CHAPTER 3 METHODOLOGY

3.1 Data and Experiment Cases

Tropical cyclones that are formed in the Gulf of Thailand and used in this study are shown in Table 3.1.

Table 3.1 Experiment cases

Case	Name of Tropical cyclone	Year
1	Gay	1989
2	Vamei	2001

The observed radial wind data are approximated using data obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) (European Centre for Medium-Range Weather Forecasts, 2009). The satellite images of the storms are downloaded from Digital Typhoon of the Joint Typhoon Warning Center (JTWC) (Joint Typhoon Warning Center, 2009) and Regional Specialized Meteorological Center (RSMC) (Japan Meteorological Agency, 2009). Information on tropical cyclones for this study is shown in Tables 3.2-3.3. Surface wind speeds during the period when tropical storms are in the Gulf of Thailand are shown in Figures 3.1-3.2. The satellite images of tropical cyclone Gay and Vamei are from Digital Typhoon (Joint Typhoon Warning Center, 2009).

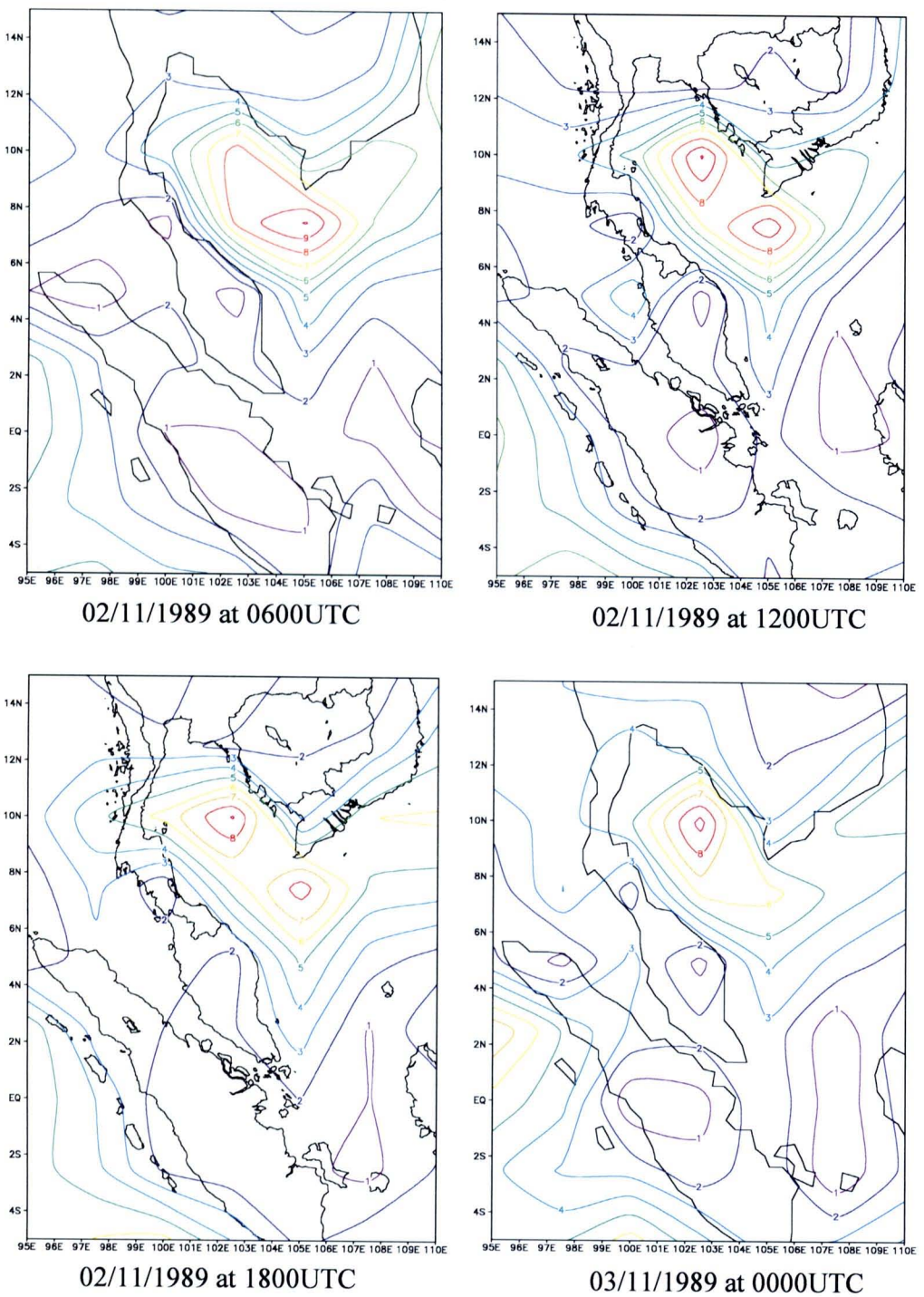
Satellite images for Gay and Vamei are obtained from GMS5 and MTSAT-1R satellites of Japan Meteorlogical Agency as compiled by Digital Typhoon (Joint Typhoon Warning Center, 2009).

Table 3.2 Typhoon Gay (Joint Typhoon Warning Center, 2009).

Name	Year	Month	Day	Hour (UTC)	Latitude	Longitude	Wind (kt)	Storm Wind Radius (nm)	Gale Wind Radius (nm)
Gay	1989	11	2	06	8.2	101.9	40	-	60
	1989	11	2	12	8.4	101.8	40	-	60
	1989	11	2	18	8.7	101.6	45	-	60
	1989	11	3	00	9.0	101.4	45	-	60
	1989	11	3	06	9.7	101.1	55	20	80
	1989	11	3	12	10.1	100.8	60	30	100
	1989	11	3	18	10.3	100.3	65	30	100
	1989	11	4	00	10.6	99.8	75	30	100
	1989	11	4	06	10.8	99.0	65	30	100
	1989	11	4	12	11.3	97.5	60	30	100

Table 3.3 Typhoon Vamei (Joint Typhoon Warning Center, 2009).

Name	Year	Month	Day	Hour (UTC)	Latitude	Longitude	Wind (kt)	Storm Wind Radius (nm)	Gale Wind Radius (nm)
Vamei	2001	12	27	00	1.5	105.2	40	-	100
	2001	12	27	06	1.5	104.4	45	-	120
	2001	12	27	12	1.6	103.9	35	-	100



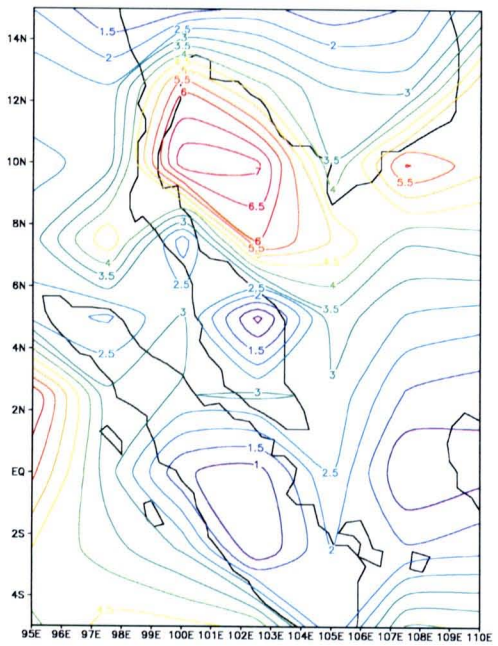
02/11/1989 at 0600UTC

02/11/1989 at 1200UTC

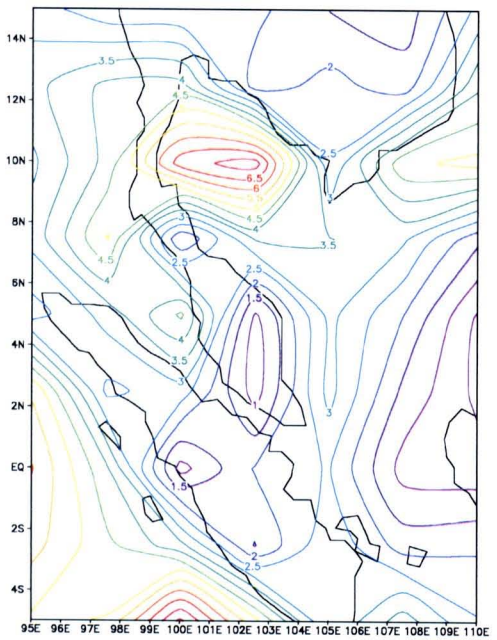
02/11/1989 at 1800UTC

03/11/1989 at 0000UTC

Figure 3.1 Surface wind speed (m/s) of typhoon Gay from ECMWF during 02-04 November 1989.



03/11/1989 at 0600UTC



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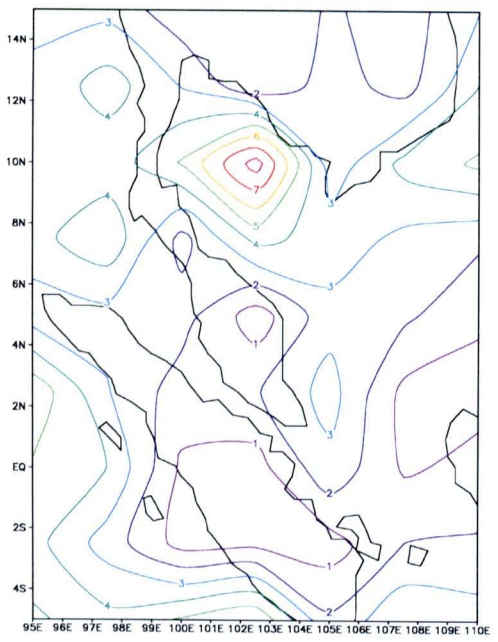
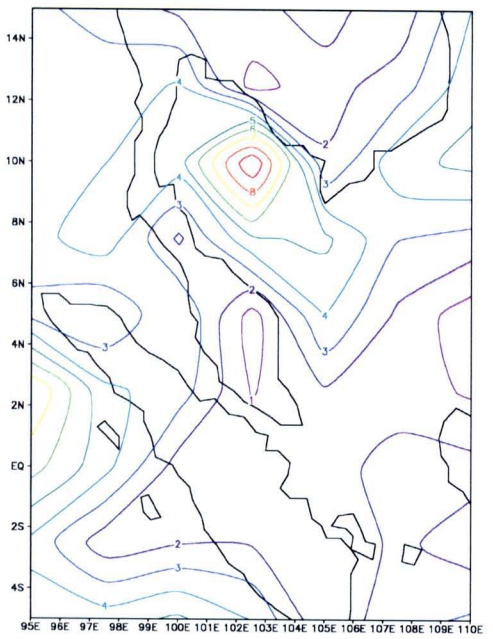
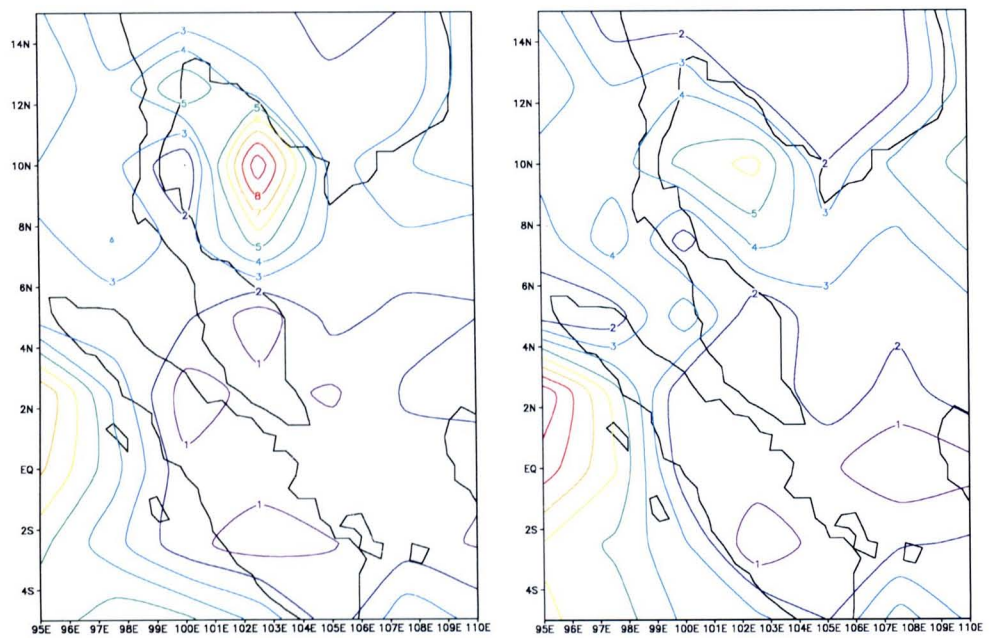


03/11/1989 at 1800UTC



04/11/1989 at 0000UTC

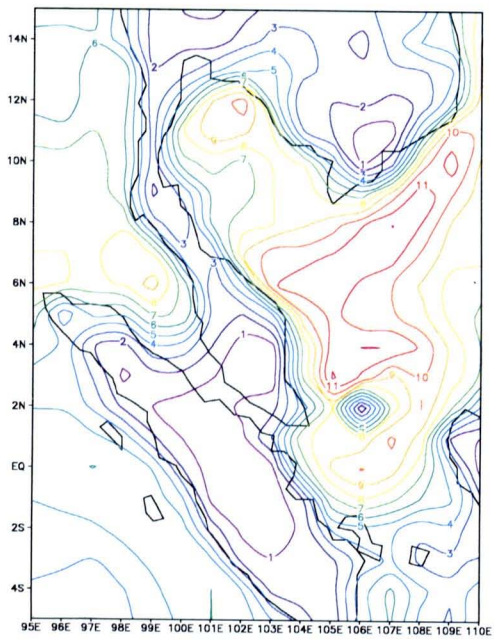
Figure 3.1 Surface wind speed (m/s) of typhoon Gay from ECMWF during 02-04 November 1989 (continued).



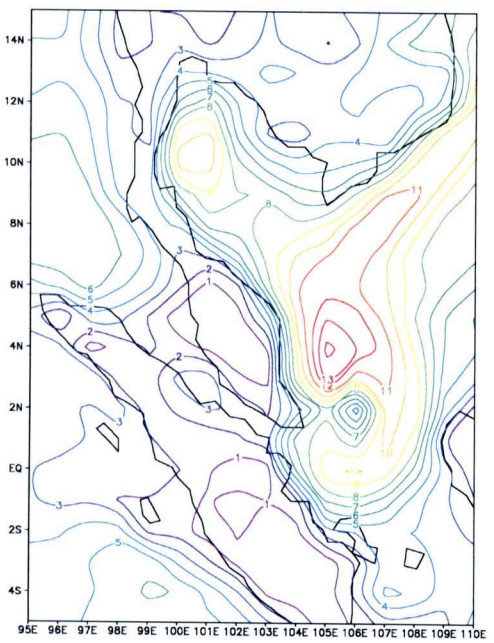
04/11/1989 at 0600UTC

04/11/1989 at 1200UTC

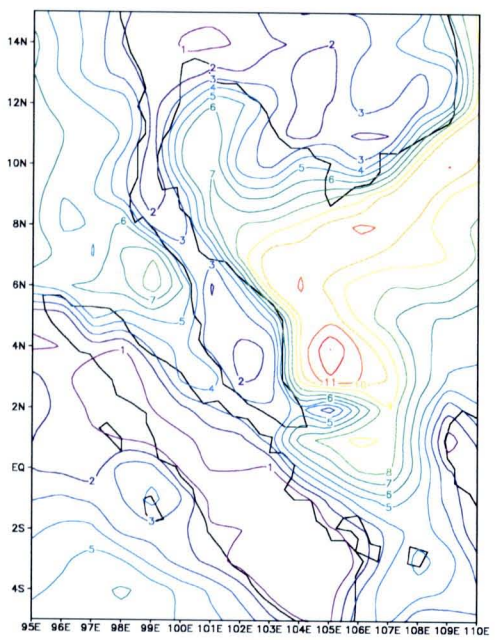
Figure 3.1 Surface wind speed (m/s) of typhoon Gay from ECMWF during 02-04 November 1989 (continued).



27/12/2001 at 0000UTC



27/12/2001 at 0600UTC



27/12/2001 at 1200UTC

Figure 3.2 Surface wind speed (m/s) of typhoon Vamei from ECMWF during 27 December 2001.

3.2 Calculation of Spiral Curve

In this research, a numerical simulation model of vortex formation in the Gulf of Thailand is developed. The model is based on the concept of collision of two fluid jets in Equation (2.7). The appropriate values of initial radius (r_o) and the ratio between radial and tangential winds (m) for tropical storm formation in the Gulf of Thailand is investigated.

Steps for development of the model are as follows.

Step 1. Determine the radius of maximum wind (R_{max}) and the radius of tropical cyclone ($r(0)$) from Digital Typhoon database. Also, specify r and calculate V_t from Equation (2.15).

Step 2. Define the values of require parameters: starting point and angle increment ($\Delta\theta$).

Step 3. Calculate tangential wind from Equation (2.15).

Step 4. Specify an arbritary value of m.

Step 5. Compute the value of $r(i)$ for the corresponding $\theta(i)$ using Equation (2.11) . Repeat this step until the radius equal to the size of the eye of the storm.

Step 6. Plot the spiral obtained from step 5 and overlay with the corresponding satellite image.

Step 7. Repeat Steps 4-6 until the appropriate value of m is obtained.

Calculation steps are shown as flowchart in Figure 3.3.

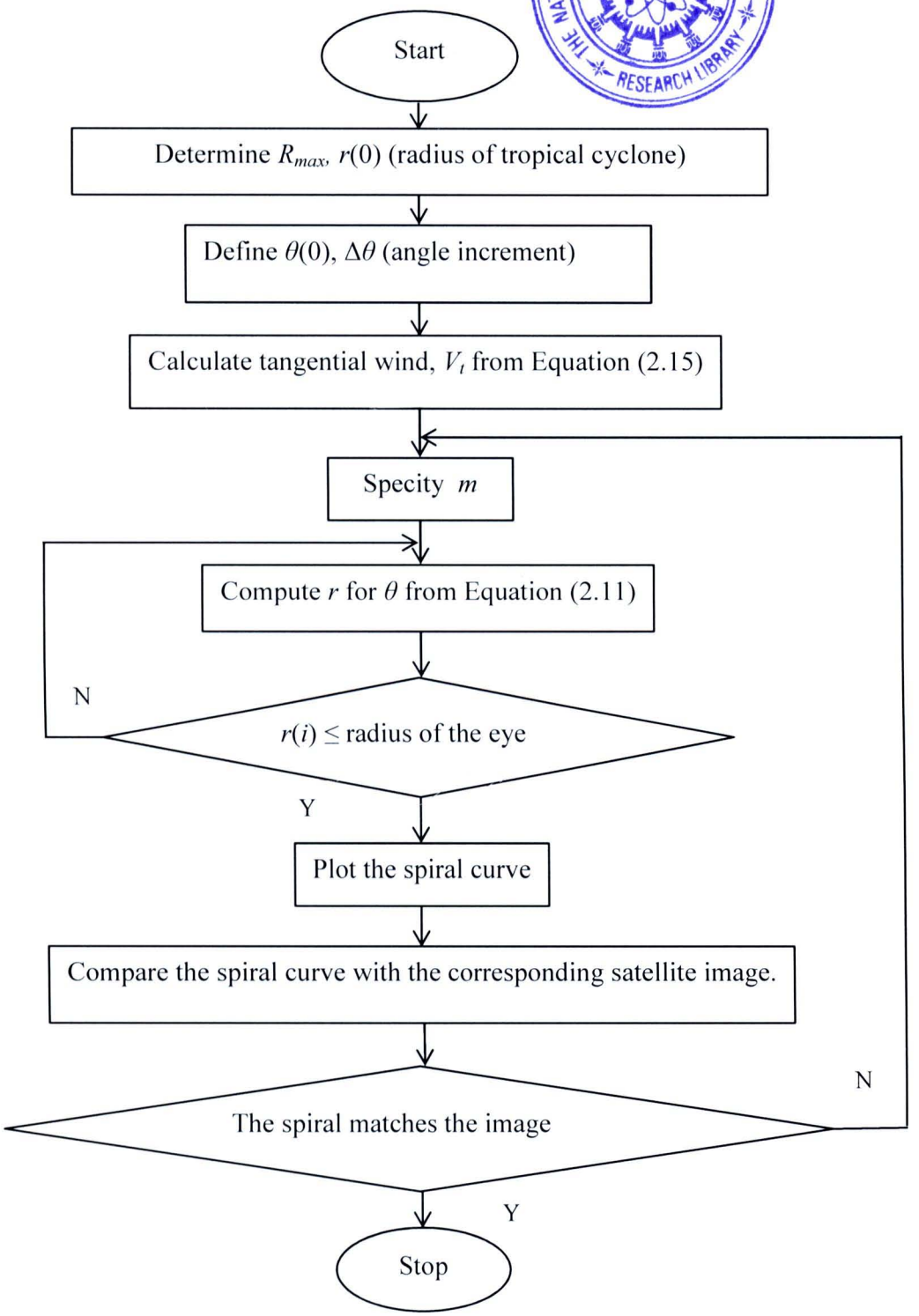


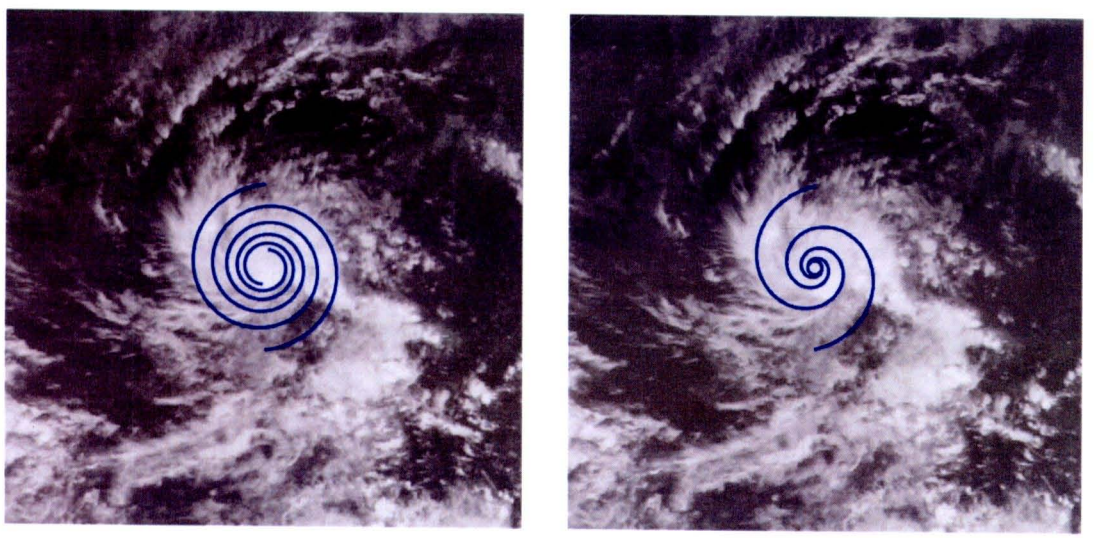
Figure 3.3 Flowchart for determination of m.

Example 1 Spiral curve for typhoon Gay (02 November 1989, 0600UTC) with the eye of 18 km, define m = -0.2, $\theta(0) = -\pi/2$ and $\Delta\theta = -0.05\pi$, the values of (r,θ) are shown in Table 3.4.

Table 3.4 An example of the values of r at various θ for m = -0.2.

m	r (km)	θ (radian)
-0.2	111.1200	-1.5708
	107.1771	-1.4137
	103.3741	-1.2566
	99.7059	-1.0995
	96.1680	-0.9424
	92.7557	-0.7854
	89.4644	-0.6283
	67.0081	0.6283
	64.6304	0.7853
	62.3371	0.9424
	60.1252	1.0995
	57.9917	1.2566
	55.9340	1.4137
	53.9492	1.5707
	40.4076	2.8274
	38.9738	2.9845
	37.5908	3.1415
	36.2570	3.2986
	34.9704	3.4557
	33.7296	3.6128
	32.5327	3.7699
	24.3668	5.0265
	23.5021	5.1836
	22.6682	5.3407
	21.8638	5.4977
	21.0880	5.6548
	20.3398	5.8119
	19.6180	5.9690

Comparision of the spiral curve and the corresponding satellite image (Figure 3.4) shows that the spiral curve matches the image very well for m = -0.2.



(a) m = -0.1 (b) m = -0.2

Figure 3.4 Satellite image on 02 November 1989 at 0600 UTC of typhoon Gay and the spiral pattern with different values of m, (a) spiral pattern does not match satellite image for m = -0.1, (b) spiral pattern matches satellite image for m = -0.2.