The 3rd International Earth Science Olympiad

Practical Test-Atmosphere

(Part I)

18 September 2009

Taipei, Taiwan

Student Name:	Nationality:

Mentor's Signature:_______________

希言自然，故飄風不終朝，驟雨不終日。孰爲此者？天地。

To seldom speak is the essence of nature. Why the winds and storm do not last whole day? Because the earth that manifests the winds and storm is constantly changing.

《老子道德經》第廿三章

Laozi Tao Te Chin 4th Century BC

南方有倚人焉曰黃繚，問天地所以不墜不陷，風雨雷霆之故。惠施不辭而應，不慮而對，遍爲萬物說。

In the south, there was a man of extraordinary views, named Huang Liao, who asked Shi how it was that the sky did not fall nor the earth sink, and what was the cause of wind, rain, and the thunder's roll and crash. Shi made no attempt to evade the questions, and answered him without any exercise of thought, talking about all things.

《莊子雜篇》天下第三十三

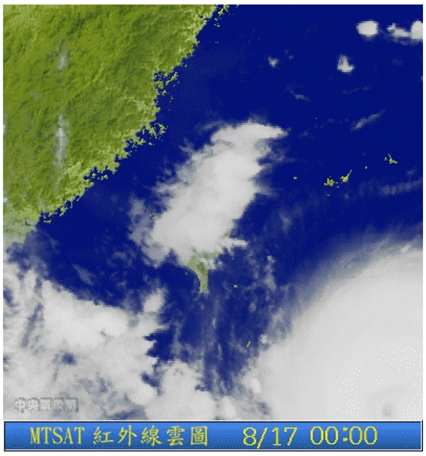
Zhuangzi Tian Xia 4th Century BC.

Instructions for the practical test (Part I of Atmosphere):

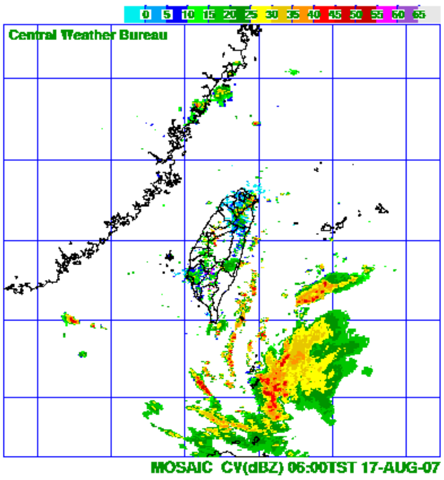
1. **Please write your name and nationality in English on the cover page.**
2. **The time allocated for this examination is 40 minutes.**
3. **Please write your answers legibly. Illegible answers will be counted as incorrect.**
4. **You may respond to questions either in English, your native language, or a combination of both.**
5. **Read the entire question group carefully before starting to answer. Each question has a point value assigned, for example, (1 pt).**
6. **For Problem 5, show all the calculations for the answers on the question paper.**
7. **Any inappropriate examination behavior will result in your withdrawal from the IESO.**

Display of Satellite and Radar Loops.

An example of satellite-picture loop is shown below.



An example of radar-picture loop is shown below.



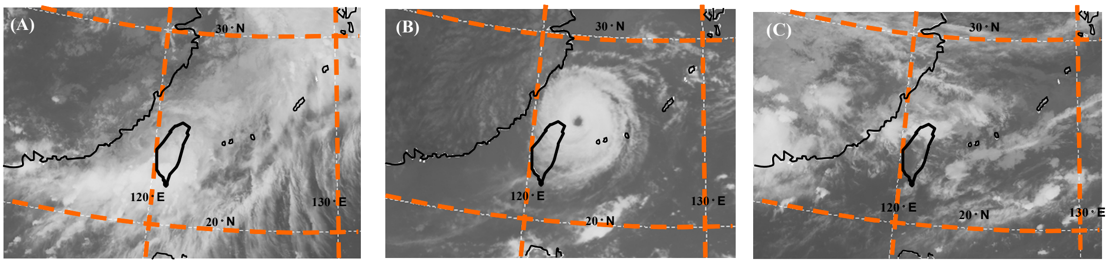
The radar picture above is observed by the Wufenshan radar station in northeastern Taiwan.

Click **here** to start the Practical Test

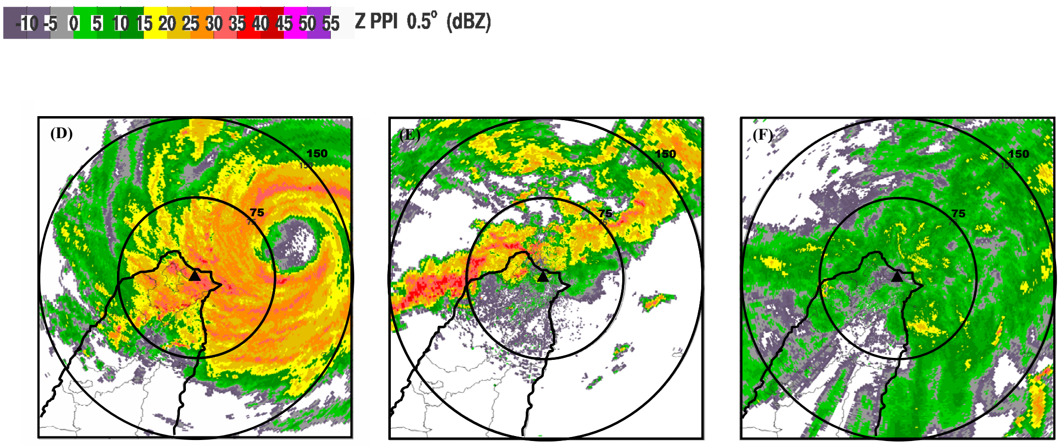
Practical Test (Part I)

Purpose: To understand the precipitation and wind patterns in different weather conditions using satellite and radar pictures.

Below are three infrared satellite pictures associated with the same three weather conditions (cold front, typhoon, and monsoon flow of southwesterly wind).

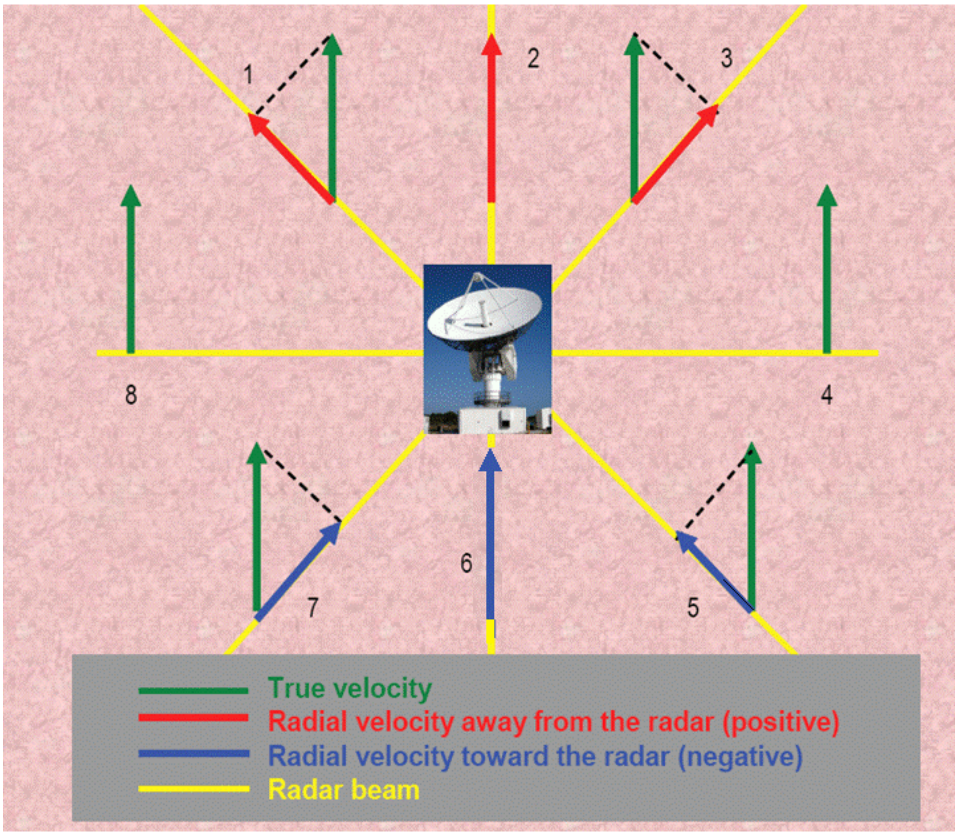


The radar echo occurs when the electromagnetic wave emitted by a weather radar is reflected by raindrops. Stronger radar echo or reflectivity usually corresponds to larger raindrops. Below are three horizontal radar reflectivity maps associated with three weather conditions which include cold front, typhoon, and monsoon flow of southwesterly wind. The intensity of radar refractivity or echo (Z; in units of dBZ) is indicated by the color scale below and the range rings are for radius of 75 km and 150 km. The location of the radar site is indicated by the triangle symbol.

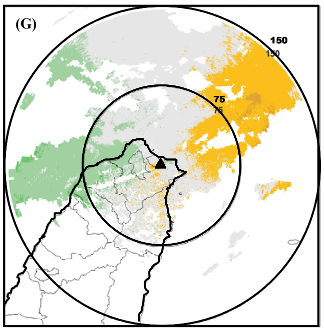


Using Doppler radars, we can also detect the raindrop motion along the radar beam (or radial) direction based on the Doppler-shift effect. To be specific, the radial velocity detected by a Doppler radar is negative if raindrops move toward the radar; on the other hand, the radial velocity detected by a Doppler radar is positive if raindrops move away from the radar.

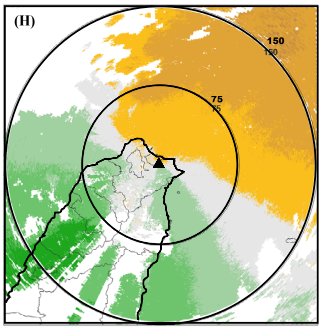
The relationship between true velocity and radar-detected radial velocity is shown in the following picture. The true velocity is indicated by the green arrow. The positive (negative) radial velocity detected by the radar is indicated by the red (blue) arrow.



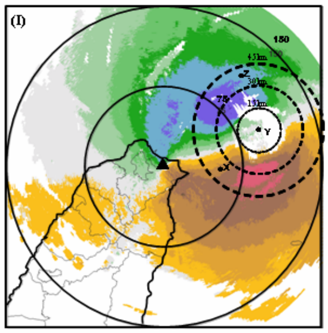
Below are three radar-observed radial velocity maps associated with the same three weather conditions (cold front, typhoon, and monsoon flow of southwesterly wind). The value of radial velocity (V_r; in units of m s^{-1}) detected by the radar is also indicated by the color bar.



Click here for the bigger Fig.(G)



Click here for the bigger Fig.(H)



Click here for the bigger Fig.(I)

Please answer the following questions:

1. Using Figure (A) to Figure (I), complete the table below using appropriate figure codes A to I for different weather conditions. (18 pts)

	Typhoon	Cold front	Monsoon flow with Southwesterly wind
Satellite picture			
Radar reflectivity picture			
Radar radial velocity picture			

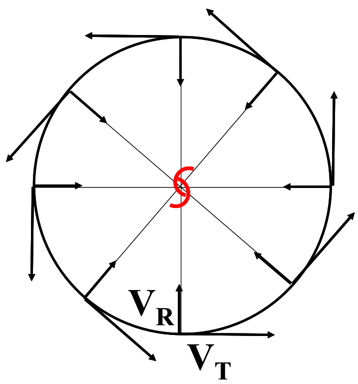
2. For Points X, Y, and Z on Fig. (I), which one is the most likely location for the circulation center? You can use the enlarged version of Fig. (I) to answer this question. (6 pts)

Answer:

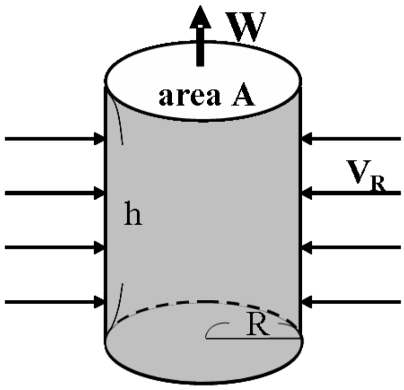
3. Use Fig. (I) to determine the values of the radar-observed radial velocity (V_r) at Points X and Z. You can use the enlarged version of Fig. (I) to answer this question. (10 pts)
   Answer:

4. Use Fig. (I) to estimate the radius of maximum wind from the typhoon center. You can use the enlarged version of Fig. (I) to answer this question. (6 pts)
   Answer:

5. The horizontal winds around a typhoon can be decomposed (vector analyzed) into the tangential wind (V_T) and radial wind (V_R) components. Below are the typical tangential and radial wind components around a typhoon over the Northern Hemisphere.



Assume that the radial inflow speed (V_R) toward the typhoon center averaged along the dashed circle is 30 percent of that of radar-observed radial velocity (V_r) at Point Z on Fig.(I) For simplicity, the geometry of typhoon circulation can be approximated by a cylinder with radius R and vertical depth h. Assume that air density ρ inside the cylinder remains a constant value of 0.6 kg m^{-3}.



The inward mass flux across the cylinder lateral surface (the gray surface in the above diagram) by the radial inflow can be expressed as

$$M_{in} = \rho V_R (2\pi R) h \,,$$

where ρ is density, V_R is radial inflow speed, R is radius, and h is the height. Fig. (I) shows the typhoon circulation with horizontal area indicated by dashed circles. Calculate the mass flux (M_{in}) across the cylinder lateral surface by the radial inflow in units of kg s^{-1} ($\pi = 3.14$). For your calculations, use a radius of 30 km, a vertical height of 8 km. (10 pts)

Answer: