Collaborative Research:
Late Pleistocene climate-induced fluctuations in California Current: a paleoceanographic study and ODP site survey.

San Diego, CA - Eureka, CA, U.S.A.
05/17/95 (JD 137) - 06/07/95 (JD 158)

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Juan Carlos Herguera, CICESE, Scientist

Jim Gardner, USGS, Scientist
Brian Edwards, USGS, Scientist
Walter Dean, USGS, Scientist

John Beck, ODP

Science Crew

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John DiBernardo, L-DEO, Chief Pneumatic Sound Source Officer
Chuck Donaldson, L-DEO, Electronic Engineer
Stefanus Budhypramono, L-DEO, System Manager

R/V EWING Crew

Jim O'Loughlin - Master R/V EWING  Al Karlyn - Chief Engineer R/V EWING
Louis J. Mello - Chief Mate  Matt Tucke - First Engineer
Bill Smith - 2nd Mate  David Reid - 2nd Engineer
Jeffrey Sylvia - 3rd Mate  Sport ??? - 3rd Engineer
John J. Santini - Boatswain  Miguel ??? - Oiler
Blaine Heinze - A/B  Michael L. Spruill - Oiler
David G. Graham - A/B  Fernando Uribe - Oiler
Darrell A. Hanna - A/B  Francisco Matos - Electrician

PAGE 1
Rick Wyatt - O/S

Andrew Blythe - Steward
John Smith - Cook
Luke Moqo - Utility
Peter Martin - Radio Operator
SCIENCE OVERVIEW:

EW-9504 was a busy cruise. The primary objective is to survey drill sites for ODP leg 167. The surveys at most drill sites consisted of twin 80 c.i. water gun seismic reflection surveys, 3.5 KHz subbottom profiling, hydrosweep swath mapping, and piston coring. Occasional sites were cored with a multi-corer.

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.

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<tr>
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<td>2100</td>
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</tbody>
</table>

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

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GPS SATELLITE FIXES:

**Instrument:** Magnavox MX-4200 Global Positioning System receiver
GPS Trimble NT200D

**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.

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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.

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</table>

SEA TEMPERATURE:

Instrument: *Omega DP10 Series*

Logging: 1 minute intervals

Checking: none

Smoothing: none

Chief scientist's final data: none.

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 id sea_temp (in °C)

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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)

<table>
<thead>
<tr>
<th>Shot Time</th>
<th>Shotnum</th>
<th>Lat</th>
<th>Lon</th>
<th>Line Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>94+173:00:04:04.333</td>
<td>000172</td>
<td>N 40 56.5884</td>
<td>W 125 42.6913</td>
<td>mcs-6a</td>
</tr>
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</table>

**FORMAT:** dg.rddd (gun depth)

<table>
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<th>Shot Time</th>
<th>Gun Depth</th>
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<tr>
<td>94+173:00:04:04.333</td>
<td>13 13 13 13 13 13 13 13</td>
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</table>

**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.

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: none.

Lamont database: processed data file format and navigation data file format.

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

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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_meters

Lamont database: final calibrated and cleaned data, interpolated to even minute. Merged with final navigation. MGG format. Depth is in fathoms.

**NOTE:** At the beginning of EW-9414, a problem was found with the swath data coming out of the Hydrosweep to the logging computer "olive". An "Unknown data type" error message appeared in "get_hs" log file. Upon closer inspection, this message was generated because the data coming out of the serial line seems to be mangled if it happens to coincide with the pop of the seismic guns. It has yet to be determined whether this was caused by the shock of the guns, or it was an acoustic-interference problem.

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WEATHER STATION:

**Instrument:** *R.M. Young Precision Meteorological Instruments 26700 Series*

**Logging:** 1 minute interval

**Checking:** none

Chief scientist's final data: none.
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 wsx1 wdc1 wds1

6 12.6 15.9 15.6 20.7 261 253 6 66.7 66.7
wdm1 wsi2 wss2 wsm2 wsx2 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

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**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 gmtsystem) 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:**  
\[ Y_0 = 978.0327 \times (1 + 0.0053024 \times \sin(\Theta) \times \sin(\Theta) - 0.000058 \times \sin(2 \times \Theta) \times \sin(2 \times \Theta)) \]

**FORMAT:** vt.ndd  
```
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 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.  
1980 International gravity formula.  

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

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<td>0000-0810</td>
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<tr>
<td>1630-2100</td>
<td>gyro went offline; bad data</td>
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**PRE-Cruise Gravity Tie-In:**

Port: San Diego, CA, U.S.A.
Date: May 14, 1995 (JD 134)
Operator: Bruce A. Francis
Reference Station:

Relative Station "DN9" made to an absolute benchmark at Elliot Field (20 miles away)
Date: 16 June 1989
Position: N 32° 42.003' W 117° 09.624'\nGravity value: 979512.23
Station is located at San Diego 10'th Ave. Pier, across from berth 3 warehouse loading dock #9, at a large cleat on the berm of the pier.

Pier/Ship's position:

R/V Ewing was docked at San Diego 10'th Ave. pier, across from 10'th Ave terminal building. The tie point was taken right at 4'th bollard from the end of the pier.

Readings and Calculations:

<table>
<thead>
<tr>
<th>TIME</th>
<th>LOCATION</th>
<th>L&amp;R READING</th>
<th>G</th>
<th>Potsdam Corr?</th>
</tr>
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<tbody>
<tr>
<td>0600Z</td>
<td>Pier</td>
<td>3136.22+- .05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0605Z</td>
<td>Ref</td>
<td>3135.88+- .05</td>
<td>979512.23</td>
<td>YES!</td>
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</table>

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<th>TIME</th>
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<tr>
<td>0600Z</td>
<td>BGM-3</td>
<td>979545.70</td>
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"C" deck was 0.3 m ABOVE the pier.
"C" deck is 5.5 m above the gravity meter.
Difference between pier and gravity lab: 5.5 - .3 = 5.2 m

*Lacoste difference in LR units:*

\[
delta_{LR} = \text{pier}_{LR} - \text{ref}_{LR}
\]

\[
0.34 = 3136.22 - 3135.88
\]

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

\[
delta_{mgal} = \delta_{LR} \times \text{constant}
\]

\[
0.36 = 0.34 \times 1.06
\]

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

\[
pier_{grv\_val} = \text{ref\_val} + \text{delta}_{mgal}
\]

\[
979526.19 = 979512.23 + 0.36 + 13.6
\]

*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.

\[
\text{hgt\textsubscript{corr}} = \text{hgt} \times \text{constant}
\]

\[
1.61 \text{ mGals} = 5.2 \times 0.31 \text{ mGals/m}
\]
Gravity at gravity meter level in mGals:
\[
grv\_at\_meter\_level = \text{pier\_grv\_val} + \text{hgt\_corr}
\]
\[
979527.80 = 979526.19 + 1.61
\]

BGM-3:

BGM\_filt\_grv = (scale factor x counts) + bias = 979545.70
using s.f. 5.0940744 and bias 8526800.
The count was filtered with a 60 filter width, run thru filter1d -FG480, and s_bgm

Mistie in mGals:
\[
mistie = \text{BGM\_grv\_val} - \text{grv\_at\_meter\_level}
\]
\[
17.90 = 979545.70 - 979527.80
\]

Drift in mGals since last tie:
prev_mistie: 15.0 mGals on date March 27, 1995 (JD 086)
\[
drift = \text{mistie} - \text{prev\_mistie}
\]
\[
2.90 = 17.90 - 15.0
\]

===> DC Shift = prev_mistie
= 15.0

Drift/Day = drift / (tot. # of day)
= 2.90 / (134-86) = 0.06042 mgals/day