ISTANBUL TECHNICAL UNIVERSITY

1773

WATER FOUNDATION

...NGS

...ON WA...

...TA...

...iz KARA...

Sev... SIRD...

SYMPOSIUM CHAIRMAN
Zekai ŞEN

ORGANIZING COMMITTEE
Zekai ŞEN
Filiz KARAOSMANOĞLU
Sevinç SIRDAŞ

SCIENTIFIC COMMITTEE

Ahmet Mete Saatçi	(TURKEY)	Jose Salas	(USA)
A.El-Shraawi	(CANADA)	Levent Kavvas	(USA)
Cuma Bayat	(TURKEY)	Levent Şaylan	(TURKEY)
Erick Parant	(FRANCE)	Mazen Kavvas	(TURKEY)
Ermek Cumabeyoğlu	(KAZAKİSTAN)	Mikdat Kadıoğlu	(TURKEY)
Erol Keskin	(TURKEY)	Otto Helweg	(USA)
Ferruh Müftüoğlu	(TURKEY)	P. Enda O'connell	(UK)
Gökmen Tayfur	(TURKEY)	Skender Osmani	(ALBANIA)
Gültekin Günay	(TURKEY)	Ünal Şorman	(TURKEY)
H. Doğan Altınbilek	(TURKEY)	Vedat Batu	(USA)
İbrahim Gürer	(TURKEY)	Yılmaz Muslu	(TURKEY)
İzzet Öztürk	(TURKEY)	Zekai Şen	(TURKEY)

TECHNICAL - SOCIAL ACTIVITIES COMMITTEE

Ahmet D. ŞAHİN
Ahmet ÖZTOPAL
Abdüsselam ALTUNKAYNAK
Didem ÖZÇİMEN
Mehmet Murat ÖZÇİMEN

SPONSORS
STATE WATER WORKS of TURKEY - DSİ
İSTANBUL WATER and SEWERAGE ADMINISTRATION - İSKİ

SYMPOSIUM CHAIRMAN
Zekai ŞEN

ORGANIZING COMMITTEE
Zekai ŞEN
Filiz KARAOSMANOĞLU
Sevinç SIRDAŞ

SCIENTIFIC COMMITTEE

Ahmet Mete Saatçi	(TURKEY)	Jose Salas	(USA)
A.El-Shraawi	(CANADA)	Levent Kavvas	(USA)
Cuma Bayat	(TURKEY)	Levent Şaylan	(TURKEY)
Erick Parant	(FRANCE)	Mazen Kavvas	(TURKEY)
Ermek Cumabeyoğlu	(KAZAKİSTAN)	Mikdat Kadıoğlu	(TURKEY)
Erol Keskin	(TURKEY)	Otto Helweg	(USA)
Ferruh Müftüoğlu	(TURKEY)	P. Enda O'connell	(UK)
Gökmen Tayfur	(TURKEY)	Skender Osmani	(ALBANIA)
Gültekin Günay	(TURKEY)	Ünal Şorman	(TURKEY)
H. Doğan Altınbilek	(TURKEY)	Vedat Batu	(USA)
İbrahim Gürer	(TURKEY)	Yılmaz Muslu	(TURKEY)
İzzet Öztürk	(TURKEY)	Zekai Şen	(TURKEY)

TECHNICAL - SOCIAL ACTIVITIES COMMITTEE

Ahmet D. ŞAHİN
Ahmet ÖZTOPAL
Abdüsselam ALTUNKAYNAK
Didem ÖZÇİMEN
Mehmet Murat ÖZÇİMEN

SPONSORS
STATE WATER WORKS of TURKEY - DSİ
İSTANBUL WATER and SEWERAGE ADMINISTRATION - İSKİ

THE ROLE OF MESO-SCALE CONVECTIVE COMPLEXES (MCCs) ON HATAY FLOOD OF MAY 8, 2001

Ali DENİZ, Hüseyin TOROS and Mikdat KADIOĞLU
İstanbul Technical University, Faculty of Aeronautics and Astronautics, Department of Meteorology, 80626, Maslak, İstanbul.

ABSTRACT

This article investigates on the cause of the recent Hatay flood that occured in May 8, 2001 in Turkey. For this reason, first meso-scale convective complexes (MCCs) have been presented, then it is questioned in Hatay flood is a result of MCCs. To forecast these kind of convective events, kinematic and thermodynamic analyses are necessary. This paper also discuses the various mechanisms that cause strong and long lasting precipitation and thus floods.

Key Words: Flood, Meso-scale Convective Complexes, Cyclones.

1. INTRODUCTION

It is easier to forecast the precipitation that occurs as a result of frontal systems of cyclones than that due to orography. By studying small-scale convective precipitation that is hard to predict by models can be determined by studying previous hurricane and flood events. In the middle latitutes where Turkey is, there are generally active cyclones and stratiform clouds are most common. These clouds cause stable precipitation that are not convective.

However, toward the end of spring and beginning of summer, there are deep convective clouds and their convective precipitation characterized by the small-scale air movements. Strong precipitation that caused loss of wealth and life in Hatay has also been seen in different flood events occured near Ankara in August 1982, in East Anatolia in May 1991 and in Marmaris 1999. In all of these events seen in Turkey, flood and overflowing occured due to unexpected and unpredicted excessive precipitation.

In this paper, we intend to analyze the meso-scale meteorological structure that is effective in the Hatay flood by using numerical and kinematical methods. But because of the flood data for this event were not sufficient to apply the objective and kinematic analysis methods we used, here we will only describe how these events must be analyzed using numerical models, and which data and methods are needed. Therefore first an introduction to meso-scale meteorological conceptions was given followed by the examples of storms and floods occured over the world were investigated. Then, MCCs have been discussed as a cause of Hatay Flood. Beginning and development mechanisms for Hatay flood have been advocated by sketches in order to study and bring some explanations on the cause of these kind of flood events.

2. MESO-SCALE CONVECTIVE COMPLEXES (MCCs)

Convective systems are generally distinguished the vertical turbulent heat and momentum flux, (Weisman and Klemp, 1986). The structure of convective systems can be determined by radar ecoes, cloud patterns by satellites, surface cloud observations, wind patterns by Doppler radar and distructions at the surface. In convective systems, buoyancy force is necessary to rise the air. This force can be determined by using various kind of instability indexes like Lifted, Showalter, Total-totals, K and the other instability indexes. The most apprepriate measure, however is the convective available potential energy, (Cotton, 1990). The direction of vertical wind plays an important role in development of convective systems. Convective systems are generally grouped as a simple, a good many and super cells. These convective cells sometimes organize into meso-scale systems and form meso-scale convective complexes (MCCs), (Maddox, 1980). MCCs, which are seen in the form of a line or a band, are also known as squall lines. MCCs can not be predicted by the numerical weather prediction models. Instantaneous flood in Johnstown city, USA, in July 20, 1977 caused to death of 76 people. Bosart and Sanders (1981) showed that this flood was caused by the MCCs. Otherwise they showed that this MCC can be estimated 4 days before.

By development of satellite technologies, satellite pictures of the clouds in various spectral wavelengths were taken. The analysis of these satellite pictures showed that convective systems for synoptic and meso-α scales in length of 250-2500 km and in the period of greater than 6 hours cause excessive precipitation and flood in USA especially in summer months and generally at night. Maddox (1980) analyzed satellite pictures at the enhanced infrared radiation for many precipitation and flood events and found the group of meso-scale convective cells in the pictures. Following this, similar studies on floods have been applied for many events like in Johnstown. Some of these studies showed that MCCs caused a lot of flood in other countries as well, (Velasco and Fritsch, 1987).

MCCs and other convective precipitation storms are called meso-scale systems. Because these systems are spatially too small, they can not be determined by routine synoptic radiosonde observations. The quantity, organization, movement and life phases of a convective system can be followed from satellite pictures. Maddox (1980) has given some of MCC physical properties seen in the satellite pictures. According to Maddox, however, in addition to satellite pictures, simultaneous other observations are also necessary to know more about interior structure of MCCs and their physical mechanisms.

Some of general properties of MCCs determined from the analysis of worldwide events are:

1. In the development phase of MCC atmosphere has a barotropic structure. On the other hand, vorticity advection is weaken and thermal advection is strong in the lower atmosphere.
2. Low level jetstream carries the air which has high equivalent potential temperature into MCC.
3. Before MCC, potential buoyant energy computed from radiosonde observations is greater than surroundings in the MCC region. For example, in this situation the typical value of lifted index is equal to –4 or less than –4. It is generally is –7. Total-totals index is greater than 50. It is generally 60.
4. The transfer of MCCs from beginning to development phase occurs generally at night.

5. Most of MCCs occur ever mountains and in the wind direction.
6. The development of MCCs is generally observed in the anticyclonic part of upper level jetstreams.
7. MCCs move towards right hand side of air flow at the level of cloud layer and this is generally in the direction of thermal wind vector.

3. NUMERIC, KINEMATIC AND THERMODYNAMIC ANALYSIS

In the meso-scale analysis of meteorological conditions that result in a flood it is necessary to determine the distribution of thermodynamic parameters such as equivalent potential temperature, to compute the instability indexes and to investigate low level jetstreams by vorticity and thermal advections. All of them must be simultaneously computed by using objective methods. Therefore numerical analysis programs that compute wind velocity and direction, divergence and the scaler grid values of vorticity and deformation are prepared for an exact determination of air flows and an analysis of synoptic maps in the flood region. Vorticity, divergence, streching and shearing deformation terms contain the partial differentials. The finite difference methods used in the solution of partial differential equations are need to carry the values of temperature and pressure (or contour) from observed stations to the grid points. Presently we are using Cressman (1959) objective analysis method to obtain the grid values. However Cressman objective analysis method has not given good results in Iraq, Iran, Turkey and neighbouring countries because of lack of data. Convective motions are related to instability structure of atmosphere and to determine the instability of the atmosphere various instability indexes were developed. 10 instability indexes applied to Atatürk Airport by using temperature and dew point temperature inputs, (Faruk, 1992 and Yücel, 1993). This kind of instability indexes and their critic values have to be used in flood regions. Still the use of instability indexes may not be correct method to analyse and forecast of convections. By using numerical methods, it is possible to reveal three dimensional structure of the precipitation stroms.

4. HATAY FLOOD (MAY 8, 2001) AND ITS NATURE

Is MCC the reason of Hatay flood occured in May 8, 2001? The answer of this question may be given by using surface observations. Flood in Hatay and its surroundings have a period of more than 6 hours. This shows that the scale of flood is meso-α. Also low pressure centre in the upper levels and lower troposphere have a barotropic structure, (see synoptic maps of DMİ). If the strongest precipitation affects the area, floods caused by MCCs are expected to be on mountains and is the direction of wind, (Erdoğmuş, 1991). Floods caused by MCCs especially occur at nights, but this is not general rule. In the literature, it is seen that convective systems on mountain areas may be most active during daytime especially afternoon, (Karr and Wooten, 1976; Maddox at all, 1980). As a result Hatay flood (May 8, 2001) may be resulted from MCC. How did this MCC or other meso-scale convective system occure ? What are the triggers and the development mechanism ? Prior to the flood day in May 8, the mid level atmosphere is cooler and more unstable than its surrounding. Therefore convective clouds cause the strong precipitation, (Bilgin and Boğuşlu, 1991). In addition, Mediterranean that has higher temperature than land may transport humidity over the region. The formation of convective clouds and beginning excessive precipitation which caused flood in Hatay can be summarized in Fig. 1 as follows:

1. Mountains block dry and severe (heavy) air.
2. The air which has high temperature and more humidity climbs towards mountain and cools adyabatically.
3. When hot air cools, some of its moisture will be free. Then convective/orographic clouds occur and lightning, precipitation begins.

Fig. 2 shows the mechanism of convective precipitation. It is suggested that due to the following meteorological reasons, Hatay flood became even stronger with excess of precipitation:

1. Strong winds at the surface carry the humid air towards mountains.
2. Mountains exert the humid air to rise.
3. When the air rises, the moisture in it begins to condense and precipitation occurs.
4. Because of cold center in the upper levels, convective cloud transforms into cumulunembus (Cb). At this level that has closed low pressure centre and weak winds, Cb does not move and it causes floods in the same region.

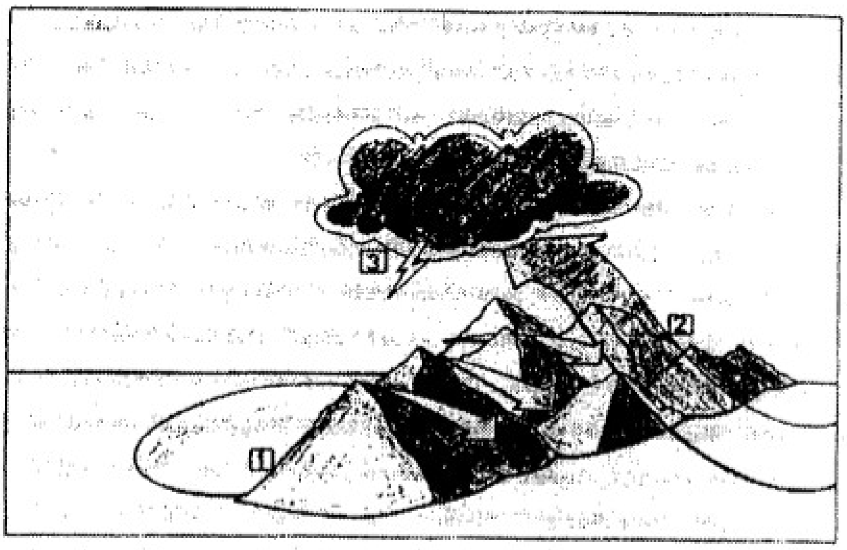

Figure 1: The trigger mechanism of excessive precipitation in Hatay floods in May 8, 2001, (Kadıoğlu and Deniz, 1993).

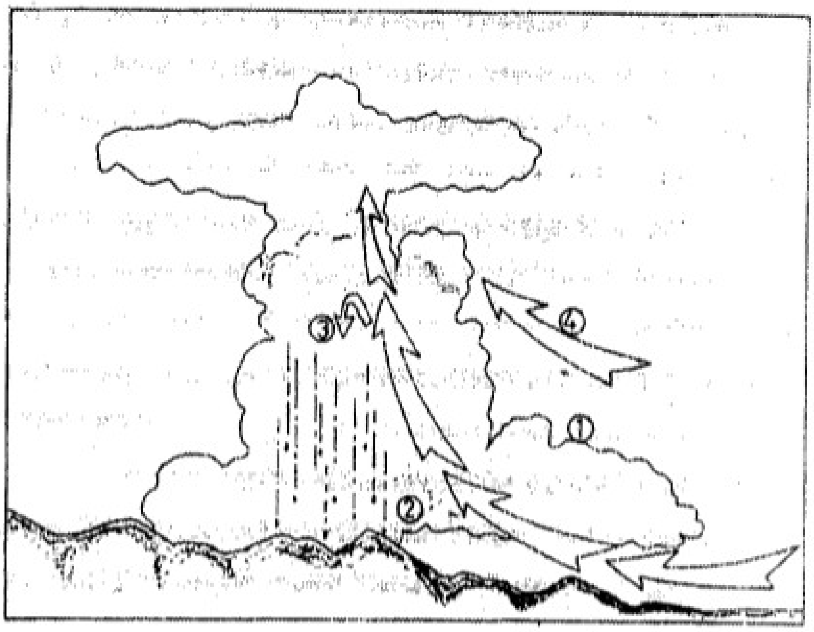

Figure 2: Vertical structure of Hatay floods in May 8, 2001 (Kadıoğlu and Deniz, 1993).

5. SUMMARY AND CONCLUSIONS

Cb clouds provide the precipitation in many places in the mid latitudes of the world for the season of growth of plants. These clouds also supply the water needed for the plants and human beings. At the same time Cb cloud's instantaneous excessive precipitation gives way to the death of human beings, house pets and wild animals. Thus destroying nature's balance, and bringing great economic losses. The amount of rain a rain storm produces is directly connected with the organization and structure of the system, the general circulation of atmosphere, including small convective clouds, and with many scales of the air system.

The rain caused by rain stroms is related, in great degree, to the value of humidity in the earth's low layers and upper levels. Sudden rains and floods do appear when the atmospheric patterns do not seem to be dangerous and when good weather is expected. When excessive rains are present strong winds (low level jetstreams) support the strom with moisture. Thus when moisture laden low level jetstreams climb on mountains floods occur. While the low level jetstreams climb on mountains, over a period of time, leave their moisture as rain over the mountain tops and valleys thus causing floods.

The moderate and weak winds in the atmosphere along with the changes in moderate horizontal and vertical winds often lay the ground for the conditions of excessive precipitations. As has happened in Hatay flood motionless weak winds in the mid levels caused precipitation in the same area for a long time.

To forecast in advance the reasons for excessive precipitation we need real time observations and data. These observations can be obtained only before and during the danger operations by meteorological radar and satellites. Along with this, it is also possible to make kinematic and thermodynamic analysis by surface and upper air observations of the systems that cause floods. In obtaining the necessary data we have to disregard focusing on excessive rains but look for the times when convective systems, which cause floods, are active. To obtain this data to increase the number of radiosonde observations may be valuable.

In conclusion to forecast excessive precipitations which cause floods and overflowings it is important to obtain all the necessary available data both from abroad as well as domestically. These data should include the radiosonde observations, satellite pictures and other meteorological parameters. By using this data the values of grid points should be obtained by numerical models. As a result the observations of convective precipitation systems and its local distributions will be determined and the climatology rain storms in Turkey will be brought out.

6. REFERENCES

Bilgin, R. and H. Boğuşlu, 1991: The analysis of strong precipitation caused overflowings in Trabzon in the period of June 20, 1990 and physical methods, (in Turkish), Second National Meteorology Symposium, March 20-23, 1991, İstanbul, 225-235.

Bosart, L. F. and F. Sanders, 1981: The Johnstown flood of July 1977: A long-lived convective system. J. of Atmosp. Sci., 38, 1616-1642.

Cotton, W. R., 1990: Storms. Geophysical Science Series, vol. 1, Aster Press, USA, 158 p.

Cressman, G. P., 1959: An operational analysis system. Monthly Weather Review, 87, 367-374.

Erdoğmuş, F., 1991: Synoptic Analysis of excessive precipitation in East Black Sea Region in the period of June 19-20, 1990 and in East Anatolia Region in the period of May 16-17, 1991 (in Turkish), TMMOB Precipitation and Flood Symposium, Ankara, 88-97.

Faruk, Ö., 1992: Otomation of instability indexes and applications for Atatürk Airport (in Turkish), ITU Department of Meteorology, Bsc. Thesis.

Kadıoğlu, M. and A. Deniz, 1993: Numerical-Kinematical-Thermodynamical analysis of East Black Sea Floods in June 18-20, 1990 (in Turkish), TUJJB, Ankara, 231-245.

Karr, T. W. and R. L. Wooten, 1976: Summer radar echo distribution around Limon, Colarado, Mon. Wea. Rev., 104, 728-734.

Maddox, R. A., 1980: Mesoscale convective complexes. Bull. Amer. Meteor. Soc., 61, 1374-1387.

Maddox, R. A., F. Canova and L. R. Hoxit, 1980: Meteorological characteristics of western U.S. flash floods. Mon. Wea. Rev., 108, 1866-1877.

Velasco, I. and J. M. Fritsch, 1987: Mesoscale convective complexes in the Americas, J. Geophys. Res., 92, 9591-9613.

Weisman, M. L. and J. B. Klemp, 1986: Characteristics of ısolated convective storms (Chap. 15), In Mesoscale Meteorolgy and Forecasting, P. Ray (ed.), AMS., Boston, 331-358.

Yücel, İ., 1993: Equivalent potential temperature analysis of East Black Sea floods in the period of June 18-20, 1990, Bsc. Thesis.