



## BÖLÜM 8

# İZMİR KÖRFEZİNDE TSUNAMİ HAREKETİNİN BİR SİSMİK SENARYO İÇİN SAYISAL MODELLEMESİ

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### 8.1. GİRİŞ

Deniz tabanında meydana gelen deformasyonlar tarafından tetiklenen tsunamiler, denize kıyısı olan birçok ülkede büyük can ve mal kayıplarına yol açmıştır. Bilinen en fazla can kaybı, küresel ölçekte farklı kıtalarda tsunamiye neden olan 26 Aralık 2004 (Mw9.3) Banda Aceh-Endonezya depreminde yaşanmıştır ve bu olayda toplamda 330.000 kişi yaşamını yitirmiştir (Lay ve diğ. 2005). Bölgede yürütülen paleotsunami araştırmalarında, bölgenin uzun bir tsunami geçmişi olduğu, bu denli büyük depremlere bağlı tsunamilerde benzer sedimantolojik çökel birikiminin en son 550-700 yıl önce yaşandığı, en eskisinin tarihinin ise günümüzden 2800 yıl öncesine dayandığı tespit edilmiştir (Şekil 88).

Tsunami olayları arasında önemli sayıdaki can kayıpları 28 Aralık 1908 (Mw7.1) Messina-İtalya (123.000 kişi, Pino ve diğ. 2009) ve 1 Kasım 1755 Lizbon (100.000 kişi, Blanc 2009) depremlerinde yaşanmıştır. Bunların dışında 30.000

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düzeyi (STK'ların da dâhil olduđu) farklı sosyal etkinliklerle bilgilendirilmeli, farkındalık oluşturulmalıdır.

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## KAYNAKLAR

- Adriano B., Fujii Y., Koshimura S., 2018. Tsunami source and inundation features around Sendai Coast, Japan, due to the 22 November 2016 (Mw6.9) Fukushima earthquake, *Geoscience Letters* 5(1), 2
- Alpar B., Dođan E., Yüce H., Altınok H., 2000. Sea level changes along the Turkish coasts of the Black Sea, the Aegean Sea and the Eastern Mediterranean, *Mediterranean Marine Science* 1(1), 141-156
- Altınok Y., Alpar B., Ersoy S., Yalçınar A., 1999. Tsunami generation of the Kocaeli earthquake (August 17th, 1999) in Izmit Bay: coastal observations, bathymetry and seismic data, *Turkish Journal of Marine Science* 5, 131-148
- Altınok Y., Ersoy S., 2000. Tsunamis Observed on and Near the Turkish Coast, *Natural Hazards* 21, 185-205
- Altınok Y., Tinti S., Alpar B., Yalçınar A.C., Ersoy S., Bortolucci E., Armigliato A., 2001. The tsunami of August 17, 1999 in İzmit Bay, Turkey, *Natural Hazards* 24, 133-146
- Altınok Y., Alpar B., Özer N., Gaziođlu C., 2005. 1881 and 1949 earthquakes at the Chios-Cesme Strait (Aegean Sea) and their relation to tsunamis, *Natural Hazards and Earth System Sciences* 5, 717-725
- Altınok Y., Alpar B., Özer N., Vardar H., 2011. Revision of the tsunami catalogue affecting Turkish coasts and surrounding regions, *Natural Hazards and Earth System Sciences* 11(2), 273-291
- Altınok Y., Alpar B., Yalçınar C., Pınar A., Özer N., 2012. The earthquakes and related tsunamis of October 6, 1944 and March 7, 1867; NE Aegean Sea, *Nat Hazards* 60, 3-25
- Ambraseys N.N., 1962. Data for the investigation of the seismic sea-waves in the Eastern Mediterranean, *Bulletin of the Seismological Society of America* 52(4), 895-913
- Ambraseys N., Synolakis C., 2010. Tsunami catalogs for the Eastern Mediterranean, revisited, *Journal of Earthquake Engineering* 14(3), 309-330
- Arikawa T., Güler H.G., Yalçınar A.C., 2017. Comparison of human response against earthquake and tsunami, *American Geophysical Union Fall Meeting 2017*, December 11-15, 2017, New Orleans, USA, Eriřim adresi: AGU-2017
- Aytore B., Yalçınar A.C., Zaytsev A., Çankaya Z.C., Süzen M.L., 2016. Assessment of tsunami resilience of Haydarpařa Port in the Sea of Marmara by high-resolution numerical modeling, *Earth, Planets and Space* 68(1), 139
- Blanc P.L., 2009. November 1, 1755 Lisbonne earthquake and tsunami: a different reading of con-

- temporaneous documentary sources, *Natural Hazards and Earth System Sciences* 9, 725-738
- Christine C., Lafemina P.C., Christine P., Daisuke K., 2012. The 1707 Mw8.7 Hoi earthquake triggered the largest historical eruption of Mt. Fuji, *Geophysical Research Letters* 39(24)
- Coşkun S., Dondurur D., Çiğçi G., Aydemir A., Drahor M.G., 2016. Natural and anthropogenic submarine morphologies revealed by high resolution acoustic data in the Gulf of Izmir, western Turkey, *Marine and Petroleum Geology* 71, 211-224
- Cowan H., Beattie G., Hill, K. ve diğ., 2011. The M8.8 Chile Earthquake 27 February 2010, *Bulletin of the New Zealand Society for Earthquake Engineering* 44(3), 124-166
- Çankaya Z.C., Süzen M.L., Yalçın A. C., Kolat C., Zaytsev A., Aytore B., 2016. A new GIS-based tsunami risk evaluation: MeTHuVA (METU tsunami human vulnerability assessment) at Yenikapı, Istanbul, *Earth, Planets and Space* 68(1), 133
- DEÜ, 2017. 12 Haziran 2017, 15:28) Mw=6.2 Izmir Karaburun, Ege Denizi) Depremi Değerlendirme Raporu, Dokuz Eylül Üniversitesi Mühendislik Fakültesi Jeofizik Mühendisliği Bölümü Sismoloji Anabilim Dalı, İzmir, 25s. Erişim adresi: DEÜ Jeofizik
- Dilmen D.I., Kemec S., Yalçın A.C., Düzgün S., Zaytsev A., 2015. Development of a Tsunami Inundation Map in Detecting Tsunami Risk in Gulf of Fethiye, Turkey, *Pure and Applied Geophysics* 172(3-4), 921-929
- Doğan G.G., Yalçın A.C., Kılıç N., Yüçemen S., 2018. Tsunami Hazard Assessment for Izmir Bay, Turkey, 16th European Conference on Earthquake Engineering, 18-21 June 2018, Thessaloniki, Greece, Erişim adresi: 16th ECEE
- Doğan G.G., Annunziato A., Papadopoulos G.A., Güler H., Yalçın A.C., Çakır T., Sözdinler C., Ulutaş E., Arikawa T., Süzen M.L., Güler I., Probst P., Kanoğlu U., Synolakis C., 2019. The 20th July 2017, Mw = 6.6) Bodrum-Kos Tsunami Field Survey, *Pure and Applied Geophysics*, 1-25
- Doğan G.G., Annunziato A., Hidayat R., Husrin S., Prasetya G., Kongko W., Zaytsev A., Pelinovsky E., Imamura F., Yalçın A.C., 2021a. Numerical Simulations of December 22, 2018 Anak Krakatau Tsunami and Examination of Possible Submarine Landslide Scenarios, *Pure and Applied Geophysics* 178, 1-20
- Doğan G.G., Yalçın A.C., Yüksel Y., Ulutaş E., Polat O., Güler I., Şahin C., Tarih A., Kanoğlu U., 2021b. The 30 October 2020 Aegean Sea Tsunami: Post-Event Field Survey along Turkish Coast, *Pure and Applied Geophysics* 178, 785-812
- Doğan G.G., Pelinovsky E., Zaytsev A., Metin A.D., Tarakcioğlu G.O., Yalçın A.C. ve diğ., 2021c. Long wave generation and coastal amplification due to propagating atmospheric pressure disturbances, *Natural Hazards* 106(2), 1195-1221
- Dunbar P., Stroker K., McCullough H., 2010. Do the 12 January 2010 Haiti, (Mw7.0) earthquake and tsunami indicate increasing trends, *Geomatics, Natural Hazards and Risk* 1(2), 95-114
- Fujii Y., Satake K., 2013. Slip Distribution and Seismic Moment of the 1960 Chile Earthquakes Inferred from Tsunami Waveforms and Coastal Geodetic Data, *Pure and Applied Geophysics* 170(9), 1493-1509
- Heidarzadeh M., Muhari A., Wijanarto A.B., 2019. Insights on the Source of the 28 September 2018 Sulawesi Earthquake, (Mw7.5) Tsunami, Indonesia Based on Spectral Analyses and Numerical Simulations, *Pure and Applied Geophysics* 176(1), 25-43
- Heidarzadeh M., Satake K., Murotani S., Gusman A.R., Watada, S., 2015. Deep-Water Characteristics of the Trans-Pacific Tsunami from the 1 April 2014, (Mw8.2) Iquique-Chile Earthquake, *Pure and Applied Geophysics* 172(3-4), 719-730
- Jankaew K., Atwater B.F., Sawai Y., Choowong M., Charoentitrat T. Martin M.E., Prendergast A., 2008. Medieval forewarning of the 2004 Indian Ocean tsunami in Thailand, *Nature* 455
- JT, 2022. Japan assesses damage after powerful magnitude 7.4 quake strikes off east coast, *Japan Times*, Japan. Erişim adresi: japantimes
- Kian R., Velioglu D., Yalçın A.C., Zaytsev, A., 2016. Effects of Harbor Shape on the Induced Sedi-

- mentation; L-Type Basin, *Journal of Marine Science and Engineering* 4(3), 55, Eriřim adresi: <http://www.mdpi.com/2077-1312/4/3/55/htm>
- Kuran U., Yalçın A.C., 1993. Crack propagations, earthquakes and tsunamis in the vicinity of Anatolia. (Kitap: *Tsunamis in the World, Advances in natural and technological hazards research*, NTHR, Volume 1, Editör: Tinti S., Springer, NJ, 230 p.), 159-175, Eriřim adresi: 15th International Tsunami Symposium
- Lay T., Kanamori H., Ammon C.J. ve dię., 2005. The great Sumatra-Andaman earthquake, (Mw9.3) of 26 December 2004, *Science*, 308(5725), 1127-1133
- Lay T., Yamazaki Y., Ammon C.J., Cheung K.F., Kanamori H., 2011a. The 11 March 2011, Mw9.0 off the Pacific coast of Tohoku-Oki Earthquake: Comparison of deep-water tsunami signals with finite-fault rupture model predictions, *Earth, Planets and Space* 63 (7), 797-801
- Lay T., Ammon C.J., Kanamori H., Yamazaki Y., Cheung K.F., Hutko A.R., 2011b. The 25 October 2010 Mentawai, Indonesia earthquake, Mw7.8) and the tsunami hazard presented by shallow mega-thrust ruptures, *Geophysical Research Letters* 38(6), L06302
- Lynett P.J., Gately K., Wilson R., Montoya L., Arcas D., Aytore B., Bai Y., Bricker J.D., Castro M.J., Cheung, K.F. David G.C., Dogan G.G., Escalante C., González-Vida J.M., Grilli S.T., Heitmann T.W., Horrillo J., Kanoęlu U., Kian R., Kirby J.T., Li W., Macías J., Nicolsky D.J., Ortega S., Pampell-Manis A., Park Y.S., Roeber V., Sharghivand N., Shelby M., Shi F., Tehranirad B., Tolkova E., Thio H.K., Velioglu D., Yalçın A.C., Yamazaki Y., Zaytsev, A., Zhang Y.J., 2017. Inter-model analysis of tsunami-induced coastal currents, *Ocean Modelling* 114, 14-32
- Mays L.W., 2011. *Water Resources Engineering*, John Wiley & Sons Inc. Publications, New Jersey, USA., 920 p. Eriřim adresi: John Wiley
- Okal E.A., Borrero J.C., Synolakis C.E., 2006. Evaluation of Tsunami Risk from Regional Earthquakes at Arica-Peru, *Bulletin of the Seismological Society of America* 96(5), 1634-1648
- Okal E., Synolakis C.E., Uslu B., Kalligeris N., Voukouvalas E., 2009. The 1956 earthquake and tsunami in Amorgos, Greece, *Geophysical Journal International* 178(3), 1533-1554
- Omira R., Doęan G.G., Hidayat R., Husrin S., Prasetya G., Annunziato A., Proietti C., Probst P., Paparo M.A., Wronna M., Zaytsev A., Pronin A., Giniyatullin A., Putra P.S., Hartanto D., Ginanjar G., Kongko W., Pelinovsky E., Yalçın A.C. 2019. The September 28th, 2018, Tsunami in Palu-Sulawesi, Indonesia: A Post-Event Field Survey, *Pure and Applied Geophysics* 176(1379)
- Papadopoulos G.A., Fokaefs A., 2005. Strong tsunamis in the Mediterranean Sea: A re-evaluation, *ISET Journal of Earthquake Technology* 463, 42(4), 159-170
- Papadopoulos G.A., Minoura K., Imamura F., Kuran U., Yalçın A.C., Fokaefs A., ve dię., 2012. Geological evidence of tsunamis and earthquakes at the eastern Hellenic arc: Correlation with historical seismicity in the eastern Mediterranean Sea, *Research in Geophysics* 2, e12
- Papadopoulos G.A., Gracia E., Urgeles R., Sallares V., De Martini P.M., Pantosti D., Gonzales M., Yalçın A.C. ve dię., 2014. Historical and pre-historical tsunamis in the Mediterranean and its connected seas: Geological signatures, generation mechanisms and coastal impacts, *Marine Geology* 15
- Papadopoulos G.A., Papageorgiou A., 2014. Large earthquakes and tsunamis in the Mediterranean region and its connected seas. (Kitap: *Extreme Natural Hazards, Disaster Risks and Societal Implications*, Editör: Ismail-Zadeh A., Cambridge University Press, UK, 402 p.), 252-266
- Papadopoulos G.A., 2015. *Tsunamis in the European-Mediterranean Region*, Elsevier, Amsterdam, 271 p., ISBN: 978-0-12-420224-5, Eriřim adresi: Elsevier
- Pino N.A., Piatanesi A., Valensise G., Boschi E., 2009. The 28 December 1908 Messina Straits Earthquake, (Mw7.1): A Great Earthquake throughout a Century of Seismology, *Seismological Research Letters* 80(2), 243-259
- Romano F., Molinari I., Lorito S., Piatanesi A., 2015. Source of the 6 February 2013 (Mw8.0) Santa

- Cruz Islands Tsunami, *Natural Hazards and Earth System Sciences* 15(6), 1371-1379
- Rothaus R.M., Reinhardt E., Noller J., 2004. Regional Considerations of Coastline Change, Tsunami Damage and Recovery along the Southern Coast of the Bay of İzmit (The Kocaeli (Turkey) Earthquake of 17 August 1999), *Natural Hazards* 31, 233-252
- Sahal A., Roger J., Allgeyer S., Lemaire B., Hebert H., Schindele F., Lavigne F., 2009. The tsunami triggered by the 21 May 2003, Mw=6.9) Boumerdes-Zemmouri, (Algeria) earthquake: Field investigations on the French Mediterranean coast and tsunami modelling, *Natural Hazards and Earth System Science* 9(6), 1823-1834
- Saito T., Matsuzawa T., Obara K., Baba T., 2010. Dispersive tsunami of the 27 February 2010, (Mw8.8) Maule, Chile, Earthquake recorded by the high-sampling-rate ocean-bottom pressure gauges, *Geophysical Research Letters* 37(23), L23303
- Sheehan A.F., Gusman A.R., Satake K., 2019. Improving Forecast Accuracy with Tsunami Data Assimilation: The 15 July 2009, (Mw7.8) Dusky Sound, New Zealand, Tsunami, *Journal of Geophysical Research: Solid Earth* 124(1), 566-577
- Sorensen M.B., Spada M., Babeyko A., Wiemer S., Grünthal G., 2012. Probabilistic tsunami hazard in the Mediterranean Sea, *Journal of Geophysical Research: Solid Earth* 117(1), B01305
- Sozdinler C.O., Yalçın A.C., Zaytsev A., Suppasri A., Imamura F., 2015. Investigation of Hydrodynamic Parameters and the Effects of Breakwaters During the 2011 Great East Japan Tsunami in Kamaishi Bay, *Pure and Applied Geophysics*, 1-19
- Tanioka Y., Seno T., 2001. Sediment effect on tsunami generation of the 1896 Sanriku tsunami earthquake, *Geophysical Research Letters* 28(17), 3389-3392
- Tanioka Y., Ramirez A.G.C., Yamanaka Y., 2018. Simulation of a Dispersive Tsunami due to the 24 November 2016 El Salvador-Nicaragua Earthquake, (Mw6.9), *Pure and Applied Geophysics* 175(4), 1363-1370
- Triantafyllou I., Papadopoulos G.A., Lekkas E., 2020. Impact on built and natural environment of the strong earthquakes of April 23, 1933, and July 20, 2017, in the southeast Aegean Sea, eastern Mediterranean, *Natural Hazards* 100, 671-695
- Triantafyllou I., Gogou M., Mavroulis S., Lekkas E., Papadopoulos G.A., Thravalos M., 2021. The Tsunami Caused by the 30 October 2020 Samos (Aegean Sea) Mw7.0 Earthquake: Hydrodynamic Features, Source Properties and Impact Assessment from Post-Event Field Survey and Video Records, *J. Mar. Sci. Eng.* 9(68), 1-31
- Tsimplis M.N., 1994. Tidal oscillations in the Aegean and Ionian Seas. *Estuarine, Coastal and Shelf Science* 3, 201-208
- Tüfekçi D.E., Süzen M.L., Yalçın A.C., Zaytsev A., 2018. Revised MeTHuVA method for assessment of tsunami human vulnerability of Bakırköy district, Istanbul, *Nat Hazards* 90, 943-974
- Ulutaş E., İnan A., Annunziato A., 2012. Web-based Tsunami Early Warning System: a case study of the 2010 Kepulauan Mentawai Earthquake and Tsunami, *Natural Hazards and Earth System Science* 12, 1855-1871
- UNESCO IOC, 2014. The UNESCO Intergovernmental Oceanographic Commission International Tsunami Survey Team, ITST) Post-Tsunami Field Survey Guide, 2nd Edition, Belgium, Erişim adresi: UNESCO-IOC.
- Vacchi M., Rovere A., Zouros N., Desruelles S., Caron V., Firpo M., 2012. Spatial distribution of sea-level markers on Lesbos Island (NE Aegean Sea): Evidence of differential relative sea-level changes and the neotectonic implications, *Geomorphology* 159-160, 50-62
- Velioglu D., Kian R., Yalçın A.C., Zaytsev A., 2016. Performance Assessment of NAMI DANCE in Tsunami Evolution and Currents Using a Benchmark Problem, *Journal of Marine Science and Engineering* 4(3), 49, Erişim adresi: <http://www.mdpi.com/2077-1312/4/3/49/htm>
- Vousdoulakos M.I., Velegrakis A.F., Dimou K., Zervakis V., Conley D.C., 2009. Wave run-up observations in microtidal, sediment-barred pocket beaches of the Eastern Mediterranean, *Journal*

of Marine Systems 78, 37-47

- Yalçın A.C., Kuran U., Akıyarl A., Imamura F., 1995. An investigation of the propagation of tsunamis in the Aegean Sea by mathematical modelling. (Kitap: Tsunami: Progress in prediction, disaster prevention and warning, Advances in Natural and Technological Hazards Research, NTHR, vol.4, Editör: Tsuchiya Y., Shuto.N., Springer, NJ, 337 p.), 55-70, Eriřim adresi: Springer
- Yalçın A.C., Gülkan P., Dilmen D.I., Aytore B., Ayça A., İnel I., Zaytsev A., 2014. Evaluation of tsunami scenarios for western Peloponnese, Greece, Bollettino di Geofisica Teorica ed Applicata, 55(2), 485-500
- Yalçın B, Zaytsev A., 2017. Assessment of efficiency and performance of tsunami numerical modeling with GPU, European Geoscience Union (EGU), 23-28 April 2017, Vienna, Austria, Eriřim adresi: EGU-2017.
- Yalçın A.C., Annunziato A., Papadopoulos G., Dođan G.G., Güler H.G., Çakır T.E., Sözdinler C.O. ve diđ., 2017a. The 20th July 2017, 22:31 UTC Bodrum/Kos earthquake and tsunami; post tsunami field survey report, Eriřim adresi: ODTÜ.
- Yalçın B, Zaytsev A, Yalçın A.C., 2017b. Accelerated solutions in tsunami simulation and visualization with case studies, 27th International Tsunami Symposium, 21-25 August 2017, Bali Indonesia, Eriřim adresi: ITS-2017
- Yalçın A.C., Dođan G.G., Ulutař E., Polat O., Tarih A., Yapar E.R., Yavuz E., 2020a. The 30 October 2020 (11:51 UTC) Izmir-Samos Earthquake and Tsunami; Post-Tsunami Field Survey Preliminary Results, Online Report, Middle East Technical University, Department of Civil Engineering, Ocean Engineering Research Center, Turkey, 33p, Eriřim adresi: Google Drive.
- Yalçın A.C., Dođan G.G., Yüksel Y., Ulutař E., Polat O., Güler I., řahin C., Kanođlu U., Tarih A., Yapar E.R., Yavuz E., Süzen M.L., Enginar D.T., Bingöl C., Gözlet S., Güler H.G., Yalçın B., Özacar A.A. 2020b. Tsunami Sonrası Saha Arařtırma Bulguları. (Kitap: 30 Ekim 2020 İzmir-Seferihisar Açıkları (Sisam) Depremi (Mw6.6) Keřif Gözlemleri ve Bulgular Rapor No: ODTÜ/DMAM 2020-03, Editör: Azak S., ODTÜ, Ankara, 58 s.), 15-21. Eriřim adresi: ODTÜ-DMAM
- Yalçın A.C., Süzen M.L., Enginar D.T., Dođan G.G., Çınar G.E., Çelikbař B., Yaman M., Çoban I., Devran A., Yalçın B., Çimen N., Kolat C., 2020c. İstanbul Tsunami Eylem Planı, İstanbul Büyükşehir Belediyesi, Orta Dođu Teknik Üniversitesi Raporu (No: DÖ-SİM-2019-03-03-2-02-101), İstanbul, 334s, Eriřim adresi: İBB İstanbul.
- Zaytsev A., Kostenko I., Kurkin A., Pelinovsky E., Yalçın A.C., 2016. The depth effect of earthquakes on tsunami heights in the Sea of Okhotsk, Turkish Journal of Earth Sciences 25, 289-299