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APPLICATIONS OF INTEGRATED DATA VIEWER – IDV IN AN
INTRODUCTORY METEOROLOGY CLASS FOR
NON-SCIENCE MAJORS

by

Ricardo C. Nogueira

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Geography

Western Michigan University
Kalamazoo, Michigan
June 2005

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Ricardo C. Nogueira

APPLICATIONS OF INTEGRATED DATA VIEWER – IDV IN AN INTRODUCTORY METEOROLOGY CLASS FOR NON-SCIENCE MAJORS

Ricardo C. Nogueira, M.A.

Western Michigan University, 2005

Computer products developed to visualize and integrate meteorological products with real-time data can create a virtual reality of the atmosphere. These advanced technologies help educators to improve teaching techniques in the classroom for science and non-science majors and increase the students' interest in learning as well. One of these products, the Integrated Data Viewer (IDV), was recently developed by University Corporation for Atmospheric Research (UCAR) project, Unidata, to visualize and integrate geoscience data. This study compares students' performance in the laboratory sessions using IDV-based and MANUAL-based exercises. Comparison of lab scores with exam scores of questions on the same topic shows that there is no statistically significant difference at 95% of confident interval between both methods' scores. However, students in the IDV lab show an exam average slightly higher than students in the MANUAL lab.

Another important aspect of this study was the evaluation of student performance related to four specific topics: station model, frontal systems, air mass/temperature advection and 500 hPa geopotential. The results show that the students have difficulty in interpreting the wind direction convention. Survey about the IDV method shows the students found the IDV-based exercises very useful.

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CHAPTER I

INTRODUCTION

“The atmosphere is the most intimate part of our environment, constantly surrounding us and even entering within us with every breath we take. (Neiburger et al, 1973, p 01)”

Understanding Weather

“From the beginning of the civilization the weather has been a subject not merely of curiosity but of vital interest and frequently of profound anxiety” (Sir Napier Shaw, 1933, p.01). Thunder was considered god’s temper, and lives were sacrificed in order to have “good” weather and a good harvest. In 340 B.C., Aristotle in his book called “*Meteorologica*” makes the first compilation about weather phenomena. Understanding and predicting the weather has been a huge challenge for mankind. Ross Hoffman (2002) on the other side of the spectrum described the chaotic aspect of the atmosphere and the innovative idea about controlling the weather in order to protect lives and properties. Atmospheric phenomena influence every aspect of life.

The incoming spatial and temporal distributions of solar radiation play an important role in Earth’s surface. Because of the earth’s shape, it receives an uneven distribution of solar energy the equator region receives a surplus of energy and the poles a deficit of energy. Secondly, each hemisphere, during each season of the year receives different amounts of energy. “Earth is an open system in terms of energy - solar energy enters freely and heat leaves freely back into space” (Christopherson

2002, p 7). The atmosphere absorbs only a small portion of this energy, about one third is reflected back to space, and the largest amount reaches Earth's surface. The atmosphere, the thin layer which envelops the planet, is mostly composed of the permanent gases, nitrogen, oxygen and by a small amount of variable gases, which play a very important role in the atmosphere. Among these variable gases, the most important for weather phenomena is water vapor. Besides the effect of the direct solar radiation on the atmosphere, the surface of the earth is directly responsible for heating the atmosphere from below. The distribution of land and water in both hemispheres affects the daily and annual energy budget. Radiated energy patterns differ for deserts, oceans, mountaintops, plains, rain forest and ice-covered landscape (Christopherson 2002, 46-47). The combination of incoming and outgoing energy effects results in the seasons, climate, and the daily weather.

Weather analysis is the way meteorologists interpret the state of the atmosphere by visualizing one or more atmospheric parameters displayed in the form of maps. The most important of these is the surface map. Surface weather maps show the current atmosphere condition as reported from ground based weather stations. The observed parameters measured at the surface include temperature, dew point, pressure corrected to sea level, wind direction and intensity, cloud cover, and more. Weather maps identify patterns, such as, pressure systems, cold and warm fronts, and high and low pressure centers. Upper level maps show information, such as geo-potential heights, temperature, wind intensity and direction at conventional pressure levels. However, before computer generated weather forecasting models, the forecaster needed experience to interpret two-dimensional maps and create a three-dimensional model visualization in the mind. In the same way, students undergo a similar visualization exercise when analyzing weather.

Problem Statement

Conventional weather products utilized in the teaching of synoptic meteorology reduce three-dimensional time-dependent phenomena to two-dimensional form. This represents a challenge to the visualization of the spatial and temporal distribution of the atmospheric conditions, especially for non-science majors. Efforts have been made to create interactive learning using the personal computer, (e.g. Whittaker et al. 2002; and Carbone et al. 2005) leading to development of interactive exercises using web-based graphics with Java. Synoptic meteorology, defined as the study of weather phenomena in synoptic scale (e.g. mid-latitude cyclone bringing snow to Michigan), requires software for acquisition, processing, analysis and visualization of meteorological data and products. However, this group of software is usually UNIX, or C++ based and requires advanced knowledge of computer sciences, indispensable to meteorology majors (Koval and Young 2001). This presents a roadblock for non-atmospheric-science majors who are required to take meteorology as a non-mathematical and complementary course to their programs (Nogueira & Cutrim 2005). Recently, the three-dimensional integration of meteorological data was made possible through efforts of the University Corporation for Atmospheric Research's Unidata Program Center software, Integrated Data Viewer (IDV). Developed in JAVA, IDV is platform independent and allows real-time data acquisition and visualization of data in the areas of geosciences.

Efforts to improve the teaching of meteorology with this new technology have been tested at Western Michigan University in the Geography Department. For five consecutive semesters, new techniques in teaching meteorology were incorporated in

an introductory meteorology class entitled Weather and Climate (Cutrim et al. 2004). Since the advent of the personal computer technology, faculty, researchers and computer technicians have been continuously working to develop new ways to facilitate understanding of meteorological concepts and visualization of weather phenomena (Ehrmann 1977 and Ramamurthy et al 1992). Another effort using the computer to improve learning was made in Illinois and resulted in raising the students' interest to learning meteorology (Ramamurthy et al 1992). Carbone et al. (2005) presents some interesting conclusions regarding students use of interactive web-based exercises, local weather stations and their own observations to write weather journals; "Our experience shows that such comparison leads to more refined personal observations". In the "Flashlight Project" (Ehrmann 1977) students were surveyed about the applets (qtd. in Whittaker 2002). The results were positive about the usefulness of applets. *The experiments cited above have generated only qualitative results, lacking qualitative measurements and analysis.*

Research Objectives:

The objective of this research is to quantitatively assess student learning in the laboratory environment by comparing IDV-based with traditional, MANUAL-based exercises. In order to assess short and long-term learning, questions on the topic studied in lab sessions were incorporated in two different exams, two weeks apart.

CHAPTER II

REVIEW OF THE LITERATURE

Computer Resources for Meteorologists

History of Weather Observation and Analyses

Weather phenomena affect our daily life, and for many centuries it has been observed and registered. In the beginning only individual *qualitative observations* were possible. Each observer used their own knowledge to describe atmospheric condition like clouds, types of precipitation, lightning, moon phase, and another possible weather related phenomena. A new phase in the weather observations started with the invention of the thermometer and the barometer, the *quantitative observation* era. In the early 19th century, with the advance of the telegraph, weather observations made at the same time were shared: the synoptic meteorology idea. That idea consisted of observing and registering the weather conditions at the same time for comparison and analysis. Heinrich Wilhelm Brandes was the first one in the history to draw a meteorological map in 1819. Brandes' map signifies two distinct innovations: the portrayal of atmospheric pressure with isolines, and the juxtaposition of wind and air pressure on the same map (Monmonier, 1999). Centuries passed and now days many new technologies have been incorporated in meteorological analysis.

The first technology used to benefit meteorology was the electric telegraph in 1846, helping to disseminate weather observations in Europe; two years after Samuel Morse linked Washington to Baltimore (Monmonier, 1999). The weather network was established. However, in only 1922 the "Life Cycle of Cyclones and the Polar

front theory of atmospheric circulation” were published by J Bjerknes and H. Solberg (Djuric, 1999). This publication describes the development and structure of mid-latitude cyclones and fronts. This important theory sparks a new era in mid-latitude weather analysis. Two decades later, in 1942, the computer was introduced in weather forecasting. On April 1, 1960, the first sun-synchronous weather satellite TIROS I was launched. Placed in a nearly circular orbit, 450 miles above the earth, the satellite carried two miniature black-and-white TV cameras designed for mapping cloud cover. Finally, the RADAR and numerical weather prediction was incorporated into the analysis and the forecast (NASA 2004).

Combining surface map, upper level information, satellite images and radar, meteorologists can analyze the atmosphere in three dimensions. However, before the advance of the computer-based visualization tools, weather analysis depended only on the meteorologists’ knowledge and experience. “This was accomplished by stacking sets of height-sequenced contour plots of atmospheric data fields on clipboards and flipping through them to develop a mental three-dimension picture of their structure” (Schiavone and Papathomas, 1990).

Four-Dimensional (4-D) Weather Displays

A new level was reached with the increase of the computer capacity to process images in three dimensions. Hibbard (1986) pointed out groups that were developing three-dimensional weather displays in the mid 80s, to help meteorologists analyze weather parameters. One of those projects was developed at the University of Wisconsin-Madison Space Science and Engineering Center using a stereo Man-computer Interactive Data Access System – McIDAS (Hibbard 1986). Since the atmosphere is not a static phenomenon, another dimension was incorporated in order

to complete the chain. Hibbard (1986) describes the concept of 4-D as a combination of the three spatial dimensions and time. Nevertheless, developing a software package to visualize weather phenomena in 4-D has to take into consideration the intricacy of meteorological fields, resulting in a complex combination of techniques in order to display each type of data without errors. Hibbard (1986) has described the concept used to display weather fields:

Display techniques must be developed for each type of data, suited to the mathematical form as well as the density and texture of the data. It is also desirable to combine different types of data into a single display without confusion between parameters or too much clutter.

In addition, Hibbard (1986) highlighted a particular problem of three-dimensional display related to aspect ratio between vertical and horizontal scale. The vertical scale should be multiplied by a factor of tens or hundreds. This procedure makes it possible to better visualize the atmospheric structure.

According to Schiavone & Papathomas (1990) "An additional challenge is the need to optimize the human/computer visual interface in order to take advantage of the tremendous processing power of the human visual system...". Computer imaging developers must take into consideration the human vision perception of depth, motion, color, shape and other cues for proper visualization of meteorological parameters (Schiavone & Papathomas 1990). The combination of these two fields resulted in state-of -the-art 4-D products, with the principal objective being better weather forecasting.

Teaching Approach

All concepts described above are focused on meteorological technology. However, how do faculties bring this new technology into the classroom and use it to improve teaching and student learning? Ramamurthy et al (1992) presented one of these successful efforts on computer visualization of weather in a synoptic laboratory at the University of Illinois' Department of Atmospheric Sciences. The project transformed a traditional paper-based synoptic laboratory in a virtual synoptic laboratory accessible to students at any computer on the local campus network. The campus computer network played an essential role in this experiment. The improvement was not restricted to generated maps but allowed work with real-time data, creating a dynamic environment with a positive impact on teaching.

With the Internet growth, a massive number of real-time meteorological data in gridded format became available. These data cannot be visualized directly on the computer screen and have to be converted to another format. However, in order to convert gridded data to visualize a specific field, researchers and students should know a computer language. The most widespread languages in work with gridded data are C++ and FORTRAN, which form part of the curriculum for science majors. Koval & Young (2001) observed students with a meteorology major displaying an increase in motivation when they learned computer programming and the results were operationally useful as visualization products. On the other hand, how can non-science majors have access the same meteorological products without learning computer programming?

According to Morss (2000) "Datasets such as these [unprocessed model output and unprocessed satellite signals] represent the level of detail, and require the processing hardware and programming, beyond the skill levels or interest of the

majority of the students in the Creighton classes” [non-science students]. A new approach in teaching meteorology for non-science majors was developed by Whittaker and Ackerman (2002) using applets coded in Java. They created a series of interactive exercises (e.g. Learning to Contour, Interpreting Satellite Images, Greenhouse Warning, etc), where students skills in computer programming were not necessary for the use of the applets. Another important detail about the Whittaker and Ackerman (2002) project was that the applets are platform independent, i.e., they run in any computer with a Java-enabled browser. Whittaker and Ackerman (2002) surveyed students for three years in their introductory weather and climate course and identified four different student learning styles:

- A preference for visual over verbal learning styles...
- A balance in the number of students who are global versus sequential learners...
- A balance between active and reflective learning...
- A slight bias toward sensory over intuitive learning...

Recently, another project involving interactive web-based exercises, applied in an introductory course, showed results in increasing students’ interest in learning meteorology. Carbone and Power (2005) have developed a series of interactive exercises to facilitate students’ leaning about meteorological concepts. The key factor in their approach is the fact that students can connect what they learn in the lab with current weather, reporting. “Our experience shows that such comparison leads to more refined personal observation” (Carbone and Power 2005).

The use of computer-based exercises with real-time data has proven to be an excellent tool in the teaching of meteorology. Interactive exercises and weather parameter visualization in 3-D bring into the classroom a new concept to increase the

students' interest in learning. However, how effective are these methodologies in comparison with the traditional paper-based exercises? Is the difference only an increase in the students' curiosity? How can different methodologies be assessed in order to determine the effectiveness of each one? The next section will discuss assessment techniques and evaluate the computer-based methodology related to traditional paper-based methodology.

Computer-Based Methodology in Teaching

Assessment

Assessment is a tool used to help teachers collect feedback about how well their students are learning in the classroom and labs. Student assessment can be applied to quizzes, tests, homework, and surveys. Angelo and Cross (1998) have developed seven assumptions on their model of Classroom Assessment. These assumptions describe important characteristics in the relationship between teaching approaches, effectiveness of student learning, and the feedback given to the students. They have developed a framework model to help teachers fashion their own classroom project; it is called the Classroom Assessment Project Circle, or Project Circle. The Project Circle has three main phases (Planning, Implementing and Responding) and each phase consists of three steps. A classical example of assessment application is identifying students' misconceptions (Haslam & Treagust, 1987; Philips, 1991; Aron et al, 1994; Sneider & Ohadi, 1998). Furthermore, Alexander et al (2002) states "An effective method of student assessment is necessary in all areas and levels of education". Finally, after teachers evaluating assessment results can adapt different teaching approaches in the classroom. Hewson and Thorley

(1989) declared “Teachers must be able to do two things: diagnose the conceptions that the students are using to interpret the phenomena and monitor the status of old and new conceptions in the minds of the student.” The next topic discussed is how to use student assessments to evaluate the effectiveness of the computer in improving student learning.

Computer-aid Approach

Duit et al (1996) point out another advance in students’ learning. They described several issues to be considered in investigating student understanding and emphasized the importance of the computer as a tool in investigating student understanding. The new era in students’ assessment techniques has been growing with the advance of computer and web-based technology. Teachers are using computers to develop scientific models to enhance learning (Bakas & Mikropoulos, 2003). They describe the use of a 3-D computer solar system model in the classroom and the advantages of this model in creating students’ opportunities to explore places they could not real visit. Bakas and Mikropoulos (2003) emphasize the state-of-the-art in terms of visual technology, Virtual Reality (VR), as a tool in learning and teaching. “We believe that the educational virtual environment supports science teaching where abstract ideas and phenomena [such as the physical concepts embedded in the atmosphere], impossible to be observed and experienced in other ways, are involved” (Bakas & Mikropoulos 2003). Another field to apply computer-aid is GIS. Bunch (2000) emphasized computers’ advances in GIS with the capacity to overlay related objects or apply user interaction by panning or zooming a specific layer.

Computer-based vs. Paper-based

At the present time, more and more labs and classrooms are equipped with powerful computers and new methodologies in teaching have been developed. For example, Clariana and Wallace (2002) compared studies to evaluate those two methodologies and found no conclusive evidence that one methodology is better than the other. They believed that individual learner characteristics, like gender, race and computer skills, could affect the results. Nevertheless, the numbers of web-based courses and computer-based tests have been increasing recently, making necessary additional research to compare those different methodologies. Computer-based versus paper-based testing is widely used in different educational fields to compare written tasks (MacCann et al 2002), cognitive workloads (Noyes et al 2004), laboratory dissections (Franklin et al 2002) and teaching of English to Speakers of Other Languages (ESOL) (Thirunarayanan & Perez-Prado 2001). Teachers and researchers are using this new tool to assess students' learning; however, several studies comparing paper-based with computer-based have been published with no conclusive results. Improving quantitative exercises might lead to the real differences between computer-based and paper-based methodology.

CHAPTER III

METHODOLOGY

Unidata

With the advancement of technology in the early 1980s, powerful and affordable personal computers became available on the market, allowing educators and researchers to bring new technology, new data, and new ideas directly onto their campuses (Fulker et al, 2002). Since the late 1970s, universities had identified the need of real-time weather data in concert with on-campus computer capabilities. The National Science Foundation (NSF) and scientists from leading atmospheric science programs in the United States conceptualized a national program to disseminate real-time weather data and to visualize and integrate tools through the Internet. As a result, in 1983 Unidata was created. The University Corporation for Atmospheric Research (UCAR) operates this project, and governing committees provide guidance and peer leadership. Successful, cooperative endeavors have been launched through Unidata and its member institutions to enrich the geosciences community (Fulker et al, 2002).

Unidata develops, maintains, and supports a variety of software packages. Some of these packages are developed at the Unidata Program Center (UPC). Others have originated from universities and research institutions within the Unidata community, and have been modified, maintained, and supported at the UPC. Software provided by Unidata is available at no charge. However, there are conditions on

accessing and obtaining support for some packages. Basically, universities and research institutions must register as Unidata members and comply with the rules of use and dissemination of the tools and data. This research is based on the use of Integrated Data Viewer (IDV) as a teaching tool. IDV is the most recent software created by Unidata and will be discussed in the next session.

Integrated Data Viewer (IDV)

According to Unidata (May 21, 2005), the IDV characteristics and capabilities to work with many data sources are described as such:

“The Integrated Data Viewer (IDV) from Unidata is a Java™-based software framework for analyzing and visualizing geoscience data.

The software is freely available under the terms of the GNU Lesser General Public License.

The IDV "reference application" is a geoscience display and analysis software system with many of the standard data displays that other Unidata software (e.g. GEMPAK and McIDAS) provide. It brings together the ability to display and work with satellite imagery, gridded data (for example, numerical weather prediction model output), surface observations, balloon soundings, NWS WSR-88D Level II and Level III RADAR data, and NOAA National Profiler Network data, all within a unified interface. It also provides 3-D views of the earth system and allows users to interactively slice, dice, and probe the data, creating cross-sections, profiles, animations and value read-outs of multi-dimensional data sets. The IDV can display any Earth-located data if it is provided in a known format (Unidata).”

Human Subject

The human subjects involved in this thesis were students enrolled in the Introduction to Meteorology (Appendix E) and Climate - GEOG 225 course sessions offered by the Geography Department at Western Michigan University during the fall 2004 and spring 2005 semesters. Most of the students were aviation and secondary

education majors (75% and 10%, respectively). The remaining 15% came from others majors, such as geography, environmental sciences, and earth sciences (Cutrim et al, 2004). The course consist of a three-hour lecture and a two-hour lab per week. On average, 80 to 160 students are enrolled per semester, with lab sessions of 20 students each. The laboratory room has 20 desktop computers with CD readers and Internet connection.

During the two-semester study period, a total of 116 students enrolled in GEOG225. In each semester there were four lab sessions taught by two different instructors. For selected topics, each TA applied this experiment in two lab sessions: one using IDV and another, the control group, using the traditional exercise book. In order to have the same number of students in the lab experiment and exams, subjects who did not participate in one of these activities, exam or lab, were excluded from the analysis.

Procedure

Each semester, the instructors used two teaching techniques a) IDV as a learning tool in two of the labs, and b) the traditional lab exercise book in the other two, as the control group. In order to avoid bias by the thesis author, one IDV group and one control group were taught by a Teaching Assistant without previous knowledge of meteorology and with a basic familiarity in IDV. The chapter selected was “Weather Map Analysis” in the exercise book *Weather and Climate*, Carbone (2004, p. 95-110), covering topics from station models to frontal systems. In addition, the students could use other resources, such as, the textbook, Aguado and Burt (2004), TA help, peer discussion, or the internet. For the IDV group, 13 questions

(Appendix A) were created in order to cover the same topics as the exercise book and the students had to read the same paragraphs in the book exercise in sequence to have the same understanding as the control group. Students in the IDV group did not receive any previous training in IDV for this lab. To start the IDV program they had to click in the IDV icon and a bundle containing all necessary maps and graphics was created. The graphics generated by the bundle consist of:

1. Real-time station model with:
 - a. Sea Level Pressure,
 - b. Temperature and Dew Point,
 - c. Wind barbs (direction and speed),
 - d. Cloud cover.
2. The latest ETA model output:
 - a. Surface Isobars,
 - b. 850, 700, 500 and 200 hectopascal isohights,
 - c. 850 hectopascal isotherms and wind direction.

In addition, students were asked to draw isotherms, isobars, and frontal systems in maps created by IDV and printed on the paper exercise. To measure whether IDV had improved students' learning about weather maps, ten questions about the same lab topics were incorporated in the next exam (Appendix B). In 2005 another four questions were incorporated into exam #3 in order to measure long-term learning.

During the lab session with IDV, it was observed that many students were comfortable with the software and some found features to help themselves localize stations model without the TA's help.

Fall 2004

The semester of Fall 2004 was the first time IDV was compared with a paper-based exercise. Fifty-four students enrolled this semester, but only forty-three (80%) participated in the experiment, both the lab and the exam. The group was composed of thirty-five males and eight females, of which twenty-nine worked with IDV in the lab and fourteen worked with the paper-based exercise. From the total students 58% (25) were Aviation majors, and 42% (18) had majors in Geography, Biology, and other disciplines.

Students were split into four labs, two using the IDV-based exercise and two with the paper-based exercise. A spreadsheet was created using Microsoft EXCEL with all student grades separated by lab and TA. In order to maintain confidentiality, each name was substituted with a four-digit code (Table 1.0). In lab #1 and lab#3 paper-based exercises (control group) were applied, and in labs #2 and #4 the IDV-based exercises were applied. To get the same knowledge about the topic, both groups used the Carbone (2004) Lab Manual as a text reference.

LAB #1	Student	Gender	Curricula	Majors
	1985	F	PED	BIO
	5462	M	LEC	GEG
	1616	M	AFL	AFL
	7374	F	PED	GEG
	0115	M	AFL	AFL,SPA
	1492	M	LEC	GGP
	9131	M	PED	GEG
	4493	F	SED	EAR
LAB #3	2463	M	AFL	AFL
	6721	M	AFL	AFL
	2887	M	AFL	AFL
	7723	M	AFL	AFL
	6790	M	AFL	AFL
	7808	M	AFL	AFL
	1116	M	AFL	AFL,BBB
	5410	M	AVA	AVA
	1189	M	AVA	AVA
	2846	M	PED	EGM
	1504	M	AFL	AFL
	2110	M	AFL	AFL
	2741	M	AFL	AFL
	5555	M	AFL	AFL,BBB,BCB
LAB #2	1416	M	LEC	GEG
	6387	F	SED	PHY
	7742	M	PEP	PYE
	8383	M	AFL	AFL
	0629	M	SED	BIO
LAB #4	2802	F	PEP	HET,LHC
	1985	F	AFL	AFL
	1924	M	AFL	AFL
	7474	M	AFL	AFL
	2850	F	AFL	AFL
	0824	F	AVA	AVA
	1331	M	AFL	AFL
	1355	M	AVA	AVA
	3181	M	AVA	AVA
	1810	M	AFL	AFL
	9856	M	AFL	AFL
	0115	M	AFL	AFL
	3708	M	PED	TAD,BBB
	1278	M	AFL	AFL
	1184	M	AFL	AFL

Table 1 - Students enrolled in Fall 2004.

Spring 2005

During this semester the number of the students enrolled increased by 46% in relation to the previous semester. From a total of seventy-nine students, only sixty-seven (85%) participated in the lab sections and the exam. The spring class was composed of fifty-seven male (85%) and ten female students (15%). The majority were Aviation majors (78%), and 22% from a variety of majors, such as Geography and Psychology.

The same procedure was applied in relation to the fall semester. Four labs were formed: two worked with IDV (36 students, 54% of the total sample) and the other two with the traditional paper-based exercise (31 students, 46% of the total sample).

LAB #1	Student	Gender	Curricula	Majors		Student	Gender	Curricula	Majors	
	2085	M	AFL	AFL	LAB #3	1223	M	AVA	AVA	
	1204	F	AVA	AVA		3112	M	SED	HIS	
	4525	M	AFL	AFL		5913	M	LEC	PSY,HIS	
	1124	M	AFL	AFL		0723	M	AFL	AFL	
	2402	F	AFL	AFL		7270	F	AFL	AFL	
	5684	M	AFL	AFL		0000	M	AFL	AFL	
	1441	M	AVA	AVA		9428	M	AVA	AVA	
	2280	M	AFL	AFL		6529	M	AFL	AFL	
	4275	M	AFL	AFL		6503	M	AFL	AFL	
	2653	M	AFL	AFL		1284	F	AFL	AFL	
	3782	M	AVA	AVA		7730	M	AVA	AVA	
	1134	F	AFL	AFL		1072	M	AFL	AFL	
	6888	M	AFL	AFL		4008	M	AFL	AFL,BBB	
	0836	M	AFL	AFL		LAB #4	1868	M	LEC	GGE
	8401	M	AFL	AFL			1017	M	AFL	AFL
	4139	M	AFL	AFL	0425		M	AFL	AFL	
	1168	M	AFL	AFL	2111		M	AFL	AFL	
	8591	M	AFL	AFL	0860		M	AFL	AFL,BBB	
LAB #2	2225	M	AFL	AFL	0249		F	CTE	SEB,BBB	
	8641	M	PED	POL	0308		F	SED	MAT	
	0827	M	AFL	AFL,LHC	0385		F			
	7055	M	AFL	AFL	1104		F	PBA	UNB	
	4004	M	AFL	AFL	7972		M	PED	EAR	
	2740	M	SED	EAR	3610		M	AFL	AFL,CRJ,LHC	
	5411	M	AFL	AFL	1960		M	AFL	AFL	
	0623	M	PED	BIO	5852		M	AFL	AFL	
	3456	M	AFL	AFL	0709		M	AFL	AFL	
	1105	M	AFL	AFL	0083		M	AFL	AFL	
	9753	M	AFL	AFL	8470	F	AFL	AFL		
	2350	M	AFL	AFL	0324	M	AVA	AVA,BBB		
	5710	M	AFL	AFL	2463	M	AFL	AFL		
	5898	M	AFL	AFL						
	0518	M	AFL	AFL,BBB						
	0916	M	LEC	EVS,EAR						
	1715	M	AFL	AFL						
	4428	M	AFL	AFL						

Table 2– Students enrolled in Spring 2005.

IDV-Based Exercise

The same procedures were applied in fall 2004 and spring 2005 semesters, with the same IDV version (IDV 1.1b) and the same lab exercises. All computers in the meteorology lab were set up to open the IDV bundle by clicking on the IDV icon. The first task took place while the students were waiting for IDV to set up all graphics; they had to read pages 95, 97, and 99 in the exercise book for the first exercise. Those pages explain how the station models are designed and how to identify each parameter. The students were encouraged to read pages 402 and 403 of the Aguado and Bur (2004) textbook. Four stations were selected using the station identification four letter code stipulated by the International Civil Aviation Organization (ICAO). That first task consisted of selecting the *Observation Box* on the column *Display* (Figure 1) and using the navigating tools on the left side to identify each station, plot all information around the circle and decode 8 parameters (Barometric pressure, Air temperature, Dew point temperature, Sky coverage, Wind speed and direction, Pressure change during last 3 hours and Pressure tendency) (question #1 on Appendix A).

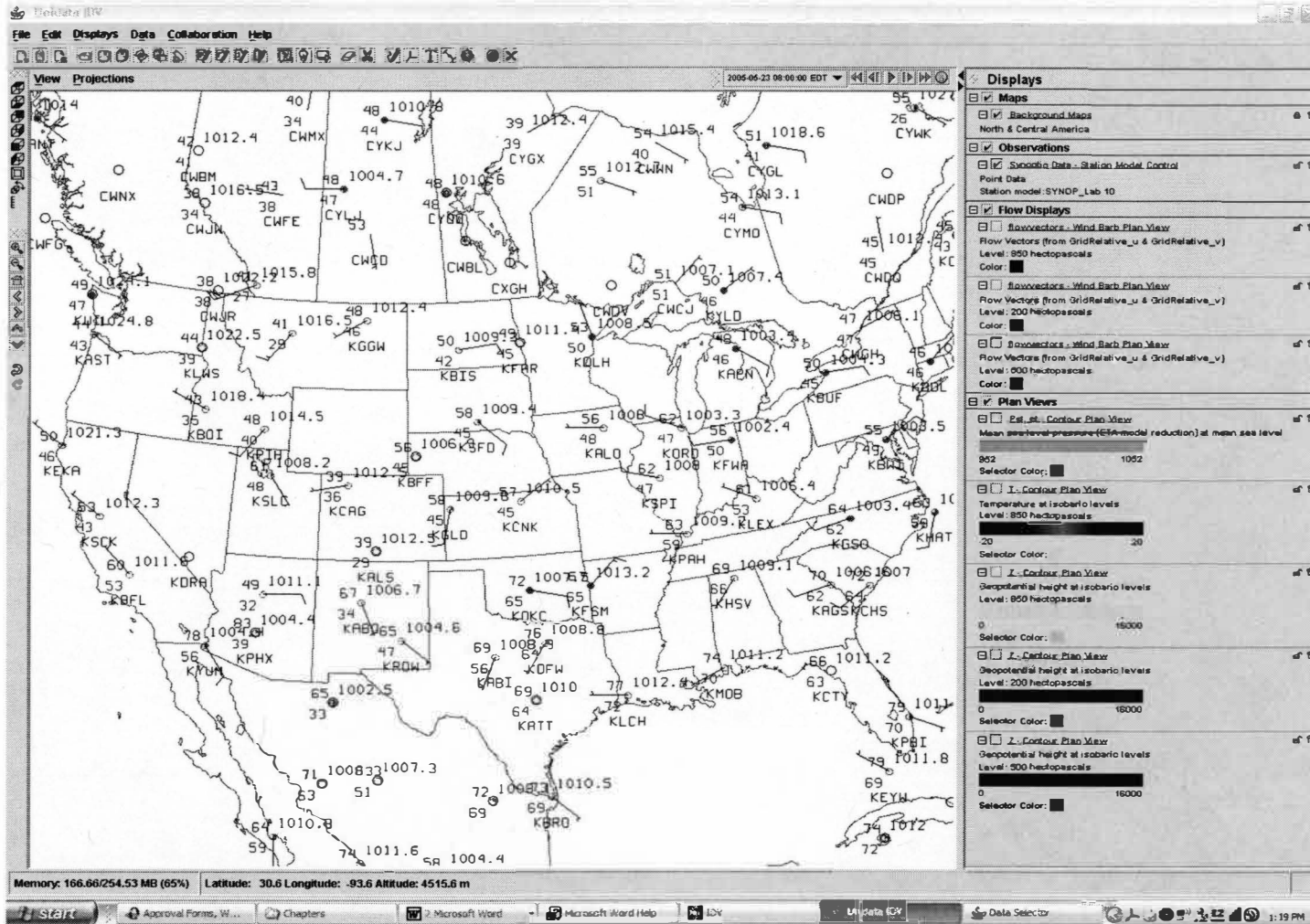


Figure 1- IDV output with station model

The objective of the second exercise was identifying the student capacity to draw isolines (isotherms) at 5°C intervals, interpolating and extrapolating the given data in the map, draw streamlines, and identify air masses. The map shows air temperature and wind speed and direction. That exercise was paper-based in order to save ink from the printer. In the future, because of the new features in the latest IDV version, another approach can be applied using only computer resources.

The third exercise was the same as the one in the manual exercise. The student has to identify the air mass by the source region (e.g. mT, mP, cP, and cA). Because this exercise presents no difference between the two approaches, it will not be included in future analysis.

In the fourth exercise, the student should demonstrate the same skill in drawing isolines (isobars) with 4-hectopascal intervals. In addition, it is expected that the student will identify high and low pressure centers and draw cold and warm front systems. The map shows station models with pressure corrected to sea level, cloud cover, air temperature, dew point temperature, and wind speed and direction. As it occurred in exercise #2, students had to use a printout of the IDV map to hand-draw the requested features. With the future IDV version, a new way to complete this type of exercise will be developed.

To complete exercises 5 to 7, the students should read pages 106 to 109 in the Carbone (2004) manual book, to learn how to interpret 850 hectopascal isotherms and wind direction combined to identify cold and warm advection, Aguado and Burt (2004). With a latest available ETA model (see Aguado and Burt, 2004, page 417 for ETA model definition), the student has to identify, in exercise 5, where they can locate on the U.S. map the wind barbs crossing the isotherm lines at 850 hPa, and

what type of advection (cold or warm) is occurring (Figure 2).

In exercise 6, the students use 850 hPa geo-potential heights to determine the range in that specific time. That means the maximum height minus the minimum height. Finally, students are asked to determine what kind of temperature advection is expected for the Western Michigan University hometown, Kalamazoo, Michigan.

The following exercises, 8 to 10, are about 500 hPa, in which the students use the geo-potential height contours and wind direction and speed to determine the range of the isolines on the map, the contour interval between two lines, and finally, identify a low pressure and the direction it would likely move. In addition to the information in the exercise book, the students can use the Aguado and Burt (2004) textbook, page 406.

Exercises 11 and 12 use a 200-hPa geo-potential height contour map, and wind direction and speed, and require students to demonstrate knowledge of upper level configuration, in the Aguado and Burt text book(2004), page 406.

The final question is about the weather forecast for Kalamazoo. This question was not used in the study. However, the idea was that given all information, from the surface to upper level, to see if the students could make their own local forecast. Most of the students used the Internet to look up the local forecast.

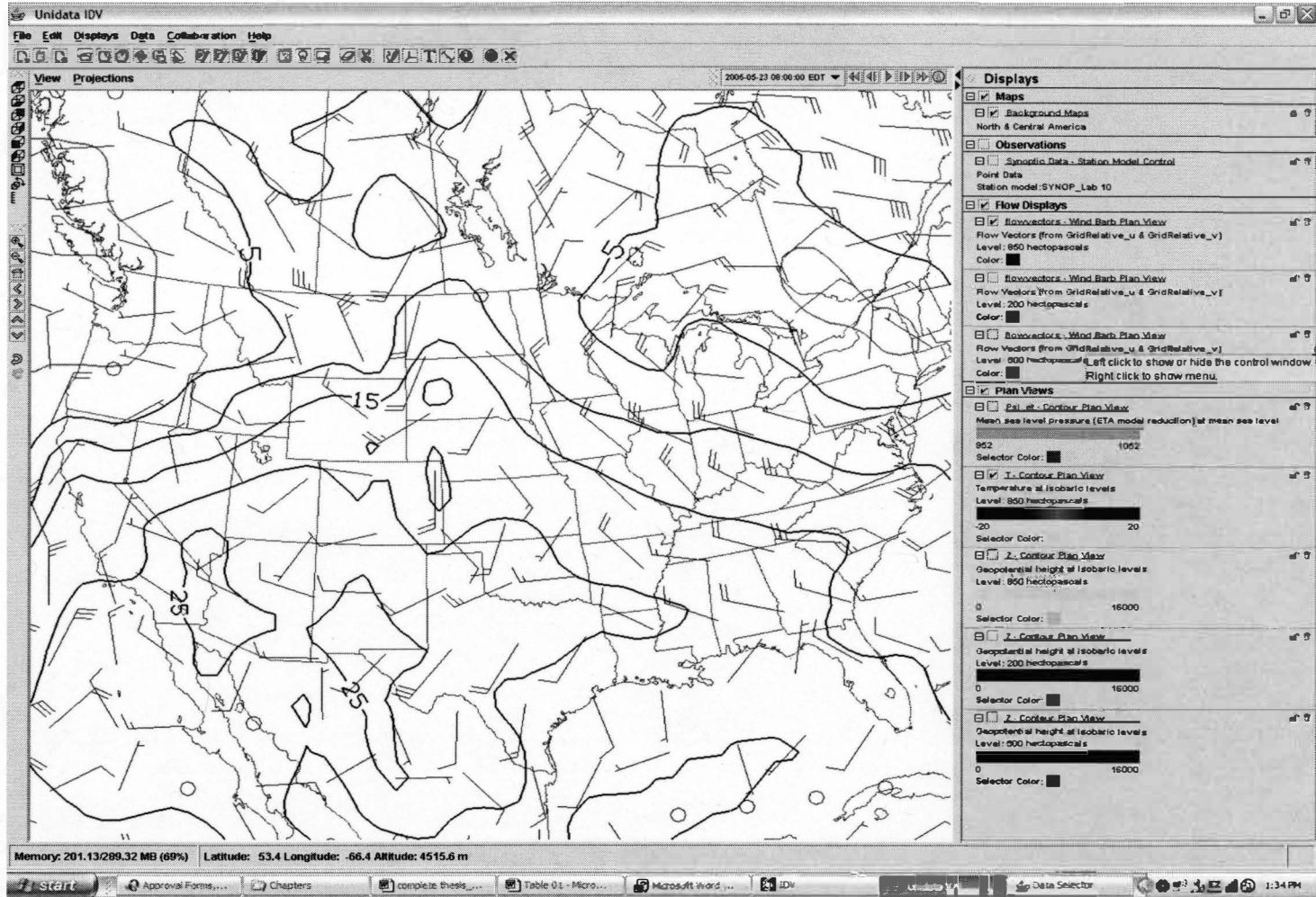


Figure 2- IDV output, 850 hPa isotherm and wind

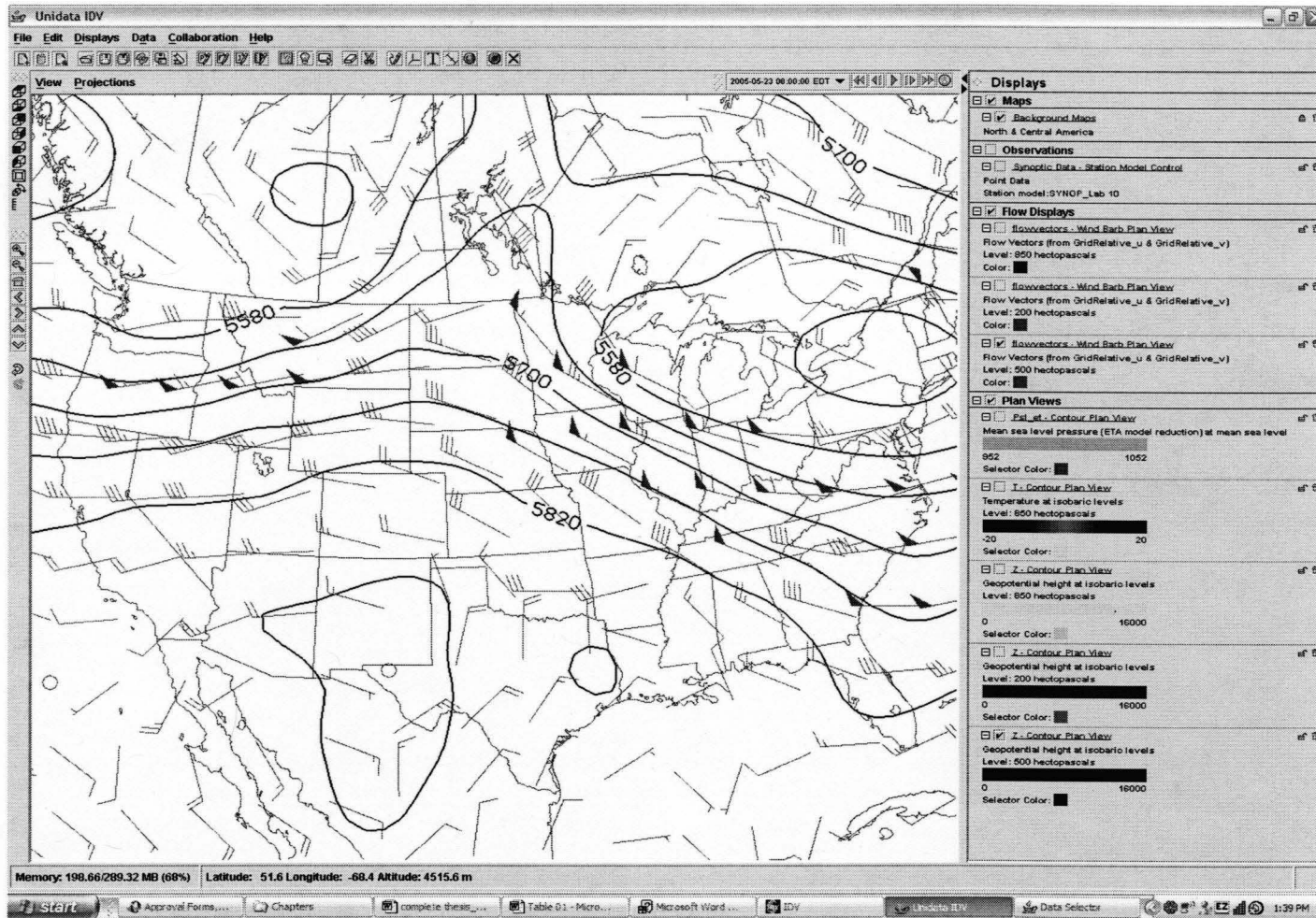


Figure 3– IDV output, 500 hPa geo-potential and wind

Exam Test –Short Term Learning

To assess the IDV-based and paper-based lab learning, ten questions were incorporated into the next exam (Appendix B). The first two questions (81 and 82) covered temperature advection and air mass. An 850-hPa map with isotherm and wind speed and direction was given to the students to be analyzed. The next two questions (83 and 84) were about a 500-hPa map, with geo-potential heights and winds. Questions 85 to 88 covered the station model subject. The last two questions, 89 and 90, were about surface sea level pressure and frontal systems.

The lab section in weather map analysis, Carbone (2004), pages 95 to 110, basically focuses on four subjects.

1. Station model
2. Temperature advection and air mass classification
3. 500-hPa geo-potential heights and wind
4. Surface map (frontal system concept)

The exercise in both labs using IDV and the manual were grouped according to those subjects and the exam questions as well, and then it was possible to compare the results. All data from both semesters was compiled in an EXCEL spreadsheet, and the following convention was used in order to identify the lab, the method, the year, and the instructor:

- 04 or 05 to identify Fall 2004 or Spring 2005
- IDV or MAN, to identify the methodology
- A for a TA with expertise in meteorology and IDV
- B for a TA with no expertise in meteorology and IDV
- TOT for total scores on labs with same methodology and different TA's

Exam Test- Long Term Learning

A posttest was conducted 47 days after to assess short-term learning, by including four questions in exam #3. Those questions covered the following four topics: temperature advection, surface map, station model, 500 hPa geo-potential heights. On the first question an 850-hPa-isotherm map was given with wind direction. Since the temperature advection was related to the air mass, the question is to identify what air masses were affecting the Midwest and South of the United States. The second question assessed the students' knowledge of surface analysis. A surface isobar map with station model was given, and the student was asked to localize a low-pressure cell. On the next question students were asked about a station model. The station model parameters were plotted on a Michigan map (Wind, Pressure, Air temperature, Dew point temperature and ICAO identification). The task was to identify which station shows 25% in cloud cover and northeasterly winds with 10 knots. The last question covered the 500hPa isoheights. In that question students were asked to identify trough and ridges as defined in Aguado and Burt (2004), page 126.

In the next chapter the data analysis and results for each semester will be discussed.

CHAPTER IV

DATA ANALYSIS AND RESULTS

Data Processing

Student scores from labs and exams were entered and stored into a Microsoft Excel (2002) spreadsheet. The data was analyzed semester by semester, for each of the teaching approaches, i.e., teaching with IDV or with the traditional Lab Manual, for each of the lab sessions. To eliminate possible bias inflicted by the mode of method application, the lab instructors also grouped scores. To assure confidentiality, scores were linked to the four-digit code number that the students had selected at the beginning of the semester. This allowed individual student scores to be tracked throughout the study period and enabled paired sample analysis. Student scores were considered only from those who were present at both lab sessions and exams.

Graphics and descriptive statistics were performed with the Microsoft Excel built-in statistical package. Further statistical analyses were conducted using SPSS for Windows (SPSS 11.0). These SPSS-based analyses included: a) independent-samples t-test to examine if there was a bias inflicted by the lab instructor (TA), b) independent-samples t-test to examine if there was a difference between teaching approaches in exam scores, c) paired sample test for lab/exam comparison for each method. The analyses were performed to answer the principal research question: Did significant differences exist between the group that used the IDV-based exercise and the control group that used the traditional paper-based exercises? Additionally,

questions, such as the influence of the meteorological background of the instructors on students' learning and the difference between different classes in two semesters were analyzed.

The first step taken was to organize the raw data into a format that can be used in SPSS, i.e., classifying the students by semester, by lab session, by teaching method, and by instructor. The second step consisted of grouping the lab and exam grades associated with the questions pertaining to the four topic types listed below;

1. Question type A -Station model,
2. Question type B -Frontal systems,
3. Question type C- Temperature advection/air masses,
4. Question type D - 500hPa geo-potential heights isolines.

Further analysis was performed to ascertain whether the new method (IDV) influenced the exam scores for each topic to assess short- and long-term learning.

First Results

Here we identify each of the four lab groups as lab#1, lab#2, lab#3, and lab#4. The four following tables present statistical analysis results for the Fall 2004 semester class. Tables 3 and Table 4 show the descriptive statistics for lab#1 and lab#2, for the control groups, and the score by type of question. The two instructors participating in this experiment are identified as TA-A and TA-B. The control group lab conducted by TA-B scored slightly higher than that of the lab conducted by TA-A (means of 9.4 and 9.0, respectively). Tables 5 and 6 show results for the IDV-based lab (lab #3 and lab #4). The average observed shows that the students in the lab conducted by TA-A had higher scores than those of the lab conducted by TA-B (means of 8.2 and 7.0, respectively). Another relevant fact is that the average score for the lab with IDV

exercises was lower than that of the traditional method. The possible reason is that the IDV method was a new approach and some students had difficulties in the beginning of the lab work with the newly introduced software.

Tables 7, 8, 9 and 10 show the results for spring 2005. The results are similar to those of the previous semester. TA-A labs have higher score than the labs with TA-B. The difference in levels of meteorology knowledge of the instructors can inflict bias in the experiment. Consecutively, the independent sample tests were applied to test this hypothesis.

LAB #1	Exercise Book					Total
	Model Station	2,3,5	7	12	13	
Questions	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	
1985	4	2	2	1	1	10
5462	3	2	2	1	1	9
1616	4	2	2	1	1	10
7374	3	2	2	1	1	9
0115	4	2	1	1	1	9
1492	4	2	2	1	0	9
9131	3	1	1.5	1	0	6.5
4493	4	2	2	1	1	10
1234	4	2	1.5	1	0	8.5
sum	33	17	16	9	6	9.0
freq	92%	94%	85%	100%	67%	1.1

Table 3 - Fall 2004 lab #1, applied by TA-A, control group scores.

LAB #2	IDV					
Questions	Model Station	2	4	9	10	
Students	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
2463	4	1	1.5	1	1	8.5
6721	4	1	1.5	1	1	8.5
2887	4	2	2	1	1	10
7723	2	1	1.5	1	1	6.5
6790	4	1	1.5	0	1	7.5
7808	2	2	1.5	0	1	6.5
1116	2	1	1.5	1	1	6.5
5410	4	2	2	1	1	10
1189	4	2	2	1	1	10
2846	4	1	1.5	1	1	8.5
1504	4	1	2	0	0	7
2110	4	2	2	1	1	10
2741	2	1	1.5	1	1	6.5
5555	4	1	1.5	1	1	8.5
sum	48	19	23.5	11	13	8.2
freq	86%	68%	56%	79%	93%	1.4

Table 4 –Fall 2004 lab#2, applied by TA-A, control group scores.

LAB #3	Exercise Book					
Questions	Model Station	2,3,5	7	12	13	
Students	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
1416	4	2	2	1	1	10
6387	4	2	2	1	1	10
7742	4	2	1.5	1	1	9.5
8383	4	2	2	0	1	9
0629	3	2	1.5	1	1	8.5
sum	19	10	9	4	5	9.4
freq	95%	100%	60%	80%	100%	0.7

Table 5 –Fall 2004 lab #3 applied by TA-A, IDV group scores.

LAB #4	IDV					
Questions	Model Station	2	4	9	10	
Students	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
2802	2	2	0	1	1	6
1985	4	2	1.5	1	1	9.5
1924	3	1	1	0	1	6
7474	3	1	0	0	1	5
2850	4	1	1.5	1	1	8.5
0824	3	0	1.5	1	1	6.5
1331	2	1	1	1	1	6
1355	4	2	1.5	1	1	9.5
3181	3	2	1.5	1	1	8.5
1810	2	1	1.5	1	1	6.5
9856	2	1	0	0	1	4
0115	2	1	1.5	1	1	6.5
3708	2	2	1.5	1	1	7.5
1278	4	2	1	1	1	9
1184	2	1	1	1	1	6
sum	42	20	16	12	15	7
freq	70%	67%	36%	80%	100%	1.7

Table 6 – Fall 2004 lab #4, applied by TA-B, IDV group scores.

LAB #1	IDV					
	Model Station	2	4	9	10	
Questions						
Students	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
2085	4	2	1.5	1	1	9.5
1204	3	1	2	1	1	8
4525	4	1	2	1	1	9
1124	4	2	2	1	1	10
2402	4	2	1.5	0	1	8.5
5684	4	2	2	1	1	10
1441	4	2	1.5	1	1	9.5
2280	4	2	1.5	1	1	9.5
4275	3	2	1.5	0	1	7.5
2653	4	1	1.5	1	1	8.5
3782	3	1	1.5	1	1	7.5
1134	4	2	2	1	1	10
6888	3	2	1.5	1	1	8.5
0836	4	1	2	0	1	8
8401	3	2	2	1	1	9
4139	3	2	2	1	1	9
1168	4	2	2	1	1	10
8591	4	2	1.5	1	1	9.5
sum	66	31	31.5	15	18	9.0
freq	69%	82%	55%	79%	95%	0.8

Table 7 – Spring 2005 lab #1, applied by TA-A, IDV group scores.

LAB #2	IDV					Total
	Model Station	2	4	9	10	
Questions	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	
Students						
2225	4	2	2	1	0	9
8641	4	2	1	1	1	9
0827	4	1	1.5	1	0	7.5
7055	4	2	1.5	1	1	9.5
4004	3	1	1.5	1	1	7.5
2740	4	2	2	1	0	9
5411	4	1	2	1	1	9
0623	4	2	1	1	1	9
3456	3	1	1.5	1	0	6.5
1105	4	2	2	1	1	10
9753	4	1	2	0	0	7
2350	2	2	1.5	0	1	6.5
5710	4	2	1.5	1	1	9.5
5898	3	2	1.5	1	1	8.5
0518	4	2	2	1	1	10
0916	4	2	2	1	1	10
1715	3	1	2	1	1	8
4428	3	1	1	1	0	6
sum	65	29	29.5	16	12	8.4
freq	62%	69%	47%	76%	57%	1.3

Table 8 – Spring 2005 lab #2, applied by TA-B, IDV group scores.

LAB #3	Exercise Book					
Questions	Model Station	2,3,5	7	12	13	
Students	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
Code #						
1223	4	2	2	1	1	10
3112	4	1	2	1	1	9
5913	3	2	1	0	0	6
0723	4	1	1.5	1	1	8.5
7270	3	2	1.5	1	1	8.5
0000	4	2	2	1	1	10
9428	4	2	2	1	1	10
6529	4	2	2	1	1	10
6503	4	1	1	1	0	7
1284	3	2	2	1	1	9
7730	4	1	1	1	1	8
1072	3	2	1	0	1	7
4008	4	2	2	1	1	10
sum	48	22	21	11	11	8.7
freq	74%	85%	54%	85%	85%	1.4

Table 9 – Spring 2005 lab #3, applied by TA-B, control group scores.

LAB #4	Exercise Book					
	Model Station	2,3,5	7	12	13	
Questions	(4points)	(2 points)	(2 points)	(1 point)	(1 point)	Total
Students						
Code #						
1868	4	2	2	1	1	10
1017	4	2	1.5	1	1	9.5
0425	4	2	1.5	1	1	9.5
2111	4	1	1.5	1	1	8.5
0860	4	2	2	1	1	10
0249	4	2	1.5	1	1	9.5
0308	4	2	2	1	1	10
0385	4	2	1	1	1	9
1104	4	2	2	1	1	10
7972	4	1	1.5	1	1	8.5
3610	4	1	2	1	1	9
1960	4	2	1.5	0	1	8.5
5852	4	2	2	1	1	10
0709	4	2	1.5	1	1	9.5
0083	4	2	1.5	1	1	9.5
8470	4	2	1.5	1	1	9.5
0324	4	2	2	1	1	10
2463	4	2	1.5	1	1	9.5
sum	72	33	30	17	18	9.4
freq	76%	87%	53%	89%	95%	0.5

Table 10 –Spring 2005 lab #4, applied by TA-A, control group scores.

Statistical Analysis-Fall 2004

An independent-sample *t*-test was computed to determine if the mean difference between the groups with MANUAL-based and different instructors were statistically different.

H0= There is no difference between the lab scores with MANUAL-based

exercises applied by different instructors

HA= There is a difference between lab scores with MANUAL-based exercises applied by different instructors.

Using a 95% confidence interval, and 12 degrees of freedom, the $t_{critic} = \pm 2.18$. The SPSS 11.0 output is shown in Table 11. Based on the F-test (Sig = 0.713) we can assume the samples have equal variance. The t value is $-0.742 < t_{critic}$, therefore the results have failed in rejecting the null hypothesis and concluding that there is no difference between TAs in MANUAL-based scores.

Independent Samples Test

Equal variances assumed

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
LAB04	.142	.713	-.742	12	.472	-.400	.5389	-1.5741	.7741

Table 11- SPSS output comparing Manual-based groups' average.

The same analysis was conducted comparing TAs based on IDV lab results.

H0= There is no difference between the lab scores with IDV-based exercises applied by different instructors.

HA= There is a difference between lab scores with IDV-based exercises applied by different instructors.

Using a 95% confidence interval and 12 degrees of freedom, the $t_{critic} = \pm 2.052$. The SPSS 11.0 output is shown on Table 12. Based on the F-test > 0.05 we can assume the samples have equal variance. The t -test statistic value was $2.867 > t_{critic}$, therefore the conclusion was that the null hypothesis was rejected and alternate hypothesis was accepted. There is a difference between TAs in the IDV-based scores.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB04	Equal variances assumed	.782	.384	2.867	27	.008	1.643	.5731	.4670	2.8187
	Equal variances not assumed			2.885	26.686	.008	1.643	.5694	.4738	2.8119

Table 12 - SPSS output comparing IDV-based groups' average.

The previous results indicated the TAs expertise might have affected the IDV-based lab scores, however, small samples and heterogeneity between students could have affected the results as well. For this reason, the results were not grouped and another t-test was applied at lab scores to determine if there was a difference between IDV and MANUAL caused by each TA.

H0= There is no difference between the lab scores with IDV-based and MANUAL-base exercises applied by TA-A.

HA= There is difference between lab scores with IDV-based and MANUAL-base exercises applied by the TA-A.

Using a 95% confidence interval and 21 degrees of freedom, and based on the F-test > 0.05, we can assume the samples have equal variance. The SPSS 11.0 output is shown on Table 13, and the t-test value is 0.65 > ± 0.05. The result for two-tailed test was 0.523 > 0.025. The results fail to reject the null hypothesis, on the other hand, there is no difference between student scores using IDV and MANUAL labs applied by TA-A. They performed equally well.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB04	Equal variances assumed	2.099	.162	.650	21	.523	.357	.5493	-.7852	1.4995
	Equal variances not assumed			.687	20.030	.500	.357	.5201	-.7276	1.4419

Table 13- SPSS output to compare TA-A effect in both lab sessions.

The same t-test was applied with the TA-B lab scores to analyze if there are differences between the two approaches, IDV-based and MANUAL-based.

Using a 95% confidence interval, and 21 degrees of freedom, and $t_{critical} = \pm 1.721$, and based on the F-test < 0.05 we can not assume the samples have equal variance. The SPSS 11.0 output is shown on Table 14. The t value is $4.613 > t_{critical}$. Therefore, the null hypothesis was rejected, and we concluded that there was a difference between the lab scores applied by TA-B. The lab with the MANUAL-based group (average = 9.4) showed better results than the IDV-based group (average = 7.0) applied by TA-B.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB04	Equal variances assumed	5.255	.034	3.091	18	.006	2.400	.7765	.7686	4.0314
	Equal variances not assumed			4.613	17.164	.000	2.400	.5203	1.3031	3.4969

Table 14- SPSS output to compare TA-B effect in both lab sessions.

The previous tests showed bias between those instructors; however, labs with the same methodology will be grouped in order to compare lab scores with exam scores. The next hypothesis to be tested is if there was retention of what was learned in the lab compared with the exam. A paired test was used to compare lab scores with exam scores.

H₀= the lab average scores are equal to exam scores

H_A= the average scores are different between lab and exam

Using a 95% confidence interval, and 42 degrees of freedom, and $t_{critical} = \pm 1.684$, the SPSS 11.0 output is shown on Table 15. The t value is $3.383 > t_{critical} = \pm 1.687$. Therefore the results for the paired sample rejected the null hypothesis; there is a difference between lab and exam score average.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	LAB04 - EX_04	1.465	2.8398	.4331	.591	2.339	3.383	42	.002

Table 15– Paired samples test results.

The lab score average for all the lab sessions, regardless of teaching technique, in Fall 04 was 8.2. The exam score average on the related questions was 6.8. This was expected because the students had more thinking time and resources in the lab session in comparison to the closed-book exam, where students had limited time, more questions to answer, and added stress associated with the exam taking.

However, when exam scores were examined according to the employed technique, MANUAL-based and IDV-based results were different.

Null hypotheses 01): There is no difference between lab MANUAL-based and exam scores.

Alternate hypotheses 01) There is a difference between lab MANUAL-based and exam scores

Null hypotheses 02): There is no difference between lab IDV-based and exam scores.

Alternate hypotheses 02) There is a difference between lab IDV-based and exam scores

Running the paired sample test by SPSS 11.0, the results for a 95% of confidence level are shown in the table below.

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	LABMAN - EXAMAN	2.4286	2.26051	.60415	1.1234	3.7337	4.020	13	.001
Pair 2	LABIDV - EXMIDV	1.0000	3.00595	.55819	-.1434	2.1434	1.792	28	.084

Table 16 -SPSS output for lab and exam scores compared by methodology.

The lab with the MANUAL-based average shows $p < 0.05$, therefore the null hypothesis was rejected; there was difference between lab and exam scores. The lab with the IDV-based average showed $p < 0.05$ for one-tailed t -test. Therefore the null was rejected: there was a difference between exam and lab scores. However, $p = 0.042$ is very close to the limit 0.05 , and it appears that students who used IDV retained information more successfully compared with the students who had the traditional MANUAL-based exercises. On the other hand, students with MANUAL-based exercises have a higher average (2.4288) than students with IDV-based exercises (1.0).

Finally, another t -test was run to evaluate if the exam scores showed significant difference between scores of students who learned with IDV and those who learned with the MANUAL. Table 17 shows the results, and at a 95% confidence level and based on the F -test > 0.05 we can assume the samples have equal variance. The p -value of $0.912 > 0.05$ indicated that there was no statistically significant difference between the two student groups. However, students in the IDV group have an exam score average slightly higher when compared with student scores in the MANUAL group (IDV = 6.79; MANUAL = 6.71).

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
EX_04	Equal variances assumed	.655	.423	-.111	41	.912	-.08	.711	-1.514	1.357
	Equal variances not assumed			-.106	23.141	.916	-.08	.743	-1.615	1.457

Table 17– SPSS output comparing students’ exam scores.

Statistical Analysis-Spring 2005

Data collected during lab and exam sessions in spring 2005 received the same analysis in order to compare results between semesters. Independent samples and paired t-test were used to do the analyses with 95% of confidence interval.

The first t-test was applied to determine if there was difference between TAs teaching in labs where MANUAL-based was used. With an F-test < 0.05 we cannot assume the samples have equal variance. The second line on Table 18 shows a p-value $0.079 > 0.05$, indicating there was no difference between averages in labs with MANUAL-based exercises caused by TA bias.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB_05	Equal variances assumed	12.318	.001	-2.133	29	.041	-.752	.3526	-1.4733	-.0310
	Equal variances not assumed			-1.887	14.737	.079	-.752	.3986	-1.6031	.0989

Table 18– SPSS output for Spring 2005 MANUAL-based labs.

The second hypothesis was whether differences existed between TAs, with respect to the lab, with IDV-based scores. With an F-test < 0.05 , we cannot assume

the samples have equal variance. The second line in Table 19 shows a p-value of $0.139 > 0.05$ indicating that there is no difference between TAs teachings relating the IDV-based score.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB_05	Equal variances assumed	4.843	.035	1.520	34	.138	.556	.3654	-.1871	1.2982
	Equal variances not assumed			1.520	29.288	.139	.556	.3654	-.1915	1.3026

Table 19- SPSS output for Spring 2005 IDV-based labs.

Since the TA has no effect on these results, labs with the same teaching technique will be combined in order to determine if there are differences between groups with IDV-based and MANUAL-based methods.

The results shown in Table 20 compared student scores on IDV-based lab sessions and MANUAL-based lab sessions. The t-test with a confidence interval at 95% and F-test > 0.05 indicates that the samples have equal variance. The results show a p-value $0.104 > 0.05$, indicating that IDV-based scores are not statistically different from the MANUAL-based scores. The results showed that both teaching techniques performed equally well.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
LAB_05	Equal variances assumed	.664	.418	-1.650	65	.104	-.435	.2634	-.9607	.0915
	Equal variances not assumed			-1.661	64.720	.102	-.435	.2617	-.9573	.0881

Table 20– SPSS output Spring 2005 comparing methodology.

The next paired t-test compares lab scores with exam scores in Spring 2005 classified by teaching technique. Table 21 shows a 95% of confidence interval and

with a p-value $0.00 < 0.05$, that the statistical lab scores in both techniques (IDV and MANUAL) are significant differently from the exam scores. The results are the same as those of Fall 2004. However, the MANUAL paired group showed an average of 0.51 higher than the paired IDV group.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	LAB05IDV - EXM05IDV	1.5833	1.94753	.32459	.9244	2.2423	4.878	35	.000
Pair 2	LAB05MAN - EXM05MAN	2.0968	1.95542	.35120	1.3795	2.8140	5.970	30	.000

Table 21– SPSS output Spring 2005, comparing lab and exam scores by methodology.

The next test compared exam scores for each teaching technique. The null hypothesis is that there is no difference in exam scores by groups. The alternative hypothesis is that there is a difference in exam scores by group. Table 22 shows that, at a 95% of confidence and F-test > 0.05 , equal variances can be assumed. The results show a p-value > 0.05 , and we accepted the null hypothesis: there is no difference in exam scores by groups. That means that the IDV group had the same performance as that of the MANUAL group. However, students in the IDV-based group showed a slightly higher average (7.111) compared with the MANUAL-based group average (7.032).

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
EX_05	Equal variances assumed	1.644	.204	.180	65	.858	.079	.4389	-.7976	.9553
	Equal variances not assumed			.177	57.408	.860	.079	.4461	-.8143	.9720

Table 22– SPSS output results for exam Spring 2005.

The next hypothesis to be tested was if there was retention of what was learned in the lab compared with the exam. A paired test was used to compare lab scores with exam scores.

H₀= the lab average scores are equal to exam scores

H_A= the average scores are different between lab and exam

A 95% confidence interval, 66 degrees of freedom, and $t_{critical} = \pm 1.671$ was used. The SPSS 11.0 output is shown in Table 23. The t value is $7.630 > t_{critical}$, therefore the results for the paired sample for two tailed t -test reject the null hypothesis: there is difference between lab and exam score average.

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	LAB_05 - EX_05	1.821	1.9534	.2387	1.344	2.297	7.630	66	.000

Table 23 – Spring 2005, paired t -test.

As in the Fall 2004 semester, the overall lab score average (8.89) was higher than the overall exam score average (7.07), indicating that the students performed better in the lab.

Long Term Learning

During the Spring 2005 semester the author had an opportunity to measure long-term learning. In exam #3 four extra questions covered the four topics analyzed in this experiment and described in chapter 4 (Station model, Frontal systems, Temperature advection/air masses, 500hPa geo-potential heights isolines). First, the total scores of the IDV group were compared with the total scores of the MANUAL group using a one-tailed independent t -test at a 95% of confidence level.

The null hypothesis is that there is no difference between groups (IDV and MANUAL) in exam #3, and the alternative hypothesis is that there is difference between groups (IDV and MANUAL) in exam #3. Since the F -test > 0.05 we can assume equal variances. Table 23 shows p -value > 0.1 , resulting in acceptance of the

null hypothesis: there is no difference between groups (IDV and MANUAL) in exam #3. However, the IDV group shows a slightly higher mean value (0.8403) compared with the MANUAL group average (0.7984).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper	
EXAME3	Equal variances assumed	2.849	.096	1.058	65	.294	.0419	.03958	-.03717	.12095
	Equal variances not assumed			1.034	53.813	.306	.0419	.04053	-.03938	.12316

Table 24 – SPSS output for exam #3 in Fall 2005 semester.

Analysis of Questions Grouped by Topics

Grouping data

Lab and exam exercises covered four topics in the “Weather Map Analysis” chapter: station model, frontal systems, temperature advection and air mass, and 500 hPa geo-potential heights. In the first part of this chapter, each lab was compared with the exam scores considering only the average. In this section, the focus was how the lab section scores were in relation to the type of question. The first step was to group scores from questions in the same topic in the lab session. We organized these questions into four topics, namely, model station (type A), frontal systems (type B), temperature advection/air mass (type C) and 500 hPa geopotential heights (type D). Tables 25 through 27 show the distribution of questions and respective assigned values by lab technique and exam. The content of these questions is shown in appendices A, B and C respectively.

IDV LAB			
Question Type	Question number	Topic	Assigned Value
A	#1	model station	4 points.
B	#4	frontal system	2 points.
C	#2	temperature advection/ air mass	2 points.
D	#9, #10	500hPa geo-potential	2 points

Table 25 –Questions for IDV lab.

MANUAL LAB			
Question Type	Question number	Topic	Assigned Value
A	#1	model station	4 points.
B	#7	frontal system	2 points.
C	#2, #3 and #5	temperature advection/ air mass	2 points.
D	#12 #13,	500hPa geo-potential	2 points

Table 26 – Questions for MANUAL lab.

EXAM			
Question Type	Question number	Topic	Assigned Value
A	#84 to #87	model stations	4 points
B	#89, #90	frontal systems	2 points
C	#81, #82	temperature advection/ air mass	2 points
D	#83, #84	500hPa geo-potential	2 points

Table 27 – Questions for exam.

Normalization of assigned question values was applied in order to compare questions of different weight. A Microsoft Excel spreadsheet was used to convert all scores into a percentage in both semesters. For clarification, an example of this conversion is given below.

A given lab or exam had questions with average of 3 points in the question type A, 2 points on the type B, 1 point on the type C, and zero points on the type D. The converted score in this lab or exam becomes:

$$A=3/4 = \mathbf{0.75}; B=2/2 = \mathbf{1.0}; C=1/2 = \mathbf{0.5}; D =0/2 = \mathbf{0.0}$$

Results of Fall 2004

The first two graphics shows the results for labs and exams with MANUAL-based groups. Figure 4 shows the results in lab #1 with MANUAL-based and conducted by TA-A. Figure 5 show the results in lab #2 with MANUAL-based and conducted by TA-B. Student exam scores in lab #1 and lab #2 showed almost the same results as those of the lab sessions with a slight variation among types of question. However, the student exam scores in TA-A session had the lowest scores in the question type B (Frontal systems), while in the TA-B session students obtained the lowest exam score in question type C (Air mass/temperature advection).

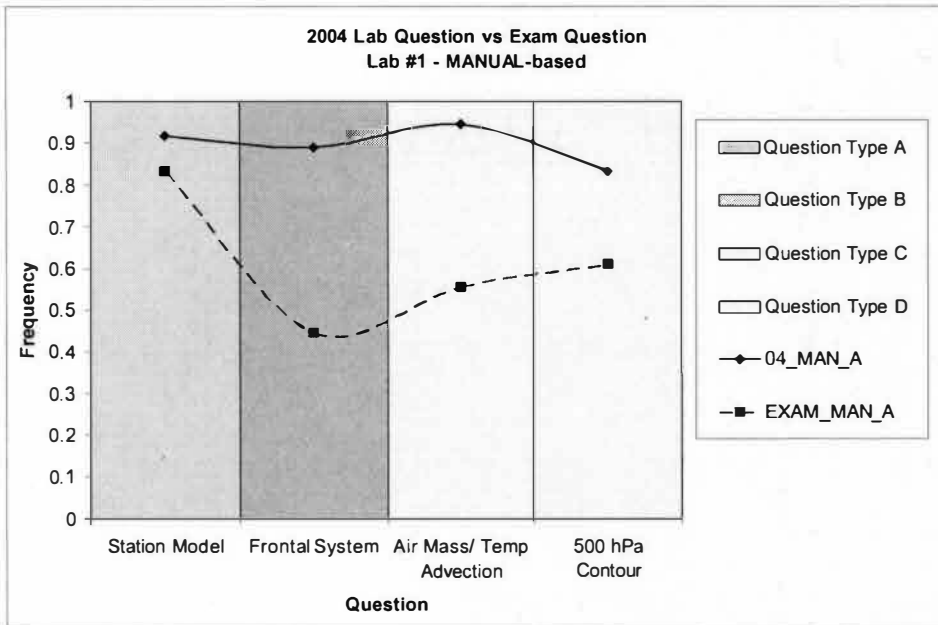


Figure 4– Fall 2004 – results for lab#1 conducted by TA-A

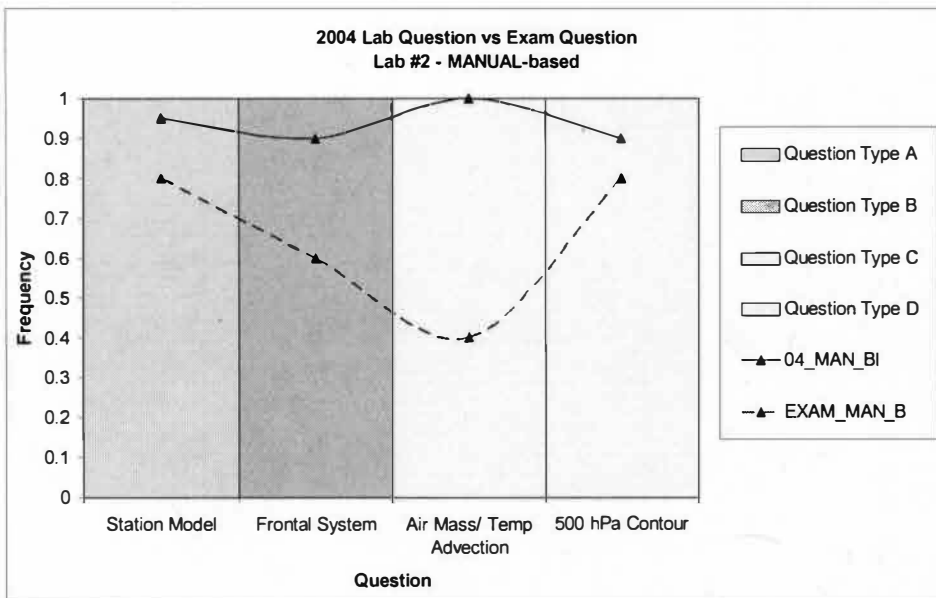


Figure 5- Fall 2004 – results for Lab #2 conducted by TA-B

Figure 6 shows a comparison of the IDV-based lab scores in TA-A lab session (lab#3) with exam scores. The score distribution curve of the IDV-based lab parallels

that of the exam scores. The lowest score in the exam was in question type C, air mass/temperature advection. Interestingly, the IDV-based instruction on TA-B lab session (Figure 7) shows higher scores on questions Type C and Type D.

The last two graphics show the total scores in lab and exam sessions. Figure 8 shows the comparison between teaching techniques. There is a slight difference between student scores learning with IDV and with MANUAL, favoring students learning with the MANUAL. However, this difference is not statistically significant. On Figure 9, exam scores were classified by methodology taught in the labs. Overall, there is no statistically significant difference between lab teaching modes on the exams scores. However, on the frontal system and 500 hPa geopotential height questions, students who learned with IDV scored 12% and 8% higher, respectively, than the MANUAL group.

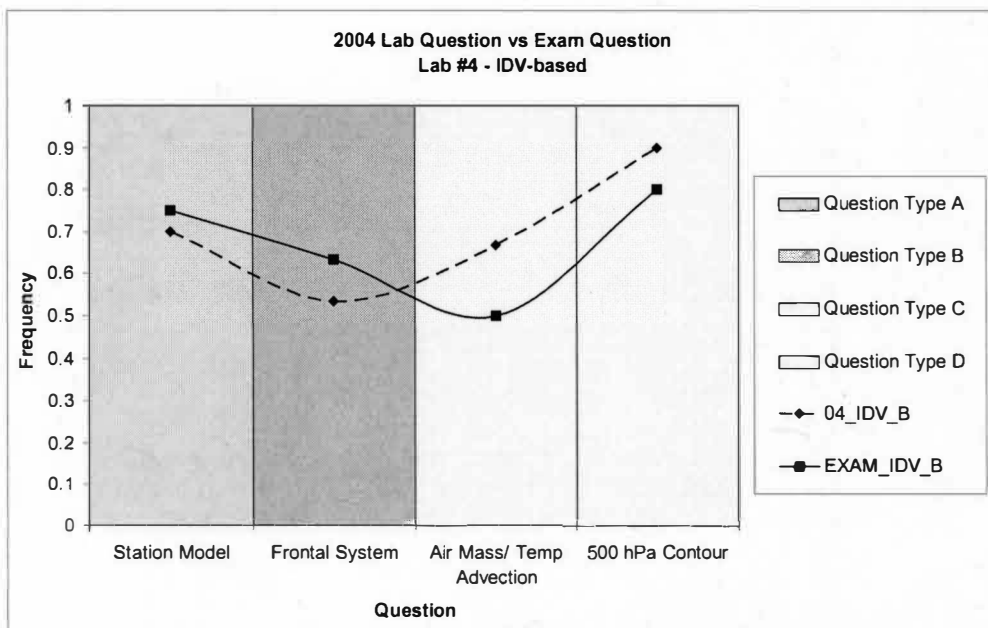


Figure 6 – Fall 2004 –results for Lab #3 conducted by TA-A

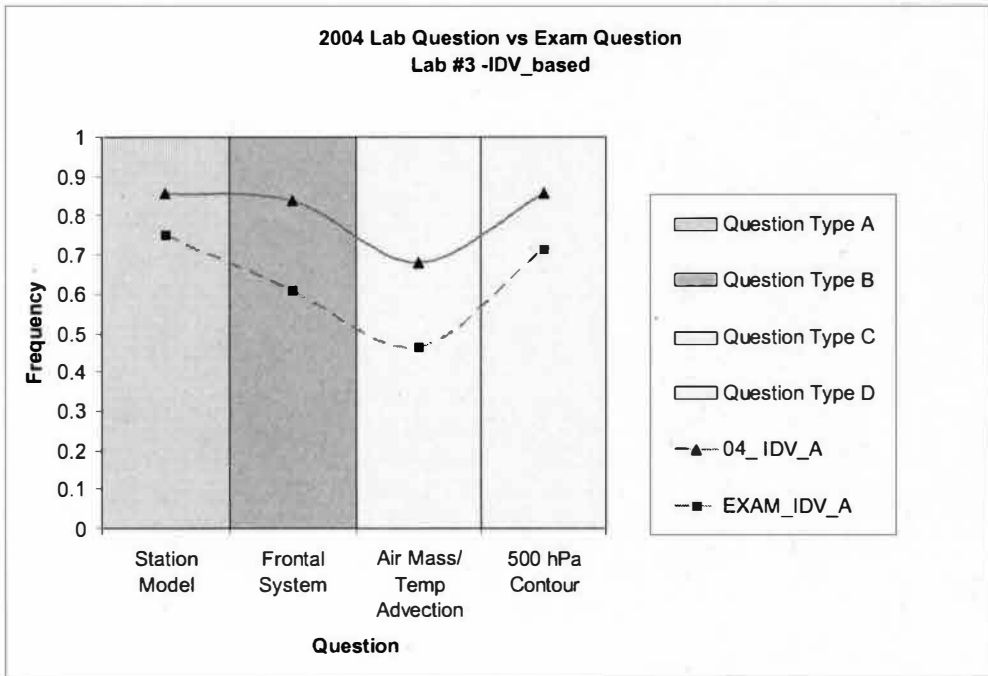


Figure 7- Fall 2004 – results for Lab #4 conducted by TA-B

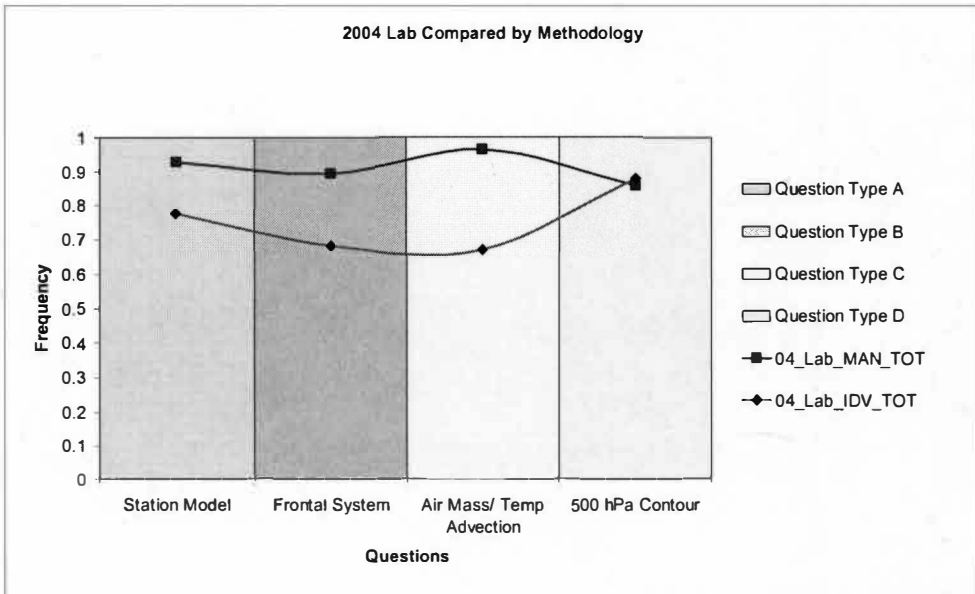


Figure 8- Fall 2004 – results for all lab sessions conducted by TA-A and TA-B and grouped by teaching techniques

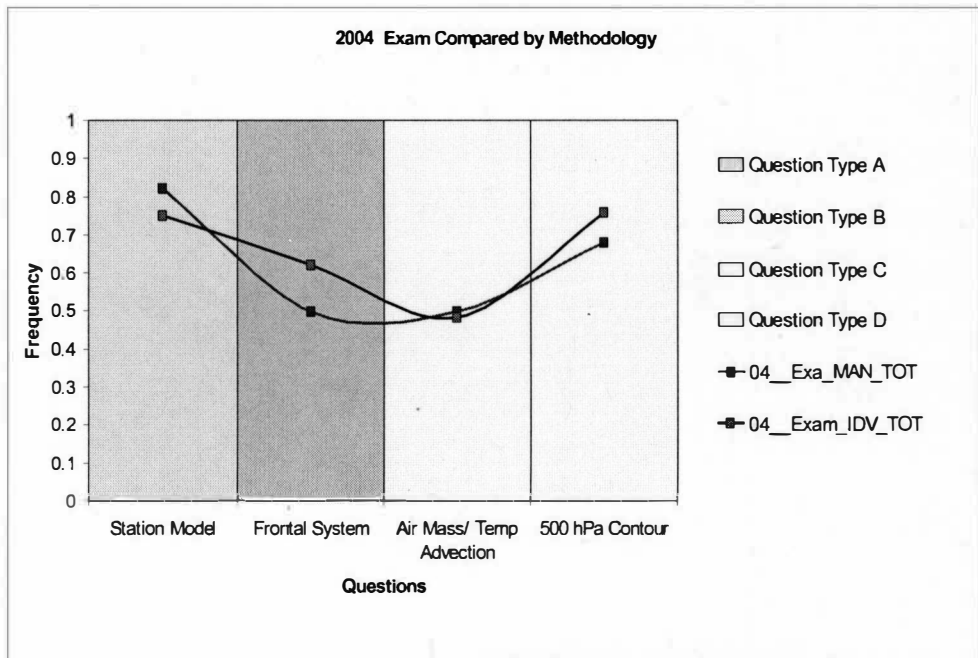


Figure 9- Fall 2004 – exam results per teaching technique

Results of Spring 2005

The same grouping questions technique analysis was applied to 2005 data. Figure 10 shows the scores for lab#3, where the MANUAL-base exercise was applied by TA-B. There is a slight difference between the lab and exam related questions type C and D favoring the lab, as in the Fall 2004 semester. This difference is more evident in Figure 11, where students in the MANUAL-based session conducted by TA-A had decreased scores in exam questions type C and D.

The next two graphics show the results for the lab session with IDV-based exercises. Figure 12 shows a lower score in question type C in the exam, but there are no differences in the lab score taught by TA-A, lab #1. Students in the session taught by TA-B (Figure 13) show better results in questions type A and D, and only a slight difference in questions type B and C.

The score results for both teaching methodology, IDV and MANUAL, shown in Figure 14, indicate only a slight difference between the average scores. Comparing exams scores by teaching methods Figure 15 shows a slight difference between methods. Students score lowest on the exam questions related to air mass and temperature advection. This observation will be discussed in the next chapter.

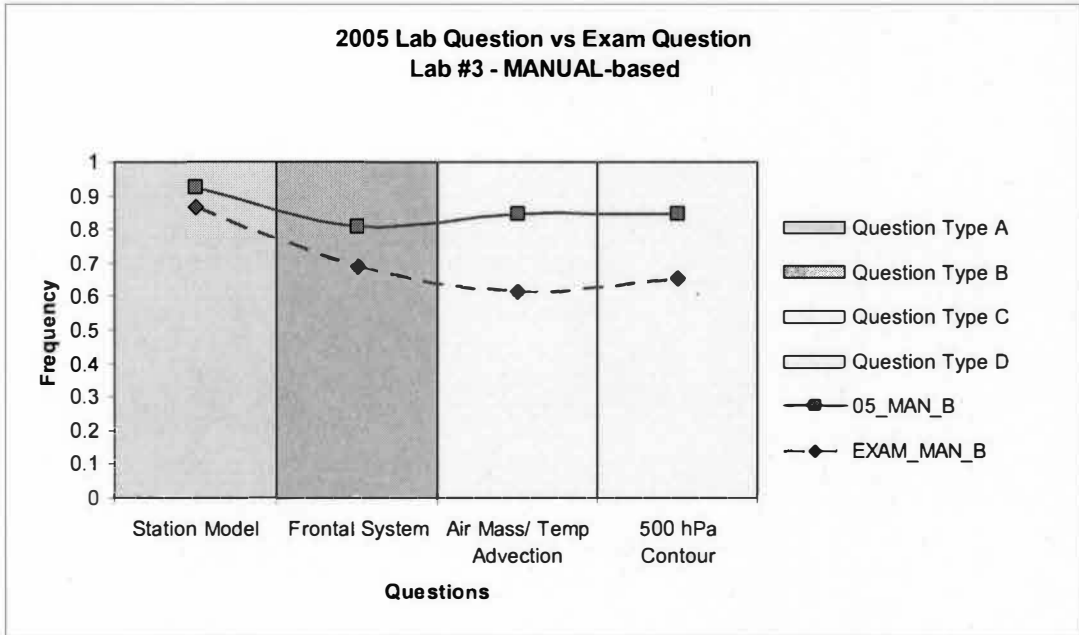


Figure 10–Spring 2005, results for Lab #3 conducted by TA-B

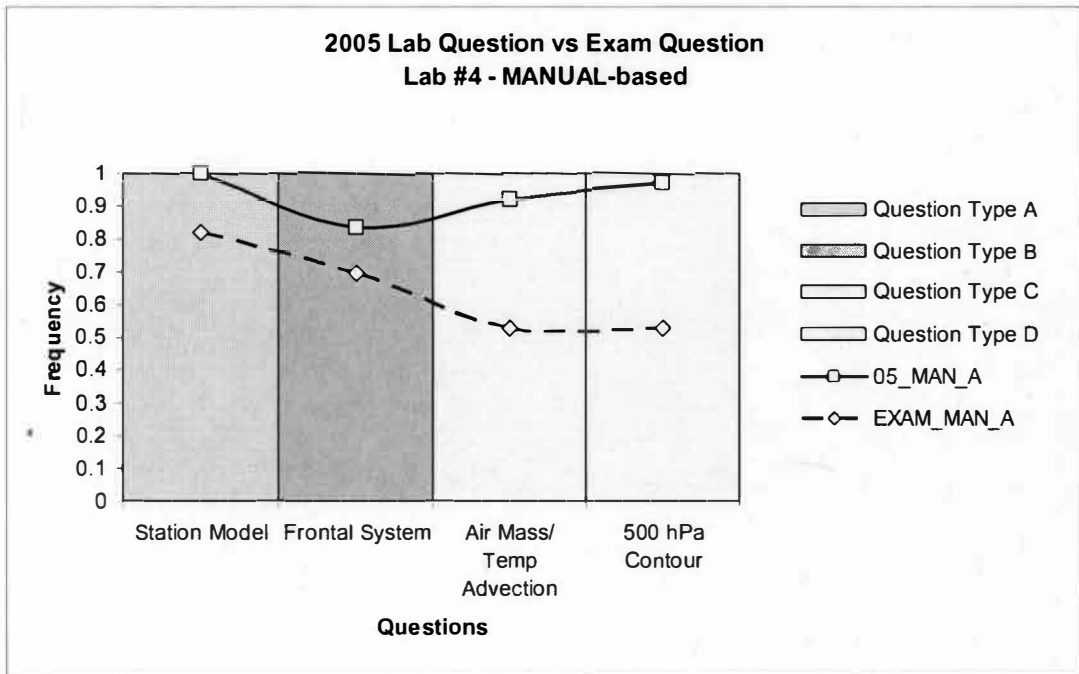


Figure 11– Spring 2005, results for lab #4 conducted by TA-A

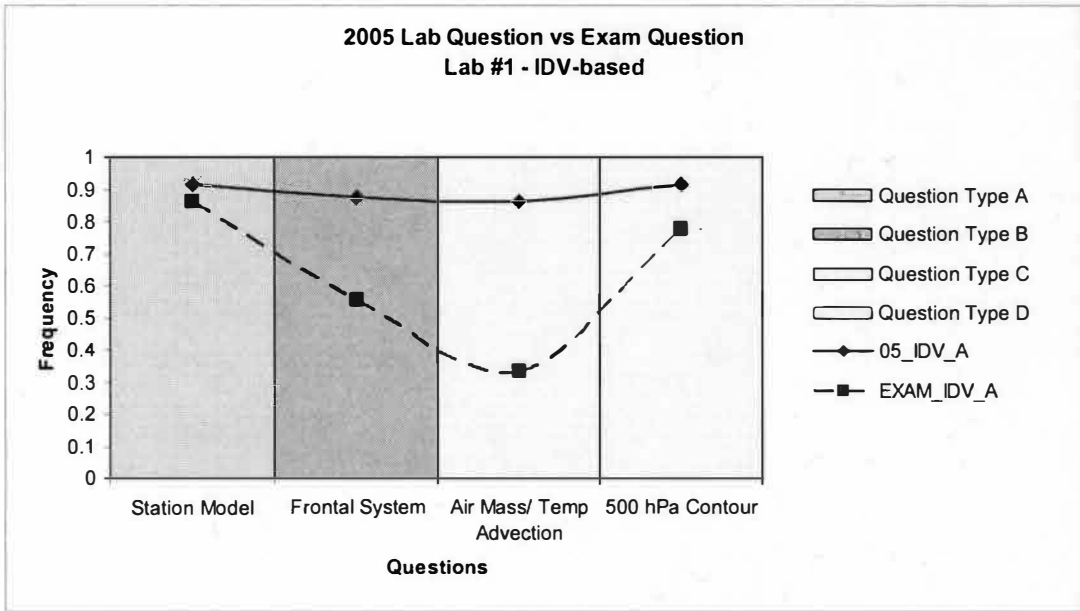


Figure 3– Spring 2005, results for lab #1 conducted by TA-A

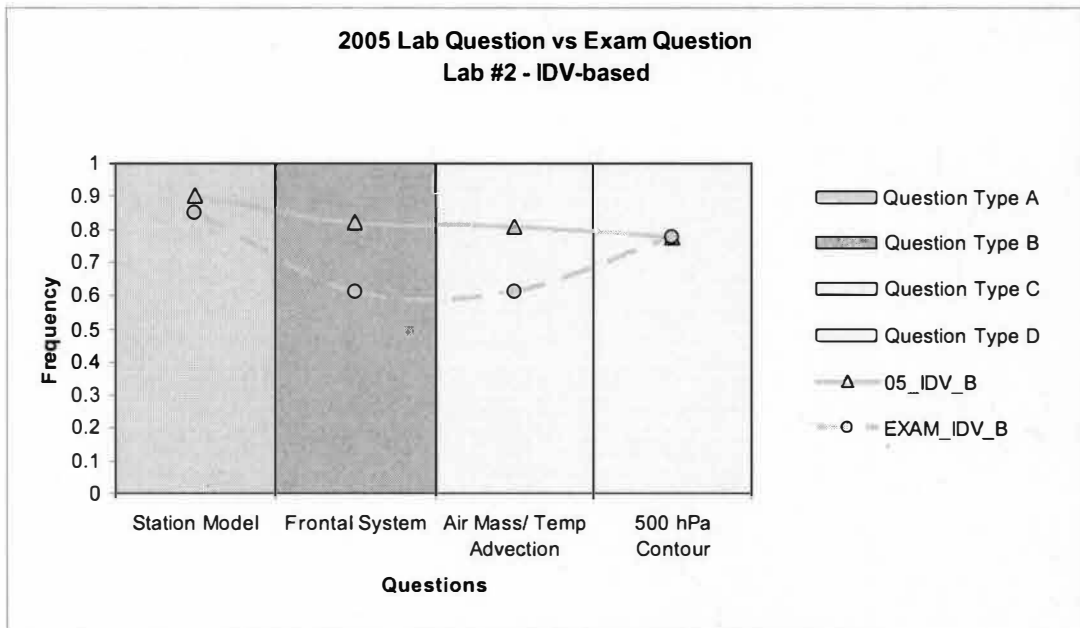


Figure 4– Spring 2005, results for lab #2 conducted by TA-B

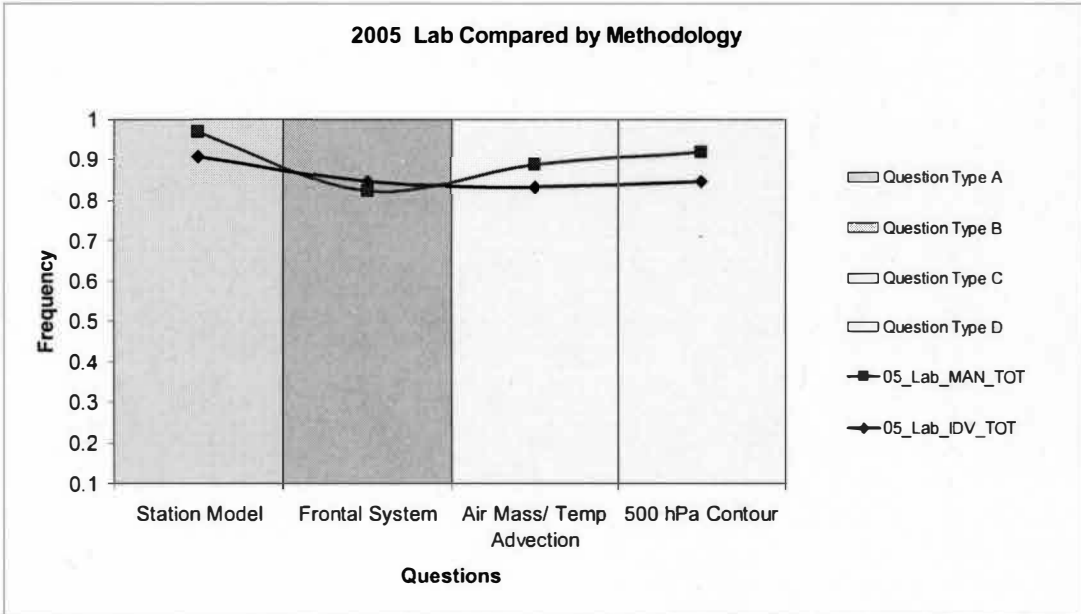


Figure 5– Spring 2005, results for all lab sessions conducted by TA-A and TA-B, and grouped by teaching techniques

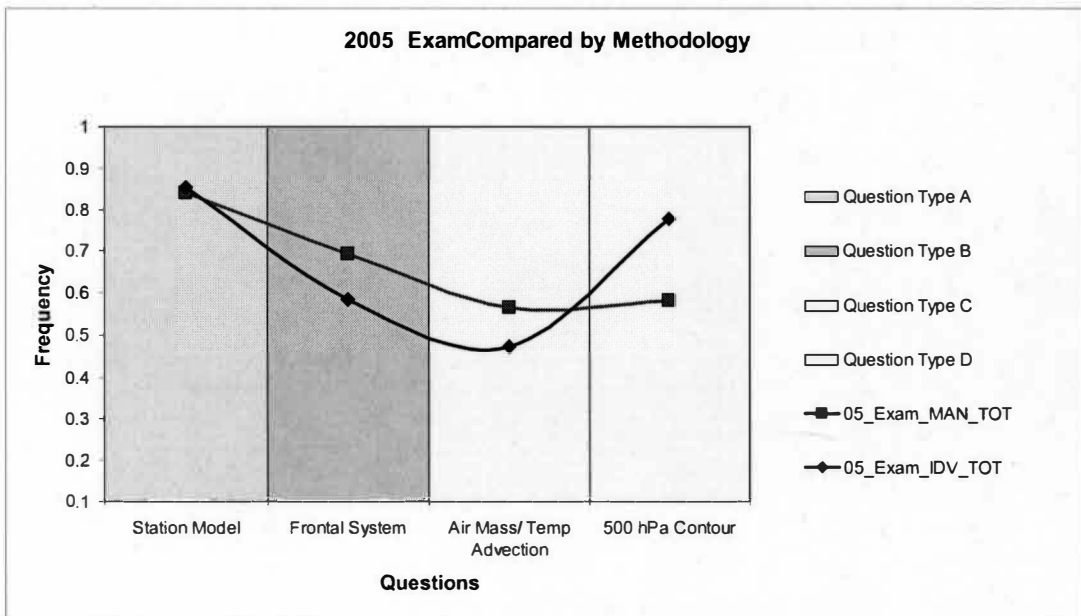


Figure 6- Spring 2005 – exam results per teaching technique

Students Survey of IDV Method

Students who received lab instruction on weather analyses using IDV were surveyed to assess learning. This survey was conducted one week after the last IDV-based lab exercises during the Spring 2005 semester. The survey questions (Appendix D) were based on Whittaker and Ackerman 2002. The results were very similar to those of the Whittaker and Ackerman 2002 survey.

- 68% of the students believed, or somewhat believed, the IDV helped them to master their skills and concepts more quickly than traditional methods.
- 82% of the students believed, or somewhat believed, that IDV helped to develop their skills and better their understanding than traditional reading and pencil-and-paper exercises.
- 40% of the students believed, or somewhat believed, that IDV allowed them to learn more on their own with less assistance from the TA.

Results of this last question regarding the importance of the TA in learning with IDV, shows the highest score of 43% on Neutral option of the scales. This might be interpreted that most of the students believed that the instructor's assistance has little influence in their learning with IDV. Comparing these results with Whittaker and Ackerman (2002) findings in their survey,

- "82% "believed" or "somewhat believed" that the applets helped them to master skills and concepts more quickly than with traditional methods.
- 75% "believed" or "somewhat believed" that the applets helped to develop their skills and understanding better than through traditional reading and pencil-and-paper exercises.
- 71% "believed" or "somewhat believed" that the applets allowed them to learn more on their own, with less assistance from the TA."

With the exception of the last questions, the results of this survey agree with those of the Whittaker and Ackerman (2002).

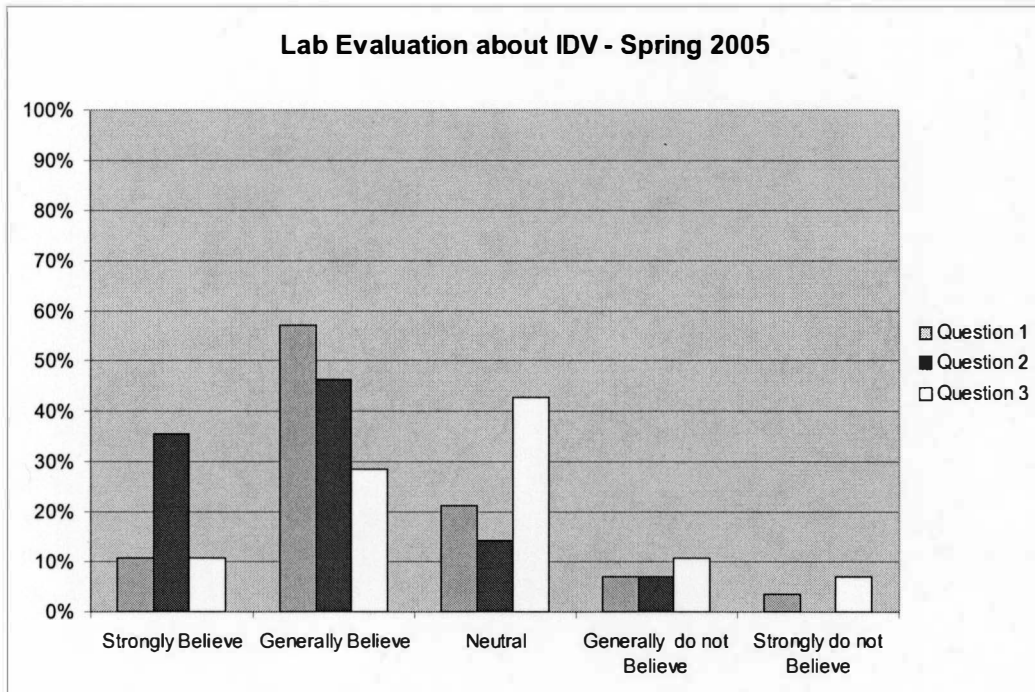


Figure 16- Survey results for 2005

CHAPTER V

CONCLUSION

Meteorology is one of the disciplines that most benefits from the visualization technology. Software with capability of creating images in three-dimensions has been used to visualize atmospheric computer models, not only in weather forecast centers, but in schools and in the media as well.

This study was conducted in the laboratory part of Introduction to Meteorology and Climate classes of Fall 2004 and Spring 2005. Students in the four lab sessions in each semester received two different teaching approaches to reinforce learning concepts presented in the lectures. This research compared the performance of students in lab sessions using computer-based (IDV) exercises with that of the students using traditional paper-based (MANUAL) exercises.

Two instructors, with different knowledge in meteorology and IDV, applied the exercises using the two different approaches. In order to determine whether there is bias in student learning due to instructor expertise, an independent *t*-test analysis of the lab scores was performed. In the Fall 2004, the results for the IDV-based exercises taught by TA-A showed a statistically significant difference when compared with those of the lab taught by TA-B, implying that the difference in TA expertise can influence student scores. However, other factors, such as a small sample, could have contributed for this bias. In relation to the MANUAL-based exercises applied in the Fall 2004 and Spring 2005, and the IDV-based exercises in the Spring 2005, the TA

expertise showed no statistical significant different.

In looking for the influence of the IDV-based versus the MANUAL-based methods, as reflected on the exam performance, laboratory scores were compared with exam scores on the same subject. Results of the statistical analysis show that the Fall 2004 students in the IDV-based lab session retained learning. However, in the Spring 2005 the exam scores did not reflect retention in learning when compared with IDV-based and MANUAL-based lab scores (short term learning).

The average exam scores in 2004 and 2005 were compared, between students with IDV-based and MANUAL-based, and showed that there was no statistically significant difference between the two student groups. Both groups have equivalent scores in the exam questions related to the laboratory exercises. However, the IDV-based group showed a slightly higher exam score average comparing to the MANUAL-based group in 2004 and 2005.

Testing the long-term learning, seven weeks between the two exams in the Spring 2005, show no statistically significant difference between IDV-based group scores and MANUAL-based group scores. However, the IDV group obtained exam score average slightly higher than the MANUAL group.

Statistical testing of the principal hypothesis, leads to the conclusion that the IDV-based method did not prove to be a better teaching tool than the traditional paper-based method. However, two observations were made in relation to the new approach in teaching meteorology to non-science students:

1. The survey about IDV method shows that the students found the IDV-based exercises very useful.
2. The exam scores in 2004 and 2005 showed not statistically significant difference between groups with IDV and MANUAL. However, the

students' average score was slightly higher in the IDV-based group, proving that this teaching technique, at least, stands at the same level as the traditional method.

Finally, comparing different types of questions showed the same low score pattern in question type C. This question is about air mass/temperature advection, and the results might be explained by the students' difficulty in understanding the convention on displaying wind direction. Even though the wind direction was well explained during the lab session and lectures, it seems that the students had difficulty in retaining this convention.

In conclusion, this research shows that the use of IDV as a teaching tool is comparable with the conventional lab manual. Meteorology labs using IDV might improve student interest in learning how the atmosphere works by comparing the weather computer models, station models, satellite images and radars with what the students are seeing through the lab windows. Future IDV versions with improved teaching features could lead to the formulation of better laboratory exercises.

APPENDIX A - IDV LAB EXERCISE

GEOG 225 – Meteorology and Climate – Spring 2005

Dr. Cutrim

Ricardo Nogueira/ Todd Norwood

Lab 10 Map Analysis

Name: _____ Code#: _____

In this lab you will work with *Integrated Data Viewer* – IDV to understand weather maps.

Click on IDV icon, and while you are waiting, reads pages 95, and 97 to 99 in your exercise book.

Check in Observations box on the column Displays (right).

- 1) Decode and plot all information from each of the following station models



KORD

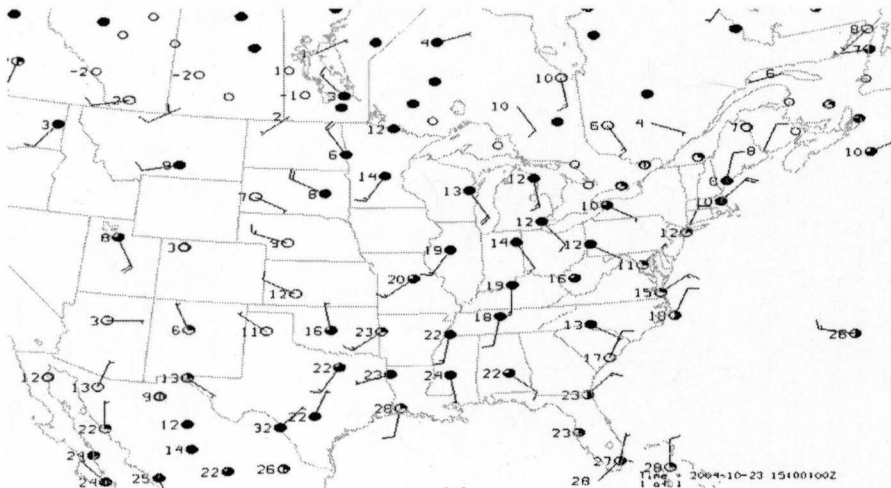
KLCH

KEKA

KHAT

Barometric	Barometric pressure	Barometric pressure	Barometric pressure
Temperature	Temperature	Temperature	Temperature
Dew point temperature	Dew point temperature	Dew point temperature	Dew point temperature
Sky coverage	Sky coverage	Sky coverage	Sky coverage
Wind Speed	Wind Speed	Wind Speed	Wind Speed
Wind Direction	Wind Direction	Wind Direction	Wind Direction
Pressure change during	Pressure change during	Pressure change during	Pressure change during
Pressure tendency	Pressure tendency	Pressure tendency	Pressure tendency

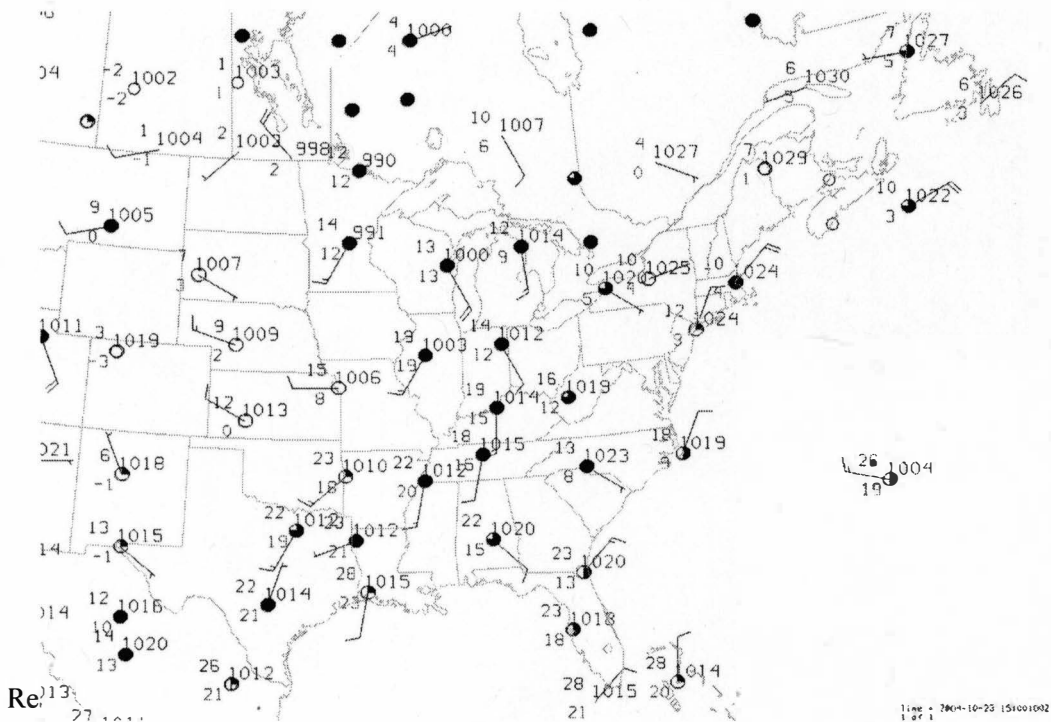
- 2) Construct isotherms at 5°C intervals with solid lines and draw streamlines to illustrate the general wind flow, and identify the air masses.



- 3) Read page 102. Based on the source regions, indicate each type of air mass influencing North America (mT, mP, cT, cP, and cA)



- 4) Using the map below
- Draw isobars at 4 hectopascal interval (1004, 1008...)
 - Label the high center pressure with H and the low pressure center with L
 - Identify warm and cold fronts



Uncheck Observations box. Select in Flows Display 850 hectopascal WIND BARB PLAN, on Plan views select T-COUNTOUR PLAN VIEW (Temperature at isobaric level-850- Black lines represent positive temperature, blue line Zero degrees Celsius, and the dash line negative temperature)

- 5) In which US region do you observe cold advection, and in which one warm advection?
- 6) What range of geopotential heights do you see in 850 hectopascal scale?
- 7) What types of temperature advection do you expected for Kalamazoo?

Uncheck the previous boxes. Select in Flow Displays wind barb for 500 hectopascals and on Plan Views Z-contour plan for 500 hectopascals.

- 8) What range of geopotential heights do you see on 500 hectopascals map?
- 9) What contour interval is used to show geopotential heights on 500 hectopascals map?
- 10) Find a surface low pressure on the map and determine in which direction would it likely move?

Uncheck the previous boxes. Select wind and geopotential for 200 hectopascals.

- 11) What contour interval is used to show geopotential heights on 200 hectopascals map?
- 12) In which US region do you expect winds exceeding 60 knots?
- 13) What is your weather forecast for Kalamazoo? Explain your forecast.

APPENDIX B - EXAM EXERCISES

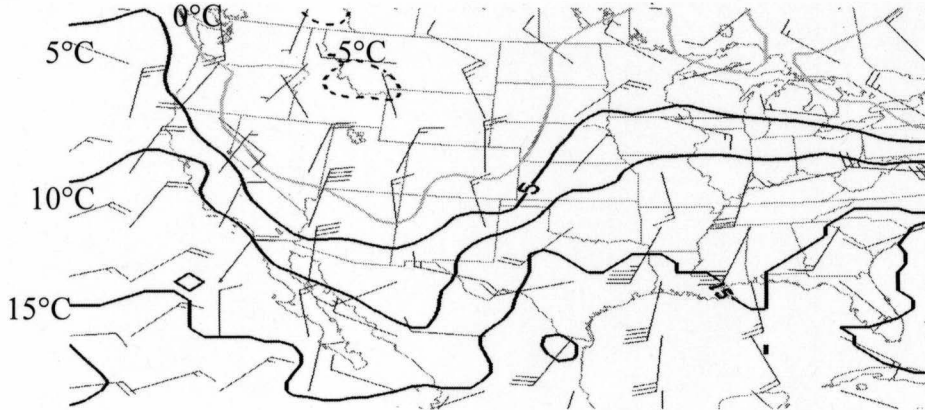
Geog 225 – intro to Meteorology and Climate-

Exam 2

Dr. Cutrim/ Ricardo Nogueira/ Todd Norwood

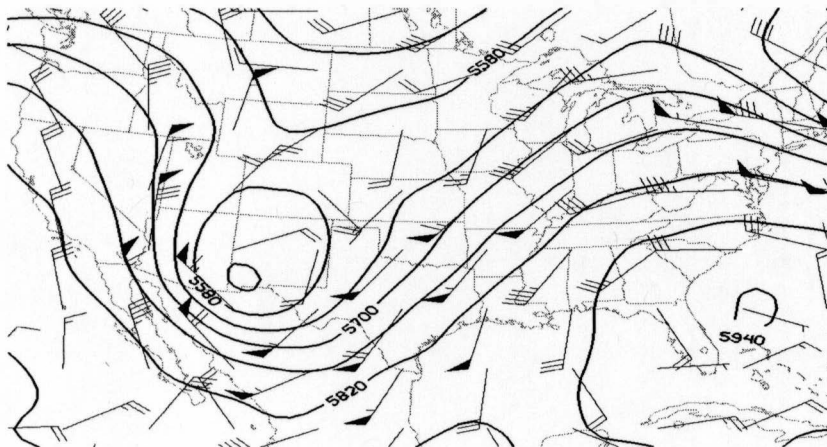
Name: _____ Code: _____ (4 digits)

The following picture shows the isotherms and wind barsbs for 850 hectopascal. Answer questions 81 and 82.



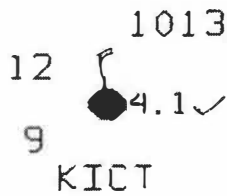
- 81) What kind of temperature advection would you expect for Mexico and Arkansas respectively?
a) Cold and Warm b) Warm and moderate c) Hot and Freezing d) Warm and Cold
- 82) What air masses are affecting those states respectively?
a) mT and cP b) cP and mT c) mT and cA d) cP and cT

The following picture shows 500 hectopascal geopotential and wind barbs. Answer questions 83 and 84.



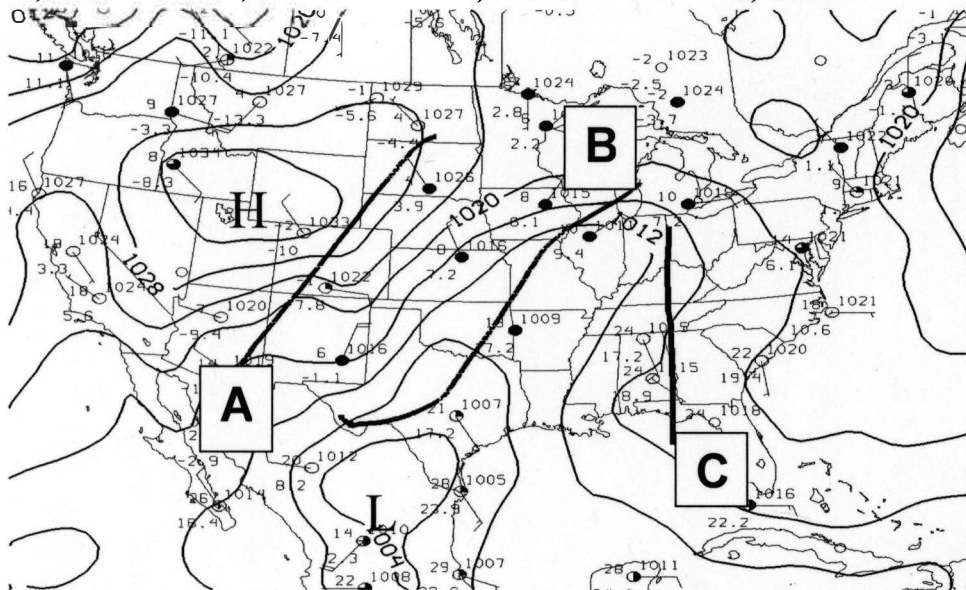
- 83) What contour interval is used to show geopotential heights on 500 hectopascals map?
a) 120 m b) 80 m c) 40 m d) 60 m

- 84) Find a surface low pressure on the map and determine in which direction would it likely move?
 a) NE b) SE c) NW d) SW



Based on the station model, answer the following questions.

- 85) The barometric pressure
 a) 12 b) 9 c) 4.1 d) 1013
- 86) Sky coverage
 a) Clear b) Partly Cloudy c) Overcast d) Mostly Cloudy
- 87) Wind direction
 a) South b) Calm c) West d) North
- 88) Pressure change during the last 3 hours.
 a) 9 hPa b) 12 hPa c) 1013 hPa d) 4.1 hPa



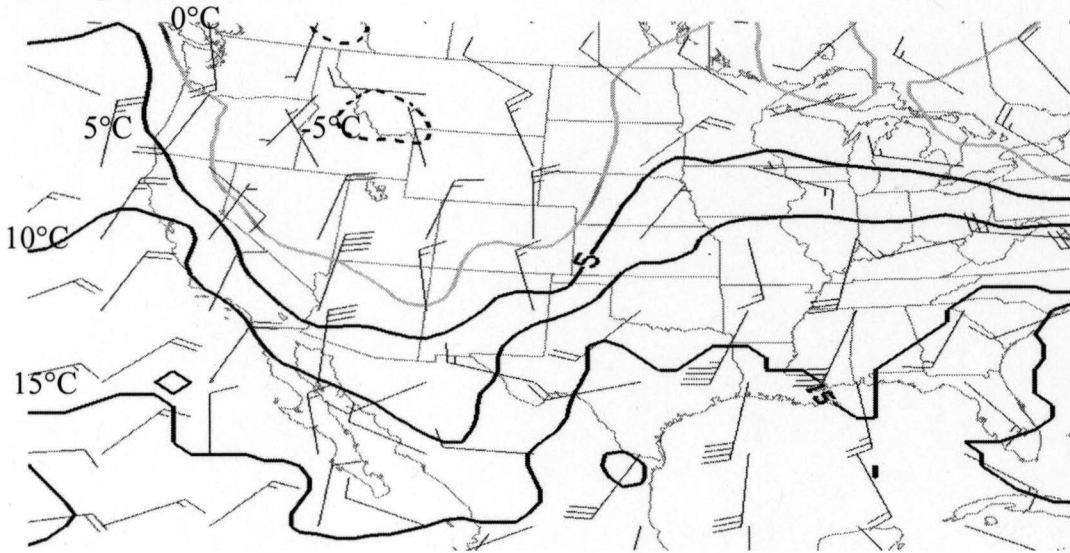
- 89) From the above map, which line represents a cold front? (Hint: wind direction, temperature, isobars and cloud cover)
 a) Line A b) Line B c) Line C d) There is no cold front

90) What contour interval is used to show the surface sea level pressure on the map?

- a) 4hPa b) 8hPa c) 10 hPa d) 5 hPa

APPENDIX C - EXAM #3

The following picture shows the isotherms and wind barbs at 850 hectopascal surface in February. Answer question 85.

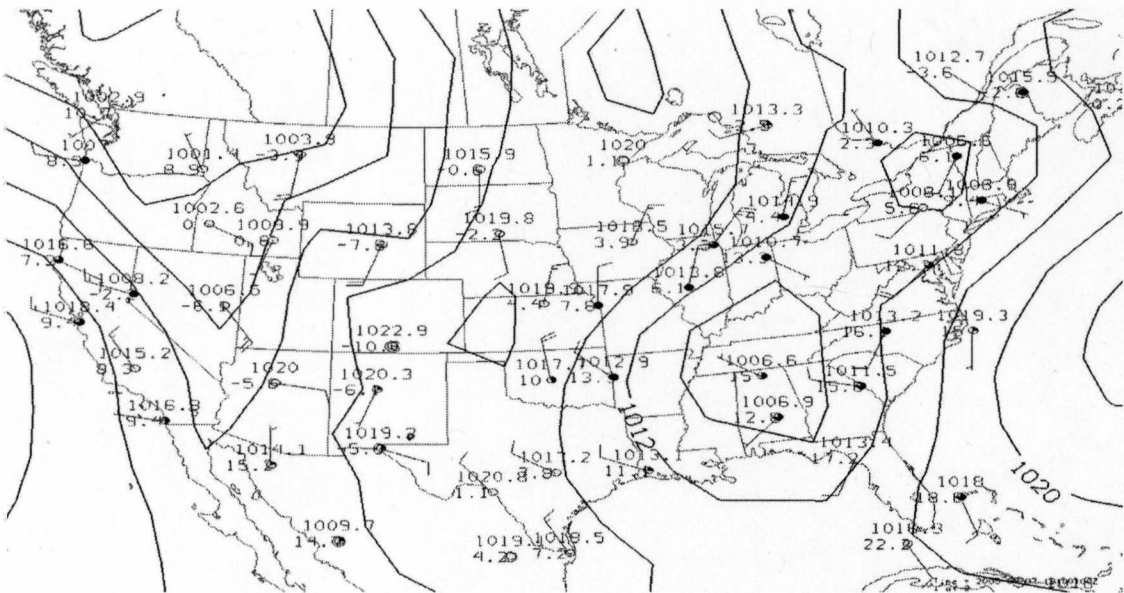


87) What air masses are affecting Middle West and South of the United State respectively

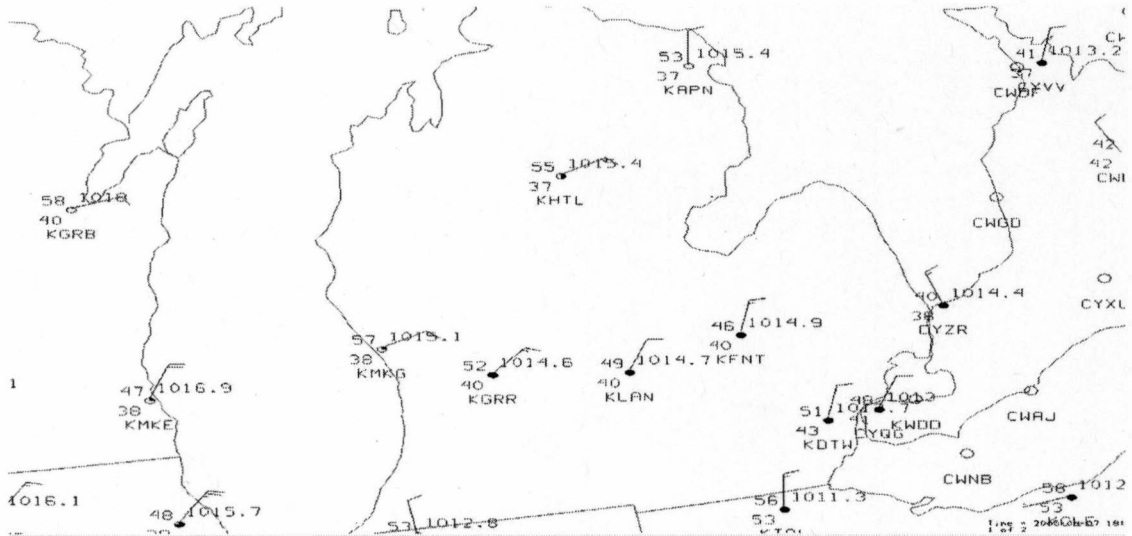
- a) mT and cP b) cP and mT c) mT and cA d) cP and cT

88) Judging from the pressure contours and the wind direction, on the surface weather map, a low pressure cell is located _____.

- a) Florida b) Tennessee c) Texas d) Washington

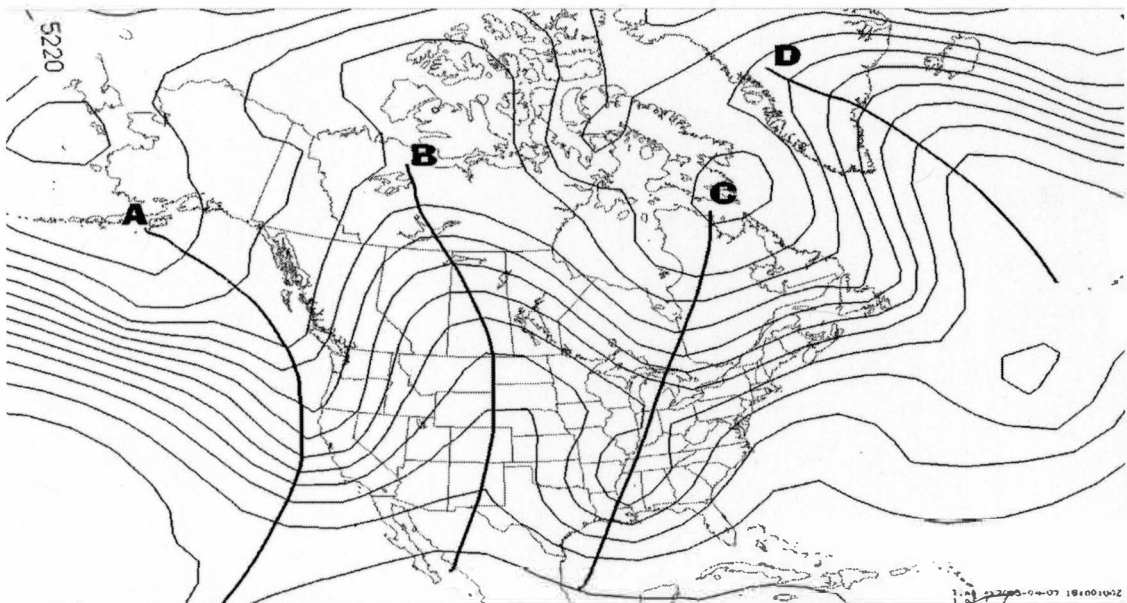


89) According to the next surface weather map, the Michigan city experiencing about 25% cloud cover and a northeasterly wind around 10 knots is probably



- a) KGRR b) KHTL c) KMMG d) KLAN

90) The following picture shows 500 hectopascal geopotential. That level is used to identify Rossby waves. Which 2 lines represent the Trough and which 2 represent the ridges respectively?



- a) Trough A and B, Ridge C and D b) Trough A and C, Ridge B and D
 c) Trough C and D, Ridge A and B d) Trough B and C, Ridge A and D

APPENDIX D - IDV LAB EVALUATION

**Geog 225 – intro to Meteorology and Climate-
Spring 2005**

IDV Lab

Evaluate the IDV lab about Weather Map Analysis.

1. I BELIEVE THAT THE IDV IN THE LAB EXERCISE HELPED ME TO MASTER SKILLS AND CONCEPTS MORE QUICKLY THAN THE TRADITIONAL METHODS.

Yes, I strongly believe

No, I strongly do not believe

5

4

3

2

1

2. I BELIEVE THAT THE IDV LAB HAS DEVELOPED MY SKILLS AND UNDERSTANDING BETTER THAN THE BLACK AND WHITE COLOR MAP EXERCISES?

Yes, I strongly believe

No, I strongly do not believe

5

4

3

2

1

3. I BELIEVE THAT THE IDV LAB ALLOWED ME TO LEARN MORE ON MY OWN, WITH LESS ASSISTANCE FROM TA?

Yes, I strongly believe

No, I strongly do not believe

5

4

3

2

1

APPENDIX E - HUMAN SUBJECT AUTHORIZATION



Centennial 1903-2003 Celebration

Human Subjects Institutional Review Board

Date: July 13, 2004

To: Elen Cutrim, Principal Investigator
Ricardo Nogueira, Student Investigator for thesis

Chair *Amy Naugle*

From: Amy Naugle, Ph.D., Interim Re:

HSIRB Project Number 04-07-16

This letter will serve as confirmation that your research project entitled "Using IDV to Learn Meteorology in Non-Science Majors" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals. Approval
Termination: July 13, 2005

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