Friday, 3 May 2024—Oral Sessions

Presenting author is indicated in bold.

Time	*Tikahtnu Ballroom B*
	The 3 April 2024 Magnitude 7.4 and 6.4 Earthquakes and Aftershock Sequence Near Hualien City, Eastern Taiwan (see page 3).
10:30 AM	Performance of the CWA Earthquake Early Warning System for the 2024 ML 7.2 Hualien Earthquake, Taiwan. **Lin, Y.**, Chen, D.
10:45 AM	Comparative Analysis of the M 7.4 April 3rd, 2024, and ML6.9 Nov. 15th, 1986, Earthquakes in Hualien, Taiwan. **Ma, K.**
11:00 AM	STUDENT: Near Real-time Catalog of the 2024 ML7.2 Hualien Earthquake Sequence. **Sun, W.**, Kuo-Chen, H., Liu, Y., Pan, S., Ho, C., *et al.*
11:15 AM	Multiscale 3D View of Faults Activated in the 3 April 2024 Hualien Taiwan Earthquake Sequence, Illuminating the Walls of a Giant Subduction Channel and the Orthogonal Juncture of Two Subduction Systems. **Suppe, J.**, Carena, S., Hsieh, Y., Liu, C., Huang, H., *et al.*
11:30 AM	Characterizing Building Dynamics During the 2024 Hualien Earthquake Sequence Using the Quake Structural Integrity System (QSIS). **Kumar, U.**, Liang, W., Ma, K., Chen, L.
	The 5 April 2024 Magnitude 4.8 Tewksbury (Whitehouse Station), New Jersey Earthquake (see page 5).
2:00 PM	In a New York Minute: The M4.8 Whitehouse, New Jersey Earthquake and Rapid Insights on the U.S. Geological Survey Response. **McBride, S. K.**, Earle, P., Jobe, J., Goulet, C., Quitoriano, V., *et al.*
2:15 PM	Reactivation of the Flemington Fault by the 2024 Mw4.8 Whitehouse Station Earthquake: Slip Potential of the Southwestern Ramapo Fault System, Central NJ. **Levandowski, W.**
2:30 PM	Apparent Stress for the Mw 4.8 Whitehouse Station, NJ Earthquake from Coda Spectral Ratios. **Mayeda, K.**, Roman-Nieves, J., Shelly, D., Bent, A.
2:45 PM	Rutgers and Yale Rapid Seismic Array Deployment and Contribution to the 2024 Whitehouse Station, NJ, Earthquake Response: Collaborations, Reactions, and Education and Public Outreach. **Link, F.**, Bourke, J., Masis Acre, R., Frazer, W., Long, M. D., *et al.*
3:00 PM	A TexNet's Joint Field Deployment in Support of Monitoring the Aftershock Sequence of the M4.8 Earthquake, Whitehouse Station, New Jersey. Huang, D., O'Sullivan, V., Domino, J., Burke, G., **Savvaidis, A.**
	The 5 April 2024 Magnitude 4.8 Tewksbury (Whitehouse Station), New Jersey Earthquake (see page 5).
4:30 PM	The April 5th, 2024, M4.8 New Jersey Earthquake: Overview, USGS Response, and Collaborative Efforts. **Boyd, O. S.**, Burke, J., Chapman, M., Earle, P., Jobe, J., *et al.*
4:45 PM	The April 5, 2024 Mw4.8 New Jersey Earthquake: A Need for Regional Seismic Network Operation to Characterize Complex Fault Activation in Intra-plate Settings. **Waldhauser, F.**, Kim, W., Beauce, E., Wang, K., Schaff, D., *et al.*

The 3 April 2024 Magnitude 7.4 and 6.4 Earthquakes and Aftershock Sequence Near Hualien City, Eastern Taiwan [Poster Session] (see page 4).

191. Prediction Power for Strong Ground Motions on the 2nd Apr. 2024 Mw 7.37 Taiwan Earthquake: Migrated from Ergodic to Nonergodic GMM for FAS. **Huang, J.**, Sung, C., Huang, J., Kuo, C., Abrahamson, N. A., *et al.*
192. STUDENT: Observations from Recent Mw 7.4 Earthquake Along the Eastern Coast of Taiwan. **Lee, H.**, Lin, L., Lee, H., Marschall, E., Chuang, R. Y.
193. STUDENT: Infrasound Observations from April 3rd Taiwan Earthquakes. **Liang, T.**, Saplakoglu, H., Wu Li, C., Clayton, Z., Zink, M.
194. Real-time Performance of the SED-ETHZ SeisComP Earthquake Early Warning (ESE) System at CWA During the 3 April 2024 Magnitude 7.4 Earthquake Sequence Near Hualien City, Taiwan.. Massin, F., Song, G., Wu, Y., Chen, D., **Massin, F.**, *et al.*
195. Hualien, Taiwan Tsunami: Observation and Modeling. **Moore, C.**, Wei, Y., Titov, V. V., Sannikova, N.
196. New Active Fault Map of Offshore Eastern Taiwan and the 3 April 2024 Taiwan Hualien Earthquake Sequence. Hsieh, Y., **Suppe, J.**, Liu, C., Carena, S., Huang, H.

The 5 April 2024 Magnitude 4.8 Tewksbury (Whitehouse Station), New Jersey Earthquake [Poster Session] (see page 7).

197. TransmaxNET: Detecting P-Wave Arrivals and Predicting Earthquake Parameters for the 5 April 2024 Magnitude 4.8 Whitehouse Station, New Jersey Earthquake. **Owusu Duah, J.**
198. Coupling of Brittle Crustal Fabrics and Seismic Anisotropy Near the 2024 Mw4.8 New Jersey Earthquake. **Kolawole, F.**, Foster-Baril, Z., Ajala, R., Xue, L., Tielke, J., *et al.*
199. U.S. Geological Survey Aftershock Response for the M4.8 Whitehouse Station, New Jersey Earthquake. **Ringler, A.**, Litherland, M., Earle, P., Holcomb, A., Ploetz, S., *et al.*
200. STUDENT: Rupture Model for the 5 April 2024 New Jersey Earthquake. Han, S., Park, J., **Seo, M.**, Kim, Y., Kim, W.

Abstracts of the Annual Meeting

The 3 April 2024 Magnitude 7.4 and 6.4 Earthquakes and Aftershock Sequence Near Hualien City, Eastern Taiwan

Oral Session • Friday 3 May • 10:30 AM Pacific

Convener: Kuo-Fong Ma, Academia Sinica (fong@earth.sinica.edu.tw)

Performance of the CWA Earthquake Early Warning System for the 2024 ML 7.2 Hualien Earthquake, Taiwan

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On April 3, 2024 at 7:58:9.9 am (Taiwan local time), an ML 7.2 earthquake struck the eastern coast of Hualien County at a depth of 15.5 km, causing strong shaking with the maximum intensity of 6+ on the seismic scale of Central Weather Administration, Taiwan (CWA) near the epicenter. It also generated intensity 5- in northern Taiwan and intensity 4 for most of Taiwan island. The 2024 Hualien earthquake is the largest damaged earthquake after the 1999 Chi-Chi earthquake. Unfortunately, tens of people died, thousands were injured, and hundreds of buildings collapsed or seriously damaged not only near the epicenter, but in the metropolis in northern Taiwan island. Furthermore, the shaking triggered large scale landslides in the Taroko National Park and along the important highways, the #9 Suhua and #8 Central Cross-Island Highway in northern Hualien County.

The earthquake early warning (EEW) system operating by CWA issued the first warning for an M 6.2 earthquake at 9 s after the origin time of the earthquake to parts of central and eastern Taiwan. The system issued an updated warning for an M 6.8 earthquake at 15 s after the event origin time. The warning regions extended to parts of northern, southern, and entire central Taiwan. In this study, we evaluate the performance of the EEW system based on the warning time which is the time difference between the first warning issue and arrival of the maximum peak ground velocity phase from the strong motion network, then taking away another 5 s for broadcasting. We recognize that public had the warning times of 10 s, 5 s, 7 s, and 7 s near the epicenter, in the Hualien City, in the Taroko National Park, and in the #9 Suhua Highway, respectively. There was no blind zone in the source region for the earthquake. The EEW system indeed plays a key role to prevent life loss and numbers of injuries in the 2024 Hualien earthquake in the source area.

Comparative Analysis of the M 7.4 April 3rd, 2024, and ML6.9 Nov. 15th, 1986, Earthquakes in Hualien, Taiwan

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On April 3rd, 2024, a significant ML7.2 (Mw7.4) earthquake struck offshore Hualien, causing severe ground shaking felt across the entire island, with local intensity reaching 6+ (PGA>400 gal; PGV>0.8m/s). Even Taipei, approximately 100km from the epicenter, experienced severe shaking (PGA> 200 gal), marking Taiwan's largest earthquake since the 1999 Chi-Chi Mw7.6 Earthquake. The Hualien region, situated near the Ryukyu subduction zone, has historically experienced seismic activity. Notably, severe earthquakes occurred in October and November of 1951. Additionally, a similar event on November 15th, 1986, inflicting severe damage on Taipei Metropolitan. The resemblances in shaking patterns between the 1986 and 2024 earthquakes provide valuable insights for understanding the impact of such collision zone earthquakes, especially on nearby cities and distant Taipei Metropolitan. Following the 1986 earthquake, Taiwan initiated the Taiwan Strong Motion Implementation Program (TSMIP) in 1993, highlighting the importance of seismic monitoring and hazard assessment. The preliminary finite-fault model based on seismic, GPS, and InSAR data for the 20240403 earthquake suggests it may have resulted from an offshore western-dipping fault, with a significant slip as an asperity at a depth of around 20-30km inland. In contrast, the fault plane determination for the 1986 earthquake considered an eastern-dipping rupture plane, though data at that time were limited. Resolving this discrepancy in fault plane orientation is crucial for understanding the seismogenic structure from offshore to inland Taiwan. This study aims to compare seismic waveforms, analyze tectonic implications, and enhance future seismic hazard assessment efforts in Hualien and beyond.

Near Real-time Catalog of the 2024 ML7.2 Hualien Earthquake Sequence

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On 3 April 2024, at 07:58 local time (UTC+8), a strong magnitude 7.2 earthquake struck Shoufeng, Hualien, Taiwan, at a depth of 23 km. This earthquake, which occurred along a fault line trending northeast-southwest, was of the thrust type. Understanding the distribution of aftershocks following a devastating earthquake is crucial for deciphering the seismic activity in the source area. To achieve this, we utilize SeisBlue, an advanced seismic analysis platform based on deep learning techniques. SeisBlue processes real-time continuous waveform data collected from two broadband seismic networks: the Broadband Array in Taiwan for Seismology (BATS) and the Seismic Array of NCREE in Taiwan (SANTA). These networks are maintained respectively by the Institute of Earth Sciences at Academia Sinica (IES-AS) and the National Center for Research on Earthquake Engineering (NCREE). Within 6 days after the mainshock (from April 3, 00:00 UTC to April 8, 23:59 UTC), SeisBlue recorded a total of 8,059 seismic events, providing near real-time information on earthquake activity. As of now, the aftershock distribution suggests complex seismogenic structures, and we anticipate updating the earthquake locations with more accurate data over the coming days.

Multiscale 3D View of Faults Activated in the 3 April 2024 Hualien Taiwan Earthquake Sequence, Illuminating the Walls of a Giant Subduction Channel and the Orthogonal Juncture of Two Subduction Systems

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The shallow 3 April 2024 M~7.4 Hualien earthquake sequence took place precisely at the orthogonal juncture of the Ryukyu and Luzon Manila Trench subduction systems at the northeastern coast of Taiwan, activating major interfaces of both systems, including faults of the Ryukyu subduction channel and the Luzon forearc subduction interface of the Manila system. We integrate multiscale data in 3D in Aspentech Gocad software, including local tomographies, previous seismicity, previous multi-scale focal-mechanism stress inversion, marine seismic reflection data, offshore bathymetry and fault mapping (Y-H Hsieh, this meeting), April 2024 aftershock locations and mechanisms (CWB and BATS), and finite fault models (Shiann-Jong Lee, IES). We had mapped faults in 3D after the 2013 Ruisui and 2018 Hualien earthquakes using high resolution local tomography and relocated seismicity. These fault models fit the April 2024 aftershocks well, and we are refining them with 2024 data. The 2024 mainshock hypocenter and many aftershocks fit well with the mapped forearc subduction interface from ~45km depth up to its intersection with a west-dipping fault that projects eastward to the surface trace of the Takangko High thrust (Y-H Hsieh et al. 2020; fault 22 of the TEC Taiwan Fault Model of Bruce Shyu). The high-slip portion of the 3 April 2024 mainshock is confined to a 15 km x 30 km geometric segment of this fault, as shown by projecting the west-dipping finite-fault model of Shiann-Jong Lee (IES) onto our pre-earthquake fault model. The Takangko High fault is the shallow up-dip portion of a regional ~110km long west-dipping fault that we have informally called the Suao-Hualien-Ruisui fault that activated in the 2013 Ruisui earthquake. At the northern end of the 2024 sequence this fault turns eastward to become the roof-thrust of the Ryukyu subduction channel. The floor thrust, which is the main detachment of both the Ryukyu accretionary wedge and the offshore eastern Taiwan thrust belt (Y-H Hsieh et al. 2020), was illuminated by aftershocks of the April 2024 sequence.

Characterizing Building Dynamics During the 2024 Hualien Earthquake Sequence Using the Quake Structural Integrity System (QSIS)

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The April 2024 Hualien Earthquake sequence presented a significant opportunity to evaluate the performance of the Quake Structural Integrity System (QSIS), a sophisticated structural health and seismic monitoring technology, under real seismic events. QSIS integrates cost-effective MEMS accelerometers with advanced cloud computing to analyze seismic data and characterize building dynamics in real time. We will cover the deployment of QSIS at 70 sites across Taiwan, including diverse building forms ranging from residential blocks to the iconic Taipei 101. The system utilized PhidgetSpatial sensors coupled with Raspberry Pi microprocessors to capture the earthquake's intense motions with exceptional precision.

During the seismic events, QSIS collected detailed three-component acceleration data crucial for evaluating the structural integrity of different building types. It utilized automated methods to rapidly assess building dynamic characteristics, such as dominant resonance frequencies, damping ratios, and response patterns, enhancing our understanding of seismic wave interactions within structures. These insights into the buildings' dynamic behaviors and potential vulnerabilities will be highlighted through the presentation of our results.

We will highlight the essential role of innovative technologies like QSIS in seismic engineering, especially in areas frequently affected by earthquakes. We will discuss QSIS's implementation during the Hualien Earthquake sequence and propose potential system enhancements to improve seismic risk mitigation efforts in the future.

The 3 April 2024 Magnitude 7.4 and 6.4 Earthquakes and Aftershock Sequence Near Hualien City, Eastern Taiwan

Poster Session • Friday 3 May

Convener: Kuo-Fong Ma, Academia Sinica (fong@earth.sinica.edu.tw)

POSTER 191

Prediction Power for Strong Ground Motions on the 2nd Apr. 2024 Mw 7.37 Taiwan Earthquake: Migrated from Ergodic to Nonergodic GMM for FAS

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An Mw 7.37 earthquake occurred at 23:58 on 2nd Apr. 2024 (UTC) in offshore Hualien, Taiwan. The closest rupture distance of strong-motion stations is approximately 13 km. From data processing with filtered, the largest peak ground acceleration and velocity observed are 0.63g and 73 cm/s. In the last decade, the modern ground-motion model (GMM) has migrated from a spatially independent ergodic GMM (EGMM) toward a nonergodic GMM (NGMM, e.g., Sung et al., 2023; Lavrentiadis et al., 2023), which captures the systematic biases on the scaling of ground-motions (GM) related to the source location, 3-D Q and velocity structure along the propagation path, and site-specific site amplification. Sung et al. (in preparation) developed a NGMM for the Fourier Amplitude Spectrum (FAS) for Taiwan. The functional form of the reference ergodic model follows Bayless and Abrahamson (2019). The NGMM includes spatial-correlated source and site location effects, a quality-factor related cell-specific term (δP2PQ), and a propagation path-related term (δP2PV) which reflects the special focusing, multiple reflection or topography effects due to surrounding 3-D velocity structure.

We test the prediction power for the FAS NGMM using data from the M7.37 earthquake, which was not used in the model-building process. The preliminary results indicate that the median prediction from the NGMM captured more of the spatial distribution of the ground motion compared to the reference EGMM. Specifically, the strong site-amplification pattern in southwestern, north, and northeastern Taiwan with deep sediments near the surface is well explained by the NGMM. The azimuthal variation in the GM residuals that may be due to rupture directivity and dynamic radiation pattern effects are not captured in either the EGMM or the NGMM because these effects are not included in the GMMs. Overall, the comparison with the GM data from the M7.37 event shows that the NGMM provides a more accurate estimate of the median GM and a smaller standard deviation than the EGMM and can be used to improve the accuracy of future seismic hazard analysis applications in Taiwan.

POSTER 192

Observations from Recent Mw 7.4 Earthquake Along the Eastern Coast of Taiwan

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A moment magnitude 7.4 earthquake struck eastern Taiwan on April 3rd 2024 local time. Up until the submission of this abstract, the earthquake has brought about 17 fatalities, 1155 injuries and damaged several structures. The rupture propagated to the north of Hualien city, followed by a series of aftershocks with some having magnitudes over 6.0. The mainshock took place in the northern part of the Longitudinal Valley in eastern offshore Taiwan, a complex tectonic setting resulting from the oblique collision of the Philippine Sea Plate and the Eurasian Plate. Recent seismic reflection and high-resolution bathymetry data showed multiple parallel structures with similar strike directions but opposite dipping orientations. A study using earthquake sequences and seismic velocity models also inferred faults with opposite dipping directions. Preliminary earthquake relocation and focal mechanism suggested the mainshock could either nucleate on a west-dipping or an east-dipping plane with dominant thrusting motion. Both inferred fault planes fitted with the current understanding of the regional tectonics, and thus the seismogenic structure still remained debatable.

We combined seismic and geodetic data, along with dynamic modeling to offer a quick first-order constraint. Early aftershock distribution exhibited a high east-dipping angle fault and a rather obscure west-dipping structure further offshore. Coseismic InSAR displacement showed surface deformation gradient going inland south-westerly, suggesting the deformation center should be located offshore. For surface damage mapping, we used the time-series amplitude of SAR radar echo to map out the damaged areas. Results showed damages were distributed in the mountains and urban areas due to the change in surface backscattering property. Since the earthquake very likely happened in the ocean, subsequent seafloor geodetic survey and ocean bottom seismic data would be the key to resolve the complete story of this seismic event.

POSTER 193

Infrasound Observations from April 3rd Taiwan Earthquakes

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In this abstract, we present observations made by two barometers used for infrasound measurements located in Taiwan. One sensor is in the Huisun Forest Recreation Area. The other is located at the horticulture test site of National Chung Hsing University.

Both sensors are separated by roughly 10 kilometers. The first sensor is 74 kilometers away from the epicenter while the second sensor is 65 kilometers away. In addition to the sensors located in Taiwan, a third sensor is located at the University of Massachusetts Amherst, US. This sensor is approximately 12,488 kilometers away from the epicenter.

All three sensors house a Paroscientific broadband barometer, with a range of 620 – 1100 hPa and a precision of ±0.08 hPa. The sensor nodes house a Raspberry Pi and a 5G modem. This setup allows for local processing and archiving and the transmission of the data to an archival and display server that is located at UMass. Data can be retrieved from the server via an API.

Our presentation will delve into the observations made by the three sensors after the Taiwan earthquakes and aftershocks on April 3rd. It will mainly focus on the infrasound signals emitted by the earthquakes, including the 13 and 94 aftershocks greater than M4.5 that occurred within 1 and 24 hours, respectively. We believe that this data is valuable since it provides a different modality in comparison to the data usually provided by seismometers, since the barometers measure the atmospheric pressure change caused by the earthquakes. The ground vibration caused atmospheric pressure changes that lasted more than two minutes. Furthermore, we discovered a direct relationship between the earthquake's magnitude and the magnitude of atmospheric pressure change.

Furthermore, we will make our data available to the broader research community, to allow scientists to use it for their research and analysis.

POSTER 194

Real-time Performance of the SED-ETHZ SeisComP Earthquake Early Warning (ESE) System at CWA During the 3 April 2024 Magnitude 7.4 Earthquake Sequence Near Hualien City, Taiwan.

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Since mid-2023, the Central Weather Administration Seismographic Network (CWASN) and Taiwan Strong Motion Instrumentation Program network (TSMIP) have been testing the ESE Earthquake Early Warning (EEW) system nationwide across Taiwan. ESE provides access to the (point source) Virtual Seismologist and (extended source) FinDer EEW algorithms through the popular SeisComP seismic data processing software platform. ESE is currently used in the operational EEW systems across Central America, and in test systems in other countries, including Switzerland, New Zealand, and Italy.

The CWASN and TSMIP also operate the public national EEW system for Taiwan. During the recent M7.4 3 April 2024 earthquake near Hualien city, this system successfully distributed alerts nationwide via channels including the Public Warning System (PWS), television broadcasts, and the internet. The ESE system was also running in real-time during the event for internal testing. In this contribution, we compare the performance of the public system with ESE, which was accessing the same network data. In particular, we focus on FinDer's ability to provide rapid information on the source extent, which would have important consequences on estimating ground motions across Taiwan, improving the performance of an EEW system.

POSTER 195

Hualien, Taiwan Tsunami: Observation and Modeling

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The April 2, 2024, Hualien, Taiwan tsunami was generated by a strong Mw 7.4 earthquake that occurred in a zone of tectonic transition from eastward-oriented subduction of the Eurasia plate to westward-oriented subduction of the Philippine Sea plate in the West Pacific (23.819°N 121.562°E). The tsunami was detected at the DART 4G 52404 station, located approximately 1,200 km southeast of the epicenter, 1 hour and 15 minutes after the earthquake, with a maximum wave amplitude in deep water just above 1 cm. The tsunami was recorded at many coastal sea-level stations around the world. The largest coastal tsunami amplitude, approximately ~72 cm, preceded by a ~1.3 m depression, was measured at the Hualien, Taiwan tide station 30 minutes after the earthquake. According to the National Centers for Environmental Information, it was the largest tsunami ever recorded by tide gauges in Taiwan. We present preliminary tsunami modeling analysis, providing qualitative and quantitative information about the tsunami, including its interaction with ocean floor bathymetric features and neighboring coastlines.

POSTER 196

New Active Fault Map of Offshore Eastern Taiwan and the 3 April 2024 Taiwan Hualien Earthquake Sequence

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We present a new seafloor active fault map of offshore eastern Taiwan including the region of the 3 April 2024 NE Taiwan Hualien earthquake based on multi-channel seismic reflection profiles and detailed bathymetry. This area is the juncture of the Ryukyu and Luzon Manila Trench subduction systems with a convergence between the Eurasian and Philippine Sea plates of ~90mm/y. An active fault map is an essential element for assessing hazards of strong ground motion and improving earthquake early warning. We reprocess larger-offset legacy seismic reflection data using Aspentech-Paradigm Echos and GeoDepth software to obtain prestack depth-migrated profiles that better image offshore structure, which we integrate with seismicity, local tomography and onshore geology (Suppe et al, this meeting). The 3 April 2024 M~7.4 Taiwan Hualien earthquake mainshock took place on the steeply east-dipping Luzon forearc subduction interface whereas largest slip took place updip on the shallow gently west-dipping Takangkou-High thrust, which extends >110km along strike from Chimei Canyon to the northern limit of 2024 rupture north of Xincheng ridge. The Luzon forearc subduction interface and its updip Longitudinal Valley splay is very active, including the 2003 Chengkung sequence. South of the Coastal range is the Southern Longitudinal Trough, which is a wedge-top basin on the west-dipping Huatung Ridge thrust belt. The Huatung Ridge thrust belt runs through the Luzon arc ridge north of Lutao Island and ends as relay ramps, forming a major segment boundary between the Offshore East Taiwan thrust belt and Longitudinal Valley fault to the north and the Huatung Ridge thrust belt to the south. The Offshore East Taiwan thrust belt is detached from the underlying ~125Ma oceanic crust of the Huatung Basin along the Chimei Canyon thrust detachment (Y-H Hsieh et al. 2020) and carries the Luzon arc in its hanging wall east of the Coast Range, but does not continue east of the Luzon arc farther south (Y-H Hsieh et al. submitted). This detachment is also the floor thust of the western Ryukyu accretionary wedge, illuminated by 2024 aftershocks.

The 5 April 2024 Magnitude 4.8 Tewksbury (Whitehouse Station), New Jersey Earthquake

Oral Session • Friday 3 May • 02:00 PM Pacific

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In a New York Minute: The M4.8 Whitehouse, New Jersey Earthquake and Rapid Insights on the U.S. Geological Survey Response

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On April 5th, 2024, an M4.8 rattled New Jersey, New York and the surrounding population, startling many who had never felt a moderate shaking earthquake in this area. This area, having been recently upgraded in terms of hazard probability in the 2023 U.S. Geological Survey (USGS) Natural Hazard Seismic Model, rarely experiences such widely felt earthquakes, with the last similarly sized earthquake occurring almost two centuries ago. In February 2024 the USGS released a science communication publication entitled "In a New York minute" that outlines the hazard and preparedness information for this area. Given that this earthquake was widely felt by millions of people, interest from various audiences was high. The USGS released a variety of information products following the earthquake, including an aftershock forecast, which are typically released only for M5.0 and above in the United States and associated territories. USGS "Did You Feel It?" (DYFI) received over 183,000 responses for the M4.8 Whitehouse Station, New Jersey earthquake . This is the largest number of responses to DYFI for a single event since the program began in 1999, exceeding the previous record of 131,636 responses for the M5.8 Mineral, Virginia earthquake in 2011. For Friday's earthquake, over 134,000 responses were submitted during the first hour, with the first response coming in only 2 minutes after the origin time. The submission rate peaked at 172 responses in one second. The M3.8 aftershock that followed 7 hours later garnered over 12,500 responses. Combined, the mainshock and aftershock yielded 205,000 responses so far, which is a record for the DYFI system. Compounding the complexity of the communication response regarding this earthquake included alternate theories regarding the relationship with this uncommon earthquake, the M7.4 Taiwan earthquake on April 3rd, and the full solar eclipse on April 8th. This presentation explores early response insights and media response from this uncommon earthquake sequence in a highly populated area and explores early research questions regarding this rare event.

Reactivation of the Flemington Fault by the 2024 Mw4.8 Whitehouse Station Earthquake: Slip Potential of the Southwestern Ramapo Fault System, Central NJ

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The 2024 Mw4.8 Whitehouse Station, NJ earthquake occurred on or near a known NNE-striking strand of the Flemington Fault, the southwestern continuation of the Ramapo fault system. In 1983, two scientific cores were drilled through this strand 1 km from the 2024 epicenter. These indicate a strike/dip (right-handed) of N1–10E/~35° that comports with N11E/45° mainshock and N8E/36° Mw3.7 aftershock focal planes but contrasts with N30–45E/45–55° at other sites along the Ramapo system. Similarly, much of the Ramapo system is reactivated in the modern stress field to accommodate ENE-WSW shortening, yet focal planes differ from the system's overall NE trend, instead striking between NW and NNE. Stress inversions indicate near-horizontal N65E-trending maximum stress and a stress ratio that favors oblique shortening, both similar to the mainshock and aftershock source mechanisms. Fault slip potential modeling delineates several previously mapped fault strands in the epicentral area amenable to reactivation. The ~N10E strand of the Flemington Fault is well oriented with respect to this stress field, while the overall NE trend of the Ramapo system is not. Aftershock epicenters delineate two primary NE trends, separated by an aseismic patch (of Jurassic basalts?). Aftershocks have been restricted to within 6 km of the epicenter and rates have decayed with time^-0.84, consistent with the ≤15 km and time^-0.88 typical of eastern U.S. sequences. However—just as seismicity along the Ramapo system activates favorably oriented NNW-striking (±30°) planes within an overall NE-trending zone that itself is comparatively stable—the NE aftershock alignments may not illuminate the operative fault planes. The Whitehouse Station earthquake reinforces the pattern that modern intraplate seismicity typically exploits fault zones inherited from prior tectonism, but it also demonstrates that the active fault planes may be highly oblique to the overall trend of the reactivated tectonic belt that contains them. Thus, epicentral alignments may not illuminate the causative faults in intraplate settings.

Apparent Stress for the Mw 4.8 Whitehouse Station, NJ Earthquake from Coda Spectral Ratios

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We present stable, coda-derived spectral ratios of the recent Mw 4.8 Whitehouse Station earthquake using local and regional waveform data. The stability of the measurements are unprecedented and show an average corner frequency of 1.1-Hz and an apparent stress of ~1.0 MPa, under a Brune source model assumption. We used the Mw 3.7 aftershock several hours later as the eGf and find that this ratio, up to ~20-Hz, appears self-similar. We compare other events from the east coast and Canada which also exhibit high apparent stress, but in sharp contrast to events from other more active regions which have lower apparent stress and often are non-self-similar.

Rutgers and Yale Rapid Seismic Array Deployment and Contribution to the 2024 Whitehouse Station, NJ, Earthquake Response: Collaborations, Reactions, and Education and Public Outreach

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The 5 April 2024, Mw 4.8 earthquake at Whitehouse Station, NJ, reminded the densely populated Tri-State population that the earth can quake beneath their feet. Teams of seismologists including personnel from the USGS, Lamont-Doherty Earth Observatory, and the University of Texas at Austin deployed rapid response equipment. These stations will provide recordings of the ephemeral near-field aftershocks and ambient noise that provide valuable insight into fault and miscroseismic structure around the epicenter. As part of this cooperative deployment, Rutgers and Yale installed 10 (of the total of ~30) temporary broadband instruments from the EarthScope Consortium's NSF-Funded RAPID instrumentation pool. The stations continue to record the aftershock sequence and are expected to remain in the field for ~2 months, with some planned for ~1 year. The deployment augments the permanent seismic network in the area to improve azimuthal coverage and provide additional near-field observations. In addition, a nodal deployment of 100 instruments is in preparation to further densify the coverage of the area in the close vicinity to the epicenter, with the aim to improve the sensitivity for smaller aftershocks.

Following the earthquake, community outreach has been established with local schools to educate students on the event and the field of Earth Science in general. We plan to work with local school leaders to install affordable seismic equipment (Raspberry Shakes) as teaching aids for students who have now felt an earthquake. Additionally, fast response public outreach by both Rutgers and Yale Universities aided the public by providing critical geologic information to an unsettled public. This contribution summarizes the motivation and goals of the deployment, details of the configurations of the network. We expect the resulting data to be useful for a range of studies including detailing variability in ground motions, determining stress drops and rupture directivity of small events, imaging the fault zone, documenting the evolution of crustal properties within and outside of the fault zone, and others.

A TexNet's Joint Field Deployment in Support of Monitoring the Aftershock Sequence of the M4.8 Earthquake, Whitehouse Station, New Jersey

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On Apr 5th 2024, an M4.8 earthquake and therefore a series of aftershocks occurred near the Whitehouse Station, New Jersey. After the main shock, the Texas Seismological Network and seismology research team (TexNet) at the University of Texas at Austin has joined an effort to collaboratively monitor the aftershock sequence. This collaboration campaign includes efforts from the Lamont-Doherty Earth Observatory of Columbia University, the United States Geological Survey, Rutgers University, as well as TexNet. In this campaign, TexNet has installed 6 monitoring stations (network code: 4N; station names are NJ10 through NJ15) to fill in the monitoring gap existing in the current station distribution of a local seismic network. Each station is equipped with a 3-component seismometer and records at high sample rates (either 250 sps or 100 sps). Additionally, at station 4N.NJ15, we deployed an accelerometer which is almost on top of the reported hypocenter of the M4.8 mainshock. An accelerometer at this site allows for recording of strong motion in a close proximity to the main rupture zone. Data are provided to the public and research organizations 24/7 through the TexNet data hub at the University of Texas at Austin. In addition to deploying seismic stations, TexNet plans to perform data analysis to understand the seismicity evolution, rupture geometry and its association with nearby faults, providing more insight into the seismogenic characteristics of the faulting process.

The April 5th, 2024, M4.8 New Jersey Earthquake: Overview, USGS Response, and Collaborative Efforts

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On April 5th, 2024, at 10:23 am local time, a magnitude 4.8 earthquake struck Whitehouse Station, NJ, about 65 km west of New York City. Millions of people from Florida to Maine felt the ground shaking, resulting in the largest number (> 180,000) of U.S. Geological Survey (USGS) "DYFI?" reports of any earthquake. A National Institute of Standards and Technology (NIST)/Geotechnical Extreme Events Reconnaissance (GEER) team visited the area and found minor damage to some structures and significant damage to a historic stone building in Lebanon, NJ. There were many reports of non-structural damage, such as objects falling from shelves. The USGS National Earthquake Information Center (NEIC) reports a hypocentral depth of 4.7 km, slightly above the moment tensor solution depth at 7 km. There is no detectable surface deformation in InSAR (Interferometric Synthetic Aperture Radar) observations, which is consistent with the depth range of the earthquake by the NEIC. The focal mechanism solution is strike-slip with a strong thrust component. There is a north–south striking nodal plane dipping to the east, and a northwest–southeast striking plane dipping steeply to the southwest. Neither of these planes is parallel to mapped faults in the region, including the Ramapo, Hopewell, Flemington, or Tewksbury faults. Relocated aftershocks are more consistent with rupture on the north–south striking plane and lie between the Tewksbury and Flemington faults. The geophysical community, including researchers from the USGS, TexNet at the University of Texas at Austin, Lamont Doherty Earth Observatory at Columbia University, Rutgers University, and Yale University, quickly deployed temporary seismic stations in the epicentral area, twenty as of April 18th. Much of this data is being telemetered, and the NEIC is presently using the USGS instruments to locate and report on aftershocks. As of Friday, April 12th, the USGS aftershock forecast reported a 20% chance of an M3 or greater earthquake in the next month, implying that in that time the aftershock deployments may record about 200 M0 or larger earthquakes.

The April 5, 2024 Mw4.8 New Jersey Earthquake: A Need for Regional Seismic Network Operation to Characterize Complex Fault Activation in Intra-plate Settings

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On Friday, April 5, 2024, at 10:23 AM, a MW4.8 earthquake occurred near Whitehouse Station, New Jersey. It was the largest earthquake known to occur within 50 miles of New York City since 1884. The earthquake caused shaking throughout the NY metropolitan region and a record number of felt reports, but surprisingly little damage. The mainshock occurred near the Ramapo Fault, a prominent but misoriented fault zone that runs in a northeast direction sub-parallel to the coastline through Pennsylvania, New Jersey, and New York. Moment tensor solutions for the mainshock and the MW3.7 aftershock 7.5 hours later indicate strike-slip faulting with a substantial thrust component on nodal planes striking NNE or ESE. This is at odds with the general trend of the Ramapo Fault in that area. The four closest operating seismic stations were ~75 km from the mainshock. Three belonged to the regional Lamont Cooperative Seismic Network (LCSN) and one to the Pennsylvania Seismic Network. Two LCSN stations within 10 and 35 km from the mainshock were not operating at the time but have since been revived. Hundreds of more distant stations, including those from other regional networks and the U.S. and Canadian national networks, recorded the mainshock and subsequent aftershocks. Due to the sparse station coverage the early aftershock locations lacked the resolution necessary to determine the causative faults. On April 6th, Lamont began deploying temporary seismometers within 10 km of the mainshock. On the 9th, the USGS, followed by the University of Texas, Rutgers University, and Yale University began installing additional stations. A preliminary analysis of some of the continuous waveform data suggests a complex faulting pattern, with (possibly subparallel) faults roughly trending NNE at a high angle to the Ramapo Fault and dipping ESE towards the Newark Basin. The new data are expected to shed light on the role of the prominent Ramapo fault system and other border faults further northeast and southwest along the Grenville Highlands and the Newark Basin-Manhattan Prong, and the hazard and risk these intra-plate faults pose.

The 5 April 2024 Magnitude 4.8 Tewksbury (Whitehouse Station), New Jersey Earthquake

Poster Session • Friday 3 May

Conveners: Alexandros Savvaidis, University of Texas, Austin (alexandros.savvaidis@beg.utexas.edu); Felix Waldhauser, Lamont-Doherty Earth Observatory, Columbia University (felixw@ldeo.columbia.edu)

POSTER 197

TransmaxNET: Detecting P-Wave Arrivals and Predicting Earthquake Parameters for the 5 April 2024 Magnitude 4.8 Whitehouse Station, New Jersey Earthquake

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We present TransmaxNET, a novel deep learning framework for detecting P-wave arrivals from seismic noise 5 seconds prior to the arrival of P-waves and predicting Peak Ground Acceleration (PGA) and Peak Ground Velocity

(PGV) of earthquakes. TransmaxNET is a transformer neural network augmented with fully connected and softmax layers, trained on 29,000 records of 81 events from the New NGA-East Ground Motion Database.

We evaluate the performance of TransmaxNET using the April 5, 2024 magnitude 4.8 earthquake near Whitehouse Station, New Jersey, as part of the test data. TransmaxNET achieves an F1 score of 96% on unseen test data for P-wave arrival detection. Additionally, a version of TransmaxNET without the softmax layer, called TransNET, is used to predict PGA and PGV, resulting in coefficient of determination values of 0.78 and 0.83, respectively.

These results demonstrate the effectiveness of our deep learning approach in accurately detecting P-waves and predicting PGA and PGV from ground recordings preceding P-wave arrival, which can aid in early warning systems and seismic hazard assessment. The inclusion of the Whitehouse Station earthquake in our test data further validates the model's performance in real-world seismic events.

POSTER 198

Coupling of Brittle Crustal Fabrics and Seismic Anisotropy Near the 2024 Mw4.8 New Jersey Earthquake

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The recent Mw4.8 New Jersey Earthquake ruptured a basement-rooted fault at ~4.7 km depth near the ~300-km long ENE-to-NE-trending Ramapo border fault system of the Newark Basin. This event represents one of the largest earthquakes in the region since the 1884 Mw5.3 New York earthquake and adds to the growing number of Mw<5 events, most of which appear to cluster within 15 km of the Ramapo Fault trace. However, all these events commonly ruptured fault planes oriented at high angles to the Ramapo Fault system and intra-rift faults. Although the Mw4.8 earthquake was an oblique strike-slip event, previously recorded events show thrust faulting kinematics, documenting a compressive stress regime with ENE-WSW-to-NE-SW-oriented SHmax. The Ramapo Fault and its sub-parallel intra-rift faults are misoriented for reactivation in the current stress state, highlighting the need to understand the structure and geomechanical characteristics of secondary basement-hosted brittle faults in the region. We present preliminary results from field geological mapping of ancient slip surfaces and fracture networks, crustal shear wave splitting analysis, frictional stability experiments on basement fault rocks, and Coulomb stress change analysis of the earthquake sequence. Field mapping reveals prominent NNE, NNW, and ~E-W -trending slip surfaces within 3 km of the epicenter area, which changes to dominantly NE, WNW, and NNW trends at greater distances from the epicenter. Fast polarization directions from shear wave splitting measurements near the mainshock are dominantly N-S and WNW but transition to NE at farther distances along the Ramapo Fault Zone. Our Coulomb stress change analysis shows that failure on an NNE-trending fault and aftershocks on N-to-NNE-trending surfaces are most compatible with the aftershock distribution. These results highlight that although the Ramapo Fault Zone may represent a mechanical weakness and topographic anomaly that localizes regional tectonic strain, the secondary pre-existing faults oriented at high-angles to it are most critically-oriented for unstable frictional failure in the modern stress state.

POSTER 199

U.S. Geological Survey Aftershock Response for the M4.8 Whitehouse Station, New Jersey Earthquake

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The U.S. Geological Survey (USGS) routinely deploys temporary seismic monitoring stations after moderate to large earthquakes to record information about the aftershock sequence. These stations allow smaller aftershocks to be detected and improve azimuthal coverage and depth constraints. Often these deployments are based on targeted scientific objectives or unique seismic events that could help improve our understanding of earthquake processes to ultimately mitigate loss of life and property. The M4.8 Whitehouse Station, New Jersey, earthquake on April 5, 2024, provided the USGS a chance to respond to an uncommon "non-plate boundary" earthquake in the eastern U.S.

Following this earthquake, the Albuquerque Seismological Laboratory (ASL) deployed five aftershock stations within 20 km of the mainshock on three sites used by the USGS New Jersey Water Science Center and two privately owned sites. These aftershock stations provide near real-time broadband and strong motion data which is publicly available through EarthScope and is being used by the National Earthquake Information Center (NEIC) to locate aftershocks down to ~M4.0. Additional stations were deployed by the Lamont-Doherty Earth Observatory and TexNet. The goal of this presentation is to document how the USGS aftershock deployment contributes to an increased understanding of the aftershock sequence of the Whitehouse Station, NJ, event, as well as investigating ways that the ASL, in collaboration with NEIC, could improve aftershock station deployment strategies to provide the very best data for use by NEIC as well as the greater community. This includes considerations of station locations relative to the mainshock, time from mainshock to first data transmitted, as well as duration of the deployment.

POSTER 200

Rupture Model for the 5 April 2024 New Jersey Earthquake

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The 5 April 2024 earthquake sequence is the largest instrumentally recorded earthquake in New Jersey since early 1900. It presents an unprecedented opportunity to decipher the role of the prominent Ramapo Fault system in the region and other border faults continuing northeast and southwest along Grenville Highlands and Newark Basin-Manhattan Prong. The Mw 4.8 earthquake generated some foreshocks and many aftershocks of considerable size that will help us define the activated seismogenic fault(s). The largest aftershock of Mw 3.7 occurred about 7.5 hours after the mainshock with a similar focal mechanism and within about 3 km. We analyzed waveform data at local and regional distances by employing the empirical Green's function method in which source characteristics of the mainshock are retrieved by deconvolution of a smaller event. We obtained relative source time functions (RSTFs) of the target mainshock at stations in various azimuths. The RSTFs indicated that stations in the east-northeast (~75°) direction have a shorter duration with a strong amplitude, whereas stations in the west-southwest show a broader duration and weaker amplitudes. This trend is well correlated with corner frequency variation in spectral ratio, which shows higher and lower corner frequencies in the east-northeast and west-southwest directions, respectively. It suggests that mainshock rupture propagated toward the east-northeast direction along the nodal plane dipping to the east (downdip) or southwest (updip). In addition, we investigated the azimuthal variation of directivity parameters of the Mw 3.7 event in both time and frequency domains, which shows similar directivity with the mainshock.

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