Emerald Ocean Engineering LLC

Data Report:

Wave Conditions on Southern Lake Pontchartrain
August 27 – September 5, 2005

Prepared by

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INTRODUCTION

This report presents the qualified data measured by two wave gages that were recovered from Lake Pontchartrain. Three of these miniature wave-measuring buoys were deployed by Dr. Harley Winer, CELMN two days before the landfall of Hurricane Katrina. The gages were intended to collect data sets of large, episodic waves on Lake Pontchartrain for calibration and validation of numerical models. The models would then be used by planners to simulate the extreme storm that could cause catastrophic flooding of New Orleans by wind waves overtopping the levees on the south shore of Lake Pontchartrain. Details of the system design, including the Neptune Sciences, Inc. (NSI) Mini Wave Sentry buoy (Figure 1) and the strategic approach of the episodic gage deployment program, can be found in McGehee, 2002 (a) and (b). Following is a description of the recovery efforts and the results of the data analysis and quality control effort.

Figure 1. Mini wave Sentry Buoy with Drogue, Mooring Line, and Anchor

DEPLOYMENT AND RECOVERY

Three gages were deployed at pre-selected sites just north of the south shore of Lake Pontchartrain around midday on Saturday, September 27th, 2005. The planned and actual deployment locations (based upon averages of the recorded position data) are given in Table 1 and shown on Figure 2. Dr. Winer, along with all of CELMN and most of the city of New Orleans, evacuated the following day. Hurricane Katrina made landfall early on the 29th, passing just east of New Orleans. Winds were from the northern quadrant as the storm made its closest approach to the lake, placing the gages at the maximum fetch during the highest wind speeds. By August 30 it was evident that the gages, if they functioned, had measured the actual event that was only supposed to be simulated.

Table 1 – Planned and Actual gage Deployment Sites

	Western Site - Gage 23	Central Site Gage 22	Eastern Site – Gage 24
Planned Deployment Sites	30º 01.977’ N 90º 07.932’ W	30º 02.040’ N 90º 07.348’ W	30º 02.203’ N 90º 06.837’ W
Actual (averaged) Deployment Sites	30º 1.989’ N 90º 7.932’ W	30º 02.053’ N 90º 07.358’ W	NA

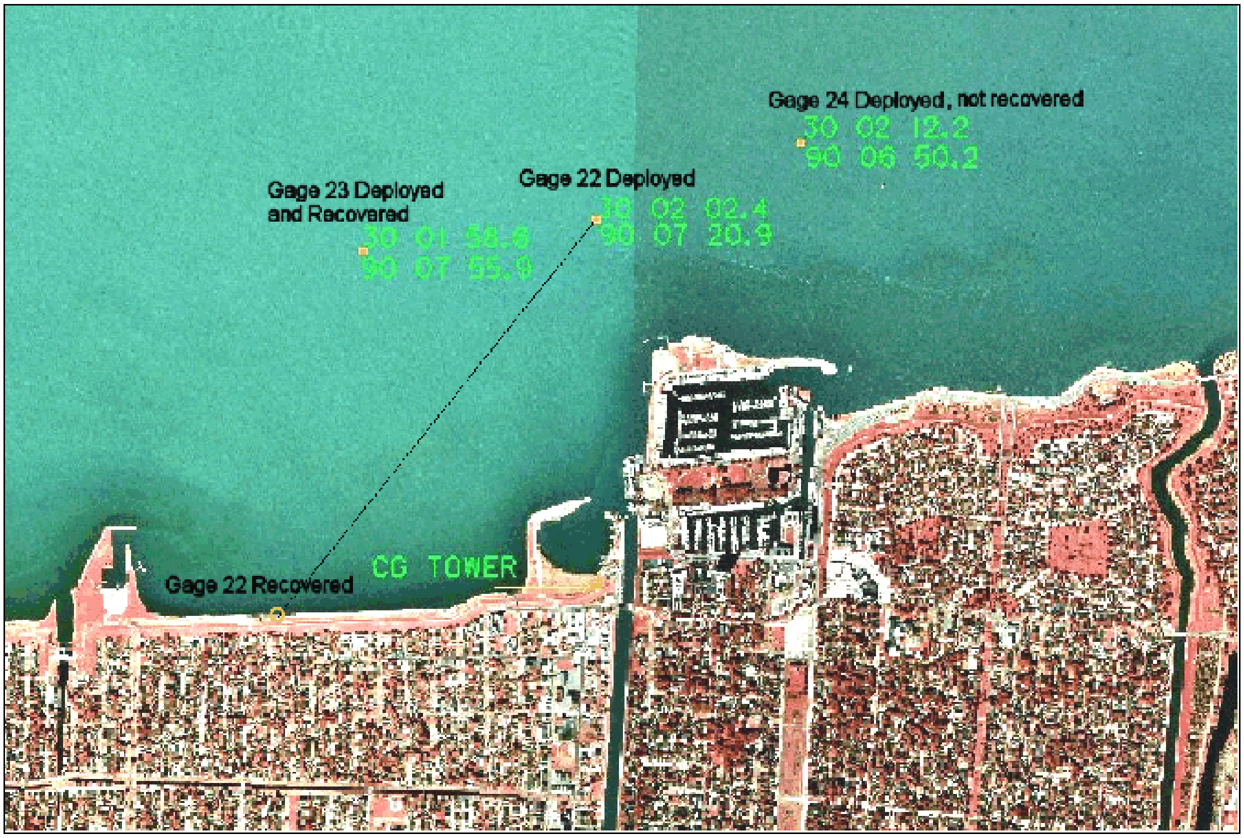

Figure 2 - Gage Deployment and Recovery Locations

On the evening of September 1st I successfully made contact with Dr. Winer at the temporary CELMN Emergency Operations Center in Vicksburg, MS and we began making plans to recover the gages, if possible. While the basic plan was for me to proceed as fast as possible to the deployment sites, it was foreseeable that the buoys could drag and even be thrown over the levies if entangled in debris. In addition to its wave sensor each Mini Wave Sentry buoy has a GPS receiver. Both wave and position data are stored in internal memory in the buoy but are also broadcast on the UHF radio band. Acquisition of the radio signals (and thus buoy position) with a Wave Sentry radio receiver before the buoy's batteries died would greatly facilitate their recovery. The nominal life of the internal batteries is 7 days, though they sometimes lasted as long as 8-10 days. The receiver belonging to CELMN was still at CELMN headquarters in (flooded) downtown New Orleans. Unfortunately, the NSI headquarters in Slidell, LA was severely damaged by Katrina, with a total loss of their entire equipment inventory, so that resource was eliminated. The only other known receiver was owned by CESPL at a shore station located at Ventura Harbor, CA.

I contacted CESPL on Friday, September 2nd. My contact, Mr. Chuck Mesa, was on leave and no one else at the District was familiar with the system at Ventura. Fortunately, Mr. Mesa checked his voicemail while on vacation with his family and contacted me on Sunday, September 4th. He offered to retrieve the receiver and antenna first thing Monday morning and have it shipped to me in Pensacola by Tuesday morning. Meanwhile I made arrangements to charter a private airplane, to maximize the chance of picking up the signal anywhere in the area, and a chartered, trailerable vessel to access the deployment sites and, if necessary, the city from the north shore of the lake.

While awaiting the receiver at Pensacola airport Tuesday morning, I was told that Federal Express lost the package with the transceiver. I recalled the vessel in transit and rescheduled the plane for the next day. The package was delivered on Wednesday morning but additional delays were experienced by the conflict between FEMA and the FAA over the appropriate authority for air traffic control over New Orleans. Eventually, with the assistance of Mr. Brett Herr, CELMN liaison, I received permission to fly over the northern half of Lake Pontchartrain, but not into the restricted airspace over the southern half of the lake and the city itself.

We departed Pensacola airport at 1400 and proceeded to the lake, where we circled for over 2 hours without detecting a signal. I landed at the just re-opened Slidell regional airport and rendezvoused with the truck carrying the chartered vessel. The Lake Pontchartrain Causeway was open to emergency traffic, so we were able to drive directly to the USCG station. I directed the vessel captain to launch at the nearby public boat ramp while I contacted the station commander. CWO3 Dan Brooks was extremely helpful in spit of having an overwhelming search and rescue mission to deal with. He provided me with a vessel and the same coxswain that had deployed the buoys with Dr Winer the previous week. We motored to the deployment sites and, just after sunset, located one of the buoys (gage 23) on station at the westernmost gage site. I transferred to the chartered vessel and continued searching the lake until after dark without success.

The captain and crew were willing to spend that night on the banks of the levee, which was fortunate because the nearest motels were at lest 4 hours away. This allowed us to continue our search early the next morning. I sent the vessel to search the lake while I walked the levee and shoreline. After several hours I spotted the second buoy (gage 22) in rocks just above the waterline, about two miles west of the USCG station (Figure 1). The 3-ft rope pennant directly below the buoy with an eye and thimble was still attached and undamaged when the buoy was found, indicating the shackle connecting it to the next link in the mooring either worked loose or was deliberately removed.We continued to search by foot and vessel for the rest of the day but were unsuccessful in locating the third buoy. This easternmost buoy was deployed offshore of the City Marina. If it drug southward, it ended up somewhere in the immense pile of boats, structural debris, vehicles, and vegetation that was piled tens of feet thick at that part of the lakeshore.

DATA RECOVERY

On September 10 I opened the buoys' cases, confirmed that they were dry. Both battery packs measured in the low 9 volts range – too low to power the electronics. Once again, the storm's impacts threatened success. The only copies of the software that allowed access to and transfer of the on-board data were in a laptop at the still inaccessible CELMN headquarters, and on the flooded NSI computers. (The CESPL software system collected data from the shore station only, and did not contain the code for direct download from the buoy memory.) Over the ensuing weeks, Mr. Richard Smith and other NSI employees performed a painstaking recovery of the hardware and data from these computers, saving the data transfer software and many other valuable company records. On September 23 I drove the gages to NSI offices at Stennis Space Center, MS, where the data were successfully downloaded.

DATA SAMPLING AND STORAGE SCHEME

Data from the system accelerometer are sampled at 4 Hz for 2048 points for a sample length of 512 sec at approximately 12-minute intervals. An FFT is performed on the time series to produce the standard spectrum – 128 bins at Δf of 4/512 = 0.007813 Hz. Periods corresponding to the center frequency of the bins range from 128 sec to 1 sec. The short sample length, results in a "spiky" spectrum with fewer degrees of freedom than is typical for high-quality wave measurements (e.g., as specified in the Filed Wave Gaging Program Wave Data Analysis Standard). The parameters produced from the spectra – significant wave height (Hm0), dominant period (DP) and average period (AP) – can be expected to have more record-to-record variability than would result from a longer, more statistically stable, sample. In order to optimize the limited internal memory capacity of the buoy, a custom spectrum was developed by Dr. Winer for the CELMN buoys and incorporated into the buoy's firmware. The averaging scheme to produce the coarse spectrum from the standard spectrum is not evenly distributed; some low frequency bins are dropped, others maintained, and some higher frequencies are combined to produce coarser resolution at the upper end of the spectrum. The resulting custom spectrum is shown in Table 2.

Table 2 – Measured Frequency Bins

Bin Number	Center Freq (Hz)	Period (sec)	Band Width (Hz)	Standard Bins Averaged
1	0.070313	14.2222	0.0078125	1
2	0.078125	12.8000	0.0078125	1
3	0.089844	11.1304	0.015625	2
4	0.105469	9.4815	0.015625	2
5	0.121094	8.2581	0.015625	2
6	0.136719	7.3143	0.015625	2
7	0.152344	6.5641	0.015625	2
8	0.175781	5.6889	0.03125	4
9	0.207031	4.8302	0.03125	4
10	0.238281	4.1967	0.03125	4
11	0.285156	3.5068	0.0625	8
12	0.347656	2.8764	0.0625	8
13	0.410156	2.4381	0.0625	8
14	0.472656	2.1157	0.0625	8
15	0.535156	1.8686	0.0625	8
16	0.597656	1.6732	0.0625	8
17	0.660156	1.5148	0.0625	8
18	0.722656	1.3838	0.0625	8
19	0.816406	1.2249	0.125	16
20	0.941406	1.0622	0.125	16

The wave parameters stored by the gage and reported in the data files were calculated form the standard, high density spectrum before the spectral averaging is completed. Thus, the apparent peak of the spectrum in the spectral tables and plots may not be exactly the same value as DP from the parameter tables and plots.

The standard sample interval for the buoy is 11 – 13 min. The CELMN buoys were modified with a threshold criterion to further conserve memory. When measured significant wave height was below 1.00 m, only every 4th record is retained in memory, providing approximately 30 wave record per day. When the significant wave height equals or exceeds 1.00 m, every record is retained providing approximately 128 records per day.

DATA

Analyzed data are provided in Excel spreadsheet files. All dates and times in the data files are in UTC; to convert to local, Central Daylight Savings time, subtract 5 hours. For convenience in plotting, times have been converted to decimal days on the plots.

Two data sets are provided for each of the two recovered gages. The * *all.xls* file contains the complete measured record for the entire deployment in one file for each gage. No editing has been done on these records. The * *all.xls* file contains parameter lists, parameter plots, spectral list, spectral plots, and position plots for the entire deployment. Note that records gage 22 was off station after mid day on September 4th.

The **_QC.xls* files have been edited. Records with noisy or questionable spectra have been deleted, but all valid data are retained. Four **_QC.xls* files were produced for each gage containing one to 4 days of data each. The dates covered are contained in the file name. The storm event, which extends from August 29 0000 UTC through August 29th 2000 UTC is contained on one file for each gage. The storm file contains records collected at 10-12 min intervals and Hs > 1 m.

Figure 3 illustrates the planned and actual deployment location and track of the position gage 23. It was deployed near its planned location and stayed on station until it stopped operating just before noon on September 5th. Figure 4 shows the significant wave height, peak period and average period for the entire record of gage 23 from 1831 UTC, August 27th to 1101 UTC, September 5th. Figure 5 is a stack plot of all of the spectra from gage 23 for September 29th, showing the growth and decay of the wave energy during the storm's passage.

Figure 6 illustrates the planned and actual deployment location and track of the position of gage 22. It was deployed near its planned location and remained on station throughout the storm, but drifted off station and landed on shore on September 4th, where it was recovered three days later. Figure 7 shows the significant wave height, peak period and average period for the entire record of gage 22 from 1714 UTC, August 27th to just after midnight on September 6th. The significant wave height curve is marked to illustrate when the buoy was dragging and when it stopped on the shoreline. Figure 8 is a stack plot of all of the spectra from gage 22 for August 29th.

Figure 9 overlays the significant wave height and peak period for both gages for August 29th.

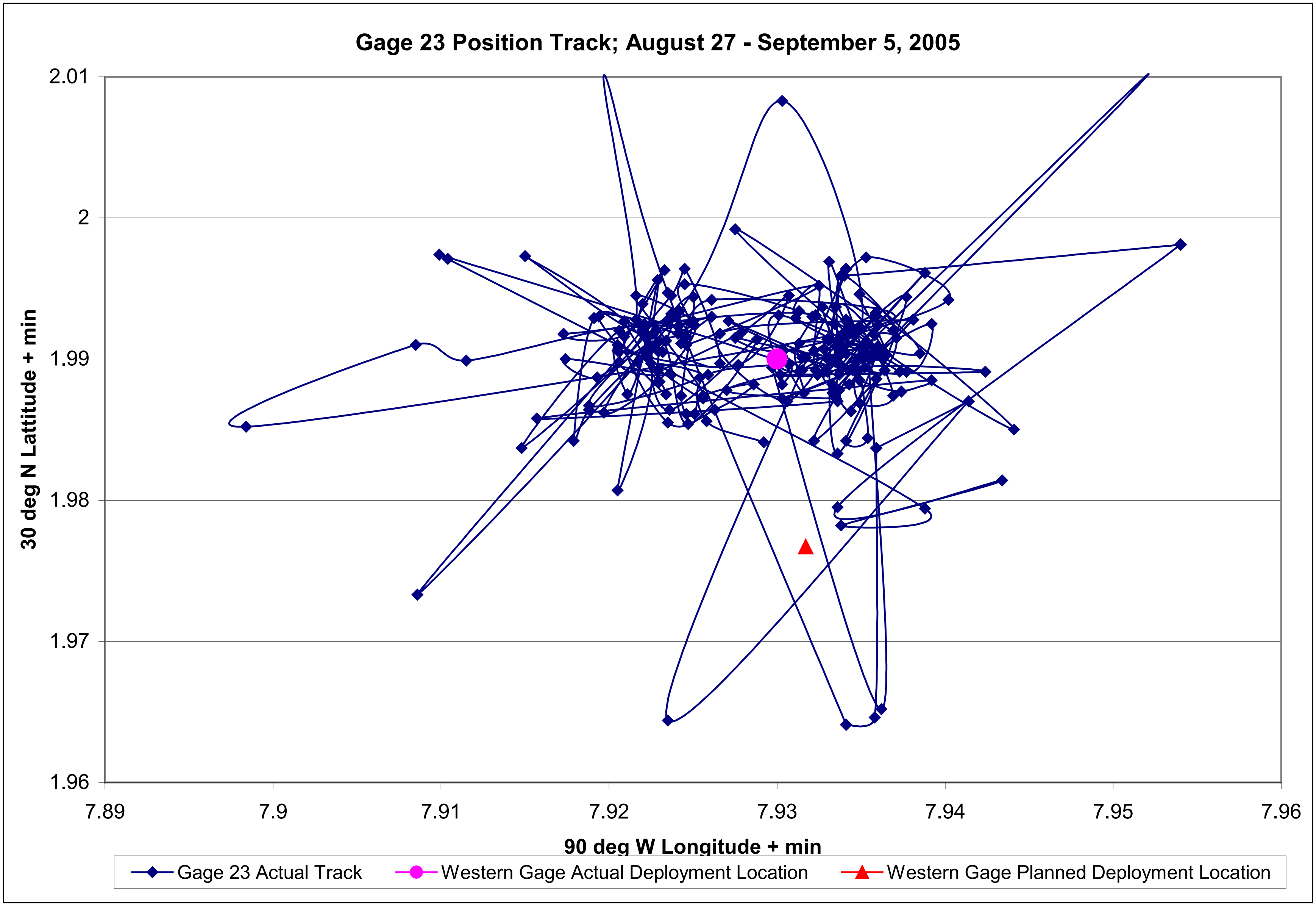

Figure 3 - Gage 23 Position Track

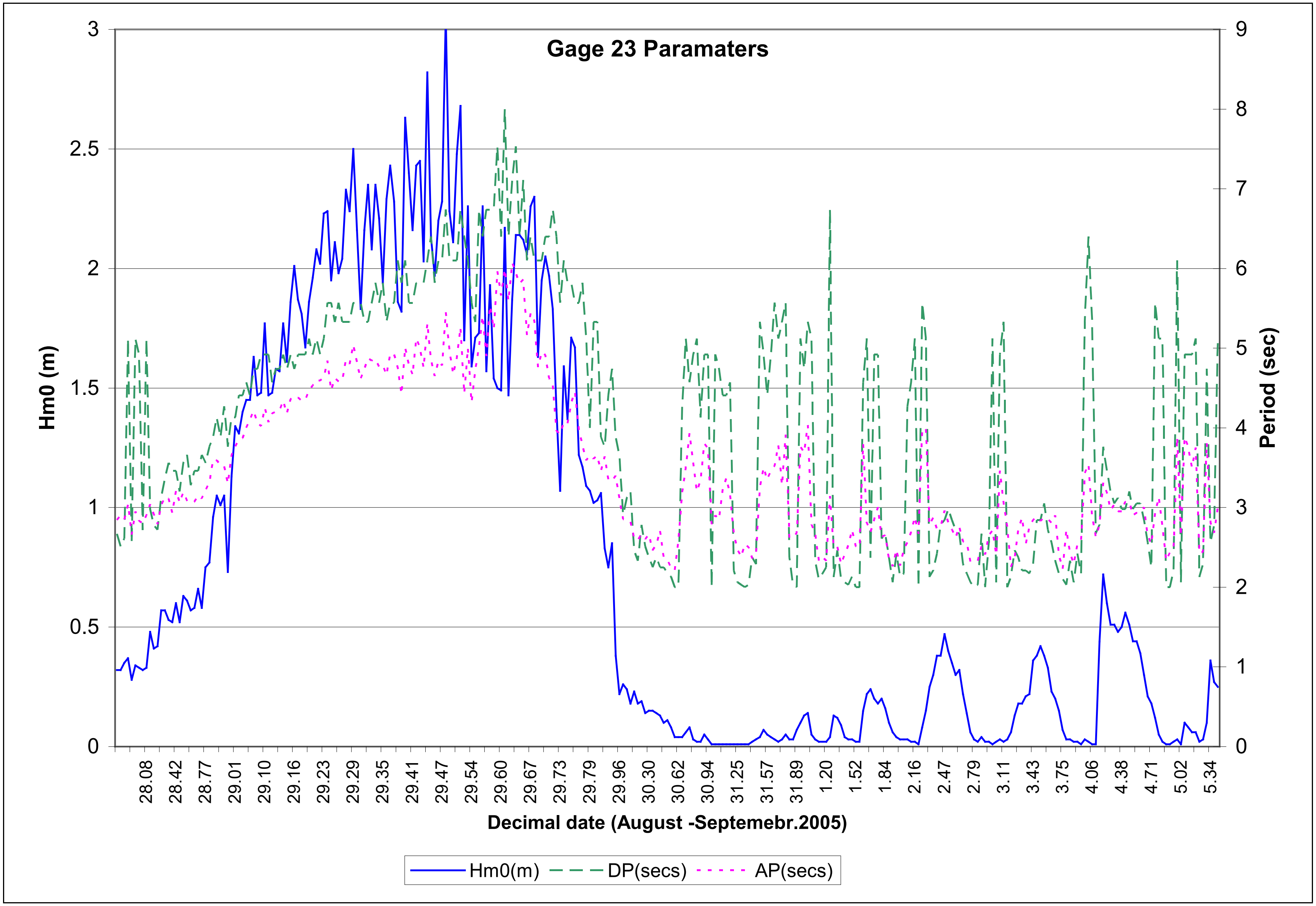

Figure 4 - Gage 23 Parameter Plot

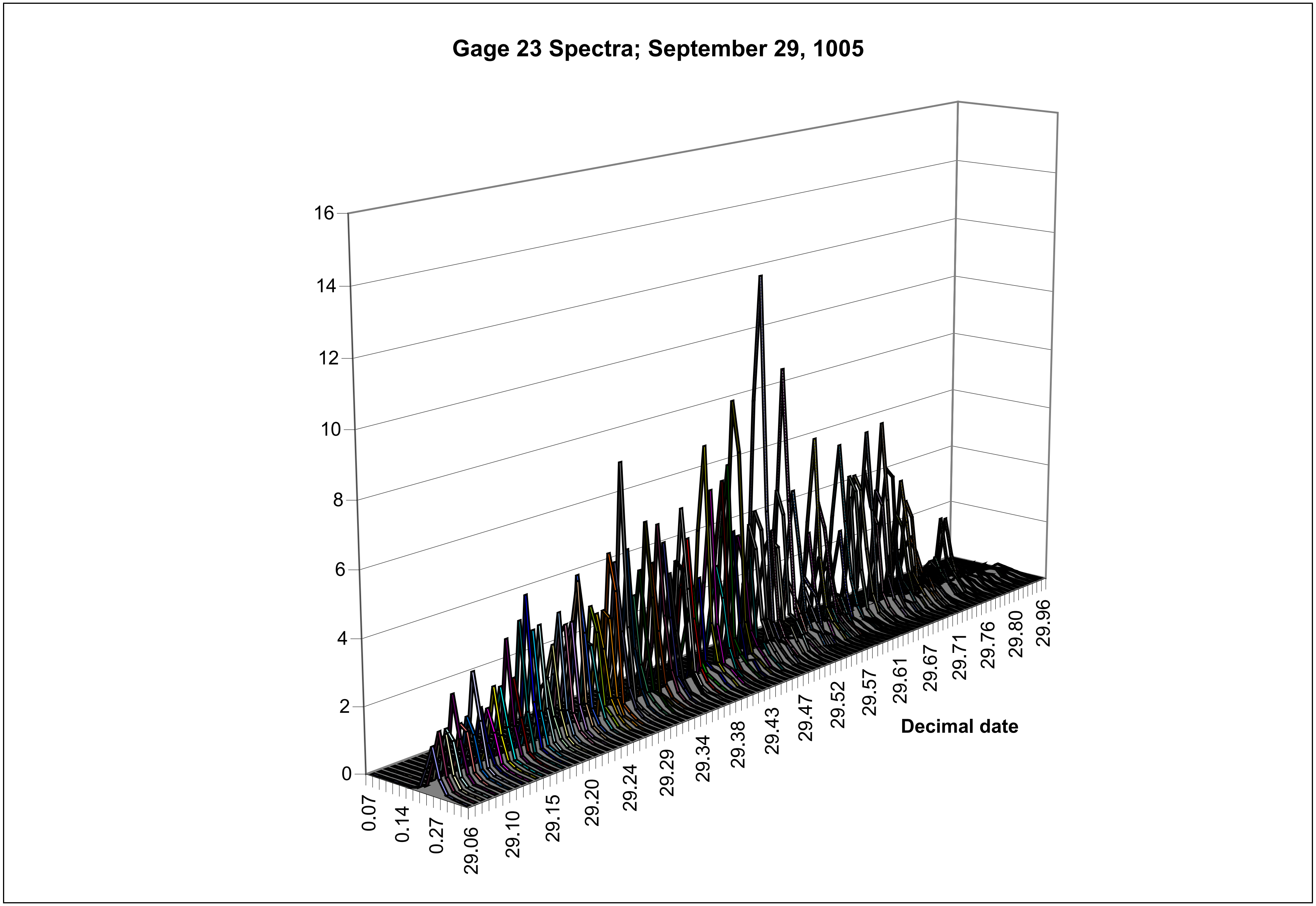

Figure 5 - Gage 23 Spectral Stack Plot

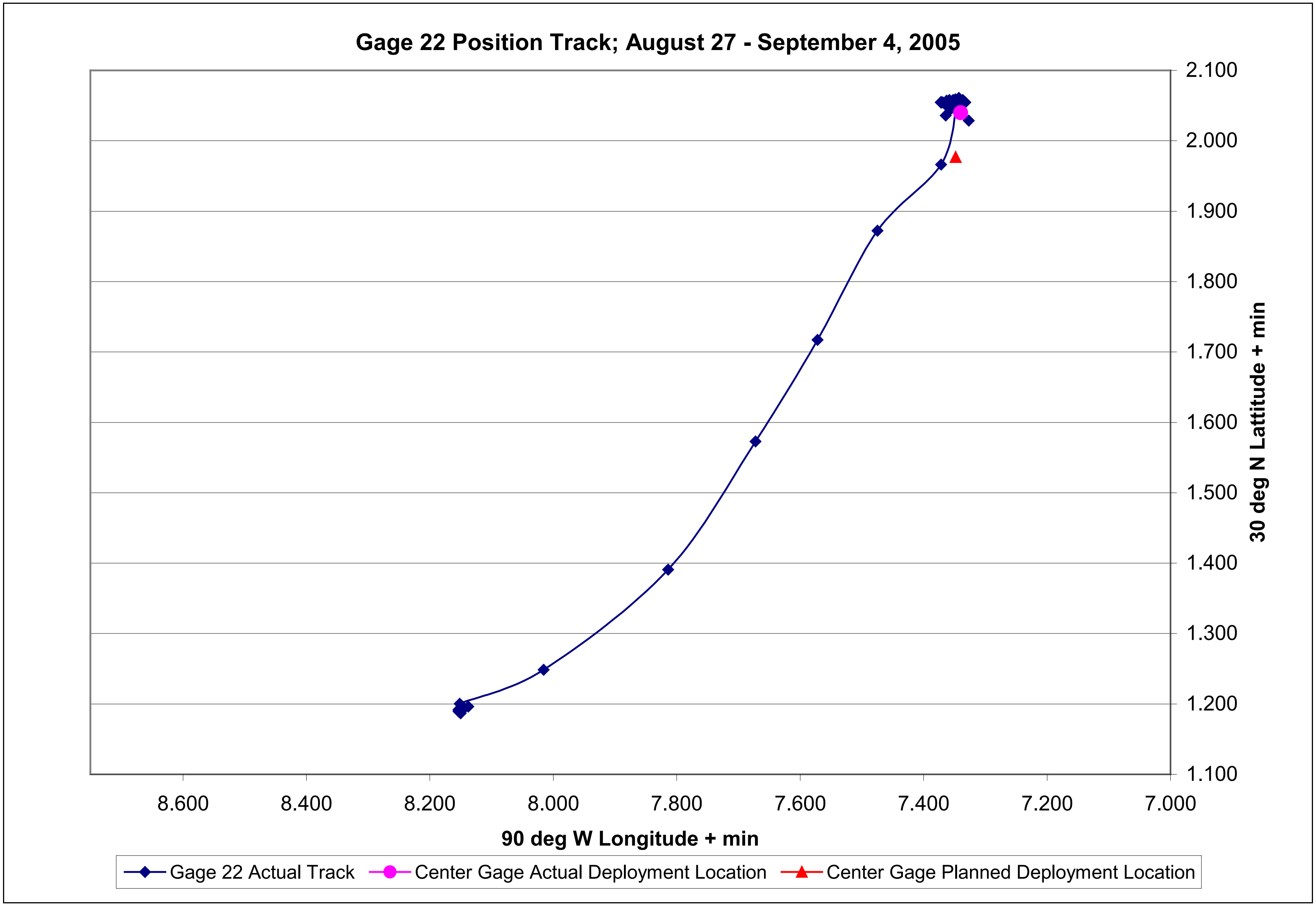

Figure 6 - Gage 22 Position Track

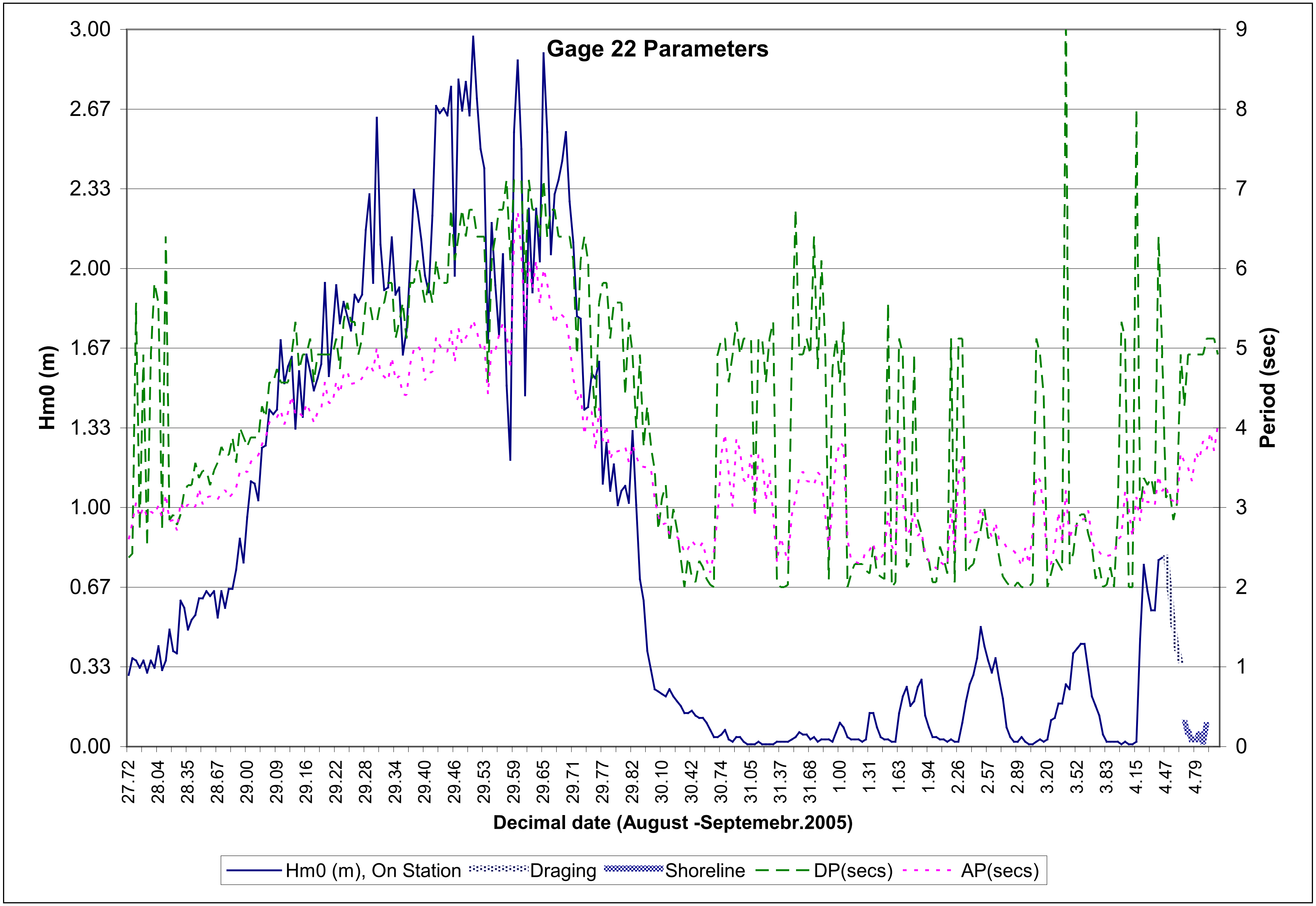

Figure 7 – Gage 22 Parameter Plot

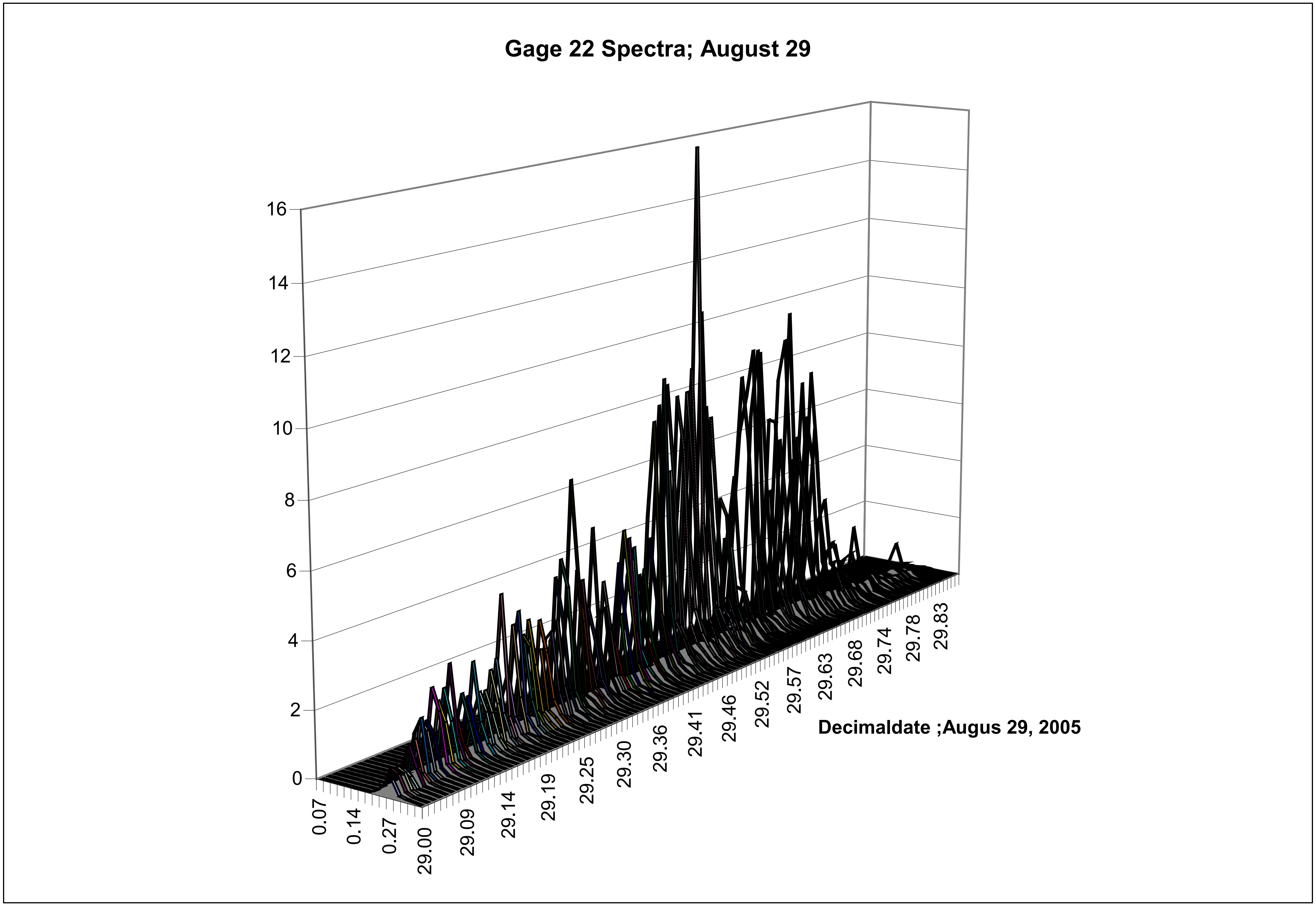

Figure 8 - Gage 22 Spectral Stack Plot

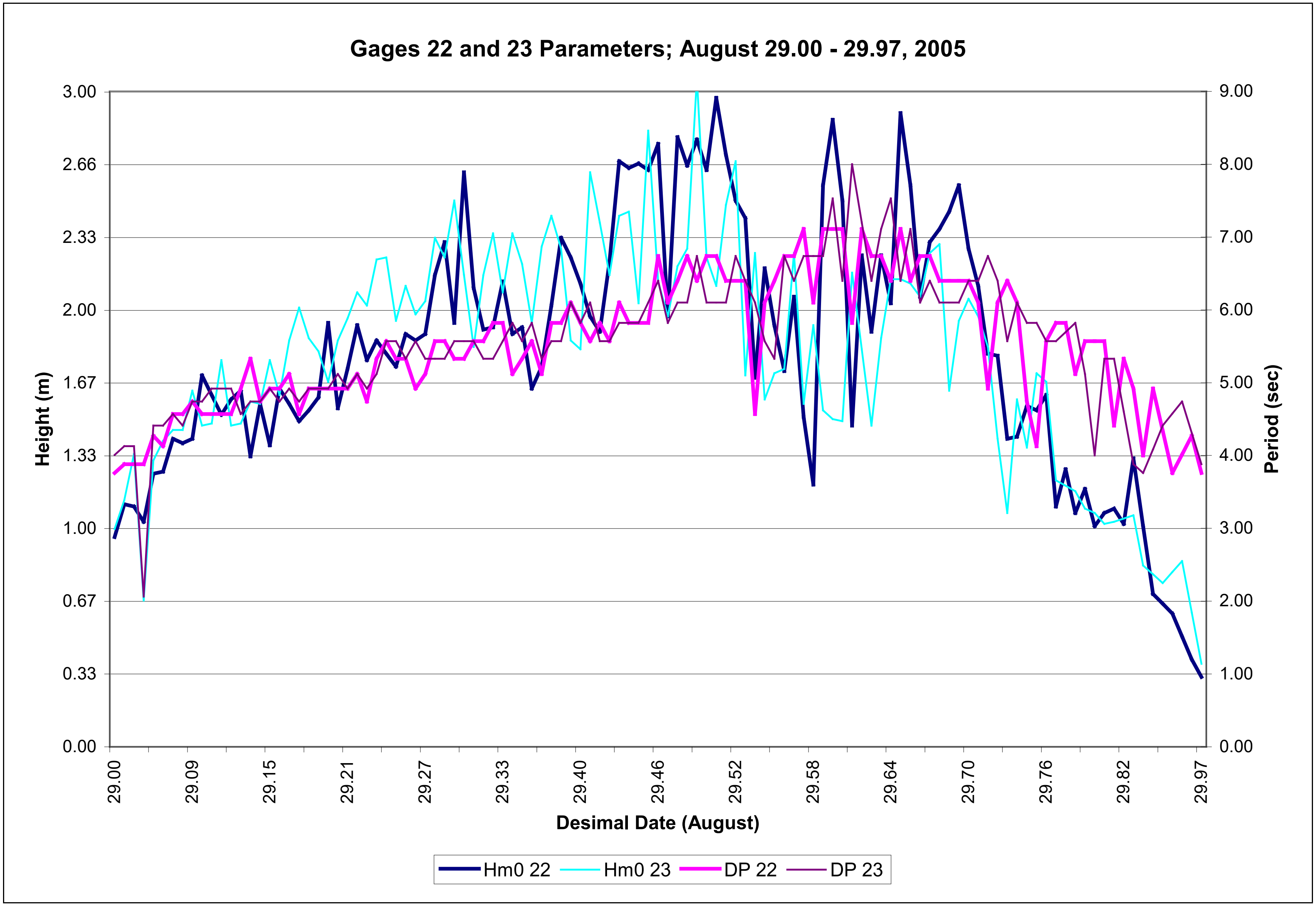

Figure 9 - Gages 22 and 23 Parameter Plot

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