Journal of the Korean Society of Remote Sensing, Vol.16, No.4, 2000, pp.293~303

Characteristics of Typhoon Jelawat Observed by OSMI, TRMM/PR and QuikSCAT

Hyo-Suk Lim, Gi-Hyuk Choi and Han-Dol Kim

Korea Aerospace Research Institute

Abstract : The typhoon Jelawat, which was formed over the tropical Pacific ocean on August 1, 2000 and made a landfall over China on August 10, 2000, was observed by Korea Multi-purpose Satellite (KOMPSAT-1) Ocean Scanning Multispectral Imager (OSMI), Tropical Rainfall Measuring Mission (TRMM)/Precipitation Radar(PR) and Quick Scatterometer (QuikSCAT). In spite of discontinuous observation, important mesoscale features of typhoon depending on life cycle were detected prominently. It is possible to distinguish on the OSMI photograph between the eye-wall convection and the stratiform and other convective clouds near the center of typhoon Jelawat. The TRMM/PR observations show quite clearly the eye-wall convection, stratiform regions, and convective bands. Vertical cross section of rainfall in the genesis stage of typhoon Jelawat exhibits circular ring of intense convection surrounding the eye. The mature stage of typhoon Jelawat consists of a strong rotational circulation with clouds which are well organized about a center of low pressure. The OSMI, TRMM/PR and QuikSCAT measurements presented here agree qualitatively with each other and provide a wealth of information on the structure of typhoon Jelawat.

Key Words : Typhoon, Tropical cyclone, OSMI, TRMM/PR, QuikSCAT.

1. Introduction

The life cycle of tropical cyclones consist of three stages such as the genesis stage, the mature stage and the decaying stage (Anthes, 1982). In the genesis stage, a relatively disorganized array of clouds and squall lines are observed. The mature stage consists of a strong rotational circulation which display a high degree of circular symmetry in their pressure pattern. In the decaying stage, the circulation weakens, expands in size and becomes asymmetric about the center. Generally, tropical cyclones contain important mesoscale features depend on life cycle, including a ring of towering cumulonimbus clouds called the eye-wall cloud; a region of stratiform precipitation outside the eye-wall. Data from weather radar and enhanced satellite images have provided the detailed structure of tropical cyclones. The motivation for this study comes from that observations from multi sensors such as Korea Multi-Purpose Satellite (KOMPSAT-1) Ocean Scanning

---

Received 10 November 2000; Accepted 5 December 2000.

Multispectral Imager(OSMI), Tropical Rainfall Measuring Mission (TRMM)/Precipitation Radar(PR), Quick Scatterometer (QuikSCAT) can provide a wealth of information on the structure of tropical cyclones.

2. Data and Methodology

The data involved in this study include an imagery of KOMPSAT-1 OSMI, level 2A23 and 2A25 of TRMM/PR data, and SeaWind on QuikSCAT level 3 data. The KOMPSAT-1 aboard OSMI was successfully launched December 21, 1999 from Vandenberg Air Force Base in California. During the first four weeks after launch, many tests for satellite and payloads had been attempted. The first onboard solar calibration data arrived on early January of 2000. After additional calibration data were received, the OSMI science data have been received from the middle of January 2000. The staffs of the KOMPSAT-1 Receiving and Processing Station (KRPS) have been working with the OSMI working group to calibrate and make OSMI products reliable.

The TRMM satellite was launched November 27, 1997 into a near circular orbit of approximately 350km in altitude with an inclination of 35 degrees to the equator and a period of 91.5 minutes. The TRMM/PR is the first space-borne rain radar and one of five instruments on the TRMM satellite. It is an active 13.8 GHz radar with a 17° scan angle, resulting in a 215 km swath width. Resolution is 4.3km(horizontal) and 250m(vertical) at nadir. The TRMM Science Data and Information System (TSDIS) processes TRMM/PR data. The PR level 2A23 and 2A25 products are available from http://lake.nascom.nasa.gov/data/dataset/TRMM. More details on the data products are found at http://tsdis.gsfc.nasa.gov/tsdis/tdsis.html (Tutorial for reading TRMM data products, 1998).

The SeaWinds on QuikSCAT mission is a "quick recovery" mission to fill the gap created by the loss of data from the NASA Scatterometer (NSCAT) when the ADEOS-1 satellite lost power in June 1997. It will continue to add to the important ocean wind data set begun by NSCAT in September 1996. The QuikSCAT was launched from California's Vandenberg Air Force Base aboard a Titan II vehicle on June 19, 1999. The QuikSCAT satellite was launched into a sun-synchronous, 803km, circular orbit with a local equator crossing time at the ascending node of 6:00 A.M.±30 minutes. The SeaWinds instrument on the QuikSCAT satellite is a specialized microwave radar that measures near-surface wind speed and direction under all weather and cloud conditions over Earth's oceans. See QuikSCAT Science Data Product User's Manual (2000) for more details. The SeaWinds on QuikSCAT level 3 data is distributed electronically via the PO.DAAC ftp site(ftp://podaac.jpl.nasa.gov/pub/ocean_wind/quikscat).

In order to investigate the distribution of cloud, precipitation and wind of typhoon Jelawat, visible OSMI image, TRMM/PR and QuikSCAT data observed at the nearest time were analyzed. Especially, the TRMM/PR data is very useful for vertical structure of precipitation in the typhoon Jelawat.

3. Results

The typhoon Jelawat, which was formed over the tropical Pacific ocean on August 1, 2000 and made landfall over China on August 10, 2000 has a trajectory in Fig. 1. The typhoon Jelawat discontinuously observed by TRMM/PR on August 2 (orbit 15432), 7 (orbit 15514), and 8 (orbit 15526) 2000 and the results were superimposed on simultaneous Geostationary Meteorological Satellite(GMS)-5 images. In life cycle of tropical cyclone based on Table 1, orbit 15432 may be in the genesis stage and orbit 15514 and 15526 may be in the mature stage. The TRMM/PR has provided dramatic views of hurricane Bonnie and Floyd, among others (Chandler, 2000).

Fig. 2 shows the visible OSMI image of typhoon Jelawat at 01:40:17 UTC, August 8, 2000. It is the nearest time image with orbit 15526 of TRMM/PR. It is possible to distinguish on the OSMI photograph between the eye-wall convection, the stratiform and other convective clouds near the center of typhoon Jelawat which have different reflectivities and shapes. As the OSMI data is still in calibration, qualitative consideration hasn't been made. Despite the limitations, OSMI image clearly shows the mesoscale features of tropical cyclone in the mature stage when it was compared with imagery of TRMM/PR which will be displayed later in this study.

When radars were introduced to study tropical cyclones after World War II, observers were surprised to find that rain echoes occurred in well-defined spiral bands rather than uniformly throughout the interior region of the tropical cyclone (Wexler, 1947). The spiral bands consist of

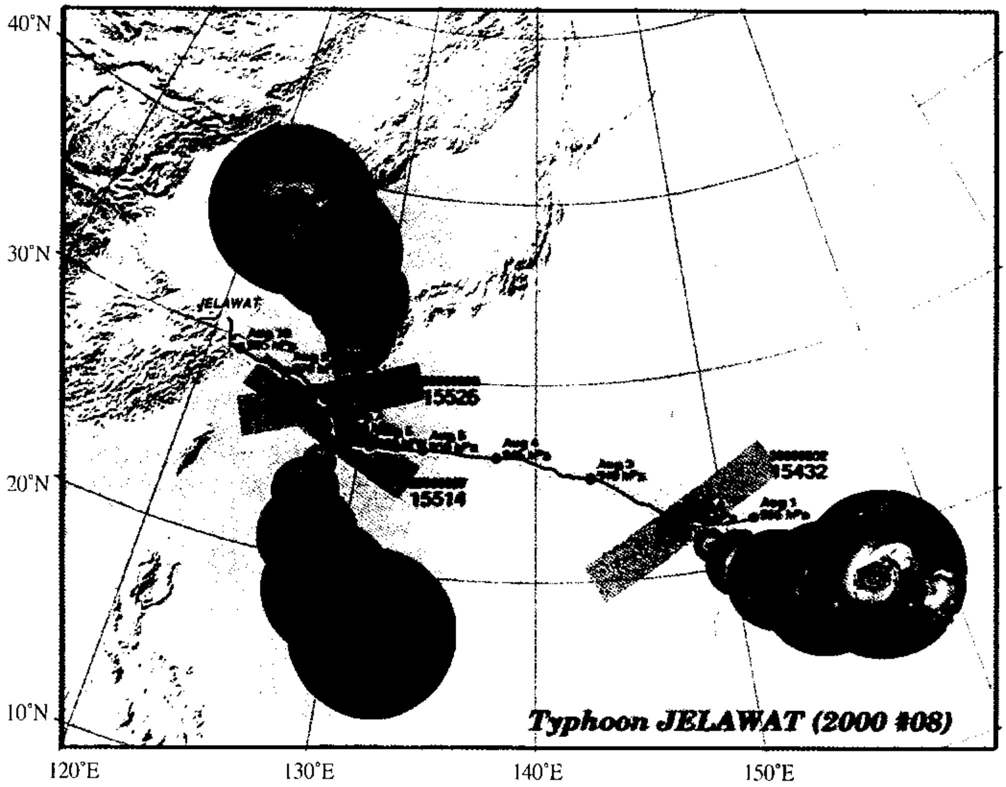


Fig. 1 Trajectory of Typhoon Jelawat(2000 #8) prepared by NASDA/EORC.

Table 1. Development of typhoon Jelawat.

Date	Classification	Pressure at Center	Moving Direction	Moving Speed	Wind speed at center	Radius of Wind speed >15m/s	Radius of Wind speed >25m/s
15:00:00 GMT August 3	TYPHOON	940 hPa	NW	24 Km/h	44 m/s	280 Km	110 Km
15:00:00 GMT August 4	TYPHOON	945 hPa	WNW	24 Km/h	41 m/s	280 Km	90 Km
16:00:00 GMT August 5	TYPHOON	950 hPa	W	17 Km/h	41 m/s	280 Km	90 Km
03:00:00 GMT August 6	TYPHOON	950 hPa	W	13 Km/h	41 m/s	280 Km	90 Km
15:00:00 GMT August 6	TYPHOON	960 hPa	W	15 Km/h	39 m/s	280 Km	100 Km
15:00:00 GMT August 7	TYPHOON	960 hPa	WNW		39 m/s	200 Km	100 Km
03:00:00 GMT August 8	TYPHOON	965 hPa	NW		39 m/s	200 Km	100 Km
15:00:00 GMT August 8	TYPHOON	965 hPa	NW	13 Km/h	39 m/s	260 Km	100 Km
03:00:00 GMT August 9	TYPHOON	965 hPa	WNW		36 m/s	220 Km	110 Km
15:00:00 GMT August 9	TYPHOON	965 hPa	WNW	10 Km/h	36 m/s	220 Km	100 Km
03:00:00 GMT August 10	TYPHOON	970 hPa	W	11 Km/h	36 m/s	190 Km	110 Km
15:00:00 GMT August 10	STS	980 hPa	W	15 Km/h	31 m/s	130 Km	56 Km
06:00:00 GMT August 11	TS	994 hPa	WNW	15 Km/h	21 m/s	100 Km	
09:00:00 GMT August 11	TD	998 hPa	NW	18 Km/h			

individual convective cells associated with small-scale cumulus convection. The averaged rainfall of typhoon Jelawat observed by TRMM/PR appears in Fig. 3. The rain rate is averaged for each ray between the two predefined heights of 2 and 4 km. For orbit 15432, classified into the genesis stage, the cloud-free eye is very small in diameter and the highest rainfall rate are found within the eye-wall cloud which is whirling around the eye. At larger distances from the eye, heavy rain is concentrated within spiral rainbands. For orbit 15514 and 15526, classified into the mature stage, the cloud-free eye is about 100 km in diameter and outer rainband begins at 100 – 150 km from the typhoon center with a prominent spiral shaped feature. Comparing an image of 15526 to a photograph of OSMI in Fig. 2, a schematic demonstrating the eye-wall, rainband and rain type (convective or stratiform) is dramatically consistent.

Although there are many theories to explain the formation and the maintenance of the typhoon eye, it is possible to observe a well defined eye in the mature stage. Generally, following conceptual model of eye formation is consistent with many observations (Anthes, 1982). As a tropical storm

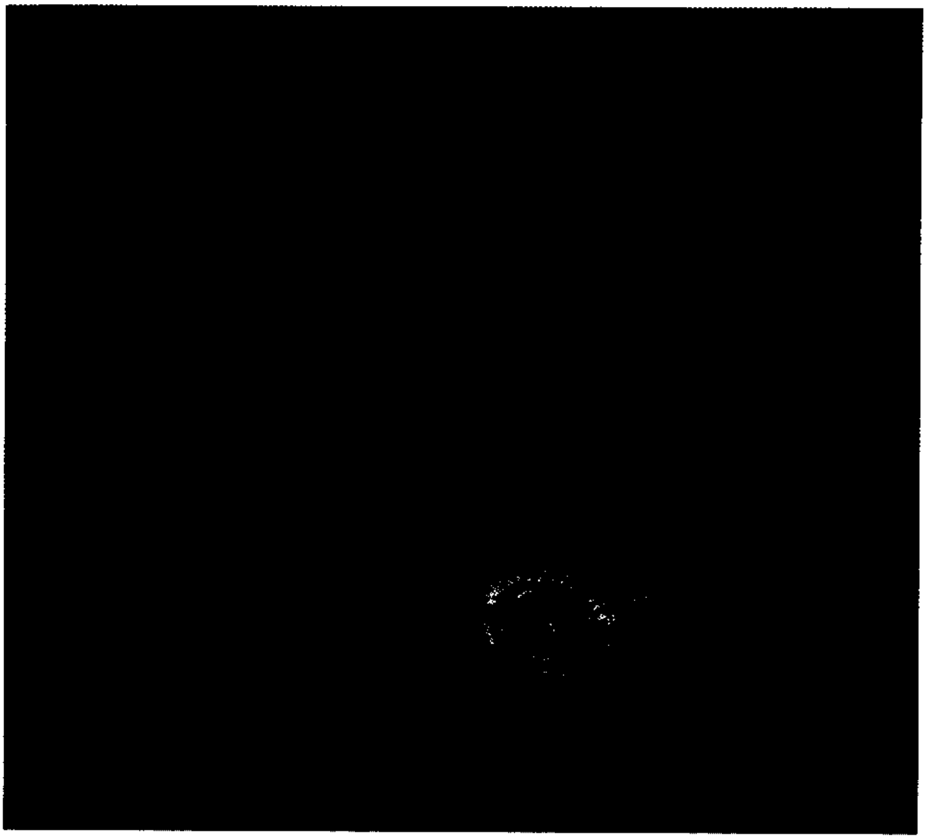


Fig. 2. Photograph from OSMI of Typhoon Jelawat at 01:40:17 UTC, 8 August, 2000.

intensifies, the air rises in vigorous thunderstorms and tends to spread out horizontally near the tropopause or in the lower stratosphere. As the air spreads out aloft, a positive perturbation pressure at high level is produced, which accelerates a downward motion next to the deep convection. With the inducement of subsidence, the air warms by compression and a positive buoyancy is generated. Eventually, this buoyancy term grows to balance the perturbation pressure gradient term and the downward vertical acceleration decreases. At this point the interior of the storm may reach a steady state, with little or no vertical motion in the eye of the typhoon. Although subsidence in the eye is sometimes sufficiently strong to produce clear skies, there are often shallow cumulus clouds near the surface.

The total rainfall from TRMM/PR of typhoon Jelawat in Fig. 4 is the integral of rain rate from rain top to rain bottom. Because of deep convection in the genesis stage, highest rainfall is observed within the eye-wall and spiral rainband. Generally, total rainfall in the genesis stage (orbit 15432) is higher than that in the mature stage (orbit 15514 and 15526). The vertical cross sections of rainfall along the central line of latitude in Fig. 3 also show that deep convection with height up to 13km can be found in the genesis stage (Fig. 5). The vertical cross section of orbit 15514 and 15526, typical of other mature typhoons, exhibits an intense circular eye-wall.

The most prominent characteristic of the

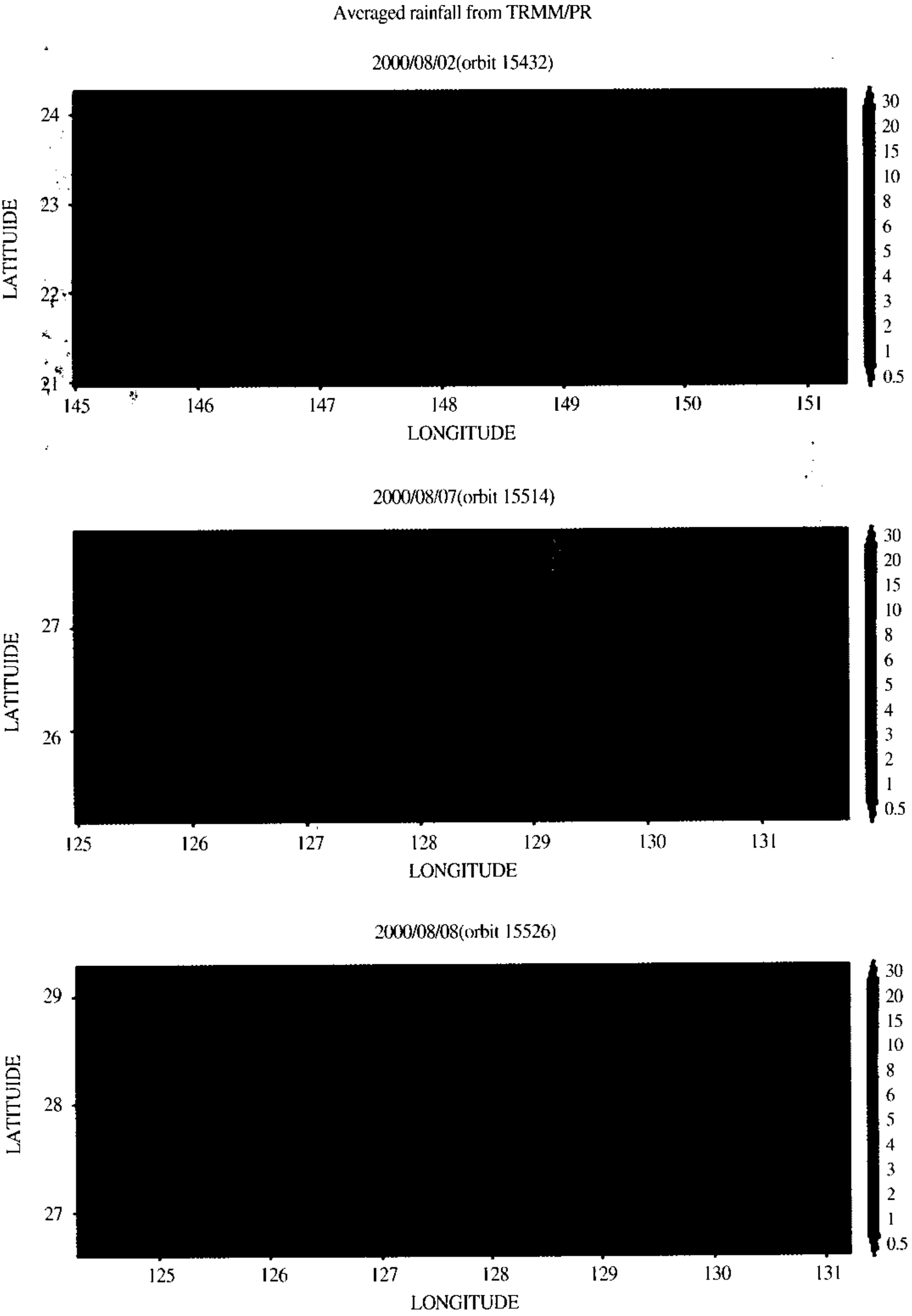
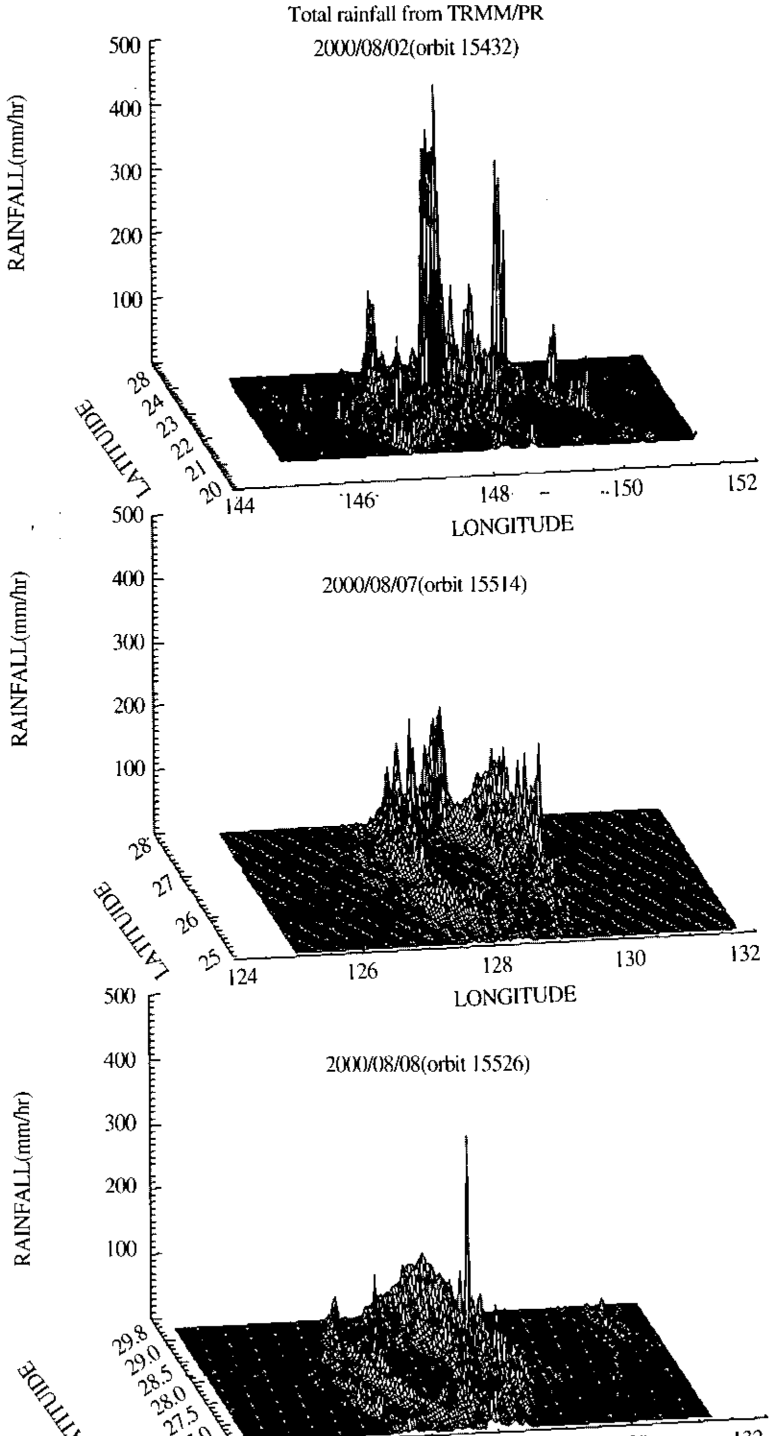


Fig. 3. Averaged rainfall from TRMM/PR of Typhoon Jelawat on 2, 7, and 8 August 2000.



Total rainfall from TRMM/PR

2000/08/02(orbit 15432)

2000/08/07(orbit 15514)

2000/08/08(orbit 15526)

Fig. 4. Same as in Fig. 3 except for total rainfall.

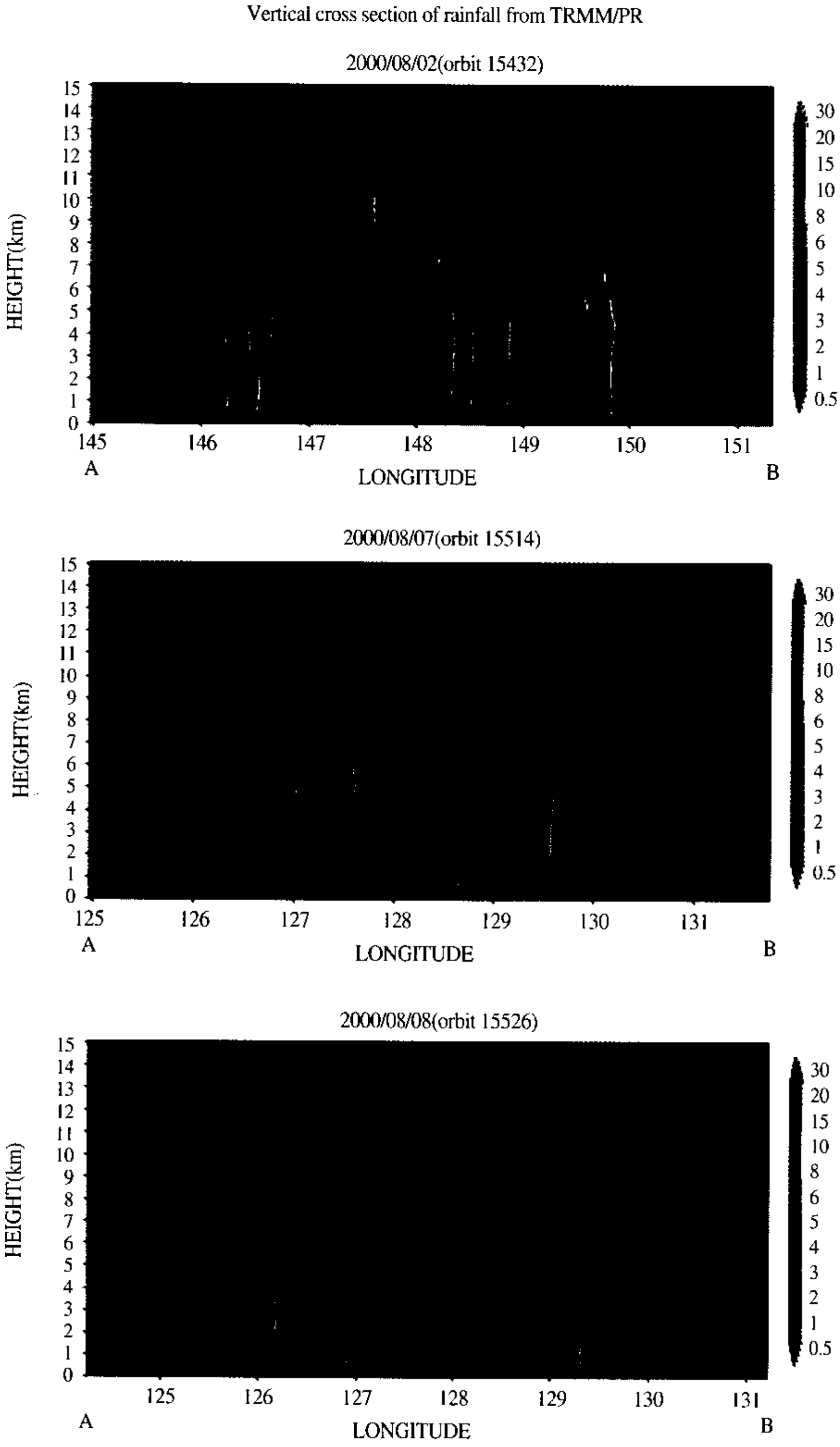


Fig. 5. Same as in Fig. 3 except for vertical cross section of rainfall.

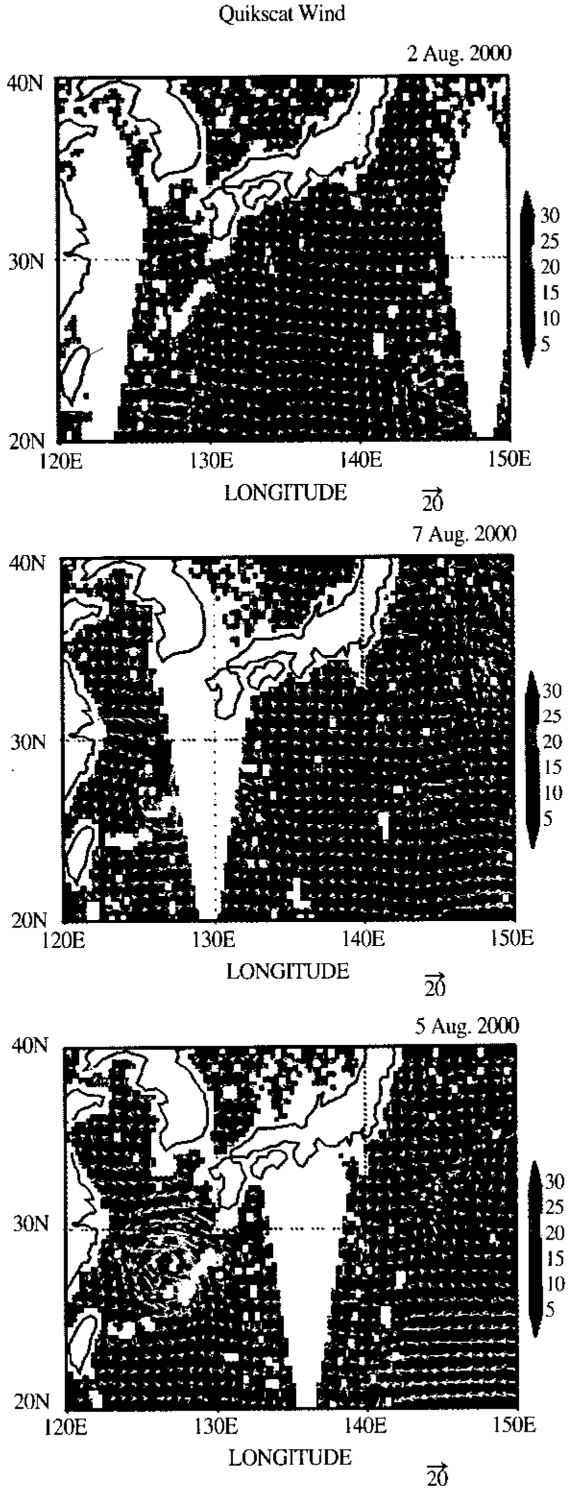


Fig. 6. Same as in Fig. 3 except for averaged wind velocity and speed from QuikSCAT.

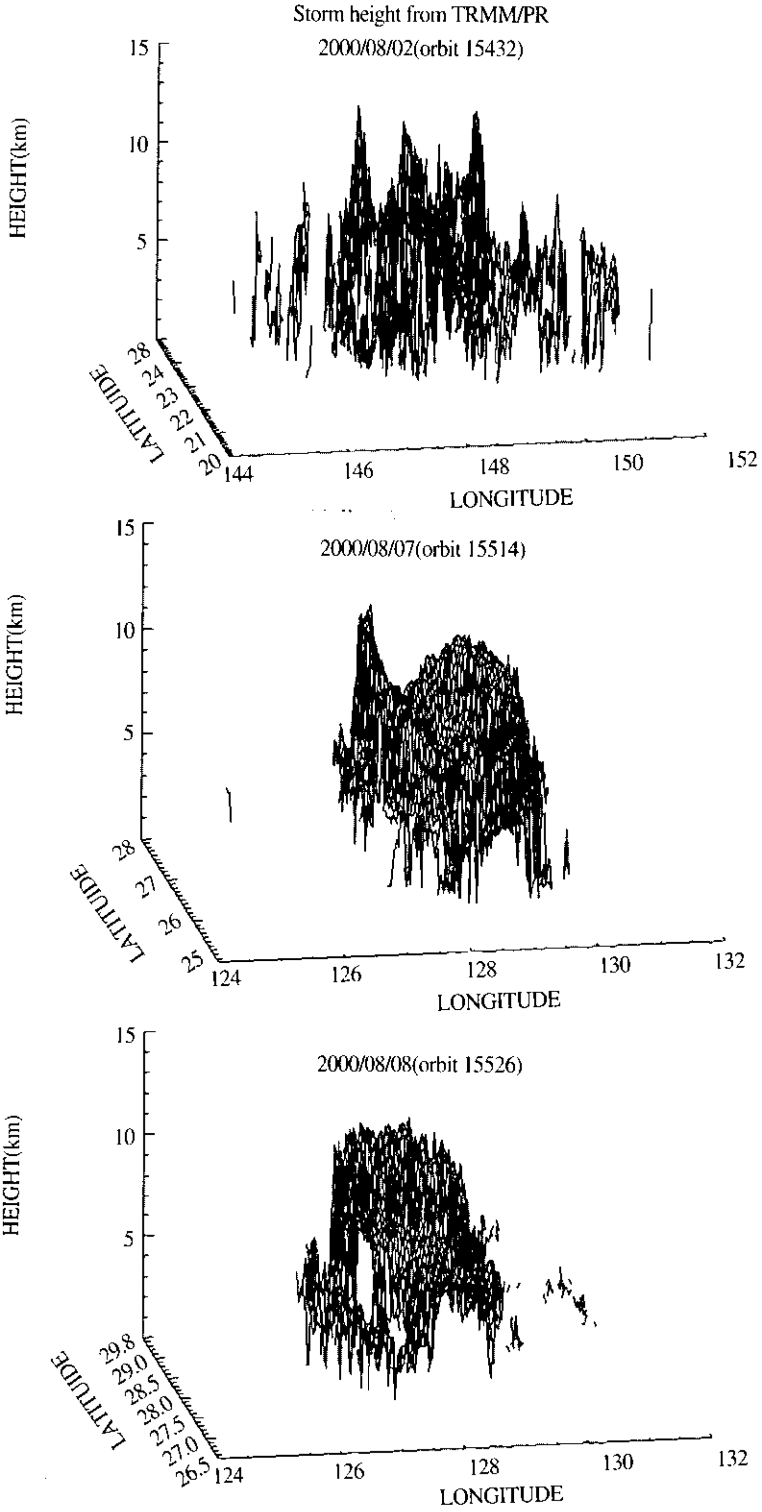


Fig. 7. Same as in Fig. 3 except for storm height.

tropical cyclone is a doughnut-shaped ring of strong winds surrounding an area of extremely low pressure at the center of the storm. These strong winds may drive the ocean into waves exceeding 6m in height. As mentioned above, the hole of the doughnut called the eye is a relatively calm region of clear skies. The production of rotational component to the flow arises from the simple law of conservation of angular momentum. As the radius becomes small, the conservation of an angular momentum demands higher speeds. The SeaWinds instrument on the QuikSCAT satellite measures near-surface wind speed with a local equator crossing time at the ascending node of 6:00 A.M. ± 30 minutes. The wind velocity and speed are averaged for each day and the results are displayed in Fig. 6. Because of passing orbit, the wind distribution of typhoon Jelawat was not completely observed except for August 8, 2000. In spite of limited data, it is evident that the counter clockwise circulation is intensified in the mature stage. The storm height from TRMM/PR shows that typhoons in the mature stage are well organized about a center of low pressure (Fig. 7). It is consistent with the strongest wind speed which can be found in the mature stage.

4. Conclusions

The typhoon Jelawat was observed by OSMI, TRMM/PR and QuikSCAT. In spite of discontinuous observation, important mesoscale features of typhoon depending on life cycle were detected prominently. The OSMI, TRMM/PR and QuikSCAT measurements presented here agree qualitatively with each other and provide a wealth of information on the structure of typhoon Jelawat. The further study is planned to describe the vertical distribution of hydrometeor using TRMM Microwave Imager(TMI).

Acknowledgement

This study has been supported by Development of Remote Sensing Technologies funded by Ministry of Science and Technology and Advanced Environmental Monitoring Research Center, KwangJu Institute of Science and Technology.

References

Anthes, R., 1982, *Tropical Cyclones*, Boston, American Meteorological Society.

Chandler, L., 2000, Hurricane forecasts more accurate on 100th anniversary of deadly Galveston storm, *NASA News Archive*, September 2000, NASA/GSFC.

QuikSCAT Science Data Product User's Manual, 2000, NASA/JPL.

Tutorial for reading Tropical Rainfall Measuring Mission (TRMM) Data Products, 1998, NASA/GSFC.

Wexler, H., 1947, Structure of hurricanes as determined by radar, *Ann. N.Y. Acad. Sci.*, 48: 821-844.