Application of the FY2H images for the dynamic monitoring of clouds and humidity during the devastating flood events at Shiraz metropolis

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Introduction

Flood in global scale

The occurrence of flood events particularly in urban areas are the catastrophic incidents that causes loss of life, economic costs and destruction of infrastructures. Figures 1 and 2 are the examples of the economic costs of flood in Germany and China.

Figure 1: flooding in Germany, Belgium and the Netherlands, 2021

https://www.nature.com/articles/d41586-021-02330-y

Figure 2: flooding in China, 2021

https://www.reuters.com/world/china/china-braces-summer-floods-71-rivers-exceed-warning-levels-2021-05-26/

Flash flood

Since the flood event that is the theme of the present study is categorized as a flash flood the scientific definition of such events is presented:

According to the AMS Glossary, flooding that caused by rapidly rising water level in streams, creeks, rivers, or other waterways, normally dry stream beds, or in urban areas, usually as a result of intense rainfall over a relatively small area or for moderate to intense rainfall over highly saturated or impervious land surfaces, and generally occurring within minutes to several hours of the rainfall event.

Comparing the upper and lower parts of Figure 3 depicts the devastating power of a flash flood.

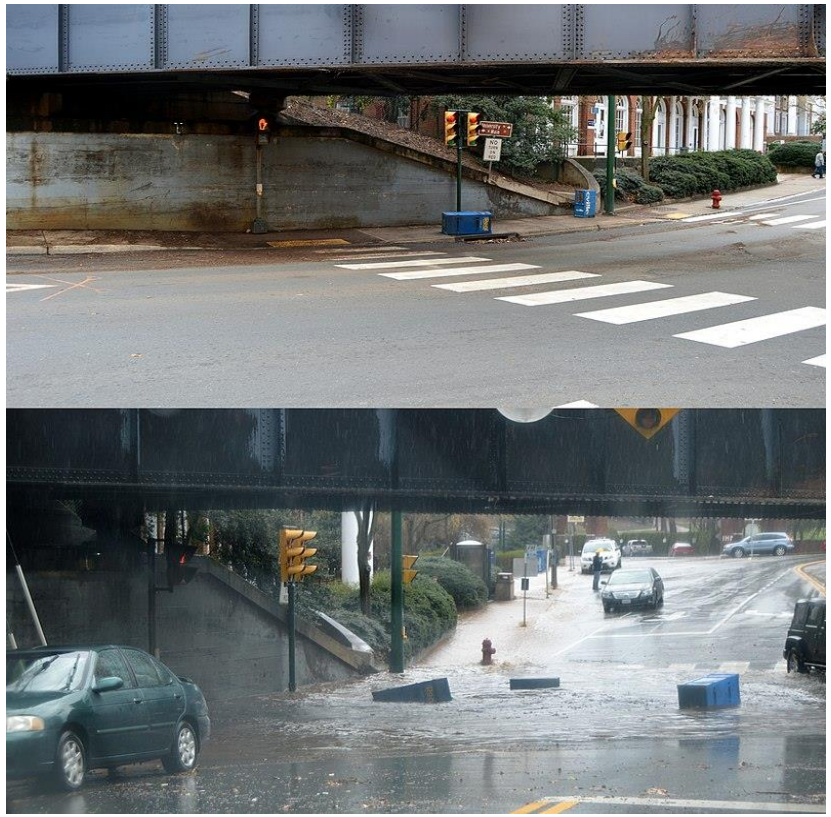


Figure 3: An urban underpass during normal conditions (upper) and after fifteen minutes of heavy rain (lower) https://en.wikipedia.org/wiki/Flash_flood#/

Methodology

The study area

Figure 4 shows the geographical position of the study area in central south of Iran. As indicated the Iran is an Middle Eastern country in the west of Asia (Figure 4a). Shiraz with a population around 2.2 millions, is located in the central part of Fars province at 29°36′ N and 52°32′ E (Figures 4b and 4c). The city is a valley that is bounded by Zagros Ranges with temperate climate and elevation between 1480 to 1670 meters above sea level .

According to the historical climate data, The mean annual temperature and precipitation for Shiraz are 18.1℃ and 318 mm, respectively.

Figure 4: Geographical location of Shiraz city
https://www.rugman.com/blog/rug101/shiraz-rug/

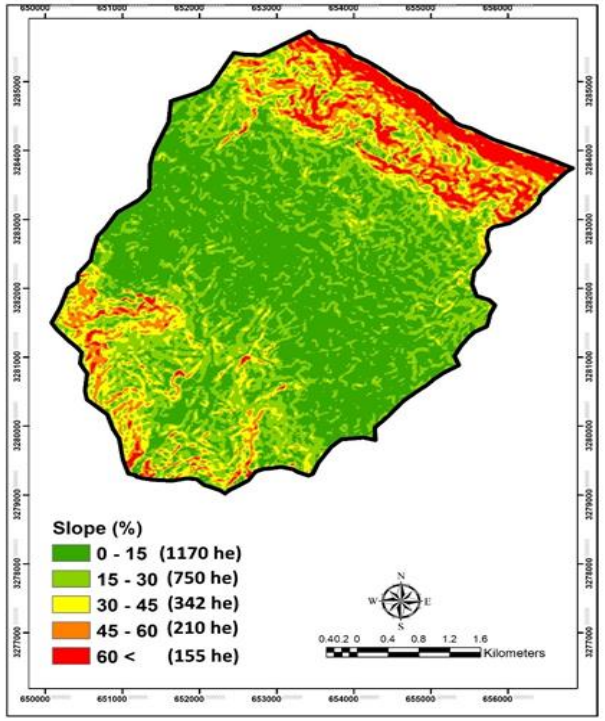
Flash flood at Shiraz metropolitan area

On March 25, 2019, after a heavy 20 minutes storm with intensity around 75 mm / hr a flash flood occurred in the downstream of a small catchment (around 26 km²) in the northeast of Shiraz, the capital city of Fars province, Iran (Figure 5). Water flowed at a rate of about 30 to 40 cubic meters per second from the steep northern slopes to one of the busiest streets below. Because the cars were blocking the passage of water, the water moved them. In addition to the huge financial losses, 20 innocent people died as a result of the flood.

Figure 5: Flash flood at Shiraz
https://donya-e-eqtesad.com/

As it can be seen in figure 6 , The black patch in the southeast of the left side map shows the location of the catchment total area 26 km². Water flowed from this small catchment toward one of the crowded street in southern parts of the catchment.

Figure 6: Geographical location of Quran cathment



Goals of the study

The main purpose of this study is to utilize the images of China's satellite FY2H (Geo-stationary) for evaluating the characteristics of the:

cloud and atmosphere humidity on March 25, 2019

FY2H is realized as the closest meteorological satellite of its kind to Iran.

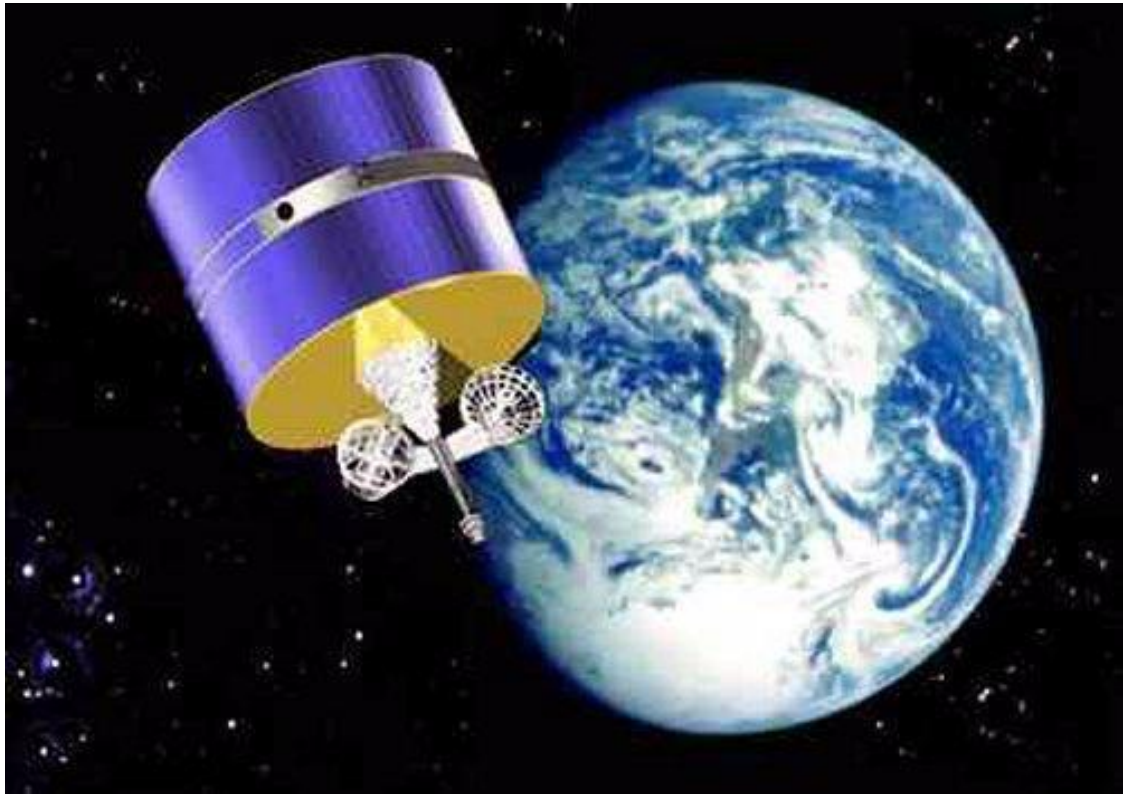


Figure 7: Artist's view of the FY-2 satellite

https://directory.eoportal.org/web/eoportal/satellite-missions/f/fy-2

Discussion

The obtained Images

The extracted data from the images were compromised cloud type, cloud top temperature and humidity index.

For each considered variables, six images were extracted between 5:00 to 7:30 UTC (8:30 to 12:00 AM local time). The images are taken for 30 minutes interval

The humidity index were collected for 6:00 to 9:00 UTC.

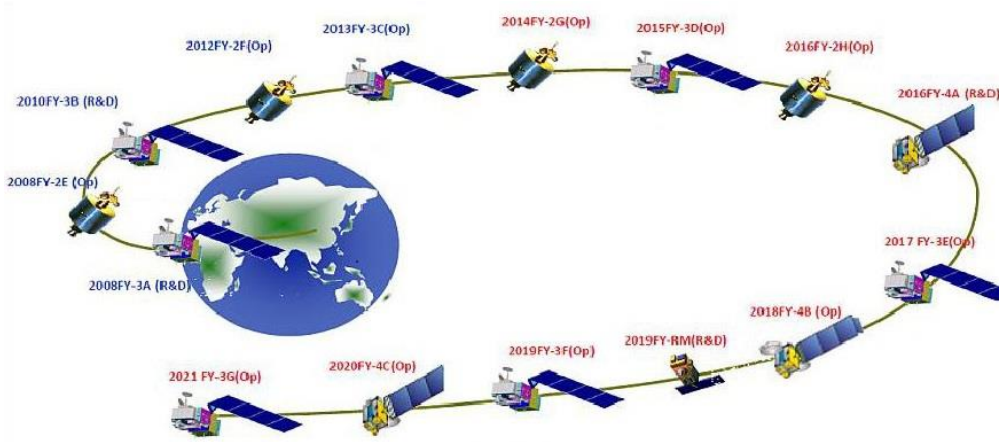


Figure 8: Planning overview of the CMA satellite systems up the the year 2020 (image credit: CMA

https://directory.eoportal.org/web/eoportal/satellite-missions/f/fy-2

Figure 9 (next slide) shows the images of cloud types acquired from 5:00 UTC to 7:30 UTC. These Figures demonstrate how clouds got intense during these two and half hours.

As indicated, at 5:00 AM, most of Iran are covered by the white Cirrus clouds which are generally formed at a distance of more than 5 km above sea level in the Mid latitudes areas.

The temperature of these clouds fluctuates mostly between -30 to 40 ℃ and the particles that make them up are ice. Although no precipitation occurs from such clouds, they can play a major role in fertilizing clouds below them.

Another type of clouds that can be seen in the southern part of the country and near Shiraz is the mixed type of Cirrostratus, Altostratus and Stratocumulus.

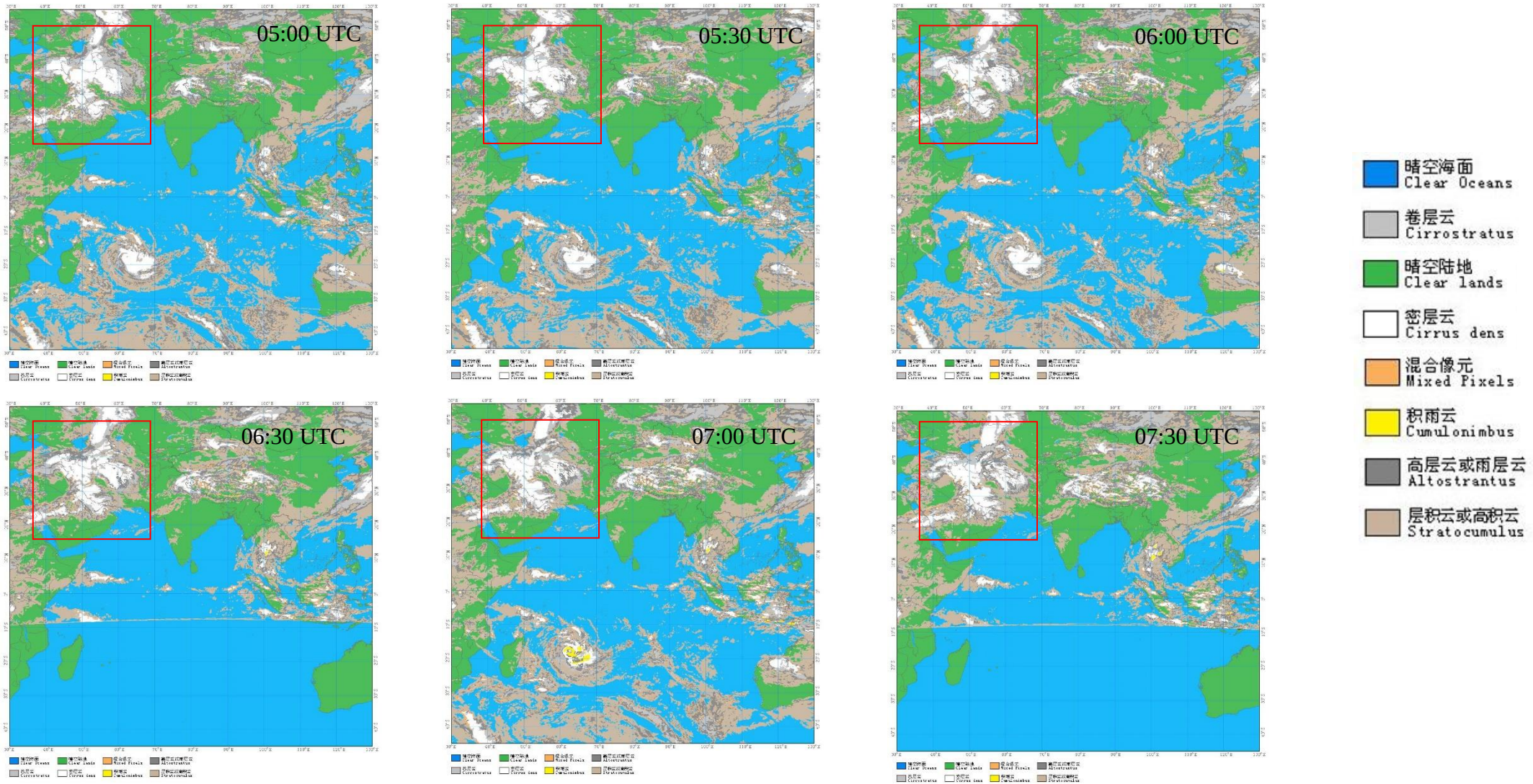


Figure 9: Cloud cover of Iran and large parts of Asia, Indian Ocean and Australia from the point of view of China Geostationary FY2H satellite at 5:00 to 7:30 UTC

It is worthwhile to note the appearance of a cloudless area within this cloud mass. This cloudless area starts from the southern parts of Pakistan and progresses obliquely inside Iran, and enters Fars province. (Green in Figure 10). Rain bearing clouds as well as tall Cirrus clouds are located on both sides of this zone.

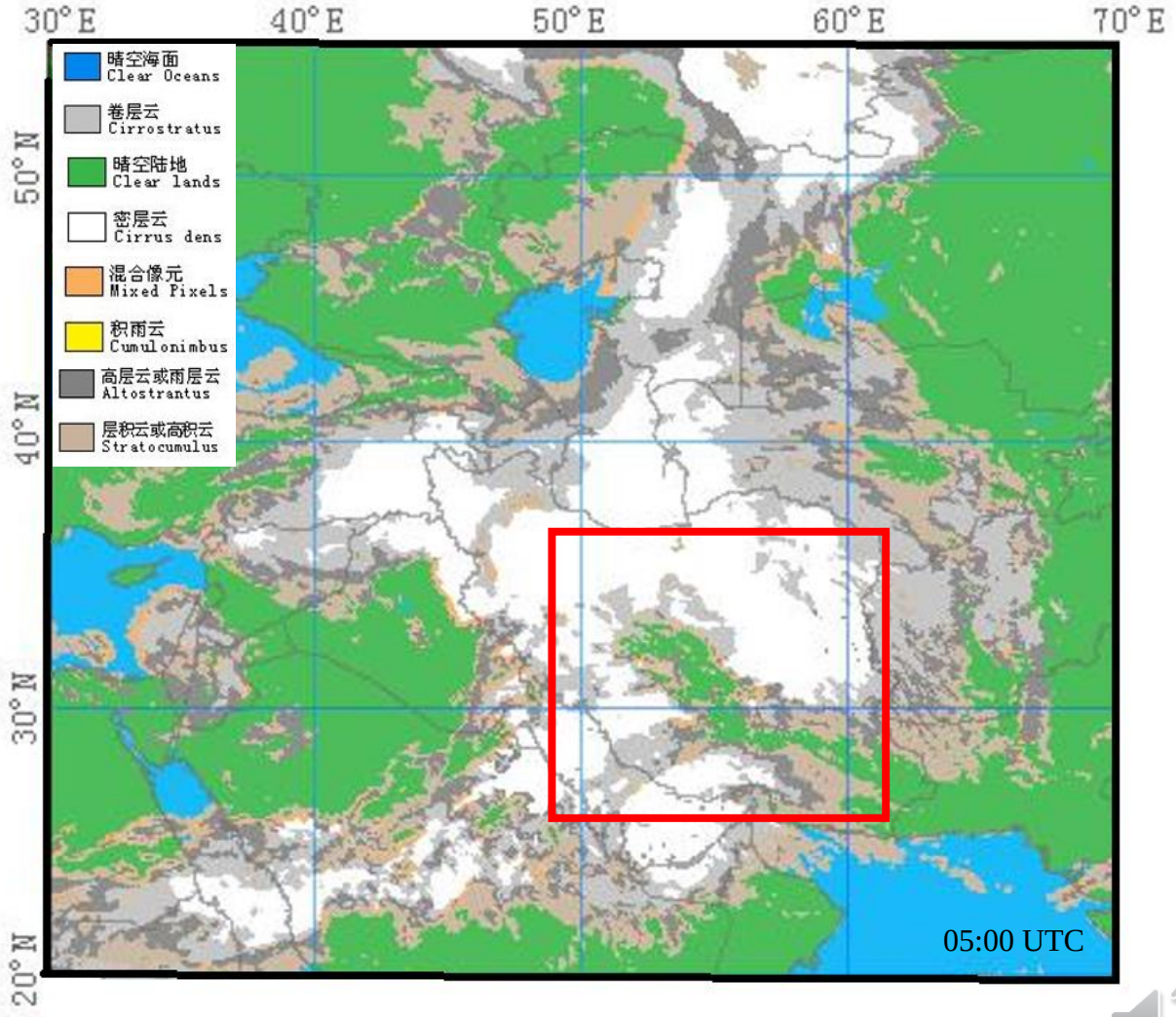


Figure 10: A cloudless area within the cloud mass over Iran from the point of view of China Geostationary FY2H satellite at 5:00 UTC

At 5:30 UTC, the coverage of rain bearing clouds including Altostratus and Stratocumulus has increased over the western and southern sides of Shiraz. This coverage had a west-east orientation indicating that moisture is mostly supplied from the Atlantic Ocean and tropical Africa. These clouds are re-moisturized in their passage over the Persian Gulf.

At 5:30 UTC, the middle clouds of Altostratus that are seen in black color, are more widespread than the other types. The general height of these clouds are between 6,500 and 20,000 feet (2,000-6,000 meters) above mean sea level.

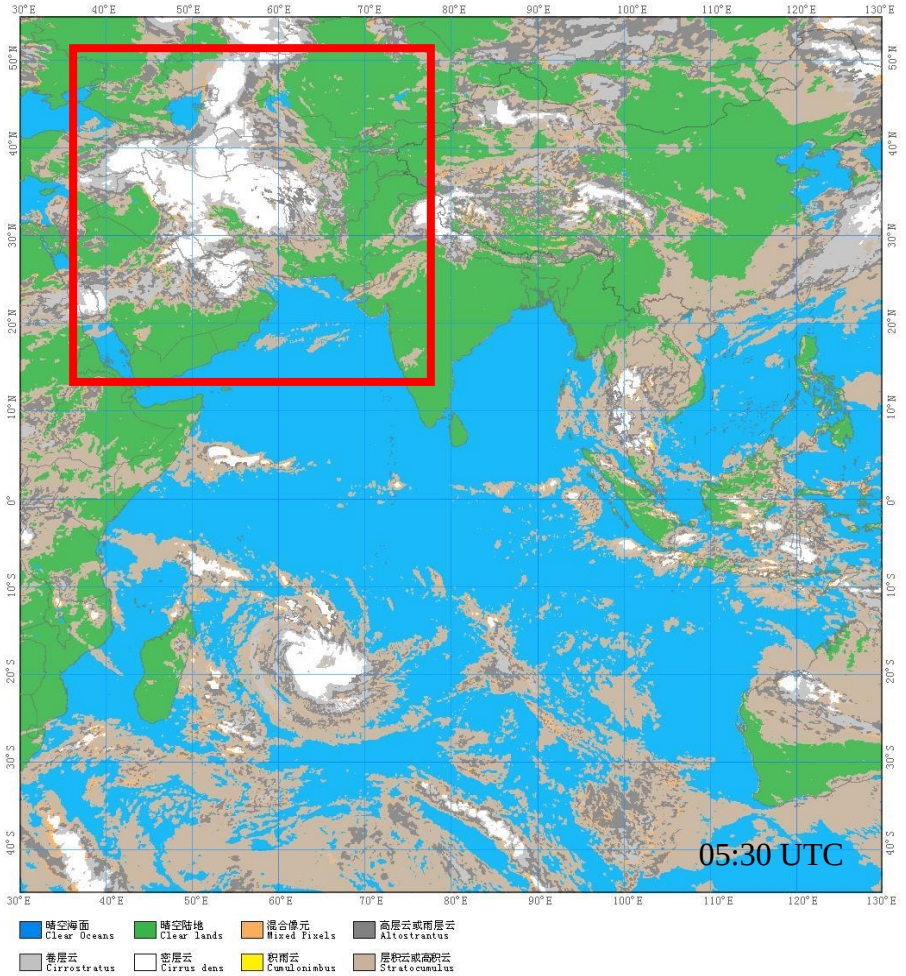


Figure 11: Cloud cover of Iran and large parts of Asia, Indian Ocean and Australia from the point of view of China Geostationary FY2H satellite at 5:30 UTC

At 6:00 UTC the intensity of Altostratus clouds that are depicted by gray to blue-green colors had been increased over Fars province.

These Altostratus clouds can transform into Nimbus Stratus clouds if they continue to be unstable.

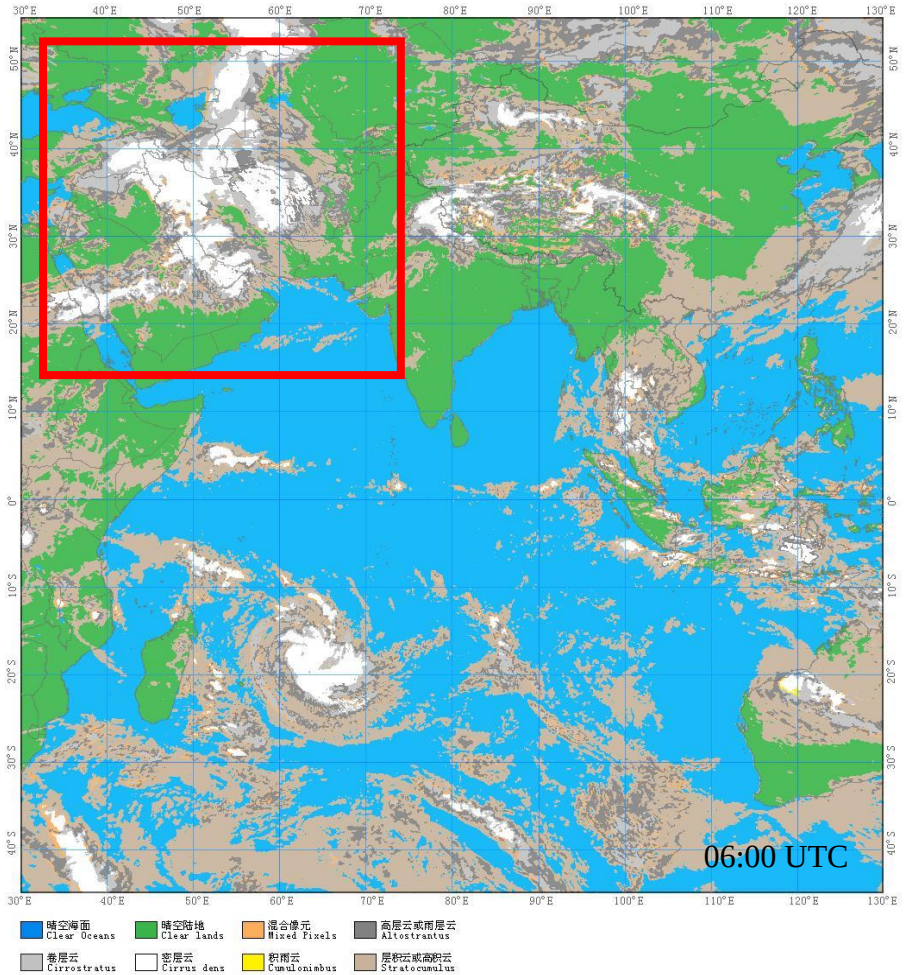


Figure 12: Cloud cover of Iran and large parts of Asia, Indian Ocean and Australia from the point of view of China Geostationary FY2H satellite at 6:00 UTC

At 6:30 UTC the Altostratus clouds are spread around Shiraz although their intensity seems slightly less than that of at 6:00 UTC.

Figure 13: Cloud cover of Iran and large parts of Asia, Indian Ocean and Australia from the point of view of China Geostationary FY2H satellite at 6:30 UTC

At 7:00 and 7:30 UTC, the spread of Cirrus clouds over Iran and Fars province has been increased. The increase of these clouds suggest that the Warm Fronts are developing near the study area.

At the same time, the above-mentioned cloudless area that was extended from Pakistan to central parts of Iran are getting small. These areas are mostly covered by a mix of rain-bearing clouds.

Also, the air temperature above the cloud is close to -73 ℃, indicating that the cloud column on the southern part of Iran and Shiraz capital city has enjoyed a large vertical expansion and it is a warning for heavy rains. Very low temperature of the cloud from 9:30 can be considered as a warning.

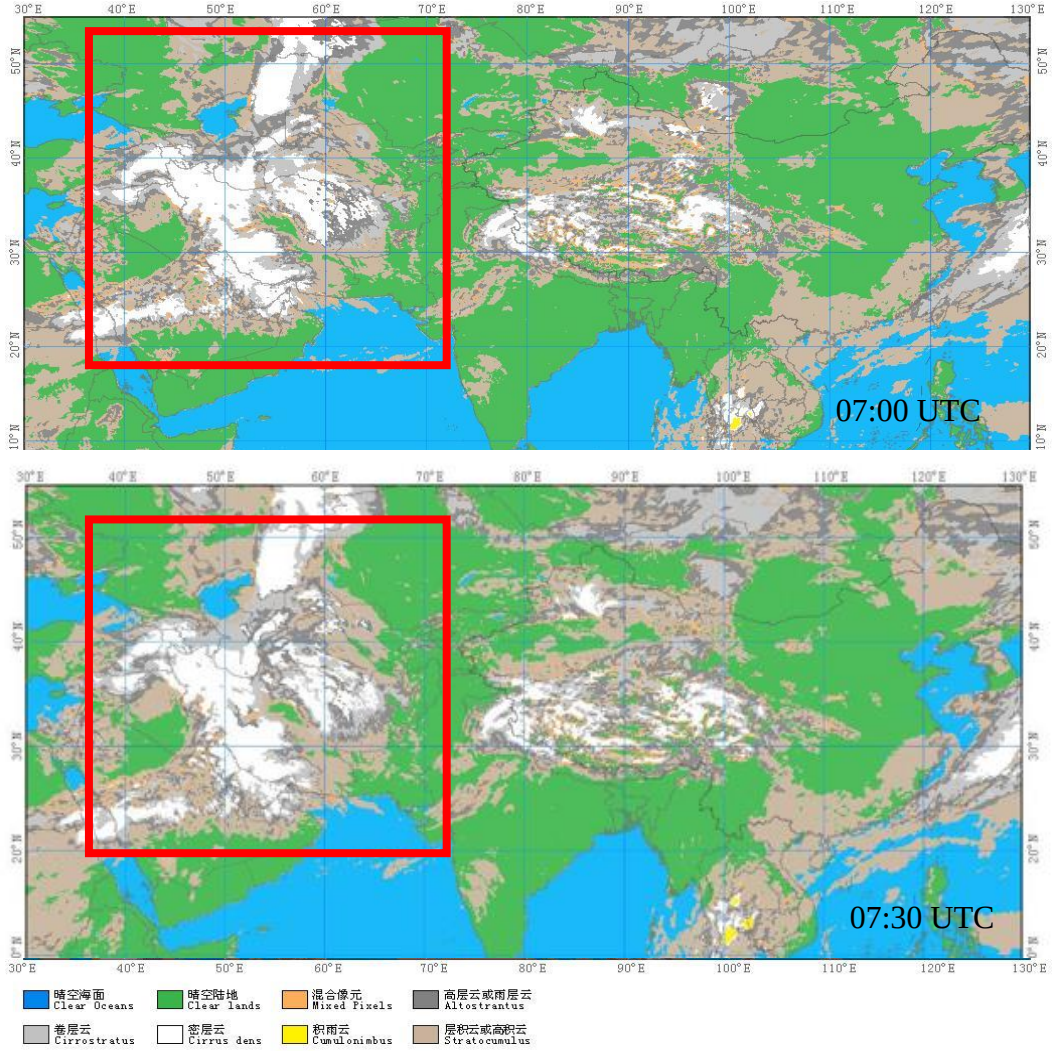


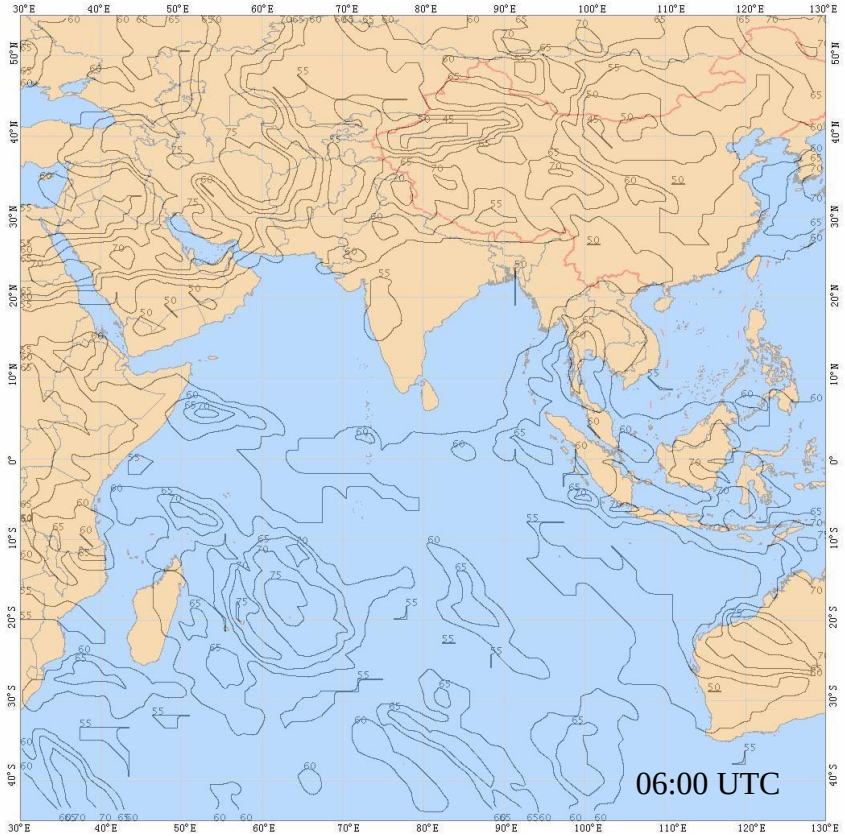
Figure 14: Cloud cover of Iran and large parts of Asia, Indian Ocean and Australia from the point of view of China Geostationary FY2H satellite at 7:00 and 7:30 UTC

Figure 15 (next slide) shows the geographical distribution of moisture in the 850mb layer at 6:00 UTC, approximately one hour before the flood in Shiraz. As can be seen, in the southwestern part of Iran, the size of the damp reaches its maximum size of 75%. This amount of moisture is not seen anywhere else on the map of Asia, which indicates the high volume of moisture in this part of the country.

The amount of moisture in these rainy regions of the world and also around the equator on the Indian Ocean is between 55% and 60%.

As shown in the map, the humidity counter lines on the eastern parts of Iran have a sharp twist. The lands within this torso have cloudless air, although they are surrounded by cloudy weather.

Monitoring of air humidity profile derived from 6:00 to 9:00 UTC also shows the high volume of humidity and its significant increase during heavy rainfall.



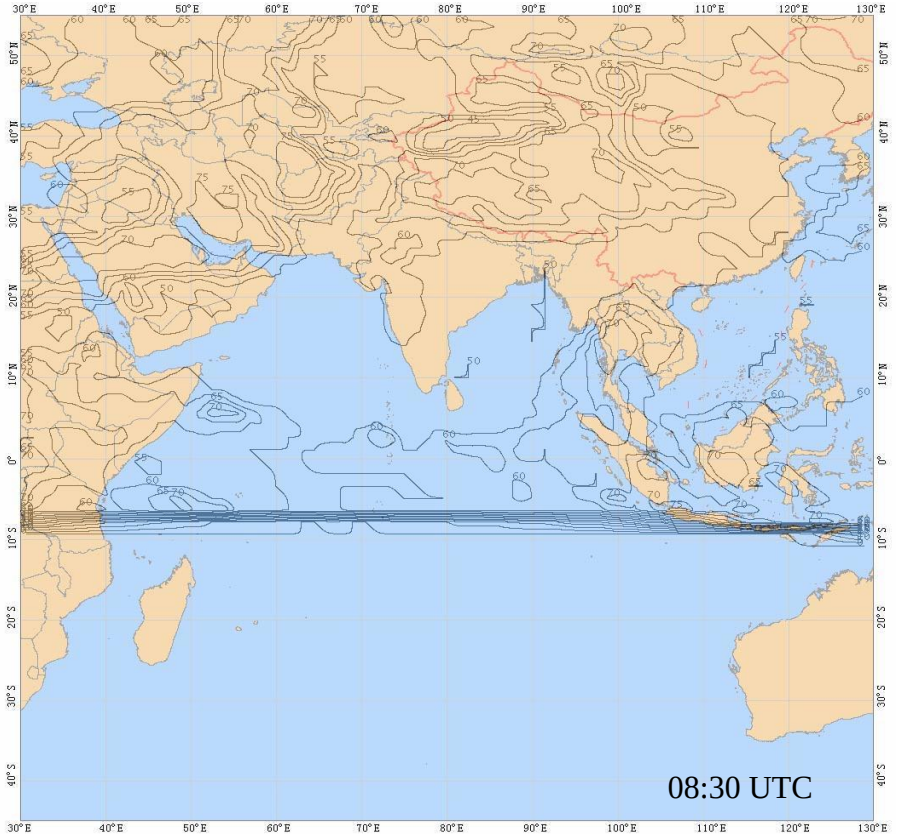


Figure 15: Geographical distribution of air humidity over Asia and the Indian Ocean from the perspective of China's FYH2 fixed land satellite. Measuring time 6:00 UTC and 8:30 UTC

Conclusions

This study is aimed to utilize the FY2H images for detecting the type and dynamics of clouds in southwest of Iran on 25 of March 2019. The characteristics and dynamics of the humidity index are also analyzed.

In this day a 20 min heavy storm had occurred over a small catchment in the northeast of Shiraz city.

This storm had led to a deadly flash flood in the downstream of the catchment; in one of the busiest street of Shiraz city. In addition to huge economical lost, 20 innocent people had died.

Six FY2H images that were taken from 5:00 to 7:30 UTC were analyzed for detecting cloud characteristics. Similar images were also examined to compare humidity index around Shiraz with the other parts of world that is detected by the satellite.

The analyses of the extracted images has indicated that the clouds are generally intensified over the study area from early morning to around 11:30; when the heavy storm has occurred. The intensification had weakened after the heavy storm.

The cloud type was generally categorized as mix cloud mostly Altocumulus and Cumulonimbus.

The top cloud temperature had dropped to around -70°C.

It was shown that the humidity in the southwest of Iran was on of the greatest in the world.

In general the FY2H images are capable for detecting and predicting heavy storms.

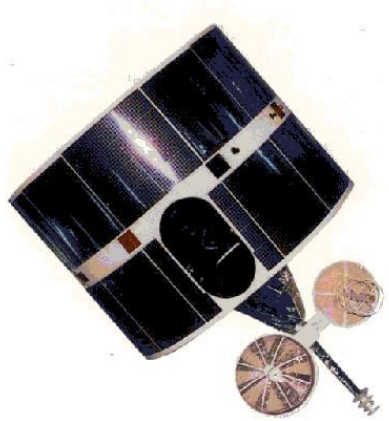


Figure 16: Illustration of the FY-2 spacecraft

https://directory.eoportal.org/web/eoportal/satellite-missions/f/fy-2

Thank you