An Assessment of COMET's Distance Learning Program

by

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Introduction

Doppler radar represents one of the most significant advances in meteorological technology in recent years. It provides meteorologists with new techniques and methodologies for forecasting weather accurately. Now meteorologists must learn to implement this technology in practical, everyday weather forecasting. COMET (Cooperative Program for Operational Meteorology Education and Training) is designed to meet this need, through three programs: the Residence Program, the Outreach Program, and the Distance Learning Program. The specific goals of the Distance Learning Program are to educate and train operational weather forecasters in the techniques of modern weather forecasting. (COMET's Activities Fiscal Year Report 1991)

The Distance Learning Program has generated significant interest because of its approach to teaching principles and techniques in meteorology. It develops and utilizes computer based learning (CBL) modules. There are currently two completed modules, Doppler Radar Interpretation, and Boundary Detection and Convection Initiation. These multi-media CBL modules enable the user to interact with the program in a step by step process for learning meteorology. However, the educational potential of the modules needs to be assessed to determine their effectiveness for users with various degrees of experience in meteorology. This is accomplished by getting feedback from a number of people who have completed the modules.

This paper will assess how well the Distance Learning Program teaches meteorological forecasting. The three methods I used to accomplish this assessment were to a) work through the COMET meteorological modules, b) study the 11 July 1990 meteorological case for presentation in the workshop, Project Learn, and c) perform a nowcast of the 29 June 1989 case.

The modules are not designed for a layperson, but rather for a meteorologist or graduate student in meteorology. However, significant interest in the modules by laypersons has produced the need to re-evaluate the effectiveness of the modules as a learning tool for non-meteorologists. One target group is people with an extensive science background in areas other than meteorology. The primary concern is whether the COMET products provide a non-meteorologist with the necessary background information to begin applying basic meteorological ideas in forecasting. As such a person, I was assigned to work through the modules and critique them in order to give initial feedback.

The other parts of the project are designed to gauge the meteorology I have learned from the modules. This was done in two phases. I began by studying the 11 July 1990 Colorado hailstorm case. Then I helped teach Doppler radar and satellite interpretation to secondary and high school teachers using this example case. As a final test, I made a nowcast (see Appendix A for definition of terms) of the 29 June 1989 Greeley, CO case.
Materials and Methods

I am a senior at the University of Colorado at Boulder in Molecular Cellular Developmental Biology (MCDB). My science background is extensive in the biological sciences with an emphasis in the physical sciences. I have worked in several laboratories doing independent molecular biological research projects as an undergraduate research assistant. Therefore, I bring to this project a strong science background and the logical reasoning skills learned for my discipline. I was chosen for this specific project because I have a strong science background. All the meteorology I learned, including principles, use of instruments, and a nowcasting methodology, I gained during this internship. Initial learning was based on the modules and then enhanced by interaction within the work environment.

The two computer based learning modules use a delivery system consisting of a Dell 386-33 MHz personal computer (PC), a Dell VGA (Video Graphics Array) Color Plus monitor, a SONY Lasermax laser disk player, a Realistic SA-150 Integrated Stereo amplifier, a Realistic speaker and assorted cables for connecting the equipment mentioned above. The complete unit is called the CBL delivery system. While the CBL delivery systems may differ slightly in types of attachments, the basic computer components remain the same.

The modules are PC driven computer programs with video and audio images accessed from two double-sided laser disks. A person works through the module by using a mouse with occasional keyboard input. The modules were evaluated and a review was written about each one. (Note: a sample review is included in Appendix B) After using the CBL modules as a basis for learning meteorology, I did two projects to test my new knowledge.

The first project was a study of the 11 July 1990 hailstorm case. This involved understanding the meteorological causes of the storm through satellite and radar image interpretation. The next step was to assist junior high and secondary teachers in learning the same principles through a workshop called Project Learn. The second project was to perform a nowcasting exercise of a past meteorological case of 29 July 1989.

The methodology for performing a nowcast is to look at and compare many different types of data images in order to make an accurate nowcast. A standard method is to first view satellite data on a nationwide scale; then identify large scale meteorological features that may have an effect on regional area weather. Since my area of concern was Colorado, I concentrated specifically on Colorado satellite data. I used Colorado Doppler radar images, both reflectivity and velocity, to obtain information not available through satellite imagery. The information from both sources was combined in order to make a nowcast. However, the radar data served as the dominant guide for the nowcasts. All images were cross referenced to validate predictions.

All meteorological cases were analyzed by using the Forecast System
Laboratory (FSL) PC computer workstation. The FSL PC is composed of a Hitachi Accuvue color monitor, a Omnicomp graphics generator, a Dell 333D PC, a Dell color monitor, a Touchstone 3 graphics manipulator keypad, and a Logitech mouse. The FSL PC displays graphical images of past cases and present weather for analysis using DARE 1 and DARE 2 software. A person can retrieve Doppler radar, satellite images, and other graphical products at different times over North America. The images can be animated to display fronts, pressure systems, and thunderstorm activity.

All reports were generated using WordPerfect 5.1 for Windows and a HP Laserjet IIID PostScript printer.

Results and Discussion

The results and discussion portion consists of two parts. The first part deals with the COMET CBL modules and the second part deals with the results of nowcasting the 29 July 1989 case in Colorado. The opinions expressed below are based upon my own personal learning experiences.

Modules

Module 1

Module one is Doppler Radar Interpretation. The goals of the first module are to 1) recognize radar data patterns, 2) build associations between these patterns and their meteorological implications, and 3) select strategies for dealing with radar complications. The specific topics covered in the module are a) Basic Velocity Patterns, b) Radar Complications, c) Changes in Speed and Direction, d) Wind Maxima and Fronts and e) Using Spectrum Width. The format of the module is to have the user take a preliminary examination of all the module's material. Then the user works through the module by viewing a presentation on each topic. At the end of each major topic, a test over the information is presented. A score of 70% or above is required to advance to the next topic. A final exam at the end of the module tests the user's comprehension of the material. Again a score of 70% is required. The first time I used the module, I scored 72% on the final exam. The total time required to complete the module was nine hours.

The module explains how to identify and distinguish between the three types of radar images: velocity, reflectivity, and spectrum width. The module also explains the limitations of Doppler radar and how problems such as velocity aliasing, range folding, and ground clutter are palliated.

The overall effectiveness of the module was very good. As a person without a meteorology background, I could work through the module relatively easily. By completing the module, I gained a good foundation for understanding Doppler radar and some meteorology.

However, the information presented was abundant and overwhelming at times. Also, some of the information presented may require a prior knowledge of the principles behind Doppler radar. For example, the module failed to explain the
Doppler effect and its relation to conventional radar. The module’s questions on identifying different types of radar images could be problematic for a non-meteorologist. And, the module did not clearly explain the differences between the reflective, velocity, and spectrum-width images.

Some of the meteorological terminology was not explained very well. Words like convection, advection, and baroclinicity held little meaning for me. Other aspects of the module’s language that I found confusing were acronyms, such as PPI and the flag symbols for wind profile determination. This prevented me from fully understanding the material presented.

In general, specific course matter was well presented, especially velocity aliasing and range folding. However, I found a potential problem with the range folding section. To determine whether an image was valid or invalid, by the subtraction of two total volume samples, only required simple mathematical manipulations, but the relevance was vague. I also encountered problems with the veering and backing wind sections. Because I lacked meteorological knowledge, it was difficult to label the horizontal wind field correctly. I encountered similar difficulty in labelling and comprehension in the turbulence and cold front sections.

The module provided a good foundation for further work in Doppler radar. I learned the basics of Doppler radar interpretation. However, an introductory meteorology course would have enhanced the module’s effectiveness. Repeated use of the module did improve my understanding of the material and imagery interpretation, however, I still had trouble molding the material into a cohesive net and explaining why images appear the way they do. Realistically, the module provided a foundation, but I had to build upon it.

Module 2
The second module is called Boundary Detection and Convection Initiation. The goal of this module is to teach the user how to identify different boundaries using Doppler radar and satellite data to make an effective and accurate forecast of convective activity (thunderstorms). There are two lessons in this module: Boundary Detection and Nowcasting Convection. The sections in the Boundary Detection lesson are the Variable Boundary Layer, Horizontal Rolls, Boundary Layer Convergence Lines, and the Boundary Challenge. The sections in the Nowcasting Convection lesson are, Stationary Boundaries, Moving Boundaries, Colliding Boundaries, and Metwatch Simulation. The total time it took to work through this module was seven hours.

The format of this module is slightly different from the first module. A user can continue to work through the module even though a grade of 70% is not achieved. I was able to monitor my progress by accessing the user’s student record. The record visually depicted my level of understanding on a bar graph. The bar graph indicated the areas in which I needed further review. The second module required passage of a review test at the completion of all
sections in the first lesson before proceeding. This module was significantly more difficult than the first. The module was still user friendly in that I had no problem navigating through it, but I did have problems with the material in the Horizontal Rolls, Boundary Challenge, Stationary Boundaries, and Moving Boundaries sections.

In the Stationary Boundary and Moving Boundary sections, the outlining of moving boundaries and convergent zones was frustrating. I could recognize the boundary locations, but the accuracy with which the lines needed to be drawn was difficult to determine. For example, if a line was not drawn long enough, the answer was rejected. The problem may lie in trying to draw the lines with a mouse. Another potentially beneficial modification to this section would be to separate the questions evenly throughout the case. The module would not have to display all of the right answers, but displaying a few answers within the section would give the user a better idea of what the module wants.

The sections on Horizontal Rolls and Boundary Layer Convergence Lines required a meteorological background that I did not have. The material was difficult to understand and I did not know how to use some of the data like the Skew-T plots. These sections were frustrating, because I did not know how to apply this sounding data in order to make a nowcast given certain conditions.

During the first session, I reviewed problematic sections as the module suggests, but I still was unable to improve my understanding of the material. After discussing my problems with the module with my supervisor and working on the module again, I was able to improve my understanding. An introductory course in meteorology would be beneficial for people lacking a background in meteorology before they attempt to use this module.

Further study outside of the modules helped me understand the significance of the Skew-T plot or sounding data. Soundings are obtained by weather balloons that are released into the atmosphere every 12 hours. Sounding data indicates the degree of stability or instability of the atmosphere. The major lines of a Skew-T plot are dry adiabats, isotherms, saturation mixing ratio, free-air temperature (T), and dew-point temperature (T_d). I still do not have enough meteorological knowledge to completely analyze soundings, however, I do have a general knowledge of what soundings may look like if severe weather is imminent. I also learned to recognize dew point depressions, temperature inversions, and the tropopause.

Working with Project Learn, I learned through first-hand experience, that the WSR-88D Doppler radar is a device which transmits an electromagnetic energy wave and receives an echo from the wave's reflection and/or refraction off an object. With conventional radar data, only information on the distance and intensity of a storm can be revealed. However, Doppler radar utilizes the Doppler shift to also determine the velocity of moving objects.

The Doppler shift can be illustrated in the following way. A train moving toward a person with its whistle sounding, would appear to sound louder or
have a higher frequency than when it was moving away. This shift in frequency enables the Doppler radar to detect velocity and reflectivity changes of meteorological phenomena in the atmosphere. The hardware of the radar does not differ much from conventional radar. The difference between the two types lies in the software used by the Doppler radar which allows it to determine both the velocity and reflectivity of meteorological phenomena.

Another forecasting instrument to which I was exposed during Project Learn was the wind profiler. It is a vertically pointing Doppler radar which gives a vertical profile of hourly average horizontal winds both velocity (in knots [kts]) and direction (in degrees). Again, the radar transmits a pulse which measures fluctuations in atmospheric density.

Nowcast

This phase was a test of my knowledge gleaned from modules 1 and 2 and Project Learn. Because my meteorology background now consisted of a) identifying simple Doppler radar signatures, b) satellite imagery interpretation and c) some wind profiler exposure, I used these tools in a nowcasting exercise of Greeley, CO on 29 June 1989.

While a meteorologist would use a computer forecast model, sounding data and constant pressure maps in addition to the above tools, I did not because of my limited experience. Thus, this exercise concentrated on factors (as seen through radar) that contributed to storm formation.

During the exercise, time increments were expressed in Greenwich Mean Time (GMT), which is minus six hours for Mountain Standard Time (MDT), and it is expressed in Zs, (e.g. 12:00Z is 6:00 a.m. MDT). The data of the exercise are included in Appendix C.

The exercise was staged as though I were a meteorologist who just arrived on the job at 19:00Z and had to assess the possibility of storm activity in the next few hours. Even though I did not have the benefit of a map briefing, I was able to ask questions about what I saw and to receive feedback on meteorological phenomena that I might have missed, but needed to recognize in order to continue the exercise successfully. To begin, I set the clock to 19:00Z and reviewed the weather activity that had occurred during the morning.

A data loop of regional satellite/infrared (IR) imagery from 15:00Z to 18:45Z, showed a boundary moving from the NW to SE in Colorado. From 17:45Z to 19:00Z, a line of convection significantly increased along the Front Range. Cloud motion was in two directions. Counter-clockwise, rotating, mid-level clouds indicated a low pressure system over southeastern Colorado. However, developing horizontal rolls over northeastern Colorado indicated a near surface wind direction from the NE. The Denver profiler confirmed a 10 kts NE surface wind. The Flagler and Platteville wind profilers indicated that upper level winds were from the S at 250 millibar (mb). Water vapor and
infrared (IR) imagery indicated that a moisture plume was being drawn up through southwestern Colorado. Just like the visible imagery, mid-level, counter-clockwise rotation was evident in the 400-600 mb water vapor imagery. In summary, the surface winds were at 15° from the N/NE, at 5-10 kts from the NE, (also confirmed using velocity radar imagery at an elevation angle of 1.8°. Mid-level winds were from the SE at 5-15 kts. And, upper level winds from the south at 25-30 kts.

The temperatures in eastern Colorado ranged from 83°F to 92°F. The warm temperatures were coupled with high dew points of 47°F to 53°F, indicating that this air had a high moisture content. And, a precipitable water amount of .87 inches was observed from the incomplete Denver sounding. Clear skies, high temperatures and high dew points in Weld county helped set the stage for further horizontal roll development.

Turning to radar, the local (Colorado) reflectivity radar data at an elevation angle of 0.7° showed ground clutter visible near the radar site. A storm was in progress west of Fort Collins, in Larimer county, with a maximum decibel (dBz) value of 65. Typically, the reflectivity values of 30 dBz or greater means rain while 60 dBz means possible hail. Where only a change of 5 dBz occurred in the last hour of the storm, the storm did show new cell development at the rear. Therefore, I decided to keep an eye on this storm in case a gust front developed. The storm was intense and very slow moving. Thus, accumulated precipitation amounts should be monitored. A second radar feature was the presence of horizontal rolls indicating instability. The dBz values were 20 to 30. Therefore, the rolls should be monitored for further development.

The next reading was at 19:30Z. Again, examining the local reflectivity radar data at elevation angles of 0.7° and 1.8°, the horizontal rolls were distinctly visible. The Larimer county storm was stationary. Generally, I thought the 19:30Z radar images looked nearly the same as the 19:00Z images. Although, I had recognized the wind shear in the wind profiler, I had difficulty recognizing on radar that the upper level winds were moving from the south while the lower level winds were moving from the northeast. I incorrectly predicted hail at this time for the Larimer county storm. Although the reflectivity readings were 60+ dBz, there was no hail spike radar echo present on the image. I also missed the presence of a gust front emanating from the Larimer county storm. (Note: All following radar data were at 0.7° of elevation unless otherwise noted.)

At 20:00Z, the radar data showed further horizontal roll development that led to storm formation in central Weld county. At this time, the gust front was emanating from the Larimer county storm. Both were visible in satellite and radar data. Using the velocity radar data, the measured speed of the gust front was approximately 20 kts. The gust front and the horizontal rolls were estimated to be 40 km apart. Therefore, I predicted the boundaries would hit in 1.0 hours, at 21:00Z over Greeley and Platteville.
At 20:30Z, the horizontal rolls in central Weld county south of Briggsdale had undergone further development from 25 dBz to 45 dBz. A new velocity was calculated for the Larimer county gust front from 19:55Z to 20:25Z. The new estimate was 25-30 kts. The two boundaries were approximately 20 km apart. The new estimated time of collision was in 30 minutes, 21:00Z. I issued a thunderstorm advisory for the Briggsdale Platteville area.

The workstation clock was then set to 21:00Z. The gust front collided with the western most horizontal roll at 20:45Z, which deviated from my estimate of 21:00Z made at 20:30Z. Reflectivity values jumped from 25 to 65 dBz. The gust front moved faster than I expected because the meso-high behind the gust front helped accelerate it. The gust front then collided with a second horizontal roll. At 20:40Z, a second moving boundary was identified in Longmont. I incorrectly identified another boundary behind it at 20:50Z. I issued a weather advisory for western Arapahoe and Adams county as the gust front continued to collide with the horizontal rolls. I issued a separate thunderstorm advisory for Loveland and Greeley due to intense storm activity with dBz values of 50 to 65 and rain accumulation of greater than 2 inches within the first hour.

The next data loop was analyzed at 21:30Z. The second moving boundary identified at 20:40Z was about to collide with the first line of horizontal rolls SW of Greeley. The storm in Weld county appeared to have moved to the west, but very slowly. Radar imagery indicated the continuation of the Larimer county storm gust front was still moving SE and colliding with horizontal rolls. This collision resulted in convergence and vertical uplift of the air causing intense storms in western Arapahoe and Adams county at 21:30Z.

The gust front increased its velocity to 30 kts away from the radar. The velocity image at 21:30 showed mid-level warm moist air moving westward toward the radar at 50 kts, feeding the Greeley storm. The low-level winds near Denver had increased from 15 to 25 kts and changed direction from NE to NW. This wind shift and a temperature drop of 10°F, from 88°F to 76°F, was indicative of gust front passage over Denver. As the gust front continued to move east and south, collisions with the horizontal rolls occurred in Douglas county. This resulted in storm development in Douglas county at 21:12Z. I failed to predict the storms because that was the first time I was able to see the extent of the horizontal rolls to the south of Denver.

On the velocity imagery, divergence was visible at the top of the horizontal roll over Douglas county. This was expected because the structure of horizontal rolls means two adjacent rolls were rotating in opposite directions. One roll rotates clockwise while the adjacent roll rotates counterclockwise. The result was convergence at the bottom and divergence at the top.

A second velocity feature was a velocity couplet that began to form in Douglas county at 21:45Z. Since I learned to identify velocity couplets on the 11 July 1990 case, I wanted to compare the two couplets. This couplet was
larger than the 11 July 1990 couplet and slower. A velocity couplet means rotation was occurring in the clouds and could lead to possible tornado formation. A smaller and faster velocity couplet has a higher probability of forming a tornado.

The radar imagery also indicated range folding south of Douglas county and caused the storm in Elbert county to look imposing. The storm appeared to cover more geographical area than it really did. The "blocky" appearance of the velocity data helped me identify this feature as not really being part of the storm. I also identified divergence occurring in Weld county and range folding occurring in NW Larimer county.

The next nowcast was at 22:00Z. The rain accumulation indicated two inches of rain fall in an hour from 21:00Z to 22:00Z over Weld county. So there was a total of four inches by 22:00Z. The given threshold for the area was 2.5 inches. Therefore, I issued a flood watch at 21:10Z. Another area to watch was Denver, because two inches of rain had already accumulated there in the previous hour.

The final nowcast was at 22:30Z. With the severe storm over Greeley, the rainfall accumulation had increased another inch in the previous half hour. I continued the flood watch for Greeley. The precipitation amount also increased another inch in Denver. Storm movement was still slow over Greeley and to the west, leading to heavy precipitation. Eventually, a total of eight inches of rain fell over the Greeley area and severe flooding occurred.

In this particular case, neither a warning or a watch was issued for Greeley by the National Weather Service (NWS). This case occurred when there was still some speculation about the validity of Doppler radar's rain accumulation data and forecasters were not sure of its accuracy. This particular case has been used to bolster the Doppler radar precipitation accumulation algorithm as an effective instrument for flood forecasting.

After I completed the nowcast, I was able to compare what I observed with the information an operational forecaster was expected to observe. For instance, I recognized that an important storm would develop when the gust front moved eastward and collided with the horizontal rolls. However, I did not have the knowledge to anticipate that low level moisture would be drawn westward toward the mountains by the strong northeast low-level winds. Neither could I explain the reasoning behind the storm's lack of movement.

Summary

The COMET modules provide a short/review course in meteorology. The modules are geared to a meteorological audience. A layperson with a science background can pick up the modules and use them. However, the modules can in no way substitute for an introductory course in meteorology. The modules would be a good supplement to course material. The modules teach a user how to associate certain visual images with specific phenomena. These
visual images are coupled with some theories and principles. Frequent exposure can help a user learn the principles and theories associated with these images.

In addition, the modules alone cannot give a user enough background to perform a nowcast. A nowcast involves more than just recognizing images. Images and meteorological principles have to be linked to a cohesive mesh if a nowcast is to be accurate. The interaction with the work environment and my own reading enabled me to reach a level of semi-literacy in meteorology. Although I now recognize some meteorological phenomena, I still do not fully understand their origin and implications.

The modules are a valuable educational tool for meteorologists. Their value to the layperson is subjective. They can be of greater value if a person is willing to spend extra time pursuing meteorology, in the form of reading or taking a course in meteorology.
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Appendix A

advection:
   The process of moving an atmospheric property solely by the mass
   motion of the atmosphere. (Module 1 User’s Manual)

backing wind:
   A counterclockwise change in wind direction with increasing
   height. (Module 1 User’s Manual)

baroclinicity:
   A state represented on a constant pressure chart by isotherms crossing
   the contour lines. Therefore, temperature advection exists.

boundary:
   A border generated by an air mass that is either stationary or moving.

cold front:
   The leading part of a cold atmospheric air mass moving against and
   eventually replacing a warm air mass. (Am. Heritage)

computer based learning:
   Learning consisting of text and graphics provided by a personal
   computer or a mainframe.

convection:
   The upward transfer of heat in the atmosphere by massive motion within
   the atmosphere. (Am. Heritage)

dew point depressions:
   An indicator of moisture in clouds. A difference of less than 5 to 6°C
   between the temperature of the atmosphere and dew point at a
   particular altitude indicates high moisture in the clouds.

fronts:
   The interface between two air masses at different temperatures.

ground clutter:
   Ground clutter is the interference of the radar energy by ground targets,
   such as buildings, trees, mountains, etc. The energy wave from the
   radar is returned completely from these objects. The velocity data will
   show ground clutter are zero velocity targets since they do not move and
   reflectivity data will show them as high reflectivity returns.
gust front:
    A boundary that moves horizontally from a thunderstorm as a result of cold air outflow.

hail spike:
    A residual radar echo which trails a hail storm resulting from range folding.

horizontal wind field:
    The surrounding wind flow above the earth’s surface at a specific radar elevation angle.

horizontal rolls:
    Lines of clouds that are parallel to wind flow. They are visible as lines of enhanced reflectivity.

infrared:
    A wavelength of energy on the electromagnetic spectrum that is longer than visible light and shorter than microwaves. Infrared is used to measure cloud top temperatures in satellites.

meso-high:
    A small high pressure system generated behind a thunderstorm by the cooler down draft of the storm’s gust front as it moves toward the surface.

nowcast:
    A nowcast is a short term forecast out to a maximum of about 2 hours. Nowcasts are typically used for prediction of possible thunderstorm formation (convection).

pulse repetition frequency:
    The number of pulses transmitted per second.

range folding:
    Range folding is a problem encountered by Doppler radar when the energy from a previous pulse returns during a listening time of a later pulse and is displayed in the wrong location, that is it's range folded. This occurs when a energy pulse hits a meteorological target and not all of the energy is absorbed by the first target. The partial energy of the first pulse can hit another meteorological target further away and return to the radar at a later listening period.
reflectivity:
A measure of the fraction of radar energy reflected by a given object.

refraction:
A change in the direction of radar energy due to changes in the density of the medium within which the energy wave is traveling.

spectrum-width:
A measure of dispersion of velocities with the radar sample volume.(Module 1 User's Manual)

temperature inversions:
An increase in temperature with increasing height in the atmosphere visible on a Skew-T plot.

tropopause:
The boundary between the upper troposphere and the lower stratosphere. Weather occurs below the tropopause.

veering wind:
A clockwise change in wind direction with increasing height.

velocity aliasing:
Velocity aliasing occurs when wind speed is greater than the maximum unambiguous velocity at a particular pulse rate frequency (PRF) of the radar. The velocity of winds are measured on color scales. There are color scales designated for inbound and outbound winds from the radar. If an incoming wind velocity is greater than the maximum unambiguous value on the incoming color scale, the radar switches around and shows a color from the outbound color scale. This resulting data is falsely indicating outbound winds when the winds are actually inbound. Velocity aliasing can occur for inbound or outbound wind velocity data that exceeds the maximum unambiguous inbound and outbound velocity.

velocity:
A vector representing both wind speed and direction.
Appendix B
Review of Doppler Radar Interpretation Module 1 (6/10/92)
Reviewer: Joe Ng - Undergraduate molecular biology major (senior status) with no previous meteorology background. First run through.
Date/Time of Module Completion: 6/9/92 10:00a-4:45p completed lesson 3. 6/10/92 9:00a-11:00a completed module.
Final Exam Score: 72%

Comments:
The overall effectiveness of the module is very good. A person without a meteorology background can work through the module relatively easily. After completing the module, a person gains a good foundation for understanding Doppler radar and some meteorology. However, there is a large amount of information presented.

Some of the information presented may require a prior knowledge of the principle behind Doppler Radar. For instance, the module’s question on identifying different types of radar generated images is problematic for a non-meteorologist. And, the module does not clearly explain the differences between the reflective, velocity, and spectrum-width images. Specifically, a better definition of what is the Doppler effect and its relation with radar would be beneficial.

Some of the terminology used is not explained, eg. convection, advection, and baroclinicity. Other aspects of the module’s language which need to be explained are acronyms, such as PPI in the velocity aliasing section, and the flag symbols used for determining the wind profile.

Specific course matter is well presented, especially velocity
aliasing and range folding. The repeated need to hit "continue" is a good method to maintain a user's attention, but it is a little excessive. This repeated need to hit "continue" detracts from the overall flow of the module.

In the range folding section, the significance of determining whether a image is valid or invalid by subtracting two volume samples from first and second trip (TOVER) is vague. The manipulations mathematically are easy to follow, but the purpose was unclear.

Difficulty with the material is encountered in the veering & backing wind section. There are problems with labelling the horizontal wind field due to a lack of meteorological knowledge. Similar difficulty is encountered with the turbulence and cold front sections. The material presented in this section is challenging.

In summary, the module is easy to work through and it is interesting. There is an abundance of material for a non-meteorological person to digest. A single run through of the module is not enough to learn all of the material presented.
Appendix C
Figure 1. PROFS surface mesonet. See Appendix A for exact station latitude and longitude.
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