UNITED STATES MARINE CORPS

LESSON PLAN

# GEOSTROPHIC WIND FLOW

INTRODUCTION:

1. Gain Attention. When looking at synoptic weather charts, have you ever wondered why the winds cross the isobars (contours) at some levels, but not others? Have you ever wondered what causes the winds to flow directly in between them?

2. Overview. Once all the atmospheric forces that act upon or influence the motion of air parcels have been defined, it becomes necessary to look at how some of these forces act together upon a parcel of air. This period of instruction strictly concerns the pressure gradient force and the Coriolis force and the balance that may be created between them.

3. Introduce Learning Objectives.

a. Terminal Learning Objective. Given a 500 millibar upper-level constant pressure chart, and without the aid of references, accurately locate a geostrophic wind and dynamically explain its significance.

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

(1) Define and discuss the geostrophic wind process.

(2) State the steps necessary to compute a geostrophic wind using the geostrophic wind scale.

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 Earth’s Atmosphere”.

5. Evaluation. You will be evaluated at the end of this period of instruction by physically completing the Terminal Learning Objective.

TRANSITION. For the purpose of this instruction, we will only be concerned with the airflow above the boundary layer where friction has no effect on the winds. Recall from previous discussions, the atmospheric forces (QMMPH1-031) that affect the upper-level winds.

BODY:

1. The Geostrophic Wind Process.

a. The Coriolis force (CoF) is responsible for balancing the Pressure Gradient Force (Pgf) in the upper levels of the atmosphere. Figure 1 depicts how a balance is reached between these two (2) forces. The parcel at the beginning of figure 1, for instructional purposes only, is stationary. At this point, because the parcel of air is stationary, the CoF has no influence on the parcel. Only the Pgf can act upon the parcel, always directing it perpendicular to the isobars pointing towards lower pressure.

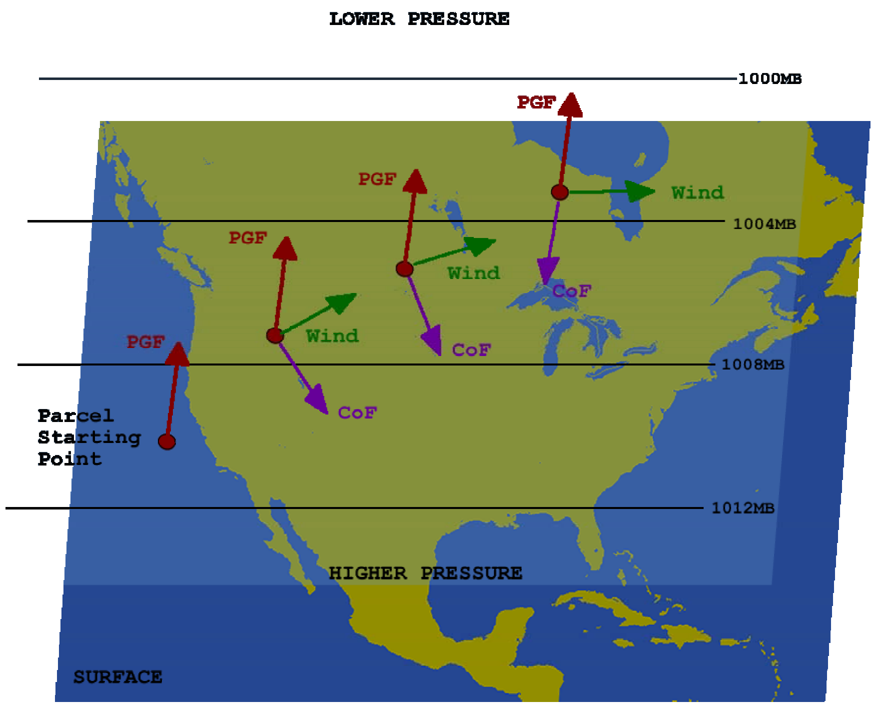


Figure 1 – The process of how the Coriolis force acts upon a parcel of air.

b. However, as soon as the parcel begins to move, the CoF begins to act upon the parcel by deflecting it to the right of its path in the Northern Hemisphere (left of its path in the Southern hemisphere). As the parcel continues to accelerate, the CoF strengthens and the increased wind speed (recall that the magnitude of the Coriolis Force is directly proportional to the wind speed) results in further deflection. Eventually the wind turns so that it is flowing parallel to the contours.

c. When the wind is flowing parallel to the contours in straight-line flow, the CoF and the Pgf are in balance. The PGF is pointing towards the lower pressure (to the left of parcel movement) and the CoF is pointing to the right of flow. As long as these two forces remain in balance, the resulting wind flow will be parallel to the contours at a constant speed. The wind will not accelerate or decelerate, but is consider to be "coasting" along a path dictated by the contours. When these conditions occur, the wind is said to be in *geostrophic balance*.

d. The winds produced by this balance are geostrophic winds. Geostrophic winds flow in a straight-line path, parallel to the contours, with speeds proportional to the pressure gradient force. A steep pressure gradient will cause strong winds, and a weak pressure gradient will cause weak winds.

e. It is important to note that the geostrophic wind is actually an idealized model (theory) that only approximates to the actual behavior of the airflow in the upper levels of the atmosphere. However, the geostrophic wind model does provide a useful approximation of the wind flow aloft. By measuring the spacing and orientation of the contours (the pressure field), forecasters can determine both the wind speed and wind direction.

f. The geostrophic flow can forecast the winds parallel to the contours with wind speeds that are proportional to the contour spacing. The closer the contours, the higher the wind speed. On the other hand, a forecaster may also use the wind speeds to determine the pressure (contour) gradient aloft.

TRANSITION. By understanding what the process of a geostrophic wind is, we may now focus on how to manually determine the geostrophic wind speed by use of an appropriate scale.

2. Measuring Geostrophic Winds.

a. Directions based on a surface chart. At the point on your map where you want to determine the wind speed, measure the perpendicular distance between the isobars on either side of the point. You can use a pair of dividers or simply mark the distance on a piece of paper. Make note of the latitude at this point. You will need to know both to use the wind scale.

b. Example. Suppose the distance between the two isobars is equal to line AB as shown in the figure below, and your point of latitude is 40°N. Starting at the left side of the wind scale, measure off the distance AB along the line for 40°. You can see point B falls on a curved line. Follow down this line to the base of the scale. Read the geostrophic wind (10 knots). This example uses latitude and isobar spacing that fell directly on lines of the wind scale. If your point of latitude falls between lined increments on the scale, simply measure mid-way between the increments. When the measured spacing falls between speed curve lines, you must interpolate the wind speed.

c. To determine isobaric or contour spacing, you must know the wind speed and latitude. Take the known wind speed and move up the curve to the latitude increment corresponding to the point of latitude you've chosen. Measure the distance from this point to the scale's left edge.

d. This distance is the correct spacing. As an example, use a wind speed of 10 knots and latitude of 40° as in the preceding example. Move up the speed curve marked 10 knots to the 40° line. Measure from this point (point B) to the left edge of the scale (point A). The line BA is the correct spacing for the isobars on either side of the 10-knot wind speed point on a chart.

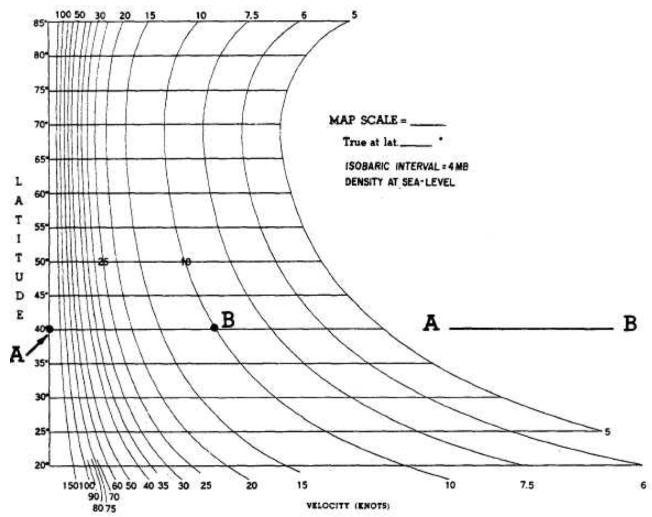


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Figure 2 – Geostrophic Wind Scale. Note – a larger scale is including at the end of this period of instruction.

TRANSITION. Use of the geostrophic wind scale is not one of the easiest ways to determine the geostrophic wind speed, however the process was included in this period of instruction for the simple fact that on many charts, the scale is available for use.

OPPORTUNITY FOR QUESTIONS:

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

2. Questions to the Class. There will be no questions to the class for this period of instruction. Knowledge shall be demonstrated by evaluation.

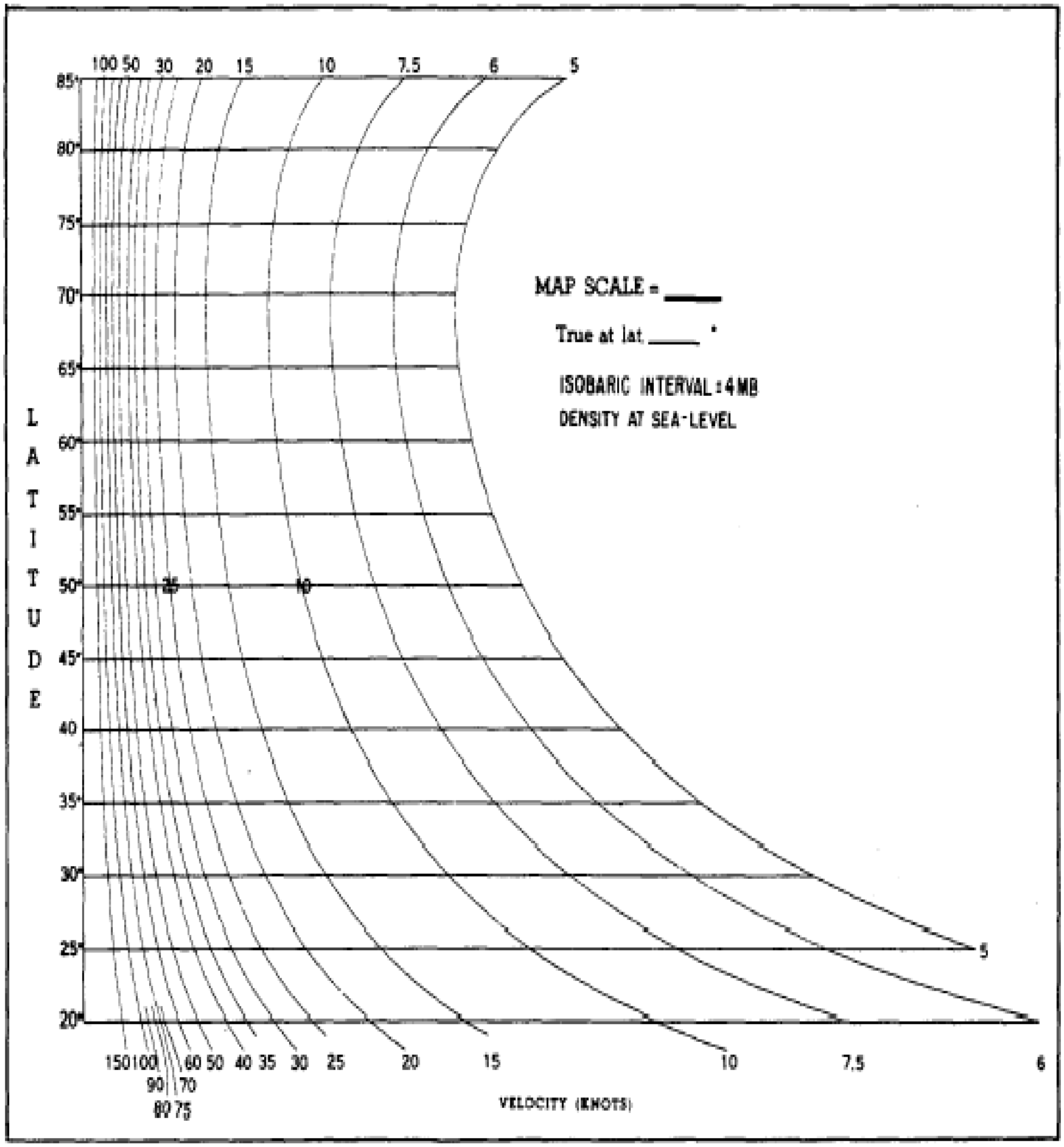
SUMMARY: During this period of instruction, the geostrophic wind process was described, as well as, the process to determine the geostrophic wind utilizing the geostrophic wind scale.

REFERENCE.

Meteorology and Oceanographer Analyst/Forecaster (MOAF) Dynamics I. N61RCB1-ST-201. Rev. October 2002.

Lutgens, Frederick K. and Tarbuck, Edward J. The Atmosphere, An Introduction to Meteorology. 9th edition. Pearson Education Inc, 2004.

Geostrophic Wind Scale.






Last revised 9/28/04.