DROUGHT ANALYSIS USING CORDEX SIMULATIONS OVER THE MEDITERRANEAN CLIMATE REGIONS OF TURKEY

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DROUGHT ANALYSIS USING CORDEX SIMULATIONS OVER THE MEDITERRANEAN CLIMATE REGIONS OF TURKEY

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ABSTRACT

DROUGHT ANALYSIS USING CORDEX SIMULATIONS OVER THE MEDITERRANEAN CLIMATE REGIONS OF TURKEY

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Drought has been a significant result of climate change that causes variance on precipitation regimes. Mediterranean region is one of the hotspots of the world in this respect. Dry summers and rainy winters -the characteristic of this climate type- makes this region more vulnerable to the effects of climate change. Hence, it is important to monitor drought considering the increasing population and economic facilities in the regions that are under Mediterranean climate conditions in Turkey. This study aims to assess the trends in drought by applying the Standardized Precipitation Index(SPI) for 5 timescales – from 1 month to 12 months. The model grid data that corresponds to meteorological stations distributed from south to west within the study area was obtained from 12 different Global Circulation Model / Regional Climate Model couplings of CORDEX project. Observed and modeled prediction data were compared for reference period (1971-2005) in order to detect the most reliable models. Afterwards, modified Mann-Kendall trend test was applied on the SPI and annual precipitation values for the entire period (1972-2100). The trends were estimated by linear regression for the locations in which Mann-Kendall results indicated a significant change. In conclusion, a persistent increasing drought trend was detected for Muğla and western Antalya parts such that all models are coherent. On the other hand, the divergence of the trends for some regions according to different models signifies the discrepancy of models. Besides, the drought trends are decreasing for some regions (especially Southern Marmara) as the timescale increases.

Keywords: Climate change, drought, Standardized Precipitation Index, Mediterranean climate region, CORDEX project

ÖZ

CORDEX SİMÜLASYON VERİLERİ KULLANILARAK TÜRKİYE'NİN AKDENİZ İKLİM BÖLGELERİNDE KURAKLIK ANALİZİ

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Yağış rejimlerinde değişimlere sebep olan iklim değişikliğinin önemli sonuçlarından biri de kuraklıktır. Akdeniz Bölgesi bu açıdan Dünyadaki hassas noktalardan biridir. Bu iklim tipinde yazların kurak, kışların yağışlı olması bölgeyi iklim değikliğinin etkilerine daha açık hâle getirmiştir. Bu sebeple, Türkiye'nin Akdeniz iklimi etkisi altındaki bölgelerinde artan nüfus ve ekonomik etkinlikler de düşünüldüğünde kuraklığı incelemek oldukça önemlidir. Bu çalışmada, Standartlaştırılmış Yağış İndeksi(SPI) 1 aydan 12 aya kadar 5 zaman ölçeğinde uygulanarak kuraklıktaki trendler değerlendirilmiştir. 12 farklı iklim modelinin, incelenen alanının güneyinden batısına yayılmış meteorolojik gözlem istasyonlarının konumuna denk gelen yağış verileri CORDEX projesinden alınmıştır. En güvenilir modelleri belirlemek amacıyla referans dönemi (1971-2005) için gözlem ve model yağış verileri karşılaştırılmıştır. Ardından, düzenlenmiş bir Mann-Kendall testi tüm dönem için (1972-2100) SPI ve yıllık yağış değerlerine uygulanmıştır. Mann-Kendall testinin anlamlı değişim işaret ettiği noktalar için lineer regresyon yöntemiyle trendler hesaplanmıştır. Sonuçta,

Muğla ve Batı Antalya için kuraklıkta tüm modellerin sonuçlarının uyum içinde olduğu ciddi bir artış trendi tespit edilmiştir. Öte yandan, bazı bölgeler için model sonuçların çeşitliliği, modellerin farklılıklarına işaret etmektedir. Ayrıca, Güney Marmara başta olmak üzere bazı bölgelerde zaman ölçeği arttıkça kuraklık trendinde azalış sözkonusudur.

Anahtar kelimeler: İklim değişikliği, kuraklık, Standartlaştırılmış yağış indeksi, Akdeniz iklim bölgesi, CORDEX projesi

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ABBREVIATIONS

CLMcom	Climate Limited-area Modelling Community
CNRM	Météo-France/Centre National de Recherches Météorologiques
CORDEX	Coordinated Regional Climate Downscaling Experiment
CORR	Correlation Coefficient
DMI	Danish Meteorological Institute
GCM	General Circulation Model/Global Climate Model
IPCC	Intergovernmental Panel on Climate Change
IPSL	Institut Pierre-Simon Laplace
KNMI	Royal Netherlands Meteorological Institute
MGM	Turkish State Meteorological Service
MOHC	Met Office Hadley Centre
NASA	The National Aeronautics and Space Administration
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RMSE	Root Mean Square Error
SMHI	Swedish Meteorological and Hydrological Institute
SPI	Standardized Precipitation Index

CHAPTER 1

INTRODUCTION

1.1. Introduction

Water moves in a cycle on the earth and in the atmosphere. It evaporates from the surface of the earth, cools and condenses as it rises into atmosphere, and falls again to the surface in different forms of precipitation (WEB1).

Climate is the typical and averaged weather of a region or a city over many years. Climate characteristics consist of many attributions from seasonal temperature differences to precipitation regimes. Changes in climate take several years - decades, centuries and even millennials (WEB2).

Frequent and precise measurements of any form of precipitation is indispensable to determine changes in and make models of Earth's water cycle. In addition to observations, climate models reproduce observed features of recent climate and past climate changes by benefiting well-established physical principles to (Randall et al., 2007). A General Circulation Model (also known as Global Climate Model and abbreviated as GCM) can provide reliable prediction information on big scales (around 1000 by 1000km) while Regional Climate Models applied over a limited area and driven by GCMs can provide information on much smaller scales (WEB3). This improves assessing the changes in precipitation regimes in many vulnerable regions of the world.

Turkey is a country that has a climatic diversity though it is situated in large Mediterranean location. This diversity of climatic conditions is mainly due to diverse nature of the landscape. The mountains in the south and north coast run parallel to the seashore and therefore marine climate cannot penetrate to the interior parts. Only the western parts are relatively more open to marine effects since the mountains are not parallel to the shore, but perpendicular.

The climatic differences between regions of Turkey can be figured out by geographical distribution of annual precipitation (
Figure *1*) Annual rainfall along Mediterranean Sea and Aegean Sea varies from 580 to 1,300 millimeters, depending on location whilst Black Sea coast receives the highest annual rainfall (Sensoy et al., 2016). The amount of rainfall decreases gradually to the inland. Only a small part from the east of the country receives precipitation as much as coastline.

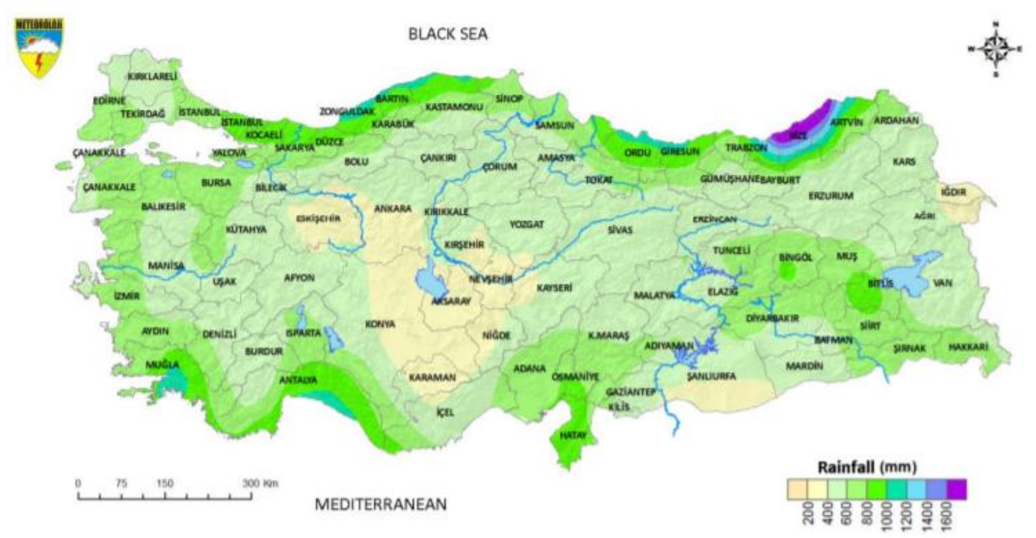


Figure 1. The distribution of annual precipitation for Turkey based on the period 1981-2010 (Downloaded from WEB4)

The increasing concentration of greenhouse gases leads the atmosphere to be warmer as a result of trapped solar energy. This phenomenon is called ‘global warming’ which refers to global temperature rises for long-term, whereas ‘climate change’ is a broader term that indicates not only the changes in averages but also increases in occurrence of extreme events like floods, drought and heatwaves or changes in rain and snow patterns (WEB2).

Drought is a bit latent phenomenon comparing to other extreme weather events since it is not as instantaneous as floods that emerge in minutes or heatwaves that evokes itself immediately. However, it is such an event that has widespread and long-termed effects to nature and society. Even, mass migration of people is one of the striking results of these effects (Raleigh et al., 2008). The cost of drought must also be taken into account at evaluation of its damage. The estimation of the cost of a four-year drought that hit California is 2.7 billion US Dollars in 2015, according to a study from University of California-Davis (WEB5). At the beginning of 2018, an increase in electricity price was discussed due to decreases in electricity production of hydropower plants in consequence of drought in Turkey (WEB6).

Since precipitation is a vital component of water cycle, the changes in climate directly affect the spatial and temporal distribution and quantity of precipitation. Assessing the changes and trends in precipitation and concluding about drought is an arguable issue as well as essential. This complexity arises from the problem of defining drought. Redmond(2002) explains drought simply ‘insufficient water to meet needs’ following a discussion on the approaches to the phenomenon. This definition highlights the importance of both the supply and the demand sides of the subject (Redmond, 2002).

Wilhite and Glantz (1985) endeavored to categorize the drought. They categorized the definitions into four: meteorological, hydrological, agricultural, and socioeconomic.

Meteorological definitions are the most common and define drought usually based on the degree of dryness and the duration of the dry period. Definitions of meteorological drought must be considered separately for every region since the meteorological conditions that result in deficiencies of precipitation are highly irregular from region to region.

Agricultural drought associates numerous characteristics (precipitation shortages, soil water deficits etc.) of meteorological drought to agricultural impacts. A useful definition of agricultural drought should consider the variable susceptibility of crops at different stages of crop growth.

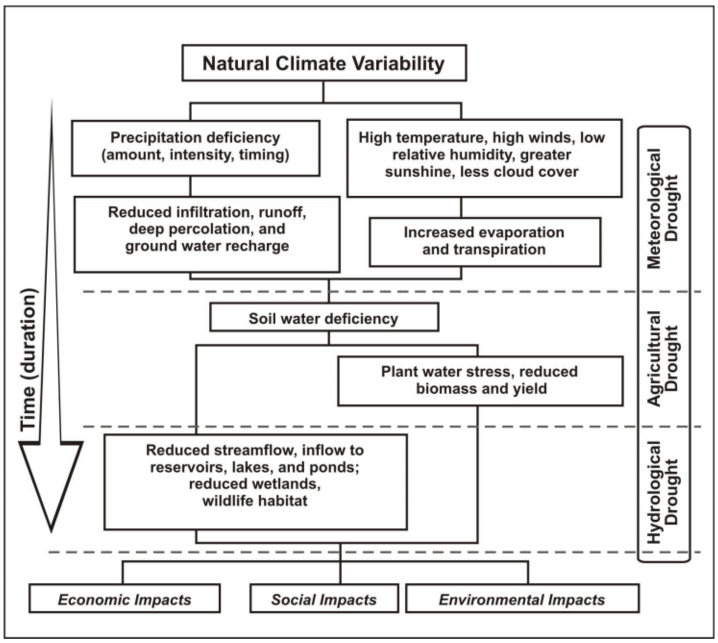


Figure 2 Classification of drought depending on duration and effects (Downloaded from WEB7).

Hydrological drought is linked with the effects of duration of precipitation shortfalls on surface or subsurface water supply (WEB7). This type of droughts is mostly out of phase with both meteorological and hydrological droughts since it takes longer to show up precipitation deficiencies on hydrological system components such as soil moisture, streamflow, and groundwater and reservoir levels.

A variety of indices have been proposed and used to assess drought up to now. However, developing an index to assess drought is an inseparable matter from defining drought. Thus, quantifying drought by indices is a difficult geophysical endeavor. Standardized Precipitation Index(SPI) is a meteorological drought index that is widely used to detect drought for different timescales. Keyantash and Dracup (2002) finds out that SPI is the most successful index in measuring drought right after rainfall deciles. They analyze 14 types of indices from all drought forms (meteorological, hydrological and agricultural) based on six criteria: robustness, tractability, transparency, sophistication, extendability, and dimensionality. SPI is also distinguished with its ability to measure the severity of drought and selected to measure drought in this study owing to all these features of it.

1.2. The Significance of the Study

The main goal of this study is to investigate the drought conditions from past to the end of 21st century in Mediterranean climate region of Turkey that is most vulnerable to the effects of climate change because of the increase in temperature and decrease in precipitation (Dabanlı et al., 2017; Topcu et al., 2010). The drought analyses were performed by calculating the well-known SPI values for drought at 1, 3, 6, and 12 months timescales, assessing the impact of drought at different levels, i.e. meteorological, hydrological and agricultural droughts. Ensemble modeling approach releases 12 GCM/RCM pairs from CORDEX (the Coordinated Regional Climate Downscaling Experiment) project was used to make drought predictions not only for the past but also future period till the end of century. First, in reaching the main goal of this study, the performance analyses of the GCM/RCMs pairs in estimating monthly precipitation that are used to derive SPI indices were made at 46 grid locations corresponding to meteorological stations distributed to the study area. Second, the Mann Kendall trend test was applied to SPI values calculated through the period from 1972 to 2100 for each model pair. Finally, the assessment of drought at various magnitudes was performed at locations where drought is statistically significant from multi-model system over entire study area. As a result, the consistency of drought that appears within the region by the end of century was documented with the support of ensemble model approach.

1.3. Literature Review

IPCC reports (2013) revealed that decreases in soil moisture and increases in agricultural drought are likely in presently dry regions by the end of 21st century according to the projections from regional to global scale under RCP8.5 scenario. The drying in soil moisture is also consistent with projected changes in Hadley circulation (Figure 3) and surface temperature increases in Mediterranean, Southwestern US and Southern African regions (IPCC, 2013). In addition to this, Giorgi (2006) highlighted the vulnerability of Mediterranean and North Eastern European regions by defining them the climate change hot-spots.

An extensive research that was conducted by Cook et al. (2016) investigated the drought for the whole region around Mediterranean Sea. They analyzed the drought variability for 900 years (1100-2012) in the Old World Drought Atlas (OWDA), a spatiotemporal tree ring reconstruction of the June-July-August self-calibrating Palmer Drought Severity Index. The outcomes indicated an east-west coherence in drought on multidecadal and centennial timescales. However, the analysis results of Levant region (Cyprus, Israel, Jordan, Lebanon, Palestine, Syria, and Turkey) indicated that recent dry extremes are extraordinary during the last millennium. This provided a support to studies claiming that the anthropogenic climate change has a significant effect (Cook et al., 2016).

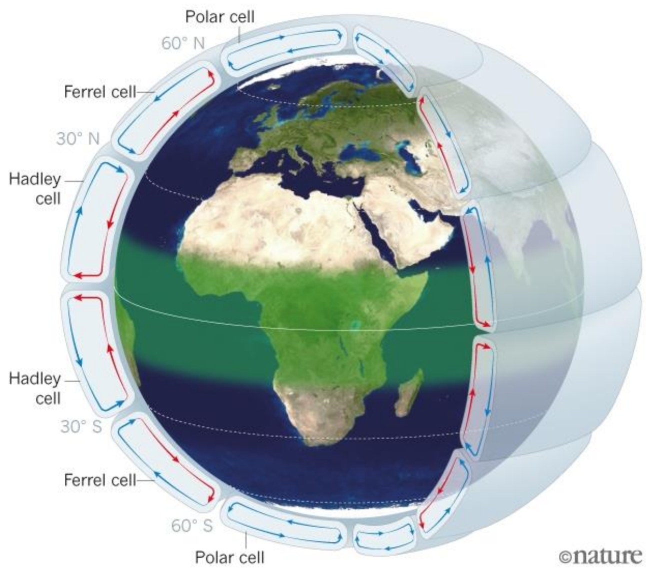


Figure 3. Illustration of Hadley Circulation (Heffernan, 2016). Dry zones are extending as Hadley cell is shifting polewards.

Many studies have been done based on the evaluation of the performance of the climate models and making predictions depending upon them. The followings provide a summary of the results of some of these studies.

Giorgi and Lionello (2008) determined that GCM and RCM simulations are generally similar to each other at large scale. Though, it was pointed that precipitation change signal produced by RCMs also take into the orographically effects account.

Leng et al. (2015) investigated climate change impacts on drought in China. They detected the different response of same models (HadGEM2-ES and MIROC-ESM-CHEM) for different drought types. Predicting more extreme droughts than mean droughts is another significant result of their study.

Osuch et al. (2016) analyzed SPI and rainfall trends for Poland with RCM projections from ENSEMBLES project. These analyses were conducted for a period that consists both historical and future data: 1971-2099. Bias correction was applied to model data, though, the trends in SPI slightly changed after correction. Considering the consistency of the models, it was detected that the results are similar for some models for the study area. Modified Mann-Kendall test was used for trend detection in this study. Lee et al. (2017) determined the influence of climate change and possible rises on drought conditions for Hwanghae Plain in Korea with regionally downscaled data. Stagge et al. (2015) investigated future meteorological drought based on CORDEX data for RCP 4.5 and RCP 8.5 scenarios. They highlighted the conflicting results of previous studies on drought severity even though their consistency on regional hotspots and CORDEX project's capacity to improve the reliability and consistency of the analyses since the projections have been processed at a much finer resolution. The results of this study indicated significant increases in meteorological drought frequency and severity for Mediterranean region while areal extensions were likely for Atlantic coast and Southern Europe according to period 1971-2000. It was also detected that the changes in the occurrence of moderate and severe droughts and the affected area were regardless of the long-term emission scenarios for the near term (2011-2040). Additionally, the increase scenarios in drought are consistent around Mediterranean for both scenarios.

Kara et al. (2016) investigated climate change impacts on extreme precipitation of Ömerli catchment in İstanbul by using ensemble climate modeling. The ensembles of daily precipitation time series from 15 different RCMs driven by 5 different GCMs under A1B climate change projections obtained through EU-ENSEMBLES project for two periods: reference (1960-1990) and future (2071-2100). An increase in extreme precipitation in winter, spring and summer is expected while a decrease in autumn is likely according to the results. They also used the geographically weighted regression (GWR) method to downscale climate change impacts to this small catchment and GWR provided significant modifications to these changes and agreed on the direction of change from RCMs.

There are many studies dedicated to analyze the drought for entire Turkey and certain basins of Turkey’s Mediterranean climate region as well. Sönmez et al. (2005) found out that drought vulnerability of Turkey for varying time steps portrayed diverse but consistent picture. Their study also revealed varying trends for different regions in terms of drought severity and duration. While the southeastern and eastern parts of Turkey are more open to moderate droughts at short timescales, the impact would be anticipated less at the coastal part since the droughts are only effective at longer durations and occur at moderate levels. Nevertheless, coastal and interior parts more tend to occur severe droughts. These facts bring negative consequences for different sectors that needs water for varying periods of the year. Interior parts will suffer from agricultural drought whilst hydrological drought will occur at longer time steps at the coastal parts.

Türkeş (2012) revealed briefly the effects of climate change in a study that examines the observed and projected drought and desertification in Turkey. The effects of global warming were considered with evaluating the changes in extremes in this study. It is important that the results based on a modified standardized precipitation index(MSPI) showed increase in drought severity for the regions under Mediterranean climatic conditions and the inland parts of the country which is neighbor to this climate region. The vulnerability of Turkey with respect to intensive and broad winter droughts -which are related to high positive modes of North Atlantic Oscillation- is critical as well.

Unlike the other studies that are dedicated to determine the effects of climate change, Türkeș et al. (2016) also inquired if the climate of Turkey is really changing in a study that compared two consecutive time periods: 1950-1980 and 1981-2010. They detected some variations in the present geographical patterns of climate regions. Increasing precipitation amounts in the northern and eastern regions in contrast to decreasing amounts in the west, central and southern regions were serious outcomes of this study.

Gümüş and Algın (2017) examined the relation between meteorological and hydrological drought for Seyhan-Ceyhan River Basins using SPI and SDI (Streamflow Drought Index). They found that a meteorological drought demonstrates hydrological drought for the following year. This result is crucial for water management with more frequent and severe droughts.

1.4. Description of Thesis

In the first chapter of the thesis, a brief information about climate change, GCM-RCM simulations and drought indices are given. The previous studies are also mentioned in this chapter. Details about data, study area and methods are explained in the following chapter. The third chapter presents the results of analysis. The results are discussed in chapter 4. The last chapter provides the summary, conclusions and recommendations.

CHAPTER 2

DATA, STUDY AREA AND METHODS

2.1. Data and Study Area

2.1.1. Study Area

Mediterranean climate is a major climate type of the Köppen classification and characterized by hot, dry summers and cool, wet winters. The regions which under this climatic condition are located between about 30° and 45° latitude north and south of the Equator and on the western sides of the continents (Kottek et al., 2016). Figure 4 shows five Mediterranean climate regions on the Earth.

This region presents several aspects of interest, such as its important inter-annual variability in precipitation and temperature, and the severe economic damages and losses of life due to droughts, flooding events or heat or cold waves occurred in the last decades, together with an increase in population and infrastructure (Easterling et al., 2000). In this study, the climatic conditions were mainly taken into consideration at determination of study area rather than other identifiers like regional or provincial borders. Climate frontiers are not very certain and differ a bit from one map to other for Turkey. Still, the maps are consistent in general. Climate regions showed in
Figure 5 were taken as a basis at determination of study area in the thesis. Only a small part consisting of the north and east coast of the Marmara Sea was not studied.

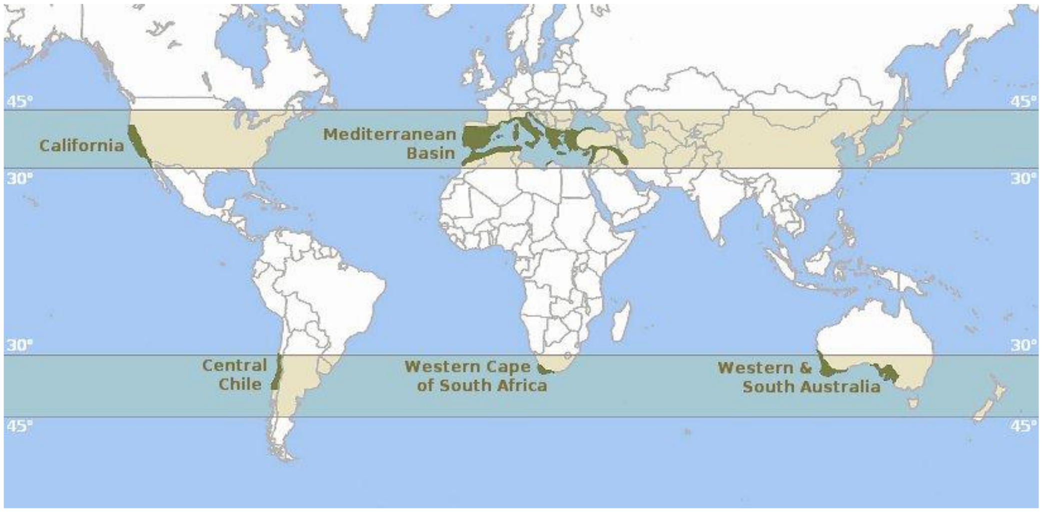


Figure 4. Mediterranean climate regions on the Earth (Downloaded from WEB8).

Figure 5. Climate map of Turkey (Downloaded from WEB9).

2.1.2. Observation Data

Observed precipitation data for monthly rainfall was obtained from MGM (Turkish State Meteorological Service) for 46 stations to evaluate the performance of model data (Table 1). This evaluation period was also called ‘reference period’, which refers to the period 1971-2005. The stations were selected homogeneously for the whole study area as much as possible (Figure 7).

2.1.3. Model Data

Model data was selected from Eur11 domain (Figure 6), that includes data in 0.11degree (~12.5 km) resolution. This is the highest resolution produced in CORDEX project (WEB10).

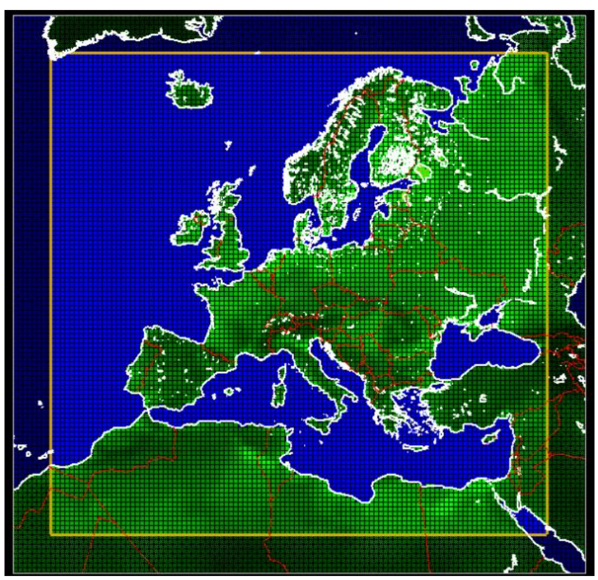


Figure 6. EURO-CORDEX domain area surrounded by the inner square (Stagge et al., 2015)

Table 1. Location of the observation stations (* signifies the locations which were only studied in projection)

Station Name	Latitude	Longitude	Station Name	Latitude	Longitude
BANDIRMA	40.35	27.97	KARAİSALI	37.27	35.07
AYVALIK	39.32	26.70	MANAVGAT	36.78	31.43
DİKİLİ	39.07	26.88	ERDEMLİ	36.62	34.30
AKHİSAR	38.92	27.85	CEYHAN	37.03	35.82
KUŞADASI	37.87	27.25	DÖRTYOL	36.85	36.22
DİDİM*	37.48	27.27	ISLAHİYE	37.03	36.63
BODRUM	37.05	27.43	GAZİPAŞA	36.27	32.32
DALAMAN	36.75	28.78	YUMURTALIK	36.77	35.78
ANAMUR	36.08	32.83	SAMANDAĞ	36.08	35.97
SİLİFKE	36.38	33.93	ACIPAYAM	37.42	29.33
İSKENDERUN	36.58	36.17	TEFENNİ	37.32	29.77
FİNİKE	36.30	30.15	GEMLİK*	40.44	29.15
KAŞ*	36.20	29.65	KARACABEY*	40.13	28.33
SALİHLİ	38.48	28.13	MUDANYA*	40.37	28.90
SEFERİHİSAR	38.35	26.83	M.KEMALPAŞA*	40.04	28.40
ÖDEMİŞ	38.23	27.97	AYVACIK*	39.61	26.40
NAZİLLİ	37.92	28.32	OSMANIYE*	37.08	36.25
ELMALI	36.75	29.92	ALANYA*	36.55	32.025
MUT	36.65	33.43	MANISA	38.62	27.43
KARATAŞ	36.57	35.38	IZMIR	38.43	27.17
*MENEMEN	38.58	27.07	AYDIN	37.85	27.85
FETHİYE	36.62	29.12	DENIZLI	37.78	29.08
MARMARİS	36.85	28.27	MUGLA	37.22	28.37
BURHANİYE*	39.50	26.98	ANTALYA	36.88	30.7
MİLAS	37.32	27.78	MERSIN	36.8	34.6
YATAĞAN	37.35	28.13	ADANA	37	35.33
KOZAN	37.45	35.82	ANTAKYA	36.2	36.17
DATÇA	36.75	27.67	BALIKESİR*	39.63	27.88
KÖYCEĞİZ*	36.97	28.68	CANAKKALE	40.15	26.42
KORKUTELİ	36.75	30.20	BURSA	40.18	29.07

Model data was obtained for 12 models from CORDEX project (Table 2). RCM-GCM couplings was made of 4 different Global Climate Models (in other words Driving Models) and 6 Regional Climate Models. The producers of the RCMs were stated for information purposes.

Table 2. Model data list. 'Model no' numbering was given to provide a convenience throughout the thesis.

Model No	GCM	Institute	RCM
1-1	ICHEC-EC-EARTH	DMI	HIRHAM5
1-2		CLMcom	CCLM4-8-17
1-3		KNMI	RACMO22E
1-4		SMHI	RCA4
2-1	CNRM-CERFACS-CNRM-CM5	CNRM	ALADIN53
2-2		CLMcom	CCLM4-8-17
2-3		SMHI	RCA4
3-1	MOHC-HadGEM2-ES	CLMcom	CCLM4-8-17
3-2		KNMI	RACMO22E
3-3		SMHI	RCA4
4-1	IPSL-IPSL-CM5A-MR	SMHI	RCA4
4-2		IPSL-INERIS	WRF331F

The model data was extracted for 60 locations (Figure 7) from CORDEX data grids. 46 of these were used in performance analysis since reliable data could be obtained for 46 observation stations. On the other hand, all of 60 locations were analyzed for future projection. RCP 8.5 - the scenario of highest greenhouse gas emission- was considered for future in the study.

Figure 7. The locations of model data for projection period

2.2. Methods

In this part, the process of analysis was introduced. Estimation methods that were applied to precipitation data and SPI values are stated as well. Figure 8 describes the analysis steps.

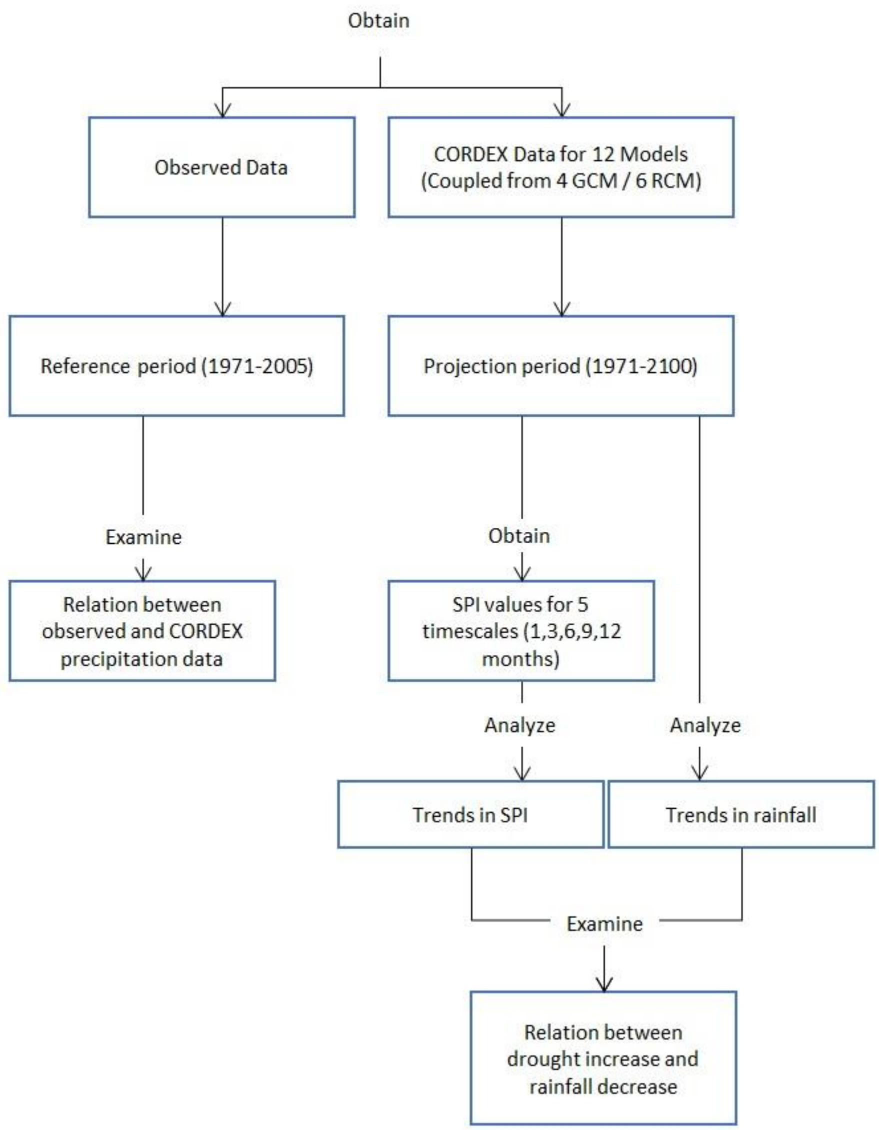


Figure 8. The steps of the study based on the data and operations used.

2.2.1. Standardized Precipitation Index

The Standardized Precipitation Index is a meteorological drought index that was introduced by Mckee et al. (1993). It interprets observed precipitation as a standardized departure with respect to a rainfall probability distribution function (Keyantash and Dracup, 2002). The calculation of SPI value for desired period is based on the long-term precipitation record. Guttman (1999) recommends at least 50 years of data for a reliable calculation.

The calculation of SPI begins with modeling the monthly precipitation time series using different statistical distributions (Lloyd-Hughes and Saunders, 2002). The first is the gamma distribution, whose probability distribution is defined as

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta} \quad \text{for} \quad x > 0 \tag{1}$$

where, $\alpha > 0$ is shape parameter, $\beta > 0$ is scale parameter, and $x > 0$ is the amount of monthly precipitation. $\Gamma(\alpha)$ is the gamma function, which is defined as

$$\Gamma(\alpha) = \lim_{n\to\infty} \prod_{\upsilon=0}^{n-1} \frac{n!\, n^{y-1}}{y+\upsilon} \equiv \int_0^{\infty} y^{a-1}\, e^{-y} dy \tag{2}$$

Fitting the distribution to the monthly precipitation data requires estimating α and β. Edwards and McKee (1997) suggest using the approximation of Thom (1958) to estimate these parameters as follows:

$$\hat{\alpha} = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right) \tag{3}$$

$$\hat{\beta} = \frac{\bar{x}}{\hat{\alpha}} \tag{4}$$

where, for n observations

$$A = \ln(\bar{x}) - \frac{\sum \ln(x)}{n} \qquad (5)$$

The expression of cumulative probability G(x) of an amount of precipitation occurring for a given month and timescale is yielded by integrating the probability density function with respect to x and inserting the estimates of α and β:

$$G(x) = \int_0^x g(x)dx = \frac{1}{\hat{\beta}^{\hat{\alpha}}\Gamma(\hat{\alpha})}\int_0^x x^{\hat{\alpha}}\, e^{-x/\hat{\beta}}dx \qquad (6)$$

Substituting t for x/^β reduces Equation (6) to

$$G(x) = \frac{1}{\Gamma(\hat{\alpha})}\int_0^x t^{\hat{\alpha}-1}e^{-1}dt \qquad (7)$$

which is the incomplete gamma distribution function. Since the gamma distribution is undefined for x = 0, and q = P(x = 0) > 0 where P(x = 0) is the probability of zero precipitation, the cumulative distribution becomes

$$H(x) = q + (1 - q)G(x) \qquad (8)$$

The cumulative probability distribution is then transformed into the standard normal distribution to obtain the SPI value. This process is illustrated in Figure 9. The first panel shows the empirical cumulative probability distribution for a 3-month average December–January–February (DJF) of precipitation over the south east of England for the period 1901–99. Over-plotted is the theoretical cumulative probability distribution of the fitted gamma distribution. The second panel indicates the standard normal cumulative probability. To convert a given precipitation level to its corresponding SPI value, first locate the precipitation value on the abscissa of the left-hand panel, draw a perpendicular, and locate the point of intersection with the theoretical distribution. Then project this point horizontally (maintaining equal cumulative probability) until it intersects with the graph of standard normal cumulative probability. The intersection between a line drawn vertically downward from this point and the abscissa determines the SPI value (1.1 in this example for 77 mm precipitation).

The above approach is not practical for calculating the SPI for large numbers of data points. The approximate conversion provided by Abramowitz and Stegun (1965) can be employed as an alternative following Edwards and McKee (1997):

$$Z = \mathrm{SPI} = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \text{ for } 0 < H(x) \leq 0.5 \tag{9}$$

$$Z = \mathrm{SPI} = +\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \text{ for } 0.5 < H(x) \leq 1 \tag{10}$$

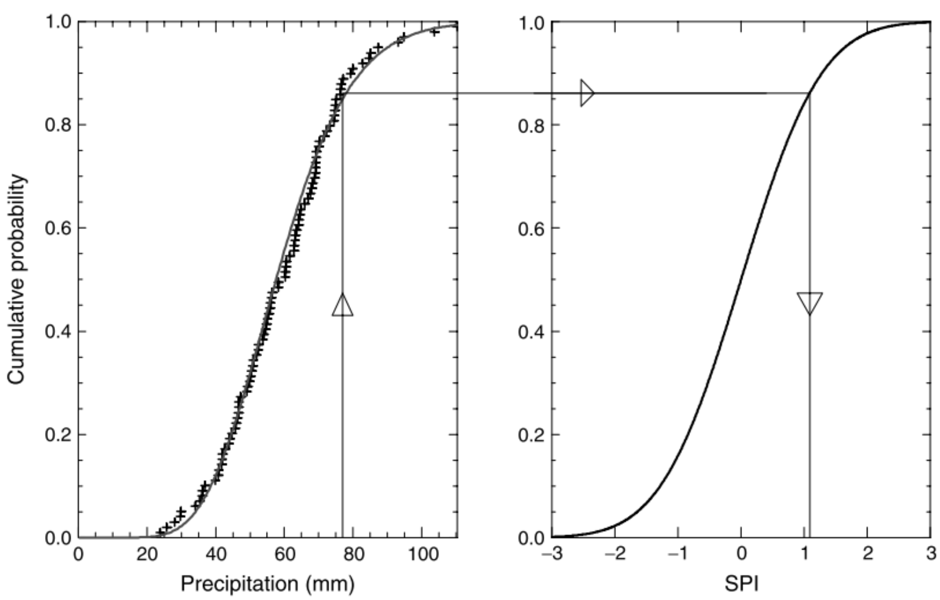


Figure 9 Example of an equiprobability transformation from a fitted gamma distribution to the standard normal distribution (Hughes and Saunders, 2002)

In this thesis, the index values were obtained via a MATLAB code that is stated in Appendix A.

McKee and others used a classification system based on SPI values to define drought intensities as shown in Table 3 . It extends from extremely wet to extremely dry.

Table 3 SPI value interpretation (Mckee et al., 1993)

Extremely wet	2.00 or more
Very wet	1.50 to 1.99
Moderately wet	1.00 to 1.49
Near normal	0.99 to –0.99
Moderately dry	–1.00 to –1.49
Severely dry	–1.50 to –1.99
Extremely dry	–2.00 and less

The SPI can be computed for any chosen timescales from 1 month to 48 months. This flexibility is a powerful feature of the SPI that provides useful information unless we have a clear idea of the desired intervals. In this study SPI was calculated for five intervals (1,3,6,9 and 12 months) for given periods. Afterwards, trends of SPI values were evaluated for these five intervals consecutively.

It should be noticed that SPI values were shown and analyzed since 1972 instead of 1971. This difference arose from the nature of SPI calculation. To obtain the SPI 12 value the former 12 months precipitation data is required. Namely, the first SPI 12 value was calculated for the first month of 1972. Then, the SPI values at shorter timescales were also assessed from 1972 to provide consistency with SPI 12.

2.2.2. Modified Mann-Kendall Test

Mann Kendall test (Mann, 1945 ; Kendall, 1975) is one of the widely used non-parametric tests for detecting trends in time series. The Mann-Kendall trend test is derived from a rank correlation test for two groups of observations proposed by Kendall (1975). The correlation between the rank order of the observed values and their order in time is the key part of Mann-Kendall trend test. However, a modified Mann– Kendall test has been developed in order to avoid problems with autocorrelation (Hamed and Ramachandra Rao, 1998). The Mann-Kendall test statistics S calculated from the following equation:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}(x_j - x_k) = \begin{cases} +1 \text{ if } (x_j - x_k) > 0 \\ 0 \text{ if } (x_j - x_k) = 0 \\ -1 \text{ if } (x_j - x_k) < 0 \end{cases} \tag{11}$$

Where, number of data is n. Additionally, the correction ratio n/n_S^* is introduced during the calculation of a variance of the S statistics to account for an effect of serial correlation.

$$\mathrm{var}^*(S) = \mathrm{var}(S)\frac{n}{n_S^*} \tag{12}$$

$$\frac{n}{n_S^*} = 1 + \frac{2}{n(n-1)(n-2)} \sum_{i=1}^{n-1} (n-i)(n-i-1)(n-i-2)\rho_S(i) \tag{13}$$

where, ρ_S denotes the autocorrelation function.

Since we are detecting the trend in SPI values, it is important to use such a modified trend test that considers serial correlation. This test was also applied to annual precipitation in order to detect any relation with drought. The significance level was taken 0.05 (95% confidence level) for the all trend tests performed in this study. The MATLAB code that was used in calculation is stated at Appendix A.

2.2.3. Linear Regression

The slopes of the trendlines were obtained by linear regression. This linear approach models the relationship between a response variable y (SPI and rainfall) and one or more explanatory variables (years) denoted x. Since negative values of SPI denotes dry conditions, negative slope means increasing drought.

Figure 10 illustrates how a regression line is fitted to variables. The predicted values of y are denoted by ŷ whose equation includes two constants: intercept (w_0) and slope (w_1).

$$\hat{y} = w_0 + w_1 x \tag{14}$$

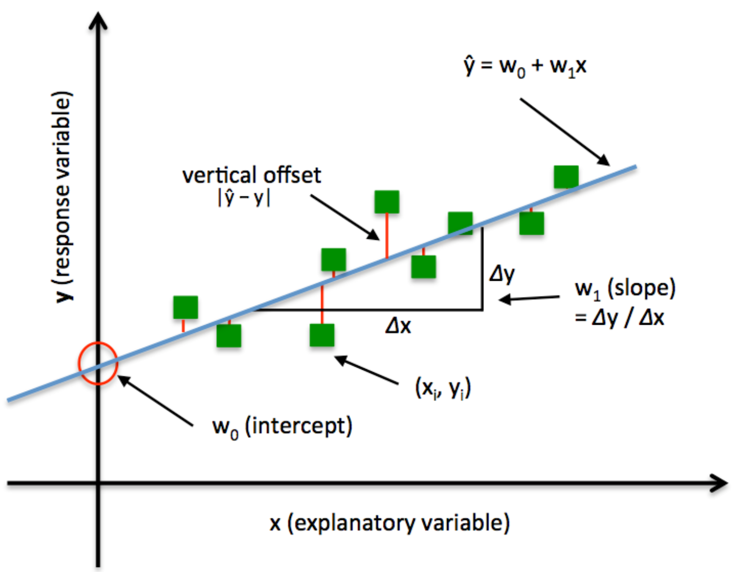


Figure 10 Obtaining linear regression line

2.2.4. Statistics Used for Measuring Model Performance

Root mean square error (RMSE) values of the model precipitation data were estimated for reference period to analyze the reliability of the models. It is one of the methods that are used to measure the closeness of model data to real values along with correlation coefficient (CORR). Schaller et al. (2011) evaluate climate models by ranking their RMSE and CORR values. They use an updated version of the model ranking performed by Reichler and Kim (2008).

RMSE is calculated by following equation which is based on the difference between observed and model data values:

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}} \tag{15}$$

where, O denotes amount of observed precipitation while P denotes predicted precipitation and n denotes number of data.

The correlation coefficient of two random variables is a measure of their linear dependence. If each variable has n scalar observations, then the Pearson correlation coefficient (r) is defined as

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y}}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{16}$$

where, x_i and y_i are the single samples (observation and model values) indexed with i; $\bar{x}$ and $\bar{y}$ are the sample means.

CHAPTER 3

RESULTS

3.1. Performance of the Models

In the first step of analysis, the observed and model precipitation data were compared for the reference period 1971-2005. The averages of daily and monthly precipitation were compared at the same time as long term statistics were calculated and evaluated.

3.1.1. Daily Evaluations

The plots in Figure 11 demonstrate the mean precipitation of each day of year for reference period. In addition, 31-days moving averages were plotted for both observation and model data.

Daily averages of model 1-1 well correlated with observation means (Figure 11a). However, summer and autumn daily means slightly underestimated observation as well as partially underestimated observed daily mean precipitation for winter and spring seasons. Model 1-2 diverged from observation averages for almost the entire year (Figure 11b). This model overestimated observation for spring and summer days while underestimated in autumn and winter. Model 1-3 correlated with observation for autumn (Figure 11c). Still, the daily averages of spring overestimated observation. Summer and winter are the two seasons which daily averages of model 1-3 partially overestimated and underestimated observation. Summer, autumn and winter daily means of model 1-4 diverged from observation as well as model correlated with observation means overall (Figure 11d).

Model 2-1 and 2-2 greatly diverged from observed means (Figure 11e and Figure 11f). Both models overestimated summer precipitation. Overestimation carried on for model 2-2 autumn daily means while model 2-1 underestimated observation winter daily averages. Model 2-3 well correlated with observation though it is forced by same GCM with model 2-1 and 2-2 (Figure 11g). Besides, the mean values are very close to observation at model 2-3.

Model 3-1 correlated with observation to some extent (Figure 11h). Despite, it overestimated observation means for winter, spring and autumn seasons. Model 3-2 greatly overestimated observation for winter, spring and summer seasons (Figure 11i). Model 3-3 (Figure 11j) well correlated with observation like models 1-4 and 2-3 which are forced by same RCM: RCA4. Though, model 3-3 underestimated observation daily means for autumn and winter seasons.

Model 4-1 underestimated observation daily averages for entire year (Figure 11k). The divergence is greater for winter and spring seasons. Model 4-2 did not correlate with observation as well as the model daily means greatly overestimated observation for spring and summer seasons (Figure 11l).

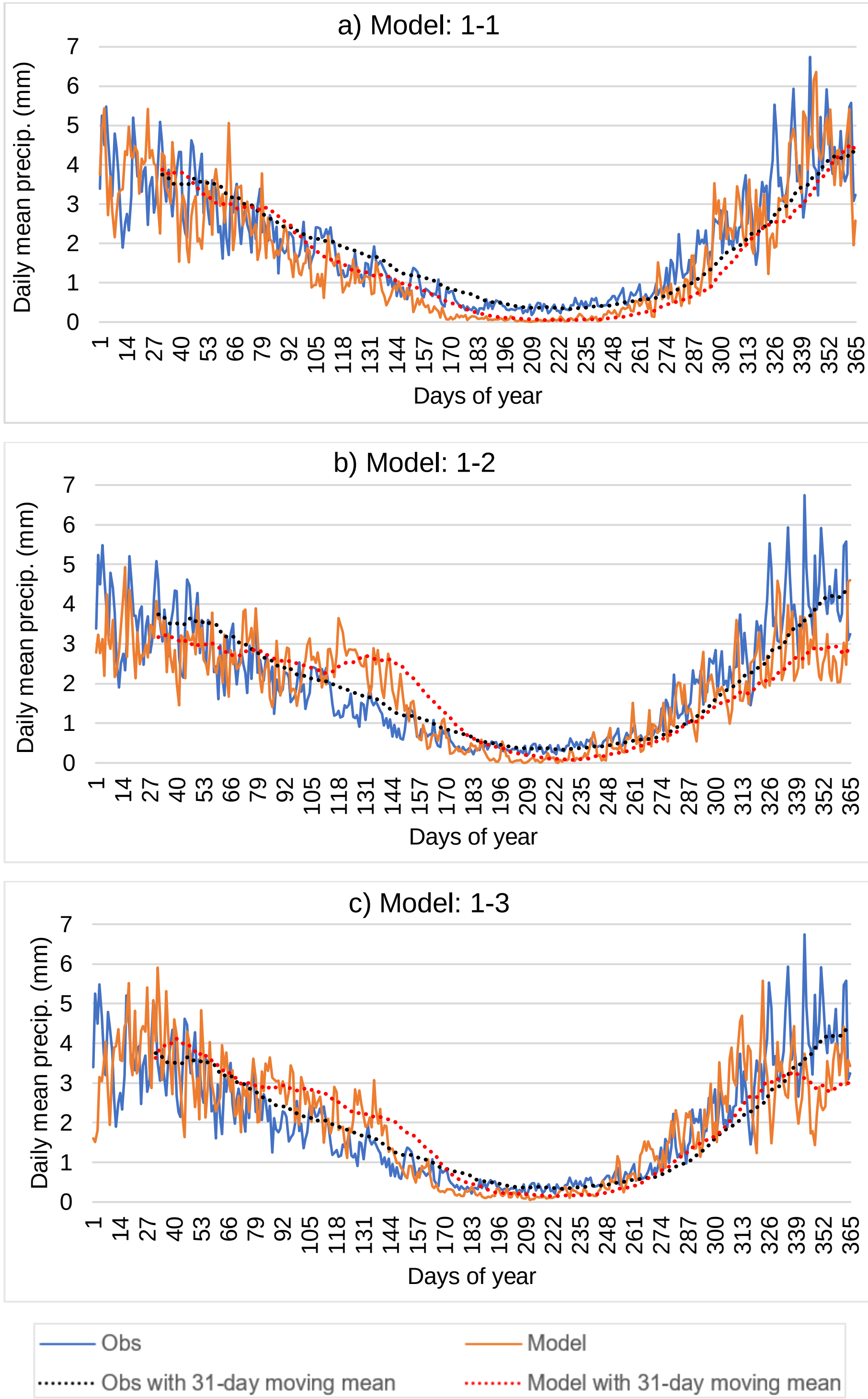


Figure 11. Daily mean precipitation of entire area for reference period.

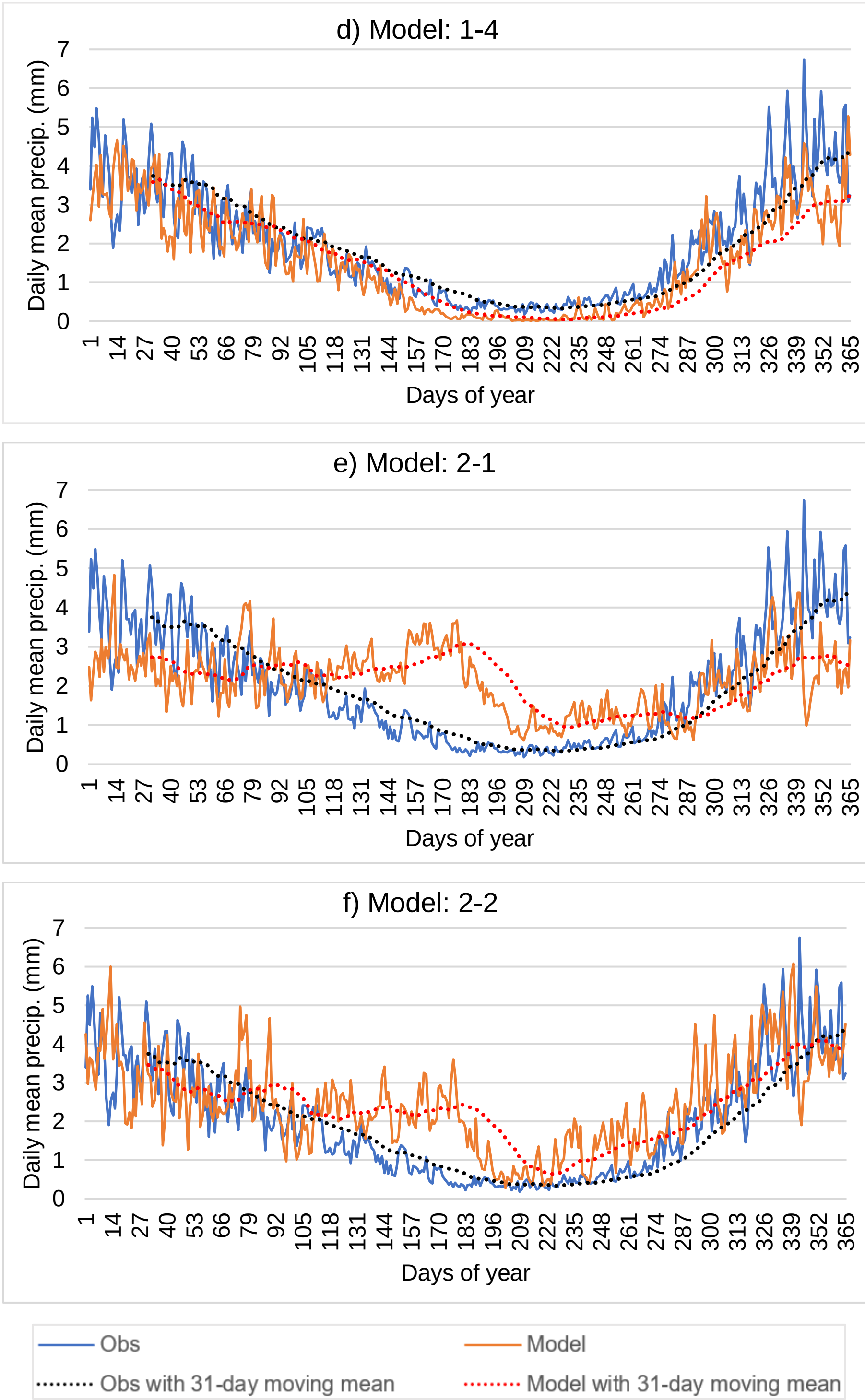


Figure 11. (cont'd)

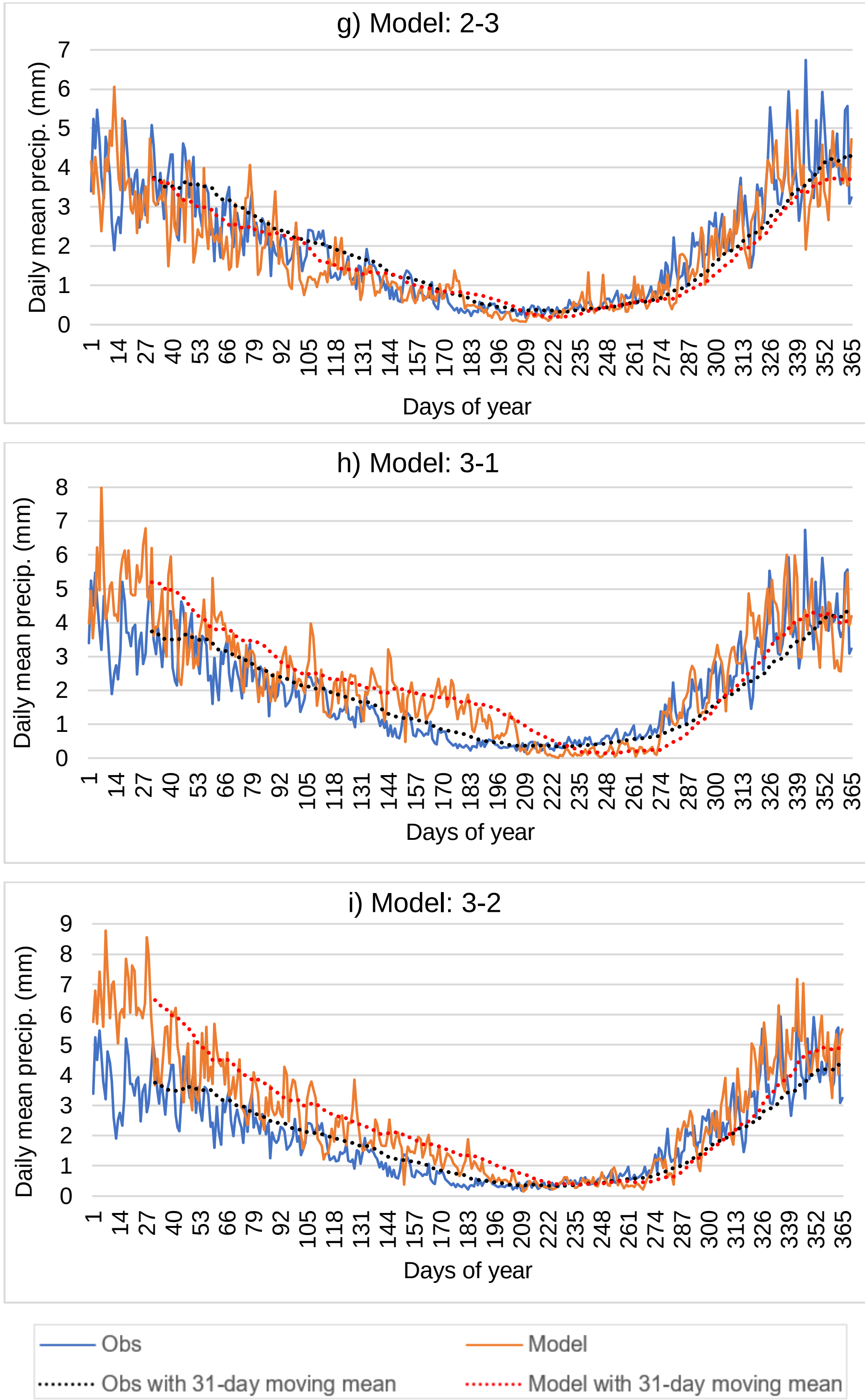


Figure 11. (cont'd)

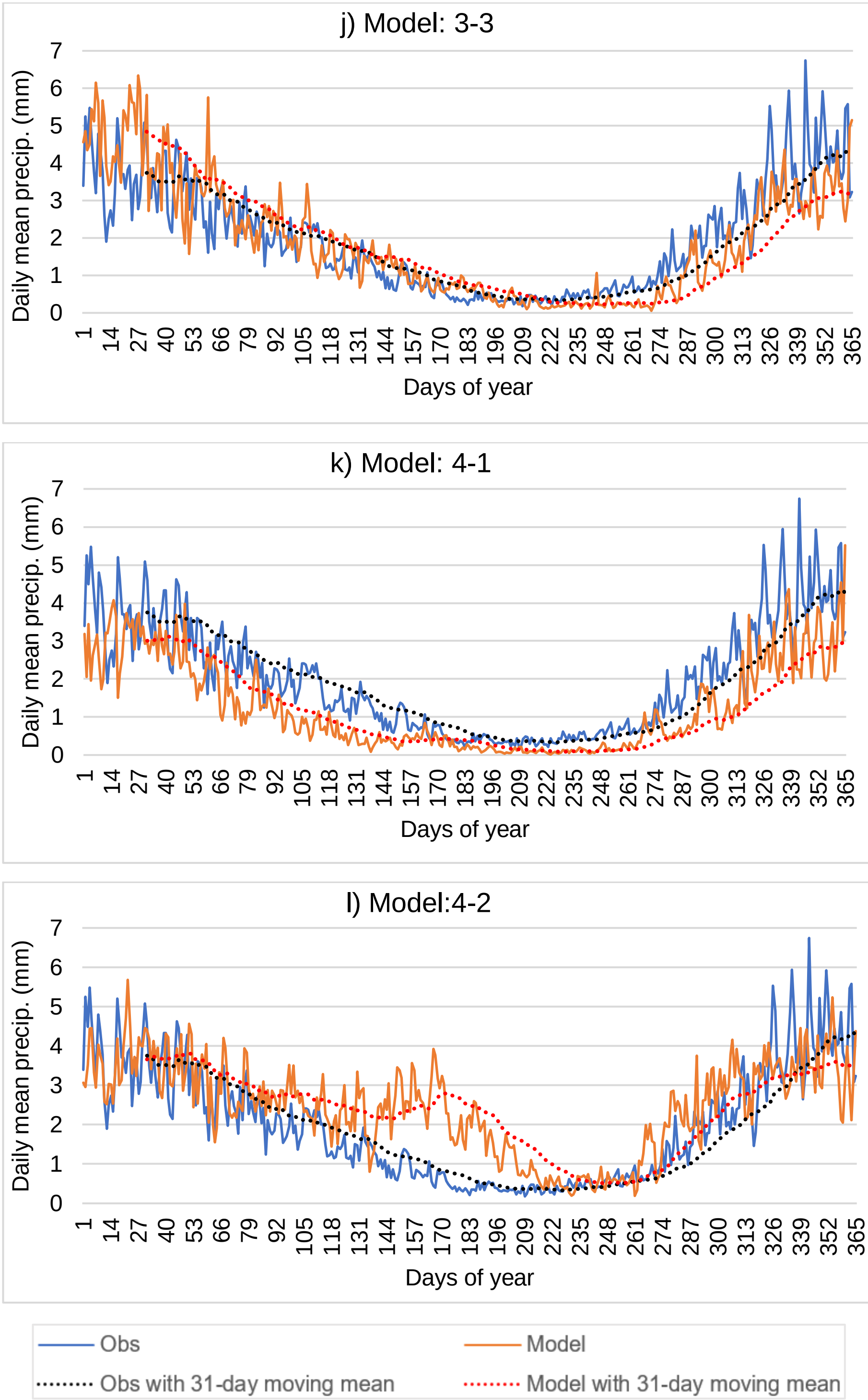


Figure 11. (cont'd)

Table 4 shows CORR and RMSE values for moving averages based on daily means of the models. Predictions of three models (1-1, 2-3, 1-4) are well correlated with observed values according to statistics. Daily mean values of model 1-3 predictions are not far from observed means while correlation is relatively low for this model. For model 4-1, analysis of daily means revealed opposite situation: The values differed greatly for all days of the year while followed similar seasonal variation with observed values (Figure 11k and Table 4).

Table 4. Correlation coefficient(CORR) and Root mean square error(RMSE) values for moving averages of daily means

Rank	Model No	CORR	Model No	RMSE
1	1-1	0.9923	2-3	0.27
2	2-3	0.9908	1-1	0.31
3	1-4	0.9795	1-3	0.45
4	4-1	0.9734	1-4	0.46
5	3-2	0.9565	3-3	0.49
6	3-1	0.9458	1-2	0.56
7	1-3	0.9349	3-1	0.63
8	3-3	0.9264	4-1	0.76
9	1-2	0.8908	2-2	0.79
10	2-2	0.8895	4-2	0.82
11	4-2	0.8663	3-2	0.87
12	2-1	0.5198	2-1	1.08

Table 5 and Table 6 show the CORR and RMSE values for monthly data. 420 monthly precipitation values (from 1971 to 2005) were ordered and analyzed successively to obtain the outcomes in Table 5. These monthly values were grouped seasonally and analyzed to obtain Table 6 as well. Since correlation coefficients are relatively low for a reliable evaluation, RMSE values have been discussed rather than CORR values.

Table 5. Correlation coefficient(CORR) and Root mean square error(RMSE) values for successive monthly

Rank	Model No	CORR	Model No	RMSE
1	3-2	0.3976	4-1	72.58
2	2-3	0.3900	1-4	73.62
3	1-1	0.3881	2-3	74.87
4	3-3	0.3857	1-2	76.62
5	1-4	0.3828	1-3	77.10
6	4-1	0.3768	3-3	78.89
7	3-1	0.3647	1-1	79.02
8	1-3	0.3242	3-1	83.87
9	1-2	0.2946	2-1	84.90
10	2-2	0.2434	2-2	85.00
11	4-2	0.2148	3-2	88.10
12	2-1	0.1434	4-2	90.23

Seeing the RMSE ranking in Table 5, the difference of RMSE values between rank 7 and 8 can be considered as a threshold. The values increased almost with a 1.00 mm/month interval till 7th ranked model while a 4.00 mm/month increase occurred at 8th rank. Models 1-1, 1-4, 2-3, 3-3 and 4-1 are distinguished from these 7 top models in RMSE ranking along with their high ranks in CORR ranking.

Outcomes of daily means statistics indicated both consistency and divergency for different models. Models 1-4, 2-3 and 3-3 showed consistency with observation values according to daily means as well as they are in top ranks in RMSE analysis

(Figure 11d, Figure 11g, Figure 11j and Table 4) . However, it should be noticed that a few models from top ranks in Table 4 diverged from observation daily means especially for spring season. RMSE values for spring months also indicated this divergency: models 1-1, 1-2 and 1-3 ranks at 7th, 11th and 8th place for spring respectively (Table 6). However, the seasons can be ordered as autumn, spring, summer and winter in terms of the CORR values of models. The models projected the best performance during autumn and the worst in winter.

Table 6. Correlation coefficient(CORR) and root mean square errors(RMSE) analysis for seasonally grouped months

Rank	Winter				Spring			
	Model No	CORR	Model No	RMSE	Model No	CORR	Model No	RMSE
1	2-3	0.1056	2-1	102.61	2-3	0.1974	4-1	60.36
2	3-1	0.1046	2-2	102.61	1-1	0.1568	2-3	62.01
3	3-2	0.0806	4-1	102.76	3-3	0.1401	3-3	62.93
4	2-2	0.0795	1-2	103.02	4-1	0.1320	1-4	63.54
5	2-1	0.0699	1-4	104.75	1-4	0.1202	3-2	64.52
6	1-4	0.0585	2-3	105.04	3-1	0.1126	3-1	65.88
7	1-1	0.0546	3-1	109.41	3-2	0.1033	1-1	65.99
8	3-3	0.0448	1-3	109.83	1-3	0.0945	1-3	69.25
9	4-1	0.0431	4-2	113.29	2-2	0.0932	2-1	69.50
10	1-2	0.0091	3-3	113.73	1-2	0.0536	2-2	72.28
11	1-3	-0.0242	1-1	115.61	2-1	0.0388	1-2	72.32
12	4-2	-0.0375	3-2	124.26	4-2	0.0282	4-2	77.04
Rank	Summer				Autumn			
	Model No	CORR	Model No	RMSE	Model No	CORR	Model No	RMSE
1	2-1	0.1613	1-3	25.09	3-2	0.3136	4-1	69.81
2	3-1	0.1324	1-1	25.13	3-3	0.3055	1-4	70.99
3	1-3	0.1230	1-4	26.16	2-3	0.3021	1-3	74.17
4	3-2	0.1082	4-1	29.31	1-1	0.2859	2-3	74.19
5	1-2	0.1080	3-3	29.40	1-4	0.2642	1-1	74.67
6	4-1	0.0906	1-2	32.04	4-1	0.2629	1-2	74.93
7	2-2	0.0867	3-2	32.16	1-3	0.2516	3-3	78.61
8	1-1	0.0867	2-3	33.11	3-1	0.2294	2-1	79.07
9	4-2	0.0850	3-1	39.38	4-2	0.1904	2-2	88.04
10	2-3	0.0828	2-2	66.33	1-2	0.1896	4-2	88.70
11	1-4	0.0519	4-2	66.85	2-2	0.1895	3-1	96.44
12	3-3	0.0296	2-1	68.96	2-1	0.1448	3-2	97.78

Table 7 indicates the trends in annual rainfall for five locations for reference period. These locations were selected since they are well representing the study area. Models 1-1, 2-2 and 4-2 predicted significant trend for few stations though no significant trend was detected according to observation and rest of the models. This result can be considered as a negative outcome on reliability of these three models. Though, Table 7 indicates that the models are generally trustable in trend analysis.

Table 7. Trends in annual precipitation for reference period (1971-2005). ↘ denotes negative slope, ↔ denotes no significant trend, ↗ denotes positive slope.

	Obs	**1-1**	**1-2**	**1-3**	**1-4**	**2-1**	**2-2**	**2-3**	**3-1**	**3-2**	**3-3**	**4-1**	**4-2**
Adana	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↗
Antalya	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Balıkesir	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
İzmir	↔	↘	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Muğla	↔	↘	↔	↔	↔	↔	↘	↔	↔	↔	↔	↔	↔

Table 8 and Table 9 show the mean and standard deviation values of daily precipitation simulated by different GCM/RCM pairs for period 1971-2100. These two tables enable comparing the initiative effects of GCMs and RCMs.

The mean standard deviation of various RCMs with the same GCM model is 1.804 (Table 8) while the mean deviation value of different GCMs with the same RCM is 1.644 (Table 9). This implies the greater impact from RCM models than that from GCM models on daily precipitation. The uncertainty that comes from RCM models is higher than that from GCM models in daily precipitation simulation during period 1971-2100.

Table 8. The statistics of coupled models for projection period

Model No	GCM	RCM	mean	mean of means	standard deviation	mean of s.d.	s.d. of s.d.
1-2	ICHEC-EC-EARTH	CCLM4-8-17	1.697	1.708	1.491	1.804	0.129572
1-3		RACMO22E	1.913		1.727		
1-4		RCA4	1.515		1.516		
3-1	MOHC-HadGEM2-ES	CCLM4-8-17	2.193	2.160	1.932		0.263024
3-2		RACMO22E	2.526		2.329		
3-3		RCA4	1.761		1.832		

Table 9. The statistics for coupled models for projection period

Model No	GCM	RCM	mean	mean of means	standard deviation	mean of s.d.	s.d. of s.d.
1-2	ICHEC-EC-EARTH	CCLM4-8-17	1.697	2.079	1.491	1.644	0.240143
2-2	CNRM-CERFACS-CNRM-CM5		2.348		1.546		
3-1	MOHC-HadGEM2-ES		2.193		1.932		
1-4	ICHEC-EC-EARTH	RCA4	1.515	1.691	1.516		0.174796
2-3	CNRM-CERFACS-CNRM-CM5		1.796		1.544		
3-3	MOHC-HadGEM2-ES		1.761		1.832		

3.1.2. Monthly Evaluations

Figure 12 shows boxplots of monthly precipitation from all models and observation for each season. Each box includes values from 46 locations for reference period. In addition to this, the mean of the models for monthly precipitation values including whole stations were shown in Figure 13. The bars around model means denote the standard deviations of 12 model pairs.

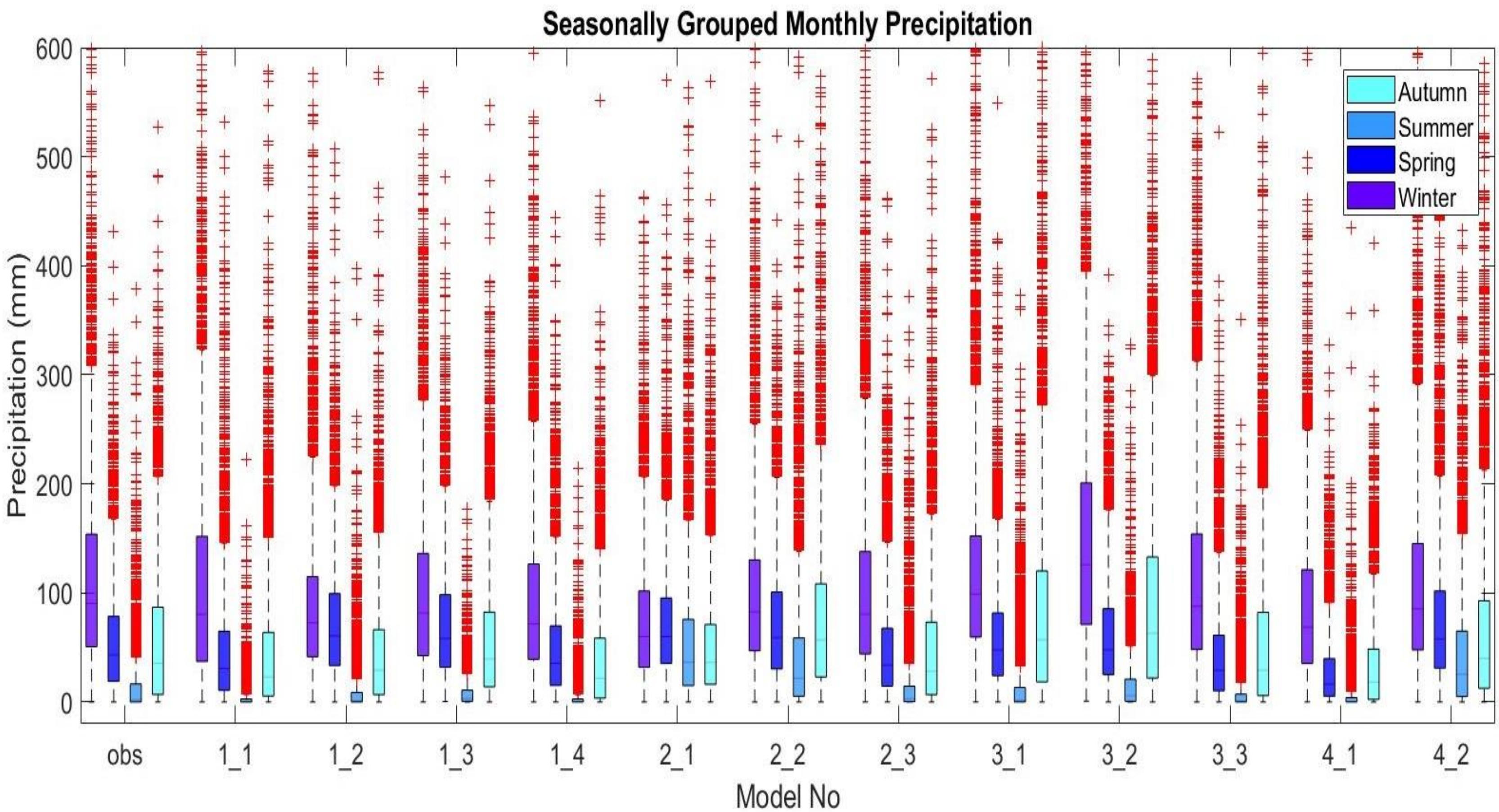


Figure 12. Seasonally grouped boxplot of monthly precipitation for entire area

The ensemble mean of monthly precipitation values is very near to observation for most of the months (Figure 13). However, monthly rainfall predictions of a few models caused a significant divergence of model means from observation means for the months January, February, May, June and December.

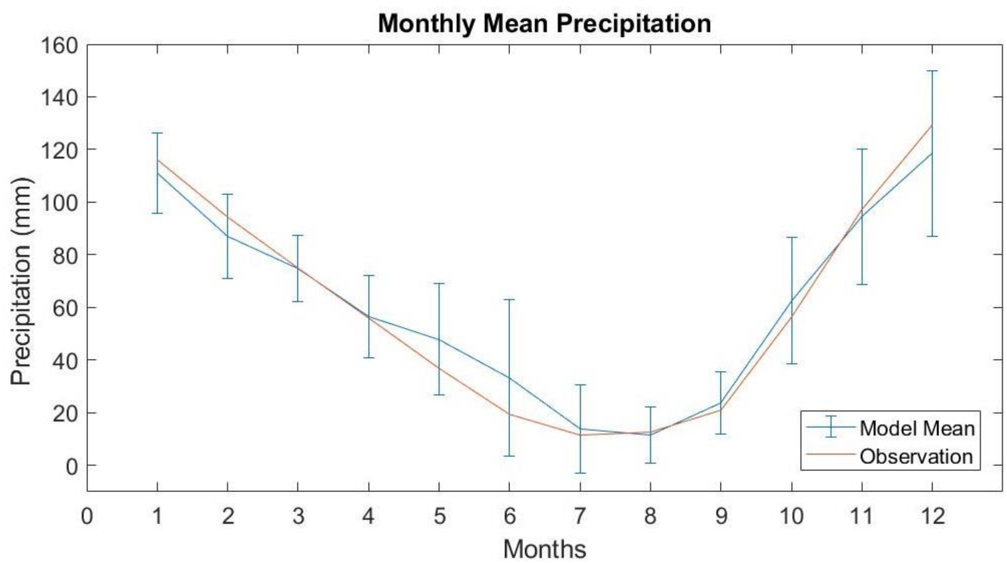


Figure 13. Plot of monthly precipitation means of observation and models. The bars on model mean line show the standard deviation gap of 12 models.

It can be distinguished which models caused such a divergence at model means by Figure 14. Models 2-1, 2-2 and 4-2 overestimated summer rainfalls while 2-1 underestimated winter rainfalls. 3-2 overestimated autumn and winter rainfalls as well. Models 2-1, 2-2, and 4-2 yielded highly meaningless monthly precipitation from winter months to summer months when they were compared with observed precipitation.

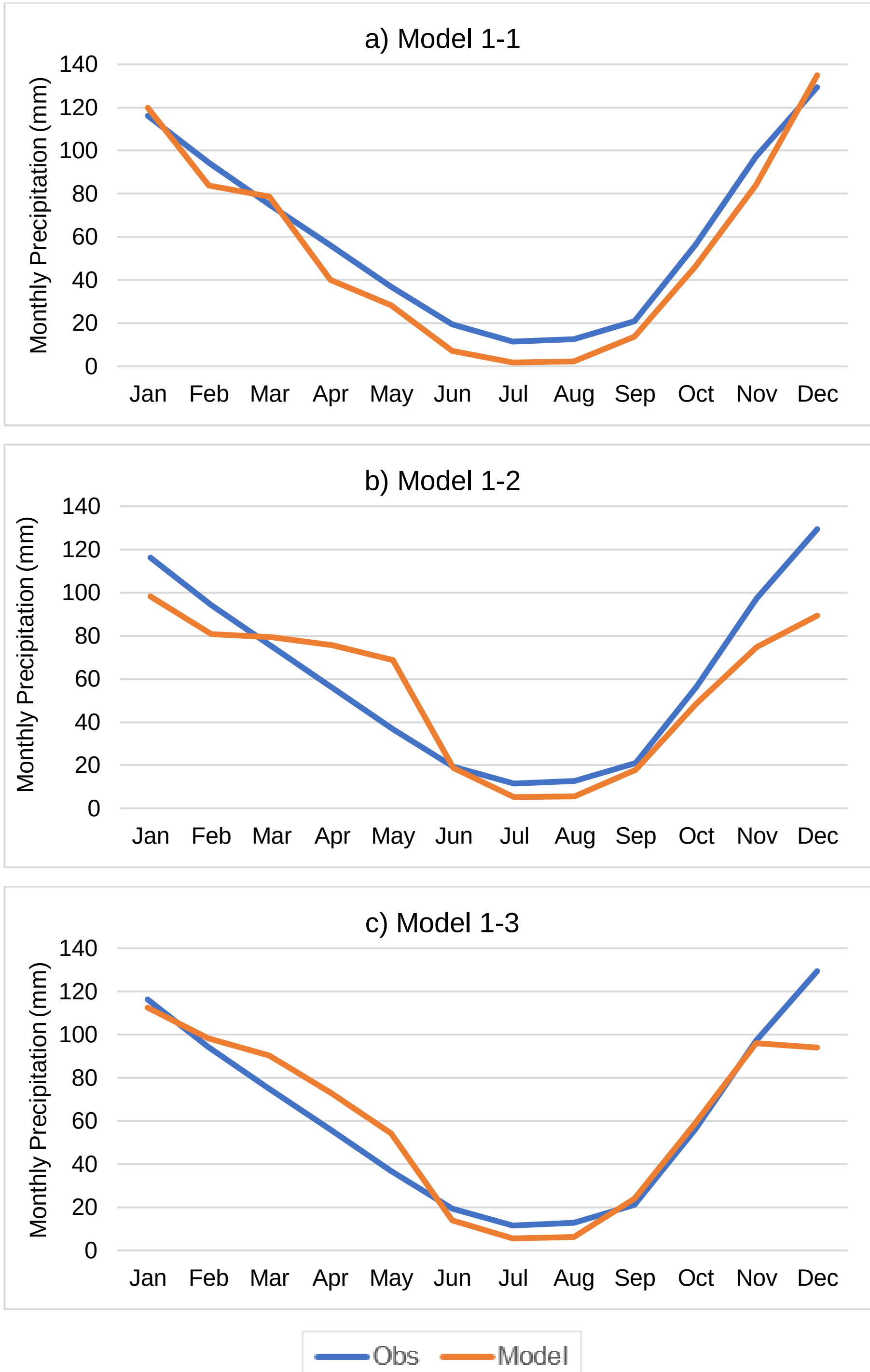


Figure 14. Monthly precipitation means of observation (Obs) and models (Model)

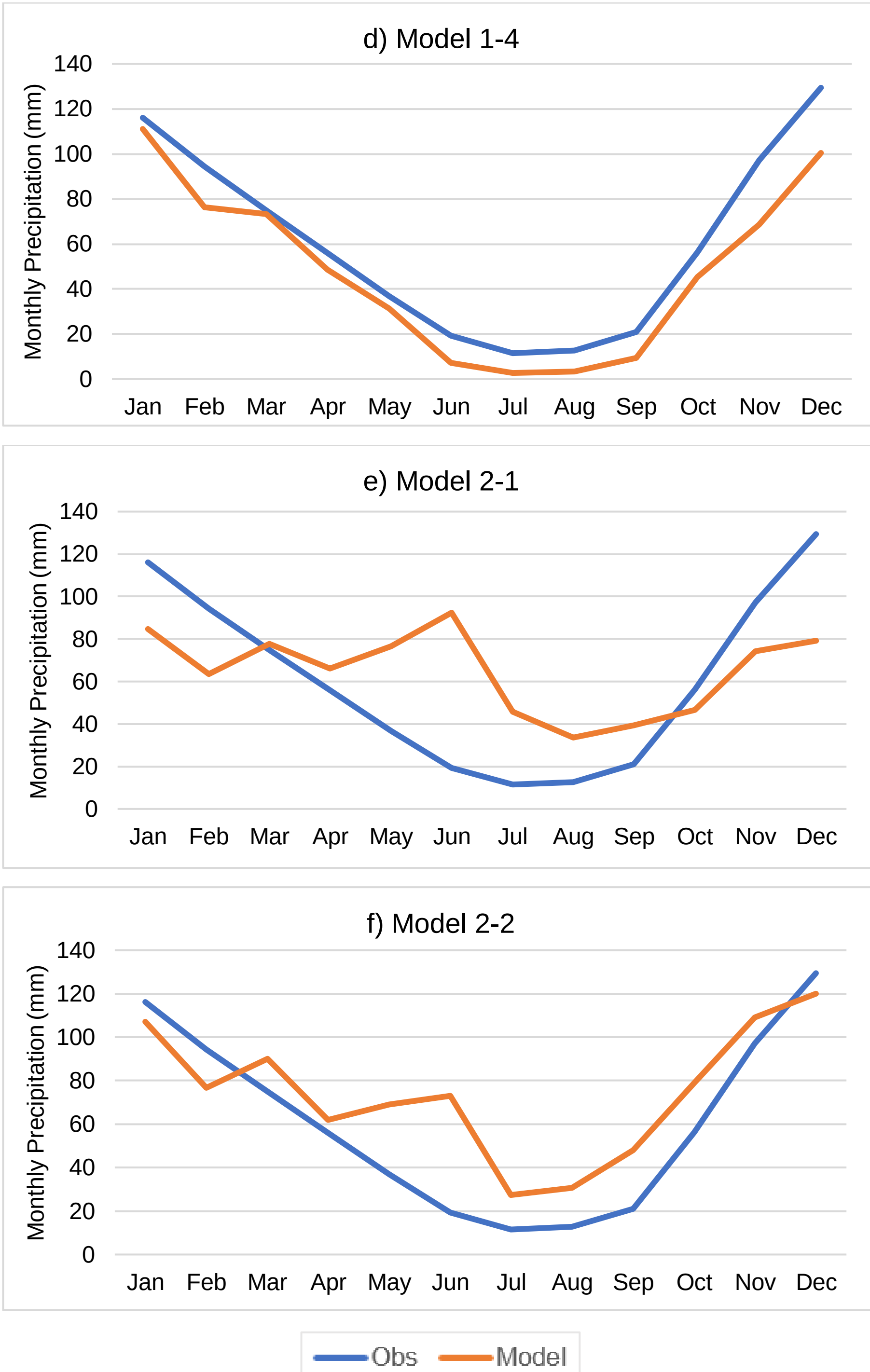


Figure 14. (cont'd)

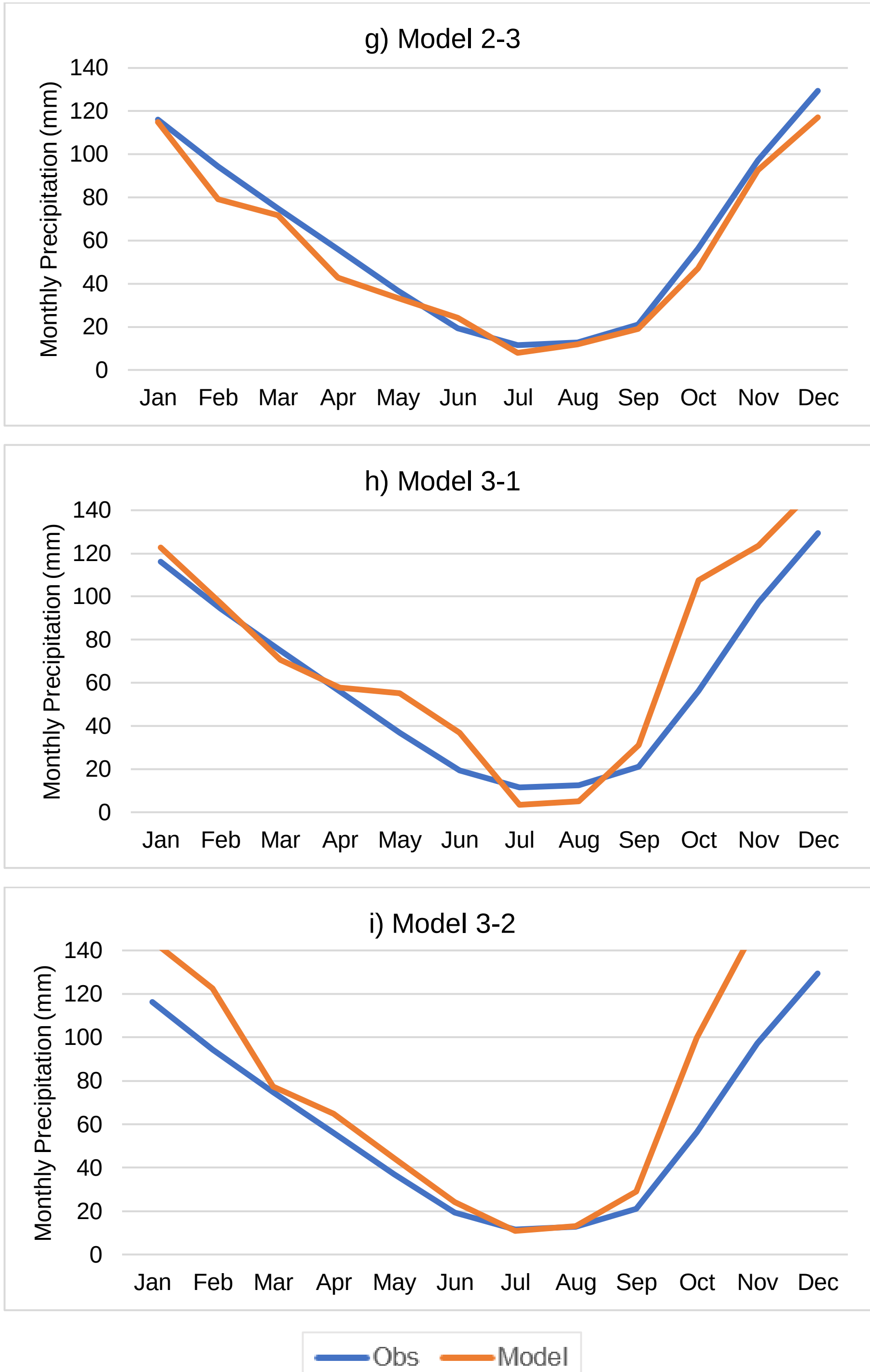


Figure 14. (cont'd)

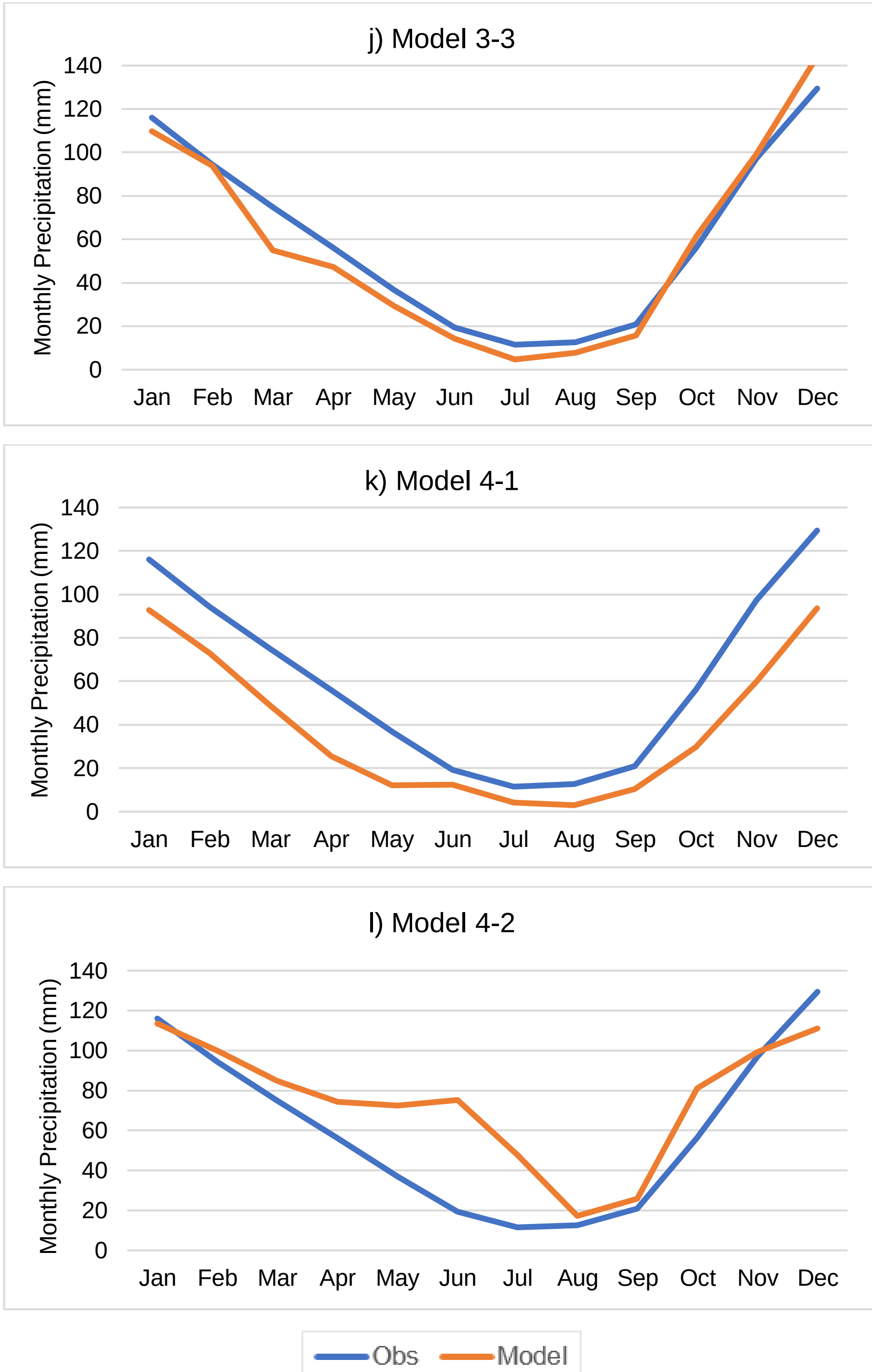
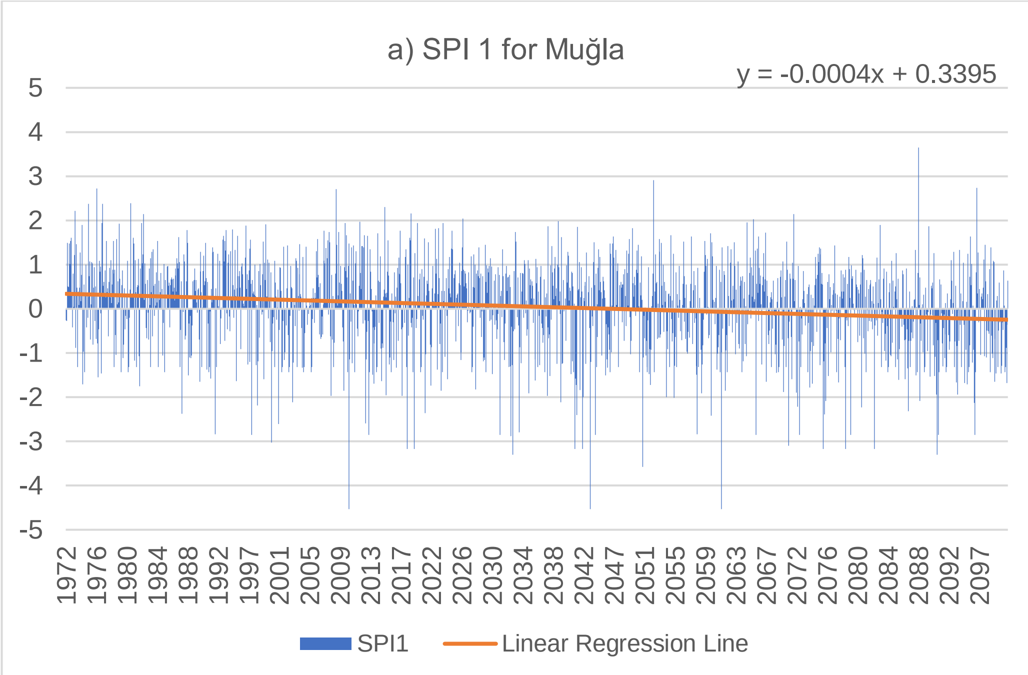


Figure 14. (cont'd)

3.2. Effects of Time Duration in SPI Analysis

The plots in Figure 15 show the successive SPI values for 5 timescales and trendlines obtained by linear regression for model 1-1 predictions between the years 1972-2100 on Muğla location. This location was considered at this step since modified Mann-Kendall test results pointed a significant change in trends for all timescales. The negative slope in SPI signifies increase in drought as negative SPI values mean dry conditions. Thus, these plots indicate increasing drought condition for Muğla. Further, the magnitude of trendline slope increases in negative direction as timescale increases. This can be interpreted as the drought increase is not limited at meteorological scale.

The significance of dry and wet periods within the evaluation period is more evident with increasing time duration from 1-month to 12 months in SPI values (Figure 15). Fluctuations in SPI with wet and dry values are reduced and they become more compact. For example, with the longer duration the drought condition changes its phase (level) from meteorological to agricultural drought and finally it may reach to the level of hydrological drought. If the drought with its magnitude and duration is persistent, it may be referred as agricultural to hydrological drought (SPI 9 and 12).



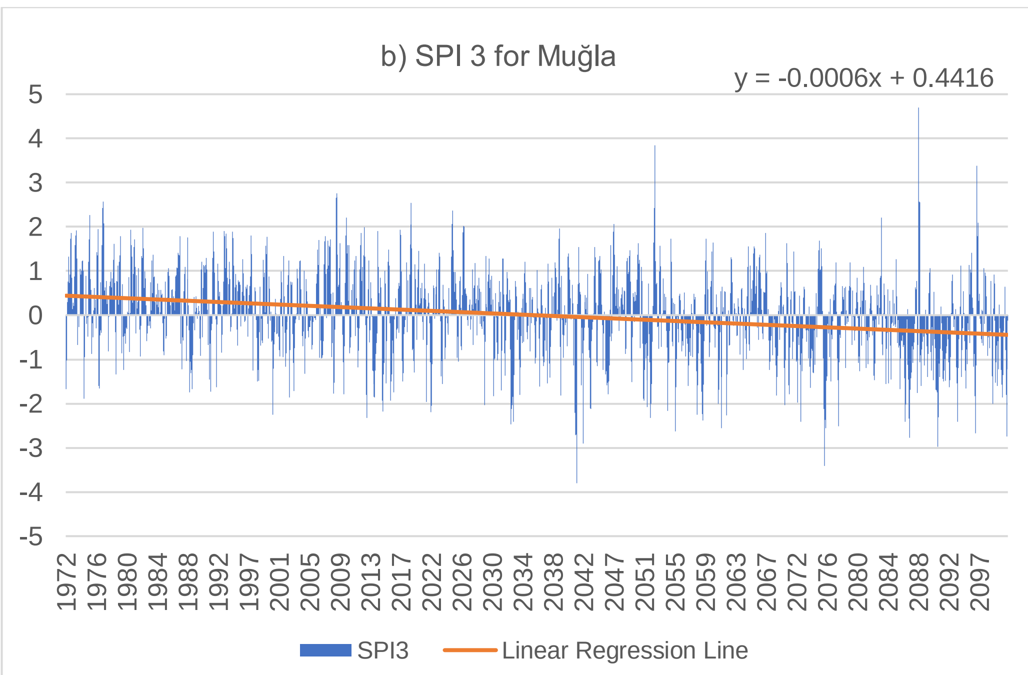
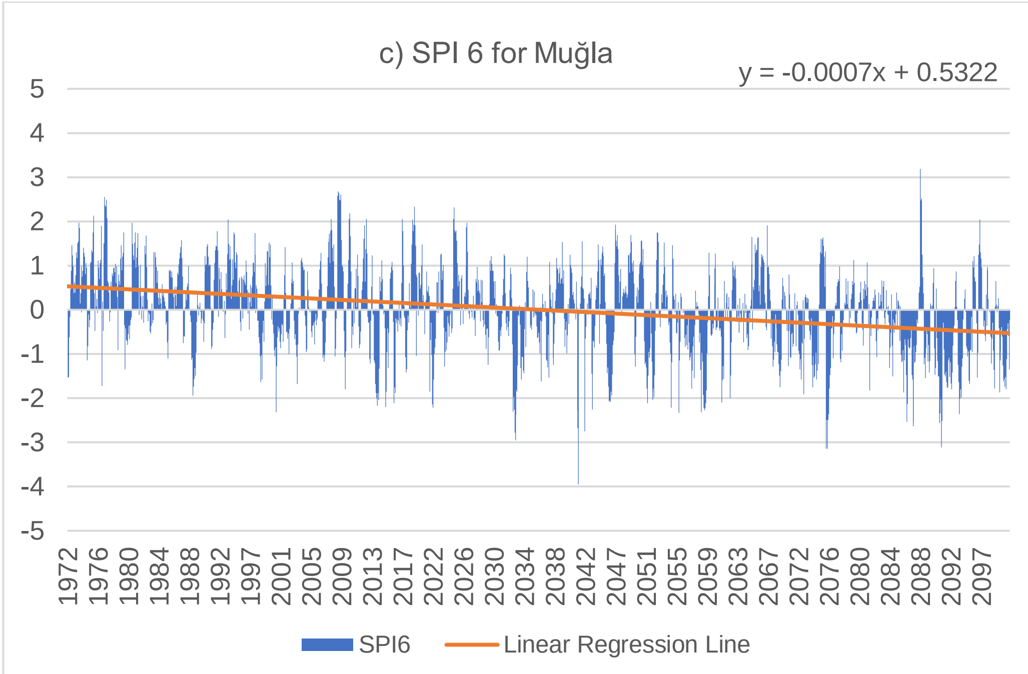


Figure 15. SPI values for Muğla station according to model 1-1 predictions (1972-2100). The linear regression equation is on top-right hand corner.



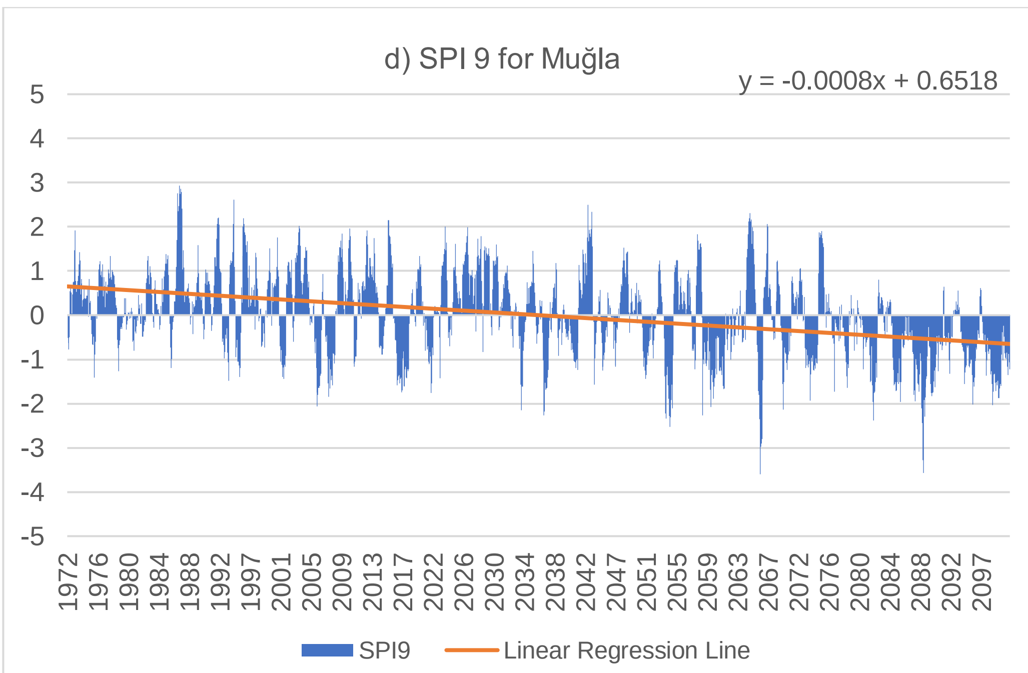


Figure 15. (cont'd)

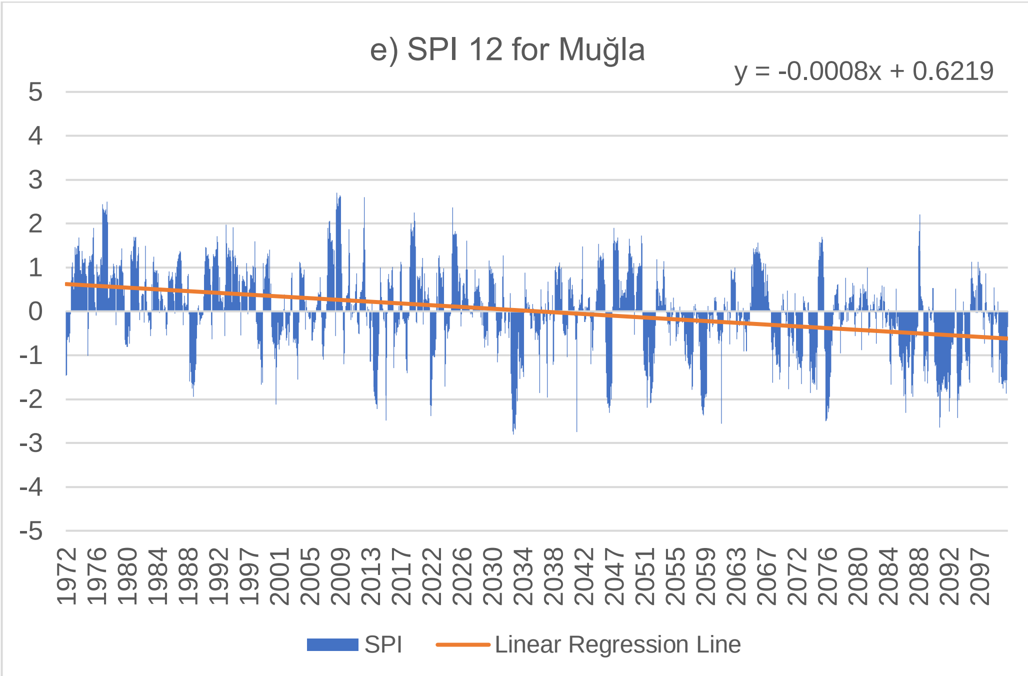


Figure 15. (cont'd)

3.3. Modeled trend analysis of SPI-3, -12, and annual precipitation at selected stations

Table 10 demonstrates the trend analysis results for 5 stations from different parts of Mediterranean climate region of Turkey. This table indicates the consistency and divergency of model predictions.

There is no significant trend in drought and annual rainfall according to four of the models on Adana location. The forcing effect of Global Climate Models can be inferred since three of these four models (2-1, 2-2, 2-3) are forced by same GCM (CNRM-CERFACS-CNRM-CM5). Model 4-2 predicted no significant change at trend for this location.

Almost all models predicted an increase in drought and decrease in annual rainfall for Antalya and Muğla locations while the analysis results are divergent for other three locations. Only model 4-2 diverged from rest of the models since no significant trend was detected for Muğla.

Balıkesir is the location in which relatively wetter conditions are expected. The models did not predict an increasing drought for both 3-monthly and 12-monthly scales except 3 of them (1-2, 3-1, 4-1). Further, model 3-2 predicted an increase in SPI 12 that signifies wetter conditions.

The increase in drought at İzmir location is limited at 3 monthly scale for model 1-1, 1-3 and 2-2. However, models 1-2, 1-4, 2-3, 3-1, 3-2, 3-3 and 4-1 predicted a negative slope at SPI trendline for not only 3-monthly but also 12-monthly scale. Lastly, a decreasing annual rainfall accompany the increasing drought according to half of the models. Model 4-2 predicted wetter conditions unlike the other 11 models.

Table 10 also enables detecting the forcing effect of Regional Climate Models. This case is particularly obvious at Balıkesir and İzmir locations. Model 1-2 (forced by CCLM4-8-17 RCM) predicted drier conditions for Balıkesir in contrast to other three models which are forced by same GCM: ICHEC-EC-EARTH. IPSL-IPSL-CM5A-MR GCM is also susceptible to RCM effect. The results are totally different on 4 of 5 locations for 2 models: 4-1 and 4-2.

The prediction divergence of the models on İzmir is similar to Balıkesir. Models 1-2, 1-4, 2-3, 3-1, 3-2, 3-3 and 4-1 predicted drier conditions on İzmir location considering SPI 3 and SPI 12 trends together. The forcing effect of RCA4 RCM is significant since slope of all predictions forced by this RCM are at the same direction no matter which GCM is forcing. Model 4-2 predicted wetter conditions in contrast to other 11 models.

Table 10. Trend change table for 5 stations. ↘ denotes negative slope, ↔ denotes no significant trend, ↗ denotes positive slope.

Location	**Analysed trendlines**	**Model No**											
		1-1	1-2	1-3	1-4	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2
Adana	SPI 3	↘	↘	↘	↘	↔	↔	↘	↘	↘	↘	↘	↔
	SPI 12	↘	↘	↘	↔	↔	↔	↔	↘	↘	↘	↘	↔
	Annual	↘	↘	↘	↘	↔	↔	↔	↘	↘	↘	↘	↔
Antalya	SPI 3	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘
	SPI 12	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘
	Annual	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘
Balıkesir	SPI 3	↔	↘	↔	↘	↔	↔	↔	↘	↔	↔	↘	↔
	SPI 12	↔	↘	↔	↔	↔	↔	↔	↘	↗	↔	↘	↔
	Annual	↔	↘	↔	↔	↔	↔	↔	↔	↔	↔	↘	↔
İzmir	SPI 3	↘	↘	↘	↘	↔	↘	↘	↘	↘	↘	↘	↗
	SPI 12	↔	↘	↔	↘	↔	↔	↘	↘	↘	↘	↘	↗
	Annual	↔	↘	↔	↘	↔	↔	↘	↘	↔	↘	↘	↗
Muğla	SPI 3	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↔
	SPI 12	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↔
	Annual	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↔

Stacked line plots show the magnitude of fluctuations between years and the trends along with the period (Figure 16). The upper lines in the y-axes show the higher variability between the years and towards the origin the lines follow smoother curve. These plots help us to identify the models, which indicate the largest and smallest inter annual variability in precipitation and their general trend tendency along the years. For example, these two features, general trend tendency and level of inter annual variability among models appeared distinctly in Antalya and Muğla (Figure 16b and 16e respectively).

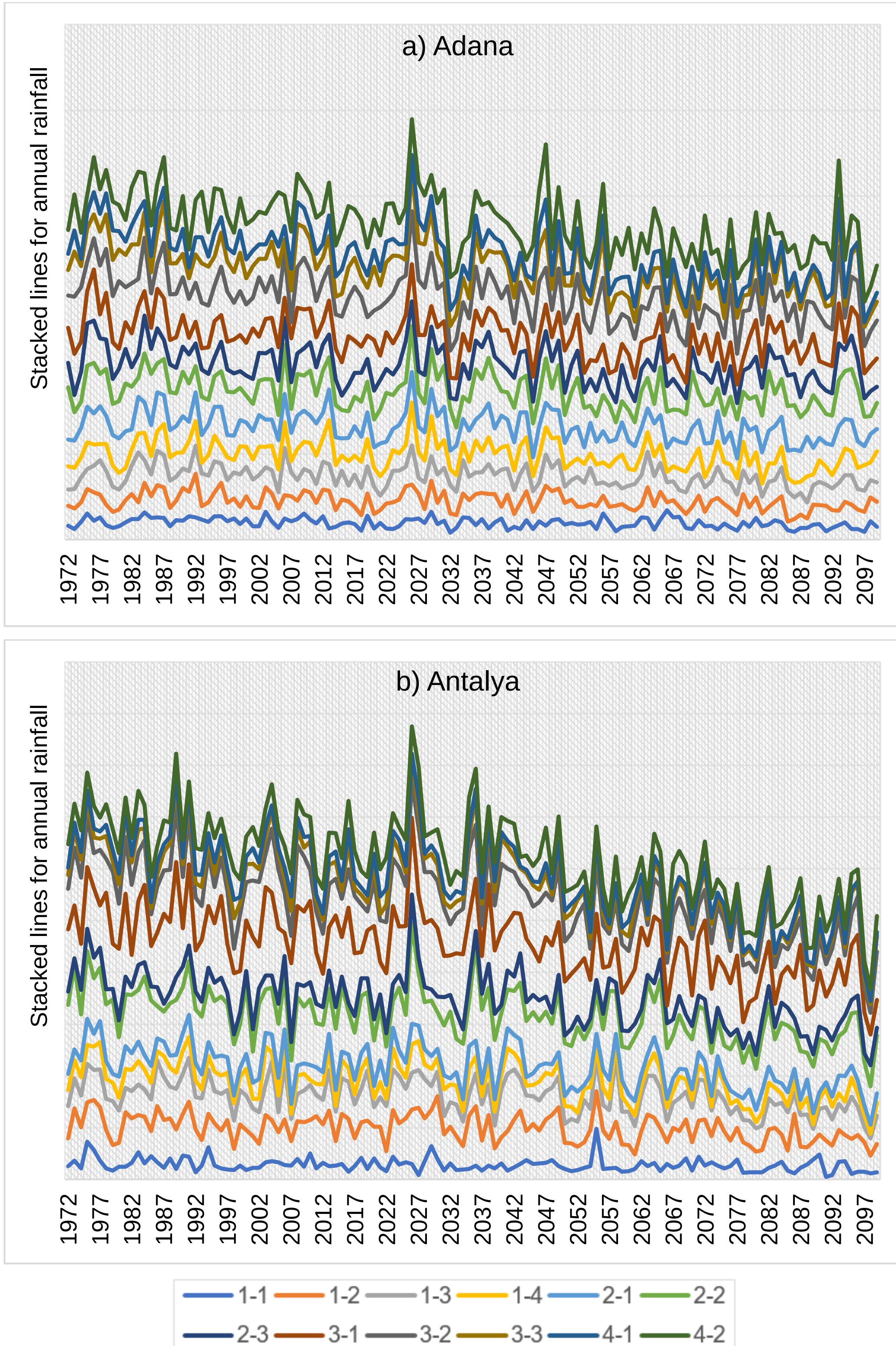


Figure 16. Annual precipitation for all models with stacked lines

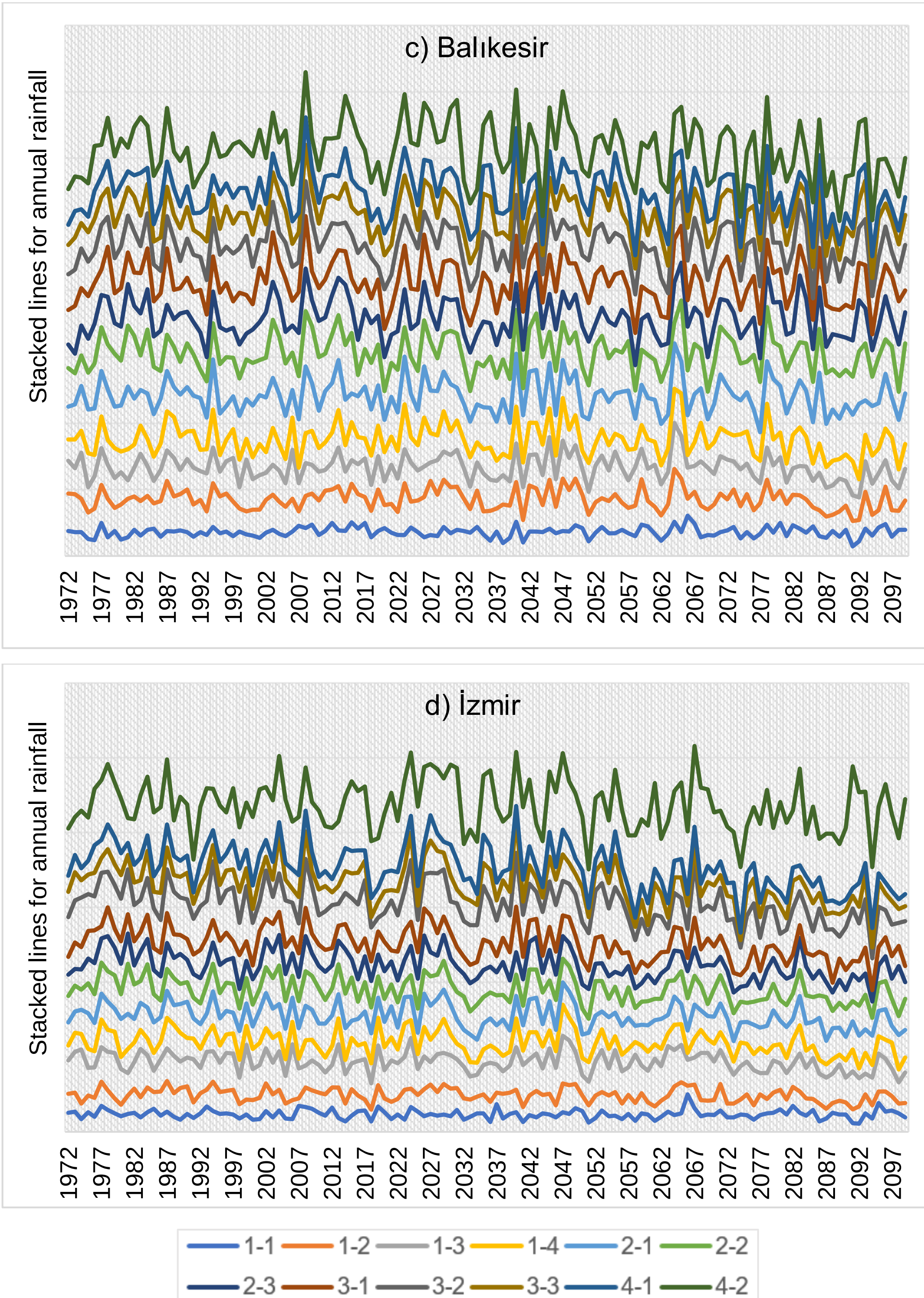


Figure 16. (cont’d)

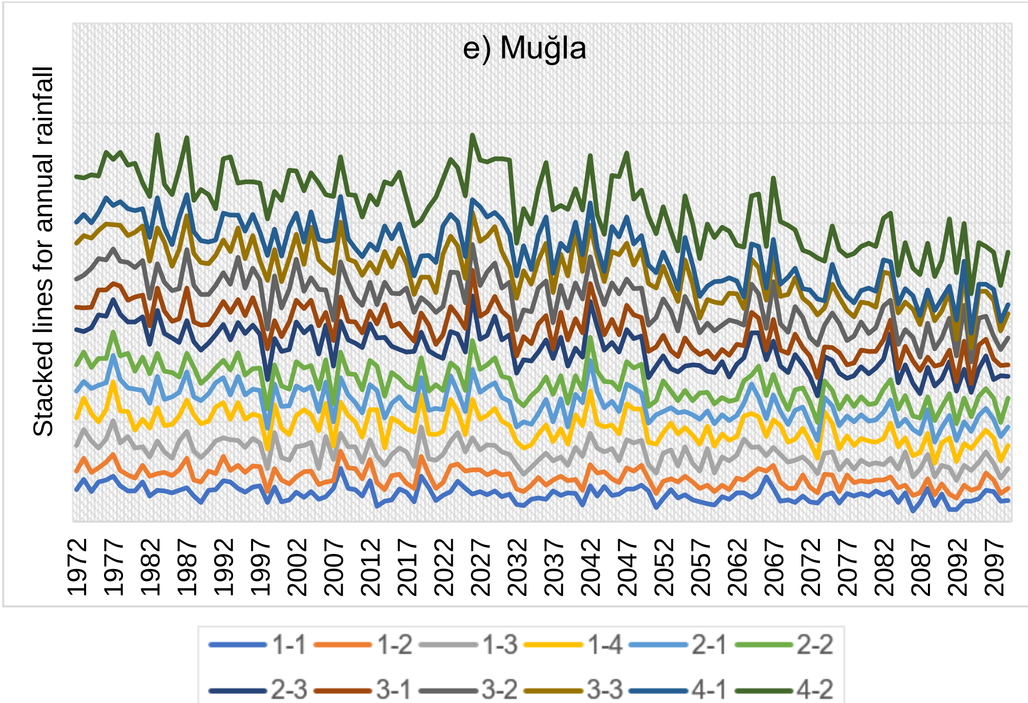


Figure16. (cont'd)

3.4. The Slope of Trend Analysis of SPI and Annual Precipitation From Ensemble Model Results

Following the methodology and methods presented in previous chapter, future changes in drought and rainfall were analyzed. The corresponding data of 12 CORDEX models was extracted for 60 locations -which have the same locations with the observation stations of the counties in the study area. SPI indices were analyzed for 1,3,6,9 and 12 monthly timescales based on the predicted monthly precipitation values between 1972-2100. Afterwards the trends of SPI indices and annual rainfall for each location were tested in terms of 5% significance level. Lastly, the trend slope of each SPI and rainfall time series which referred to a significant change according to modified Mann-Kendall test was obtained with linear regression. The slope values for each model and location were also presented in Appendix B.

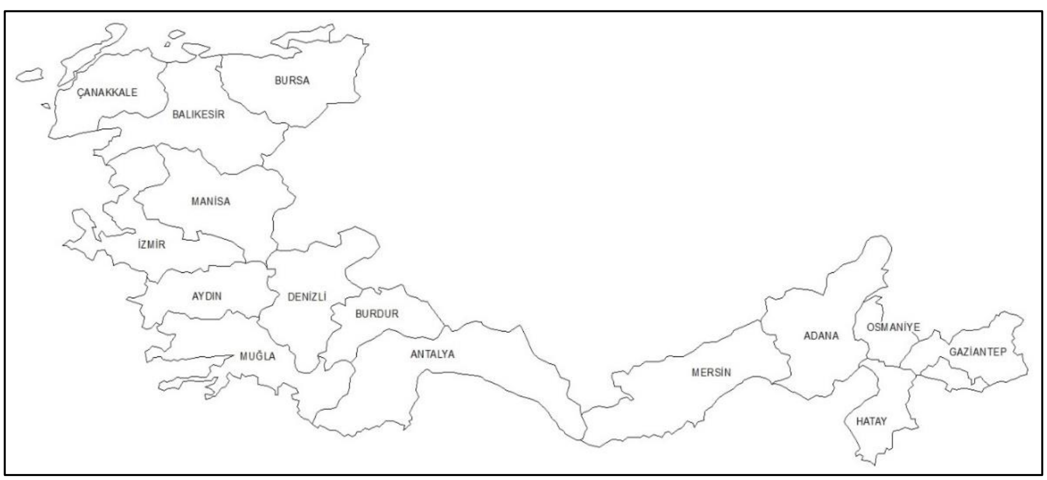


Figure 17 The study area with province names

In the mapping of the trend results, only the provinces covered in the study area were visualized (Figure 17). A red or blue circle was fixed up depending on slope direction. No circle was fixed up for the locations in which the significant trend was not detected. Thus, all the circles in the maps were fixed up for only the locations where a significant trend was detected and the results were interpreted noticing this situation.

3.4.1. SPI 1

Trend analysis of successive SPI 1 values is important to detect changes in short term drought as well as it is susceptible to seasonality effects. On the other hand, examination of trends for this timescale is necessary to observe any tendency to meteorological drought. Following paragraphs interpret the outcomes of trend analysis results for SPI 1 showed in Figure 18. The legend indicated in Figure 18a is valid for all SPI trend maps in the thesis.

Model 1-1 predicted negative slope in SPI 1 trendline for all the locations which modified Mann-Kendall test detected significant change (Figure 18a). The magnitudes of slopes were relatively greater on the points which are located in Muğla and Adana provinces and western Antalya as well. Another model which is forced by same GCM (model 1-2) predicted similar results to model 1-1 (Figure 18b). However, Denizli is the only province which a significant trend was not detected for any location according to model 1-1 while model 1-2 indicated no significant trend for the locations in only Bursa province (Figures 18a and 18b).

Though both of the other two models (1-3 and 1-4) from ICHEC-EC-EARTH GCM predicted only negative slope in SPI 1 trendlines, the geographical distribution of significant changes is limited to a smaller area comparing to models 1-1 and 1-2 (Figures 18a, 18b, 18c and 18d). Modified Mann-Kendall test results depending on model 1-3 predictions revealed no significant trend in SPI 1 values for Bursa, Balıkesir and Osmaniye provinces and eastern Antalya (Figure 18c). Though the trend result map of model 1-4 is like model 1-3 result map in terms of the locations with highest drought increase trend, model 1-4 also projected negative slope in SPI 1 trendline for two provinces from northern part of study area -Balıkesir and Bursa (Figure 18d).

The expected drought increase is considerably limited to a region according to models forced by CNRM-CERFACS-CNRM-CM5 GCM (Figures 18e, 18f and 18g). Model 2-1 predicted negative slope for locations extending from western Antalya to İzmir (Figure 18e). Still, there are three locations in which a drought increase was expected from eastern part of study area -at least for one-monthly timescale. This model predicted significant trend in SPI 1 values for none of the locations from Çanakkale, Balıkesir and Adana provinces. On the other hand, there is one location in which positive slope was detected from each of two provinces: Bursa and Mersin.

Model 2-2 predicted greater slope magnitude for the locations in which model 2-1 projected negative slope (Figure 18f). In addition to this, the location in which drought decrease was expected from Bursa province is same with model 2-1, but slope magnitude is smaller. Thus, it can be interpreted that model 2-2 predicted drier conditions than model 2-1 predicted. Balıkesir and Adana are two common provinces in which both models predicted no significant trend.

The area in which highest drought increase trends are likely to occur according to model 2-3 is similar to model 2-1 and 2-2 (Figures 18e, 18f and 18g). This area includes locations from Muğla province and western part of Antalya. However, this model predicted negative slope in SPI 1 trendline for locations from Adana province whereas other two models from same GCM did not predict significant trend. In addition to this, no significant trend was detected for any location in Aydın province as distinct from model 2-1 and 2-2 (Figures 18e, 18f, and 18g). The divergence of these trend results for SPI 1 indicated the effect of RCA4 RCM which forces model 2-3 as well as a high probability of drought increase for certain parts of study area.

Model 3-1 predicted negative slope in SPI 1 trendline for locations from all provinces covered in study area (Figure 18h). Particularly, the slope magnitudes are greater at some locations from Muğla, Denizli, Burdur and Antalya provinces. The geographical distribution of negative slope is relatively limited according to model 3-2 and the magnitudes are smaller (Figure 18i). This model did not predict any significant trend for locations from Bursa province and northern parts of Çanakkale and Balıkesir as well.

The drought increase trends are highest around Adana and Hatay provinces according to model 3-3 (Figure 18j). There is no location in which model 3-3 predicted significant trend from Aydın province like model 2-3 which is forced by same RCM: RCA4.

Model 4-1 diverged from rest of the models owing to greater slope magnitudes that all indicated a significant negative trend for SPI 1 (Figure 18k). Though, the highest drought increase trends are around two regions (Muğla-Antalya and Adana-Hatay) which are partially common with rest of the models (Figure 18). This model also diverged from the other model couplings which are forced by same RCM (RCA4) in terms of the wideness of significant trend locations (Figure 18d, 18g, 18j and 18k).

The other model 4-2 which is forced by same GCM (IPSL-IPSL-CM5A-MR) is the only model that predicted positive slope in SPI 1 trendline for many locations (Figure 18l). Aegean coast -from Aydın to Çanakkale- is the part where drought decrease expectations at its highest level. On the other side, negative slope was obtained in SPI 1 trendline for some locations from southern part of the study area which are common with rest of the models (Figure 18).

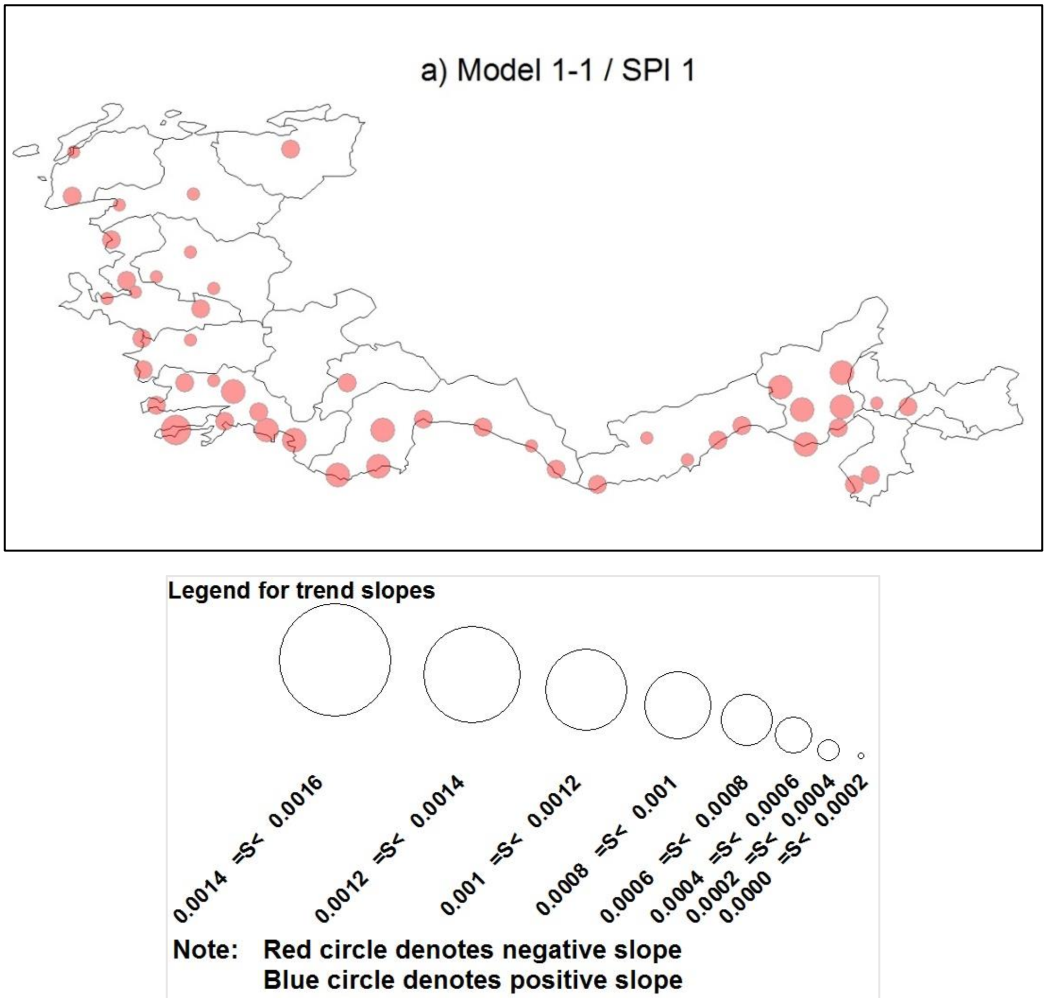
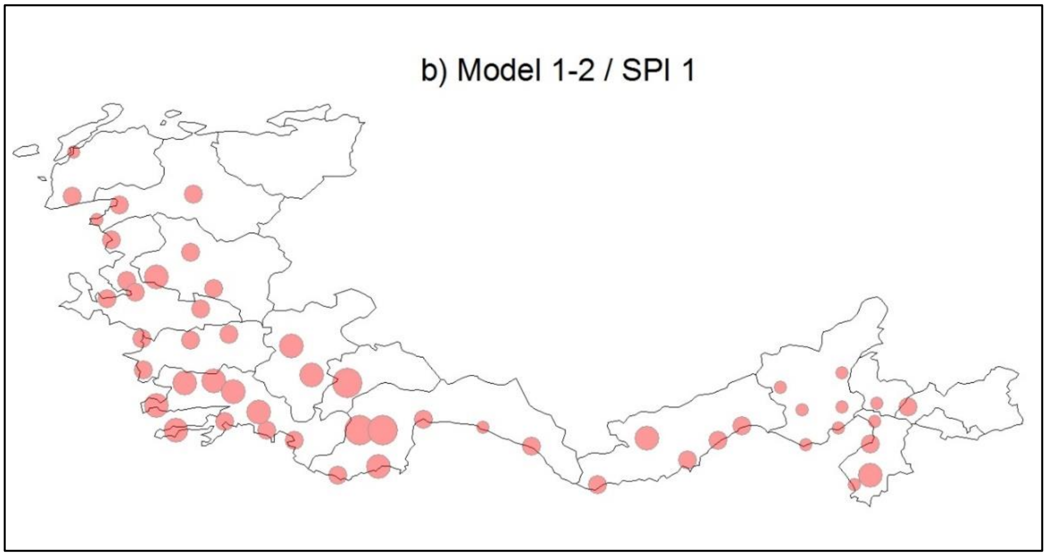


Figure 18 The geographical distribution of trends for SPI 1. The legend is valid for rest of the SPI trend maps



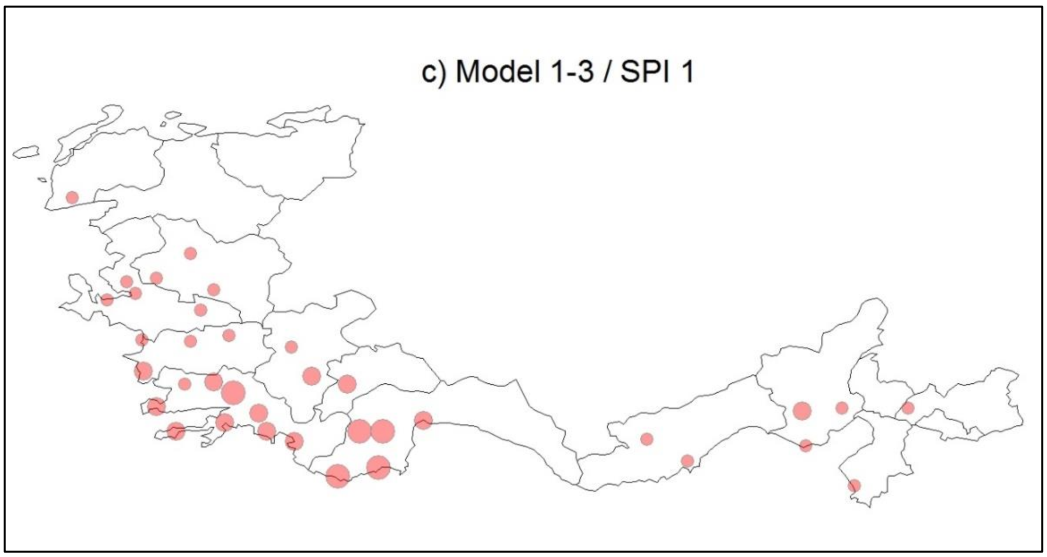
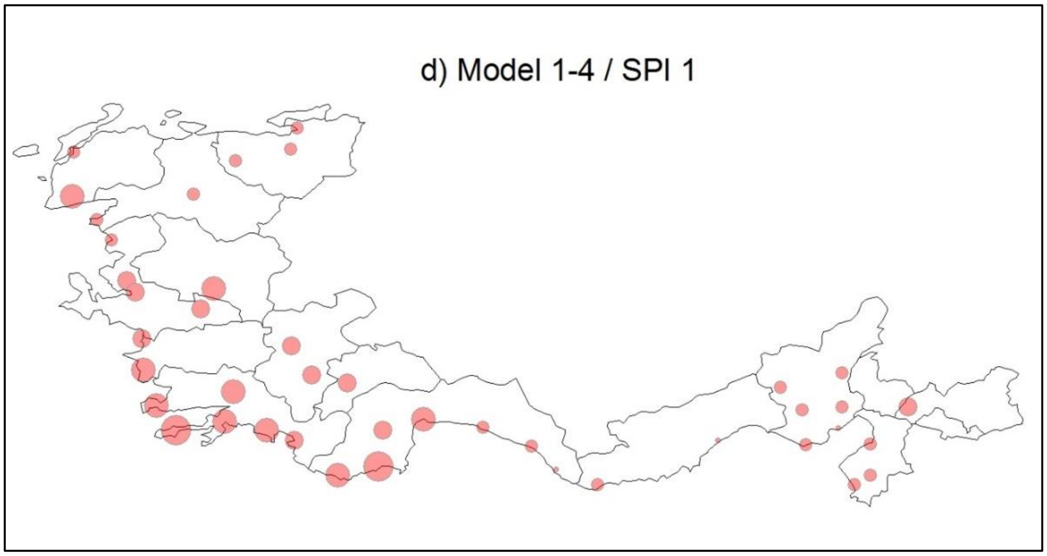


Figure 18. (cont'd)



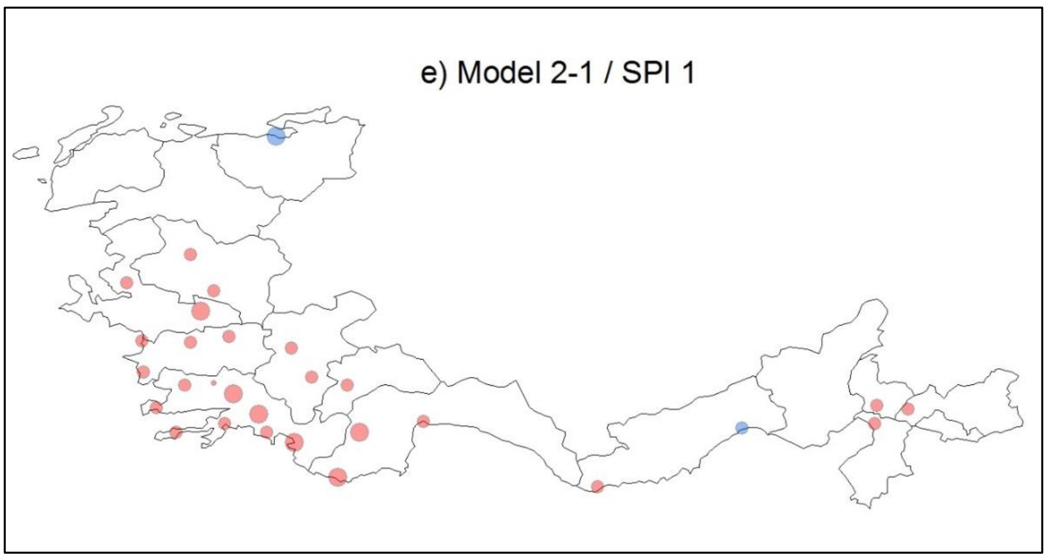
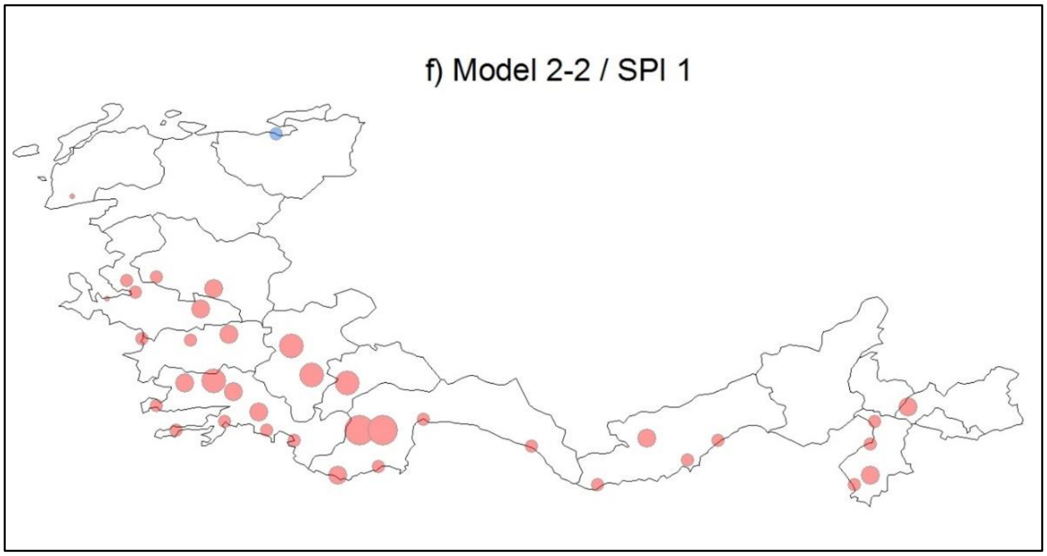


Figure 18. (cont'd)



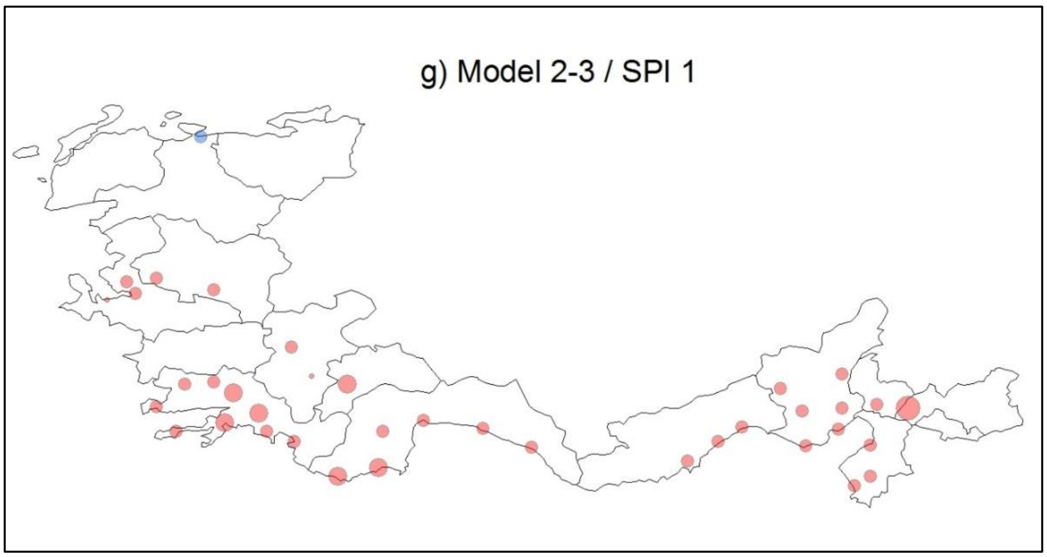
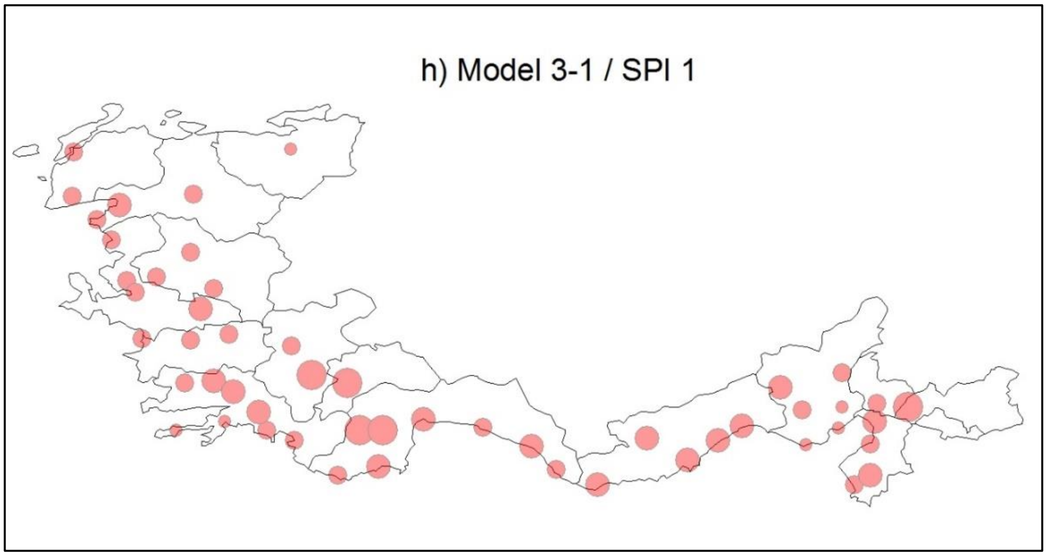
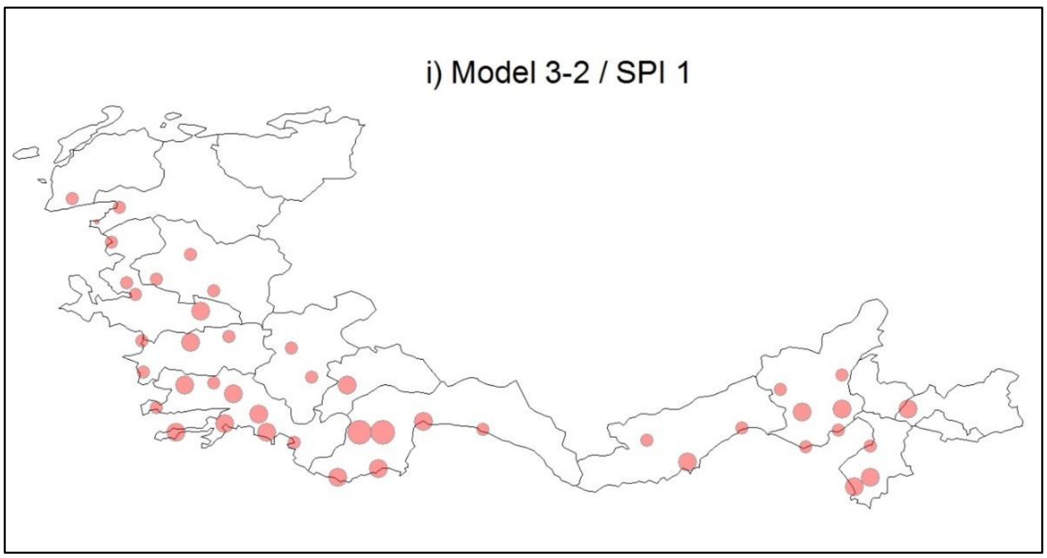


Figure 18. (cont'd)





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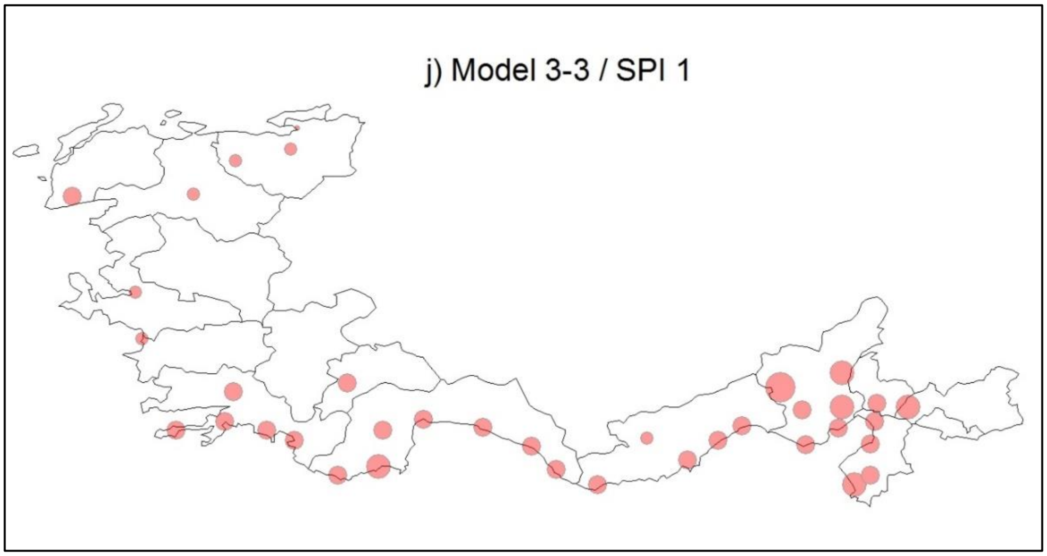


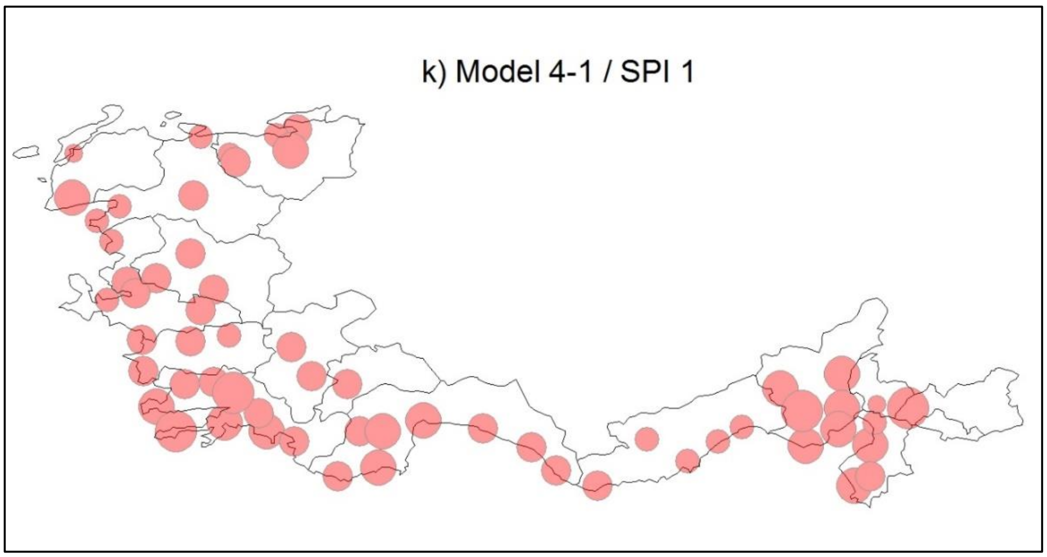


Figure 18. (cont'd)

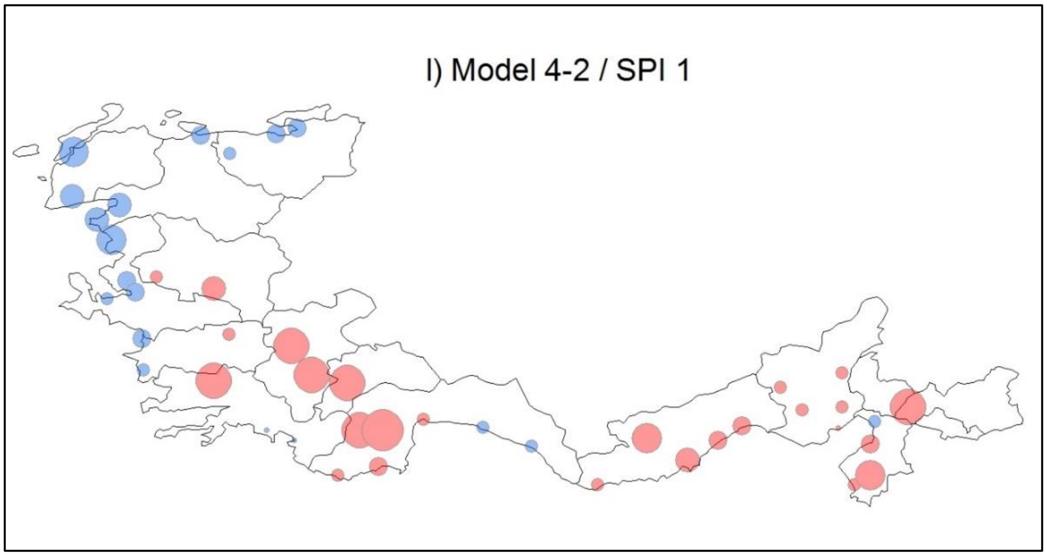


Figure 18. (cont'd)

Considering the effect of GCMs by comparing the model couplings from same RCM is also another aim of this study. There are three RCMs which coupled with different GCMs: CCLM4-8-17, RACMO22E and RCA4 (Table 2). Model 1-2, 2-2 and 3-1 are the models which are forced by CCLM4-8-17 RCM but different GCMs respectively: ICHEC-EC-EARTH, CNRM-CERFACS-CNRM-CM5 and MOHC-HadGEM2-ES. The number of significant trend detected locations according to model 2-2 which is forced by CNRM-CERFACS-CNRM-CM5 GCM is less than model 1-2 and 3-1 detections (Figures 18b, 18f and 18h). The expected drought increase area is relatively limited for model 2-3 in comparison to other models forced by RCA4 RCM (Figures 18d, 18g, 18j, and 18k). On the other hand, the trend analysis maps of models 1-2 and 3-1 (forced by CCLM4-8-17 RCM) are similar to each other (Figure 18b and 18h). This similarity is also valid between models 1-3 and 3-2 (both forced by RACMO22E RCM) and between models 1-4 and 3-3 (both forced by RCA4 RCM). These matchings highlight the distinctness of CNRM-CERFACS-CNRM-CM5 GCM from other two GCMs (ICHEC-EC-EARTH and MOHC-HadGEM2-ES) which were considered in this comparison. IPSL-IPSL-CM5A-MR is also a more impact GCM since model 4-1 projects a quite wider drought increase area with greater magnitudes than models 1-4, 2-3 and 3-3 predict which are forced by same RCM: RCA4 (Figures 18d, 18g, 18j and 18k).

3.4.2. SPI 3

Significant trend in successive SPI 3 values can be interpreted a first step to agricultural drought. In this part the trends in SPI 3 were interpreted comparing the models and SPI 1 trend results.

Considering model 1-1, two different behavior on SPI trends occurred for the locations in which a significant trend was detected for SPI 1 values (Figure 18a and 19a). Slope magnitudes became greater at this timescale for most of the locations in which a negative slope was detected in SPI 1 trendline whereas significant trend did not exist anymore for some of them. On the other hand, positive slope in SPI 3 trendline was detected for four locations from different provinces: Bursa, Balıkesir, Antalya and Denizli. Still, the highest drought increase expectations according to SPI 3 trends are on the same area with SPI 1: Muğla, Antalya and Adana. This fact indicated a tendency to agricultural drought increase.

Though significant trend disappeared for a few locations from northern Aegean coast, rest of the locations in which a negative slope was estimated for SPI 1 signified a greater magnitude for SPI 3 for model 1-2 (Figure 18b and 19b). This projection pretty much fitted model 1-1 projection in terms of tendency to agricultural drought. However, the drought increasing expectations became evident for a region from western Antalya to İzmir and Mersin tend to live drier conditions rather than Adana as a distinction from model 1-1 (Figures 19a and 19b).

There are new locations in which a significant trend (negative slope) for SPI 3 was detected from southern part of the study area according to model 1-3 (Figure 19c). Two locations from Manisa did not signify a significant trend at this timescale anymore. The drought increase expectation aggregated around Muğla and western Antalya according to this model considering the increasing slope magnitudes on negative direction. Yet, the significant trend detected locations for SPI 3 are relatively limited for model 1-3 in comparison to other models from same GCM (Figures 19a, 19b, 19c and 19d). This variation was also valid for SPI 1 trends (Figure 18a, Figure 18b, Figure 18c and Figure 18d).

Model 1-4 (Figure 19d) predicted greater slope magnitudes on negative direction for SPI 3. The drought increase expectation is most likely for an area extending from western Antalya to İzmir. Besides, there are new locations in which a significant trend was detected from Mersin province.

The significant trend detected locations are even more limited for SPI 3 than SPI 1 according to model 2-1 (Figure 19e). However, the slope magnitudes increased on both negative and positive directions comparing to SPI 1 (Figure 18e). This fact is also valid for model 2-2 (Figure 18f and 19f). There is also one new location with positive slope from Bursa province.

There is no location with significant trend on negative direction for SPI 3 from İzmir, Denizli and Osmaniye provinces as distinct from SPI 1 for model 2-3 (Figure 18g and 19g). This model predicted wetter conditions for southern Marmara considering 4 locations with positive slope from Çanakkale, Balıkesir and Bursa provinces. Though, the negative slope magnitude increased for some locations from Muğla and Gaziantep.

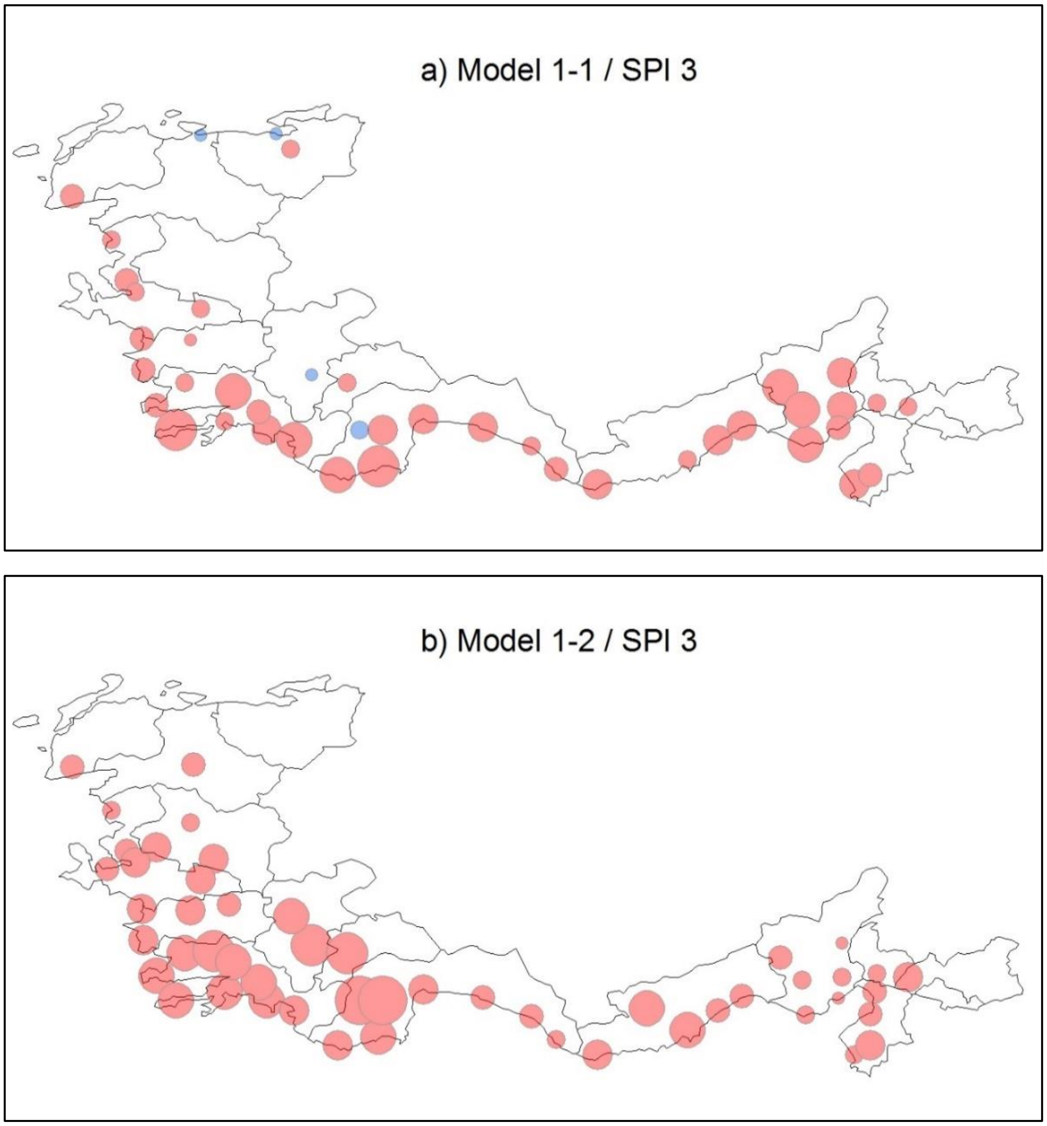
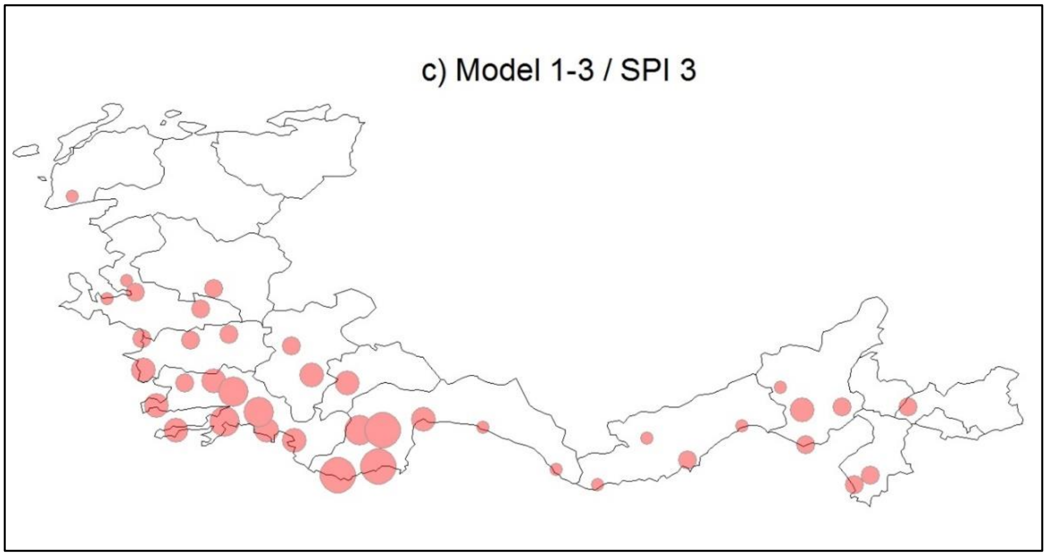
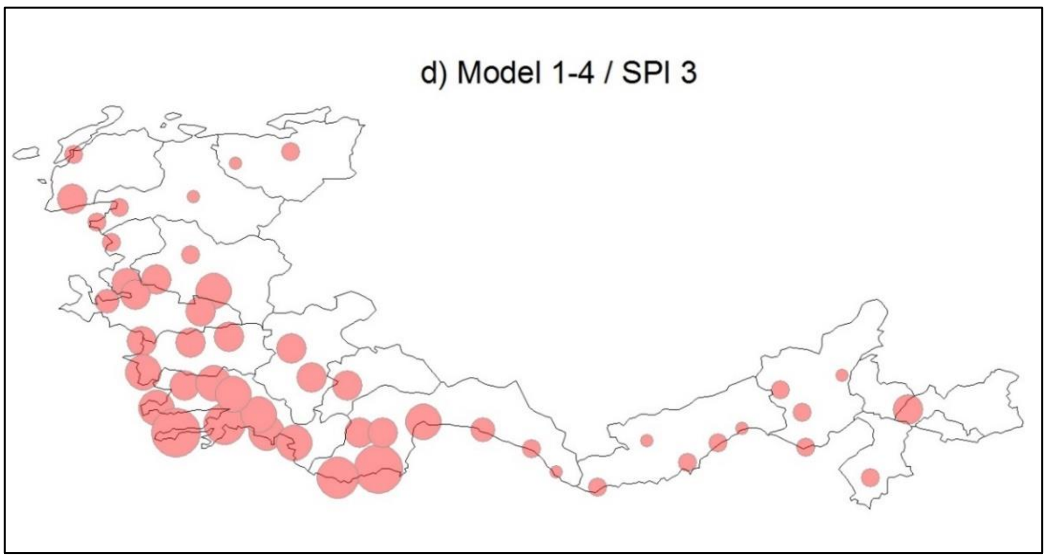


Figure 19. The geographical distribution of trends for SPI 3





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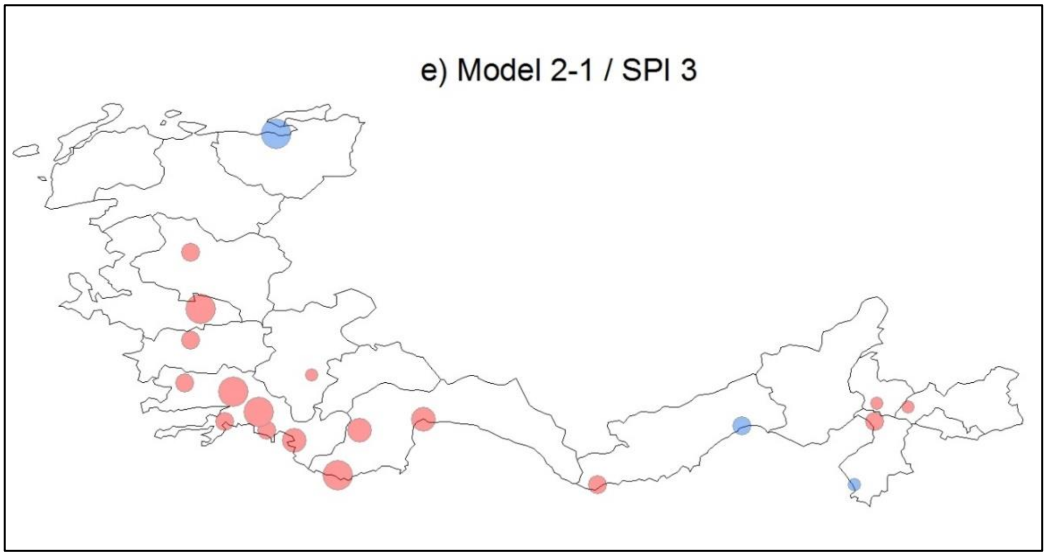

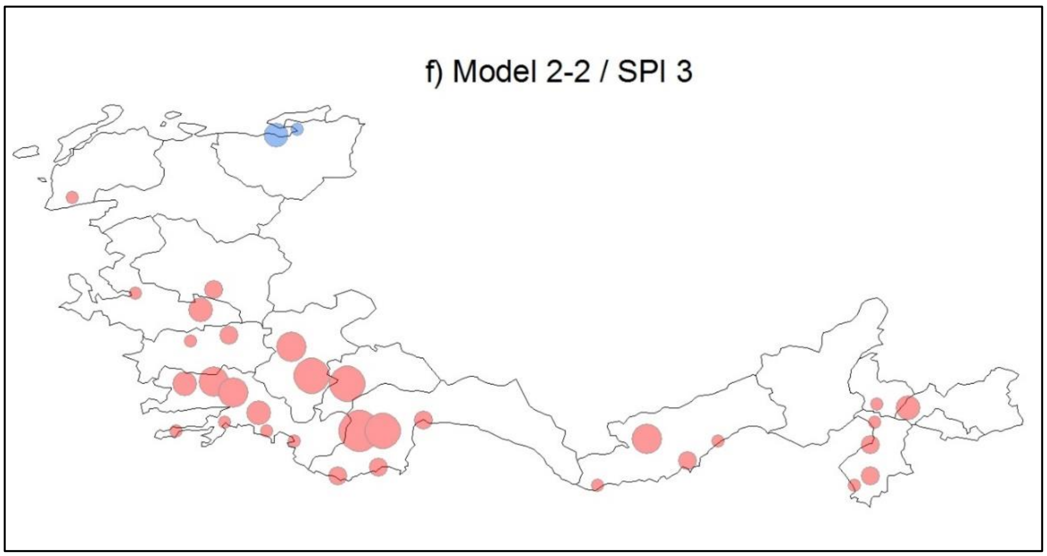

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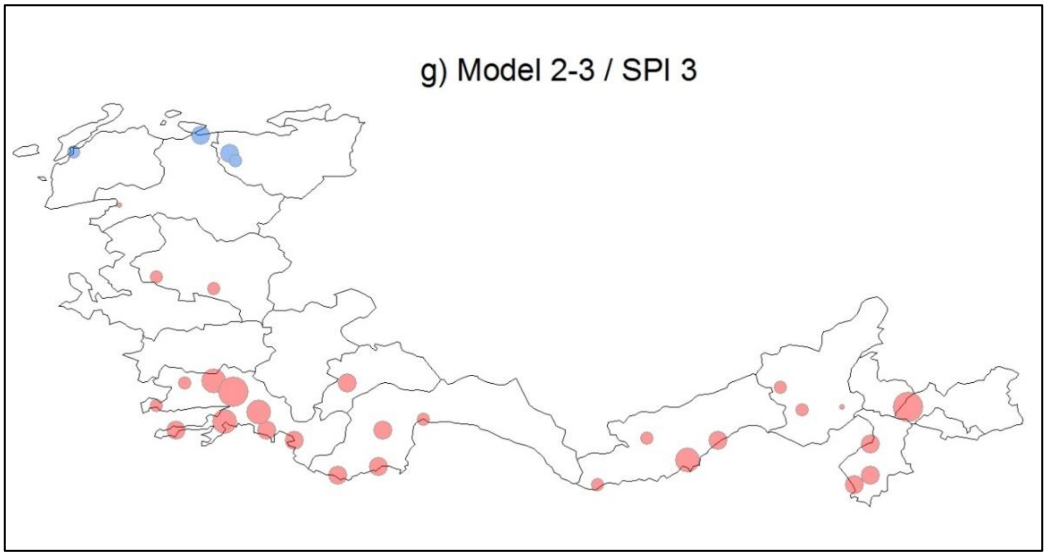


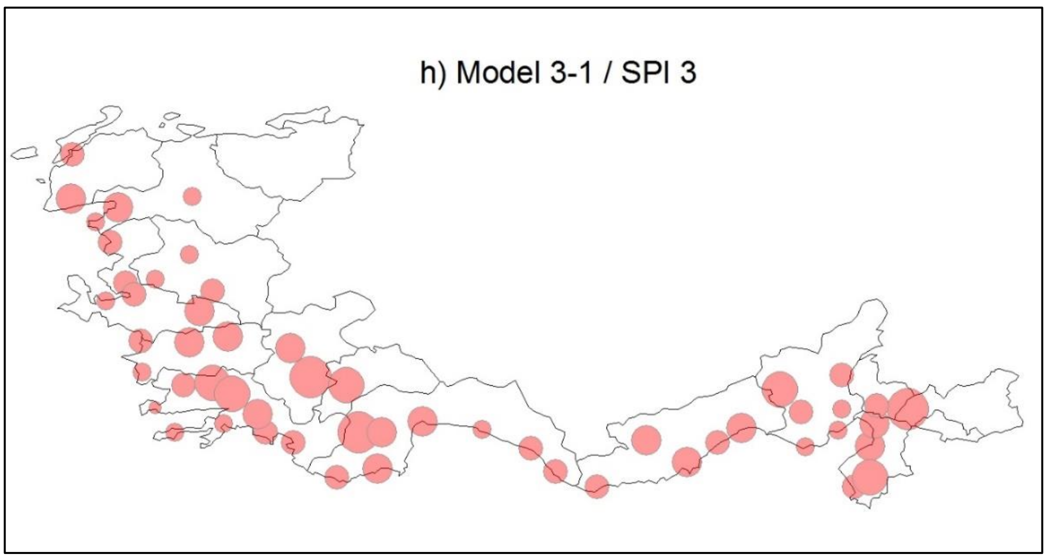
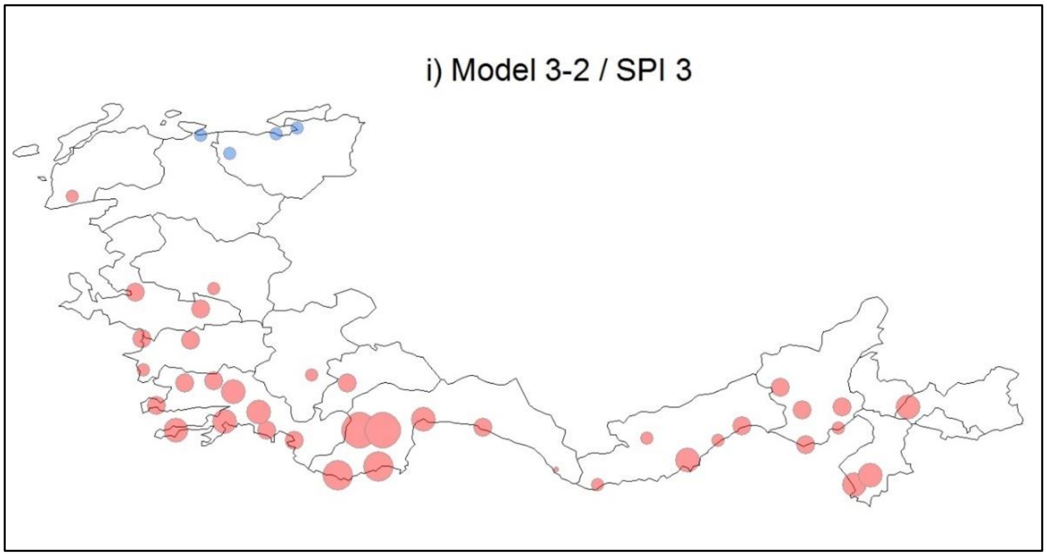


Figure 19. (cont'd)



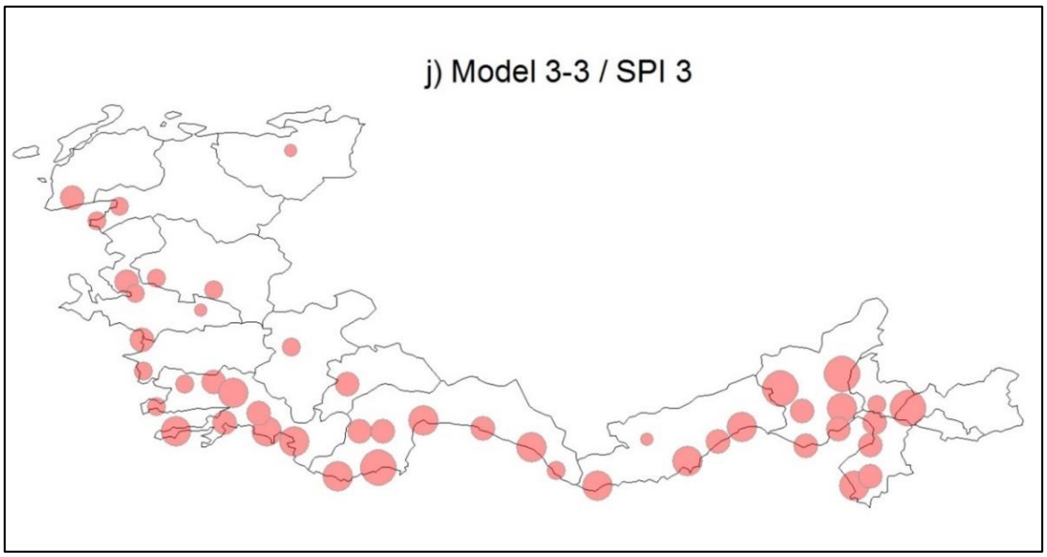
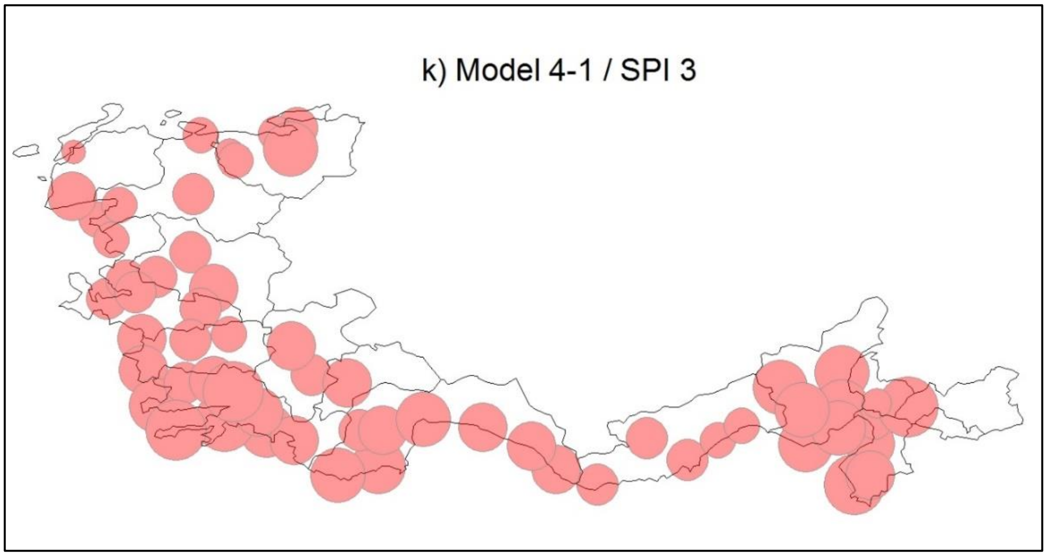


Figure 19. (cont'd)



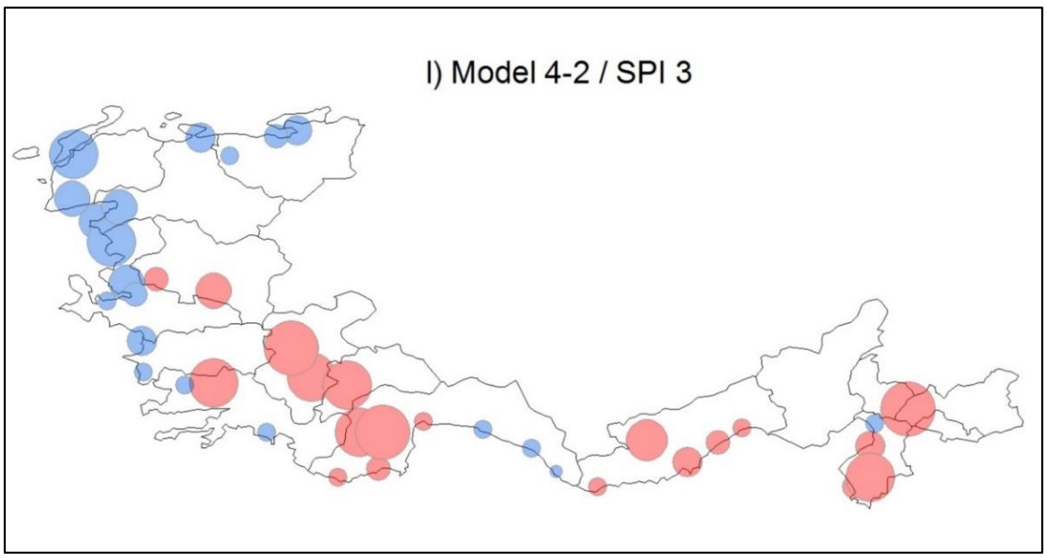


Figure 19. (cont'd)

Model 3-1 (Figure 19h) predicted negative slope in SPI 3 trendlines for all provinces except Bursa. The locations with greatest slope magnitudes are from Muğla, western Antalya, Denizli, Hatay and Gaziantep at this timescale. The drought tendency is not limited at meteorological level for almost whole study area according to this model.

The drought increasing expected locations shifted southernly according to model 3-2 considering the differences between SPI 1 and SPI 3 (Figure 18f and 19f). Six locations from Manisa, İzmir and Aegean coast of Balıkesir did not signify a negative SPI slope at three-months timescale as well as new locations with negative slope came out from Antalya, Mersin, Adana and Hatay provinces. Besides, a positive slope was detected for four locations from southern Marmara.

The magnitudes of slopes in SPI 3 trendlines increased overall for model 3-3 projections comparing to SPI 1 (Figures 18j and 19j). Additionally, Manisa and Denizli cover locations with negative slopes at this timescale. In general, the slope magnitudes are close to each other for southern part of study area (along Mediterranean coastline).

The geographical distributions of SPI 3 trend results are almost same with SPI 1 trend results for model 4-1 and 4-2 (Figures 18k, 18l, 19k and 19l). However, the slopes sharpened in both directions like rest of the models (Figure 18 and 19).

The regions in which drought expectations aggregated according to SPI 1 trendlines (Muğla, western Antalya and Adana) keep this characteristic at SPI 3 as well (Figure 18 and 19). This fact can be interpreted as a transition from meteorological drought to agricultural drought. However, the disappeared drought increasing signs for some locations should be noticed (particularly for northern parts of the study area).

3.4.3. SPI 6

Considering the trendlines for SPI 6, the results of all models tend to predict drier conditions for almost same areas with SPI 3 (Figures 19 and 20). However, all models indicated greater slope magnitudes for both negative and positive directions. These facts signify a tendency to hydrological drought for the locations which agricultural drought increase likely to occur.

Muğla and western Antalya is the region which all models project drought increases at 6-monthly timescale (Figure 20). Model 4-2 and three models (2-1, 2-2, 2-3) forced by CNRM-CERFACS-CNRM-CM5 GCM diverged from rest of the models since they do not predict drier conditions for Adana province as much as the others predicted (Figures 20e, 20f, 20g and 20l). The northern parts of study area (Southern Marmara) are likely not to live drier conditions at this timescale according to most of the models. However, İzmir is the province which model projections did not fit each other widely. Model 1-1, 1-2, 1-3, 1-4, 3-1, 3-2, 3-3 and 4-1 predicted a negative slope in SPI 6 trendlines for more than one location from this province (Figure 20). On the other hand, models 2-1 and 2-2 predicted drier conditions for only one location from İzmir while models 2-3 and 4-2 did not predict negative slope for any location in İzmir (Figures 20e, 20f, 20g and 20l).

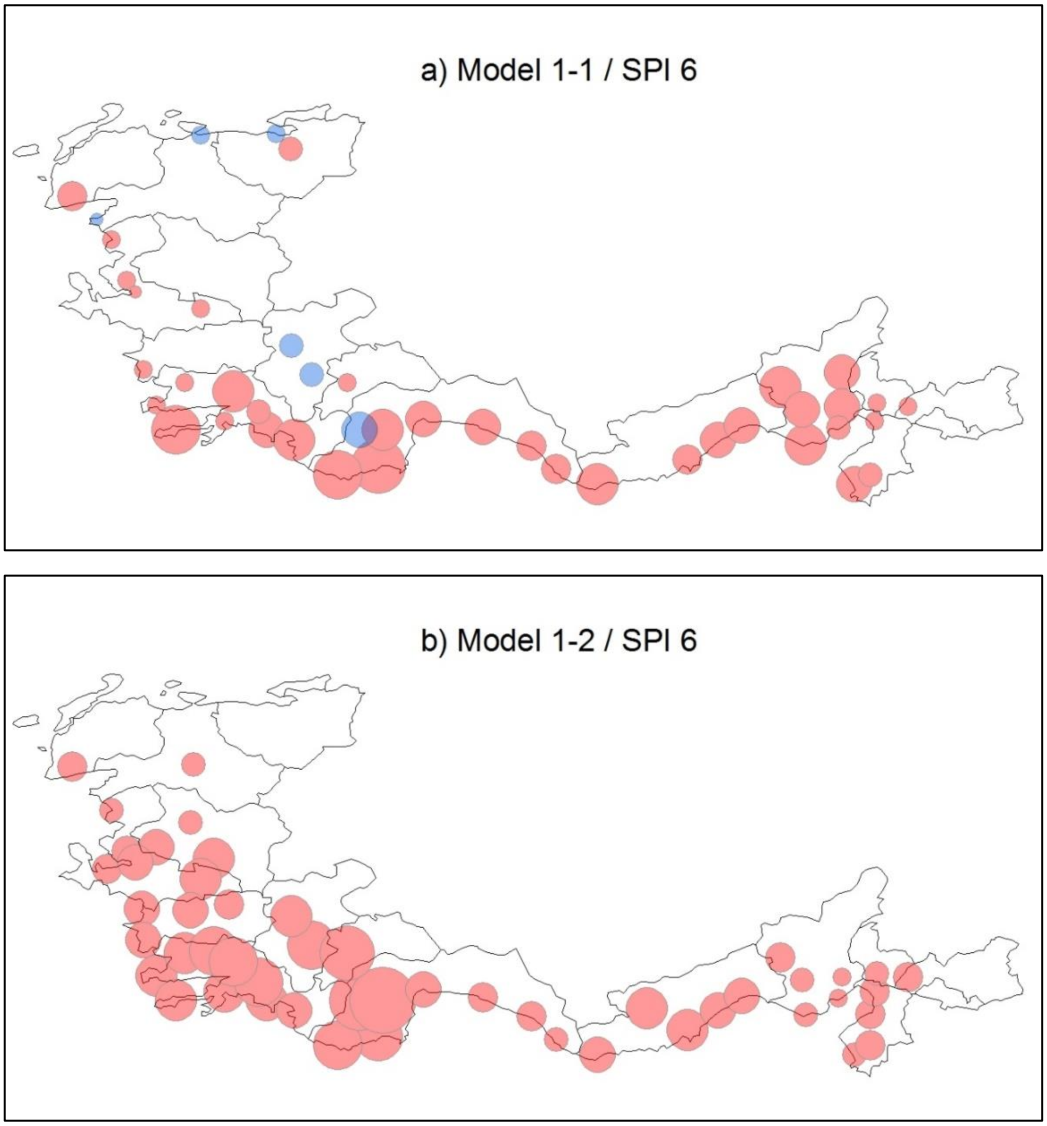
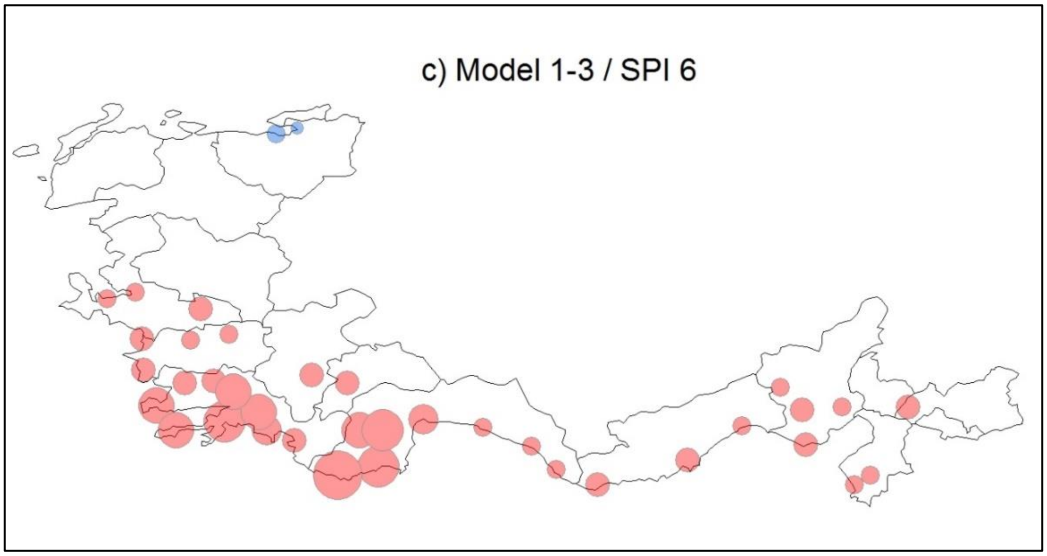
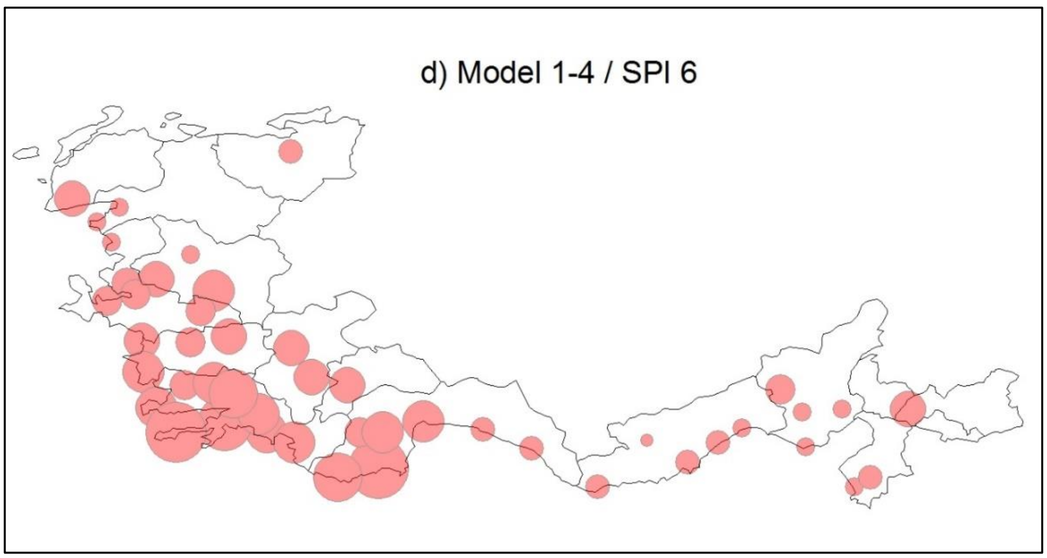


Figure 20. The geographical distribution of trends for SPI 6





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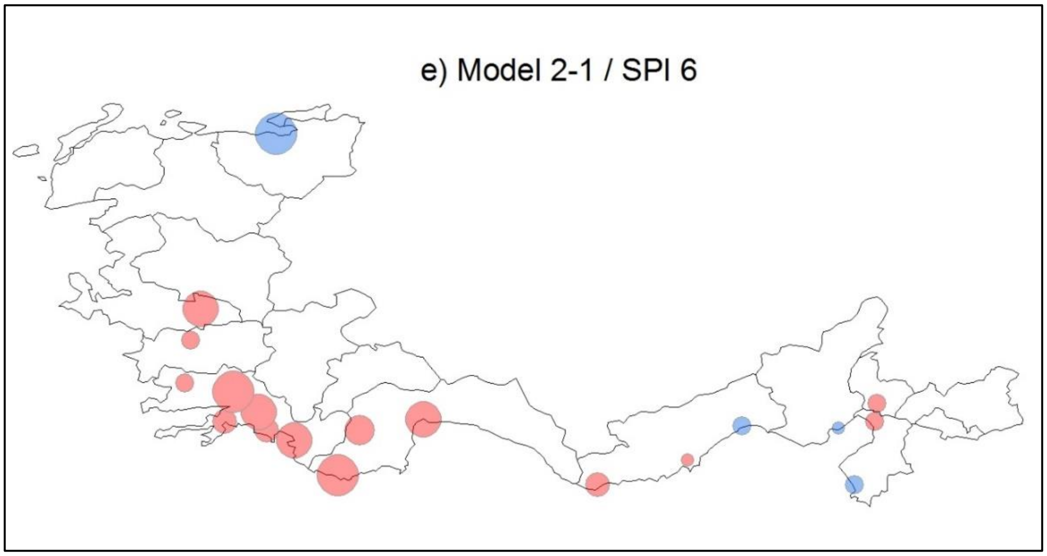

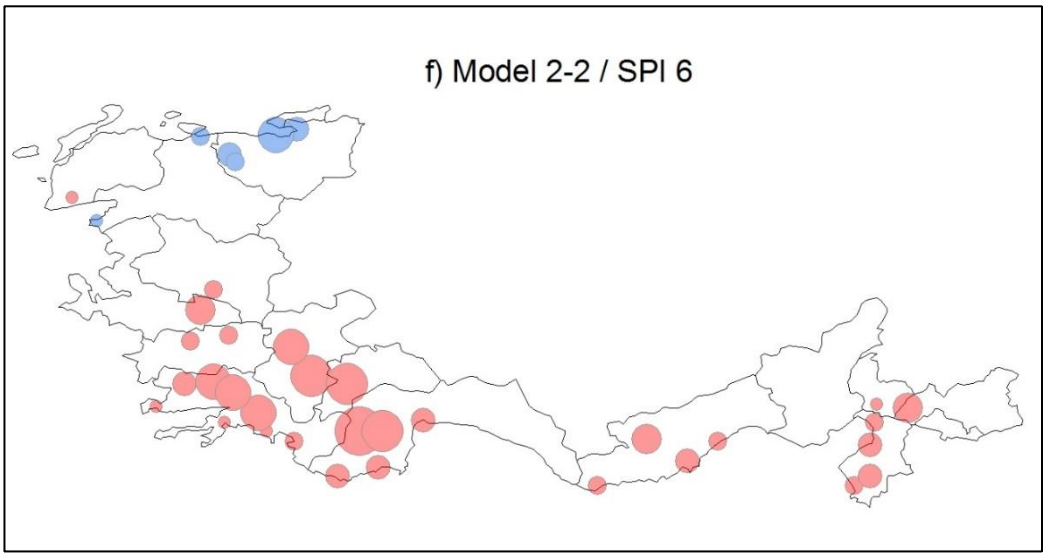

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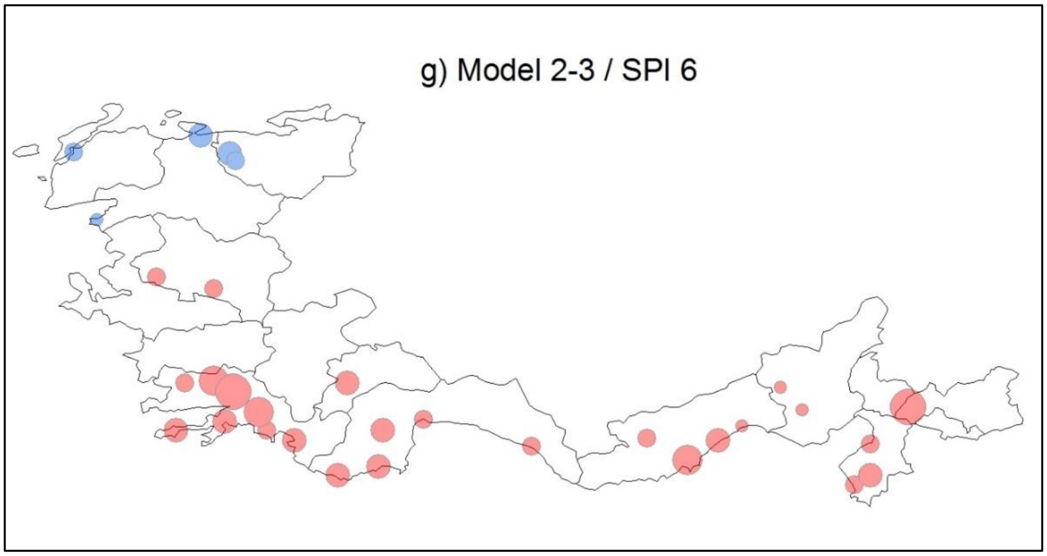


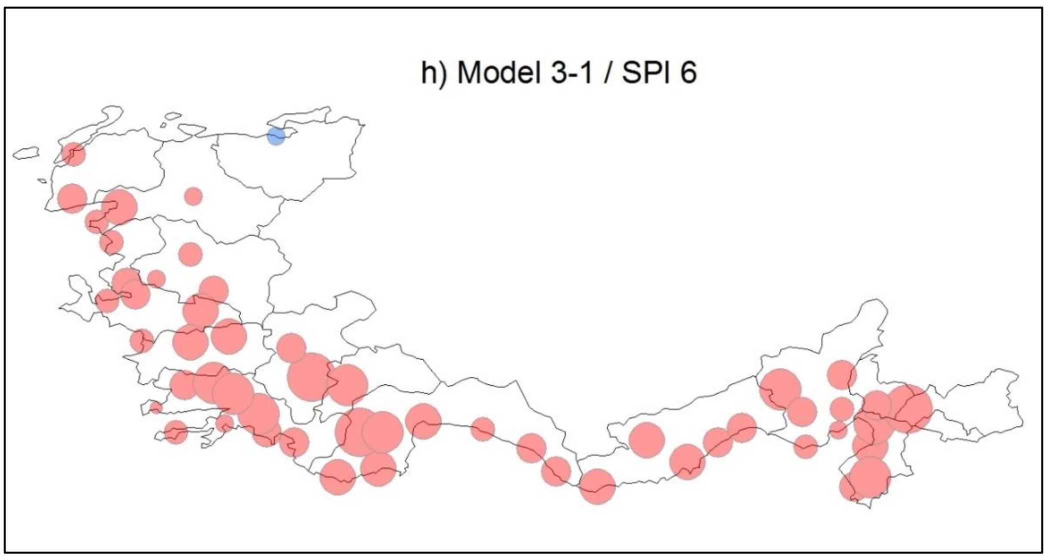
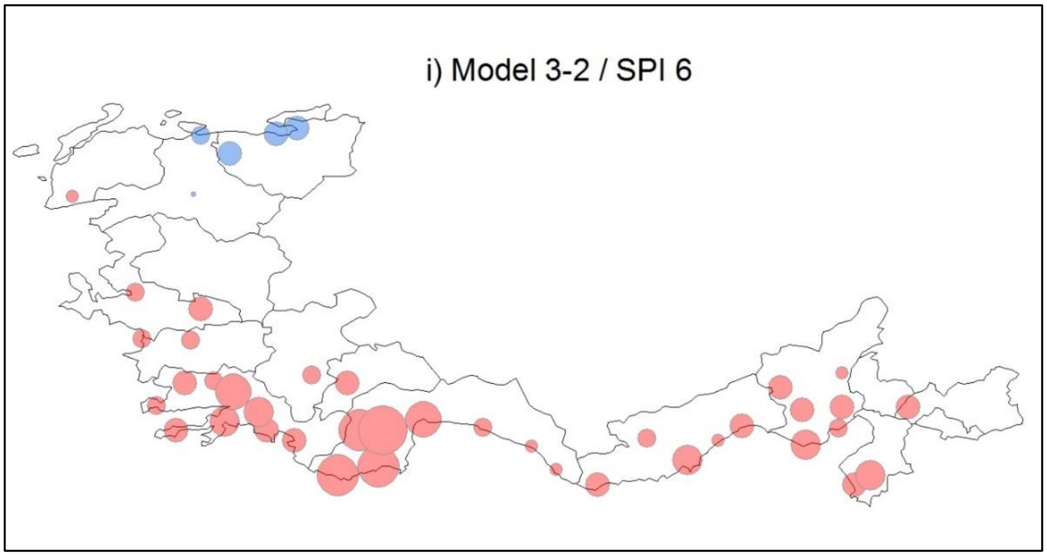


Figure 20. (cont'd)



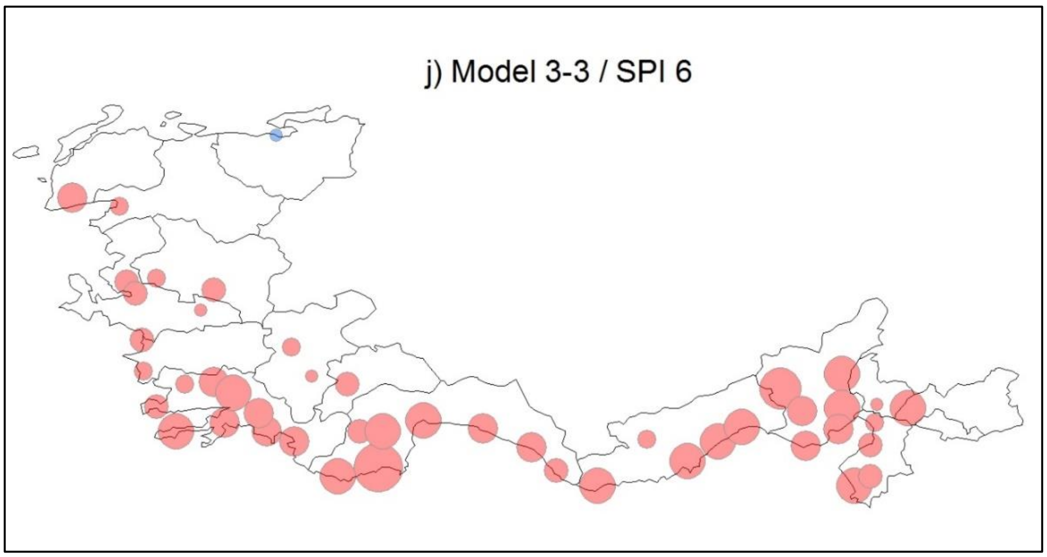


Figure 20. (cont'd)

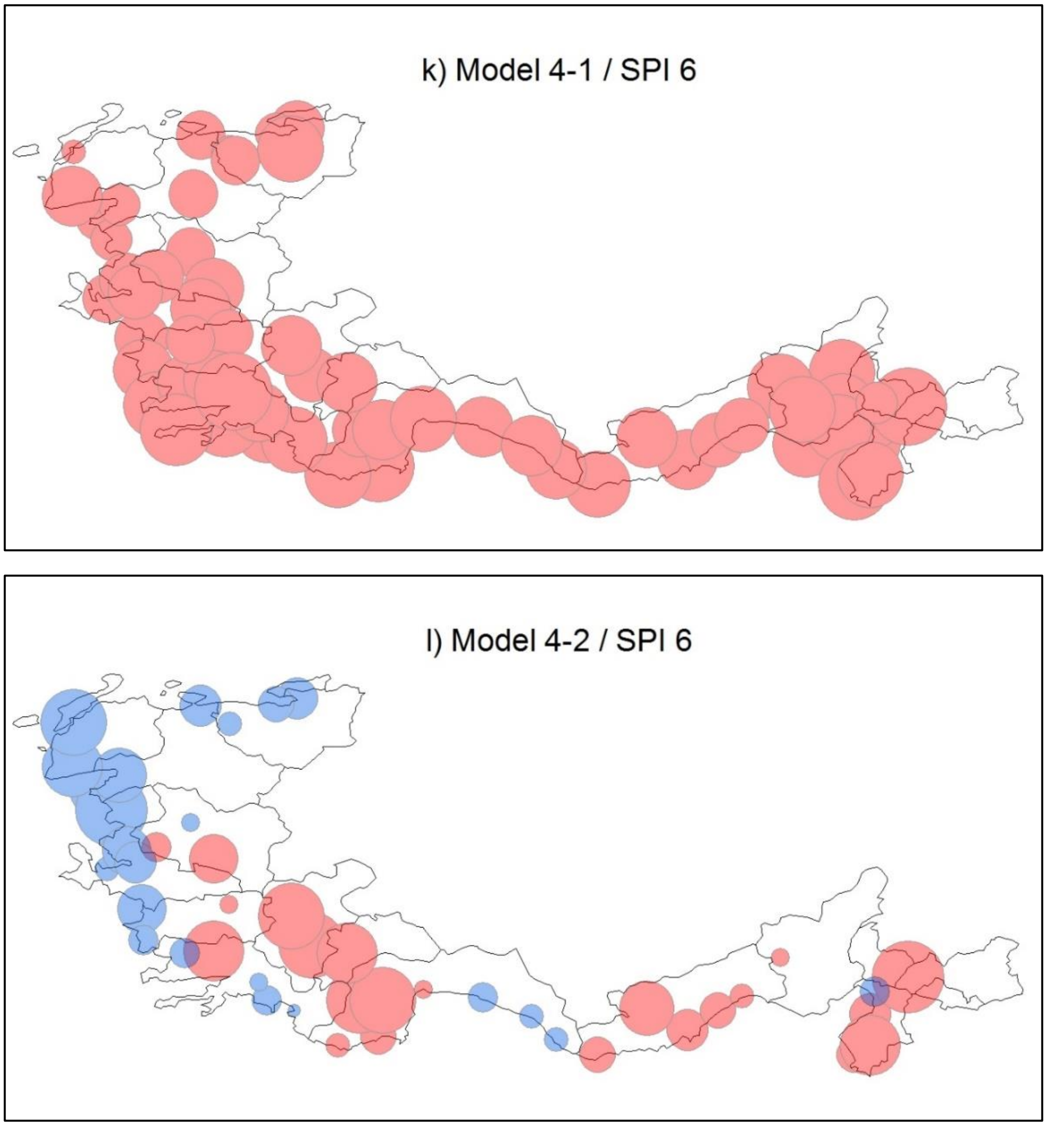


Figure 20. (cont'd)

3.4.4. SPI 9

Though the trend result maps for SPI 9 resembles SPI 6 result maps, there are some locations which slope direction changed at this timescale (Figures 20 and 21).

There are seven new locations in which a significant trend was detected for SPI 9 according to model 1-2 (Figure 21b). All of them are from northern part of study area -from Bursa, Balıkesir and Çanakkale provinces. One location from Bursa is likely to live wetter conditions at this timescale whereas the rest are drier. The rest of the trend result maps for SPI 9 did not change a lot from SPI 6 compared to model 1-1 and 1-2 (Figures 20a, 20b, 21a and 21b). Still, the sharpening slopes should be noticed for these models.

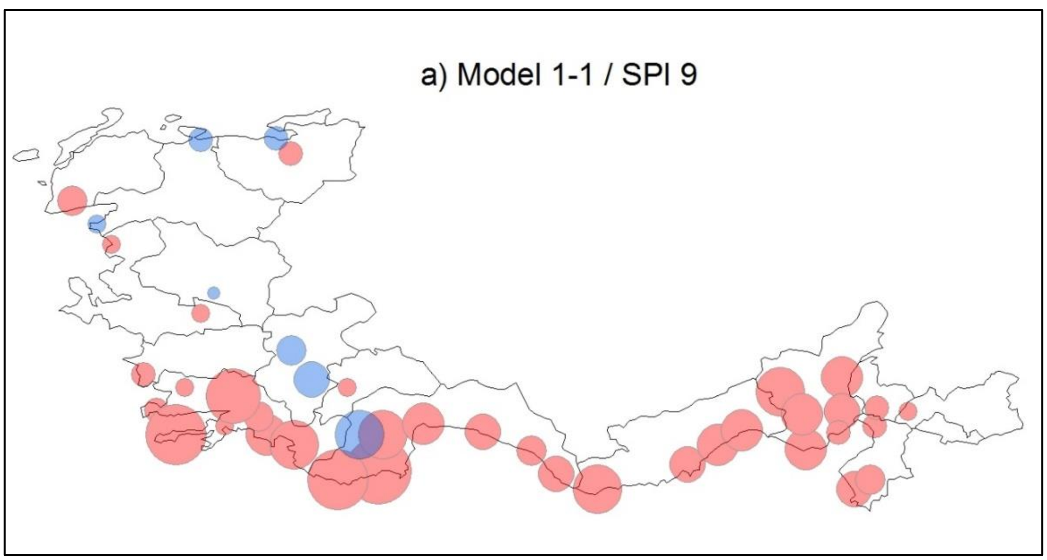


Figure 21. The geographical distribution of trends for SPI 9

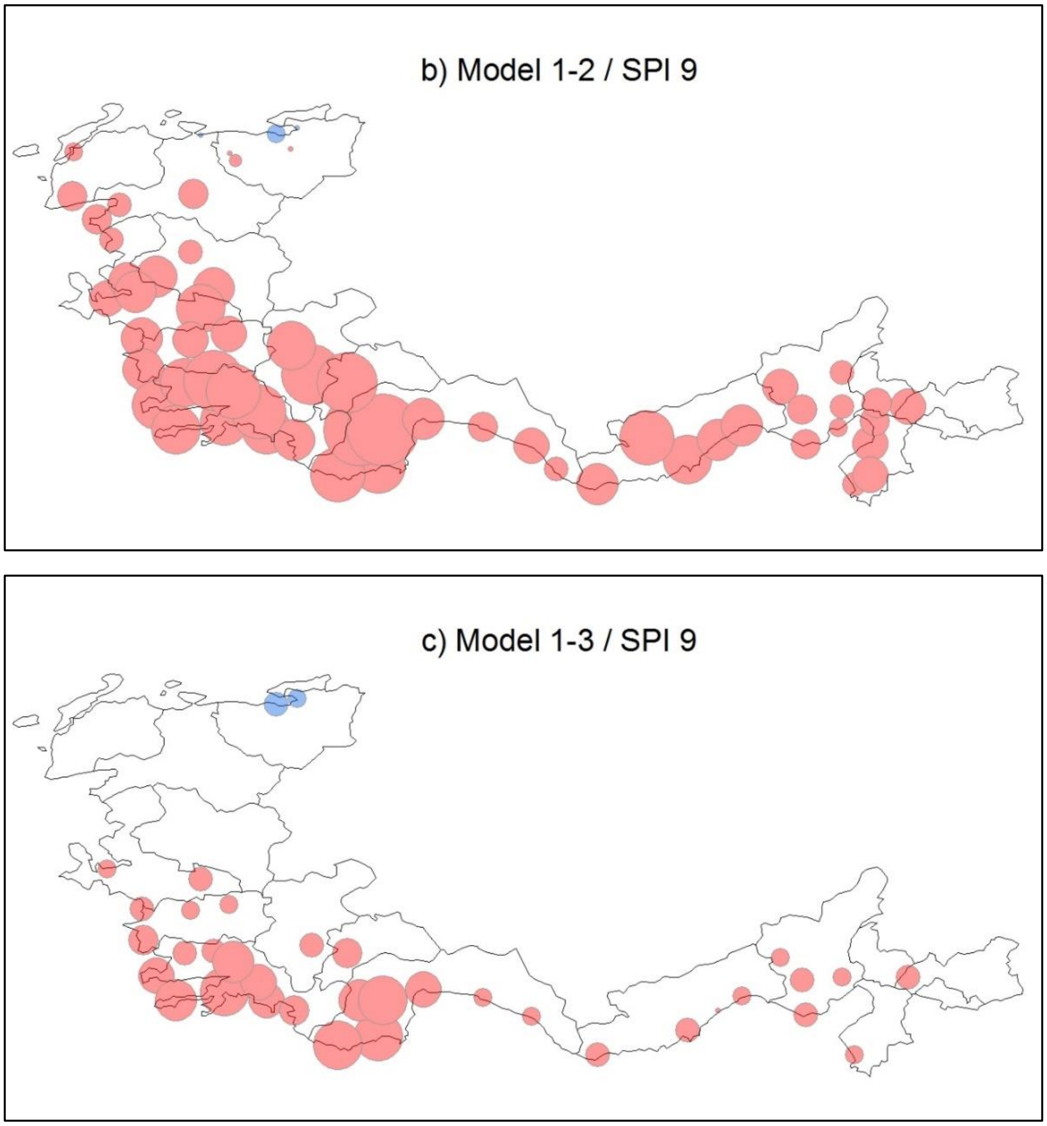
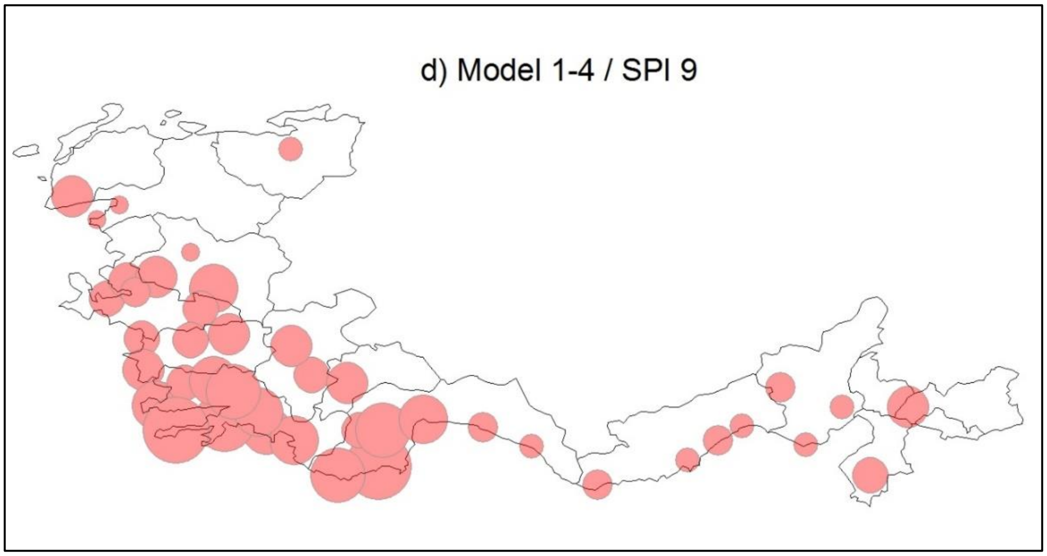


Figure 21. (cont'd)



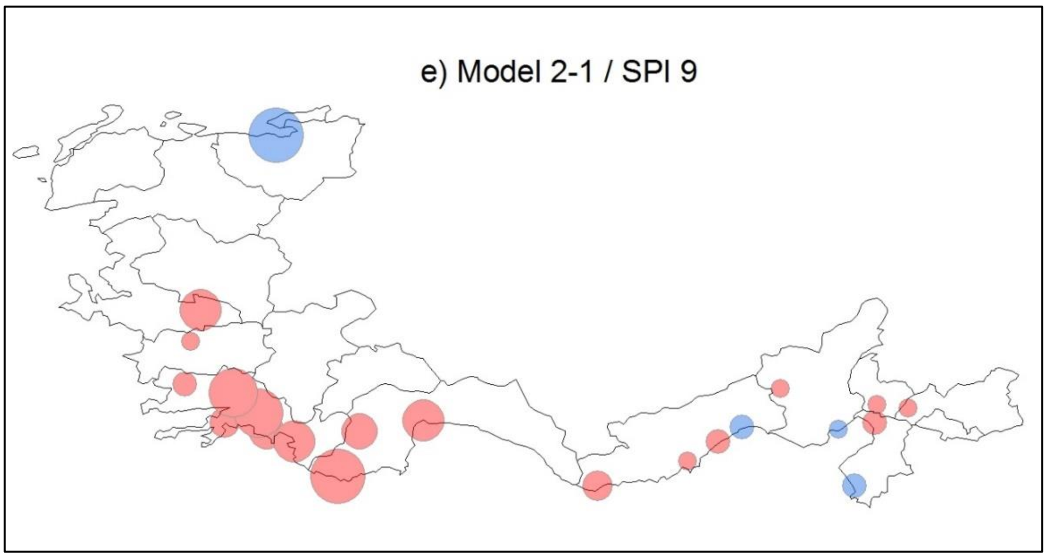
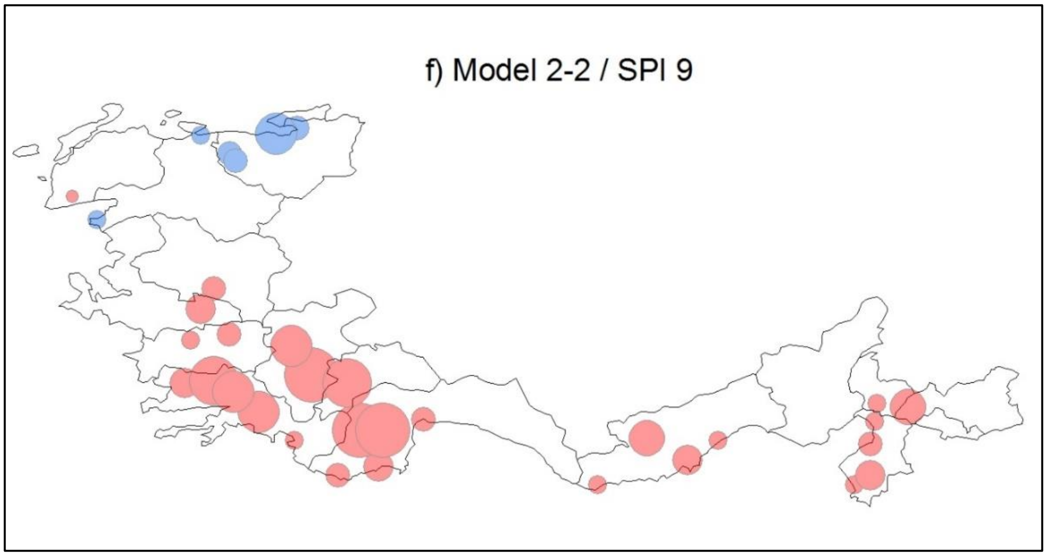


Figure 21. (cont'd)



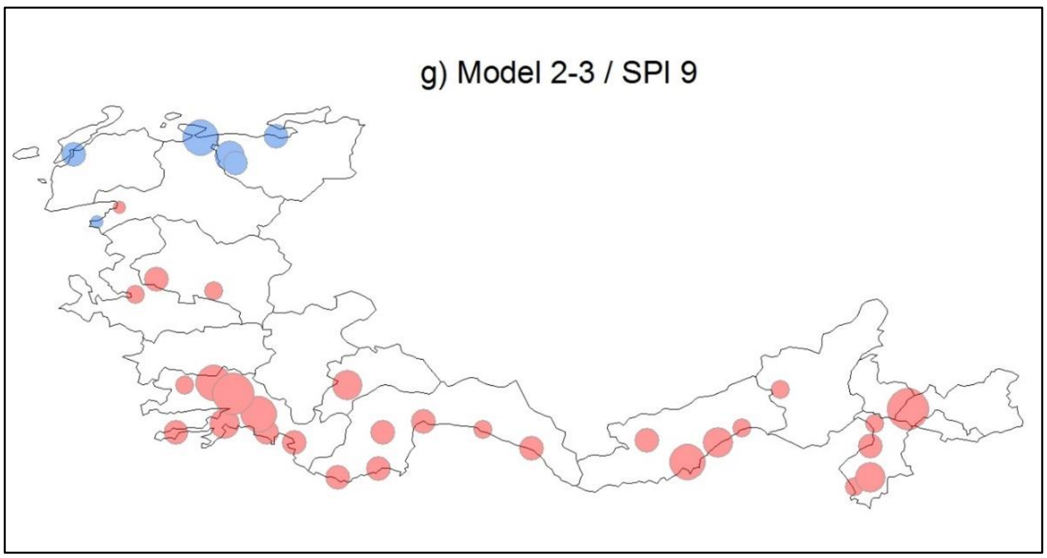


Figure 21. (cont'd)

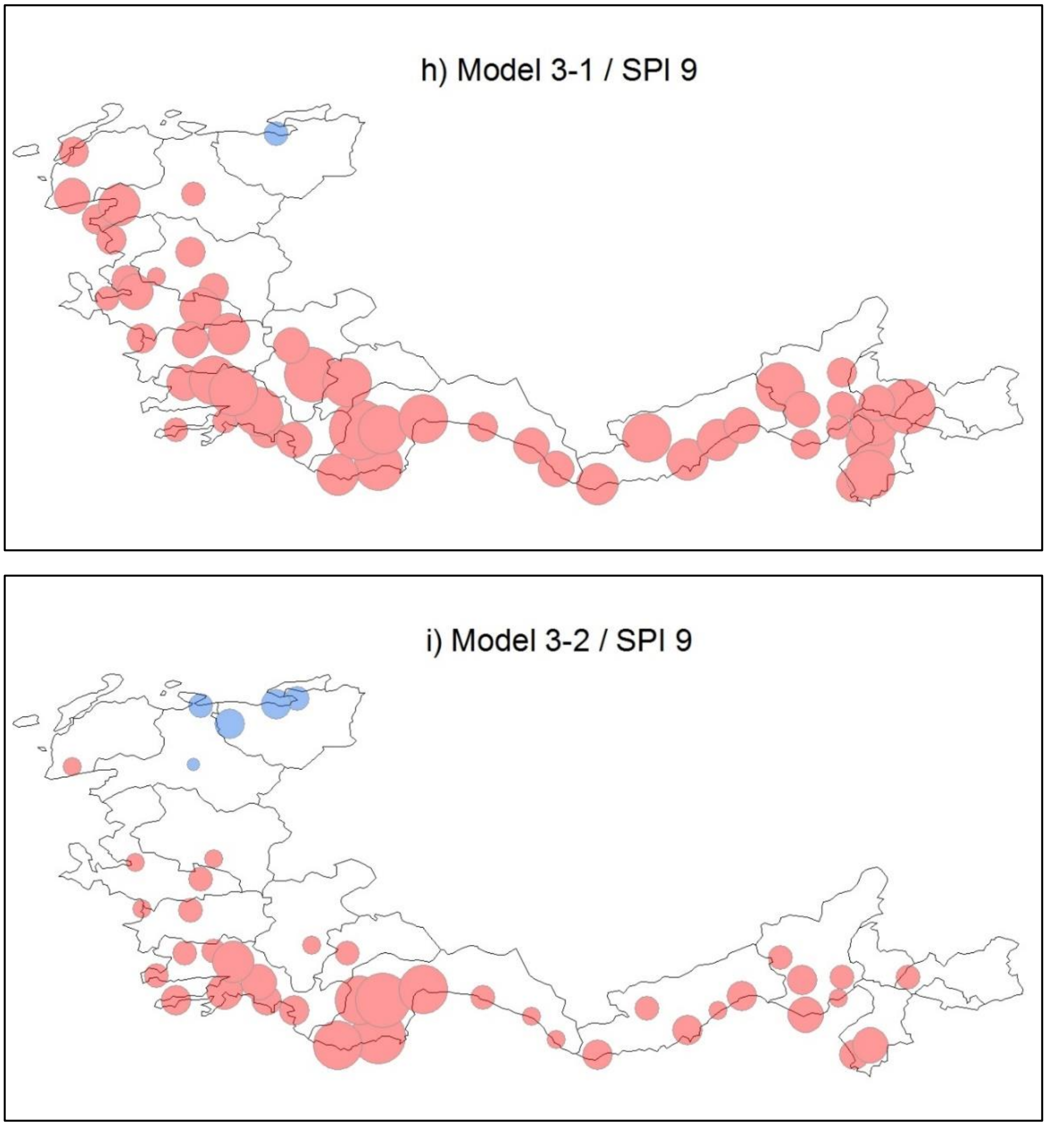


Figure 21. (cont'd)

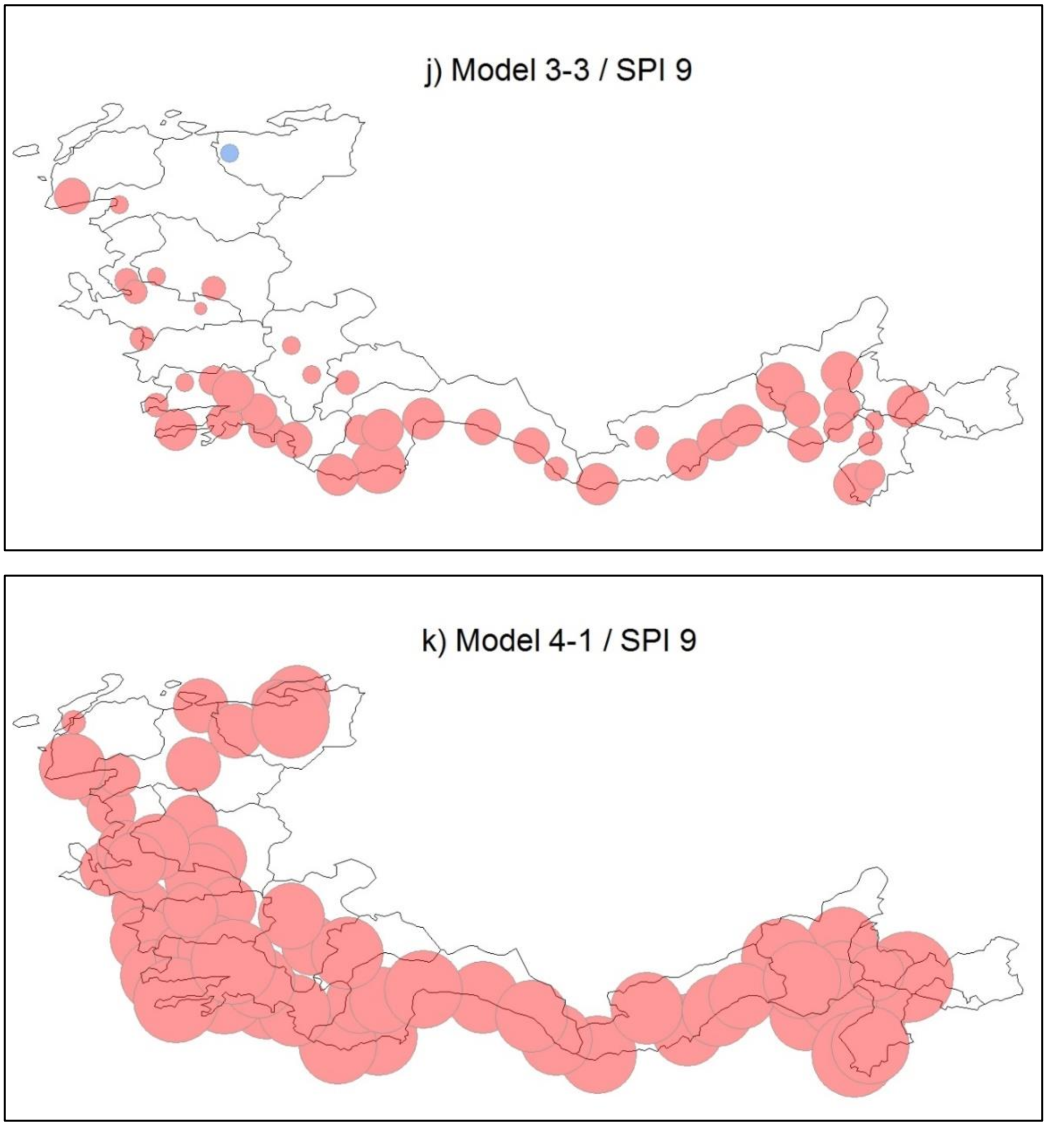


Figure 21. (cont'd)

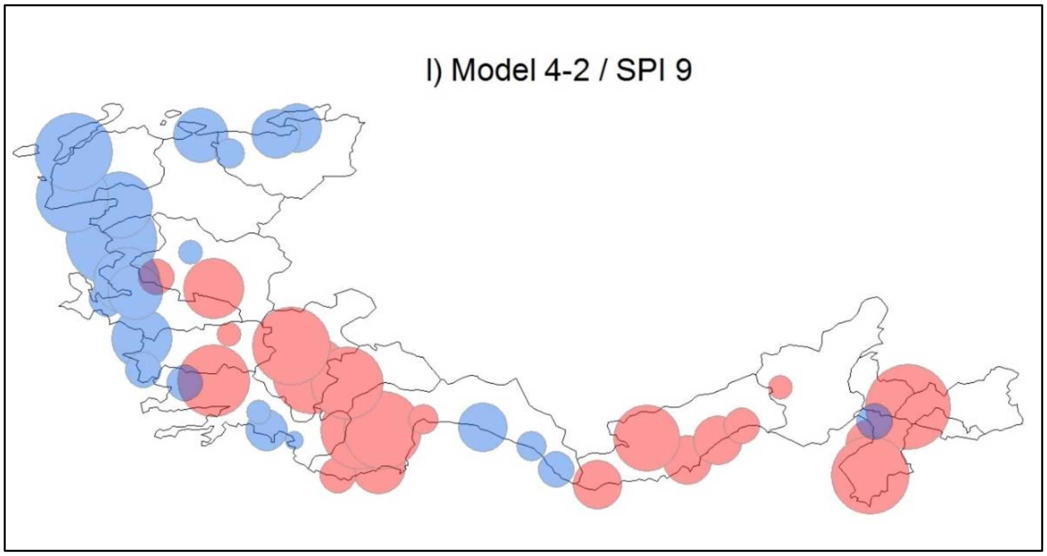


Figure 21. (cont’d)

3.4.5. SPI 12

Evaluating trends in SPI 12 values is important since dryness for 12 months indicate a serious tendency to hydrological drought. The geographical distribution of regions which expected drier and wetter conditions aggregated for SPI 12 is same with SPI 9, SPI 6 and even SPI 3 (from Figure 19 to 22). Muğla and western Antalya is still the most vulnerable region to drought increase whereas northern part of study area (southern Marmara) is likely to live wetter conditions (Figure 22). However, trends for different timescales are not persistent at some locations. Four locations from Bursa and Çanakkale provinces which signaled a significant trend at negative slope for SPI 9 disappeared at 12-monthly timescale according to model 1-2 (Figures 21b and 22b).

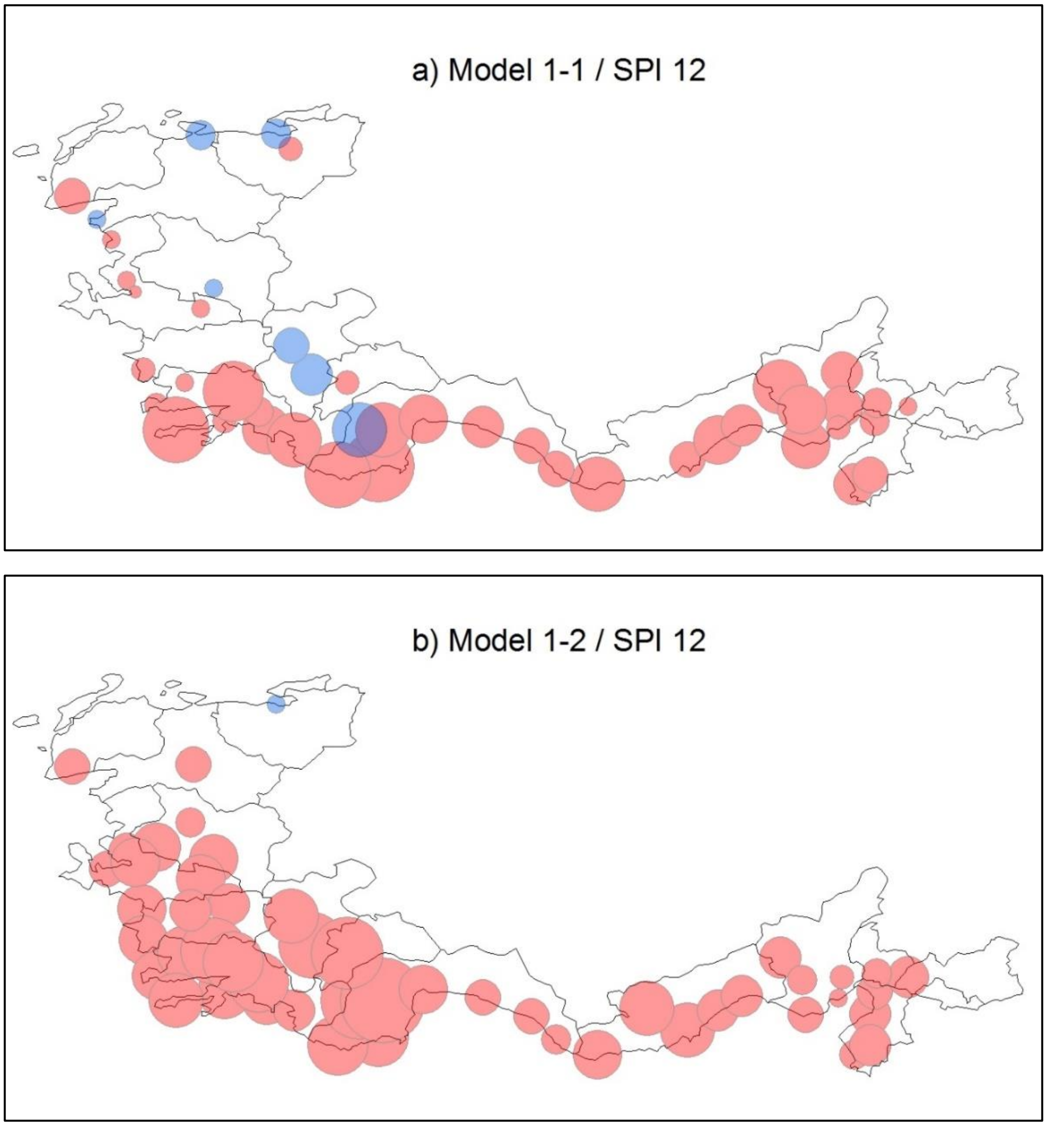
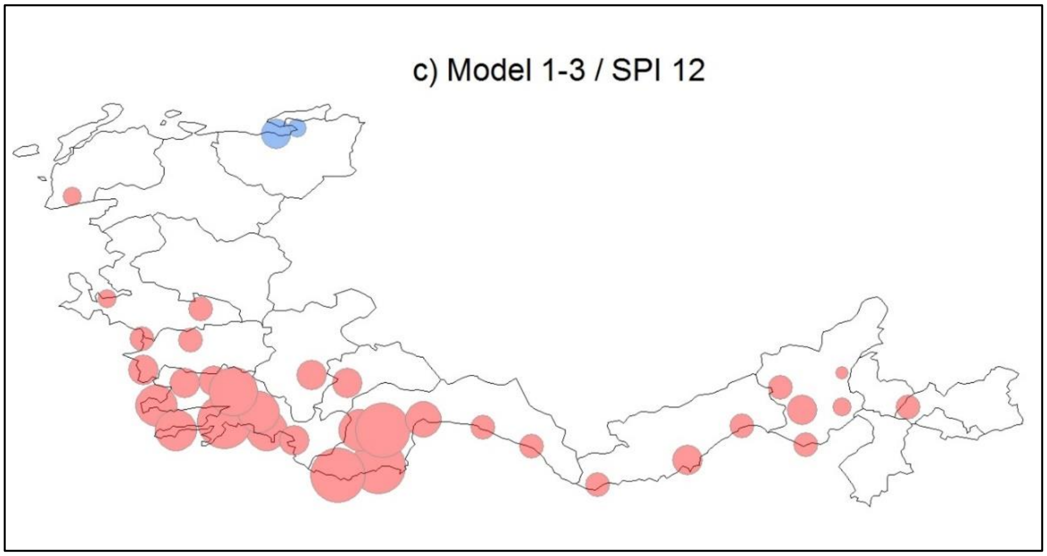


Figure 22. The geographical distribution of trends for SPI 12



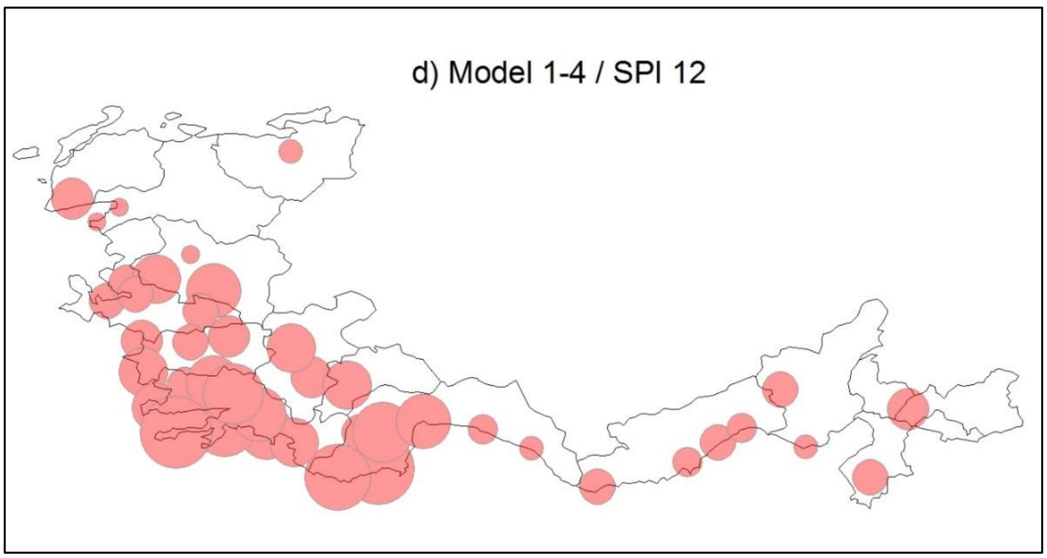
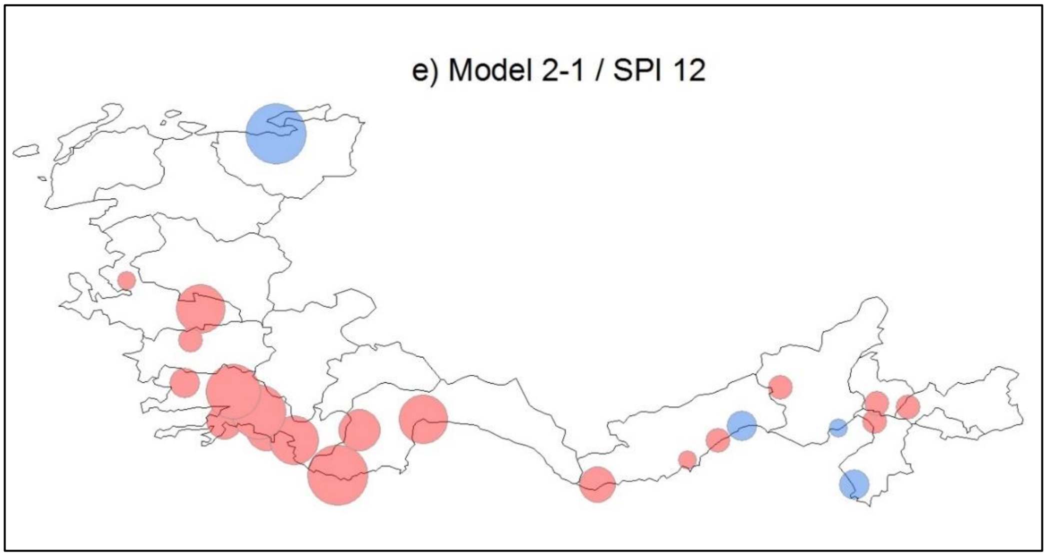


Figure 22. (cont’d)



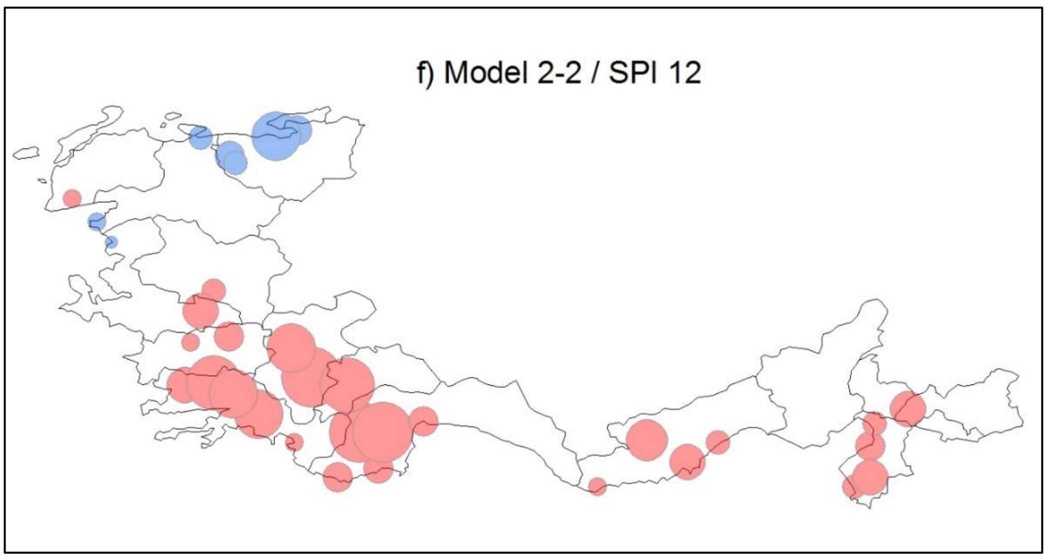


Figure 22. (cont'd)

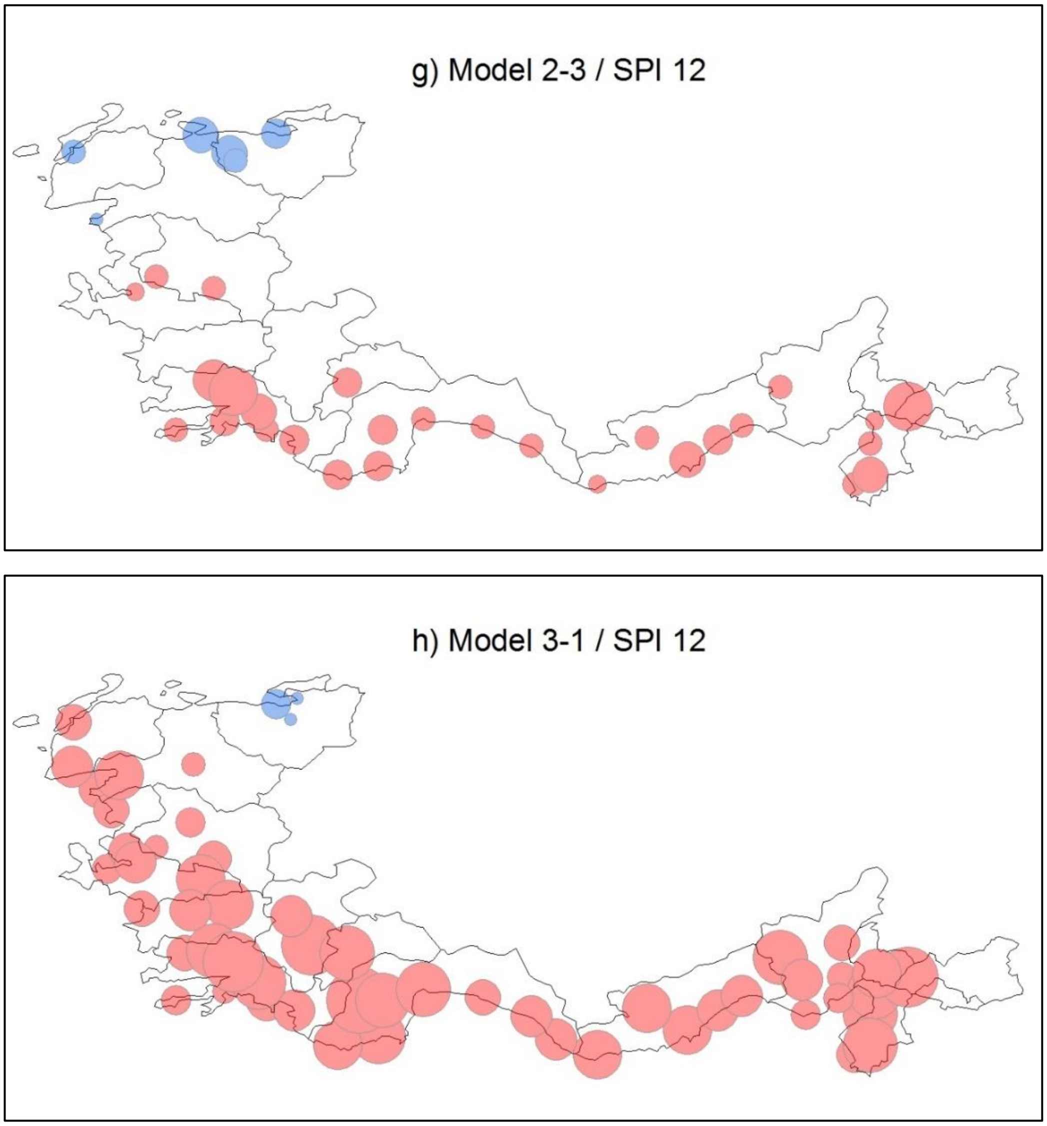
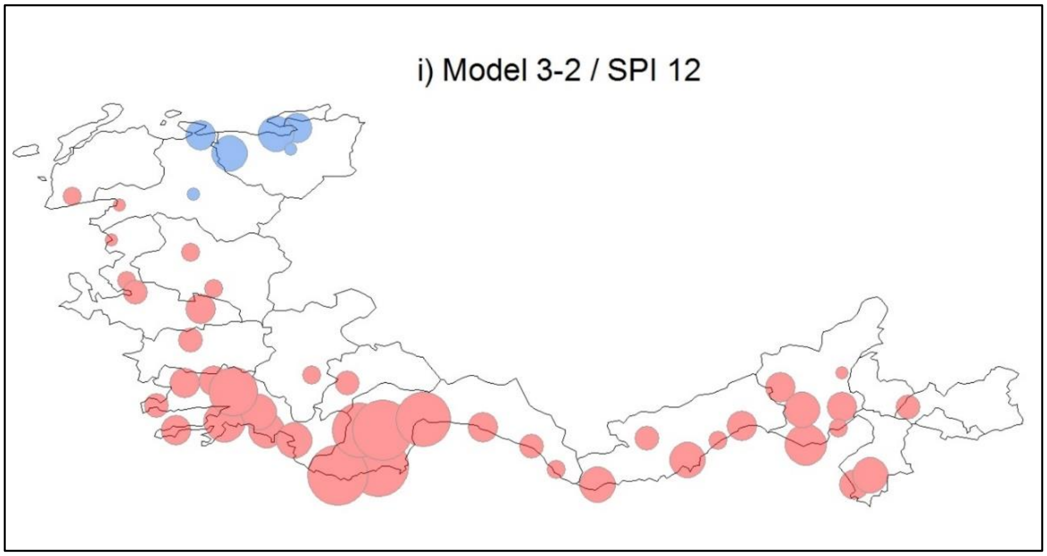


Figure 22. (cont’d)



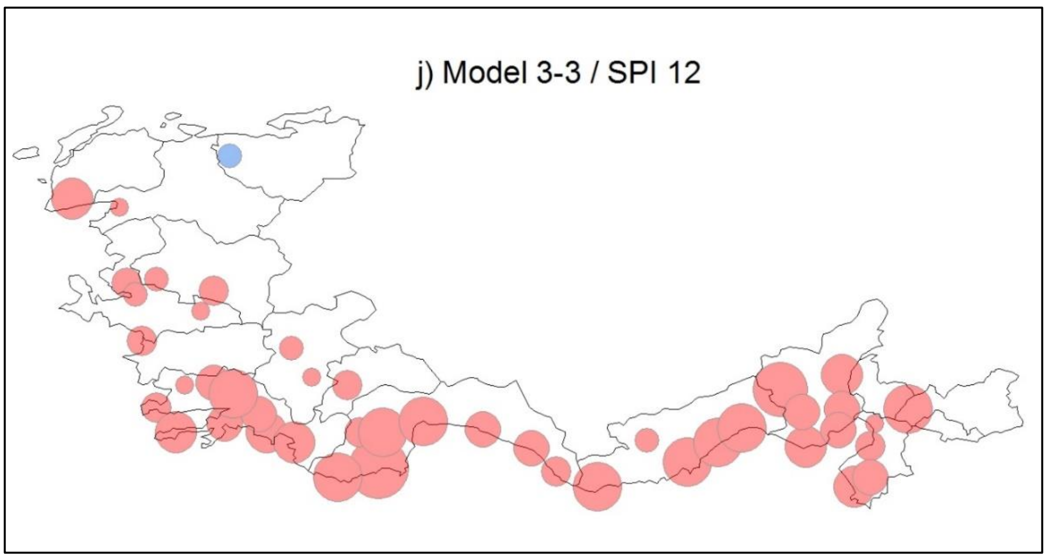


Figure 22. (cont'd)

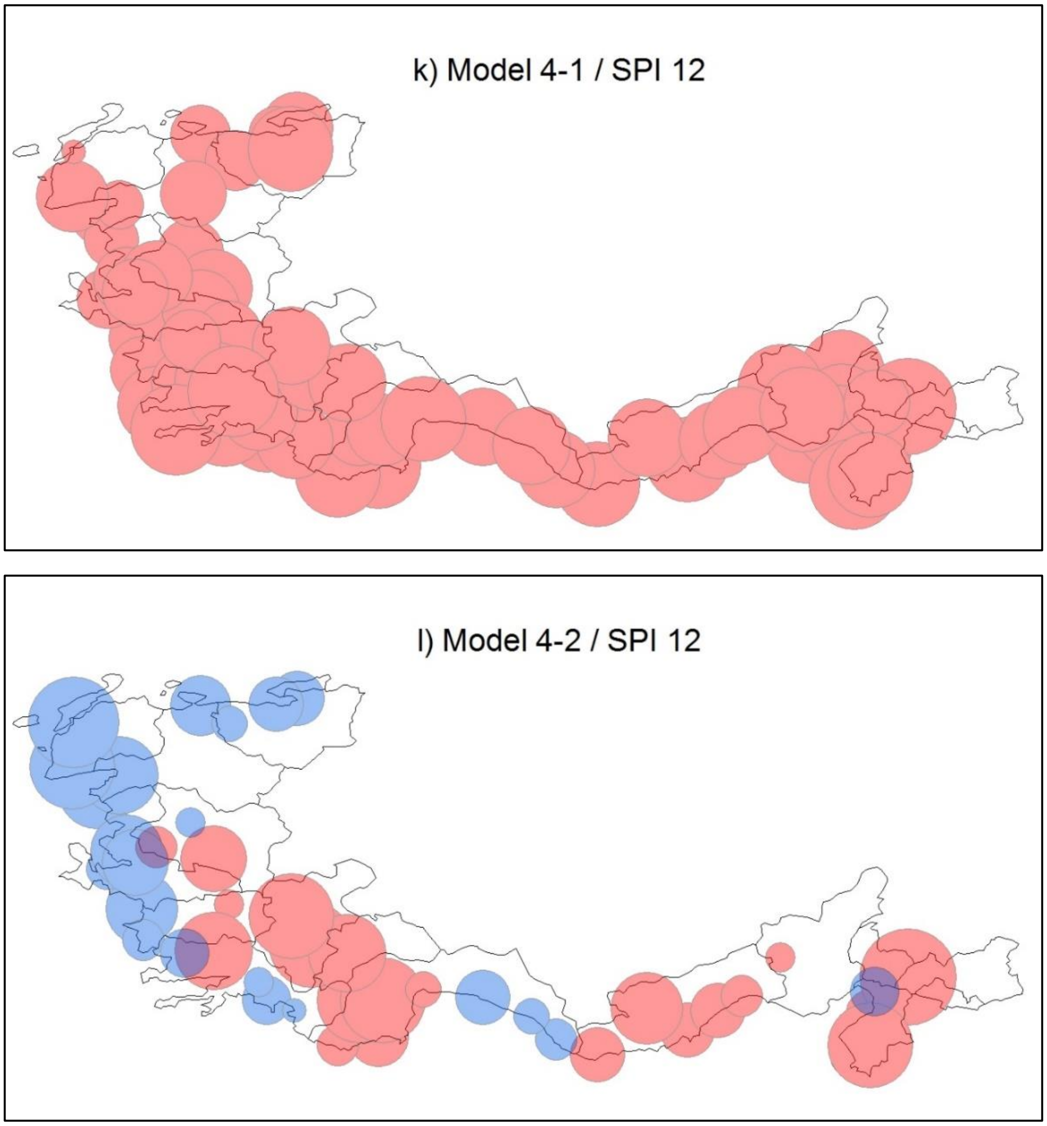


Figure 22. (cont’d)

İzmir should be separately discussed in terms of continuity of trends for proceeding timescales. Models 1-1 and 3-2 predicted negative slope at fewer locations from İzmir for SPI 12 than SPI 9 and model 2-1 vice versa (Figures 21a, 21i, 21e, 22a, 22i and 22e). This fact indicated a discrepancy between models for certain locations.

3.4.6. Annual Precipitation

Detecting trends in annual precipitation is another part of this study. Relations between drought and rainfall amount can be examined owing to this analysis. In this part, the geographical distribution of annual rainfall trends was discussed with trends in SPI.

Model 1-1 (Figure 23a) predicted a decrease in annual rainfall for the locations which are sensitive to drought increases according to SPI trends. Muğla and western Antalya is the most sensitive region while a decreasing trend is valid along with whole Mediterranean coast. However, neither rainfall decrease accompanied drought increase at every location nor rainfall increase accompanied drought decrease at every location (Figures 22a and 23a). Model 1-2 is like to model 1-1 in terms of drought and rainfall trend consistency (Figures 22b and 23b). Nonetheless, annual rainfall decrease expectations is more common according to model 1-2 projection. Not only Mediterranean coast but also Aegean region is likely to receive less annual precipitation.

Model 1-3 (Figure 23c) predicted annual rainfall decrease for a smaller area than most of the models predicted. Muğla and western Antalya is the region which drought increases almost followed rainfall decreases. The locations which are most likely to receive less annual rainfall according to model 1-4 is same with rest of the models (Figure 23). On the other hand, the vulnerable locations across entire study area like model 1-2 (Figures 23b and 23d).

The parts of the study area which signaled trends in annual rainfall are almost same for models 2-1, 2-2 and 2-3 which are forced by CNRM-CERFACS-CNRM-CM5 GCM (Figures 23e, 23f and 23g). These models predicted rainfall increase for at least one location from Bursa province. In addition to this, few locations from Balıkesir and Çanakkale are likely to receive more annual rainfall according to model 2-3 (Figure 23g). Model 3-1 predicted decrease in annual rainfall across the entire study area like model 1-2, 1-4 and 4-1 (Figure 23). Model 1-2 is forced by same RCM (CCLM4-8-17) with model 3-1 while models 1-4 and 4-1 are forced by RCA4 RCM. Mediterranean coast is likely to receive less annual precipitation rather than Aegean coast according to models 3-2 and 3-3 (Figures 23i and 23j). Additionally, drought increase accompanied precipitation decrease in most of the locations for model predictions discussed in this paragraph.

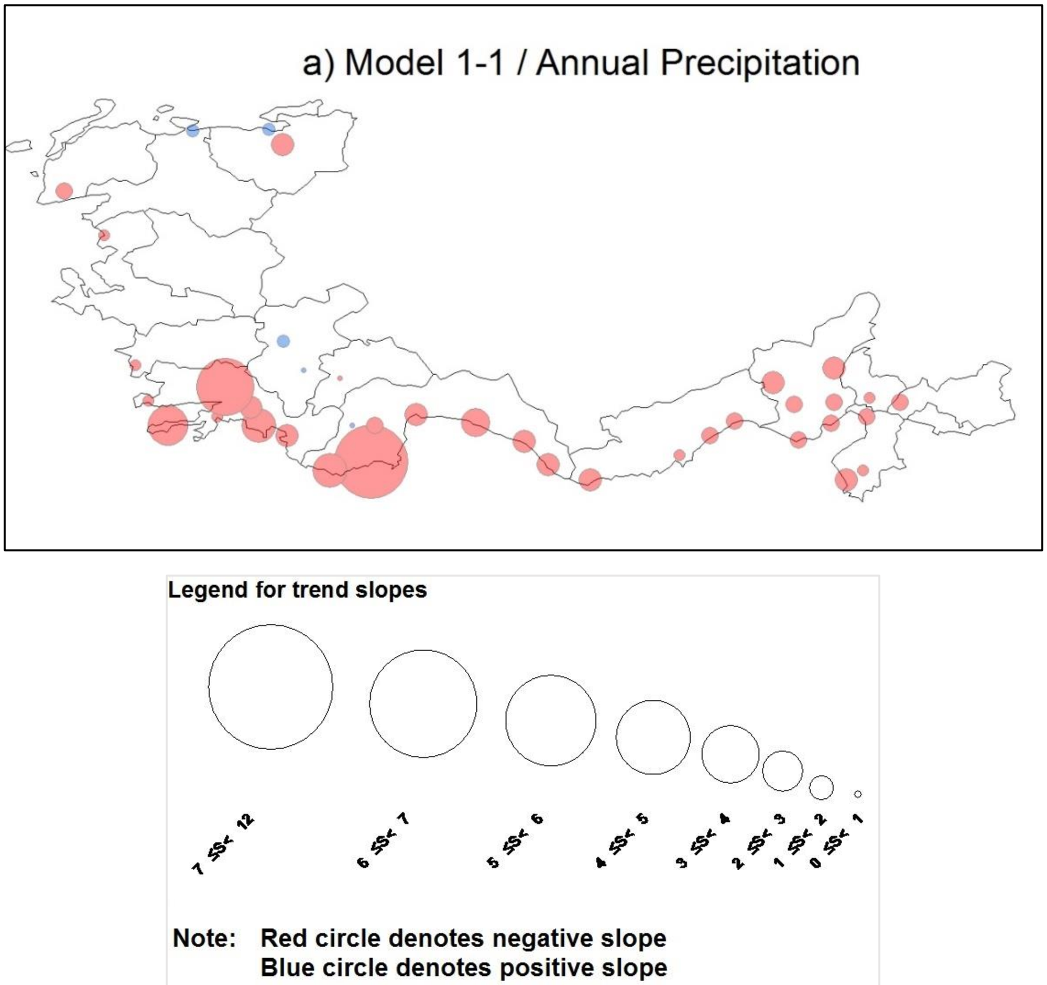


Figure 23. The geographical distribution of trends for annual rainfall

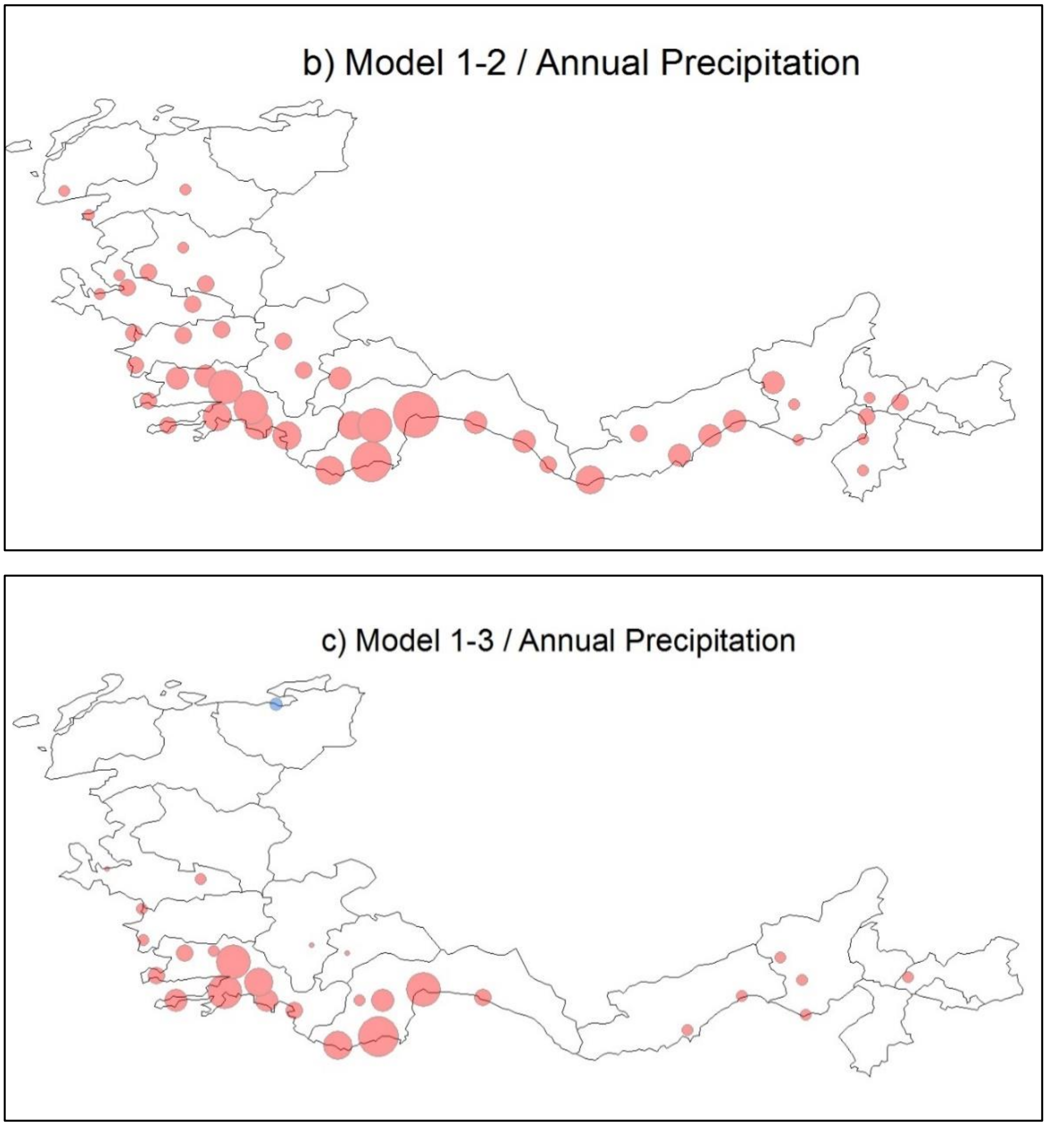
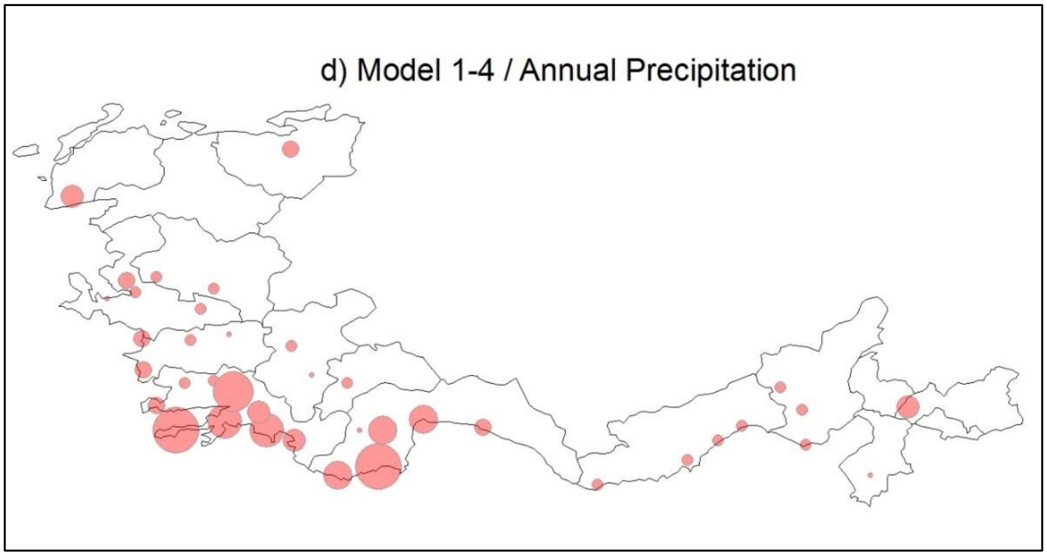


Figure 23. (cont'd)



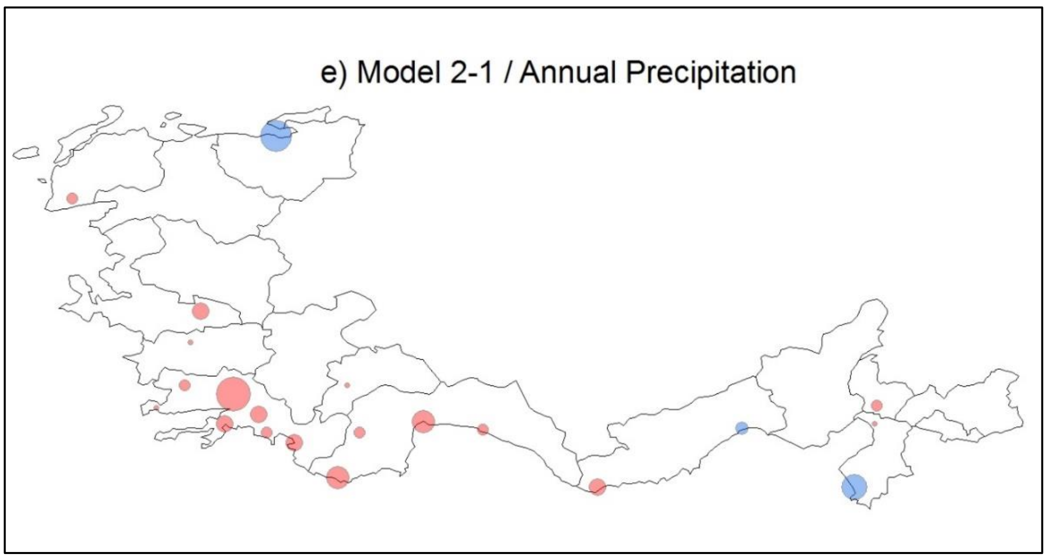
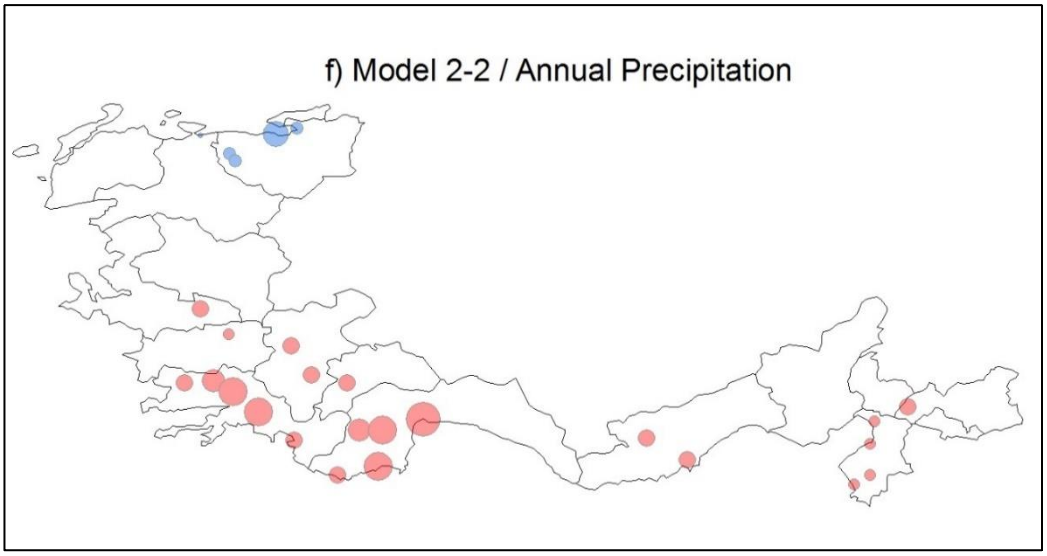


Figure 23. (cont'd)



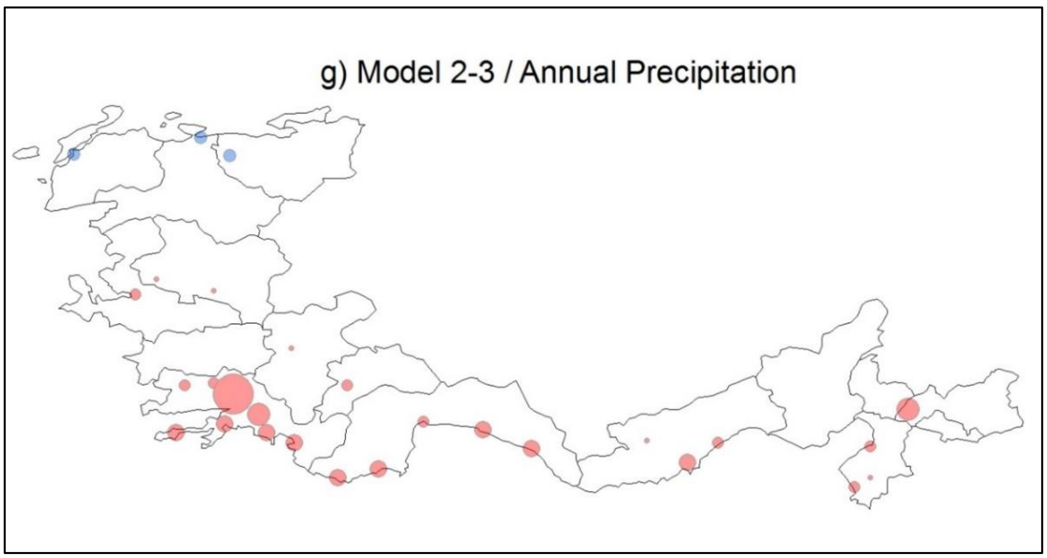
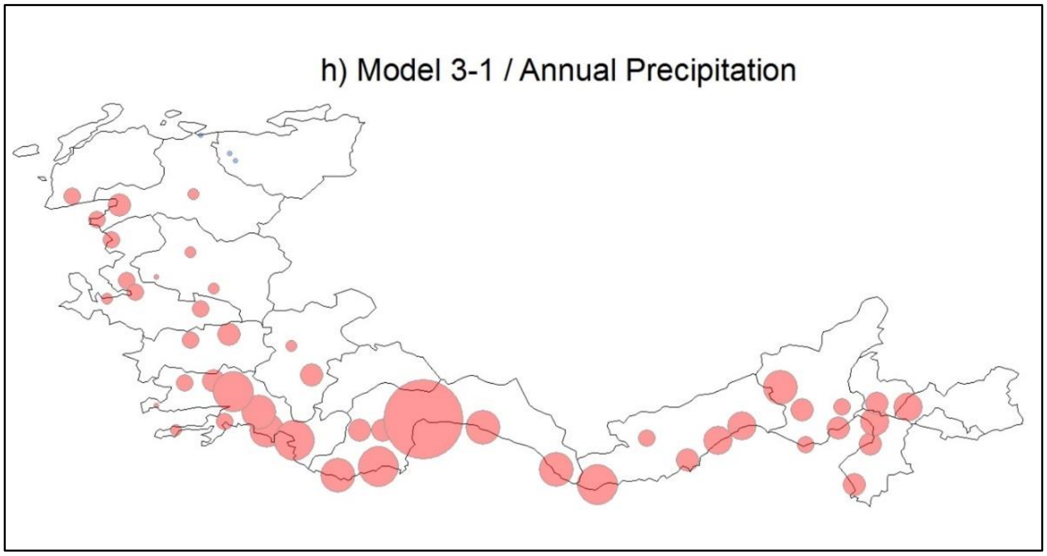
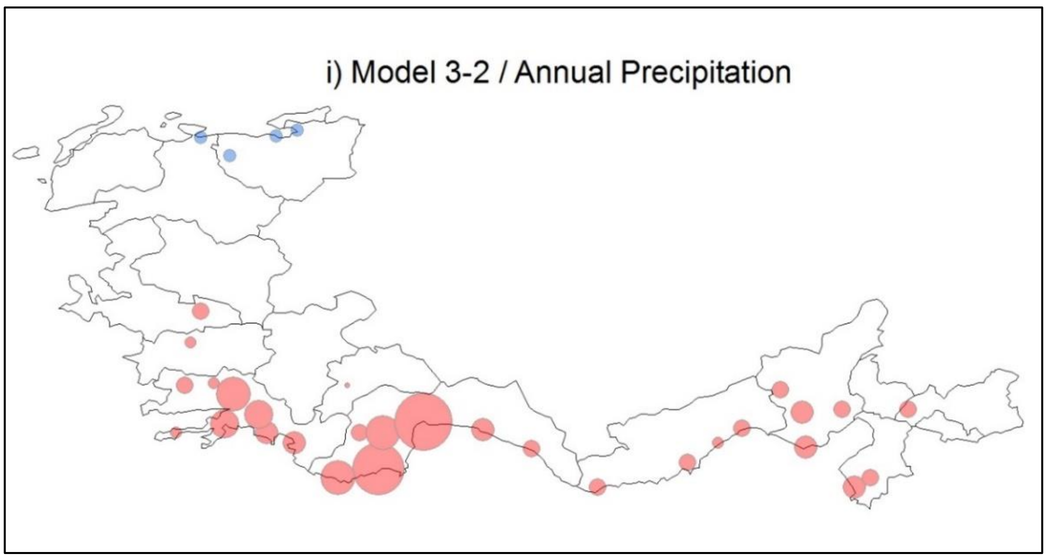


Figure 23. (cont’d)





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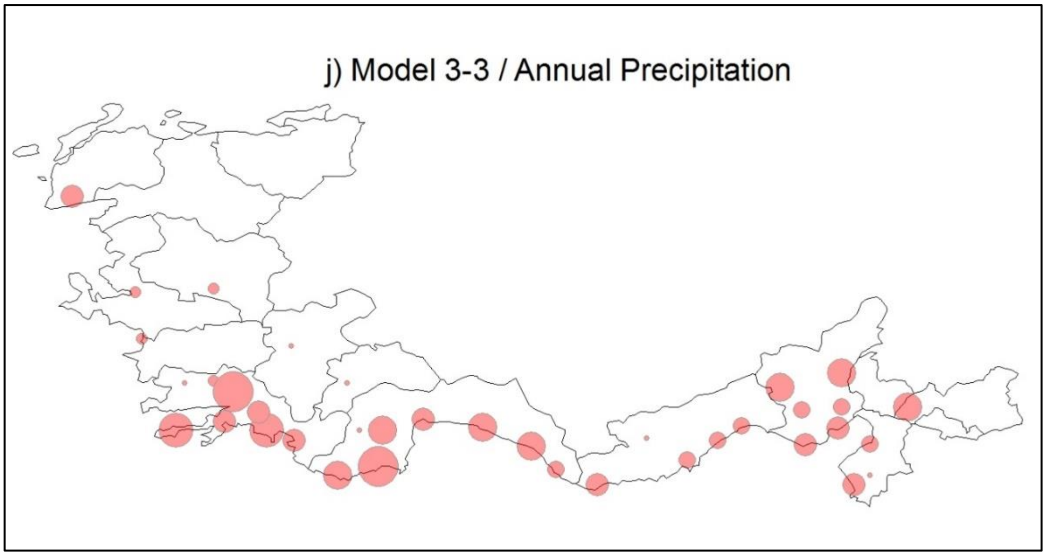

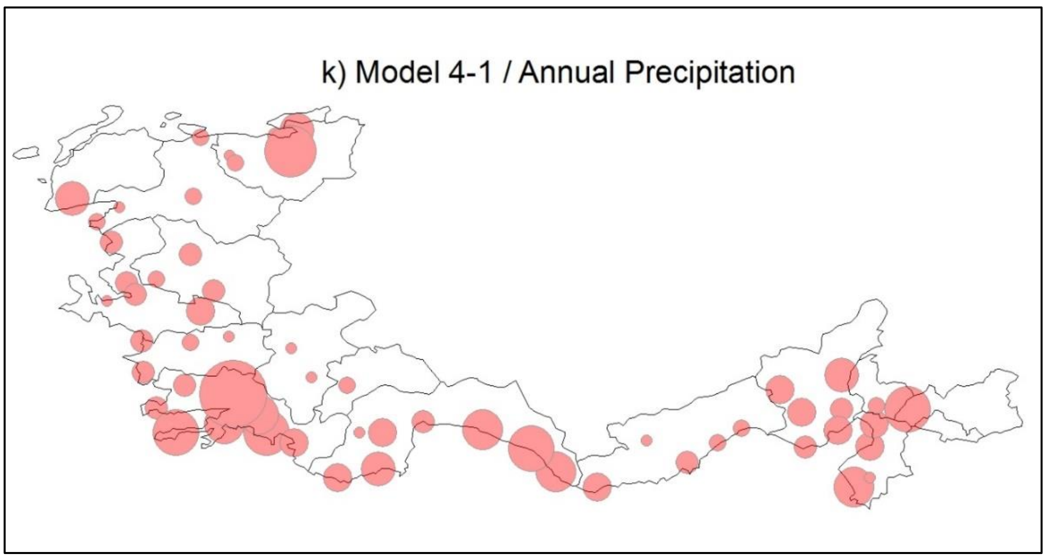

Figure 23. (cont'd)

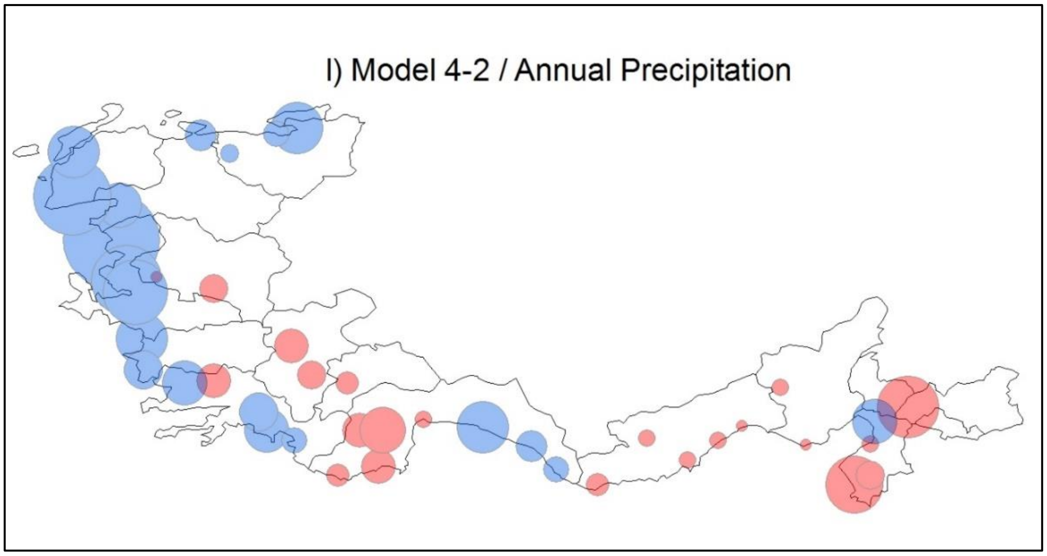

Figure 23. (cont'd)

Model 4-1 predicted rainfall decrease for almost all locations like its predictions on drought trends (Figure 23k). Model 4-2 (Figure 23l) diverged from rest of the models considering its projections which signaled rainfall increase almost entire Aegean coast and some other parts like eastern Antalya.

3.5. Changes in the Frequency of Drought Between the Mid and End of the Century

Changes in intensity of drought were analyzed and mapped in this step of the study. The projection period is divided into two periods: 1972-2050 and 2051-2100. Then, the frequency of occurrence of three drought severity class (moderate, severe and extreme) depending on SPI values was calculated through divided periods for 3 and 12 monthly scales. The proportion of frequencies was obtained at the final step as shown in Eq. 17:

$$r = \frac{\frac{o_2}{n_2}}{\frac{o_1}{n_1}} \qquad (17)$$

where, r is the ratio of frequencies for each drought severity class, o_1 is number of occurrences for a severity class within 1972-2050 period, o_2 is the same as within 2051-2100 period, n_1 and n_2 are number of total months within each period.

In the mapping of the ratios, a base map prepared with provincial borders was practiced. Though some provincial borders do not entirely fit to the study area since they extend inner parts of the country, this mismatch was partly eliminated owing to the implied interpolation method: Natural neighbor. This method was firstly introduced by Sibson (1981), and ArcGIS software was used in practice of this study. The limits at legends of the maps were constituted with the highest value of changes, concerning demonstration of the divergence between models. The result maps were presented in Figure 24.

The most significant result of this analysis is the frequency increase in the second half of the century for severe and extreme droughts consistently for almost all models and timescales (Figure 24). To clarify, the drought gets more often as the intensity gets bigger. More frequent droughts are more possible for southern provinces, either.

The geographical distribution of ratios is consistent with trend analysis results. Southern parts of study area are likely to occur more intense drought. Besides, the geographical distribution of the ratios of frequency is quite homogeneous for SPI 3 compared to SPI 12 for all models. The highest ratios aggregate in certain parts of study area (especially southwestern parts) considering changes in drought frequency according to SPI 12 values. For example, the ratio exceeds 62 times for model 1-4 (Figure 24) under extreme drought severity condition considering SPI 12.

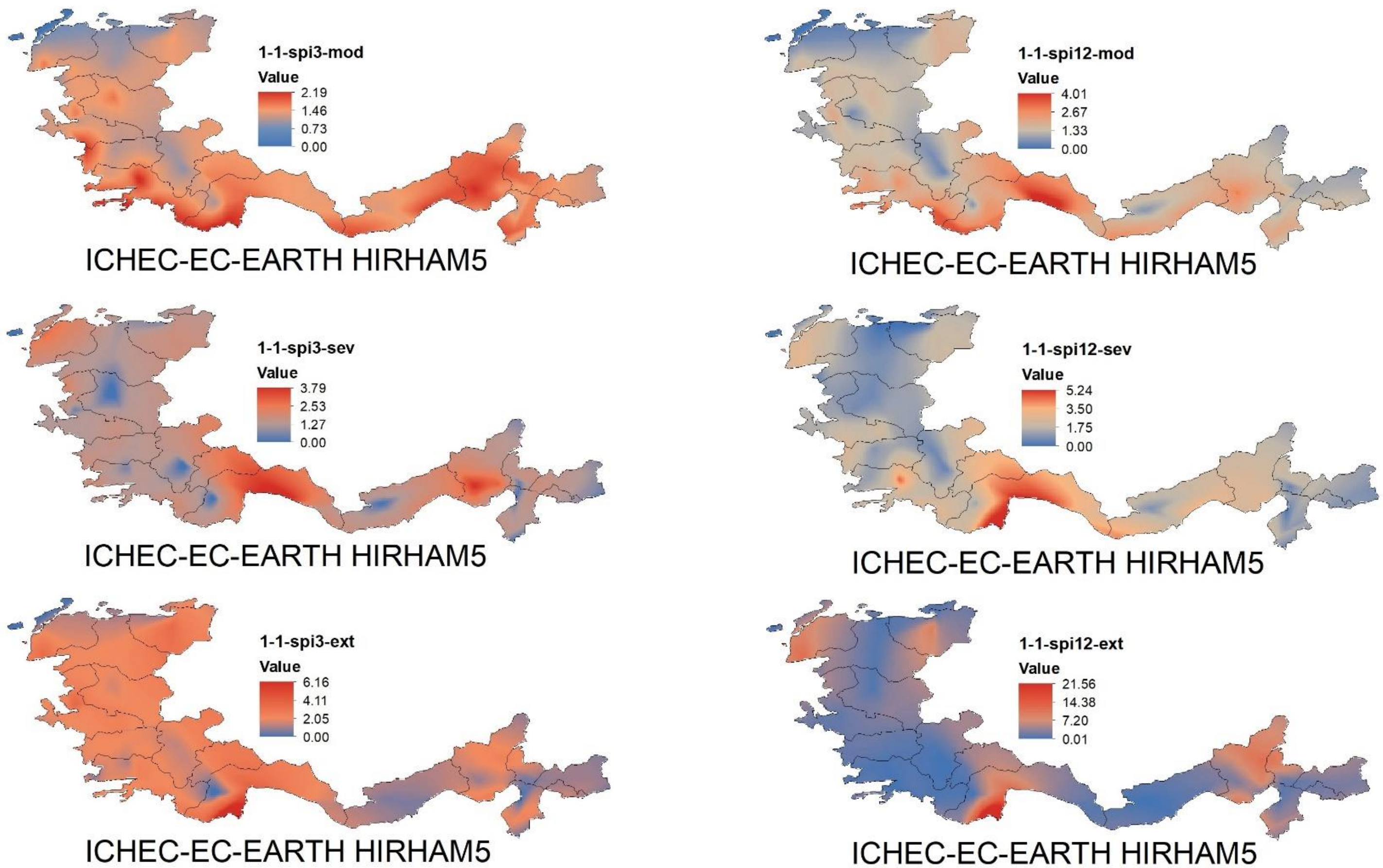

Figure 24. Changes in the frequency of drought. ‘Mod’, ‘sev’ and ‘ext’ indicate moderately, severely and extremely dry classes respectively.

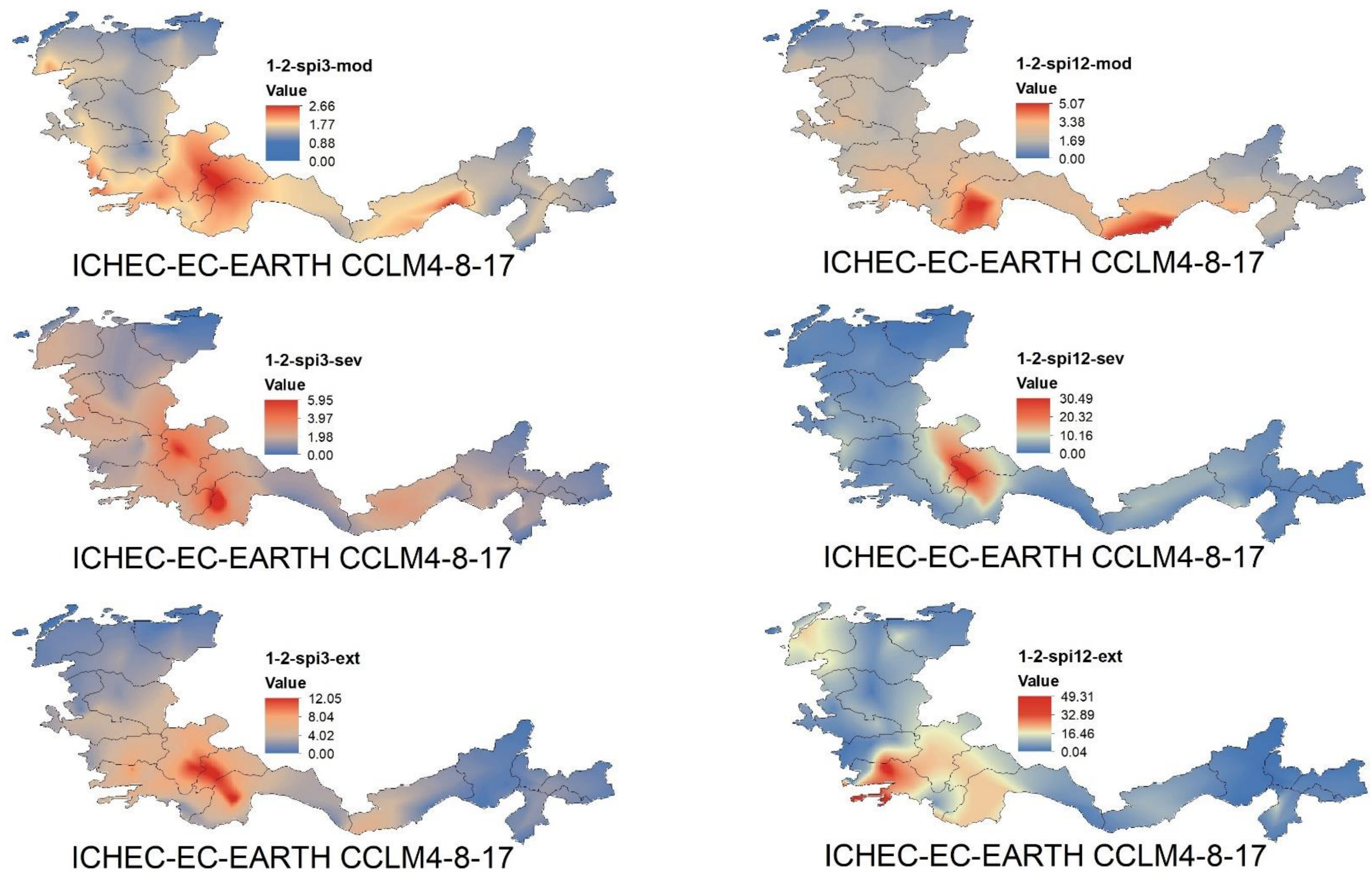

Figure 24. (cont'd)

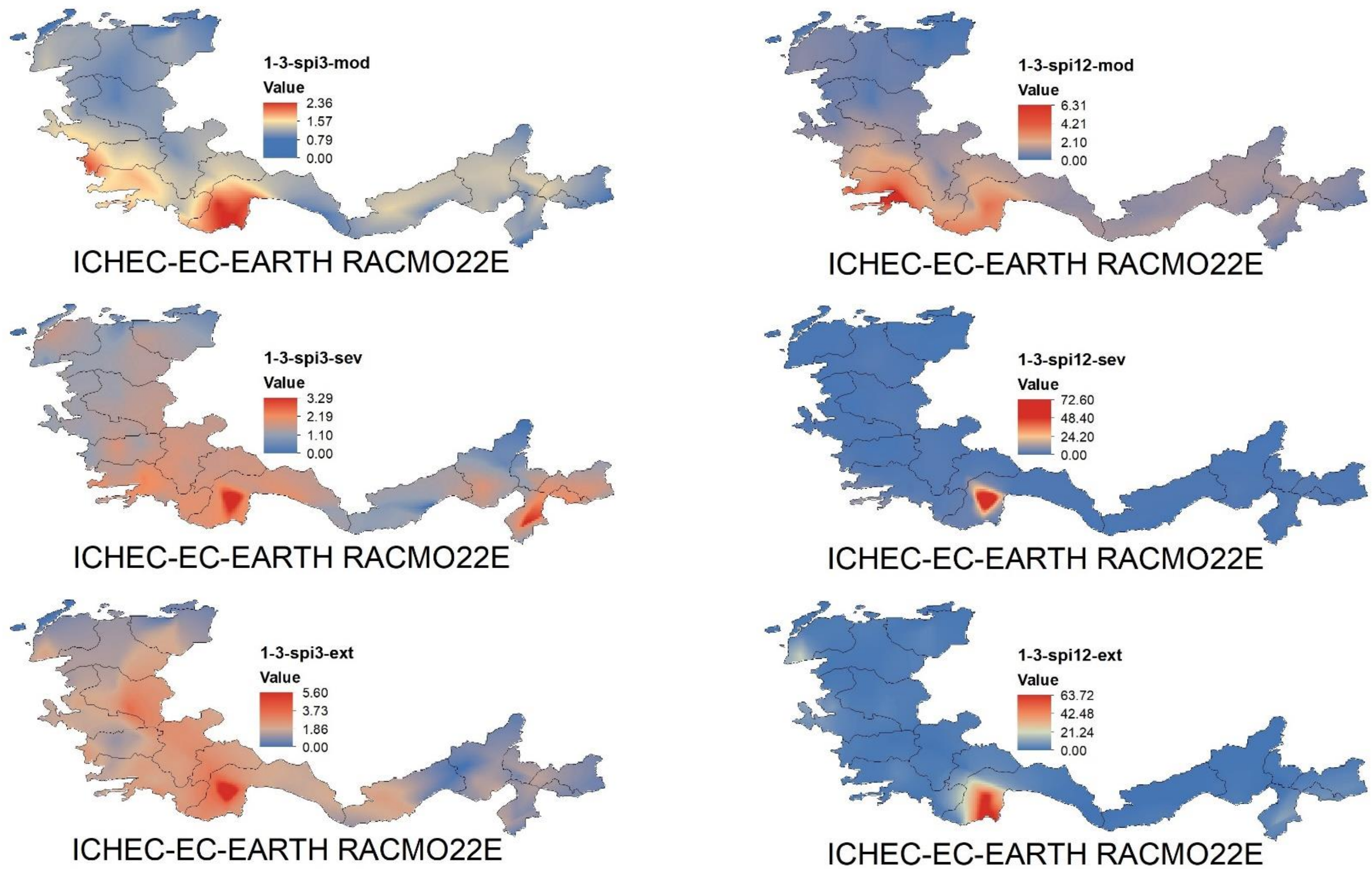

Figure 24. (cont'd)

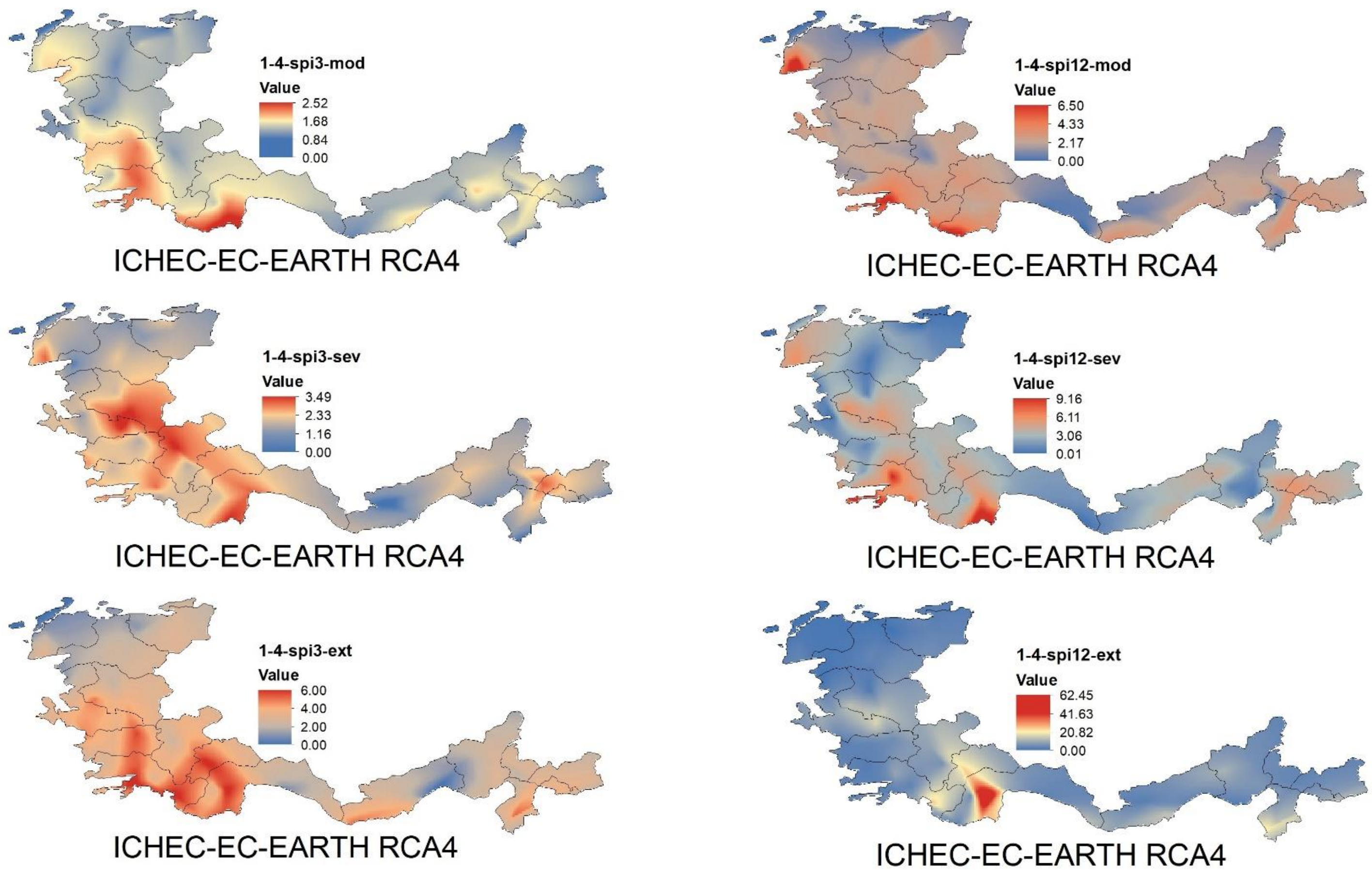

Figure 24. (cont'd)

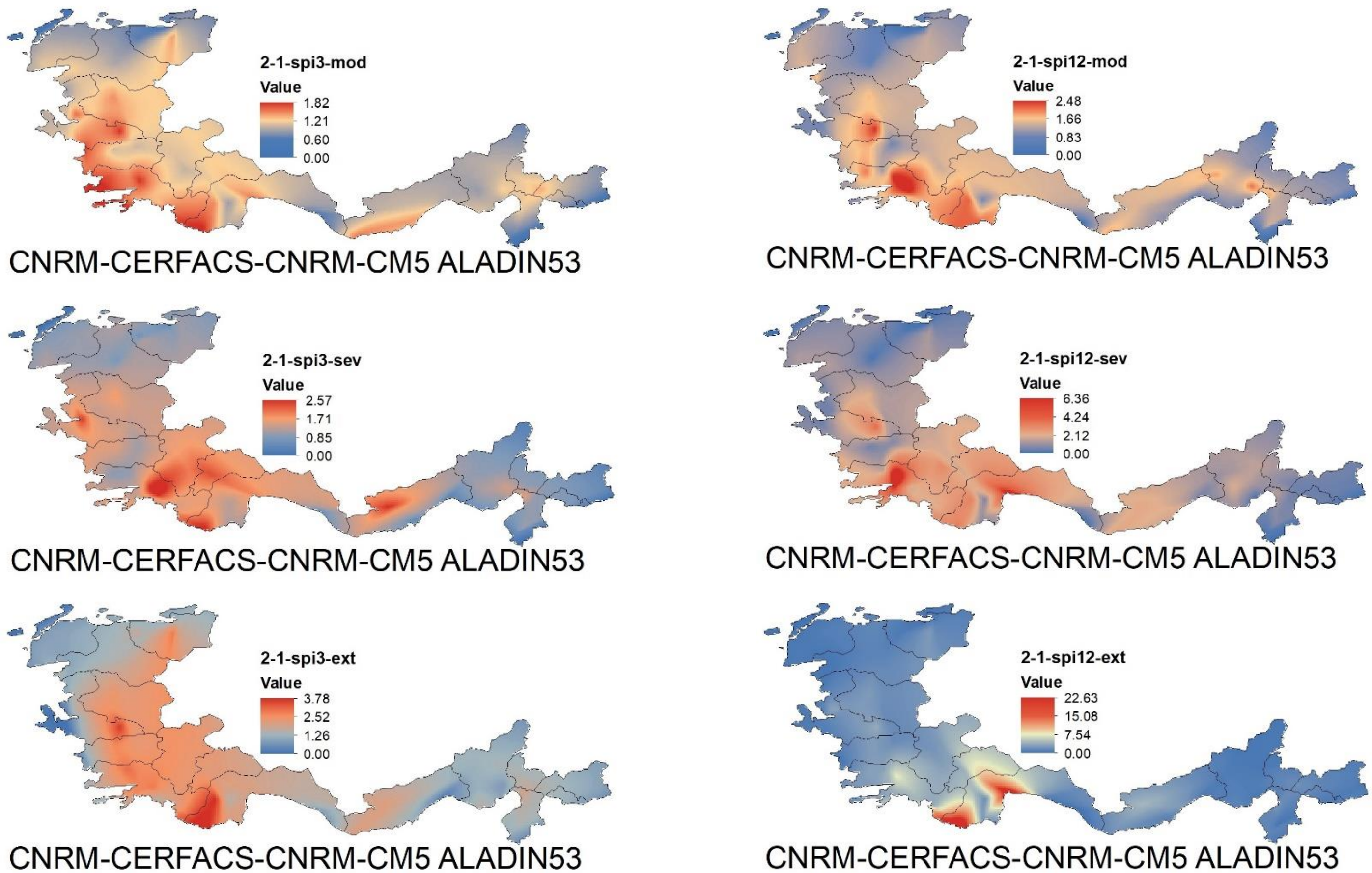

Figure 24. (cont’d)

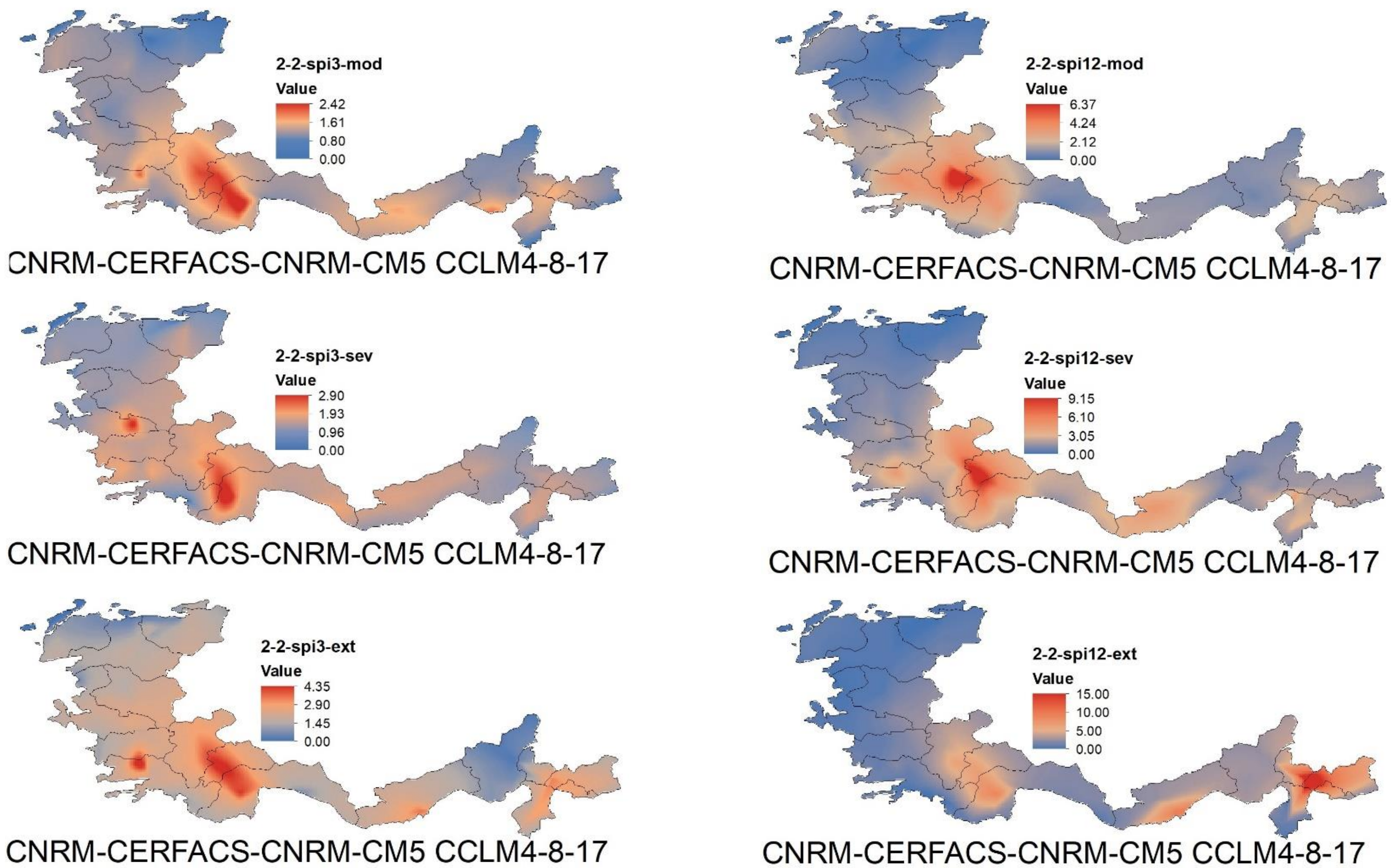

Figure 24. (cont’d)

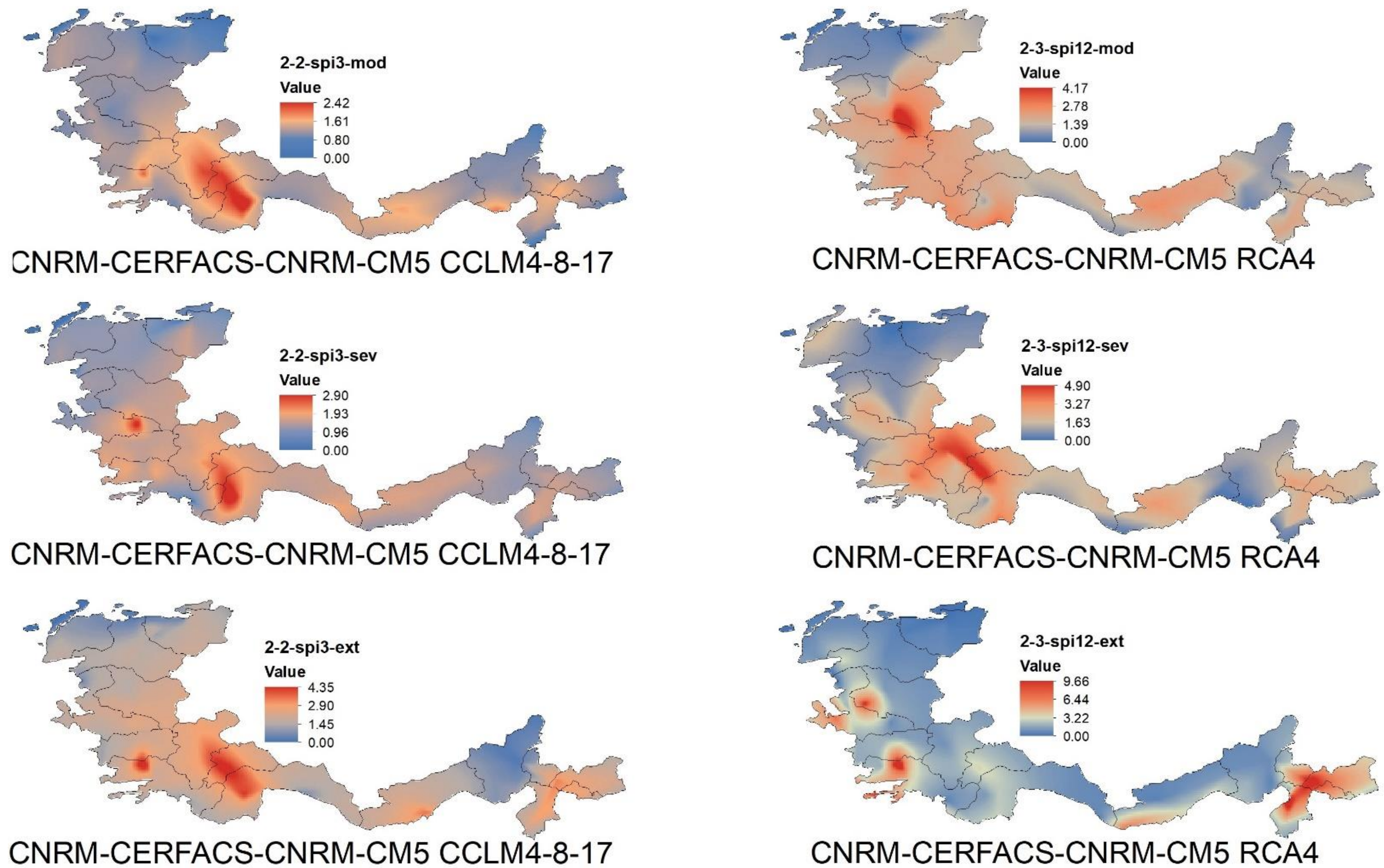

Figure 24. (cont'd)

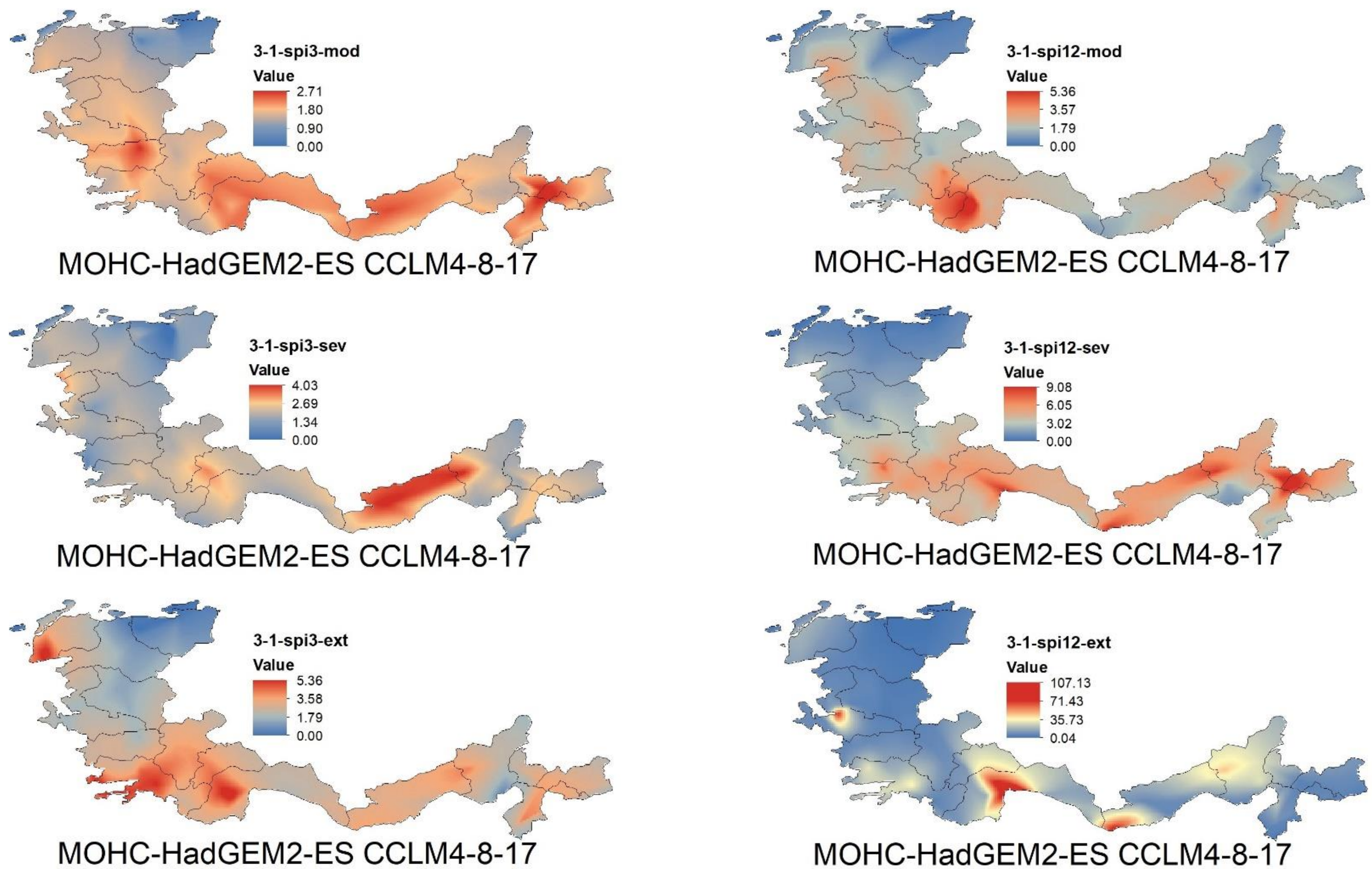

Figure 24. (cont'd)

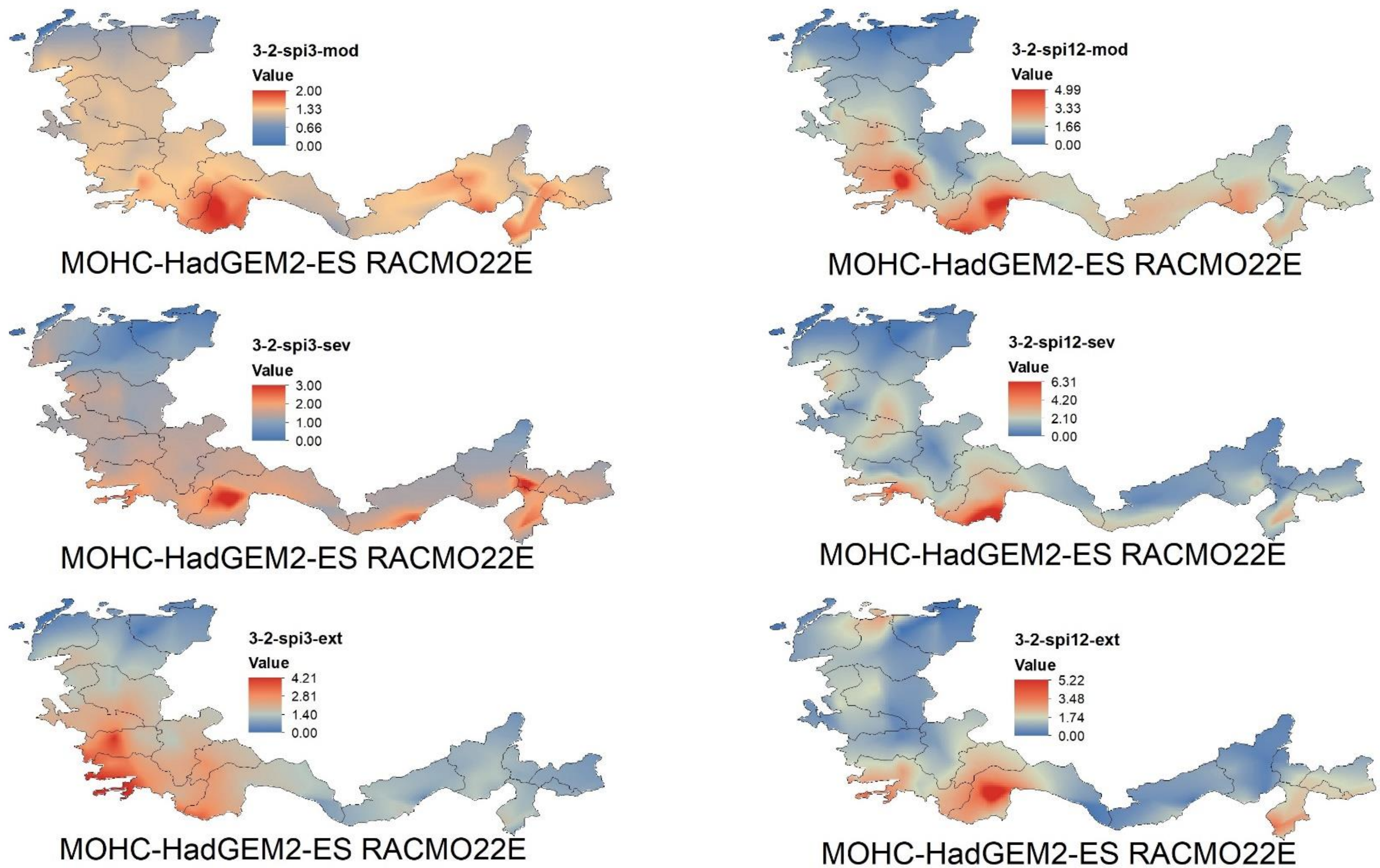

Figure 24. (cont'd)

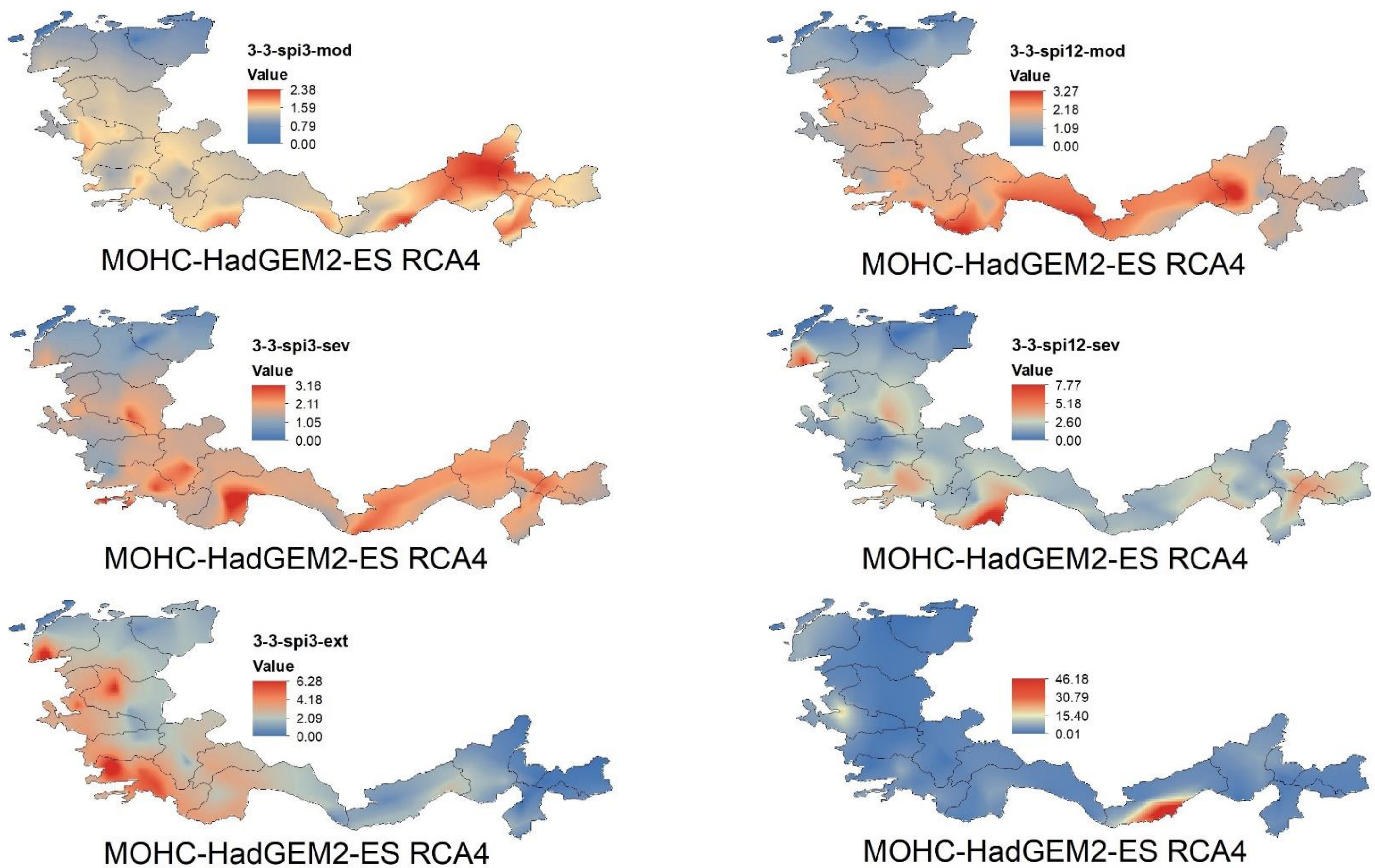

Figure 24. (cont'd)

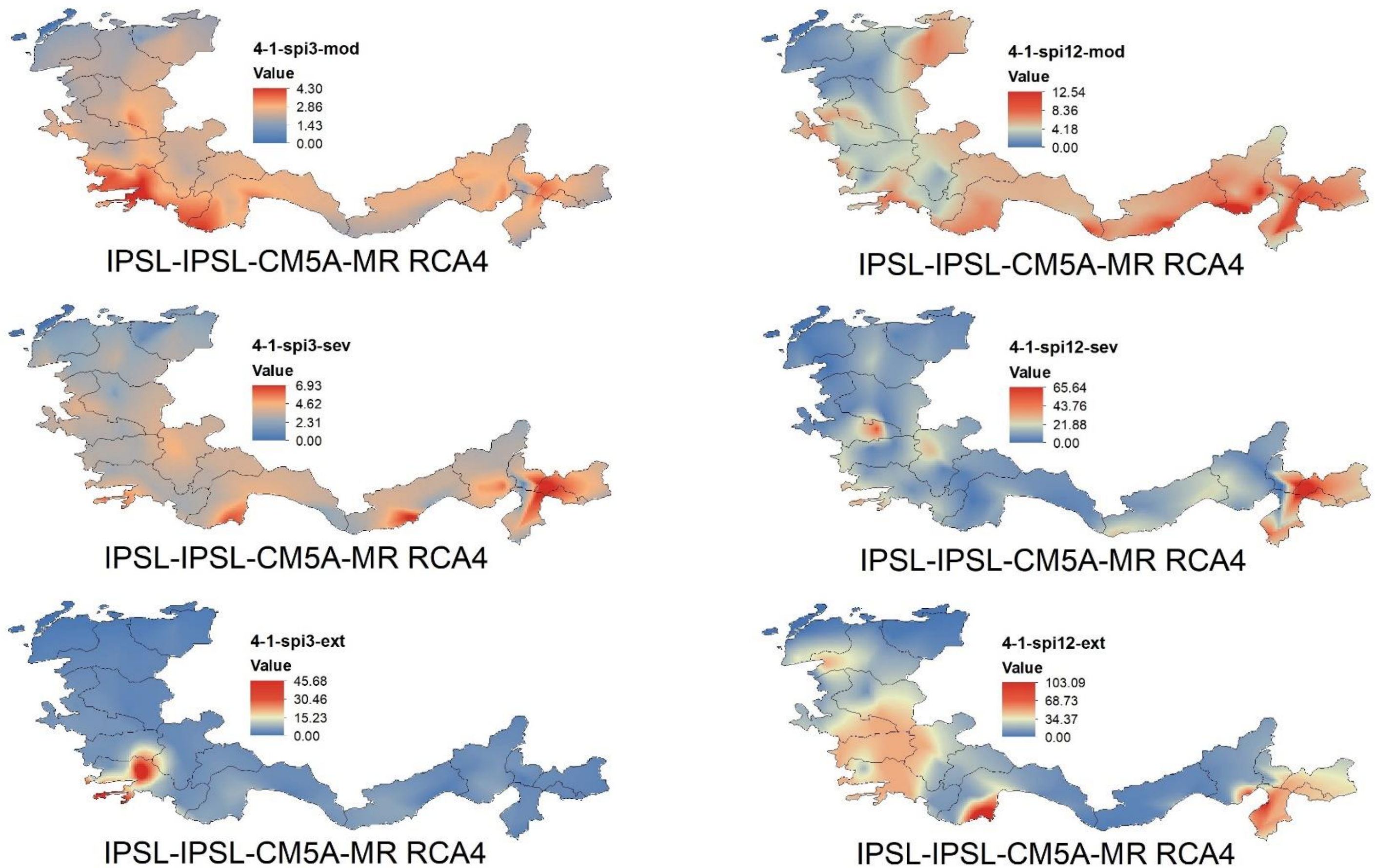

Figure 24. (cont'd)

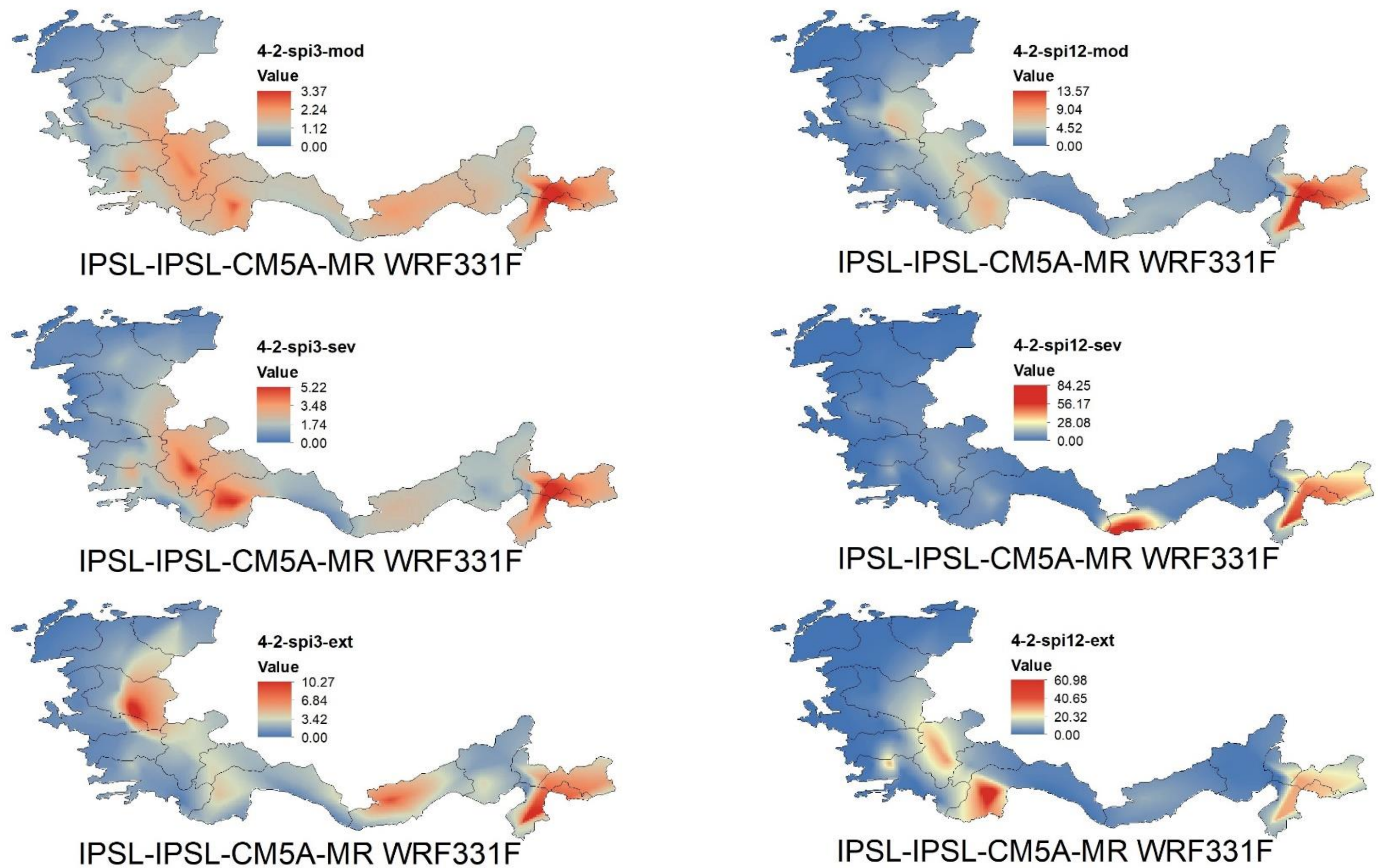

Figure 24. (cont’d)

3.6. Areal Extension of Drought within the Period

The plots in Figure 25 show the areal change of drought based on SPI severity classes. The percentage of the locations at each month which is in relevant SPI value interval for each class was calculated. Afterwards, the monthly averages were obtained for 4 periods: 1971-2005, 2006-2040, 2041-2075, 2076-2099. SPI 3 values were considered at this evaluation. The area under dry conditions is no more than 30% for the driest model (4-1), yet, the increase is related to intensity as the plots indicated. For instance, extremely dry area does not exceed 6 % whereas the sharpest increase is the case for this severity class.

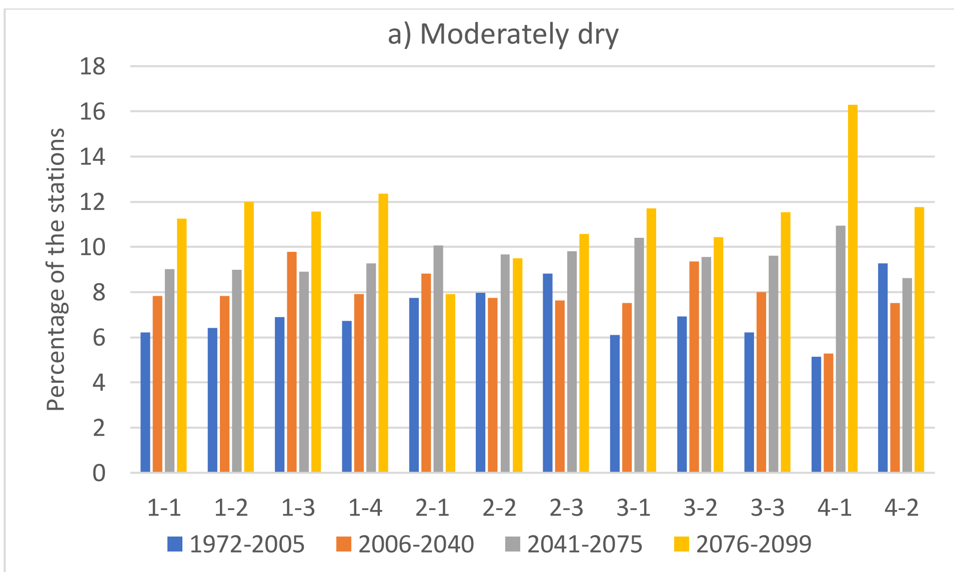

Figure 25. The percentage of the stations under dry conditions

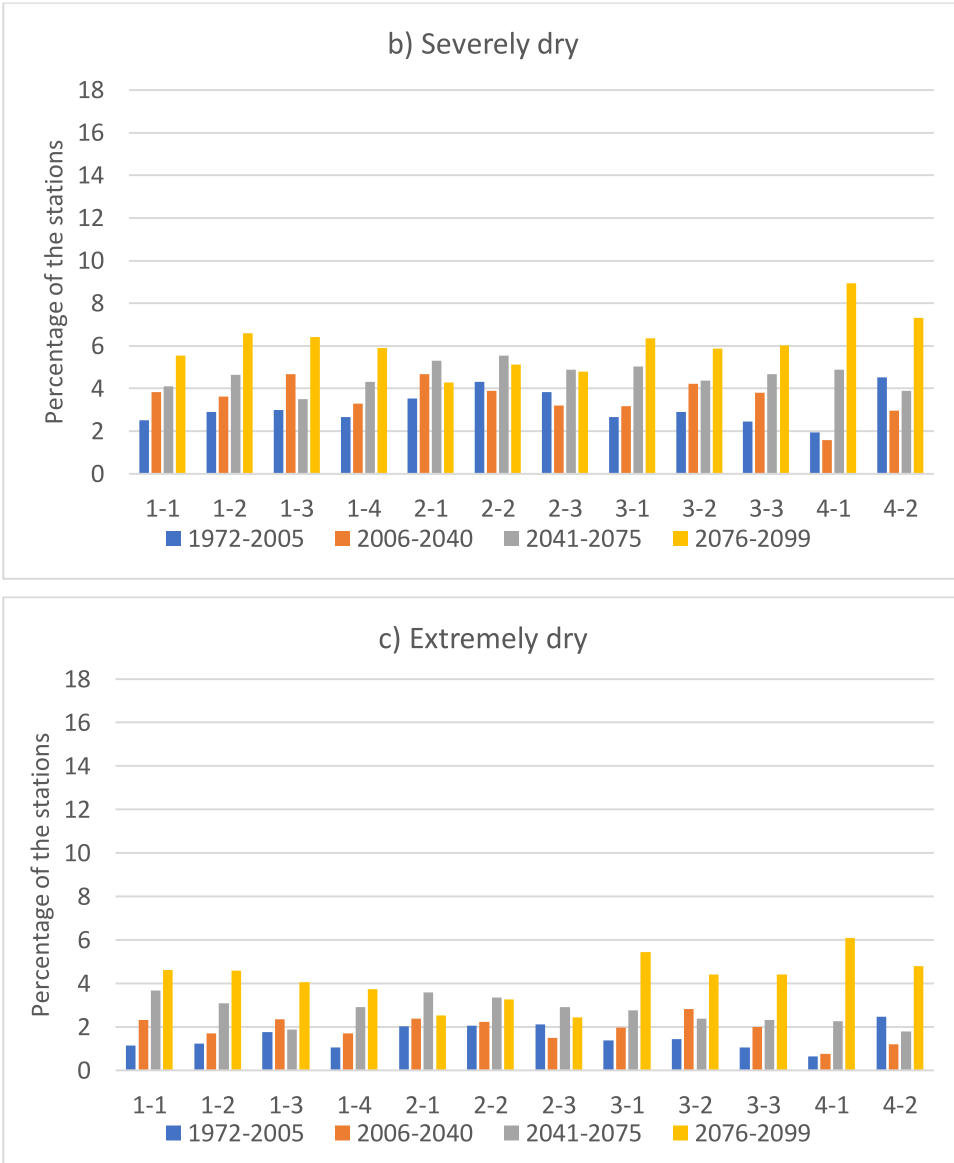

Figure 25. (cont'd)

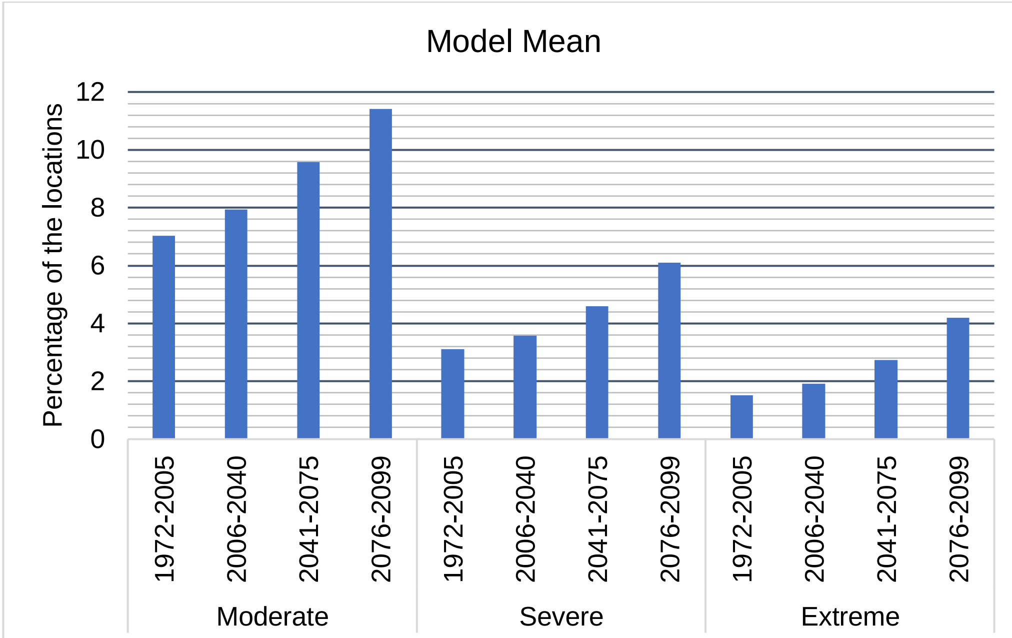

Figure 26. The average percentage of the stations under dry conditions for all models

Figure 26 indicates the percentages of stations under dry conditions by averaging percentiles of 12 models. Though the percentages raised for all dryness classes, the increase rates are diverse. While moderate dry locations raised from 7% to 11%, percentages of severe and extreme dry locations raised almost 2 times (from 3% to 6% and from 1.5% to 4% respectively)

CHAPTER 4

SUMMARY, CONCLUSION AND RECOMMENDATIONS

In this thesis, Ensemble modeling approach was used to make predictions for drought in the future of Turkey's Mediterranean climate region. Observation and model precipitation data were compared to measure the performance of each model within the ensemble system. Afterwards, trends in drought depending on Standardized Precipitation Index values and annual rainfall amounts were investigated. Geographical distribution of trends was mapped. Frequency of different drought severities was compared for two periods divided at half of 21st century. Areal extension of drought severities was studied for 4 periods as well.

Models 1-4, 2-3 and 3-3 are distinguished from rest of the models with their high consistency with observation data. It should be noticed that these models used the same RCM (RCA4) but initiated with different GCMs. Additionally, RCM show more impact on predictions considering the uncertainties that come from GCM and RCM. Model 1-1 is also distinguished owing to its well correlation with observation data considering daily means. Though, this model diverged from observation at 2 of 5 locations when annual rainfall trends were compared., Model 4-1 is another model from RCA4 RCM that partially fitted observation though its underestimation remains for entire year.

In case of projections, south of the study area (especially Muğla province and western part of Antalya province) is the most sensitive region to drought in future according to all model predictions. This result is consistent with other studies which investigated drought trends in Turkey (Topcu et al., 2010; Sen et al., 2012). Hence, the closeness of the results from all models for these regions indicated the consistency of the models and the importance of drought signals. On the other hand, the variation of the trend results of models for the rest of the area -especially along the Aegean region- causes the necessity for evaluating the RCM projections more in detail in this area. Most of the models project either no significant trend or wetter conditions for locations from Çanakkale, Balıkesir and Bursa. Besides, the Marmara coast of these provinces is likely to receive more precipitation.

Another significant result that can be inferred from both result tables and maps is the increasing drought tendency for larger timescales. This means that the drier conditions may not be limited to meteorological or agricultural scale. Increase in hydrological drought is probable for most of the study area. Therefore, the measurements that will be held to manage the effects of climate change should be designed taking into account this projection outcome at this region.

The analyses revealed drought increase with decreasing trend at annual total precipitation for most of the locations. Increase in drought may have a positive correlation with decrease in annual precipitation in the region. However, the more detailed drought and precipitation assessments considering the correlation between these should be performed.

The increase in the frequency of different drought types based on SPI classification is related to severity of class according to most of the models. This analysis result is common with findings of Leng et al. (2015) on China. Areal extension proportions of drought classes also consist with this result. Severely and extremely dry areas extend more than moderately dry areas proportionally.

This thesis was dedicated to Mediterranean climate region of Turkey. The drought analysis can be extended to entire Turkey. Other drought indices can also be implied. Changes in temperature should also be studied to clarify the effect of climate change. The relation between trends in drought and changes in seasonal distribution of precipitation can be analyzed. The effects of climate change should be assessed via analyzing the phenomena at larger scale as well. Poleward shift of Hadley cell is one of these phenomena. Evaluating the trends in meteorological parameters on the belt around 30° latitude will be useful to determine any significant change.

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APPENDICES

A. MATLAB CODES

MATLAB code for Modified Mann-Kendall Test (prepared by Simone Fatichi)

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% MANN-KENDALL TEST MODIFIED by Hamed and Rao, (1998) %%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
function[H,p_value]=Mann_Kendall_Modified(V,alpha)
%%%%%%%%%%%%%%%%%
%%% Performs Mann-Kendall test modified to account for autocorrelation on
the time series
%%% The null hypothesis of trend
%%% absence in the vector V is tested,  against the alternative of trend.
%%% The result of the test is returned in H = 1 indicates
%%% a rejection of the null hypothesis at the alpha significance level. H
= 0 indicates
%%% a failure to reject the null hypothesis at the alpha significance
level.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% INPUTS
%V = time series [vector]
%alpha =  significance level of the test [scalar]
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% From Matlab Help %%%%%%%%%%%%%%%
%The significance level of a test is a threshold of probability a agreed
%to before the test is conducted. A typical value of alpha is 0.05. If the
p-value of a test is less than alpha,
%the test rejects the null hypothesis. If the p-value is greater than
alpha, there is insufficient evidence
%to reject the null hypothesis.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% OUTPUTS
```

```
%H = test result [1] Reject of Null Hypthesis [0] Insufficient evidence to
reject the null hypothesis
%p_value = p-value of the test
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% From Matlab Help %%%%%%%%%%%%%%%
%The p-value of a test is the probability, under the null hypothesis, of
obtaining a value
%of the test statistic as extreme or more extreme than the value computed
from
%the sample.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% References
%Mann, H. B. (1945), Nonparametric tests against trend, Econometrica, 13,
%245 259.
%Kendall, M. G. (1975), Rank Correlation Methods, Griffin, London.
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%for autocorrelated data, J. Hydrol., 204, 182196.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Simone Fatichi -- simonef@dicea.unifi.it
%   Copyright 2009
%   $Date: 2009/10/03 $
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
V=reshape(V,length(V),1);
alpha = alpha/2; %
n=length(V);
i=0; j=0; S=0;
for i=1:n-1
    for j= i+1:n
        S= S + sign(V(j)-V(i));
    end
end
VarSo=(n*(n-1)*(2*n+5))/18;
%%%%%%%%%%%%%%%%%%%%%%%%
ANSW = 3;  %%% It depends on computational time
switch ANSW
    case 1
        xx=1:n;
        aa=polyfit(xx,V,1);
        yy=aa(1,1)*xx+aa(1,2);
        V=V-yy';
    case 2
        [b]=Sen_Slope(V);
```

```
        xx=1:n;
        yy=b*xx+ (mean(V) -(b*n)/2);
        V=V-yy';
    case 3
        V=detrend(V);
end
%%%%%%%%%%%%%%%%%%%%%%%%%
[V,I]=sort(V); %% I = ranks
[Acx,lags,Bounds]=autocorr(I,n-1);
%[Acx,lags]=xcov(I,I,n-1,'coeff'); %%
%Acx=Acx(n:end);
ros=Acx(2:end); %% Autocorrelation Ranks
i=0; sni=0;
for i=1:n-2
    if ros(i)<= Bounds(1) andand ros(i) >= Bounds(2)
        sni=sni;
    else
        sni=sni+(n-i)*(n-i-1)*(n-i-2)*ros(i);
    end
end
nns=1+(2/(n*(n-1)*(n-2)))*sni;
VarS=VarSo*(nns);
StdS=sqrt(VarS);
if S >= 0
   Z=((S-1)/StdS)*(S~=0);
else
   Z=(S+1)/StdS;
end
p_value=2*(1-normcdf(abs(Z),0,1));
pz=norminv(1-alpha,0,1);
H=abs(Z)>pz; %
end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%% Trend Magnitude ---> Sen (1968)%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
function[b]=Sen_Slope(X)
i=0; %
n=length(X);
V= zeros(1,(n^2-n)/2);
for j=2:n
    for l=1:j-1
        i=i+1;
```

```
        V(i)=(X(j)-X(l))/(j-l);
    end
end
b=median(V);
end
```

MATLAB code for Standardized Precipitation Index (prepared by Taesam Lee)

```
%%
% Programmed by Taesam Lee,  Dec.03,2009
% INRS-ETE, Quebec, Canada
function [Z]=SPI(Data,scale,nseas)
%Standardized Precipitation Index
% Input Data
% Data : Monthly Data vector not matrix (monthly or seasonal
precipitation)
% scale : 1,3,12,48
% nseas : number of season (monthly=12)
% Example
% Z=SPI(gamrnd(1,1,1000,1),3,12); 3-monthly scale,
% Notice that  the rest of the months of the fist year are removed.
% eg. if scale =3, fist year data 3-12 SPI values are not estimated.

%if row vector then make coloumn vector
%if (sz==1) Data(:,1)=Data;end
erase_yr=ceil(scale/12);

% Data setting to scaled dataset
A1=[];
for is=1:scale, A1=[A1,Data(is:length(Data)-scale+is)];end
XS=sum(A1,2);

if(scale>1), XS(1:nseas*erase_yr-scale+1)=[];   end

for is=1:nseas
    tind=is:nseas:length(XS);
    Xn=XS(tind);
    [zeroa]=find(Xn==0);
    Xn_nozero=Xn;Xn_nozero(zeroa)=[];
    q=length(zeroa)/length(Xn);
    parm=gamfit(Xn_nozero);
    Gam_xs=q+(1-q)*gamcdf(Xn,parm(1),parm(2));
    Z(tind)=norminv(Gam_xs);
end

%Gamma parameter estimation and tranform
```

B. TREND SLOPE TABLES

Table 11. Trend slope values for model 1-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	0.0001	0.0003	0.0004	0.0004	0.7152
AYVALIK	-	-	0.0001	0.0002	0.0002	-
DİKİLİ	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-0.7359
AKHİSAR	-0.0002	-	-	-	-	-
KUŞADASI	-0.0002	-0.0003	-	-	-	-
DİDİM	-0.0003	-0.0004	-0.0003	-0.0003	-0.0003	-0.6720
BODRUM	-0.0003	-0.0003	-0.0003	-0.0003	-0.0003	-0.8070
DALAMAN	-0.0004	-0.0005	-0.0005	-0.0006	-0.0006	-2.9368
ANAMUR	-0.0003	-0.0004	-0.0006	-0.0007	-0.0007	-1.9160
SİLİFKE	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-0.8126
İSKENDERUN	-	-	-	-	-	-
FİNİKE	-0.0004	-0.0006	-0.0009	-0.0010	-0.0010	-6.2084
KAŞ	-0.0003	-0.0006	-0.0008	-0.0010	-0.0010	-2.7616
SALİHLİ	-0.0001	-	-	0.0002	0.0002	-
SEFERİHİSAR	-0.0002	-	-	-	-	-
ÖDEMİŞ	-0.0003	-0.0003	-0.0002	-0.0002	-0.0002	-
NAZİLLİ	-	-	-	-	-	-
ELMALI	-	0.0003	0.0005	0.0007	0.0007	0.2513
MUT	-0.0001	-	-	-	-	-
KARATAŞ	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.2930
MENEMEN	-0.0003	-0.0003	-0.0002	-	-	-
FETHİYE	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.7236
MARMARİS	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-0.9714
BURHANİYE	-0.0002	-	-	-	-	-
MİLAS	-0.0002	-0.0003	-0.0002	-0.0002	-0.0002	-
YATAĞAN	-0.0002	-	-	-	-	-
KOZAN	-0.0003	-0.0005	-0.0005	-0.0006	-0.0006	-1.6484

Table 11. (cont'd) Trend slope values for model 1-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
DATÇA	-0.0004	-0.0006	-0.0008	-0.0009	-0.0009	-3.2641
KÖYCEĞİZ	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004	-1.5417
KORKUTELİ	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.4587
KARAİSALI	-0.0003	-0.0005	-0.0007	-0.0008	-0.0008	-1.6726
MANAVGAT	-0.0002	-0.0004	-0.0005	-0.0006	-0.0006	-2.3695
ERDEMLİ	-0.0002	-0.0004	-0.0006	-0.0007	-0.0007	-1.0295
CEYHAN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.0131
DÖRTYOL	-	-	-0.0003	-0.0004	-0.0004	-1.2068
ISLAHİYE	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003	-1.0821
GAZİPAŞA	-0.0002	-0.0004	-0.0005	-0.0005	-0.0005	-1.9558
YUMURTALIK	-0.0003	-0.0004	-0.0003	-0.0004	-0.0004	-1.1646
SAMANDAĞ	-0.0002	-0.0004	-0.0005	-0.0006	-0.0006	-1.7947
ACIPAYAM	-	0.0002	0.0004	0.0005	0.0005	0.2864
TEFENNİ	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-0.2395
GEMLİK	-	-	-	-	-	-
KARACABEY	-	-	-	-	-	-
MUDANYA	-	0.0001	0.0003	0.0004	0.0004	0.6982
M.KEMALPAŞA	-	-	-	-	-	-
AYVACIK	-0.0002	-0.0004	-0.0004	-0.0005	-0.0005	-1.2531
OSMANIYE	-0.0001	-0.0002	-0.0003	-0.0004	-0.0004	-0.5273
ALANYA	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.9989
MANISA	-0.0002	-	-	-	-	-
IZMIR	-0.0002	-0.0002	-0.0002	-	-	-
AYDIN	-0.0002	-0.0002	-	-	-	-
DENIZLI	-	-	0.0003	0.0005	0.0005	0.5198
MUGLA	-0.0004	-0.0006	-0.0007	-0.0008	-0.0008	-4.6311
ANTALYA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.9478
MERSIN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.0536
ADANA	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.1703
ANTAKYA	-0.0003	-0.0004	-0.0004	-0.0005	-0.0005	-0.6076
BALIKESİR	-0.0001	-	-	-	-	-
CANAKKALE	-0.0001	-	-	-	-	-
BURSA	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-1.6586

Table 12. Trend slope values for model 1-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	0.0000	-	-
AYVALIK	-0.0002	-	-	-0.0004	-	-0.7978
DİKİLİ	-0.0002	-0.0003	-0.0003	-0.0003	-	-
AKHİSAR	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-0.8166
KUŞADASI	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.1836
DİDİM	-0.0002	-0.0005	-0.0006	-0.0007	-0.0007	-1.2741
BODRUM	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.2539
DALAMAN	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-2.1662
ANAMUR	-0.0002	-0.0004	-0.0006	-0.0007	-0.0007	-2.0738
SİLİFKE	-0.0003	-0.0005	-0.0006	-0.0008	-0.0009	-1.8544
İSKENDERUN	-0.0003	-0.0004	-0.0004	-0.0005	-0.0006	-0.8768
FİNİKE	-0.0003	-0.0005	-0.0007	-0.0009	-0.0009	-3.2208
KAŞ	-0.0003	-0.0005	-0.0007	-0.0008	-0.0009	-2.2175
SALİHLİ	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.1015
SEFERİHİSAR	-0.0002	-0.0004	-0.0005	-0.0005	-0.0006	-0.7468
ÖDEMİŞ	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.3725
NAZİLLİ	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.0521
ELMALI	-0.0005	-0.0007	-0.0010	-0.0011	-0.0012	-2.1464
MUT	-0.0003	-0.0006	-0.0007	-0.0008	-0.0009	-1.1675
KARATAŞ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-0.8206
MENEMEN	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-0.9390
FETHİYE	-0.0003	-0.0005	-0.0005	-0.0006	-0.0007	-2.0024
MARMARİS	-0.0003	-0.0005	-0.0007	-0.0008	-0.0008	-2.4706
BURHANİYE	-0.0002	-	-	-0.0004	-	-
MİLAS	-0.0003	-0.0005	-0.0007	-0.0008	-0.0009	-1.6289
YATAĞAN	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-1.7983
KOZAN	-0.0001	-0.0002	-	-0.0003	-	-
DATÇA	-0.0003	-0.0005	-0.0007	-0.0008	-0.0008	-1.2993
KÖYCEĞİZ	-0.0003	-0.0006	-0.0008	-0.0009	-0.0010	-2.6385
KORKUTELİ	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-2.6246
KARAİSALI	-0.0002	-0.0003	-0.0005	-0.0005	-0.0006	-1.7505
MANAVGAT	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.5245
ERDEMLİ	-0.0002	-0.0004	-0.0005	-0.0006	-0.0007	-1.5895

Table 12. (cont'd) Trend slope values for model 1-2

Station	**SPI 1**	**SPI 3**	**SPI 6**	**SPI 9**	**SPI 12**	**Annual Pr.**
CEYHAN	-0.0001	-0.0002	-0.0003	-0.0003	-0.0003	-
DÖRTYOL	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.2645
ISLAHİYE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.0859
GAZİPAŞA	-	-0.0003	-0.0004	-0.0004	-0.0004	-1.1386
YUMURTALIK	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-
SAMANDAĞ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-
ACIPAYAM	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-1.2656
TEFENNİ	-0.0004	-0.0006	-0.0008	-0.0010	-0.0011	-1.5683
GEMLİK	-	-	-	0.0001	-	-
KARACABEY	-	-	-	-0.0001	-	-
MUDANYA	-	-	-	0.0002	0.0003	-
M.KEMALPAŞA	-	-	-	-0.0001	-	-
AYVACIK	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-0.8111
OSMANIYE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.9943
ALANYA	-0.0002	-0.0004	-0.0005	-0.0005	-0.0006	-1.7941
MANISA	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.0241
IZMIR	-0.0003	-0.0005	-0.0006	-0.0007	-0.0007	-1.2277
AYDIN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.2547
DENIZLI	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.0201
MUGLA	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-2.5862
ANTALYA	-0.0002	-0.0004	-0.0006	-0.0007	-0.0008	-3.9625
MERSIN	-0.0002	-0.0004	-0.0005	-0.0006	-0.0007	-1.7131
ADANA	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.8752
ANTAKYA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-0.9184
BALIKESİR	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-0.6535
CANAKKALE	-0.0002	-	-	-0.0002	-	-
BURSA	-	-	-	0.0000	-	-

Table 13. Trend slope values for model 1-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	-	-	-
AYVALIK	-	-	-	-	-	-
DİKİLİ	-	-	-	-	-	-
AKHİSAR	-0.0001	-	-	-	-	-
KUŞADASI	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.9031
DİDİM	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.9960
BODRUM	-0.0002	-0.0004	-0.0005	-0.0006	-0.0007	-1.4405
DALAMAN	-0.0002	-0.0004	-0.0005	-0.0006	-0.0006	-1.8145
ANAMUR	-	-0.0002	-0.0003	-0.0003	-0.0004	-
SİLİFKE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-0.8435
İSKENDERUN	-	-	-	-	-	-
FİNİKE	-0.0003	-0.0005	-0.0007	-0.0008	-0.0009	-3.2487
KAŞ	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-2.2196
SALİHLİ	-0.0002	-0.0002	-	-	-	-
SEFERİHİSAR	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-0.4410
ÖDEMİŞ	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.8051
NAZİLLİ	-0.0001	-0.0002	-0.0002	-0.0002	-	-
ELMALI	-0.0003	-0.0005	-0.0005	-0.0006	-0.0007	-0.8198
MUT	-0.0001	-0.0002	-	-	-	-
KARATAŞ	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.7611
MENEMEN	-0.0001	-0.0002	-	-	-	-
FETHİYE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-1.1707
MARMARİS	-0.0003	-0.0005	-0.0007	-0.0008	-0.0008	-2.7955
BURHANİYE	-	-	-	-	-	-
MİLAS	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.0603
YATAĞAN	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-0.7799
KOZAN	-	-	-	-	-0.0002	-
DATÇA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.5281
KÖYCEĞİZ	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-2.2773
KORKUTELİ	-0.0004	-0.0005	-0.0007	-0.0007	-0.0008	-1.8245
KARAİSALI	-	-0.0002	-0.0002	-0.0003	-0.0003	-0.6273
MANAVGAT	-	-0.0002	-0.0003	-0.0003	-0.0003	-1.0409
ERDEMLİ	-	-	-	-0.0001	-	-

Table 13. (cont'd) Trend slope values for model 1-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-
DÖRTYOL	-	-	-	-	-	-
ISLAHİYE	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-0.7705
GAZİPAŞA	-	-0.0002	-0.0002	-	-	-
YUMURTALIK	-	-	-	-	-	-
SAMANDAĞ	-0.0001	-0.0002	-0.0002	-0.0002	-	-
ACIPAYAM	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-0.3892
TEFENNİ	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.3714
GEMLİK	-	-	0.0002	0.0003	0.0003	-
KARACABEY	-	-	-	-	-	-
MUDANYA	-	-	0.0003	0.0004	0.0004	0.6907
M.KEMALPAŞA	-	-	-	-	-	-
AYVACIK	-0.0001	-0.0002	-	-	-0.0002	-
OSMANIYE	-	-	-	-	-	-
ALANYA	-	-	-0.0002	-0.0003	-0.0003	-
MANISA	-0.0001	-	-	-	-	-
IZMIR	-0.0002	-0.0002	-0.0002	-	-	-
AYDIN	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-
DENIZLI	-0.0001	-0.0002	-	-	-	-
MUGLA	-0.0003	-0.0005	-0.0006	-0.0006	-0.0007	-2.6603
ANTALYA	-0.0002	-0.0003	-0.0005	-0.0005	-0.0006	-2.5428
MERSIN	-	-0.0001	-0.0002	-0.0003	-0.0003	-0.6400
ADANA	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-0.7370
ANTAKYA	-	-0.0002	-0.0002	-	-	-
BALIKESİR	-	-	-	-	-	-
CANAKKALE	-	-	-	-	-	-
BURSA	-	-	-	-	-	-

Table 14. Trend slope values for model 1-4

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	-	-	-
AYVALIK	-0.0002	-0.0003	-0.0003	-0.0003	-0.0003	-
DİKİLİ	-0.0002	-0.0002	-0.0002	-	-	-
AKHİSAR	-	-0.0003	-0.0003	-0.0003	-0.0003	-
KUŞADASI	-0.0003	-0.0005	-0.0005	-0.0006	-0.0006	-1.0224
DİDİM	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.4823
BODRUM	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.3338
DALAMAN	-0.0003	-0.0006	-0.0007	-0.0008	-0.0009	-2.8391
ANAMUR	-0.0001	-0.0003	-0.0004	-0.0005	-0.0006	-0.9105
SİLİFKE	-	-0.0002	-0.0003	-0.0004	-0.0004	-0.6056
İSKENDERUN	-0.0001	-	-	-	-	-
FİNİKE	-0.0004	-0.0007	-0.0009	-0.0011	-0.0012	-3.6544
KAŞ	-0.0003	-0.0006	-0.0008	-0.0009	-0.0010	-2.2666
SALİHLİ	-0.0003	-0.0005	-0.0007	-0.0008	-0.0009	-0.9584
SEFERİHİSAR	-	-0.0004	-0.0005	-0.0005	-0.0006	-0.4760
ÖDEMİŞ	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-0.8065
NAZİLLİ	-	-0.0005	-0.0006	-0.0006	-0.0007	-0.4756
ELMALI	-	-0.0004	-0.0005	-0.0005	-0.0006	-0.3239
MUT	-	-0.0002	-0.0002	-	-	-
KARATAŞ	-0.0001	-0.0002	-0.0003	-0.0003	-0.0004	-0.7029
MENEMEN	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-1.0610
FETHİYE	-0.0003	-0.0005	-0.0007	-0.0007	-0.0008	-1.8234
MARMARİS	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-2.6772
BURHANİYE	-	-0.0003	-0.0003	-0.0003	-0.0003	-
MİLAS	-	-0.0004	-0.0005	-0.0005	-0.0006	-0.8210
YATAĞAN	-	-0.0006	-0.0007	-0.0008	-0.0009	-0.9778
KOZAN	-0.0001	-0.0002	-	-	-	-
DATÇA	-0.0004	-0.0007	-0.0009	-0.0011	-0.0012	-3.9260
KÖYCEĞİZ	-	-0.0005	-0.0007	-0.0007	-0.0008	-1.9815
KORKUTELİ	-0.0003	-0.0005	-0.0006	-0.0008	-0.0009	-2.1072
KARAİSALI	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-0.9432
MANAVGAT	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-1.4669
ERDEMLİ	-0.0001	-0.0002	-0.0003	-0.0004	-0.0005	-0.5452

Table 14. (cont'd) Trend slope values for model 1-4

Station	**SPI 1**	**SPI 3**	**SPI 6**	**SPI 9**	**SPI 12**	**Annual Pr.**
CEYHAN	-0.0002	-	-0.0003	-0.0003	-	-
DÖRTYOL	-	-	-	-	-	-
ISLAHİYE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.7000
GAZİPAŞA	-0.0001	-0.0002	-	-	-	-
YUMURTALIK	-0.0001	-	-	-	-	-
SAMANDAĞ	-0.0001	-	-0.0003	-	-	-
ACIPAYAM	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-0.4870
TEFENNİ	-0.0003	-0.0005	-0.0006	-0.0006	-0.0007	-0.7070
GEMLİK	-0.0001	-	-	-	-	-
KARACABEY	-	-	-	-	-	-
MUDANYA	-	-	-	-	-	-
M.KEMALPAŞA	-0.0001	-0.0001	-	-	-	-
AYVACIK	-0.0003	-0.0005	-0.0005	-0.0006	-0.0007	-1.6756
OSMANIYE	-	-	-	-	-	-
ALANYA	-0.0001	-0.0003	-0.0003	-0.0003	-0.0004	-
MANISA	-	-0.0004	-0.0006	-0.0007	-0.0007	-0.6581
IZMIR	-0.0003	-0.0004	-0.0005	-0.0005	-0.0005	-0.8163
AYDIN	-	-0.0004	-0.0005	-0.0005	-0.0006	-0.7465
DENIZLI	-0.0003	-0.0005	-0.0006	-0.0006	-0.0007	-0.5057
MUGLA	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-3.3837
ANTALYA	-0.0003	-0.0006	-0.0007	-0.0008	-0.0009	-2.3454
MERSIN	-	-0.0002	-0.0003	-0.0004	-0.0004	-0.5228
ADANA	-0.0002	-0.0002	-0.0003	-	-	-0.6302
ANTAKYA	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-0.3788
BALIKESİR	-0.0002	-0.0002	-	-	-	-
CANAKKALE	-0.0002	-0.0003	-	-	-	-
BURSA	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-1.1386

Table 15. Trend slope values for model 2-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	-	-	-
AYVALIK	-	-	-	-	-	-
DİKİLİ	-	-	-	-	-	-
AKHİSAR	-0.0002	-0.0002	-	-	-	-
KUŞADASI	-0.0002	-	-	-	-	-
DİDİM	-0.0001	-	-	-	-	-
BODRUM	-0.0001	-	-	-	-	-0.4787
DALAMAN	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-0.7803
ANAMUR	-0.0001	-0.0002	-0.0004	-0.0005	-0.0005	-1.1723
SİLİFKE	-	-	-0.0002	-0.0002	-0.0003	-
İSKENDERUN	-	-	-	-	-	-
FİNİKE	-	-	-	-	-	-
KAŞ	-0.0002	-0.0004	-0.0006	-0.0008	-0.0009	-1.8069
SALİHLİ	-0.0001	-	-	-	-	-
SEFERİHİSAR	-	-	-	-	-	-
ÖDEMİŞ	-0.0003	-0.0004	-0.0005	-0.0007	-0.0007	-1.4170
NAZİLLİ	-0.0001	-	-	-	-	-
ELMALI	-0.0002	-0.0003	-0.0005	-0.0006	-0.0007	-0.8330
MUT	-	-	-	-	-	-
KARATAŞ	-	-	-	-	-	-
MENEMEN	-0.0001	-	-	-	-0.0003	-
FETHİYE	-0.0002	-0.0004	-0.0005	-0.0007	-0.0007	-1.0119
MARMARİS	-0.0002	-0.0002	-0.0003	-0.0004	-0.0005	-1.3780
BURHANİYE	-	-	-	-	-	-
MİLAS	-0.0002	-0.0002	-0.0003	-0.0004	-0.0004	-0.5783
YATAĞAN	-0.0001	-	-	-	-	-
KOZAN	-	-	-	-	-	-
DATÇA	-0.0001	-	-	-	-	-
KÖYCEĞİZ	-0.0003	-0.0004	-0.0006	-0.0007	-0.0008	-1.2032
KORKUTELİ	-	-	-	-	-	-
KARAİSALI	-	-	-	-0.0003	-0.0003	-
MANAVGAT	-	-	-	-	-	-0.6980
ERDEMLİ	-	-	-	-0.0003	-0.0004	-

Table 15. (cont'd) Trend slope values for model 2-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-	-	-	-	-	-
DÖRTYOL	-0.0001	-0.0002	-0.0003	-0.0003	-0.0004	-0.3883
ISLAHİYE	-0.0001	-0.0002	-	-0.0003	-0.0003	-
GAZİPAŞA	-	-	-	-	-	-
YUMURTALIK	-	-	0.0002	0.0002	0.0003	-
SAMANDAĞ	-	0.0002	0.0003	0.0004	0.0005	1.9858
ACIPAYAM	-0.0002	-0.0002	-	-	-	-
TEFENNİ	-0.0002	-	-	-	-	-0.4306
GEMLİK	-	-	-	-	-	-
KARACABEY	-	-	-	-	-	-
MUDANYA	0.0002	0.0004	0.0007	0.0008	0.0009	2.4122
M.KEMALPAŞA	-	-	-	-	-	-
AYVACIK	-	-	-	-	-	-0.5220
OSMANIYE	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-0.5156
ALANYA	-	-	-	-	-	-
MANISA	-	-	-	-	-	-
IZMIR	-	-	-	-	-	-
AYDIN	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003	-0.4104
DENIZLI	-0.0001	-	-	-	-	-
MUGLA	-0.0003	-0.0005	-0.0006	-0.0008	-0.0009	-2.6566
ANTALYA	-0.0002	-0.0004	-0.0005	-0.0007	-0.0007	-1.5869
MERSIN	0.0001	0.0002	0.0003	0.0004	0.0004	0.6073
ADANA	-	-	-	-	-	-
ANTAKYA	-	-	-	-	-	-
BALIKESİR	-	-	-	-	-	-
CANAKKALE	-	-	-	-	-	-
BURSA	-	-	-	-	-	-

Table 16. Trend slope values for model 2-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	0.0002	0.0003	0.0003	0.4893
AYVALIK	-	-	0.0002	0.0002	0.0002	-
DİKİLİ	-	-	-	-	0.0002	-
AKHİSAR	-	-	-	-	-	-
KUŞADASI	-0.0001	-	-	-	-	-
DİDİM	-	-	-	-	-	-
BODRUM	-0.0001	-	-0.0001	-	-	-
DALAMAN	-0.0001	-0.0001	-0.0002	-	-	-
ANAMUR	-0.0001	-0.0002	-0.0002	-0.0002	-0.0003	-
SİLİFKE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-1.4521
İSKENDERUN	-0.0002	-0.0002	-0.0003	-0.0004	-0.0004	-0.7100
FİNİKE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-2.0834
KAŞ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.4103
SALİHLİ	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-
SEFERİHİSAR	-0.0001	-	-	-	-	-
ÖDEMİŞ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.1444
NAZİLLİ	-0.0002	-0.0002	-0.0003	-0.0004	-0.0004	-0.9157
ELMALI	-0.0004	-0.0006	-0.0007	-0.0009	-0.0010	-1.8405
MUT	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.1899
KARATAŞ	-	-	-	-	-	-
MENEMEN	-0.0001	-	-	-	-	-
FETHİYE	-0.0001	-0.0002	-0.0002	-0.0002	-0.0003	-1.1177
MARMARİS	-0.0001	-0.0002	-0.0002	-	-	-
BURHANİYE	-	-	-	-	-	-
MİLAS	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-1.1883
YATAĞAN	-0.0003	-0.0004	-0.0006	-0.0007	-0.0008	-1.7752
KOZAN	-	-	-	-	-	-
DATÇA	-0.0001	-0.0001	-	-	-	-
KÖYCEĞİZ	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.2099
KORKUTELİ	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-2.1082
KARAİSALI	-	-	-	-	-	-
MANAVGAT	-	-	-	-	-	-
ERDEMLİ	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-

Table 16. (cont'd) Trend slope values for model 2-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-	-	-	-	-	-
DÖRTYOL	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-0.7822
ISLAHİYE	-0.0003	-0.0004	-0.0004	-0.0005	-0.0006	-1.0588
GAZİPAŞA	-	-	-	-	-	-
YUMURTALIK	-	-	-	-	-	-
SAMANDAĞ	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-0.9092
ACIPAYAM	-0.0004	-0.0005	-0.0007	-0.0008	-0.0009	-1.4951
TEFENNİ	-0.0004	-0.0005	-0.0006	-0.0008	-0.0009	-1.3775
GEMLİK	-	0.0002	0.0003	0.0004	0.0004	0.8583
KARACABEY	-	-	0.0003	0.0004	0.0004	0.7794
MUDANYA	0.0002	0.0003	0.0005	0.0006	0.0007	1.5519
M.KEMALPAŞA	-	-	0.0003	0.0003	0.0004	0.7508
AYVACIK	-0.0001	-0.0001	-0.0002	-0.0002	-0.0002	-
OSMANIYE	-	-0.0001	-0.0002	-0.0002	-	-
ALANYA	-0.0001	-	-	-	-	-
MANISA	-0.0001	-	-	-	-	-
IZMIR	-0.0001	-0.0002	-	-	-	-
AYDIN	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-
DENIZLI	-0.0003	-0.0004	-0.0006	-0.0007	-0.0008	-1.4013
MUGLA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.3274
ANTALYA	-0.0002	-0.0002	-0.0003	-0.0004	-0.0004	-2.9119
MERSIN	-	-	-	-	-	-
ADANA	-	-	-	-	-	-
ANTAKYA	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.7609
BALIKESİR	-	-	-	-	-	-
CANAKKALE	-	-	-	-	-	-
BURSA	-	-	-	-	-	-

Table 17. Trend slope values for model 2-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	0.0001	0.0002	0.0004	0.0005	0.0006	0.8874
AYVALIK	-	-	0.0001	0.0002	0.0002	-
DİKİLİ	-	-	-	-	-	-
AKHİSAR	-	-	-	-	-	-
KUŞADASI	-	-	-	-	-	-
DİDİM	-	-	-	-	-	-
BODRUM	-0.0001	-0.0001	-	-	-	-
DALAMAN	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003	-1.4235
ANAMUR	-	-0.0001	-	-	-0.0003	-
SİLİFKE	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.0499
İSKENDERUN	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-0.7376
FİNİKE	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.4041
KAŞ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.0963
SALİHLİ	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-0.4387
SEFERİHİSAR	-0.0001	-	-	-	-	-
ÖDEMİŞ	-	-	-	-	-	-
NAZİLLİ	-	-	-	-	-	-
ELMALI	-	-	-	-	-	-
MUT	-	-0.0002	-0.0002	-0.0003	-0.0004	-0.3133
KARATAŞ	-0.0001	-	-	-	-	-
MENEMEN	-0.0001	-	-	-	-	-
FETHİYE	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.2153
MARMARİS	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-1.4218
BURHANİYE	-	-0.0001	-	-0.0002	-	-
MİLAS	-0.0001	-0.0002	-0.0002	-0.0003	-	-0.6283
YATAĞAN	-0.0002	-0.0003	-0.0005	-0.0006	-0.0006	-0.9051
KOZAN	-0.0001	-	-	-	-	-
DATÇA	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-1.3057
KÖYCEĞİZ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.7555
KORKUTELİ	-0.0002	-0.0002	-0.0003	-0.0004	-0.0004	-
KARAİSALI	-0.0001	-0.0001	-0.0002	-0.0003	-0.0003	-
MANAVGAT	-0.0001	-	-	-0.0003	-0.0003	-1.4126
ERDEMLİ	-0.0001	-0.0002	-0.0003	-0.0004	-0.0005	-0.7625

Table 17. (cont'd) Trend slope values for model 2-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-0.0001	-0.0001	-	-	-	-
DÖRTYOL	-	-	-	-0.0002	-0.0003	-
ISLAHİYE	-0.0003	-0.0005	-0.0005	-0.0006	-0.0007	-1.8122
GAZİPAŞA	-	-	-	-	-	-
YUMURTALIK	-0.0001	-	-	-	-	-
SAMANDAĞ	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003	-0.8575
ACIPAYAM	-0.0001	-	-	-	-	-
TEFENNİ	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.5122
GEMLİK	-	-	-	-	-	-
KARACABEY	-	0.0002	0.0004	0.0005	0.0006	0.6831
MUDANYA	-	-	-	0.0004	0.0004	-
M.KEMALPAŞA	-	0.0001	0.0002	0.0003	0.0004	-
AYVACIK	-	-	-	-	-	-
OSMANIYE	-0.0001	-	-	-	-	-
ALANYA	-0.0001	-	-0.0002	-0.0003	-0.0004	-1.4152
MANISA	-0.0001	-0.0002	-0.0002	-0.0003	-0.0003	-0.3649
IZMIR	-0.0001	-	-	-0.0002	-0.0003	-0.5513
AYDIN	-	-	-	-	-	-
DENIZLI	-0.0001	-	-	-	-	-0.2599
MUGLA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-3.0774
ANTALYA	-0.0002	-0.0002	-0.0002	-0.0003	-0.0004	-0.9998
MERSIN	-0.0001	-	-0.0002	-0.0003	-0.0004	-
ADANA	-0.0002	-0.0001	-0.0001	-	-	-
ANTAKYA	-0.0002	-0.0002	-0.0004	-0.0005	-0.0005	-0.4665
BALIKESİR	-	-	-	-	-	-
CANAKKALE	-	0.0002	0.0003	0.0003	0.0004	0.5070
BURSA	-	-	-	-	-	-

Table 18. Trend slope values for model 3-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	-	-	0.0944
AYVALIK	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.1208
DİKİLİ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.2501
AKHİSAR	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.9951
KUŞADASI	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-
DİDİM	-	-0.0002	-	-	-	-
BODRUM	-	-0.0002	-0.0002	-	-	-0.3317
DALAMAN	-0.0002	-0.0003	-0.0004	-0.0006	-0.0007	-2.5499
ANAMUR	-0.0003	-0.0004	-0.0005	-0.0007	-0.0007	-3.2585
SİLİFKE	-0.0004	-0.0005	-0.0005	-0.0007	-0.0008	-1.9831
İSKENDERUN	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.6765
FİNİKE	-0.0004	-0.0004	-0.0005	-0.0007	-0.0008	-3.4102
KAŞ	-0.0003	-0.0004	-0.0005	-0.0007	-0.0008	-2.5599
SALİHLİ	-0.0003	-0.0004	-0.0004	-0.0005	-0.0006	-0.8362
SEFERİHİSAR	-	-0.0003	-0.0003	-0.0004	-0.0005	-0.7297
ÖDEMİŞ	-0.0003	-0.0005	-0.0005	-0.0006	-0.0007	-1.3885
NAZİLLİ	-0.0003	-0.0004	-0.0005	-0.0007	-0.0008	-1.5202
ELMALI	-0.0005	-0.0006	-0.0008	-0.0010	-0.0011	-1.9958
MUT	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-1.3588
KARATAŞ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0005	-1.3051
MENEMEN	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.0065
FETHİYE	-0.0002	-0.0003	-0.0004	-0.0006	-0.0007	-3.1756
MARMARİS	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-1.4533
BURHANİYE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.7963
MİLAS	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-1.2424
YATAĞAN	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-1.7317
KOZAN	-0.0003	-0.0003	-0.0004	-0.0005	-0.0006	-
DATÇA	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-0.6776
KÖYCEĞİZ	-0.0003	-0.0005	-0.0006	-0.0008	-0.0009	-2.7808
KORKUTELİ	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-1.7738
KARAİSALI	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-2.7659
MANAVGAT	-0.0003	-0.0003	-0.0004	-0.0005	-0.0006	-2.7792
ERDEMLİ	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.0348

Table 18. (cont'd) Trend slope values for model 3-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-0.0002	-0.0003	-0.0003	-0.0004	-0.0005	-1.1572
DÖRTYOL	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-2.3914
ISLAHİYE	-0.0005	-0.0006	-0.0007	-0.0008	-0.0009	-2.2514
GAZİPAŞA	-0.0003	-0.0003	-0.0005	-0.0006	-0.0006	-2.6127
YUMURTALIK	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-1.6012
SAMANDAĞ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.8287
ACIPAYAM	-0.0004	-0.0006	-0.0007	-0.0009	-0.0010	-1.6232
TEFENNİ	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-
GEMLİK	-	-	-	-	0.0002	-
KARACABEY	-	-	-	-	-	0.2343
MUDANYA	-	-	0.0003	0.0004	0.0004	-
M.KEMALPAŞA	-	-	-	-	-	0.2164
AYVACIK	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.2506
OSMANIYE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.9880
ALANYA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-
MANISA	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-0.4944
IZMIR	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.2204
AYDIN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.3892
DENIZLI	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-0.8954
MUGLA	-0.0004	-0.0005	-0.0007	-0.0008	-0.0009	-3.1253
ANTALYA	-0.0004	-0.0004	-0.0005	-0.0007	-0.0008	-6.8051
MERSIN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.0581
ADANA	-0.0002	-0.0004	-0.0004	-0.0005	-0.0006	-1.5713
ANTAKYA	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-
BALIKESİR	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.6198
CANAKKALE	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-
BURSA	-0.0001	-	-	-	0.0001	-

Table 19. Trend slope values for model 3-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	0.0002	0.0003	0.0003	0.0004	0.9017
AYVALIK	-0.0001	-	-	-	-	-
DİKİLİ	-0.0001	-	-	-	-0.0002	-
AKHİSAR	-0.0002	-	-	-	-0.0002	-
KUŞADASI	-0.0002	-0.0002	-0.0002	-0.0003	-	-
DİDİM	-0.0002	-0.0002	-	-	-	-
BODRUM	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-
DALAMAN	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.9095
ANAMUR	-	-0.0002	-0.0003	-0.0004	-0.0005	-1.2869
SİLİFKE	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.4583
İSKENDERUN	-0.0001	-	-	-	-	-
FİNİKE	-0.0002	-0.0004	-0.0006	-0.0008	-0.0009	-4.1823
KAŞ	-0.0003	-0.0004	-0.0006	-0.0008	-0.0009	-2.6461
SALİHLİ	-0.0002	-0.0002	-	-0.0002	-0.0002	-
SEFERİHİSAR	-	-	-	-	-	-
ÖDEMİŞ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.1531
NAZİLLİ	-0.0001	-	-	-	-	-
ELMALI	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.4453
MUT	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-
KARATAŞ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-1.9938
MENEMEN	-0.0002	-	-	-	-0.0002	-
FETHİYE	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.6547
MARMARİS	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-2.1082
BURHANİYE	-0.0001	-	-	-	-0.0002	-
MİLAS	-0.0002	-0.0003	-0.0003	-0.0004	-0.0005	-1.2091
YATAĞAN	-0.0002	-0.0002	-0.0003	-0.0003	-0.0004	-0.8074
KOZAN	-0.0002	-	-0.0002	-	-0.0002	-
DATÇA	-0.0002	-0.0003	-0.0004	-0.0004	-0.0005	-0.9445
KÖYCEĞİZ	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006	-2.4524
KORKUTELİ	-0.0003	-0.0005	-0.0007	-0.0008	-0.0010	-2.6903
KARAİSALI	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.4494
MANAVGAT	-0.0001	-0.0002	-0.0003	-0.0004	-0.0005	-1.9299
ERDEMLİ	-	-0.0001	-0.0002	-0.0002	-0.0003	-0.6527

Table 19. (cont'd) Trend slope values for model 3-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.2249
DÖRTYOL	-	-	-	-	-	-
ISLAHİYE	-0.0003	-0.0003	-0.0003	-0.0003	-0.0004	-1.2682
GAZİPAŞA	-	-0.0001	-0.0002	-0.0002	-0.0003	-
YUMURTALIK	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-
SAMANDAĞ	-0.0003	-0.0003	-0.0004	-0.0004	-0.0005	-1.8372
ACIPAYAM	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-
TEFENNİ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-0.4529
GEMLİK	-	0.0002	0.0003	0.0004	0.0005	0.9707
KARACABEY	-	0.0002	0.0003	0.0004	0.0005	0.7738
MUDANYA	-	0.0002	0.0003	0.0004	0.0005	0.8824
M.KEMALPAŞA	-	-	-	-	-	-
AYVACIK	-0.0001	-0.0002	-0.0002	-0.0002	-0.0002	-
OSMANIYE	-	-	-	-	-	-
ALANYA	-	-	-0.0002	-0.0003	-0.0003	-1.1261
MANISA	-0.0001	-	-	-	-	-
IZMIR	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-
AYDIN	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.9821
DENIZLI	-0.0001	-	-	-	-	-
MUGLA	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.9318
ANTALYA	-0.0002	-0.0004	-0.0006	-0.0007	-0.0008	-4.6493
MERSIN	-0.0001	-0.0003	-0.0003	-0.0004	-0.0005	-1.3385
ADANA	-0.0002	-0.0003	-0.0004	-0.0005	-0.0005	-1.5819
ANTAKYA	-0.0003	-0.0003	-0.0004	-0.0005	-0.0006	-1.4510
BALIKESİR	-	-	0.0001	0.0001	0.0002	-
CANAKKALE	-	-	-	-	-	-
BURSA	-	-	-	-	0.0001	-

Table 20. Trend slope values for model 3-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-	-	-	-	-	-
AYVALIK	-	-0.0002	-	-	-	-
DİKİLİ	-	-	-	-	-	-
AKHİSAR	-	-	-	-	-	-
KUŞADASI	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-0.9115
DİDİM	-	-0.0003	-0.0003	-	-	-
BODRUM	-	-0.0003	-0.0003	-0.0004	-0.0004	-
DALAMAN	-0.0002	-0.0004	-0.0005	-0.0006	-0.0006	-2.6239
ANAMUR	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.5644
SİLİFKE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.3257
İSKENDERUN	-0.0003	-0.0003	-0.0003	-0.0004	-0.0005	-1.1992
FİNİKE	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-3.0494
KAŞ	-0.0003	-0.0004	-0.0006	-0.0007	-0.0008	-2.0672
SALİHLİ	-	-0.0003	-0.0003	-0.0004	-0.0004	-0.5154
SEFERİHİSAR	-	-	-	-	-	-
ÖDEMİŞ	-	-0.0002	-0.0002	-0.0002	-0.0002	-
NAZİLLİ	-	-	-	-	-	-
ELMALI	-	-0.0003	-0.0004	-0.0004	-0.0005	-0.3509
MUT	-0.0001	-0.0002	-0.0003	-0.0003	-0.0004	-0.2685
KARATAŞ	-0.0003	-0.0004	-0.0004	-0.0005	-0.0006	-1.9121
MENEMEN	-	-0.0003	-0.0004	-0.0004	-0.0004	-
FETHİYE	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.9081
MARMARİS	-0.0002	-0.0004	-0.0005	-0.0005	-0.0006	-1.7822
BURHANİYE	-	-0.0002	-0.0002	-0.0002	-0.0003	-
MİLAS	-	-0.0002	-0.0002	-0.0002	-0.0002	-0.4515
YATAĞAN	-	-0.0003	-0.0004	-0.0005	-0.0006	-0.7760
KOZAN	-0.0003	-0.0005	-0.0006	-0.0006	-0.0007	-2.1659
DATÇA	-0.0003	-0.0004	-0.0006	-0.0006	-0.0007	-2.6884
KÖYCEĞİZ	-	-0.0004	-0.0004	-0.0005	-0.0006	-1.6422
KORKUTELİ	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-2.0579
KARAİSALI	-0.0004	-0.0006	-0.0007	-0.0008	-0.0008	-2.1444
MANAVGAT	-0.0002	-0.0004	-0.0004	-0.0005	-0.0006	-2.2814
ERDEMLİ	-0.0002	-0.0004	-0.0005	-0.0006	-0.0007	-1.1042

Table 20. (cont'd) Trend slope values for model 3-3

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
CEYHAN	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-1.4530
DÖRTYOL	-0.0003	-0.0003	-0.0003	-0.0003	-0.0003	-
ISLAHİYE	-0.0004	-0.0005	-0.0006	-0.0006	-0.0007	-2.3811
GAZİPAŞA	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-1.4562
YUMURTALIK	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-1.6826
SAMANDAĞ	-0.0004	-0.0005	-0.0005	-0.0006	-0.0007	-1.7906
ACIPAYAM	-	-	-0.0002	-0.0002	-0.0002	-
TEFENNİ	-0.0002	-0.0003	-0.0003	-0.0004	-0.0004	-0.4668
GEMLİK	-0.0001	-	-	-	-	-
KARACABEY	-	-	-	0.0003	0.0003	-
MUDANYA	-	-	0.0001	-	-	-
M.KEMALPAŞA	-0.0001	-	-	-	-	-
AYVACIK	-0.0003	-0.0004	-0.0005	-0.0006	-0.0006	-1.7674
OSMANIYE	-0.0003	-0.0003	-0.0002	-	-	-
ALANYA	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-2.1112
MANISA	-	-0.0002	-0.0002	-0.0003	-0.0003	-
IZMIR	-0.0002	-0.0003	-0.0003	-0.0003	-0.0004	-0.6595
AYDIN	-	-	-	-	-	-
DENIZLI	-	-0.0003	-0.0003	-0.0003	-0.0003	-0.2515
MUGLA	-0.0003	-0.0004	-0.0006	-0.0006	-0.0007	-3.1938
ANTALYA	-0.0003	-0.0005	-0.0006	-0.0007	-0.0008	-1.9951
MERSIN	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-1.2421
ADANA	-0.0003	-0.0004	-0.0005	-0.0005	-0.0006	-1.4225
ANTAKYA	-0.0003	-0.0003	-0.0004	-0.0005	-0.0005	-0.4881
BALIKESİR	-0.0002	-	-	-	-	-
CANAKKALE	-	-	-	-	-	-
BURSA	-0.0001	-0.0001	-	-	-	-

Table 21. Trend slope values for model 4-1

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-1.2155
AYVALIK	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-1.4128
DİKİLİ	-0.0004	-0.0006	-0.0007	-0.0007	-0.0008	-1.5068
AKHİSAR	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-1.6499
KUŞADASI	-0.0005	-0.0007	-0.0008	-0.0009	-0.0010	-1.5502
DİDİM	-0.0005	-0.0008	-0.0009	-0.0010	-0.0011	-1.8023
BODRUM	-0.0006	-0.0009	-0.0010	-0.0012	-0.0013	-1.8496
DALAMAN	-0.0005	-0.0009	-0.0011	-0.0012	-0.0013	-3.9283
ANAMUR	-0.0004	-0.0007	-0.0010	-0.0012	-0.0014	-2.0766
SİLİFKE	-0.0004	-0.0007	-0.0010	-0.0012	-0.0013	-1.9075
İSKENDERUN	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-2.2981
FİNİKE	-0.0006	-0.0009	-0.0011	-0.0013	-0.0014	-2.8071
KAŞ	-0.0005	-0.0008	-0.0011	-0.0012	-0.0013	-2.1842
SALİHLİ	-0.0005	-0.0007	-0.0009	-0.0011	-0.0012	-1.6147
SEFERİHİSAR	-0.0004	-0.0006	-0.0008	-0.0009	-0.0009	-0.7805
ÖDEMİŞ	-0.0005	-0.0007	-0.0009	-0.0011	-0.0013	-2.0717
NAZİLLİ	-0.0003	-0.0005	-0.0008	-0.0009	-0.0010	-0.6492
ELMALI	-0.0004	-0.0007	-0.0009	-0.0010	-0.0011	-0.5104
MUT	-0.0003	-0.0007	-0.0009	-0.0011	-0.0012	-0.6598
KARATAŞ	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-1.8939
MENEMEN	-0.0005	-0.0007	-0.0009	-0.0010	-0.0011	-1.9823
FETHİYE	-0.0005	-0.0008	-0.0010	-0.0011	-0.0013	-2.4982
MARMARİS	-0.0006	-0.0009	-0.0012	-0.0013	-0.0014	-3.1877
BURHANİYE	-0.0004	-0.0005	-0.0006	-0.0007	-0.0007	-0.7858
MİLAS	-0.0004	-0.0007	-0.0008	-0.0009	-0.0010	-1.5322
YATAĞAN	-0.0005	-0.0007	-0.0010	-0.0011	-0.0013	-1.5941
KOZAN	-0.0006	-0.0008	-0.0011	-0.0012	-0.0013	-2.9038
DATÇA	-0.0006	-0.0010	-0.0012	-0.0013	-0.0014	-3.5946
KÖYCEĞİZ	-0.0005	-0.0007	-0.0010	-0.0011	-0.0012	-3.0215
KORKUTELİ	-0.0005	-0.0007	-0.0009	-0.0011	-0.0011	-2.3294
KARAİSALI	-0.0005	-0.0009	-0.0011	-0.0012	-0.0013	-2.0062
MANAVGAT	-0.0004	-0.0007	-0.0010	-0.0012	-0.0013	-3.4744
ERDEMLİ	-0.0003	-0.0005	-0.0009	-0.0011	-0.0013	-1.1609

Table 21. (cont'd) Trend slope values for model 4-1

Station	**SPI 1**	**SPI 3**	**SPI 6**	**SPI 9**	**SPI 12**	**Annual Pr.**
CEYHAN	-0.0006	-0.0009	-0.0010	-0.0012	-0.0013	-1.8455
DÖRTYOL	-0.0004	-0.0006	-0.0008	-0.0010	-0.0011	-2.2443
ISLAHİYE	-0.0006	-0.0010	-0.0012	-0.0014	-0.0016	-3.7407
GAZİPAŞA	-0.0004	-0.0007	-0.0010	-0.0012	-0.0013	-3.0907
YUMURTALIK	-0.0006	-0.0009	-0.0011	-0.0012	-0.0013	-2.2480
SAMANDAĞ	-0.0006	-0.0009	-0.0011	-0.0013	-0.0014	-3.0354
ACIPAYAM	-0.0004	-0.0007	-0.0008	-0.0010	-0.0011	-0.8360
TEFENNİ	-0.0005	-0.0007	-0.0010	-0.0011	-0.0013	-1.2053
GEMLİK	-0.0005	-0.0007	-0.0009	-0.0010	-0.0012	-2.8118
KARACABEY	-0.0003	-0.0004	-0.0005	-0.0006	-0.0007	-0.6614
MUDANYA	-0.0004	-0.0005	-0.0006	-0.0007	-0.0008	-1.4393
M.KEMALPAŞA	-0.0004	-0.0006	-0.0007	-0.0008	-0.0009	-1.2135
AYVACIK	-0.0005	-0.0008	-0.0010	-0.0011	-0.0012	-2.7502
OSMANIYE	-0.0003	-0.0005	-0.0007	-0.0009	-0.0010	-1.3446
ALANYA	-0.0004	-0.0007	-0.0010	-0.0011	-0.0012	-3.5498
MANISA	-0.0004	-0.0007	-0.0009	-0.0010	-0.0011	-1.1182
IZMIR	-0.0004	-0.0007	-0.0008	-0.0009	-0.0010	-1.7293
AYDIN	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-1.2404
DENIZLI	-0.0004	-0.0007	-0.0009	-0.0011	-0.0012	-0.8129
MUGLA	-0.0007	-0.0010	-0.0012	-0.0013	-0.0015	-5.6805
ANTALYA	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-1.8437
MERSIN	-0.0003	-0.0006	-0.0009	-0.0011	-0.0012	-1.1522
ADANA	-0.0006	-0.0009	-0.0011	-0.0012	-0.0014	-2.0974
ANTAKYA	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-0.8290
BALIKESİR	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-1.0592
CANAKKALE	-0.0002	-0.0003	-0.0004	-0.0004	-0.0004	-
BURSA	-0.0005	-0.0008	-0.0010	-0.0012	-0.0013	-4.2393

Table 22. Trend slope values for model 4-2

Station	SPI 1	SPI 3	SPI 6	SPI 9	SPI 12	Annual Pr.
BANDIRMA	0.0003	0.0004	0.0006	0.0009	0.0010	2.1309
AYVALIK	0.0003	0.0006	0.0008	0.0011	0.0012	4.0884
DİKİLİ	0.0005	0.0008	0.0012	0.0015	0.0016	11.1233
AKHİSAR	-	-	0.0003	0.0004	0.0004	-
KUŞADASI	0.0003	0.0004	0.0007	0.0010	0.0012	4.3631
DİDİM	0.0001	0.0002	0.0004	0.0006	0.0006	2.5433
BODRUM	-	-	-	-	-	-
DALAMAN	0.0001	0.0002	0.0004	0.0006	0.0008	3.3405
ANAMUR	-0.0002	-0.0003	-0.0005	-0.0007	-0.0008	-1.8209
SİLİFKE	-0.0003	-0.0005	-0.0006	-0.0008	-0.0009	-1.1679
İSKENDERUN	-0.0003	-0.0004	-0.0006	-0.0007	-0.0008	-1.2993
FİNİKE	-0.0003	-0.0004	-0.0006	-0.0008	-0.0010	-2.7210
KAŞ	-0.0002	-0.0002	-0.0004	-0.0005	-0.0007	-1.9564
SALİHLİ	-0.0004	-0.0006	-0.0008	-0.0009	-0.0010	-2.2055
SEFERİHİSAR	0.0001	0.0002	0.0004	0.0005	0.0006	1.2161
ÖDEMİŞ	-	-	-	-	-	-
NAZİLLİ	-0.0001	-	-0.0003	-0.0003	-0.0004	-
ELMALI	-0.0006	-0.0008	-0.0010	-0.0012	-0.0014	-2.7304
MUT	-0.0004	-0.0006	-0.0008	-0.0010	-0.0011	-1.0511
KARATAŞ	-	-	-	-	-	-0.9660
MENEMEN	0.0003	0.0005	0.0008	0.0010	0.0012	5.6682
FETHİYE	0.0000	-	0.0002	0.0003	0.0004	1.5669
MARMARİS	-	-	-	-	-	-
BURHANİYE	0.0003	0.0006	0.0008	0.0011	0.0012	3.7722
MİLAS	-	0.0002	0.0004	0.0006	0.0007	3.4625
YATAĞAN	-0.0005	-0.0007	-0.0010	-0.0012	-0.0013	-2.8793
KOZAN	-0.0001	-	-	-	-	-
DATÇA	-	-	-	-	-	-
KÖYCEĞİZ	-	-	0.0002	0.0003	0.0004	2.5084
KORKUTELİ	-0.0006	-0.0008	-0.0010	-0.0012	-0.0014	-3.5397
KARAİSALI	-0.0002	-	-0.0003	-0.0004	-0.0004	-1.0600
MANAVGAT	0.0001	0.0002	0.0005	0.0007	0.0009	4.2760
ERDEMLİ	-0.0003	-0.0004	-0.0005	-0.0007	-0.0009	-1.0033

Table 22. (cont'd) Trend slope values for model 4-2

Station	**SPI 1**	**SPI 3**	**SPI 6**	**SPI 9**	**SPI 12**	**Annual Pr.**
CEYHAN	-0.0002	-	-	-	-	-
DÖRTYOL	0.0002	0.0003	0.0004	0.0006	0.0007	3.3084
ISLAHİYE	-0.0006	-0.0009	-0.0012	-0.0014	-0.0015	-5.0346
GAZİPAŞA	-	0.0002	0.0003	0.0005	0.0006	1.8991
YUMURTALIK	-0.0001	-	-	-	-	-
SAMANDAĞ	-0.0002	-0.0004	-0.0005	-0.0007	-0.0008	-4.5645
ACIPAYAM	-0.0006	-0.0008	-0.0010	-0.0012	-0.0013	-2.1494
TEFENNİ	-0.0005	-0.0008	-0.0010	-0.0011	-0.0012	-1.9704
GEMLİK	0.0003	0.0005	0.0006	0.0008	0.0009	4.1890
KARACABEY	0.0001	0.0003	0.0004	0.0005	0.0005	1.0010
MUDANYA	0.0002	0.0004	0.0006	0.0007	0.0008	1.8873
M.KEMALPAŞA	-	-	-	-	-	-
AYVACIK	0.0003	0.0006	0.0009	0.0012	0.0014	6.0496
OSMANIYE	-	-	-	-	-	-
ALANYA	0.0001	0.0002	0.0003	0.0005	0.0006	2.0866
MANISA	-0.0002	-0.0003	-0.0004	-0.0006	-0.0007	-0.9838
IZMIR	0.0002	0.0004	0.0006	0.0009	0.0010	5.2708
AYDIN	-	-	-	-	-	-
DENIZLI	-0.0006	-0.0008	-0.0011	-0.0013	-0.0014	-2.6969
MUGLA	-	-	-	-	-	-
ANTALYA	-0.0002	-0.0002	-0.0003	-0.0004	-0.0005	-1.3877
MERSIN	-0.0002	-0.0003	-0.0004	-0.0005	-0.0007	-0.8997
ADANA	-0.0001	-	-	-	-	-
ANTAKYA	-0.0004	-0.0007	-0.0010	-0.0012	-0.0014	-2.3972
BALIKESİR	-	-	-	-	-	-
CANAKKALE	0.0004	0.0007	0.0010	0.0013	0.0014	4.1352
BURSA	-	-	-	-	-	-