Comparative Analysis of Tropical Cyclones in the North of the Arabian Sea and the Gulf of Oman over the Past Decade (2005-2015)

Faeze Shoja[a], Mahmood Khosravi[b1], Ali Akbar Shamsipour[c]

[a] *Ph.D. Candidate of Climatology, Department of Physical Geography, University of Sistan and Baluchestan, Zahedan, Iran.*
[b] *Associate Professor in Climatology, Department of Physical Geography, University of Sistan and Baluchestan, Zahedan, Iran.*
[c] *Associate Professor in Climatology, Department of Physical Geography, University of Tehran, Teheran, Iran.*

Received: 3 June 2016
Accepted: 26 October 2016

1. Introduction

Tropical cyclones(TC) are the important hazardous phenomena in tropical zones that impact on subtropical regions of both hemispheres. These storms originate from tropical sea and oceans where the sea surface temperature is at least 27°c.
The abnormal development of two tropical cyclones (Gonu and Yamin) in June 2007 concerns to the Arabian Sea more warming than to the Bay of Bengal. Generally, the tropical storms that are formed in Arabian sea tend to move to the west and north side and rarely were entered to the Gulf of Oman but the Indian Meteorological Department (IMD) recent publications showed that a few numbers of these strong storms entered the Gulf of Oman and can impact on the Iranian coastline in north of Gulf of Oman.
The aim of this study was to compare and analyze the tropical cyclones in Arabian and Gulf of Oman structurally in order to investigate the role of the atmospheric and oceanic parameters in determining the tracks of these cyclones.

2. Material and Methods

At first, according to the statistics available in the Joint Typhoon Warning Center (JTWC), the characteristics of tropical cyclones including Gonu, Phet, Nilophar, Ashoba and Chapala were extracted and the principle components of these cyclones such as wind speeds, velocity and tracks from formation to vanishing were analyzed. Also, the directions of Tc were plotted by using ArcGIS and calculated angles of azimuth .
In the next step, by using reanalyzed data from the European Centre for Medium-Range Weather Forecasts (ECMWF), the variables such as sea level pressure, 850 hp Geopotential height, sea surface temperature and surface temperature for the life periods of cyclones were extracted and by using Grads software, the maps for 5-up to 40° north

1 Corresponding author: Mahmood khosravi. Tel: +989151412281 E-mail: Khosravi@Gep.usb.ac.ir

latitude and 40° to 80° East longitude, was prepared. Finally, the correlation coefficient between sea surface temperature and pressure were calculated and based on the "Traction and driving" rules, similarities and differences of these tropical cyclones were analyzed.

3. Results and Discussion

Gonu on June 1, 2007, at azimuth 270° was formed in the east of Arabian Sea, then moved to the North West and by reaching to the coasts of Oman changed direction to northern coasts of the Gulf of Oman.

The maximum intensity was on June 4 that it turned to the form of a super cyclonic storm and with peak, 3-min sustained winds reaching 240 km/h (150 mph) and an estimated pressure of 920 HP. Gonu was a Category 5 tropical storm, according to the Saffir-Simpson scale.

Phet cyclone was formed as a tropical disturbance on May 31, 2010, at azimuth 320.°

During the second and third days of its activity, the intensity of this tropical cyclone reached to peak and was a category 2 tropical storm, according to the Saffir-Simpson scale .

This system by changing its tracks converted to a tropical cyclone on 5 June and crossed southern coast of Pakistan near Karachi. The minimum sea level pressure (SLP) has occurred in northern and southern coasts of Oman and Pakistan and the maximum temperature in the West and South West Indian subcontinent has been recorded. The northward spread of high pressure in the southwest of Indian subcontinent to accompany with a strong ridge cause the Phet TC drive to west and northwest. In the next day's subtropical high-pressure deployment in the southern part of the Arabian Sea and Arabian Peninsula have prevented the establishment of Phet TC on the Gulf of Oman.

Niloofar TC was formed on October 25, 2014, and moved at azimuth 320° to the north west. The intensity of this tropical cyclone reached to peak and on 29 October was a category 3 tropical storm, according to the Saffir-Simpson scale.

The highest sea surface temperature and the air temperature in the TC location are respectively 28.8°c and 27°c. The correlation coefficient between temperature and pressure was negative in the onset of Niloofar TC and increase to 0.8 in the peak of activity. The wide high-pressure system in the north of Afghanistan, Pakistan and the Caspian Sea prevented the transition of Niloofar TC to the northern latitudes.

A low-pressure system at the same time with the onset of southwest monsoon was formed in the Arabian Sea on June 6, 2015, and moved to the north and northwest after the intensification. Since the wind speed of Ashoba tropical storm was not too much, it was not in the category of the Saffir-Simpson scale. The coincidence of low-pressure areas and maximum temperature at the time of deployment of Ashoba tropical storm justifies the correlation between these two factors well. High-pressure systems in the south of the Arabian Sea, north of Iran and northern areas of Arabia prevented the northward transition of Ashoba tropical storm and caused the system to be concentrated in the south of Yemen and southern Oman.

Chapala on October 28, 2015, was originated in the form of a tropical disturbance from a low-pressure area in the Arabian Sea and by a movement towards the west on 30 October reached its maximum intensity and ranking in category 4, according to the Saffir-Simpson scale.
During the Chapala TC activity, in high latitudes, the high-pressure systems were prevailing and acted like an obstacle to control the location and movement of the cyclone to the north.

4. Conclusion

Analysis of tropical cyclonic tracks azimuth were showed except the Gonu TC that changes its direction depending on the sudden rising and decreasing of velocity, in other cyclones these changes do not follow certain trends.
Also, in Gonu and Ashoba TC minimum pressure regions coincident with maximum temperature and there was a significant correlation between sea surface temperature and pressure.
The analysis of sea level pressure showed that according to the laws of "attraction and driving", the cyclones tracks have been influenced by the movement of low-pressure and high-pressure centers. The Niloofar and Chapala TC, due to differences in the season of formation and the prevailing of high-pressure systems, cannot move to northern latitudes.
Finally, the establishment of high-pressure systems in higher latitudes and season have important roles in displacement the tropical cyclones to the northern coasts of Oman and Gulf of Oman.

Keywords: Tropical cyclones (TC), The Arabian Sea, The Gulf of Oman, Azimuth, Traction and driving, Sea Surface Temperature.

References(in persian)

Alam, M., Hossain, A., & Shafee, S. (2003). The frequency of Bengal cyclonic storms and depressions crossing different coastal zones. *International Journal of Climatology*, *23*, 1119-1125.

Ghavidel Rahimi, Y. (2011). Drawing and the analysis of atmospheric moisture flux convergence (MFC) during the heavy rainfall caused by the phet tropical super cyclone in Chabahar coastal region.*Journal of Spatial Planning*, *2*, 101-118.

Ghavidel Rahimi, Y., Abbasi, E., & Farajzadeh Asl, M. (2015). Analysis of the dynamism and hazards of Niloofar tropical storm. *Journal of Hazards Science*, *1*, 21-34.

Golshani, A. A., & Taebi, S. (2008). Numerical modeling of Gonu cyclone and its resulting waves in the gulf of Oman. *Journal of Marine Engineering*, *4*(72), 25-29.

Khosravi, M., & Poodineh, M. R. (2010). A survey on climatic impacts of Gonu tropical cyclone (June 2007) in the southeast of Iran. *Physical Geography Research Quarterly*, *72*, 53-72.

Lashkari, H., & keikhosravi, G. (2010). Synoptic analysis of Gonu storm and its effects on southeastern of Iran. *Geography and Environmental Planning*, *21*(3), 1-20.

Mashhadi, L., Hajizadeh Zaker, N., Soltanpour, M., & Moghimi, S. (2013). Numerical simulation of waves and storm surge induced by the Gonu tropical cyclone in the Chahbahar bay area. *Journal of Marine Engineering*, *9*, 37-50.

Mazraeh Farahani, M., Ahmadi, M., & Saghafi, M. A. (2015). Evaluating the operating forces in formation and development of the Gonu tropical cyclone using Kiue analytical model and numerical models. *Journal of the Earth and Space Physics*, *2*, 273-280.

Salmanian, F., Khosh Akhlagh, F., Shamsipour, A. A., & Zarei, K. (2012). A synoptic analysis on occurrence and development of Phet tropical cyclones in southwest of Asia. *Journal of Climate Research*, *3*(11), 79-98.

Wahiduzzaman, M. (2011). An analysis on cyclonic track in the coastal region of Bangladesh. *International Journal of Geomatics and Geosciences*, *2*, 530-543

Wu, L., Ni, Z., Duna, J., & Zong, H. (2013). Sudden tropical cyclone track changes over the Western North Pacific: A composite study. *Monthly Weather Review*, *141*, 2597-2610.

References (in English)

Dare, R., & Mcbride, J. (2011). Sea surface temperature response to tropical cyclones. *Monthly Weather Review*, *139*, 3798-3808.

ECMWF. (2016). European Centre for Medium-Range Weather Forecasts datasets website, ERA Interim, Daily,http:// apps.ecmwf.int/ datasets/ data/ interim-full-daily/ levtype= sfc/

Emanuel, K. (2005). Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, *436*, 686-688.

Evan, A., & Camargo, J. (2010). A climatology of the Arabian Sea cyclonic storms. *Journal of Climate*, *24*, 140-158.

Haggag, M., & Badry, H. (2012). A hydrometeorological modeling study of tropical cyclone Phet in the Arabian Sea in 2010. *Atmospheric and Climate Sciences*, *2*, 174-190.

Indian Meteorological Department (IMD) Report. (2008). Report on Cyclonic Disturbances over the North Indian Ocean during 2007, *RSMC-Tropical Cyclones, New Delhi*, 1-98.

Indian Meteorological Department. (2016). Regional Specialized Meteorological Center for Tropical Cyclones over Northern Indian, *Indian Meteorological Department website*,(www.rsmcnewdelhi.imd.gov.in)

Mei, W., & Pasquere, C. (2013). Spatial and temporal characterization of sea surface temperature response to tropical cyclones. *Journal of Climate*, *26*, 3745-3765.

Neumann, C. J. (1993). Global Guide to Tropical Cyclone Forecasting,Chapter1, WMO/TC-No. 560,Report No. TCP-31, *World Meteorological Organization*; Geneva,Switzerland.

Rana, A. S., Zaman, Q., Afzal, M., & Haroon, M. A. (2014). Characteristics of sea surface temperature of the Arabian Sea coast of Pakistan and impact of tropical cyclones on SST. *Pakistan Journal of Meteorology*, *11*, 61-70.

Zhu, X., Sun, J., Liu, Z., Liu, Q., & Martin, J. (2007). A synoptic analysis of the interannual variability of winter cyclone activity in the Aleutian low region. *Journal of Climate*, *20*, 1523-1538.