UNITED STATES MARINE CORPS

LESSON PLAN

GRADIENT WIND FLOW

INTRODUCTION:

1. Gain Attention. There is no gain attention for this period of instruction.

2. Overview. This period of instruction provides an introduction to gradient winds and the forces that balance each other in order to obtain gradient wind flow.

3. Introduce Learning Objectives.

a. Terminal Learning Objective. Without the aid of references, verbally discuss while physically depicting the balance of forces required to obtain gradient wind flow in cyclonic and anticyclonic wind circulation systems.

b. Enabling Learning Objective(s). Without the aid of references, but in accordance with the instruction:

(1) Verbally define the forces that produce gradient wind flow.

(2) Physically demonstrate the balance of forces for high and low pressure systems required to obtain gradient wind flow.

4. Method/Media. This period of instruction will be taught using the lecture method with aid of QMMCBT-001 "Introduction to the Dynamics of the Atmosphere".

5. Evaluation. The student shall be evaluated by successfully demonstrating the Terminal Learning Objective.

TRANSITION. The winds change direction and speed across the Earth. Something has to cause this action, and for every action there is a opposite and equal reaction. But before we can learn about the forces acting upon the winds in the atmosphere we should first define them.

BODY:

INSTRUCTOR NOTE: The first section, Review of Forces, may be skipped if the previous class QMMPH1-031 Atmospheric Forces has just been presented.

1. Review of Forces. Recall that there are various forces acting upon air parcels within the atmosphere. The following serves as a brief review of material that has already been introduced and discussed (QMMPH1-031 Atmospheric Forces).

a. Pressure gradient Force (PGF) – The force due to differences in pressure within the atmosphere that causes air to move and therefore the wind to blow. It is directly proportional to the pressure gradient.

b. Coriolis force (Cof)– An apparent force observed on any free-moving object in a rotating system. On the Earth this deflective force results from the rotation of the Earth and causing moving particles (including the wind) to deflect to the right in the northern hemisphere and to the left in the southern hemisphere.

c. Centrifugal force (Cef) – An apparent force that exists in curved flow causing the parcel of air to be deflected outward and away from the center of rotation.

d. Frictional Force (Fr) – Frictional forces occur within the boundary layer where terrain acts to slow parcels of air. Friction opposes motion and acts opposite the wind direction.

TRANSITION. These definitions will set the foundation for the rest of the class. Putting all of the terms together is what will give us an understanding of gradient winds.

2. Gradient Circulation. A *gradient* wind is a wind that is parallel to the isobars or contours in curved flow. The flow becomes parallel with a balance of forces.

a. High Pressure Systems. Air moving around high pressure is termed anticyclonic circulation. In the Northern Hemisphere, anticyclonic circulation is clockwise rotation. To obtain anticyclonic gradient circulation (V_a), there must be a balance of CoF against PGF and CeF. This occurs if the pressure gradient is constant around the high-pressure center. Figure 1 shows the balance of forces for gradient anticyclonic circulation. Also, notice the equal spacing of the circular isobars in the figure. This represents an equal pressure gradient around the pressure center producing gradient winds.

b. Low Pressure Systems. Low pressure, or cyclonic gradient circulation (V_c), is the exact opposite of high-pressure gradient circulation (V_a), with PGF directed inward. Were it not for CoF, air movement would be directed toward the low center. Still, CoF deflects the movement of air to the right of PGF, resulting in a counterclockwise rotation. As with high-pressure circulation, if we discount friction, the forces balance and a gradient flow circulation results. Notice CoF and CeF now balance against PGF in figure 1.

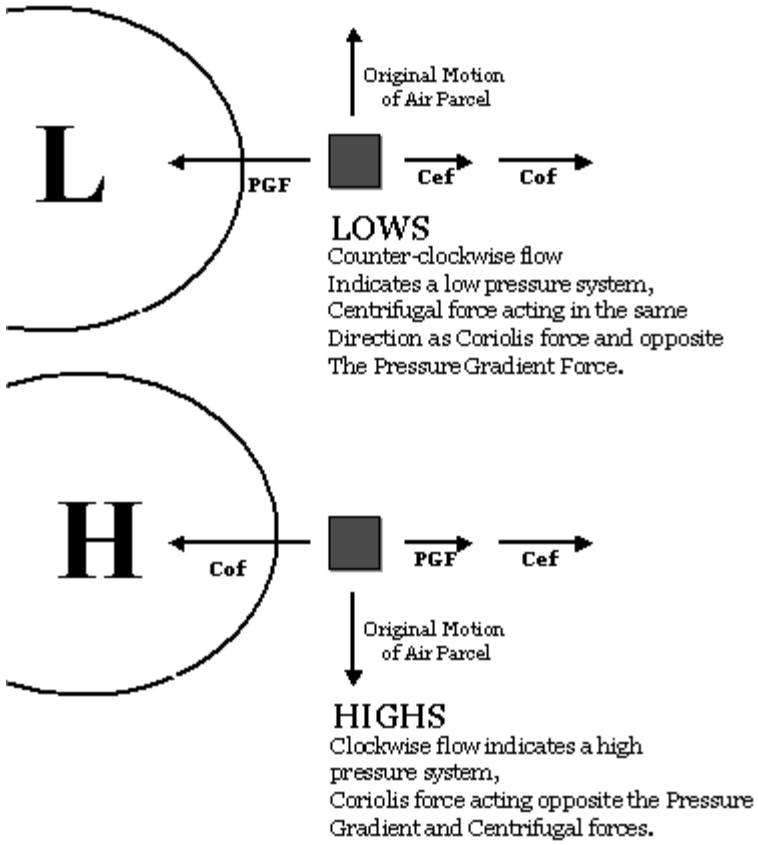

Figure 1 - The balance of forces that produce Gradient winds.

OPPORTUNITY FOR QUESTIONS:

1. Questions from the Class. At this time are there any questions pertaining to the information that has just been presented to you?

2. Questions to the Class. There are no questions for the student(s) at this time.

SUMMARY: This period of instruction explained that when the Pressure Gradient, Coriolis and Centrifugal forces balance each other, it produces a gradient flow found in curved wind flow.

REFERENCE:

Commander Naval Ice Center. Handbook of Dynamic Meteorology. Washington D.C., 1994.

Gradient, Artic Climatology and Meteorology Glossary. http://nsidc.org/arcticmet/glossary/gradient_wind.html.