ucsd.edu – Chief Scientist
Jeffery Koch - jkoch4@hawaii.edu – UH resident technician
Trevor Young - tnyoung@hawaii.edu – UH resident technician
Jake Perez – M - jmperez@ucsd.edu – SIO MT technician
Chris Armerding - M - carmerding@ucsd.edu – SIO MT technician
Josephine Jorgensen – F - jjoergensen@ucsd.edu
Matthew Brandin – M - mbrandin@ucsd.edu
Raymond Thicklin – M - rthicklin@ucsd.edu
Lane Souza – F - lsouza@ucsd.edu
Thalia Esquivel – F – tavilesesquivel@gmail.com
Nicholas Hasson – M - nhasson@alaska.edu
Zahra Beatty-James – F – zbeatty.build@gmail.com

Data Acquired:
Appendix A. Seafloor Magnetotelluric data (Thalia and Nick)
Appendix B. Multibeam sonar data (David, Josephine)
Appendix C. Konter Seamount (David, Lane, Ray)
Appendix D. Magnetics data (Lane)
Appendix E. Gravity data (Matt and Ray)
Appendix F. Navigation data: XBT, GPS, compass, gyro, inertial, (Lane - XBT, Ray and Lane)
Appendix G. Daily Ship Log Reports

Activities aboard the ship:
Standing watch
Daily lab meetings
Equator crossing
Tee-shirt design
Stargazing
Birthday Celebrations

Acknowledgments:
The science party thanks the captain and crew of the Kilo Moana for an excellent expedition and for creating a safe and supportive work environment for the 5 weeks at sea. They welcomed us into their ship/home and provided a wealth of activities and wonderful meals to keep everyone safe and occupied when not working. The cooks went above and beyond the call of duty with exquisite/diverse meals and cakes for special events.

References:
Buck, W. R., & Parmentier, E. M. (1986). Convection beneath young oceanic lithosphere: Implications for thermal structure and gravity. Journal of Geophysical Research: Solid Earth and Planets, 91(B2), 1961–1974.
Ballmer, M. D., et al. "Non-hotspot volcano chains originating from small-scale sublithospheric convection." *Geophysical Research Letters* 34.23 (2007).
Egbert, G. D. (1997). Robust multiple-station magnetotelluric data processing. *Geophysical Journal International*, *130*(2), 475-496.
https://doi.org/10.1111/j.1365-246X.1997.tb05663.x
Mayer, D. (2008). Magnetotelluric Processing manual.
Mayer, Larry, Martin Jakobsson, Graham Allen, Boris Dorschel, Robin Falconer, Vicki Ferrini, Geoffroy Lamarche, Helen Snaith, and Pauline Weatherall. 2018. "The Nippon Foundation—GEBCO Seabed 2030 Project: The Quest to See the World's Oceans Completely Mapped by 2030" *Geosciences* 8, no. 2: 63. https://doi.org/10.3390/geosciences8020063
D. W. Caress and D. N. Chayes, "New software for processing sidescan data from sidescan-capable multibeam sonars," *'Challenges of Our Changing Global Environment'. Conference Proceedings. OCEANS '95 MTS/IEEE*, San Diego, CA, USA, 1995, pp. 997-1000 vol.2, doi: 10.1109/OCEANS.1995.528558.
Ware, C., Mayer, L., Johnson, P. (2023). BathyGlobe GapFiller: A planning tool to help fill the gaps in world bathymetry. The International Hydrographic Review, 29(2), pp. 16-27. https://doi.org/10.58440/ihr-29-2-a19

Standing Watch:
Standing watch has two main purposes. The first is to keep track of the operations of the ship and the sensors related to this expedition. The second is to have a written log available so one can look back and see how operations proceeded.

The most important data that is collected while surveying is the multibeam bathymetry. Our objective is to obtain high quality data in unsurveyed areas to resolve the abyssal hill fabric of the seafloor, seamounts, and other tectonic structures. Factors that affect the quality of the bathymetry are ship speed, sea state/direction, and ocean sound velocity. We will also be collecting gravity, magnetics, and perhaps 3.5 kHz sub-bottom data. The time tag for data is always Universal Time (UTC) or the time at the Greenwich meridian so we will use that for the log as well.

We will make entries in the logbook every 30 minutes; a cron on the computer will remind you. There are nominally two people on watch so there is plenty of time for other activities. You may be asked to assist in deck operations and deploy XBT's for measuring the sound velocity of the upper ocean or deploy ARGO floats. Feel free to add notes to the logbook and use an extra line for other entries. We can change the columns to reflect the current data collections.

During the deployment and retrieval of the MT instruments, the underway data is much less important so your entries may be incomplete or missing. However, we should keep notes about each MT deployment, for example, the station number 1-40, the time and location, and any other relevant details such as the time when the instrument was triggered to surface.

Watches (local time) 1/9/24

time	scientists
0 – 6	Ray, Thalia
6 – 12	Matt, Lane
12- 18	Nick (only one person on this shift)
18 – 24	Josephine, Zahra

Watches 1/19/24

time	scientists
0 - 6	Josephine, Zahra
6– 12	Ray, Thalia
12-18	Matt, (only one person on this shift)
18 – 24	Nick, Lane

Watches 1/31/24

0 - 6	Nick, Lane
6 – 12	Josephine, Zahra
12-18	Ray, (only one person on this shift)
18 – 24	Thalia, Matt

Watches end 2/6/24 when we enter the French EEZ

Daily Lab Meetings: – KM Conference RM, 4 PM

	topic	leader
1/5	MT Theory - 1	Constable - zoom
1/3-1/4	travel - loading	
1/5	pre-cruise dinner	All
1/6	acclimate	
1/8 Noon	tour of ship: computer lab, multibeam, grav., mag., deck	UH tech - Trevor
1/8	gravity rolls hypotheses	David
1/9	multibeam theory	Matt
1/10	Sextant Navigation	Bridge
1/11	MB_System	Lane and Josephine
1/12	MT deployment training – 12:30	Chris and Jake
1/13	Magnetic anomaly theory, Exam, Prepare costumes	Lane
1/14	King Neptune	
1/15	deploy	
1/16	deploy	
1/17	deploy	
1/18	review MB data/cruise planning/lab meeting planning	Lane and Matt
1/19	plate tectonics	Zahra and Nick
1/20	abyssal hills	Josephine
1/21	MT Theory – 2 and modeling	Thalia
1/22	isostatic gravity modeling - GMT	Ray and Matt
1/23	Tectonic Setting	David
1/24	MT Recovery procedures	Chris and Jake
1/25	recovery	
1/26	Small scale convection	Ray
1/27	First look at MT data,	Chris, Jake, Thalia, Nick
1/28	InSAR Theory and Practice	David
1/29	Jupyter/Python - 101	Lane, Nick
1/30	InSAR Theory and Practice	David
1/31	Jupyter/Python - 101	Lane, Nick
2/1	InSAR Theory and Practice	David
2/2	Jupyter/Python - 101	Lane, Nick
2/3	InSAR Theory and Practice	David
2/4	Jupyter/Python - 101	Lane, Nick
2/5	InSAR Theory and Practice	David
2/6	Coherence InSAR Time Series	Matt
2/7	Practice talk for MESA	Zahra
2/8	InSAR Time Series - Hawaii	Ray/Lane
2/9	Review Cruise Report	All

2/10	Agnew Lecture	
2/11	last day at sea	Superbowl

Equator Crossing

During the Equator crossing, the scientific crew eagerly awaited the moment when the latitude transitioned to 0 degrees. Following this significant event, a ceremony was held to commemorate the crossing for both the scientific team and uninitiated members of the ship's crew. It was a privilege to welcome King Neptune himself, accompanied by his esteemed wife, the queen, and their royal court, aboard our vessel.

As part of the traditional crossing ritual, we were honored to transition from "Polly Wogs" to "Shell Backs" under the auspices of King Neptune. Given the spontaneous nature of the ceremony, we hastily crafted our own ceremonial attire, having failed to anticipate this esteemed occasion. Additionally, we prepared gifts to present to the royal family, all of which were graciously accepted.

With great reverence, we underwent the knighting ceremony, symbolized by the pouring of ocean water over our newly bestowed statuses. It was a momentous occasion, marked by tradition, camaraderie, and the timeless symbolism of crossing the equator.

Tee-shirt design: (Josephine)

The final Tee shirt design is provided in the two images below. 10 Tee-shirts were ordered for the science party at https://www.customink.com . If you like this design you can order more shirts by looking for the design KM240103. The design is white on a transparent background so works best on a dark shirt.

The front of the tee-shirt design has a symbol on the upper right area of the shirt, containing a simplified cartoon of the R/V Kilo Moana, as well as the name of the R/V Kilo Moana and the route the ship took, from Honolulu to Papeete. The islands of Hawaii and Tahiti have been drawn around the top and bottom of the symbol, in order to show, once again, the route of the R/V Kilo Moana on this research cruise.

The back of the tee-shirt design has the title of our research expedition, as well as the year. Beneath the title is a simplified cartoon of the MT instruments deployed on the cruise, and a set of gravity rolls composed of the five closely spaced, curved lines.

Stargazing (all)

Three exceptional nights were transformed into ship-wide stargazing experiences, characterized by the dimming of all non-essential ship lights to enhance celestial visibility. Knowledgeable crew members adept in astronomy conducted informative sessions for both fellow crew and members of the science team, imparting insights into celestial bodies and the fundamentals of celestial navigation.

During these sessions, the search for the Southern Cross, also known as Crux, led to the discovery of a counterfeit constellation nearby. Additionally, the brilliance of Jupiter illuminated the night sky, casting reflections on the tranquil waters below.

A highlight of these evenings was the gathering of female passengers on the bridge deck, equipped with blankets, fostering a sense of camaraderie through shared laughter, music, and bonding experiences. Numerous shooting stars captivated onlookers, with some claiming sightings of a meteor, colloquially known as a fireball. Impressively, Josephine managed to capture stunning images of the celestial spectacle on her iPhone.

On January 24th, 2024, Thalia orchestrated a lively rendition of the Macarena on the deck under the full moon's glow, joined by Matt, Ray, and Zahra. The culmination of this stargazing series coincided with Nick's birthday, marked by the dimming of lights despite thick clouds and rain, underscoring the unwavering enthusiasm for celestial observation among passengers and crew alike.

Birthday Celebrations: (Lane, Nick)

The ship's culinary team prepared personalized birthday cakes for Lane and Nick, adding a delightful touch to their special day. Lane was treated to a delectable strawberry vanilla cake, while Nick indulged in a rich chocolate creation.

It is worthed to mention some soft skills that we exercise participating in the Gravity Rolls Expeditions 2024: communication, teamwork, being observant, adaptability, open to learn and teach, organization, and critical thinking.

Appendix A. Seafloor Magnetotelluric data (Thalia and Nick, Jake and Chris)

The collection of the magnetotelluric data consists of three main parts: the training, the deployment of the instruments, and their recovery. After the recovery of each marine MT, we inspect their spectrograms to have a general idea of their quality, and we start the processing of the data.

Marine MT collection training

Jake Perez and Chris Armerding, both SIO MT technicians, gave the training. The training consisted of theoretical and practical sessions where they explained the configuration of the instruments, procedures to assemble and disassemble the OBEMS (Ocean Bottom Electromagnetic), and the use of some tools to carry out these activities. Furthermore, safety rules to follow in the deck were explained in detail.

The first training was on January 12, 2024, before the start of the deployments, and the second training session was performed on January 24, 2024, prior to the recoveries.

During the deployment of the instruments, the activities as a student consisted of helping with assembling the equipment: coils, electrodes, acoustics, DPG, compass, the flag, and connecting the cables with the logger, etc. We must be careful with each process step since the correct connection and configuration of the instrument parts are essential to obtain good-quality data.

After each recovery and once the MT were dissembled (coils, electrodes, logger, DPG, compass, flag, etc) we tested the voltage between each pair of the electrodes (mV), we assessed the resistance of each one of the cables used in the instruments (Ohms). This activity is twofold, one helps to keep track of the state of the equipment for future surveys, and the second determines if there is something in the equipment that could produce a problem with the data.

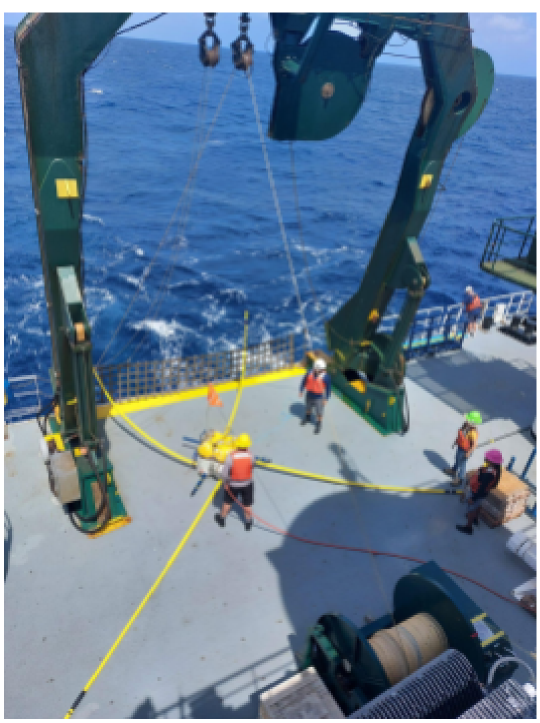


Figure A1. Photo of one of the MT station, moments before the station was deployed. During the deployment and recovery, technicians, students, and crew members participate.

Deployment and recovery of the marine MT instruments

Before initiating the deployment of the marine MT instruments, a calibration test for each logger should be done. The calibration broadly consists of checking the values of the batteries, synchronizing the instruments with the GPS, determining the deviation time from the GPS, and setting up the time when the instruments will start to record data. This activity was done on January 14th, 2024.

The deployments of the 40 MT stations were performed from 15 to 17 of January 2024 (Figure A1); meanwhile, the recovery was from January 25 to February 4, 2024. We successfully recovered 39 of the 40 MT sites. Station MT-25 (Penguin) was not recovered due to a potential failure of the acoustic release system. Upon arrival at station MT-25 several attempts to communicate with the instrument on the seafloor were performed, but none of these attempts obtained a response. After waiting 4 hours after the final release command was sent, it was determined that MT-25 was lost.

Figure 2 shows the location of the 40 MT sites; they were distributed in two NE-SW parallel profiles separated by 42 nautical miles (78 km). Along each line, 20 MT instruments were deployed with a distance of 17 nautical miles (32 km) between them. Figure A2 shows the time of the deployment and the time of the recovery of the first 10 MT sites. This figure shows that the sites are recording data simultaneously, which is a fundamental factor in MT to obtain good-quality data. In total, each station was recording data for approximately 10 days at a frequency of 62.5 Hz, which will able us to have enough data and improve the quality of the data.

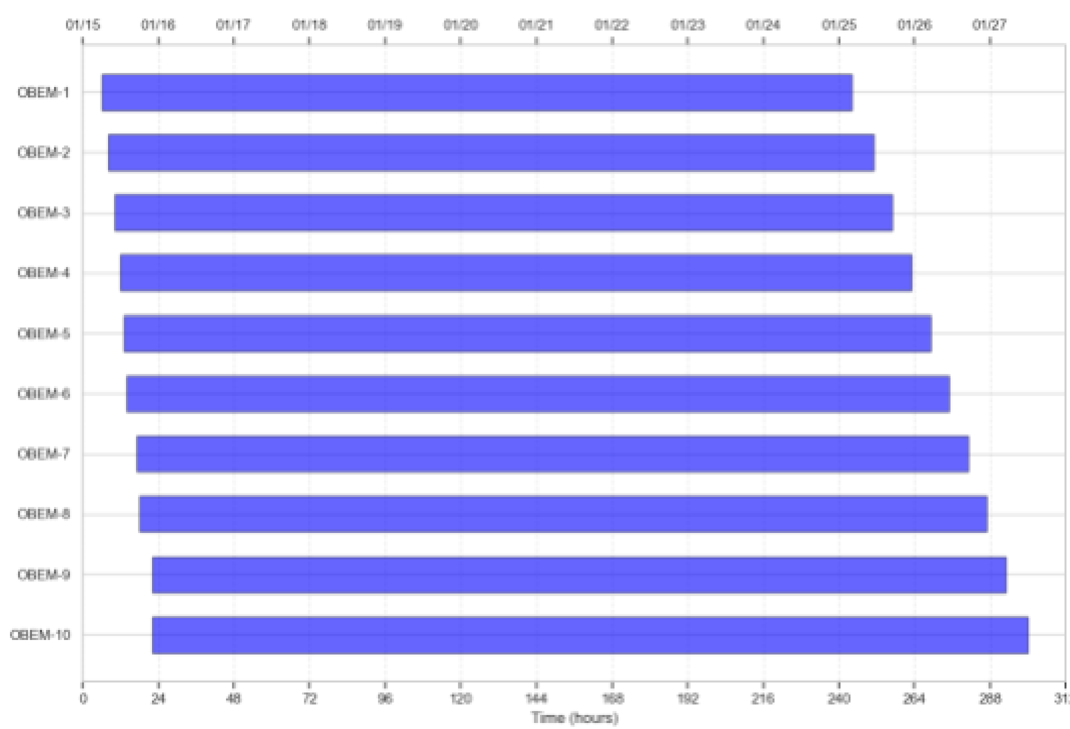


Figure A2. MT instrument (OBEM) deployment and duration of seafloor observation time.

First guess to MT Data quality

The MT instruments measure horizontal electric and magnetic fields (Ex, Ey, Bx, and By), four channels in total. Additionally, half of the MT stations measured differential pressure gauge (DPG), which is used for seismic analysis (five channels in this instrument). The review of the spectrograms is a common practice in the field to observe the quality data of each station. A spectrogram for each channel is obtained per station. In Figure A3, we show some examples and features that are relevant for future processing of the data.

Feature F1 corresponds to the time when the station was recording data, but the instruments were not in the bottom of the ocean. Feature F2 is related to the movement of the instrument when it comes to the surface. These behaviors are observed in all the frequency bands and at the four channels, especially at channels 1 and 2, which correspond to magnetic fields. The former is due to magnetics being more sensitive to movement. Both attributes, F1 and F2, should be removed for future processing.

Feature F3 is observed mainly at the electrical channels in sites MT-01, MT-08, MT-18, MT-23, and MT-40 at frequencies between 1 and 10 Hz, we are unsure what is the source of these features. Feature F4 is characterized for having lower values in the spectrum, localized in the frequencies between 0.1 and 1 Hz. We relate this signature with the dead band (0.5 to 5 Hz) which is a band with lower energy in the ionosphere. Finally, feature F5 appears with higher values at lower frequencies in the spectrogram, we relate these features with daily tidal variations. In general, the spectrograms present good quality.

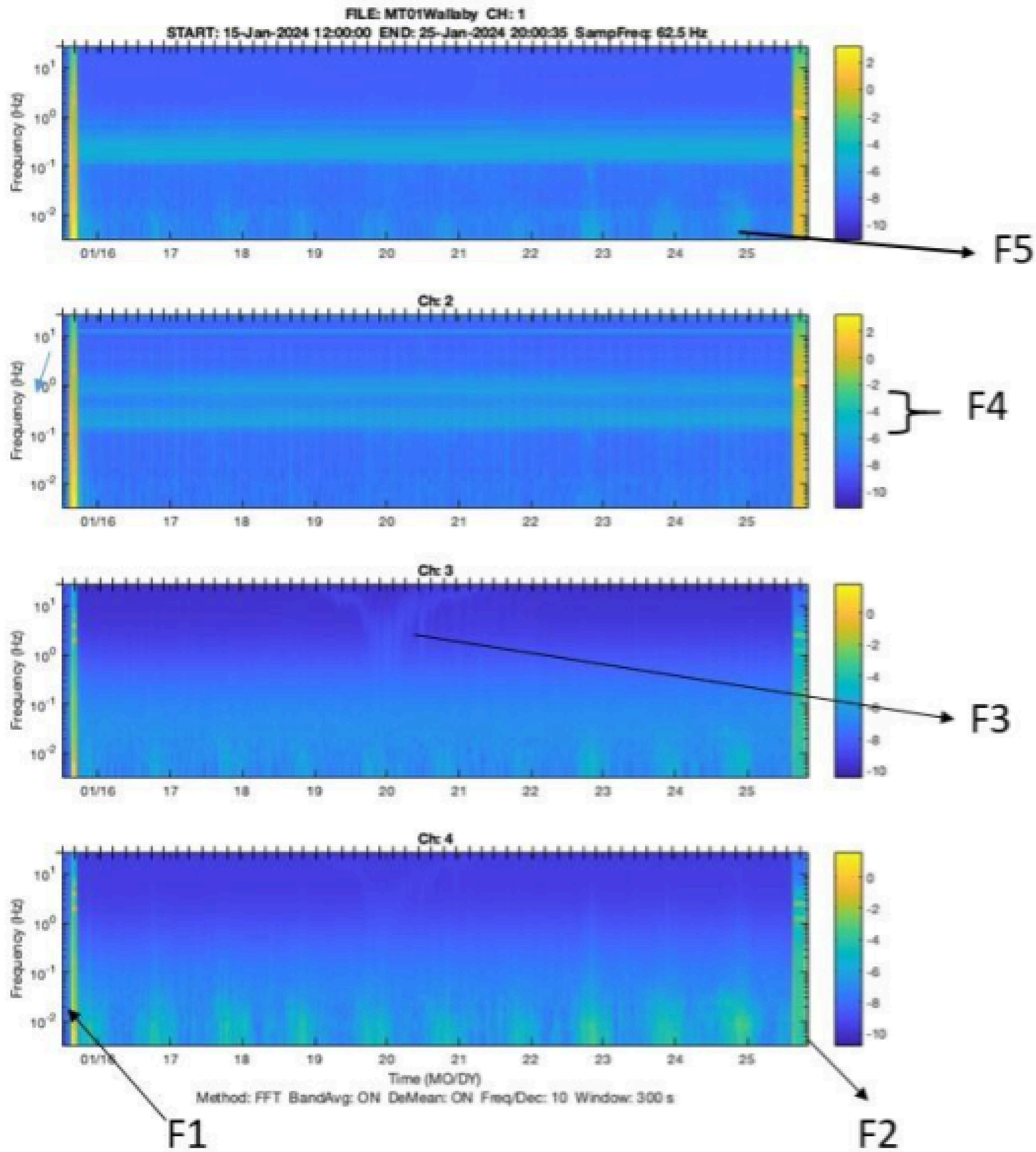


Figure A3: The spectrograms of station MT-01. The spectrograms are in terms of counts. CH:1, CH:2, CH:3, and CH:4 correspond to channels Bx, By, Ex, and Ey, respectively.

Can a marine MT station be sensitive to a seismic event?

When the MT instruments were recording data, a couple of seismic events occurred. In the present list, we enumerated the seismic events with a magnitude of more than 6, and in Figure A4 we show an example of how marine MT is sensible to detect the seismic event occurred on January 23, 2024 at 14:33:44 (UTC time). We observed a first pick in the electric and magnetic channel two minutes after the seismic event, we associated this sudden increase and decrease in the signal with the arrival of the P wave. In later times (not included), we can also observe a feature associated with the arrival of the S wave. After four minutes, the signal from the channels eventually came back to the original signature before the seismic event occurred.

Table 1. Seismic events with a magnitude above 6 during the time MT stations were recording data.

DATE and TIME (UTC)	LAT	LON	MAG	DEPTH (km)	LOCATION
23-JAN-2024 14:33:44	-18	168.05	6.3	31	VANUATU ISLANDS
22-JAN-2024 18:09:04	41.27	78.65	7	13	KYRGYZSTAN-XINJIANG BORDER REG.
20-JAN-2024 22:09:39	-39.92	46.18	6.2	10	SOUTHWEST INDIAN RIDGE
20-JAN-2024 21:31:05	-7.28	-71.47	6.6	614	WESTERN BRAZIL
18-JAN-2024 22:12:22	-18.9	-175.4	6.4	211	TONGA ISLANDS

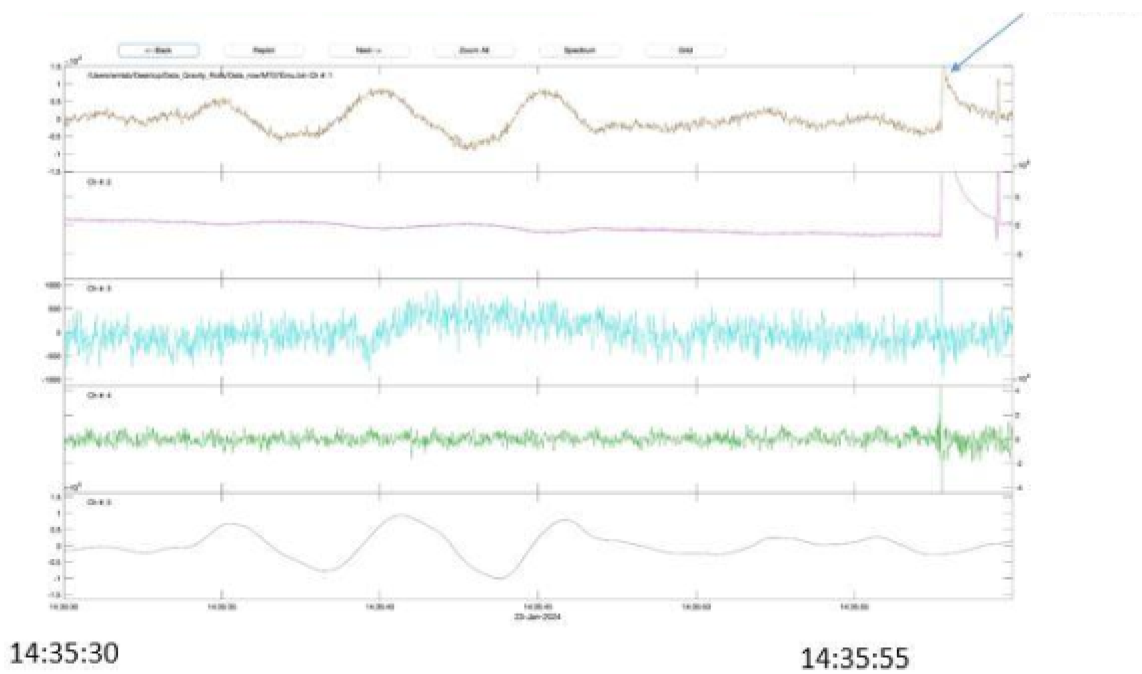


Figure A4: Seis event registered by the MT-07. The seismic event occurred on January 23, 2023 at 14:33:44 hrs (UTC time). The sudden increase in the signal after 14:35:55 hrs is associated with the arrival the P wave.

Processing data

During the ship, we start processing 10 MT data sets to review the process. The workflow that we followed from the raw data contained in the *.bin to the impedance tensor is well described by Mayer (2008). We describe a general overview:

To obtain the Fourier coefficients, it is necessary to delimit the times when the data presents good quality in the spectrograms. For this process, a Windows decimation is used, and it is already set in the files. However, it can be changed if necessary. Also, the channels of the sites should be rotated to the geographic north using the heading information from the compass, and corrections in the roll and pitch were also made.

After we obtained the Fourier coefficients (*.fc files) we carried out the multistation processing, which consisted of improving the proportion of signal-noise and finding biases generated by coherent noise (Egbert, 1997). The product of this process is the impedance tensor components. We completed this process for the 10 MT station. However, our process should be improved.

Appendix B. Multibeam Sonar Data

We collected bathymetry data for the majority of the cruise. To accomplish this, we utilized an EM 122 Kongsberg multibeam echo sounder on board the Kilo Moana. The average water depth ranged from about 4000-5000 m, yielding a swath width of about 15-17 km. On the way to the study area from Honolulu, we consciously routed around existing multibeam tracks, so as to collect novel data and contribute to the world database of multibeam seafloor tracks (Mayer et al. 2018). When crossing the equator, we identified a seamount in the global gravity grid, and changed our route to maximize the amount of coverage around the seamount. As we mapped the majority of the seamount, we elected to name it the Konter seamount, which is discussed in Appendix C. Around this time, we also began processing multibeam data using MB-system (Caress & Chayes, 1995), an open source software allows the user to organize multibeam files, view the data, clean the data according to specified parameters, and grid the data in preparation for plotting. We used MB-system to process data from previous cruises around Konter seamount, as well as the study area, in order to determine where to map and maximize ship time. We also used a software called BathyGlobe GapFiller (Ware et al. 2023)), which aids in the planning of multibeam tracks. By inputting various configurations and parameters, BathyGlobe GapFiller can help calculate the best path to take, and returns important statistics about drawn paths, such as the cost and time taken. We used BathyGlobe to determine how to space the tracks in order to allow for just the right amount of overlap and maximize both ship time and contribution to Seabed 2030. In addition to the processing of past data, we processed our own data almost in real time using MB-system, to check for any large holes and ensure the data quality. We were able to fill almost all of the space between the two magnetotelluric profiles, but due to lost ship time, we were unable to fill out the spaces to the left and right of the profiles, constituting the rest of the space in the box outlined by the proposal. The collection of multibeam data ceased once the ship entered French waters on its route to Papeete, French Polynesia.

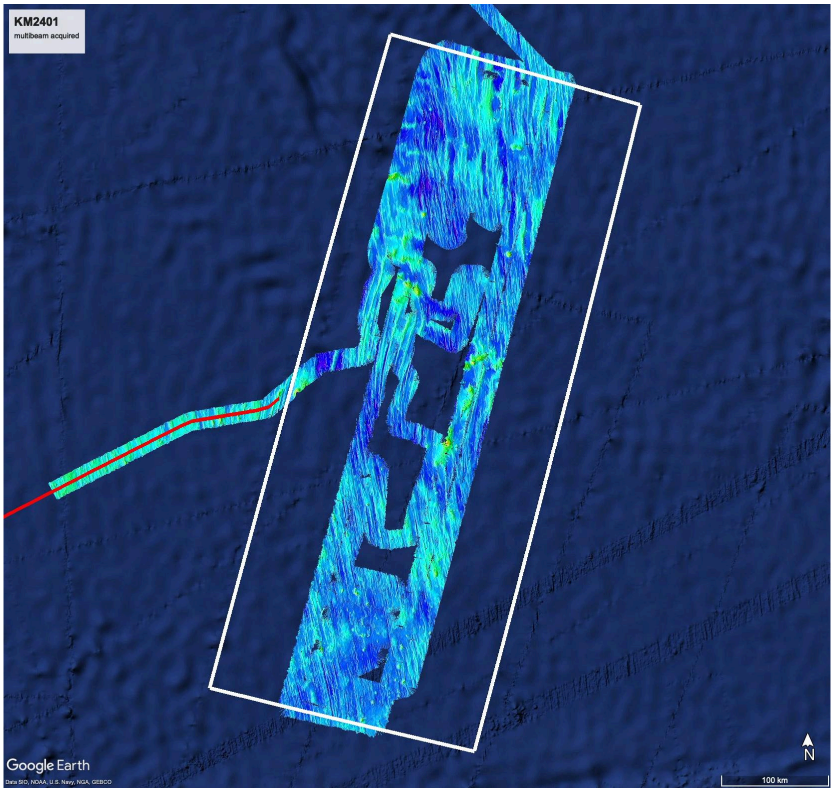


Figure B1: Multibeam acquired on this cruise (KM2401). Total multibeam, past and new data. A few of the holes in the left map are filled by past data on the right, as planned in order to maximize ship time.

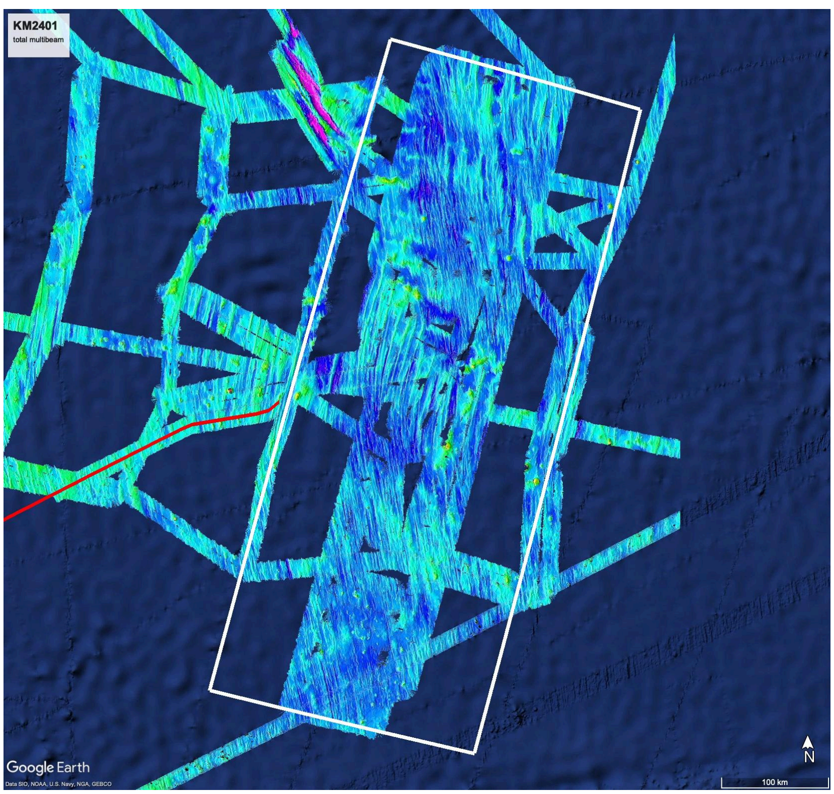


Figure B2: Total multibeam, past and new data. A few of the holes in Figure B1 are filled by past data in Figure B2, as planned in order to maximize ship time.

Appendix C. Konter Seamount

During the transit from Honolulu to the start of the MT deployments, we used 6 hours of ship time to complete a multibeam survey of a large seamount exactly on the equator (yellow line) (Figure C1). We proposed to name this seamount after the late Jasper Konter (see box below). Some say that King Neptune lives on this seamount and suggest that he came aboard the Kilo Moana when we crossed the equator. The following day the King and Queen presided over a ceremony to initiate the pollywogs aboard our ship and now they are shellbacks.

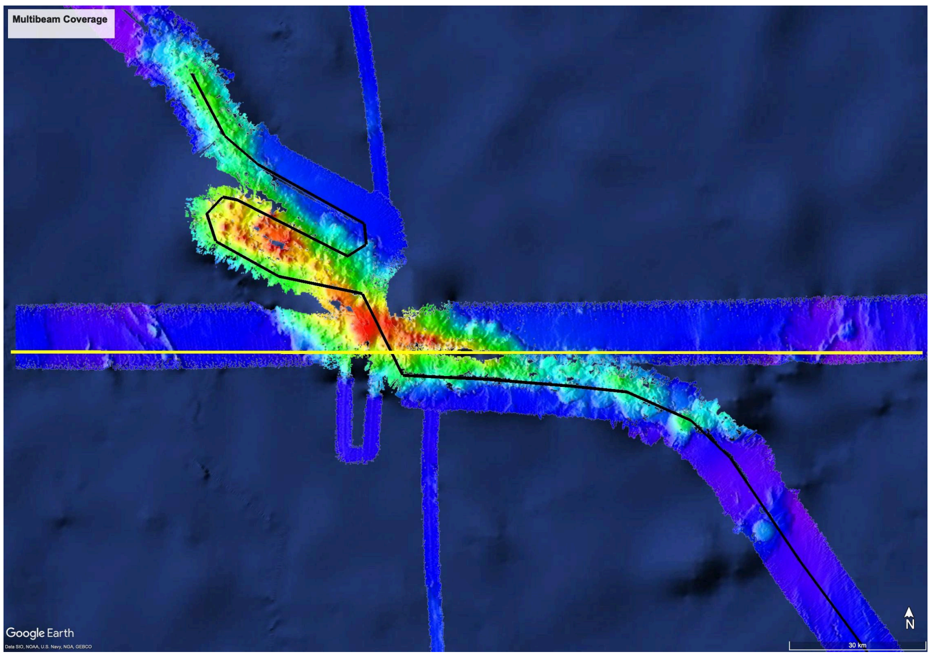


Figure C1. Multibeam bathymetry collected over Konter Seamount. The black line is the track of our cruise KM2401 where we surveyed areas not covered during the other mappings. The two prior cruises were CRGN01WT, March 1987, with a N-S crossing over the eastern summit and the KN195-03 (January, 2009) with the E-W crossing. The CRGN01WT cruise did not have GPS navigation so some mislocated data was edited.

The proposed Konter Seamount was surveyed by three multibeam sonar expeditions. The first survey in March of 1987, aboard the R/V Thomas Washington, was led by Jerry Winterer and Jacqueline Mammerickx to investigate gravity rolls in the Equatorial Pacific. David Sandwell and Jeff Gee were participants in that cruise. The seamount was first detected in Seasat altimeter gravity data leading to a multibeam map of the eastern summit. The second survey in 2009 was a transit of the R/V Knorr along the equator to study *Oceanographic Control and Global Distributions of Subseafloor Microbial Life and Activity*. Our cruise was the third survey in January, 2024 aboard the R/V Kilo Moana. It was led by David Sandwell to further investigate gravity rolls in the Equatorial Pacific. The gravity of the seamount was well mapped by numerous satellite altimeters so both summits were well located and could be surveyed in a few hours of ship time. All the data are, or will be, available at (https://www.ncei.noaa.gov/products/bathymetry).

A detailed map of the proposed Konter seamount is provided in Figure 2 and the grids and other products are compiled at: https://drive.google.com/drive/folders/1vHZkwcRrpuCq0nN7zRpK82HJoD_pLL_J?usp=drive_link The main part of the seamount is 75 km long and 20 km wide. The regional depth is 4500 meters and the shallowest part of the seamount, located on the NW summit, is 1340 m for a total relief of 3160 m. The summit is not as flat as a typical guyot although the summit depth and modeled age are consistent with this feature forming near the ridge axis.

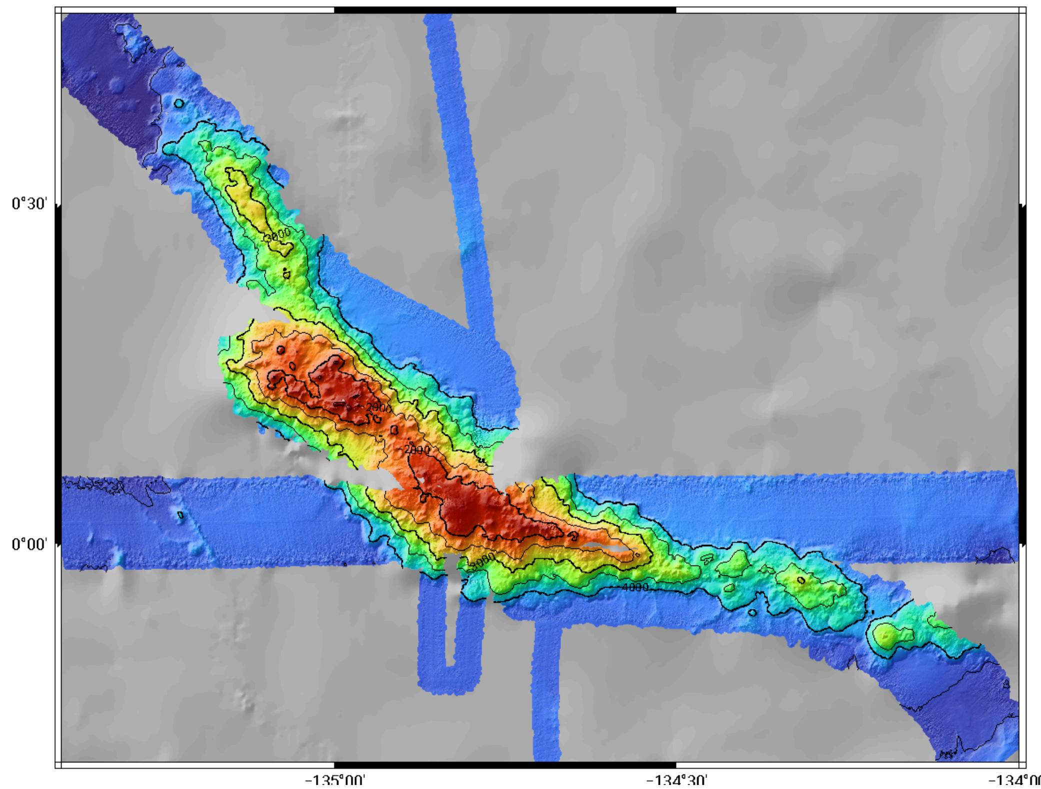


Figure C2. Detailed bathymetry of Konter Seamount. Contours are at 500 m and 1000 m (thick) intervals.

Using this bathymetry and the available satellite gravity we performed an isostatic gravity model of this feature. The model consists of a volcanic load of density rhoc on a thin elastic plate of thickness Te. The modeling code is based on GMT and is available at the site linked above. The results are shown in Figure A3 where a suite of models were tested with crustal density ranging from 2700 to 2900 kg m^{-3} and elastic thickness ranging from 0 to 6000 m. The best models have very thin elastic plates between 2000 and 3000 m suggesting the plate was very young (< 5 Ma) when the seamount formed. A modern analog is Easter Island which is forming on the boundary of the Easter microplate. The present-day age of the seafloor surrounding Konter seamount is 35 Ma. At this age there has been about 1450 m of subsidence of the seafloor from the ridge axis. This suggests that Konter Seamount was once at sea level although it does not have a prominent flat top of a guyot. One would need to dredge the summit to look for evidence of shallow water corals to establish that it was once at sea level.

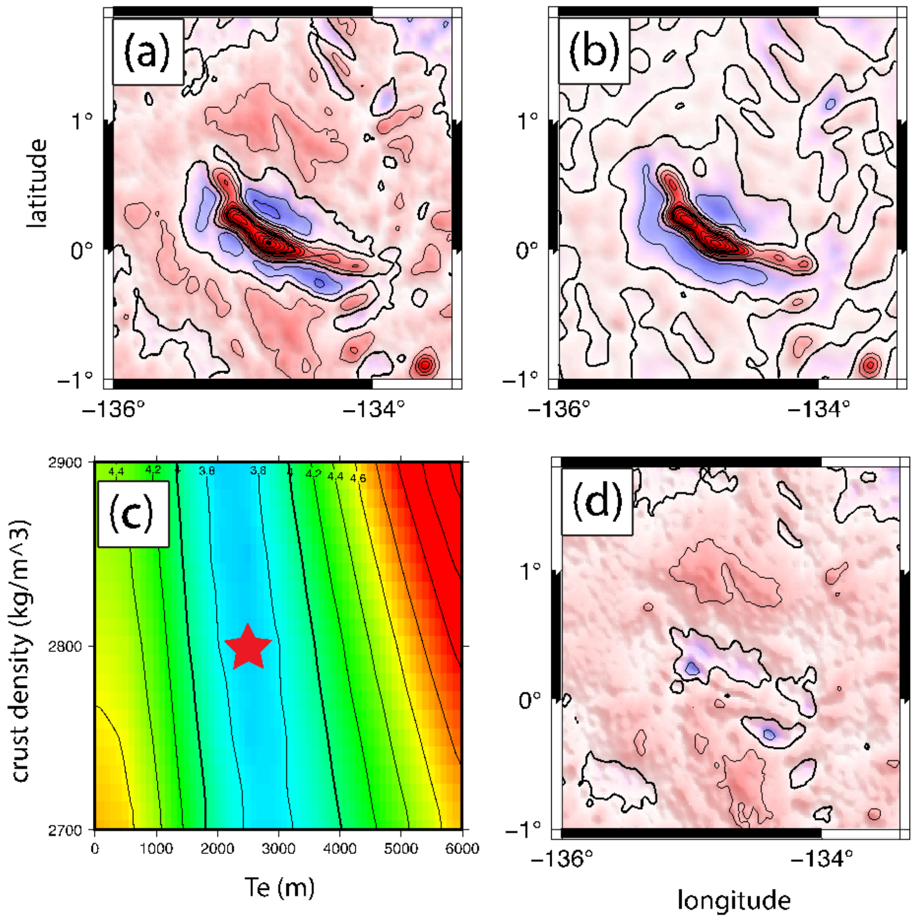


Figure C3. (a) Gravity anomaly (10 mGal contours) of Konter Seamount based on satellite altimetry. (b) best fit isostatic gravity model with (c) density of 2800 km m^{-3} and elastic thickness of 2500 m.

Box A1 Biography of Jasper Konter

(https://www.soest.hawaii.edu/GG/people/faculty/konter_memoriam.html)

The late Jasper Konter, Professor of Earth Sciences at the University of Hawaiʻi at Mānoa, is recognized globally for his research on oceanic volcanism and isotope geochemistry. Jasper's investigations explored the role that long-lived, plume-fed Pacific hotspots play in generating age-progressive volcanic chains that sample the deep mantle over 100-million-year timescales. His scientific contributions include using evidence from isotope geochemistry and mantle seismology to confirm the deep origin of mantle plumes, and to show that materials that were once subducted in the ancient geologic past are returned again to the surface by these rising mantle plumes. Jasper's work on the different stages of intraplate volcanism advanced our understanding of the evolving source materials and magma production mechanisms as the volcanoes age. He and co-workers also used a combination of isotope geochemistry, lava rock ages, and volcano locations to identify motions of the Pacific Plate relative to plumes sourcing hotspots, as well as the motions of plume sources relative to each other. Jasper and colleagues also developed methods for using non-traditional iron isotopes to identify source materials and magma genesis at oceanic volcanoes.

Jasper received his B.Sc+M.Sc. from the Vrije University Amsterdam in 2000. He received his Ph.D. from Scripps Institution of Oceanography at the University of California, San Diego in 2007, with a dissertation aptly titled "*The origin and geologic evolution of seamounts in the Pacific Ocean*." After conducting post-doctoral research at San Diego State University (SDSU), he joined the faculty of the University of Texas at El Paso (UTEP, 2008-2013). Jasper was then recruited to the University of Hawaiʻi at Mānoa in 2014, where he had the honor of living out his dream job as a scientist, mentor, and explorer of Pacific seamounts. Jasper's research was interdisciplinary and addressed fundamental problems at the intersection of geochemistry and geodynamics, with numerous collaborators spanning the U.S. and from Japan to Europe. He was also a devoted and admired research advisor during his tenure at UTEP and UHM, supervising 12 undergraduate students and 7 graduate students.

While Jasper was meticulously skilled in laboratory analysis, instrumentation, and geochemical modeling, his real passion was field-based seamount exploration. Throughout his professional career, Jasper participated in 10 research cruises and acquired multiple years of ocean-based field work, with 11 weeks as Chief Scientist for cruises exploring the Pacific Ocean. One of his greatest contributions was in 2013, where Jasper was Chief Scientist on a major expedition onboard the R/V Revelle to the Rurutu-Arago hotspot. Under Jasper's leadership (and including the efforts of 17 graduate and undergraduate students), the science party was able to establish that Rurutu-Arago is one of the longest-lived Pacific hotspots with volcanism continuing along the Tuvalu Islands and into the Gilbert Ridge, extending the hotspots back to 80 million years. In 2022, Jasper led the KM2201 cruise on the R/V Kilo Moana, during challenging COVID times and with many other typical cruise-related logistical challenges. During his last voyage, Jasper brought home many invaluable dredge samples from the West Pacific from seamounts older than 100 Ma and related to the Rurutu-Arago and Samoan hotspots. The teams and students he left behind are hard at work generating the geochemical and geochronological datasets needed to close out the decades-long debate about the origin of this hotspot - and serves as a true legacy to Jasper's career and life.

Jasper, at age 45, was killed by a drunk driver during a family vacation in Arizona on July 3, 2022. Jasper is survived by Bridget (UHM Earth Science Professor) and their two sons, Ryan (14) and Wesley (10).

Appendix E. Magnetic Data

The Marine Magnetic survey started on January 7th and finished on January 25th. After, data was collected again on February 5th and 6th (day 36 and 37 in Julian Calendar). The Figure 1E shows the area of the survey and the Julian date representing the acquisition date.

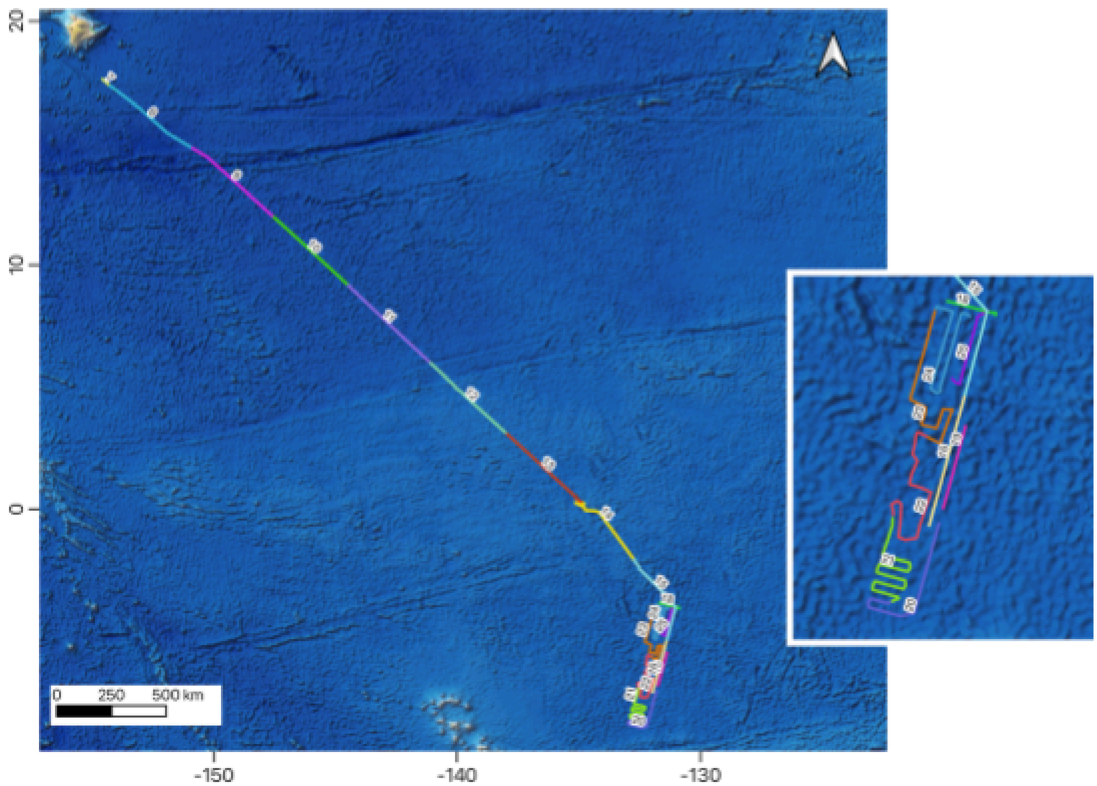
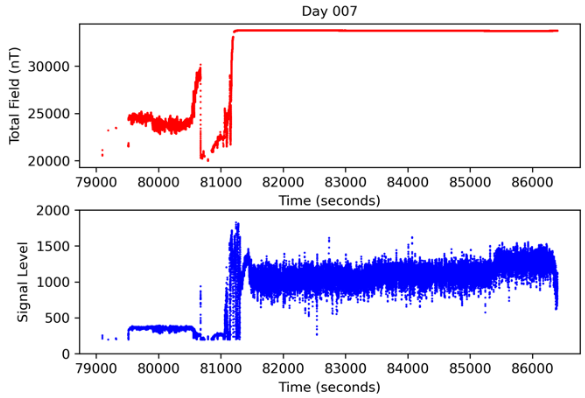
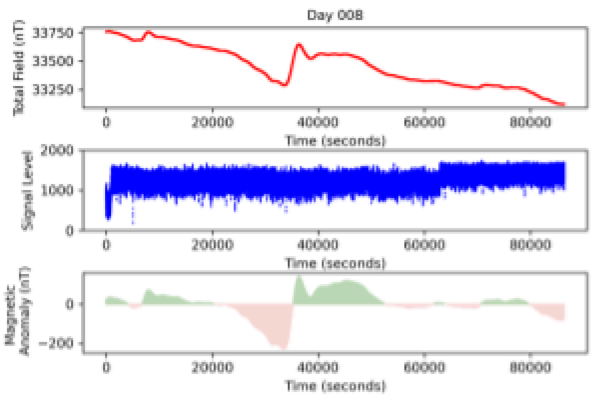


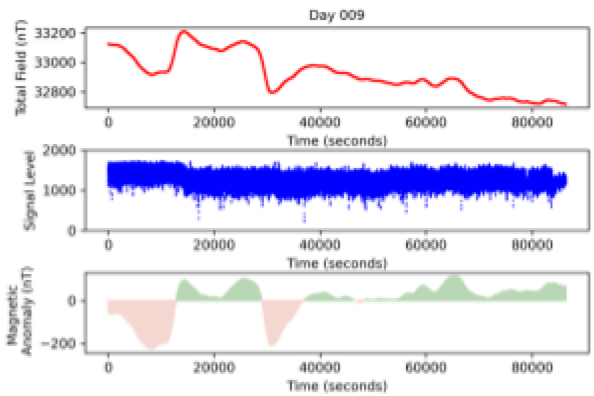
Figure E1 - Survey area with the different line colors representing different Julian days of the acquisition.

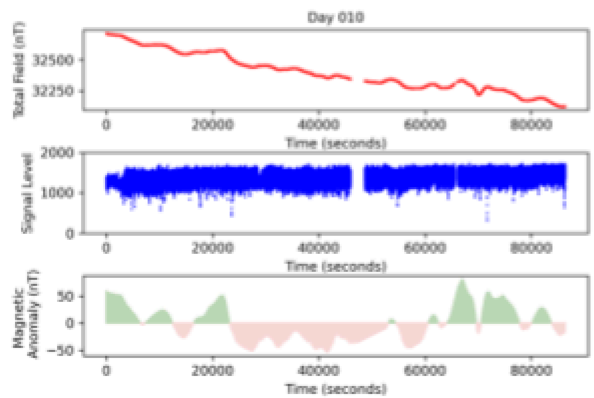
The survey was performed using the 882 Marine Magnetometer by Geometrics with 10 samples per second. The raw files were saved in the folder "magy", with the respective columns: year, julian day, hour, minute, second, millisecond, code, total field (nanotesla), signal level and depth (meters). According to the MagLog Users Guide by Geometrics, signal levels lower than 300 are considered suspect, while good data is characterized by a strong signal. A good range for this value is probably somewhere between 600 and 1200.

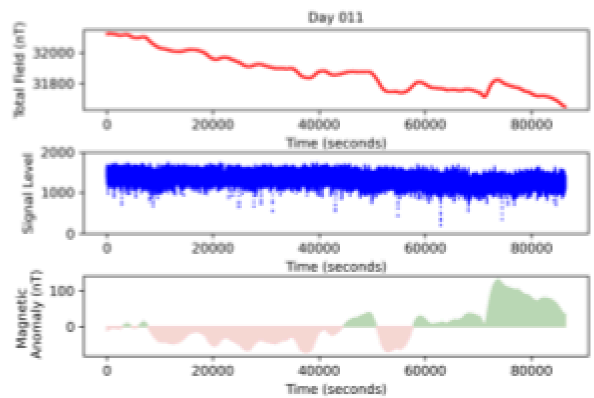
Therefore, the quality control of the data was performed using the signal level of 200 as a lower value. The data was plotted and signals with a good temporal time series were used to calculate the magnetic anomaly. The magnetic anomaly is the result of the subtraction of the Total Field and the Theoretical Magnetic Field, provided by the International Geomagnetic Reference Field. The data was interpolated to the positioning time with 2 samples per seconds. Diurnal variation correction, removal of outliers and filtering was not performed.

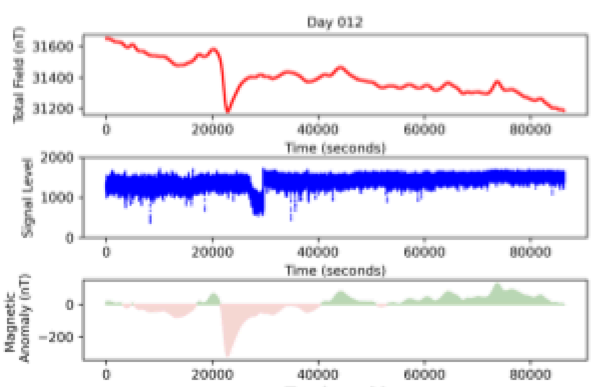

Day 007
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)

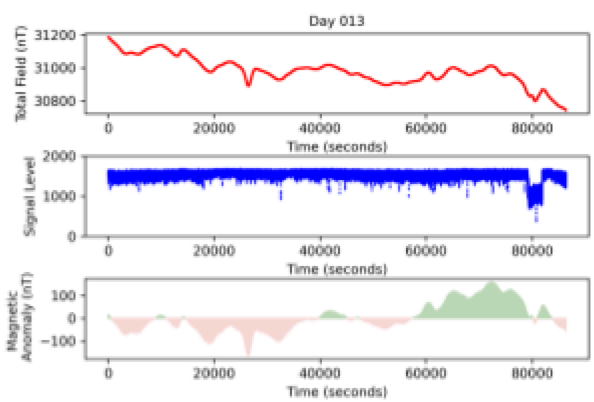

Day 008
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)


Day 009
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)


Day 010
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)


Day 011
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)


Day 012
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)


Day 013
Total Field (nT)
Time (seconds)
Signal Level
Time (seconds)
Magnetic Anomaly (nT)
Time (seconds)

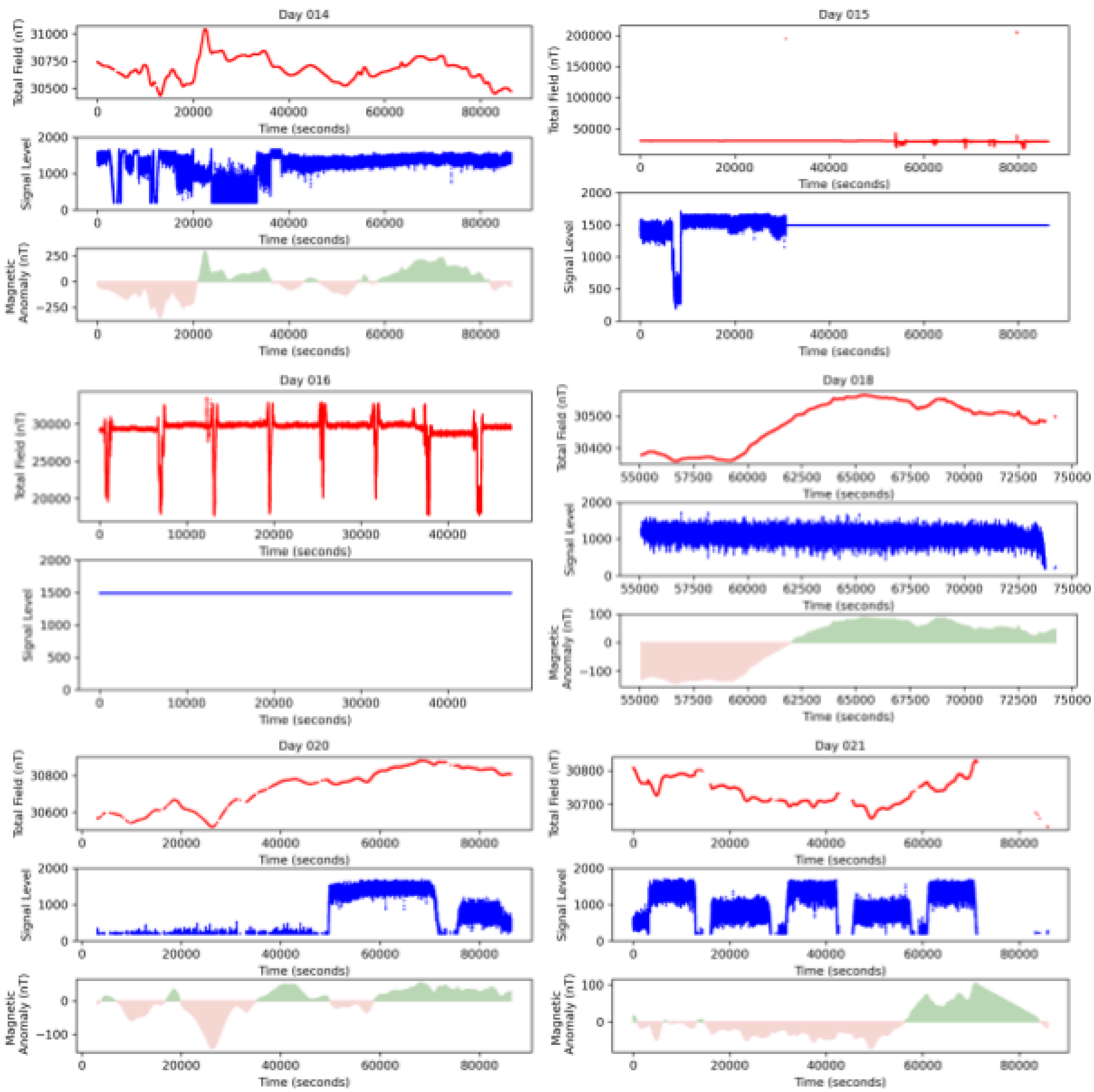
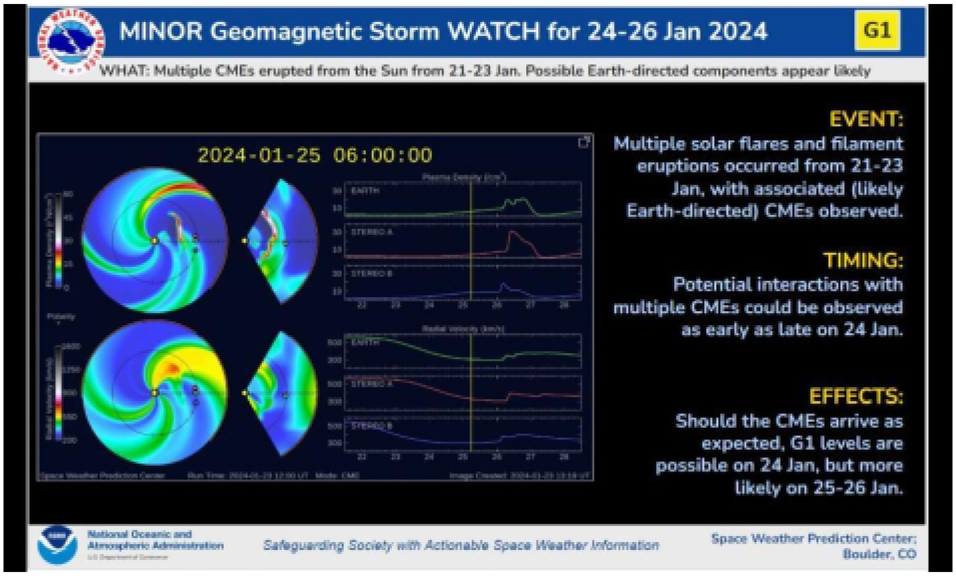


Figure E2 – Total Field, Signal Level, Magnetic Anomaly with a signal level higher than 200. Day 007, 015, and 016 need more processing techniques (spikes removal and filtering) before calculating the Magnetic Anomaly.

According to the Space Weather Prediction Center - NOAA - Figure 3E, multiple solar flares and eruptions occurred from 21-23 Jan, and its influence was anticipated to 22-23 Jan. As we can observe in the figure 4E, the signal level was intermittent during those days, varying from lower than 500 and higher than 1000. However, we need to highlight that during those days the survey had an increase in the amount of turns, influencing the quality of the data.



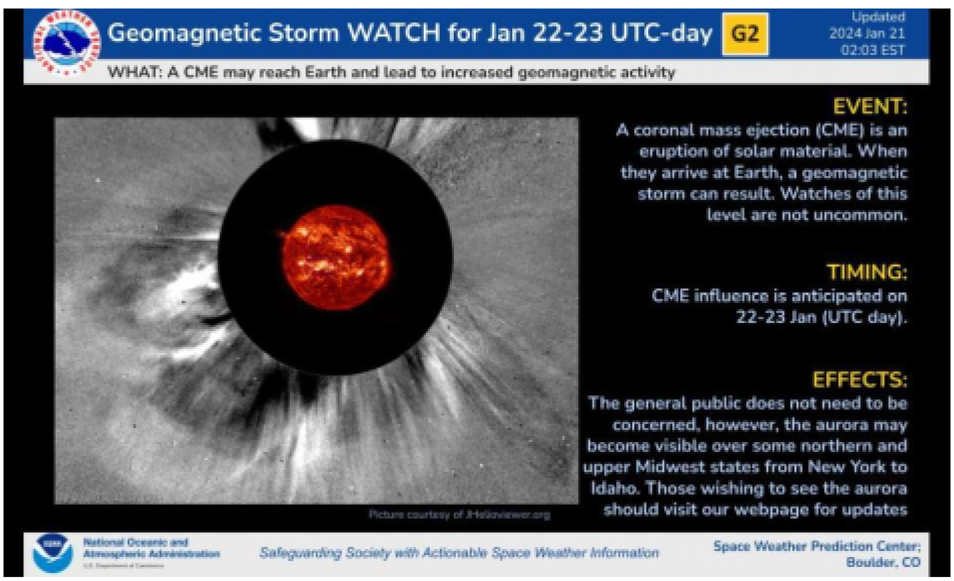


Figure E3 – Geomagnetic storms according to the Space Weather Prediction.
https://www.swpc.noaa.gov/news/g1-minor-storm-levels-likely-24-26-jan-2024
https://www.swpc.noaa.gov/news/g2-moderate-geomagnetic-storm-watch-22-23-jan

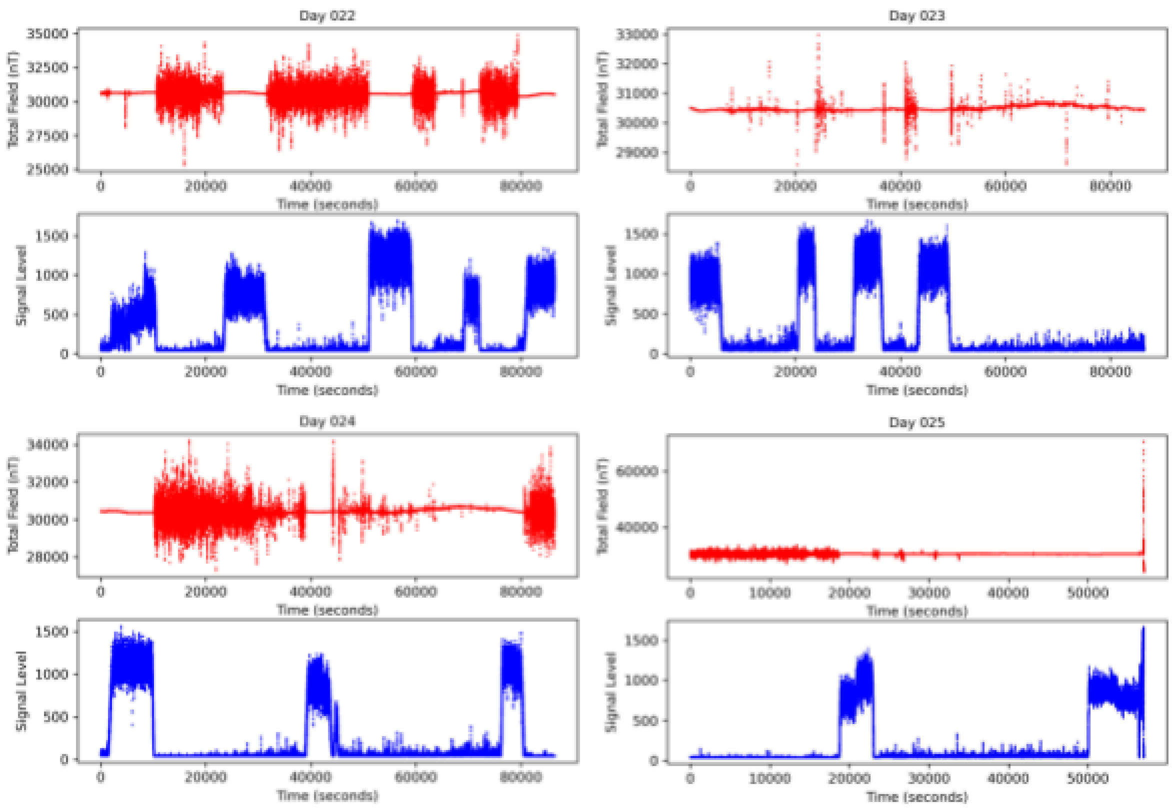


Figure E4 – Total Field and Signal Level for days after the Geomagnetic Storm.

The data collected on January 19th, February 5th and 6th (day 19, 36 and 37 in Julian Calendar) had lower signal levels - Figure 5E, so these signals are considered suspected in the quality control.

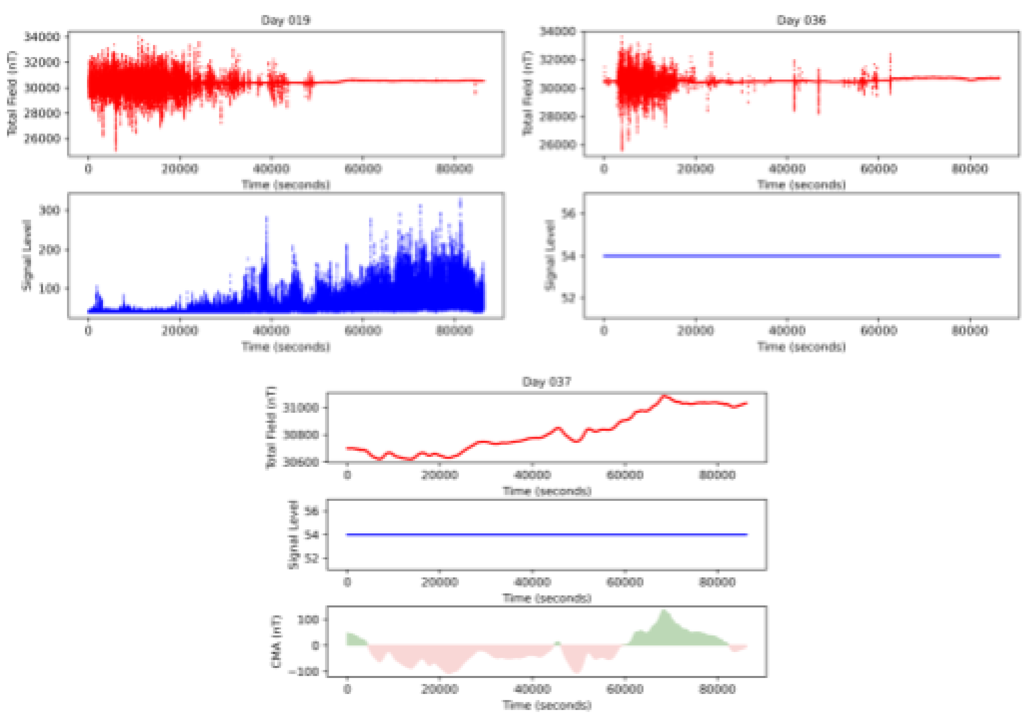


Figure E5 – Total Field, Signal Level, Magnetic Anomaly of days with a lower signal.

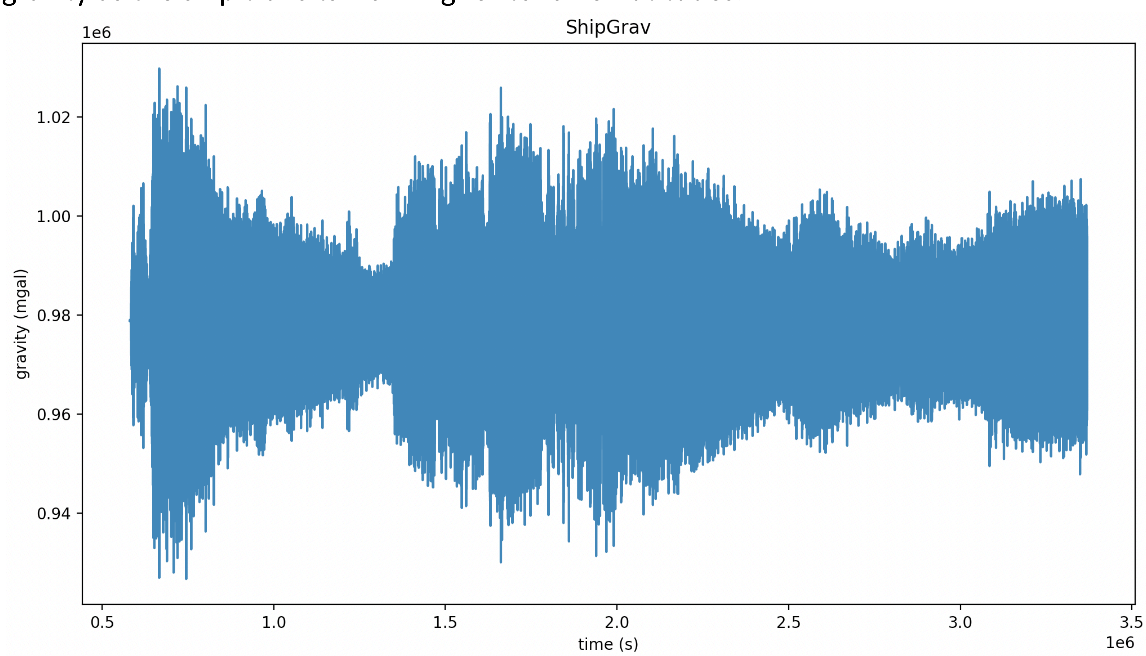
Appendix E. Gravity Data

The collected Gravity data can be used to determine the cause of the Haxby gravity lineament rolls. The observed gravity data can be separated into its source components and compared against lithosphere-asthenosphere models such as that published in Buck and Parmentier's 1986 paper (Buck & Parmentier, 1986). There, Buck and Parmentier show the topography of ocean crust as a primary source of gravity roll anomaly. As a result of stresses by small scale convection in the mantle on newly formed oceanic lithosphere, deformation can occur. This deformation can have rolling peaks and valleys which align with measured gravity anomalies. The primary source of the gravity anomaly under this model is the lateral density variations between water and ocean crust in deformed regions.

Partial melt of the lower ocean lithosphere is another possible source of gravitational anomalies as presented by Ballmer in his 2009 paper (Ballmer 2009). While also acknowledging crust topography as a potential cause, Baller introduces the melt of peridotite as another potential cause. Ballmer's simulations showed that the hot upwellings of small scale convection can cause the partial melt of the lower lithosphere. The component of anomalous gravity due to partial melt of peridotite can be approximated. When compared with the total measured gravity, the potential of partial melt, topography, or some combination thereof can be supported or refuted.

Additionally, the measured gravity is expected to be in agreement with satellite measurements, but could vary in accuracy and resolution.

The amplitude of the gravity data (Figure 1A) correlates well with the sea roughness throughout the trip (Figure 1B), with high amplitudes corresponding to fiercer waves and higher crew discomfort. The initial downward trend in gravity amplitude during the first several days of transit correlates well with the expected decrease in gravity as the ship transits from higher to lower latitudes.



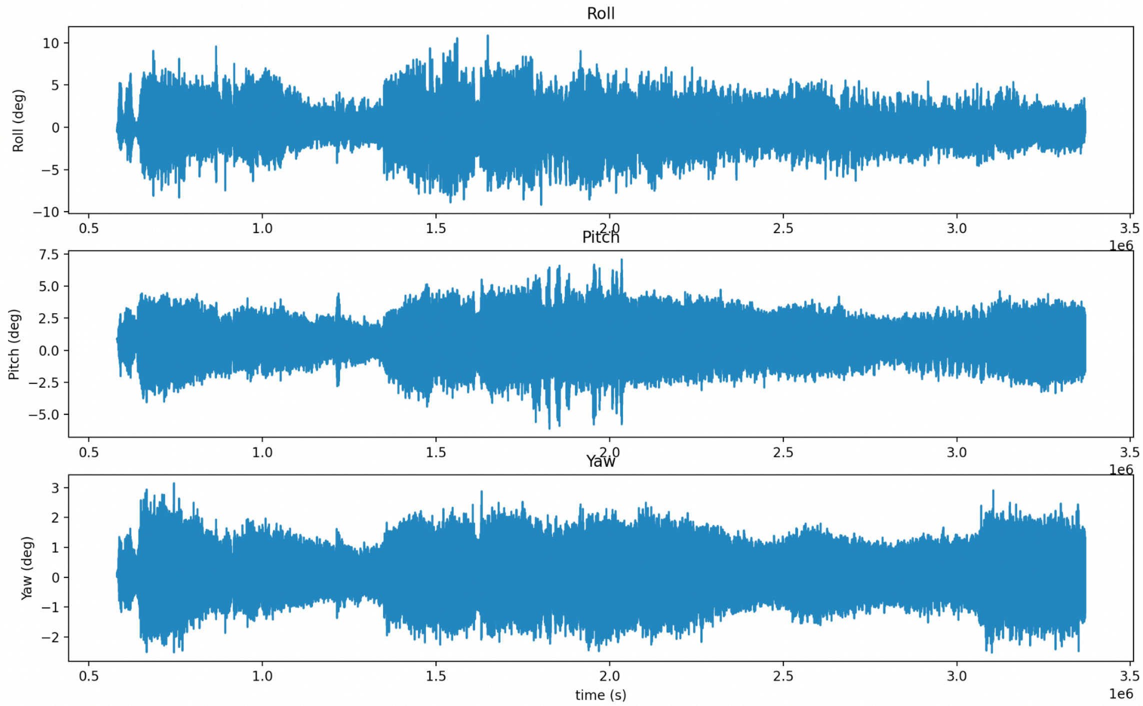


Figure 1: A.) Gravity Raw Data Time Series from January 6th to February 7th. B.) From top down, Roll, Pitch, and Yaw ship data over same time interval

As can be seen in the Welch's Periodogram of the data (Figure 2), the peak energy is at around 0.1 Hz, or 10 seconds, about the same period of the ship's motion due to waves.

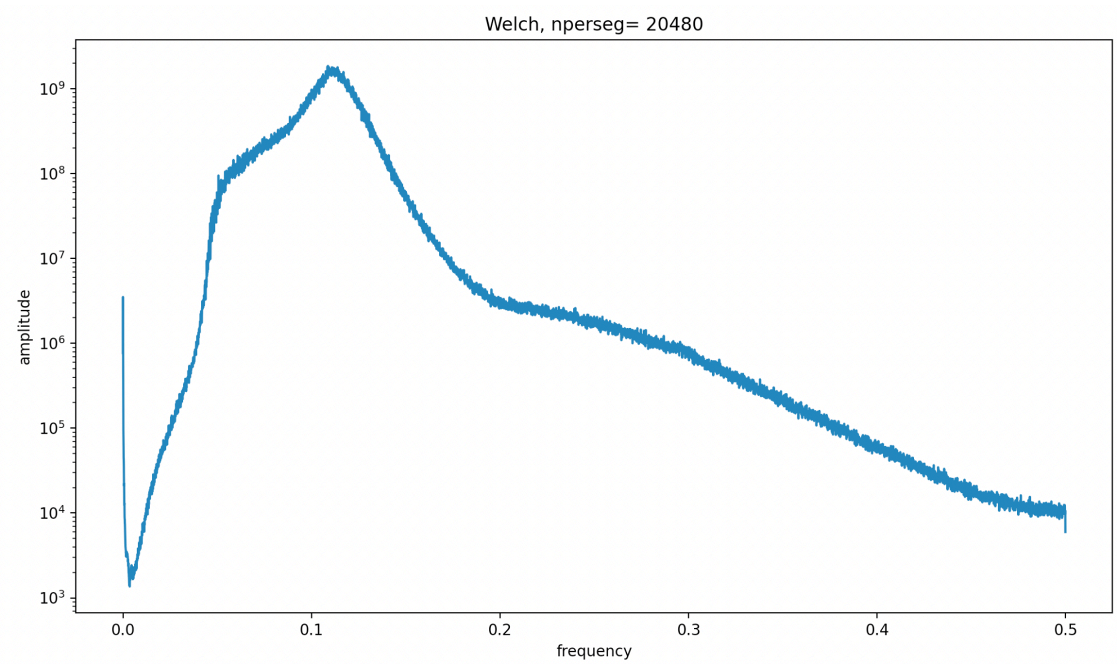


Figure 2: Periodogram of raw gravity data created using Welch's Method, 20480 point segment size used.

In order to get the marine gravity, we first filter the data using gmt, applying a gaussian filter at 360 seconds using the command filter1d. We then apply an Eotvos Correction to the gravity data, using the ship's gps positional and velocity data (gaussian filtered at 60 seconds), calculated using the formula of Glicken (1960). We then apply a latitude-gravity correction calculated using the WGS84 theoretical gravity formula.

We then compare our final result with the satellite gravity, as is shown in Figure 3. Sharp spikes in the filtered ship gravity data correlate well with times at which the ship was turning sharply or engaging in many turns in a short period of time (Figure 4). Looking through the gravity we can find many interesting features, such as the aforementioned Kontor Seamount (Figure 5).

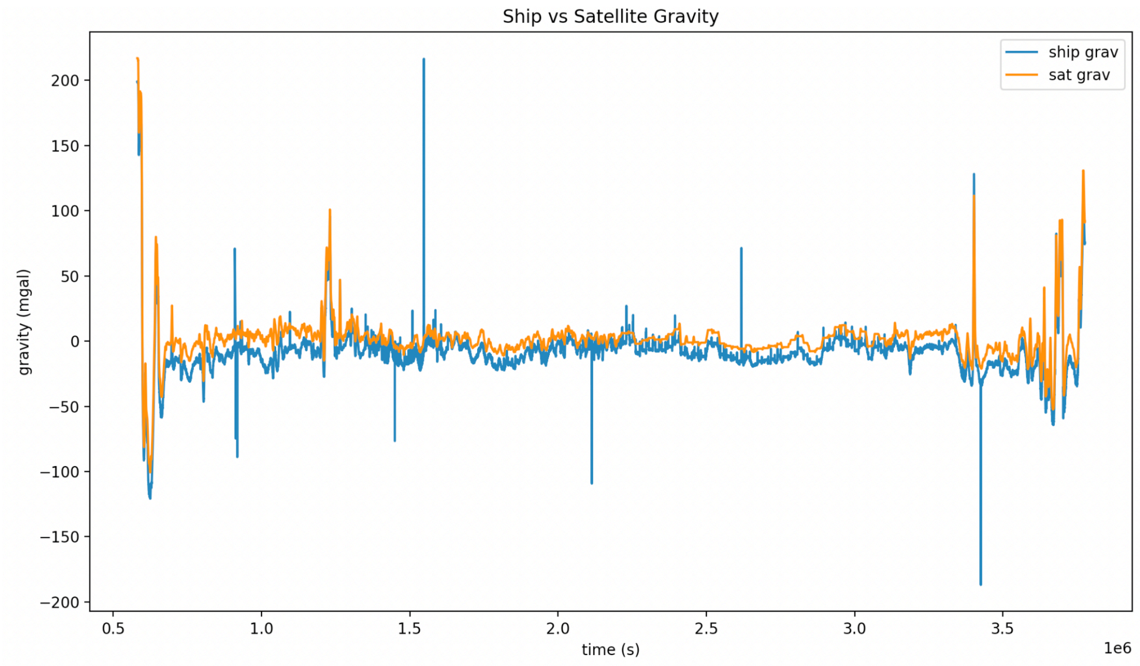


Figure 3: Blue line shows the filtered and corrected ship gravity over the length of the entire cruise, from Jan 6 to Feb 12. Calculated RMS of the ship data is 22.7. Orange line shows 1 arcminute satellite gravity at the same locations as derived from Cryosat-2 and Jason-1 satellite data. Calculated RMS of the satellite data is 20.7.

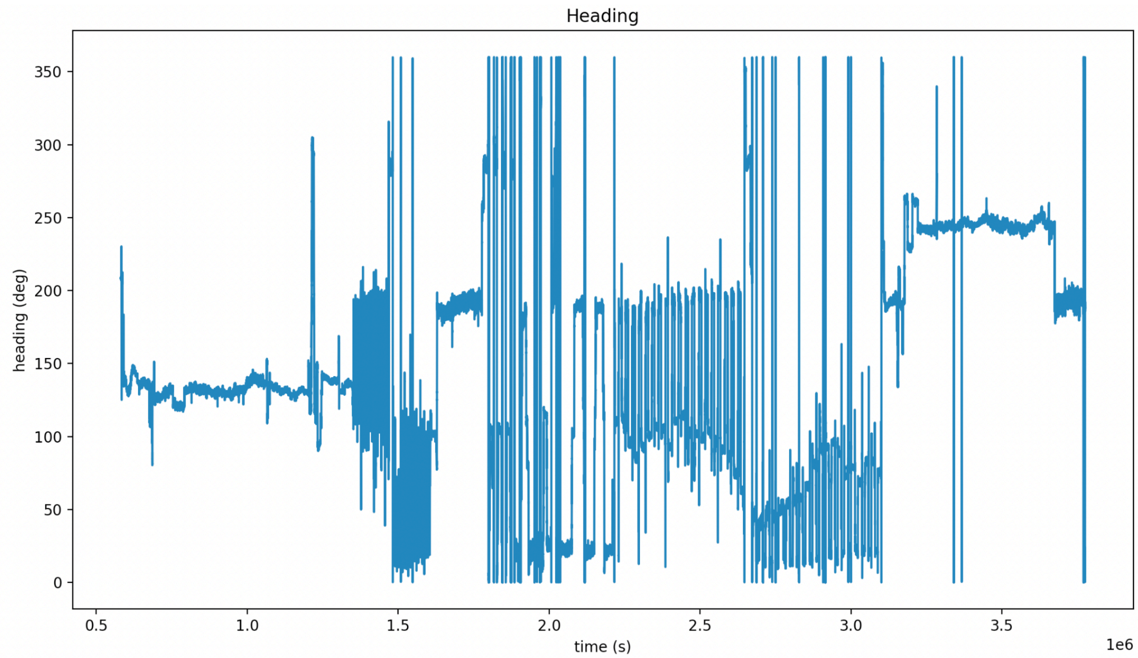


Figure 4: Ship heading data from Jan 6 to Feb 12

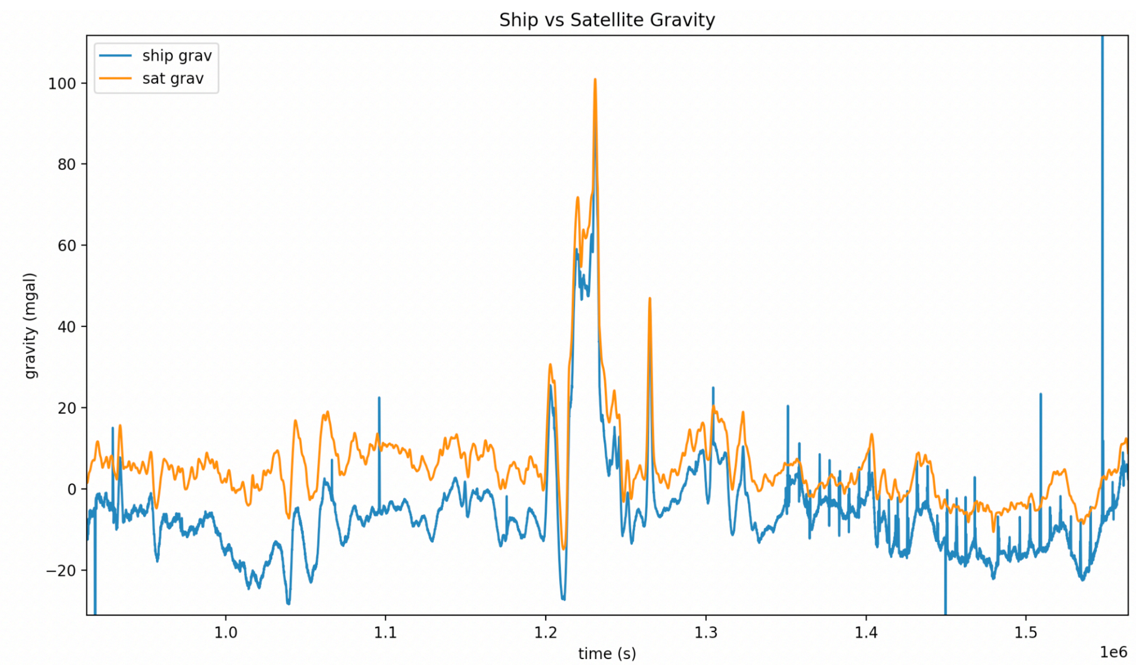


Figure 5: Figure 3 zoomed into the time frame at which we crossed Konter Seamount.

Satellite gravity shows fairly good agreement with our data, as can be seen in Figure 5. To illustrate this further, we plot both data sets along the same axes (Figure 6). A linear regression between the two data sets gives a slope of 0.957 and an intercept of 9.94. We also calculated the Mean Absolute Difference (MAD) between the ship and satellite data to be 10.382.

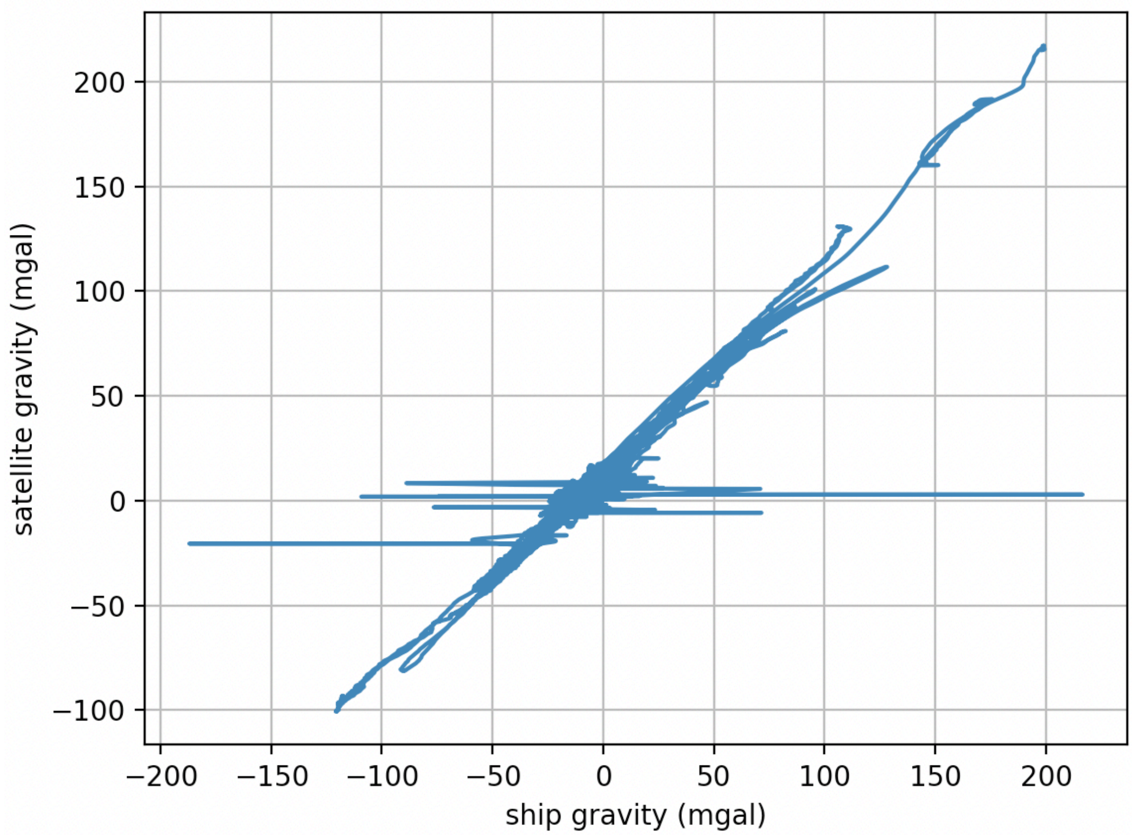


Figure 6: ship gravity data along the x axis, satellite gravity data along the y axis.

Appendix F. Navigation data and XBT

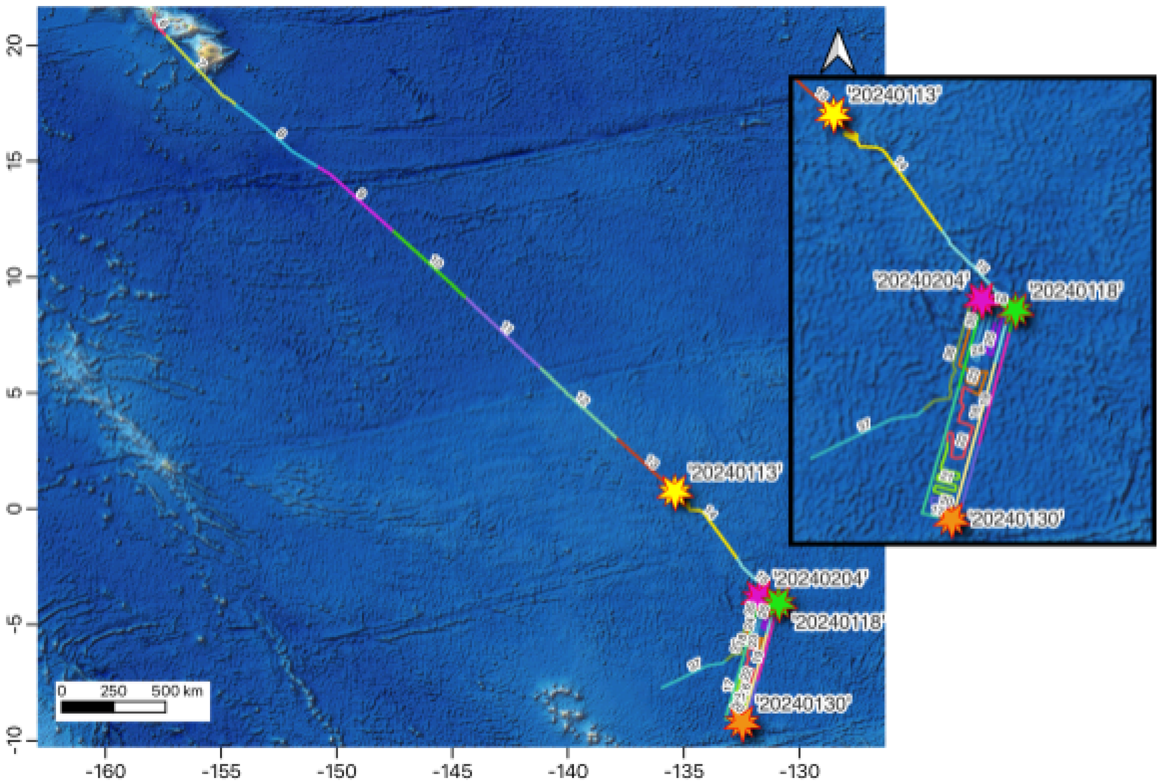


Figure F1 – Navigation data and XBT locations.

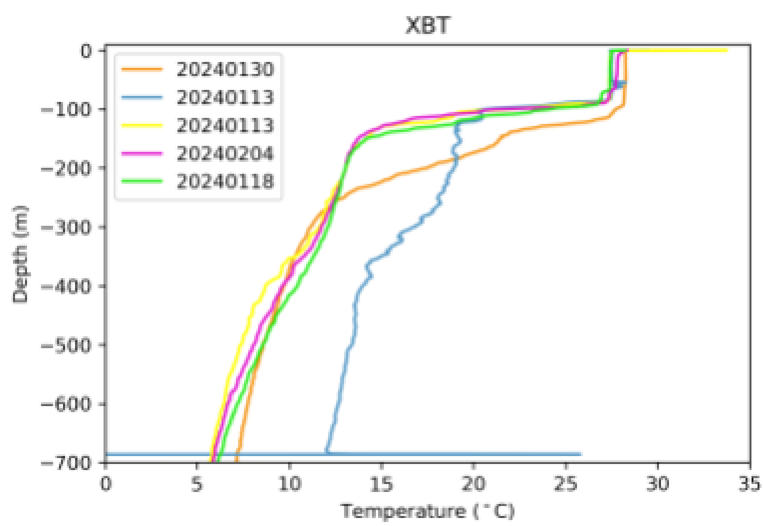


Figure F2 – XBT profiles in the different dates.

Appendix G. Daily Ship Log Report

The crew aboard the vessel logged the daily activity for the ship report #KM2401. Each daily log provides the ships reference position with respect to the oceanographic measurements (see Methods). The synopsis of the daily activity is provided.

The daily log report heading format:

[Datetime, *UTC*]
[Ocean column depth, *m*]
[Earth gravity, *m/s*]
[Magnetic data (*nano Tesla), nT*]
[Speed over ground (SOG), *knots*]
[Heading of ship, *degrees*]
[Observational notes, *obs*]

January 7.

On January 7th, the R/V Kilo Moana navigated steadily with an average SOG of 10 knots, maintaining 130-degree range heading. Gravity and magnetic data was nominal during day without interpretation. The vessel's speed over ground (SOG) consistently hovers around 10 knots, with headings mainly in the 130-degree range. The ocean bottom features ranged from abyssal hill seamounts from 12-16 UTC, flattening at 17:30, and returning to abyssal hills from 18:30-19:30. A very large seamount detected at 20:00, followed by deep channel at 20:30, and abyssal hills onward through 22:40 (end of day).

January 8.

On January 8th, the R/V Kilo Moana navigated steadily with an average SOG of 10.5 knots, maintaining 130-degree range heading. Gravity and magnetic data was nominal during day without interpretation. Throughout the day, magnetic readings averaged around 33,000 nT. Notable observations included flat bathymetry in the morning and the possibility of a transform fault identified in the afternoon at 10:00:11 UTC. The vessel also navigated through a ~50m trough and detected seamounts, indicative of varied underwater terrain.

January 9.

On January 9th, the R/V Kilo Moana maintained a consistent navigation speed, averaging around 10.2 knots with a heading mainly in the 127° range. Gravity and magnetic data was nominal during day without interpretation. Throughout the day, magnetic readings averaged around around 32,000 nT. Depth readings ranging from 5100 to 5600 m. The log noted several passes through what was identified as a fracture zone, suggesting active geological formations were surveyed. Additionally, the vessel's path took it over areas of abyssal hills and seamounts.

January 10.

On January 10th, the R/V Kilo Moana maintained SOG varied between 9.8 and 11.5 knots, with the heading staying relatively steady around 10.5 degrees. Gravity and magnetic data was nominal during day without interpretation. Throughout the day, magnetic readings averaged around 32,000 nT. Depth readings ranging from 5041 to 5167 m.

January 11.
January 12.
January 13.
January 14.
January 15.
January 16.