UNITED STATES MARINE COPRS

LESSON PLAN

THERMAL WIND VECTORS

INTRODUCTION:

1. Gain Attention. Have you ever wondered why sometimes it seems as though it gets colder as the day goes on rather than warming up as usual?

2. Overview. During this period of instruction we will discuss the thermal wind vector and how it applies to thermal advection and atmospheric stability.

3. Introduce Learning Objectives.

   a. Terminal Learning Objective. With the aid of, and in accordance with the reference, given an upper level wind profile for a station, determine the thermal wind vector and the mean wind, and how they apply to thermal advection and atmospheric stability.

   b. Enabling Learning Objective. Without the aid of references, complete the following tasks:

      (1) Determine the thermal wind vector for a layer of the atmosphere.

      (2) Determine the mean wind for a layer of the atmosphere.

      (3) Determine the type of advection occurring in a layer of the atmosphere.

      (4) Determine the type of advection occurring by utilizing the thermal wind vector and the mean wind.

      (5) Determine the stability of the atmosphere above a given station.

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. You will be evaluated by a question and answer period upon completion of the lesson plan.

TRANSITION. Are there any questions on the material to be covered, TLO’s, ELO’s, Method/Media, or how you will be evaluated upon completion of this period of instruction?

BODY:

1. <u>Defining Thermal Wind Vector</u>. The thermal wind vector (Vth) is a calculated (non-existent/theoretical) wind found by computing the vector difference of the geostrophic winds at two levels for the same location. The thermal wind is not really a wind at all, nothing actually moves in the direction of the thermal wind.

<u>TRANSITION</u>. Are there any questions over what the thermal wind vector is?

2. <u>Equation</u>. The following equation relates the vertical shear of the geostrophic wind to the horizontal temperature gradient.

a. Vth = Vgu – Vgl, where Vgu is the upper wind and Vgl is the lower wind.

b. The magnitude, or length, of this vector is directly proportional to the strength of the mean temperature gradient within the layer (commonly referred to as thickness packing), see figure 1. The direction of the thermal wind indicates the orientation of the thickness lines with cold air on the left and warmer air to the right. With the thermal wind to your back, colder temperature is to your left.

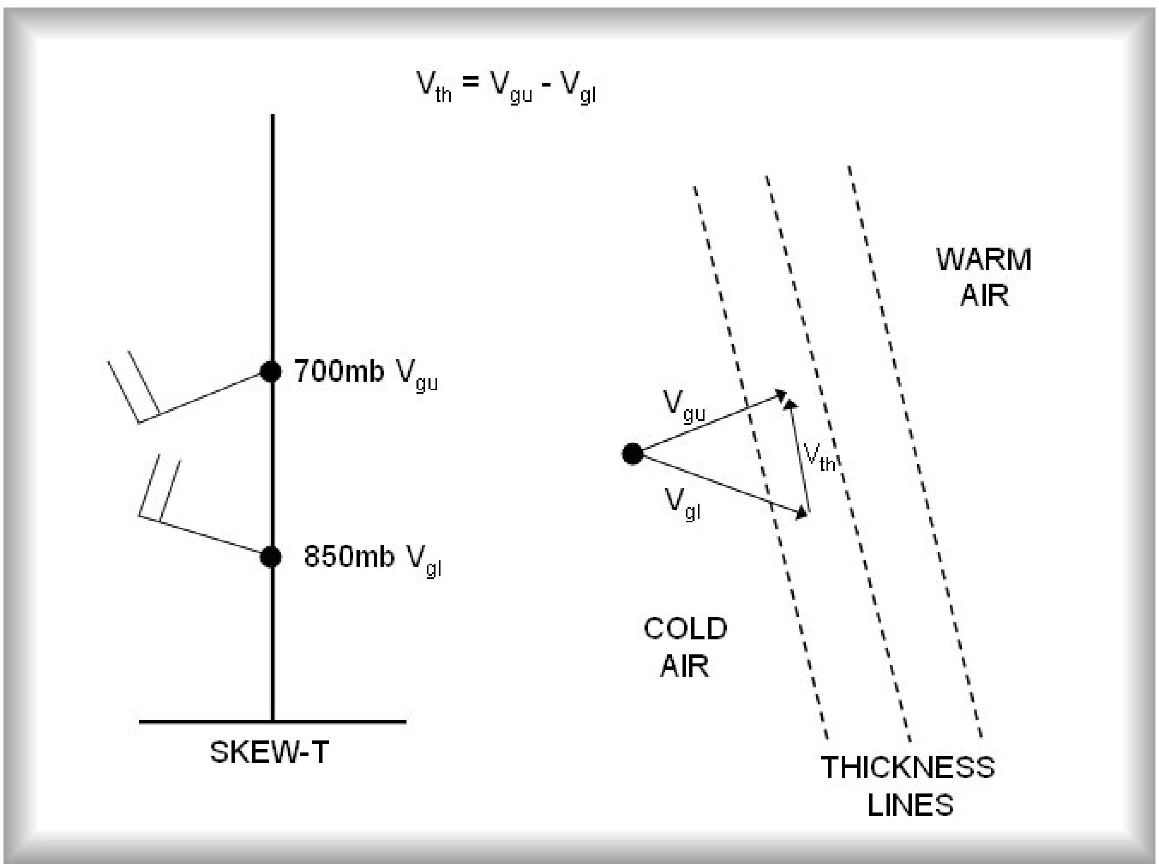

Figure 1 – Example of Thermal Wind Vector.

c. The observed winds above the gradient level (which are approximately geostrophic) are commonly used to calculate the thermal wind vector, rather than determining the geostrophic wind at each level.

3. Interpreting Thermal Wind Vectors. Winds veering with height indicate warm air advection (WAA) in that layer. Winds backing with height indicate cold air advection (CAA) in that layer. This is easily viewed by looking at the winds on a Skew-T diagram (see figure 2).

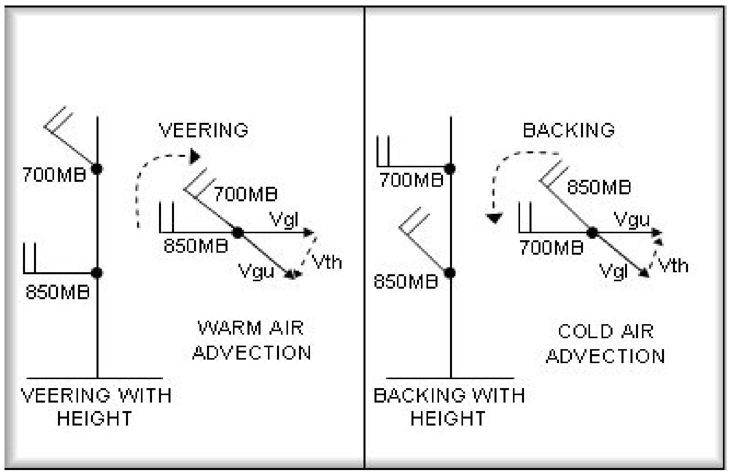

Figure 2 – Veering and backing winds show warm and cold air advection.

4. Vector Characteristics.

a. The thermal wind vector is parallel to the thickness lines, just as winds are parallel to isobars and contours.

b. Colder air and lower thickness values lie to the left and warmer air and higher thickness values lie to the right.

c. Within the boundary layer (SFC-3,000ft AGL), friction causes the actual winds to veer with height and may not accurately represent advection. Therefore, it is best to use winds above the boundary layer.

5. Applications of Thermal Wind Vectors.

a. Advection Trend. This is simply looking at the strength of advection and layers of warm, cold, or neutral temperature advection over a region. In order to determine the type and intensity of advection, we must first determine the mean wind for that layer. We can find the mean wind by using the following formula:

$$\text{Mean wind for a layer } V = \frac{Vgu + Vgl}{2}$$

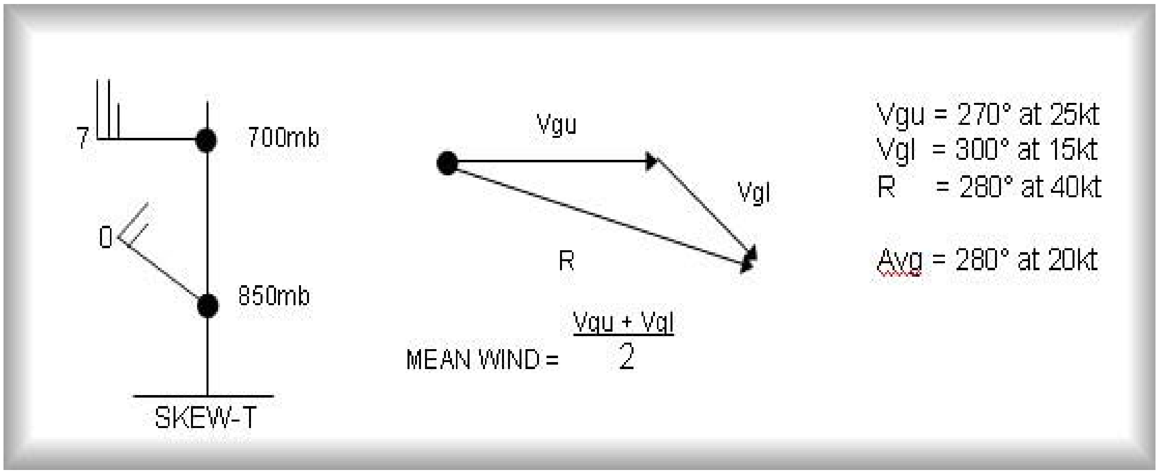

Figure 3 – Advection Trend.

b. Type of Thermal Advection. In order to determine the type of thermal advection we must combine the thermal wind vector (Vth) with the mean wind for that layer.

a. Step 1. Determine Vth by vector subtraction.

b. Step 2. Find the mean wind by vector addition.

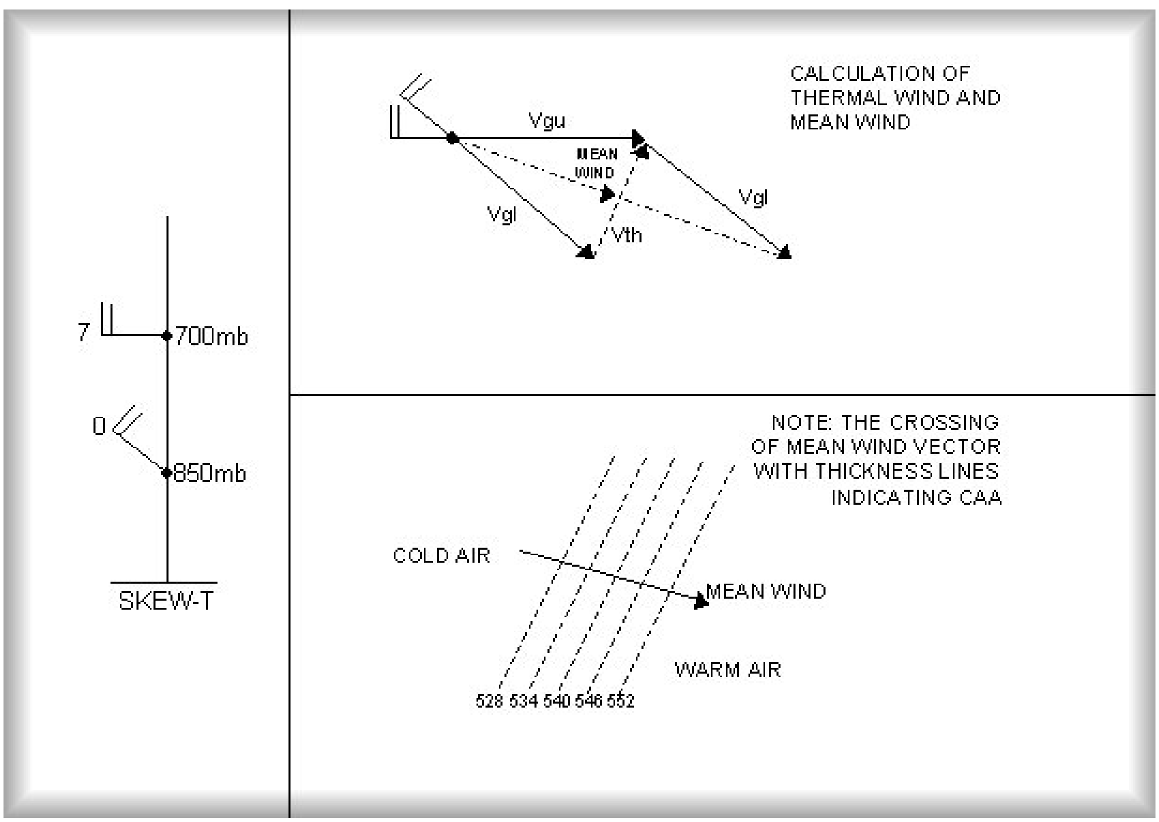

Figure 4 – Calculating the Thermal and Mean Wind for a Layer.

c. Stability. Cold air advection (CAA) under warm air advection (WAA) indicates increasing stability because the density of the air increases at the surface and decreases aloft. WAA under CAA indicates decreasing stability because the density of the air decreases at the surface and increases aloft. The easiest way to determine atmospheric stability is by viewing the wind field on a Skew-T. If a Skew-T is not available the constant pressure charts can be used, so long as you ensure you are using the same station for each level.

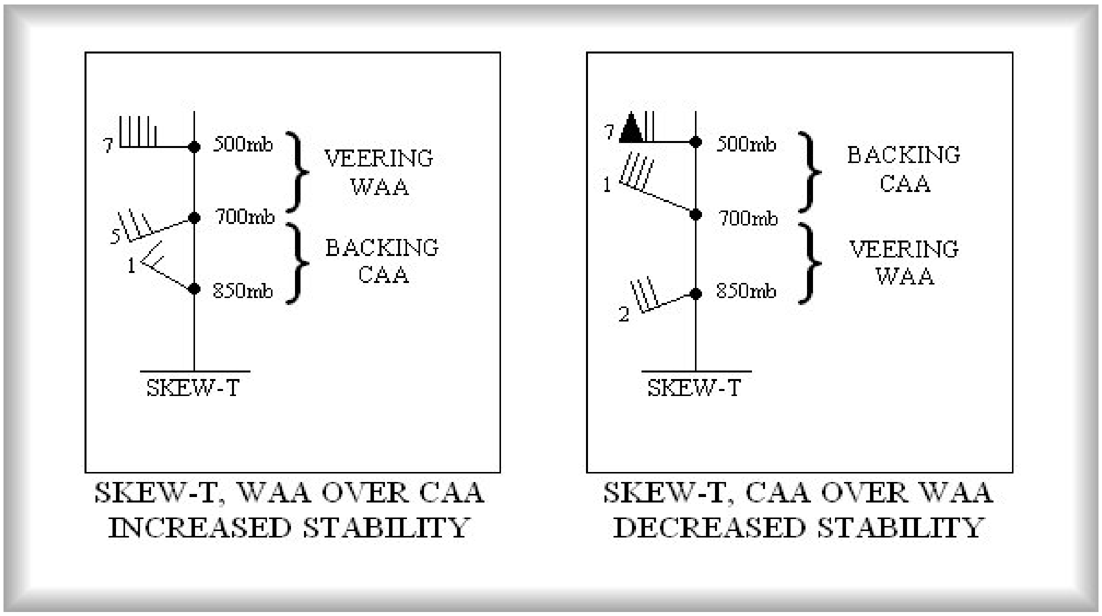

Figure 5 – Determining Advection and Stability Using a Vertical Profile.

<u>TRANSITION</u>. Are there any questions on how to determine the mean wind, how to determine the type of thermal advection by utilizing the mean wind and thermal wind vector, or how to determine atmospheric stability by looking at the vertical wind profile of a station?

<u>OPPORTUNITY FOR QUESTIONS</u>:

1. <u>Questions from the class</u>. At this time are there any questions pertaining to the information that has just been presented to you?

2. <u>Questions to the class</u>.

a. <u>QUESTION</u>. What is the thermal wind vector?

b. <u>ANSWER</u>. It is a calculated (theoretical) wind found by computing the vector difference of the geostrophic winds at two levels for the same location.

c. <u>QUESTION</u>. What do veering winds with height indicate? Backing with height?

d. ANSWER. WAA and CAA, respectively.

e. QUESTION. WAA over CAA indicates what type of stability? CAA over WAA?

f. ANSWER. Increased and decreased, respectively.

SUMMARY: Throughout this class we have discussed thermal wind vectors and how they apply to weather. The thermal wind vector can tell us what type of thermal advection is occurring at our station, which can provide the forecaster with a wealth of knowledge in determining atmospheric stability, the evolution of systems and fronts, and also aiding the forecaster in working up a sound forecast.

REFERENCE:

Meteorology and Oceanographer Analyst/Forecaster (MOAF) Physics II, Chapter 2. N61RCB1-ST-104. Rev. October 2002.