Improving the Crustal and Upper Mantle Velocity Model and Seismic Event Location Accuracy in Jordan through Integrated Analysis of Local, International Monitoring System and Non-International Monitoring System Data

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INTRODUCTION AND MAIN RESULTS

This study aims to improve the understanding of Jordan's crustal and upper mantle structure by refining local and regional velocity models. Building on previous research, seismic data from Jordanian, IMS, and non-IMS stations were integrated and analyzed using the NDC-in-a-Box software. Selected seismic events from SEL3 and the Revised Event Bulletin were re-evaluated with multiple velocity models (e.g., El-Isa, 1987; IASPI) to assess their effectiveness in enhancing event localization.

As a results The integration of local, IMS, and non-IMS seismic data improved the accuracy of seismic event locations and refined the local velocity model for Jordan. These improvements strengthen seismic monitoring capabilities, support seismic hazard assessment, and enhance the reliability of monitoring and verification processes. The outcomes contribute to advancing the CTBTO's objectives and reinforce global peace and security.

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Introduction

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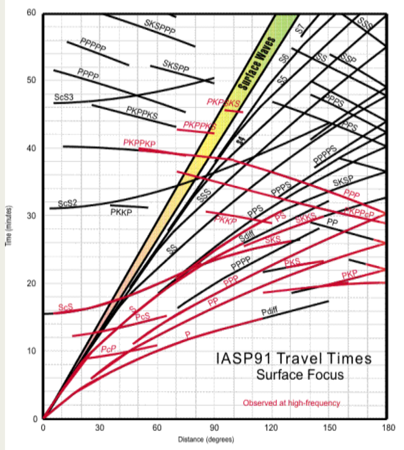
Seismic travel time models are essential tools in seismology, providing critical information for locating the origin of seismic events. These models describe the time it takes for seismic waves to travel from the source to various recording stations.



Accurate travel time models are necessary for determining the location, depth, and magnitude of seismic events, which are vital for understanding earthquake dynamics, assessing seismic hazards, and implementing risk mitigation strategies.

Jordan Velocity-Depth Model

The velocity-depth model used for earthquake hypocenter location is based on deep seismic refraction data from a survey done in Jordan (El-Isa et al., 1987). The survey shows a typical continental type of crust with a thickness of about 32 km in Aqaba (southwest part) region and increases to 35 km in Amman region, and about 37 km in the northeast of Jordan.

The crust, underlain by mantle with a P-velocity of 8.0 to 8.2 km/sec, has a north-south profile west of Amman showing:

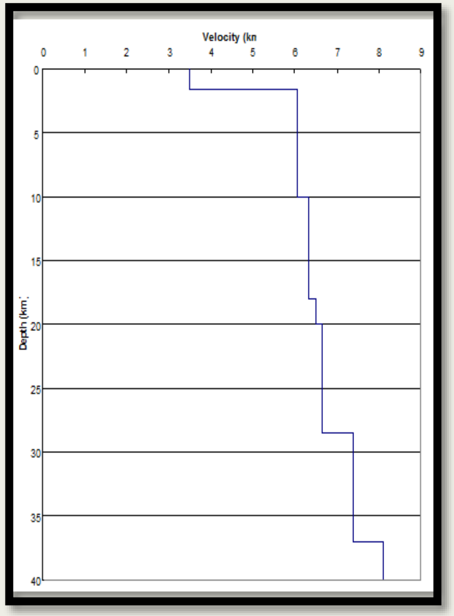
Upper sedimentary layer: P-velocity of 3.5 km/sec

Upper crustal layer: Extends to 18 km depth with a velocity of 6.05-6.55 km/sec

Intracrustal zone (18-20 km): Velocity increases to 6.65 km/sec

Lower crust: Constant velocity of 6.75 km/sec

Transition zone (5.0 km): Velocity increases to 7.38 km/sec



Methods and data

- GT5 or GT20 methods use high-quality seismic event data, ensuring epicenter accuracy within 5 km or with 95% or 90% confidence.
- GT methods: Provides reliable seismic event localization, crucial for understanding seismic hazards and improving earthquake response.

Global GT Criteria (Bondár *et al.*, 2004)

Network	Distance Range (degrees)	Primary Azimuthal Gap	Secondary Azimuthal Gap	Number of Stations within Specified Distance: Between 250 km and 1000 km	<250 km	<30 km	GT level
Local	0°–2.5°	110°	160°	—	10	1	$GT5_{95\%}$
Near Regional	2.5°–10°	—	120°	10	—	—	$GT20_{90\%}$
Teleseismic	28°–91°	—	120°	—	—	—	$GT25_{90\%}$

Data

Date	Time	Lat	Long	Depth	Magnitude	Region
02 June 2025	23:17:27	36.650	28.250	69	5.8	DODECANESE ISLANDS-TURKEY BORDER
22 May 2025	3:19:34	35.72	25.91	53	6.2	CRETE, GREECE
13 May 2025	22:51:13	35.18	27.003	54	6.0	DODECANESE ISLANDS, GREECE

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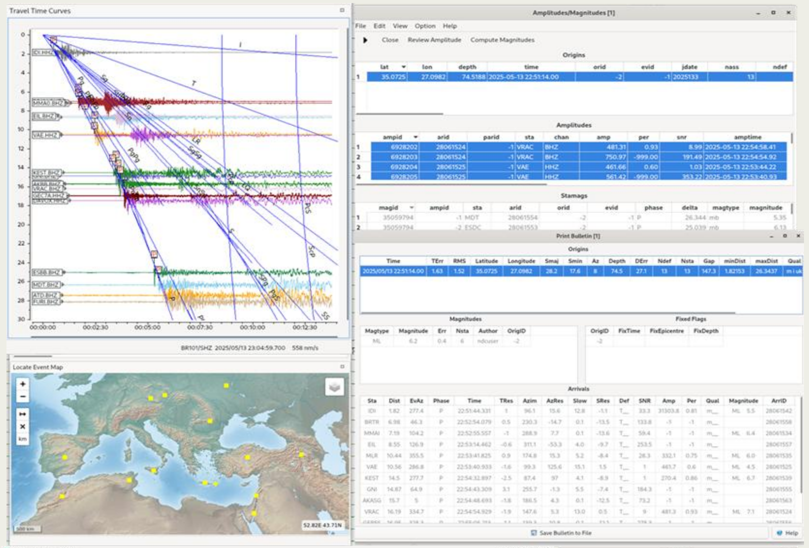
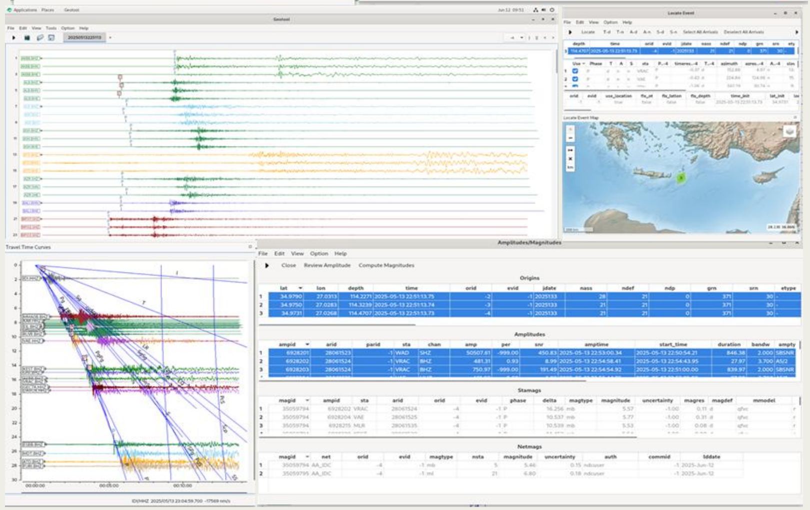
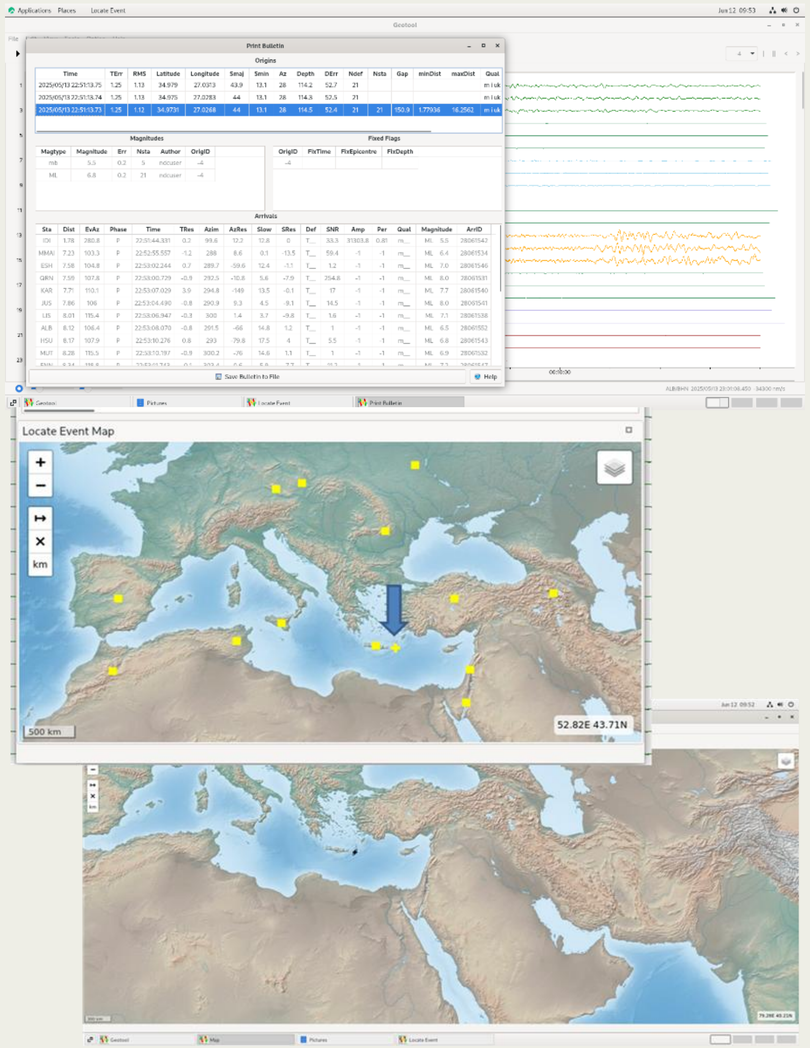
DODECANESE ISLANDS, GREECE



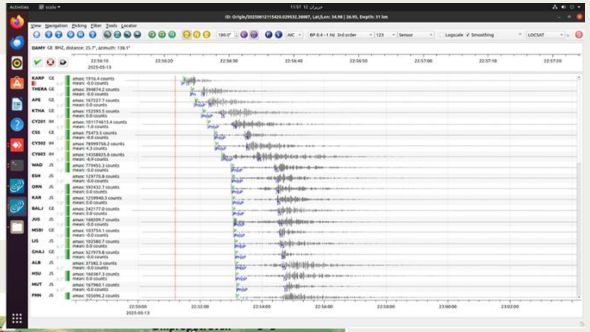


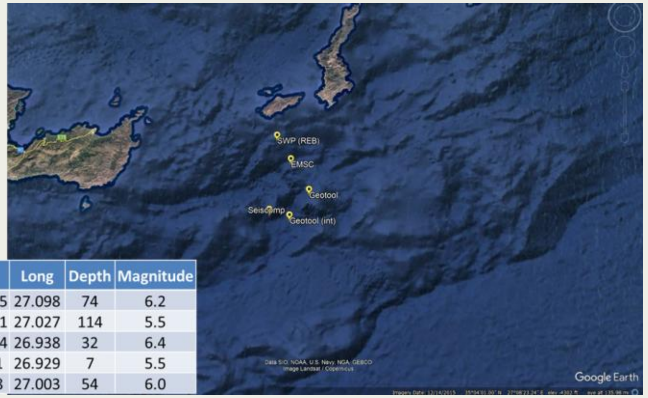
DODECANESE ISLANDS, GREECE



DODECANESE ISLANDS, GREECE

Time: 2025-05-13 22:51:11
Depth: 32 km +/- 6 km
Lat: 34.98 °N +/- 4 km
Lon: 26.93 °E +/- 3 km
Phases: 53 / 53
RMS Res.: 1.2 s
Az. Gap: 53 °
Min. Dist.: 0.6 °





	Lat	Long	Depth	Magnitude
Geotool	35.0725	27.098	74	6.2
Geotool (int)	34.9731	27.027	114	5.5
Seiscomp	34.9854	26.938	32	6.4
SWP (REB)	35.261	26.929	7	5.5
EMSC	35.178	27.003	54	6.0

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SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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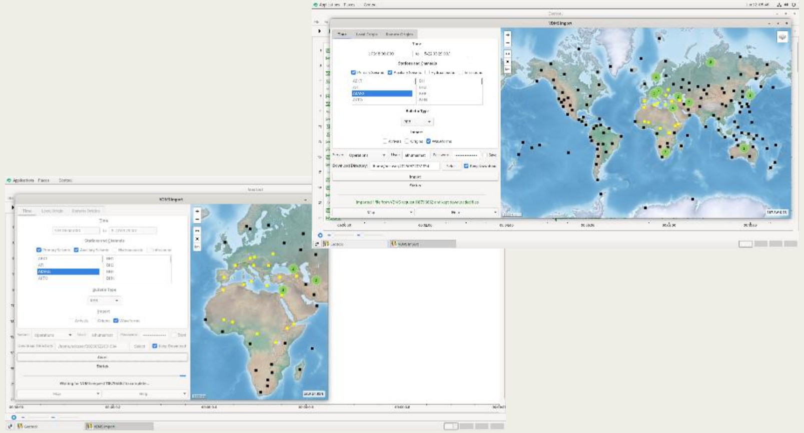
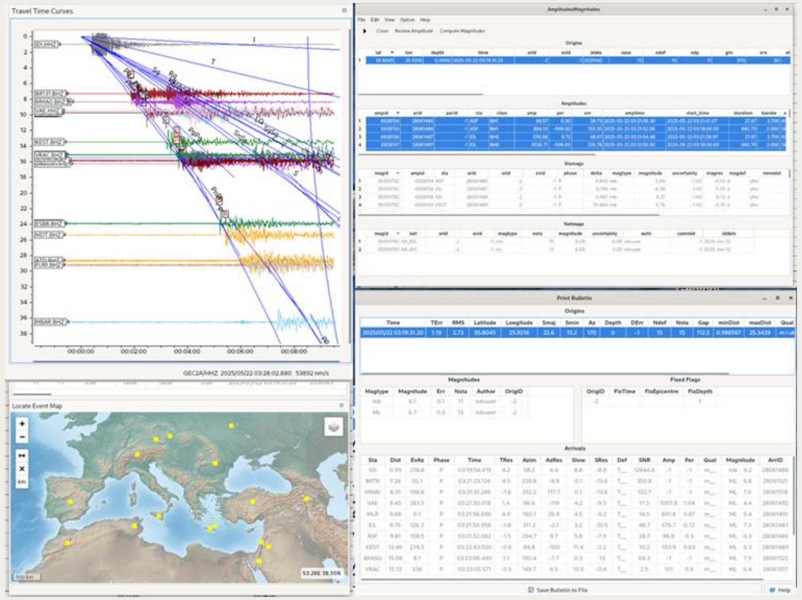
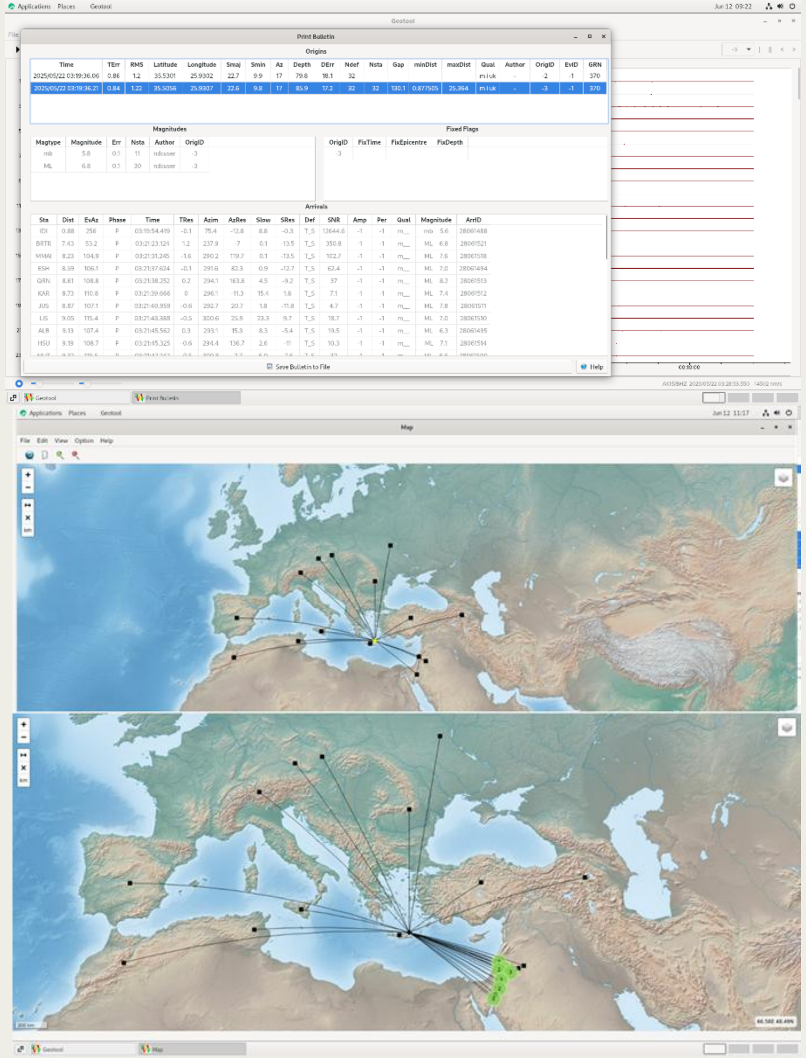
CRETE, GREECE

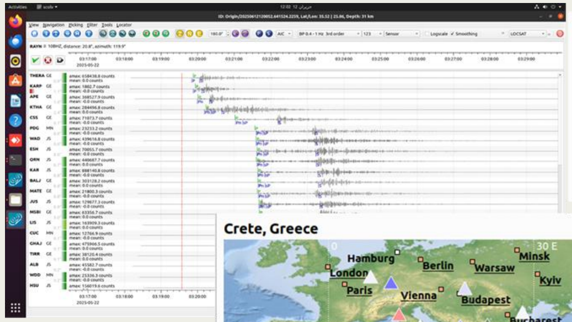




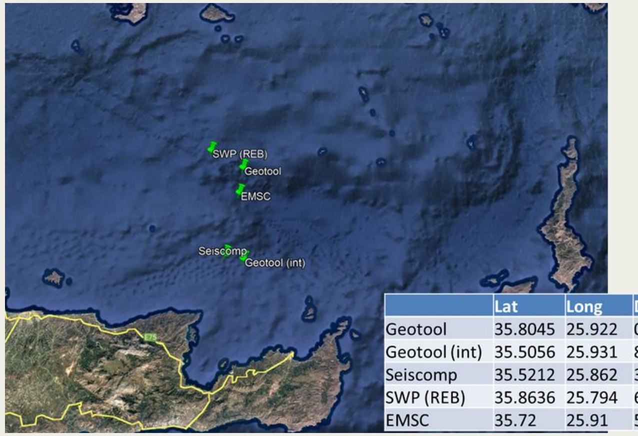
CRETE, GREECE



CRETE, GREECE



Time:	2025-05-22 03:19:33			
Depth:	31 km	+/- 6 km		
Lat:	35.52 °N	+/- 4 km		
Lon:	25.86 °E	+/- 3 km		
Phases:	49 / 49			
RMS Res.:	1.3 s			
Az. Gap:	55 °			
Min. Dist.:	0.9 °			



	Lat	Long	Depth	Magnitude
Geotool	35.8045	25.922	0	6.1
Geotool (int)	35.5056	25.931	85.9	5.8
Seiscomp	35.5212	25.862	31	6.5
SWP (REB)	35.8636	25.794	67	5.8
EMSC	35.72	25.91	53	6.2

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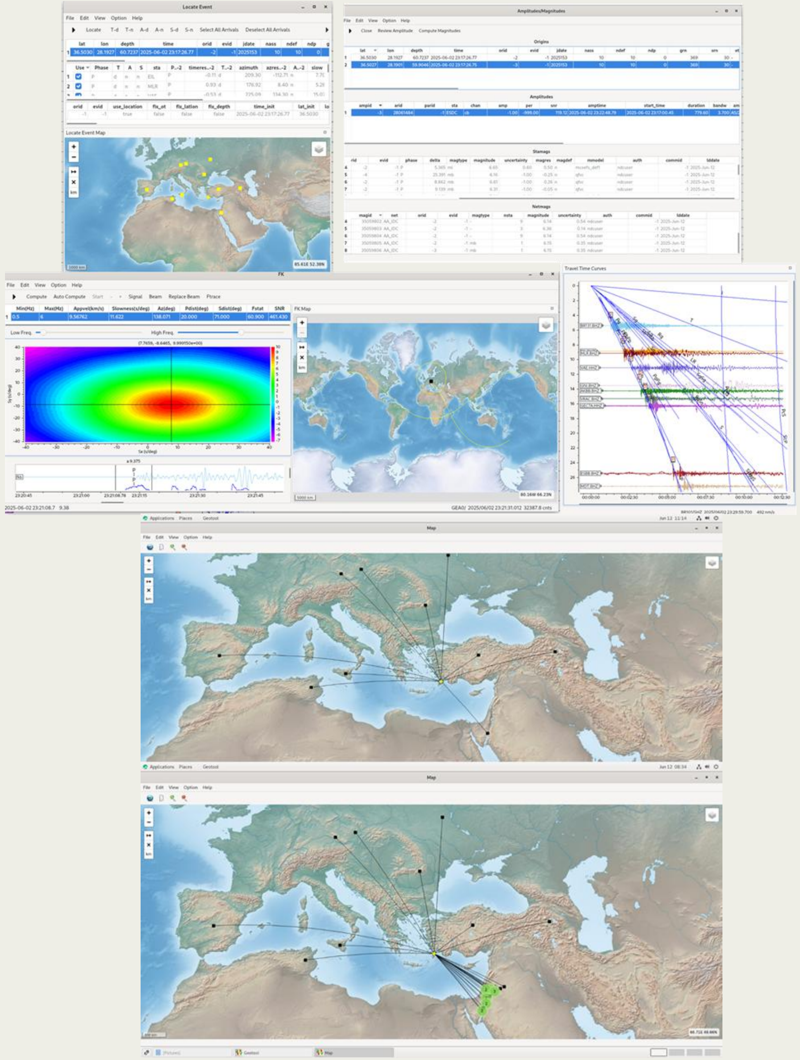
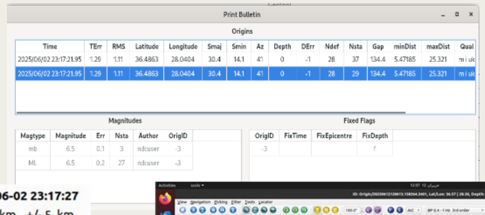
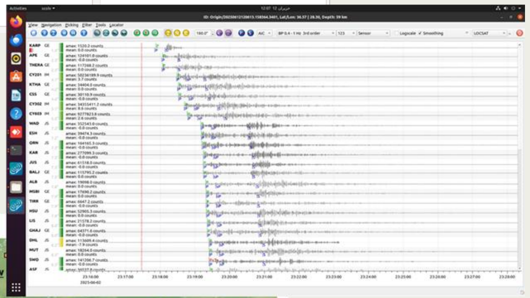
DODECANESE ISLANDS-TURKEY BORDER

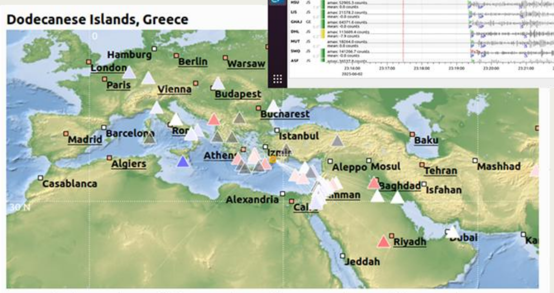


DODECANESE ISLANDS-TURKEY BORDER

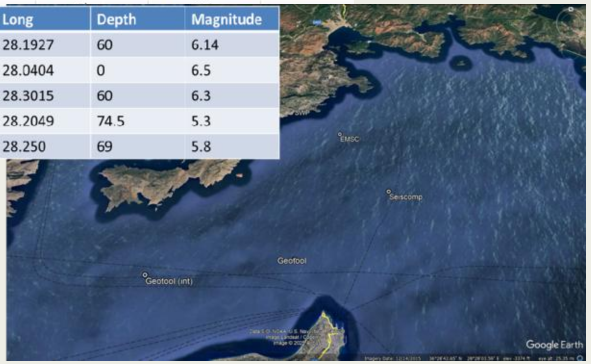


Time:	2025-06-02 23:17:27		
Depth:	60 km	+/- 5 km	
Lat:	36.57 °N	+/- 4 km	
Lon:	28.30 °E	+/- 2 km	
Phases:	50 / 53		
RMS Res.:	0.9 s		
Az. Gap:	83 °		
Min. Dist.:	1.4 °		





	Lat	Long	Depth	Magnitude
Geotool	36.5030	28.1927	60	6.14
Geotool (int)	36.4863	28.0404	0	6.5
Seiscomp	36.5742	28.3015	60	6.3
SWP	36.6838	28.2049	74.5	5.3
EMSC	36.650	28.250	69	5.8



CONCLUSION

- Seismic travel time models are vital for accurately locating seismic events, understanding earthquake dynamics, and assessing seismic hazards.
- The velocity-depth model for earthquake hypocenter location in Jordan, based on deep seismic refraction data, indicates a typical continental crust with varying thicknesses and distinct velocity layers, crucial for accurate seismic analysis.
- The seismic activity in Jordan, particularly along the Dead Sea Transform Fault, has been studied and monitored using the Jordan Seismological Network.
- Integration of IMS and NON-IMS data plays a crucial role in validating velocity models and improving location accuracy.
- Improvements in location accuracy for seismic (GT5) events, which provide epicenter accuracy within 5 km with 95% confidence, further advance our understanding of seismic activity in Jordan.

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