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An Analysis on the Impacts of Zagros Heights on Life Cycle of Mesoscal Convective Systems in West of Iran

Dariush Yarahmadi[a1], Saeid Basati[b], Behrouz Nasiri[c], Somayeh Rafati[d]

[a] *Department of Physical Geography, University of Lorestan, Khoramabad, IRAN.*
[b] *Ph.D. Candidate of Climatology , University of Lorestan, Khoramabad, IRAN.*
[c] *Department of Physical Geography, University of Lorestan, Khoramabad, IRAN.*
[d] *Department of Civil Engineering, University of Seyed Jamaleddin Asadabadi, Asadabad, IRAN.*

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1. Introduction

Mountains are the main sources of turbulence and change in the shape of atmospheric flows, and they can cause airflow upward as well as clouds formation and rain through productive mechanisms such as upslope condensation and convection. They also have an important effect on regional and world precipitation turbulence (Banta, 1990; Barros & Lettenmaier, 1994), and can cause severe incidents such as destructive floods (Pastor, Gomez, & Estrella, 2010).
Previous researchers have done numerous studies on mountainous region weather and climate, and cause of precipitation phenomenon using different methods such as numerical modeling of airflow and satellite images. Using RegCM model, Insel, Christopher, Poulsen and Ehlers (2009) have studied the effect of Andes Mountains on convection, precipitation and humidity transformation in South America. They showed that Andes Mountains have lots of effects on humidity transfer between Amazon basin and central Andes, deep convention processes and precipitation across South America through low–level jet (LLJ) and topographical blocking from Pacific Ocean.
Zagros mountain range located in west of Iran plateau is among vast mountain ranges that locates in path of zonory flows with its south-north expansion and can affect those flows.
Therefore, the present study aims to investigate different factors affecting mesoscal convective systems from Zagros heights, and analyze their life cycle dynamic conditions using brightness temperature threshold, area expansion and RegCM4 numerical modeling.

2. Material and Methods

This study was done in an area of about 220000 km^2 in west of Iran including Kermanshah, Kurdistan, Hamadan, Khuzestan, Lorestan, Kohgiloyeh and Boyer Ahmad, Ilam, and cheharmahal and Bakhtiari provinces. Using satellite images obtained

1 Corresponding author: Dariush Yarahmadi . Tel: +09188878030 E-mail: Dr.Yarahmadi@Gmail.com

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from infrared band of Meteosat geostationary satellite, GOES and GMS, the mesoscal convective systems and their life cycle were identified.

Regarding that Inoue, Vila, Rajendran, Hhamada, Wu and Machado (2009) proved if we use one colder or warmer threshold, both initiation and dissipation phases may not indicate the life cycle, in this study, brightness temperature threshold of 224 K (Volasco & Fritsch, 1987) and 243 K (Machado, 1998) were used for identifying and analyzing systems life cycle. The researchers have tried to choose some days for this study over which mesoscal convective systems have been made and spent their life cycle without merger or split.

By transfering these systems to GIS environment using area expansion index (ΔE) whose validation and viability have been confirmed by Vila, Machado, Laurent, and Velasco (2008) its life cycle was verified (eq. 1).

$$\Delta E = \frac{1}{A}\frac{\delta A}{\delta t} \qquad (1)$$

A = the system area in a given time (T_{ir}<224)

It shows the positive values of the system growth and promotion process and negative values of the system reduction size. After considering mesoscal convective systems in west of Iran, the life cycle expansion and independence of mesoscal convective system of December 7^{th} and 8^{th} , 2001, were chosen as a case study due to not being affected by other systems of these days, its life cycle expansion and independence were chosen as a case study and its triple life cycle was verified and analyzed in details using RegCM4 numerical tests model.

Required data was obtained from NCEP reanalyzed data with 2.5 degrees horizontal resolution. In the first step, the model was performed with ready data integration (Control run). Then, regarding the purpose of the research, in Zagros Mountain range and Iran's central mountains, some topographic data were omitted and the model was performed again (Exprimental run).

3. Results and discussion

The sudden reduction process of system ΔE in the dissipation with respect to slow increasing process of ΔE in the initiation phase shows that convective system is sensitive to increase in heights and this situation indicates heights can effect system maturation and dissipation.

In initiation phase, according to precipitation rate there was not any difference between the two runs. This situation in maturation phase completely changes and mountains role in precipitation fields formation is seen well and precipitation follows heights pattern. In control run, precipitation concentrates in higher parts of Zagros while in experimental run the precipitation of Iran's central areas increase and its quantity in Zagros region and its western slopes reduces.

Because the flow is steady before hitting the mountains, the relative vortices have become zero. By the flow approaching quite close to mountain and in its slope relative vorticity increases, its value becomes positive. This change is around mountain chain slope, in a continuing movement and at ascending heights, vorticity sign changes in a

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way that at the top of the mountain it becomes completely negative, which continues to Zagros eastern slopes and Iran central plains; therefore, in the controlling phase, in Zagros and its western skirt, positive vorticity centers and areas are initiated, which include whole mountain chain slope from northwest to southeast. While in experimental run, above mentioned conditions have been cancelled, a new situation has been created to initiate vorticity centers and convergence-divergence in eastern Zagros; then, centers of positive vorticity are seen in center and east of Iran. In initiation phase of control run, there is a negative vorticity in different regions of the studied areas, but, at its maturation phase, by reaching to the heights, positive vorticity will be created in the region and the more height increases, the stronger vorticity becomes. Instead, at experimental run of maturation phase, the positive vorticity weakens and precipitation reduces in Zagros region. At dissipation of this run, positive vorticity in Iran central plains and east of Zagros have provided condition for air saturation and more precipitation.

The patterns which are available to converged and diverged fields of both runs for the life cycle are almost similar to vorticity fields so that their centers were disappeared at the initiation phase of experimental run. On the contrary, in the control run, a weak positive value of these centers has covered north of Persian Gulf. At maturation phase of control run, positive quantities have been created as alternative strips of convergence and divergence (positive and negative) from north of Zagros to its south. Whereas negative core in second run in north of Persian Gulf and Zagros western slopes and positive core in Zagros eastern slopes are seen. At dissipation phase of convective system in experimental run, convergence positive values have changed and moved towards Zagros eastern regions.

Omega vertical profile of each phase of system shows that the effect of this mountain range continues along the lower levels and high levels of the atmosphere. The omega of system's life cycle in experimental run with respect to control run has enhanced and spatially expanded. The only omega difference of these two runs is the movement to east in experimental run.

4. Conclusion

By considering simulation results and comparing them with control run consequences and reviewing the theory studied, it can be concluded that RegCM model for indicating Zagros mountain chain role in mesoscal convective systems life cycle, which is located in west of Iran and is related dynamic and physical quantities, acts successfully and its function is acceptable.

The available pattern in vorticity quantity centers for convergence fields have also been repeated identically. By omitting mountain chain in second run, positive and negative vorticity and convergence, areas of west of Iran have been entirely canceled and positive and negative vorticity and convergence-divergence centers in Zagros eastern regions and central plains of Iran have partially and clearly been reinforced. The availables patterns in both runs, i.e., convergence-divergence, for life cycle look like vorticity fields. In controlling run, centers of vorticity, convergence-divergence and omega have been created that cause precipitation in this region. On the contrary, in

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experimental run these centers are canceled and precipitation core has moved to eastern Zagros and center plains.

In system initiation phase, there are not a lot of differences between two runs according to precipitation rate, and in experimental run the precipitation has happened in a larger scope and mainly concentrated on east parts. This situation is canceled in maturation phase and mountains role is seen clearly in centers formation, so, vorticity and convergence-divergence patterns have obeyed the heights pattern.

Key words: Mesoscal Convective Systems, Life Cycle, West of Iran, Brightness Temperature

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