©2018 Published in 2ND International Symposium on
Natural Hazards and Disaster Management 04-06 MAY 2018 (ISHAD2018 Sakarya Turkey)

An Interpolation Applied with Barriers: Modeling to Predictions of Earthquake Occurrences Using Kernel Smoothing and Diffusion Kernel Methods in The Marmara Sea, Turkey

*[1]Tuğba TÜRKER and [2]Yusuf BAYRAK
*[1] *Student. Geophysical Engineering, Karadeniz Technical University, Trabzon*
[2]*Prof. Dr. Geophysical Engineering, Karadeniz Technical University, Trabzon*

Abstract

In this study, interpolation with barriers applied modeling to predictions of earthquake occurrences using Kernel Smoothing and Diffusion Kernel Methods in the Marmara Sea, Turkey. We used the instrumental and historical catalog for all M_s magnitudes. Kernel methods give a systematic and principled approach to training learning and the good generalization performance achieved can be readily justified using statistical learning theory. Kernel Interpolation with Barriers is a moving window predictor that uses the shortest distance between points so that points on either side of the line barriers are connected. Additionally, Kernel interpolation is a variant of a first-order local polynomial interpolation in which instability in the calculations is prevented using a method similar to the one used in the ridge regression to estimate the regression coefficients. So, the bandwidth of the kernel is determined by a rectangle around the observations. We applied two different Kernel Function (Exponential and Gaussian) with this methods. Respectively, we used $e^{-3(\frac{r}{h})}$ and $e^{-3(\frac{r}{h})^2}$ basis formulas in this methods. We are obtained low, medium, high estimations for predictions of earthquake occurrences by taking the faults barrier in each seismogenic source zones. Consequently, we determined an interpolation applied with barriers for making predictions of earthquake occurrences using different Kernel methods in the Marmara Sea. This study, scientists will be benefited to examined of next earthquakes and predictions of earthquake occurrences in Turkey.

Key words: Interpolation with barriers, Kernel Smoothing and Diffusion Kernel Methods, Kernel Function (Exponential and Gaussian), Marmara Sea

1. Introduction

The North Anatolian Fault Zone (NAFZ) was one of the world's most seismically active fault zones. Though the western part of NAFZ has high seismic hazard, because it contained the Marmara Sea and separated 2 or 3 different branches in the Marmara (Zor et al. 2010). It has been formed in neotectonic period starting collision with the Eurasian plate as a consequence of movement toward the north of the Arabian plate in the Eastern Mediterranean (McKenzie 1972; Ketin 1948). Specially, this region observed high magnitudes earthquakes and dead a lot of humans in the past earthquake disasters.

*Corresponding author: Address: Faculty of Engineering, Department of Civil Engineering Sakarya University, 54187, Sakarya TURKEY. E-mail address: caglar@sakarya.edu.tr, Phone: +902642955752

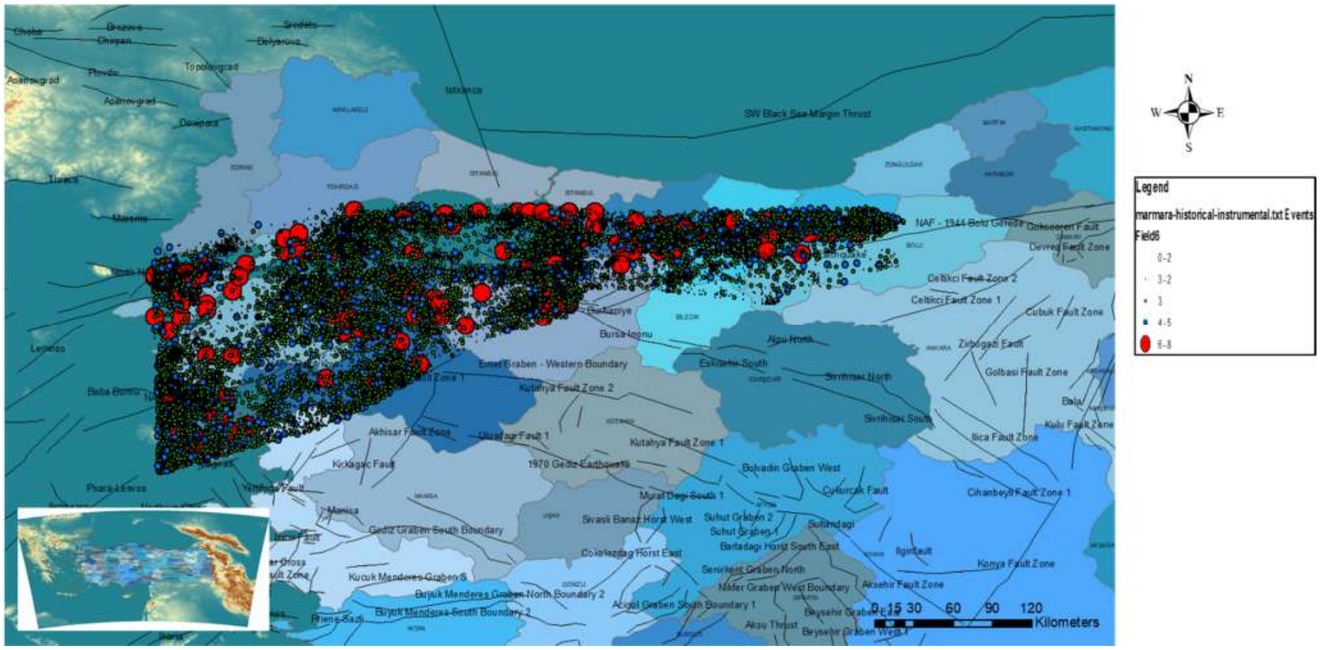

Figure 1. The tectonic and epicenter map plotted for the Marmara Sea.

Kernel methods had a systematic and principled approximation to training learning and the good generalization exhibition reached can be easily bear out using statistical learning theory. Kernel Interpolation with barriers was a moving window predictor and used the shortest distance between points but points on either side of the line barriers were connected. Furthermore, Kernel interpolation was a version of a first-order local polynomial interpolation. It is prevented indecision in the calculations using a method similar to the one used in the back regression to predict the regression coefficients. That's why, the bandwidth of the kernel is determined by a rectangle around the observations.

The kernel function used in the different methods.

- EXPONENTIAL — The function grows or decays proportionally.
- GAUSSIAN — Bell-shaped function that falls off quickly toward plus/minus infinity.
- QUARTIC — Fourth-order polynomial function.
- EPANECHNIKOV — A discontinuous parabolic function.
- POLYNOMIAL5 — Fifth-order polynomial function.

We used the instrumental and historical for all M_s magnitudes in six different seismogenic zones (Saroz Gulf, Marmara Sea, between İzmit-Sakarya, between Sakarya-Düzce, the southern branch of NAFZ, the southern of Marmara) (Fig. 1 and 2). We selected Gaussian and Exponential methods. We applied two methods all database for instrumental and historical period (Fig. 3, 4 5, 6, 7 and 8).

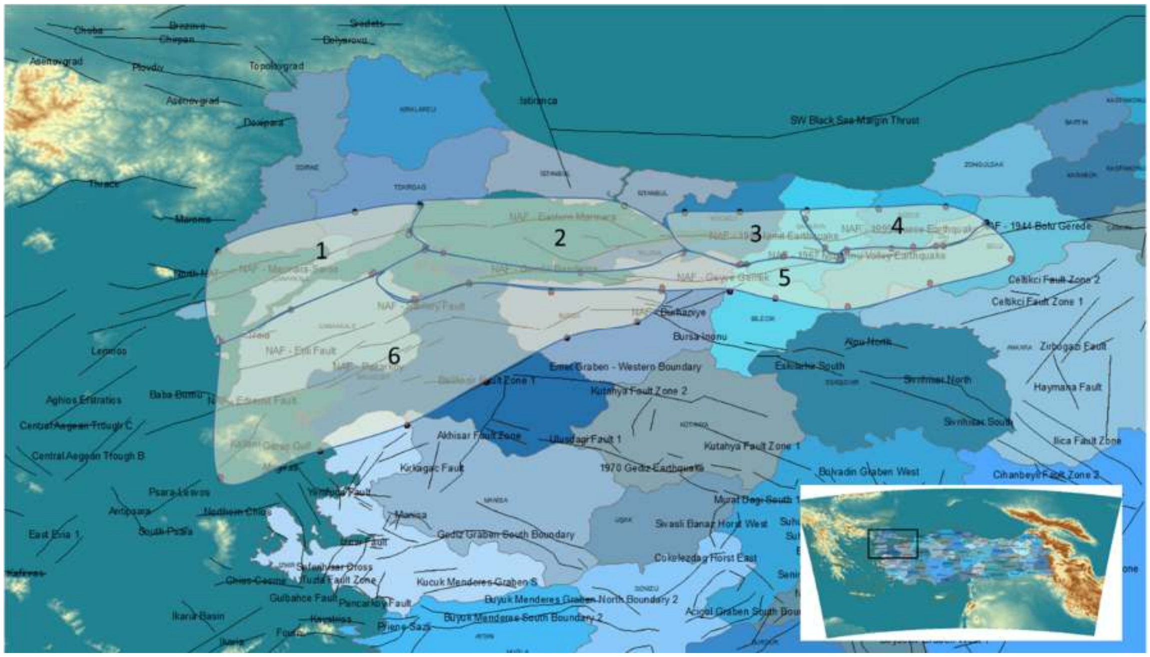

Figure 2. 6 different seismogenic source zone plotted in the Marmara Sea.

2. METHOD

2.1.Kernel Functions

The Kernel functions were Exponential, Gaussian, Quartic, Epanechnikov, Polynomial Order5, Constant. Method: denote by X the domain of covariates and by Y the domain of labels. Moreover, denote X := {x1,...,xn} and Y := {y1,...,yn} data drawn from a joint distribution p over X ×Y. Finally, let k : X ×X →R be a Hilbert Schmidt kernel [Mercer, 1909]. Loosely speaking we require that k be symmetric, satisfying that every matrix Kij := k(xi,xj) be positive semidefinite, K>= 0. The key idea in kernel methods is that they allow one to represent inner products in a high-dimensional feature space implicitly using.

$$k(x, x') = \langle \phi(x), \phi(x') \rangle \tag{1}$$

While the existence of such a mapping Φ is guaranteed by the theorem of Mercer (1909), manipulation of is not generally desirable since it might be infinite dimensional. Instead, one uses the representer theorem (Kimeldorf and Wahba, 1970, Schölkopf et al., 2001) to show that when solving regularized risk minimization problems, it can be found as linear combination of kernel functions:

$$\langle w, \phi(x) \rangle = \left\langle \sum_{i=1}^{n} \alpha_i \phi(x_i), \phi(x) \right\rangle = \sum_{i=1}^{n} \alpha_i k(x_i, x) \tag{2}$$

While this expansion is beneficial for small amounts of data, it creates an unreasonable burden when the number of data points is large. This problem can be overcome by computing approximate expansions.

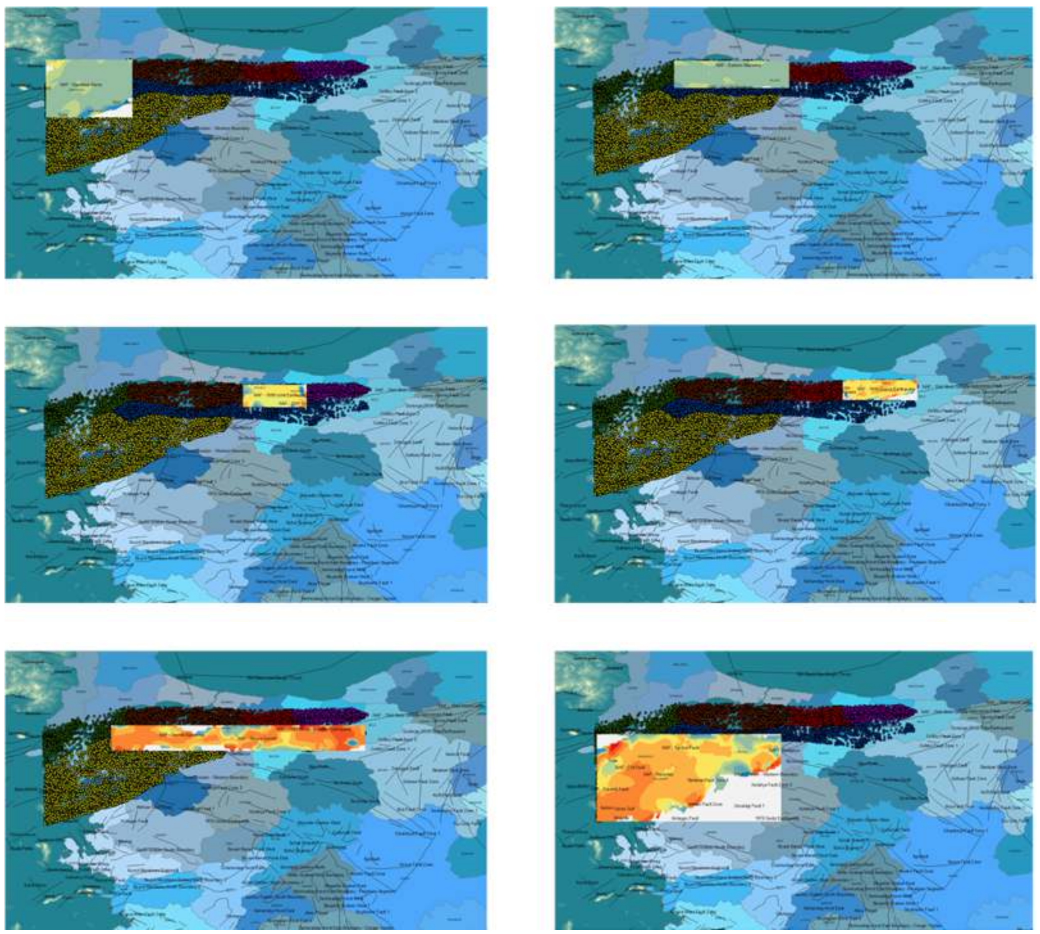

Figure 3. Kernel Gaussian method plotted separately for 6 seismogenic zones in the Marmara Sea.

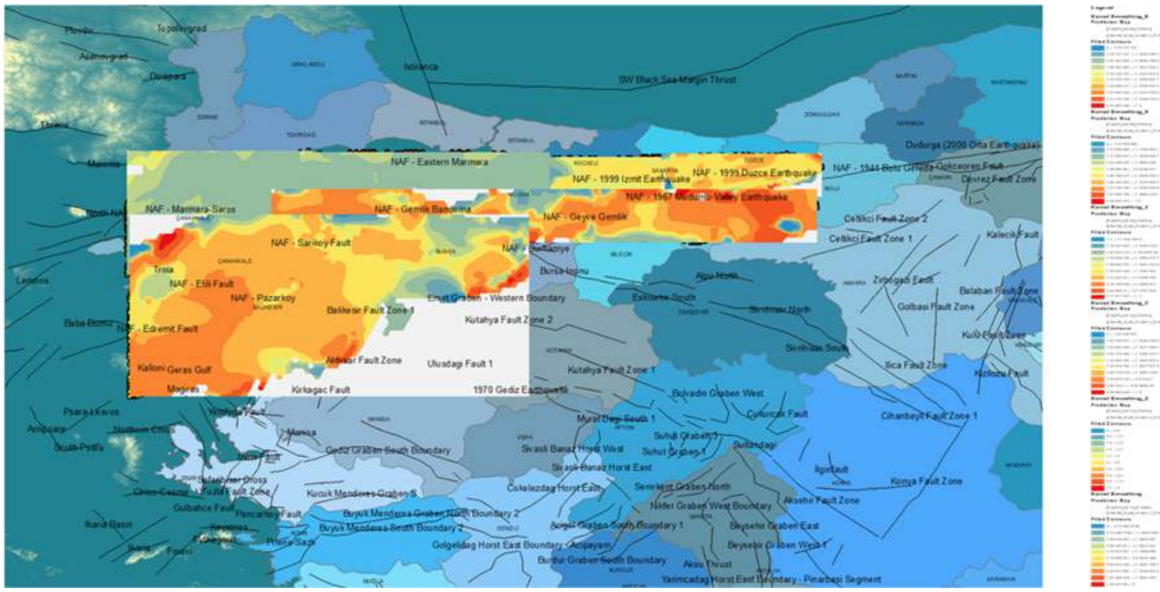

Figure 4. Kernel Gaussian Method plotted to all seismogenic zones.

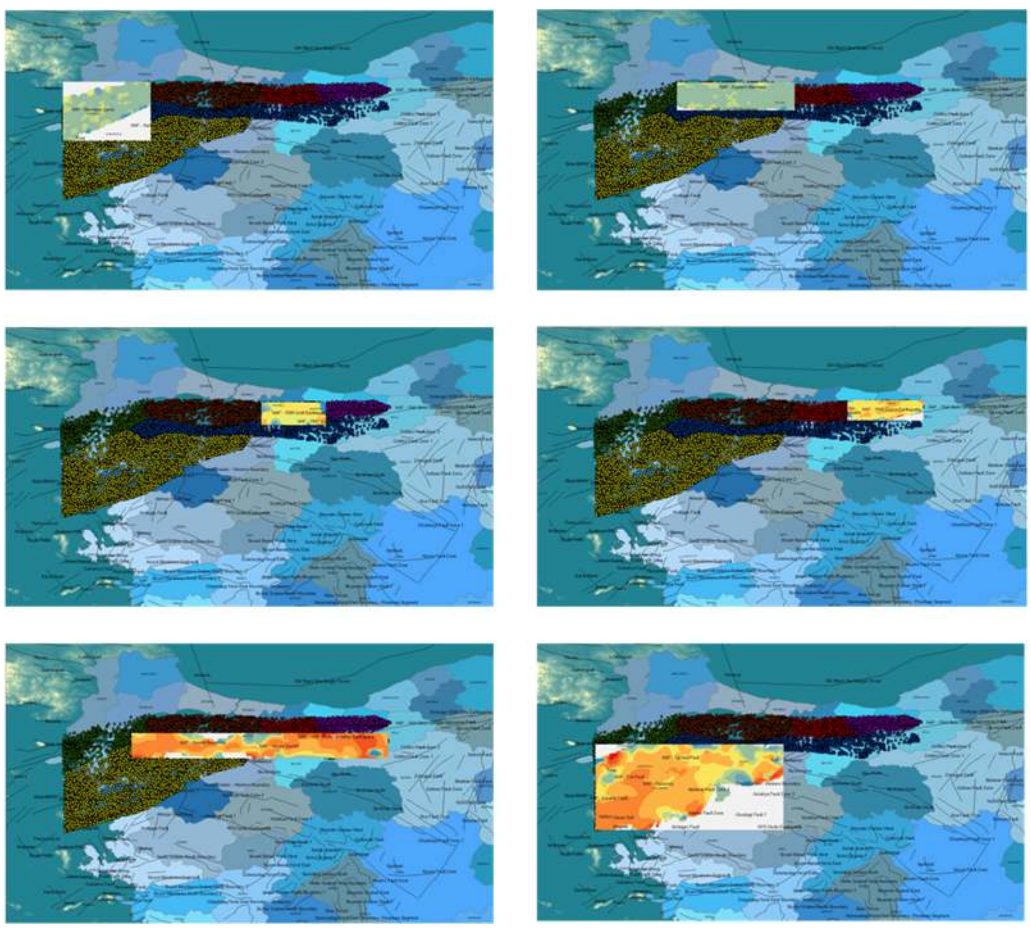

Figure 5. Kernel Exponential method plotted separately for 6 seismogenic zones in the Marmara Sea.

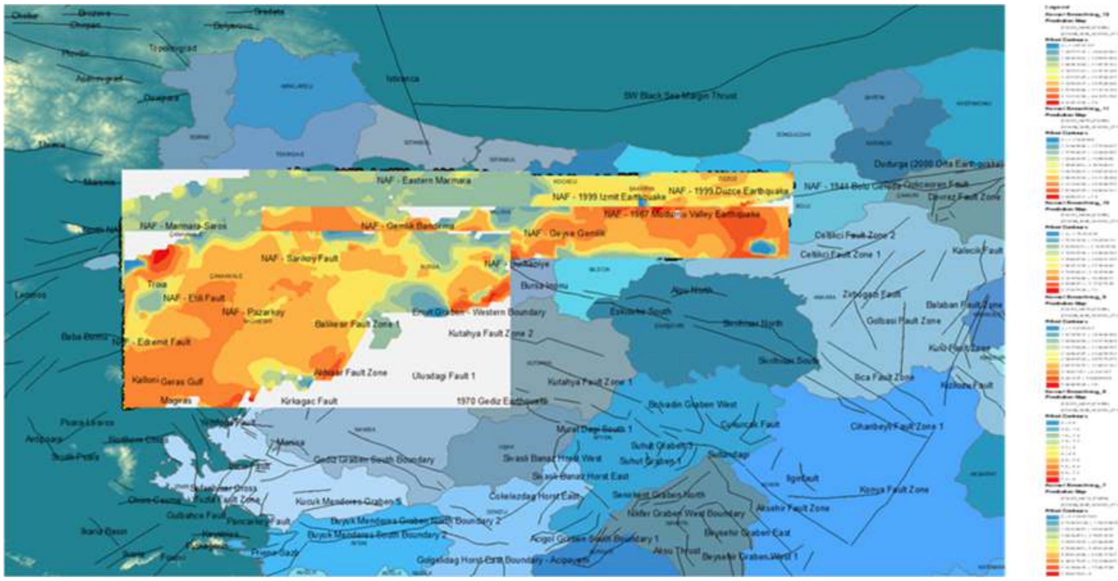

Figure 6. Kernel Exponential method plotted to all seismogenic zones.

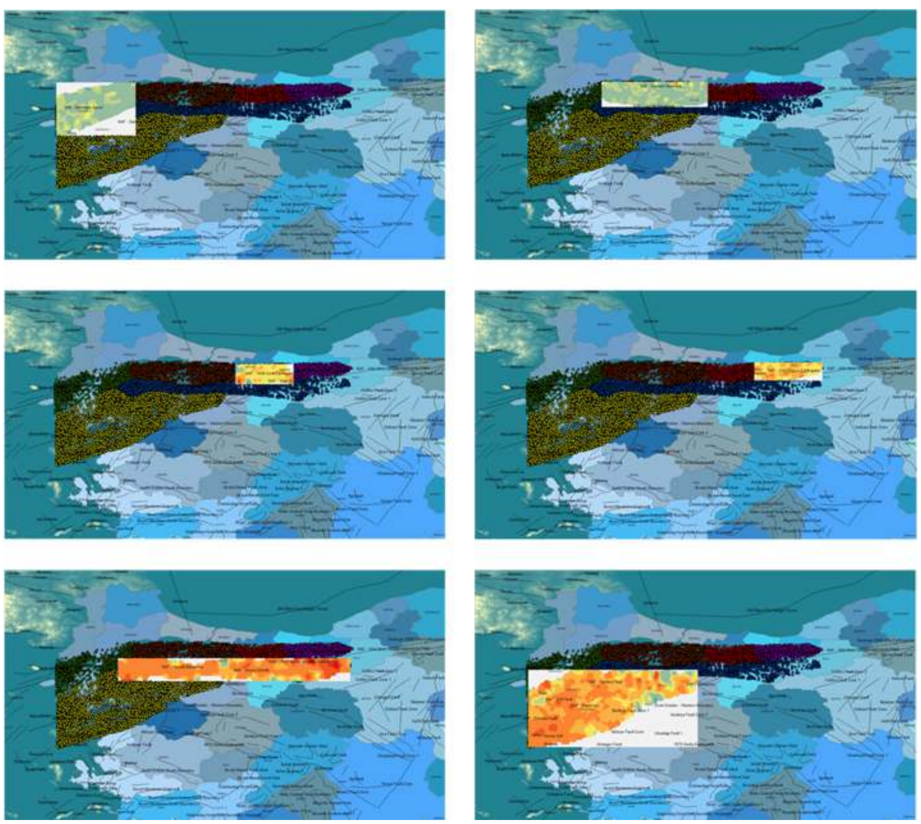

Figure 7. Diffusion Kernel method plotted separately for 6 seismogenic zones in the Marmara Sea.

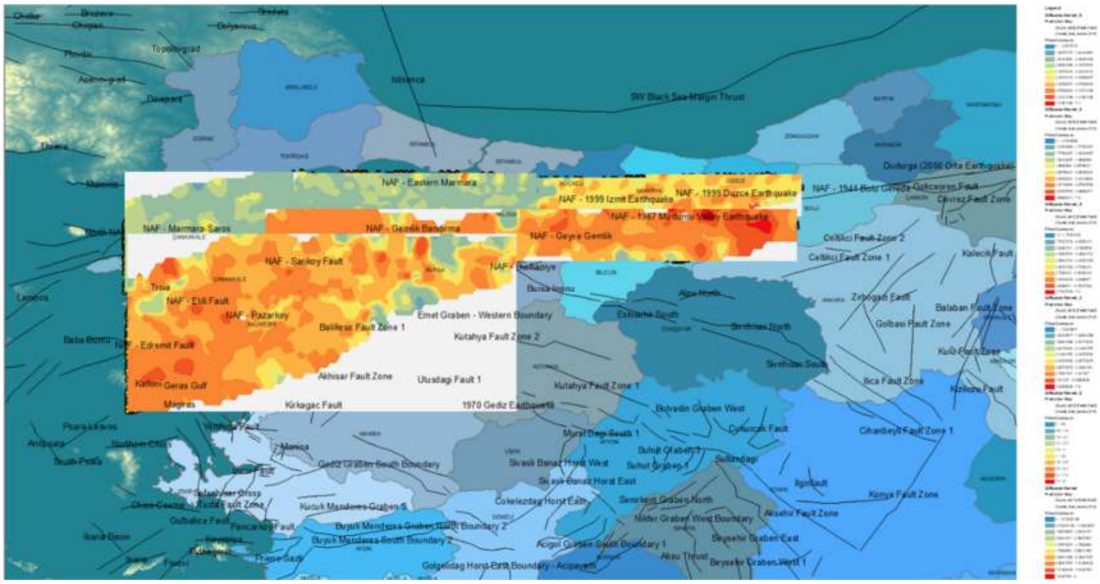

Figure 8. Diffusion Kernel method plotted to all seismogenic zones.

3. Results and Discussions

We plotted and estimated to prediction maps for 6 different seismogenic zone (Saroz Gulf, Marmara Sea, between İzmit-Sakarya, between Sakarya-Düzce, the southern branch of NAFZ, the southern of Marmara) in the Marmara Sea. We used Kernel Function (Exponential and Gaussian) and Diffusion Kernel methods. Respectively, we used $e^{-3(\frac{r}{h})}$ (Exponential) and $e^{-3(\frac{r}{h})^2}$ (Gaussian) basis formulas in Kernel Function method. We obtained prediction values of earthquake occurrence. We used all faults as barrier for Diffusion Kernel method in the Marmara Sea. So, we obtained low, medium, high estimations for predictions of earthquake occurrences by taking the faults barrier in each seismogenic source zones. Consequently, we determined an interpolation applied with barriers for making predictions of earthquake occurrences using different Kernel methods in the Marmara Sea. This study, scientists will be benefited to examine of next earthquakes and predictions of earthquake occurrences in Turkey.

References

[1] Ketin I. (1976) A comparison between the San Andreas and North Anatolian Fault: Turkey. Geol Inst Bull 19:149–154.
[2] Kimeldorf G. S. and Wahba G. (1970. A correspondence between Bayesian estimation on stochastic processes and smoothing by splines. Annals of Mathematical Statistics, 41:495, 502.
[3] Mercer J. (1909). Functions of positive and negative type and their connection with the theory of integral equations. Philos. Trans. R. Soc. Lond. Ser. A Math. Phys. Eng. Sci.,A 209:415, 446.
[4] McKenzie D.P. (1972). Active tectonics of the Mediterranean region. Geophys Astron JR Soc 30(2):109–185.

[5] Schölkopf, R. Herbrich, and A. J. Smola. A. (2001). Generalized representer theorem. In D. P. Helmbold and B. Williamson, editors, Proc. Annual Conf. Computational Learning Theory, number 2111 in Lecture Notes in Comput. Sci., pages 416, 426, London, UK. Springer-Verlag.
[6] Zor E, Özalaybey S, Karaaslan S, Tapırdamaz MC, Özalaybey SÇ, Tarancıoğlu A, Erkan B (2010). Shear wave velocity structure of the İzmit Bay area (Turkey) estimated from active–passive array surface wave and single-station microtremor methods. Geophys J Int 182:1603–1618.