



*Lamont-Doherty  
Earth Observatory  
of Columbia University*

DATA REDUCTION CRUISE SUMMARY

EW-9414

Seismic Survey offshore Cape Blanco,  
Central Oregon Coast

Coos Bay, OR - Long Beach, CA, U.S.A.

10/03/94 (JD-276) -- 10/10/94 (JD-283)

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***R/V MAURICE EWING***

**SCIENCE OVERVIEW:**

This project involves collection and interpretation of a wide spectrum of marine geophysical data from previously studied areas in the Mendocino triple junction region and the central Oregon offshore. The focus is to enhance understanding of (1) the Mendocino triple junction and of triple junction-related processes and deformation, and of (2) shallow-to-deep structure, along-strike segmentation, and seismogenesis in the central and southern Cascadia subduction zone.

**TRUE TIME CLOCK:**

**Instrument:** *Kinematic/TrueTime Division Model GPS-DC GPS Synchronized Clock*

**Logging:** 1 minute intervals

**NOTE:** The True 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
276	1518	start of cruise, started logging/processing
283	1600	end of cruise; stopped logging/processing

**SPEED AND HEADING:**

**Instrument:** *Furuno CI-30 2-axis Doppler speed log, Sperry MK-27 gyro*

**Logging:** 3 second intervals

**Checking:** visual check of plot of data

**Smoothing:** mean value of all good values within the same minute

DAY	TIME	COMMENTS
276	1518	start of cruise; started logging/processing
283	1600	end of cruise ; stopped logging/processing

**TRANSIT SATELLITE FIXES:**

**Instrument:** *Magnavox MX-1107RS dual frequency Transit satellite receiver*

**Logging:** all fixes

**Checking:** reject receiver flagged fixes, fixes with high drifts in navigation

DAY	TIME	COMMENTS
276	1518	start of cruise; started logging/processing
283	1600	end of cruise ; stopped logging/processing

**GPS SATELLITE FIXES:****Instrument:** *Magnavox MX-4200 Global Positioning System receiver***Logging:** 10 second intervals on GPS MX-4200 #1  
10 second intervals on GPS MX-4200 #2**Checking:**

minimum number of SATs: 3

dilution of precision maximum: north = 4.0, east = 4.0

carrier signal-noise ratio minimum: 35.0

standard deviation maximum: north =4.0, east = 4.0

time step maximum: 3

speed maximum: 30.0

compared GPS speed and course with Furuno smooth speed and heading

compared positions with Transit-Furuno navigation

reject fixes with high drifts in navigation

reject fixes producing Eotvos correction errors in gravity larger than 5 mGals

**Interpolation:** interpolated positions at 00, 30 seconds of each minute**Smoothing:** smoothed interpolated positions with 9 or 41 point running average depending on the quality of GPS data and the sea state.**Note:**

The GPS data has a sinusoidal wave which is assumed to come from some degrading of the GPS quality for civilian usage. This wave seems to vary in period and shapes and is not a perfect sine curve. The periods are less than 20 minutes. The amplitudes tend to vary over 24 hours and the sea state condition. This degrading produces a false ship's track in real-time navigation and introduces extreme errors, up to 10 mGals, in the Eotvos correction for the gravity. As this problem varies in its intensity depending on the sea state and GPS data quality itself, several methods of data reduction has been developed to achieve the best possible navigation.

1. A 9 point (4 minutes) GPS smoothing
2. A 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes
3. A 41 point (20 minutes) GPS smoothing
4. A 41 point (20 minutes) GPS smoothing, decimated to a 20 min. fixes

It should be noted that the use of 41 point smoothing causes the turn to "widens". Hence, in the instances where a 41 point smoothing is called for, the GPS data at and around the turn are decimated to 20 minutes.

Throughout this cruise, a 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes were used to produce final navigation data.

DAY	TIME	COMMENTS
276	1518	started data logging/processing
283	1600	end of cruise ; stopped data logging/processing

**NAVIGATION:**

A "1 minute navigation" is produced from the above sources, which in this cruise is a 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes. Acceptable fixes are merged at 1 per minute with priority given to GPS. The smooth speed and heading data is used to fill any gaps of 2 minutes or longer between fixes by computing 1 minute DR'ed positions corrected for set and drift between fixes. The DR'ed positions are produced at 00 seconds of each minute.

Chief scientist's final data: 1 minute navigation.

FORMAT: n.ddd

yy+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234 id 123.1 12.1  
 yr. day time lat. lon id set drift

Lamont database: 1 minute navigation, in MGG format.

DAY	TIME	COMMENTS
276	1518	started data processing
283	1600	end of cruise ; stopped data processing

**SEA TEMPERATURE:**

**Instrument:** *Omega DP10 Series*

**Logging:** 1 minute intervals

**Checking:** none

**Smoothing:** none

Chief scientist's final data: one minute data, merged with navigation.

Lamont database: one minute data, merged with navigation.

FORMAT: ct.nddd

yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234 26.3  
 yr day time lat lon sea\_temp (in °C)

DAY	TIME	COMMENTS
276	1518	started data processing
283	1600	end of cruise ; stopped data processing

**MAGNETIC:****Instrument:** *Varian V75 magnetometer***Logging:** 6 second intervals**Checking:** visual check of plot of data**Reference field:** International Geomagnetic Reference Field 1990  
( *IGRF 1990* ) model of the main field at 1985.0 and a predictive model of the secular variation for adjusting to dates between 1990.0 and 1995.0.**Residual field:** Applied by bi-linear interpolation across a 1 degree square.

Chief Scientist's final data: final calibrated and cleaned data.

FORMAT: mg.nddd

yr+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234 41200.8 -367.1  
yr. day time lat lon total\_intensity anomaly

Lamont Database: interpolated total intensity value at 00 second of each minute

**NOTE:**

DAY	TIME	COMMENTS
277	0227	started logging
280	1541	maggie off the water; end of logging

**BATHYMETRY:****Instrument:** *Krupp Atlas Hydrosweep Center Beam***Logging:** At each ping of *Hydrosweep*, data is being broadcasted real time to the network, which is received by data logger. The logger computer then extracted the center beam depth.**Checking:** Visual checking aided by graphic editor to remove major spikes.Chief scientist's final data: final calibrated and cleaned center beam data, two nearest point to the minute interpolated to even minute.  
Merged with final navigation.  
Depth is in meters.

FORMAT: hb.nddd

yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123 12.1234 2222.0  
yr. day time lat. lon depth\_in\_metersLamont database: final calibrated and cleaned data, interpolated to even minute.  
Merged with final navigation. MGG format.  
Depth is in fathoms.

DAY	TIME	COMMENTS
276	1518	started logging/processing
283	1600	end of cruise; stopped logging/processing

**ADCP (Acoustic Doppler Current Profilers):****Instrument:** *RD Instrument RD-VM Model ADCP***Logging:** logging is done by a 386 IBM PC compatible**Checking:** none**Smoothing:** none

Chief scientist's final data: processed data file format and navigation data file format.  
 Lamont database: processed data file format and navigation data file format.

FORMAT: Refer to Transect User's Manual for Narrowband ADCP Appendix B.

DAY	TIME	COMMENTS
276	1518	beginning of the cruise ; started logging/processing
283	1600	end of cruise; stopped logging/processing

**SHOT TIME & GUN DEPTH:****Instrument:** *L-DEO Time Tagger and GunDepth Interface***Logging:** Shot Time from the Time tagger. Gun Depth from Gun Depth Interface

FORMAT: ts.nddd (shot time)

94+173:00:04:04.333 000172 N 40 56.5884 W 125 42.6913 mcs-6a

SHOT TIME shotnum lat lon line name

FORMAT: dg.rddd (gun depth)

94+173:00:04:04.333 13 13 13 13 13 13 13 ....

SHOT TIME GUN DEPTH

**Note:**

A '-' sign following the year means that shottime was not received in time.  
 A CPU timetag is placed instead. This sometimes happens at the beginning of the line when the computer and the DMS-2000 are trying to get in sync with each other. No gun was fired, and no data is recorded to the tape.

JDAY & TIME	Shot Number	LINE NAME	COMMENTS
277:02:43:13-277:07:15:10	0103-0876	cb01	shot-by-dist 50m
277:10:08:51-277:20:12:42	0104-1854	cb05	shot-by-dist 50m
277:20:31:56-278:00:58:15	0102-0864	cb04	shot-by-dist 50m
278:01:44:40-278:12:11:16	0101-1746	cb06	shot-by-dist 50m
278:13:10:51-278:16:53:13	0103-0755	cb06T	shot-by-dist 50m
278:18:49:43-279:07:11:22	0104-1985	cb03	shot-by-dist 50m
279:09:45:57-279:23:07:59	0101-2377	cb02	shot-by-dist 50m
280:00:33:10-280:07:46:42	0102-1362	cb07	shot-by-dist 50m
280:08:02:04-280:15:23:54	0105-1380	cb04s	shot-by-dist 50m

**Partial CO2:****Instrument:** *L-DEO PCO2 Group PCO2 Analysis Instrument***Logging:** as is.**Checking:** none

Chief scientist's final data: none.

Lamont database: merged data with final navigation.

**FORMAT:**

94+036:22:35:00.000 S 21 31.0624 W 31 27.2926 94036.9360  
 Yr Day Hr Mn Second Lat Lon YrDay.frac  
 2033.8 2033.8 1014.0 34.64 33.8 419.9 404.5 28.41 Equil 28.2  
 IR\_1 IR\_2 Baro CellT Flow VCO2 pCO2 Eq\_T Type SeaT

YrDay.frac = Time of analysis

IR\_1 = CO2 signal (mv)

IR\_2 = CO2 signal (mv)

Baro = IR Cell pressure (mbar)

CellT = IR Cell temperature (deg C)

Flow = Sample/Standard gas flow rate through IR cell (ml/mn)

VCO2 = Concentration of CO2 in dry gas sample (preliminary value) (ppm)

pCO2 = Partial pressure of CO2 in water-saturated air at temperature of equilibration (uatm); (or residual of 2nd order fit if standard (calibration) gas)

Eq\_T = Equilibration temperature (deg C)

Type = Type of analysis [Equil= equilibrated seawater, Airi= atmospheric air, Stdn= calibration gas]

SeaT = Sea Surface Temperature, measured using thermistor on ship's keel (depth= ?? meters) (deg C)

**Note:**

The IR system was found not working properly at the beginning of the cruise. Due to the lack of spares, the system was turned off during the duration of the cruise.

DAY	TIME	COMMENTS
276	1518	beginning of the cruise ; started logging/processing
283	1600	problem with instrument, stopped logging

**WEATHER STATION:****Instrument:** *R.M/. Young Precision Meteorological Instruments 26700 Series***Logging:** 1 minute interval**Checking:** none

Chief scientist's final data: as is.

Lamont database: as is.

FORMAT: wx.rddd

Port bird is bird #1; starboard bird is bird #2.

```

94+022:00:00:00.244  9.3  15.4  13.2  21.1  271  261
date  time           wsi1  wss1  wsm1  wxs1  wdc1  wds1

   6   12.6 15.9  15.6  20.7  261  253    6  66.7 66.7
wdm1 wsi2  wss2  wsm2  wxs2  wdc2  wds2  wdm2  tcur  tavg

66.5 67.0 66 58 68 1016.8
tmin tmax rh rhn rhx  baro

```

wsi1/2 = wind speed, instantaneous, bird #1/#2

wss1/2 = wind speed, 60 second average, bird #1/#2

wsm1/2 = wind speed, 60 minute average, bird #1/#2

wsx1/2 = wind speed, 60 minute maximum, bird #1/#2

wdc1/2 = wind direction, current, bird #1/#2

wds1/2 = wind direction, 60 second average, bird #1/#2

wdm1/2 = wind direction, 60 minute average, bird #1/#2

tcur = temperature, current

tavg = temperature, 60 minute average

tmin = temperature, 60 minute minimum

tmax = temperature, 60 minute maximum

rh = relative humidity

rhn = relative humidity, 60 minute minimum

rhx = relative humidity, 60 minute maximum

baro = barometric pressure

DAY	TIME	COMMENTS
276	1518	beginning of the cruise ; started logging
283	1600	end of cruise; stopped logging

**KSS-30 GRAVITY:****Instrument:** *Bodenseewerke KSS-30 marine gravity meter***Logging:** 6 second intervals**Merge with navigation:** calculate Eotvos correction and Free Air Anomaly.**Checking:** Visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.**Velocity smoothing:** 5 point running average throughout the cruise**Processing:**

The KSS-30 times tag is first adjusted for the filtering delay. For "Seastate" setting 2, the delay due to filtering is 75 seconds. Thus 75 seconds are subtracted from the time tag and a new, adjusted time is computed.

A smooth KSS-30 gravity mgal value at one minute interval is calculated on 00 second of the minute by computing the unweighted mean values from the raw values that lie between +30 seconds of 00 seconds of the minute.

**Calculation:**

$$\begin{aligned} \text{eotvos\_corr} &= 7.5038 * \text{vel\_east} * \cos(\text{lat}) + .004154 * \text{vel} * \text{vel} \\ \text{corrected\_grv} &= \text{raw\_grv} + \text{eotvos\_corr} - \text{drift} - \text{dc\_shift} \\ \text{faa} &= \text{corrected\_grv} - \text{theoretical\_grv} \end{aligned}$$

Chief scientist's final data: Observed, Eotvos, Free Air Anomaly value at 00 seconds of each minute.

**1980 theoretical gravity formula:**

$$Y_0 = 978.0327 \times ( 1 + .0053024 \times \sin( Q ) \times \sin( Q ) - .0000058 \times \sin( 2 \times Q ) \times \sin( 2 \times Q ) )$$

FORMAT: vk.nddd

```
yy+ddd:hh:mm:ss.mmm N 10 20.1234 W 120 23.1234 1980 77.1
yr. day time lat. lon. theog FAA
979317.5 64.1 1.5 10.2 -1.7 9.7 -1.6 9.8
raw_grav eotvos drift dc_shift raw_vel smo_vel
```

Lamont database: Free Air Anomaly value at 00 seconds of each minute.  
1930 International gravity formula.

**Note:**

A '-' sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont. Further discussion also revealed that *1980 theoretical gravity formula* has incorporated Potsdam correction in its formula.

At the start of the cruise, KSS-30 platform was found turned off. As a result, there is no data until the start of JD 164.

DAY	TIME	COMMENTS
276	1518	started data processing
283	1600	end of cruise ; stopped data processing

**BGM-3 GRAVITY:****Instrument:** *Bell Aerospace BGM-3 marine gravity meter***Logging:** 1 second intervals**Merge with navigation:** calculate Eotvos correction and Free Air Anomaly.**Checking:** Visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.**Velocity smoothing:** 5 point running average throughout the cruise.**Processing:**

Since current BGM-3 output has double counts every few minutes the following scheme has been implemented until the hardware and interface code has been fixed:

(1) Run a 1 minute Gaussian filter through the data. This will narrow the output spikes and make them stand out better. Output interval has been hard-wired to every 15 seconds.

(2) Pass the output through filter1d (see gmssystem) using -FG480 (an 8 minute Gaussian filter with robust option, i.e., ignore "outlier" points (i.e. the spikes)).

**Calculation:**

```
eotvos_corr      = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
corrected_grv    = raw_grv + eotvos_corr - drift - dc_shift
faa              = corrected_grv - theoretical_grv
```

Chief scientist's final data: Observed, Eotvos, Free Air Anomaly value at 00 seconds of each minute.

**1980 theoretical gravity formula:**

$$Y_0 = 978.0327 \times ( 1 + .0053024 \times \sin( \Theta ) \times \sin( \Theta ) - .0000058 \times \sin( 2 \times \Theta ) \times \sin( 2 \times \Theta ) )$$

FORMAT: vt.nddd

```
yy+ddd:hh:mm:ss.mmm N 10 20.1234 W 120 23.1234 1980 77.1
yr. day time lat. lon. theog FAA
979317.5 64.1 1.5 10.2 -1.7 9.7 -1.6 9.8
raw_grav eotvos drift dc_shift raw_vel smo_vel
```

Lamont database: Free Air Anomaly value at 00 seconds of each minute.  
1930 International gravity formula.

**Note:**

A '-' sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont.

Further discussion also revealed that *1980 theoretical gravity formula* has incorporated Potsdam correction in its formula.

DAY	TIME	COMMENTS
276	1518	started data processing
283	1600	end of cruise ; stopped data processing

**PRE-CRUISE GRAVITY TIE-IN:**

Port: Dutch Harbor, Alaska, U.S.A.

Date: July 6, 1994 (JD 187)

Operator: Bruce A. Francis

Reference Station:

ACIC 2178-1

Reference Value: 981552.07 mGals

Pier/Ship's position:

R/V Ewing was at the pier by the Delta Western Warehouse.  
 Moved here on July 6th to take on fresh water.

Gravity meter: *L & R Model G, serial number 237.*

Temperature of meter: 49 °C.

Readings and Calculations:

TIME	LOCATION	L&R READING	G	Potsdam Corr?
2015Z	Pier	5046.64+- .05		
2032Z	Ref	5046.43+- .05	981552.07	NO!
2042Z	Pier	5046.62+- .05		

TIME	GRAVITY	G READING
2042Z	BGM-3	981564.3
2042Z	KSS-30	1396.08

Pier reading 2.8 m above waist deck. Waist deck is 5.5 m above gravity meter.  
 Difference between pier and gravity meter :  $5.5 + 2.8 = 8.3$  m.

*Lacoste difference in LR units:*

$$\begin{aligned} \text{delta\_LR} &= \text{pier\_LR} - \text{ref\_LR} \\ 0.19 &= 5046.62 - 5046.43 \end{aligned}$$

*Difference in mgal: ( 1 LR unit = 1.06 mGals )*

$$\begin{aligned} \text{delta\_mgal} &= \text{delta\_LR} \times \text{constant} \\ 0.2 &= 0.19 \times 1.06 \end{aligned}$$

*Pier gravity value in mgal: ref\_val = G (+13.6 if Potsdam corrected)*

$$\begin{aligned} \text{pier\_grv\_val} &= \text{ref\_val} + \text{delta\_mgal} \\ 981552.27 &= 981552.07 + 0.2 \end{aligned}$$

*Height correction:**Height correction in mGals:*

note: free-air constant of +0.31 mGals per meter going towards  
 the center of earth; -0.31 mGals per meter going away.

$$\begin{aligned} \text{hgt\_corr} &= \text{hgt} \times \text{constant} \\ 2.57 \text{ mGals} &= 8.3 \times 0.31 \text{ mGals/m} \end{aligned}$$

*Gravity at gravity meter level in mGals:*

$$\begin{aligned} \text{grv\_at\_meter\_level} &= \text{pier\_grv\_val} + \text{hgt\_corr} \\ 981554.84 &= 981552.27 + 2.57 \end{aligned}$$

**KSS-30:**

KSS-30 value was smooth and time adjusted by 75 secs.

$$\begin{aligned} \text{KSS\_grav\_val} &= \text{kss\_unbiased\_output} + \text{bias} \\ 981556.37 &= 1396.08 + 980170.29 \end{aligned}$$

*Mistie in mGals:*

$$\begin{aligned} \text{mistie} &= \text{KSS\_grav\_val} - \text{grv\_at\_meter\_level} \\ 11.53 &= 981556.37 - 981554.84 \end{aligned}$$

*Drift in mGals since last tie:*

prev\_mistie: 15.6 mGals on date May 20, 1994 (JD 140)

$$\begin{aligned} \text{drift} &= \text{mistie} - \text{prev\_mistie} \\ -4.07 &= 11.53 - 15.6 \end{aligned}$$

$$\begin{aligned} \Rightarrow \text{DC Shift} &= \text{prev\_mistie} - \text{bias} \\ &= 15.6 - 980170.29 = -980154.69 \\ \text{Drift/Day} &= \text{drift} / (\text{tot. \# of day}) \\ &= -4.07 / (187-140) = -0.0866 \text{ mGals/day} \end{aligned}$$

### **BGM-3:**

BGM\_filt\_grv = ( scale factor x counts ) + bias = 979537.0  
using s.f. 5.0940744 and bias 8526800, filter width 360. ( 6 minutes)

*Mistie in mGals:*

$$\begin{aligned} \text{mistie} &= \text{BGM\_grv\_val} - \text{grv\_at\_meter\_level} \\ 9.5 &= 981564.3 - 981554.84 \end{aligned}$$

*Drift in mGals since last tie:*

prev\_mistie: 9.83 mGals on date May 20, 1994 (JD 140)

$$\begin{aligned} \text{drift} &= \text{mistie} - \text{prev\_mistie} \\ -0.3 &= 9.5 - 9.83 \end{aligned}$$

$$\begin{aligned} \Rightarrow \text{DC Shift} &= \text{prev\_mistie} \\ &= 9.83 \\ \text{Drift/Day} &= \text{drift} / (\text{tot. \# of day}) \\ &= -0.3 / (187 - 140) = -0.0064 \text{ mgals/day} \end{aligned}$$