

THE NEW DIGITAL SEISMIC NETWORK IN GHANA - THE WAYFORWARD AND THE CHALLENGES



By

NICHOLAS OPOKU

Seismologist, Ghana Geological Survey

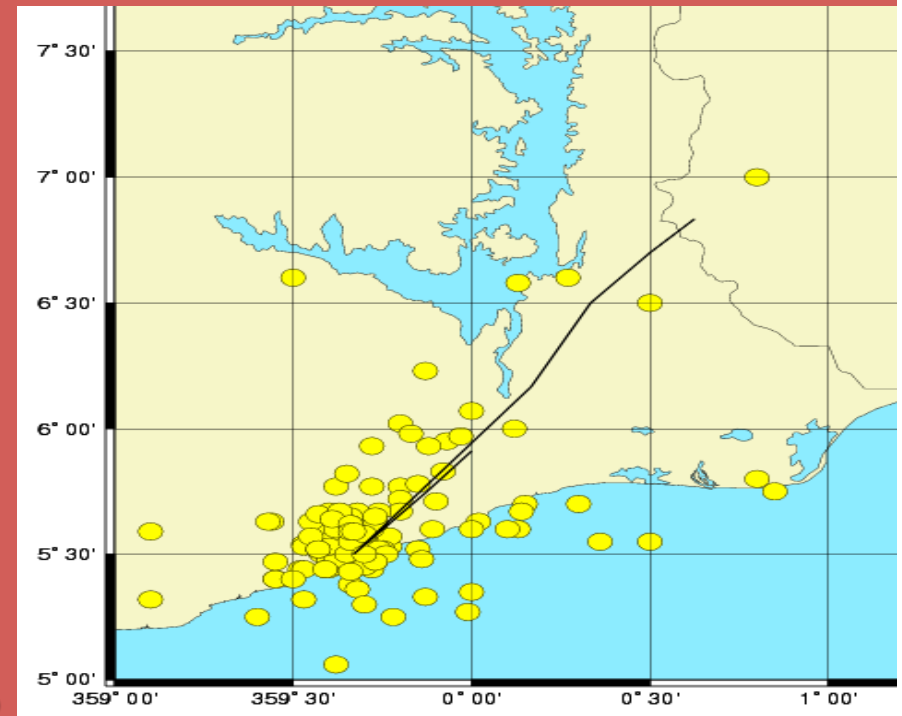
JANUARY, 2013

IRIS METADATA WORKSHOP - KUWAIT



Seismicity / Instrumental Recording of Earthquakes in Ghana

- The first Documented Earthquake in Ghana Occurred in the year 1636
- Magnitudes of significant events 4 to 6.5
- A Milne's single-boom seismograph was the first Seismic Instrument installed in the year 1914.
- Geotech Long Period Z component Seismograph was installed in March, 1973
- An Analog seismic network which were all S-13 short period seismometers were procured from Teledyne Geotech (U.S.A) and the installation was completed in June 1987.



System Components of the Real Time Analog Seismic Network



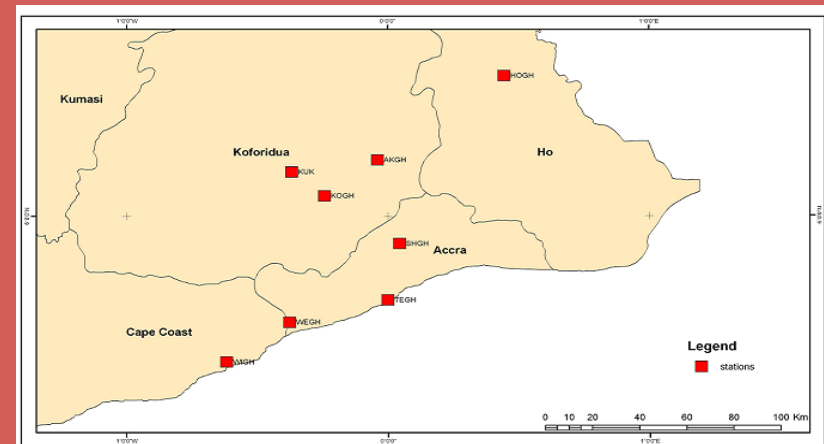
**S-13 Short Period Seismometer
in a Vault at Shai Hills .**



Booster Station at Amanokrom



**Central Recording Station at GGS
HeadQuarters, Accra**



Analog seismic Network

The New Digital Seismic Network

The Government of Ghana in 2010 gave budgetary support to GGS to fund the purchase and installation of six remote stations digital broadband seismic network to replace the defunct analogue seismic network.

The package also included ten stand alone strong motion accelerometers and the building of a new Seismological Observatory.

The Digital Seismic Network equipment were procured from Nanometrics Inc., Canada.

The network consist of six remote sites digital broad band stations transmitting real time seismic data to the central Observatory Accra.

System Components and Setup



Cygnus205 Transceiver



Cygnus205 Transceiver



Carina105 Transceiver



GGG LAN



Ethernet



Data Acquisition Servers



Trident305 Digitizer



Trident305 Digitizer



Trillium Compact



Trillium 120 PA



GGG Workstations

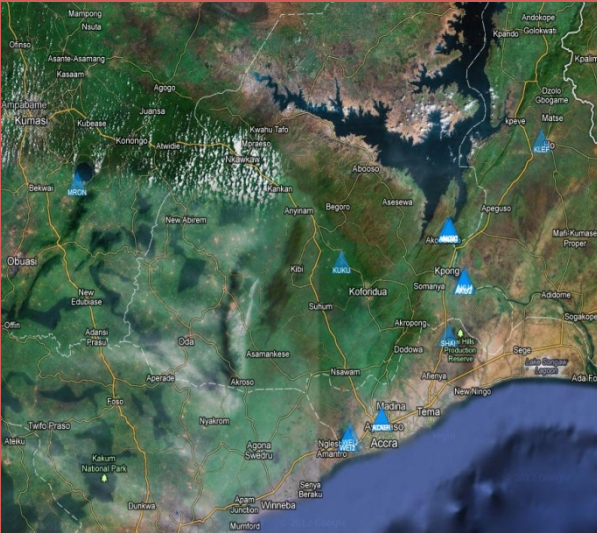
Event Detection & Processing, Network & Data Management, Data & SOH Monitoring, etc.

GGG Acquisition Hub

3 x Trillium Compact Stations
(Transmitted over V-Sat Telemetry)

3 x Trillium 120PA Stations
(Transmitted over V-Sat Telemetry)

Remote And Central Recording Stations Facilities



Map of stations location



Remote Station



Seismological Observatory



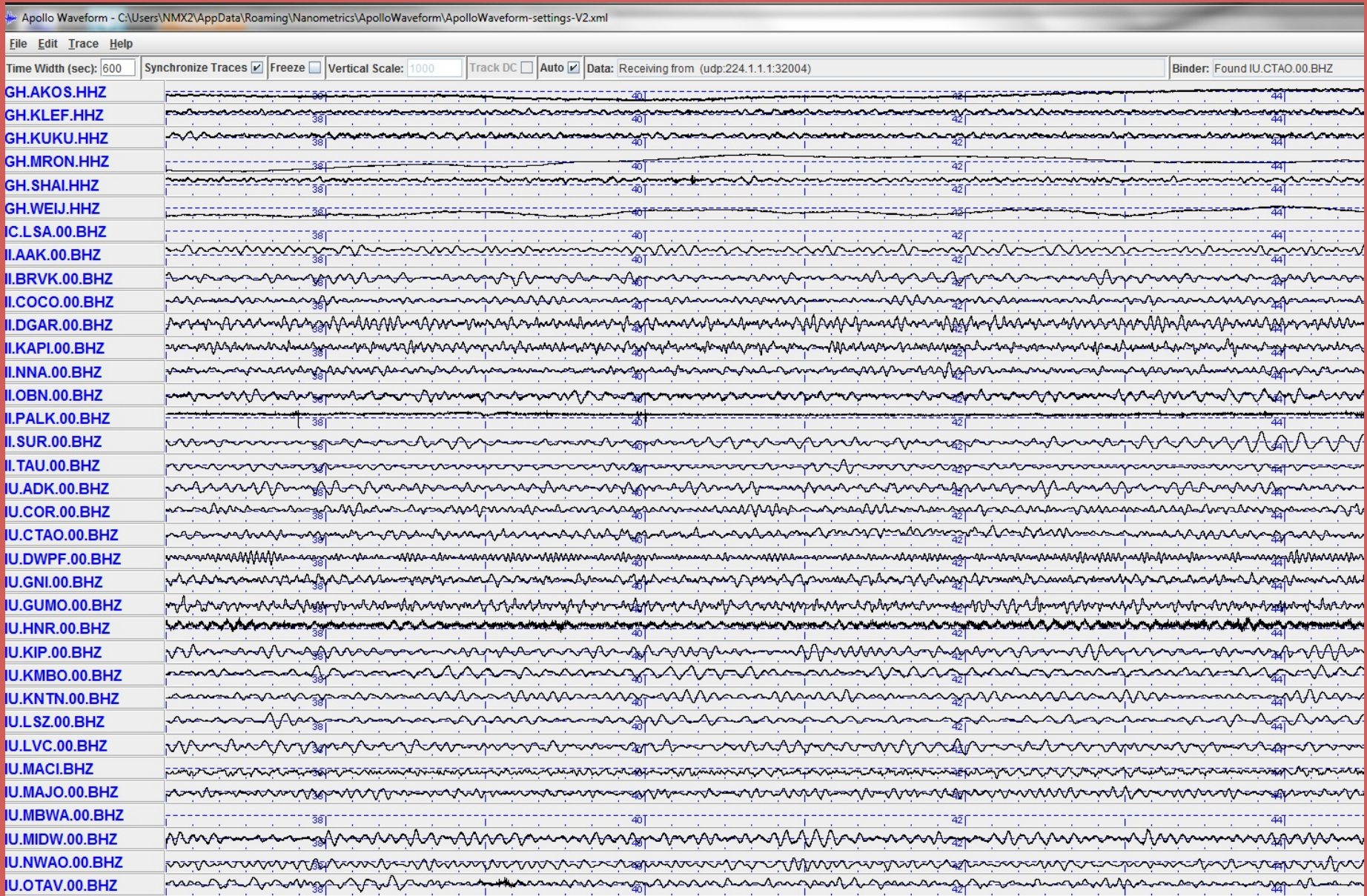
Satellite Receiver (bigger) at Seismological Observatory

CRF for Data Acquisition, Event Processing, Publication, Notification & Storage

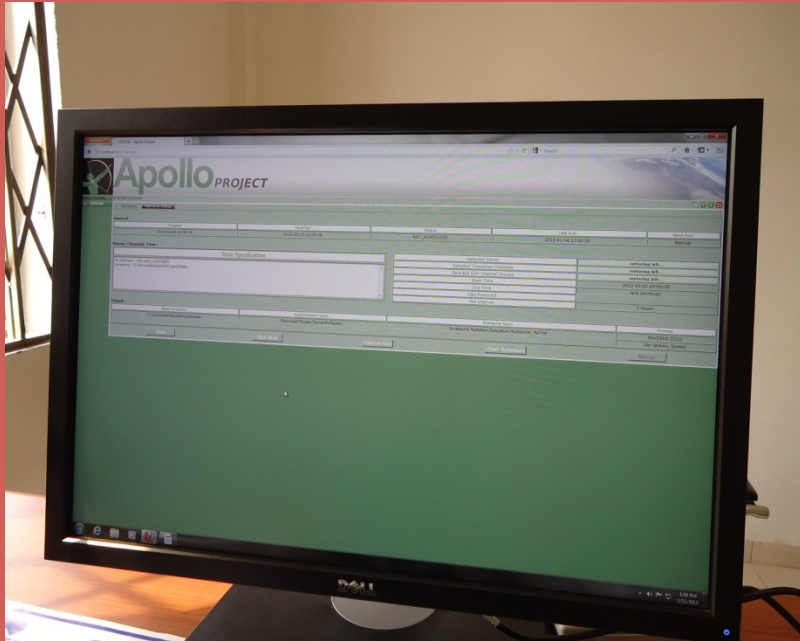


- ❖ All data from the Remote Sites are Received by the 3.8meter Satellite antenna on to the Carina
- ❖ The Carina streams the data onto the Apollo Server.
- ❖ The Apollo server temporary stores and displays the waveform.
- ❖ The Hydra Server detects and processed any events in real time automatically. It then post the event and processing history to
- ❖ Athena Web page for display, permanent storage and e-mail notification.

Apollo Waveform



Apollo Project on Client Workstation Computer Retrieves and Archives Waveform Data



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GH.AKOS_20130104_010000	1/4/2013 4:54 PM	SEED File	1,372 KB
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Hydra Software Main Page

Catalog
Map

MapDisplay - Response Hydra 2.0 (v1.47dm1)

Station	Component	Network	Location	Count	Last Seen	Station List	PZs	AssocQual
AAK	BHZ	II	00	277615	01/11/2013 09:18:16	Yes	Yes	95
ABPO	BHZ	II	00	451335	01/11/2013 09:17:55	Yes	Yes	44
ADK	BHZ	IU	00	501461	01/11/2013 09:18:02	Yes	Yes	14
AFI	BHZ	IU	00	347214	12/13/2012 07:57:10	Yes	Yes	10
AKOS	HHE	GH	--	1925760	01/11/2013 09:18:40	Yes	Yes	10
AKOS	HHN	GH	--	2071907	01/11/2013 09:18:41	Yes	Yes	10
AKOS	HHZ	GH	--	1805107	01/11/2013 09:18:43	Yes	Yes	20
ANTO	BHZ	IU	00	282203	01/11/2013 09:18:19	Yes	Yes	23
ASCN	BHZ	II	00	574074	01/11/2013 09:18:26	Yes	Yes	19
BRVK	BHZ	II	00	340195	01/11/2013 09:18:24	Yes	Yes	100
CMLA	BHZ	II	00	619426	01/11/2013 09:17:57	Yes	Yes	100
COCO	BHZ	II	00	643622	01/11/2013 09:18:26	Yes	Yes	2
COLA	BHZ	IU	00	334874	01/11/2013 09:18:16	Yes	Yes	62
COR	BHZ	IU	00	510196	01/11/2013 09:18:16	Yes	Yes	64
CTAO	BHZ	IU	00	369011	01/11/2013 09:18:25	Yes	Yes	20
DAV	BHZ	IU	00	1234167	01/11/2013 09:18:03	Yes	Yes	2
DGAR	BHZ	II	00	719918	01/11/2013 09:18:27	Yes	Yes	19
DWPF	BHZ	IU	00	436606	01/11/2013 09:17:48	Yes	Yes	6
EFI	BHZ	II	00	502304	01/11/2013 09:18:29	Yes	Yes	14
ERM	BHZ	II	00	385392	01/11/2013 09:17:54	Yes	Yes	46
FURJ	BHZ	IU	00	384947	01/11/2013 09:17:51	Yes	Yes	2
GNI	BHZ	IU	00	331524	01/11/2013 09:17:49	Yes	Yes	10
GRFO	BHZ	IU	--	285312	01/11/2013 09:17:57	Yes	Yes	30
GLMO	BHZ	IU	00	553606	01/11/2013 09:18:23	Yes	Yes	6
HNR	BHZ	IU	00	764981	01/11/2013 09:18:21	Yes	Yes	2
INCN	BHZ	IU	00	6458	10/14/2012 11:21:16	Yes	Yes	10
JTS	BHZ	II	00	416482	01/11/2013 09:18:06	Yes	Yes	3

Filter:

Show Strangers (0)

Show Missing PZs (0)

Show All (89)

Refresh Display

Save "Strangers"... Reset Tracker Table Load HIT List Ignore L

Save "No PZs"... Create GLASS list Create Picker list

Save All... Create HIT list

```

Startstop console
file2ew_glew file2ew_glew.d 2632 alive High Time
ew2file ew2file.d 2696 alive High Time
naqs2ew naqs2ew.d 2724 alive High Time
slink2ew slink2ew.d 2736 alive High Time
pick_ev pick_ev.d 2764 alive High Time
binder_ev binder_ev.d 2864 alive Normal Normal
egppoc egppoc.d 2872 alive Normal Normal
pickwasher pickwasher.d 2952 alive Normal Normal
raypicker raypicker.d 2964 alive High Time
global_pick_recorder pick_recorder.d 2972 alive Normal Normal
tracetracker tracetracker.d 5036 alive Normal Normal
glass glass.d 3036 alive Normal Normal
glevt2zora_local glevt2zora_local.d 4980 alive Normal Normal
wave_server0 wave_server0.d 3068 alive Normal Normal
pick2zora pick2zora.d 5360 alive Normal Normal
glevt2zora glevt2zora.d 5408 alive Normal Normal
copystatus PICK_LOCAL_RING ASSOC_RING 3160 alive Normal Normal
copystatus HYPO_RING ASSOC_RING 3168 alive Normal Normal
copystatus ASSOC_LOCAL_RING ASSO 3176 alive Normal Normal
copystatus WAVE_RING ASSOC_RING 3184 alive Normal Normal
copystatus PICK_RING ASSOC_RING 3192 alive Normal Normal
statngr2 statngr.d 2348 alive Normal Normal
    
```

Event List

Event ID	Origin Time	Region	Magnitude	Num Phases	Depth	Latitude	Longitude	Event Source	Release Status	Event Type	Claimed By
1214	01/11/2013 09:10:46		4.46 Mb (2)	6 (6)	356.2	13.68	92.93	Locator	Automatic	Earthquake	
1213	01/11/2013 07:25:41		5.89 Mb (1)	5 (5)	22.0	-6.52	4.14	Locator	Automatic	Earthquake	
1212	01/11/2013 06:51:43		5.03 Mb (3)	5 (5)	60.2	66.14	-21.61	Locator	Automatic	Earthquake	
1211	01/11/2013 03:26:13		5.39 Mb (2)	5 (5)	672.6	-26.77	13.42	Locator	Automatic	Earthquake	
1210	01/10/2013 21:26:36		4.97 Mb (2)	6 (6)	79.7	-26.65	142.87	Locator	Automatic	Earthquake	
1209	01/10/2013 19:16:49		4.52 Mb (3)	5 (5)	24.7	-12.79	9.07	Locator	Automatic	Earthquake	
1208	01/10/2013 17:45:15		4.57 Mb (3)	5 (5)	378.5	-18.89	20.00	Locator	Automatic	Earthquake	
1207	01/10/2013 17:20:56		4.94 Mb (6)	11 (11)	5.5	52.12	-170.84	Locator	Automatic	Earthquake	
1206	01/10/2013 17:19:32		1.67 ML (2)	5 (5)	54.3	5.42	-0.30	Locator	Automatic	Earthquake	
1205	01/10/2013 16:33:35		5.40 Mb (9)	16 (16)	1.0	19.38	-64.47	Locator	Automatic	Earthquake	

Zoom In Region Zoom Snap To Latest

Show All Events

Zoom Out World Zoom Show Station Codes

Hold Zoom Level

Review Event Create Event Flag Unreviewed

P S PP SKPbc PKPPKP <1 Hour >8.0 >7.0 >6.0 >5.0 <5.0

Pn Sn pP PKPab SKIKP <1 Day >1 Week >1 Week

p s PcP PKPbc PKIKP Unknown Unused

Pb Sb ScP PKPab PKPPbc Unused

Pdiff Sdiff PS PKPPbc

0-70 km 70-300 km 300-600 km

```

Glass Status --v1.61- build 1 20050...
101537: LSA.BHZ.IC.00 P 09:14:02.00 2
14 seconds since last pick received.
0.07 Percent of system capacity
0.03 Picks per second (throughput)
39.20 Picks per second (associator)
4.67 Percent picks associated
21244 Picks processed
992 Picks associated
219 Quakes associated
    
```

Event Post Processing by Hydra

Catalpa
LocDisplay - Event: 1201 - Origin: 5720 (Response Hydra 2.0 (v1.47dm1))

Location Summary:

Latitude: 4.741	Longitude: 95.165	Depth: 39.7 km	Origin Time: 01/10/2013 13:47:04
+/- 8.30 km	+/- 8.20 km	+/- 25.3 km	
Region			Elapsed Time: 0 Day(s) 20:10:22
Num Phases: 40 (40)	Gap: 35 deg	Min Dist: 16.90 deg	RMS: 0.83 sec

Residual Display: By Azimuth

Phase Arrivals:

Passport Use	Locator Use	Sta	Comp	Net	Loc	Phase Name	Arrival Time	Res
✓	Y	COCO	BHZ	II	00	Pn	13:50:56.56	-1.50
✓	Y	LSA	BHZ	IC	00	P	13:52:25.94	-0.30
✓	Y	DGAR	BHZ	II	00	P	13:52:33.76	0.00
✓	Y	KAPI	BHZ	II	00	P	13:52:38.01	0.50
✓	Y	TATO	BHZ	IU	00	P	13:53:32.21	2.30
✓	Y	SSE	BHZ	IC	00	P	13:54:02.12	1.50
✓	Y	WMQ	BHZ	IC	00	P	13:54:31.12	0.20
✓	Y	AAK	BHZ	II	00	P	13:54:52.31	0.50
✓	Y	NWAO	BHZ	IU	00	P	13:54:59.51	0.10
✓	Y	KURK	BHZ	II	00	P	13:55:38.21	-0.20
✓	Y	MAJO	BHZ	IU	00	P	13:55:59.61	0.40
✓	Y	BRVK	BHZ	II	00	P	13:56:11.66	-0.50
✓	Y	ABPO	BHZ	II	00	P	13:56:15.21	-0.90
✓	Y	CTAO	BHZ	IU	00	P	13:56:38.71	-0.20
✓	Y	ERM	BHZ	II	00	P	13:56:43.51	0.80
✓	Y	KMBO	BHZ	IU	00	P	13:56:56.11	1.00
✓	Y	ANTO	BHZ	IU	00	P	13:57:45.86	-0.70
✓	Y	HNR	BHZ	IU	00	P	13:57:47.56	-0.40
✓	Y	OBN	BHZ	II	00	P	13:58:01.76	-1.20
✓	Y	LSZ	BHZ	II	00	P	13:58:08.26	0.30
✓	Y	PET	BHZ	IU	00	P	13:58:14.11	-0.70
✓	Y	WAKE	BHZ	IU	00	P	13:58:18.51	0.00
✓	Y	KIEV	BHZ	IU	00	P	13:58:17.78	-1.70
✓	Y	SUR	BHZ	II	00	P	13:59:08.31	1.20
✓	Y	GRFO	BHZ	IU	--	P	13:59:22.56	-0.40
✓	Y	ADK	BHZ	IU	00	P	13:59:35.51	-1.00
✓	Y	AKOS	HHZ	GH	--	P	14:00:22.13	3.60
✓	Y	KLEF	HHZ	GH	--	P	14:00:20.40	0.60
✓	Y	PAB	BHZ	IU	00	P	14:00:20.01	-0.20
✓	Y	CHAI	BHZ	IU	00	P	14:00:22.47	0.10
✓	Y	...	...	...	...	...	14:00:24.10	0.50
✓	Y	...	...	...	...	...	14:00:28.65	0.30
✓	Y	...	...	...	...	...	14:00:30.11	-0.80
✓	Y	...	...	...	...	PKPdf	14:06:06.11	-1.30
✓	Y	...	...	...	...	PKPdf	14:06:06.86	-6.80
✓	Y	...	...	...	...	PKPdf	14:06:18.56	-0.10
✓	Y	...	...	...	...	PKPdf	14:06:23.91	-6.70
✓	Y	...	...	...	...	PKPdf	14:06:41.91	0.10
✓	Y	...	...	...	...	PKPdf	14:06:53.01	5.10
✓	Y	...	...	...	...	PKPdf	14:06:57.46	1.00

Waveforms - Event: 1201 - Origin: 5720 (Response Hydra 2.0 (v1.47dm1))

Zoom In More WFs Less WFs Show Predicted Reset Scale Manually Scale Help

✓ **COCO BHZ II 00**
16.90 Dist
174.4 Azm

✓ **LSA BHZ IC 00**
25.12 Dist
351.7 Azm

✓ **DGAR BHZ II 00**
25.68 Dist
242.1 Azm

Apply To All Go To 2013 Jan 10 13:47:04 Change Duration 1 min

Refresh Applied Filter 1 Default Low Pass Hz: High Pass Hz: # High Poles: # Low Poles: Align C

Event Summary - Event: 1201 - Origin: 5720 (Response Hydra 2.0 (v1.47dm1))

Region

Nearest Cities

Location

Latitude: 4.74	Longitude: 95.17	Depth: 40 km	Origin Time: 01/10/2013 13:47:04	Elapsed Time: 0 Day(s) 20:10:22
+/- 8.30 Km	+/- 8.20 Km	+/- 25.30 Km		
Num. Phases: 40 (40)	Gap: 35 Deg	Min. Distance: 16.90 Deg	RMS: 0.83 Sec.	Location Display

Magnitude

5.8 MT

Mag: Type: Quality:

5.8	MT:	28(0)	MT Display
--	Mwp:	-(-)	Mwp Display
6.1	Mb:	17(33)	Mb Display
5.3	Ms:	21(39)	Ms Display
--	MI:	-(-)	MI Display
--	Mblg:	-(-)	Mblg Display
--	Md:	-(-)	Md Display
--	--	--	Official Mag
5.7	CMT:	51(0)	CMT Display

New Travel Times... Rework for All Changes...

Comments Wavefront

Event Type: Earthquake

Claimed By: Unclaimed

Processing Status

Overall Status: **Success**

Locator MI Md Mb Mwp Ms Mblg MT CMT Alarms RayPellets

Event Passport Proc. History This event has been automatically processed.

Quick Review Test Publish Event Has NOT Been Reviewed Or Published.

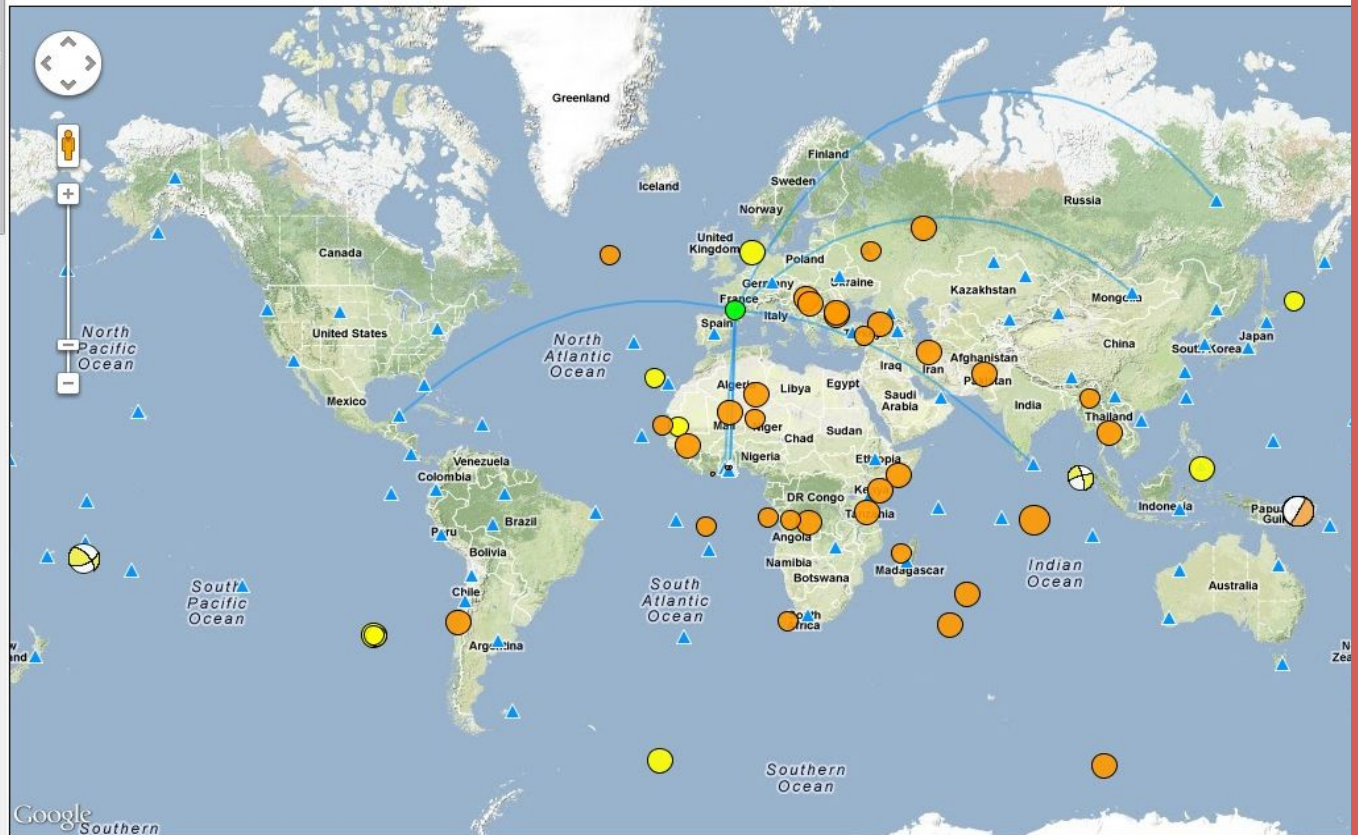
Athena Web Page Displaying Processed Events by Hydra

Recent Earthquakes

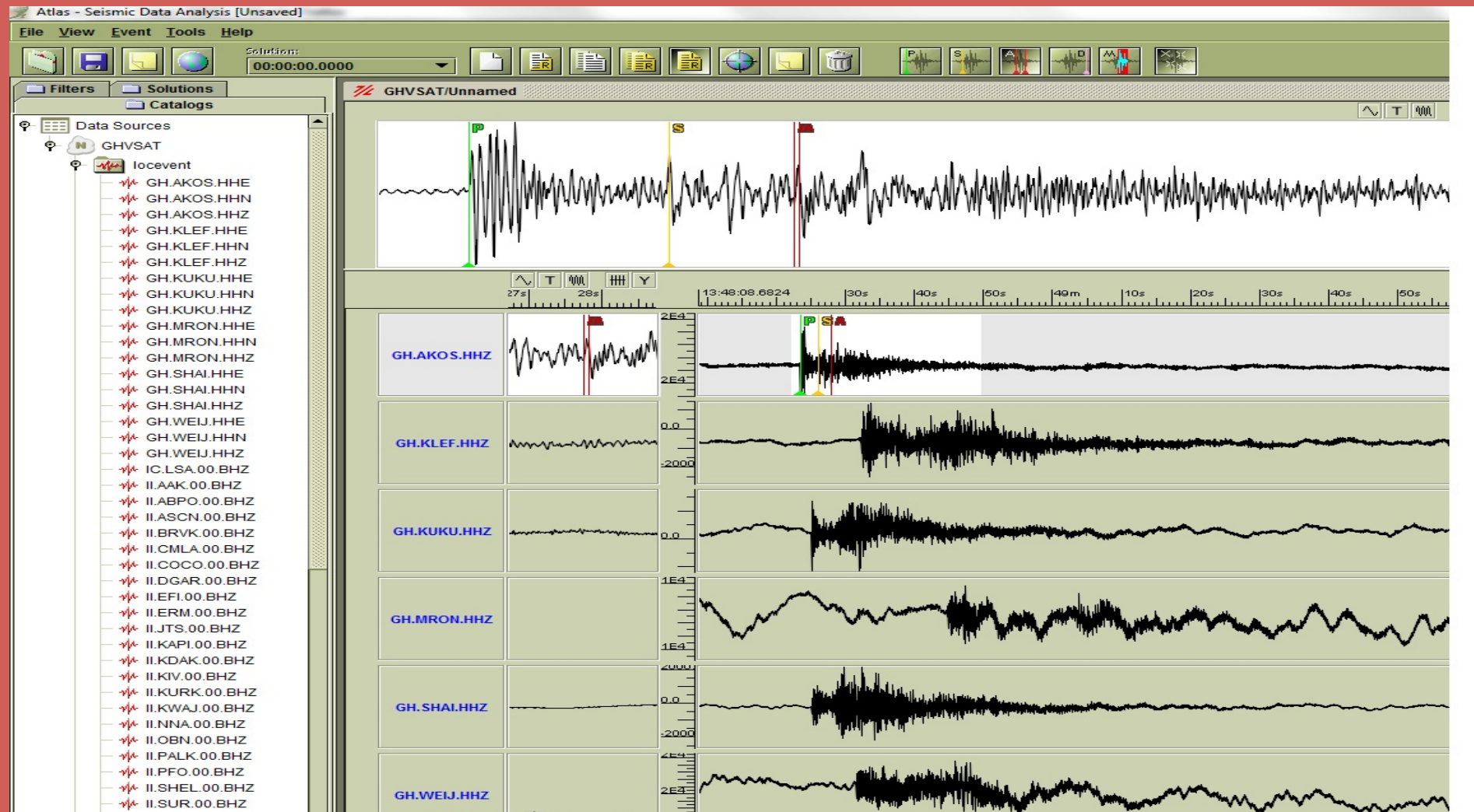
showing 50 of 303 [Report]

Time	Position	Depth	Mag.
2012-11-19 Monday			
18:55:58.0	44.2384°N, 1.5047°E 2.5 km from Lacave, Midi-Pyrénées, France	457.3 km	4.3 Mb
18:41:04.4	6.4461°N, 0.5933°W 1.6 km from Enyiresi, Ghana	0.3 km	
18:24:16.1	6.3215°N, 0.0067°E 0.4 km from Odonaw, Ghana	14.1 km	1.8 ML
17:54:05.6	30.4823°N, 67.7320°E	0.6 km	5.2 Ms
17:49:20.9	27.4689°S, 63.2001°E Indian Ocean	633.4 km	5.0 Mb
17:26:11.5	24.5204°N, 96.0599°E 2.5 km from Nyaunggôn, Sagain, Myanmar [Burma]	107.2 km	4.8 Mb
17:20:35.7	33.8072°S, 15.5170°E South Atlantic Ocean; 143 km from Elephant Park, South Africa	513.2 km	4.8 Mb
17:04:08.3	4.7213°N, 4.7189°W North Atlantic Ocean; 49 km from Toukouzou, Sud-Bandama, Ivory Coast	10.0 km	1.9 ML
16:45:50.8	33.9970°S, 72.3886°W South Pacific Ocean; 44 km from Polcura, O'Higgins, Chile	10.2 km	5.5 Mb
16:25:27.5	9.6282°S, 6.3045°W South Atlantic Ocean; 102 km from Stvor Seamount, Southern Ocean	36.3 km	4.3 Mb
16:02:03.6	59.9952°S, 99.9896°E Southern Ocean	343.8 km	5.8 Mb
14:38:12.4	43.8581°N, 28.4805°E 1.4 km from Arsa, Romania	35.0 km	5.7 Mb
14:21:08.1	19.4243°N, 6.6211°E 73 km from Oubandawaki Makiani, Maradi, Niger	31.1 km	4.4 Mb
14:21:03.7	7.3854°S, 10.2258°E South Atlantic Ocean	12.8 km	4.2 Mb
14:17:33.8	0.1650°N, 40.0479°E 23 km from Sabule, North-Eastern, Kenya	252.0 km	5.1 Mb

Date
 From:
 To:
 Magnitude
 Min: Max:
 Type:
 Position
 From:
 To:
 Depth
 Min:
 Max:
 Show beachballs Limit: 50 Criteria: Choose

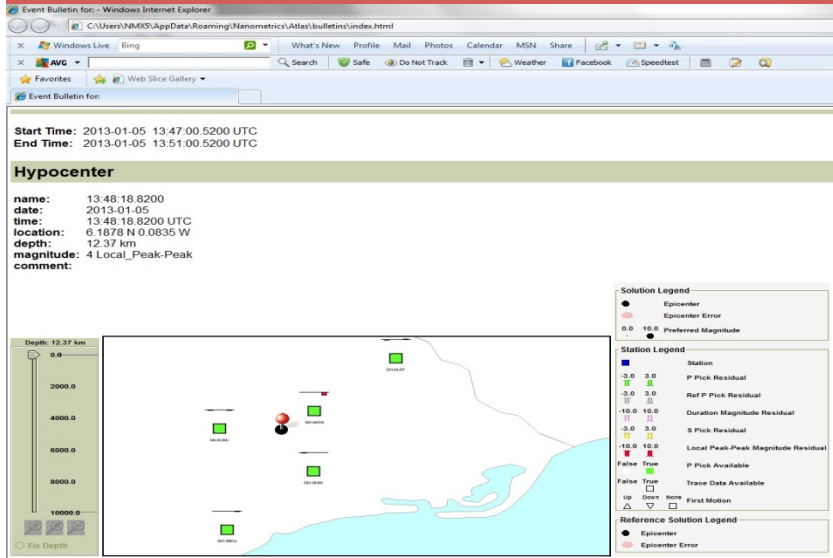


Atlas Local Event Post Processing Software



Locally recorded event by Ghana Digital Seismic Network. Automatically Processed by Hydra. Waveform extracted using atlas for Post Processing

Atlas Event Bulleting



Phases

Network	Station	Channel	Location	Phase	Date	Time	Pick Weight	Pick Residual
GH	AKOS	HHZ		P	2013-01-05	13:48:23.2946 UTC	100.0%	0.02
GH	KLEF	HHZ		P	2013-01-05	13:48:31.8701 UTC	100.0%	-0.01
GH	KUKU	HHZ		P	2013-01-05	13:48:24.9543 UTC	100.0%	-0.01
GH	SHAI	HHZ		P	2013-01-05	13:48:25.0265 UTC	100.0%	-0.02
GH	WEUJ	HHZ		P	2013-01-05	13:48:31.4251 UTC	100.0%	0.02

Duration Phases

Network	Station	Channel	Location	Date	Time	Pick Weight
---------	---------	---------	----------	------	------	-------------

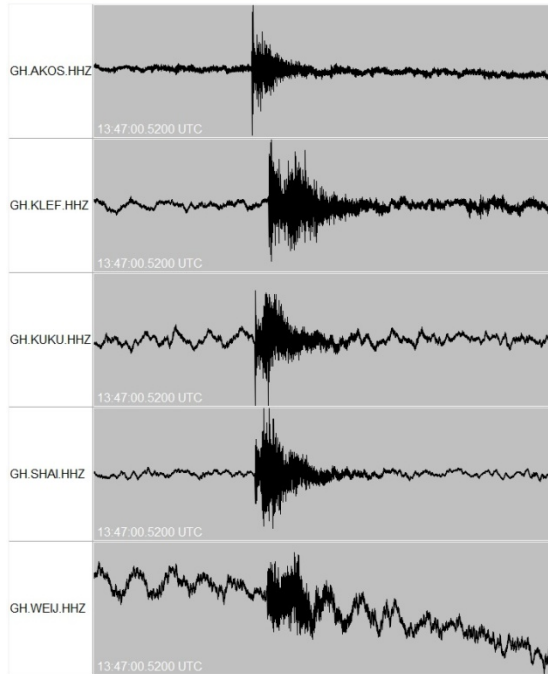
Amplitude Phases

Network	Station	Channel	Location	Amplitude1	Date	Time	Amplitude2	Date	Time	Pick Weight
GH	AKOS	HHZ		10841.2237	2013-01-05	13:48:51.7500 UTC	10989.3973	2013-01-05	13:48:55.9400 UTC	100%
GH	KLEF	HHZ		1193.8924	2013-01-05	13:48:46.4200 UTC	1401.854	2013-01-05	13:48:43.3600 UTC	100%
GH	KUKU	HHZ		88.6862	2013-01-05	13:48:50.1200 UTC	129.6718	2013-01-05	13:48:51.7100 UTC	100%
GH	SHAI	HHZ		495.1656	2013-01-05	13:48:43.3200 UTC	728.4993	2013-01-05	13:48:40.4800 UTC	100%
GH	WEUJ	HHZ		20447.2197	2013-01-05	13:48:50.4600 UTC	20455.5377	2013-01-05	13:48:49.8800 UTC	100%

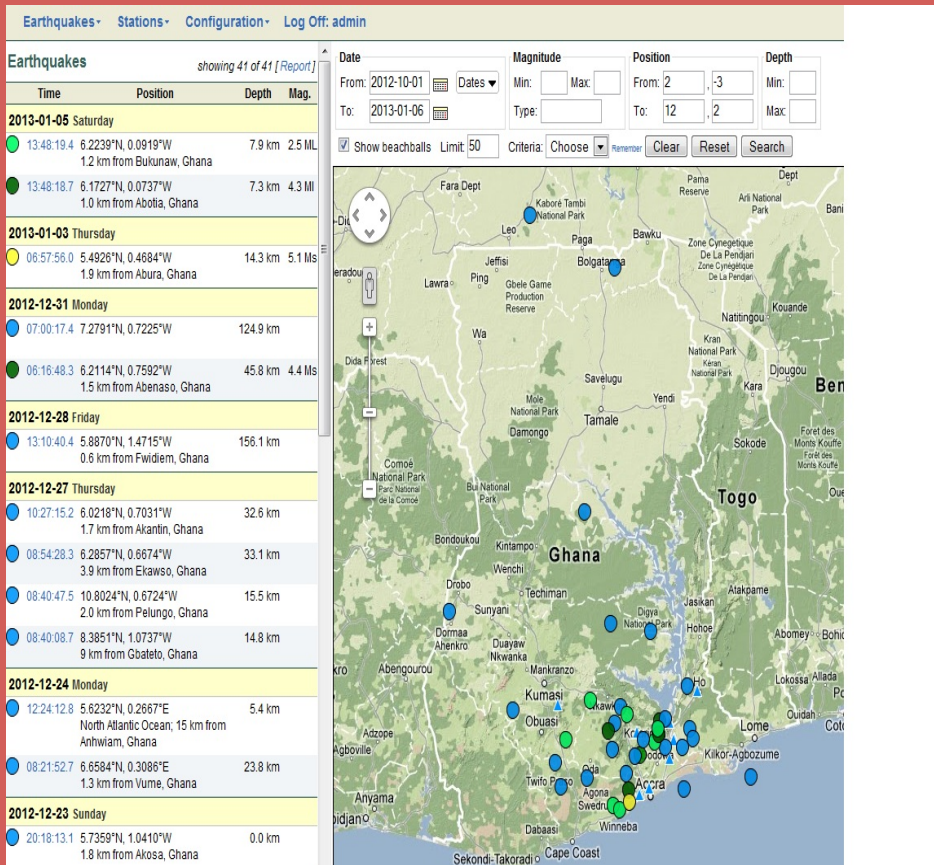
Channels

Network	Station	Channel	Location	Latitude	Longitude	Elevation	Azimuth	Dip
GH	AKOS	HHZ		6.2984°N	0.0681°E	217.0 m	0.00	90.00
GH	KLEF	HHZ		6.6142°N	0.4406°E	313.0 m	0.00	90.00
GH	KUKU	HHZ		6.1924°N	0.3686°W	240.0 m	0.00	90.00
GH	SHAI	HHZ		5.9371°N	0.0627°E	107.0 m	0.00	90.00
GH	WEUJ	HHZ		5.5885°N	0.3333°W	203.0 m	0.00	90.00

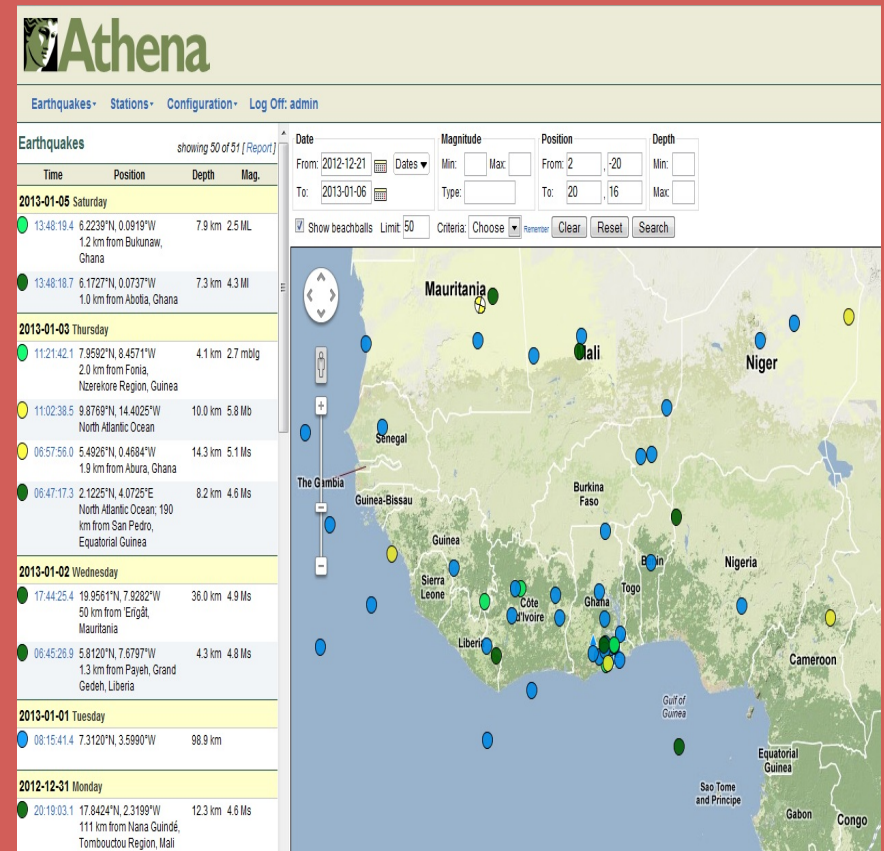
Waveforms



Epicentral location of local events in Ghana and beyond



Micro-Seismic events Recorded in Ghana



Seismic events Recorded within W/A Sub - Region

The Strong Motion Equipments

10 x Strong Motion Stations
(Data recorded to local CF
media)

Taurus Digitizer



Titan Accelerometer

Buffered operations
mode assures
minimal
power consumption.

Requires scheduled
station visits to swap
media before
reaching
full recording
capacity

Ten standalone strong motion accelerometers installed on critical or lifeline structures such as electrical power facilities (Akosombo and Akuse dams) and water supply and sewage treatment facilities (Weija dam).

The Purpose of this strong motion accelerometers is to determine:

The nature of earthquake ground motion and its impact on structures

The duration of the shaken

The frequencies of the motion



Expected Aims and Objectives to be Achieved

The recorded data from the entire set up will help Ghana obtain Ground Motion Estimates to generate a new national seismic hazard map.

This will then form the basis for:

- Effective Land Use Planning
- A new Building Code Provision
- Seismic Design Criteria Critical or Lifeline Structures

And For Research into the internal composition of the earth.

Way Forward

- ❖ Extend the seismic network to cover other places to have a good coverage area in Ghana.
- ❖ Co-operation, sharing of data and extension of the network within the entire West African Sub-region.
- ❖ Efforts are underway to integrate our system into the Global Seismic Network for the sharing of information.
- ❖ Sustenance of capacity building of Seismologists, Earthquake Engineers, Technicians and other supporting staff to keep them abreast with time.

Challenges

Funding for the maintenance of the Seismic Network including the main Central Observatory.

Funding of activities to be carried out in the West African Sub - Region.

Rapid access to spare parts for replacement when there is a break down (especially batteries and solar panels) to avoid data lost over a long period.

Training of Seismologists and other Technical Staff.