MIDDLE EAST METEOROLOGY

H.M. Hasanean
Meteorology Department, Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University

Keywords: Middle East Meteorology, Arid and sub arid climate, Dust storm, Climate change, Circulation systems.

Contents

Summary

The Middle East is a region that spans southwestern Asia, western Asia, and northeastern Africa. Although much of the Middle East region has a Mediterranean climate type, i.e. Csa in the widely used Koeppen classification with wet winters and

dry summers. Middle Eastern climatic conditions vary greatly, depending on the season and the geography. Although the hot arid, or desert, climate predominates in the region, the well-watered highlands of Turkey and the mountains of Iran and Ethiopia are important as sources of the region's major rivers.

The Middle East is as one of the regions most affected by dust, in the world, next to Africa. Dust or sand storms are caused by the outflow from low-pressure cells passing through a desert area from west to east. Sand storms can occur throughout the year in the Middle East, but the prime months are May-September.

The results of many researchers showed a linear warming across the Middle East. The maximum warming is occurring in the spring, and the minimum warming is occurring in the winter. Local and regional warming signal may be associated with human-induced desertification and overgrazing. The results of model in the 21st century show widespread warming, with a maximum in interior Iran during summer. It also found some cooling in the southeast Black Sea region during spring and summer that is related to increases in snowfall in the region. The results also show widespread decreases in precipitation over the eastern Mediterranean and Turkey, and increases were found over the southeast Black Sea, southwest Caspian Sea, and Zagros mountain regions during all seasons except summer. While the Saudi desert region receives increases during summer and autumn.

The variability of atmospheric circulation is the most important factor determining changes in spatial distribution of temperature, cloudiness, precipitation and other climatic elements. The North Atlantic Oscillation (NAO) atmospheric circulation pattern appears to exhibit a clear influence on the climate of the region on inter-annual and decadal timescales. Drier-than-average conditions prevail over parts of the Middle East during high NAO index winters. There is recent evidence that the El Niño/Southern Oscillation (ENSO) has influence on the climate of the Middle East in recent decades. El Niño conditions weaken the Indian monsoon and warm the Arabian Sea thus weakening the pressure gradient and reducing the wind speed. La Niña conditions make the pressure gradient stronger thus bringing more rainfall in the region. Anomalous temperature variations over the Middle East (cooling) associated with the stronger clockwise flow around the subtropical Atlantic high-pressure center. The oscillation and strength of Asiatic monsoon low pressure and subtropical high pressure play an important role in rainfall over the River Nile. The annual migration of the ITCZ and seasonal development of the monsoon winds are key-components of the climatology in the Indian Ocean and the surrounding areas.

Tropical Easterly jet stream was weakened in El Nino year and enhanced in La Nina year accompanying with the dry and wet condition respectively. Subtropical jet stream has affect on temperature and rainfall over Arabian Peninsula, where the core of the subtropical jet is stronger during the winter than the other seasons and located near 27.5^{o}N, while it’s weaker during the summer and shifted north ward to appear at 43^{o}N.The interaction between the polar front jet stream (PFJ) and subtropical jet stream (SJS) and its role in the surface cyclogenesis has been affected not only over the North African region but also over other subtropical regions.

1. Introduction

1.1 Middle East Definition

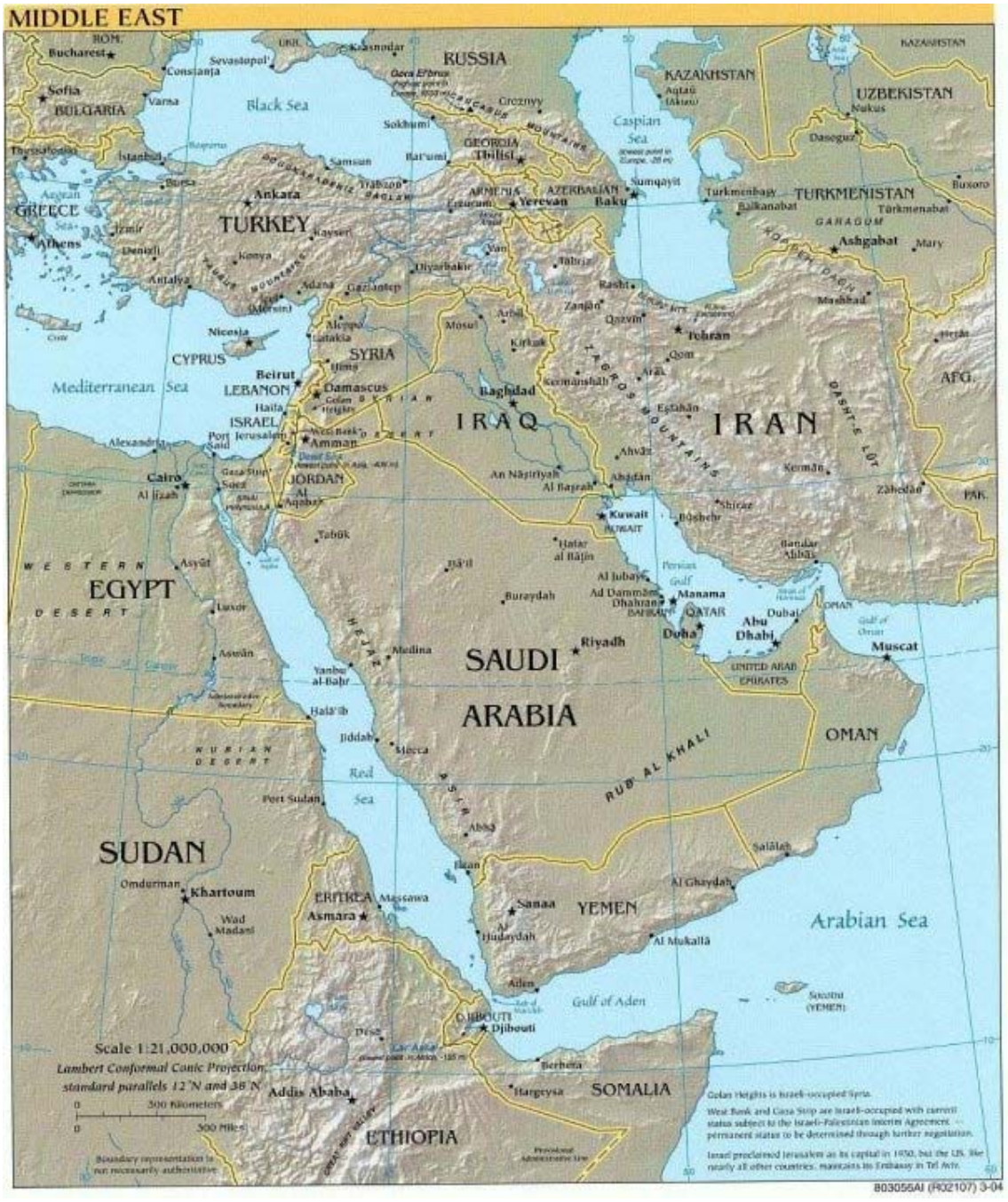

Figure 1 The topo map of the Middle East shows the topography of the Middle Eastern countries. Map features include country names and borders plus rivers, lakes, and land features.

The Middle East borders are not well established. The boundaries of this region change with changing topics. A different approach in defining the area is used in politics,

geography, history, environment, economics, and so on. The term "Middle East" was popularized around 1900 in the United Kingdom (http://en.wikipedia.org/wiki/Middle_East#cite_note-1). The Middle East (or, formerly more common, the Near East (http://en.wikipedia.org/wiki/Middle_East#cite_note-0) is a region that spans southwestern Asia, western Asia, and northeastern Africa. The term refers collectively to the Asian countries of Bahrain, Cyprus, Iran, Iraq, Palestine, Israel, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, the United Arab Emirates, and Yemen, and the African country of Egypt. Much of the Middle East is arid, and the region's topography features extensive desert areas, rugged mountains, and dry plateaus. Water is in short supply, and agriculture often depends on expensive irrigation systems. The Middle East map (Figure 1) identifies the primary countries of the Middle East and shows their national boundaries.

1.2 Overview of the Middle East Climate

In the Middle East, investigations of long-term variations and trends in temperature data are not suffer serious environmental, agricultural and water resources problems, receiving enough attention even though, these countries. The Middle East is interesting for several reasons. The landscape has been massively altered by developing human activity over the last 8000 years, including forest removal, rangeland degradation by grazing and trampling, and watercourse damming and diversion. Due to rapid population growth, political conflict and water scarcity are common throughout the area, rendering it sensitive to changes in climate. A significant impact on the history of the region may be due to climate change. Although much of the Middle East region has a Mediterranean climate type, i.e. Csa in the widely used Koeppen classification (Oliver and Hidore, 1984) with wet winters and dry summers, the spatial gradients in climate are far sharper than in the broad prototype Csa region to the west. For example, along the 40°N meridian, the northward transition from desert (BWh) through steppe (BSh) to cool highland climate (H) occurs within 400 km. Elsewhere in the region, numerous coastlines and mountain ranges modify the local climates (Oliver and Hidore, 1984).

Middle Eastern climatic conditions vary greatly, depending on the season and the geography. The basic climate of the Middle East can be characterized in two words: hot and dry, although winters are mild with some rain. The exception is the mountains, where desert turns to steppe in northern Iraq, northern Iran and eastern Turkey. Winters here can be severe. The Arabian Peninsula has among the hottest and driest conditions found anywhere in the world. The hot desert conditions induce a strong seasonal wind pattern in the region, known as the monsoon. Although we often associate "monsoon" with flooding rains, it comes from an Arabic word meaning "season". During the summer, winds blow unabated toward the hot interior of the Arabian Peninsula, whereas in winter, the winds are in the south and blow off the land. In northern regions, continental winds usher in cold Siberian air which wrings some rain and snow out of the sky along the coasts. Across the Middle East, summer temperatures are usually around 29°C (84.2°F), but often soar above 38°C (100.4°F). In Baghdad, the record high is 49°C (120.2°F); in Basra, 51°C (123.8°F), the highest temperatures recorded in any major Middle Eastern city. In the Saudi desert, however, temperatures over 49°C (120.2°F) are common. Most storms crossing the Middle East become dust- or sandstorms when strong winds whip the dry desert surface; as many as 38 occur

annually.

Precipitation on the semiarid margins of Middle Eastern deserts ranges from 14 inches (350 mm) to 30 inches (750 mm) annually. Rainfall variability within the area of desert climate exceeds 40 percent, reducing to 20 percent on the moist margins of the semiarid zone, which forms a transition between the true desert to the south and the more humid areas farther north. The Black Sea coast of Turkey receives from 78 inches (2,000 mm) to 101 inches (2,600 mm) per year, although the transition from the windward, watered side of the Pontic range to the leeward, dry side can be very abrupt due to the topography. The Mediterranean climate, which is limited to a narrow coastal strip reaching from Gaza to Istanbul is marked by mild winters with ample rain and long, hot summers when Sahara-like conditions prevail. During the summer solstice, the sun is directly overhead at 23° 30′ at north latitude (e.g., at Aswan, Egypt). Annual periods of high sun in combination with clear skies through much of the year allow intense solar radiation with subsequent extreme evapotranspiration demands.

Precipitation results from different processes. Orographic precipitation in the Taurus and Zagros Mountains supplies the flow of the Euphrates and Tigris Rivers, which in turn supply the Mesopotamia region with needed water. The mountainous southern coasts of the Black and Caspian Seas, and eastern coast of the Mediterranean Sea, are experience upslope seasonal precipitation. Although, the Red Sea and Persian Gulf acting as powerful sources of water vapor trigger little precipitation locally due to descending air in the Hadley cell. Because latitudinal position of the interior steppe and deserts of Syria, Iraq, Jordan and Saudi Arabia, are made still drier by the surrounding mountain ranges (Evans et al 2004). Convective precipitation occurs on the Anatolian plateau and the steppes of northern Syria which experience receive small quantities of rain in summer season. Equatorial convectional rains provide the waters of the White Nile. Northward migration of inter-tropical convergence zone (ITCZ) in summer season is affected southern region of the Arabian Peninsula. Frontal precipitation particularly in the wintertime occurs mainly in the Northern region of the Middle East and sometimes extending to the south region depending on the deepening of frontal depression. Frontal systems passage from west to east across the region bringing alternating high and low pressure cells. Frontal systems are propelled eastward by the subtropical jet stream.

Surface winds in the Middle East have distinctive qualities and have received local names famous throughout the region. The cold northern wind blowing from the Anatolian plateau to the southern Turkish shore in the winter is the Poyraz (derived from the Greek: bora, i.e., north); the warm on-shore wind in the same location is known as the meltem. Searing desert winds are infamous: The Egyptian Khamasine, which blows in from the desert, is matched by the Ghibli in Libya and the Simoon in Iran.

The rest of the article is arranged in the following way. Regional climate in the Middle East is discussed (section 2). Dust Storms over the Middle East and its impact is described (section 3). Climate change and future climate over the Middle East are explained (section 4). Climate Change Impacts on Water Resources in Middle East is illustrated (section 5). Circulation systems affect the climate of Middle East is described in detail (section 6). Finally, a summary and conclusion are given (section 7).

2. Regional Climate in the Middle East

2.1 Climate of Egypt

Egypt is located in the northern part of Africa; however, it includes the Sinai Peninsula, which is considered part of Southwest Asia (Figure 2). Therefore, Egypt is located in both North Africa and Southwest Asia. Egypt has shorelines on the Mediterranean Sea and the Red Sea. It borders Libya to the west, Sudan to the south, and the Gaza Strip and Israel to the east. Egypt is covering 1,001,449 square kilometers of land. Its longest distance from north to south is 1,024 kilometers, and from east to west is 1,240 kilometers. Egypt's natural boundaries consist of more than 2,900 kilometers of coastline along the Mediterranean Sea, the Gulf of Suez, the Gulf of Aqaba and the Red Sea.

Figure 2: Map of Egypt (http://www.climate-zone.com/climate/egypt/)

Egypt, the North African country, has a weather that is characteristic of the arid to semiarid regions. Egypt has four seasons, Summer, Winter, Autumn and Spring. The climate of Egypt in the winter season (December–February) is cold, moist and rainy while in the summer season (June–August) the climate is hot, dry and rainless, and clear skies, prevail. The main features in the spring season (March–May) are the desert or Khamasine depressions. These winds usually originate in the low-pressure regions which create over Atlas Mountain and move towards the North African coast. They are always associated with strong, hot and dry winds (140 kilometers per hour) that are often laden with dust and sand, increasing the atmospheric pollution. These erratic winds and sandstorms may even persist for numerous days, thus disrupting regular life and damaging crops and properties. The climate in autumn season (September–November) is similar to that in spring as it is another transitional season. Khamasine-like depressions begin to cross Egypt during late September and cause a breakdown of the settled summer regime. On the other hand, the higher humidity in this season favors greater frequency of thunderstorms and heavier precipitation, a fact especially true in November.

The circulation pattern may be determined or powerful influence on weather and climate over Egypt. In winter the polar low pressure system (Iceland low) and subtropical high pressure are affected the weather over Egypt. In summer season the low pressure system (Indian monsoon low) and also subtropical high pressure are prevailing, which act as swim i.e. when Indian monsoon is dominant the subtropical high pressure is go back and vice versa. In Spring and Autumn season the Sudan monsoon low in the south and may be a Mediterranean low pressure in north are invaded.

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Bibliography

Abdel Basset, H., 2001: Energy conversions of a desert depression. Meteorol. Atmos. Phys. Vol.76, 203-222

Abdel Basset, H. and Hasanean, H.M., 2006: Heat waves over Egypt during the summer of 1998. Int. J. Meteor. Vol.31, No.308, 133-145.

Abdullah, M. A., Al-Mazroui., M. A., 1998: Climatological study of the southwestern region of Saudi Arabia. I. Rainfall analysis. Climate Research, 9: 213-223.

Abdul Salam, M, .and Al Mazrooei S., 2007: Changing Patterns of Climate in Kuwait. Asian Journal of Water, Environment and Pollution, Vol. 4, No. 1, pp. 119-124.

Aboukhaled, A., Sarraf, S., 1970. A comparison of water use for a hybrid corn in the Bekaa and the coastal plain. Magon 12, 1-14.

Ahrens, C.D. 1998. Essentials of Meteorology, an In6itation to the Atmosphere, 2nd edition, Wadsworth Publishing Company, 443pp.

AkyoL, İ. H., 1944: Türkiye'de Basınç, Rüzgarlar ve Yağış Rejimi, Türk Coğrafya Derg. C: 2, S:5-6, s:1-34, İstanbul.

Alamodi, A. O., Mashat, A., S. and Abdel Basset, H.M., 2008: On the relation between atmospheric pressure systems and rainfall prediction over the Kingdom of Saudi Arabia. Project Number: 302/427 is supported from King Abdelaziz University, Kingdom of Saudi Arabia.

Al-Falahi, A.A., 2008: Middle East Water and Livelihoods Initiative. ICARDA, Aleppo 7-9 July, 2008.

Alkolibi FM. 2002. Possible effects of global warming on agriculture and water resources in Saudi Arabia: impacts and responses. Climatic Change 54: 225–245.

Al Kulaib, A.A., 1984: The Climate of Kuwait. Directorate General of Civil Aviation, Meteorological

Department, Kuwait, pp. 178.

Almazroui, M. A., Al Khalaf, A. K., Abdel Basset H.M., and Hasanean H.M., 2009: Detecting Climate Change Signals in Saudi Arabia Using Surface Temperature. Project Number (305/428) is supported from King Abdelaziz University, Kingdom of Saudi Arabia.

Alpert, P. and Reisin, T. 1986: An early winter polar air mass penetration to the eastern Mediterranean, Mon. Weather Rev., 114, 1411–1418.

Alpert, P., Neeman, B.U. and Shay-El, Y. 1990. 'Climatological analysis of Mediterranean cyclones using ECMWF data', Tellus, 42A, 65–77.

Alpert P. and Ganor, E., 2001: Sahara mineral dust measurements from TOMS Comparison to surface observations over the Middle East for the extreme dust storm, March 14-17, 1998. J. Geophys. Res. Vol. 106, No. D16, pp18,275-18,286.

Alpert, P., Ben-Gai, T., Baharad, A., Benjamini, Y., Yekutieli, D., Colacino, M., Diodato, L., Ramis, C., Homar, V., Romero, R., Michaelides, S., Manes, A., 2002: The paradoxical increase of Mediterranean extreme daily rainfall in spite of decrease in total values. Geophys. Res. Lett. 29 (11), 31-1–31-4 (June issue).

Alpert, P., Osetinsky, I., Ziv, B., Shafir, H., 2004: Semi-objective classification for daily synoptic systems: application to the Eastern Mediterranean climate change. Int. J. Climatol. 24, 1001–1011.

Alpert, P., Price, C., Krichak, S.O., Ziv, B., Saaroni, H., Osetinsky, I., Barkan, J., Kishcha, P., 2005: Tropical tele-connections to the Mediterranean climate and weather. Adv. Geosci. 2, 157–160.

Alpert, P., Ilani, R., da-Silva, A., Rudack, A., and Mandel, M. 2006: Seasonal prediction for Israel winter precipitation based on northern hemispheric EOF, MERCHAVIM special issue, 397–412.

Alpert, P. Krichak, S.O. Shafir, H. Haim, D. Osetinsky, I., 2008: Climatic trends to extremes employing regional modeling and statistical interpretation over the E. Mediterranean. Global and Planetary Change 63, 163–170.

Al-Zidjali, T.M., 1996: Country report to the FAO, International technical conference on plant genetic resources, Leipzig,1996.

Amanatidis, G. T., Paliatsos, A. G., Repapis, C. C. and Bartzis, J. G. 1993: Decreasing precipitation trend in the Marathon area, Greece. Int. J. Climatol., 13:191-201.

Ardekani, H., 1972: The South-West Monsoon: Reading University, Reading, Berkshire, England.

Arkin, P.A, Cullen, H.M., Xie, P, 2002: A diagnostic study of oceanic precipitation variability associated with the North Atlantic Oscillation. 1st Workshop, Madrid, Spain, 23-27 September 2002.

Aslan, Z., 2004: Climatological Changing Effects on Wind, Precipitation and Erosion: Large, Meso and Small Scale Analysis. ICTP Lecture Notes Series, Volume 18.

Babikir, A. A. A., 1985: On the distribution of rainfall over the Sultanate of Oman. GeoJournal, Vol. 11, No 2, 165-172.

Barrett, B. S., 2006: Relationship between sea-surface temperature anomalies and precipitation across Turkey, 1st International Conference on Climate Change and the Middle East: Past, Present, and Future, Istanbul Technical University, Istanbul, Turkey .

Barth., H, rank Steinkohl., F., 2004: Origin of winter precipitation in the central coastal lowlands of Saudi Arabia. Journal of Arid Environments, 57, 101–115.

Ben-Gai, T., Bitan, A., Manes, A., Alpert, P., 1993: Long-term change in October rainfall patterns in southern Israel. Theor. Appl. Climatol. 46, 209–217.

Ben-Gai, T. Bitan, A., Manes, A. and Albert, P.1994: Long-term change in annual rainfall patterns in Southern Israel. Theor. Appl. Climatol., 49:59-67.

Ben-Gai, T, Bitan, A, Manes, A, Alpert, P, Israeli, A., 1998: Aircraft measurements of surface albedo in relation to climate change in southern Israel. Theor. Appl. Climatol. Vol. 61, 177-190

Ben-Gai, T., Bitan, A., Manes, A., Alpert, P., Rubin, S., 1999: Temporal and spatial trends of temperature patterns in Israel. Theor. Appl. Climatol. Vol. 64, 163–177.

Ben-Gai, T., Bitan, A., Manes, A., Alpert, P., Rubin, S., 2001: Temperature and surface pressure anomalies in Israel and the North Atlantic Oscillation. Theor. Appl. Climatol. 69, 171–177.

Bina, M. 1994. 'Water resources, utilization, problems and development in Iran', Preprints of papers combining the XXV Congress of the International Association of Hydrogeologists with the International Hydrology and Water Resources Symposium of the Institution of Engineers, Adelaide, Australia, Vol. 1, pp. 391–397.

Bitan, A. and Saaroni, H. 1990: The unusual rain spell of October 1985. Isr. J. Earth Sci., 39, 33–46.

Boer, B., 1997: An introduction to the climate of the United Arab Emirates (Review). Journal of Arid Environments, 35: 3–16

Briffa, K.R., Osborn, T.J., Schweingruber, F.H., Harris, I.C., Jones, P.D., Shiyatov, S.G., Vaganov, E.A., 2001: Low-frequency temperature variations from a northern tree ring density network. J. Geophys. Res., 106 D3, 2929-2941.

Brooks, D. B. and Mehmet, O., eds., 2000: Water balances in the Eastern Mediterranean. Inter-national Development Research Center, Ottawa, Ont.

Bürger, G., and Cubasch, U., 2005: Are multiproxy climate reconstructions robust?, Geophys. Res. Lett., 32, L23711

Businger, S, Reed, R.J., 1989: Cyclogenesis in cold air masses. Weather Forecast 4: 133–156

Chakraborty, A., Mujumdar, M., Behera, S. K., Ohba, R., and Yamagata, T., 2006: A cyclone over Saudi Arabia on 5 January 2002: A case study Meteorol Atmos Phys 93, 115–122.

Cicek, I. and Turkoglu, n., (2005): Urban effect precipitation in Ankra. Atmosfera, 18(3), 173-187.

Cohen S, Stunhill G. 1996. Contemporary climate change in the Jordan Valley. Journal of Applied Meteorology 35: 1051–1058.

Corte-Real, J. Zhang, X. and Wong, Y. 1995: Large-scale circulation regimes and surface climate anomalies over the Mediterranean. Int. J. Climatol. 15:1135-1150.

Crowley, T.J. and Lowery, T., 2000: How warm was the Medieval warm period? Ambio, 29, 51-54.

CSIRO for the Australian Greenhouse Office, Department of the Environment and Heritage, 2006: How unusual is the late 20th century warming? (http://www.climatechange.gov.au/science/ hottopics/)

Cullen, H.M. and P.B. deMenocal, 2000: North Atlantic influence on Tigris-Euphrates stream flow, Int. J. Climatol. 20, 853.

Cullen, H.M., A. Kaplan, P.A. Arkin and P.B. deMenocal, 2002: Impact of the North Atlantic Oscillation on Middle Eastern climate and stream flow, Climatic Change 55, 315-338.

Davidson, K., 2003: Sandstorms- Test of True Grit, San Francisco Chronicle, p. 15, March 18, 2003.

Dayan, U, Heffter, J., Miller, J. and Gutman, G., 1991: Dust Intrusion Events into the Mediterranean Basin. J Appl Meteorol Vol. 30, 1185–1199.

Dayan, U. and Koch, J., 1999: Implications of Climate Change on the Coastal Region of Israel. Mediterranean Action Plan, United Nations Environment Programme.

Dayan, U. and Rodnizki, J. 1999: The temporal behavior of the atmospheric boundary layer in Israel. J. Appl. Meteor., 38, 830–836.

D'Arrigo, R.D. and H.M. Cullen, 2001: A 350-year (AD 1628-1980) reconstruction of Turkish precipitation, Dendrochronologia 19, 167.

De Pauw, E., 2002: An Agroecological Exploration of the Arabian Peninsula. ICARDA, Aleppo, Syria. pp77.

Delworth, T., Manabe, S. and Stouffer, R. J., 1993: Interdecadal variations of the thermohaline circulation in a coupled ocean-atmosphere model, J. Climate, Vol. 6, 1993-2011.

Drosdowsky, W. 1993: The analysis of Australian seasonal rainfall anomalies. 1950-1987 II: Temporal variability and teleconnection patterns. Int. J. Climatol., 13:111-149.

Edgell, H. S., 2006: Arabian Deserts: Nature, Origin, and Evaluation. Springer.

Elagib NA, Addin Abdu AS. 1997. Climate variability and aridity in Bahrain. Journal of Arid Environment 36: 405–419.

El-Fandy, M.G., 1940: The formation of depression of the Khamsin type. Q. J. R. Meteorol. Soc. 66: 323-335

El-Fandy, M. G., 1946: Barometeric low of Cyprus. Quart. J. R. Met. Soc., 7, 291-306.

El-Kadi, A.K.A., 2001: Variation of rainfall and drought conditions in Gaza-Palestine: On a regional and global context. Journal of the Islamic University of Gaza v. 9 no. 2, pp41–66.

Eltahir, E.A.B. and G. Wang, 1999: Nilometers, El Nino, and Climate variability, Geophys. Res. Lett. 26, 489.

El-Tantawy AI (1964) The role of jet stream in the formation of desert depression in the Middle East, WMO Tech. Note 64, 159-171, World Meteorol. Organ, Geneva, Switzerland.

El-Tantawy AI (1969) On the cyclogenesis and structure of spring desert depressions in subtropical Africa, Meteorol Res Bull 69: 68-107, Dep of Meteorol, United Arab Republic, Cairo.

Essa, A., 1989: Climate of Bahrain 1902–1988. Bahrain: Al-Fager Printing and Publications. (In Arabic). 131 pp.

Evans, J.P., Smith, R.B. and Oglesby, R.J., 2004; Middle East Climate Simulation and Dominant Precipitation Processes. Int. J. Climatol. 24: 1671–1694.

Evans, J. P., 2009: Global warming impact on the dominant precipitation processes in the Middle East. Theor Appl Climatol, Paper online view.

Farquharson, F. A. K., Plinston, D. T. and Sutcliffe, J. V., 1996: Rainfall and runoff in Yemen. Hydmlegical Sciences -Journal- des Sciences Hjdmlogiques.

Felis, T., J. Pätzold, Y. Loya, M. Fine, A.H. Nawar and G. Wefer, 2000: A coral oxygen isotope record from the northern Red Sea documenting NAO, ENSO, and North Pacific teleconnections on Middle East climate variability since the year 1750, Paleoceanography 15, 679.

Felis, T., G. Lohmann, H. Kuhnert, S.J. Lorenz, D. Scholz, J. Pätzold, S.A. Al-Rousan and S.M. Al-Moghrabi, 2004: Increased seasonality in Middle East temperatures during the last interglacial period, Nature 429, 164.

Fisher M, Membery, D.A., 1998: Climate. In Vegetation of the Arabian Peninsula, Ghazanfar SA, Fisher M (eds). Kluwer Academic Press: Netherlands; 5–38.

Findlater, J., 1969: Inter-hemispheric transport of air in lower troposphere over Western Indian Ocean. Q. J. R. Meteorol. Soc., Vol. 95, 362–380.

Flamant, C. and Pelan, J. 1996: Atmospheric boundary-layer structure over the Mediterranean during Tramontane event. Q. J. R. Meteorol. Soc., 122:1741-1778.

Fleitmann, D., Burns, J.S., Mudelsee, M., Neff, U., Kramers, J., Mangini, A., and Matter, A., 2003: Holocene forcing of the Indian Monsoon recorded in a Stalagmite from Southern Oman. Science, Vol. 300., pp 1737-1739.

Fleitmanna, D., Burnsb, S.J. Manginic, A., Mudelseed, M., Kramersa, J., Villaa, I., Neffc, U., Al-Subbarye, A.A., Buettnera, A., Hipplera, D., Matter, A., 2007: Holocene ITCZ and Indian monsoon dynamics recorded in stalagmites from Oman and Yemen (Socotra). Quaternary Science Reviews 26 (2007) 170–188.

Freiwana M, Kadioglu, M. 2008a: Climate variability in Jordan. International Journal of Climatology.28: 69–89.

Freiwana M, and Kadioglu, M, 2008b: Spatial and temporal analysis of climatological data in Jordan. Int. J. Climatol. 28: 521–535.

Fryrear, D.W., 1981: Long–term effect of erosion and cropping on soil productivity. Geological Societyof America Vol. 186, 253–259.

Fu G, Niino H, Kimura R, Kato T., 2004: A polar low over the Japan Sea on 21 January 1997, part I: observational analysis. Mon. Wea. Rev. 132: 1537–1551.

Fu, C., Diaz, H. F, Dong, D., Fletcher, J. O., 1999: Changes in atmospheric circulation over northern hemisphere oceans associated with the rapid warming of the 1920s. Int. J. Climatol., Vol. 19, 581–606.

Gagin, A. and Gabriel, K. R. 1987: Analysis of recording rain gage data for the Israeli II experiment. Part 1: effects of cloud seeding on the component of daily rainfall. J. Climate and Appl. Meteorol., 26:913-921.

Gasse, F., Fontes, J.C., VanCampo, E., Wei, K., 1996: Holocene environmental changes in Bangong Co basin (western Tibet).4.Discussion and Conclusions: Palaeogeography Palaeoclimatolog Palaeoecology 120, 79–92.

Ghahraman, B., 2006: Time trend in the mean annual temperature of Iran. Turk J. Agric. Vol. 30, 439-448

Ghasemi A. R and Khalili, D., 2006: The influence of the Arctic Oscillation on winter temperatures in Iran. Theor. Appl. Climatol. 85, 149–164.

Ghazanfar, S.A., 1997: The phenology of desert plants: a 3-year study in a gravel desert wadi in northern Oman. Journal of Arid Environments 35: 407–417.

Ghazanfar, S.A. and Fisher, M., 1998: Vegetation of the Arabian Peninsula. Kluwer Academic Publishers.

Ghohroudi, T, M. a 2008: Comparative Study Climatic Changes with Contemporary Basin River Changes in Iran. 13th IWRA World Water Congress, 2008, 1-4 September, Montpellier, France. (http://wwc2008.msem.univ-montp2.fr/resource/authors/abs80_article.pdf)

Goldreich, Y. 1987: Temporal changes in the spatial distributions of rainfall in the Central coastal plain of Israel. In Recent climate change-A regional approach, ed. S. Gregory, 116-124. London: Belhaven.

Goldreich, Y., 1995: Temporal variations of rainfall in Israel (Review). Climate Research Vol. 5: 167-179.

Goldreich, Y. and Manes, A. 1979: Urban effects on precipitation patterns in Greater Tel-Aviv area. Arch. Met. Geoph. Biockl., Ser. B., 27:213-234.

Goudie, A. 1990: The Nature of the En6ironment, 2nd edition, Basil Blackwell, London, 370 pp.

Grumm, 2003: Southwest Asian Dust Storm of 25-27 March 2003 (nws.met.psu.edu/severe/2003/ 25Mar-Dust.pdf)

Gullu,G., Dogan, G., Tuncel, G., 2005: Source Regions of Dust Transported to the Eastern Mediterranean. Proceedings of the Third International Symposium on Air quality Management at Urban

Regional and Global Scales. 26-30 September 2005, Istanbul-Turkey.

Habib, E.; Elsayed, E. A.; Abdel-Motaleb, M., 2008: Rainfall-Runoff Simulations in Arid Catchments in Sinai Peninsula, Egypt, using a Distributed Physically-based Hydrologic Model. American Geophysical Union, Spring Meeting 2008

Hafez, Y. Y., and H.M. Hasanean, 2000: The variability of winter precipitation in the Northern coast of Egypt and its relationship with the North Atlantic Oscillation. ICEHM2000, September, 2000, page175-186.

Hafez, Y. Y., 1995: Impact study concerning the effect of blocking highs persisting over eastern Europe on weather in Egypt. M. Sc. THESIS, Faculty of Scien0ce, Cairo University, Egypt.

Hafez, Y. Y., 1999a: On the characteristics of blocking highs that persist over Europe in winter. The fourth conference, "Meteorology and Sustainable Development to 21st Century, 15-33, 7-9, March 1999, EMA, Egypt.

Hagen, L.J. and Woodruff, N.P. 1973: Air pollution from dust storms in the Great Plains. Atmos Environ Vol. 7, 323–332.

Hakim, G.J., and L.W. Uccellini, 1992: Diagnosing Coupled Jet-Streak Circulations for a Northern Plains Snow Band from the Operational Nested Grid Model. Wea. and Forecasting, Vol. 7, 26-48.

Halpert, M. S. and Ropelewski, C. F., 1992: Surface Temperature Patterns Associated with the Southern Oscillation. J. Climate Vol. 5, 577–593.

Harley, D.G., 1960: Frontal contour analysis of polar low. Meteorol Mag 89: 146–147

Hassan AA (1974) A diagnostic study of a northern African depression, PhD thesis, University of Reading, UK (unpublished).

Hasanean HM. 2001. Fluctuations of surface air temperature in the east Mediterranean. Theoretical and Applied Climatology 68(1–2): 75–87.

Hasanean, H., .M., 2003: Teleconnection between global climatic events, atmospheric circulation change and stream flow over the River Nile. J. Meteorology, Vol. 28, No. 279, 161-177.

Hasanean, H., .M., 2004: Winter surface temperature in Egypt in relation to the associated atmospheric circulation. Int. J. Climatol. 24: 985–999.

Hasanean, H.M., 2005: Variability of teleconnections between the Atlantic subtropical high and the Indian monsoon low and related impacts on summer temperature over Egypt. Atmos. Sci. Let. 6: 176–182.

Hasanean, H., M., and Abdel Basset H., 2006: Variability of summer temperature over Egypt. Int. J. Climatol. 26: 1619–1634.

Hasanean, H., M., 2008: Large-scale circulation anomaly indices in relation to very high temperature in Egypt during summer season 1998 (A case study). The International Journal of Meteorology. Vol.33, No.327, 75-87.

Herman, J. R., P. K. Bhartia, O. Torres, C. Hsu, C. Seftor, and E. Celarier, 1997: Global distribution of UV-absorbing aerosols from Nimbus-7/TOMS data, J. Geophys. Res., 102, 16,911–16,922.

Herzog, M., 1998: Shrubland Management in Tribal Islamic Yemen. Social Forestry as Development of a Local and Sustainable (Sylvi-)Culture. An Essay in Practical Philosophy. A short photo-report on forestry-development in Yemen, (http://www.brainworker.ch/reports/yemen/index.htm#TOC).

Hoskins, B.J., Pedder, M.A., 1980: The diagnosis of middle latitude synoptic development. Quart J Roy Meteor Soc 106: 707–719

Hou, A. Y., 1998: Hadley circulation as a modulator of the extratropical climate. J Atmos Sci 15: 2437-2457.

Houghton, J.T, Callander, B.A, Varney, S.K. (eds), 1992: Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. Cambridge University Press: Cambridge.

Hunt, B.G. and Davies, H. L. 1997: Mechanism of multi-decadel climatic variability in a global climatic model. Int. J. Climatol., 17, 565-580.

Hurrell, J.W., 1995: Decadal Trends in the North Atlantic Oscillation: Regional Temperatures and Precipitation. Science: Vol. 269, 676-679.

Hurrell, J.W. and H. van Loon, 1997: Decadal Variations associated with the North Atlantic Oscillation. Climatic Change: Vol. 36, 301-326.

Hurrell, J.W, Hoerling, M.P., and Folland, C.K., 2000 Climatic Variability over the North Atlantic "Meteorology at the Millennium" Editor, R. Pearce.

Hurrell, J. W., K., Ottersen, G., Visbeck, M. (editors) 2003: The North Atlantic Oscillation Climatic Significance and Environmental Impact. Geophysical Monograph 134, ISBN 0-87590-994-9.

Idso, S.B., 1976: Dust storms. Scientific American, 235 (4):108-11, 113-14.

IPCC, 1991: Climate Change, The IPCC Scientific Assessment, Cambridge Uni. Press, U.K.

IPCC, 1996: 'Climate Change 1995', in Houghton, J. T. et al. (eds.), The Science of Climate Change, Cambridge University Press, Cambridge. U.K.

IPCC-WGI, 1996a: Climate change 1995: Impacts, adaptation and mitigation of climate change, scientific-technical analyses. Cambridge University Press, Cambridge, U.K.

IPCC-WGI, 1996b: Climate change 1995: The science of climate change. Cambridge University Press, Cambridge, U.K.

IPCC-WGII, 1996 Climate Change 1995-Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses - IPCC Second Assessment Report. Cambridge University Press,Cambridge, U.K.

IPCC-WGI, 1999: Aviation and the Global Atmosphere - IPCC Special Report. Cambridge University Press, Cambridge., U.K.

IPCC-DCC, 1999: Intergovernmental Panel for Climate Change, Data Distribution Center (IPCC-DCC) (1999). (http://ipcc-dcc.cru.uea.ac.uk>. (Feb. 24, 2000)

IPCC, Climate Change, 2001: The Scientific Basis, Contribution of WG I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K.

Israel Meteorological Service, 1967: Climatological Standard Normals of Rainfall 1931 –1960, Series A, No. 21, Bet Dagan.

Issar, A. S., 1995: Climatic change and the history of the Middle East. American Scientist 83: 350-355.

Jacobeit J., 2000: Petermanns Geographische Mitteilungen, 144, 22.

Jauregui E., 1989: The dust storms of Mexico City. Intl. J. Climatol. Vol.9, 169–180.

Jones, P.D., 1995: Maximum and minimum temperature trends in Ireland, Italy, Thailand, Turkey and Bangladesh. Atmospheric Research 37, 67-78.

Jones, R.G., Murphy, J.M., Noguer, M., and Keen, A.B., 1997: Simulation of climate change over Europe using a nested regional-climate model. II: comparison of driving and regional model responses to a doubling of carbon dioxide." Q. J. Roy. Meteo. Soc., Vol. 123 No.538, 265.

Jones, P.D., Briffa, K.R., Barnett T.P. and Tett, S.F.B., 1998: High-resolution palaeoclimatic records for the last millennium: interpretation, integration and comparison with General Circulation Model control run temperatures. The Holocene, 8, 455-471.

Kadioglu, M., 1997: Trends in surface air temperature data over Turkey. Int. J. Climatol., VOL. 17, 511–520.

Kadioglu, M., Ozturk, N., Erdun, H. and Sen, Z., 1999: On the precipitation climatology of Turkey by harmonic analysis. Int. J. Climatol. 19: 1717–1728.

Kadioglu M, Tulunay Y, Borhan Y. 1999. Variability of Turkish precipitation compared to El Nino

events. Geophysical Research Letters 26: 1597–1600.

Kadioglu, M, Sen, Z. and Gültekin, L., 2001: Variations and Trends in Turkish Seasonal Heating and Cooling Degree-Days. Climate change, Vol. 49, Numbers 1-2, 209-223

Kadioglu, M. and Saylan, L., 2001: Trends of growing degree-days in Turkey. Water, air and soil pollution. 2001, vol. 126, no1-2, pp. 83-96

Kahya E. and Karabork M¸ C. 2001. The analysis of El Nino and La Nina signals in streamflows of Turkey. Int. J. Climatol. Vol.21, 1231–1250.

Kaplan, M L., Lin, Y., Hamilton, D. W. and Rozumalski, R. A., 1998: The Numerical Simulation of an Unbalanced Jetlet and Its Role in the Palm Sunday 1994 Tornado Outbreak in Alabama and Georgia. Mon. Wea. Rev., Vol. 126, 2133-2165.

Kappus, U., Bleeks, J. M., Blair, S., H., 1978: Rainfall frequencies for the Persian Gulf coast of Iran. Hydrological Sciences-Bulletin-des Sciences Hydrologiques, 23,1-3, 119-129pp.

Karaca M, Deniz A, and Tayanc M. 2000. Cyclone track variability over Turkey in association with regional climate. Int. J. Climatol. Vol. 20, 122–136.

Karabork, M.C. and Kahya, E, 2003: The teleconnections between the extreme phases of the southern oscillation and precipitation over Turkey. Int. J. Climatol. 23: 1607–1625. Karl, T.R. and Trenberth, K.E., 2002: Mensch und Klima. Spektrum der Wissenschaften Klima—Dossier 1, 12–17.

Katsenelson, J. 1969: Rainfall in Israel as a Basic Factor in the Water Budget of the Country, Series A, No. 24, Israel Meteorological Service, Bet Dagan (in Hebrew).

Kiladis, G.N. and Diaz, H.F., 1989: Global climate anomalies associated with extremes in the southern oscillation. Journal of Climate Vol.2, 1069–1090.

Khalili, A. 1992: Fundamental Study of Iranian Water Resources, Climatological Understanding of Iran, Parts 1 and 2. Jamab consultant reports, the Iranian Ministry of Energy (in Persian).

Kondrashov, D., Feliks, Y. and Ghil, M. 2005. Oscillatory modes of extended Nile River records (A.D. 622-1922). Geophysical Research Letters 32: doi:10.1029/2004 GL022156.

Koppen, W. and Geiger, R., 1928: Klimakarte der Erde. Gotha.

Kozuchowski, K. M., 1993: Variations of hemispheric zonal index since 1899 and its relationships with air temperature. Int. J. Climatol., Vol. 13, 853–864.

Krichak, S.O., Alpert, P., 2005a: Decadal trends in the East Atlantic/West Russia pattern and the Mediterranean precipitation. Int. J. Climatol. 25, 183–192.

Krichak, S.O., Alpert, P., 2005b: Signatures of the NAO in the atmospheric circulation during wet winter months over the Mediterranean region. Theor. Appl. Climatol. 82 (1–2), 27–39.

Krichak, S.O., Kishcha, P., Alpert, P., 2002: Decadal trends of main Eurasian oscillations and the Mediterranean precipitation. Theor. Appl. Climatol. 72, 209–220.

Kushnir, Y., 1994: Interdecadal Variations in North Atlantic Sea Surface Temperature and Associated Atmospheric Conditions. Vol. 7., No. 1, 141-157.

Kutiel, H.1990. Variability of factors and their possible application to climatic studies. Theor. Appl. Climatol., 42:169-175.

Kutiel, H.1991. Recent spatial and temporal variations in mean sea level pressure over Europe and the Middle East and their influence on the rainfall regime in the Galilee, Israel. Theor. Appl. Climatol., 44:151-166.

Kutiel, H. and Sharon, D. 1981: Diurnal variation in the spatial structure of rainfall in the northern Negev Desert, Israel. Arch. Meteorol. Geophys. Bioklimatol., Ser. B, 29, 239–243.

Kutiel, H. and Kay, P.A. 1992: Recent variations in 700 hPa geopotential heights in summer over Europe and the Middle East, and their influence on other meteorological factors. Theor. Appl. Climatol., 46, 99–108.

Kutiel, H. Maheras, P. and Guika, S. 1996: Circulation and extreme rainfall conditions in the Eastern Mediterranean during the last century. Int. J. Climatol., 16:73-92

Kutiel, H. and Furman, H., 2003: Dust Storms in the Middle East: Sources of Origin and their Temporal Characteristics. Indoor Built Environ. Vol.12, 419–426.

Kwarteng, A. Y., Dorvlo, A.S., and Kumar, G.T.V, 2009: Analysis of a 27-year rainfall data (1977–2003) in the Sultanate of Oman. Int. J. Climatol. 29: 605–617.

Lapin M., 1995. Climatological Monitoring of Territory Affected by Construction of the Danube Hydroelectric Power Project and Evaluation of Initial Impact. Gabcyvo Part of the Hydroelectric Power Project - Environmental Impact Review. Faculty of Natural Sciences, Comenius University, Bratislava, 15-22. URL: http://www.mpsr.sk/slovak/dok/gn/book/03kap/03kap.htm.

Lashof, D.A., DeAngelo,B. J., Saleska, S.R., and Harte, J., 1997: Terrestrial Ecosystem Feedbacks to Global Climate Change, Annu. Rev. Energy Environ. Vol. 22, 75-118.

Laurent Z. and Li, X., 2006: Atmospheric GCM response to an idealized anomaly of the Mediterranean sea surface temperature. Climate Dynamics (2006) 27: 543–552

Lee, T.P., Silberg, S.R., and Bosart, L.F., 1988: A case study of a severe winter storm in the Middle East. Quart J Roy Meteor Soc 114: 61–90.

Leslie, L. M. and Speer, M. S., 2005: Changes in dust storm occurrence over Eastern Australia 1950 to 2004, Proceedings of the Third International Symposium on Air Quality Management at Urban Regional and Global Scales. 26-30 September 2005, Istanbul-Turkey.

Liu CM, and Ou, S.S., 1990: Effects of tropospheric aerosols on the Solar radiative heating in a clear atmosphere. Theor. Appl. Climatol. Vol.41, 97–106.

Liu, Y.M, Wu, G.X, Liu, H and Liu, P., 2001: Dynamical effects of condensation heating on the subtropical anticyclones in the Eastern Hemisphere. Climate Dynamics, Vol. 17, 327–338.

Lolis, C. J., Bartzokas, A. and Metaxas, D. A., 1999: Spatial co-variability of the climatic parameters in the Greek area. Int. J. Climatol., Vol. 19, 185-196.

Lonergan, S.C. and Brooks, D.B., 1994: Watershed: The role of fresh water in the Israeli Palestinian Conflict. International Development Research Center. Ottawa, Ontario, Canada.

Luterbacher, J., Schmutz, C. Gyalistras, D. Xoplaki, E. and Wanner, H., 1999: Reconstruction of monthly NAO and EU indices back to AD 1675. Geophys. Res. Lett., Vol. 26, 2745-2748.

Luterbacher, J., and Xoplaki, E., 2003: 500-year winter temperature and precipitation variability over the Mediterranean area and its connection to the large-scale atmospheric circulation. In Bolle, H.-J. (Ed): Mediterranean Climate - Variability and Trends. Springer Verlag, Berlin, Heidelberg, pp. 133-153.

Makrogiannis, T. T., Sahsamanoglou, H. S., Flocas, A. A., Bloutosos, A. A. 1991: Analysis of monthly zonal index values and long-term changes of circulation over the North-Atlantic and Europe. Int. J. Climatol., 11:493-503.

Malekifard,F, Rezazadeh P: http://balwois.com/balwois/administration/full_paper/ffp-465.pdf

Mann, M. E. and Park, J., 1996: Joint spatialtemporal modes of surface temperature and sea-levelpressure variability in the Northern Hemisphere during the last century. J. Clim., Vol. 9, 2137–2162.

Mann, M.E., R.S. Bradley and M.K. Hughes, 1998: Global-scale temperature patterns and climate forcing over the past six centuries, Nature 392, 779-787.

Mann, M.E., 2002b: Large-scale climate variability and connections with the Middle East in past centuries, Climatic Change 55, 287.

Mann, M. E., 2002: The Value of Multiple Proxies, Science, 297, 1481– 1482.

Mann, M.E. and Jones, P.D., 2003: Global surface temperatures over the past two millennia. Geophys. Res. Lett., 30 (15), 1820-1823.

Marcella M., P., and Eltahir, A., B., E., 2008: The Hydro-climatology of Kuwait: Explaining the

Variability of Rainfall at Seasonal and Inter-annual Time Scales. Journal of hydrometeorology, Vol. 9, 1095-1105.

Mariotti A, Zeng N, Lau K-M, 2002: Euro-Mediterranean rainfall and ENSO - a seasonally varying relationship. Geophysical Research Letters, 29 (12) 10.1029/2001GL014248

Mariotti A, Ballabrera-Poy J, Zeng N, 2005: Tropical influence on Euro-Asian autumn rainfall. Climate Dynamics, 24 (5) 10.1007/s00382-004-0498-6: 511-521.

Martyn D. 1992: Development in Atmospheric Science: Climates of the World. 18, Elsevier, New York.

Menzel, L., Teichert, E., and Weiss, M., 2007: Climate change impact on the water resources of the semi-arid Jordan basin. 3rd International Conference on Climate and Water, Helsinki, 3. - 6. September 2007.

Meteorologıcal Offıce 1962: Weather in The Mediterranien (Volume I), Her Majesty's Stationery Office, M.O. 391, London.

Meteorologıcal Offıce 1963: Weather in The Black Sea, Her Majesty's Stationery Office, M.O. 706, London

Middleton, N.J., 1986:. Dust storms in the Middle East. Journal of Arid Environments 10:83–96.

Middleton, N.J. and Chaudhary, Q.Z., 1988: Severe dust storm at Karachi, 31 May 1986. Weather, Vol. 438, 298–301.

Mitchell, J.M., 1971: The effect of atmospheric particles on radiation and temperature Mathews WH, Kellogg WW, Robinson GD (eds): Man's inspection on the Climate. Cambridge, M.I.T. Press, 1971, pp. 295–301.

Ministry of Water Resources. 1995. Water Resources of the Sultanate of Oman: An Introductory Guide. Ministry of Water Resources: Sultanate of Oman.

Moberg, A., Sonechkin, D., Holmgren, K., Datsenko, N. and Karlen, W., 2005:. Highly variable Northern hemisphere temperatures reconstructed from low- and high-resolution proxy data. Nature,433, 613-617.

Moore, E., 1986: Gardening in the Middle East. London: Stacey International. 144 pp.

Morales, C., 1979: Saharan Dust. Scope 14, New York, John Wiley & Sons, 1979, 297 pp.

Muller, M.J., 1982:. Selected climatic data for a global set of standard stations for vegetation science. In: Lieth, H. (Ed.), Tasks for Vegetation Sciences, Vol. 5. Dordrecht: Kluwer Academic Publishers Group. 306 pp.

Nasrallah HA, Balling RC. 1995: Impact of desertification on temperature trends in the Middle East. Environmental Monitoring and Assessment 37: 265–271.

Nasrallah HA, Nieplova E, Ramadan E. 2004. Warm season extreme temperature events in Kuwait. Journal of Arid Environments 56: 357–371.

Nasrallah H. A., Balling Jr, R. C., Selover, N. J., and R. S. Vose 2001: Development of a seasonal forecast model for Kuwait winter precipitation. Journal of Arid Environments (2001) 48: 233–242

Nazzal, N., 2009: Heavy snowfall on Ras Al Khaimah's Jebel Jais mountain cluster". Gulf News. http://www.gulfnews.com/nation/General/10278477.html. Retrieved on 2009-01-31.

Nazemosadat, M. J.; Cordery, I. and Eslamian, S., 1995: The impact of the Persian Gulf sea surface temperature on Iranian rainfall. The Proceedings of the Regional Conference on Water Resources Management, Isfahan, Iran.

Nazemosadat, M. J., 1998: Persian Gulf Sea Surface Temperature as a Drought Diagnostic for Southern Iran. University of Nebraska – Lincoln, available from (http://digitalcommons.unl.edu/droughtnetnews/55).

Nazemosadat, M. J. and Cordery, I., 2000a: On the relationships between ENSO and autumn rainfall in Iran. Int. J. Climatol, 1, 47-62.

Nazemosadat, M. J. and Cordery, I., 2000b: The impact of ENSO on winter rainfall in Iran. Proceedings of the 26th National and 3rd International Hydrology and Water Resources symposium, Inst. Engs.

Australia, 20-23 November, 538-543.

Nazemosadat, M. J. (2001a). Winter rainfall in Iran: ENSO and aloft wind interactions. Iranian Journal of Science and Technology. 25, 611-624.

Nazemosadat, M. J. (2001b). The impact of the Caspian Sea surface temperature on rainfall over northern parts of Iran. Book of Abstracts, 2nd National Conference of the Royal Meteorological Society, 12-14 September, England.

Nazemosadat, M.,J, Ghasemi, A., R., 2004: Quantifying the ENSO Related Shifts in the intensity and probability of Drought and Wet periods in Iran. J Climate 20:4005–4018

Nazemosadat, M. J., Samani, N., Barry, D. A. and Niko, M., M., 2006: ENSO forcing on climate change in Iran: Precipitation analysis. Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 30, No. B4

Nihlen, T, and Lund, S.O., 1995: Influence of aeolian dust on soil formation in the Aegean area. Zeitschrift fur Geomorphologie. Vol. 393, 341–361.

Oliver, J.E, Hidore, J.J., 1984: Climatology. Charles E. Merrill Publishing Company.

Otterman, J., Manes, A., Rubin, S., Alpert, P., Starr, D., 1990: An increase of early rains in Israel following land use change? Bound. Lay. Meteorol. 53, 333–351.

Palutikof, J. P. and Wigley, T. M. L., 1996: Developing climate change scenarios for the Mediterranean region. pp. 27-56 in: Jeftic, L., S. Keckes and J. C. Pernetta (Eds.). Climatic Change and the Mediterranean. Environmental and societal impacts of climatic change and sea-level rise in the Mediterranean region . Vol. 2 (London: Edward Arnold).

Pease, P. P., Tchakerian, V. P. and Tindale, N. W. 1998: Aerosols over the Arabian Sea: Geochemistry and source areas for aeolian transport. Journal of Arid Environments 39:477–96.

Perlin, N. and Alpert, P., 2001. Effects of land-use modification on potential increase of convection — a numerical study in south Israel. J. Geophys. Res. 106, 22,621–22,634.

Pollack, H.N. and Smerdon, J.E., 2004: Borehole climate reconstructions: spatial structure and hemispheric averages. J. Geophys. Res., Vol. 109, D11106.

Price, C., Stone, L., Huppert, A., Rajagopalan, B., Alpert, P., 1998: A possible link between El-Nino and precipitation in Israel. Geophys. Res. Lett. 25 (21), 3963–3966.

Prospero, J. M., and Carlson, T. N., 1981: Saharan air outbreaks over the tropical NorthAtlantic. Pure and Applied Geophysics 119 (3): 677–91.

Qureshi, S and Khan, N., 1994: Estimation of climatic transition in Riyadh (Saudi Arabia) in global warming perspectives. GeoJournal, Vol. 33, No. 4.

Ragab R. and Prudhomme C. 2002. Climate change and water resources management in arid and semi-arid regions: prospective and challenges of the 21st century. Biosystem Engineering 81(1): 3–34.

Rahmstorf, S. and Ganopolski, A., 1999: Long term warming scenarios computed with an efficient coupled climate model. Climate Change 43, 353–367.

Raicich, F., Pinardi, N. and Navarra, A., 2001: Tele-connections between Indian monsoon and Sahel rainfall and the Mediterranean. Archo. Oceanogr. Limnol., Vol. 22, 9-14

Ramaswamy, V. et al., 2001: Radiative Forcing of Climate Change, in: Climate Change 2001: The Scientific Basis, J.T. Houghton et al. (Eds.), Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, UK, 2001.

Raziei, T., Arasteh, P., D., and Saghfian, P. 2005: Annual Rainfall Trend in Arid and Semi-arid Regions of Iran. ICID 21st European Regional Conference 2005 - 15-19 May 2005 - Frankfurt (Oder) and Slubice - Germany and Poland.

Rehman, S. and El Gebiely, M, 2008: Study of meteorological parameters of coastal regions of sauid Arabia using wavelets. Proceedings of the 2nd WSEAS International Conference on Wavelets Theory and Applications in Applied Mathematics, Signal Processing and Modern Science, Istanbul, Turkey

pp195-200.

Reddaway, J. M. and Bigg, G. R. 1996: Climatic change over the Mediterranean and links to the more general atmospheric circulation. Int. J. Climatol., 16:651-661.

Rieter, E.R., 1975: Handbook for forecasters in the Mediterranean. Technical Report No. 5–75, Navy Environmental Research and Prediction Facility, Monterey, California 93043, USA

Rehman, S. 2009: Temperature and rainfall variation over Dhahran, Saudi Arabia, (1970–2006). Int. J. Climatol. (Articles online in advance of print)

Rimbu, N., Lohmann, G., Felis, T., and P¨atzold, J., 2001: Arctic Oscillation signature in a Red Sea coral, Geophys. Res. Lett., 28, 2959–2962.

Rimbu, N, Felis, T, Lohmann, G, Pätzold, J, 2006: Winter and summer climate patterns in the European-Middle East during recent centuries as documented in a northern Red Sea coral record. The Holocene, 16, 321-330 (RCOM0344)

Robaa, S.M. and Hasanean, H.M., 2007: Human climates of Egypt. Int. J. Climatol., Vol. 27, 781–792.

Rodwell, M.R, Hoskins, B.J., 2001: Subtropical anticyclones and monsoons. Journal of Climate 14: 3192–3211.

Rogers, J. C., 1984: The Association between the North Atlantic Oscillation and the Southern Oscillation in the Northern Hemisphere. Mon. Wea. Rev. Vol. 112, 1999–2015.

Rogers J.C., 1997: North Atlantic storm track variability and its association to the north Atlantic oscillation and climate variability of northern Europe. Journal of Climate, Vol., 10, 1635–1647.

Ropelewski, C.F. and Halpert, M.S., 1987: Global and regional scale precipitation patterns associated with El Nino/Southern Oscillation. Monthly Weather Review, 115: 1606–1626.

Ropelewski CF, and Halpert MS., 1989: Precipitation patterns associated with the high index phase of the southern oscillation. Journal of Climate Vol. 2, 268–284.

Roberts N, Wright HE Jr. 1993. Vegetational, lake-level, and climatic history of the Near East and Southwest Asia. In Global Climates Since the Last Glacial Maximum, Wright HH Jr, Kutzbach JE, Webb T III, Ruddiman WR, Street-Perrott FA, Bartlein PJ (eds). University of Michigan Press: Minneapolis, MN; 194–220.

Rodo, X, Baert, E, Comin, F.A. 1997: Variations in seasonal rainfall in southern Europe during the present century: relationships with the North Atlantic Oscillation and the El Nin˜o Southern Oscillation. Climate Dynamics Vol. 13, 275–284.

Sarroni, H., Bitan, A. Alpert, P. and Ziv, B. 1996: Continental Polar outbreaks into the Levant and Eastern Mediterranean. Int. J. Climatol., 16:1175-1191.

Saaroni, H. and Ziv, B., 2000: Summer rain episodes in a Mediterranean climate, The case of Israel: Climatologica-Dynamical analysis. Int. J. Climatol. 20: 191–209.

Saaroni, H., Ziv, B. and Alpert, P., 2003: Long-term variations in summer temperatures over the eastern Mediterranean. Geoph. Res. Lett. 30, 18. doi:10.1029/2003GL017742.

Saaroni, H., Halfon, N., Ziv, B., Alpert, P. and Kutiel, H., 2009: Links between the rainfall regime in Israel and location and intensity of Cyprus lows. Int. J. Climatol, paper online in Wiley InterScience.

Safar, M.I., 1985: Dust and Duststorms in Kuwait. Directorate General of Civil Aviation, Meteorological Department, Kuwait, pp. 212.

Safavi, A. A., and Nazemosadat, 2004: Intelligent forecasting of rainfall and temperature of Shiraz city using Neural Networks. Iranian Journal of Science & Technology, Transaction B, Vol. 28, No. B1

Science Plan, United Arab Emirates Unified Aerosol Experiment (UAE), 2004: Prepared for DWRS, NASA, NRL, and ONR, Version 1.0 September 15th, 2004. Compiled and Edited by: Jeffrey S. Reid, Charles Gatebe, Brent N. Holben, Michael King, Stuart Piketh, and Douglas L. Westphal.

Sahsamanoglou, H. S. 1990: A contribution to the study of action centers in the North America. Int. J.

Climatol., 10:247-261.

Sahsamanoglou, H. S., Makrogiannis, T. J. and Kallimopoulos, P. D. 1991: Some aspect of the basic characteristics of the Siberian anticyclone. Int. J. Climatol., Vol. 11, 827-839.

Sahsamanoglou, H. S. and Makrogiannis, T. J. 1992. Temperature trends over the Mediterranean regions, 1950-88. Theor. Appl. Climatol., 45:183-192

Sarachik, E.S., Alverson, K., 2000: Opportunities for CLIVAR/ PAGES NAO Studies. Past Global Changes 8, 14–16.

Schyfsma, E., 1978: Climate. In: Al-Sayari, S.S., Z. otl, J. (Eds.), Quaternary Period in Saudi Arabia, Vol. 1. Springer, Vienna, New York, pp. 31–44.

Segal, M., Alpert, P. Stein, U. Mandel, M. and Mitchell, M. J., 1994: Some assessments of the potential 2X CO_2 climatic effects on water balance components in the Eastern Mediterranean. Climatic Change 27: 351-371.

Shmida, A., 1985. Biogeography of the desert flora. In: Hot Deserts and Arid Shrublands, A. Ecosystems of the World 12A. (Evenari et al. eds.). Elsevier Science Publishers B.V. Amsterdam, The Netherlands. pp. 23-77.

Shwehdi, M. H., 2005: Thunderstorm distribution and frequency in Saudi Arabia. J. Geophys. Eng. 2 252-267, doi: 10.1088/1742-2132/2/3/009

Shwehdi, M. H., 2005: Thunderstorm distribution and frequency in Saudi Arabia. J. Geophys. Eng. 2 252-267, doi: 10.1088/1742-2132/2/3/009

Slonosky V.C, Jones P.D. and Davies, T.D., 2001. Atmospheric circulation and surface temperature in Europe from the 18th century to 1995. International Journal of Climatology 21: 63–75.

Slonosky, V.C, and Yiou, P., 2002: Does the NAO index represent zonal flow? The influence of the NAO on North Atlantic surface temperature. Climate Dynamics. Vol. 19, 17–30.

Smadi, M., M., 2006: Observed Abrupt Changes in Minimum and Maximum Temperatures in Jordan in the 20th Century. American Journal of Environmental Sciences 2 (3): 114-120.

Soliman, K., H., 2006: Rainfall over Egypt. The Quarterly Journal of the Royal Meteorological Society, Volume 79 Issue 341, Pages 389 – 397.

Soliman, K., H., 2007: Notes on Rainfall over Egypt. Quarterly Journal of the Royal Meteorological Society, vol. 80, issue 343, pp. 104-104.

Stelio Pashiardis, 2008: http://www.fao.org/sd/climagrimed/pdf/ws01_08.pdf

Striem, H.L., 1981: Climatic fluctuations in Israel viewed through rainfall regimes. Meteorology and Atmospheric Physics, Vol. 29, No. 4, 357-364.

Subyani, A.M., 2004: Geostatistical study of annual and seasonal mean rainfall patterns in southwest Saudi Arabia. Hydrological Sciences–Journal–des Sciences Hydrologiques, 49, 803-817.

Sud, Y.C., Chao, W.C. & Walker, G.K., 1993: Dependence of rainfall on vegetation: theoretical considerations, simulation experiments, observation and inferences from simulated atmospheric soundings. Journal of Arid Environments, 25: 5–18.

Taha, M. F., S. A. Harb, M. K. Nagib, and A. H. Tantawy, 1981: The Climate of the Near East, In Takahashi. K. and H. Arakawa (eds.), Climate of Southern and Western Asia, Elsevier, 183-241.

Taghavi, F. and Asadi A. 2007: The Persian Gulf 12th April 2007 dust storm: Observation and model Analysis (www.eumetsat.int/groups/cps/.../ pdf_conf_p_s5_25_taghavi_p.pdf).

Tayanc, M., and Toros, M., 1997: Urbanization effects on regional climate change in the case of four large cities in Turkey. Clim. Change. 35, 501-524.

Tegen I and Fung, I., 1994: Modeling of mineral dust in the atmosphere: Sources, tranport and optical thickness, *J. Geophys. Res.*, 99, no d11, 22897-22914, 22897-914.

Tindale, N. W., and Pease, P. P., 1999: Aerosols over the Arabian Sea: Atmospheric transport pathways

and concentrations of dust and sea salt. Deep-Sea Research Part II 46:1577–95.

Torres,O., Bhartia, P. K. Herman, J. R. Ahmad, Z. and Gleason, J., 1998: Derivation of aerosol properties from satellite measurements of backscattered ultraviolet radiation: Theoretical basis. J. Geophys. Res. Vol. 103, 17099–110.

Touchan, R., E. Xoplaki, G. Funkhouser, J. Luterbacher, M.K. Hughes, N. Erkan, Ü. Akkemik and J. Stephan, 2005: Reconstructions of spring/summer precipitation for the Eastern Mediterranean from tree-ring widths and its connection to large scale atmospheric circulation, Clim. Dynam. doi: 10.1007/s00382-005-0016-5.

Trigo, I.F., Bigg, G.R, Davis, T.D., 2002: Climatology of cyclogenesis mechanisms in the Mediterranean. Mon Wea Rev 130: 549–569.

Tsoar, H, and Pye, K., 1987: Dust transport and the question of desert loess formation. Sedimentology Vol. 34, 139–153.

Troll, C. and Paffen, K.H., 1980:. Jahreszeitenkarte der Erde. Berlin.

Turkes, M. 1996: Spatial and temporal analysis of annual rainfall variations in Turkey. Int. J. Climatol., 16:1057-1076.

Turkes, M., 1998: Influence of geopotential heights, cyclone frequency and southern oscillation on rainfall variations in Turkey. Int. J. Climatol. Vol.18, 649–680.

Turkes M, Sumer U.M, and Demir I. 2002: Re-evaluation of trends and changes in mean, maximum and minimum temperatures of Turkey for the period 1929–1999. International Journal of Climatology 22: 947–977.

Türkeş M and Erlat E. 2003: Precipitation changes and variability in turkey linked to the North Atlantic oscillation during the period 1930-2000. International Journal of Climatology, 23, 1771-1796.

Türkeş, M., and E. Erlat, 2005: Climatological responses of winter precipitation in Turkey to variability of the North Atlantic Oscillation during the period 1930- 2001. Theor. and App. Climatol., 81, 45-69.

UNDP, Human Development Report 2006 (HDR) – Beyond Scarcity: Power, poverty, and the global water.

Unal Y, Kindap T, and Karaca M., 2003: Redefining the climate zones of Turkey using cluster analysis. Int. J. Climatol. Vol. 23, 1045–1055.

Untermeyer, C. and Al Mahmoud, S. 2005: A comparison between winter and autumn climate in the state of Qatar for the years 2003-2004-2005. The 4th GLOBE Program Regional Conference in the Middle East, 6-10 March 2005.

Uccellini, L.W., Kocin P.J., 1987: The interaction of jet streak circulations during heavy snow events along the east coast of the United States. Wea Forecast 2: 289–308.

Visbeck, M., 2003: The North Atlantic Oscillation. http://www.ldeo.columbia.edu/NAO/).

Vorhees, C.D., Murphree, Tom and Pfeiffer., L. K., 2006: Tropical Climate Variations and Their Impacts on the Northwest Indian Ocean – Northeast Africa –Southwest Asia Region. Tropical Met Conf Apr06.

Von Storch, H, Zorita, E., Jones, J.M., Dimitriev, Y., Gonzalez-Rouco, F. and Tett, S.F.B., 2004: Reconstructing past climate from noisy data. Science, 306, 679621.

Wallace J. M., Gutzler, D. S., 1981: Teleconnections in the geopotential height field during the northern Hemisphere winter, Monthly Weather Review, 109, 784-812.

Walh, E.R., Ritson, D.M. and Ammann, C.M., 2006: Comment on "Reconstructing past climate from noisy data". Science, Vol. 312, p 529.

Wang, C., 2002: Atlantic climate variability and its associated atmospheric cells. Journal of Climate, Vol. 15, 1516–1536.

Walter, H. and Lieth, H., 1967: Klimadiagramm-Weltatlas. Jena: VEB Gustav Fischer Verlag.

Washington, R., Todd, M., Middleton, N.J., Goudie, A.S., 2003: Dust-storm source areas determined by

the total ozone monitoring spectrometer and surface observations. Annals of the Association of American Geographers, Vol. 93, 297-313.

Watts, D., 1978: Severe cyclones in the Arabian Gulf- June 1977. Weather 33: 95–97.

Whitney, L.F., 1977: Relationship of the subtropical jet stream to severe local storms. Mon Wea Rev Vol. 105, 398–412

Webster, P.J., Magana, V.O., Palmer, T.N., Shukla, J., Tomas, R.A., Yanai, M., Yasunari, T., 1998: Monsoons: processes, predictability, and the prospects for prediction. Journal of Geophysical Research-Oceans 103, 14451–14510.

Wheaton, E.E. and Chakravarti, A.K., 1990: Dust storms in the Canadian Prairies. Intl J Climatol, Vol.10, 829–837.

Willson R.C., 1997. Total solar irradiance trend during solar cycles 21 and 22. Science 277: 1963–1968.

Yakir, D.S., Lev-Yadun and Zangvil, A., 1996: El Nino and tree grows near Jerusalem over the last 20 years. Global Change Biology, 2., 101-105.

Yanase, W., Niino, H, Saito, K., 2002: High-resolution numerical simulation of a polar low. Geophys Res Lett 29(14): 1658.

Yang, S. 1996: ENSO-summer monsoon association and seasonal inter-annual prediction. Int. J. Climatol., 16:125-134.

Yarnal, B., 1984: The effect of weather map scale on the results of a synoptic climatology. J. Climate Vol. 4, 481–493.

Yong-Seung, C. and Ma-Beong, Y 1996: On the occurrence of yellow sand and atmospheric loadings. Atmos Environ 1996;3013:2387–2397.

Yosef, Y., Saaroni, H. and Alpert, P., (submitted for publication). Trends in daily rainfall intensity over Israel 1950/1-2003/4, Geoph. Res. Let.

Yousef, A., 1988: Development and application of a limited area numerical model. PhD thesis, Cairo University, Egypt (unpublished).

Zangvil, A. and Drulan, P. 1990: Upper air trough axis orientation and the spatial distribution of rainfall over Israel. Int. J. Climatol., 10:57-62.

Ziv, B., Saaroni, H. and Alpert, P., 2004: The factors governing the summer regime of the eastern Mediterranean. Int. J. Climatol. 24, 1859–1871.

Ziv, B., Dayan, U., Kushnir, K., Roth, C., and Enzel, Y, 2006: Regional and global atmospheric patterns governing rainfall in the southern Levant. Int. J. Climatol. 26: 55–73.

Biographical Sketch

Hosny Hasanean was born and raised in Asuot, Egypt. After high school, he joined in a Meteorological Authority of Egypt for four years, which offered him an experience in Meteorology. He gained his Higher Diploma in Meteorology in 1987 from Cairo University. He has been hired in Department of Astronomy and Meteorology, Faculty of Science, Cairo University in 1988. He received his MS and PhD in Meteorology in 1992 and 1996 respectively. His MS research interest was “Causes of Climatic Change over Egypt” and PhD research interest was “Validation and evaluation of cloud parameterization roles in atmospheric radiation process". In The Department of Astronomy and Meteorology, Cairo University he has been a pointed as a Lecturer (1992-1996), Assistance Professor (1996-2003), Associate Professor (2003-2007) and Professor (2007-present). Climate and climate change have been his main research interests since graduate school. In addition to the above topics he is very interested in Middle East Meteorology which was his main research foci for years. His other research interests have been tropical-subtropical interaction and atmospheric circulation. Also he interests climatic global indices and its affect on climatic element. Recently, his research repertoire has expanded to the climate and climate change over Arabian Peninsula. In 2004, Dr. Hasanean has joined the international editorial board of The International Journal of Meteorology. Also, he works as a referee for many international journals in

Meteorology. He is an associate member of The Abdu-Salam International Center for theoretical physics (ICTP) Trieste, Italy. Dr. Hasanean is currently a Professor in the Department of Meteorology, Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia.