

Environmental Seismology (EnviroSeis): Advancing in real-time monitoring of nature hazards



Dept. of Civil Engineering, National Chiao Tung University 國立交通大學土木工程學系 Comprehensive Landtoring Lab. (CoLLab) 地表過程地動監測研究室

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地表過程地動監測研究室 Comprehensive Landtoring Lab. (CoLLab)





For large landquake Large area > 0.1 km² Deep failure surface > 10 m Rapid movement

(Cruden & Varnes, 1996)



Block model: single-force mechanism



Block model: landslide-induced seismogram V.S. Synthetic waveform



Detection module: grid-based SF inversion (20-50 sec period) grid size 0.2°



Relocated procedure using 1-3 Hz seismic signals: LED

grid size 0.01



Flowchart:

real-time landquake monitoring system (RLMS)

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<pre>wvert: UnableToOpenConfigureFile `delegates.xml' & configure.c/GetConfig Driginal time: 20161208074648.40 120.60 22.40 0.1217E+15 290.20 -7.80 0.2869</pre>	$\leftarrow \rightarrow \mathbb{C}$ (140.112.57.117/rlms_south.html	**	
<pre>wvert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfig Driginal time: 20161208074650.00 5 121.60 25.00 0.9937E+14 32.52 -38.13 0.2460</pre>	Real-time Landquake Monitoring Sys	em	
<pre>avert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfig Driginal time: 20161208074653.20) 121.40 23.40 0.1520E+15 166.85 -30.70 0.2239 avert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfigureFile `delegates.xml' @ configureFile `delega</pre>	Normalized cross-correlation coefficient (CC) Time shift (T5) Signal-to-noise ratio (SNR) Variance reduction (VR) Available traces: 43/45 Ver	016/12/08 07:47:03 (UTC) cal Radial Tangential	

Original time: 20161208074656.90 5 121.40 25.00 0.1993E+15 350.19 59.31 0.2977 nvert: UnableToOpenConfigureFile `delegates.xml' & configure.c/GetConfigu Original time: 20161208074701.10 120.60 23.40 0.7362E+14 2.96 -16.03 0.2705 22.80 0.1860E+15 254.99 -32.43 0.2963 120.80 nvert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfigu Original time: 20161208074703.50 nvert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfigu Original time: 20161208074703.80 5 121.20 24.60 0.1373E+15 23.18 -28.88 0.2404 nvert: UnableToOpenConfigureFile `delegates.xml' & configure.c/GetConfigu Original time: 20161208074708.80 120.80 23.20 0.2144E+15 293.22 -70.57 0.3050 121.20 23.80 0.2217E+15 152.09 -51.14 0.2622 nvert: UnableToOpenConfigureFile `delegates.xml' & configure.c/GetConfigu Original time: 20161208074710.70 nvert: UnableToOpenConfigureFile `delegates.xml' @ configure.c/GetConfigu Original time: 20161208074711.00

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-55LB 40.0 m (AZ), dep Ante BEST SOLUTION r distance (EPI, km) Location (120.8 23.2) Observed displacement: Different grey levels indicate different weighting factors based on SNR of individual records FORCE_DIP = SHR is calculated from the ratio between short-term Fitness = 0.3050(1 5 s from the peak envelope amplitude) average and hole-trace average The waveform fitness (-3.0 - 2.0) between synthetic and observed seismograms is defined by both the VR and CC values A time shift of up to 15 s is allowed independently for each cross-correlation coefficient (CC) value. "A value of 0.55 is used in the detection module block-mass sliding force C Historical Event 0.1E+17 dyna Down [+] Namaxia IES BAT + Source grid RLMS central area

- RLMS north area
- RLMS south area
- RLMS catalog
- Home



RLMS web display: http://140.112.57.117/main.html

1.0



Correlated to collapse area from satellite image mapping

Guestion: only roughly consistent?





2014 Askjas event: 39 million cubic meters



LFH inversion: waveform fitting 0.02-0.08 Hz



Force (LFH) --> acceleration --> velocity --> displacement (trajectory)



Collapse Mass: from fitting observed runout distance



Downstream early warning: dam-formation seismic signal- D phase



Real-time operation in 2016







Question: can RLMS system detect the relatively small event?





Collapse dinec.



~0.3 ha

Rogo

Flow direction



Taroko National Park: Spatial and temporal patterns of landquake activity





SPOT 2016.06.16









2016 錐鹿事件



2016 錐鹿事件

X axis start from 2016.01.27 22:47:00 Component: Z LW03 3 km石隧道 LED location

2016 錐鹿事件



Collapse area estimation using seismic signal



五月十一日(星期四) 第三演講廳		三演講廳	主持人:張竝瑜、李坤松		
GP1/GP2					
時間	議程代碼	作者	主題		
08:00~08:15	O-2-GP1-1	李健平,林孝維, 梁守謙,張國雄, 徐祥宏	重合前震测逆推分析西非外海深 海濁流岩之油氣潛能		
19					
08:15~08:30	O-2-GP1-2	李坤松, 陳浩維	海底地震儀資料的雙方根走時成 析成像 -全波形逆推初始模型的 建立		
08:30~08:45	O-2-GP1-3	羅祐宗, 顏宏元	結合重力與地震資料探討台灣地 區之地殼構造		
08:45~09:00	O-2-GP1-4	何恭睿, 張竝瑜	三義斷層近地表構造特性調查		
09:00~09:15	O-2-GP1-5	伍允豪, 曾衡之, 邱維毅, 傅式齊	三維震測及井測資料逆推岩石物 理特性應用於非洲 B 礦區		
09:15~09:30	O-2-GP2-1	張睿明, 陳宏宇, <mark>趙韋安</mark>	Controlled factors of rockfall disaster in active mountain belts: a case study in Liwu catchment, Taiwan		
09:30~09:45	O-2-GP2-2	林俊宏,林志平, 劉興昌	應用跨孔雷達井測於汙染整治之 土中新體全量監測		

周遭噪訊法-交互相關函數

非破壞性、連續性、單點延伸至多點(面)



Seismic monitoring of groundwater on hillslope







Daily cross-correlation function (CCF)



Stretching technique



Hydrological model: Darcy-like acuifer



Hydrological model: Darcy-like acuifer

2016年 烏來西羅岸邊坡實例



五月十一日(星期四) 國際會議集

主持人:雉聿安、傅慶州

S5/S6/S7									
時間	議程代碼	作者	主題	五月十一日(王期(四) 調	原士诚素	主持人: <mark>道掌</mark> 旁、傅慶州		
08:00-08:15	0-2-85-1	陳凱勛, 冀源成,	Crustal structure and deformation fabrics in the Tohoku region,	S5/S6/S7 時間	10.	作者	主题	國際會議廳	
08:15-08:30	0-2-85-2	郭本道, 黃梓殷 Ying-Nien Chen, Yuancheng Gung,	Japan, revealed by ambient noise tomography On the fluctuations of the noise correlation function and its	10:15~10:30	C \$5.4	陳映年, Yuancheng Gung, Ling-Yun Chiao, Junkee Rhie	Characteristics of Microseism Excitations Revealed by Noise Correlations	S5/S6/S7 噪聲、環境 地震學與 油電前非四次	
		Ling-Yun Chiao 簡志傑, 陳映年,	implications Shallow Seismic Structure of	10:3010:45	O-2-S6-5	陳卉瑄	環境裏動訊號之自動分類:構想 與初標	地展前死研究 主持人:	
08:30-08:45	0-2-85-3	黄梓殷, 龔源成, 梁文宗	Taiwan Constrained by Noise-derived Rayleigh Waves	10:45~11:00	O-2-S7-1	陳宏嘉,陳宏嘉	地電場統計異常與地震的關連性 分析	<mark>趙韋安</mark> 傅慶州	
08:45-09:00	0-2-85-4	洪瑞駿, 馬圖麗, 宋浩棠, 西田家,	利用車籠埔深鑽計畫并下地震儀	11:0011:15	O-2-87-2	蘇足倚	連續GPS應用於震前基線異常變 化之研究		
		林彦宇	非均向性	11:15~11:30	O-2-87-3	蒲新杰	20160206 美濃地震震前微震活 動特微分析		
09:00-09:15	0-2-85-5	王蔵蔵, 楊欣頴, 洪淑蕙, 郭本垣	利用海底地展復的運噴記錄研究 台灣東部外海淺層地殼構造和嗓 訊來源			傅慶州,李羅權, 楊燦亮,王鵬綱, 劉曉桂,	Radon and gamma rays anomalies	S5/S6/S7 噪聲、環境 地震學與	
09:15~09:30	0-2-86-1	黃信禅, 許雅儒	利用被動式地震干涉影像監測室 蘭蘭台地區慢滑移山崩潛勢區之 初步研究	11:30~11:45	5 O-2-S7-4	5 O-2-S7-4 Vivek Walia, 陳正宏,林正洪, Gioacchino	Vivek Walia, 陳正宏,林正洪, Gioacchino	observed in northern Taiwan: a possible connection with the seismicity near the subduction	地震前兆研究 主持人:
		20				Giuliani, Dimitar Ouzounov	zone	超章安 傅慶州	

09:3009:45		陳助吾, 黃千芬, 林建文, 郭本垣	花東海盆的 T 波:海底地震儀的 觀測與模擬
09:45~10:00	O-2-86-3	<mark>趙韋安</mark>	遗遇地震方法分析發生於西藏西 都之大規模冰川崩塌

- Chen, C. H., <u>W. A. Chao*</u>, Y. M. Wu, L. Zhao, Y. G. Chen, W. Y. Ho, T. L. Lin, K. H. Kuo and R. M. Zhang (2013) A Seismological Study of Landquakes Using a Real-Time Broadband Seismic Network. *Geophys. J. Int.*, 194, 885-898.
- Chao, W. A.*, Y. M. Wu, L. Zhao, V. C. Tsai and C. H. Chen (2015) Seismologically determined bedload flux during the typhoon season, *Sci. Rep.*, 5, 8261; doi: 10.1038/srep08261.
- Chao, W. A.*, L. Zhao, S. C., Chen, Y. M. Wu, C. H. Chen and H. H. Huang (2016) Seismology-based early identification of dam-formation landquake events, *Sci. Rep.*, 5, 19259; doi: 10.1038/srep19259.
- Chao, W. A.*, Y. M. Wu, L. Zhao, H. Chen, Y. G. Chen, J. M. Chang and C. M. Lin (2017) A first online real-time seismology-based landquake monitoring system, *Sci. Rep.* 7:43510; doi: 10.1038/srep43510.

Thanks for your listening



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