

A Preliminary Study of the Flood Disaster in Hudhramout by Using Data Obtained Via the TRMM Satellite

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Abstract

The data concerning the amounts of rainfall which rely on the measurements carried out by the satellites has contributed in providing the researchers with a lot of important information about this vital element (rainfall), especially that these measurements are conducted in a regular basis and cover vast areas, the thing that facilitated the process of monitoring the temporal and spatial differences for different weather phenomena. This data is considered better alternative to the traditional field measurements, especially in many countries where there is no more adequate data.

The present study used the radar TRMM daily data to study the air storm with its consequences of heavy rainfall and floods that Hudhramout has witnessed in October 2008. The analysis of the data obtained before and after this phenomenon (heavy rainfall) has revealed the great possibility that this radar provides in monitoring these weather phenomena and the amount of the rainfall accompanying them. These rainfalls have turned out after that to raging floods inundated large areas in Hudhramout. The study showed clearly the possibility of using this data in periodical and regular basis in the early forecasting of air depressions and weather disasters and thus help in warning of the possibility of witnessing heavy rains and raging floods.

Introduction

The occurrence of sudden disasters and crises and what they cause of harmful and serious sequences upon interests of citizens

and states necessitates an informational integrated-system that may help in making accurate and quick decision by specialized people who are capable of monitoring and

forecasting weather phenomena in an early time to prevent major damages for the human and property. Such early informative and accurate forecasting may also help in taking all necessary reservations to confront and reduce the amount of losses that may arise from those disasters. Often such data might not be provided easily due to the hindrances of obtaining them using traditional survey methods. Consequently, there must be other non-traditional alternatives to get this data. One of the most valuable alternatives which approve its effectiveness in forecasting disasters and obtaining the required data is the utility of the satellites and geographic information systems (GIS henceforth) techniques.

The past years have witnessed continuing remarkable development in the techniques of remote sensing and the **GIS**, which helped in the immediate monitoring, early warning, and quick assessment of the adverse effects of flood disasters and heavy rains. The **GIS** techniques are considered effective tools that can support local officials and decision-makers with adequate information on the areas exposed to the impact of the floods and the communities living in those areas. Using **GIS** stored in the database, data can be easily obtained by "inquiring" about the information, or "displaying" its analysis. They are also considered a suitable device for the process of Overlay. Further, they can be used to put different geographic information through which one can know the areas that may be

vulnerable to the effects of the floods in order to take preliminary procedures to mitigate these potential effects.

The most striking feature of heavy rain and floods caused by it is its disastrous effects on the people and properties in general (Khanna *et.al.*, 2006). Moreover, the damages caused by such floods might be great to an unimaginable degree because they do not occur frequently, and cannot be predicted. Further, the calibration of these floods using the traditional hydrological models is considered difficult task.

The present study deals with a case study of the catastrophic floods that swept Hudhramout and Almahra in Yemen in October 2008, as a result of the depression that caused heavy rains accompanied by raging floods. Consequently, the floods have led to great damages to human, prosperities and environment. This study aims to conduct a theoretical analysis of the incident of these floods and the possibility of using remote sensing data available to describe them in a scientific manner.

The Role of Remote Sensing Techniques in Studying the Floods

Information has become one of the most important commodities traded at the beginning of the third millennium. Therefore, the states have begun to allocate physical and human resources to take maximum advantage of modern technologies to obtain the correct data needed in accurate and fast manner.

Thus, the possibilities of making right decisions in a timely manner are usually associated with the availability, quantity, quality and reliability of data.

Information technology possesses effective elements that can change the way the institutions and governments deal to obtain the necessary information. Thus, such information might help thereafter in making decisions and insurance services, developing the means, and giving real-time and are guaranteed results with the lowest cost and least time, especially in the times of disasters and crises.

Perhaps, one of the most important techniques that have proven great effectiveness in crisis management is the techniques of remote sensing and GIS. Therefore, the data obtained via the techniques of remote sensing provides the most important periodic information about many weather phenomena that can be used to predict big disasters. Furthermore, such information can be used after disasters such as floods in the totally-integrated management of the crisis for the purpose of relief procedures coordination among others.

Predicting and assessing the impact of floods is considered a very complex process that can be done with the participation of different sectors and multiple research works, and by following certain steps that can be summarized as follows (Minghu *et. al.*, 2001):

1. Determining the potential dimensions of the floods and flash floods using mono-dimensional hydrologic models, and the hydrograph design so that it gives an indication of the likely flow of water to the mouth of the water (the basin) in the exact location and at a specific climate as well.
2. Assessing the consequences of the Maximum Flow for the area relevant, for instance, a city near the river or estuary. In this case, it is possible to use as two-dimensional models to describe the risk of flooding, particularly the maximum speed of the flow, the water depths, alarm timing, flow period, sedimentation and erosion, and others.
3. Assessing the overlapping of the floods with humanitarian activities in the affected area, the number of people who will be affected by the floods and health effects, the impact on people's homes and properties, the potential damage in agriculture and industrial production, and the infrastructure environment. Therefore, the aspects of civil protection must be taken into account, for example, when people should be evacuated and what are the lines of transportations which are still in good condition in the area affected by the floods.

All of these steps included in the process of assessing the risk of floods require current and accurate information about the nature of the terrain and land use, among others. Remote sensing data provided by satellites and aircraft can sometimes be the only source

that can provide the authorities designated with this information for any geographical spot and at a reasonable cost or may be for free. Such information can be obtained through the Internet, and it is considered an important source for many researchers and those who are interested in the field of environment.

The satellites are characterized with their unique capability of providing comprehensive coverage for large areas of our planet. The most important thing about this coverage is its temporal and spatial diversity. This technology provides periodically significant and ongoing information during definite periods, the thing that makes this technology a valuable tool for monitoring and management of floods flash floods (Minghu *et. al.*, 2001).

Remote Sensing Data Used for Studying Floods& Flash Floods

The space radar carried on the back of the mobile satellite Tropical Rainfall Measurement Mission (TRMM henceforth) is capable of monitoring the distribution of rainfall even above the oceans and high mountains on the earth. The **TRMM** was launched by the end of 1997. This satellite is a joint project between NASA and JAXA which was launched to provide the researchers with data on the process of precipitation in the tropic areas. The data obtained via this satellite are heavily used in American research centers and weather

agencies. Further, the data and images obtained via **TRMM** are used worldwide for monitoring and forecasting hazardous weather situations (such as floods, tropical storms, etc.). Moreover, these data and images are considered very vital for studying the Earth's Hydrological Cycle, verifying the climate models and their capability to similarly predict climate phenomena in accurate way (Nirala and Cracknell, 2002).

The last two decades have witnessed the emergence of some concepts and ideas in the field of studying the precipitation. Among the major factors that contributed to the development of these concepts are the followings:

1. The availability of a large and diverse amount of data concerning the monitoring of rainfall via the ground radars and satellite data.
2. The need for developing the process of using the changing values and laboratories of hydrological processes in climate models.

Study Area

The study focused on some parts of Hudhramout, which is considered the largest province in Yemen with regard to its area (about 161749 km²), therefore, it makes up about 29% of the total area of Yemen. The estimated total population of this province, according to 2004 census, is 1,029,462 people. Hudhramout, geographically, located almost between latitudes 14 degrees north at its southern border, which overlooks the

Arabian Sea and approximately 19 degrees north latitude in the northern border with Saudi Arabia. While it located almost between latitudes 48 degrees east longitude, from the west adjacent to Shabwa and 51 degrees east to the east side adjacent to Almahra (Yemeni Information Center,2009).

The rains, which have fallen in October 2008 causing floods and flash floods, have fallen over vast areas of Hudhramout starting from the coastline plain, which is an extension of the southern coasts of Yemen. These southern coasts overlook the beaches of the Aden Gulf and the Arabian Sea which extends from the village (Bear Ali) in Shabwa at the west to the village of (Hodatahm) locating in Al-Raideh and Gosai'ar at the east.

The height of the coastal plain is graded from the sea level above up to 150 m near the internal mountain range. The coastal plain is crossed by a number of vast valleys originating from the mountains and creeks and pour into the sea. The most important valleys in the west of this area are: Hajjar Valley, Alkhirbeh Valley, Bowaish Valley, and Howirah Valley. In the east, there is also a number of important valleys such as: Sam'oun Valley, Araf Valley, Khrad Valley,

and Thanabaat Valley. However, the other area which was badly damaged due to the flash floods is Hudhramout Valley (see Figure 1). This valley is considered one of the largest valleys in Yemen, in addition to its being a distinct topographic phenomenon with clear landmarks. It is streaming in parallel with the southern coast of the Arabian Peninsula 200 kilometers far, then it veers towards the south-east breaking through the coastal highlands across Almasilah Valley to pour into the Arabian Sea near the city of Sayhoot which locates in Almahra.

There are some sub-valleys flow in Hudhramout Valley and they cross into its southern plateau. These sub-valleys include: Dahar, Rakhiyah, Amad, Bin Ali, Aynaat, and Sana. In the northern plateau, there are other sub-valleys such as: Haynan, Na'aam, Ja'imah, Thabi, among other valleys. This region is well- known for agriculture where dates, cotton, fruits and vegetables are grown. Besides, this region is famous for the magnificent skyscraper mud architecture. An example of this amazing architecture is Shibam buildings, and the Palaces in Say'oon and Tareem (Yemeni Information Center,2009).

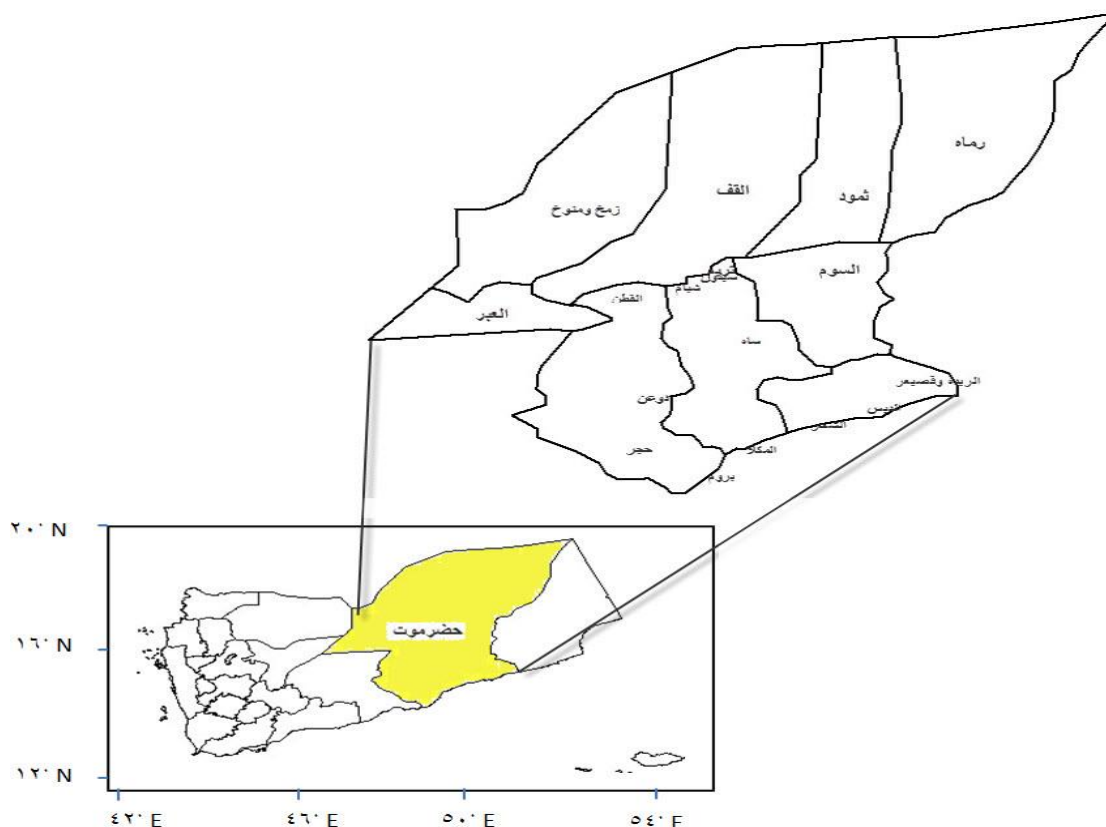


Figure (1): Hudhramout and its Administrative Divisions

The main data used in the present study include images taken by the multispectral domains radar (TRMM). This radar is a type of (Multispectral Precipitation Analysis) TMPA 3B42RT. The data in question were obtained and downloaded free of charge from NASA. These data are radar images that include information about rainfall rates taken in timescale (once after every three hours) and a spatial scale which includes a geographic area with an estimated length and width 25.0 x 025.

Discussion and Analysis

The tropical storm that hit large parts of Hudhramout and Almahra is classified in the order (3B) due to Safer-Simpson Storm Scale (<http://www.nhc.noaa.gov>, 2009)

This storm was formed early in the Indian Ocean in the southeast of Socotra island on 18th of October of 2008. This storm has also been monitored by different satellites and it appears clear in the data used and illustrated in this study (see Figure 2).

In the 19th of October, the hurricane began to move towards the Horn of Africa and large parts of it has covered Socotra Island where the total amount of rain in the middle of this hurricane was more than 25 mm.

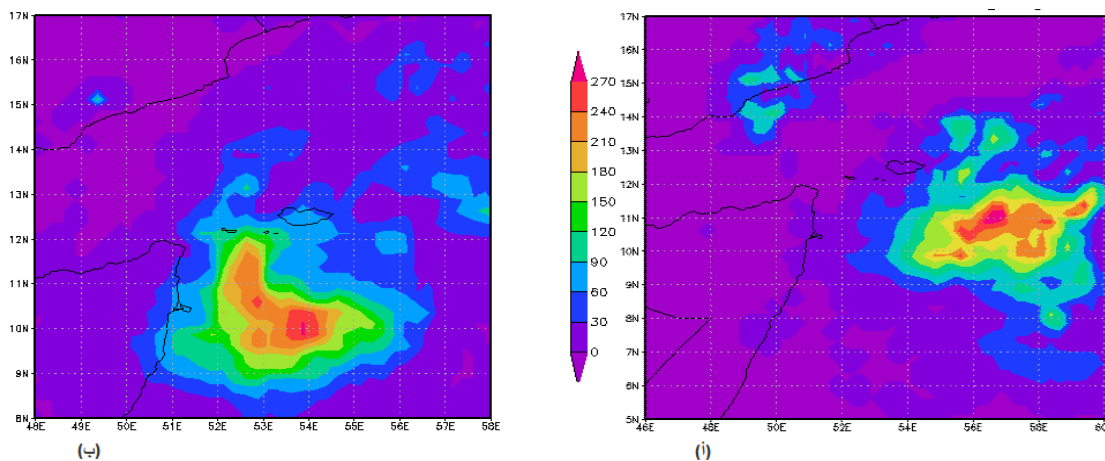


Figure (2): The Images Taken by the Multispectral Domain Radar TRMM ((a) in the 19th Oct. and (b) in the 20th Oct.)

On the 21st of October, the hurricane has spread on large areas of Somalia. It has been monitored by the French Meteorological Agency which in sequence issued a warning bulletin from the Tropical Cyclones Center which showed that the storm formed in the

Indian Ocean was heading towards the north-west where the speed of the winds was 10 knots while it was 35 knots in the center of the hurricane (<http://weather.unisys.com>, 2009).

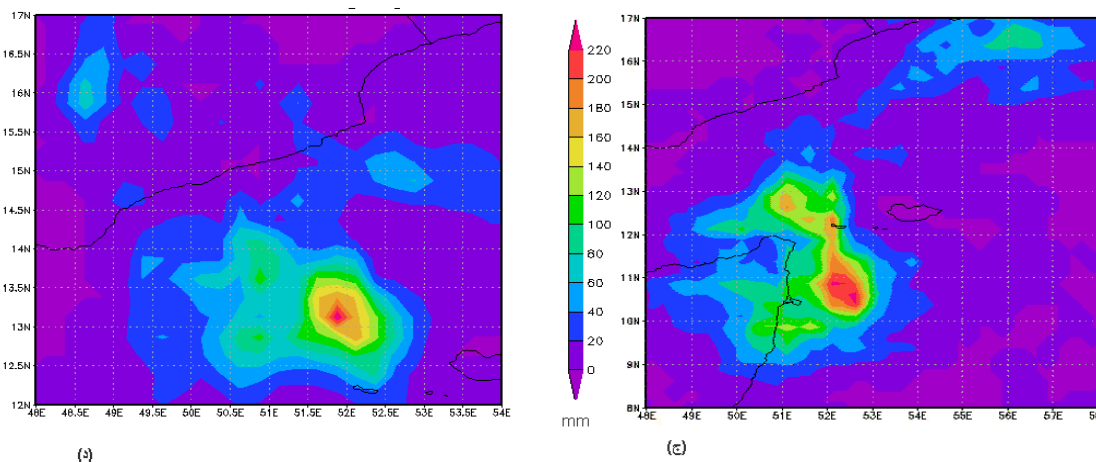


Figure (3): The Images Taken by the Multispectral Domain Radar TRMM ((c) in the 21st of Oct. and (d) in the 22nd of Oct.)

During this time, large amounts of rain have dropped along the concentration of the hurricane (Figure 3). This rainfall began to decrease sharply, with the passage of time, during its moving towards the southern coast

of Yemen. This decrease occurred due to several factors which include the followings:

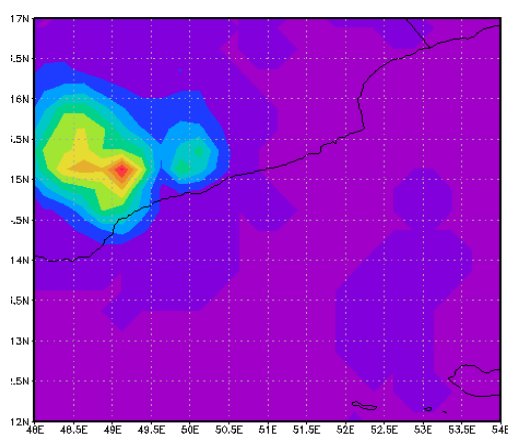
- The decrease in the Enthalpy (heat content) in the region (ocean) which means that the sea surface temperatures were not enough to help

the continuity of rainfall (temperatures dropped to 260C).

- The intense increase in the speed of the wind heading towards the north-west in the high atmosphere.
- A decrease in the orbital wet and warm air flow in the lower layers of the atmosphere, especially, in the northern part of the area of study. (<http://weather.unisys.com>, 2009)

All these weather conditions lead to a sharp decrease in the rainfall, in addition to that the activity within the thunderstorm clouds began

to decrease as well, with the passage of time. In the 23rd of October, the depression take another new form due to the previously-mentioned factors where it split into two parts of rainy thunder clouds. The first part occupied the vast areas of the southern coast in Hudhramout northwards to include many areas of Hudhramout Valley. The second part of these rainy thunder clouds has spread over different areas in Almahra and parts of the Sultanate of Oman, as shown in Figure (4).



4.

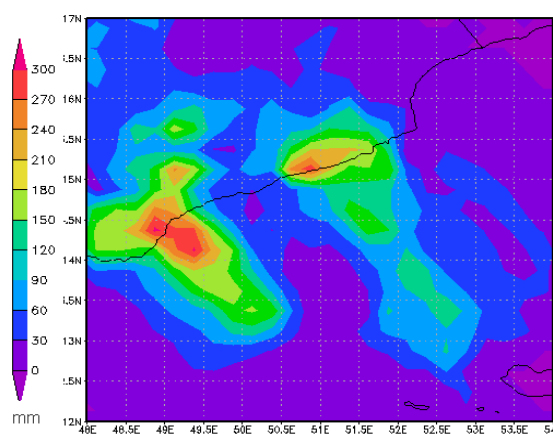


Figure (4): The Images Taken by the Multispectral Domain Radar TRMM ((a) in the 23rd of Oct. and (b) in the 24th of Oct.)

In the early hours of the morning of the 23rd of October, large amounts of rain began falling, on the area of study, and has reached more than 200 mm. This situation continued till the next day, which witnessed a change in the direction of the depression where the movement began to take the direction of the north-west to settle over almost all the areas

in Hudhramout Valley (Figure 24). On this day, large amounts of rain have fallen heavily on the high mountain with high downgrades that characterize this region (the form of slope + dem), in addition to other large cities and villages in Hudhramout such as Say'oon, Tareem, Alqaten, Saah, Shibam and others.

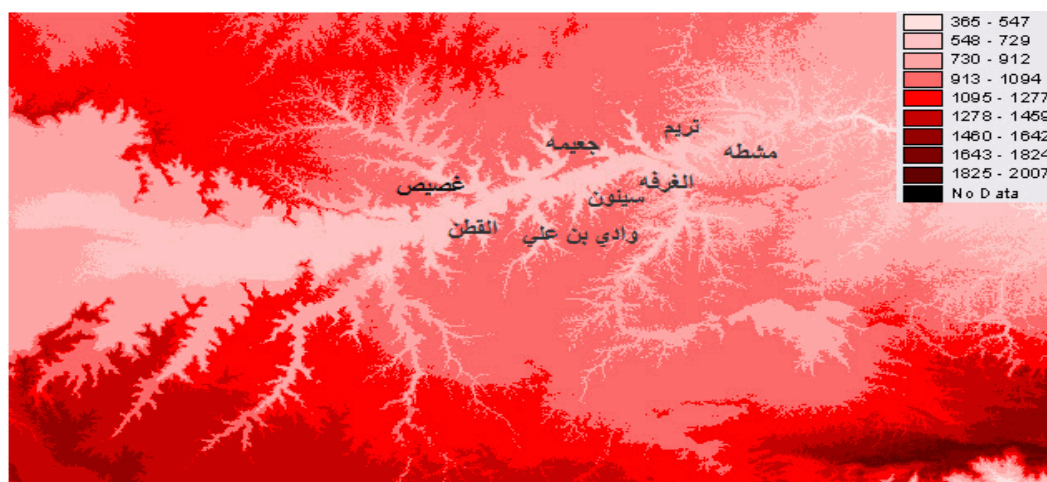


Figure (5) Digital Elevation Model for Hudhramout Valley

The rapid flow of water over the highland areas into the plains and valleys led to a high increase in the water level in these plains and valleys and thus caused floods in the form of raging flash floods invaded most the cities in the valley leaving many victims and destruction of many houses and properties behind. These floods also caused serious damage to the agricultural sector, which is considered the most important economic sector in Hudhramout Valley. Shibam, the historical city which was considered by the UNESCO one of the World Heritage sites, has been damaged by the torrential rain and floods. This damage occurred especially in the towering mud buildings most of which have become domed to fall. The coastal cities were not in a better condition than the cities in the valley. In these coastal cities, the rains and floods caused a large damaged for the infrastructure as a result of some buildings that have been recently build randomly in the floodplain and places of drainage, the thing

that caused the floods to move towards other areas causing serious damage.

Conclusions

The data provided by the satellite on the quantities of rain and wind among others are considered specifically important in the detection and early warning of air hazardous conditions and natural disasters such as floods and landslides, especially in areas that lack ground Informatics centers that could provide such data. Sometimes, these centers might be available but they fall short of covering all parts of the region to be studied. Besides, such data often become essentially unavailable in complete and periodical manner or they might not be affordable. Consequently, it is considered a great opportunity for researchers in many developing countries, which suffer from the scarcity of financial resources, to obtain remote sensing data through the Internet. And thus, they could make benefit of this free data, as well as its periodicity, continuity and

coverage of vast areas of the earth's surface, the thing that make it compete with meteorological information which is difficult to obtain in most cases.

This study is an initial attempt to analyze the weather phenomenon of tropical storm (3B) since it has first originated till it comes into being in the area of study. Further, the study investigated the sequences of this phenomenon and what it caused of heavy rains that turned into raging floods leading to damage in Hudhramout and Almahra.

The study has showed that the TRMM radar data can be efficiently used in the studies dealt with the forecasting, monitoring and analyzing the tropical cyclones. Besides, the study considered this kind of data an important source of information relevant to the specific data of the early warning system of natural disasters, especially, floods. One of the main difficulties faced by the researchers who conduct such studies is the lack of accurate meteorological data covering all areas to be studied so that the researcher can compare them with the data obtained by remote sensing to increase the credibility and effectiveness of these data.

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دراسة أولية لكارثة السيول في حضرموت باستخدام بيانات القمر الصناعي TRMM

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الملخص

لقد أسهمت البيانات عن كميات التساقط والتي تعتمد على القياسات التي تقوم بها الأقمار الاصطناعية في تزويد الباحثين بالكثير من المعلومات الهامة عن هذا العنصر الهام، خاصة أن هذه القياسات تتم بشكل دوري منتظم وتغطي مساحات شاسعة الأمر الذي سهل عملية رصد الاختلافات الزمانية والمكانية للظواهر الجوية المختلفة. تعد هذه البيانات بديلاً منافساً للقياسات الحقلية التقليدية خاصة في كثير من الدول التي لا توجد بها بيانات كافية. استخدمت في هذه الدراسة بيانات الرادار TRMM اليومية لدراسة العاصفة الجوية وما صاحبها من سيول وفيضانات اجتاحت محافظة حضرموت خلال شهر أكتوبر 2008م، وقد بينت نتائج تحليل البيانات للفترة التي سبقت السيول وأيضاً للفترة التي تلتها مدى الإمكانية الكبيرة التي يوفرها هذا الرادار في تتبع هذه الظواهر الجوية مع بيان كميات الأمطار المصاحبة لها والتي تحولت الى سيول جارفة غمرت مياهها أجزاءً كبيرة من منطقة الدراسة. أوضحت الدراسة جلياً إمكانية استخدام خاصية دورية وانتظام هذه البيانات في التنبؤ و الإنذار المبكر عن المنخفضات الجوية وحالات الجو الخطرة والتحذير من إمكانية حدوث السيول والفيضانات.