ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

LOCATION SELECTION FOR COAL-FIRED POWER PLANTS USING GIS AND CALPUFF DISPERSION MODEL: A CASE STUDY FOR THRACE REGION

M.Sc. THESIS

Barış SARIDİKMEN

Department of Environmental Engineering

Environmental Sciences, Engineering and Management Programme

DECEMBER 2019

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

LOCATION SELECTION FOR COAL-FIRED POWER PLANTS USING GIS AND CALPUFF DISPERSION MODEL: A CASE STUDY FOR THRACE REGION

M.Sc. THESIS

Barış SARIDİKMEN
(501161729)

Department of Environmental Engineering

Environmental Sciences, Engineering and Management Programme

Thesis Advisor: Assoc. Prof. Burçak KAYNAK TEZEL

DECEMBER 2019

İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

KÖMÜR YAKITLI TERMİK SANTRALLER İÇİN CBS VE CALPUFF DAĞILIM MODELİ KULLANILARAK YER SEÇİMİ: TRAKYA BÖLGESİ ÖRNEĞİ

YÜKSEK LİSANS TEZİ

Barış SARIDİKMEN
(501161729)

Çevre Mühendisliği Anabilim Dalı
Çevre Bilimleri, Mühendisliği ve Yönetimi Programı

Tez Danışmanı: Doç. Dr. Burçak KAYNAK TEZEL

ARALIK 2019

Barış Sarıdikmen, a M.Sc. student of ITU Graduate School of Science Engineering and Technology student ID 501161729, successfully defended the thesis entitled “LOCATION SELECTION FOR COAL-FIRED POWER PLANTS USING GIS AND CALPUFF DISPERSION MODEL: A CASE STUDY FOR THRACE REGION”, which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor: **Assoc. Prof. Burçak KAYNAK TEZEL** ....
Istanbul Technical University

Jury Members: **Prof. Kadir ALP** ....
Istanbul Technical University

Prof. Arslan SARAL ....
Yıldız Technical University

Date of Submission : 15 November 2019
Date of Defense : 11 December 2019

vi

To my family,

FOREWORD

I would like to thank my family who supported me during the writing of this thesis. I would also like to thank all that helped me in writing this thesis. Especially my old friend and former classmate Ezgi Akyüz who taught me ArcGIS and CALPUFF.

December 2019

Barış SARIDİKMEN
Environmental Engineer

TABLE OF CONTENTS

Page

ABBREVIATIONS

AQMS	**:** Air Quality Monitoring Station
CPP	**:** Coal Power Plant
TPP	**:** Thermal Power Plant

SYMBOLS

NO_2 : Nitrogendioxide
PM_{10} : Particulate Matter smaller than 10µm
SO_2 : Sulfurdioxide

LIST OF TABLES

Page

LIST OF FIGURES

Page

LOCATION SELECTION FOR COAL-FIRED POWER PLANTS USING GIS AND CALPUFF DISPERSION MODEL: A CASE STUDY FOR THRACE REGION

SUMMARY

Globally, 23,789,000 MW of electricity production capacity is installed. In Turkey, various types of power plants are operated for electricity production. More than half (55.37%) of national installed power is from fossil fuels with natural gas 32.29%, lignite 11.36% and regular coal being 1,26%. In Thrace, which acts like an island in Turkish electricity grid, 19,544 GWh is produced while 32,341 GWh is consumed in 2016. Its consumption is expected to rise to 43,000 GWh in 2027. Thrace has a limited access to Turkish electricity grid since any power lines either has to go through the Bosphorus which has a limited amount of space or through the Dardanelles which because of its width has to be a subterranean/submarine line which is expensive and needs to be imported.

Thrace has five provinces in it (two of which are partly in Thrace): Çanakkale (Gelibolu and Eceabat districts), Edirne, Istanbul (European side), Kırklareli and Tekirdag of which the combined population of Thrace is 11,550,000. In the north it borders the Black Sea and Bulgaria, in the south and east it borders Istanbul Asian side, Çanakkale's Biga Peninsula and the Sea of Marmara, in the west it borders Greece and Bulgaria. The agricultural production, industrial activities and intensive population make the region an important area for the Turkish economy. Almost all of the Turkish rice and sunflower production is produced in this region.

In this study, a location selection methodology was detailed and with that three different alternative locations were chosen and compared with each other and with an existing project site with respect to their contribution to air pollution in Thrace.

Air quality in Thrace has issues of SO_2 and PM_{10} pollution. Air quality monitoring stations which indicated high pollution in Edirne, Kırklareli and Tekirdağ provinces were taken into consideration. NO_2 pollution is below the standard. Keşan MTHM station exceeded the SO_2 and PM_{10} hourly and daily limit values for the last three years with very high concentrations and high number of exceedances up to 200 days. Winter SO_2 limit value was exceeded almost in all stations all years except for the year of 2018. Annual SO_2 limit value was exceeded or slightly below the limit value, which results in exceedances in winter averages except for three stations in 2018.

PM_{10} concentrations were observed significantly higher than daily limit value in all the stations with minimum of 55 days and a maximum of 181 days in the most recent year, 2018. Annual PM_{10} concentrations exceeded the limit value for all stations except Çerkezköy MTHM station in 2018.

In location selection, there are sets of factors were chosen: economical, environmentral and geographical. Environmental and geograhical factors include: wind directions compared to population centers, existence of historical and natural reserve areas, agricultural areas, forests, elevation and ruggedness, existing air pollution and population density. Whereas, economical factors include: proximity to transportation infrastructure, proximity to coal reserves, proximity to consumers and available workforce in the area. As a reference, two thermal power plant projects in Thrace were chosen. Çerkezköy Thermal Power Plant, a lignite-fired 990 MW power plant project owned by EÜAŞ is very close to Çerkezköy town center (Çerkezköy case). The other one, Çebi Thermal Power Plant, is an imported coal-fired power plant project with 350 MW power and located 6 km west of Marmara Ereğlisi (Marmara Ereğlisi case). Latter location is compatible with criteria in this study. The dominant wind direction in its location is from Northeast and it is located on an arable land. Two additional alternative locations have been selected using the methodology. The first one is in Tekirdağ province, Çorlu district, Karamehmet village 15 km North of Çorlu town center (Çorlu case). It is less than 1 km away from E80 highway. The dominant wind direction in its location is Northeast, carrying the pollutant plume away from Çorlu and towards Muratlı more than 30 km away. The other alternative location is in Edirne province, Havsa district, Azatlı village 15 km west of Havsa town center and 35 km southeast of Edirne city center (Havsa case). It is 7 km away from D100 state road and situated on an unused arable land. Wind direction is mostly from the North, but not very dominant. The wind from the north carries the pollution plume towards Greece.

An air quality dispersion model, CALPUFF was used estimating PM_{10}, NO_2 and SO_2 pollution contribution for all alternative locations with dry deposition values. One year simulations were performed for the year of 2016 and seasonal pollution distributions were investigated. CALPUFF is an advanced non-steady-state meteorological and air quality modeling system. The model has been listed by the U.S. Environmental Protection Agency (EPA) as an alternative model for assessing long range transport of pollutants and their impacts on certain near-field applications involving complex meteorological conditions.

Çerkezköy's dispersion usually occurs towards southwest. Main affected population centers are Çerkezköy and Çorlu. Çorlu's SO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu, with Tekirdağ being affected in some cases. Marmara Ereğlisi's SO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Çorlu and Çerkezköy are affected only in spring. In other seasons concentrations usually dirperse towards the Marmara Sea. Havsa's SO_2 and PM_{10} concentrations usually disperse towards south, except in winter when it is spreading toward north as well. Edirne city center is affected only in winter and spring, whereas Keşan, famous for its air pollution is slightly affected in summer and fall. Havsa site caused the least amount of air pollution in SO_2, PM_{10} and NO_2 in both peak and average values.

This study found that, Çorlu case affected a smaller region with lower population density than Çerkezköy, despite being very close to each other. Resulting concentrations in Havsa and Marmara Ereğlisi cases were similar and lower than other two cases. Çerkezköy location resulted in the highest air pollution impact, and the most suitable location for the CPP was found to be Havsa.

KÖMÜR YAKITLI TERMİK SANTRALLER İÇİN CBS VE CALPUFF DAĞILIM MODELİ KULLANILARAK YER SEÇİMİ: TRAKYA BÖLGESİ ÖRNEĞİ

ÖZET

Dünyada 23,789,000 MW kurulu elektrik üretim kapasitesi mevcuttur. Türkiye'de elektrik üretimi için çeşitli kaynaklara sahip enerji santralleri işletilmektedir. Ulusal kurulu gücün yarısından fazlası (% 55,37) fosil yakıtlarla elde edilmektedir. Doğal gaz %32,29 linyit % 11,36 ve taşkömürünün payı % 1,26'dır. Türkiye elektrik şebekesinde bir ada gibi olan Trakya'da 2016 yılında 19.544 GWh elektrik üretilirken, 32.334 GWh tüketilmiş olup 2027 yılında tüketiminin 43.000 GWh'ye yükselmesi beklenmektedir. Trakya'ya elektriğin sınırlı bir alana sahip olan Boğaziçi'nden veya genişliğinden dolayı pahalı ve ithal edilmesi gereken bir yeraltı / denizaltı hattı olması gereken Çanakkale Boğazı'ndan geçmesi gerekmektedir.

Trakya'da iki tanesi kısmen Trakya'da olmak üzere beş il mevcuttur: Çanakkale (Gelibolu ve Eceabat ilçeleri), Edirne, İstanbul (Avrupa yakası), Kırklareli ve Tekirdağ. Trakya'nın toplam nüfusu 11.500.000'dur. Kuzeyde Karadeniz ve Bulgaristan, güneyde ve doğuda İstanbul Asya yakası, Çanakkale'nin Biga Yarımadası ve Marmara Denizi, batıda ise Yunanistan ve Bulgaristan ile sınırlanmıştır. Tarımsal üretim, sanayi faaliyetleri ve yoğun nüfus, bölgeyi Türkiye ekonomisi için önemli bir alan haline getirmektedir. Türkiye'nin pirinci ve ayçiçeği üretiminin neredeyse tamamı bu bölgede gerçekleştirilmektedir.

Bu çalışmada, bir yer seçimi yöntemi detaylandırılmış ve bu yöntem ile Trakya'da üç farklı alternative yer seçilmiştir ve birbirleriyle ve mevcut bir proje sahası ile hava kirliliğine katkıları bakımından karşılaştırılmıştır.

Trakya'daki hava kalitesinin SO_2 ve PM_{10} kirliliği ile ilgili sorunları mevcuttur. Yüksek kirliliğe işaret eden ve Edirne, Kırklareli ve Tekirdağ illerinde bulunan hava kalitesi izleme istasyonları dikkate alınmıştır. NO_2 kirliliği büyük ölçüde sınır değerin altındadır. Keşan MTHM istasyonunda saatlik SO_2 ve PM_{10} ölçümleri sınır değeri sürekli olarak aşmakta ve yıllık 200'e varan günlük aşımlar görülmektedir. Kış SO_2 sınır değeri, 2018 yılı hariç tüm yılların hemen hemen tüm istasyonlarında aşılmıştır. Yıllık SO_2 sınır değeri, 2018'deki üç istasyon hariç, sınır değerin üstünde veya biraz altında görülmüştür. PM_{10} değerleri günlük ortalamaların çok üzerinde gözlenmiştir ve

yılda en az 55, en fazla 181 kere aşılmıştır. Yıllık PM_{10} konsantrasyonları Çerkezköy MTHM hariç tüm istasyonlarda standartların üzerindedir.

Yer seçiminde, belirlenmiş faktörler şunlardır: ekonomik, çevresel ve coğrafi. Çevresel ve coğrafi faktörler şunlardır: nüfus merkezlerine göre rüzgar yönleri, tarihi ve doğal rezerv alanlarının varlığı, tarım alanları, ormanlar, yükseklik ve yüzey pürüzlülüğü, mevcut hava kirliliği ve nüfus yoğunluğu. Ekonomik faktörler ise şunları içerir: ulaşım altyapısına yakınlık, kömür rezervlerine yakınlık, tüketicilere yakınlık ve bölgedeki mevcut işgücü. Referans olarak, Trakya'daki iki termik santral projesi seçildi: EÜAŞ'a ait Çerkezköy ilçe merkezine çok yakın 990 MW'lık linyit yakıtlı bir enerji santrali projesi olan Çerkezköy Termik Santrali (Çerkezköy alternatifi) ve Marmara Ereğlisi'nin 6 km batısında yer alan 350 MW gücünde ithal kömür yakıtlı enerji santrali projesi olan Çebi Termik Santrali (Marmara Ereğlisi alternatifi). İkincinin konumu bu çalışmadaki kriterlerle uyumludur. Yerindeki hakim rüzgar yönü kuzeydoğudandır ve ekilebilir bir arazide bulunur. Kriterler kullanılarak iki alternatif konum daha seçilmiştir. Bunlardan ilki, Çorlu ilçe merkezinin 15 km kuzeyindeki Çorlu ilçesi, Karamehmet köyü Tekirdağ'da. E80 karayoluna 1 km'den daha az bir mesafededir (Çorlu alternatifi). Yerindeki hakim rüzgar yönü kuzeydoğudur. Diğer alternatif lokasyon Edirne ilinde, Havsa ilçesinde, Havsa ilçe merkezinin 15 km batısında ve Edirne il merkezinin 35 km güneydoğusunda bulunan Azatlı köyündedir (Havsa alternatifi). D100 devlet yoluna 7 km uzaklıktadır ve kullanılmayan bir ekilebilir arazidedir. Rüzgâr yönü çoğunlukla Kuzey'den gelir, fakat çok baskın değildir. Kuzeyden esen rüzgar kirliliği Yunanistan'a doğru taşımaktatır.

CALPUFF hava kalitesi dispersiyon modeli kullanılarak tüm alternatif yerler için PM_{10}, NO_2 ve SO_2 kirlilik katkısı ve kuru çökelme miktarları hesaplaması yapılmıştır. 2016 yılı için bir yıllık simulasyonlar gerçekleştirilmiş olup mevsimsel kirlilik dağılımları incelenmiştir. CALPUFF kararsız-hal meteorolojik ve hava kalitesi modelleme sistemidir. Model, ABD Çevre Koruma Ajansı (EPA) tarafından, kirleticilerin uzun menzilli taşınımını ve bunların karmaşık meteorolojik koşulları içeren saha uygulamaları üzerindeki etkilerini değerlendirmek için alternatif bir model olarak listelenmiştir.

Çerkezköy TS'in dağılımı genellikle güneybatı yönünde gerçekleşmektedir. Etkilenen ana nüfus merkezleri Çerkezköy ve Çorlu'dur. Çorlu TS'in SO_2 ve PM_{10} konsantrasyonları genellikle, güneybatı rüzgarları tarafından kuzeydoğuya doğru yayıldığı bahar hariç, güneye ve güneydoğuya doğru yaymaktadır. Etkilenen başlıca nüfus merkezleri, Çerkezköy ve Çorlu'dur, bazı durumlarda Tekirdağ da etkilenmektedir. Marmara Ereğlisi TS'in SO_2 ve PM_{10} konsantrasyonları genellikle, güneybatı rüzgarları tarafından kuzeydoğuya doğru yayıldığı bahar hariç, güneye ve güneydoğuya doğru yayılmaktadır. Çorlu ve Çerkezköy sadece ilkbaharda etkilenmektedir. Diğer mevsimlerde, konsantrasyonlar genellikle Marmara Denizi'ne yönelmektedir. Havsa TS’in SO_2 ve PM_{10} konsantrasyonları genellikle, kuzeye de yayıldığı kış hariç, güneye doğru yayılmaktadır. Edirne şehir merkezi sadece kış ve ilkbahar aylarında, hava kirliliği ile ünlü Keşan ise yaz ve sonbahar aylarında hafif etkilenmektedir. Havsa bölgesi SO_2, PM_{10} ve NO_2’de en az miktarda hava kirliliğine hem pik hem de ortalama değerlerde sebep olmuştur.

Bu çalışmada bulunanlara göre, Çorlu konumu Çerkezköy konumuna çok yakın olsa da daha düşük nüfusu olan daha küçük bir bölgeyi etkiledi. Havsa ve Marmara Ereğlisi’ndeki konumlar diğerlerine göre daha düşük konsantrasyonlara yol açtı. Çerkezköy konumunun en yüksek hava kirliliği katkısına yol açtığı ve en iyi termik santral konumunun Havsa olduğu görüldü.

1. INTRODUCTION

Increasing industrial production results in increased air pollution. The energy policies and the lack of high quality natural resources in Turkey necessitates all domestic resources to be used to satisfy population needs. The main driver behind air pollution is industry, especially cement, energy and iron industries. These three industries produce the most man-made air pollution in Turkey.

Anthropogenic sources of SO_2 (sulfur dioxide) are industrial fuel consumption (fossil fuels, biomass), residential heating (fossil fuel, biomass), some chemicals, transportation (fossil fuel), wate disposal and recycling. Natural sources in Turkey are limited to sea-salt emissions since the atmospheric life of SO_2 is not long enough. When SO_2 is combined reacts with water (humidity) in the atmosphere acid rains occur which lowers the pH of environmental bodies (water, soil, etc.).

Particulate matter (PM) is either directly from the source or produced via secondary reactions in the atmosphere. Its main resources are natural, like dust storms through long range transportation and man-made, like combustion engines, power plants that use solid fuels and any kind of open-pit mines. PM disturbs respiratory system of human and animals greatly, and disrupts photosynthesis by partially blocking sunlight and blocking respiratory pores.

1.1 Energy Sector and Air Pollution

Globally, 23.789.000 MW of electricity production capacity is installed 39% of which is thermal. In Turkey, various types of power plants are operated for electricity production. According to Electricity Market Development Report (2017) more than half (55,37%) of national installed power is from fossil fuels with natural gas 32,29%, lignite 11.,36% and regular coal being 1,26%.

In Thrace, which acts like an island in Turkish electricity grid produced 19.544 GWh while consumed 32.341 GWh in 2016 and its consumption is expected to rise to 43.000 GWh in 2027. Thrace has a limited access to Turkish electricity grid since any power lines either has to go through the Bosphorus which has a limited amount of space or through the Dardanelles which because of its width has to be a subterranean/submarine line which is expensive and needs to be imported.

Power plants pollute water and soil through acid rains, pollute water through cooling water discharge, polluted soil through erosion, loss of vegetation (if built upon farmable land) and deforestation (if built on a forest).

Power plants release PM, NO_x, SO_2, CO, HF and HCl from its stack and releases PM during their construction and from its ash storage area.

1.2 Thrace Region

Thrace has 5 provinces in it (2 of which are partly in Thrace): Çanakkale (Gelibolu and Eceabat districts), Edirne, Istanbul (European side), Kırklareli and Tekirdag. The combined population of Thrace is 11.550.000. In the north it borders the Black Sea and Bulgaria, in the south and east it borders Istanbul Asian side, Çanakkale's Biga peninsula and the Sea of Marmara, in the west it borders Greece and Bulgaria. The agricultural production, industrial activities and, intensive population make the region an important area for the Turkish economy. Almost all of the Turkish rice and sunflower production is produced in this region.

Istanbul, a metropolitan city, is located in both Asia and Europe, and is known by its industrial activities and intensive population estimated 20 million. Long term average annual precipitation was 797mm in Istanbul (for Sarıyer/Istanbul station) covering years from 1949 to 2001. Kırklareli region, which is famous for its winter wheat production, had an average annual precipitation of 564mm between years 1938 and 2001. Precipitation was measured as 574 and 584mm in Tekirdağ and Edirne, respectively. A map of Thrace is given in **Figure 1.1.**

Figure 1.1. Map of Thrace

1.2.1 Meteorological Conditions

The usual wind direction in majority of Thrace is northeast. Winds from southwest are strong and is called southwesterly winds, famous for its storms and high PM_{10} concentrations. These will be important in the location selection. Inversion risk is usually not high. A wind rose of a sample meteorological station is given in **Figure 1.2.** and inversion risks are given in **Figure 1.3.**

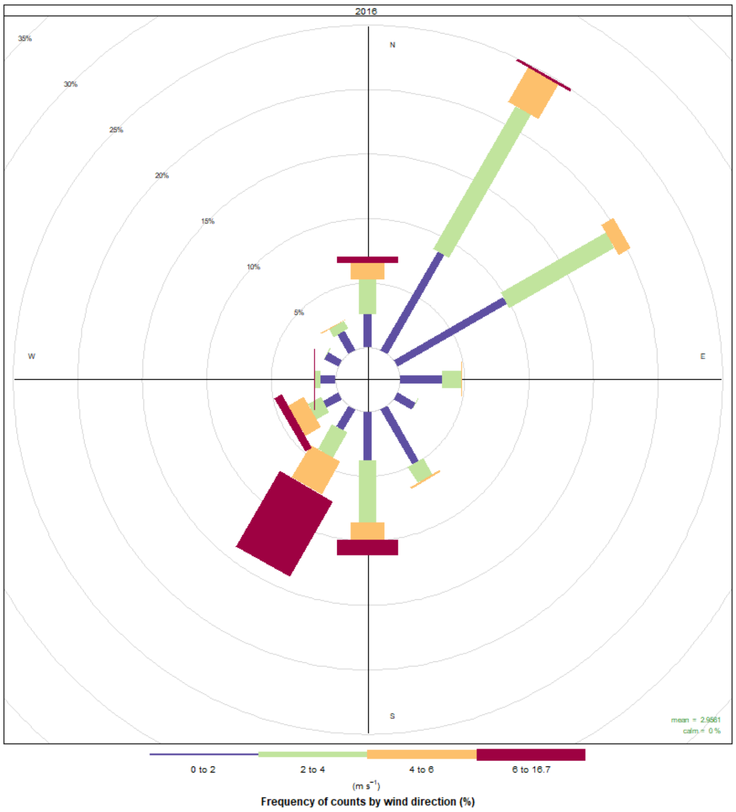

Figure 1.2. Wind rose of sample meteorological station in Thrace

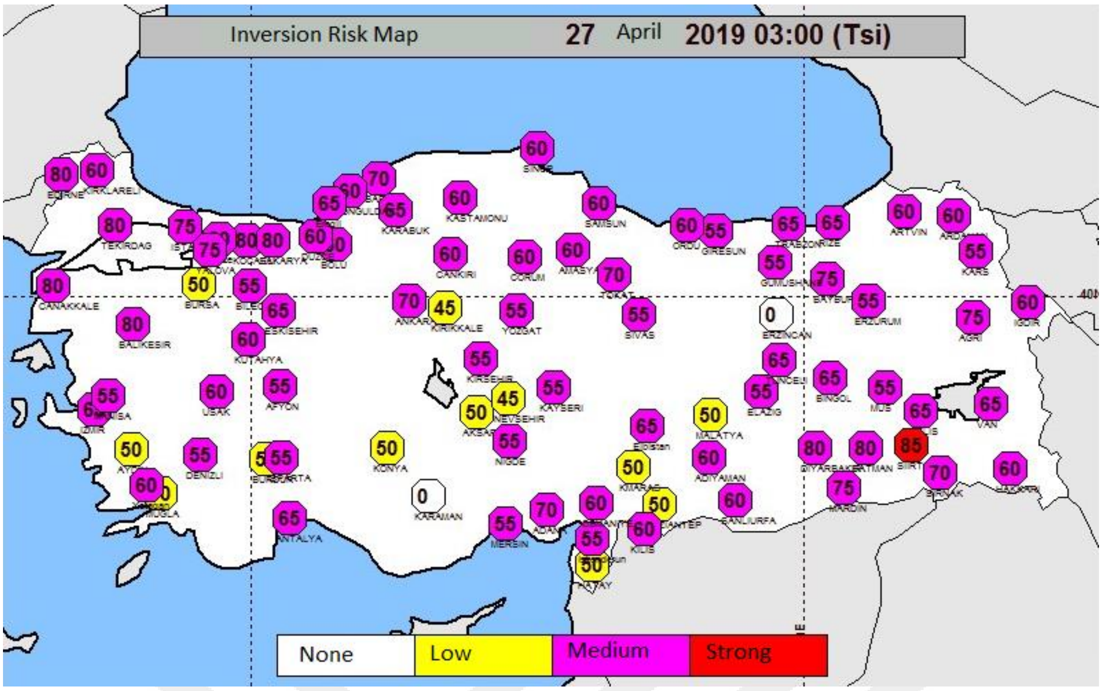

Figure 1.3: Inversion Risk Map in 27th April 2019 for Turkey

1.2.2 Air Quality

Air quality in Thrace has issues of SO_2, NO_2 and PM_{10} pollution. Air Quality Monitoring Stations which indicated high pollution and are located in Edirne, Kırklareli and Tekirdağ provinces were taken into consideration.

Keşan MTHM station exceeded the SO_2 and PM_{10} hourly and daily limit values for the last three years with very high concentrations and high number of exceedances up to 200 days. Winter SO_2 limit value was exceeded almost in all stations all years except for the year of 2018. Annual SO_2 limit value was exceeded or slightly below the limit value, which results in exceedances in winter averages except for three stations in 2018.

PM_{10} concentrations were observed significantly higher than daily limit value in all the stations with minimum of 55 days and a maximum of 181 days in the most recent year, 2018. Annual PM_{10} concentrations exceeded the limit value for all stations except Çerkezköy MTHM station in 2018. The worst concentration is 94 μg/m^3 in Tekirdağ station which is more than twice the limit value of 40 μg/m^3.

Last 10 years of available daily SO_2 and PM_{10} concentrations in the selected air quality monitoring stations were also investigated with respect to annual and seasonal variation. Historically, the region has exceedances in both pollutants, especially in winter months. Although SO_2 pollution is observed to be decreased within the years in the stations, there are still exceedances. PM_{10} concentrations shows a seasonal trend with maximum concentrations observed in winter, with very minor decrease within the years with significant exceedances. Considering the current level of SO_2 and PM_{10} pollution, during the location selection of CPP, close proximity to Tekirdağ, Keşan MTHM and Edirne MTHM stations were avoided.

2. LITERATURE REVIEW

Aydın et al. (2013) developed a GIS based site selection method for hybrid renewable energy systems in Turkey. They have set environmental objectives for wind power for acceptability in terms of natural reserves, safety and aesthetics for airports, town centers, large city centers, noise and bird habitats. They have set environmental objectives for solar power for acceptability in terms of natural reserves, agricultural areas, flight security, lakes and wetlands and coastline or river. They have also set economic feasibility objectives for wind energy for acceptable slope, proximity to transmission lines and main roads and sufficient potential for wind energy generation. For solar energy they have set economic feasibility objectives as sufficient solar energy potential, acceptable slope, proximity to transmission lines and to urban areas. Their methodology is given in **Figure 2.1.**

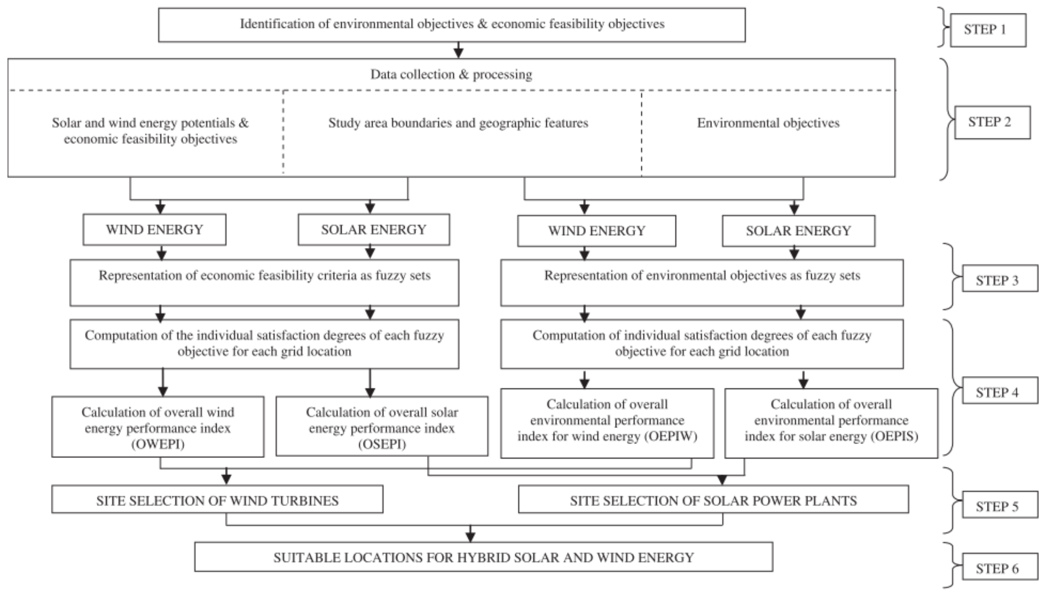

Figure 2.1. Methodology for site selection process for hybrid solar-wind power plants (adapted from Aydın et al., 2013)

Vardar and Yumurtacı (2010) calculated the pollutant emissions of some lignite-fired power plants in Turkey using the coal content and found out that only one power plant uses the circulating fluidized bed technology, which is designed to use low-quality lignite with high sulfur content. They suggested that all other CPPs have to be modernized with effective measurement and control equipment in order to improve the combustion efficiencies.

Khan (2018) has developed a location analysis methodology that can minimize the pollutant exposure to the public while ensuring that the combined costs of electric transmission losses and coal logistics are minimized. He has used a variety of distance calculations, picks the most suitable location alternatives and then uses a plume dispersion model (METI-LIS) to pick the best location in a small domain.

Özkurt et al. (2013) characterised air pollution in Çanakkale by determining SO_2 and NO^2 contributions of Çan and Bayramiç districts. In this content, they used CALPUFF air-dispersion model and examined the correlation between ten air quality monitoring stations and CALPUFF simulations. In 2007, it has been observed that almost all the stations in January, February, March, April, October, November and December has been in correlation with the CALPUFF model estimations. Though, the model estimations and station measurements were incompatible with each other in the summer months. This correlation decreased throughout the year in 2008.

Biberacher et al. (2015) observed that different layers on a GIS yields important results in energy planning where they studied bioenergy and power plant location optimization for Pakistan. They first assessed time-series of bioenergy potentials (2001-2010) from agricultural side products on a spatial resolution of 1 km2, for which they used Biosphere Energy Transfer Hydrology (BETHY/DLR) model to calculate Net Primary Productivity (NPP) which was then used to calculate energy potentials. In the second step they used the new biomass power plant optimization tool ASECO (Autarkic Spatial Enegy Cluster Optimization) approach.

Zheng et al. (2011) proposed a methodological framework for site optimization in designing a Regional Air Quality Monitoring Network (RAQMN) for regional air quality management. The study uses gridded synthetic assessment concentrations as a basis, and maximizes the approximate degrees between selected grid cells and all candidate grid cells with the constraints of cost and budget, terrain conditions, administration district, population density, and spatial coverage. The results indicated that the framework can successfully conduct regional site optimization of a RAQMN, implying its feasibility and practicality in designing an optimal RAQMN. An air quality model has to be used in conducting site optimization of a RAQMN.

Şaylan et al. (2011) researched the correlation of chemical properties of rainwater and air quality in Thrace region at four locations in four provinces in their work “Spatial Variation of the Precipitation Chemistry”. They found out that the precipitation chemistry, a direct result of air quality, changes from season to season in the region.

As of March 2019, there are no studies made for location optimization of thermal power plants in Turkey. There is a location optimization study for a biomass plant in the Aegean Region by Cebi et al. (2016). They used a fuzzy set theory and linguistic scales to deal with vague, imprecise information and uncertainty. Linguistic scales describe the evaluation system of human logic which is used in daily life. They have determined their criteria in four main categories: Main biomass source produced in the region, alternative biomass sources produced in the region, energy potential of the region and setup and operating costs.

Villacreses et al. (2017) has calculated the availability for wind farms in Ecuador to build a Geographical Information System using multi-criteria decision-making (MCDM) methods. They calculated that central Andes region of Ecuador is more efficient for wind farms.

Fıratlı (2016) has used satellite retrievals to determine large scale SO2 point resources in Turkey. Kauria (2016) developed a global location optimization model for utility-scale solar power plants. She has concentrated in Harare/ Zimbabwe, Helsinki/ Finland and Denver/ USA. Overall, Harare was the most suitable of all three.

3. METHODOLOGY

The method for selection of the power and for the rest of the study is given in **Figure 3.1.**

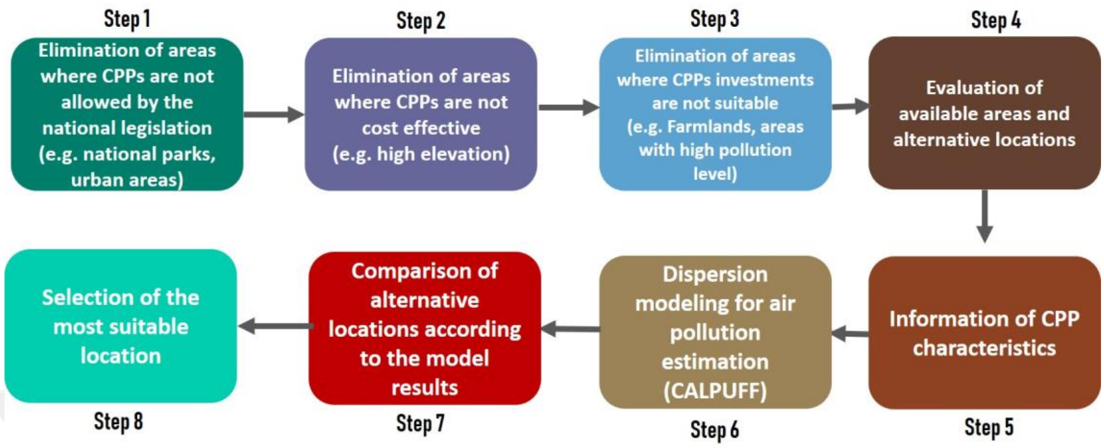

Figure 3.1. Methodology stages of location selection for CPPs.

3.1 Site Selection

For the selection of the best site for a coal-fired power plant, various factors need to be taken into account. Within the modelling area there are Turkey's neighboring countries to west Bulgaria and Greece, whereas it is important that this power plant is within the Turkish borders. Since a power plant can't be built in urban areas, according to the Corine Land Cover 2018 data, 2 km around urban fabrics are disqualified for site selection. Already occupied areas like industrial facilities, ports and airports, as well as 4 km in the direction of airport runways are disqualified.

The second step is the elimination of areas where a thermal power plant wouldn't be cost effective. Within the modelling area there are locations that doesn't have any land connection with the Thracian region, like the southern coasts of Marmara Sea and some islands. Considering the reasons stated in the Introduction part (lack of space to build transmission lines through Bosporus and width of the Dardanelles, which increases the cabling costs and decreases transmission efficiency) the southern coast of Marmara Sea and islands in the Marmara Sea are disqualified from selection. Thrace has high mountain chains near its Black Sea coast and to the south of Tekirdağ city center as taken from European Union Digital Elevation Map (EU-DEM).

The third step is the elimination of areas where a coal-fired power plant would not be suitable. Farmlands and forests are very important for both Turkish and Thracian economy and therefore their destruction has to be avoided. Farmlands and forests data was taken from Corine Land Cover European seamless vector database v.18.5 (CLC12). Since most of Thrace is arable land, irrigated farmlands and forested areas were disqualified, but usable lands like arable lands and scrubs were not.

Areas with already polluted air were found via National Air Quality Surveillance Network and Marmara Clean Air Center (MTHM) and will be avoided not to increase the existing air pollution. Contribution to air pollution in these areas will be studied with a dispersion model. Environmental, geographical and economical factors in site selection are given in **Table 3.1.**

Table 3.1. Environmental, geographical and economical factors in site selection.

Environmental and Geographical	Economical
Wind direction	Proximity to roads, railroads and ports
Historical and natural reserve areas	Proximity to coal reserves
Agriculture	Proximity to consumers
Forests	Available workforce
High elevation and ruggedness	
Existing air pollution	
Population density	

The fourth step is the manual evalutation of available areas to pick 4 best areas. Factor in this manual evaluation will be grouped into 2 categories: environmental and geographical, economical. Environmental factors include historical and natural reserves, agricultural use, forested areas, high elevation and ruggedness of terrain, atmospheric stability, existing air pollution, rainfall, wind direction and population density. The economical factors include, proximity to roads, railroads, ports, coal reserves, ash-using industries, consumers and workforce. Economical, environmental and geographical factors can be seen in Table 3.1. **Environmental**, geographical and economical factors in site selection**..**

3.1.1 ArcGIS

ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web.

3.2 TPP Characteristics

As a reference, two thermal power plant projects in Thrace were chosen. Çerkezköy TPP, a lignite-fired 990 MW power plant project owned by EÜAŞ is very close to Çerkezköy town center. The other one, Çebi TPP, is an imported coal-fired power plant project with 350 MW power. It is 6 km west of Marmara Ereğlisi. Its location is compatible with criteria in this study. The dominant wind direction in its location is from Northeast and East and it is located on an arable land.

Two alternative locations has been selected using the criteria stated above. The first one is in Tekirdağ province, Çorlu district, Karamehmet village 15 km North of Çorlu town center. It is less than 1 km away from E80 highway. The dominant wind direction in its location is Northeast, blowing the plume away from Çorlu and towards Muratlı more than 30 km away.

The other alternative location is in Edirne province, Havsa district, Azatlı village 15 km west of Havsa town center and 35 km southeast of Edirne city center. It is 7 km away from D100 state road and situated on an unused arable land. Wind direction is mostly from the North, but not very dominant. The wind from the north will blow the plume towards Greece.

The final step before air dispersion modelling is the determination of the power plant's characteristics. These characteristics will include, the capacity of the plant, technology to be used, stack height, any pollution control measures, etc. These characteristics will be determined to have the least capital expense with acceptable (or profitable) operation expenses while also satisfying the national regulations. The reference TPP has been chosen as Çan-2 TPP in Çanakkale province. It is a single unit 330 MW lignite-fired power plant that was commissioned in August 2018. Its emissions and specifications are listed in **Table 3.2.**

Table 3.2. Emissions and Specifications of Çan-2 TPP and Study TPP

	Çan-2 TPP	Study TPP
SO_2 (kg/hr)	280	280
NO (kg/hr)	266	266
NO_2 (kg/hr)	14	14
PM_{10} (kg/hr)	28	28
Stack HeIght (m)	120	150
Stack DIameter (m)	6.25	6.25
Exit Velocity (m/s)	15	15
Exit Temperature (^oK)	336	336

In this study a unit with 330 MW power plant was chosen. The stack will have a height of 150 m instead of Çan-2's 120 m for safety because of the population density of Thrace.

3.3 Dispersion Modeling: CALPUFF

An air quality dispersion model has been made using CALPUFF for PM_{10}, NO_2 and SO_2 for all alternative locations with dry deposition included.

CALPUFF is an advanced non-steady-state meteorological and air quality modeling system. The model has been listed by the U.S. Environmental Protection Agency (EPA) as an alternative model for assessing long range transport of pollutants and their impacts on certain near-field applications involving complex meteorological conditions.

The modeling system consists of three main components and a set of preprocessing and post-processing programs. The main components of the modeling system are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (an air quality dispersion model), and CALPOST (a post-processing package). In addition to these components, there are numerous other processors that may be used to prepare geophysical (land use and terrain) data in many standard formats; meteorological data (surface, upper air and precipitation data).

Some examples of applications for which CALPUFF is suitable are; near-field impacts in complex flow or dispersion situations on complex terrain, stagnation, inversion, recirculation, and fumigation conditions, overwater transport and coastal conditions and light wind speed and calm wind conditions. CALPUFF is also suitable in the research of long-range transport, criteria pollutant modeling and secondary pollutant formation and particulate matter modeling.

CALMET uses the outputs of preprocessor as input files. Surf.dat is created with data of ground-level meteorology stations, Up.dat is created with data of upper air (radiosonde) meteorology stations and Geo.dat is created with land use and land cover data are compulsory to run CALMET. Oversea.dat file is selective. Files required to run CALMET module are given in **Table 3.3.**

Table 3.3: Files required to run CALMET module

Files used in CALMET	Name of file	Necessity	Content
Surface meteorology data	Surf.dat	Compulsory	Hourly wind speed, wind direction, temperature, cloud cover, mixing height, surface pressure, humidity, precipitation
Upper air meteorology data	Up.dat	Compulsory	12-hr wind speed, wind direction, temperature, surface pressure, height
Overwater data	Sea.dat	Selective	Air-sea temperature difference, air temperature, humidity, wind speed, wind direction, water surface mixture height
Geophysical data of domain	Geo.dat	Compulsory	Compulsory: land use categories, terrain height Selective: surface roughness, albedo, Bowen ratio, soil heat flux constant, anthropogenic heat flux, vegetative leaf area index

4. RESULTS AND DISCUSSION

Two alternative locations has been selected using the criteria. The first one is in Tekirdağ province, Çorlu district, Karamehmet village 15 km North of Çorlu town center. It is less than 1 km away from E80 highway. The dominant wind direction in its location is Northeast, blowing the plume away from Çorlu and towards Muratlı more than 30 km away.

The other alternative location is in Edirne province, Havsa district, Azatlı village 15 km west of Havsa town center and 35 km southeast of Edirne city center. It is 7 km away from D100 state road and situated on an unused arable land. Wind direction is mostly from the North, but not very dominant. The wind from the north will blow the plume towards Greece.

As a reference, two thermal power plant projects in Thrace were chosen. Çerkezköy TPP, a lignite-fired 990 MW power plant project owned by EÜAŞ is very close to Çerkezköy town center. The other one, Çebi TPP, is an imported coal-fired power plant project with 350 MW power. It is 5 km west of Marmara Ereğlisi. Despite being powered with imported coal, its location is compatible with criteria in this study. The dominant wind direction in its location is from Northeast and it is located on an arable land.

Usage of chemical transformation will primarily allow us to simulate NO - NO_2 transformations. During the exit from the stack 95% of the NO_x is NO, while most NO will transform into NO_2 after entering the atmosphere, which is the main pollutant in NO_x.

Dry deposition is the deposition of pollutants, including gases and particulate matter, as they settle out of the atmosphere or are absorbed by plant tissues. Whereas, wet deposition is the transfer of pollutants from the atmosphere to the earth by inclusion or solution in precipitation. Wet deposition typically involves gases and particulate matter, and especially acidic compounds or radioactive particles.

4.1 Current Air Quality Assessment

There are 11 air quality monitoring stations in the modelling area: 3 in Edirne province, 3 in Kırklareli province and 5 in Tekirdağ province.

Edirne station is close to Havsa site and will be used as an indicator for air quality in the project area. Whereas, Çorlu and Çorlu OSB are close to Çorlu site; Çerkezköy

MTHM is close to Çerkezköy site and Tekirdağ and Merkez MTHM are close to Marmara Ereğlisi site.

NO_2 is always higher in winter, because of heating. Keşan, Merkez MTHM and Çerkezköy have considerably high concentrations. With concentration slightly decreasing in all stations. Daily average NO_2 measurements in AQMSs across Thrace are given in **Figure 4.1.**

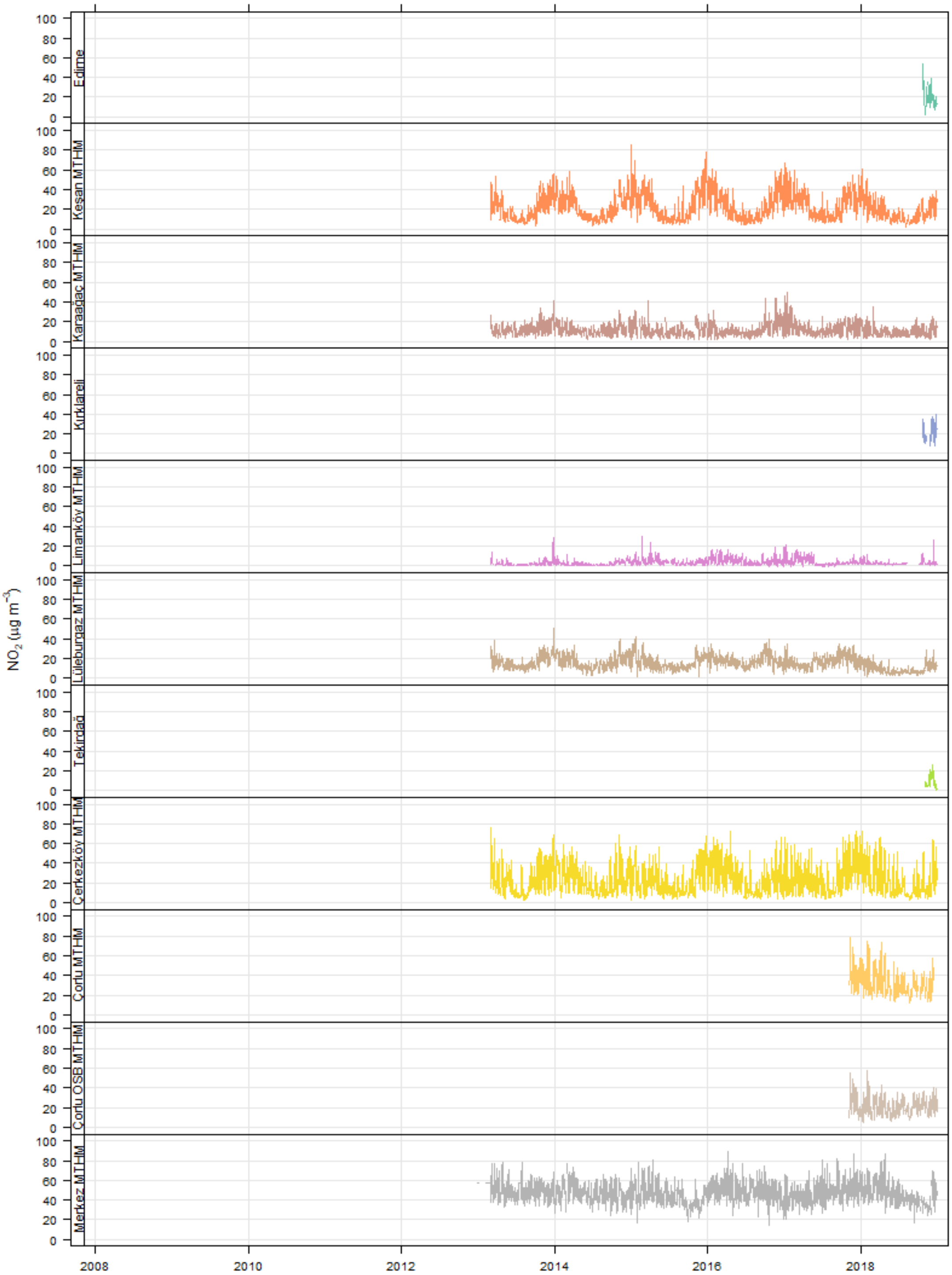

Figure 4.1. Daily average NO_2 measurements in AQMSs across Thrace

In Edirne there are two daily peaks at 8 a.m. and 6 p.m., which are also usual shift start and ends, indicating commute. Concentrations are much higher in winter, indicating less industrial NO_2 pollution and more heating pollution. Details are shown in **Figure 4.2.**

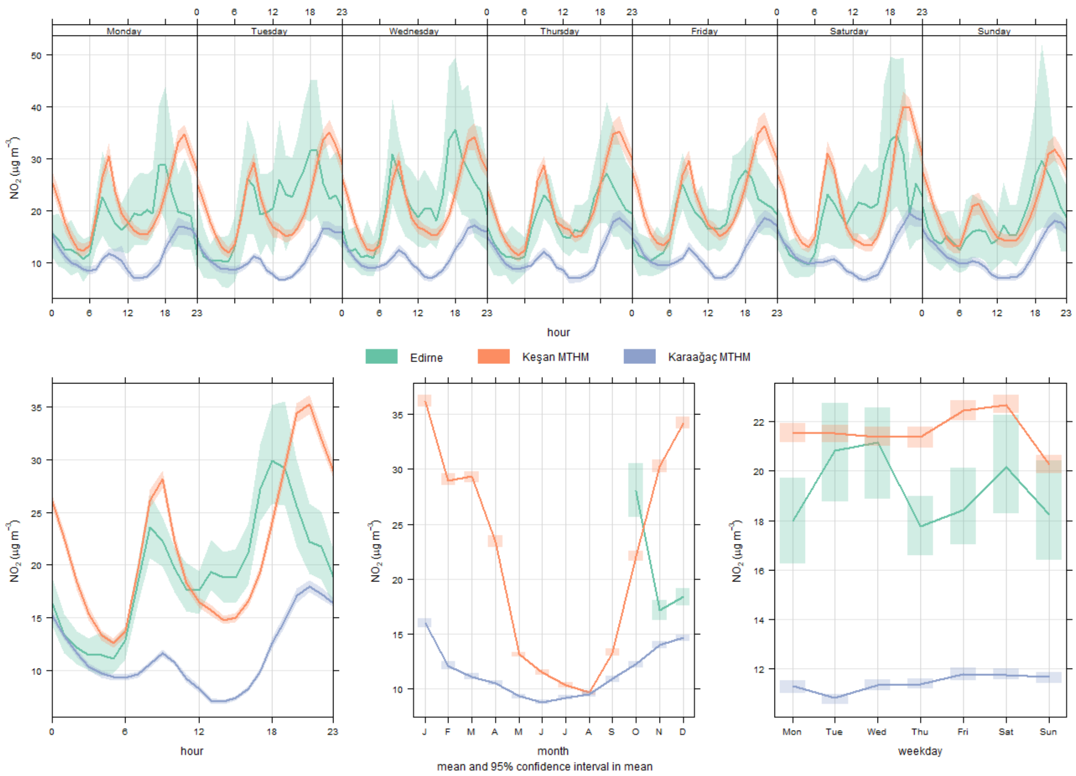

Figure 4.2. NO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Edirne

In Kırklareli Limanköy MTHM's distance from human activity describes its function as an ambient air quality station. There are two daily peaks at 8 a.m. and 6 p.m., which are also usual shift start and ends, indicating commute. Concentrations in winter don't differ much from the rest of the year, indicating industrial pollution rather than heating-induced pollution. Details are shown in **Figure 4.3.**

In Tekirdağ Merkez MTHM station stands out. It always has higher concentrations than others and its concentrations don't differ with seasons. This might be because of its proximity to main roads or to industries or both. There are two daily peaks at 8 a.m. and 6 p.m., which are also usual shift start and ends, indicating commute. Concentrations in winter don't differ much from the rest of the year, indicating industrial pollution rather than heating-induced pollution. Details are shown in **Figure 4.4.**

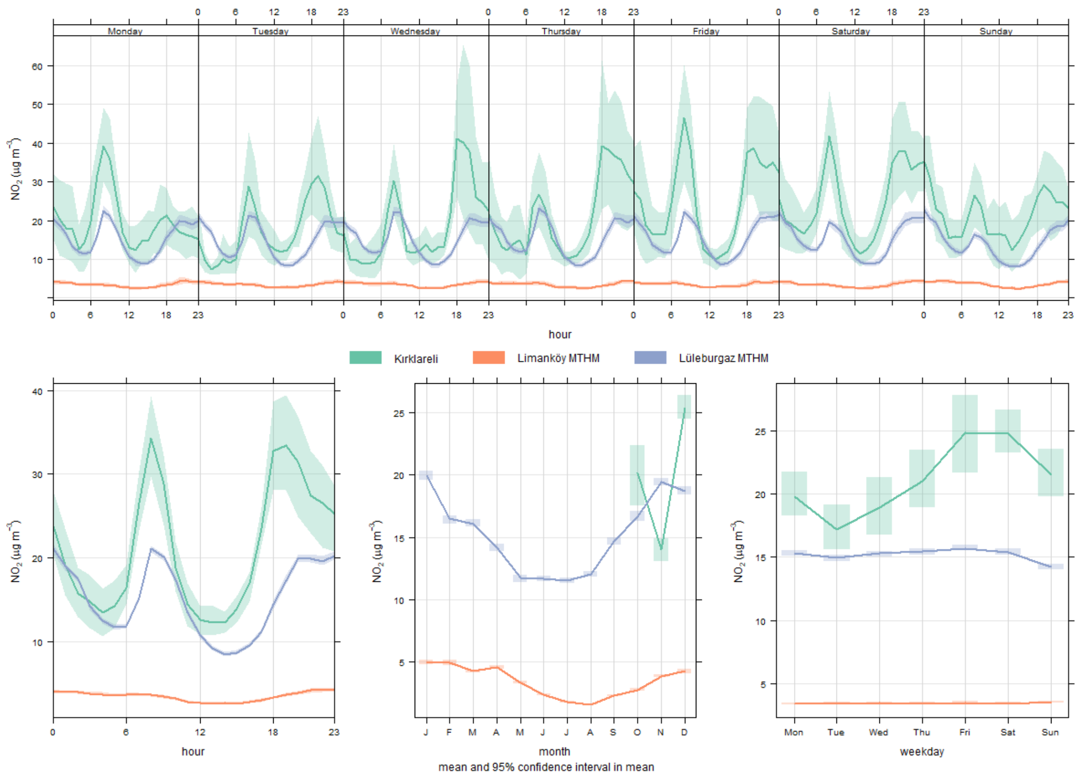

Figure 4.3. NO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Kırklareli

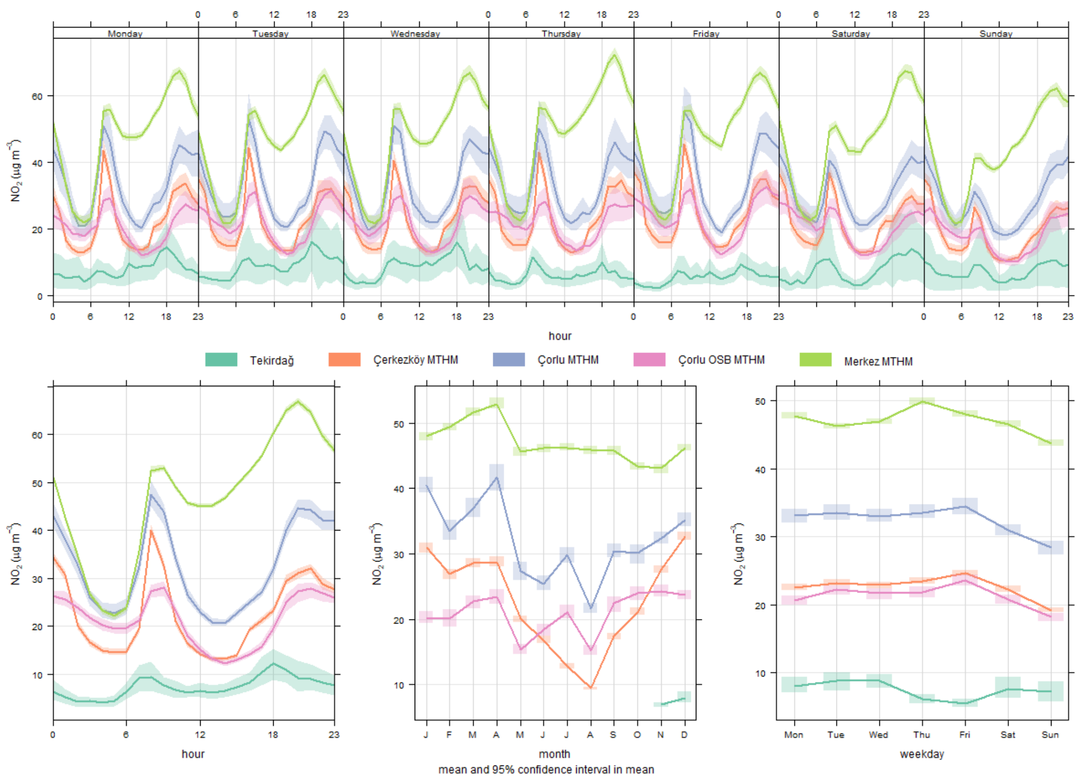

Figure 4.4. NO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Tekirdağ

As seen in **Table 4.1** all stations comply with regulations, and there is a trend of improvement.

Table 4.1. NO_2 measurements and their compliance with Air Pollution Evaluation and Management Directive.

Pollutant	AQ Station	Period[1,2]	2013	2014	2015	2016	2017	2018
NO_2 ($\mu g/m^3$)	Edirne	Hourly	-	-	-	-	-	0
		Annual	-	-	-	-	-	19.23
	Keşan	Hourly	0	0	0	0	0	0
		Annual	19.72	21.29	23.82	22.59	24.54	17.27
	Tekirdağ	Hourly	-	-	-	-	-	0
		Annual	-	-	-	-	-	7.41
	Kırklareli	Hourly	-	-	-	-	-	0
		Annual	-	-	-	-	-	21.21
	Çerkezköy	Hourly	0	0	0	0	0	0
		Annual	21.22	22.41	21.59	23.90	24.81	21.58
	Çorlu	Hourly	-	-	-	-	0	0
		Annual	-	-	-	-	38.59	31.44

[1] Hourly values are given as number of exceedences whereas, yearly values are given as averages.
[2] Hourly limit value 200 $\mu g/m^3$ (18 per year), annual limit value 200 $\mu g/m^3$

Daily average PM_{10} measurements are shown in **Figure 4.5**. Concentrations are higher in winter. Most stations are above the legal concentration limit but the air quality is slightly improving.

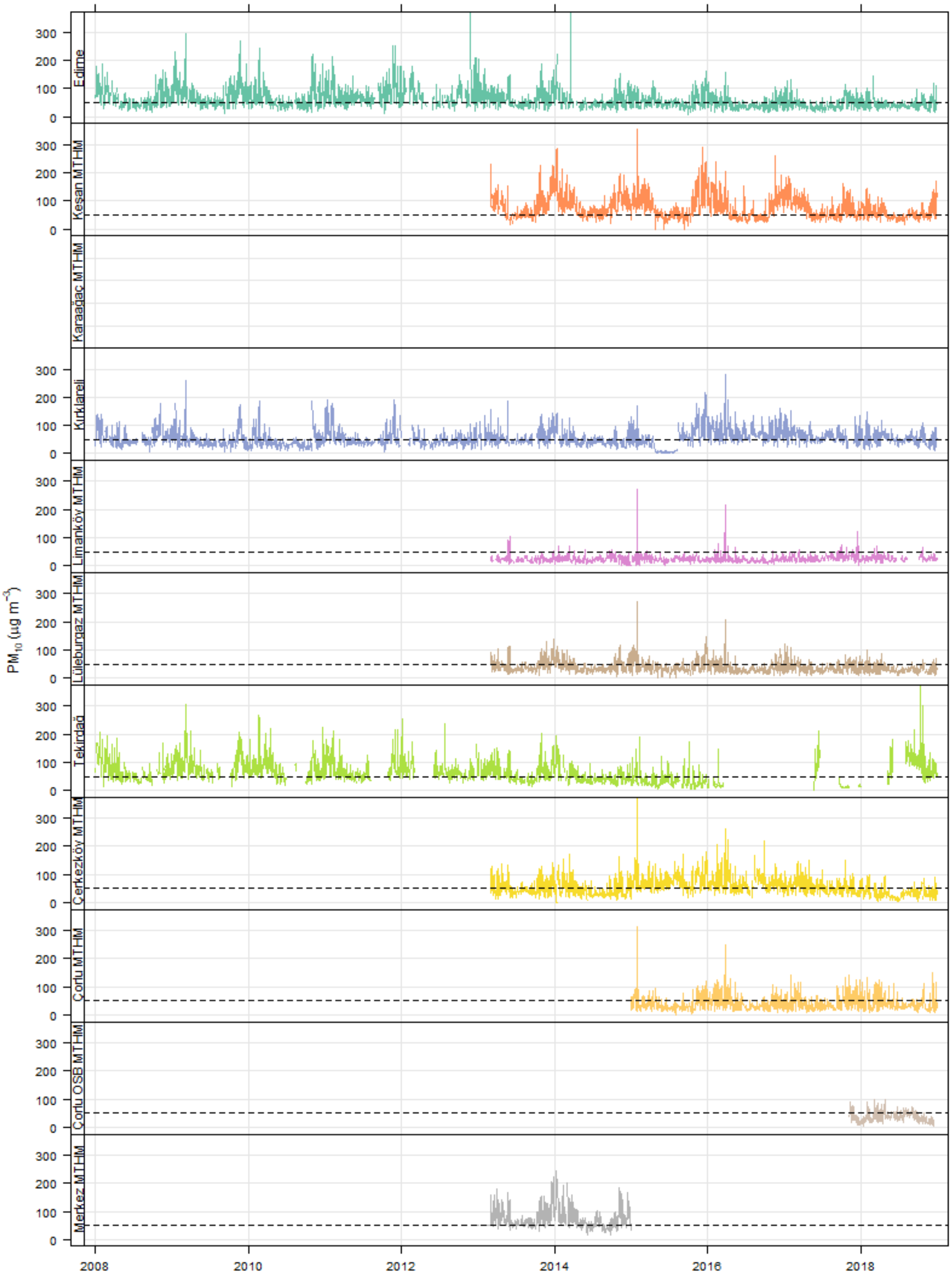

Figure 4.5. Daily average PM_{10} measurements in AQMSs across Thrace (dotted line is the legal limit)

In Edirne there are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations are much higher in winter, indicating less industrial PM_{10} pollution and more heating pollution. Details are shown in **Figure 4.6.**

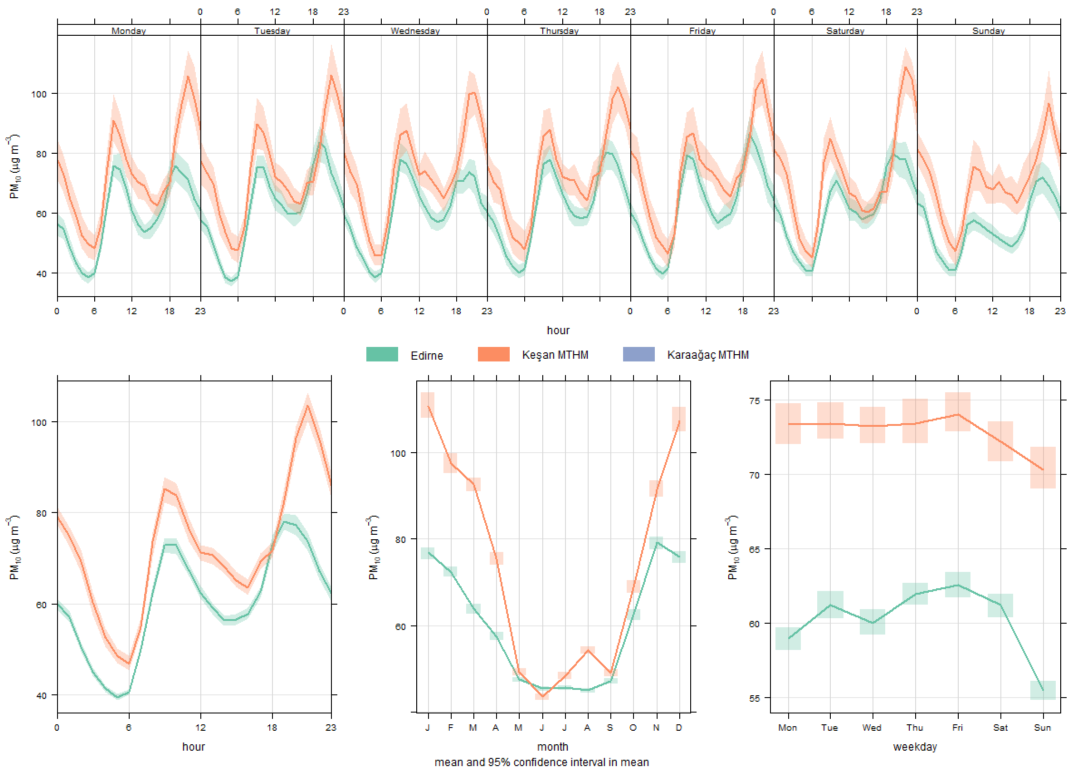

Figure 4.6. PM_{10} daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Edirne

In Kırklareli Limanköy MTHM's distance from human activity describes its function as an ambient air quality station. There are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations in winter don't differ as much from the rest of the year, indicating moe industrial pollution and less heating-induced pollution. Details are shown in **Figure 4.7.**

In Tekirdağ Merkez MTHM station stands out. It always has higher concentrations than others and its concentrations don't differ with seasons. This might be because of its proximity to main roads or to industries or both. There are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations in winter don't differ much from the rest of the year, indicating industrial pollution rather than heating-induced pollution. Details are shown in **Figure 4.8.**

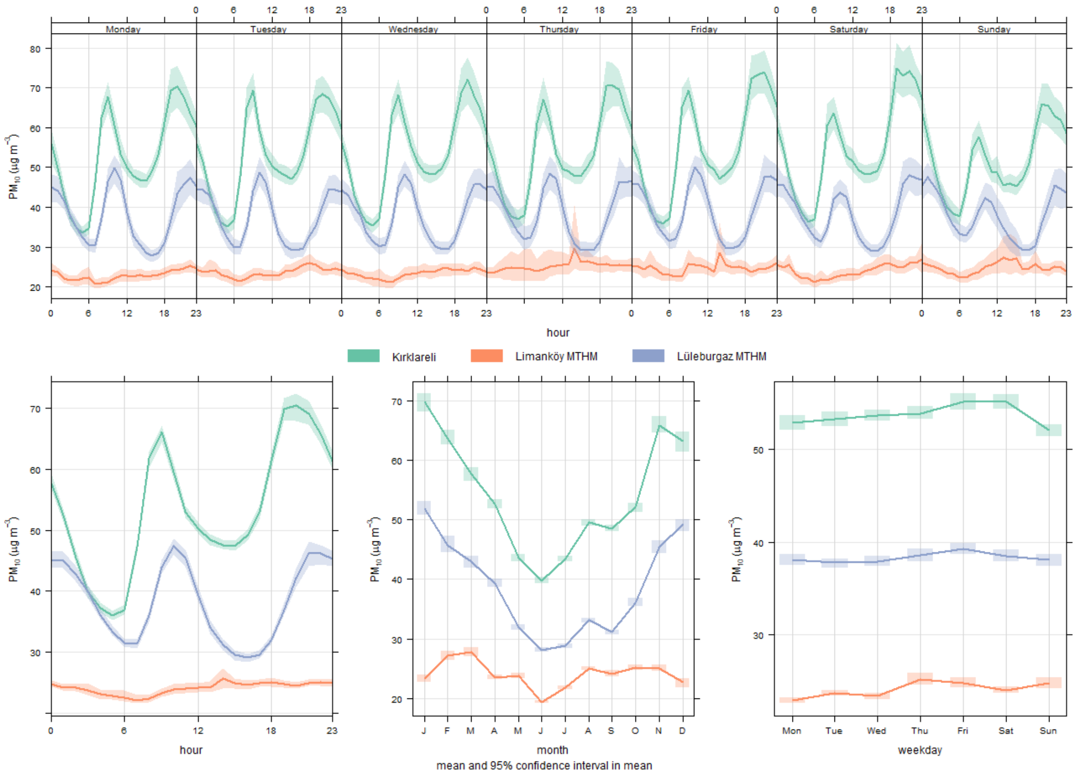

Figure 4.7. PM_{10} daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Kırklareli

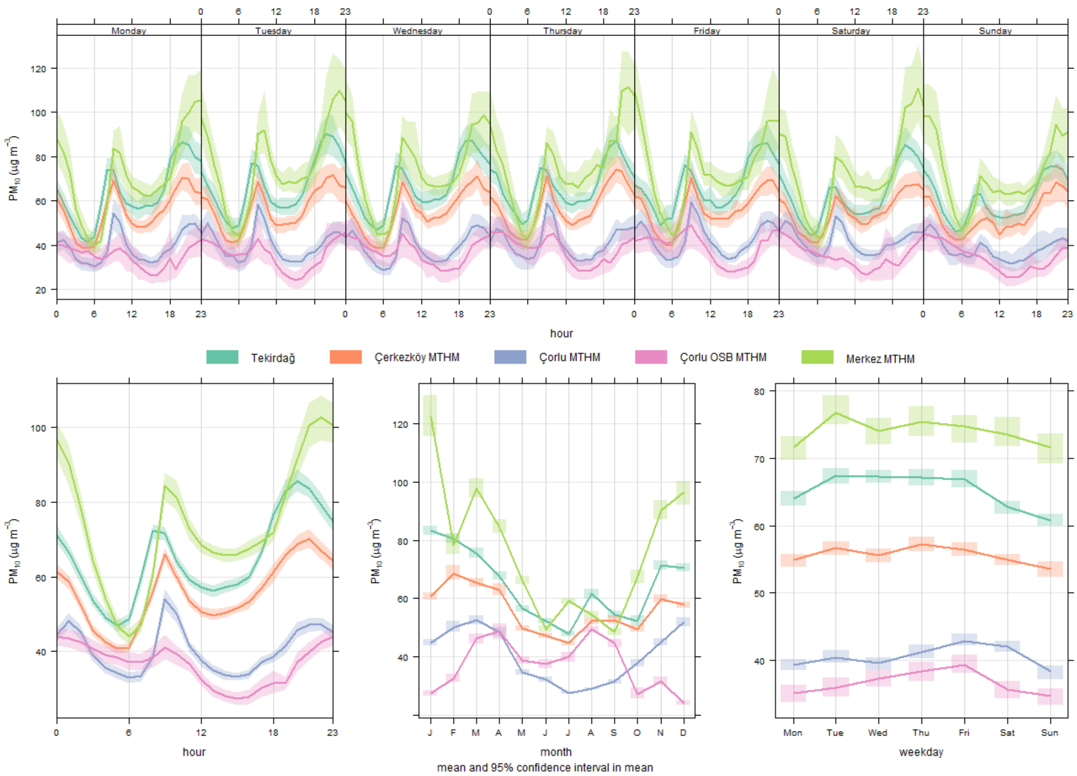

Figure 4.8. PM_{10} daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Tekirdağ

As seen in **Table 4.2** no stations comply with regulations, but there is a trend of improvement.

Table 4.2. PM_{10} measurements and their compliance with Air Pollution Evaluation and Management Directive.

Station	Pollutant	Period	2010	2011	2012	2013	2014	2015	2016	2017	2018
Edirne	PM_{10}	Daily	199	262	183	236	148	171	122	99	92
		Yearly	64.10	79.10	74.15	65.77	54.66	55.03	46.27	45.68	44.40
Keşan		Daily	-	-	-	199	303	264	222	218	178
		Yearly	-	-	-	76.17	85.77	78.69	70.49	71.61	55.45
Tekirdağ		Daily	208	193	185	176	108	56	1	24	155
		Yearly	79.00	72.12	69.03	61.17	49.71	35.14	21.16	42.19	94.30
Kırklareli		Daily	86	146	99	157	117	156	293	205	181
		Yearly	42.85	57.49	46.15	56.26	47.25	48.63	73.87	60.76	53.53
Çerkezköy		Daily	-	-	-	114	107	283	260	207	55
		Yearly	-	-	-	51.53	44.56	74.77	71.04	57.55	34.01
Çorlu		Daily	-	-	-	-	-	86	92	107	87
		Yearly	-	-	-	-	-	39.22	40.77	41.67	40.49

[1] Daily values are given as number of exceedences whereas, yearly values are given as averages.
[2] Daily limit value 50 µg/m³ (35 per year), annual limit value 40 µg/m³

Daily average SO_2 measurements are shown in **Figure 4.9**. Concentrations are much higher in winter. Some stations are above the legal concentration limit but the air quality is slightly improving.

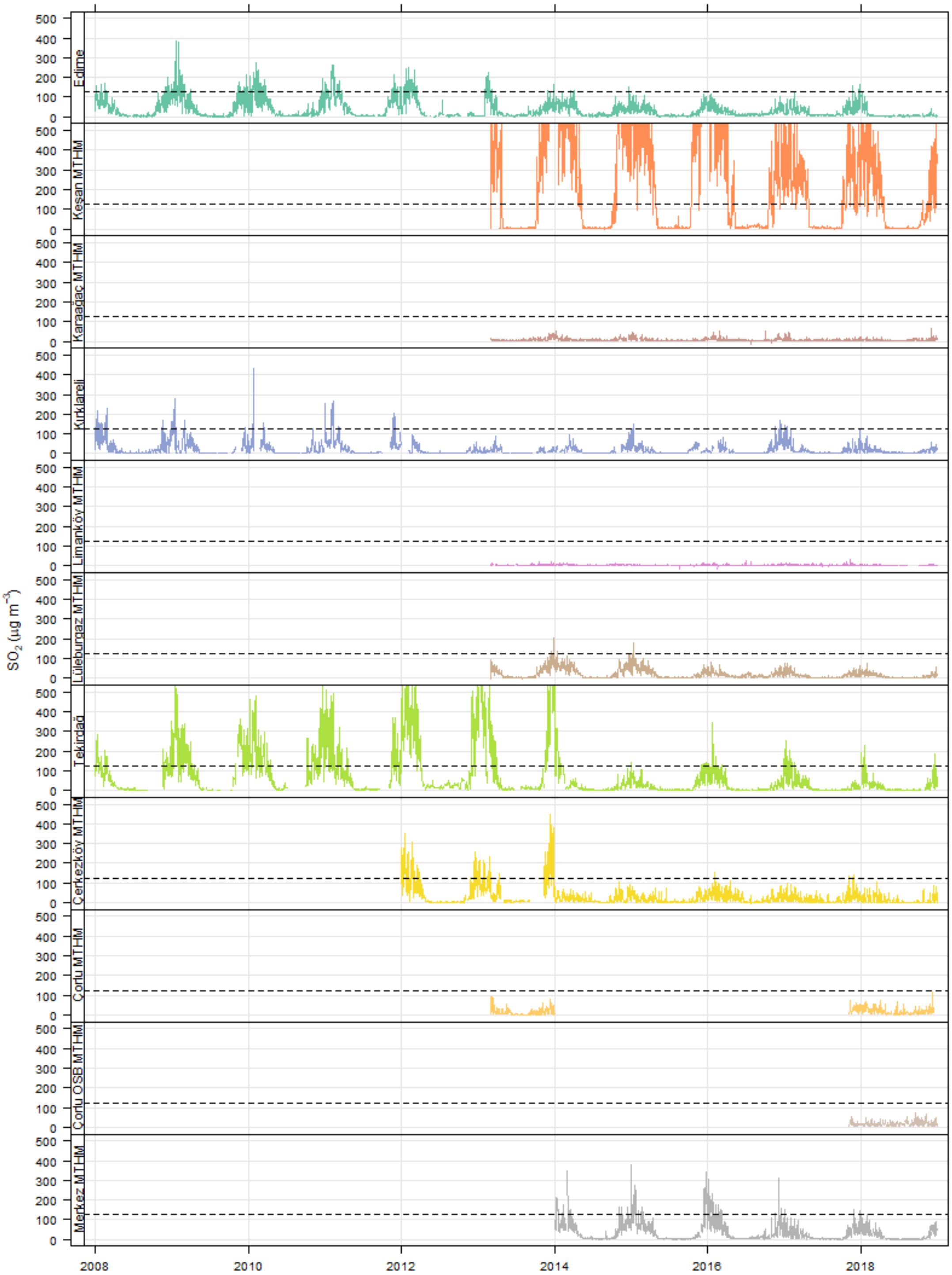

Figure 4.9. Daily average SO_2 measurements in AQMSs across Thrace (dotted line is the legal limit)

In Edirne there are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations are much higher in winter, indicating less industrial PM_{10} pollution and more heating pollution. Keşan MTHM station stands out for its high pollution. Details are shown in **Figure 4.10.**

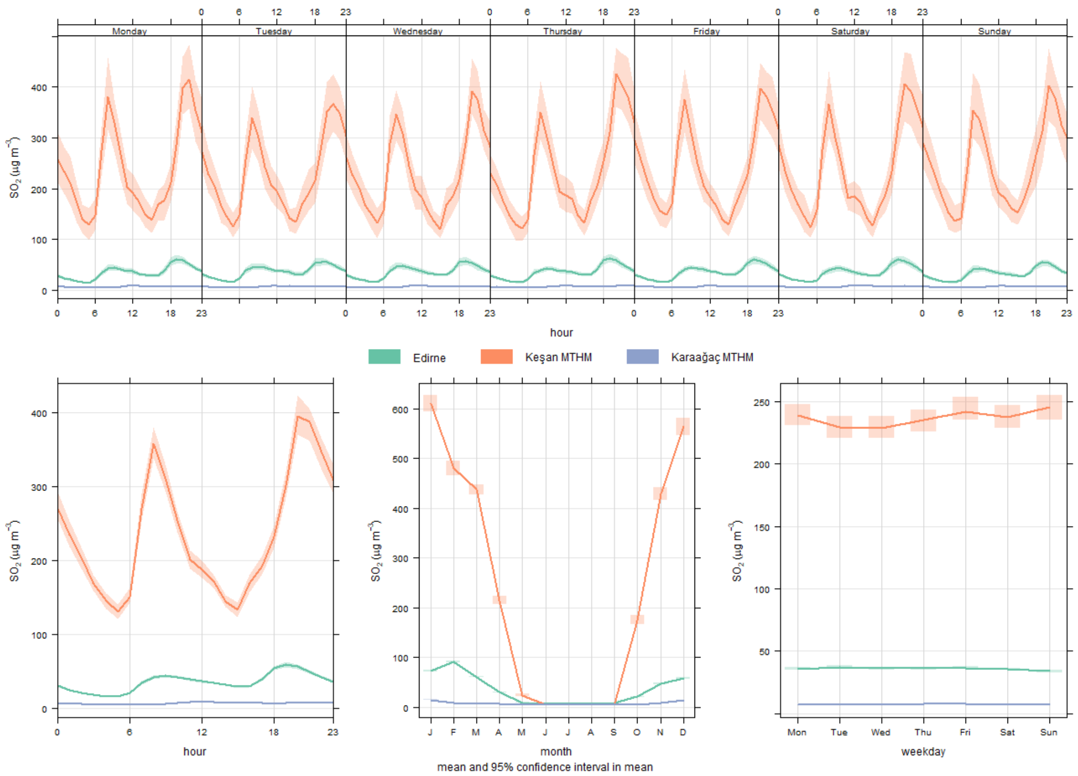

Figure 4.10. SO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Edirne

In Kırklareli Limanköy MTHM's distance from human activity describes its function as an ambient air quality station. There are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations are much higher in winter, indicating less industrial PM_{10} pollution and more heating pollution. Details are shown in **Figure 4.11.**

In Tekirdağ Merkez MTHM station stands out. It always has higher concentrations than others and its concentrations don't differ with seasons. This might be because of its proximity to main roads or to industries or both. There are two daily peaks at 9 a.m. and 8 p.m., which are 1-2 hours later than usual shift start and ends, indicating commute. Concentrations in winter don't differ much from the rest of the year, indicating industrial pollution rather than heating-induced pollution. Details are shown in **Figure 4.12.**

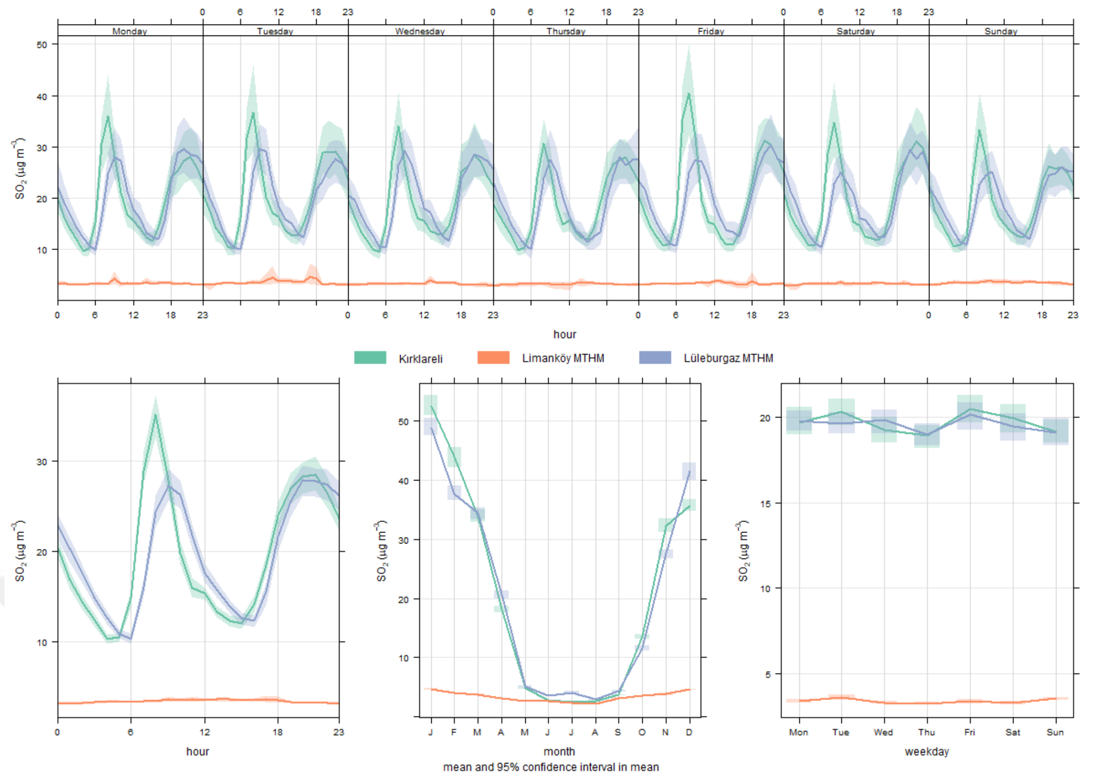

Figure 4.11. SO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Kırklareli

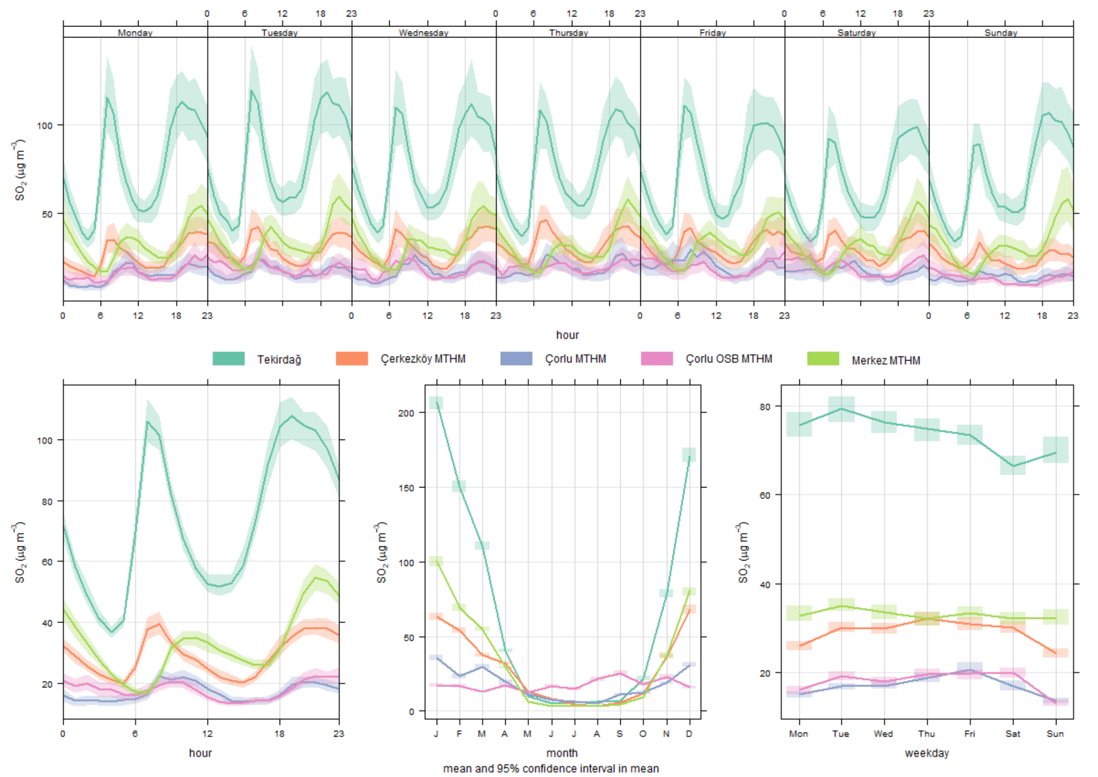

Figure 4.12. SO_2 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Tekirdağ

As seen in **Table 4.3** a few stations comply with regulations, but there is a trend of improvement.

Table 4.3. SO_2 measurements and their compliance with Air Pollution Evaluation and Management Directive.

Station	Pollutant	Period	2010	2011	2012	2013	2014	2015	2016	2017	2018
Edirne	SO_2	Hourly	103	102	57	68	26	5	2	6	3
		Daily	43	53	40	23	4	0	0	2	0
		Yearly	45.0	57.1	48.5	34.1	33.1	24.6	24.8	27.1	9.55
		Winter	75.3	95.2	62.0	56.7	49.8	38.5	36.8	42.5	15.1
Keşan		Hourly	-	-	-	1696	2593	2608	2089	1443	1221
		Daily	-	-	-	129	196	188	173	184	132
		Yearly	-	-	-	245	298	317	265	165	138
		Winter	-	-	-	538	547	589	490	294	250
Tekirdağ		Hourly	572	510	1108	1015	77	7	22	30	18
		Daily	116	96	120	104	14	10	11	16	8
		Yearly	132	96.7	144	148	30.4	24.4	27.4	26.1	18.4
		Winter	181	180	241	264	52.6	42.5	49.5	41.8	35.1
Kırklareli		Hourly	44	61	2	0	5	6	21	10	0
		Daily	11	17	1	0	0	1	5	2	0
		Yearly	23.1	35.1	9.97	10.5	15.6	15.5	18.8	17.2	12.7
		Winter	43.6	74.7	24.0	15.1	25.7	27.8	32.8	28.1	19.8
Çerkezköy		Hourly	-	-	182	251	0	2	1	1	0
		Daily	-	-	120	119	25	28	57	31	25
		Yearly	-	-	57.6	71.1	17.7	15.8	24.1	18.4	12.6
		Winter	-	-	96.4	115	24.6	21.34	31.82	28.08	18.75
Çorlu		Hourly	-	-	-	0	-	-	-	0	1
		Daily	-	-	-	10	-	-	-	7	16
		Yearly	-	-	-	13.14	-	-	-	30.70	18.33
		Winter	-	-	-	34.27	-	-	-	29.77	25.93

[1] Daily and hourly values are given as number of exceedences whereas, yearly and winter values are given as averages.
[2] Daily limit value 125 µg/m^3 (3 per year), hourly limit value 350 µg/m^3(24 per year) annual and winter limit value 40 µg/m^3
[3] Winter conditions are from 1stof October to 31stof March.

Daily average O_3 measurements are shown in **Figure 4.13**. Concentrations are higher in summer because of the increased solar radiation.

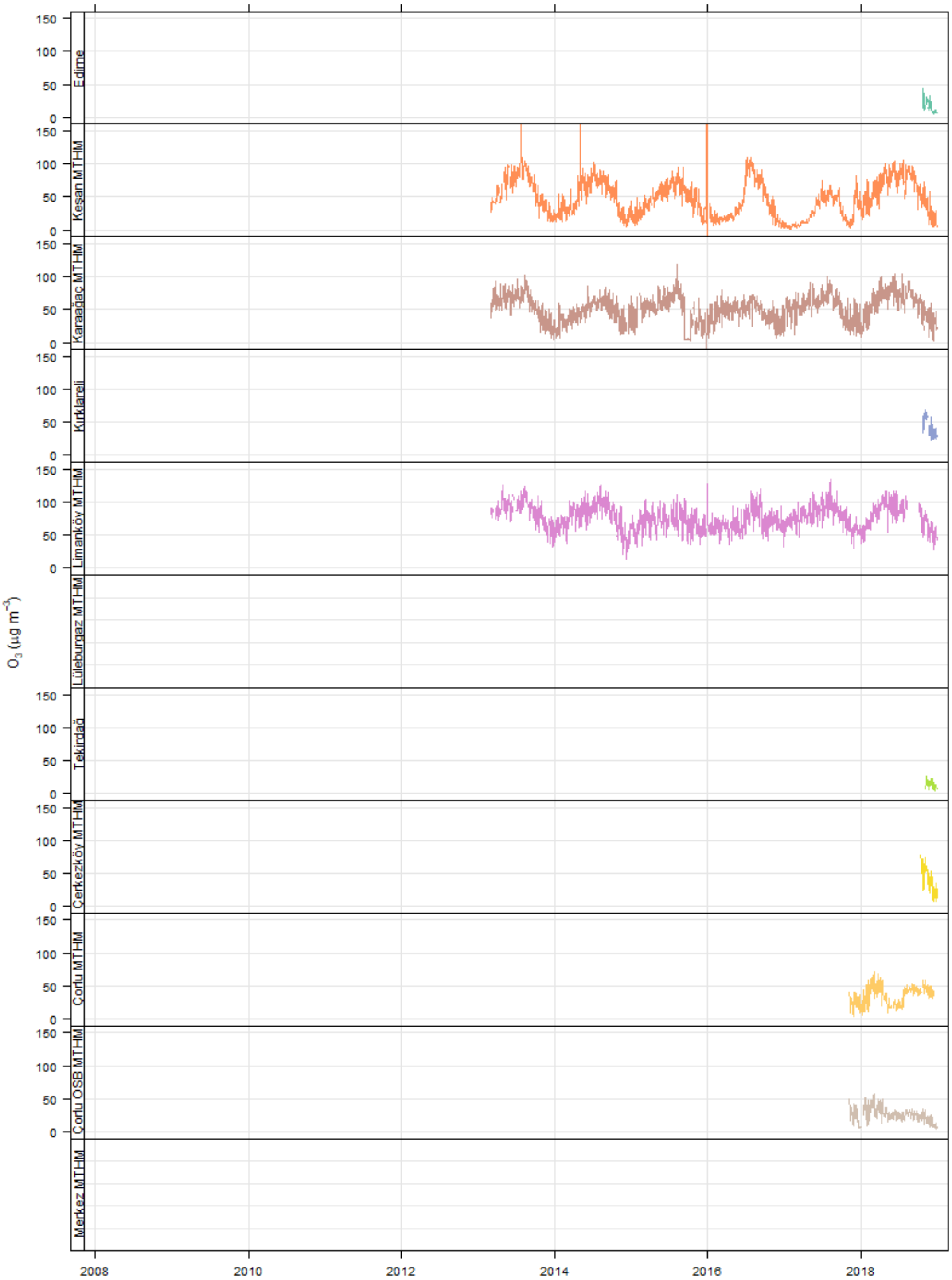

Figure 4.13. Daily average O_3 measurements in AQMSs across Thrace

In Edirne there is one daily peak at 3 p.m. Concentrations are higher in summer. Details are shown in **Figure 4.14.**

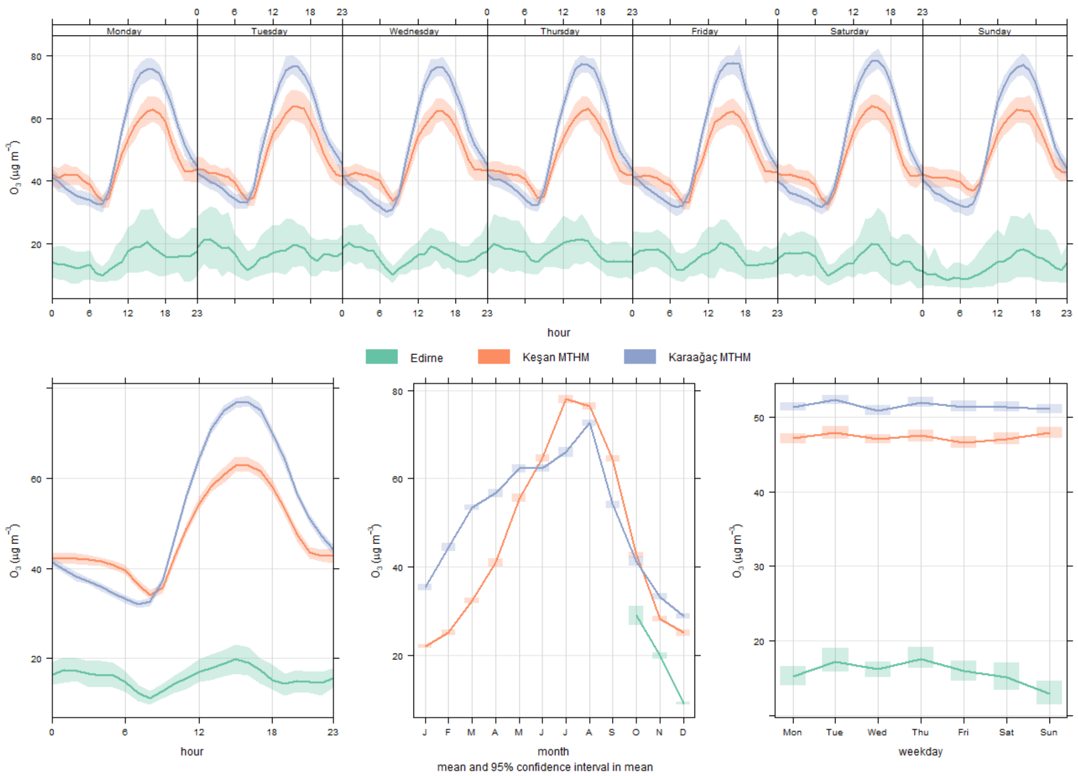

Figure 4.14. O_3 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Edirne

In Kırklareli Limanköy MTHM's distance from human activity describes its function as an ambient air quality station, the reason of its higher concentrations are because of its clearer skies. There is one daily peak at 3 p.m. Concentrations are higher in summer. Details are shown in **Figure 4.15.**

In Tekirdağ there is one daily peak at 3 p.m. Concentrations are higher in summer. Details are shown in **Figure 4.16.**

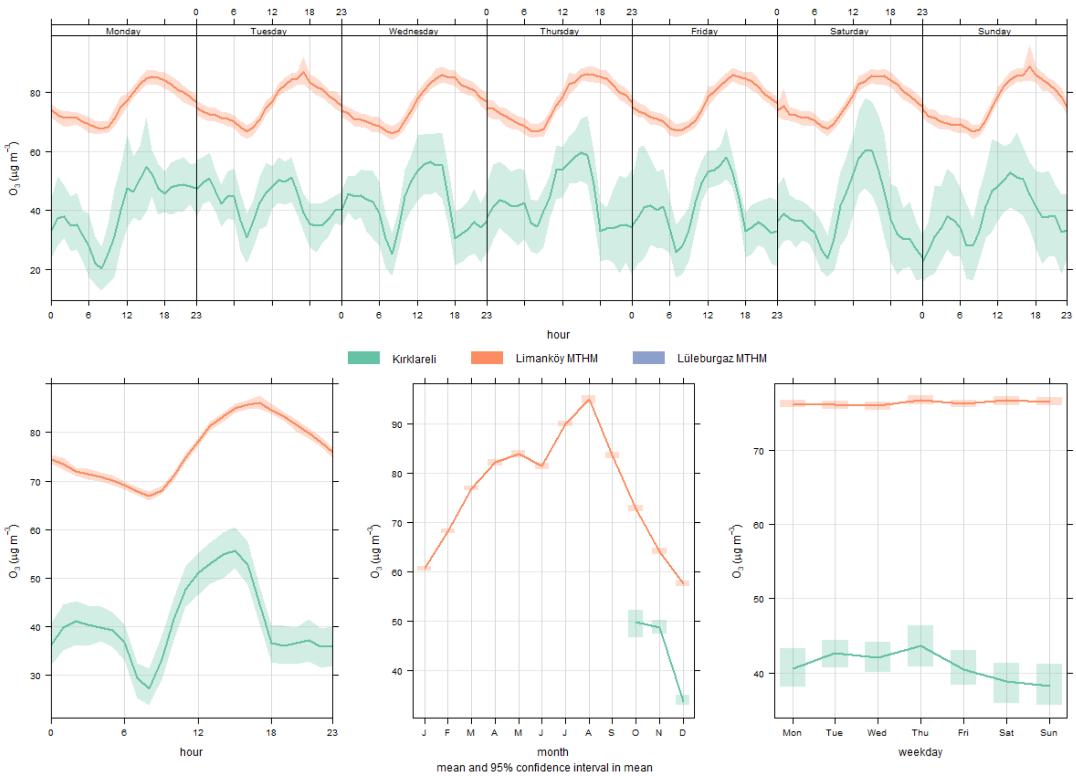

Figure 4.15. O_3 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Kırklareli

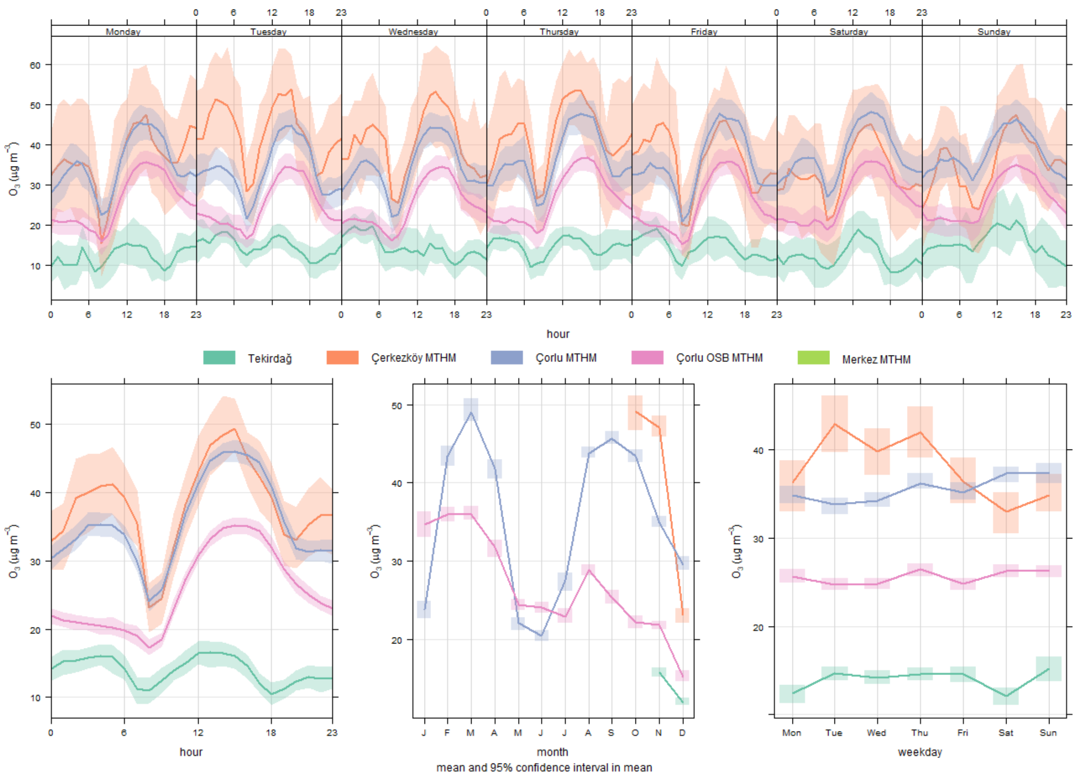

Figure 4.16. O_3 daily and hourly (top) hourly (bottom left) monthly (bottom middle) and weekly (bottom right) statistics for Tekirdağ

4.2 Dispersion Modelling Results

All stations are first modelled without chemical transformation and then with chemical transformation for concentration and dry deposition of SO_2, PM_{10} and NO_2. Wet deposition results came very close to zero and therefore not included in the results.

4.2.1 No chemical transformation

In models without chemical transformation NO-NO_2 transformation is also left out. And since there is no legal standard for NO_x, NO and NO_2 were not modelled.

4.2.1.1 Çerkezköy

Çerkezköy's SO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu. Maximum SO_2 concentration occurred in summer with 2.8 μg/m^3, given in **Figure 4.17**. Maximum PM_{10} concentration occurred in summer with 0.29 μg/m^3, given in **Figure 4.18**.

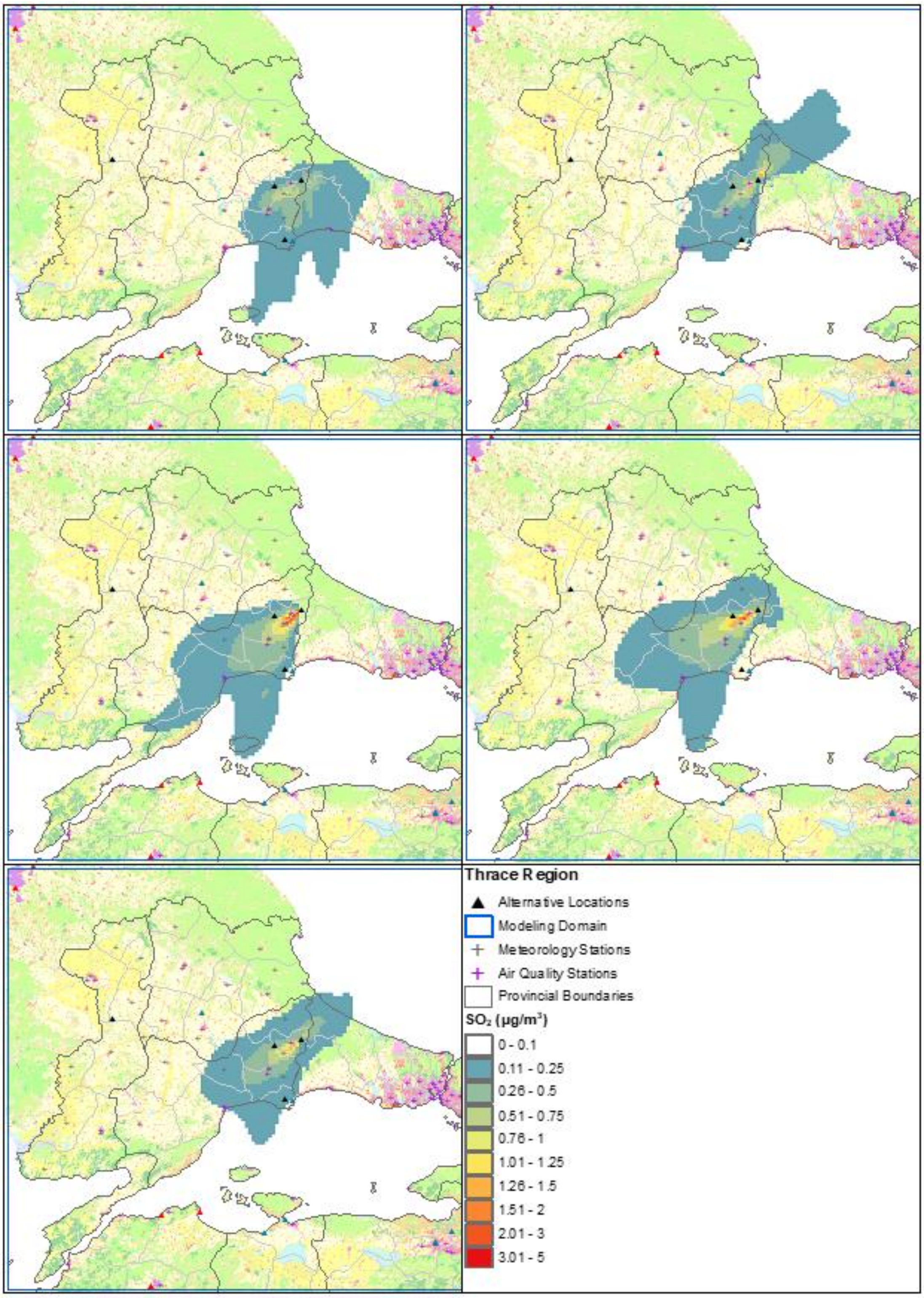

Figure 4.17. Çerkezköy SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

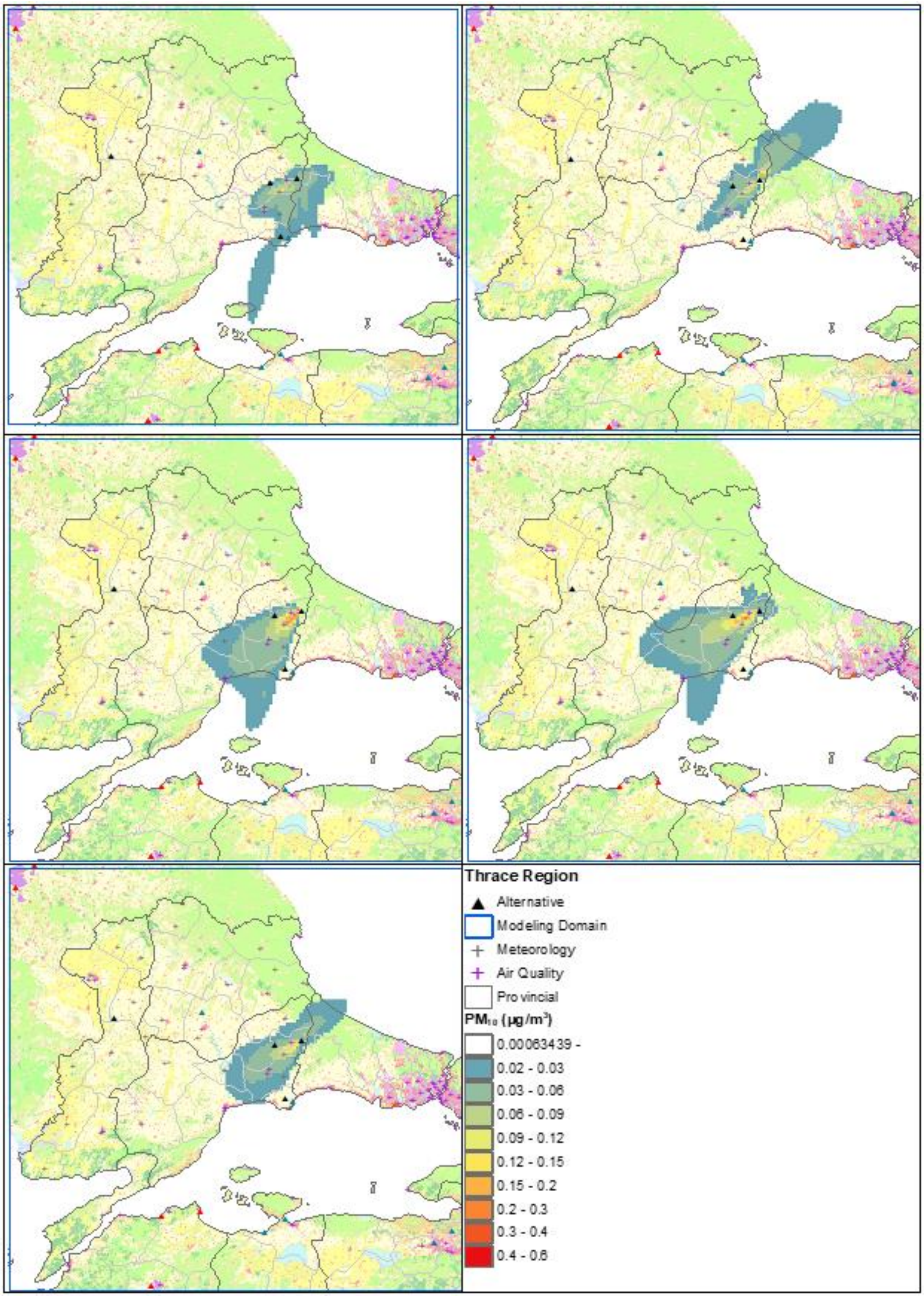

Figure 4.18. Çerkezköy PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Çerkezköy's SO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu. Deposirions are given in **Figure 4.19** and **Figure 4.20**.

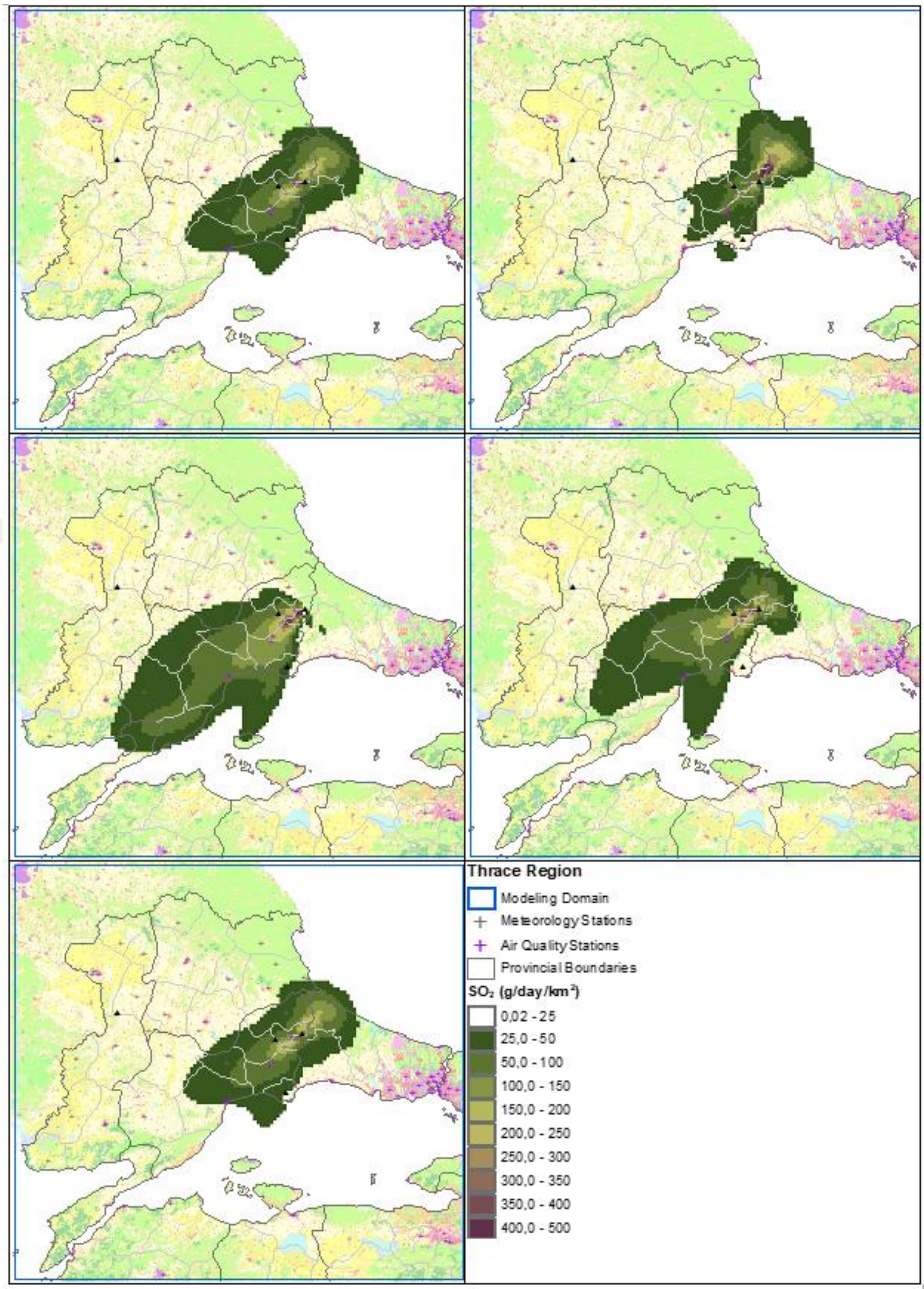

Figure 4.19. Daily SO_2 dry flux of Çerkezköy in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

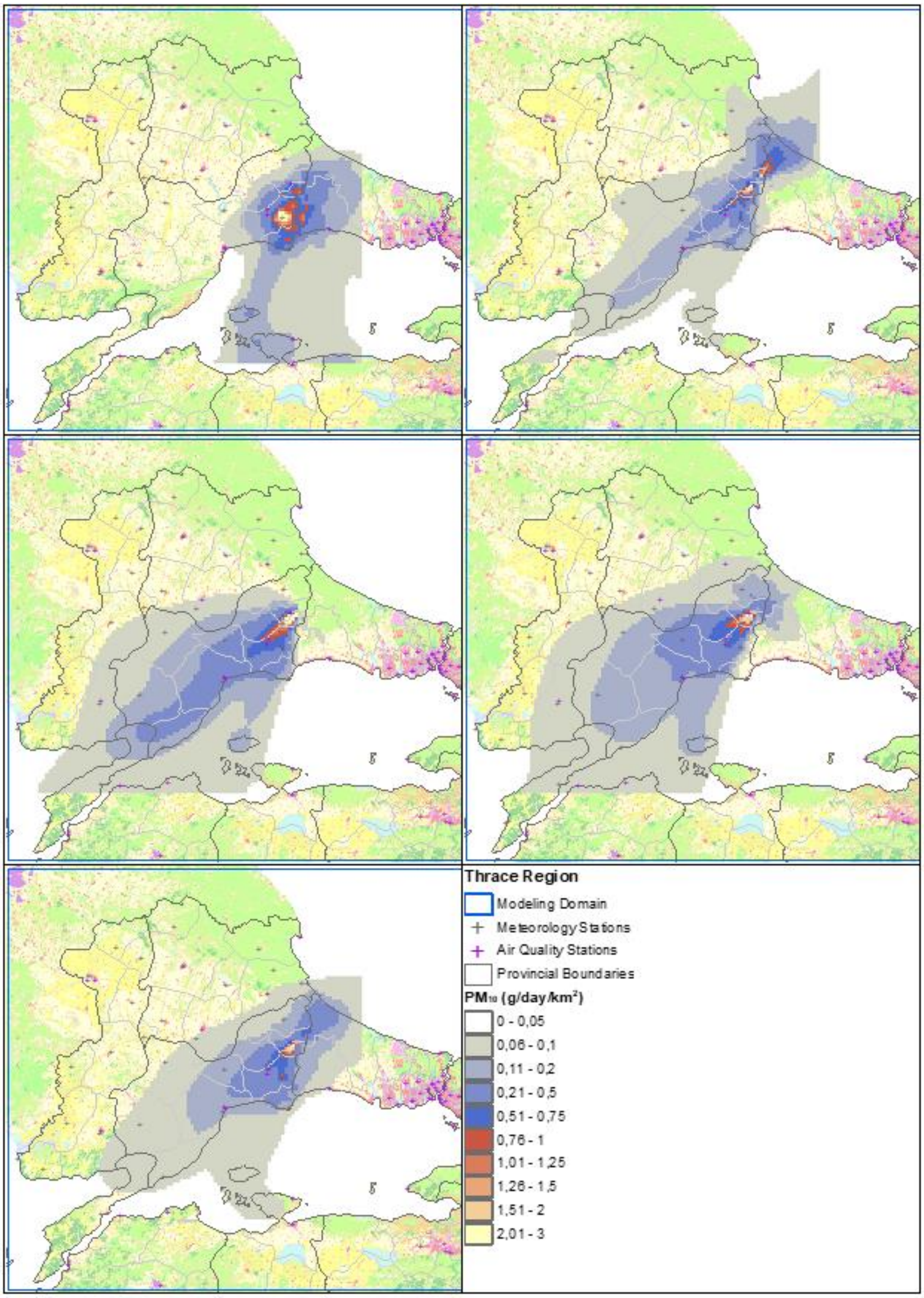

Figure 4.20. Daily PM_{10} dry flux of Çerkezköy in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.1.2 Çorlu

Çorlu's SO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu, with Tekirdağ being affected in some cases. Maximum SO_2 concentration occurred in summer with 3.73 μg/m^3, given in **Figure 4.21**. Maximum PM_{10} concentration occurred in summer 0.38 μg/m^3, given in **Figure 4.22**.

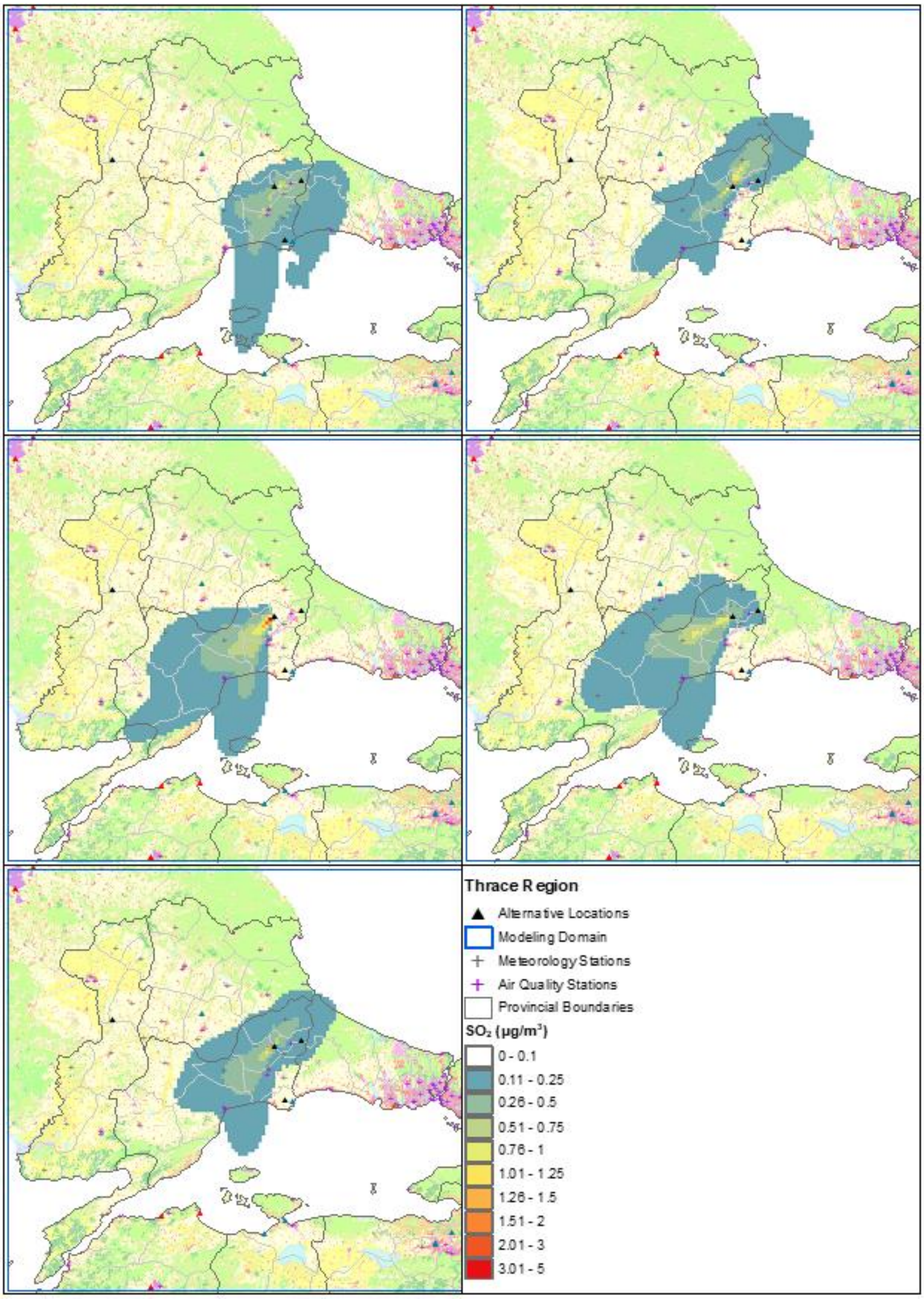

Figure 4.21. Çorlu SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

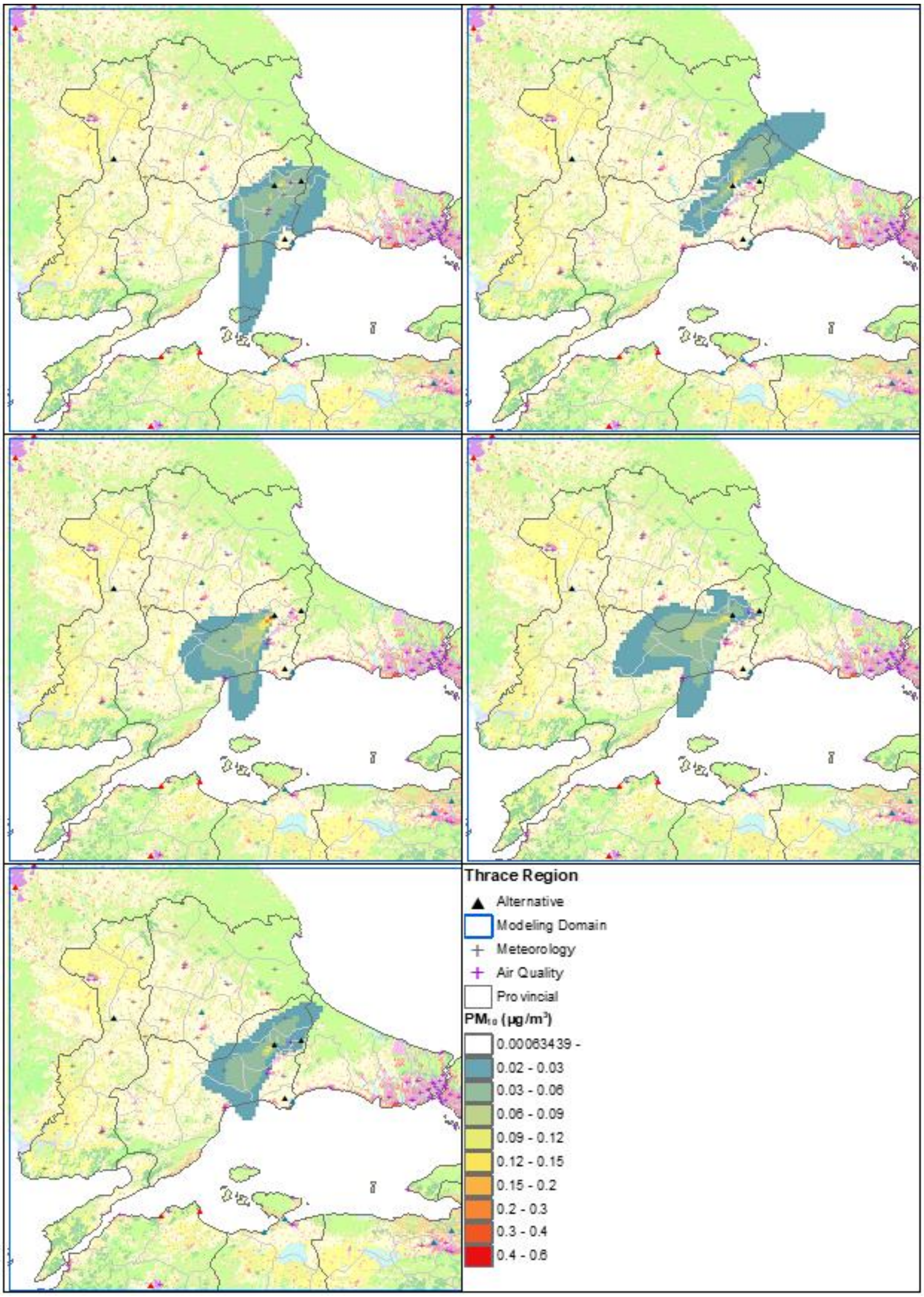

Figure 4.22. Çorlu PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Çorlu's SO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu, with Tekirdağ being affected in some cases. Dry deposition of SO_2 and PM_{10} are given in **Figure 4.23** and **Figure 4.24** respectively.

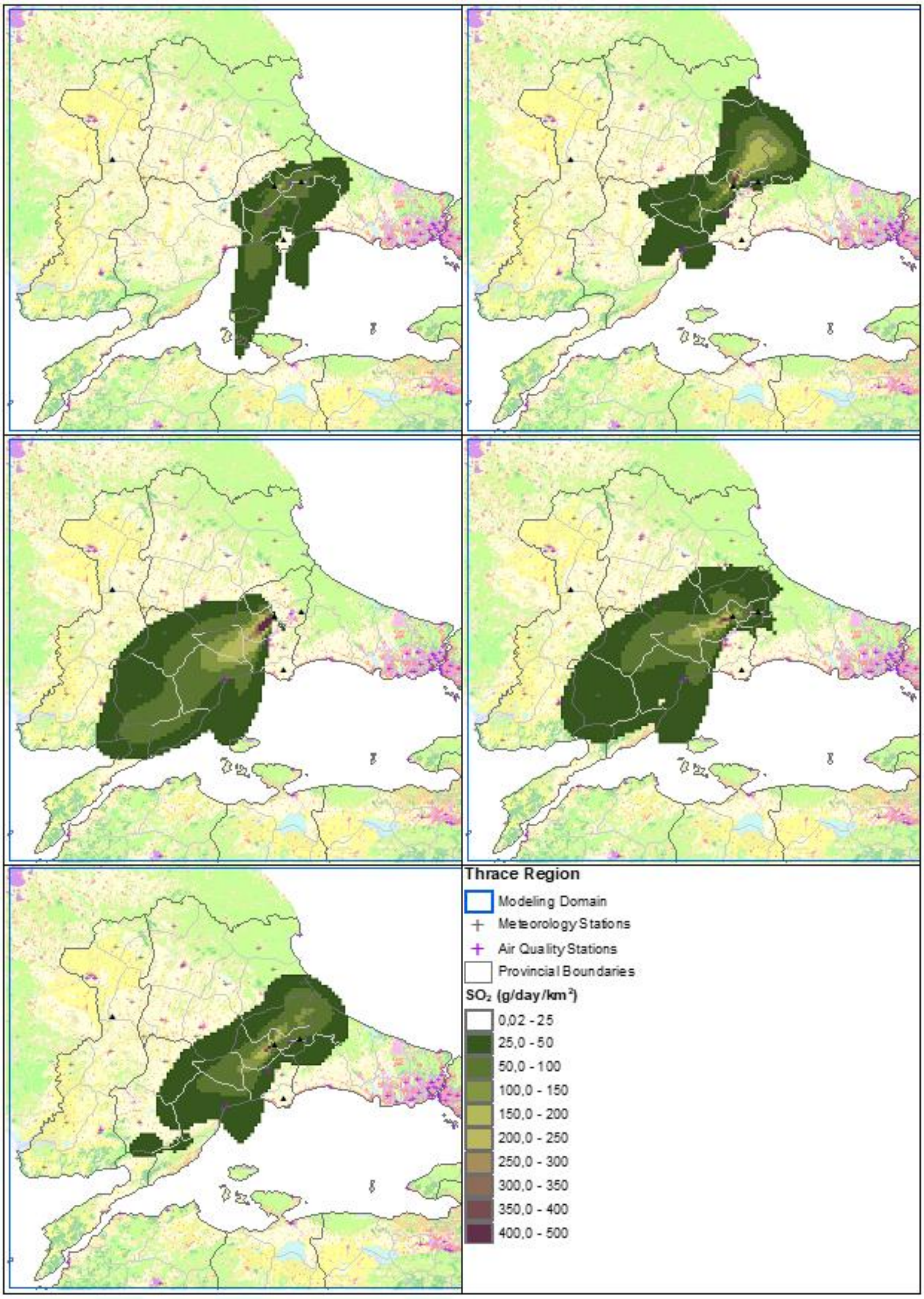

Figure 4.23. Daily SO_2 dry flux of Çorlu in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

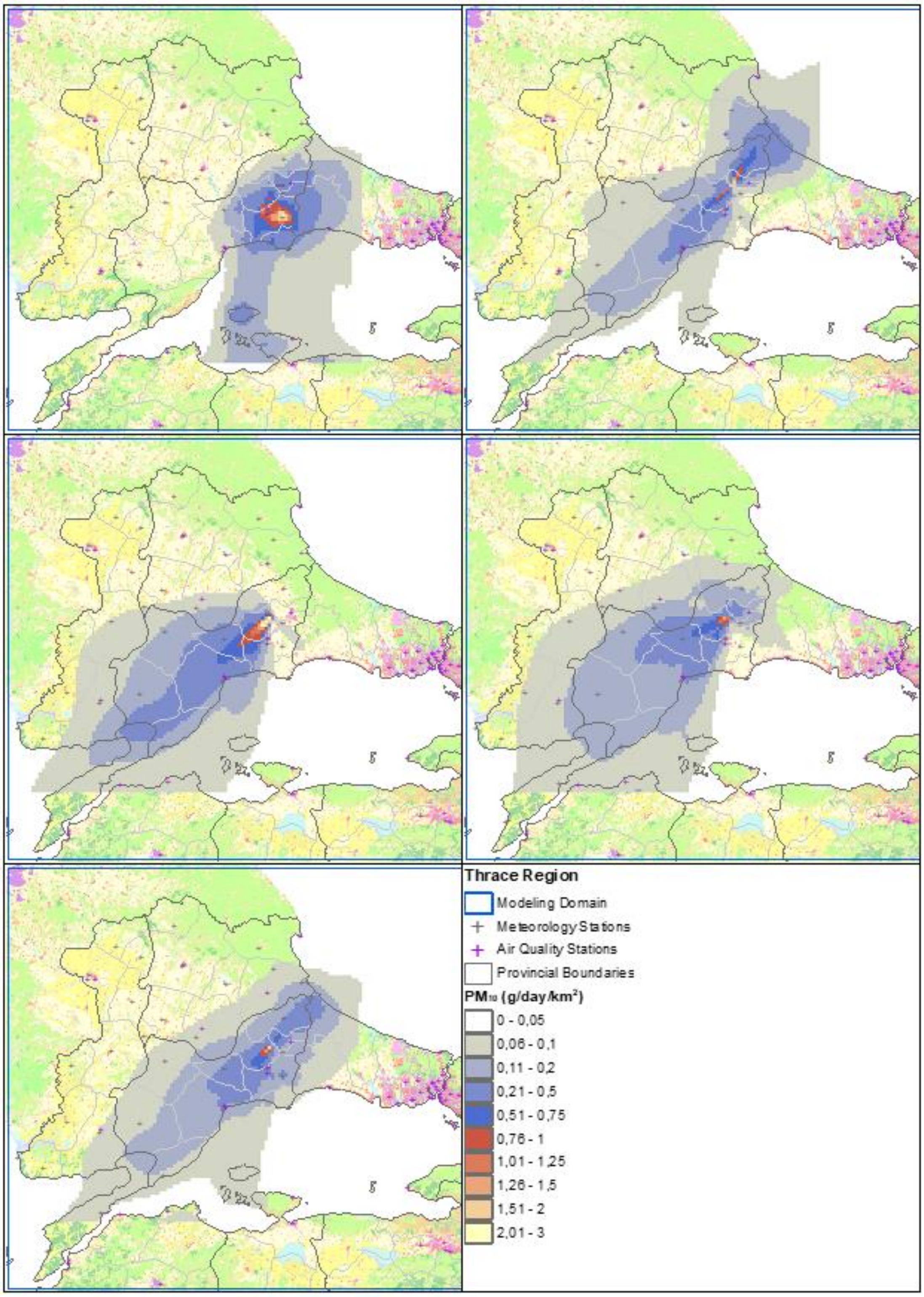

Figure 4.24. Daily PM_{10} dry flux of Çorlu in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.1.3 Marmara Ereğlisi

Marmara Ereğlisi's SO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Çorlu and Çerkezköy are affected only in spring. In other seasons concentrations usually dirperse towards the Marmara Sea. Maximum SO_2 concentration occurred in summer with 2.31 μg/m^3. Maximum PM_{10} concentration occurred in summer with 0.23 μg/m^3. Concentrations of SO_2 and PM_{10} are given in **Figure 4.25** and **Figure 4.26** respectively.

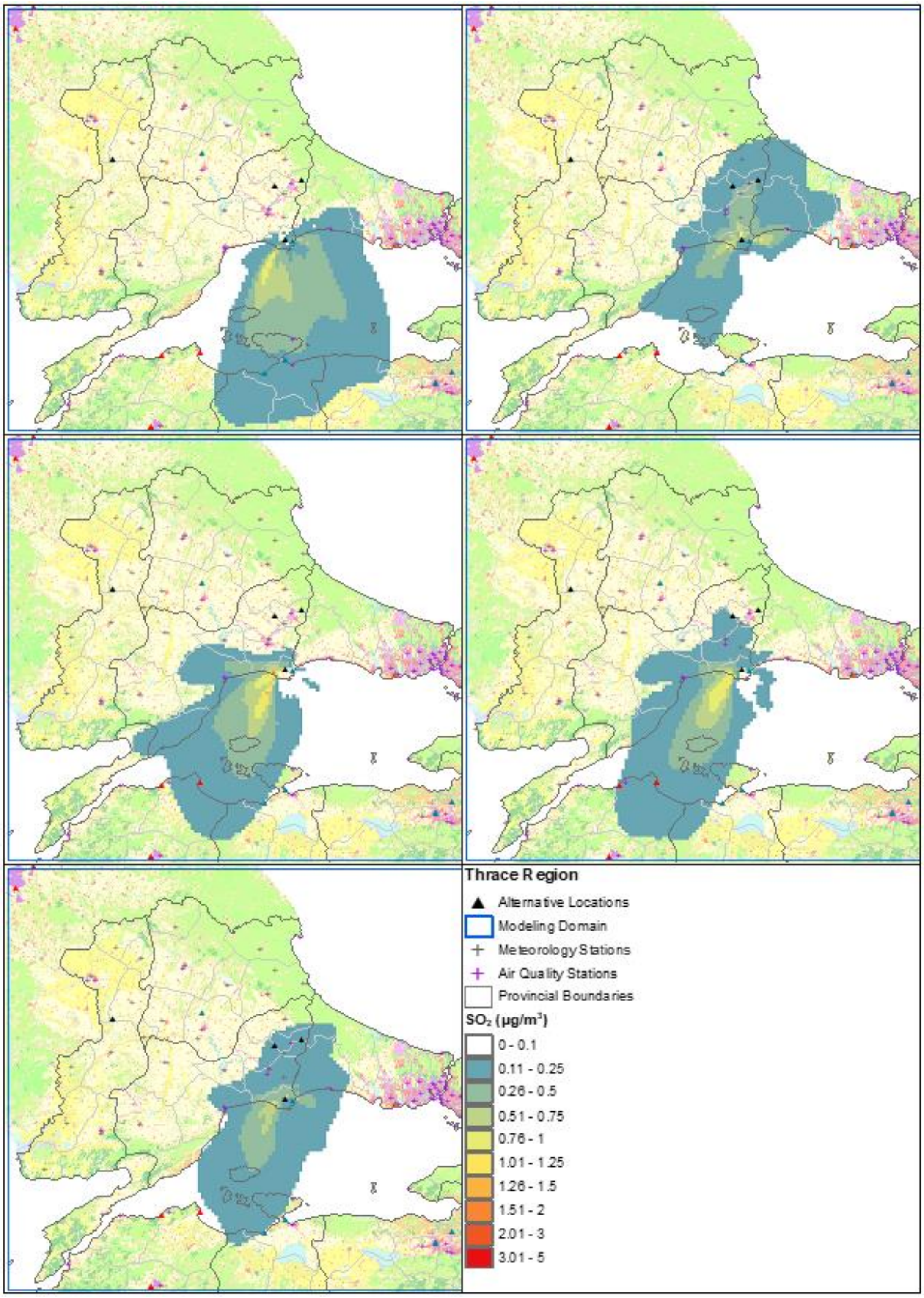

Figure 4.25. Marmara Ereğlisi SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

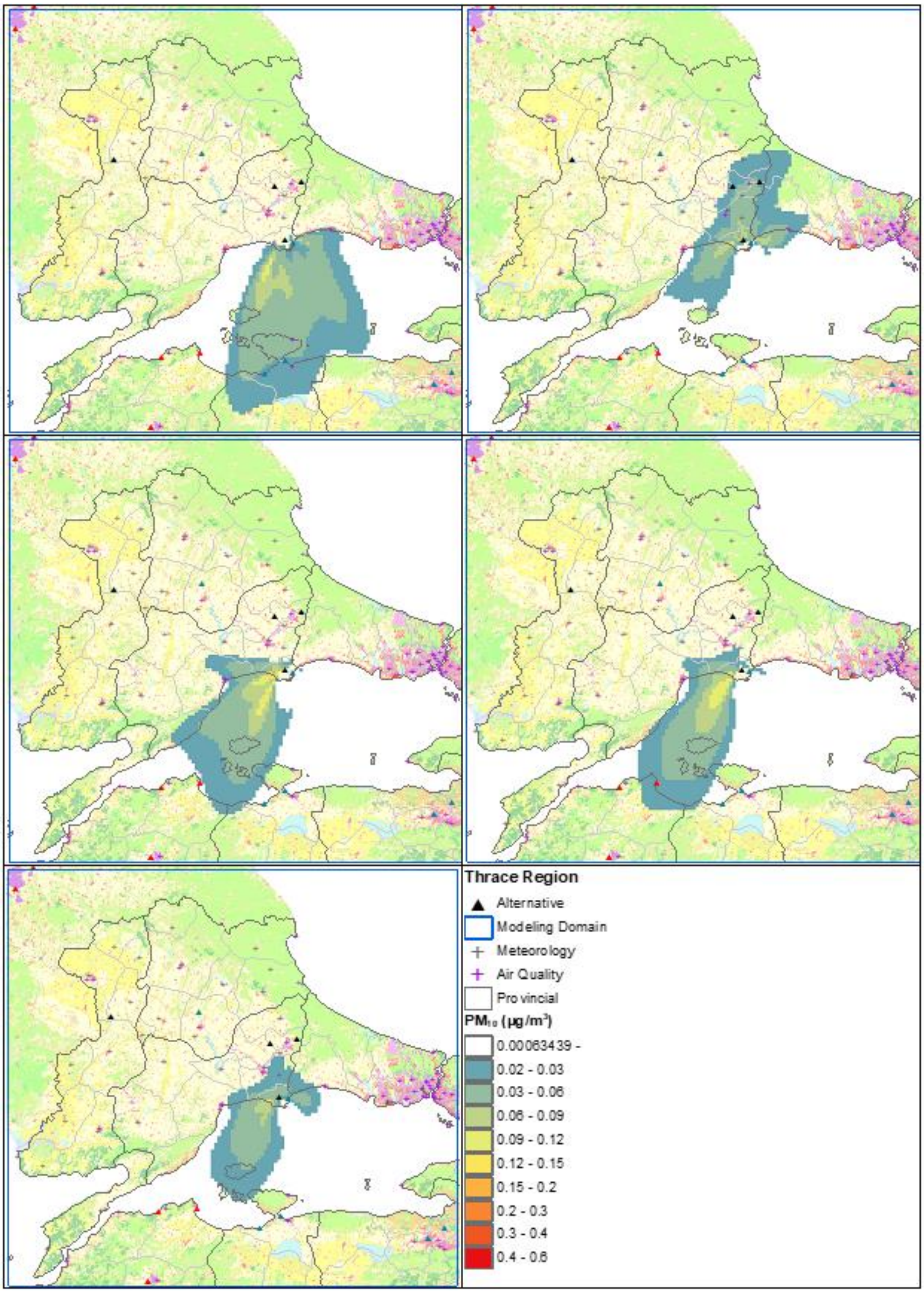

Figure 4.26. Marmara Ereğlisi PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Marmara Ereğlisi's SO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Çorlu and Çerkezköy are affected only in spring. In other seasons concentrations usually dirperse towards the Marmara Sea and Tekirdağ.

Concentrations of SO_2 and PM_{10} are given in **Figure 4.2527** and **Figure 4.268** respectively.

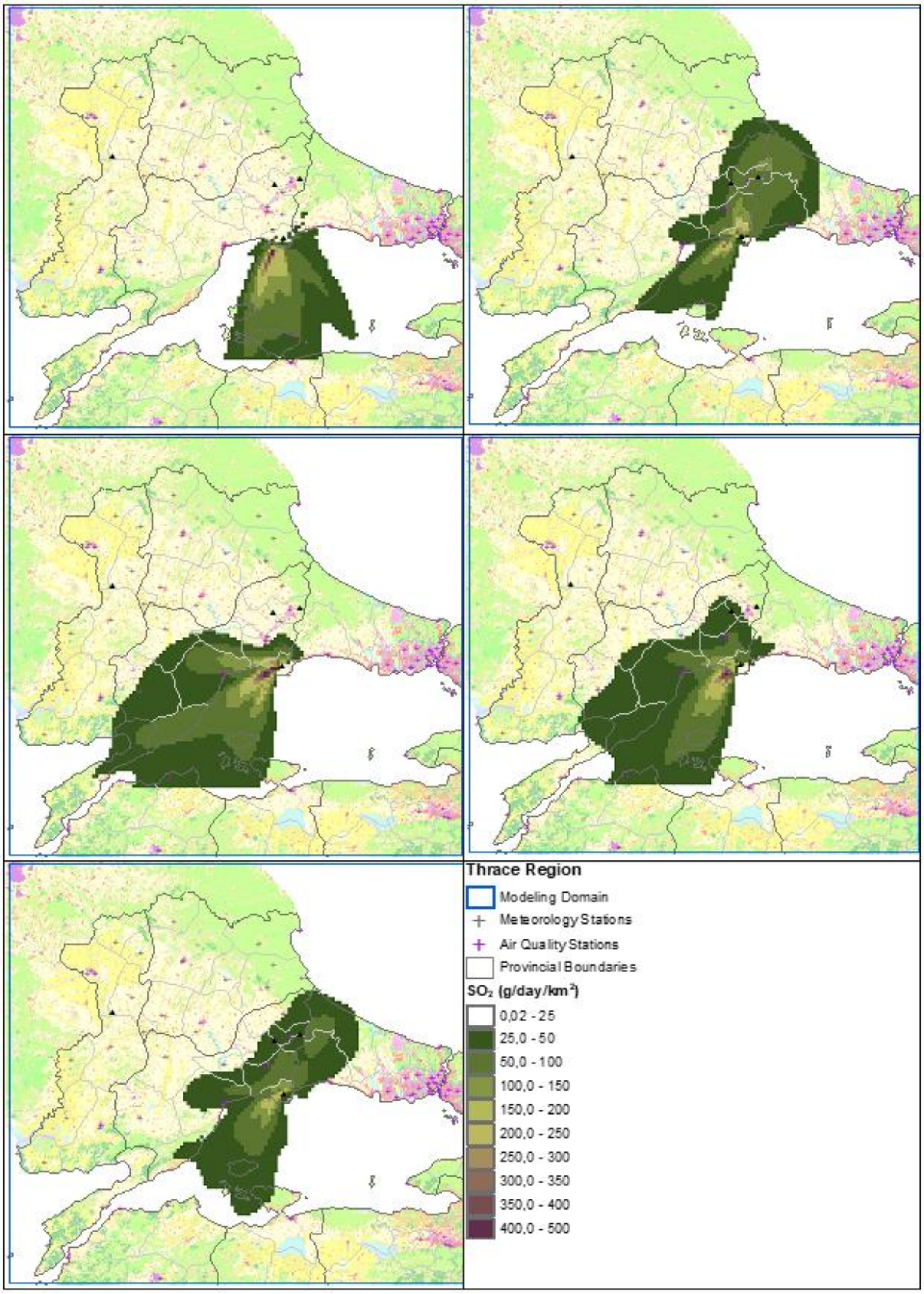

Figure 4.27. Daily SO_2 dry flux of Marmara Ereğlisi in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

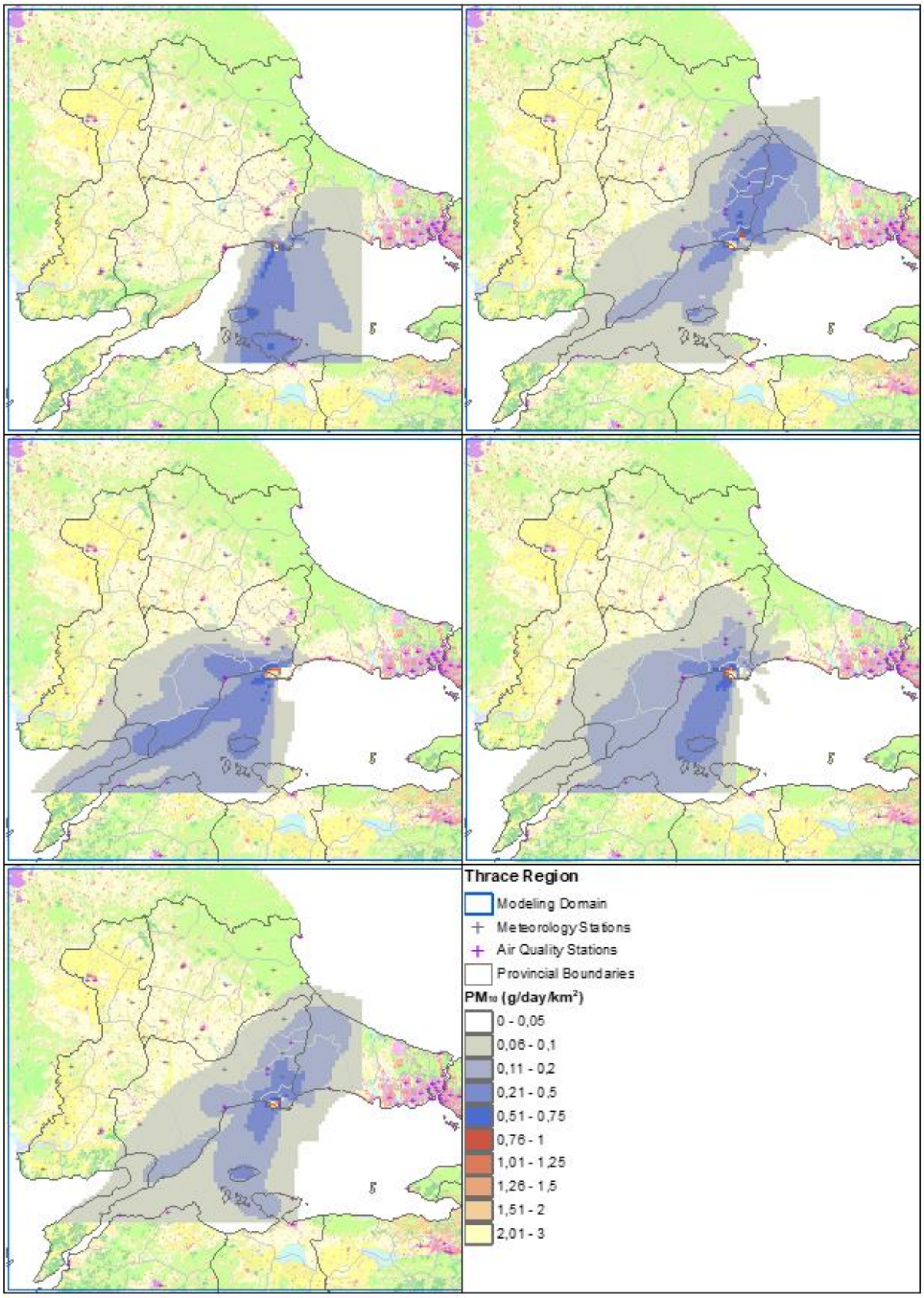

Figure 4.28. Daily PM_{10} dry flux of Marmara Ereğlisi in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.1.4 Havsa

Havsa's SO_2 and PM_{10} concentrations usually disperse towards south, except in winter when it is spreading toward north as well. Edirne city center is affected only in winter and spring, whereas Keşan, famous for its air pollution is slightly affected in summer and fall. Maximum SO_2 concentration occurred in summer with 2.36 µg/m^3. Maximum PM_{10} concentration occurred in 0.24 µg/m^3. Concentrations of SO_2 and PM_{10} are given in **Figure 4.259** and **Figure 4.26** respectively.

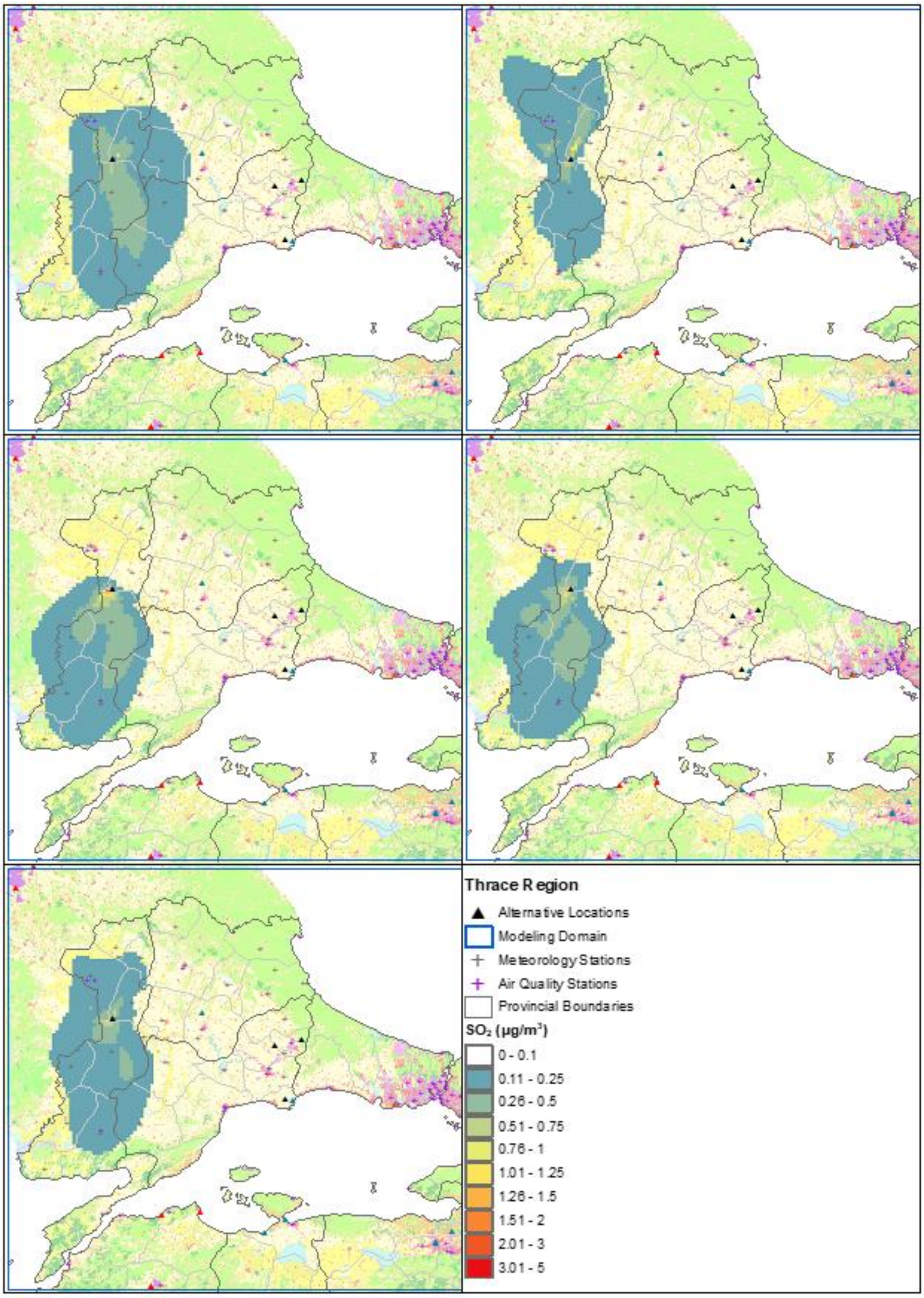

Figure 4.29. Havsa SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

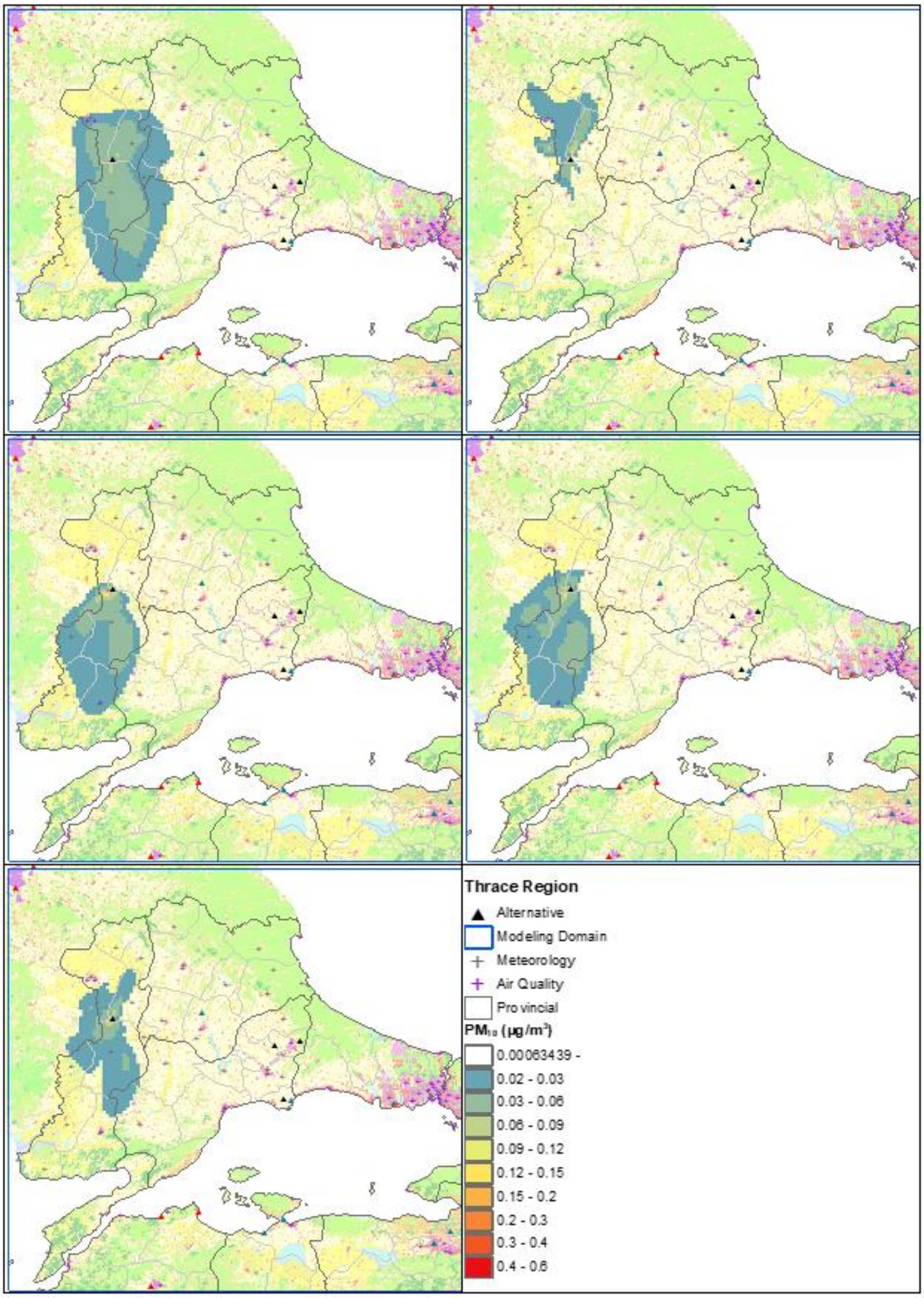

Figure 4.30. Havsa PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Havsa's SO_2 and PM_{10} dry depositions usually happen towards south, except in winter when it happens toward north as well. Edirne city center is affected only in winter and spring, whereas Keşan, famous for its air pollution is slightly affected in summer and fall. Edirne province has a high agricultural use and therefore dry deposition would be a bigger problem. Dry depositions of SO_2 and PM_{10} are given in **Figure 4.25** and **Figure 4.26** respectively.

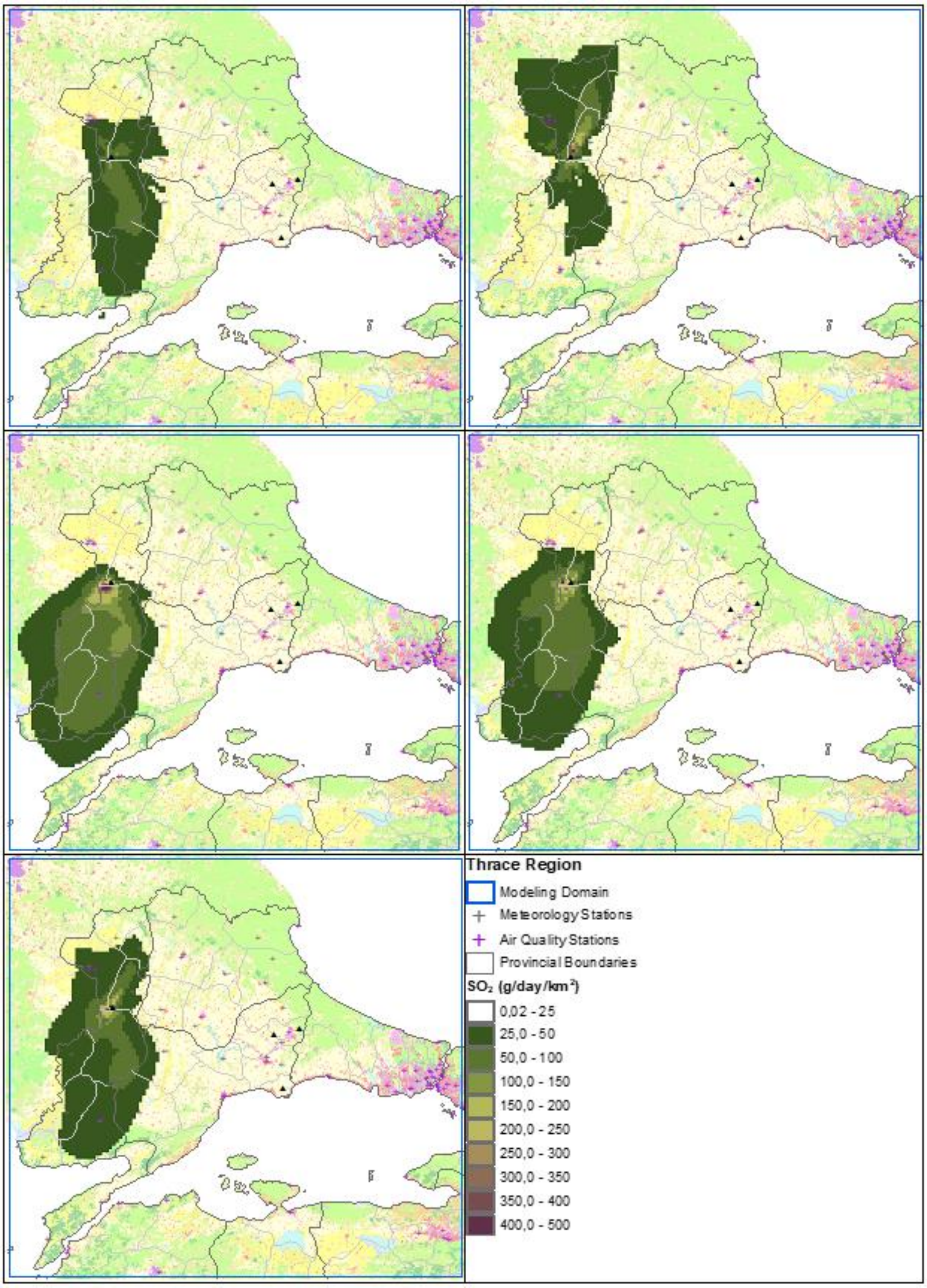

Figure 4.31. Daily SO_2 dry flux of Havsa in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

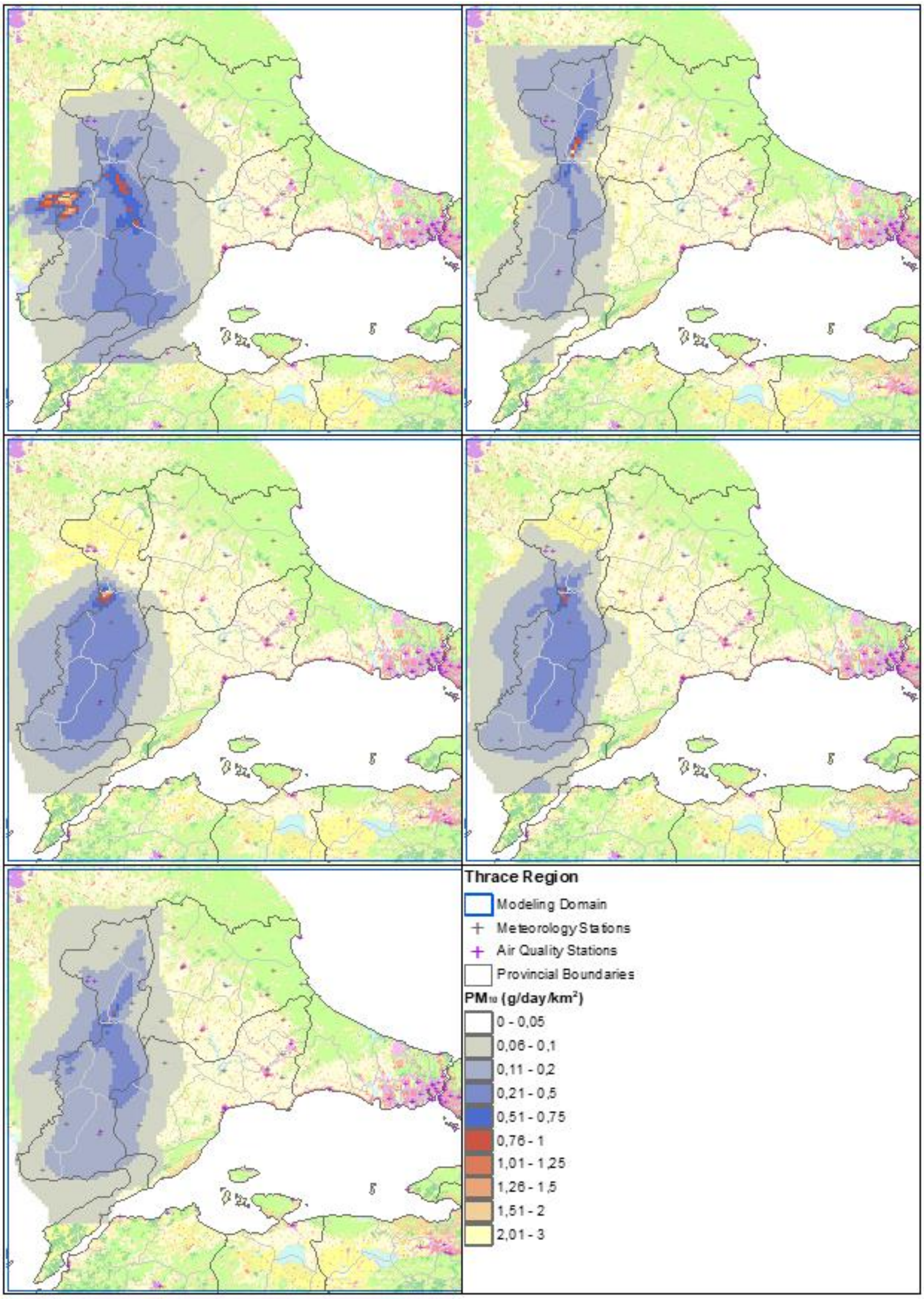

Figure 4.32. Daily PM_{10} dry flux of Havsa in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.2 With chemical transformation

In models with chemical transformation NO-NO_2 transformation and its dry deposition is also modeled.

4.2.2.1 Çerkezköy

Çerkezköy's SO_2, NO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu. Maximum SO_2 concentrations occurred in summer with 2.8 µg/m^3. Maximum PM_{10} concentrations occurred in summer with 0.28 µg/m^3. Maximum NO_2 concentration occurred in summer with 3 µg/m^3. Concentrations of SO_2 PM_{10} and NO_2 are given in **Figure 4.33, Figure 4.34** and **Figure 4.35** respectively.

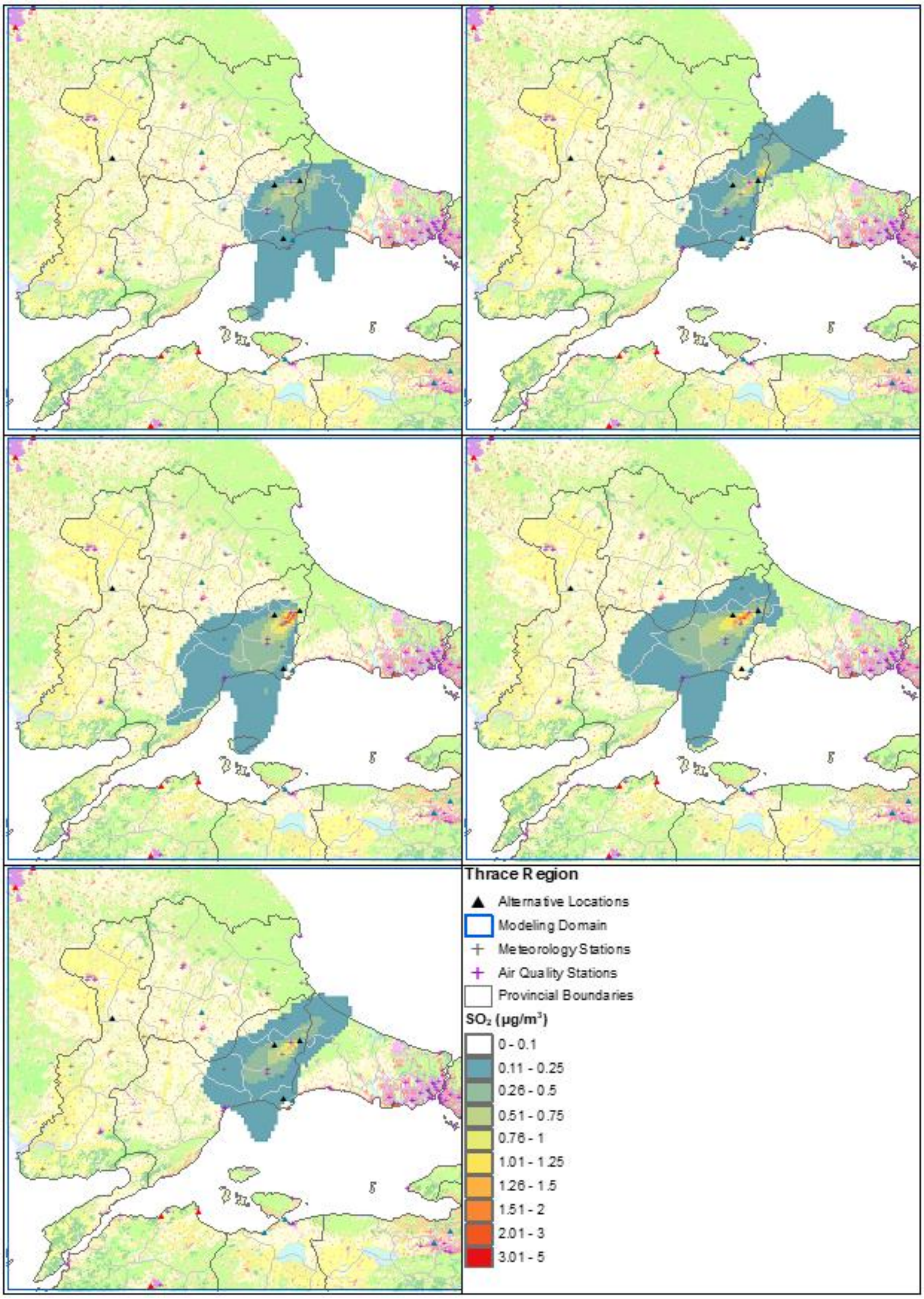

Figure 4.33. Çerkezköy SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

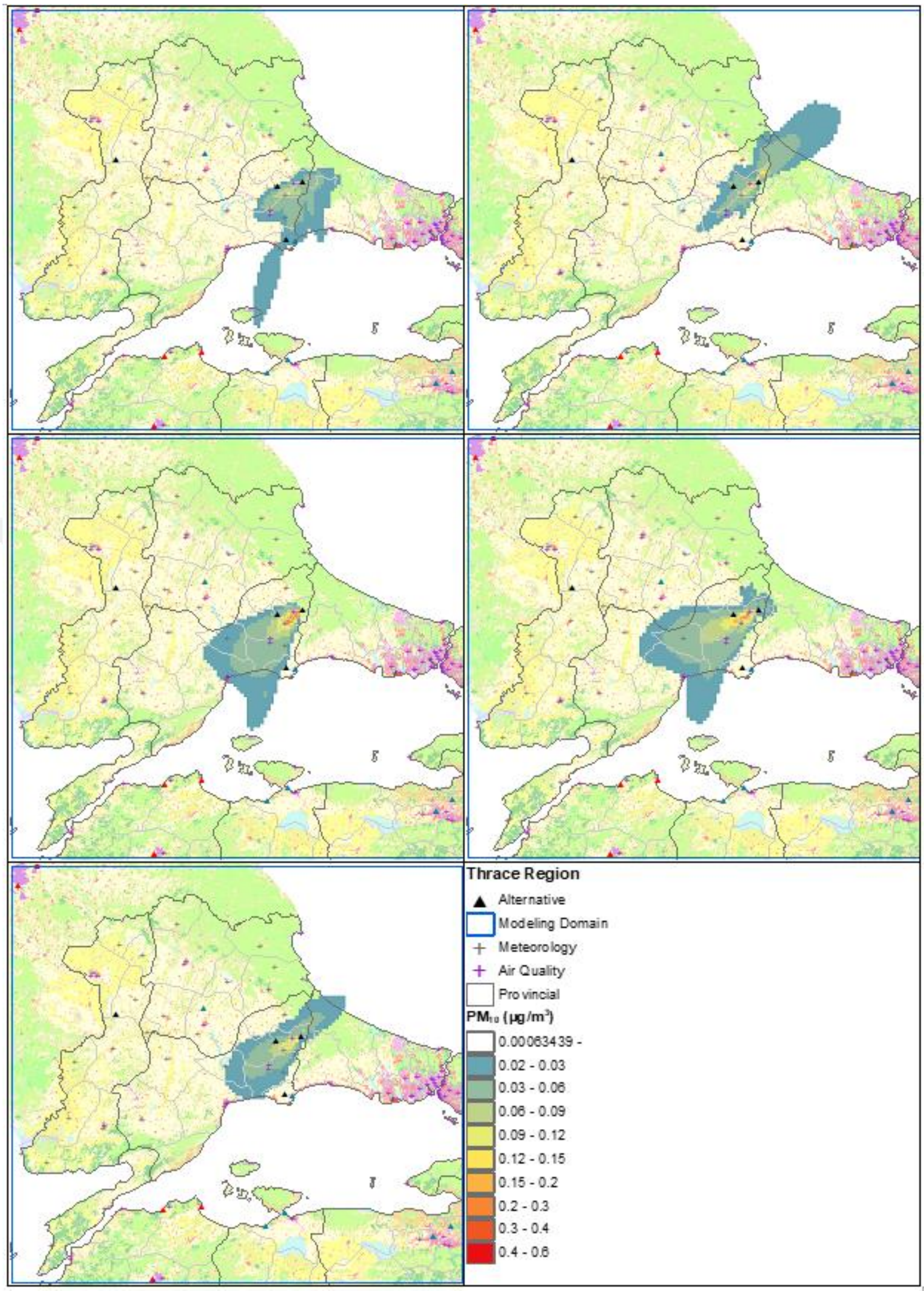

Figure 4.34. Çerkezköy PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

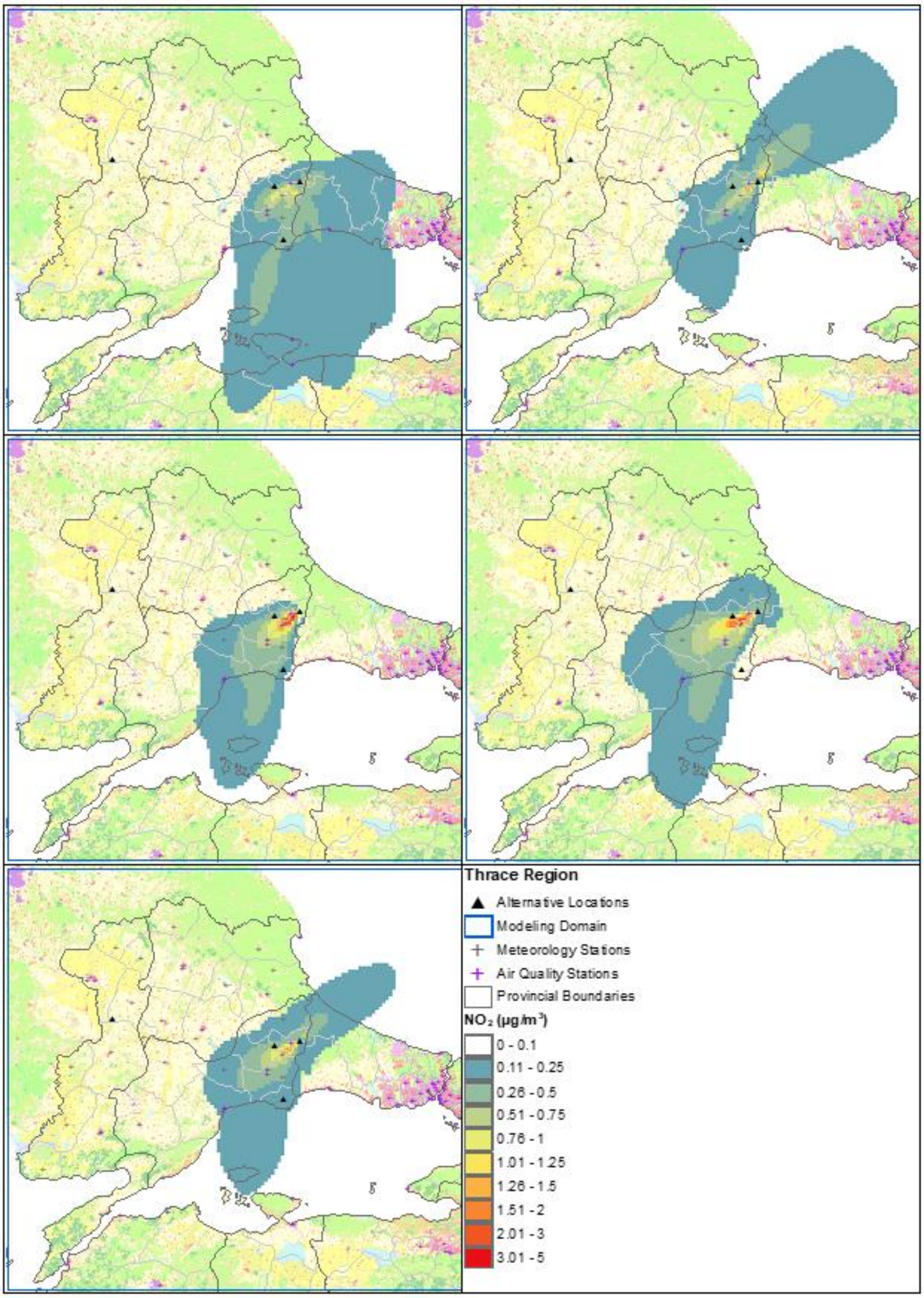

Figure 4.35. Çerkezköy NO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Çerkezköy's SO_2, NO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu.

Concentrations of SO_2 PM_{10} and NO_2 are given in **Figure 4.336, Figure 4.347** and **Figure 4.358** respectively.

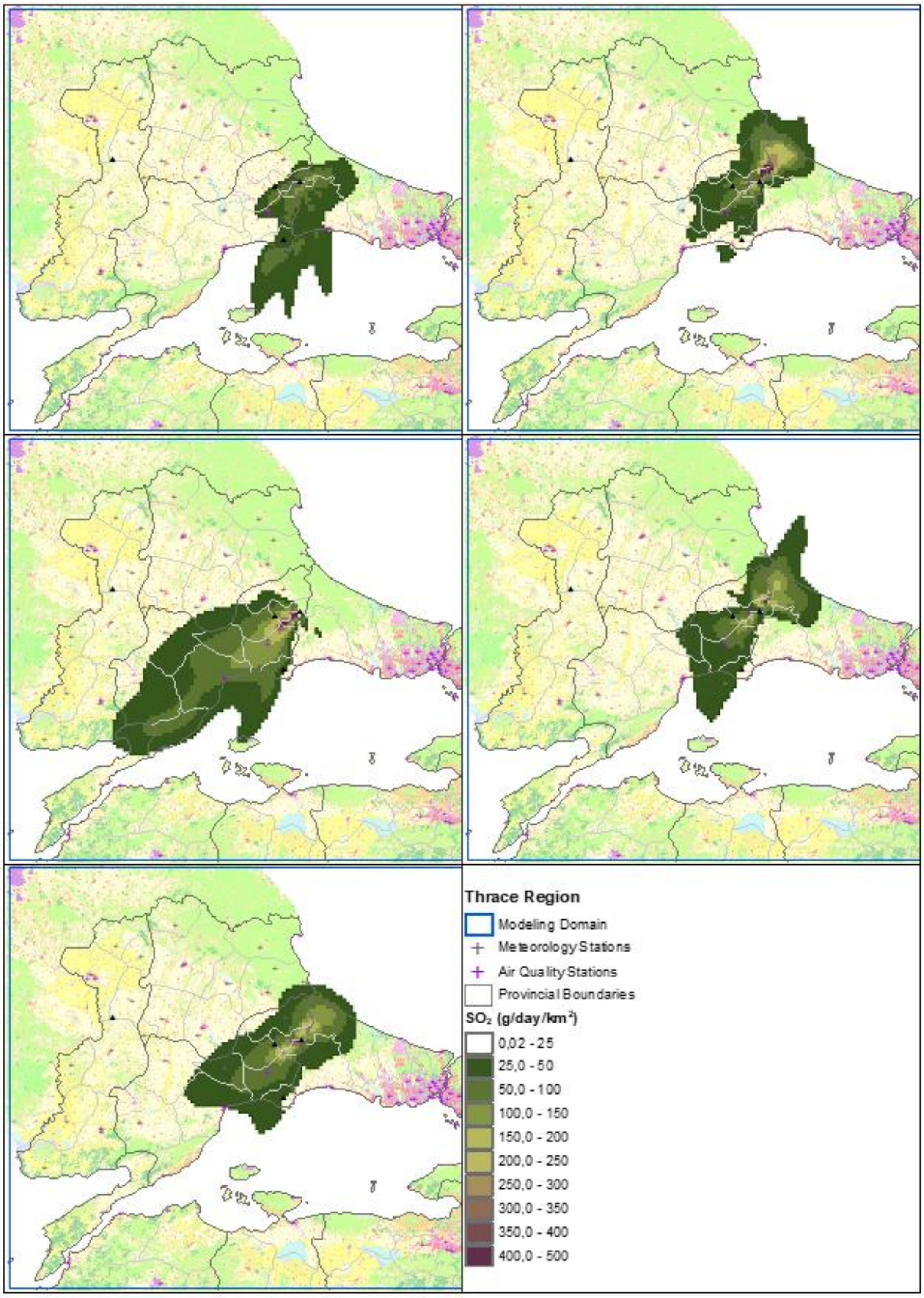

Figure 4.36. Daily SO_2 dry flux of Çerkezköy in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

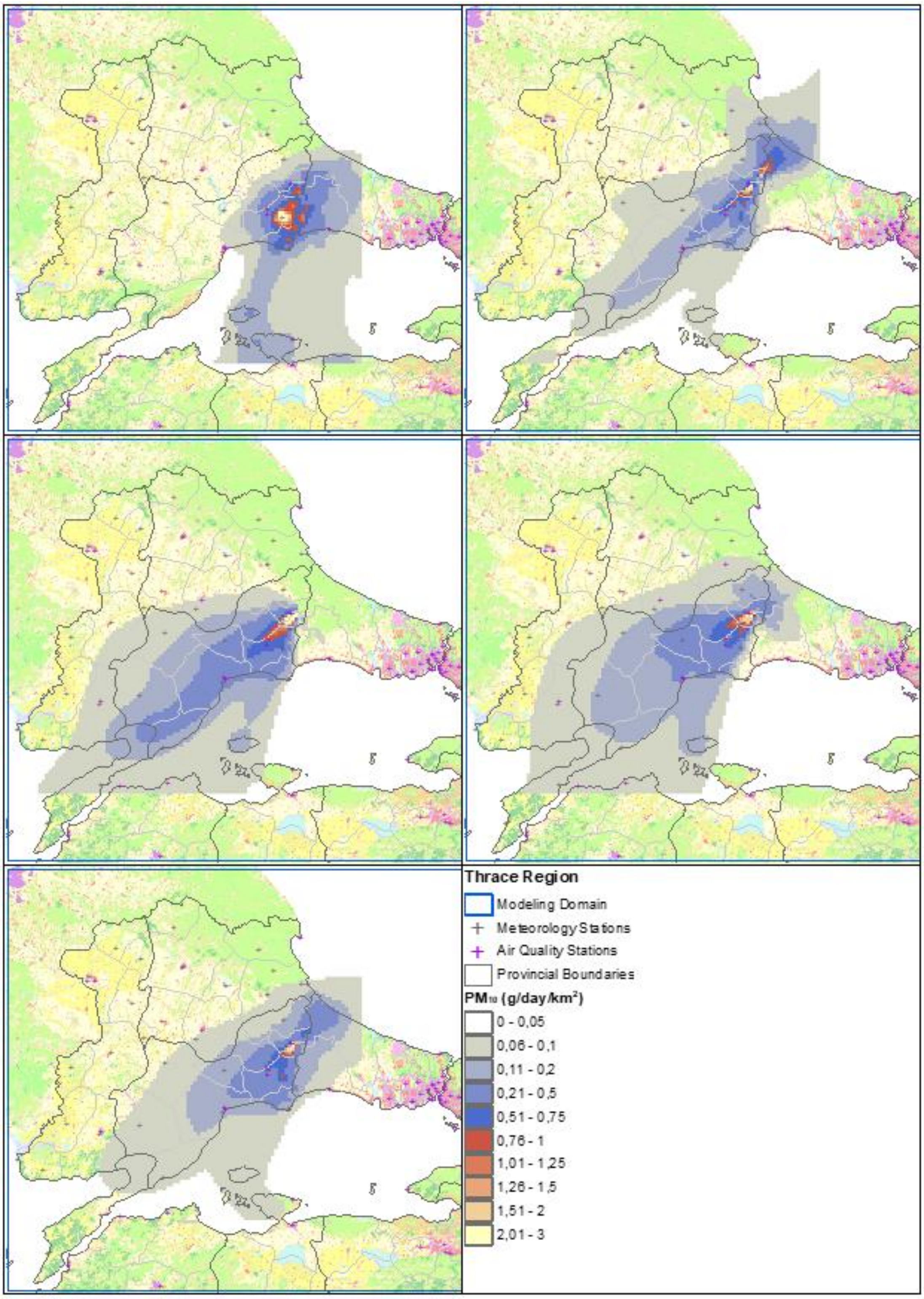

Figure 4.37. Daily PM_{10} dry flux of Çerkezköy in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

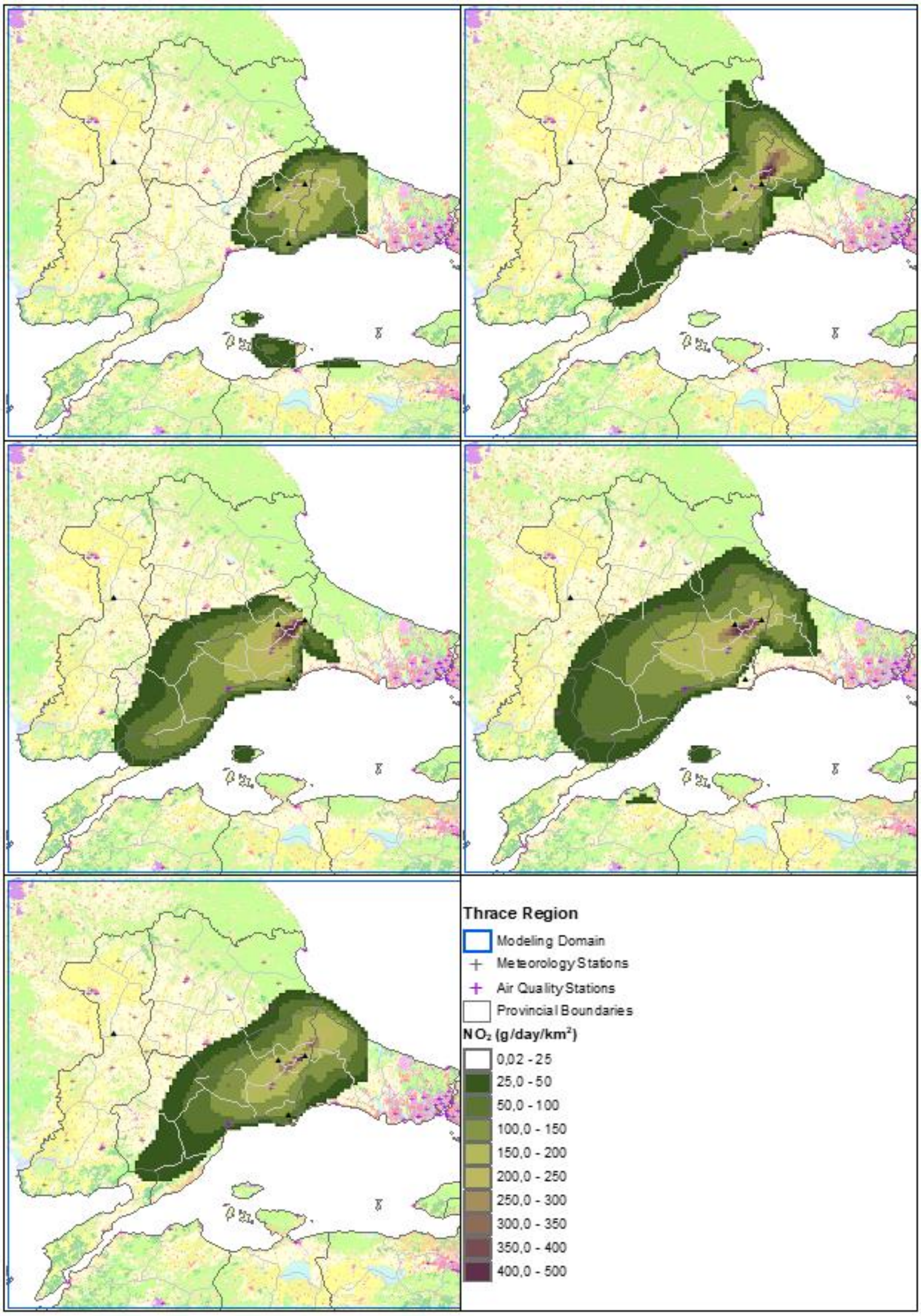

Figure 4.38. Daily NO_2 dry flux of Çerkezköy in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.2.2 Çorlu

Çorlu's SO_2, NO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu, with Tekirdağ being affected in some cases. Maximum SO_2 concentrations occurred in summer with 3.72 $\mu g/m^3$. Maximum PM_{10} concentrations occurred in summer with 0.38 $\mu g/m^3$. Maximum NO_2 concentration occurred in summer with 3.64 $\mu g/m^3$. Concentrations of SO_2, PM_{10} and NO_2 are given in **Figure 4.339, Figure 4.340** and **Figure 4.3541** respectively.

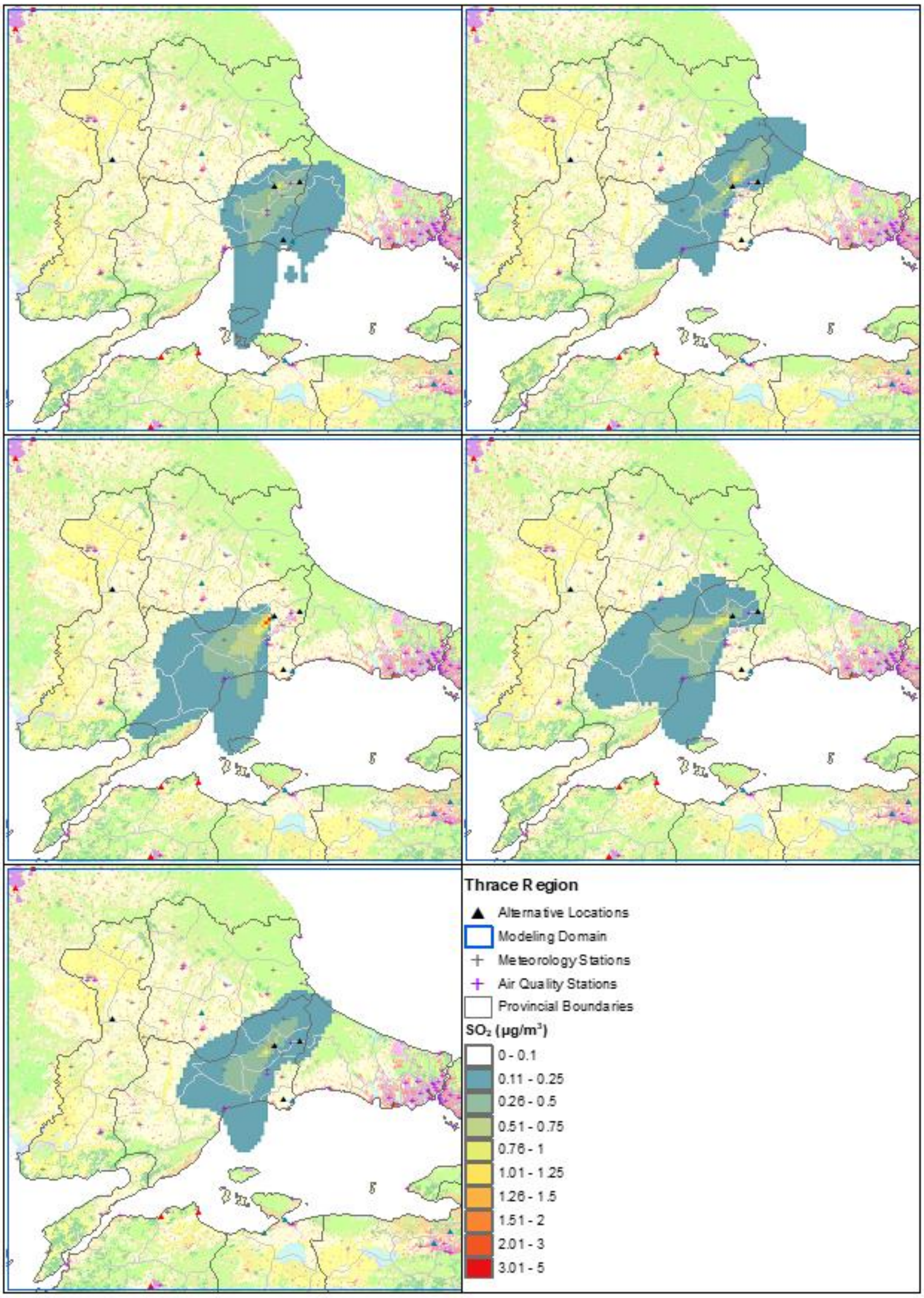

Figure 4.39. Çorlu SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

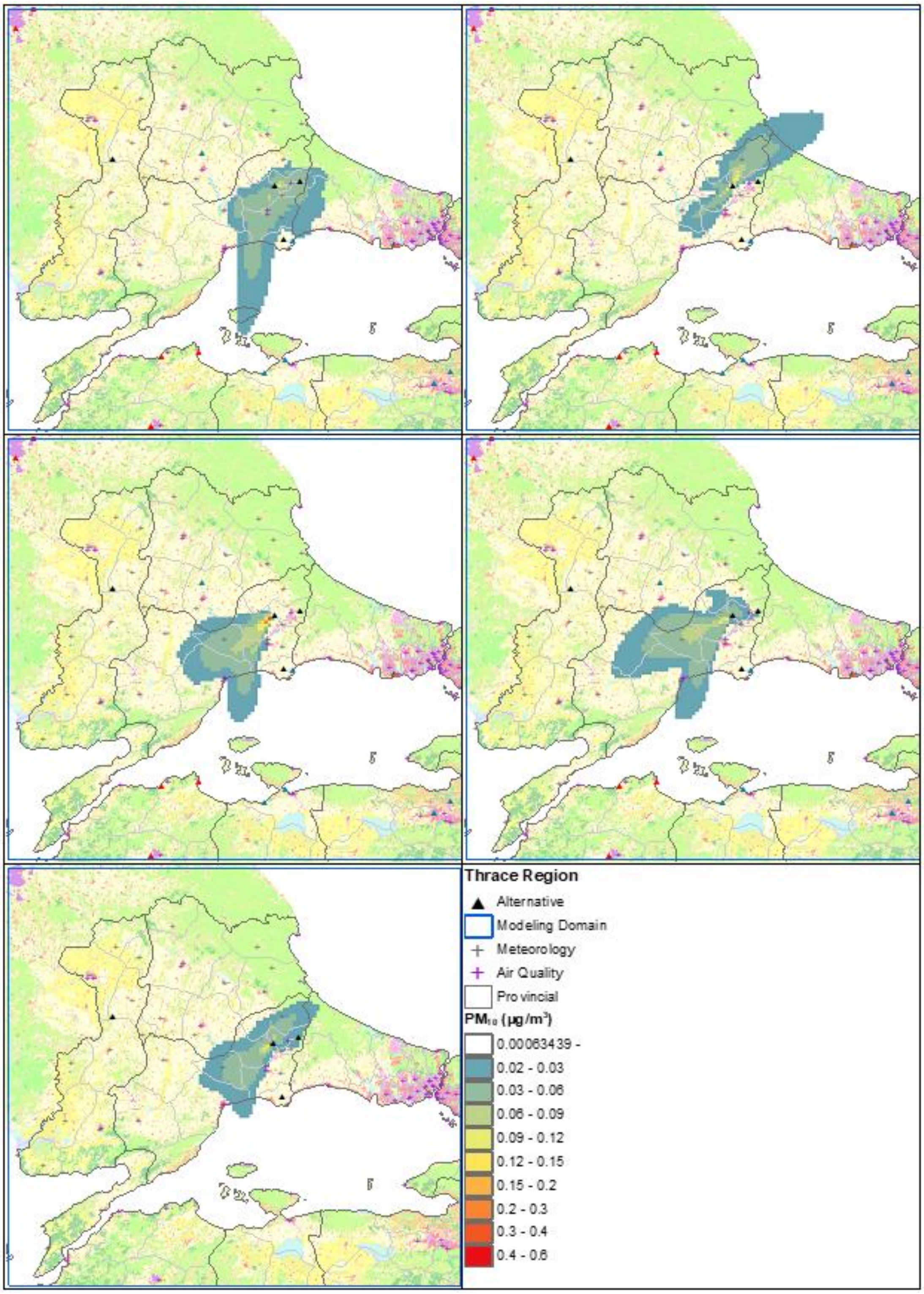

Figure 4.40. Çorlu PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

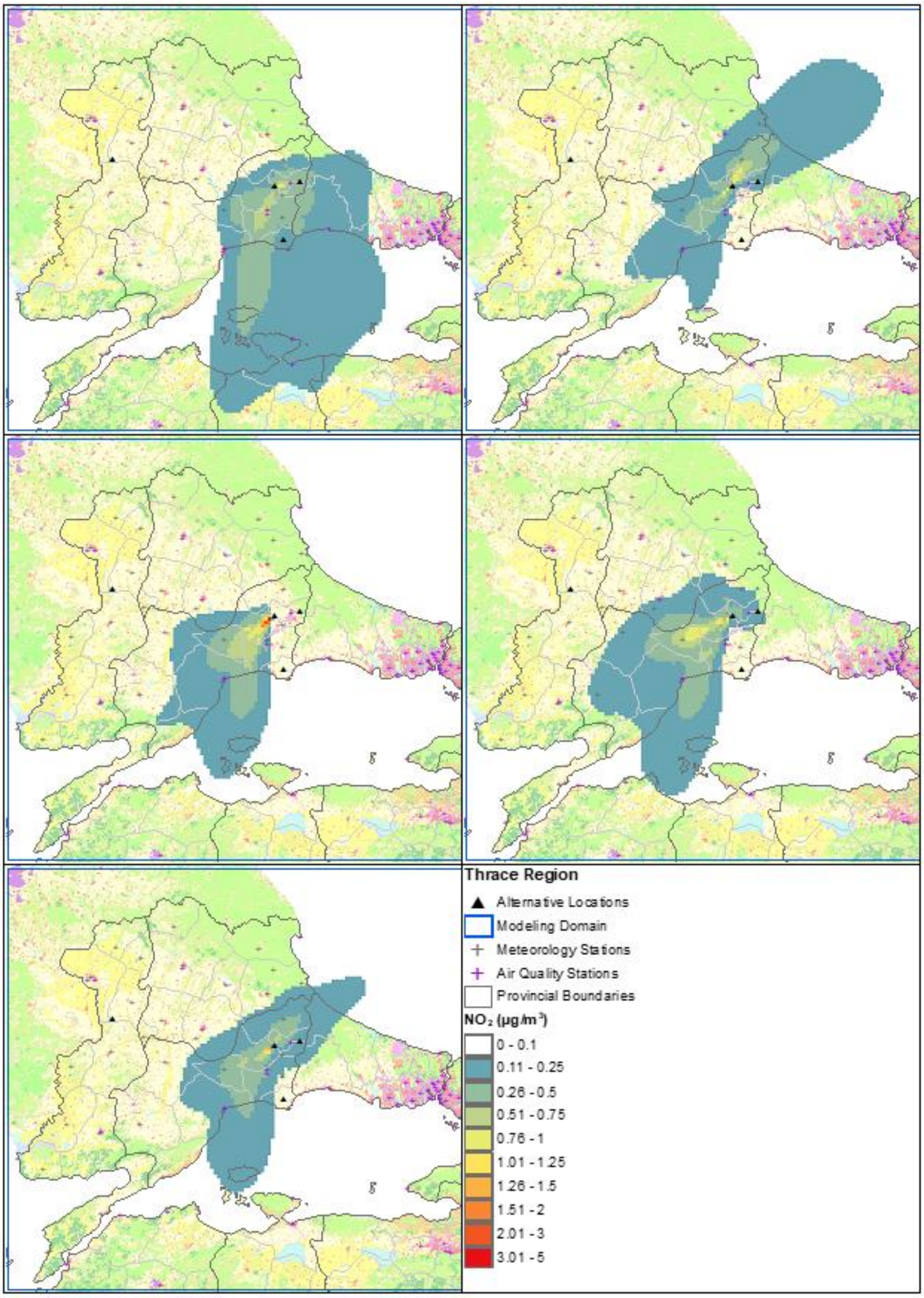

Figure 4.41. Çorlu NO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Çorlu's SO_2, NO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Main affected population centers are Çerkezköy and Çorlu, with

Tekirdağ being affected in some cases. Dry depositions of SO_2, PM_{10} and NO_2 are given in **Figure 4.3342, Figure 4.343** and **Figure 4.3544** respectively.

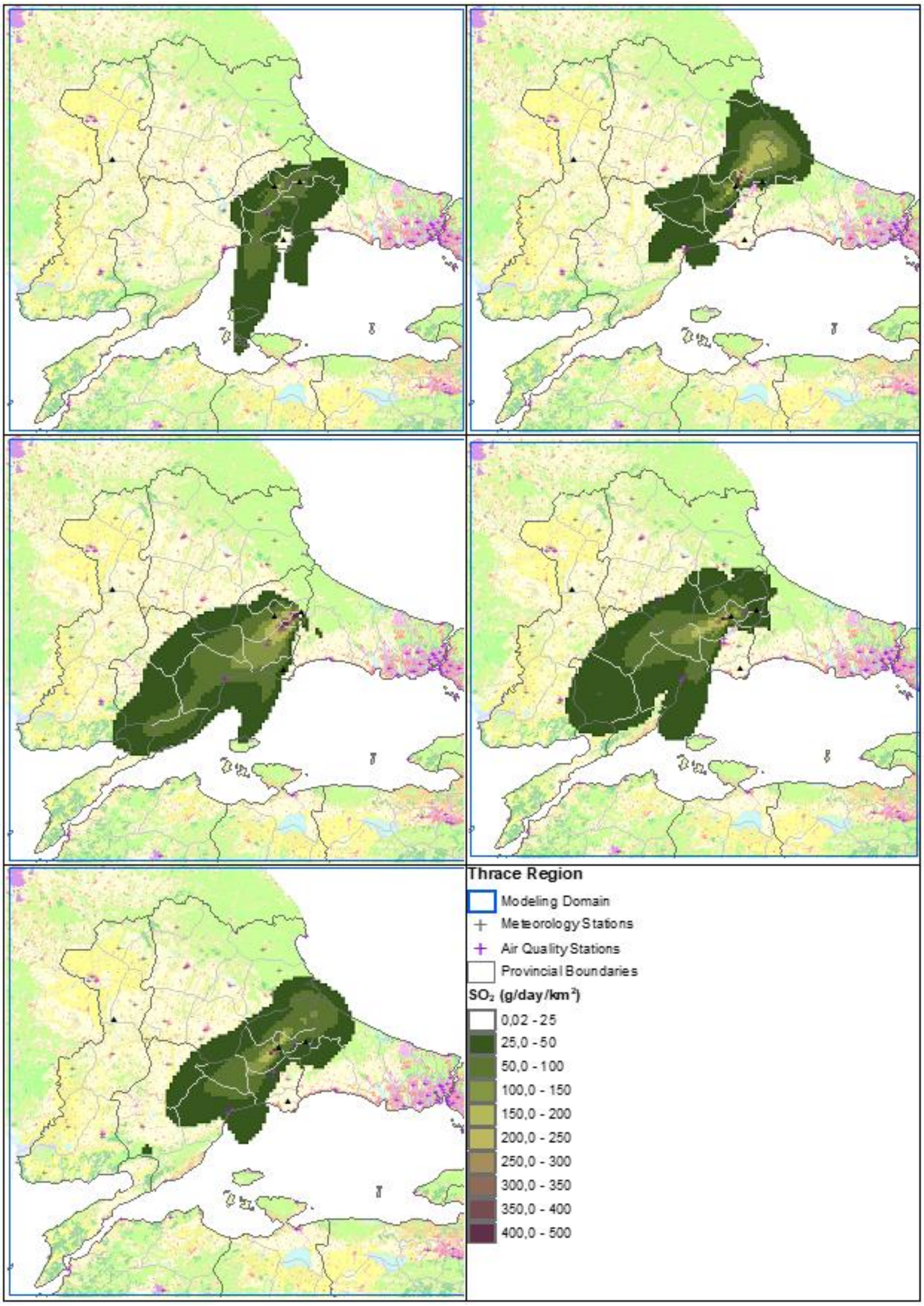

Figure 4.42. Daily SO_2 dry flux of Çorlu in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

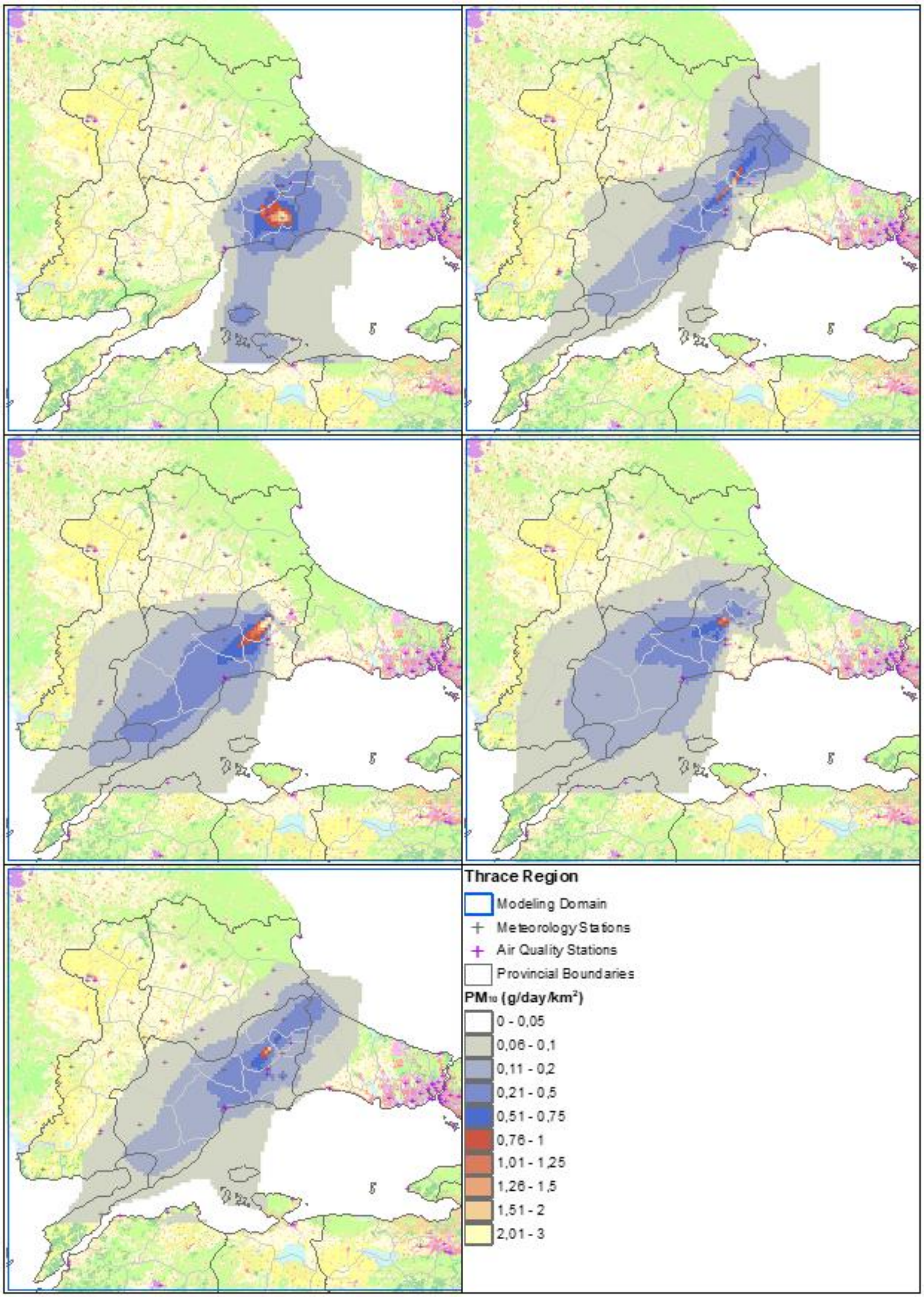

Figure 4.43. Daily PM_{10} dry flux of Çorlu in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

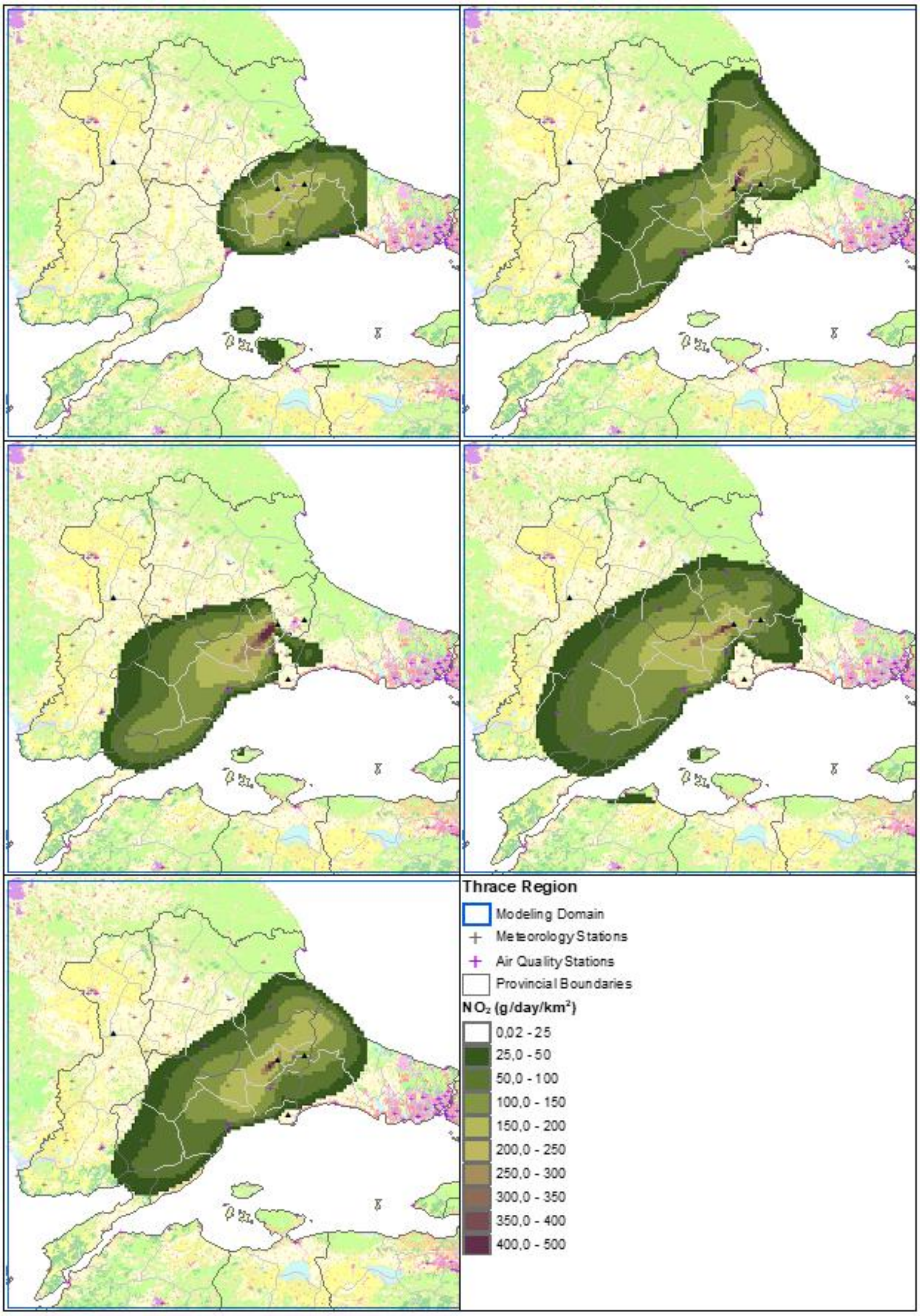

Figure 4.44. Daily NO_2 dry flux of Çorlu in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.2.3 Marmara Ereğlisi

Marmara Ereğlisi's SO_2, NO_2 and PM_{10} concentrations usually disperse towards south and southeast, except in spring when it is spreading toward northeast as well by the southwesterly winds. Most of the emission is over the sea. Çorlu and Çerkezköy are affected only in spring. In other seasons concentrations usually dirperse towards the Marmara Sea. Maximum SO_2 concentrations occurred in summer with 2.31 μg/m^3. Maximum PM_{10} concentrations occurred in summer with 0.23 μg/m^3. Maximum NO_2 concentration occurred in summer with 2.59 μg/m^3. Concentrations of SO_2, PM_{10} and NO_2 are given in **Figure 4.3345, Figure 4.346** and **Figure 4.3547** respectively.

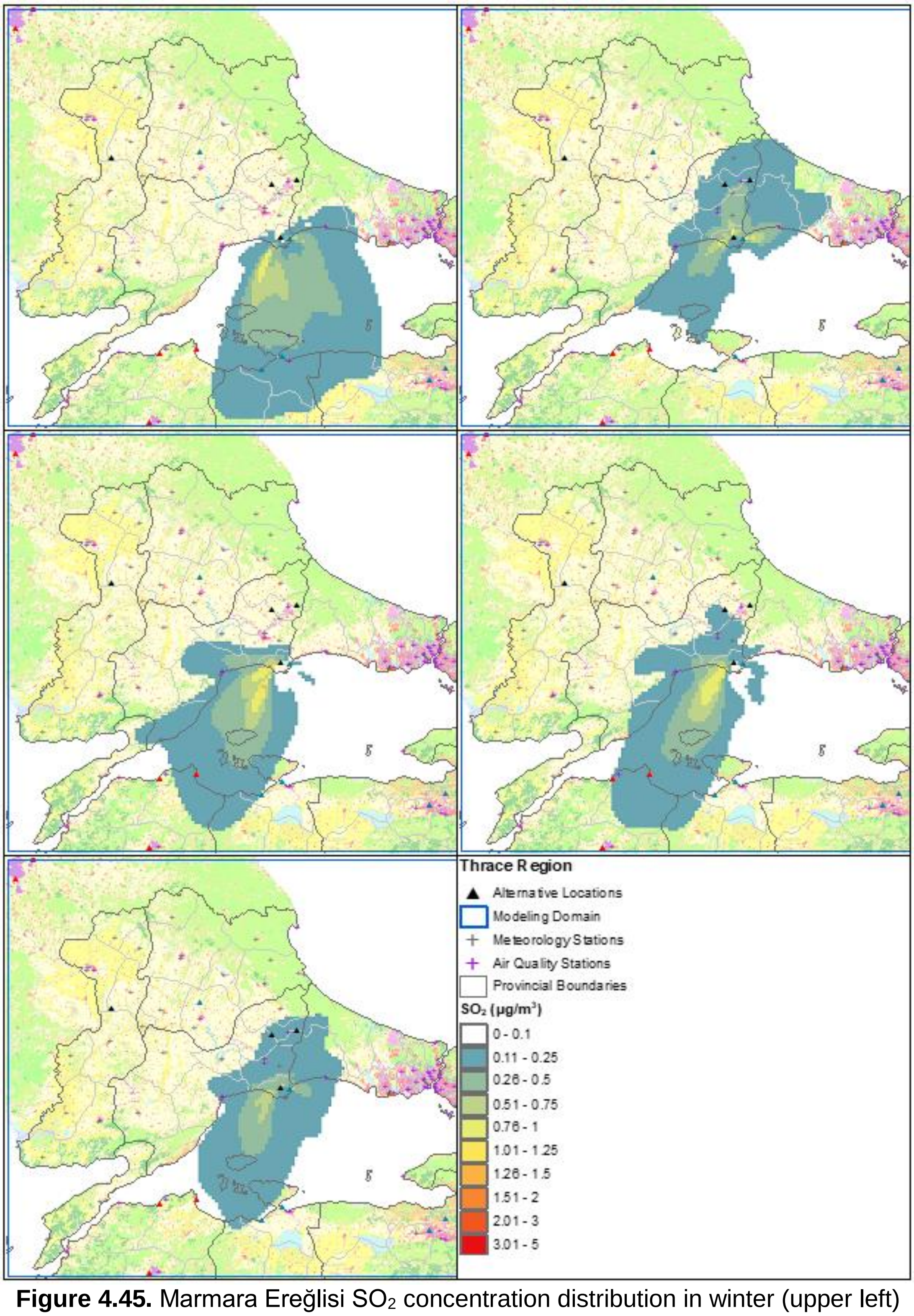

Figure 4.45. Marmara Ereğlisi SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in μg/m^3

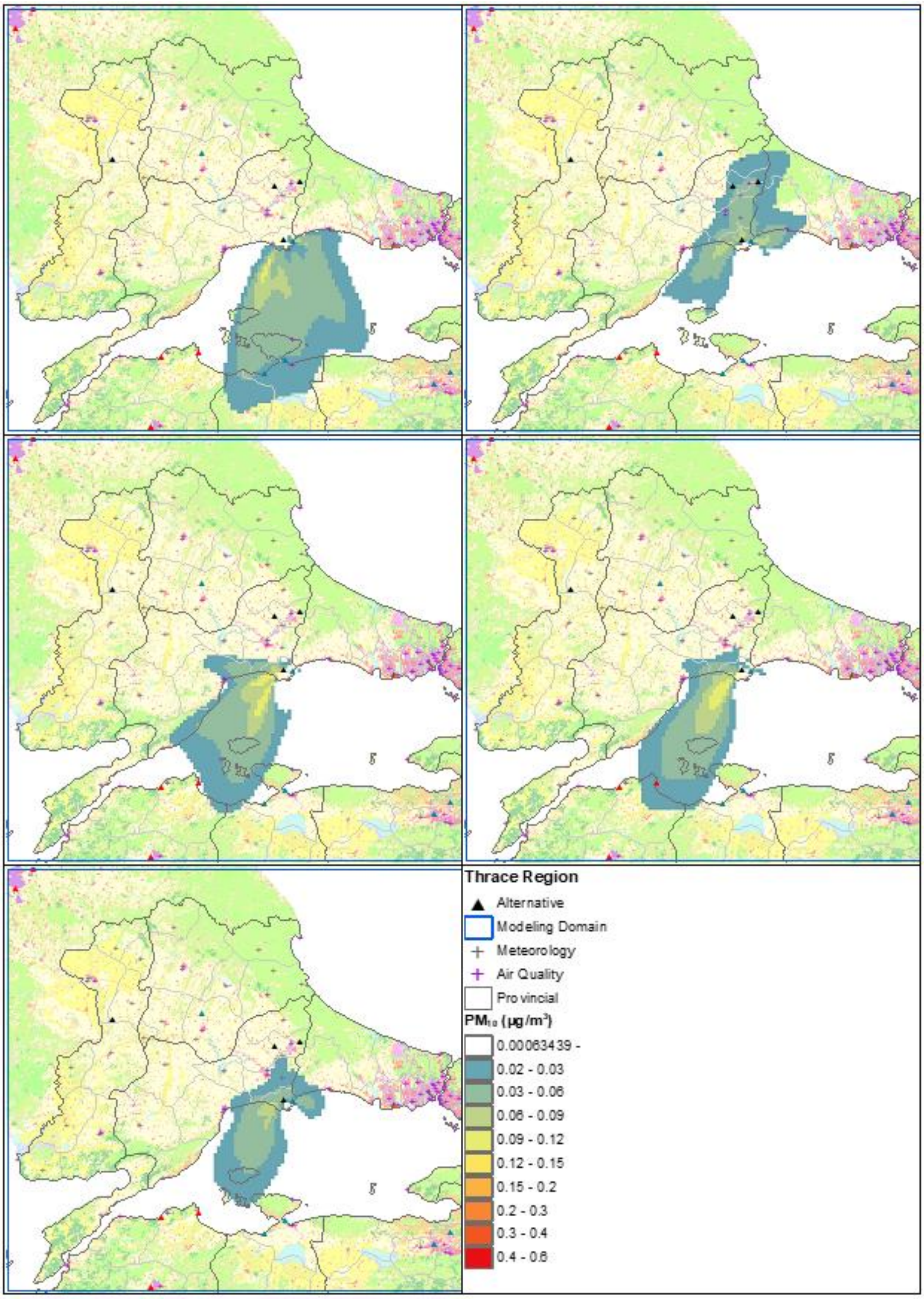

Figure 4.46. Marmara Ereğlisi PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

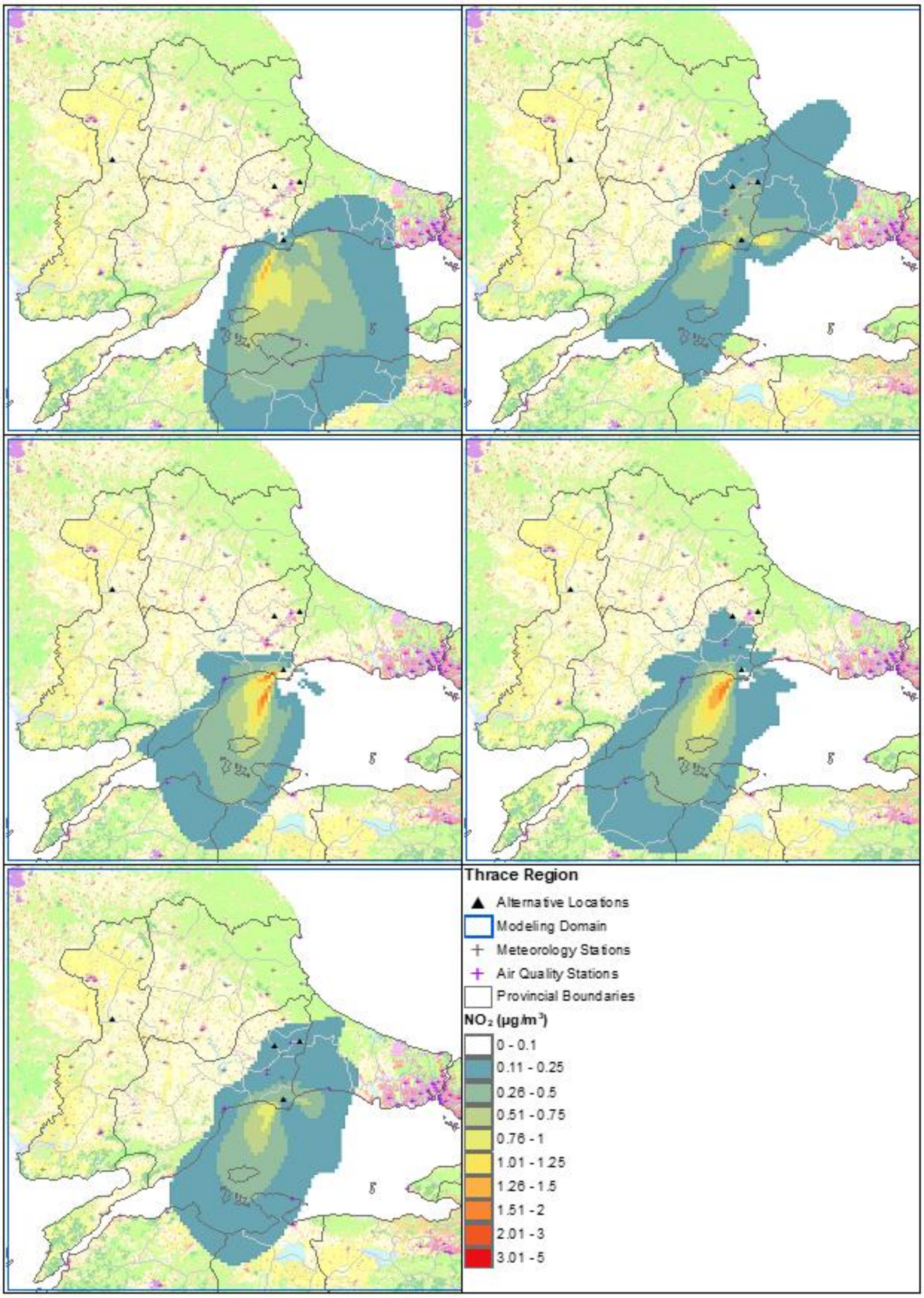

Figure 4.47. Marmara Ereğlisi NO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Marmara Ereğlisi's SO_2, NO_2 and PM_{10} dry depositions usually happen towards south and southeast, except in spring when it happens towards northeast as well by the southwesterly winds. Most of the deposition occurs over the sea. NO_2's dry deposition does not occur over the sea. Çorlu and Çerkezköy are affected only in spring. In other seasons concentrations usually dirperse towards the Marmara Sea and Tekirdağ. Dryy depositions of SO_2, PM_{10} and NO_2 are given in **Figure 4.3348, Figure 4.349** and **Figure 4.3550** respectively.

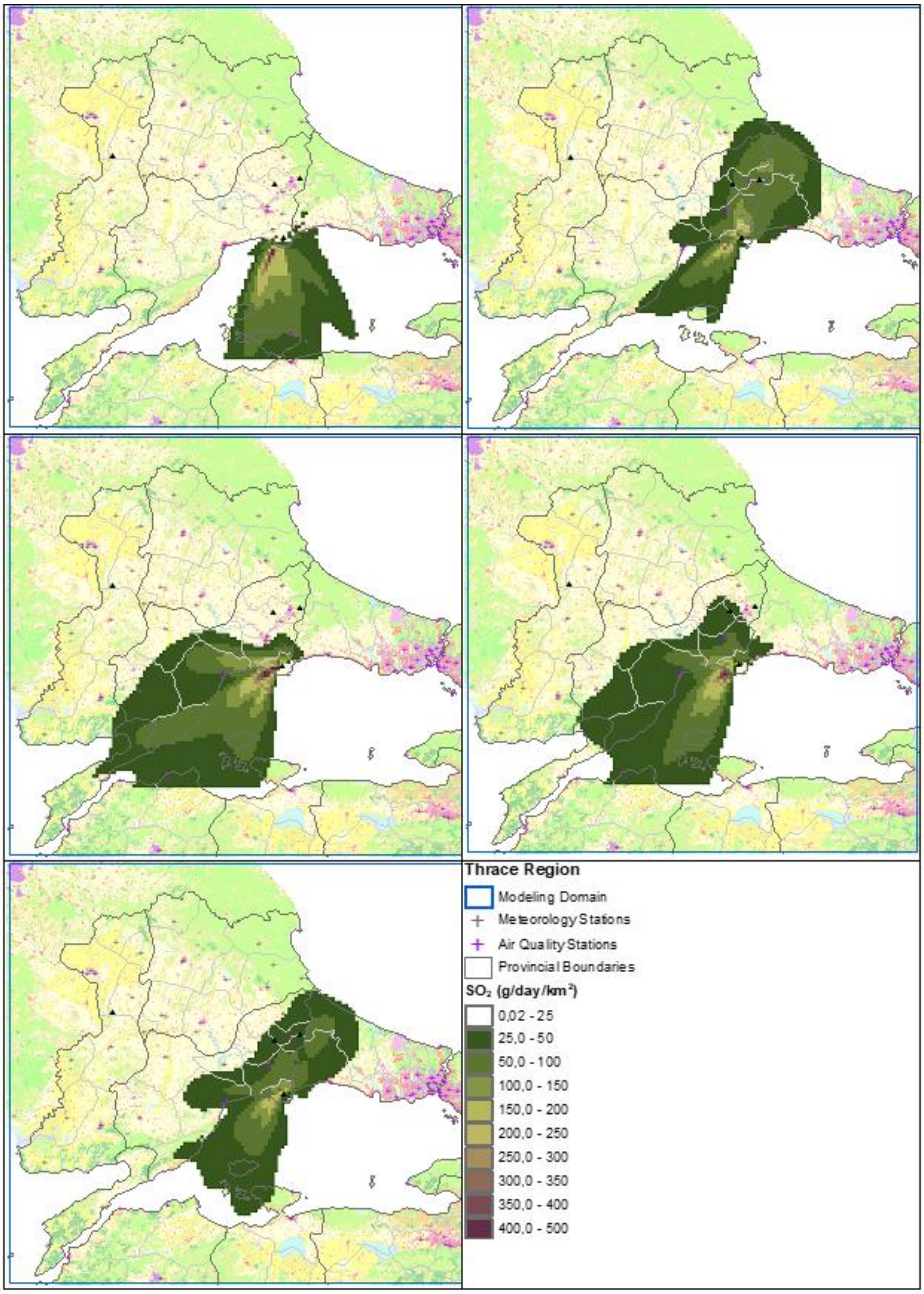

Figure 4.48. Daily SO_2 dry flux of Marmara Ereğlisi in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

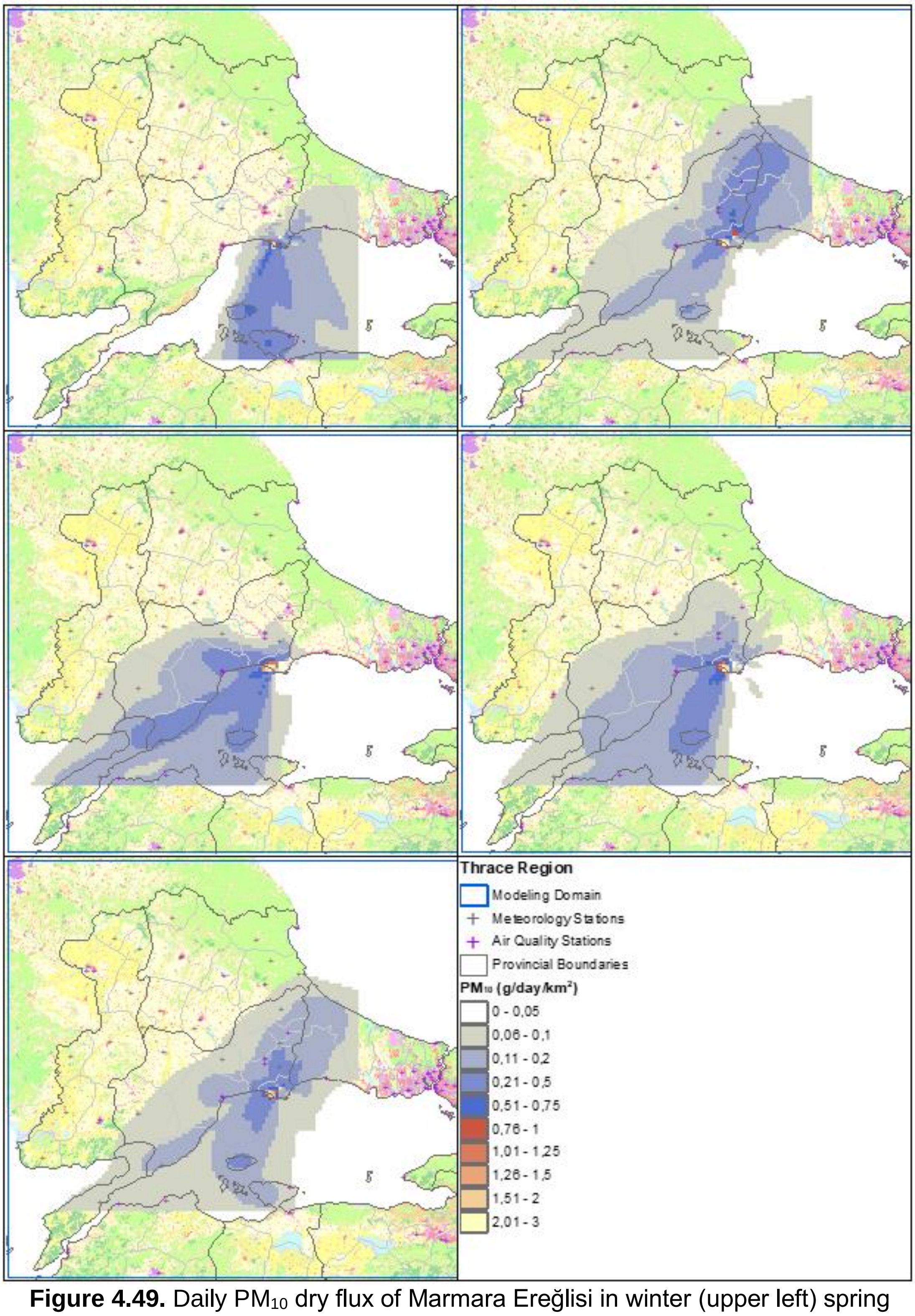

Figure 4.49. Daily PM_{10} dry flux of Marmara Ereğlisi in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

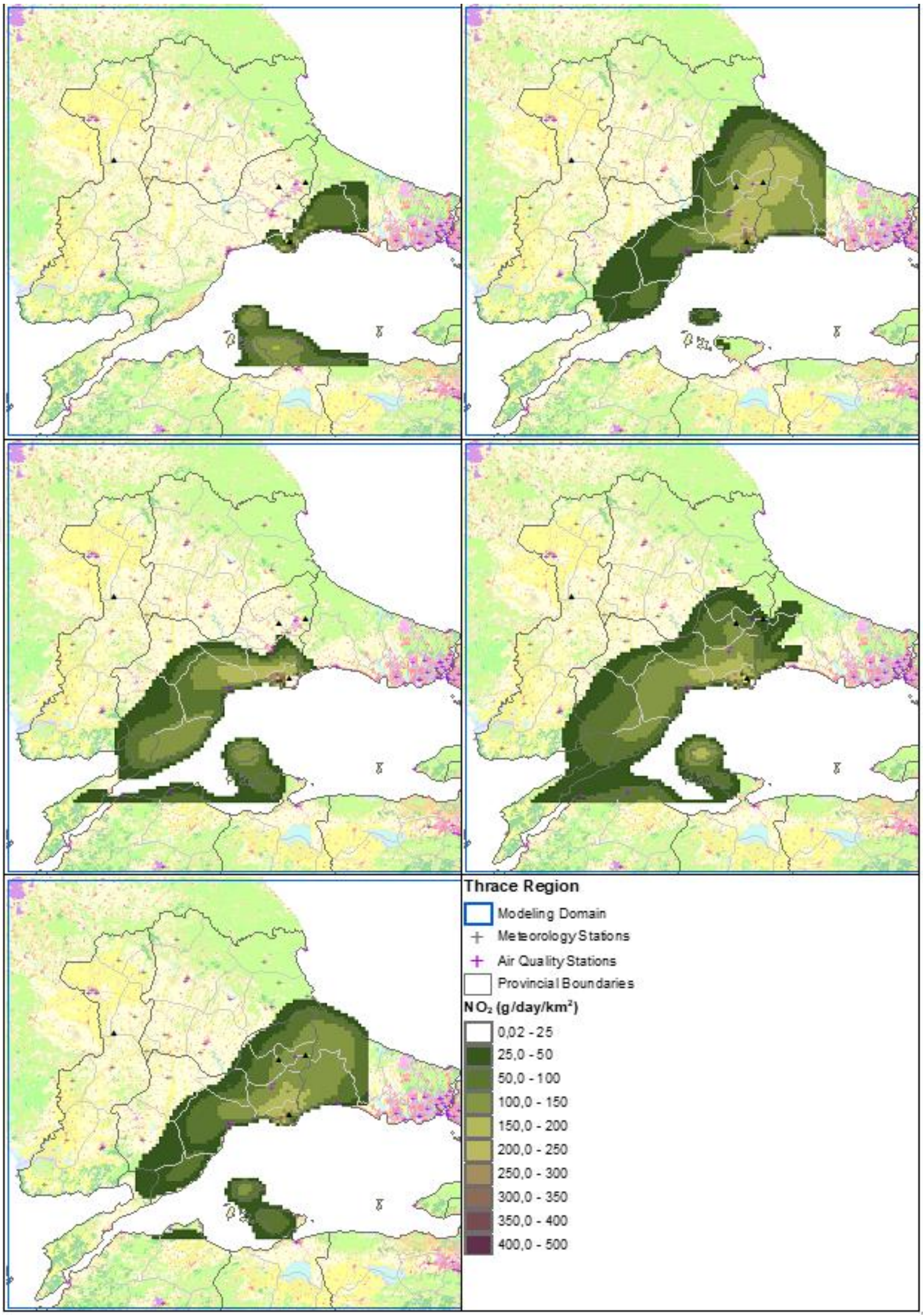

Figure 4.50. Daily NO_2 dry flux of Marmara Ereğlisi in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.2.4 Havsa

Havsa's SO_2, NO_2 and PM_{10} concentrations usually disperse towards south, except in winter when it is spreading toward north as well. Edirne city center is affected only in winter and spring, whereas Keşan, famous for its air pollution is slightly affected in summer and fall. Maximum SO_2 concentrations occurred in summer with 2.35 µg/m^3. Maximum PM_{10} concentrations occurred in summer with 0.23 µg/m^3. Maximum NO_2 concentration occurred in summer with 2.4 µg/m^3. Concentrations of SO_2, PM_{10} and NO_2 are given in **Figure 4.3351, Figure 4.3452** and **Figure 4.3553** respectively.

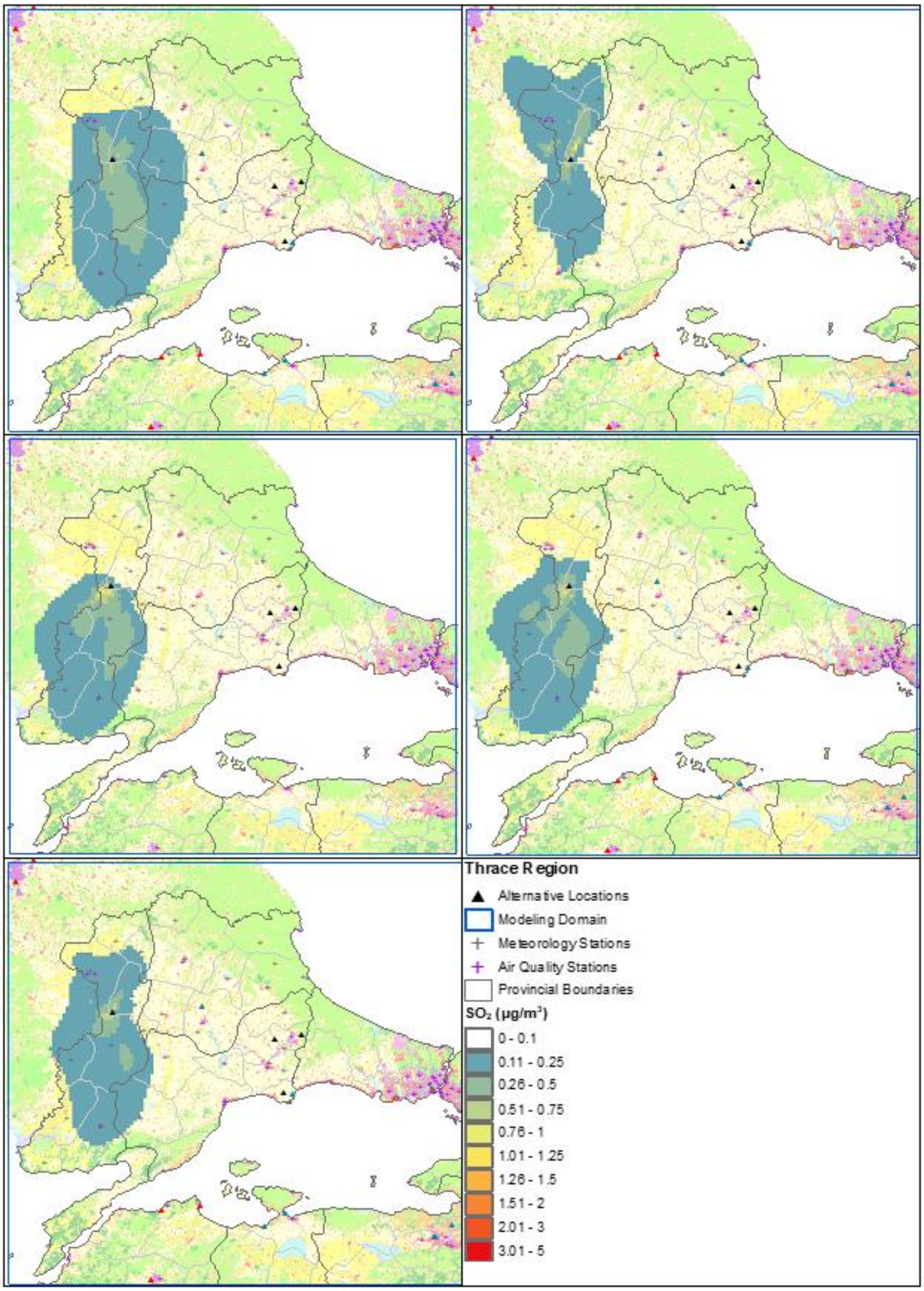

Figure 4.51. Havsa SO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

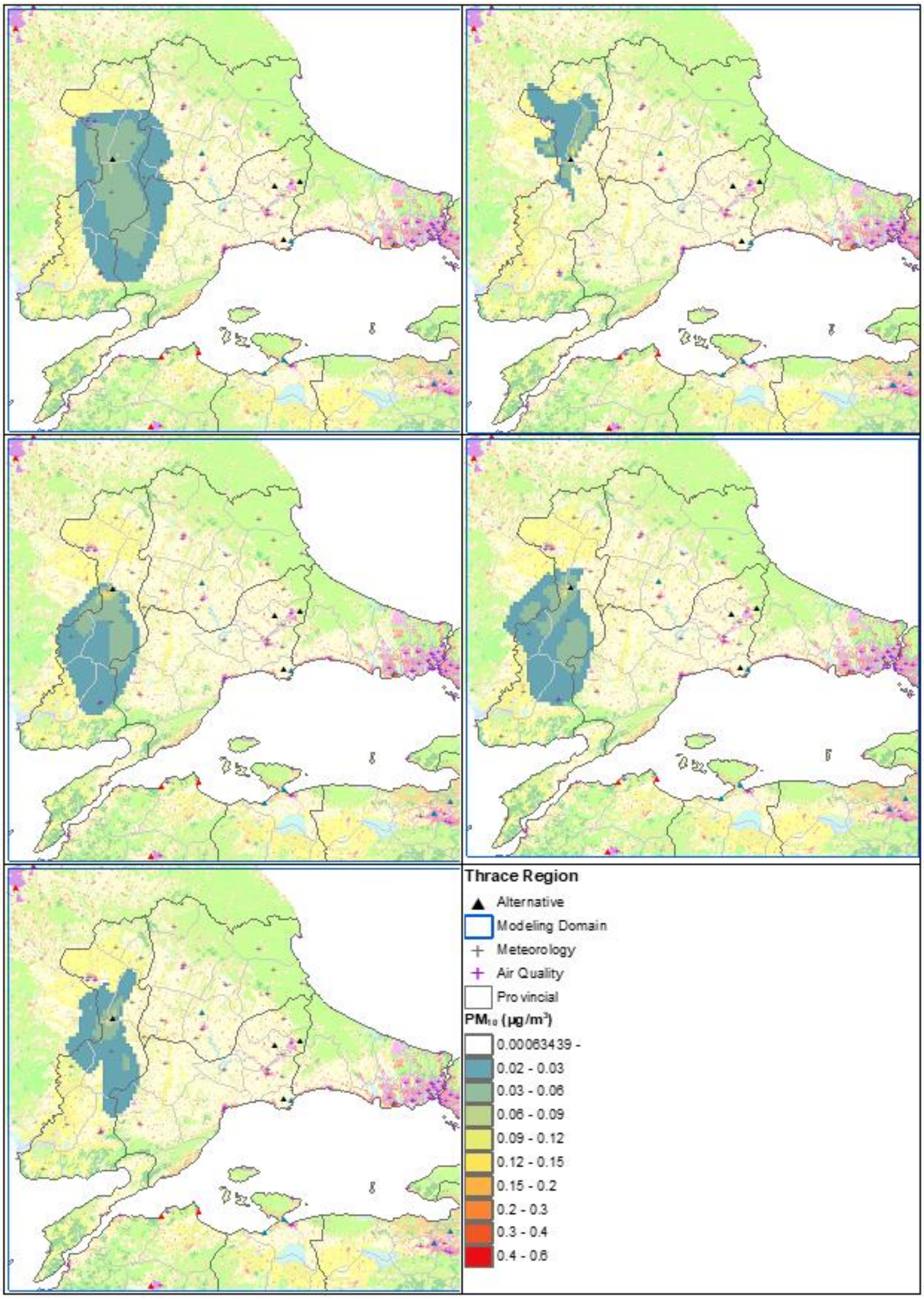

Figure 4.52. Havsa PM_{10} concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

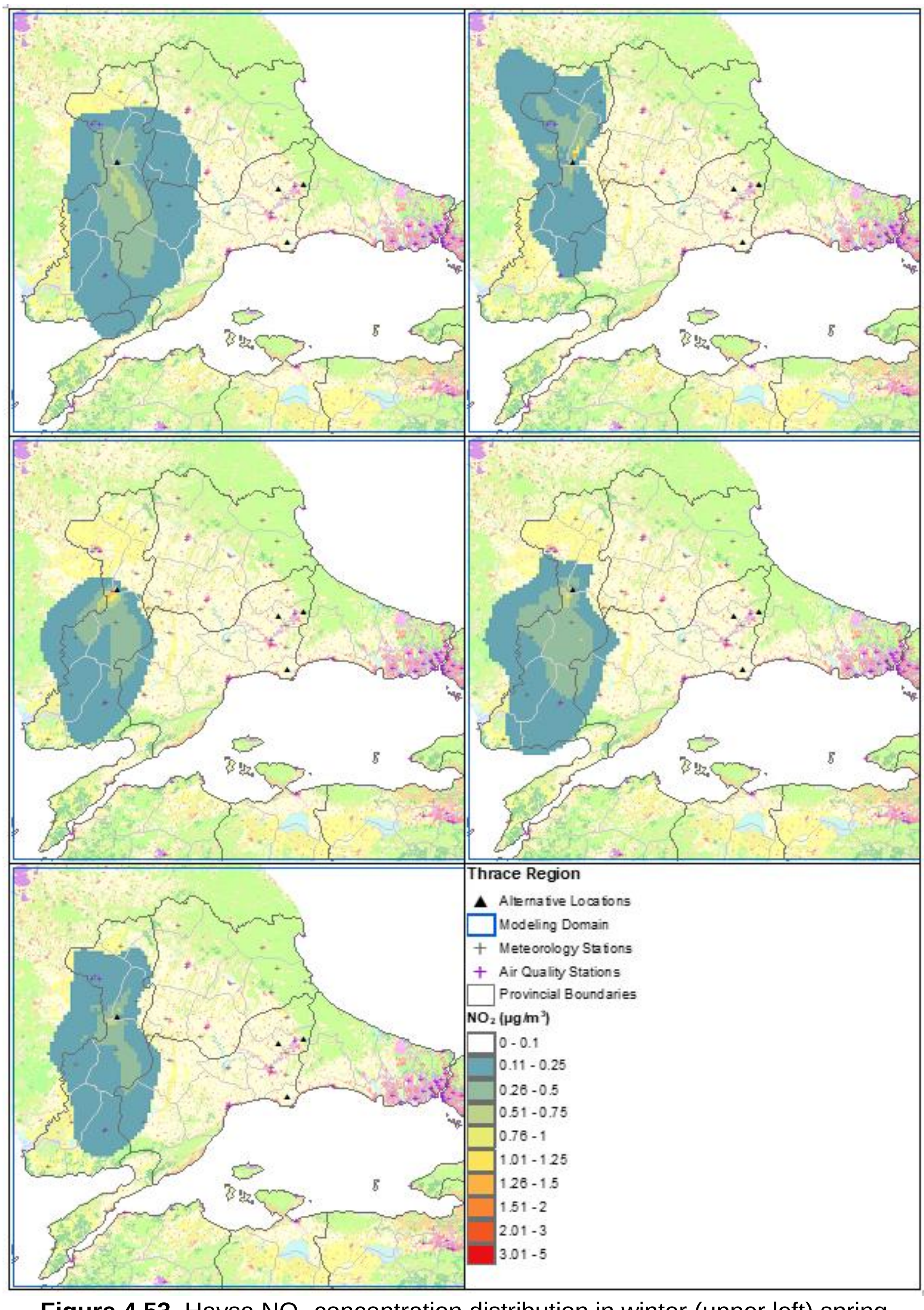

Figure 4.53. Havsa NO_2 concentration distribution in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left) in µg/m^3

Havsa's SO_2, NO_2 and PM_{10} dry depositions usually happen towards south, except in winter when it happens toward north as well. Edirne city center is affected only in winter and spring, whereas Keşan, famous for its air pollution is slightly affected in summer and fall. Edirne province has a high agricultural use and therefore dry deposition would be a bigger problem. Dry depositions of SO_2, PM_{10} and NO_2 are given in **Figure 4.3354, Figure 4.3455** and **Figure 4.3556** respectively.

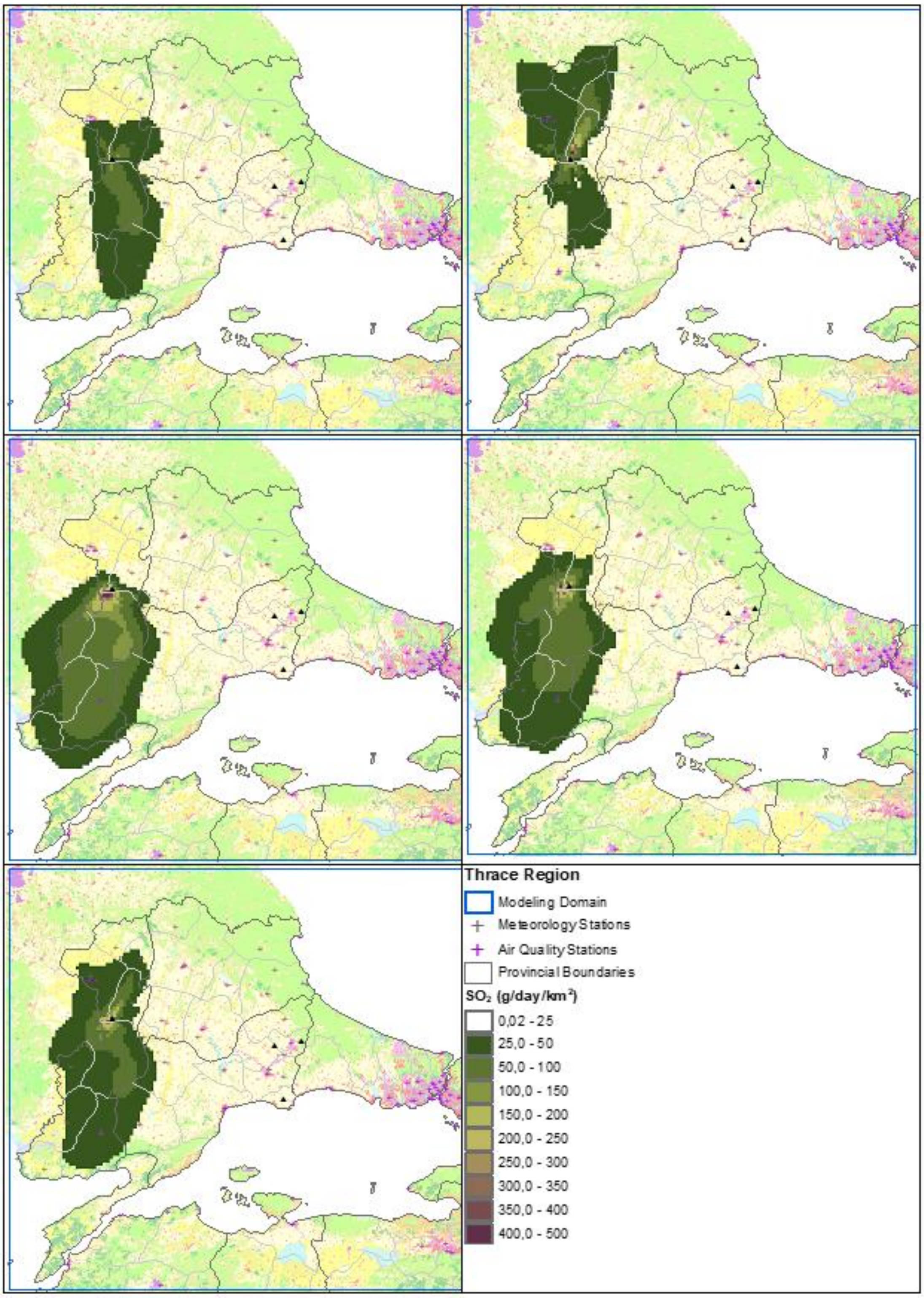

Figure 4.54. Daily SO_2 dry flux of Havsa in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

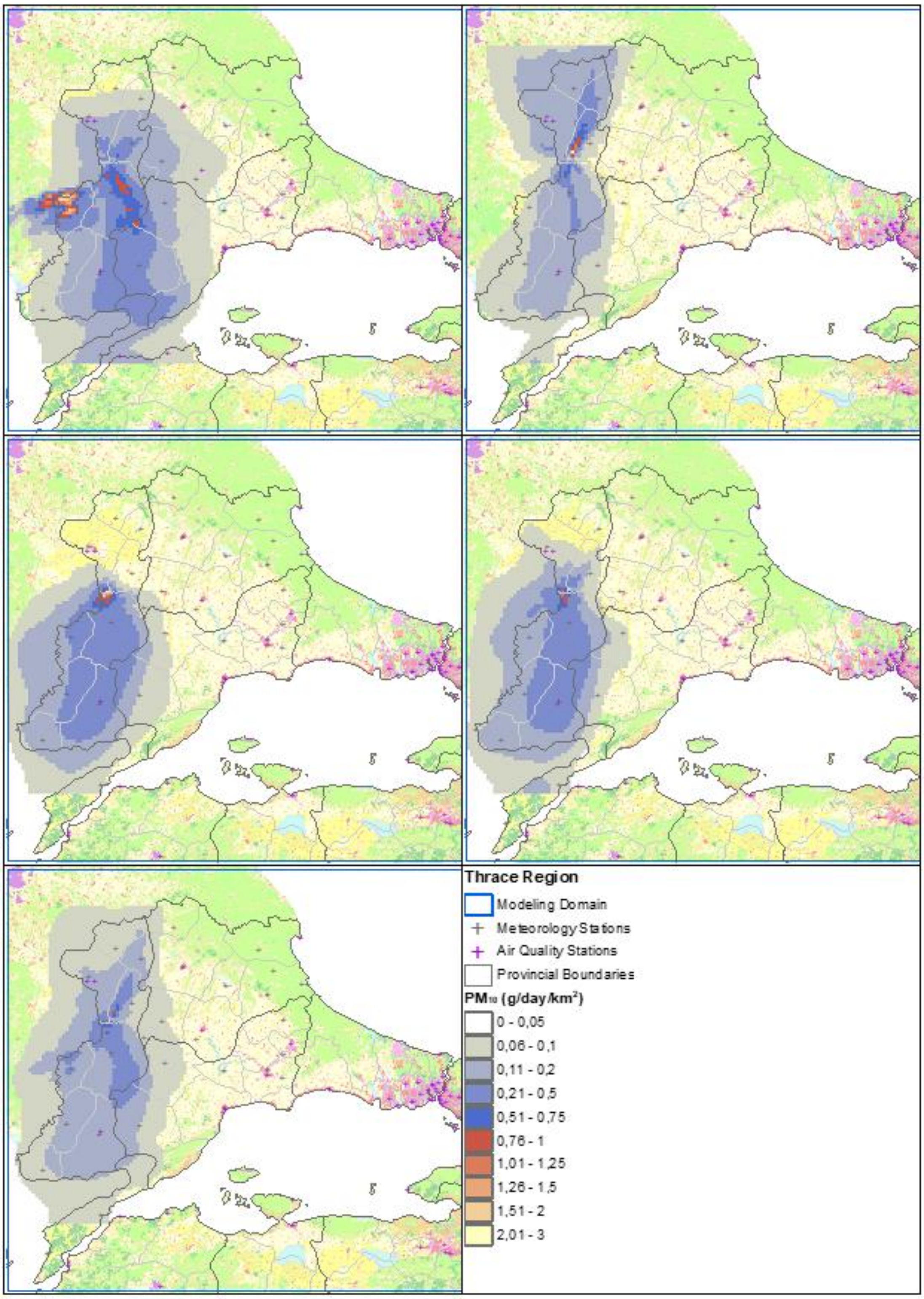

Figure 4.55. Daily PM_{10} dry flux of Havsa in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

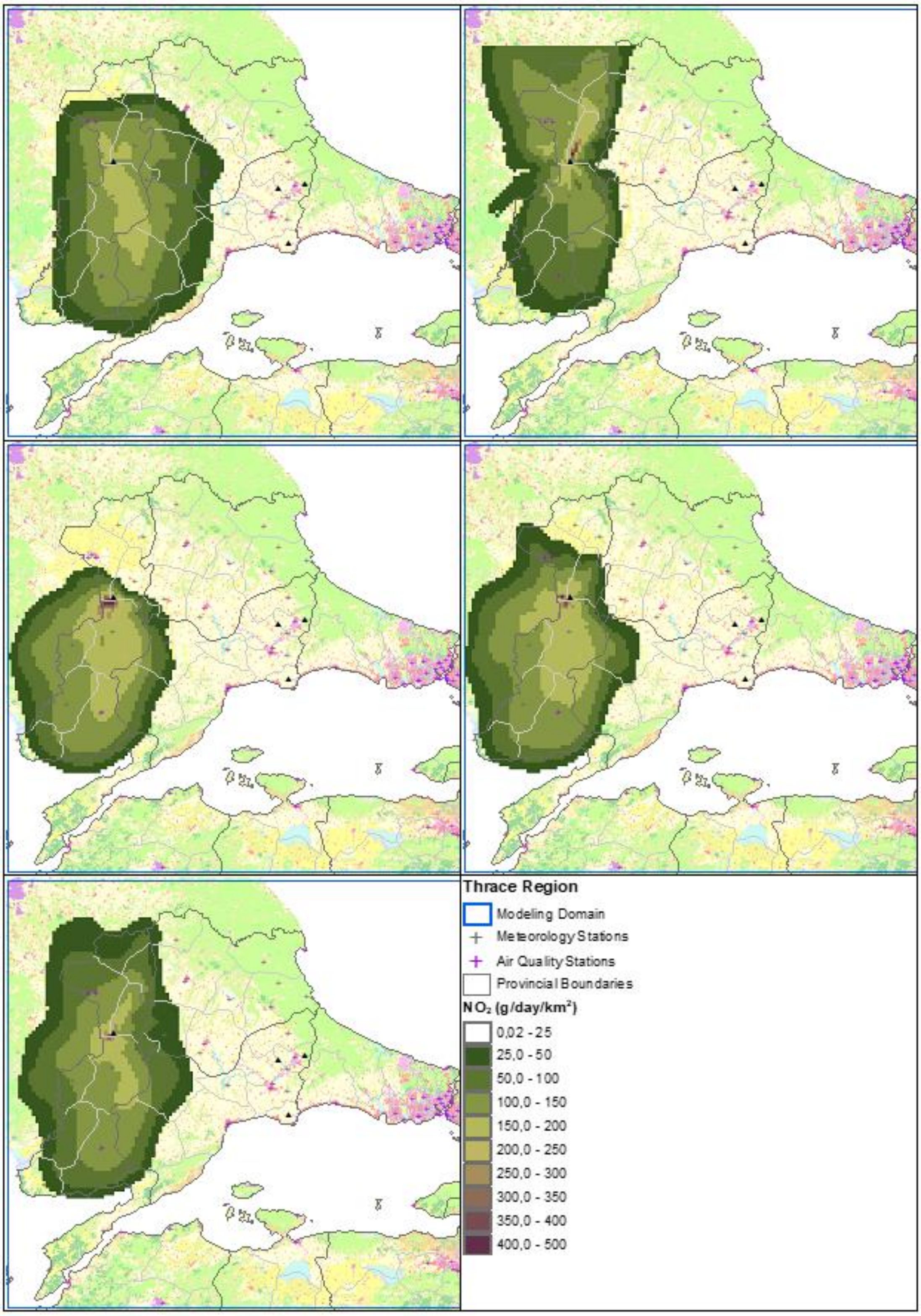

Figure 4.56. Daily NO_2 dry flux of Havsa in winter (upper left) spring (upper right) summer (middle left) fall (middle right) and annual average (bottom left)

4.2.3 Comparisons of location alternatives

SO_2 pollution will be caused in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest concentration in its domain. SO_2 comparisons without and with chemical transformation are given in **Figure 4.57** and **Figure 4.58**.

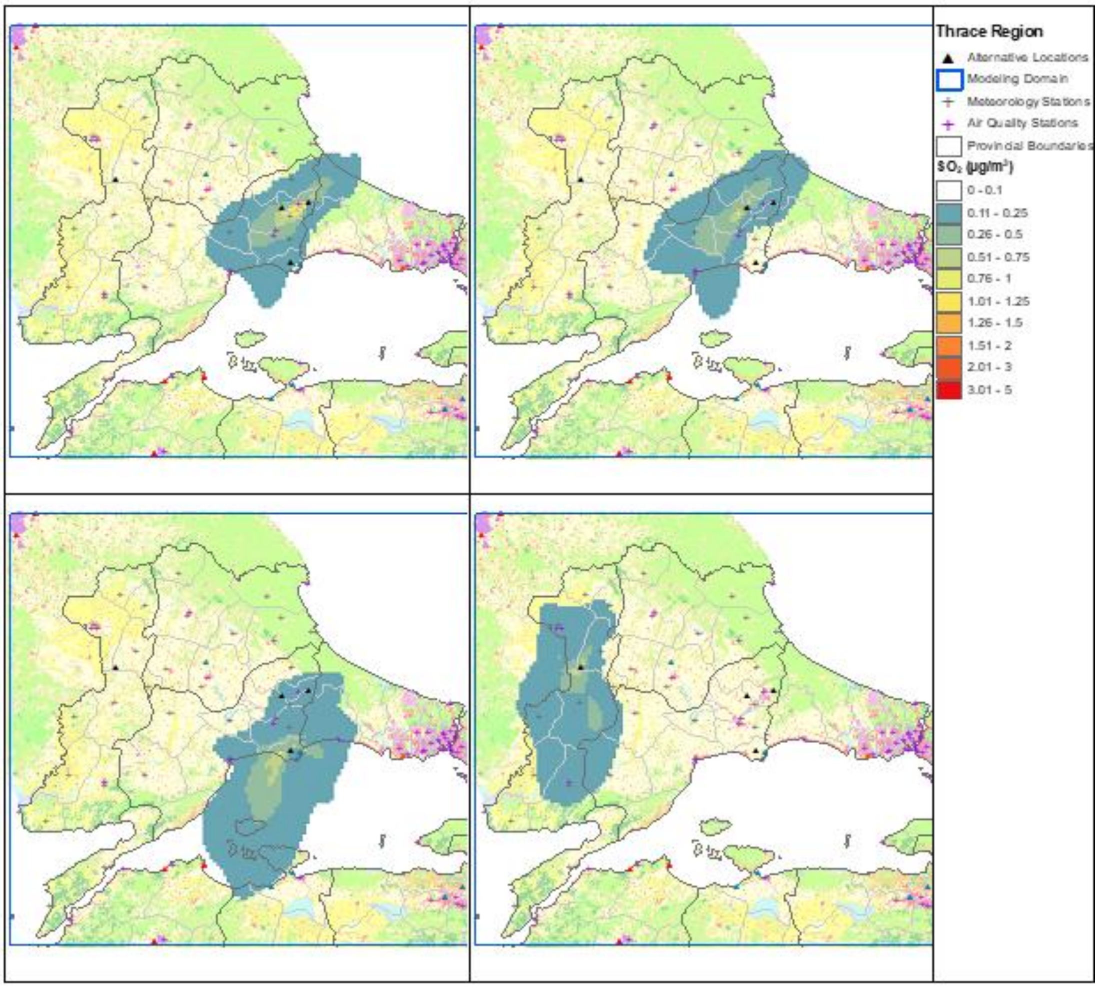

Figure 4.57. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual SO_2 comparisons with no chemical transformation

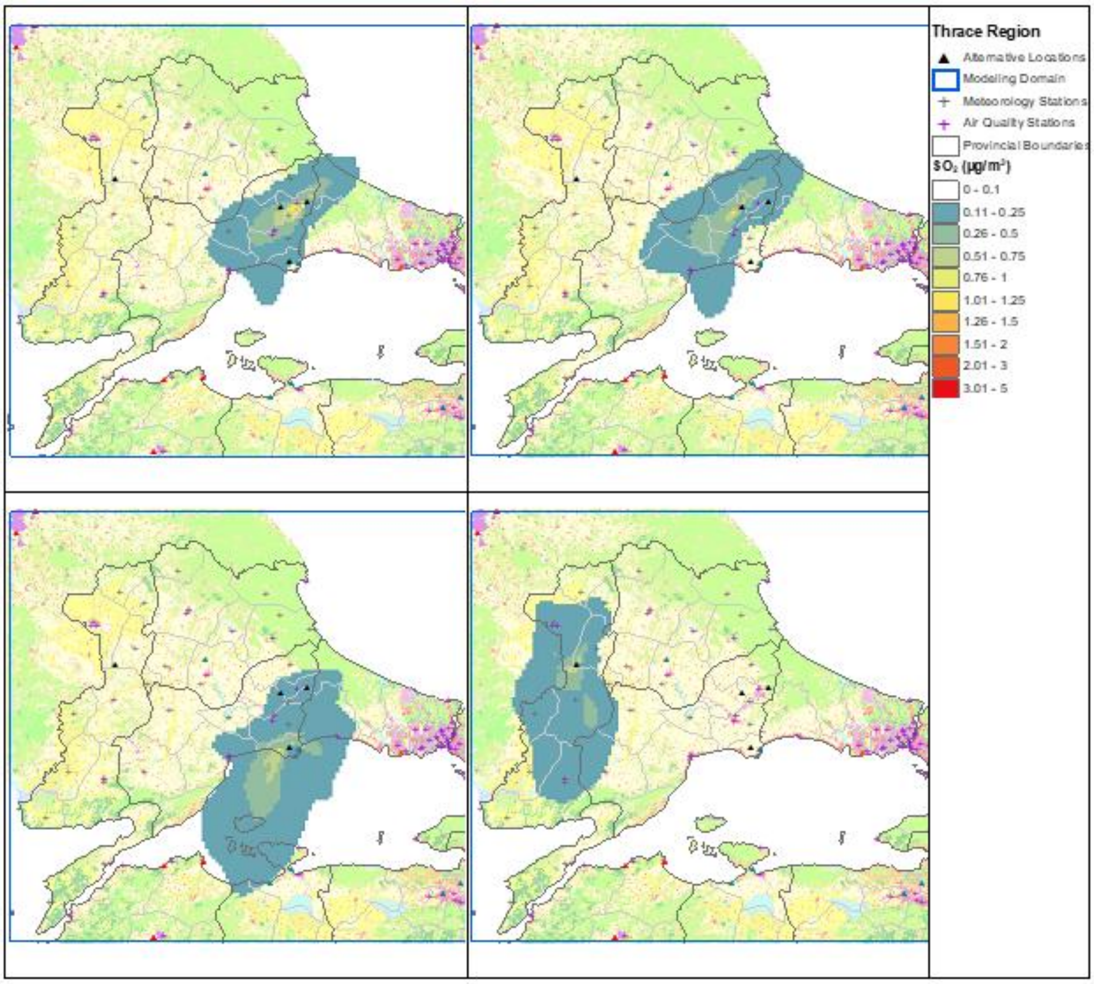

Figure 4.58. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual SO_2 comparisons with chemical transformation

SO_2 pollution will be caused in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest concentration in its domain. There isn't much difference in values compared to no chemical transformation scenario. PM_{10} comparisons without and with chemical transformation are given in **Figure 4.579** and **Figure 4.5860**.

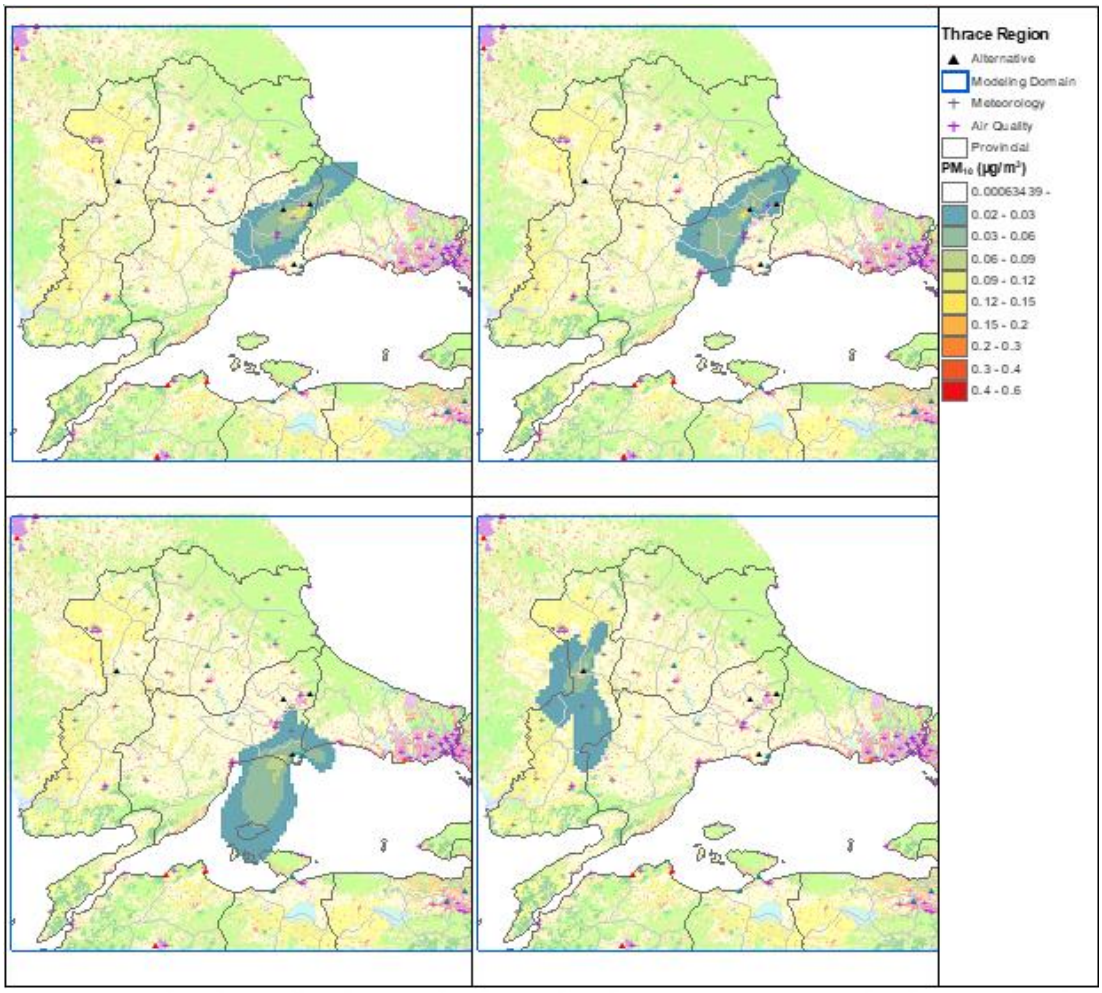

Figure 4.59. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual PM_{10} comparisons with no chemical transformation

PM_{10} pollution will be caused in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest concentration in its domain.

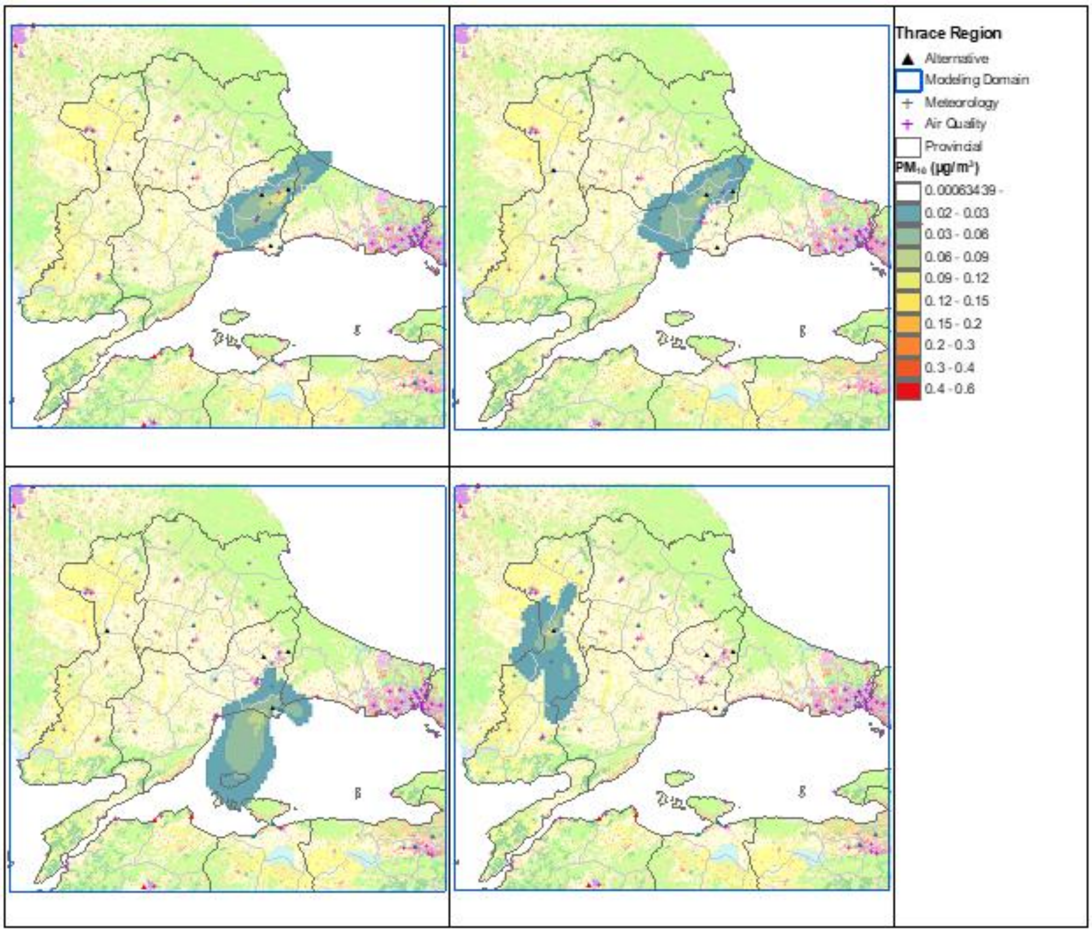

Figure 4.60. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual PM_{10} comparisons with chemical transformation

PM_{10} pollution will be caused in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest concentration in its domain. There isn't much difference in values compared to no chemical transformation scenario. NO_2 comparisons without and with chemical transformation are given in **Figure 4.61**.

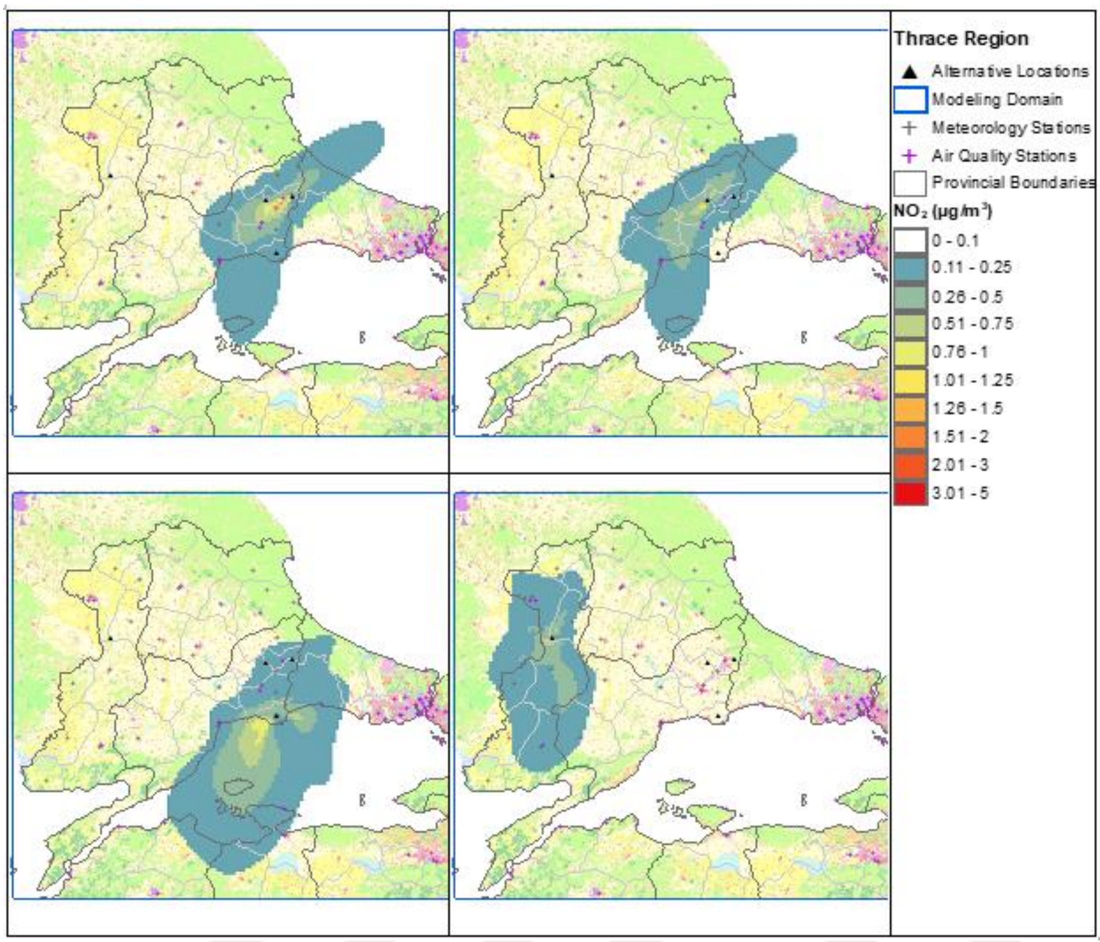

Figure 4.61. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual NO_2 comparisons with chemical transformation

NO_2 pollution will be caused in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest concentration in its domain. SO_2 dry deposition comparisons without and with chemical transformation are given in **Figure 4.5762** and **Figure 4.5863**.

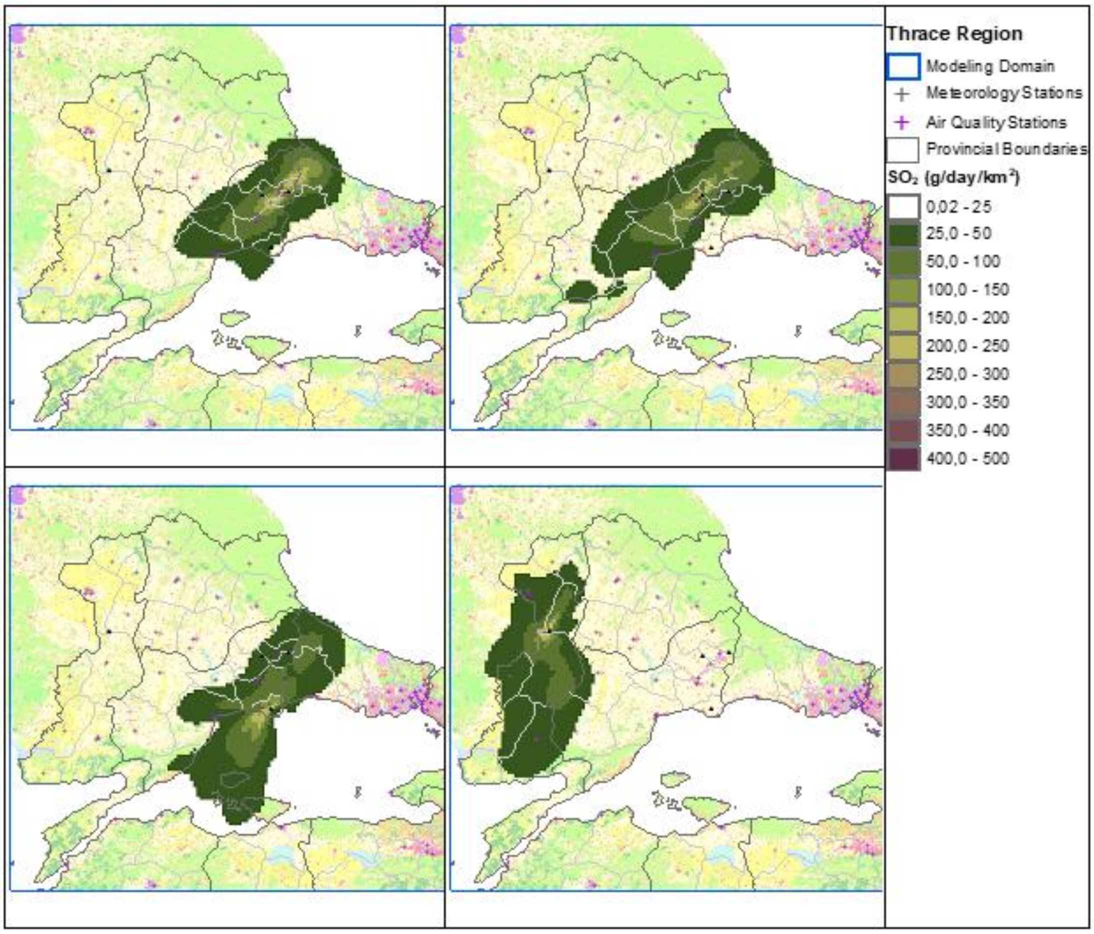

Figure 4.62. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual SO_2 dry deposition comparisons with no chemical transformation

SO_2 dry deposition will occur in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest flux in its domain.

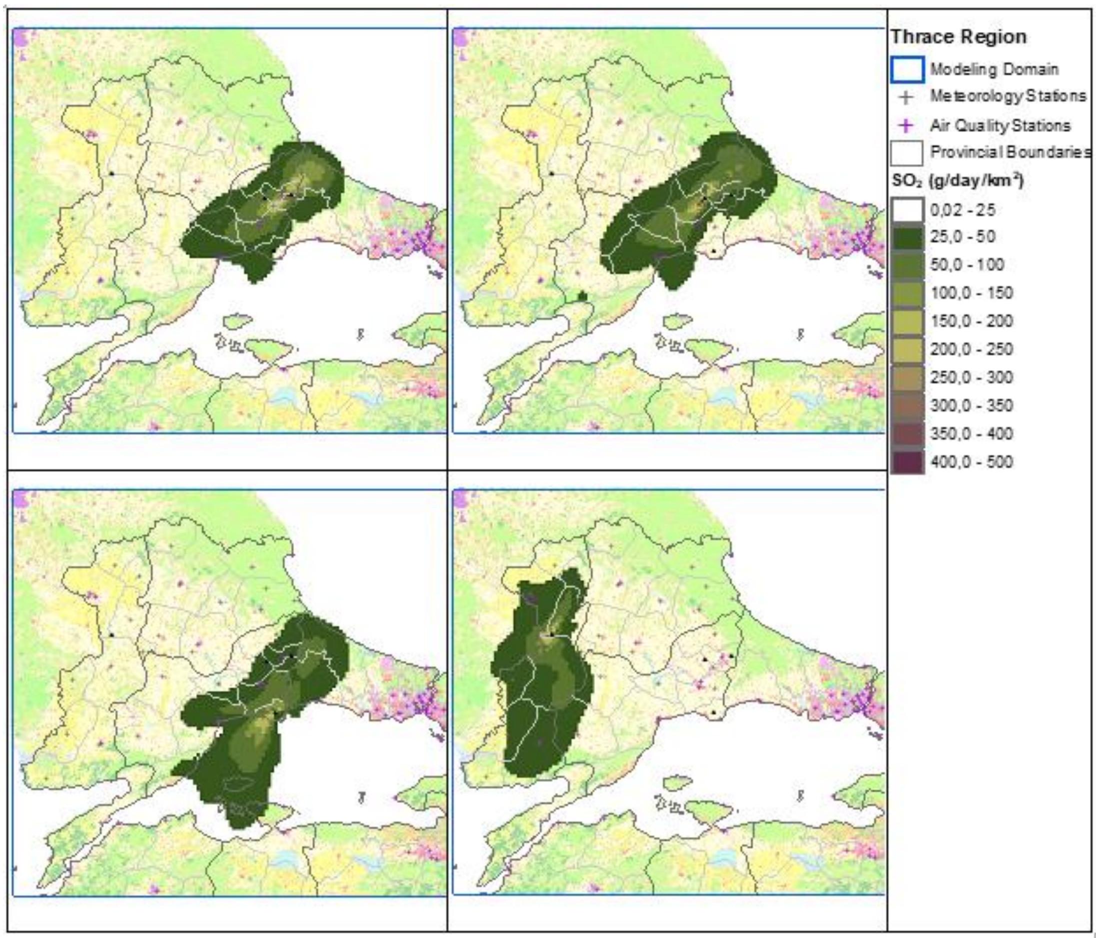

Figure 4.63. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual SO_2 dry deposition comparisons with chemical transformation

SO_2 dry deposition will occur in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest flux in its domain. There isn't much difference in values compared to no chemical transformation scenario. PM_{10} dry deposition comparisons without and with chemical transformation are given in **Figure 4.5764** and **Figure 4.58**.

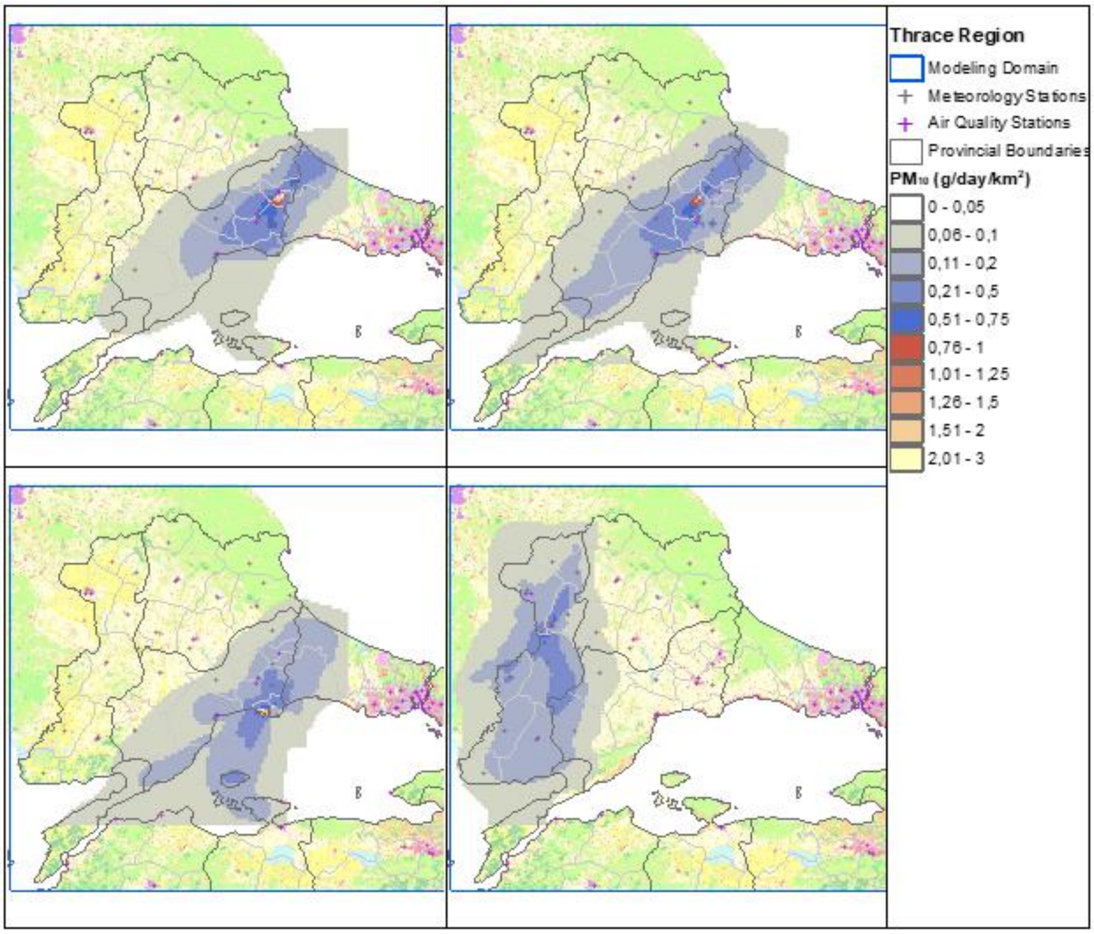

Figure 4.64. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual PM_{10} dry deposition comparisons with no chemical transformation

PM_{10} dry deposition will occur in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest flux in its domain.

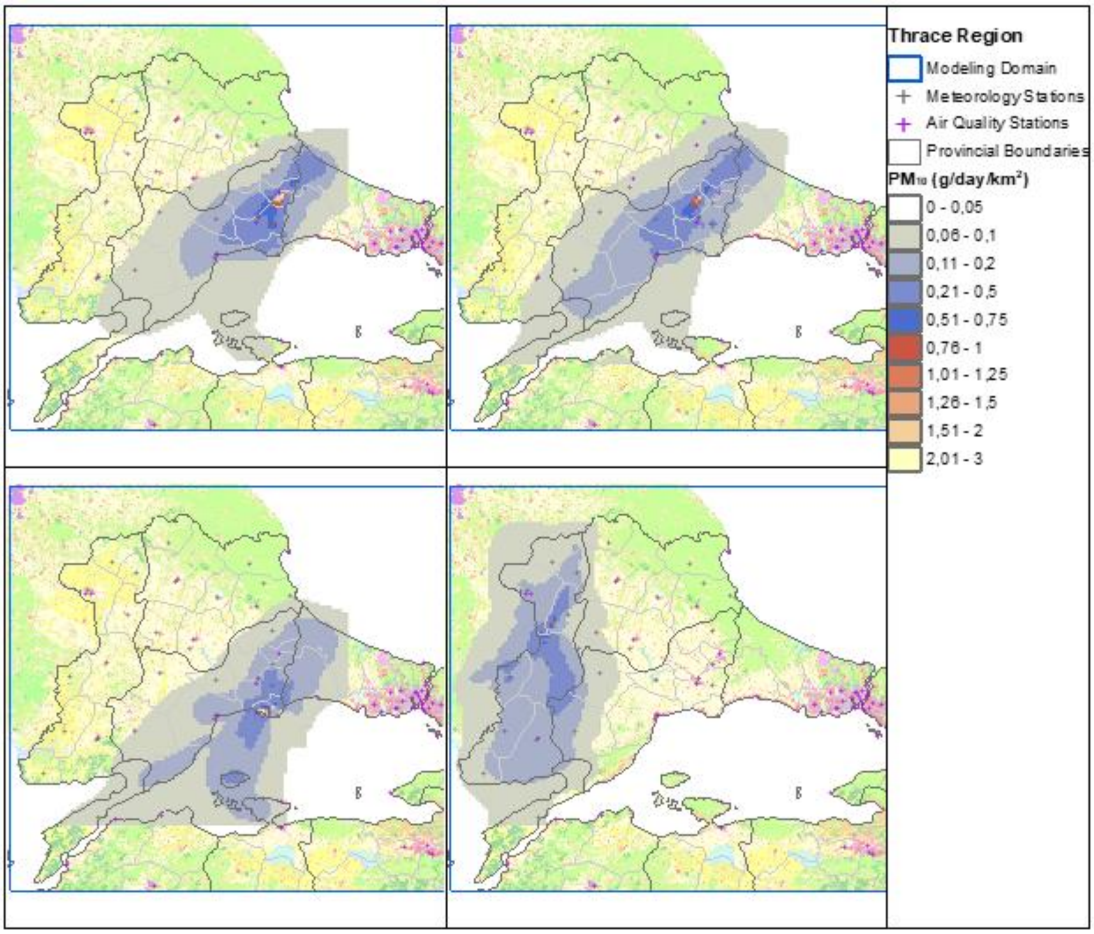

Figure 4.65. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual PM_{10} dry deposition comparisons with chemical transformation

PM_{10} dry deposition will occur in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest flux in its domain. There isn't much difference in values compared to no chemical transformation scenario. NO_2 comparisons with chemical transformation are given in **Figure 4.5766**.

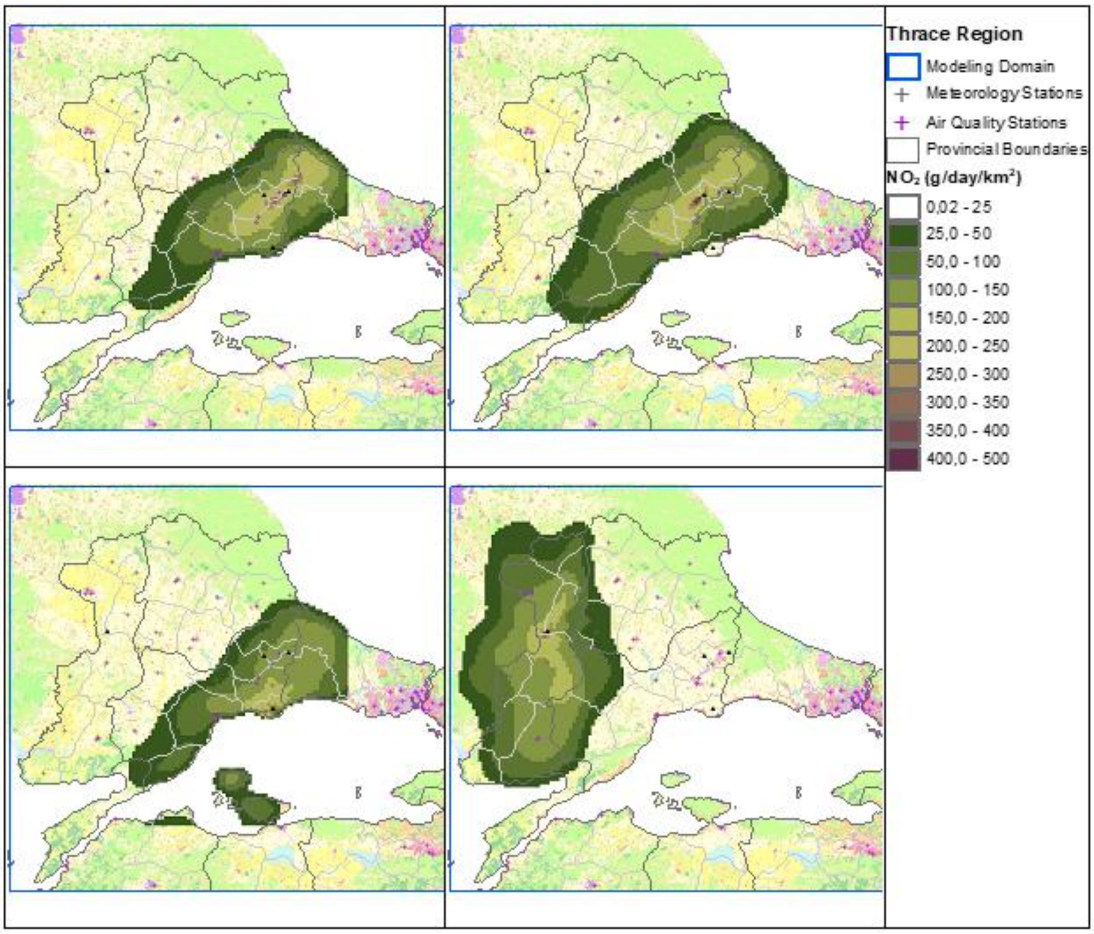

Figure 4.66. Çerkezköy (upper left), Çorlu (upper right), Marmara Ereğlisi (lower left) and Havsa (lower right) annual NO_2 dry deposition comparisons with chemical transformation

NO_2 dry deposition will occur in Çerkezköy and Çorlu town centers by Çerkezköy and Çorlu alternatives, but the concentrations are not very high. Çorlu alternative has the highest flux in its domain.

5. CONCLUSIONS

Three alternative locations instead of a proposed location for a new CPP in Thrace Region were suggested in this study. CALPUFF dispersion model was used to simulate these four cases for the year of 2016. Highest concentrations of SO_2, NO_2 and PM_{10} over larger impact areas were simulated in Çerkezköy case which is the proposed location. This case was also found to affect the highest population in the region compared to three alternatives.

Even though Çorlu case is located very close to Çerkezköy, Çorlu case affected a smaller region with lower population density than Çerkezköy. Resulting concentrations in Havsa and M. Ereğlisi cases were similar and lower than other two cases. However, they have moderate impact on some of the AQMSs which had significant exceedances. Proposed location resulted in the highest air pollution impact which indicates the necessity of the location selection methodology. The most suitable location for the CPP was found to be Havsa, considering the pollution contribution estimated by CALPUFF. However, M. Ereğlisi could also be a second alternative if economic factors such as transportation costs are taken into account. Maximum concentrations of all locations in their entire domains and in the closest AQMSs are given in **Table 5.1.**

Table 5.1. Maximum concentrations of all locations in their entire domains and in the closest AQMSs.

	Çerkezköy		Çorlu		Marmara Ereğlisi		Havsa	
SO_2	93.4	*(Study Domain)*	201	*(Study Domain)*	145	*(Study Domain)*	169	*(Study Domain)*
(μg/m^3)	53.3	*(Çerkezkoy MTHM)*	39.5	*(Çorlu OSB MTHM)*	14.9	*(Çorlu MTHM)*	10.6	*(Karaağaç MTHM)*
Hourly	12.1	*(Çorlu MTHM)*	28.8	*(Çerkezkoy MTHM)*	12.6	*(Tekirdağ)*	9.4	*(Edirne)*
	8.5	*(Çorlu OSB MTHM)*	26.5	*(Çorlu MTHM)*	12.3	*(Merkez MTHM)*	4.1	*(Lüleburgaz MTHM)*
SO_2	11.3	*(Study Domain)*	13.2	*(Study Domain)*	10.7	*(Study Domain)*	9.3	*(Study Domain)*
(μg/m^3)	8.1	*(Çerkezkoy MTHM)*	2.5	*(Çorlu OSB MTHM)*	2	*(Çorlu OSB MTHM)*	1.7	*(Edirne)*
Daily	3.3	*(Çorlu OSB MTHM)*	2.2	*(Çerkezkoy MTHM)*	1.9	*(Çorlu MTHM)*	1.4	*(Karaağaç MTHM)*
	2	*(Çorlu MTHM)*	2	*(Çorlu MTHM)*	1.5	*(Tekirdağ)*	0.6	*(Keşan MTHM)*
SO_2	1.4	*(Study Domain)*	1.4	*(Study Domain)*	0.86	*(Study Domain)*	0.87	*(Study Domain)*
(μg/m^3)	0.7	*(Çerkezkoy MTHM)*	0.2	*(Çorlu OSB MTHM)*	0.14	*(Çorlu MTHM)*	0.14	*(Keşan MTHM)*
Annual	0.4	*(Çorlu OSB MTHM)*	0.19	*(Çerkezkoy MTHM)*	0.13	*(Çorlu OSB MTHM)*	0.13	*(Edirne)*
	0.3	*(Çorlu MTHM)*	0.18	*(Çorlu MTHM)*	0.13	*(Çerkezkoy MTHM)*	0.13	*(Karaağaç MTHM)*
PM_{10}	9.5	*(Study Domain)*	20.3	*(Study Domain)*	14.8	*(Study Domain)*	17.1	*(Study Domain)*
(μg/m^3)	5.4	*(Çerkezkoy MTHM)*	4	*(Çorlu OSB MTHM)*	1.5	*(Çorlu MTHM)*	1.1	*(Karaağaç MTHM)*
Hourly	1.2	*(Çorlu MTHM)*	2.9	*(Çerkezkoy MTHM)*	1.3	*(Tekirdağ)*	1	*(Edirne)*
	0.5	*(Çorlu OSB MTHM)*	2.7	*(Çorlu MTHM)*	1.2	*(Çorlu OSB MTHM)*	0.4	*(Lüleburgaz MTHM)*
PM_{10}	1.1	*(Study Domain)*	1.3	*(Study Domain)*	1.1	*(Study Domain)*	1	*(Study Domain)*
(μg/m^3)	0.8	*(Çerkezkoy MTHM)*	0.3	*(Çorlu OSB MTHM)*	0.3	*(Çorlu OSB MTHM)*	0.3	*(Edirne)*
Daily	0.3	*(Çorlu OSB MTHM)*	0.2	*(Çerkezkoy MTHM)*	0.3	*(Çorlu MTHM)*	0.2	*(Karaağaç MTHM)*
	0.2	*(Çorlu MTHM)*	0.2	*(Çorlu MTHM)*	0.2	*(Tekirdağ)*	0.1	*(Lüleburgaz MTHM)*
PM_{10}	0.14	*(Study Domain)*	0.14	*(Study Domain)*	0.09	*(Study Domain)*	0.09	*(Study Domain)*
(μg/m^3)	0.07	*(Çerkezkoy MTHM)*	0.02	*(Çorlu OSB MTHM)*	0.02	*(Çorlu MTHM)*	0.02	*(Keşan MTHM)*
Annual	0.04	*(Çorlu OSB MTHM)*	0.02	*(Çerkezkoy MTHM)*	0.02	*(Çorlu OSB MTHM)*	0.02	*(Edirne)*
	0.04	*(Çorlu MTHM)*	0.02	*(Çorlu MTHM)*	0.02	*(Çerkezkoy MTHM)*	0.02	*(Karaağaç MTHM)*

REFERENCES

Aydın Yonca, N., Kentel, E., & Duzgun, H. S. (2013). Energy Conversion and Management GIS-based site selection methodology for hybrid renewable energy systems : A case study from western Turkey. *Energy Conversion and Management*, *70*, 90–106. https://doi.org/10.1016/j.enconman.2013.02.004

Biberacher, M., Tum, M., Günther, K. P., Gadocha, S., Zeil, P., Jilani, R., & Mansha, M. (2015). Availability assessment of bioenergy and power plant location optimization: A case study for Pakistan. *Renewable and Sustainable Energy Reviews*, *42*, 700–711. https://doi.org/10.1016/j.rser.2014.10.036

Cebi, S., Ilbahar, E., & Atasoy, A. (2016). A fuzzy information axiom based method to determine the optimal location for a biomass power plant: A case study in Aegean Region of Turkey. *Energy*, *116*, 894–907.

https://doi.org/10.1016/j.energy.2016.10.024

Kauria, L. (2016). *Master ' s* thesis Geography Geoinformatics. Developing A Global Location Optimization Model For Utility-Scale Solar Power Plants Laura Kauria Instructor : Tuuli Toivonen University Of Helsinki Faculty Of Science Department Of Geosciences And Geography Divi. 64.

Khan, N. (2018). Master ' s thesis. Location Optimization Of A Coal Power Plant To Balance Coal Supply And Electric Transmission Costs Against Plant's Emission Exposure Instructor: Ekaterine Koromyalova Najam Khan South Dakota State University Major In Operations Management

Sarıdikmen, B.; Akyüz, E.; Kaynak, B. (2019). Location optimization for future coal-fired power plants using geographical information system and dispersion model**.** World Clean Air Congress 2019

Şaylan, L., Çaldağ, B., Bakanoğullari, F., Toros, H., Yazgan, M., Şen, O., & Özkoca, Y. (2011). Spatial Variation of the Precipitation Chemistry in the Thrace Region of Turkey. *Clean - Soil, Air, Water*, *39*(5), 491–501.

https://doi.org/10.1002/clen.201000065

Villacreses, G., Gaona, G., Martínez-Gómez, J., & Jijón, D. J. (2017). Wind farms suitability location using geographical information system (GIS), based on multi-criteria decision making (MCDM) methods: The case of continental Ecuador. *Renewable Energy*, *109*(March), 275–286.

https://doi.org/10.1016/j.renene.2017.03.041

Zheng, J., Feng, X., Liu, P., Zhong, L., & Lai, S. (2011). Site location optimization of regional air quality monitoring network in china: Methodology and case study. *Journal of Environmental Monitoring*, *13*(11), 3185–3195.

https://doi.org/10.1039/c1em10560d

APPENDIX A

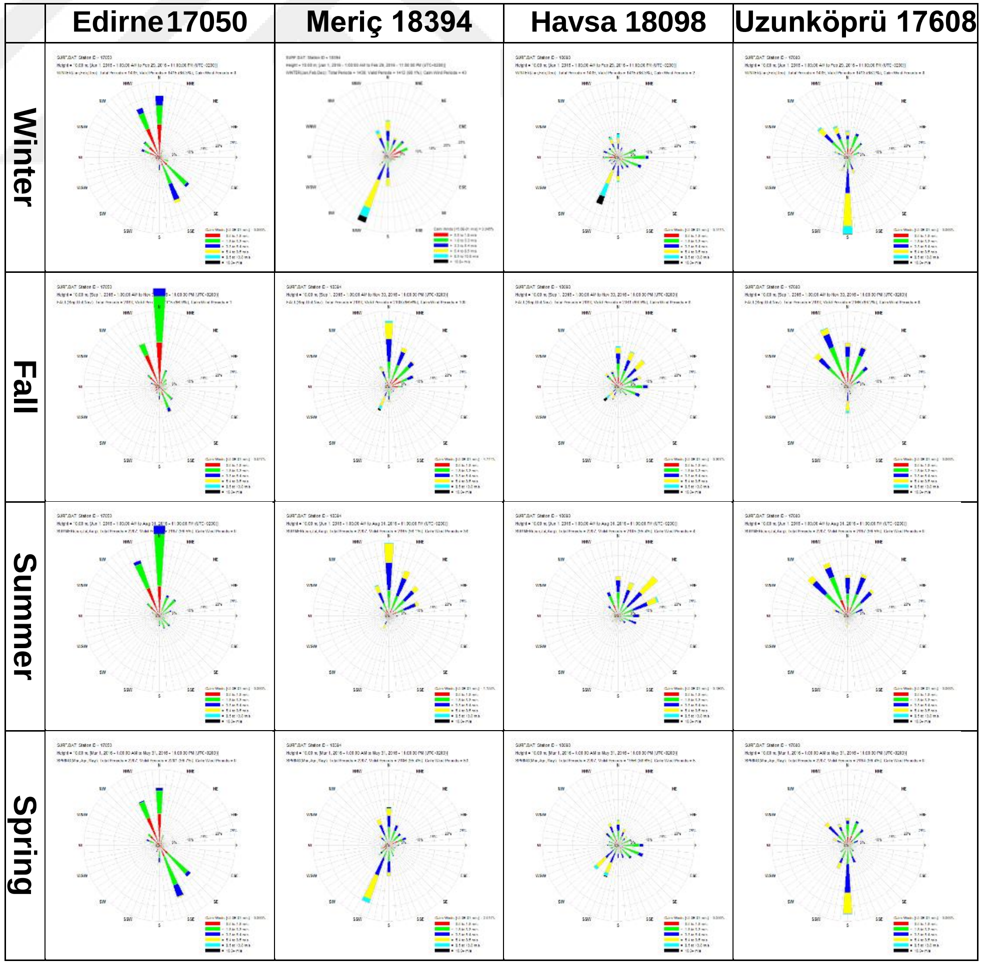

Figure A.1. Wind roses of meteorological stations closest to Havsa

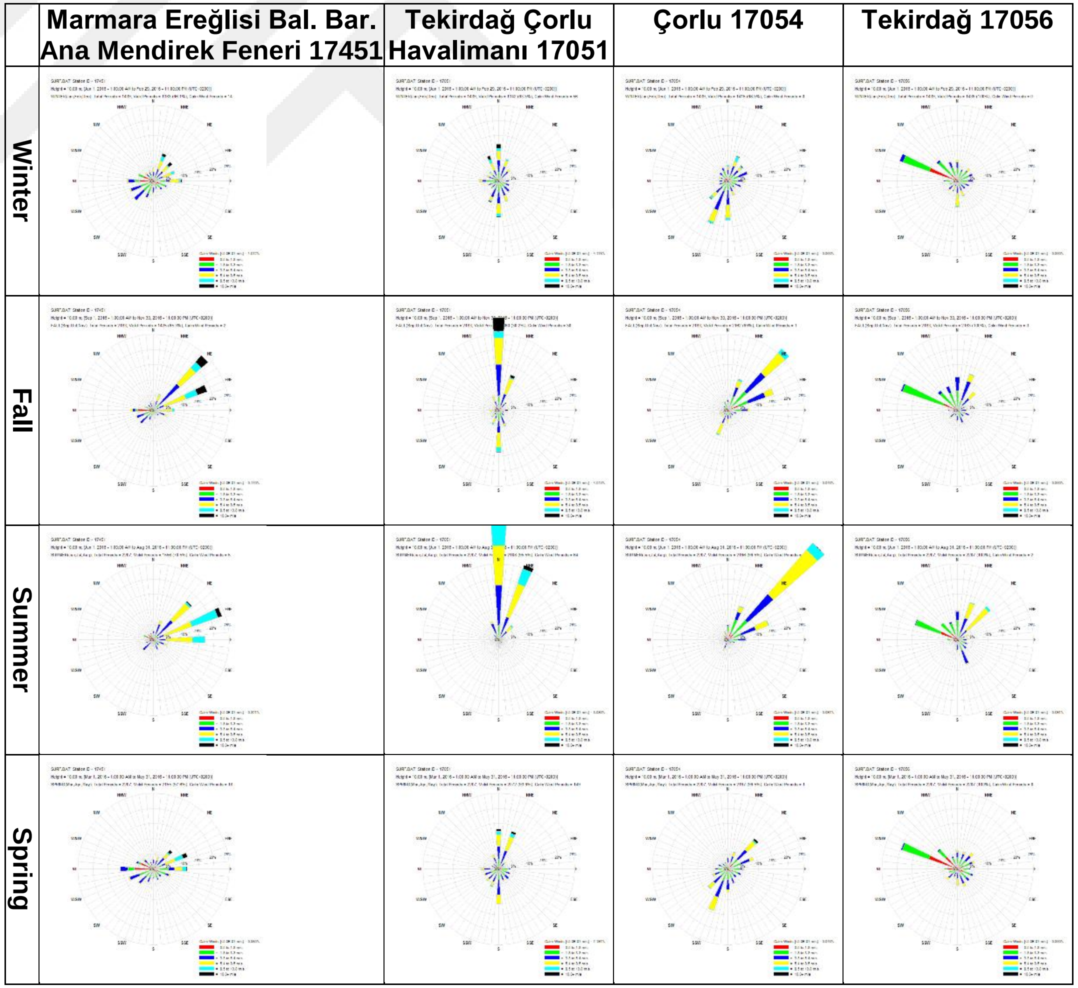

Figure A.2. Wind roses of meteorological stations closest to Marmara Ereğlisi

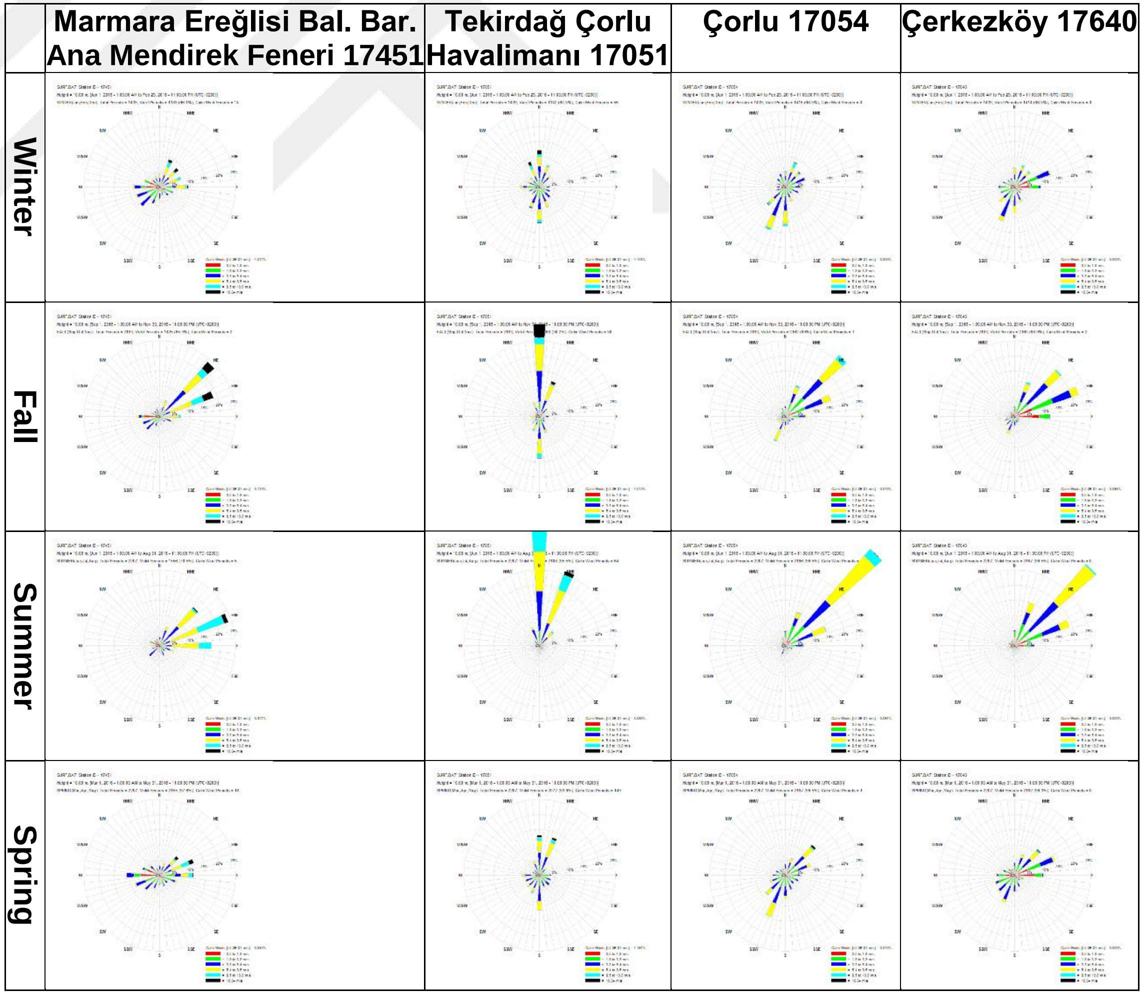

Figure A.3. Wind roses of meteorological stations closest to Çorlu

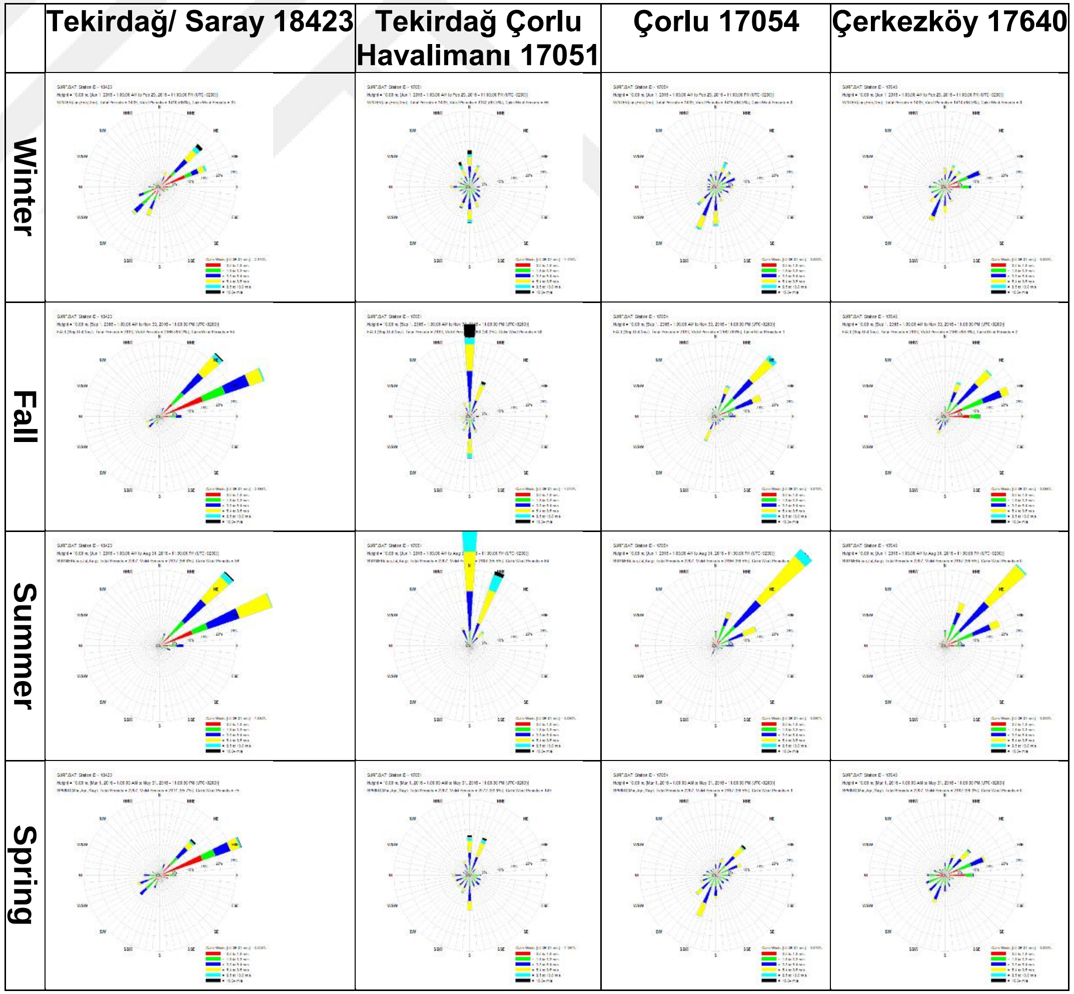

Figure A.4. Wind roses of meteorological stations closest to Çerkezköy

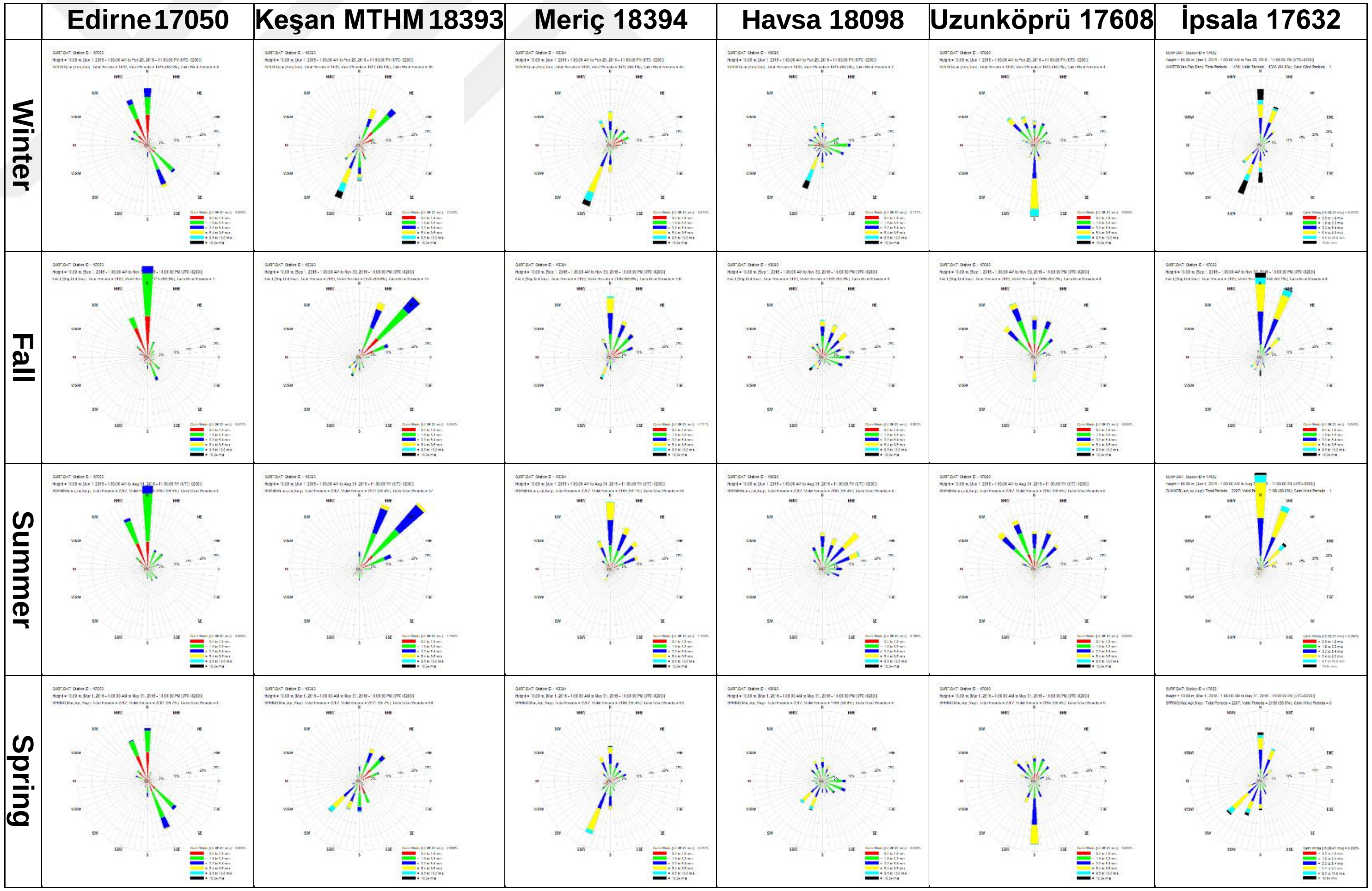

Figure A.5. Wind roses of meteorological stations in Edirne province

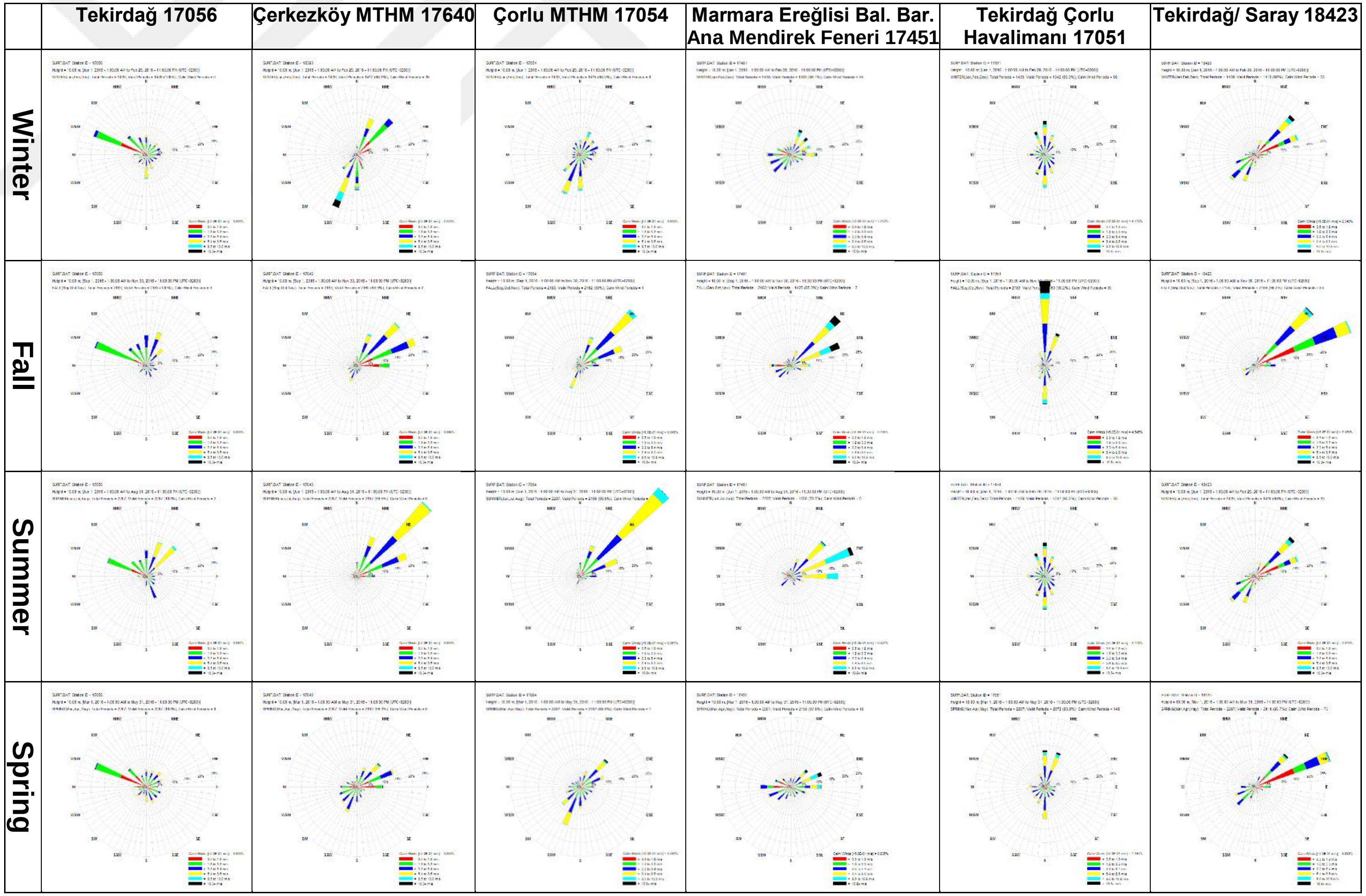

Figure A.6. Wind roses of meteorological stations in Tekirdağ province

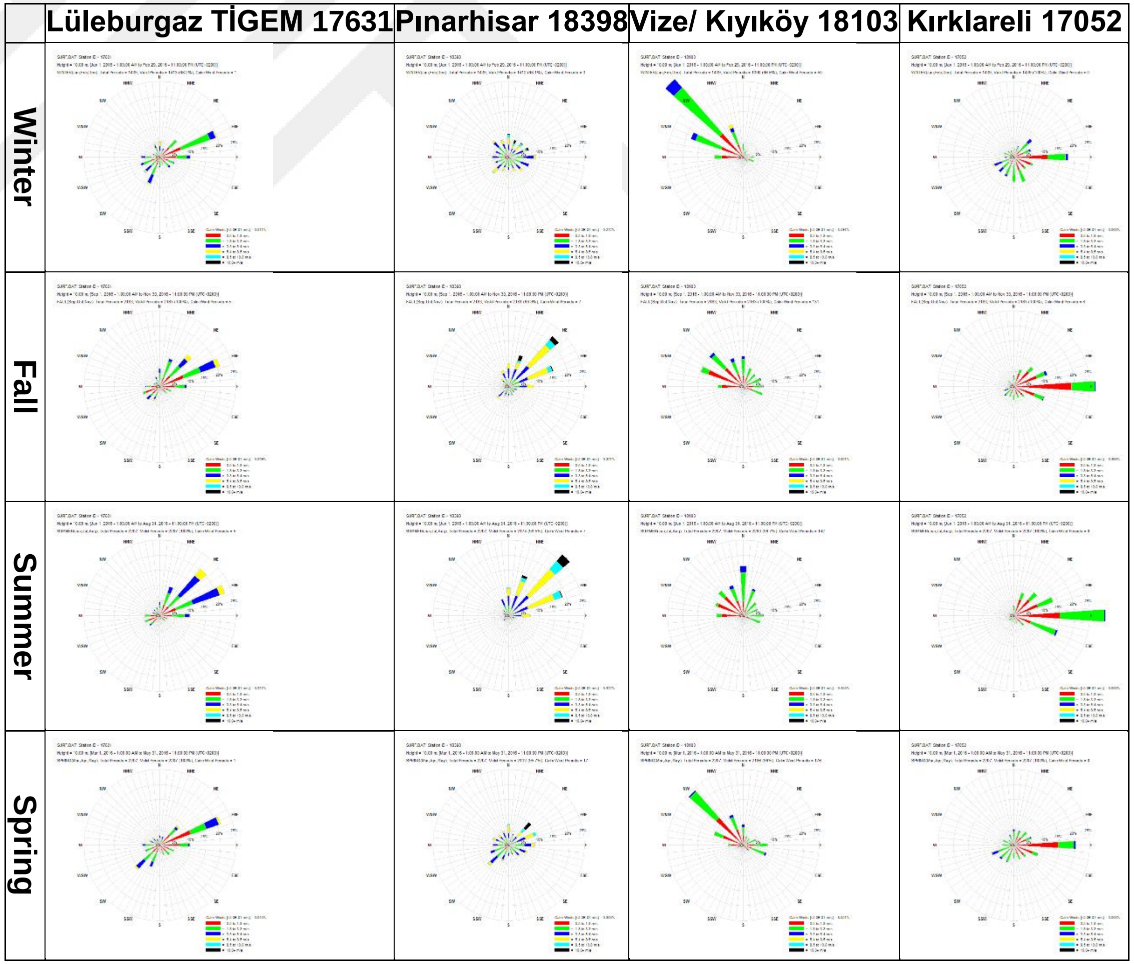

Figure A.7. Wind roses of meteorological stations in Kırklareli province

CURRICULUM VITAE

Name Surname : Barış Sarıdikmen

Place and Date of Birth : Istanbul 24.05.1993

E-Mail : saridikmen@itu.edu.tr

EDUCATION:

- **B.Sc.** : 2015, Istanbul Technical University, Faculty of Civil Engineering, Environmental Engineering

PROFESSIONAL EXPERIENCE AND REWARDS:

- **2018-** Business Development and Environmental Engineer / Yıldırım Energy Holding Inc., Istanbul
- **2015-2018** Permits and Licences Junior Expert / Yıldırım Energy Holding Inc., Istanbul
- **2015** Intern / Meta Treatment Company, 1 month, Istanbul
- **2014** Intern / Governorate of Istanbul Provincial Directorate of Environment and Urban Planning, 1 month, Istanbul
- **2013** Intern / I.T.U. Environmental Engineering Labs, 1 month, Istanbul

PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- Barış Saridikmen, Ezgi Akyüz, and Burçak Kaynak “Location Optimization for Coal-Fired Power Plants Using Geographical Information Systems and Calpuff

Dispersion Model", 18^{th} World Clean Air Congress (WCAC2019), 23-27 September, 2019, Istanbul, Turkey. (Oral Presentation)