Lamont-Doherty Earth Observatory of Columbia University

EW 9805 Data Reduction Summary
Halifax, Nova Scotia

May 23 - July 1, 1998

Western Geophysical

Job Number: 0173-9A-012
Data Shipment #2

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Notes

- No Gravity tie was taken at the first Halifax stop, however an interim gravity tie was taken at the first data drop on June 6th.
- Previous Gravity Tie in Norfolk, VA was incorrect, so previous Gravity Tie references 9802 in Barbados
- Navigation data starts on May 20th and continues through the port stop for testing purposes
- Logged data actually starts on May 24th at 1440 instead of when the cruise started, 14 hours earlier.
- Starfix (Differential) logging didn't start until June 6th.
- There is an interruption of about 1.5 hours on May 18th (transit back to site from 2nd data drop) due to transfer of data between disks.

Navigation Processing

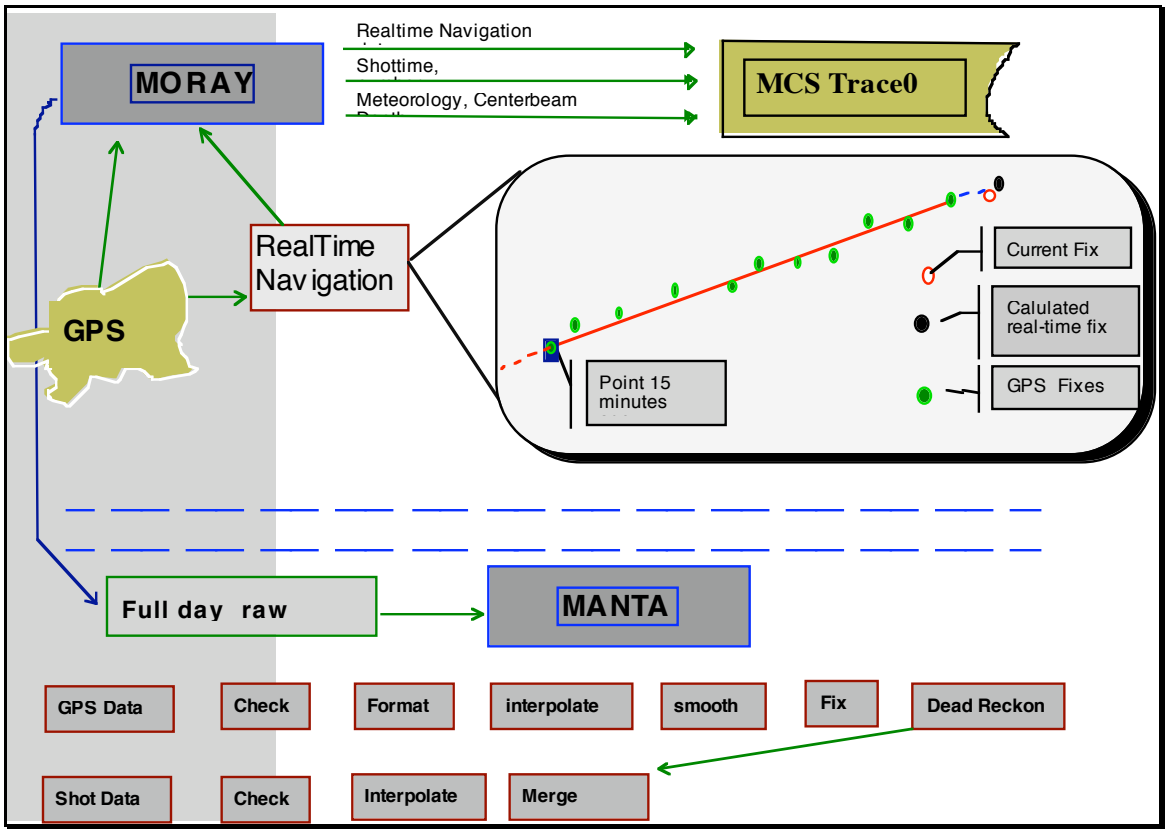

Figure 1. *Navigation Processing Pipeline*

1. **Logger** (Sparc 2, SunOS 4.1)
   Moray is the system responsible for logging all the real-time data from an array of serial ports. *Hydrosweep is the exception and is logged from a UDP broadcast from a SGI running IRIX.* Each data record logged by an instrument is time tagged with the CPU current time, which is synched every minute with one of the UTC receivers. The GPS records are also time-tagged, but the time of position comes from the times established by the receiver for the position.

   Moray also controls the firing of the guns. In order to determine the time to fire, as well as the precise location the guns were fired, it relies on the *Real-time Navigation Process.*

2. ~~**Real-time Navigation Process**~~
   ~~One GPS is selected to be the receiver for the cruise, usually the TASMAN P(Y) Code GPS Receiver. The GPS data is logged to disk once every ten seconds.~~
   ~~In order to shoot by distance, and also to predict where the shot occurred, we take two points (X seconds apart) from the specified GPS. From these two points, an average velocity is determined, and a "real-time" navigation position is output as the GPS fix. **See Figure 1.** The output of the real-time navigation is a file containing the following, used for real-time shot position and MCS data:~~

   - ~~The last lat/lon position (directly from the GPS) and the time (in seconds) of the last fix~~
   - ~~ship speed in the east direction, ship speed in the west direction~~
   - ~~Furuno speed and heading~~
   - ~~Meteorological data~~

~~From this velocity we determine the location of the shot when the shot-time does not fall precisely on a GPS fix; which is always. We also use this "RT Navigation" to determine our next "shot-by-distance". We determine our current velocity, the time it will take to travel x meters, and then set the shot-clock for that amount of time.~~

3. **GPS Post Processing**
   Navigation data is post-processed in order to accurately determine our position due to selective availability, and in the case of the P(Y) Code receiver, eliminate some of the effects of the rolling of the ship.. This post-processed navigation is then applied to all position-specific data to provide consistent positions for all devices: *Magnetometer, Gravimeter, Hydrosweep Centerbeam*.

   - Check data for mutant records and inconsistent times, and convert from GPS format to human-readable format.
   - Interpolate data where GPS coverage is missing for any amount of time 3 minutes or *less*.
   - When differential coverage is in effect, throw away fixes that are not differentially corrected.
   - Smooth the values with a 9 point running average algorithm.
   - Fix the values to 1 minute intervals
   - Perform dead reckoning based on the furuno for any gaps in the data. At this point, if there are any gaps, they will be gaps greater than 3 minutes. Output the set and drift for those points; also fixed at one minute intervals.

     97+295:03:49:00.000 N 8 59.9698 W 104 9.7289 gp2 56.0 0.1

     97+295:03:50:00.000 N 8 59.9459 W 104 9.7394 dr 1.8 0.3

   - Decimate the data to 20 minute fixes, then re-fix at 1 minute intervals using dead reckoning. This is done to smooth out peaks due to selective availability. This is the final navigation.

~~4. Shot Data Post Processing~~

- ~~Check the raw navblock file for mutant records and inconsistent times.~~
- ~~Interpolate any missing shots using a simple interpolation algorithm which does not correct for changes in latitude. Interpolated shots are marked with a - in the cpu time field.~~
- ~~Merge the shot times with the final navigation prepared in Step 2. The shot-point is calculated using the final 1 minute navigation fixes and the difference in time from the closest fix:~~

  ~~lat = final_nav[i].lat + (final_nav[i+1].lat - final_nav[i].lat) * (navblock_sec / (final_nav[i+1].tot_secs - final_nav[i].tot_secs));~~

  ~~lon = final_nav[i].lon + (final_nav[i+1].lon - final_nav[i].lon) * (navbock_sec / (final_nav[i+1].tot_secs - final_nav[i].tot_secs));~~

Data Collected During this Cruise

Data Type	File Header	Description	Days Collected
Sea Temp	ct	Sea Temperature	144 - 182
Furuno	fu	Furuno Speed and Heading	144 - 182
Tasman GPS	gp1	Y Code GPS	140 - 182
Trimble GPS	gp2	Standard GPS	140 - 182
Magnavox GPS	gp3	Standard GPS	140 - 182
Starfix GPS	gp4	Differential GPS	157 - 182
Hydrosweep Center	hb	Centerbeam depth	144 - 182
Hydrosweep Swath	hs	Full Hydrosweep	144 - 182
Datum Time	tr1	CPU time vs UTC	144 - 182
Bell Gravity	vc	Bell Gravimeter data	144 - 182
Weather Station	wx	weather instrumentation	144 - 182

Processed File Formats

n. - final navigation at even minute intervals

98+074:00:03:00.000 N 13 6.2214 W 59 37.9399 gp1 0.0 0.0
yr +day time Latitude Longitude gps set drift

hb.n - interpolated center beam merged with navigation

yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234 2222.0
yr day time lat lon depth (meters)

m. - merged bathymetry, magnetics, gravity with final navigation.

98+123:04:36:03.895 N 14 9.0555 W 67 2.3969 gp3 276.9 0.2
yr day time lat lon id set drift

5034.9 37401.8 17.2 -1.6 978349.0 13.1 9.1 13.2
depth mag tot intensity mag anomaly grv. faa raw_grv eotvos tot drift dc shift

vt.n - merged BGM-3 gravity with final nav.

yy+ddd:hh:mm:ss.mmm N 16 0.4273 W 73 20.3055 1980 -4.1
yr day time lat lon theog FAA

978416.9 27.6 9.9 13.2 -2.7 3.9 -2.8 3.8
raw_grav eotvos drift dc shift raw_vel N E smooth_vel N E

Raw File Formats

ct.r - raw sea temperatures at 1 minute intervals

yy+ddd:hh:mm:ss.mmm 0010.1 00

fu.r - raw Furuno heading

98+157:00:00:52.096 - 7.3 310.2 311.7
Track speed heading gyro

gpx.c - raw NMEA GPS

98+157:00:03:10.951 N 42 50.4311 W 061 18.8016 P-trimble

- P-trimble Pcode Fix
- D-trimble Differential Fix
- trimble S/A fix

gp3.c - raw MX4200 GPS Fix

98+157:00:03:00.159 $PMVXG,001,000300,4250.432,N,06118.781,W,00009.0,**3***5D
time Latitude Longitude Alt *POS*

POS =

0 Not Navigating
1 Remote Position (from remote device)
2 2D Solution
3 3D Solution
4 2D Differential
5 3D Differential

vc.r - raw gravity counts

98+144:00:00:16.219 01:022466 00
CPU Time pp:dddddd ss
| | |_____ status:
| | 00 = No DNV error; 01 = Platform DNV
| | 02 = Sensor DNV; 03 = Both DNV's
| |_____ count typcially 025000 or 250000
|_____ counting interval, 01 or 10

Instruments

DATUM TIME CLOCK

Instrument 9390-1000 Startime GPS Clock
Logging 1 minute intervals
Science Data **None**

The Datum Time clock is used to adjust the CPU clock of the logging computer. The logging computer captures the continuous time records from the clock and provides these as a service to the rest of the network via a UDP broadcast. This enables the computers on the network to adjust their CPU times to UTC time.

Day	Time	Comments
144	0000	Start Logging True time
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Logging True time

SPEED AND HEADING

Instrument Furuno CI-30 2-axis Doppler speed log, Sperry MK-27 gyro
Logging 3 second intervals
Processing None.
Science Data: *fu.r (raw)*

Day	Time	Comments
144	1440	Start Logging of Furuno Data
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Logging of Furuno data

SEA TEMPERATURE

Instrument Omega DP10 Series
Logging 1 minute intervals
Checking none
Smoothing none
Science Data **none**

Day	Time	Comments
144	0000	Start Logging Sea Temperature
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Logging Sea Temperature

WEATHER STATION

Instrument R.M./. Young Precision Meteorological Instruments 26700 Series
Logging 1 minute interval
Final Data raw.
Notes Bird 2 is no longer used
Science Data **none**

Notes The weather station was changed on the second week of the cruise due to incorrect wind directions.

Day	Time	Comments
144	0000	Start Logging Weather Data
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Logging Weather Data

GPS FIXES

Instruments gp1: TASMAN P(Y) GPS Receiver
gp2: GPS Trimble NT200D
gp3: Magnavox MX-4200 Global Positioning System
gp4: Starfix Differential receiver
Logging 10 second fixes, initially 1 second logging on Startfix, but due to space limitations, chaged back to 10 second fixes
Processing ***See Navigation Processing***
Science Data *gpx.n (processed), gpx.c (checked, raw positions)*

Day	Time	Comments
140	0000	Started Logging of GPS Data
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Processing of GPS Data

BATHYMETRY

Instrument Krupp Atlas Hydrosweep Center Beam
Logging Each ping is logged, and center beam data is extracted and logged separately.
Processing Use only good centerbeam records that were acquired in *survey* mode.
Produce a median value for each even minute
Final Data Merge the median with the one-minute navigation fixes.
Notes The following chart shows all discontinuities greater than 5 minutes.
Science Data *hb.n (processed), hb.r (raw)*

Day	Time	Comments
140	1430	Start logging Hydrosweep data
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Processing Hydrosweep Data

GRAVITY

Instrument Bell Gravity Meter (BGM-3)

Logging 1 second intervals, raw gravity counts

Processing Check gravity, run through 1 minute Gaussian filter and output mGals at 6 second intervals to display output spikes. Run through a second 6 minute gaussian filter. Using the smoothed data, get the median value of every minute and output as the final gravity.

Final Data Merge this with the navigation and remove the EOTVOS errors. Also remove spikes due to hard course changes.

Science Data *ts.n*

Day	Time	Comments
144	1430	Started Logging of BGM Gravity Data
168	2330	Logging Interrupted
169	0100	Logging continues
181	2359	End Processing of BGM Gravity Data

Gravity Ties It is usual practice to have a gravity tie to a gravity reference base station during the port stay. A portable gravity meter (Lacoste Model G #70) is used to make a pier-side reading, a reading at the reference station, and then another pier-side reading. The pier-side gravity value, adjusted in value according to the height of the BGM gravity meter is compared to the BGM gravity meter reading. By comparing these readings with the reference station we can determine the drift of the gravity meter from one por t to the next. We determine the drift and divide that drift by the number of days on the cruise and come up with an average drift/day. This amount is added to the gravity readings over the course of each day. Normally the drift/day is less than 0.1 mgals.

PreCruise Gravity Tie

EW-9802 Bridgetown, Barbados, West Indies

Pier/Ship	Latitude	Longitude

Bollard 23, same pier as reference pier

Reference	Latitude	Longitude
	13 06.4N	59 37.9W

Bollard 34. 3rd Bollard from north end of breakwater at the deep water harbor.

	Id	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9801	2/13/98	1.70	0.01	1.56
Post Cruise	EW9802	3/12/98	1.87	0.01	1.70
Total Days		27.00	0.17		

Time	Entry	Value	
16:58	CDeck Level BELOW Pier	0.33	meters
16:58	Pier 1 L&R Value	1969.80	L&R
17:09	Reference L&R Value	1970.40	L&R
17:16	Pier 2 L&R Value	1969.83	L&R
	Reference Gravity	978294.44	mGals
	Gravity Meter Value (BGM Reading)	978297.50	mGals
	Potsdam Corrected	0	1 if corrected

*Gravity meter is **5.5** meters below CDeck*

Difference in meters between Gravity Meter and Pier: 5.83 meters

Height Cor = Pier Height * FAA Constant

5.83	0.31			1.81	mGals/min

Difference in mGals between Pier and Gravity Meter

Delta L&R = Pier (avg) - Reference * 1.06 L&R/mGal

1969.82	1970.40	1.06		-0.62	mGals

Pier Gravity = Reference + Delta mGals [+ Potsdam]

978294.44	-0.62	0.00		978293.82	mgals

Gravity @meter = Pier Gravity+Height Correction

978293.82	1.81			978295.63	mGals

Current Mistie = BGM Reading - Calculated Gravity

978297.50	978295.63			1.87	mGals

Post Cruise Gravity Tie

EW-9805 Halifax, Canada *OFFICIAL*

Pier/Ship	Latitude	Longitude
	44 38.171N	63 33.922W

Halifax Pier 22
On the line and between 4 and 5 th bollard;
3 feet off the 5th one towards 4th.

Reference	Latitude	Longitude
	N	W

N side of Western Union Warf (Cable Warf) in Halifax. Situated on the base of the sixth bollard. Station 9402-73 is described as directly in front of the bollard's concrete base. The spot is covered with wooden deck, unstable, therefore, reading was done on the base iteslf 25 cm above the original spot.

	Id	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9802	3/12/98	1.87	0.01	1.70
Post Cruise	EW9805	7/1/98	9.60	0.07	1.87
Total Days		111.00	7.73		

Time	Entry	Value	
16:48	CDeck Level BELOW Pier	1.00	meters
16:48	Pier 1 L&R Value	4121.22	L&R
17:45	Reference L&R Value	4123.89	L&R
18:02	Pier 2 L&R Value	4121.22	L&R
Jun-82	Reference Gravity	980563.61	mGals
16:48	Gravity Meter Value (BGM Reading)	980572.40	mGals
	Potsdam Corrected	0	1 if corrected

Gravity meter is ***5.5*** *meters below CDeck*

Difference in meters between Gravity Meter and Pier: 6.50 meters

Height Cor = Pier Height * FAA Constant

6.50	0.31			2.02	mGals/min

Difference in mGals between Pier and Gravity Meter

Delta L&R = Pier (avg) - Reference * 1.06 L&R/mGal

4121.22	4123.89	1.06		-2.82	mGals

Pier Gravity = Reference + Delta mGals [+ Potsdam]

980563.61	-2.82	0.00		980560.79	mgals

Gravity @meter = Pier Gravity+Height Correction

980560.79	2.02			980562.80	mGals

Current Mistie = BGM Reading - Calculated Gravity

980572.40	980562.80			9.60	mGals