Current Weather Studies 4
TEMPERATURE AND AIR MASS
ADVECTION

Reference: Chapter 4 in the Weather Studies textbook. Complete the introductory and other appropriate sections of Investigations in the Weather Studies Investigations Manual as directed by your mentor or instructor. Check for additional Weekly Weather News updates during the week.

As a reminder, this year’s vernal equinox occurs at 2158Z on 20 March 2019 (5:58 PM EDT on 20 March 2019, etc.), marking the transition from astronomical winter to spring. The lengthening periods of daylight and successively more direct solar heating means the Northern Hemisphere is warming, most noticeably in the higher latitudes. Mid-latitude storm systems will have the net effect of delivering warmer air northward as spring approaches. The combination of net radiational warming or cooling, along with horizontal movements of warmer or cooler air, are the bases for our seasonal temperature contrasts and accompany our day-to-day weather changes. In this investigation, we consider how we detect those changes of temperature resulting from movements of air masses.

In this investigation, we will first examine a weather map created right around last year’s autumnal equinox (2018), when the Northern Hemisphere was experiencing diminishing solar heating.

Figure 1 is the map of plotted station models with reported surface weather conditions (Isotherms, Fronts, & Data) for 11Z 21 SEP 2018 (7 AM EDT, etc., Friday morning). Note that on this Figure 1 map, the isopleth lines are isotherms (not isobars). The H and L centers and frontal positions shown on the map represent their positions two hours prior to map time.
Figure 1. – U.S. surface analysis with isotherms, fronts, and station observations for 11Z 21 SEP 2018. Fronts were analyzed a two hours earlier (09Z).

At Figure 1 map time, a series of relatively weak High-pressure systems populated the Rocky Mountain and Great Basin states in the west. Conversely, a relatively weak, Low-pressure center was oriented over northern Lake Superior, with a lengthy cold front trailing to the south through the states of Wisconsin, Illinois, Iowa, and Missouri. In general, temperatures were unseasonably mild east and south of this frontal boundary, considering the observations were taken in the morning prior to further daytime heating by solar radiation.

1. The eastern half of the country displayed temperatures at map time generally in the ________ degrees Fahrenheit.
   
   a. 30s and 40s  
   b. 50s and 60s  
   c. 60s and 70s  
   d. 80s and 90s

2. The wind at Minneapolis, in southeastern Minnesota, was generally from the west at about 15 knots. The red isotherm line plotted just west of Minneapolis was the ________ degree Fahrenheit isotherm. (The value is marked along the isotherm line in Colorado).
3. The wind at Minneapolis exhibited a flow that was oriented almost perpendicular to the isotherm. This wind direction was from ________ temperature regions.

   a. lower toward higher
   b. higher toward lower
   c. undeterminable

4. Stations that were experiencing a wind flow pattern flowing directly (at an acute angle) across isotherms (e.g., Iowa, Minnesota, Nebraska, North and South Dakota) were all found ________ the advancing prominent cold front in Figure 1.

   a. behind
   b. ahead

5. From this wind flow pattern, one should conclude that ________ air advection was occurring in Iowa. This type of advection was occurring broadly over the northern High Plains.

   a. cold
   b. warm

6. Temperatures at stations further to the north and west away from the cold front (specifically the Dakotas), based upon the isotherm pattern, were found to be ________, with temperatures mostly in the ________.

   a. colder; 50s and 60s
   b. colder; 30s and 40s
   c. warmer; 50s and 60s
   d. warmer; 60s and 70s

7. Meanwhile, in Oklahoma City, Oklahoma, the reported wind direction from the ________ at 5 knots, intersected a nearby isotherm at an acute angle. Those surface winds brought ________ air advection toward the frontal boundary to the north. This region in the southern High Plains was experiencing distinctly different weather characteristics from those in the northern High Plains. This contrast typically becomes more distinct with each passing week through the progression of the fall season.

   a. northeast; cold
   b. northwest; warm
   c. southwest; cold
   d. southeast; warm
Because temperature contrasts across the U.S. were generally weak in Figure 1, the corresponding advection patterns were weak. A more dramatic contrast of air advection can be seen in the Figure 2 map (Isotherms, Fronts, & Data) for 15Z 12 FEB 2019 (10 AM EST, etc.). Cold-season analysis maps typically portray examples of advection when there are stronger weather systems and greater temperature contrasts.

At Figure 2 map time, as is common in winter, a very strong contrast in air masses existed from Canada to Florida. Temperatures along the U.S.-Canadian border were well below zero! Yet, across the winding frontal boundaries in the southeast, temperatures were well into the 60s and 70s (°F). The unique nature of the topography in the eastern U.S. (i.e., the Appalachian Mountains) enhanced the curvature of the front, identifying the contrast in air masses in the eastern U.S. Colder, denser air had “backed up” against the eastern flank of the Appalachians with an easterly wind flow at the surface (e.g., the Raleigh-Durham station (North Carolina) was evidence of a station in this cooler air mass with an easterly wind). A smaller region of high pressure centers was marked in the High Plains and Intermountain West nearest to the center of a cool air mass. This air mass in the western mountains, however, wasn’t nearly as cold as the air to the north in the Dakotas and Canadian Rockies.
8. Punctuated by a string of low pressures from eastern North Carolina to northeast Arkansas, a(n) ________ front sinuously curved north and south like a snake, with colder air to the north of the front and warmer air to the south.

   a. cold
   b. stationary
   c. warm
   d. occluded

9. In northeast Arkansas, the terminus from the front in item #8 met with a different front(s), both of which curved generally southwestward to southeastern Texas and into the Gulf of Mexico. This/these front(s) marked the boundary where colder air was barreling southward through the southern High Plains, denoted as a ________ front.

   a. cold
   b. stationary
   c. warm
   d. occluded

10. The wind at Dallas, in north-central Texas, was generally from the north at about 15 knots. Dallas was located between the ________ isotherm lines.

    a. 0 and 10
    b. 20 and 30
    c. 40 and 50
    d. 60 and 70

11. The wind at Dallas exhibited a flow that was oriented almost directly across the isotherms. This wind direction was from ________ temperature regions. Stations that were north of the frontal system, from Dallas northward into both Oklahoma and Kansas, generally displayed this same pattern of temperatures and air flow directions.

    a. lower toward higher
    b. higher toward lower

12. From this wind flow pattern, one can conclude that ________ air advection was occurring. This flow dominated the Plains states from the Dakotas southward.

    a. cold
    b. warm
13. Shifting to a different part of the U.S., the temperature at Nashville, Tennessee, was 57°F with winds from the south. The isotherm line plotted north of Nashville was the ________ degree Fahrenheit isotherm.

   a. 50
   b. 60
   c. 70

14. The wind at Nashville exhibited a flow that was directed at an angle toward that isotherm. This wind direction was from ________ temperature regions.

   a. lower toward higher
   b. higher toward lower

15. This flow of air at Nashville was in an area of ________ air advection. Figures 1 and 2 show that both types of air advection patterns are often found somewhere on weather maps, regardless of the time of year. The magnitude of advection, however, can be dramatically different, pending the season.

   a. cold
   b. warm

16. Compare the Nashville advection pattern to that of Dallas. The wind flow and air mass advection patterns on opposite (east vs. west) sides of the developing low-pressure center displayed ________ air flow advection patterns, which is consistent with the circulation expected around a low-pressure center.

   a. similar
   b. opposing

In this late winter case, the cold temperatures and the closely spaced isotherms reflected strong air advection patterns. In general, 1) stronger winds, 2) more perpendicular flow across isotherms, and 3) closer spacing of isotherms indicate stronger thermal advection patterns.

17. In Figure 2, the strong converging wind flow would strengthen the temperature gradient and aid in enhancing uplift (enhancing the low pressure) along that portion of the frontal boundary in the vicinity of northeast Arkansas. By contrast, what would hinder strong air advection patterns?

   a. weaker winds
   b. more oblique (less direct) flow across isotherms
   c. widely spaced isotherms
   d. all of the above
Wind flow patterns around Highs and Lows with associated frontal systems typically show cold air advection to the east of Highs and behind cold fronts (in the Northern Hemisphere). Warm air advection usually occurs ahead of cold fronts, behind warm fronts, and west of Highs.

**Temperature and Air Flow with GIS**

We have previously examined weather patterns and satellite imagery using the GIS (Current Weather Studies 3). Let's take it another step further and investigate temperature and air flow by also utilizing the Real Time Weather Map starting point located at:


Launch the Real Time Weather map (from link above) and click on “Content” on the left side of the screen to view the map layers. Turn on “Current Temperature Deg F” (it is ok to keep the radar layer on if it is already, but you can also toggle it on/off in order to view the temperatures across the map). Next, display the legend (click on the first icon under “Stations” within the “Current Temperature Deg F” layer). You can also do this by clicking on the “triangle” to the left of the Temperature layer, like you did in Current Weather Study 2 for the “Pressure Mb” layer). Observe the temperature pattern across the U.S..

18. Based on the legend, what colors indicate colder surface air temperatures? Note that, it is highly likely that cooler temperatures are in the Rocky Mountains due to their higher elevation.

   a. light colors
   b. dark colors

The “Current Temperatures” layer is similar to the “Current Pressure Mb” layer that you observed in Current Studies 2 and 3, with respect to its data representation scheme. You may also wish to turn the “Current Pressure Mb” layer on to observe the areas in which high and low pressure are occurring. Toggle back and forth between the temperature layer and pressure layer to observe areas of contrast or similarity.

Differential heating of air masses and the pressure differences between these air masses generally cause surface winds to flow. As you can recall from the hand twist model, surface air generally flows outward from High pressure centers and inward toward Low pressure centers.

Next, turn on the “Current Wind Speed and Direction kmh” layer. If you do not see wind directional arrows display on your Weather Map, follow the next set of directions.

On “Current Wind Speed and Direction kmh” to see the drop down of options. Under the Stations layer, click “Change Style”. Leave “Air Temperature” selected for “Choose an attribute to show.” Under “2 Select a drawing style” select “Counts and Amounts (Size)” and then click on “Options” within “Counts and Amounts”. Click on “Symbols” and in the drop down menu, choose “Arrows.” Select an arrow that points down and click “OK.” Within the
Change Style window, change the min size to 5 and the max to 35. Make the following additional changes in the Change Style window: Classify Data using “Quantile,” “5 classes,” Rotate symbols by “Wind Origin (Degrees),” “Geographic,” and click “OK.”

Your map should look something like Figure 3.

Current Wind Speed and Direction km/h - Stations

![Wind Speed Chart]

Symbols
Legend

Wind Speed (km/h)

<table>
<thead>
<tr>
<th>Size</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>35</td>
</tr>
</tbody>
</table>

Classify Data

Using: Quantile

With: 5 classes

Round classes: Select an option

Draw features with out of range or no value. Rotate symbols (degrees)

Wind Origin (Degrees)

Geographic
Arithmetic

0° 90°

OK CANCEL

Figure 3. Current wind speed and direction in km/h. Note: This is a real-time map so your wind speed values may differ from those shown here.
The arrows on your map are representative of the wind speed and direction *from which the wind is blowing*. Notice larger arrows for faster wind speeds and smaller arrows for slower wind speeds, and that wind speed is shown in kilometers per hour (km/hr), which can easily be converted to miles per hour (mph). One useful tool for wind speed conversions (as well as other quantities) and their formulas can be found at: [http://www.weather.gov/epz/wxcalc](http://www.weather.gov/epz/wxcalc).

Remember that air in the Northern Hemisphere moves counterclockwise around a Low pressure system and clockwise around a High pressure system. In the Southern Hemisphere, air moves counterclockwise around a High pressure system and clockwise around a Low pressure system.

**Figure 4:** Viewed from above in the Northern Hemisphere, winds near the Earth’s surface blow (A) clockwise and outward from a high-pressure system, and (B) counterclockwise and inward into a low-pressure system.

19. Find a High pressure system located on your map (you can revisit *Current Study 2* if you would like to remember how to label H and L pressure systems on your map). Wind directions at the stations in a several-state region about the center of the air mass (high pressure) are generally ________. The hand-twist model may again be referenced here.

a. counterclockwise and inward
b. counterclockwise and outward
c. clockwise and inward
d. clockwise and outward
20. Turning on your “Recent Weather Radar Imagery” layer in addition to the “Current Wind Speed and Direction (kmh)” layer, what do you observe about the current wind speed and direction in relation to areas of precipitation? In general, one of the primary precursors for precipitation formation is a ________ of wind arrows.

a. convergence  
b. divergence

21. Based on the wind flow pattern, the Radar Imagery layer, and the Current Pressure layer, are your map notes indicating L and H (low and high pressure systems) confirmed by the current wind direction arrows? You may wish to toggle on/off the “Current Pressure layer” in order to view all the other associated layers simultaneously and observe the trends.

a. wind is generally flowing from high to low pressure  
b. wind is generally not flowing from high to low pressure

22. Go to Weather Studies Maps & Links (>Surface Maps>Isobars, Fronts and Radar data) to view the real time surface analysis map from NOAA. Here you can view the actual Highs and Lows that were analyzed for the day when you are completing this analysis (note the time stamp on both maps). In general, are the wind flow arrows on your GIS map around Highs and Lows in agreement with with the expected air flow around highs and lows?

a. They are consistent with theory.  
b. They are not consistent with theory.

As we advance through the fall and winter seasons, successive movement of colder air will provide more frequent cold-air advections for the country. The temperature contrasts of adjacent air masses will likely make for energetic storm systems.

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